2009 IDF

XII International Digisonde Forum

11 - 14 May 2009

University of Massachusetts Lowell
UMLCAR
Center for Atmospheric Research

UMASS Lowell
University of Massachusetts Lowell

600 Suffolk Street | 3rd floor | Lowell, MA 01854 | Tel: 978-934-4900 | Fax: 978-459-7915
Director: Bodo_Reinisch@uml.edu , www.umlcar.uml.edu

UNIVERSITY OF MASSACHUSETTS LOWELL
UMLCAR
CENTER FOR ATMOSPHERIC RESEARCH

GIRO

Global Ionospheric Radio Observatory

Prof. Bodo W. Reinisch

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
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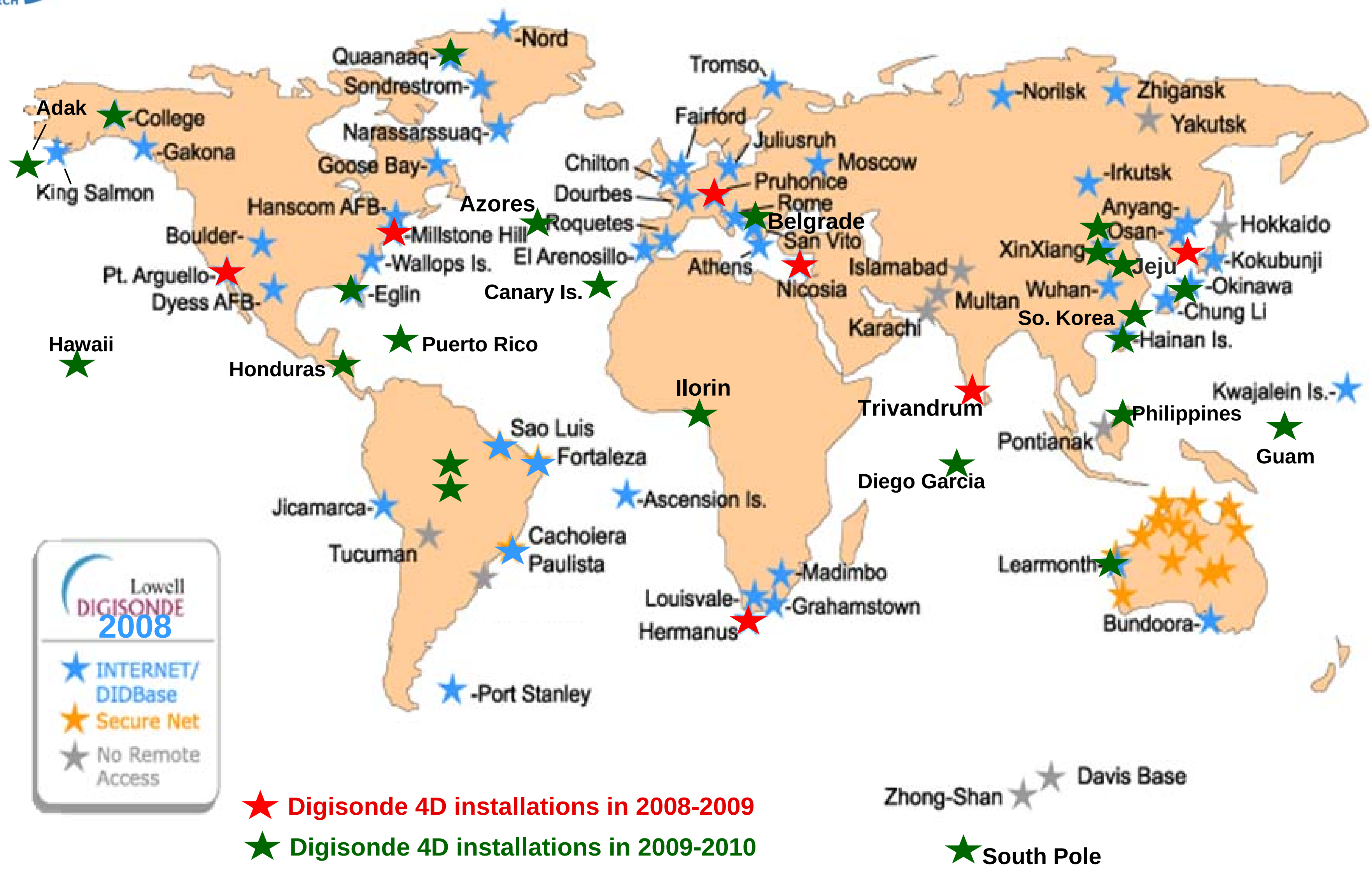
Digisonde **GIRO**

Global **I**onospheric **R**adio **O**bservatory



Additions to the DPS Fleet since 2007

104. DPS-4 serial #045, Russian Academy of Sciences, Troitsk, Russia
105. DPS-4 serial #046, SUPARCO, Multan, Pakistan
106. DPS-4S serial #047, UMLCAR, prototype
107. DPS-4D serial #048, UMLCAR, prototype
108. DPS-4D serial #049, Hermanus Magnetic Observatory, South Africa
109. DPS-4D serial #050, Frederick University, Nicosia, Cyprus
110. DPS-4D serial #051, Radio Research Laboratory, Jeju Island, Korea
111. DPS-4D serial #052, Vikram Sarabhai Space Center, Trivandrum, India
112. DPS-4D setial #053, Geomagnetic Institute, Belgrade, Serbia (shipped)
113. DPS-4D serial #054, UMLCAR, Millstone Hill, MA
114. DPS-4D NEXION serial #001, AFWA, Vandenberg AFB, California
115. DPS-4D NEXION serial #002, AFWA, Eglin AFB, Florida (shipped)

Installations Planned for 2009-2010:

NEXION, 11	3 more in 2009, then 8/year for total of 31 locations
China, 5	Muhe and South Pole (new), +3 systems to existing locations
Europe, 2	Prague, Dourbes (tentative)
Brazil, 2	(new locations)
Korea, 1	(new location)

DIDBase Status

as of May 3, 2009

- Total ionograms: 9,038,821
- Total ARTIST scaled: 9,038,821
- Total manually edited: 624,257
- Percent scaled manually: 7.1%
- New sites with real-time data streaming:
  - Moscow, Russia
  - Jeju Is., Korea
  - Sao Luis, Brazil
  - Fortaleza, Brazil

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Lowell DIDBase

Total locations: 61

(10 added since 2007)

Real-time contributors: 34

(4 added since 2007)

THANK YOU!

DIDBase Station list

Click on column header to sort. Click on URSI code to get List Of Years. Click on date to see Ionogram example.

#	URSI	STATION NAME	LAT	LONG	EARLIEST DATA	LATEST DATA
1	AN438	ANYANG	37.39	126.95	Oct 30 (304), 2000	Apr 28 (118), 2009
2	AS00Q	ASCENSION ISLAND	-7.95	345.60	Mar 22 (081), 1997	Apr 24 (114), 2009
3	AT138	ATHENS	38.00	23.50	Jan 15 (015), 2002	May 08 (128), 2009
4	BJ032	BERMUDA	32.40	295.30	Jan 01 (001), 2000	Feb 21 (052), 2001
5	BC840	BOULDER	40.00	254.70	Mar 23 (083), 2004	May 08 (128), 2009
6	BV53Q	BUNDOORA	-37.70	145.05	Jan 15 (015), 2002	Apr 28 (118), 2005
7	CAJ2M	CACHOEIRA PAULISTA	-23.20	314.20	Mar 19 (078), 2001	Oct 23 (296), 2007
8	RL052	CHILTON	51.50	359.40	Dec 16 (351), 1996	May 08 (128), 2009
9	CO764	COLLEGE AK	64.90	212.00	Dec 31 (365), 1999	Apr 22 (112), 2009
10	CS839	COLORADO_SPRINGS	39.00	255.12	Dec 22 (357), 2008	Dec 29 (364), 2008
11	DB049	DOURBES	50.10	4.60	Dec 31 (365), 2001	May 08 (128), 2009
12	DS932	DYESS AFB	32.40	260.20	Dec 31 (365), 1999	Apr 23 (113), 2009
13	EG931	EGLIN AFB	30.40	273.20	Dec 31 (365), 1999	May 08 (128), 2009
14	EA036	EL ARENOSILLO	37.10	353.30	Apr 17 (108), 2000	May 08 (128), 2009
15	FF051	FAIRFORD	51.70	358.50	Mar 25 (085), 2000	May 08 (128), 2009
16	FZA0M	FORTALEZA	-3.80	322.00	Mar 22 (081), 2001	May 08 (128), 2009
17	GA762	GAKONA	62.38	215.00	Oct 03 (276), 1998	May 08 (128), 2009
18	GSJ53	GOOSE BAY	53.30	299.70	Apr 18 (108), 1995	Oct 27 (301), 2008
19	GR13L	GRAHAMSTOWN	-33.30	26.50	Apr 12 (103), 1996	May 08 (128), 2009
20	HA419	HAINAN	19.40	109.00	Mar 24 (083), 2002	Feb 29 (060), 2008
21	HA343	HANSCOM AFB	42.50	288.70	Mar 22 (081), 1997	Aug 19 (231), 2003
22	HE13N	HERMANUS	-34.42	19.22	Jul 04 (186), 2008	May 08 (128), 2009
23	IR352	IRKUTSK	52.40	104.30	Nov 30 (334), 2002	Dec 23 (357), 2006
24	JJ433	JEJU	33.43	126.30	Jan 05 (005), 2009	Apr 24 (114), 2009
25	JI91J	JICAMARCA	-12.00	283.20	Jul 20 (201), 1993	May 08 (128), 2009
26	JR055	JULIUSRUH	54.60	13.40	Jan 01 (001), 2001	May 07 (127), 2009
27	KS759	KING SALMON	58.40	203.60	Dec 31 (365), 1999	Feb 14 (045), 2009
28	TO535	KOKUBUNJI	35.70	139.50	Oct 30 (303), 2001	Oct 30 (303), 2001
29	KJ609	KWAJALEIN	9.00	167.20	Nov 17 (321), 1999	May 08 (128), 2009
30	LA42Q	LAVERTON	-28.30	122.80	Mar 04 (064), 2008	Mar 04 (064), 2008
31	LM42B	LEARMONTH	-21.80	114.10	Dec 31 (365), 1999	May 08 (128), 2009
32	LV12P	LOUISVALE	-28.50	21.20	Aug 17 (230), 2000	May 02 (122), 2009
33	MU12K	MADIMBO	-22.39	30.88	Aug 31 (244), 2000	May 08 (128), 2009
34	MHJ45	MILLSTONE HILL	42.60	288.50	Mar 20 (080), 1992	May 08 (128), 2009
35	MO155	MOSCOW	55.47	37.30	Oct 26 (300), 2008	May 08 (128), 2009
36	MU230	MULTAN	33.03	72.01	Mar 01 (060), 2008	Mar 31 (090), 2009
37	NQ061	NARSSARSSUAQ	61.20	314.60	Mar 25 (085), 2000	Nov 25 (330), 2008
38	NI135	NICOSIA	35.03	33.16	Sep 17 (261), 2008	Sep 18 (262), 2008
39	NO369	NORILSK	69.20	88.00	Dec 11 (345), 2002	Dec 22 (356), 2006
40	OK426	OKINAWA	26.70	128.20	Dec 31 (365), 2001	Apr 05 (095), 2003
41	SN437	OSAN AB	37.10	127.00	Dec 31 (365), 1999	Aug 17 (229), 2006
42	PSJ5J	PORT STANLEY	-51.60	302.10	Feb 27 (058), 1996	May 08 (128), 2009
43	PQ052	PRUHONICE	50.00	14.60	Jan 20 (020), 2004	May 08 (128), 2009
44	PA836	PT ARGUELLO	34.80	239.50	May 07 (127), 1998	May 08 (128), 2009
45	TH077	QAANAAQ	77.50	290.60	Jan 01 (001), 1997	May 08 (128), 2009
46	PRJ18	RAMEY	18.50	292.90	Jun 09 (160), 1999	Aug 17 (229), 2007
47	RO041	ROME	41.90	12.50	Jun 07 (158), 1997	May 08 (128), 2009
48	EB040	ROQUETES	40.80	0.50	Jun 06 (158), 1998	May 08 (128), 2009
49	VT139	SAN VITO	40.60	17.80	Aug 02 (215), 2000	May 08 (128), 2009
50	SAA0K	SAO LUIS	-2.60	315.80	Jan 19 (019), 1997	May 08 (128), 2009
51	SMJ67	SONDRESTROM	66.98	309.06	Oct 27 (300), 1989	May 08 (128), 2009
52	SH42_	SOUTH HEDLAND	-20.40	118.50	Mar 04 (064), 2008	Mar 04 (064), 2008
53	TM308	TRIVANDRUM	8.53	76.86	Feb 03 (034), 2009	Feb 26 (057), 2009
54	TR169	TROMSO	69.60	19.20	Jul 01 (182), 1993	May 08 (128), 2009
55	TUJ2O	TUCUMAN	-26.90	294.60	Nov 11 (315), 2002	Dec 22 (356), 2006
56	WP937	WALLOPS IS	37.90	284.50	Jan 11 (011), 2000	Jan 08 (008), 2008
57	WU430	WUHAN	30.50	114.40	Jan 27 (027), 2002	Apr 02 (093), 2004
58	XI434	XINXIANG CHINA	35.30	113.92	Jun 20 (171), 2006	Jun 24 (175), 2006
59	YA462	YAKUTSK	62.00	129.60	Nov 29 (333), 2002	Dec 22 (356), 2006
60	ZH466	ZHIGANSK	66.80	123.40	Nov 12 (316), 2003	Dec 22 (356), 2006
61	ZS36R	ZHONG SHAN	-69.40	76.40	Jan 01 (001), 2005	Dec 26 (360), 2005

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SCIENCE WITH DIGISONDES

Prof. Bodo W. Reinisch
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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11 - 14 MAY 2009

Science Project Review

- Space Weather events in GIRO data
  - Interplanetary shock
  - Super-Fountain Effect in equatorial ionosphere
  - Storm Sudden Commencements
  - Magnetic storm timelines
- Assimilation techniques for GIRO
  - Real-time IRI
  - Uncertainty analysis for GAIM
- Single-site science
  - Plasma perturbations due to HF heating
    - Precision echolocation (skymaps)
    - High cadence ionograms (dynamics of stratifications)
    - High frequency resolution ionograms (fine structures)
  - D-region absorption
  - Fine E-layer effects seen in precision ranging mode
  - Monitoring self-scattering of HF heater signals (passive mode)

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Space Weather Events as Seen by GIRO

Qiugang Zong, Bodo Reinisch,
Paul Song and Ivan Galkin
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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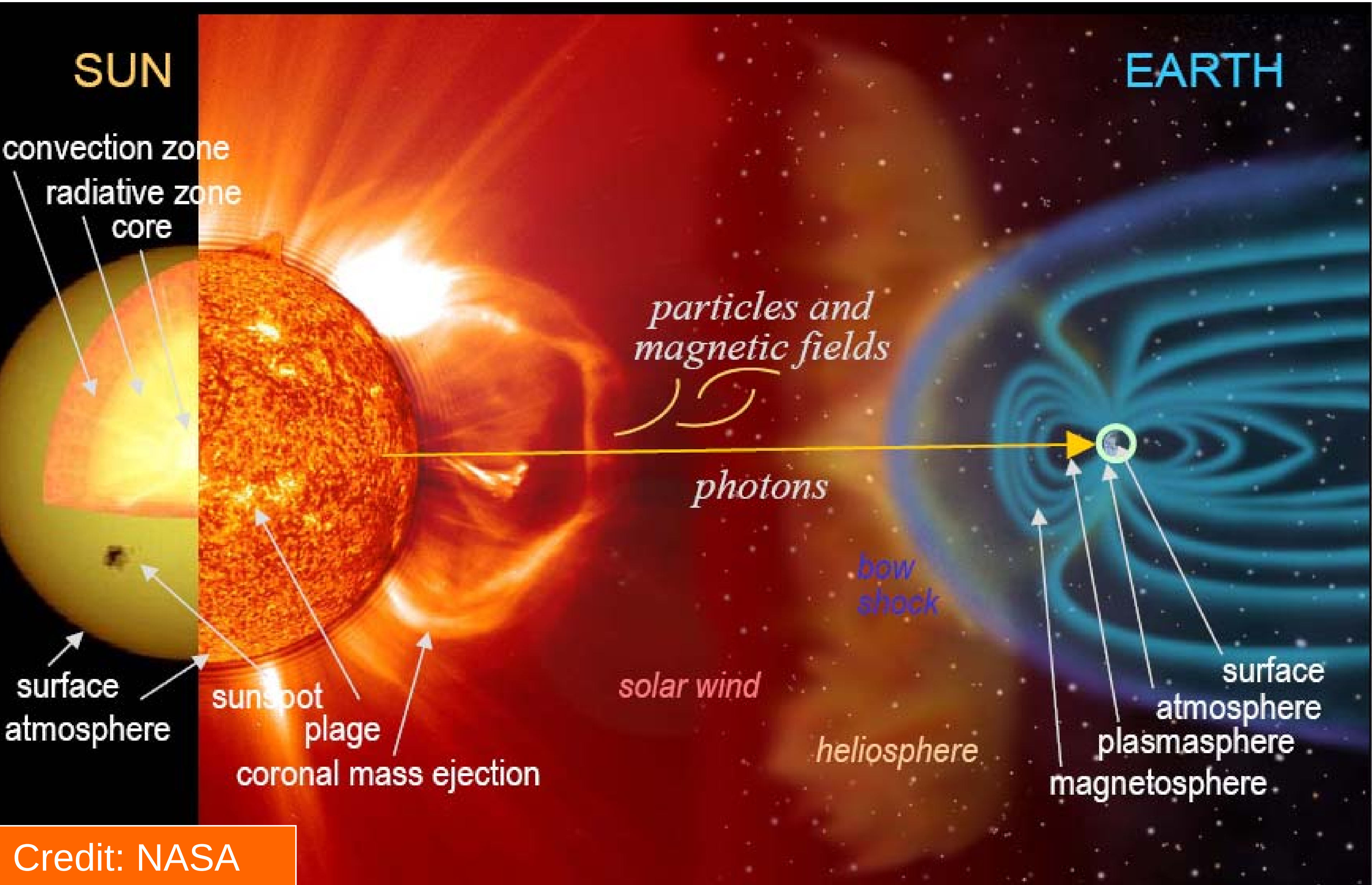
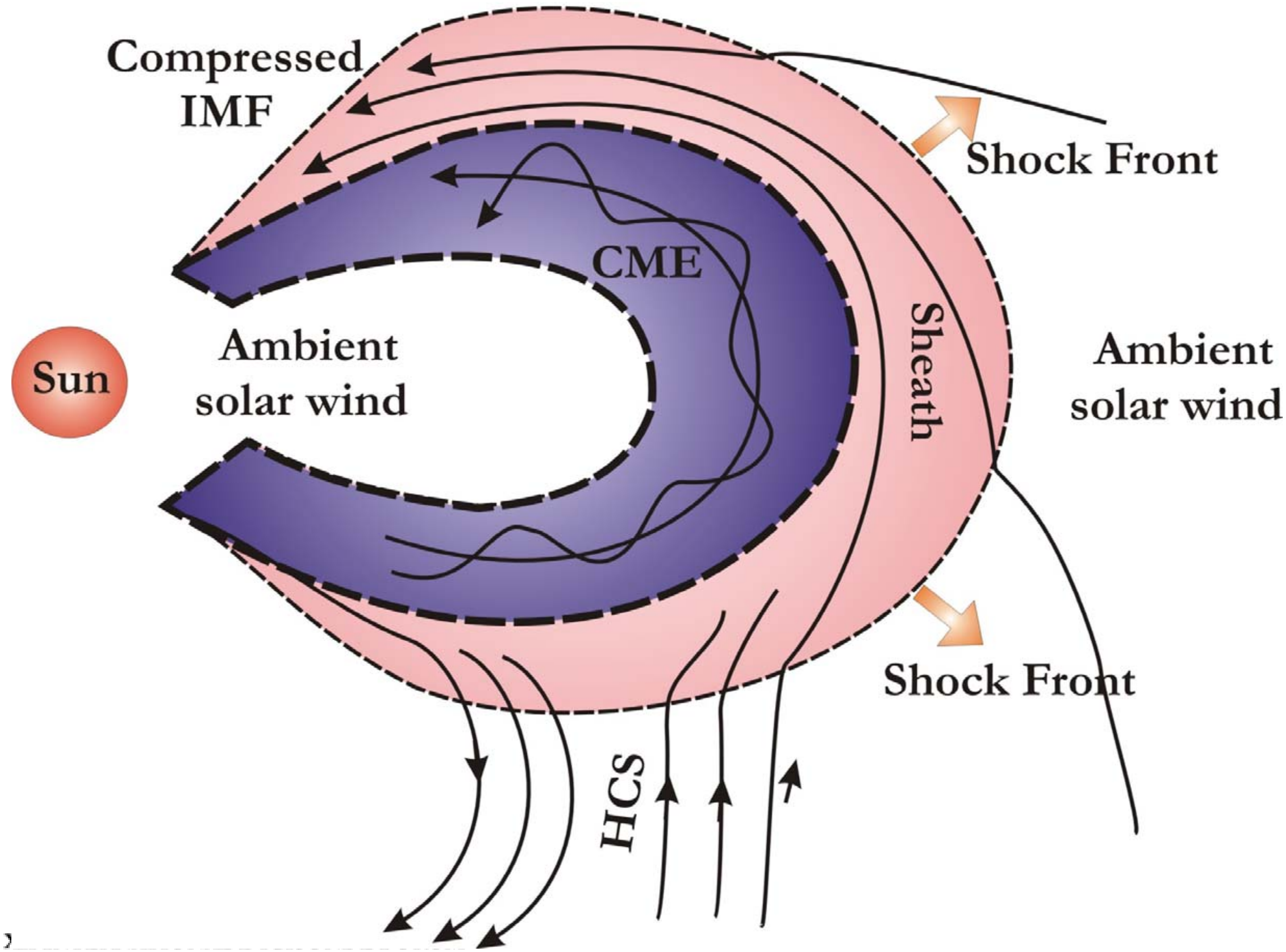
11 - 14 MAY 2009

The Sun-Earth Connection



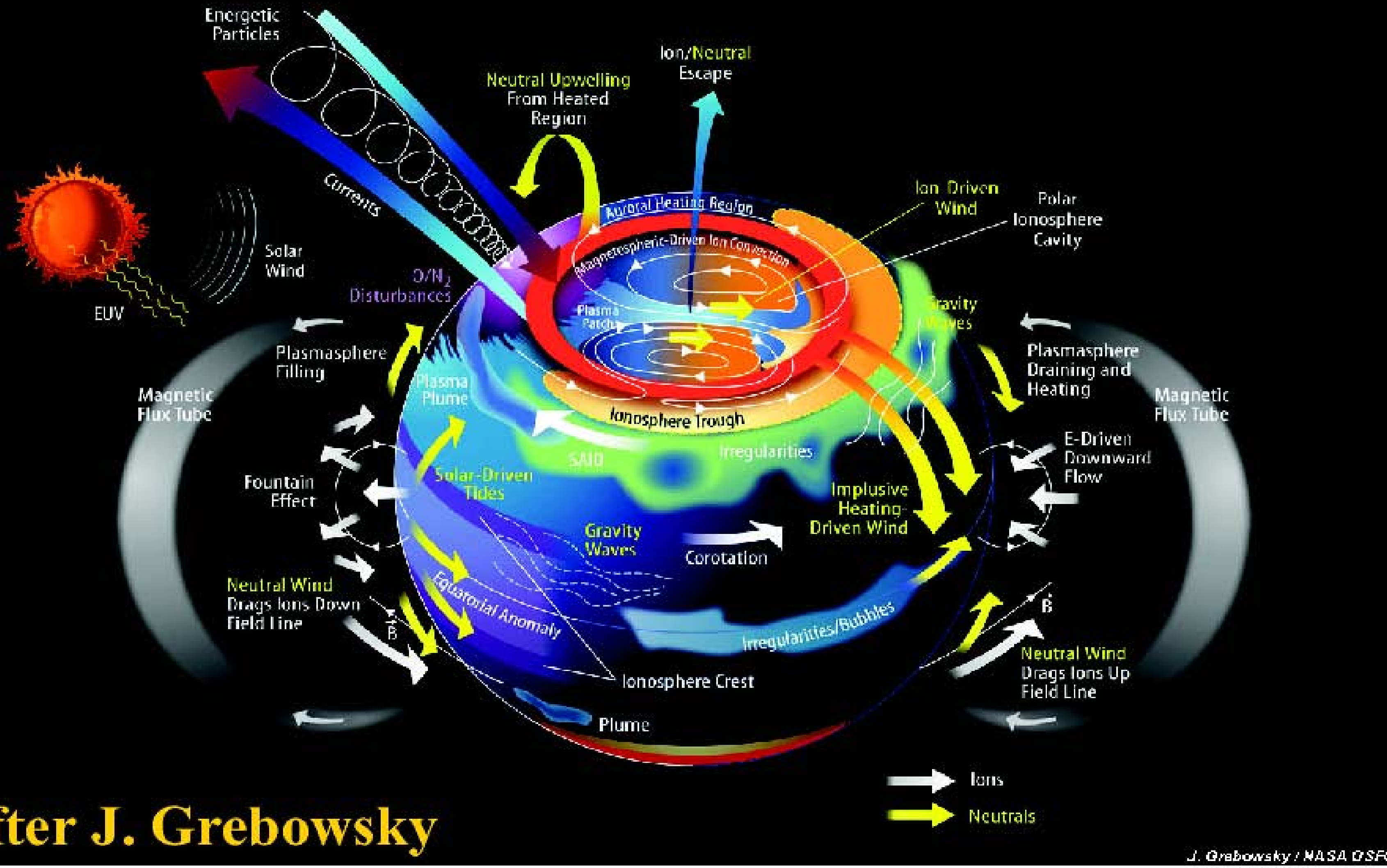
Credit: NASA

Interplanetary Shock Structure

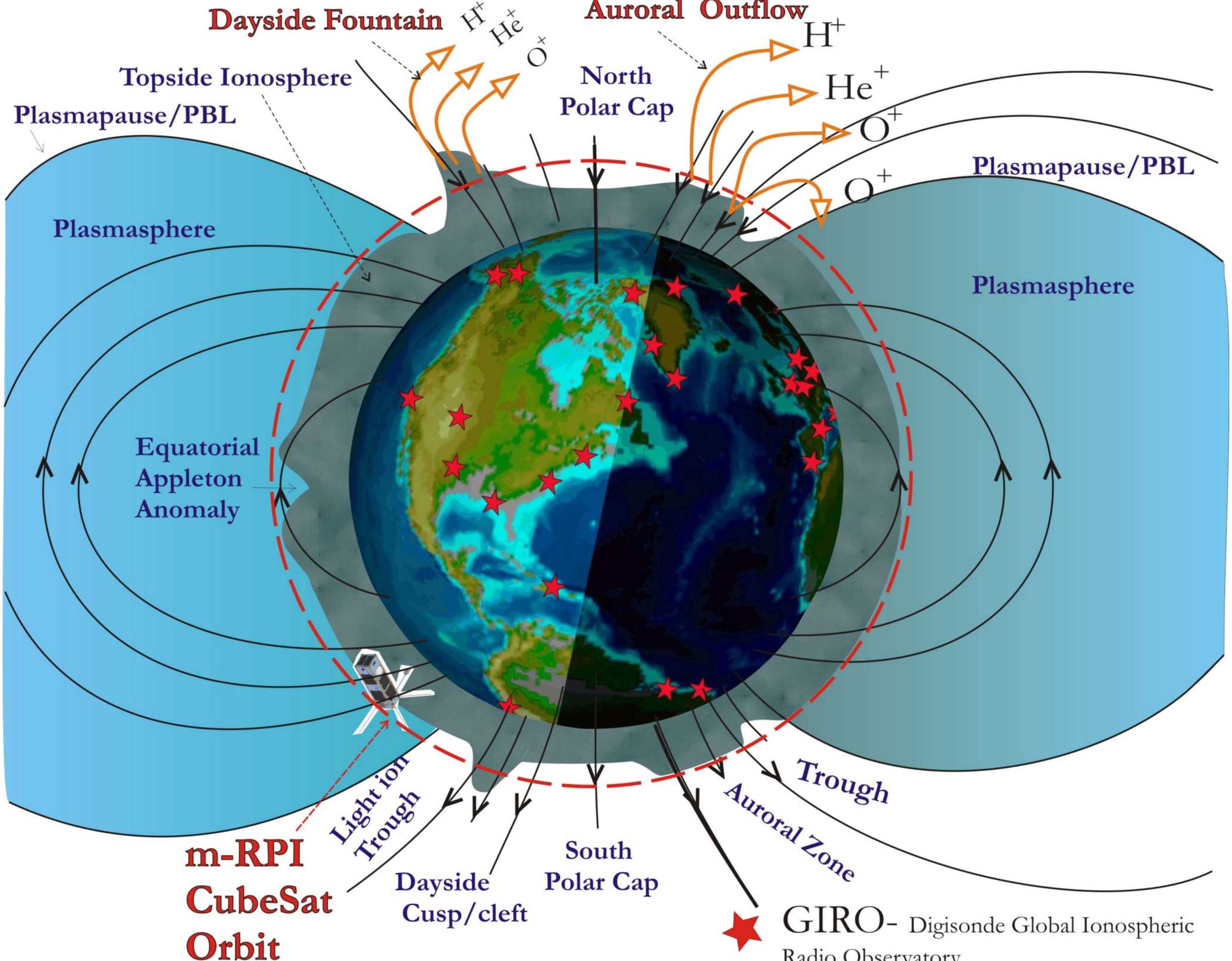


Sun-Earth Connection

During Geomagnetic Storms



After J. Grebowsky


Dayside Fountain
H^+
He^+
O^+
Auroral Outflow
H^+
He^+
O^+
O^+
Topside Ionosphere
Plasmapause/PBL
North
Polar Cap
Plasmapause/PBL
Plasmasphere
Plasmasphere
Equatorial
Appleton
Anomaly
Light ion
Trough
Trough
Auroral Zone
m-RPI
CubeSat
Orbit
Dayside
Cusp/cleft
South
Polar Cap
GIRO- Digisonde Global Ionospheric
Radio Observatory

Storm sudden commencements (ssc)

The old definition, that said that "an ssc is a sudden commencement of a magnetic storm", is **Now changed into** "sudden commencements followed by a magnetic storm or by an increase in activity lasting at least one hour".

P. N. Mayaud (IAGA Bulletin 33 : "A Hundred Years Series of Geomagnetic Data,
1868-1967. Indices aa and storm sudden commencements"; see also IAGA Bulletin 39 : "Supplementary Geomagnetic Data 957-1975“.

Thomas Gold is the first one who suggest interplanetary shocks can explain geomagnetic storm sudden compressions (in *Gas Dynamics of Cosmic Clouds,* North Holland Publishing, pg 103, 1955)

Acknowledge: DIDB system

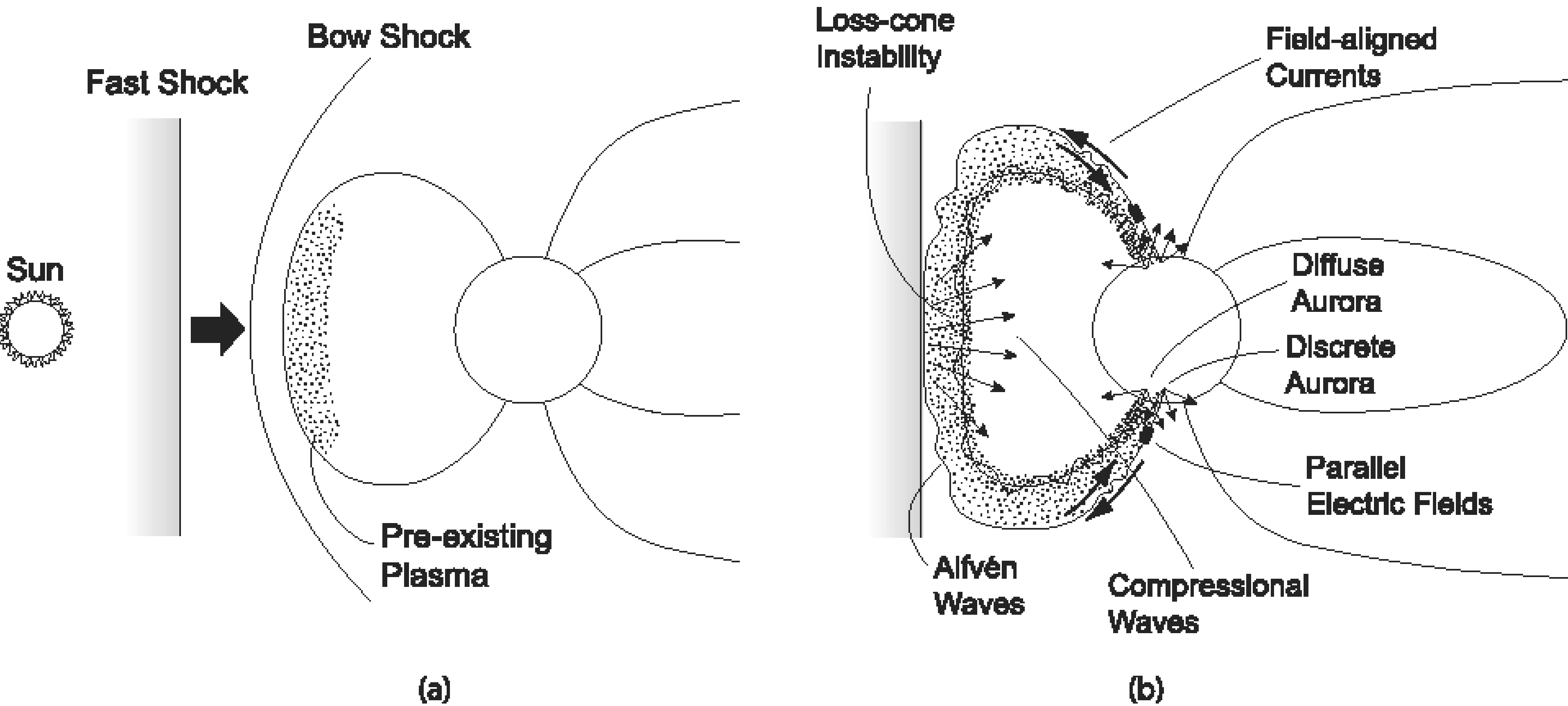


Figure 9. A schematic of possible phenomena in the dayside magnetosphere and ionosphere, which are generated by interplanetary shock/pressure pulse compression.

Zhou et al, 2003

Energy input from Solar Wind Ram Pressure -- Tsurutani and Gonzalez, 1995

The amount of solar wind energy input into the magnetosphere/ ionosphere has been estimated to be

0.1 to 0.4% of the solar wind ram energy,

that is 1.0-6.3 x 10^20 erg/s

[Tsurutani and Gonzalez], 1995, Borovsky and Steinberg [2006]

Observations

- **Motivation**

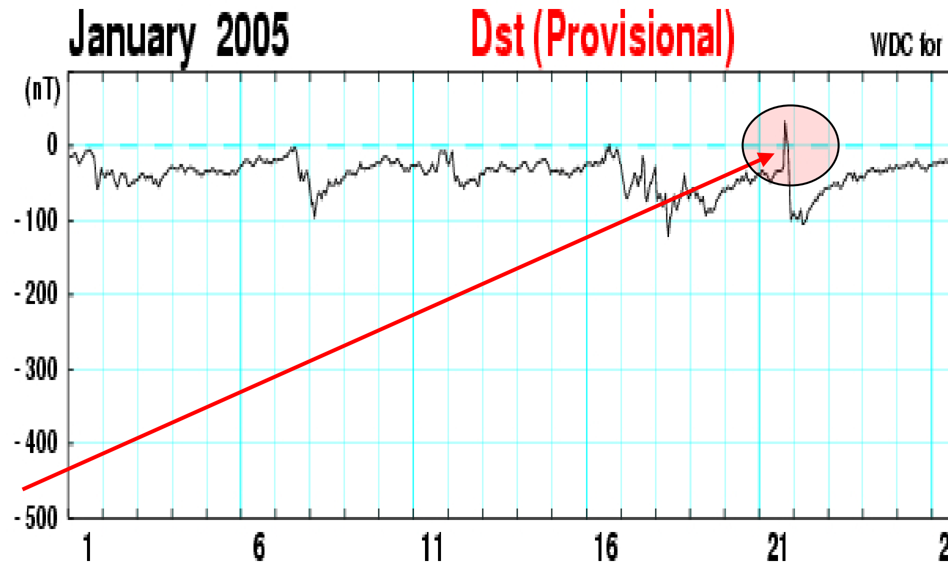
---- dayside aurora

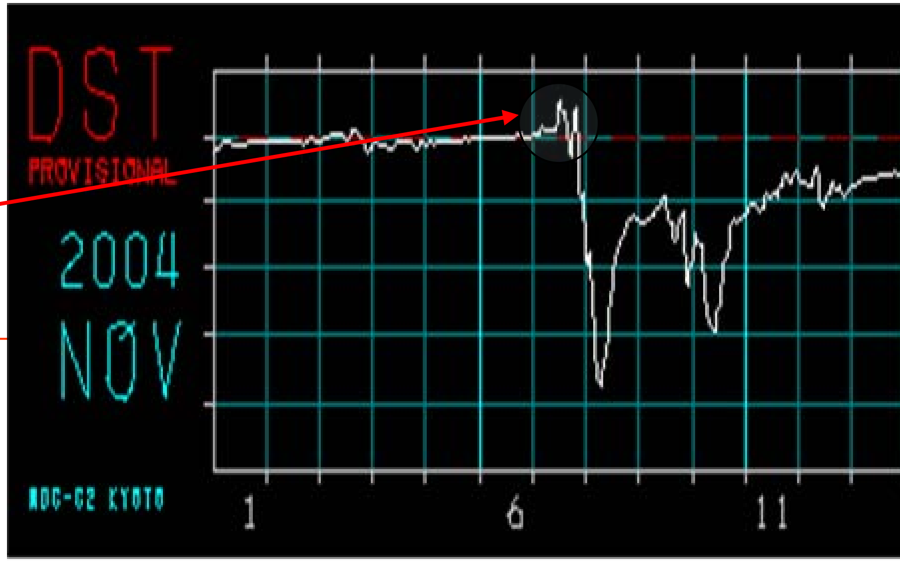
---- shock aurora

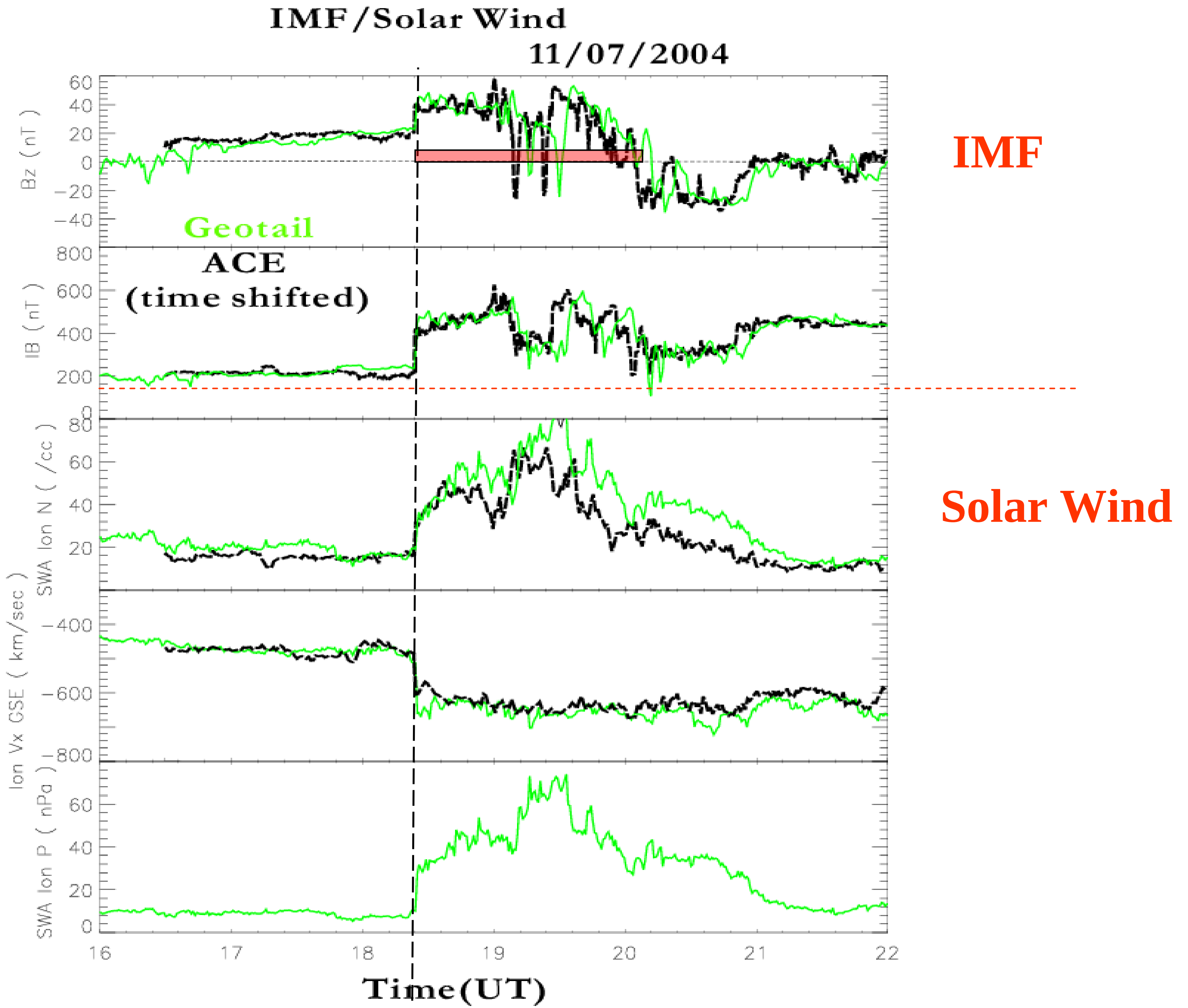
---- Interplanetary Shock

- **Jan 21, 2005 (1710UT), Dst=- 101 nT**

- **Nov. 7, 2004 (1828UT) Dst=-373 nT**







IMF/Solar Wind
11/07/2004
Geotail
ACE
(time shifted)
Bz (nT)
IB (nT)
SWA Ion N (/cc)
Ion Vx GSE (km/sec)
SWA Ion P (nPa)
Time(UT)
IMF
Solar Wind

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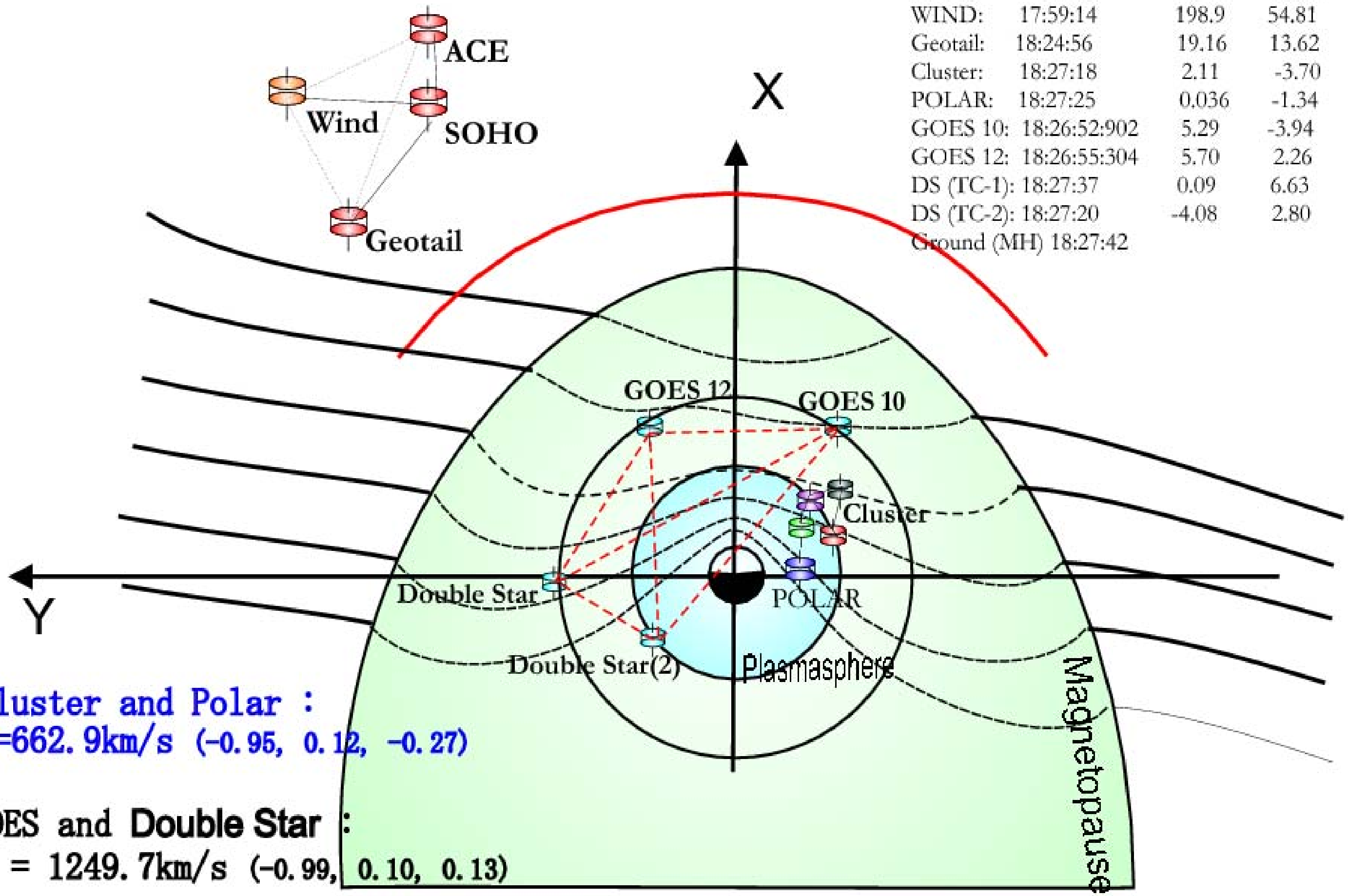
Zong et al, 2008

The Propagation of the Wave Fronts in the magnetosphere

V=724.5 km/s (-0.96, -0.13, -0.27)

ACE:	17:54:08	241.2	24.45	-16.09
SOHO	17:59:00	220.1	-103.8	-4.4
WIND:	17:59:14	198.9	54.81	-9.22
Geotail:	18:24:56	19.16	13.62	-2.67
Cluster:	18:27:18	2.11	-3.70	1.05
POLAR:	18:27:25	0.036	-1.34	0.966
GOES 10:	18:26:52:902	5.29	-3.94	0.434
GOES 12:	18:26:55:304	5.70	2.26	2.47
DS (TC-1):	18:27:37	0.09	6.63	0.128
DS (TC-2):	18:27:20	-4.08	2.80	4.91
Ground (MH)	18:27:42			



Cluster and Polar :
V=662.9km/s (-0.95, 0.12, -0.27)

GOES and Double Star :
V = 1249.7km/s (-0.99, 0.10, 0.13)

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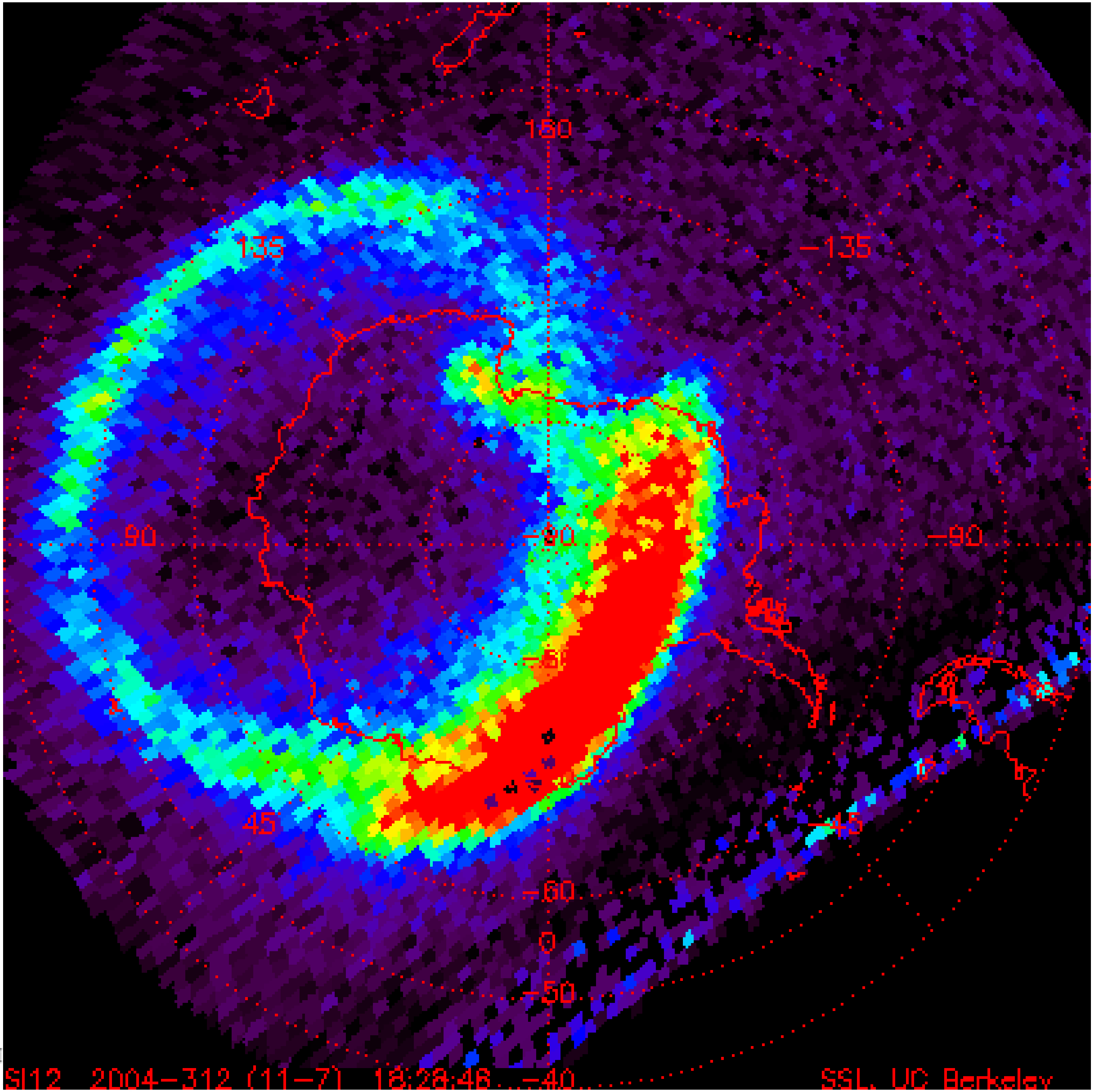
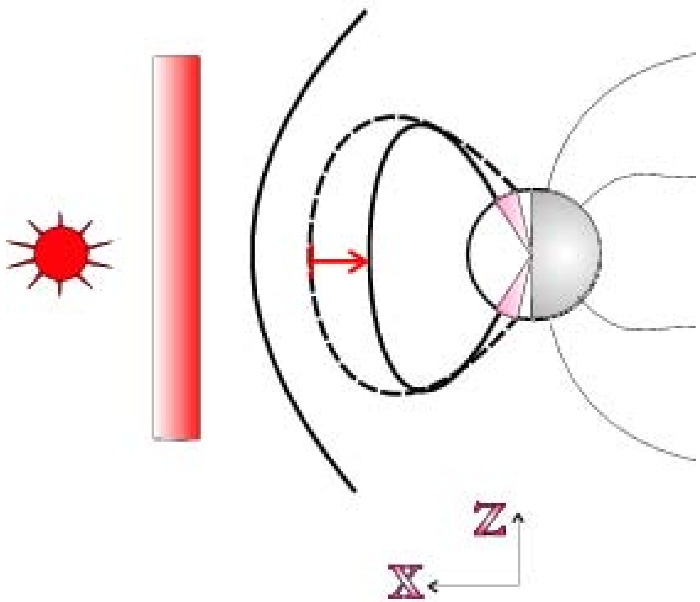
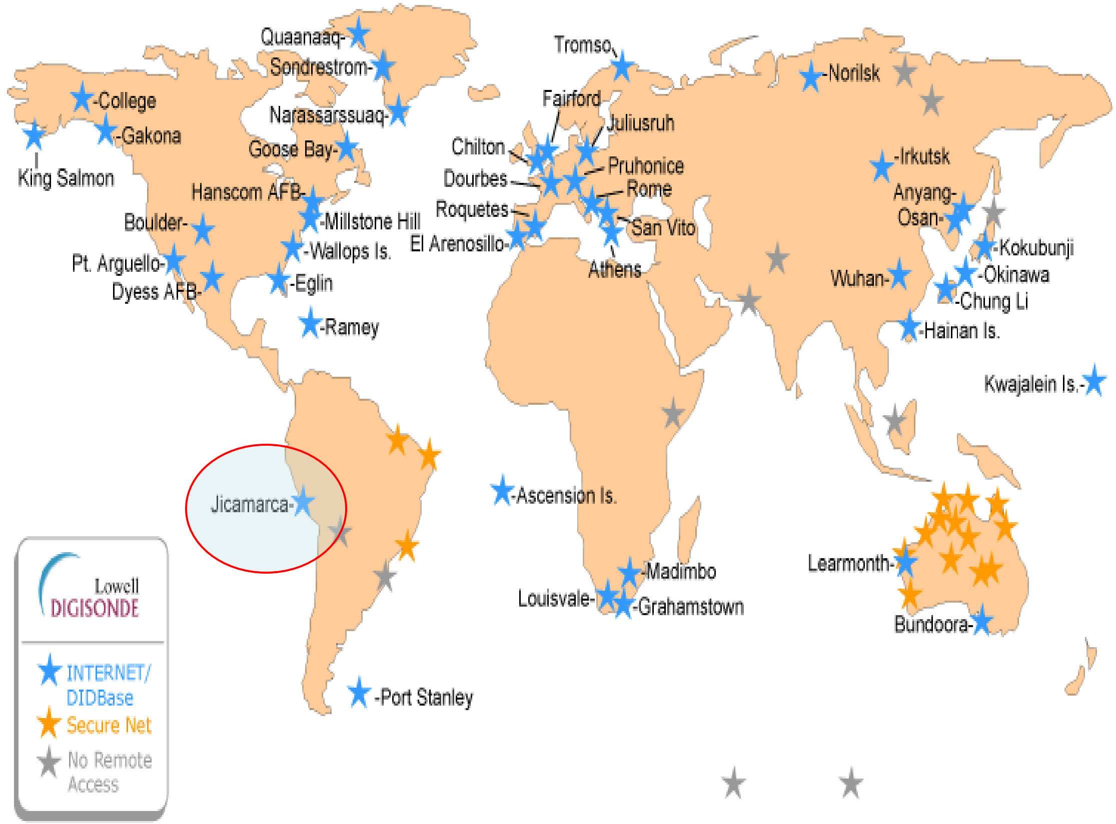


2009 IDF XII 11





1. Equatorial Ionosphere Response

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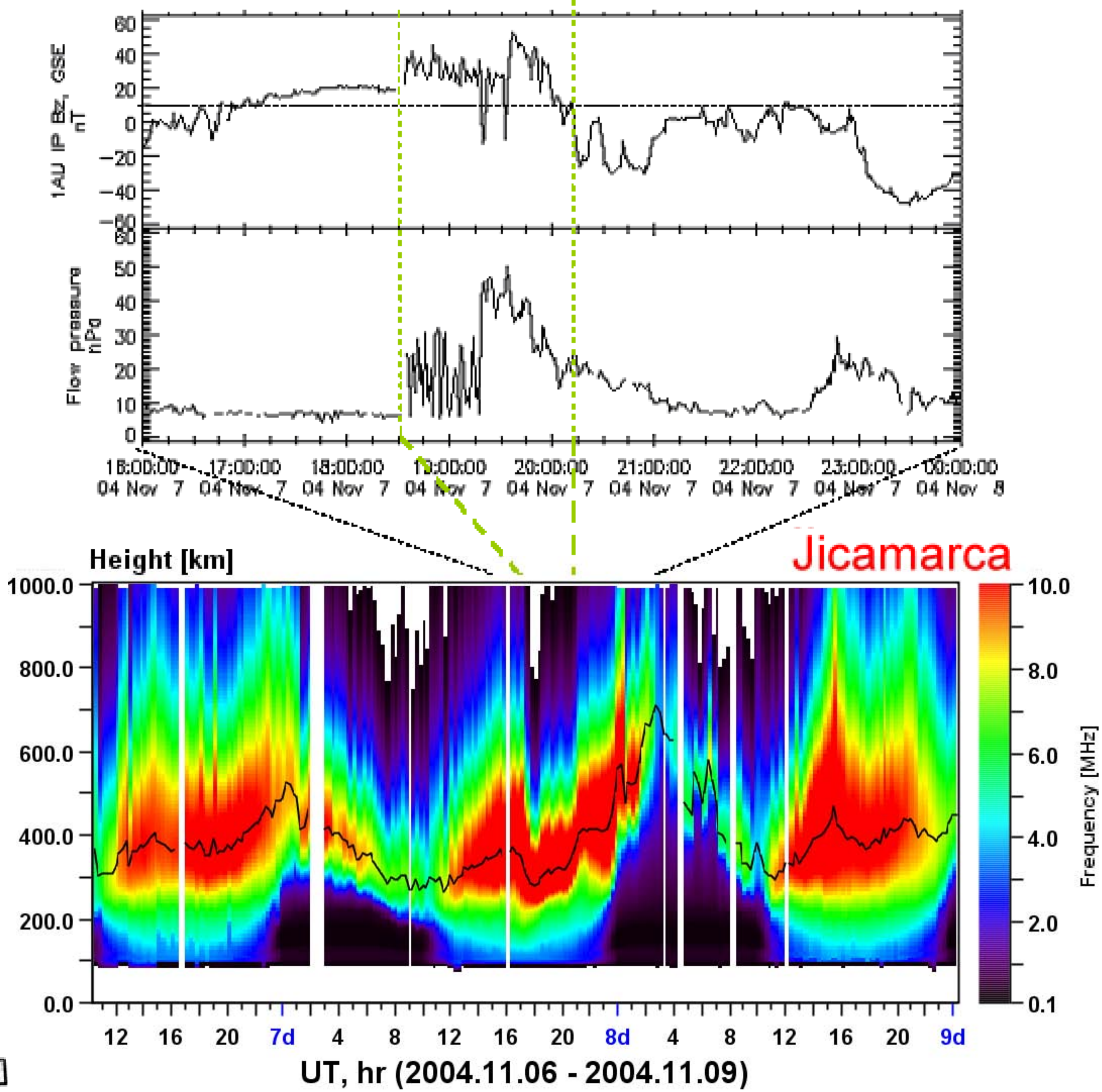
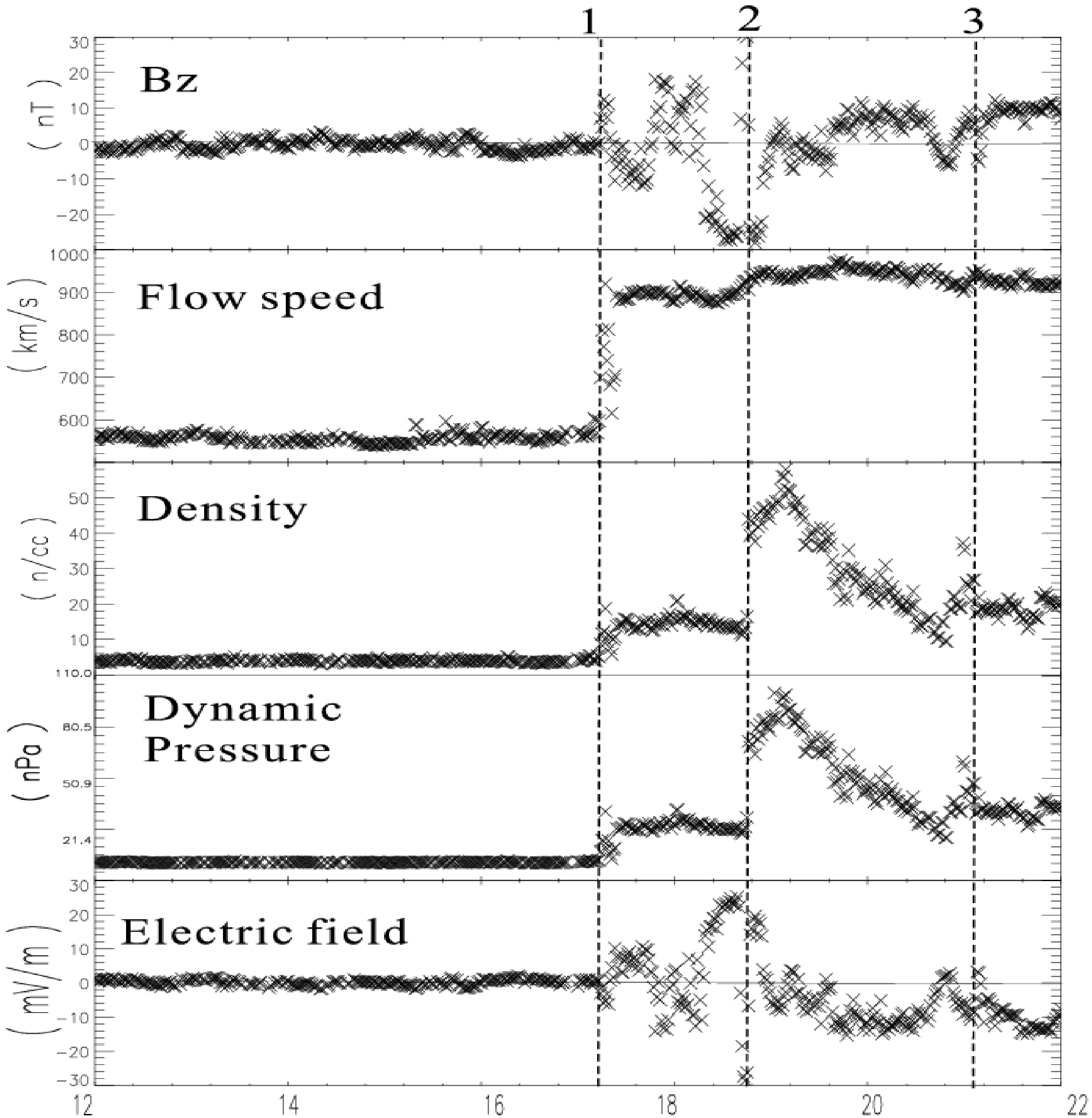
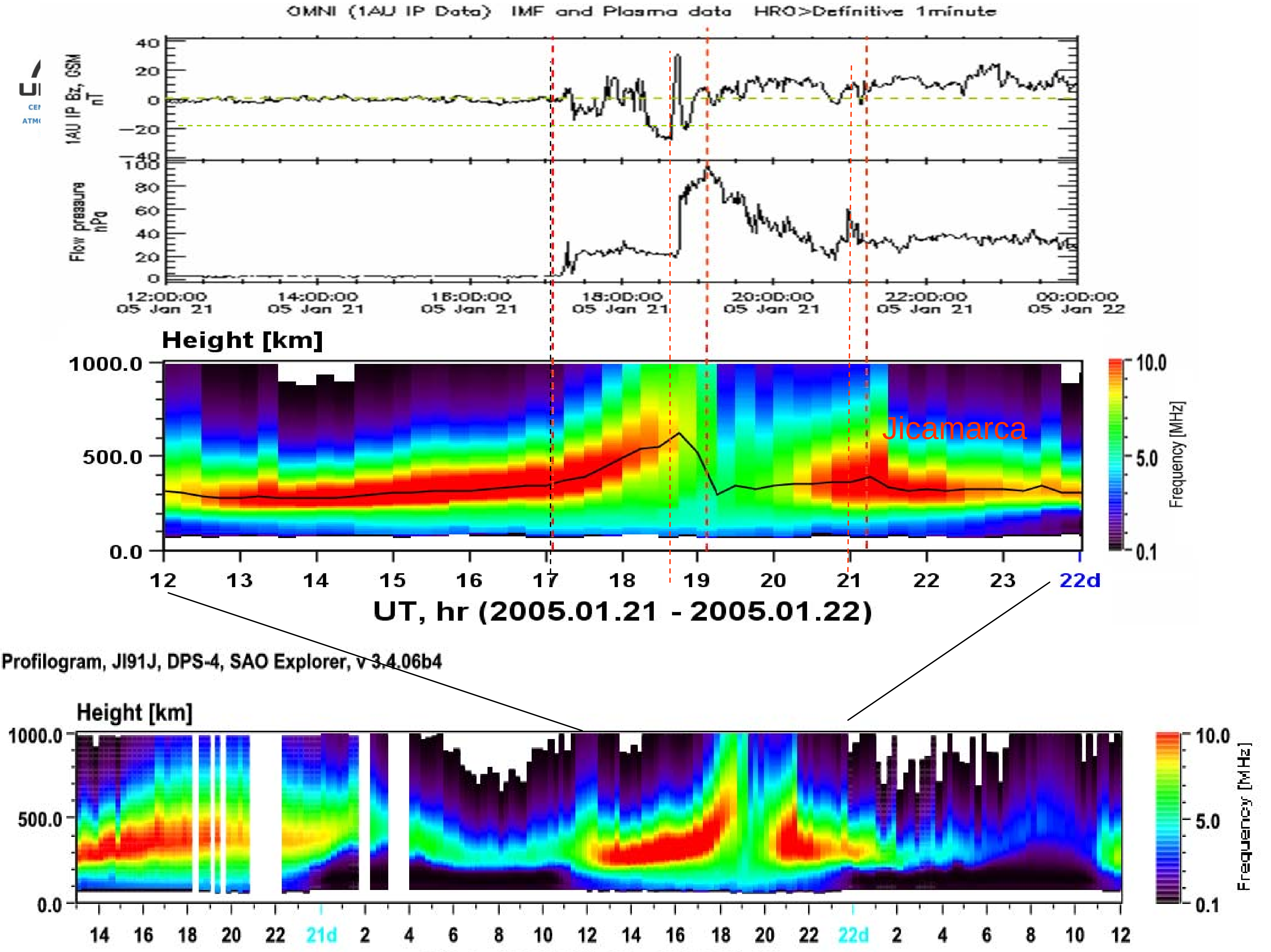
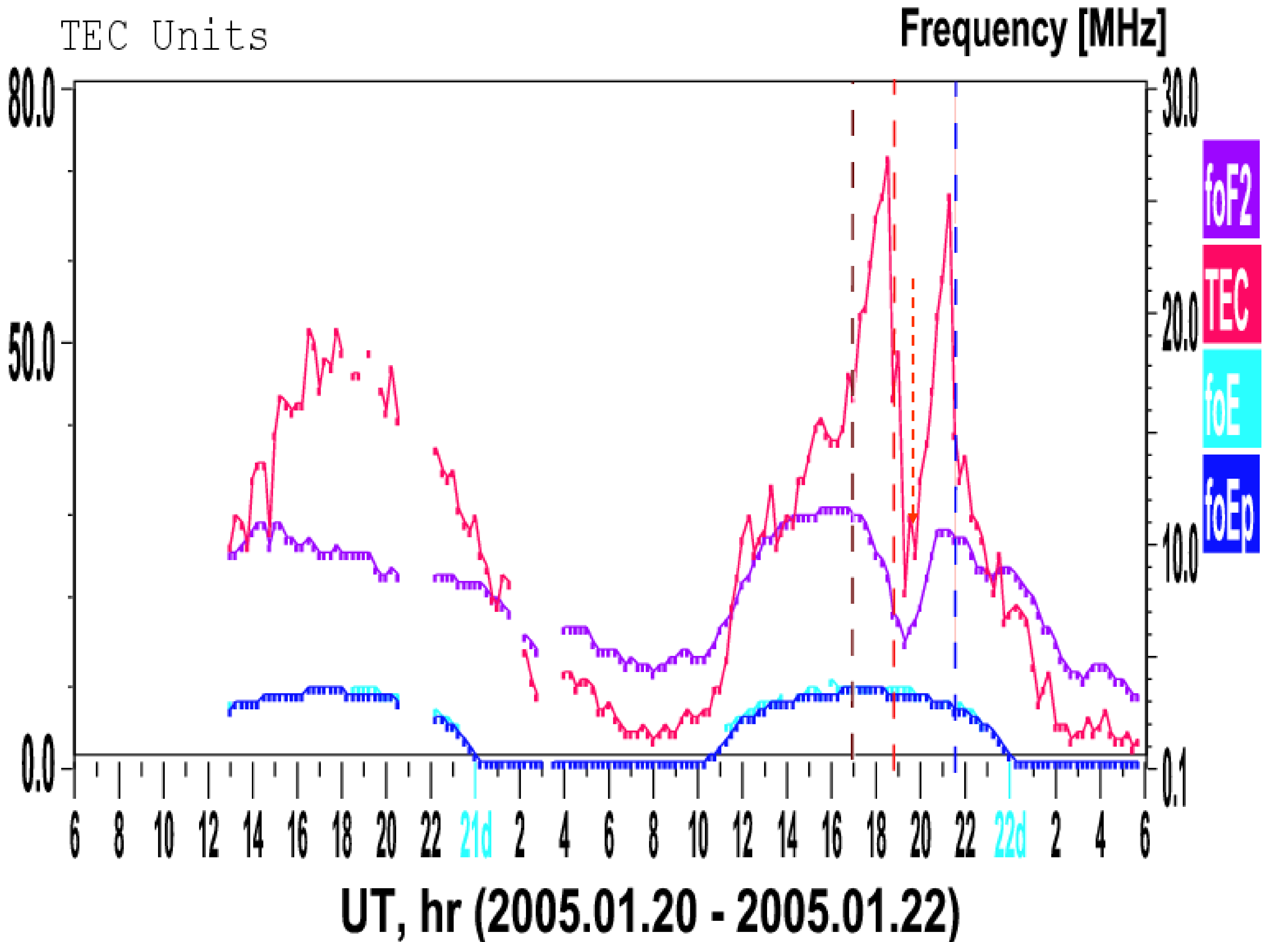


2009 IDF

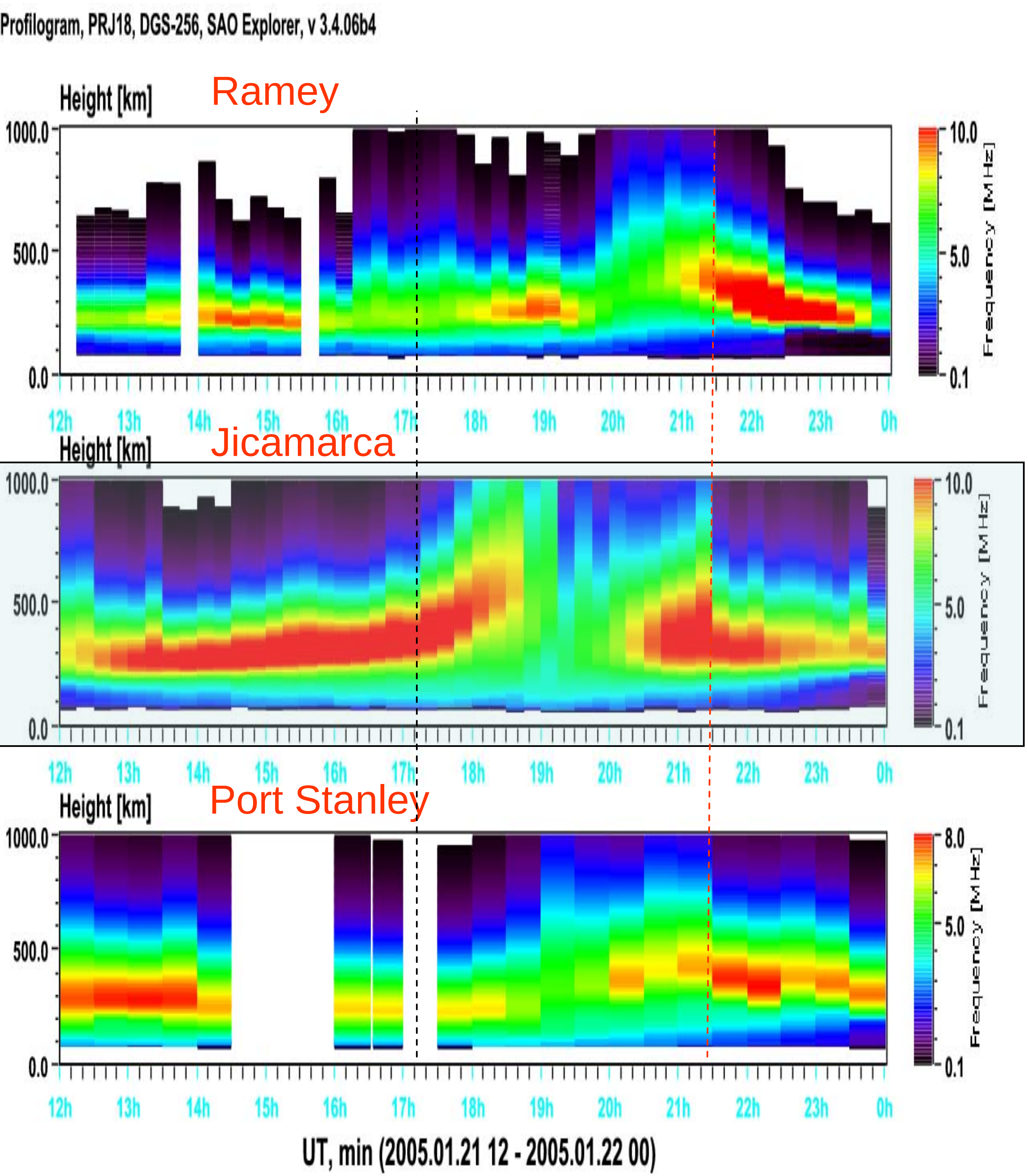
IMF/Solar Wind Jan 21, 2005

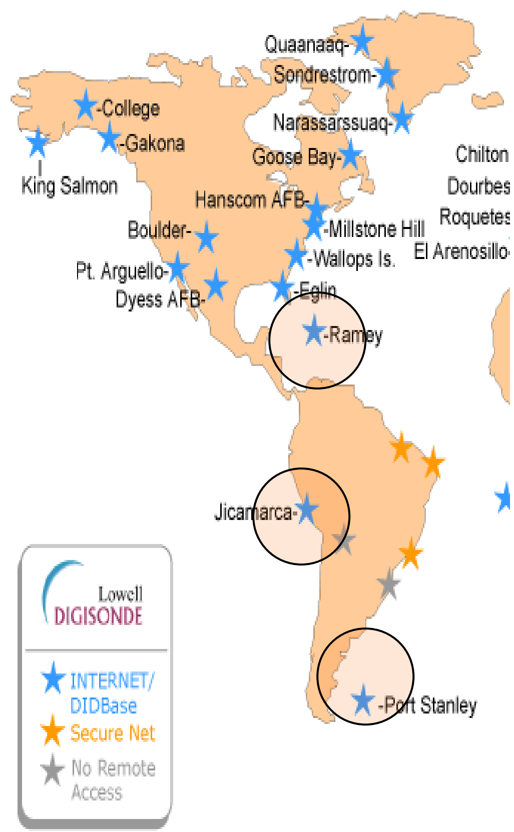



OMNI (1AU IP Data) IMF and Plasma data HRO>Definitive 1minute
1AU IP Bz, GSM nT
Flow pressure nPa
12:00:00 05 Jan 21
14:00:00 05 Jan 21
16:00:00 05 Jan 21
18:00:00 05 Jan 21
20:00:00 05 Jan 21
22:00:00 05 Jan 21
00:00:00 05 Jan 22
Height [km]
Jicamarca
Frequency [MHz]
UT, hr (2005.01.21 - 2005.01.22)
22d
Profilogram, JI91J, DPS-4, SAO Explorer, v 3.4.06b4
Height [km]
21d
22d
Frequency [MHz]

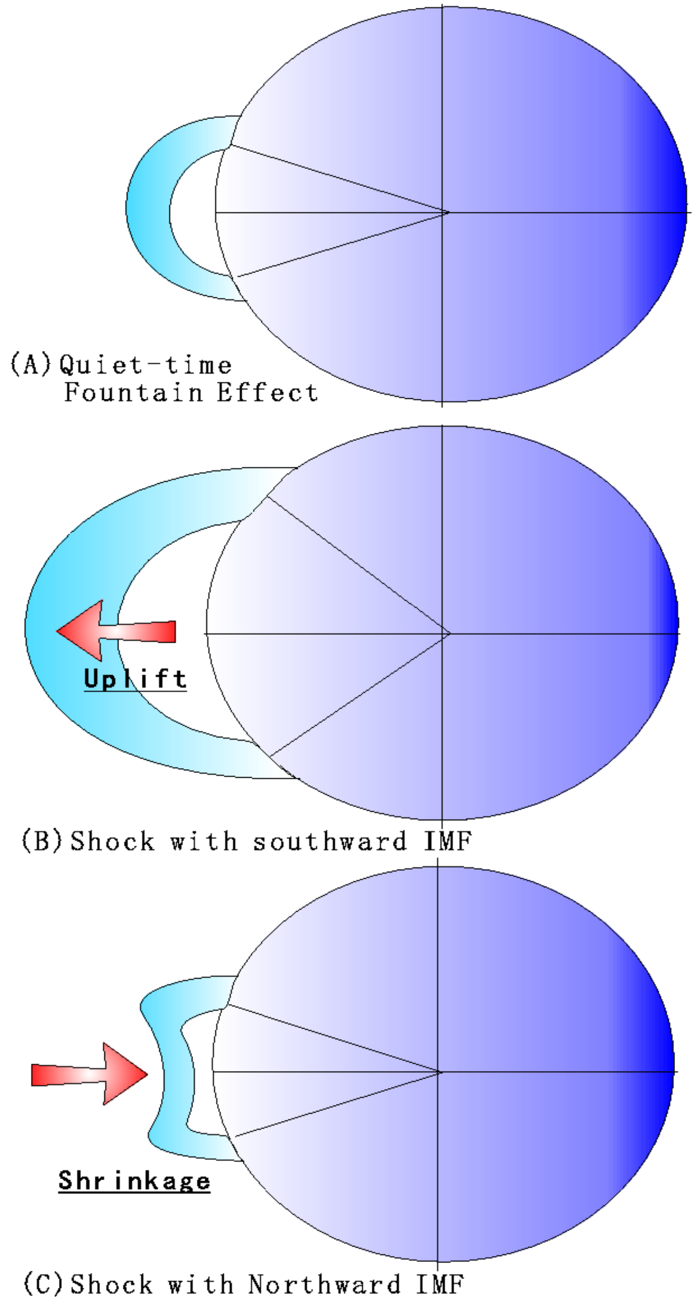


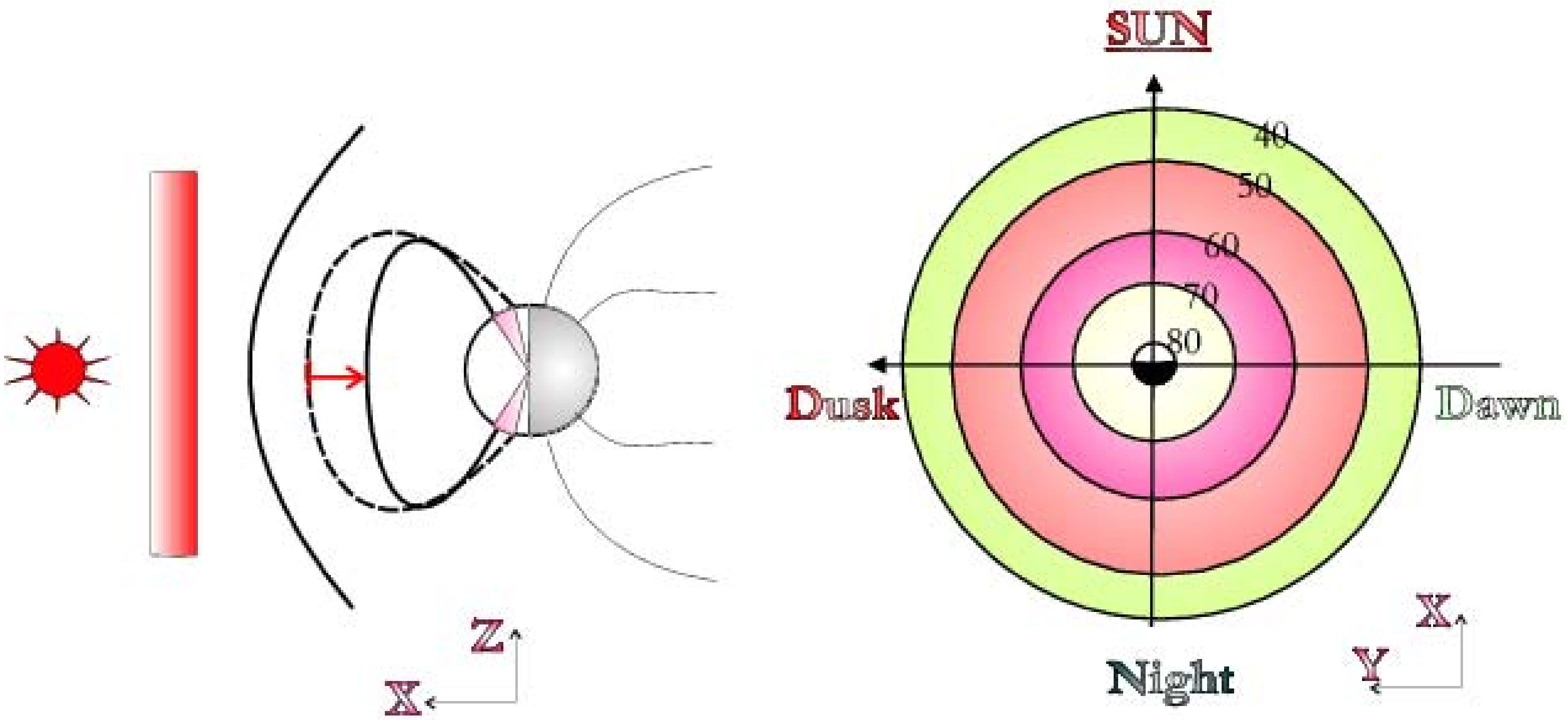
TEC Units
Frequency [MHz]
80.0
50.0
0.0
30.0
20.0
10.0
0.1
foF2
TEC
foE
foEp
6 8 10 12 14 16 18 20 22 21d 2 4 6 8 10 12 14 16 18 20 22 22d 2 4 6
UT, hr (2005.01.20 - 2005.01.22)


Profilogram, PRJ18, DGS-256, SAO Explorer, v 3.4.06b4
Ramey
Jicamarca
Port Stanley
Height [km]
1000.0
500.0
0.0
12h 13h 14h 15h 16h 17h 18h 19h 20h 21h 22h 23h 0h
Frequency [MHz]
10.0
5.0
8.0
0.1
UT, min (2005.01.21 12 - 2005.01.22 00)

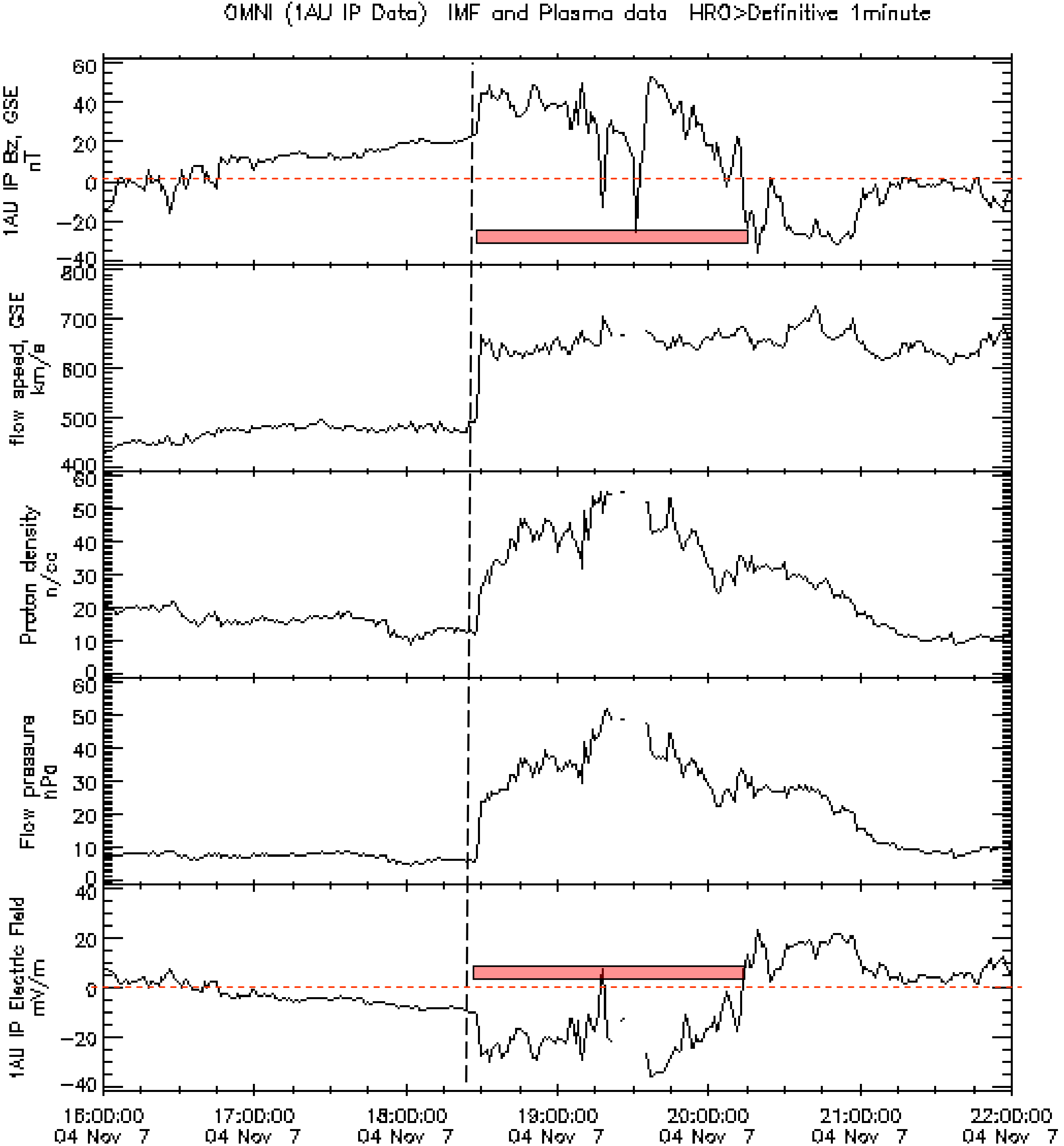

Quaanaaq
Sondrestrom
College
Gakona
King Salmon
Narassarssuaq
Goose Bay
Chilton
Dourbes
Roquetes
El Arenosillo
Hanscom AFB
Millstone Hill
Boulder
Wallops Is.
Pt. Arguello
Dyess AFB
Eglin
Ramey
Jicamarca
Port Stanley
Lowell
DIGISONDE
INTERNET/
DIDBase
Secure Net
No Remote
Access

Super-Fountain Effect
(After Tsurutani et al, 2006)





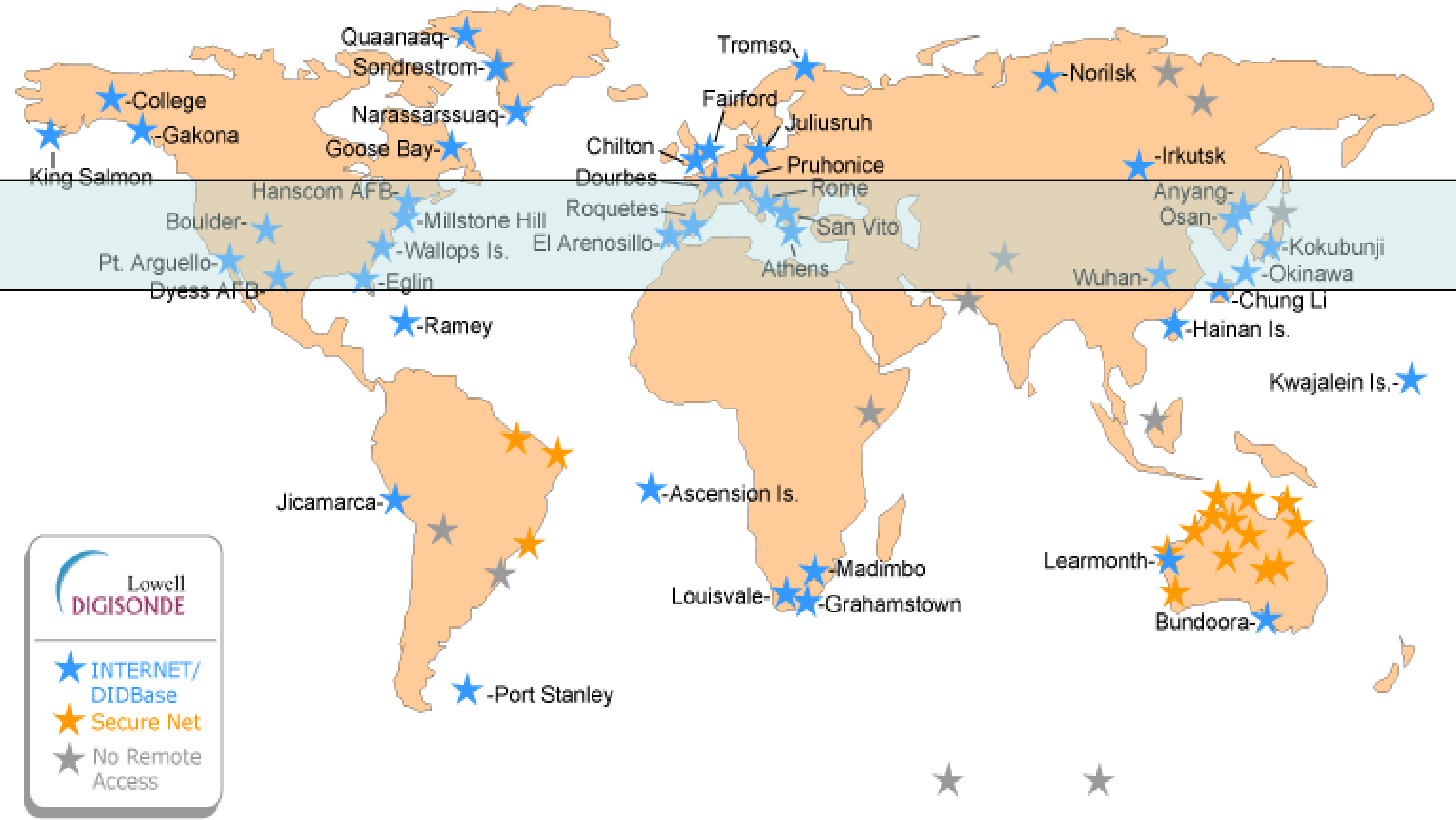
2. Midlatitude Ionosphere Response

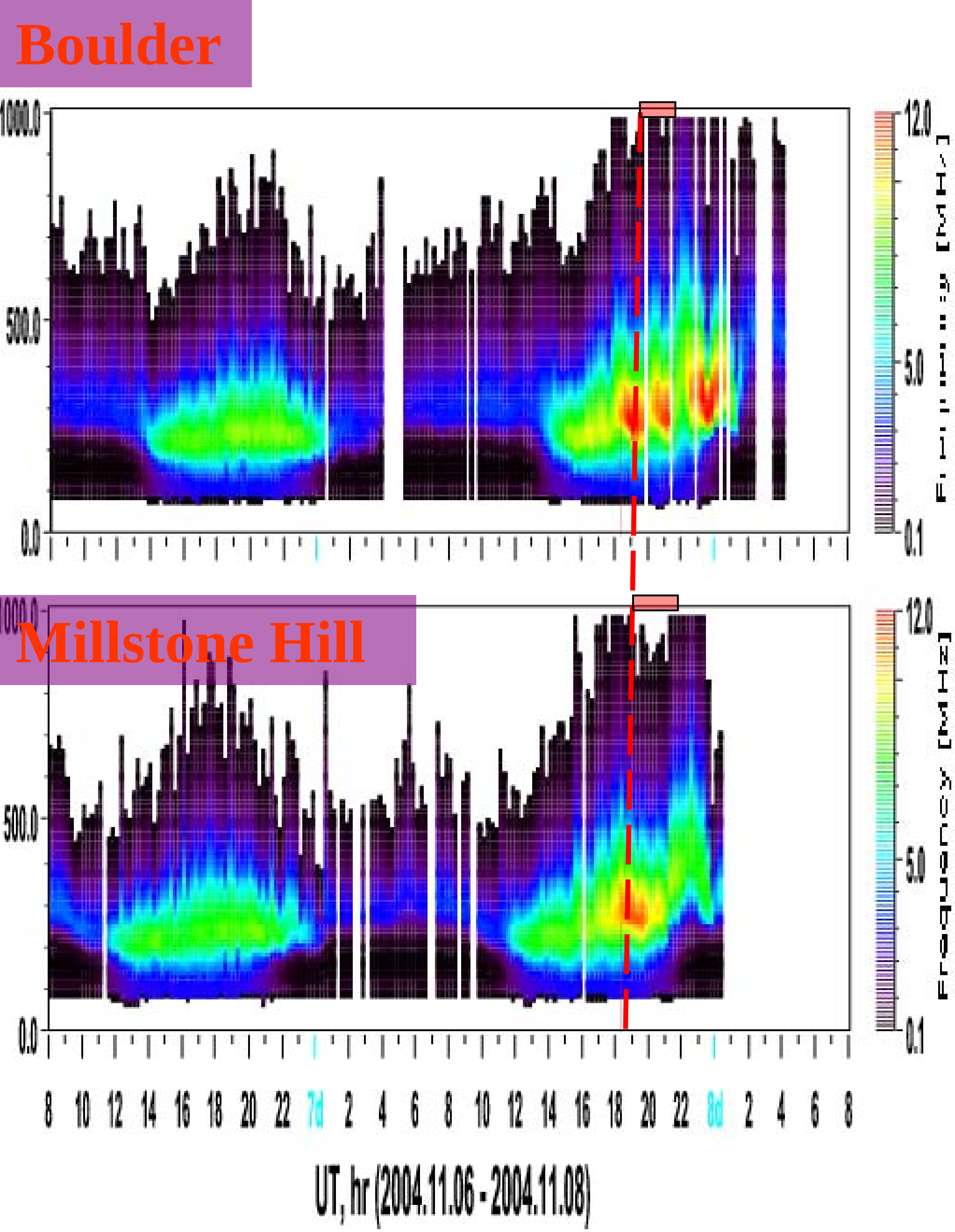


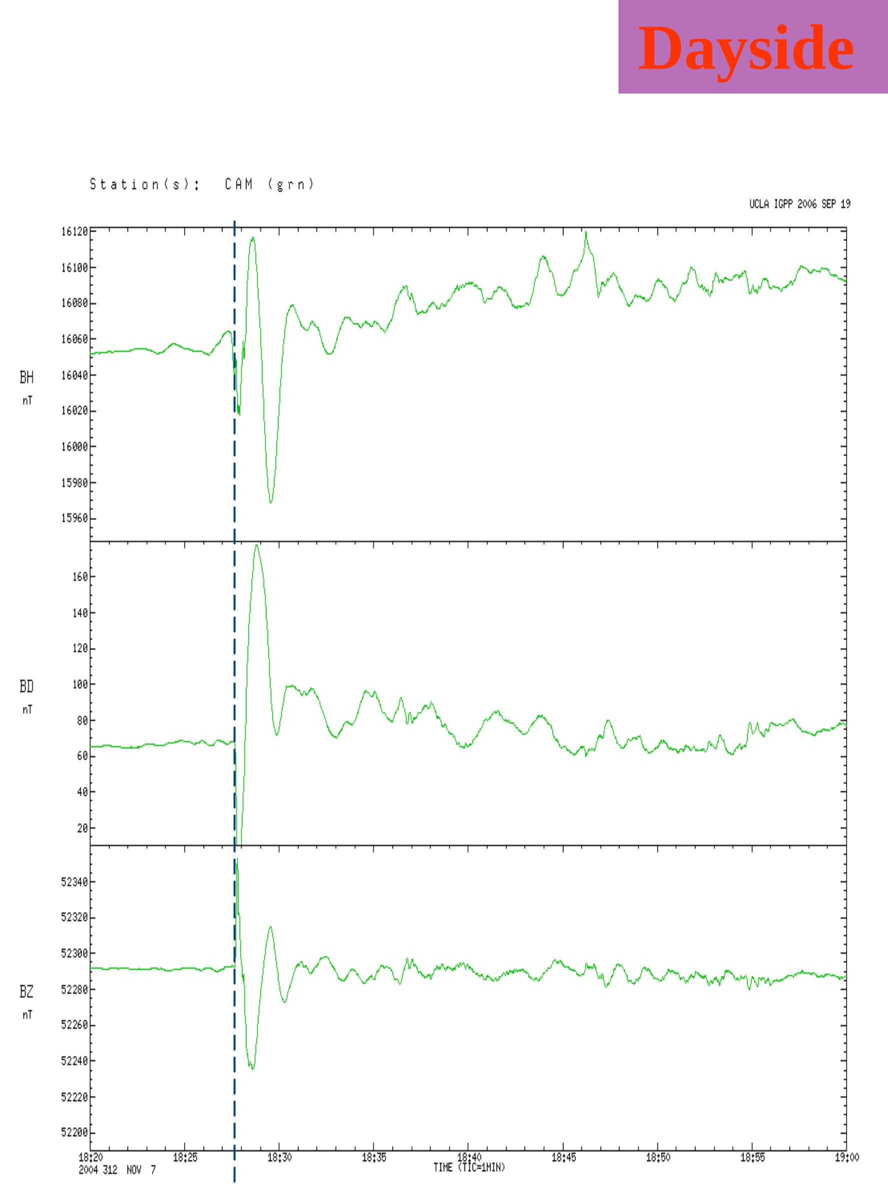
IMF

Solar Wind

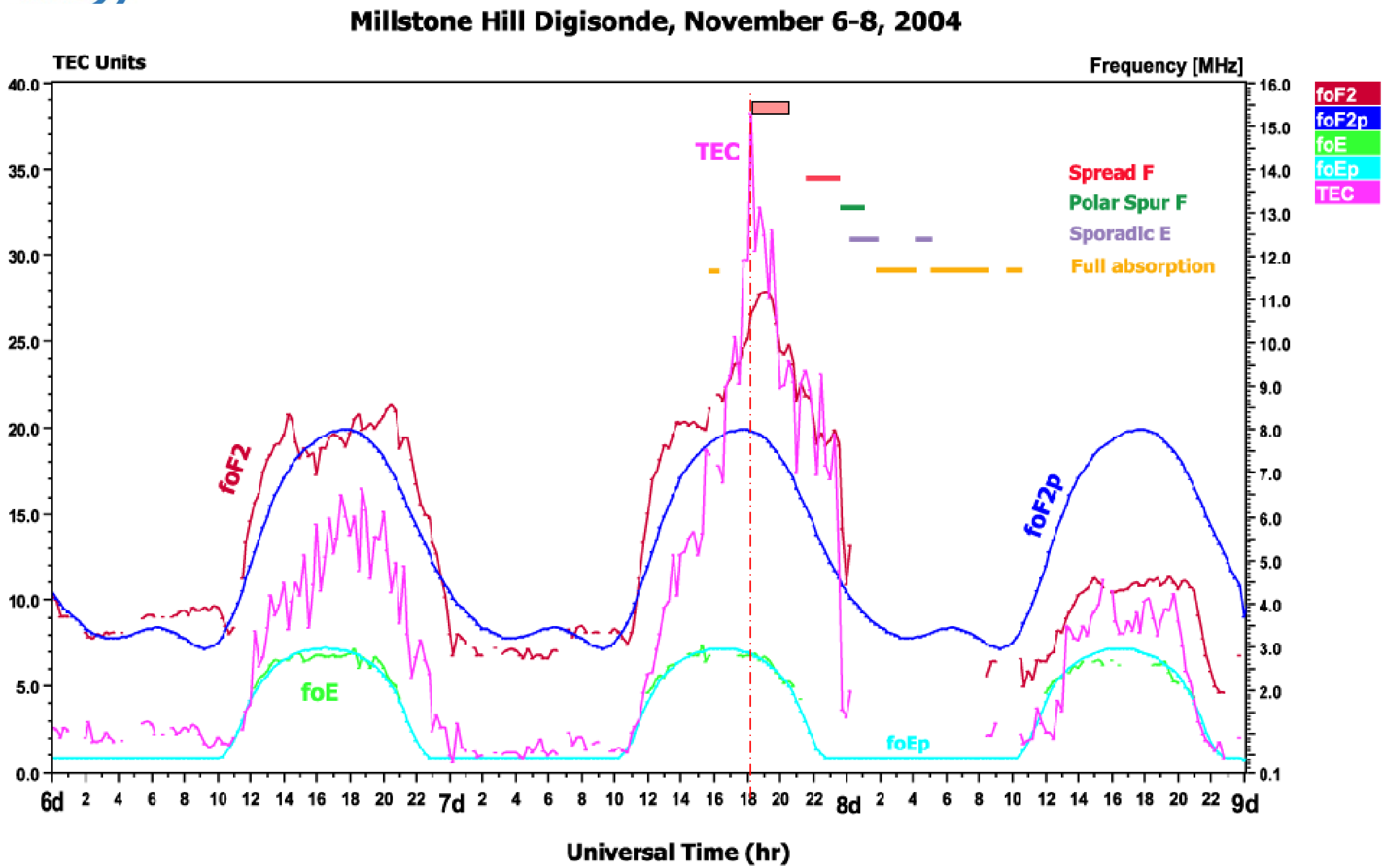
2009 IDF


Quaanaaq-
Sondrestrom-
Narassarssuaq-
Goose Bay-
-College
-Gakona
King Salmon
Hanscom AFB-
Boulder-
-Millstone Hill
-Wallops Is.
Pt. Arguello-
Dyess AFB-
-Eglin
-Ramey
Tromso
Fairford
Juliusruh
Chilton
Pruhonice
Dourbes
Rome
Roquetes
San Vito
El Arenosillo-
Athens
-Norilsk
-Irkutsk
Anyang-
Osan-
-Kokubunji
Wuhan-
-Okinawa
-Chung Li
-Hainan Is.
Kwajalein Is.-
Jicamarca-
-Ascension Is.
-Madimbo
Louisvale-
-Grahamstown
Learmonth-
Bundoora-
-Port Stanley
Lowell
DIGISONDE
INTERNET/
DIDBase
Secure Net
No Remote
Access


Boulder
Millstone Hill
1000.0
500.0
0.0
12.0
5.0
0.1
Frequency [MHz]
8 10 12 14 16 18 20 22 7d 2 4 6 8 10 12 14 16 18 20 22 8d 2 4 6 8
UT, hr (2004.11.06 - 2004.11.08)


Dayside
Station(s): CAM (grn)
UCLA IGPP 2006 SEP 19
BH
nT
BD
nT
BZ
nT
18:20
2004 312 NOV 7
18:25
18:30
18:35
18:40
TIME (TIC=1MIN)
18:45
18:50
18:55
19:00

Millstone Hill



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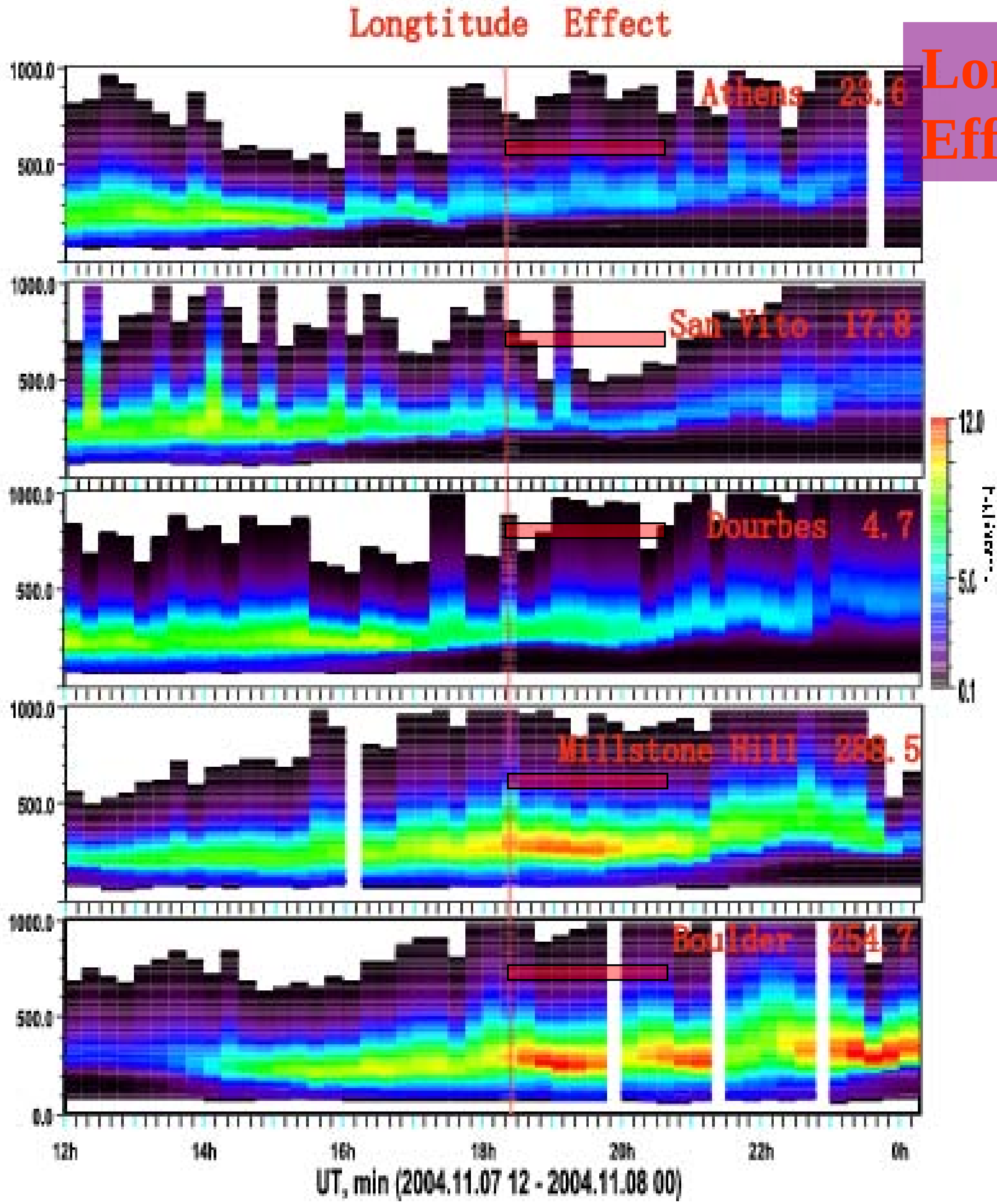
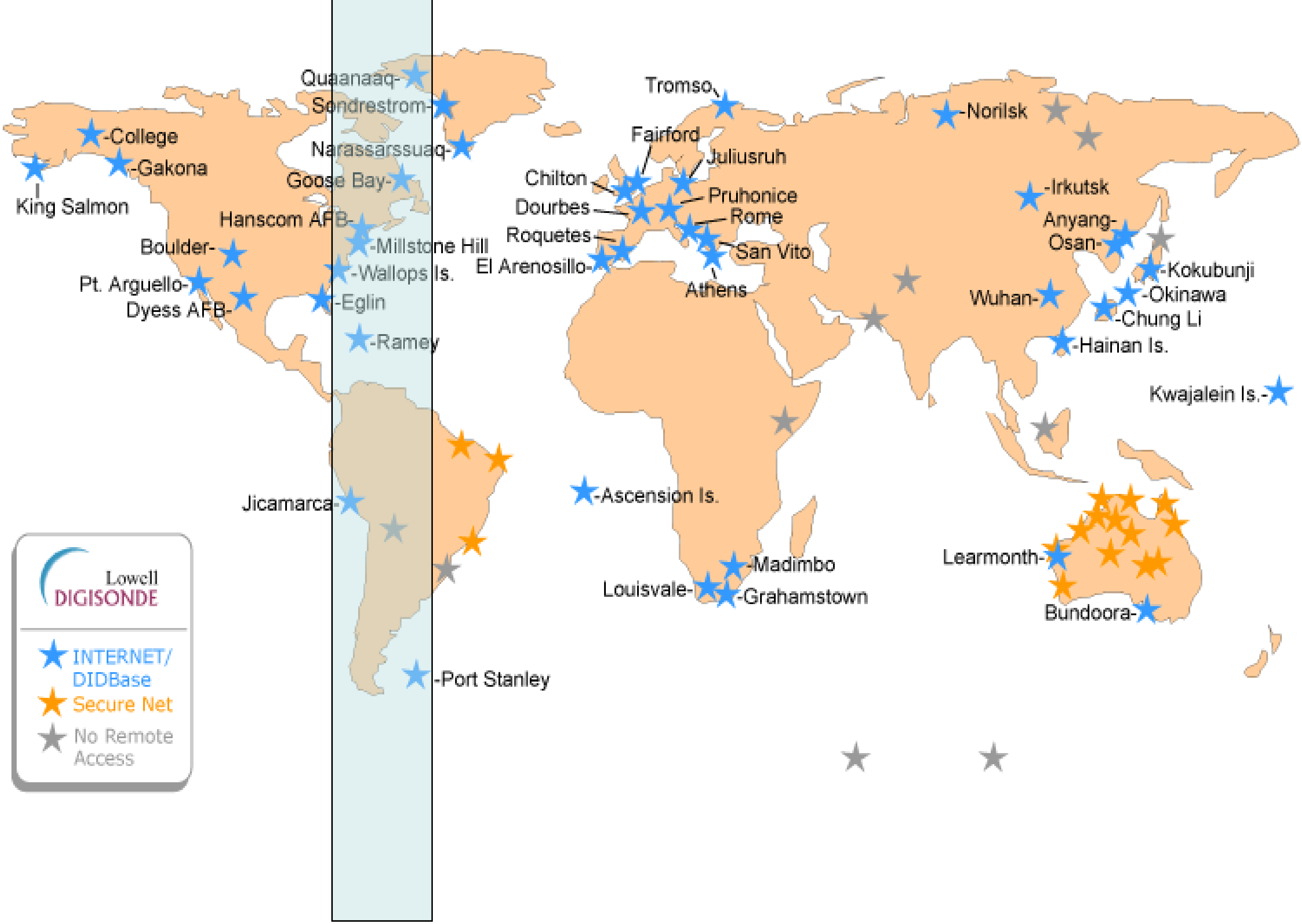
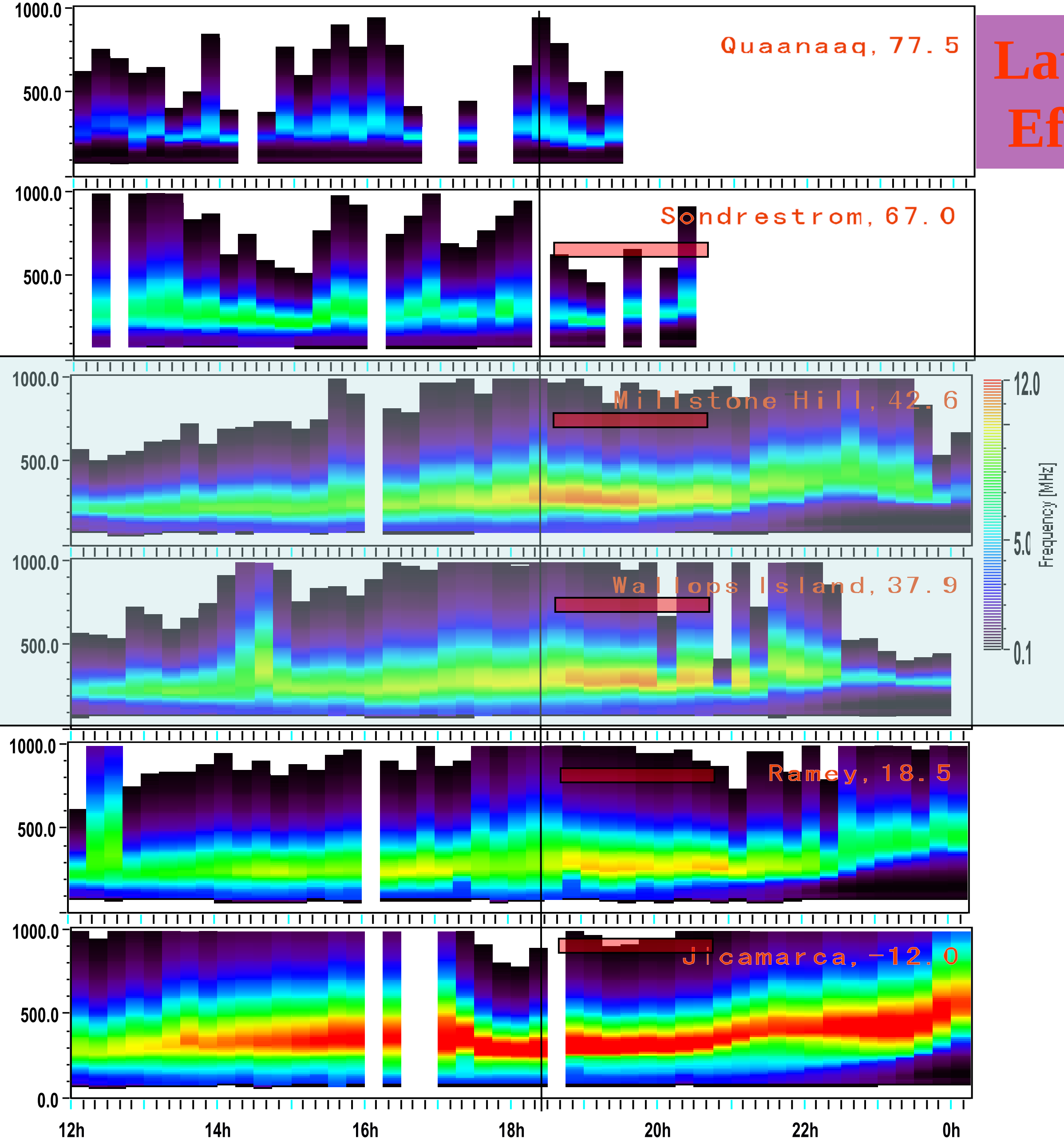
Longitude Effect





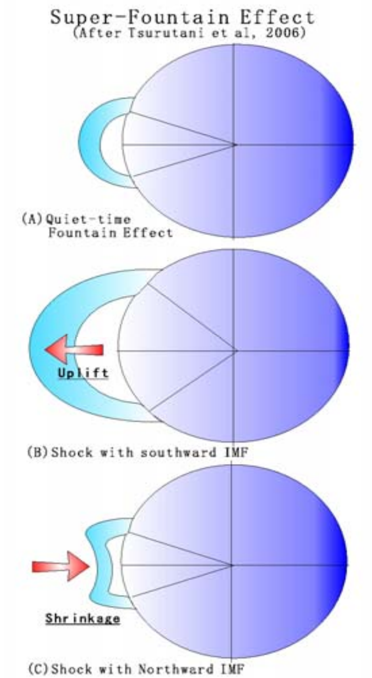
2009 IDF XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

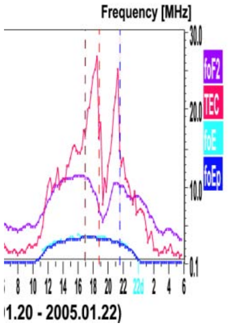
Latitude Effect



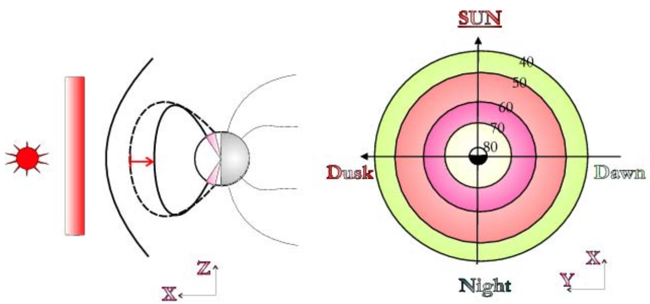
Summary

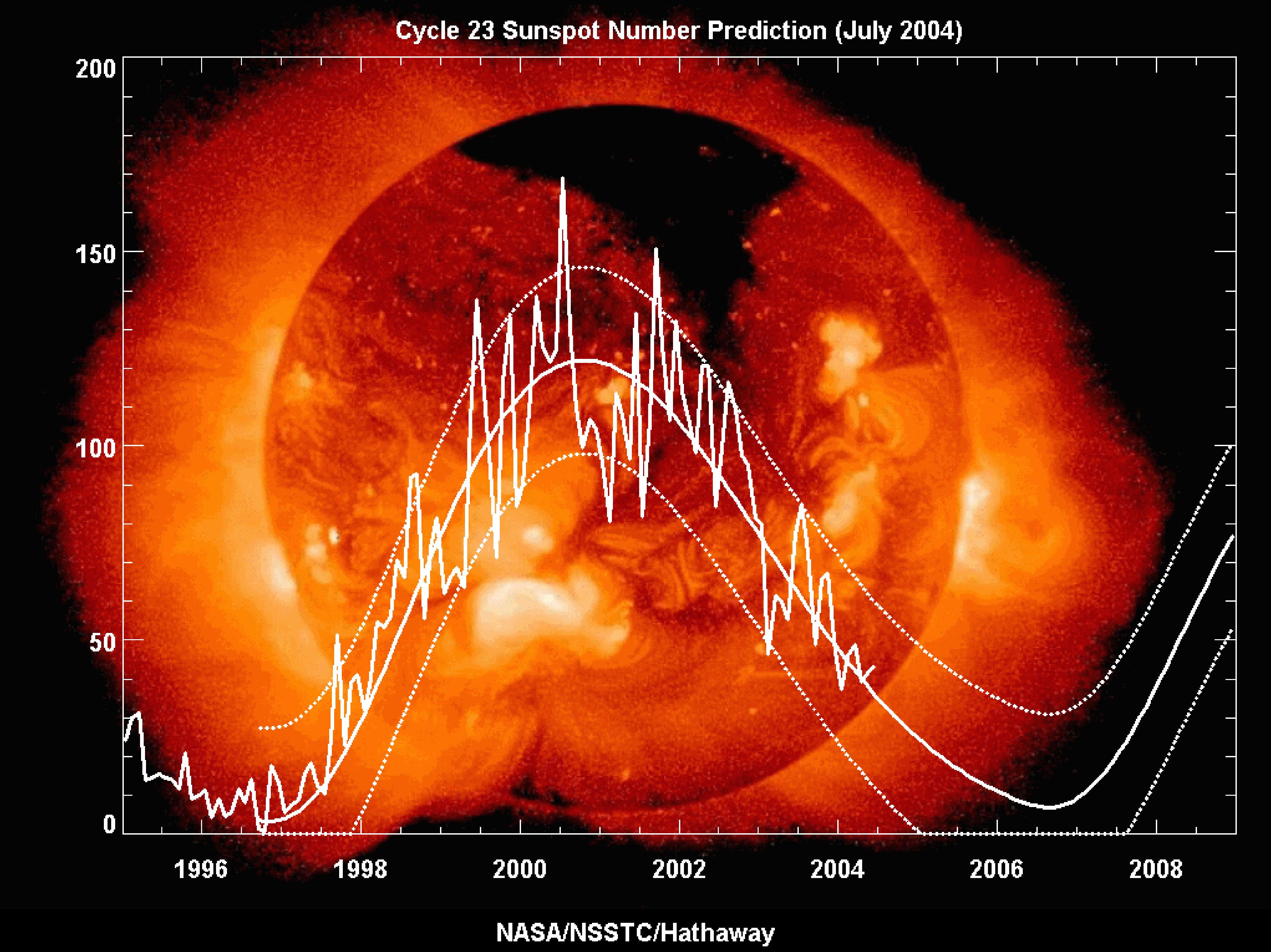
- **Equatorial ionospheric response**
  - --- 1. quick response
  - --- 2. rapid uplift (~ 66.7 m/s)
  - --- 3. shrinkage (~ 42m/s)
  - --- 4. TEC sudden dropout
    (The TEC is dropped from 72 TEC unit to 20 TEC unit, then recover to 68 TEC unit in about 2 hours)

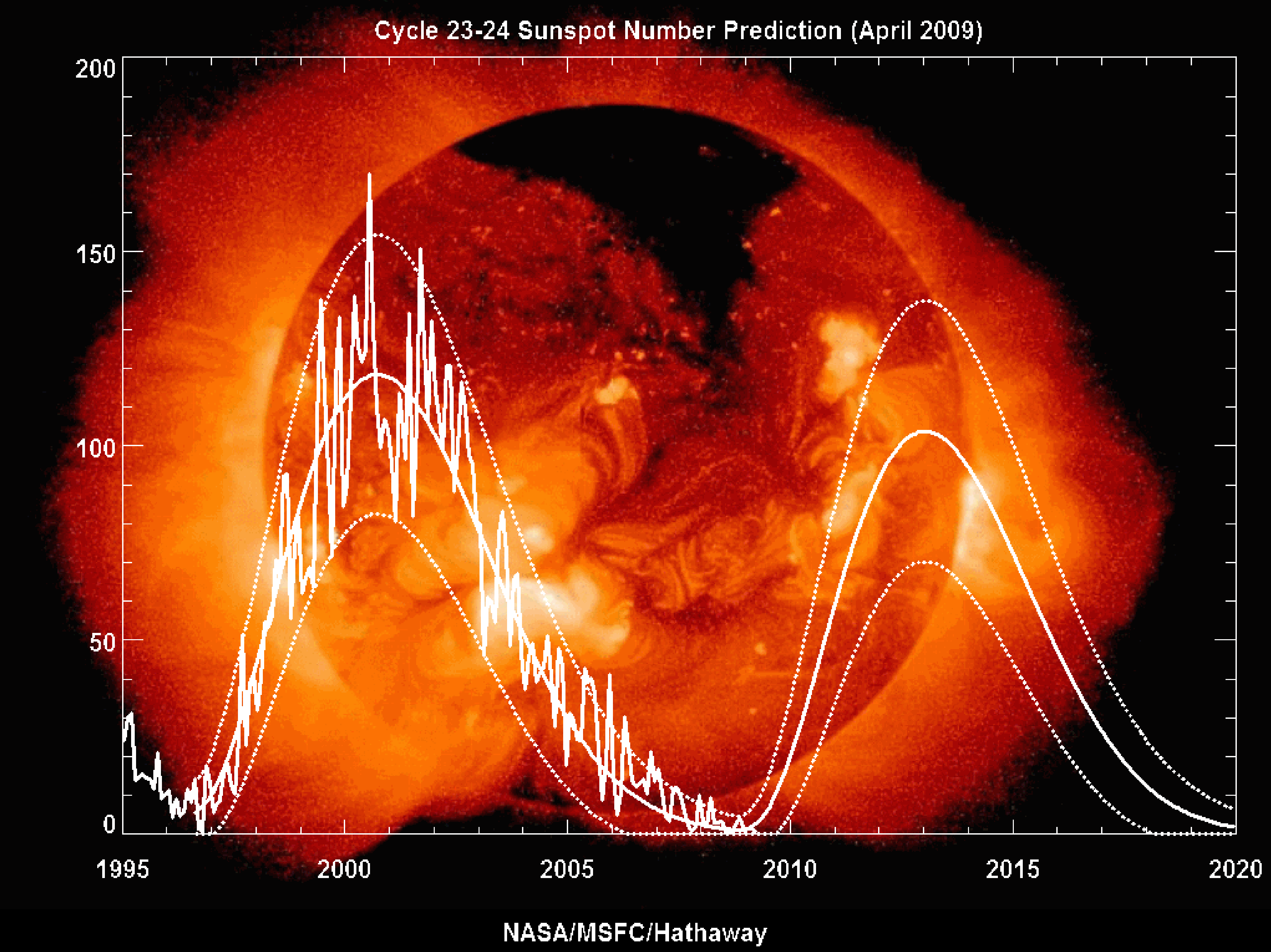


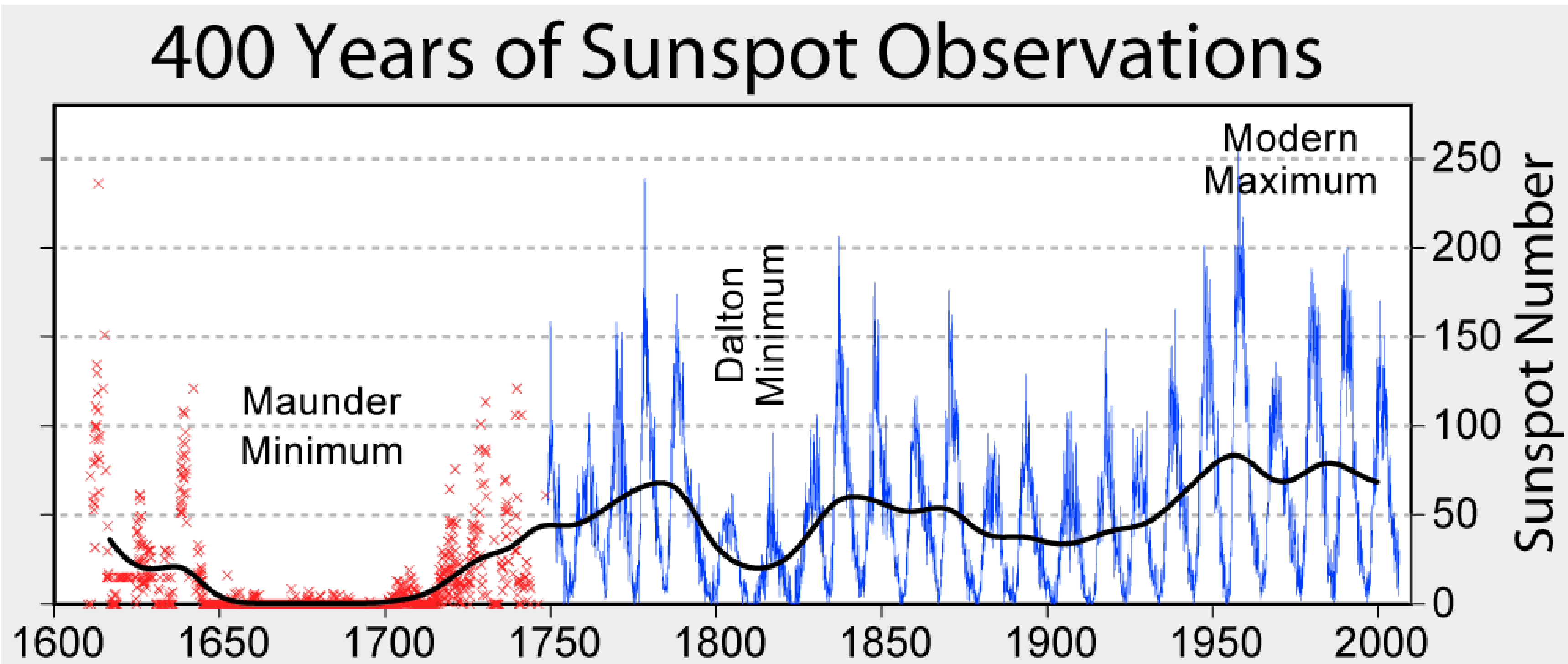


- **Midlatitude ionospheric response**
  - --- **1. Longitude effect**
  - --- **2. Latitude effect**



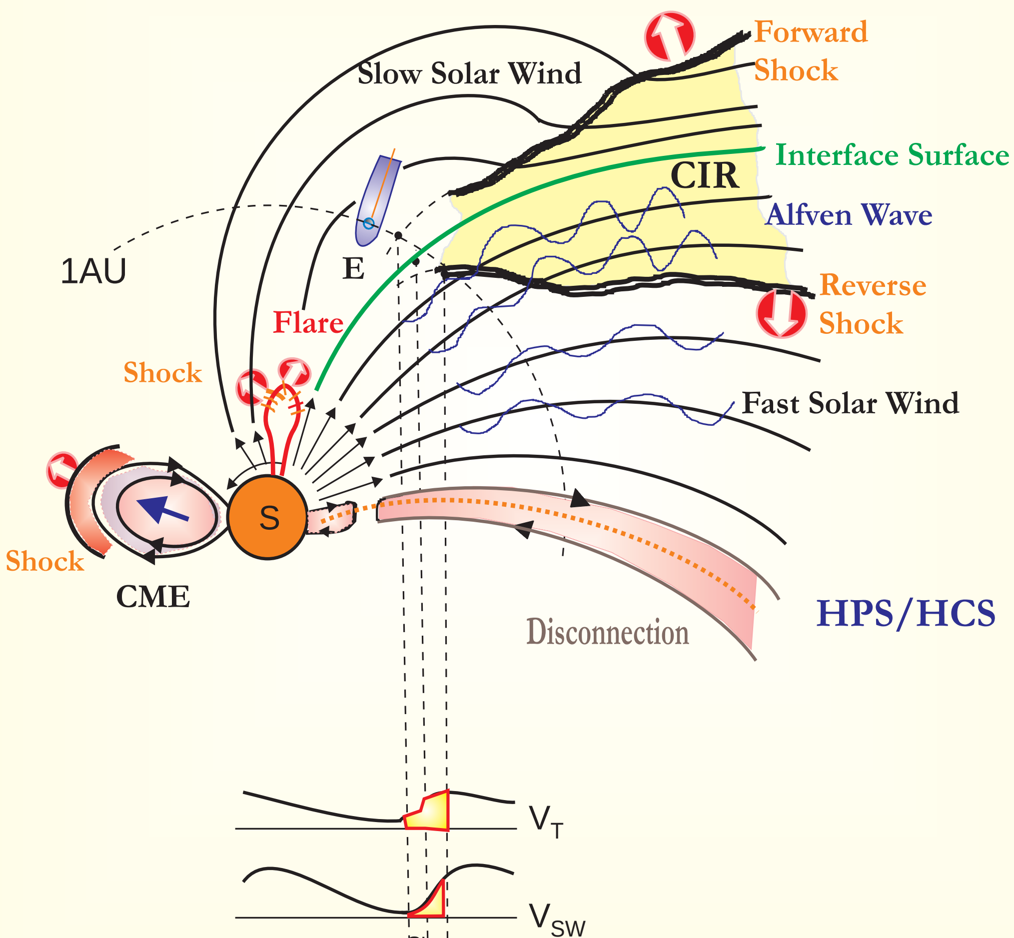

Cycle 23 Sunspot Number Prediction (July 2004)
200
150
100
50
0
1996
1998
2000
2002
2004
2006
2008
NASA/NSSTC/Hathaway


Cycle 23-24 Sunspot Number Prediction (April 2009)
200
150
100
50
0
1995
2000
2005
2010
2015
2020
NASA/MSFC/Hathaway


400 Years of Sunspot Observations
Modern
Maximum
Dalton
Minimum
Maunder
Minimum
Sunspot Number
250
200
150
100
50
0
1600
1650
1700
1750
1800
1850
1900
1950
2000

Sun - Earth Relation

Flare - CME - CIR/FS



Thanks!

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Precision ranging campaign in European digisonde network

Vadym Paznukhov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

Objective and Measuring Technique

Objective

- Measure E layer height variations as indicator for thermosphere dynamics: CAWSES Tidal Campaign 2007

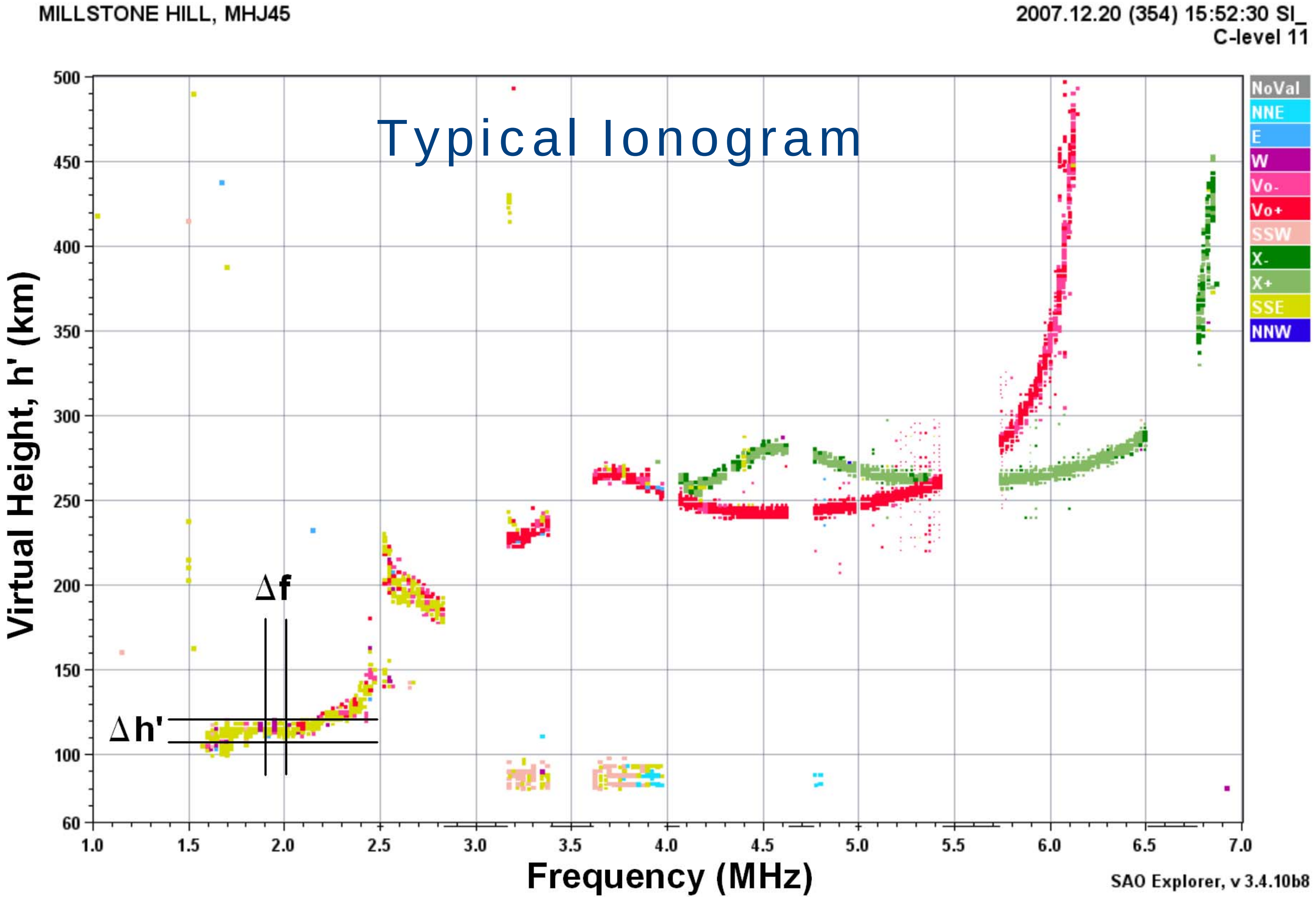
Technique

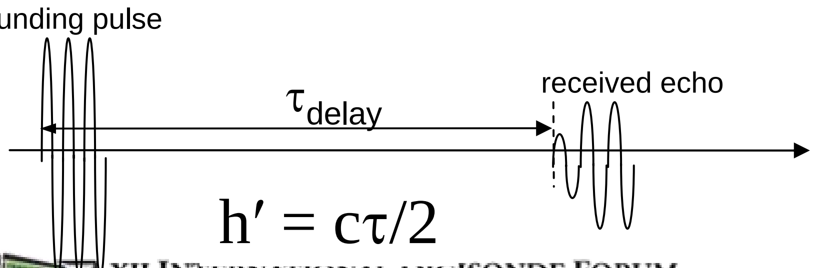
- High-precision virtual height measurements
- Measure echo phase difference at closely spaced frequencies

E layer Height Measurements

- 2006 Campaign at Millstone Hill, USA
- 2007 COST296/IHY Campaign, Europe

Typical Ionogram



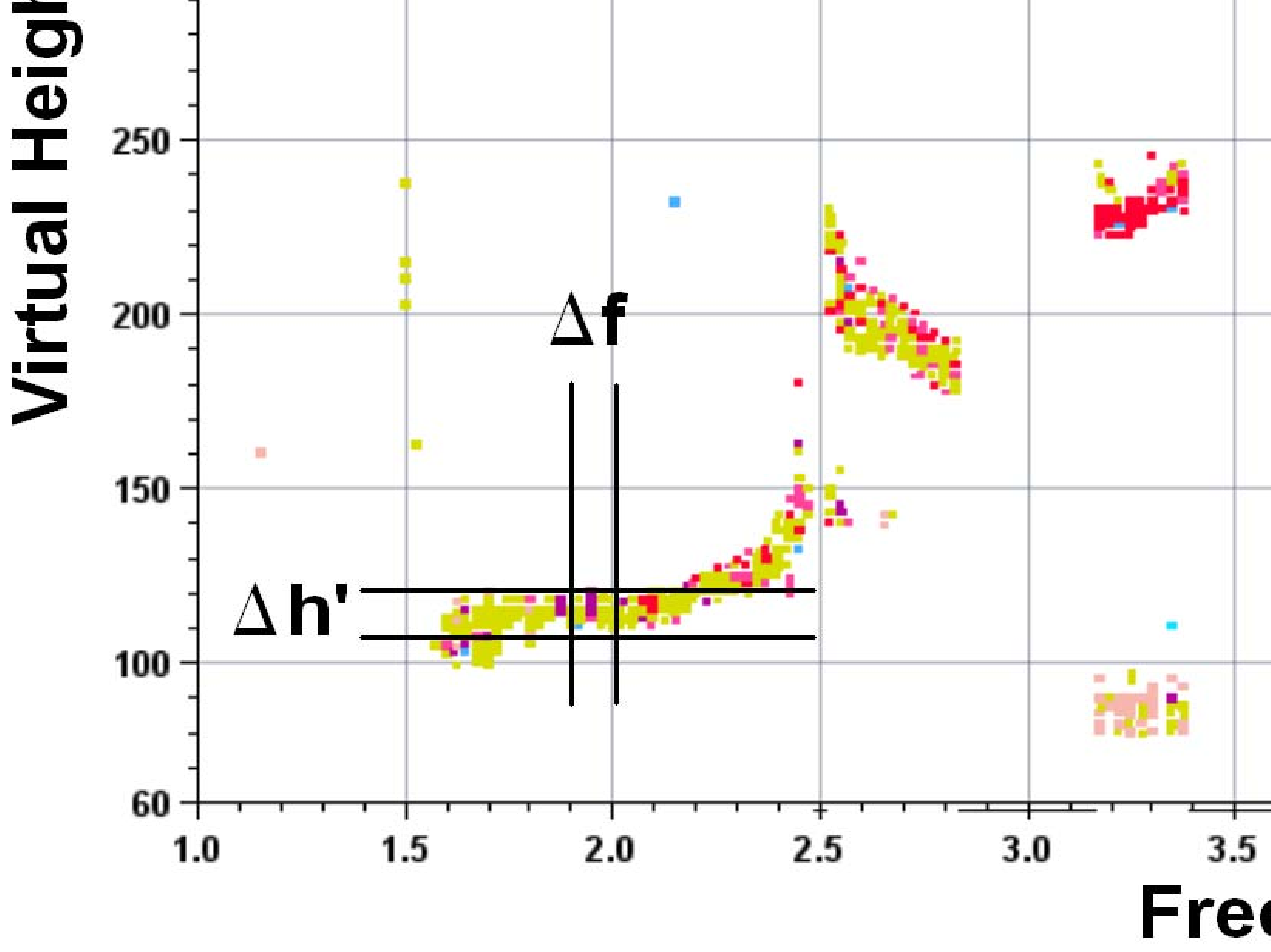


$$h' = c\tau/2$$

τ_{delay} → h'

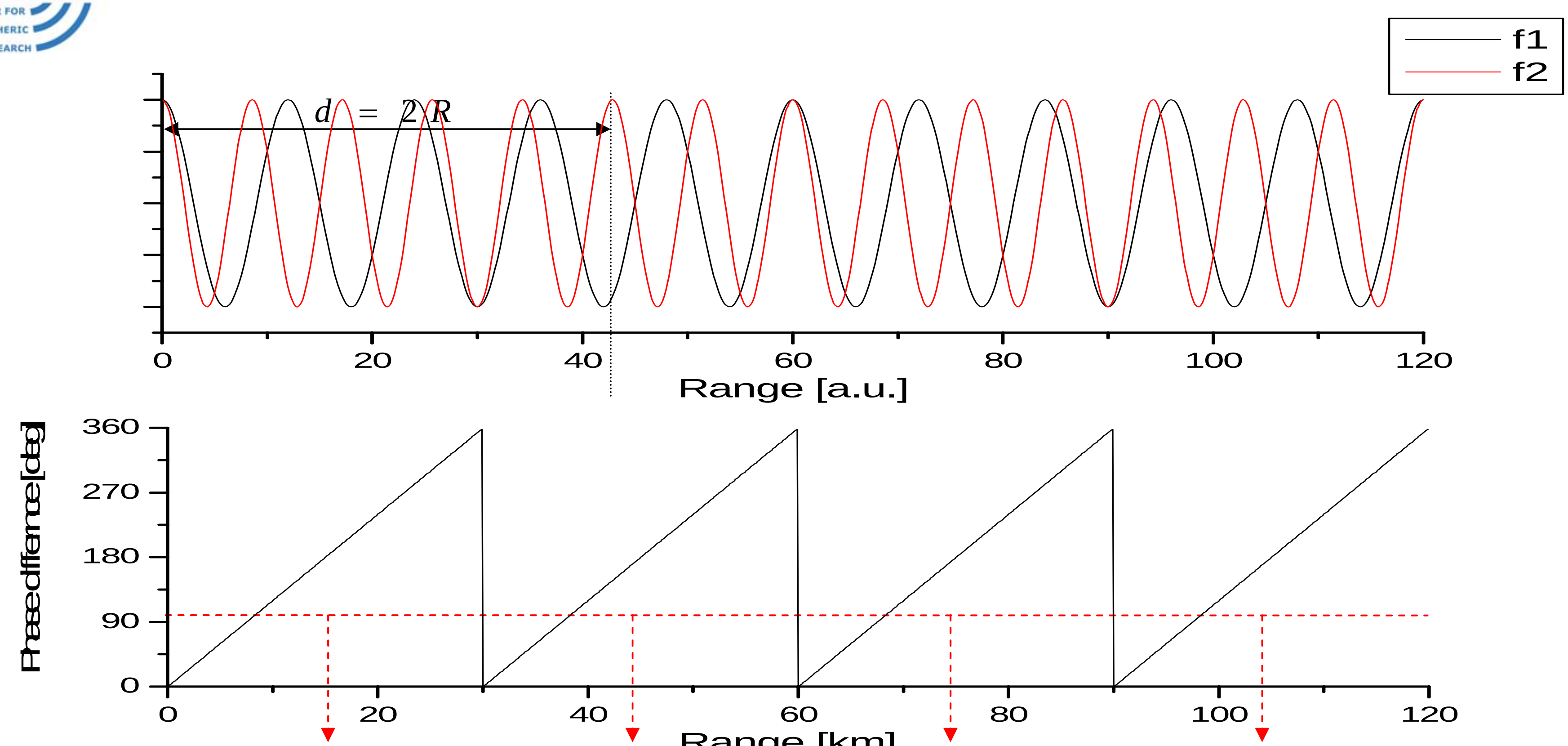
"Classic ionosonde time-delay method"

$$\Delta h' \sim \Delta\tau_{pulse}$$



Virtual Heig
250
200
150
100
60
1.0
1.5
2.0
2.5
3.0
3.5
Fre
Δf
Δh'

Phase difference technique (d$\boldsymbol{\varphi}$/df)



$$\phi_2 - \phi_1 = 2\pi(f_1 - f_2)\frac{d}{c} = 2\pi\,\Delta f\,\frac{d}{c} = 4\pi\,\Delta f\,\frac{R}{c} \qquad \boxed{\therefore R = \frac{c}{2\Delta f}\frac{\Delta\phi}{2\pi}}$$

Phase Difference Technique in Plasma

Vertical Sounding

Eikonal solution $E(\mathbf{r},t;\omega)=E_0 e^{-i\left(\omega t-\int_{\mathbf{r}_0}^{\mathbf{r}(\omega)}\mathbf{k}\cdot d\mathbf{r}-\phi_0\right)} \Rightarrow E(0,t;\omega)=E_0 e^{-i\left(\omega t-2\int_0^{h_R(\omega)}k(\omega)dh-\phi_0\right)}$

Phase at receiver $\phi_{rec}(\omega)=\dfrac{2}{c}\int_0^{h_R(\omega)}\omega n(h,\omega)\,dh+\phi_0,$

Phase Differential $\dfrac{d\phi_{rec}}{d\omega}=\dfrac{2}{c}\int_0^{h_R(\omega)}\dfrac{\partial(\omega n)}{\partial\omega}dh=\dfrac{2}{c}h'(\omega),$ since $n(h_R,\omega)=0;$

$$and \quad \frac{d\phi_0}{d\omega}=0$$

Phase Difference: $\delta_\omega\phi_{rec}=\int\limits_{\omega_1}^{\omega_2}\dfrac{d\phi_{rec}}{d\omega}d\omega=\dfrac{2}{c}\int\limits_{\omega_1}^{\omega_2}h'(\omega)d\omega=\dfrac{2}{c}\bar{h}'\delta\omega.$

$$\boxed{\bar{h}'=\frac{c}{2\delta f}\cdot\frac{\delta_\omega\phi_{rec}}{2\pi}=30\,km\cdot\frac{\delta_\omega\phi_{rec}}{2\pi}.}$$

$$h'(\omega_1)<\bar{h}'<h'(\omega_2)$$
$$\delta f=5\,kHz$$

[Reinisch et al., AIP Proceedings #974, 2008]

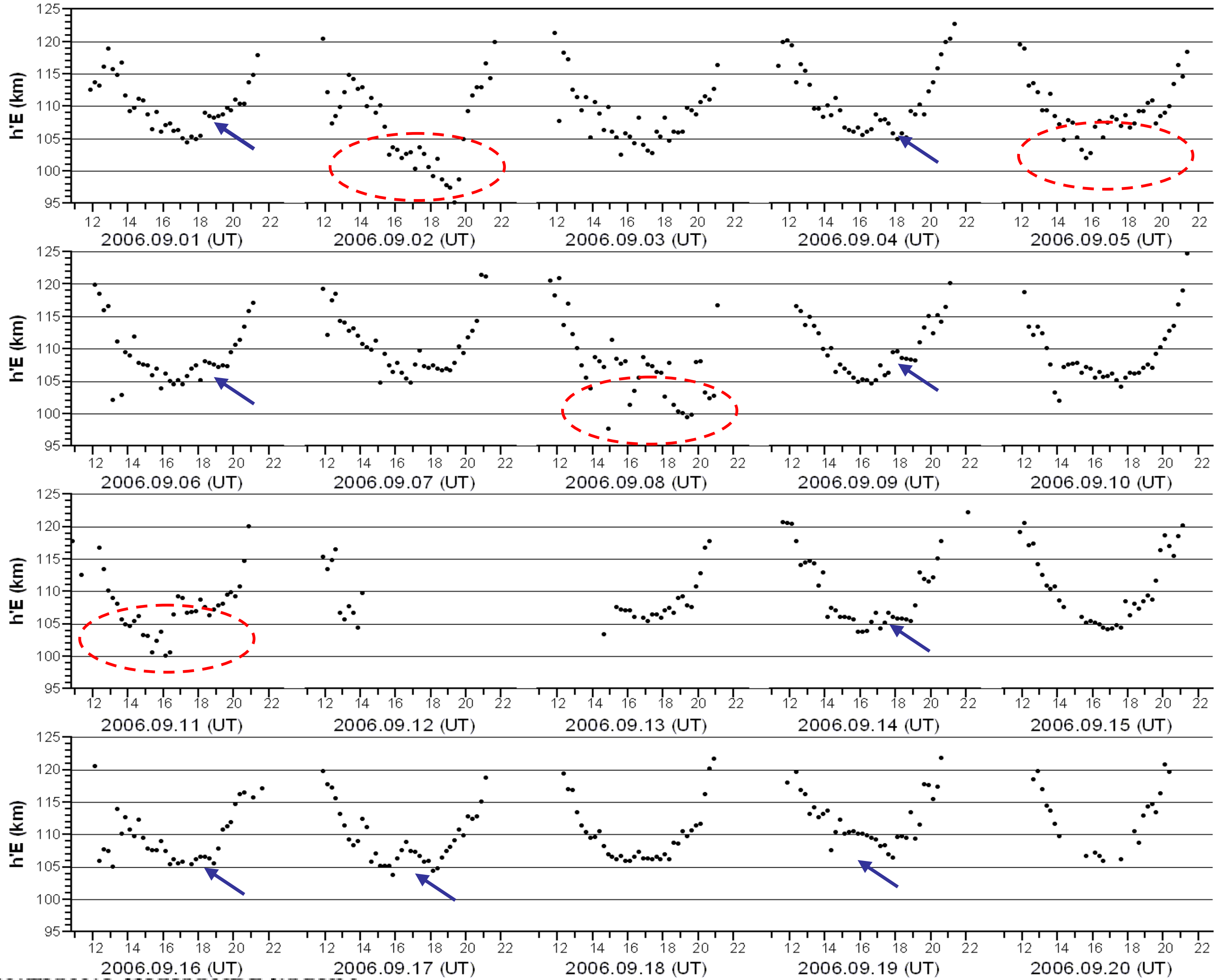
Diurnal and Day-to-Day h'E Variations

Millstone Hill, Sept 2006

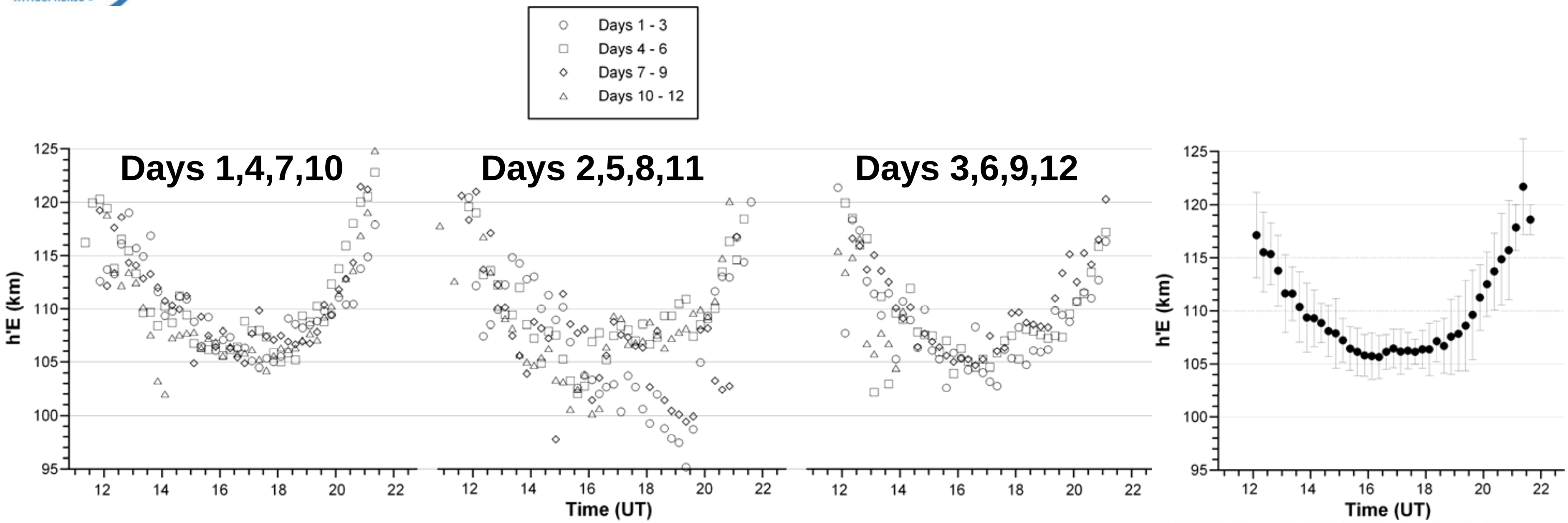
Day-to-day Variability.

Blue Arrows:
Structures Departing from Expected daily trend.

Dashed Elipses:
Unusual low Heights.

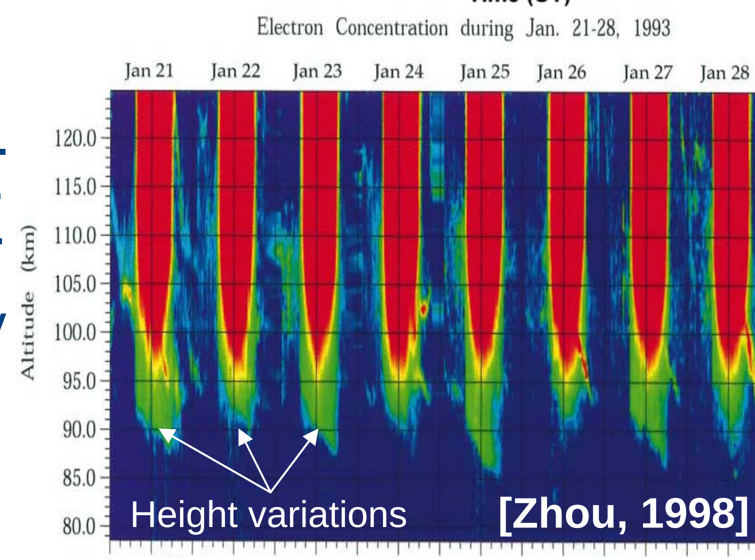


Daily h'E at Millstone Hill Sept 2006



Clear 3-day oscillation on h'E variation.

1-12 September data divided in three groups of four days each.
Days 1, 4, 7, and 10 behave very similar to average h'E pattern.
Days 2, 5, 8, and 11 significantly deviate from daily h'E pattern.
Days 3, 6, 9, and 16 weakly deviate from daily h'E pattern.
Unusual low heights of the E layer observed on every third day of the measurements starting from September 2.



Wavy thermosphere dynamics effects on the E layer ionosphere?

COST296/IHY Campaign

1 June – 14 August 2007

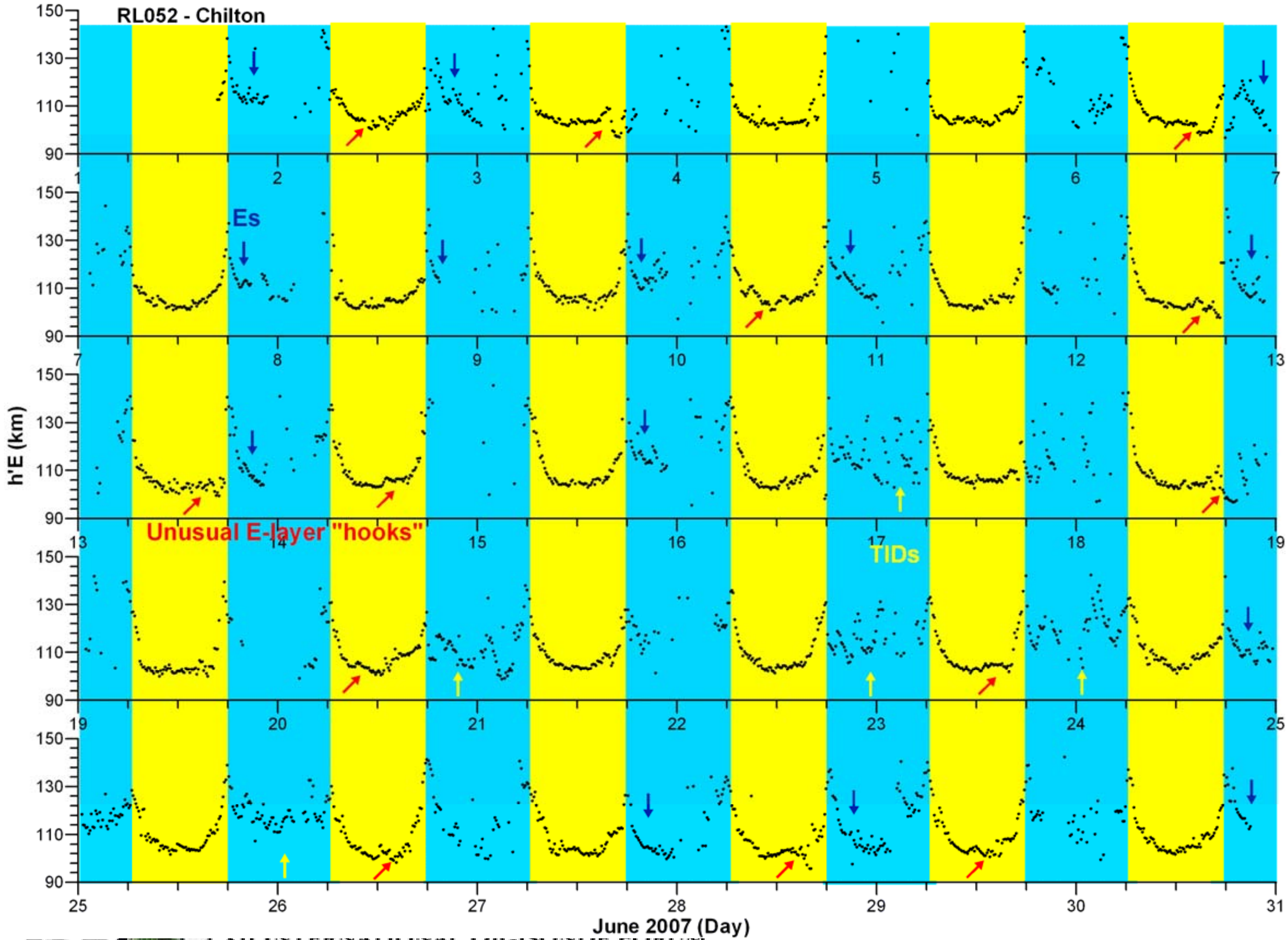
Digisonde stations contributing data:

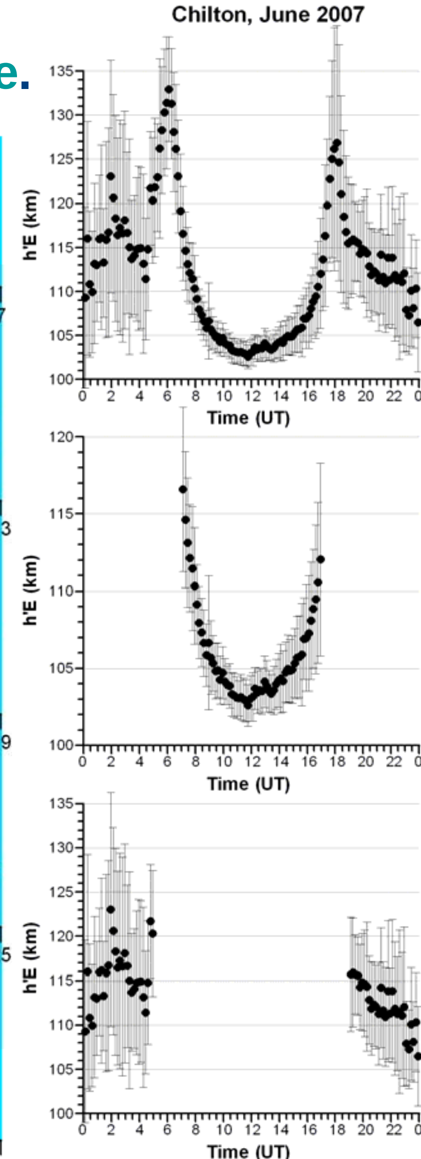
Institution	Station Details	Sounding times (minutes)	Notes
INGV (Italy)	Roma, DPS-4 (41.8N; 12.5E) RO041. Enrico Zuccheretti (zuccheretti@ingv.it)	10, 25, 40, 55	"Weak" day time E-trace
IAP Germany)	Juliusruh, DPS-4 (54.6N; 13.4E) JR055. Jens Mielich (mielich@iap-kborn.de).	0, 15, 30, 45 (Changes within the campaign)	Good data
NOA (Greece)	Athens, DPS-4 (38.00N; 023.60E) AT138. Anna Belehaki (belehaki@space.noa.gr).	12, 27, 42, 57	"Weak" day time E-trace
UFA (Czech Rep.)	Pruhonice, DPS-4 (50.00N; 014.60E) PQ052. Josef Boska (boska@ufa.cas.cz).	12, 27, 42, 57 (Changes within the campaign)	Good data. Large gap on July
RAL (UK)	Chilton, DPS-1 (51.60N; 358.70E) RL052. John Bradford (J.Bradford@rl.ac.uk).	7, 17, 27, 37, 47, 57	Best data
Quinetic (Norway)	Trosmo, DPS-4 (69.6N; 19.2E) TR169. Paul Cannon (pcannon@qinetiq.com).	12, 27, 42, 57	Good data
URL (Spain)	Ebro, DGS256 (40.8N; 0.5E) EB040. David Altadill (daltadill@obsebre.es).	2, 17, 32, 47*	Noisy E-trace, bad records. **
INTA (Spain)	El Arenosilo, DGS256 (37.10 N; 353.27 E) EA036. Iñigo Blanco (blancoai@inta.es).	2, 17, 32, 47*	Noisy E-trace, bad records. **

*** Automatically run drift after the end of the ionogram.**
**** Stopped on June 27.**

COST296/IHY Campaign Data Example

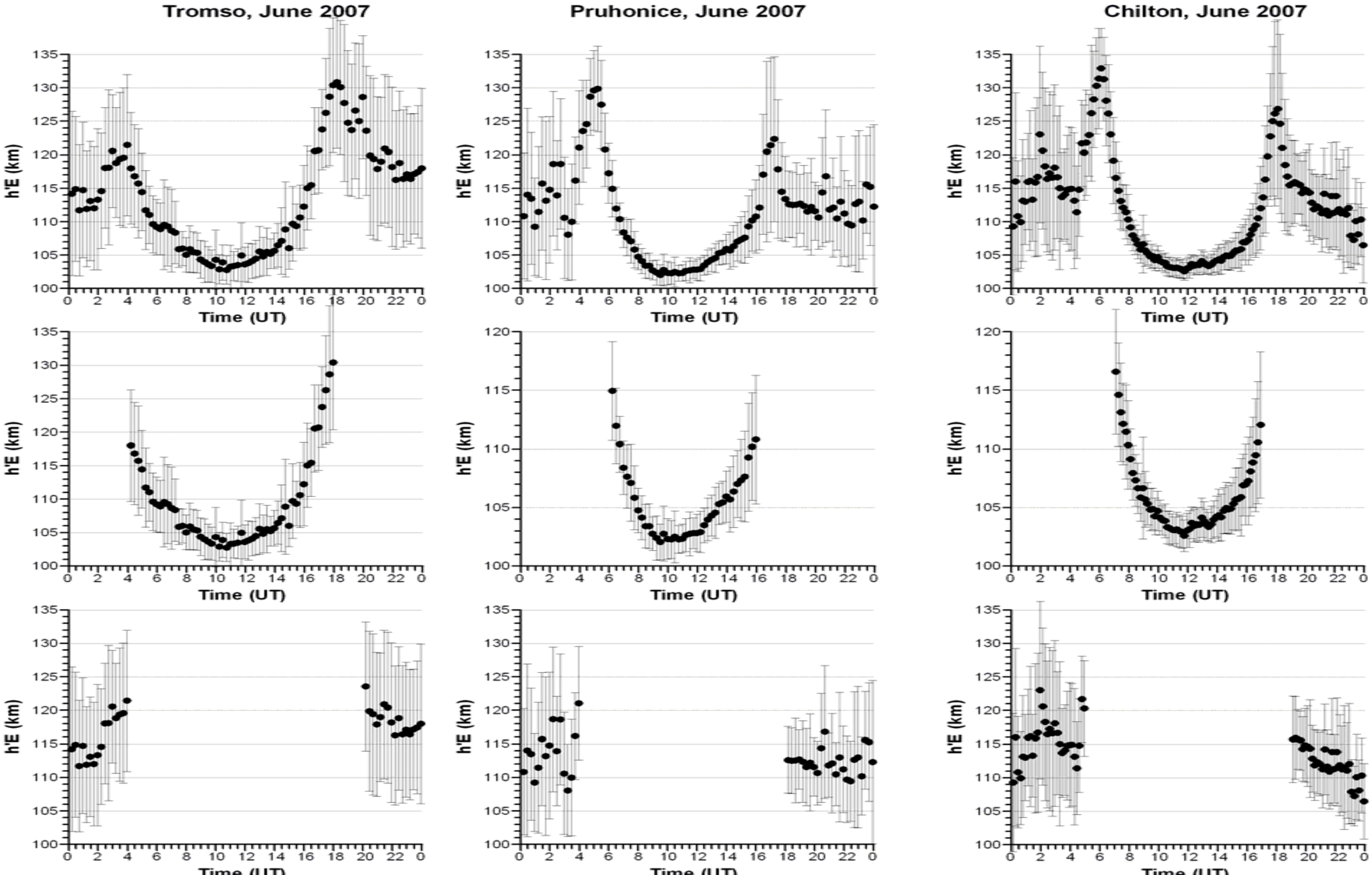
h′(t,fp=2.3 MHz), two different regimes: Day-time & Night-time.



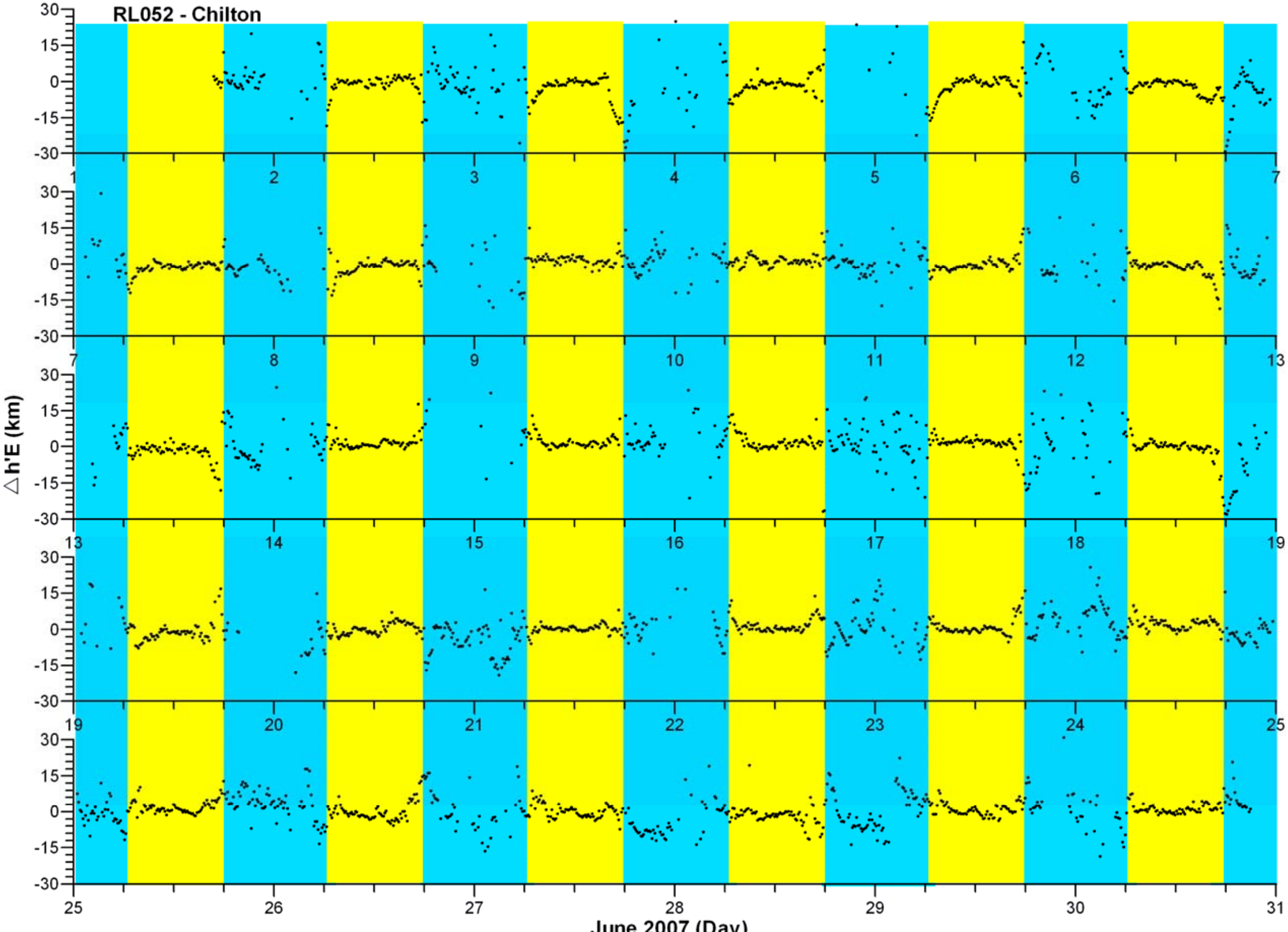


Daily average patterns of h′(t;2.3MHz)

Local-time & Latitude Differences.



Residuals: Raw Daily Data - Daily-Pattern



Search for Tidal signals - CAWSES

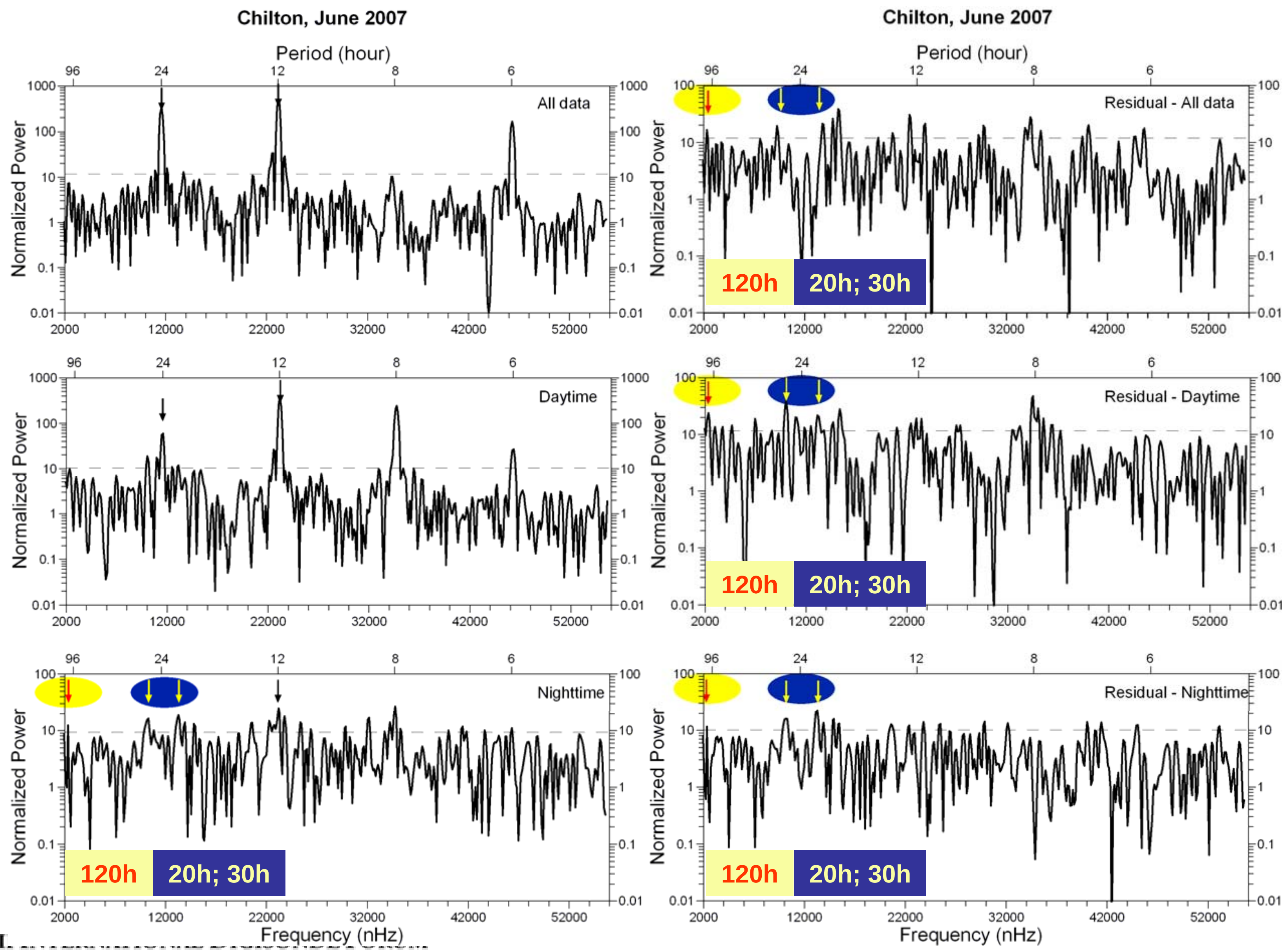
Spectral analysis results

1. Persistent peaks

2. Diurnal harmonics

3. Tidal modes (24 hours) coupled or modulated by long-period waves (120 hours)

Lines next to diurnal harmonics: 20h & 30 h (products of 24h and 120 h)



Summary & Conclusions

► A dedicated campaign by the European action COST296 was carried out in June-August 07 with six European digisondes collecting large amounts of data that may be used for studying E region dynamics.

► A number of interesting effects in the variations of E region heights were observed: day-to-day variability of the E region heights, repetitive “hooks” in the diurnal height records (inter-diurnal variations), seasonal changes in the E region height.

Preliminary ideas on the observed effects suggest that the day-to-day variability of the E region height variations relates to planetary wave modulation of metallic ion transport, while inter-diurnal variations may be caused by tidal/gravity wave activity.

► Spectral analysis reveals interesting phenomena: station-to-station variations in the diurnal harmonics (24,12,8 hours), and possible evidence for the coupling of the tidal waves (24h) and long period waves (120h).

► Results of the data analysis demonstrate the great potential offered by ionospheric sounding with precision range resolution.

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Thank You

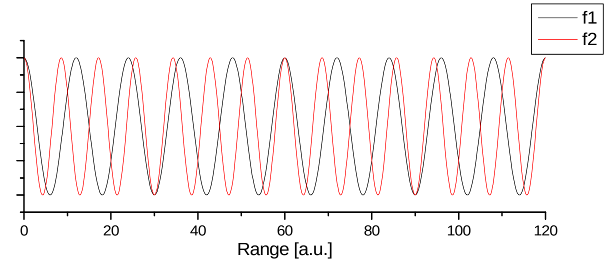
Back Ups

2π range ambiguity and accuracy

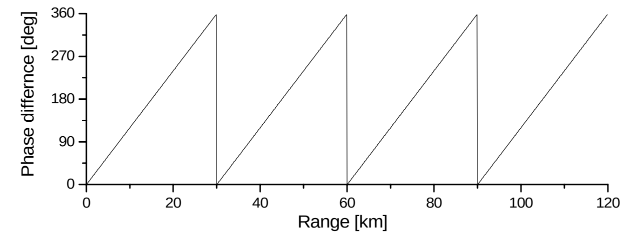
2π Ambiguity

$$\overline{h}'_m = \frac{c}{4\pi\,\Delta f}\Delta_\omega \phi_{rec} = \frac{c}{4\pi\,\Delta f}(\Delta_\omega \phi_{meas} + 2\pi\, m) \qquad m = 0,1,2.....$$

$$\Delta \overline{h}'_m = \frac{c}{2\Delta f}m = \frac{3\times 10^8 [m/s]}{2l\cdot 5[kHz]} = \frac{30[km]}{l} \quad (\Delta f = l\cdot 5\,kHz)$$



(m can be determined from the echo arrival time)



h' accuracy

$$\delta\,\overline{h}' = \delta\left(\frac{c\,\Delta_\omega \phi_{meas}}{4\pi\,\Delta f}\right) = \frac{30km}{l}\,\delta\left(\frac{\Delta_\omega \phi_{meas}}{2\pi}\right) < 1km/l$$

(since the phase measurement errors are usually smaller than 2π/32)

$$\therefore \quad \boxed{\delta\,\overline{h}' < 1km/l} \qquad (\Delta f = l\cdot 5\,kHz)$$

E-layer height measurements with DGS

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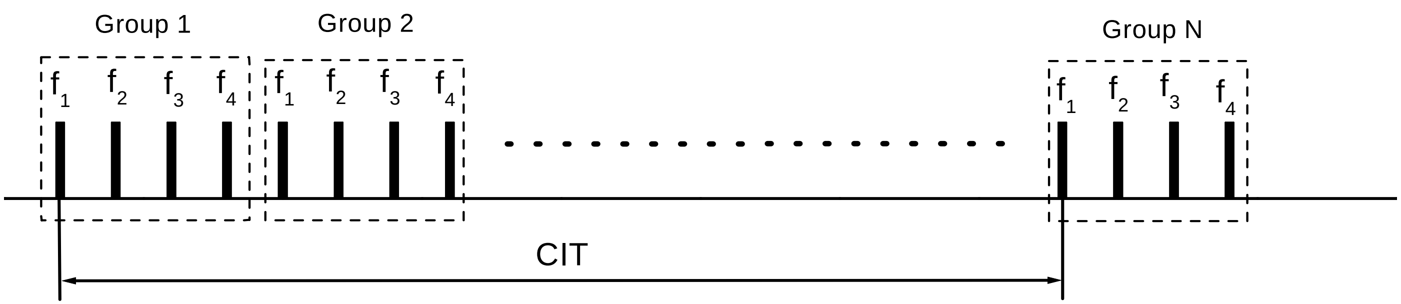
Timing of multi-frequency transmission for PGH measurements.



High Doppler resolution mode (aka "Drift mode") settings.

Frequencies used:
2.330, 2.335, 2.340, 2.345 MHz

Height range:
90-135 km

Group range step:
2.5 km

Program length:
~5sec

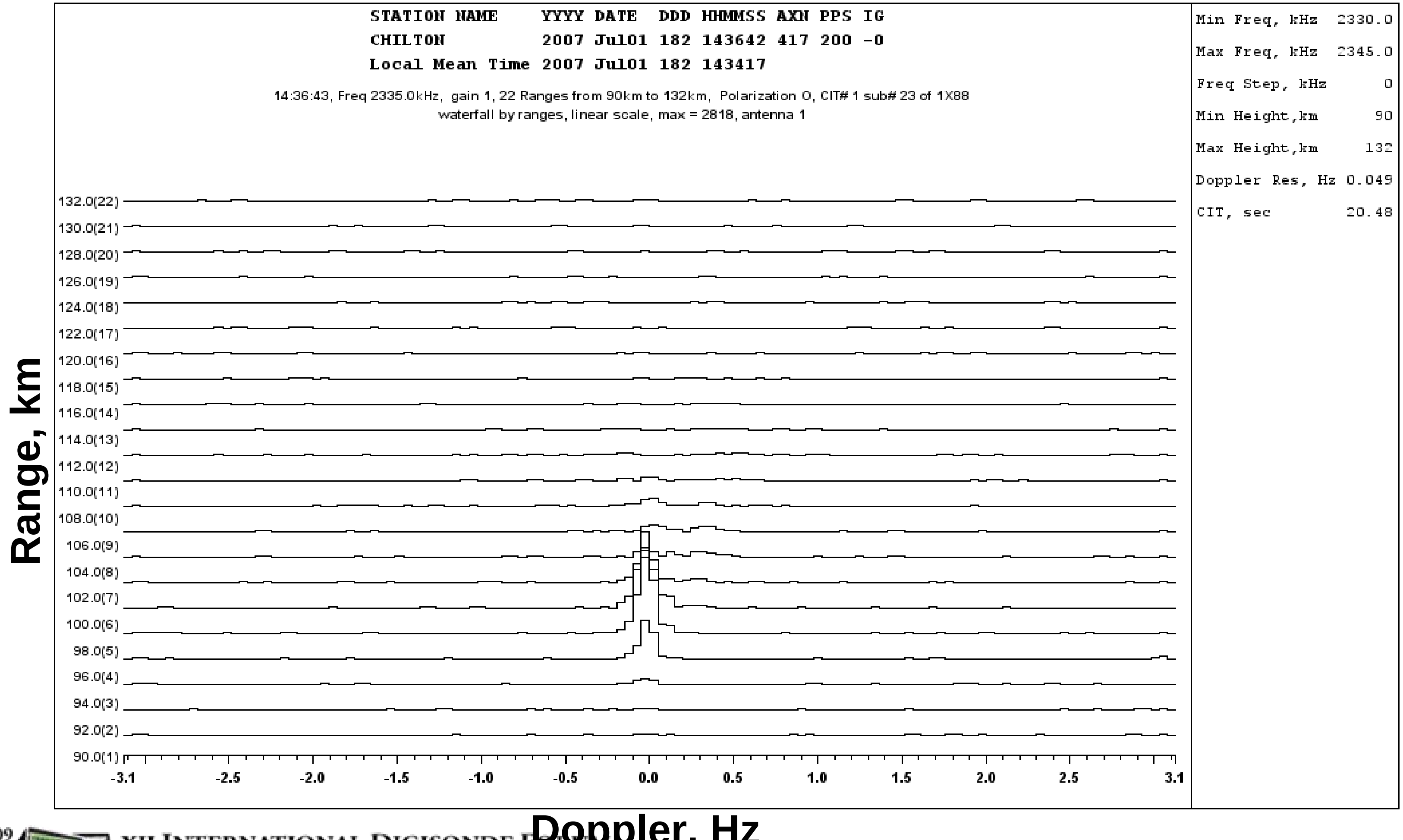
O-mode

Lower frequency (khz)	2330	Height_Res (km)	2.5
Coarse Step / # of Reps	1	# of Hghts (128 / 256 / 512)	128
Upper frequency (khz)	2330	Range Delay (km)	0
Fine frequency step (khz)	5	Gain (0 to 15)	0
# small steps (+ or -)	4	Freq Search (0,1,2,3,4)	0
Xmtr waveform (comp=1)	1	# Output Hts x 2	22
Antennas (0=beam)	15	Disk (0MSDFPCBR)	D
FFT size (power of 2)	7	Printer (0, B/w, Color)	0
Rate (50, 100, or 200)	200	Bottom_Ht to Output	90
First height (km)	90	Top_Ht to Output	134

Data & Analysis

Amplitudes & Phases.

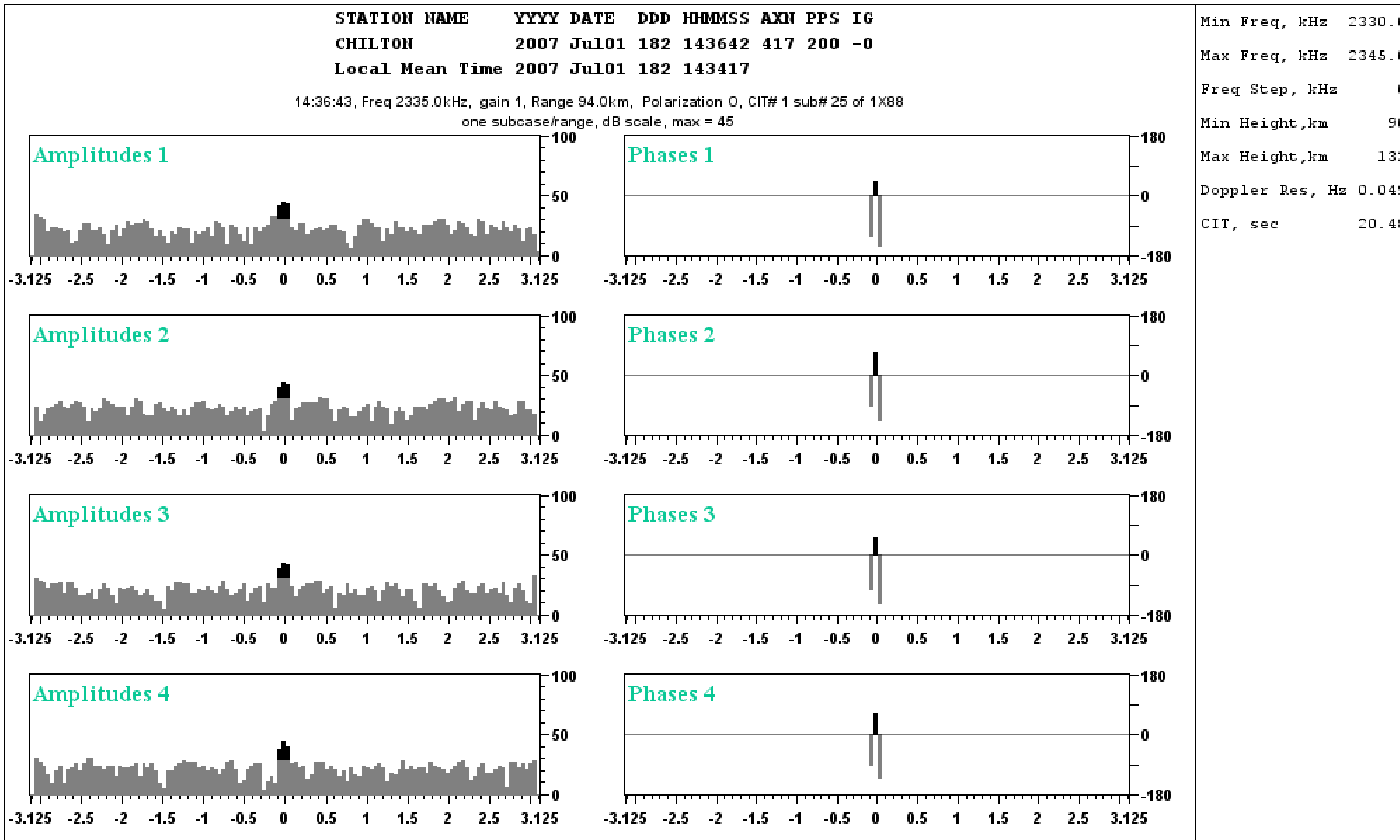
► **Single freq. reception at a particular antenna: Several Doppler Lines at several Height Ranges.**



Data & Analysis

Amplitudes & Phases.

► 4 antennas & 3 frequency pairs



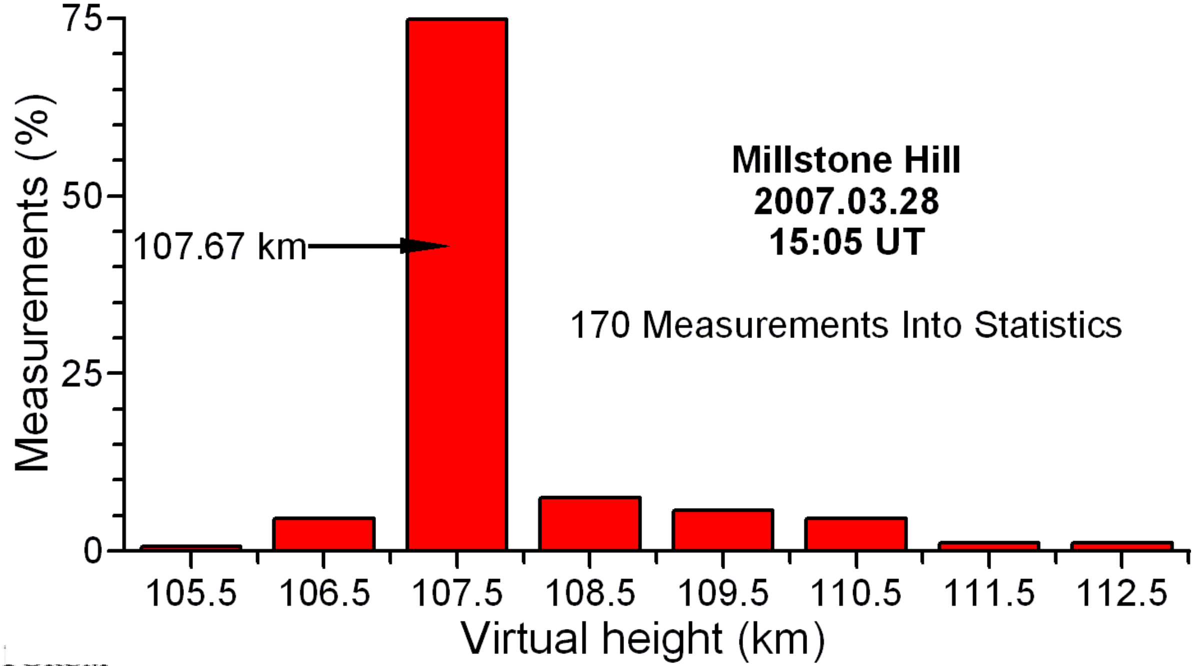
Data & Analysis

Selection criteria.

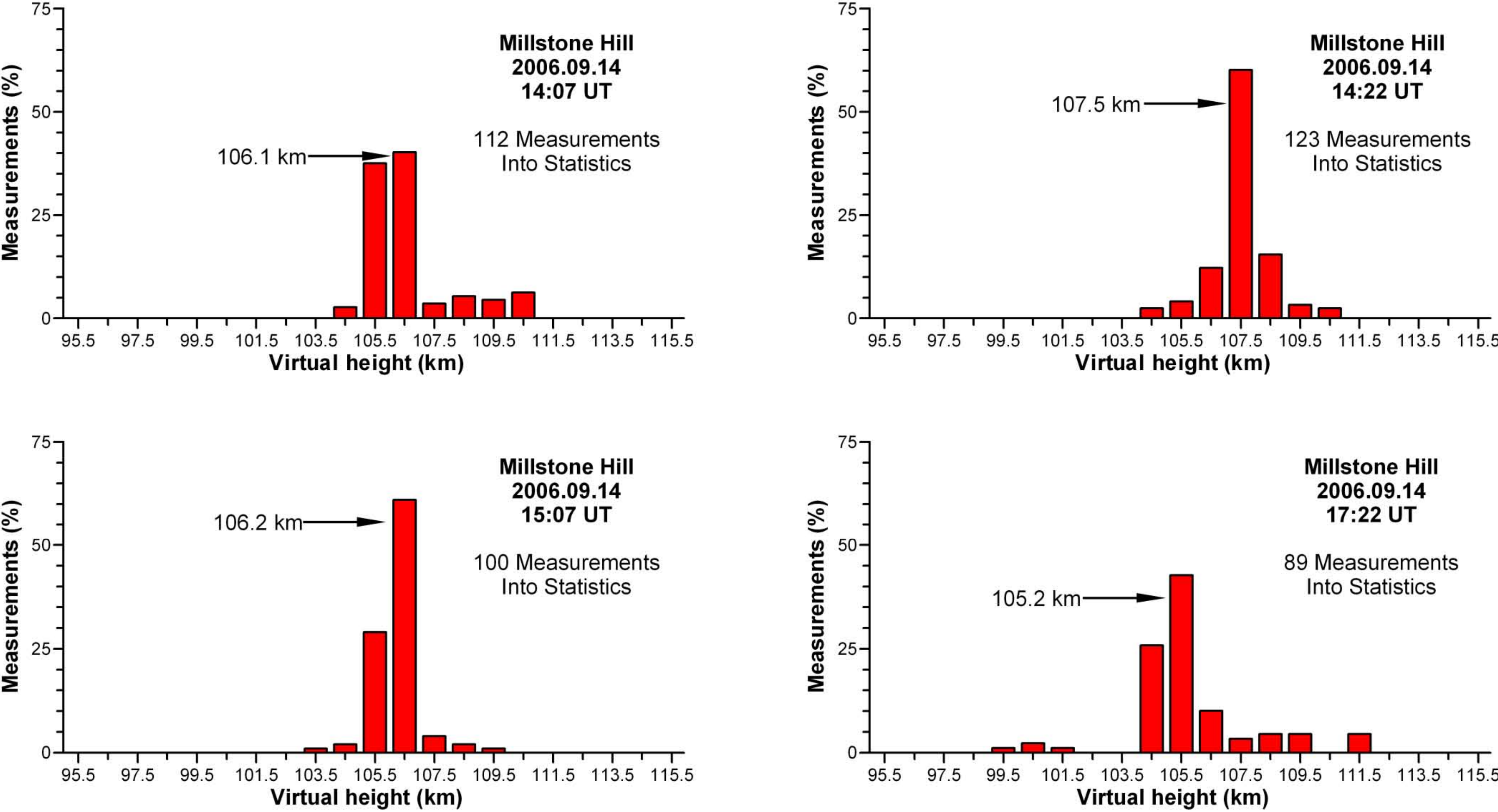
- ► Amplitudes above Noise Level (12 dB > MPA).
- ► Doppler lines close to Zero (-5 to 5).
- ► Measured PGH do not differ significantly from the course height range (<7 km).
- ► Similar signal amplitude must be seen by all antennas.
- ► Off-vertical signals are excluded.

$$\bar{h}' = \frac{c}{4\pi\,\Delta f}\Delta_{\omega}\phi_{rec}.$$

- ► 10 DL x 20 HR x 4 A x 3 FP = 2400 h'_i.



Statistical distributions



Height measurements in E region

E Layer PGH Measurements.

► **The PGH technique determines virtual heights h'(f) with an accuracy of better than 1 km.**

Assess the dynamic coupling between the neutral atmosphere and the ionosphere.
Analysis of the h'E variations possibly caused by GW, tides. **CAWSES.**

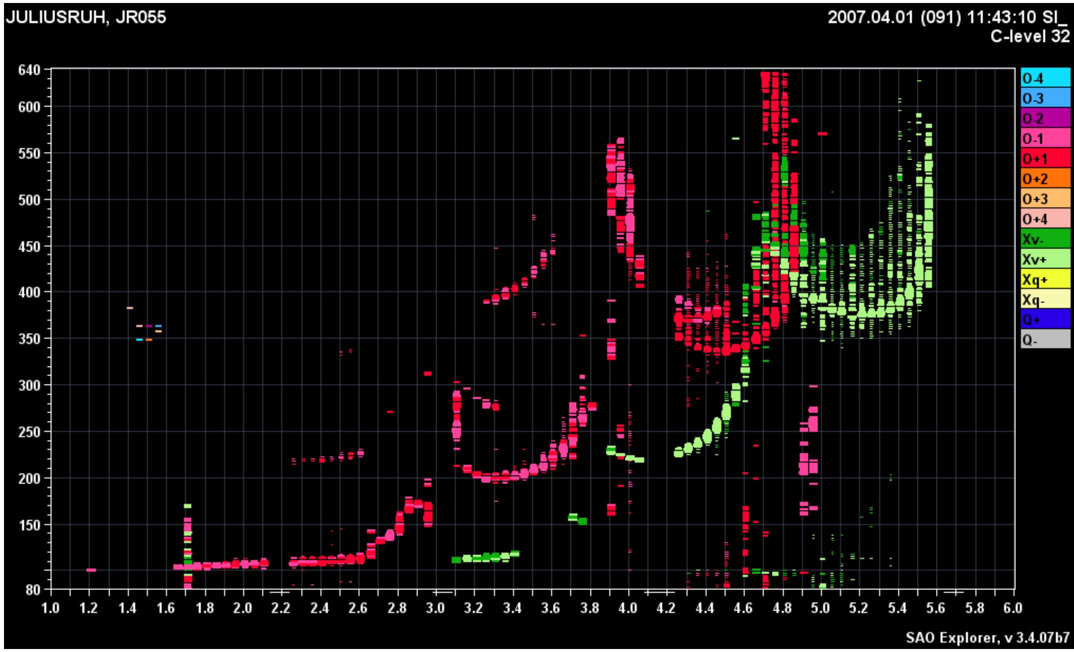
Optimum frequencies selection.

► **Phase mesurements at close frequency pairs.**

► **Low frequencies selection to get maximum time coverage.**

► **Selecting the "best" f that assures minimum interference and reliable echo amplitudes.**

► **Most sounders opperate at 2.330, 2.335, 2.340, and 2.345 MHz.**



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HAARP HF heating and digisonde sensing of plasma perturbations

Prof. Gary Sales
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

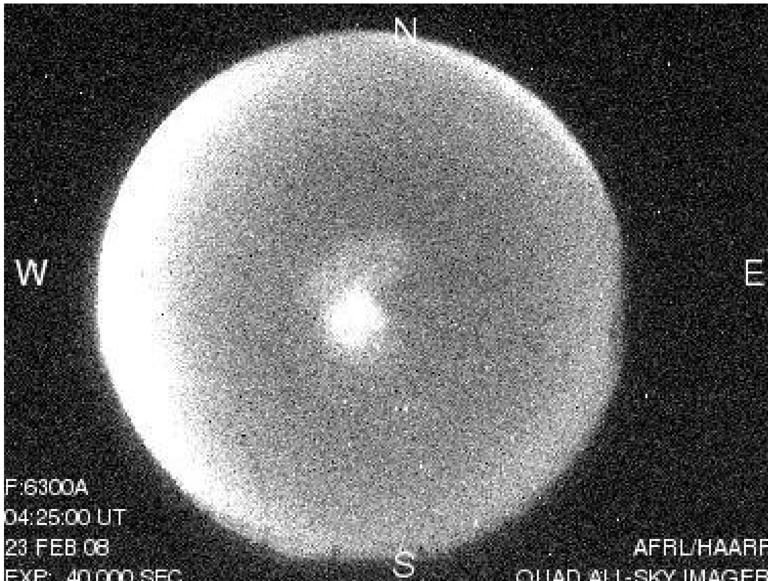
Introduction

Based on the observations of Dr. Todd Pedersen (AFRL) we have taken a look here at how the digisonde can assist in determining the temporal and physical structure of ionospheric layers that are formed during heating campaigns.

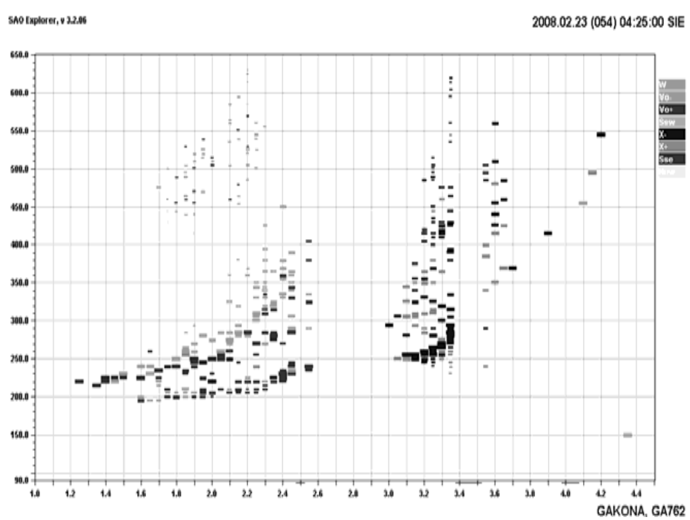
Here we are characterizing the the digisonde observations along with Pedersen’s scanning all-sky photometer. These observations lead us to speculate on the structure of the heated region.

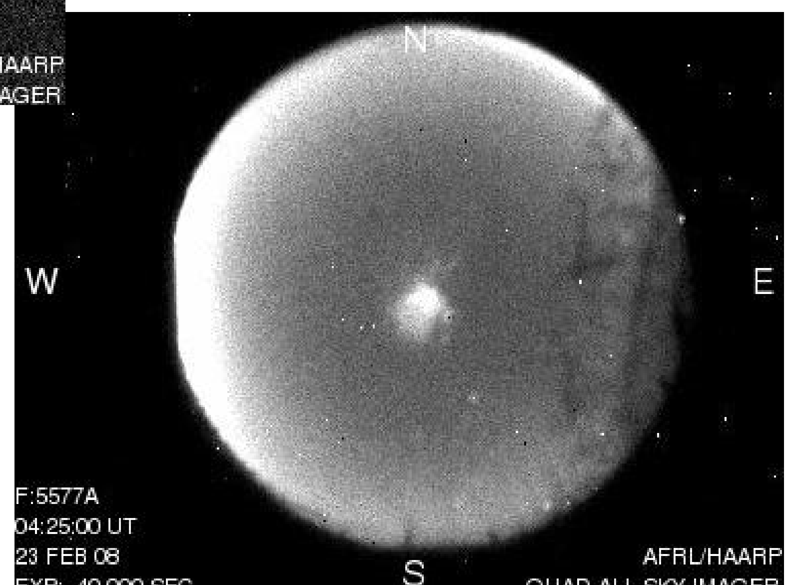
Finally, we show what the digisonde skymap capability can add to this investigation.

Secondary Layer Formation during HAARP Heating



HAARP
23 Feb. 2008
0425UT





HAARP Heating Campaign
29 Oct. 2008

During this campaign the heating cycle was 4 minutes on, followed by 4 minutes off.

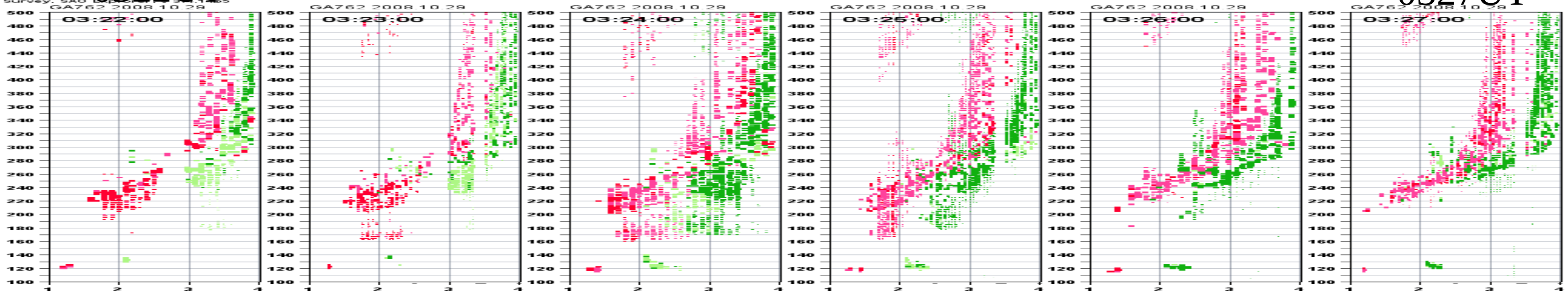
The results of 4 cycles are shown here.

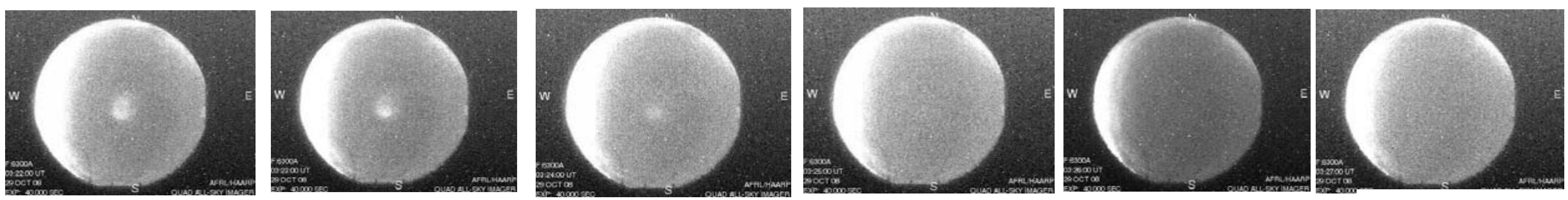
Cycle #	Start time	Stop time
1	0320UT	0324UT
2	0328UT	0332UT
3	0336UT	0340UT
4	0344UT	0348UT

HAARP Heating Cycle
29 Oct 2008
0320UT

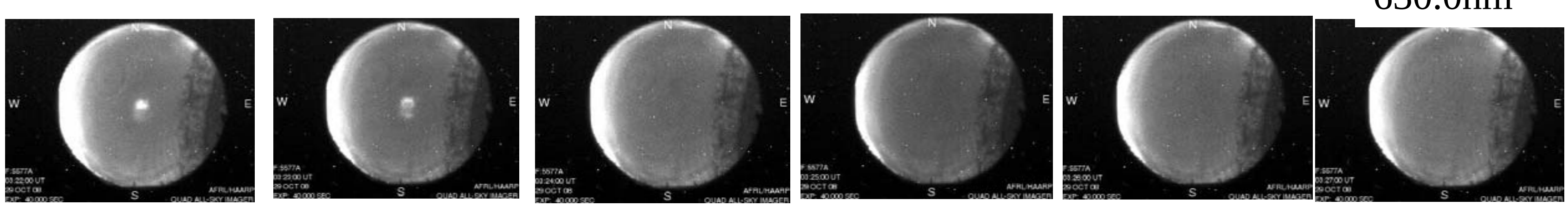
0322UT

0327UT



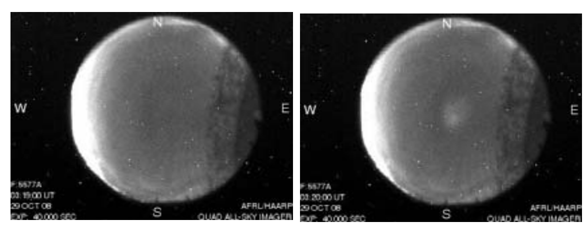


630.0nm



557.7nm

0319UT

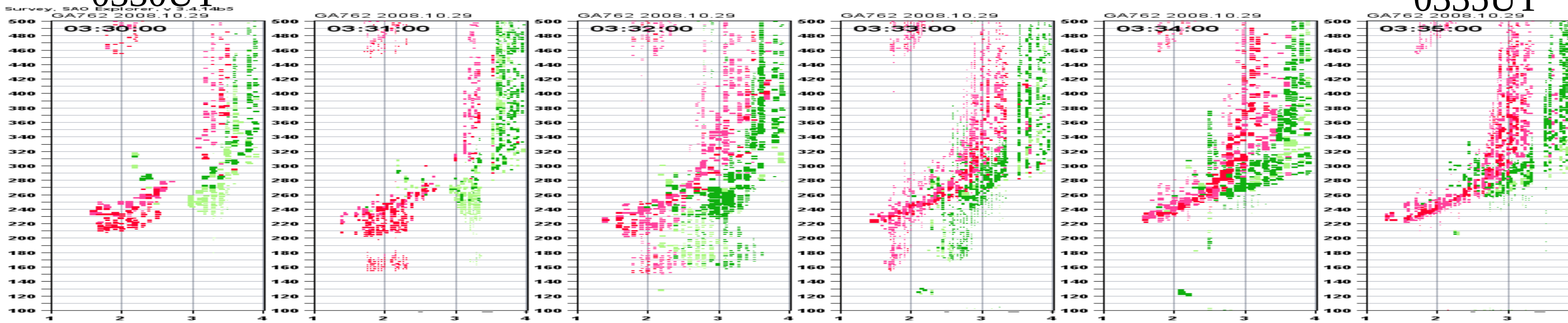


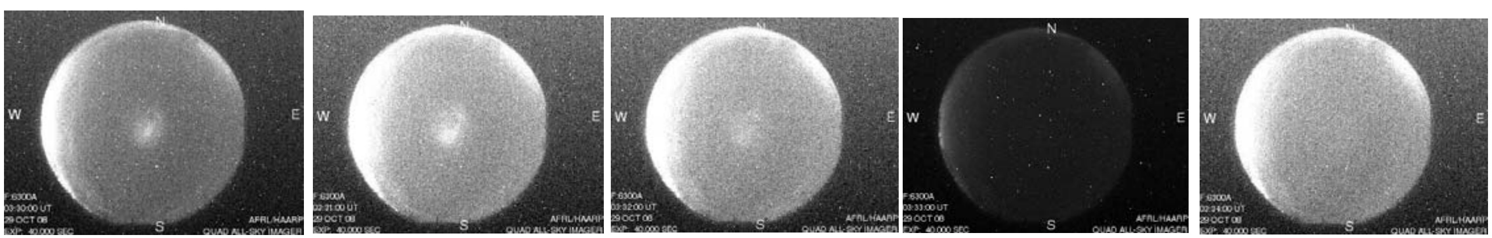
0320UT
start

HAARP Heating Cycle
29 Oct 2008
0328UT

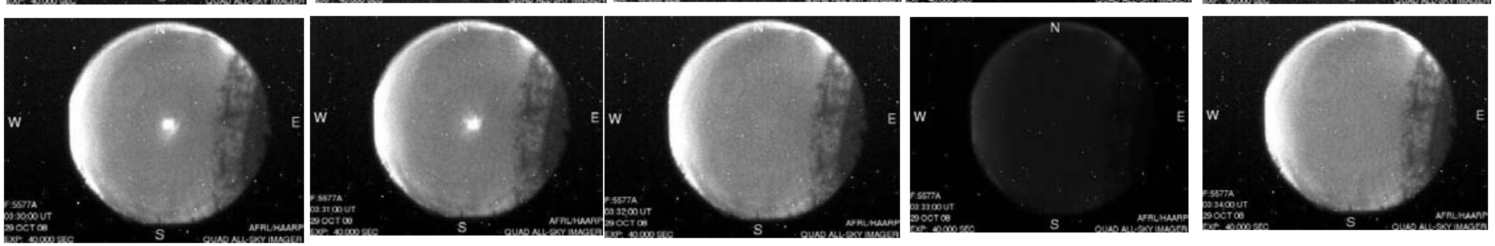
0330UT

0335UT





630.0nm



557.7

0327UT

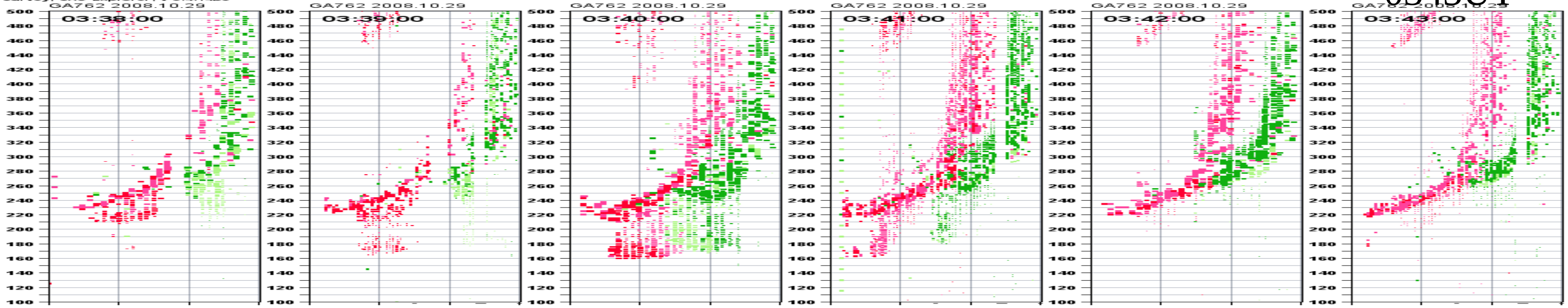
0328UT
start

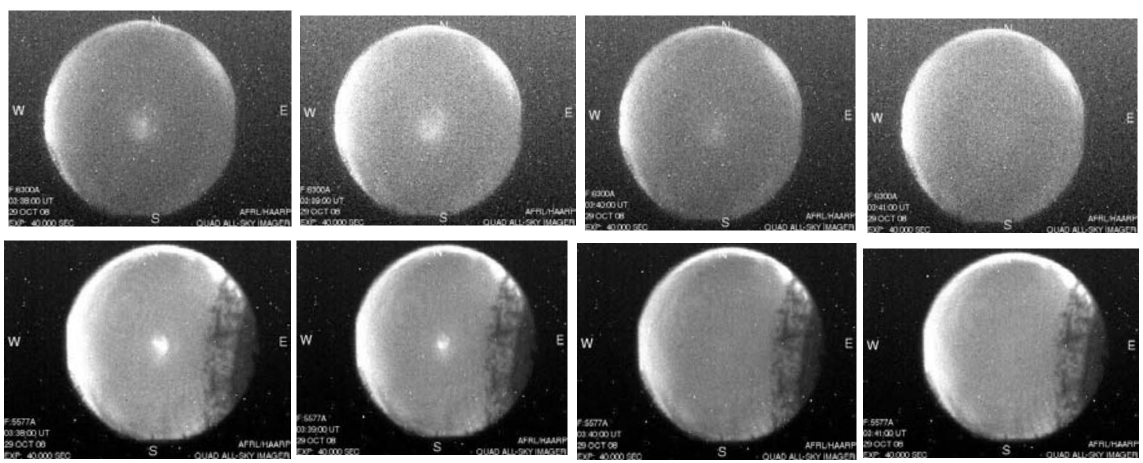
XII International Digisonde Forum
11 - 14 May 2009
2009 IDF

HAARP Heating Cycle
29 Oct 2008
0336UT

0338UT

0343UT

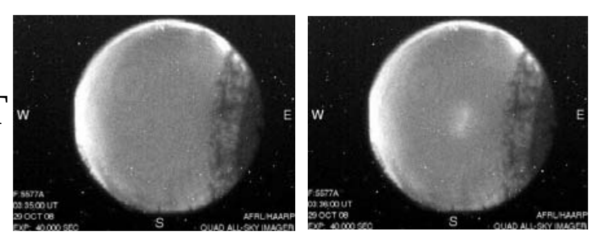




630.0nm

557.7

0335UT



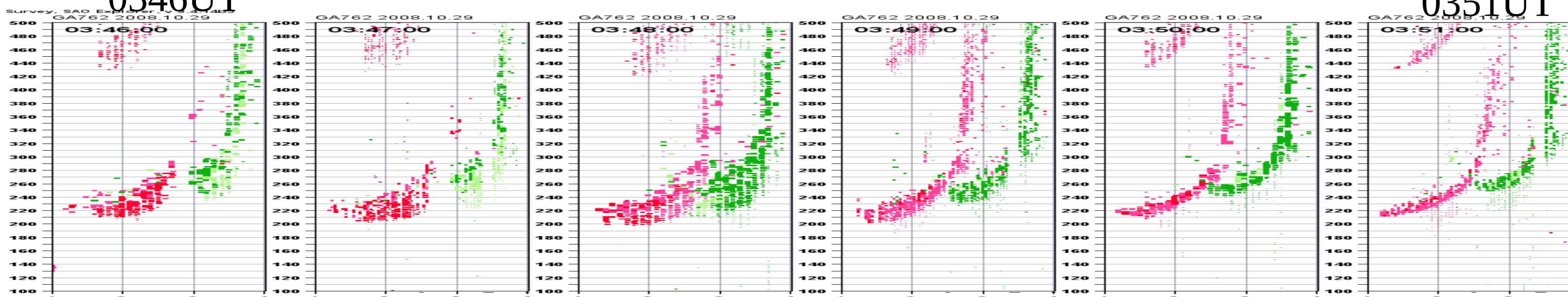
0336UT
start

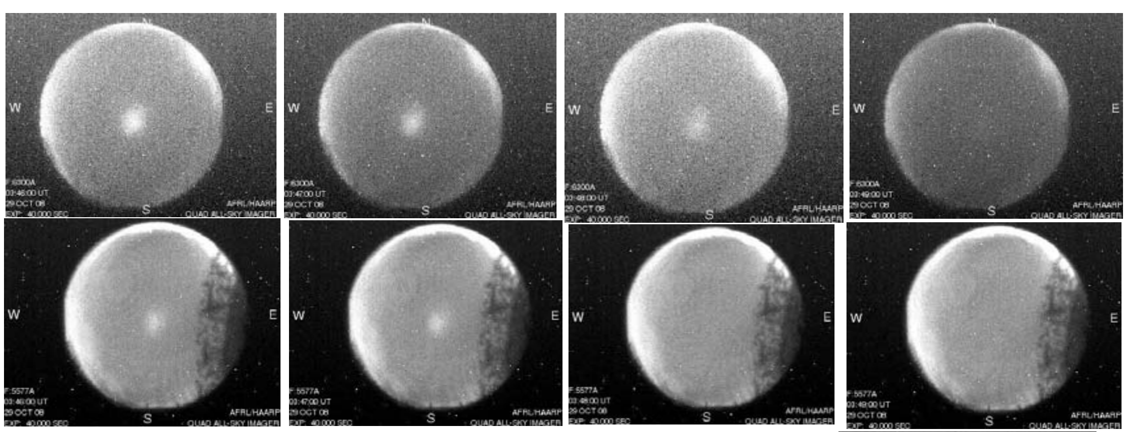
XII International Digisonde Forum
11 - 14 May 2009
2009 IDF

HAARP Heating Cycle
29 Oct 2008
0344UT

0346UT

0351UT

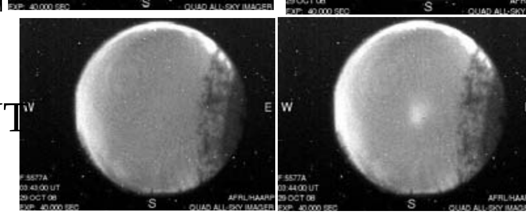




630.0nm

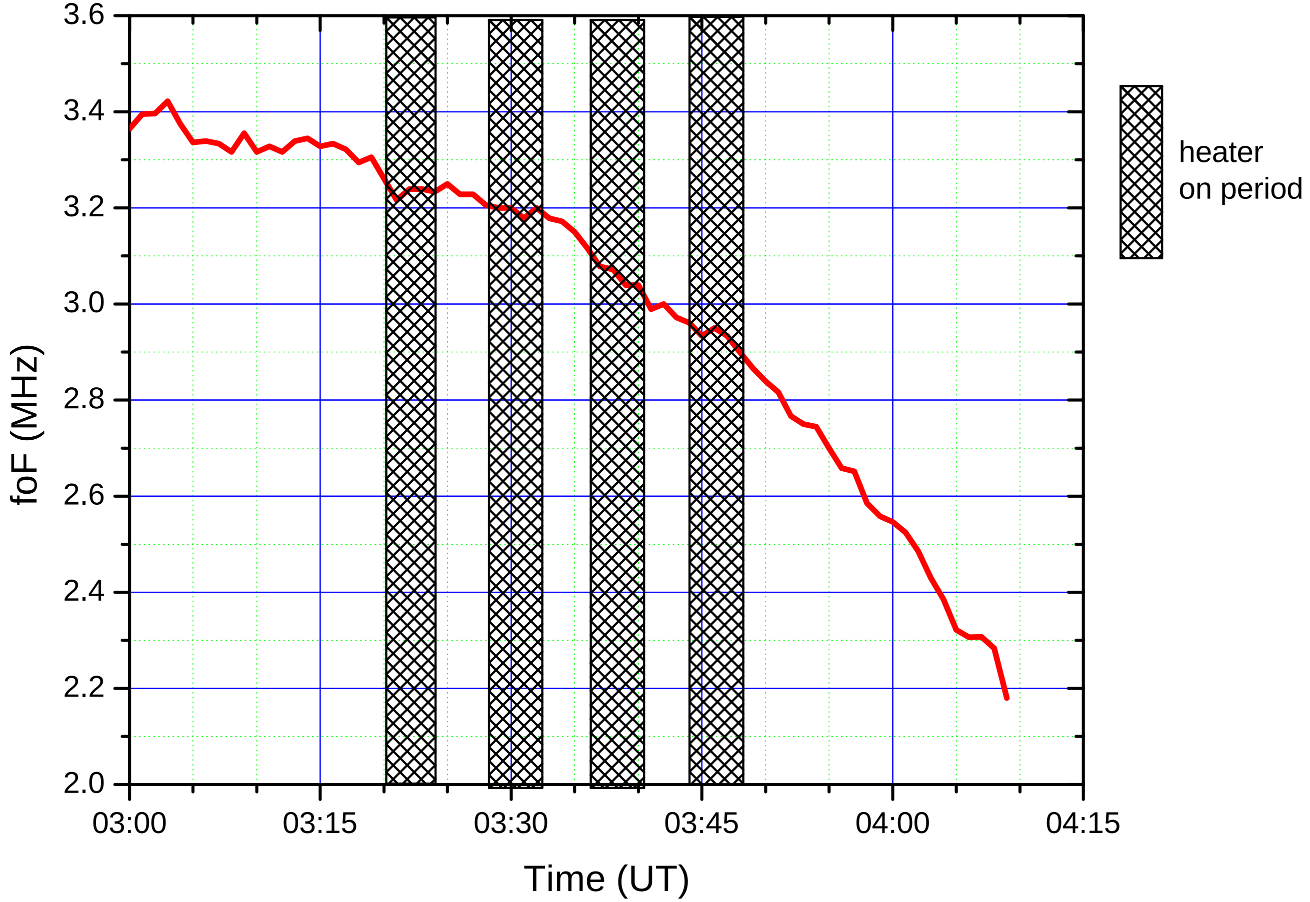
557.7

0343UT



0344UT
start

Time Variation of the F-layer Critical Frequency (smoothed)
29 Oct. 2008
Gakona/HAARP



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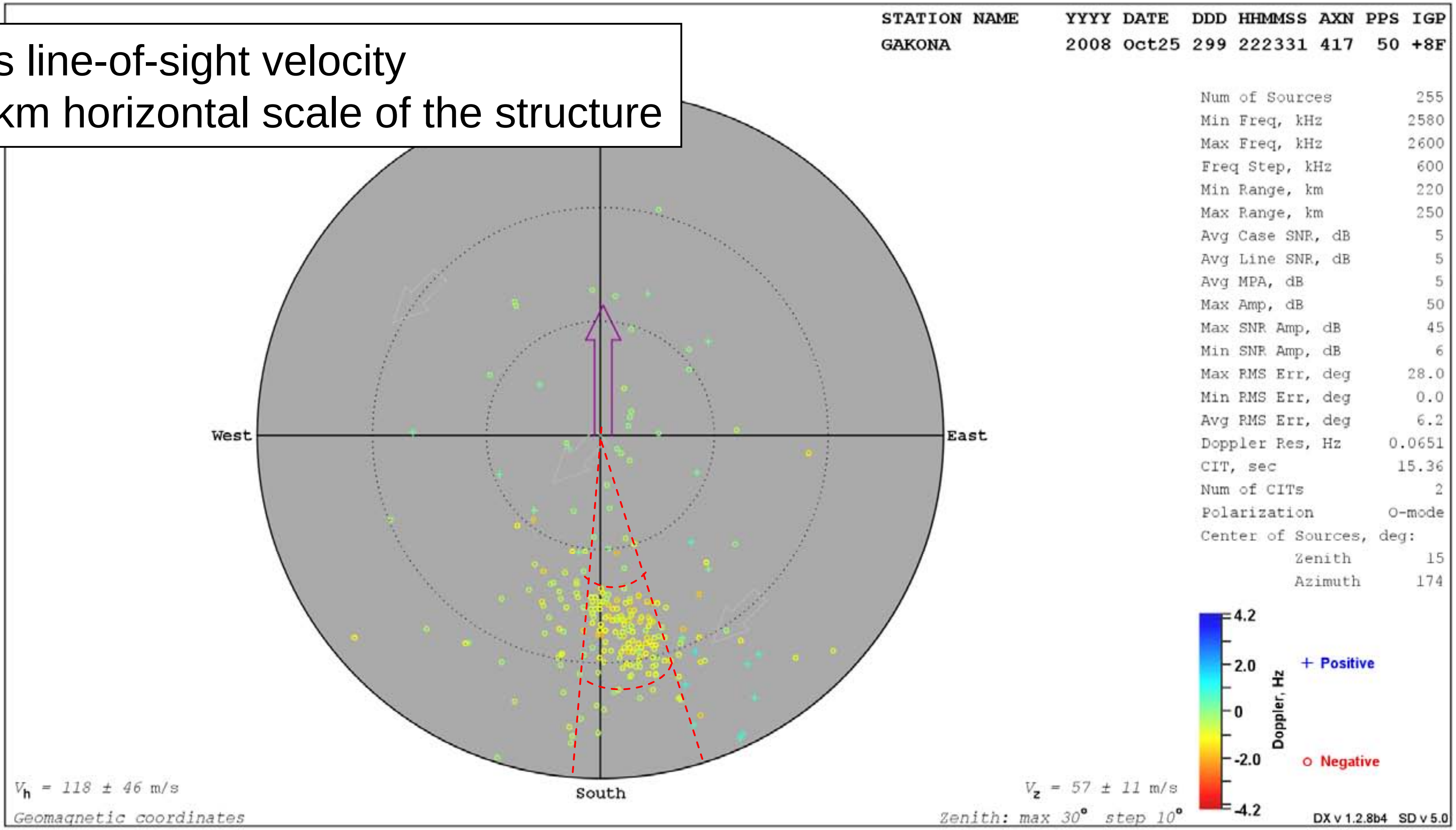
Upwelling Experiment

25 Oct. 2008

-86 m/s line-of-sight velocity
30-40 km horizontal scale of the structure



6+ degree precision in DPS-4
2 degree precision in 4D

[Courtesy Dr. Evgeny Mishin]

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Passive observations of HAARP/EISCAT signals

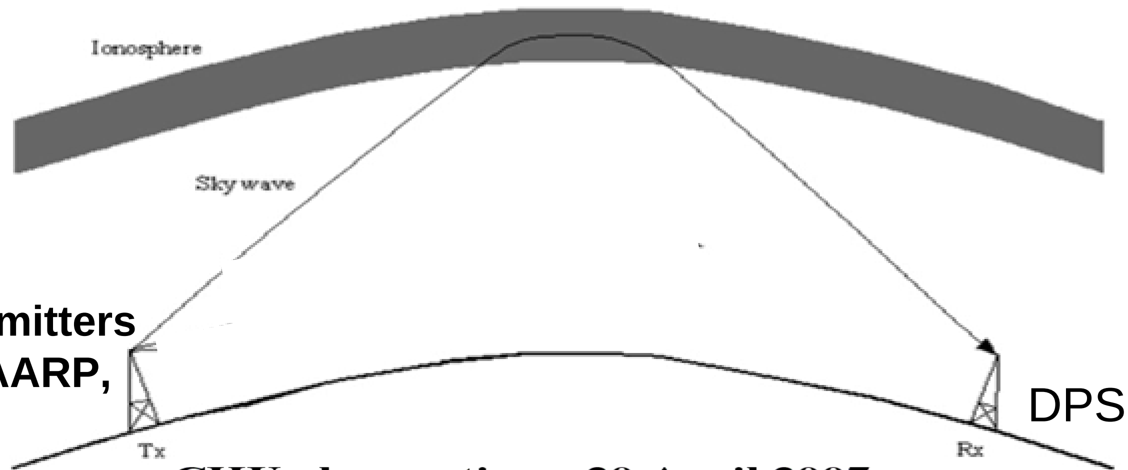
Vadym Paznukhov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

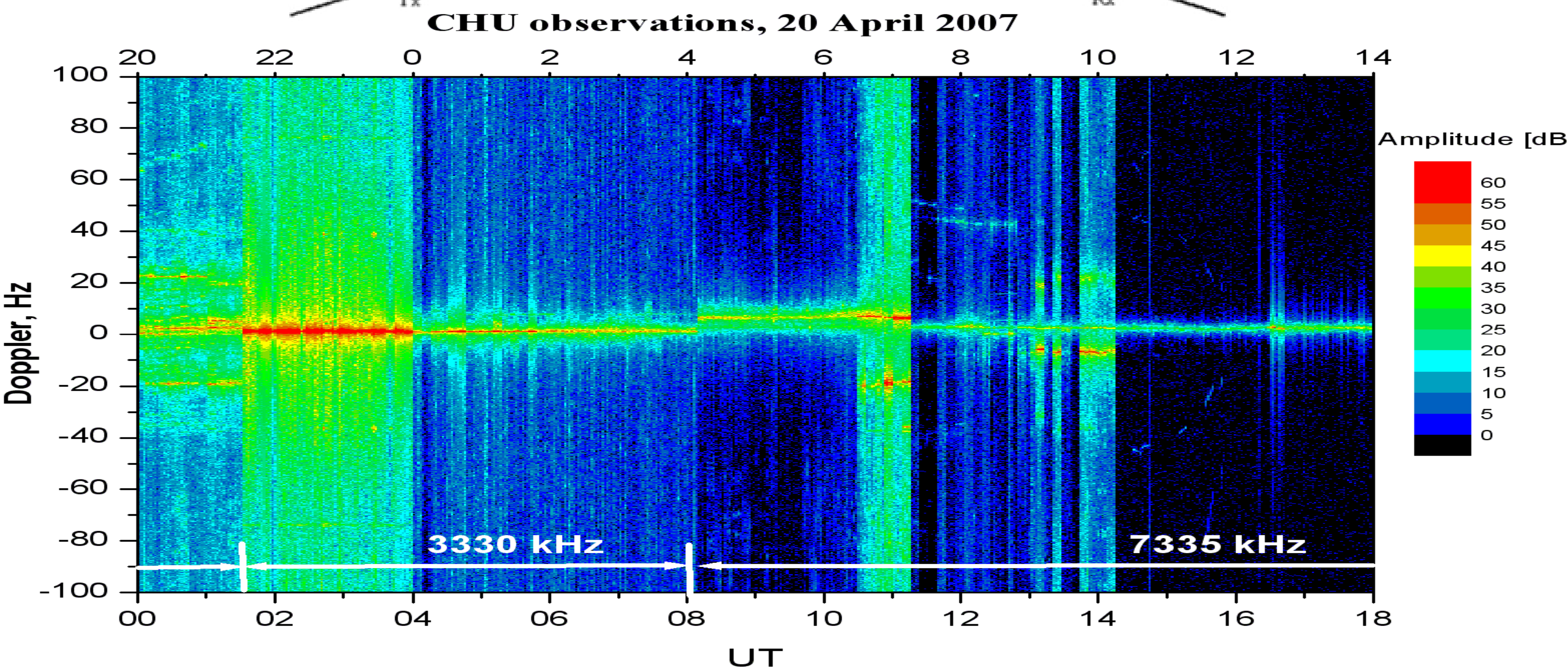
Passive RF Sensing mode

for monitoring transmitters of opportunity

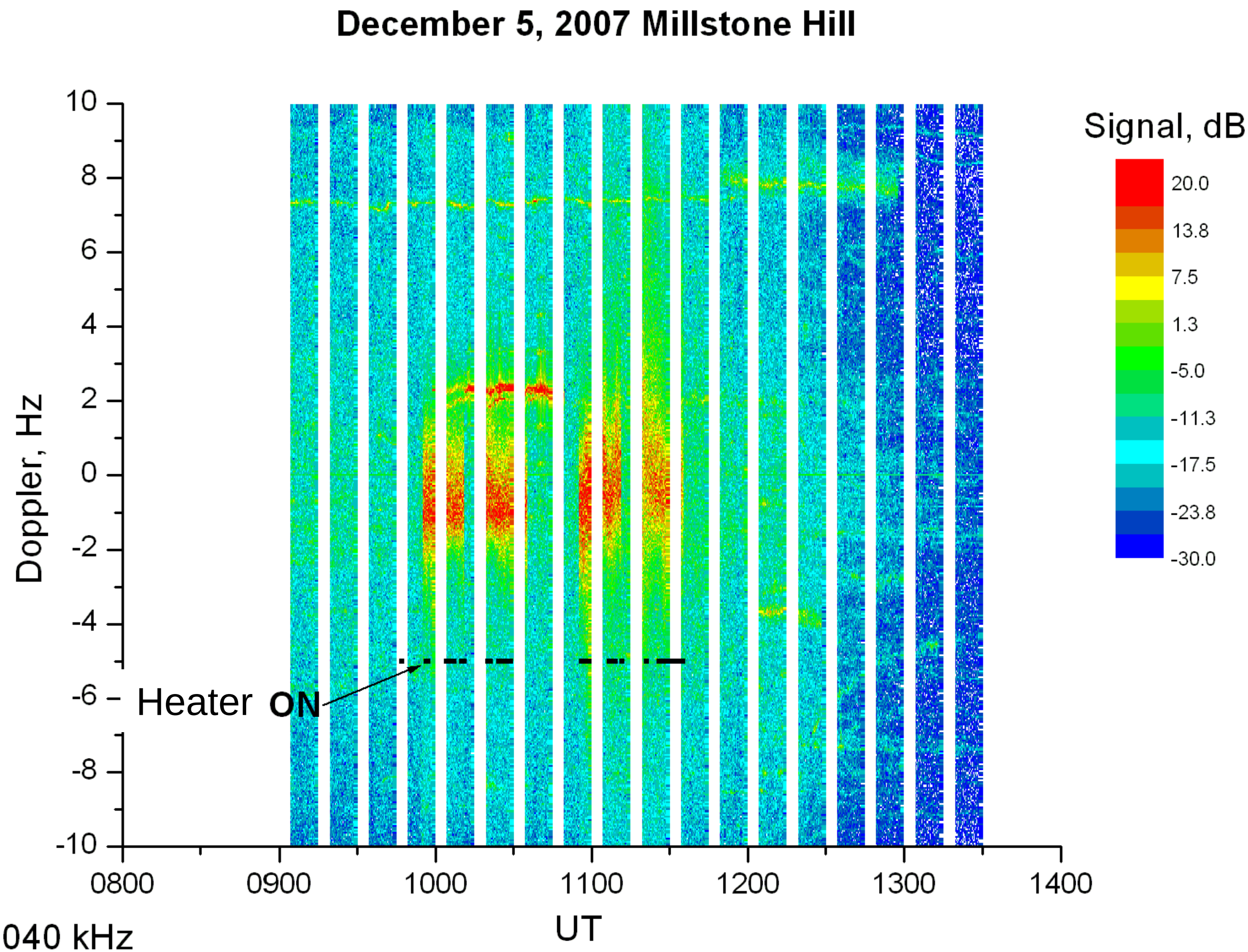


External transmitters (CHU,WWV,HAARP, EISCAT,etc.)

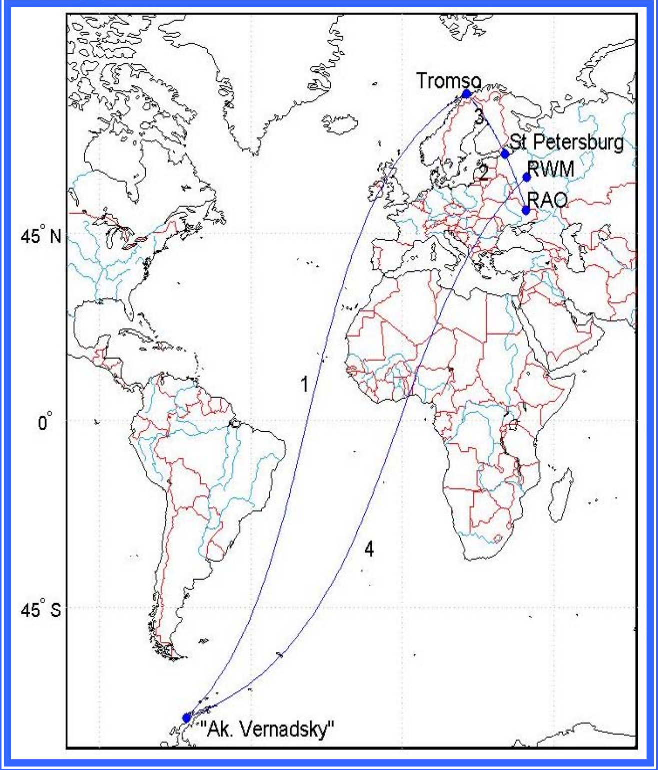
DPS-4D

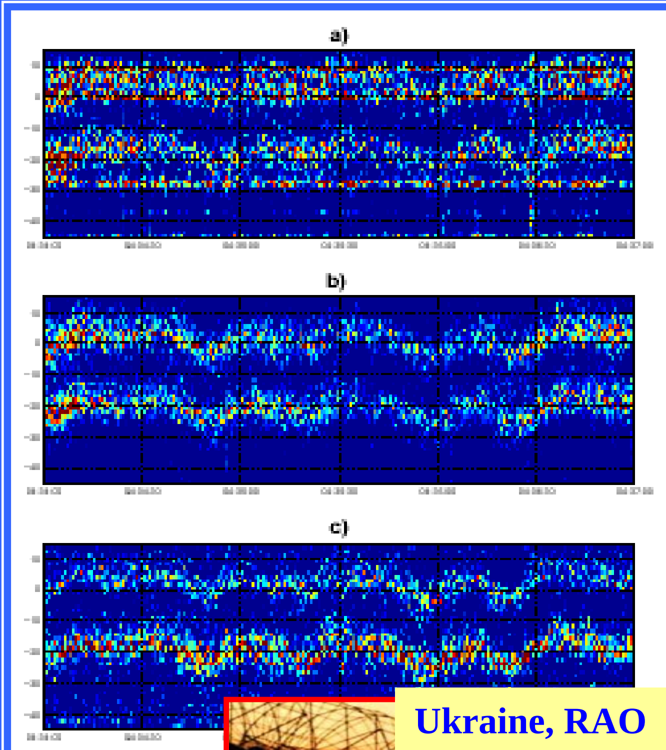


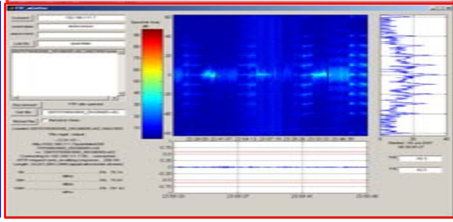
EISCAT heater signal observation with DPS-4D



Self-scattering effect; 2002 RINAN Campaign

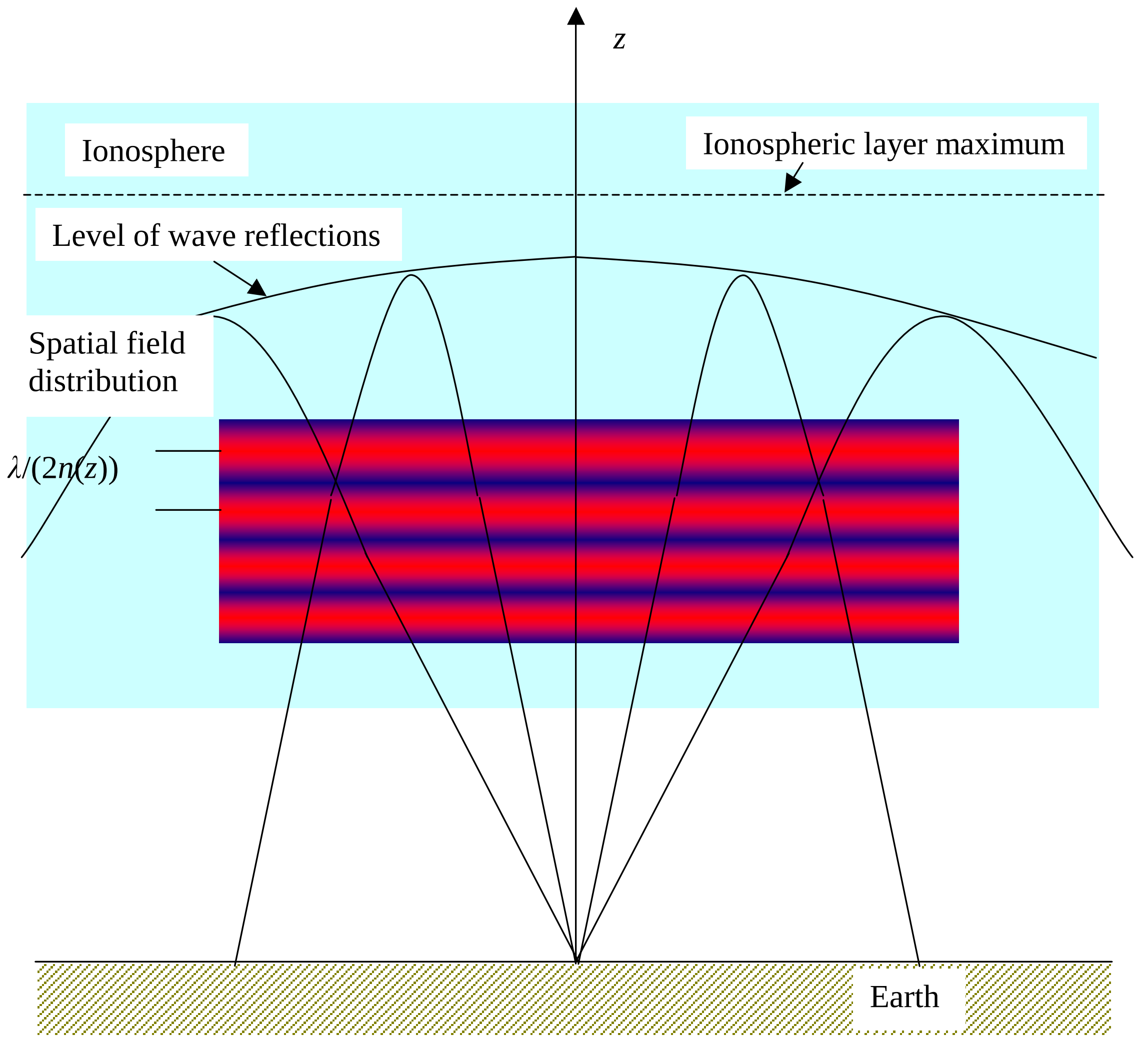




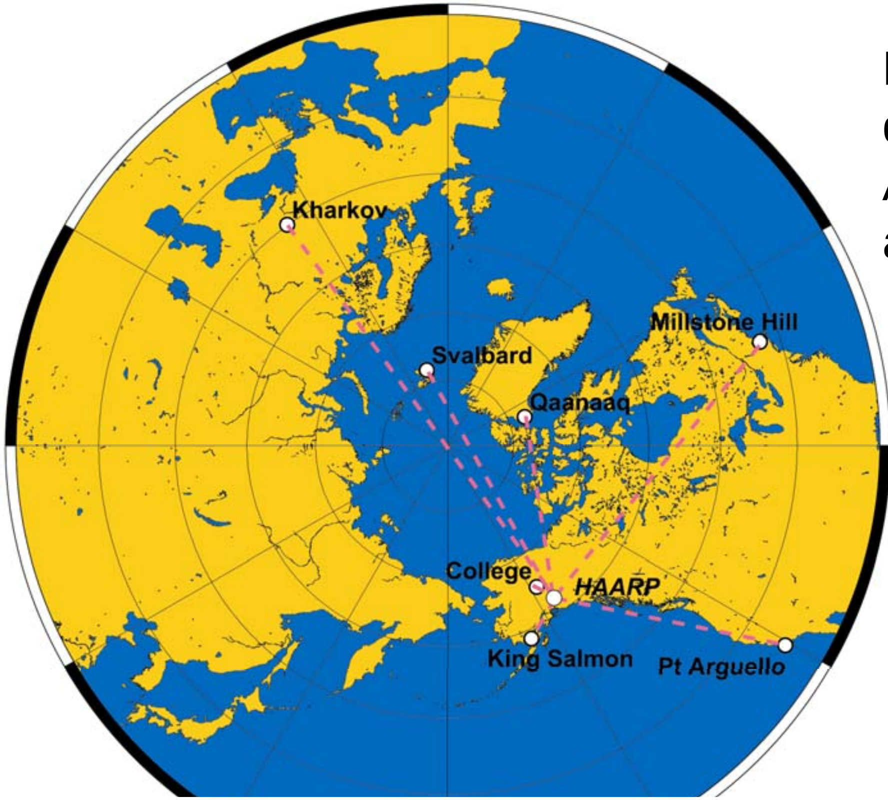


Tromsø heater experiment layout (2002, Ukraine, Russia and Antarctica)

Principle of self-scattering



February 2008 HAARP heating experiment



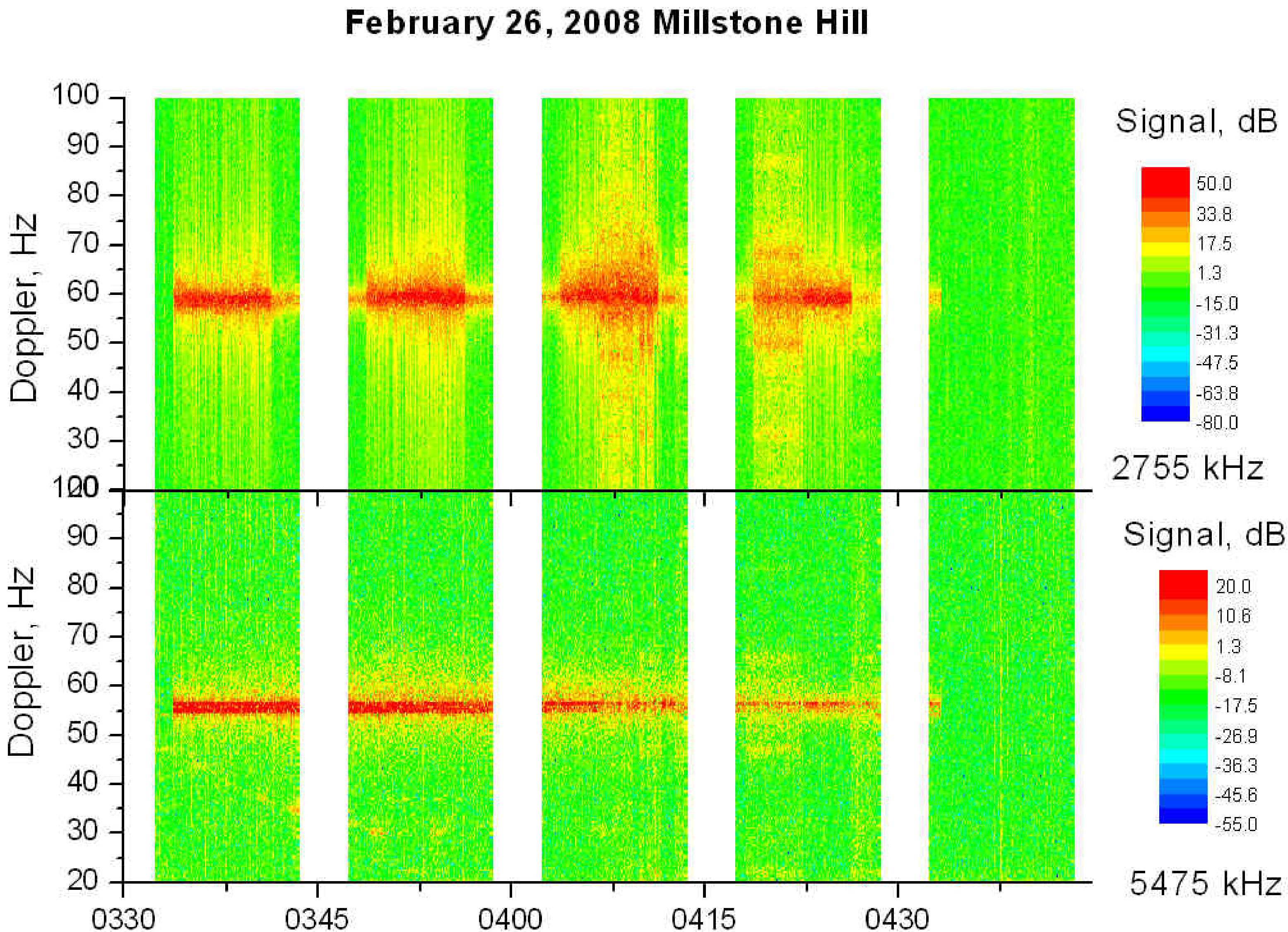
Locations of the receiver sites operated during the Winter 2008 HAARP Campaign. Approximate propagation paths are shown as well.

HAARP operation mode summary

Heating intervals	Operating frequencies (and transmit power)	Polarization	Operation sequence	Beam orientation
26.02.08 0100-0200 UT	4,100,063 Hz (3.5 MW/120 kW) 8,095,063 Hz (120 kW)	O-mode O-mode	7.5 min Hi* / Low* CW	Zenith N/A
26.02.08 0315-0445 UT	2,755,063 Hz (3.5 MW/120 kW) 5,475,063 Hz (120 kW)	O-mode O-mode	7.5 min Hi* / Low* CW	Zenith N/A
27.02.08 0300-0349 UT	2,675,058 Hz (3.5 MW) 2,835,058 Hz (120 kW)	O-mode O-mode	7.5 min Hi / OFF CW	Zenith N/A

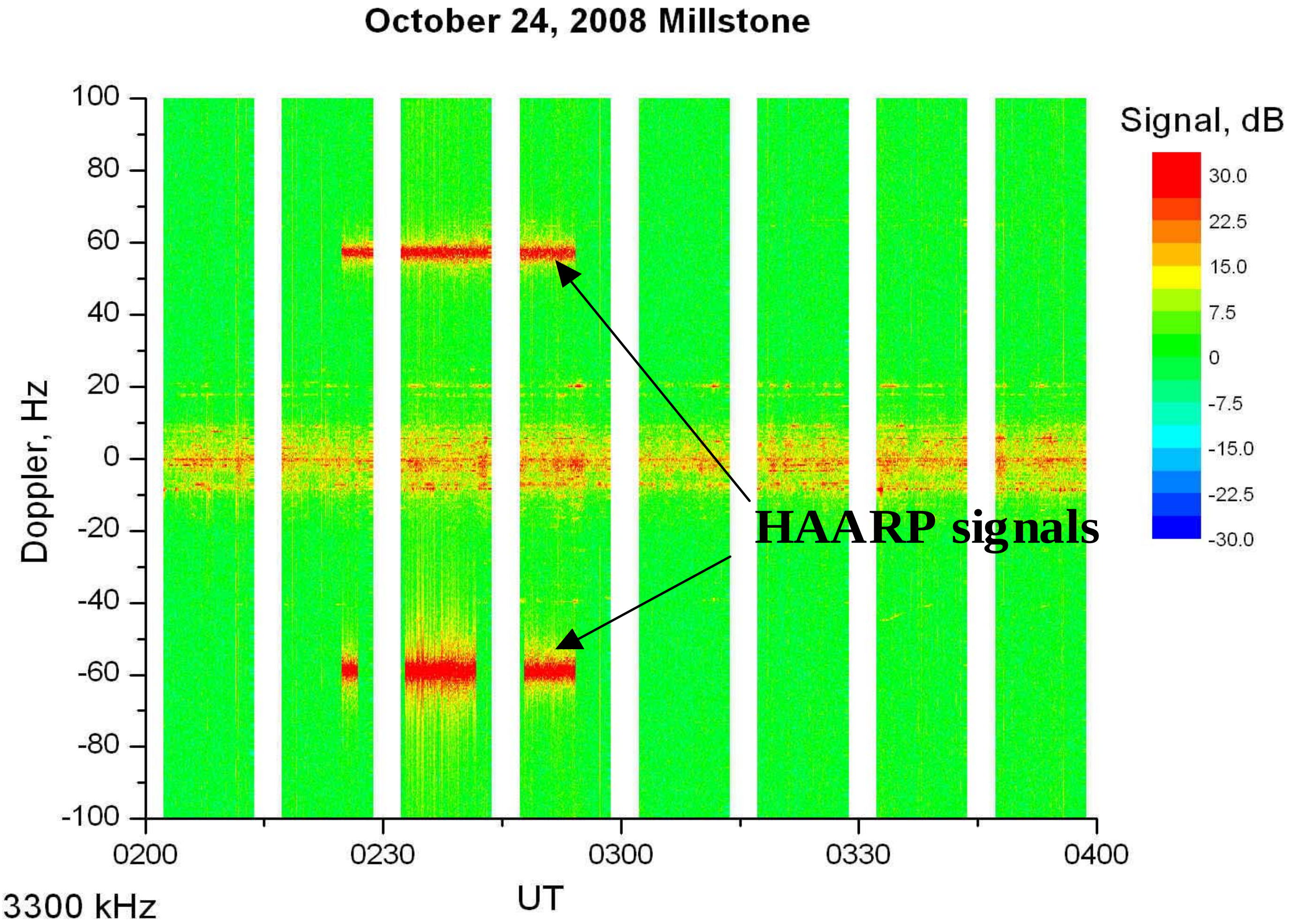
* 'Hi' denotes high power (3.5 MW) transmission, while 'Low' denotes transmission at 120 kW.

HAARP signal recorded at Millstone Hill



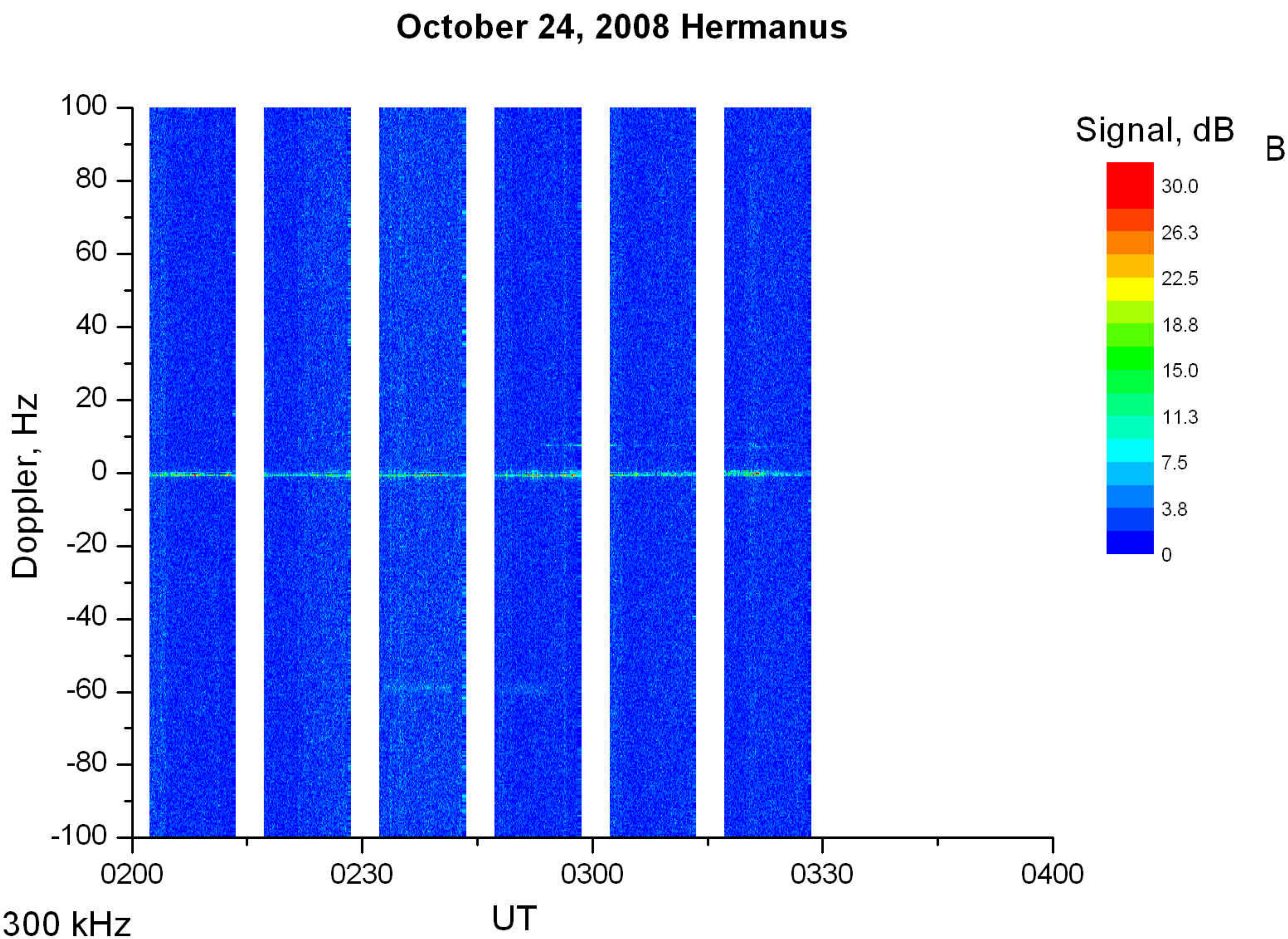
Sunset at HAARP at ~03 UT

HAARP signal recorded at Millstone Hill



HAARP transmission observations at Millstone Hill made on October 24, 2008. The operating frequencies were 3.299942 MHz (with 3.26 MW power) and 3.300058 MHz (with 100 kW power).

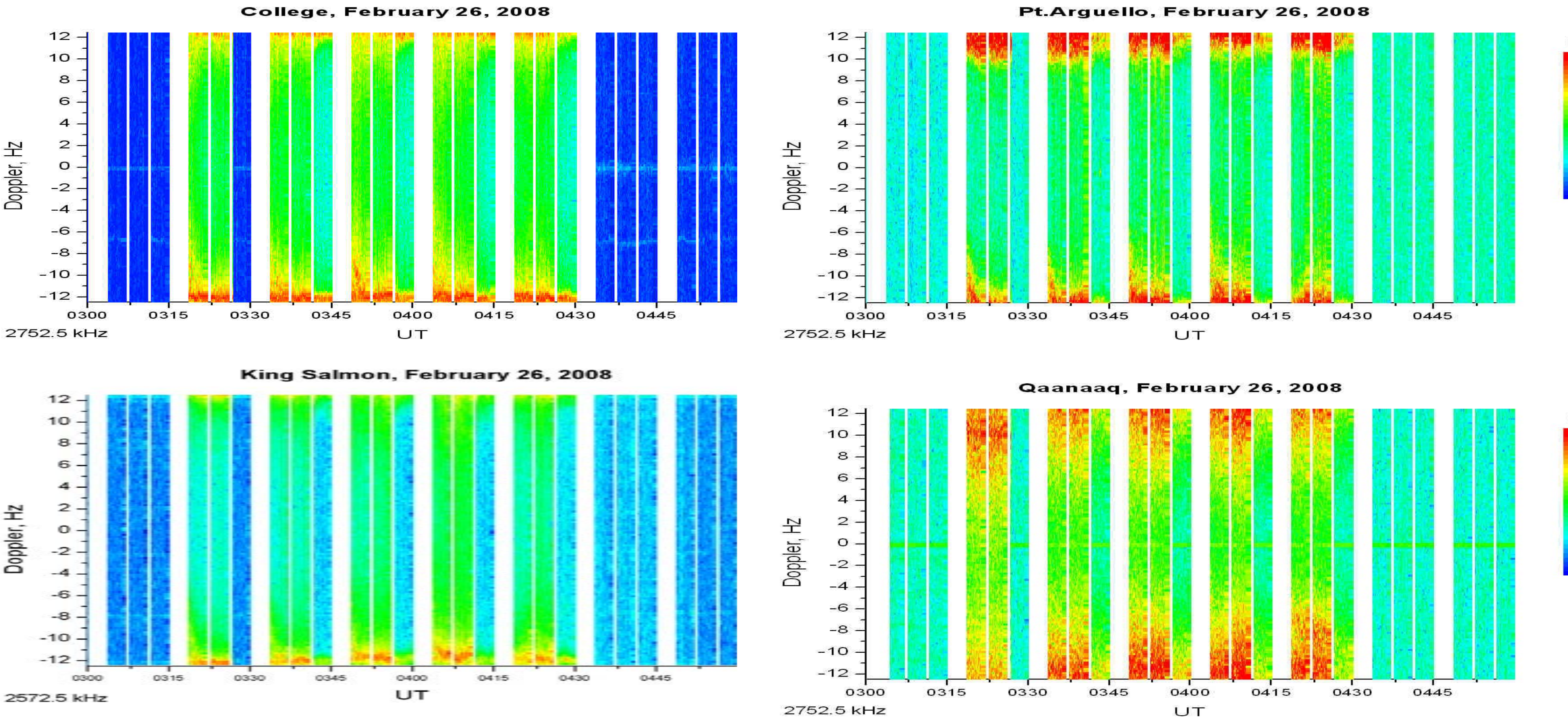
HAARP signal recorded at Hermanus



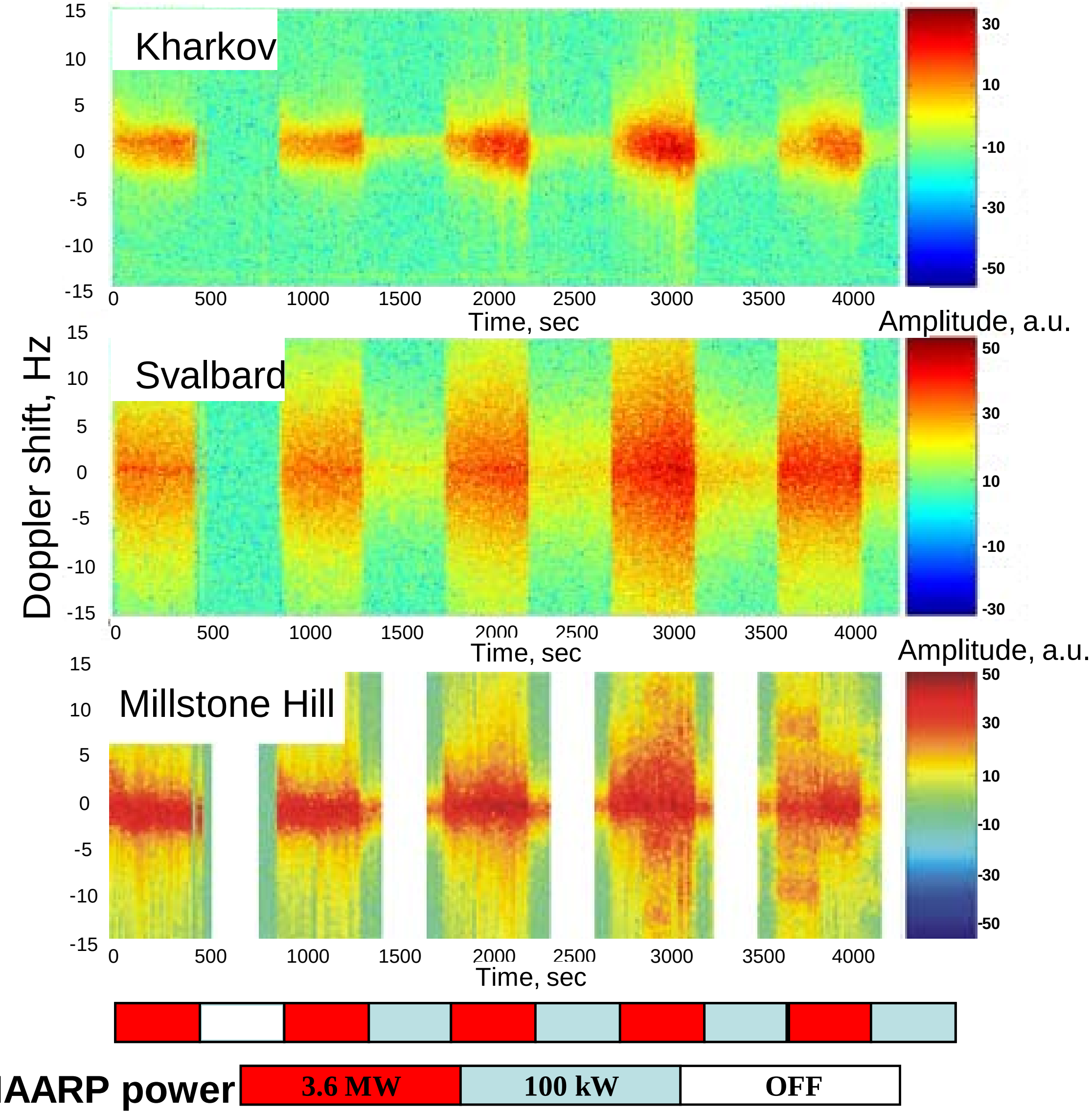
3300 kHz

HAARP signals recorded at remote Digisonde sites

February 26, 2008

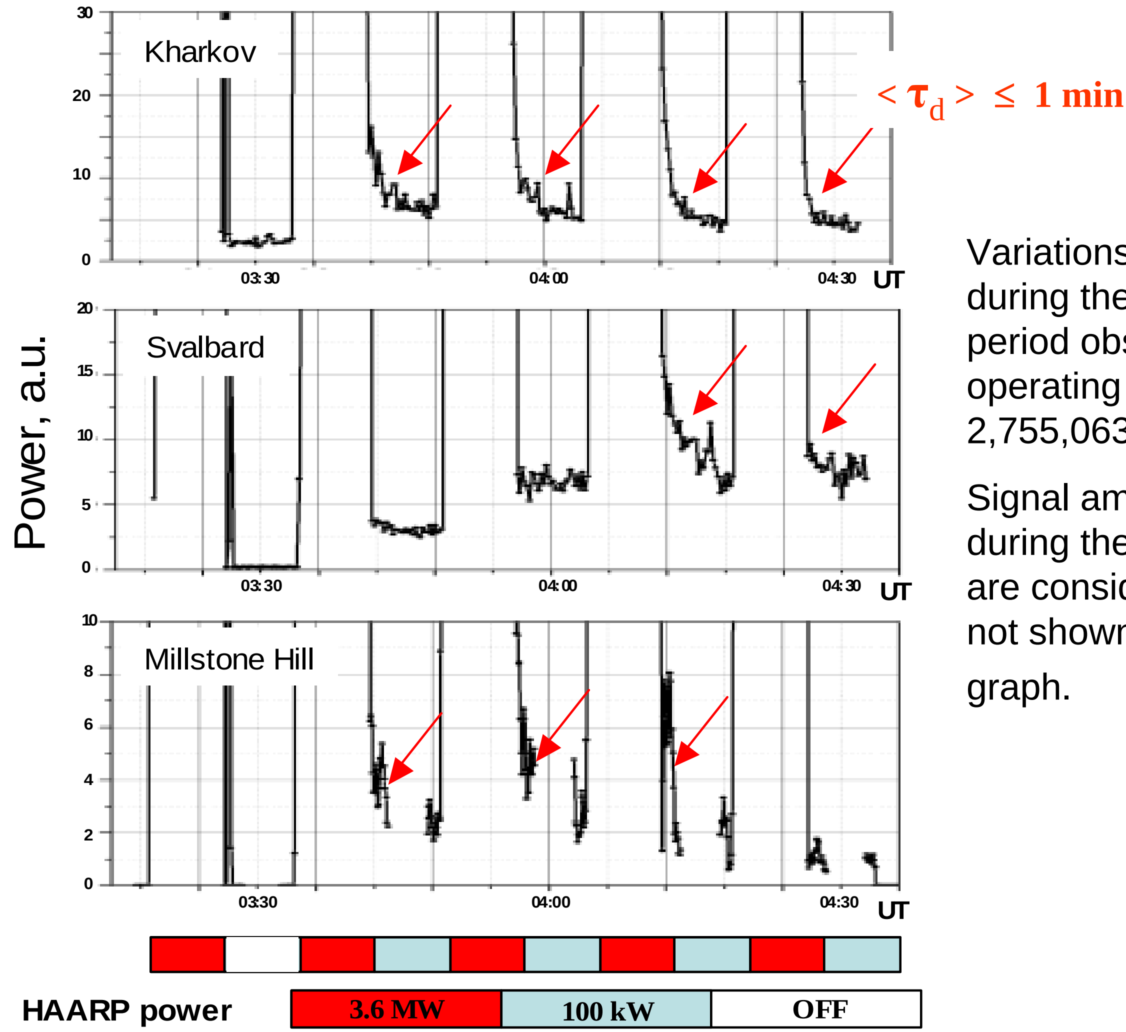


HAARP signal recorded at remote sites



Spectrograms of the HAARP transmission at 2,755,063 Hz recorded on February 26, 2008 at Kharkov, Svalbard, and Millstone Hill stations. Time is given in seconds starting from 033230 UT. Note that in the Millstone Hill data there were time gaps during the low power transmission periods made intentionally for the routine ionogram soundings performed every 15 min.

HAARP signal decay



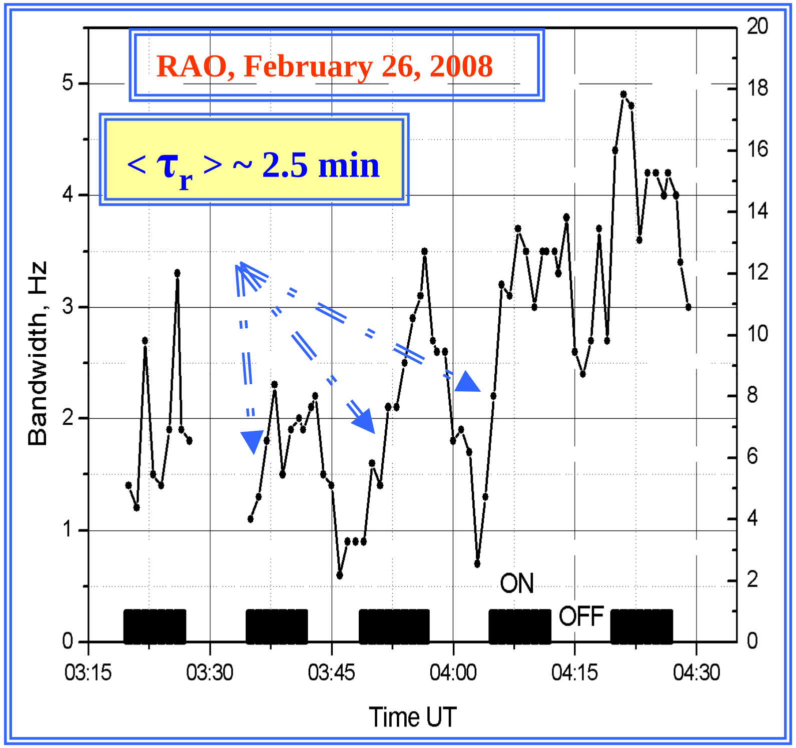
Variations in the signal strength during the OFF (low power) period observed at the operating frequency of 2,755,063 Hz.

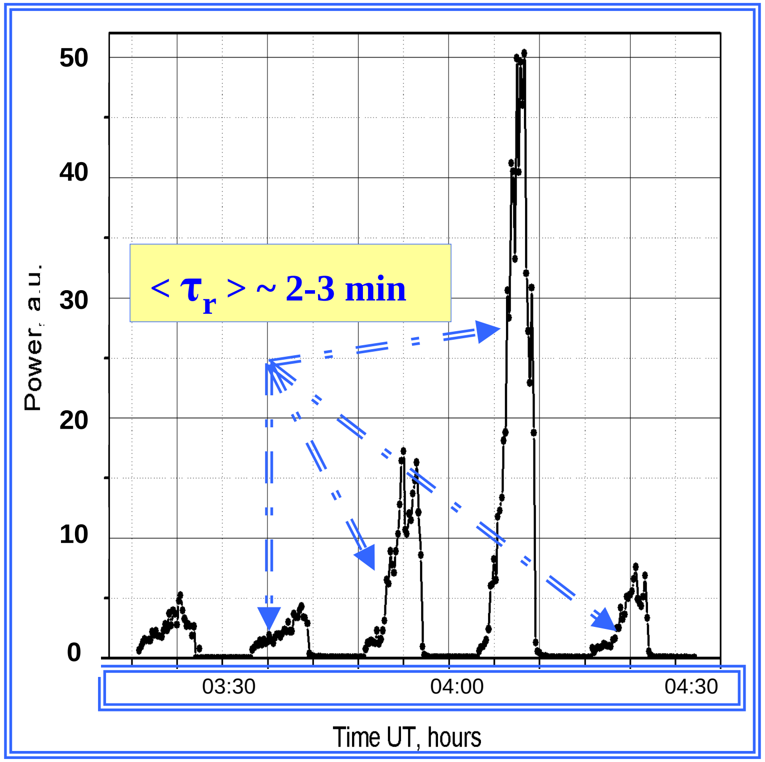
Signal amplitudes recorded during the full-power heating are considerably larger and are not shown to simplify the graph.

An average relaxation time (i.e., the time interval within which signal power decays by 1/*e*) from the observation at three stations **is about 1 minute**.

Such relaxation time constant is associated with the relaxation of small-scale irregularities with the **spatial sizes from a few to tens meters**

Rise of the spectral width and signal power



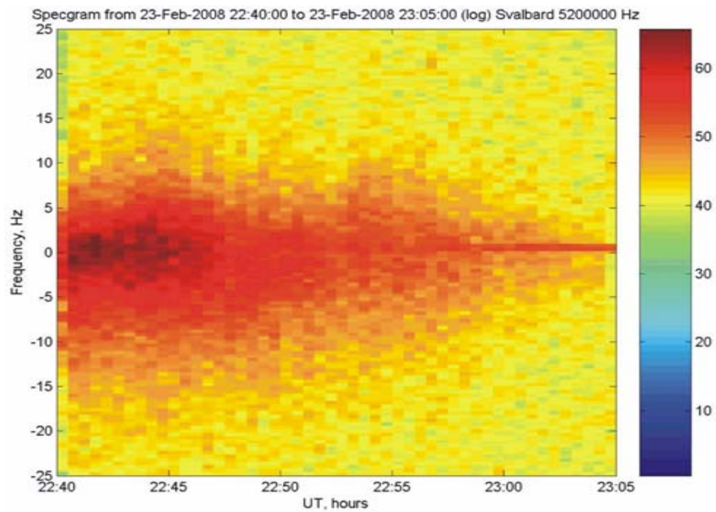


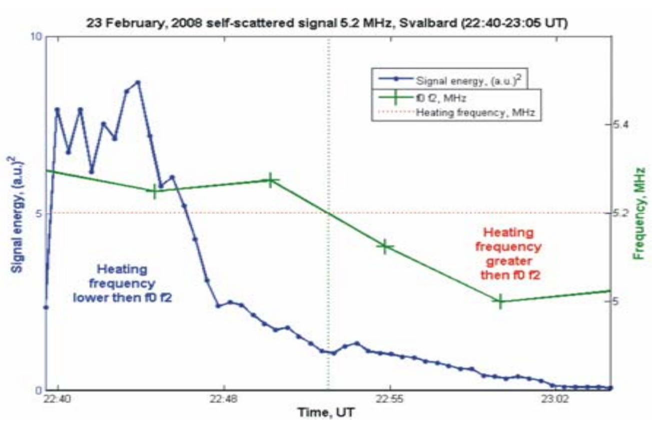
Variations in the spectrum width of the heating signal at a -6 dB-level, averaging interval - 1 minute.

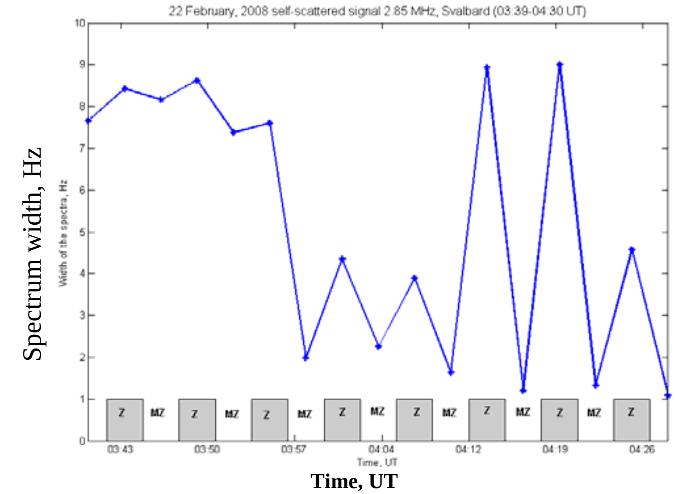
Variations of the signal power after the HAARP was switched to radiate the full power.

Observed time constant for the increase of the self-scattering signal (2-3 minutes) is associated with the large-scale ionospheric irregularities.

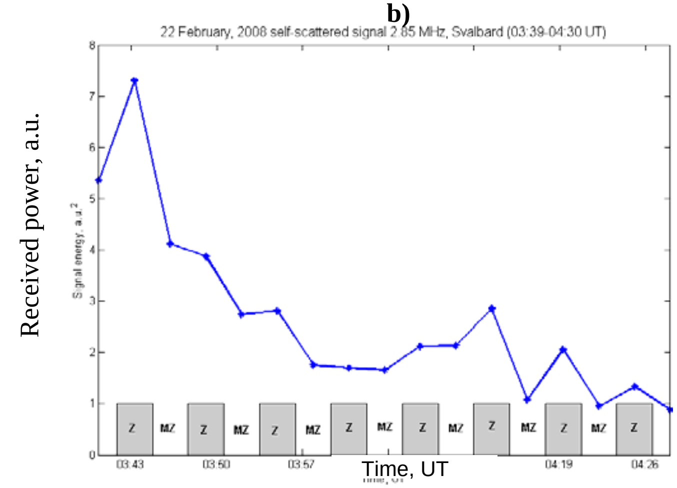
The effect of local ionospheric conditions and HAARP antenna orientation







b)



a)

Spectrogram of the heating signal at 5.2 MHz and variations of the received power in dependence on the f_0F2 magnitude (Svalbard position, February 23, 2008).

Received power (a) and spectrum width (b) of the scattered signal in dependence on the HAARP beam orientation.

Summary of February 2008 HAARP Campaign

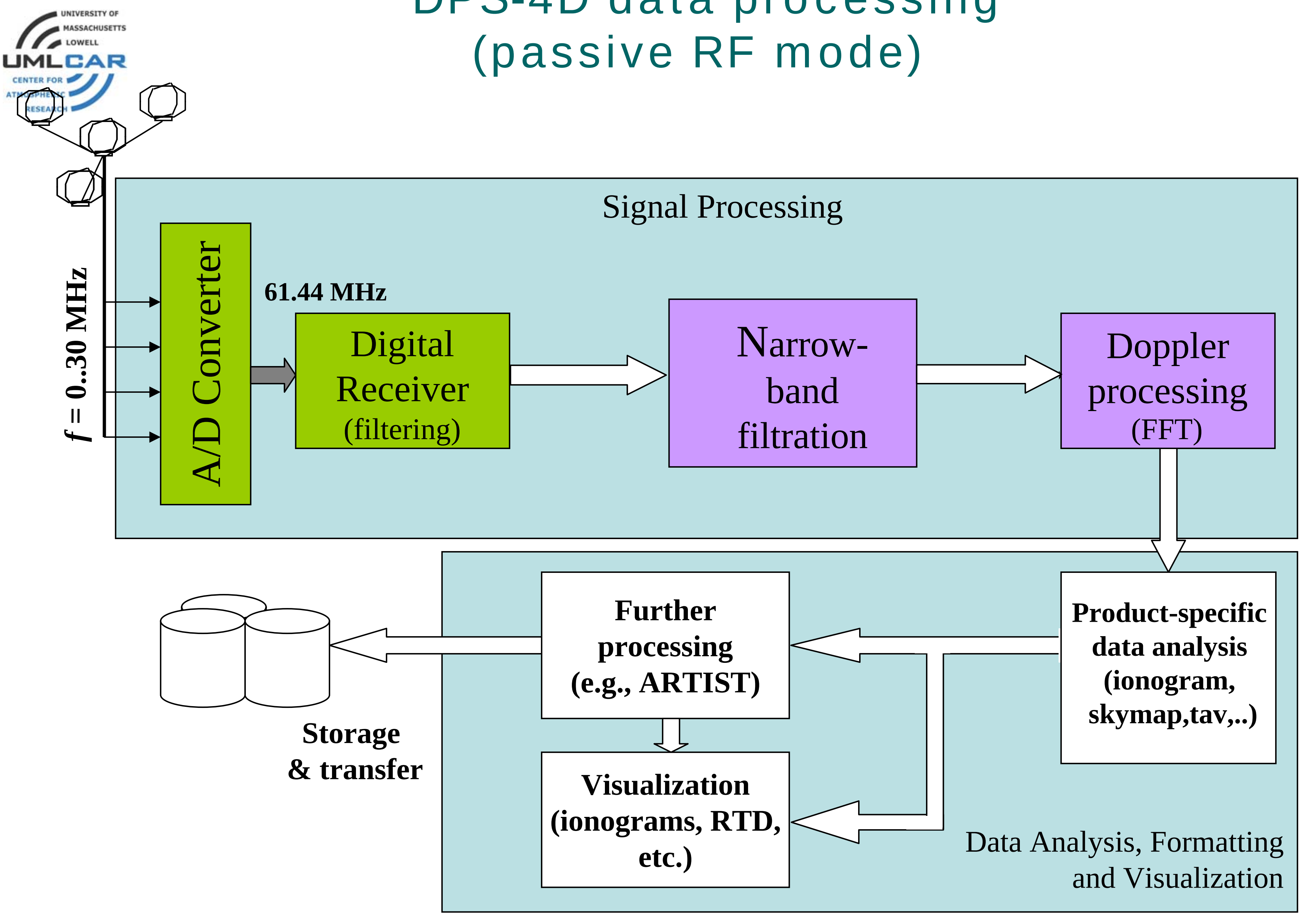
1. Multiposition observations of Doppler spectra of the HAARP emission have been performed for the first time. The measurements involved five Digisonde receive sites and two more sites located in Ukraine and Arctic (Island Svalbard).

2. During Winter 2008 Campaign the self-scattering effect was observed simultaneously at greatly dispersed receivers for several intervals of heating.

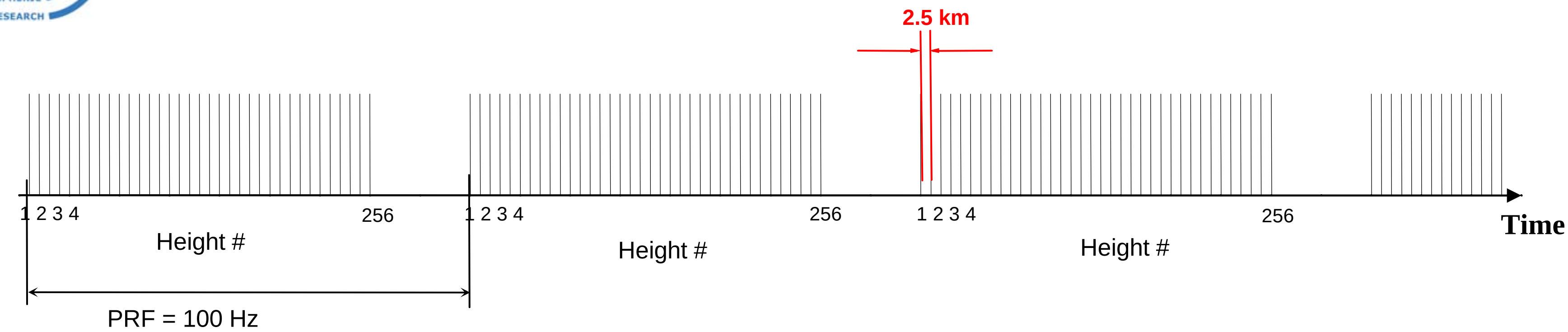
3. The relaxation and rise times of the HAARP-stimulated ionospheric inhomogeneities which are responsible for the self-scattering were determined. The relaxation time was smaller than 1 min, while the rise time reached a 2-3 minutes.

4. The signal spectra received at a greatly removed site were investigated in dependence on the local ionospheric conditions above the heater. The scattered power and Doppler spectrum width were analyzed in dependence on the HAARP beam orientation.

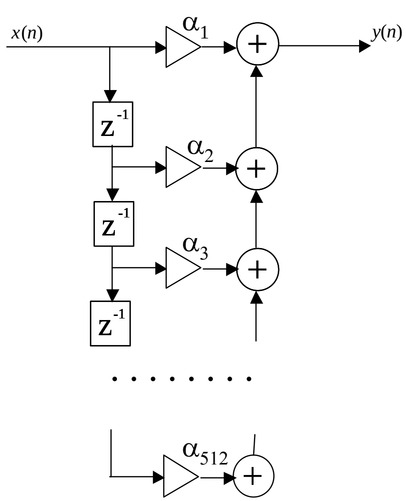
DPS-4D data processing (passive RF mode)



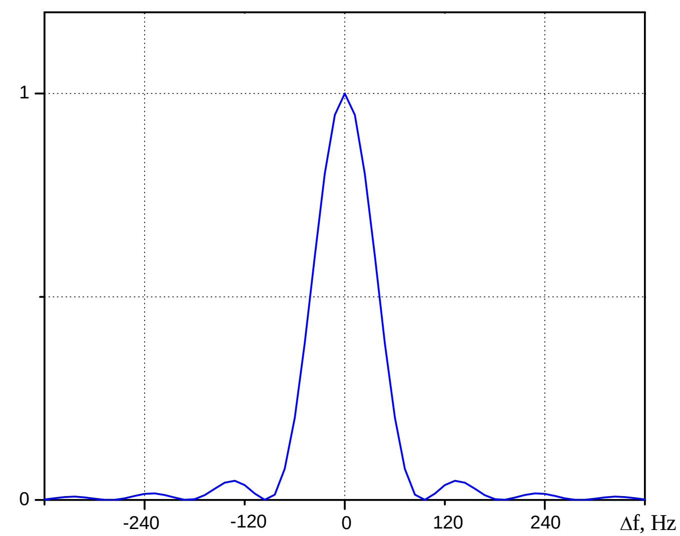
Digital filtering in DPS-4D



FIR filter

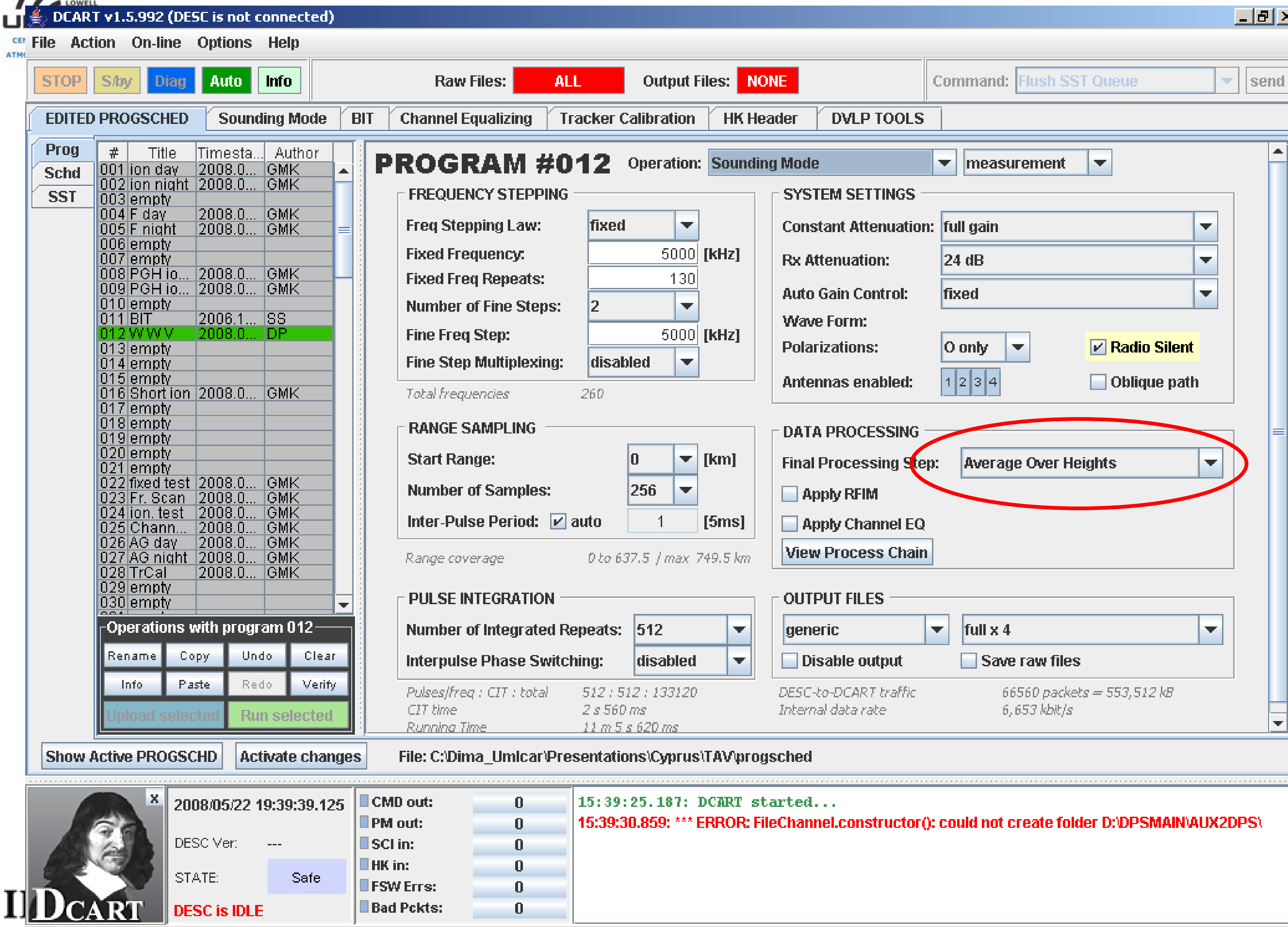


FIR filter frequency response



Design of DPS-4D narrow-band filter is equivalent to the realization of a finite impulse response (FIR) filter with decimation. For the number of taps equal to 256 (heights over which the averaging is performed) then the filter bandwidth is ±116 Hz at zero amplitude level.

DPS-4D program for passive RF reception



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HF ABSORPTION MEASUREMENTS USING ROUTINE DIGISONDE DATA

Gary S. Sales

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

OUTLINE

DIGISONDE CALIBRATION PROCESS

D-REGION PHYSICS

BOULDER DIGISONDE CALIBRATION

HF ABSORPTION

NON-ABSORPTION LOSSES
- FOCUSING GAIN
- F-LAYER REFLECTIVITY

SUMMARY

CALIBRATION PROCESS
Friis Formula for Received Power

$$P_R(f) = \frac{P_T G_T G_R(f)\,\lambda^2}{(4\pi)^2 h^2}\frac{1}{L(f)}$$

System calibration was carried out using only nighttime data. This was no D-region absorption and therefore *L(f) = 1*

Then solving for the Digisonde system parameters:

$$P_T G_T G_R(f) = \frac{(4\pi)^2 h^2}{\lambda^2} P_R$$

Where λ is known and the Digisonde measures P_R and *h* (true height).

CALIBRATION and LOSSES

Completing the system calibration allows us to then solve the Friis equation for the loss term using the sounder measurements

$$L(f) = \frac{\left[P_T G_T G_R(f)\right]\lambda^2}{(4\pi)^2 h^2 P_R(f)}$$

Where the loss term includes the following sources:

$$L(f) = L_{\text{absorption}}(f) + L_{\text{focusing}} + L_{\text{reflectivity}} \quad (dB)$$

OBJECTIVE

We are looking for D-region absorption which is a daytime phenomena. This absorption depends on the electron density and electron collision frequency along the ray path at altitudes between 60 and 90 km. If we can determine the absorption then we can gain some understanding of the production of electrons at these altitudes.

Under quiet conditions these D-region electrons are produced by UV and visible solar radiation during the daytime. X-ray flares enhance the density of electrons and produce large increases in HF radio wave absorption.

Digisonde sounding makes very sensitive absorption measurements because lower frequencies are used compared to the riometer (30 MHz). Absorption typically varies inversely with frequency. The actual exponent is to be determined.

BOULDER DIGISONDE CALIBRATION

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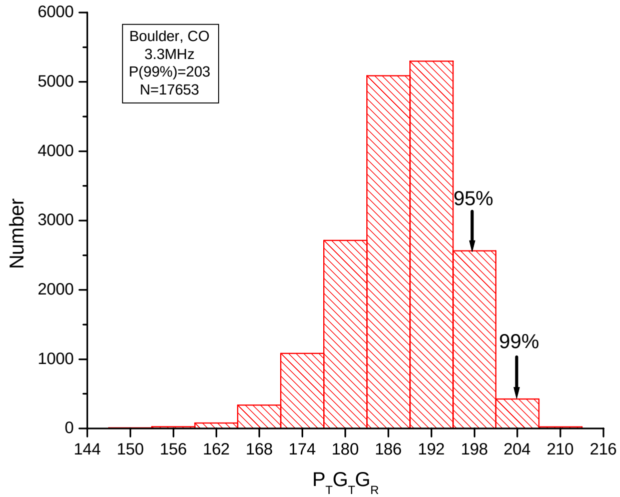
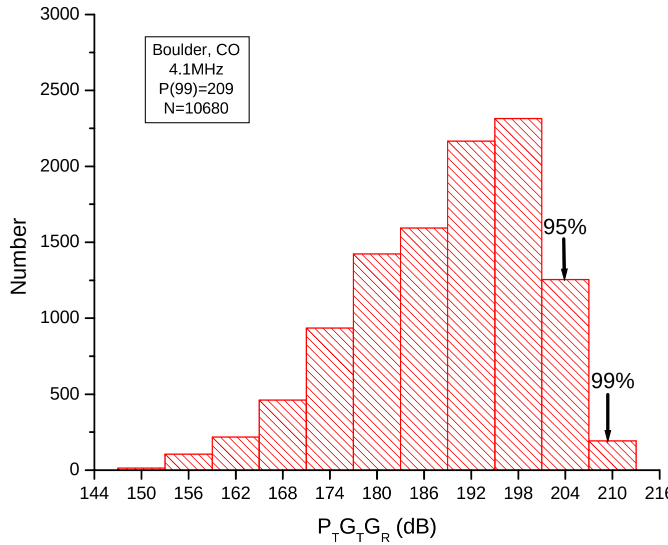
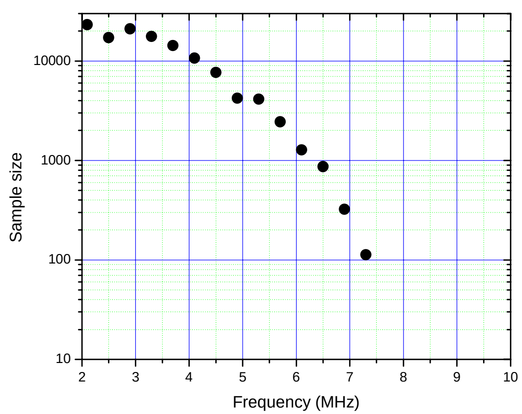
BOULDER DIGISONDE CALIBRATION







Nighttime data

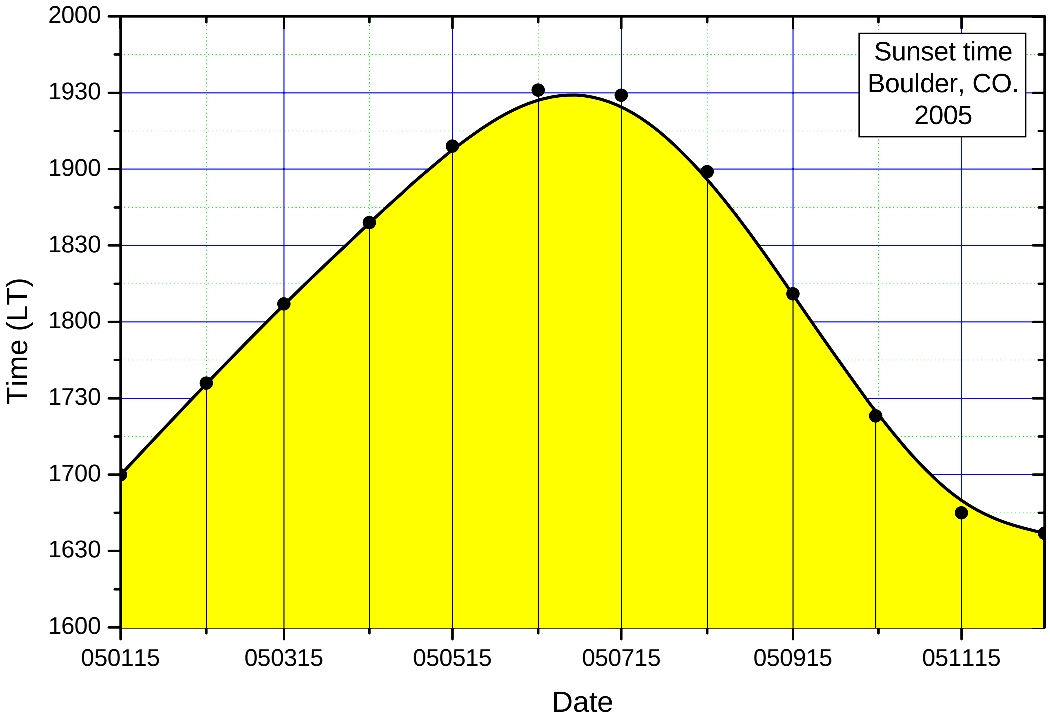
Frequency step = 400kHz (2.1MHz)

May, June July and Aug. 2005 (~120 days)

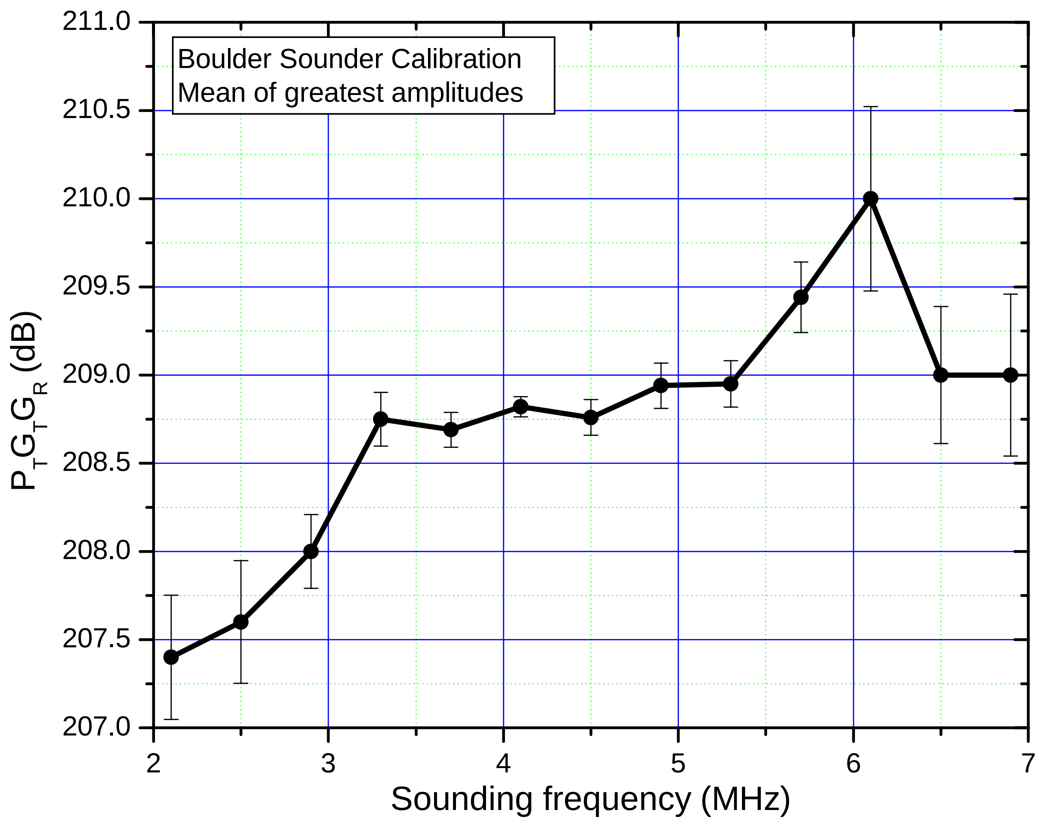
2000LT to 0500LT/ 15 min ionograms

9 frequencies/frequency (f ± 50,100,150 200kHz)

SUNSET TIMES, BOULDER, CO



BOULDER SOUNDER CALIBRATION
2.1MHz to 6.9MHz



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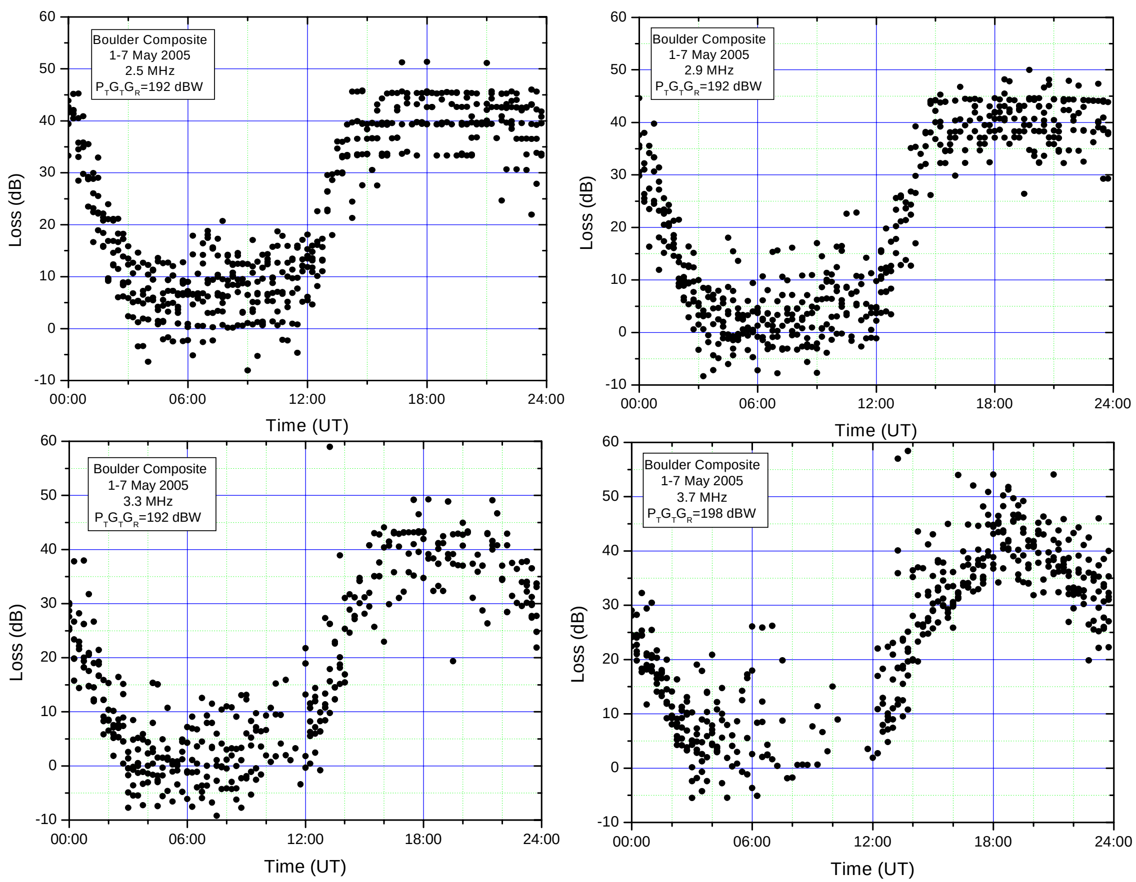
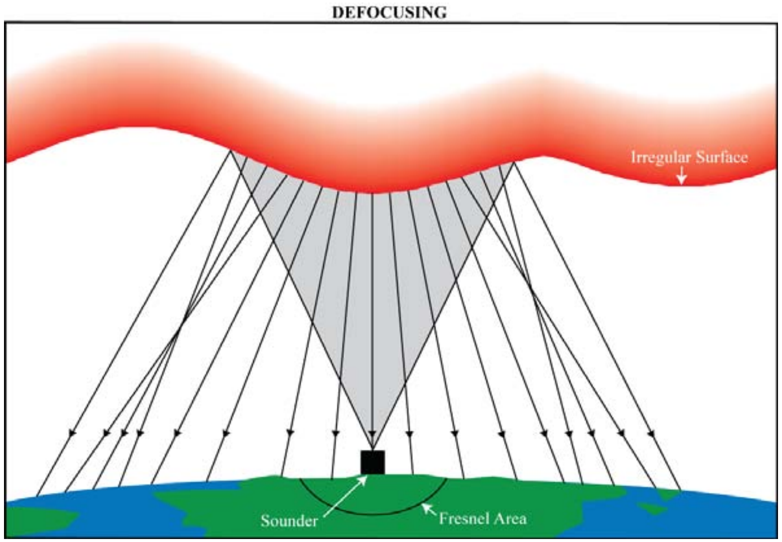
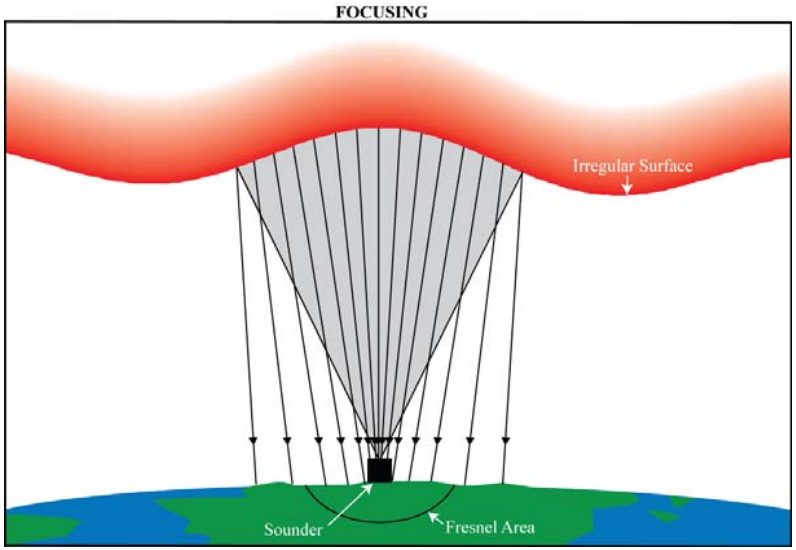
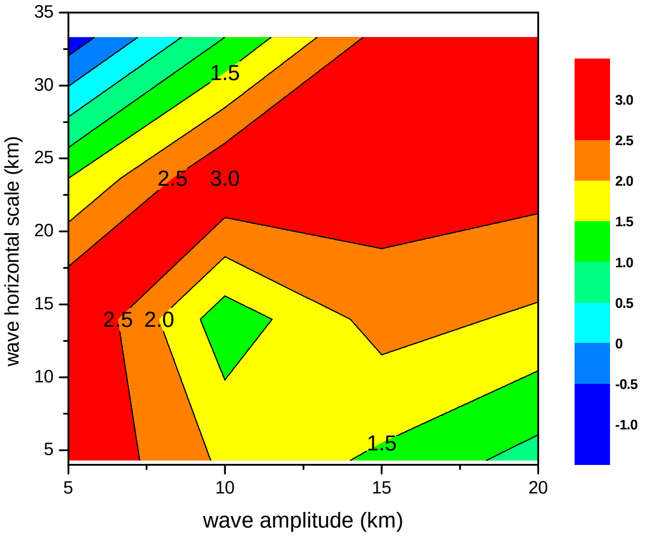
HF ABSORPTION (dB)
2.5, 2.9, 3.3 and 3.7MHz
1 – 7 May 2005



IONOSPHERIC FOCUSING GAIN







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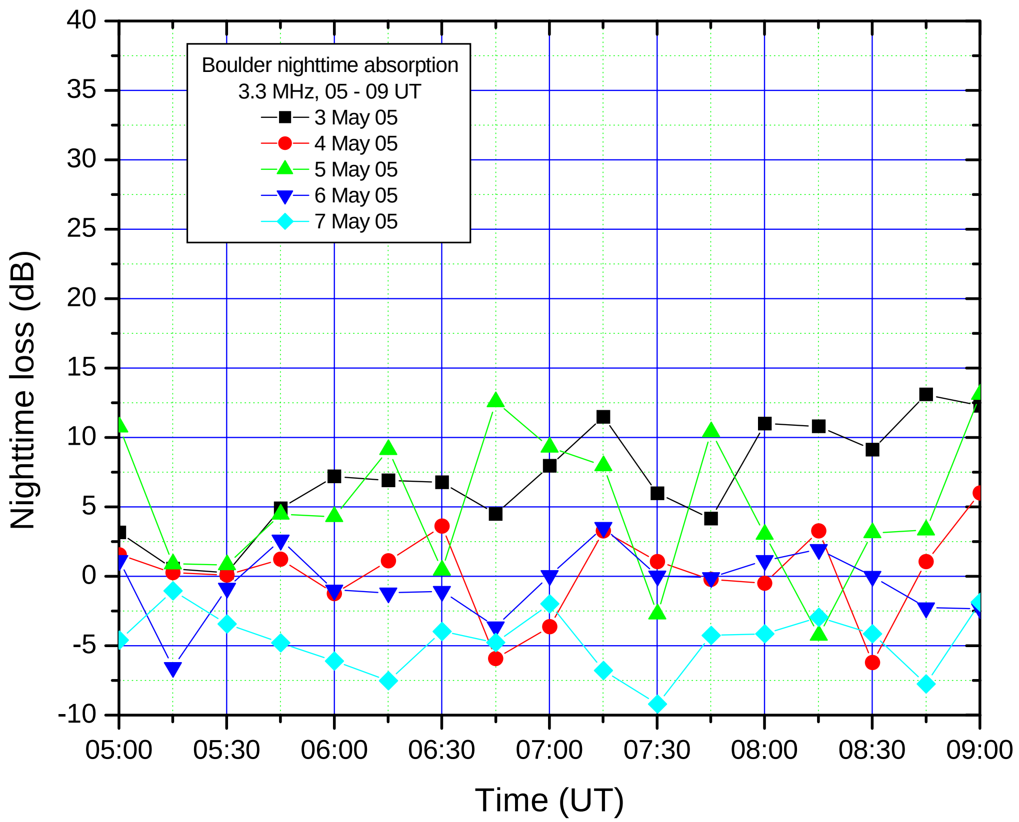
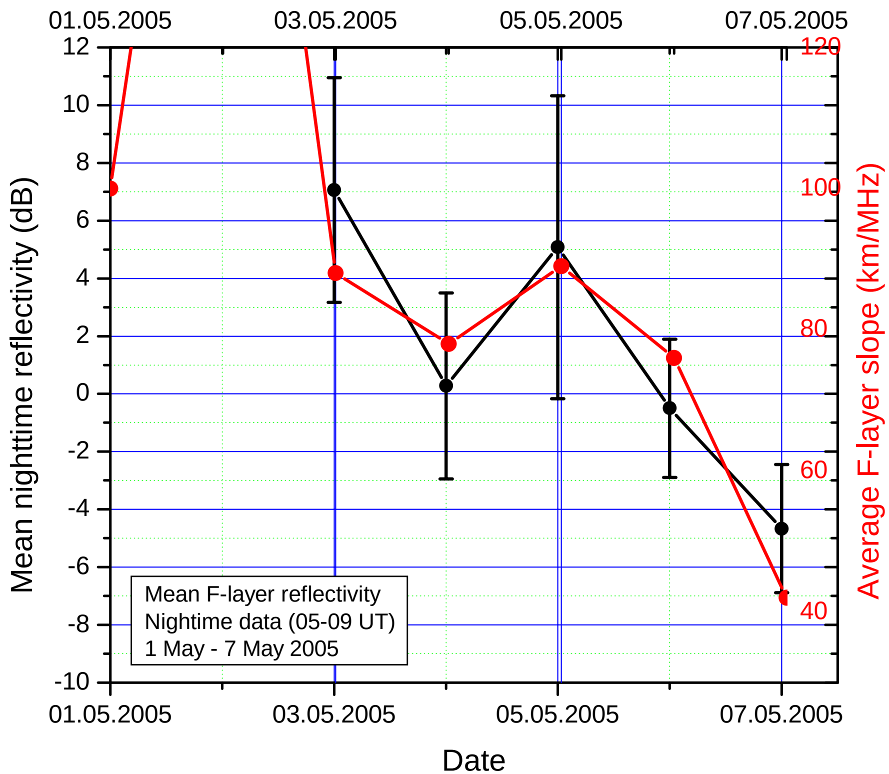
NIGHTTIME LOSS TRENDS



REFLECTIVITY LOSSES and EPSTEIN LAYER



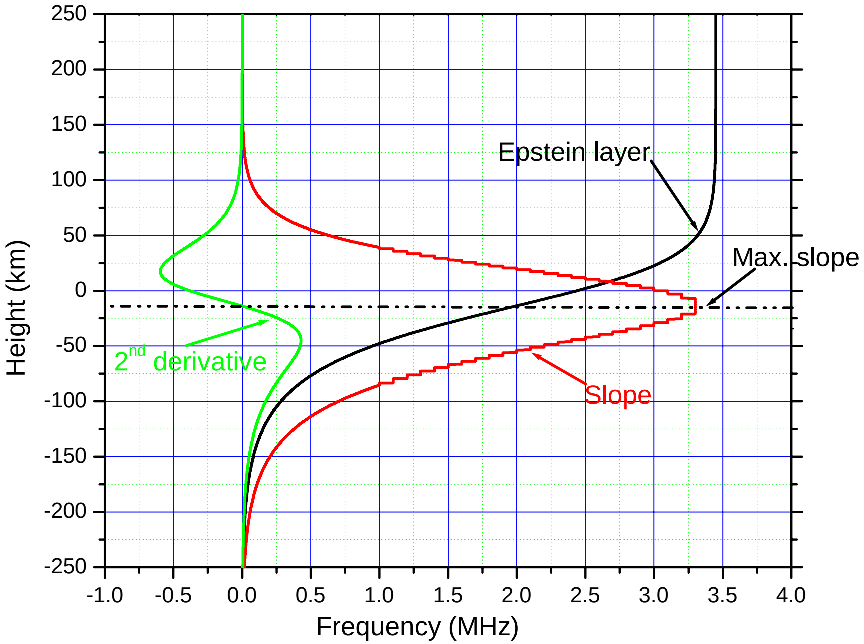
This plot compares the average nighttime loss with the average slope of the F-layer during the same night. The high degree of correlation suggested that the reflectivity of the F-layer was related to the shape of the F-region at the particular time.

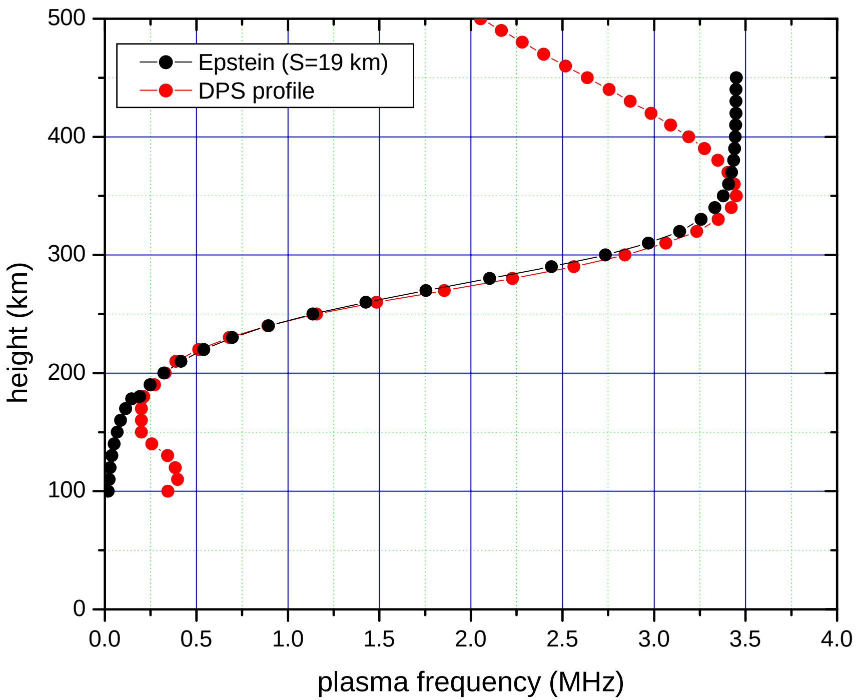
There is one F-layer model for which it is possible to calculate the reflectivity and that is the Epstein layer given as:

$$f_p(z) = foF\left[\frac{\exp\left(\frac{z-z_o}{S}\right)}{1+\exp\left(\frac{z-z_o}{S}\right)}\right]^{\frac{1}{2}}$$

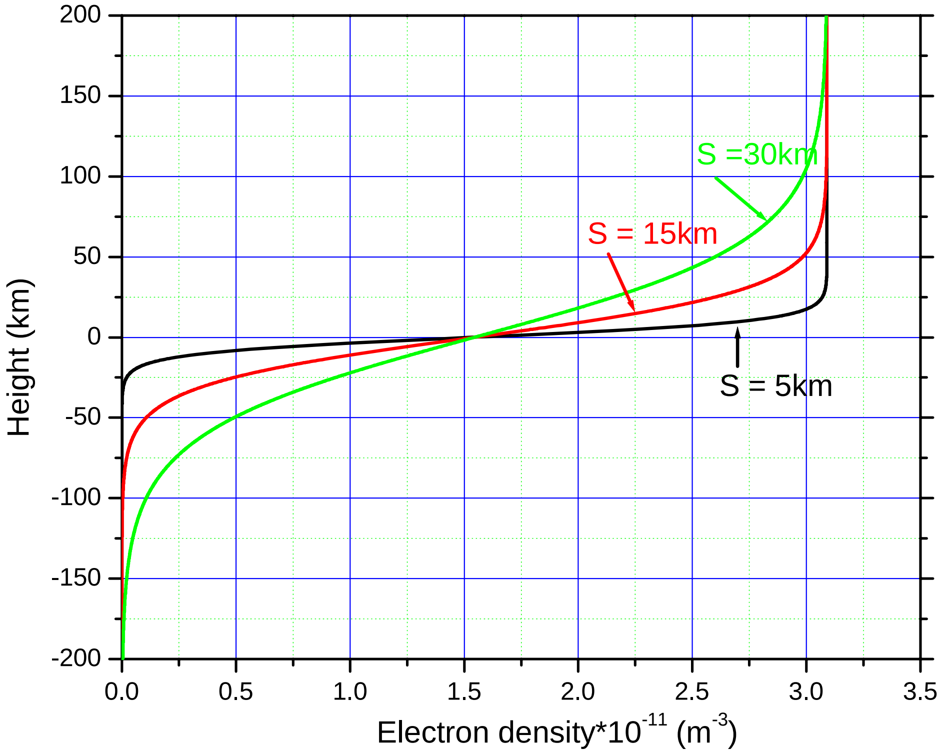
EPSTEIN LAYER

The Digisonde profile was used to determine the maximum slope and the height at which it occurred. These two parameters were used to determine the Epstein profile that best fit the measured true height profile.





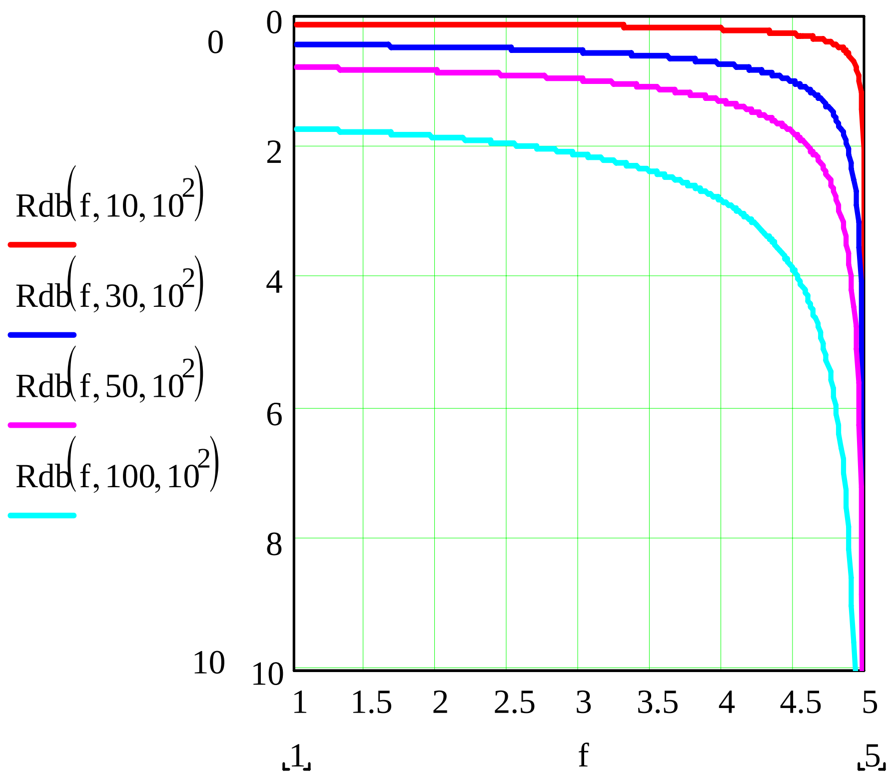
BUDDEN/RAWER REFLECTION COEFFICIENT



$$R(f,S,\nu)=10\left\{\log\left[\left|\frac{1-q(f,\nu)}{1+q(f,\nu)}\right|\right]+\left|\log\left[\Gamma_1(f,S,\nu)\right]\right|-\left|\log\left[\Gamma_2(f,S,\nu)\right]\right|\right\}\ (dB)$$

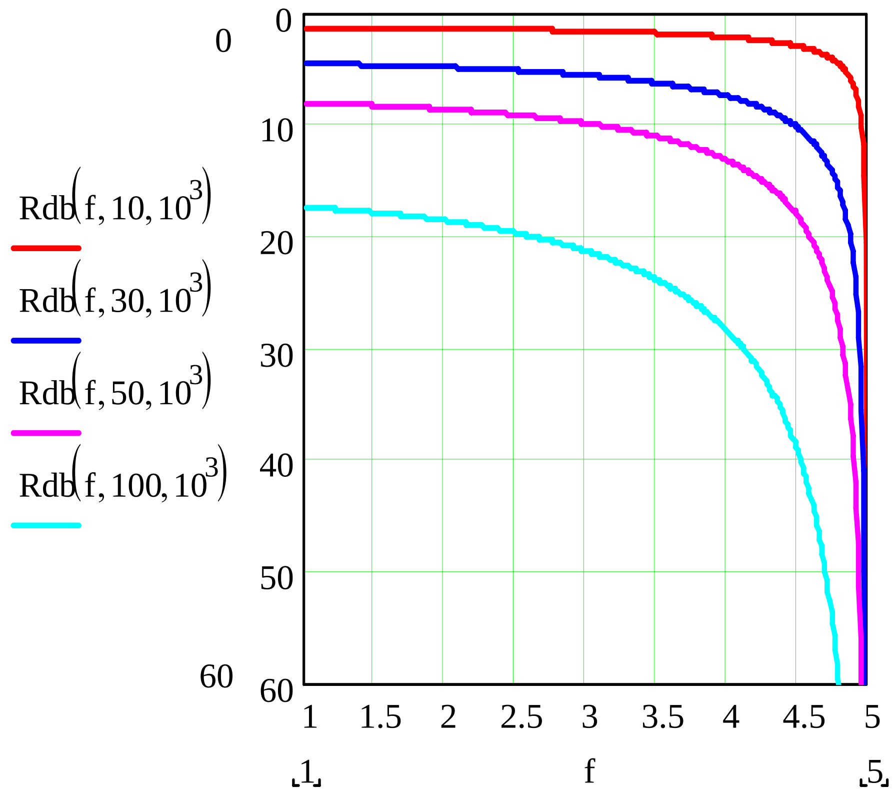
BUDDEN/RAWER REFLECTION COEFFICIENT FOR THE EPSTEIN LAYER

Low collisions



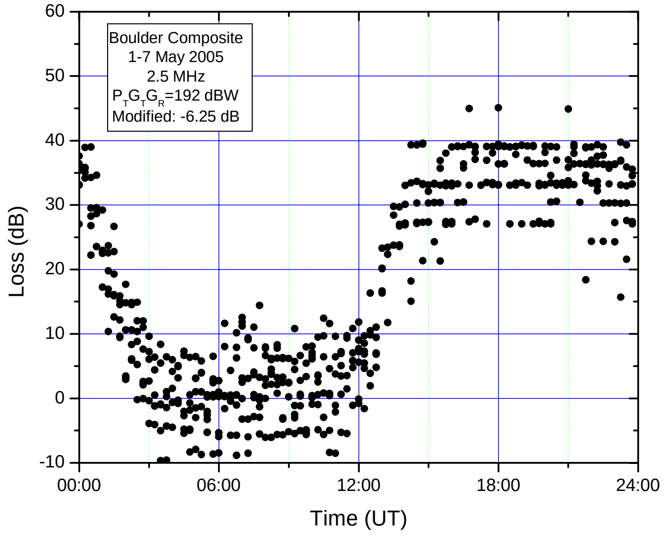
$\nu_{en} = 100\ s^{-1}$

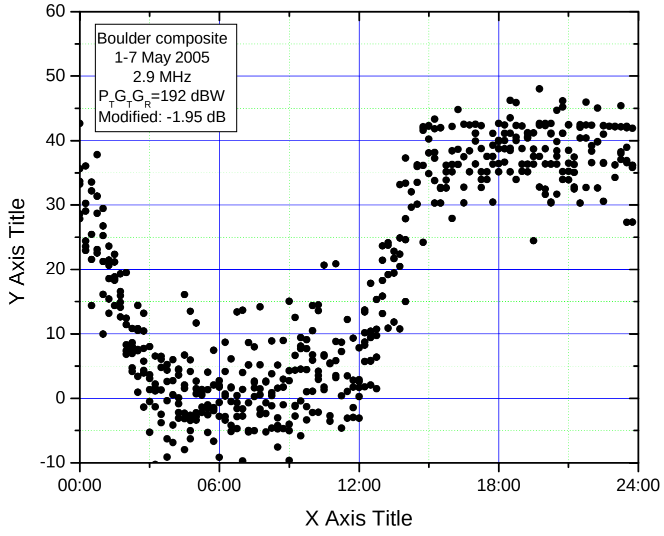
Higher collisions



$\nu_{en} = 1000\ s^{-1}$

REFLECTIVITY CORRECTED ABSORPTION





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SUMMARY

- WE NOW HAVE A METHOD USING THE DIGISONDE TO MEASURE THE DAILY D-REGION ABSORPTION OVER A FREQUENCY RANGE FROM 2MHz TO 7MHz

- THIS ANALYSIS CAN BE USED TO INVESTIGATE THE DAILY VARIATIONS IN D-REGION ABSORPTION AS IT RELATES TO SOLAR ACTIVITY IN TERMS OF X-RAY FLUX.

- THESE ABSORPTION DATA CAN BE USED TO PREDICT LOSSES ON HF RADIOWAVE COMMUNICATION PATHS IN THE VICINITY OF THE SOUNDER.

SUMMARY

- **THESE DATA CAN BE USED TO DETERMINE THE D-REGION ELECTRON DENSITY PROFILE BY INVERTING THE ABSORPTION INTEGRAL. THIS ASSUMES WE KNOW THE COLLISION FREQUENCY PROFILE.**

$$K(f) = \int_{z_1}^{z_2} N(z) \frac{\nu(z)}{(\omega \pm \omega_L)^2 + \nu^2(z)} dz$$

Where *K(f)* is the measured absorption as a function of frequency. This a Fredholm integral equation of the first kind that can be inverted (solved for *N(z)* using the quadrature method. In matrix form, this can written as:

$$\bar{K}(f) = \bar{M}(f,z)\Box\bar{N}(z) \quad or \quad \bar{N}(z) = \bar{M}^{-1}(f,z)\Box\bar{K}(f)$$

This is a work in progress

A proposed assimilative IRI with DIDBase data

Xueqin Huang

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII International Digisonde Forum
11 - 14 May 2009

Introduction

- The IRI model describes the average status of the ionosphere for any given location and time. The current IRI algorithm cannot follow the variation of the ionosphere and the accuracy is not good enough for many applications.
- Now the Global Ionospheric Radio Observatory ‘GIRO’ provides the data in/near real time. The measurements can be used to adjust the model so as to give a description of the ionosphere status at its time variation for a region and/or the whole globe.
- For a single station we have successfully adjusted
- the IRI parameters to match the measured data. The adjusted IRI can well give the density distribution in a small area around the station. The problem is how to adjust the parameters at a place where there is no sounding data.
- The peak characteristics of the F2 layer are most important for the modeling, and this presentation focuses on the mapping of these characteristics assimilating the measured values into the IRI model.

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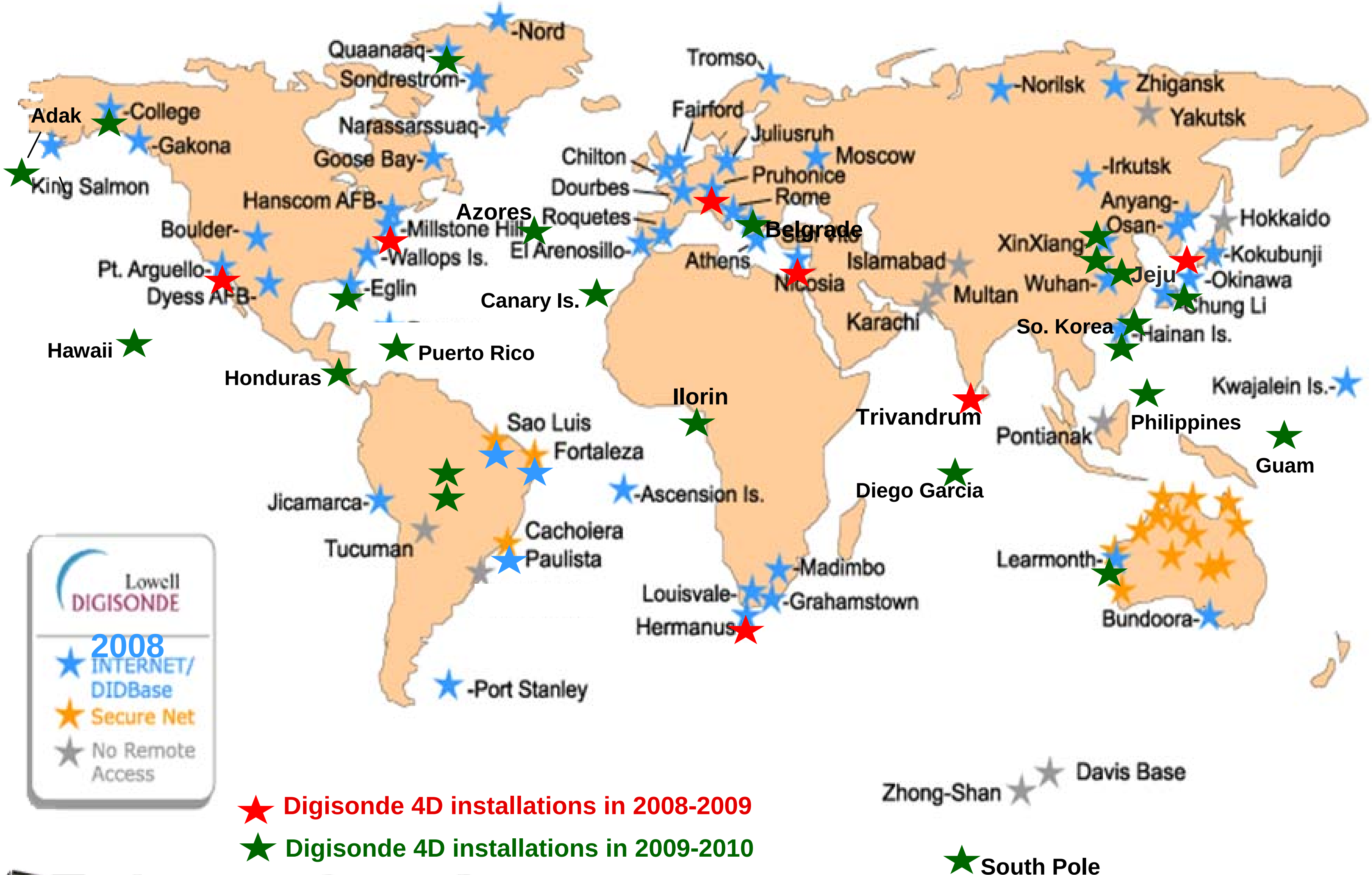
Digisonde **GIRO**

Global **I**onospheric **R**adio **O**bservatory



Comments on Interpolation and Correlation

- One can be adjust the coefficient so as to make the calculated values match the observations. The adjustments are changing from one station to another and the problem is how to determine an adjustment for a place where there is no observed data.
- We have tried to use interpolation and correlation methods to determine the adjustments. The advantages of the methods are simple. However, some “holes” and “peaks” can be seen in the mapping result. These “holes” and “peaks” should be understood as irregularities, but their sudden appearances and disappearances suggest that they are not real but created by the methods.

Overview of the Numerical Mapping of foF2/hmF2 in the current IRI

- $P = foF2$ or $hmF2$ is a function of longitude ($\varphi \in (0^0, 360^0)$), latitude ($\lambda \in (-90^0, 90^0)$), and universal time t.

  It is expanded into a Fourier series in time angle $T = 15t - 180$ (degrees)

$$P(\lambda,\varphi,t) = P_0(\lambda,\varphi) + \sum_{i=1}^{I_t} P_{ci}(\lambda,\varphi)\cos iT + P_{si}(\lambda,\varphi)\sin iT$$

where $P_0(\lambda,\varphi)$, $P_{ci}(\lambda,\varphi)$ and $P_{si}(\lambda,\varphi)$ can well be described by

$$\begin{cases} P_{ci}(\lambda,\varphi) = \sum_{k=0}^{K} C_{2i,k} G(\lambda,k)\cos k\varphi \\ P_{si}(\lambda,\varphi) = \sum_{k=0}^{K} C_{2i-1,k} G(\lambda,k)\cos k\varphi \end{cases}, \qquad i = 1,2,\ldots I_t$$

The function $G(\lambda,k)$ is given according to the morphological study of the ionosphere characteristics and the coefficients, C, with total elements of 1000 with $I_t = 6$ are given by CCIR/URSI.

Calculation of CCIR/URSI coefficients

- Data source: Median values of ground-based ionosonde data collected in Data Centers,
  A few data from various other radio techniques.
- Method: Least sqares fitting with constraints. Because of lack of data over the oceans, some constrains are established for fitting.
- Regression for smoothed sunspot number to reduce to two sets of coefficients for $SSN = 0$ and $SSN = 100$.
- Accuracy:

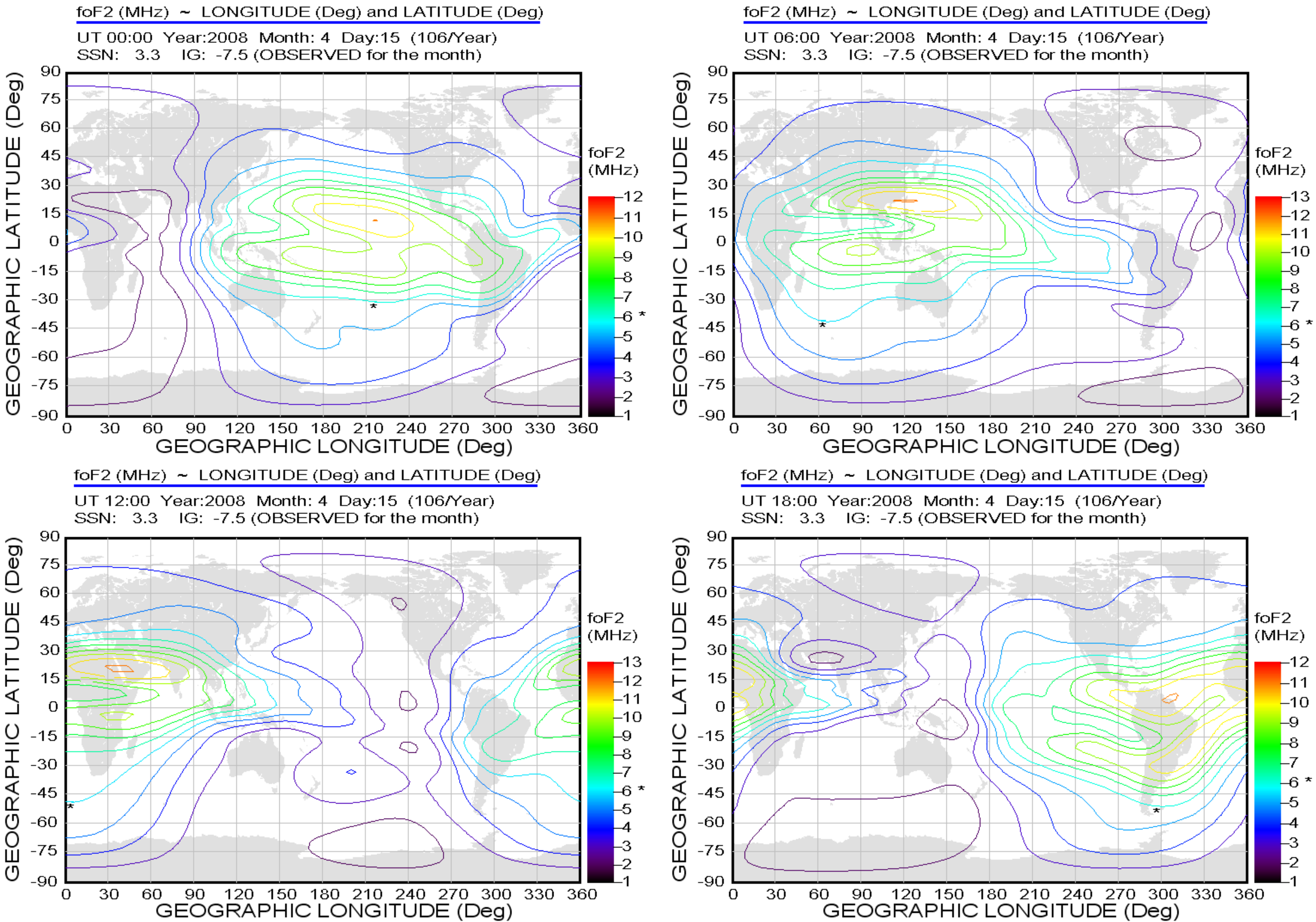
  -- Median values used.

  --Truncation of expansion (in IRI, $I_t = 6$).

  -- It does give a good description of the diurnal variation of the ionosphere, but short term and short range scale variations are filtered out.

  -- Accuracy $\leq 10\%\sim20\%$ or 0.5~3 MHz for foF2

Examples of Numerical Mapping foF2 in IRI



Concept of Proposed RT Mapping

- The current IRI mapping is based on harmonic analysis

$$P(\lambda,\varphi,t) = P_0(\lambda,\varphi) + \sum_{i=1}^{I_t} P_{ci}(\lambda,\varphi)\cos iT + P_{si}(\lambda,\varphi)\sin iT$$

$$\begin{cases} P_{ci}(\lambda,\varphi) = \sum_{k=0}^{K} C_{2i,k} G(\lambda,k)\cos k\varphi \\ P_{si}(\lambda,\varphi) = \sum_{k=0}^{K} C_{2i-1,k} G(\lambda,k)\cos k\varphi \end{cases}, \qquad i = 1, 2, \ldots I_t$$

- The amplitudes of the time harmonics are determined by the historical observations at all stations of the network. If one could recreate the coefficients one certainly could make the calculated values match the observations. Hwever, this is not realistic.
- Instead, one can modify the existing oefficients so as to best fit the observations at all stations and give a good estimation for any place where there are no sounding data.
- The produced maps can be expected to show the occurrance and development of the irregularities in space and their movements with time.

Outline of the Proposed Mapping foF2/hmF2 in Real Time

- The peak characteristics, foF2 or hmF2, can be separated into two parts: the average part and the variation part. The average part is calculated by the current IRI algorithm. The variation part is the difference between the measured and modeled values.

  As the average part is an approximation of the median, the variation part represents the day-to-day variation.
- For each of the sounding sites the variation part is calculated by the adjusted coefficients which best fit to the measured variation part. This is done for 24 hour data set.
- By finding the relationship of the adjustments at various stations, the variation part at any location can be determined.

Proposed Real Time Mapping

- Measured data : 24 hour time sequence of $P = foF2$ or $hmF2$ from the sounding station network over a region or the globe.

  $$P(\lambda_n, \varphi_n, t_m), \quad n = 1,2,\ldots N, \quad m = 1,2,\ldots M \quad (t_M < t,\ t_{M+1} \geq t)$$

- Proposed algorithm :

-- Step 1 : Separate the measured value into two parts, the average part and the variation part :

$$P(\lambda_n, \varphi_n, t_m) = \bar{P}(\lambda_n, \varphi_n, t_m) + \Delta P(\lambda_n, \varphi_n, t_m)$$

The average part, $\bar{P}(\lambda_n, \varphi_n, t_m)$, is the value calculated with the current IRI.

-- Step 2 : The variation part is expanded into harmonics in time angle T :

$$\Delta P(\lambda_n, \varphi_n, t) = \Delta P_0(\lambda_n, \varphi_n) + \sum_{i=1}^{I_t} \Delta P_{ci}(\lambda_n, \varphi_n) \cos iT + \Delta P_{si}(\lambda_n, \varphi_n) \sin iT$$

The harmonic amplitudes $\Delta P_0(\lambda_n, \varphi_n)$, $\Delta P_{ci}(\lambda_n, \varphi_n)$, and $\Delta P_{si}(\lambda_n, \varphi_n)$ are calculated by fitting method.

Proposed Real Time Mapping

-- Step 3: For each station calculate $\delta_0(\lambda_n)$, $\delta_{ci}(\lambda_n)$ and $\delta_{si}(\lambda_n)$ from

$$\begin{cases} \Delta P_0(\lambda_n,\varphi_n)=\delta_0(\lambda_n)\,\bar{P}_0(\lambda_n,\varphi_n) \\ \Delta P_{ci}(\lambda_n,\varphi_n)=\delta_{ci}(\lambda_n)\sum_{k=0}^{K} C_{2i,k}G(\lambda_n,k)\cos k\varphi_n \\ \Delta P_{si}(\lambda_n,\varphi_n)=\delta_{si}(\lambda_n)\sum_{k=0}^{K} C_{2i-1,k}G(\lambda_n,k)\cos k\varphi_n \end{cases}$$

It is done for all stations then we have

$\delta_0(\lambda_1)$, $\delta_{ci}(\lambda_1)$ and $\delta_{si}(\lambda_1)$ for Station 1,

$\delta_0(\lambda_2)$, $\delta_{ci}(\lambda_2)$ and $\delta_{si}(\lambda_2)$ for Station 2,

......

$\delta_0(\lambda_N)$, $\delta_{ci}(\lambda_N)$ and $\delta_{si}(\lambda_N)$ for Station N.

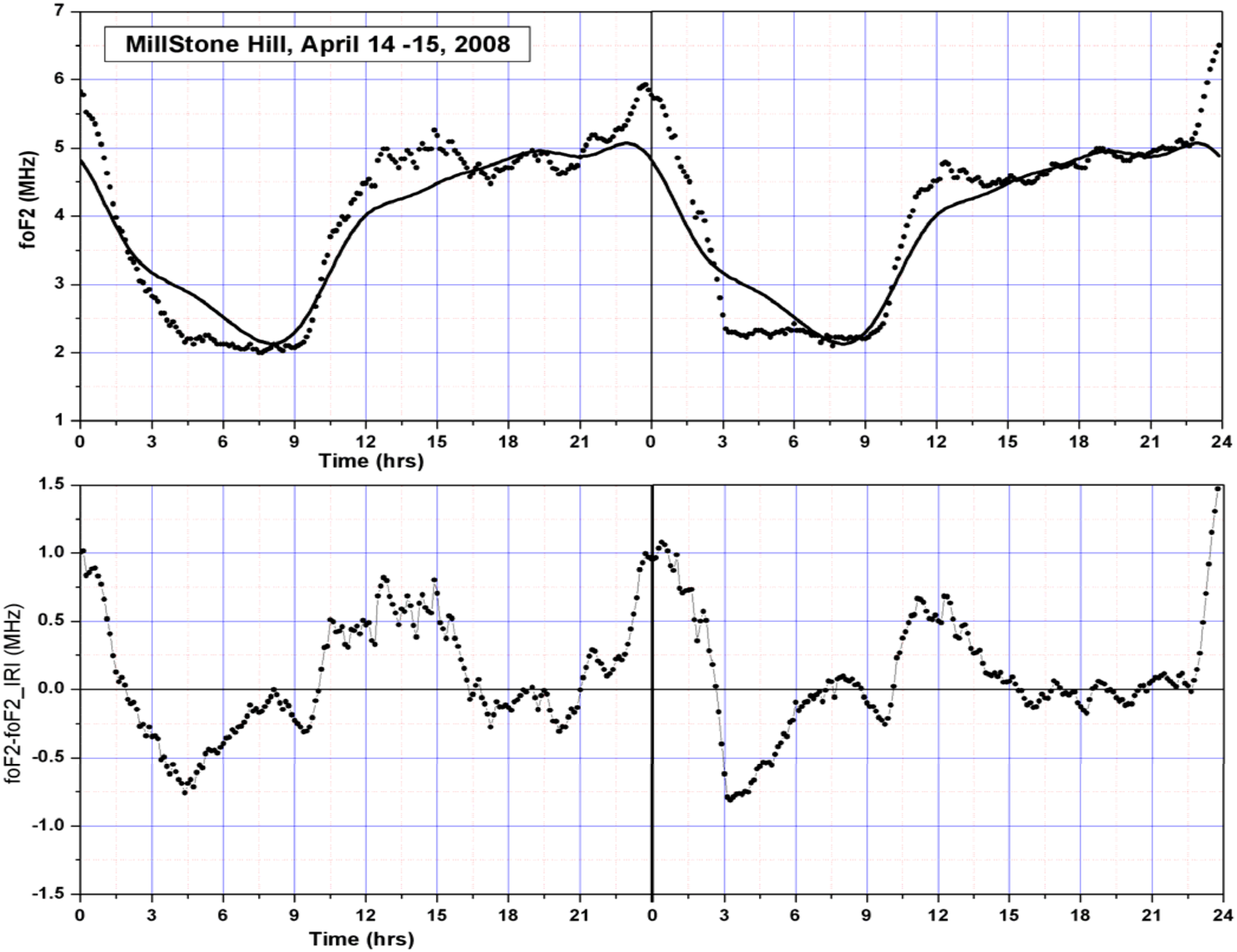
Try to find the functions $\delta_0(\lambda)$, $\delta_{ci}(\lambda)$ and $\delta_{si}(\lambda)$ which best fit to the above tabulated values.

Proposed Real Time Mapping

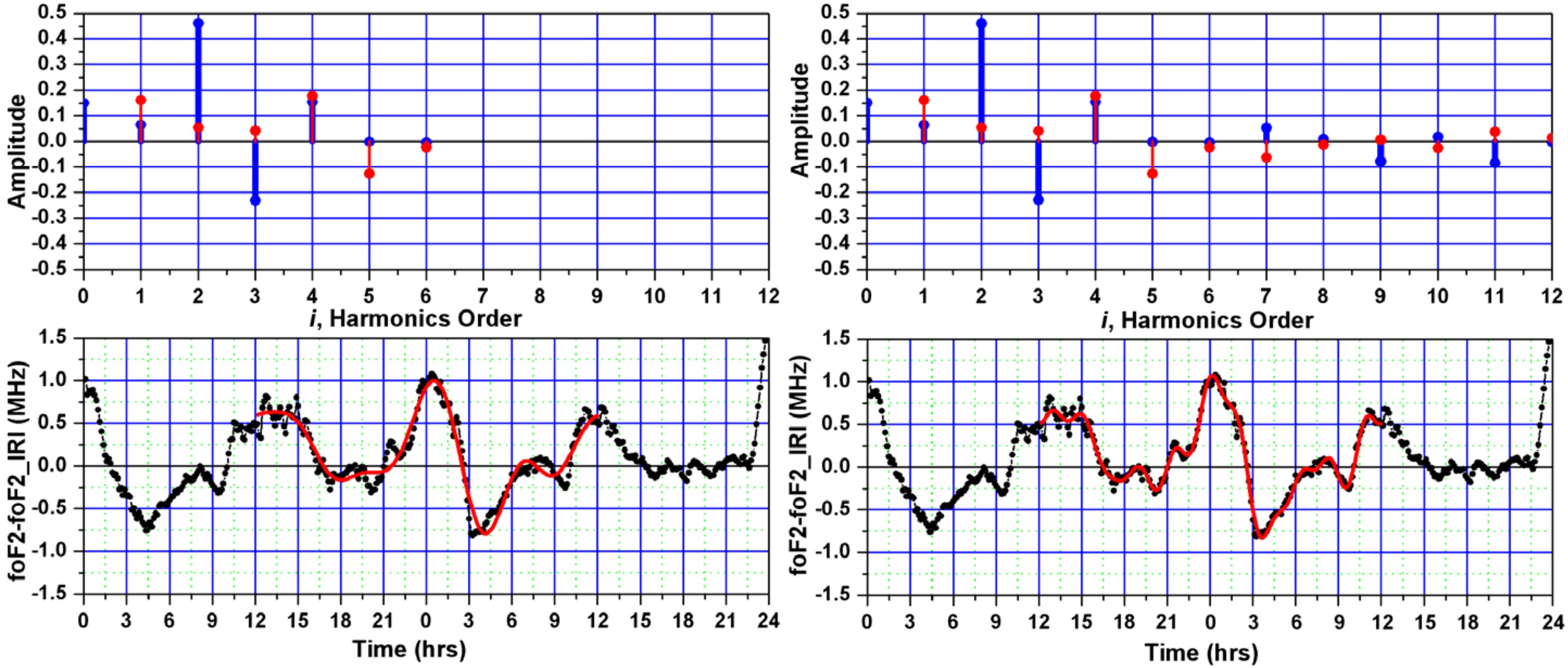
-- Step 4: For any given location (λ,φ) at the time t, the value $P(\lambda,\varphi,t)$ is calculated with

$$
\begin{cases}
P(\lambda,\varphi,t) = \bar{P}(\lambda,\varphi,t) + \Delta P(\lambda,\varphi,t) \\
\Delta P(\lambda,\varphi,t) = \Delta P_0(\lambda,\varphi) + \sum_{i=1}^{I_t} \Delta P_{ci}(\lambda,\varphi)\cos iT + \Delta P_{si}(\lambda,\varphi)\sin iT \\
\Delta P_0(\lambda,\varphi) = \delta_0(\lambda)\,\bar{P}_0(\lambda,\varphi) \\
\Delta P_{ci}(\lambda,\varphi) = \delta_{ci}(\lambda)\sum_{k=0}^{K} C_{2i,k}G(\lambda,k)\cos k\varphi \\
P_{si}(\lambda,\varphi) = \delta_{si}(\lambda)\sum_{k=0}^{K} C_{2i-1,k}G(\lambda,k)\cos k\varphi
\end{cases}
$$

Processing for One Station



Processing for One Station



Processing in ARTIST

- The truncation $(I_t = 6)$ is used in the given example and so it cannot recover the variation smaller than 4 hours.
  Do we have coefficients with more terms?
- The processing can be done in ARTIST at the sounding site to provide the data of all harmonic amplitudes.

Future Work

- We have not complete this study. The future work includes:
  1. To find the best functional forms for fitting foF2/hmF2.
  2. To overcome difficulties to process the F1 layer.
  3. Figure out the method to adjust other IRI parameters.

Conclusion Remarks

- A real time assimilation of ionogram data, foF2/hmF2, from the digisonde network is proposed.
- This proposed method is expected to give a good description of the peak parameters of the F2 layer for any place in/near real time.

Thank you!

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Major magnetic storms as seen by GIRO

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Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

Objective

- Use data from GIRO to determine the electron density **and height** variations in the F layer during ionospheric storms

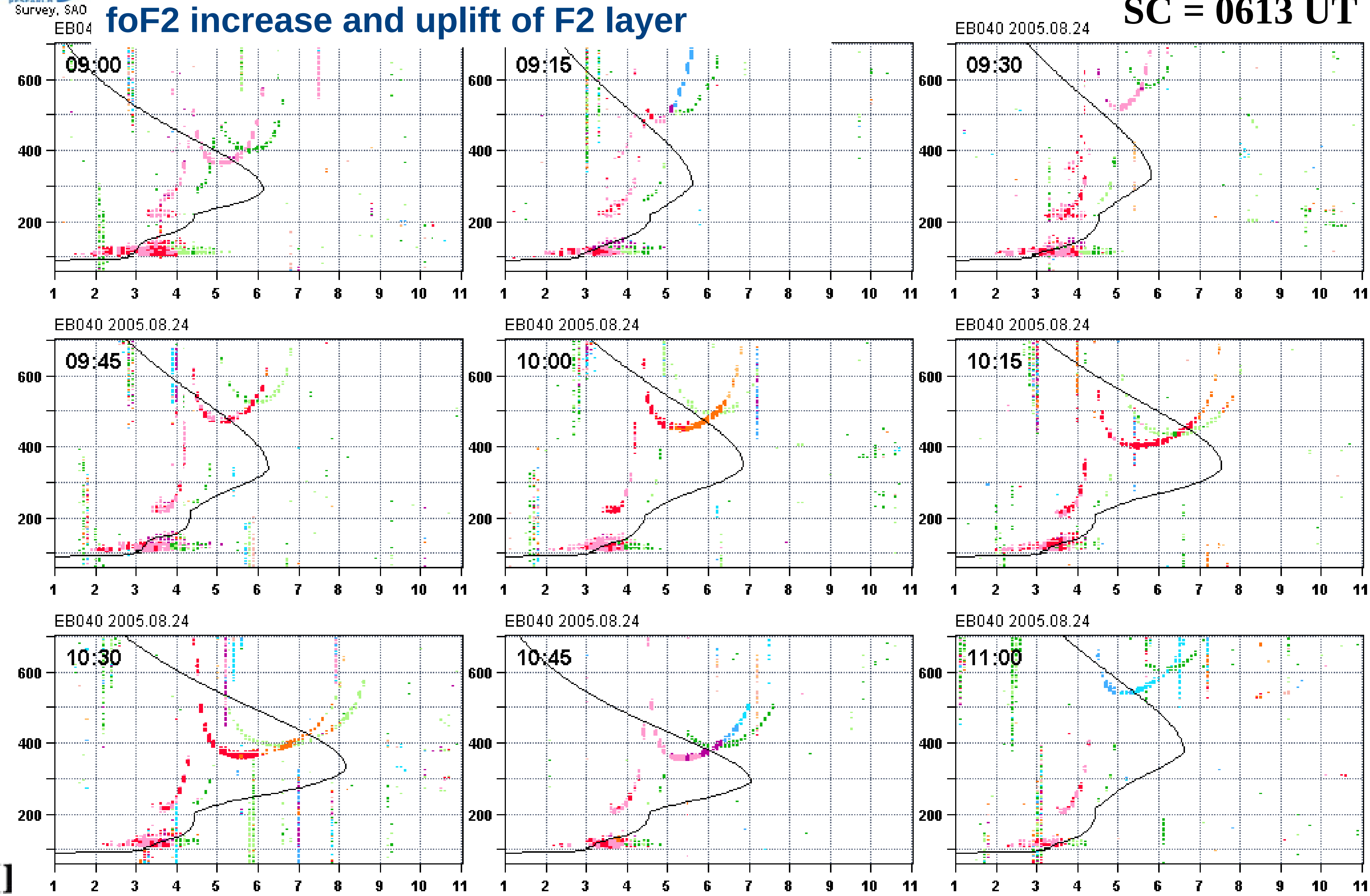
- Determine the time-space variations in the ionospheric storms

- Establish the driving mechanisms

Typical Storm Signatures - Ebro Ionograms, **Aug 24, 2005**

foF2 increase and uplift of F2 layer

SC = 0613 UT



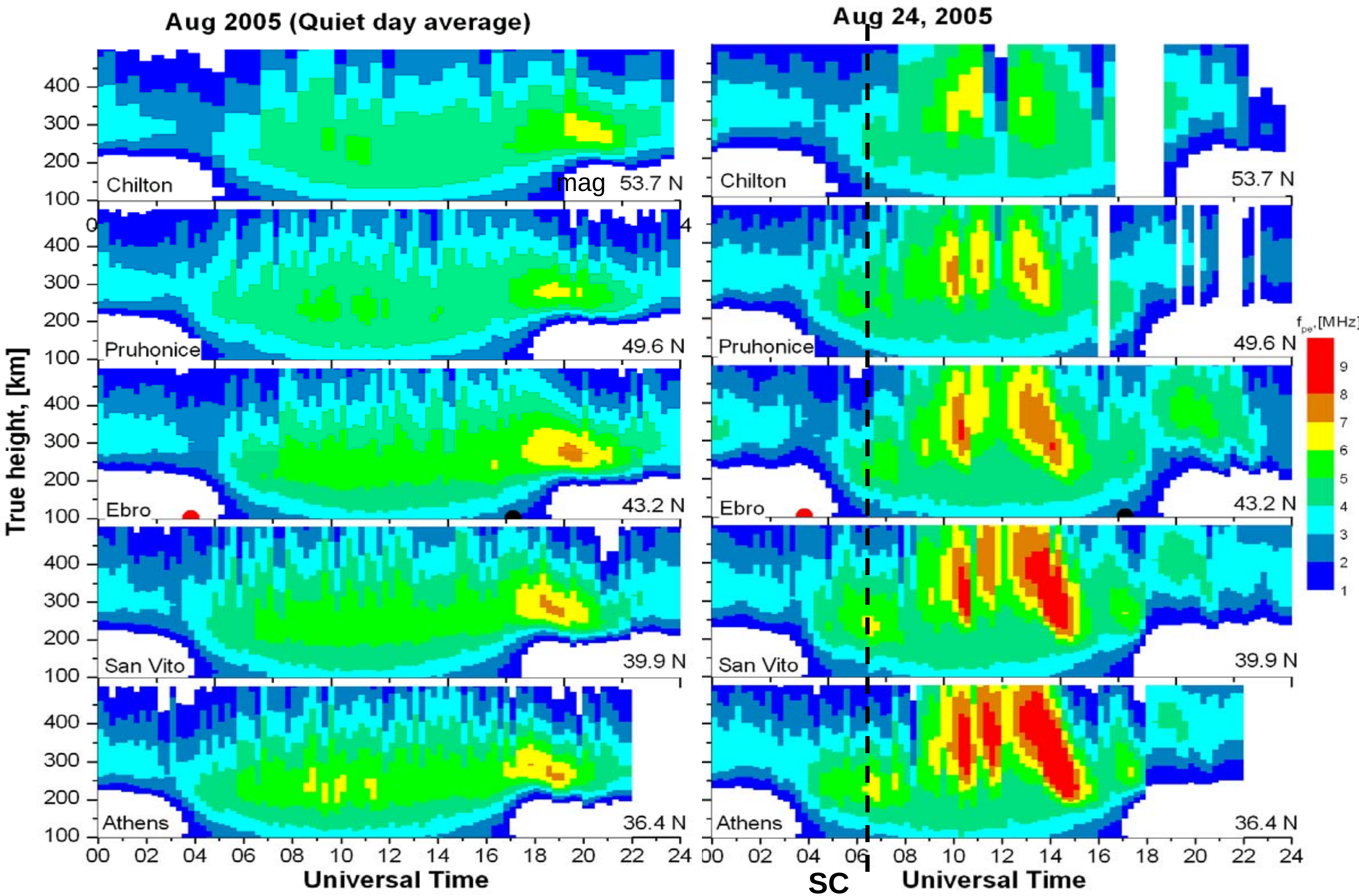
Digisonde stations used in the analysis

http://ulcar.uml.edu/DIDB/DIDBHome.html

9 major storms in 2001-2005 :

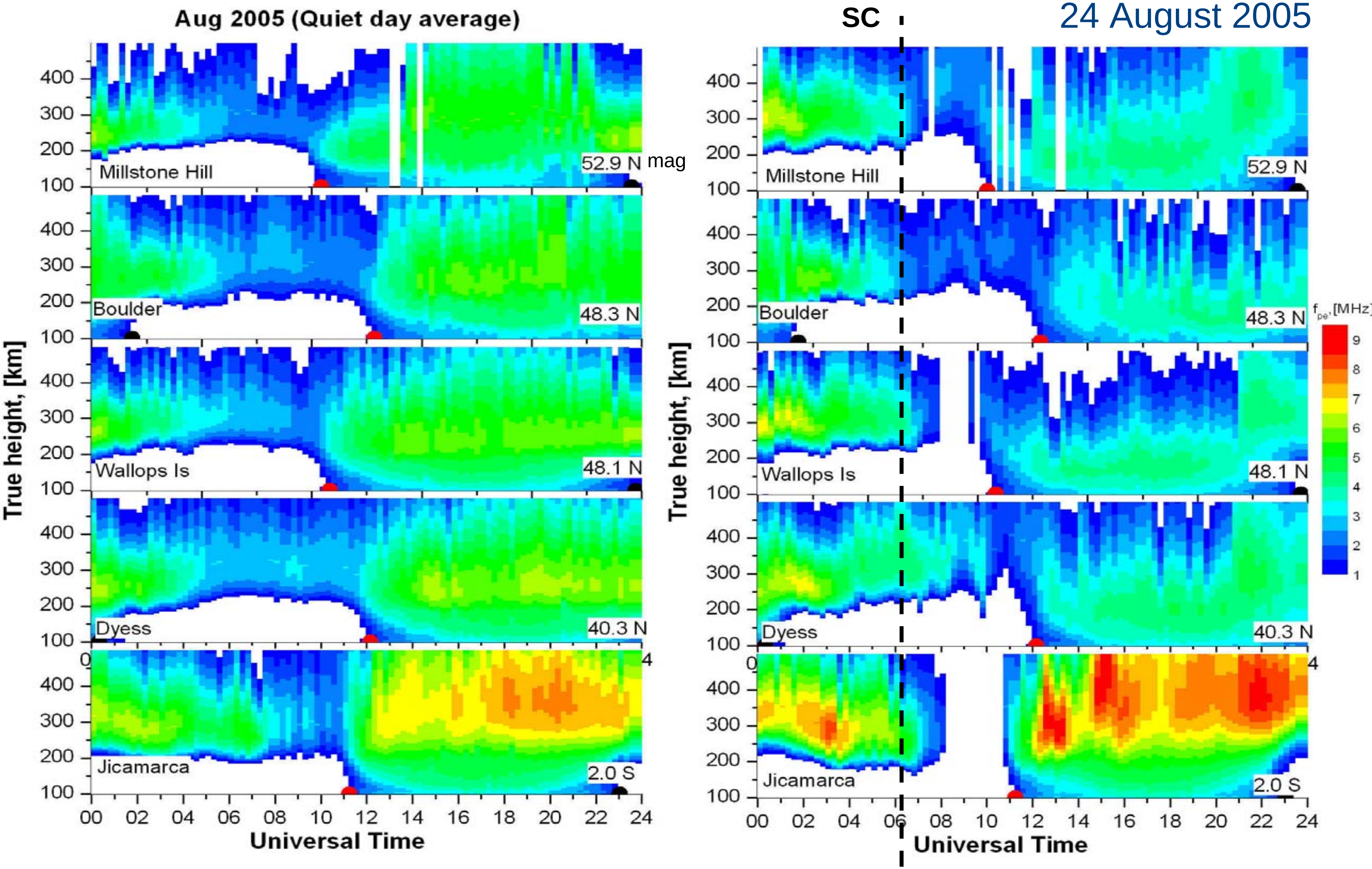
11 September 2005, **24 August 2005**, 15 May 2005, 21 January 2005
5 December 2004, 7 November 2004, 22 July 2004, 22 January 2004
20 November 2003 (~**20,000 ionograms validated**)

Daytime Storm in European Sector
Diurnal Variations of Electron Density Profiles



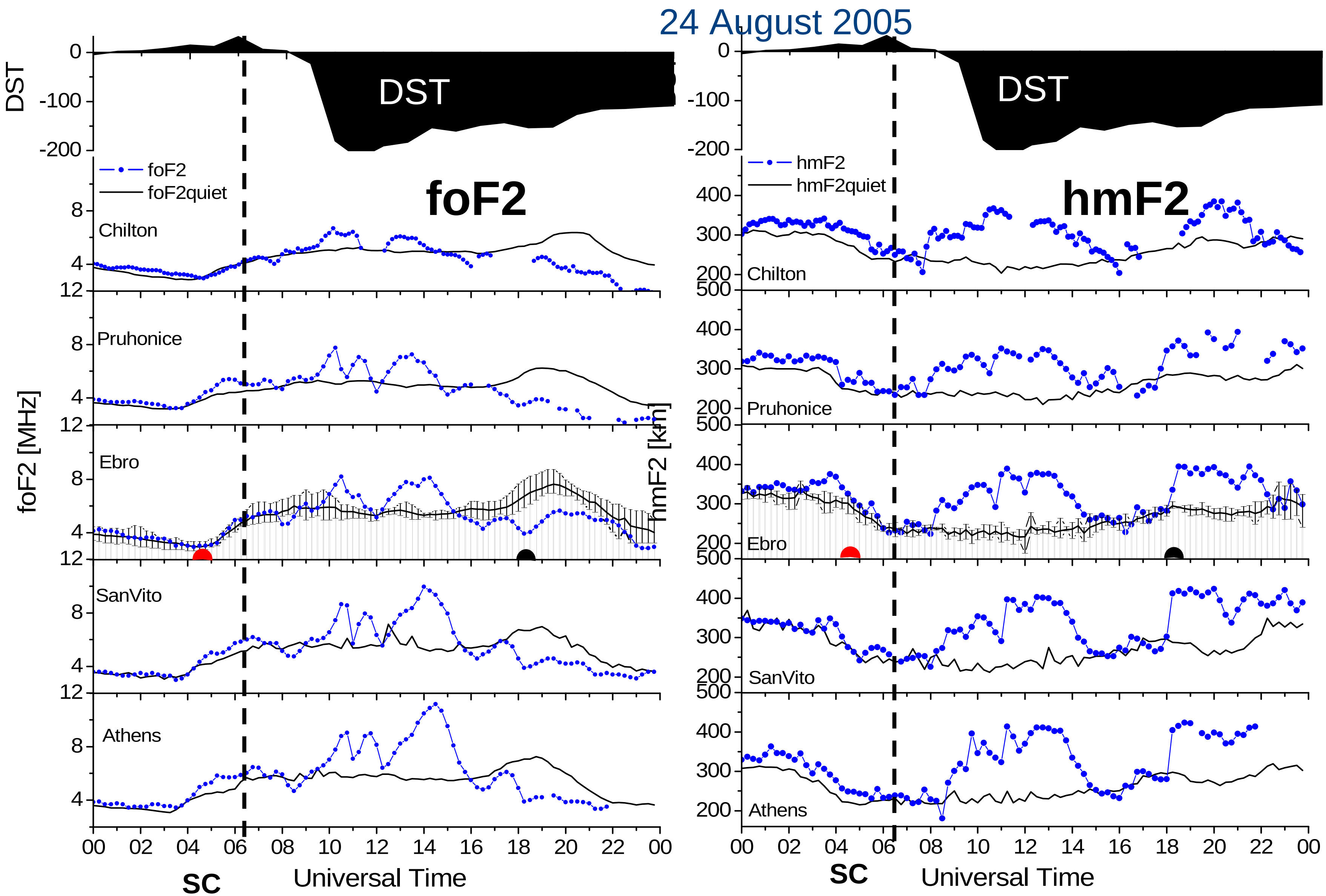
Nighttime Storm in American Sector

Diurnal Variations of Electron Density Profiles

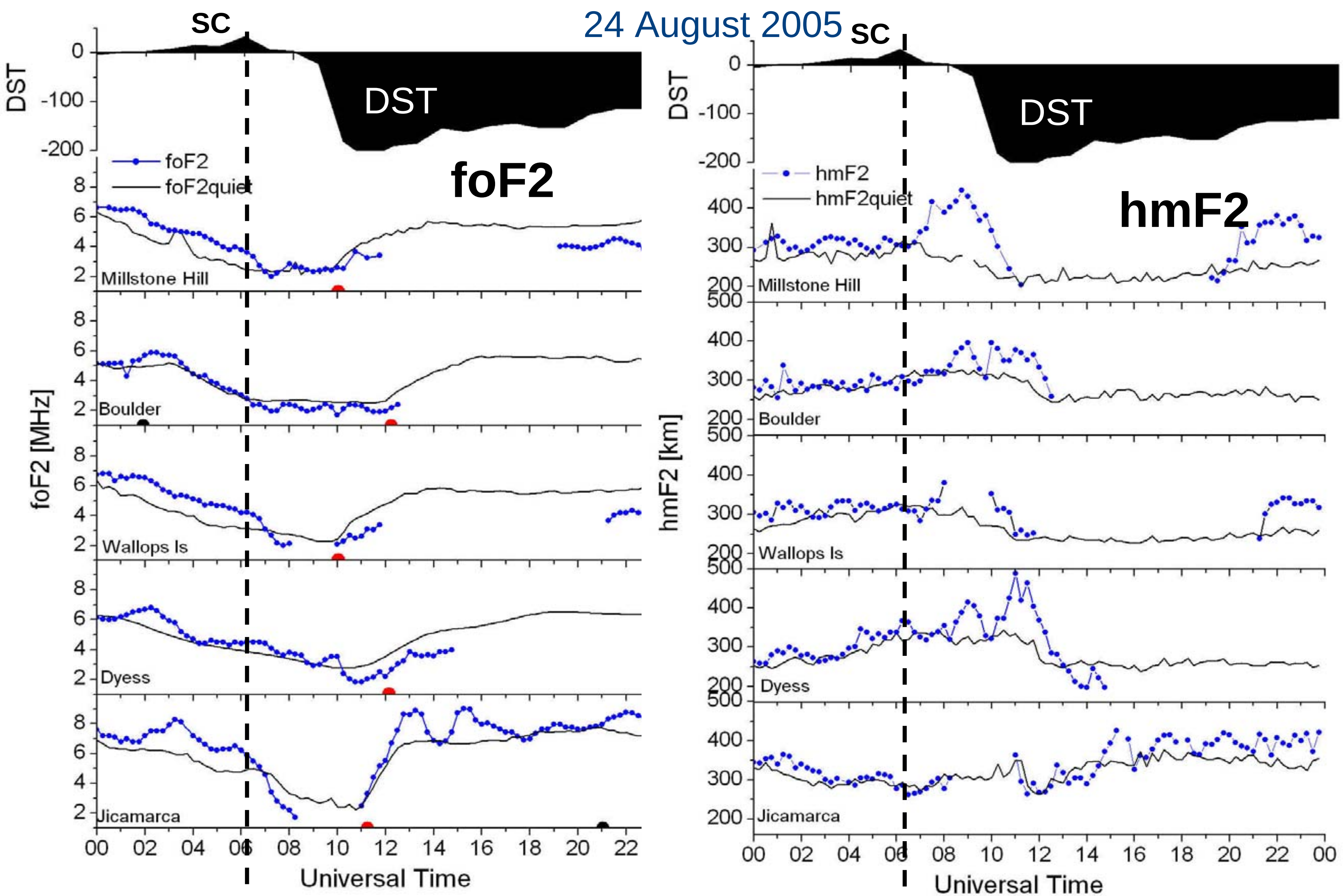


foF2 and hmF2

European Sector – Daytime Storm

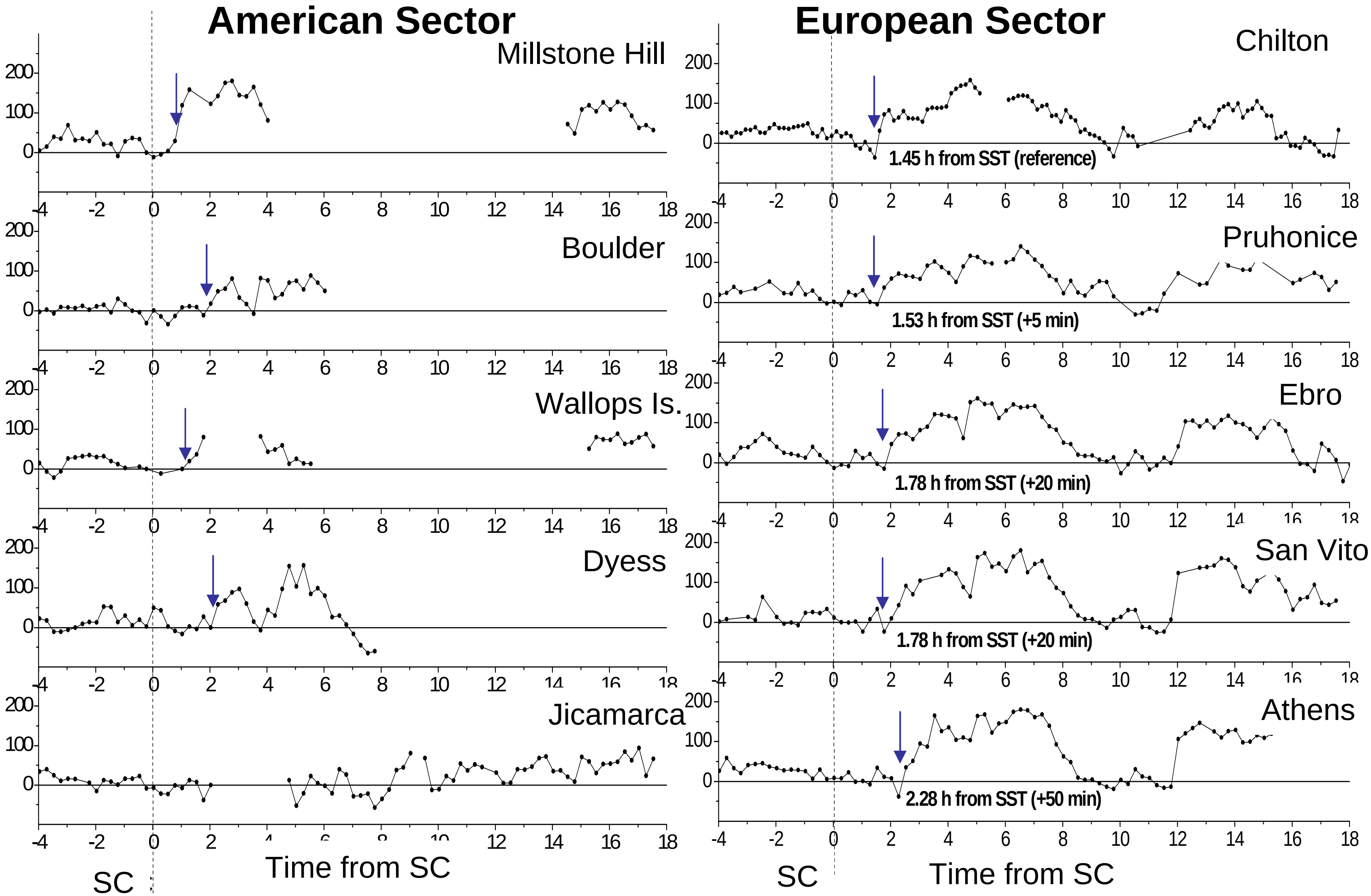


foF2 and hmF2
American Sector – Nighttime Storm



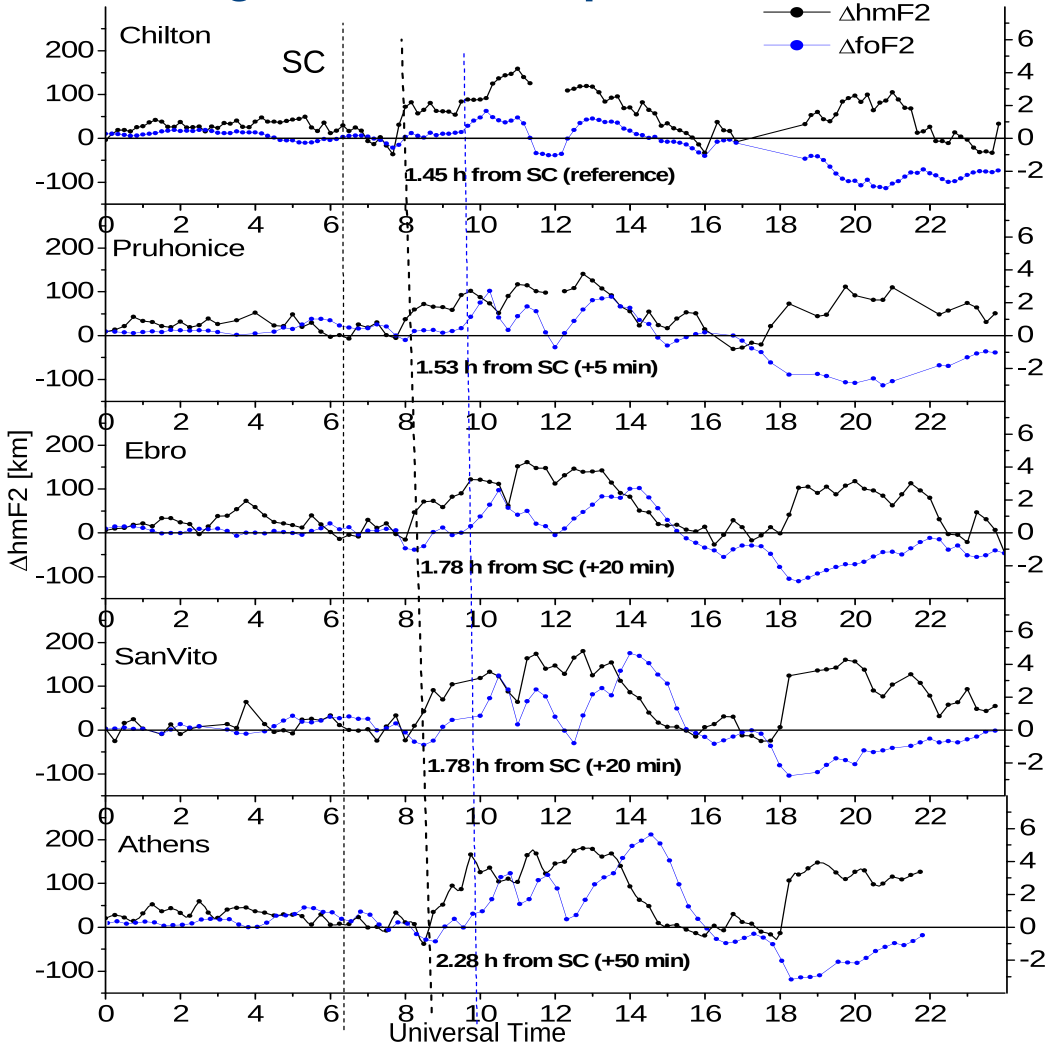
Δ hmF2

Onsets of layer rise in the two sectors, 24 August 2005

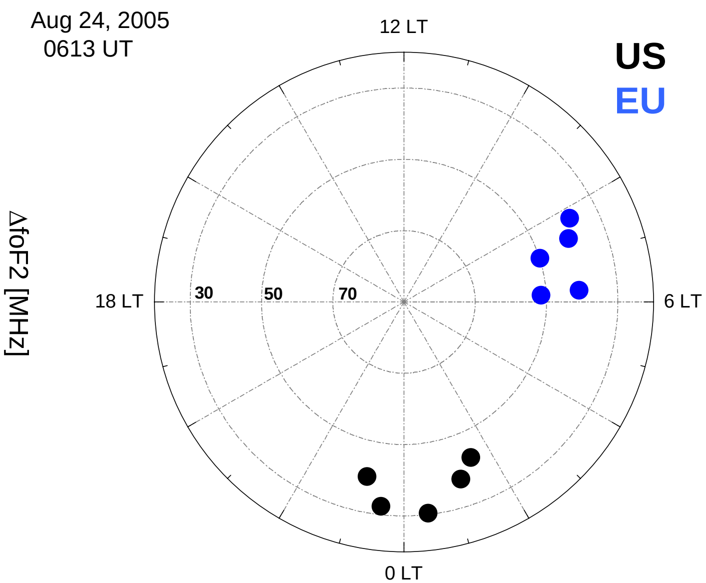


Δ hmF2 & Δ foF2

Geomagnetic storm impact mechanism



Positions of the stations at the time of storm commencement (Latitude vs. Local Time)



∴ Increase in foF2 follows the uplifting of the F2-layer

N-S disturbance propagation speed: ~600 m/s (based on the observed delays at the stations)

Summary of Observations for 24 August 2005

► Positive NmF2 effect in Europe, negative effect in America following the storm commencement

► 12 hours after the storm commencement: negative effect in European sector

► F2 layer uplifts in America & Europe

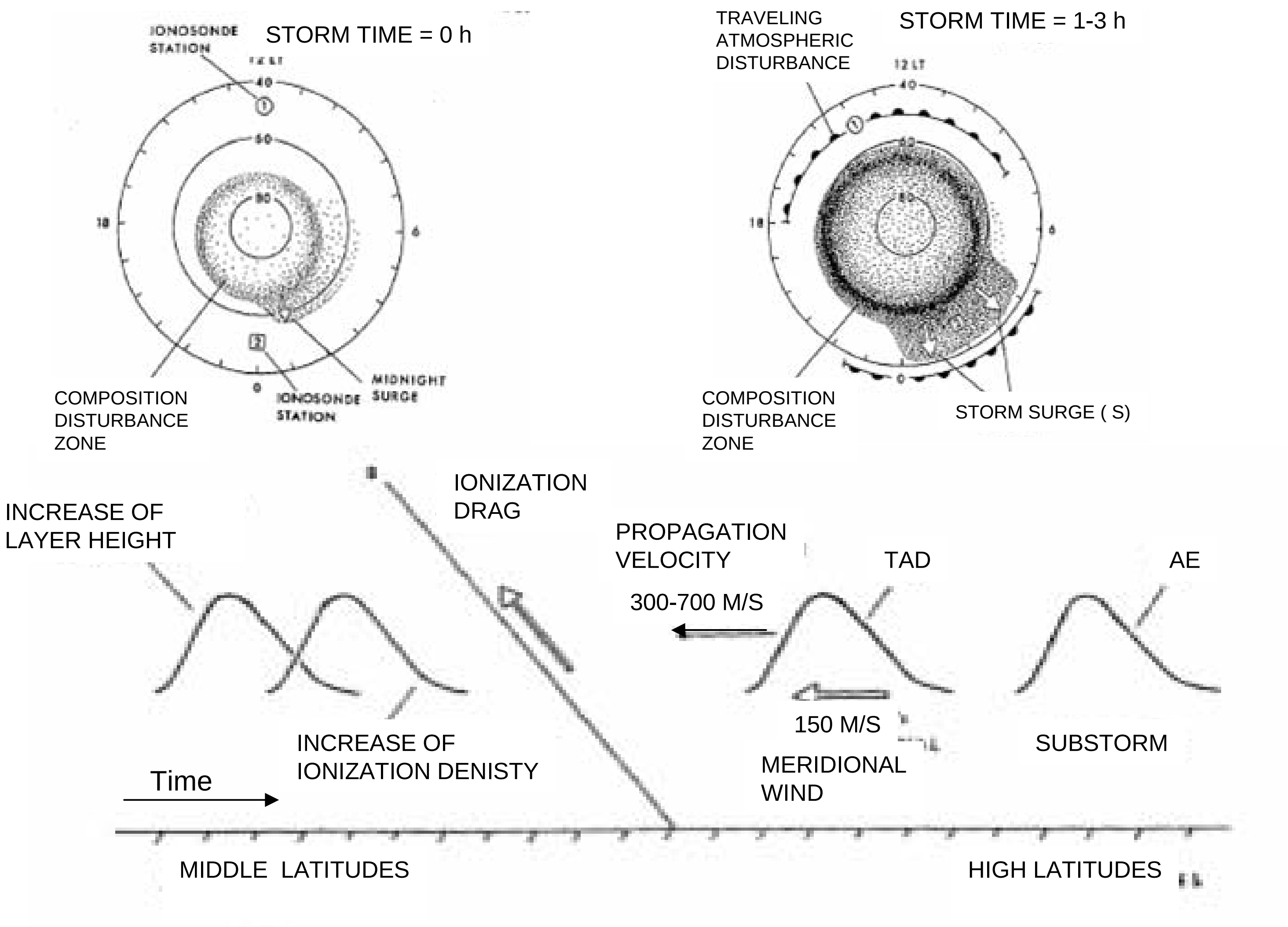
- **Height increase leads NmF2 increase**

► Latitudinal delay of the start of the F2 disturbance observed in European sector

- **Delay time increases from higher to lower latitudes**

Modeling Geomagnetic Storm Effects

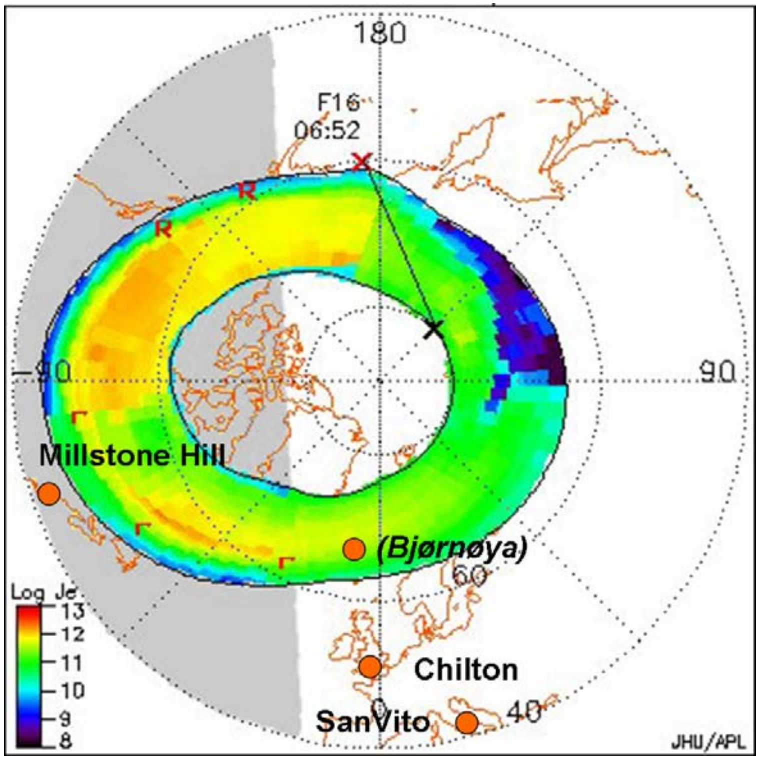
Geomagnetic storm impact mechanism



[*Prölss*, 1993; *Fuller-Rowell et al.*, 1995]

24 August 2005: Substorm Signatures

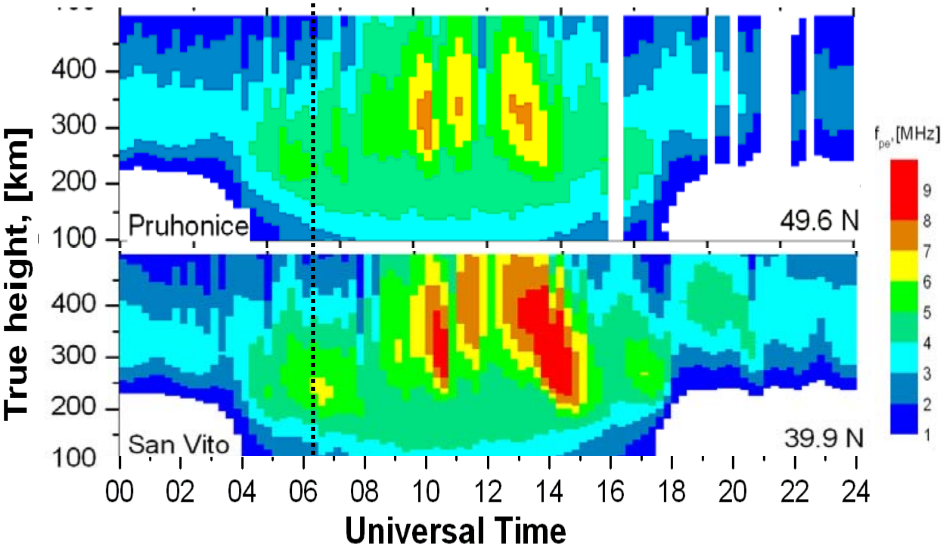
Energy input in the auroral zone

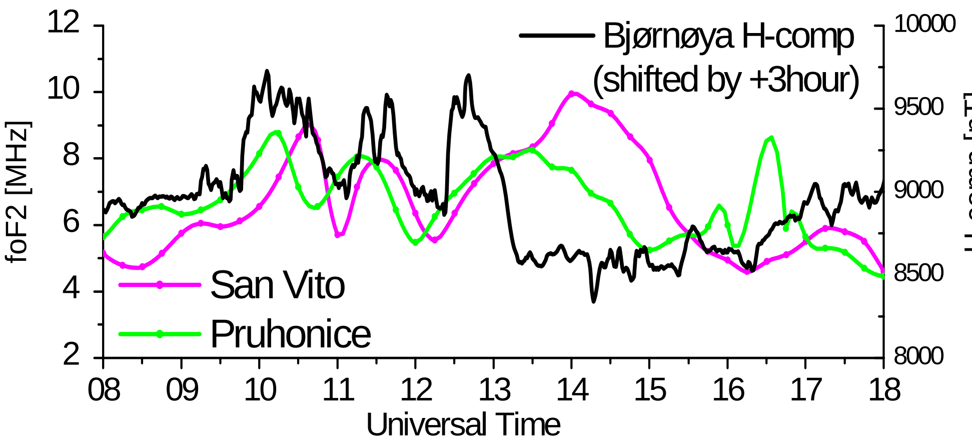


(from APL OVATION database)

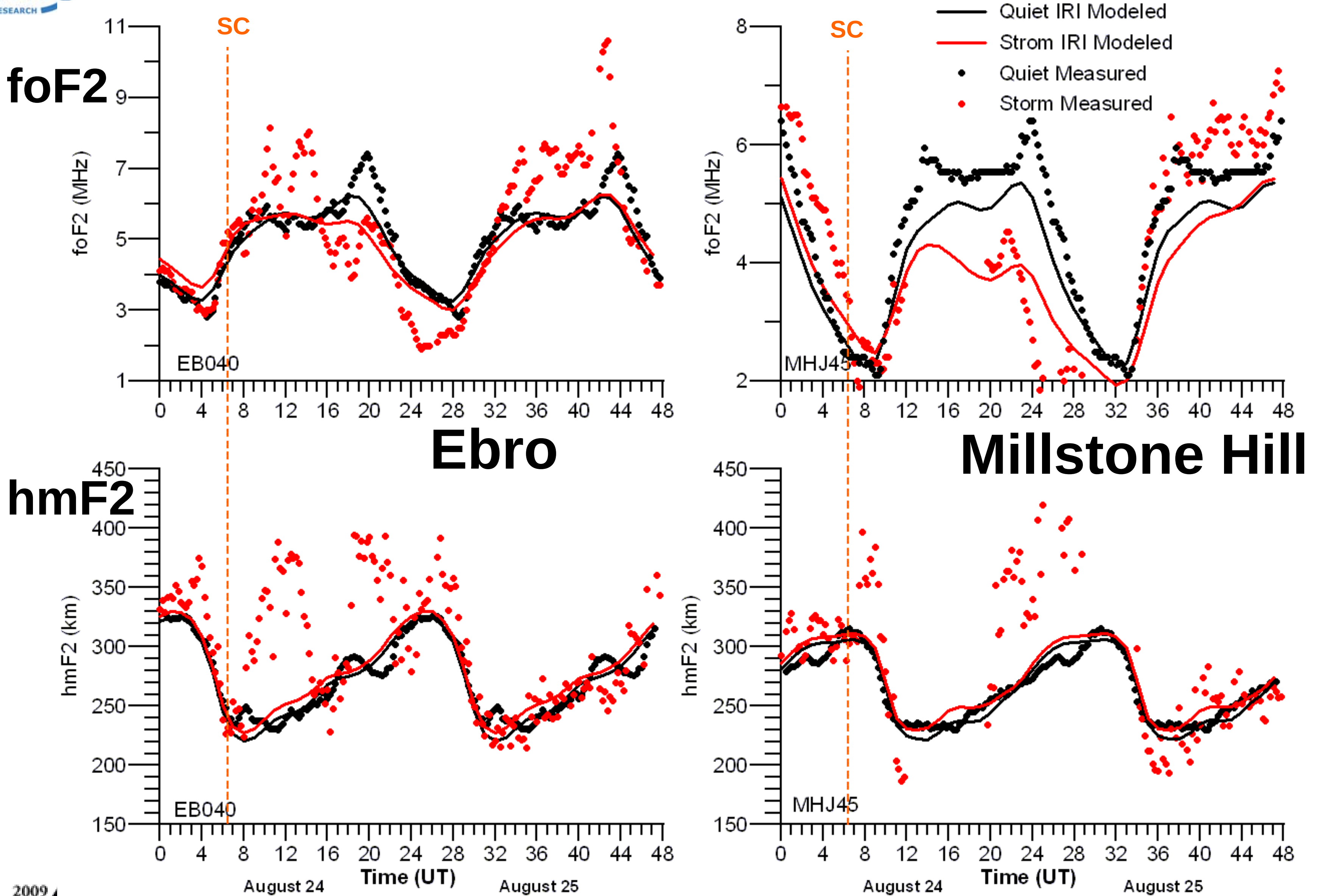
Je-energy flux of electrons

Electron density profiles



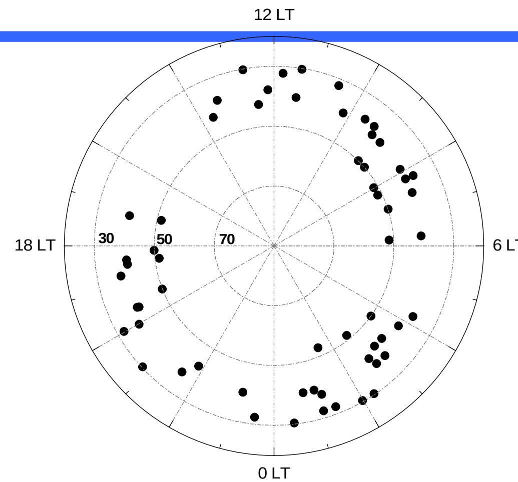


24 August 2005: Comparison with IRI Model



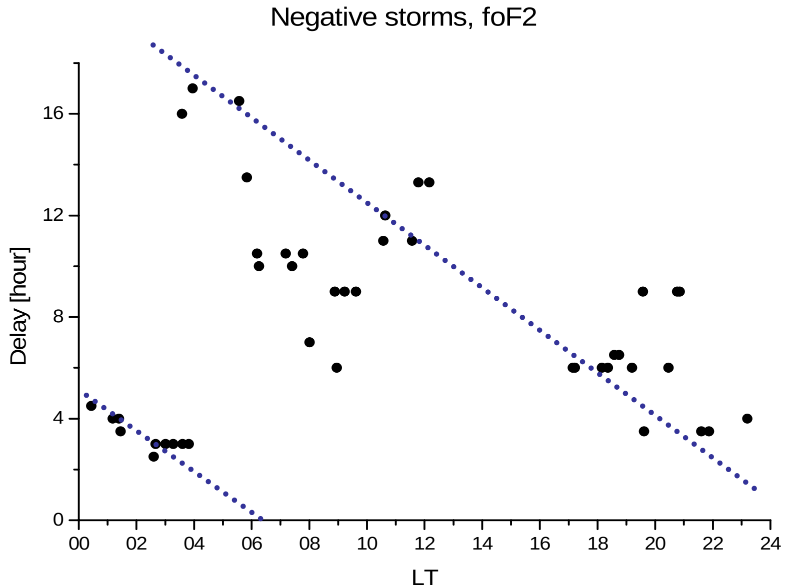
Negative storms local time dependence

Positions of the stations at the time of storm commencements (for all 9 storms)

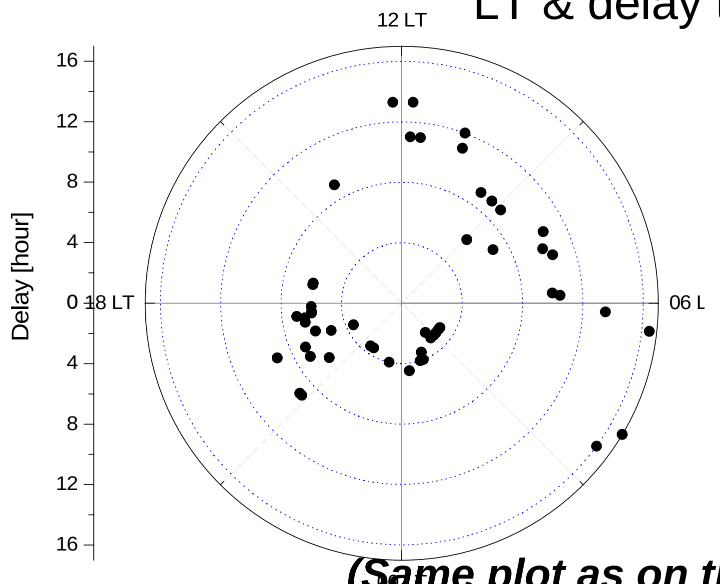


LT & latitude

Observed time delay between the SC and foF2 decrease as a function of local time

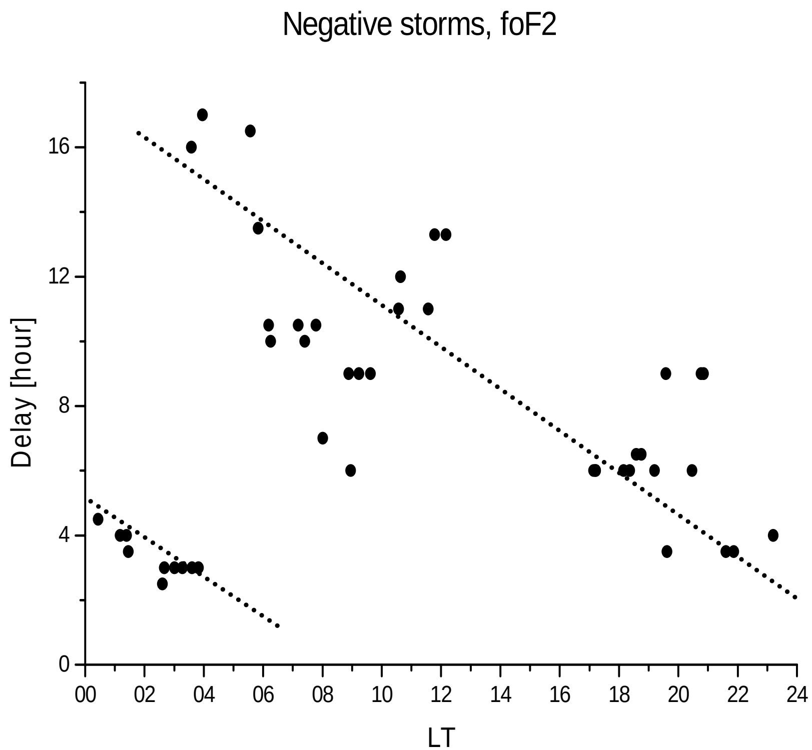


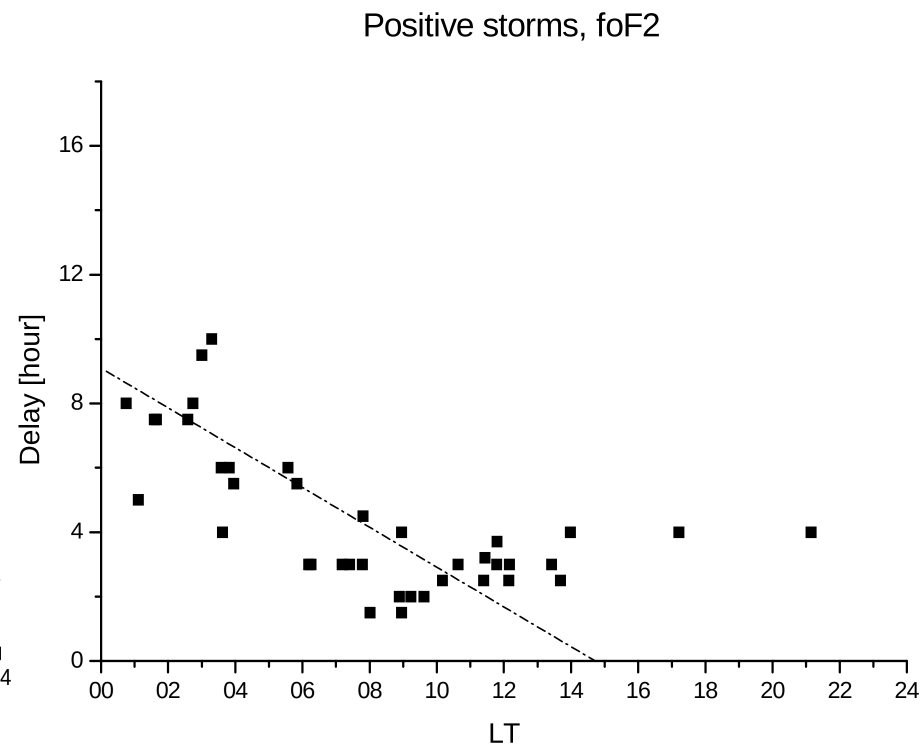
LT & delay time



(Same plot as on the left, but in polar coordinates)

Observed Delay vs Local Time at SC





1. No very long time delays are observed for positive storms
2. Shortest delays concentrate around 03-05 LT for negative storms, but for positive storms at around 12 LT.
3. Practically no positive storms began after 14 LT.

Summary

► **Results presented suggest that the main driver of the ionospheric response is the neutral wind and composition change bulge.**

► **The uplifting of the ionosphere plays an important part in ionospheric storm development. It was observed both for positive and negative storms.**

► **In this study it was possible to evauate the local time dependence of the storm effects. The patterns for negative and positive storms are significantly different, in rough agreement with the neutral wind driven storm scenario.**

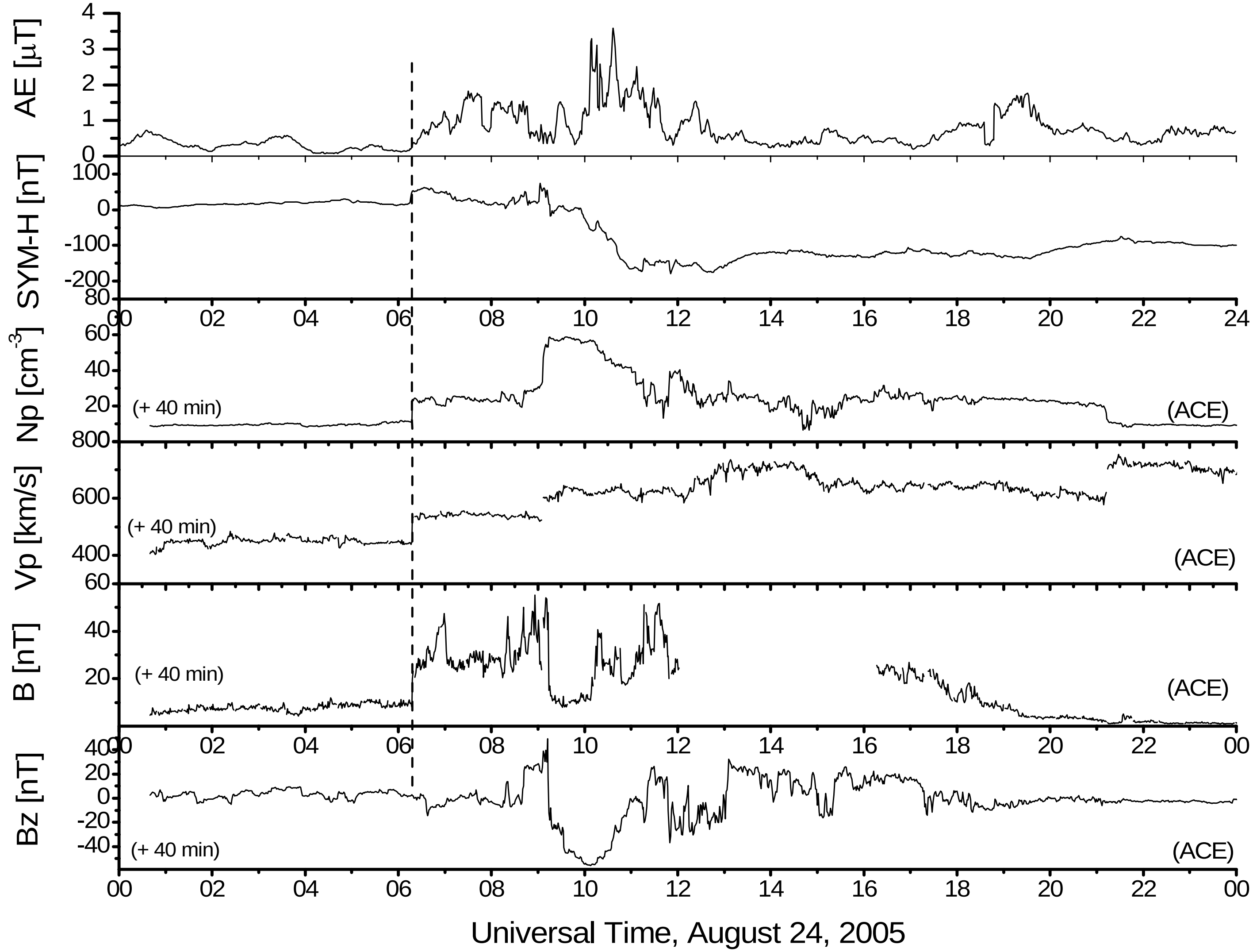
► **From the time delays observed at the European station chain it was possible to estimate the speed of the positive disturbance propagation to be about 600m/s, which is chracteristic for TADs.**

► **The IRI storm model does not always reproduce the observed increase in foF2. Also it does not consider storm-time perturbations of the F2 layer height.**

► ***Global data on the database "DIDBase" offer an excellent opportunity for studying the space-time evolution of the ionospheric response to magnetic storms.*** **http://umlcar.uml.edu/DIDB/DIDBHome.html**

Helio-geophysical Conditions for 24 August 2005

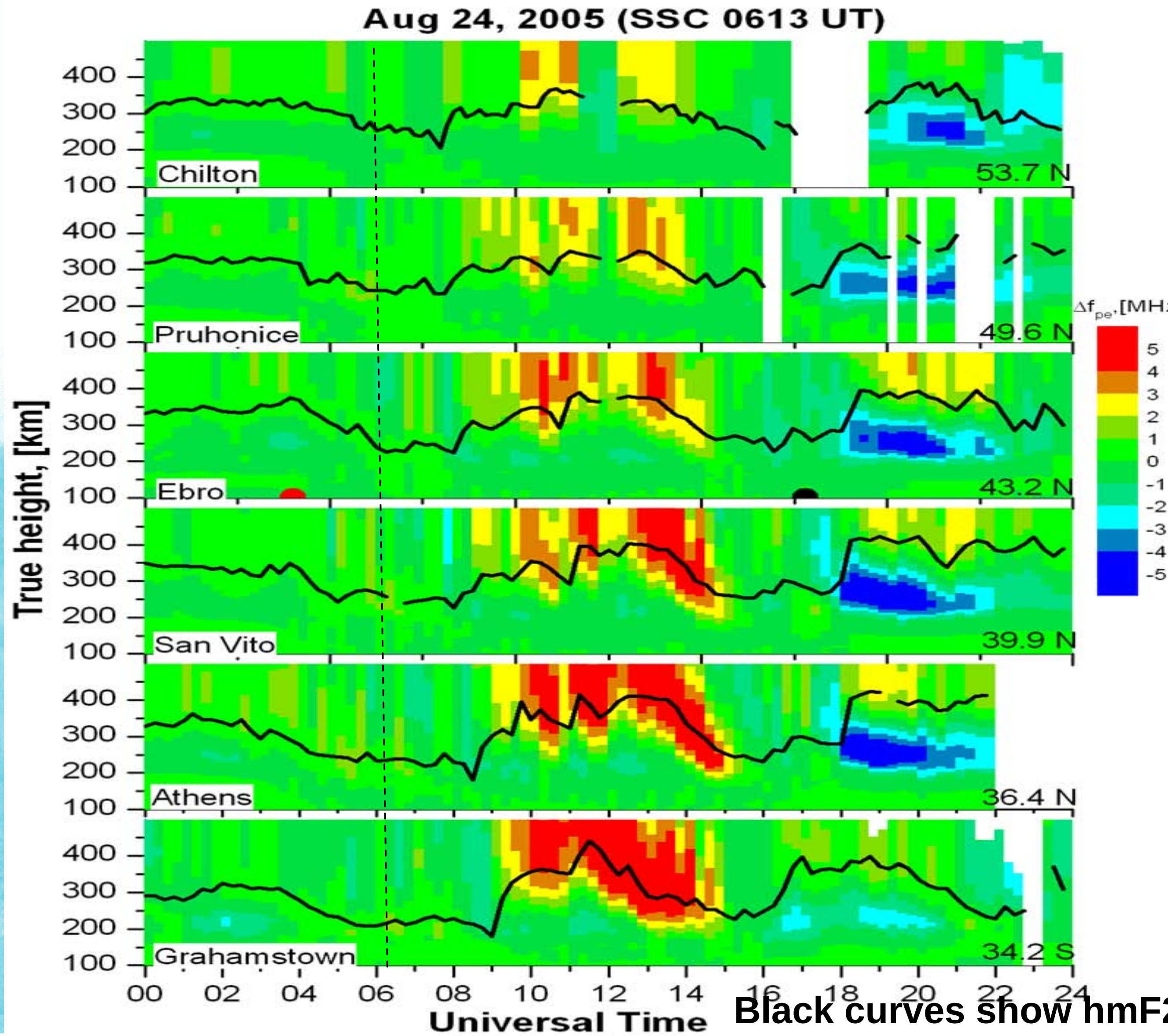
Helio-geophysical conditions



24 August 2005: Daytime Storm in European Sector

RelativeDiurnal Variations of Electron Density Profiles

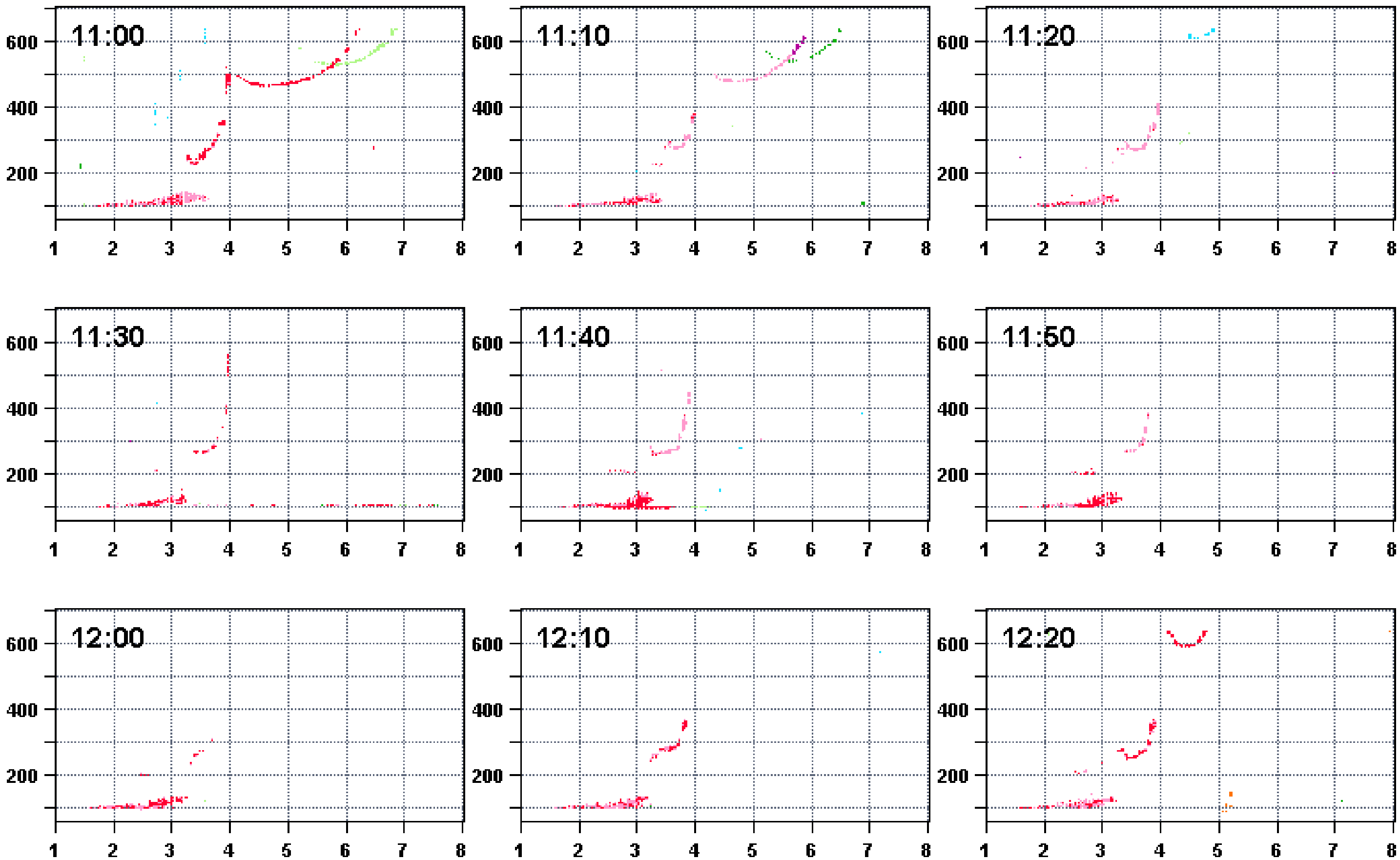
Difference **between electron density on 24 August 2005 and quiet time reference level**



Black curves show hmF2

Typical Storm Signatures - Chilton Ionograms, **Aug 24, 2005**

Uplift of F2 layer (beyond maximum height in ionogram) **SC = 0613 UT**



9 main storms analyzed:

11 September 2005, **24 August 2005**, 15 May 2005, 21 January 2005

5 December 2004, 7 November 2004, 22 July 2004, 22 January 2004

20 November 2003 (~**20,000 ionograms validated**)

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TRENDS IN IONOGRAM ANALYSIS

Prof. Bodo W. Reinisch
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

Digisonde Ionograms

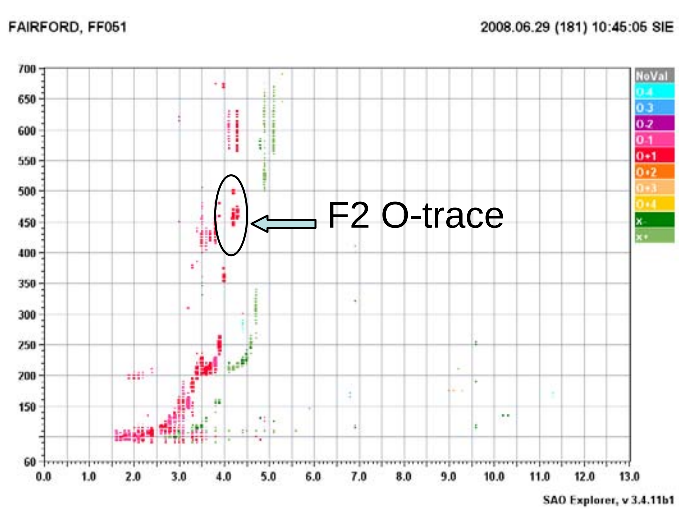
UMLCAR Good Practice Guidelines (GPG)

- Precision Ranging shall be standard
  - Digisonde 256: card mod may be needed; doubling of running time may not be desirable for these old systems
  - DPS-4: only generation 5 systems (C40)
  - Digisonde 4D: default mode
  - ARTIST-5 is needed to take advantage of PR
- DPS-4: re-process data with ARTIST-5 to remove range bias
  - Stand-alone ARTIST-5 is now available
- SAO.XML is now fully supported
  - ARTIST-5 is needed to use SAO.XML
  - DIDBase accepts SAO.XML records
  - Autoscaling uncertainty are reported only in SAO.XML

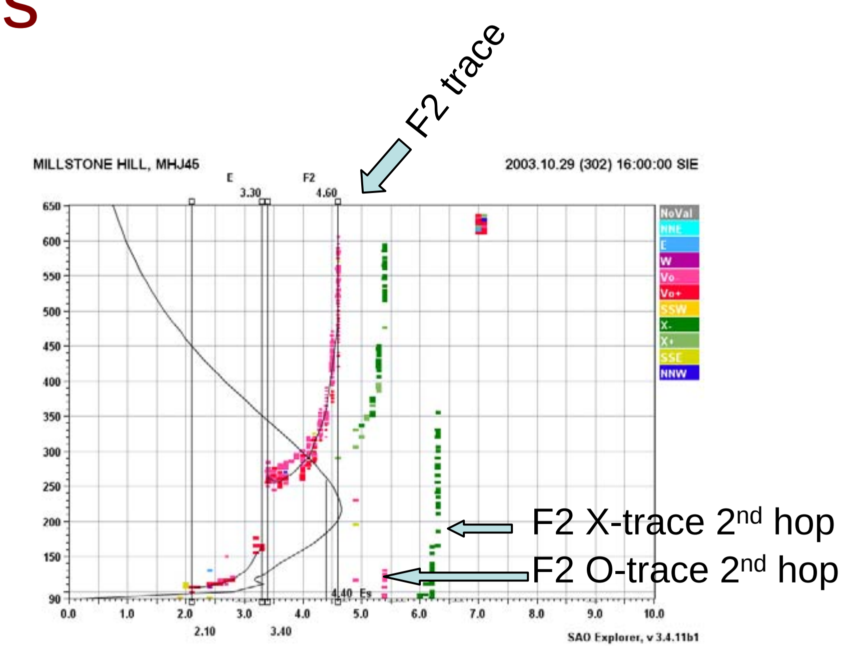
Digisonde Ionograms

UMLCAR Good Practice Guidelines (GPG)

- Use 50 kHz (day) and 25 kHz (night) stepping
- Always use 1,280 km upper height to capture storm periods



100 kHz too coarse



650 km not enough

Ionograms: Future efforts

- Topside density profile to be replaced with the Vary-Chap model
- Specify ARTIST profile uncertainty for individual digisonde locations
- DIDBase: looking to establish mirror sites in Europe and elsewhere

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ARTIST-5

Dr. Ivan Galkin

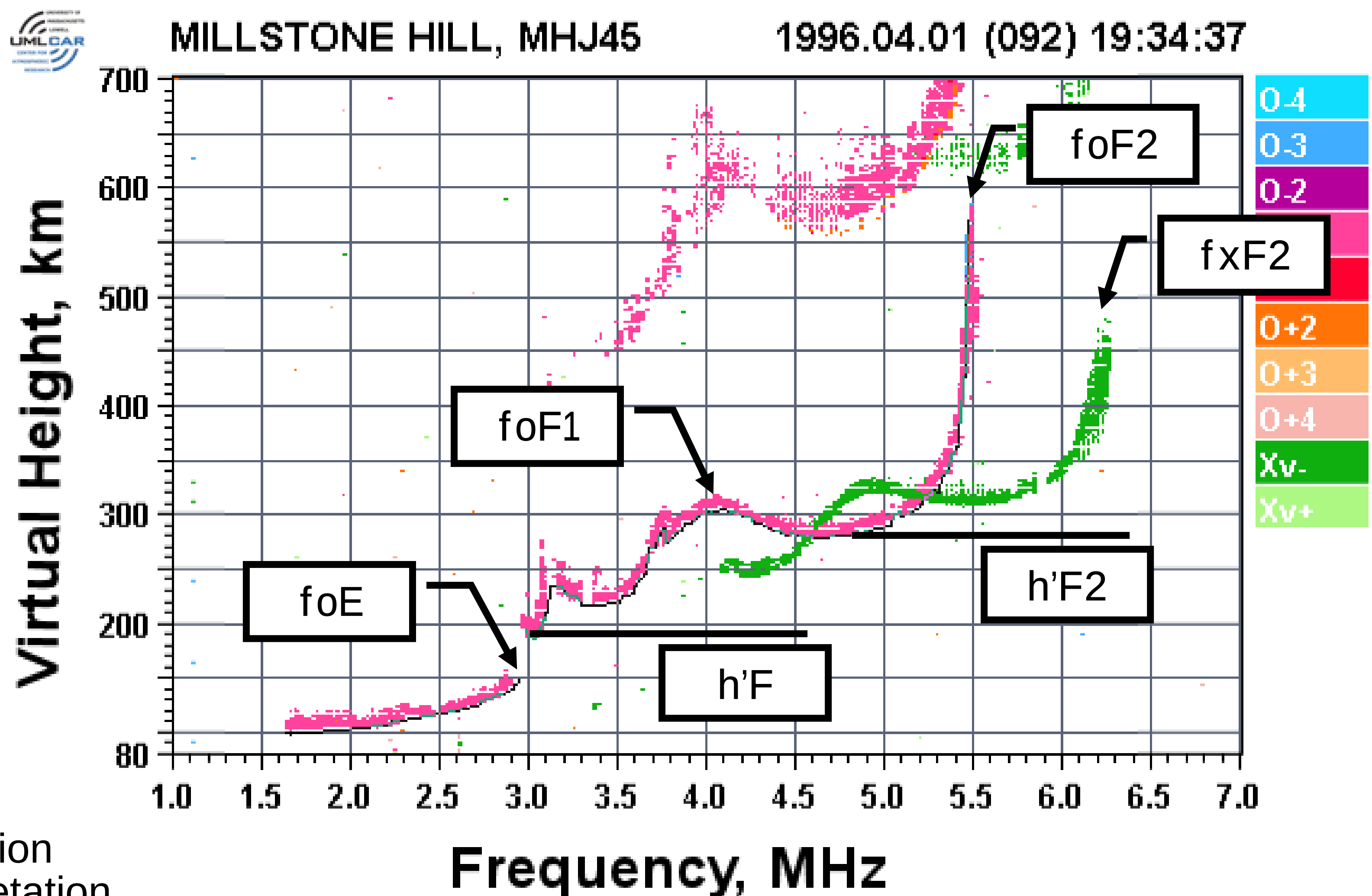
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

Ionogram & Autoscaling

Autoscaled:

foF2	5.49
foF1	4.86
foF1p	4.56
foE	2.96
foEp	3.23
fxI	6.20
foEs	2.95
MUF	18.70
M	3.415
D	3000
h'F	185
h'F2	285
h'E	98
h'Es	98
zmF2	227
zmF1	196
zmE	106
yF2	67
yF1	40
yE	30
C-level	1

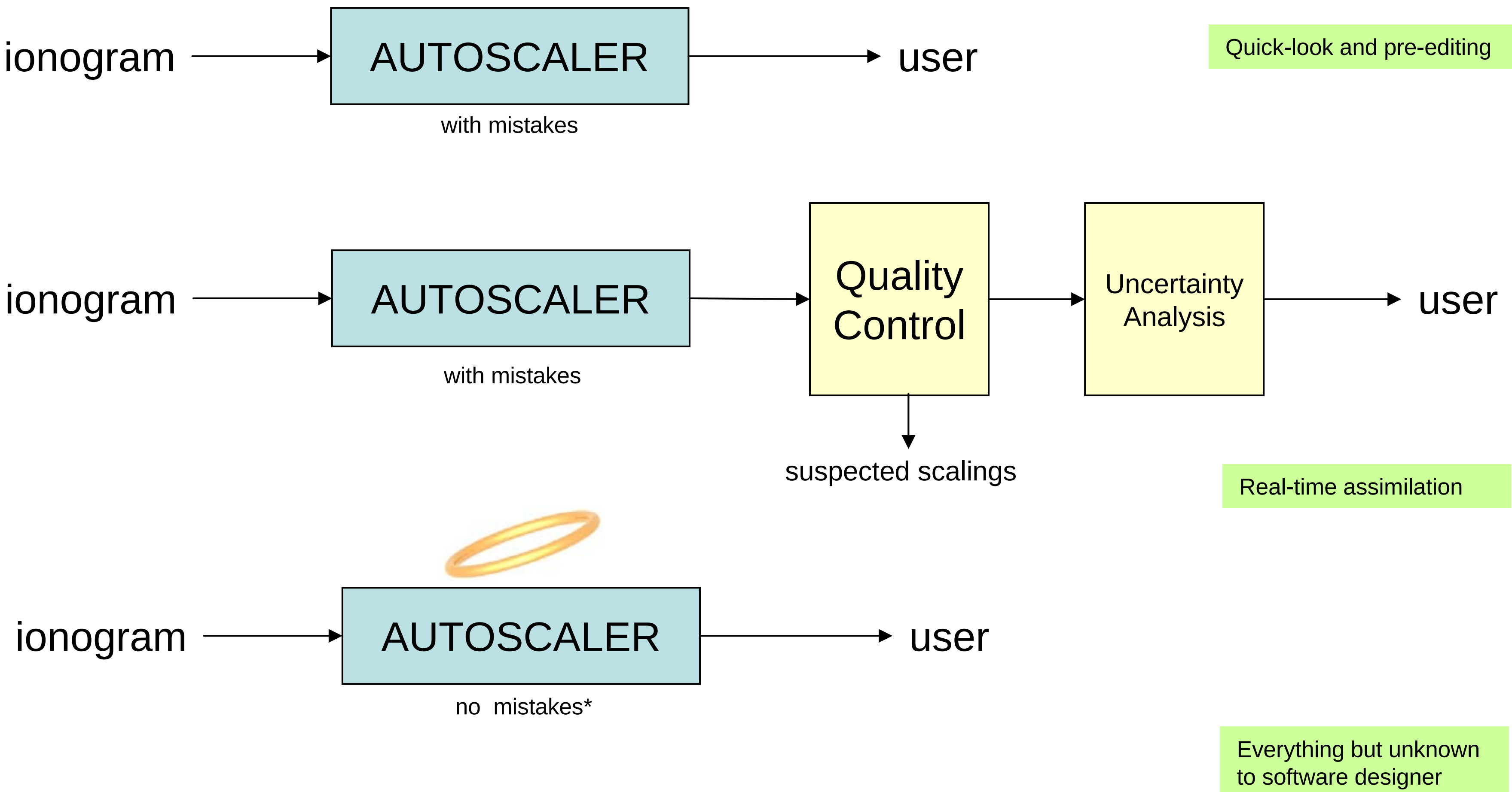


Ionogram
Trace Extraction
Trace Interpretation

Outline

- Challenges of Automatic Ionogram Scaling
- ARTIST-5 advances
  - Autoscaling Confidence Level (ACL)
    - Prevent low confidence data from assimilation
  - ARTIST-5 Uncertainty Study
    - Error Bounds for Characteristics
    - Error Boundaries for Electron Density Profile (EDP)
- Where do we go from here

Autoscaler Employment



* only uncertainty due to ionospheric conditions

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Autoscaling Challenges

- A. Make less errors
- B. Detect significant errors by post-analysis to disqualify such data
- C. Characterize uncertainty of qualified ionogram-derived data (due to autoscaling errors)

Next, we review ARTIST advances in A, B, and C

A. Make Less Autoscaling Errors

- Solutions vary among different ionosonde providers
- Solutions are specific to autoscaling software design
  - Computer Vision approach
  - Signal Processing approach
    - Phase-aware techniques
  - Ne Profile Morphing approach
- ARTIST-5 released May 2007
  - Improved performance
  - Improvements qualified by manual vs. auto studies
    - Using ~250,000 manually scaled ionograms in Lowell DIDBase

Lessons Learned

- ARTIST needs to operate during periods of degraded hardware capability
  - Polarization tagging
  - Directional analysis
  - Precision ranging
  - Signal to noise ratio
  - Non-optimal measurement settings
    - Frequency resolution
    - Range coverage
- Warranted additional effort directed at computer vision techniques
  - Good “background” model

ARTIST-5 Innovations

© 1993-2007

Artificial
Neural
Network
Algorithm

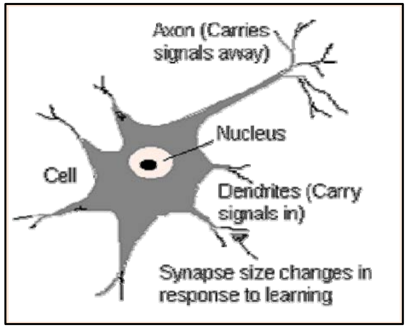
© 1985-1993, 2006-2008

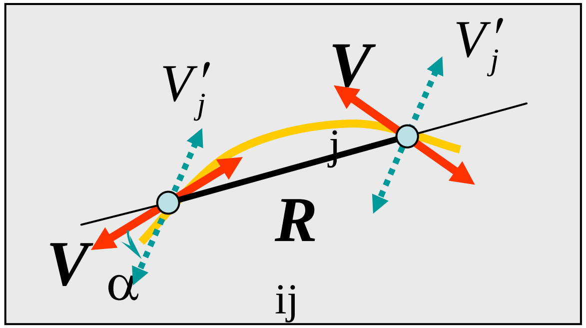
Program for
Autoscaling of
Conventional
Ionograms with
Flexible
Interpretation
Control

© 2007

ANNA: Extraction of traces

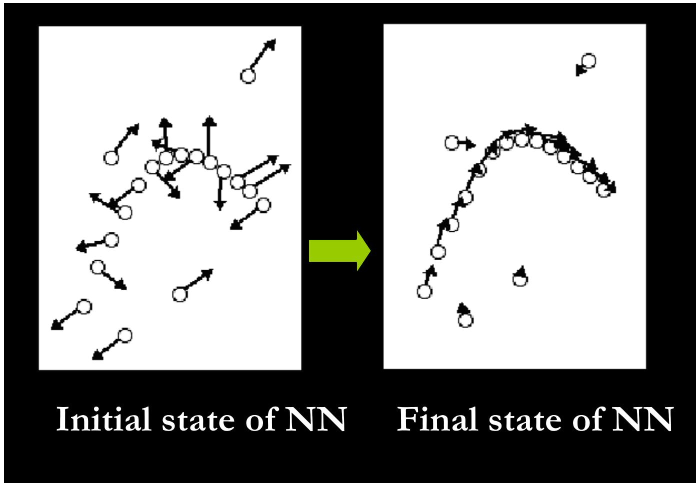
- Original design: 1993-1994
- Bio-plausible additions: 2003-2004
- New clustering algorithm: 2007

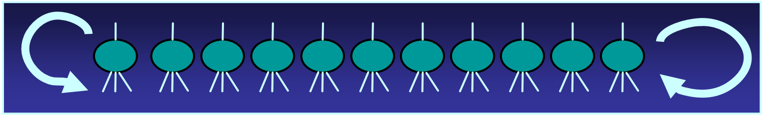




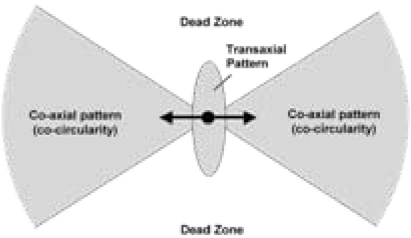
i

Rotor interaction
(co-circular model)



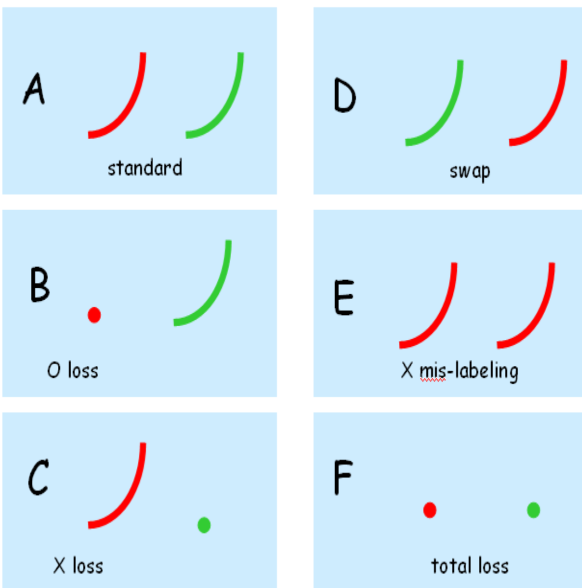


Hopfield Recurrent ANN



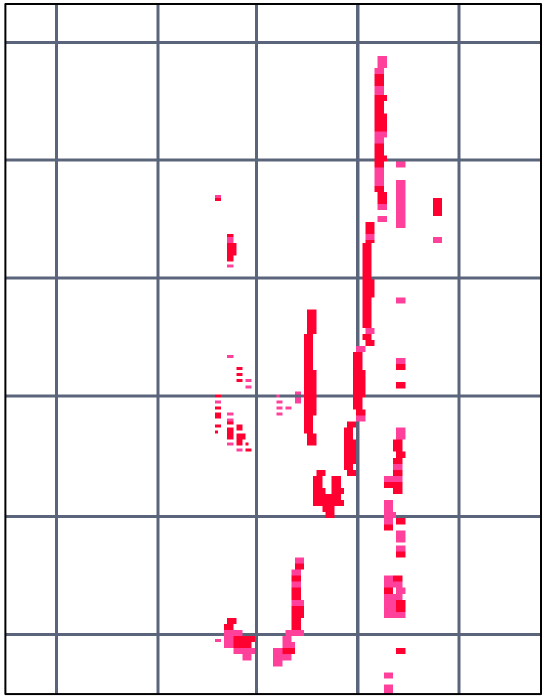
Honda ASIMO

PACIFIC

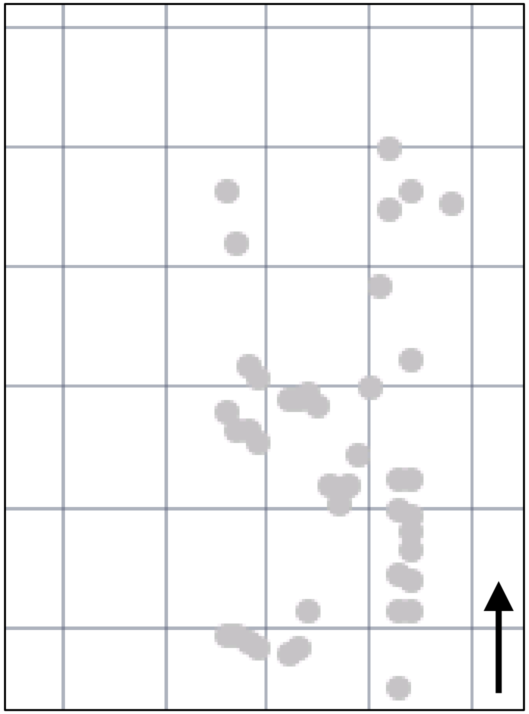


- Seeks trace segments pointing up
- Considers 6 configurations A-F
- Fits O- and X-cusps independently and refits if they do not match
- Allows down-grading to ionograms without polarization tagging or with swapped polarizations
  - Learmonth, Australia
  - Jicamarca, Peru

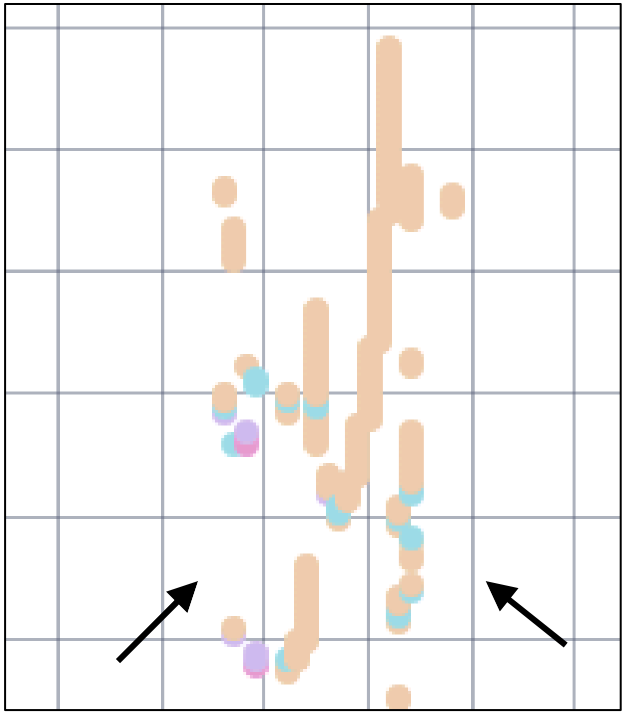
A45: Edgel detection



IONOGRAM
thresholded

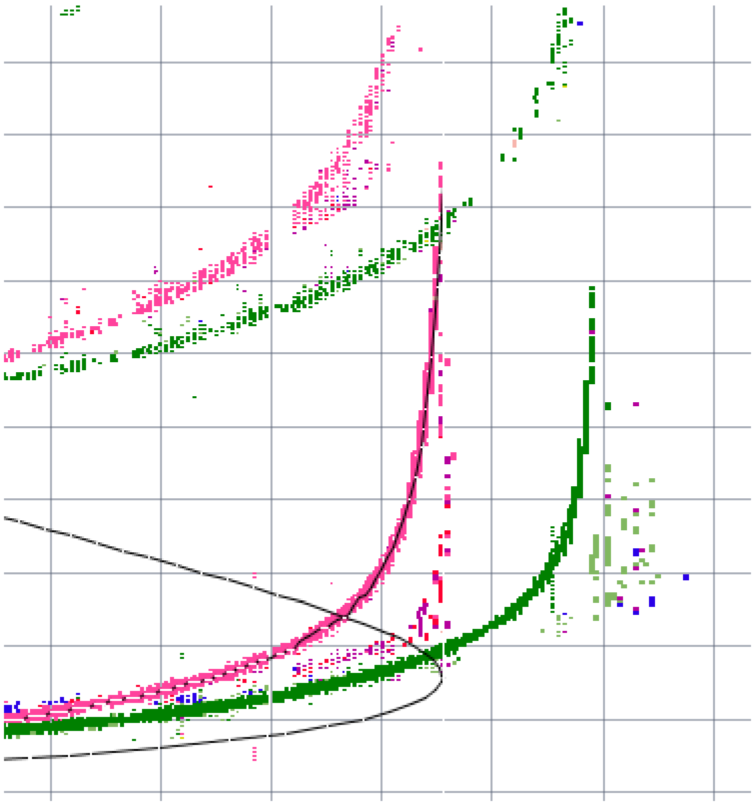


Classic edgel detection



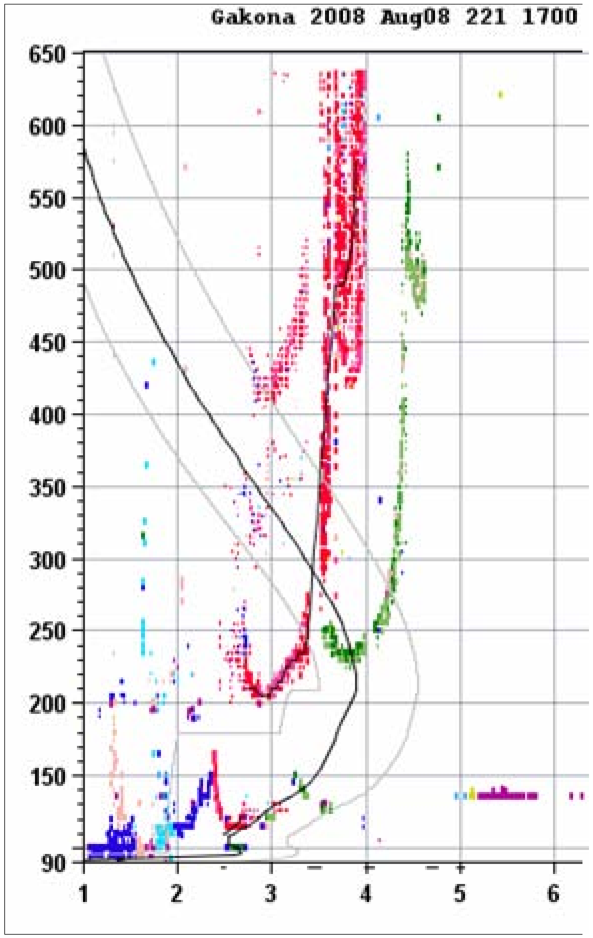
“Dual” A45 edgel detection

ARTIST-5 Lessons learned



- Accurate foF2 cusp processing is most important
  - Careful with cusp extrapolation above last trace point
- Imperfections in trace extraction are not important
  - Small effect on Ne density profile
- NHPC Profile inversion works as trace gap interpolator

ARTIST-5: Lessons learned (2)



- Short steep high traces are most difficult
  - Summer
  - Low solar activity
  - Storm time / F3 layer
- Second hop traces are difficult
  - from sporadic E layer
  - stronger than 1st hop trace
- Ionograms taken during spread F conditions shall be processed differently

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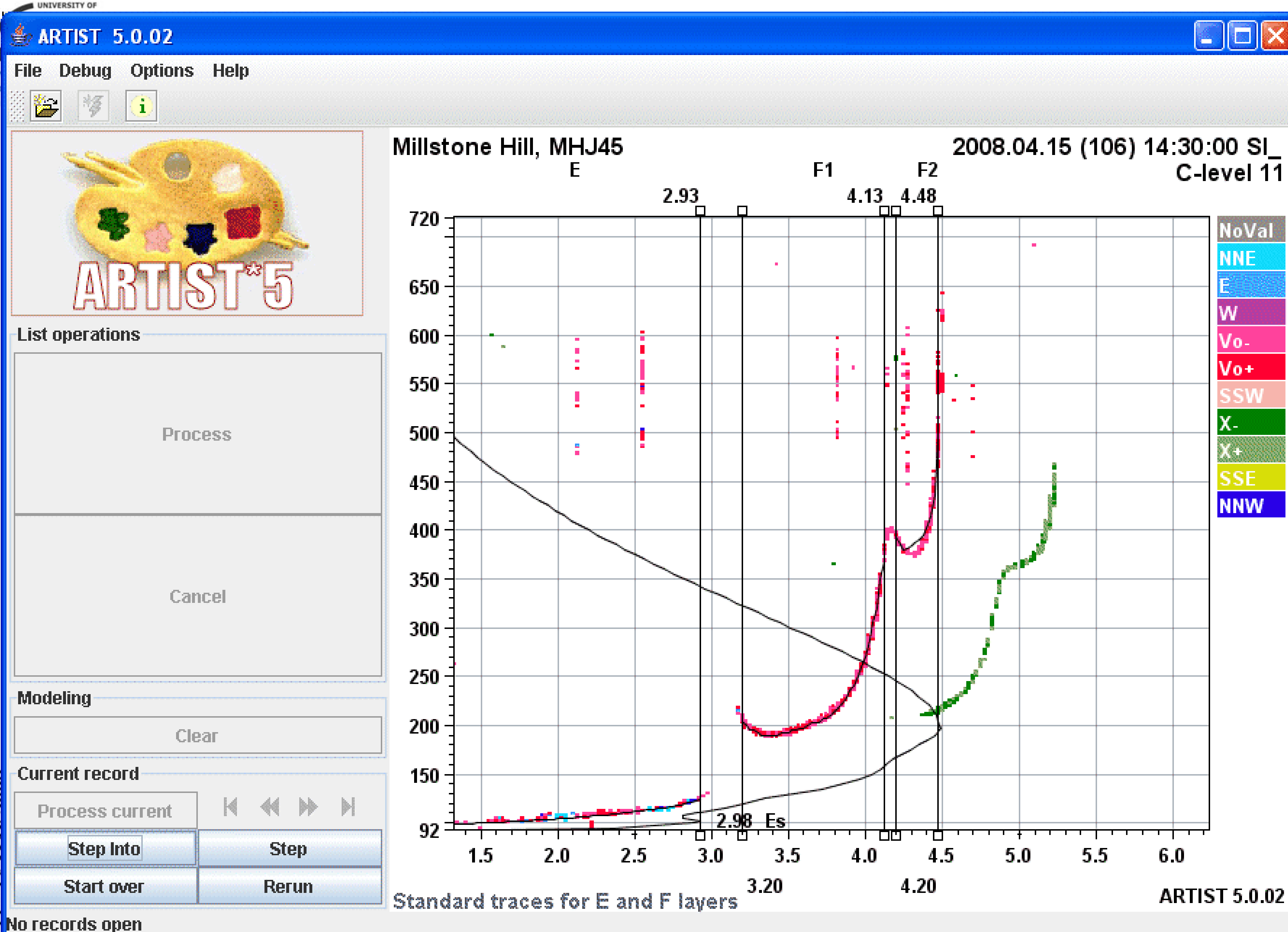
ARTIST-5: optimize ionograms

- Use smallest frequency step possible under measurement time restrictions
- Use Precision Ranging mode
  - Subject to PR quality verification
- 5 km may be better than 2.5 km
- Reliable polarization tagging is important
  - Special considerations apply for equatorial locations


ARTIST 5.0.02
File
Debug
Options
Help
ARTIST*5
List operations
Process
Cancel
Modeling
Clear
Current record
Process current
Step Into
Step
Start over
Rerun
No records open
Millstone Hill, MHJ45
2008.04.15 (106) 14:30:00 SI_
C-level 11
E
F1
F2
2.93
4.13
4.48
720
650
600
550
500
450
400
350
300
250
200
150
92
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
2.98 Es
3.20
4.20
Standard traces for E and F layers
ARTIST 5.0.02
NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW

B. Detect Significant Errors

- Detect significant autoscaling errors to avoid their assimilation
  - Describe remaining minor errors statistically
    - Error bars for characteristics
    - Error boundaries for EDP
- History of error detection by post-analysis:
  - USAF QUALSCAN © 1986-2008
  - ADEP “Merit check” © 1990-1992
  - ARTIST-4 C-Level © 1994-1995
  - JORN Australia Quality Control
  - ARTIST 5 © 2006-2008

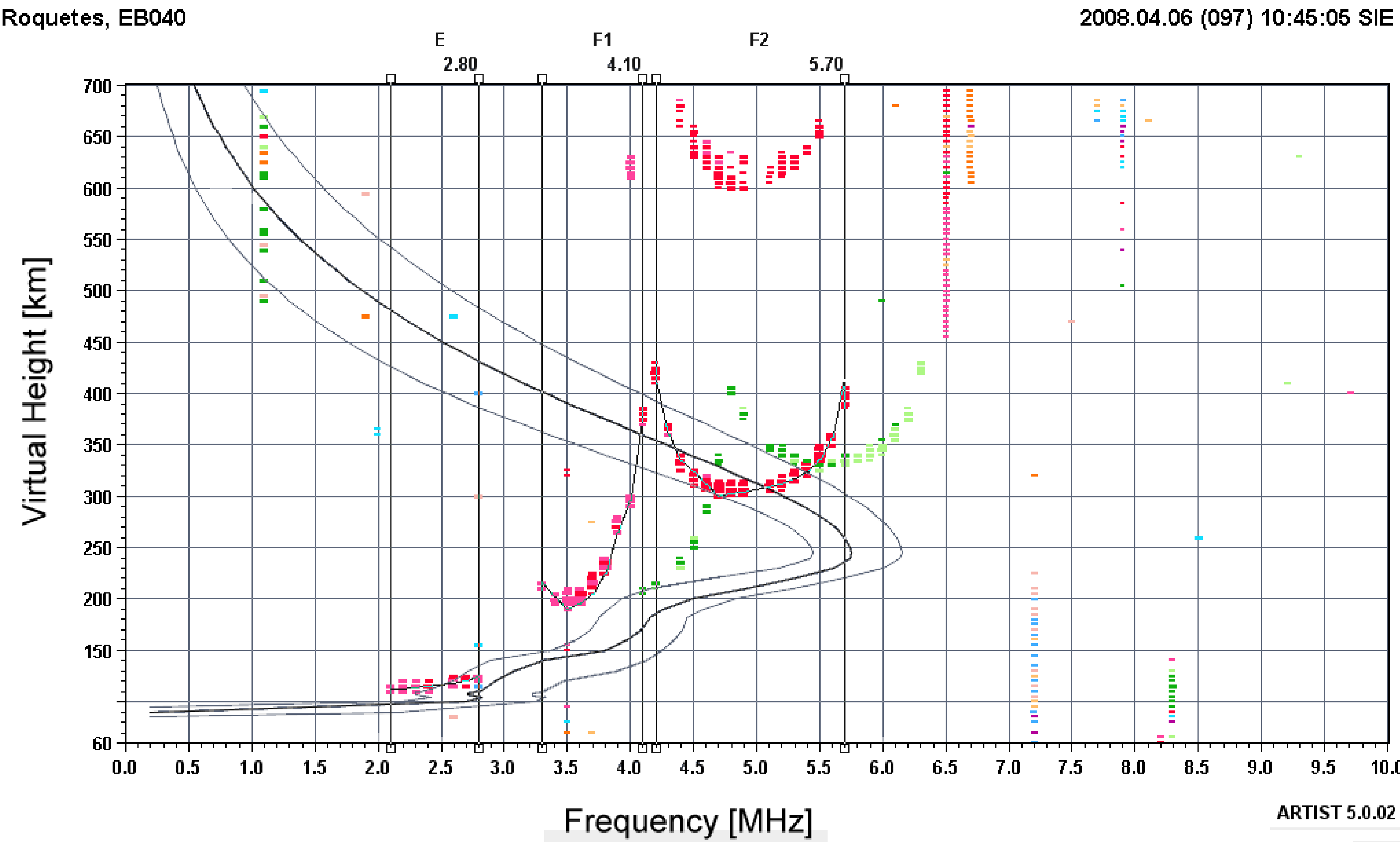
ARTIST-5 Confidence Score

- Determined automatically by inspecting both interpretation process and its outcome for anomalies
- Confidence Score ranges from 0 to 100
- Starting score is 100
- Confidence score is lowered each time a quality criterion is violated
- If final score gets below 50, the scaling is flagged as low confidence

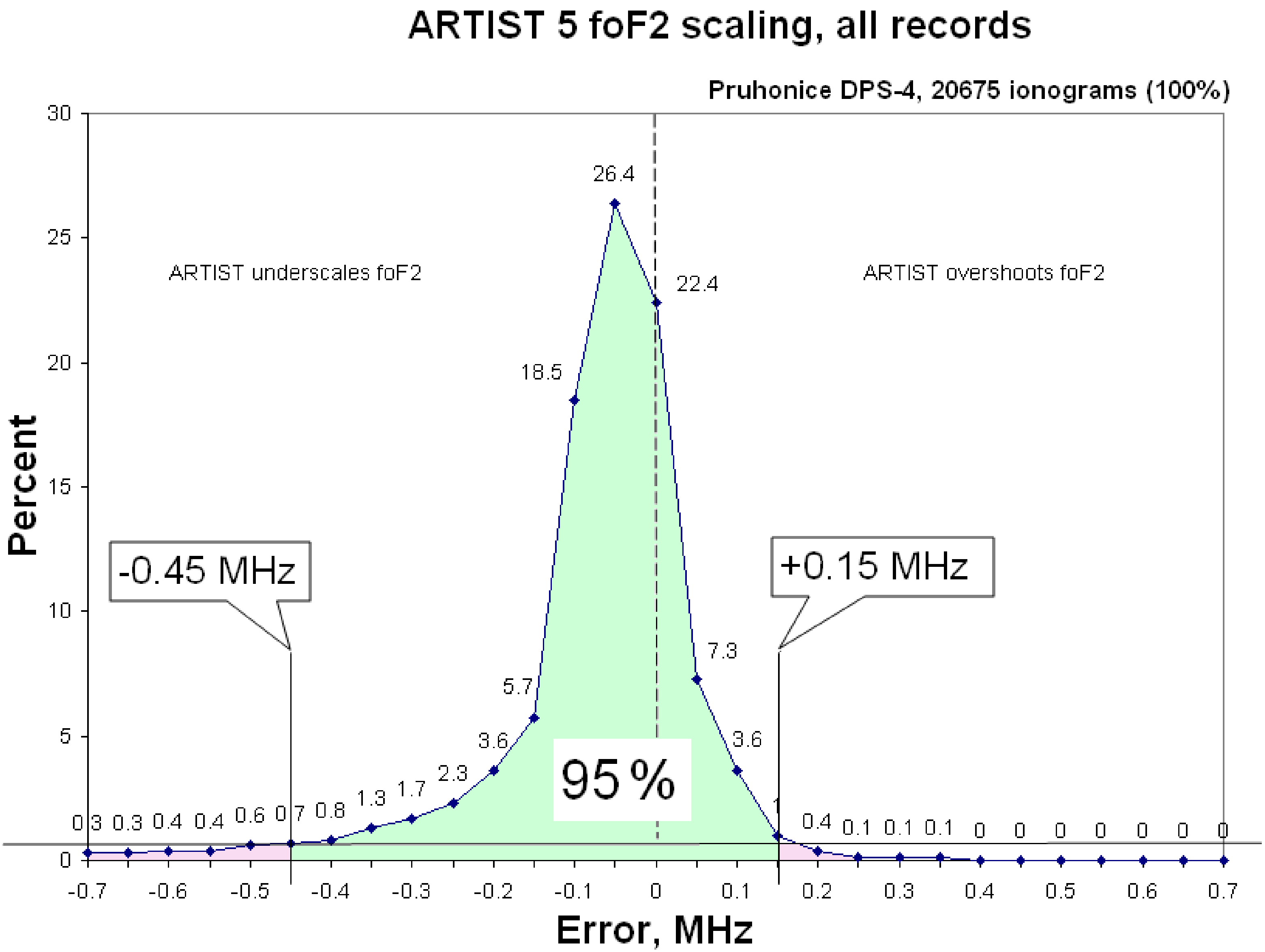
C. Characterize Uncertainty

- Probability that true value lies within the uncertainty bounds placed around given value
  - σ, 2σ, 3σ, 80%, 90%, 95% probability
- Frequently called “Error Bar” for a measured value
- Multiple sources of uncertainty:
  - Autoscaling errors
  - Model assumptions
  - Equipment and processing bias
  - HF propagation factors

Error Bounds and Error Boundaries

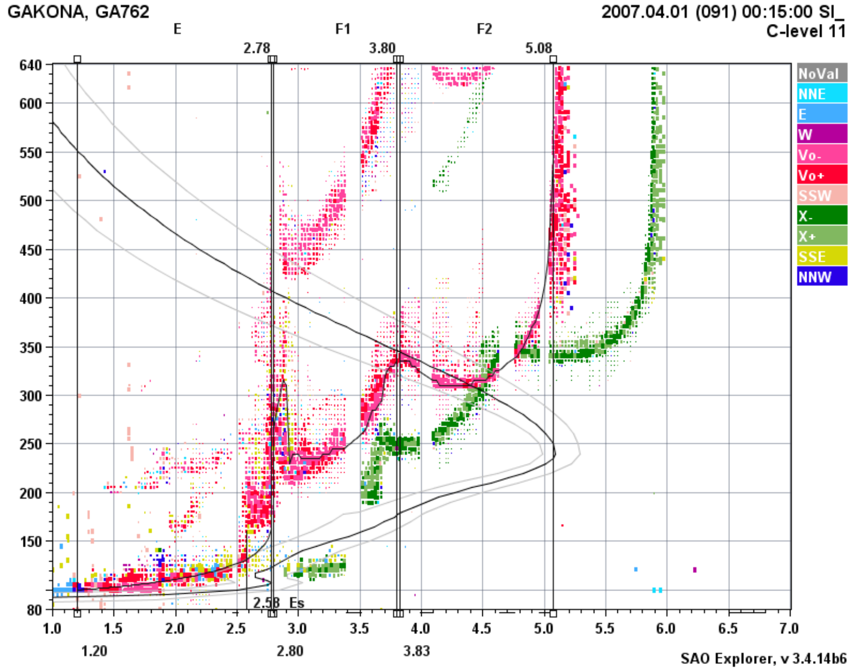


ARTIST foF2 – Manual foF2



Error Bar -> Uncertainty Bar

- For example, foF2:
  - Manual vs. automatic comparison produces the ERROR BAR for foF2
  - Then, when ARTIST scales a new ionogram, foF2 value is attributed the UNCERTAINTY BAR



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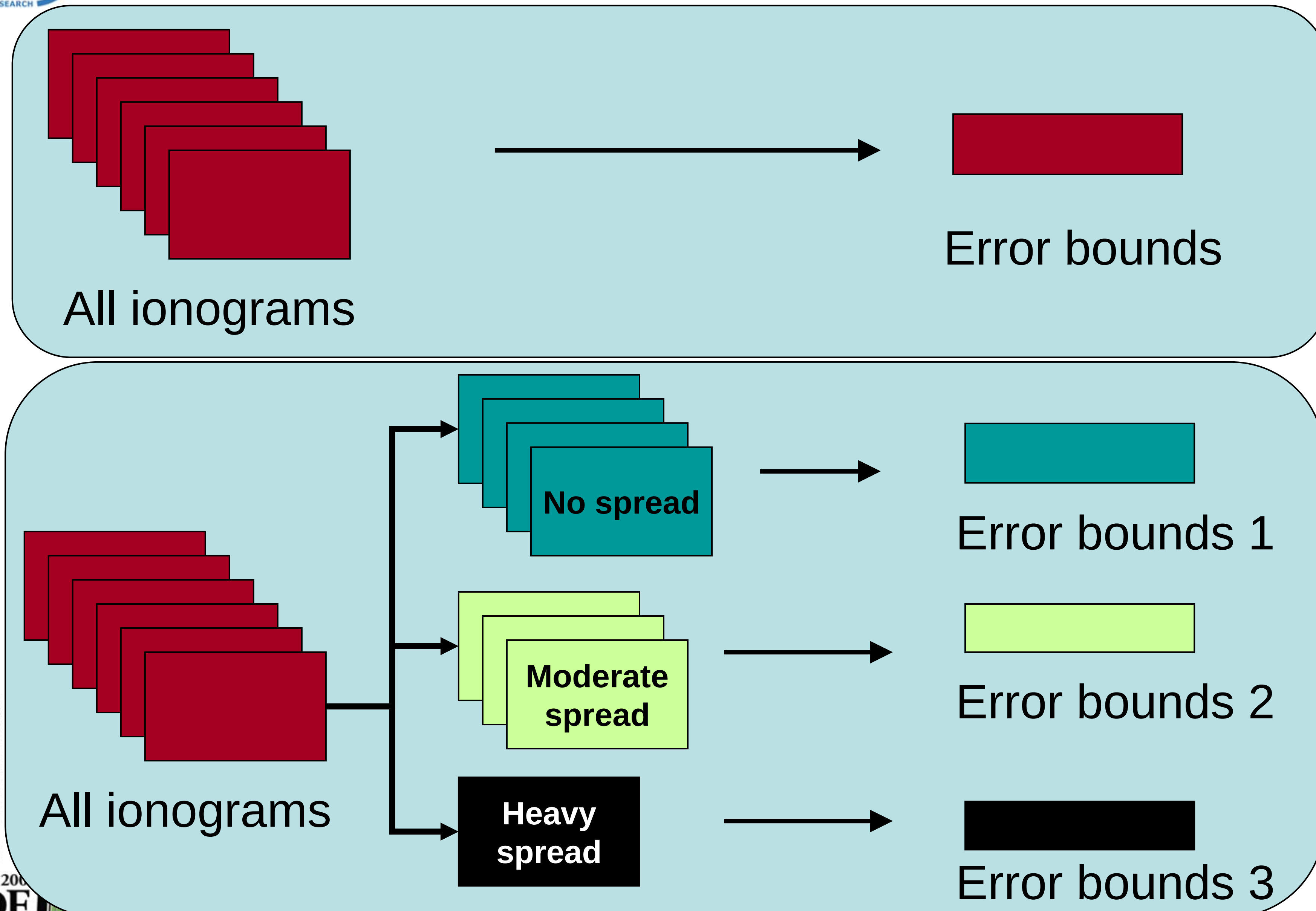
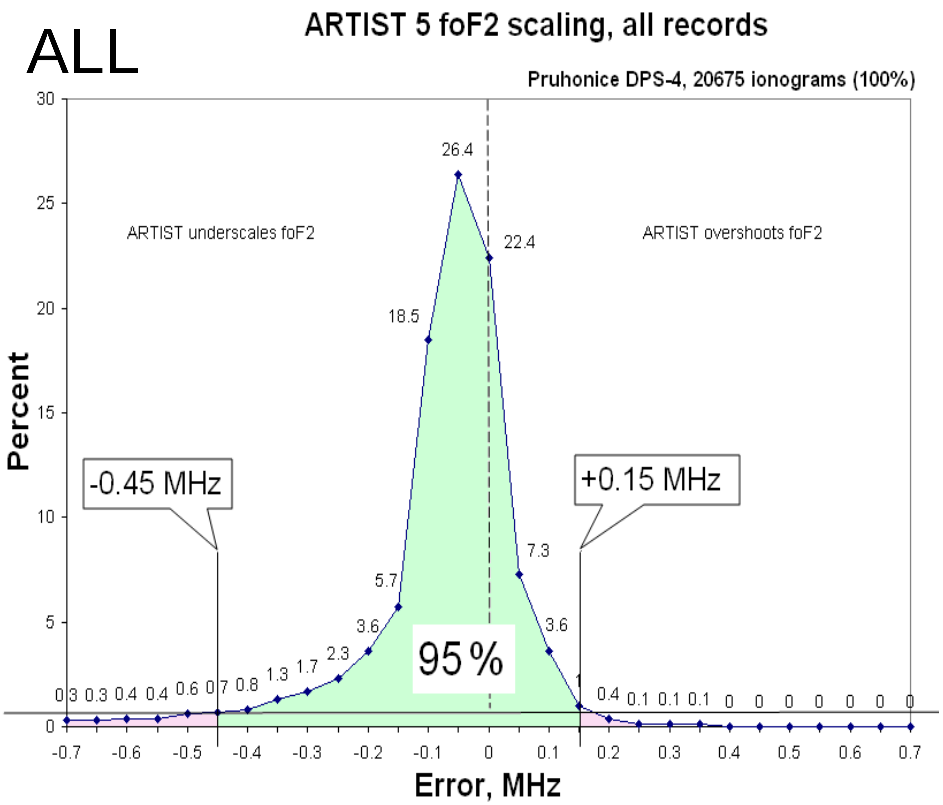
Automatic Spread-F Detection

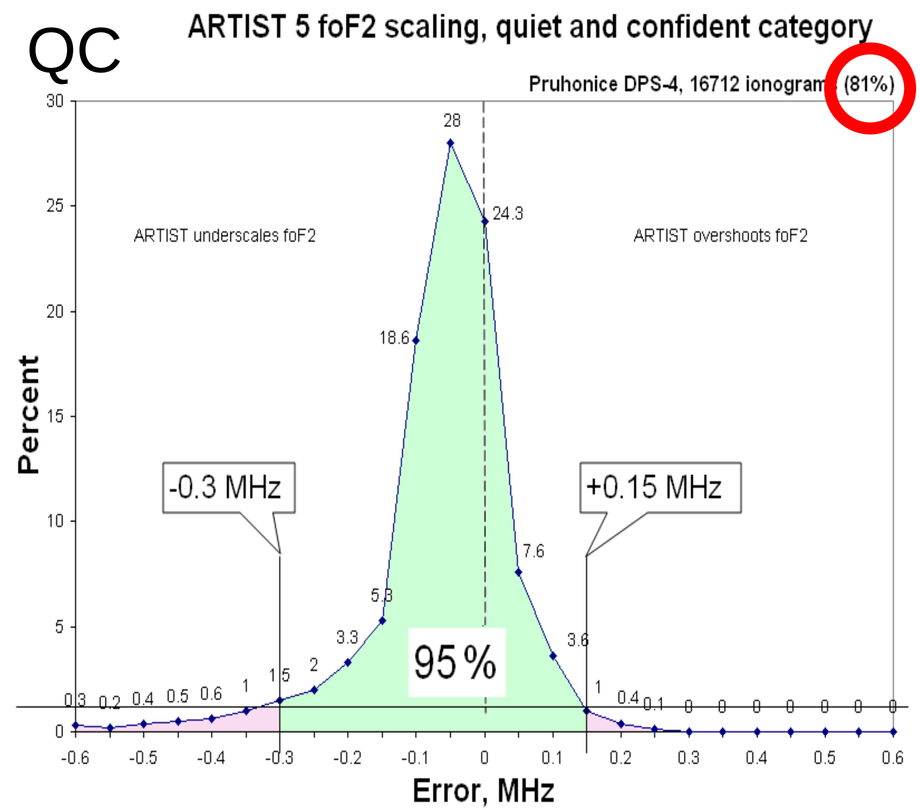


Ionogram Classification

- Qualification is tailored to each digisonde station individually
- THREE CLASSES:
  - Quiet ionosphere (no spread)
  - Moderately disturbed ionosphere
  - Heavily disturbed ionosphere
- TWO SUB-CLASSES in each class based on Autoscaling Confidence Level (ACL)
  - Confidently scaled ionograms (ACL=1)
  - Not confidently scaled ionograms (ACL=0)
    - Only confident (ACL=1) records are sent to assimilation

Quiet-Confident Category

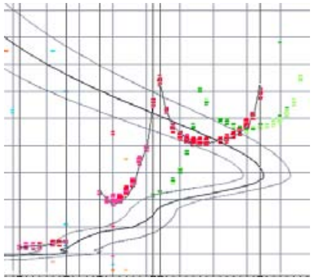




ARTIST-5 Error Bars

Digisonde 4D, mid-latitude station

Para meter	% ionograms with perfect match to manual value			Error bounds encompassing 95% of all cases (2σ) High ARTIST confidence		
	QC	**MC**	**HC**	**Quiet (23%)**	**Moderate (41%)**	**Heavy (23%)**
foF2	69%	60%	52%	-0.15 to +0.05 MHz	-0.25 to +0.25 MHz	-0.45 to +0.40 MHz
foF1	46%	31%	-	-0.05 to +0.10 MHz	-0.1 to +0.1 MHz	insufficient statistics
foE	40%	20%	-	-0.30 to +0.05 MHz	-0.45 to +0.25 MHz	insufficient statistics



Comparison Results for foF2

TABLE 3: ARTIST foF2 validation results. Error bounds are given at 95% probability level for ionograms in quiet & confident category.

Location	System	ARTIST version	Total manual ionograms	ACL=1 percentage of all ionograms	Lower bound foF2 MHz	Upper bound foF2 MHz	Unscalable ionograms % of all ionograms
Boulder, CO	DISS	4.5	47,261	82 %	-0.3	+0.3	8 %
Vandenberg	DISS	4	4,660	78 %	-0.7	+0.7	4 %
Dyess	DISS	4	6,881	87 %	-2.4	+1.0	3 %
Dyess	DISS	5	6,881	90 %	-0.3	+0.5	3 %
Roquetes	D-256	5	125,046	85 %	-0.3	+0.4	5 %
Grahamstown	DPS-4	5	5,251	85 %	-0.1	+0.2	1 %
Pruhonice	DPS-4	5	20,675	88 %	-0.15	+0.35	3 %
Gakona, AK	DPS-4	5	11,109	48 %	-0.25	+0.6	13 %

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Where do we go from here?

- Use of PR data prior to trace extraction
- Use of other echo parameters for trace extraction
- Better neural network model
- Baseline construction improvements

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SAO.XML

data exchange format for ionogram-derived data

Dr. Ivan Galkin

University of Massachusetts Lowell

Environmental, Earth, & Atmospheric Sciences Department

Center for Atmospheric Research

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SAO.XML 5 Project Status

Component	Prototyped	Released	Deployed
Data Model & Data Format	√	√	WWW
Schema	√	√	WWW
White Paper	√	√	WWW
Fortran R/W Library	√	√	WWW
URSI Standard	√	√	WWW
ARTIST	√	ARTIST 5.0.2.32	In progress
SAO Explorer	√	SAOX 3.4.11+	√
Dissemination	√	Dispatcher	√ DIDBase
User Applications	In progress	In Progress	RSA AFWA (soon)

digisondes

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Digisondes with ARTIST-5 and SAO.XML

- AR-5 with SAO.XML to DIDBase
  - Hermanus, RSA
  - El Arenosillo, Spain
  - Gakona, Alaska
- AR-5 with SAO to DIDBase
  - Pruhonice
  - Roquetes
  - Moscow
  - Rome
  - Kwajalein Is.
  - Jeju Is.
  - DISS: Eglin AFB, Pt. Arguello, Dyess AFB
- AR-5 with SAO.XML, no DIDBase connection yet
  - NEXION: Vandenberg AFB, Eglin AFB (soon)

AR-5 Candidates:

1. All NEXIONs
2. Juliusruh
3. Grahamstown
4. Madimbo
5. Louisvale
6. Jicamarca
7. Tromso
8. Port Stanley
9. Chilton

SAO.XML Information Central

- SAO.XML Homepage
  – http://ulcar.uml.edu/SAOXML/
- Topics
  – Format Specification (PDF), version Oct 2005
  – White paper on SAO.XML concept and design
  – Document Type Definition (schema)
  – Data Examples
  – FORTRAN 90 read/write library source code

SAO.XML homepage

SAO.XML Data Model Specification v5.0

Preprint of SAO.XML.5 paper given at XI Digisonde Forum, May 2007

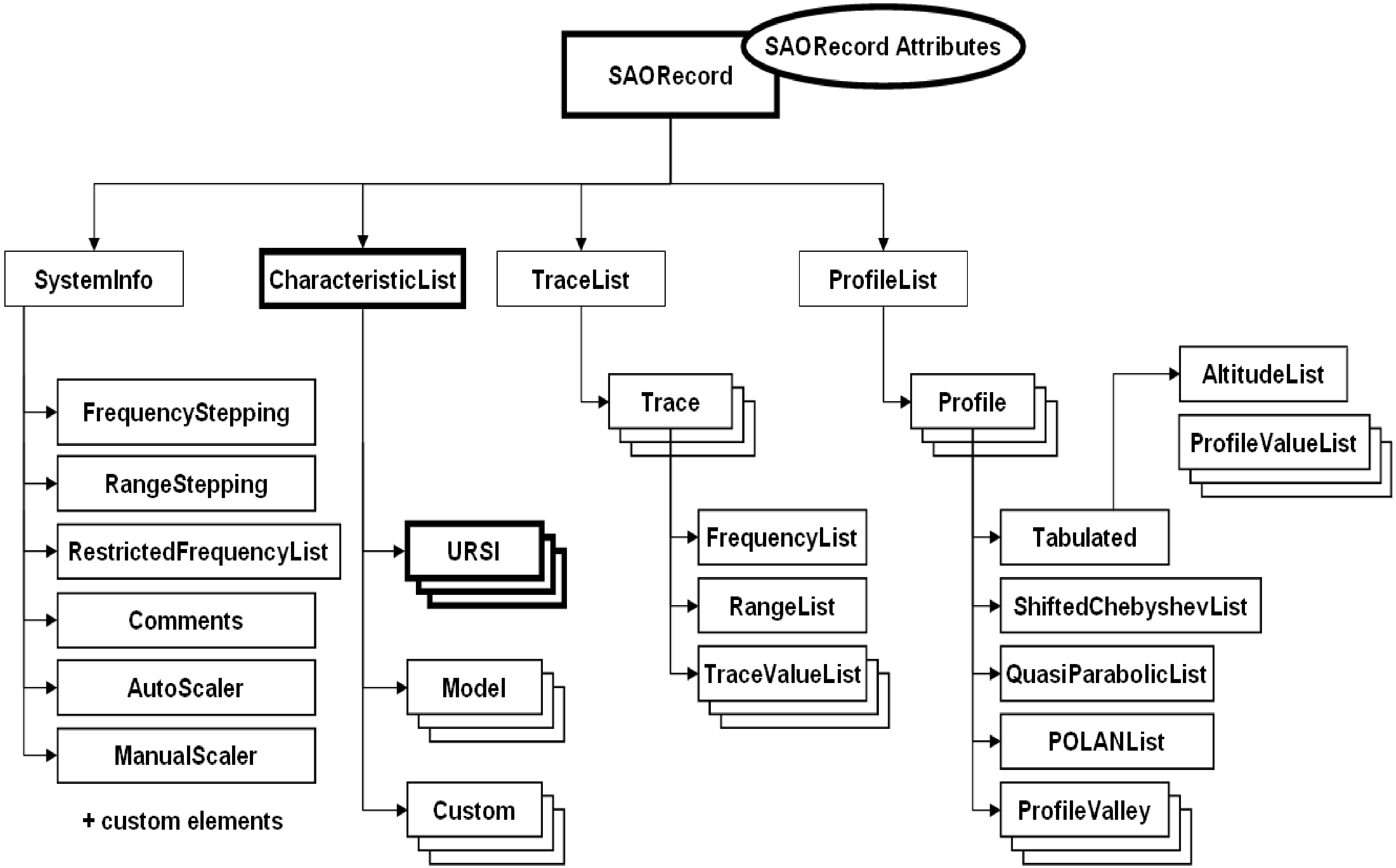
SAO.XML 5.0.1f: Document Type Definition (DTD)

SAO.XML 5.0: One Record example

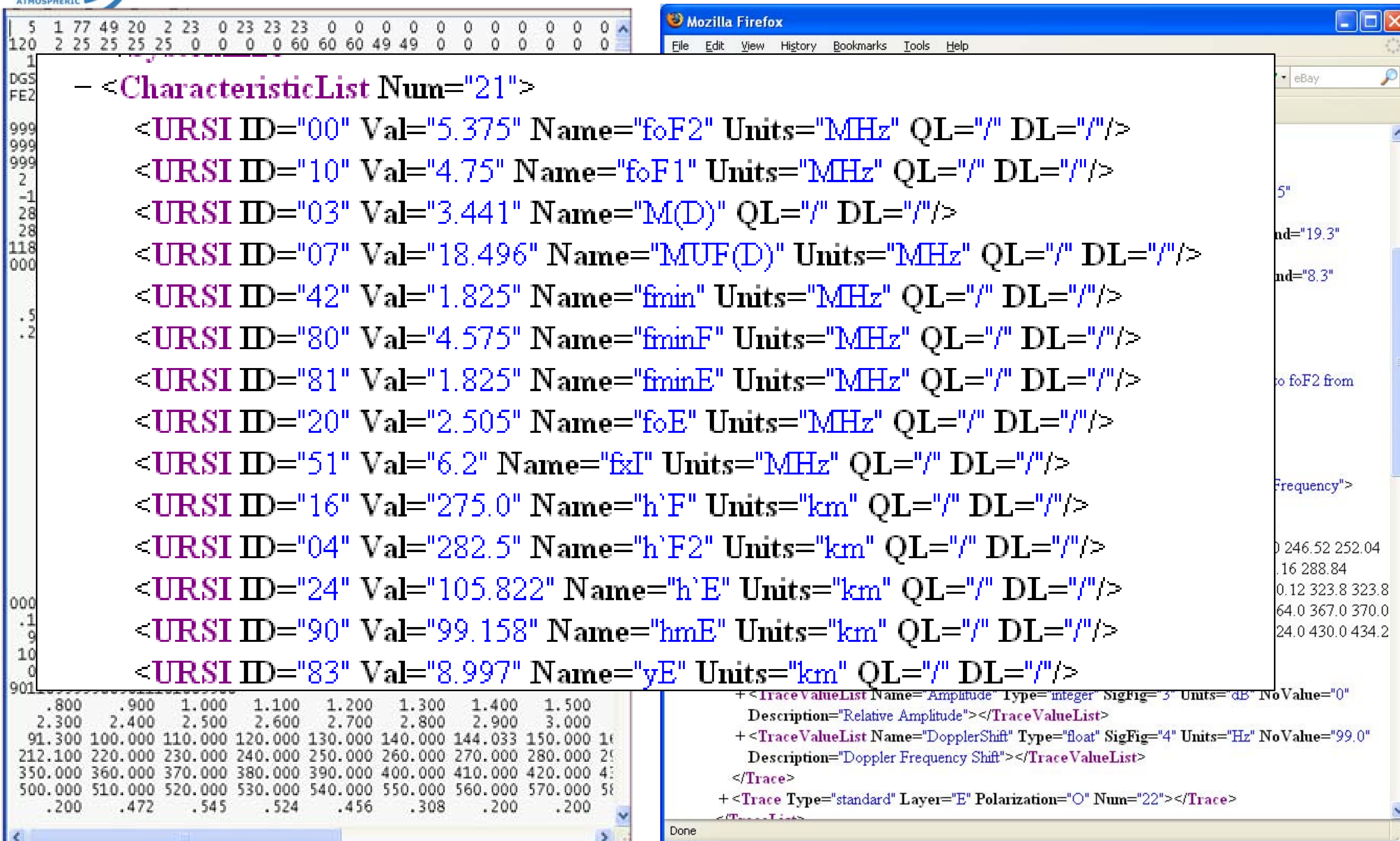
FORTRAN library for reading and writing SAO.XML 5.0 (g95 compiler)

http://ulcar.uml.edu/SAOXML/

SAO.XML Data Model



SAO.XML Readability



SAO 4.2

SAO.XML 5

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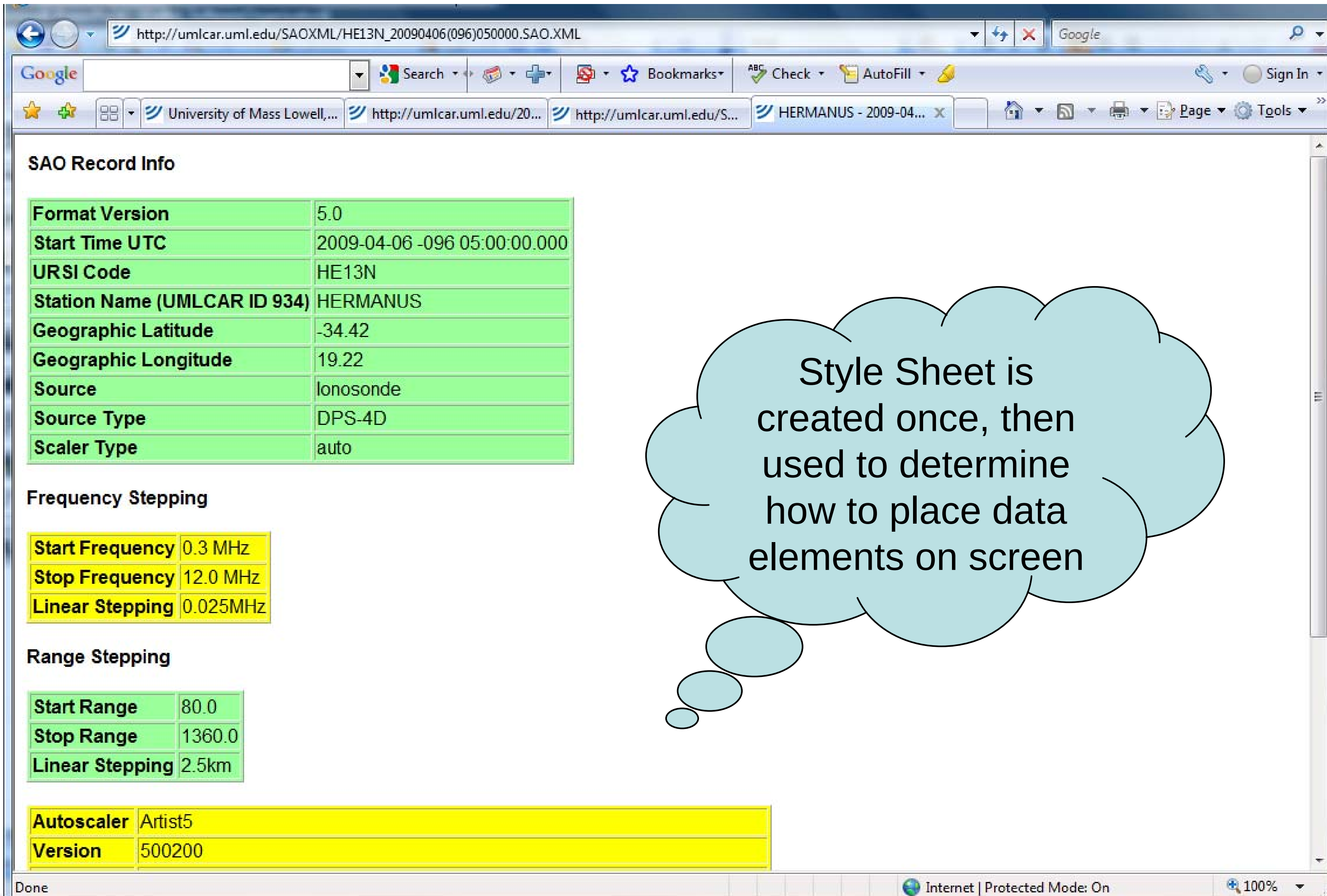
XML Style Sheets

for a nicer / simpler / friendlier display!



SAO Record Info

Format Version	5.0
Start Time UTC	2009-04-06 -096 05:00:00.000
URSI Code	HE13N
Station Name (UMLCAR ID 934)	HERMANUS
Geographic Latitude	-34.42
Geographic Longitude	19.22
Source	Ionosonde
Source Type	DPS-4D
Scaler Type	auto

Frequency Stepping

Start Frequency	0.3 MHz
Stop Frequency	12.0 MHz
Linear Stepping	0.025MHz

Range Stepping

Start Range	80.0
Stop Range	1360.0
Linear Stepping	2.5km

Autoscaler	Artist5
Version	500200

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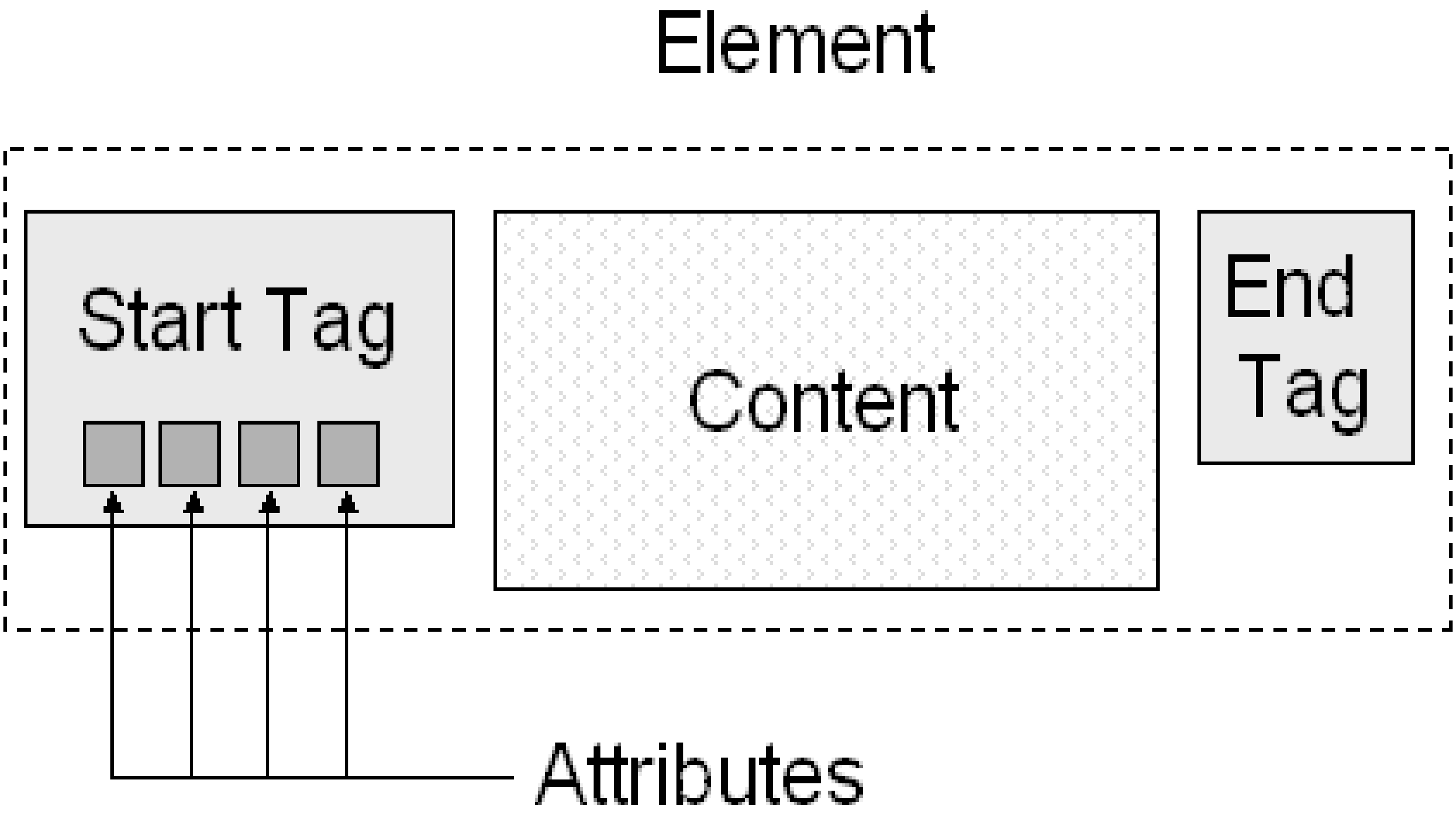
Work by Dan Khmyrov and Steve Mendonca

Data Elements



Features: Upward Compatibility

- Start and End Tags serve to allow OLD software to read NEW data files
  - Old software can skip new, previously unknown data elements
  - No need to update software to sustain operations through SAO data format updates
- Example: format converter from SAO.XML to EDP2 for GAIM model operated at AFWA
  - Addition of foF3 to <CharacteristicList>
  - Addition of <Tracelet> element and new kind of <TraceValueList>

Operational freedom not possible with previous SAO versions

Key Concepts

- Simplifications:
  - No links between elements
  - Use of attributes instead of elements, where possible
  - Separate storage of multiple scalings of the same ionogram
- No ionogram data
- Storage of tables by column

Ownership of SAO.XML

- SAO.XML Task Force at INAG
  - Data Model
  - Data Format & Dictionary
  - Technology & Software Support
- Previous Contributors
  - Terence Bullett, Rob Redmon, Ray Conkright, Eric Kihn, Nick Zabotin (NGDC/CIRES)
  - Richard Stamper (UKSSDC, COST 296)
  - Martin Jarvis (BAS)
  - Iwona Stanislawska (COST 296)

Fundamental Principles of NHPC true height inversion from ionograms

Xueqin Huang

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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11 - 14 MAY 2009

Rays in inhomogeneous media

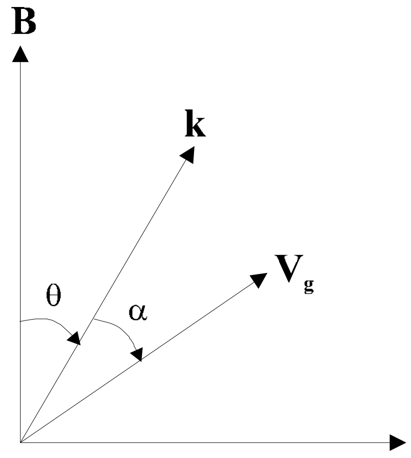
- Approximation of geometry optics.
- Ray=the trace of energy for a wave traveling in a medium.
- For magnetized plasma, a ray is, in general, traveling in a direction deviated from the wave normal.

Group Velocity

- **GROUP VELOCITY**: the velocity of wave energy traveling in the anisotropic plasma

Three components in the spherical coordinate:

$$\begin{cases} v_{gk} = \dfrac{c}{\partial(n\omega)/\partial\omega} \\ v_{g\theta} = -v_{gk}\dfrac{1}{n}\dfrac{\partial n}{\partial\theta} \\ v_{g\phi} = -v_{gk}\dfrac{1}{n\sin\theta}\dfrac{\partial n}{\partial\phi} \end{cases}$$

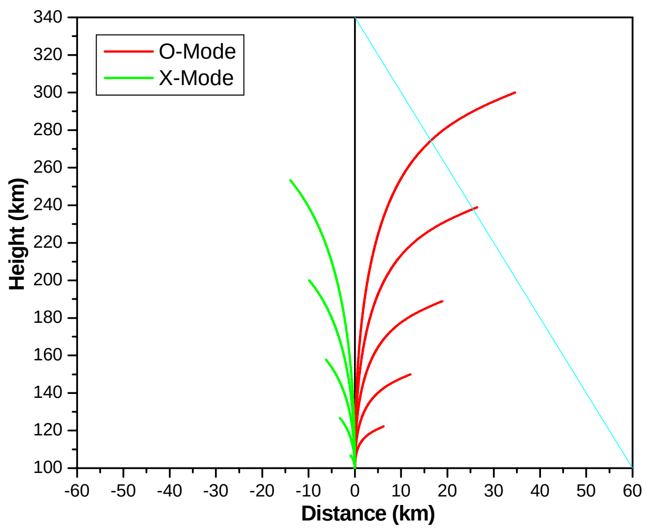


The amplitude:

$$v_g = \frac{c}{\cos\alpha\partial(n\omega)/\partial\omega} = \frac{v_{gk}}{\cos\alpha}$$

$$\tan\alpha = -\frac{1}{n}\frac{\partial n}{\partial\theta} = \mp\frac{Y(n^2-1)\sin\theta\cos\theta}{\left[Y^2\sin^4\theta+(1-X)^2\cos^2\theta\right]^{\frac{1}{2}}}$$

Virtual Height



If a wave with frequency f is incidant to the ionospher and reflected back to the sounder, the traveling time is

$$t(f) = 2\int_0^{r_t} \frac{ds}{v_g(f)}$$

The vitual height is defined as

$$h'(f) = \frac{t}{2c} = \frac{1}{c}\int_0^{r_t} \frac{ds}{v_g(f)}$$

If the ionosphere is horizontally stratified, the the virtual height is simplified to

$$h'(f) = \int_0^{h_r} \mu'(f)dh$$

where $\mu'(f)$ is called the group refractive index,

$$\mu'(f) = \frac{\partial(nf)}{\partial f}$$

Inversion Method

Assuming the apparent ranges $h'(f_k)$ were determined for a set of frequencies $f_k(k=1,2,\ldots,K)$, we want to find the electron density profile $N(z)$ or plasma frequency $fN(z)$ from the integral equation:

$$h'(f_k) = \int_0^{Z_{rk}} \mu'[N(z), f_k, fH(z), \theta(z)]dz$$

where

$\mu' = group \quad index \; of \; refractive$

$fH(z) = gyrofrequency$

$\theta(z) = dip \quad angle$

Difficulties in Inversion

- At the reflection point, where the refractive equals zero, the integrand approaches infinity.
- At the layer cusp, the virtual height approaches infinity.
- There are data gaps in the trace, even the trace for the whole layer (E or F1 layer) is missing.
- Treatment for the E-F valley.

Integral Equation

- Introducing the reduced frequency

$$f'^2_k = \begin{cases} f_k^2 & , for \quad O - trace \\ f_k^2 - f_k \cdot fH_r & , for \quad X - trace \\ f_k^2 + f_k \cdot fH_r & , for \quad Z - trace \end{cases}$$

$$f_k' = fN(Z_r)$$

- Changing the variable

$$t^2 = \frac{f'^2_k - fN^2(z)}{f'^2_k - fN_S^2}$$

- The integral equation becomes

$$h'(f_k) = 2(f'^2_k - fN_S^2)\int_0^1 \mu' \cdot t \left[\frac{dz}{dfN^2}\right] dt$$

The Profile of a Layer

- When the electron density profile is given as

$$Z = A_m + g^{1/2} \sum_{i=0}^{I} A_i T_i^*(g), \qquad with \qquad g = \frac{\ln(fN / fN_m)}{\ln(fN_S / fN_m)}$$

- the apparent range *h´* is related to the polynomial coefficients by

$$h'(f_k) = \sum_{i=0}^{I} A_i S_{ik}$$

$$S_{ik} = \frac{f'^2_k - fN^2_S}{2\ln(fN_S / fN_m)} \int_0^1 \frac{\mu' \cdot t}{fN^2 g^{1/2}} \left\{ T_i^*(g) + 2g \frac{dT_i^*(g)}{dg} \right\} dt$$

Linear Equations for Coefficients

- The best coefficients in a least squares sense are found by minimizing the error

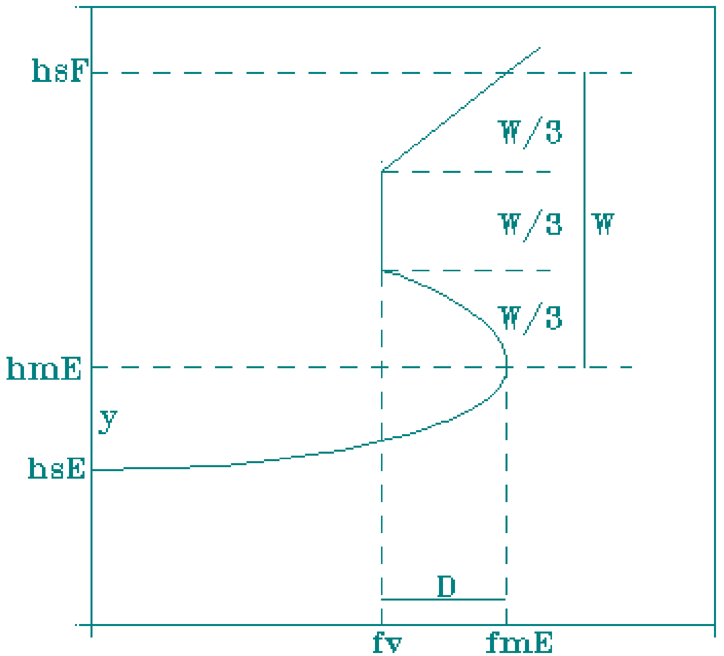
$$\varepsilon = \sum_{k=1}^{K}\left[p'_k - \sum_{i=1}^{I} A_i S_{ik} \right]^2$$

- Linear equations for coefficients

$$\sum_{i=0}^{I} A_i Q_{ij} = \sum_{k=1}^{K} P'_k S_{jk}, \qquad j = 0,1,\ldots I$$

$$Q_{ij} = \sum_{k=1}^{K} S_{ik} S_{jk}$$

Valley Model



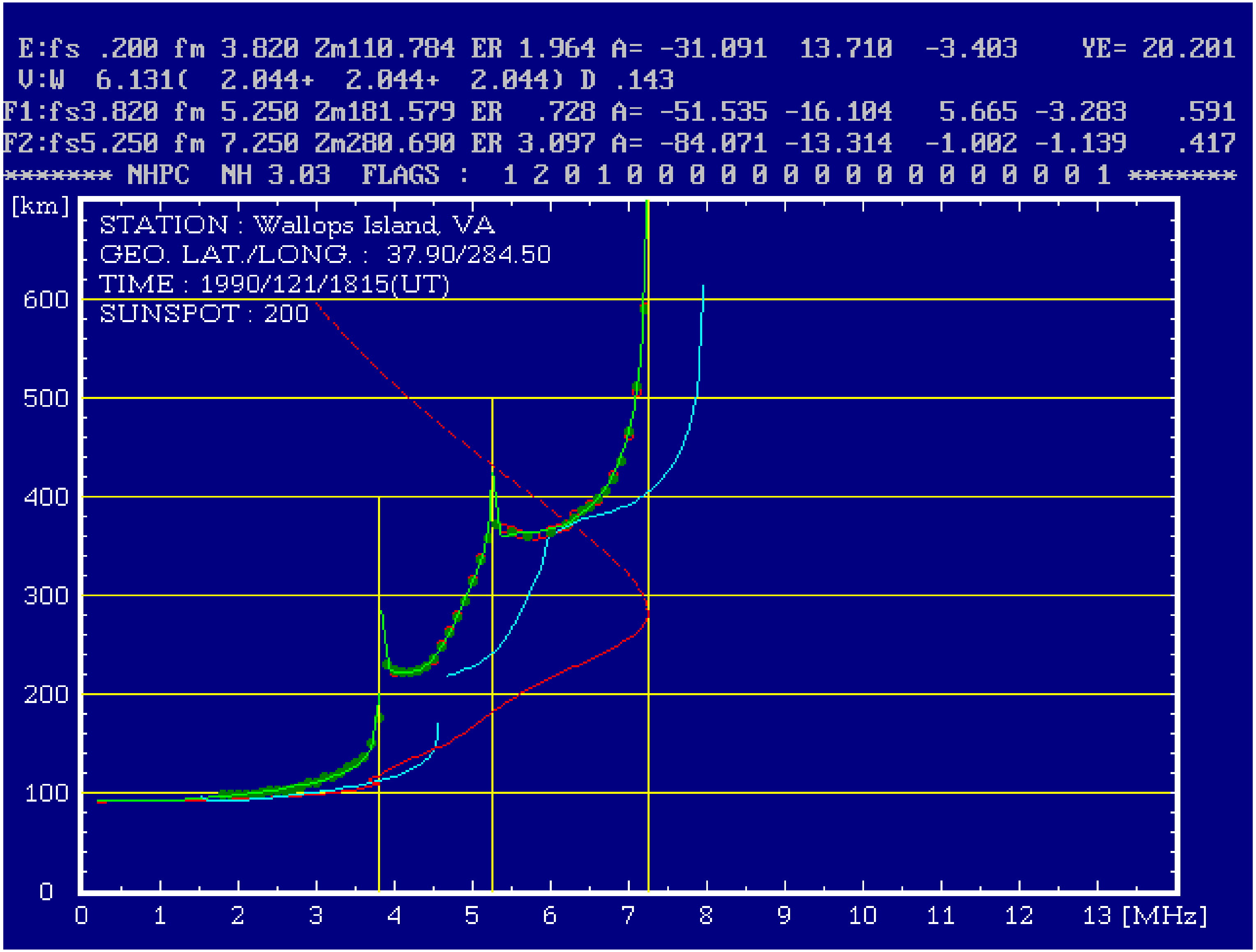
*Incoherent scatter radar measurements show that

~The E layer always exists even at nighttime although ionosondes hardly observe it.

~There is a valley between the E and F layers.

*NHPC uses CCIR Predicted E Model if no E-trace observed.

*The E/F valley is modeled based on the analysis by K.K. Mahajan of incoherent scatter radar measurements.

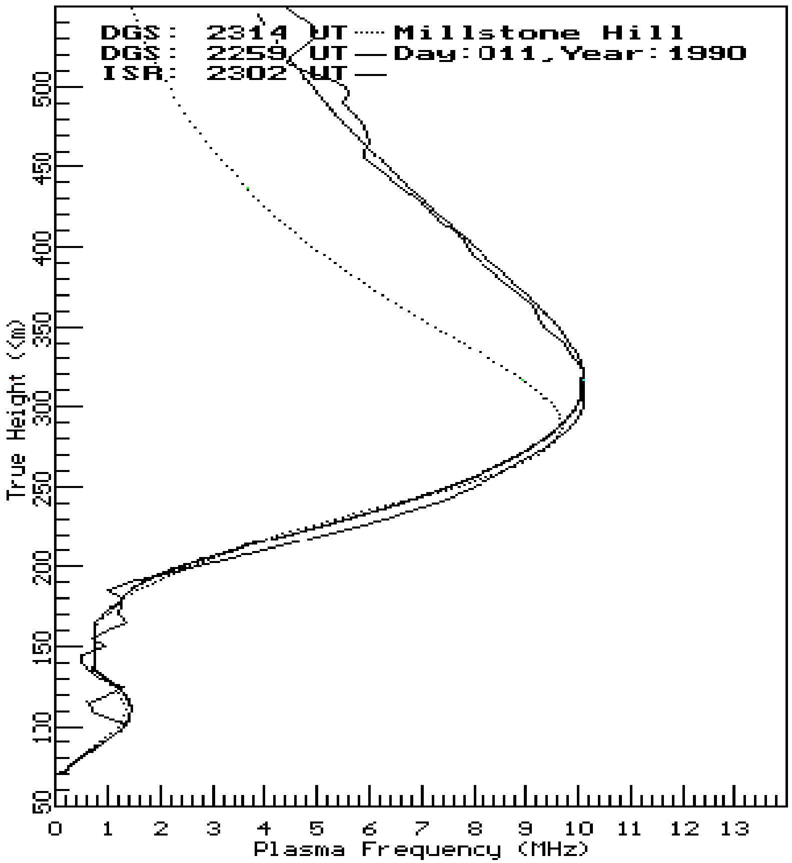

E:fs .200 fm 3.820 Zm110.784 ER 1.964 A= -31.091 13.710 -3.403 YE= 20.201
V:W 6.131(2.044+ 2.044+ 2.044) D .143
F1:fs3.820 fm 5.250 Zm181.579 ER .728 A= -51.535 -16.104 5.665 -3.283 .591
F2:fs5.250 fm 7.250 Zm280.690 ER 3.097 A= -84.071 -13.314 -1.002 -1.139 .417
******** NHPC NH 3.03 FLAGS : 1 2 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 ********
[km]
STATION : Wallops Island, VA
GEO. LAT./LONG. : 37.90/284.50
TIME : 1990/121/1815(UT)
SUNSPOT : 200
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13 [MHz]

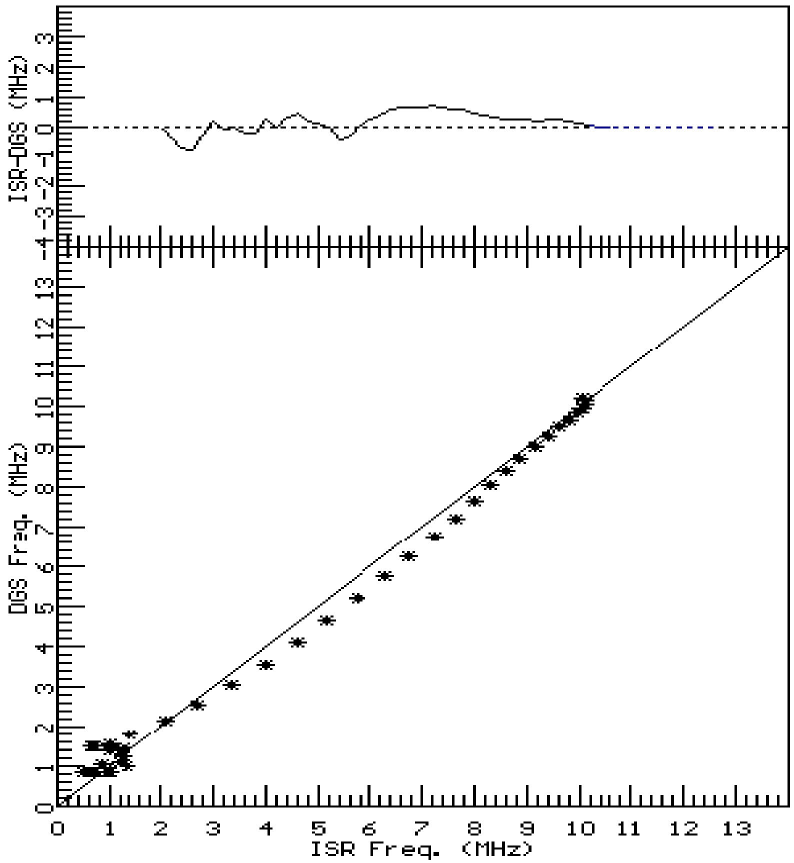
Comparisons with incoherent scatter radar measurements

- Several thousand inverted profiles from Digisonde ionograms at Millstone Hill (42.6N,284.5E) and Arecibo (18.5N,292.9E) were compared with the colocated incoherent scatter radar measurements for 1990-1996

  (C.C. Chen, et al., 1992; 1994).
- Comparison summary:
  - (1) The differences in the upper F layer are in the average less than 5 km;
  - (2) The valley model is very good in general, but during the twilights or ionosphere storms larger deviations occur.
  - (3) The CCIR model for predicting E layer is very good.

One example for comparison of DGS and ISR profiles

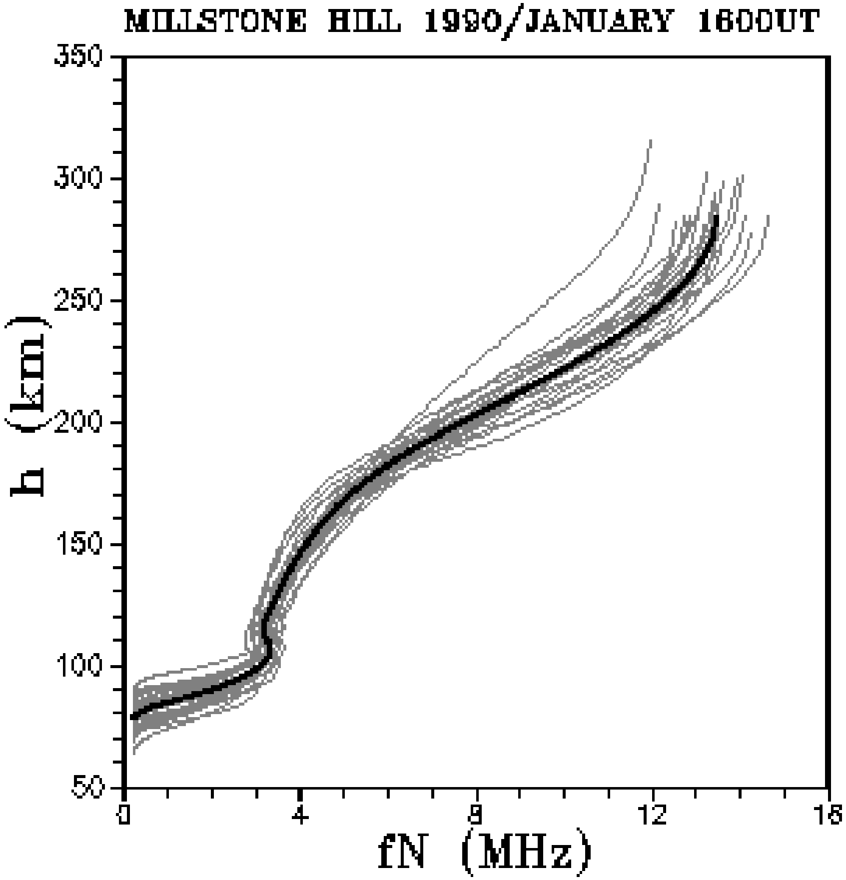




NHPC

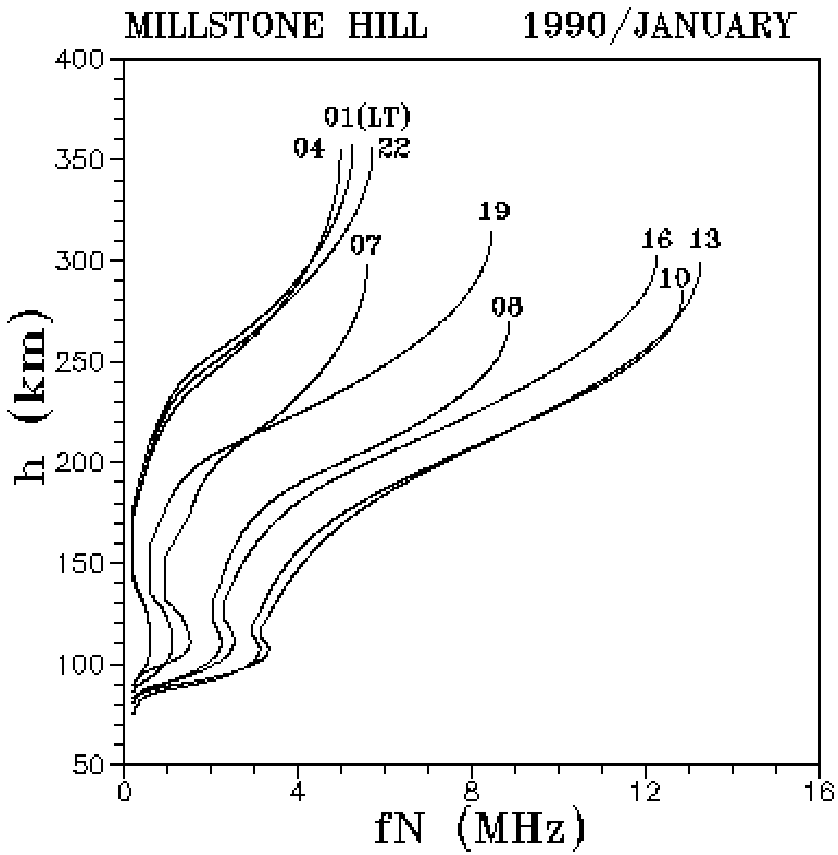
- NHPC used in ARTIST and SAO-Explorer.
- NHPC stand alone version.

ARP - Average Representative Profile



- A method to find the average for a set of profiles.
- It can be used to calculate the monthly averages (MARP) for comparison with models such as IRI.

MARP -
Monthly Average Representative Profile



Diurnal variation of the MARPs for January 1990 at Millstone Hill.

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Modeling the Topside profiles

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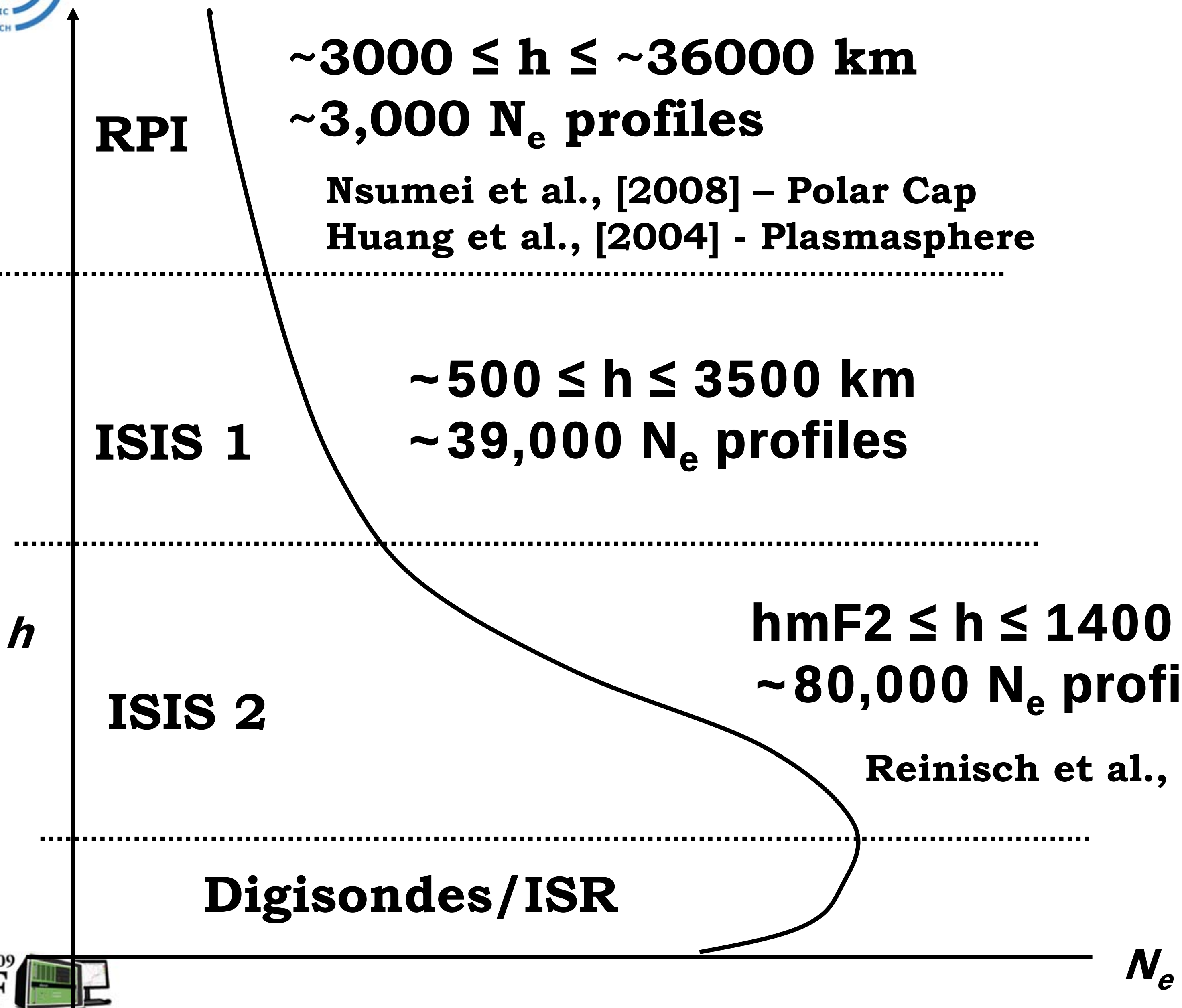
Approach

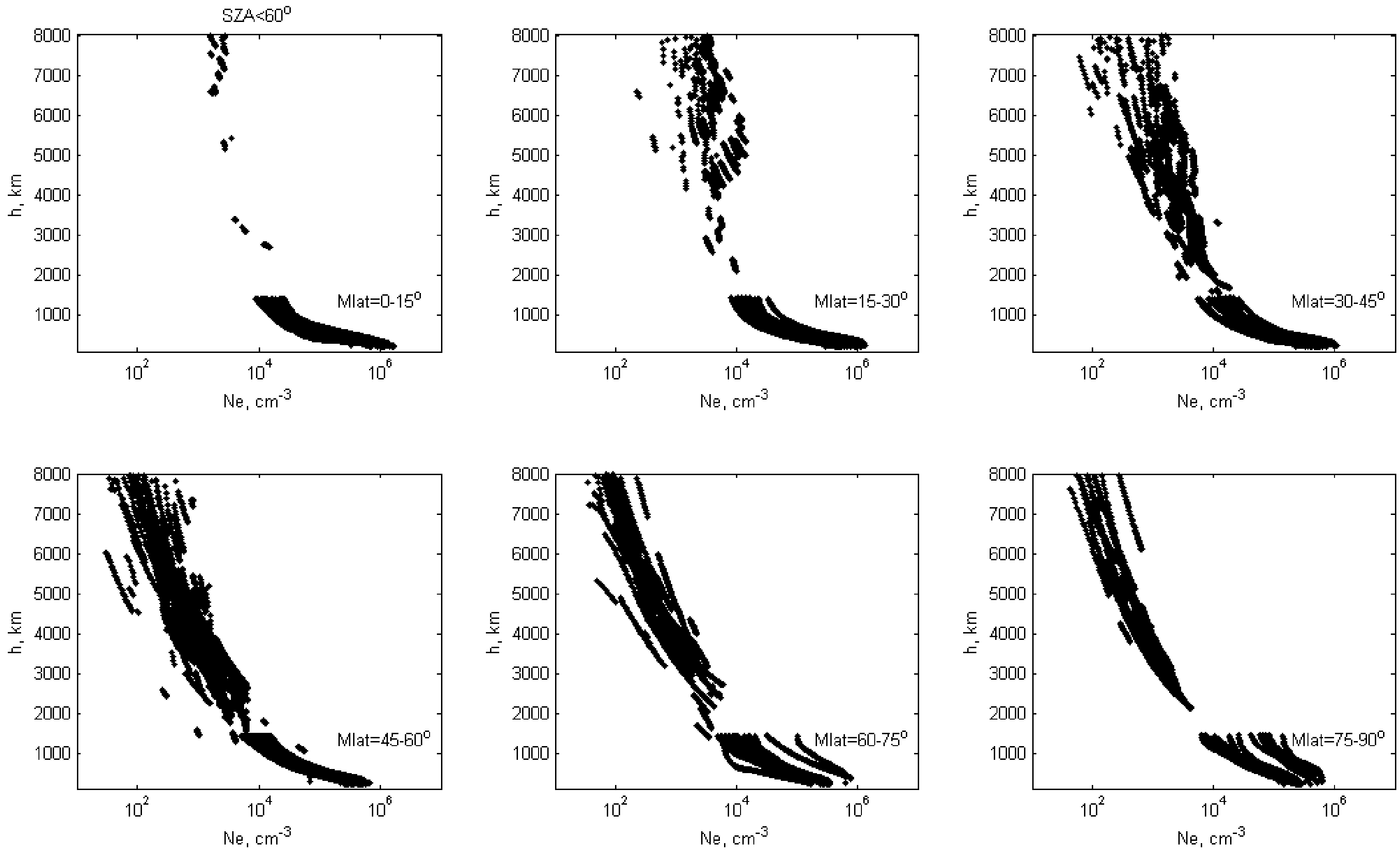
1. Use ~80,000 measured ISIS profiles.
2. Compare topside and bottom-side peak parameters.
3. Modeling: Express profiles as Vary-Chap functions. Find
   - Scale height function H(h) and its value Hm_T at hmF2
4. Develop model of H(h)/Hm as function of MLT,Latitude and Season.

Database

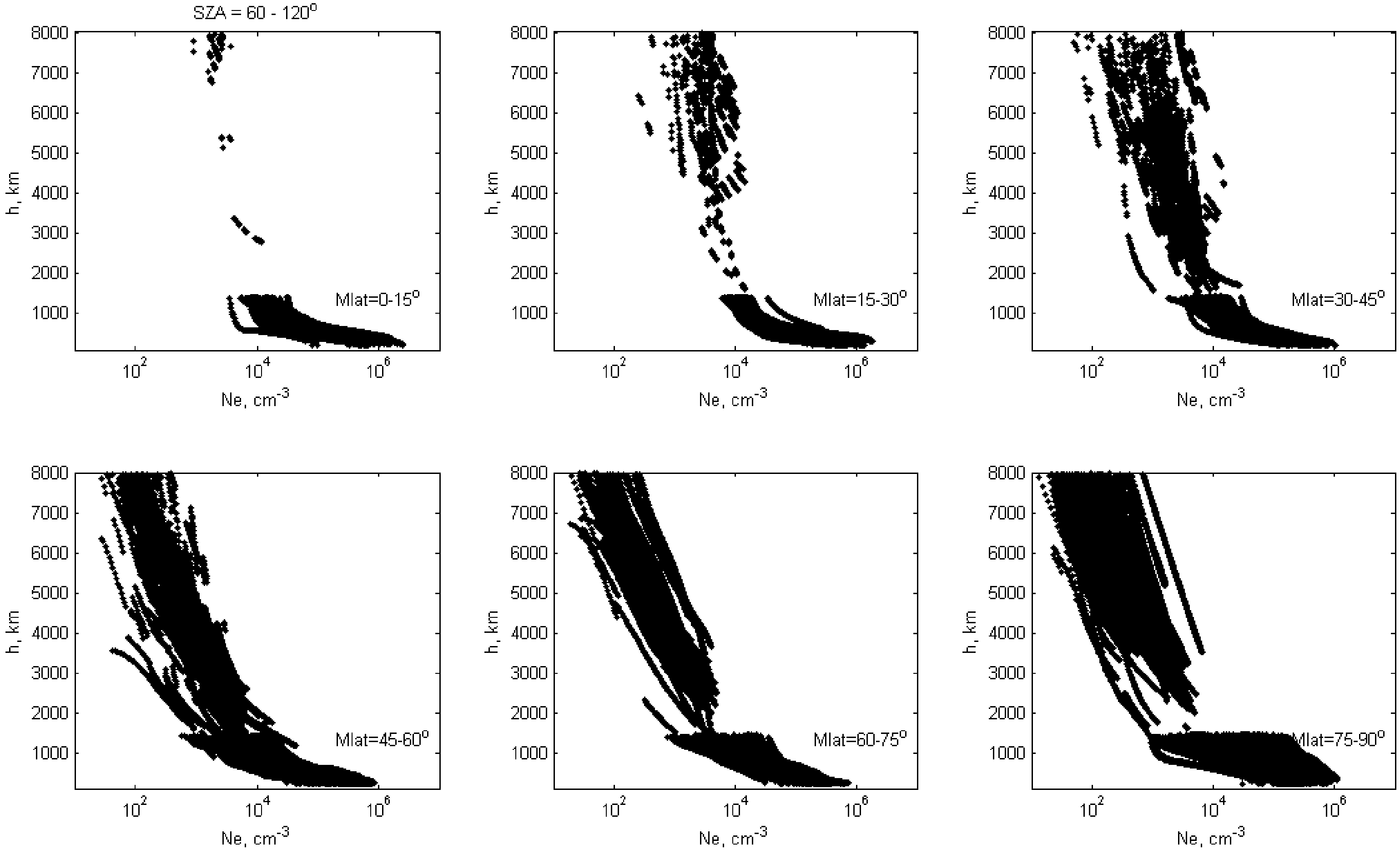


~3000 ≤ h ≤ ~36000 km
~3,000 N_e profiles
RPI
Nsumei et al., [2008] – Polar Cap
Huang et al., [2004] - Plasmasphere
~500 ≤ h ≤ 3500 km
~39,000 N_e profiles
ISIS 1
h
hmF2 ≤ h ≤ 1400 km
~80,000 N_e profiles
ISIS 2
Reinisch et al., [2007]
Digisondes/ISR
N_e

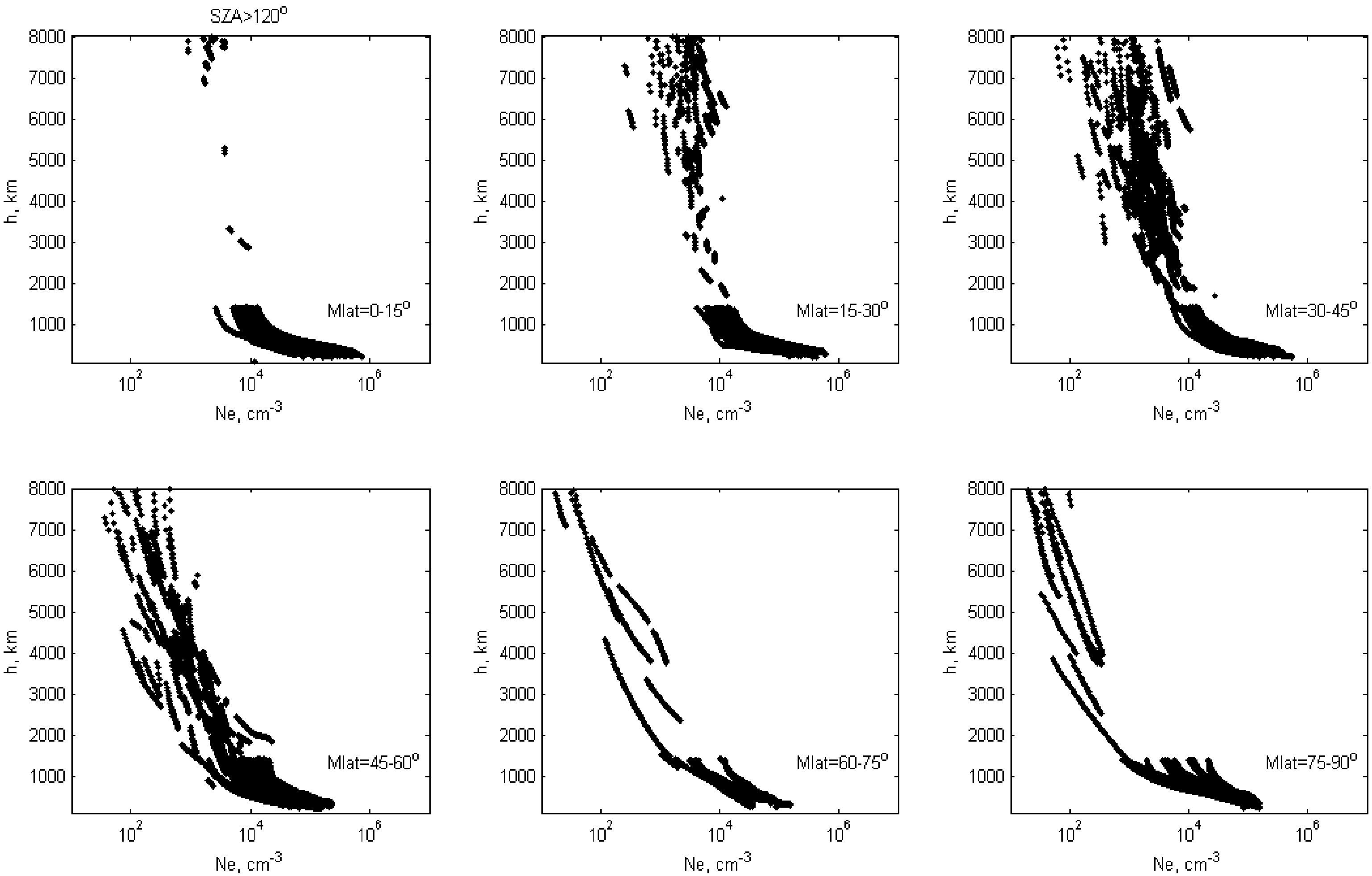
ISIS 2 and RPI data (SZA < 60°)



ISIS 2 and RPI Data
(SZA < 60-120°)



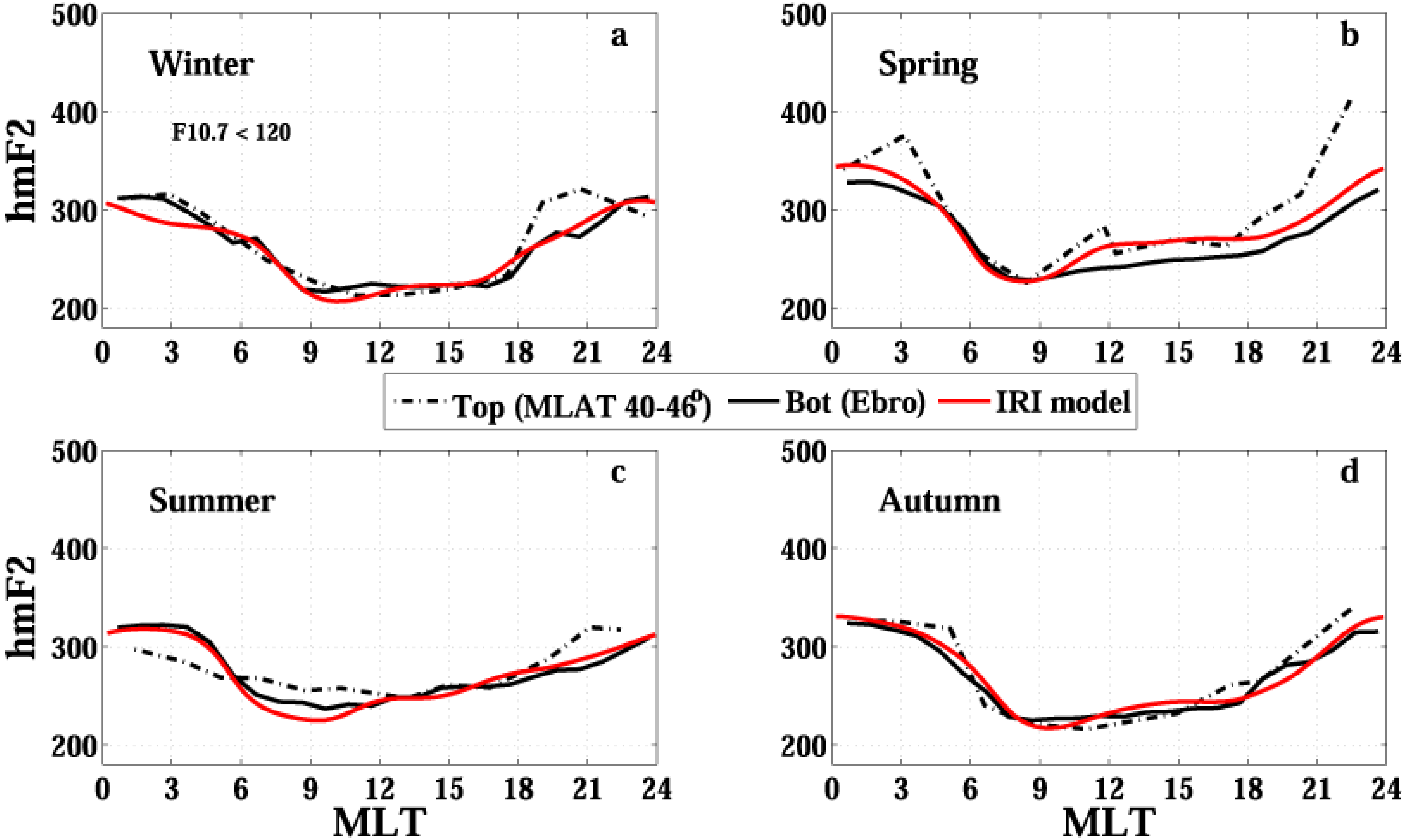
ISIS 2 and RPI data (SZA < 120º)



Comparison of topside and bottom-side peak parameters

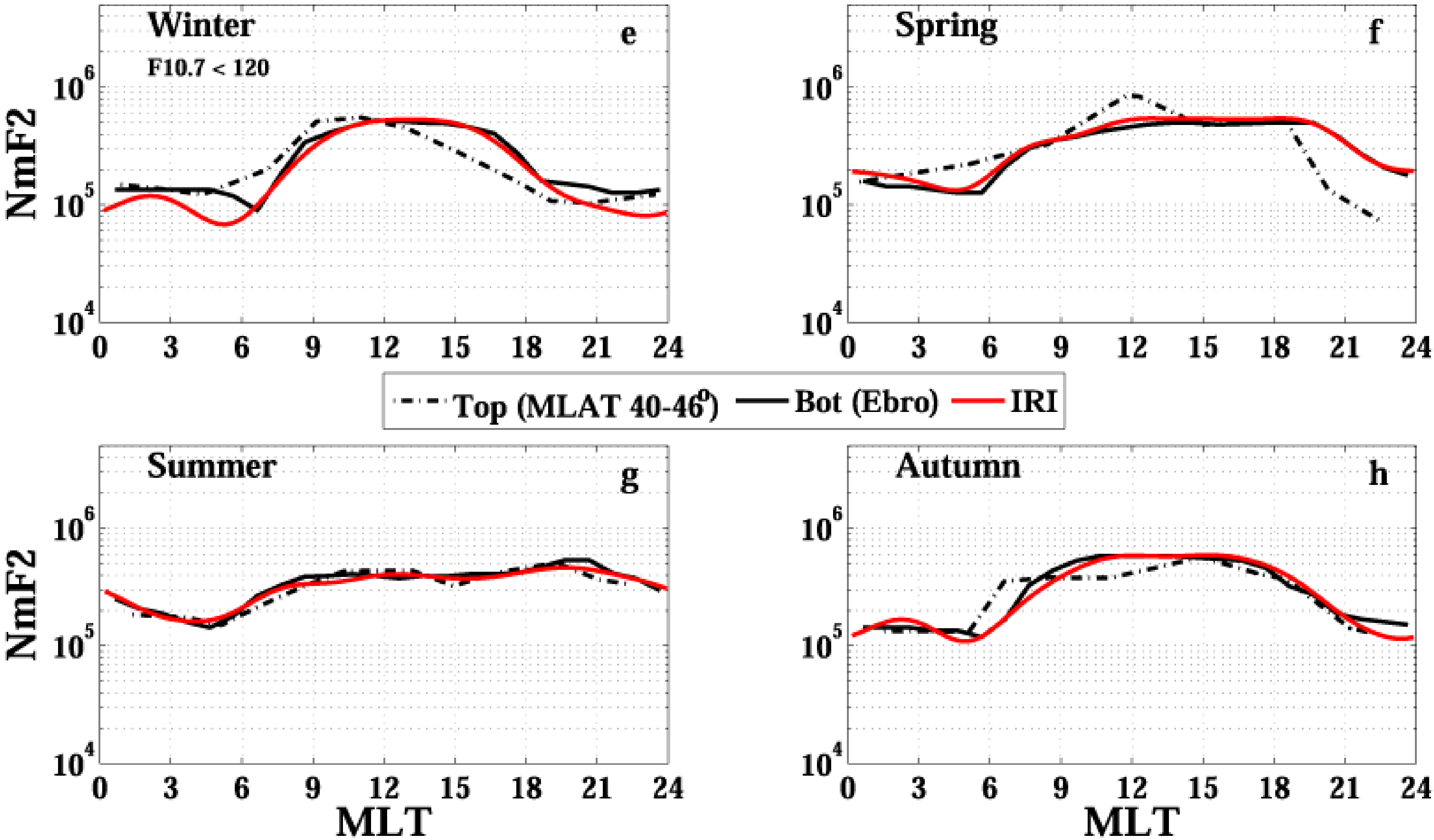
hmF2 and NmF2
(Kp < 3)

Ebro h_{mF2}



Winter
a
F10.7 < 120
Spring
b
Summer
c
Autumn
d
hmF2
MLT
500
400
300
200
0
3
6
9
12
15
18
21
24
Top (MLAT 40-46°)
Bot (Ebro)
IRI model

Ebro N_{mF2}


Winter
e
F10.7 < 120
Spring
f
Summer
g
Autumn
h
NmF2
MLT
Top (MLAT 40-46°)
Bot (Ebro)
IRI
10^4
10^5
10^6
0 3 6 9 12 15 18 21 24

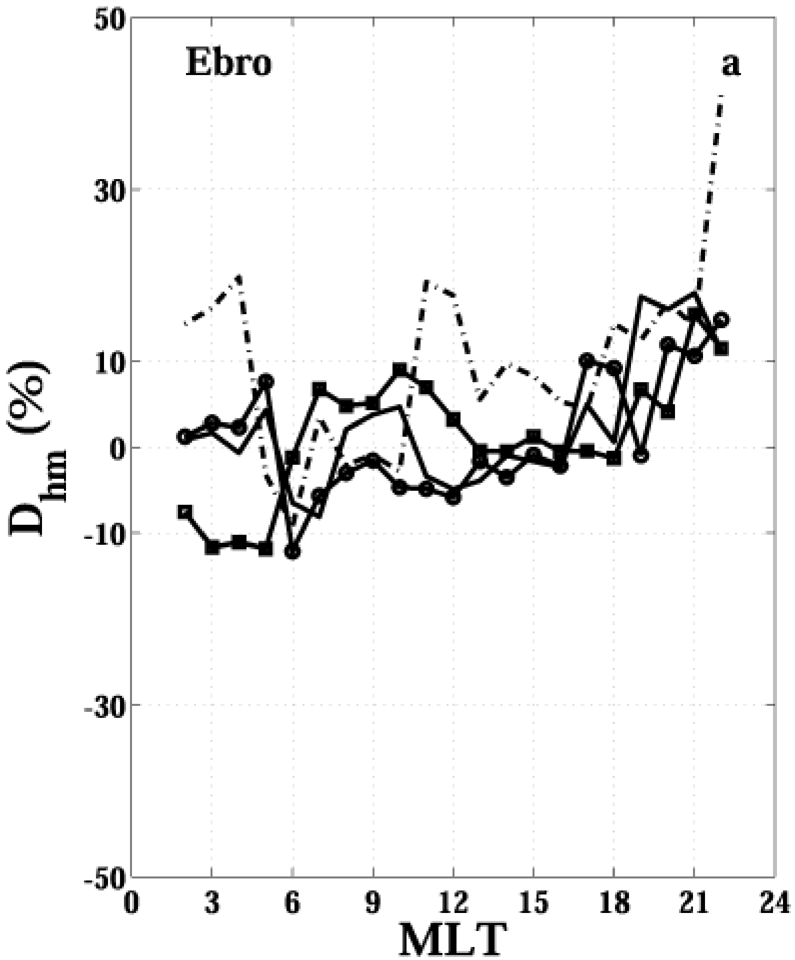
Deviation of topside peak parameters from bottomside

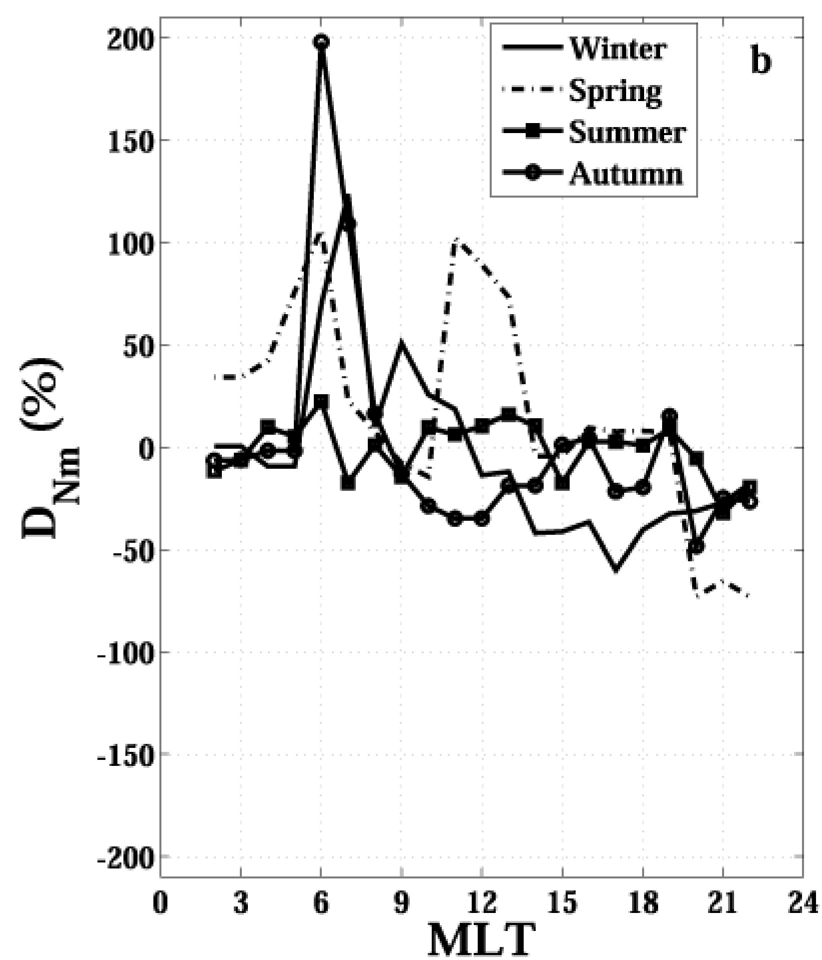
We define deviation, D as

$$D_{hm} = \frac{h_{mF2}(\text{topside}) - h_{mF2}(\text{bottomside})}{h_{mF2}(\text{bottomside})}$$

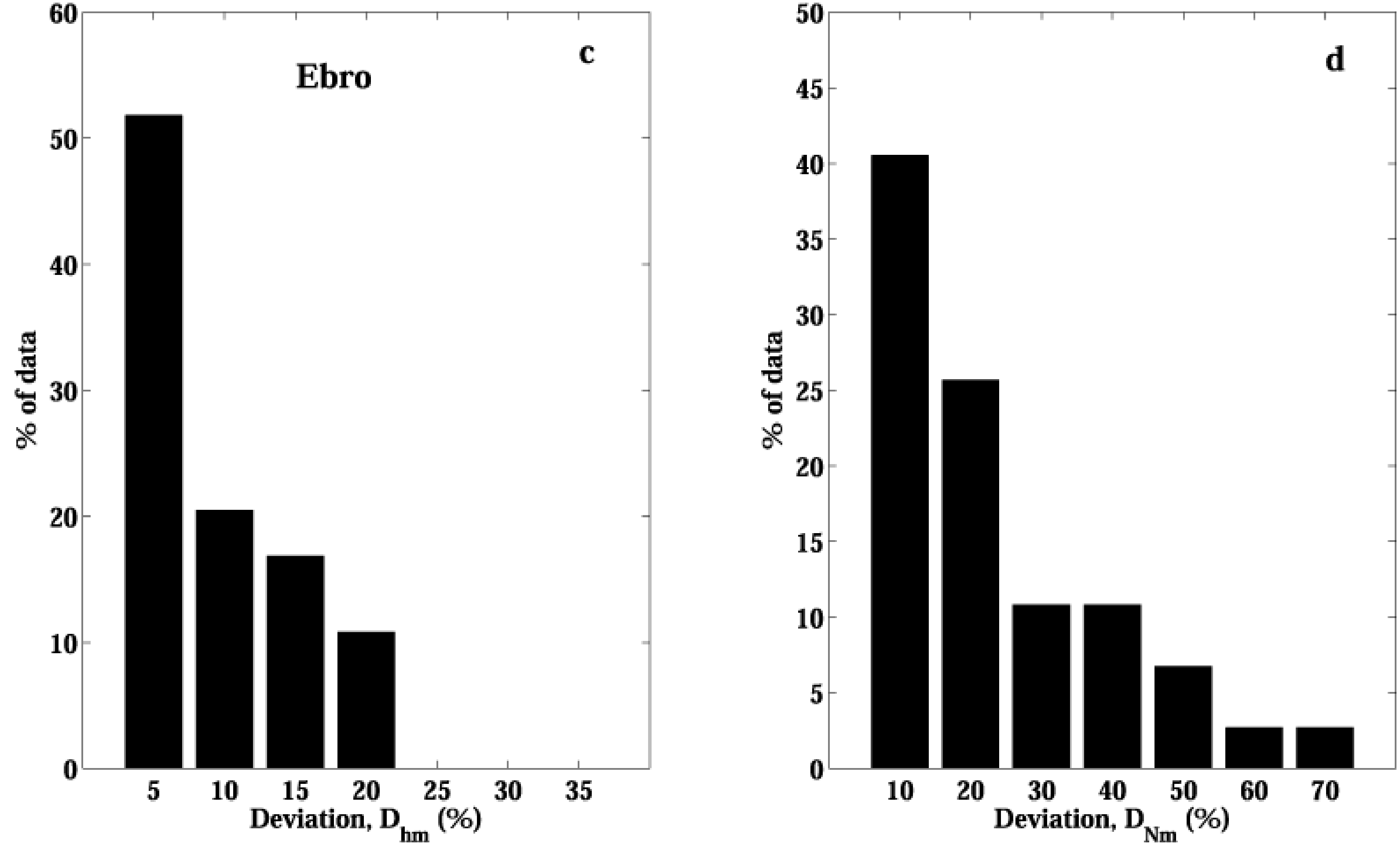
$$D_{Nm} = \frac{N_{mF2}(\text{topside}) - N_{mF2}(\text{bottomside})}{N_{mF2}(\text{bottomside})}$$

Deviation



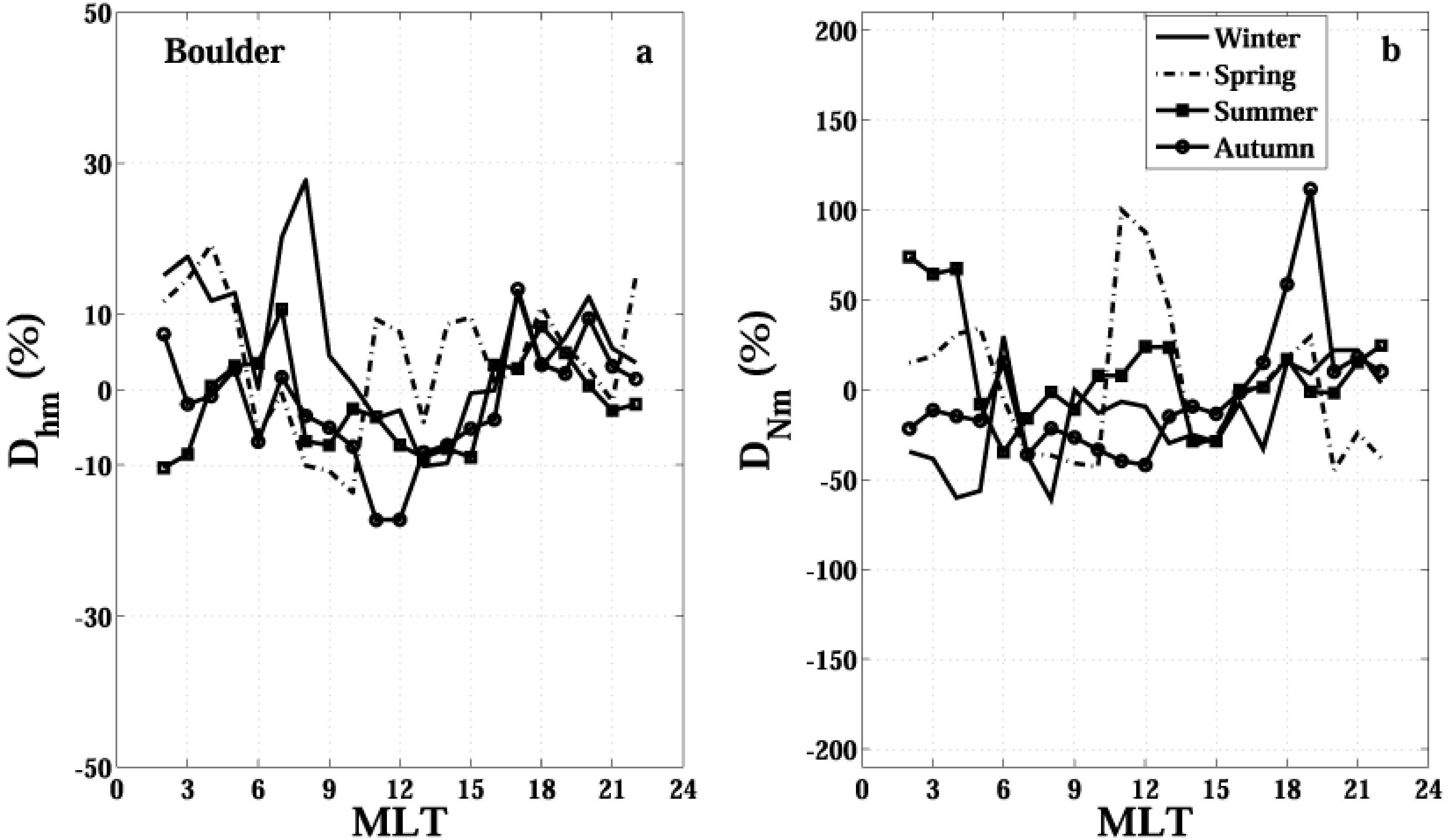


Deviation



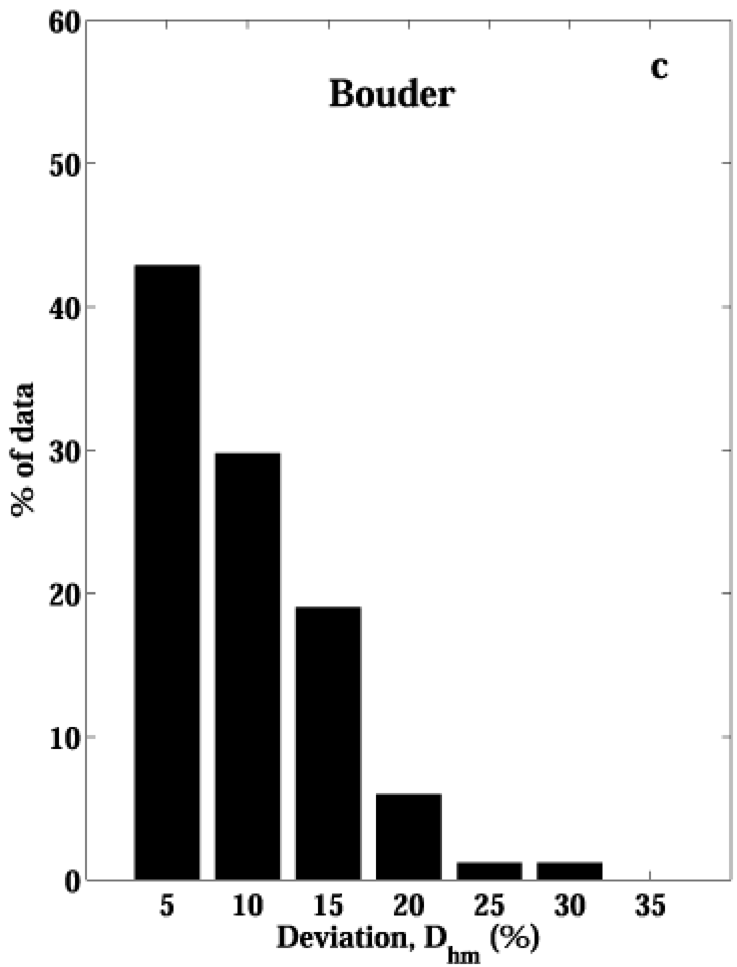
Ebro
c
60
50
40
30
20
10
0
% of data
5 10 15 20 25 30 35
Deviation, D_{hm} (%)
d
50
45
40
35
30
25
20
15
10
5
0
% of data
10 20 30 40 50 60 70
Deviation, D_{Nm} (%)

Boulder

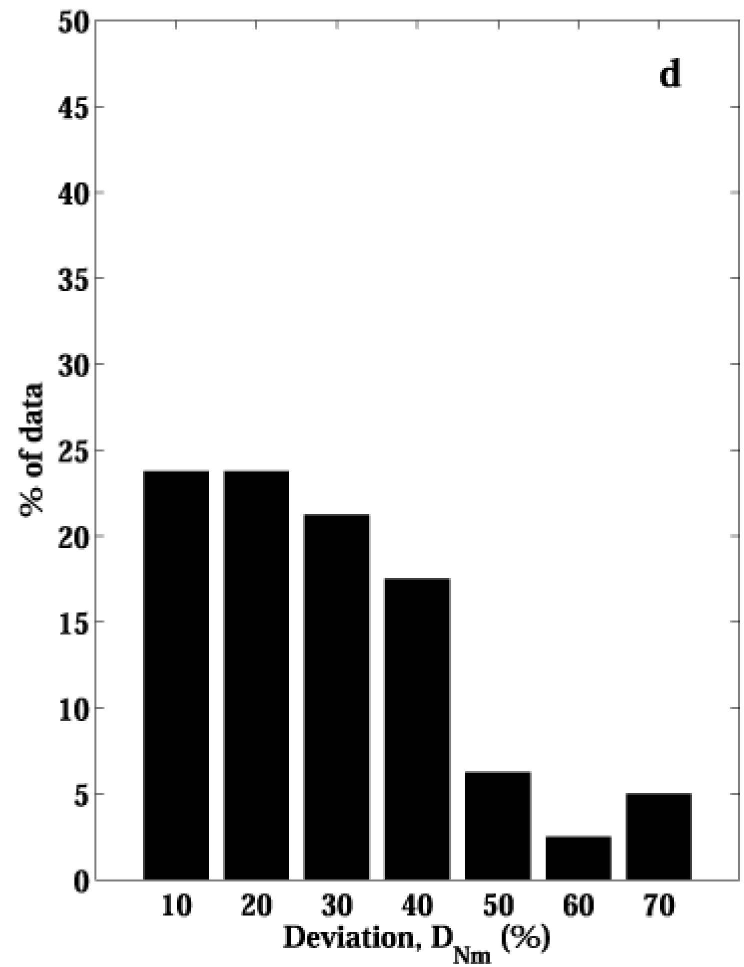


Boulder
a
b
Winter
Spring
Summer
Autumn
D_{hm} (%)
D_{Nm} (%)
50
30
10
0
-10
-30
-50
200
150
100
50
0
-50
-100
-150
-200
0 3 6 9 12 15 18 21 24
MLT
MLT

Boulder



Bouder
c
% of data
Deviation, D_{hm} (%)
0
10
20
30
40
50
60
5
10
15
20
25
30
35



d
% of data
Deviation, D_{Nm} (%)
0
5
10
15
20
25
30
35
40
45
50
10
20
30
40
50
60
70

Results of Comparison

- Over 70 - 80 % of the topside median h_{mF2} data fall within deviations of $D_{hm} = \pm 15\%$

- 60 - 75% of the topside median N_{mF2} data fall within deviations of $D_{Nm} = \pm 30\%$.

Topside Ne(h) Profile as a vary-Chap Function

Vary-Chap function [Rishbeth & Garriott,1969] :

$$N_T = Nm \left(\frac{H(h)}{H_m} \right)^{-1/2} \exp\left[\frac{1}{2} \left(1 - y - \exp(-y)\right) \right]$$

$$y = \int_{h_m}^{h} \frac{dh}{H(h)}$$

Solution for H(h)

[Huang and Reinisch, 2001]

$$H(h) = H_m \left(\frac{N(h)}{N_m} \right)^{-\frac{1}{2}} X(h)[1 - \ln X(h)]$$

where

$$X(h) = 1 - \frac{1}{H_m} \int_{h_m}^{h} \left(\frac{N(h)}{N_m} \right) dh$$

$$H_m = \int_{h_m}^{h_s} \left(\frac{N(h)}{N_m} \right)^2 dh$$

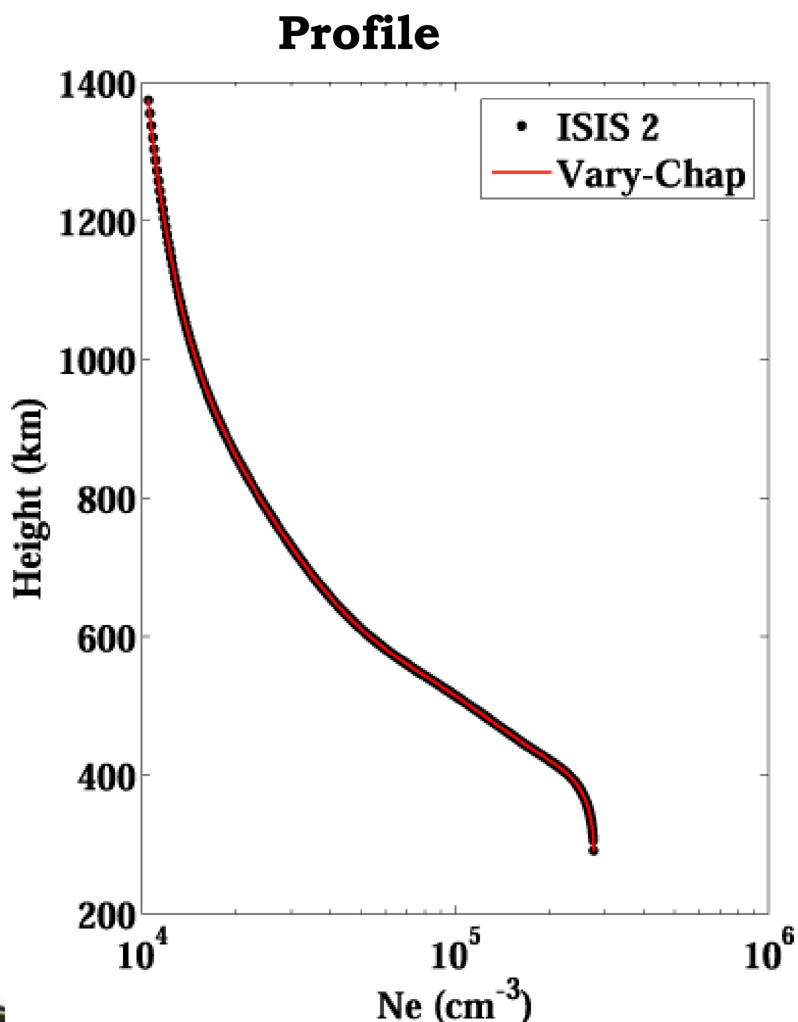
Vary-Chap Scale Height

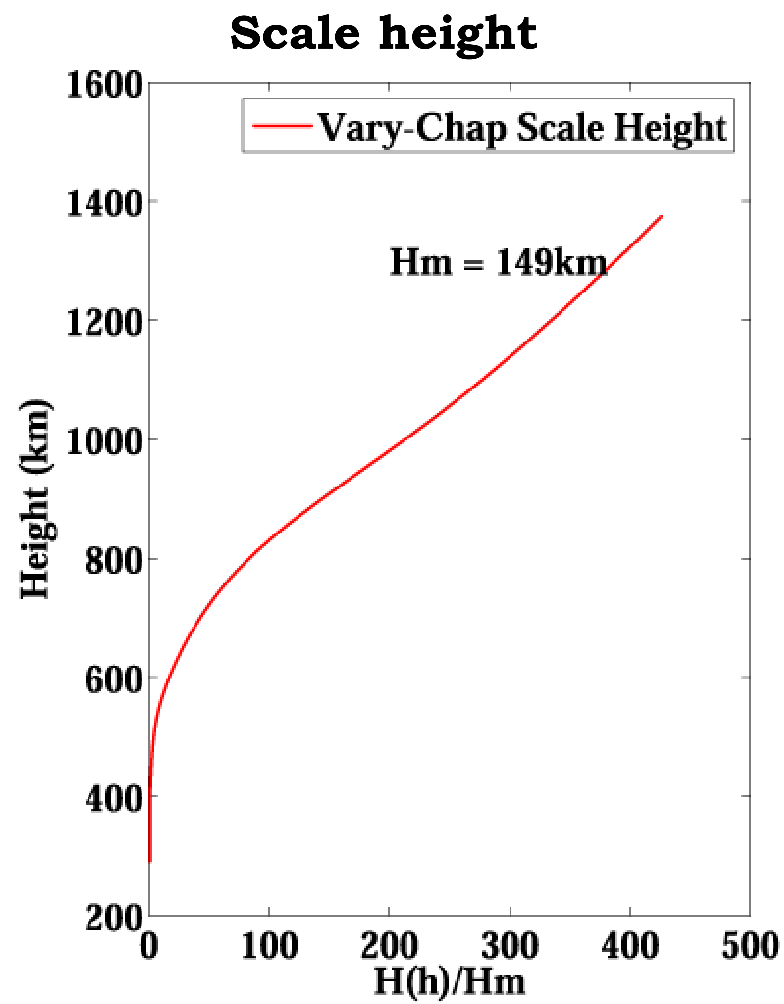
$$H(h) = H_m \left(\frac{N(h)}{N_m} \right)^{-\frac{1}{2}} X(h)\left[1 - \ln X(h)\right] \text{ (Vary - Chap Scale Height)}$$

$$H_p = \frac{k_b (T_i + T_e)}{m_i g} \text{ (Plasma Scale Height)}$$

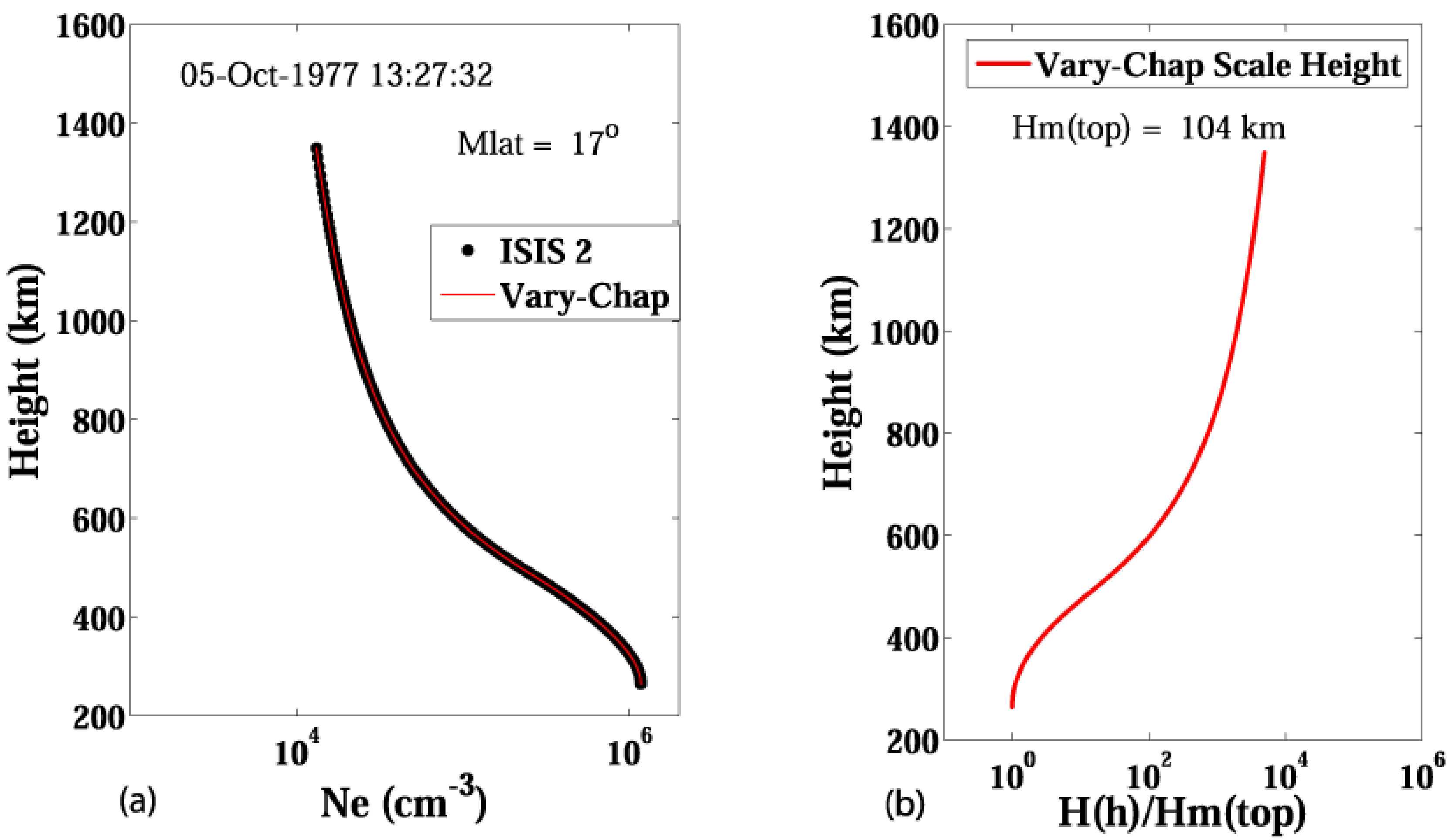
$$VSH = -\frac{dh}{d\ln N_e} \text{ (Vertical Scale Height)}$$

ISIS Ne(h) as vary-Chap Function – H(h)/Hm profile





H(h)/Hm profile



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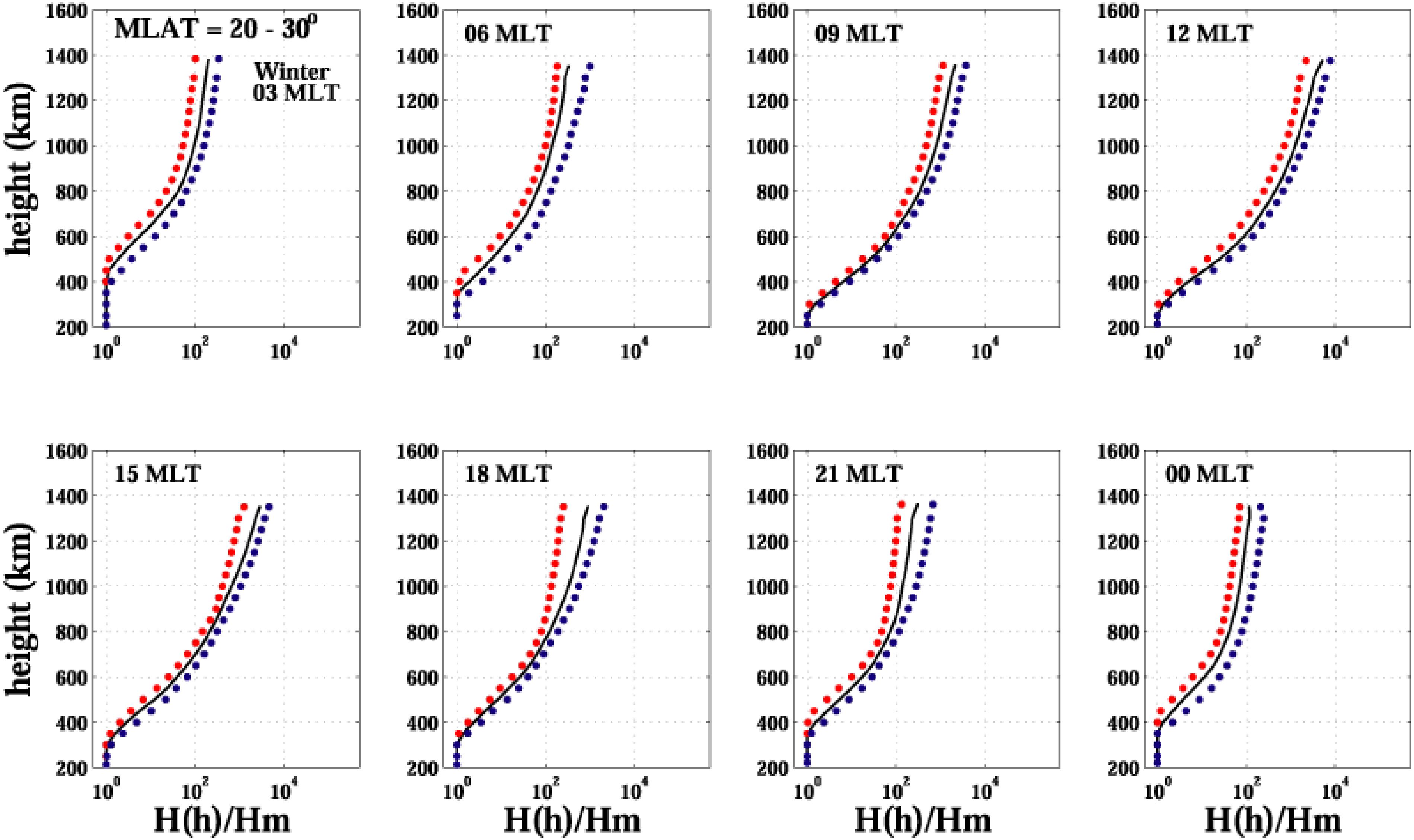
Median, Upper and Lower Quartile $H(h)/H_m$ Profiles

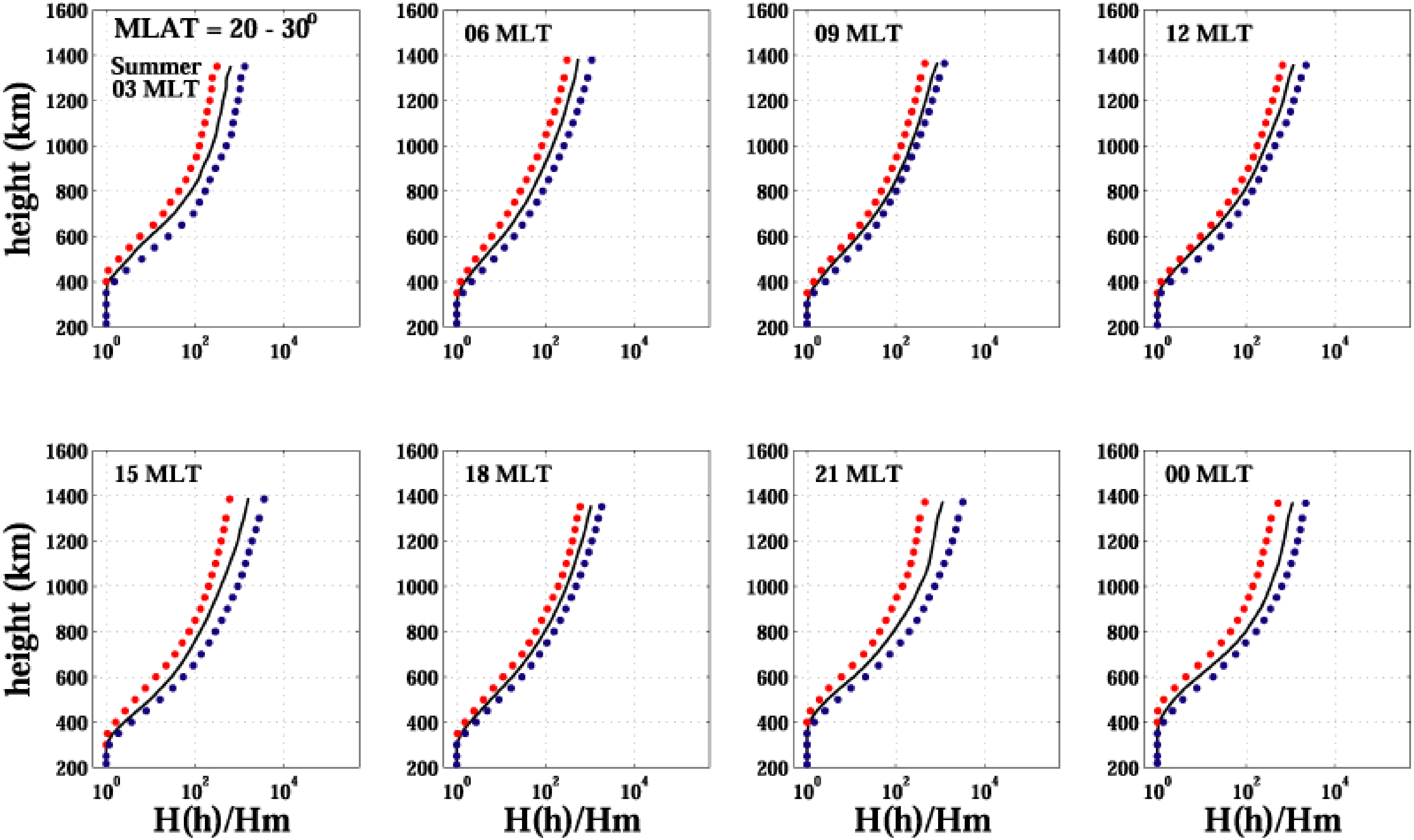
$$N_T = N_m \left(\frac{H(h)}{H_m} \right)^{-1/2} \exp\left[\frac{1}{2} \left(1 - y - \exp(-y) \right) \right];$$

$$\frac{H(h)}{H_m} = \left(\frac{N(h)}{N_m} \right)^{-\frac{1}{2}} X(h)\left[1 - \ln X(h)\right]$$

MLAT 20-30° (Winter)

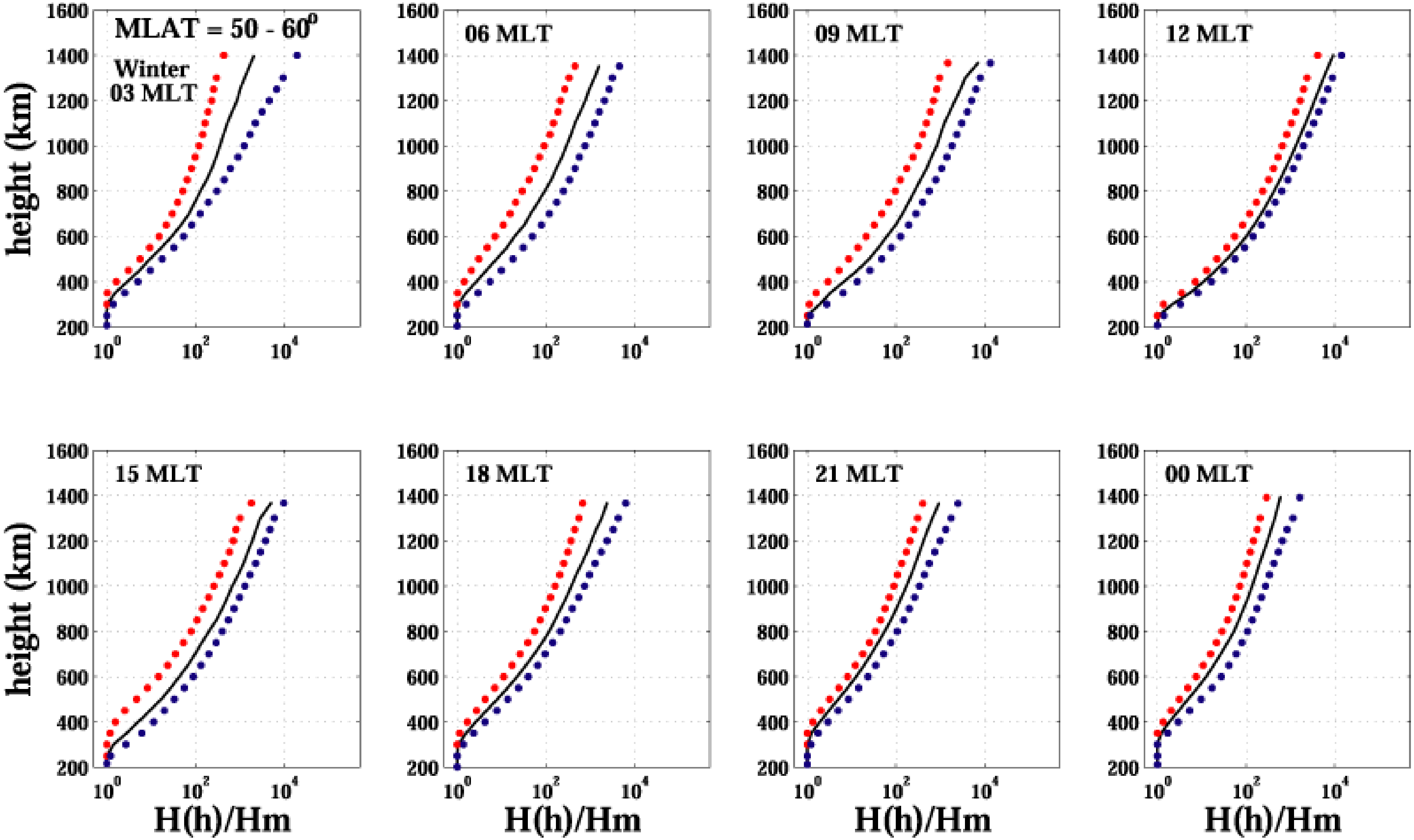


MLAT 20-30° (Summer)

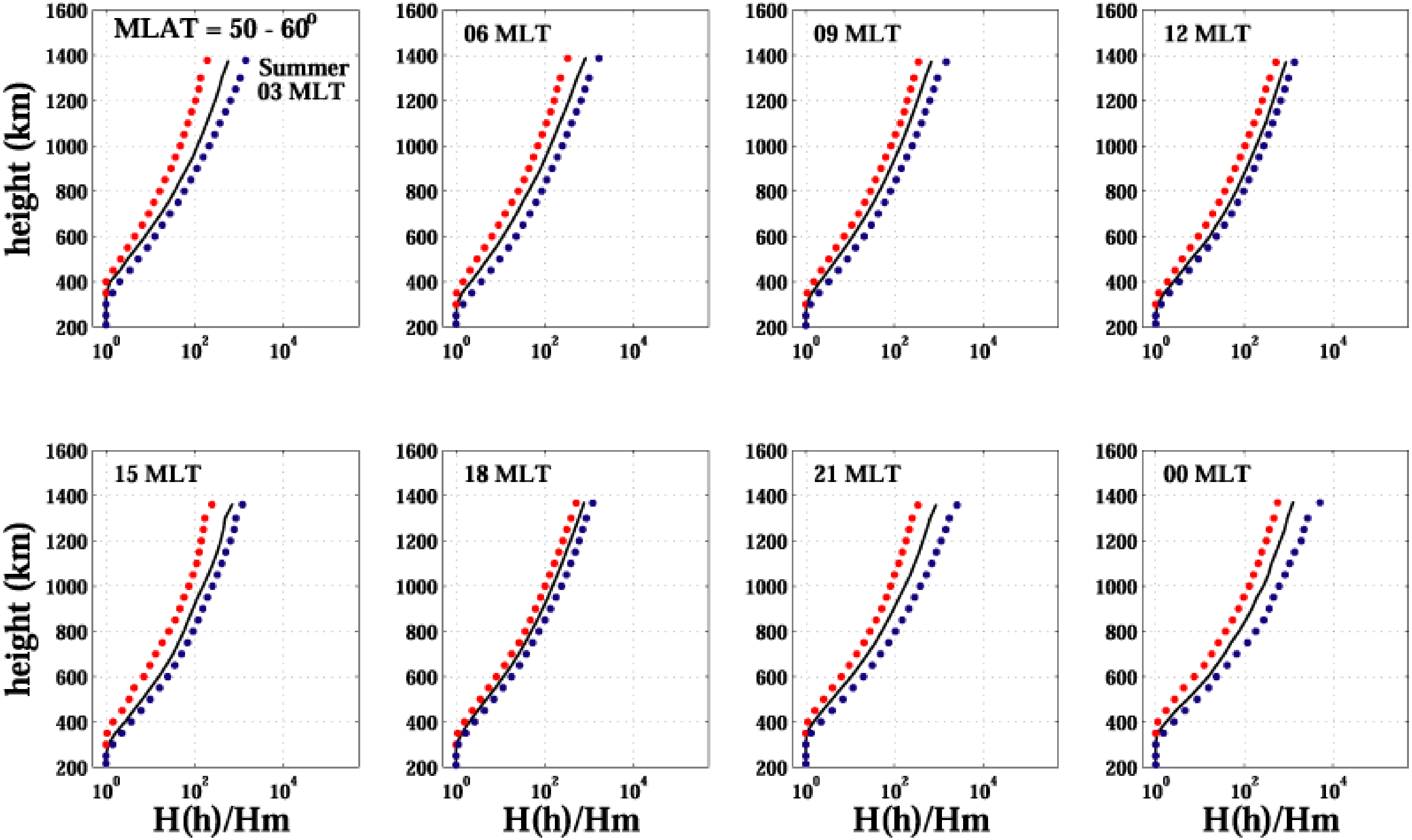


2009 IDF

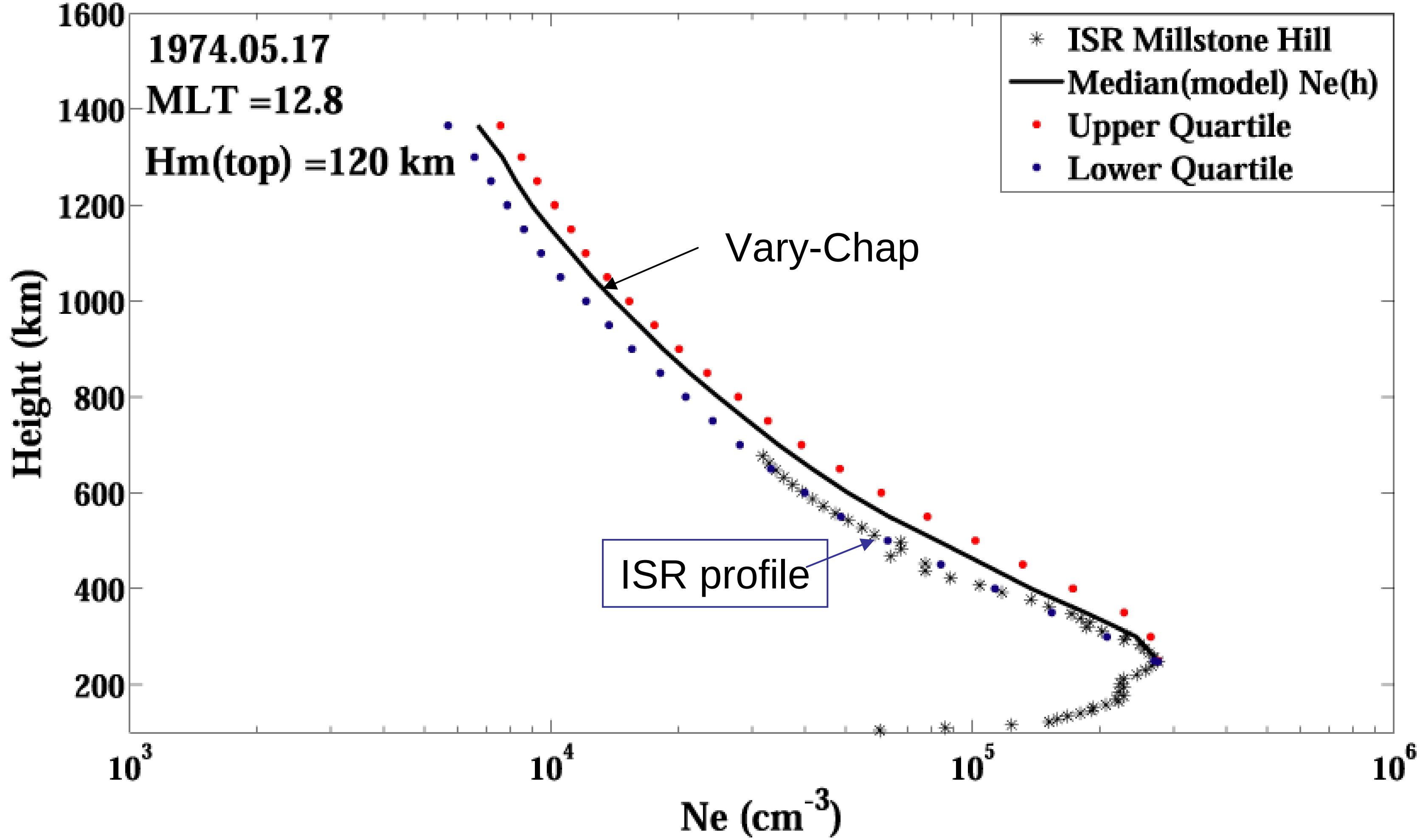
MLAT 50-60° (Winter)



MLAT 50-60° (Summer)

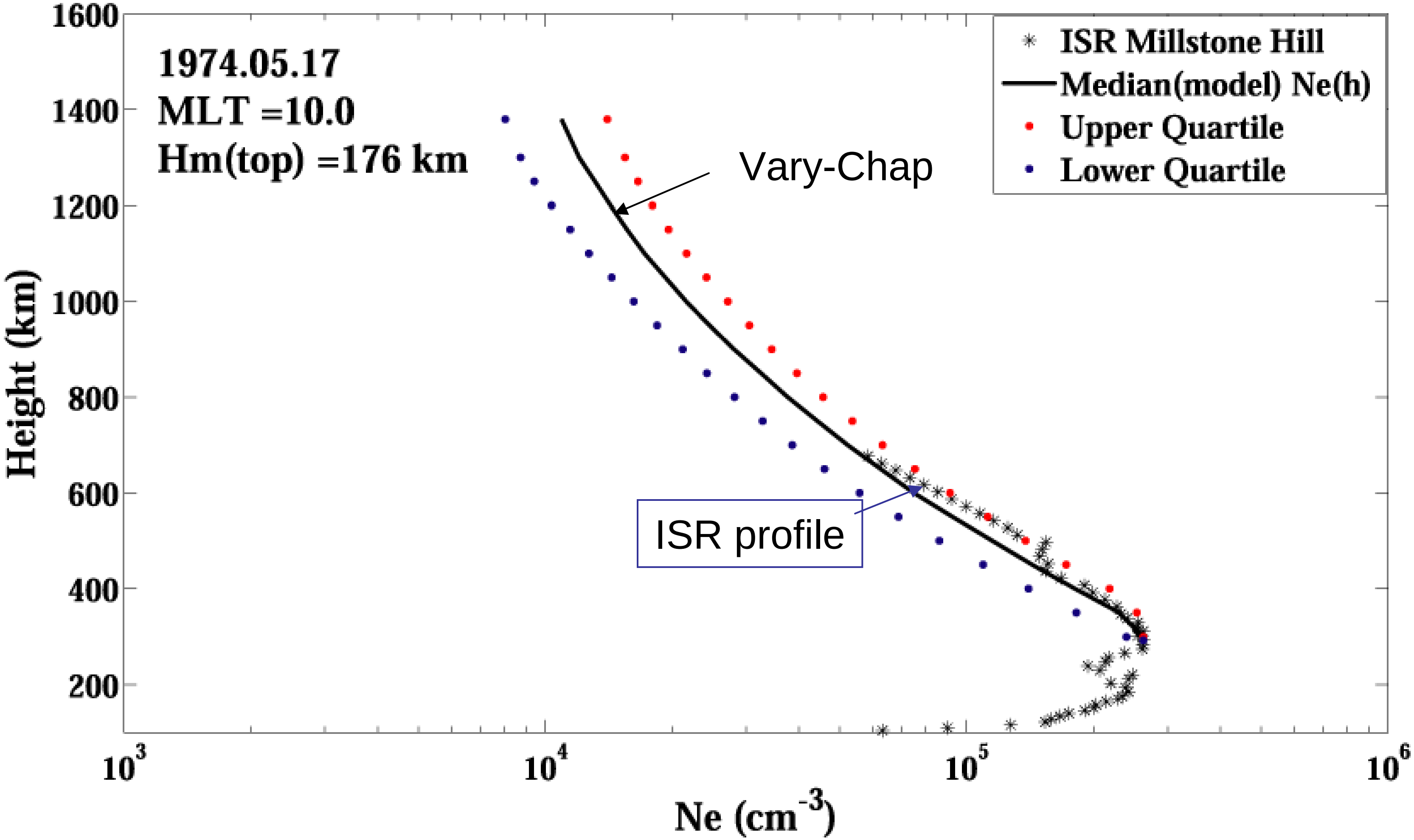


Validation with ISR Profiles Millstone Hill, Noon



(ISR profile courtesy of Millstone Hill Madrigal database)

Validation with ISR Profiles Millstone Hill, MLT=10.00



(ISR profile courtesy of Millstone Hill Madrigal database)

Modeling H(h)

Modeling Options:

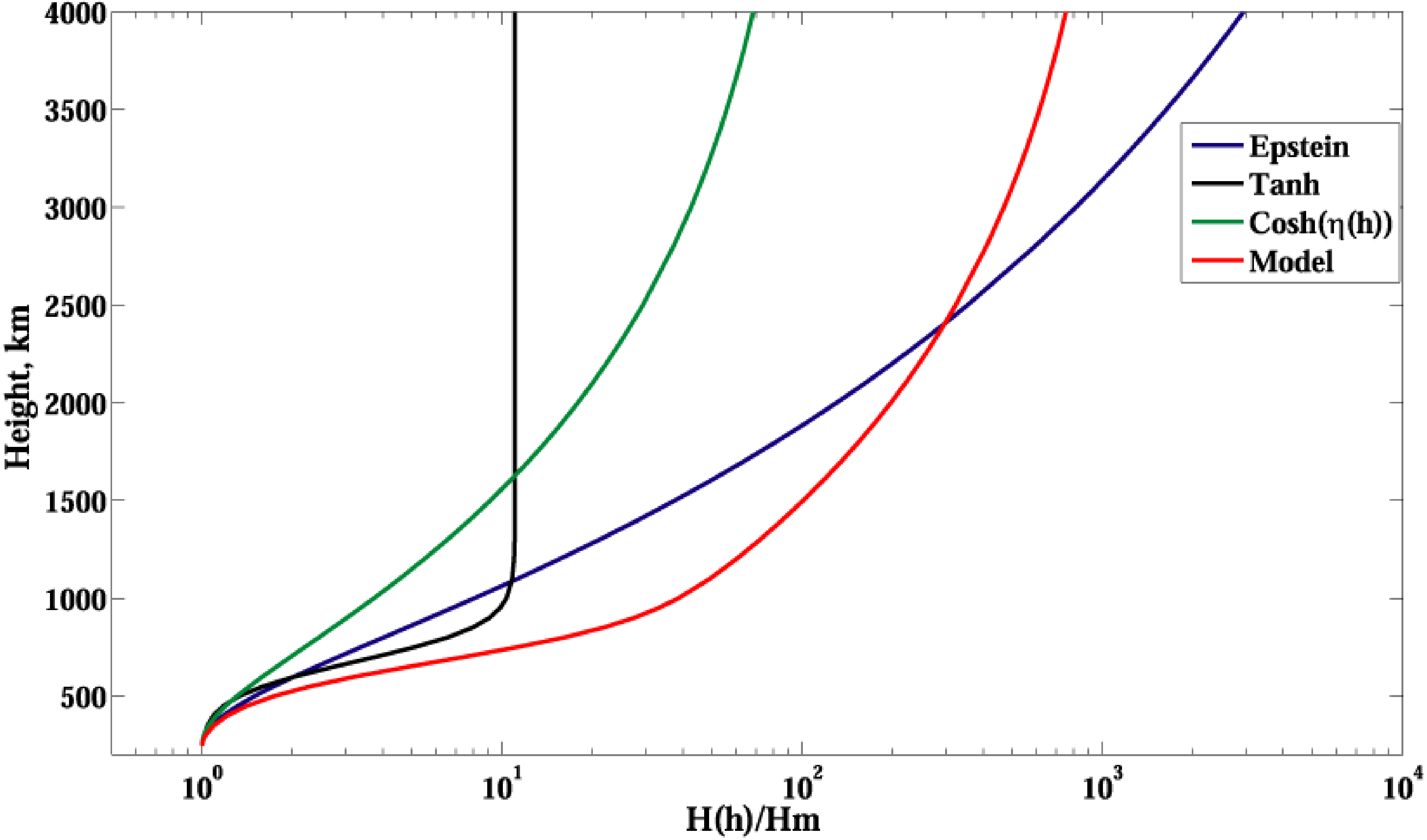
- Hyperbolic tangent function.
- Inverse Epstein function.
- New Model combines Cosh and Tanh functions.

$$N_T = Nm\left(\frac{H(h)}{H_m}\right)^{-1/2} \exp\left[\frac{1}{2}\left(1 - y - \exp(-y)\right)\right]$$

$$\frac{H(h)}{H_m} = \cosh(\eta(h)) \cdot \left[H_{Tn} + \frac{(1 - H_{Tn})}{\tanh(\beta)} \tanh\left(\beta \frac{h - h_T}{h_m - h_T}\right)\right]$$

$$\eta(h) = \gamma\left[1 - \exp\left(-\alpha \cdot (h/h_m - 1)\right)\right]$$

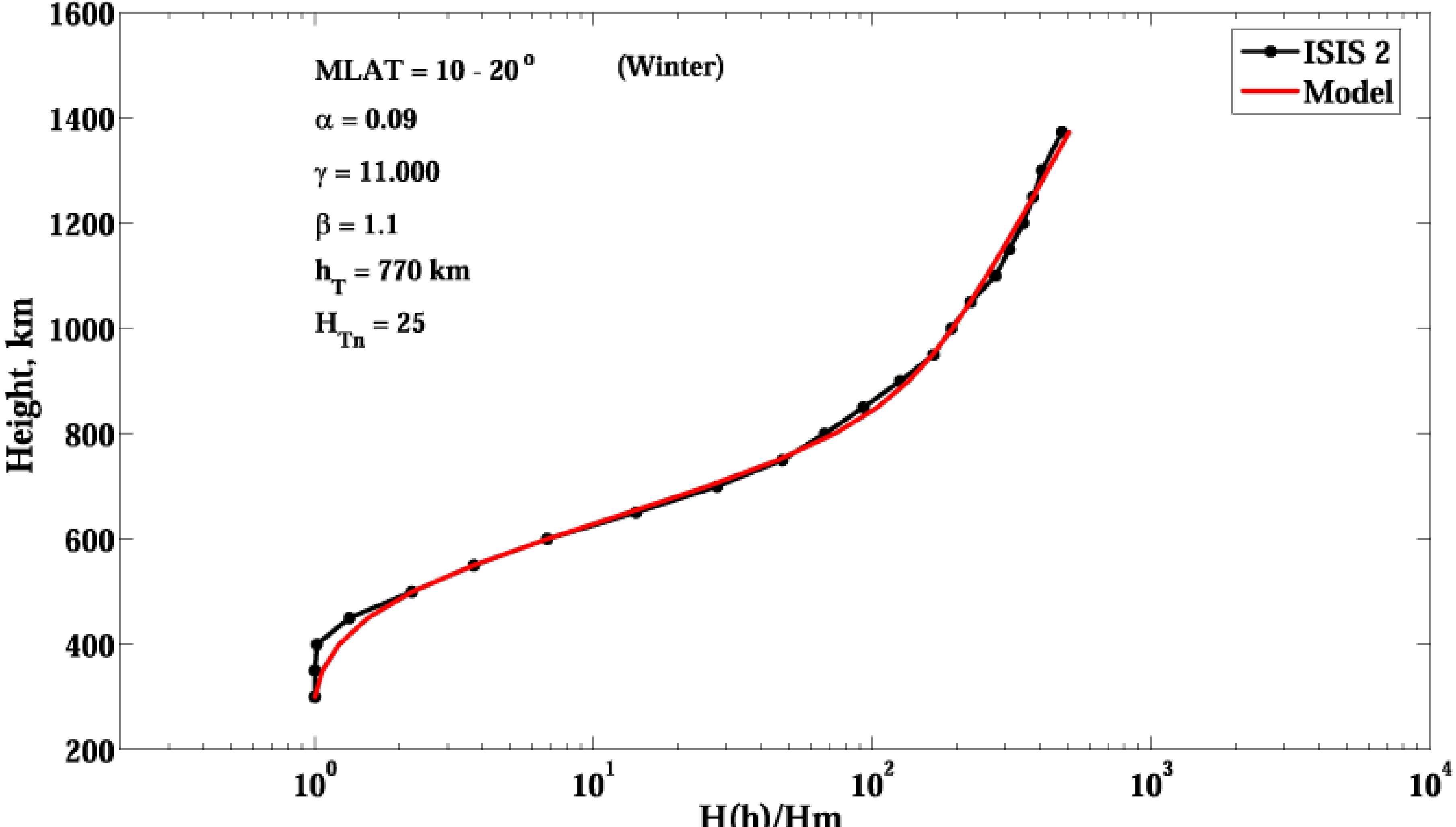
Model functions



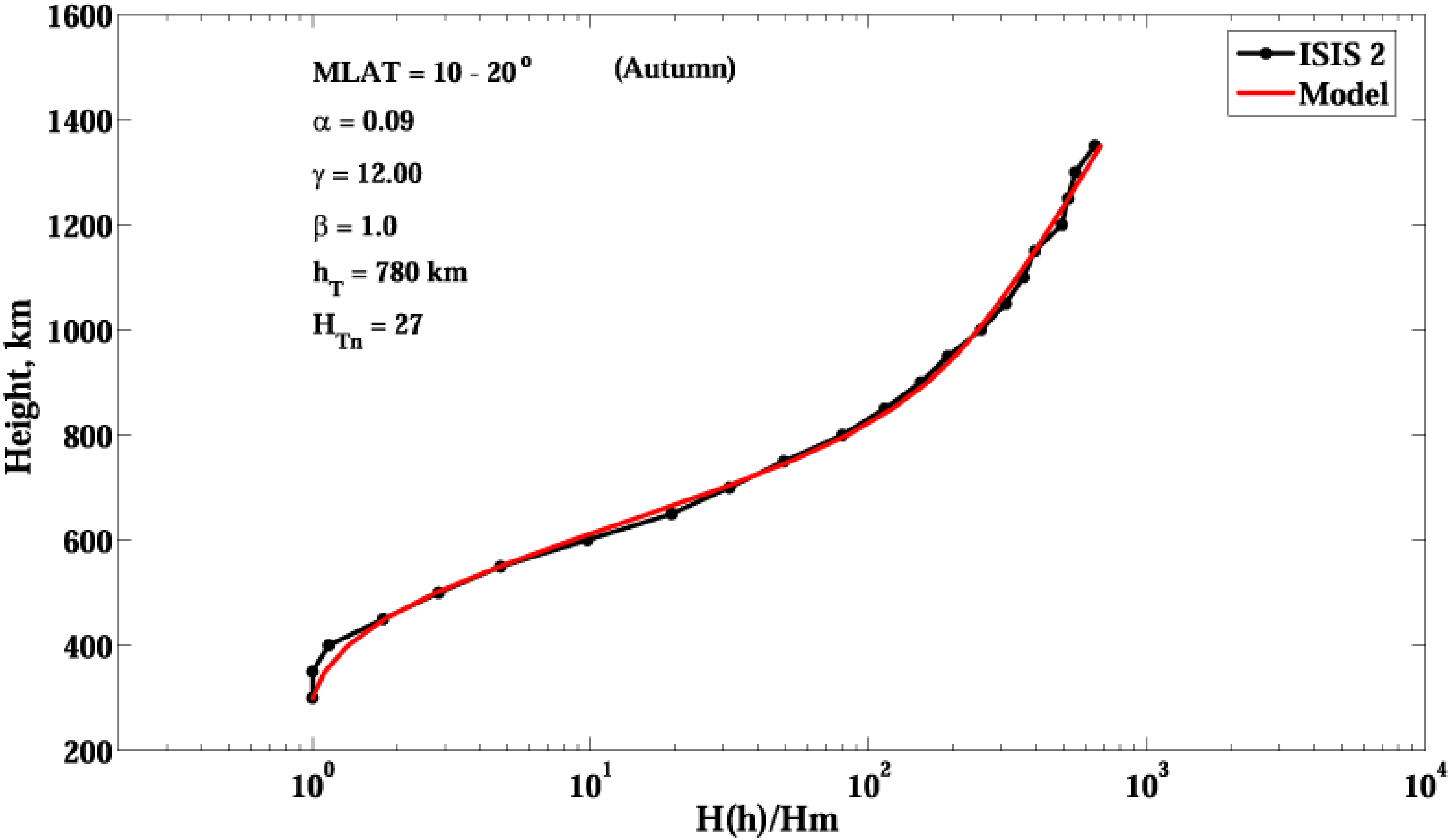
Determining the Parameters

α, γ, β, h_T, H_{Tn} are determined using a least-square method.

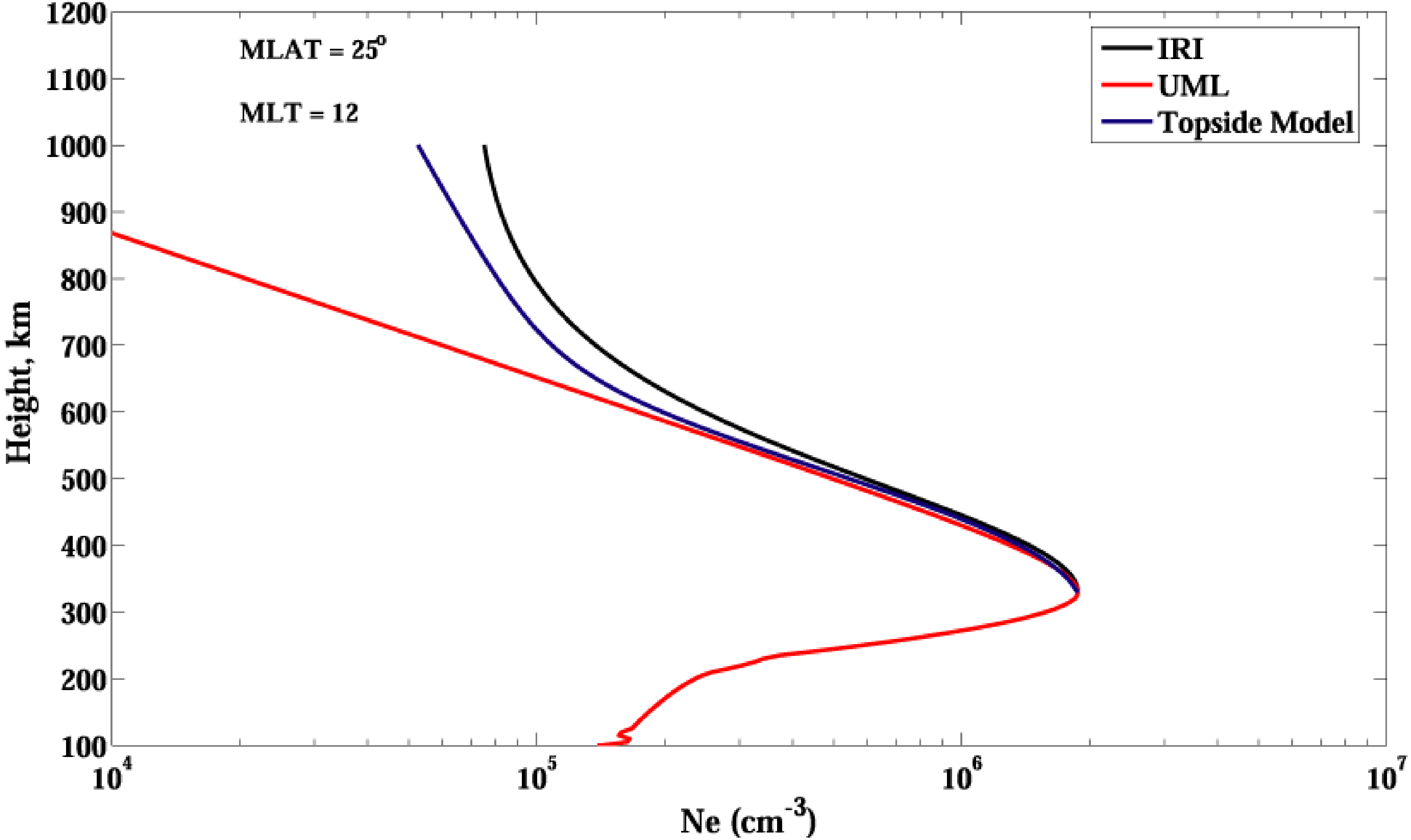
Model Fitting



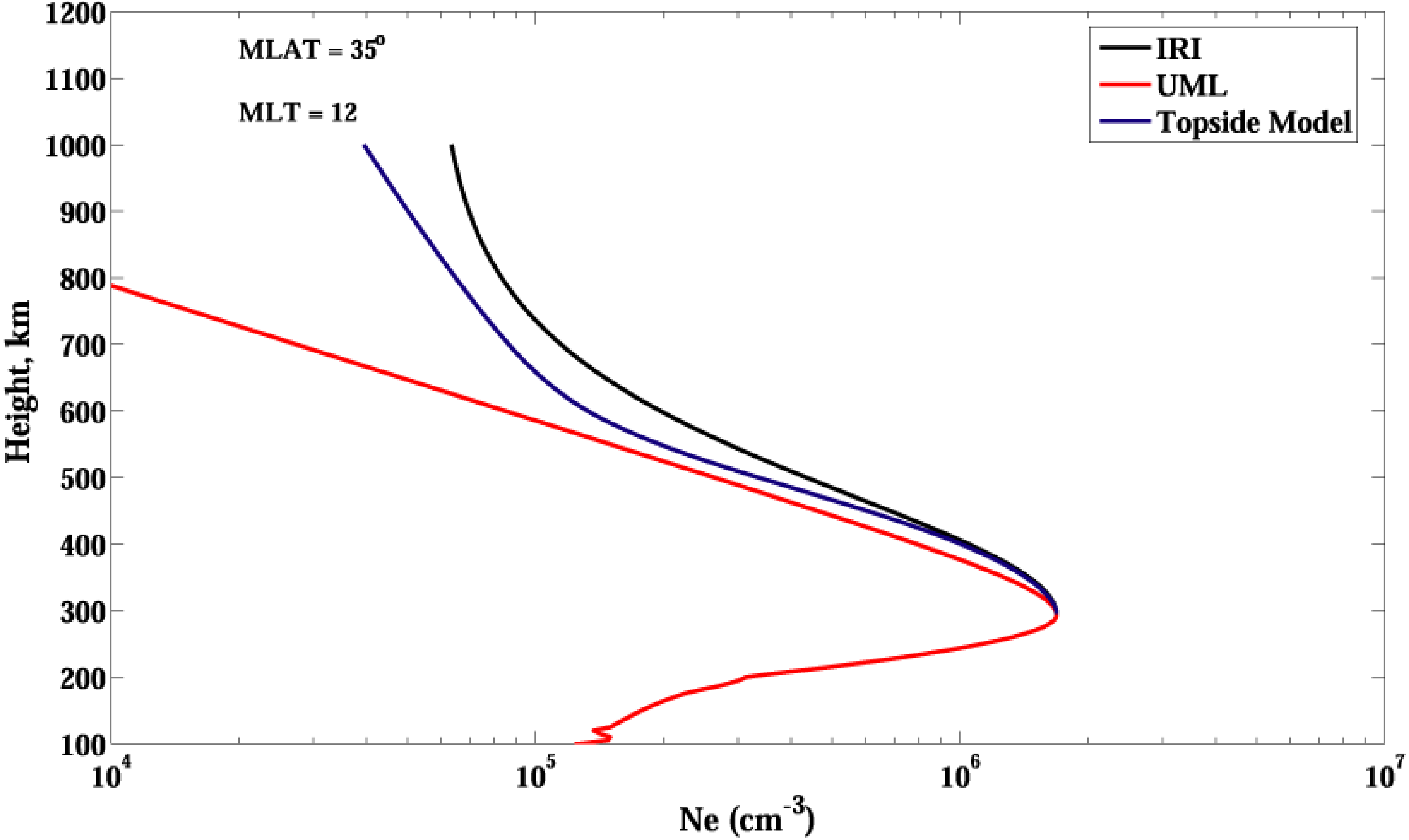
Model Fitting



Topside model and Digisonde/IRI profiles



Topside and IRI profiles



SUMMARY (1)

- The vary-Chap function is used to model the topside scale height .
- We have developed the topside Ne model as a function of MLAT, Season, MLT ($h_m \leq h \leq 1400$ km).
- This model connects smoothly to the bottom-side measured or model profiles.
- Input: N_m, h_m, H_m and the topside parameters.

Dual-Frequency Precision Ranging for Digisondes

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University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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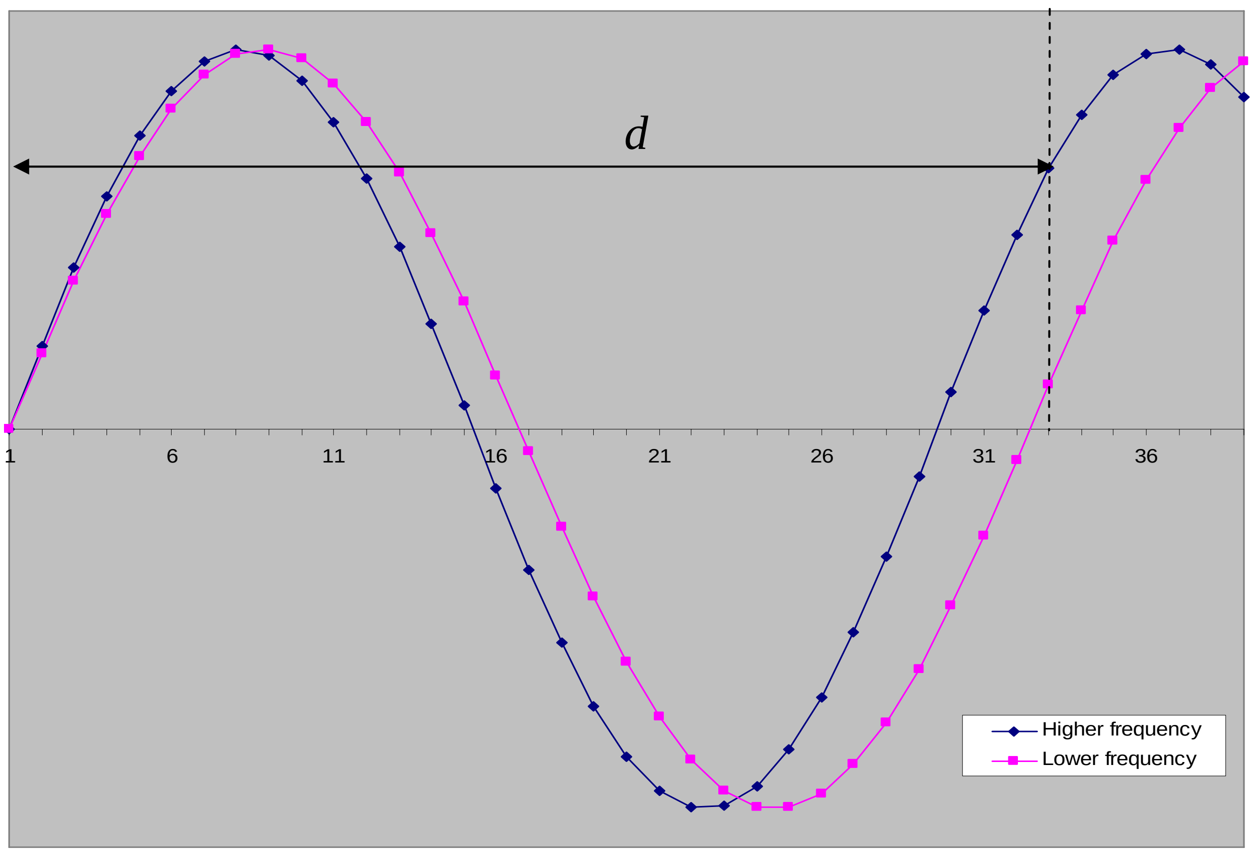
11 - 14 MAY 2009

Two "closely-spaced" frequencies



Distance to Target

Phase difference between higher and lower frequencies increases with distance

At receiver location, measured phase difference between f_1 and f_2 can be converted to target distance

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Calculating Range R from Δφ

for a pulse sounder and a hard target

Signal:

$$s(t) = A\cos(kx - 2\pi ft + \phi_0)$$

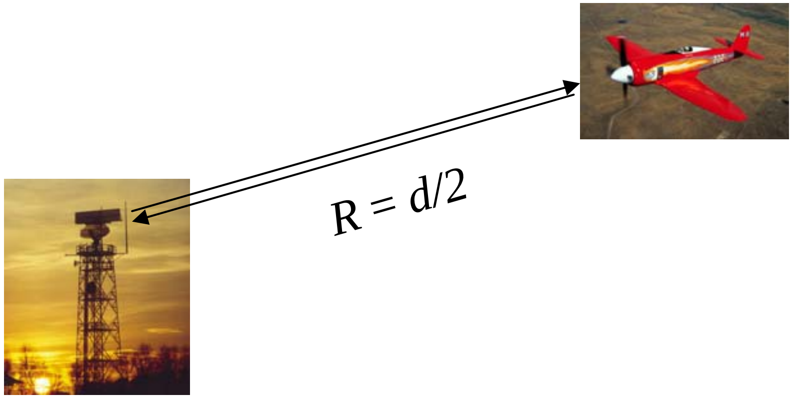
At x = 0:

$$s_1(t) = A_1\cos(-2\pi f_1 t + \phi_{01})$$

$$s_2(t) = A_2\cos(-2\pi f_2 t + \phi_{02})$$

$$\phi_1(f) = -2\pi f_1 \tau_p = -2\pi f_1 \frac{d}{c}$$

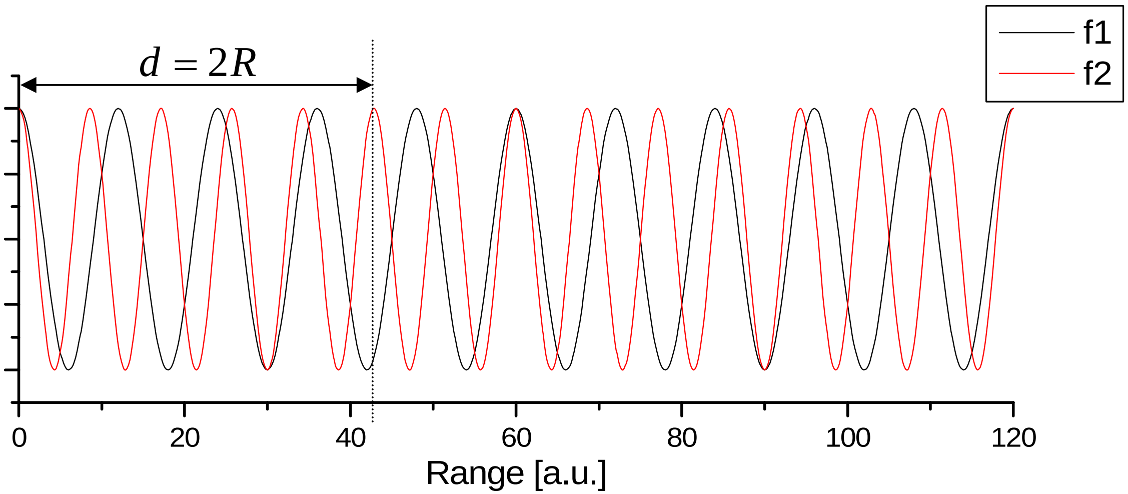
$$\phi_2(f) = -2\pi f_2 \tau_p = -2\pi f_2 \frac{d}{c}$$

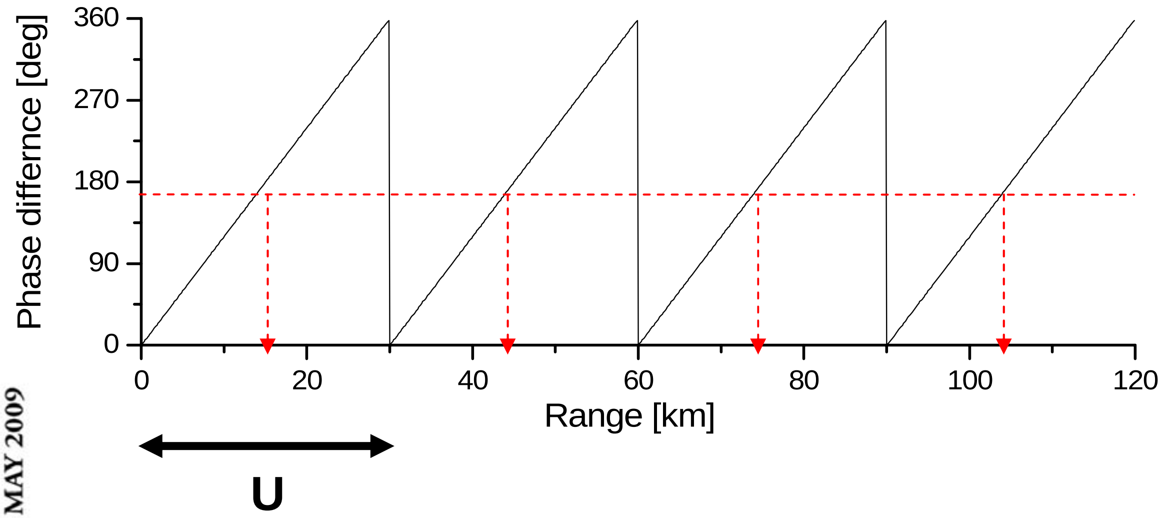


$$\phi_2 - \phi_1 = 2\pi(f_1 - f_2)\frac{d}{c} = 2\pi\Delta f\,\frac{d}{c} = 4\pi\Delta f\,\frac{R}{c}$$

$$\boxed{\therefore R = \frac{c}{4\pi\Delta f}\Delta\phi}$$

Phase Ambiguity





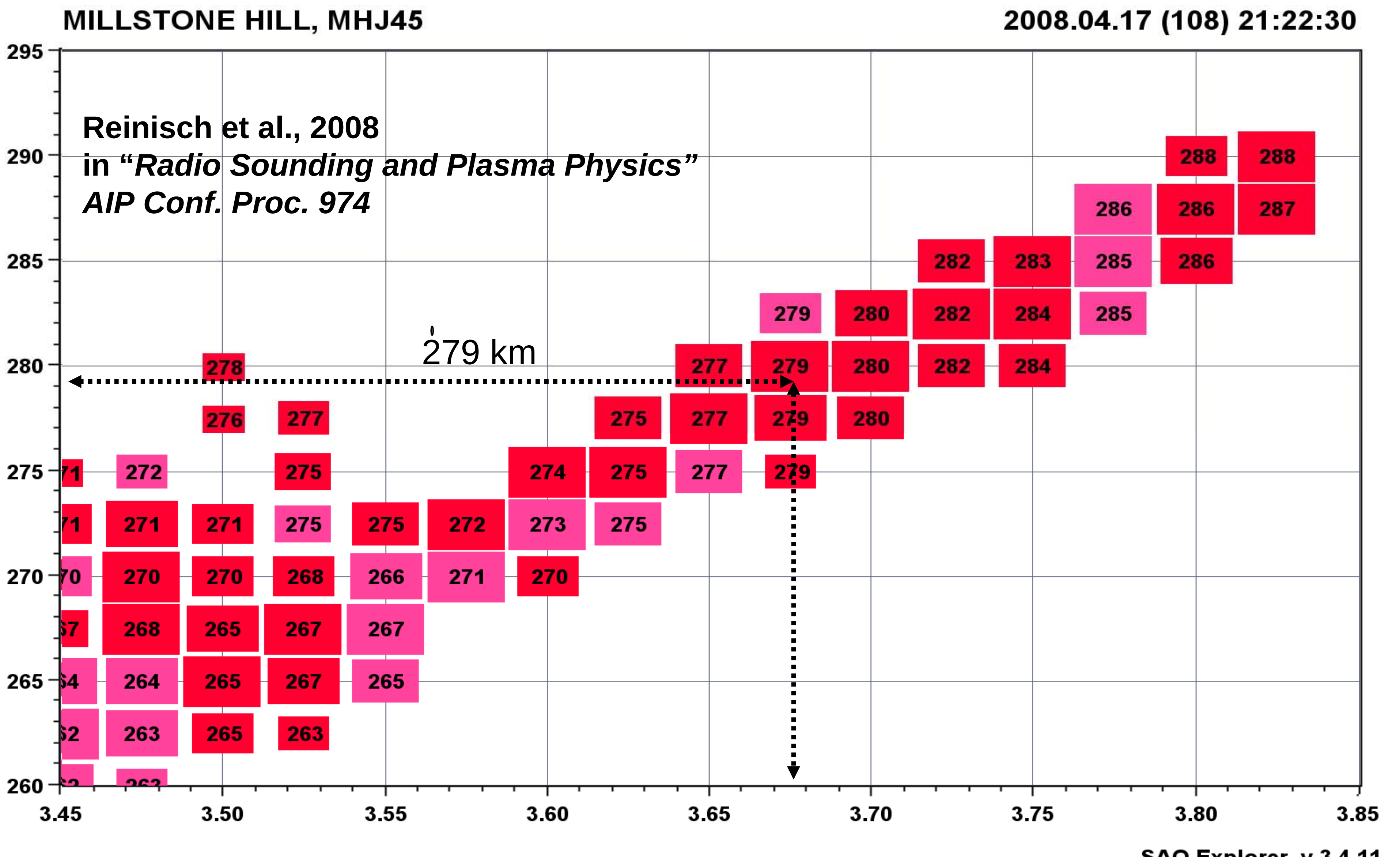
Concept:

1. Estimate range R_t from the pulse travel time
2. Truncate R_t to the nearest smaller multiple of U
3. Add precise range r obtained from Δφ

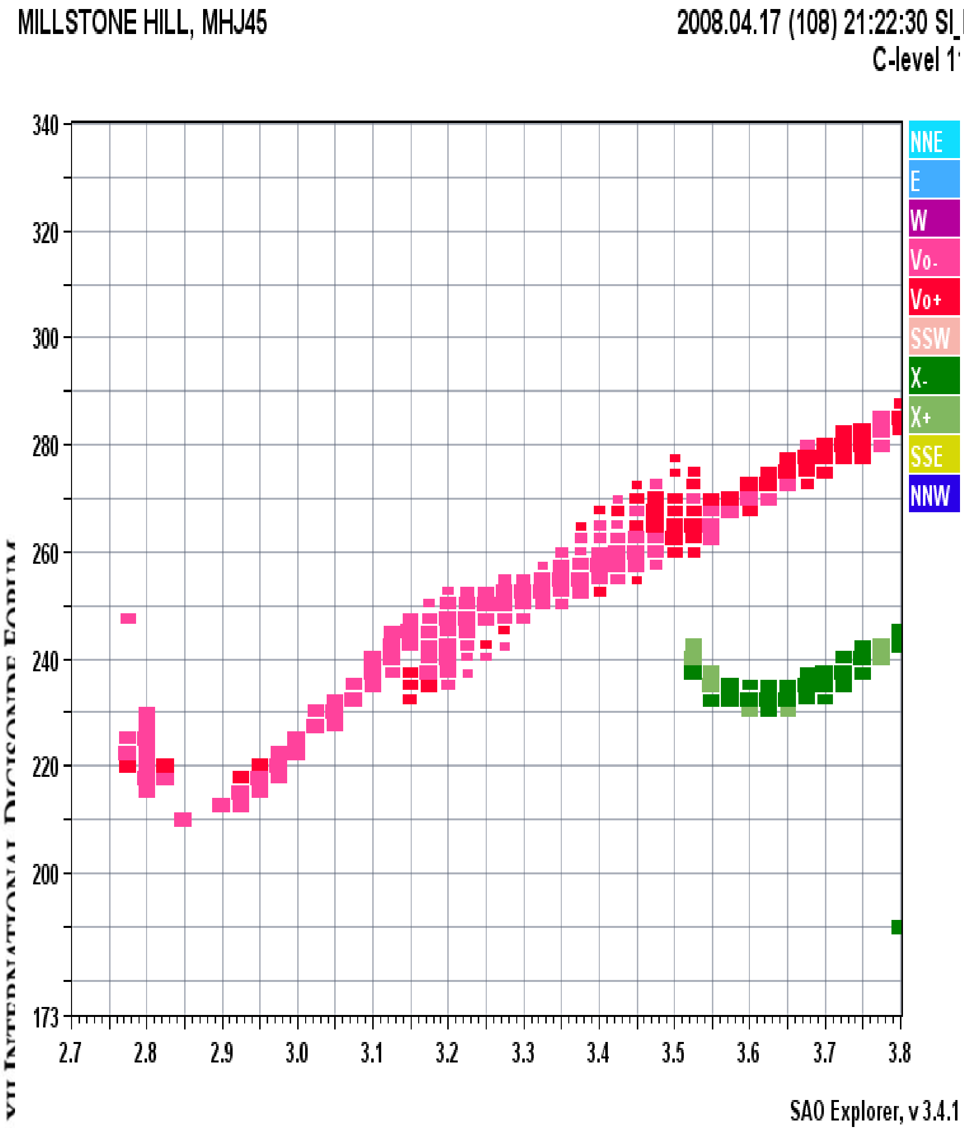
$$R = \lfloor R_t \rfloor^U + r$$

Example: for 5 kHz spacing, U=30 km

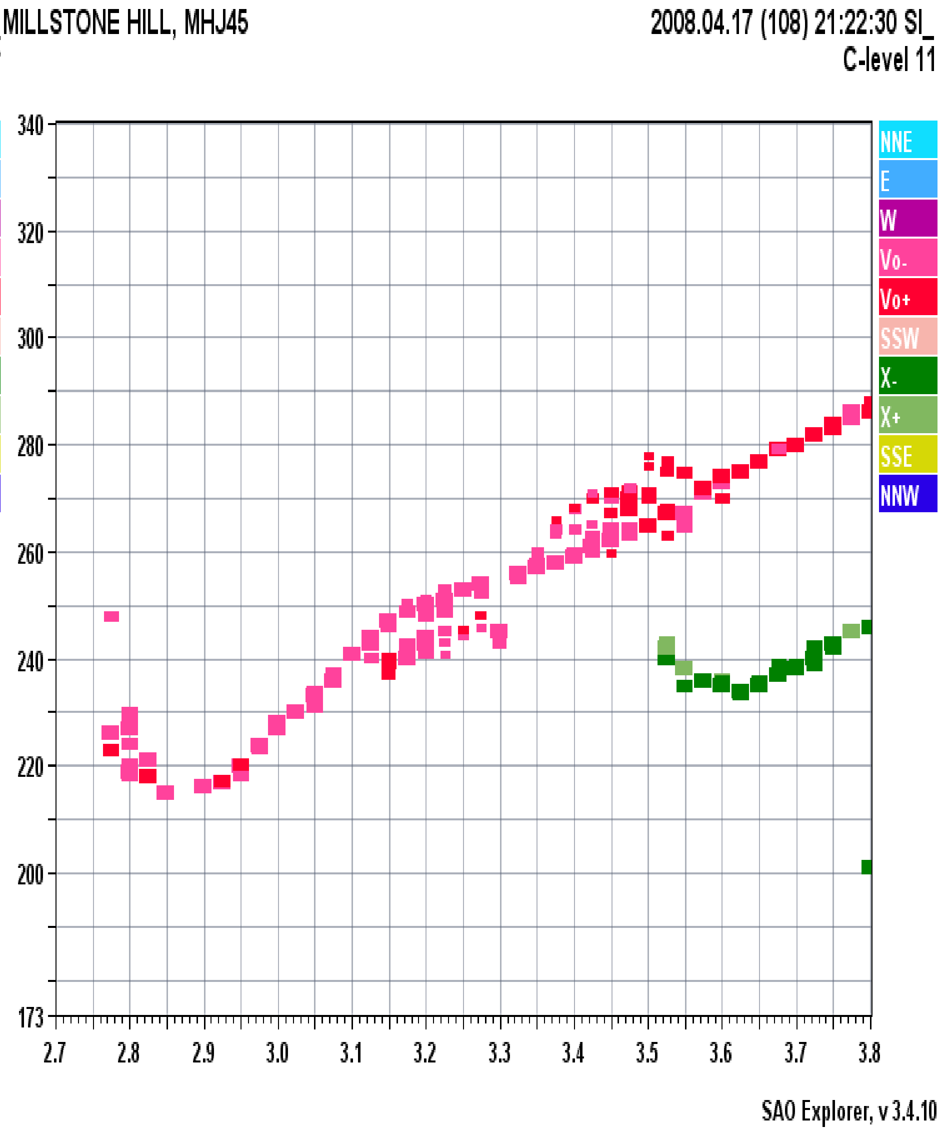
Precision Ranging Example



Precision Ranging Example

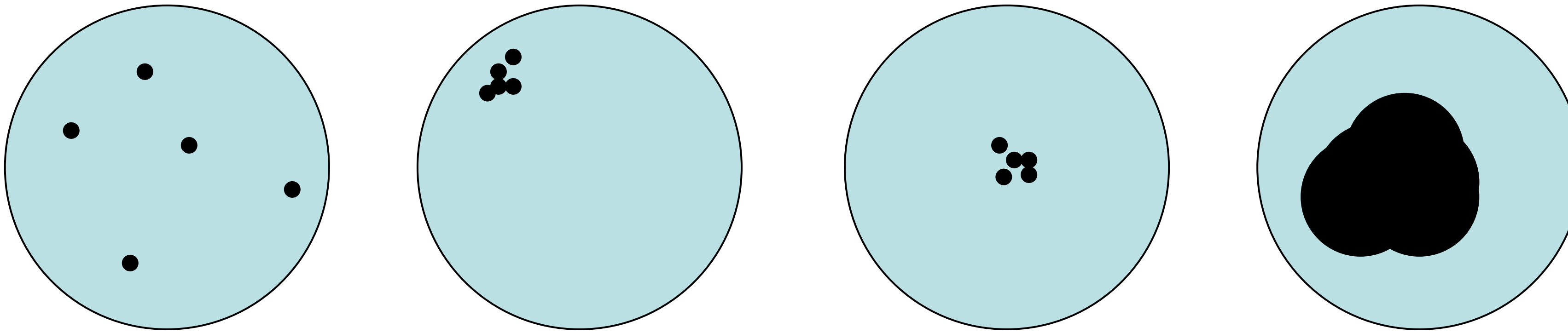


Classic Ionogram Display



Ionogram Display with PR

Accuracy, Precision, Resolution



Poor precision
Good accuracy

Good precision
Poor accuracy

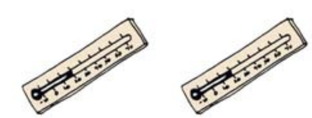
Good precision
Good accuracy

Poor resolution

Accuracy:
How close measurement is to the true value

Precision:
Repeatability of the individual measurements

Resolution:
Number of significant figures of the measured value. Indicates capability of the instrument to resolve two measurements as different. Depends on precision (poor precision of a measurement means its poor resolution).



30.51°   30.52°

t_1 t_2

Q: Did temperature really change?
A: Depends on thermometer's precision (not resolution).
Resolution must match precision

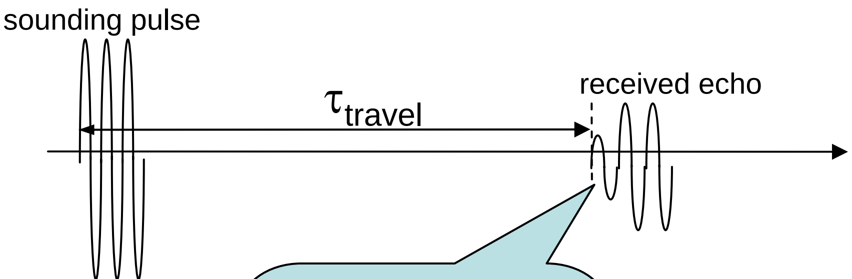
Precision Ranging Benefits

- PR improves all three:
  - Accuracy,
  - Precision, and
  - Resolution

  of echo range measurement

Improvement of Precision

Classic method of determining range to the target R from the pulse travel time τ:



Leading edge of the echo has to be determined

$\tau_{travel} \longrightarrow R = c\tau_{travel} / 2$

$\Delta R \sim \Delta\tau_{travel}$

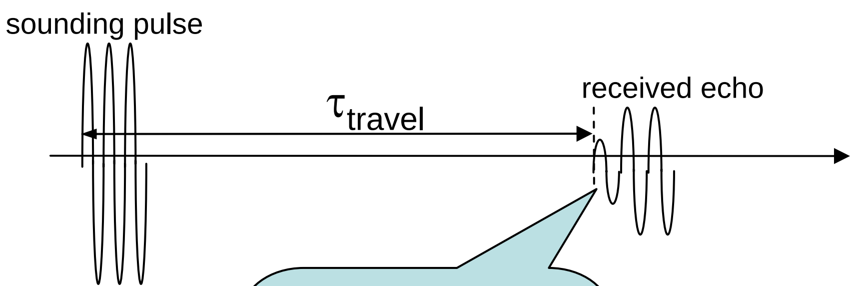
Precision is affected by range sampling rate, sharpness of the leading edge (i.e., system bandwidth), and presence of noise

Typical precision of the leading edge determination is 1-2 range bins, i.e. 5 km

PR method relies on evaluation of signal phase (1-2° precision), which translates to ~150 m at 5 kHz separation of frequencies

Improvement of Accuracy

Classic method of determining range to the target R from the pulse travel time τ:



Leading edge of the echo has to be determined

$\tau_{travel} \longrightarrow R = c\tau_{travel} / 2$

$\Delta R \sim \Delta\tau_{travel}$

Accuracy is affected by unknown delays in the narrow-band circuitry of the receivers (Range Bias)

Typical accuracy of the 0 km calibration is 1-2 range bins, i.e. 5 km

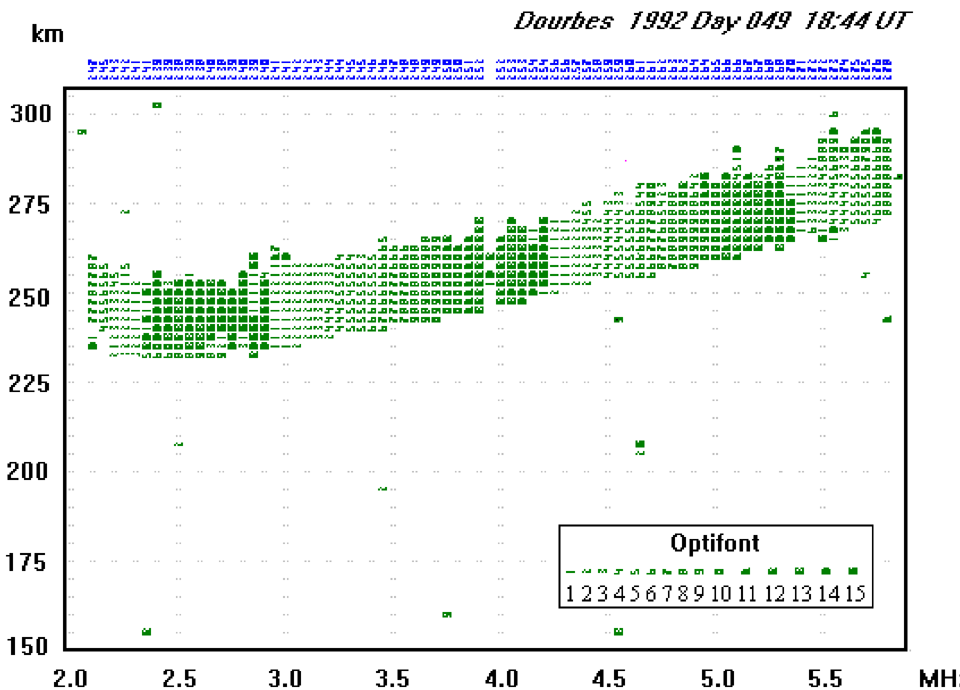
PR method relies on evaluation of phase difference between close frequencies, which is not affected by unknown time delays in the system (0 km bias) and affected negligibly by differences in phase shifts at f_1 and f_2.

Improvement of Resolution

- Current data format allows storage of PR data with 1 km resolution
- Digisonde 4D: Phase precision of 2 degrees translates to 150 m (for 5 kHz spacing)
- DPS-4: phase precision is 6 degrees (750 m resolution)
- Real-life phase measurements are subject to greater uncertainties due to multipath propagation and interference
- We specify 1 km resolution for now

PR in Digisondes

- Digisonde 256: "P1=b" mode
- DPS-4: "PGH" mode



- Why we did not recommend PR before?

Did not believe it would work

Differential Phase Technique

Plasma Sounding

Eikonal solution $E(\mathbf{r},t) = E_0 e^{-i\left(\omega t - \int_{\mathbf{r}_0}^{\mathbf{r}(\omega)} \mathbf{k}\cdot d\mathbf{r} - \phi_0\right)} \Rightarrow E(0,t) = E_0 e^{-i\left(\omega t - 2\int_{h_0}^{h_R(\omega)} k dh - \phi_0\right)}$

Signal phase at receiver $\phi_{rec}(\omega) = \frac{2}{c}\int_0^{h_R(\omega)} \omega\, n(h,\omega)\, dh + \phi_0 ,$

Phase differential $\frac{d\phi_{rec}}{d\omega} = \frac{2}{c}\int_0^{h_R(\omega)} \frac{\partial(\omega n)}{\partial \omega} dh = \frac{2}{c} h'(\omega),$ since $n(h_R,\omega) = 0$

$$and \quad \frac{d\phi_0}{d\omega} = 0$$

$$\therefore \quad \Delta_\omega \phi_{rec} = \int_{\omega_1}^{\omega_2} \frac{d\phi_{rec}}{d\omega} d\omega = \int_{\omega_1}^{\omega_2} h'(\omega) d\omega = \frac{2}{c}\bar{h}'\Delta\omega.$$

$$\boxed{\bar{h}' = \frac{c}{4\pi\,\Delta f}\Delta_\omega \phi_{rec} = 30\,km \cdot \frac{\Delta_\omega \phi_{rec}}{2\pi}.}$$

$$h'(\omega_1) < \bar{h}' < h'(\omega_2)$$

$$\Delta f = 5\,kHz$$

[Reinisch et al., AIP Proceedings #974, 2008]

Details of phase difference

$$\frac{d\phi_{rec}}{d\omega}=\frac{2}{c}\left[\int_{h_0}^{h_R(\omega)}\frac{\partial(\omega n)}{\partial\omega}dh+\omega n(h_R,\omega)\left(\frac{dh(h_R)}{d\omega}\right)-\omega n(h_0,\omega)\left(\frac{dh_0}{d\omega}\right)\right]$$

(Leibniz Theorem)

$$\frac{d\phi_{rec}}{d\omega}=\frac{2}{c}\left[\int_{h_0}^{h_R(\omega)}\frac{\partial(\omega n)}{\partial\omega}dh\right]\quad \text{since } n(h_R,\omega)=0, \text{ and } \left(\frac{dh_0}{d\omega}\right)=0.$$

But $\int_{0}^{h_R(\omega)}\frac{\partial(\omega n)}{\partial\omega}dh=h'(\omega)$ (proof on page 4). Therefore:

$$\frac{d\phi_{rec}}{d\omega}=\frac{2}{c}h'(\omega),\ \text{or}$$

$$\Delta_\omega\phi_{rec}=\int_{\omega_1}^{\omega_2}\frac{d\phi}{d\omega}d\omega=\frac{2}{c}\int_{\omega_1}^{\omega_2}h'(\omega)d\omega=\frac{2}{c}h_i'\Delta\omega,\ \text{where } h'(\omega_1)<h_i'<h'(\omega_2)$$

$$\therefore\ \boxed{h_i'=\frac{c}{4\pi\,\Delta f}\Delta_\omega\phi_{rec}}$$

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2π-ambiguity and h’ accuracy

$$h_i^{i} = \frac{c}{4\pi\,\Delta f}\,\Delta_{\omega}\phi_{rec} = \frac{c}{2\,\Delta f}\left(\frac{\Delta\phi_{meas}}{2\pi}+m\right);\ \Delta f = 5\,kHz \text{ in DPS}$$

$$h_i^{i} = 30km\left(\frac{\Delta\phi_{meas}}{2\pi}+m\right); \quad \text{i.e., } 2\pi \text{ ambiguity is 30 km}$$

m is determined by comparison with amplitude ionogram.

Accuracy:

$$\delta\,\mathrm{h}_{\mathrm{i}}^{'} = 30\,km\left(\delta\,\frac{\Delta\phi_{meas}}{2\pi}\right).$$

$$\text{Since } \delta\,\Delta\phi_{meas} < \frac{2\pi}{32}$$

$$\delta\,\mathrm{h}^{'} \le 1km$$

Group height h'(ω)

$$h' = \frac{1}{2} c t_g = c\int_0^{h_R(\omega)} \frac{dh}{\mathrm{v_g}(h,\omega)} = c\int_0^{h_R(\omega)} \frac{\partial k}{\partial \omega} dh, \text{ since } \mathrm{v_g} = \frac{\partial \omega}{\partial k}$$

$$k = \omega / \mathrm{v} = \omega n / c, \text{ since } \mathrm{v} = c/n.$$

$$\therefore \boxed{h' = \int_0^{h_R(\omega)} \frac{\partial(\omega n)}{\partial \omega} dh} \quad \text{q.e.d.}$$

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Uncertainty $h'_2 - h'_1$

From slide 13:

$$\Delta_{\omega}\phi_{rec} = \frac{2}{c}\overline{h}'\Delta\omega \quad \text{where } h'_1 < \overline{h}' < h'_2.$$

The uncertainty u is therefore:

$$u \approx \frac{1}{2}\left|h'(f_2) - h'(f_1)\right|.$$

Estimates from ionogram traces show:

Region	Δh'/1 MHz	u(5 kHz)
E	10 km	25 m
E cusp	50 km	125 m
F bottom	30 km	75 m
F cusp	300 km	750 m

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PRECISION RANGING DATA in ARTIST-5

Dr. Ivan Galkin

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Center for Atmospheric Research

2009 IDF

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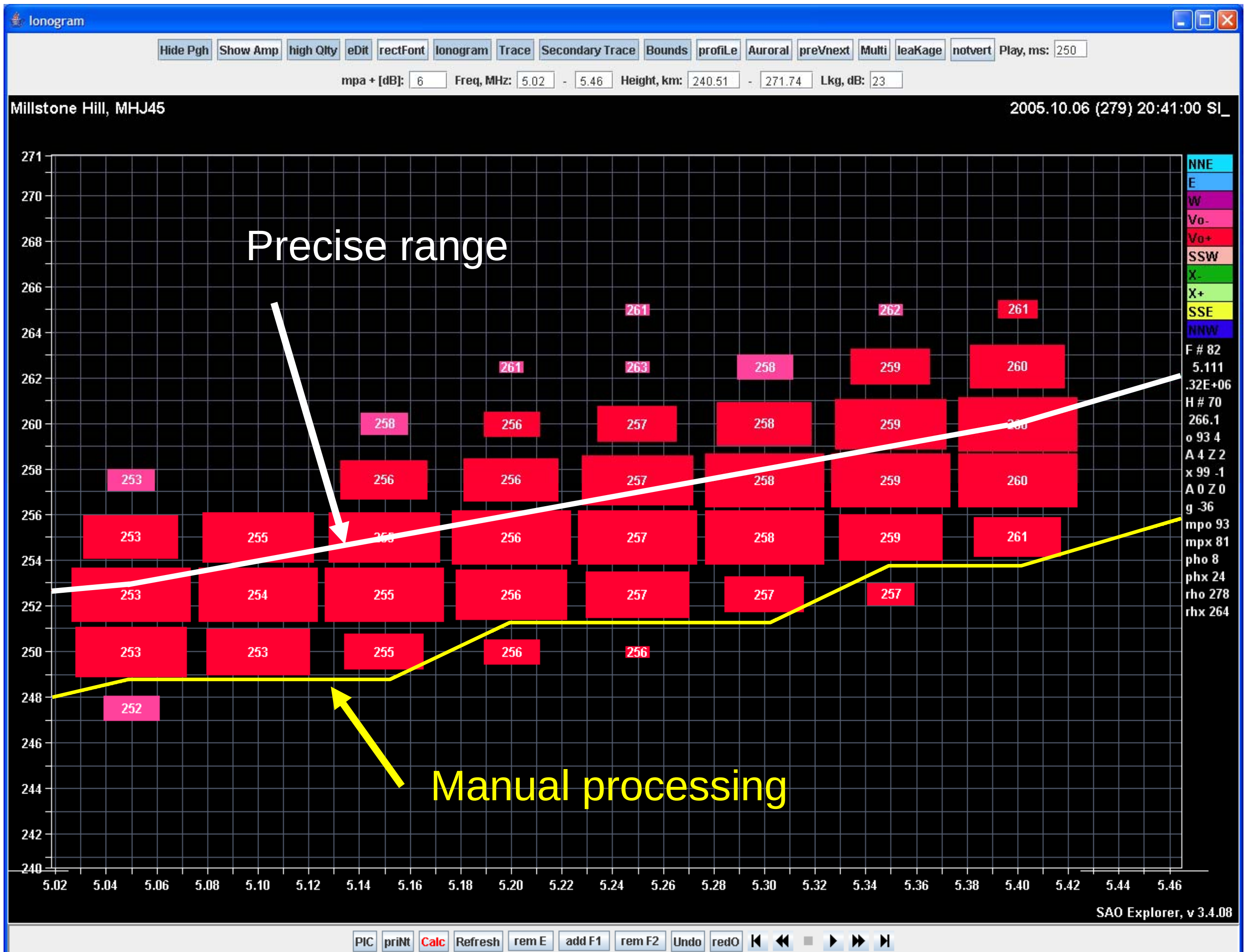
Precision Ranging Ionogram
DPS-4 “PGH” mode



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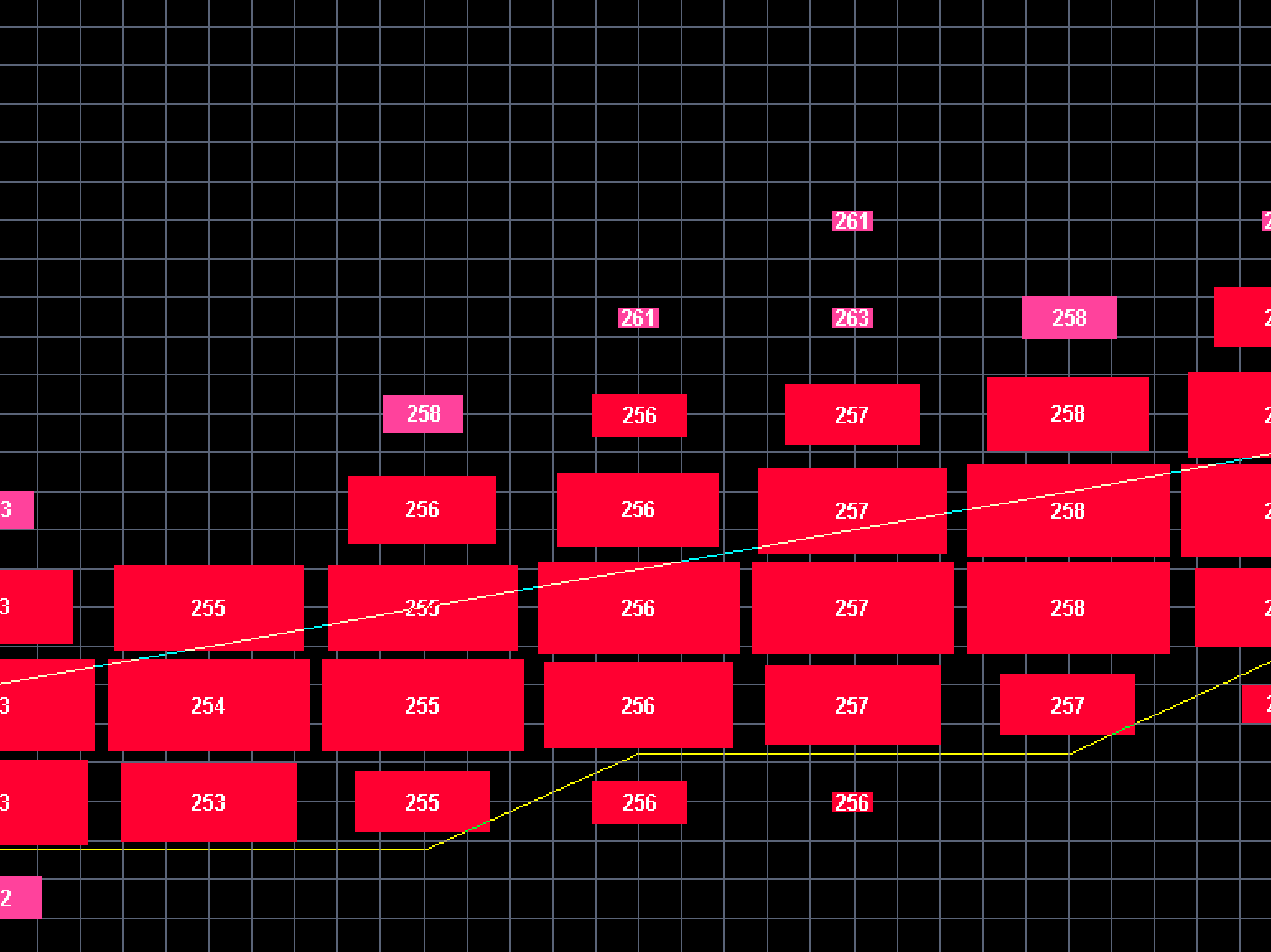
261
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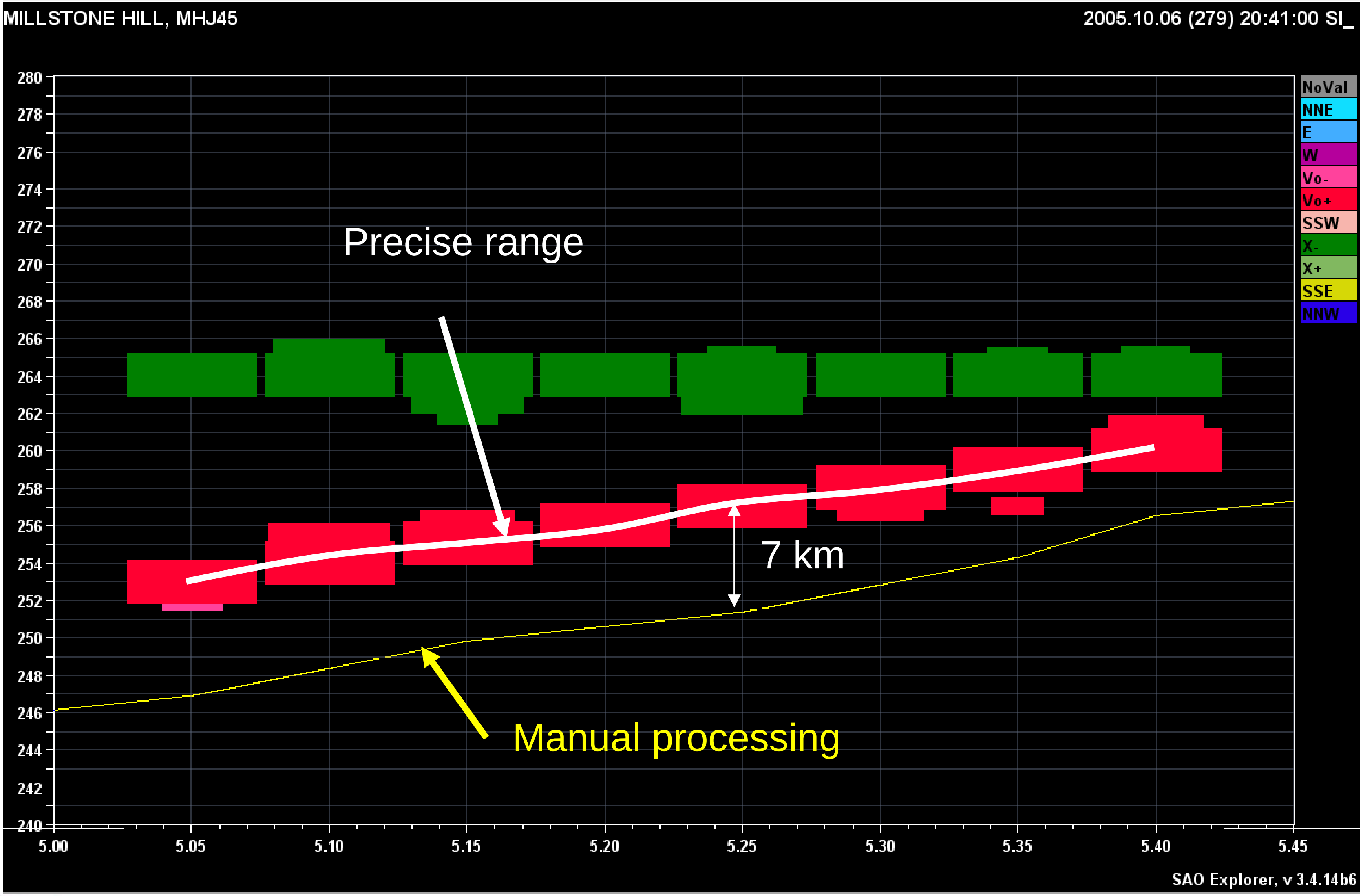
256

“Snapped to PGH” Display



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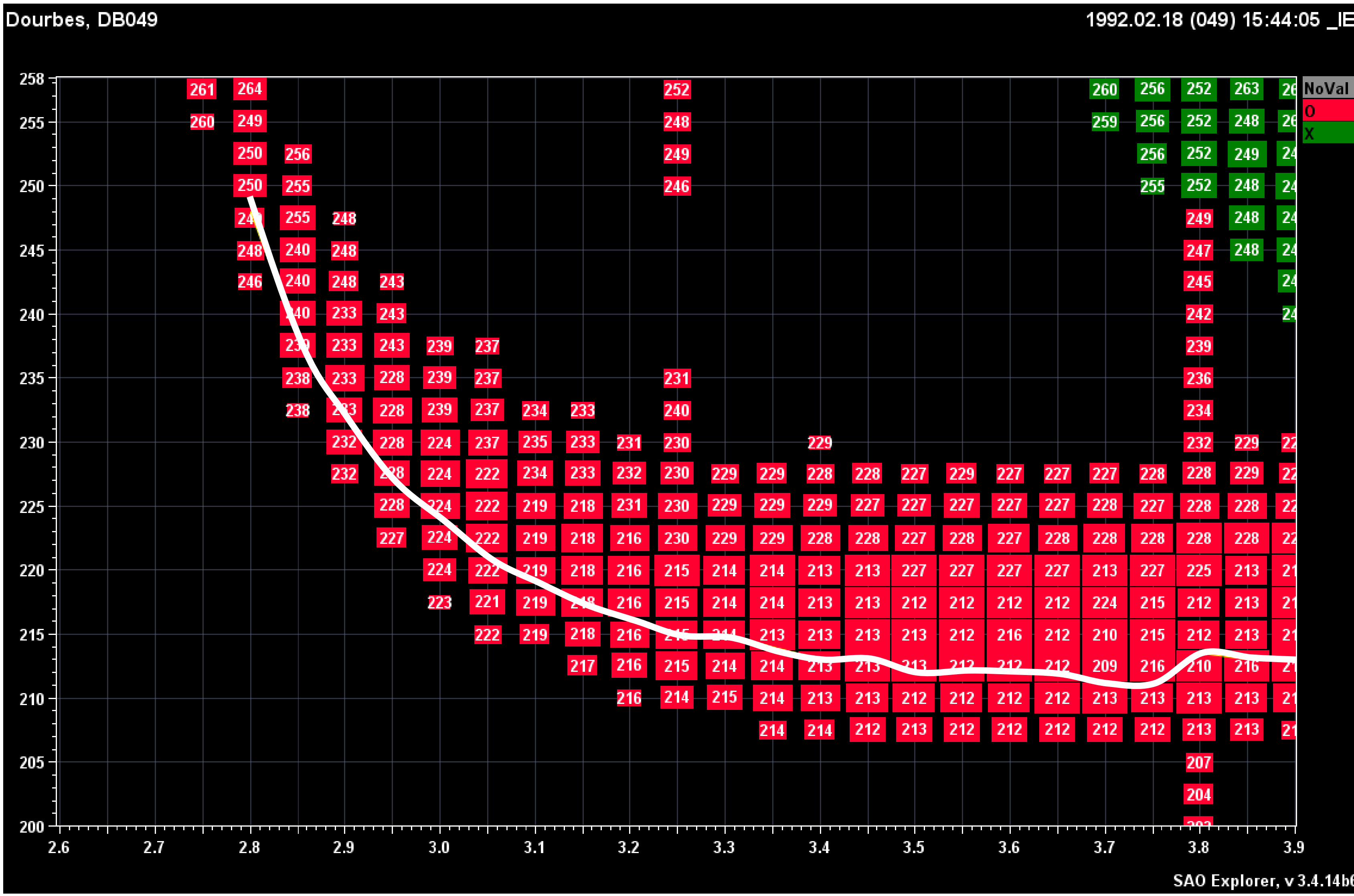
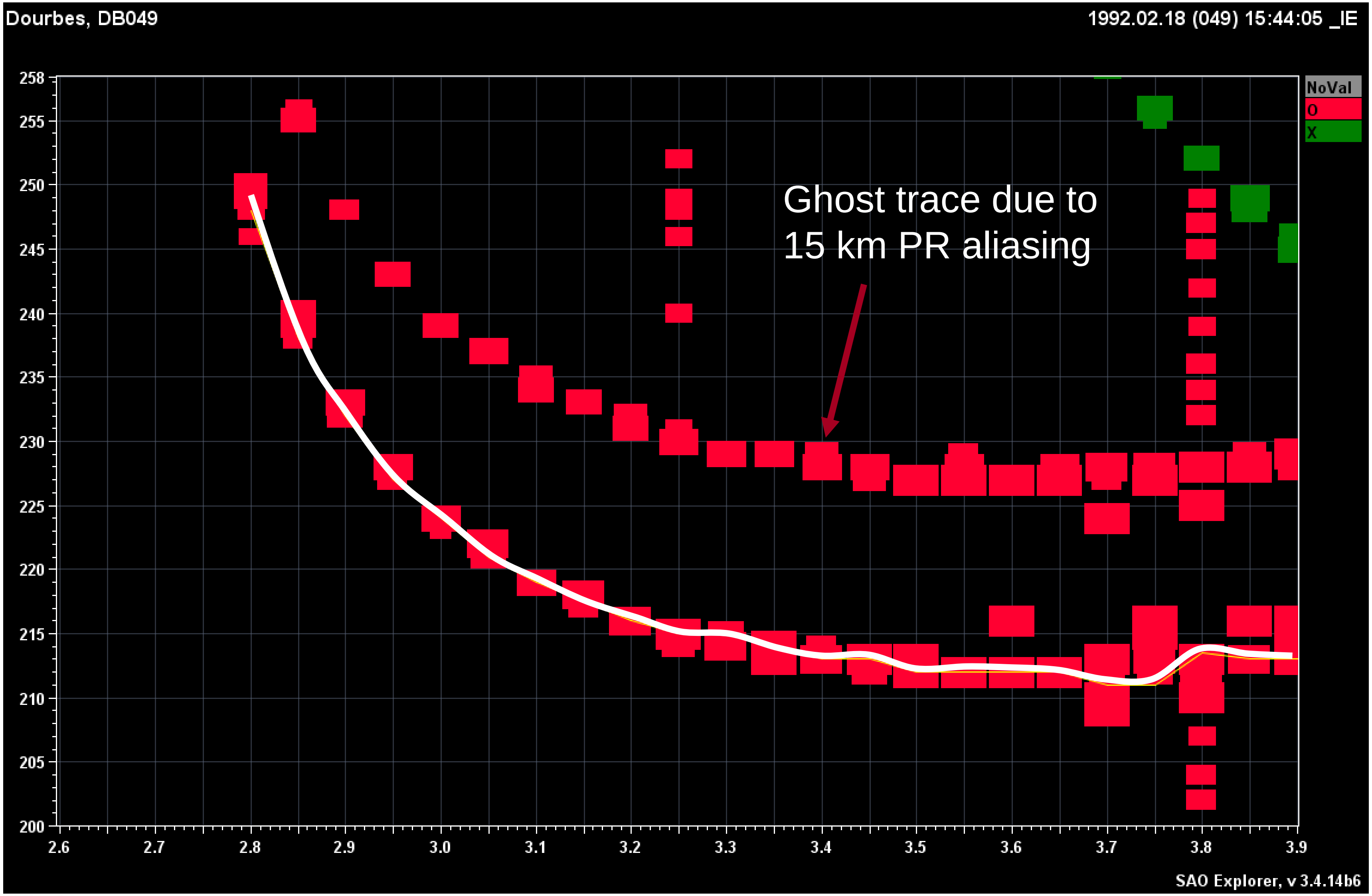
Precision Ranging Ionogram

Digisonde 256 “P1=B” mode



“Snapped to PGH” Display



Lowering of Trace in ARTIST

- ARTIST 4.x lowers scaled traces to the leading edge of the echoes.
  - The leading edge was thought to be a better reference for calculating the travel time
  - Apparently, Precision Ranging suggest that lowering shall be avoided
- ARTIST 5 does not lower the trace
  - Lowering disabled for “portable” family (DPS-1, DPS-4, and Digisonde-4D)
  - Lowering still enabled for Digisonde-256 family

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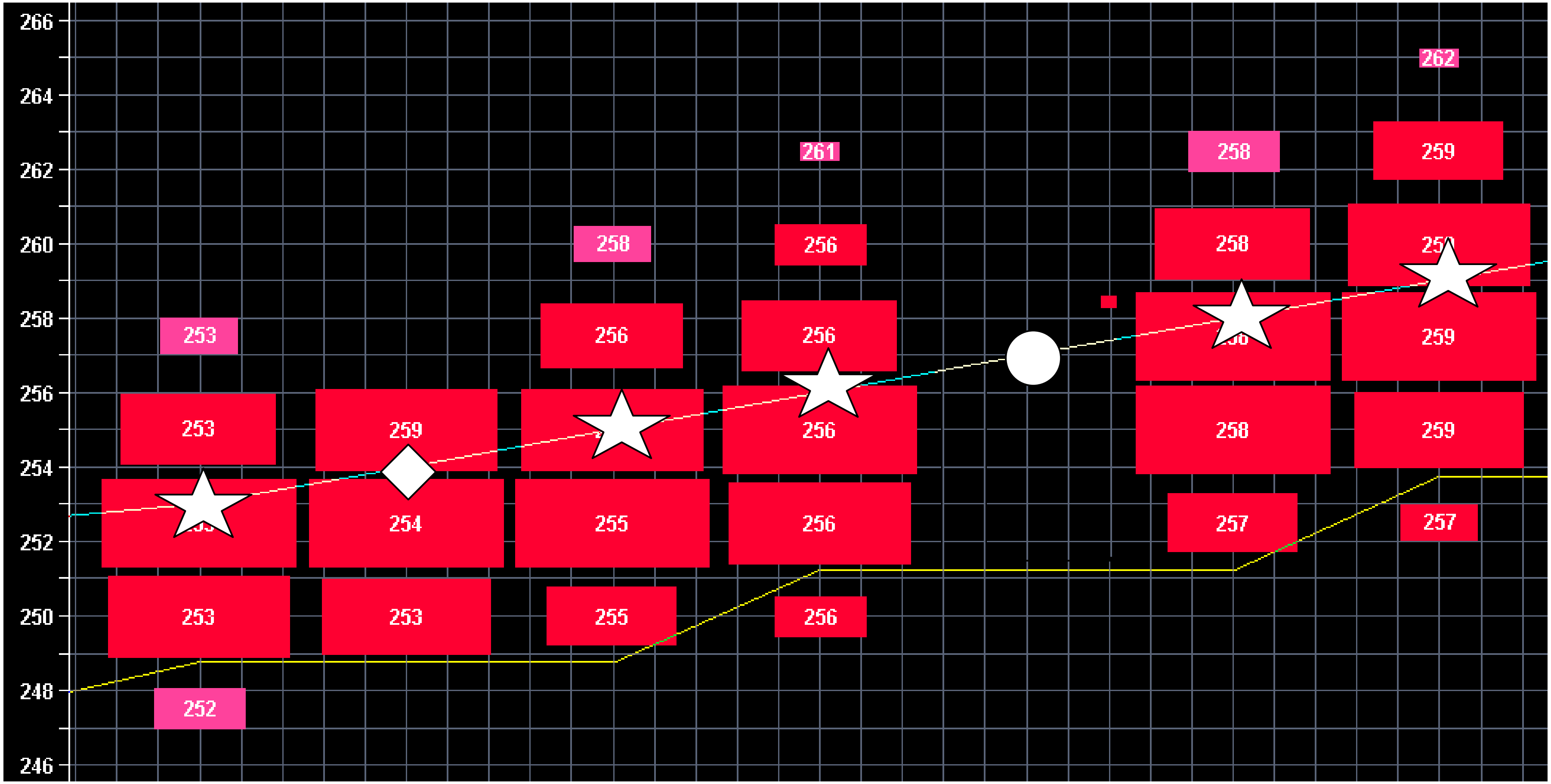
Use of Precise Ranges in ARTIST-5

- PR values are more accurate but not quite reliable
  - Occasional “bad” values are observed
  - Possibly due to the phase measurement error from multi-path propagation or interferer
- Not quite ready to use PR values prior to trace extraction
- Instead, apply corrections from PR data to nominally autoscaled traces
- Use of PR in ARTIST is subject for further investigation

Principles of PR adjustments



Good PR value, adjust directly

Bad PR value, use average adjustment from neighbors

No PR data, re-interpolate

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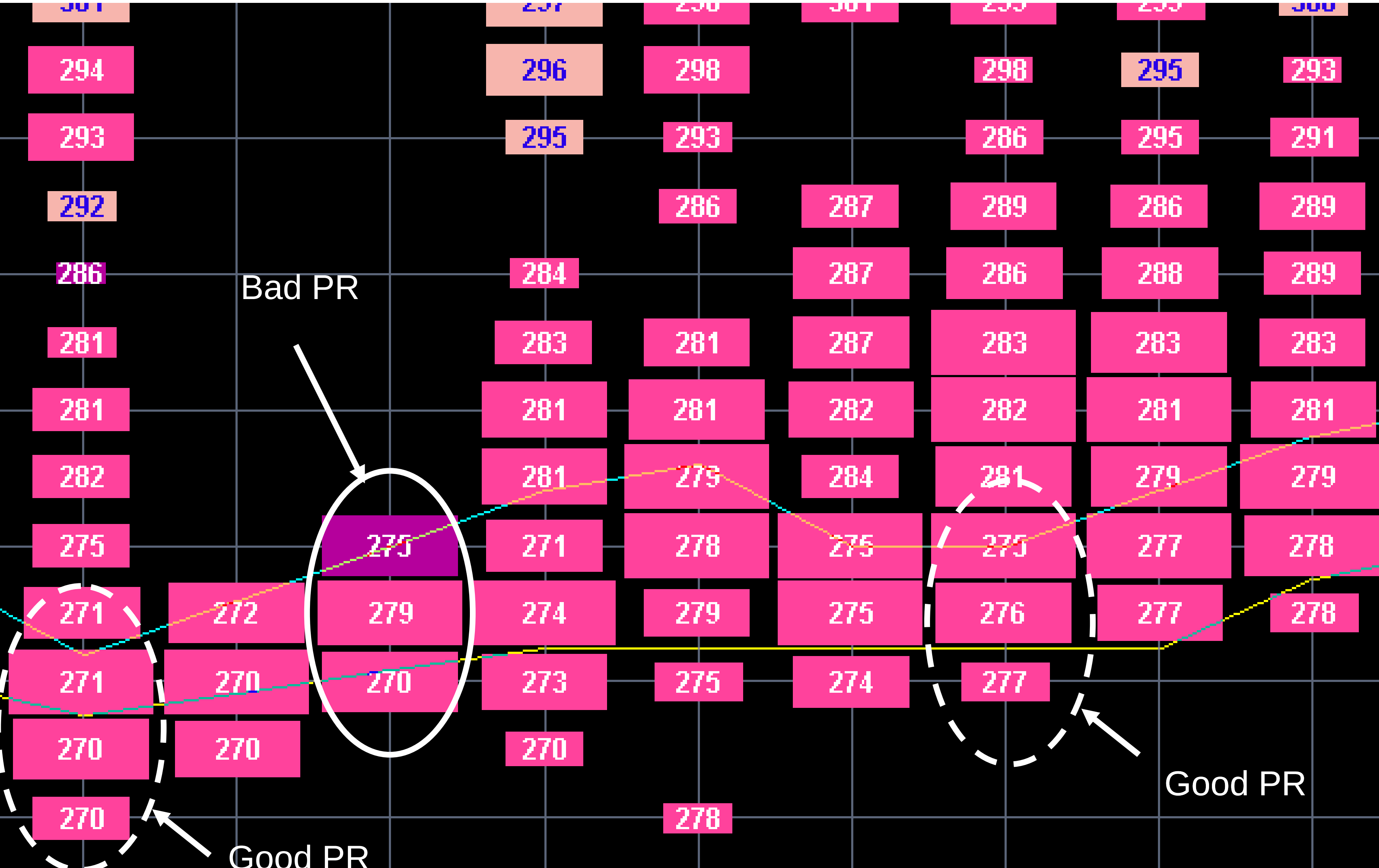
Good PR versus Bad PR



Good PR Criteria

- Compare three abutting range bins
  – the PR value is used if differences between three values are less than 3 km
  – the PR value is used if it differs from the “leading-edge” value not more than 6 km
- Investigate: compare PR values from pulse to pulse
  – Currently phase values for PR method come out of the beamforming algorithm for particular Doppler line and particular beam (vertical or oblique)

Lessons Learned

- Digisonde directors: use PR mode where possible
  - Digisonde 256/DISS: "P1=B" mode (subject to hardware modification)
  - DPS-4 and DPS-1: "PGH" mode (works well in generation 5 systems with C-40 DSP)
  - Digisonde-4D: 2-frequency PGH mode
- Ionogram scalers: use "Snap to PGH" option to scale ionograms accurately
- ARTIST-5: do not lower the trace for DPS family
  - Difference in h' values is expected for comparisons between AR-4 and AR-5

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GIRO Front End: SAO Explorer with DIDBase and ADRES

Grigori Khmyrov

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Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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Key Features

- Java Technology Advantages
  - power of software development
  - platform independence
  - screen resolution freedom
  - choice of output image formats
- Input data flexibility
  - "Open all files with this extension"
  - database queries (DIDBase)
  - List of available records with random access
- Density contours, time series and profilograms while editing
- "Details on demand"
  - light GUI
  - on mouse position
  - context menus
- ASCII information export and copy/save
- Qualifying and descriptive letters (URSI, IIWG), edited/validated flags
- User preferences
- Embedded auto-scaling software Artist 5

Interactive Ionogram Processing

- Ionogram Data Visualization
  - ionogram display with zoom-in and details-on-demand
  - ionogram surveys (using “thumbnails”)
  - ionogram movies
- Interactive Ionogram Scaling
- Profile Inversion
- Time series of Scaled Data
  - Ionospheric characteristics
  - Plasma density contour/profilogram
  - Directogram
  - Text tables for ASCII export

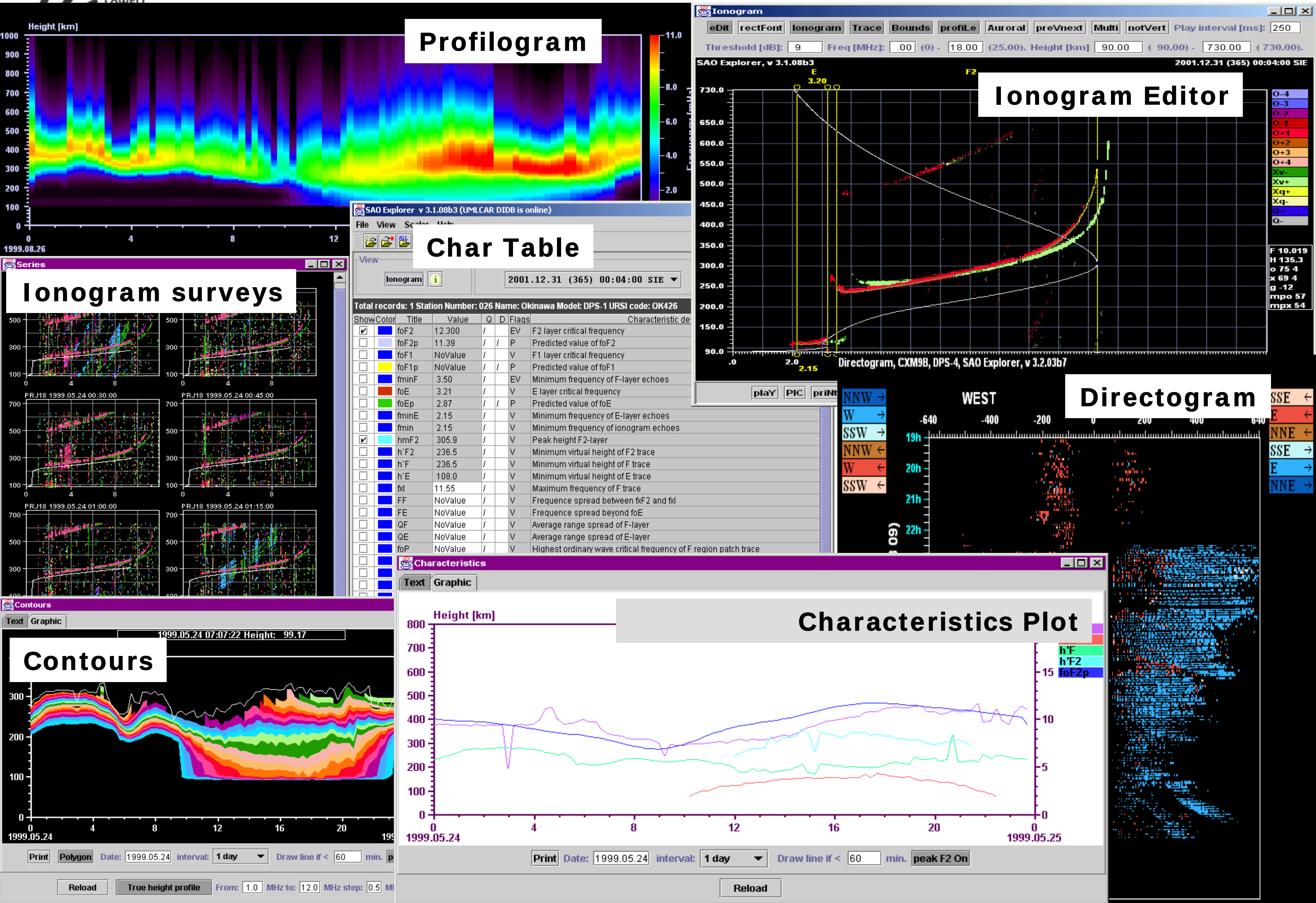
New features

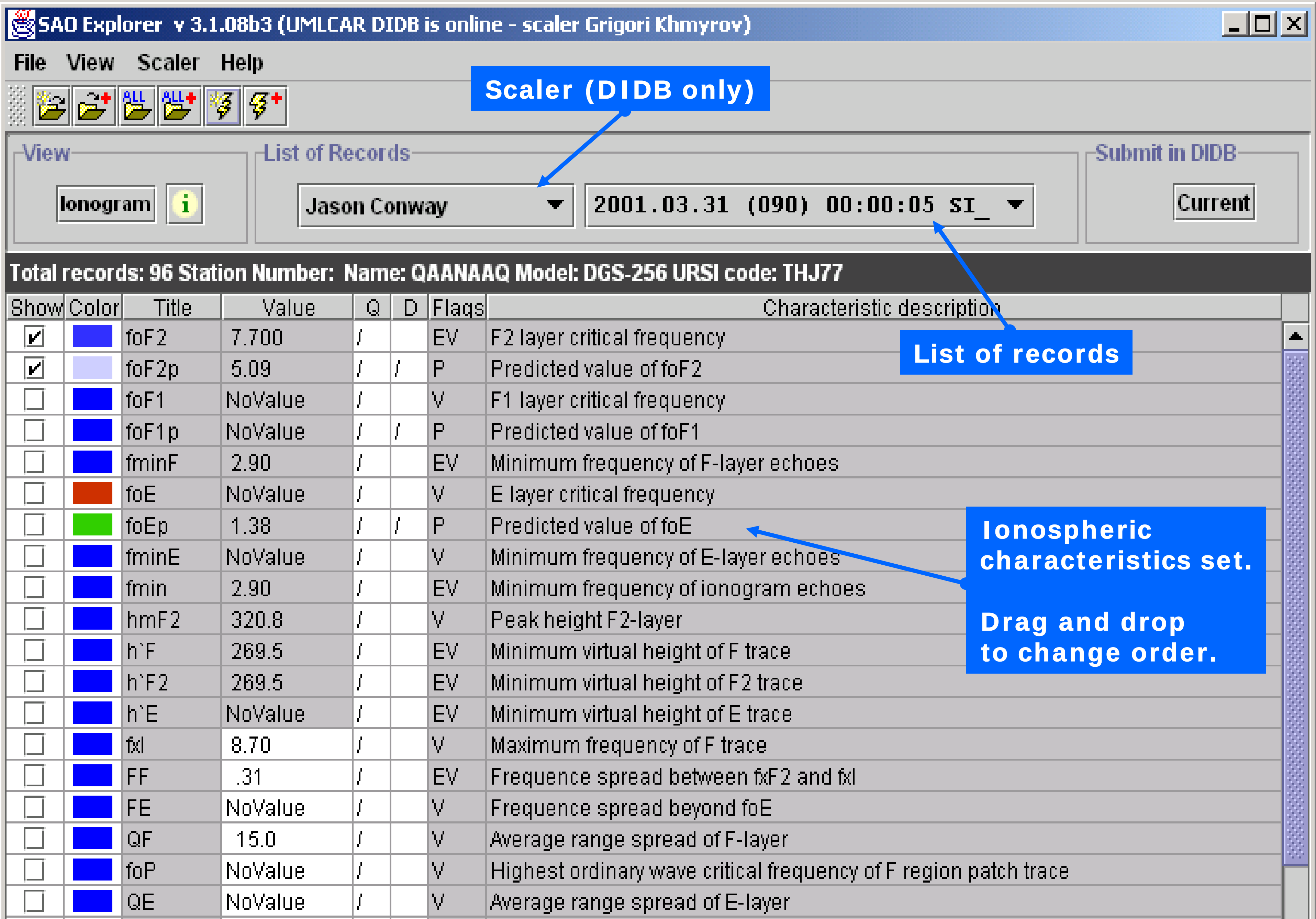
- DPS-4D new data format support (RAW)
- SAO.XML 5.0 format
- Save SAO format choice (Option Frame)
- Embedded ARTIST 5 (Ionogram Frame)
- Tools menu: for all opened records
  - Save Autogain table
  - Save trace data
  - Make pictures
- Ionogram data ASCII export (Info Frame)
- Close subset of records

Data Formats Supported

- Ionograms
  - MMM
  - BEM
  - SBF
  - RSF-flex
  - PGH
  - RSF
  - RAW
- Scalings
  - SAO.XML 5.0
  - SAO 3.0 - 4.3
  - ART
  - ADP binary

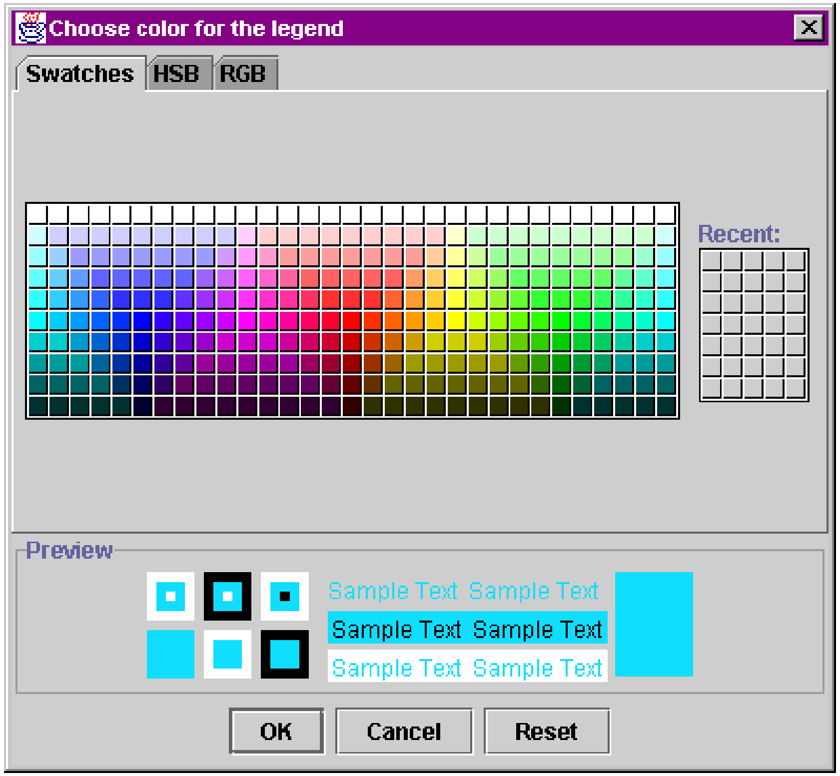
Welcome to SAO-X

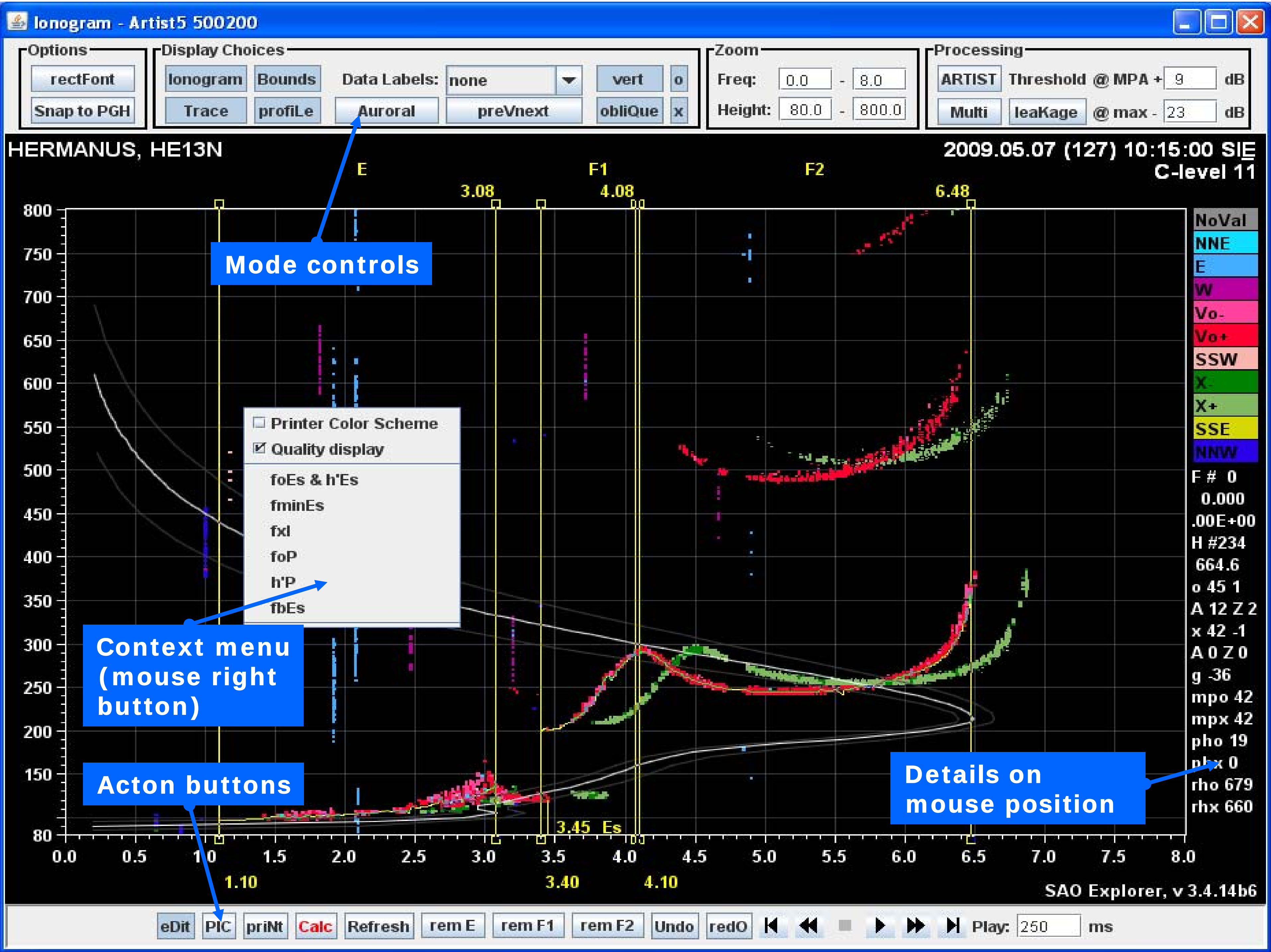



SAO Explorer v 3.1.08b3 (UMLCAR DIDB is online - scaler Grigori Khmyrov)
File View Scaler Help
Scaler (DIDB only)
View
Ionogram
List of Records
Jason Conway
2001.03.31 (090) 00:00:05 SI_
Submit in DIDB
Current
Total records: 96 Station Number: Name: QAANAAQ Model: DGS-256 URSI code: THJ77
Show Color Title Value Q D Flags Characteristic description
foF2 7.700 / EV F2 layer critical frequency
foF2p 5.09 / / P Predicted value of foF2
foF1 NoValue / V F1 layer critical frequency
foF1p NoValue / / P Predicted value of foF1
fminF 2.90 / EV Minimum frequency of F-layer echoes
foE NoValue / V E layer critical frequency
foEp 1.38 / / P Predicted value of foE
fminE NoValue / V Minimum frequency of E-layer echoes
fmin 2.90 / EV Minimum frequency of ionogram echoes
hmF2 320.8 / V Peak height F2-layer
h`F 269.5 / EV Minimum virtual height of F trace
h`F2 269.5 / EV Minimum virtual height of F2 trace
h`E NoValue / EV Minimum virtual height of E trace
fxI 8.70 / V Maximum frequency of F trace
FF .31 / EV Frequence spread between fxF2 and fxI
FE NoValue / V Frequence spread beyond foE
QF 15.0 / V Average range spread of F-layer
foP NoValue / V Highest ordinary wave critical frequency of F region patch trace
QE NoValue / V Average range spread of E-layer
List of records
Ionospheric characteristics set.
Drag and drop to change order.

Change legend color

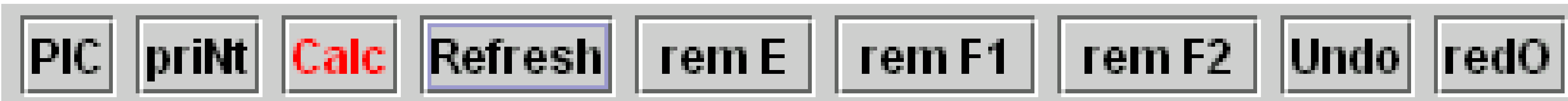
- Double click on a legend color invokes the color editor (except for the Characteristics frame that shall be adjusted from the Main Frame)





Ionogram - Artist5 500200
Options
rectFont
Snap to PGH
Display Choices
Ionogram
Bounds
Data Labels:
none
vert
o
Trace
profiLe
Auroral
preVnext
obliQue
x
Zoom
Freq:
0.0
8.0
Height:
80.0
800.0
Processing
ARTIST
Threshold @ MPA +
9
dB
Multi
leaKage
@ max -
23
dB
HERMANUS, HE13N
2009.05.07 (127) 10:15:00 SIE
C-level 11
Mode controls
Context menu (mouse right button)
Printer Color Scheme
Quality display
foEs & h'Es
fminEs
fxI
foP
h'P
fbEs
Acton buttons
Details on mouse position
NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW
SAO Explorer, v 3.4.14b6
eDit
PIC
priNt
Calc
Refresh
rem E
rem F1
rem F2
Undo
redO
Play:
250
ms

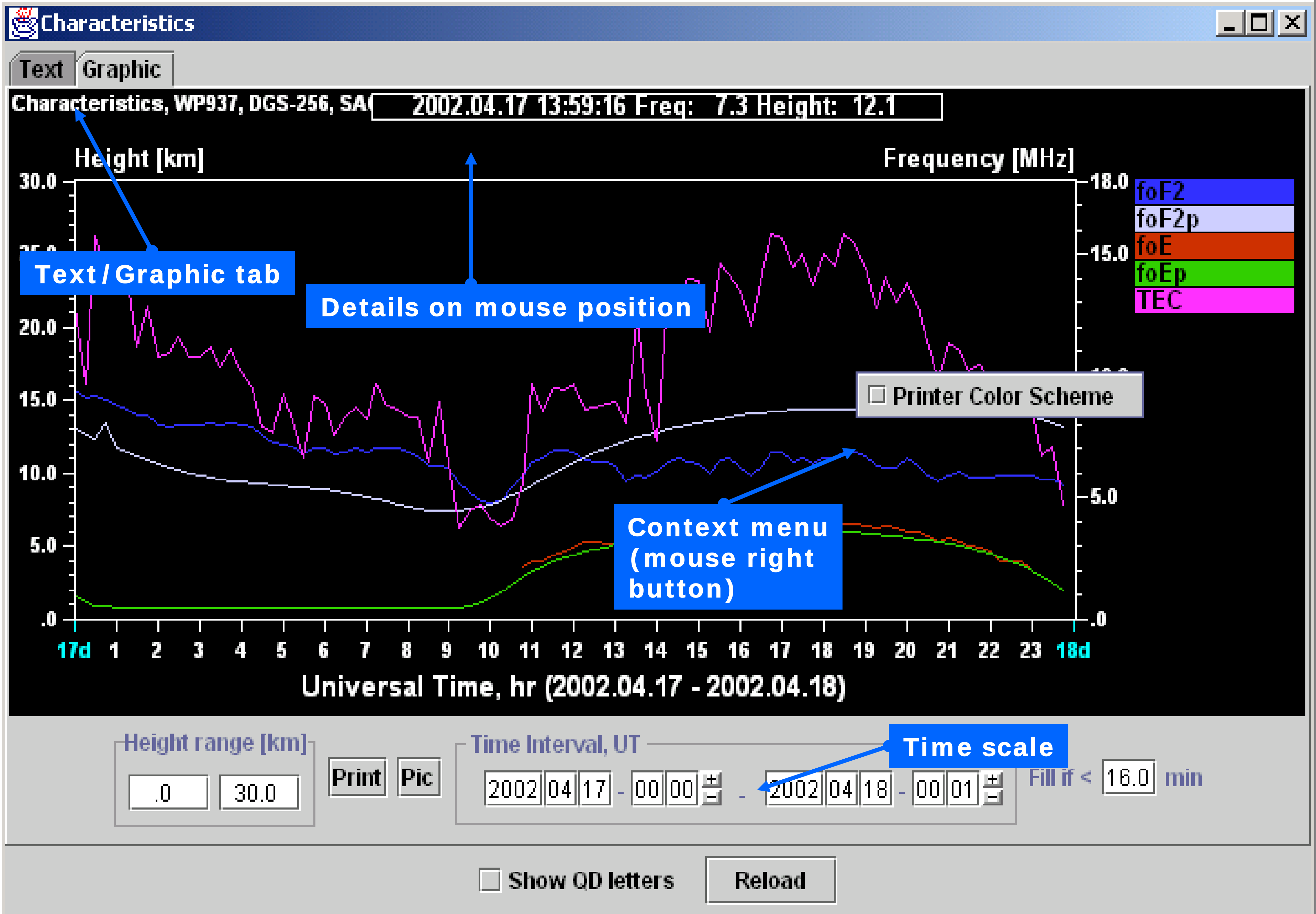
Hot keys



Use keyboard Hotkeys for most operations. The hotkey is shown in uppercase.

Also, use

+	to zoom-in
-	to zoom-out
arrows	to navigate within the ionogram
0,1,2,…n	threshold level above MPA (n*dB)
Alt + 0,1,2,…n	threshold level below MPA (-n*dB)
z, x	previous, next ionogram
F10	ARTIST 5


Characteristics
Text
Graphic
Characteristics, WP937, DGS-256, SA(
2002.04.17 13:59:16 Freq: 7.3 Height: 12.1
Height [km]
Frequency [MHz]
Text / Graphic tab
Details on mouse position
foF2
foF2p
foE
foEp
TEC
Printer Color Scheme
Context menu (mouse right button)
Universal Time, hr (2002.04.17 - 2002.04.18)
Height range [km]
Print
Pic
Time Interval, UT
Time scale
Fill if < 16.0 min
Show QD letters
Reload

Information

Scaling/Ionogram information 2003.12.24 (358) 07:00:01

System settings and file layout

Total records in list:	47
Station (UMLCAR ID):	MADIMBO
URSI code:	MU12K
Ionosonde model:	DPS-4
Scaling file (opened) SAO:	SAO-X_DIDB_SCAL_BLOB_
Scaling statistics:	Offset: 0, length: 10330, from database
Scaler:	auto Artist4 199905
Ionogram file (opened) RSF:	SAO-X_DIDB_IONO_BLOB_
Ionogram statistics:	Offset: 0, length: 131072, from database
Temporary file SAO:	f:\program files\sao-x_3\temp\MU12K_20031224(358)070001.TMP
MeasurementID:	1232532
UDD file:	from database
Geographic coordinates:	latitude = -22.390, longitude = 30.880
Geomagnetic coordinates:	latitude = -24.253, longitude = 98.153
Solar local time constants in UT:	sunrise = 03:11:28, sunset = 16:41:39, offset = 02:03:31
Gyrofrequency (IGRF):	.73
Dip angle (IGRF):	-58.445
Declination (IGRF):	-13.126
Sun spot number (from record):	55
Sun spot number (SUNSPT.ASC):	53
foF2 predicted (IRI):	7.765
foF1 predicted (IRI):	4.669
foE predicted (IRI):	3.364
PZAD file:	f:\program files\sao-x_3\PZAD\BEAM_STD.PZA
ARTIST version:	0599
NH version:	4.21
Schedule:	1
Program:	A
Starting frequency:	2.0 MHz
Ending frequency:	14.0 MHz
Frequency step:	0.05 MHz
Total frequences:	240
Coarse frequency step:	50.0 kHz

Operator's notes

NO NOTES

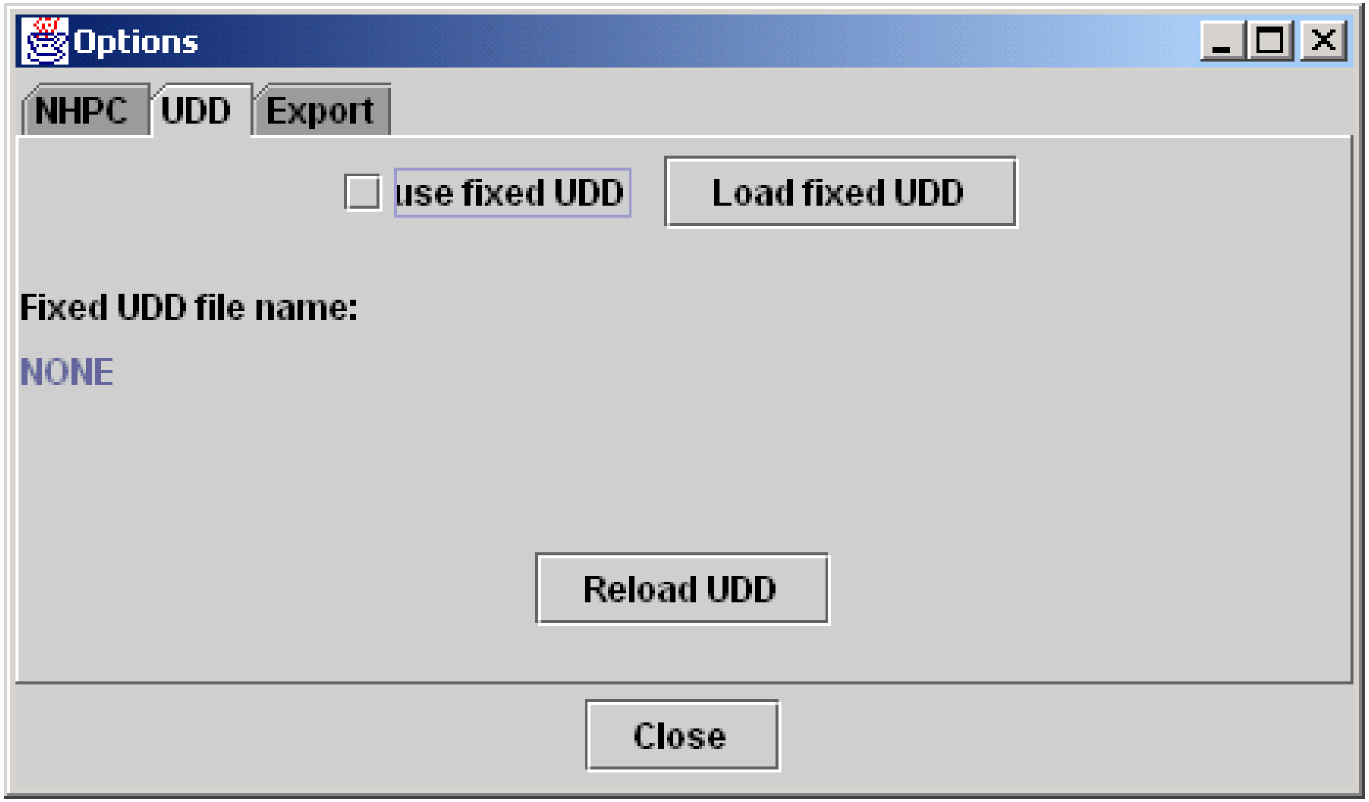
Export features

Scaling Ionogram

OK

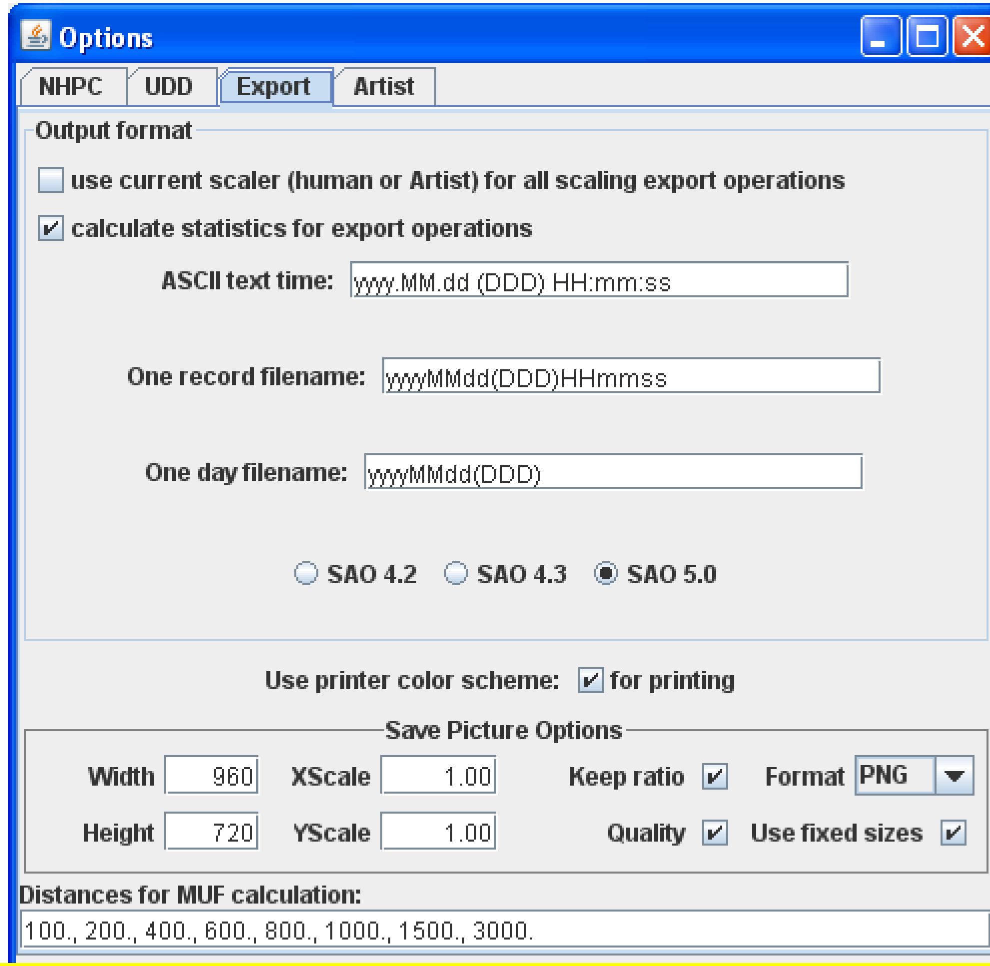
Option frame - UDD

- UDD file format with equipment history



Option frame - Export

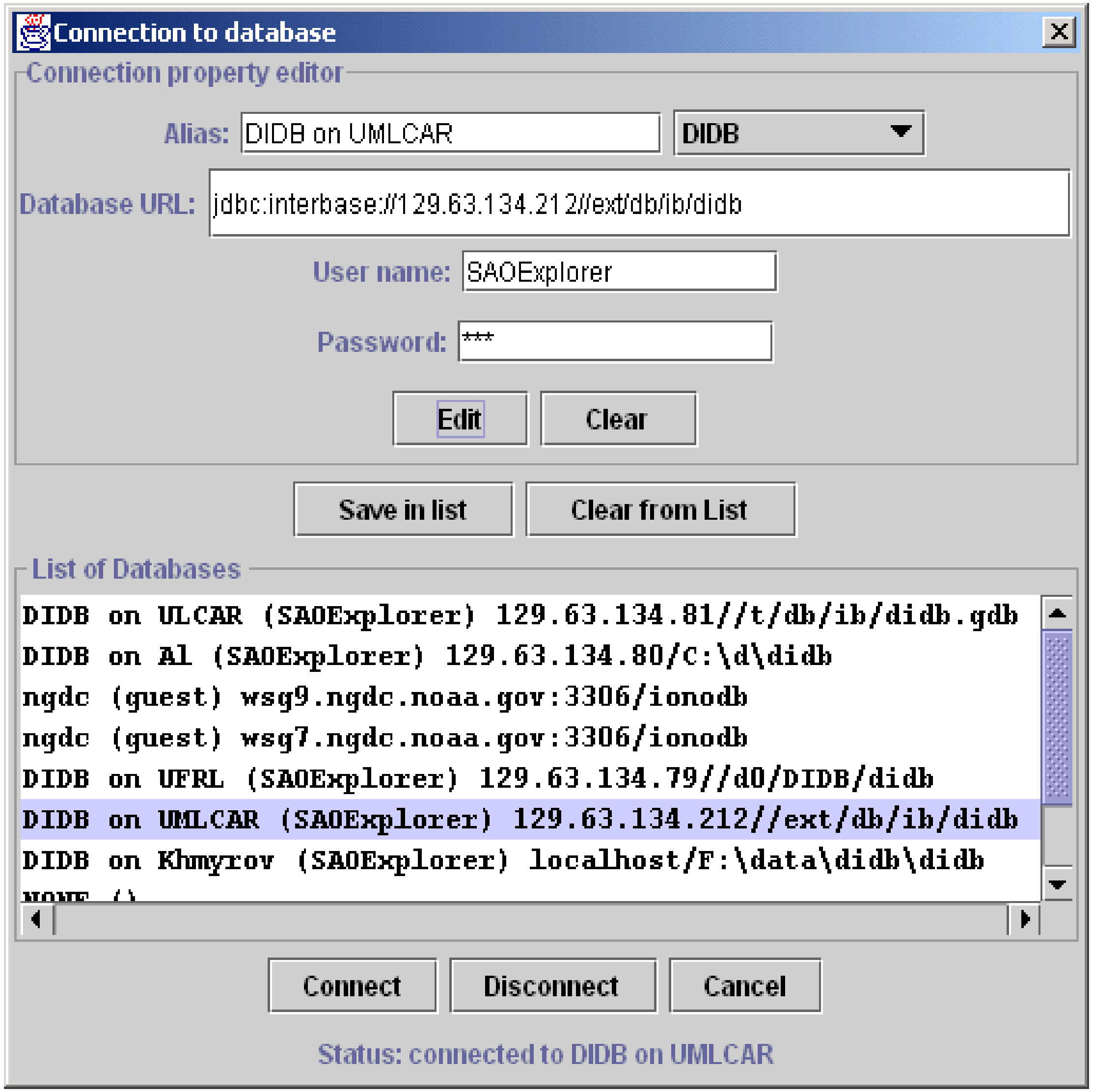
- Use current Scaler for output (DIDB)
- Date format
- SAO format
- Picture default output options
- MUF table



To get more picture formats just type extension BMP, PCX, TIF … in Save File Dialog

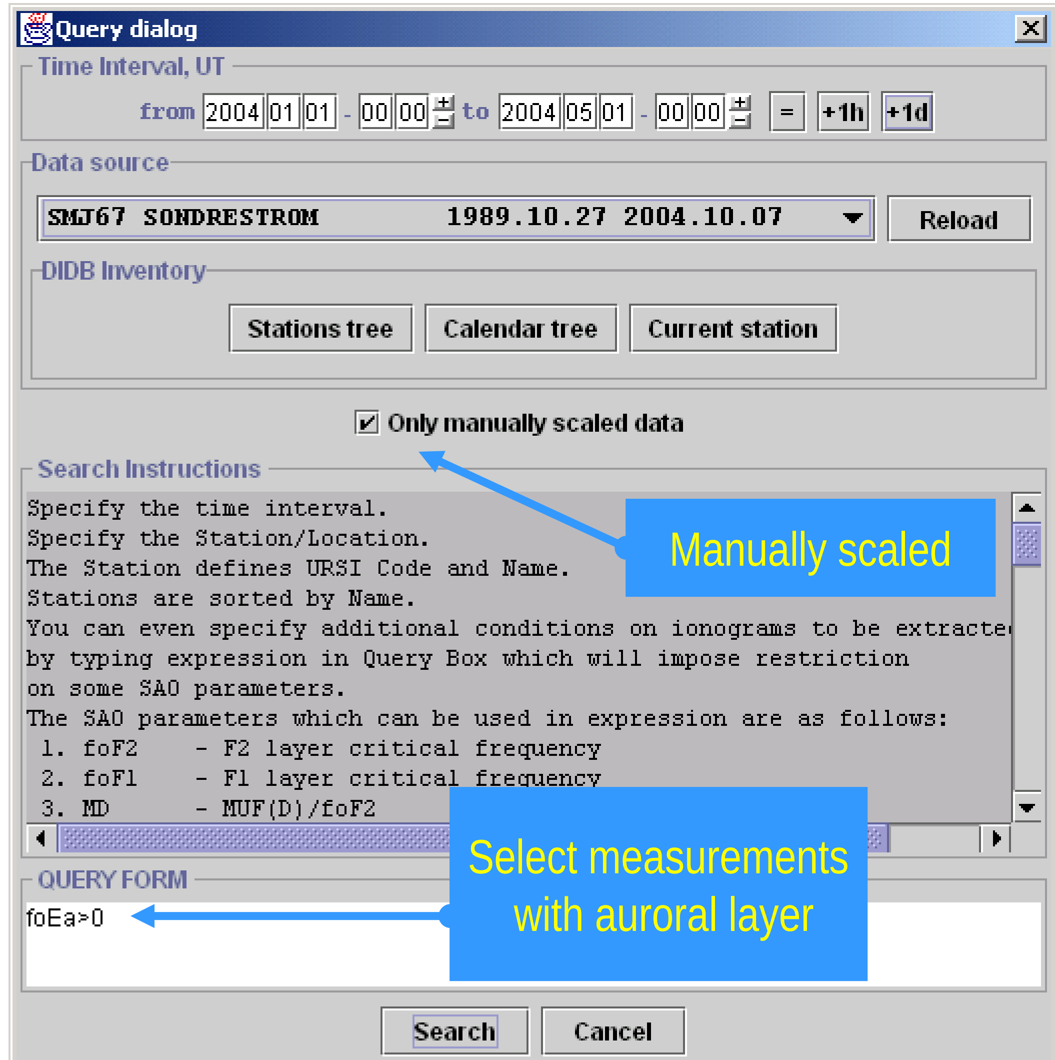
Database connection

- Read-only connection to DIDB over the Internet
- Remembers last connection information



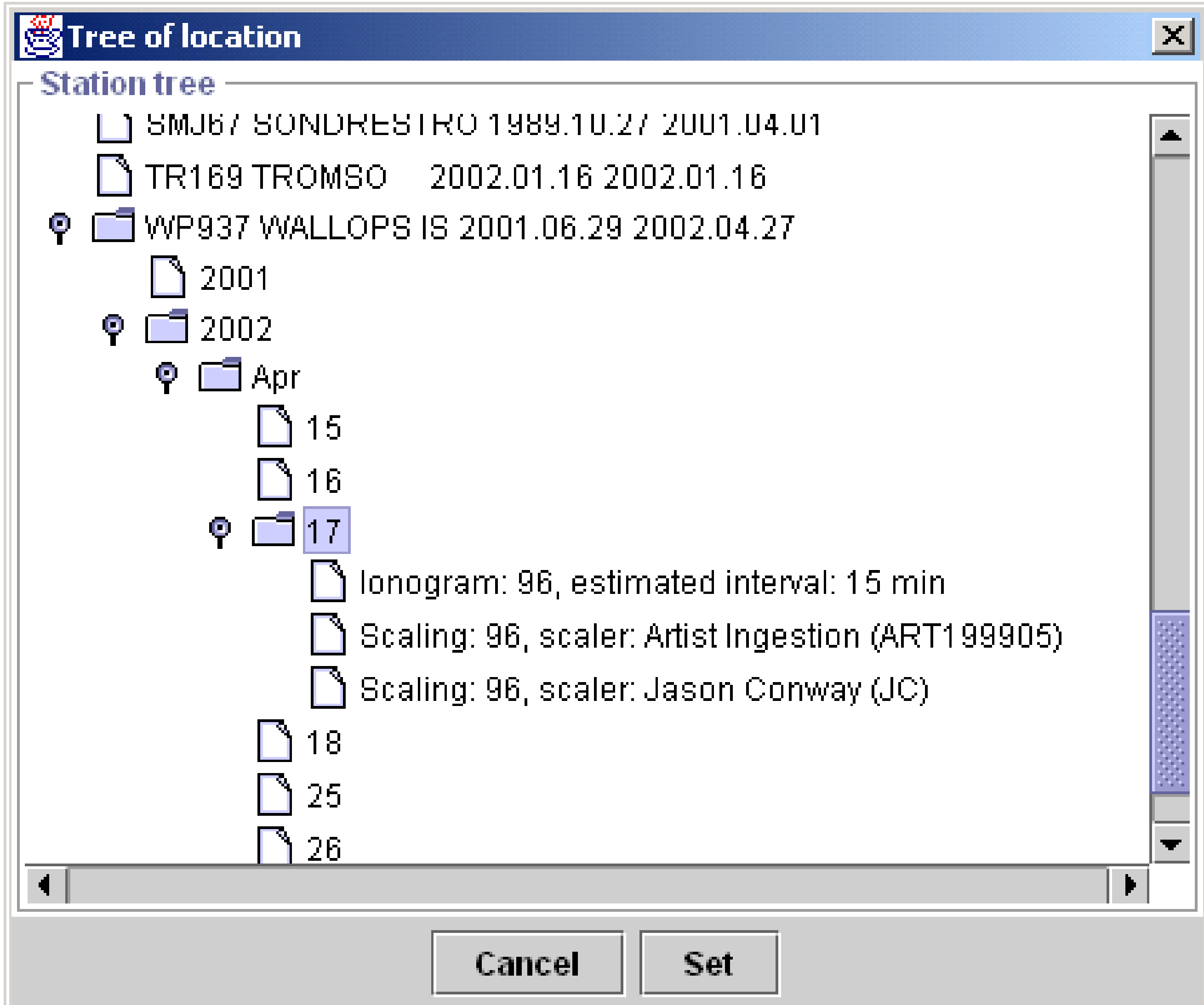
Database queries

- It fast (start/end times request works in background)
- List of available stations
- DIDB inventory available
- Use of ionospheric characteristics as search criteria
- Query only manual data



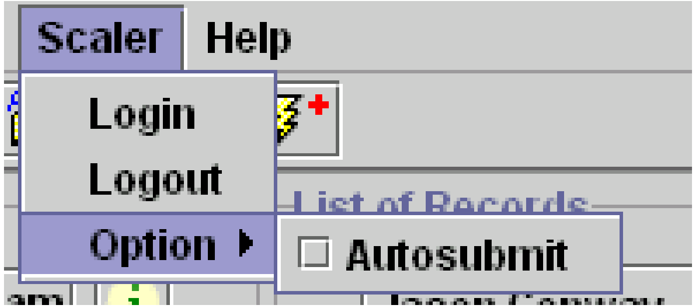
Inventory tree (DIDB only)

- Simple navigation
- Easy to check what is stored in DIDB
- Comprehensive information about data
- “One click” to set station/date in the Query dialog



DIDB write access

- Scaler password protected login
- Submit current record
- Auto submit option

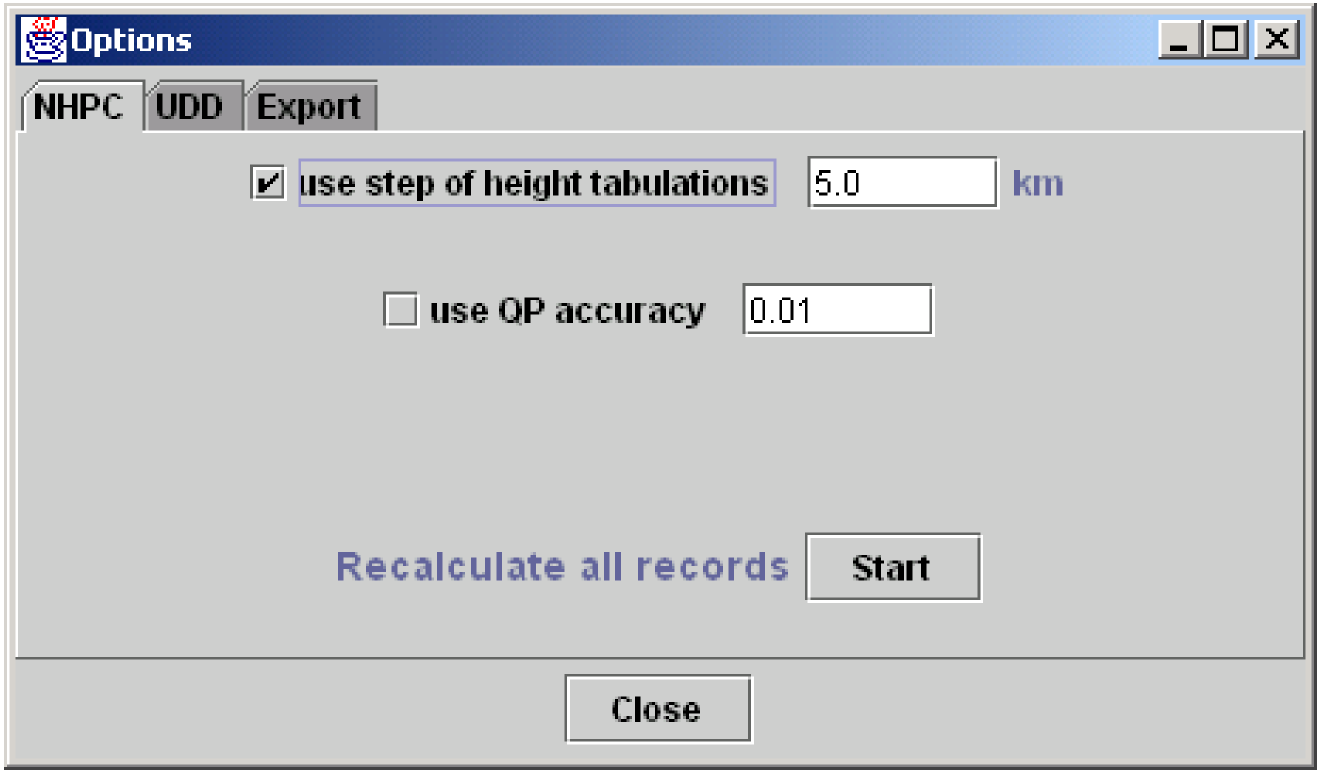


NHPC for SAO-X

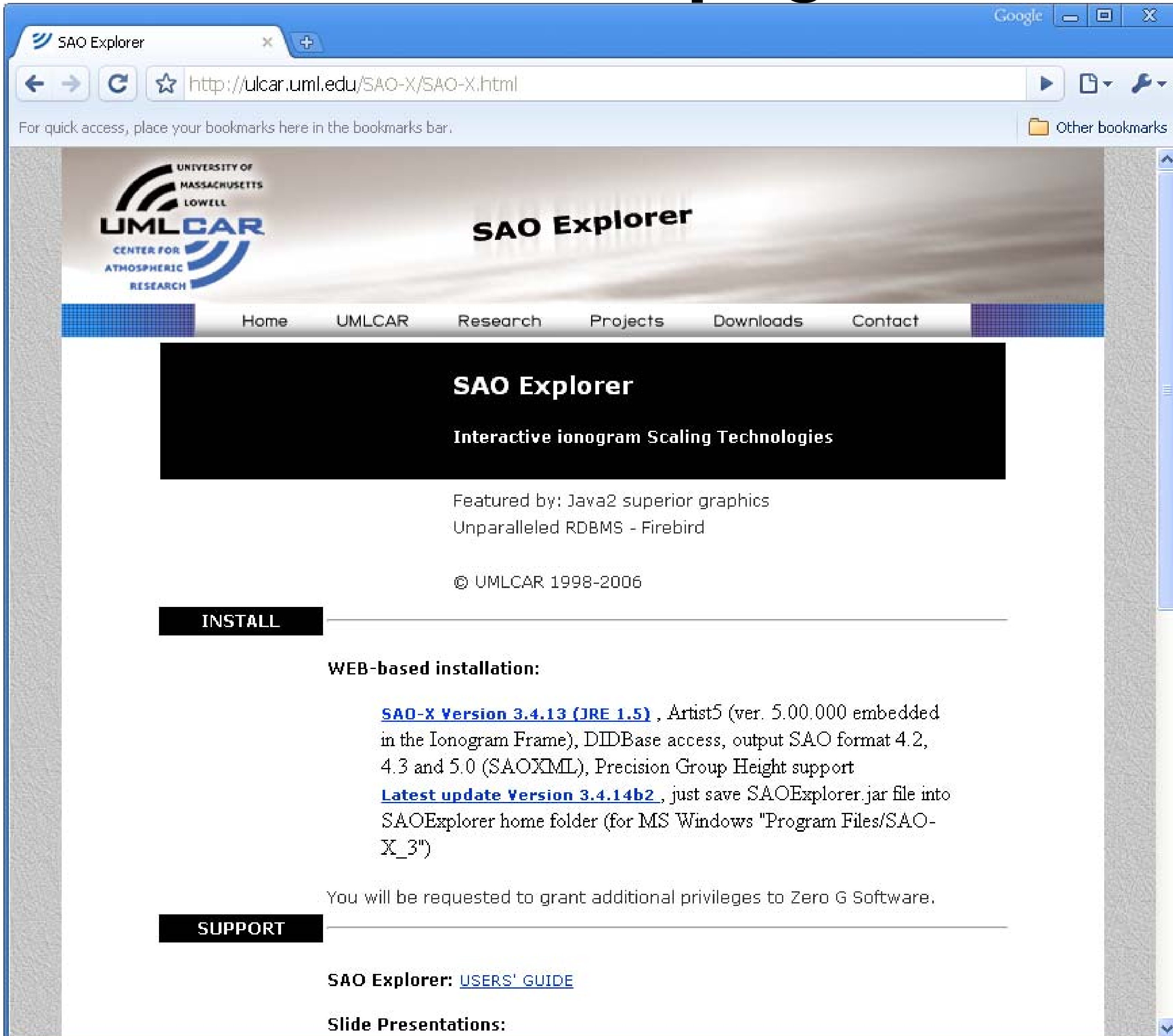
- NHPC v. 4.31 is a FORTRAN-90 application
- F90 compiler is required to obtain executable file for various platforms
- Existing NHPC for SAO-X:
  - Windows
  - LINUX

Option frame - NHPC

- set parameters for NHPC
- start recalculation



SAO-X homepage



Installation

Available Installers

	Platform	includes Java VM	without Java VM	Instructions
>	Windows	Download (22.4M)	Download (6.7M)	View
	Mac OS X		Download (6.1M)	View
	AIX	Download (78.2M)	Download (7.6M)	View
	Solaris	Download (54.9M)	Download (7.6M)	View
	Linux	Download (56.4M)	Download (7.6M)	View
	HP-UX	Download (70.3M)	Download (7.6M)	View
	Any Unix Platform		Download (7.6M)	View
	Other Java-enabled Platforms		Download (6.3M)	View

http://car.uml.edu/Installation/SAO-X_3.4/install.htm

Our choice

- Language – Java
- Client - JDBC
- RDBMS Server - Firebird (Interbase)
- Middleware - Inter Client, Jaybird Client
- Application Server - Tomcat

All of them are free or Open Source

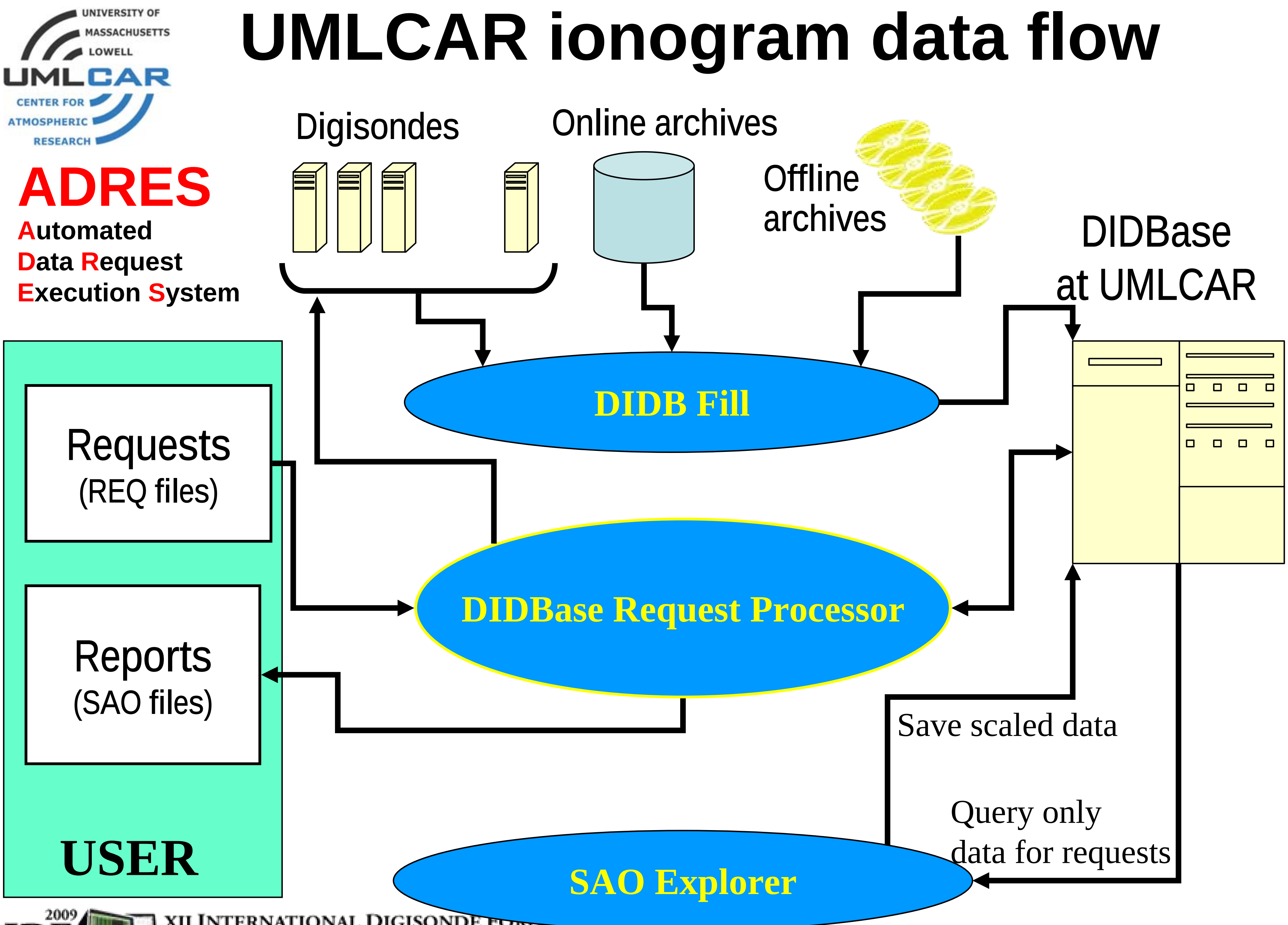
Data Management Automation

- Data ingestion
  - Ionogram and auto scaling
  - Manual scaling
- ADRES
- Smart Backup
- Database backup
- Watch It - stations control

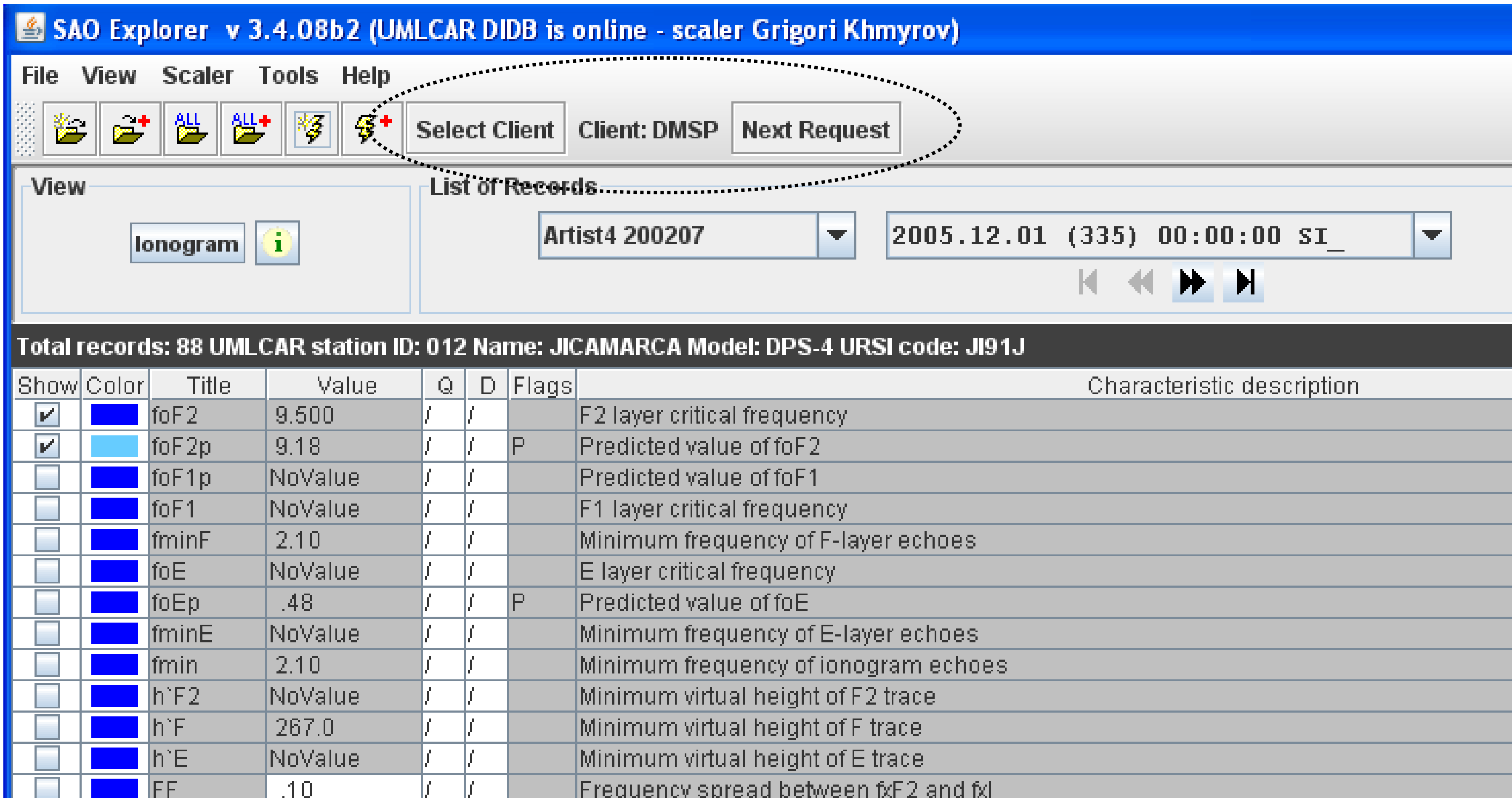
Extended data quality analysis

- Bad data
- Incomplete data
- Future data

UMLCAR ionogram data flow



SAOExplorer – ADRES support



ADRES statistic

Request status	**Total, as of Apr 2007**
Total requests	49329
Request data loaded to DIDBase	43759
Manually scaled and reported requests	41839
Manually scaled and reported ionograms	162366

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http://car.uml.edu/DIDBase

Station list

DIDBase Fast Station list

Created: Apr 26, 2007 15:14:35 UT

Use Detailed Station List that includes time coverage for each station but takes time to be built.

Click on column headers to sort. Click on URSI code to get List Of Years.

#	URSI	STATION NAME	LAT	LONG
1	AN438	ANYANG	37.39	126.95
2	AS00Q	ASCENSION ISLAND	-7.95	345.60
3	AT138	ATHENS	38.00	23.50
4	BJJ32	BERMUDA	32.40	295.30
5	BC840	BOULDER	40.00	254.70
6	BV53Q	BUNDOORA	-37.70	145.05
7	CAJ2M	CACHOEIRA PAULISTA	-23.20	314.20
8	RL052	CHILTON	51.50	359.40
9	CO764	COLLEGE AK	64.90	212.00
10	DB049	DOURBES	50.10	4.60
11	DS932	DYESS AFB	32.40	260.20

Calendar tree

List of years for All Stations

Created: Apr 26, 2007 15:18:12 UT

Click on Year to get List Of Months

1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

List of months for All Stations, 2007

Created: Apr 26, 2007 15:23:12 UT

Click on Month to get List Of Days

Jan (1-31) Feb (32-59) Mar (60-90) Apr (91-120)

Return to DIDBase home page

List of days for All Stations, April 2007

Created: Apr 26, 2007 15:23:20 UT

Click on Day to get Ionogram/Scaling Statistic

1 (91) 2 (92) 3 (93) 4 (94) 5 (95) 6 (96) 7 (97) 8 (98) 9 (99) 10 (100) 11 (101) 12 (102) 13 (103) 14 (104) 15 (105) 16 (106) 17 (107) 18 (108) 19 (109) 20 (110) 21 (111) 22 (112) 23 (113) 24 (114) 25 (115) 26 (116)

Station list for day

DIDBase Station list for 22 April 2007

Created: Apr 26, 2007 15:23:30 UT

Click on URSI code to get Ionogram/Scaling Statistic

#	URSI	STATION NAME	EXAMPLE	LATITUDE	LONGITUDE
1	AS00Q	ASCENSION ISLAND	ionogram	-7.95	345.6
2	AT138	ATHENS	ionogram	38.0	23.5
3	BC840	BOULDER	ionogram	40.0	254.7
4	DB049	DOURBES	ionogram	50.1	4.6
5	DS932	DYESS AFB	ionogram	32.4	260.2
6	EG931	EGLIN AFB	ionogram	30.4	273.2
7	EA036	EL ARENOSILLO	ionogram	37.1	353.3
8	FF051	FAIRFORD	ionogram	51.7	358.5
9	GA762	GAKONA	ionogram	62.38	215.0
10	GSJ53	GOOSE BAY	ionogram	53.3	299.7
11	GR13L	GRAHAMSTOWN	ionogram	-33.3	26.5
12	JI91J	JICAMARCA	ionogram	-12.0	283.2
13	JR055	JULIUSRUH	ionogram	54.6	13.4

Measurements for one station

Statistic for GRAHAMSTOWN, 22 April 2007

Created: Apr 26, 2007 15:29:15 UT

URSI code: GR13L	Lat: -33.3	Long: 26.5
Ionogram: 96, estimated interval: 15 min		
Scaling: 96, scaler: Artist4.5 200311		

See ionogram example

Mesurements Time List
2007.04.22 (112) 00:00:01 SI
2007.04.22 (112) 00:15:00 SI
2007.04.22 (112) 00:30:00 SI
2007.04.22 (112) 00:45:00 SI
2007.04.22 (112) 01:00:01 SI
2007.04.22 (112) 01:15:00 SI
2007.04.22 (112) 01:30:00 SI
2007.04.22 (112) 01:45:00 SI

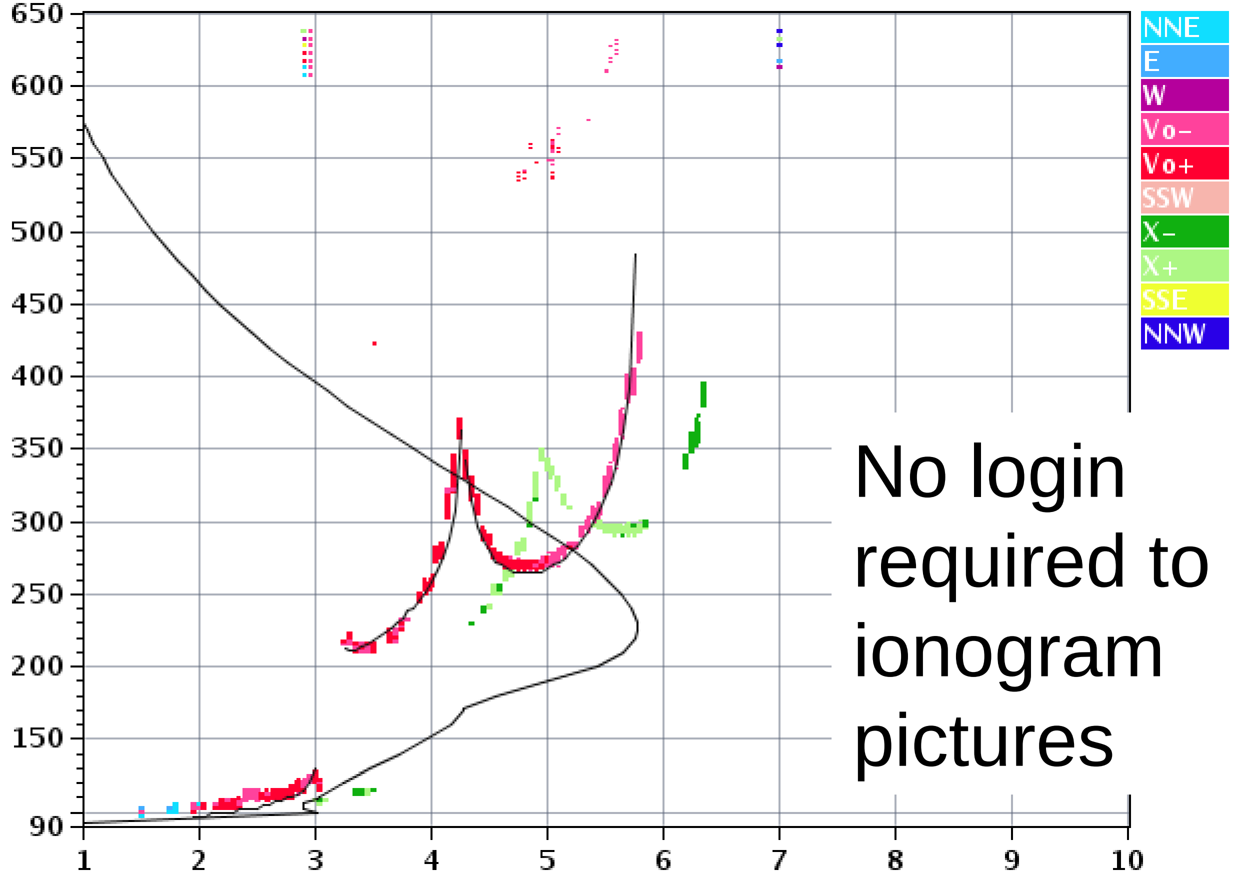
Previous ionogram   Back to statistics for 2007.04.25 (115)   Next ionogram

Lowell DIGISONDE

Station	YYYY	DAY	DDD	HHMM	P1	FFS	S	AXN	PPS	IGA	PS
PRUHONICE	2007	Apr25	115	0900	RSF	050	2	714	200	10+	A1

foF2	5.775
foF1	4.27
foF1p	4.22
foE	3.01
foEp	3.05
fxI	6.45
foEs	3.00
fmin	1.95
MUF(D)	19.82
M(D)	3.45
D	3000.0
h`F	211.0
h`F2	265.0
h`E	97.5
h`Es	97.5
hmF2	224.7
hmF1	171.9
hmE	100.1
yF2	71.5
yF1	62.0
yE	9.8
B0	76.7
B1	2.23
C-level	11

Auto:
Artist4.5
200311



No login required to see ionogram pictures

D	100	200	400	600	800	1000	1500	3000	[km]
MUF	6.4	6.5	6.8	7.3	8.0	9.0	12.0	19.8	[MHz]

180fx256h 50 kHz 2.5 km / DPS-4 PQ052 050 / 50.0 N 14.6 E   ShowIonogram v 1.0

Return to DIDBase home page

DIDBase statistic

- Total size ~500 GB
- Total measurements ~9,000,000
- Total Ionospheric characteristics ~300,000,000
- Total read only accounts 140
- Total scaler accounts 30

Manual scaling

- Total manually scaled data 642,831 (~18 years of 15 min data)

David	Altadill	189059
Jason	Conway	123194
SAO Explorer	Unknown Scaler	84460
Daniil	Khmyrov	79090
Keith	Sorota	62457
Vadym	Paznukhov	19111
Dalia	Buresova	18065
Cindy	Shugrue	17212
Ebrahim	Nasser	15110
Inigo	Blanco	8070
Katy	Alazo Cuartas	6982
Grigori	Khmyrov	5348
Andrew	Carkin	4727
Estefania	Blanch	2707
Ivan	Galkin	1987
Vera I.	Romancheva	1513
Pavel	Ozhogin	1374
Tamara E.	Bogachuk	1020
Zhao	Biqiang	498
Jorge	Landivar	281
Terence	Bullett	128
Gloria	Miro Amarante	85
Bodo	Reinisch	84

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Digisonde 4D and First Light Data

Prof. Bodo W. Reinisch

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

UNIVERSITY OF MASSACHUSETTS LOWELL
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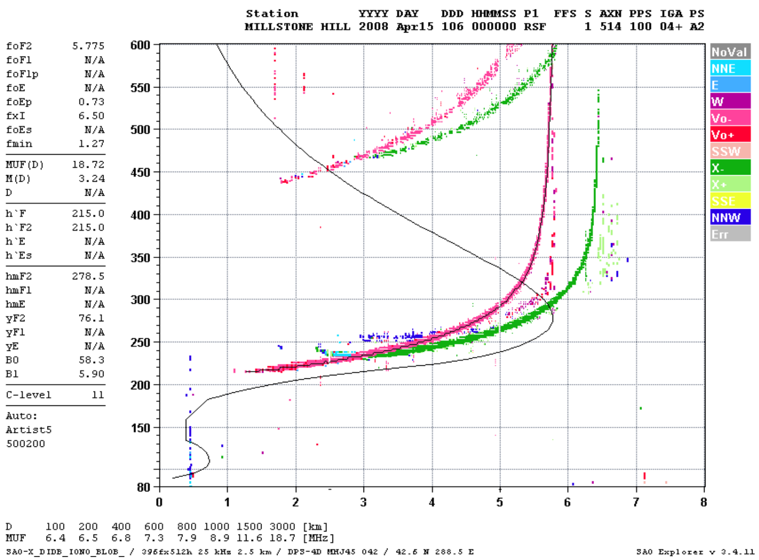
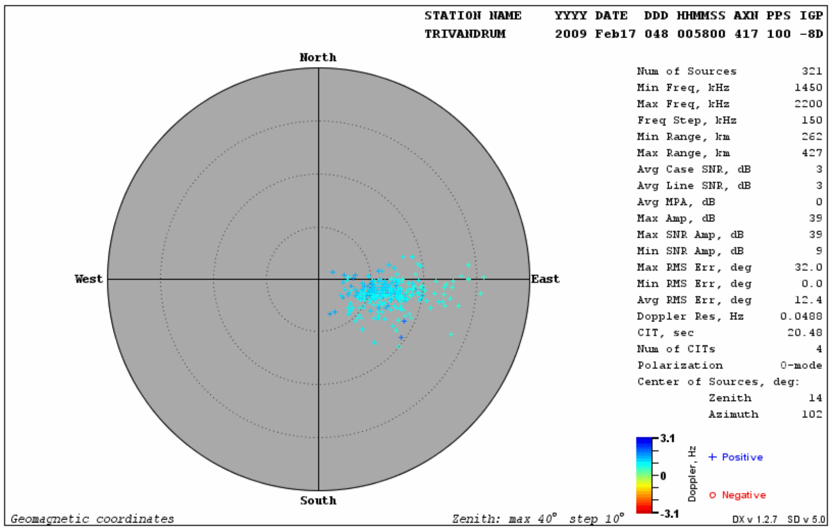
Digisonde 4D

Digisonde 4D

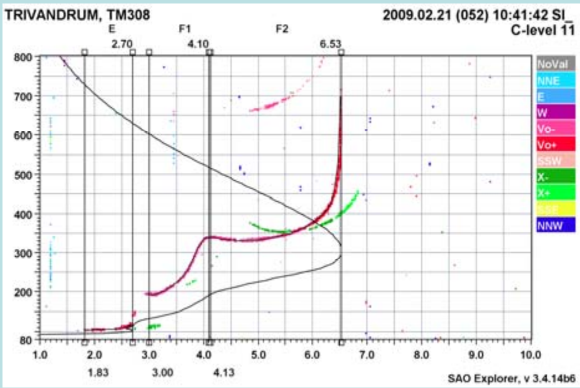
1.	**Hermanus, South Africa**
2.	**Nicosia, Cyprus**
3.	**Jeju Island, Korea**
4.	**Trivandrum, India**
5.	**Vandenberg AFB, California**
6.	**Millstone Hill, Massachusetts**
7.	**Belgrade, Serbia (soon)**



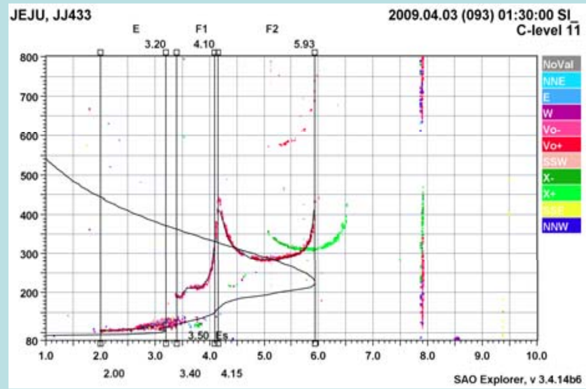


Courtesy of Dr. Sudha Ravindran

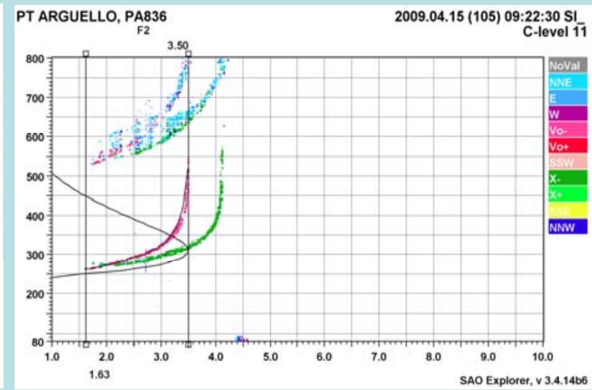
4D Data Samples



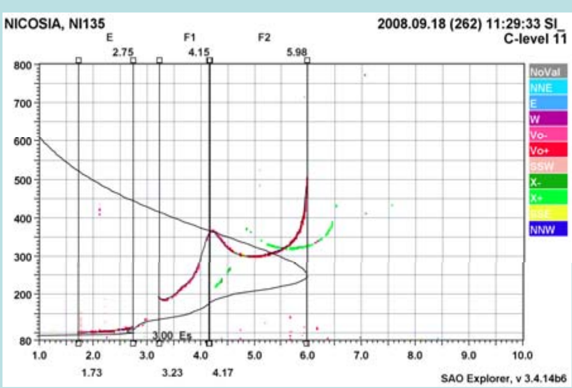
Trivandrum, India



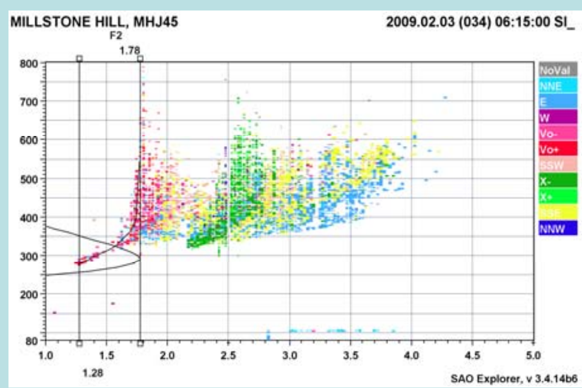
Jeju Is., Korea



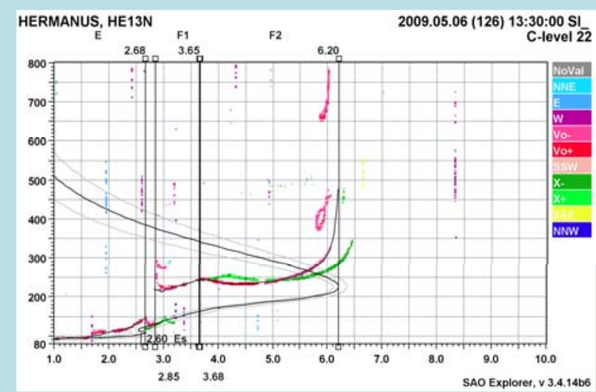
Vandenberg AFB, CA



Nicosia, Cyprus



Millstone Hill, MA



Hermanus, South Africa

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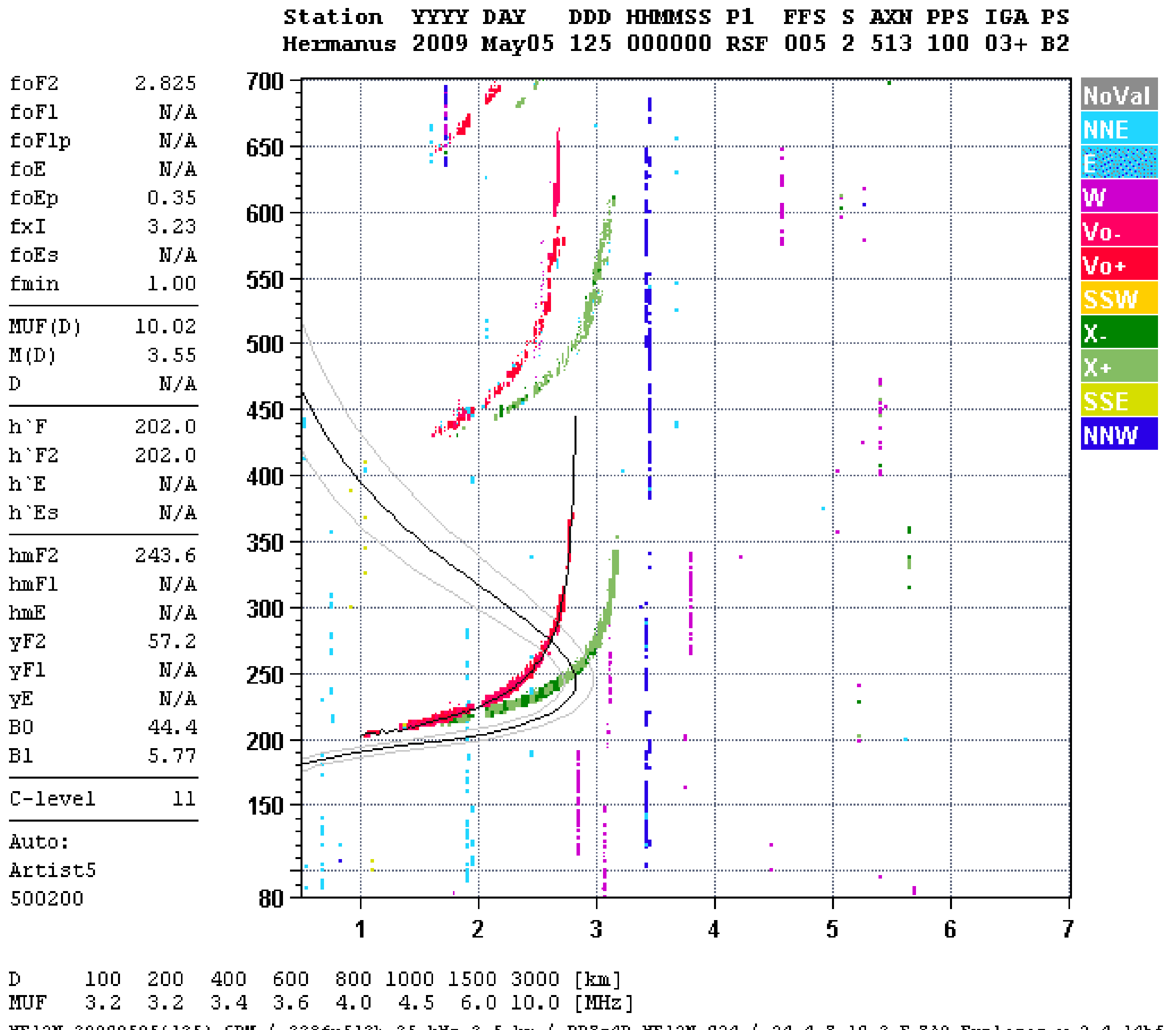
Hermanus Digisonde 4D #001



XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009
2009 IDF

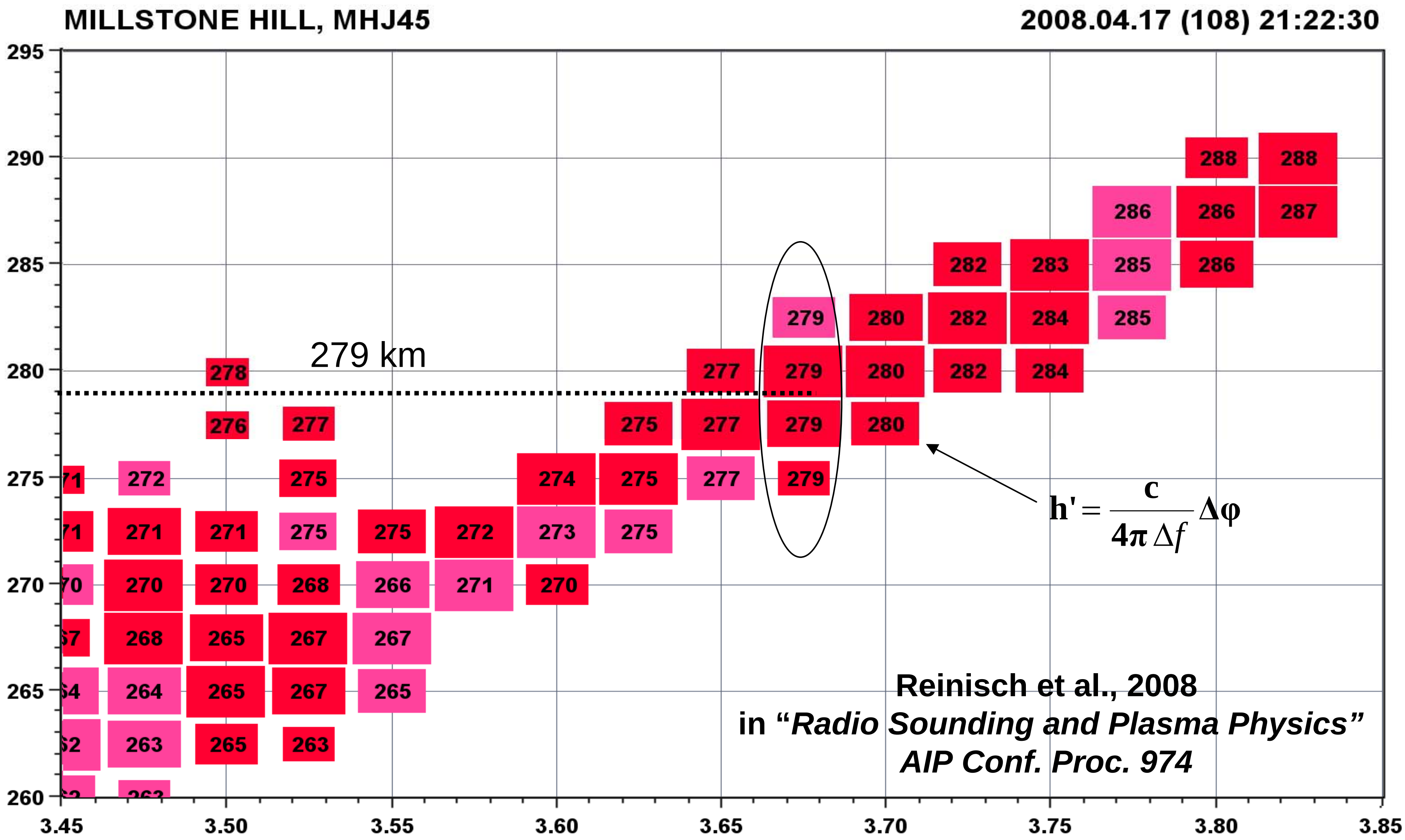
Key 4D Innovations

- **Digital Transceiver**
  - Superior accuracy, precision, and resolution of amplitude and phase measurements
    - Precision Echolocation for skymaps
    - Precision Ranging for ionograms
  - Simpler to build and maintain
- **New embedded platforms**
  - Faster processors and interfaces
  - Fast enough to record time domain raw data
  - No more pauses within a measurement
  - Modern operating systems
  - Upgrades to faster CPUs without timing issues

Key 4D Innovations (2)

- **New signal processing**
  - RFI Mitigation technique (40 dB SNR improvement)
  - Faster measurements (2 sec ionograms)
- **Software and Data Analysis**
  - New DCART terminal for real-time data monitoring and processing, experiment planning and system commanding
  - New passive mode for reception of signals from transmitters-of-opportunity
  - Fault isolation to LRM with instructions to the engineer
  - ARTIST-5 with reports of profile uncertainties

Precision Ranging

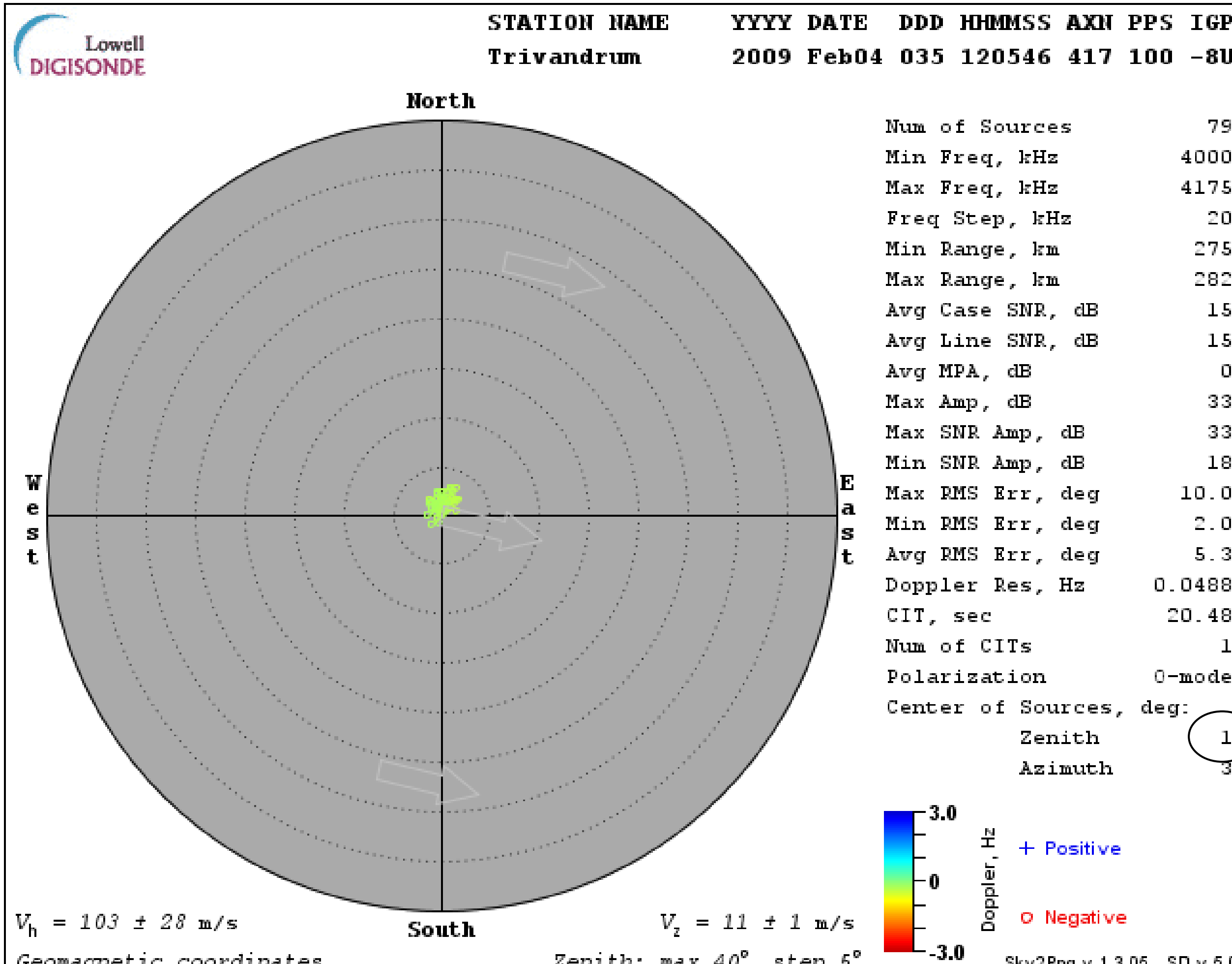


$$h' = \frac{c}{4\pi\,\Delta f}\Delta\varphi$$

Reinisch et al., 2008
in "*Radio Sounding and Plasma Physics*"
AIP Conf. Proc. 974

SAO Explorer, v 3.4.11

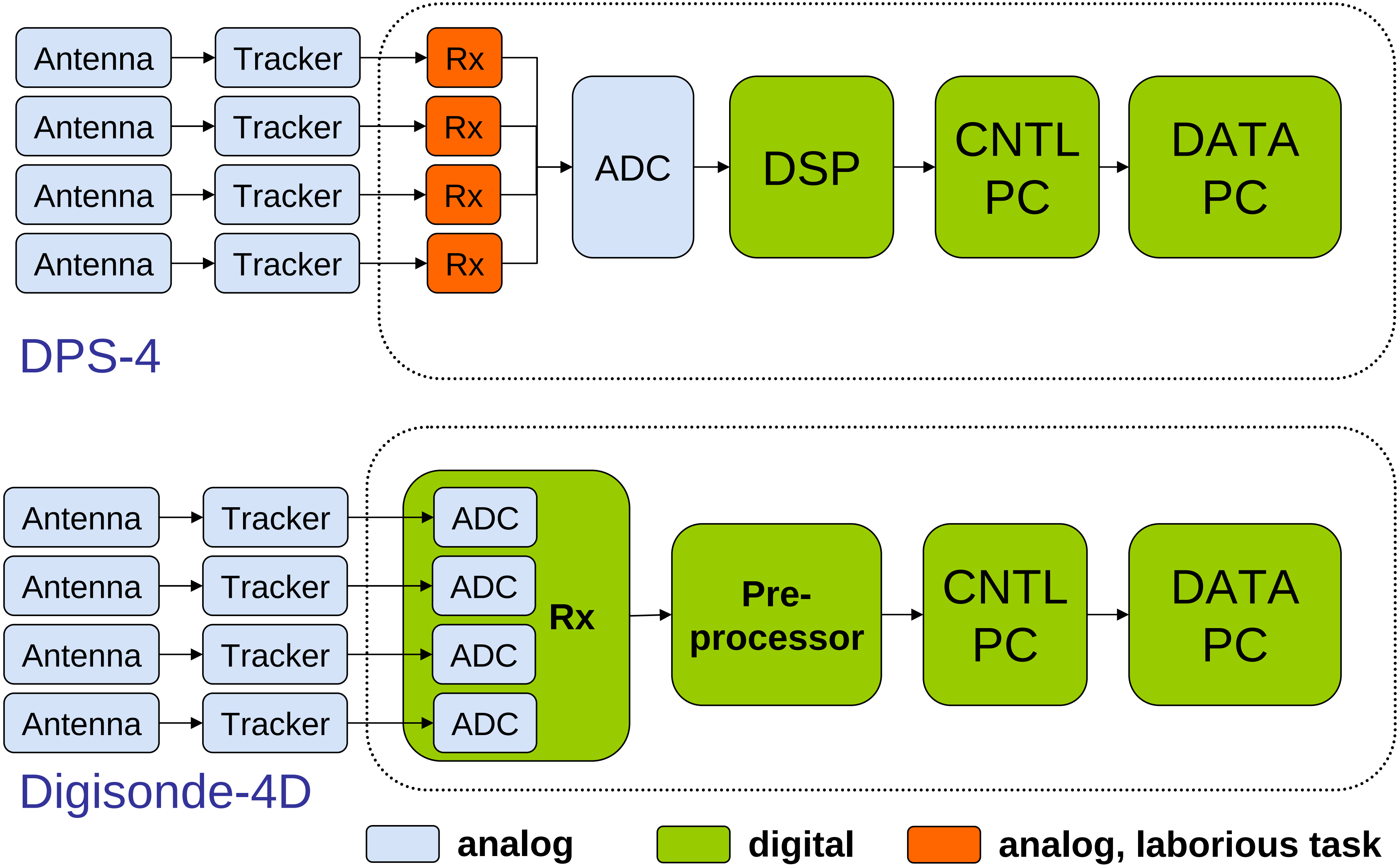
Precision Echolocation



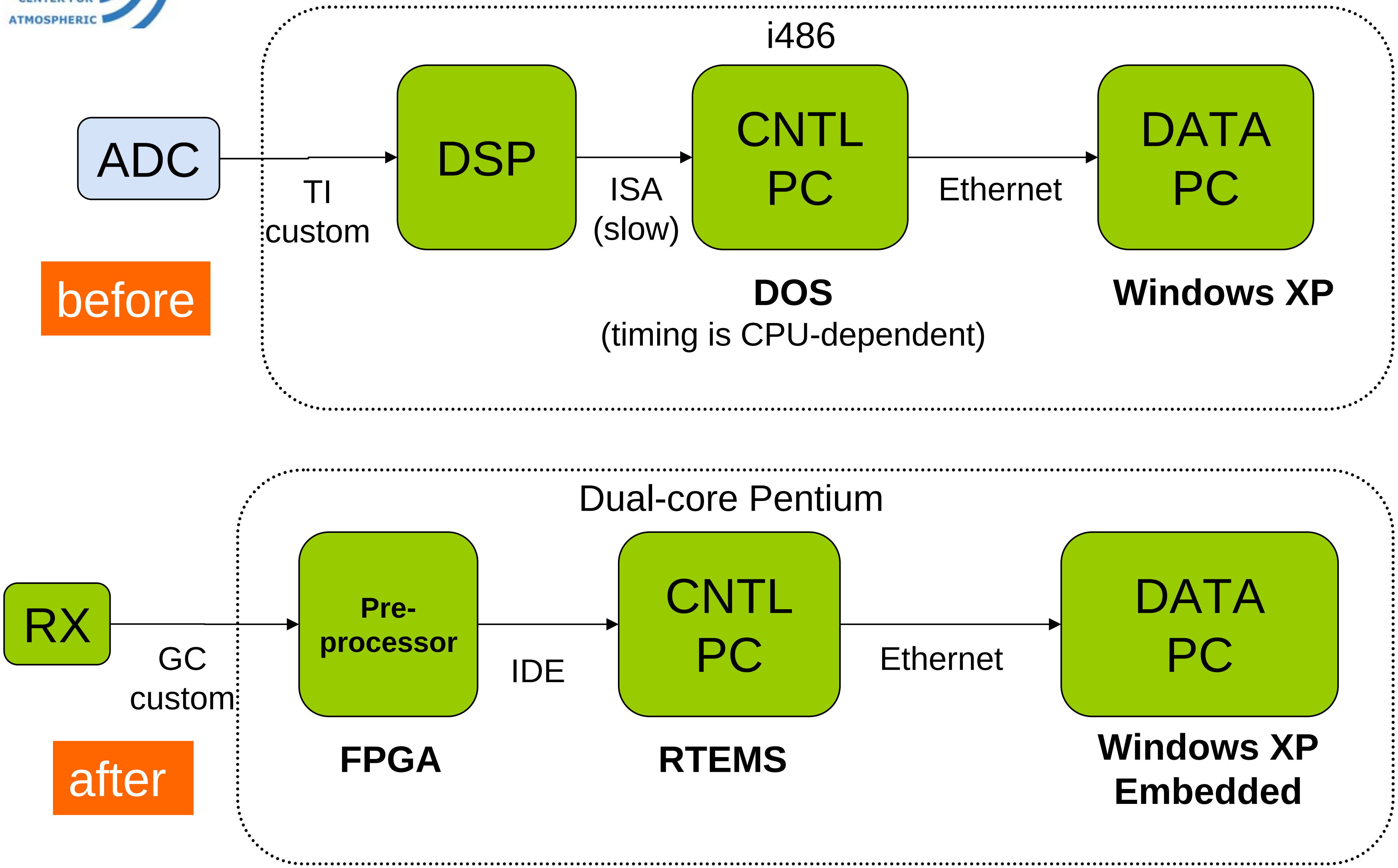
Echolocation with 4D at Trivandrum, India

Ionospheric echoes, not a lab shelf calibration

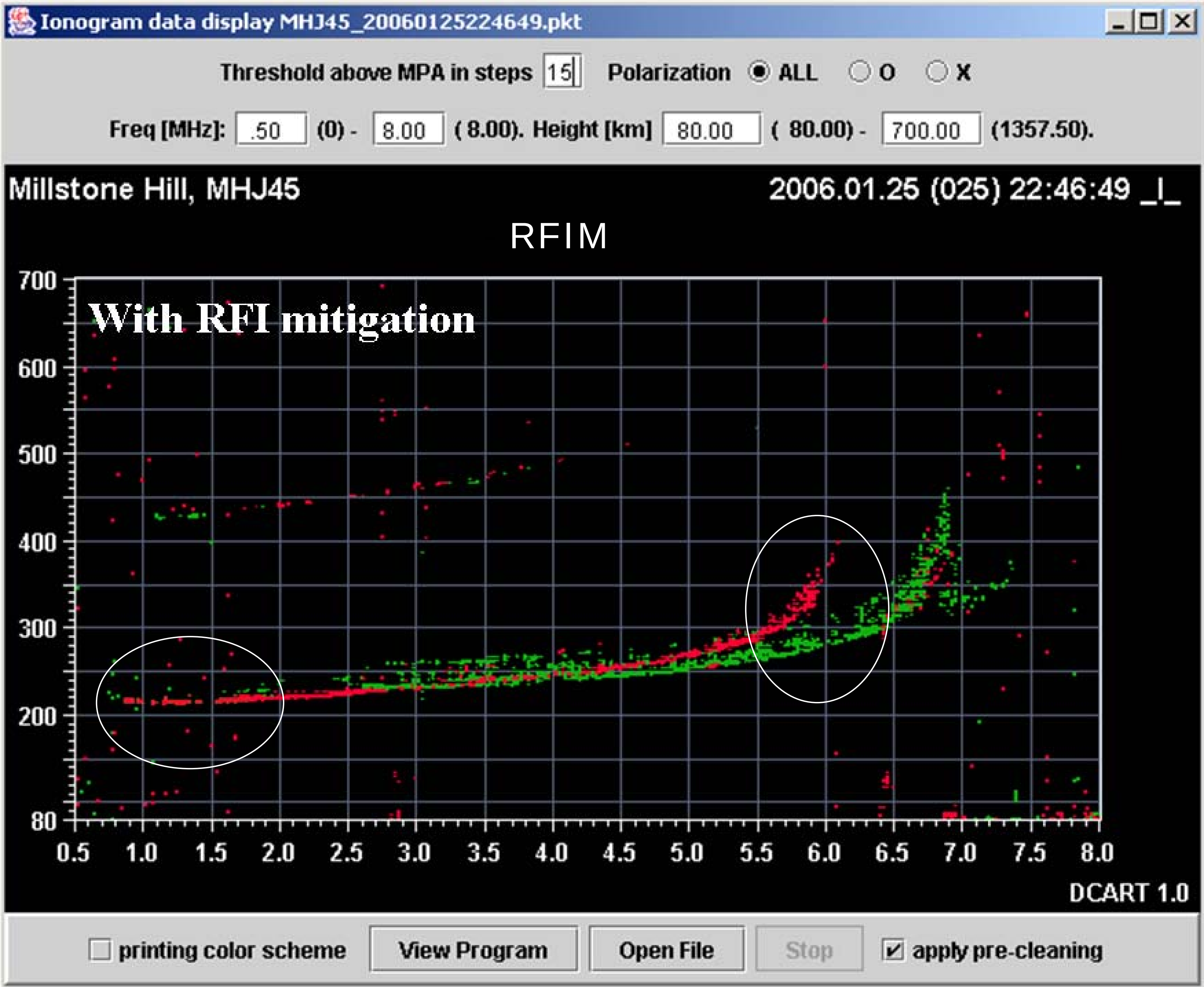
Simplified Architecture



New Embedded Systems

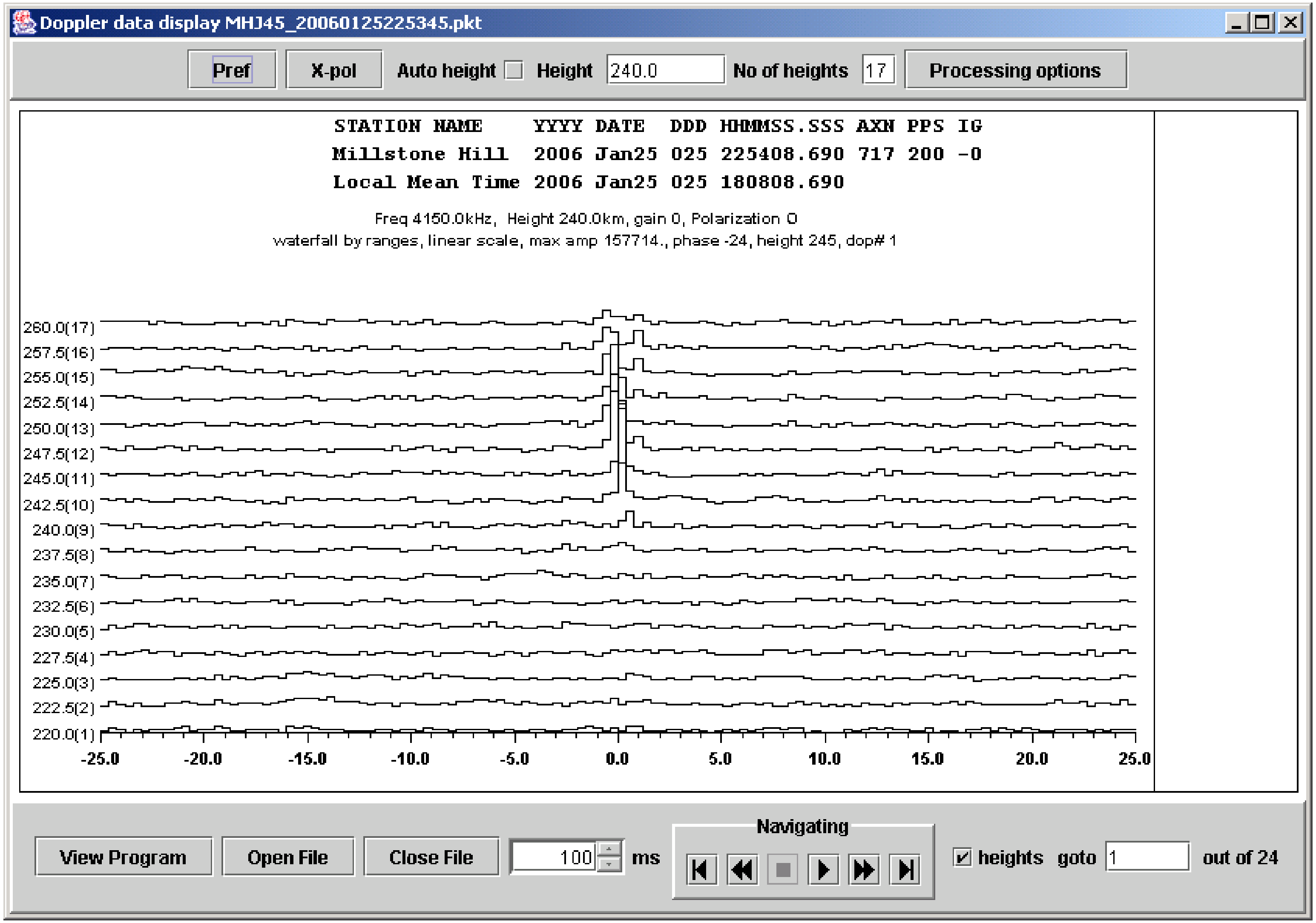


(old restrictions eliminated)

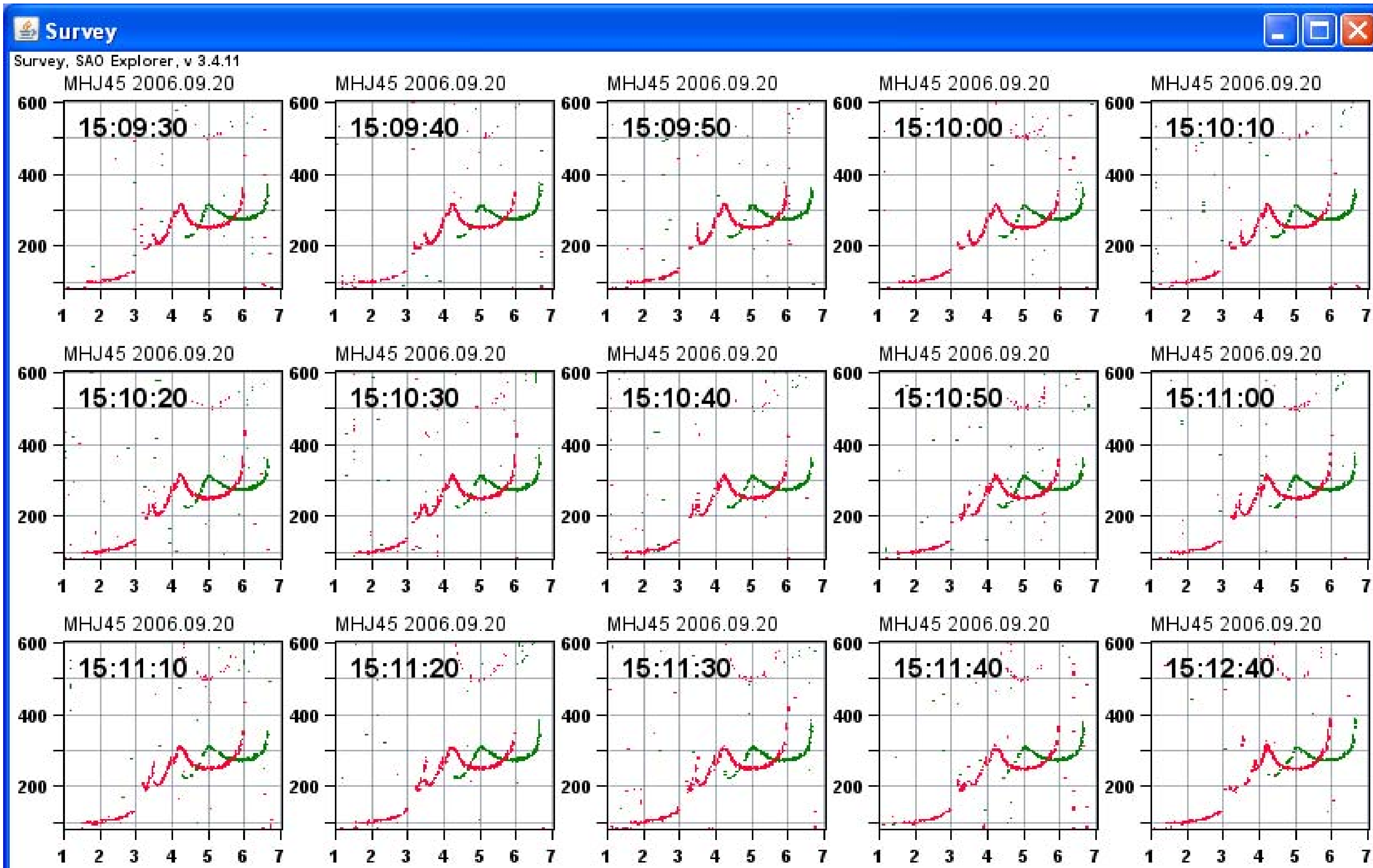


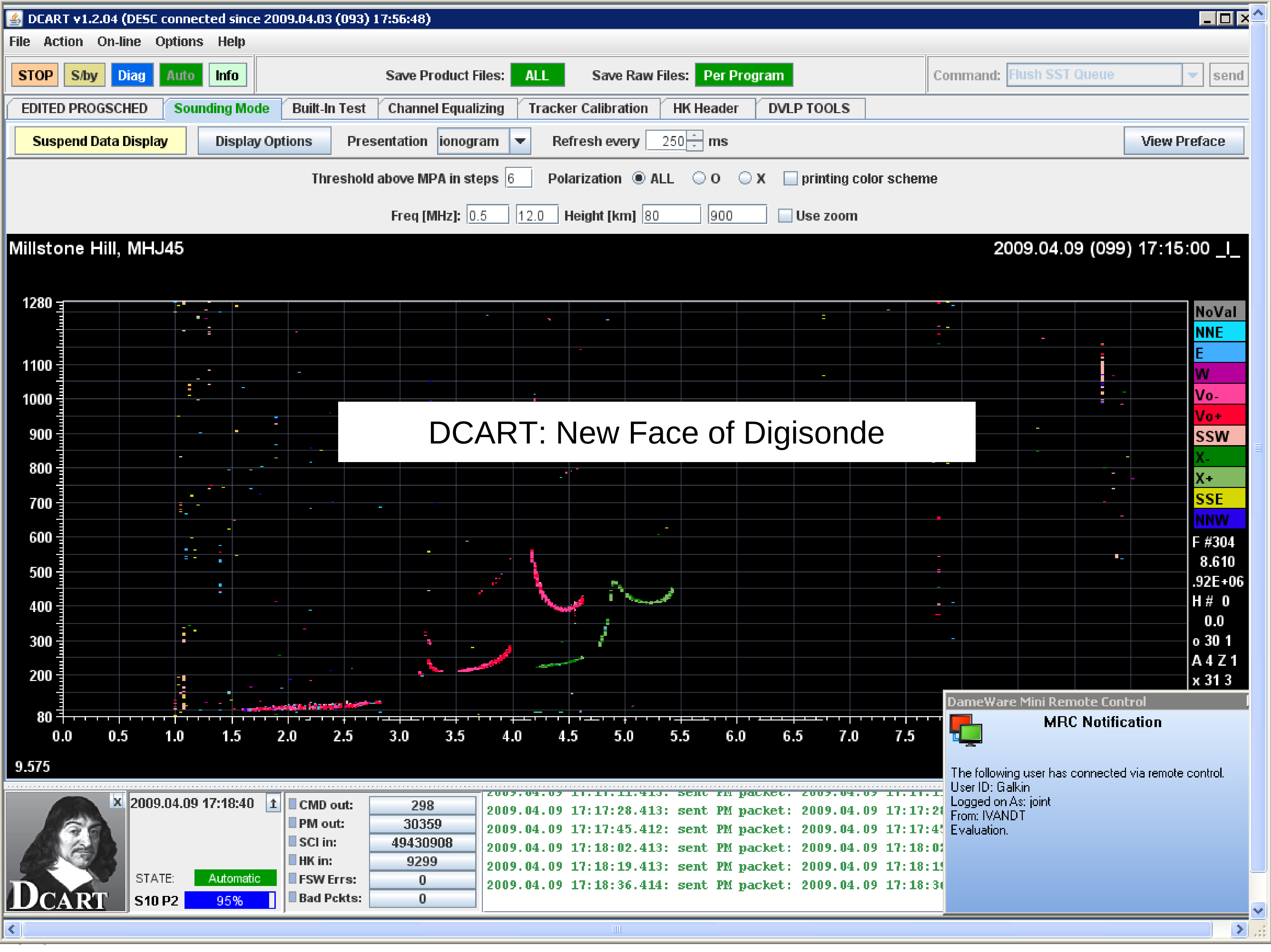
Ionogram data display MHJ45_20060125224649.pkt
Threshold above MPA in steps 15 Polarization ALL O X
Freq [MHz]: .50 (0) - 8.00 (8.00). Height [km] 80.00 (80.00) - 700.00 (1357.50).
Millstone Hill, MHJ45
2006.01.25 (025) 22:46:49 _I_
RFIM
With RFI mitigation
700
600
500
400
300
200
80
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
DCART 1.0
printing color scheme
View Program
Open File
Stop
apply pre-cleaning

Doppler Spectra with/out RFIM



Rapid Ionograms





DCART v1.2.04 (DESC connected since 2009.04.03 (093) 17:56:48)
File Action On-line Options Help
STOP S/by Diag Auto Info
Save Product Files: ALL
Save Raw Files: Per Program
Command: Flush SST Queue send
EDITED PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration HK Header DVLP TOOLS
Suspend Data Display
Display Options
Presentation ionogram
Refresh every 250 ms
View Preface
Threshold above MPA in steps 6
Polarization ALL O X
printing color scheme
Freq [MHz]: 0.5 12.0 Height [km] 80 900
Use zoom
Millstone Hill, MHJ45
2009.04.09 (099) 17:15:00
DCART: New Face of Digisonde
NoVal NNE E W Vo- Vo+ SSW X- X+ SSE NNW
F #304
8.610
.92E+06
H # 0
0.0
o 30 1
A 4 Z 1
x 31 3
9.575
DameWare Mini Remote Control
MRC Notification
The following user has connected via remote control.
User ID: Galkin
Logged on As: joint
From: IVANDT
Evaluation.
2009.04.09 17:18:40
STATE: Automatic
S10 P2 95%
CMD out: 298
PM out: 30359
SCI in: 49430908
HK in: 9299
FSW Errs: 0
Bad Pckts: 0
2009.04.09 17:17:28.413: sent PM packet: 2009.04.09 17:17:28
2009.04.09 17:17:45.412: sent PM packet: 2009.04.09 17:17:45
2009.04.09 17:18:02.413: sent PM packet: 2009.04.09 17:18:02
2009.04.09 17:18:19.413: sent PM packet: 2009.04.09 17:18:19
2009.04.09 17:18:36.414: sent PM packet: 2009.04.09 17:18:36
DCART

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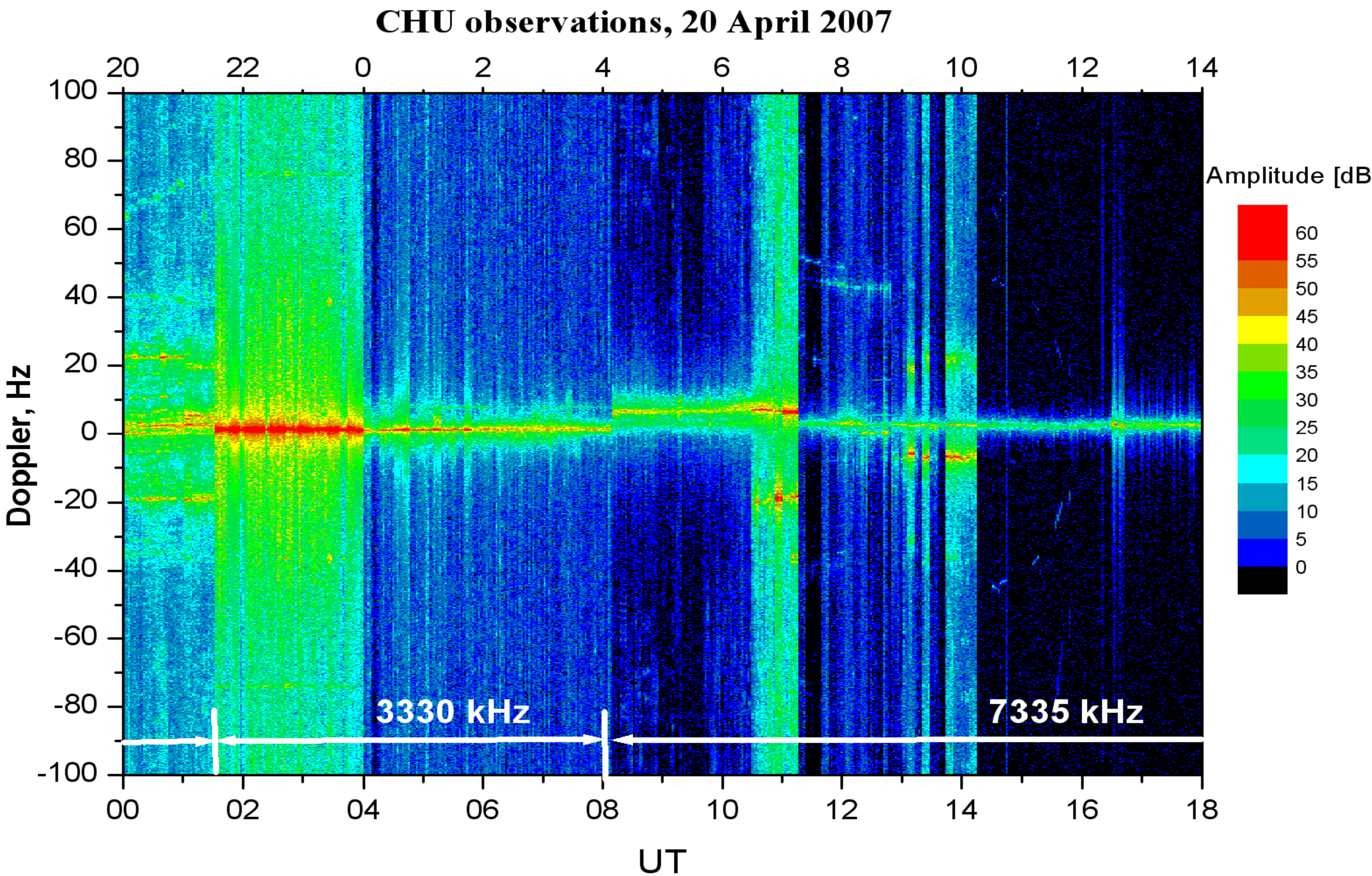
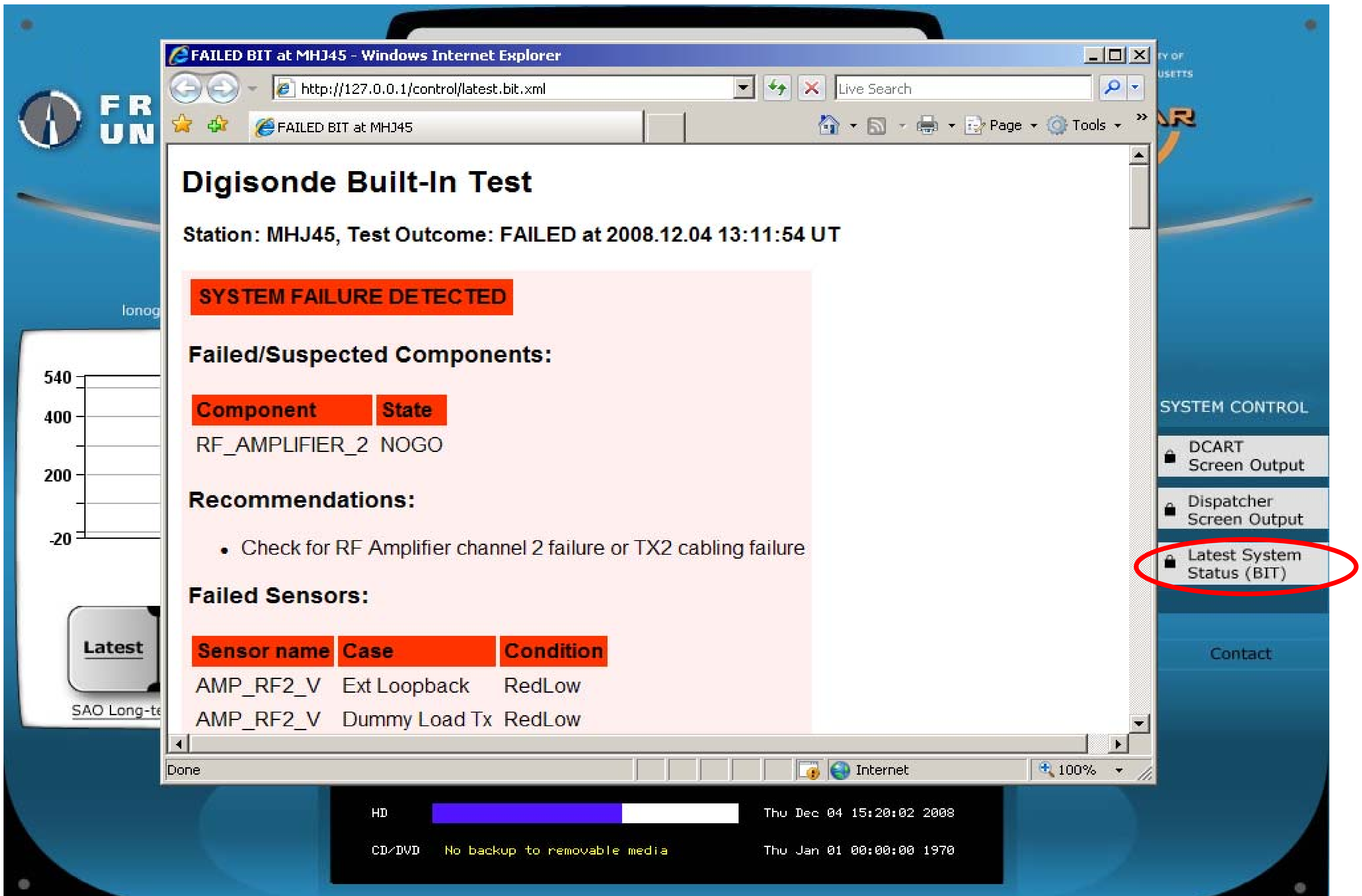
Passive RF Sensing mode

for monitoring transmitters of opportunity



Built-In Test facility
for fault isolation to LRM



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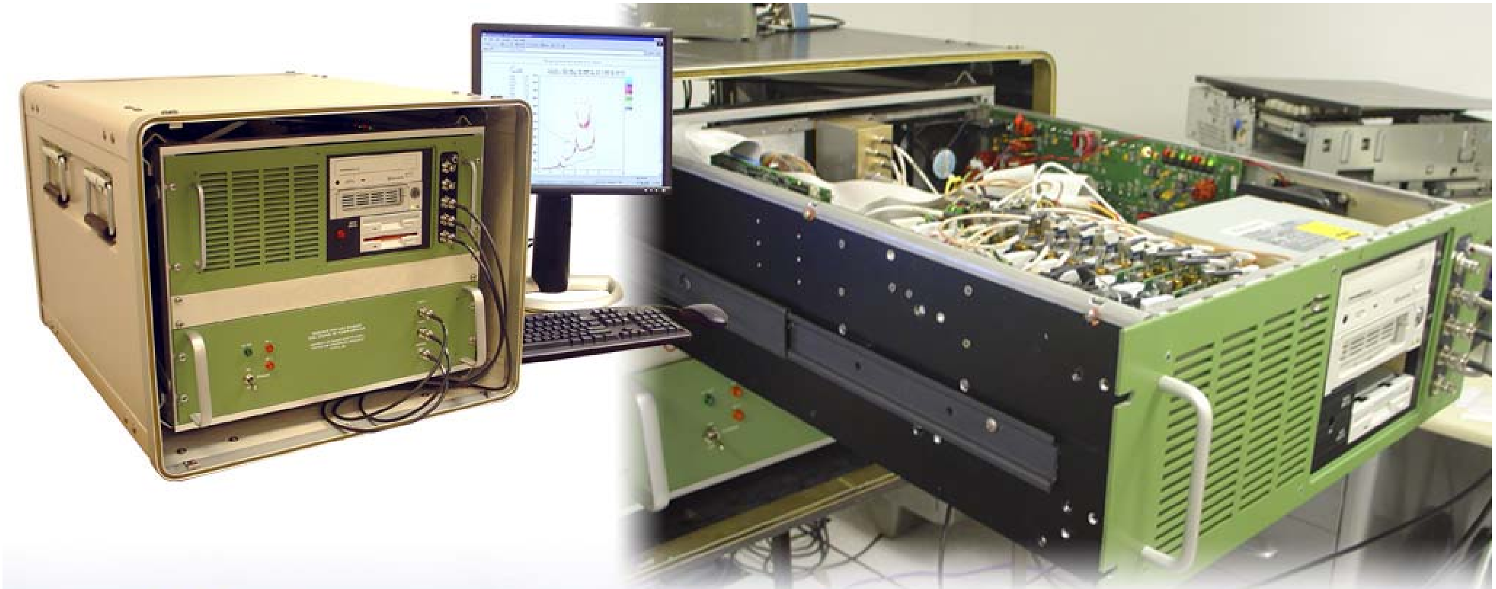
DPS-4D Hardware Overview

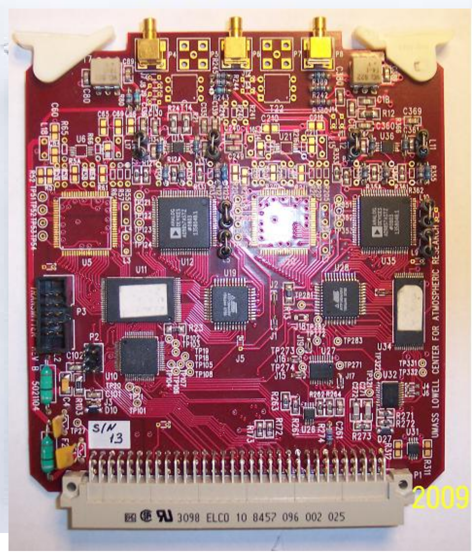
Igor Lisysyan

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

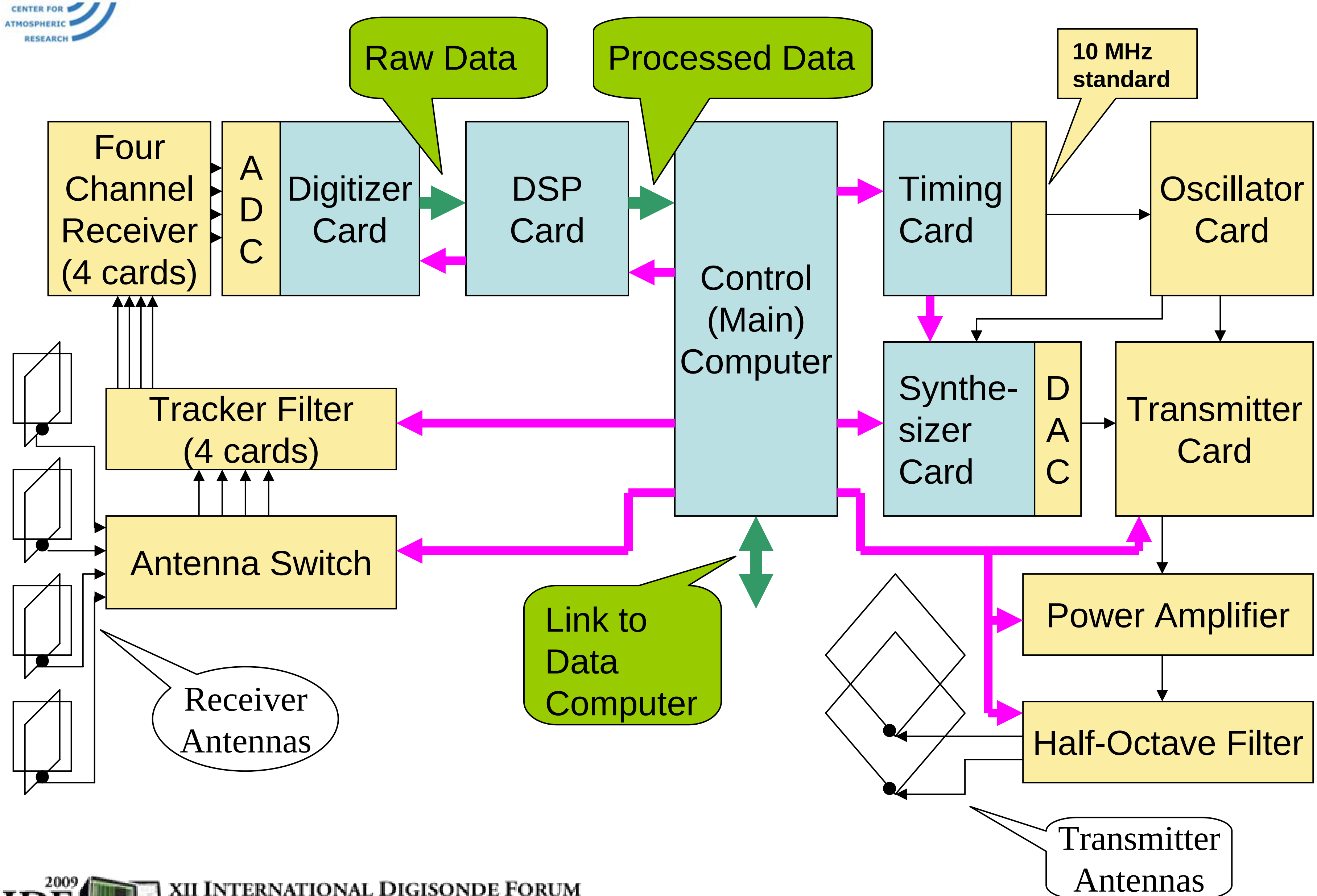
UNIVERSITY OF MASSACHUSETTS LOWELL
UMLCAR
CENTER FOR ATMOSPHERIC RESEARCH

DPS-4D

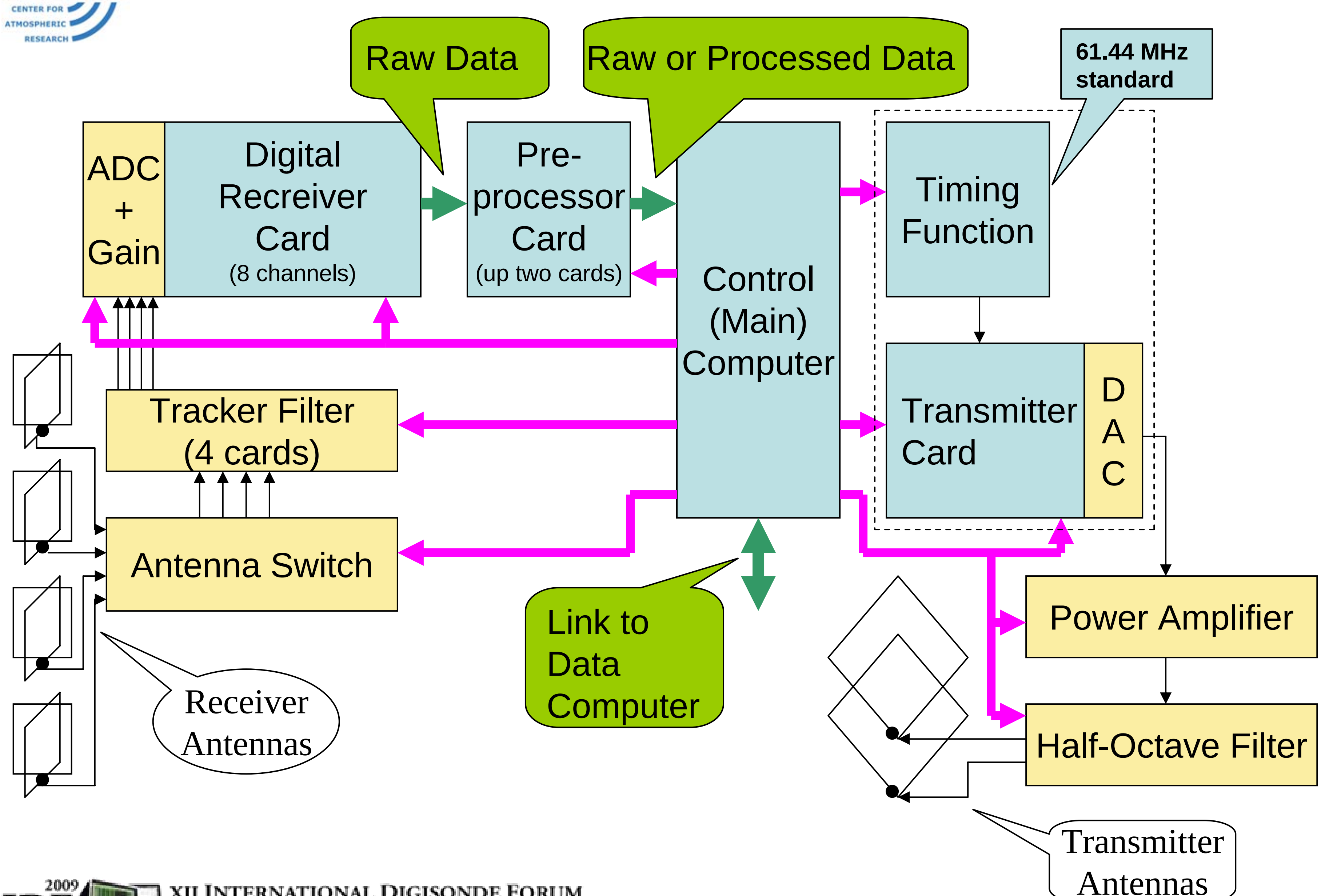




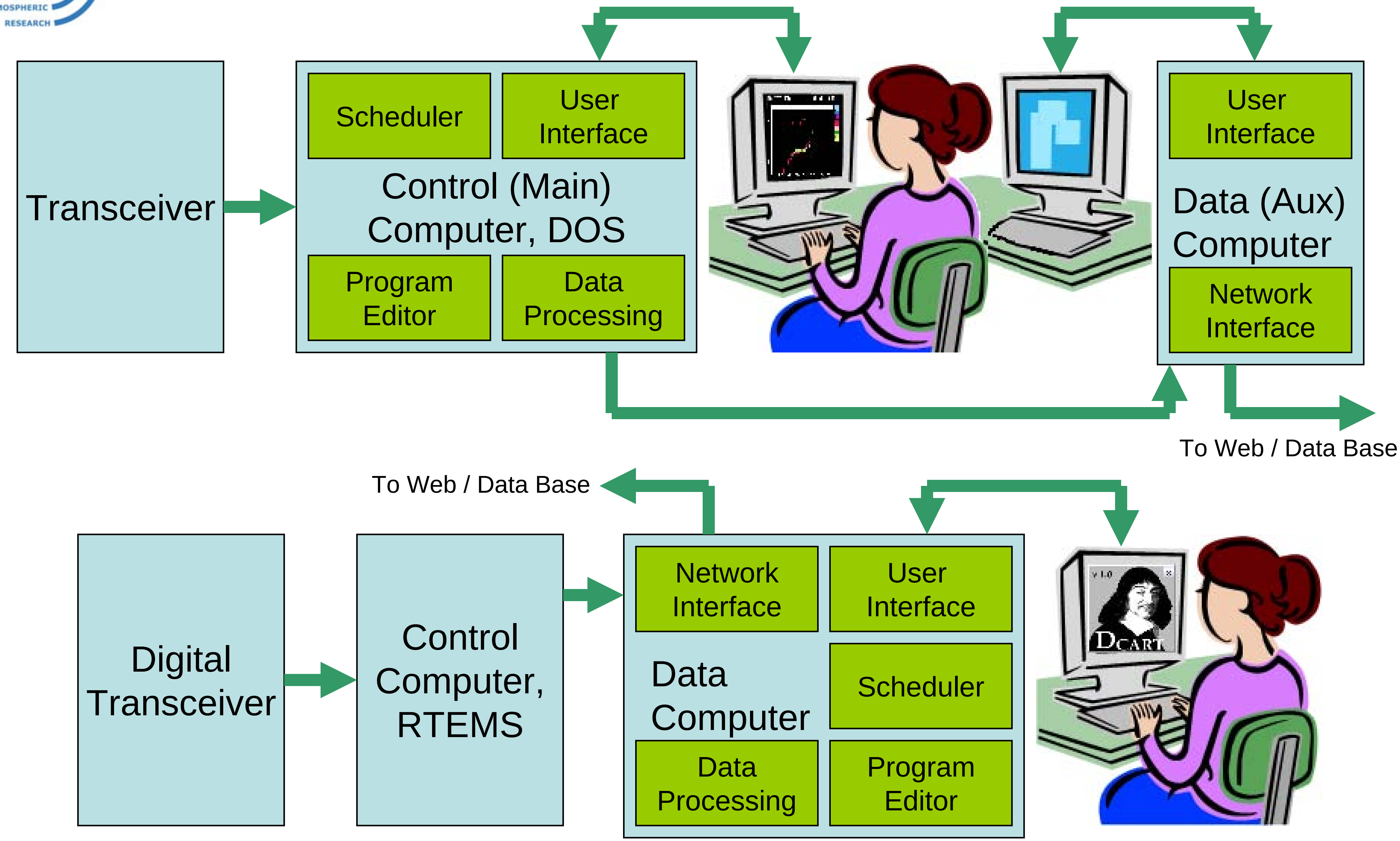
DPS-4 Analog Transceiver Block Diagram



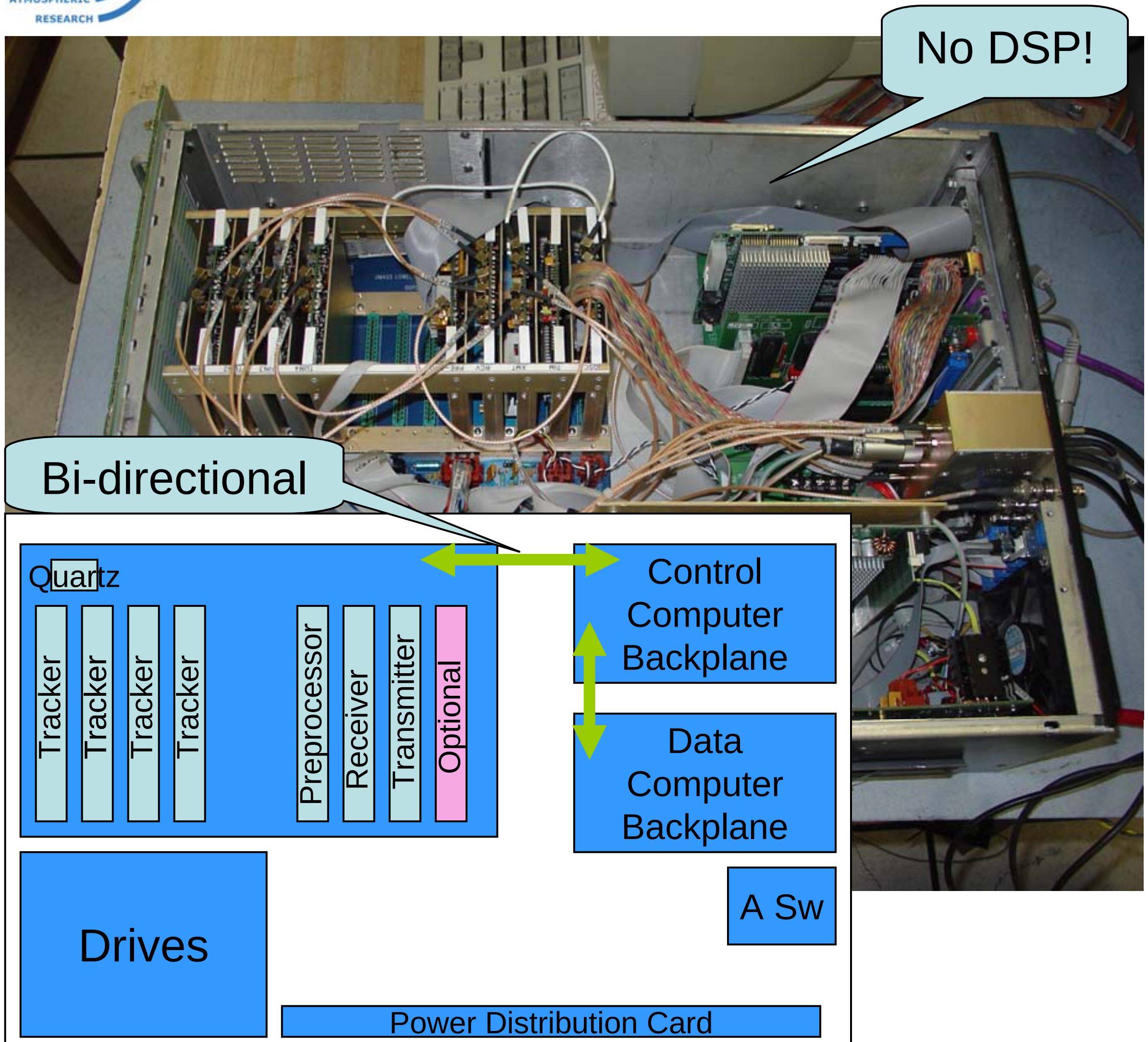
DPS-4D Digital Transceiver Block Diagram



DPS-4/DPS-4D Data Path Block Diagram



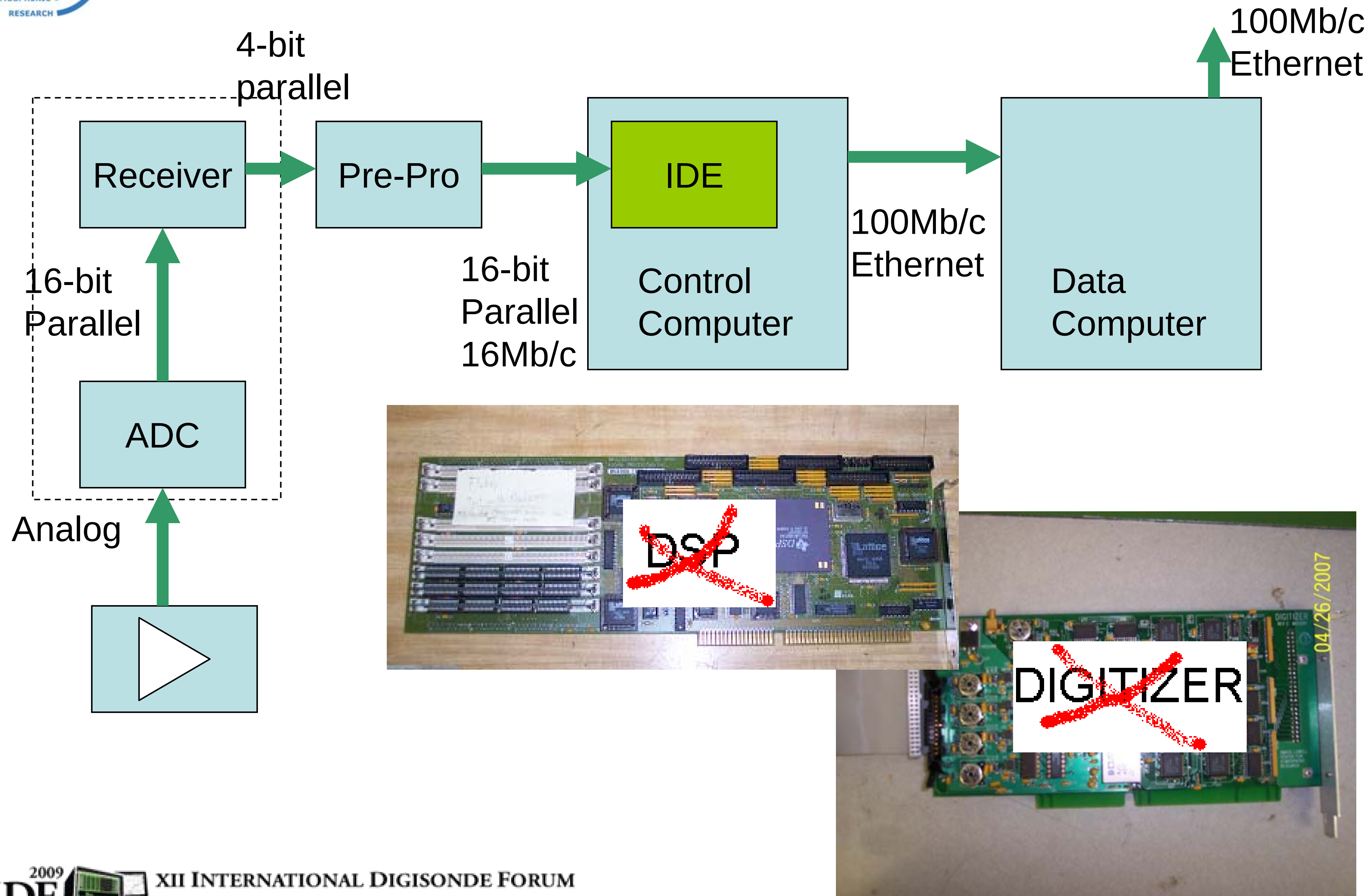
DPS-4D Chassis assembly



Features:

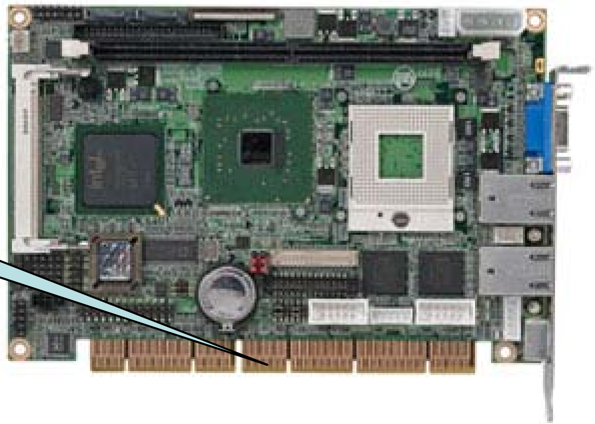
- No Digitizer Card
- No Oscillator Card
- No Timing Card
- No Synthesizer Card
- No DSP
- GPS is connected to Data Computer
- Hi-performance Data Computer
- Hi-precision Frequency Standard
- Optional Card
- Shorter backplanes
- USB Ports instead Floppy Drives
- No any drives for Control Computer
- Monitor/Kb/Mouse for Data Computer only

Data Stream and Interfaces



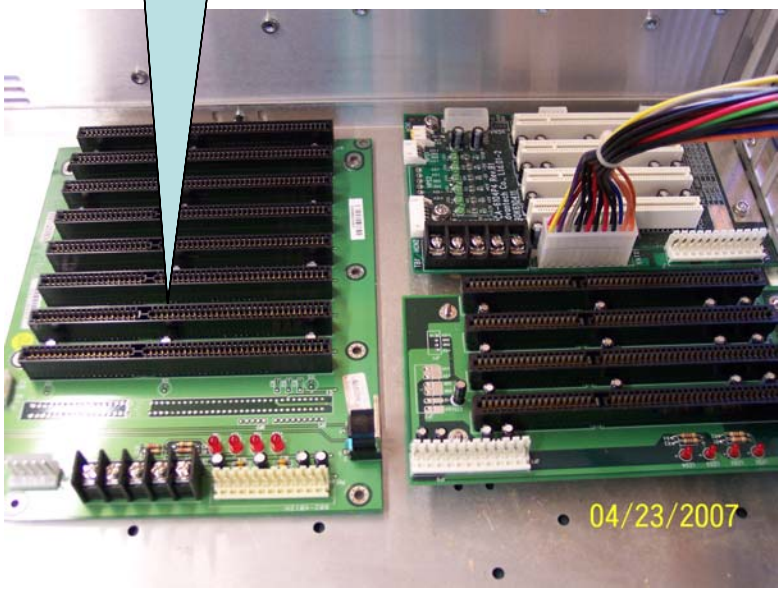
Data and Control Computers – same type

Dual Core 2 GHz

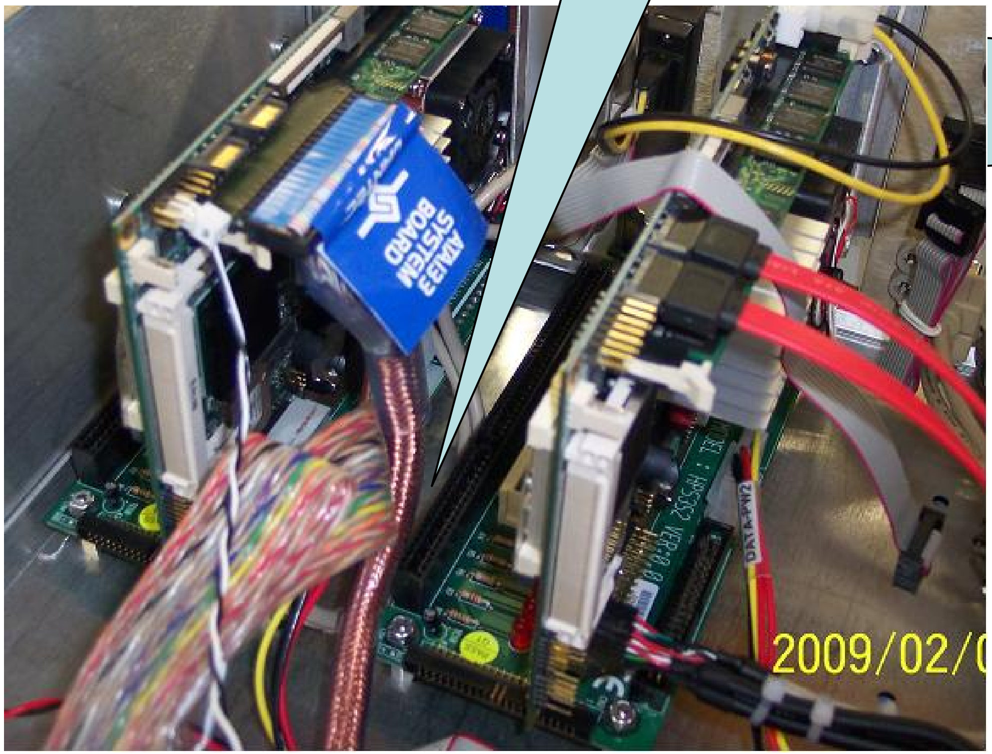


PISA Bus

Old Long ISA Backplane



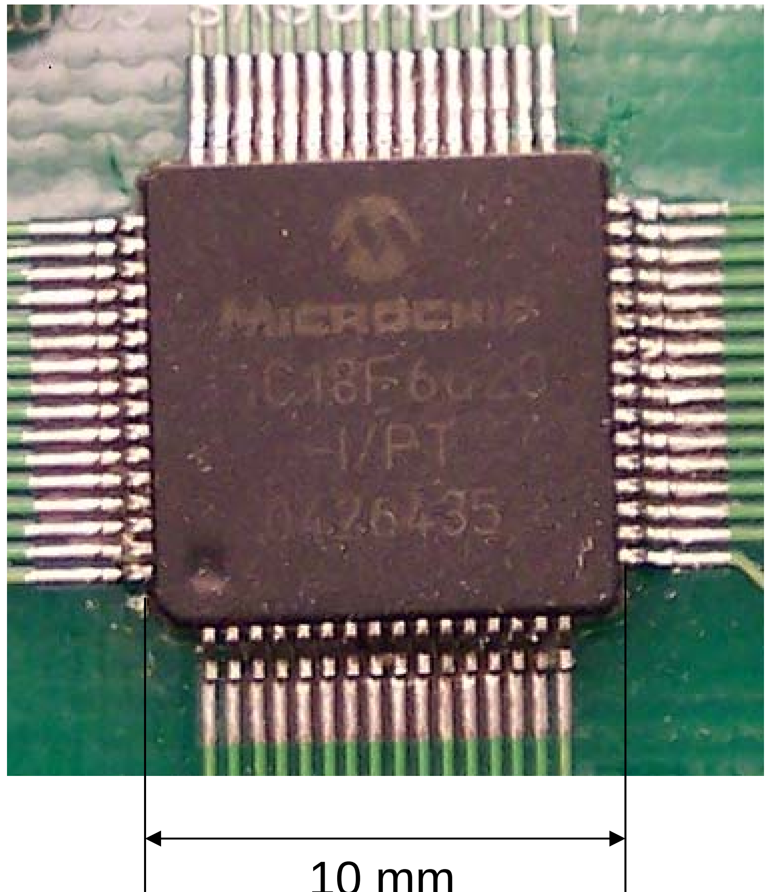
New passive PISA Backplanes are equal too

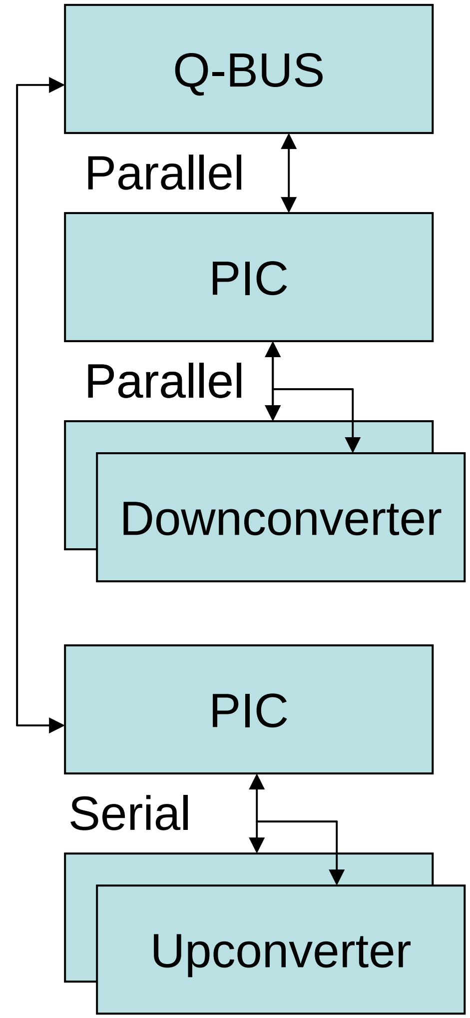


Microcontrollers PIC18LF6520

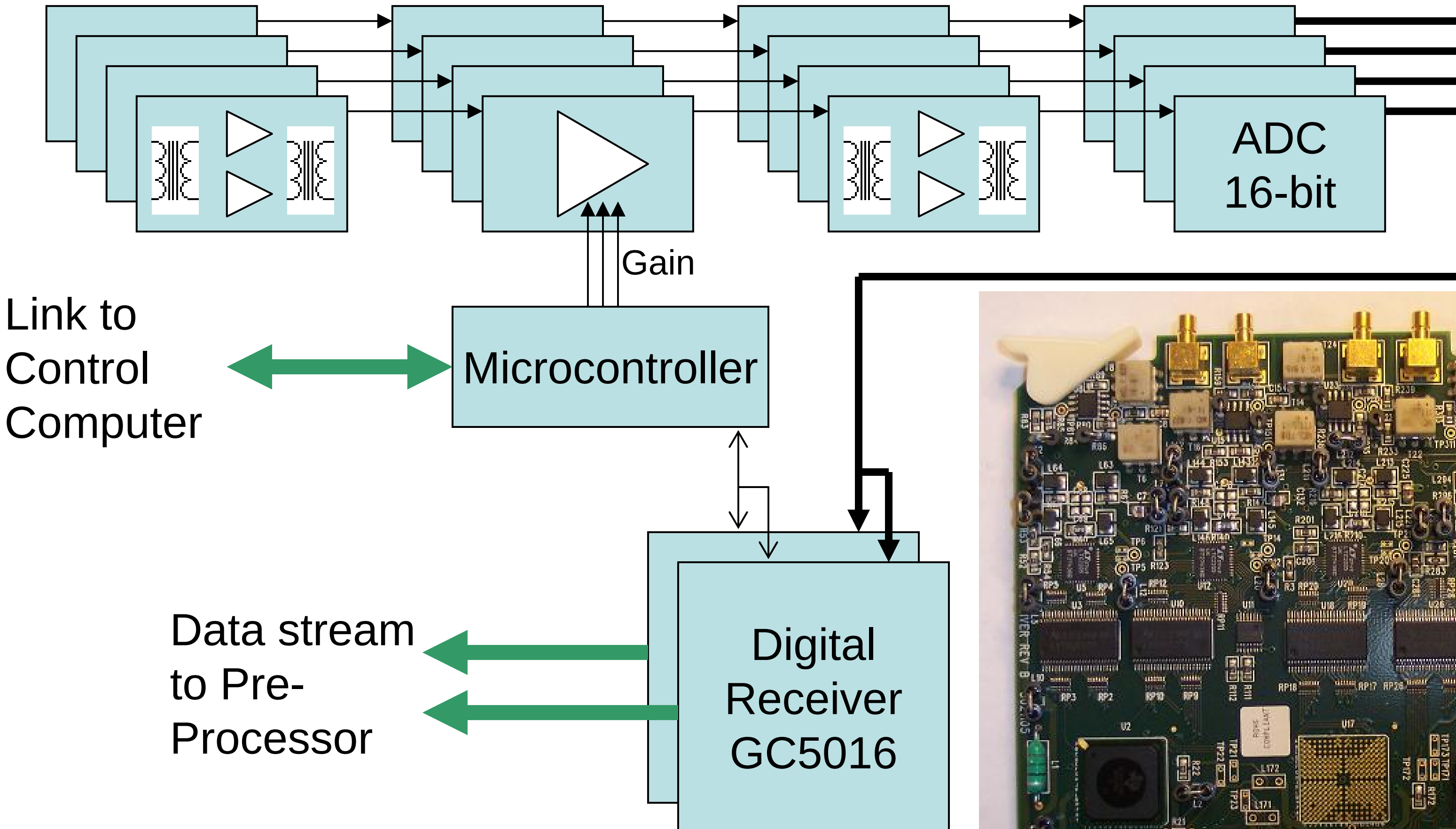
Features:

- Up to 16.7 MHz clock with 3.3 V Power
- Serial Port (SPI)
- Parallel Port
- Flash Memory
- ICP
- Free Development Tool
- Low Price

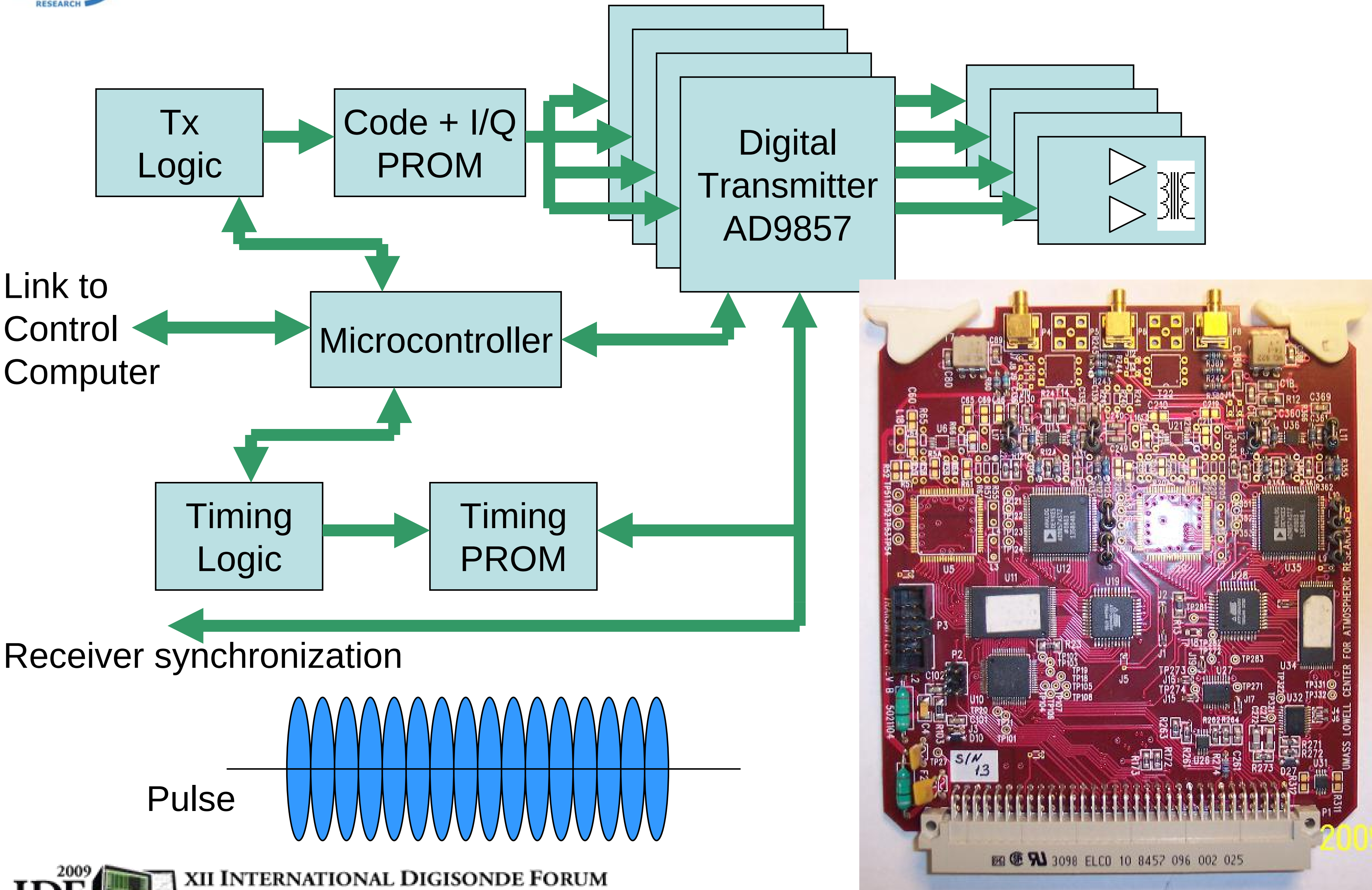




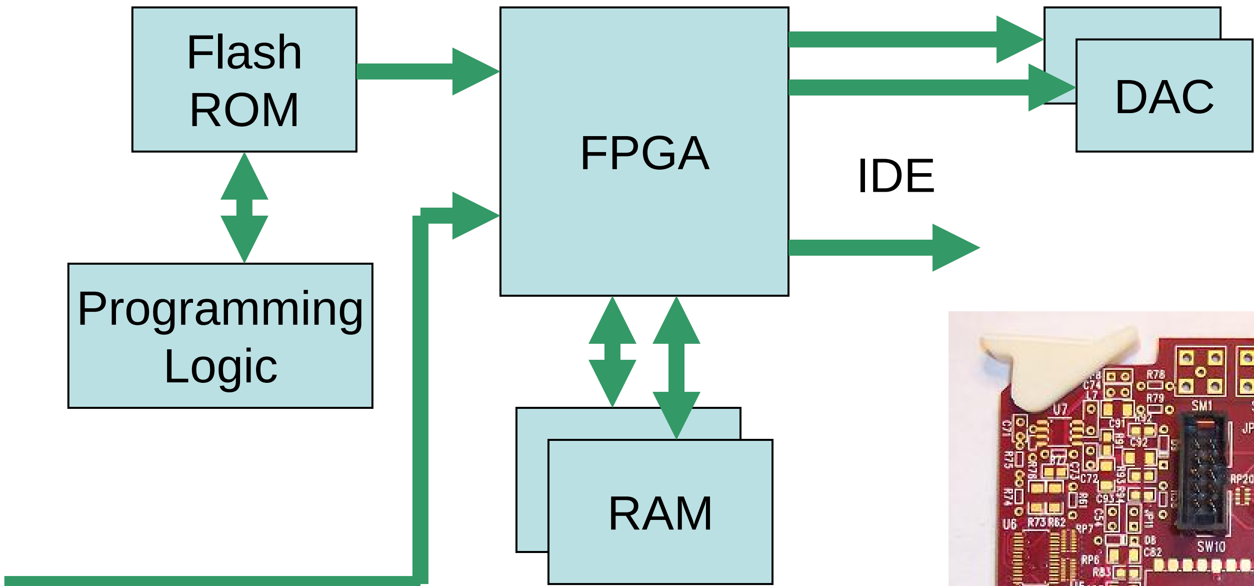
Digital Receiver



4-channel Digital Transmitter



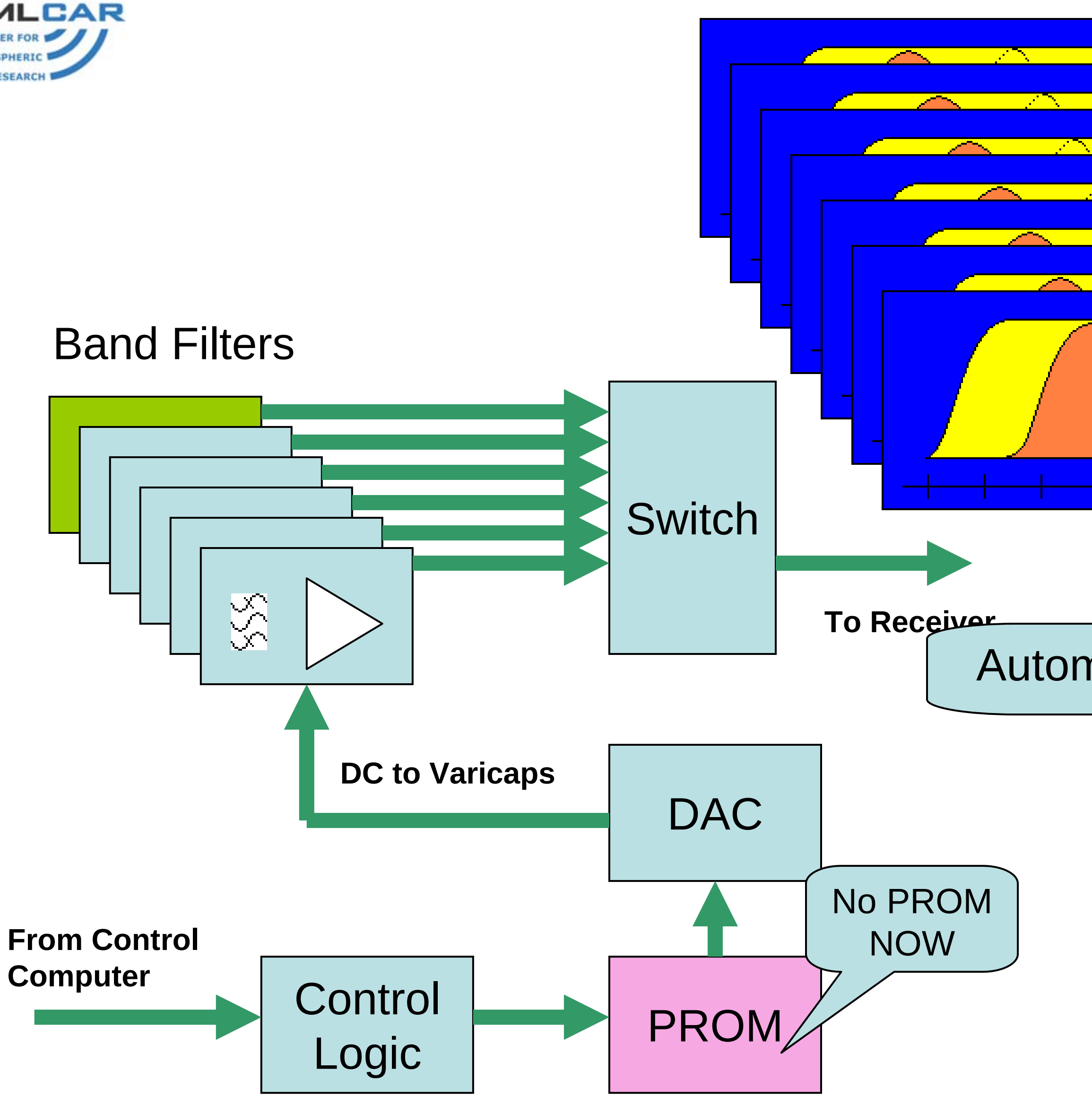
Preprocessor Card

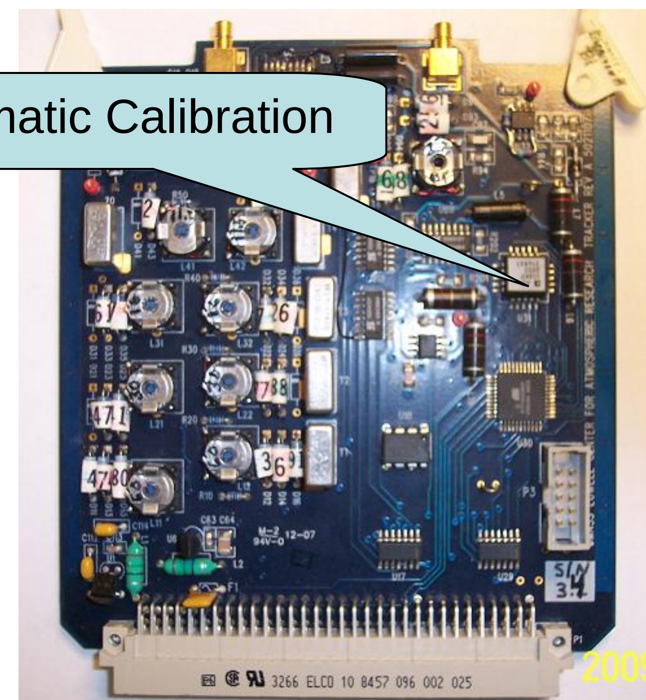


Link to Digital Receiver

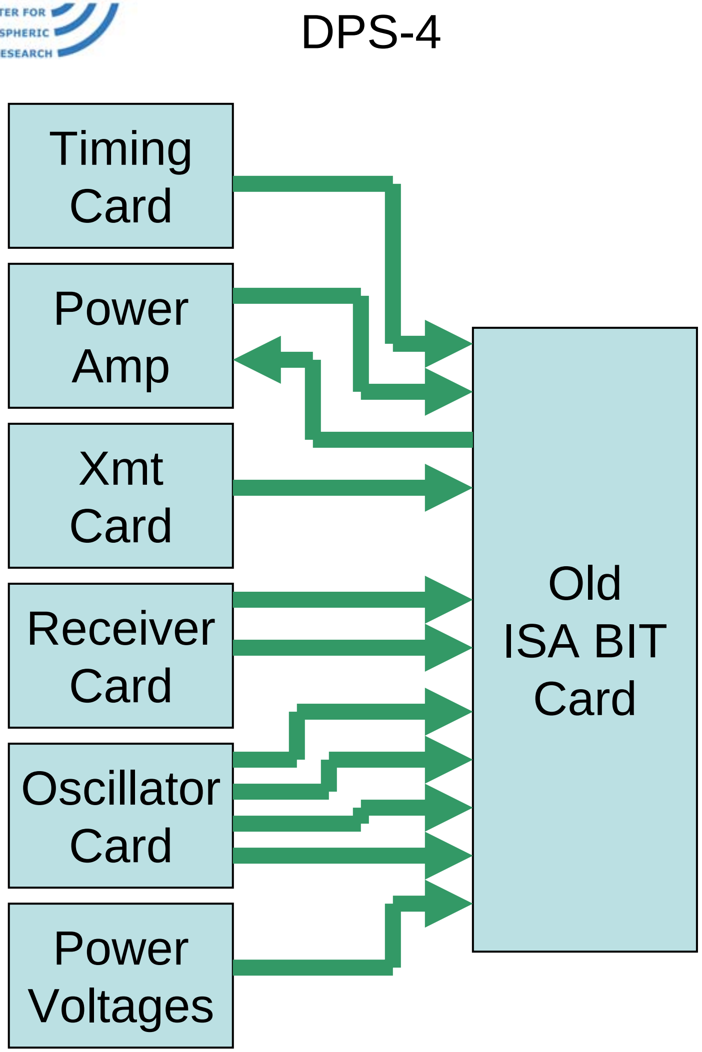
- IDE Interface
- DMA support
- Three J-TAGs
- Two DACs

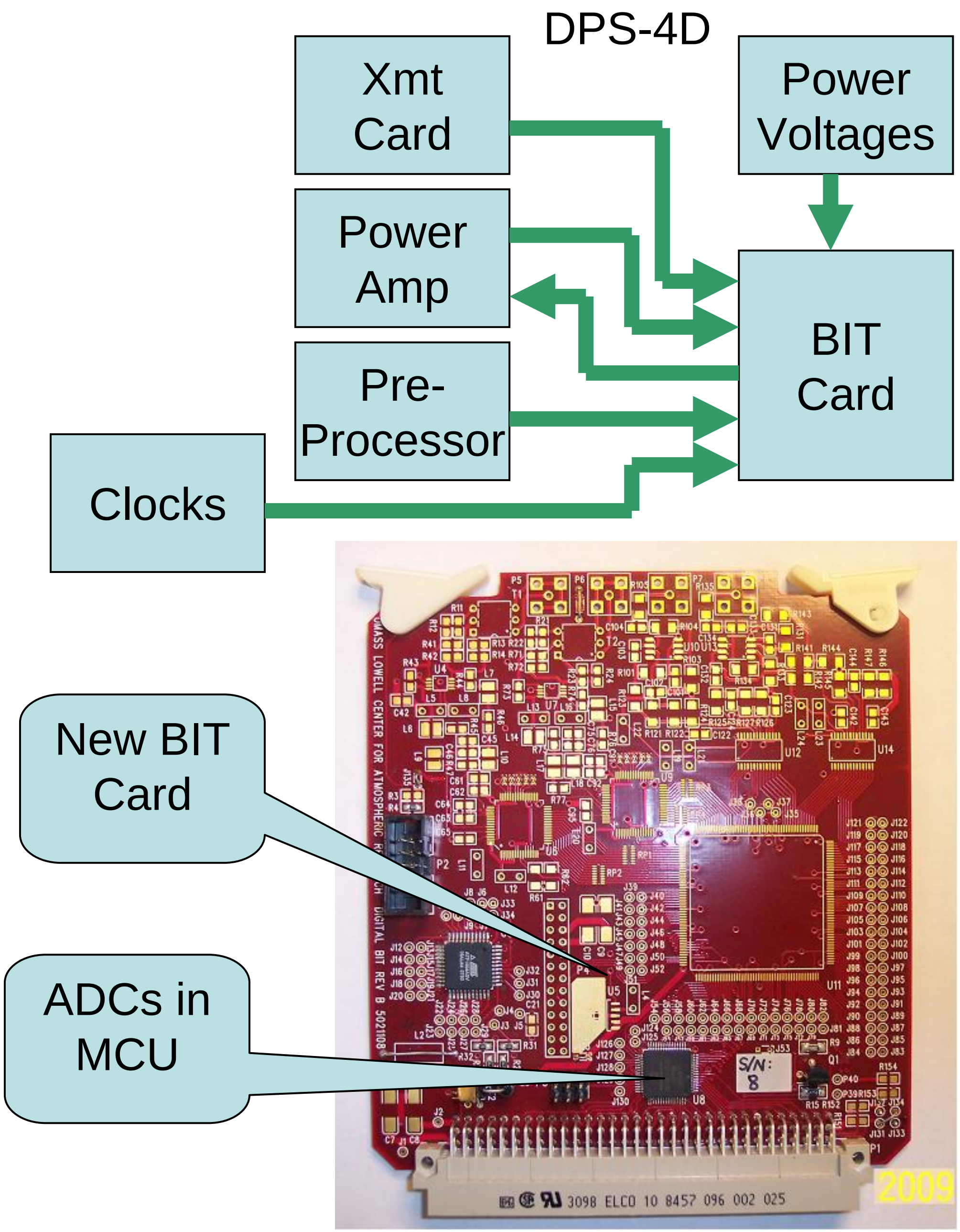
Tracker Filter



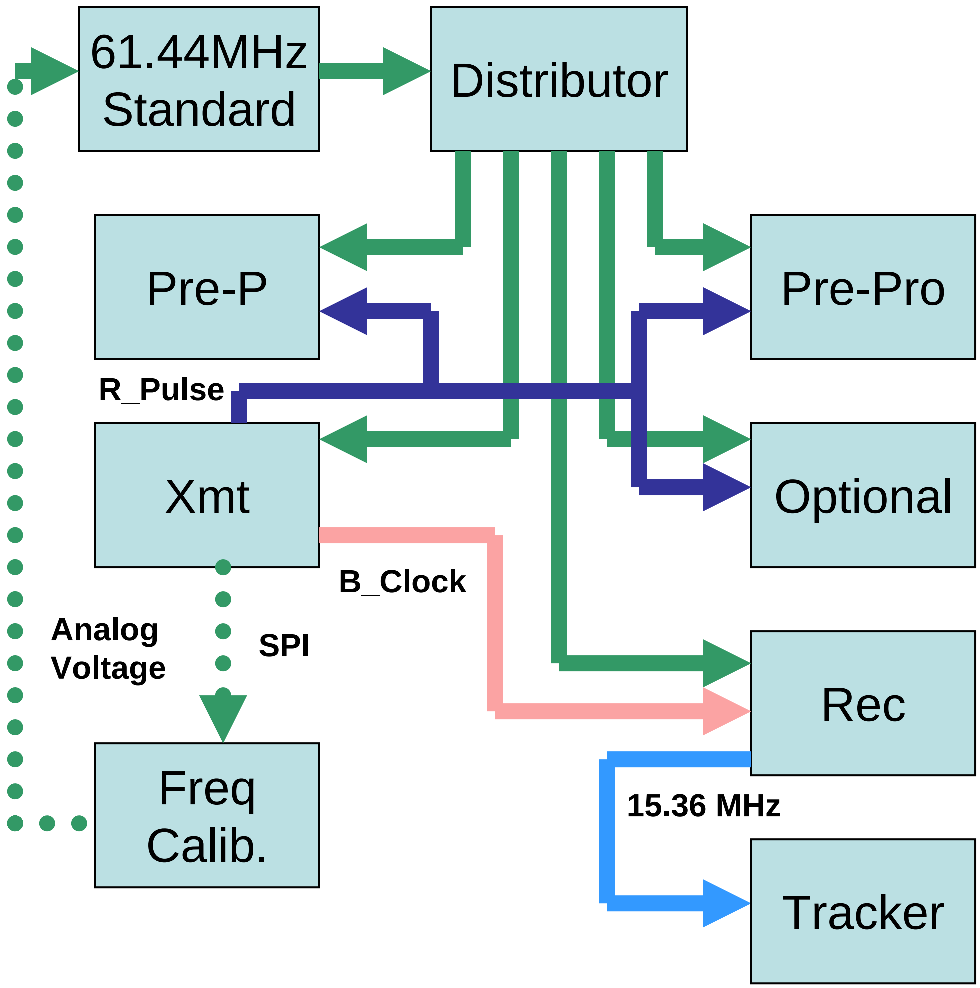


BIT-Card

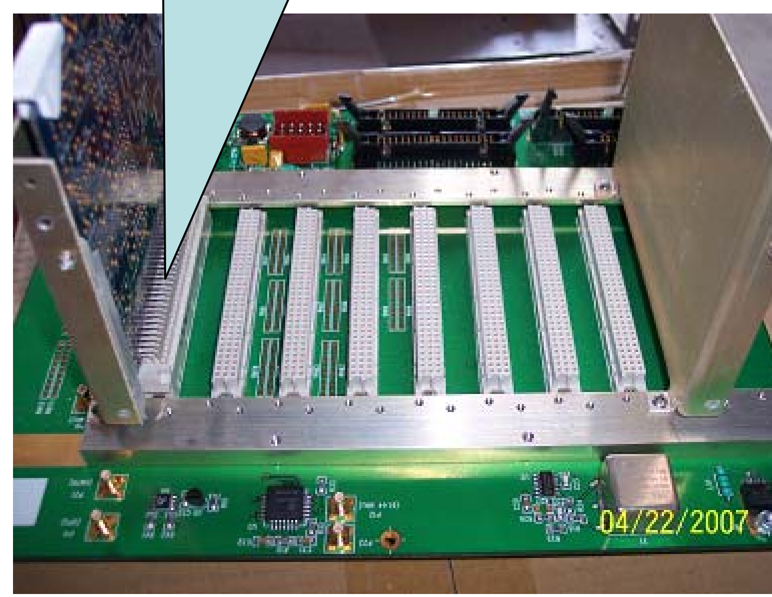

DPS-4
Timing Card
Power Amp
Xmt Card
Receiver Card
Oscillator Card
Power Voltages
Old ISA BIT Card


DPS-4D
Xmt Card
Power Voltages
Power Amp
BIT Card
Pre-Processor
Clocks
New BIT Card
ADCs in MCU

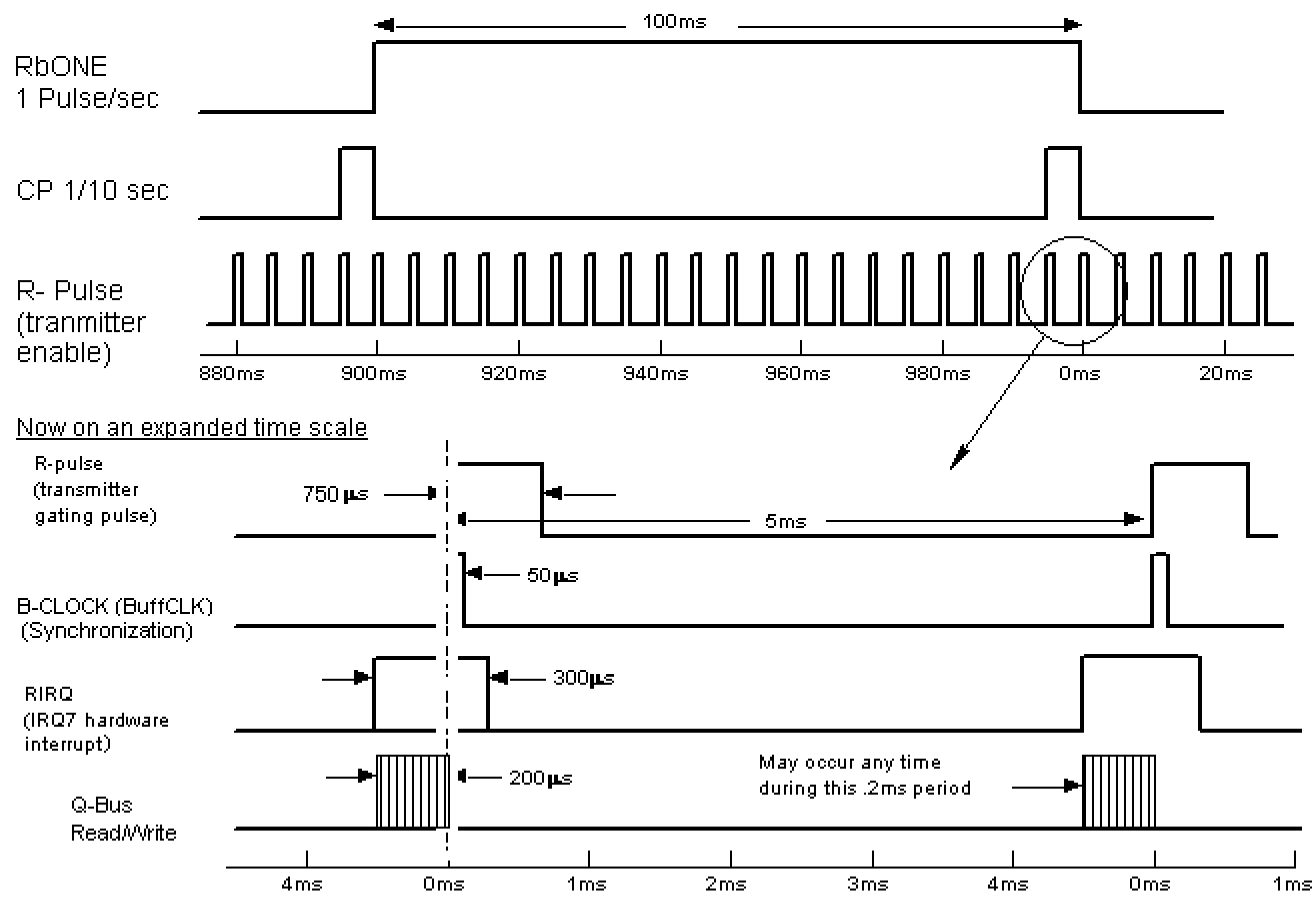
Clocking and Synchronization



Optional card can be a custom made. Currently this spot is used by BITcard



Timing



100ms
RbONE
1 Pulse/sec
CP 1/10 sec
R- Pulse
(tranmitter
enable)
880ms
900ms
920ms
940ms
960ms
980ms
0ms
20ms
Now on an expanded time scale
R-pulse
(transmitter
gating pulse)
750 µs
5ms
50 µs
B-CLOCK (BuffCLK)
(Synchronization)
300 µs
RIRQ
(IRQ7 hardware
interrupt)
200 µs
May occur any time
during this .2ms period
Q-Bus
Read/Write
4ms
0ms
1ms
2ms
3ms
4ms
0ms
1ms

Power Distribution Card

+27V to +24V

+24V to +15V

BIT volt Sensors

Option Sensors

+15V to +12V

+24V to +12V

+24V to -15V

-15V to - 5V

-15V to -12V

+24V to +5V

+24V to +17/22V

+24V to +3.3V

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DPS-4D Signal Processing

Vadym Paznukhov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF

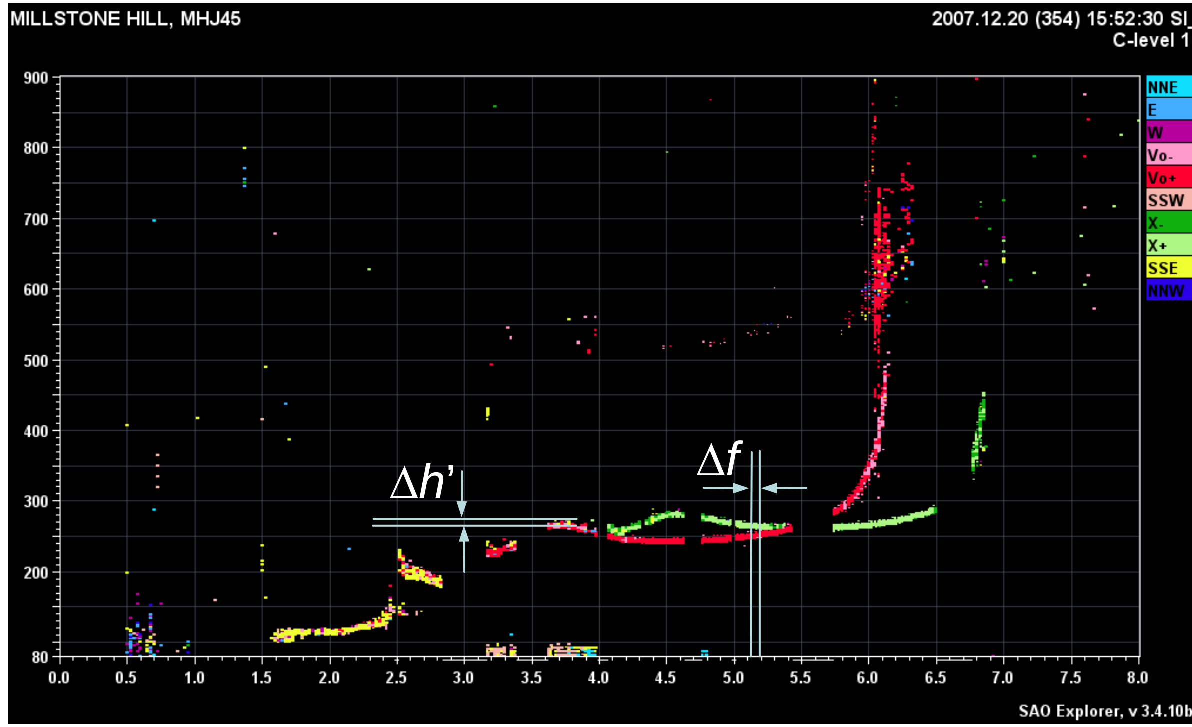
XII INTERNATIONAL DIGISONDE FORUM

11 - 14 MAY 2009

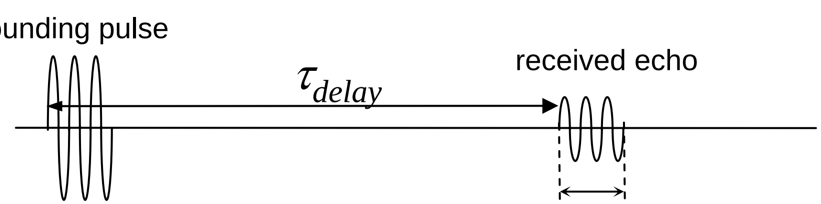
Ionosonde operation concept

Ionosonde technique:

To measure the height of signal reflection from the ionosphere at each operating frequency.



Measuring echo delay:



$$h' = \frac{c\tau_{delay}}{2}$$

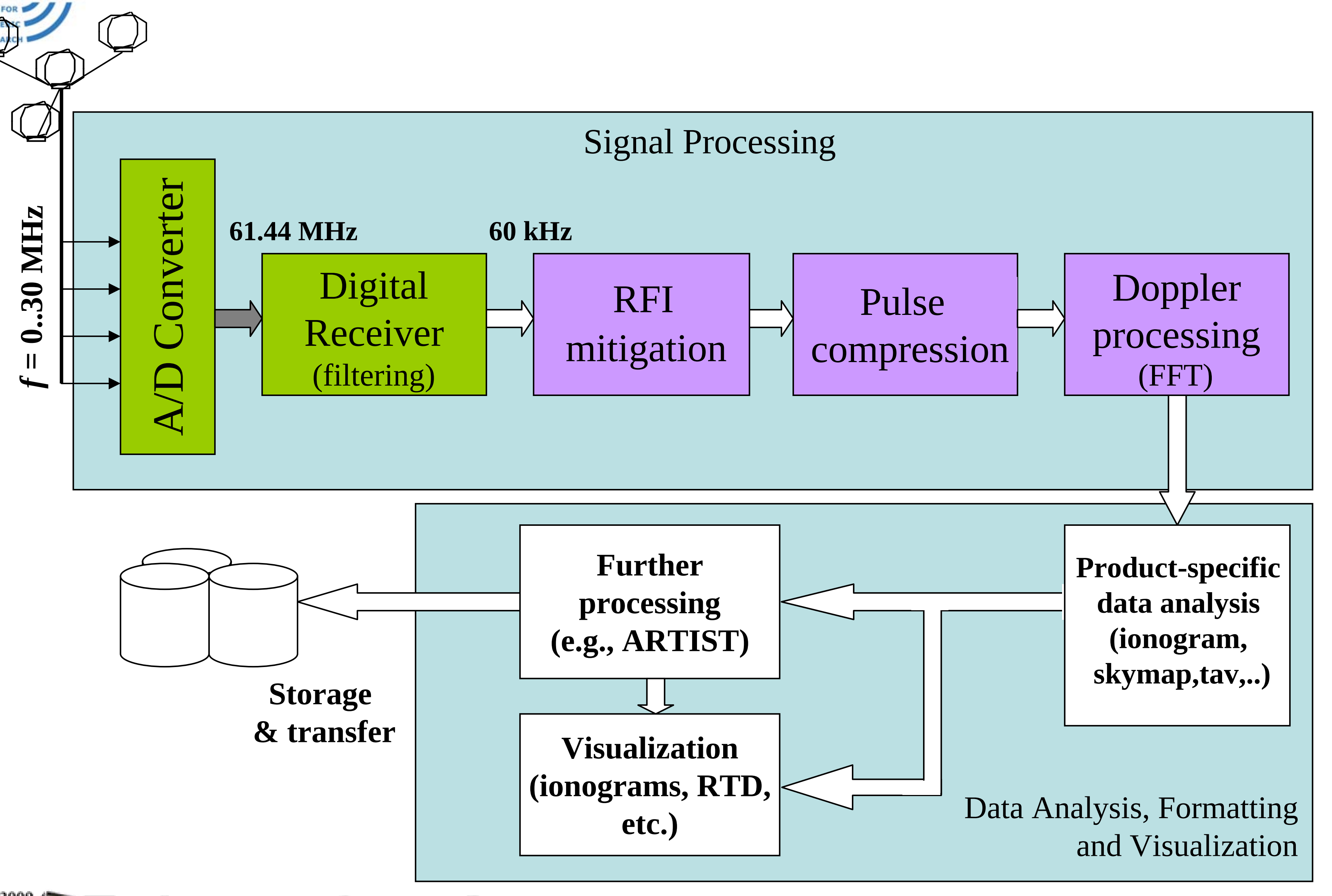
$\Delta\tau_{pulse}$

$\tau_{delay} \Rightarrow h'$ "Classic ionosonde time-delay method"

$\Delta h' \sim \Delta\tau_{pulse}$ Height resolution

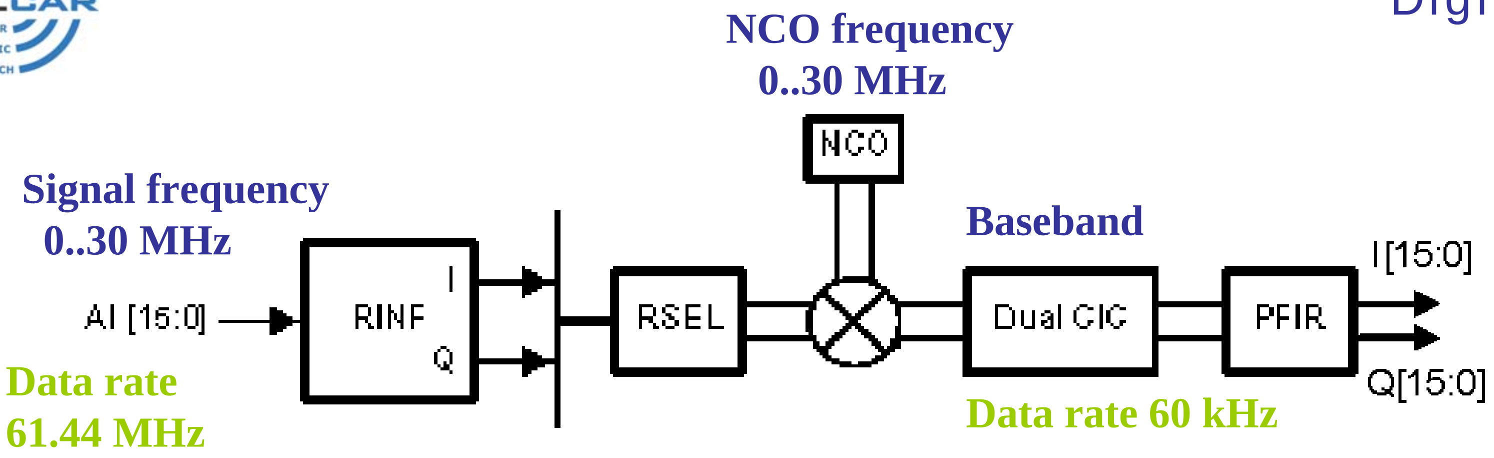
h' is a virtual height of signal reflection

DPS-4D data processing



Block diagram of the digital receiver

Digital receiver



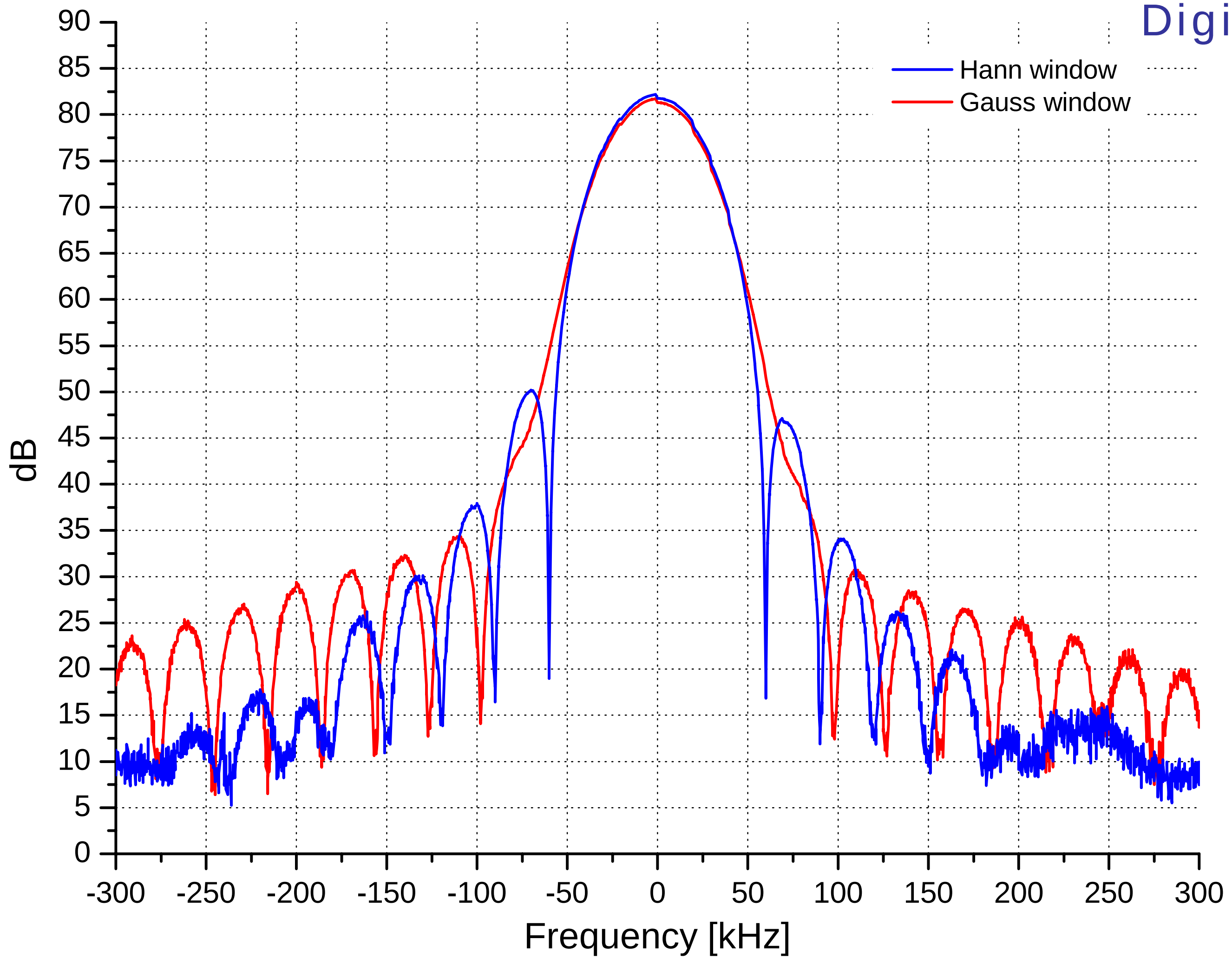
Single channel of the GC5016 chip. RINF is receive input formatter, RSEL is receive input channel selector, NCO denotes digital oscillator, CIC is cascade integrator comb filter, and PFIR is programmable finite impulse response filter.

OPERATION:

The input data on port A[15..0] are converted to a complex input format (I and Q samples) in the receive input formatter (RINF). Each down-conversion channel demodulates the sampled data down to the baseband, then performs a low-pass filter operation, reduces the signal rate (decimation), and outputs I and Q baseband data. The mixer stage provides the receive input channel selector (RSEL), digital oscillator (NCO), and complex mixing logic (mixer) to translate the input data down to the baseband. After the mixer, the 5-stage cascade integrator comb (CIC) is used for filtering and decimation. After the CIC complex filter, the programmable finite impulse response (PFIR) filter provides CIC correction, spectral shaping, and further decimation.

Frequency response of the digital receiver

Digital receiver

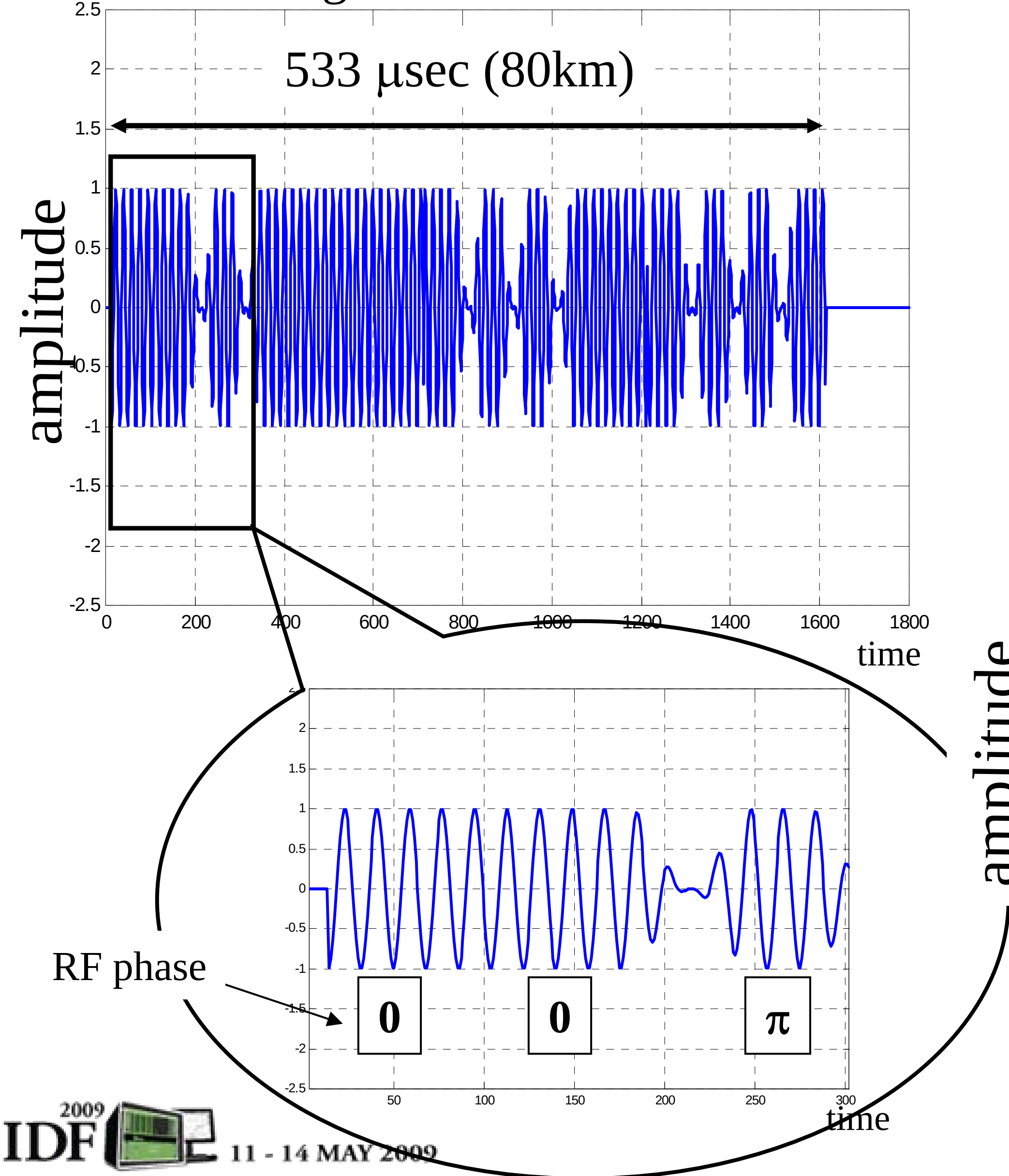


Currently there is the possibility of selecting between two programmed PFIR filter functions: Gauss window and Hann window. Measured frequency response characteristics of the digital receiver with two different PFIR settings are shown.

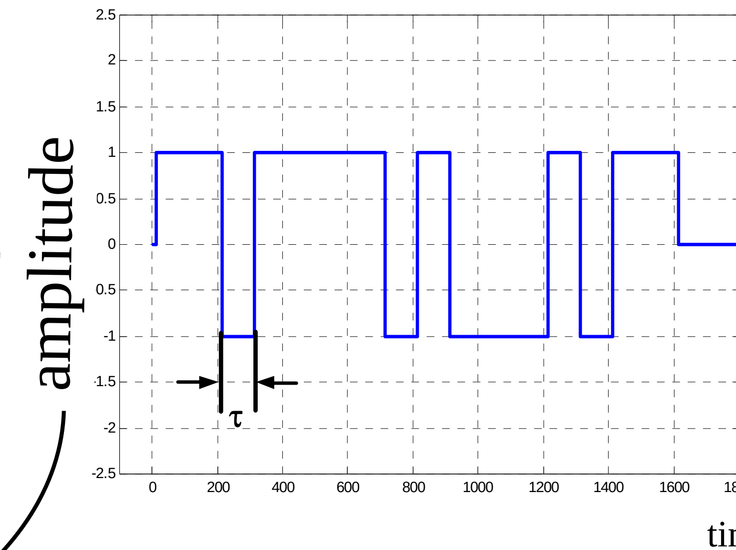
DPS waveforms in time domain

Pulse compression

Original waveform



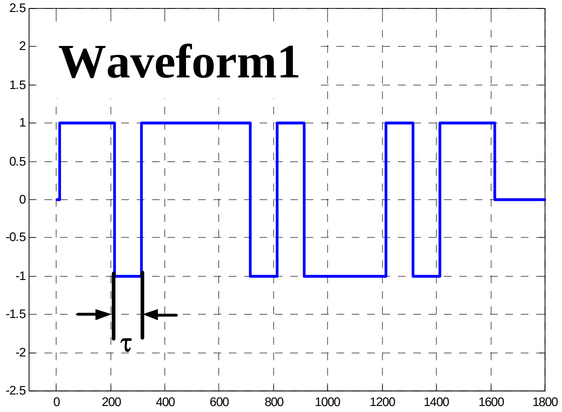
DPS waveform after "phase detection"

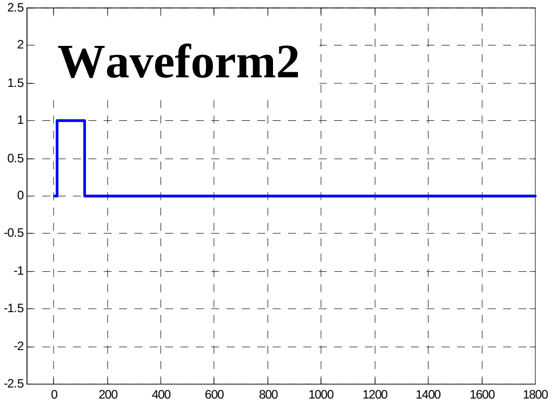


τ = 33.33μsec (5km)

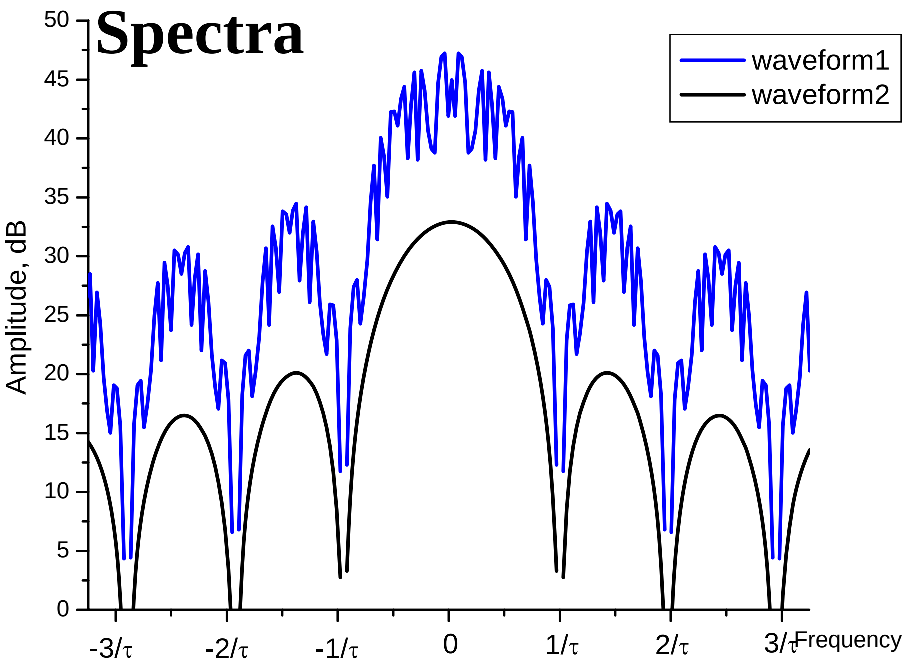
DPS waveforms

Pulse compression





$\tau = 33.33\mu sec$

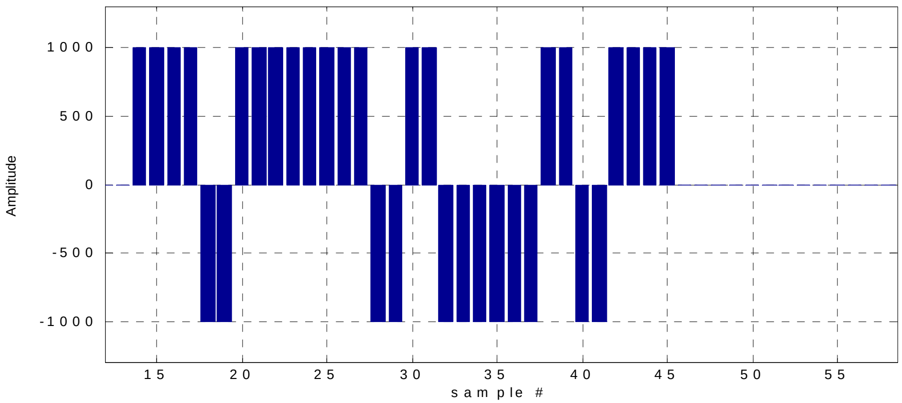


$\Delta f = 2/\tau = \pm 30$ kHz

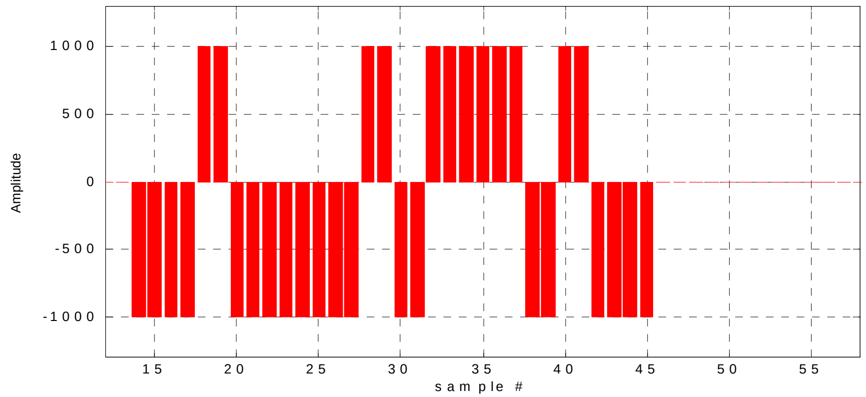
Digitized DPS-4D signal

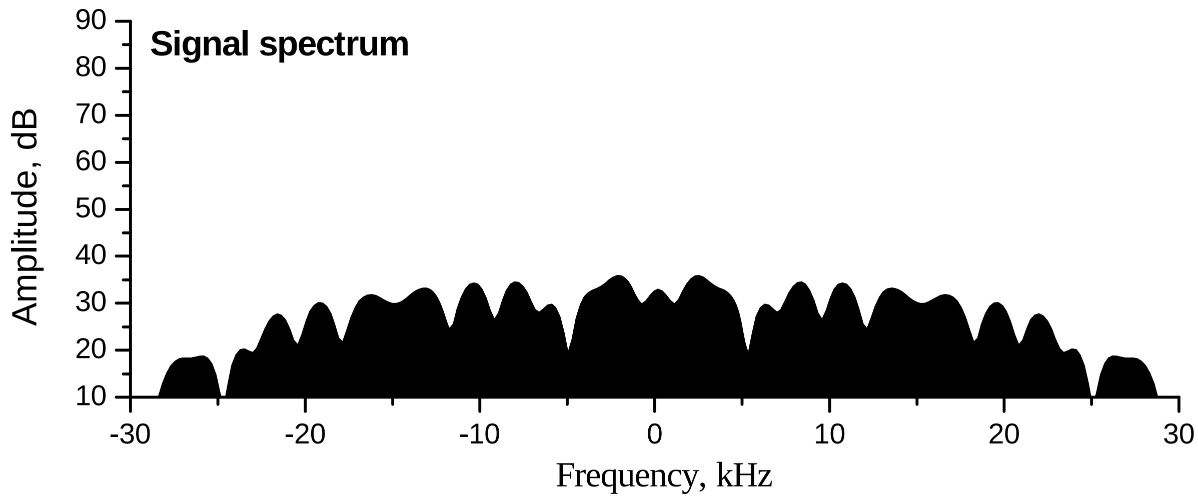
Pulse compression

“Real” samples



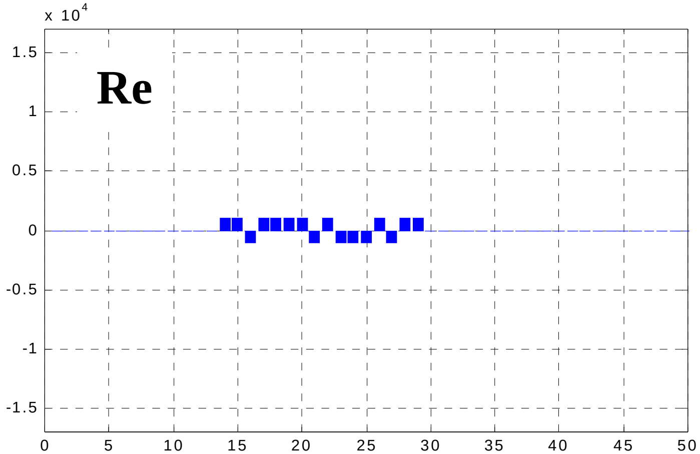
“Imag” samples

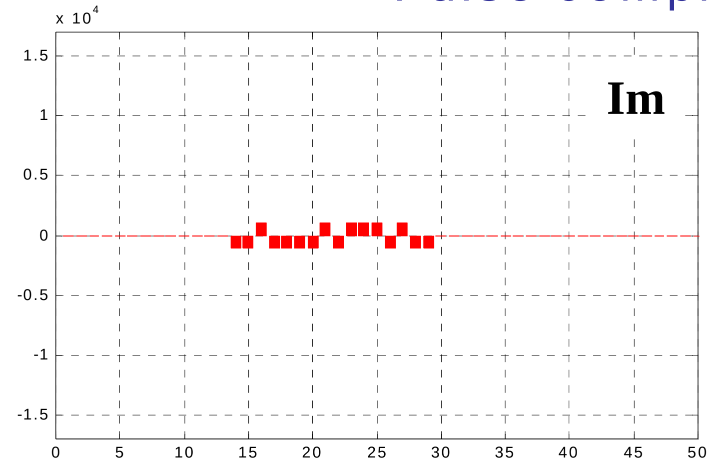


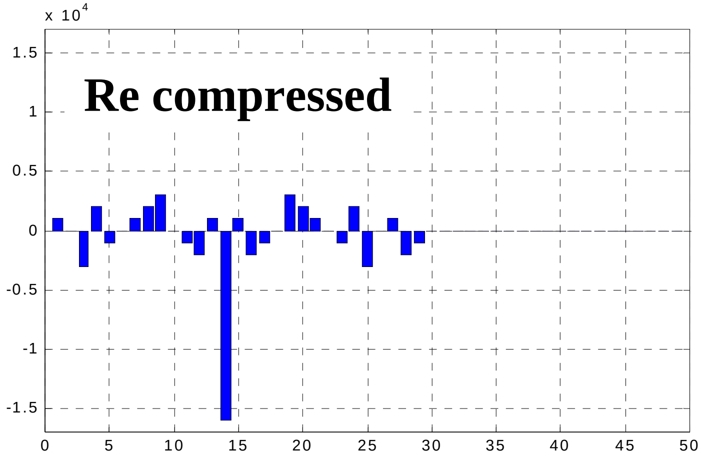


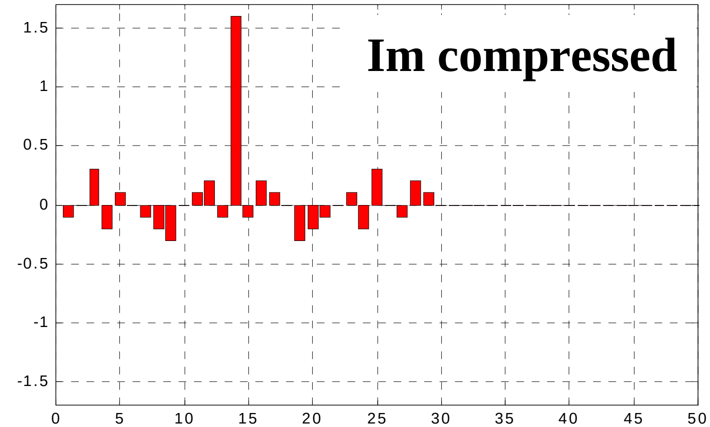
Pulse compression

Pulse compression









$$\mathrm{Re}[signal_{compr}(\tau)] = \int_0^T \mathrm{Re}[signal(t+\tau)] \cdot \mathrm{Re}[code(t)]dt$$

Compressing the pulse means calculating the convolution between received signal and the original waveform (“*code*”)

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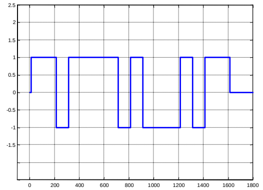
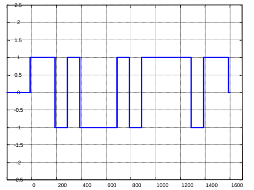
Pulse compression procedure

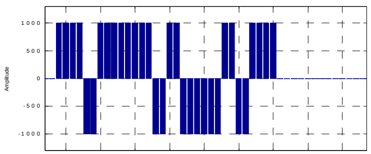
Pulse 1



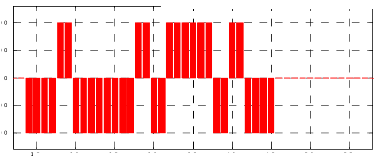
Pulse 2



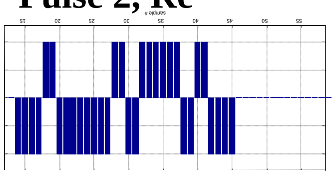
Pulse 1, Re



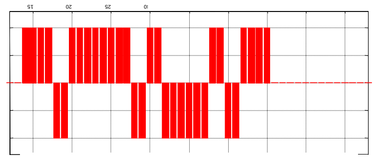
Pulse 1, Im



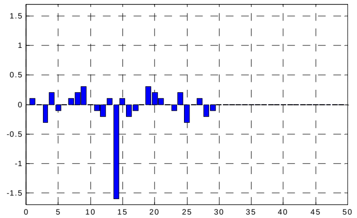
Pulse 2, Re



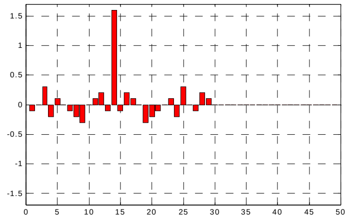
Pulse 2, Im



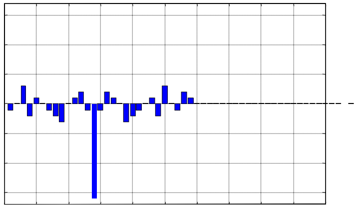
Pulse 1, Re compr.



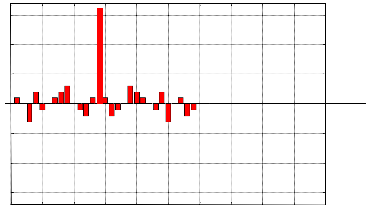
Pulse 1, Im compr.



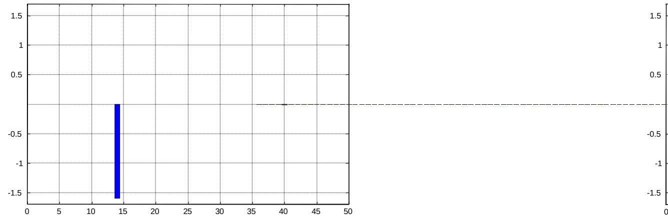
Pulse 2, Re compr.



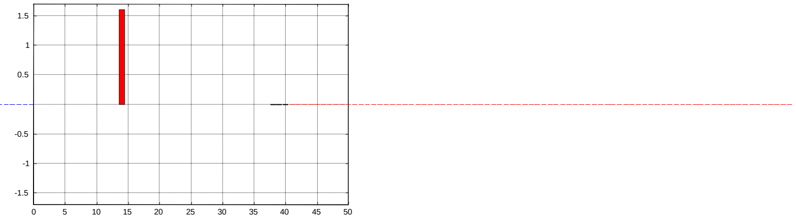
Pulse 2, Im compr.



Pulse 1, Re compr. + Pulse 2, Re compr.

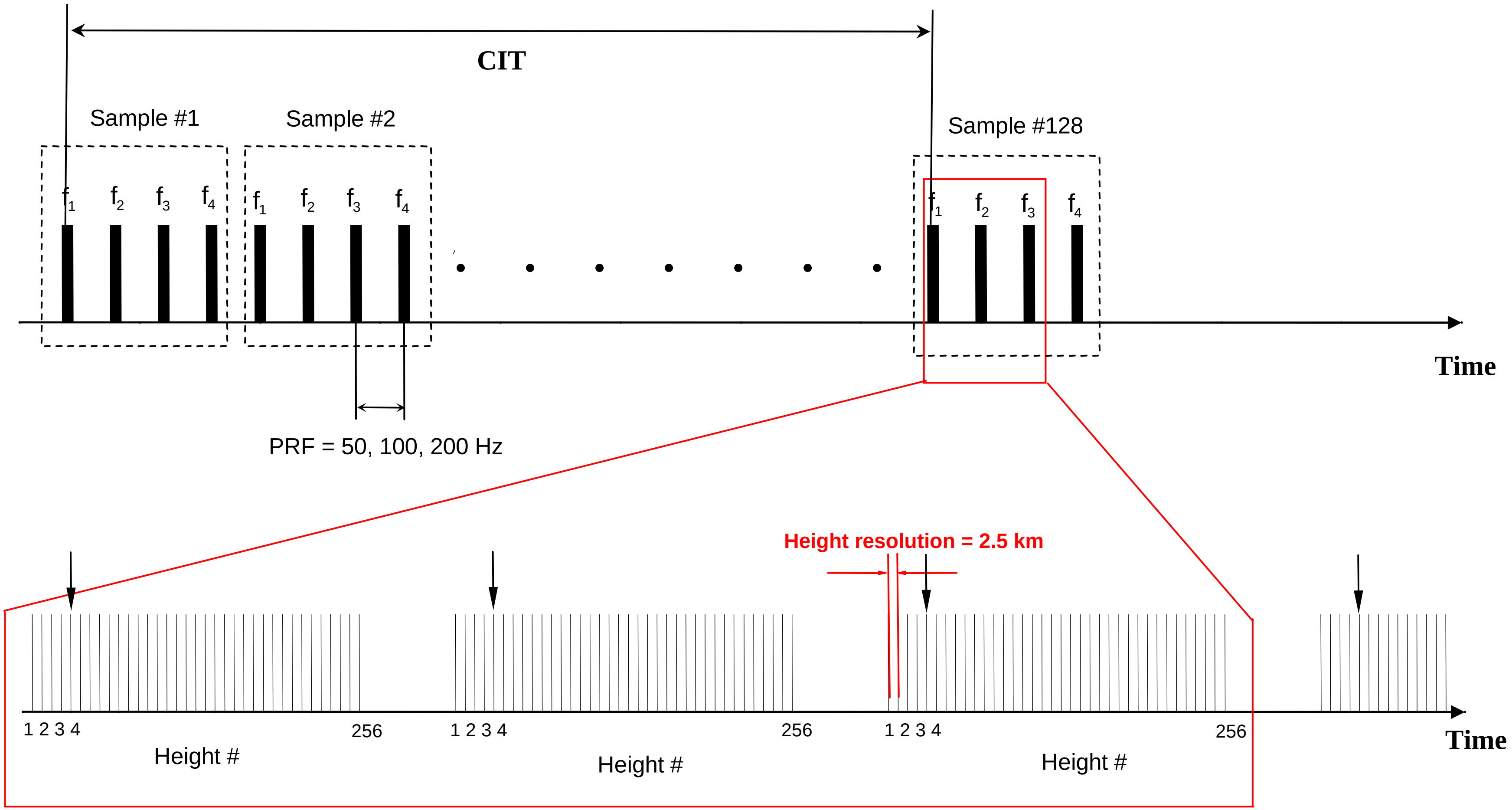


Pulse 1, Im compr. + Pulse 2, Im compr.



DPS data structure

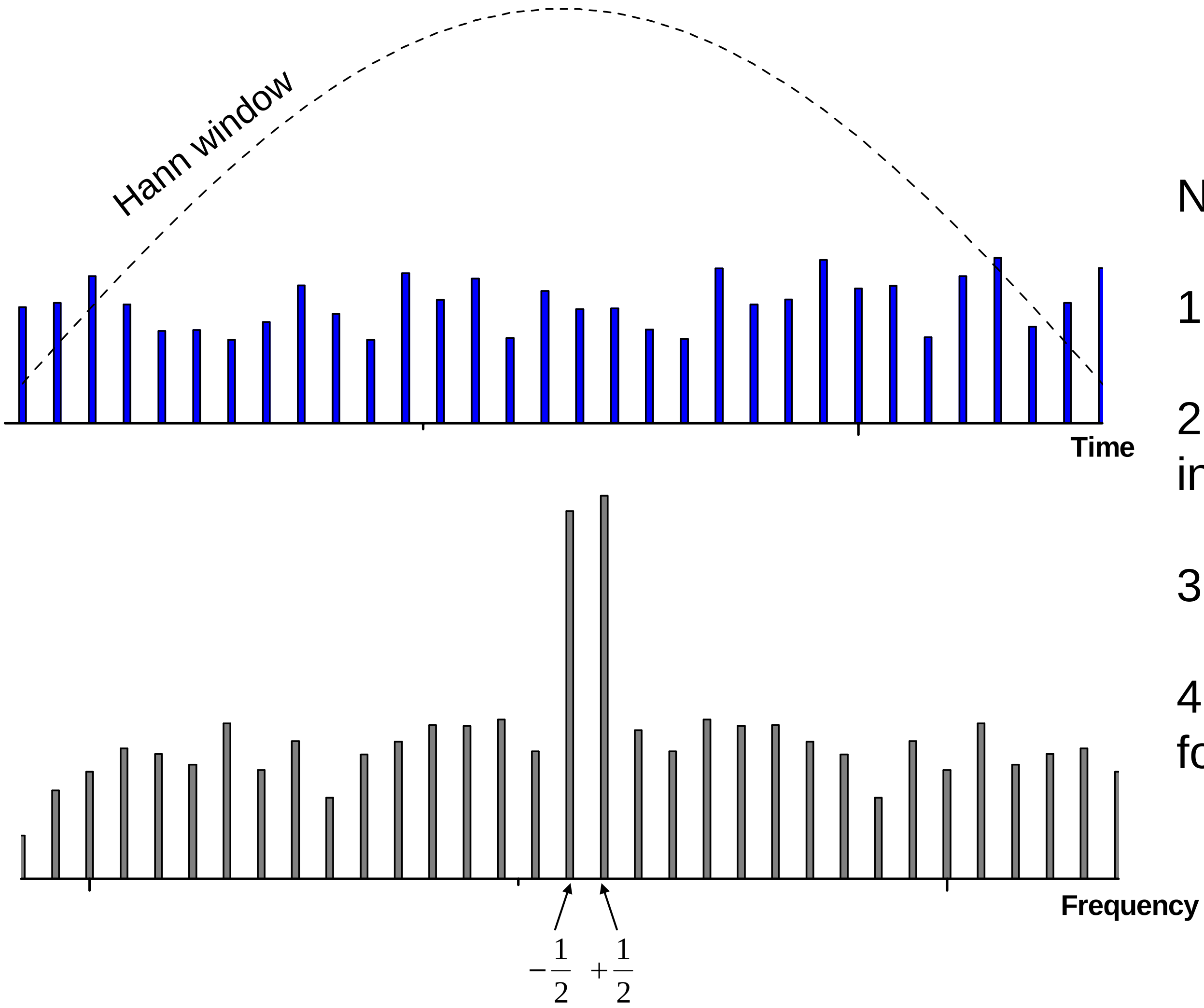
Doppler processing



Note: Spectra are calculated for the each height range

DPS Doppler spectra calculation

Doppler processing



Notes:

1. FFT algorithm is used

2. Hann window is applied in time domain

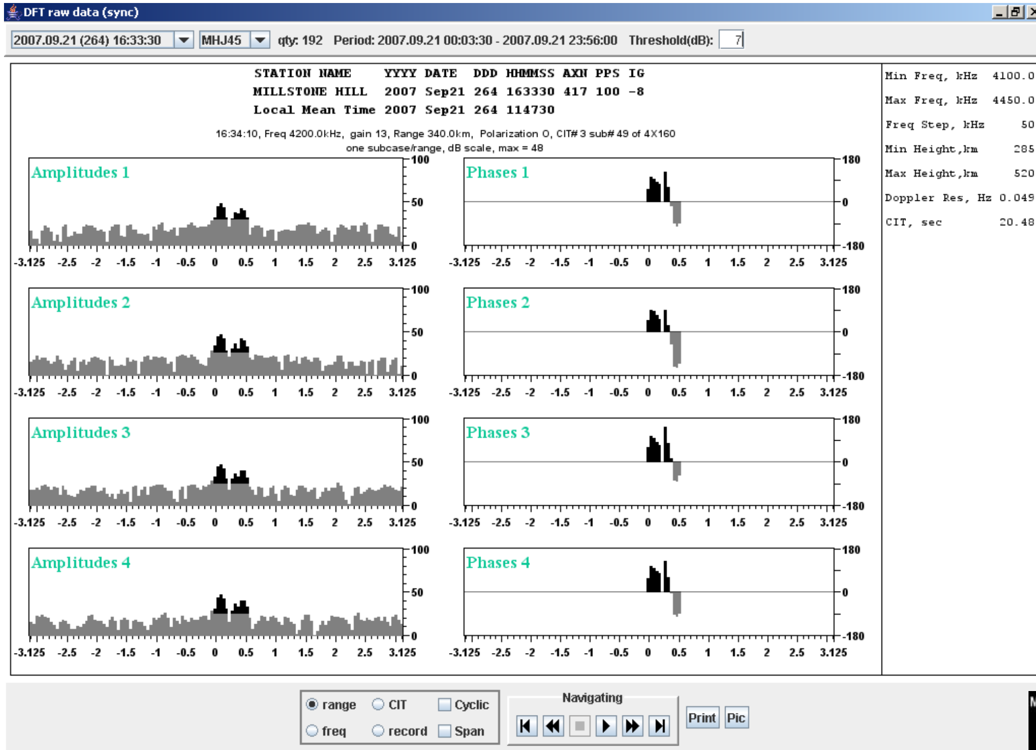
3. No zero Doppler line

4. Spectra are calculated for the each height range

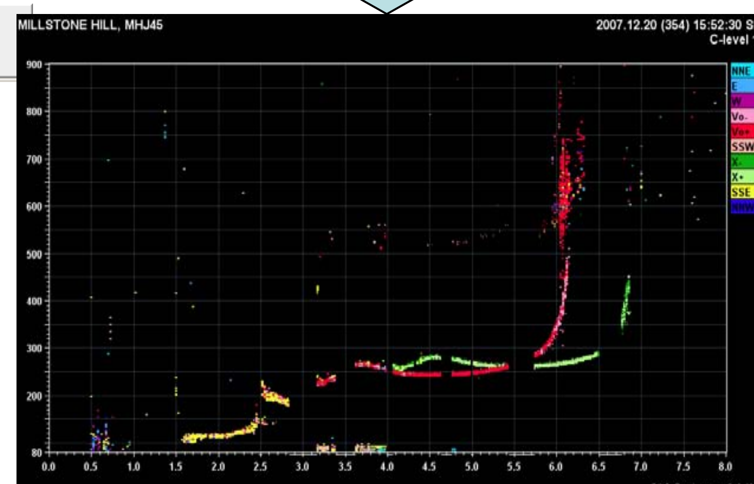
DPS Doppler Spectra

Doppler processing

Spectra for single height range, single frequency and 4 antennas

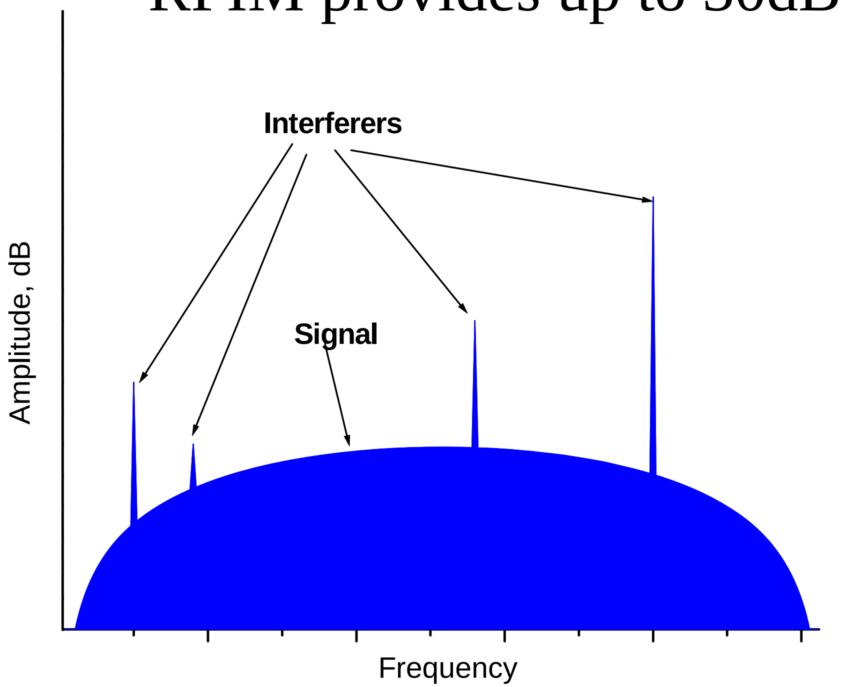


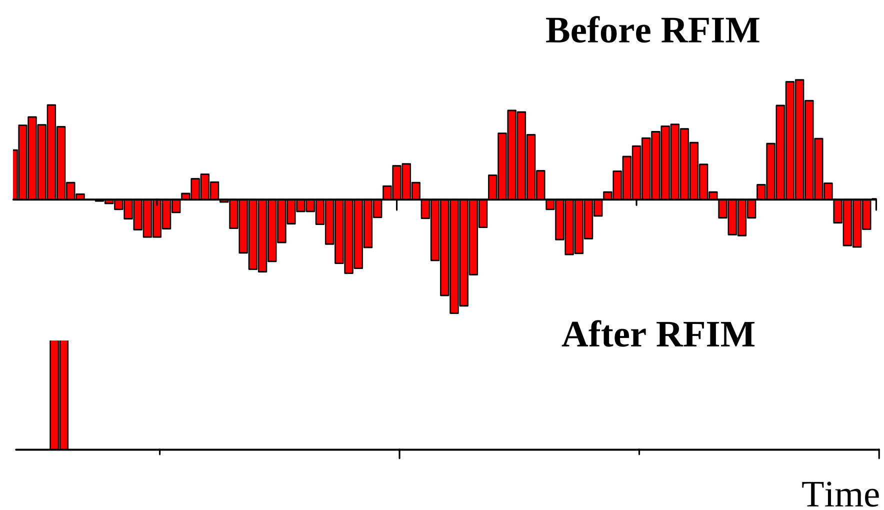
Collect maximum Doppler amplitudes for each frequency and each height range



RFI Mitigation basics

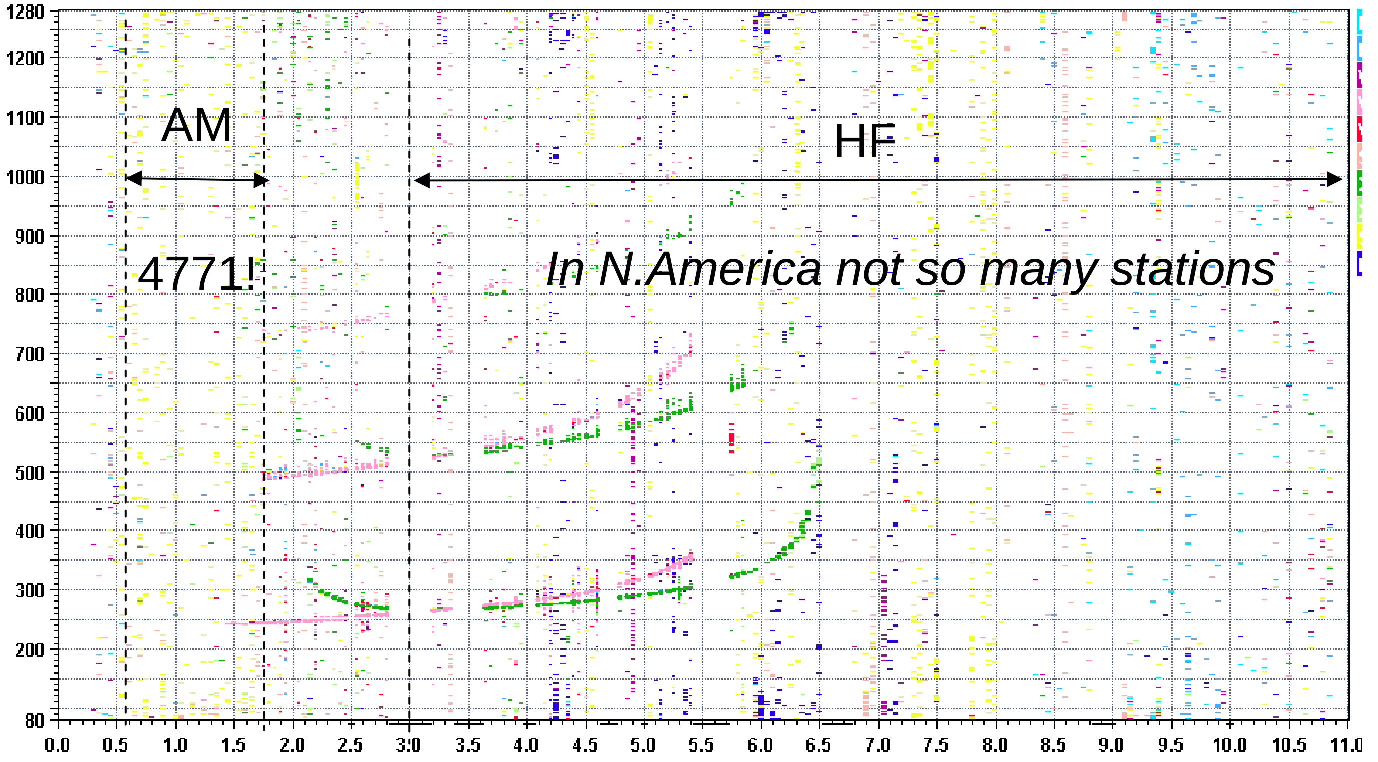
- Idea by Dr. Klaus Bibl (patented)
- RFIM is removing interferer signals from the received signal
- Interferers are associated with broadcast station signals
- Removal is performed in time domain
- Complex spectral analysis is essential
- RFIM provides up to 30dB signal-to-noise ratio improvement





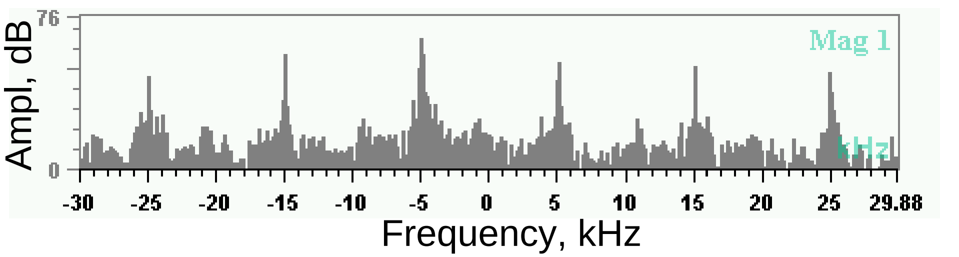
Interference

RFIM



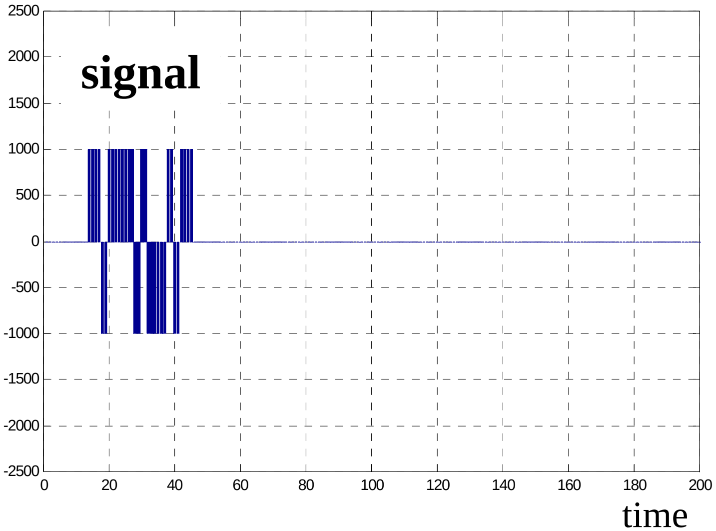
AM or Medium-wave range:
530 kHz to 1610/1710 kHz
4,771 broadcasting stations in USA, ~60 in MA
HF or Short-wave range
3 MHz to 30 MHz
~25 broadcasting stations in USA

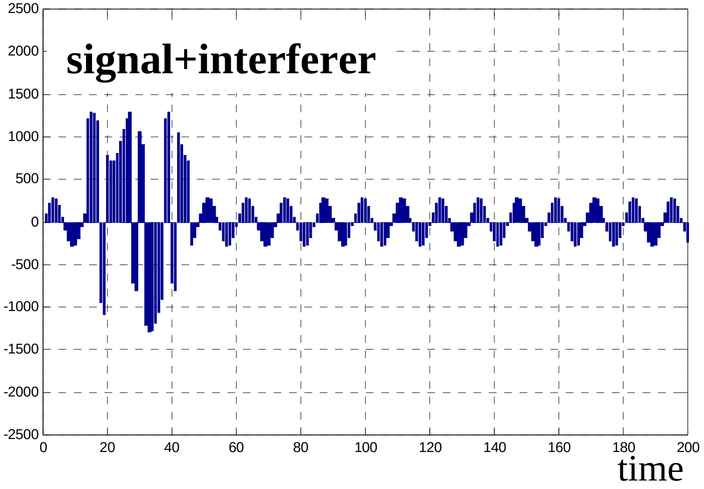
Millstone Hill, 1.6 MHz, 1830 LT

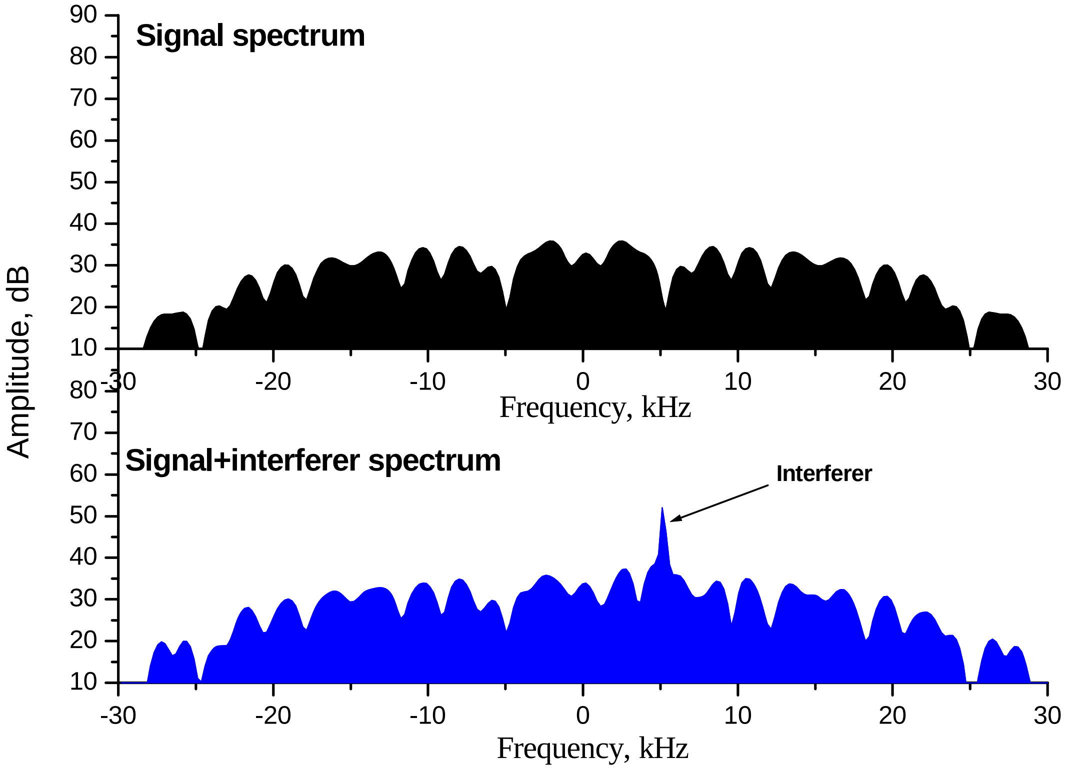


Interferer effect

RFIM

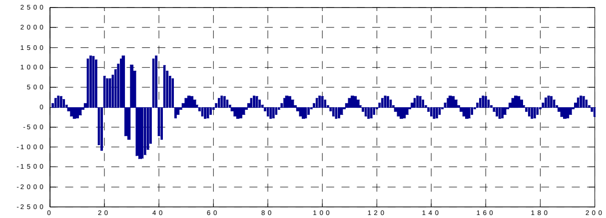






RFIM algorithm

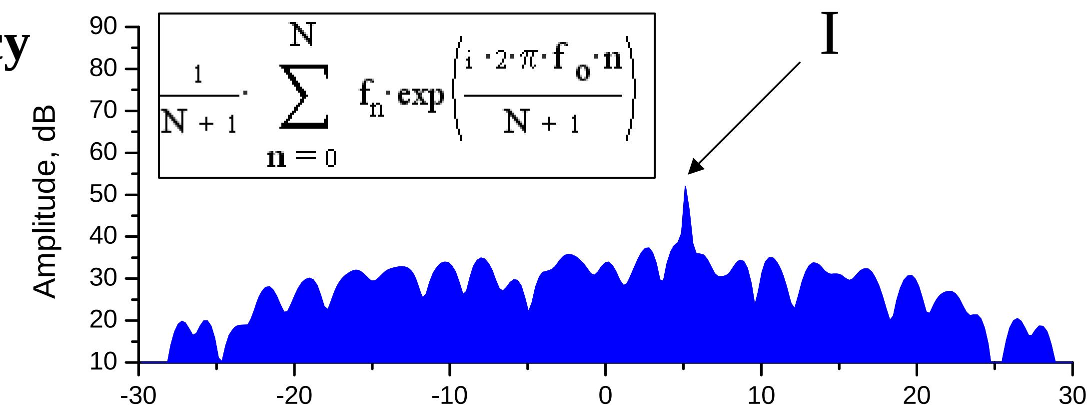
RFIM



1. **Take DFT of the signal. Find "peak" in the spectrum.**

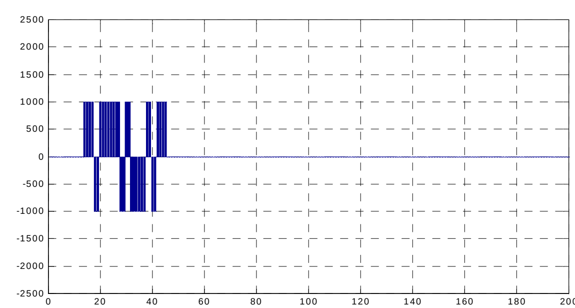
2. **Determine exact frequency of the interferer.**

$$f_o = f_A + \frac{B}{A+B}$$



3. **Do "single line spectral analysis" to determine exact interferer amplitude and phase.**

4. **Subtract interferer in time domain.**

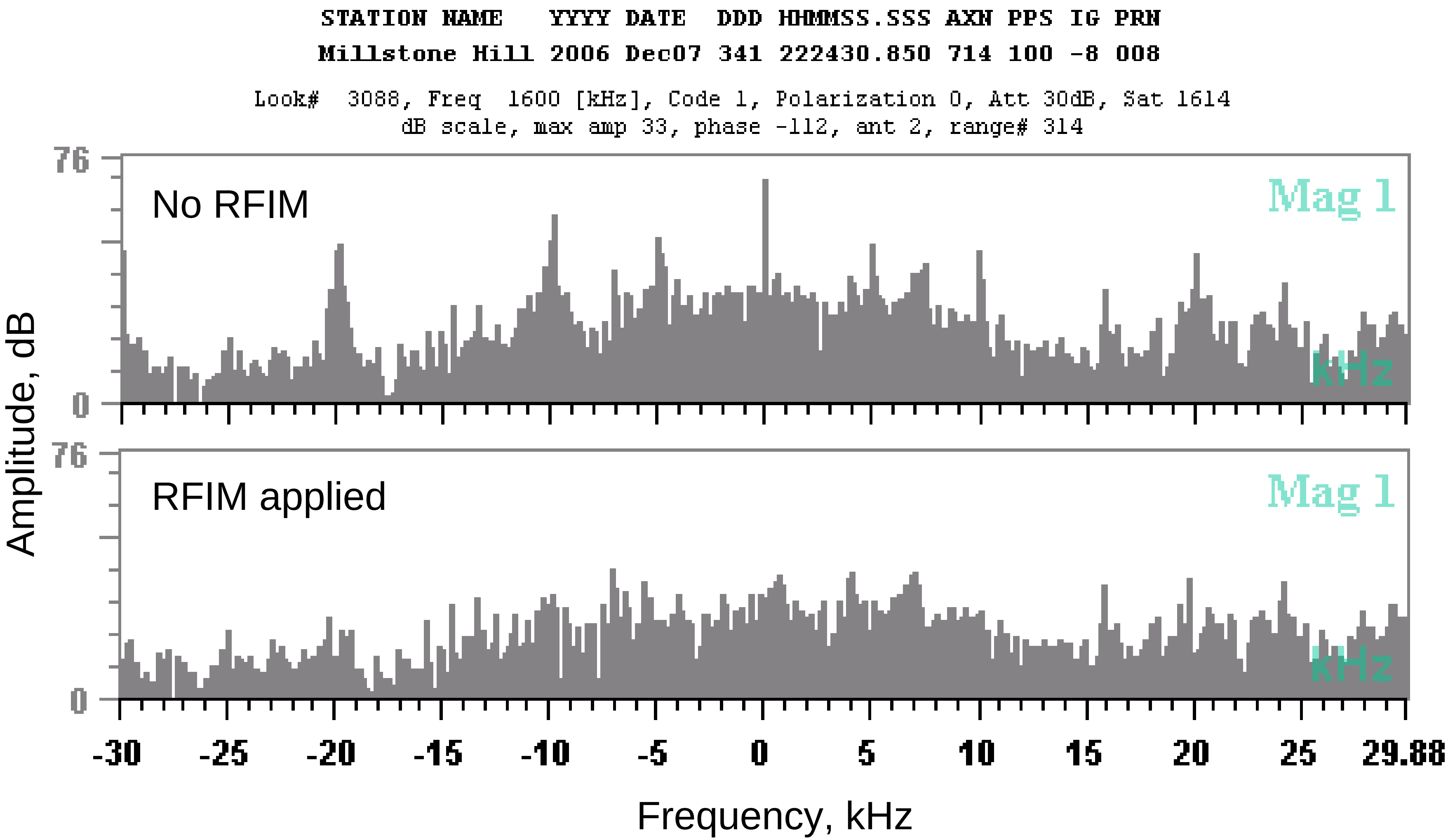


5. **Repeat steps 1-4 until happy or bored.** ***(no more peaks can be found)***

RFIM application example

RFIM

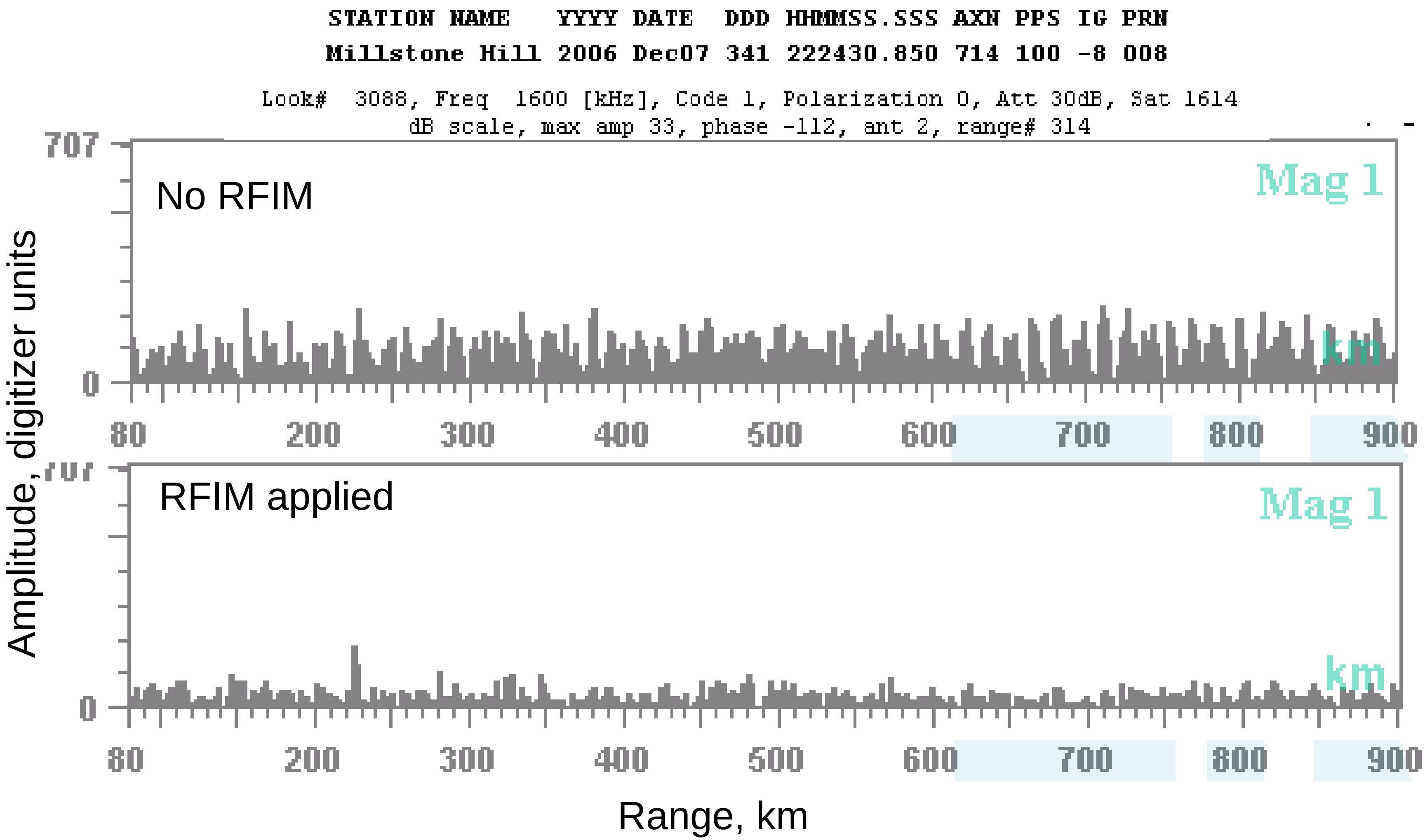
Frequency domain



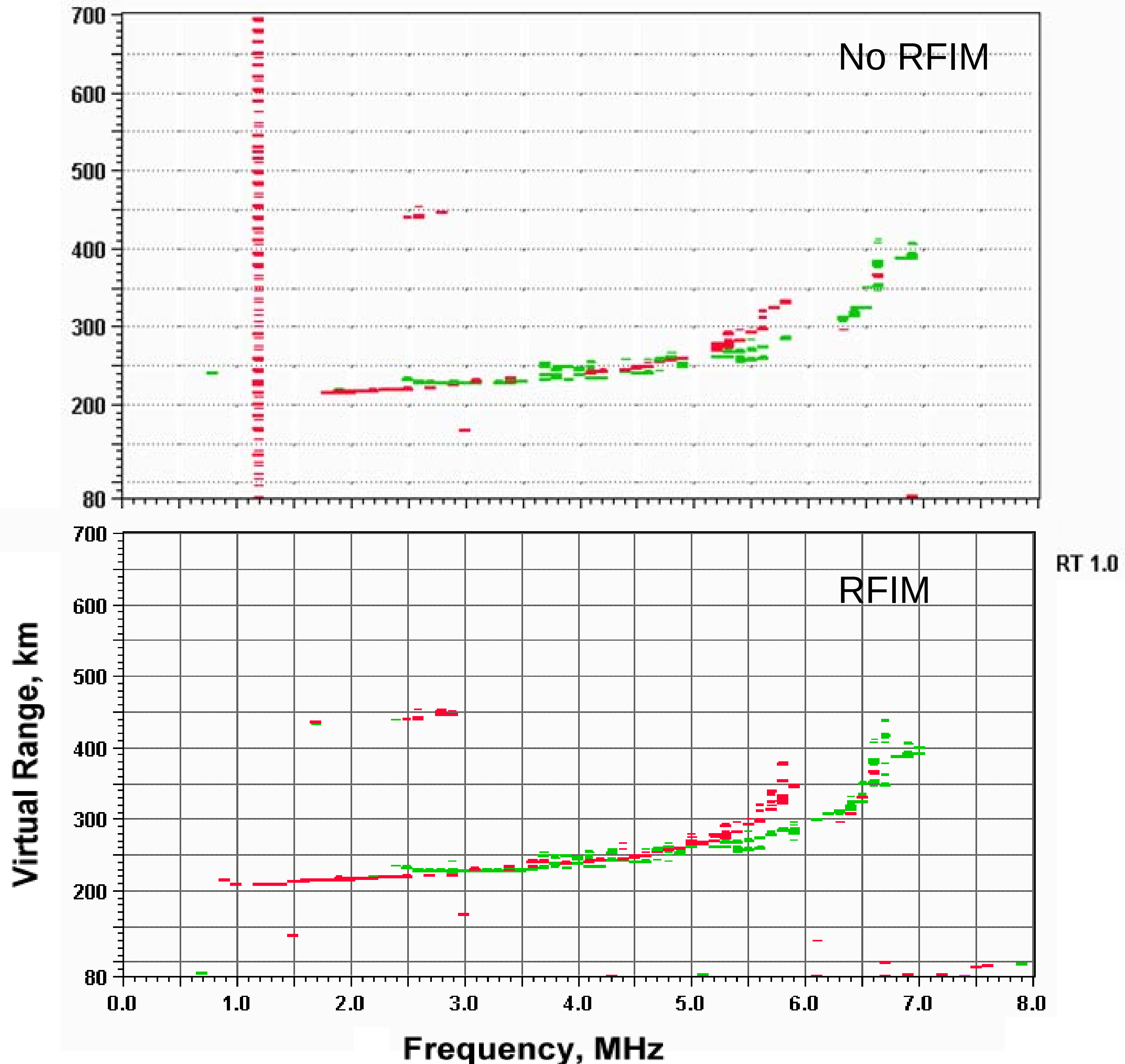
RFIM application example, cont.

RFIM

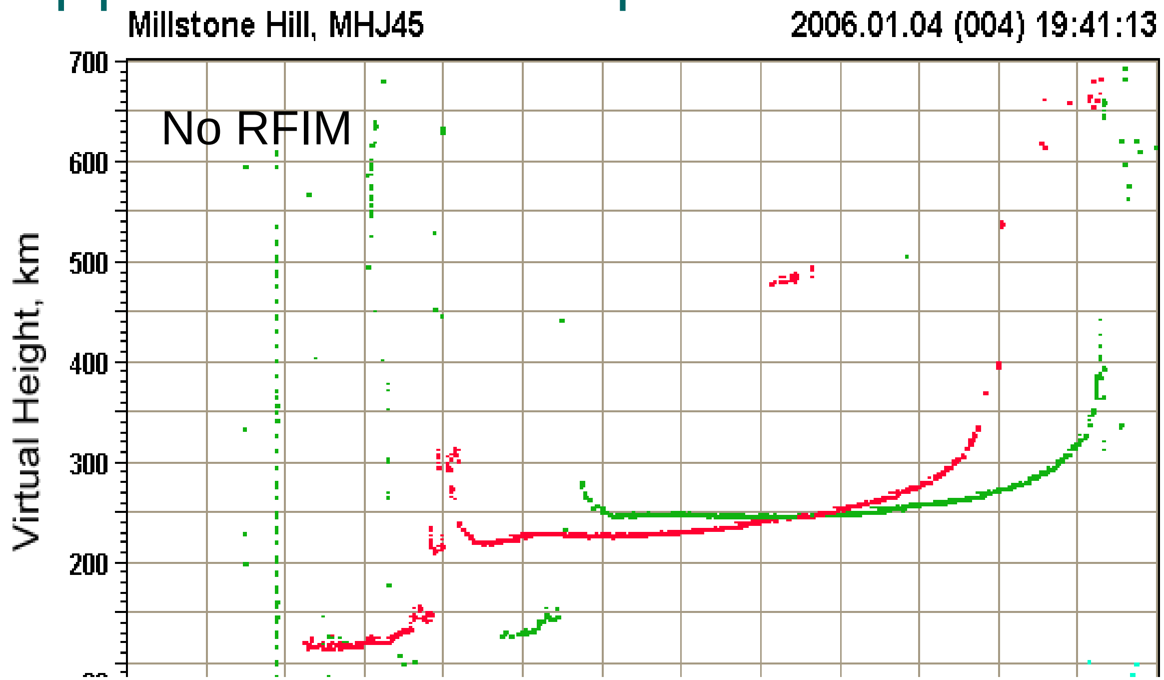
Time domain (before FFT)

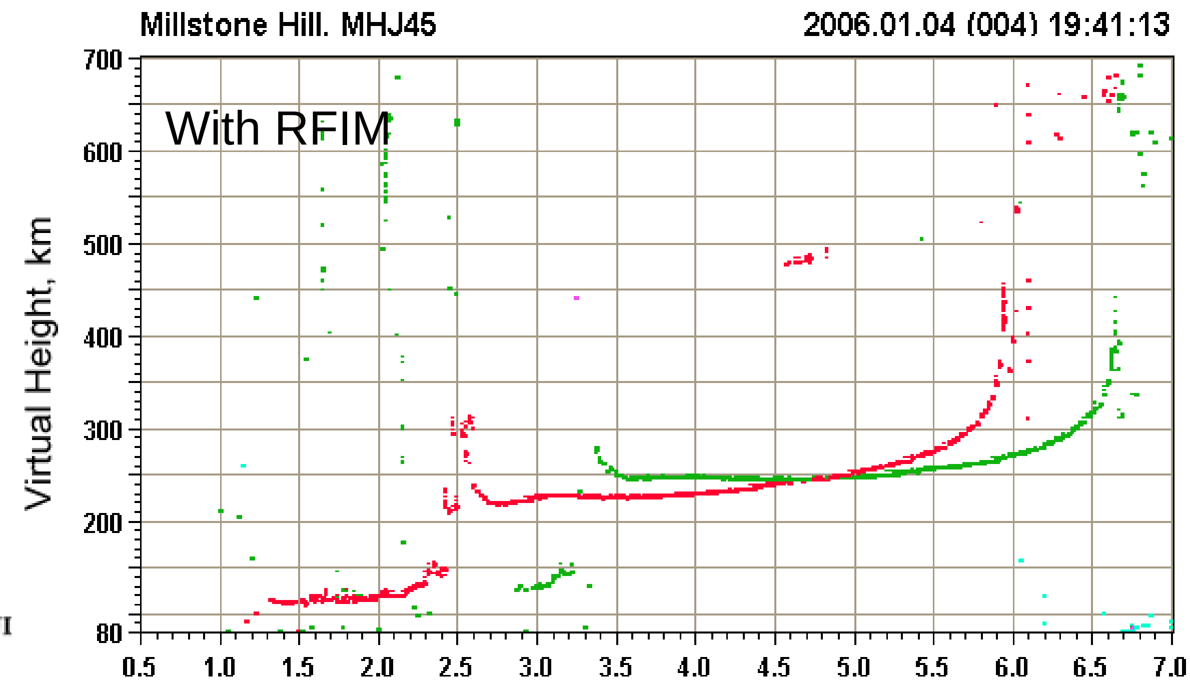


RFIM application example I



RFIM application example II





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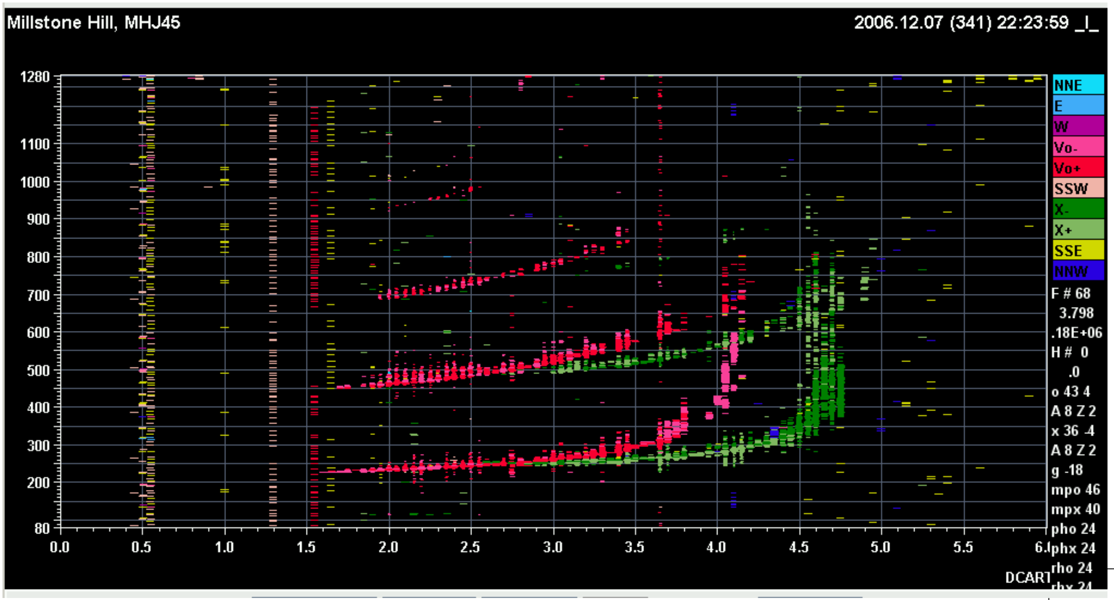
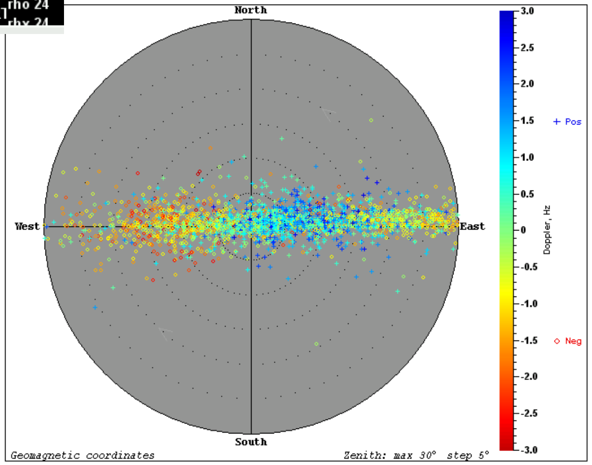
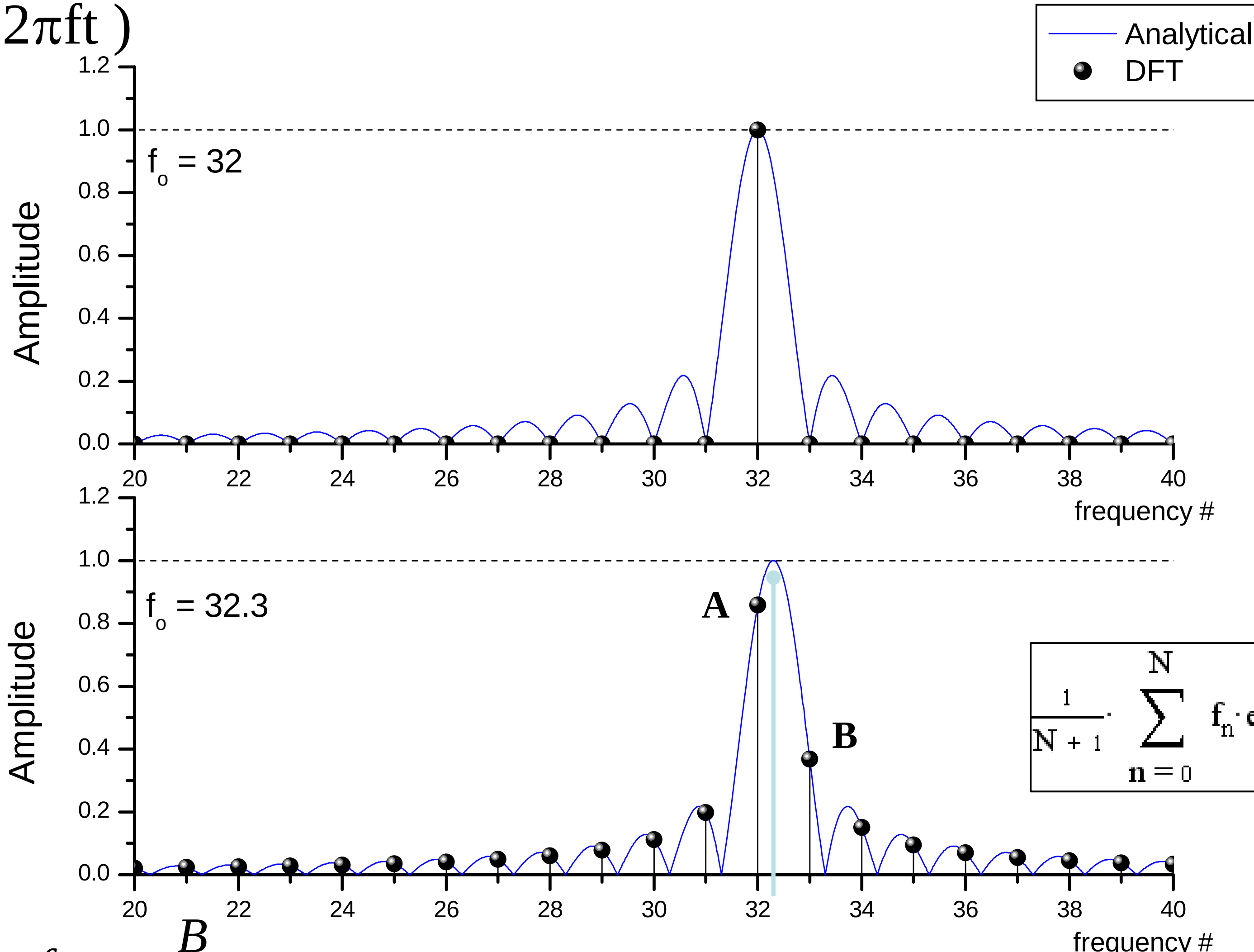
Good Luck!





Modeled interferer spectrum

$\cos(2\pi f t)$



$$\frac{1}{N+1} \cdot \sum_{n=0}^{N} f_n \cdot \exp\left(\frac{i \cdot 2 \cdot \pi \cdot f_o \cdot n}{N+1}\right)$$

$$f_o = f_A + \frac{B}{A+B}$$

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DPS-4D FPGA Technology for Hardware Data Pre-processing

George Cheney

University of Massachusetts Lowell
Department of Electrical and Computer Engineering
- and -
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

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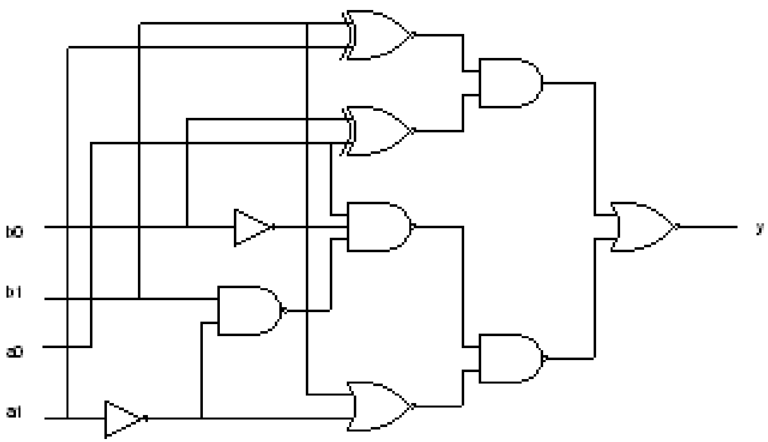
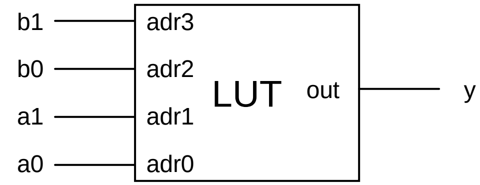
Agenda

- What is an Field programmable Gate Array (FPGA)?
  - Lookup Table Logic
  - Stratix Logic Element
  - In System Programmable vs. One Time Programmable
- FPGAs in the DPS-4D (Altera Stratix)
  - Preprocessor Card
  - Verilog™ Hardware Description Language
  - CAD Tools (Compiler, Synthesizer, Simulator)
  - Stratix Specific Resource: DSP Blocks
  - On-Chip Memory

FPGA Lookup Table (LUT)




```
module AGTB(y, a, b);
input [1:0] a,b;
output y;
reg y;
always @(a or b)
   begin
      if (a > b)
         y = 1;
      else
         y = 0;
   end
endmodule
```

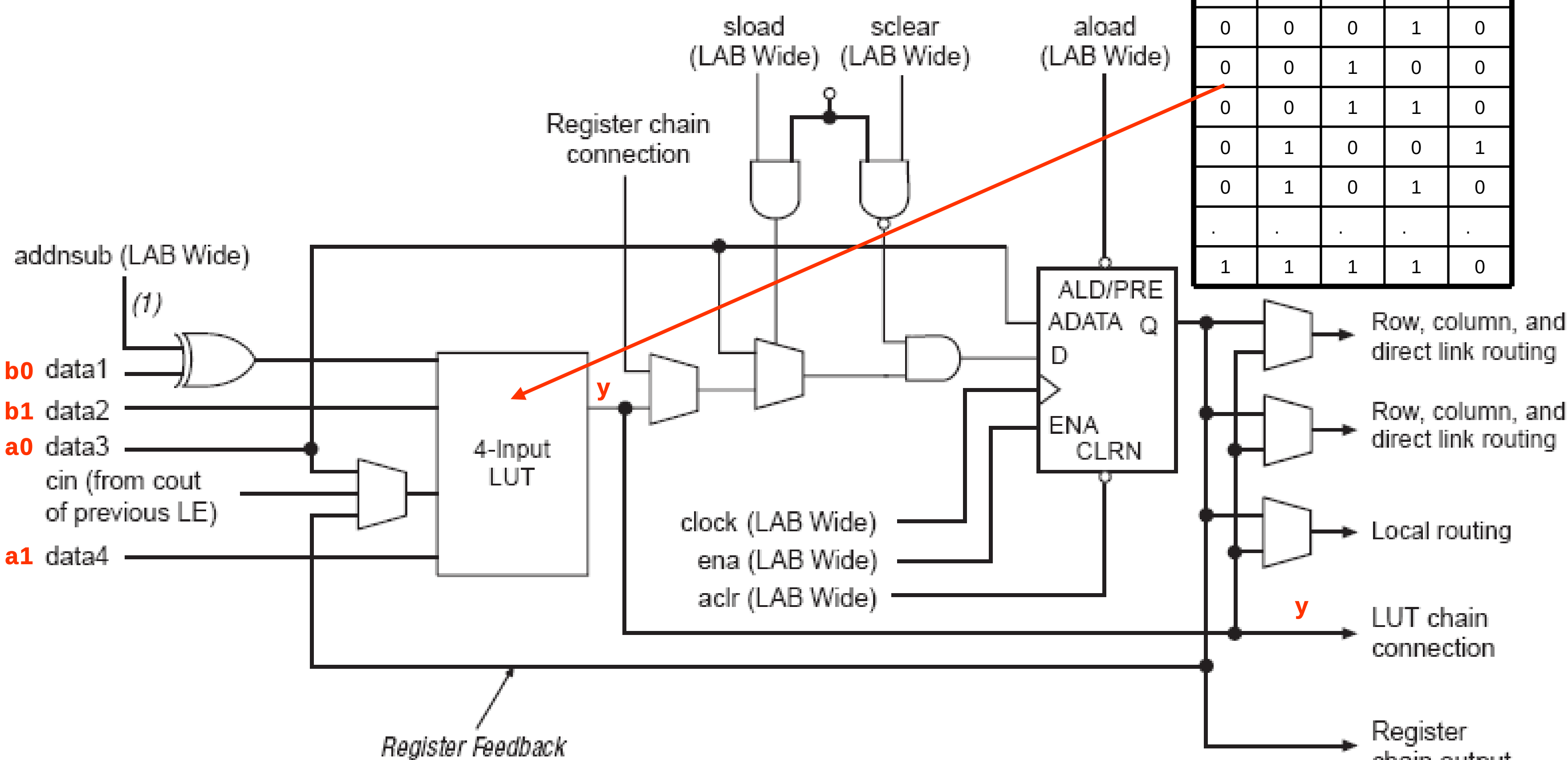


Address				Output
a1	a0	b1	b0	y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

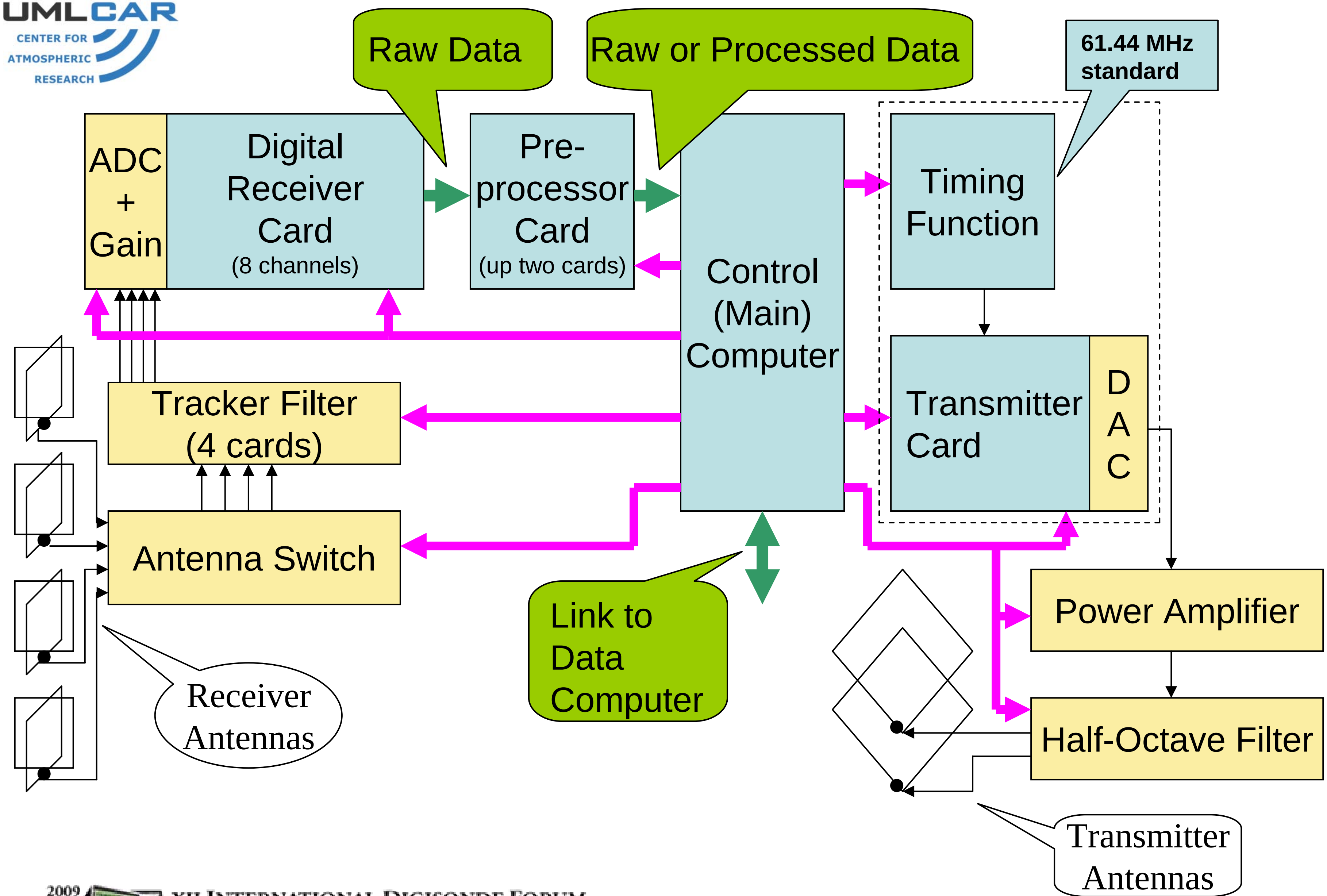
Stratix Logic Element

Figure 2–6. LE in Normal Mode

a1	a0	b1	b0	y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
.	.	.	.	.
1	1	1	1	0



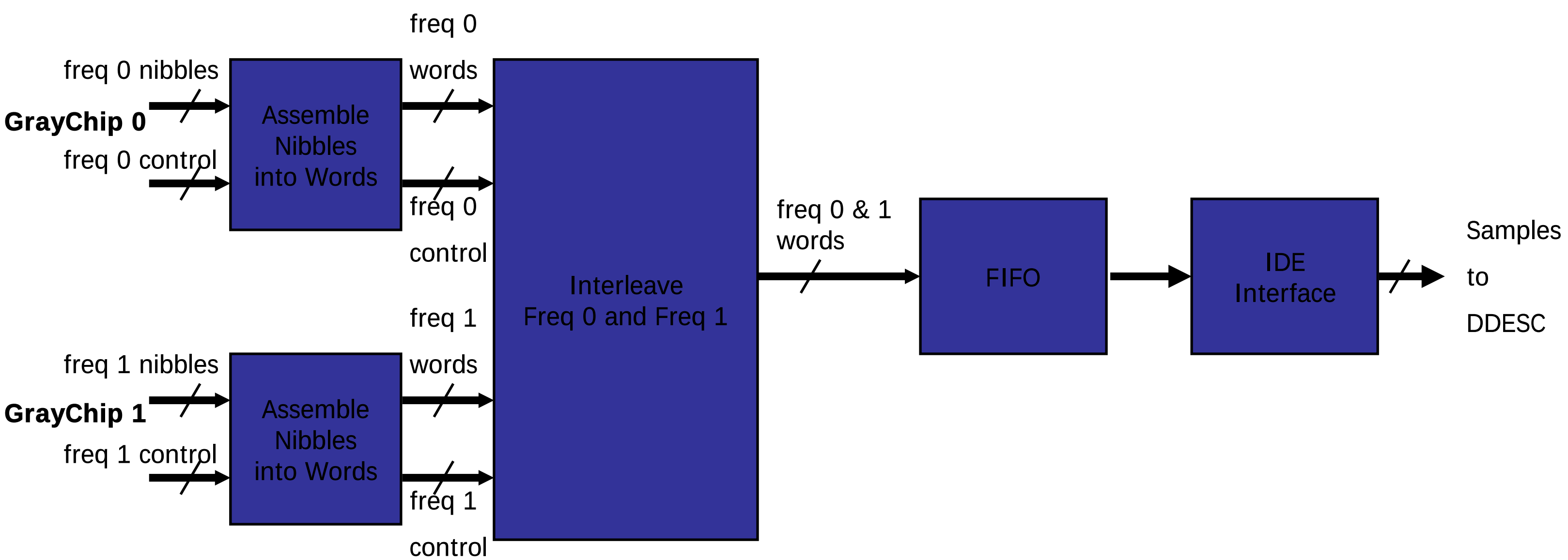
DPS-4D Digital Transceiver Block



Preprocessor Functions

- Gather Rx Samples from the Digital Receiver Card
  - Convert GrayChip Digital Down Converter Samples from 4-bit Nibbles to 16-bit words.
  - Interleave frequency 1 and frequency 2 samples.
  - Sort samples by frequency and antenna for delivery to DDESC.
  - IDE Interface to DDESC
- Future Processing Functions
  - High speed DMA interface for 1.25 km sampling
  - RFI Mitigation in hardware (Walter Jones - nearly completed)
  - Twin Frequency decoding in hardware

Pre-Processor Card Block Diagram



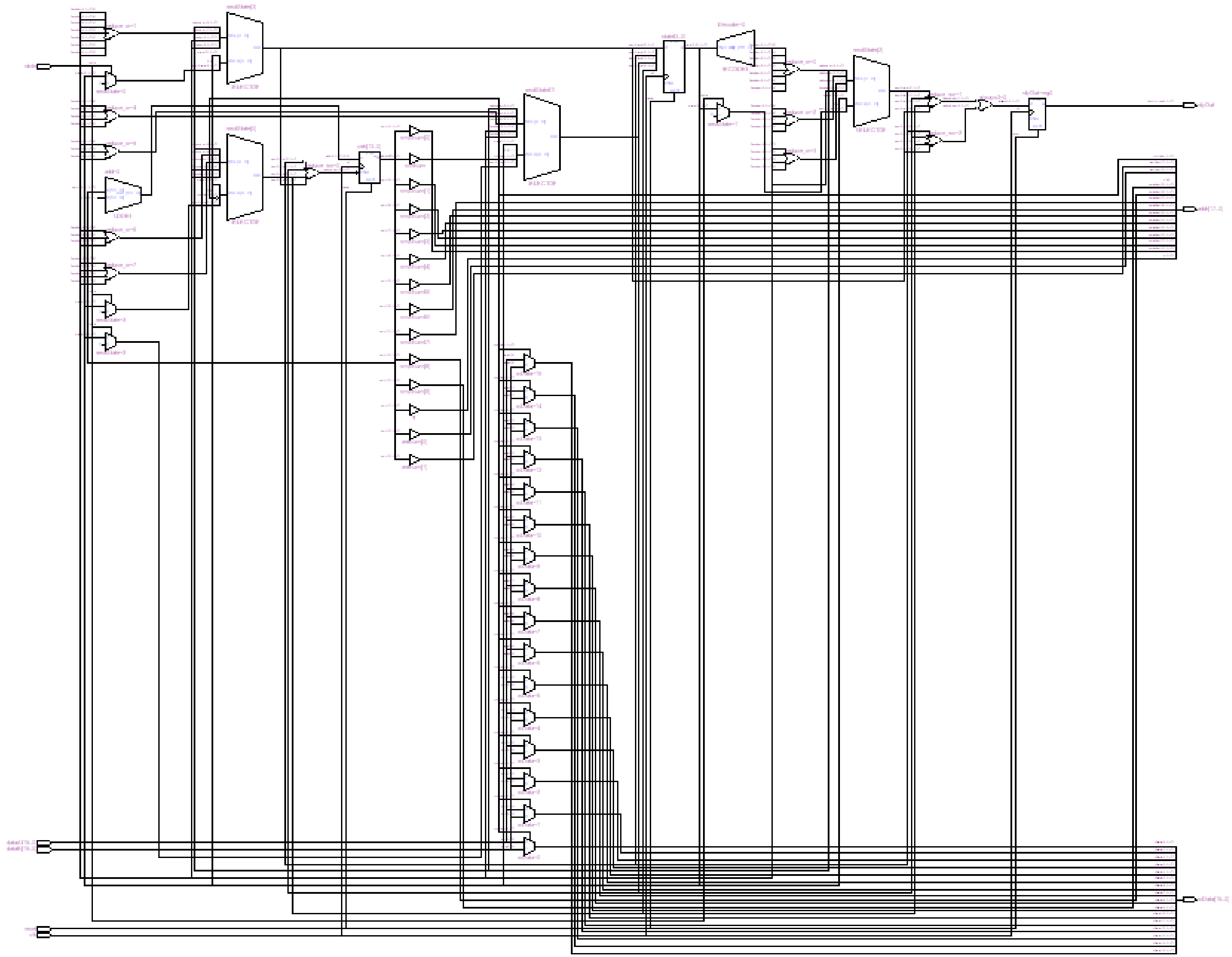
FPGA Design Resources

- Verilog Hardware Description Language
  - Behavioral level to gate level
  - Simpler design than schematic capture
  - Portable (Altera to Actel)
- CAD Tools
  - Altera's Quartus II & ModelSim
  - Gate synthesis
  - Chip place and route
  - Simulation (functional and timing)

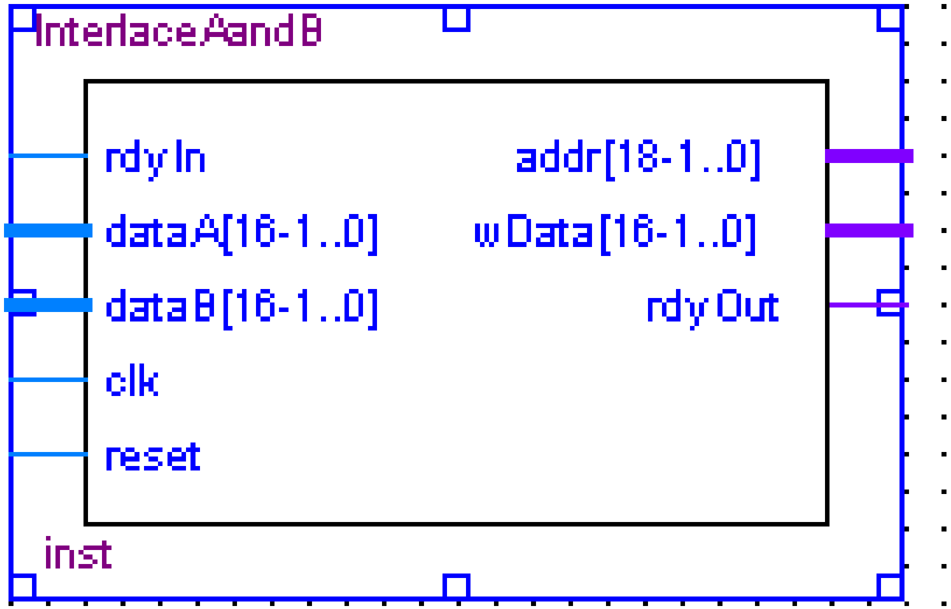
Verilog Module

```
module InterlaceAandB(  addr,    // Address to write
                        wData,   // Interlaced write data
                        rdyOut,  // Interlaces data word ready
                        rdyIn,   // A and B inputs ready
                        dataA,   // A input data
                        dataB,   // B input data
                        clk,     // System clock
                        reset);  // Global reset

`include "globals.v"

output [`AW-1:0] addr;          // Address to write
output [`DW-1:0] wData;         // Data to write
output reg rdyOut;              // Output ready flag
input rdyIn;                    // Input ready status bit
input [`DW-1:0] dataA;          // A input data
input [`DW-1:0] dataB;          // B input data
input clk;                      // System clock
input reset;                    // Global reset

// State Machine Controller

// State assignments
parameter   S0    = 0,
            S1    = 1,
            S2    = 2,
            S3    = 3,
            S4    = 4,
            S5 = 5,
            S3a = 6,
            S3b = 7,
            S3c = 8;

// Current state register
reg [3:0] state;

always @(posedge clk or posedge reset)
   if (reset)
      state <= S0;
   else
      state <= nextState;

reg [3:0] nextState; // Next state
always @*   // Next state generation logic
   begin
      nextState = state;
      case (state)
         S0:   nextState = S1;
         S1:   if (rdyIn)
                  nextState = S2;
         S2:   nextState = S3;
         S3:   nextState = S3a;
         S3a: nextState = S3b;
         S3b: nextState = S3c;
         S3c: nextState = S4;
         S4:   nextState = S5;
         S5:   if (rcvrNum)
                  nextState = S2;
               else
                  nextState = S1;
      endcase
   end
assign wData = (rcvrNum) ? dataB : dataA;
wire rcvrNum = cntr[0] /* synthesis keep */;
wire [1:0]antNum = cntr[3:2] /* synthesis keep */;
wire q = cntr[1] /* synthesis keep */;
wire [`AW-9:0]smplNum = cntr[`AW-5:4] /* synthesis keep */;
assign addr = {rcvrNum, antNum, 4'b0, smplNum, q};
reg [`AW-5:0] cntr;

always @(posedge clk or posedge reset)
   if (reset)
      cntr <= 0;
   else if (nextState == S4)
      cntr <= cntr + 1'b1;
always @(posedge clk or posedge reset)
   if (reset)
      rdyOut <= 1'b0;
   else if (nextState == S2 || nextState == S3)
      rdyOut <= 1'b1;
   else
      rdyOut <= 1'b0;
endmodule
```

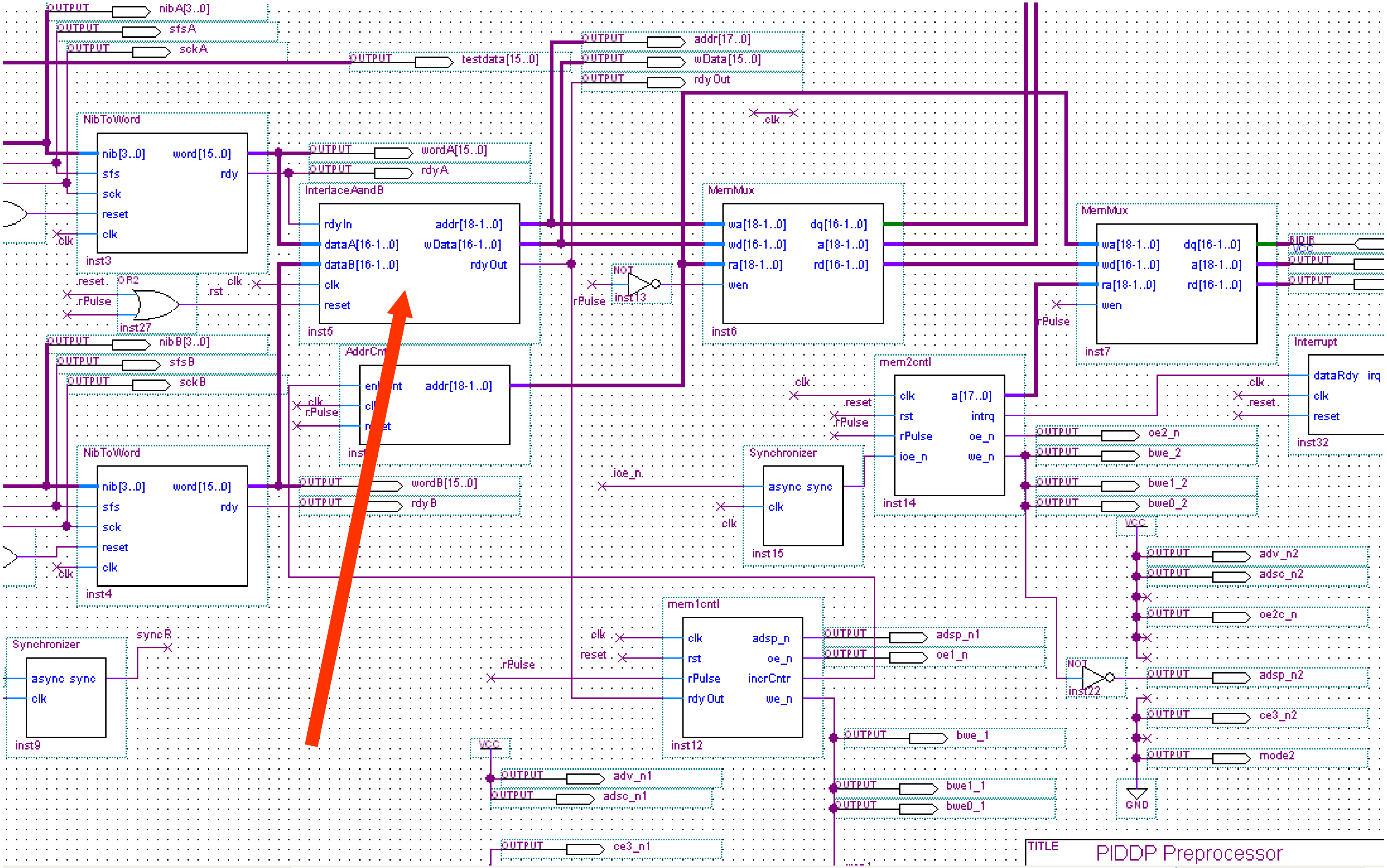
Synthesized Logic



Module Symbol



High Level Preprocessor Module Schematic



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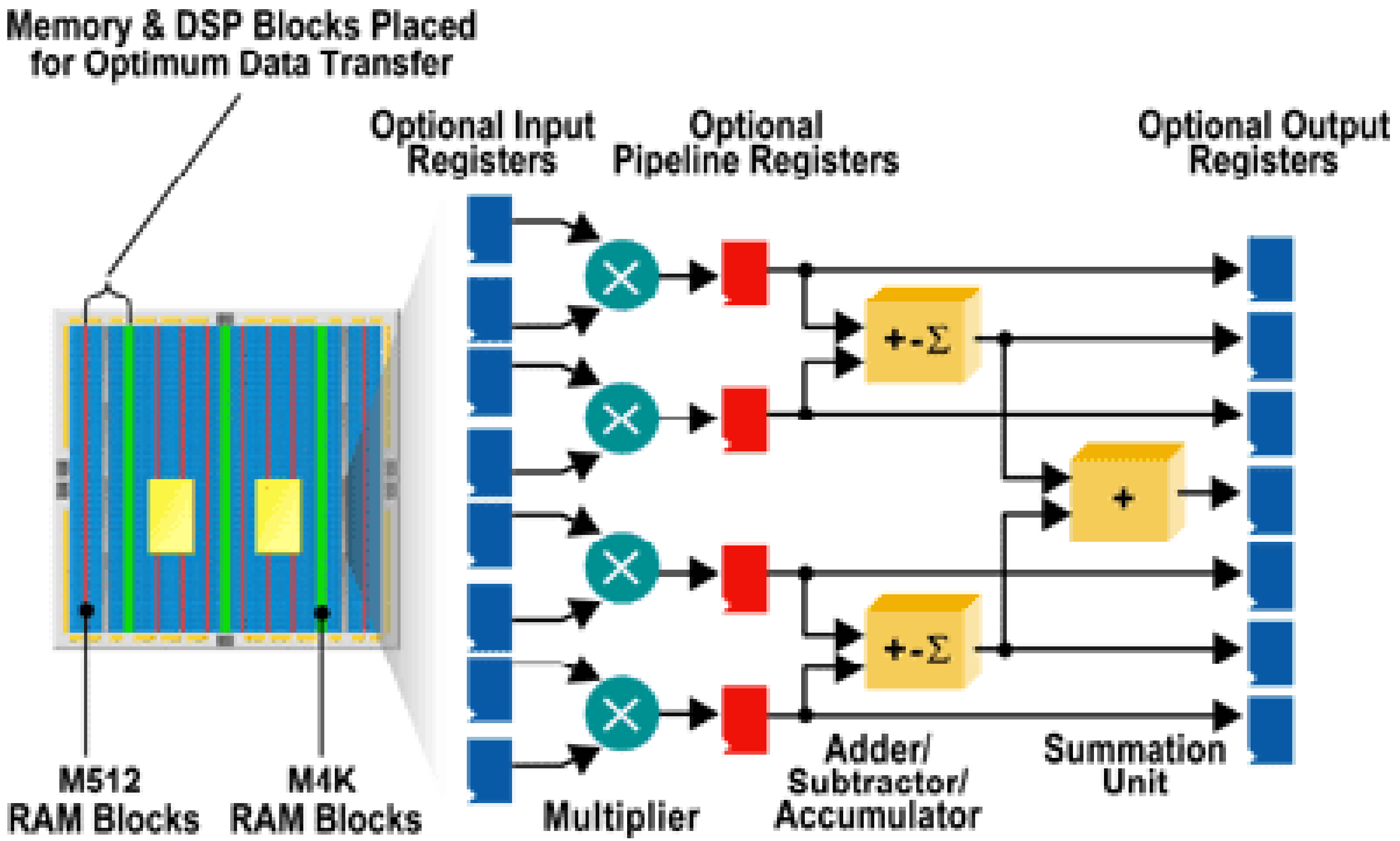
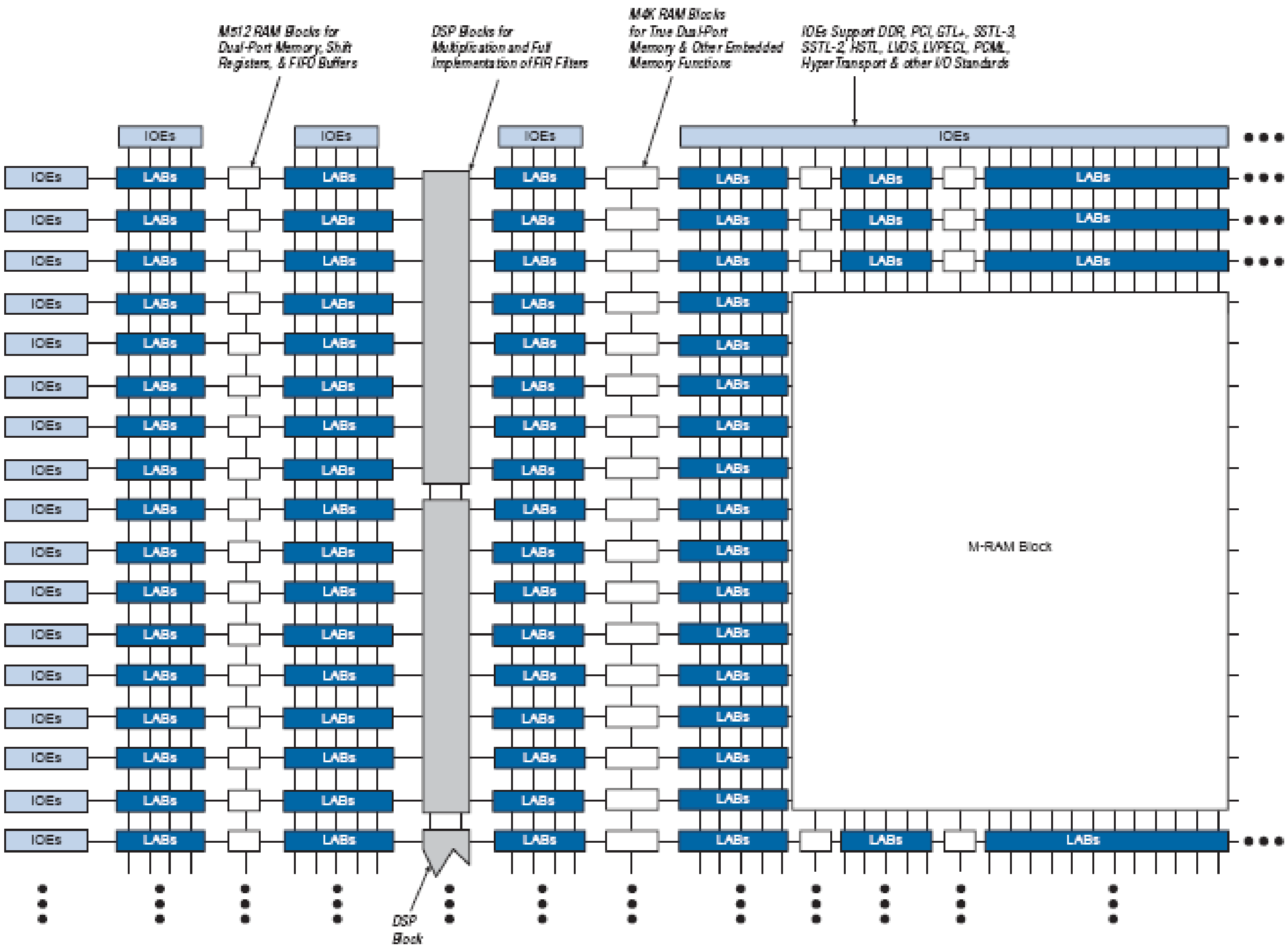
Stratix DSP Block

Figure 2. DSP Block



Stratix FPGA block Diagram

Figure 2–1. Stratix Block Diagram

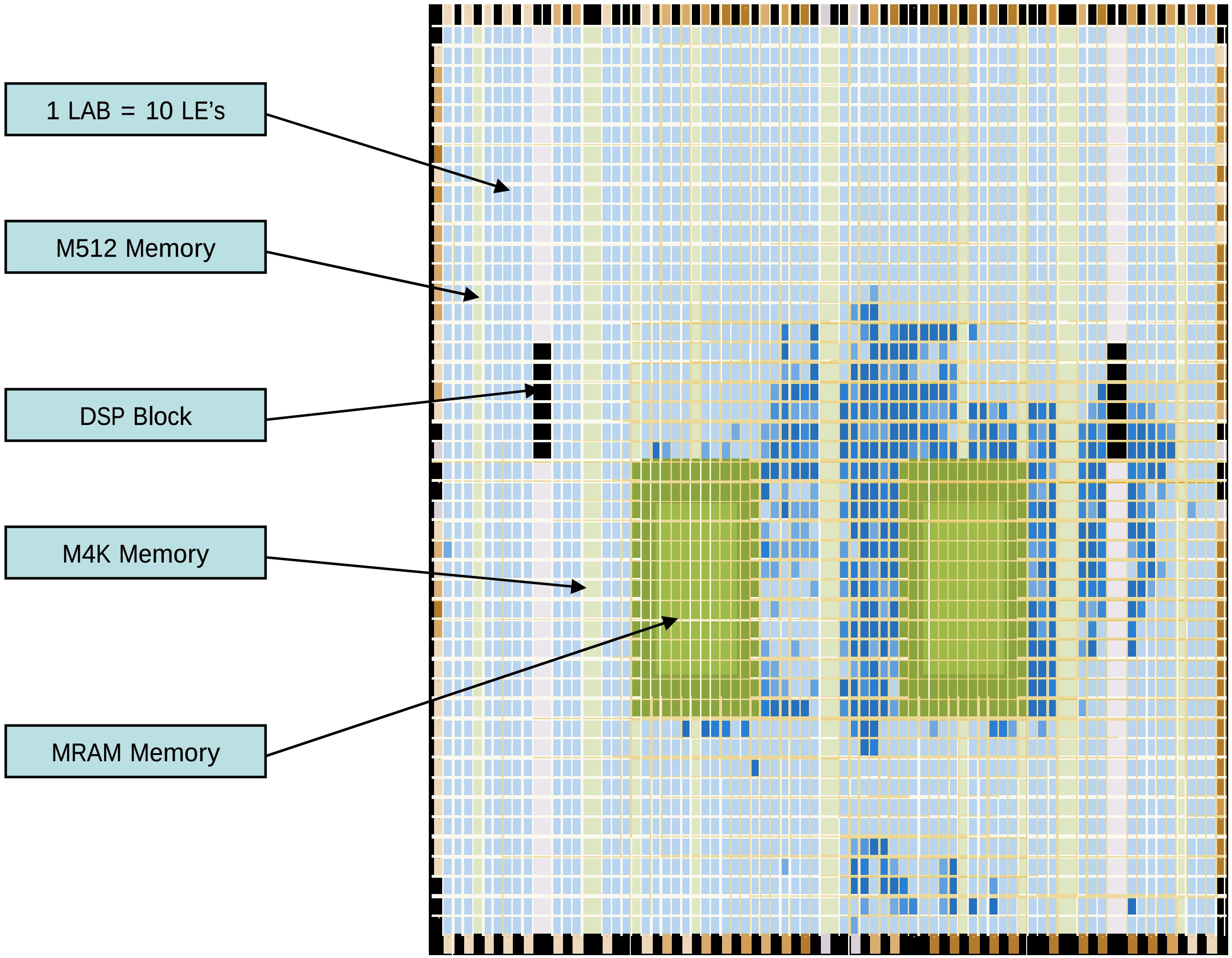


Stratix EP1S25 Resources

Table 1–1. Stratix Device Features — EP1S10, EP1S20, EP1S25, EP1S30

Feature	EP1S10	EP1S20	EP1S25	EP1S30
LEs	10,570	18,460	25,660	32,470
M512 RAM blocks (32 × 18 bits)	94	194	224	295
M4K RAM blocks (128 × 36 bits)	60	82	138	171
M-RAM blocks (4K × 144 bits)	1	2	2	4
Total RAM bits	920,448	1,669,248	1,944,576	3,317,184
DSP blocks	6	10	10	12
Embedded multipliers *(1)*	48	80	80	96
PLLs	6	6	6	10
Maximum user I/O pins	426	586	706	726

Stratix FPGA Floor Plan



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DIGISONDE 4D
PORTABLE SOUNDER

SOFTWARE

Architecture, organization, data flow, data dissemination

Dr. Ivan Galkin

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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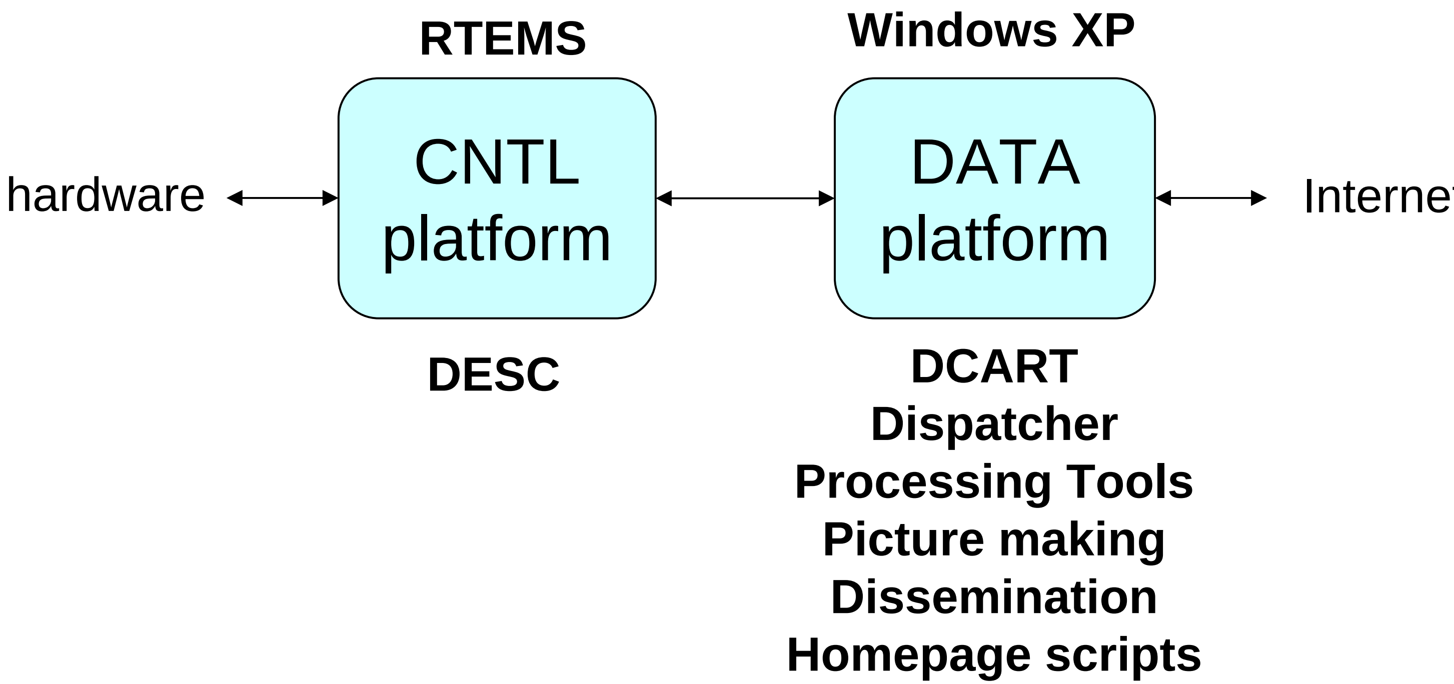
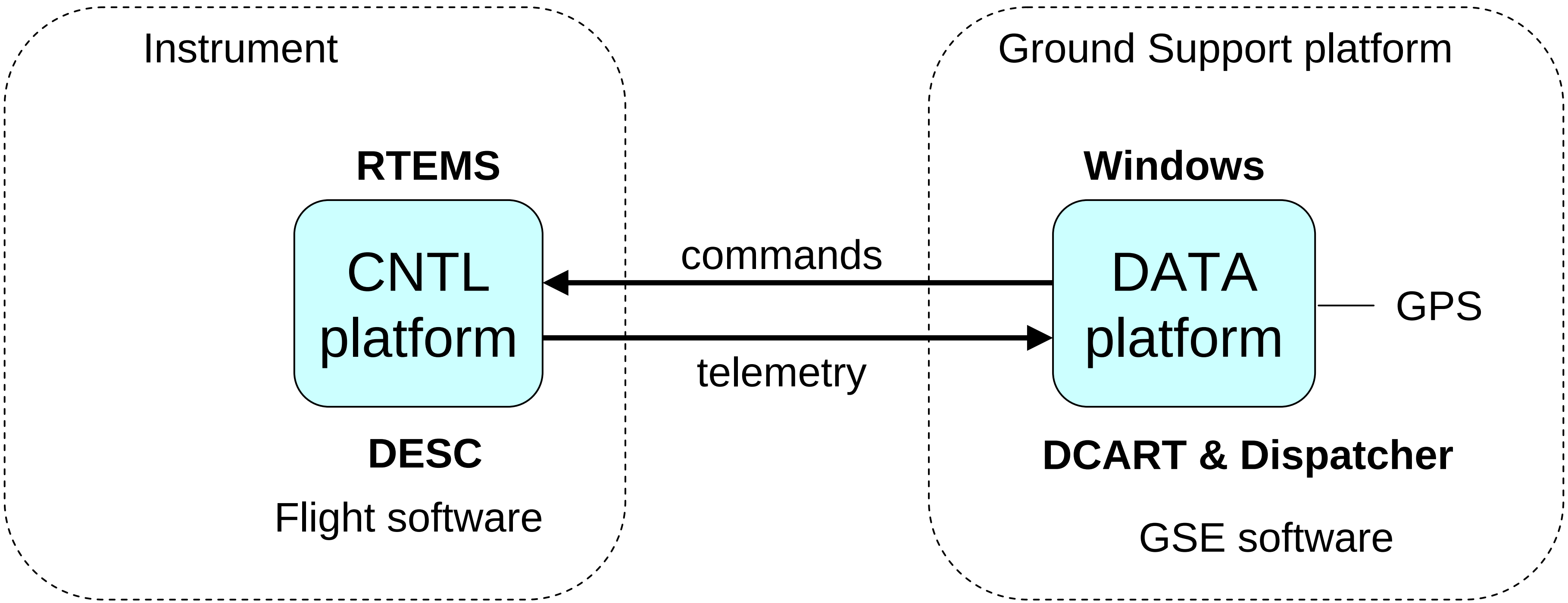
Software Architecture



DCART and DESC



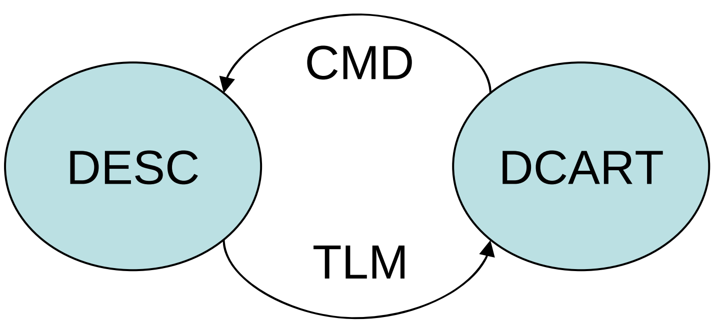
NO MONITOR
NO KEYBOARD
NO MOUSE
NO HARD DISK
NO FLOPPIES

C&T
+ MISSION PLANNING

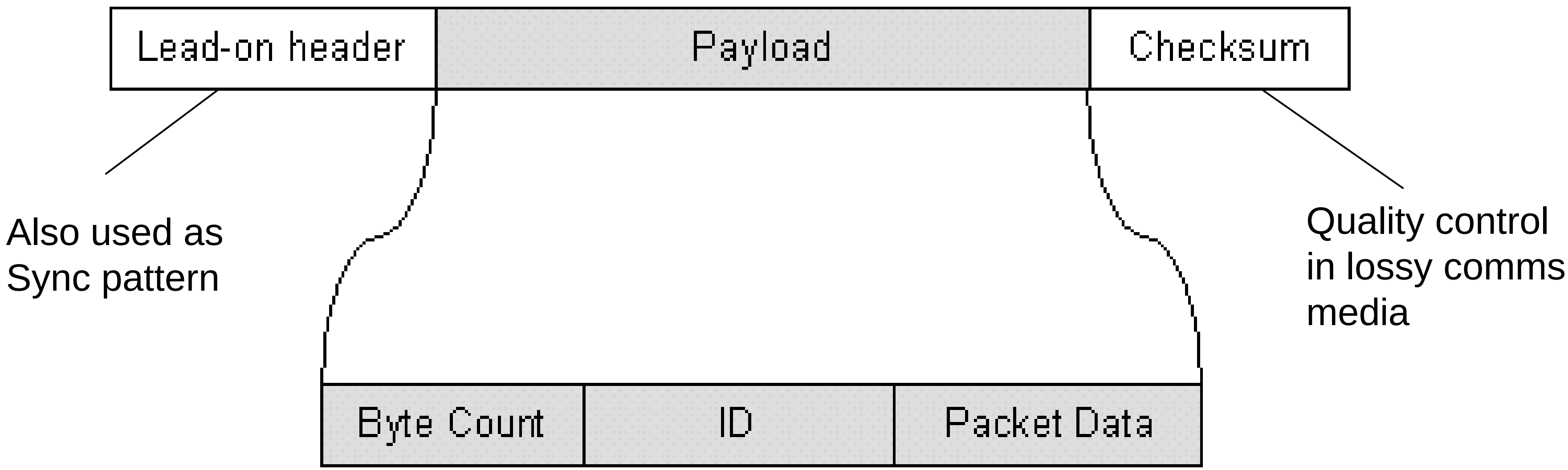
C&T – adopted from space applications

- **Command packets**
  - 0x32 Flush SST Queue
  - **0x70 Periodic Message**
  - 0x71 Upload Program
  - 0x72 Start Program
  - 0x73 Stop
  - 0x74 Upload Schedule
  - 0x75 Start Schedule
  - 0x76 Upload SST
  - 0x77 Upload RFIL
  - 0x78 Clear RFIL
  - 0x79 Reboot
  - **0x81 Standby State**
  - **0x82 Diagnostic State**
  - **0x84 Auto-scheduled State**
  - 0x33 Auto-drift selection

- **Telemetry packets**
  - *Science*
    - 0x81 Science Data
  - *Housekeeping*
    - 0x01 “I am Alive”
    - 0x02 “Event Message”
    - 0x03 “Error Message”
    - 0x04 “Countdown”
    - 0x05 “BIT”



Packet design, adopted

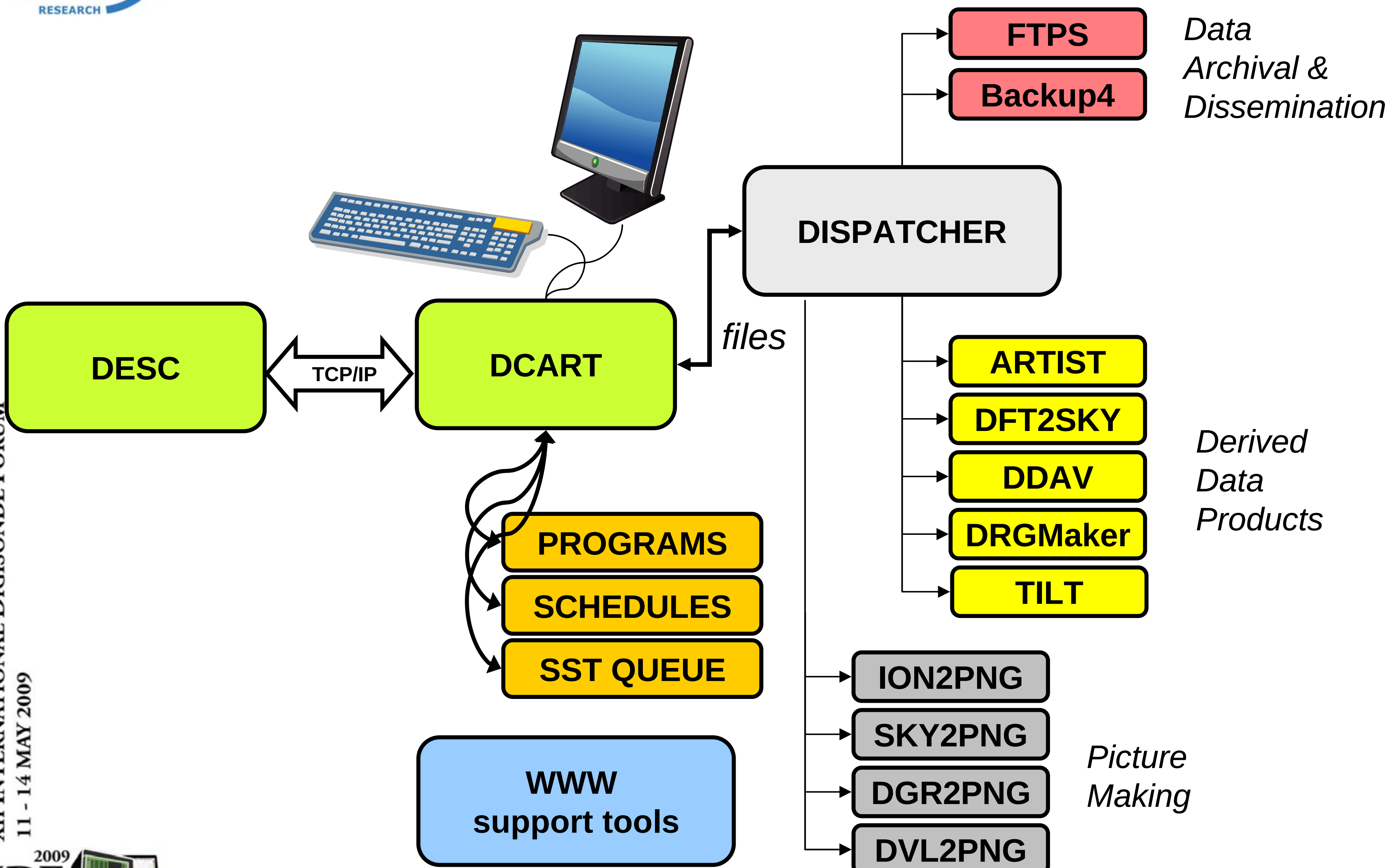


Operating States, adopted

SPACE INSTRUMENTATION TERMINOLOGY

- **SAFE** = CNTL platform is powered down [“safe” for upcoming hazardous impact, loss of spacecraft power, etc.].
  - DCART shows SAFE if
    - CNTL platform is down,
    - Two platforms not connected after DPS reboot,
    - DESC not running.
- **STAND-BY** = CNTL platform runs computer only, other systems are down
  - Used for software and configuration updates
  - Digisonde TX chassis is powered down
- **DIAGNOSTIC** = CNTL platform is fully operational, but no measurement will start without manual command
  - Used for manual operations, program/schedule design, etc.
- **AUTO-SCHEDULED** = All systems up, measurements are running automatically according to the programmed schedules
  - Routine operations, with campaigns

Software in a greater detail



Digisonde Data Tree

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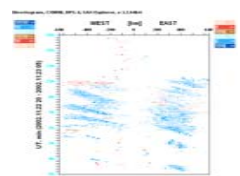
DIGISONDE

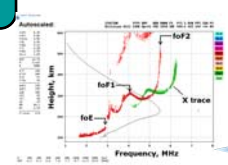
Raw Ionograms

SBF, RSF

DRG: Directograms



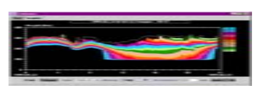
SAO.XML: Scaled data



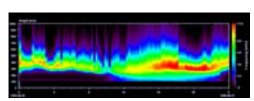
Ionogram displays

Time Series

Contours



Profilograms



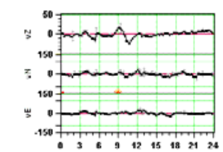
MUF

Housekeeping

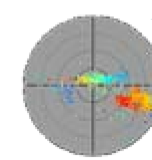
BIT.XML

DFT: Raw Drift

DVL: Velocities



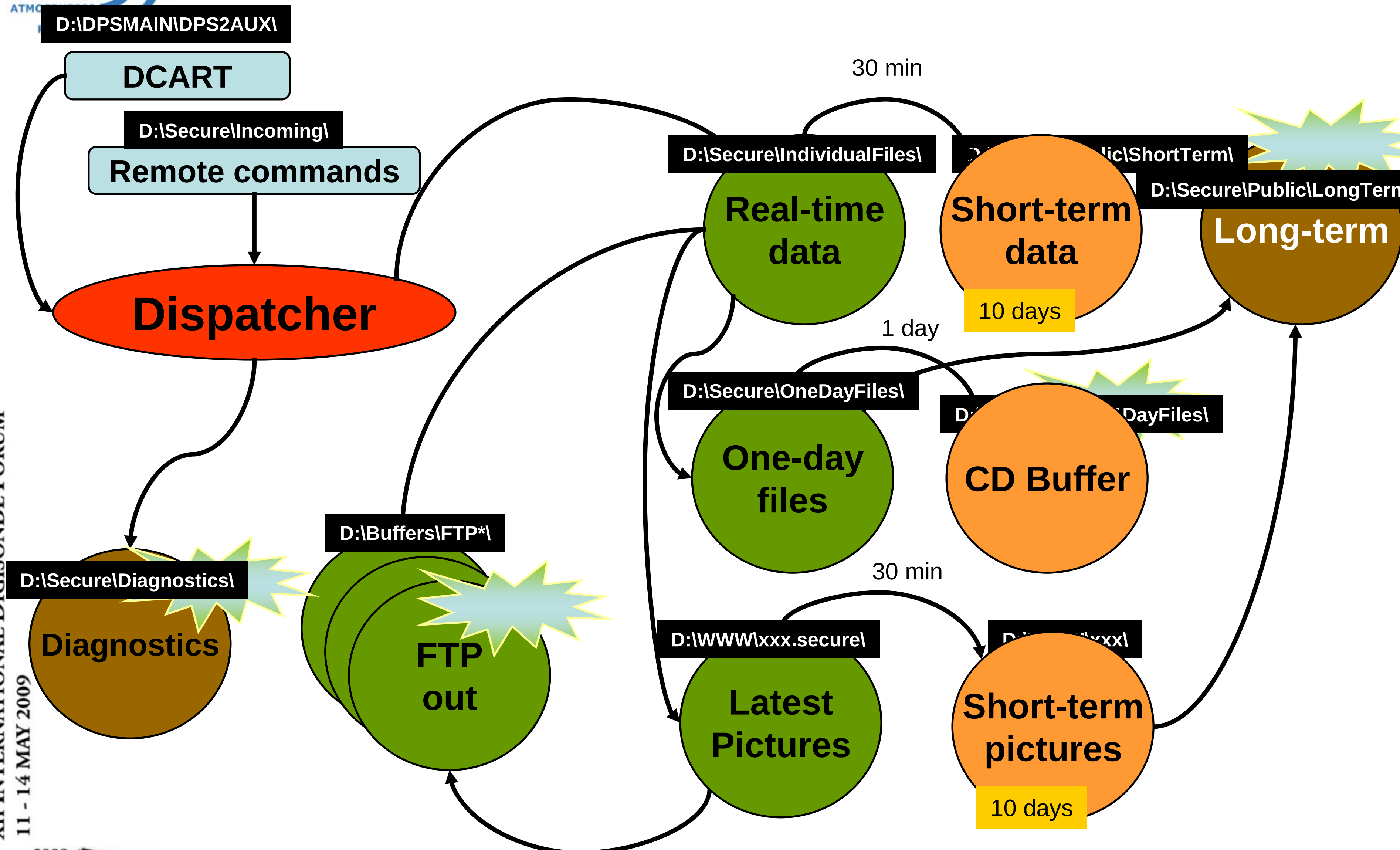
SKY: Skymaps



TLT: Tilt

online pictures

Data Traffic at Data Platform



Disk Overfill – where to look?

- Long-term archive
- CD Buffer
- FTP outgoing folders
- Diagnostics

Other Problems

- FTP problems:
  - Check D:\Buffers\FTP1\System\
    - results.ftp – remote server replies, eyeball for error messages
    - stats.ftp – packet delivery time statistics
- Problem with pictures
  - Check *.out and *.err files in D:\Dispatch for error messages
  - Always set “High color” in display adapter (not true color)
- Hard problems causing system reset:
  - In D:\www\cgi-bin\ folder, have a look at screencap-before-reset.html for screen display prior to a severe problem

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DESC

Digisonde Embedded System Control software

Grigori Khmyrov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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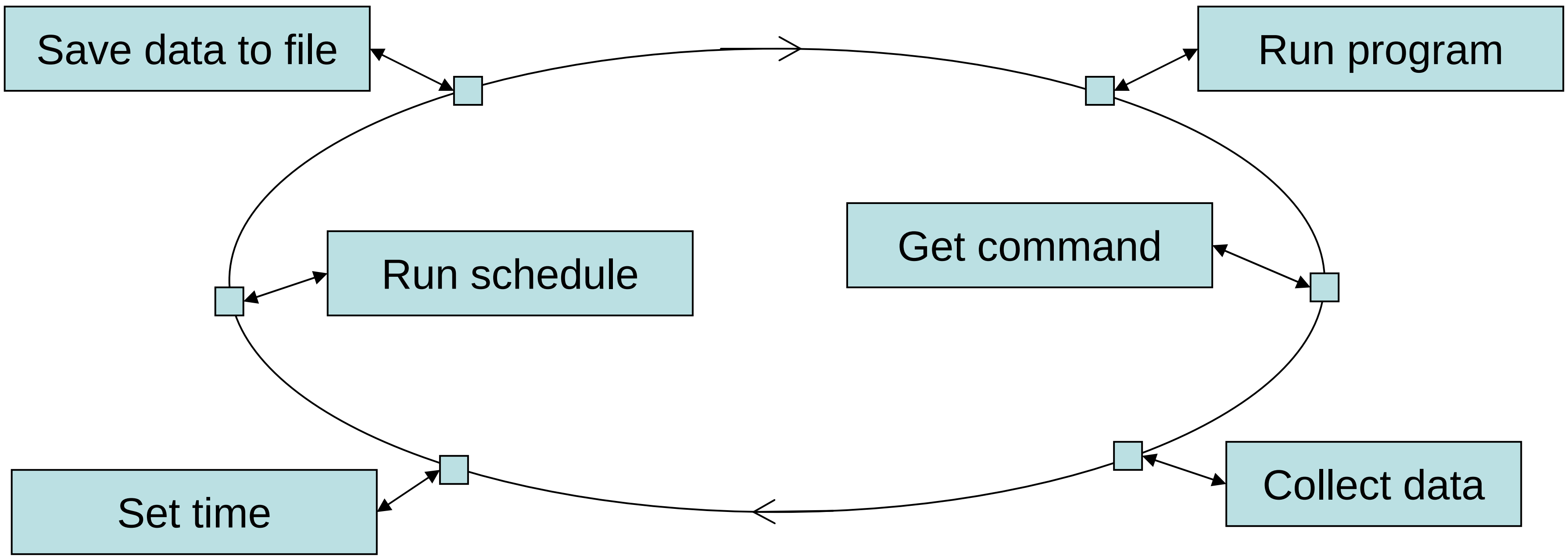
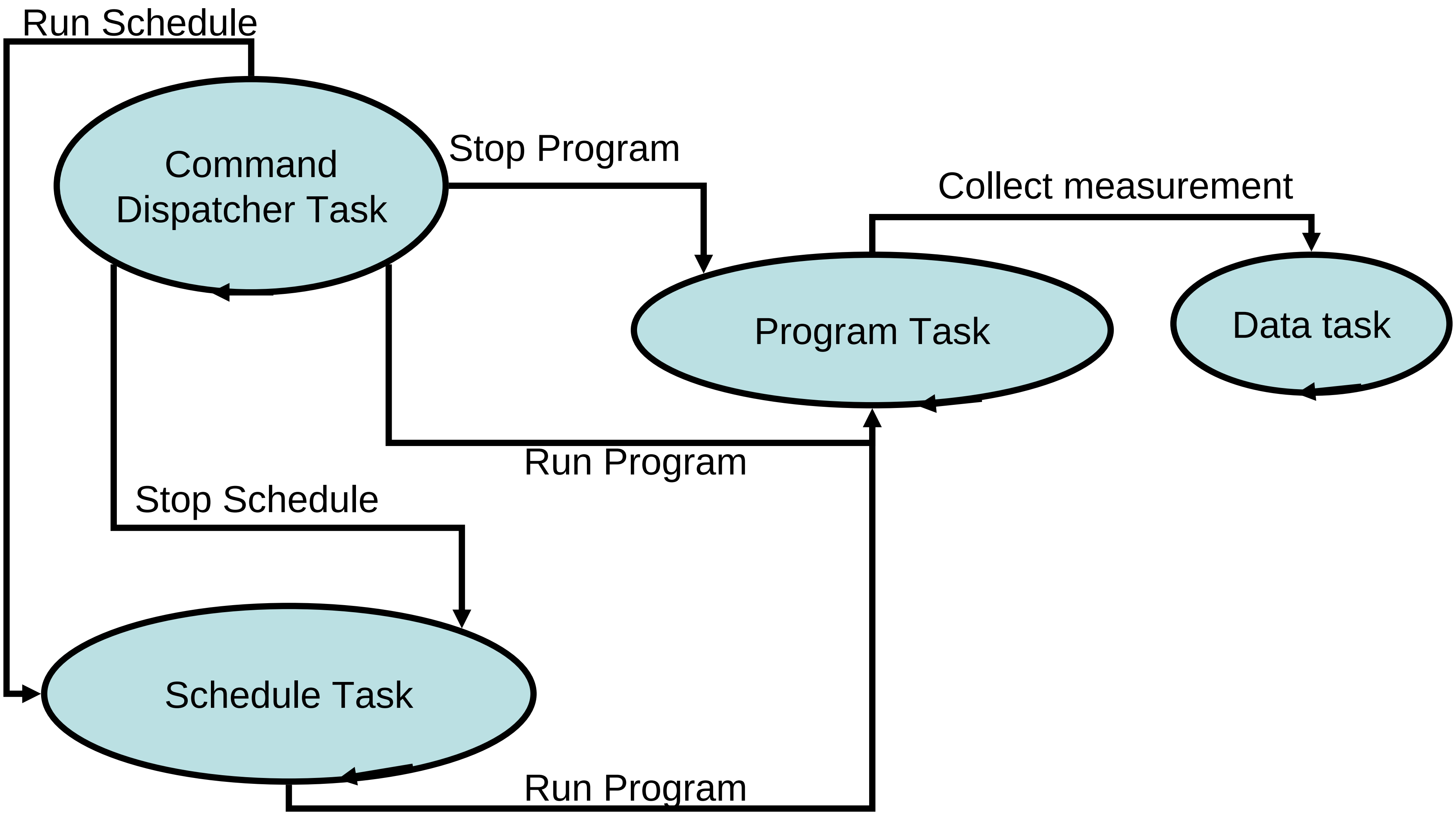
DPS Control - Background/Foreground task under DOS



DESC - Real Time Tasks under RTEMS



RTEMS - **R**eal-**T**ime **E**xecutive for **M**ultiprocessor **S**ystems

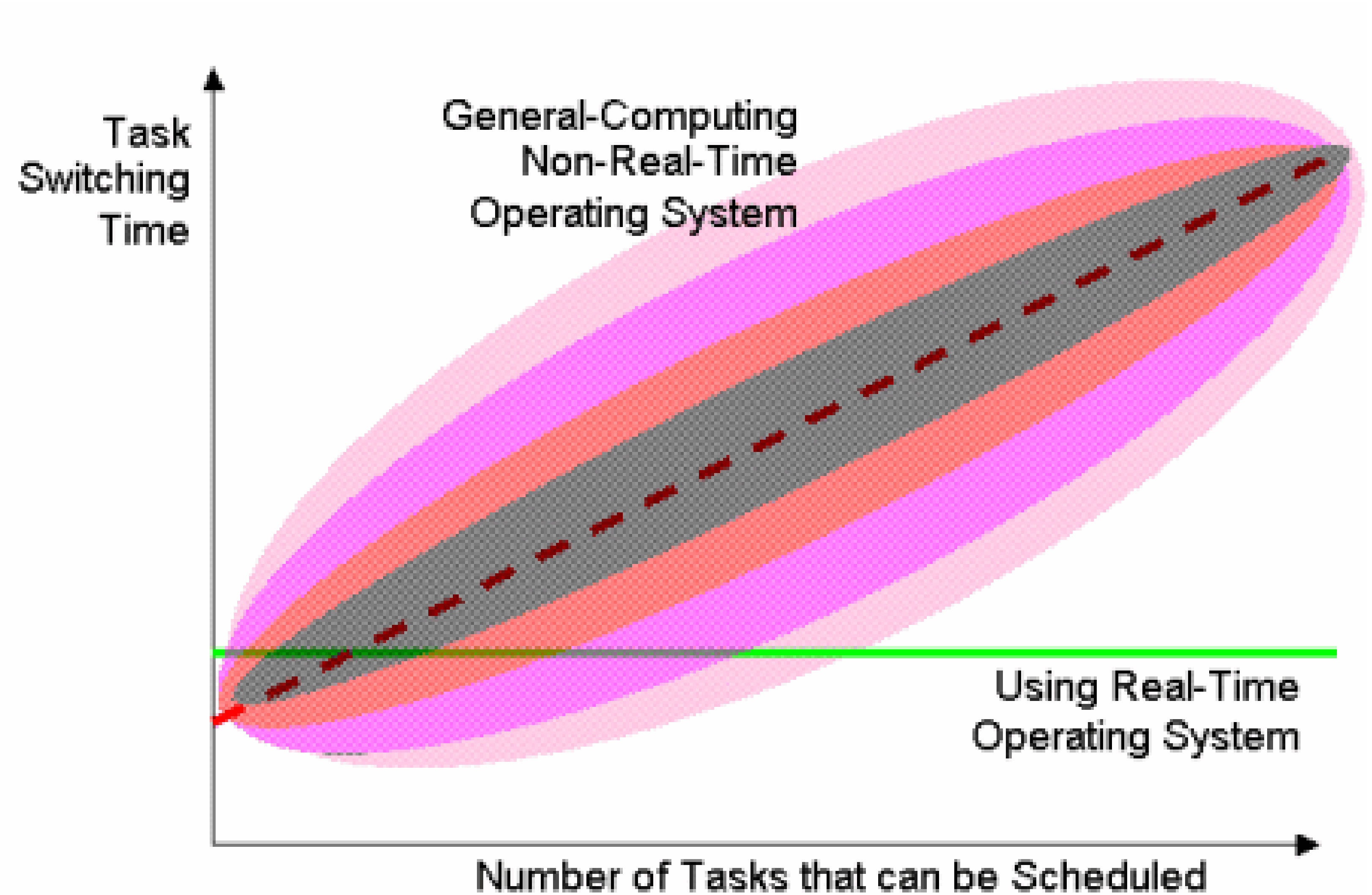
- Licensed under a modified version of the GNU General Public License (GPL). The modification places no restrictions on the applications which use RTEMS but protects the interests of those who work on RTEMS.

Real Time Operating System

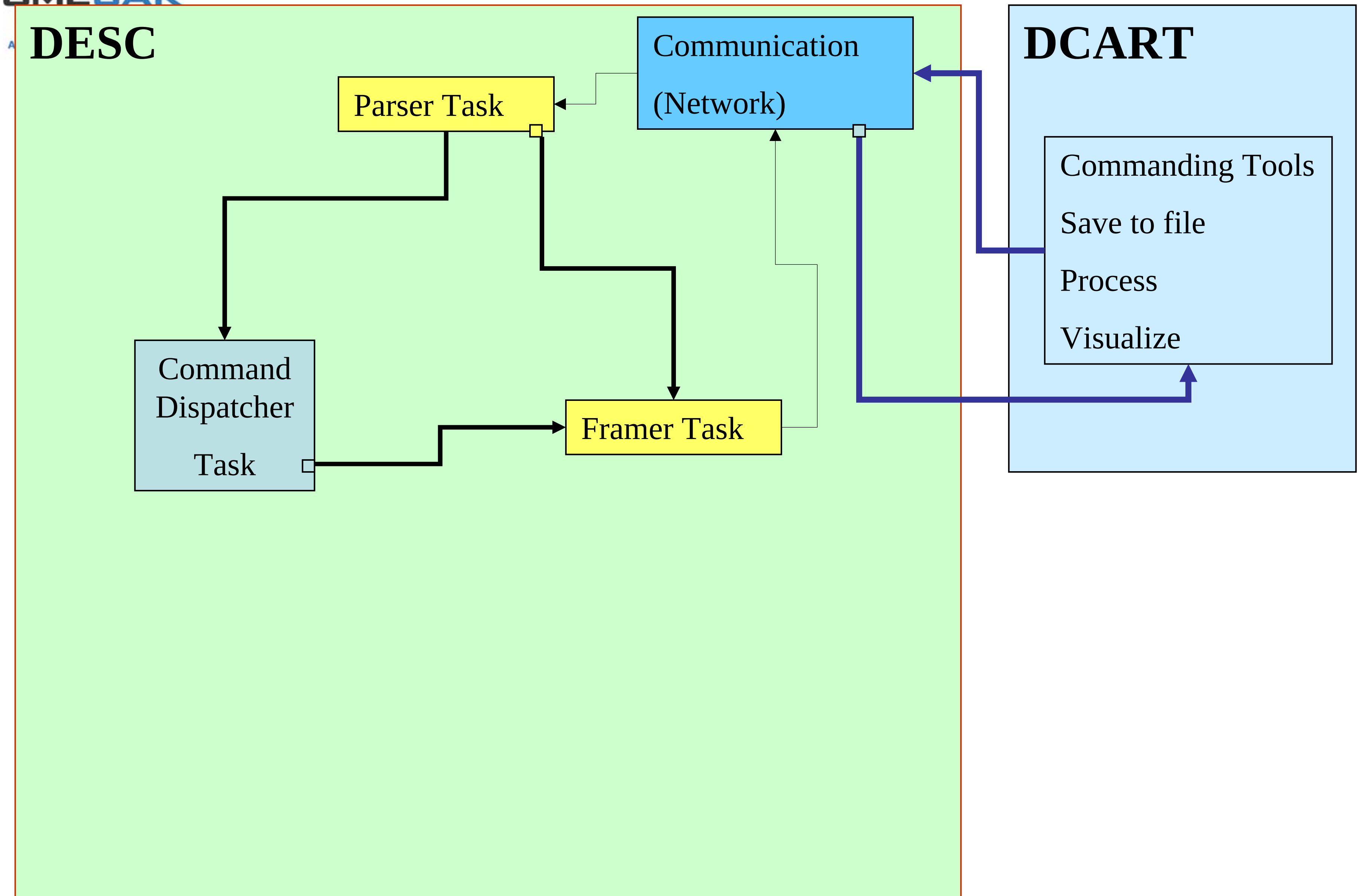
- Consume only known and expected amounts of time
- Service times could be expressed as mathematical formulas
- Priority-based preemptive scheduling

"Preemptive" means that the scheduler is allowed to stop any task at any point in its execution, if it determines that another task needs to run immediately.

Task switching



Send command / Receive acknowledge



+ Run program

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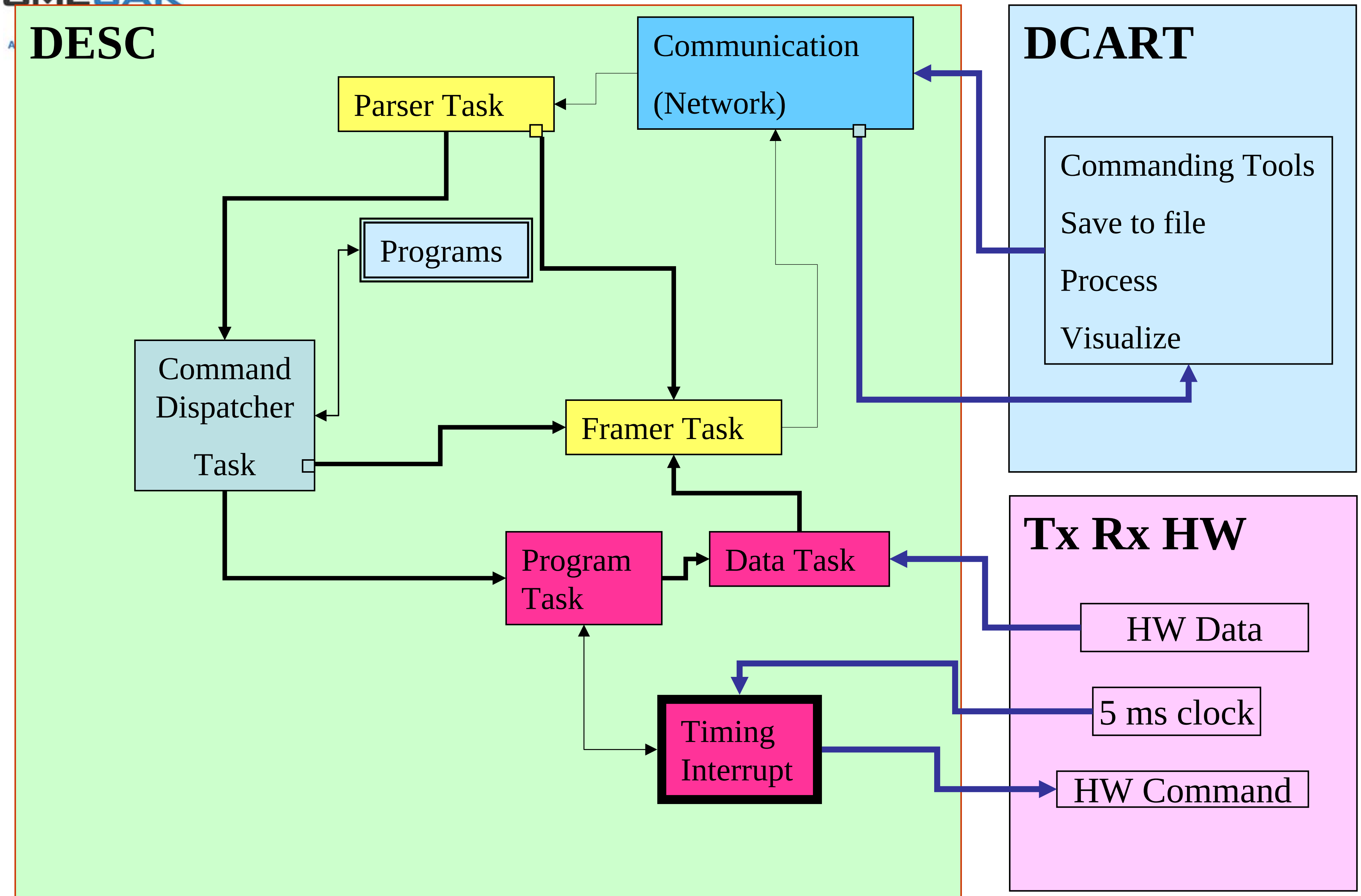
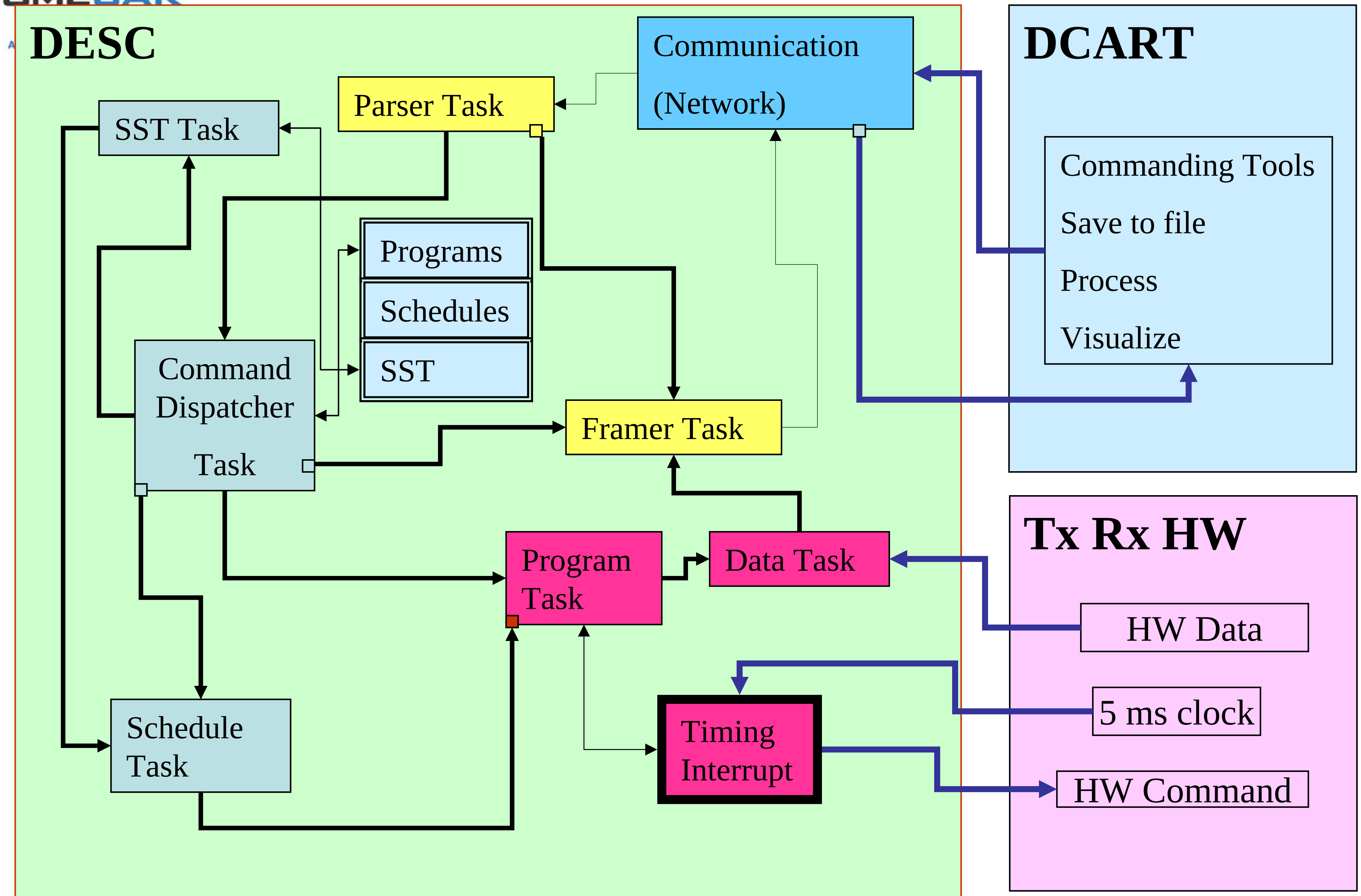
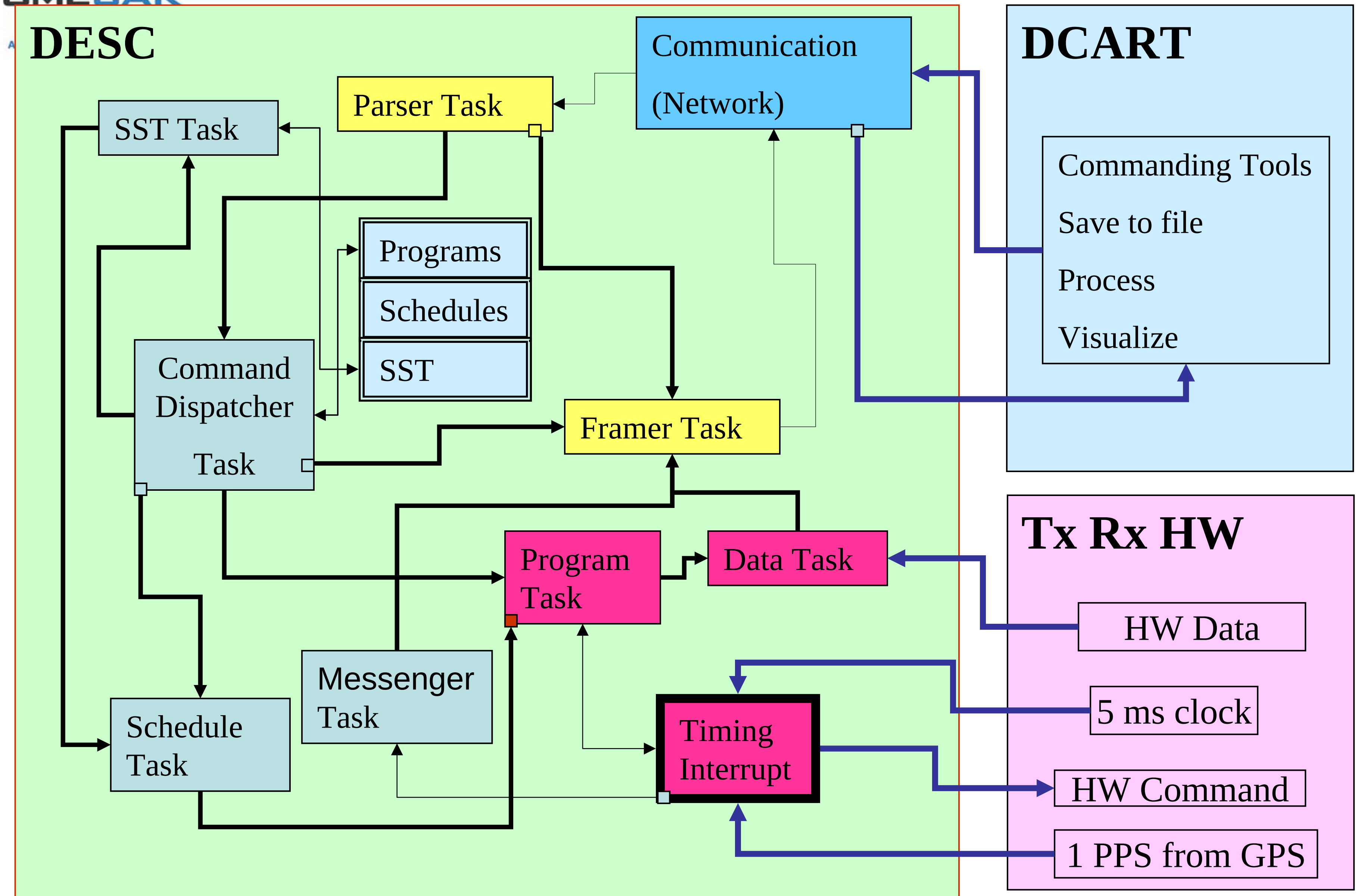


+ Run Schedule/SST



+ Time Synchronization



Time synchronization

- Data computer
  - GPS connected on COM port (RS-422) of
  - Running Simple Network Time Protocol (SNTP) Client
  - The client listens SNTP messages from GPS and corrects the system clock
- Control computer have 1PPS signal
- DCART sends Periodic Messages with timestamp
- DESC corrects Control computer time

Boot DESC

- TFTP&DHCP service running on Data computer
- Folder tftpboot has
  - DESC – control software
  - PXELinux – boot loader
- Control computer connects to DHCP
  - Loads and runs PXELinux using tftp protocol
  - PXELinux loads and runs DESC
  - DESC reads network configuration from DHCP and runs TCP/IP server, waiting DCART to connect

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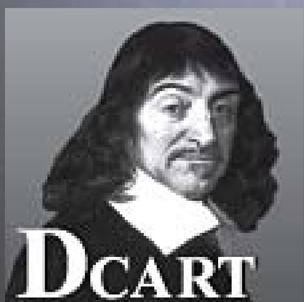

DCART
New (inter)Face of Digisonde

Dr. Ivan Galkin
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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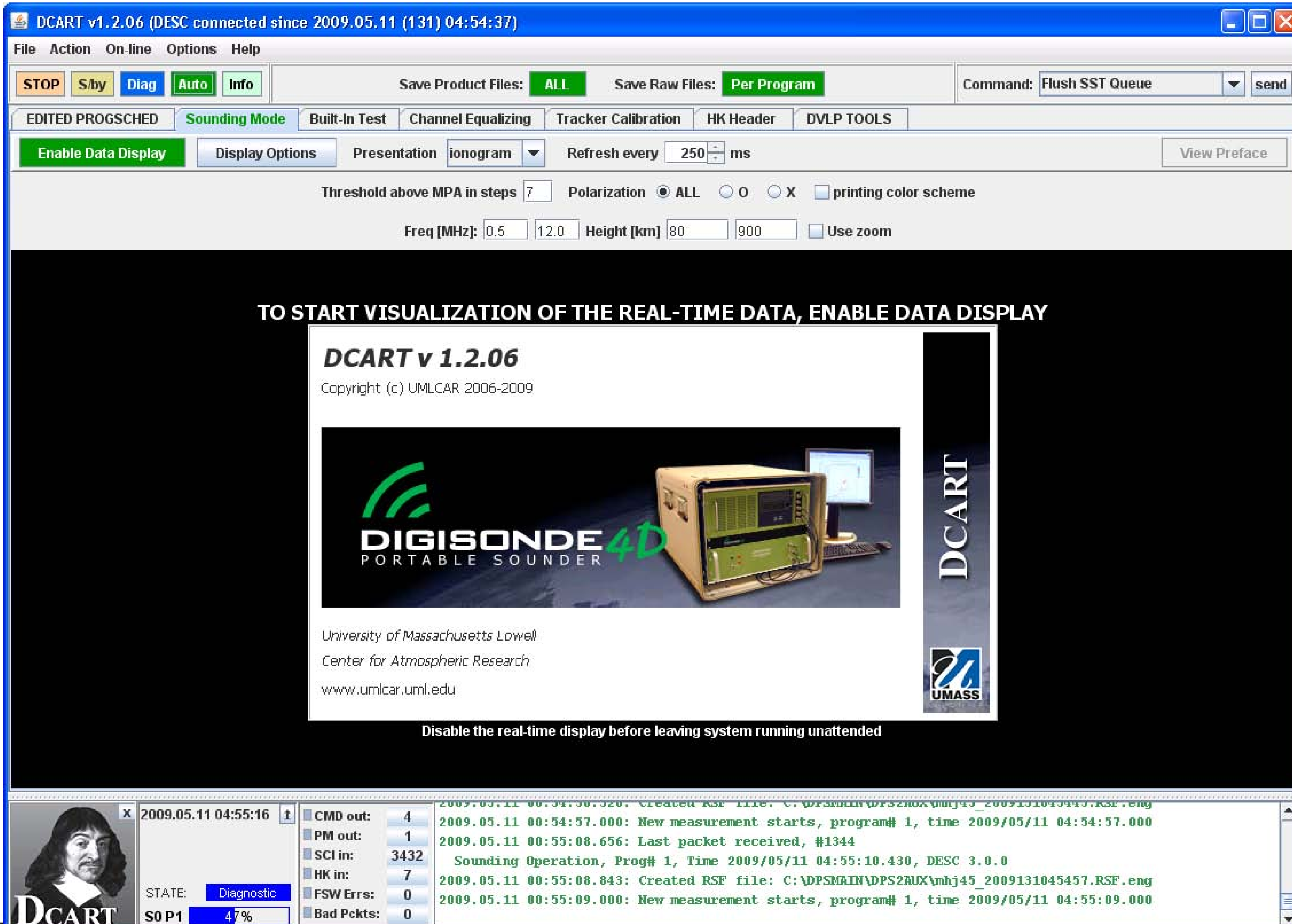
Outline

- Three DCART presentations
  - Interface (concepts) - IG
  - Under the hood (software design) - AK
  - Practice of operations (real life) – GK
- Concepts for digisonde control and experiment planning
  - Programs, schedules, SSTs, rules, campaigns
  - Concepts for GUI

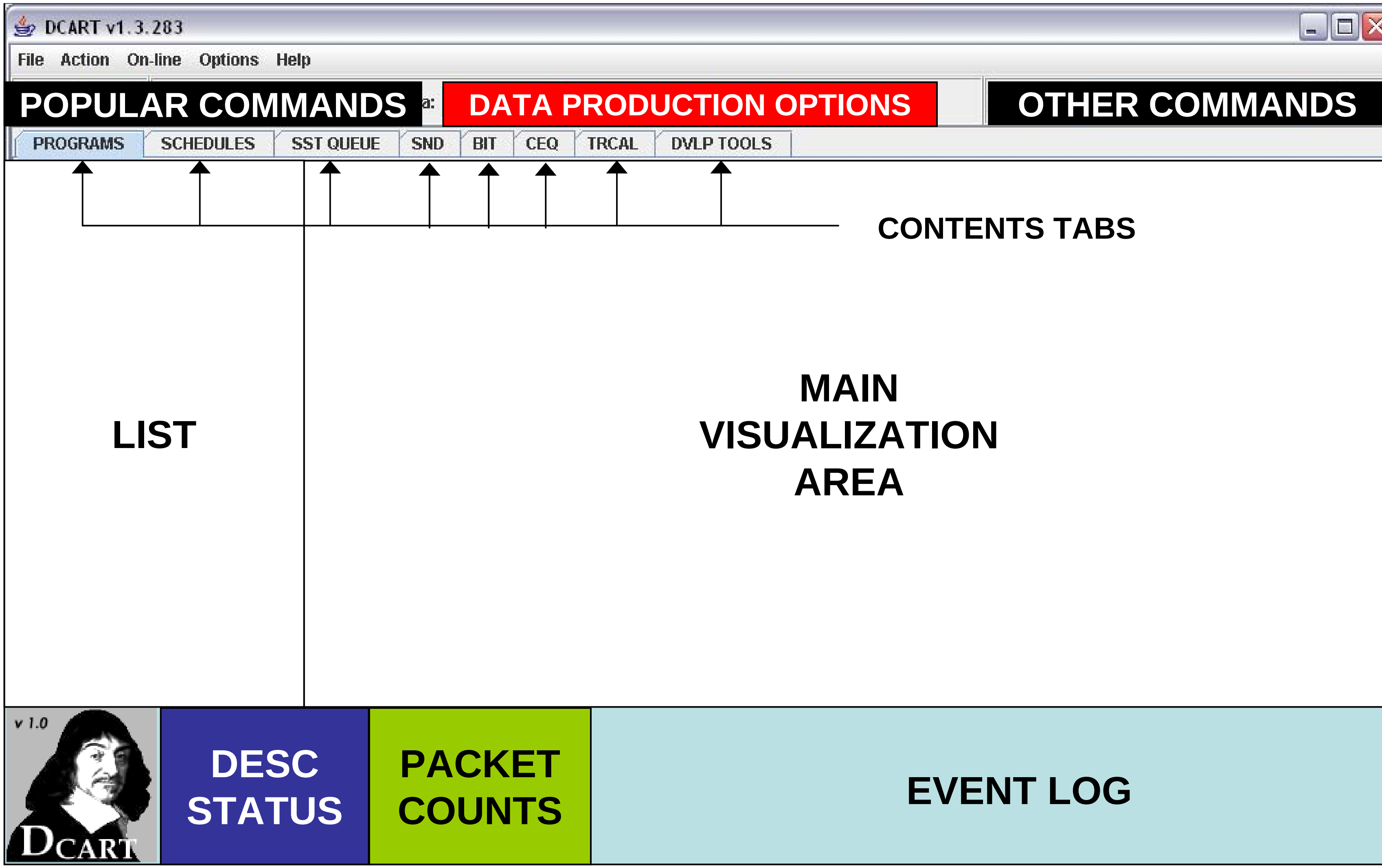
DCART : Main Functions

- PLANNING EXPERIMENTS
  - Program design
  - Schedule design
  - Daily Ops design
  - Campaign design
- MANUAL CONTROL
  - Start and stop
- DATA VISUALIZATION
  - Science data
  - Housekeeping data

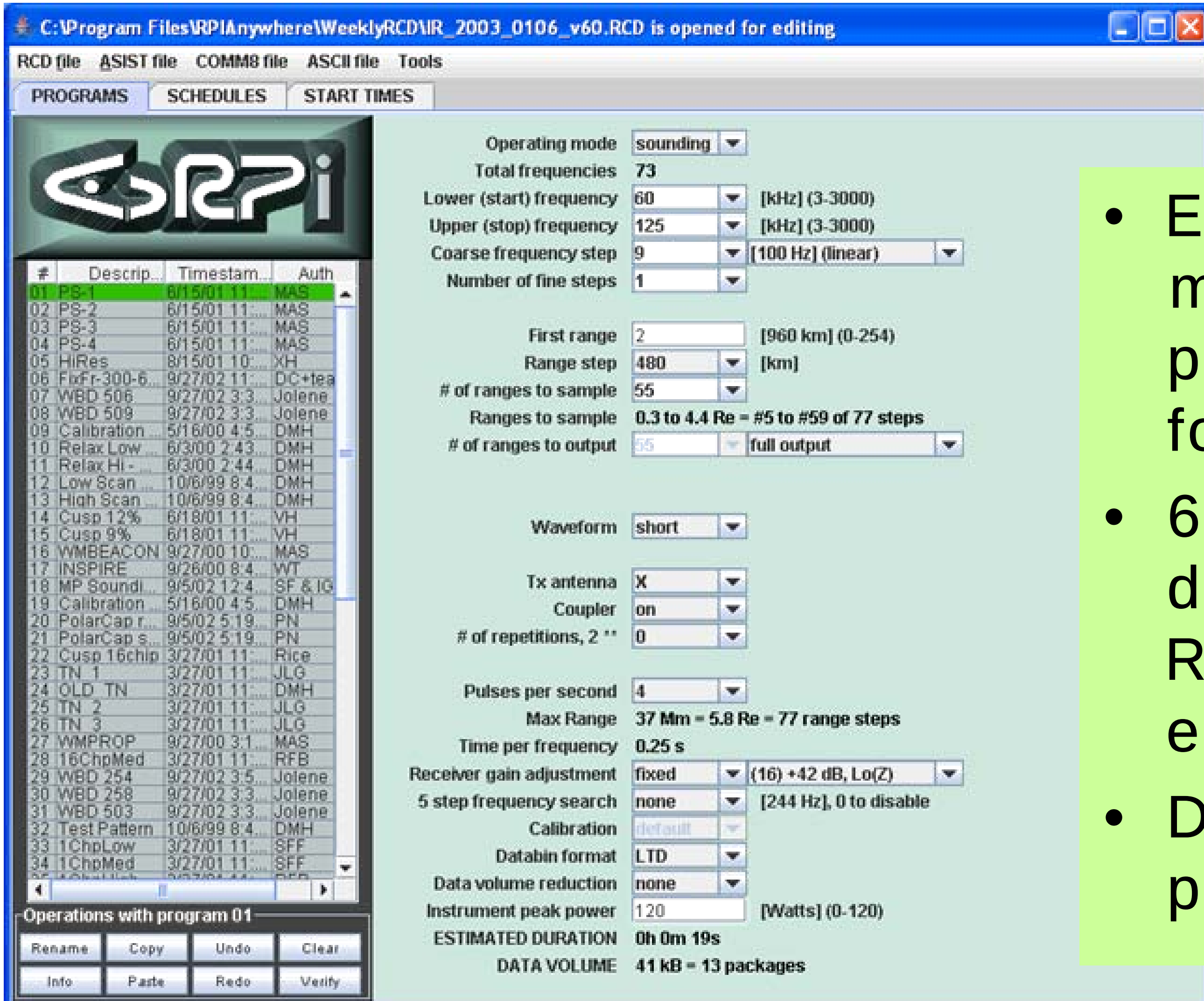
Welcome to DCART



DCART Screen Estate

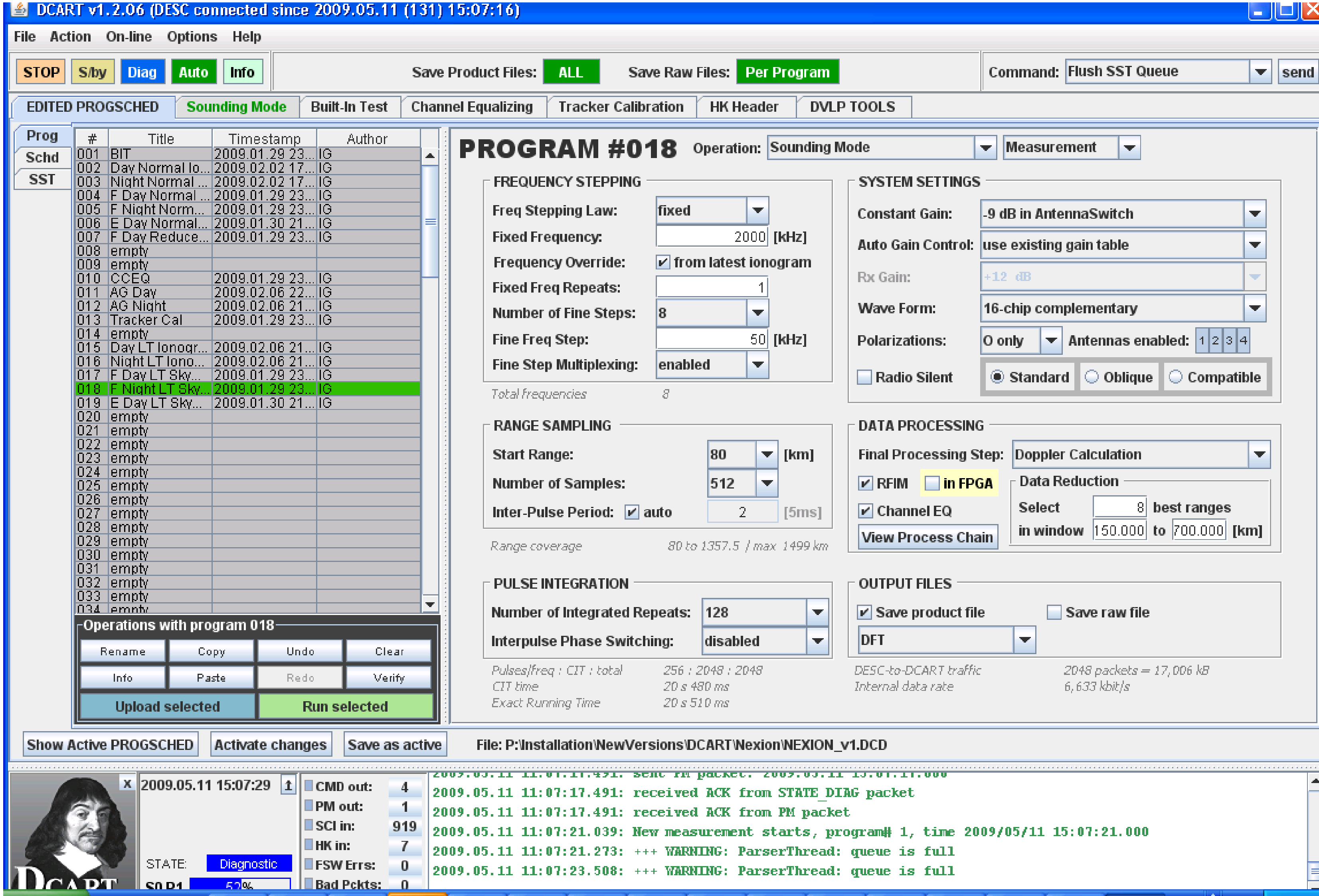


List of Programs



- EdRPI – mission planning tool for RPI
- 64 program definitions for RPI were not enough
- DCART: 128 programs

DCART List of Programs



Busy slide?

INTERFACE CONCEPTS:
Normal and Advanced modes

- Conflict between the design concept of **flexibility** in adjusting digisonde operations and **simplicity** of everyday operations
  - Too many buttons
- Two user modes
  - Normal
  - Advanced

Top Level Color Concept

- RED = error that requires operator's attention
- YELLOW = important option or control
- ORANGE = "hazardous" operation that may affect quality/amount of collected data
- GREEN = working as expected

Stop immediately

Finish measurement and stop

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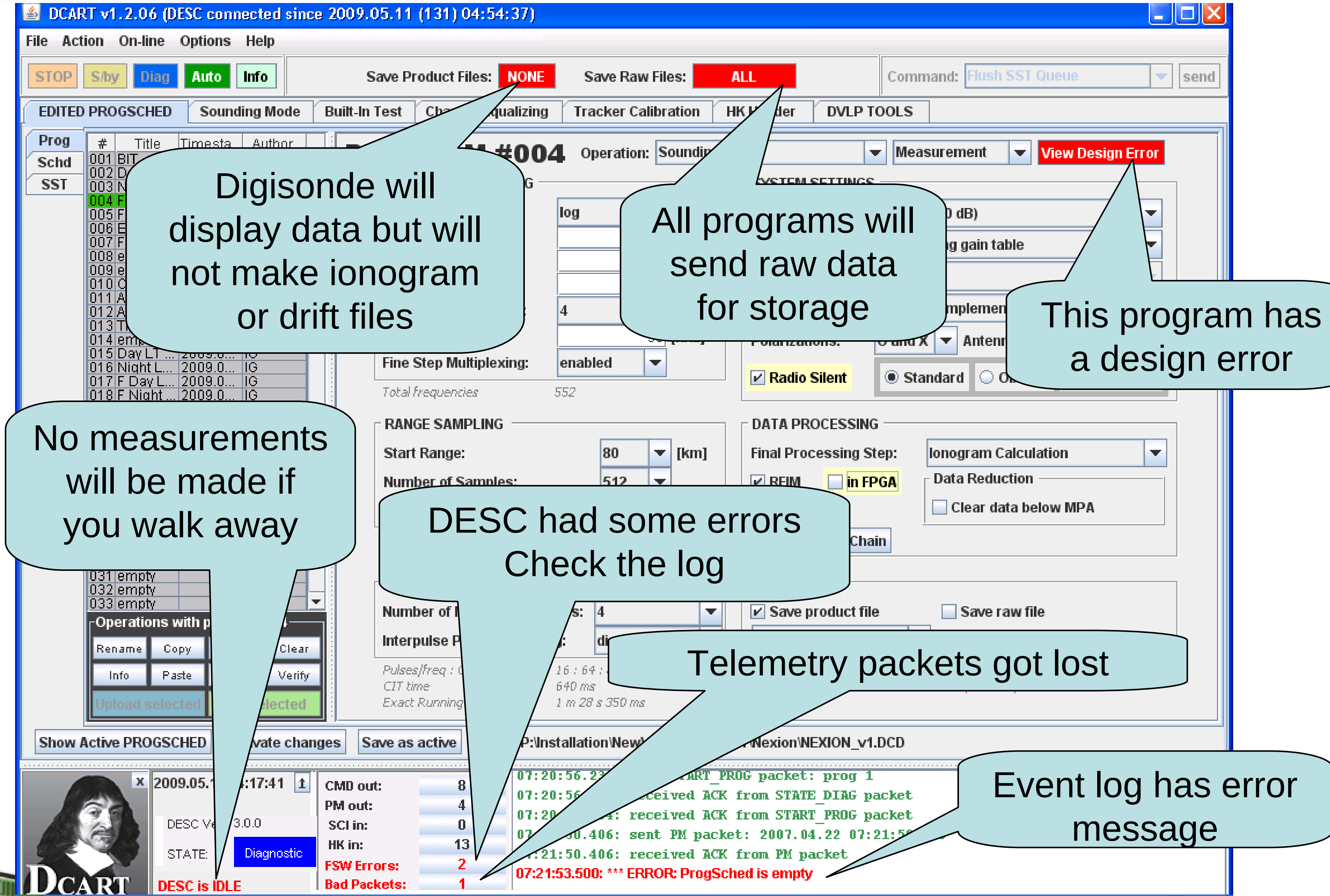
RED = Requires Attention



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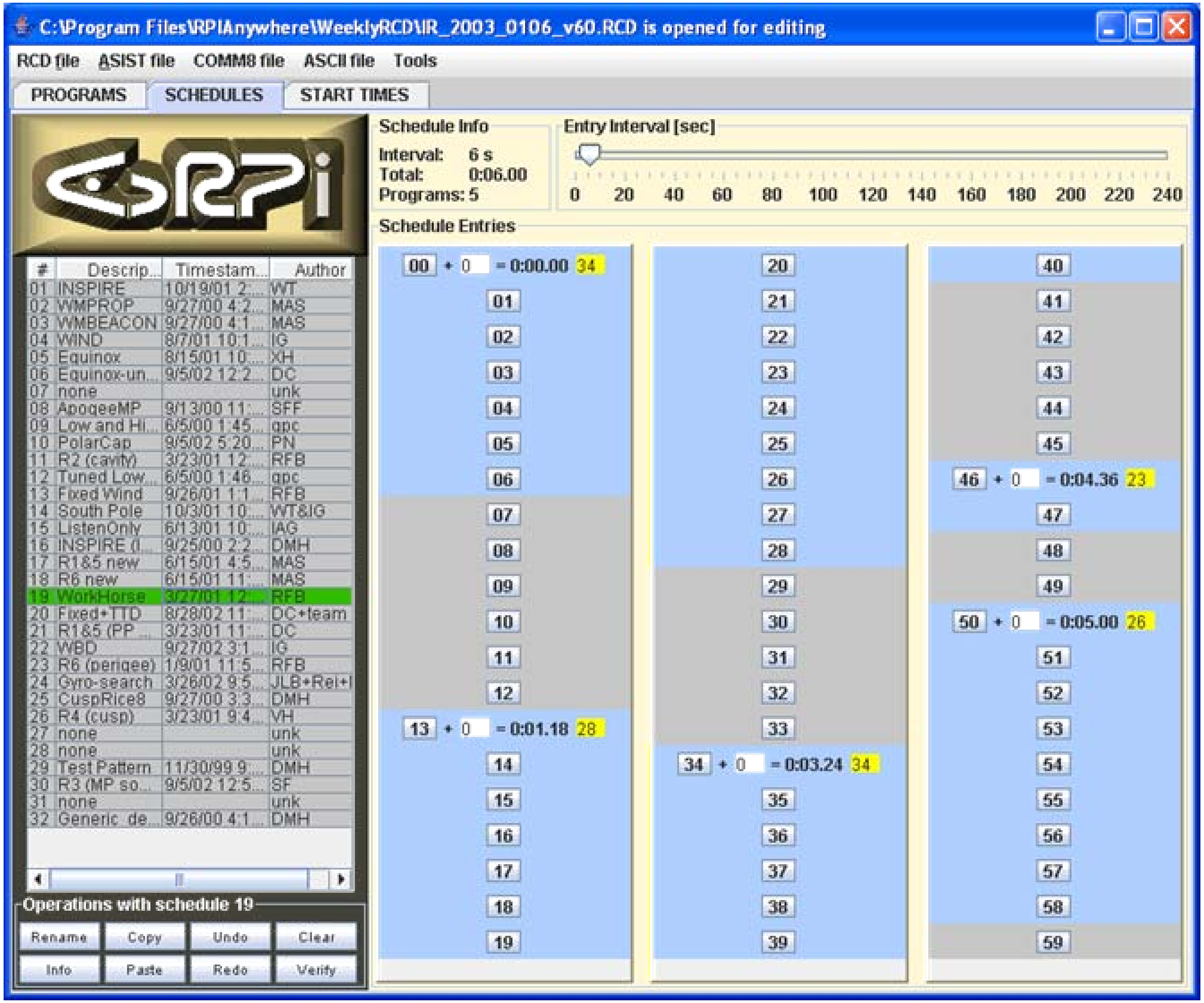
Digisonde Schedules

- Digisonde Schedule = repetitive sequence of measurement programs
- Concept of “xITL” (Air Force term)
  - DITL = Day In The Life
  - WITL = Week In The Life
  - 15MITL = 15 Minutes In The Life
  - OITL = Orbit In The Life

From HITL to PTITL

- Digisonde 256, DPS-4: HITL
  - Hour In The Life (HITL) is one schedule
  - E.g., 4 times a hour
- Digisonde 4D: PTITL
  - A Period of Time In The Life (PTITL)
  - Inspired by IMAGE RPI mission planning
    - Multiple programs run at irregular intervals
  - E.g., 5MITL is 5 minutes in the life
    - Equivalent to 12 times an hour, only that one copy of 5MITL is sufficient instead of 12 copies to describe for HITL
    - Advantage becomes clearer when 5MITL has more than 2-3 programs

RPI Schedule Editor with PTITL



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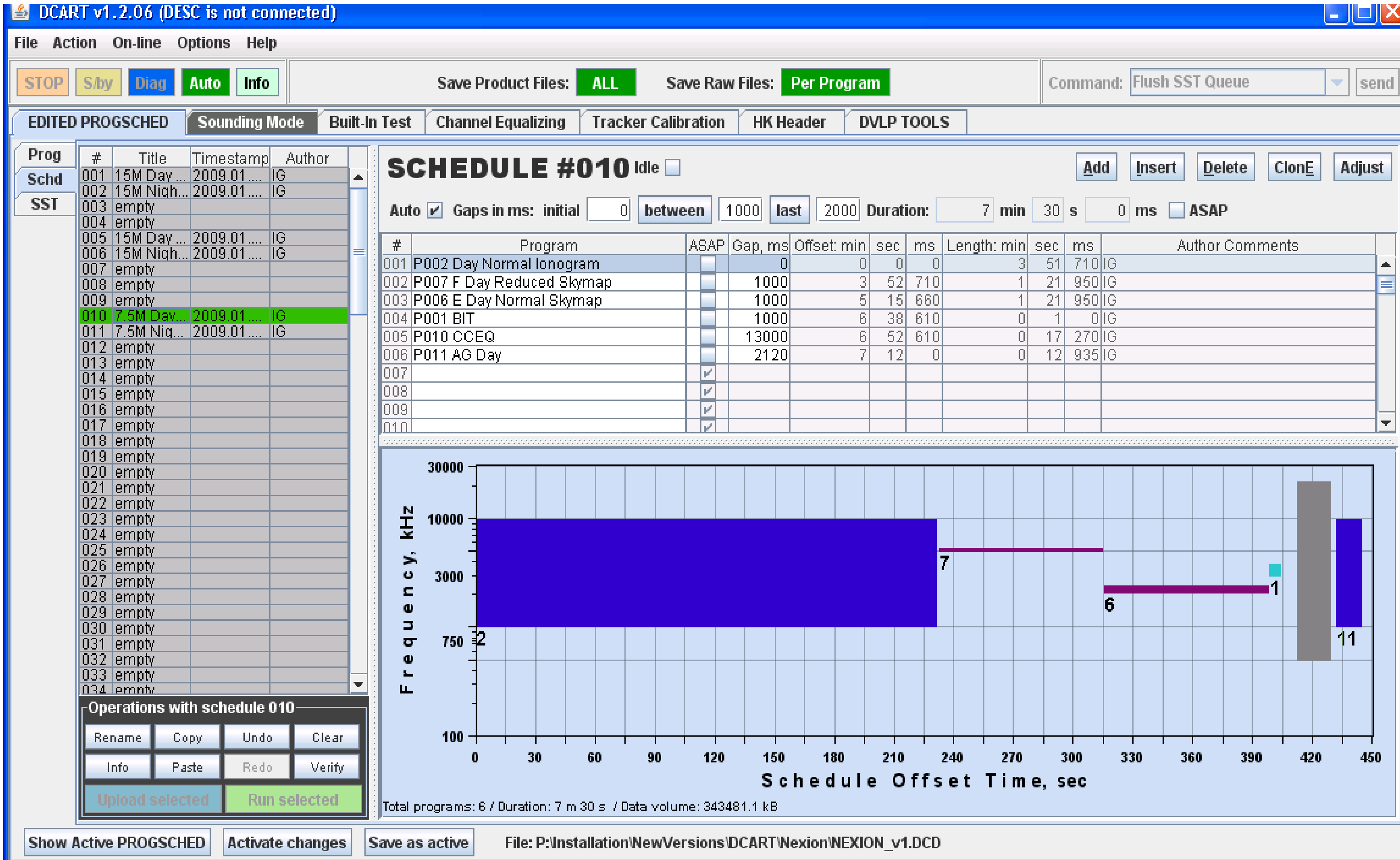
DCART Schedule Editor

with PTITL



7.5MITL

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Digisonde DITL

- We recommend different schedules for day and night
- DAY: higher upper frequency, coarser frequency stepping
- NIGHT: lower gain, lower upper frequency, finer stepping, no E-layer drift

SST and SST Queue

- **SCHEDULE START TIME**
  - Time in UT when a certain schedule starts
  - Good for day/night switching
  - Good for campaigns
- **SST Queue**
  - List of SSTs in DESC (control software)
  - When DESC is in the AUTO mode
    - look at the earliest SST in the Queue
    - when the time is right, start the schedule and remove the SST
    - repeat

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Replenishing SST Queue

a little bit funky

- DCART calculates new SSTs
- Three mechanisms to add SSTs to the Queue:
  - MANUAL
    - Just type UT and schedule # (good for lab tests)
  - RULE-BASED
    - Define rule(s) for automatic SST generation
      - E.g., day and night schedules
  - CAMPAIGN
    - Specify start and stop UT for a particular schedule

CERTAIN COMBINATIONS OF THESE METHODS ARE POSSIBLE

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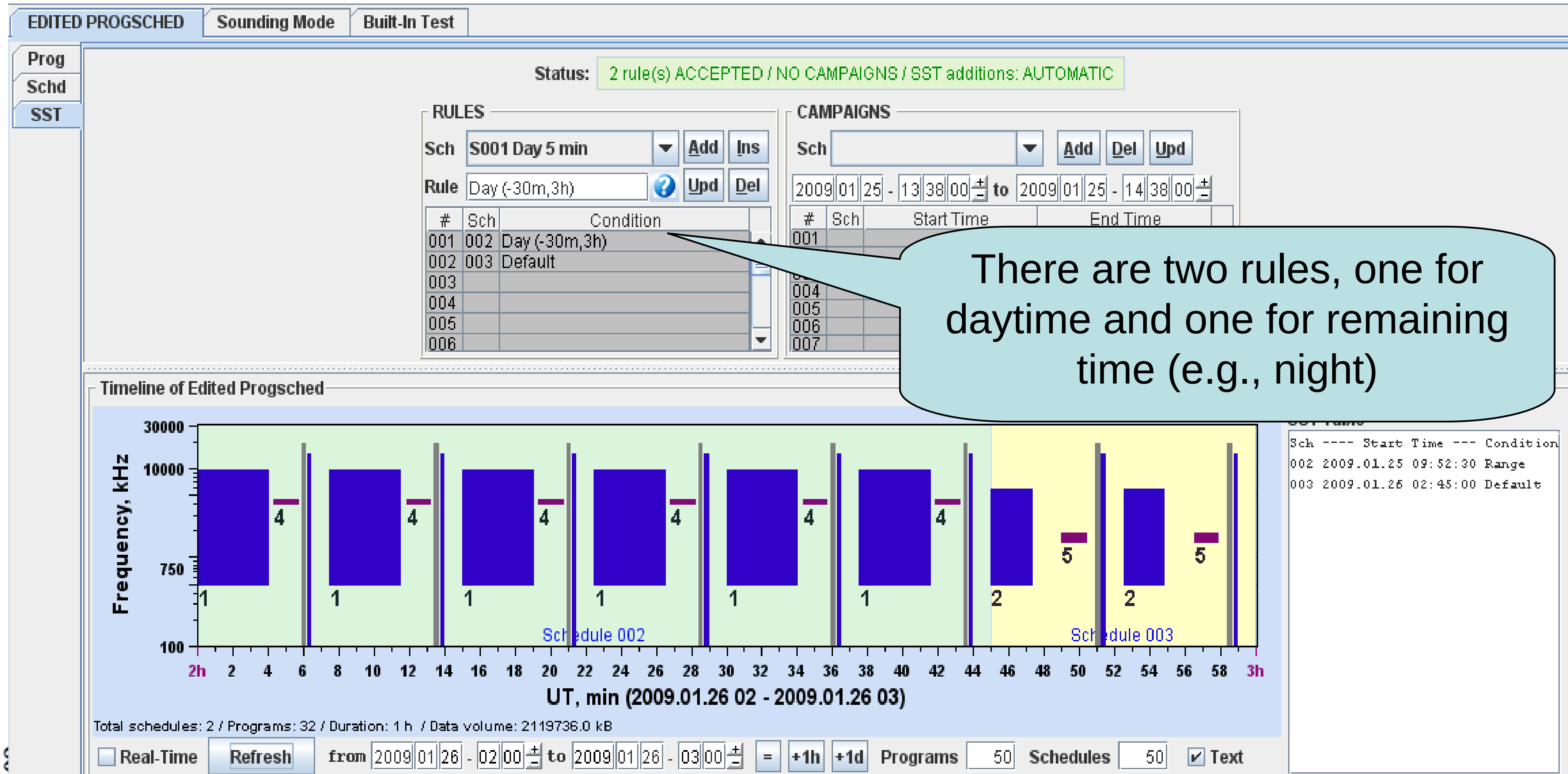
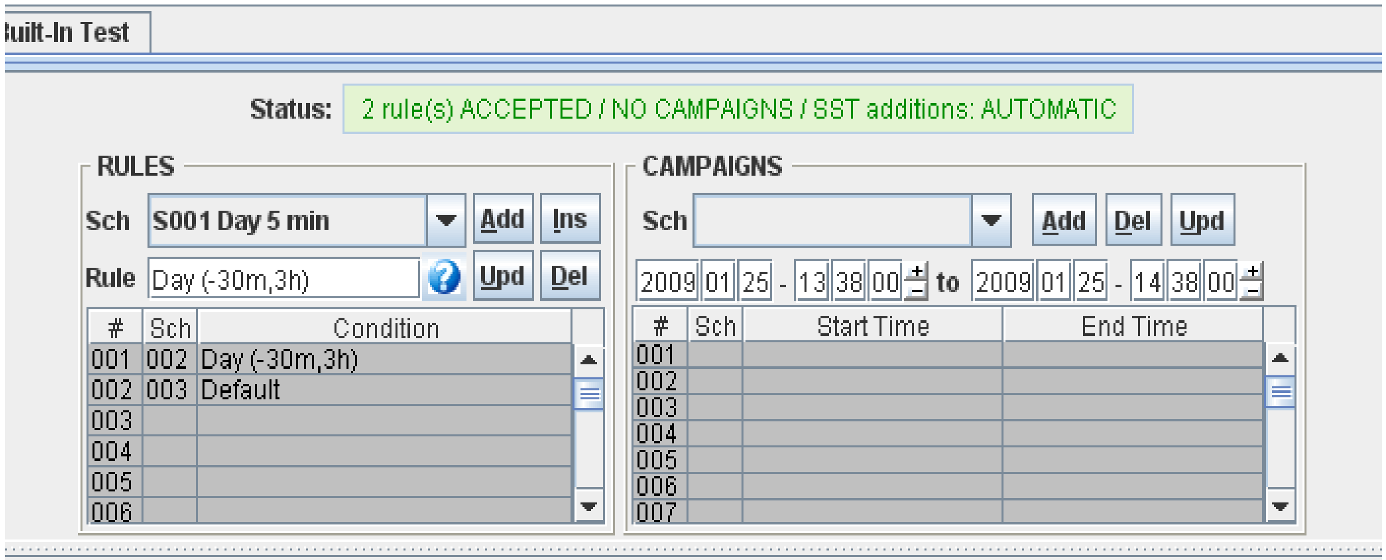
EASY SCENARIO



- DAY = schedule 2
- NIGHT = schedule 3

Campaign Mode



- Just add start and stop UT for a particular schedule, the rule-based DITL will be overwritten
- Campaign requests can be sent to DCART over the FTP as plain text files

Queue Replenishing Modes

- BUILD FOR A TIME PERIOD
  - Enter start UT
  - Enter stop UT
  - Push "Rebuild" button
  - Get list of SSTs
  - Send all SSTs to DESC
  - DESC makes them happen

TYPICAL FOR SPACE MISSIONS

- REPLENISH AUTOMATICALLY
  - No need to type times
  - DCART uses rules and campaign times to prepare SSTs
  - Shortly before the start time, the SST is sent to DESC
  - DESC makes it happen

TYPICAL FOR DIGISONDE OPS

Queue Replenishing Modes (2)

typical operation

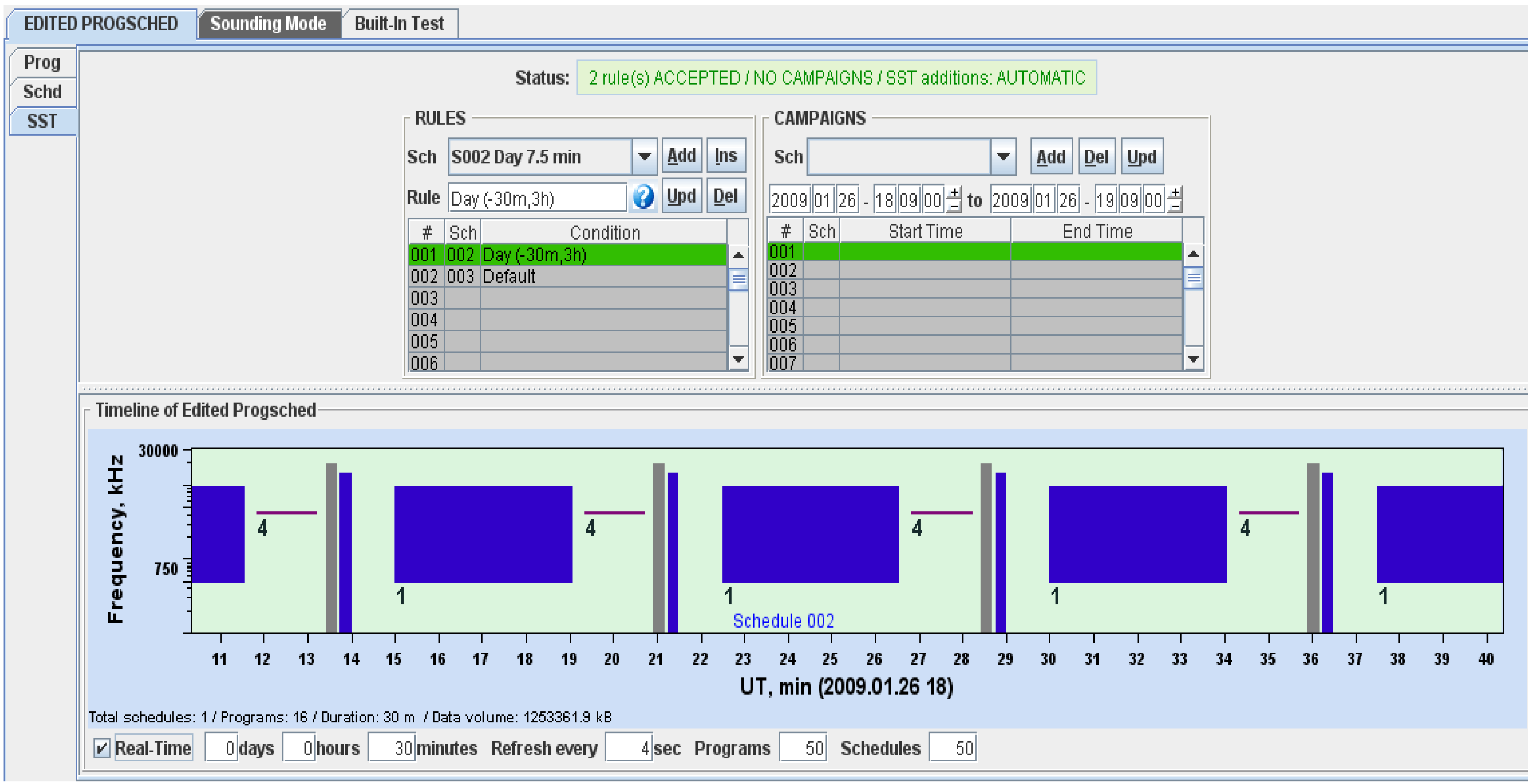
- BUILD FOR A TIME PERIOD
  - Rebuild SSTs
  - Display the timeline
  - Correct rule mistakes manually
  - Send to DESC or save as a script

MISTAKES CAN BE CORRECTED

- REPLENISH AUTOMATICALLY
  - Display the timeline
  - No manual correction of generated SSTs possible
  - Adjust rules or campaign times
  - Repeat

RELIABLE RULE ENGINE IS NEEDED

DCART Timeline Display



Under the hood of DCART project

Alexander Kozlov
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII International Digisonde Forum
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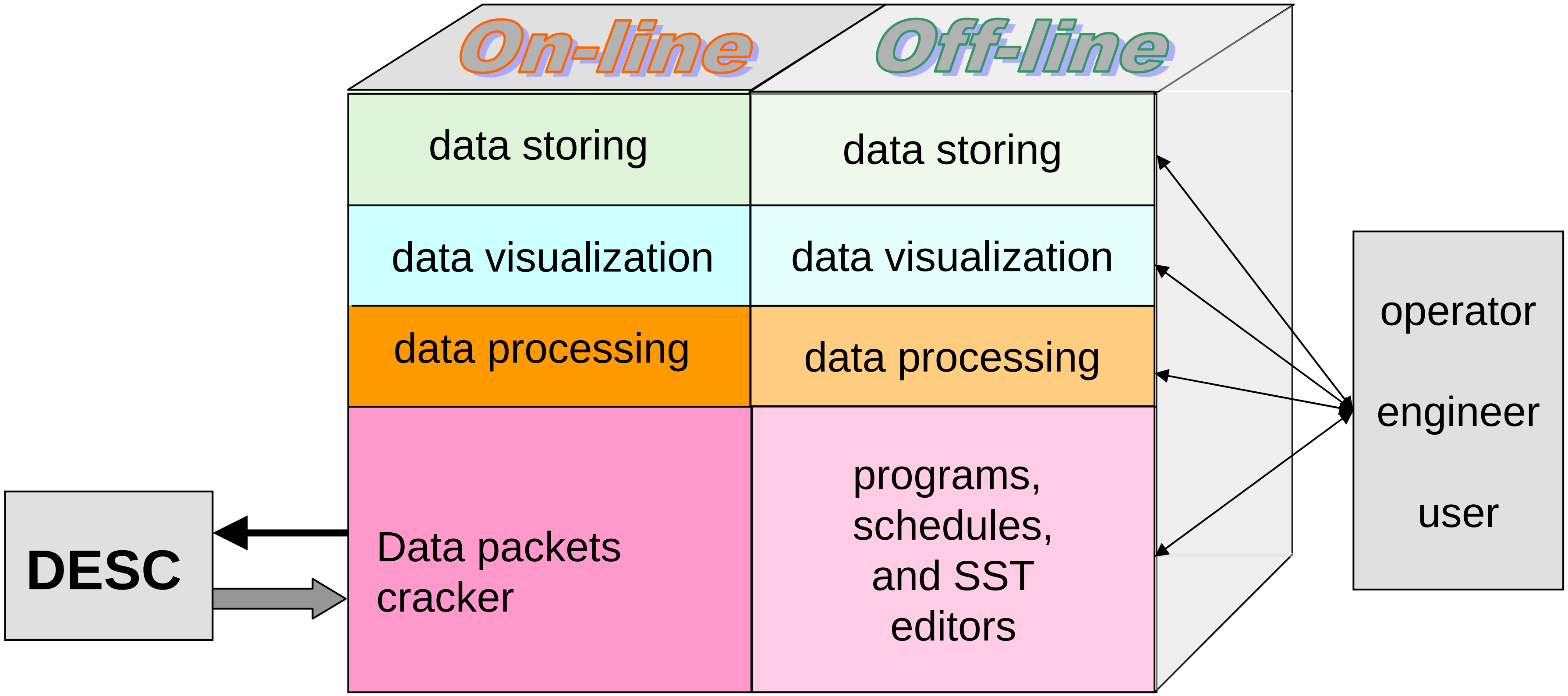
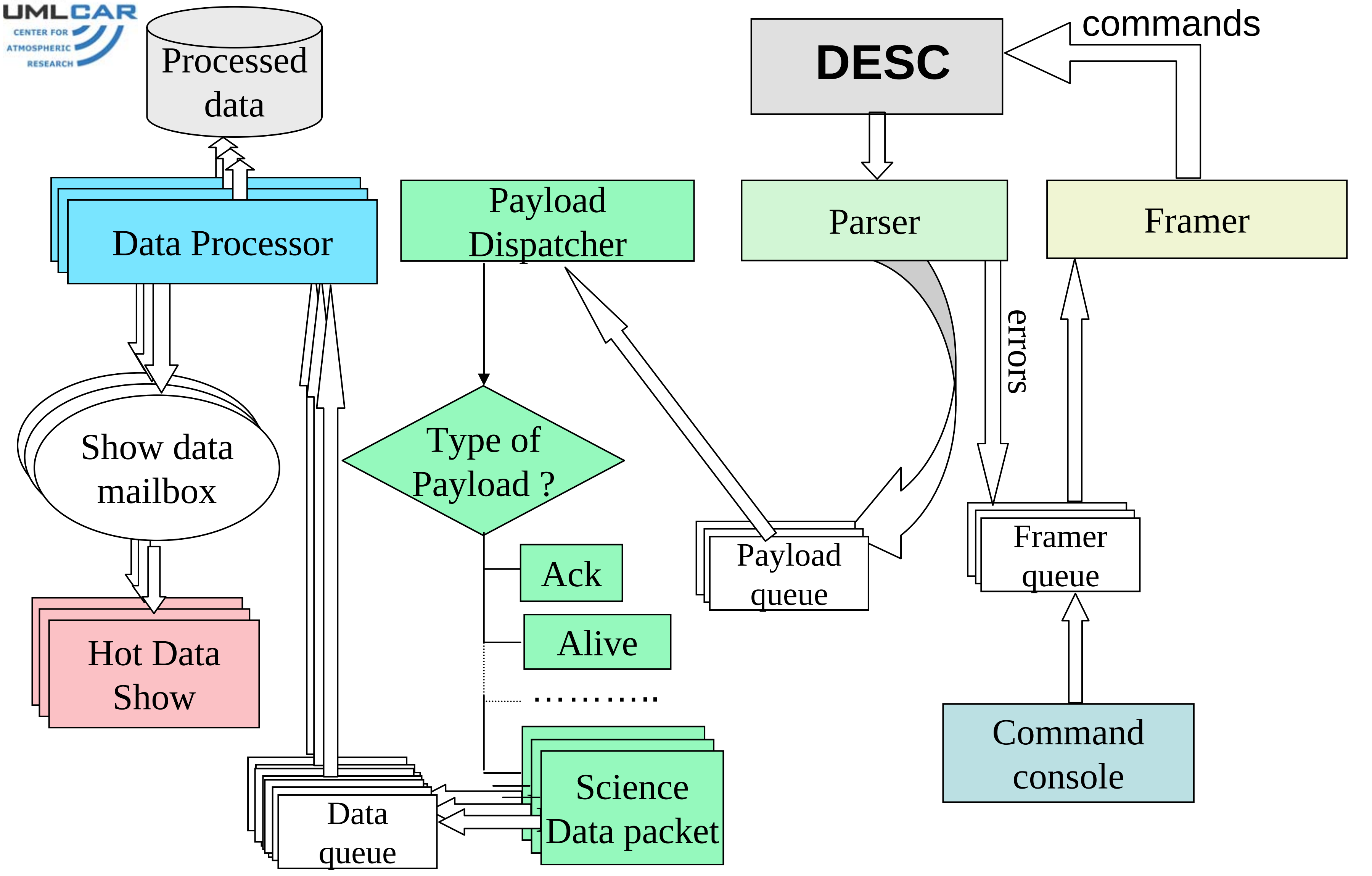
DCART general layout



On-line subsystem layout



DCART v1.2.09 (DESC is not connected)
File
Action
On-line
Options
Help
STOP
In separate frame
System information
Thread information
Monitor Processing Queues
Save Product Files:
NONE
Save Raw Files:
Per Program
Command:
Flush SST Queue
send
Built-In Test
Channel Equalizing
Tracker Calibration
HK Header
DVLP TOOLS
Presentation
ionogram
Refresh every
250
ms
View Preface
Threshold above MPA in steps
Polarization
ALL
O
X
printing color scheme
Freq [MHz]:
0.5
12.0
Height [km]
80
900
Use zoom
TO START VISUALIZATION OF THE REAL-TIME DATA, ENABLE DATA DISPLAY
DCART v 1.2.09
Copyright (c) UMLCAR 2006-2009
DIGISONDE 4D
PORTABLE SOUNDER
DCART
UMASS
University of Massachusetts Lowell
Center for Atmospheric Research
www.umlcar.uml.edu
Disable the real-time display before leaving system running unattended
2009.05.12 14:09:10
CMD out: 0
PM out: 0
SCI in: 0
HK in: 0
FSW Errs: 0
Bad Pckts: 0
2009.05.12 10:08:29.110: DCART started...
STATE:
Safe
DESC is IDLE
DCART

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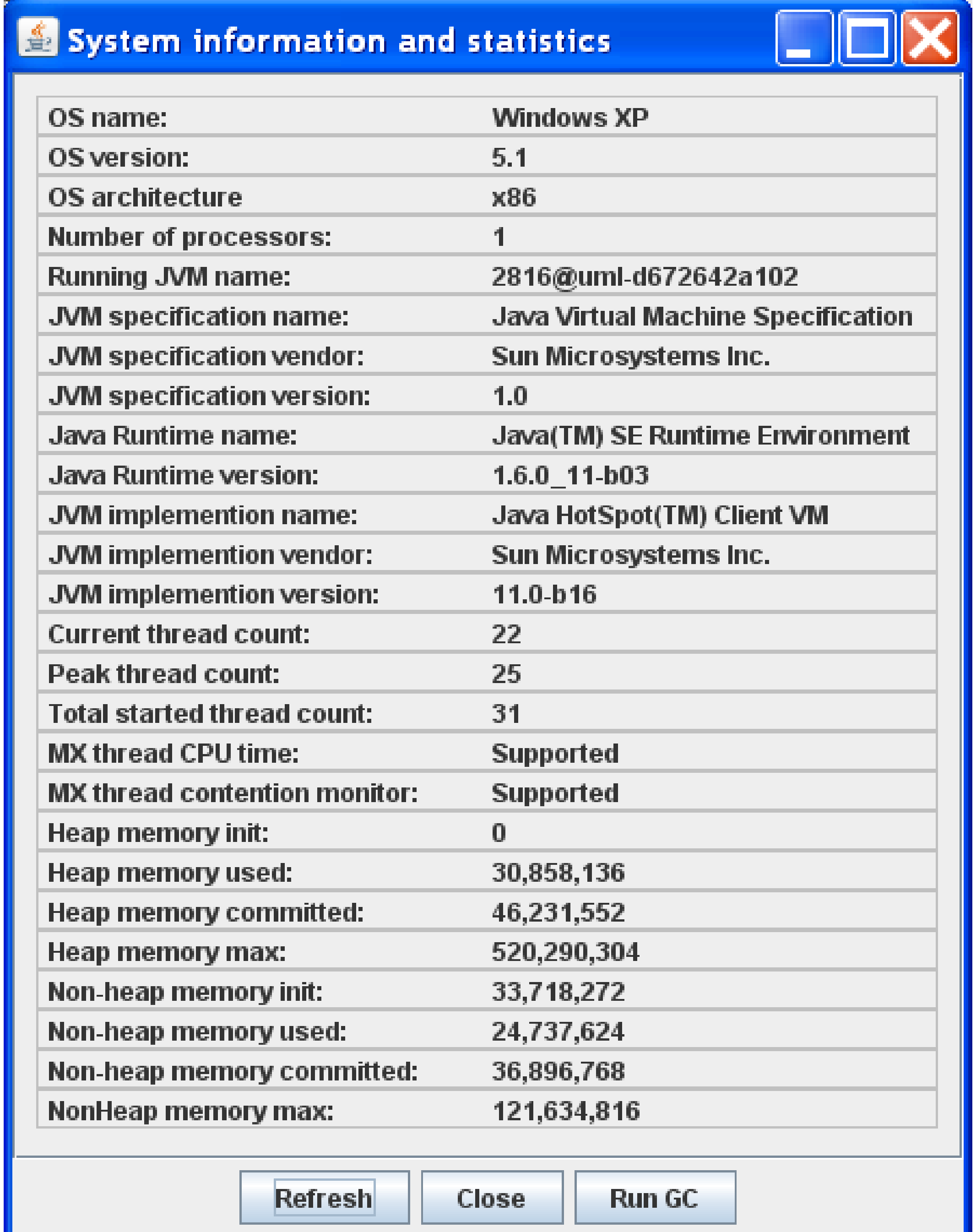
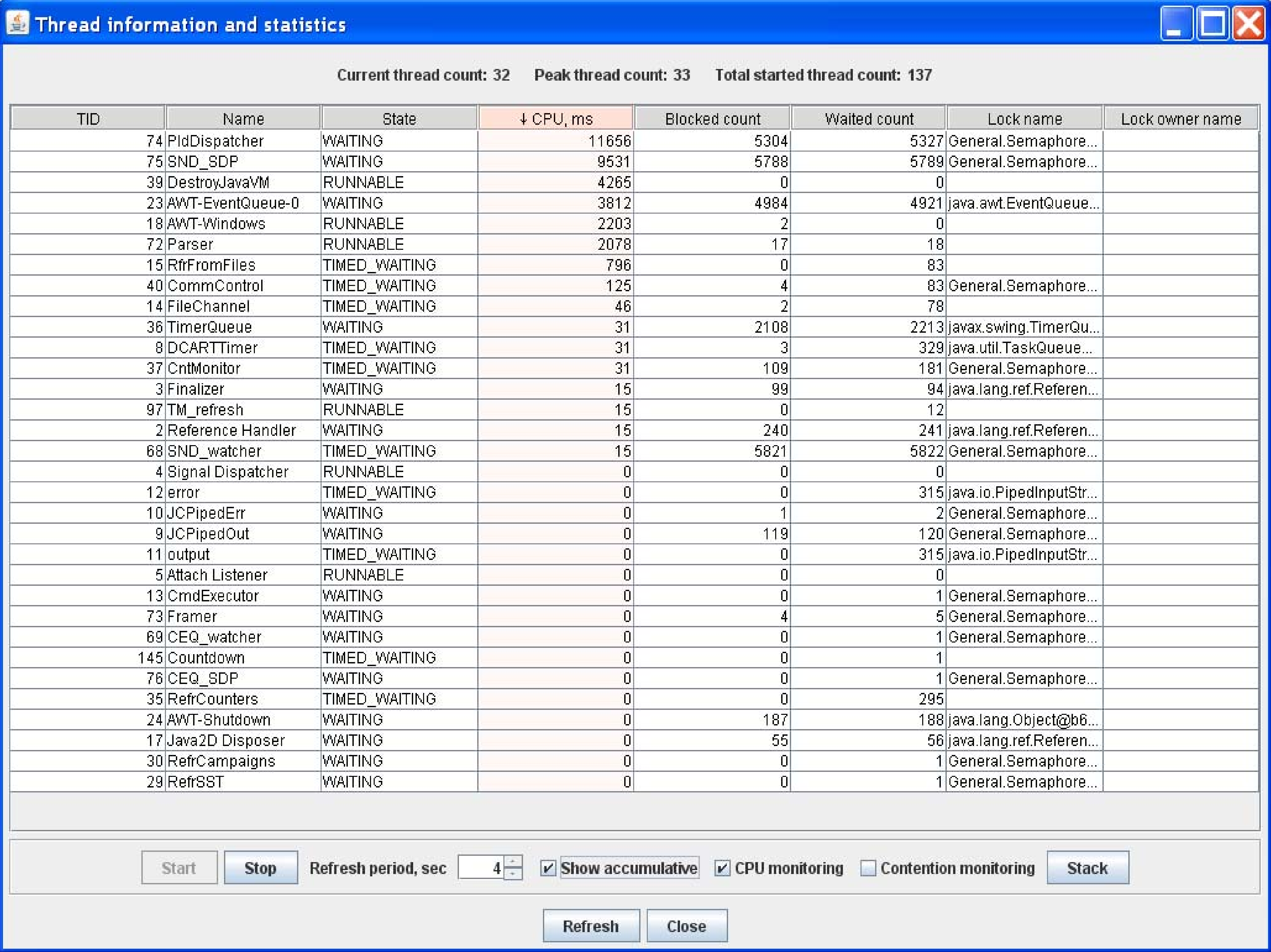
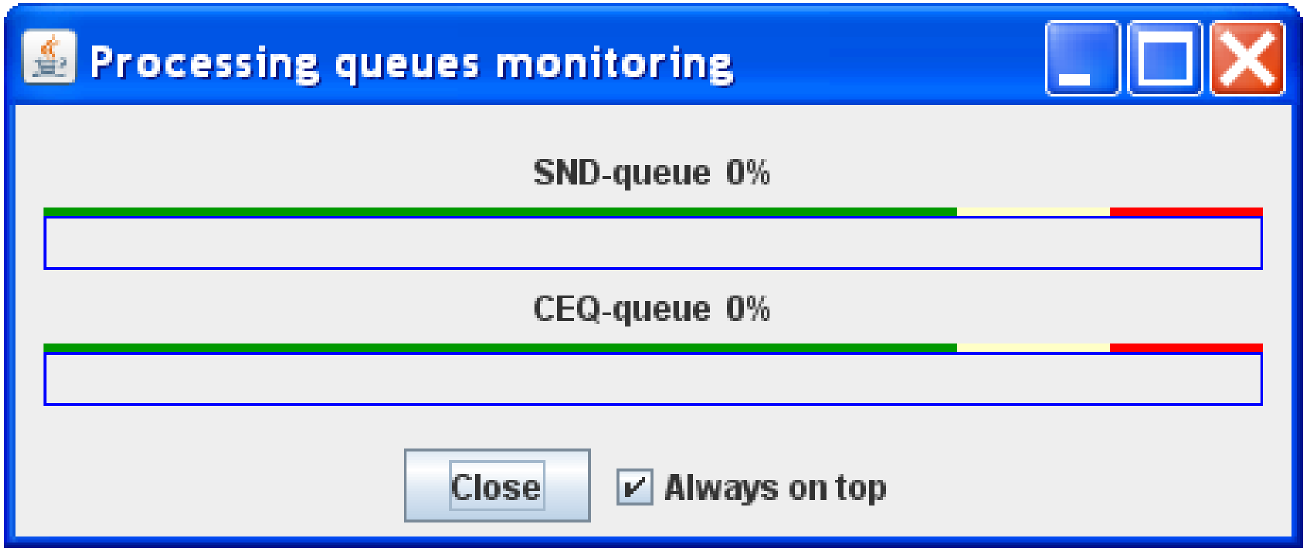


OS name:	Windows XP
OS version:	5.1
OS architecture	x86
Number of processors:	1
Running JVM name:	2816@uml-d672642a102
JVM specification name:	Java Virtual Machine Specification
JVM specification vendor:	Sun Microsystems Inc.
JVM specification version:	1.0
Java Runtime name:	Java(TM) SE Runtime Environment
Java Runtime version:	1.6.0_11-b03
JVM implemention name:	Java HotSpot(TM) Client VM
JVM implemention vendor:	Sun Microsystems Inc.
JVM implemention version:	11.0-b16
Current thread count:	22
Peak thread count:	25
Total started thread count:	31
MX thread CPU time:	Supported
MX thread contention monitor:	Supported
Heap memory init:	0
Heap memory used:	30,858,136
Heap memory committed:	46,231,552
Heap memory max:	520,290,304
Non-heap memory init:	33,718,272
Non-heap memory used:	24,737,624
Non-heap memory committed:	36,896,768
NonHeap memory max:	121,634,816



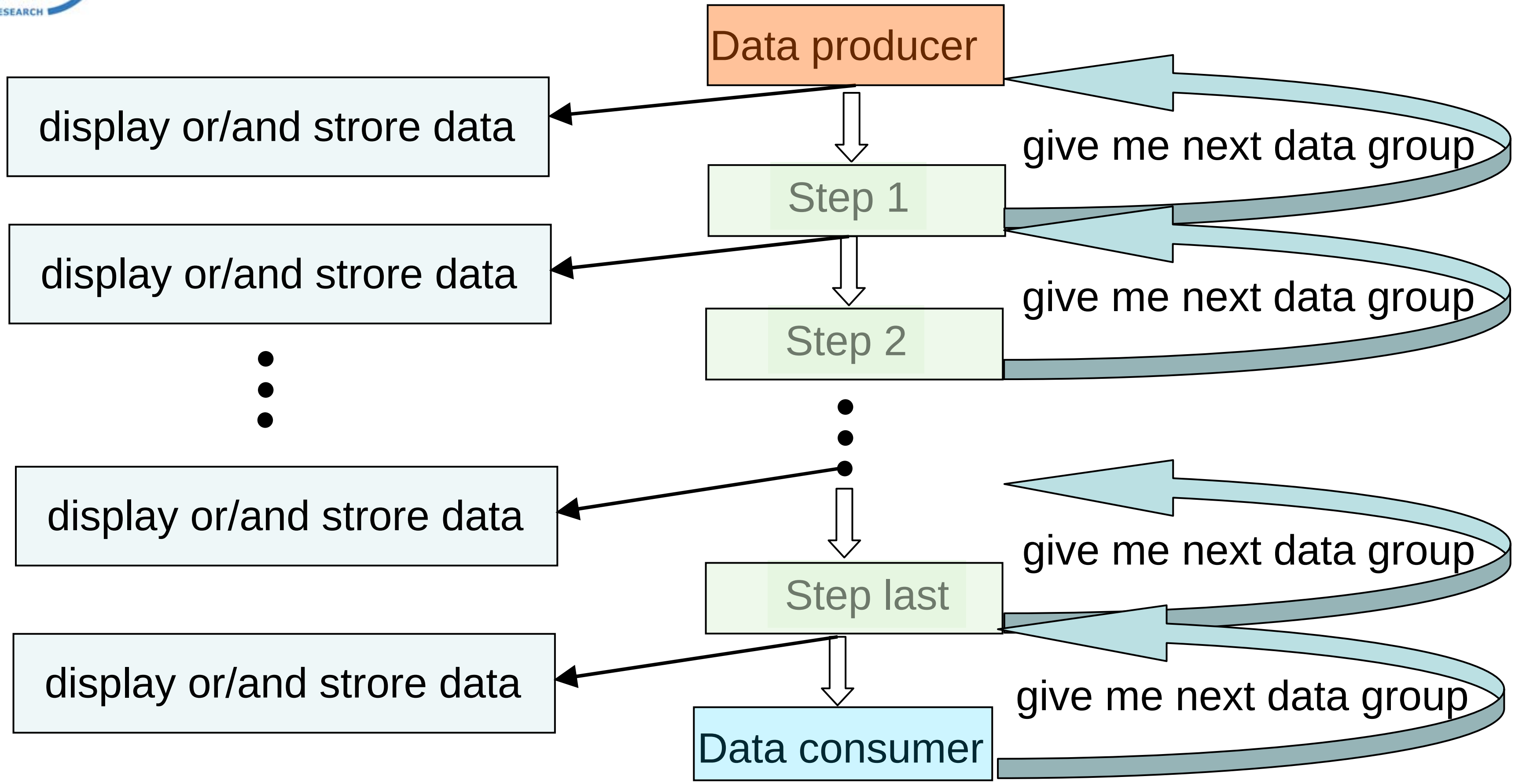
TID	Name	State	↓ CPU, ms	Blocked count	Waited count	Lock name	Lock owner name
74	PldDispatcher	WAITING	11656	5304	5327	General.Semaphore...	
75	SND_SDP	WAITING	9531	5788	5789	General.Semaphore...	
39	DestroyJavaVM	RUNNABLE	4265	0	0		
23	AWT-EventQueue-0	WAITING	3812	4984	4921	java.awt.EventQueue...	
18	AWT-Windows	RUNNABLE	2203	2	0		
72	Parser	RUNNABLE	2078	17	18		
15	RfrFromFiles	TIMED_WAITING	796	0	83		
40	CommControl	TIMED_WAITING	125	4	83	General.Semaphore...	
14	FileChannel	TIMED_WAITING	46	2	78		
36	TimerQueue	WAITING	31	2108	2213	javax.swing.TimerQu...	
8	DCARTTimer	TIMED_WAITING	31	3	329	java.util.TaskQueue...	
37	CntMonitor	TIMED_WAITING	31	109	181	General.Semaphore...	
3	Finalizer	WAITING	15	99	94	java.lang.ref.Referen...	
97	TM_refresh	RUNNABLE	15	0	12		
2	Reference Handler	WAITING	15	240	241	java.lang.ref.Referen...	
68	SND_watcher	TIMED_WAITING	15	5821	5822	General.Semaphore...	
4	Signal Dispatcher	RUNNABLE	0	0	0		
12	error	TIMED_WAITING	0	0	315	java.io.PipedInputStr...	
10	JCPipedErr	WAITING	0	1	2	General.Semaphore...	
9	JCPipedOut	WAITING	0	119	120	General.Semaphore...	
11	output	TIMED_WAITING	0	0	315	java.io.PipedInputStr...	
5	Attach Listener	RUNNABLE	0	0	0		
13	CmdExecutor	WAITING	0	0	1	General.Semaphore...	
73	Framer	WAITING	0	4	5	General.Semaphore...	
69	CEQ_watcher	WAITING	0	0	1	General.Semaphore...	
145	Countdown	TIMED_WAITING	0	0	1		
76	CEQ_SDP	WAITING	0	0	1	General.Semaphore...	
35	RefrCounters	TIMED_WAITING	0	0	295		
24	AWT-Shutdown	WAITING	0	187	188	java.lang.Object@b6...	
17	Java2D Disposer	WAITING	0	55	56	java.lang.ref.Referen...	
30	RefrCampaigns	WAITING	0	0	1	General.Semaphore...	
29	RefrSST	WAITING	0	0	1	General.Semaphore...	


Processing queues monitoring
SND-queue 0%
CEQ-queue 0%
Close
Always on top

Data processing (DP) principles

- **Atomicity of processing and data**:
  Data Processing consists of several DP steps
  One step represents data processing algorithm
  One algorithm takes one or several *Data Groups* and produces one or several *Data Groups*
- **Conveyor:**
  Data Processing steps work in the same manner as conveyor where 'processing bricks' are Data Groups
- **Isolation**:
  Data Processing steps are isolated from each other
- **Developer obligation:**
  Coding of any Data Processing step has the mandatory conventions
  These conventions are related with data processing
  DP step developer can concentrate on algorithm itself
- **Off-line debugging and testing:**
  having raw data developer can off-line debug and test data processing steps

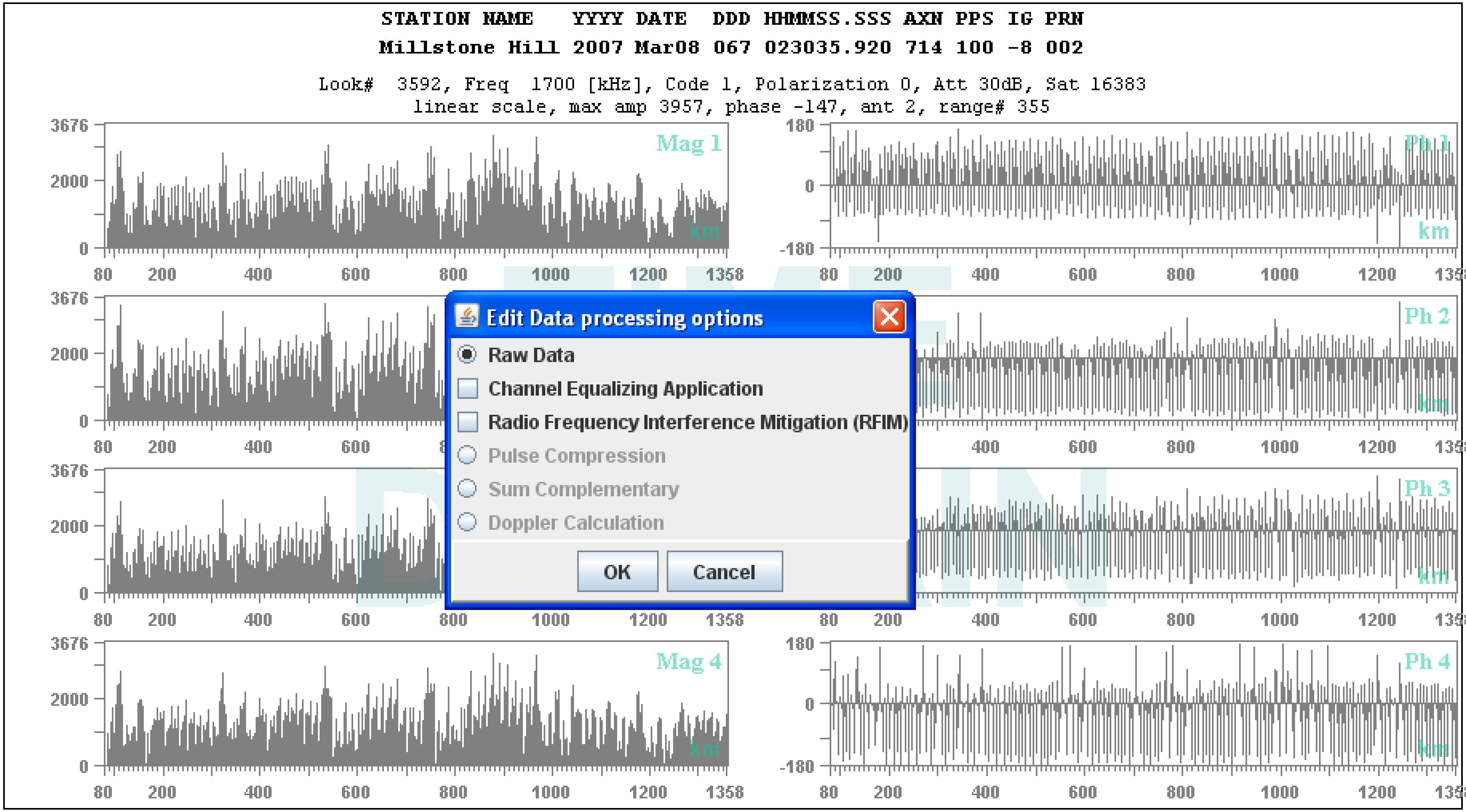
DP Conveyor

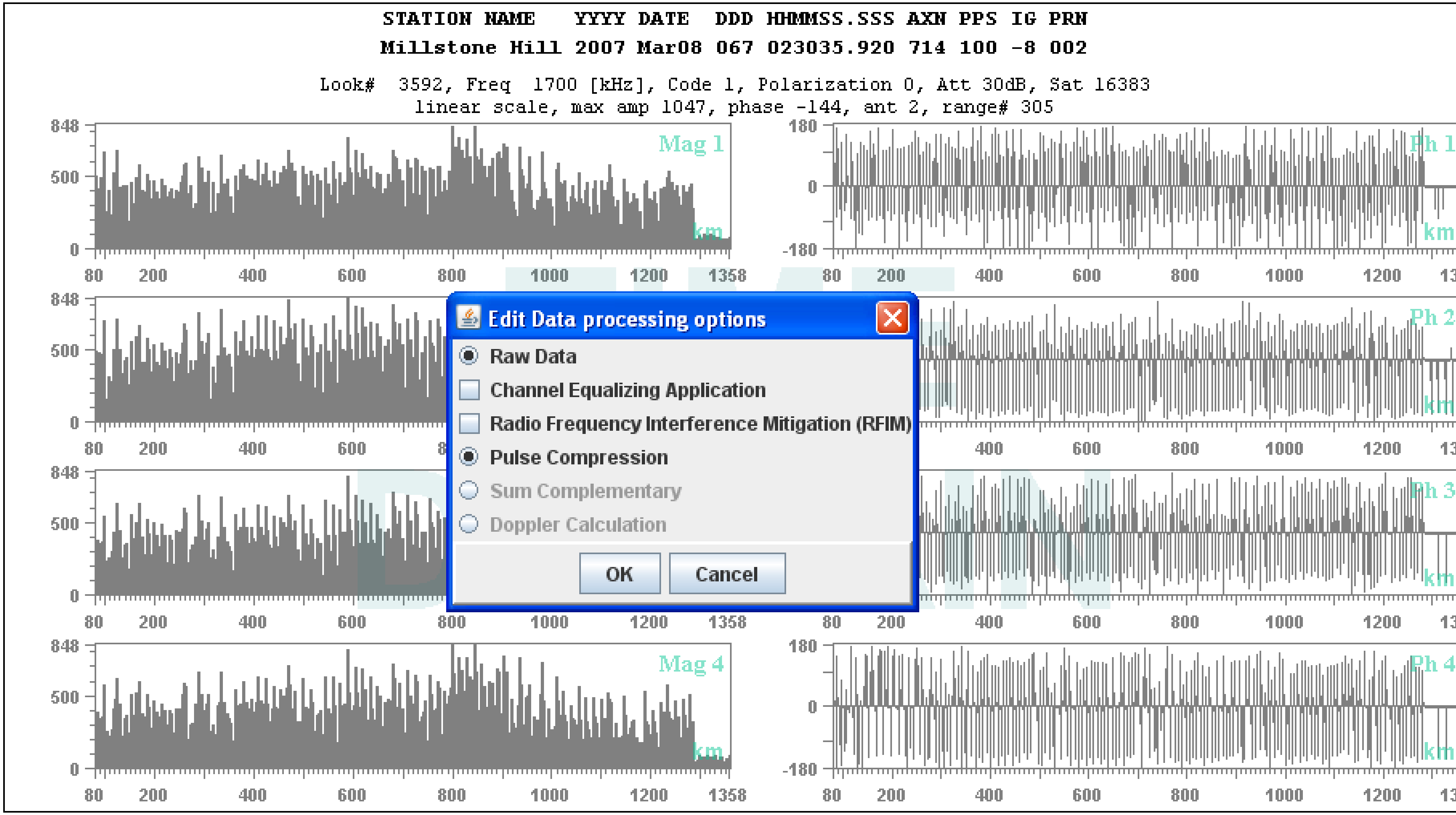


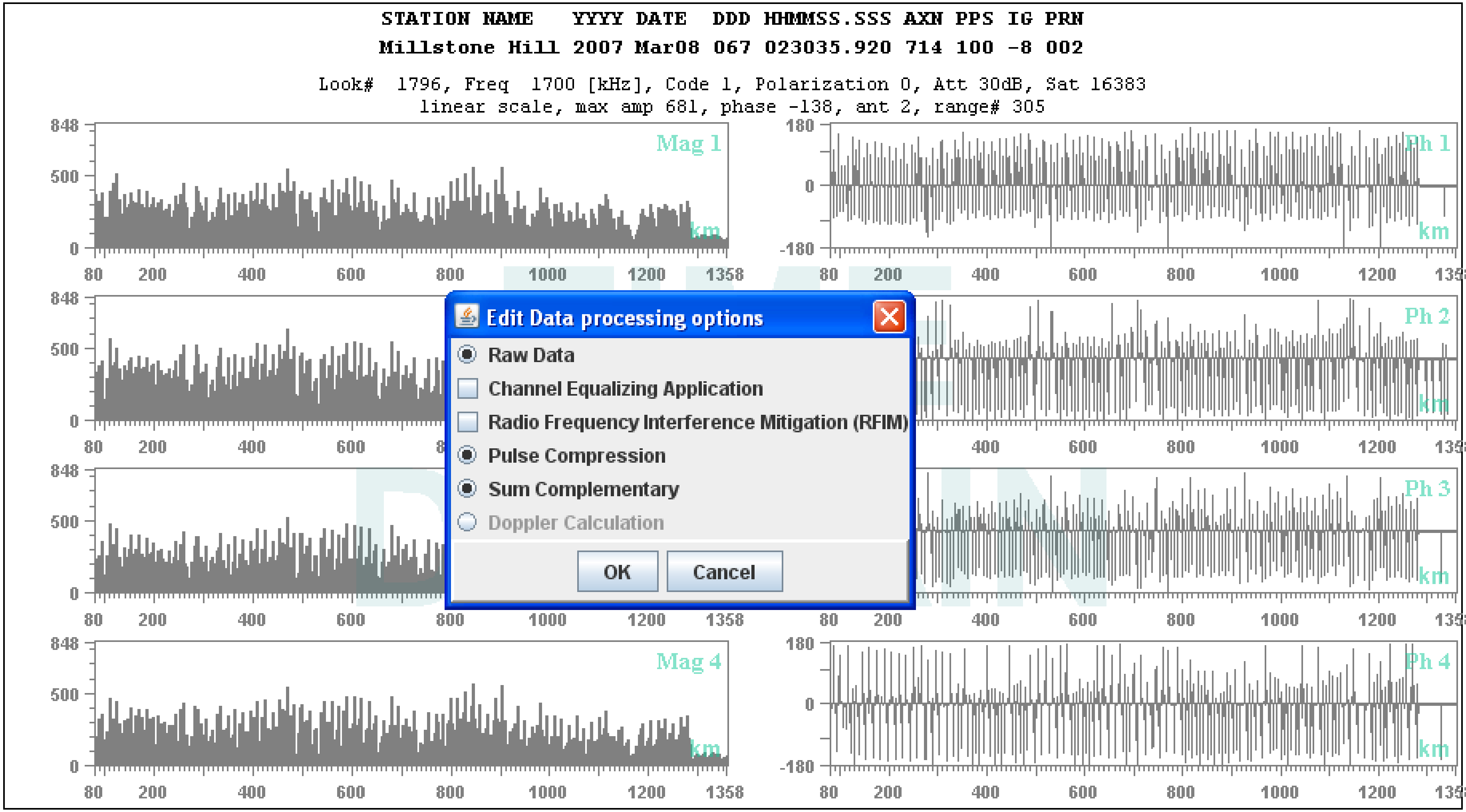
Data processing conveyor starts working from Data Consumer

Data Processing step properties

- **Get method**
- ***Accumulating* and R*eduction* N*umbers***
  - *Accumulating number* says how many Data Groups DP step will accumulate before starting to process them
  - *Reduction number* says what times number of Data Groups will be reduced by applying this DP step
  - To get reduction number of DP you need just multiply reduction numbers of steps of this DP
  - Getting of accumulating number of DP is not so obvious
- **Modified in-place flag**


STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 3592, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 3957, phase -147, ant 2, range# 355
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel

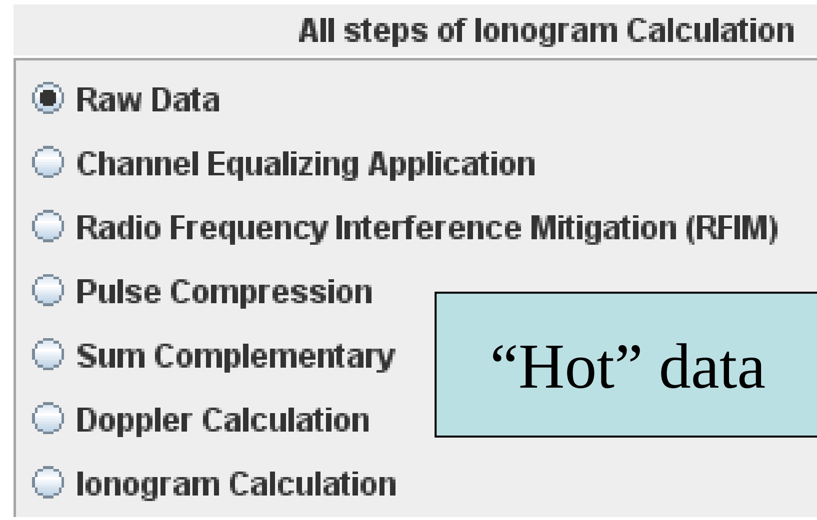

STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 3592, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 1047, phase -144, ant 2, range# 305
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel

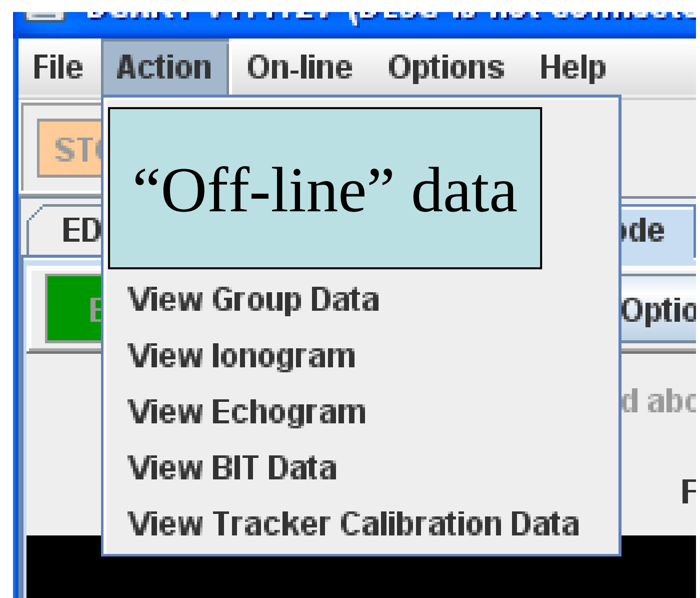

STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 1796, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 681, phase -138, ant 2, range# 305
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel


STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 1796, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 319, phase -22, ant 2, range# 12
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
848
500
0
180
-180
80 200 400 600 800 1000 1200 1358
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel

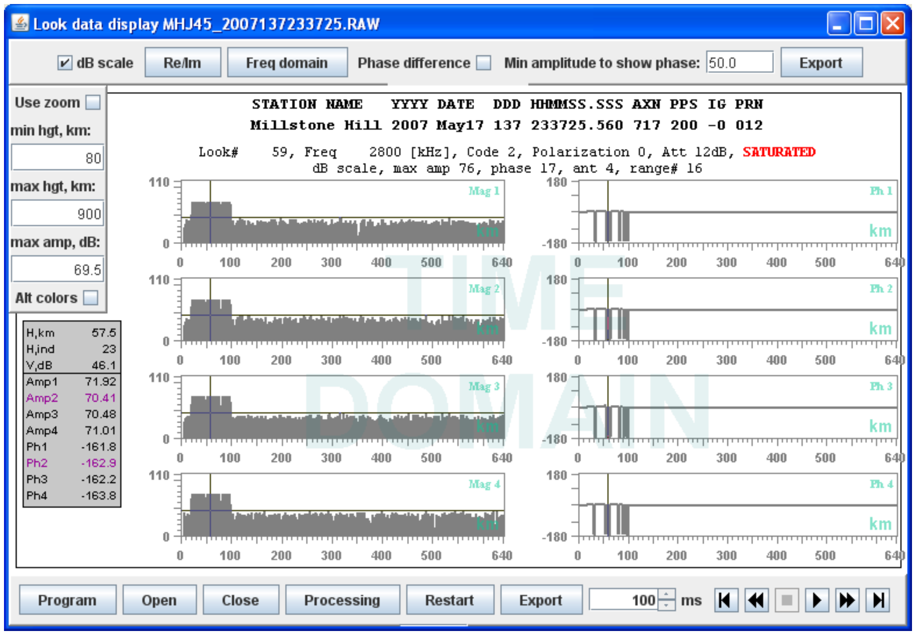
DCART Visualization Screens (1)

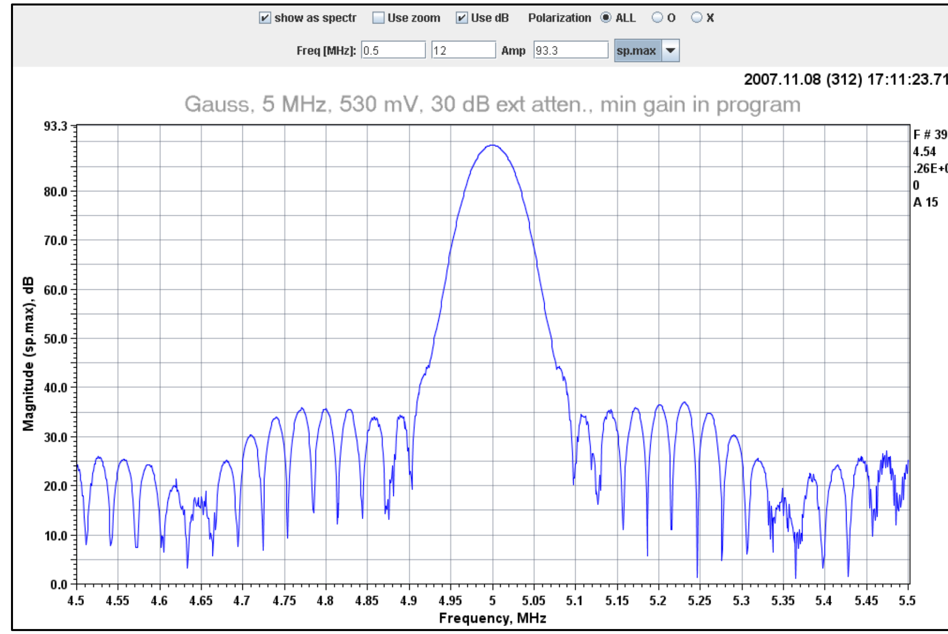
- Amplitude, Angle Of Arrival
  - Ionogram
- 4 antenna - Amplitude, Phase
  - Echogram
  - Group data
    - Original RAW
    - With RFIM
    - With channel equalizing
    - Pulse compression
    - Sum of complementary
    - Drift
- Housekeeping
  - BIT
  - Tracker Calibration





DCART Visualization Screens (2)





Raw data display showing phase code details

DCART in the spectrum analyzer mode showing Rx filter function

Step-by-step visualization of signal processing

Look data display

- Scale: db/linear
- Zoom: in/out
- Presentation:

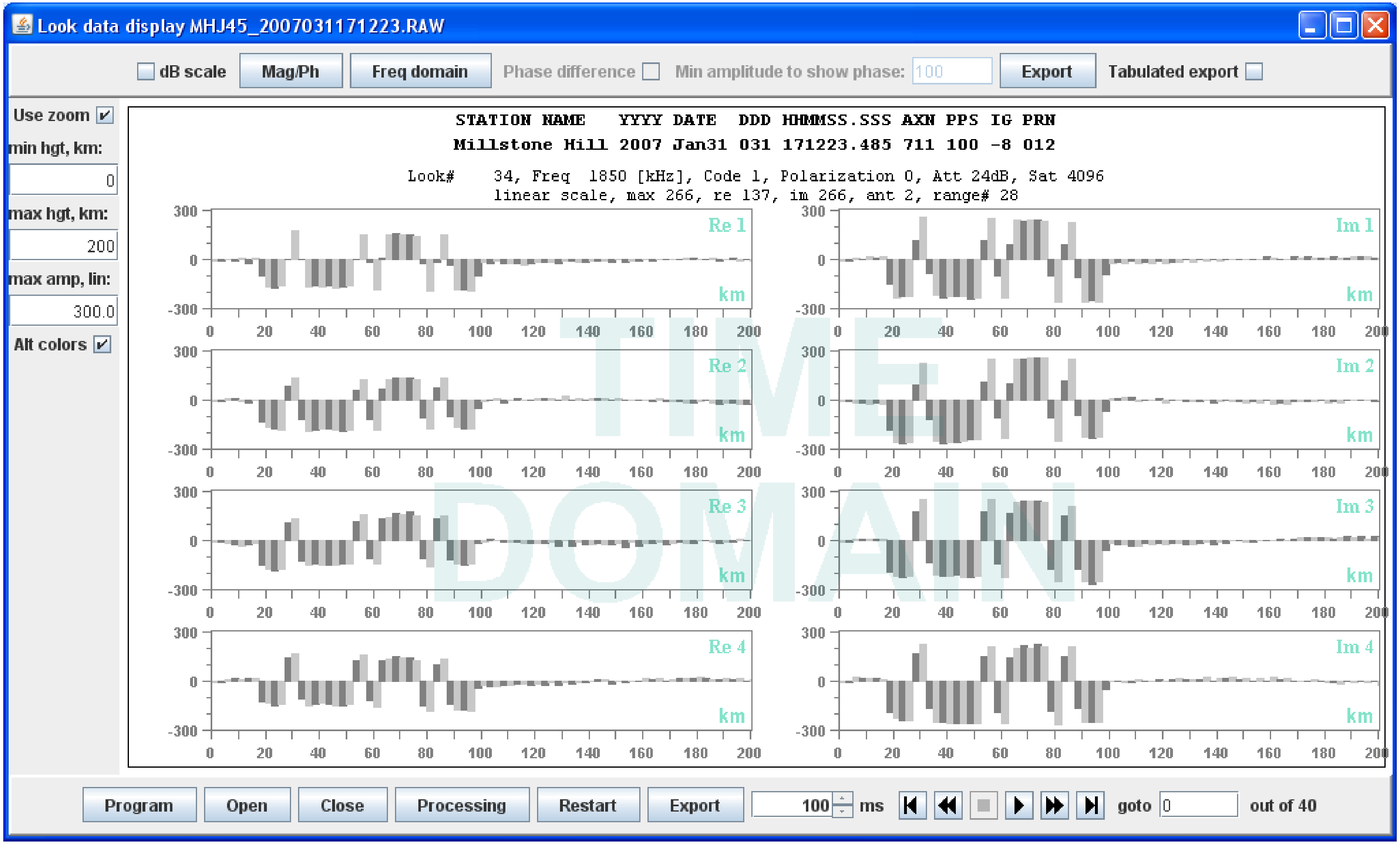
  Frequency domain / Time domain

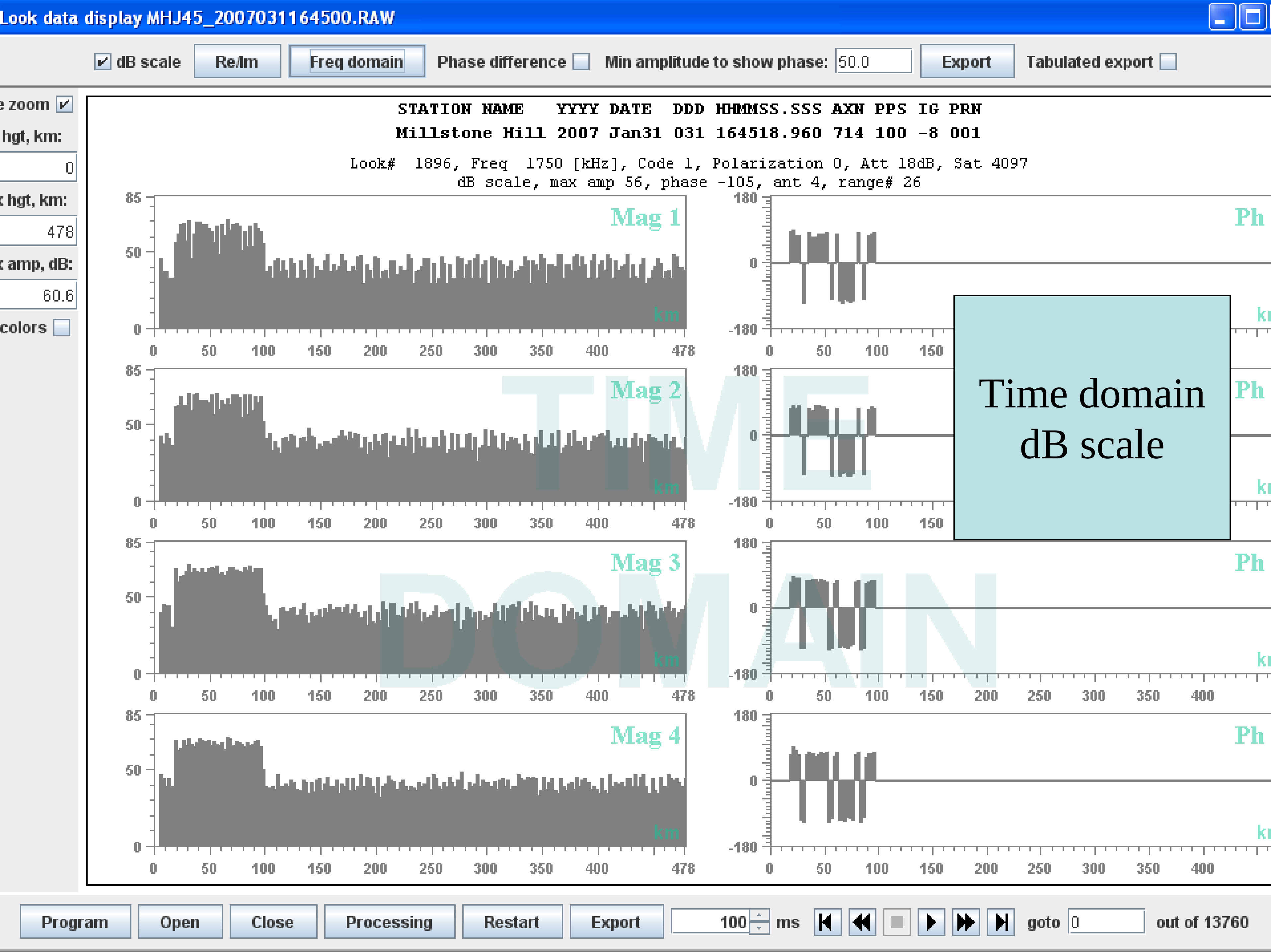
  Real + Imaginary / Amplitude + Phase
- Export:

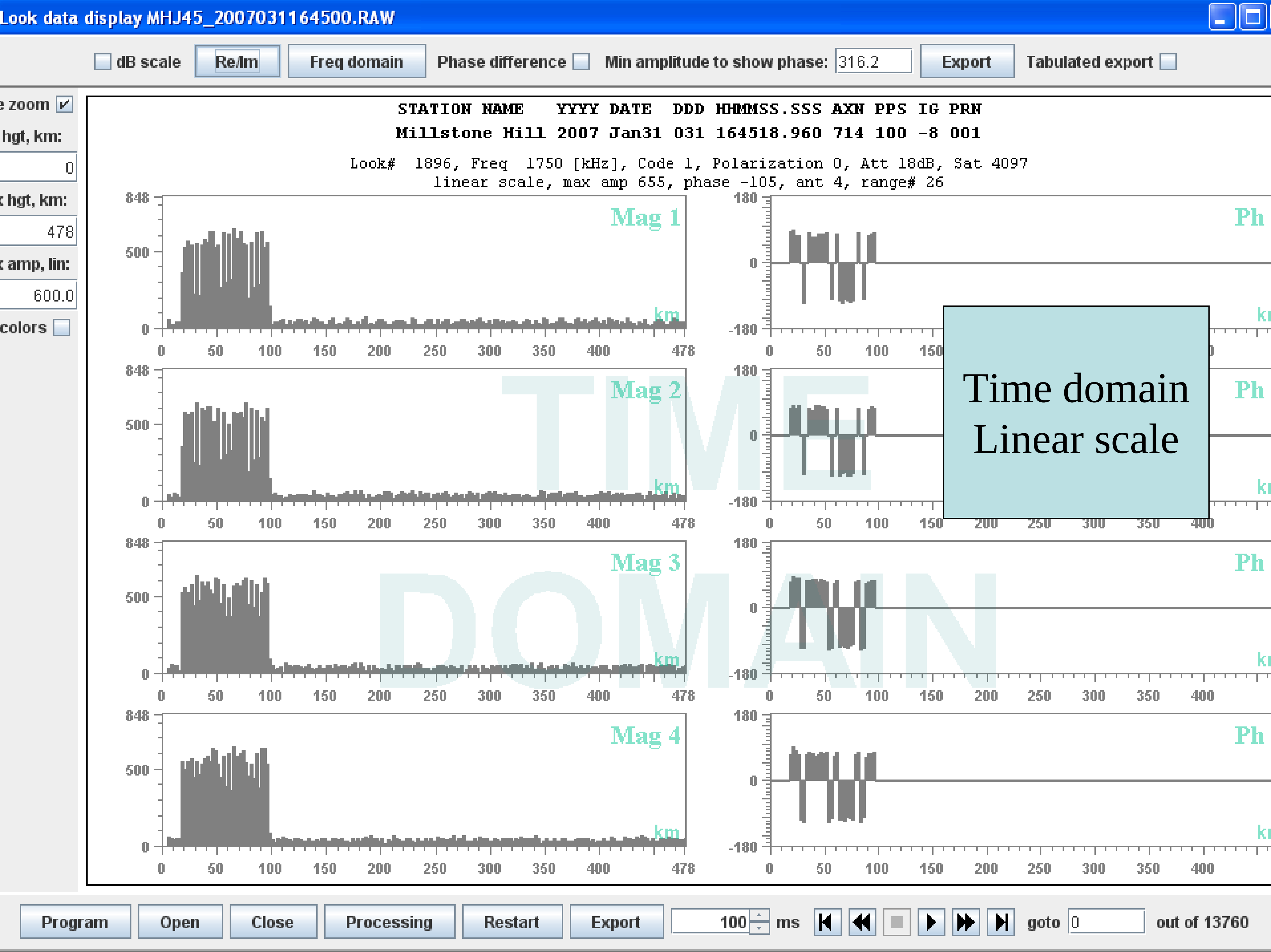
  one look

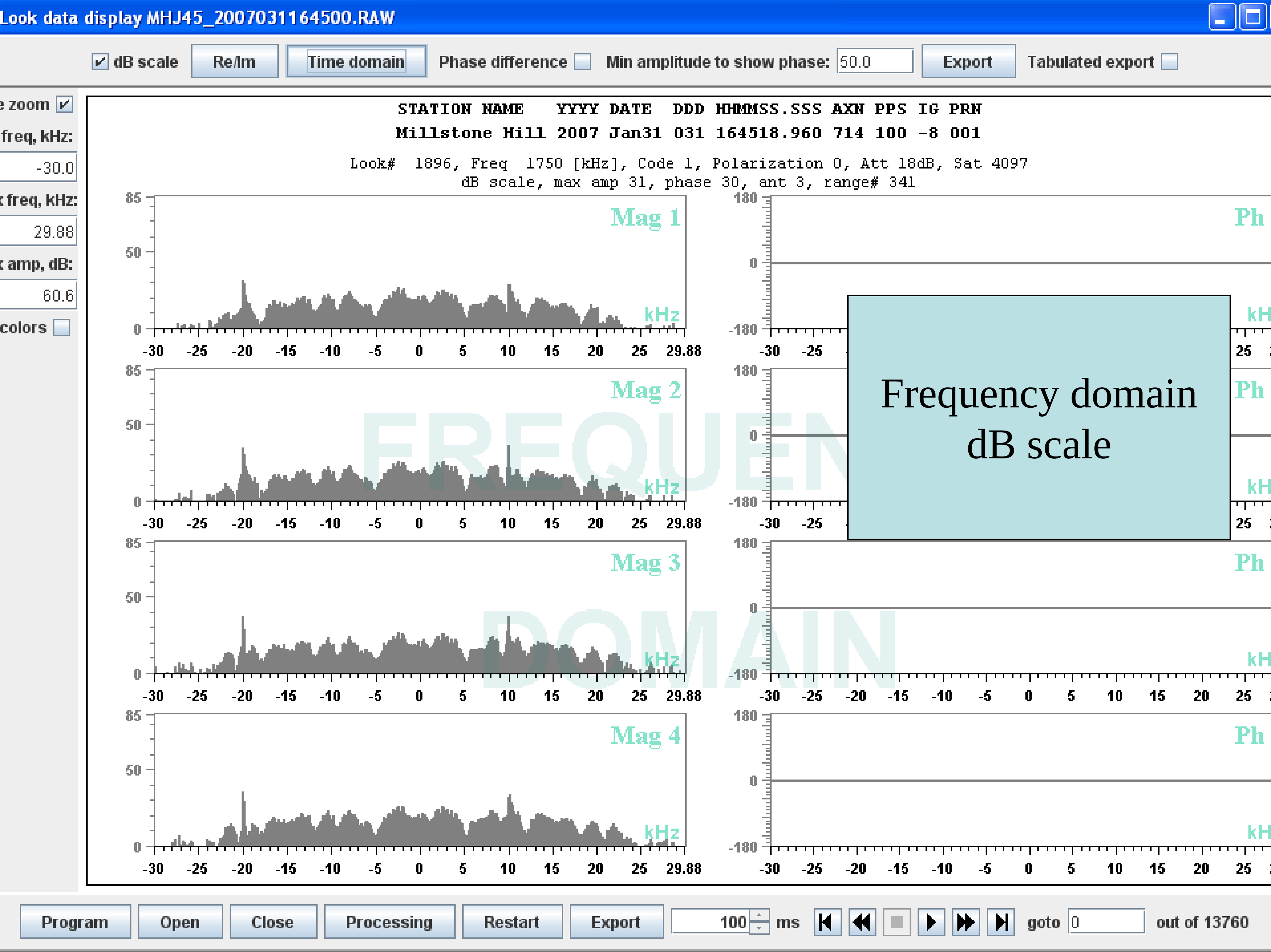
  all looks max/min/average

DCART Visualization Screens (3)




Look data display MHJ45_2007031164500.RAW
dB scale
Re/Im
Freq domain
Phase difference
Min amplitude to show phase:
50.0
Export
Tabulated export
zoom
hgt, km:
0
hgt, km:
478
amp, dB:
60.6
colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
dB scale, max amp 56, phase -105, ant 4, range# 26
Mag 1
Mag 2
Mag 3
Mag 4
Ph
km
Time domain
dB scale
TIME DOMAIN
Program
Open
Close
Processing
Restart
Export
100
ms
goto
0
out of 13760


Look data display MHJ45_20070311164500.RAW
dB scale
Re/Im
Freq domain
Phase difference
Min amplitude to show phase: 316.2
Export
Tabulated export
e zoom
hgt, km:
0
x hgt, km:
478
x amp, lin:
600.0
colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
linear scale, max amp 655, phase -105, ant 4, range# 26
Mag 1
Mag 2
Mag 3
Mag 4
Ph
km
TIME DOMAIN
Time domain
Linear scale
Program
Open
Close
Processing
Restart
Export
100 ms
goto 0
out of 13760


Look data display MHJ45_20070311645OO.RAW
dB scale
Re/Im
Time domain
Phase difference
Min amplitude to show phase: 50.0
Export
Tabulated export
e zoom
freq, kHz:
-30.0
x freq, kHz:
29.88
x amp, dB:
60.6
colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
dB scale, max amp 31, phase 30, ant 3, range# 341
Mag 1
Mag 2
Mag 3
Mag 4
Ph
kHz
FREQUENCY DOMAIN
Frequency domain
dB scale
Program
Open
Close
Processing
Restart
Export
100 ms
goto 0
out of 13760

Generic data format

- **Reusable data structures**
- **Hierarchical structure**
- **Unified reader for all data types**
- **Version of data**

PRINCIPLES

• **Program measurement** is the minimal data unit. Program measurement is uniquely identified by station and start time.

• Program measurement consists of Program header and number of Data Groups

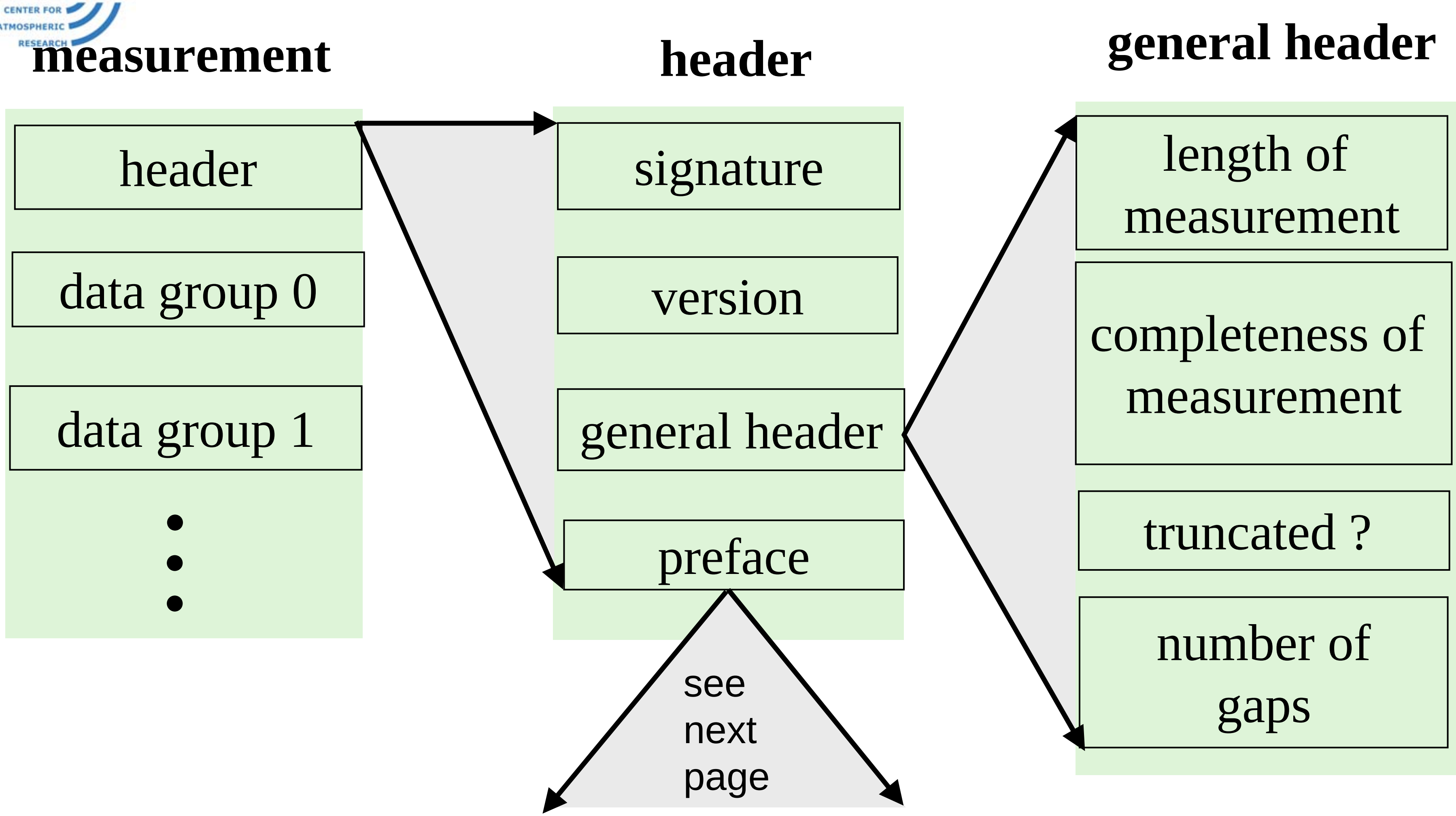
• Data Groups:

1. *Look*, corresponds to raw data acquired by DESC after one series of sampling (and it usually corresponds to one signal transmitting)

2. *Doppler Frequency Group*, corresponds to data unit after *Doppler Calculation Processing Step*

3. *Ionogram Frequency Group*, corresponds to data unit after *Ionogram Calculation Processing Step*

Generic Measurement Data Format



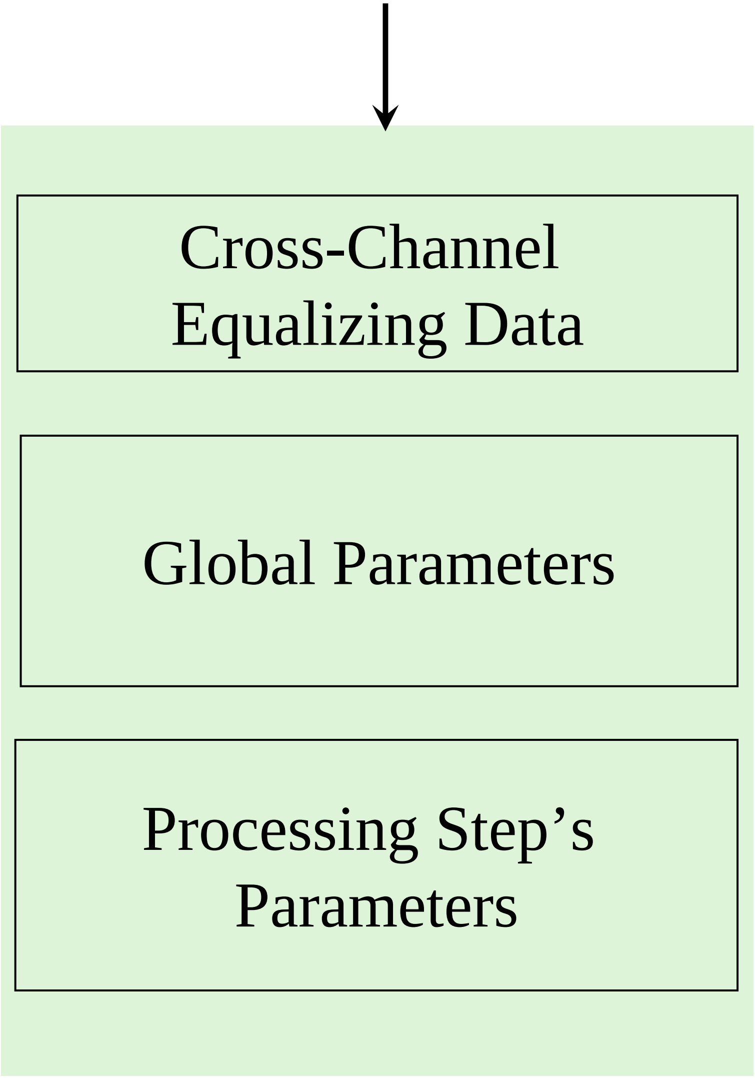
Generic Measurement Data Format (Preface)

- station ID
- start time
- run time, ms
- latitude
- longitude
- URSI code
- station name
- antenna configuration structure
- equip model

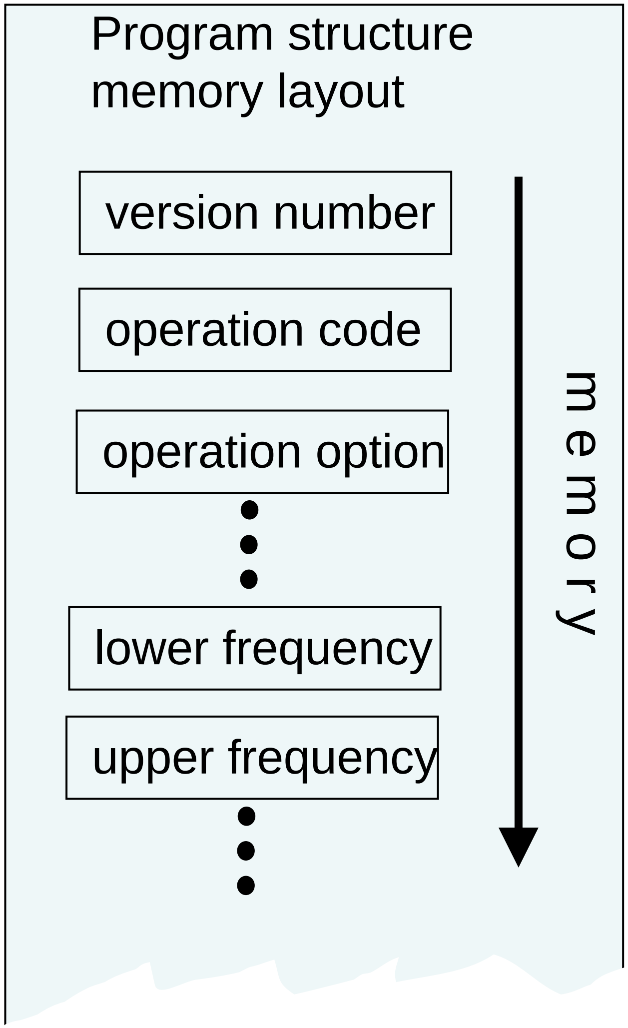
- DESC ver
- DCART ver
- schedule #
- program #
- number of applied proc steps
- array of applied proc step codes

- number of proc steps applied in DESC
- measurement program description structure

Generic Measurement Data Format (Preface)



Versioning mechanism example



Large data structures, like Program data structure, contain its version inside of its content and this version number saved on disk (serialized) as the first element of this data structure.

It gives possibility to tune-up software reading engine on-the-fly when data is retrieving.

Returning to this example, it leaves developers the possibility to change Program structure in the future still having backward compatibility of reading engine.
Of course, maintenance of versioning mechanism for any structure requires quite a bit of developer attention, so only big and versatile structures might be in consideration for this feature.

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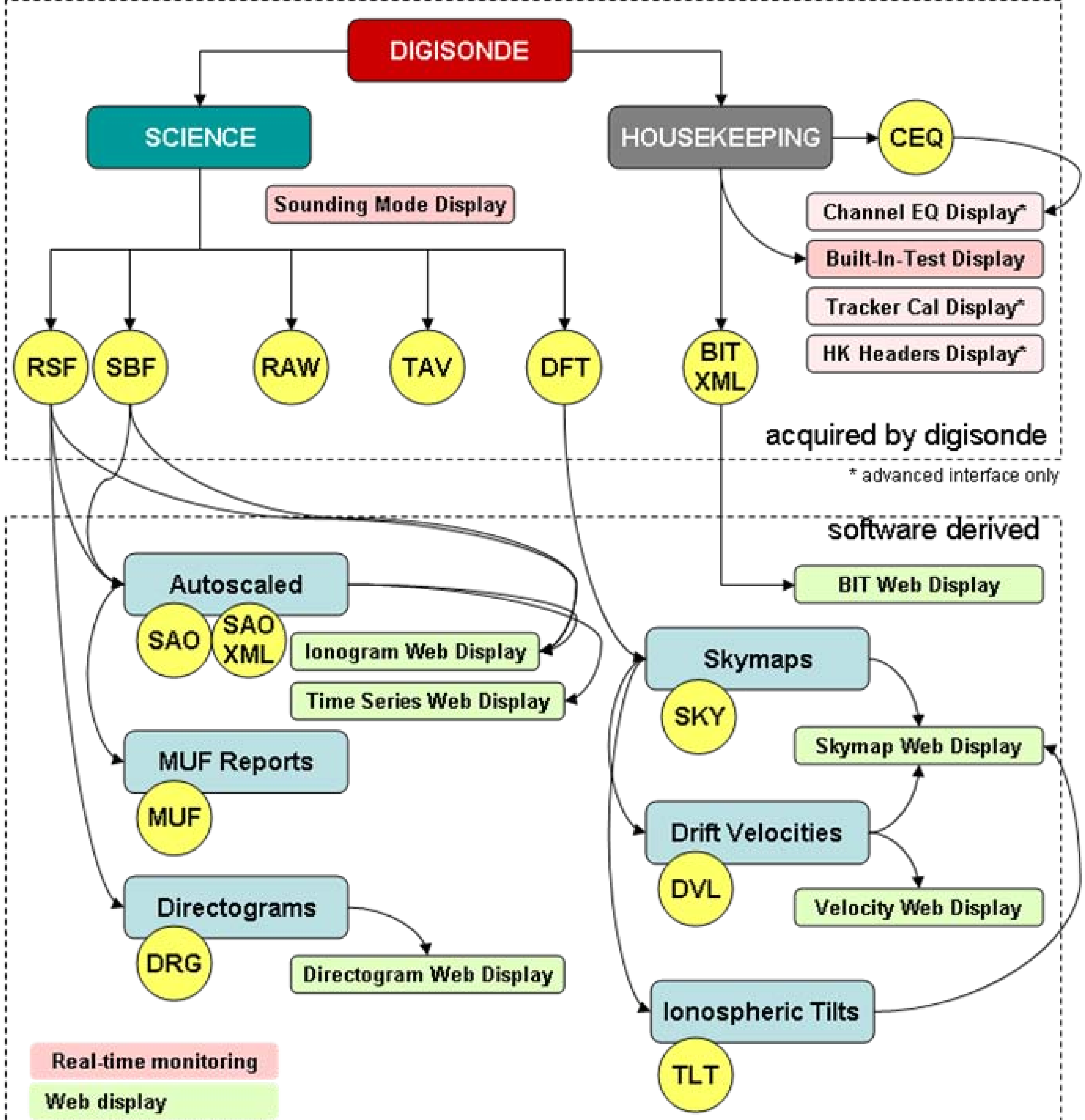
4D DATA PRODUCTS and formats

Dr. Ivan Galkin
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

FILES

REAL-TIME
DCART DISPLAY

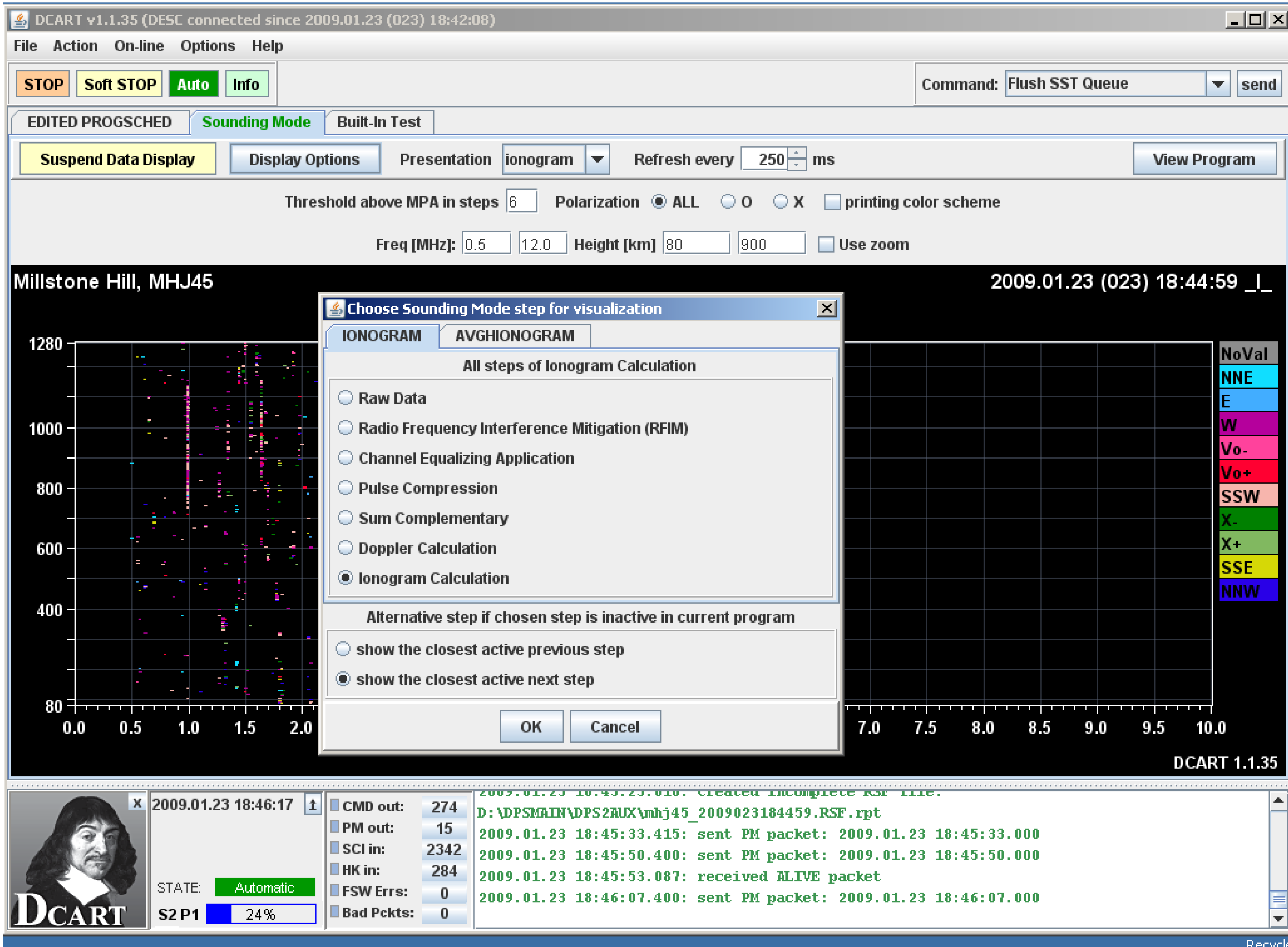
WEB DISPLAY



DCART RT Display: Process Chain

#	Step Contents	Comments
1	RFI Mitigation	optional
2	Cross-channel Equalizing (CCEQ)	optional
3	Pulse Compression	
4	Sum of complementary codes	
5	Doppler spectral analysis	
6	Reduction to ionogram	max Doppler/beam, ionogram mode only

DCART: Step selector



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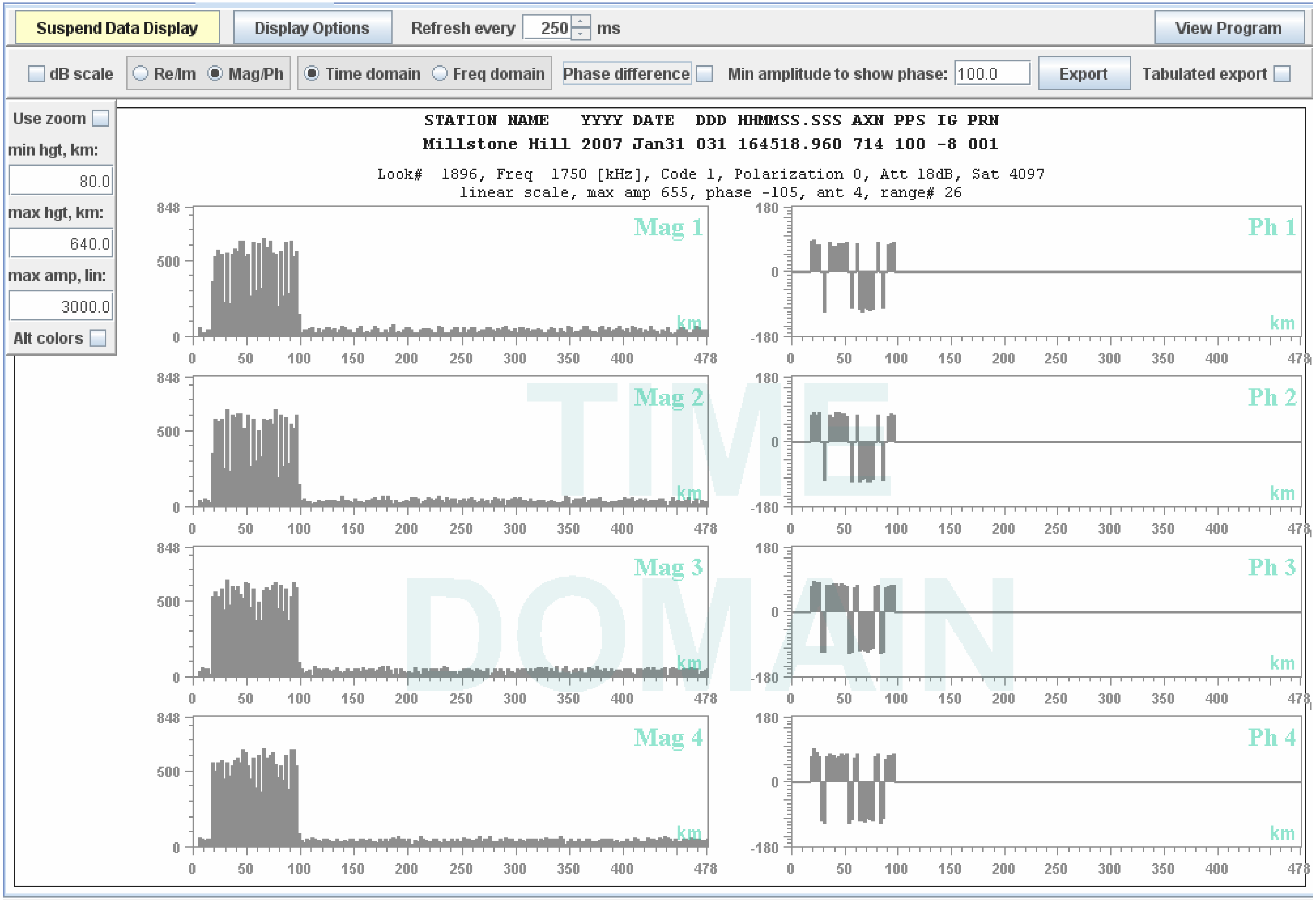
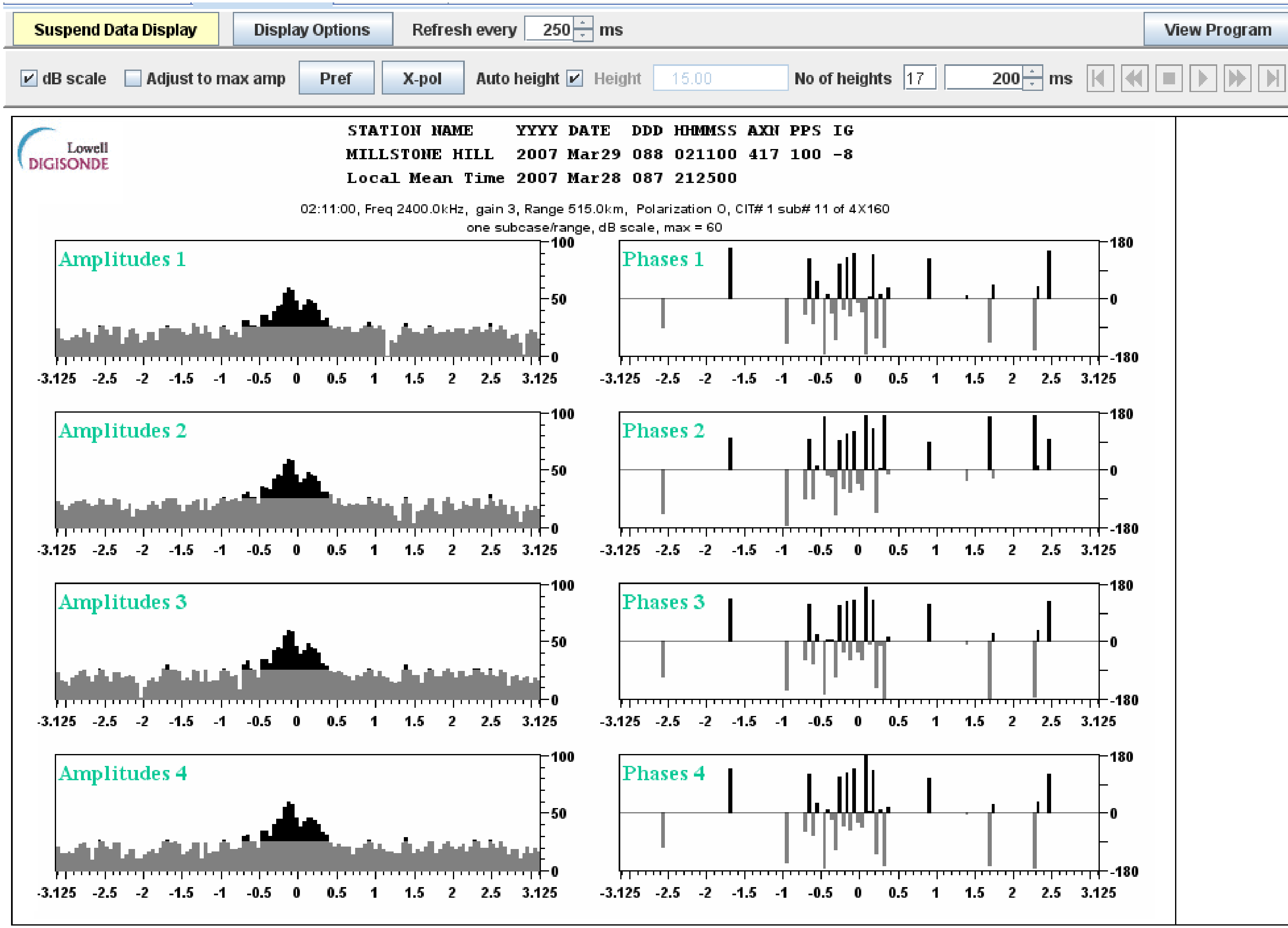
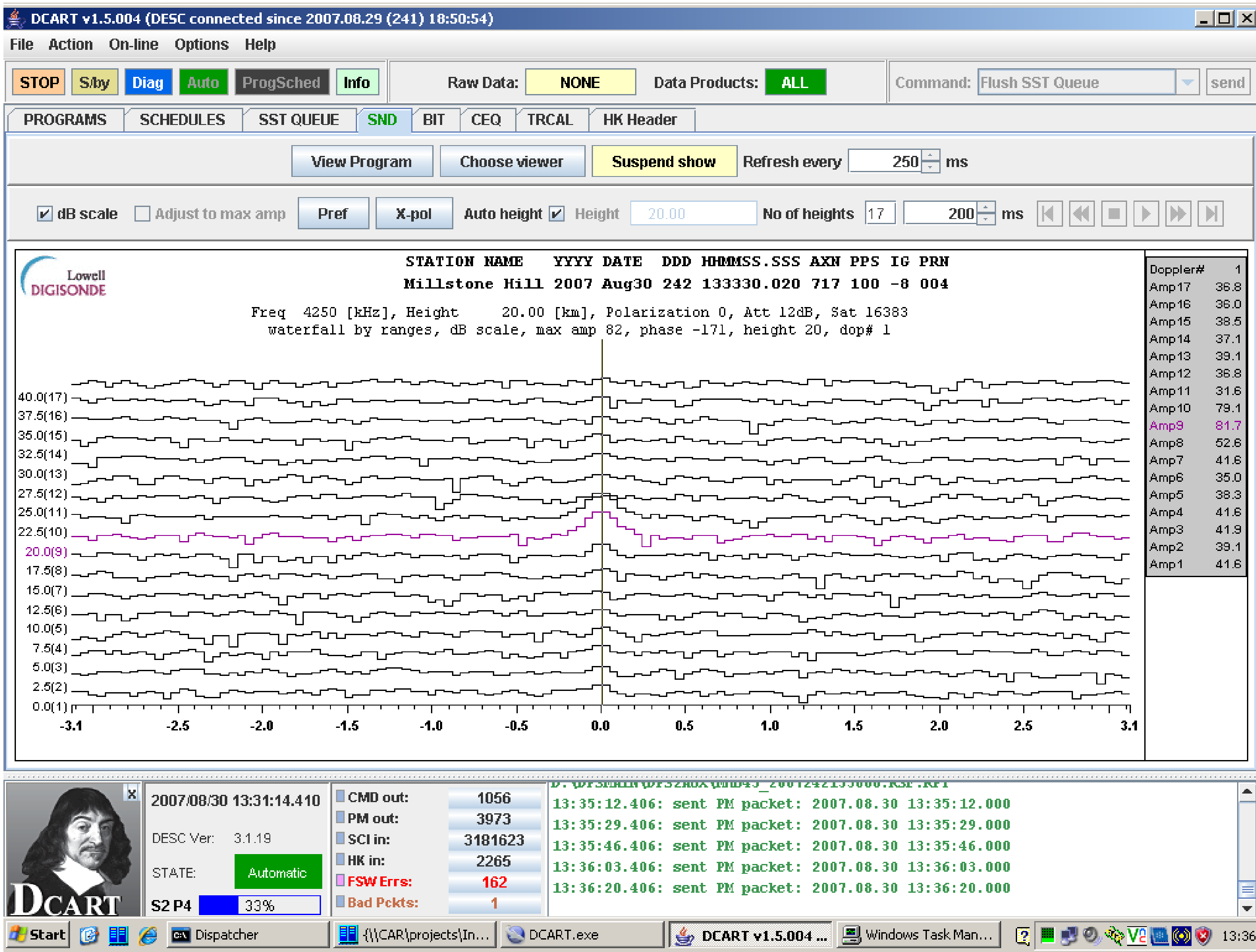
DCART RT Display: Raw



DCART RT Display: Doppler



RT Display: Waterfall



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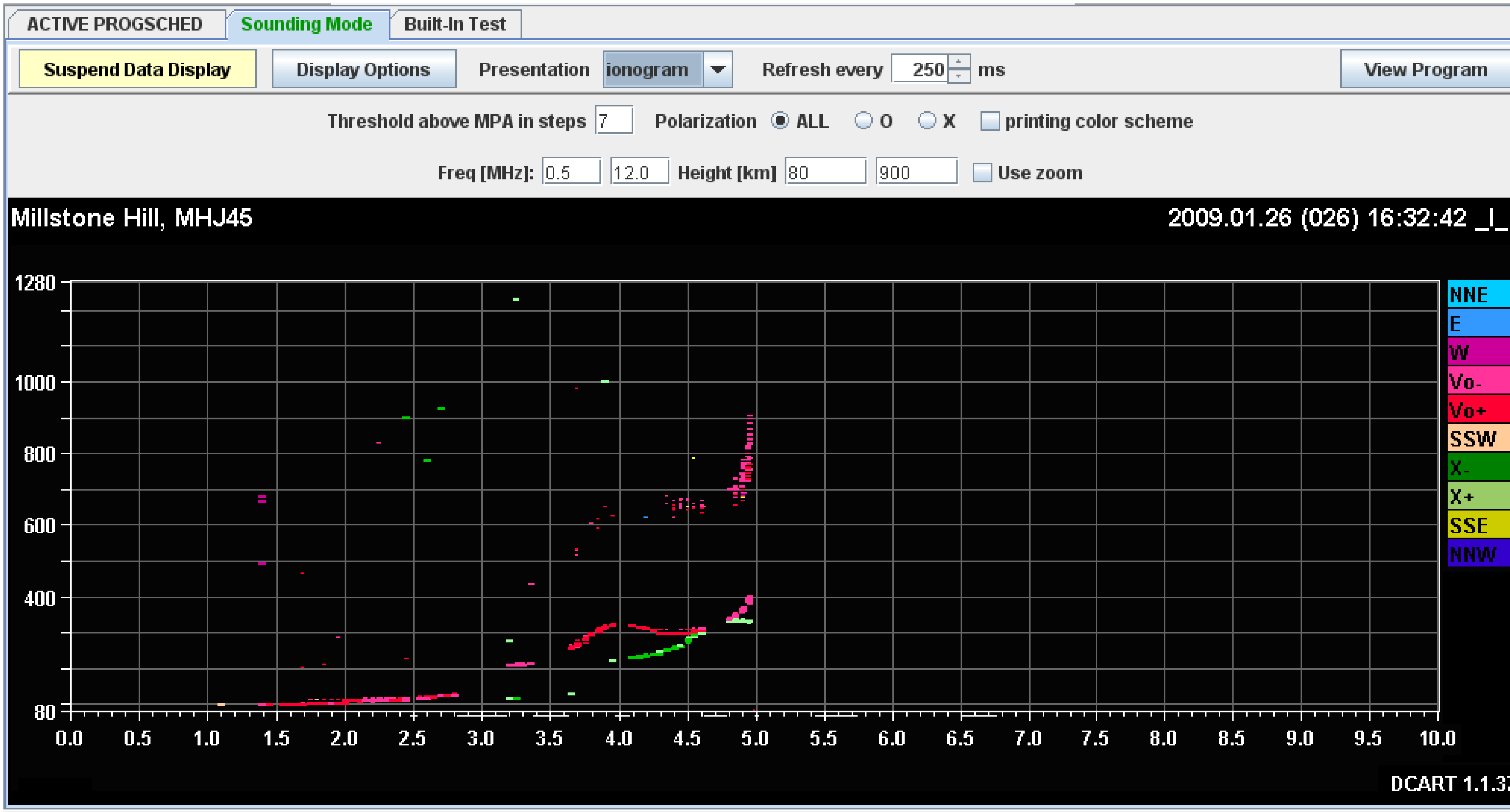
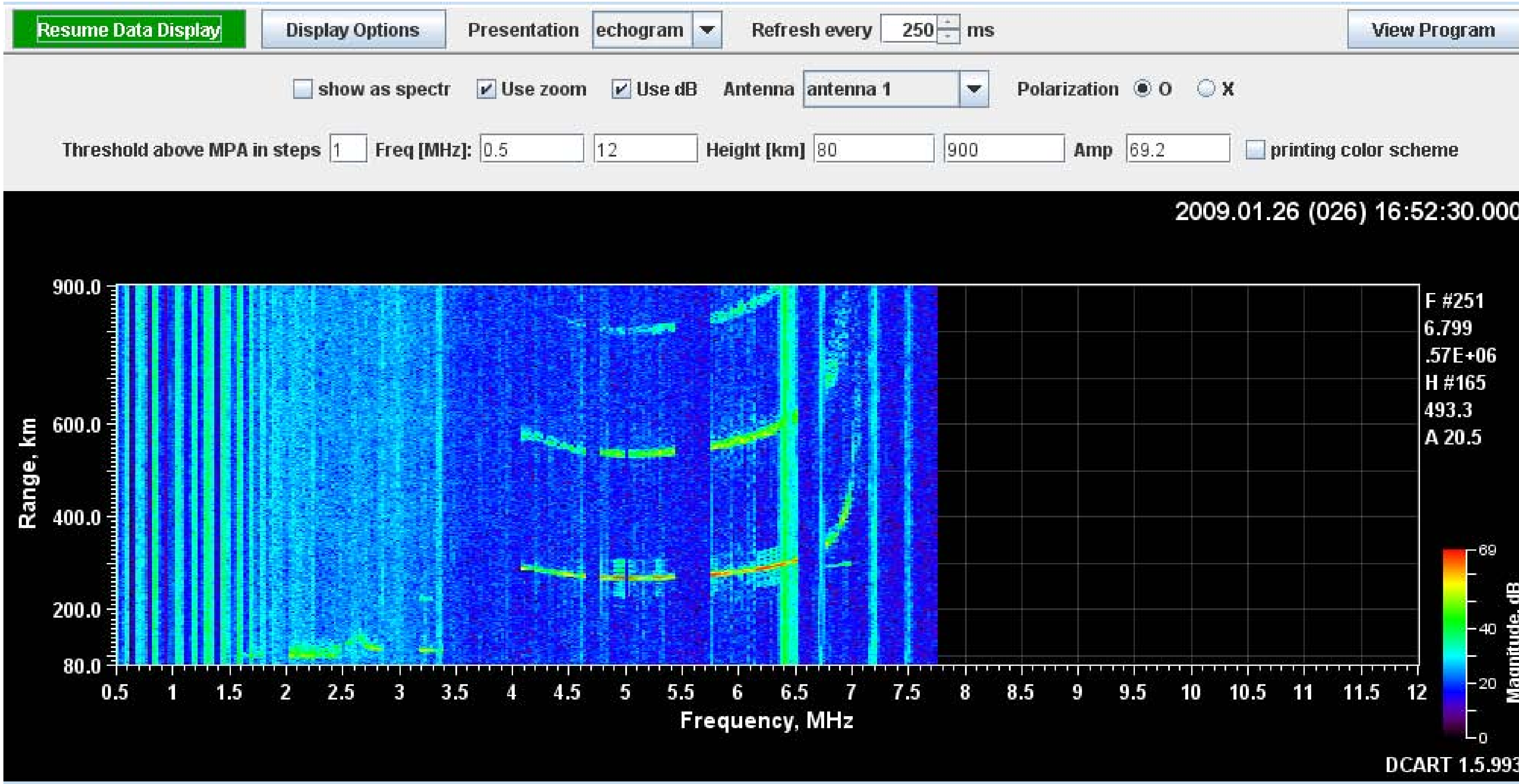
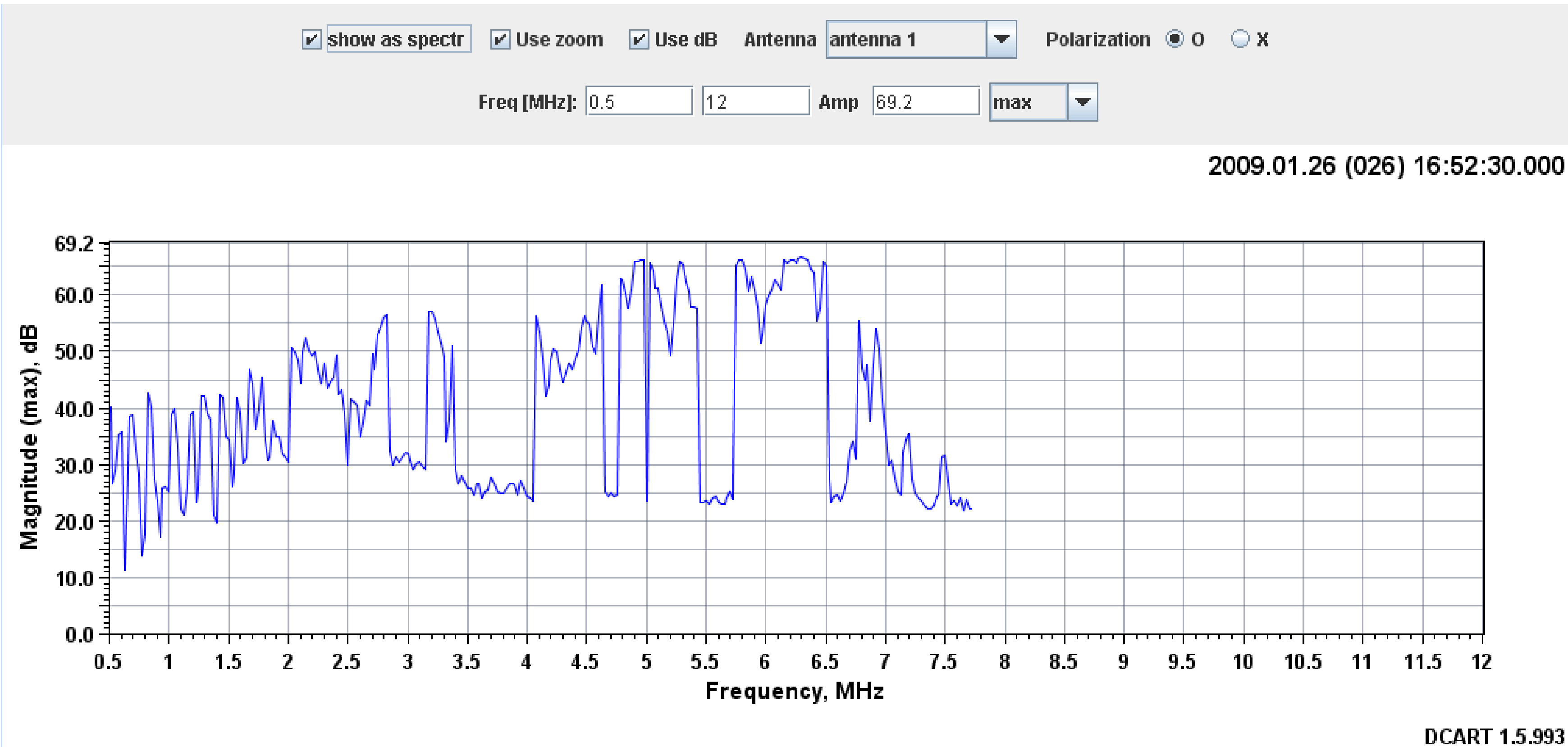
RT Display: Ionogram in progress



RT Display: Echogram



RT Display: Spectrogram



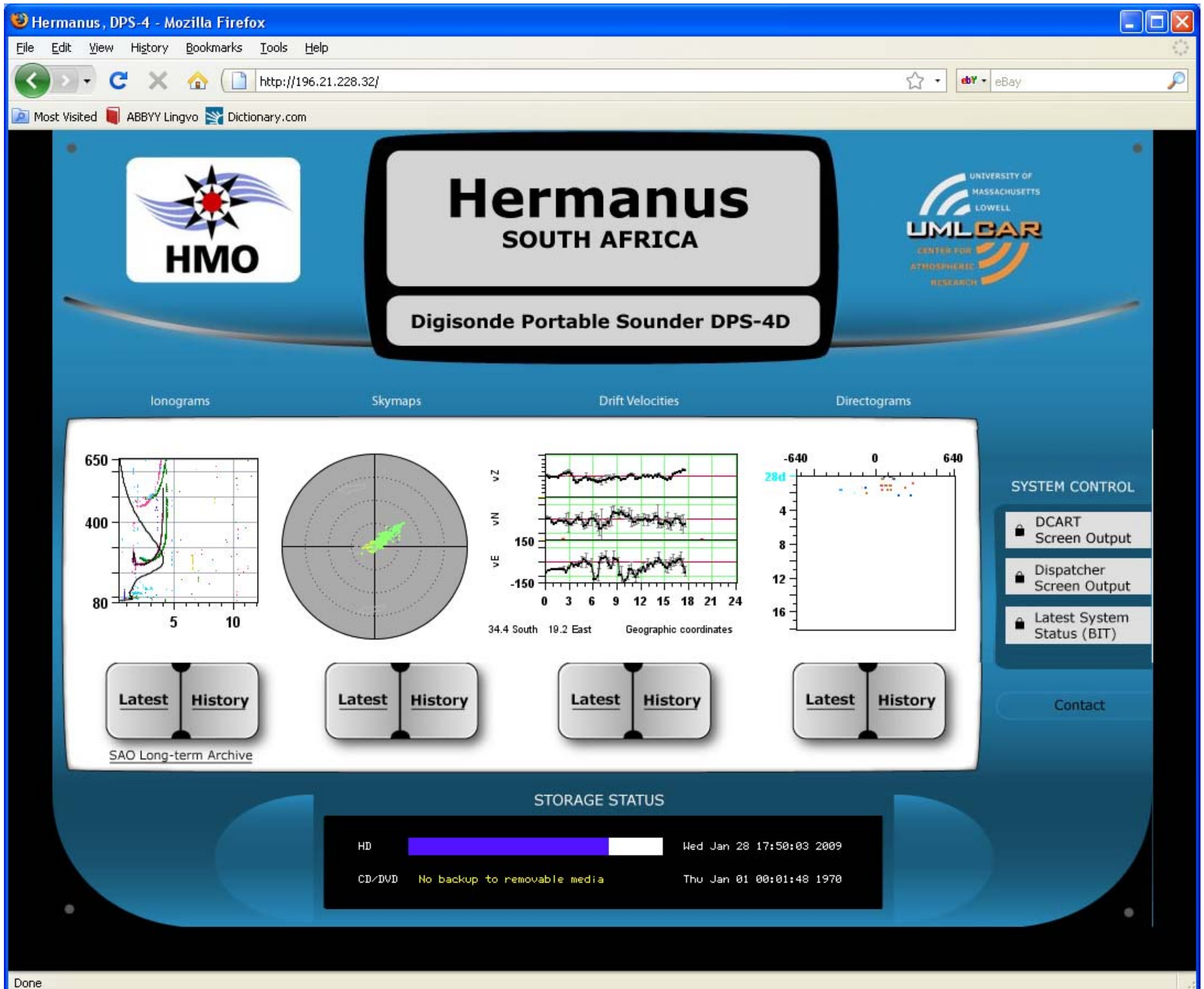
RT Display: BIT

Suspend Data Display | Refresh every 250 ms | View Program

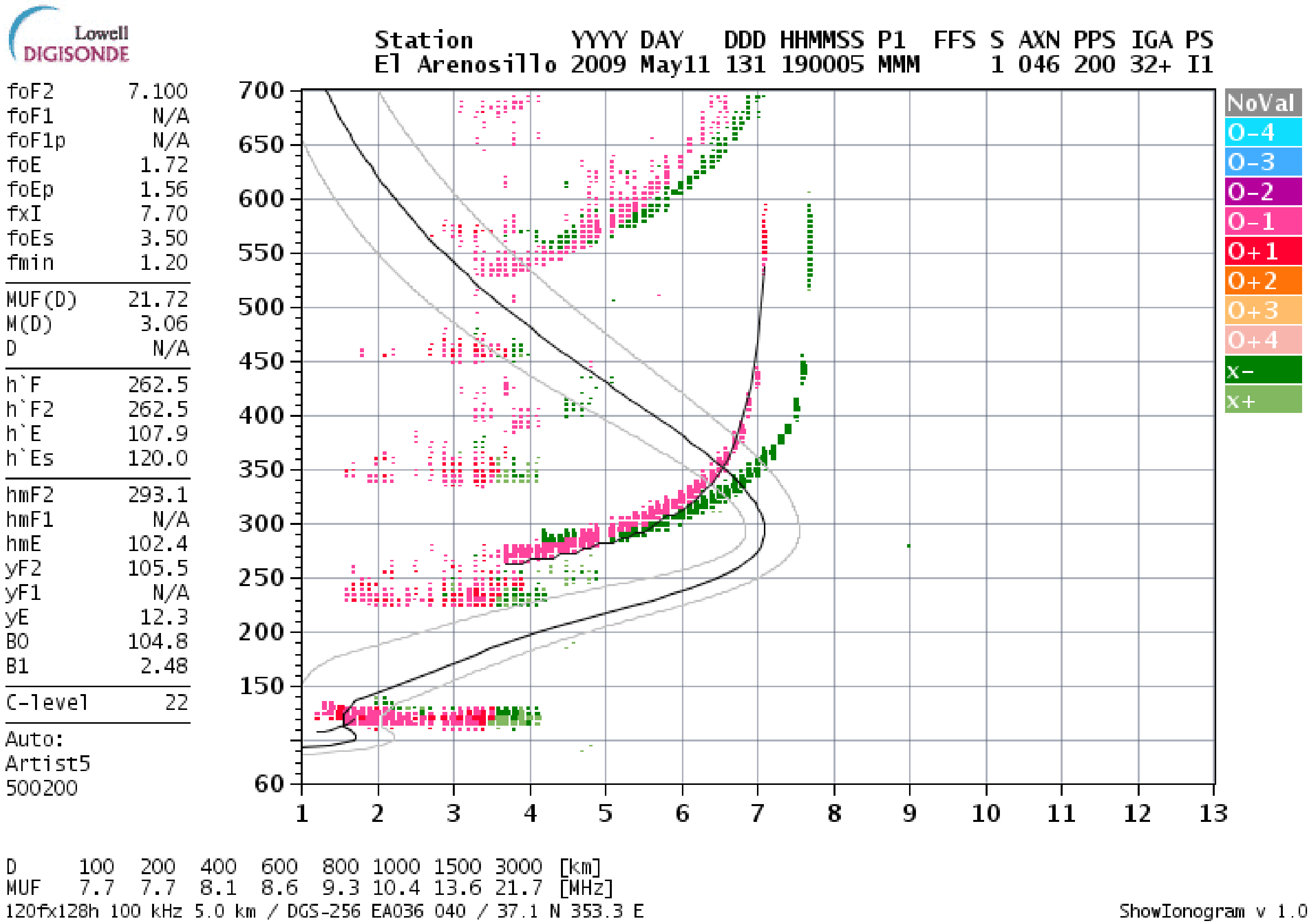
Built-In Test (BIT): 2009/01/26 17:36:59.855 Measurement | Show all | Failed | Report | Sys br

↑ Mnemonic	Sensor	Raw	Phys	Units	GO	R low	Y low	Y high	R high	Comment
SA00_AMP_TP	Lower chassis °C	355	33.654	°C	GO	1	1	45	50	Temperature sensor in lower chassis
SA01_PWR_TP	Upper chassis °C	440	29.529	°C	GO	1	1	45	50	Temperature sensor in upper chassis
SA04_TIM_DATACLK_FR	UpConv data clock	0	0	kHz	GO	0	0	1,023	1,023	Upconverter Data I+Q Clock Frequency
SA05_TIM_PARPORT_FR	ParPort clock	0	0	kHz	GO	0	0	1,023	1,023	Parallel port timing clock
SD00_PWR_PREAMP_V	Pwr Preamp V	1			GO					Preamplifier power
SD01_PWR_M15_V	Pwr -15V	1			GO					-15 Volt power
SD02_PWR_M5_V	Pwr -5V	0			GO					-5 Volt power
SD03_PWR_P3_V	Pwr +3.3V	1			GO					+3.3 Volt power
SD04_PWR_P15_V	Pwr +15V	1			GO					+15 Volt power
SD05_PWR_P12_V	Pwr +12V	1			GO					+12 Volt power
SD06_PWR_OVER_TP	Pwr overheat	1			GO					Power card overheating condition
SD07_PREP_HW_TESTPAT	HW Test Pattern	1			GO					Preprocessor HW test pattern
SD08_TX_CARD_TIMEOU...	Tx card Timeouts	0			GO					Tx Card Commanding Timeouts since last BIT program
SD09_PWR_P18_V	Pwr +18V	1			GO					+18 Volt power
SD10_CMD_TIMEOUTS	Cmd Timeouts	0			GO					Commanding Timeouts from last BIT program
SD11_RF_NOISE_LOW_V	RF noise low	1			NOGO					Environmental RF noise voltage in Antenna with 0 dB gain...
SD12_RF_NOISE_HIGH_V	RF noise high	0			GO					Environmental RF noise voltage in Antenna with 9 dB gain...
SD13_RX_CARD_TIMEOU...	Rx Card Timeouts	0			GO					Rx Card Commanding Timeouts since last BIT program
SD14_TRACKER1_CARD_...	TRACKER1 Card ...	0			GO					TRACKER1 Card Commanding Timeouts since last BIT p...
SD15_TRACKER2_CARD_...	TRACKER2 Card ...	0			GO					TRACKER2 Card Commanding Timeouts since last BIT p...
SD16_TRACKER3_CARD_...	TRACKER3 Card ...	0			GO					TRACKER3 Card Commanding Timeouts since last BIT p...
SD17_TRACKER4_CARD_...	TRACKER4 Card ...	0			GO					TRACKER4 Card Commanding Timeouts since last BIT p...
SD18_BIT_CARD_TIMEOU...	BIT Card Timeouts	0			GO					BIT Card Commanding Timeouts since last BIT program
1_DA00_AMP_RF1_V	Amp RF1 V	419	229.441	V	GO	200	225	425	450	RF voltage amplitude at the output of amplifier 1
1_DA01_AMP_RF2_V	Amp RF2 V	421	230.211	V	GO	200	225	425	450	RF voltage amplitude at the output of amplifier 2
1_DA02_TX_OUT1_V	Tx Out1 V	703	4.176	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 1
1_DA03_TX_OUT2_V	Tx Out2 V	695	4.164	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 2
1_DA04_RX_MAX1	Rx Max1	297	297		NOGO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 1
1_DA05_RX_MAX2	Rx Max2	398	398		NOGO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 2

Web Display: Homepage



Web Display : Ionogram



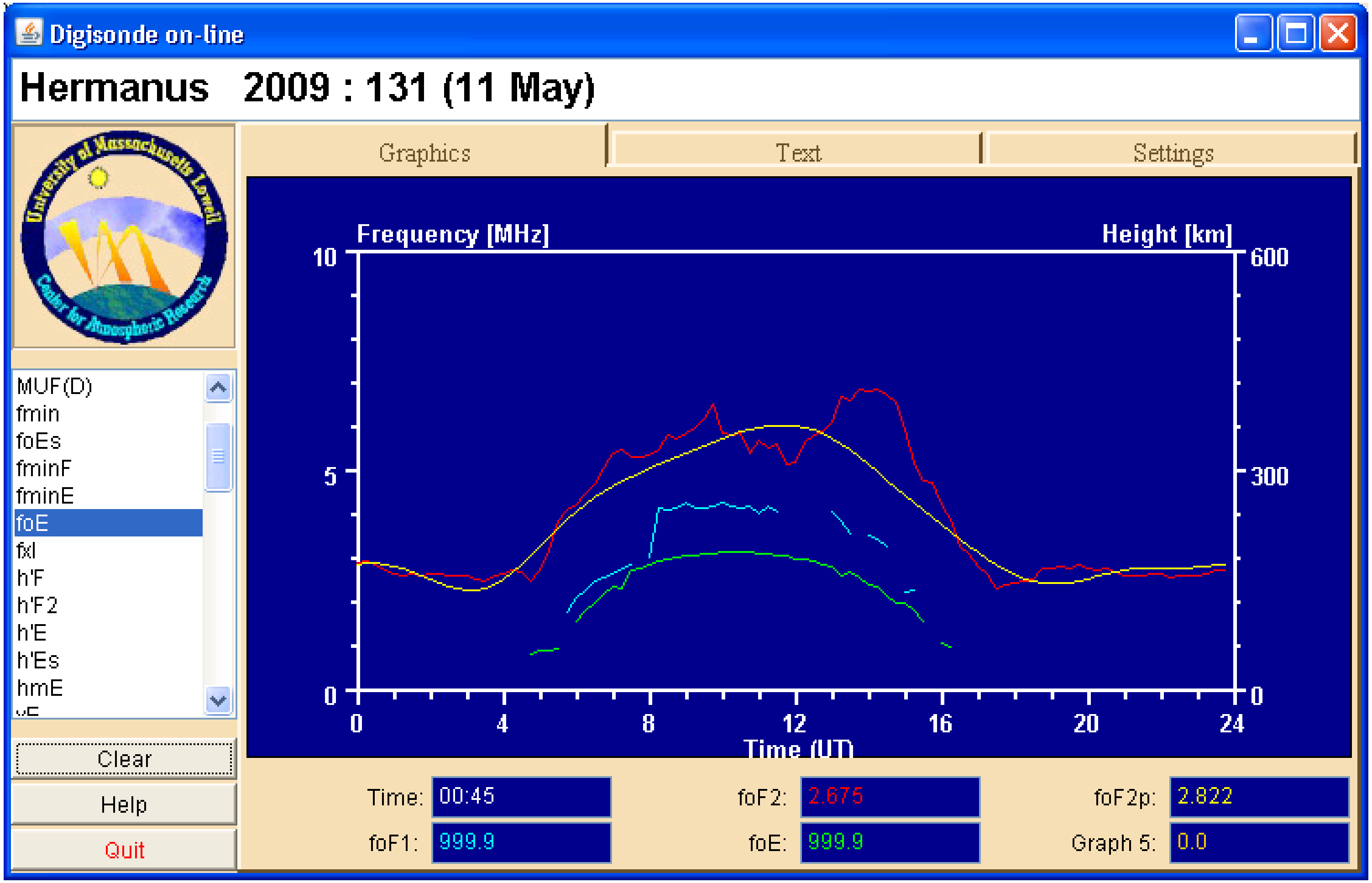
RSF

SBF

SAO

SAO XML

Web Display: Time Series



SAO

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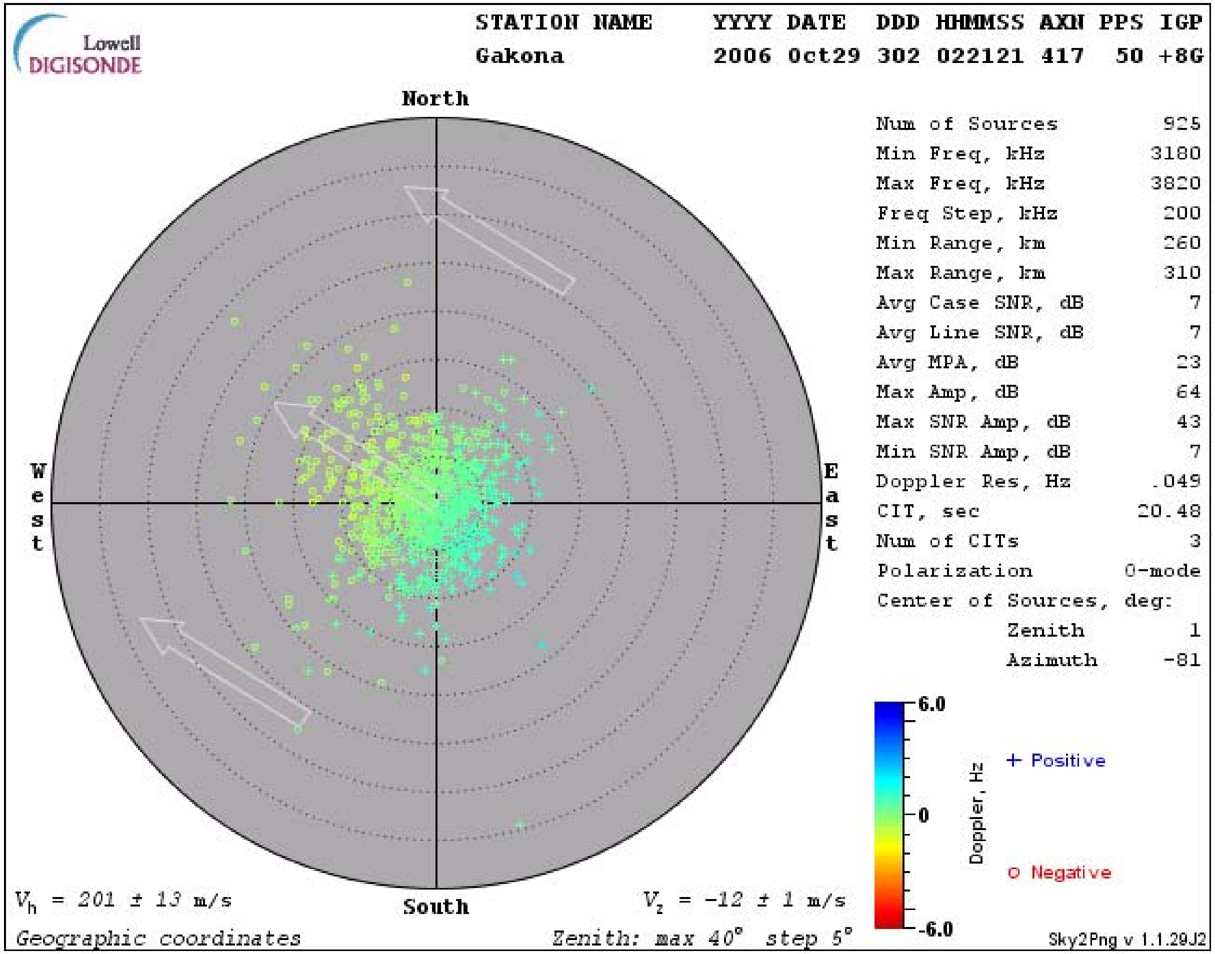
Web Display: Skymap

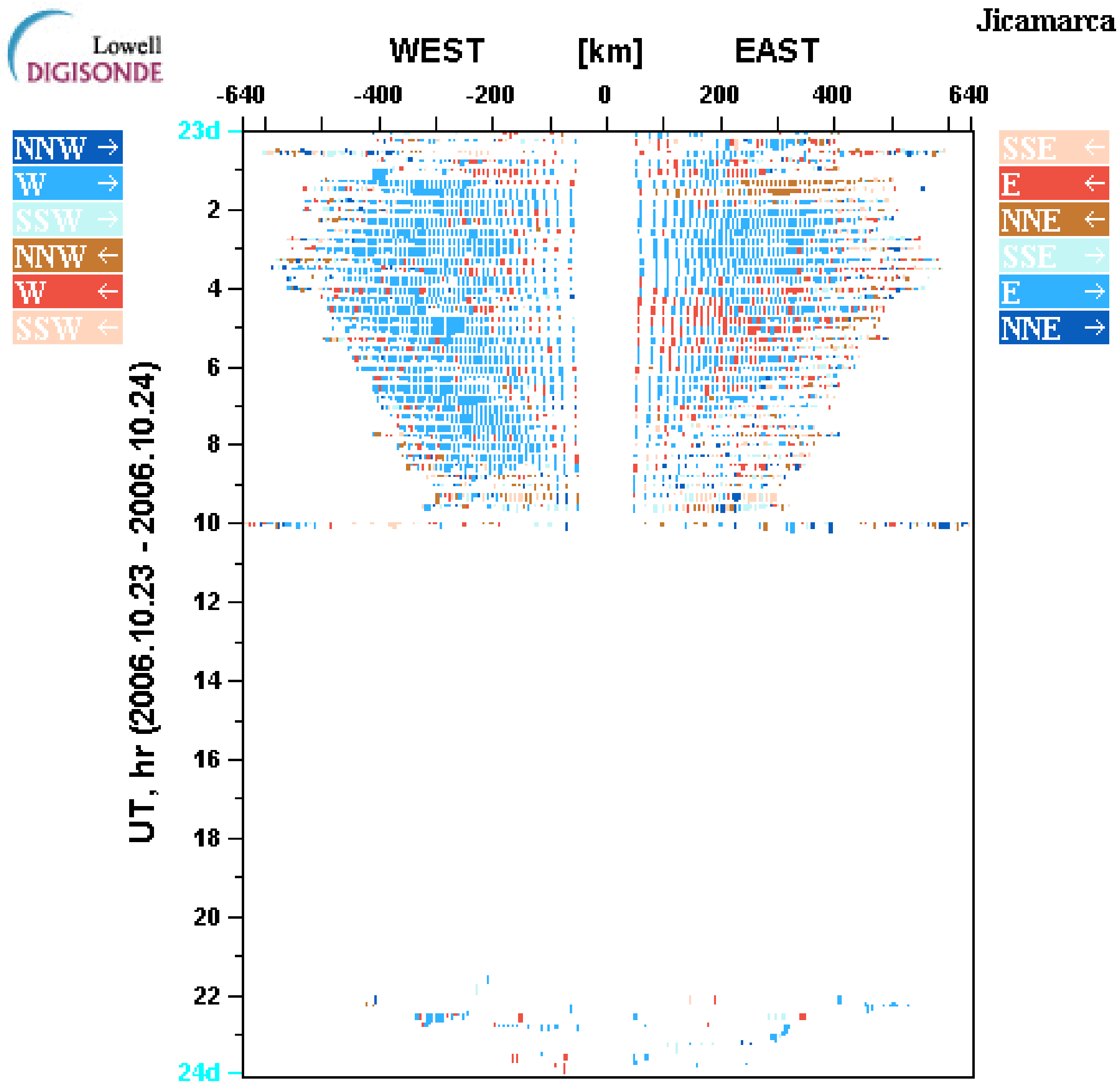


SKY

DVL

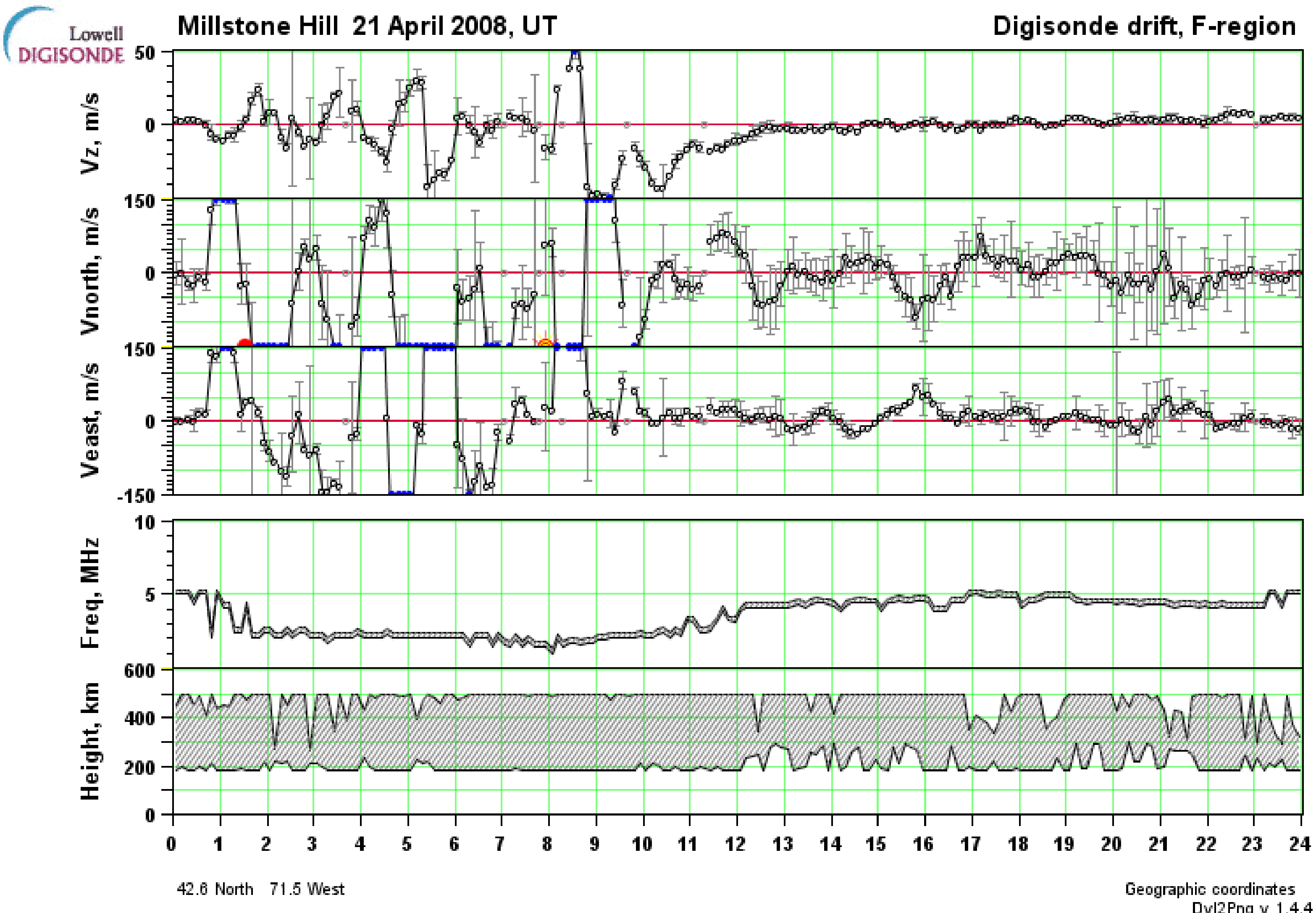
TLT

Web Display: Directogram



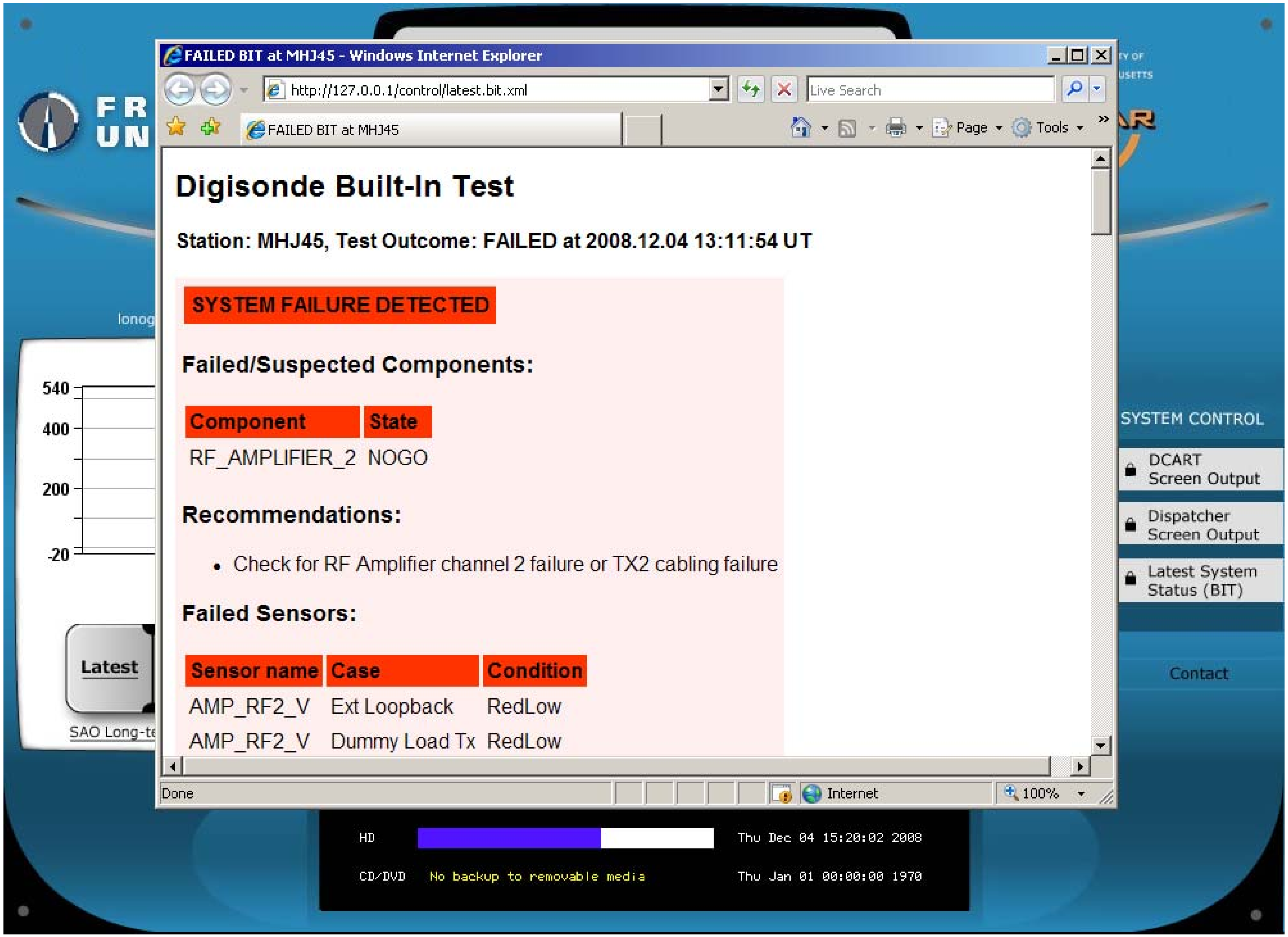
RSF

Web Display: Daily Velocity Plot



DVL

Web Display: BIT



BIT XML

Basic operations with DCART

Grigori Khmyrov
University of Massachusetts Lowell, Center for Atmospheric Research

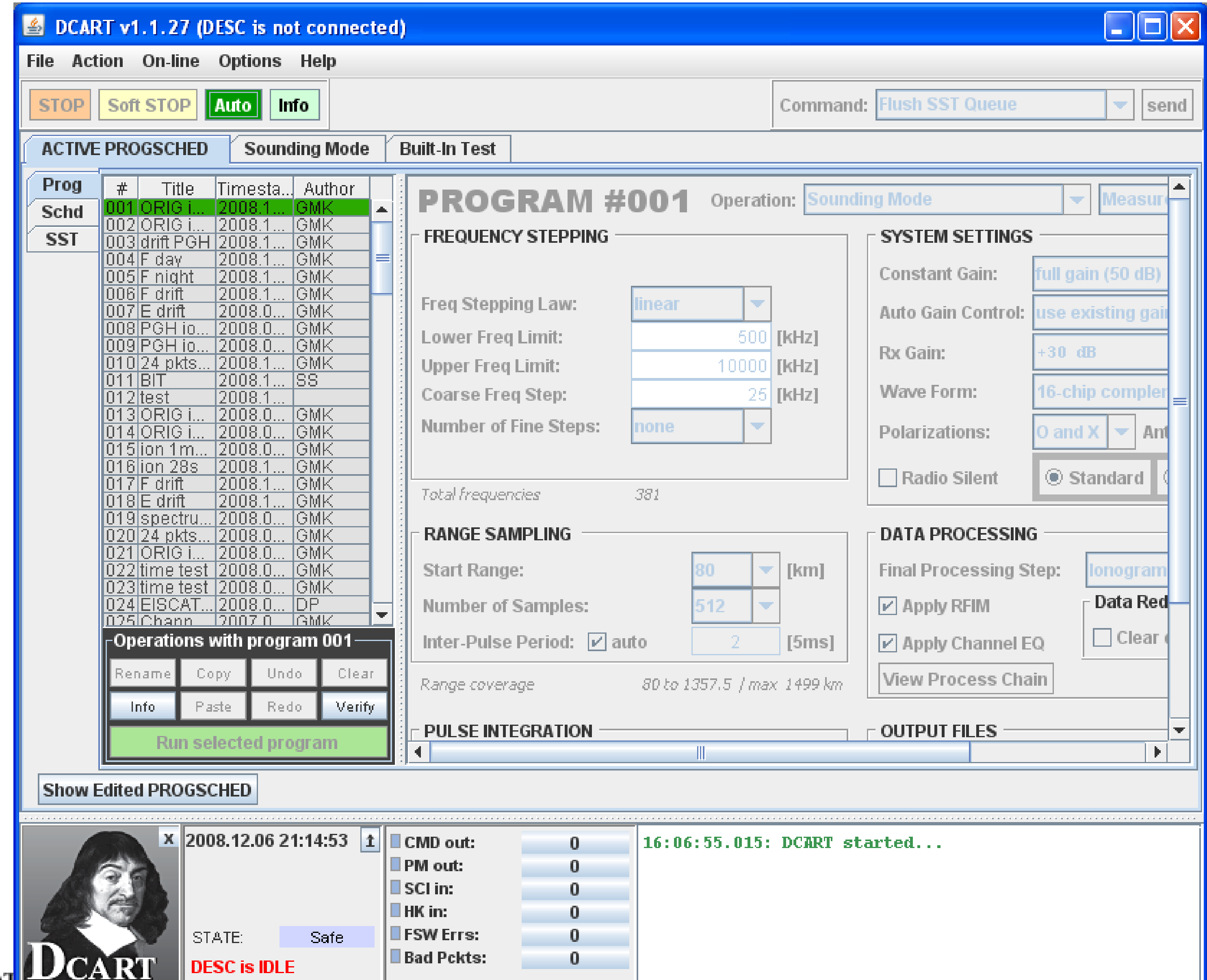
2009 IDF
XII International Digisonde Forum
11 - 14 May 2009

DCART Normal Mode

Auto

STOP

Soft STOP



Basic Ionogram Program (1)

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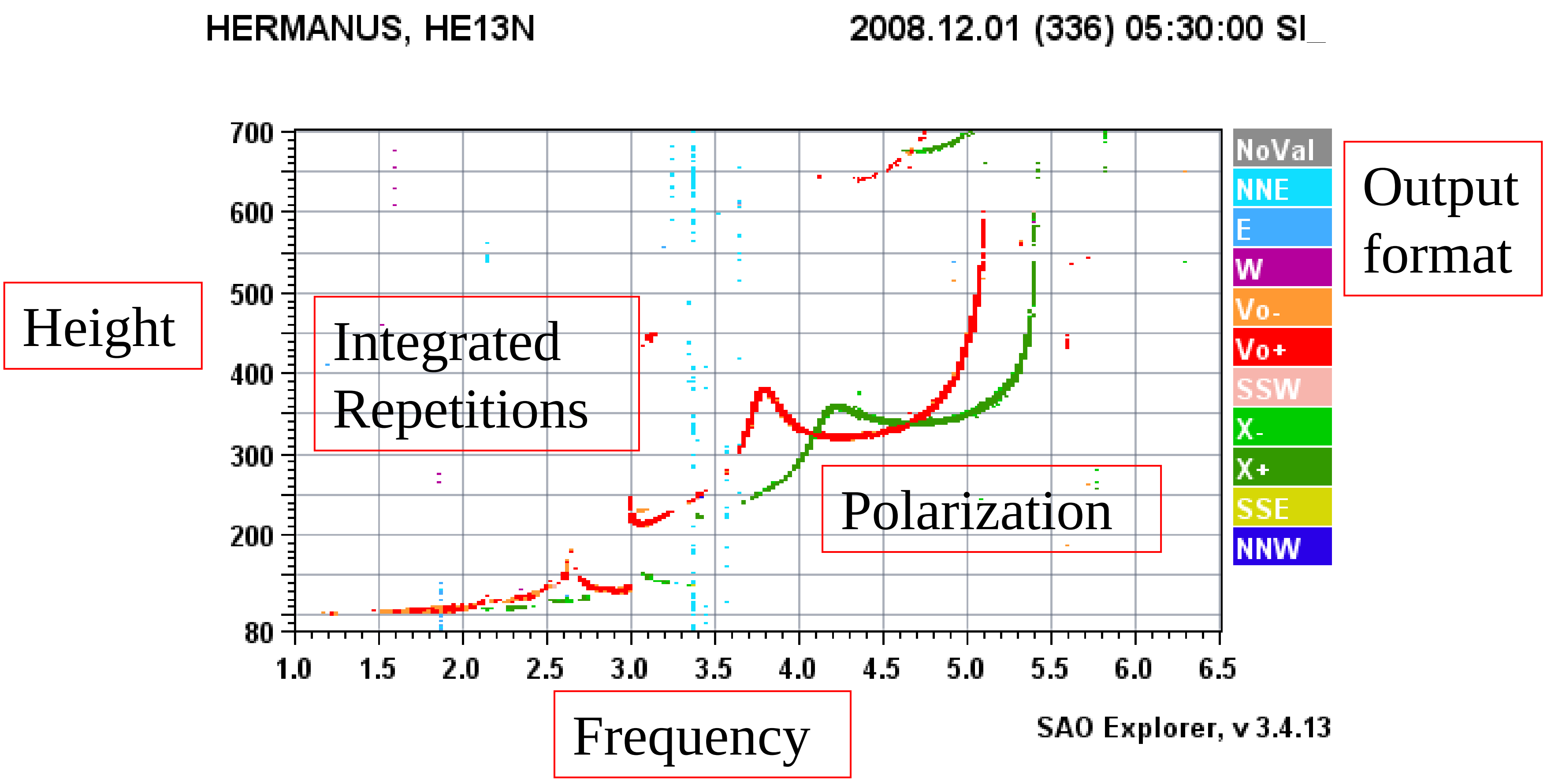
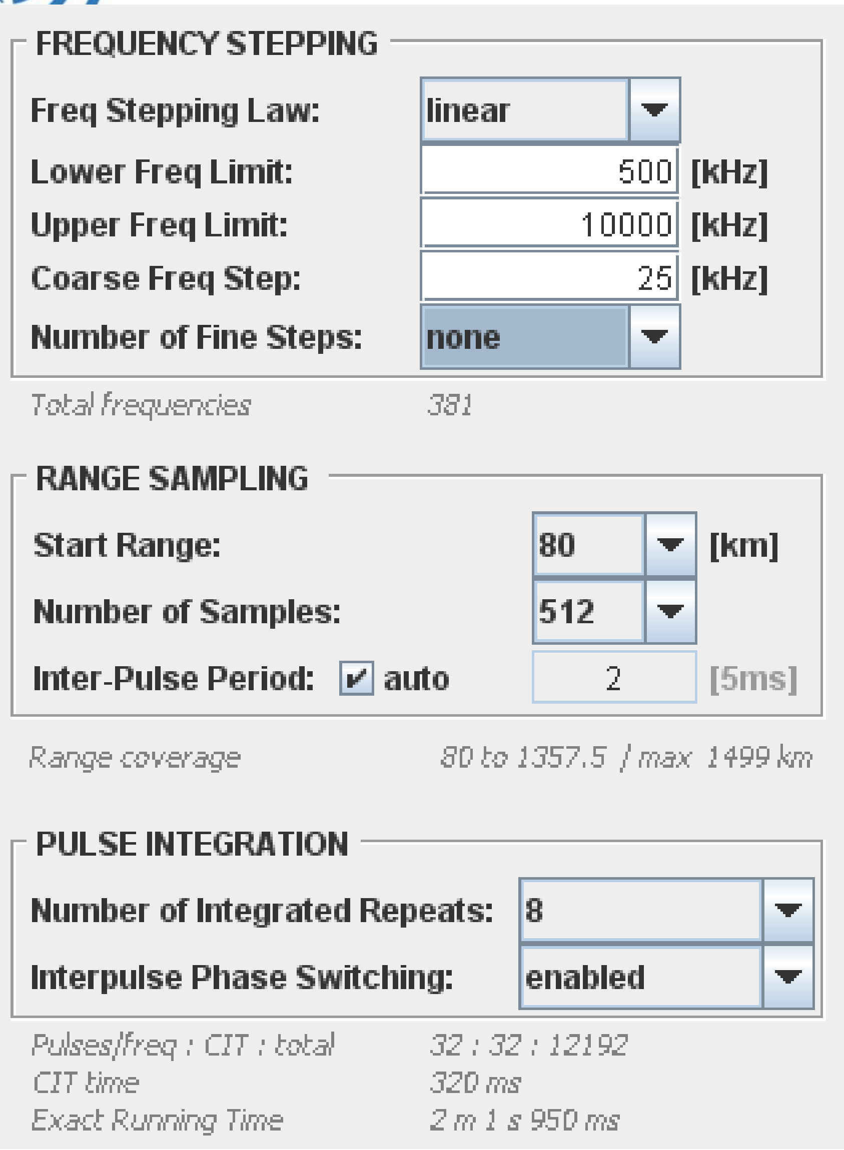


Basic Ionogram Program (2)



> **Frequency stepping**

Only linear recommended

Recommended step 25 kHz

> **Range (height)**

Start range 0 km, 80 km

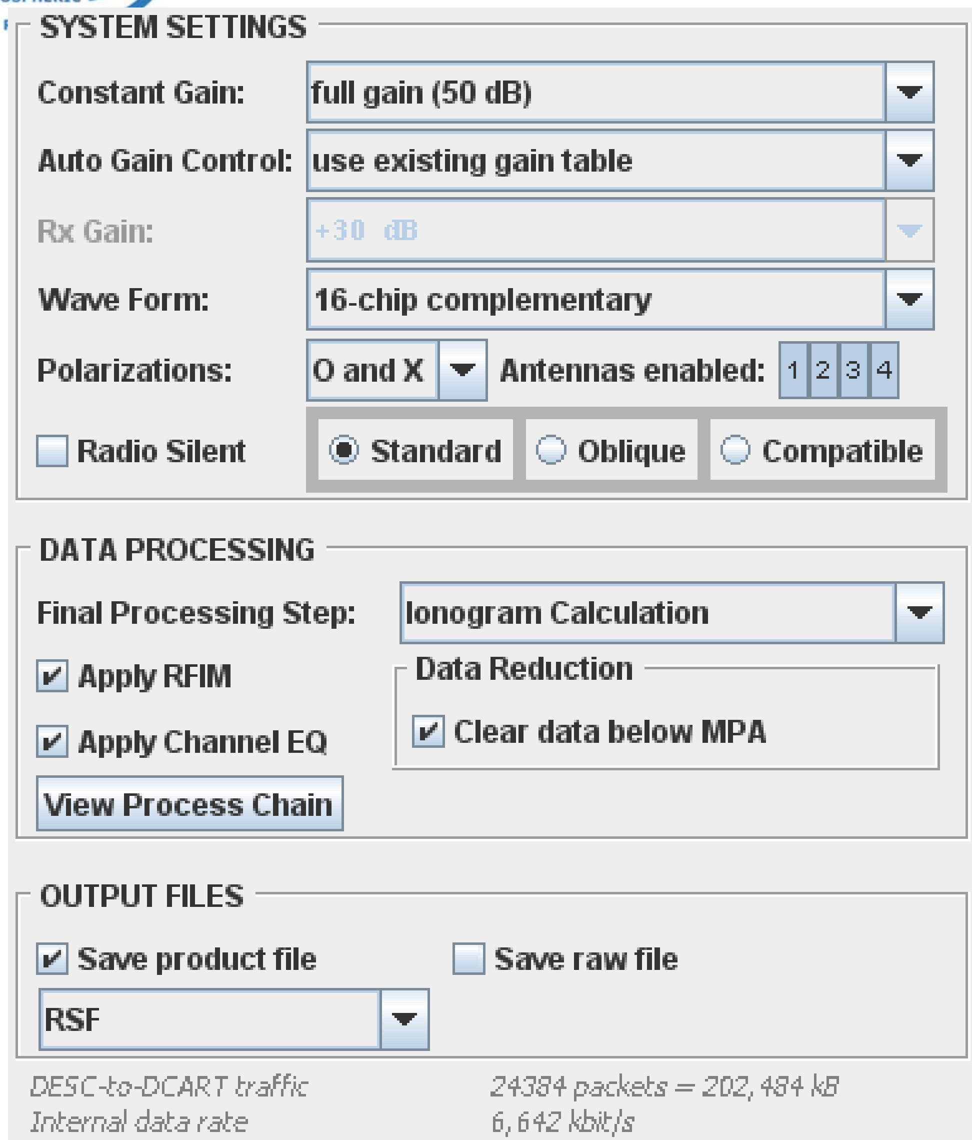
Number of 2.5 km samples:

- 256 – 640 km
- 512 – 1280 km

> **Integrated Repetitions**

From 1 to 64 for Ionogram

Basic Ionogram Program (3)



> Full gain
> Use gain table
> 16-chip only
> Both polarization
> All antennas
> Standard mode

> Ionogram processing
> RFIM ON
> Channel Equalizing ON
> Compress data

> Save data in RSF format
> No raw files

Basic Ionogram Program (4)

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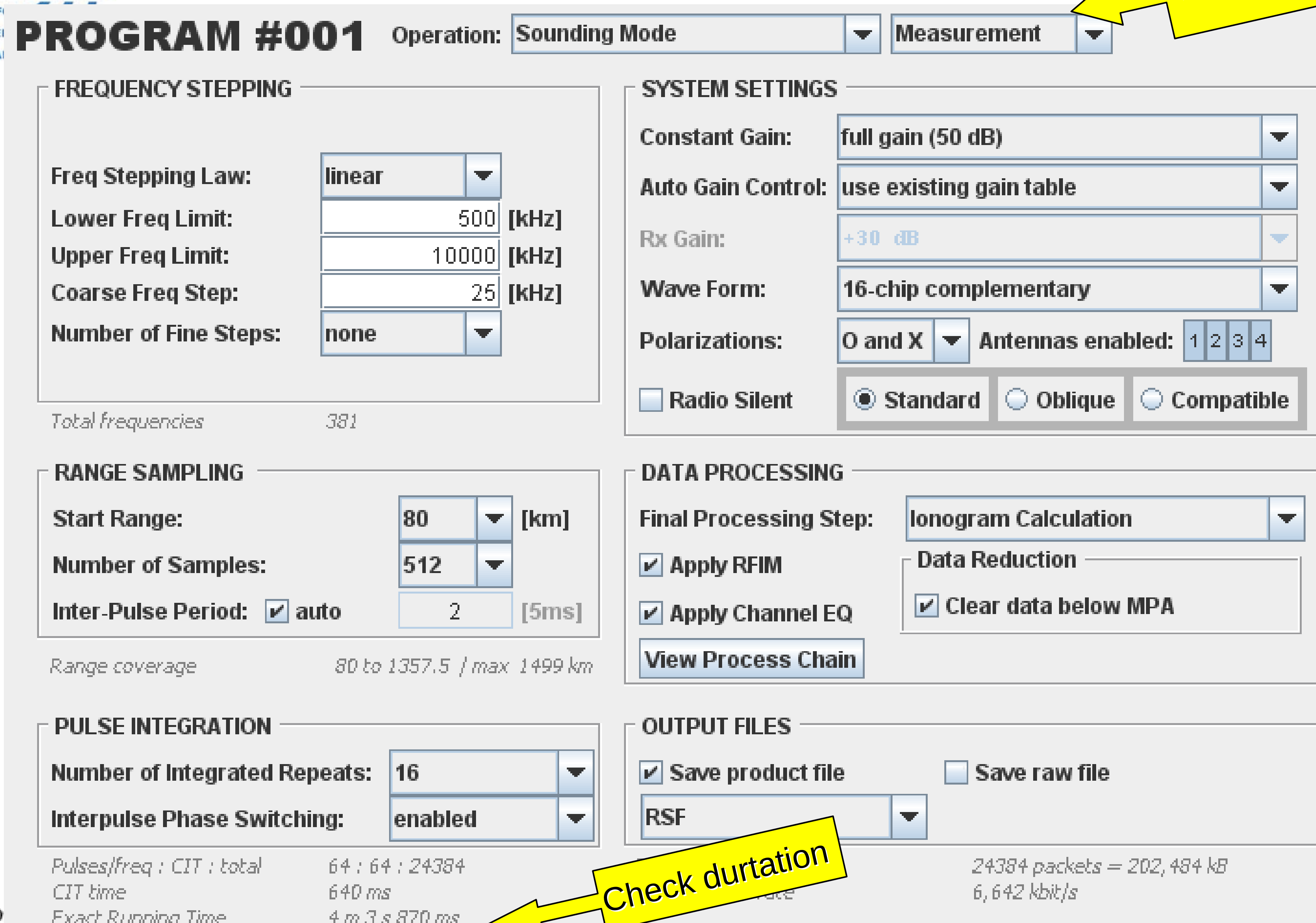
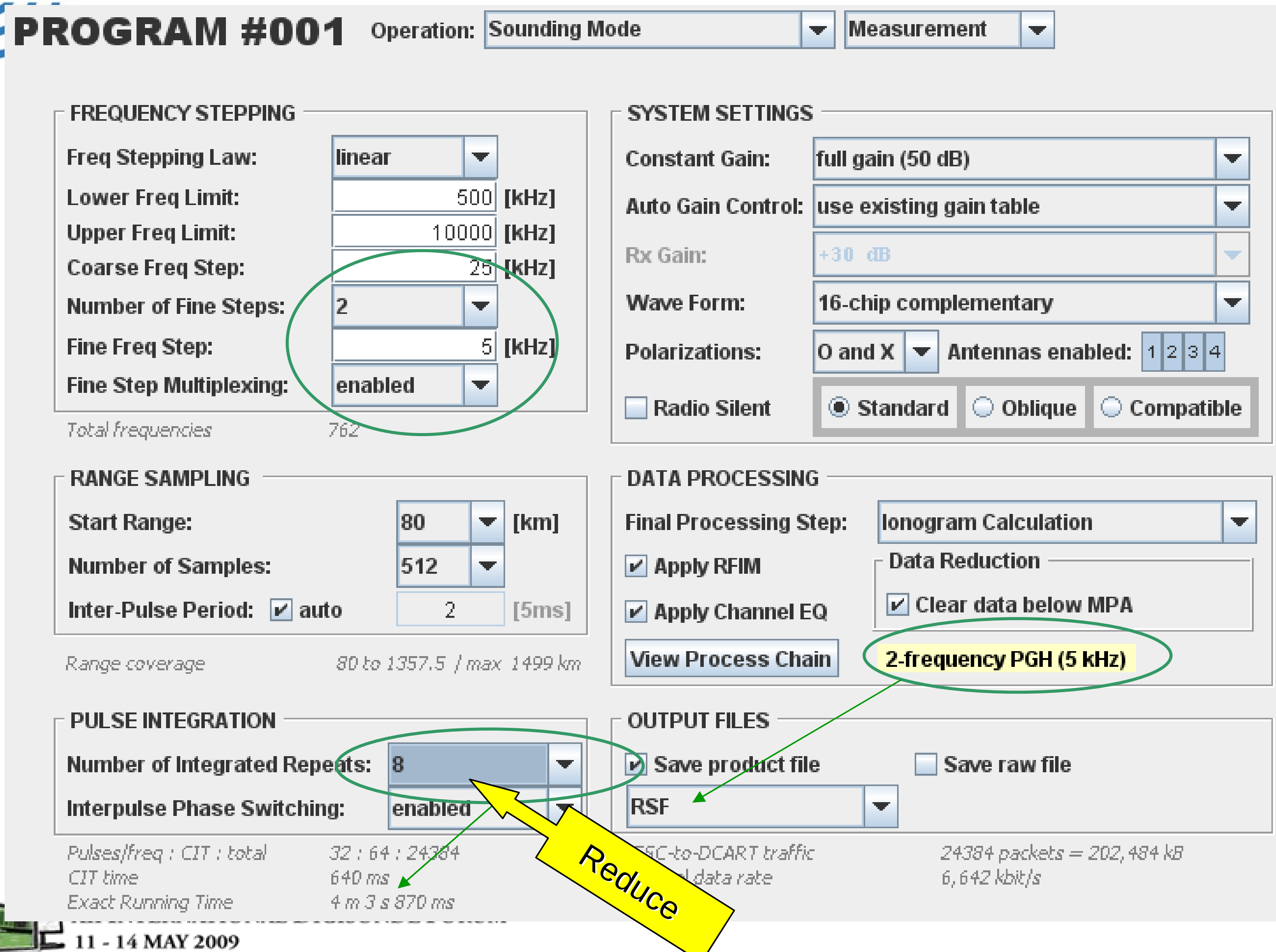
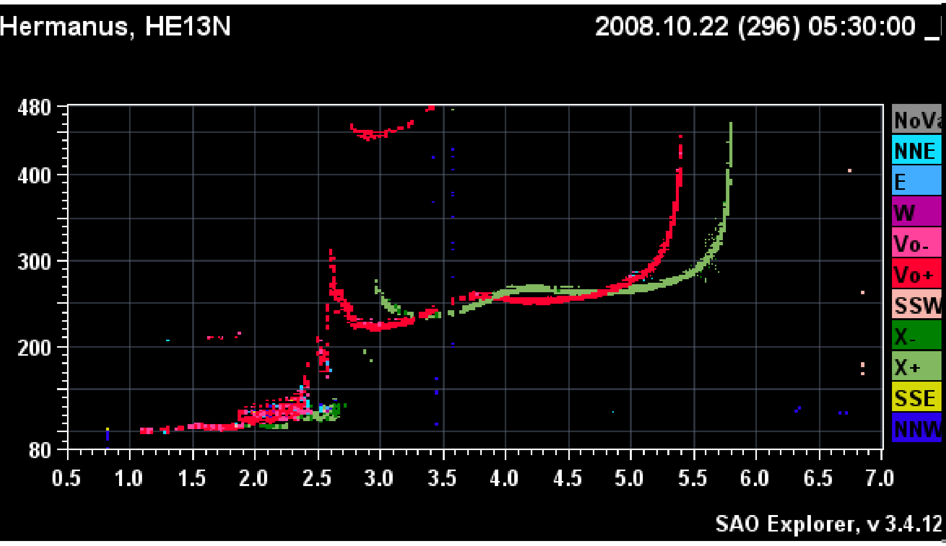


“PGH” Ionogram

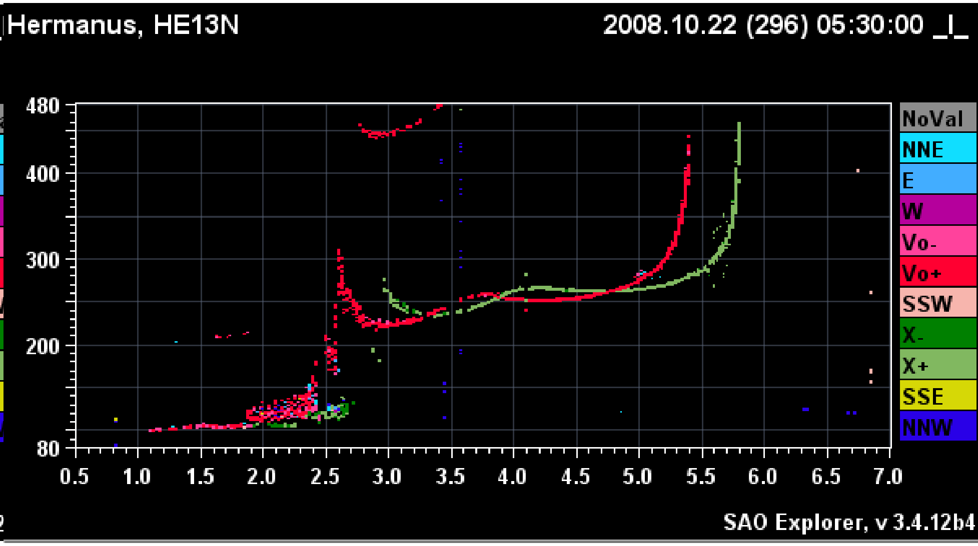


"PGH" ionogram mode

PGH – "Precision Group Height"



Digisonde ionogram in conventional presentation



Same ionogram in PGH-compressed Presentation

Special: Create Gain Table Pogram

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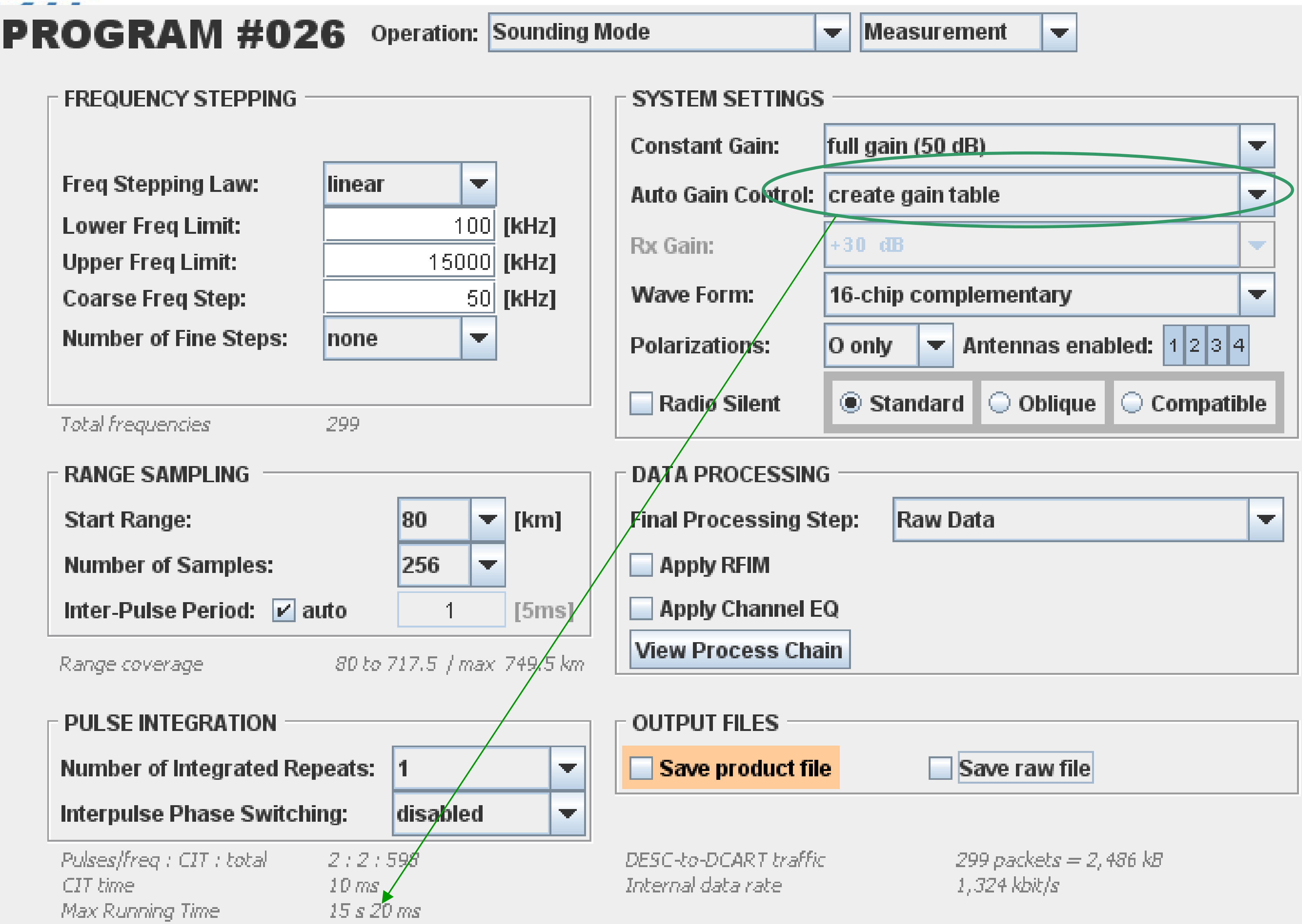
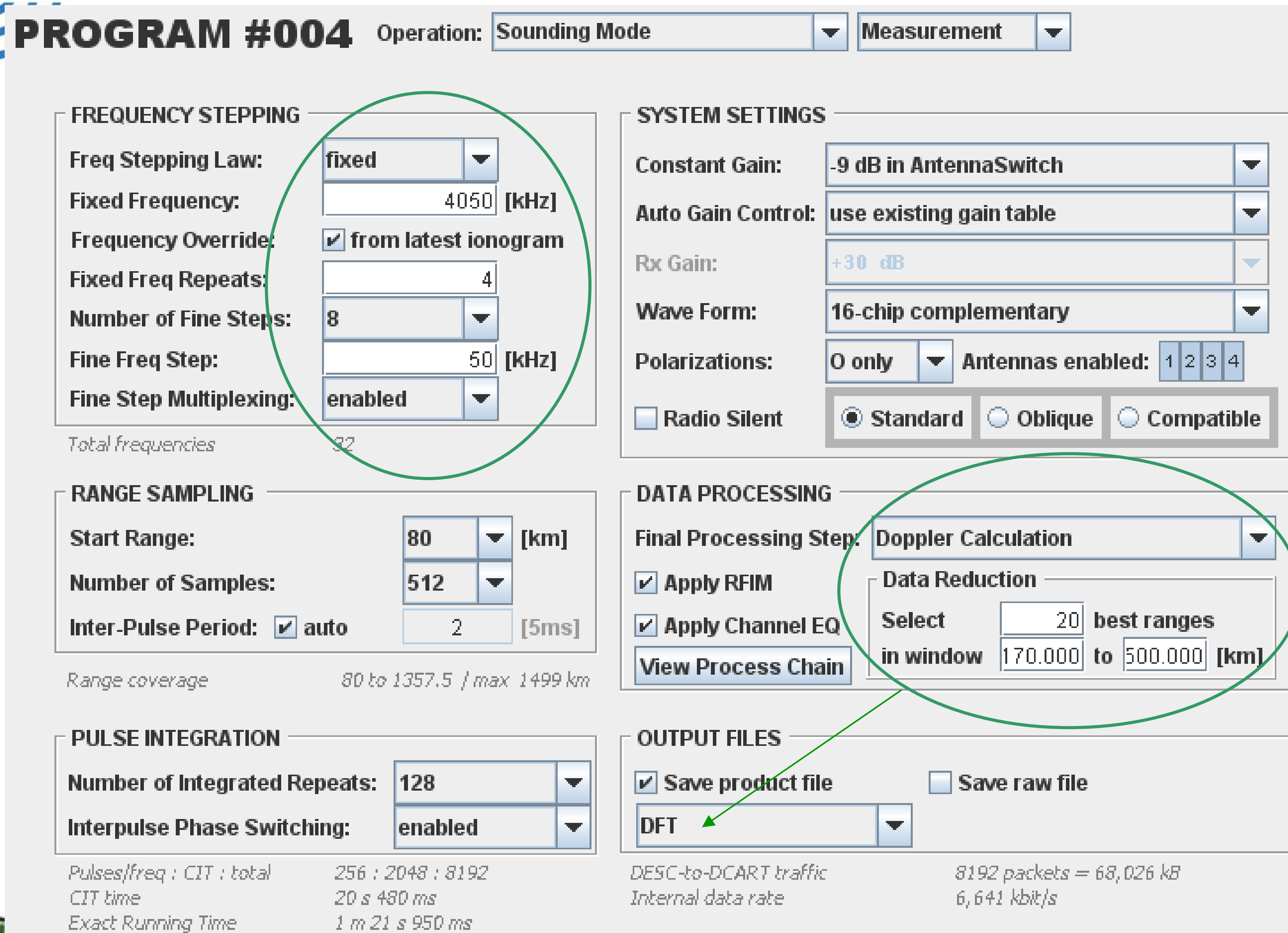
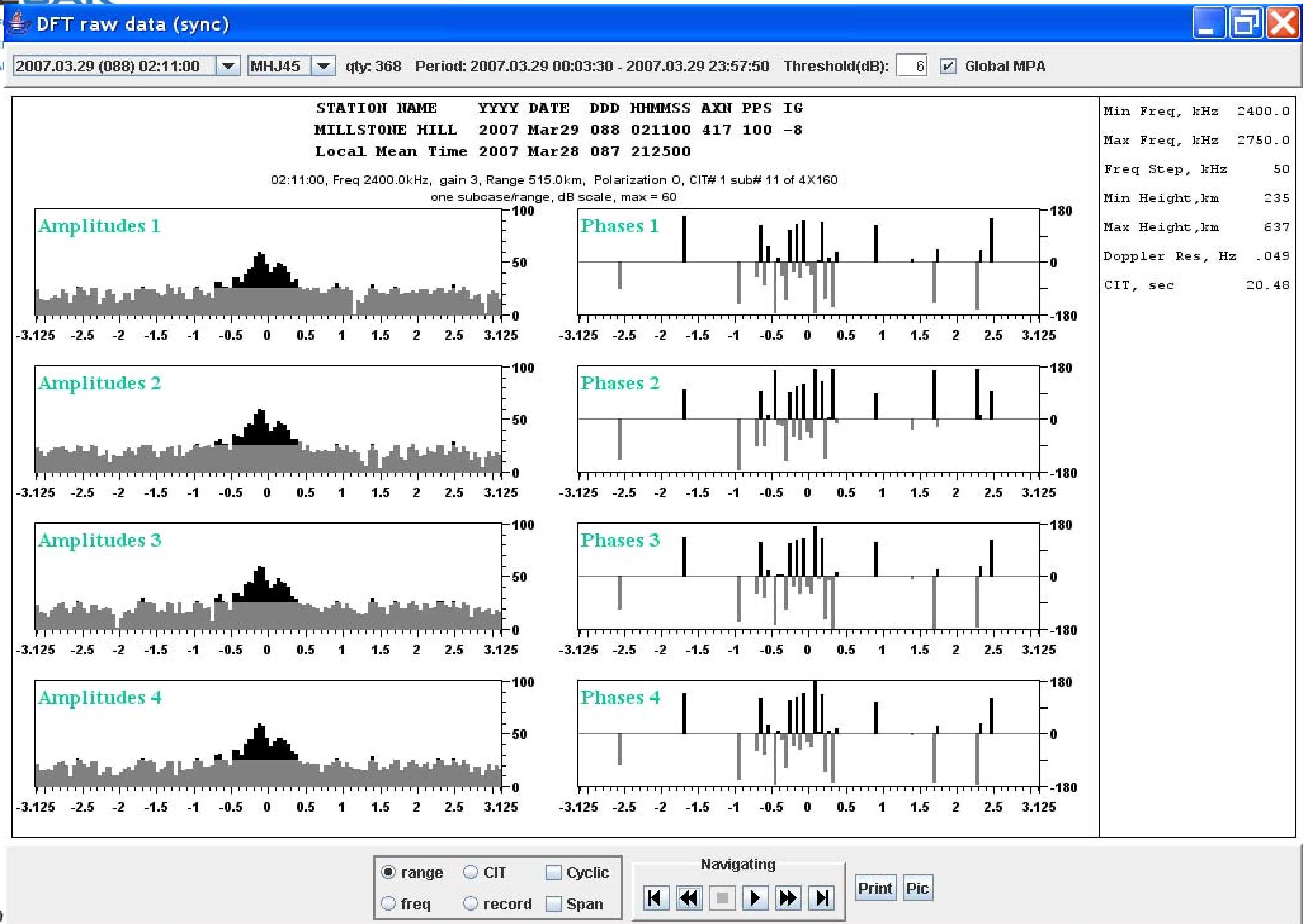


Drift Program



DRIFT measurement



DCART Programs

> **Programs:**

- **Sounding**
  - > ionogram - RSF
  - > drift - DFT
- **Housekeeping**
  - > built in test - BIT
- **Special**
  - > create gain table
  - > channel equalizing - CEQ
  - > tracker calibration

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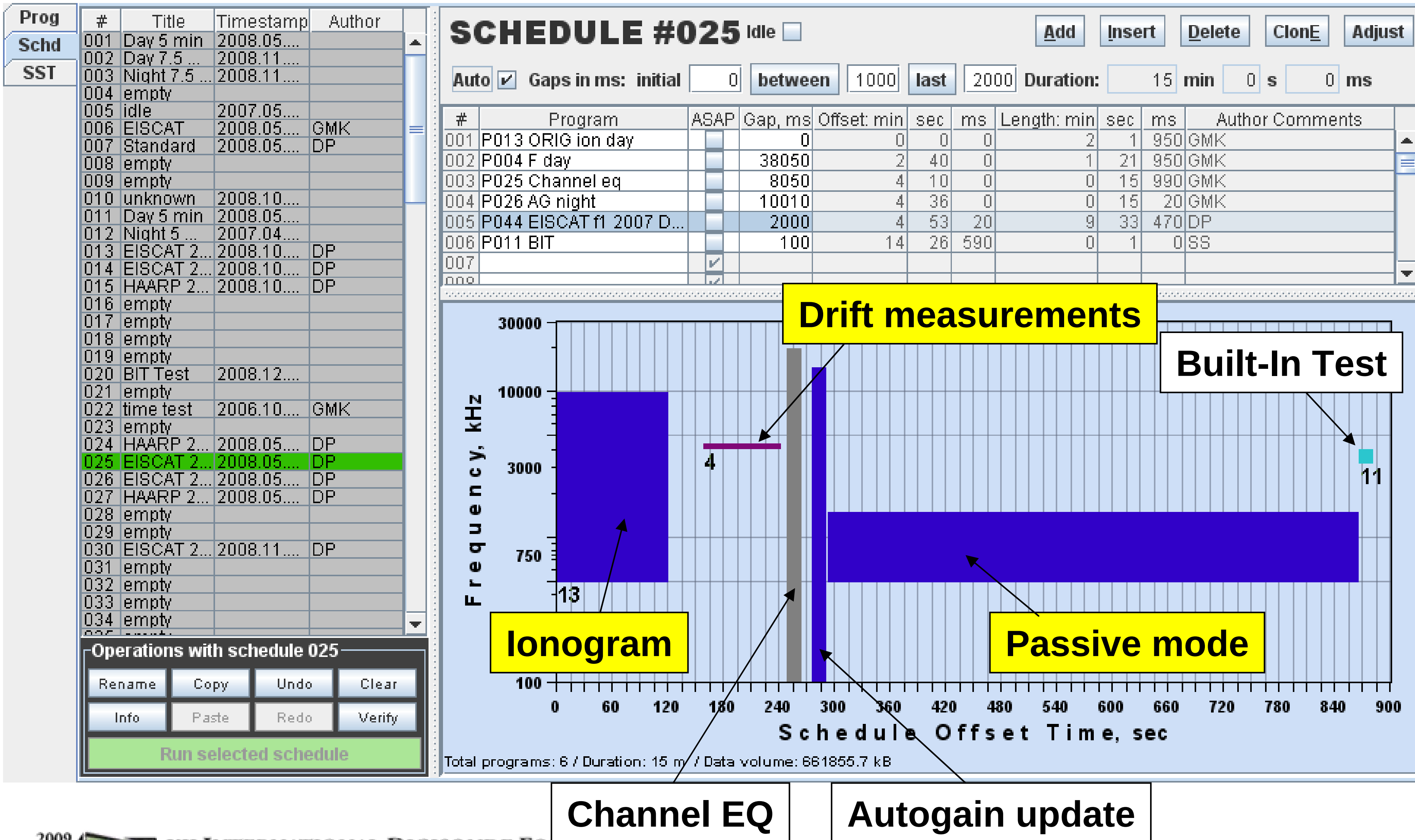
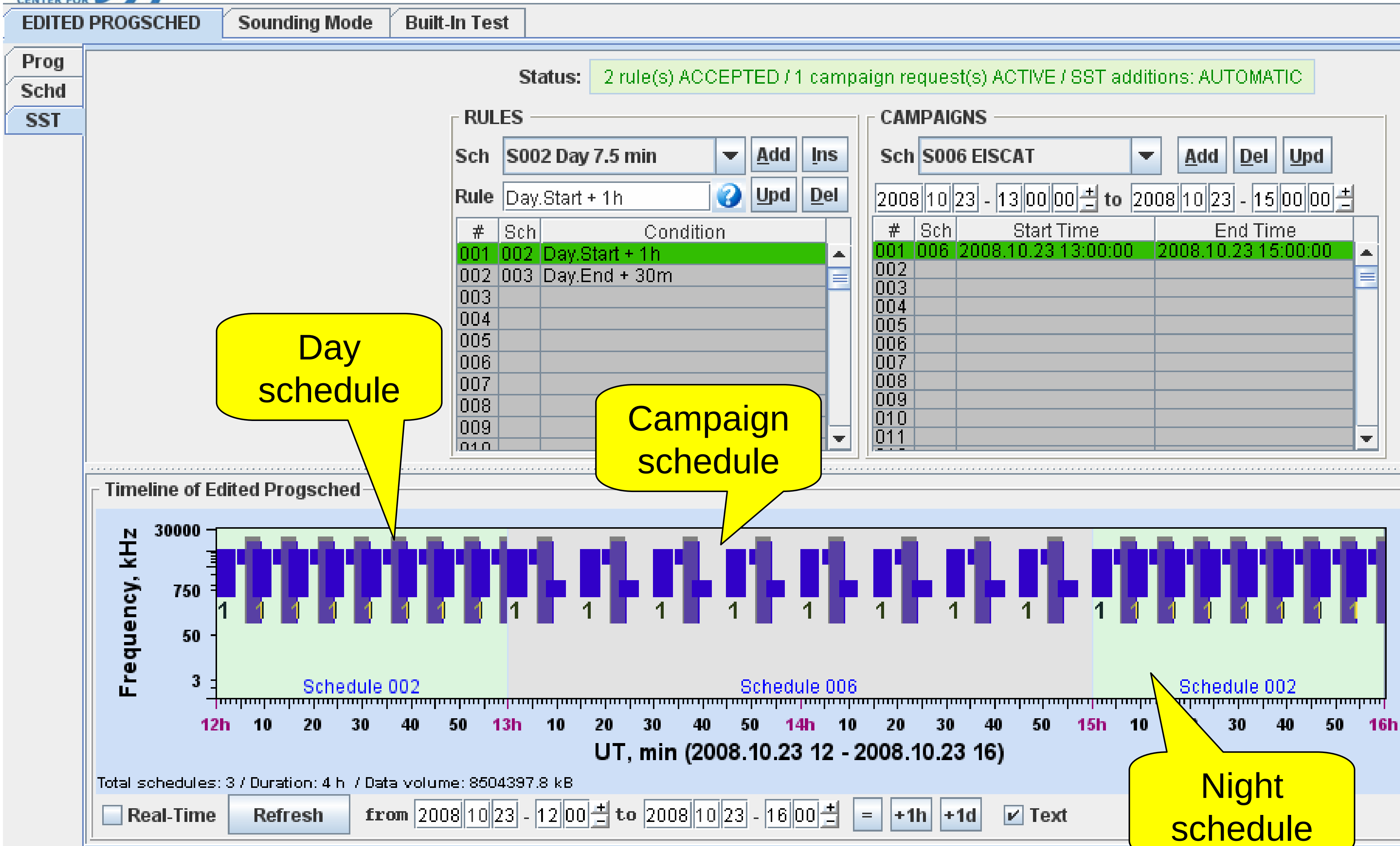
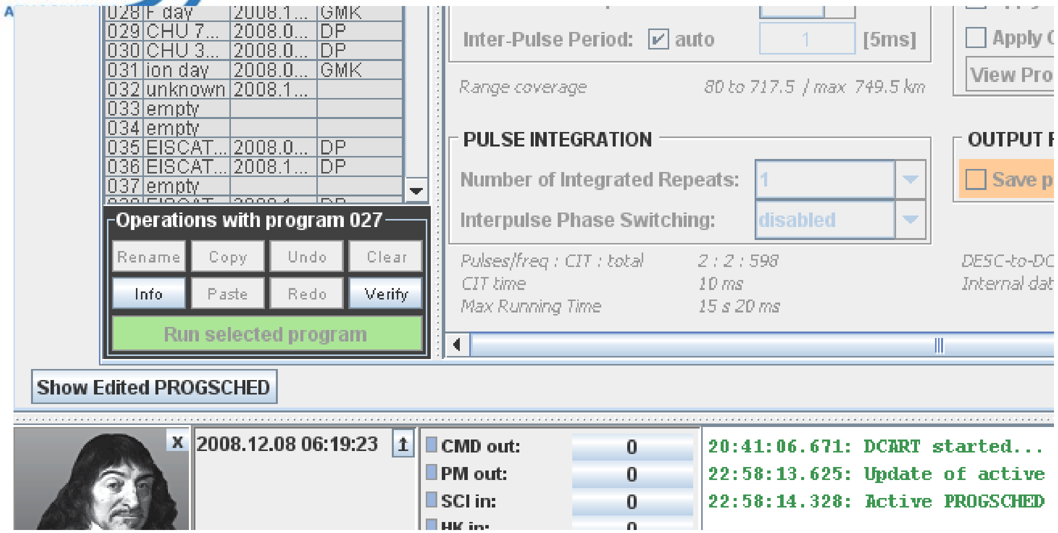
DCART Schedules

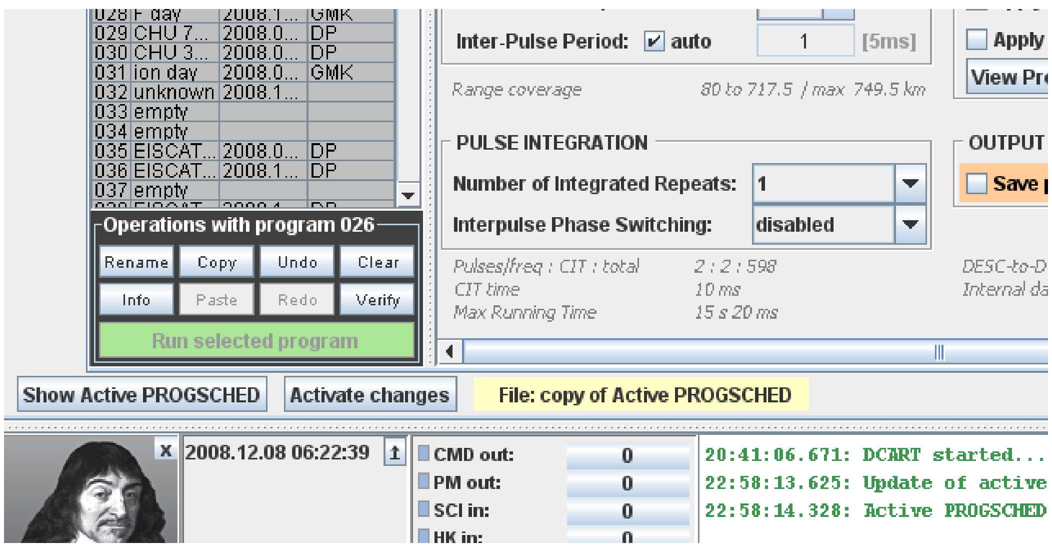


DCART Rules and Campaigns



Activate changes





- Read only mode for Active ProgSched (gray colors)
- Switch to edited ProgSched
- Change Program / Schedule / SST
- Activate changes – saves changes to Active ProgSched and send changes to DESC

Housekeeping: BIT Program

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PROGRAM #011 Operation: Built-In Test | measurement

Sampling Frequency: 3275 [kHz]

Exact Running Time 1 s
On-wire Data Volume 1 packets = 136 B
Data Flow 1 kbit/s

BIT data display: mhj45_2008165.btd2

View Program | Open File | Close File | 100 ms | goto 1 out of 117

Built-In Test (BIT): 2008/06/13 00:06:46.350 Measurement | Show all | Failed | Report

↑ Mnemonic	Sensor	Raw	Phys	Units	GO	R low	Y low	Y high	R high	Comment
SA00_AMP_TP	Lower chassis °C	420	420	°C	GO	0	0	1,023	1,023	Temperature sensor in lower chassis
SA01_PWR_TP	Upper chassis °C	613	613	°C	GO	0	0	1,023	1,023	Temperature sensor in upper chassis
SA04_TIM_DATACLK_FR	UpConv data clock	0	0	kHz	GO	0	0	1,023	1,023	Upconverter Data I+Q Clock Frequency
SA05_TIM_PARPORT_FR	ParPort clock	0	0	kHz	GO	0	0	1,023	1,023	Parallel port timing clock
SD00_PWR_PREAMP_V	Pwr Preamp V	1			GO					Preamplifier power
SD01_PWR_M15_V	Pwr -15V	1			GO					-15 Volt power
SD02_PWR_M5_V	Pwr -5V	0			GO					-5 Volt power
SD03_PWR_P3_V	Pwr +3.3V	1			GO					+3.3 Volt power
SD04_PWR_P15_V	Pwr +15V	1			GO					+15 Volt power
SD05_PWR_P12_V	Pwr +12V	1			GO					+12 Volt power
SD06_PWR_OVER_TP	Pwr overheat	1			GO					Power card overheating condition
SD07_PREP_HW_TESTPAT	HW Test Pattern	1			GO					Preprocessor HW test pattern
SD08_TX_CARD_TIMEOUTS	Tx card Timeouts	0			GO					Tx Card Commanding Timeouts since last BIT program
SD09_PWR_P18_V	Pwr +18V	1			GO					+18 Volt power
SD10_CMD_TIMEOUTS	Cmd Timeouts	0			GO					Commanding Timeouts from last BIT program
SD11_RF_NOISE_LOW_V	RF noise low	0			GO					Environmental RF noise voltage in Antenna with 0 dB gain in anten
SD12_RF_NOISE_HIGH_V	RF noise high	0			GO					Environmental RF noise voltage in Antenna with 9 dB gain in anten
SD13_RX_CARD_TIMEOUTS	Rx Card Timeouts	0			GO					Rx Card Commanding Timeouts since last BIT program
SD14_TRACKER1_CARD_TIMEOUTS	TRACKER1 Card ...	0			GO					TRACKER1 Card Commanding Timeouts since last BIT program
SD15_TRACKER2_CARD_TIMEOUTS	TRACKER2 Card ...	0			GO					TRACKER2 Card Commanding Timeouts since last BIT program
SD16_TRACKER3_CARD_TIMEOUTS	TRACKER3 Card ...	0			GO					TRACKER3 Card Commanding Timeouts since last BIT program
SD17_TRACKER4_CARD_TIMEOUTS	TRACKER4 Card ...	0			GO					TRACKER4 Card Commanding Timeouts since last BIT program
SD18_BIT_CARD_TIMEOUTS	BIT Card Timeouts	0			GO					BIT Card Commanding Timeouts since last BIT program

Special: CEQ Program

PROGRAM #025 Operation: Channel Equalizing | Internal Loopb...

FREQUENCY STEPPING

Lower Freq Limit:	100	[kHz]
Upper Freq Limit:	20000	[kHz]
Coarse Freq Step:	50	[kHz]

Pulses per frequency	8
Total frequencies	399
Pulses per CIT	8
CIT time	40 ms
Exact Running Time	15 s 990 ms
On-wire Data volume	1596 packets = 13,227,648 B
Data transfer rate	6,618 kbit/s

PULSE INTEGRATION

Number of Integrated Repetitions: 4

SYSTEM SETTINGS

Constant Gain:	full gain (50 dB)
Auto Gain Control:	fixed
Rx Gain:	+30 dB
Polarizations:	O only
Wave Form:	16-chip complementary

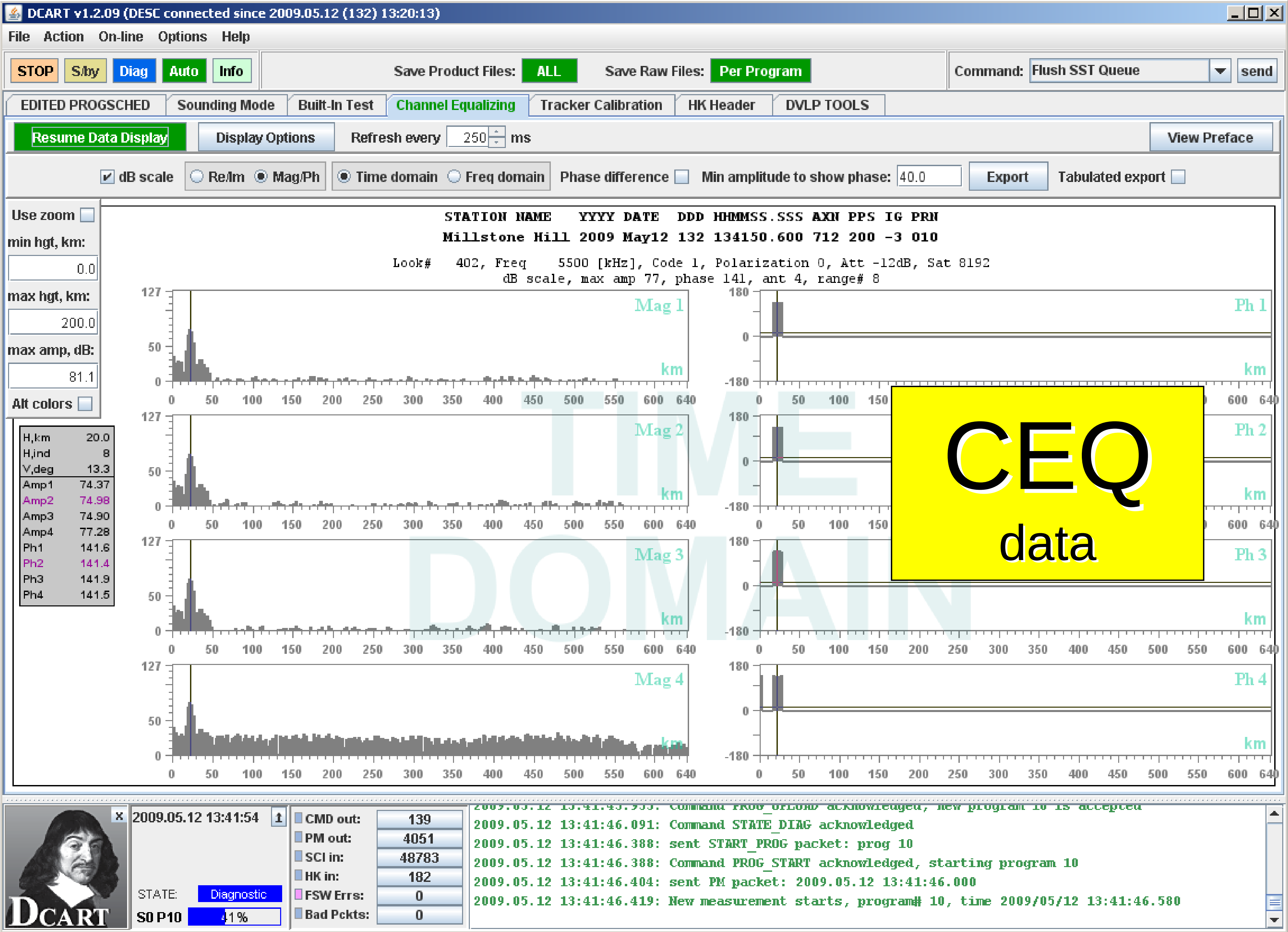
Default settings: IPP = 1 | Start Range = 0 | End Range = 510 | Range Step = 2

- Not saturated internal loopback signal
- Integration time

- Frequency
- Amplitude ratio 2/1, 3/1, 4/1
- Phase difference 2-1, 3-1, 4-1

DIGISONDE CHANNEL EQUALIZING DATA
Version: 1
Time of measurement: 2008.12.08 (343) 15:28:05
Number of antennas: 4
Referenced antenna: 1

100	1.0010	0.02	1.0020	-2.56	1.0010	-0.87
150	1.0030	-0.50	1.0030	-2.32	1.0030	-1.17
200	1.0030	-0.26	1.0030	-1.46	1.0020	-0.75
250	1.0020	1.14	1.0010	-0.05	1.0020	0.32
300	0.9690	3.99	1.0120	1.01	0.9850	2.27
350	0.9520	7.37	1.0610	1.64	0.9710	4.63
400	0.9820	6.04	1.0340	1.90	0.9890	4.44
450	0.9970	5.62	0.9970	1.73	1.0000	4.02
500	1.0100	11.22	1.0080	5.30	1.0080	5.01
550	0.9090	8.71	1.0210	7.15	0.8870	14.89
600	0.9740	-2.09	1.1090	-0.52	1.0080	3.78
650	1.0080	-9.62	1.0490	-19.16	1.0110	-5.32
700	0.9420	7.83	1.0260	0.92	0.9730	4.45
750	0.9920	6.42	1.0710	0.98	1.0360	13.58
800	1.0490	16.86	1.0820	9.98	1.0070	2.14
850	1.0250	-6.93	1.0460	-6.26	0.9990	0.12


DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File Action On-line Options Help
STOP S/by Diag Auto Info
Save Product Files: ALL
Save Raw Files: Per Program
Command: Flush SST Queue
send
EDITED PROGSCHED
Sounding Mode
Built-In Test
Channel Equalizing
Tracker Calibration
HK Header
DVLP TOOLS
Resume Data Display
Display Options
Refresh every 250 ms
View Preface
dB scale
Re/Im
Mag/Ph
Time domain
Freq domain
Phase difference
Min amplitude to show phase: 40.0
Export
Tabulated export
Use zoom
min hgt, km: 0.0
max hgt, km: 200.0
max amp, dB: 81.1
Alt colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2009 May12 132 134150.600 712 200 -3 010
Look# 402, Freq 5500 [kHz], Code 1, Polarization 0, Att -12dB, Sat 8192
dB scale, max amp 77, phase 141, ant 4, range# 8
H,km 20.0
H,ind 8
V,deg 13.3
Amp1 74.37
Amp2 74.98
Amp3 74.90
Amp4 77.28
Ph1 141.6
Ph2 141.4
Ph3 141.9
Ph4 141.5
Mag 1
Mag 2
Mag 3
Mag 4
Ph 1
Ph 2
Ph 3
Ph 4
km
TIME DOMAIN
CEQ
data
2009.05.12 13:41:54
STATE: Diagnostic
S0 P10 41%
CMD out: 139
PM out: 4051
SCI in: 48783
HK in: 182
FSW Errs: 0
Bad Pckts: 0
2009.05.12 13:41:46.091: Command STATE_DIAG acknowledged
2009.05.12 13:41:46.388: sent START_PROG packet: prog 10
2009.05.12 13:41:46.388: Command PROG_START acknowledged, starting program 10
2009.05.12 13:41:46.404: sent PM packet: 2009.05.12 13:41:46.000
2009.05.12 13:41:46.419: New measurement starts, program# 10, time 2009/05/12 13:41:46.580
DCART

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Special: Tracker Calibration Program

Tracker Clibration data display: trackers.dat

View Program | Open File | Close File

Tracker Calibration: 2008/12/0

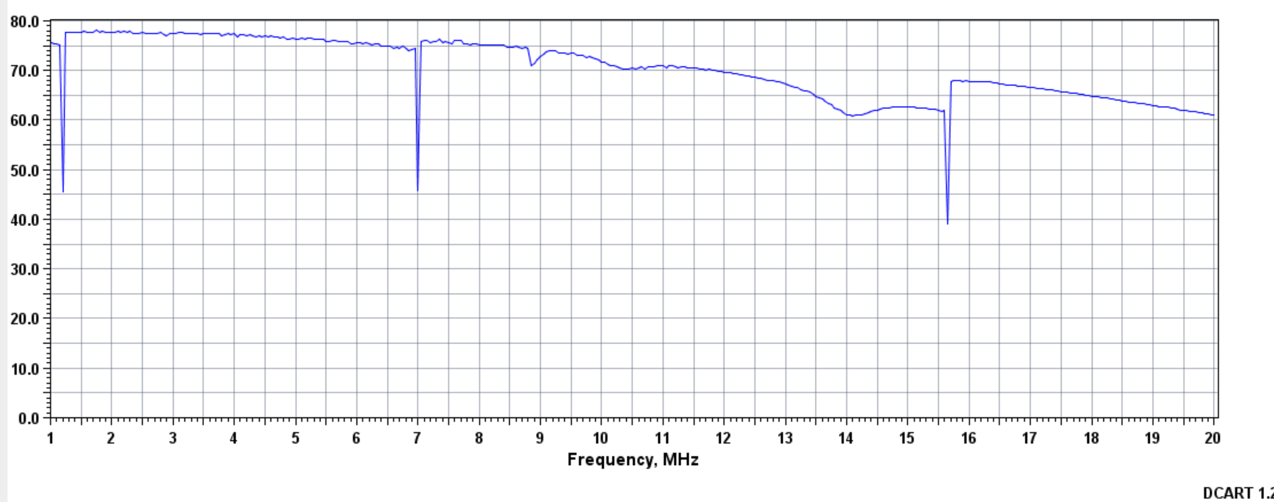
Seq	Band	Cmd	Freq	V1	V2	V3	V4
1	0	F8	100	00	00	00	00
2	1	F9	500	FF	FF	FF	FF
3	1	F9	505	FE	FD	FE	FA
4	1	F9	510	FB	FB	FB	FA
5	1	F9	515	FB	F9	FA	F6
6	1	F9	520	F7	F8	F7	F6
7	1	F9	525	F7	F5	F7	F2
8	1	F9	530	F3	F4	F3	F2
9	1	F9	535	F3	F1	F3	EF
10	1	F9	540	F0	F1	F0	EF
11	1	F9	545	F0	F0	F0	EB
12	1	F9	550	ED	EC	EC	EB
13	1	F9	555	EC	EC	EC	E8
14	1	F9	560	EA	EA	E9	E8
15	1	F9	565	E9	E9	E9	E6
16	1	F9	570	E8	E7	E6	E6
17	1	F9	575	E5	E7	E6	E2
18	1	F9	580	E5	E4	E3	E2
19	1	F9	585	E2	E4	E3	E0
20	1	F9	590	E2	E2	E1	E0
21	1	F9	595	E1	E2	E1	DE
22	1	F9	600	E0	E0	DF	DE
23	1	F9	605	DE	E0	DF	DB
24	1	F9	610	DE	DD	DB	DB
25	1	F9	615	DB	DD	DB	D9
26	1	F9	620	DB	DB	DB	D9
27	1	F9	625	DA	DB	D9	D7
28	1	F9	630	D9	D9	D9	D7
29	1	F9	635	D8	D9	D7	D5
30	1	F9	640	D7	D8	D7	D5
31	1	F9	645	D7	D7	D5	D4

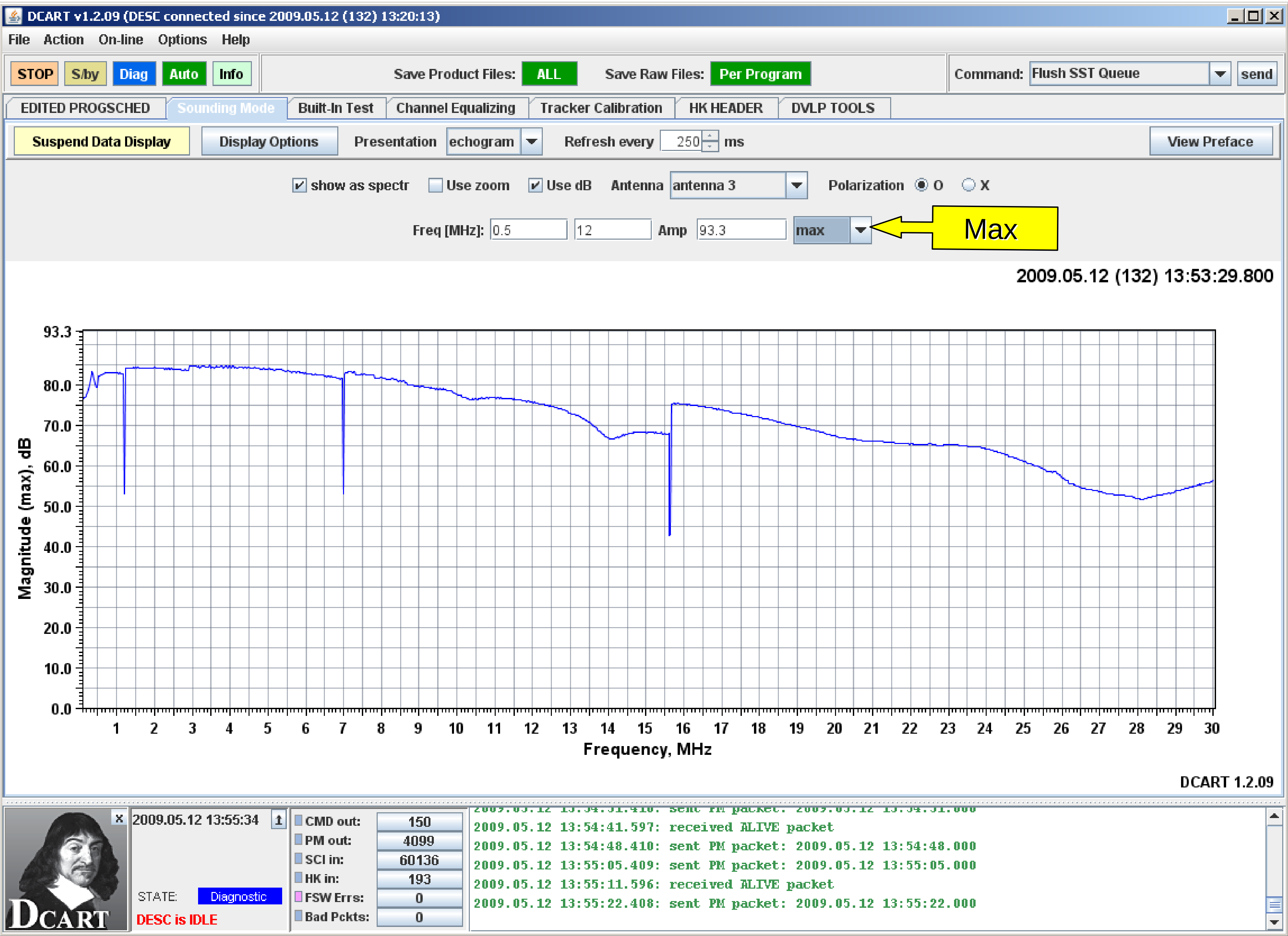
PROGRAM #048 Operation: Tracker Calibration | Internal Loopb...

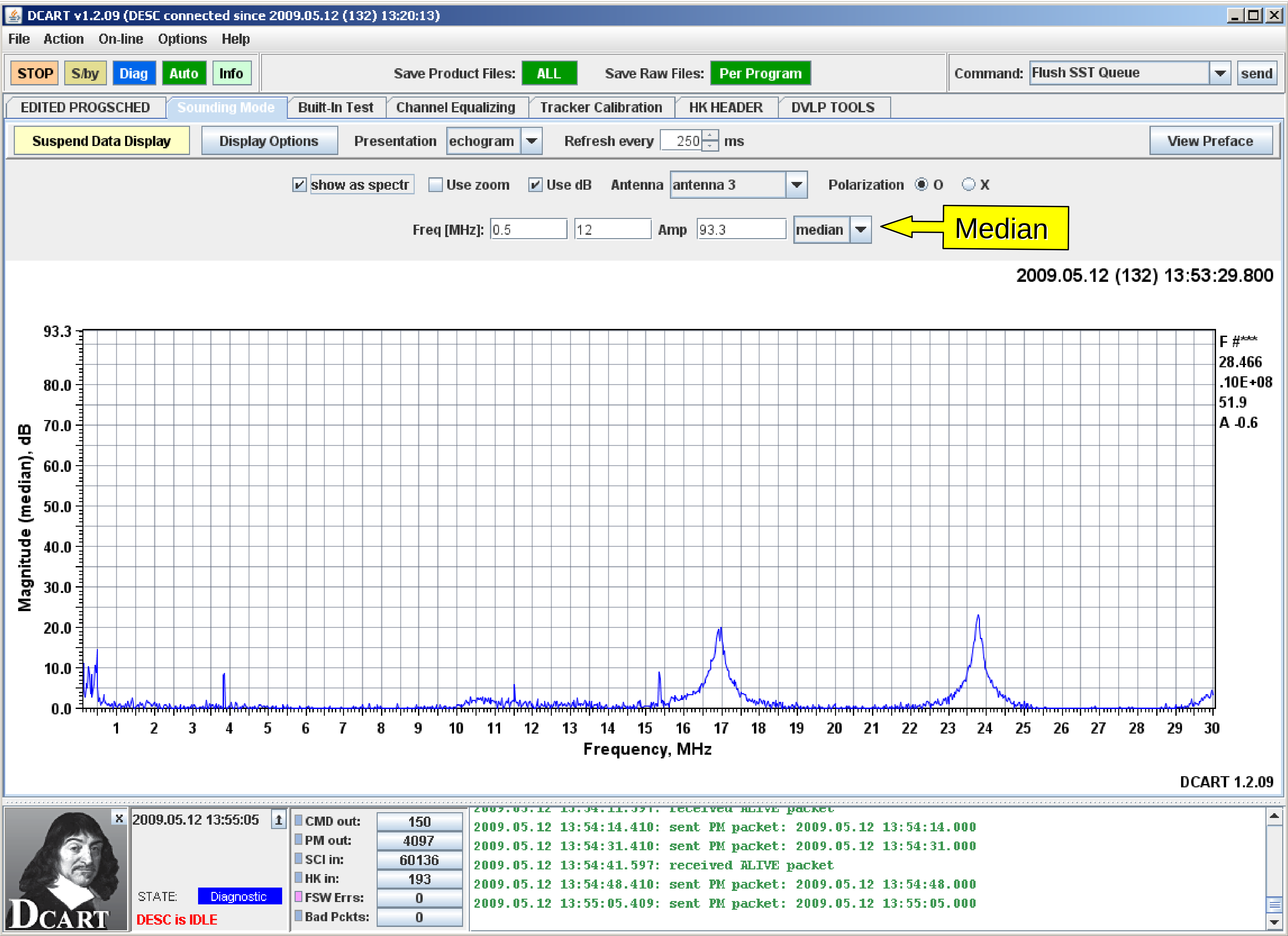
Constant Gain: full gain (50 dB)
Rx Gain: +12 dB

Max Running Time 1 m 30 s
On-wire Data Volume 1 packets = 9,007 B
Data Flow 1 kbit/s

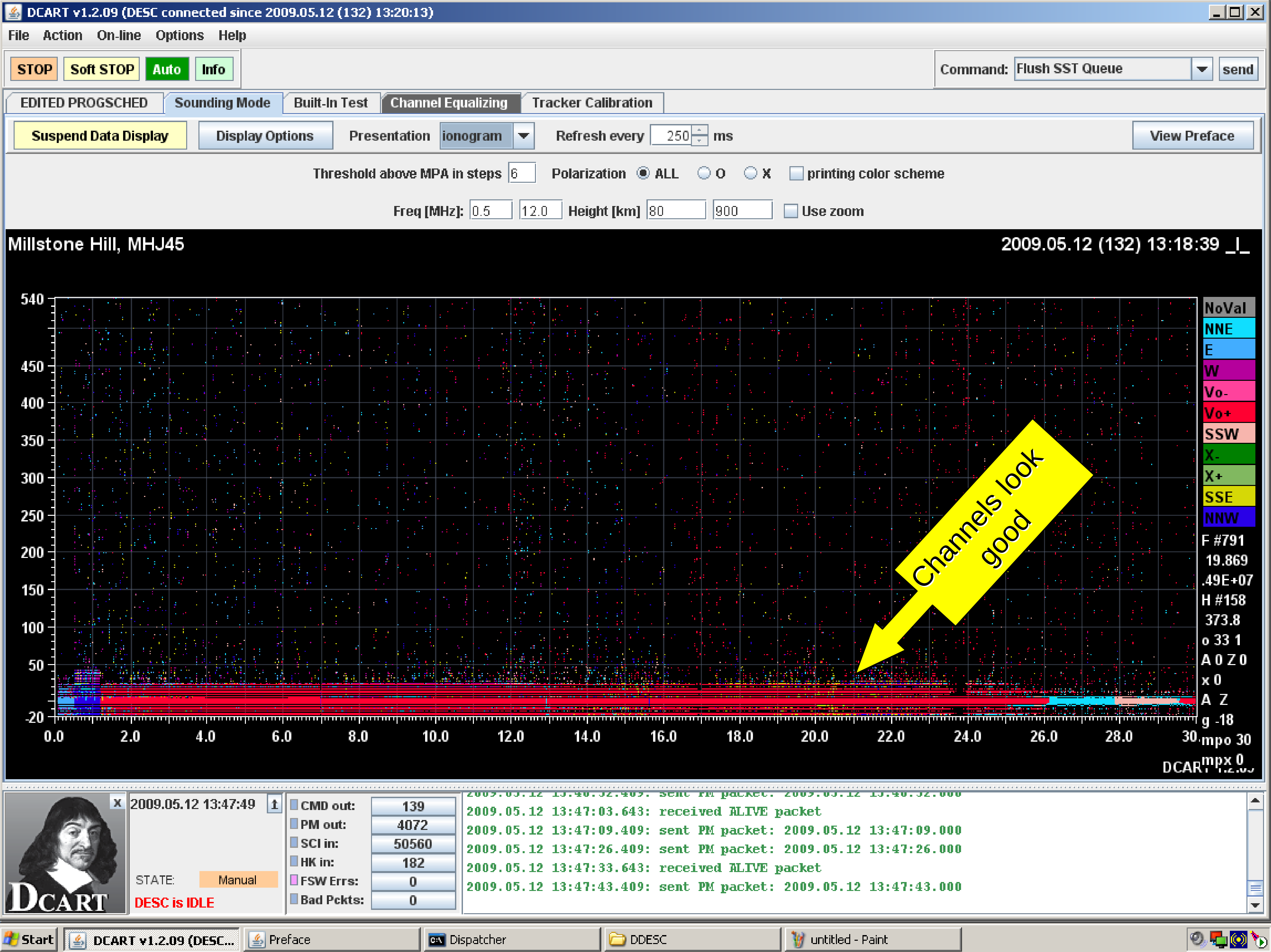
- Tracker band
- Band command
- Frequency and step
- 4 channel tracking filter voltage

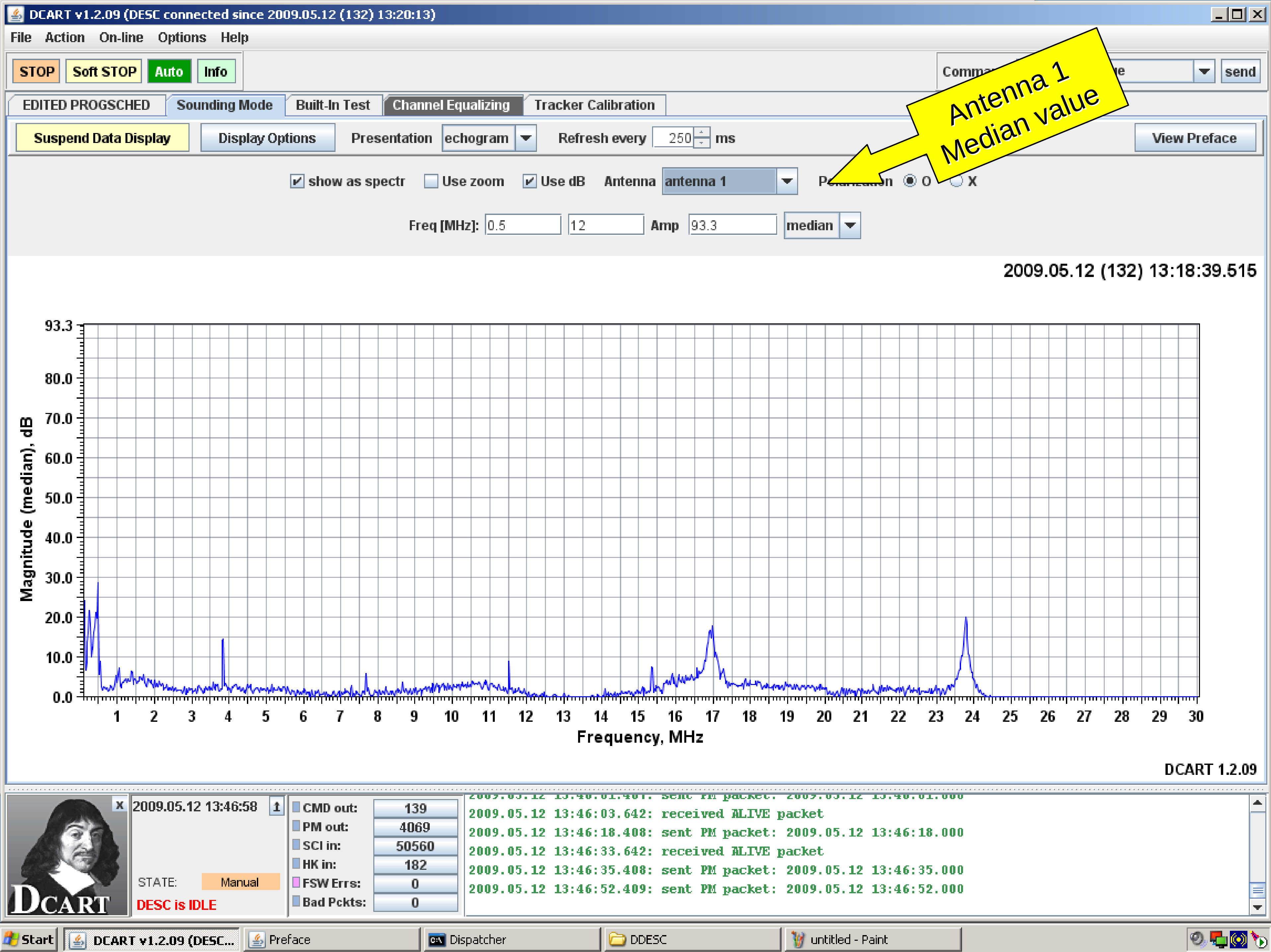


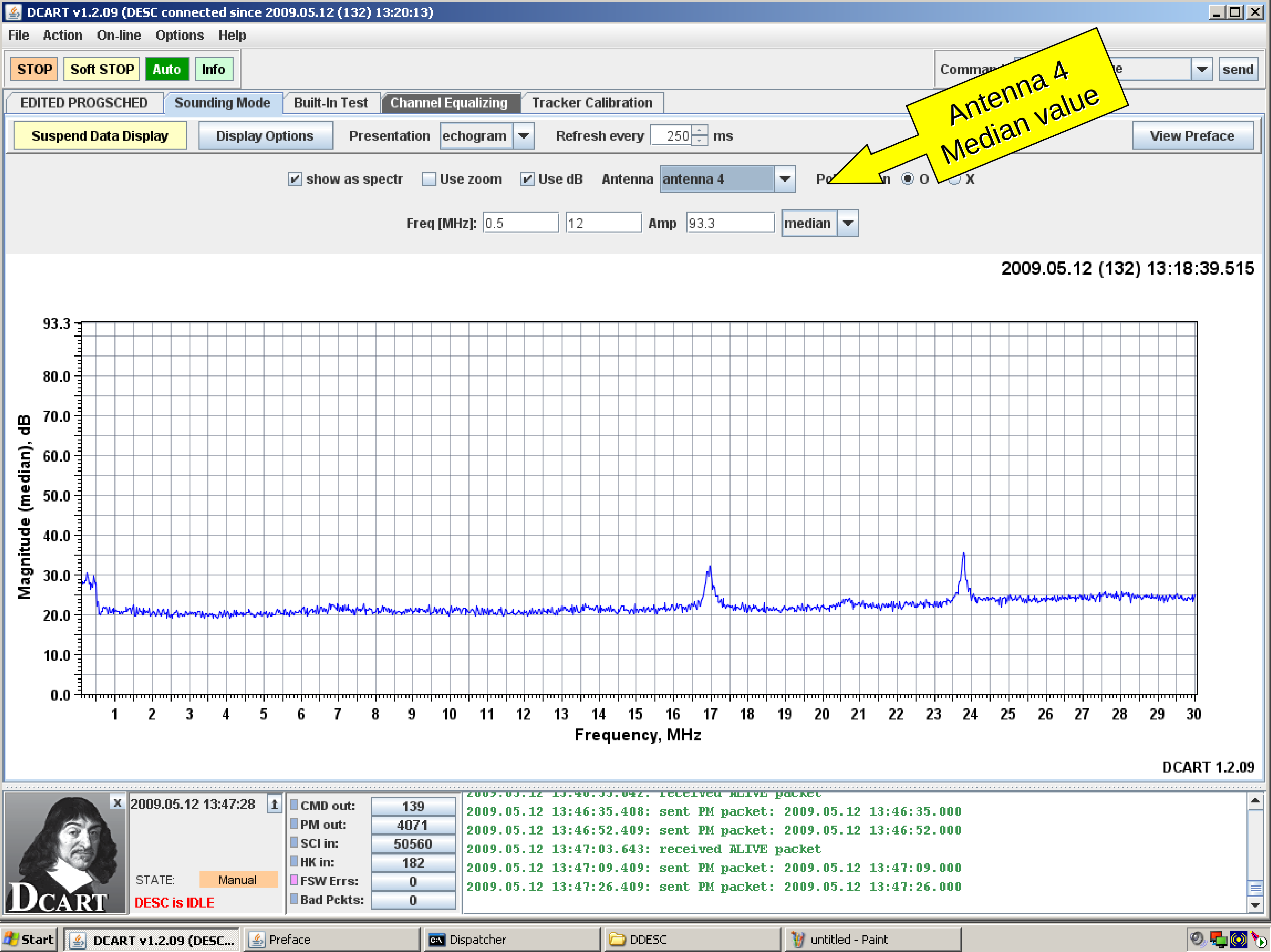

DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File Action On-line Options Help
STOP S/by Diag Auto Info
Save Product Files: ALL
Save Raw Files: Per Program
Command: Flush SST Queue send
EDITED PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration HK HEADER DVLP TOOLS
Suspend Data Display
Display Options
Presentation echogram
Refresh every 250 ms
View Preface
show as spectr Use zoom Use dB Antenna antenna 3 Polarization O X
Freq [MHz]: 0.5 12 Amp 93.3 max
Max
2009.05.12 (132) 13:53:29.800
Magnitude (max), dB
Frequency, MHz
DCART 1.2.09
2009.05.12 13:55:34
STATE: Diagnostic
DESC is IDLE
CMD out: 150
PM out: 4099
SCI in: 60136
HK in: 193
FSW Errs: 0
Bad Pckts: 0
2009.05.12 13:54:41.597: received ALIVE packet
2009.05.12 13:54:48.410: sent PM packet: 2009.05.12 13:54:48.000
2009.05.12 13:55:05.409: sent PM packet: 2009.05.12 13:55:05.000
2009.05.12 13:55:11.596: received ALIVE packet
2009.05.12 13:55:22.408: sent PM packet: 2009.05.12 13:55:22.000
DCART



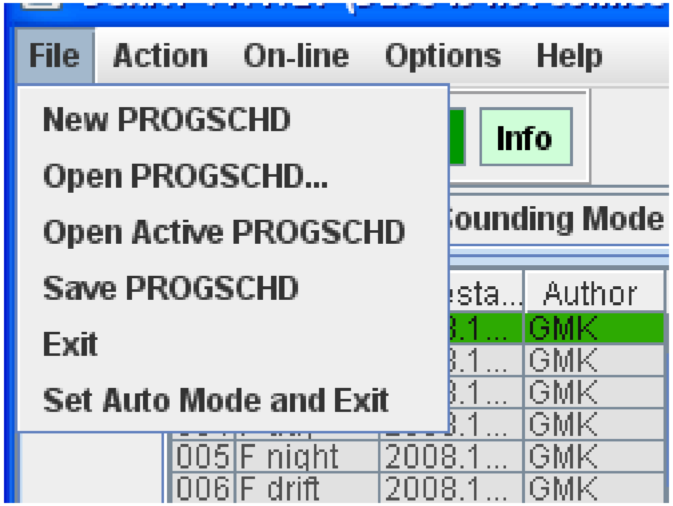
DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File Action On-line Options Help
STOP S/by Diag Auto Info
Save Product Files: ALL
Save Raw Files: Per Program
Command: Flush SST Queue send
EDITED PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration HK HEADER DVLP TOOLS
Suspend Data Display
Display Options
Presentation echogram
Refresh every 250 ms
View Preface
show as spectr
Use zoom
Use dB
Antenna antenna 3
Polarization O X
Freq [MHz]: 0.5 12 Amp 93.3 median
Median
2009.05.12 (132) 13:53:29.800
Magnitude (median), dB
Frequency, MHz
F #***
28.466
.10E+08
51.9
A -0.6
DCART 1.2.09
2009.05.12 13:55:05
STATE: Diagnostic
DESC is IDLE
CMD out: 150
PM out: 4097
SCI in: 60136
HK in: 193
FSW Errs: 0
Bad Pckts: 0
2009.05.12 13:54:14.410: sent PM packet: 2009.05.12 13:54:14.000
2009.05.12 13:54:31.410: sent PM packet: 2009.05.12 13:54:31.000
2009.05.12 13:54:41.597: received ALIVE packet
2009.05.12 13:54:48.410: sent PM packet: 2009.05.12 13:54:48.000
2009.05.12 13:55:05.409: sent PM packet: 2009.05.12 13:55:05.000


DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File
Action
On-line
Options
Help
STOP
Soft STOP
Auto
Info
Command:
Flush SST Queue
send
EDITED PROGSCHED
Sounding Mode
Built-In Test
Channel Equalizing
Tracker Calibration
Suspend Data Display
Display Options
Presentation
ionogram
Refresh every
250
ms
View Preface
Threshold above MPA in steps
6
Polarization
ALL
O
X
printing color scheme
Freq [MHz]:
0.5
12.0
Height [km]
80
900
Use zoom
Millstone Hill, MHJ45
2009.05.12 (132) 13:18:39
540
450
400
350
300
250
200
150
100
50
-20
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30
NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW
F #791
19.869
.49E+07
H #158
373.8
o 33 1
A 0 Z 0
x 0
A Z
g -18
mpo 30
mpx 0
Channels look good
2009.05.12 13:47:49
STATE:
Manual
DESC is IDLE
CMD out:
139
PM out:
4072
SCI in:
50560
HK in:
182
FSW Errs:
0
Bad Pckts:
0
2009.05.12 13:47:03.643: received ALIVE packet
2009.05.12 13:47:09.409: sent PM packet: 2009.05.12 13:47:09.000
2009.05.12 13:47:26.409: sent PM packet: 2009.05.12 13:47:26.000
2009.05.12 13:47:33.643: received ALIVE packet
2009.05.12 13:47:43.409: sent PM packet: 2009.05.12 13:47:43.000
DCART
Start
DCART v1.2.09 (DESC...
Preface
Dispatcher
DDESC
untitled - Paint


DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File Action On-line Options Help
STOP
Soft STOP
Auto
Info
send
EDITED PROGSCHED
Sounding Mode
Built-In Test
Channel Equalizing
Tracker Calibration
Antenna 1
Median value
Suspend Data Display
Display Options
Presentation
echogram
Refresh every
250
ms
View Preface
show as spectr
Use zoom
Use dB
Antenna
antenna 1
O
X
Freq [MHz]:
0.5
12
Amp
93.3
median
2009.05.12 (132) 13:18:39.515
Magnitude (median), dB
93.3
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Frequency, MHz
DCART 1.2.09
2009.05.12 13:46:58
STATE:
Manual
DESC is IDLE
DCART
CMD out: 139
PM out: 4069
SCI in: 50560
HK in: 182
FSW Errs: 0
Bad Pckts: 0
2009.05.12 13:46:03.642: received ALIVE packet
2009.05.12 13:46:18.408: sent PM packet: 2009.05.12 13:46:18.000
2009.05.12 13:46:33.642: received ALIVE packet
2009.05.12 13:46:35.408: sent PM packet: 2009.05.12 13:46:35.000
2009.05.12 13:46:52.409: sent PM packet: 2009.05.12 13:46:52.000
Start
DCART v1.2.09 (DESC...
Preface
Dispatcher
DDESC
untitled - Paint

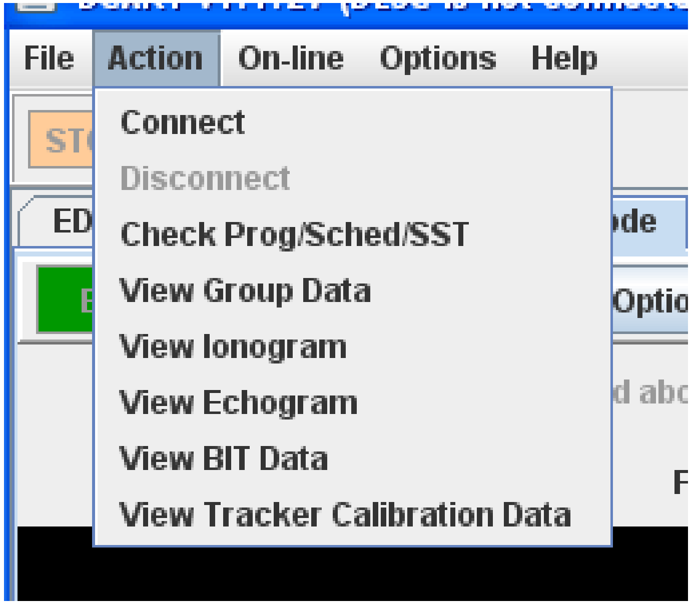

DCART v1.2.09 (DESC connected since 2009.05.12 (132) 13:20:13)
File Action On-line Options Help
STOP
Soft STOP
Auto
Info
send
EDITED PROGSCHED
Sounding Mode
Built-In Test
Channel Equalizing
Tracker Calibration
Antenna 4
Median value
Suspend Data Display
Display Options
Presentation echogram
Refresh every 250 ms
View Preface
show as spectr
Use zoom
Use dB
Antenna antenna 4
O
X
Freq [MHz]: 0.5 12
Amp 93.3
median
2009.05.12 (132) 13:18:39.515
Magnitude (median), dB
Frequency, MHz
DCART 1.2.09
2009.05.12 13:47:28
STATE: Manual
DESC is IDLE
CMD out: 139
PM out: 4071
SCI in: 50560
HK in: 182
FSW Errs: 0
Bad Pckts: 0
2009.05.12 13:46:35.408: sent PM packet: 2009.05.12 13:46:35.000
2009.05.12 13:46:52.409: sent PM packet: 2009.05.12 13:46:52.000
2009.05.12 13:47:03.643: received ALIVE packet
2009.05.12 13:47:09.409: sent PM packet: 2009.05.12 13:47:09.000
2009.05.12 13:47:26.409: sent PM packet: 2009.05.12 13:47:26.000
DCART
Start
DCART v1.2.09 (DESC...
Preface
Dispatcher
DDESC
untitled - Paint

Menu: File



- **Program / Schedule – PROGSCHD**
  - **New**
  - **Open**
  - **Save**
- **Active PROGSCHD**
- **Exit**
  - **Ordinary**
  - **Set AUTO mode**

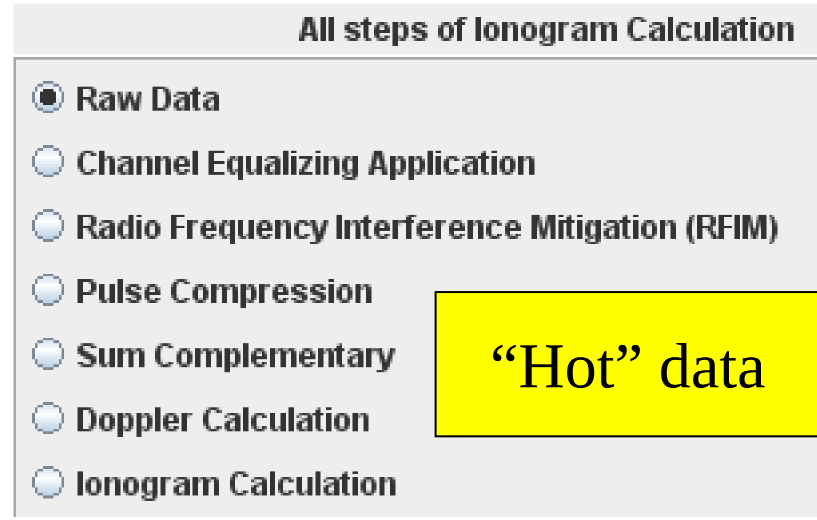
Menu: Action

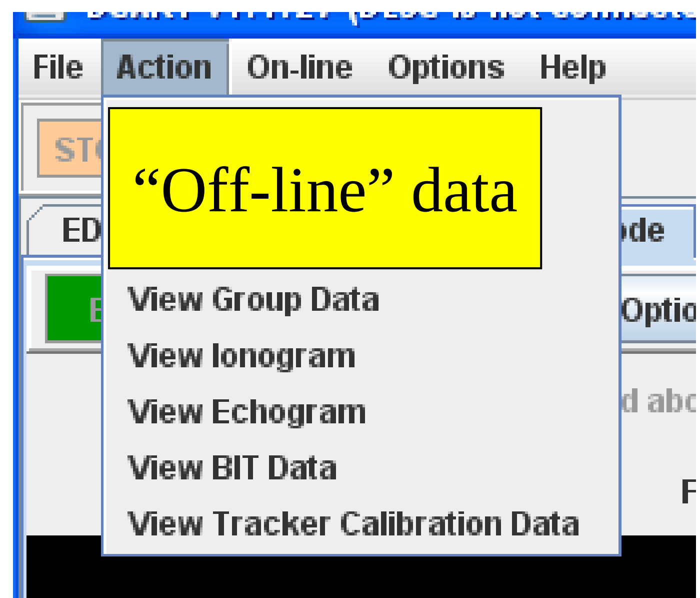


- Connect / Disconnect
- Check Programs / Schedules / SSTs
- View data from files

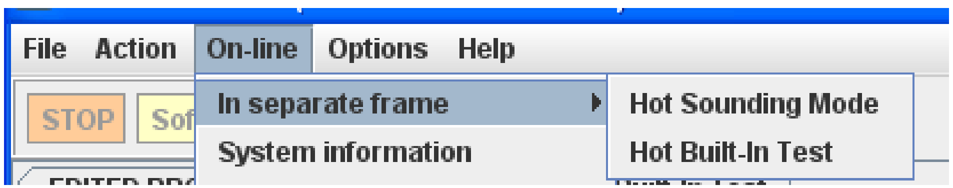
DCART Visualization Screens

- Amplitude, Angle Of Arrival
  - Ionogram
- 4 antenna - Amplitude, Phase
  - Echogram
  - Group data
    - Original RAW
    - With RFIM
    - With channel equalizing
    - Pulse compression
    - Sum of complementary
    - Drif
- Housekeeping
  - BIT
  - Tracker Calibration

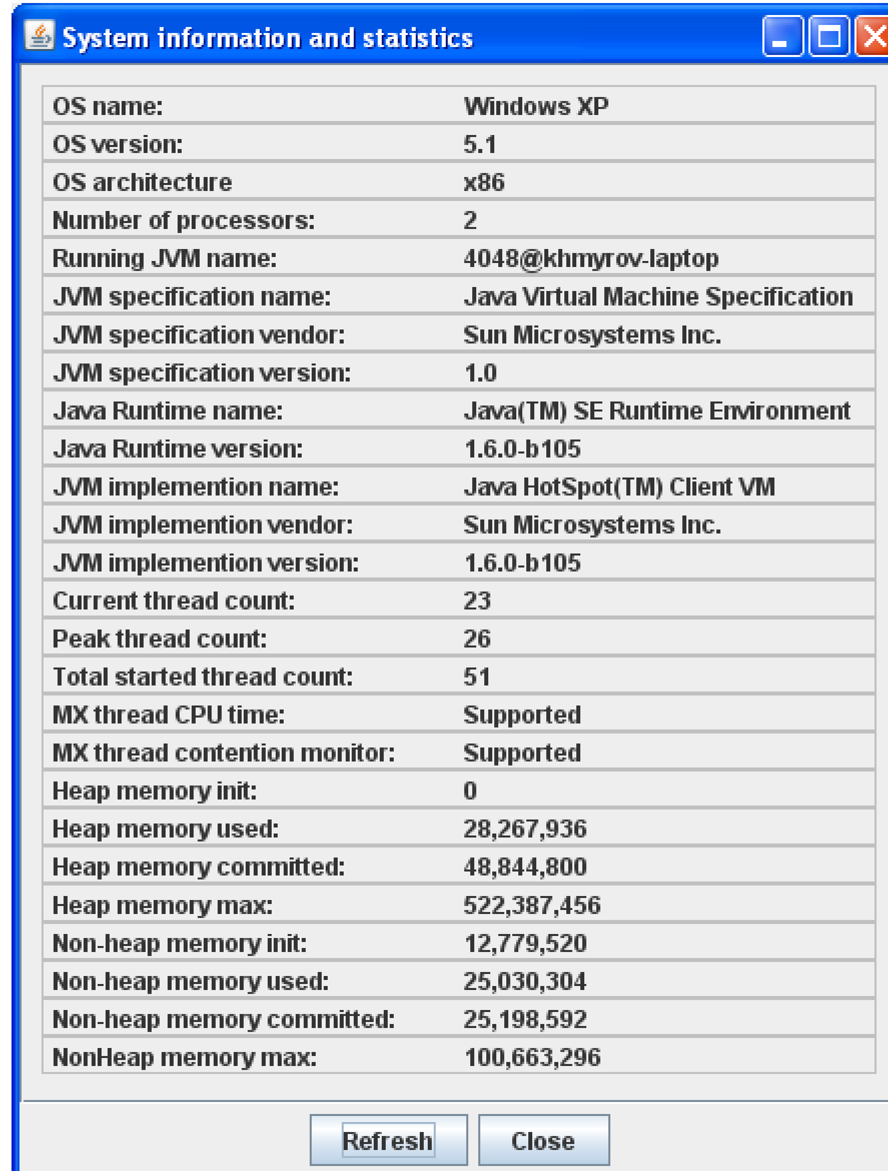




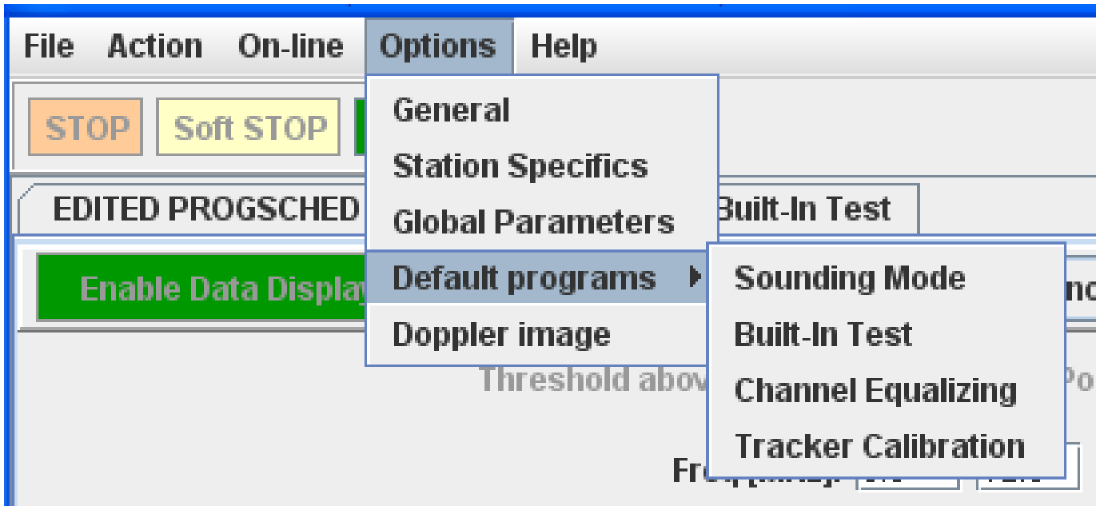
Menu: On-line

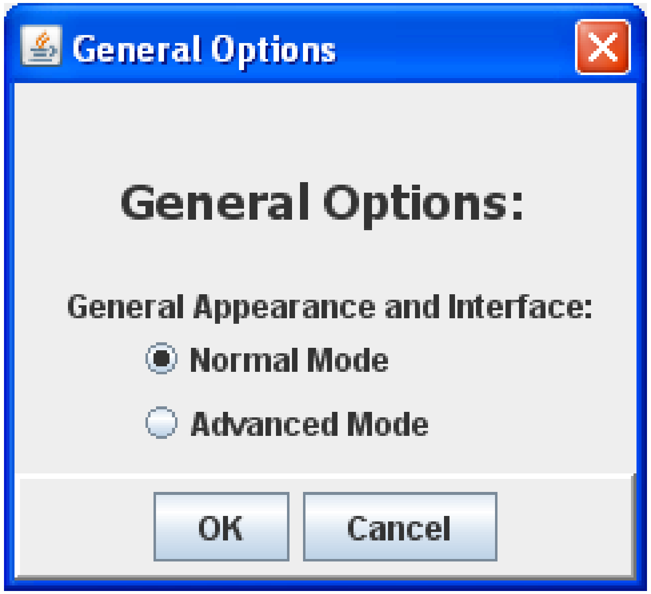


- Show tabs in separate frame
- System information



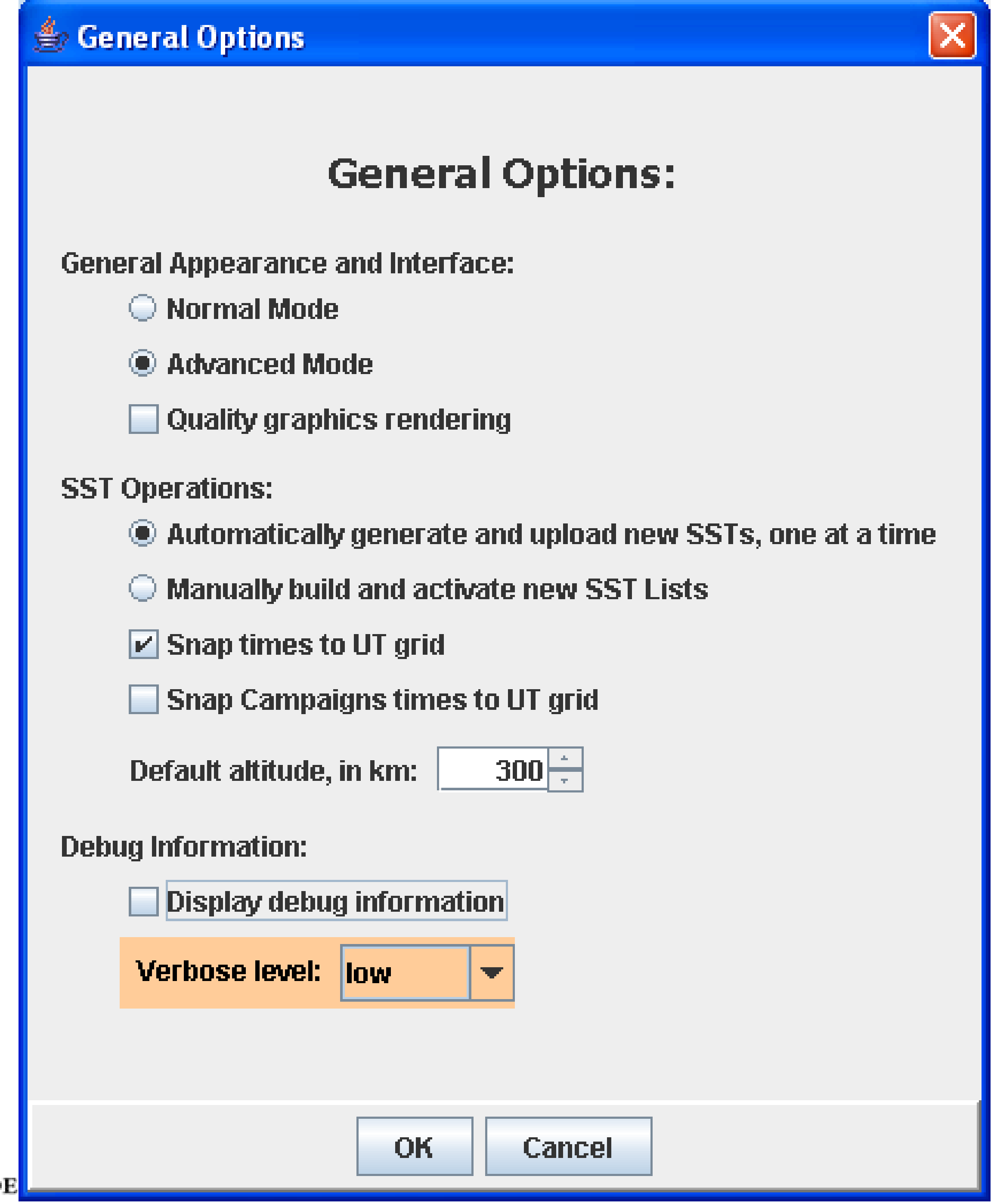
Menu: Options – Normal Mode



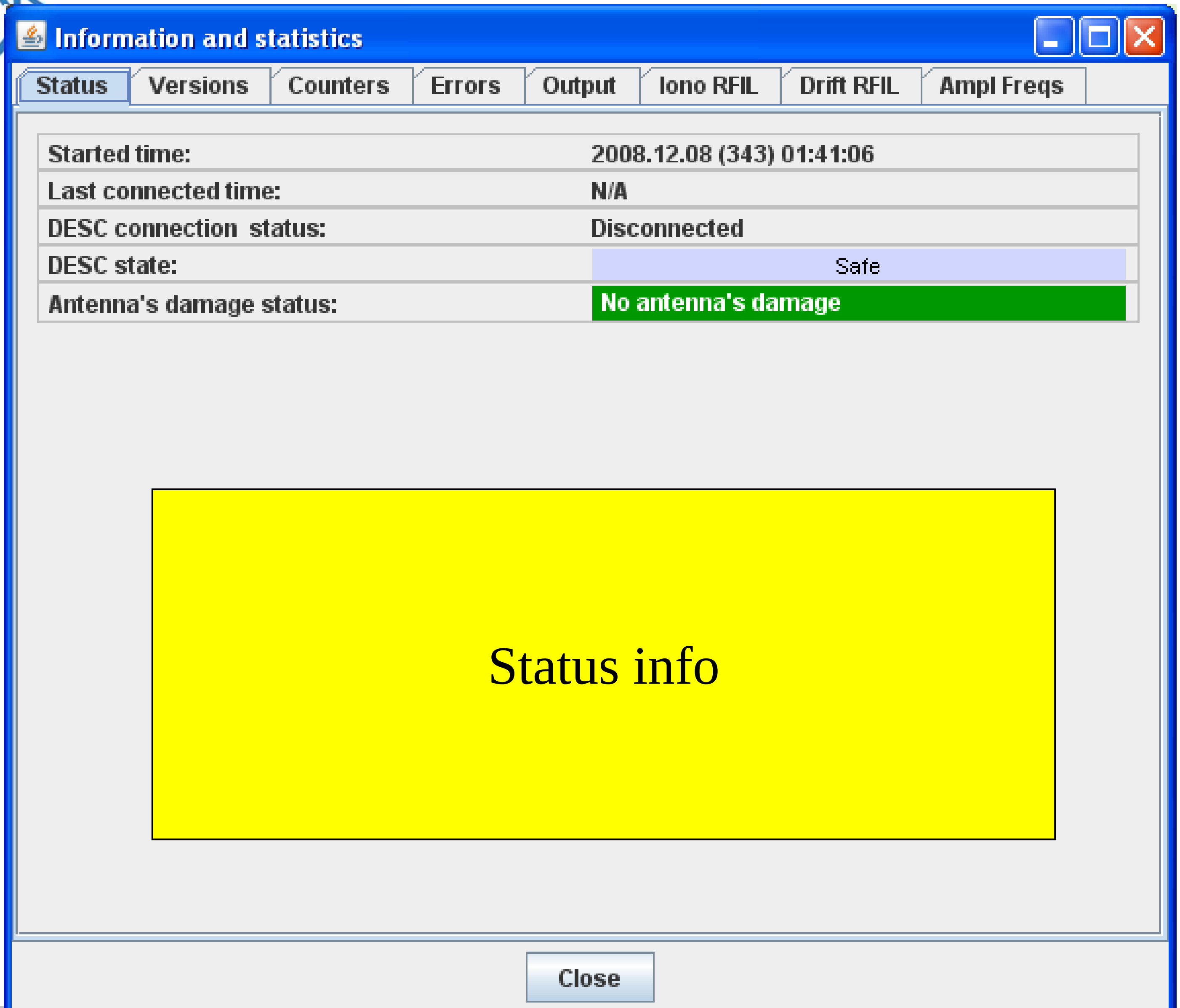


- General and Station Specific options disabled in Normal Mode
- Default programs
- Doppler image options

Menu: Options - Advanced Mode



Info: Status



Information and statistics
Status
Versions
Counters
Errors
Output
Iono RFIL
Drift RFIL
Ampl Freqs
Started time:
2008.12.08 (343) 01:41:06
Last connected time:
N/A
DESC connection status:
Disconnected
DESC state:
Safe
Antenna's damage status:
No antenna's damage
Status info
Close

Info: Version

Information and statistics

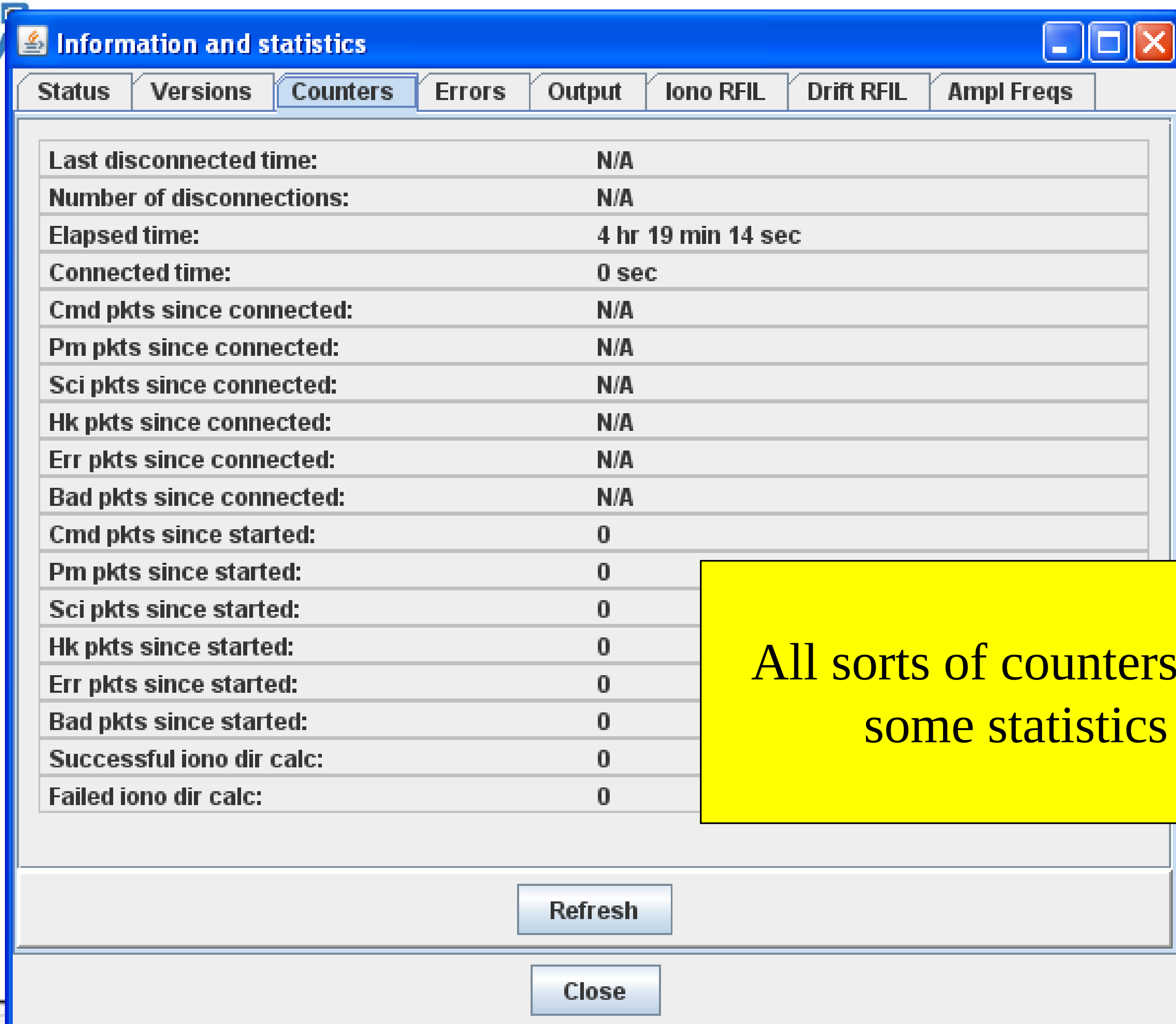
Status | Versions | Counters | Errors | Output | Iono RFIL | Drift RFIL | Ampl Freqs

DCART version:	1.1.27
DESC version:	N/A
Data versioning support:	YES
Measurement data version:	3
Measurement preface version:	1
Measurement program version:	3

Versions of DESC, DCART, and data

Close

Info: Counters



All sorts of counters and some statistics

Info: Errors and Output

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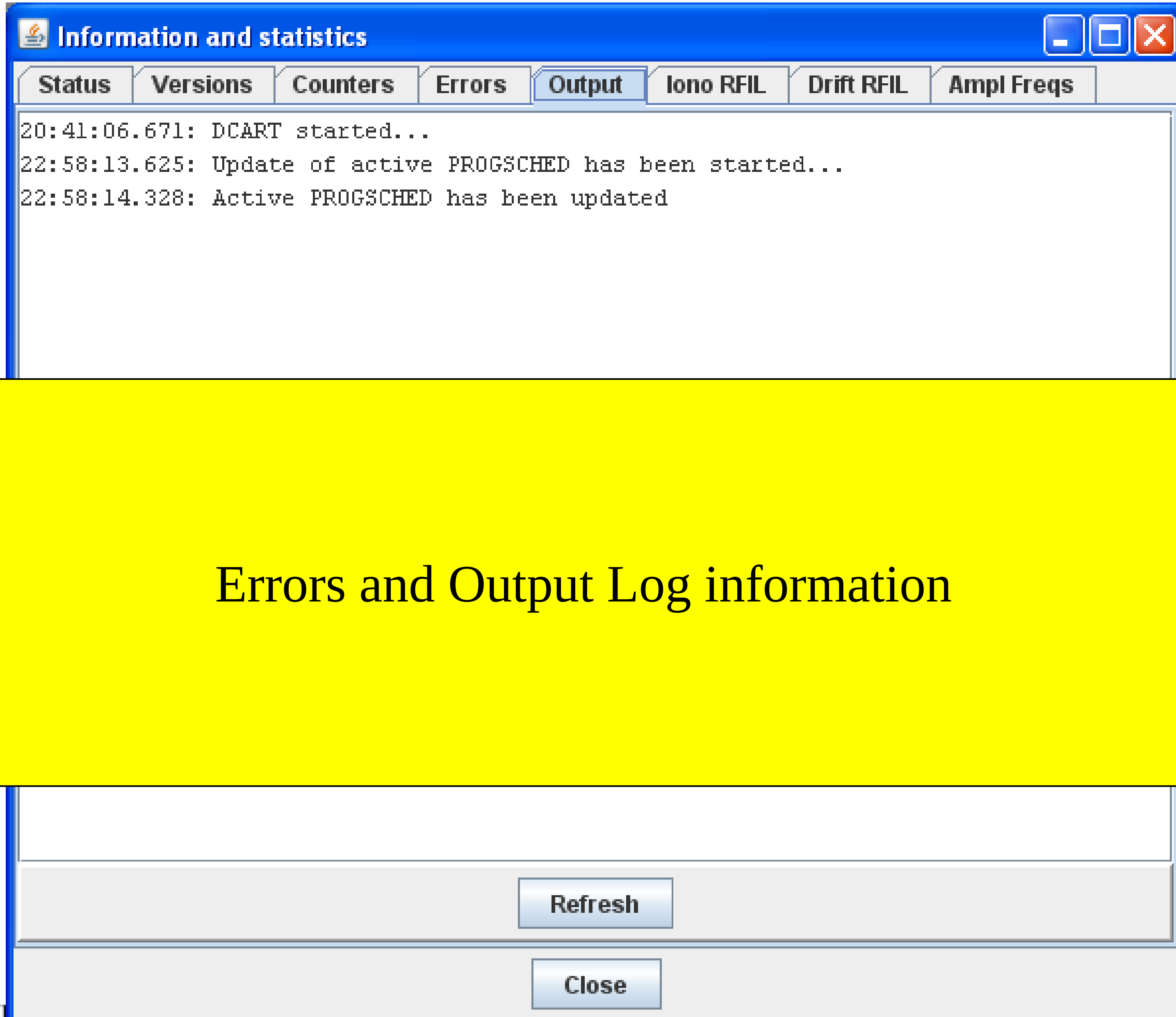
CENTER FOR ATMOSPHERIC RESEARCH



Errors and Output Log information

Info: Ionogram and Drift RFIL

Information and statistics

Status | Versions | Counters | Errors | Output | Iono RFIL | Drift RFIL | Ampl Freqs

Frequencies are given in kHz

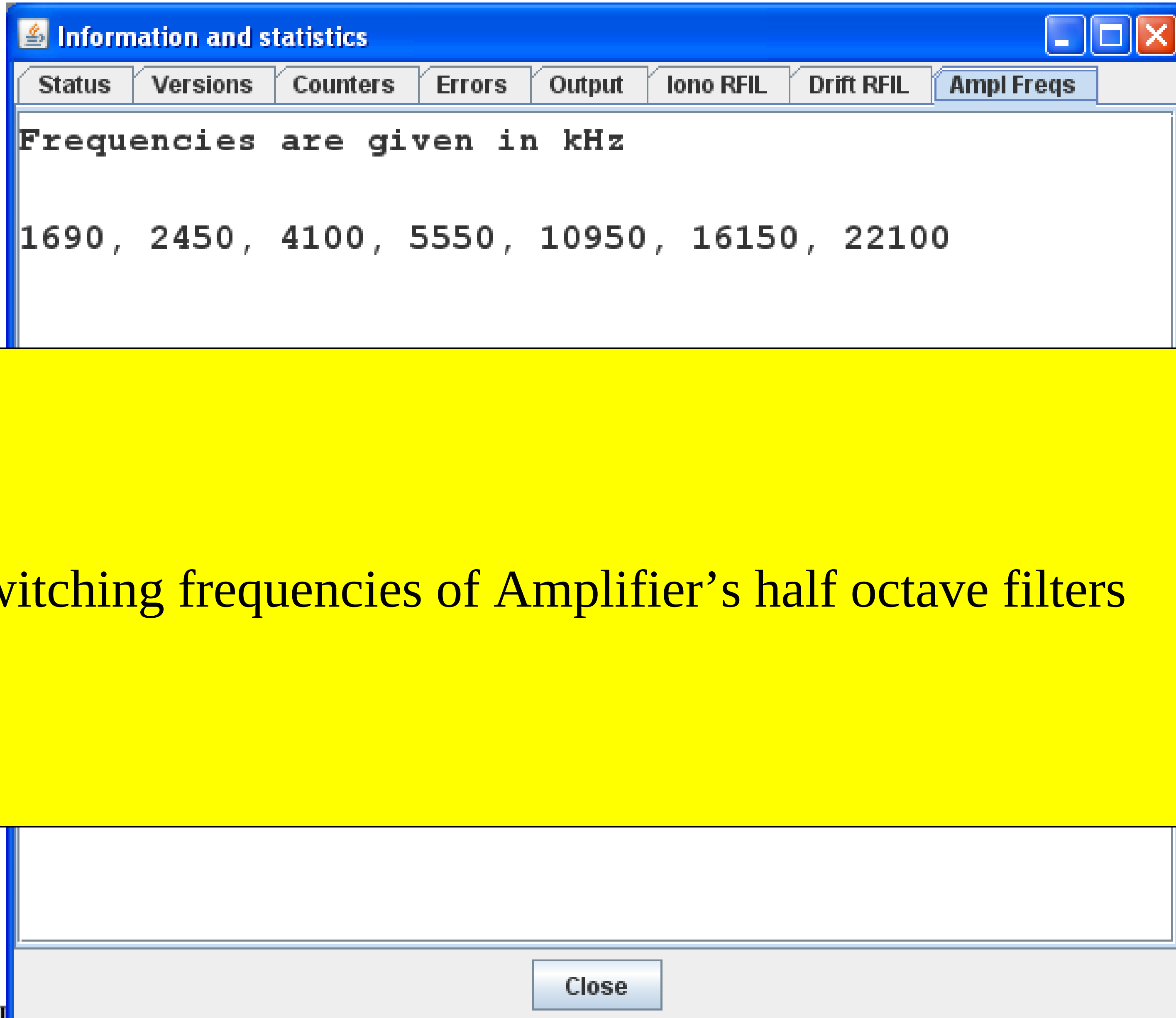
2495-2505, 2850-3155, 3400-3600, 4000-4063,
4650-4750, 4995-5005, 5450-5730, 6525-6765,
8815-9040, 9995-10010, 11175-11400, 13200-13410,
14990-15100, 17990-18030, 19990-20010, 21850-21870,
21924-22000, 23200-23350, 24990-25010, 25550-25670

Close

RFIL - Restricted Frequency Interval List
For Ionogram and Drift measurements

In Drift mode Digisonde transmits longer time on same frequency
and usually needs stronger restrictions

Info: Amplifier frequencies



Switching frequencies of Amplifier’s half octave filters

Advanced Mode

> Options
- General
- Connection
- Communication
- Station Specific

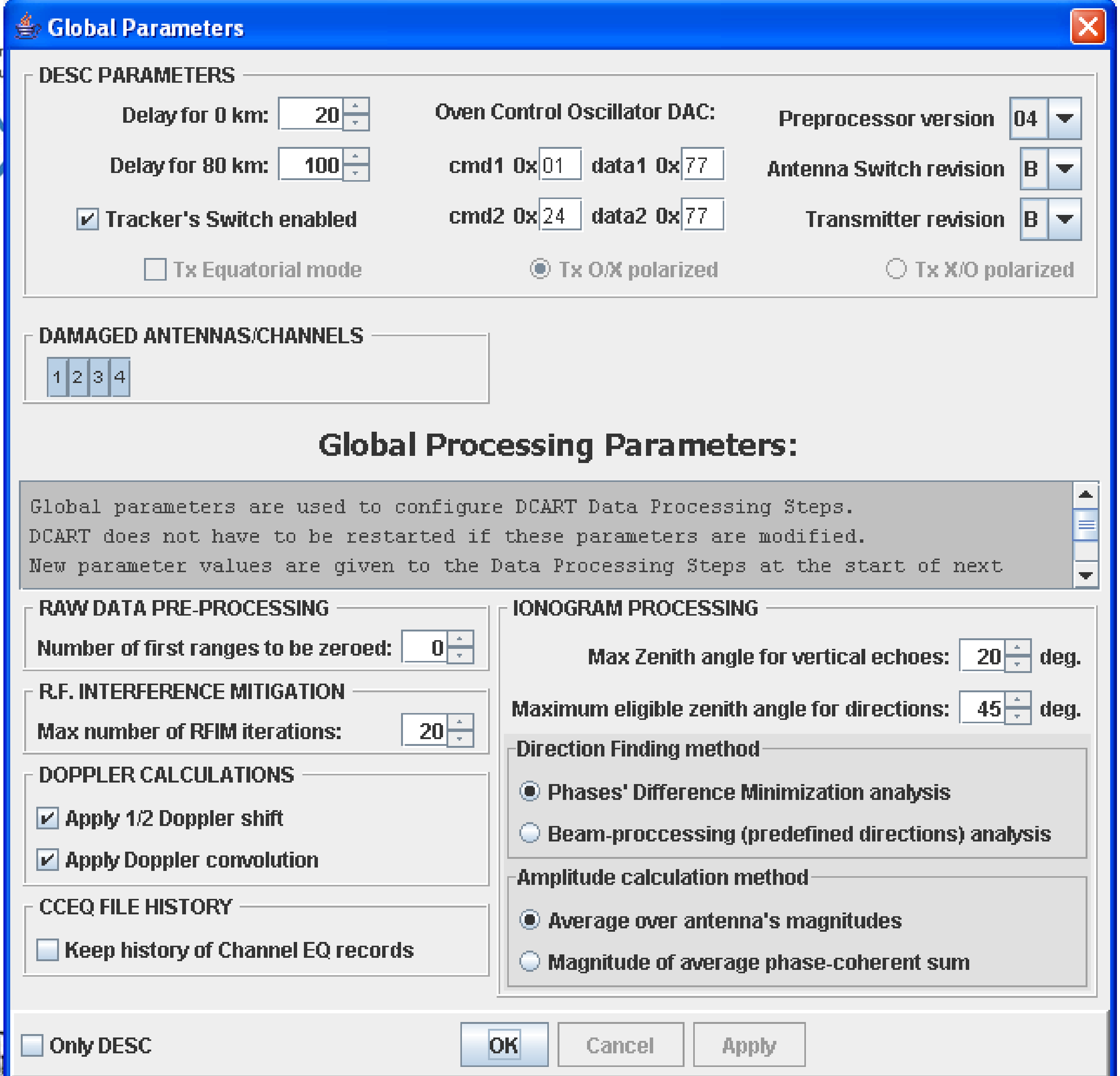
> Data Tabs
- Channel Equalizing
- Tracker Calibration Data
- HK headers
- Development Tools

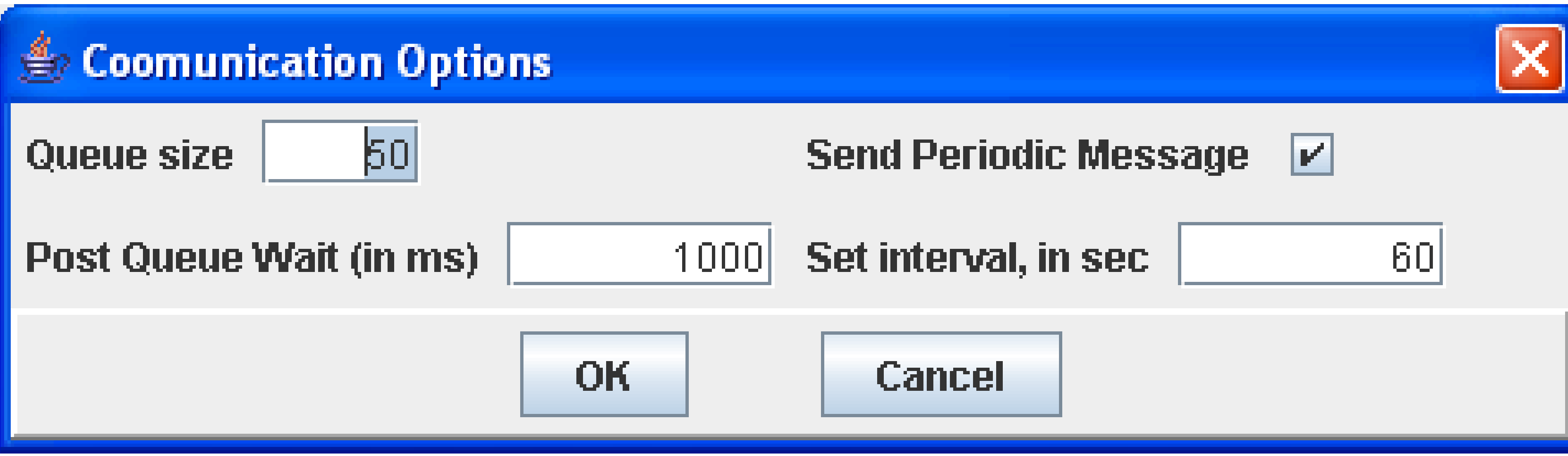
> Save data options

> Additional commands

> Thread information

> Monitor processing queues


Global Parameters
DESC PARAMETERS
Delay for 0 km: 20
Delay for 80 km: 100
Tracker's Switch enabled
Tx Equatorial mode
Oven Control Oscillator DAC:
cmd1 0x 01 data1 0x 77
cmd2 0x 24 data2 0x 77
Tx O/X polarized
Preprocessor version 04
Antenna Switch revision B
Transmitter revision B
Tx X/O polarized
DAMAGED ANTENNAS/CHANNELS
1 2 3 4
Global Processing Parameters:
Global parameters are used to configure DCART Data Processing Steps.
DCART does not have to be restarted if these parameters are modified.
New parameter values are given to the Data Processing Steps at the start of next
RAW DATA PRE-PROCESSING
Number of first ranges to be zeroed: 0
R.F. INTERFERENCE MITIGATION
Max number of RFIM iterations: 20
DOPPLER CALCULATIONS
Apply 1/2 Doppler shift
Apply Doppler convolution
CCEQ FILE HISTORY
Keep history of Channel EQ records
IONOGRAM PROCESSING
Max Zenith angle for vertical echoes: 20 deg.
Maximum eligible zenith angle for directions: 45 deg.
Direction Finding method
Phases' Difference Minimization analysis
Beam-proccessing (predefined directions) analysis
Amplitude calculation method
Average over antenna's magnitudes
Magnitude of average phase-coherent sum
Only DESC
OK
Cancel
Apply


Coomunication Options
Queue size
50
Send Periodic Message
Post Queue Wait (in ms)
1000
Set interval, in sec
60
OK
Cancel

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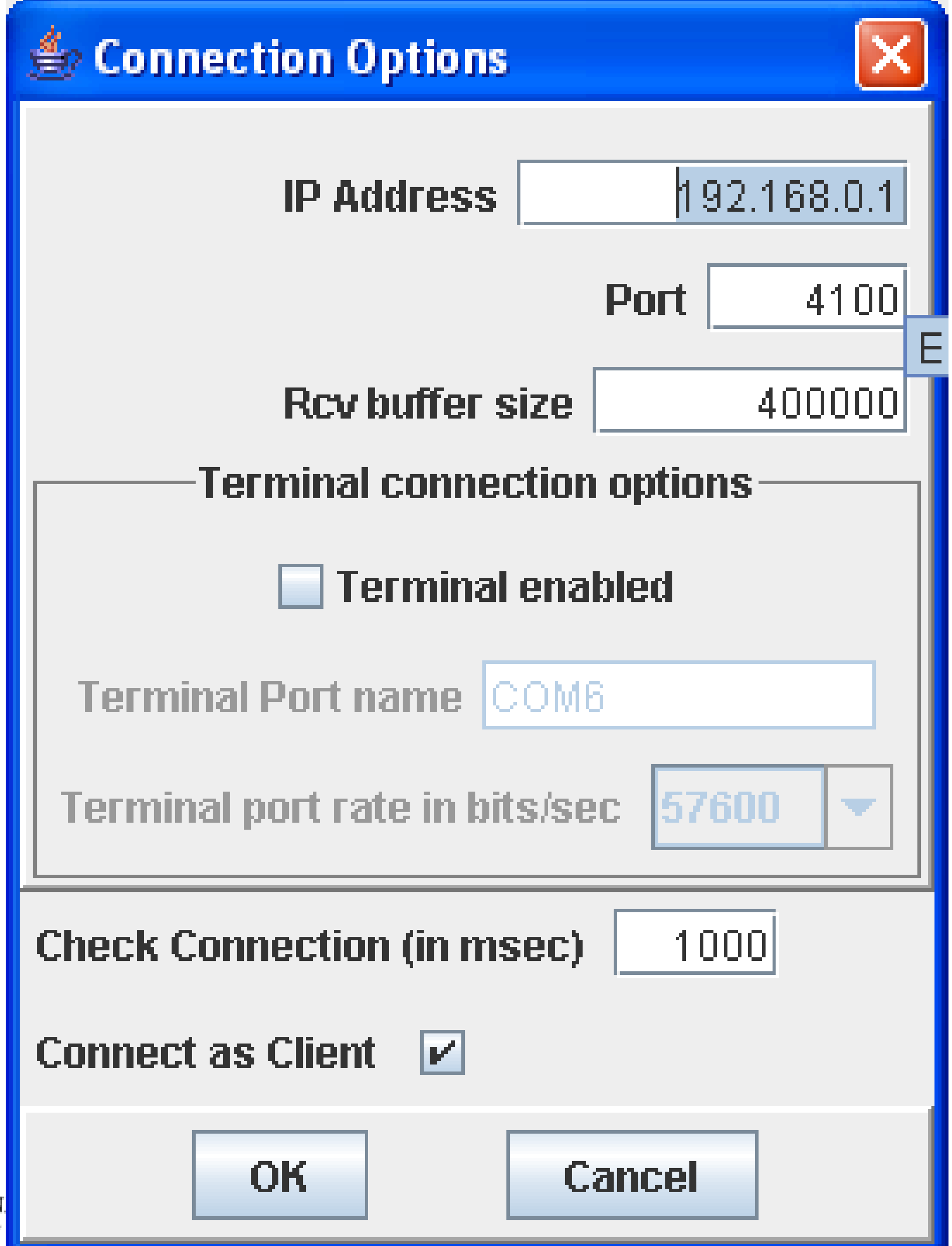
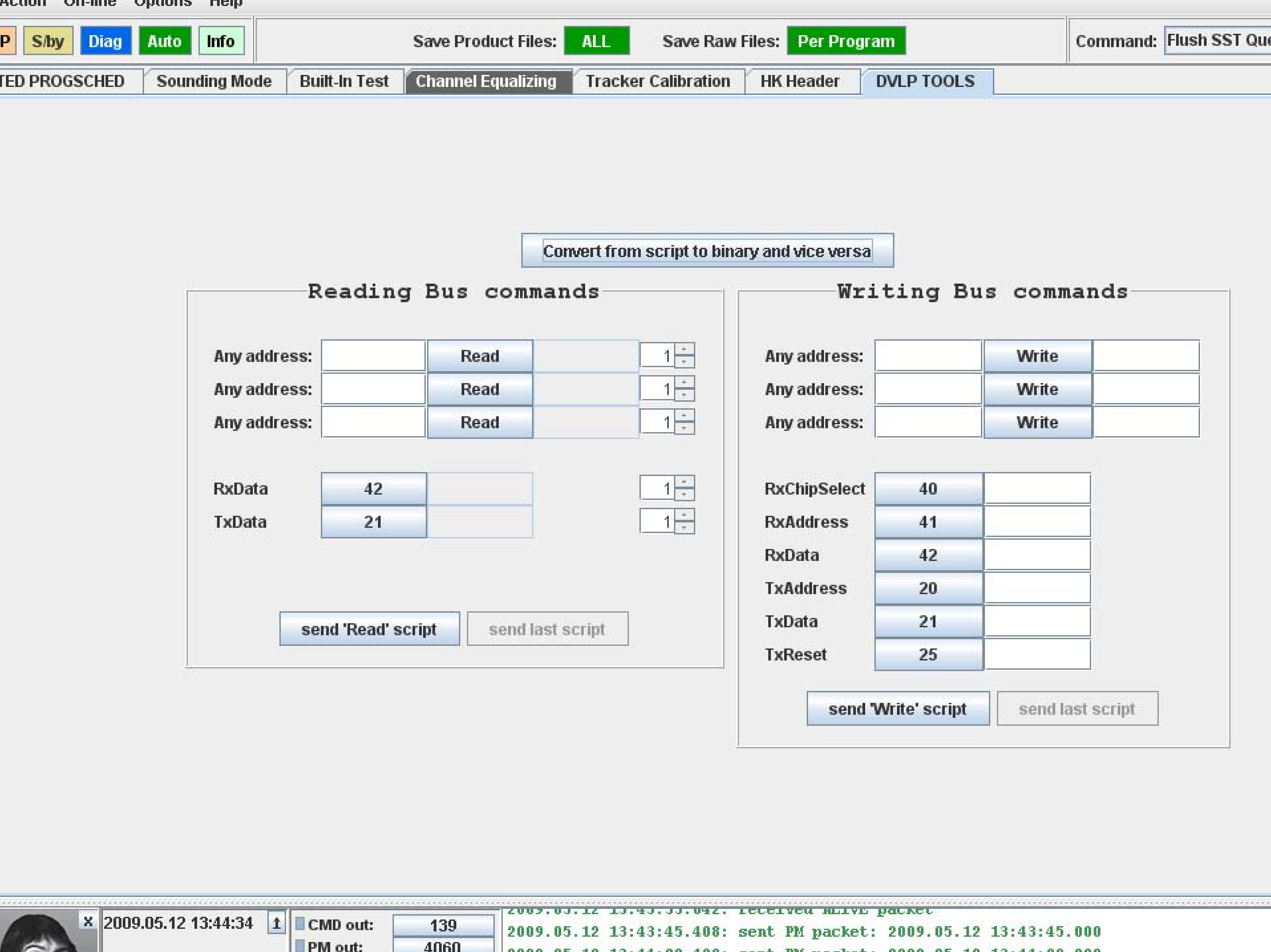
CENTER FOR ATMOSPHERIC RESEARCH



2009 IDF XII INTERN
11 - 14 MAY


P
S/by
Diag
Auto
Info
Save Product Files:
ALL
Save Raw Files:
Per Program
Command:
Flush SST Que
TED PROGSCHED
Sounding Mode
Built-In Test
Channel Equalizing
Tracker Calibration
HK Header
DVLP TOOLS
Convert from script to binary and vice versa
Reading Bus commands
Any address:
Read
1
Any address:
Read
1
Any address:
Read
1
RxData
42
1
TxData
21
1
send 'Read' script
send last script
Writing Bus commands
Any address:
Write
Any address:
Write
Any address:
Write
RxChipSelect
40
RxAddress
41
RxData
42
TxAddress
20
TxData
21
TxReset
25
send 'Write' script
send last script
2009.05.12 13:44:34
CMD out:
139
PM out:
4060
2009.05.12 13:43:45.408: sent PM packet: 2009.05.12 13:43:45.000

Diag | Auto | Info | Save Product Files: ALL | Save Raw Files: Per Program | Command: Flush SST Queue

SCHED | Sounding Mode | Built-In Test | Channel Equalizing | Tracker Calibration | HK Header | DVLP TOOLS

Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:46.575 DIAGNOSTIC Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x103A, Command PROG_START acknowle...	Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:46.120 DIAGNOSTIC Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x1082, Command STATE_DIAG acknowled...	Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:46.115 STANDBY Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x1021, Command PROG_UPLOAD acknowl...
Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:46.115 STANDBY Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x1081, Command STATE_STANDBY ackno...	Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:37.270 DIAGNOSTIC Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x1082, Command STATE_DIAG acknowled...	Packet: 0x02, EVENT_MSG Current State Timestamp: 2009/05/12 13:41:37.270 STANDBY Versions DESC 1.2.3 Scheduler Top SST: --- @ SST Queue is empty 0x1021, Command PROG_UPLOAD acknowl...

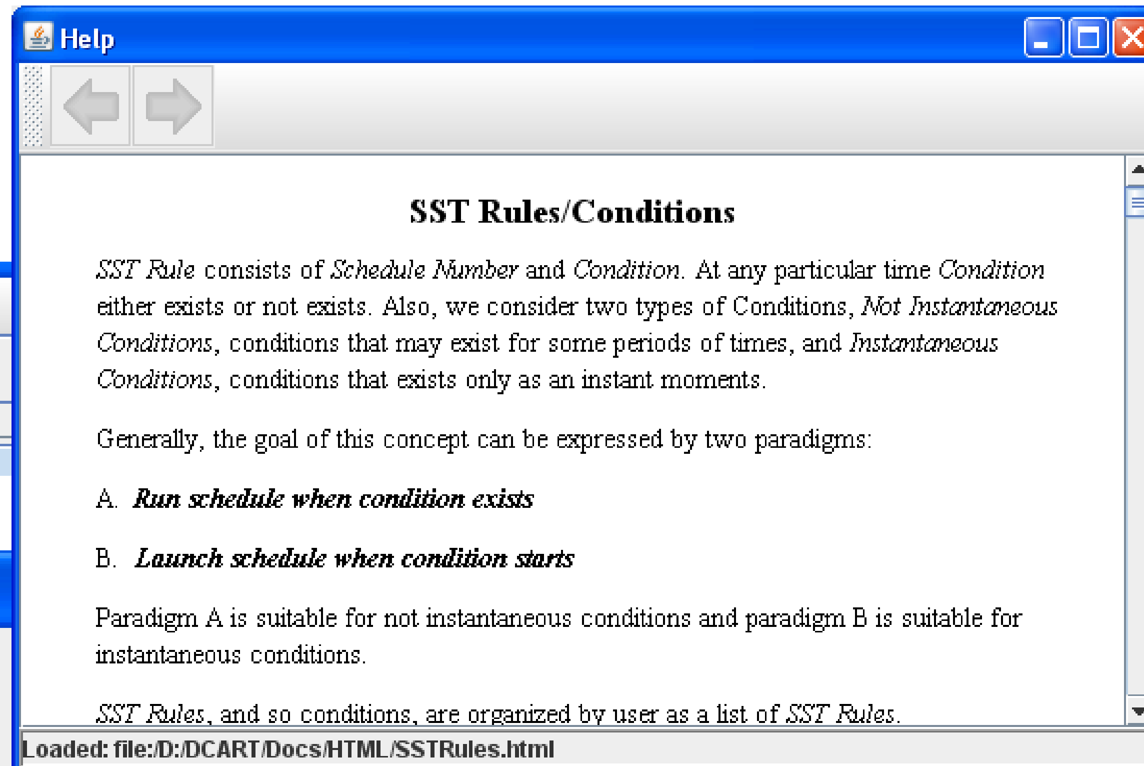
2009.05.12 13:44:00

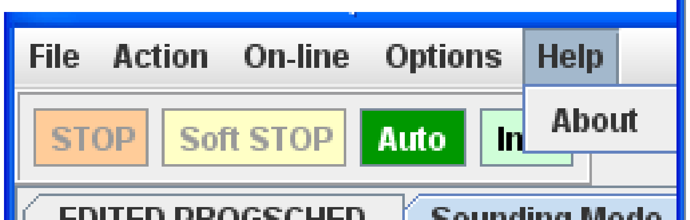
CMD out:	139
PM out:	4058
SCI in:	50560

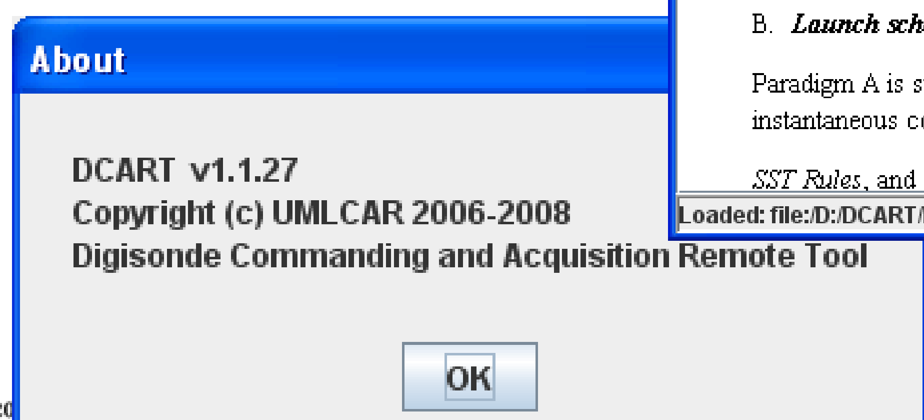
```
2009.05.12 13:43:03.641: received ALIVE packet
2009.05.12 13:43:11.407: sent PM packet: 2009.05.12 13:43:11.000
2009.05.12 13:43:28.407: sent PM packet: 2009.05.12 13:43:28.000
```

Menu: Help

- > **Intuitive and Self-explained interface**
- > **Tool tips with explanation and Hot keys**
- > **Manual**







Fault Isolation with BIT

Ryan Hamel
University of Massachusetts Lowell, Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

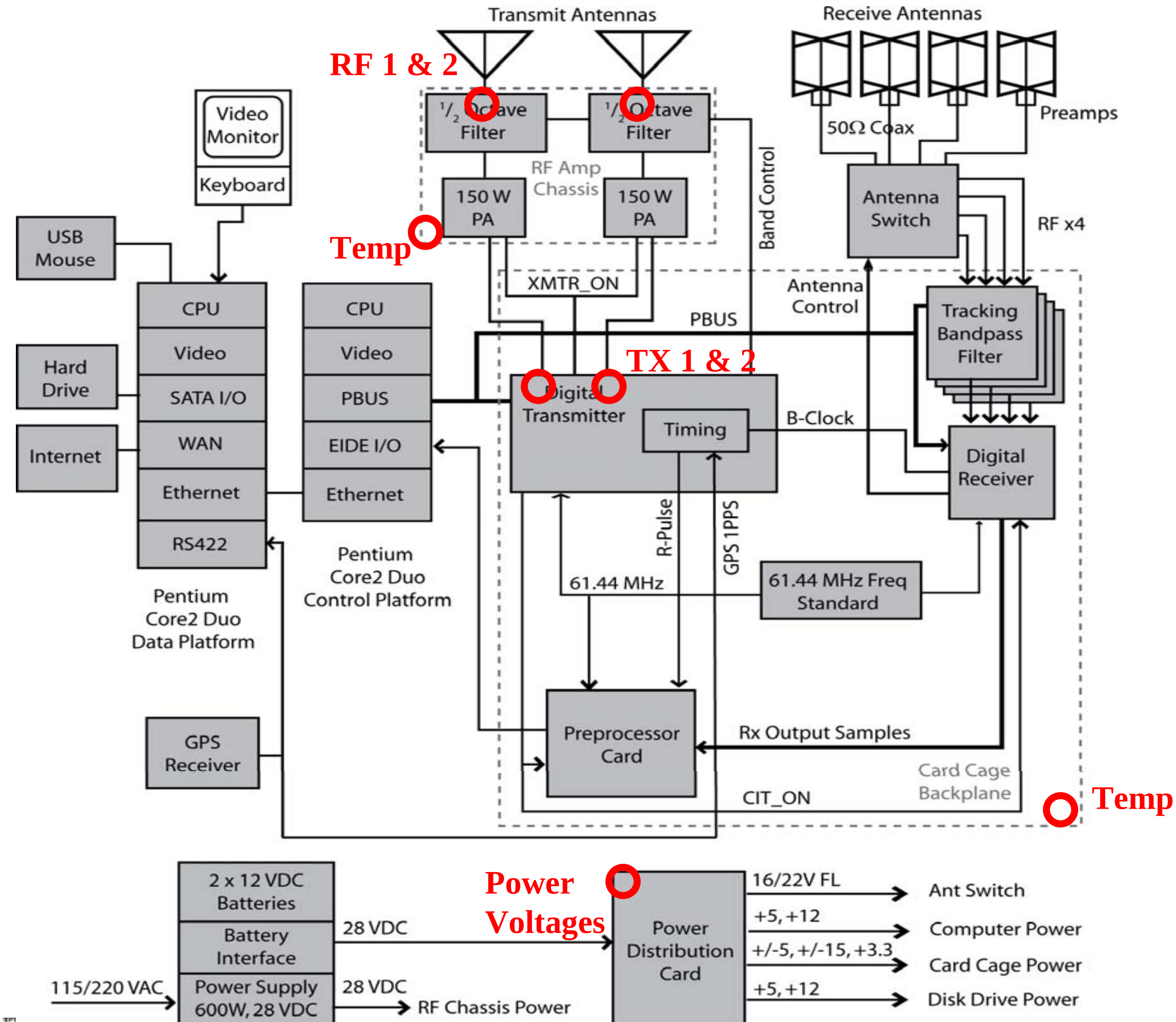
What is BIT?

- **B**uilt **I**n **T**est
- Analyzes and reports the system health
- <u>BIT Card</u> functions as a collection point for various system sensors
- <u>BIT Program</u> uses the data collected by the BIT card in addition to measurement data.

BIT Sensors

- Types of Sensors
  - Digital (Pass / Fail)
  - Static Analog (analog signals always present, temperature)
  - Dynamic Analog (analog signals present while sounding)
- BIT Card Sensors
  - Power Distribution card power for Preamplifier / Polarization Box (digital)
  - Power Distribution card -15V, -5V, +3.3V, +15V, +12V (digital)
  - Power Distribution card over-temperature condition (digital)
  - Power Amplifier power for first stage amplifier +18V (digital)
  - Transceiver Chassis Temperature (static analog)
  - Power Amplifier Chassis Temperature (static analog)
  - Power Amplifier Chassis RF channel 1 & 2 output (dynamic analog)
  - Transmitter card channel 1 & 2 output (dynamic analog)
- Other Data / Sensors
  - Receiver card channel 1, 2, 3, 4 output (dynamic analog, “routine data”)
  - Hardware Test Pattern from Pre-Processor (digital, gathered by DESC)
  - Parallel Bus Data Timeouts (digital, determined by DESC)

BIT Card Sensor Diagram

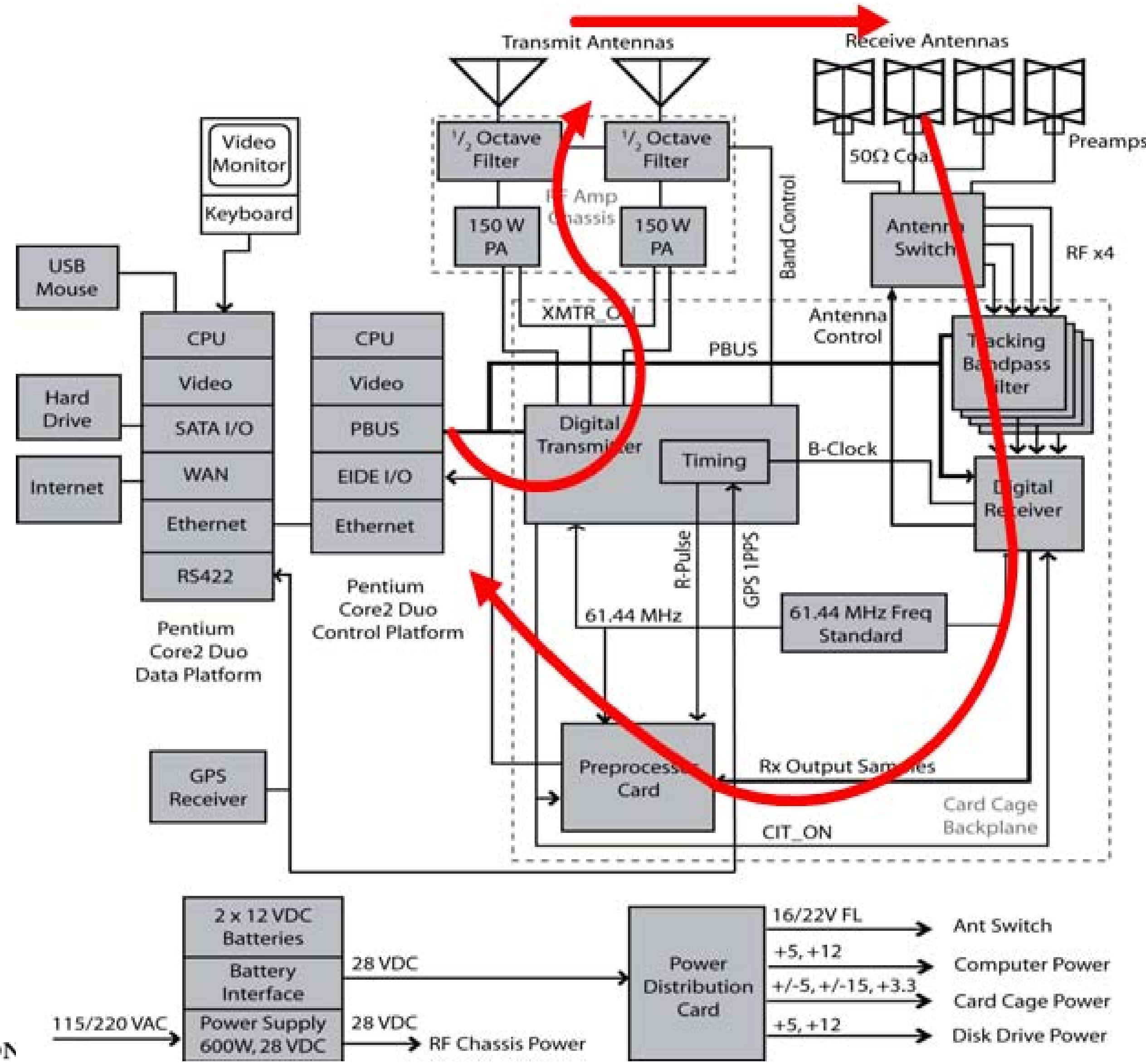


4 BIT Cases

- Case 1: External Loopback
- Case 2: Internal Loopback
- Case 3: Internal Loopback without Trackers
- Case 4: Dummy Load

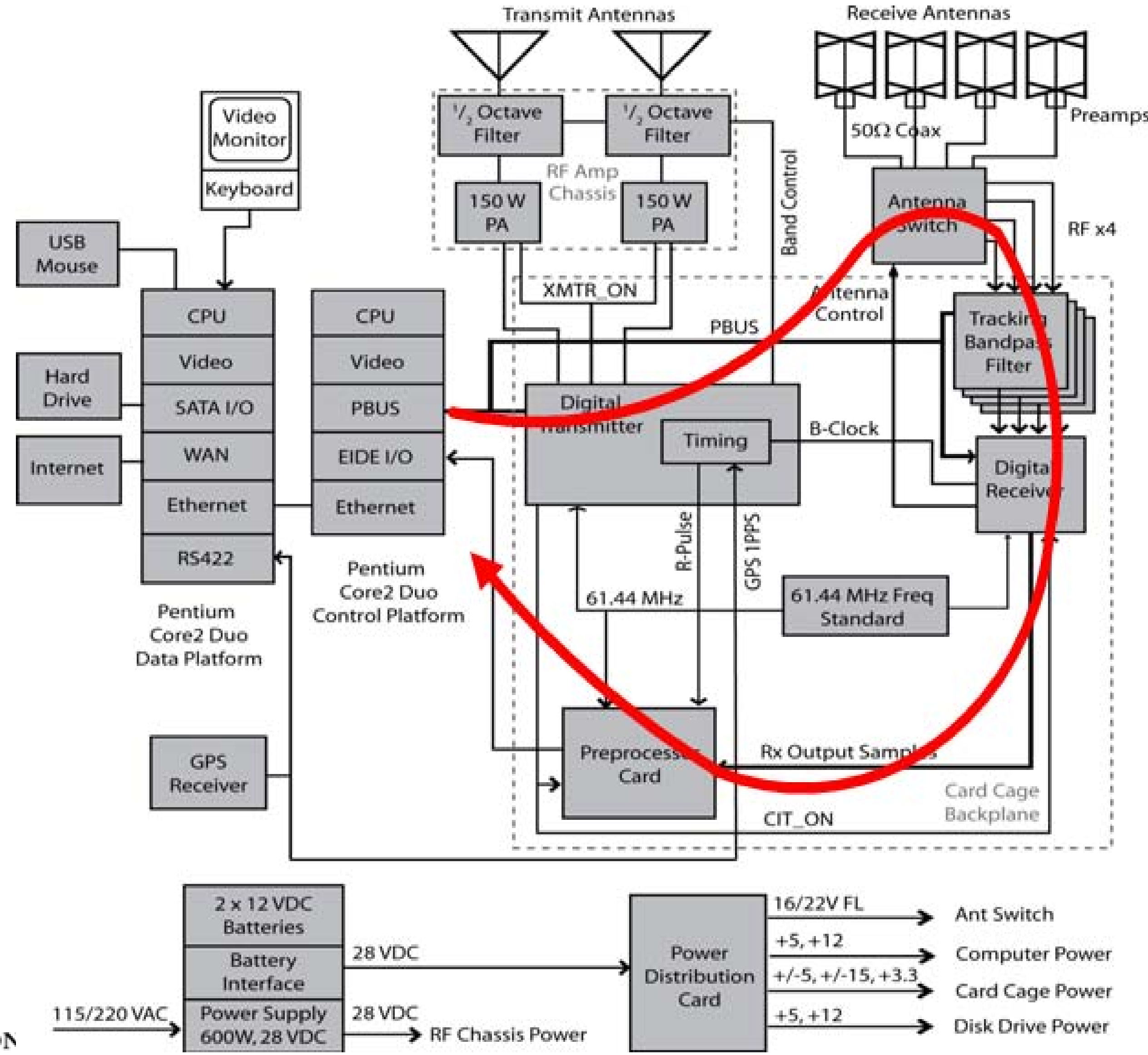
Case 1 External Loopback

- Normal transmission via transmit antenna
- Listening at 0 height for the transmitter pulse
- Signal enters through the receive antennas as it would during normal sounding



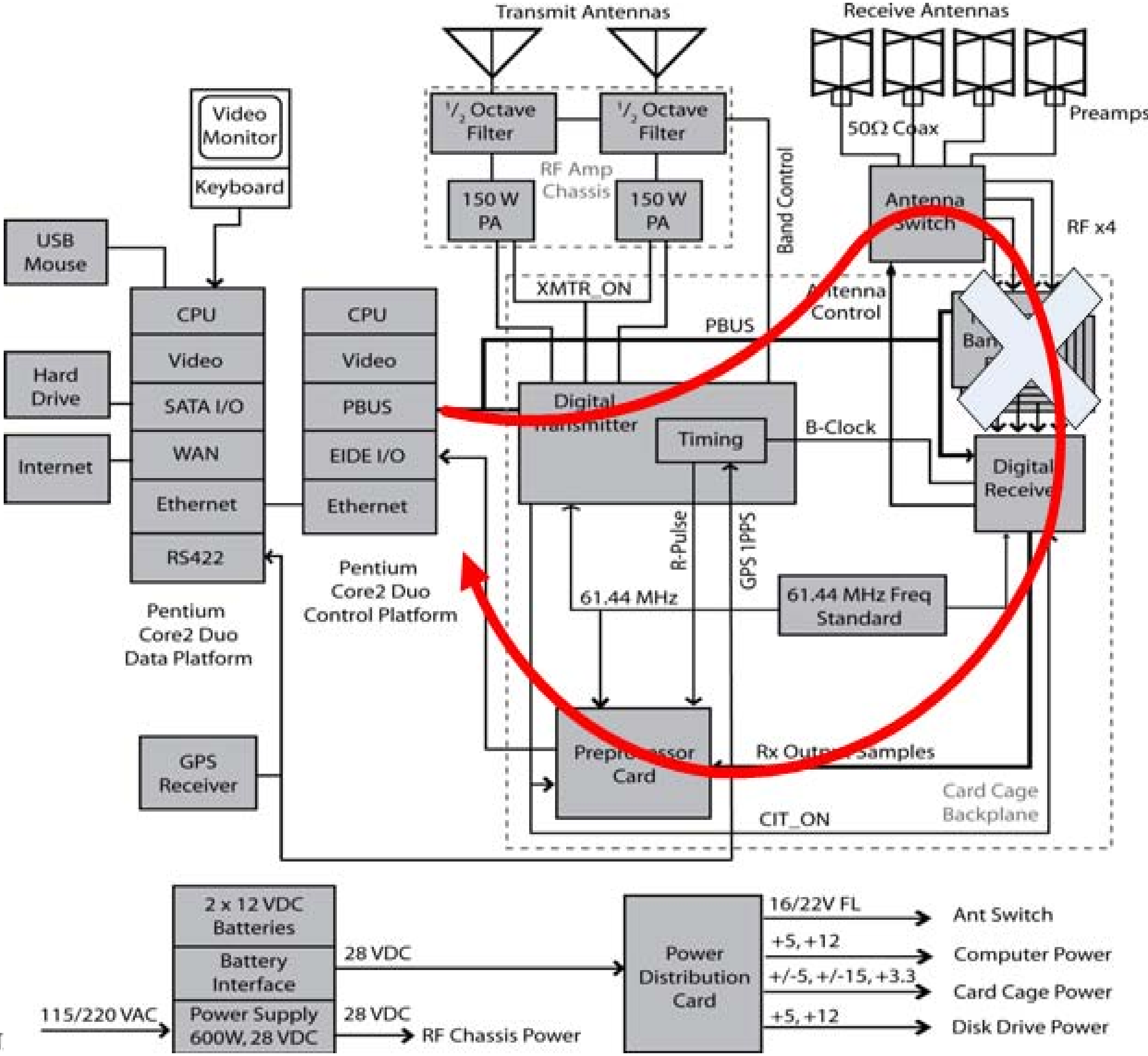
Case 2 Internal Loopback

- CAL output from Transmitter Card to Antenna Switch
- Antenna switch routes signal to trackers



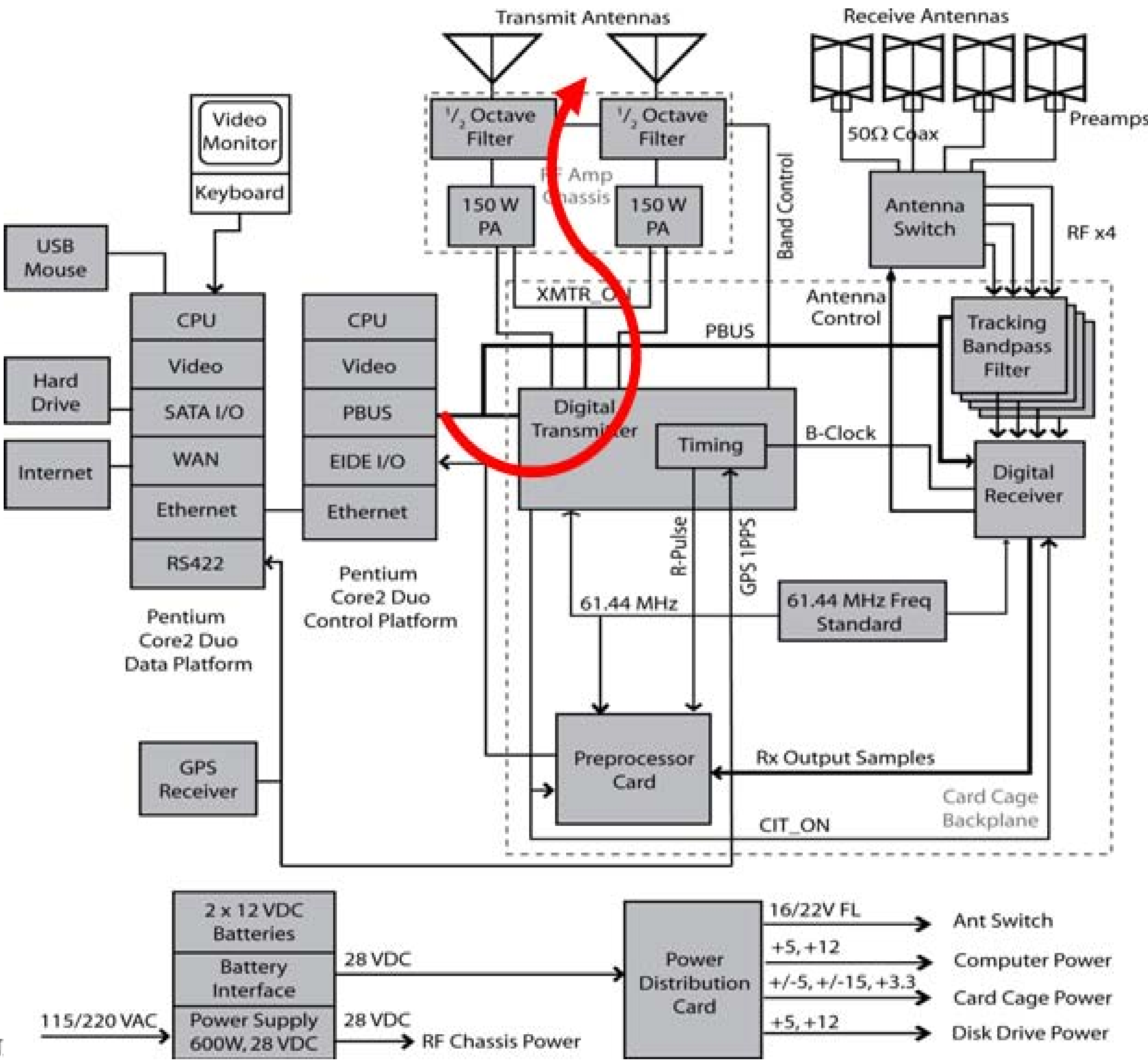
Case 3 Internal Loopback without trackers.

- CAL output from Transmitter Card to Antenna Switch
- Antenna switch routes signal to trackers
- Trackers switch input to output



Case 4 RF output to dummy loads

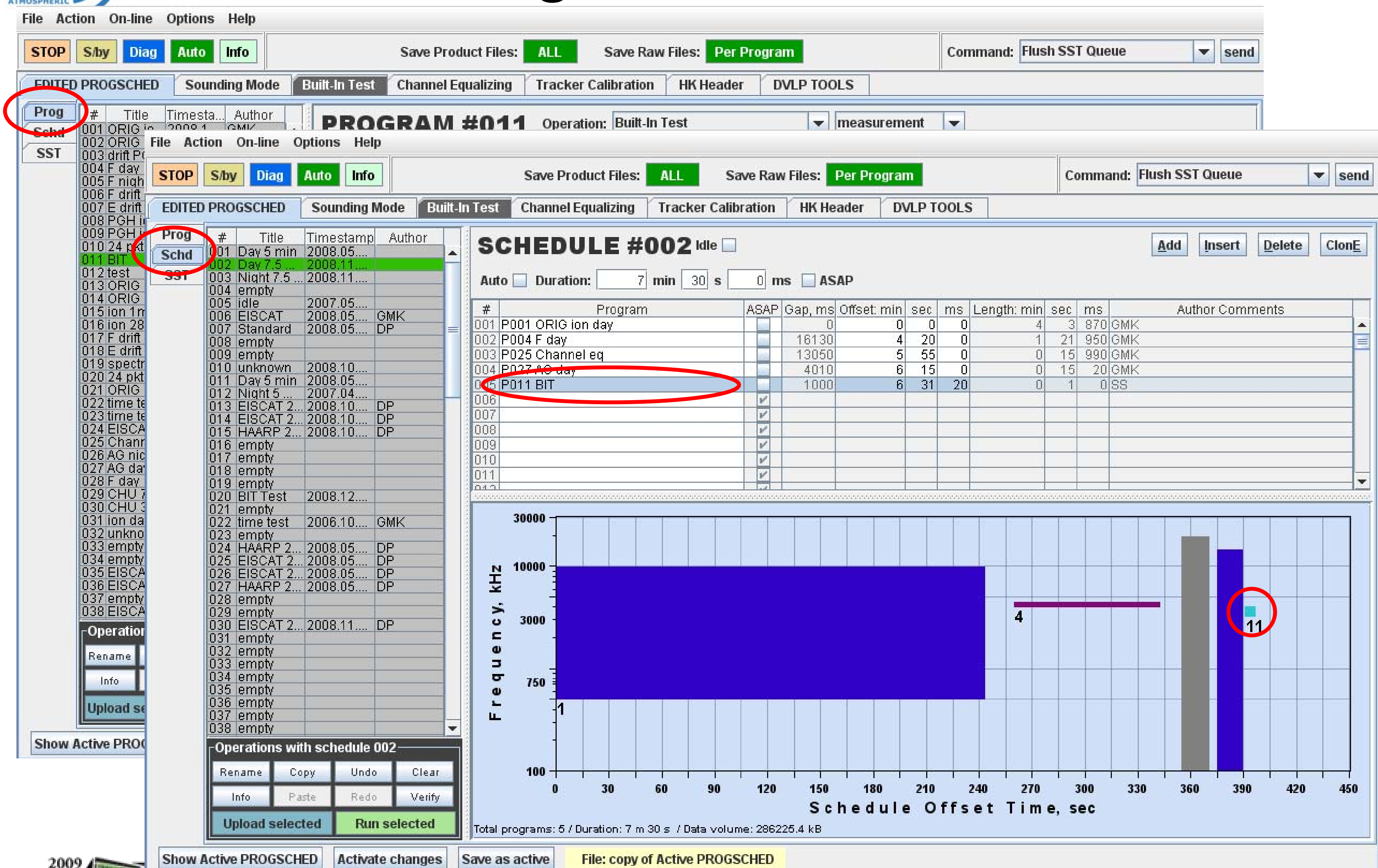
- Half Octave Filters switch to dummy loads
- No transmission
- This allows us to evaluate the transmit antenna health



BIT Program

- BIT is a program that can be scheduled
- Ensure it is included in the routine sounding schedule
- Can be run manually in DCART’s “Manual” mode
- Data display is available in 2 forms
  - Built-In Test Display
  - BIT Report
- BIT Report is also available on the Web Page

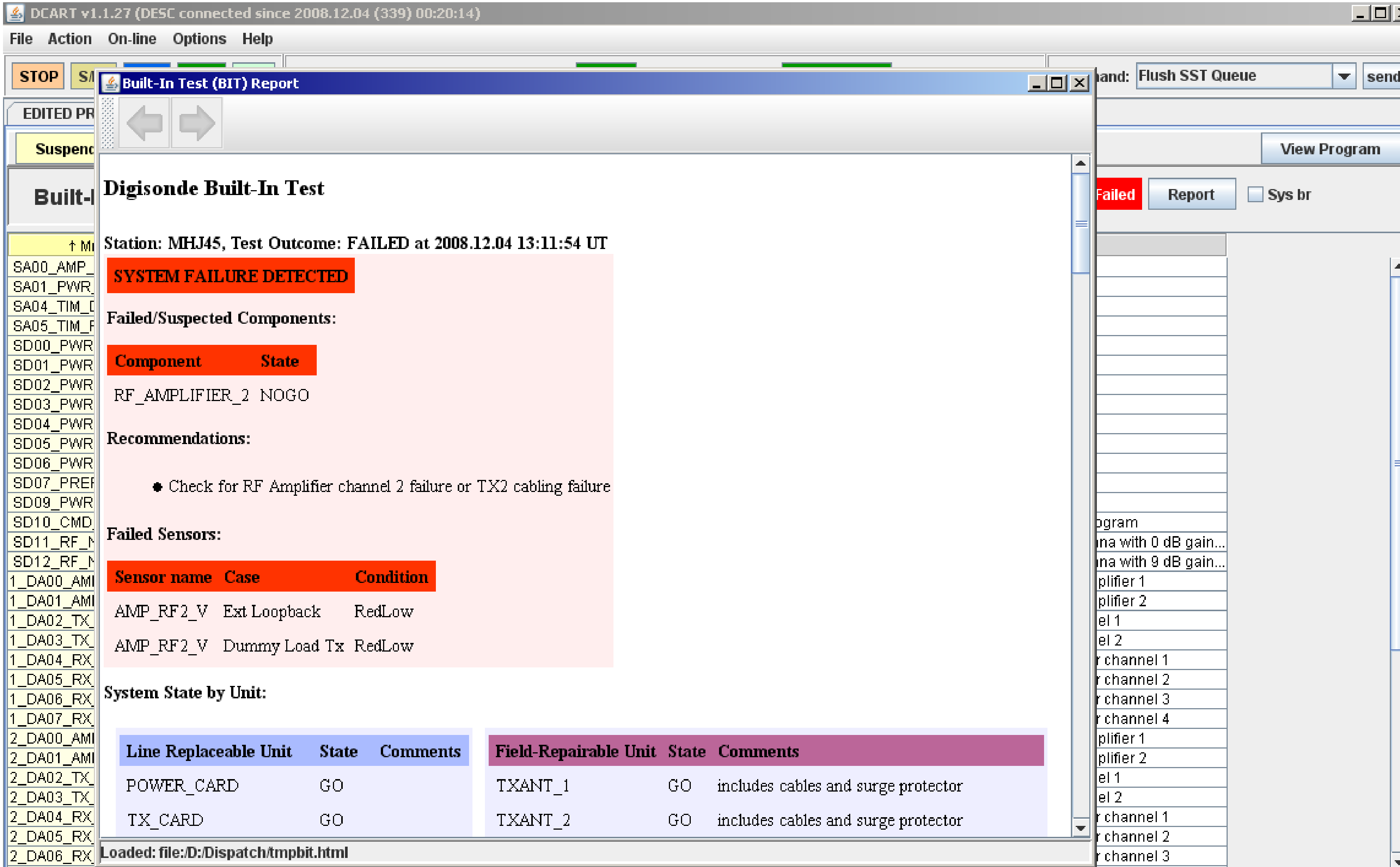
BIT Program in a Schedule



BIT Report Organization

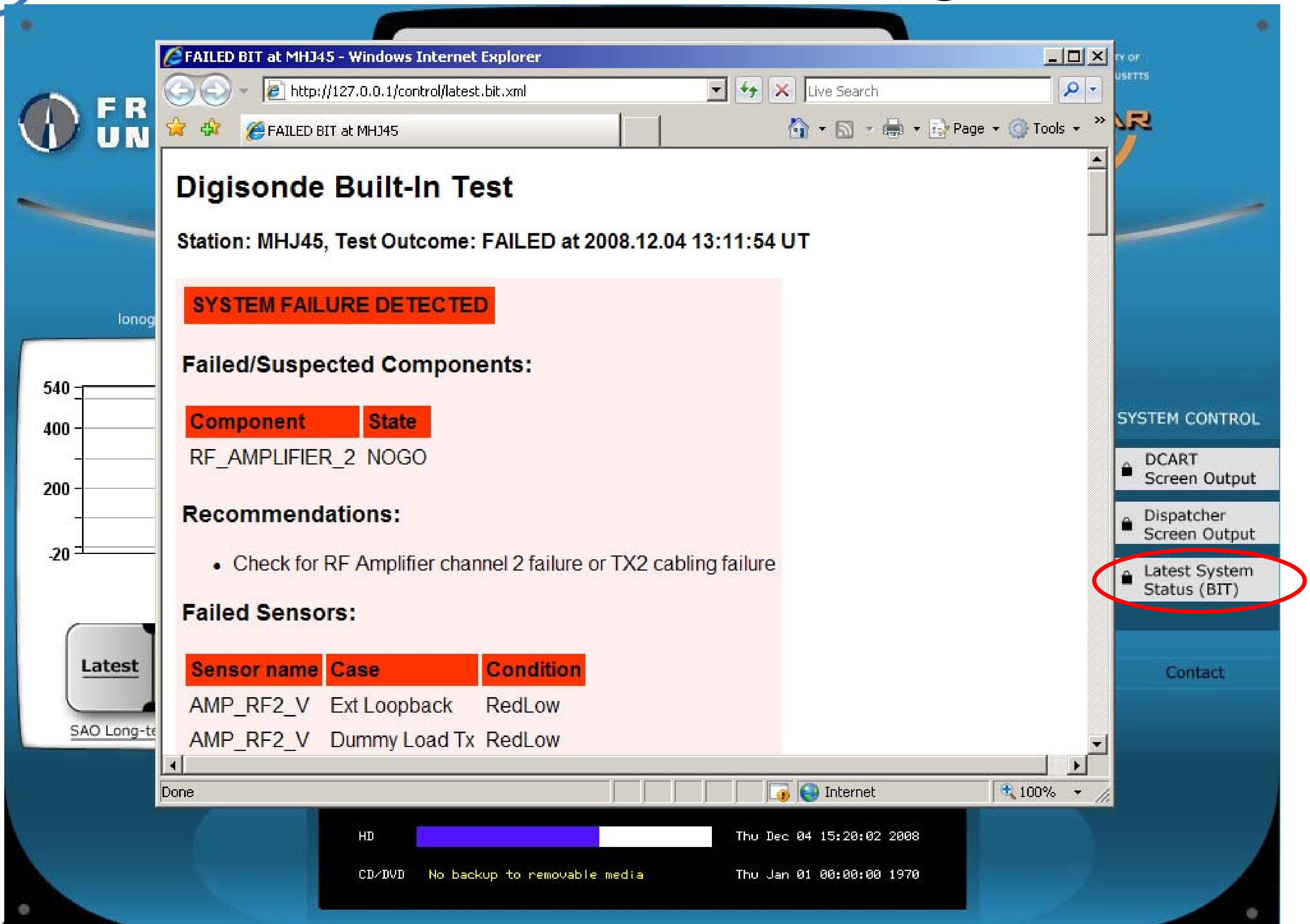
- Report system failure if occurs
- List suspected components
- Recommendations
- List of failed sensors, listing the "case" where failure occurred
- List of hardware by state; GO, NOGO, UNKNOWN
- List of sensor definitions
- List of sensor results by case (include a case 0 which means static measurements) Include a full BIT Report you can open and browse

BIT Report



DCART v1.1.27 (DESC connected since 2008.12.04 (339) 00:20:14)
File Action On-line Options Help
STOP
Flush SST Queue
send
View Program
Failed
Report
Sys br
Built-In Test (BIT) Report
Digisonde Built-In Test
Station: MHJ45, Test Outcome: FAILED at 2008.12.04 13:11:54 UT
SYSTEM FAILURE DETECTED
Failed/Suspected Components:
Component State
RF_AMPLIFIER_2 NOGO
Recommendations:
Check for RF Amplifier channel 2 failure or TX2 cabling failure
Failed Sensors:
Sensor name Case Condition
AMP_RF2_V Ext Loopback RedLow
AMP_RF2_V Dummy Load Tx RedLow
System State by Unit:
Line Replaceable Unit State Comments
POWER_CARD GO
TX_CARD GO
Field-Repairable Unit State Comments
TXANT_1 GO includes cables and surge protector
TXANT_2 GO includes cables and surge protector
Loaded: file:/D:/Dispatch/tmpbit.html

BIT on Web Page



DCART BIT Display

DCART v1.1.27 (DESC connected since 2008.12.04 (339) 00:20:14)

File Action On-line Options Help

STOP S/by Diag Auto Info Save Product Files: ALL Save Raw Files: Per Program Command: Flush SST Queue send

EDITED PROGSCHED | Sounding Mode | Built-In Test | Channel Equalizing | Tracker Calibration | HK Header | DVLP TOOLS

Suspend Data Display Refresh every 250 ms View Program

Built-In Test (BIT): 2008/12/04 13:11:54.415 Measurement Show all Failed Report Sys br

↑ Mnemonic	Sensor	Raw	Phys	Units	GO	R low	Y low	Y high	R high	Comment
SA00_AMP_TP	Lower chassis °C	328	31.461	°C	GO	1	1	45	50	Temperature sensor in lower chassis
SA01_PWR_TP	Upper chassis °C	461	30.921	°C	GO	1	1	45	50	Temperature sensor in upper chassis
SA04_TIM_DATACLK_FR	UpConv data clock	0	0	kHz	GO	0	0	1,023	1,023	Upconverter Data I+Q Clock Frequency
SA05_TIM_PARPORT_FR	ParPort clock	0	0	kHz	GO	0	0	1,023	1,023	Parallel port timing clock
SD00_PWR_PREAMP_V	Pwr Preamp V	1			GO					Preamplifier power
SD01_PWR_M15_V	Pwr -15V	1			GO					-15 Volt power
SD02_PWR_M5_V	Pwr -5V	0			GO					-5 Volt power
SD03_PWR_P3_V	Pwr +3.3V	1			GO					+3.3 Volt power
SD04_PWR_P15_V	Pwr +15V	1			GO					+15 Volt power
SD05_PWR_P12_V	Pwr +12V	1			GO					+12 Volt power
SD06_PWR_OVER_TP	Pwr overheat	1			GO					Power card overheating condition
SD07_PREP_HW_TESTPAT	HW Test Pattern	1			GO					Preprocessor HW test pattern
SD09_PWR_P18_V	Pwr +18V	1			GO					+18 Volt power
SD10_CMD_TIMEOUTS	Cmd Timeouts	0			GO					Commanding Timeouts from last BIT program
SD11_RF_NOISE_LOW_V	RF noise low	0			GO					Environmental RF noise voltage in Antenna with 0 dB gain...
SD12_RF_NOISE_HIGH_V	RF noise high	0			GO					Environmental RF noise voltage in Antenna with 9 dB gain...
1_DA00_AMP_RF1_V	Amp RF1 V	519	267.981	V	GO	85	100	400	450	RF voltage amplitude at the output of amplifier 1
1_DA01_AMP_RF2_V	Amp RF2 V	12	72.583	V	NOGO	85	100	400	450	RF voltage amplitude at the output of amplifier 2
1_DA02_TX_OUT1_V	Tx Out1 V	701	4.173	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 1
1_DA03_TX_OUT2_V	Tx Out2 V	697	4.167	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 2
1_DA04_RX_MAX1	Rx Max1	33756	33,756		GO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 1
1_DA05_RX_MAX2	Rx Max2	32770	32,770		GO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 2
1_DA06_RX_MAX3	Rx Max3	33518	33,518		GO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 3
1_DA07_RX_MAX4	Rx Max4	33347	33,347		GO	30,000	32,000	42,000	46,340	Maximum amplitude value in the receiver channel 4
2_DA00_AMP_RF1_V	Amp RF1 V	4	69.5	V	GO	0	0	75	100	RF voltage amplitude at the output of amplifier 1
2_DA01_AMP_RF2_V	Amp RF2 V	0	67.958	V	GO	0	0	75	100	RF voltage amplitude at the output of amplifier 2
2_DA02_TX_OUT1_V	Tx Out1 V	714	4.192	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 1
2_DA03_TX_OUT2_V	Tx Out2 V	705	4.179	V	GO	4.05	4.1	4.3	4.35	Output voltage at transmitter card, channel 2
2_DA04_RX_MAX1	Rx Max1	40328	40,328		GO	20,000	25,000	42,000	46,340	Maximum amplitude value in the receiver channel 1
2_DA05_RX_MAX2	Rx Max2	40212	40,212		GO	20,000	25,000	42,000	46,340	Maximum amplitude value in the receiver channel 2
2_DA06_RX_MAX3	Rx Max3	40342	40,342		GO	20,000	25,000	42,000	46,340	Maximum amplitude value in the receiver channel 3

BIT data can be delivered

- **BIT data can be delivered via Dispatcher Setting**
- **Within D:\Dispatch\Dispatch.udd file**
  - **FTP Data Delivery Questions 80 – 89, 990**
  - **Add BITXML under question 81 or 82**

Data Delivery to ARINC Sustainment

*080 < D:\Buffers\FTP3\ >	(outgoing folder)
*081 < BITXML SAO SAOXML >	(data sent uncompressed)
*082 < SBF RSF DFT TAV >	(data sent compressed)
*083 < 1 >	(accumulate data if unsuccessful)
*084 < >	(remote dir change)
*085 < >	(minutes to include [all])
*086 < >	(latest reports to include)
*088 < >	(batch file for data compression)
*089 < psftp.bat >	(command line for client)
*990 < >	(data delay)

Troubleshooting Procedure

- BIT Report
- Evaluate the science data generated by the Digisonde 4D
- Ensure Digisonde software is operating normally (DCART operations, dispatcher data management)
- Perform diagnostics via DCART
- Replace damaged components

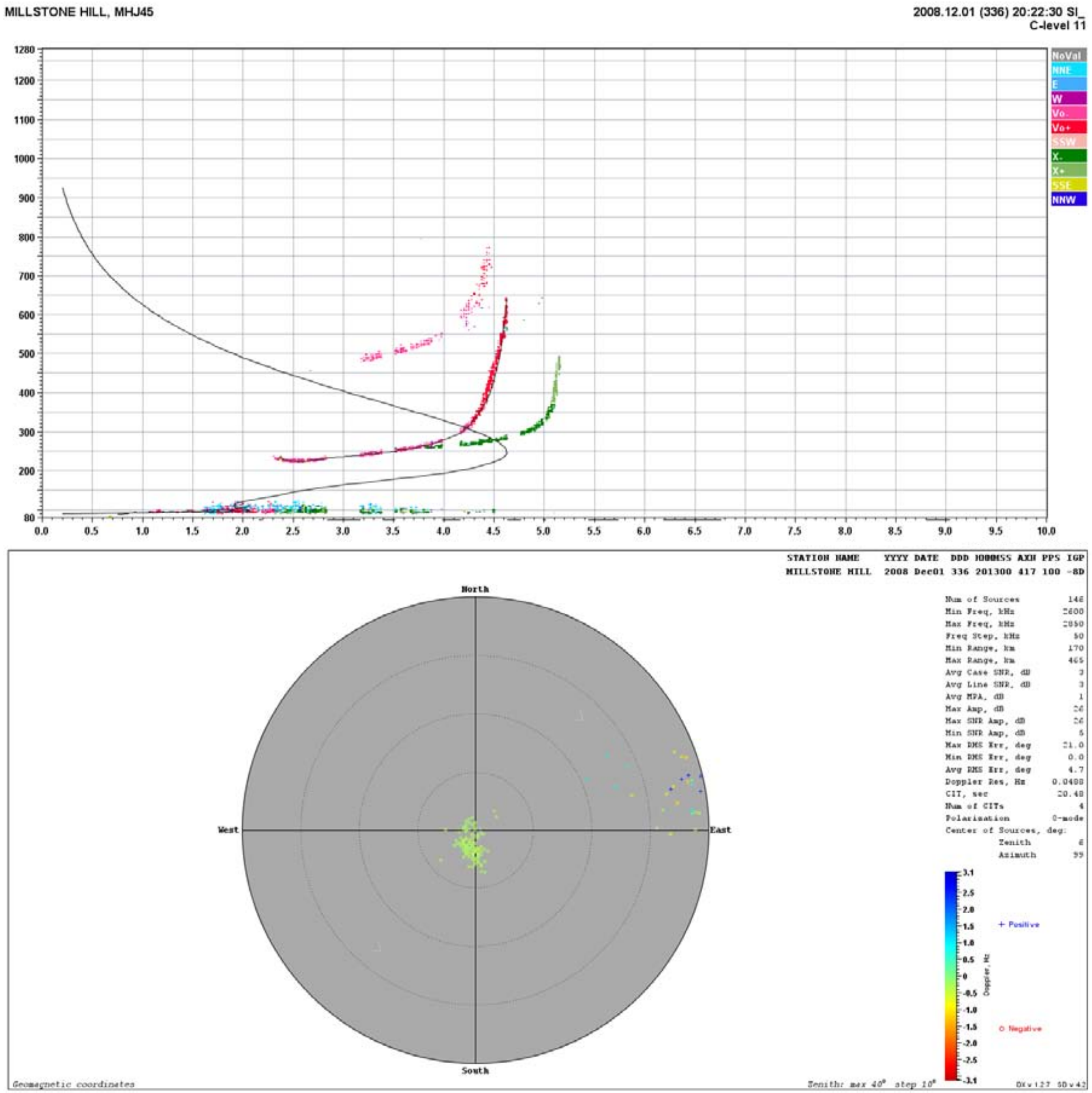
Evaluate Data

- Evaluate Data
  - SAO Explorer, Ionogram data
    - Check data history for “suspicious” data
      - Very sudden changes
    - ARTIST Confidence
    - Absorption
    - Bad directions
  - Drift Explorer, Skymap data
    - Check data history for blank data
    - Amplitude of receive channels
    - Phase of channels (if overhead phase should be essentially the same between channels)

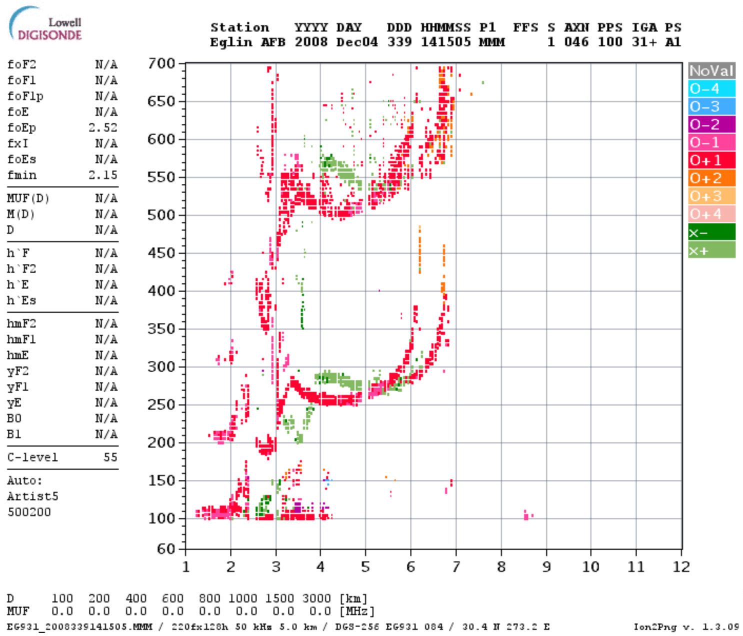
Artist Confidence

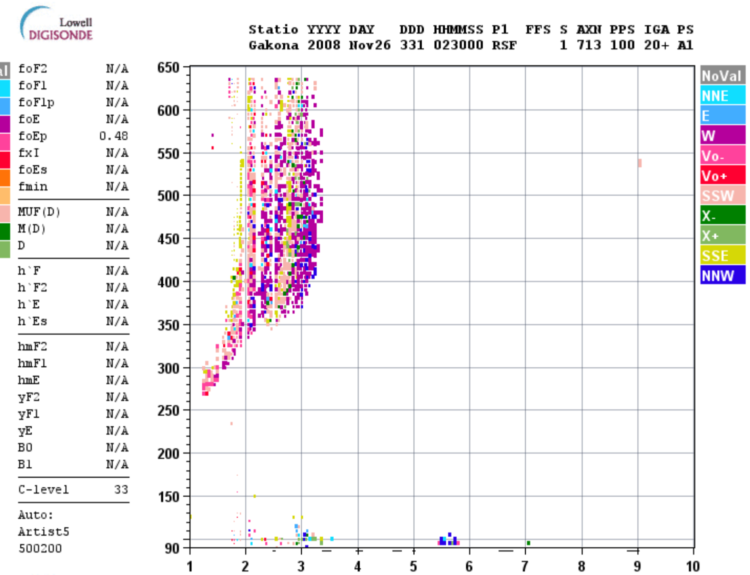
- ARTIST 5 assigns a confidence to each ionogram's scaling
- If automatically scaled results are below a certain confidence threshold the scaled data record is suppressed (empty SAOXML file)
  - Blank SAO record
- Possible reasons for low confidence data
  - Bad programming
  - External interference / Weak signal
  - Restricted frequencies
  - Complicated ionospheric conditions
  - Polarization tagging
- ARTIST may crash (unlikely) or dispatcher problems
  - No SAO data at all
- ARTIST may be unable to arrive at a solution (timeout)
  - Blank SAO record

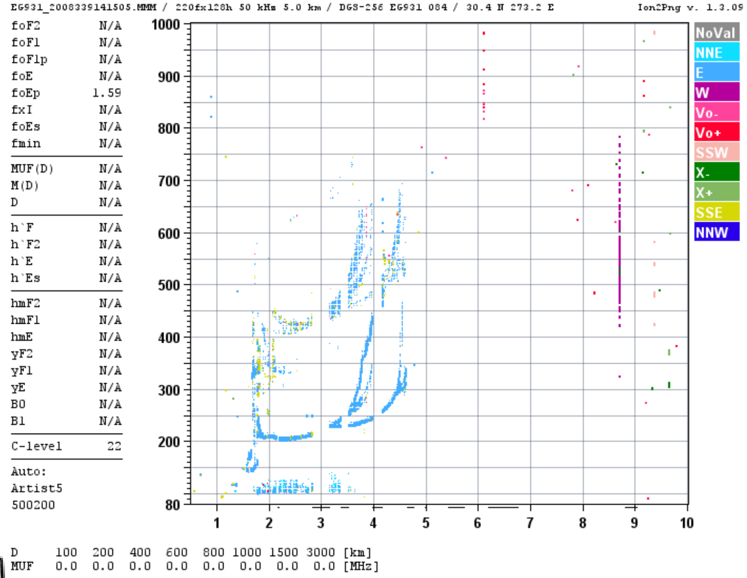
Normal Data

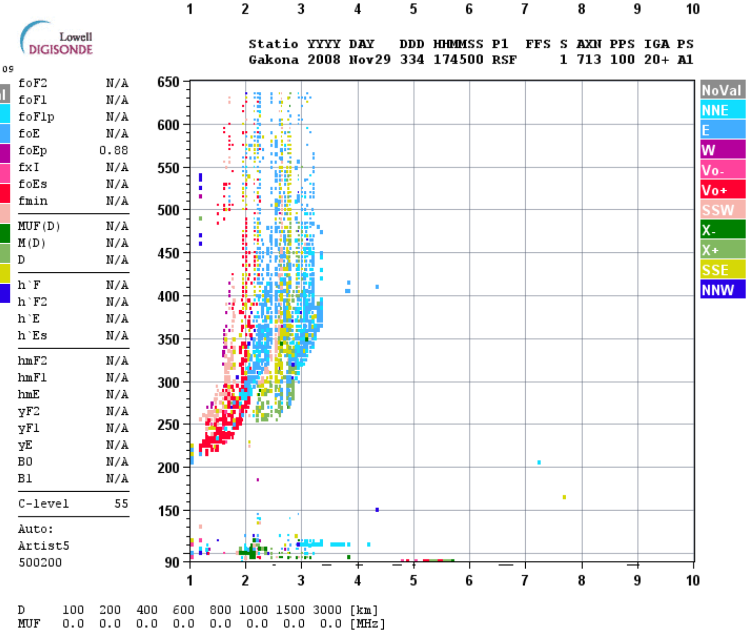

MILLSTONE HILL, MHJ45
2008.12.01 (336) 20:22:30 SI_
C-level 11
NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IGP
MILLSTONE HILL 2008 Dec01 336 201300 417 100 -8D
Num of Sources 146
Freq Step, kHz 50
Min Range, km 170
Max Range, km 465
Avg MPA, dB 1
Min RMS Err, deg 0.0
Avg RMS Err, deg 4.7
Doppler Res, Hz 0.0488
Num of CITs 4
Center of Sources, deg:
Zenith
Azimuth 99
North
West
East
South
+ Positive
o Negative
Doppler, Hz
Geomagnetic coordinates

Examples of un-scaled data

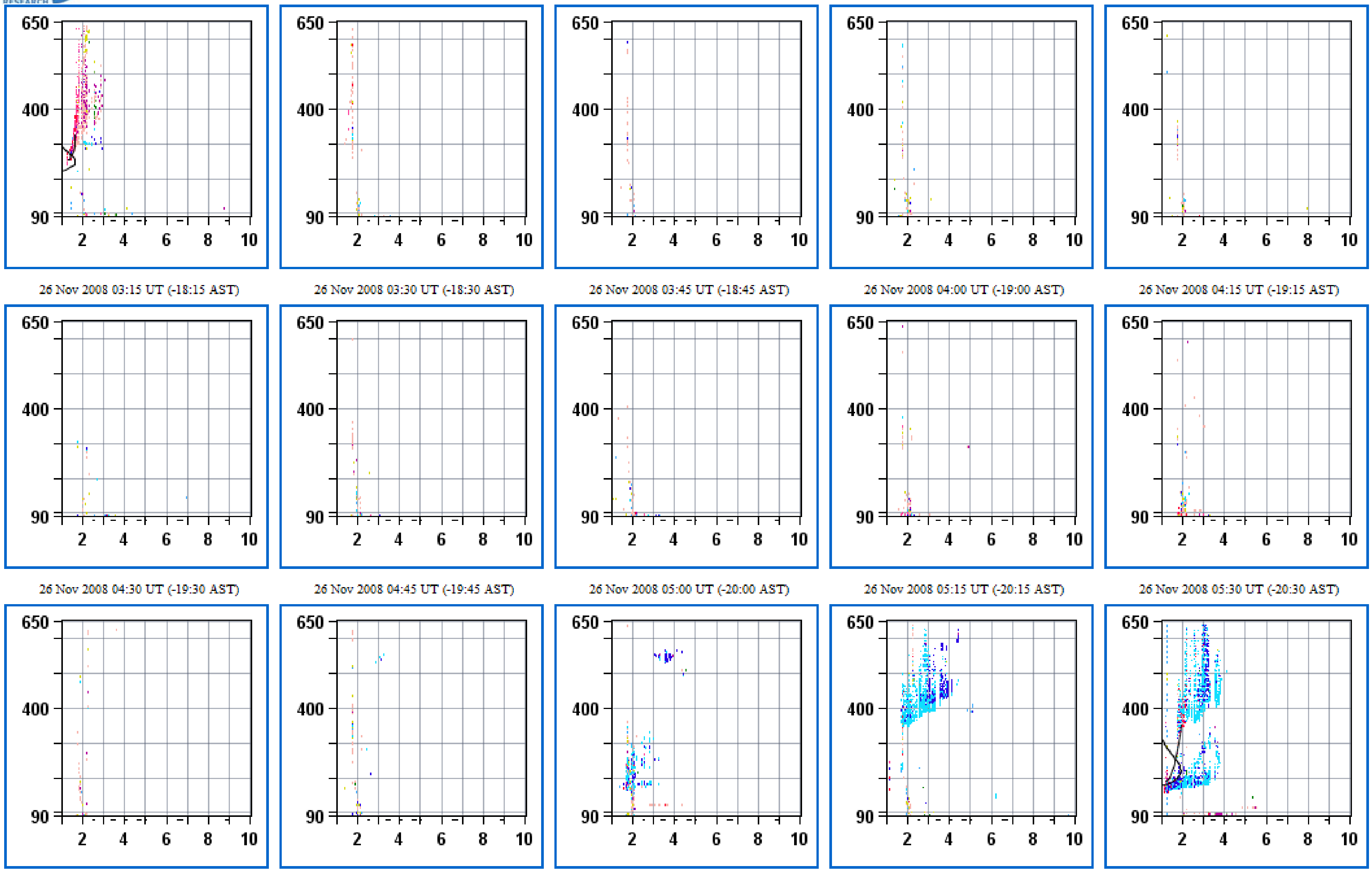








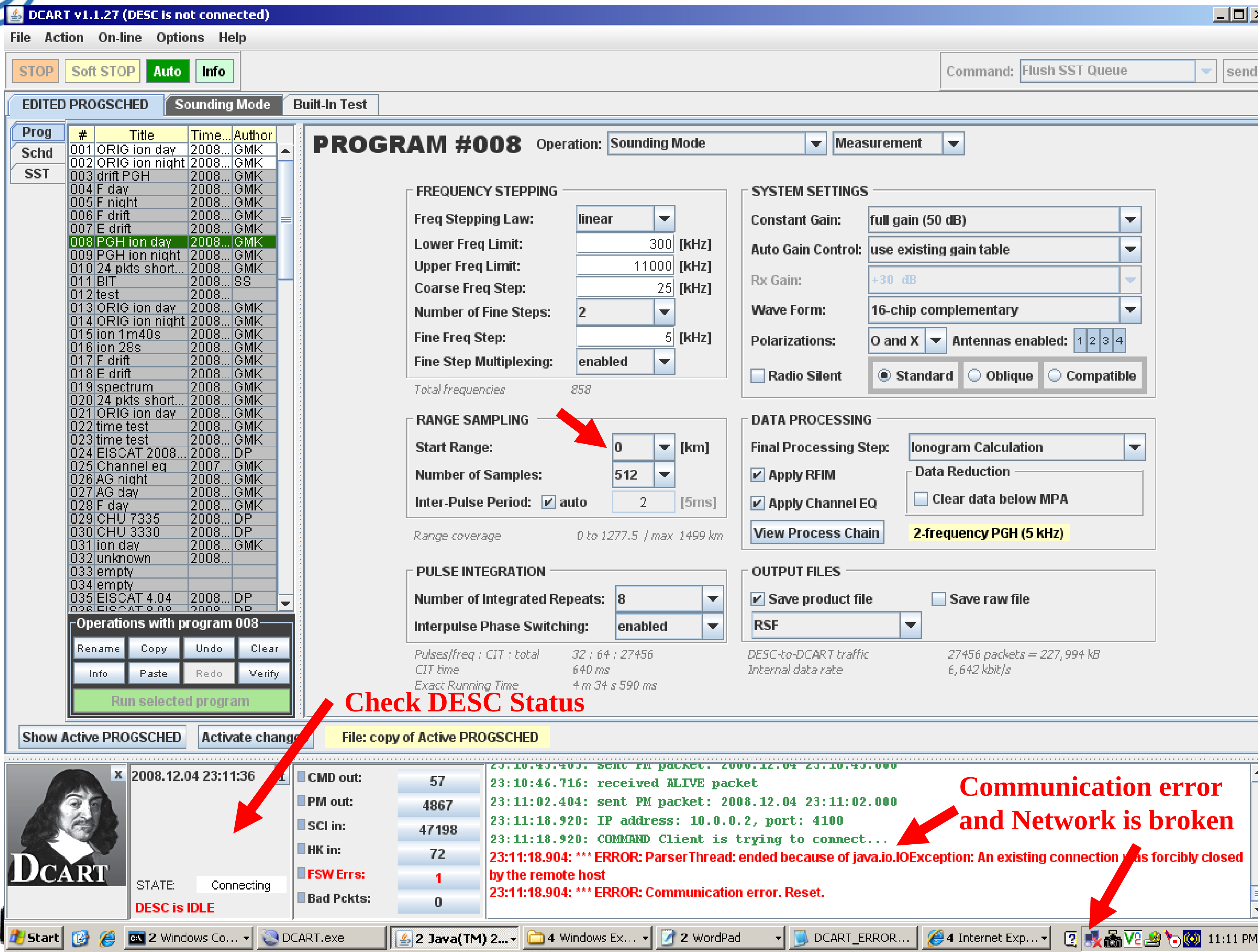
Check Data History via Web or SAOX



DCART Diagnostics and Damage Control

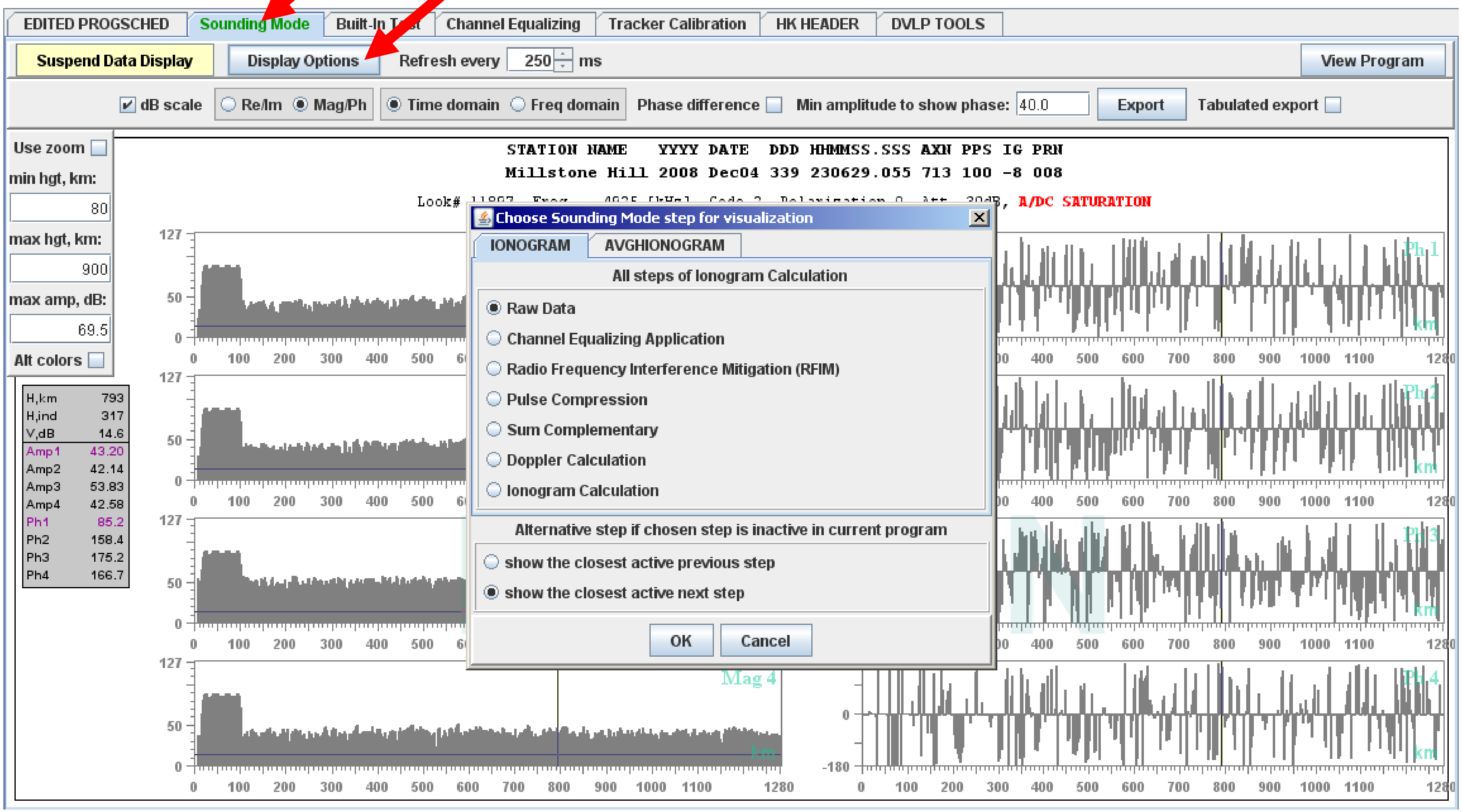
- Diagnostics performed via DCART
  - Note the state of DESC (Control Computer)
  - Manually run BIT to confirm BIT results
  - Run “internal loopback” program
  - Run “external loopback” program
  - Change the Sounding Mode display to view all channels
- Damage Control (Sustaining Operation)
  - Run SBF Ionograms
  - Bypass Trackers if necessary

DCART Important Places to Look

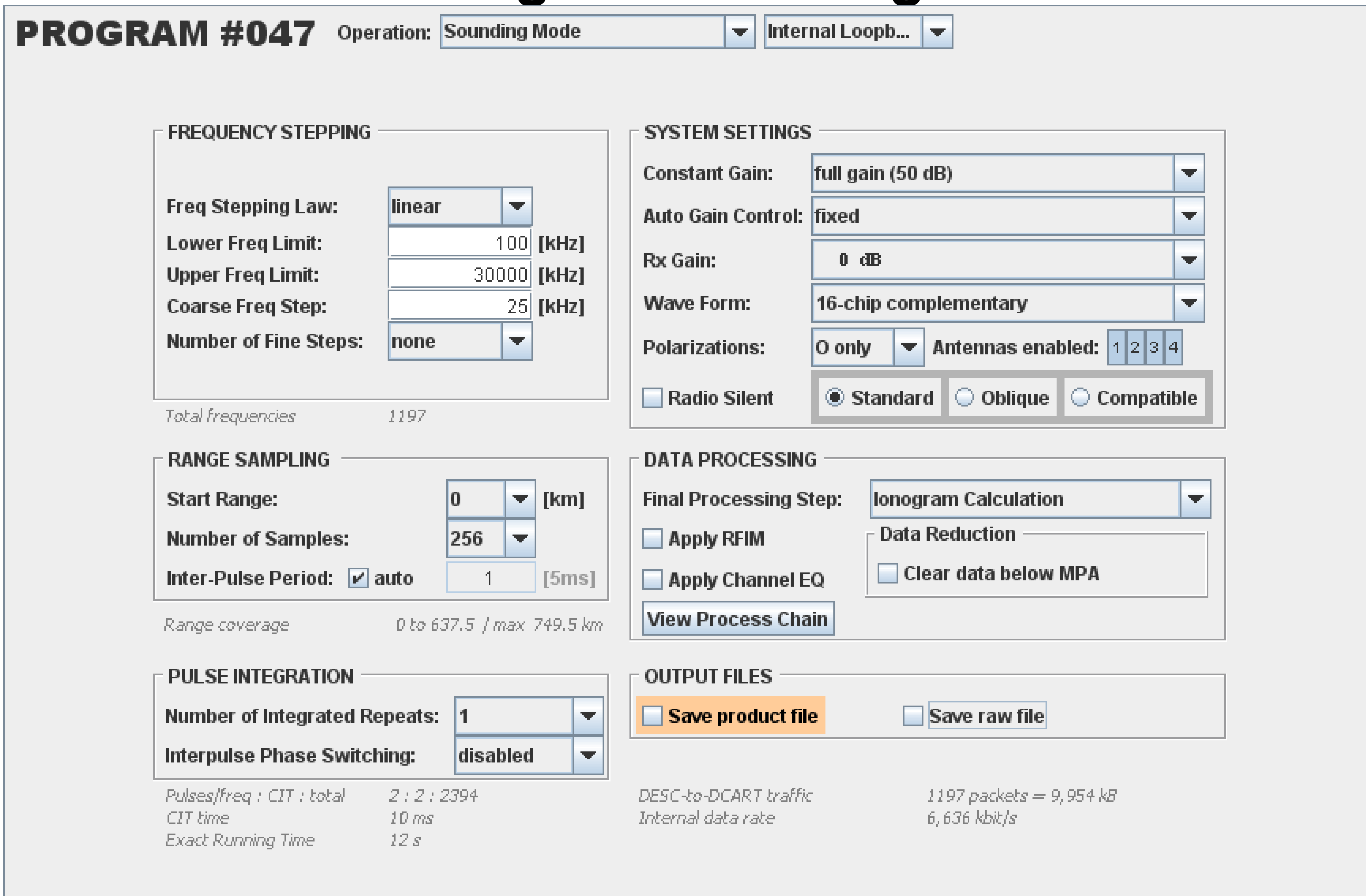


DCART / Drift Explorer observe all channels

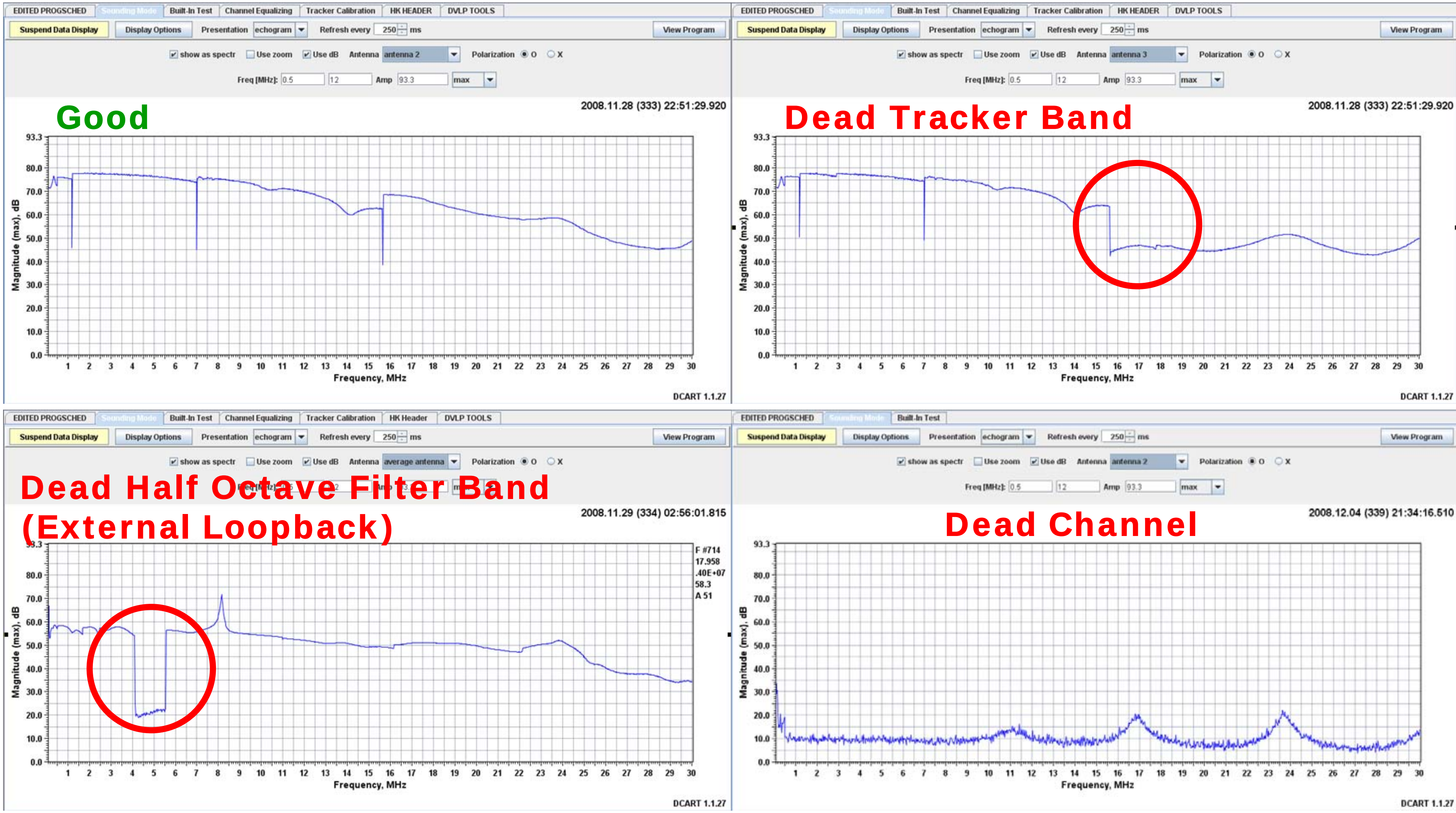
Sounding Mode / Display Options. This program is started at 0 height



Internal Loopback "Diagnostic Program"



Loopback Results



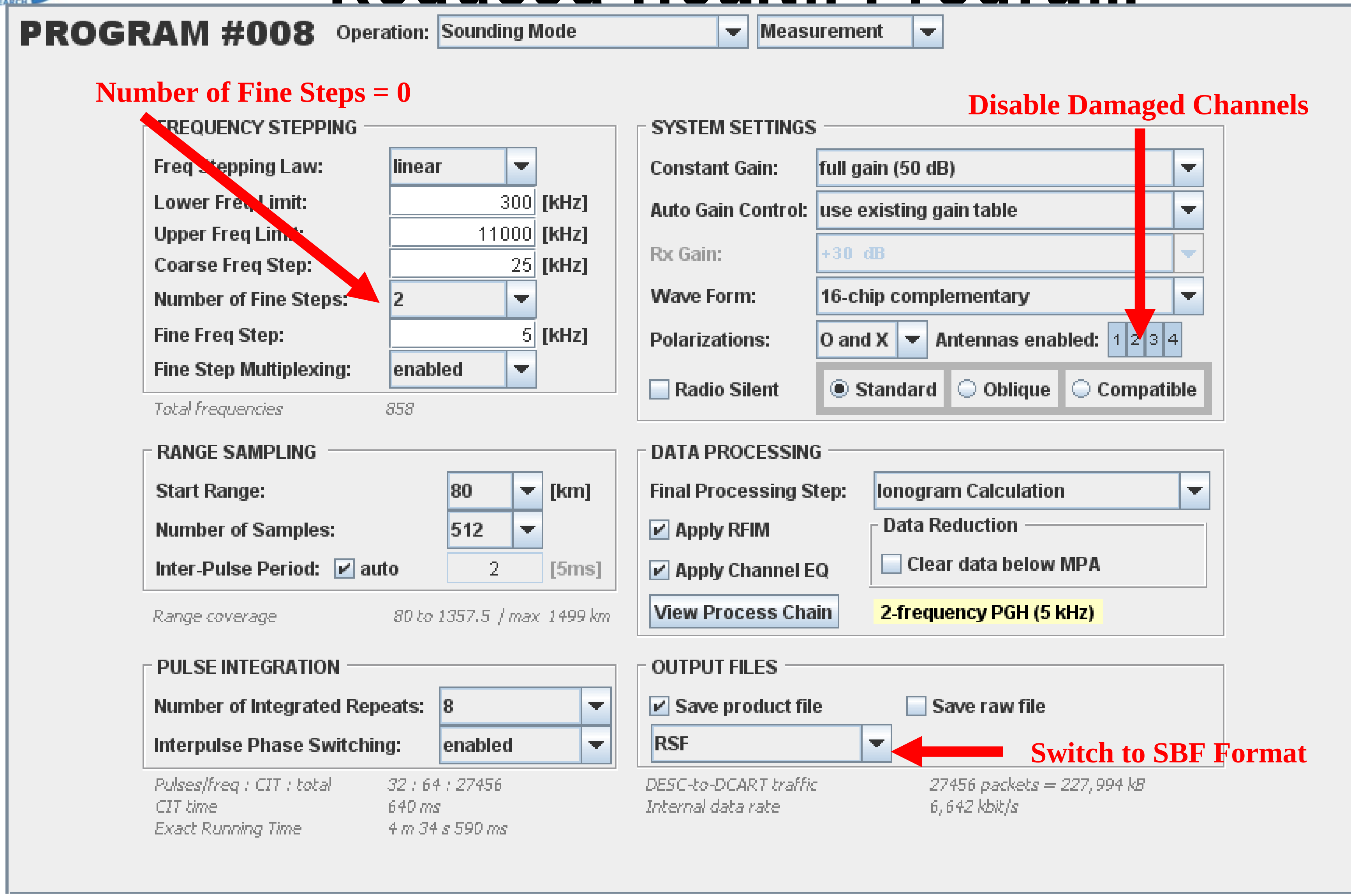
Sustainable Operations?

- Bad receive channel?
- Bad tracker?
- Bad RF channel (look at the data)

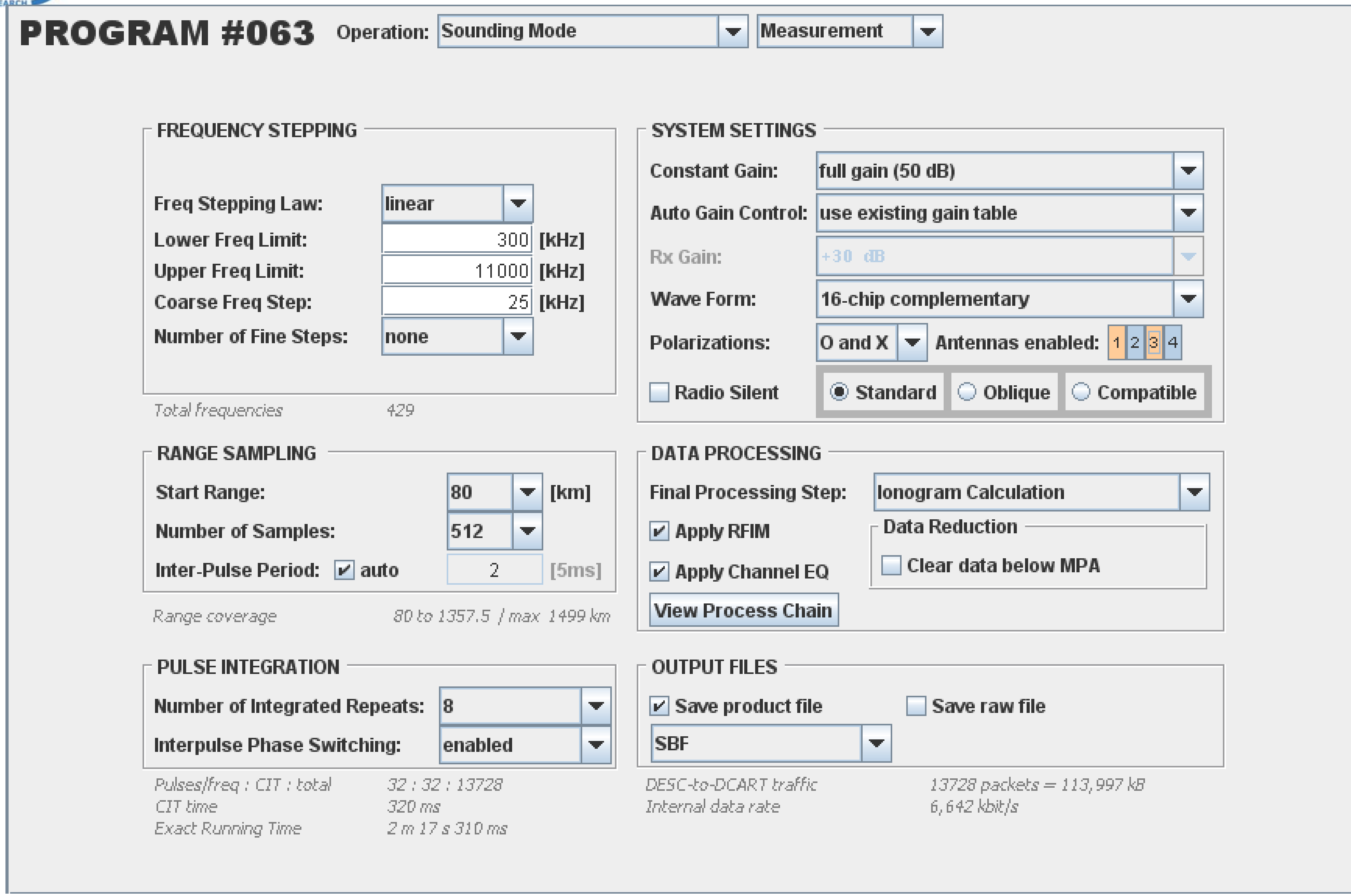
Damaged Receive Channel(s)

- Damage could be Receive Antenna / Polarization Box, Antenna Switch, Tracker, or Receiver
- Switch from RSF Precision Ranging Ionograms to SBF data format
- SBF does not calculate directional information
- Does not require all 4 channels to work

Changing from Routine Operation to Reduced Health Program

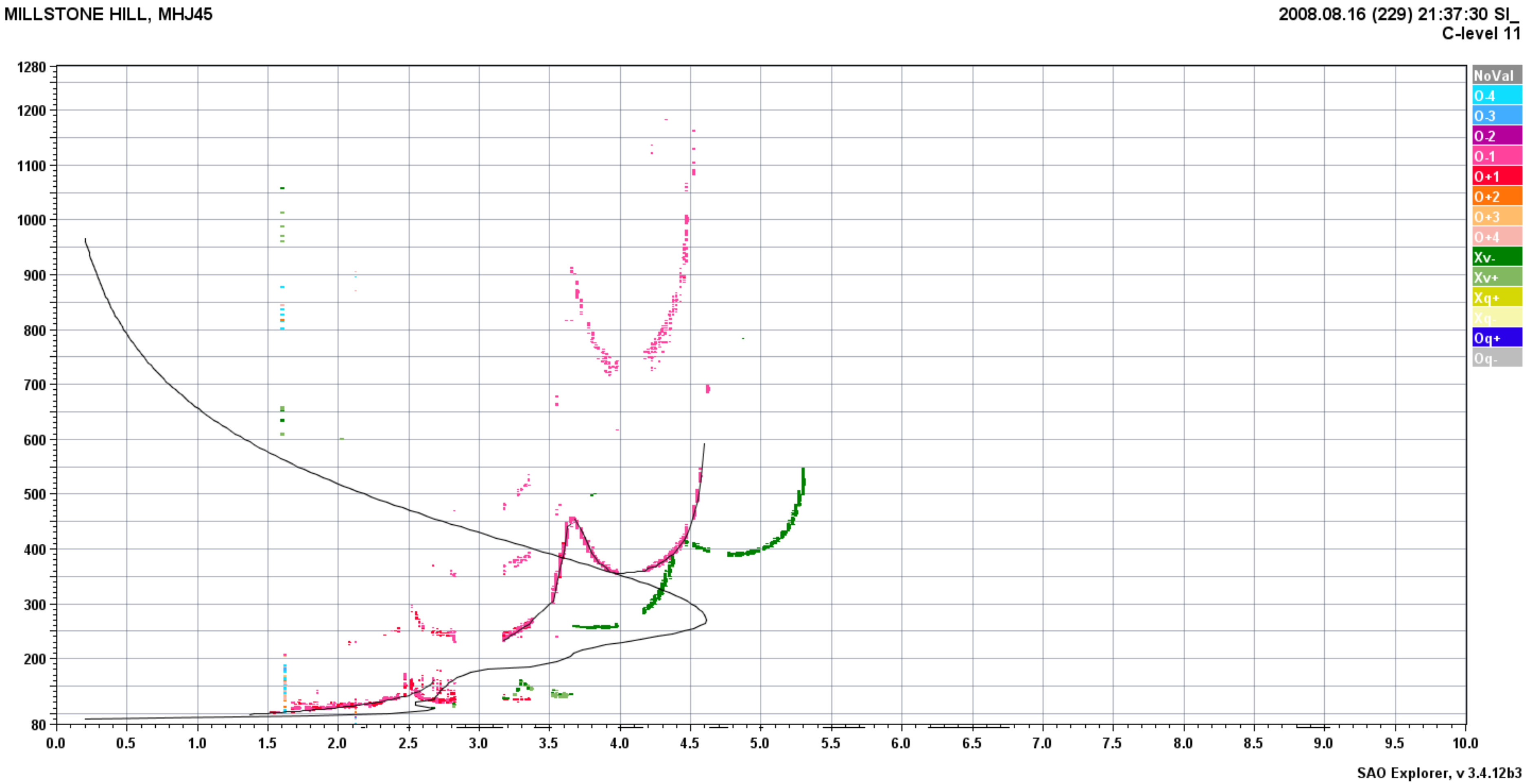


Reduced Health Program



SBF Ionogram

- Millstone Hill DPS-4D generating SBF using 2 channels



Damaged RF Channel

- No longer transmitting circularly polarized
- 6dB loss (3dB in polarization, 3dB in power)
- Evaluate the resulting data
- It is likely the system will be able to operate until it is convenient to replace the RF Power Amplifier

Software Problems

- Dispatch Screen Output for clues
  - Dispatcher is always running on the desktop (& output available on web)
  - 2 watchdogs exist on the Data Computer (software, hardware)
  - 1 watchdog on the Control Computer
- FTP delivery is "stuck"
  - Permissions change on remote server
  - Bandwidth issues
- Zip process hangs while compressing a file
- File cannot be deleted
- For Delivery D:\Buffers\FTPx\System\Results.ftp
- Locations of Interest
  - D:\Secure\Diagnostics
    - Damaged science data goes here, Channel Equalizing, DCART Logs
  - D:\Dispatch
    - Many UMLCAR programs produce .out, .err files
    - Artist5.out, Ion2Png.out, Sky2Png.out, etc

Dispatcher Remote Operations

- Dispatcher Incoming Directory <D:\Secure\Incoming\>
- New_Settings.req
  - Empty file
  - Results in re-reading configuration file D:\Dispatch\Dispatch.udd
- Reset.req
  - 1 = Reset Data Computer
  - 2 = Reset Control Computer
  - 3 = Reset Both Computers
- Progsched
  - DCART will process supplied progsched file

BIT Limitations

- Data Computer problems
  - BIT reports nothing regarding Data Computer status.
- Control Computer problems
  - No data is delivered from DESC.
  - One can determine if DCART is unable to communicate with DESC remotely. (look for network connection)
  - No way exists to gather information about the system hardware as you cannot run programs.
- Completely dead cards?
  - BIT can detect if cards are unresponsive (no communication with DESC).

Upgrading to the DPS-4D

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Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

DPS-4D vs. DPS-1 or DPS-4

- Upper Chassis completely re-designed
  - Tranceiver 8 slot, 96 Pin connector backplane
    - Digital RCVR and XMTR Pcb's
    - FPGA based Pre-processor
    - uCntrl based BIT (Built in test)
    - 4 Tracker PCB's
  - 2, Dual Core Pentium DATA and CNTL CPU's
  - Front and rear panel USB interface
  - DVD writer

DPS-4D vs. DPS-1 or DPS-4

- Lower Power Amplifier Chassis
  - Can be re-used
    - Possible up-rev of HOF (Half octave filters) based on age of system
- Environmental Transit Case (ECS Composites)
  - Can be re-used
    - Possible addition of exhaust fans and filters
    - New rear panel and cables required

Cost of Upgrading

Standard Price List
Ionospheric Radio Observatories
Digisonde-4D Systems

ITEM	DESCRIPTION	UNIT PRICE (US$)	Qty	Total (US$)
1	Quad Receiver Digisonde Portable Sounder - DPS-4D: Dual 150 watt transmitters Dual Core Pentium Control Computer Dual Core Pentium Data Computer Internet Access 500 GB Fixed Disk Storage DVD-R/W Drive Automatic Real Time Scaler and True Height (ARTIST) Ionogram & Directogram Web Display Real Time Drift and Skymaps with Web Page Display Built-in Test (BIT) GPS Receiver DPS Manual	$168,900	1	$168,900
			1	0
2A	4 Receiving Turnstile Loop Antennas	$4,750	1	$4,750
2B	4 Polarization Switches/Preamplifiers	$4,750	1	$4,750
3	SAO-Explorer System (Standard Archiving Output data editor) / Drift Explorer with Pentium IV Computer, DVD-R/W Drive, Color Laser Printer, Software, and Documentation	$6,500	1	$6,500
4	Set of Critical Spares	$19,401	1	$19,401
5	Equipment Packaging and Marking for Export,	$2,820	1	$2,820
6	Installation (Excluding Antennas and Cables) One Year Warranty, Service, and Consultation (Travel Cost and Per Diem are **not** included)	$13,950	1	$13,950
7	Antenna Cables (6 x 150 m with connectors) (4 matched receive cables, 2 matched transmit cables)	$5,400	1	$5,400
8	Dual Delta Turnstile Transmit Antenna w. 100' tower	$20,020	1	$20,020
9	3-day Training at UMass Lowell	$3,900	0	$0
	Total FOB Boston			**$246,491**

Cost of Upgrading

- Upgrade components costs $76K (us) includes:
  - New upper chassis
  - Upgrade of rear panel and cabling
  - Installation of fan and filter kit (if required)
- Set of Critical Spares upper chassis $19.4K (us)
- Refer to Standard Price List for other items if required

UNIVERSITY OF MASSACHUSETTS LOWELL
UMLCAR
CENTER FOR ATMOSPHERIC RESEARCH

Drift measurements, real-time processing and web displays

Vadym Paznukhov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
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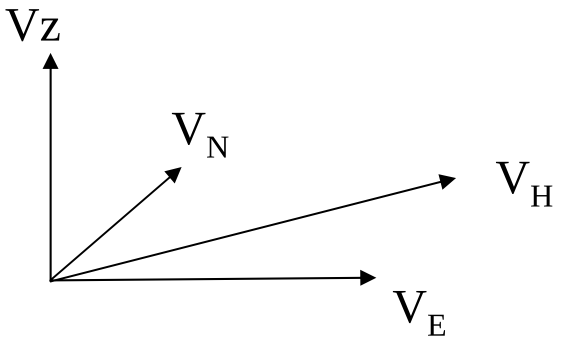
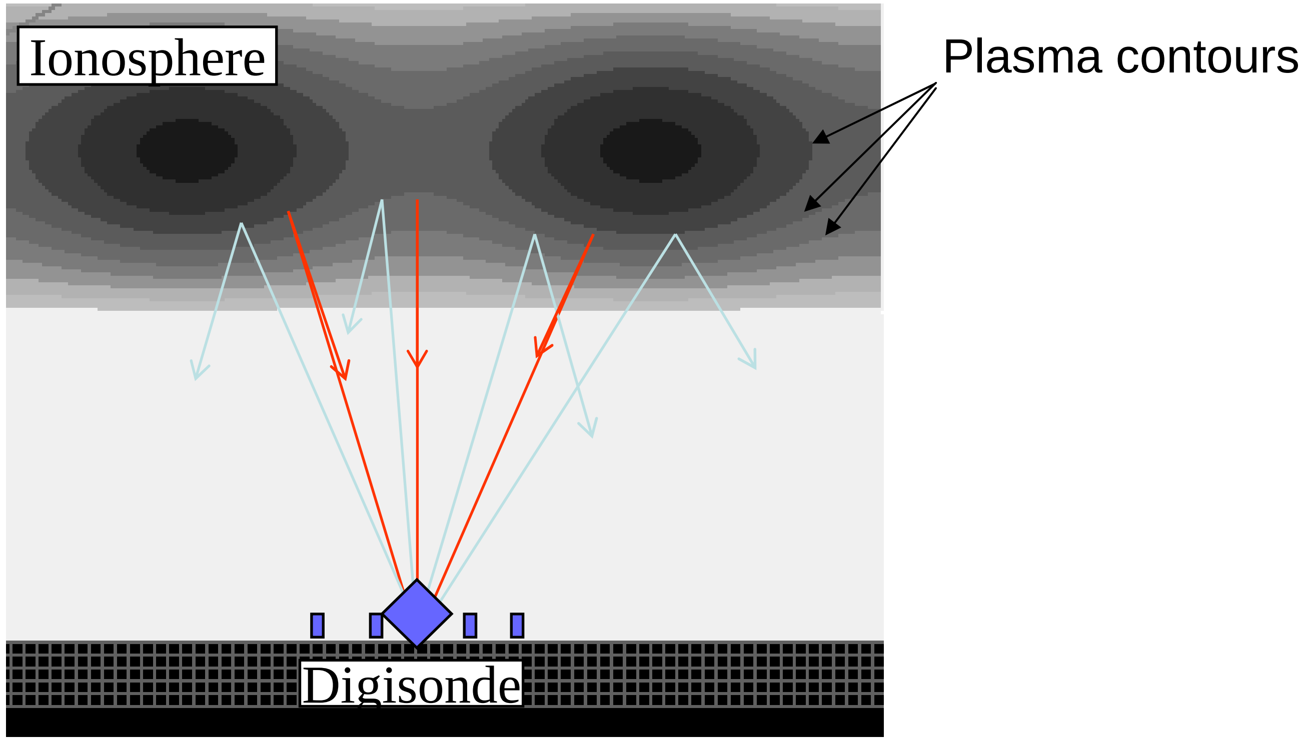
Ionospheric Plasma Drift Basics

In general, ionospheric plasma is in motion, driven by electric fields and neutral winds. This plasma drift can obviously be described by a horizontal component V_H and a vertical component V_Z. Further, the horizontal drift can be resolved into a north-south component V_N and an east-west component V_E.



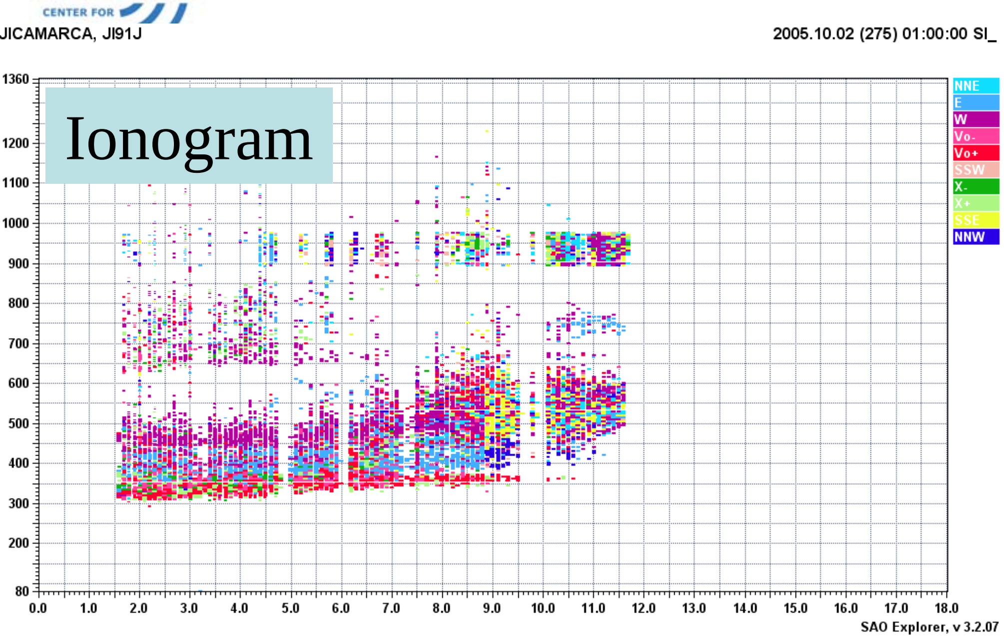
The character of the plasma drift changes dramatically with location, in particularly we often treat high latitude, mid-latitude and equatorial motions differently. These drift motions vary diurnally, with the season and with the level of solar and magnetic activity as well as with other factors.

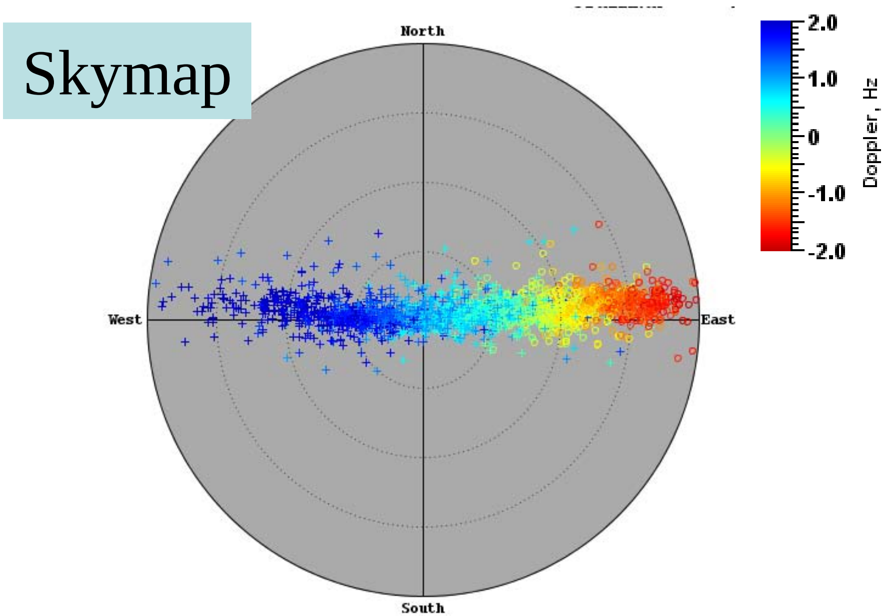
Digisonde Drift Technique



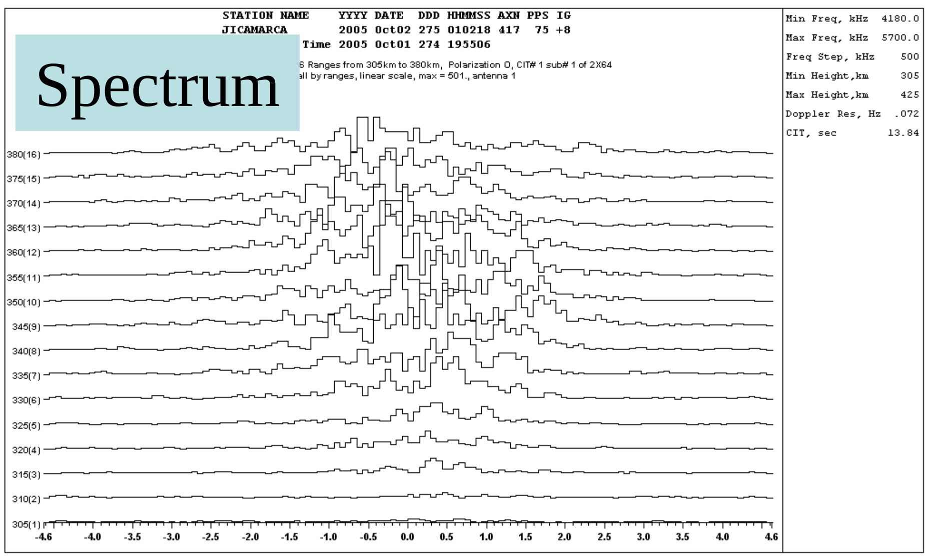
The digisonde measures plasma drifts using the following technique. The transmitted signal illuminates a large area in the ionosphere, typically a few hundred kilometers in diameter. The transmitted radiowave reflects at every point in the ionosphere where the wave encounters the cut-off frequency (index of reflection is zero). If the normal to the surface of equal electron density points exactly towards the sounder, then the reflected signal can be detected by the system. Each such reflection point is considered as a "source" of a reflected signal. Echoes from different sources overlap if the differences in their delay times are smaller than half of the digisonde pulse width.

Example of multiple source data

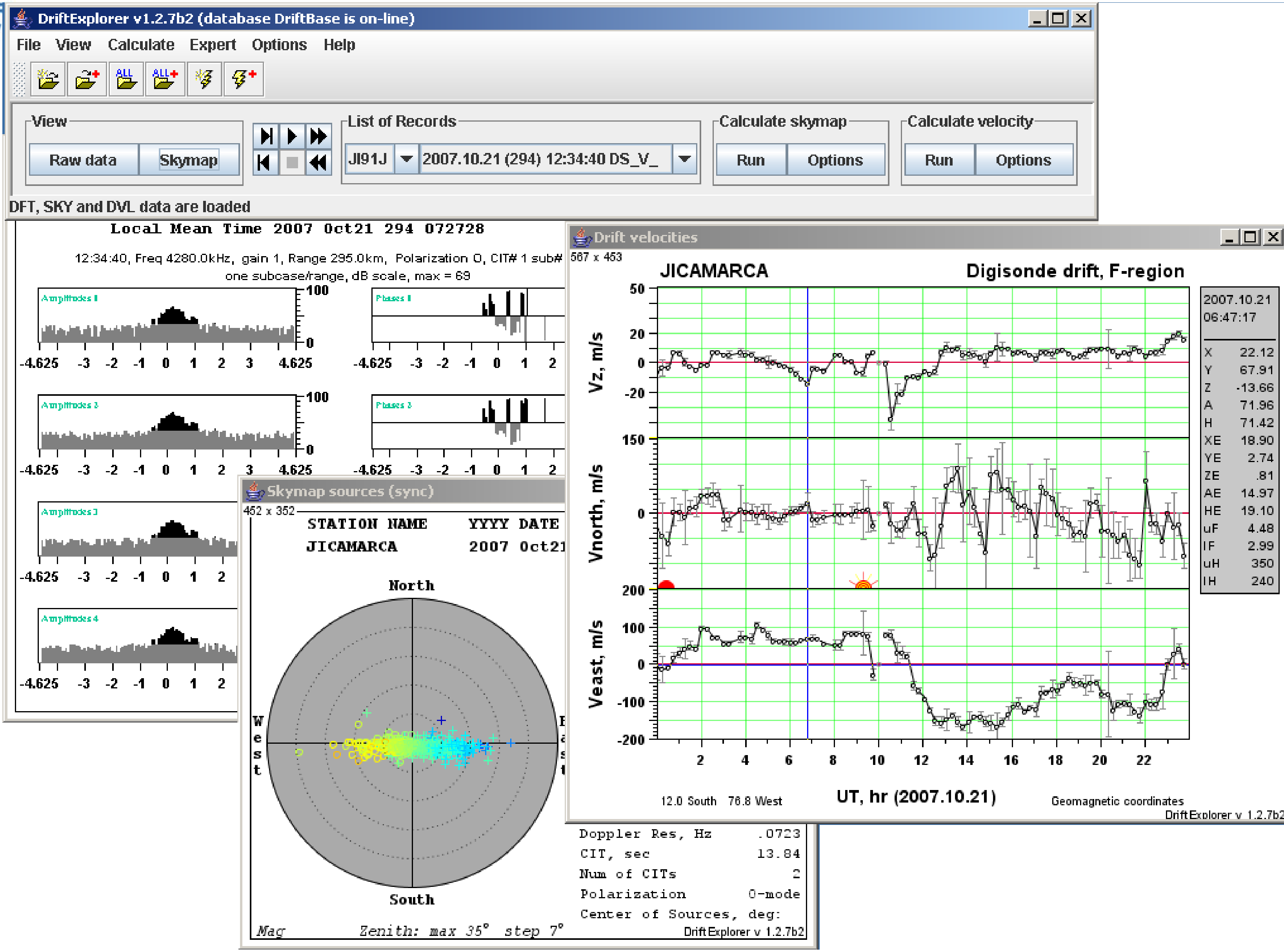




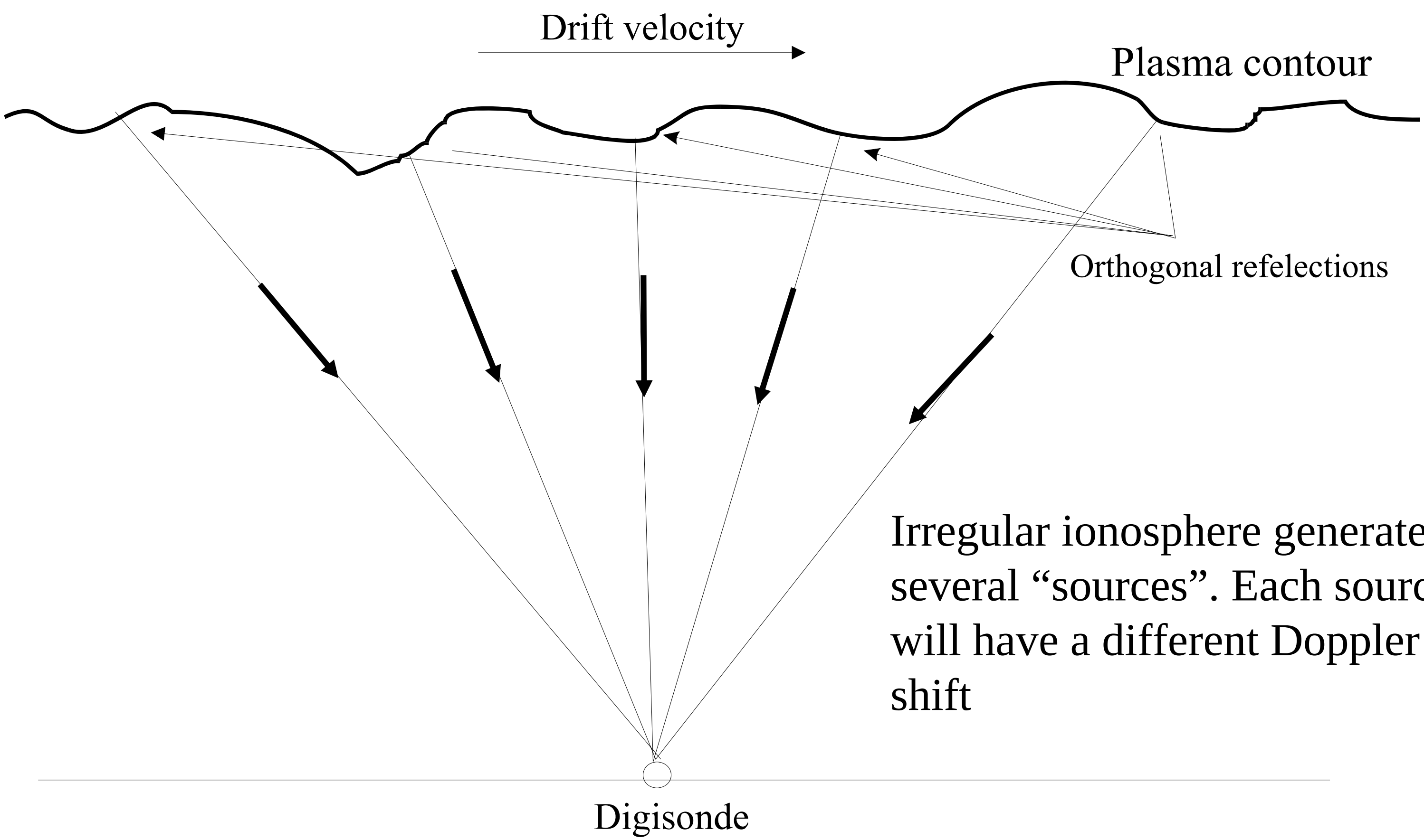
Jicamarca DPS (spread-F conditions)



Drift data example

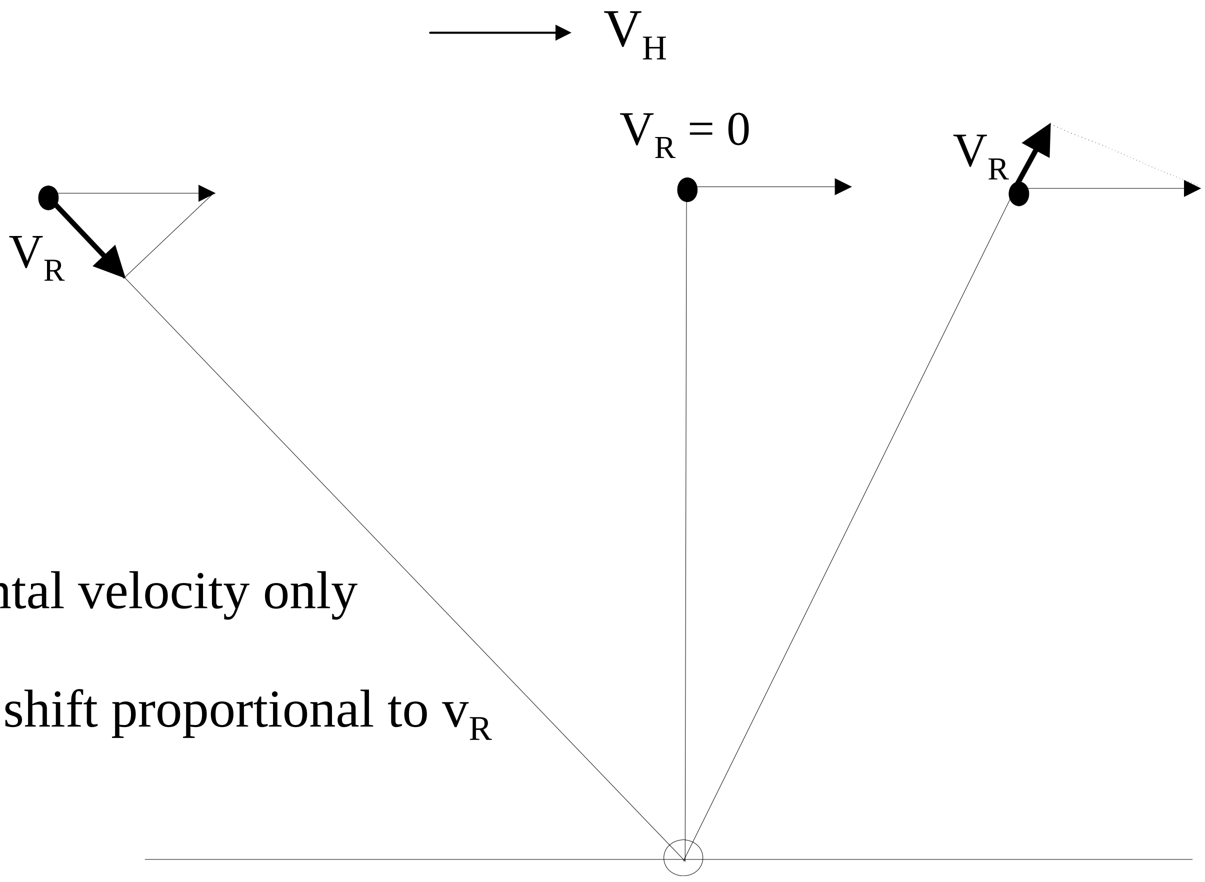


DRIFT BASICS – Skymap "Sources"



Irregular ionosphere generates several "sources". Each source will have a different Doppler shift

DRIFT BASICS – Doppler shift



Horizontal velocity only

Doppler shift proportional to v_R

Digisonde Drift Analysis (DDA)

$$\delta f_i = -\frac{2}{c}(\hat{k}_i \bullet \vec{v}) f_o$$

and

$$\hat{k}_i \bullet \vec{v} = \sin\theta_i \cos\phi_i \, v_x + \sin\theta_i \sin\phi_i \, v_y + \cos\theta_i \, v_z$$

For each source we measure **δf, θ and ϕ**. We now have an equation with three unknowns; **v_x, v_y and v_z**. With just **three sources** we could solve uniquely for **v_x, v_y and v_z**. In general, we have many more than three sources and and the problem is over determined. We can then solve for the three velocity components that provides a “best fit”, in a least square sense, to all the Doppler measurements.

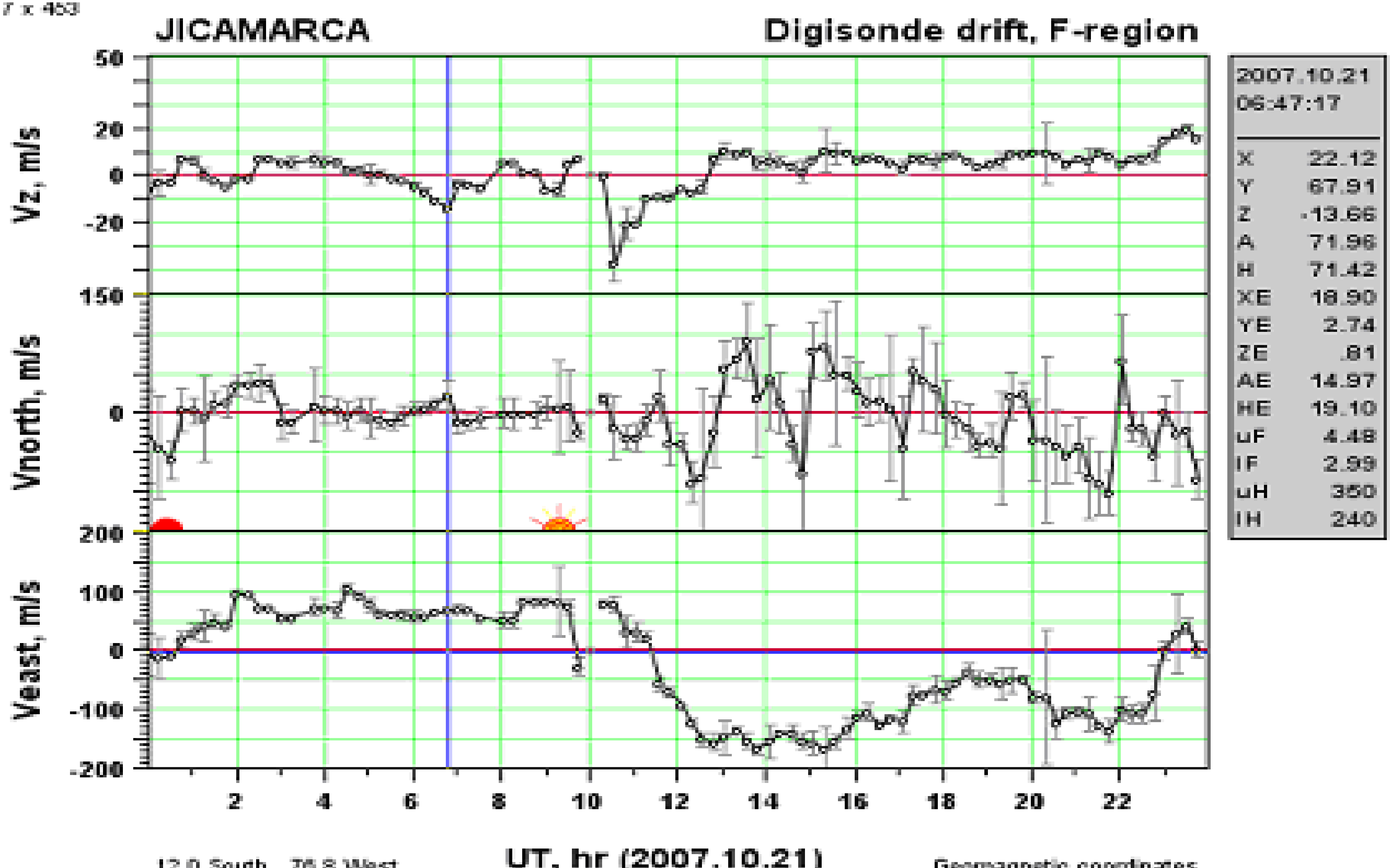
Digisonde Drift Analysis (DDA)

$$\varepsilon^2 = \sum_i \left[\frac{2}{c} (\hat{k}_i \bullet \vec{v}) f_o + \delta f_i \right]^2$$

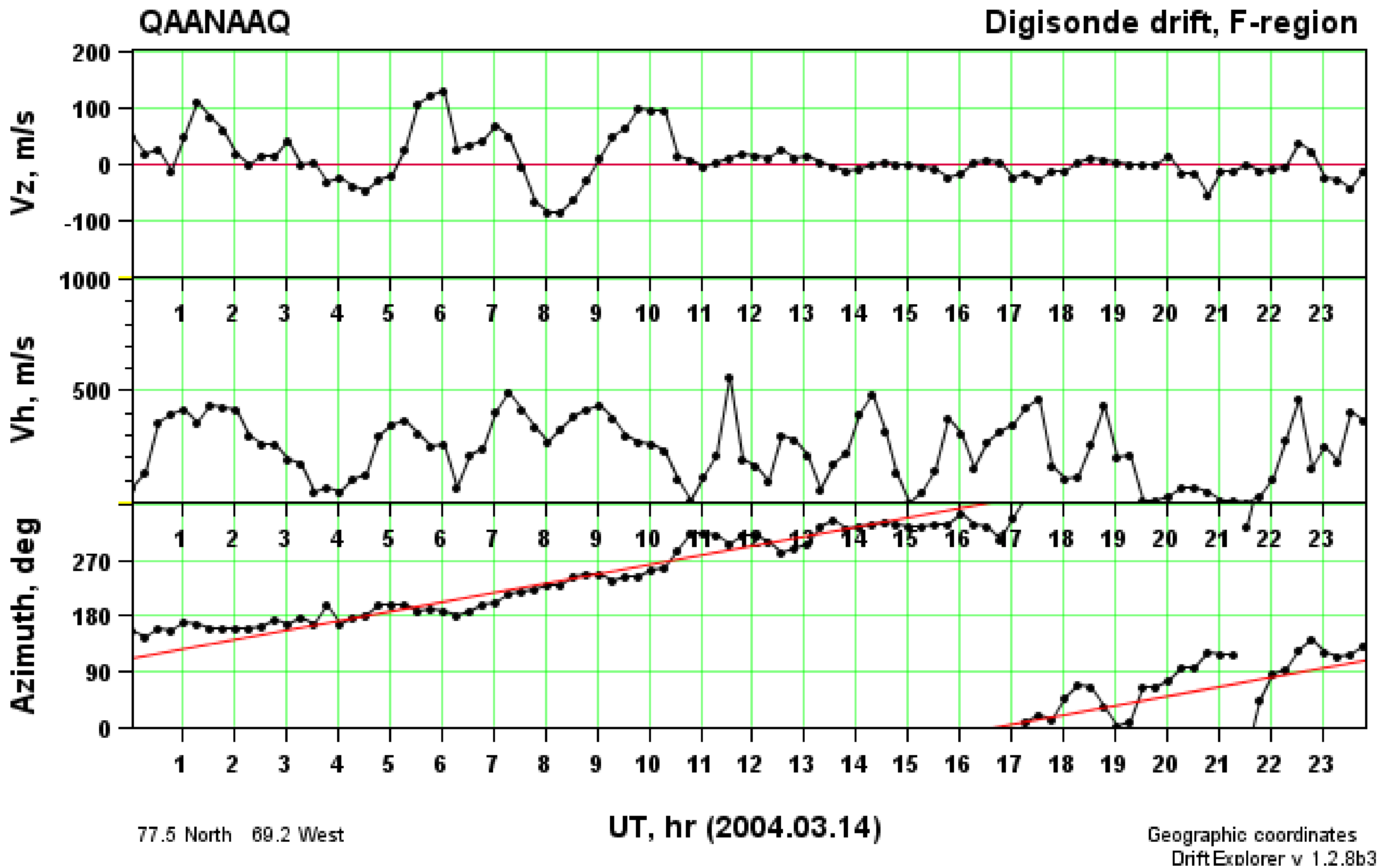
That is, we find a solution for $\mathbf{v_x}$**,** $\mathbf{v_y}$ **and** $\mathbf{v_z}$ that **minimizes** the above expression. This gives the best estimate of the drift velocity (both the horizontal and vertical components) at the time of the measurement. The **DDA** method uses all sources together, assuming a uniform drift velocity across the field of view. This calculation of the drift velocity can be performed every minute, five minutes, etc..

Digisonde Drift Analysis – Calculated velocity

67 x 453



Calculated velocities example



Drift processing diagram

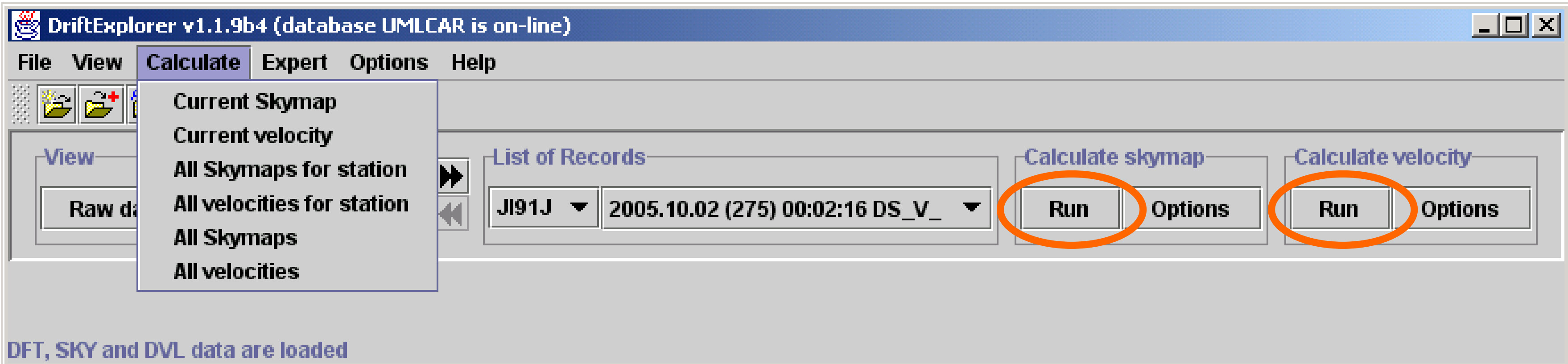
Raw Drift data is stored in the file
Stcd_YDDDHMMS.DFT

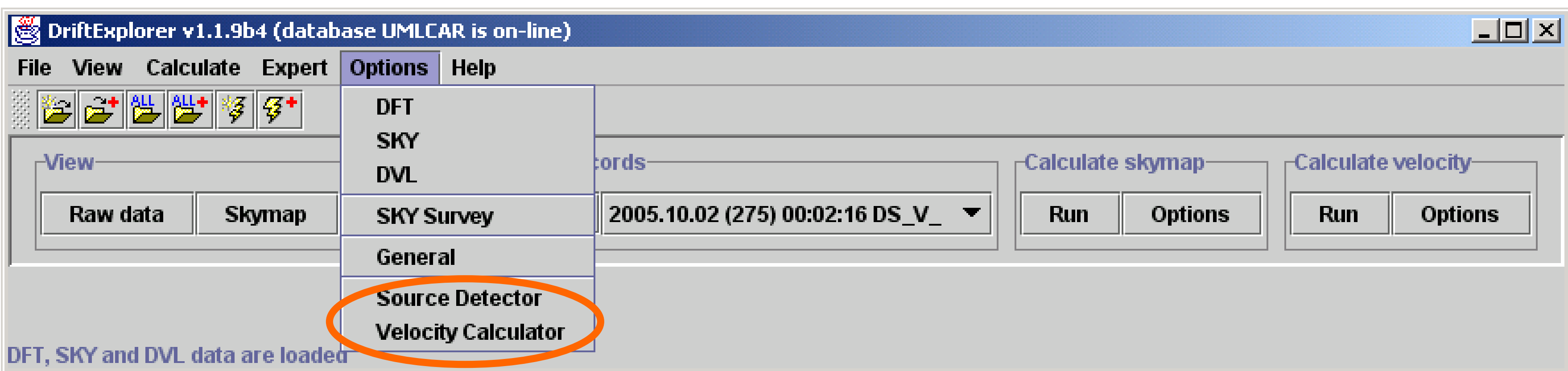
DDAS.EXE calculates the reflection source locations.
The resultant data termed **skymap** data
is stored in the file
DRIFT0.SKY or (Stcd_YDDDHMMS.SKY)

DDAS.EXE uses skymap data to determine
the **velocity** data. This
data is stored in the file
Stcd_YDDDHMMS.DVL

*Stcd stands for **St**ation **c**o**d**e

Calculating drift with DriftExplorer





Velocity Daily Pattern (Ebro)

UNIVERSITY OF MASSACHUSETTS LOWELL
UMLCAR
CENTER FOR ATMOSPHERIC RESEARCH

Daily pattern for individual months & day-to-day variability of Vz

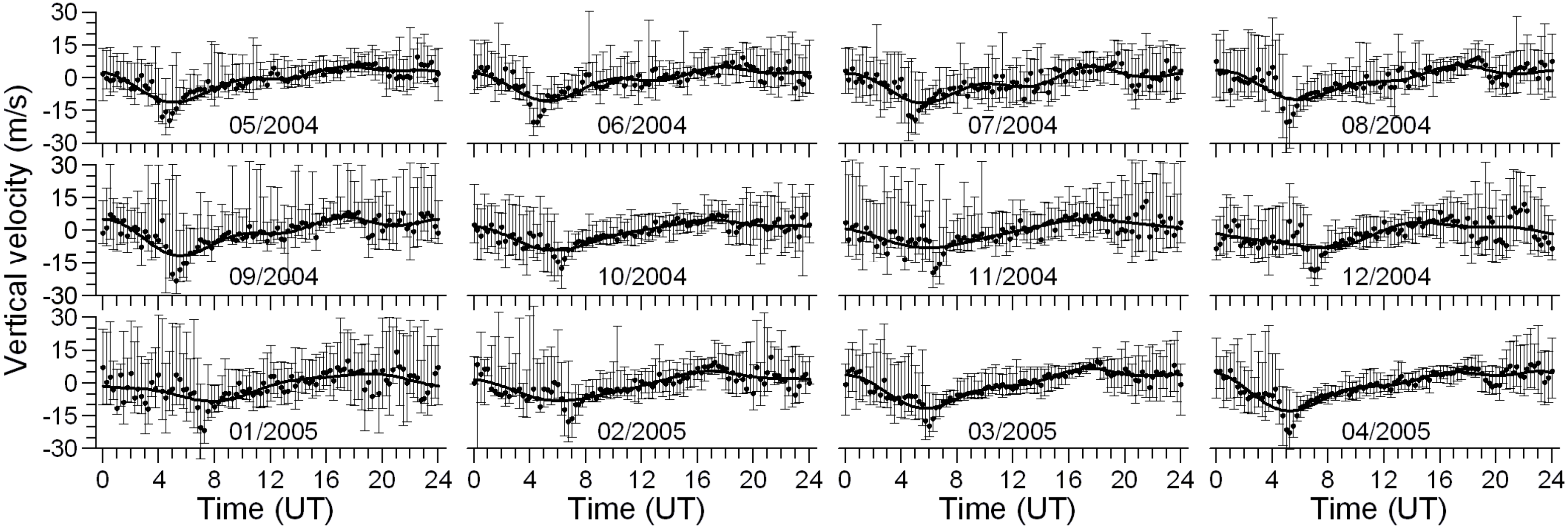
► **Chi-square fitting: $Vz = a_0 + b_{24}\cos(\Omega_{24}t - \varphi_{24}) + b_{12}\cos(\Omega_{12}t - \varphi_{12}) + b_8\cos(\Omega_8 t - \varphi_8)$.**

Diurnal harmonic (24 h.) is dominant. Semi (Ter)-diurnal are noticeable at summer/equinox.

► **Day-to-day Variability.**

Larger by nighttime than by daytime and by winter than by summer.

► **Seasonal Variation?**



2009 IDF XII International Digisonde Forum
11 - 14 May 2009

Seasonal Variations (Ebro)

Amplitudes of daily harmonics

► **Diurnal harmonic (most prominent).**

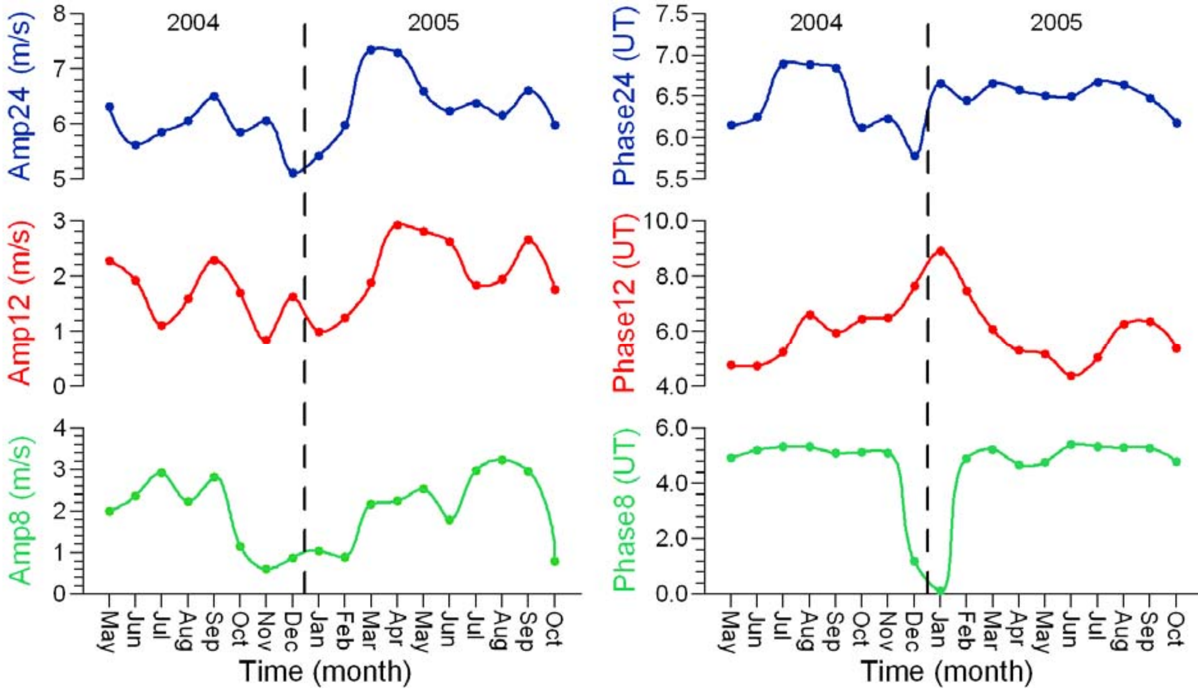
Equinoctial maxima. Semiannual.

► **Semidiurnal harmonic.**

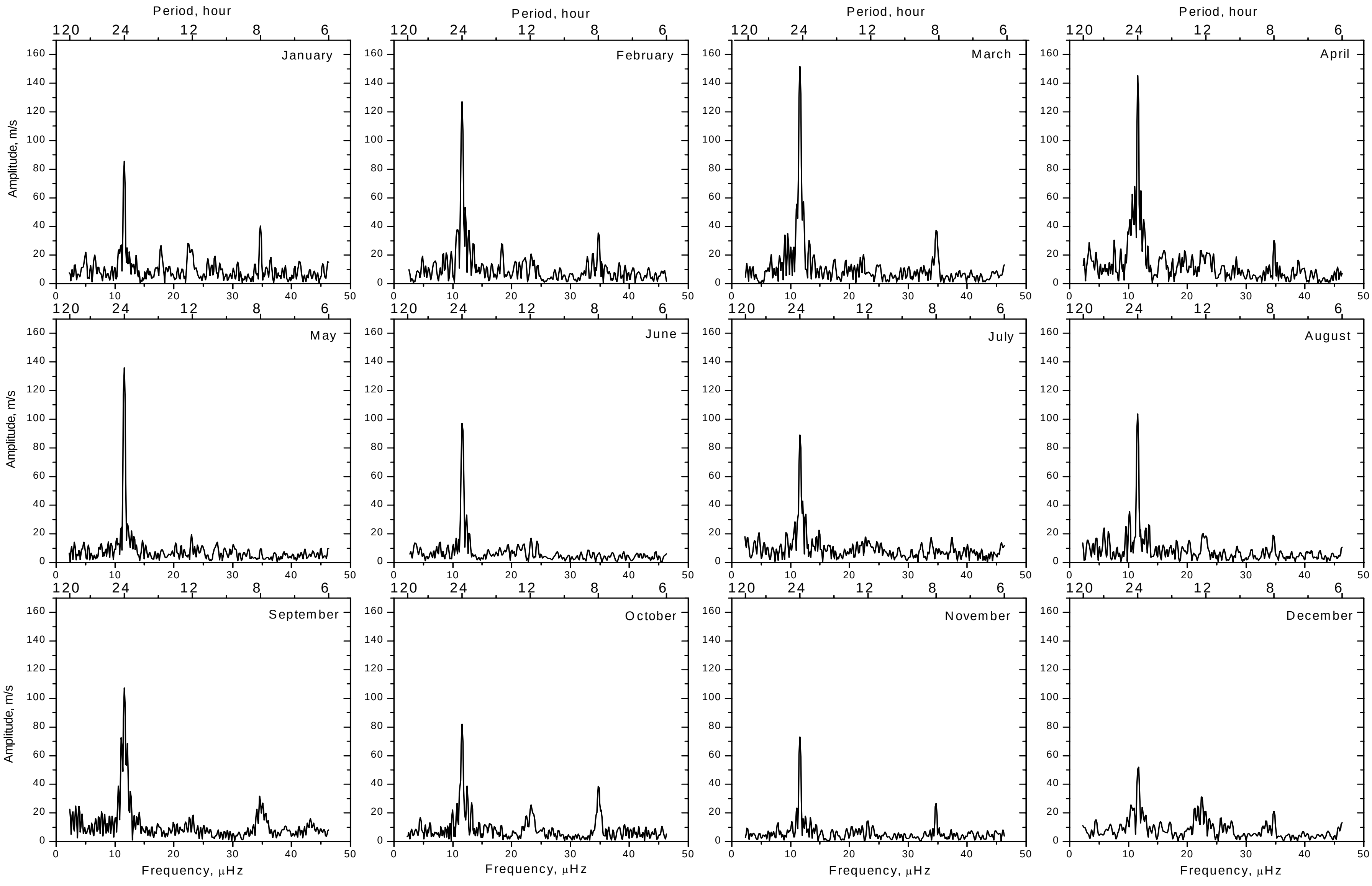
Equinoctial maxima. Semiannual.

► **Terdiurnal harmonic.**

Summer maximum. Annual.



Seasonal Variations (Jicamraca)



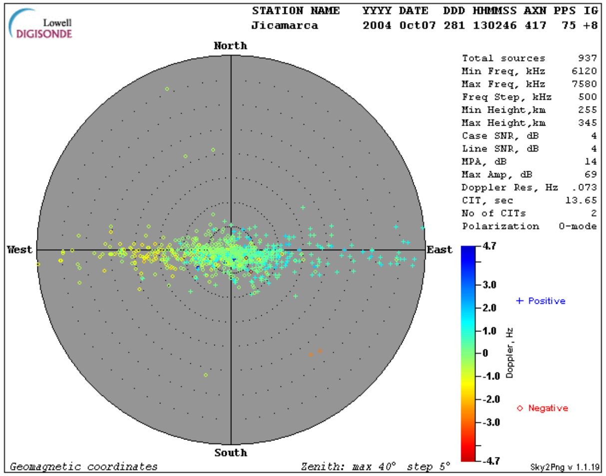
RTD package at a glance

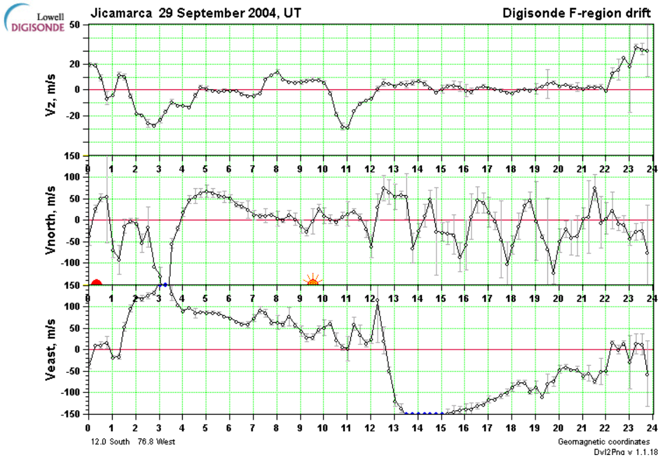
Development objectives:

- To provide the Digisonde Users with a tool for real-time monitoring the ionospheric plasma motion and DPS system performance.
- To organize automated data processing to accumulate measurements for further statistical studies of ionospheric dynamics

RTD processing outputs are:

Source location skymap plots *and* **plasma drift velocity vector component records**:

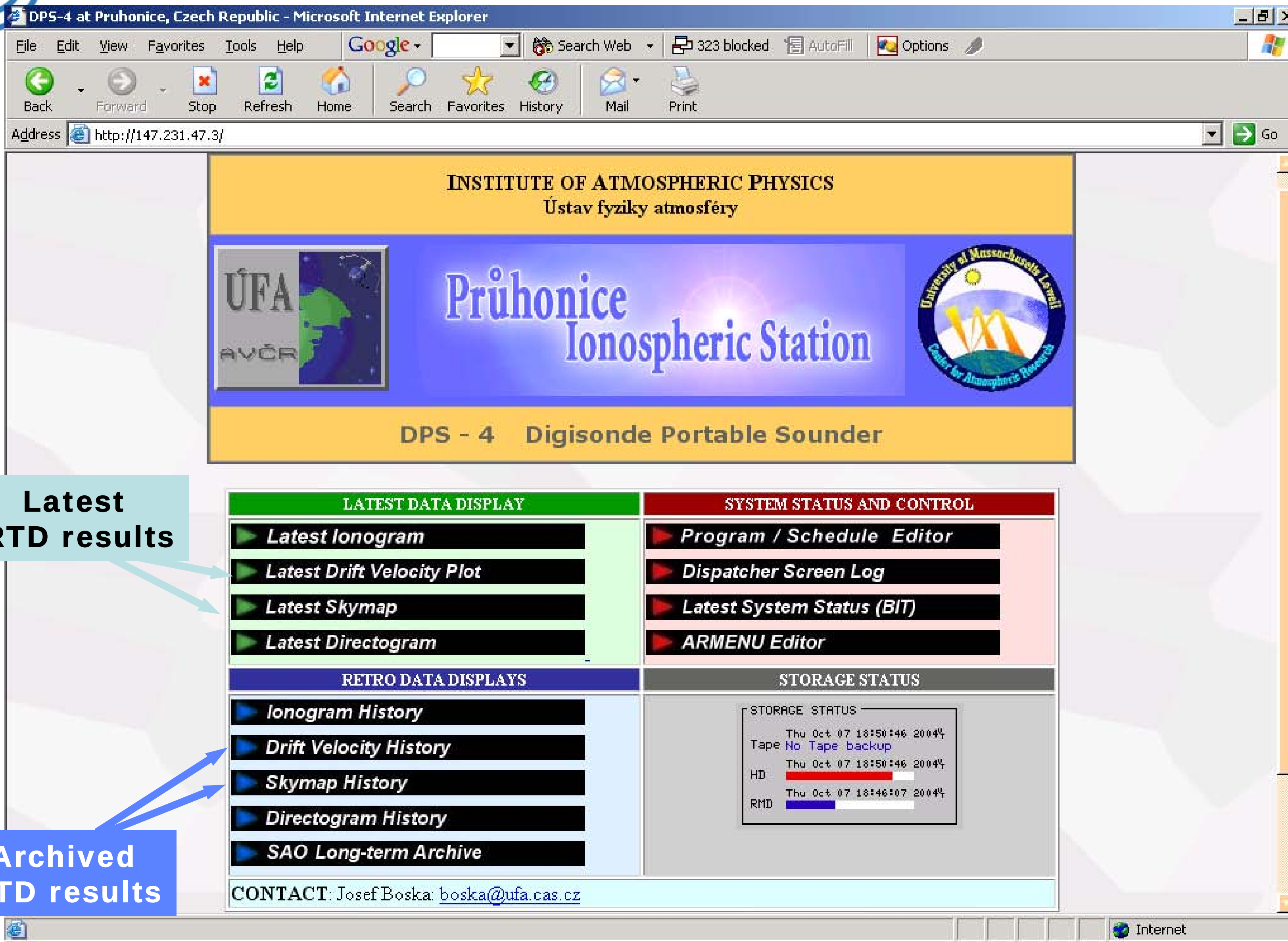




Current RTD installations

AT138 ATHENS
EB040 EBRO (ROQUETES)
FZAOM FORTALEZA
GA762 GAKONA
JI91J JICAMARCA
JJ433 JEJU IS.
MHJ45 MILLSTONE HILL
PQ052 PRUHONICE
SMJ67 SONDRESTROM
SAAOK SAO LUIS
THJ77 QAANAAQ (3day delayed publishing)
TR169 TROMSO

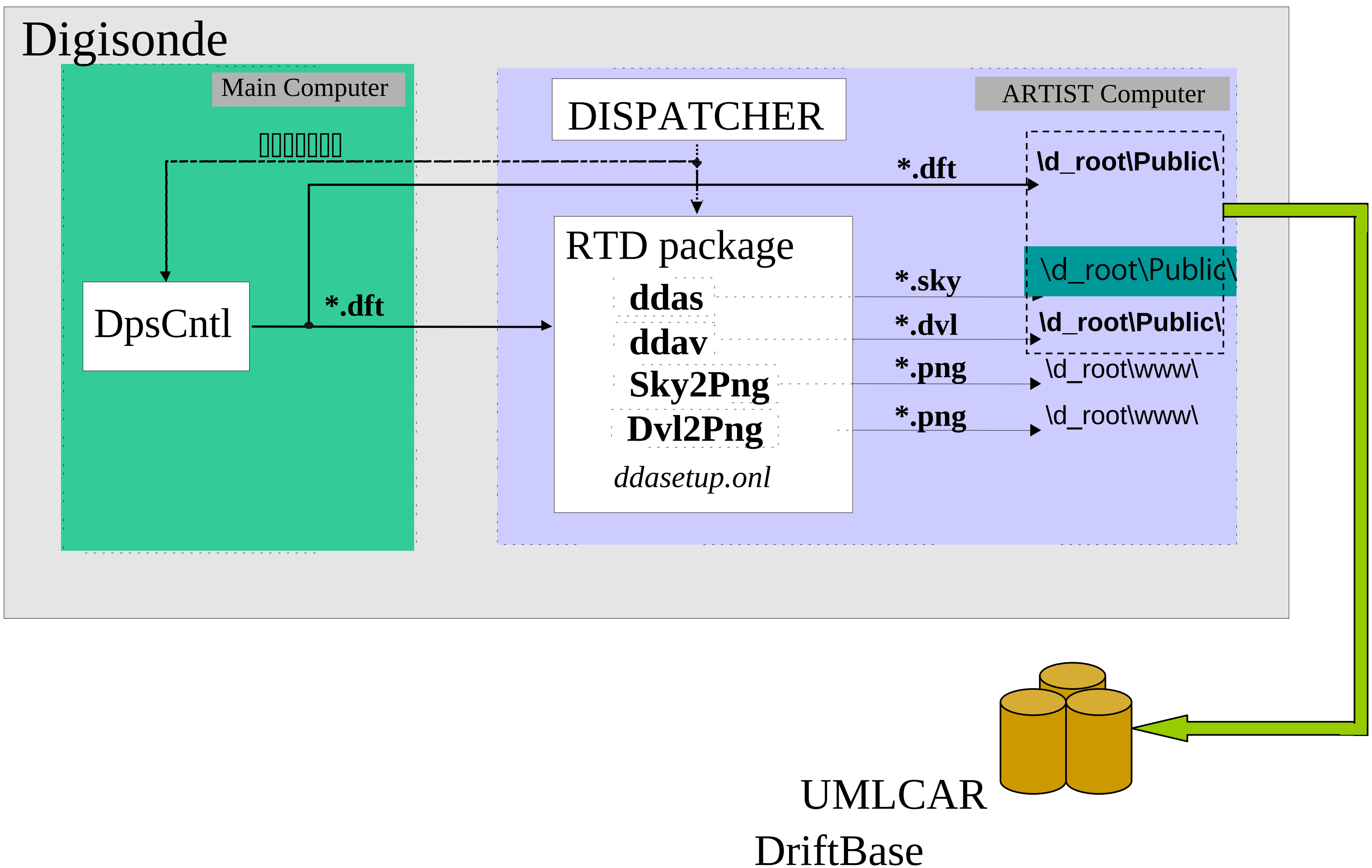
Accessing RTD results



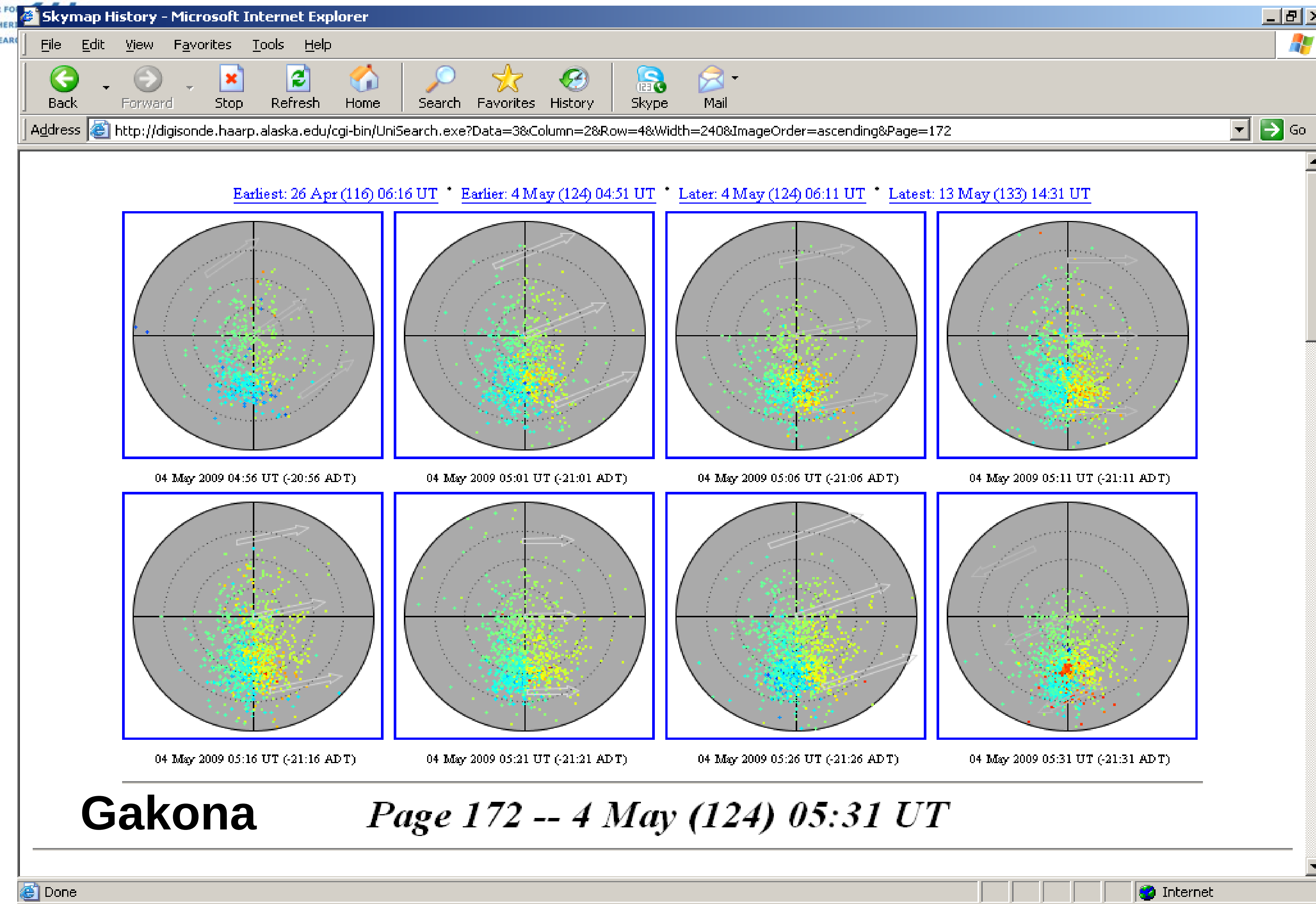
Latest RTD results

Archived RTD results

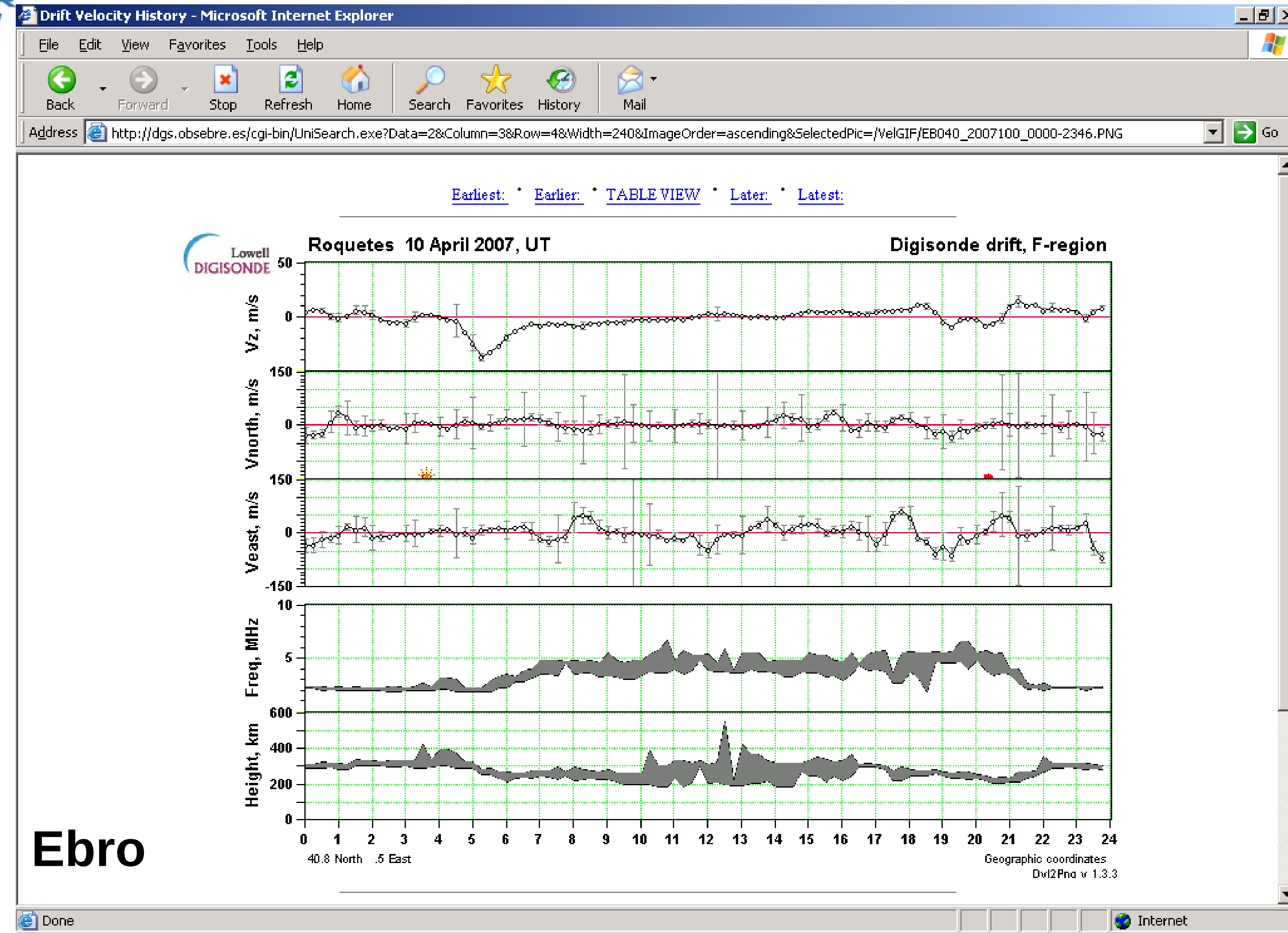
RTD operation diagram



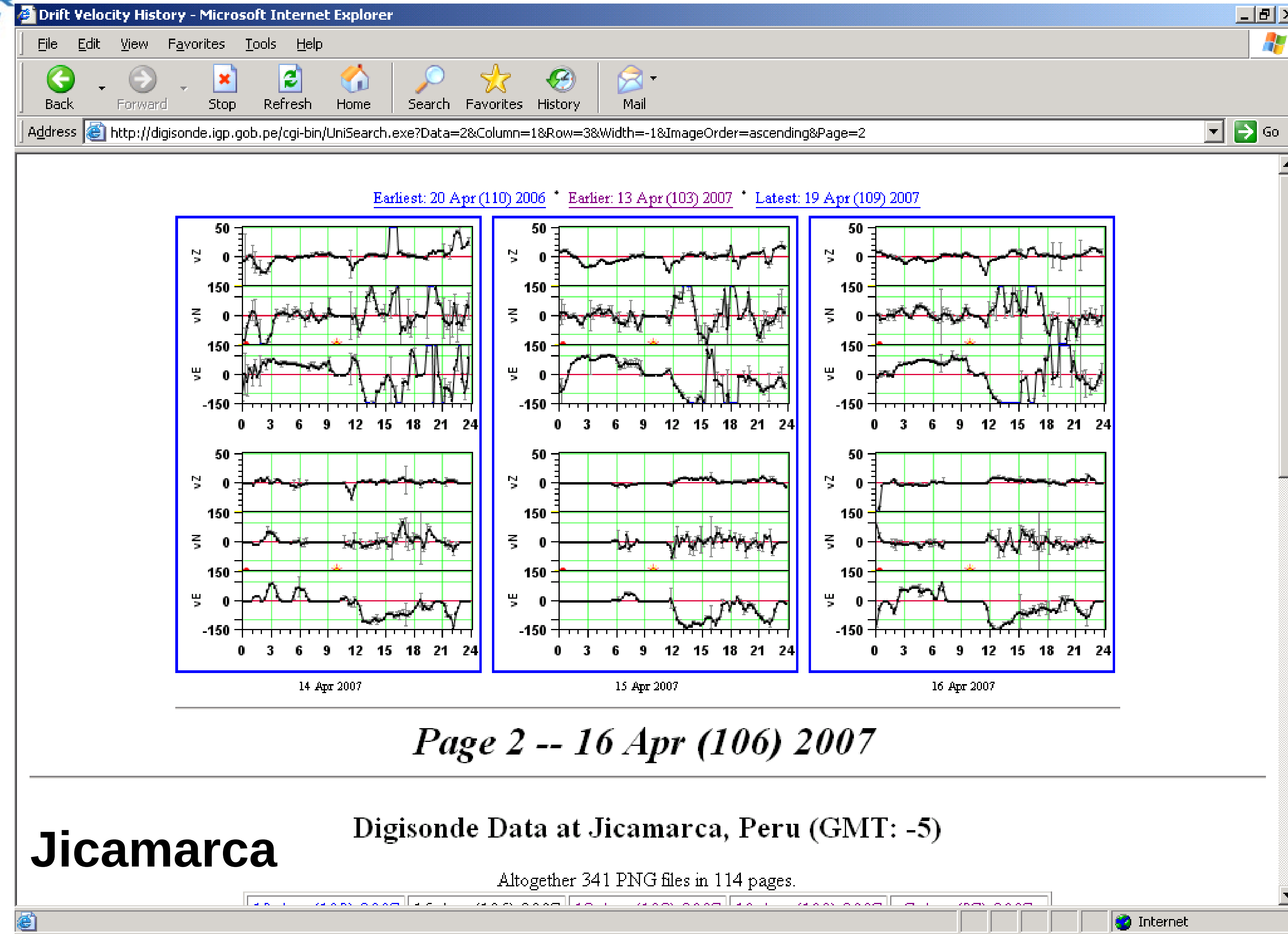
Skymap plot history



Daily velocity data example



Velocity history window



Jicamarca

RTD package components

ddas/jddas DDA package utility for initial data processing and generating skymap files. FORTRAN-coded executable/Java-based program.

ddav DDA utility for real-time velocity calculations. FORTRAN-coded executable

Sky2Png visualizing tool for displaying the real-time calculated skymaps. Java-based programs

Dvl2Png visualizing tool for displaying the real-time calculated velocities. Java-based programs

ddasetup.onl drift data processing option specifications

Note: RTD package requires Java Virtual Machine (JVM) to be installed on the ARTIST computer

Understanding RTD output files

URSIc YYYYDDDHHMMSS

HAJ43_2007067000505.DFT row drift data; binary format

HAJ43_2007067000505.SKY source location data; ASCII format

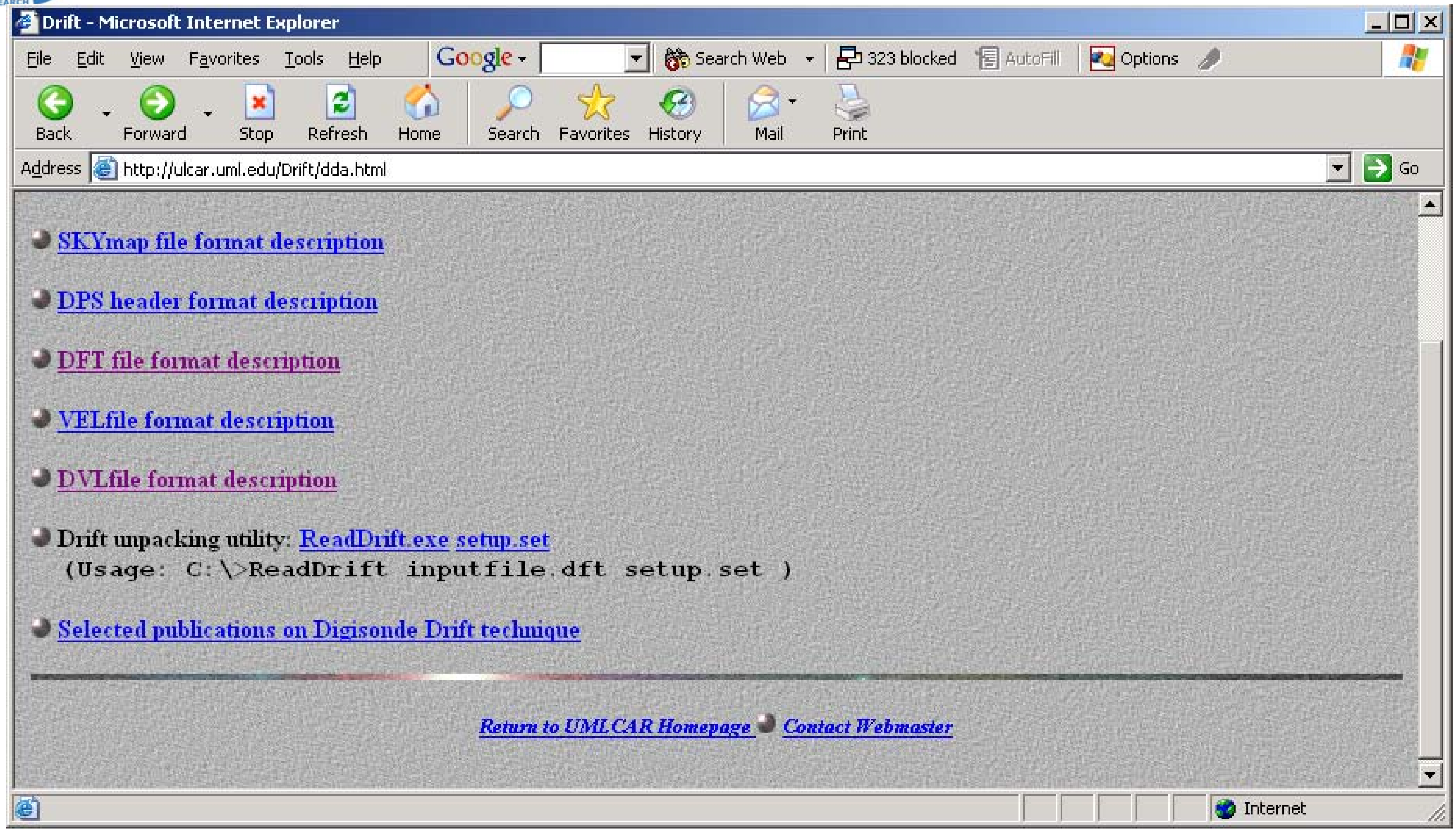
HAJ43_2007067000505.DVL velocity data; ASCII format

URSIc YYYYDDD HHMM HHMM

HAJ43_2007067_0000-2345_sk.PNG skymap plot; graphics format

HAJ43_2007067_0000-2345.PNG velocity plot; graphics format

Drift files format descriptions



http://ulcar.uml.edu/Drift/dda.html

DVL format description

http://umlcar.uml.edu/Drift/formatDVL_v2.txt - Microsoft Internet Explorer

```
The followong listing describes the format of the DVL data file.

DVL V# SID URSIc   LAT  LONG YYYY/MM/DD Day HH:MM:SS       Vx     Vx.err       Vy    Vy.err        Az     Az
DVL V2 042 MHJ45  42.0 288.0 2005/08/26 238 06:18:56     53.12      5.39   -130.16     10.28    292.20
DVL V2 042 MHJ45  42.0 288.0 2005/08/26 238 06:33:55     39.61      9.51   -104.38      6.10    290.90
DVL V2 042 MHJ45  42.0 288.0 2005/08/26 238 06:48:55     67.33      7.61   -165.79     19.93    291.65

Coordinate system convention:

COM means Compass
GEO means Geographic
CGm means Corrected Geromagnetic

For example, in the case of using the Compass coordinates:

Vx means velocity component in magnetic north direction,
Vy means velocity component in "magnetic east" direction
Vz means vertical velocity component
Az means plasma motion direction counted clockwise from the magnetic north

DVL      DVL file format identifier
V#       specifies DVL format version number
SID      is the Station ID (essentially, latitude of the station)
URSIc    stands for URSI Code of the station
LAT      Station Geographic Latitude
LONG     Station Geographic Longitude
YYYY     Year
```

http://ulcar.uml.edu/Drift/formatDVL_v2.txt

Controlling velocity output plots

Dvl2Png.ini (fragment):

Cartesian (Vx, Vy, Vz) or cylindrical (azimuth, V horizontal, V vertical)
type of coordinates for representation to use

Cartesian = true

#
Set LocalTime to <true> to display velocity plots in Local Time.
#

LocalTime = false

#
Set velocity graph scales

VXMax = 150.0
VYMax = 150.0
VZMax = 50.0
VHMax = 500.0

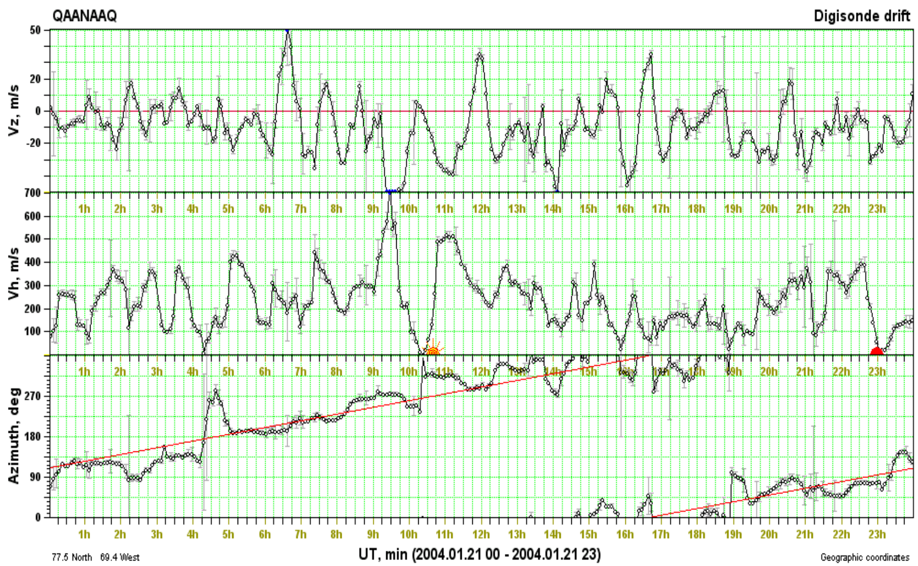
Two presentations of same DVL data

Cartesian = false

LocalTime = false

VZMax = 50.0

VHMax = 600.0



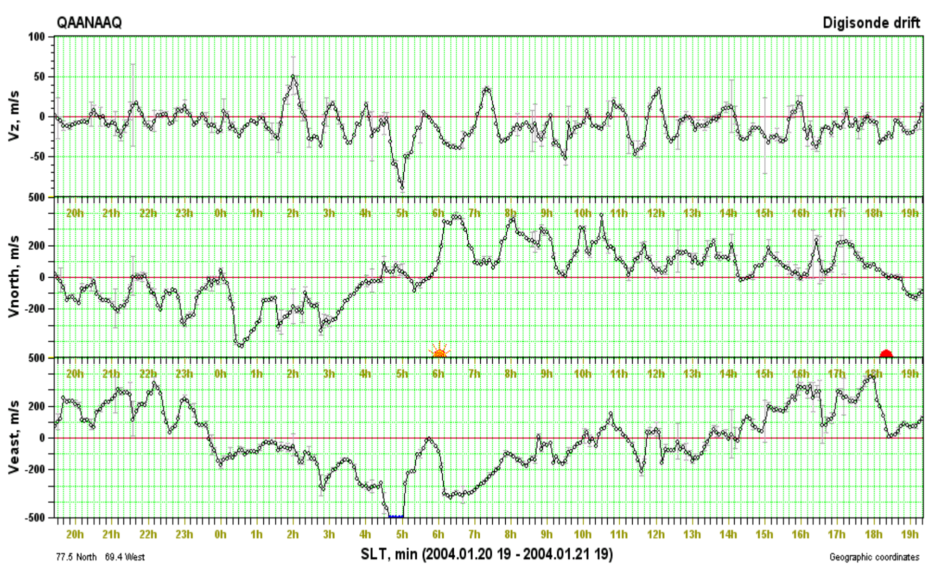
Cartesian = true

LocalTime = true

VXMax = 500.0

VYMax = 500.0

VZMax = 100.0



Controlling skymap output plots

Sky2Png.ini (fragment):

Set skymap scale and grid step size

ZenithMax = 40.0
ZenithGridStep = 5.0

Set parameter ShowLocalTime to <true> to display Solar Local Time

ShowLocalTime = false

Set parameter UseColorScale to <true> to use full color palette for
Doppler range, otherwise only two colors will be used.
Specify desired Doppler scale with DopplerRangeScale and
FixDopplerRangeScale set to <true>

UseColorScale = true
FixDopplerRangeScale = false
DopplerRangeScale = 6

Two presentations of same SKY data

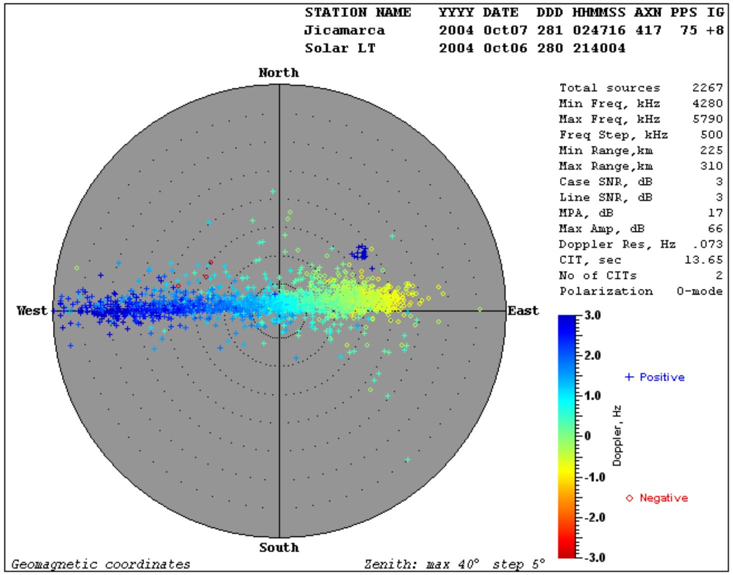
ZenithMax = 40.0

ZenithGridStep = 5.0

ShowLocalTime = true

UseColorScale = true

GreySky = true



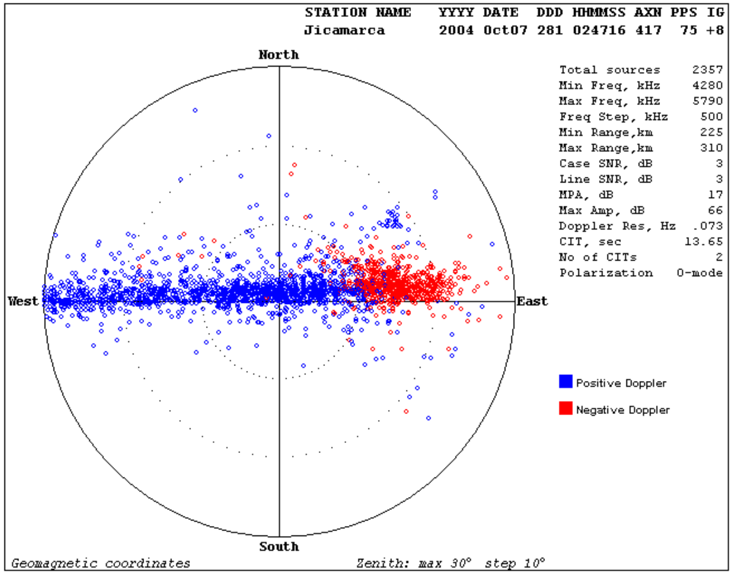
ZenithMax = 30.0

ZenithGridStep = 10.0

ShowLocalTime = false

UseColorScale = false

GreySky = false



Drift technique essential references

Digisonde Drift Analysis, 1995. compiled by J.L.Scali
DPS System Manual, 1997

Web-links:

DriftExplorer:
http://ulcar.uml.edu/Drift-X.html
Drift file formats:
http://ulcar.uml.edu/Drift/dda.html
DPS Antenna configuration:
http://umlcar.uml.edu/dda_antenna_configurations.html
Publications on Drift technique:
http://ulcar.uml.edu/Drift/Publications.html

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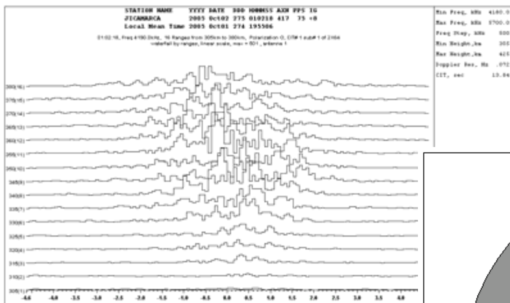
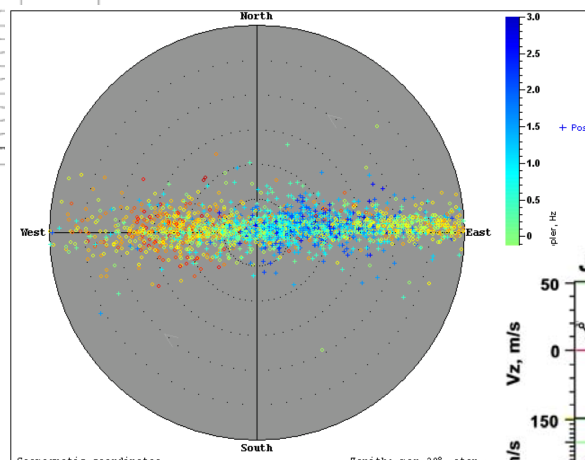
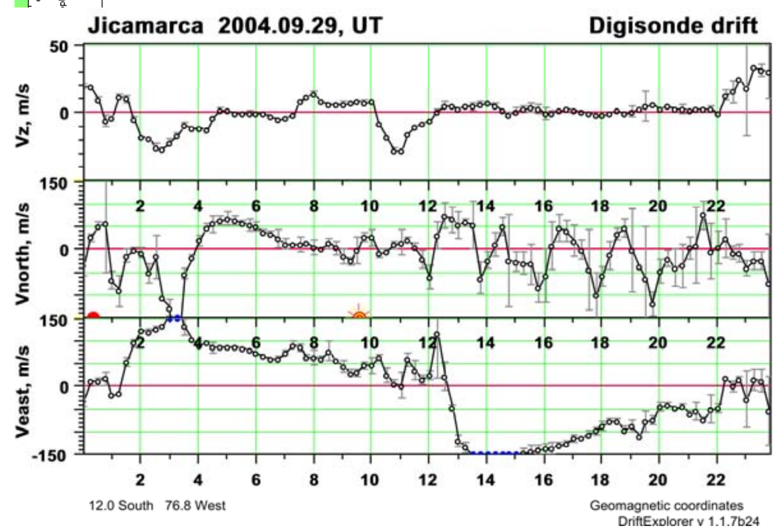
Good Luck!







ddasetup.onl file (fragment)

//ENTER MAXIMUM ZENITH ANGLE FOR THE SKYMAPS

//IN DEGREES, 0.0 FOR DEFAULT

***020 THE CURRENT MAX.ZENITH ANGLE IS < 40.0>**

//ENTER SIGNAL-TO-NOISE RATIO (SNR) THRESHOLD VALUE FOR

//SUB-CASE SELECTION

***022 THE CURRENT SNR THRESHOLD IS <2>**

//ENTER SIGNAL-TO-NOISE RATIO (SNR) THRESHOLD VALUE FOR

//SPECTRAL LINE

***024 THE CURRENT SNR THRESHOLD IS <2>**

//ENTER THE MAXIMUM ABSOLUTE DOPPLER NUMBER (0=ALL)

//-5 => Never use last 5 lines, i.e. +26 to +31 ; -26 to -31

//10 => Only use the Doppler lines -10 to 0 to 10

***025 THE CURRENT OPTION IS <0>**

//SELECT FIRST CASE TOSS-OUT OPTION

1 - Toss First DRIFT case of each group.

2 - Process all cases in each group.

***026 THE CURRENT TOSS-OUT OPTION IS < 2 >**

This file contains drift processing options.
It can be edited both manually and using DriftExplorer

UNIVERSITY OF MASSACHUSETTS LOWELL
UMLCAR
CENTER FOR ATMOSPHERIC RESEARCH

Drift Explorer and Drift Database

Alexander Kozlov
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

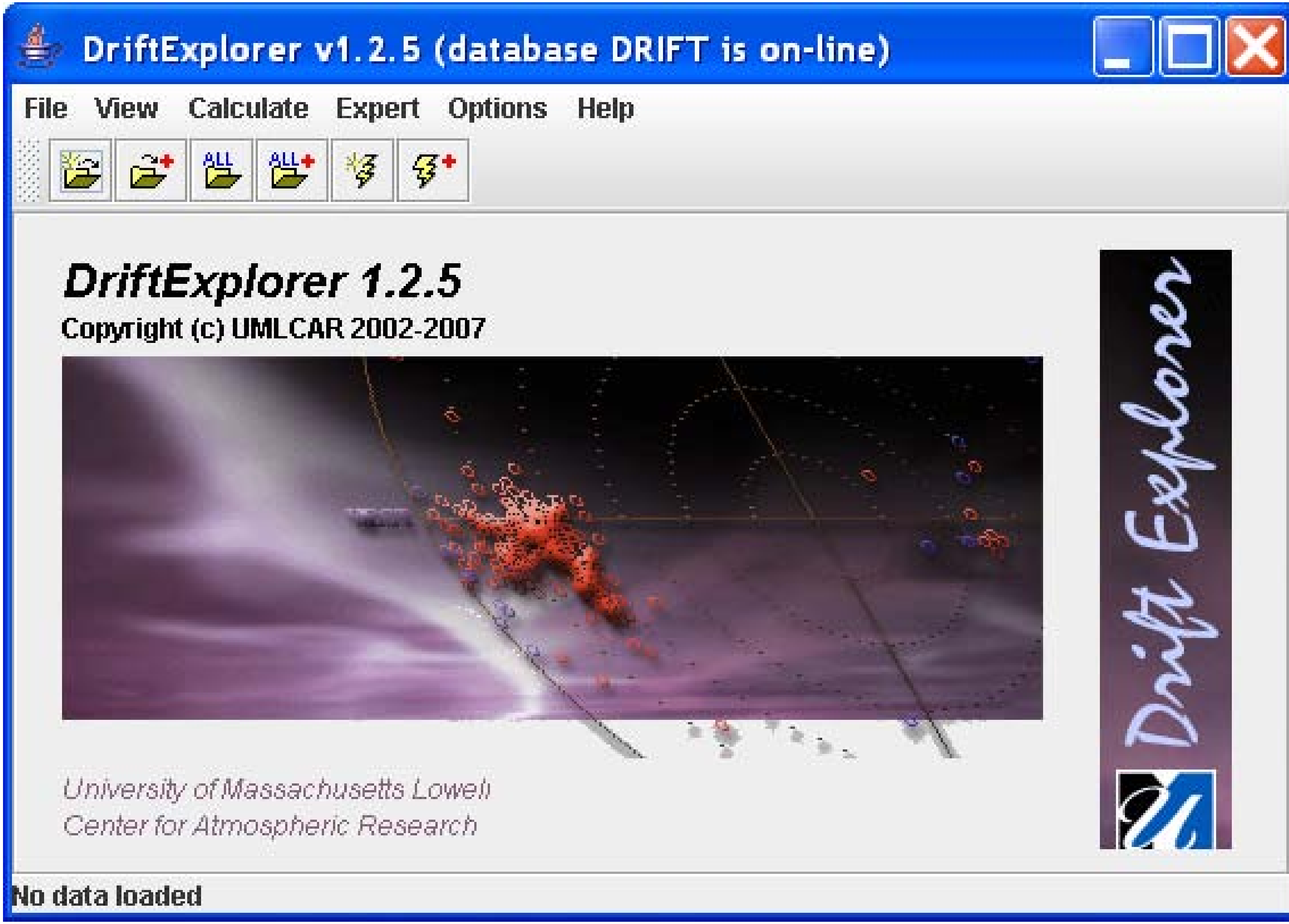
DX functionalities

• Raw-drift, skymap and velocity data navigation and viewing
• Skymap (sources of reflection points and their radial velocities) calculation using raw-drift data
• Velocities calculation using skymap data
• Raw-drift, skymap and velocity data extraction from DriftBase
• Being connected to DriftBase as Expert you can store calculated skymap and velocities data bound to this expert. So admitting multiple skymap and velocity records for one raw-drift data record in DriftBase may exist.

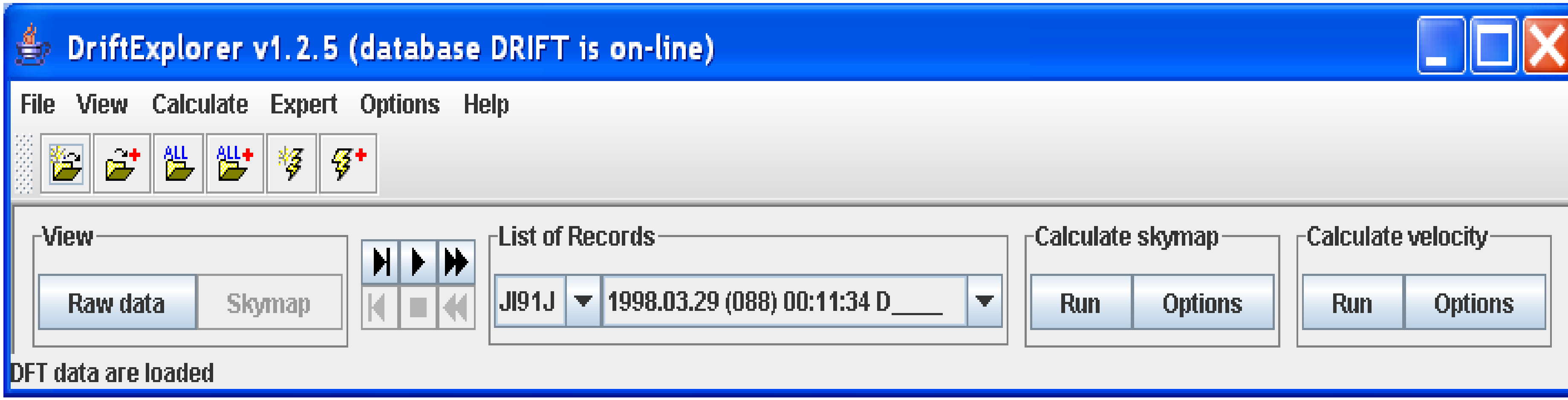
DX features

- You can load list of data for several station
- You can visually compare data by opening more than one window of data representation
- Each window of data representation has its own list of stations and records so you can independently from others to observe data in this window
- You can browse through the clustered data list and open synchronized data view windows for raw-drift (DFT) and skymap (SKY) data
- Or/and you can open any number of unsynchronized windows for any type of data (DFT, SKY or DVL)
- You can display height or frequency ranges for velocity plot
- Velocity data that represent both F and E layer will not be messed up on velocity display but will be shown in two different windows

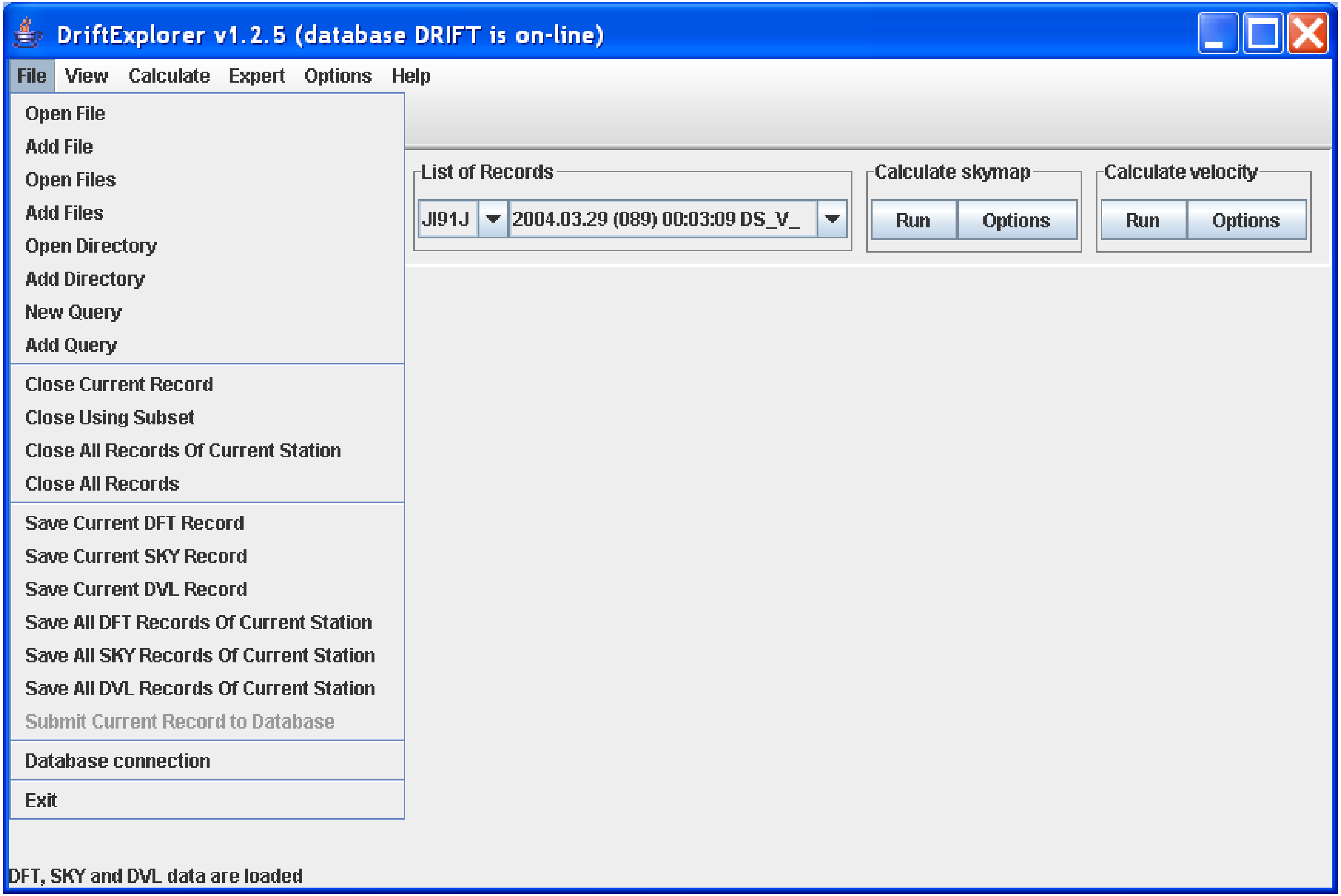
Start window



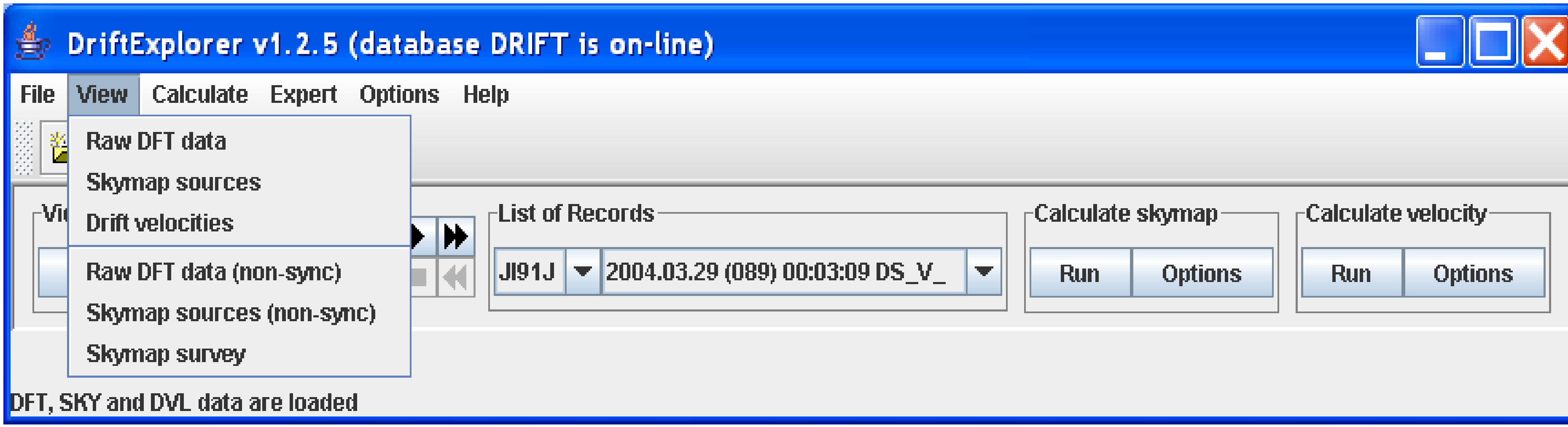
Main window


DriftExplorer v1.2.5 (database DRIFT is on-line)
File View Calculate Expert Options Help
ALL
ALL
View
Raw data
Skymap
List of Records
JI91J
1998.03.29 (088) 00:11:34 D____
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT data are loaded

Menu File

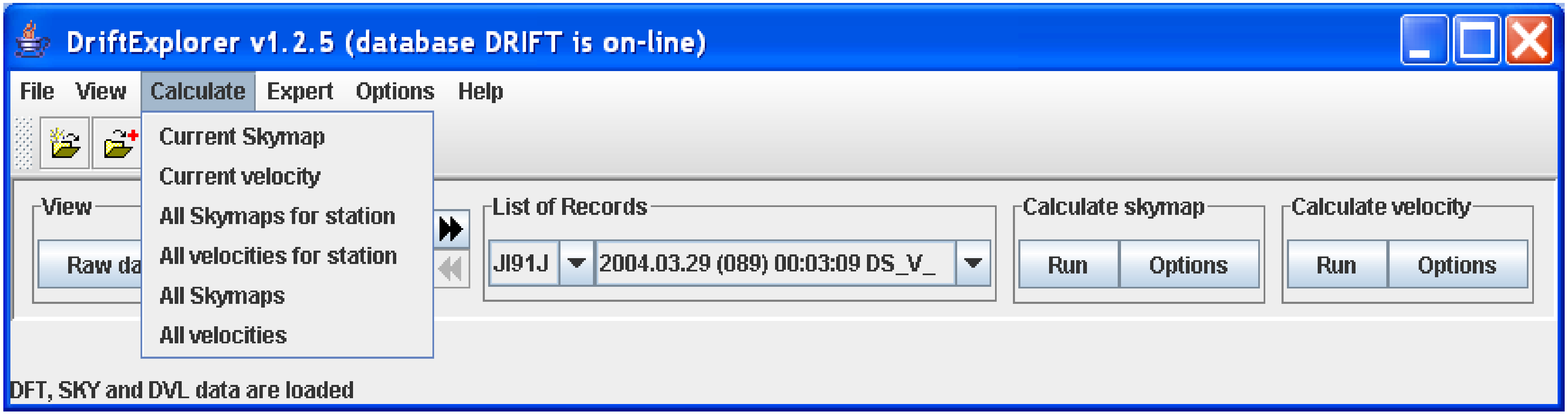

DriftExplorer v1.2.5 (database DRIFT is on-line)
File
View
Calculate
Expert
Options
Help
Open File
Add File
Open Files
Add Files
Open Directory
Add Directory
New Query
Add Query
Close Current Record
Close Using Subset
Close All Records Of Current Station
Close All Records
Save Current DFT Record
Save Current SKY Record
Save Current DVL Record
Save All DFT Records Of Current Station
Save All SKY Records Of Current Station
Save All DVL Records Of Current Station
Submit Current Record to Database
Database connection
Exit
List of Records
JI91J
2004.03.29 (089) 00:03:09 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded

Menu View

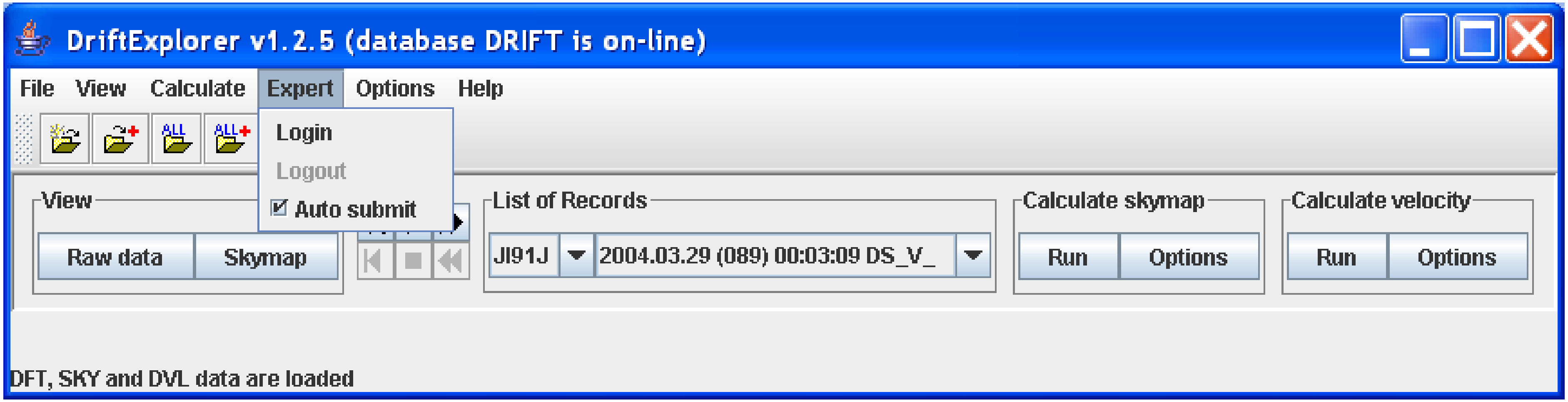


DriftExplorer v1.2.5 (database DRIFT is on-line)
File
View
Calculate
Expert
Options
Help
Raw DFT data
Skymap sources
Drift velocities
Raw DFT data (non-sync)
Skymap sources (non-sync)
Skymap survey
List of Records
JI91J
2004.03.29 (089) 00:03:09 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded

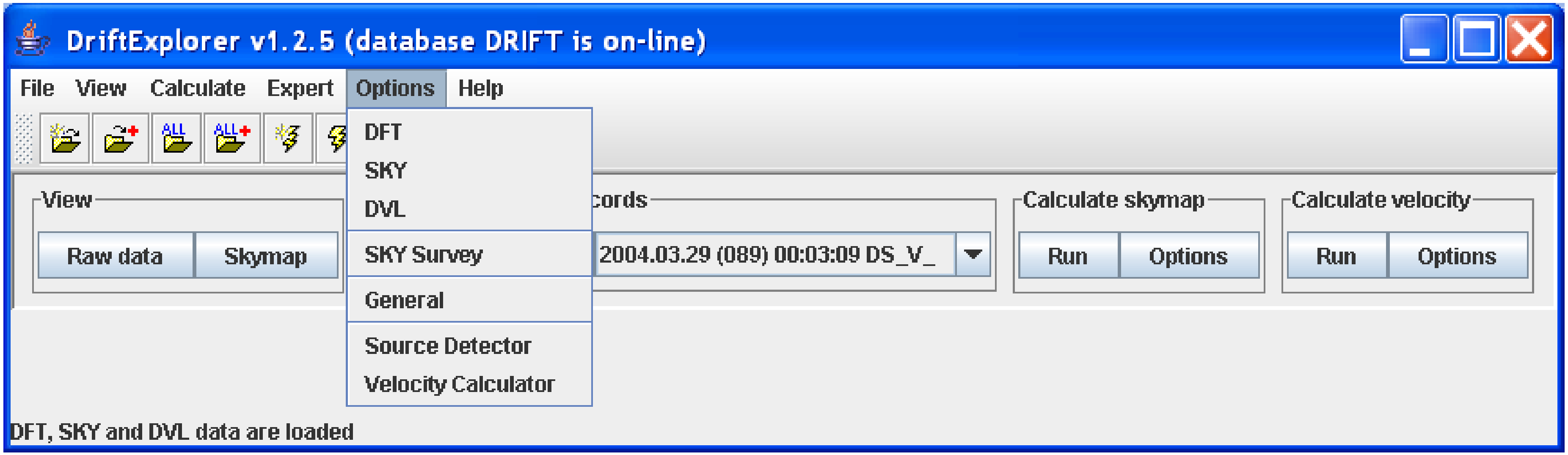
Menu Calculate



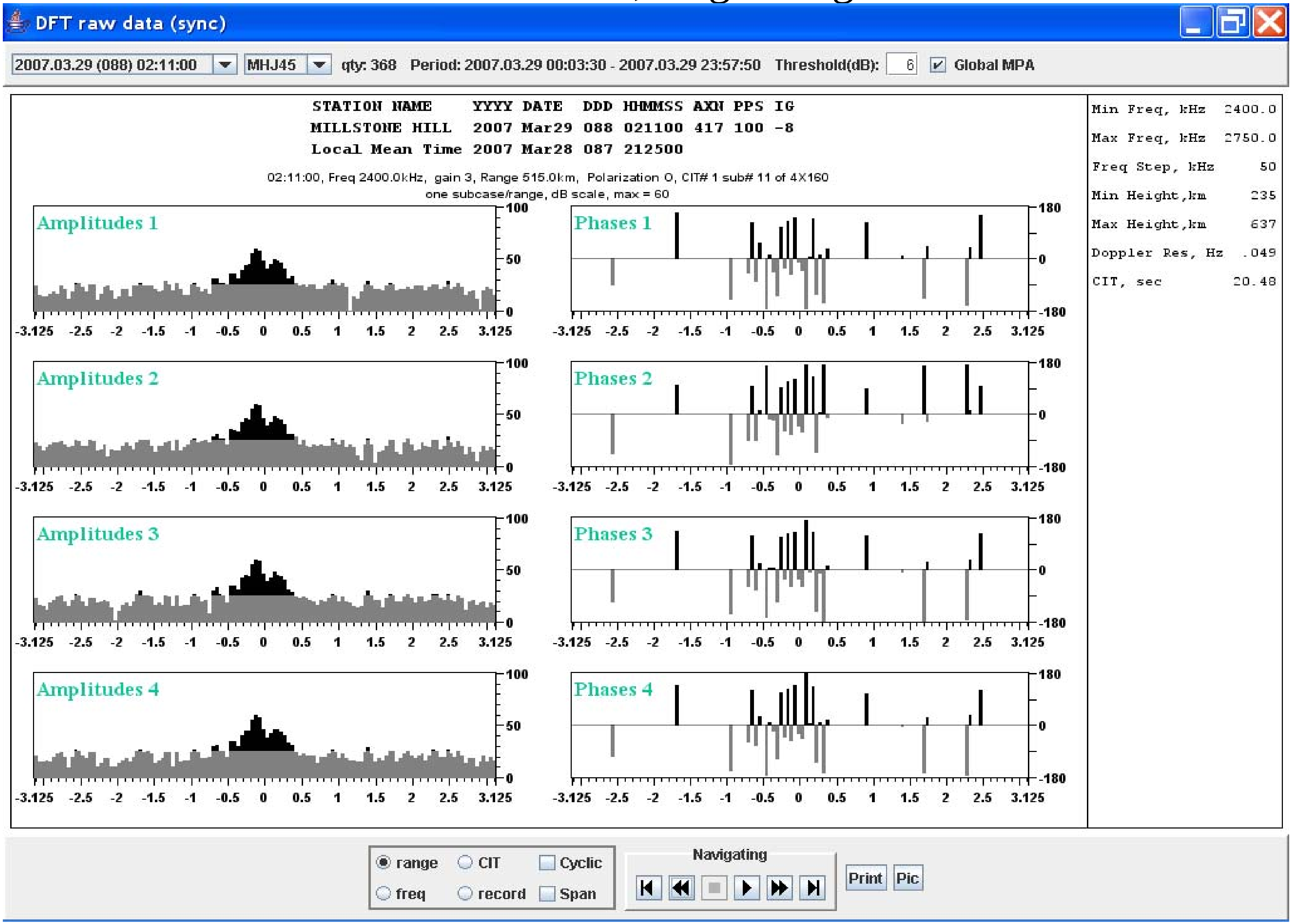
Menu Expert


DriftExplorer v1.2.5 (database DRIFT is on-line)
File
View
Calculate
Expert
Options
Help
Login
Logout
Auto submit
View
Raw data
Skymap
List of Records
JI91J
2004.03.29 (089) 00:03:09 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded

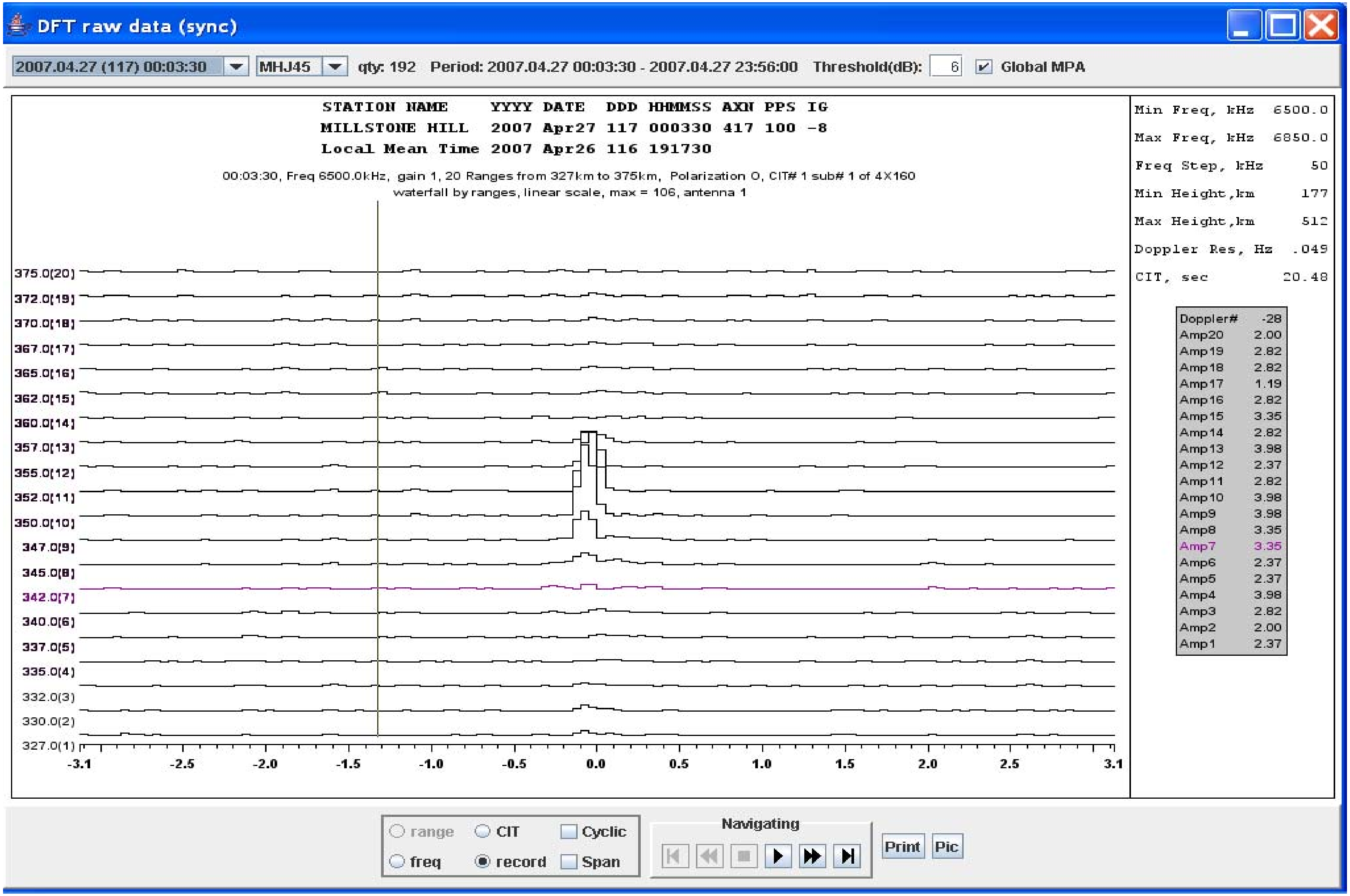
Menu Options



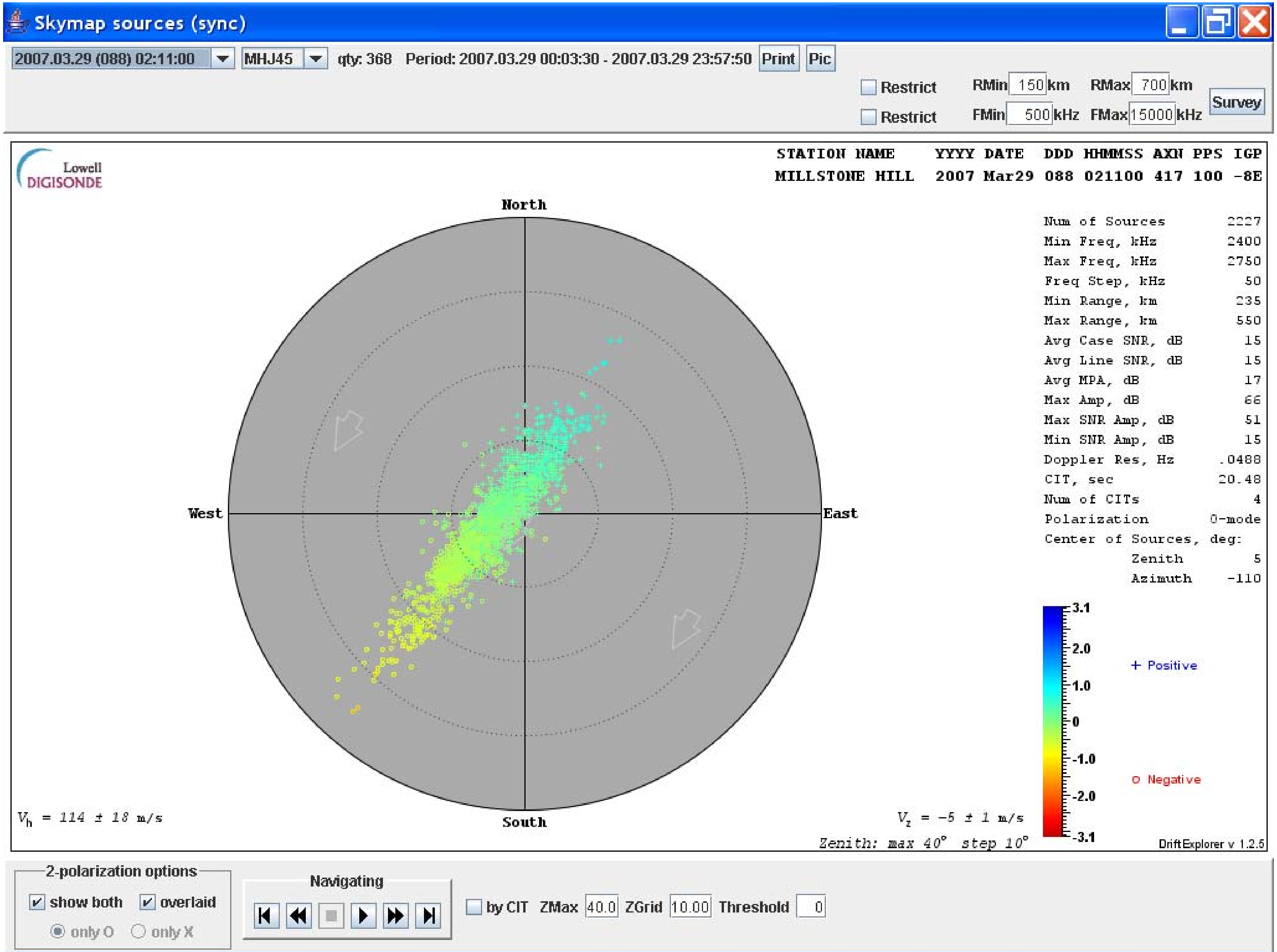
DFT View, single range



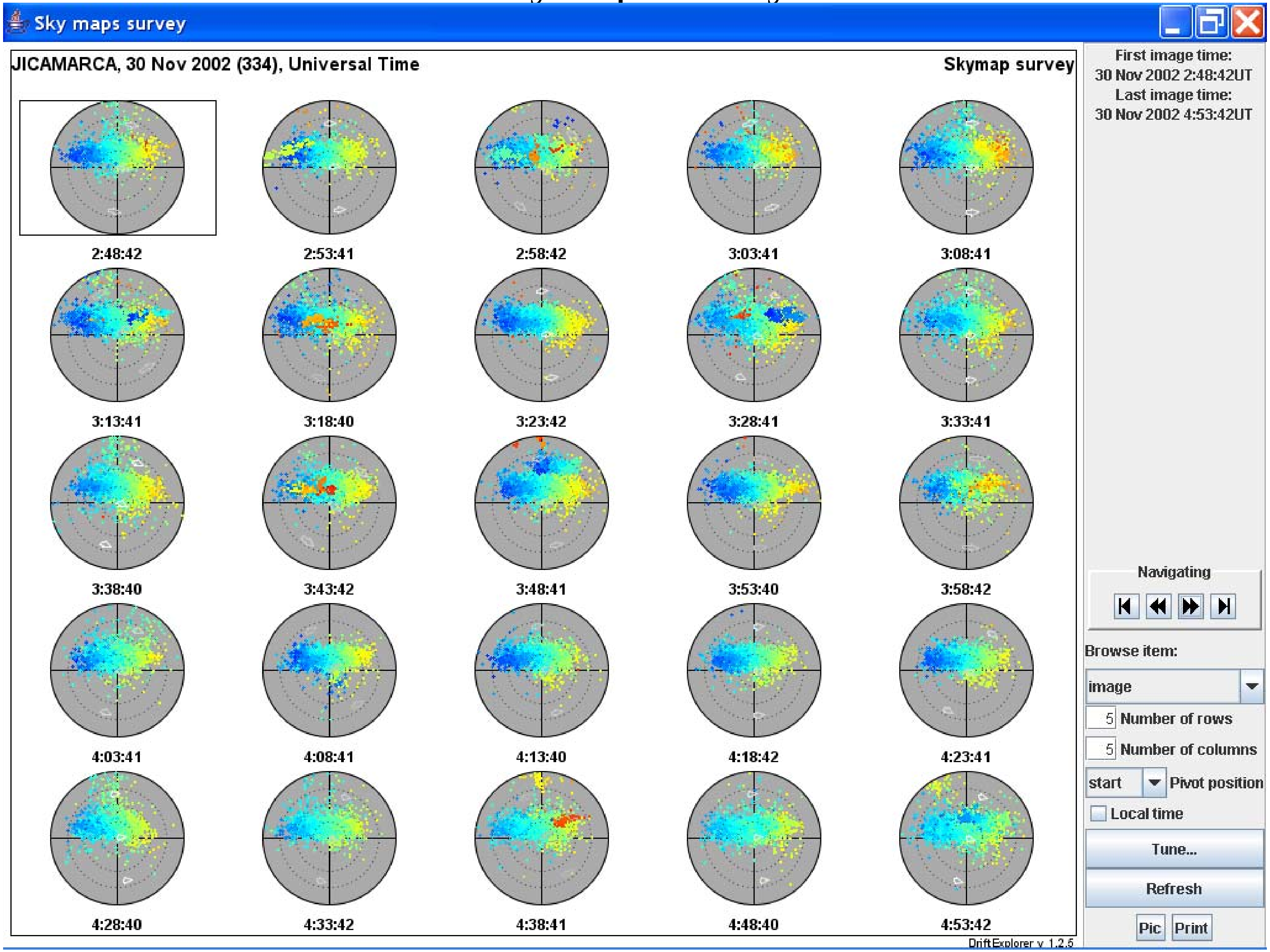
DFT View, waterfall



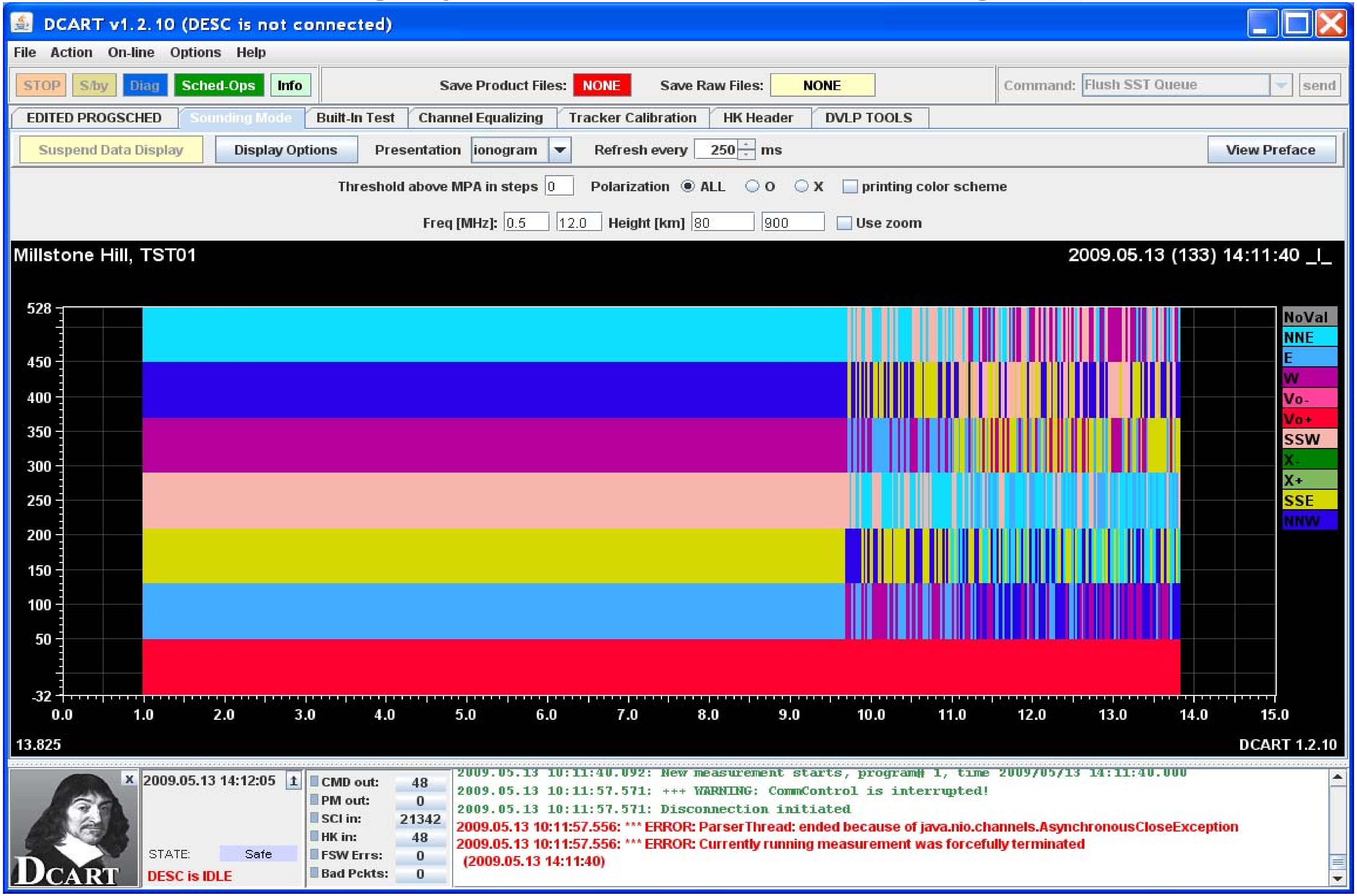
SKY View window



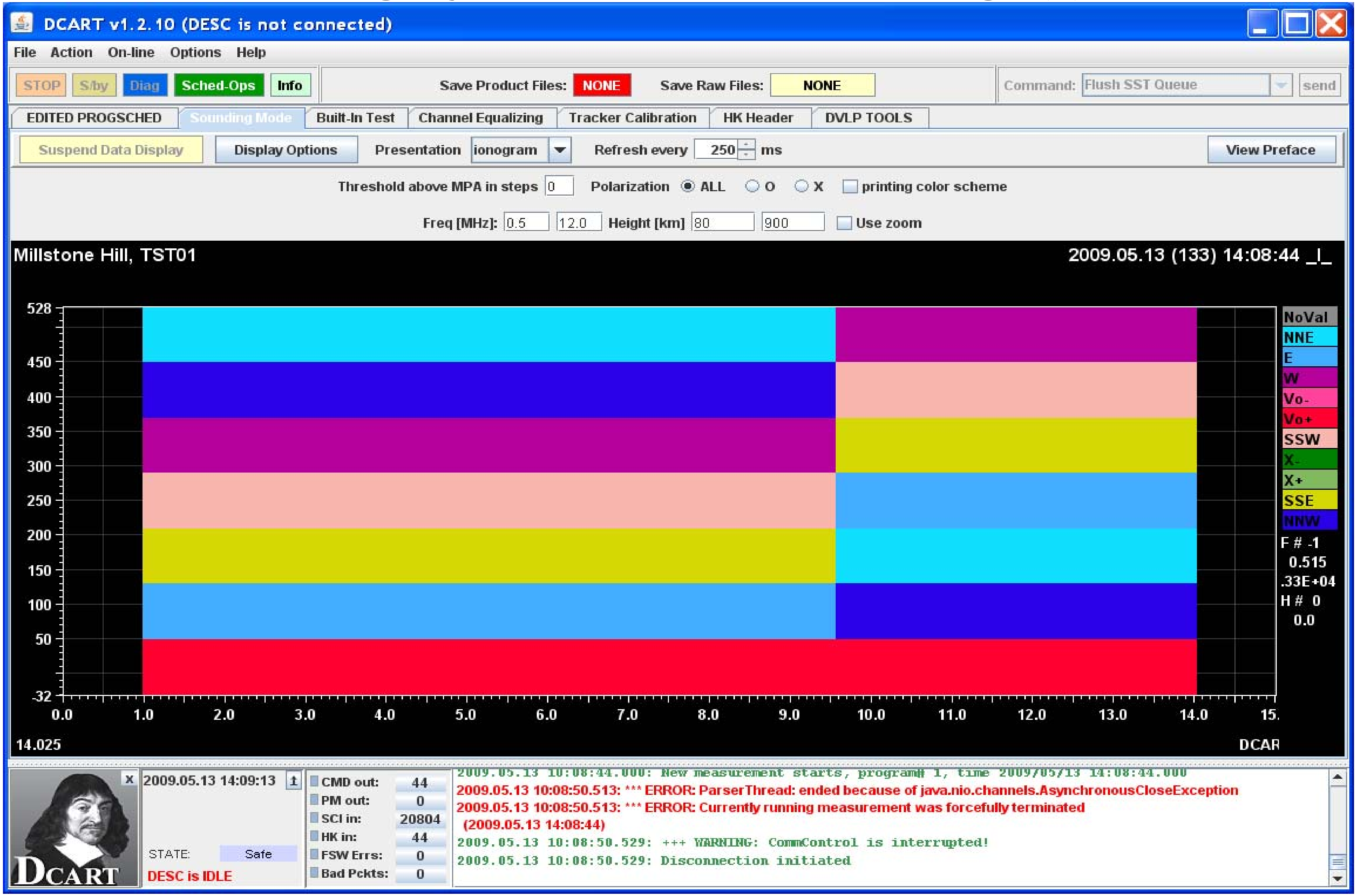
Skymap Survey



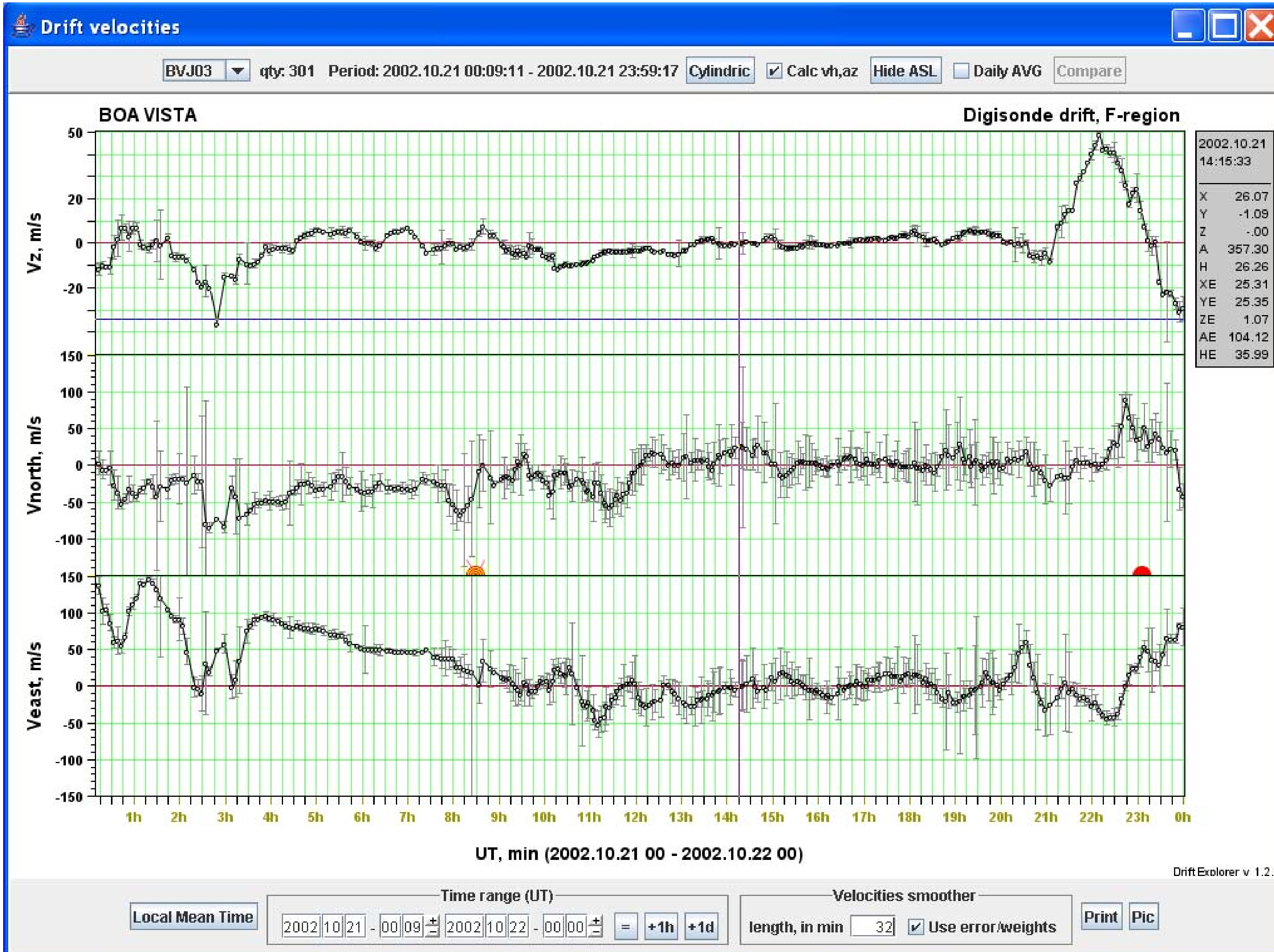
Ambiguity in calculation of arrival angle (1)



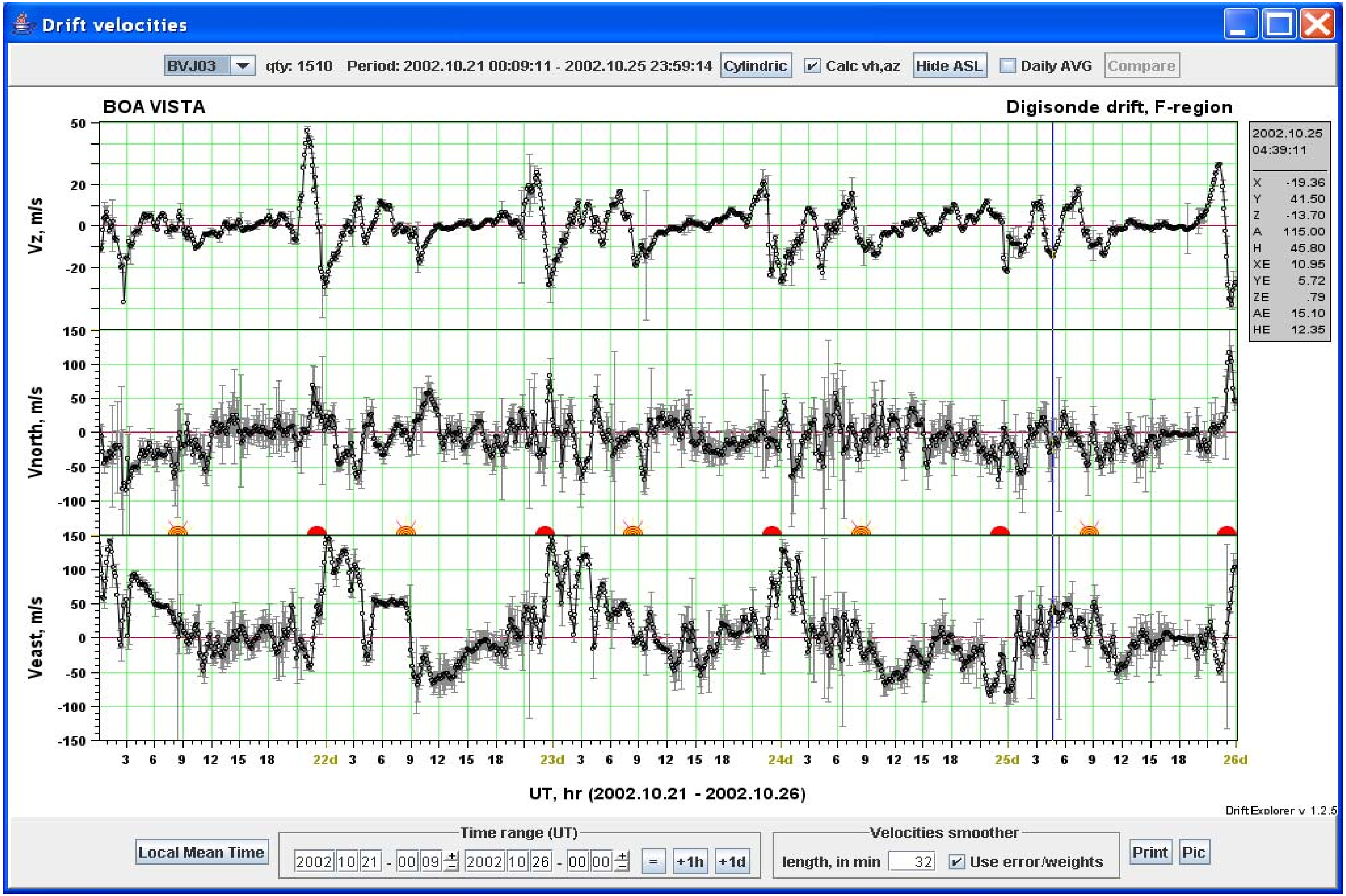
Ambiguity in calculation of arrival angle(2)



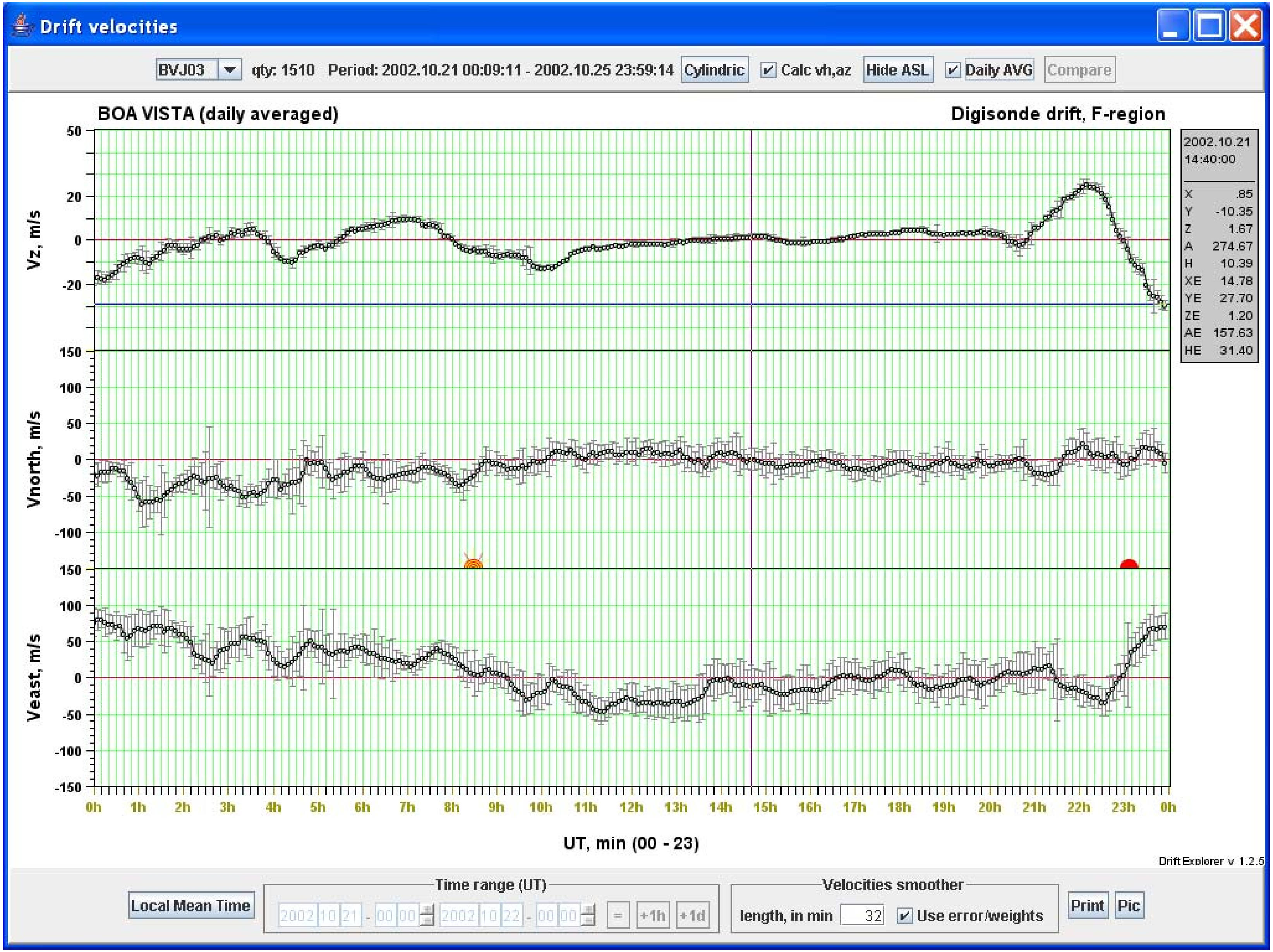
DVL View BoaVista 1



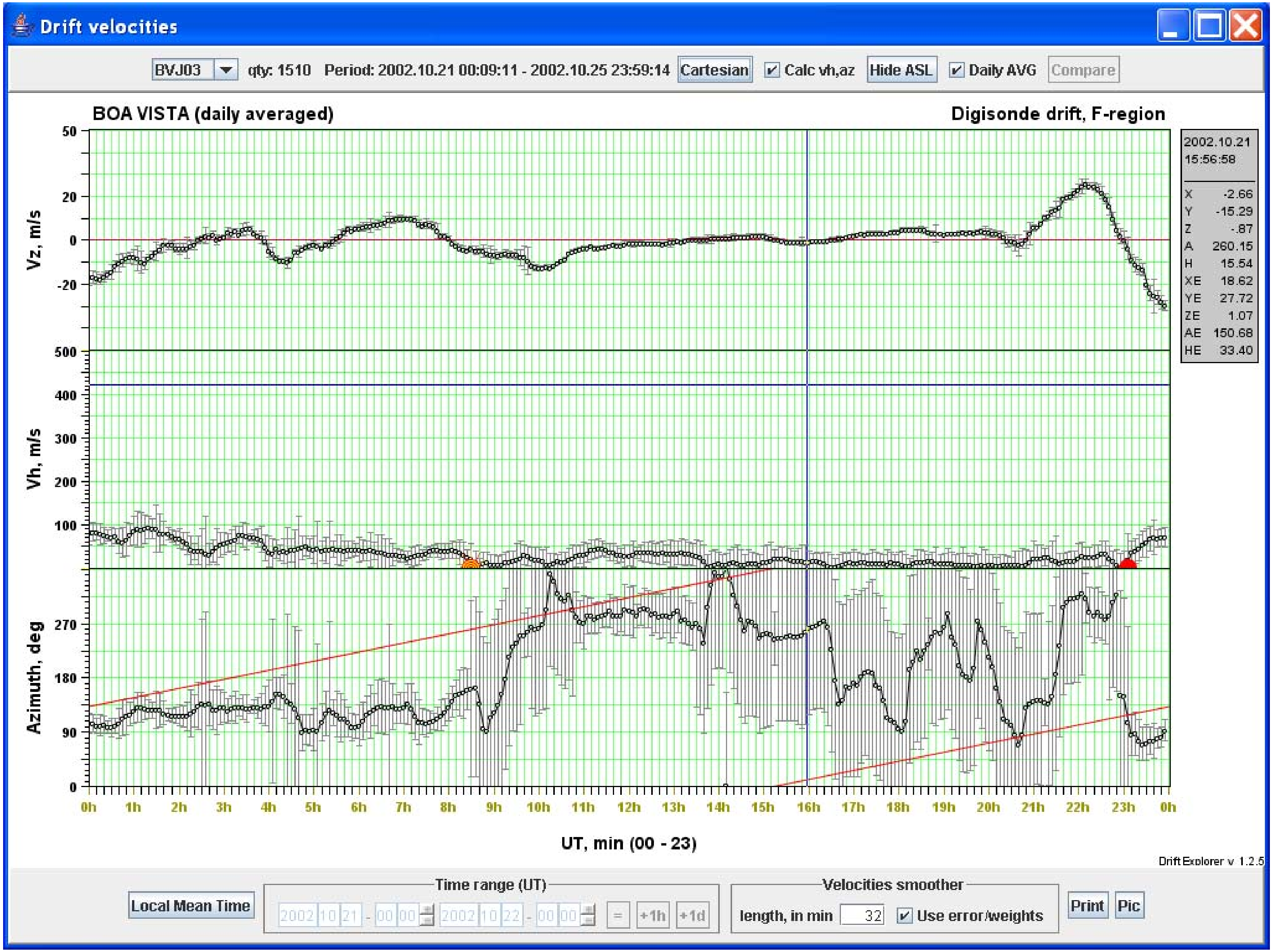
DVL View BoaVista 5 days



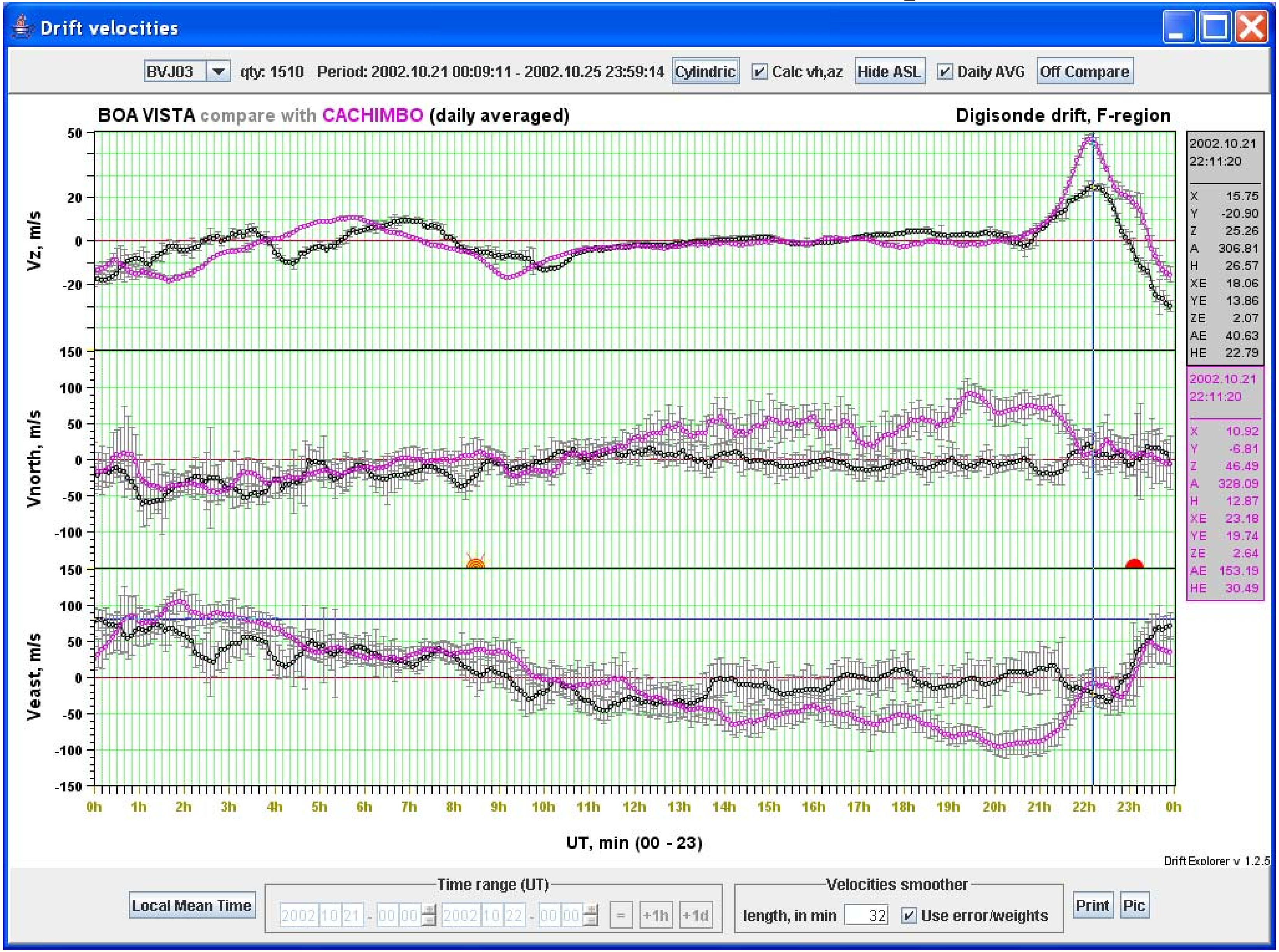
DVL View BoaVista av 1



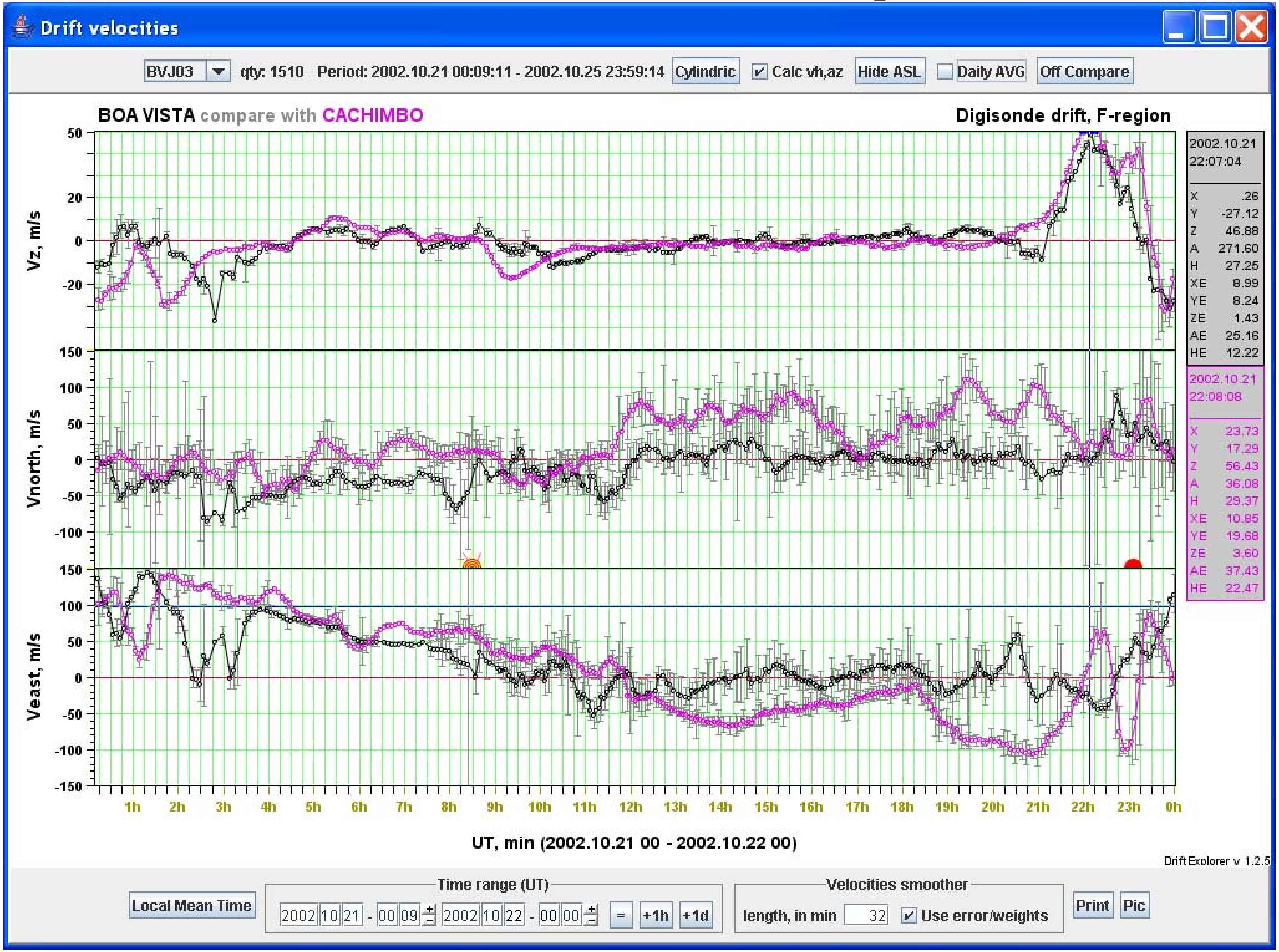
DVL View BoaVista av 2



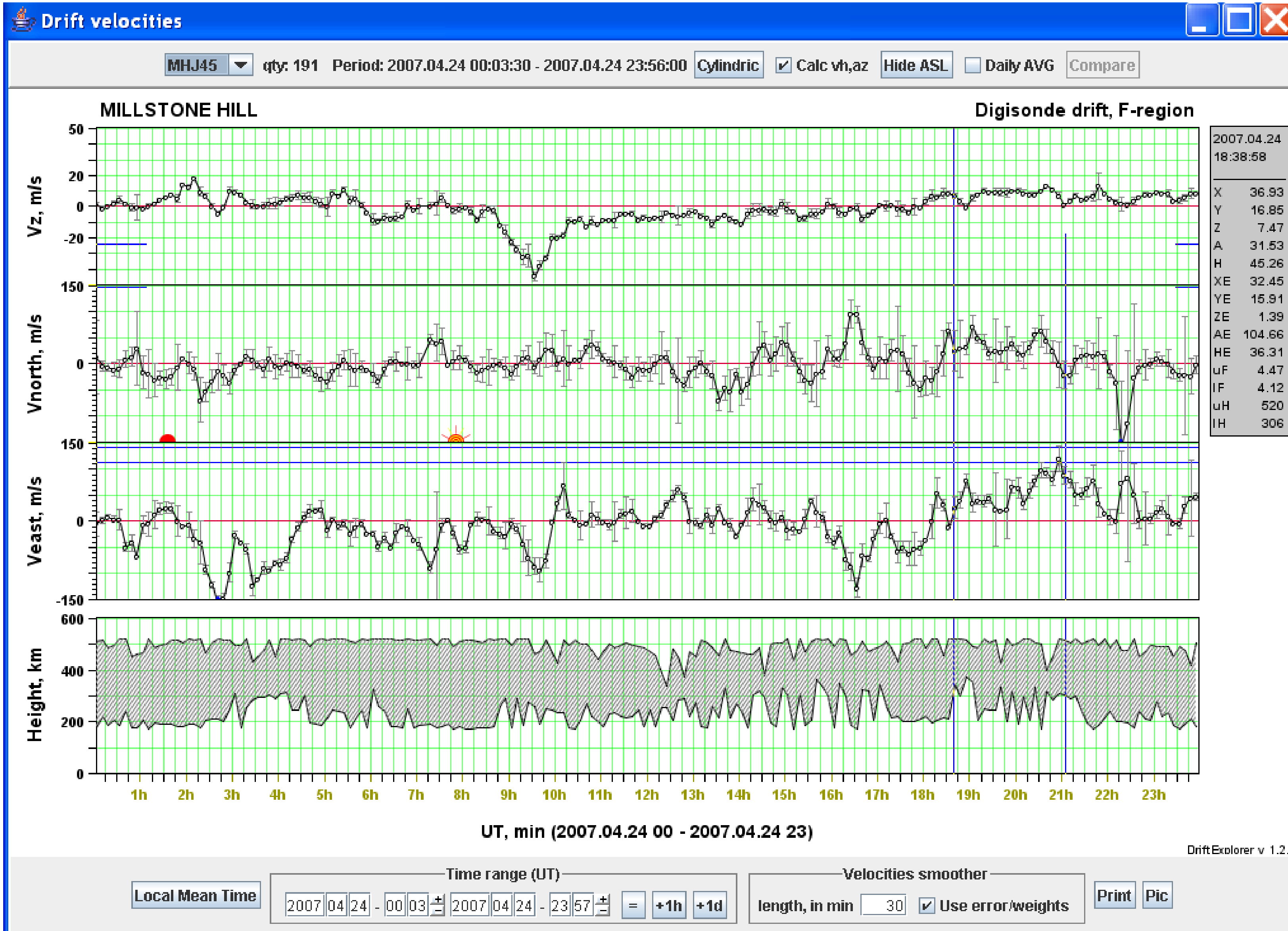
DVL View BoaVista av cmp



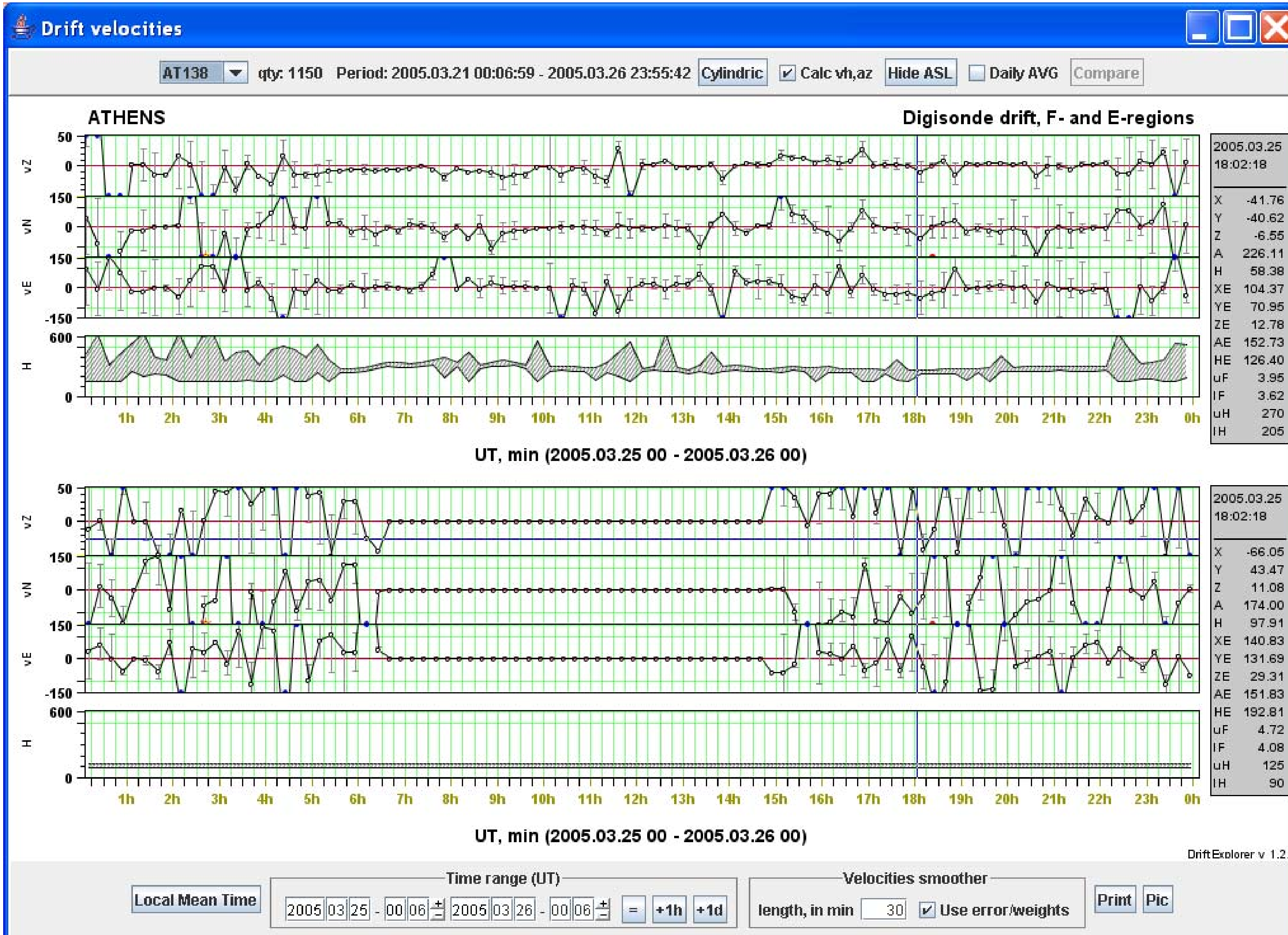
DVL View BoaVista cmp



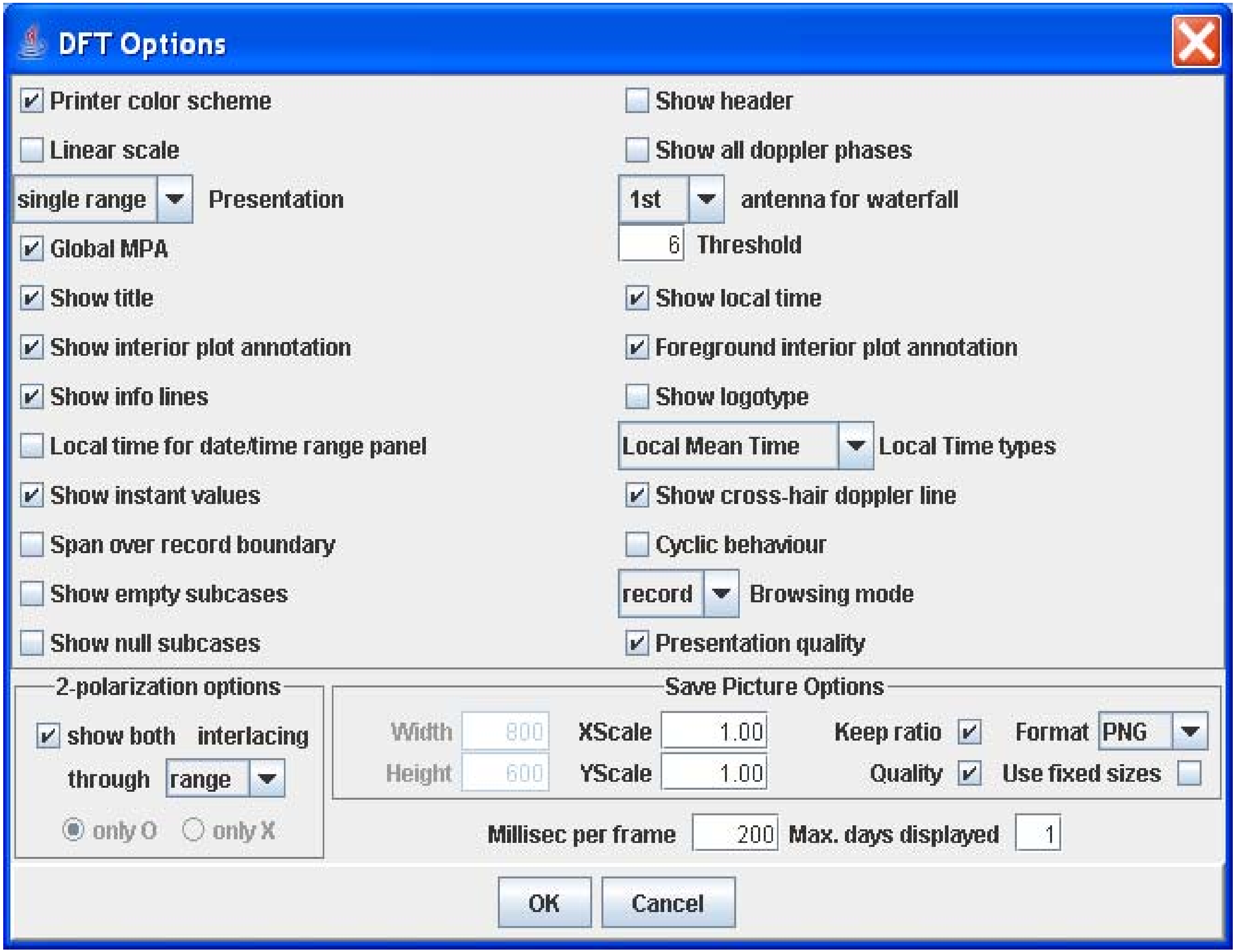
DVL Millstone Hill, height range



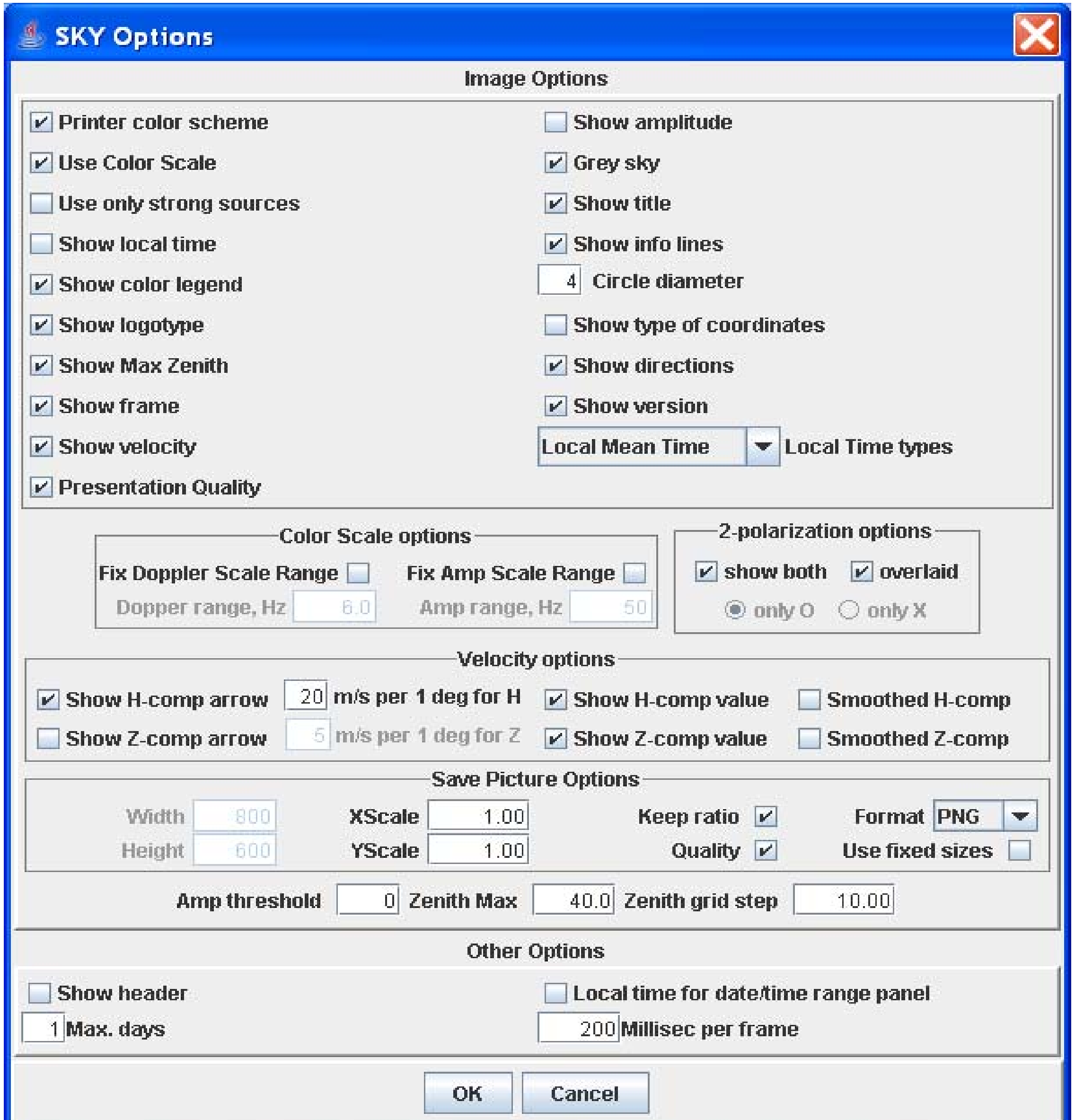
DVL Athens, F and E layers



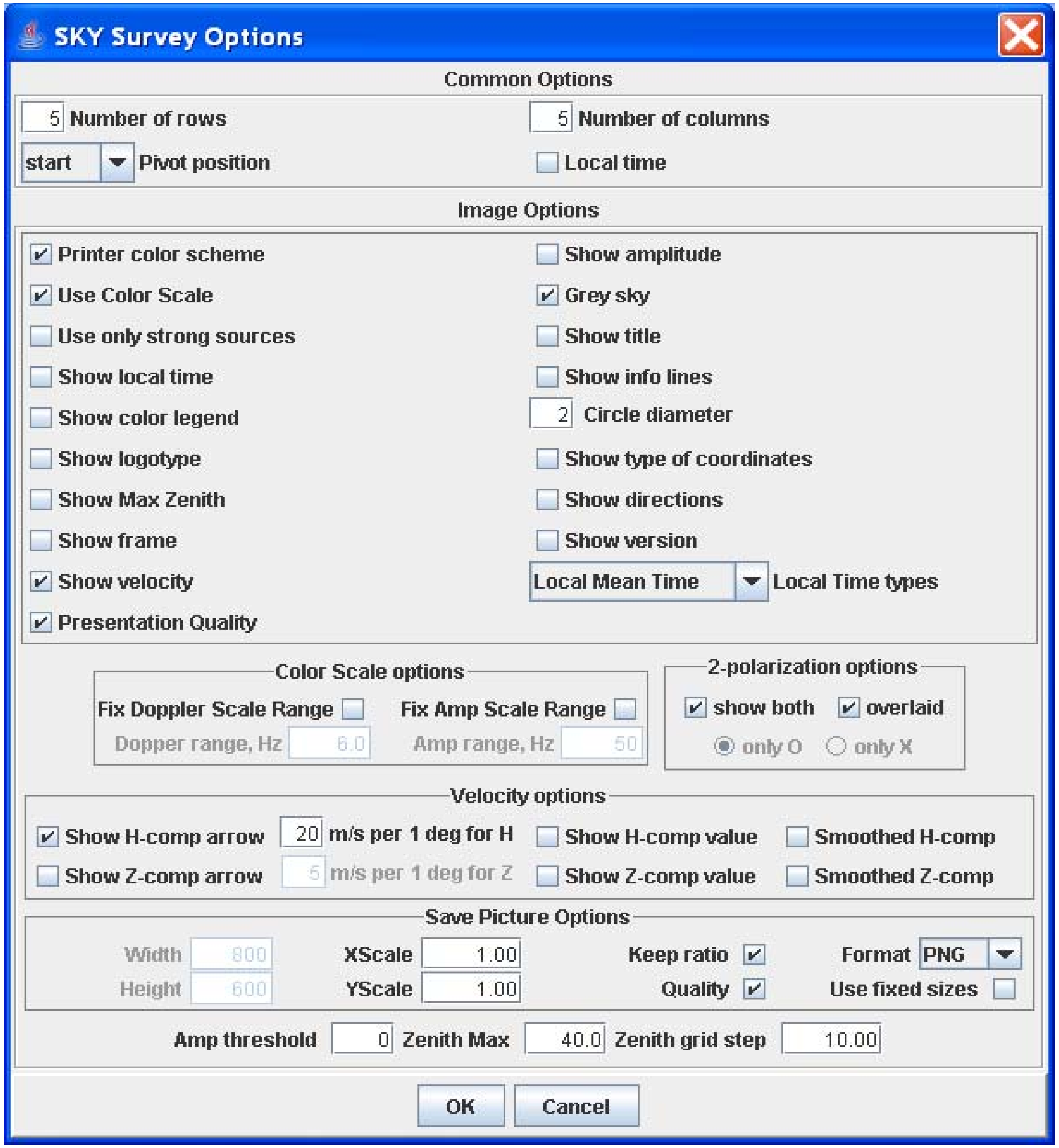
DFT Options Dialog



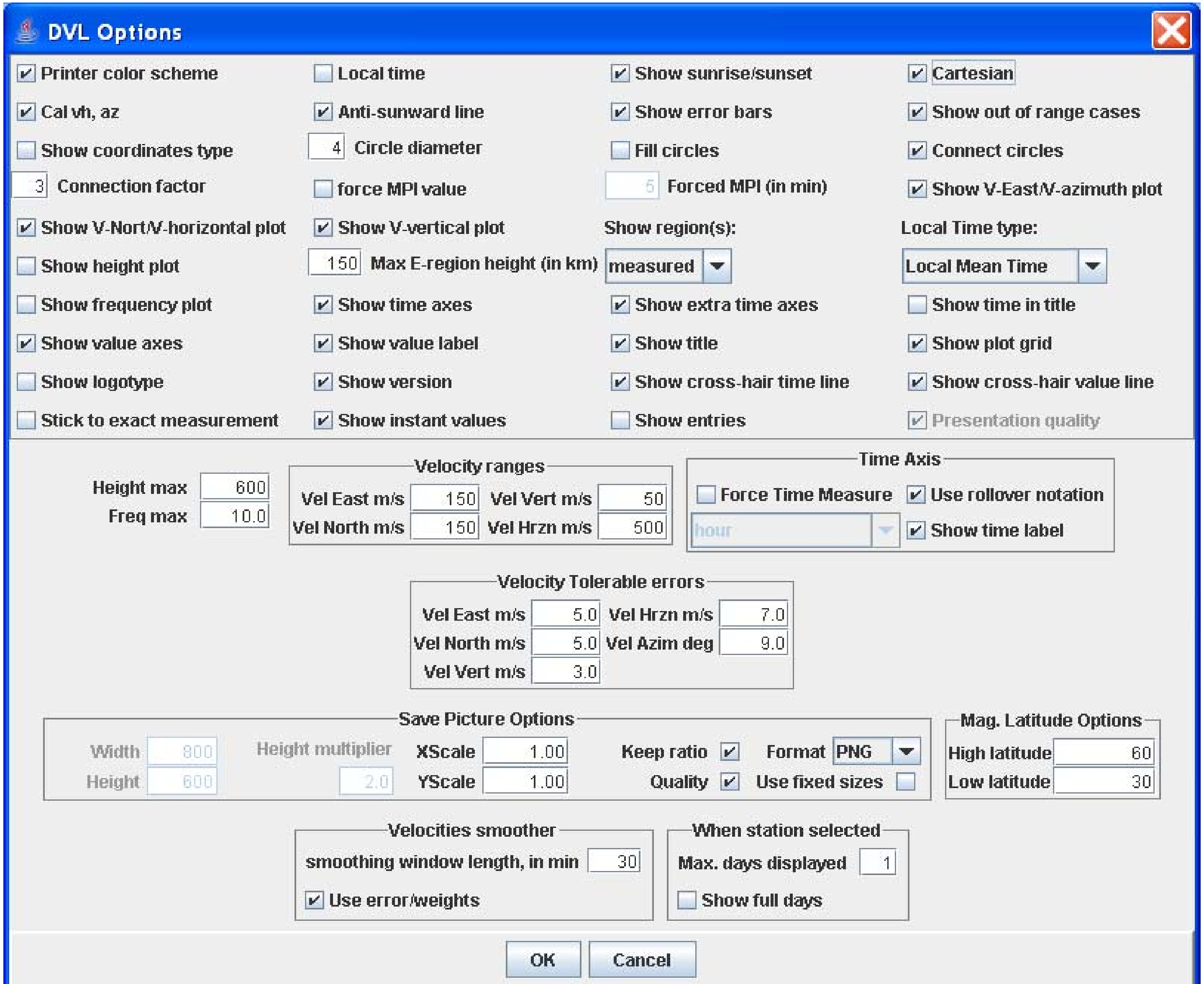
SKY Options Dialog



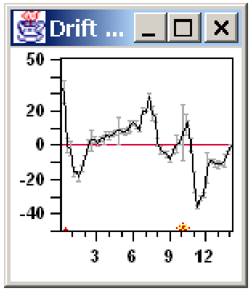
SKY Survey Options Dialog



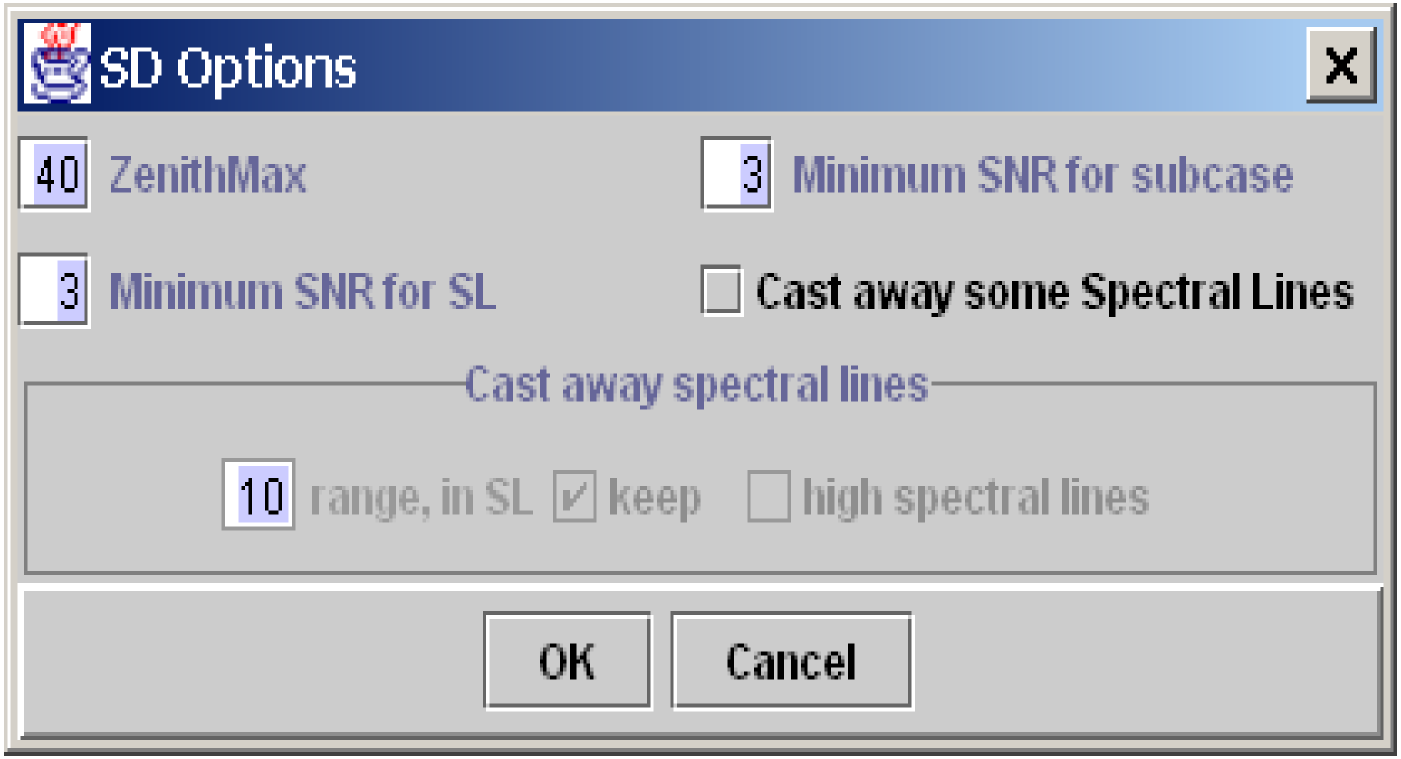
DVL Options Dialog



DVL View Jicamarca small

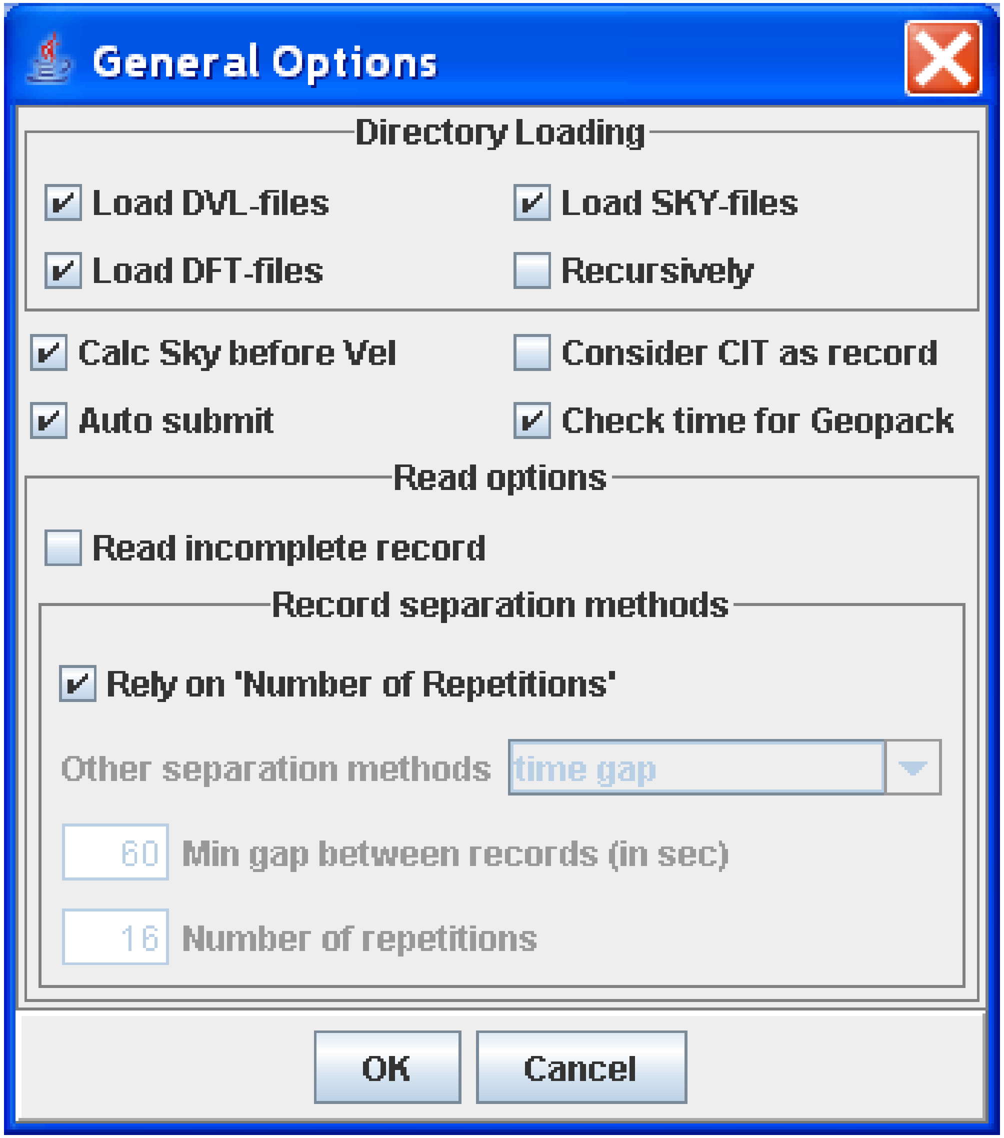


Source Detector Options Dialog

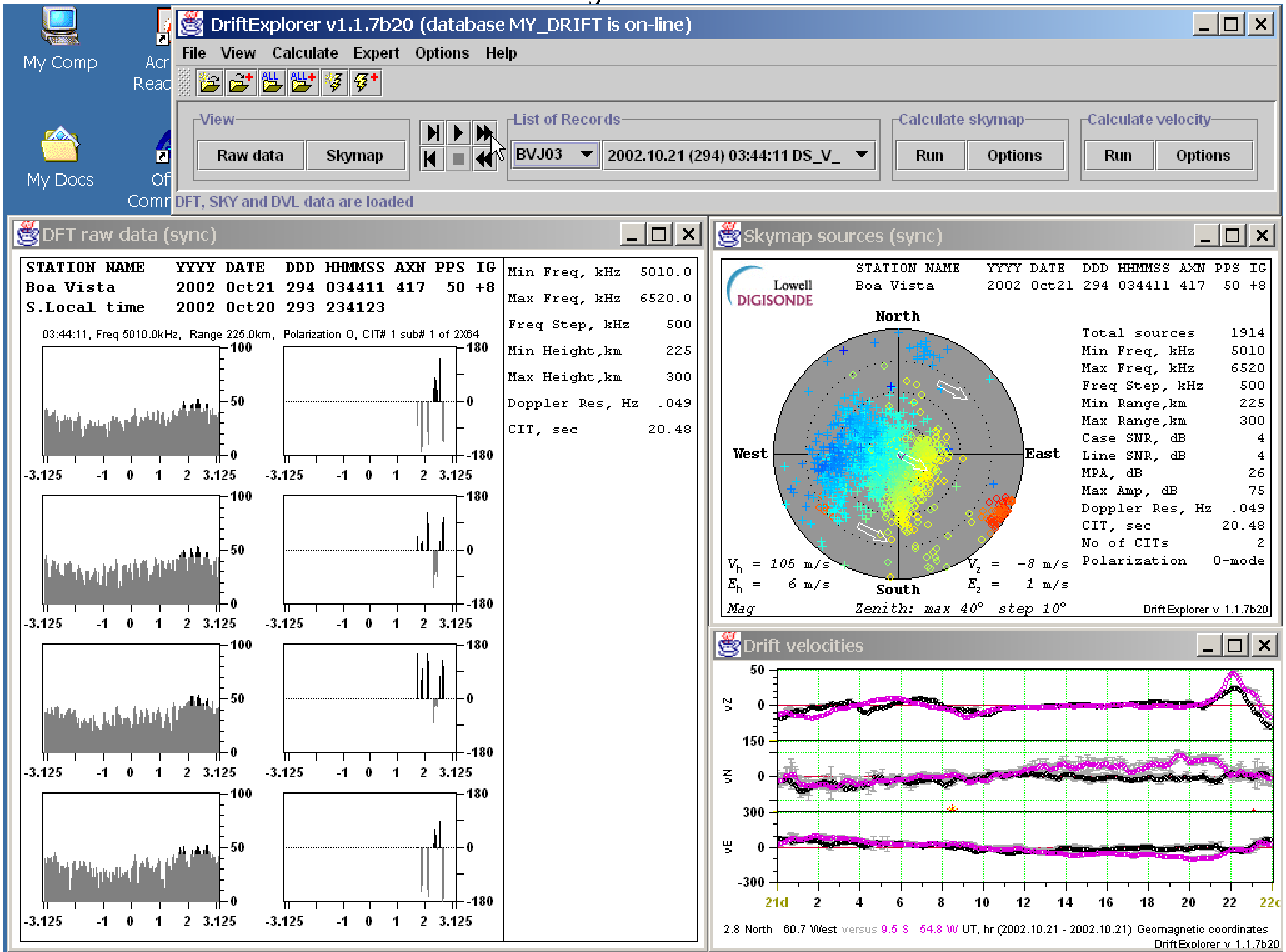


Velocity Calculator Options Dialog

General Options Dialog

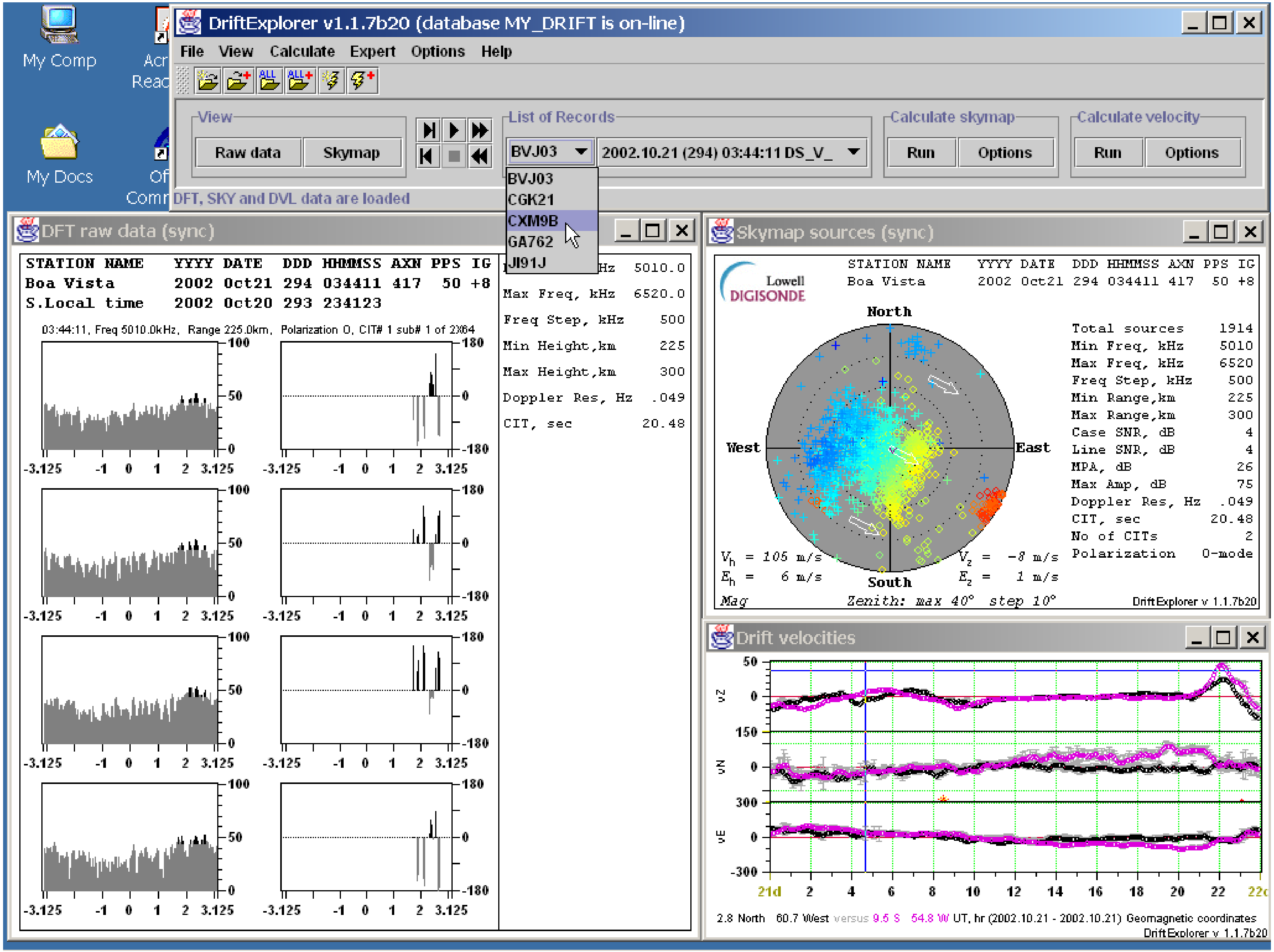


Layout A1



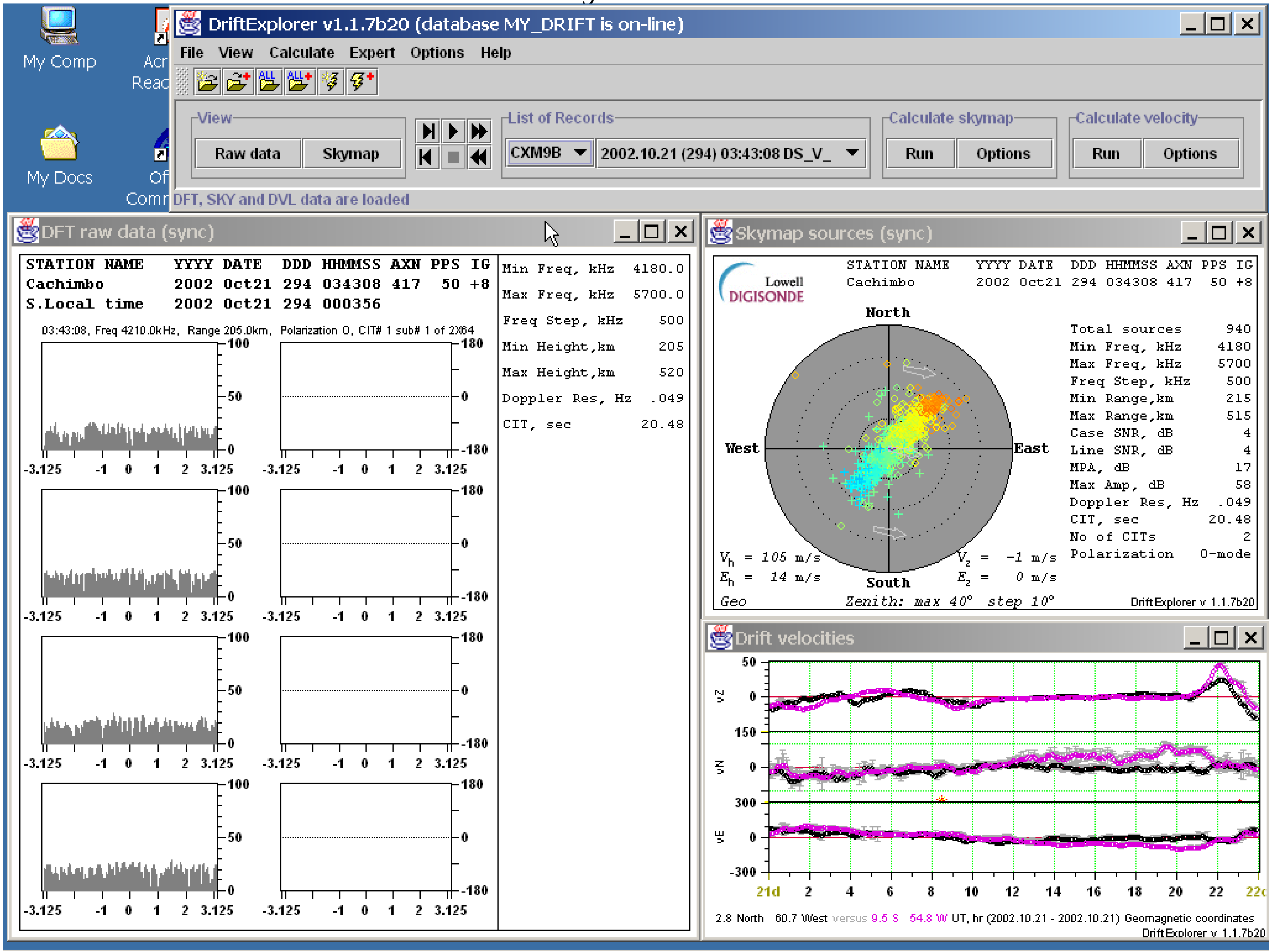
DriftExplorer v1.1.7b20 (database MY_DRIFT is on-line)
File View Calculate Expert Options Help
View
Raw data
Skymap
List of Records
BVJ03
2002.10.21 (294) 03:44:11 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded
DFT raw data (sync)
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Boa Vista 2002 Oct21 294 034411 417 50 +8
S.Local time 2002 Oct20 293 234123
03:44:11, Freq 5010.0kHz, Range 225.0km, Polarization O, CIT# 1 sub# 1 of 2X64
Min Freq, kHz 5010.0
Max Freq, kHz 6520.0
Freq Step, kHz 500
Min Height,km 225
Max Height,km 300
Doppler Res, Hz .049
CIT, sec 20.48
Skymap sources (sync)
Lowell DIGISONDE
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Boa Vista 2002 Oct21 294 034411 417 50 +8
North
West
East
South
Total sources 1914
Min Freq, kHz 5010
Max Freq, kHz 6520
Freq Step, kHz 500
Min Range,km 225
Max Range,km 300
Case SNR, dB 4
Line SNR, dB 4
MPA, dB 26
Max Amp, dB 75
Doppler Res, Hz .049
CIT, sec 20.48
No of CITs 2
Polarization O-mode
V_h = 105 m/s
E_h = 6 m/s
V_z = -8 m/s
E_z = 1 m/s
Mag
Zenith: max 40° step 10°
DriftExplorer v 1.1.7b20
Drift velocities
vZ
vN
vE
2.8 North 60.7 West versus 9.5 S 54.8 W UT, hr (2002.10.21 - 2002.10.21) Geomagnetic coordinates
DriftExplorer v 1.1.7b20

Layout A2



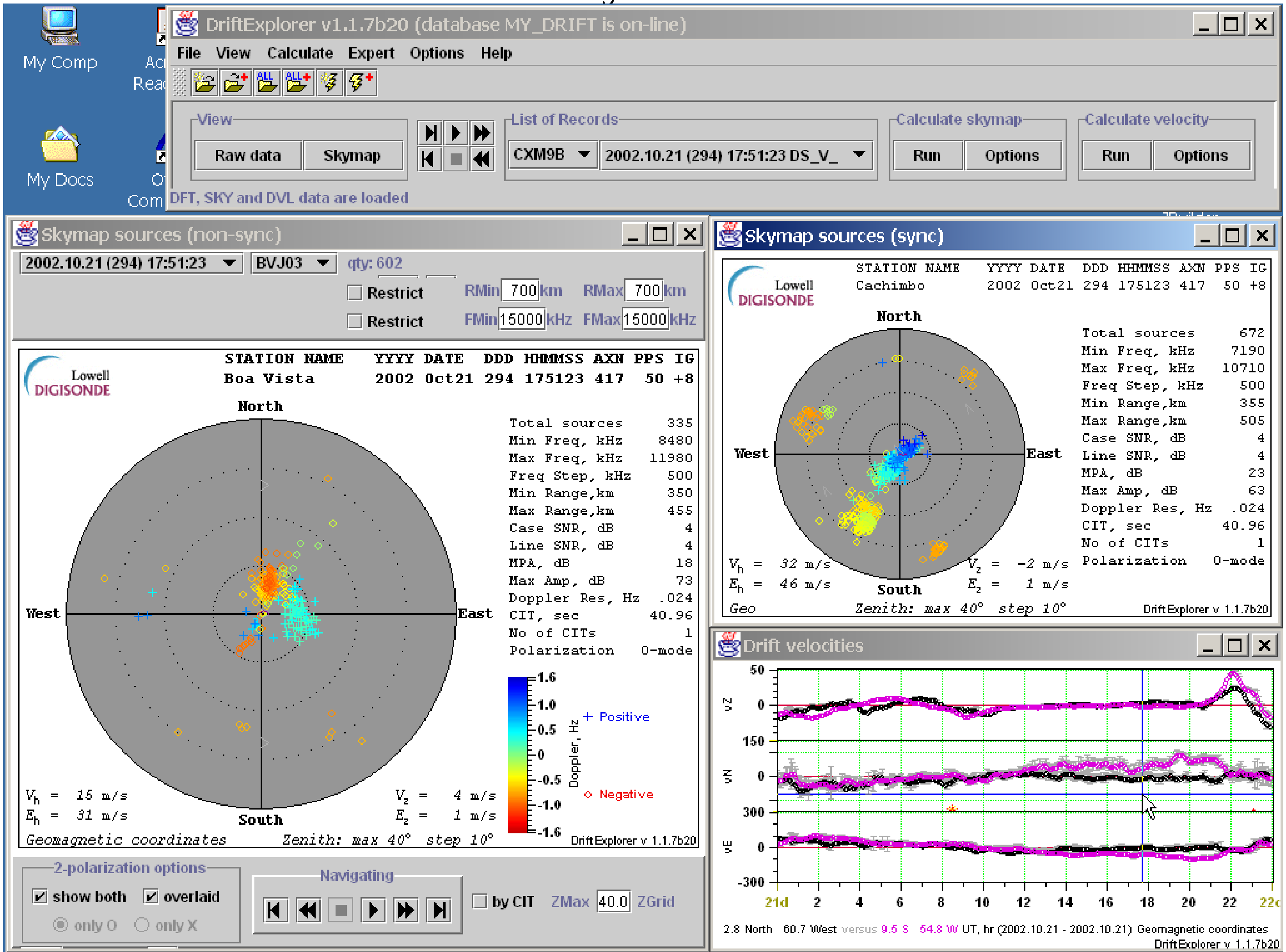
DriftExplorer v1.1.7b20 (database MY_DRIFT is on-line)
File View Calculate Expert Options Help
View
Raw data
Skymap
List of Records
BVJ03
2002.10.21 (294) 03:44:11 DS_V_
BVJ03
CGK21
CXM9B
GA762
JI91J
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded
DFT raw data (sync)
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Boa Vista 2002 Oct21 294 034411 417 50 +8
S.Local time 2002 Oct20 293 234123
03:44:11, Freq 5010.0kHz, Range 225.0km, Polarization O, CIT# 1 sub# 1 of 2X64
Max Freq, kHz 6520.0
Freq Step, kHz 500
Min Height,km 225
Max Height,km 300
Doppler Res, Hz .049
CIT, sec 20.48
Skymap sources (sync)
Lowell DIGISONDE
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Boa Vista 2002 Oct21 294 034411 417 50 +8
North
West
East
South
Total sources 1914
Min Freq, kHz 5010
Max Freq, kHz 6520
Freq Step, kHz 500
Min Range,km 225
Max Range,km 300
Case SNR, dB 4
Line SNR, dB 4
MPA, dB 26
Max Amp, dB 75
Doppler Res, Hz .049
CIT, sec 20.48
No of CITs 2
Polarization O-mode
Vh = 105 m/s
Eh = 6 m/s
Vz = -8 m/s
Ez = 1 m/s
Mag
Zenith: max 40° step 10°
DriftExplorer v 1.1.7b20
Drift velocities
vZ
vN
vE
UT, hr (2002.10.21 - 2002.10.21) Geomagnetic coordinates
2.8 North 60.7 West versus 9.5 S 54.8 W
DriftExplorer v 1.1.7b20

Layout A3



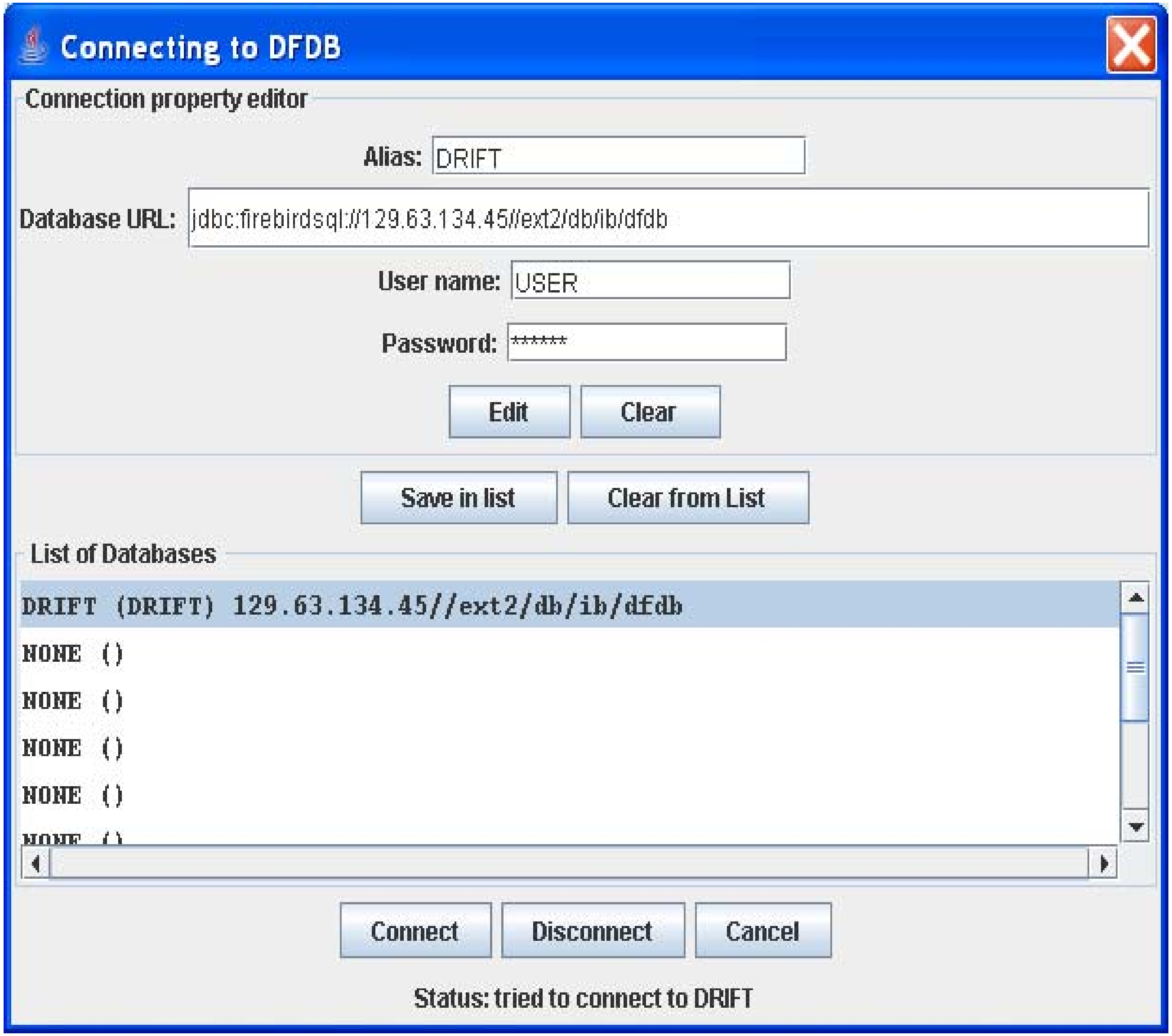
DriftExplorer v1.1.7b20 (database MY_DRIFT is on-line)
File View Calculate Expert Options Help
View
Raw data
Skymap
List of Records
CXM9B
2002.10.21 (294) 03:43:08 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded
DFT raw data (sync)
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Cachimbo 2002 Oct21 294 034308 417 50 +8
S.Local time 2002 Oct21 294 000356
03:43:08, Freq 4210.0kHz, Range 205.0km, Polarization O, CIT# 1 sub# 1 of 2X64
Min Freq, kHz 4180.0
Max Freq, kHz 5700.0
Freq Step, kHz 500
Min Height,km 205
Max Height,km 520
Doppler Res, Hz .049
CIT, sec 20.48
Skymap sources (sync)
Lowell DIGISONDE
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Cachimbo 2002 Oct21 294 034308 417 50 +8
North
West
East
South
Total sources 940
Min Freq, kHz 4180
Max Freq, kHz 5700
Freq Step, kHz 500
Min Range,km 215
Max Range,km 515
Case SNR, dB 4
Line SNR, dB 4
MPA, dB 17
Max Amp, dB 58
Doppler Res, Hz .049
CIT, sec 20.48
No of CITs 2
Polarization O-mode
Vh = 105 m/s
Eh = 14 m/s
Vz = -1 m/s
Ez = 0 m/s
Geo
Zenith: max 40° step 10°
DriftExplorer v 1.1.7b20
Drift velocities
vZ
vN
vE
2.8 North 60.7 West versus 9.5 S 54.8 W UT, hr (2002.10.21 - 2002.10.21) Geomagnetic coordinates
DriftExplorer v 1.1.7b20

Layout B

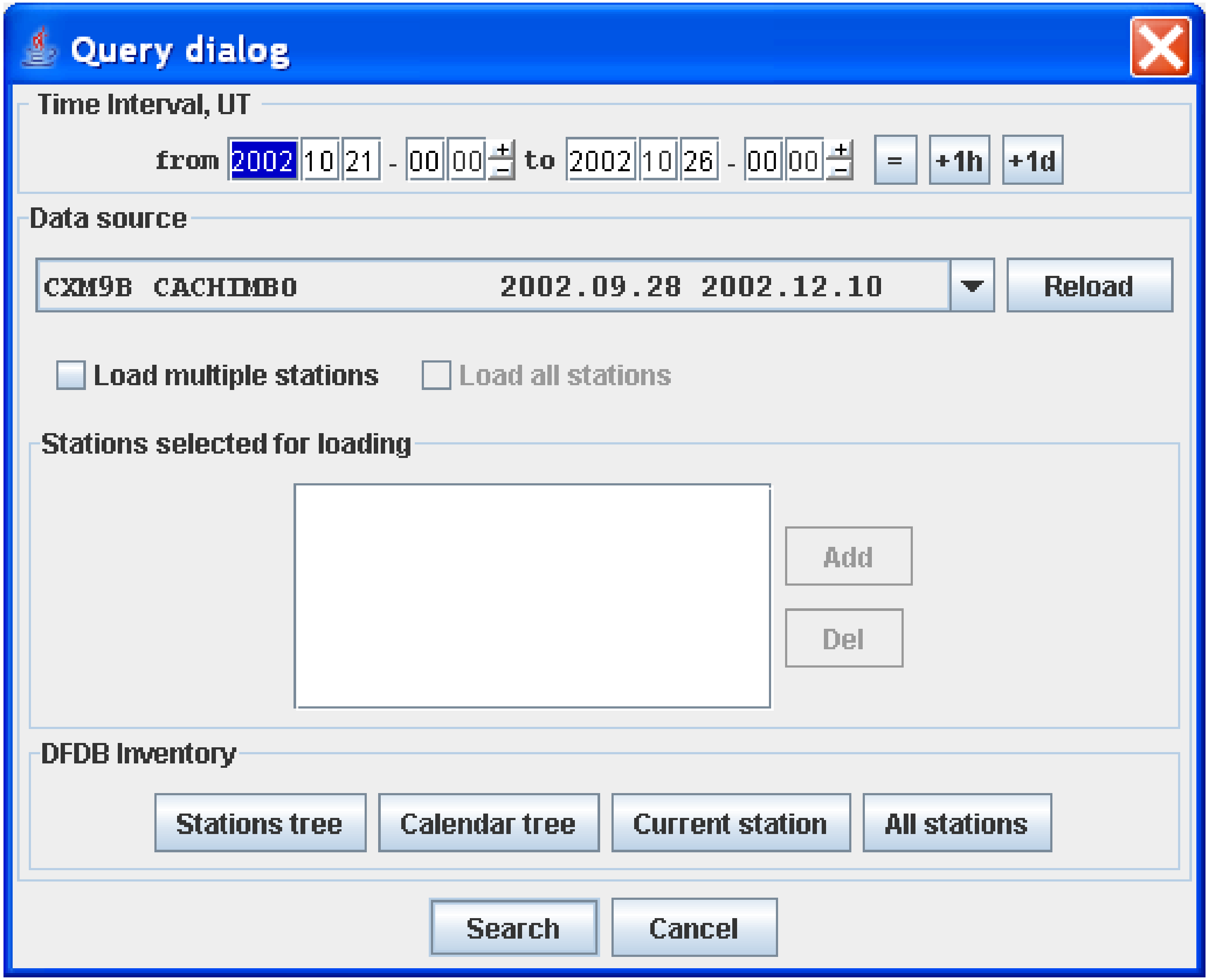


DriftExplorer v1.1.7b20 (database MY_DRIFT is on-line)
File View Calculate Expert Options Help
View
Raw data
Skymap
List of Records
CXM9B
2002.10.21 (294) 17:51:23 DS_V_
Calculate skymap
Run
Options
Calculate velocity
Run
Options
DFT, SKY and DVL data are loaded
Skymap sources (non-sync)
2002.10.21 (294) 17:51:23
BVJ03
qty: 602
Restrict
RMin 700 km
RMax 700 km
Restrict
FMin 15000 kHz
FMax 15000 kHz
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Boa Vista 2002 Oct21 294 175123 417 50 +8
North
West
East
South
Total sources 335
Min Freq, kHz 8480
Max Freq, kHz 11980
Freq Step, kHz 500
Min Range,km 350
Max Range,km 455
Case SNR, dB 4
Line SNR, dB 4
MPA, dB 18
Max Amp, dB 73
Doppler Res, Hz .024
CIT, sec 40.96
No of CITs 1
Polarization O-mode
+ Positive
◇ Negative
Doppler, Hz
Geomagnetic coordinates
Zenith: max 40° step 10°
DriftExplorer v 1.1.7b20
2-polarization options
show both
overlaid
only O
only X
Navigating
by CIT
ZMax 40.0
ZGrid
Skymap sources (sync)
STATION NAME YYYY DATE DDD HHMMSS AXN PPS IG
Cachimbo 2002 Oct21 294 175123 417 50 +8
Total sources 672
Min Freq, kHz 7190
Max Freq, kHz 10710
Freq Step, kHz 500
Min Range,km 355
Max Range,km 505
Case SNR, dB 4
Line SNR, dB 4
MPA, dB 23
Max Amp, dB 63
Doppler Res, Hz .024
CIT, sec 40.96
No of CITs 1
Polarization O-mode
Geo
Zenith: max 40° step 10°
DriftExplorer v 1.1.7b20
Drift velocities
vZ
vN
vE
UT, hr (2002.10.21 - 2002.10.21) Geomagnetic coordinates
2.8 North 60.7 West versus 9.5 S 54.8 W
DriftExplorer v 1.1.7b20

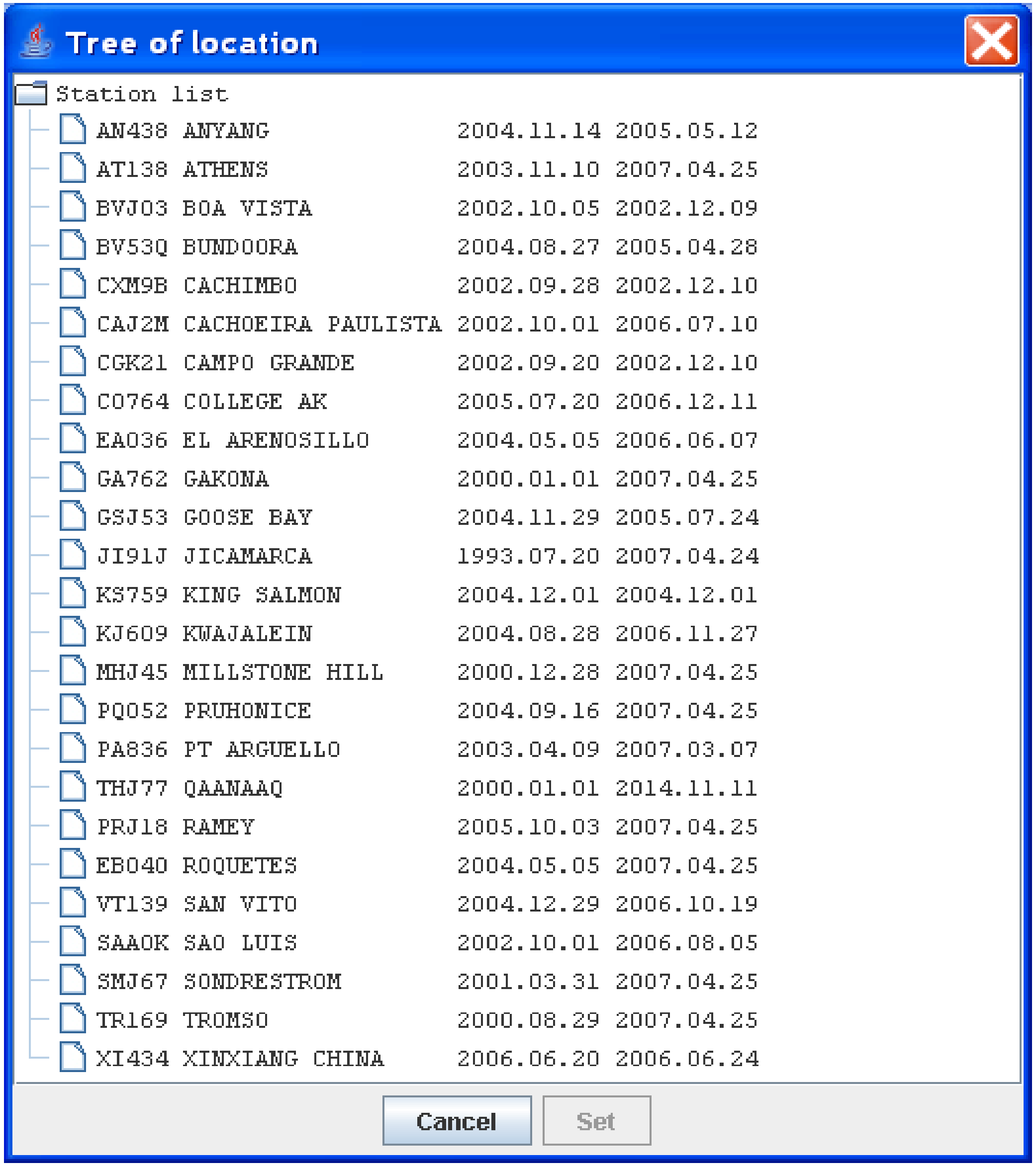
Connect Dialog



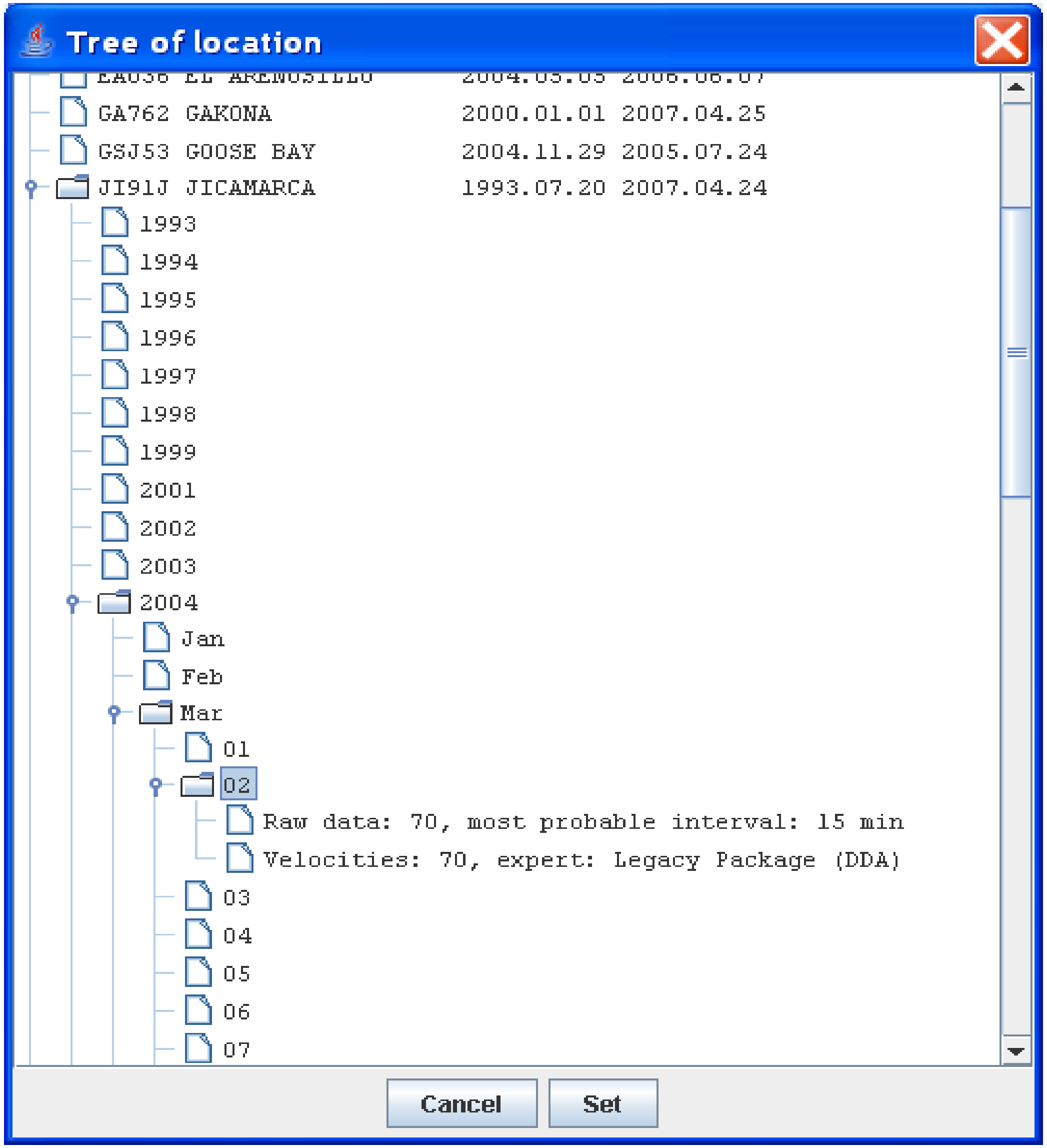
Query Dialog



Tree Of Locations 1



Tree Of Locations 2



UNIVERSITY OF MASSACHUSETTS LOWELL

UMLCAR

CENTER FOR ATMOSPHERIC RESEARCH

Transmit Antennas

David Kitrosser

Vadym Paznukhov

University of Massachusetts Lowell
Center for Atmospheric Research

2009 IDF

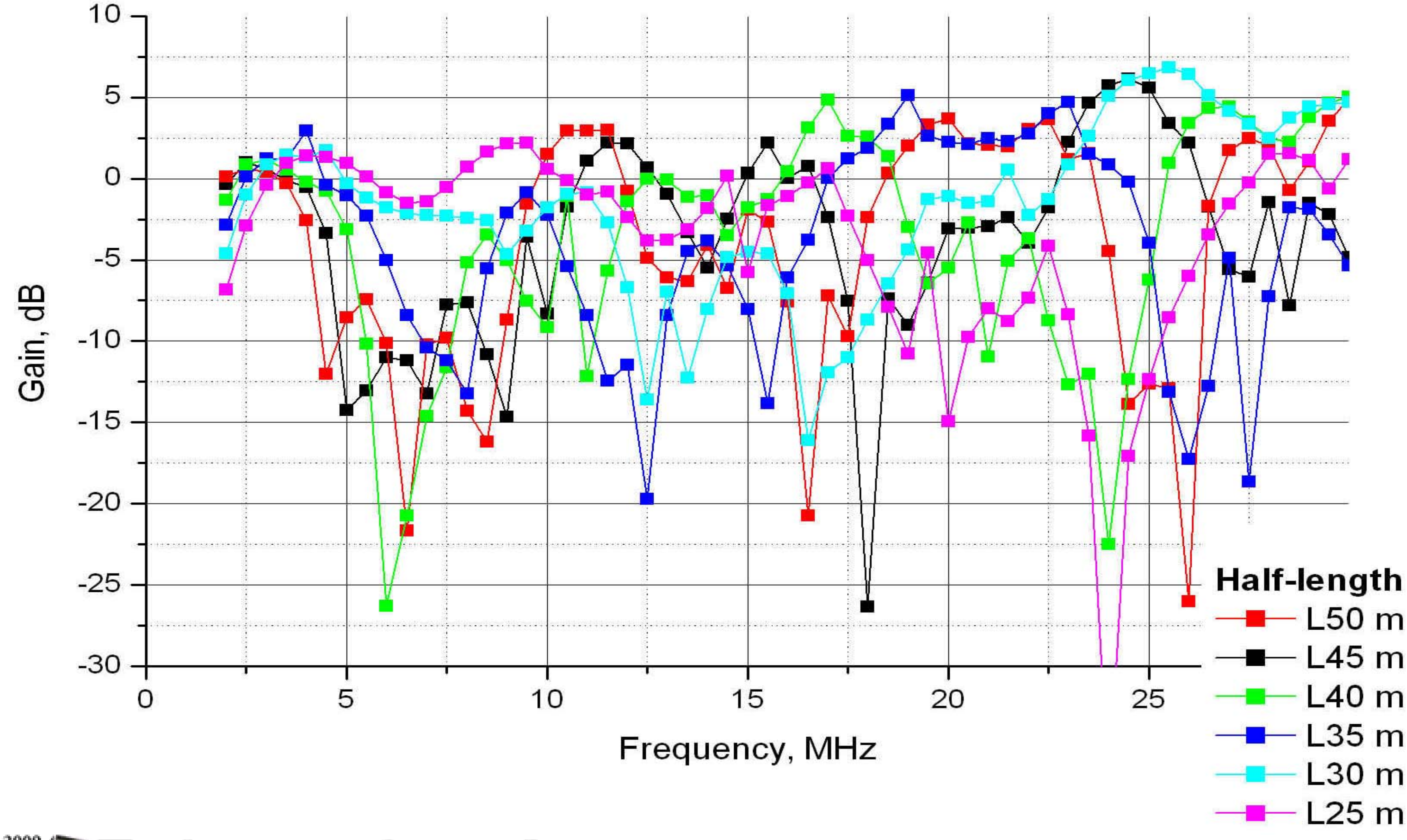
XII INTERNATIONAL DIGISONDE FORUM

11 - 14 MAY 2009

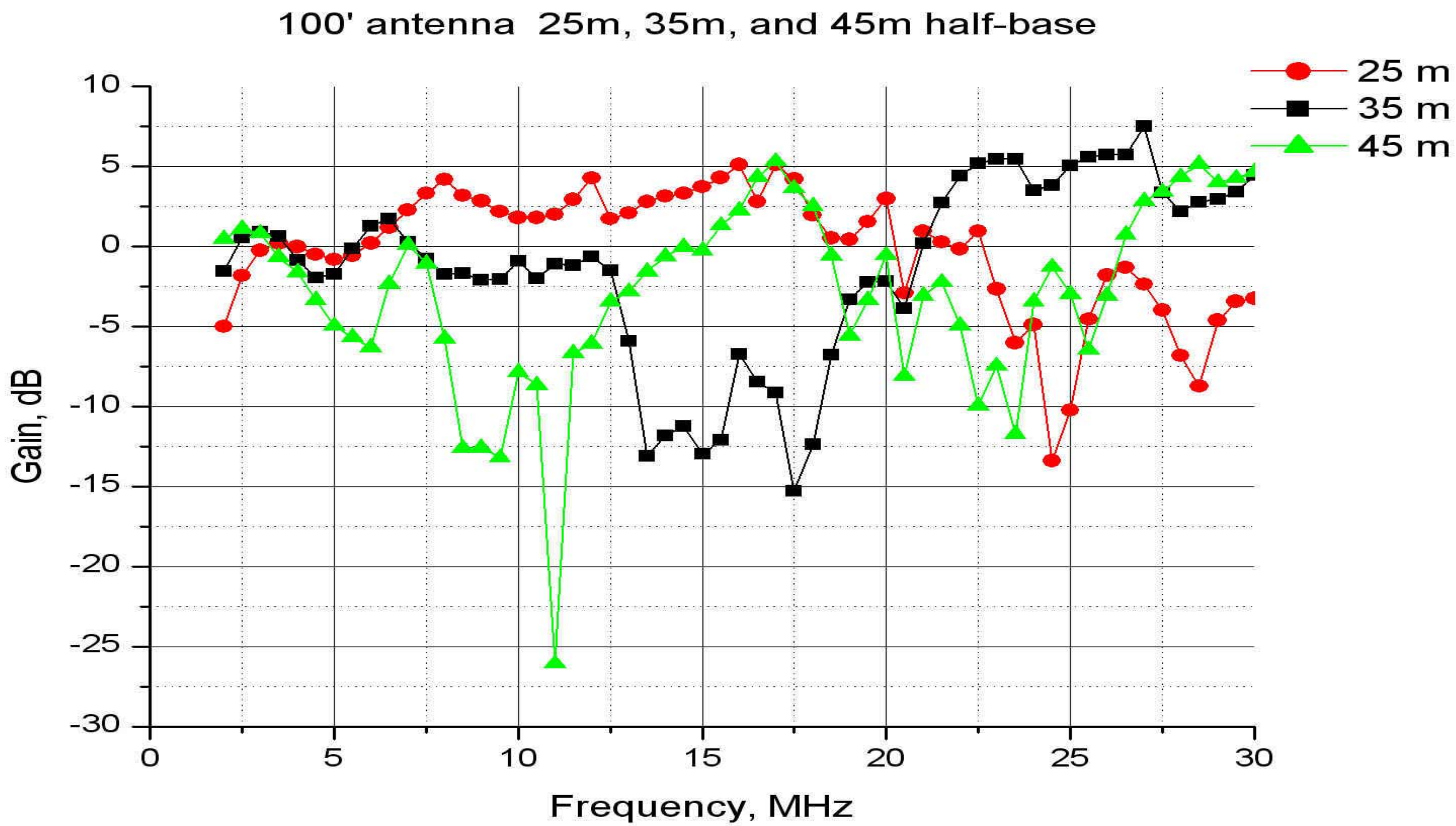
Ionosonde transmit antennas

- At one time vertical Rhombic antennas were the norm for ionosondes.
- The general consensus today is that a Delta works about the same way as a Rhombic by virtue of the ground reflection and is quite a bit less expensive to construct.
- The DPS series of Digisondes has been using two orthogonal transmit antennas fed with signals shifted by 90º to put all the transmitter output into the actual circular polarization which the sounder will receive.

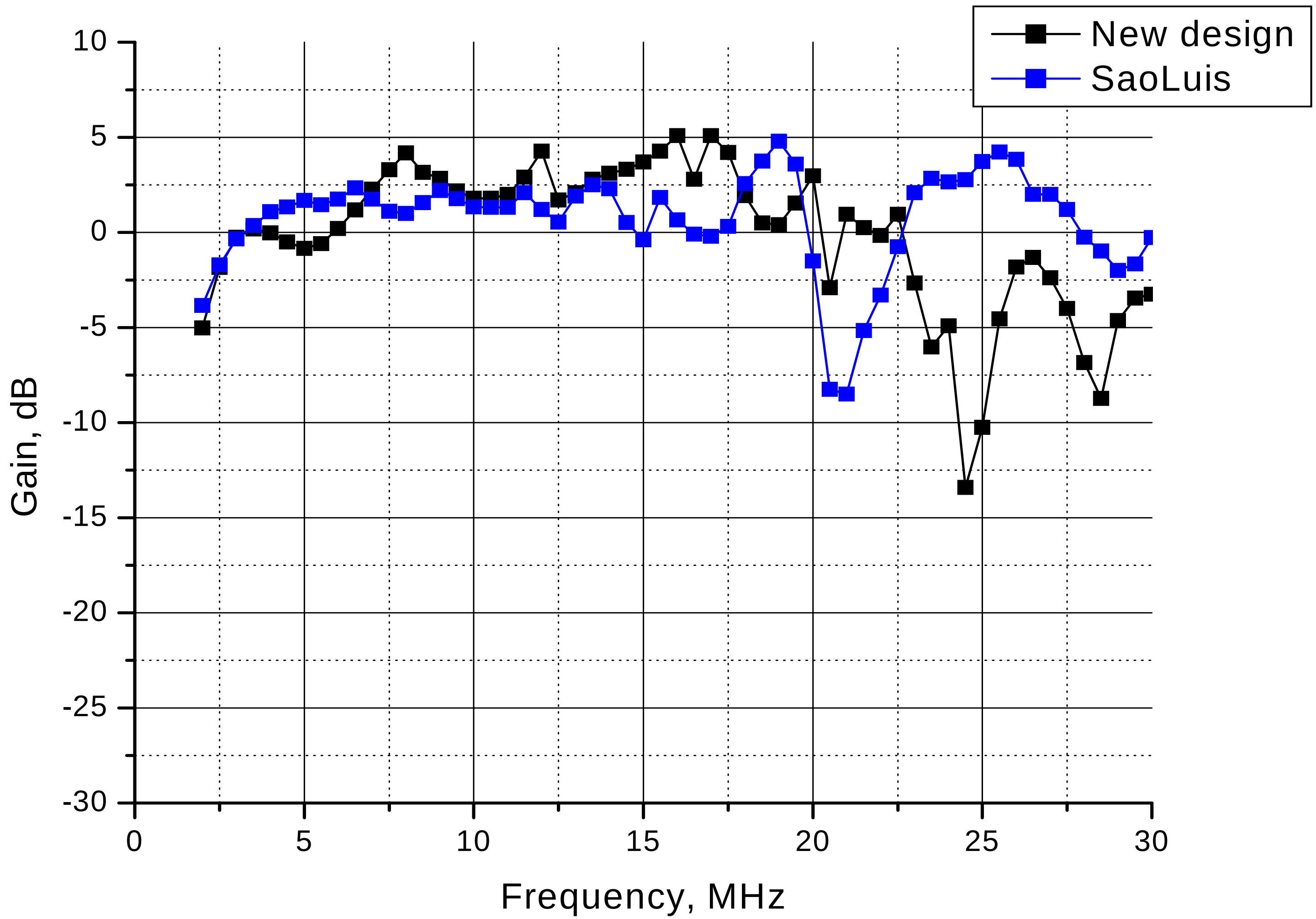
Delta 100 ft. tower
50 m. to 100 m. width
Vertical gain vs. Freq.



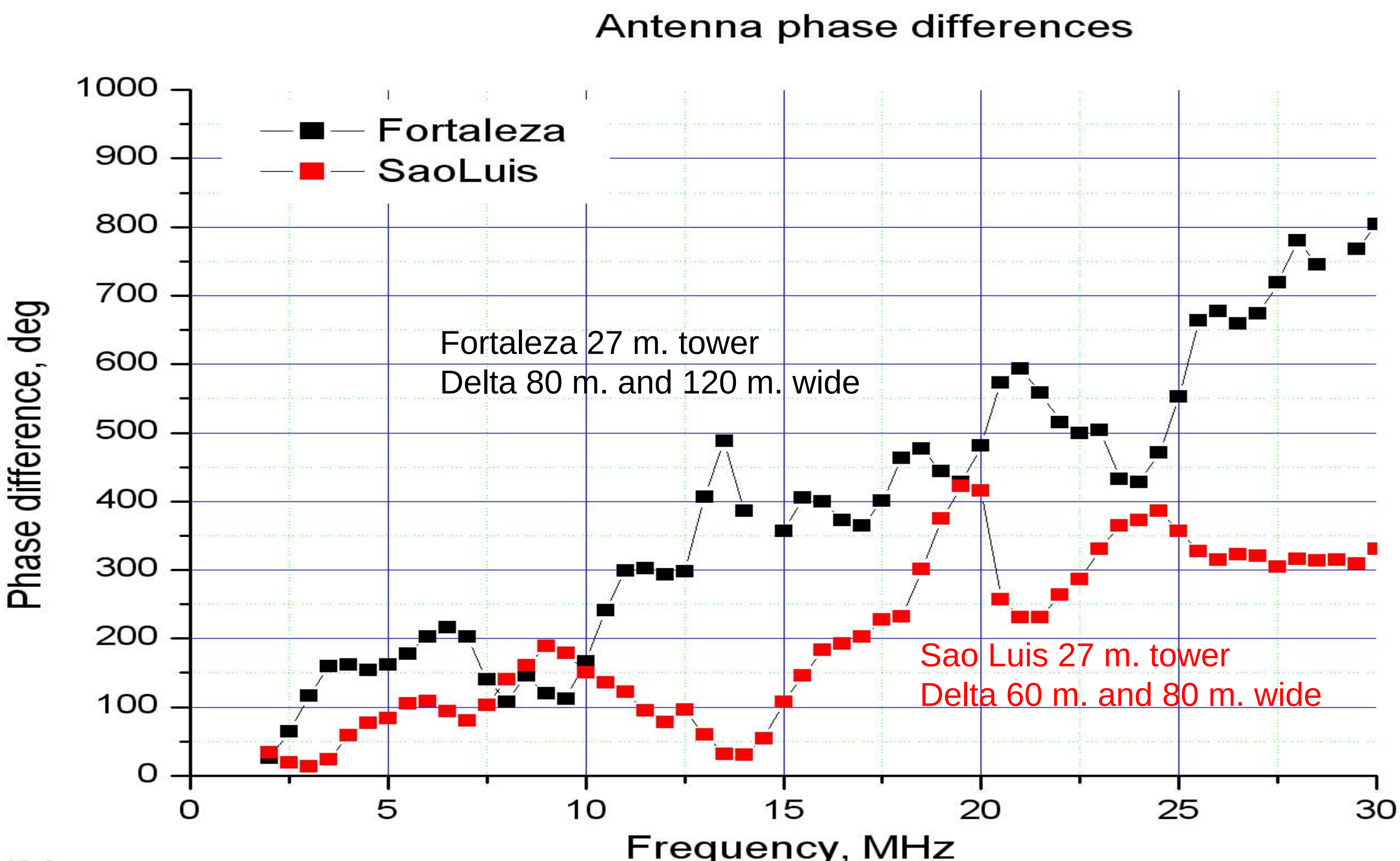
Delta 100 ft. tower
50 m. to 90 m. width
Vertical gain vs. Freq.



Blue (Sao Luis) is composite gain of 60 m. and 80 m. wide Deltas 27 m. tower

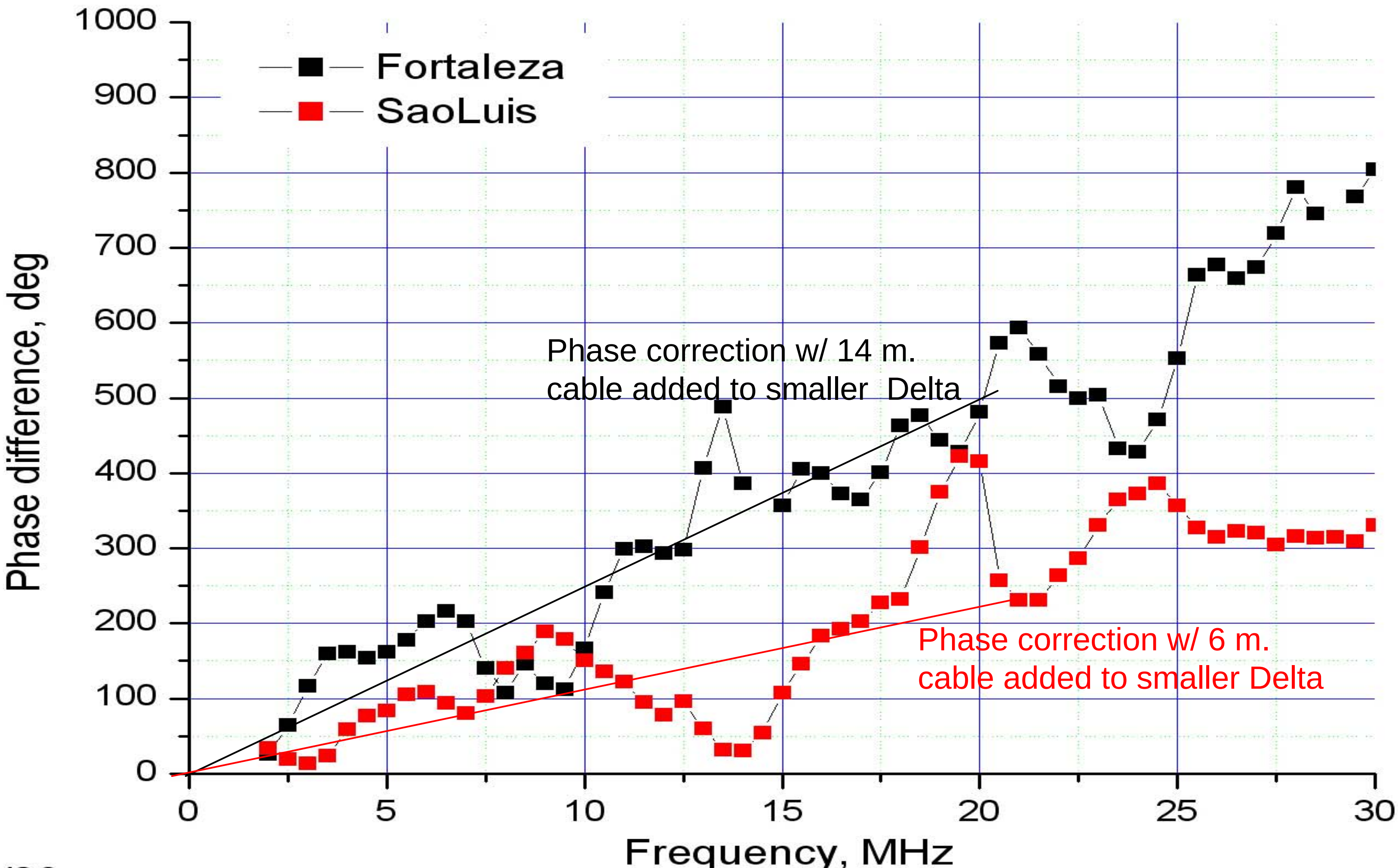


Signals propagate from smaller antenna ahead of signals from larger antenna

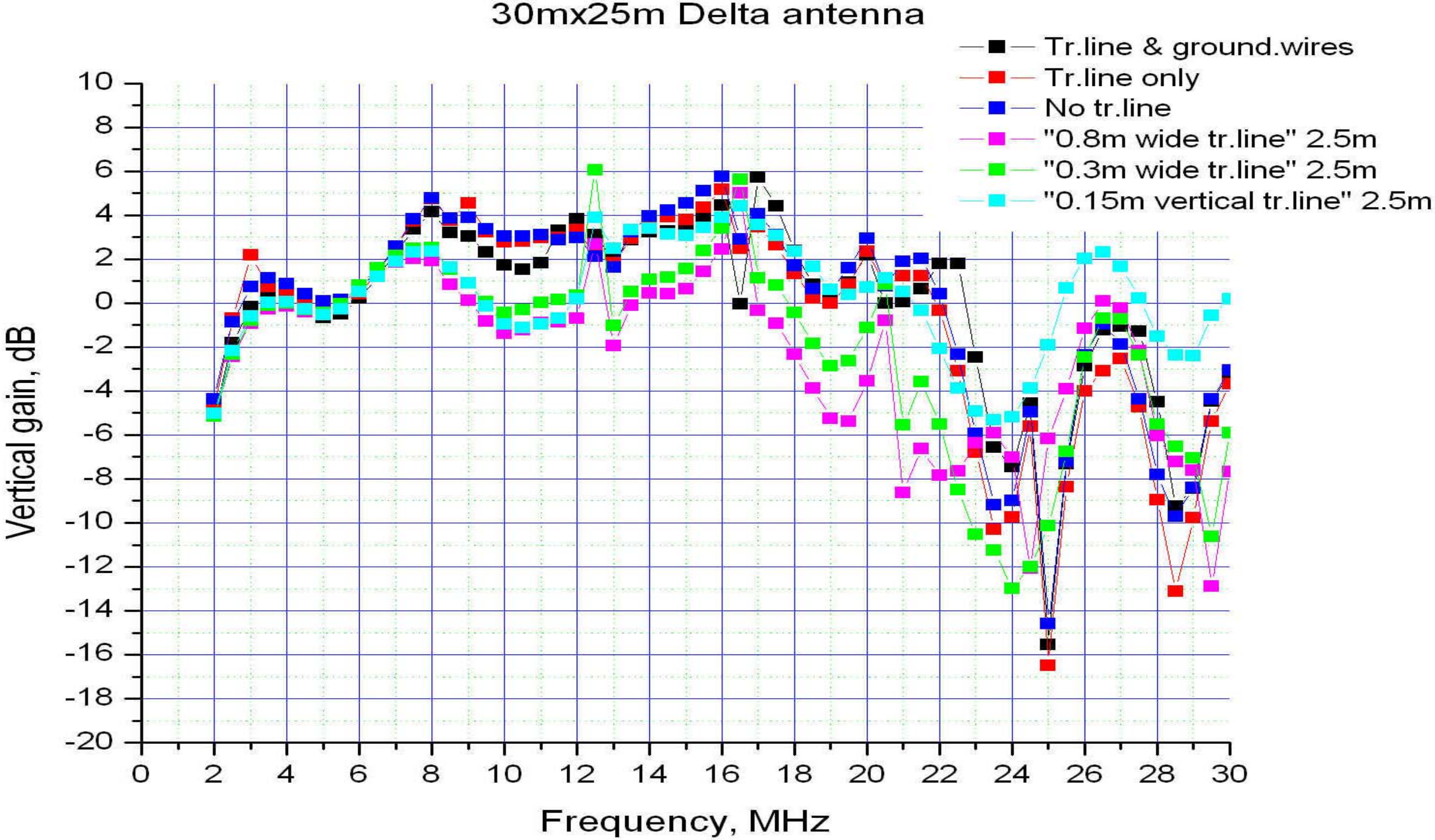


4/6/09

Antenna phase differences corrected as time difference

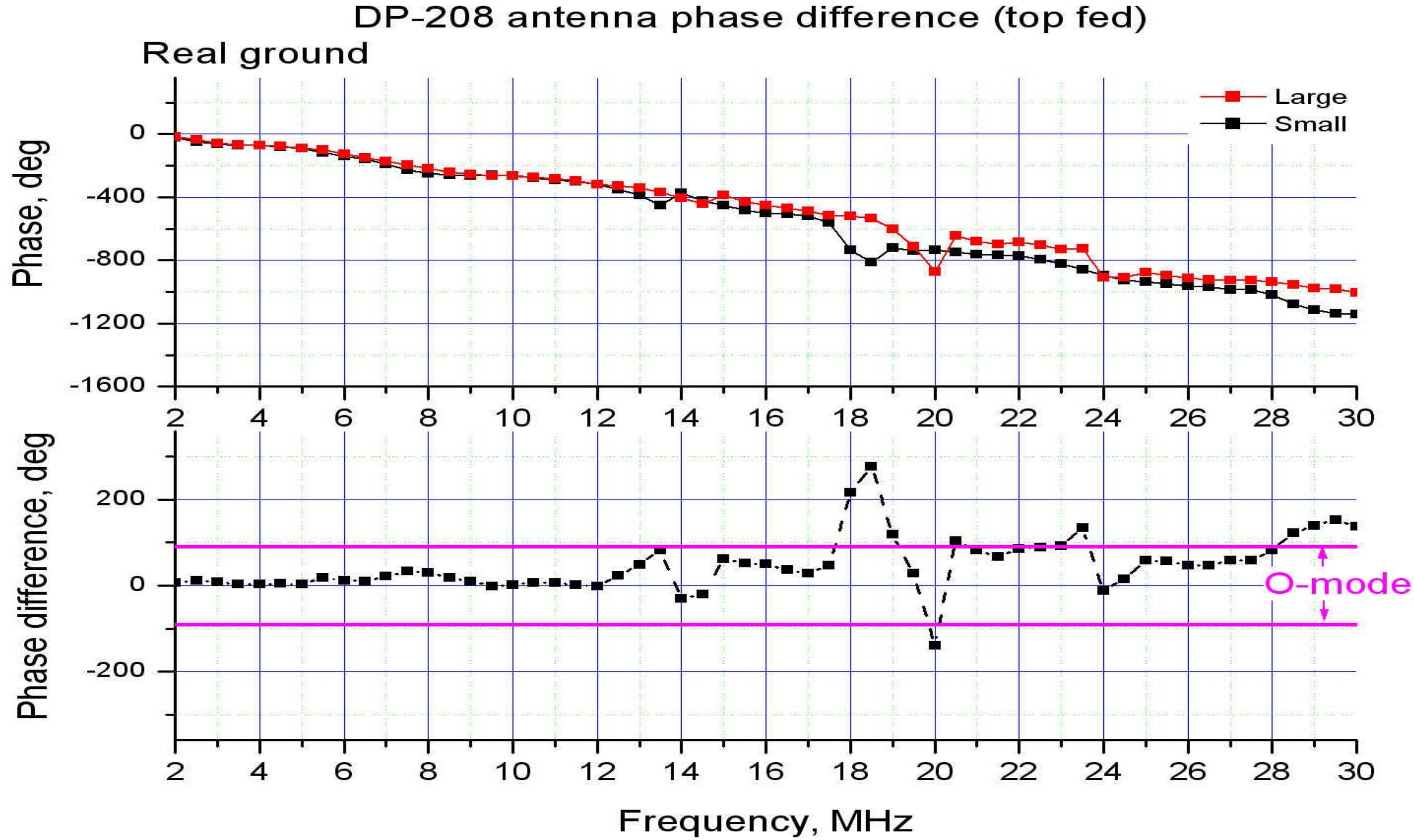


Variations on construction of horizontal element

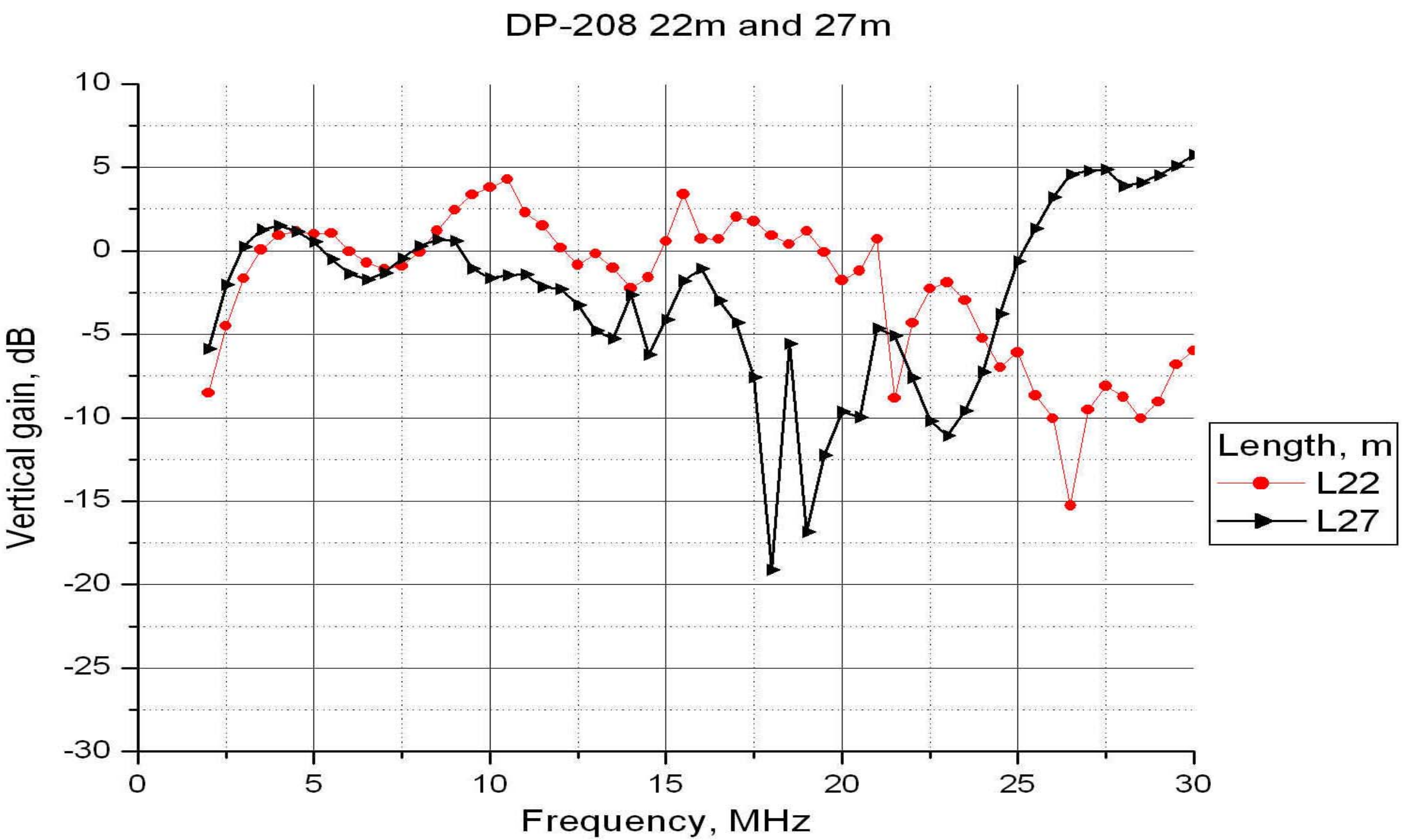


Logo: UNIVERSITY OF MASSACHUSETTS LOWELL UMLCAR CENTER FOR ATMOSPHERIC RESEARCH

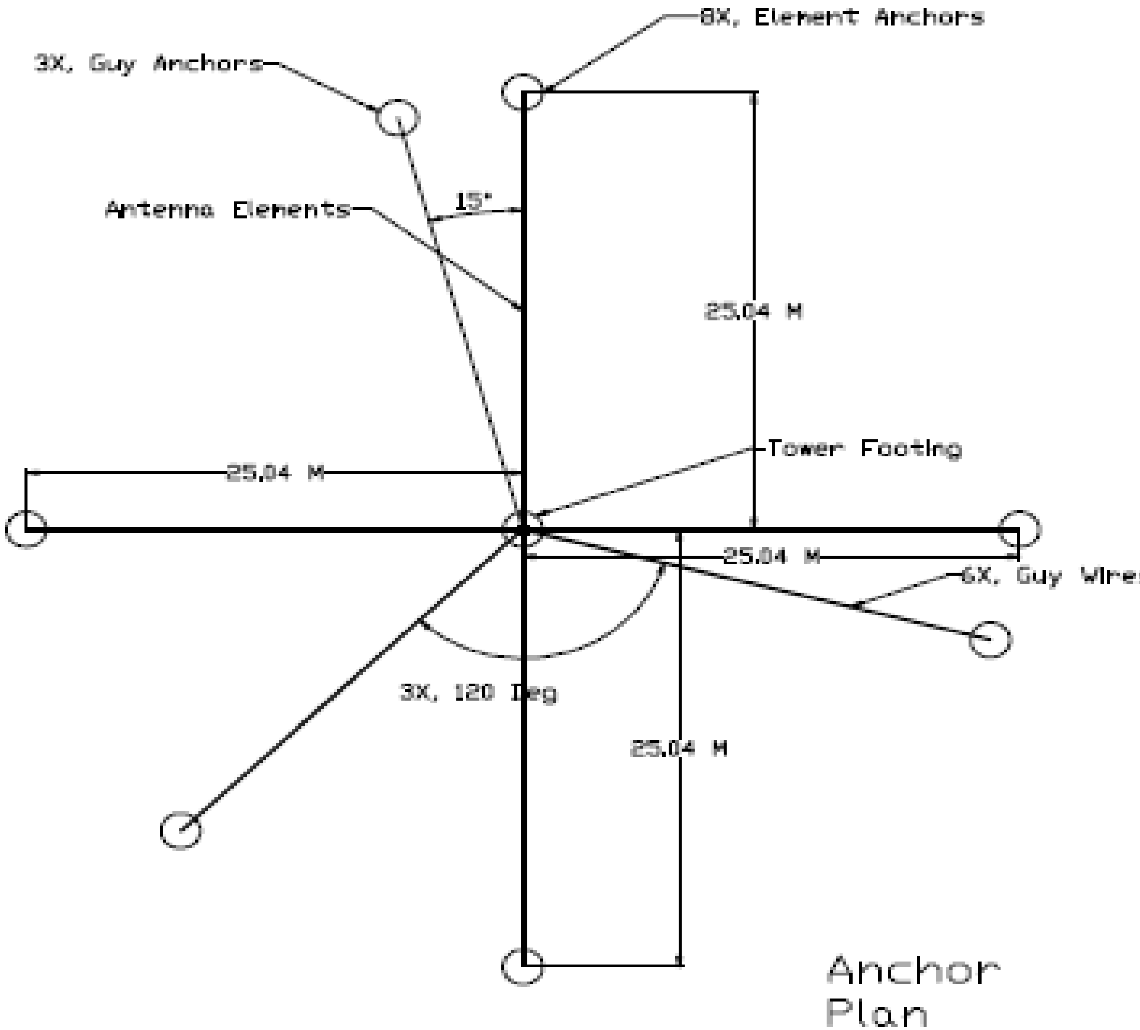
Delta 44 m. and 54 m. wide



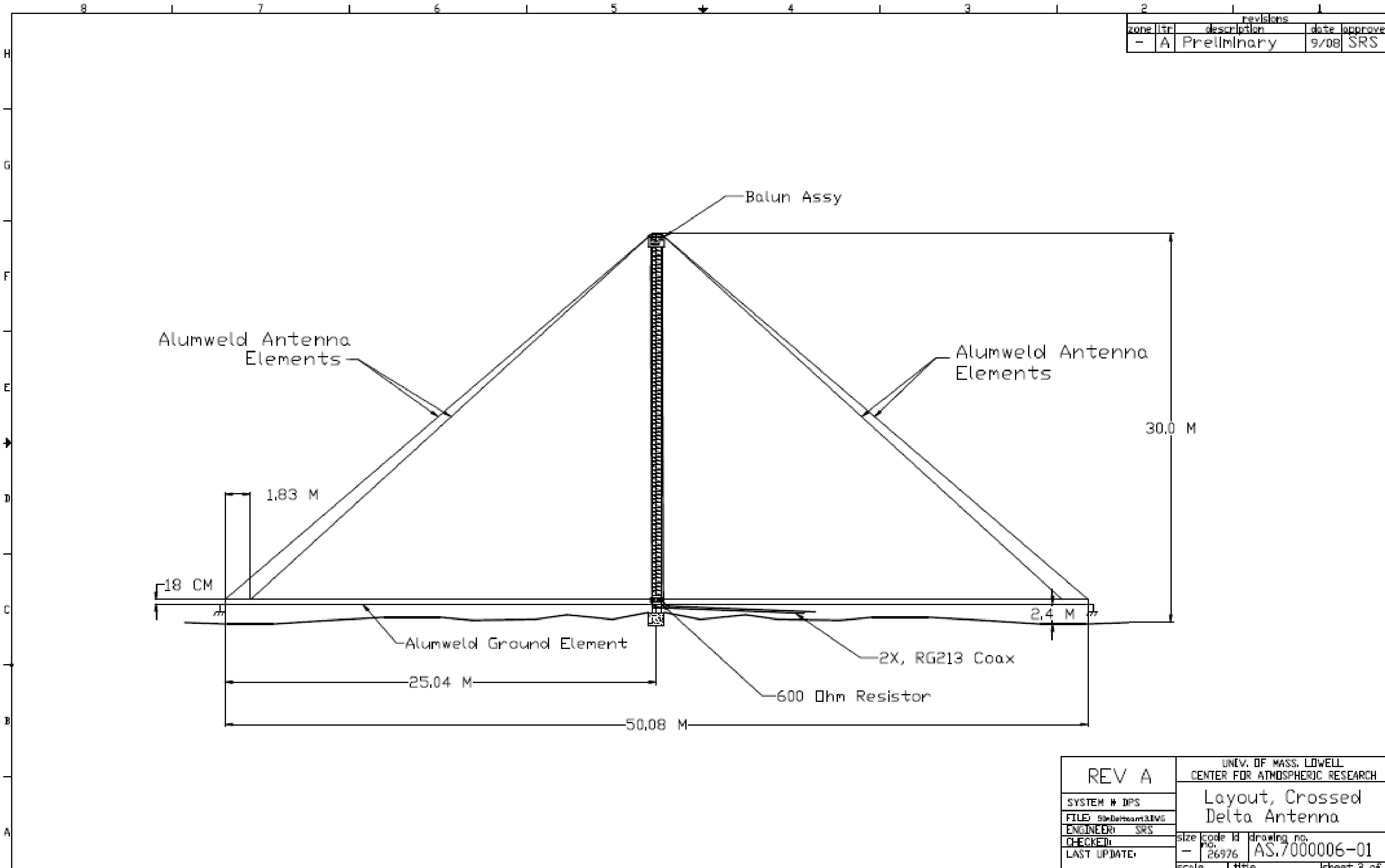
Delta 44 m. and 54 m. wide

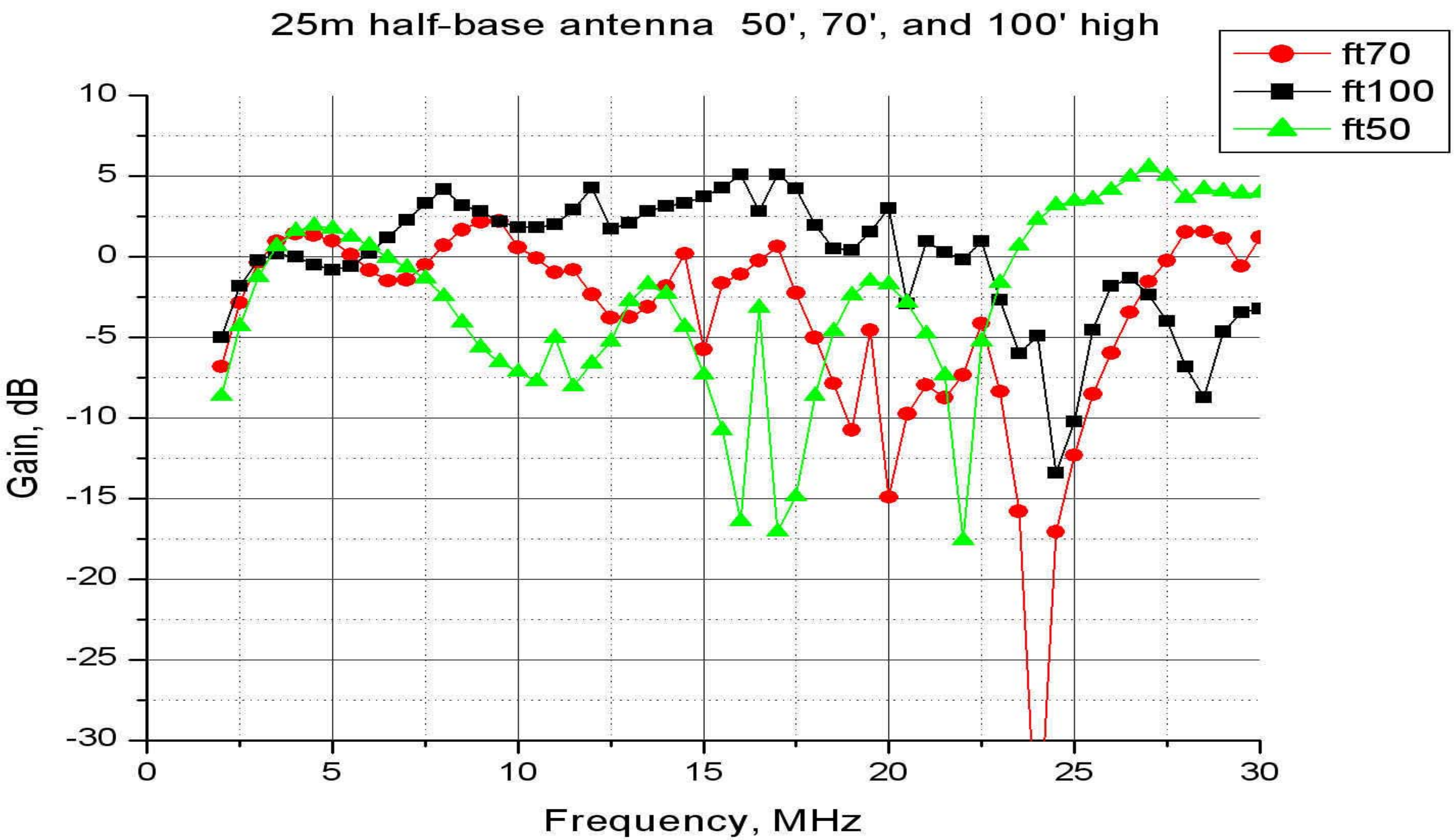


New Design Transmit Antenna
Two equal 50 m. Deltas on 30 m. tower
will fit in 42 m. x 42 m. Square

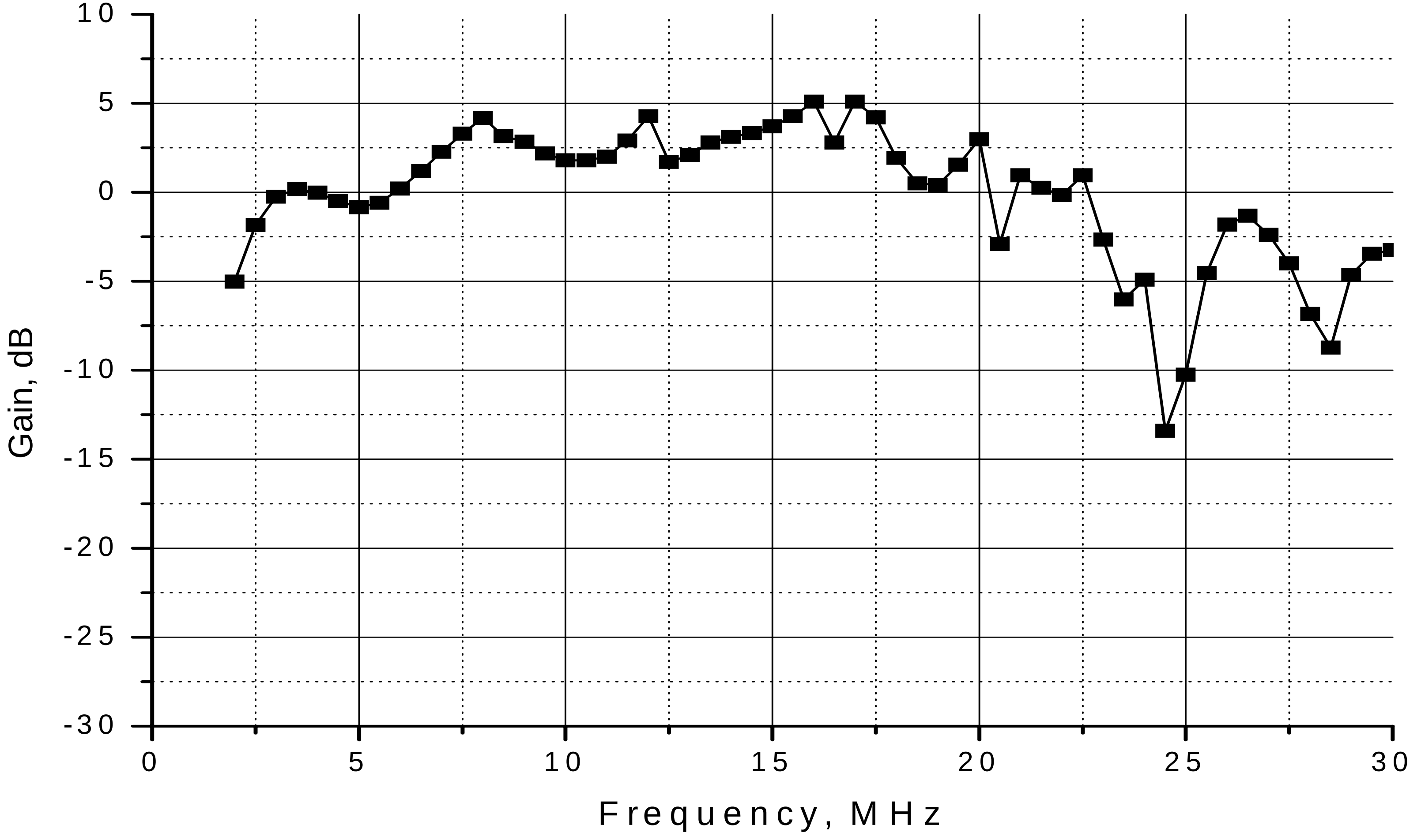


Transmit Antenna
Two equal 50 m. wide Deltas

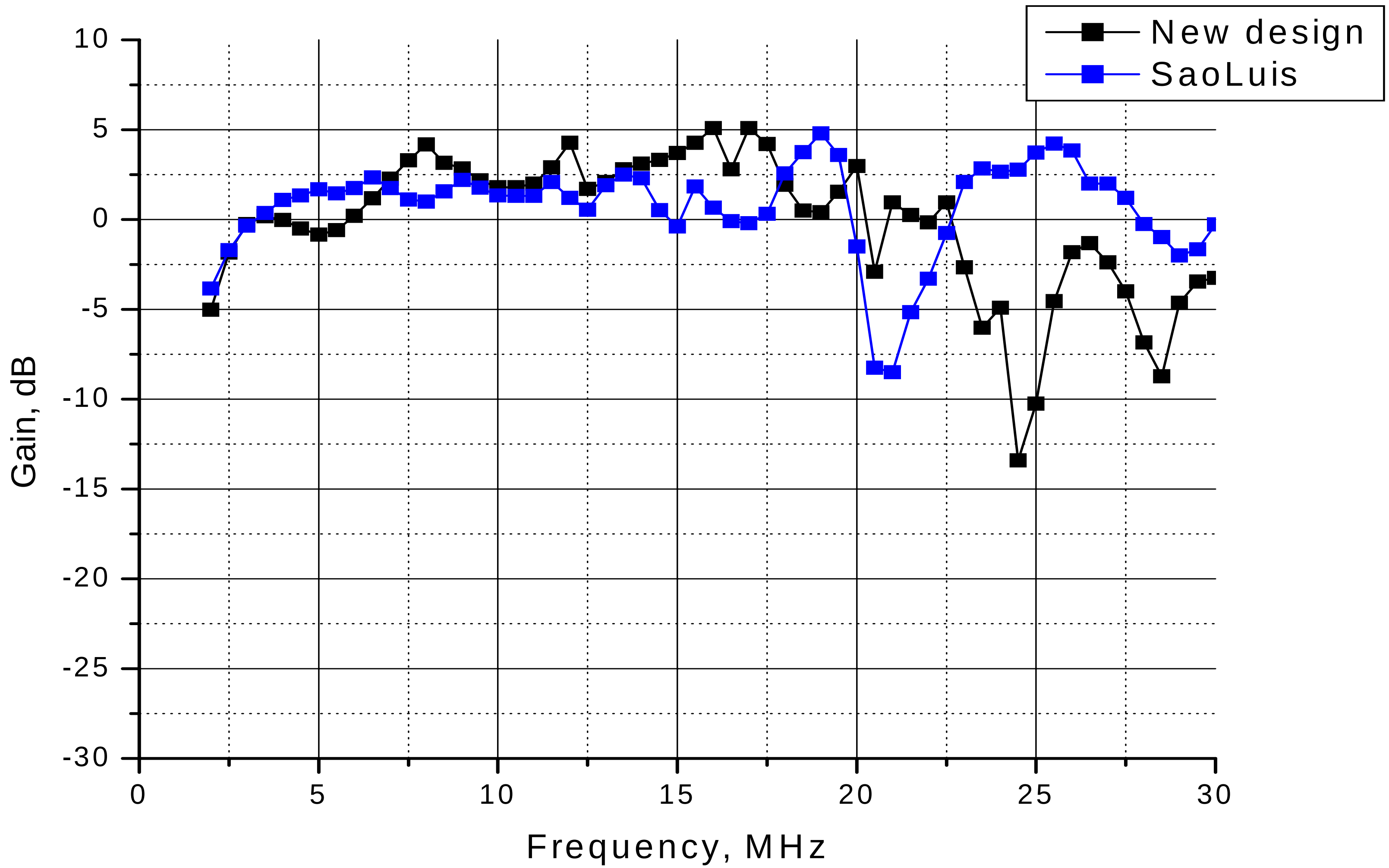



25m half-base antenna 50', 70', and 100' high
ft70
ft100
ft50
Gain, dB
Frequency, MHz
10
5
0
-5
-10
-15
-20
-25
-30
0
5
10
15
20
25
30

Delta Vertical Gain as function of Frequency
100 ft. tower, 164 and 164 ft. wide
30 m. tower, 50 m. and 50 m. wide



Composite gain of 60 m. x 80 m. crossed Delta compared to New design



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Receive Antenna Direction Verification Beam Tilting Experiment

David Kitrosser
University of Massachusetts Lowell
Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

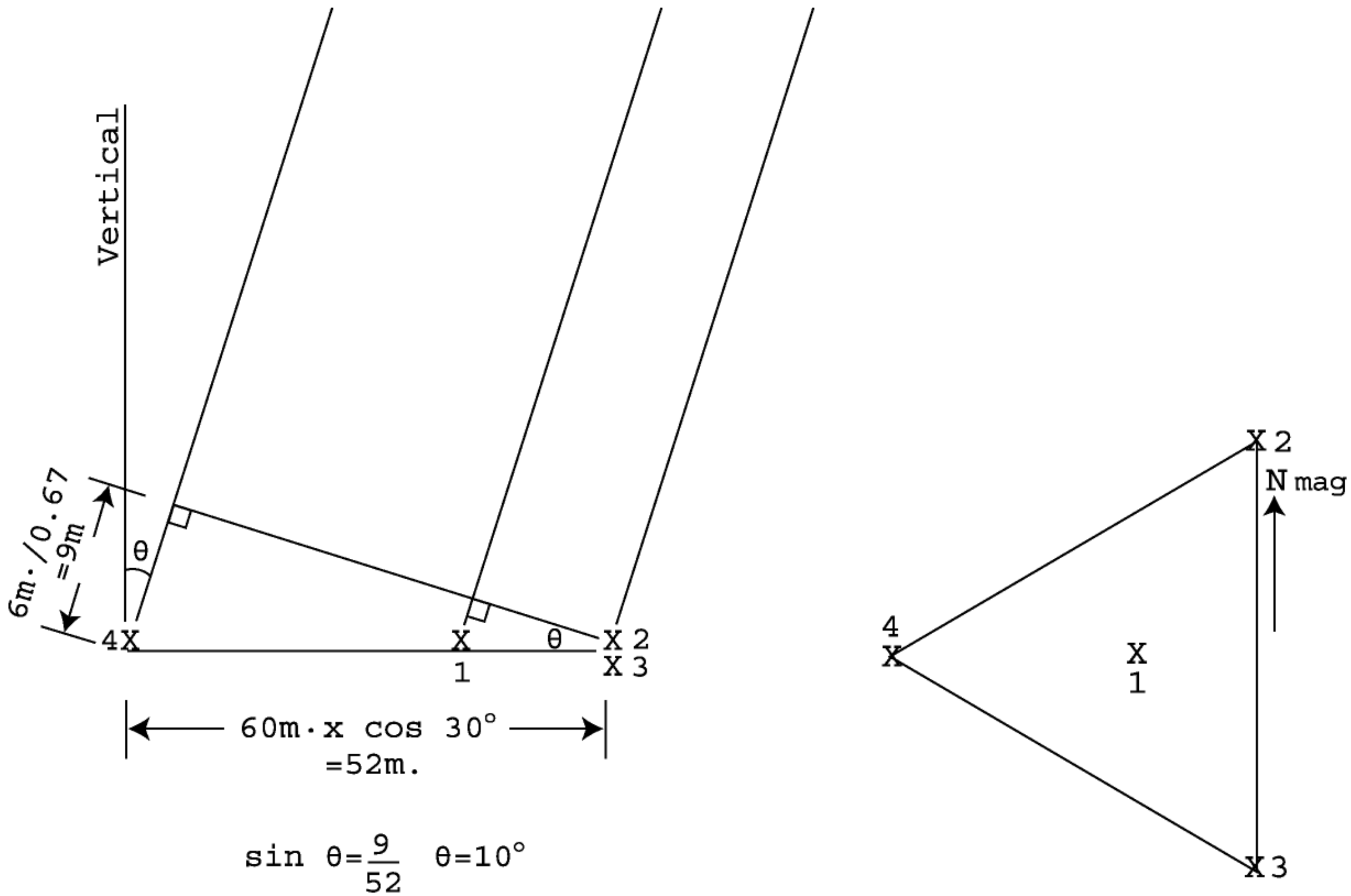
Beam Tilting Experiment

- Verify correct directions in Ionograms and Drift
- Matched antenna cables
- Corrections for varying antenna heights
- Detect defective cables and Antenna Pre-amps
- Confirm Settings in Station UDD file
  D:\ Dispatch\ udd \ xxx.udd
- Confirm Settings Real-Time Drift Configuration file D:\ Dispatch \ ddasetup.onl

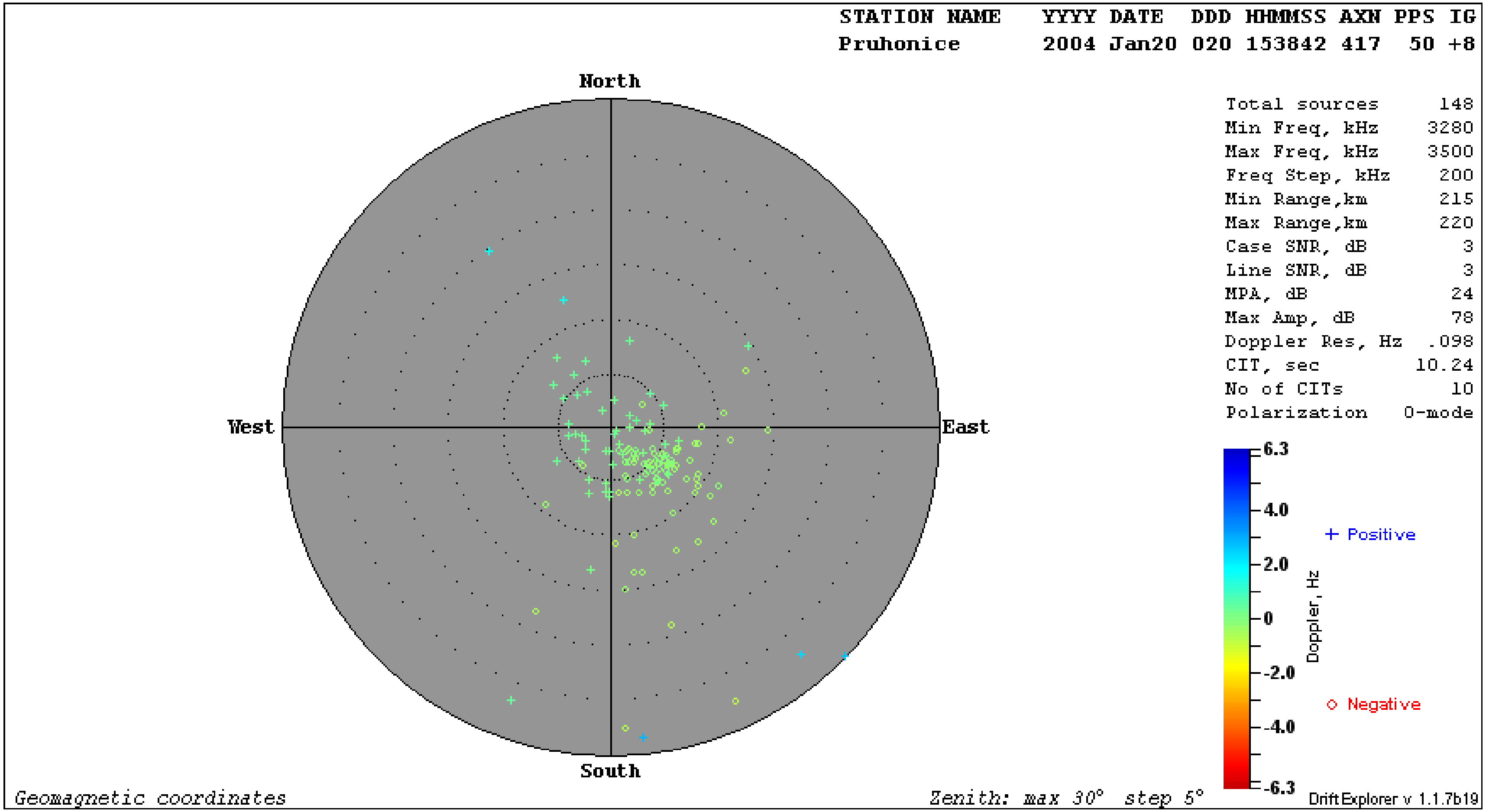
Beam Tilting Experiment

- With quiet Ionosphere, Ionograms with directions should generally be overhead. Skymaps from Drift should be overhead.
- Add two test cables to artificially tilt antenna array
- For a four antenna array, 60 meters on a side, add 6 meters to an outer antenna cable and add 2 meters to the center antenna cable. Tilts the beam approx. 10 degrees away from outer antenna with extra cable length.

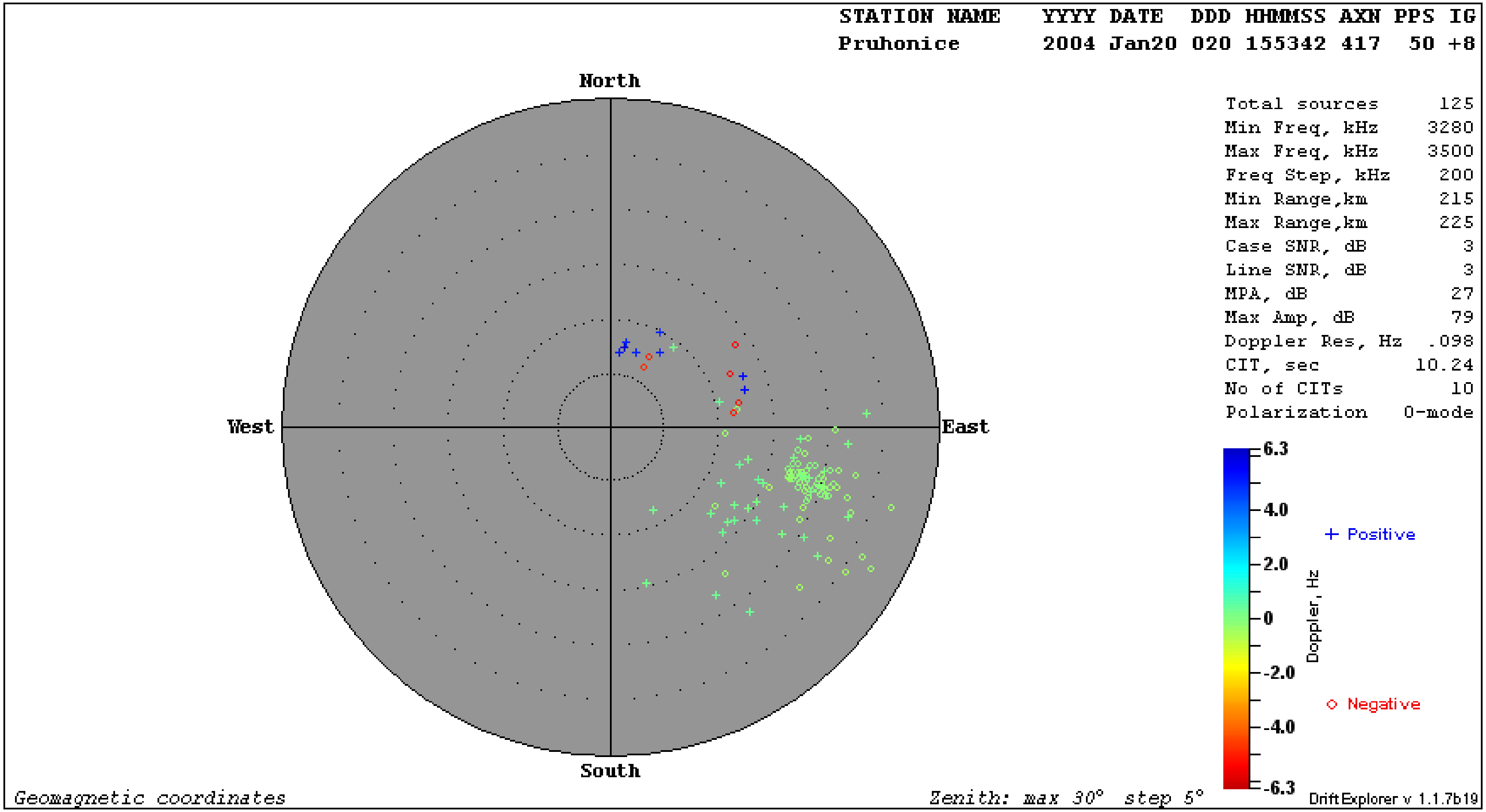
Beam Tilting Experiment



Almost overhead ionosphere
No test cables



Apparent echoes shifted 10 degrees East with test cables inserted



Apparent echoes shifted 10 degrees East with test cables inserted

Station UDD file

ANTENNA POSITIONS (X Y Z)

Assume the (central) antenna 1 at (0, 0, 0)
All length are in meters relative to antenna 1
Assume X pointing ground level compass North
Assume Y pointing ground level compass West

	Ant1	Ant2	Ant3	Ant4	Pruhonice Mirror Image
*080 <	0.00	30.00	-30.00	0.00	> X North
*081 <	0.00	-17.32	-17.32	34.64	> Y West
*082 <	0.00	0.00	0.00	0.00	> Z

Station UDD file

ANTENNA LAYOUT

0 Standard per Manual
1 180 deg rotation (Karachi,Pakistan, Beijing,China, Kokubunji,Japan)
2 Mirror Image (Millstone, Beveridge, Goose Bay)
3 None of the above

*086 < 2 >

ANTENNA ROTATION

(accompanies L parameter in Preface)

0 clockwise
1 counter-clockwise

*085 < 0 >

ddasetup.onl file

```
                Ant 1    Ant 2       Ant 3       Ant 4    Ant 5      Ant 6      Ant 7
*170  X  <  0.0000, 30.0000,-30.0000, 00.0000,999.0000,999.0000,999.0000>

*177  Y  <  0.0000,-17.3200,-17.3200, 34.6400,999.0000,999.0000,999.0000>


                       LAT.   LONG. CGPLAT CGPLONG COMPN  MAXSEP  DEVN ROTATA
*185  Pruhonice <  50.0,   14.5,   80.00,  -80.00,   2.3,   103.92,   30.00,   4 >
```

Remote Access and Computer Security

Ryan Hamel
University of Massachusetts Lowell, Center for Atmospheric Research

2009 IDF
XII INTERNATIONAL DIGISONDE FORUM
11 - 14 MAY 2009

Overview

- Brief Introduction to XPE
- Data Computer Network Services and outgoing traffic
- Remote Access Methods
- Additional Security Measures

Intro to XP Embedded

- Component based version of XP Professional
  - Over 10,000 components
- Used to build a customized operating system giving the designer flexibility to add / remove portions of the operating system to suit the application
- If desired only include a small subset of XP

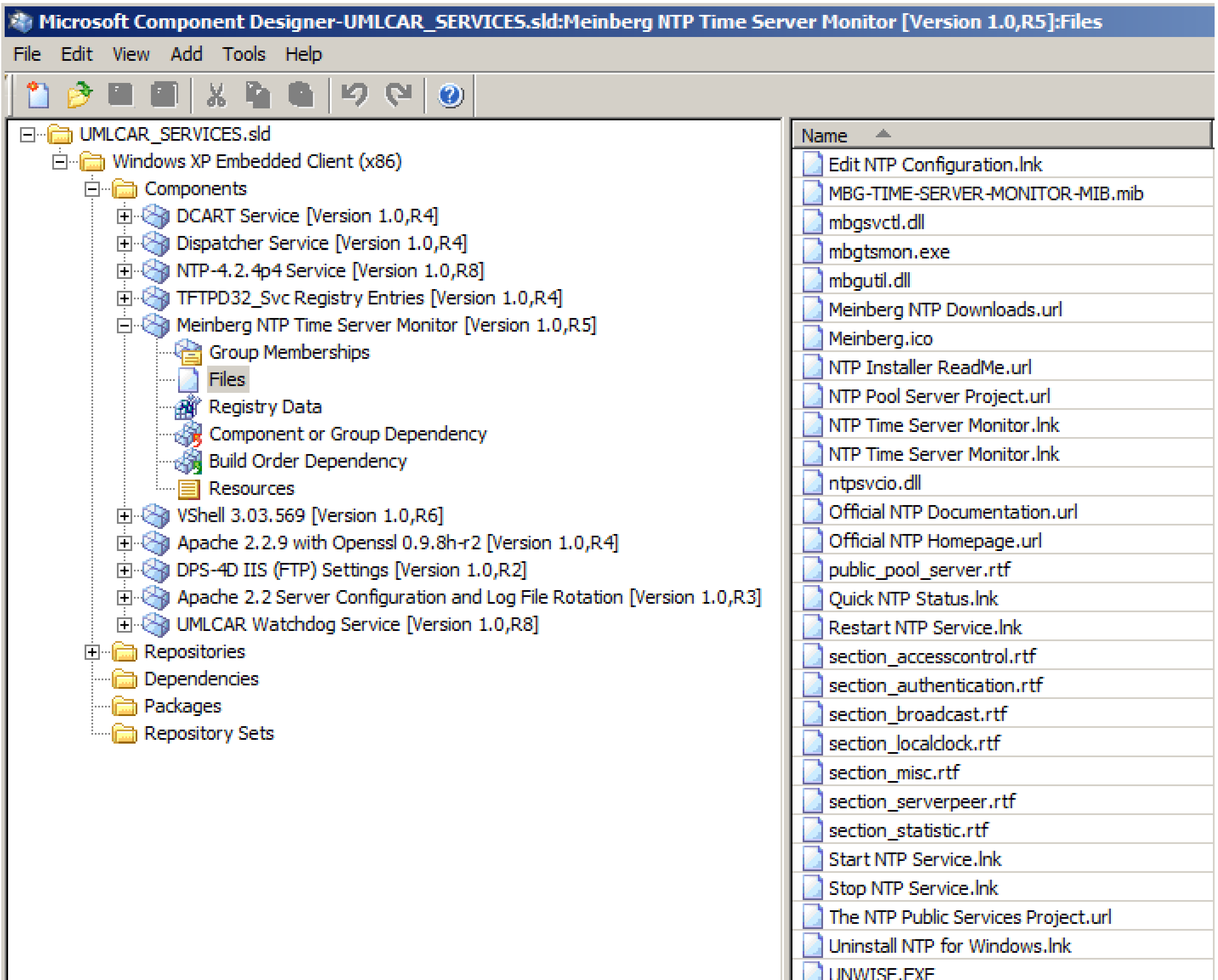
- Microsoft Windows Embedded Studio Tools
  - Component Designer
  - Target Designer

Component Designer

- Windows software is made up of files, registry entries, dependencies with other software
- XPE "components" are made up of these pieces
- Capable of not only using existing XPE components (supplied by Microsoft), but also can generate your own

- Existing Custom Built Components
  - UMLCAR software
  - Computer specific device drivers
  - Tune some of the Windows interface options

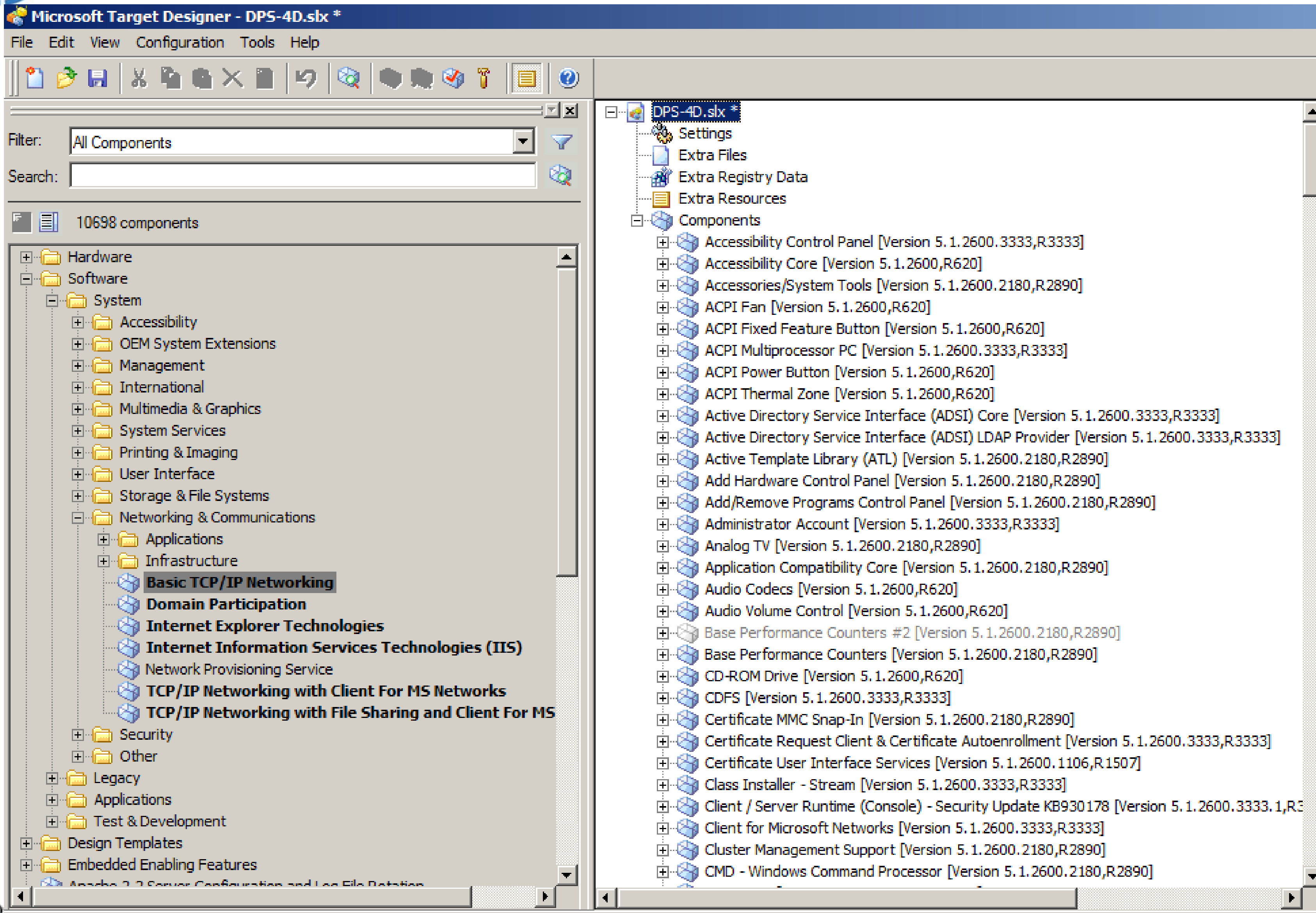
Component Designer



Target Designer

- A "Target" is a collection of components which specifies an operating system and its software (ex: Data Computer)
- Add and remove components (easily) and generate an operating system "image" instead of requiring reinstallation of Windows from scratch
- Once the os image has been generated its basically ready for use (there may be some aspects of setup which cannot be automated by the XPE tools)
- Saves a lot of time when building hard drives / migrating to other computer hardware

Target Designer



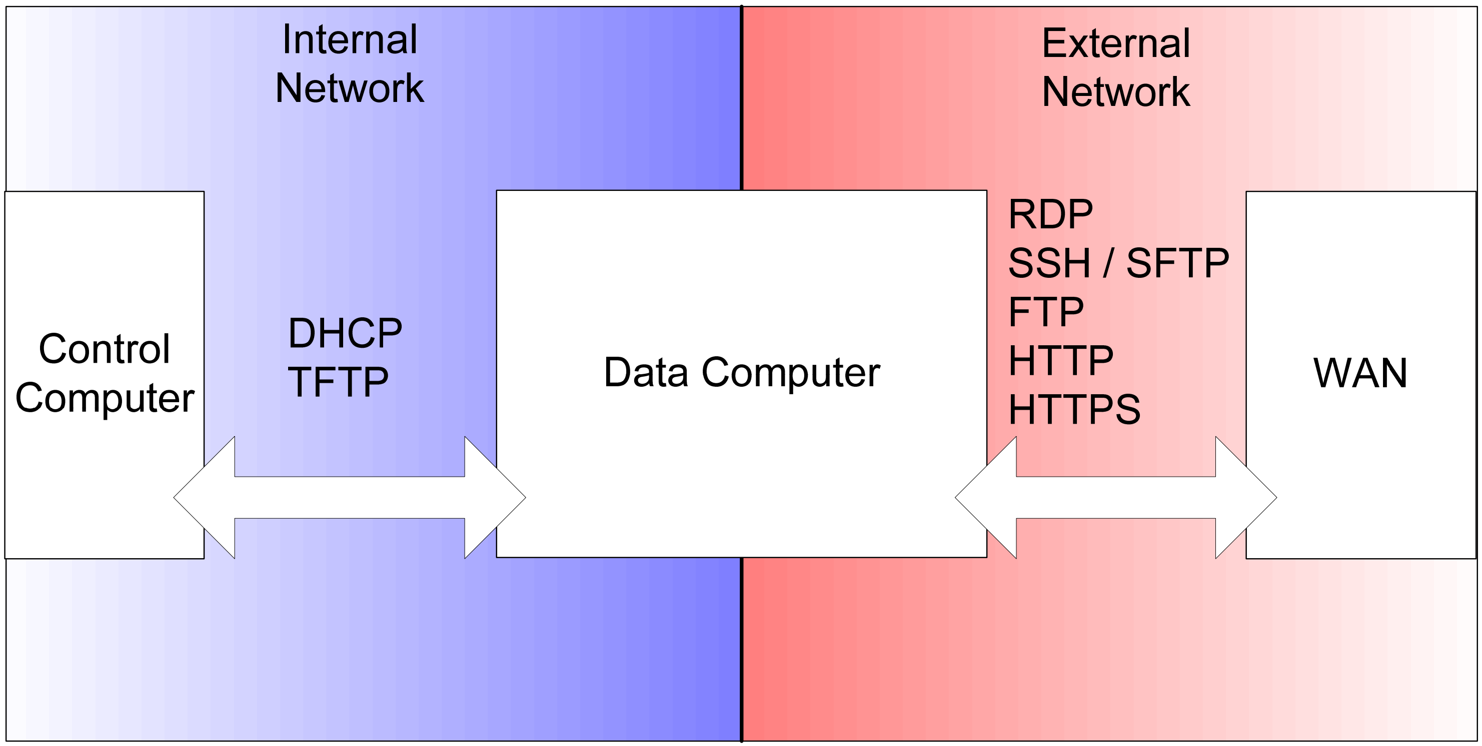
Data Computer Network Services

- DHCP (Ports UDP 67, 68), and TFTP (Port UDP 69) for Control Computer PXE
- VShell SSH / SFTP server (Port TCP 22)
- Microsoft IIS FTP server (Port TCP 20, 21)
- Apache 2.2.x HTTP / HTTPS (Port TCP 80, 443)
- Microsoft Remote Desktop RDP (TCP, UDP 3389)

- Using Microsoft Firewall
- Exceptions for “External” Interface
  - Necessary for 20, 21, 22, 80, 443, 3389
  - Also include
    - D:\Dispatch\FTPS.exe
    - D:\Dispatch\PSFTP.exe
- Firewall disabled on “Internal” (Control Computer) interface

Network Services Diagram

- Network Services by Interface



Outgoing Network Traffic
Digisonde 4D Data Delivery

- Dispatcher processes DCART science data and is responsible for data delivery.
- FTP and SFTP delivery are possible
  - D:\Dispatch\FTPS.exe
    - UMLCAR custom FTP client
  - D:\Dispatch\PSFTP.exe
    - Modified version of putty psftp.exe utility

Remote Access

- (Microsoft) Remote Desktop Software
  - Direct control of the system
  - Control of DCART
  - Run / Create Programs, Run / Create Schedules
  - Some troubleshooting is possible
  - Hard drive access (configuration files, logs, etc)
- (Recommended) SFTP Server
  - Hard drive access / ssh access allows console (os diag)
  - Access to science data (RSF, DFT), os log files, .out, .err, UMLCAR configuration files (progsched, dispatch.udd)
- (IIS) FTP Server
  - Available if necessary
  - Provides similar access as the SFTP Server
- (Apache) Web Page
  - Real Time Data (PNG pictures)
  - Data History (PNG pictures)
  - DCART Screen Output
  - Dispatcher Screen Output
  - Latest System Status (BIT)

Microsoft Remote Desktop

- Client included on any version of Windows XP sp2 or Vista
- Provides user with full control
- Locks the local terminal, you cannot share the desktop with a local user
- Requires high speed connection
- Uses Windows accounts
- Remote Desktop Connection Options
  - Be wary of using local devices and resources (printers)
  - Adjust settings to make best use of available bandwidth

DameWare Mini Remote Control

- US Air Force Approved
- FIPS 140-2 compliant
- More than 1 user can be connected simultaneously.
- Use of the RDP client does not log off Windows user (as Microsoft Desktop)
- Uses Windows accounts
- Requires high speed connection

VNC

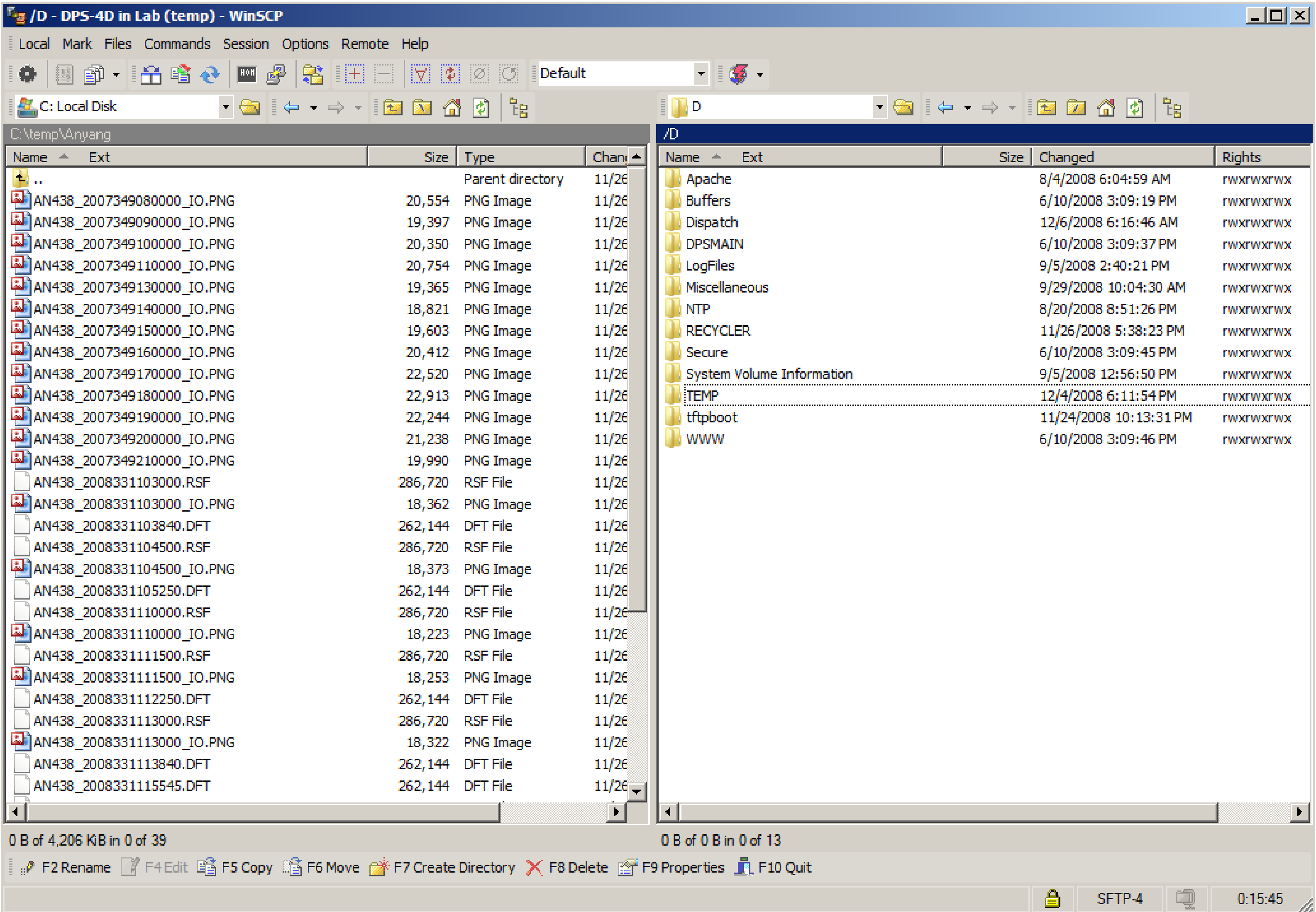
- **V**irtual **N**etwork **C**omputing
- Use of the client does not log off Windows user (as Microsoft Desktop)
- Does not use Windows accounts
- Requires high speed connection

Example of Remote Desktop

SFTP Access

- Vandyke VShell
  - Used for file transfer
  - Does not require a high speed connection
  - May be used to update program / schedule
  - Some remote control of DCART, Dispatcher
  - Also provides a remote terminal
- Any SFTP Client can be used for connection
- More cumbersome than remote desktop
- Collect data, logs, configuration files
- Upload generated progsched file
- View pictures

SFTP Client Example



FTP Access

- Inherently insecure
  - Passwords sent “in the clear”
- Most organizations discourage use of FTP
- Is provided on the Digisonde 4D via Microsoft IIS to provide redundant mechanism for file transfer
- IIS can easily be disabled

SSH Access

- VShell Server also provides for a SSH (Secure Shell) console
- Requires SSH Client
- Allows access of command prompt on Digisonde 4D
- Useful for sending commands to the operating system

Hard Drive Highlights

▪ C:\	(Windows operating system)
▪ D:\Apache	(Web server)
▪ D:\Buffers	(Outgoing data directories)
▪ D:\Dispatch	(Dispatcher, DCART, picture generating, ARTIST)
▪ D:\DPSMAIN\Dps2Aux	(DCART data is delivered here)
▪ D:\Logfiles	(Apache, FTP, Firewall)
▪ D:\Miscellaneous	
▪ D:\NTP	(NTP Service for GPS communication)
▪ D:\Secure\Diagnostics	(BIT, CEQ, DCART logs)
▪ D:\Secure\Incoming	(Dispatcher remote commanding)
▪ D:\Secure\IndividualFiles	(temp location for all data)
▪ D:\Public	(short & long term storage)
▪ D:\tftpboot	(location of desc os image)
▪ D:\WWW\Docs	(main document root)
▪ D:\WWW\IonoGIF.secure	(ionogram pictures)
▪ D:\WWW\SkyGIF.secure	(skymap pictures)

Web Page

- Provides quick browsing of recent data
  - Ionogram latest and history
  - Skymap latest and history
- DCART Screen Output
  - Communication errors with DESC
  - Bad data packets received
  - Report program run (and success)
  - Termination of program
  - Miscellaneous
- Dispatcher Screen Output
  - Report which data is being processed
  - ARTIST 5 scaling, other processing, and results
  - Picture generation
  - data delivery reports
  - Housecleaning (cleaning directories and drive space warnings)
- Latest System Status (BIT)
  - Latest BIT Report

General Windows Security

- Windows XPE service pack 3
- Latest Windows Security Updates Installed
- Default local security policy
- Default security template
- Make use of standard Windows Firewall
- No Antivirus Software Installed

- Configuration of the operating system security is done via Microsoft Local Group Policy / Local Security Policy

Antivirus and Firewall Software

- Network / IT may mandate use of antivirus or additional firewall software
- Concerns regarding performance of data computer
- Thoroughly test the new setup until comfortable
- Be aware of high cadence or “dense” schedules.

Windows Update

- Generally safe to update Data Computer via www.windowsupdate.com
- Important to routinely perform windows updates.
- Ask us about certain vulnerabilities or patches if concerned.

Microsoft Security Policy

- Additional security measures can be taken via Microsoft operating system related policies.
- Local Security Policy
- User Rights
- Auditing, etc
- mmc (Microsoft Management Console)
- Ensure Digisonde does not break!

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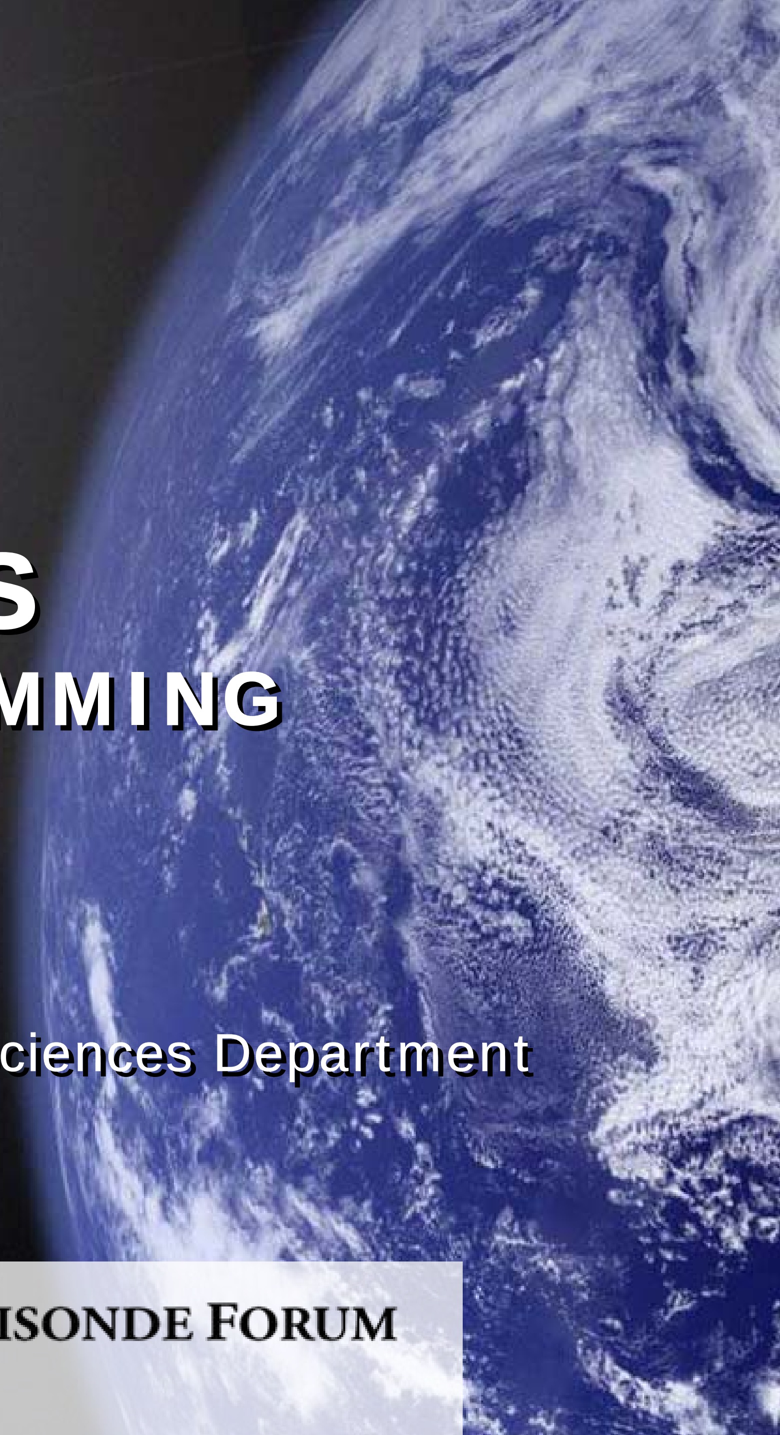
COMMON ERRORS
OF DIGISONDE PROGRAMMING

Dr. Ivan Galkin
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research



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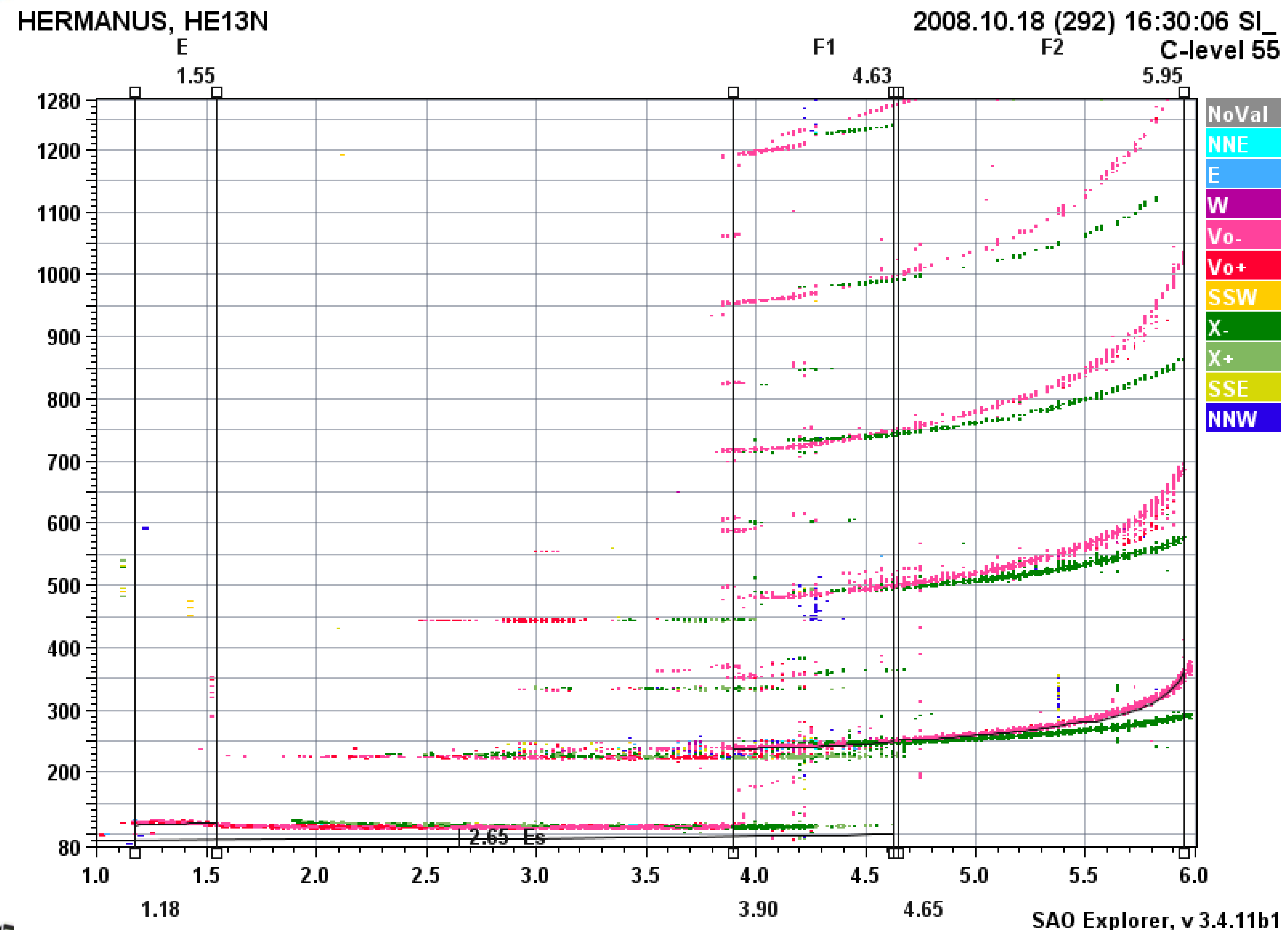
11 - 14 MAY 2009

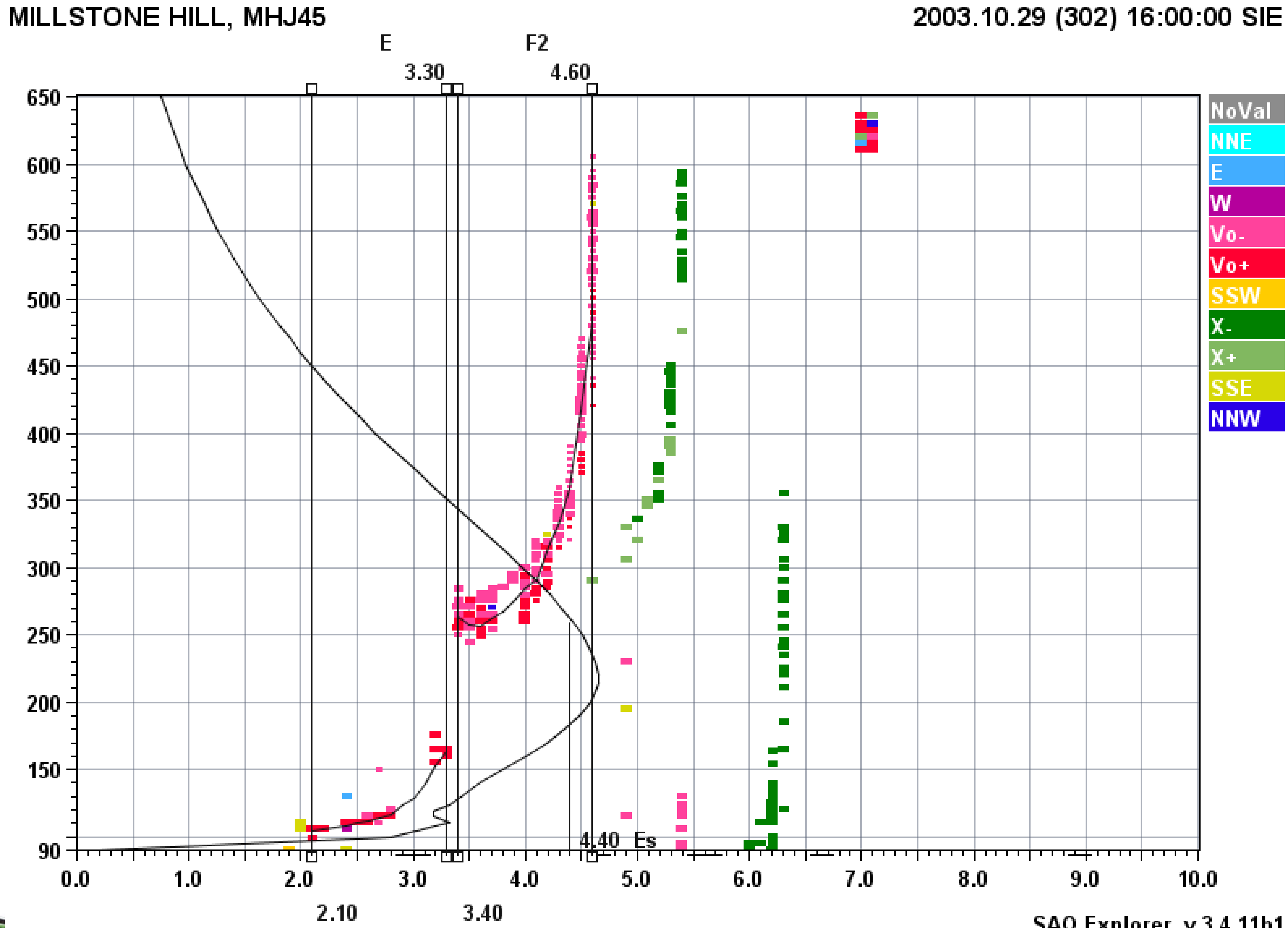
Outline

- Errors that can happen to any Digisonde
- Errors in programming DPS-4
- Errors that cannot happen to Digisonde 4D
- Error in programming 4D

Things that can go wrong



Things that can go wrong



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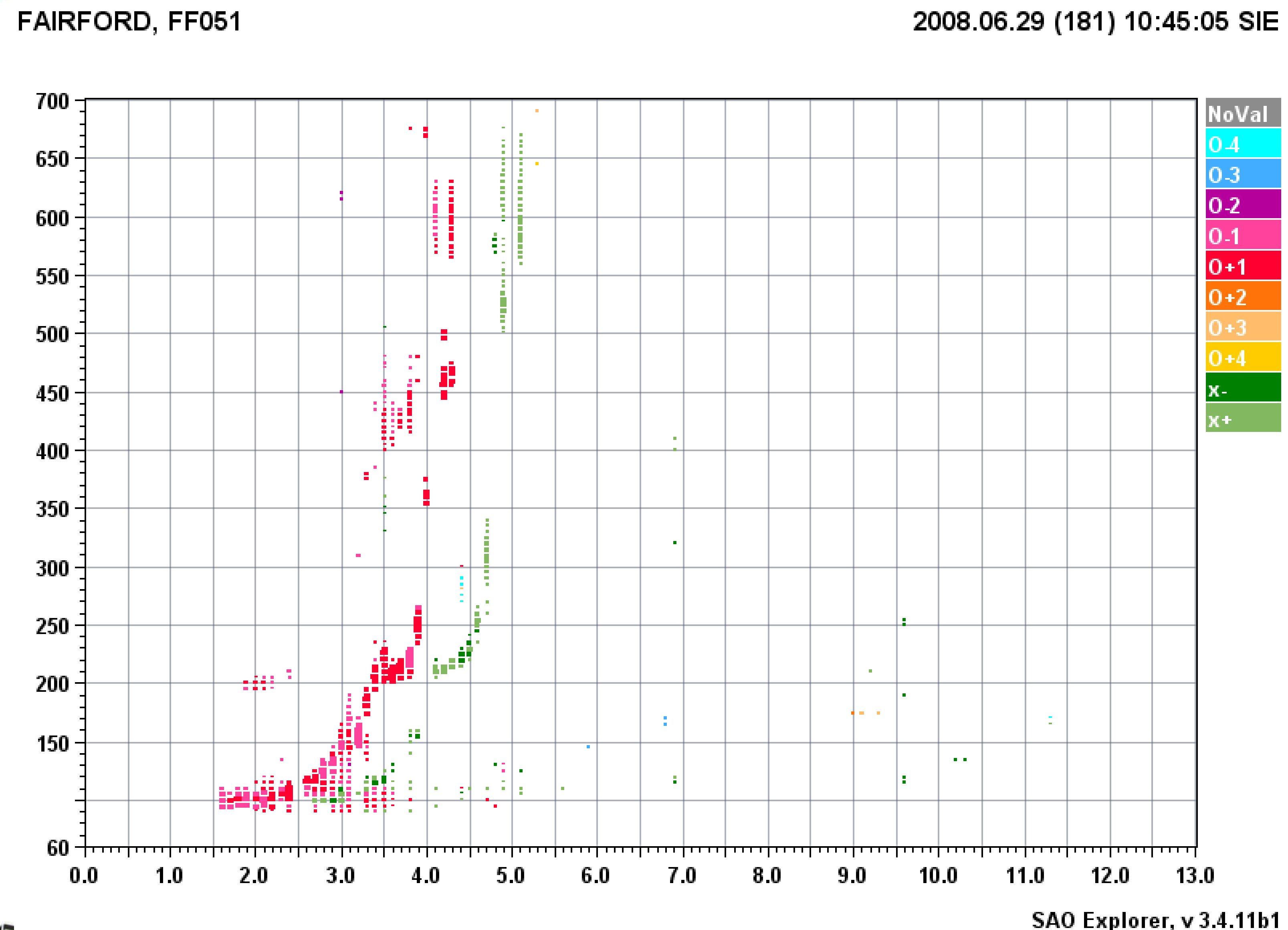
Things that can go wrong



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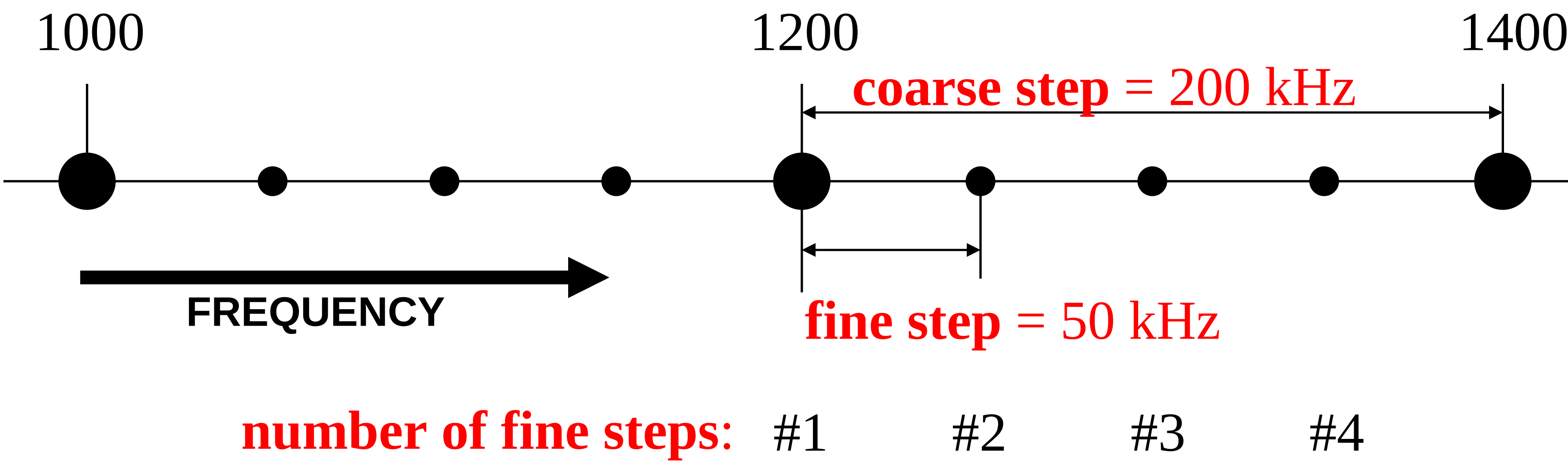
Other things that can go wrong

- Not using precision ranging in the ionogram mode
- Setting drift measurement with CIT below 10 sec (except polar locations)
- Leaving station site with Digisonde idling – watch for countdown!
- Leaving out list of restricted frequencies
- Leaving a floppy in the drive (expect for 4D)

Common DPS-4 Programming Issues

- Frequency multiplexing



EXAMPLES: to get 50 kHz stepping, use
Coarse = 200, fine = 50, number = 4
Coarse = 100, fine = 50, number = 2
Coarse = 50, fine = don't care, number = 1

Common Programming Issues (2)

- Antenna setting A
  - A=7 for RSF
  - A=0 for SBF
- Calibration shall be run at 100 kHz exactly, without frequency search, at appropriate fixed gain

Common Programming Issues (3)

- Pulse Repetition Rate too fast for sampling
  - 200 pps = 750 km
  - 256 x 5 km = 1280 km
  - 512 x 2.5 km = 1280 km
  - Use 100 pps for these modes (1500 km)
- Watch for drift selection window
  - Bottom height should not be too low (avoid E-layer echoes if you study F layer)

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DPS Online Program Editor

drift

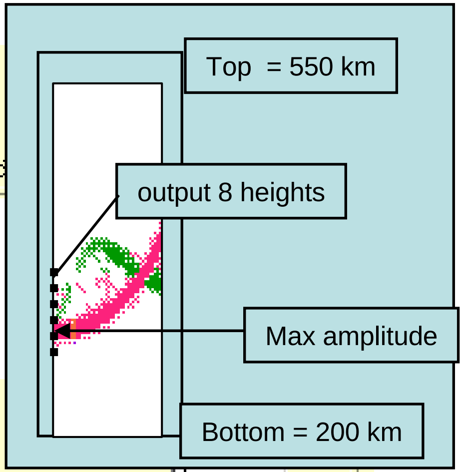
FR

Program G

note: a reference for each parameter range can be seen in the status wind

Lower frequency (khz)	5100
Coarse Step / # of Reps	4
Upper frequency (khz)	5100
Fine frequency step (khz)	200
# small steps (+ or -)	4
Antennas (0=beam)	7
FFT size (power of 2)	7
Rate (50, 100, or 200)	100

Gain (0 to 15)	
Freq Search (0,1,2,3,4)	
# Output Hts x 2	8
Disk (0MSDFPCBR)	F
Bottom_Ht to Output	200
Top_Ht to Output	550



Update Reset Parameter Help

Back to Main Page

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Errors that cannot happen in 4D

- A long list of errors in programming 4D are identified by DCART editors
  - Every field comes with allowed value range
  - Selections that are verified automatically
    - Frequency multiplexing
    - Choice of IPP to fit # of samples
    - Schedules without gain creation program
    - Features incompatible with data format and processing selection
      - RSF ionogram without beamforming
      - RSF ionogram with partial Rx array
      - Logarithmic frequency steping, etc.
    - Zero starting range for measurement
- Warnings and color codes for potential problems
  - High data volume
  - Suppressed output of data files
  - Signal saturation label in raw data display
  - Tracker saturation condition in BIT
  - Radio silent programs

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Error of 4D programming

- Use autogain evaluation program with wrong setting of the constant gain

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Lightning Protection

Igor Lisysyan

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

2007 IDF
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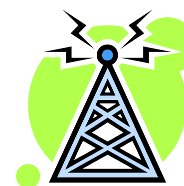
30 APRIL TO 3 MAY 2007

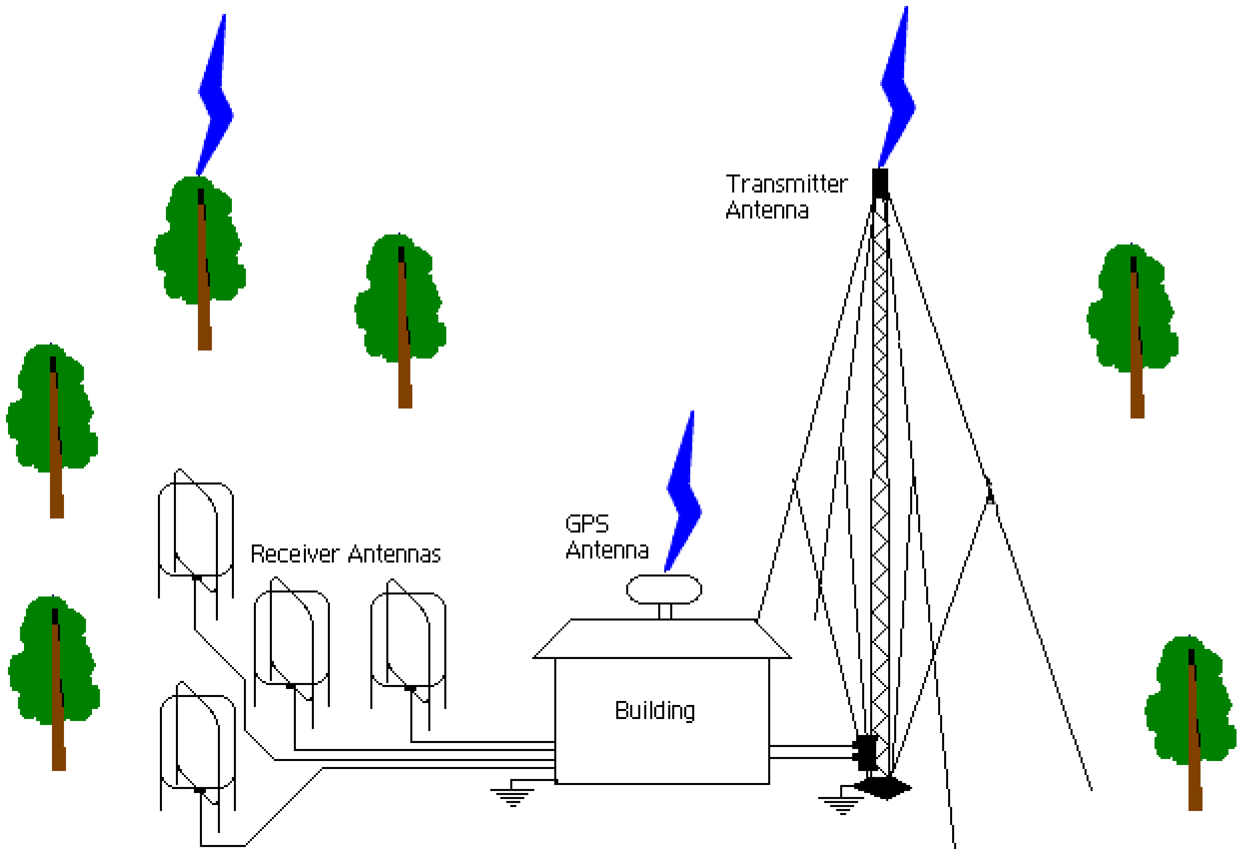
Lightening

Types of effects

1. Direct hit
2. Direct electromagnetic field
3. Ground current effect

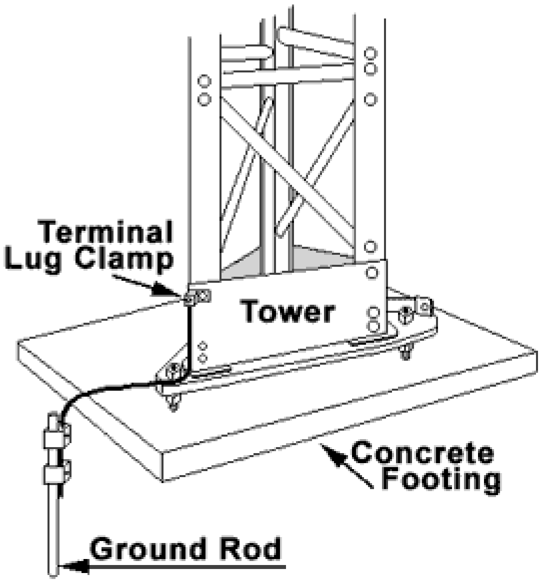


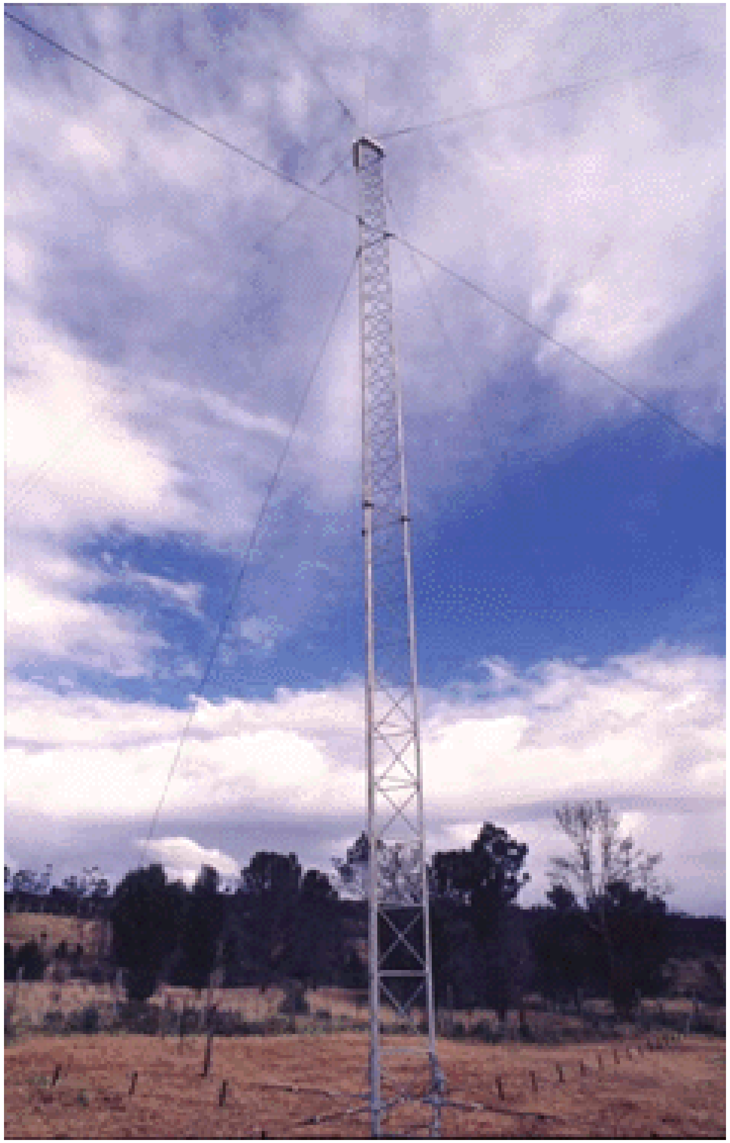
Direct hit


Transmitter
Antenna
GPS
Antenna
Receiver Antennas
Building

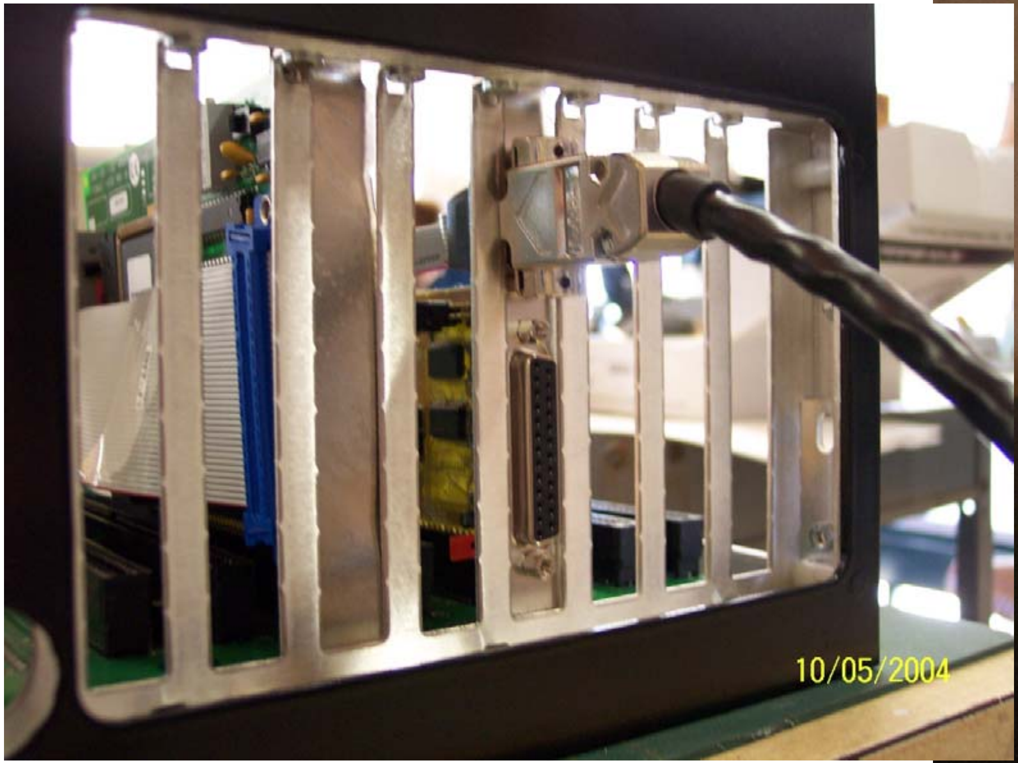
Receiver Antenna

Grounding Tx Antenna mast against direct hit

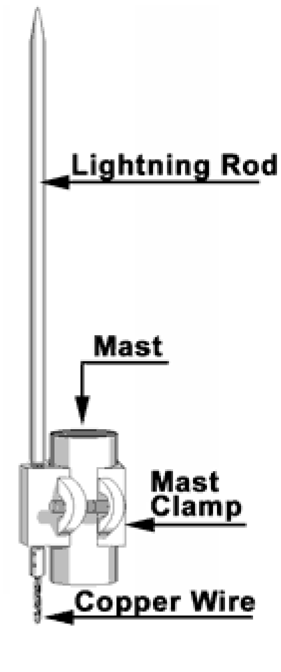


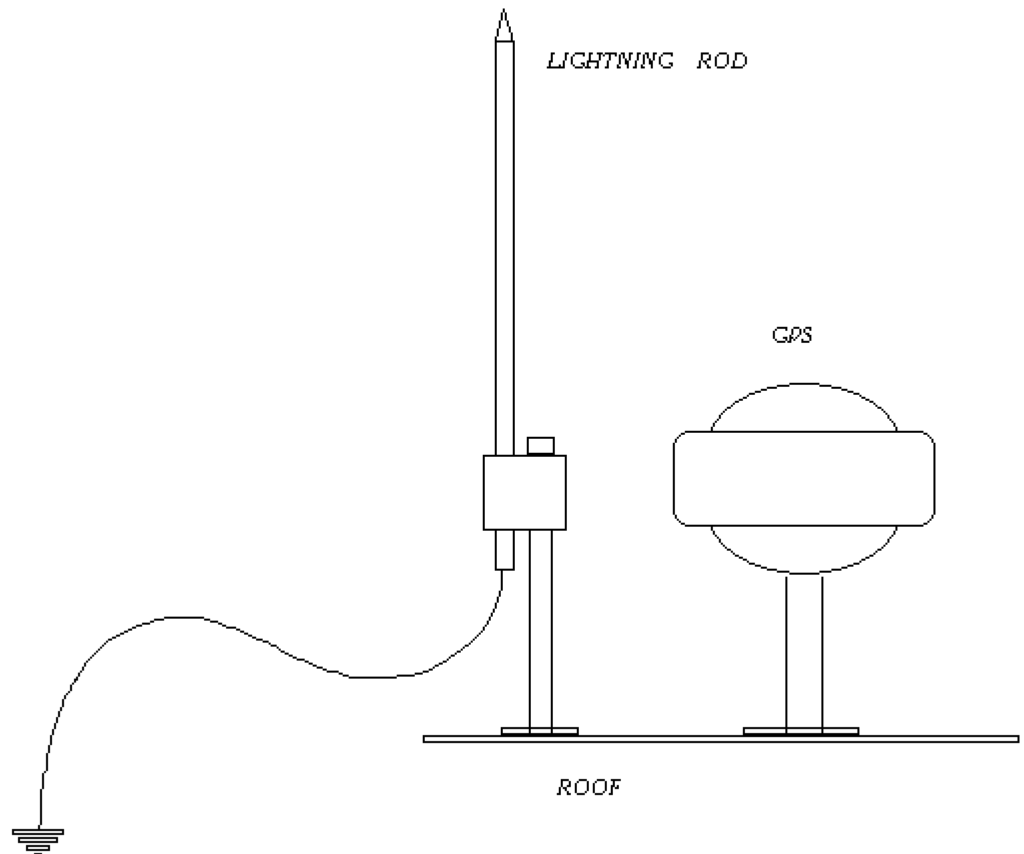


GPS Protection

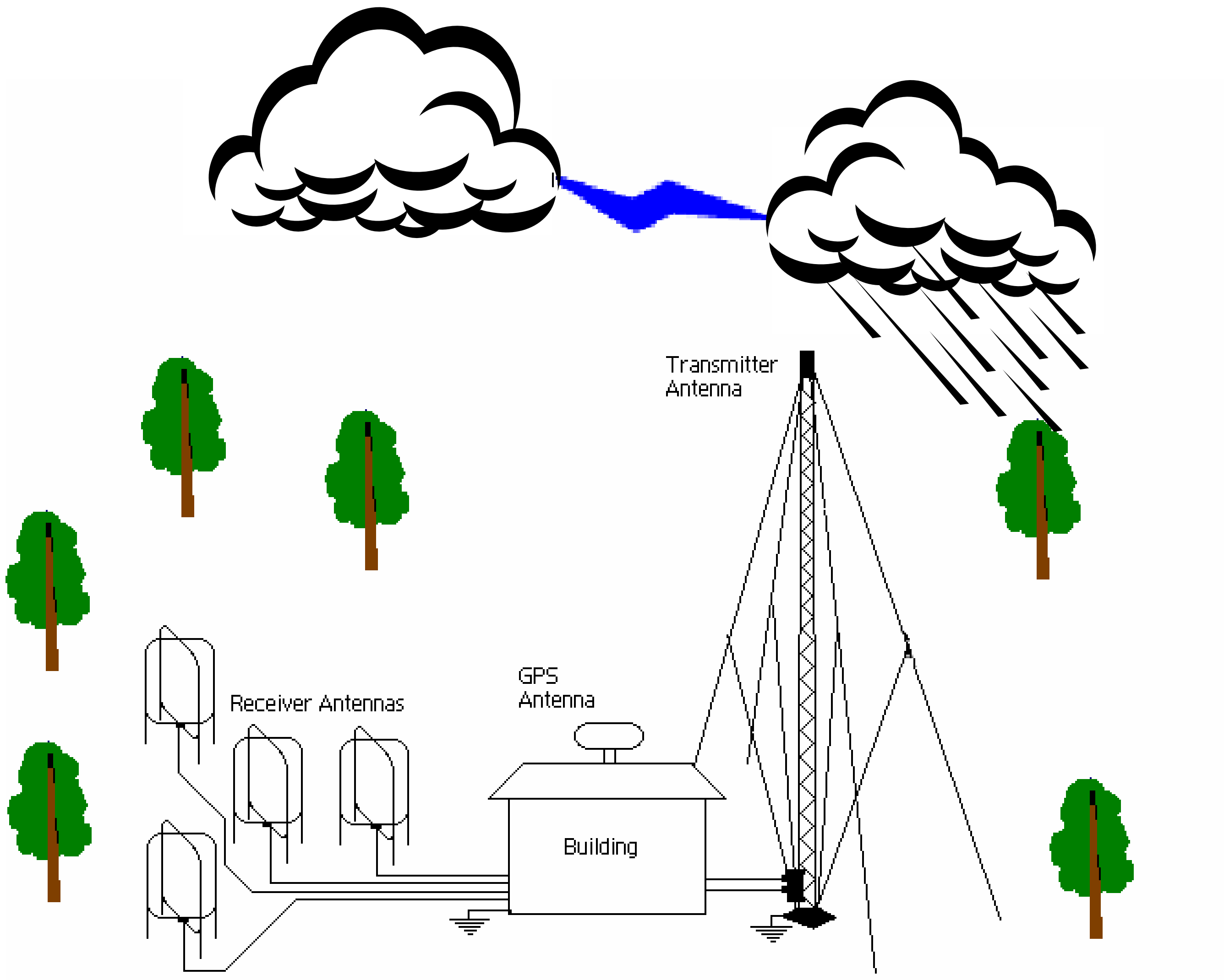


GPS Protection





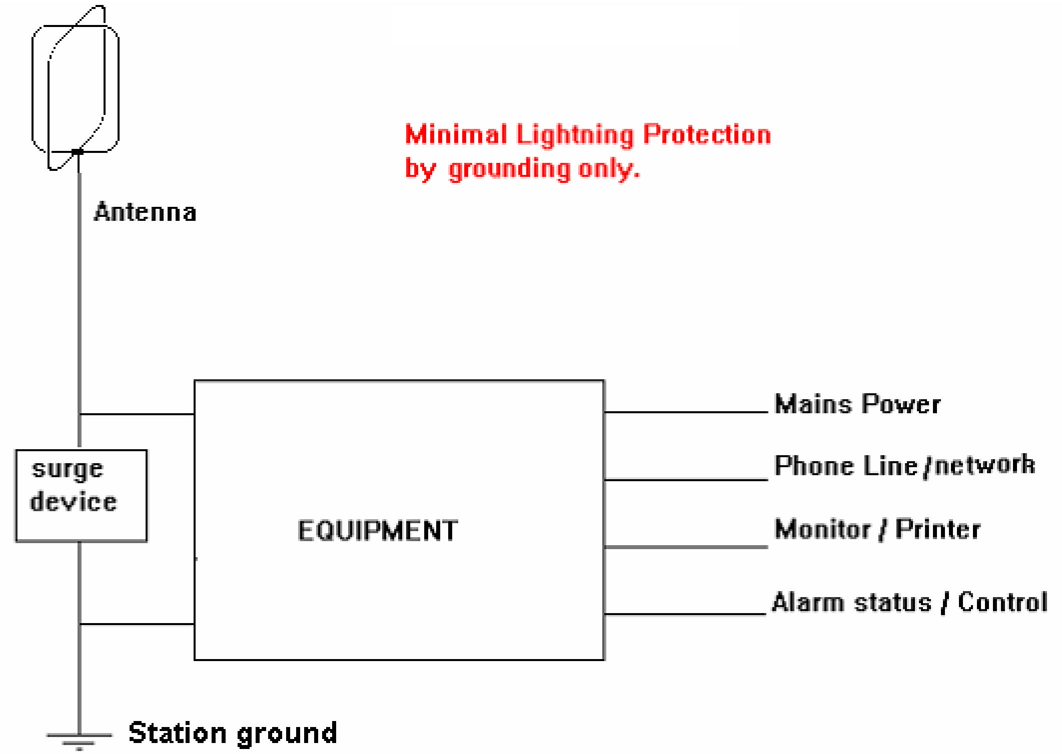
Electromagnetic field



Typical Lightning Damages

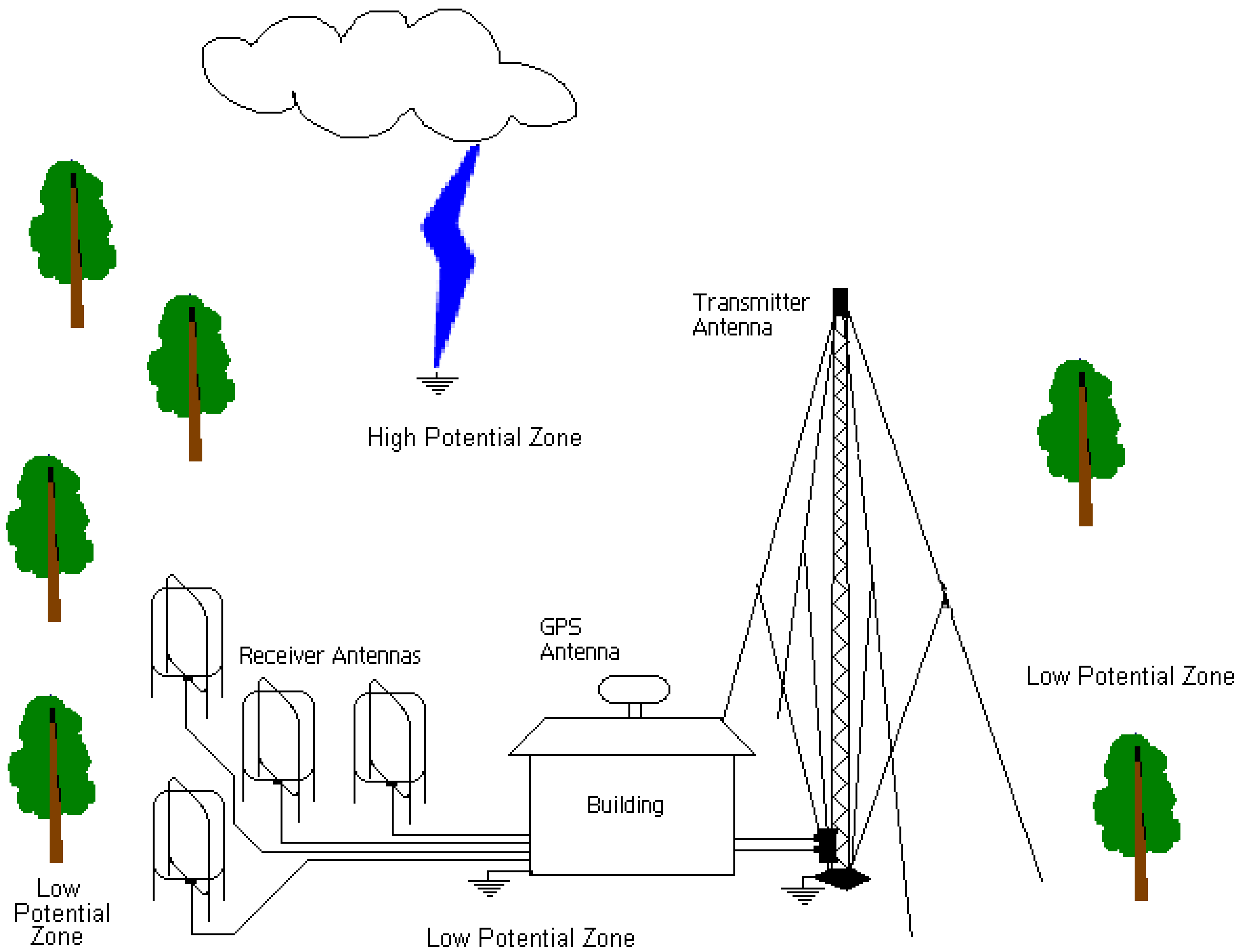
- Polarization Switch (Rx Antenna Pre-amp)
  - 7812 Voltage Regulator
  - 1733 (CLC426) Amplifier
  - 0.1μF Bypass Capacitors
- Antenna Switch 3Ω resistors
- Power Distribution Card
  - LM317T Voltage Regulator
- Solid State RF Power Amps – Usually No Problem

Minimal Installation

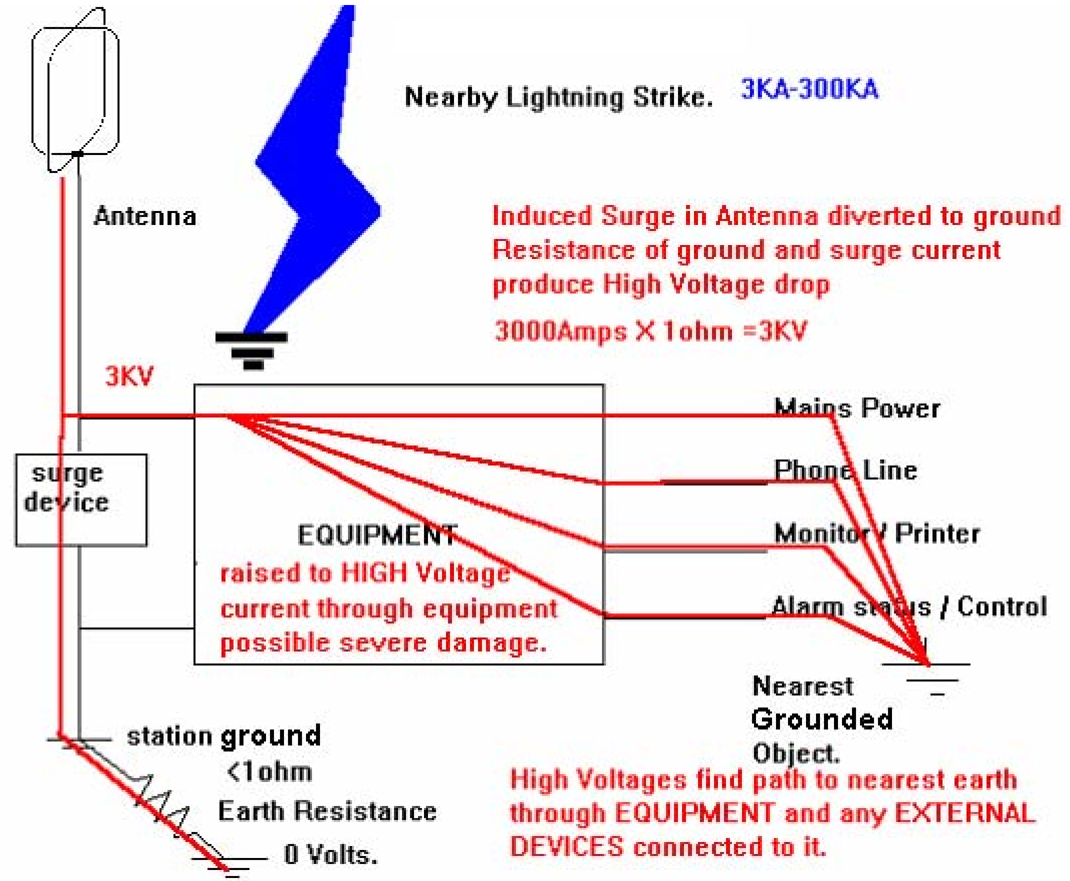


Surge Protector

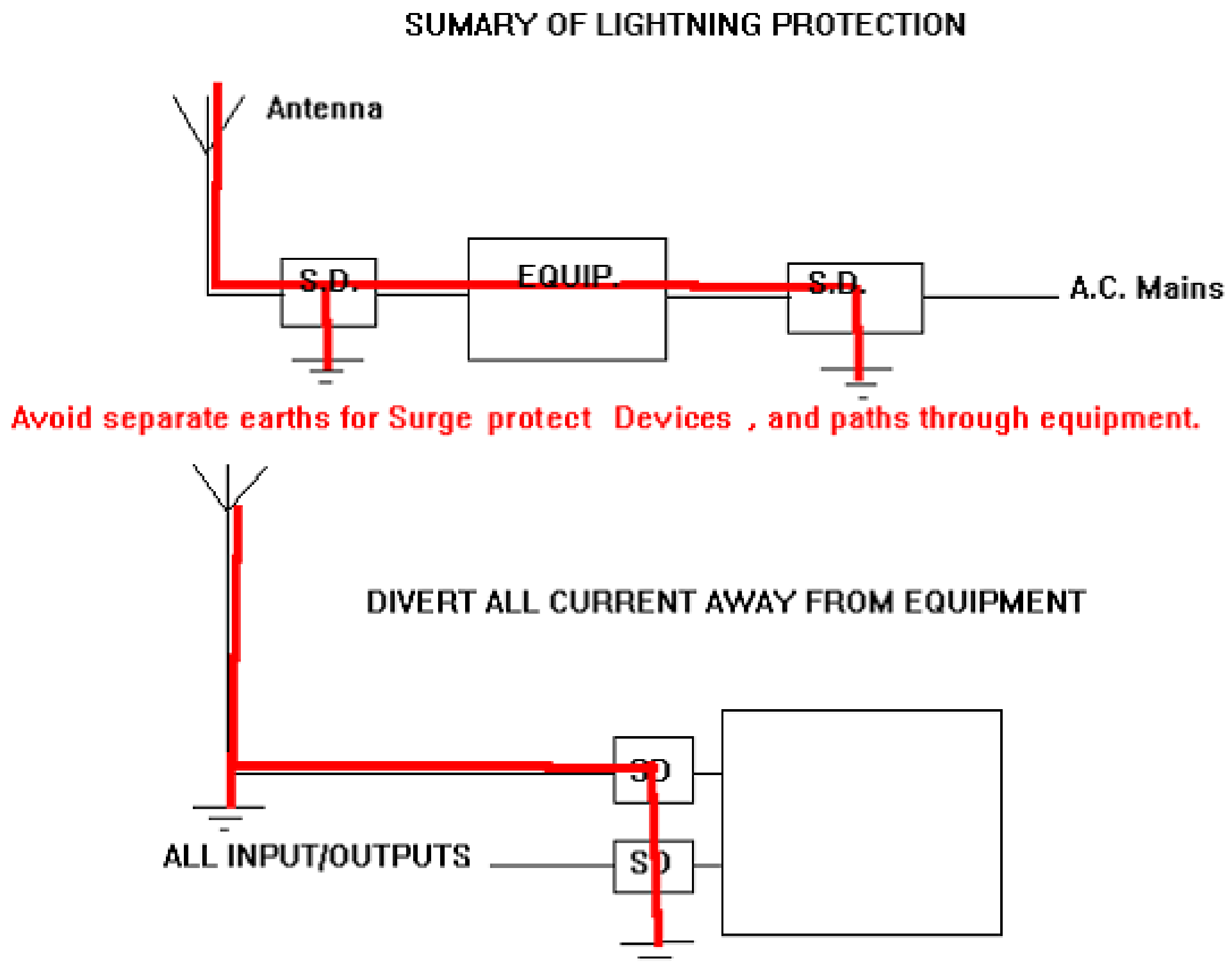
Ground potential



How Minimal Protection Works

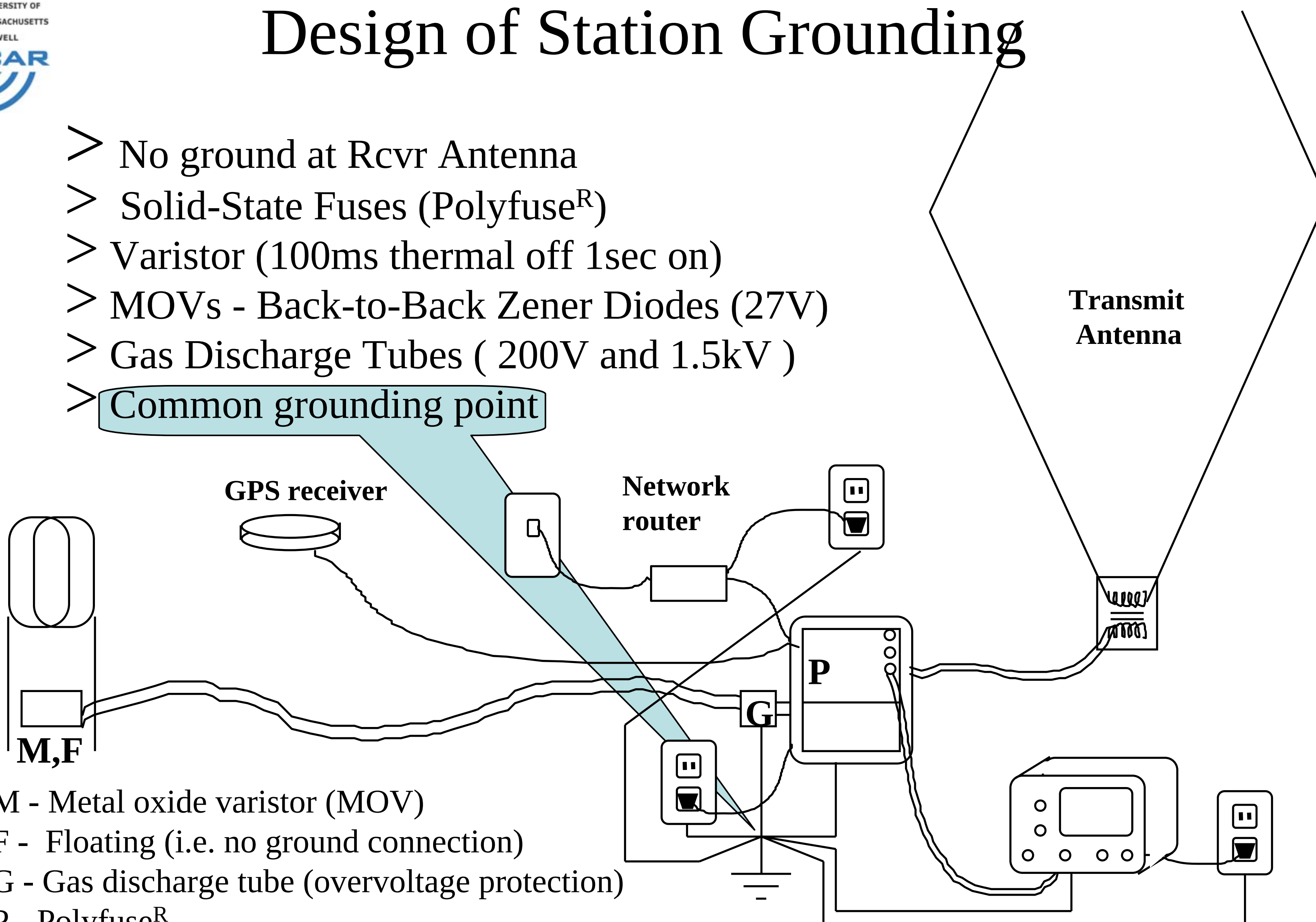


All “Grounds” must be at the same place



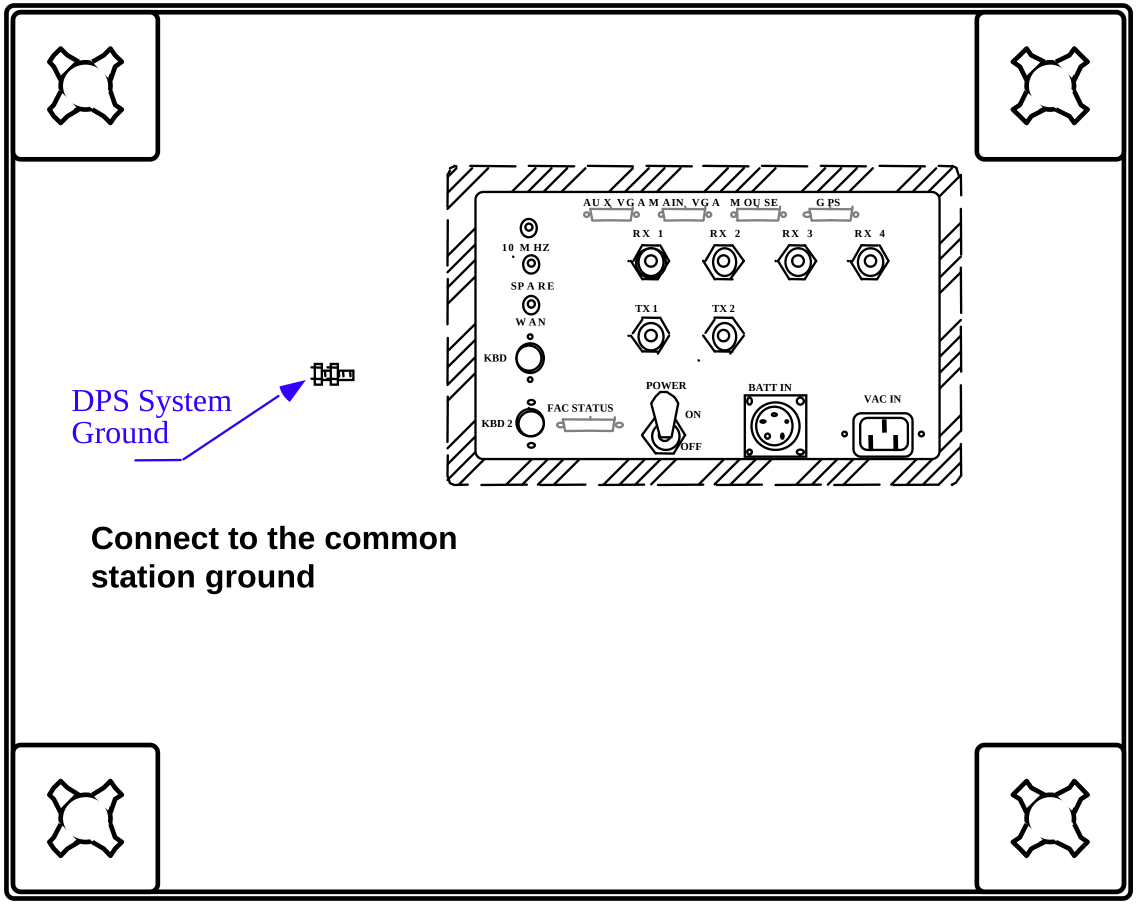
Design of Station Grounding

> No ground at Rcvr Antenna
> Solid-State Fuses (Polyfuse^{R})
> Varistor (100ms thermal off 1sec on)
> MOVs - Back-to-Back Zener Diodes (27V)
> Gas Discharge Tubes (200V and 1.5kV)
> Common grounding point



M - Metal oxide varistor (MOV)
F - Floating (i.e. no ground connection)
G - Gas discharge tube (overvoltage protection)
P - Polyfuse^{R}

Single Point Chassis Ground

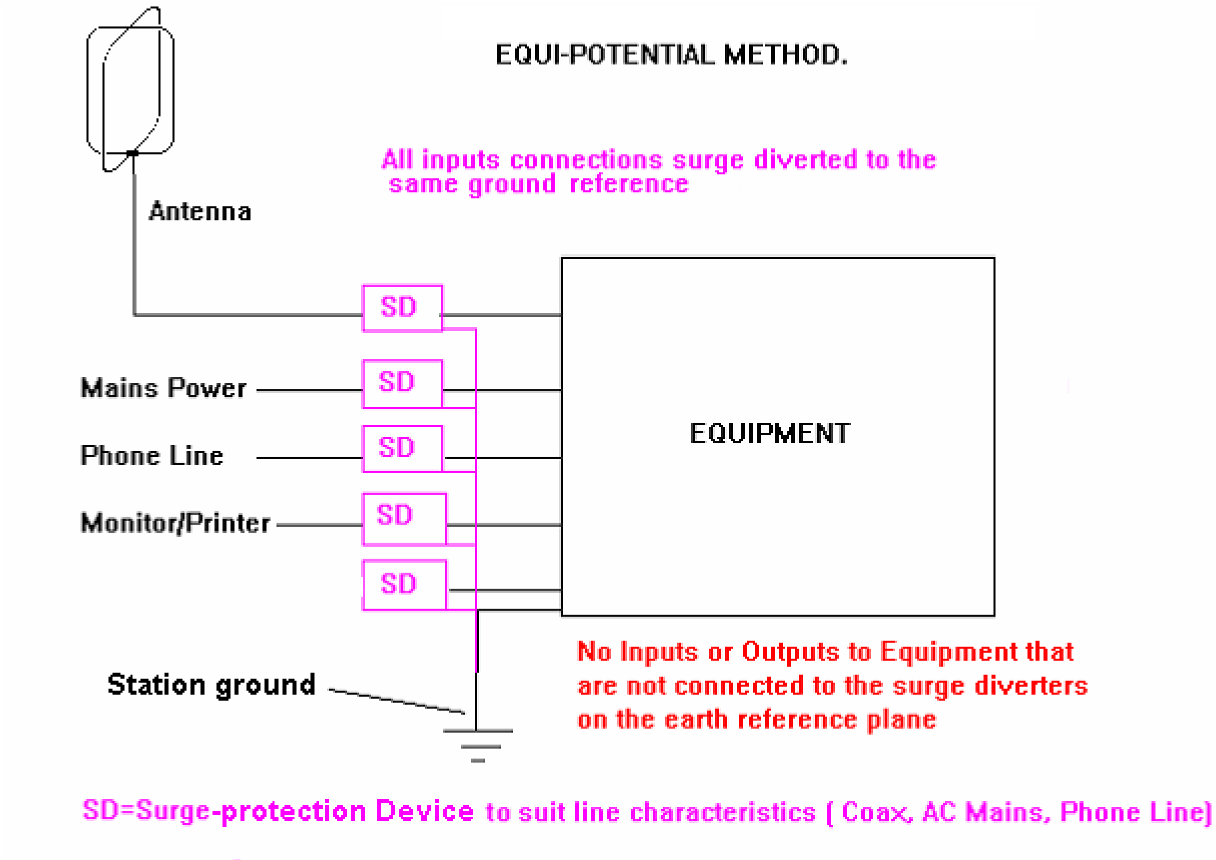


Connect to the common station ground

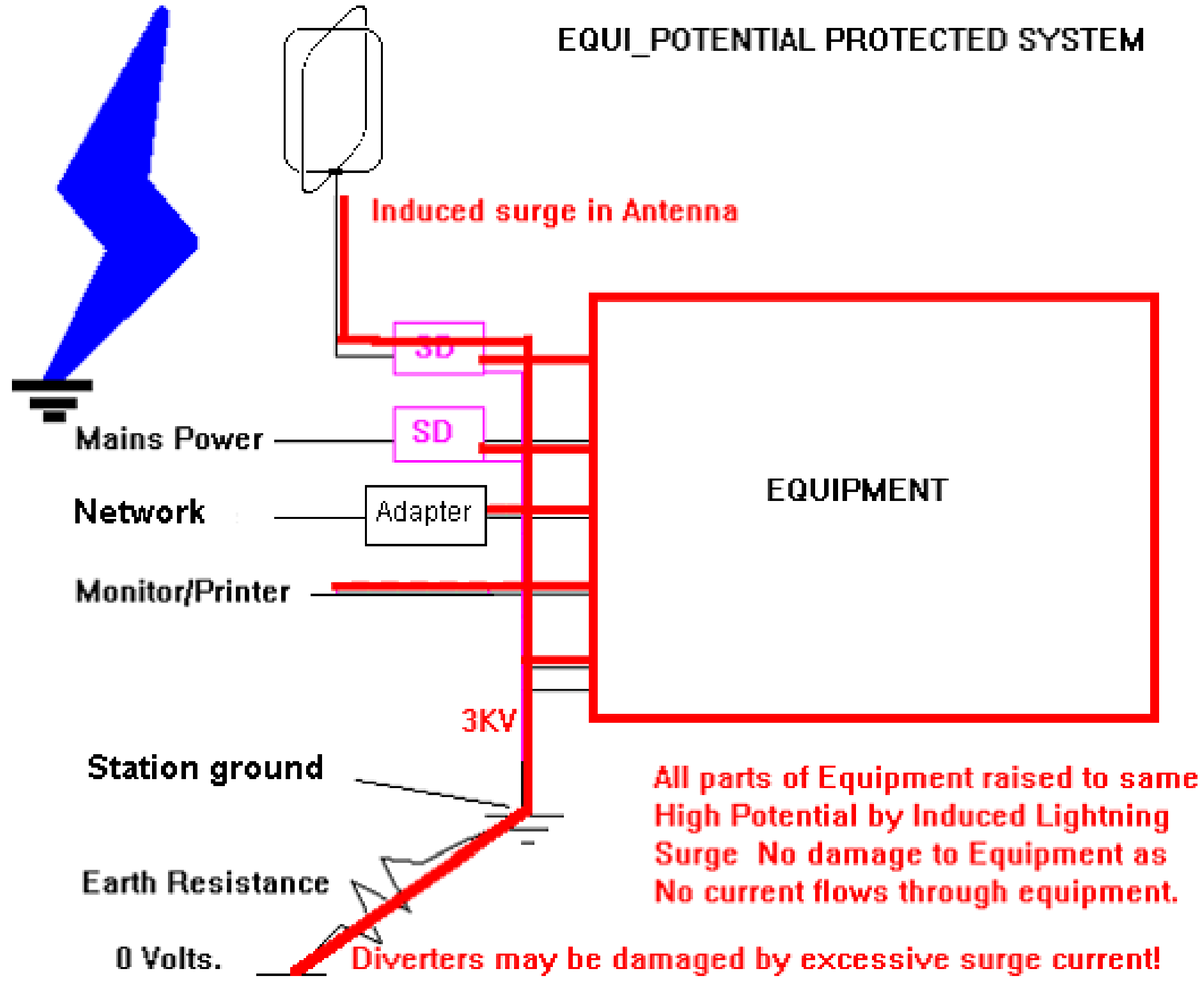
DPS Enclosure Rear Panel

EMI Gasket Area

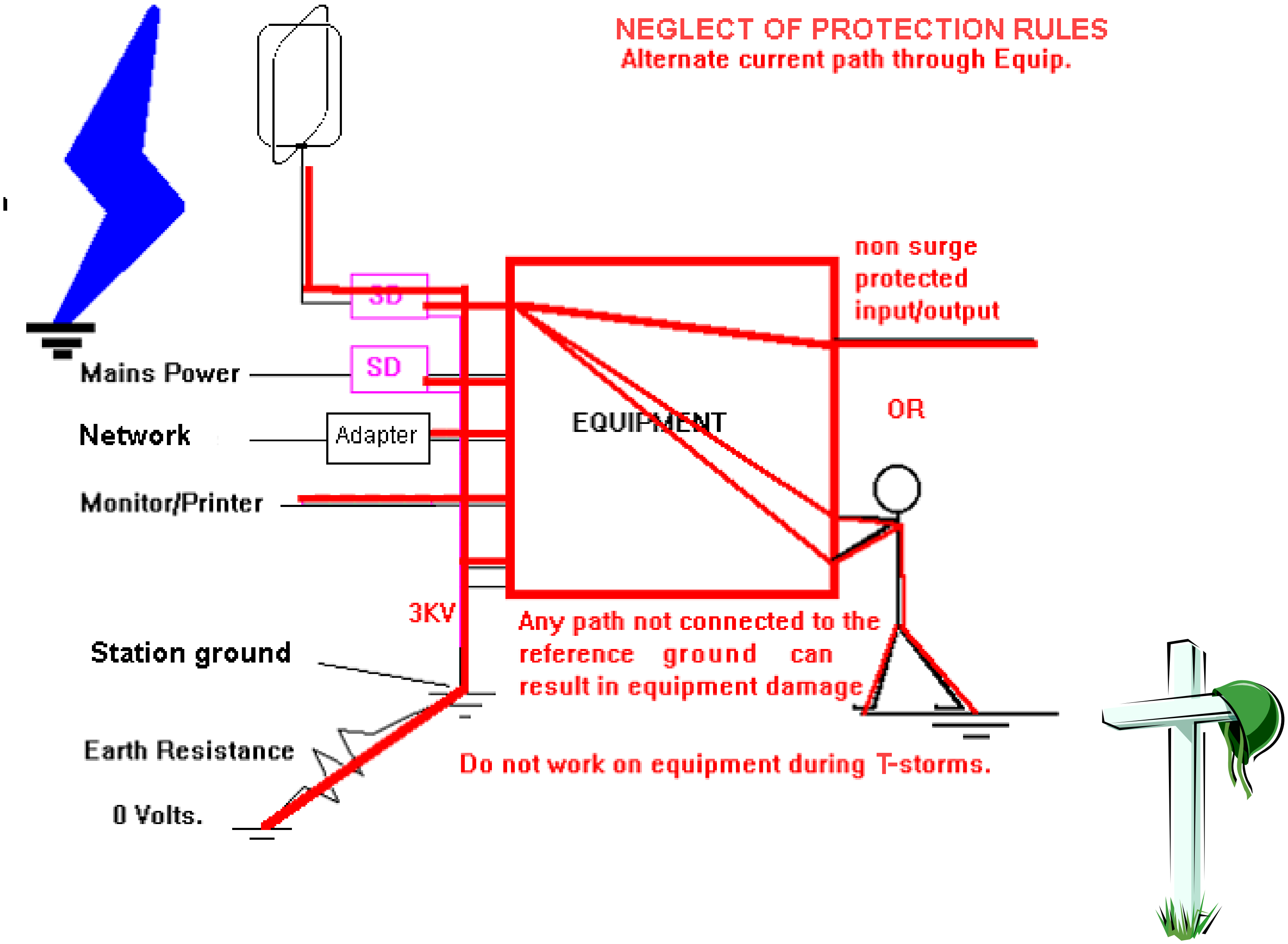
Typical well protected installation



How equi-potential system works



Don't touch equipment during a T-storm



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Oblique sounding with DPS and DPS-4D

Grigori Khmyrov

University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

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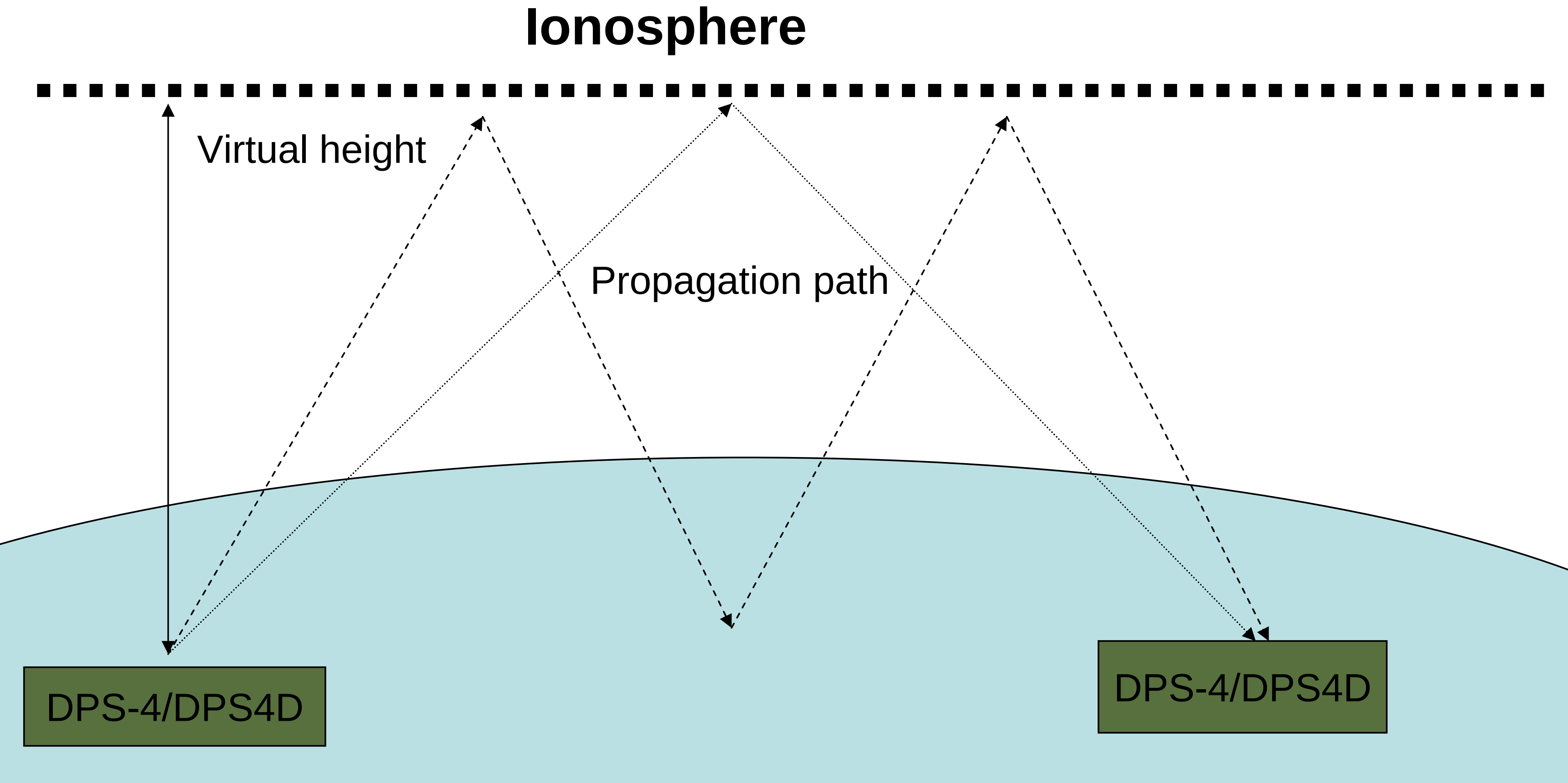
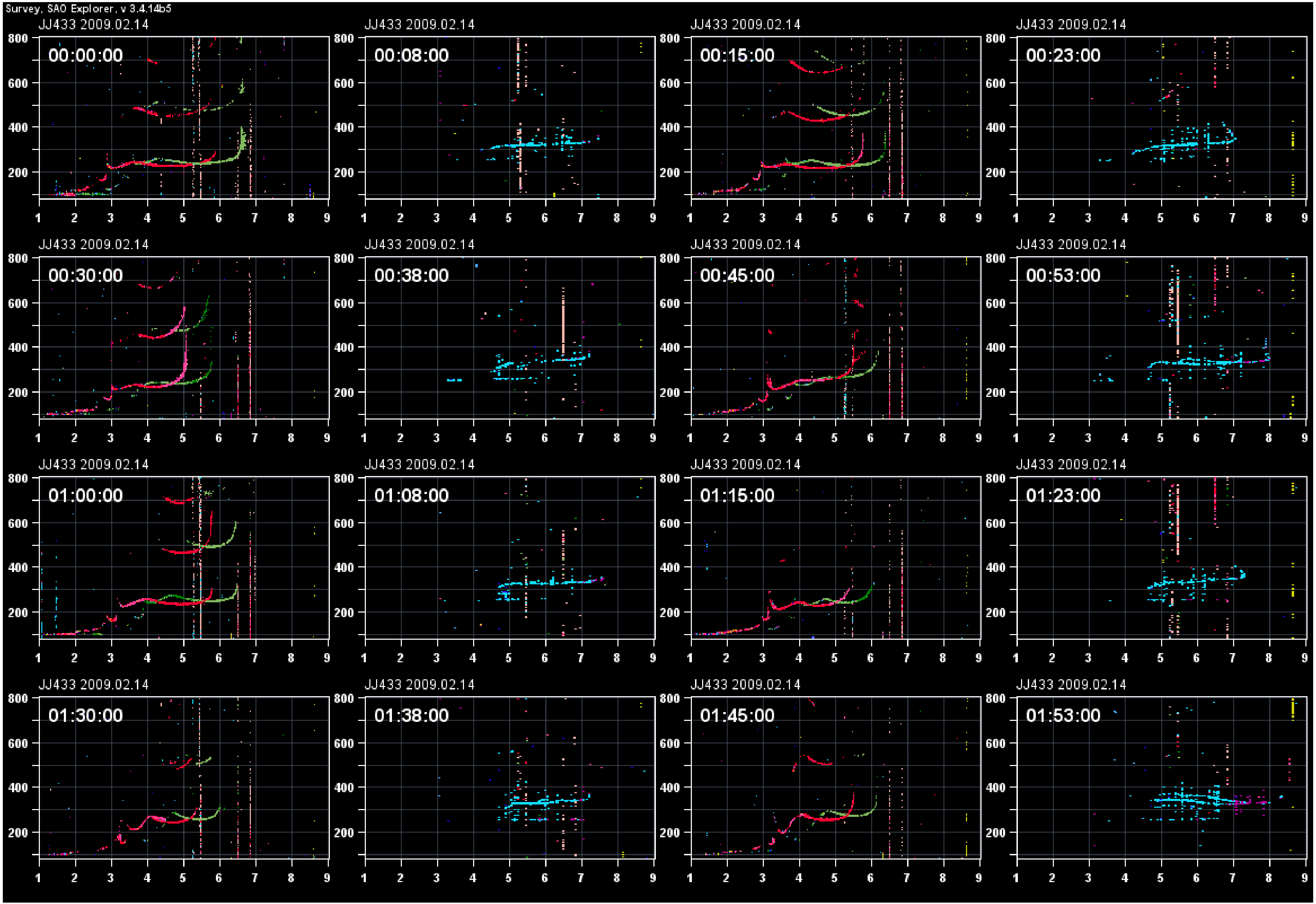
Vertical and Oblique sounding

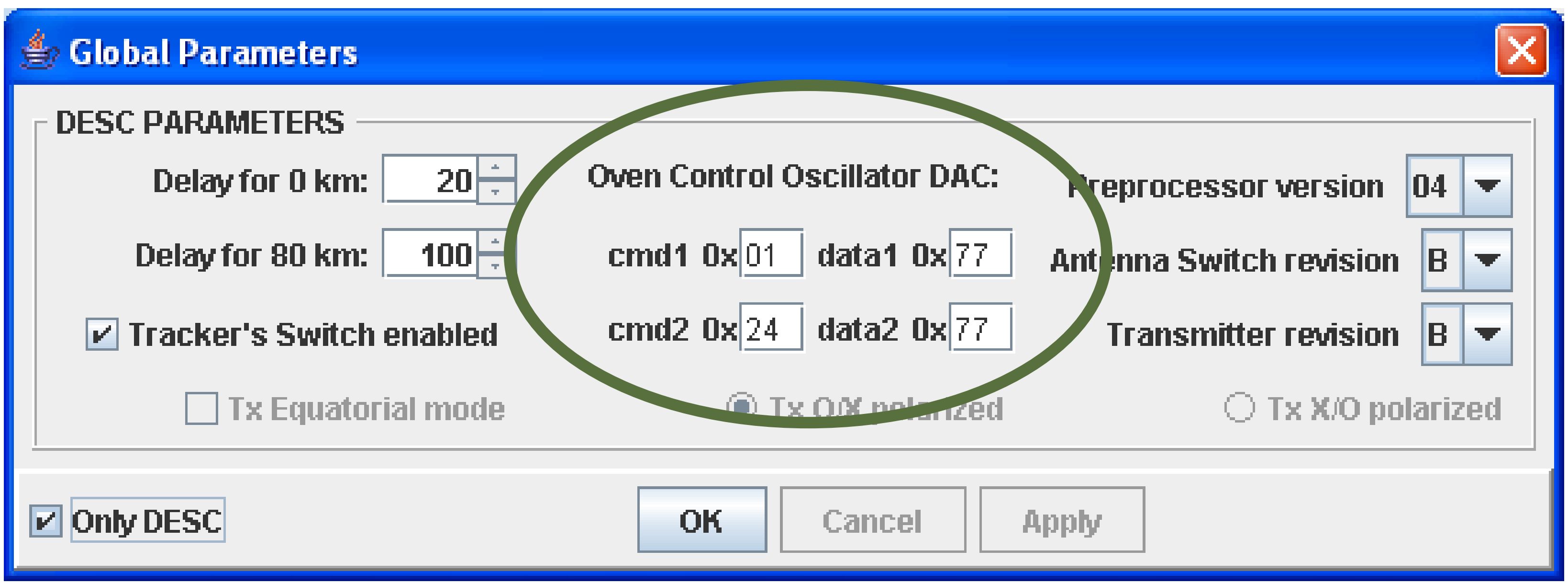


Regular Jeju (DPS-4D, SID 433, JJ433) ionograms and oblique ionograms from Anyang (DPS-4, SID 037, AN438) trancmitter and Jeju receiver. Path equals 444 km.

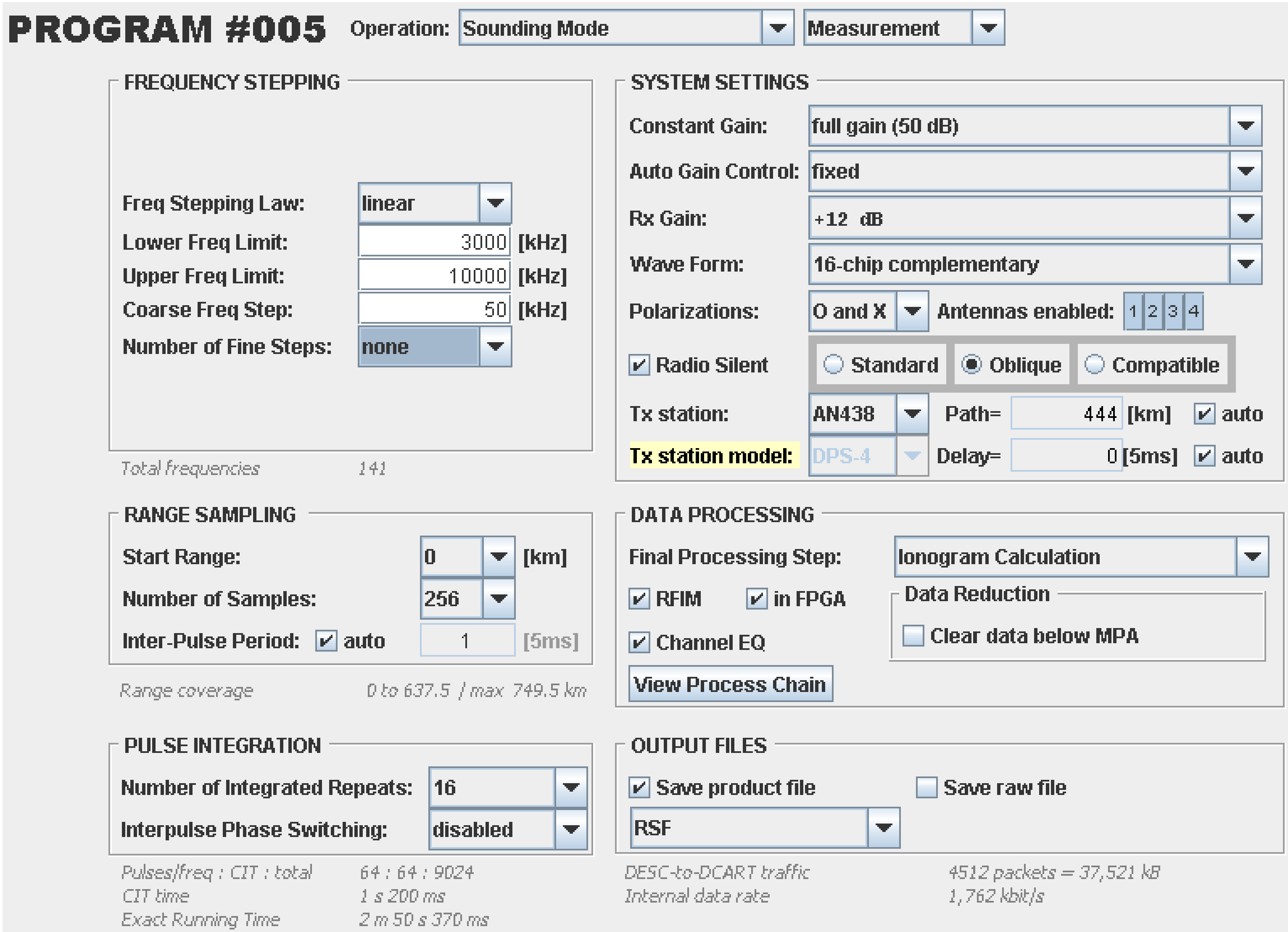


Time synchronization

- Global parameters to tune Oscillator Frequency
- GPS time synchronization

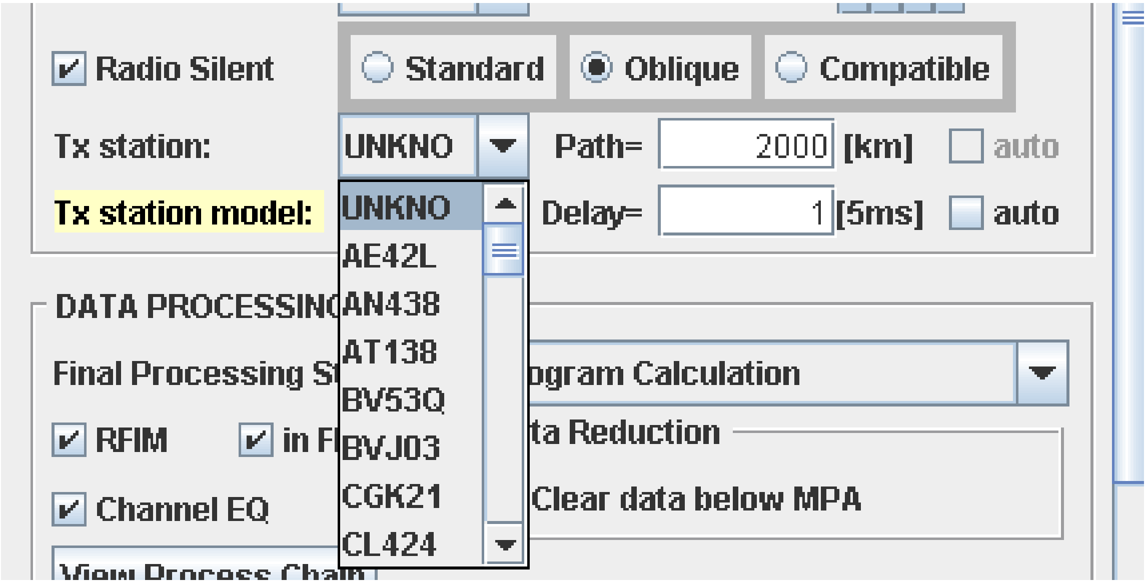


Oblique program



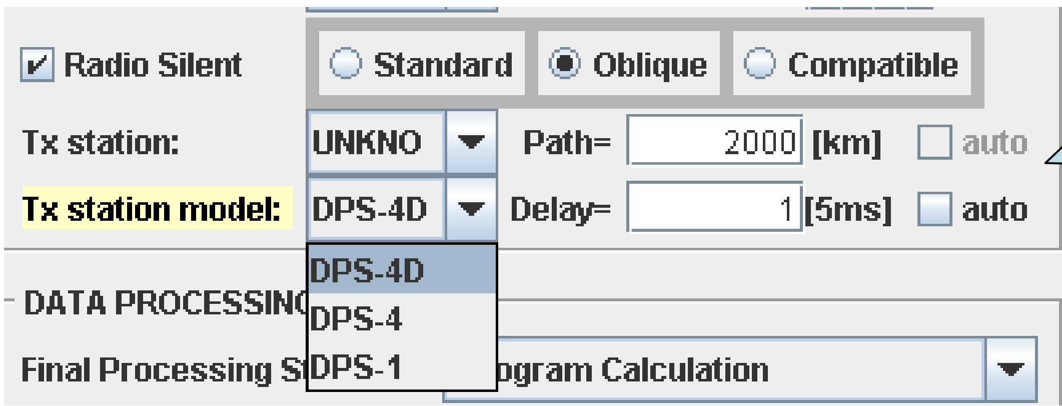
Oblique program 2

Station List / Unknown station



Oblique program 3

Type of DPS for unknown station

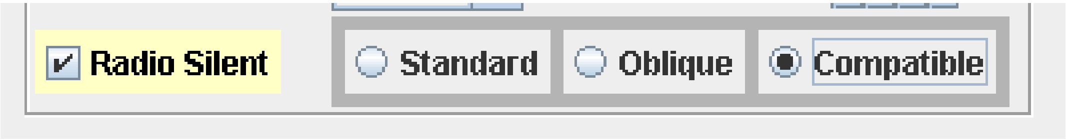


Manual input

Oblique program 4

Compatible mode

DPS-4D to DPS-4 transmission



Recommended oblique measurement settings

- 512 heights
- Use existing gain table – to adjust to background
- Run to higher frequencies

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WatchIt
automated data quality watch

Grigori Khmyrov
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

Data alert

- Digisonde network maintenance
  - 20 station
- Data alert criteria
- Alert software and technology

Alert criteria 1

- Check data in DIDBase marked as WatchIt stations
- For every station check for no data for more than 4 hours
  - Init file parameter: noDataInHours=12.0
  - Get time of latest available data
  - Compare to current time

Alert criteria 2

- For every station check for empty ionogram/scaling for more than 70.0 % of data for latest 4 hour(s)
  - Init file parameter: emptyDataInHours=12.0
  - Init file parameter: percentOfEmptyData=70.0
  - Empty data:

(countFOEP-countFMIN)/countFOEP*100

WatchIt application

- Schedule run of WatchIt application twice a day 7:00 and 16:00
- Send email if alert info changed
  - Reduce unnecessary emails
- Create Web Page
  - Always latest information on Internet

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Alert email

Subject: **Data problems**
From: Digisonde Alert <umlcar_alert@uml.edu>
Date: 4/19/2007 7:00 AM
To: Ryan_Hamel@uml.edu, Claude_Dozois@uml.edu, David_Kitrosser@uml.edu
Cc: Grigori_Khmyrov@uml.edu

```
Data problem report
(message created: 2007.04.19 07:00:52 LT, 2007.04.19 11:00:52 UT)
The webpage: http://car.uml.edu/WatchIt/dataProblems.html

No data for more than 12.0 hour(s)
Station name                 Latest data

OSAN AB                      2006.08.17 02:00:05
COLLEGE AK                   2007.04.18 08:00:05

Empty ionogram/scaling for more than 70.0 % of data for latest 12.0 hour(s)
Station name                 Magnetic latitude

GOOSE BAY                    63.200085
```

Alert Web Page

Data problem report

(message created: 2007.04.20 15:01:24 LT, 2007.04.20 19:01:24 UT)

No data for more than 12.0 hour(s)

Station name	Latest data
OSAN AB	2006.08.17 02:00:05
COLLEGE AK	2007.04.18 08:00:05

Empty ionogram/scaling for more than 70.0 % of data for latest 12.0 hour(s)

Station name	Magnetic latitude
GOOSE BAY	63.200085

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TROUBLESHOOTING SOFTWARE

Dr. Ivan Galkin
University of Massachusetts Lowell
Environmental, Earth, & Atmospheric Sciences Department
Center for Atmospheric Research

Troubleshooting

- Hardware troubleshooting with BIT and DCART – RH
- Sustaining operations in reduced configuratons – RH
- Site Installation validation – DK
- Programming mistakes – IG
- Software troubleshooting – IG

Outline

- Things NOT covered in this presentation
  - FEND/ARTIST-3, DPSCntl, and DCART
  - Windows problems
- Dispatcher with 2 Watchdogs & a Guardian
  - Hard disk overfill
- ARTIST and NHPC
  - The dreadful confidence level 55
- DFT2SKY, DDAV, TILT
- Picture making tools
- FTP deliveries
- Science data troubleshooting

“Die Hard” Dispatcher

- If dispatcher crashes, watchdogs reboot the computer
  - Software watchdog = 10 minute timeout
  - Hardware watchdog = 15 minute timeout
- Dispatcher’s screen prior to crash is available D:/WWW/control/screenCap_beforeReset.html
- If reset does not happen, try calling Guardian reset by putting Guardian.req file to D:\Secure\Incoming folder
  - This will request direct soft reset of Windows
  - Dispatcher dead and watchdogs unable to reset – indicates a very rare problem
    - Windows hangs while resetting, FTP still alive, hardware watchdog missing
    - A trip to observatory is warranted
    - Remote reset by modem is a long requested feature needed for very remote installations

Known Bad Scenarios

- File needs to be deleted, but it is however locked for access by windows
  - Example: FTP client crashes trying to append to a damaged stat file. No communications.
  - Example: ARTIST crashes trying to contact DIDBase, ARTIST502.jar is locked and cannot be upgraded. No autoscaling.
  - Example: pkzip25 crashes, leaving .zip file locked. Accumulating zip files.
  - DDAV crashes leaving DRIFT0.SKY file locked. No drift processing occurs.
- Solution: add delete command to DPS_Init.bat, then remote-reset, then remove delete command

Known Bad Scenarios (2)

- Incoming file from digisonde has an illegal character in the name and cannot be removed via call to Windows file system. Dispatcher initiates processing of the file repeatedly and indefinitely.
- Solution: rename DPS2AUX folder, create new DPS2AUX folder.

Known Bad Scenarios (3)

- New Dispatch.exe is bad after upload
  - Can happen if reset happens while dispatch.new is still uploading
  - This is one file you need to be VERY carefull upgrading. Never upload dispatch.new directly.
  - Software watchdog will be resetting windows every 10 minutes
  - Upload dispatch.new, quickly. If the link is too slow,
    - Consider temporarily uninstalling sotware watchdog in DPS_Init.bat (watchdog –remove).
    - Consider asking Ivan to provide small dispatcher program that only feeds the watchdog

ARTIST-5 and NHPC

- NHPC unable to complete inversion
  - ARTIST-5 will attempt to kill NHPC process
  - Offending SAO file goes into Output folder with added .timeout extension
  - If NHPC process cannot be terminated, memory may be filled with these processes. Not Good. (So far, does not happen).
  - Send us *.SAO.timeout files.

ARTIST-5 and NHPC (2)

- ARTIST-5 crashes (e.g., array index out of bounds)
  - Dispatcher places offending ionogram file to D:\Diagnostics\
  - Can be caused by illegal program definition, e.g., wrong frequency stepping
  - If happens frequently, problems with data gaps and many files in /Diagnostics
- Send us the offending ionogram files

ARTIST-5 and C-level 55

- Usually indicates unreasonable ARTIST trace that NHPC correctly flags down
- Smaller frequency step and smaller N can help
- Consider 5 km steps instead of 2.5 km

Drift Processing

- IMPORTANT: edit DDASETUP.ONL file to remove height restriction that blocks processing of E-layer drift.
- Visible in Daily Drift Display panel (empty E layer panel)
- Question *169 – set to 90

Picture Making Tools

- Always check pictures after software updates
- If pictures are not being made
  - check .out and .err files for diagnostic information
  - Directogram pictures require RSF ionograms

FTP deliveries

- FTP FAILED message
  - Server may have unusual response to successful rename command. Get the latest dispatcher
  - Check packet timeout statistics. Poor link may cause FTP timeouts
  - Server response and packet stats are available in Buffers/FTP_X/System/ folder.

Science Content Check

- Consistency of phase measurements is important
- Good quality of Precision Ranging is indicative of correct phase calibration and processing
- Skymaps during quiet conditions shall show one small cluster at zero zenith
  - If never the case, check 4 channels
- Equatorial locations: sanity check for eastward drift of bubbles, plus check drift plot for pre-reversal enhancement and vertical uplifting of the ionosphere
- Polar cap locations: check the azimuth of drift velocity to follow anti-sunward direction.