Electric Field Observations on the ACES Sounding Rockets

DC Electric Fields, ELF Wave Measurements

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ACES Workshop
NASA Goddard Space Flight Center

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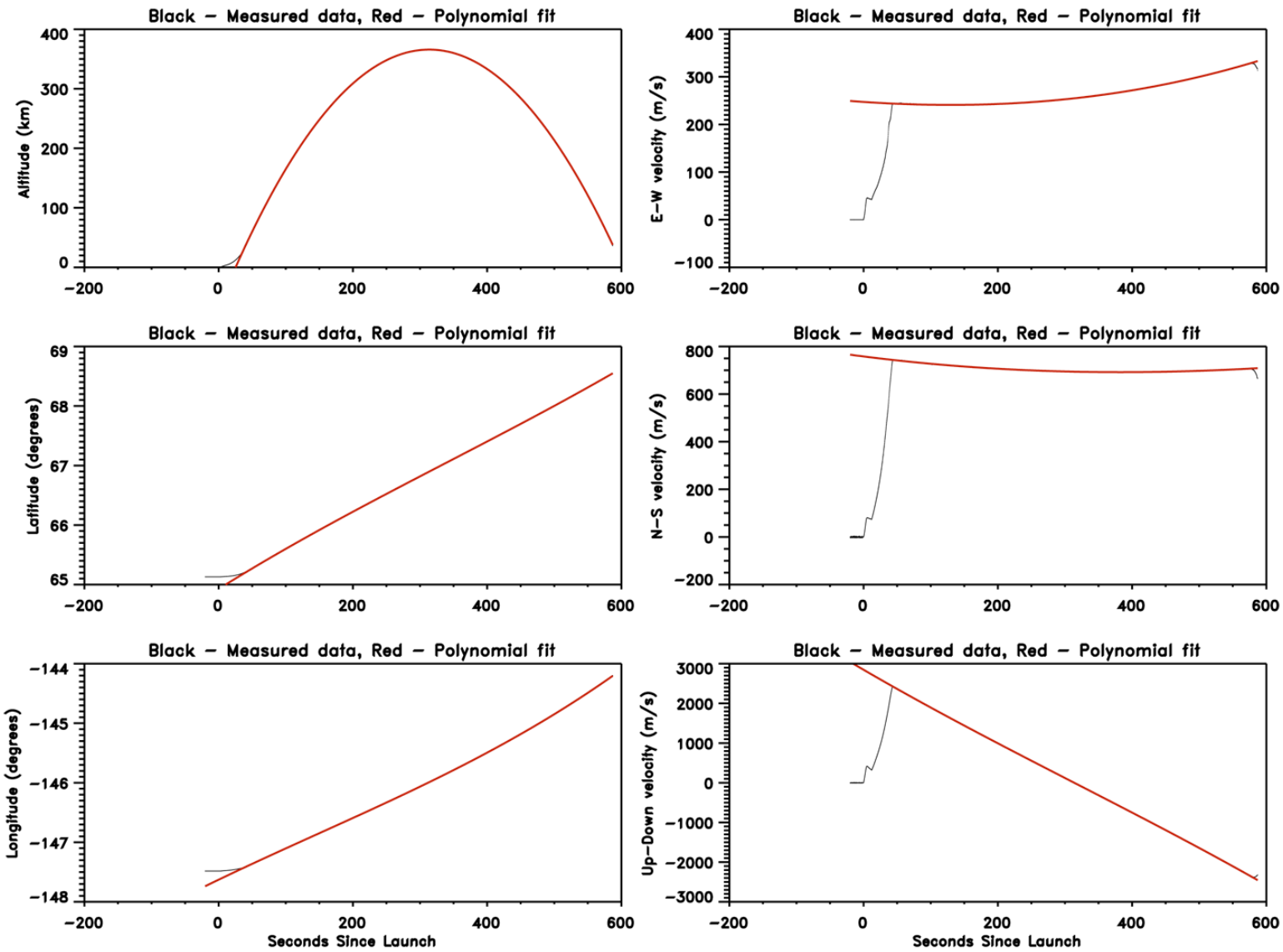
ACES Trajectory Data (from WFF)

Polynomial Fits (at GSFC) To:

Altitude, Latitude, Longitude,
E-W Velocity, N-S Velocity, Up-Down Velocity

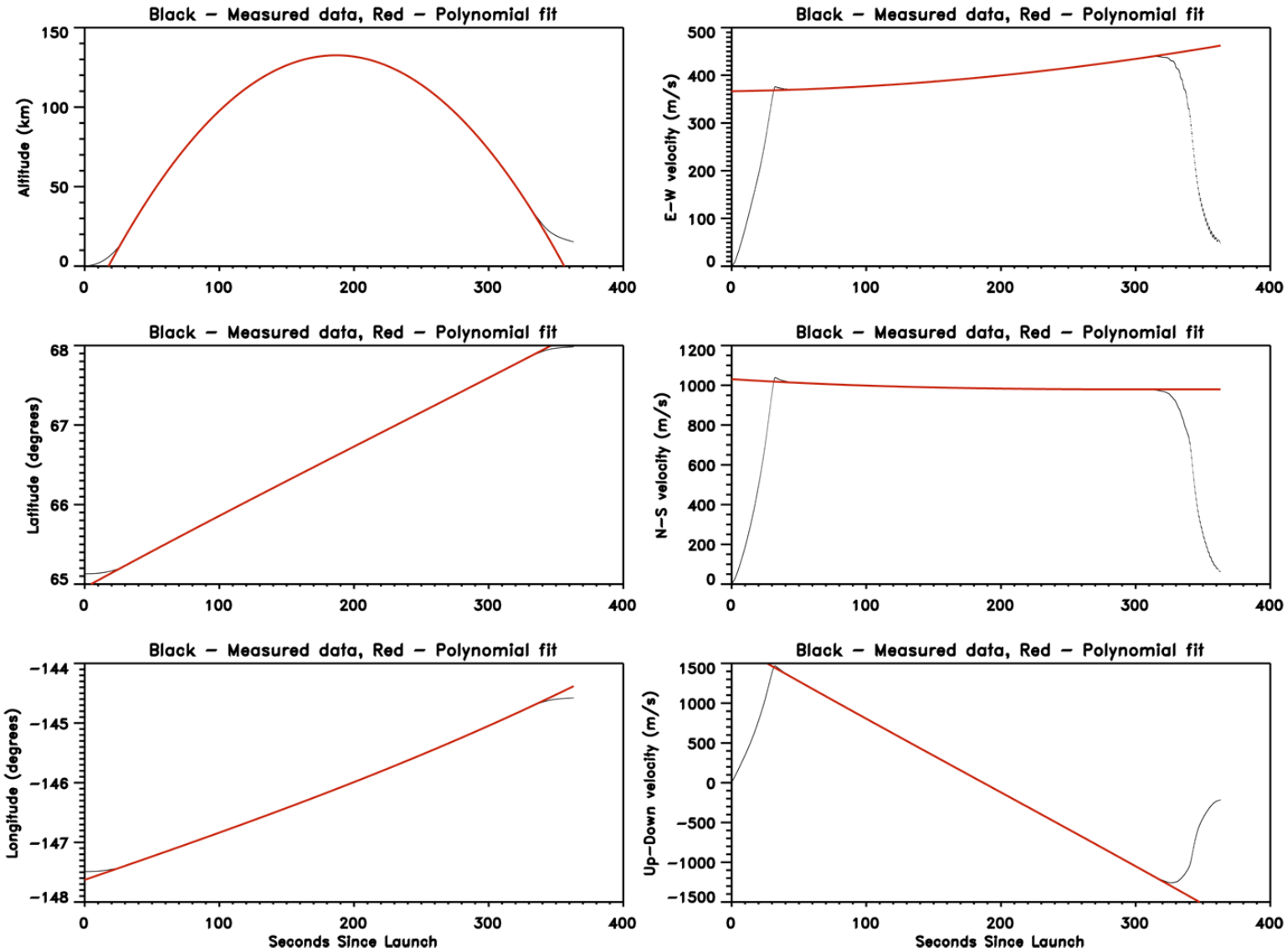
Poker Flat, Alaska -- 36.242

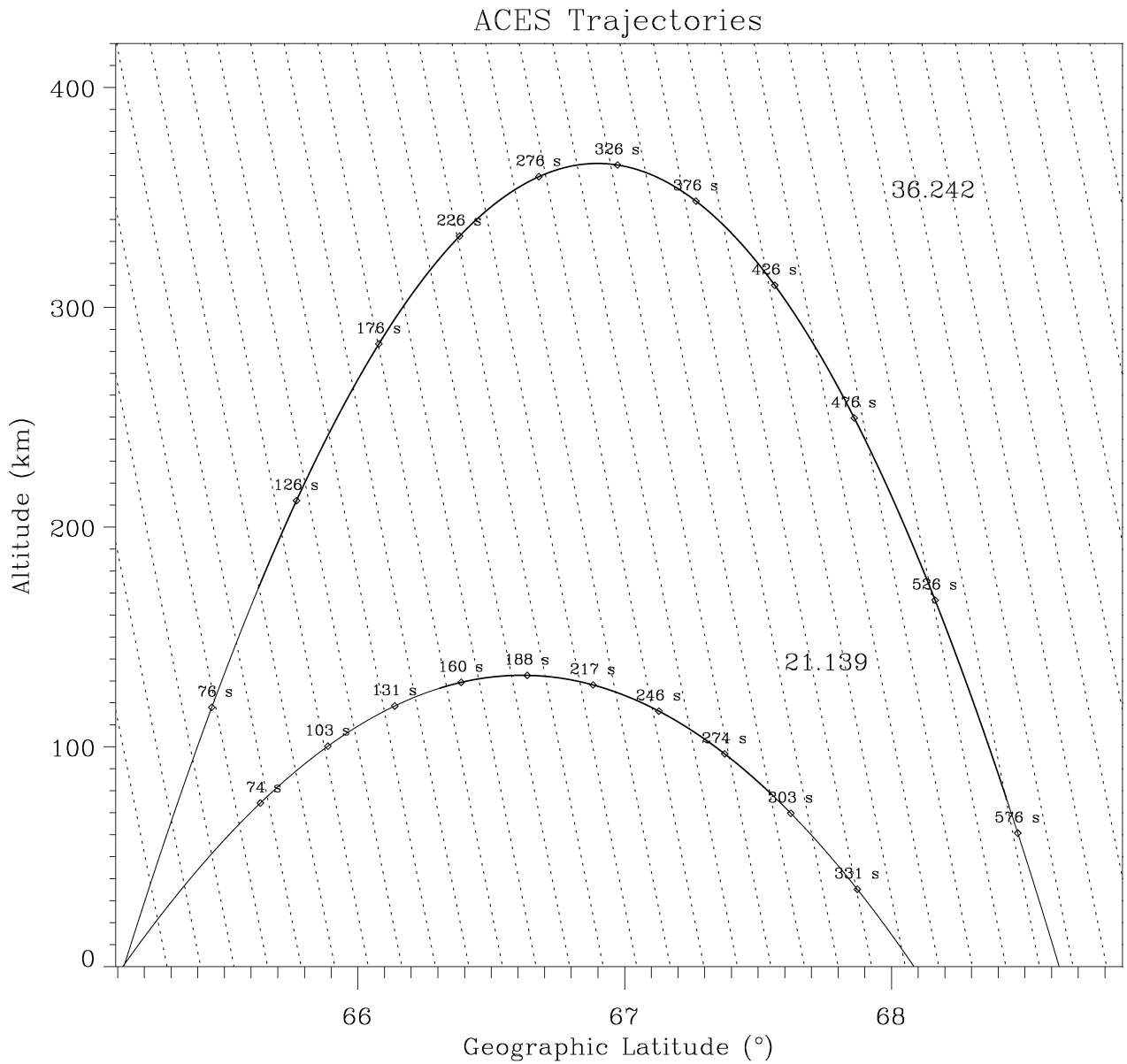
29 January 2009, 9:49:40.1 U.T.



Poker Flat, Alaska -- 21.139

29 January 2009, 9:51:10.4 U.T.



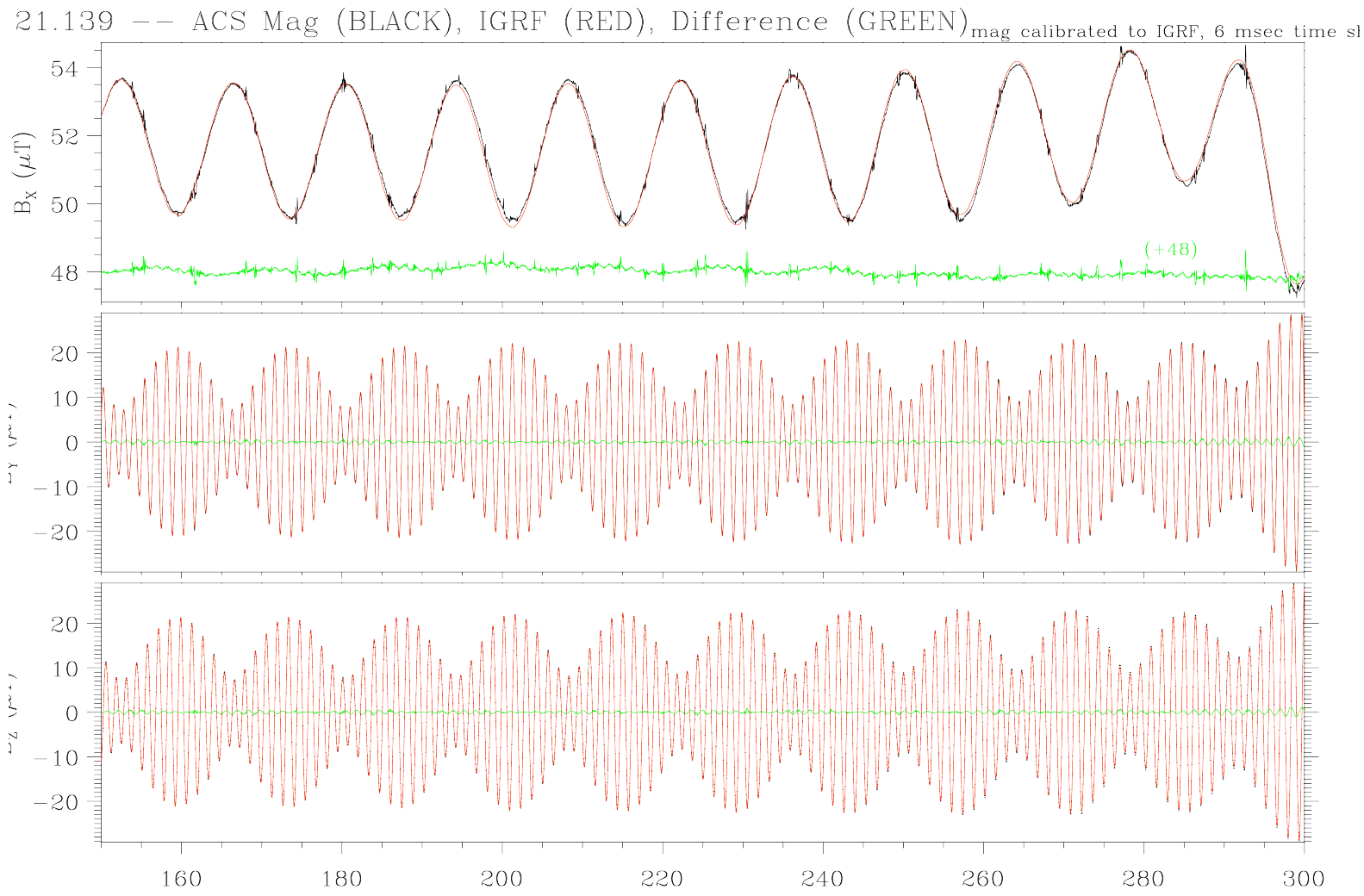


HF 9/04/09 17:55

ACES “Low” -- 21.139

Verification of Gyro (Attitude) data using magnetic field data

Predicted (using gyro attitude) and *Actual* measured (WFF) magnetic field data

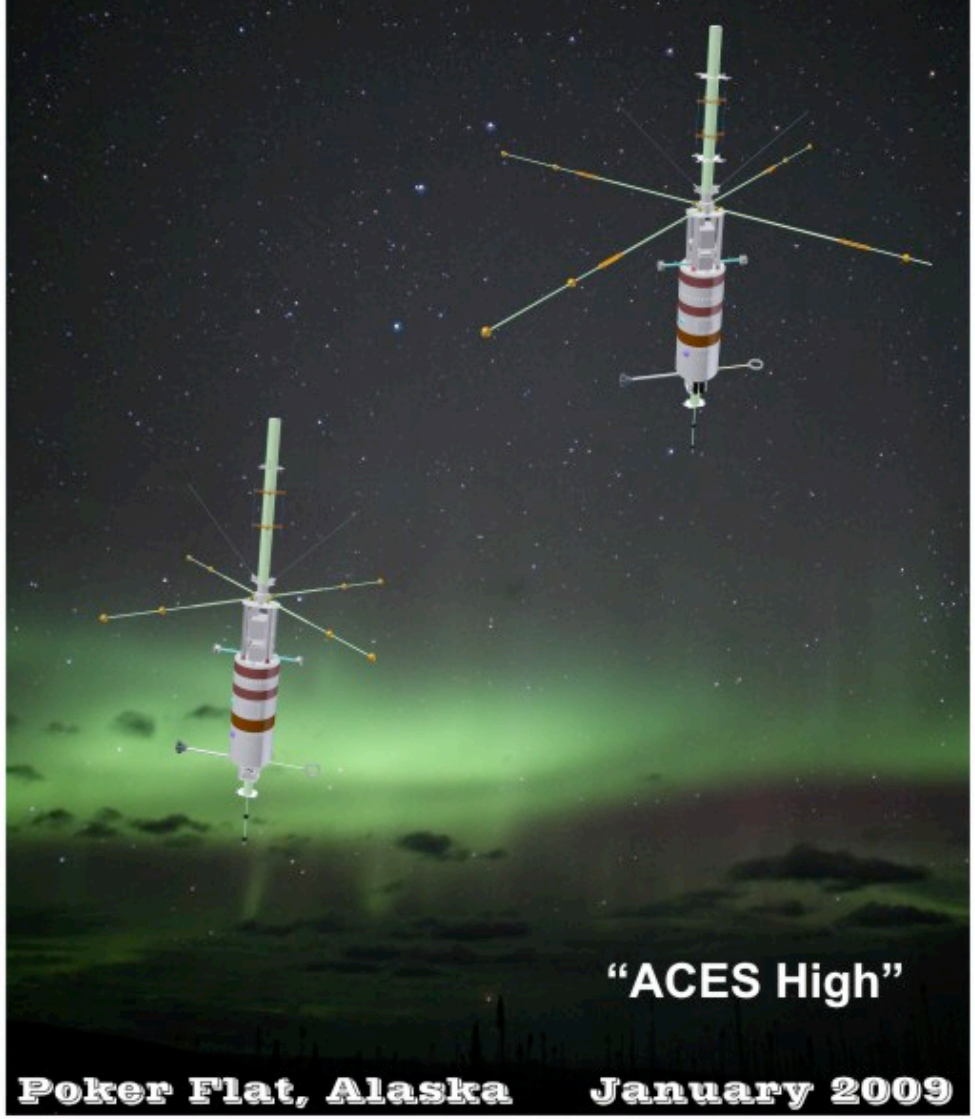


Seconds After Launch (09:51:10 UT)

ACES “Low” -- 21.139

DC Electric Field Measurements

Auroral Current and Electrodynamics Structure (ACES) Sounding Rockets 21.139 & 36.242

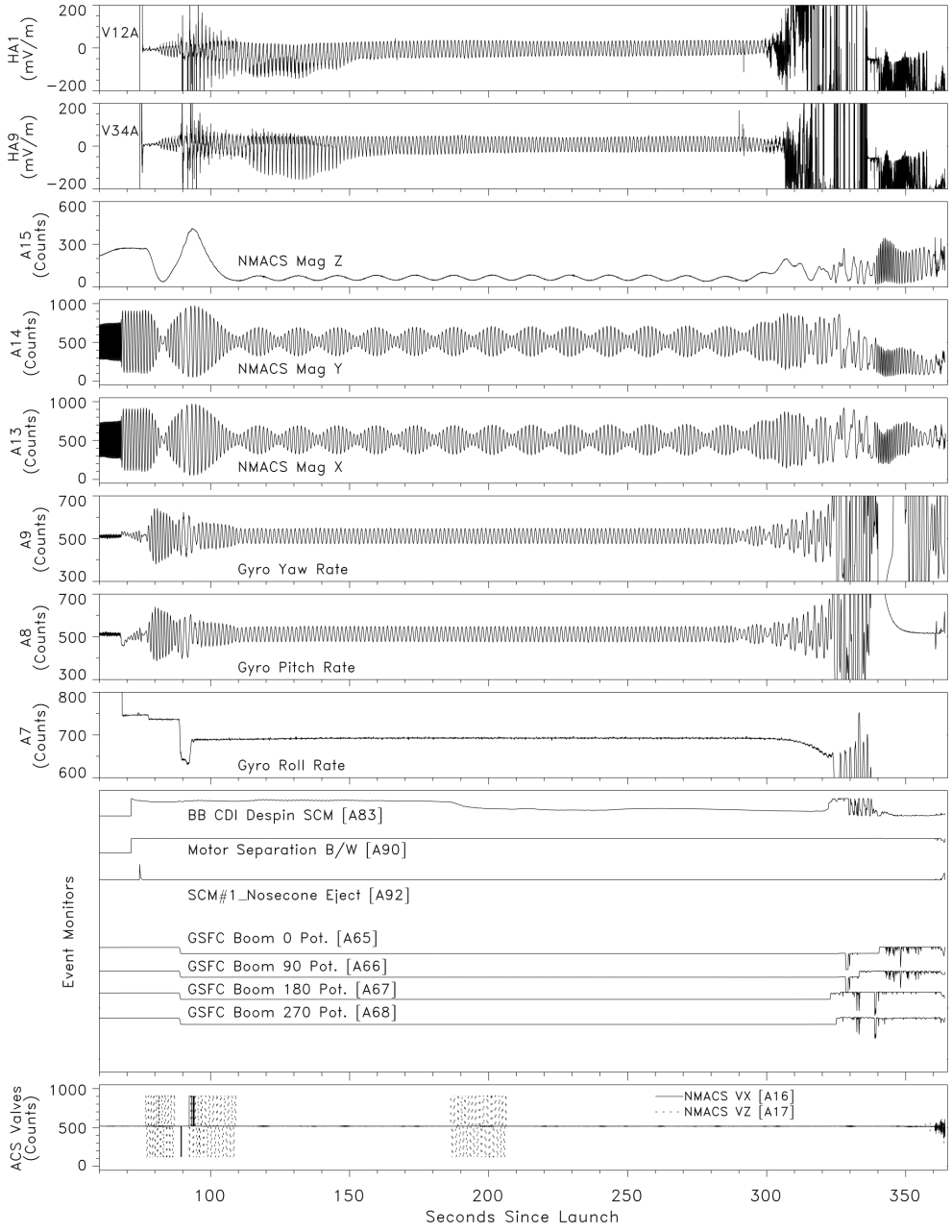


Poker Flat, Alaska January 2009

Poker Flat, Alaska -- 21.139 (ACES Low)

29 January 2009, 09:51:11.0 U.T.

Event Monitor Study



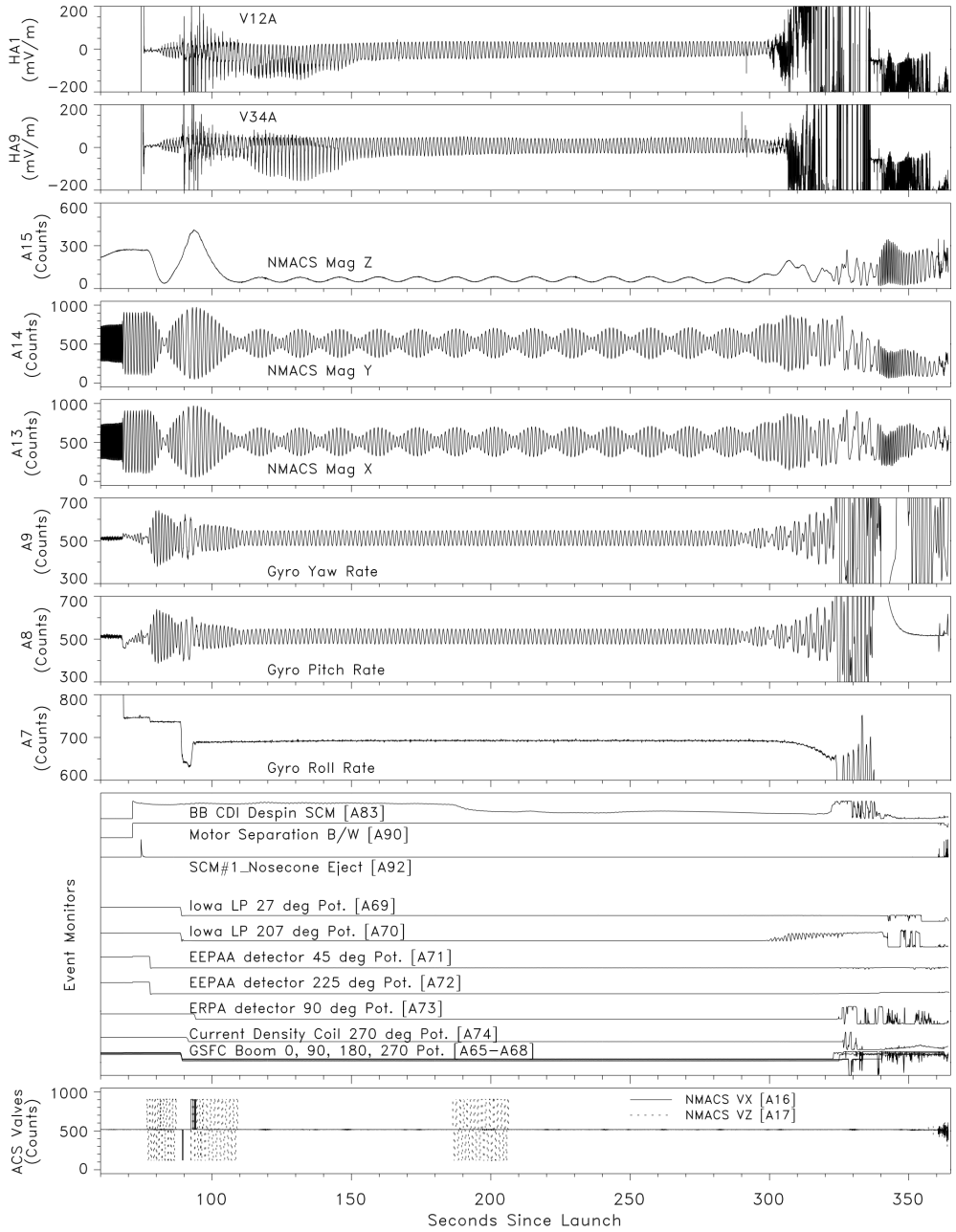
21139_BoomMonitorEvents_60sec-LOS.ps

SCM Fri Feb 6 09:34:54 2009

Poker Flat, Alaska -- 21.139 (ACES Low)

29 January 2009, 09:51:11.0 U.T.

Event Monitor Study



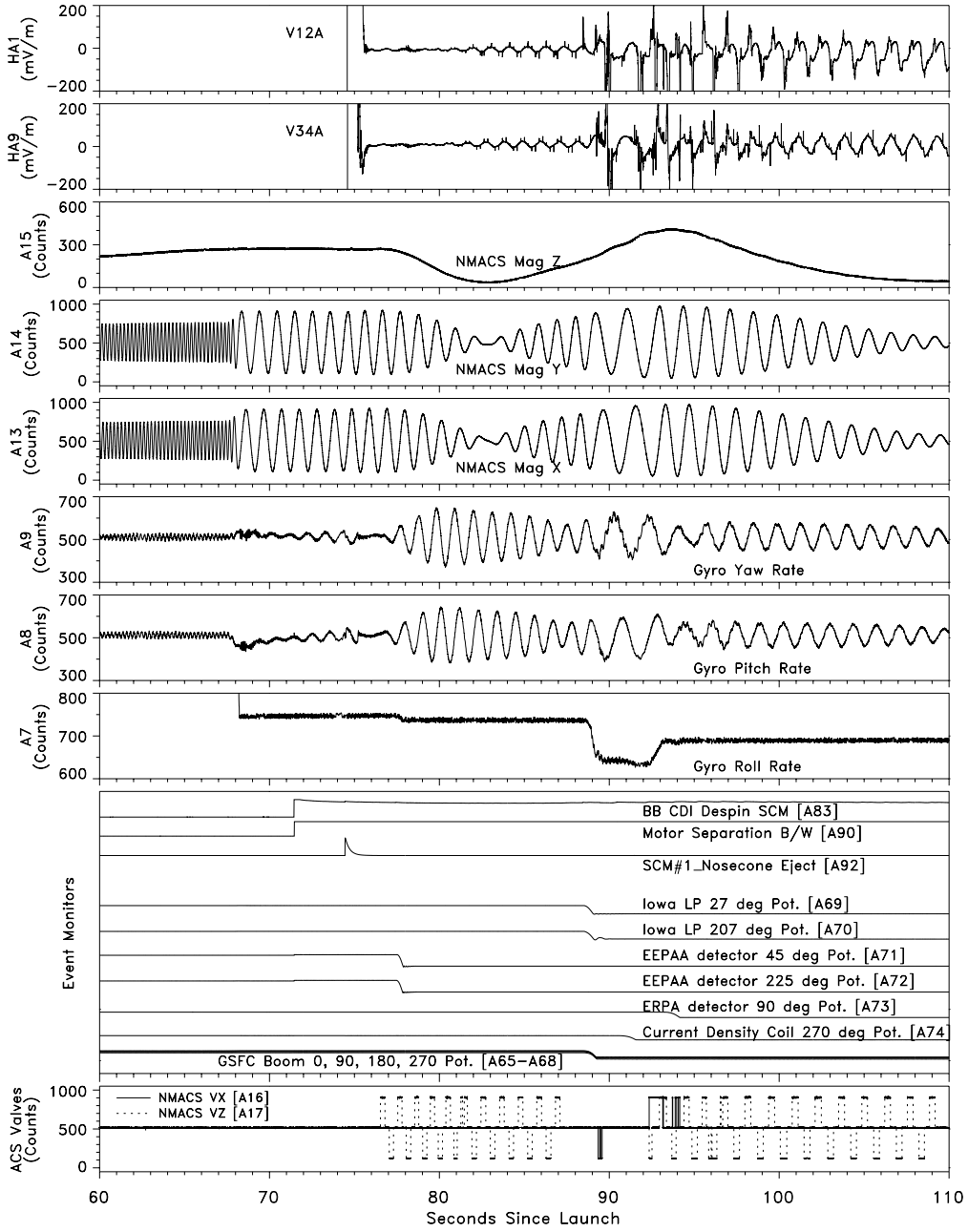
21139_BoomMonitorEvents_A65-A74_60sec-LOS.ps

SCM Fri Feb 6 09:53:59 2009

Poker Flat, Alaska -- 21.139 (ACES Low)

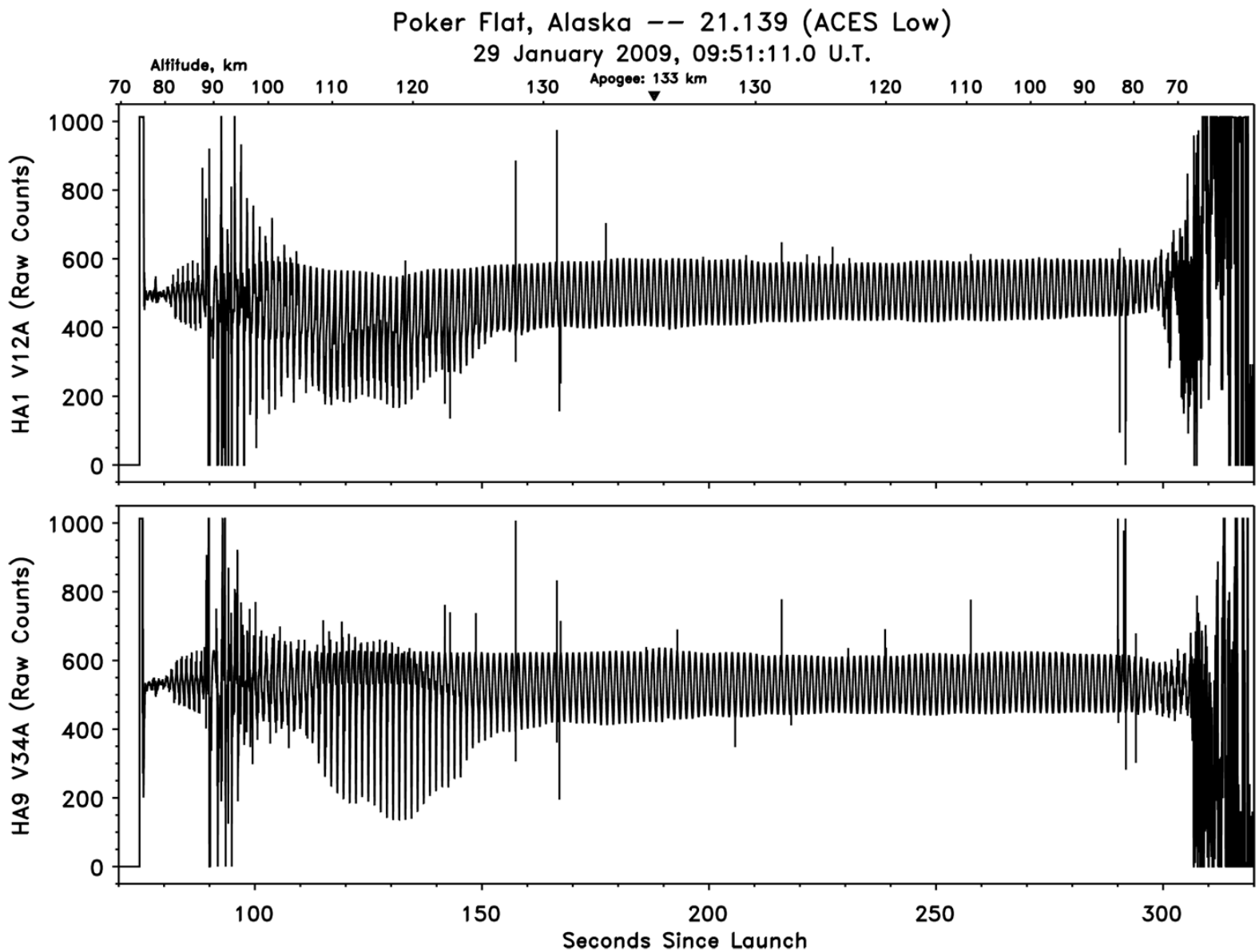
29 January 2009, 09:51:11.0 U.T.

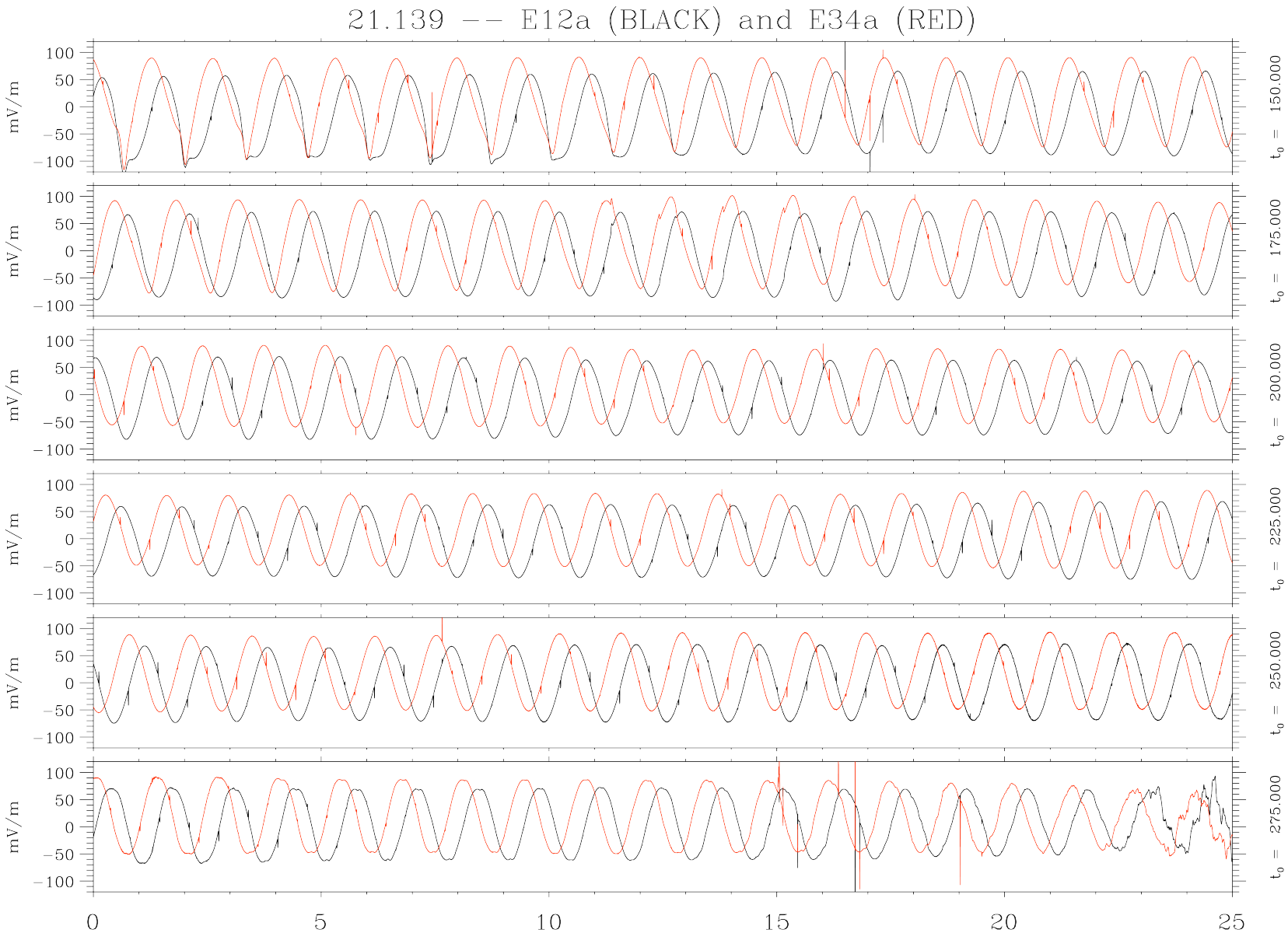
Event Monitor Study

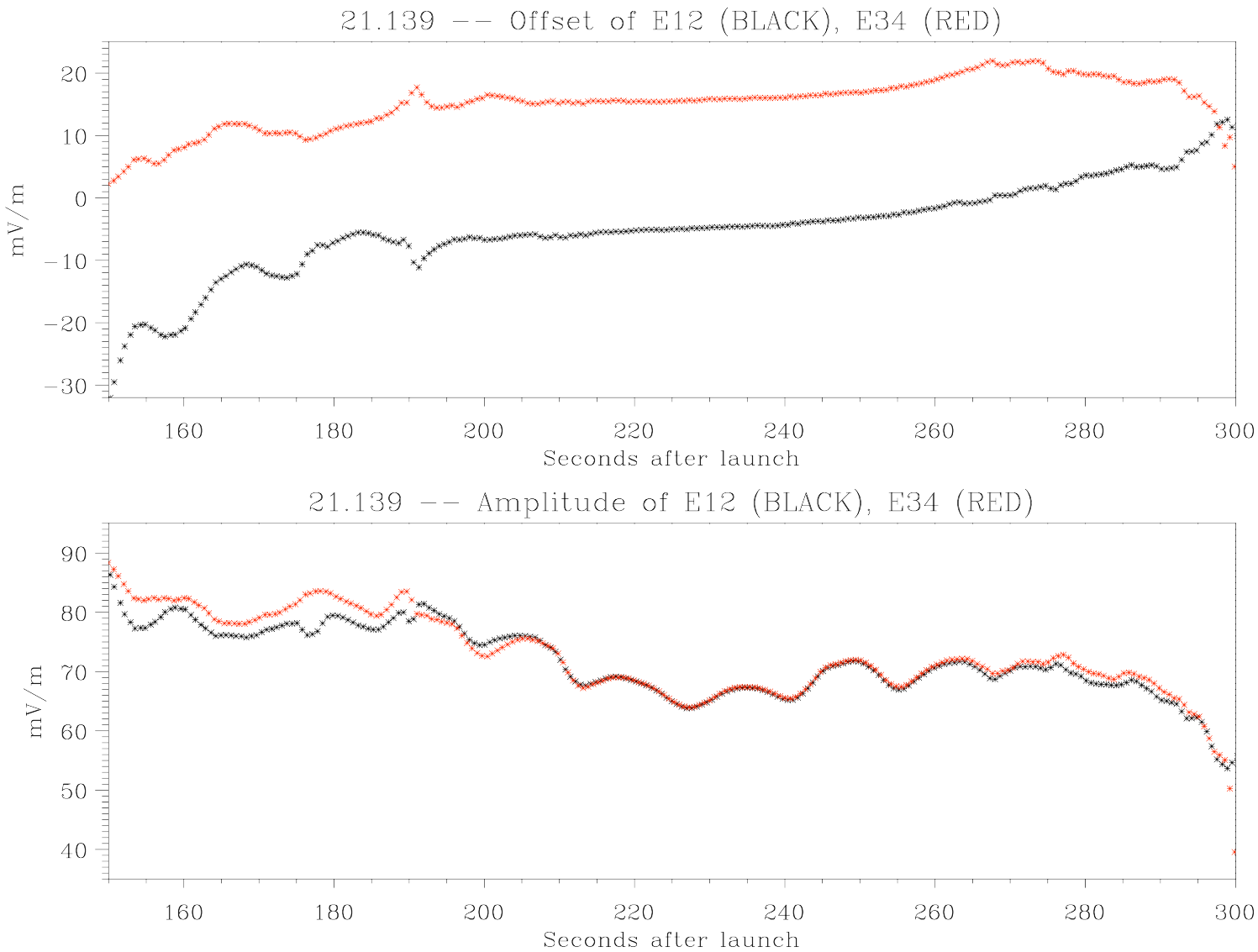


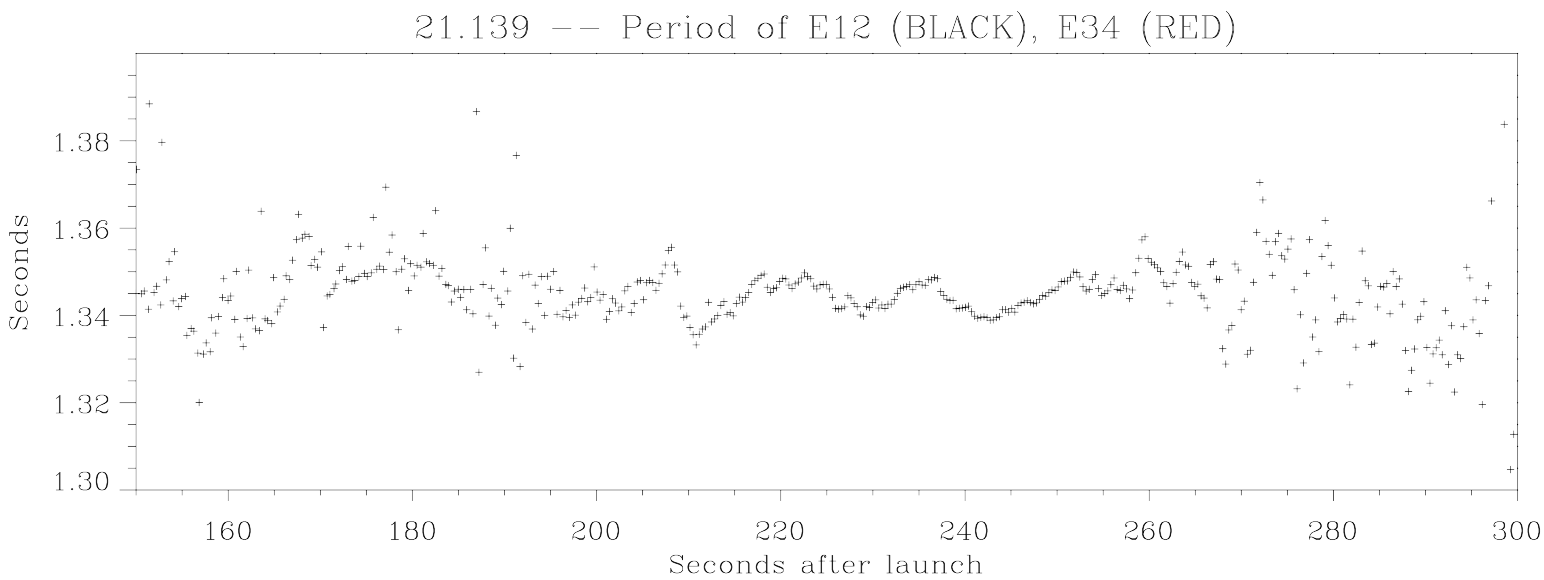
21139_BoomMonitorEvents_A65-A74_60-110sec.ps

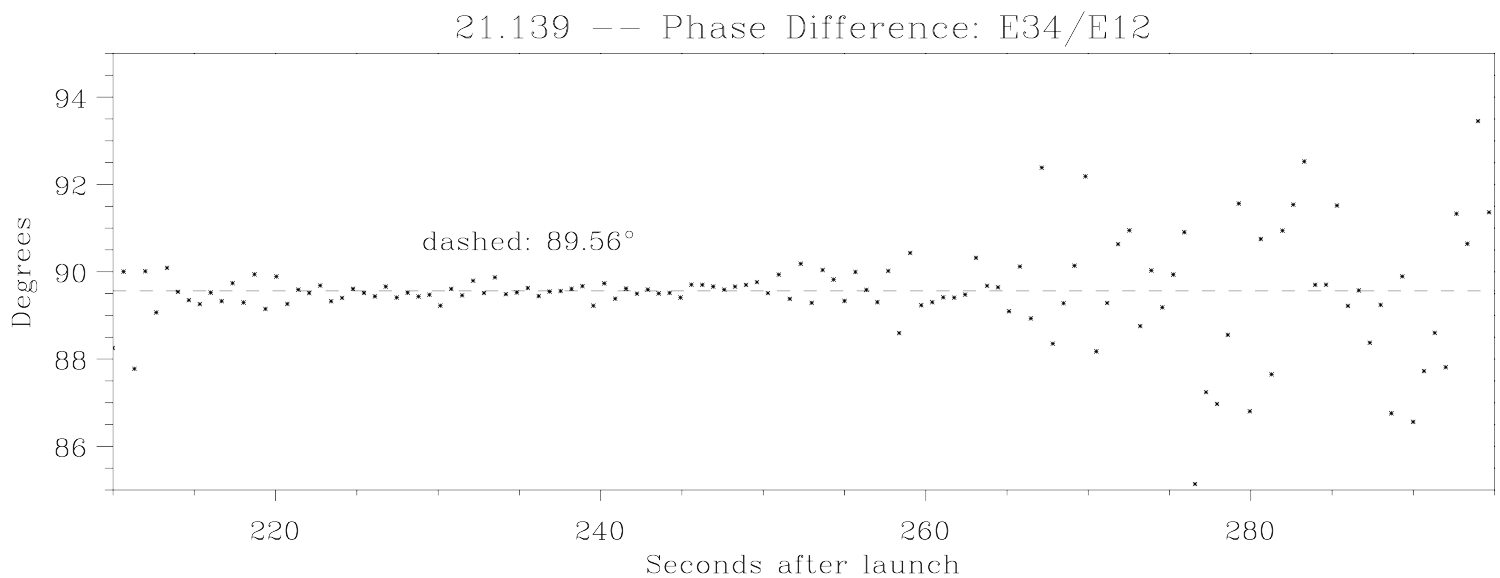
SCM Fri Feb 6 09:39:31 2009

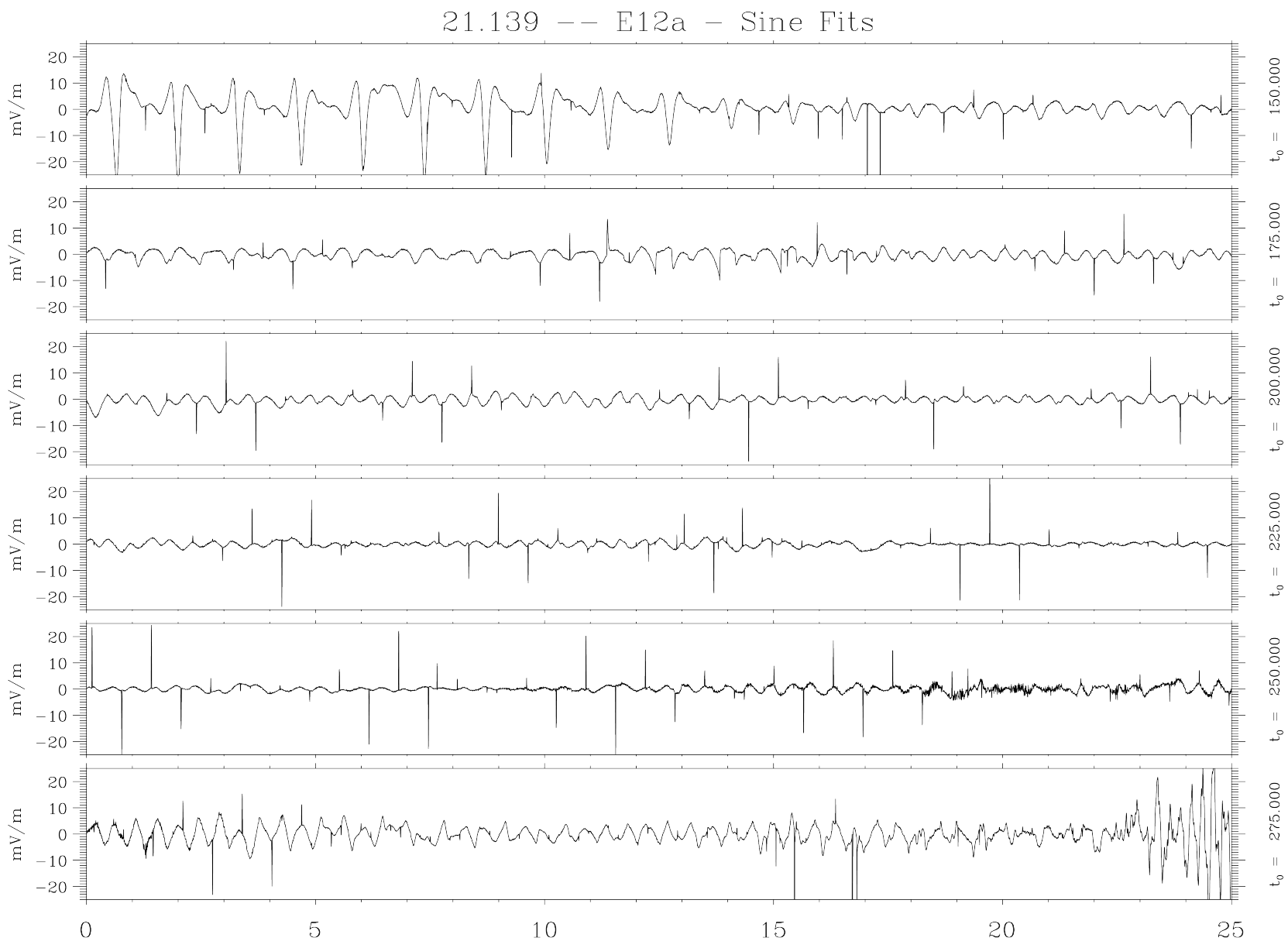

Poker Flat, Alaska -- 21.139 (ACES Low)
29 January 2009, 09:51:11.0 U.T.
Altitude, km
70 80 90 100 110 120 130 130 120 110 100 90 80 70
Apogee: 133 km
HA1 V12A (Raw Counts)
HA9 V34A (Raw Counts)
0 200 400 600 800 1000
100 150 200 250 300
Seconds Since Launch

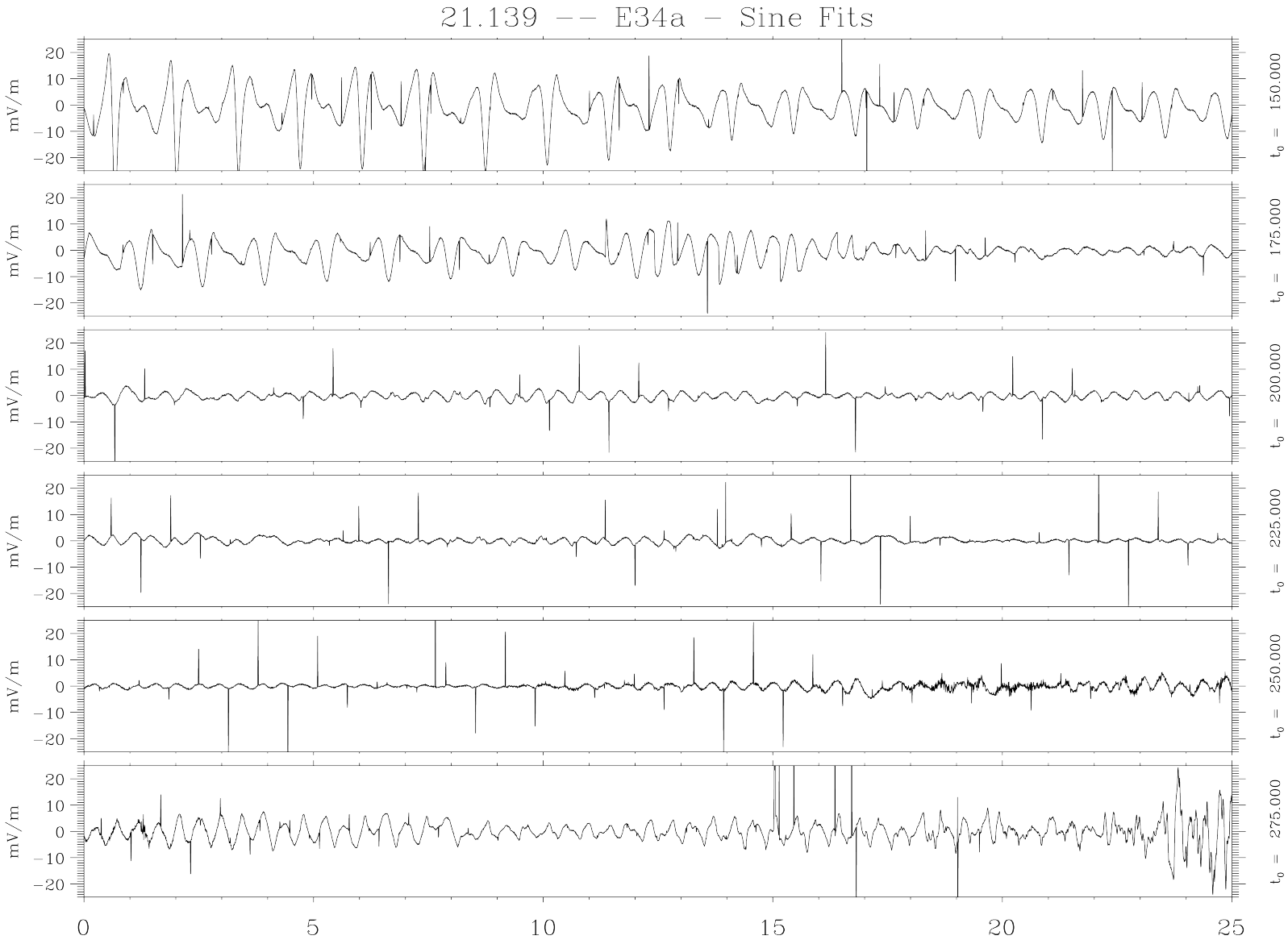

21.139 -- E12a (BLACK) and E34a (RED)
mV/m
100
50
0
−50
−100
t_0 = 150.000
t_0 = 175.000
t_0 = 200.000
t_0 = 225.000
t_0 = 250.000
t_0 = 275.000
0
5
10
15
20
25

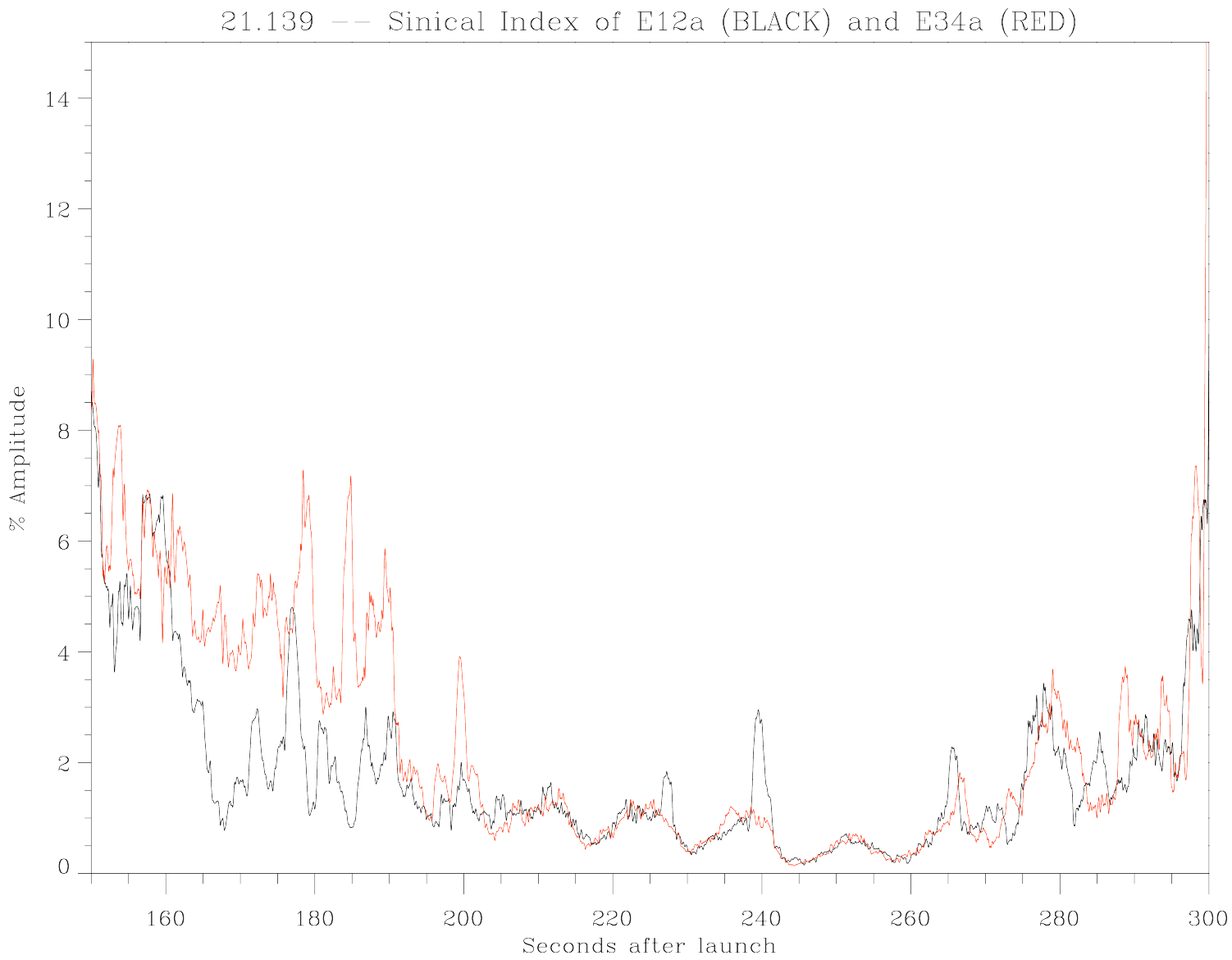

21.139 -- Offset of E12 (BLACK), E34 (RED)
mV/m
20
10
0
−10
−20
−30
160
180
200
220
240
260
280
300
Seconds after launch
21.139 -- Amplitude of E12 (BLACK), E34 (RED)
mV/m
90
80
70
60
50
40
160
180
200
220
240
260
280
300
Seconds after launch

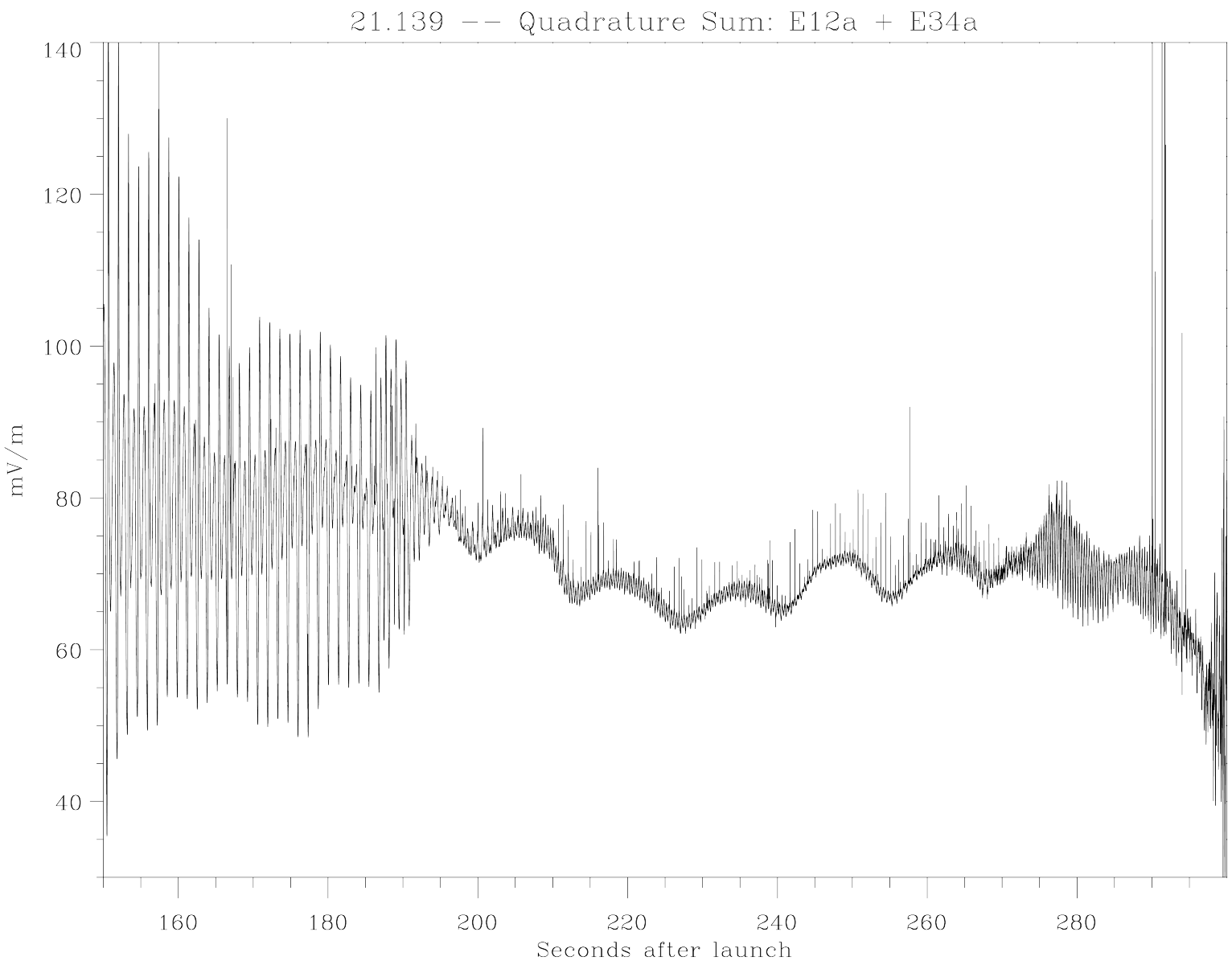

21.139 -- Period of E12 (BLACK), E34 (RED)
Seconds
1.38
1.36
1.34
1.32
1.30
160
180
200
220
240
260
280
300
Seconds after launch

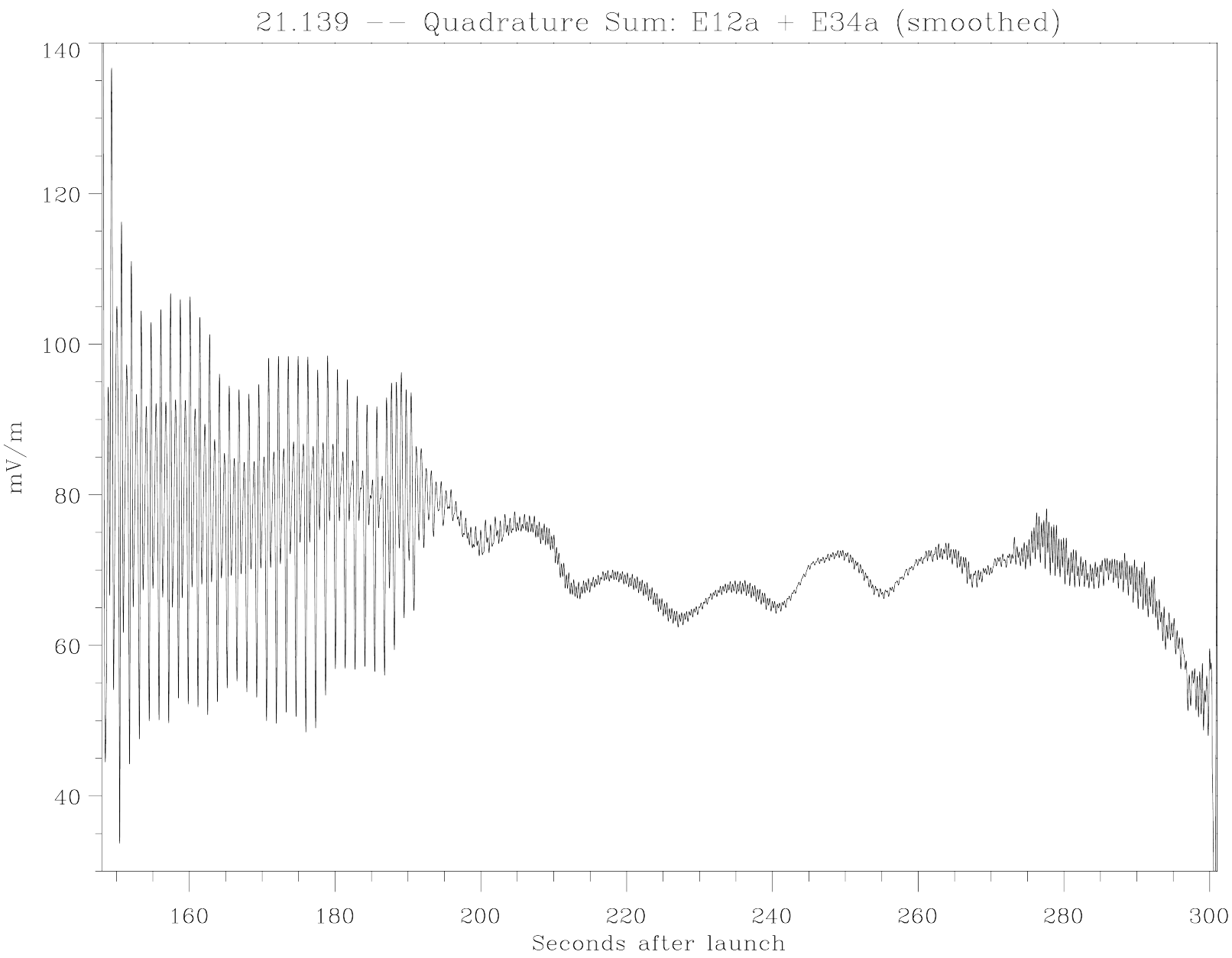

21.139 -- Phase Difference: E34/E12
Degrees
94
92
90
88
86
dashed: 89.56°
220
240
260
280
Seconds after launch

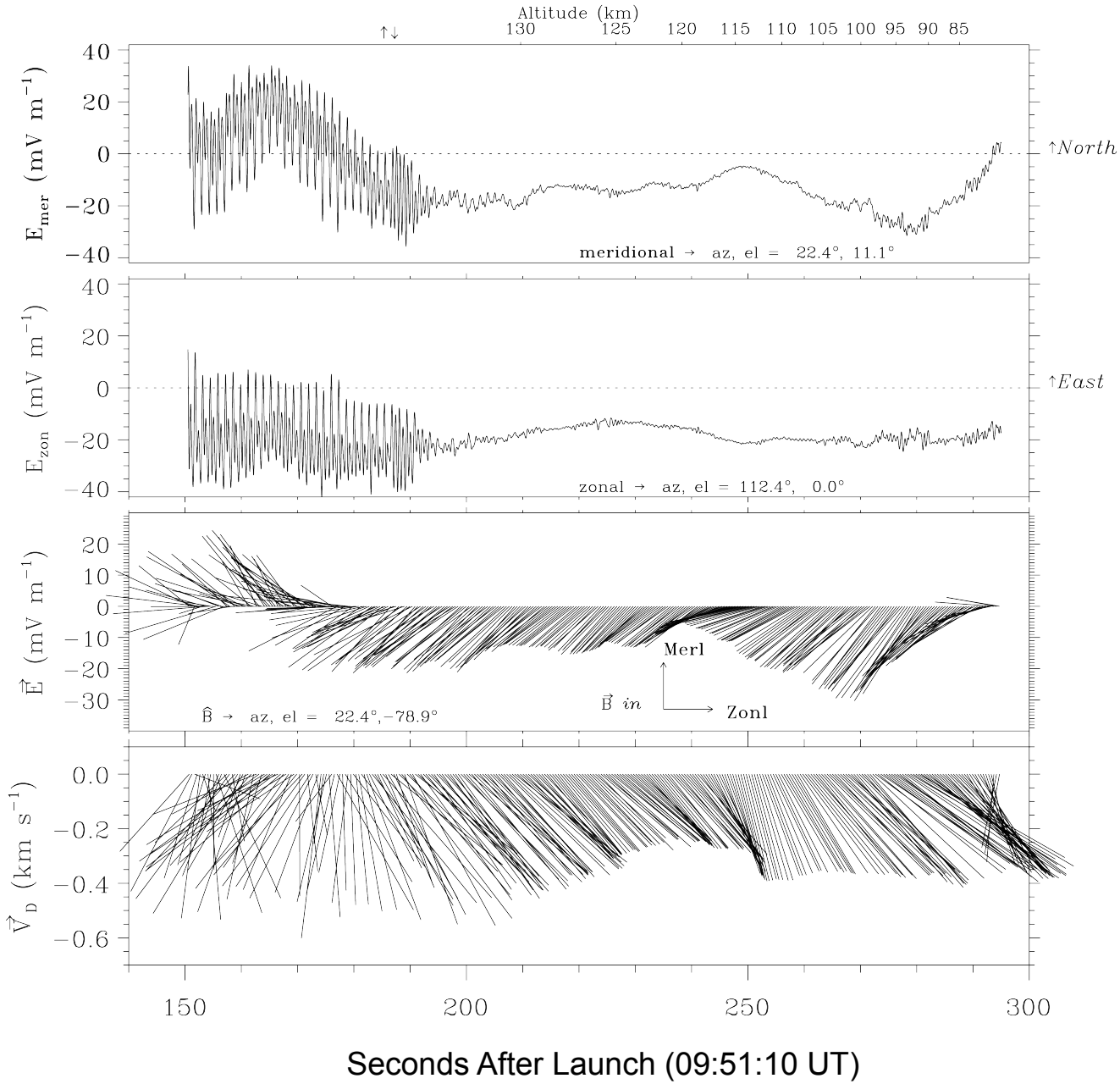

21.139 -- E12a - Sine Fits
mV/m
20
10
0
−10
−20
t_0 = 150.000
t_0 = 175.000
t_0 = 200.000
t_0 = 225.000
t_0 = 250.000
t_0 = 275.000
0
5
10
15
20
25


21.139 -- E34a - Sine Fits
mV/m
20
10
0
−10
−20
t_0 = 150.000
t_0 = 175.000
t_0 = 200.000
t_0 = 225.000
t_0 = 250.000
t_0 = 275.000
0
5
10
15
20
25

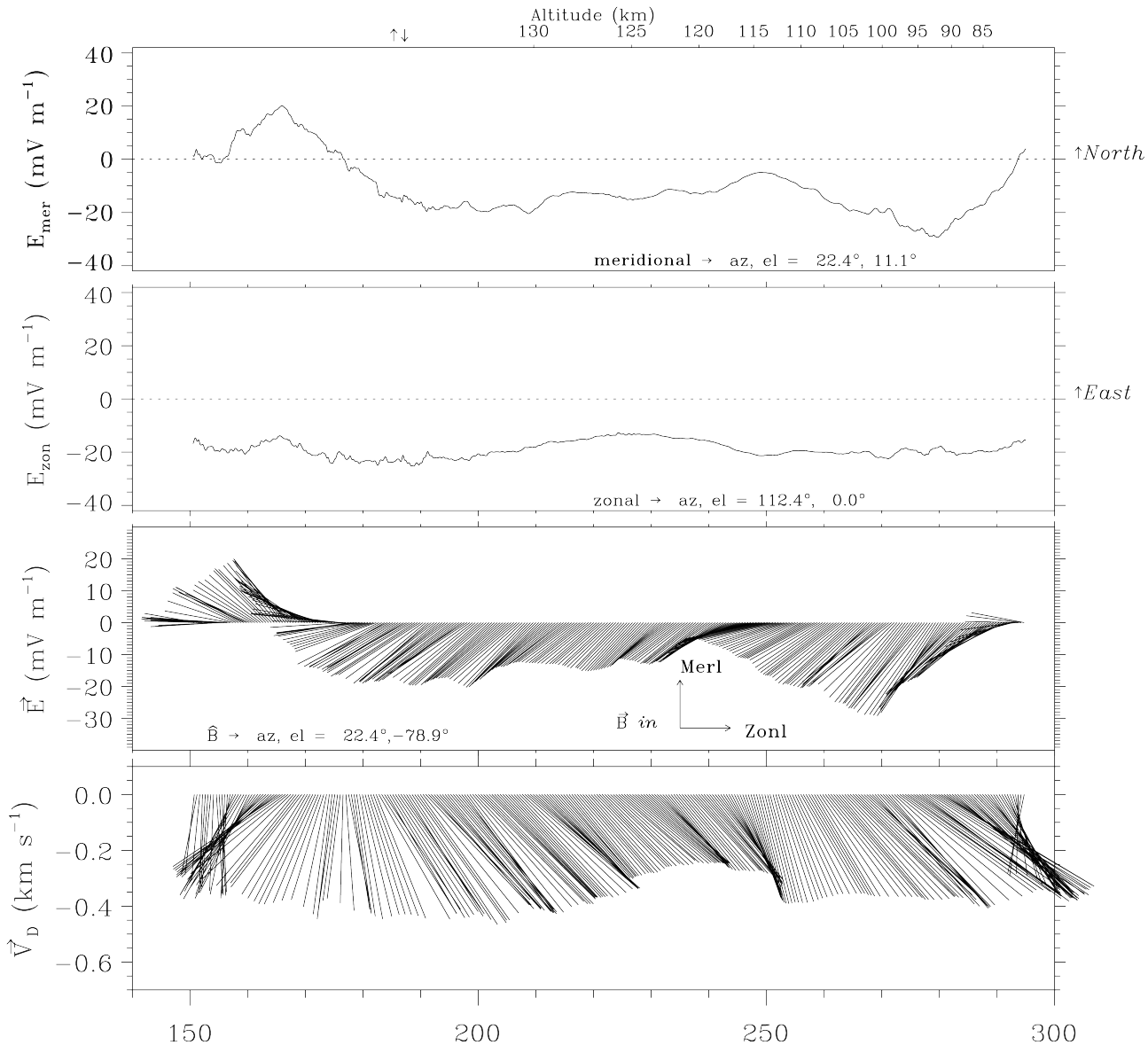

21.139 -- Sinical Index of E12a (BLACK) and E34a (RED)
% Amplitude
0
2
4
6
8
10
12
14
160
180
200
220
240
260
280
300
Seconds after launch


21.139 -- Quadrature Sum: E12a + E34a
140
120
100
80
60
40
mV/m
160
180
200
220
240
260
280
Seconds after launch


21.139 -- Quadrature Sum: E12a + E34a (smoothed)
mV/m
140
120
100
80
60
40
160
180
200
220
240
260
280
300
Seconds after launch


Altitude (km)
130 125 120 115 110 105 100 95 90 85
E_{mer} (mV m^{-1})
↑North
meridional → az, el = 22.4°, 11.1°
E_{zon} (mV m^{-1})
↑East
zonal → az, el = 112.4°, 0.0°
$\vec{E}$ (mV m^{-1})
Merl
$\vec{B}$ in
Zonl
$\hat{B}$ → az, el = 22.4°,−78.9°
$\vec{V}_D$ (km s^{-1})
150 200 250 300
Seconds After Launch (09:51:10 UT)

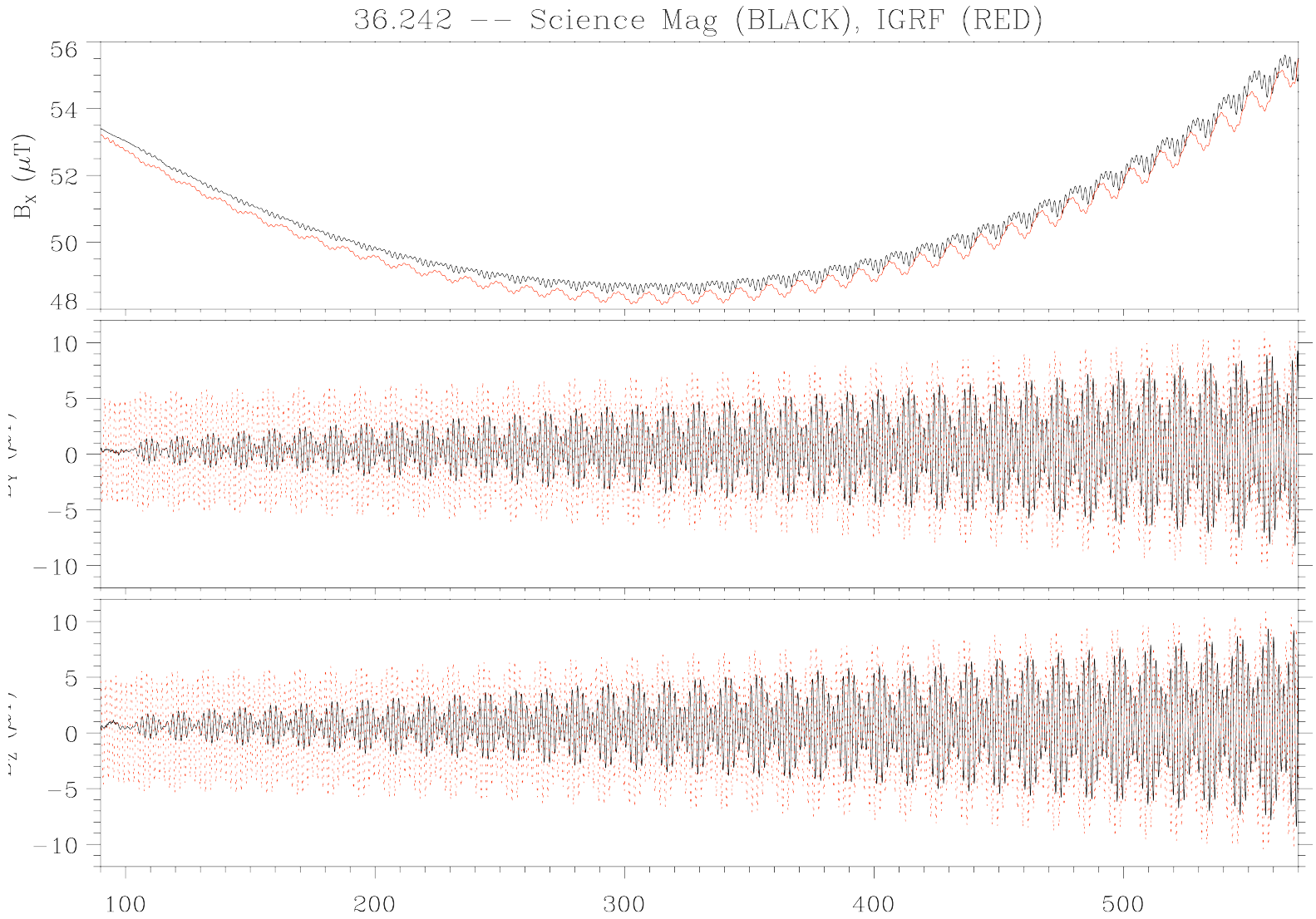
DC Electric Field Solution (Smoothed) -- ACES “Low” (21.139)

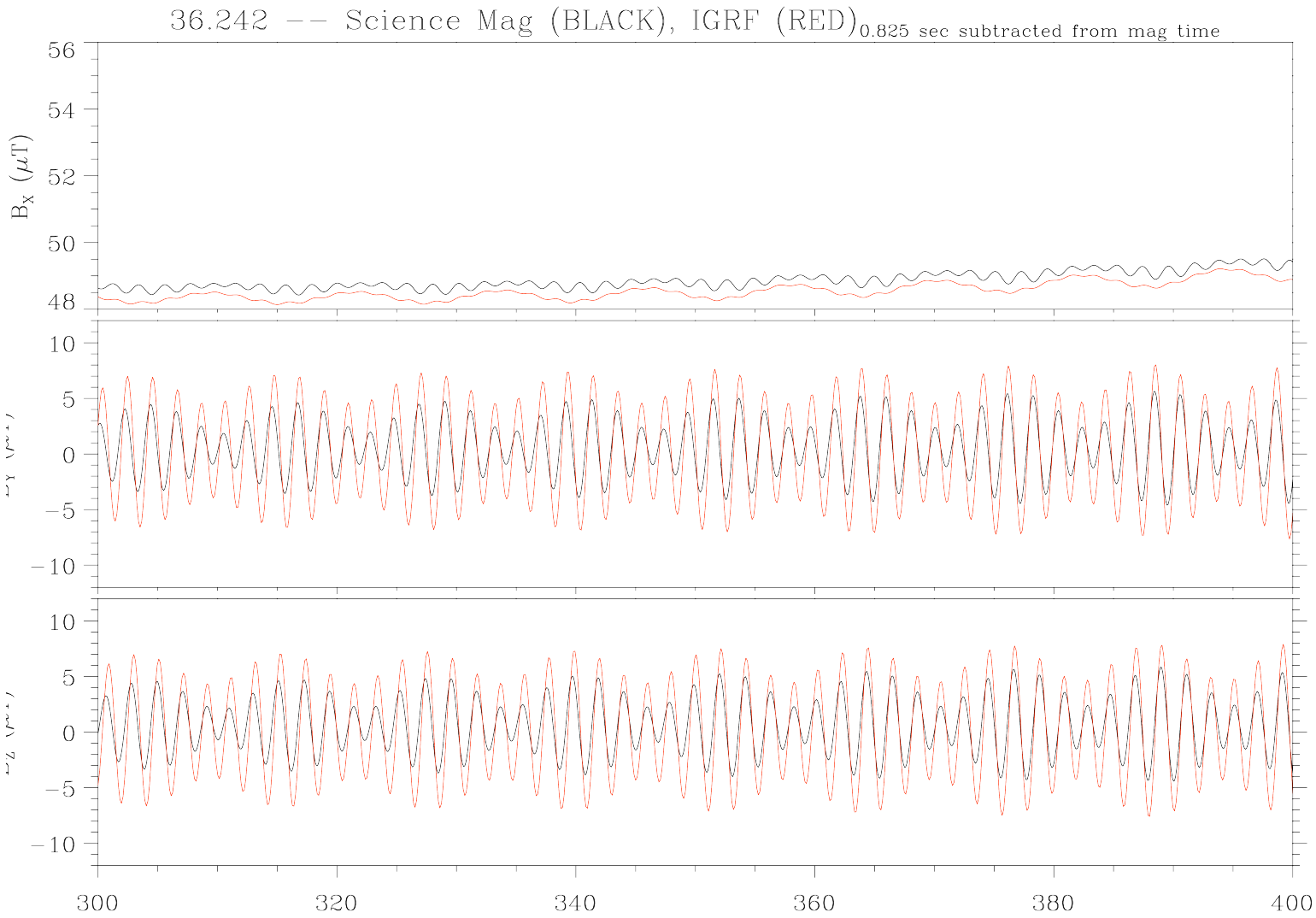


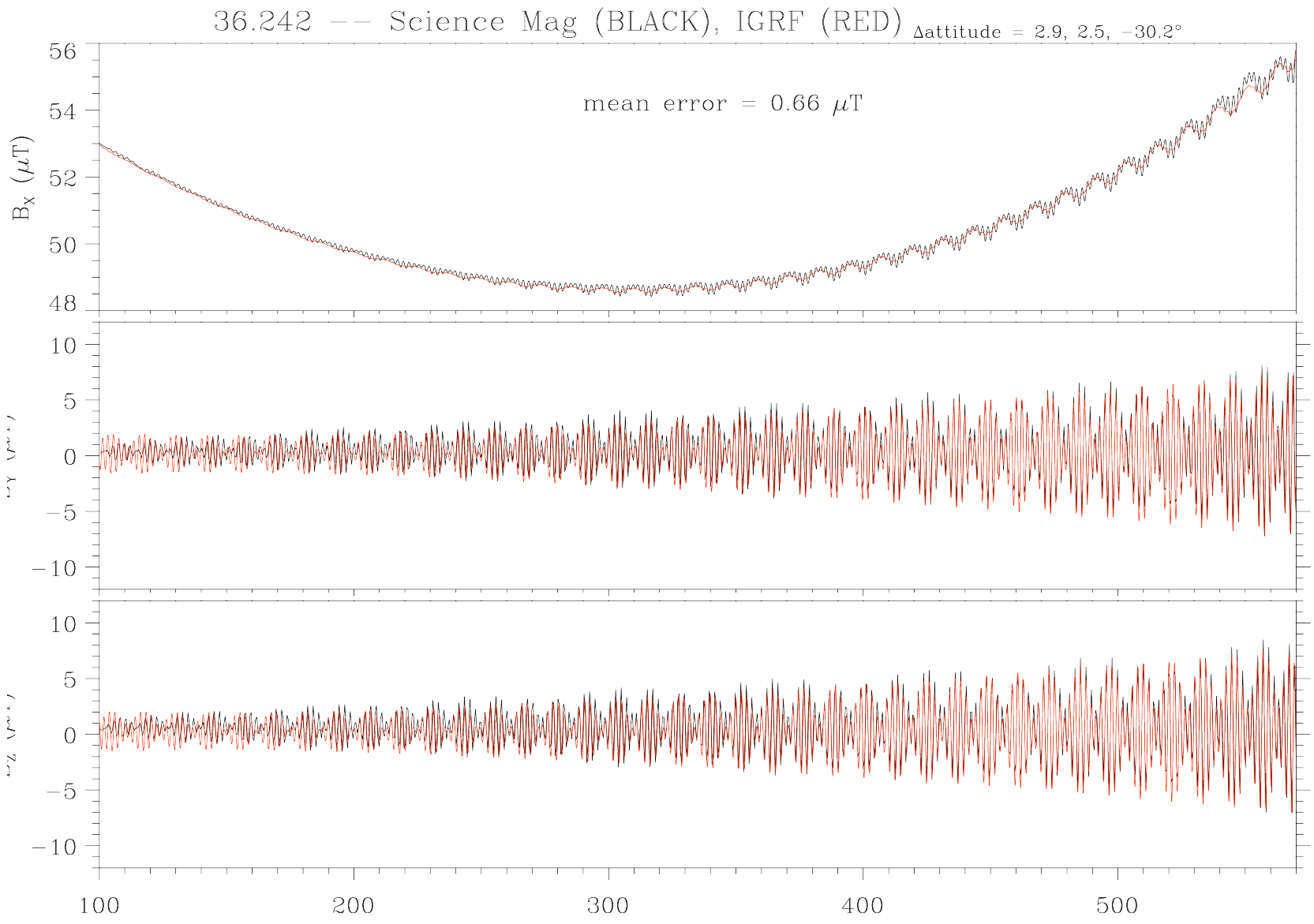
Seconds After Launch (09:51:10 UT)

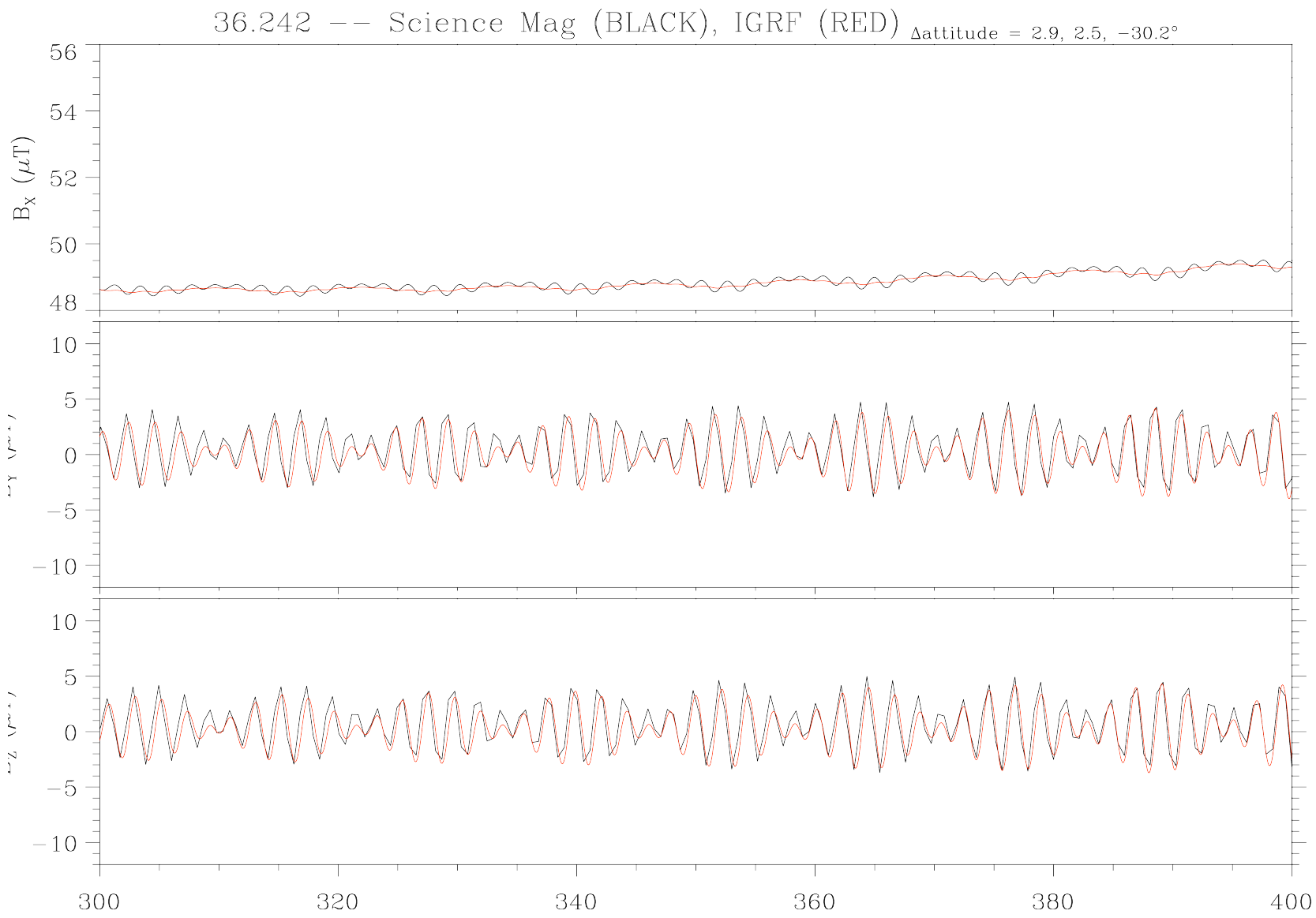
ACES “High” -- 36.242

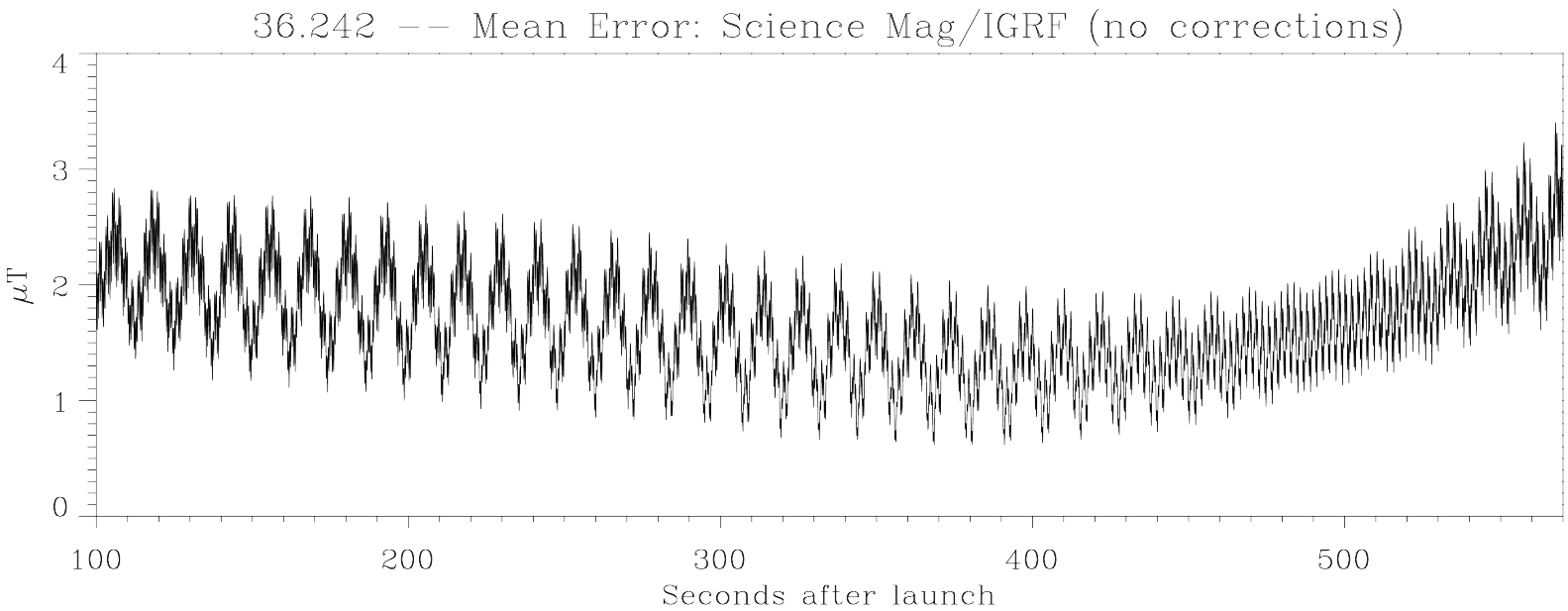
Verification of Gyro (Attitude) data using magnetic field data

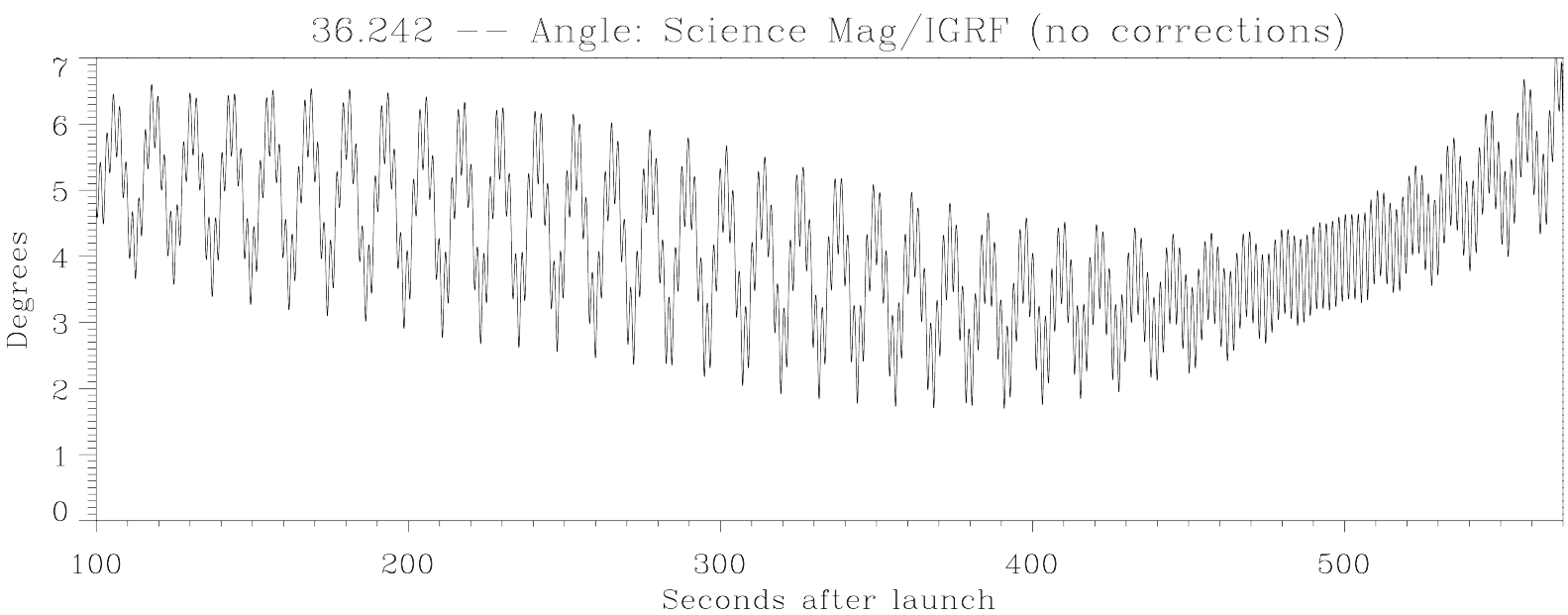

36.242 -- Science Mag (BLACK), IGRF (RED)
B_X (μT)
56
54
52
50
48
10
5
0
−5
−10
10
5
0
−5
−10
100
200
300
400
500

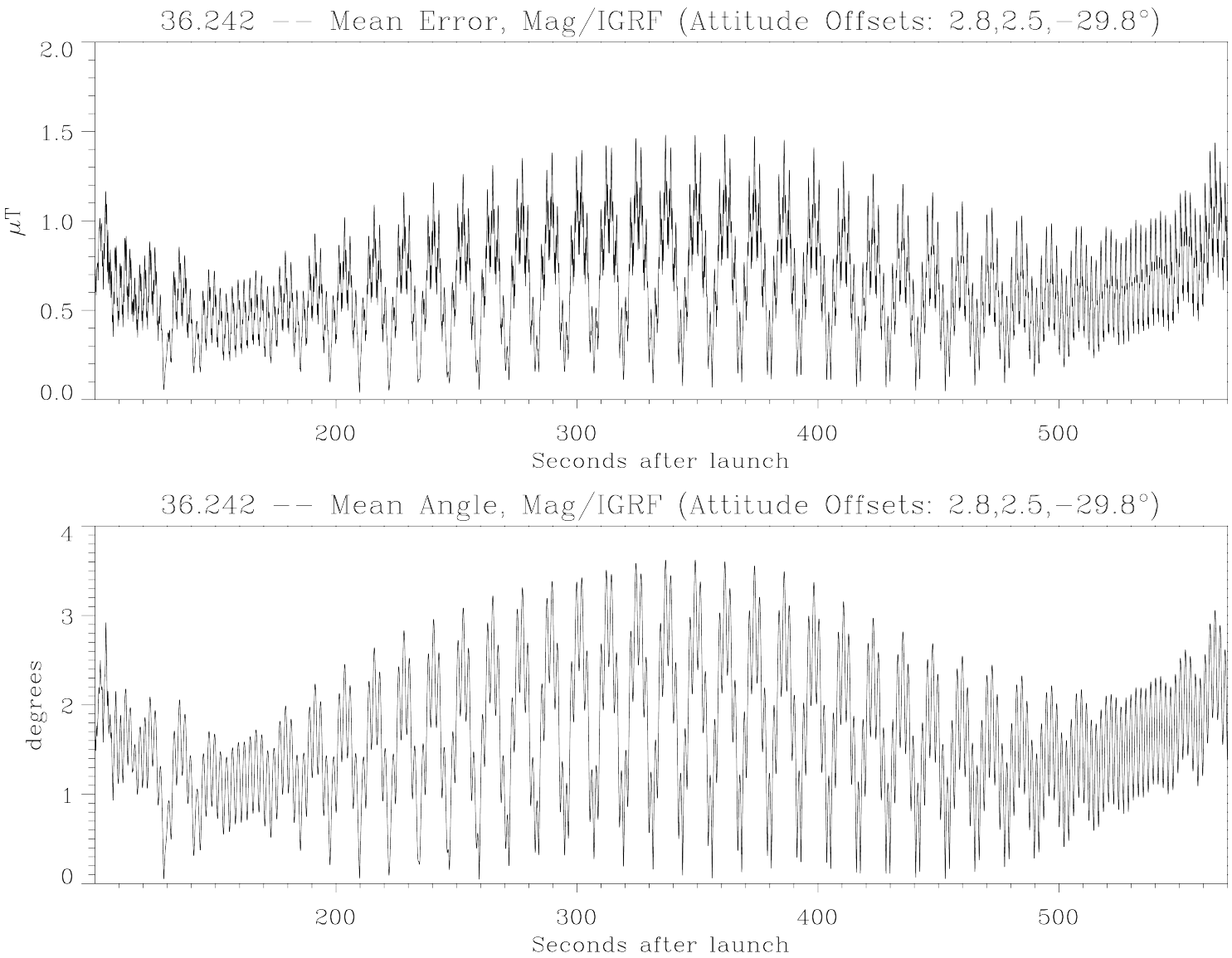

36.242 -- Science Mag (BLACK), IGRF (RED)
0.825 sec subtracted from mag time
B_X (μT)
56
54
52
50
48
10
5
0
−5
−10
10
5
0
−5
−10
300
320
340
360
380
400

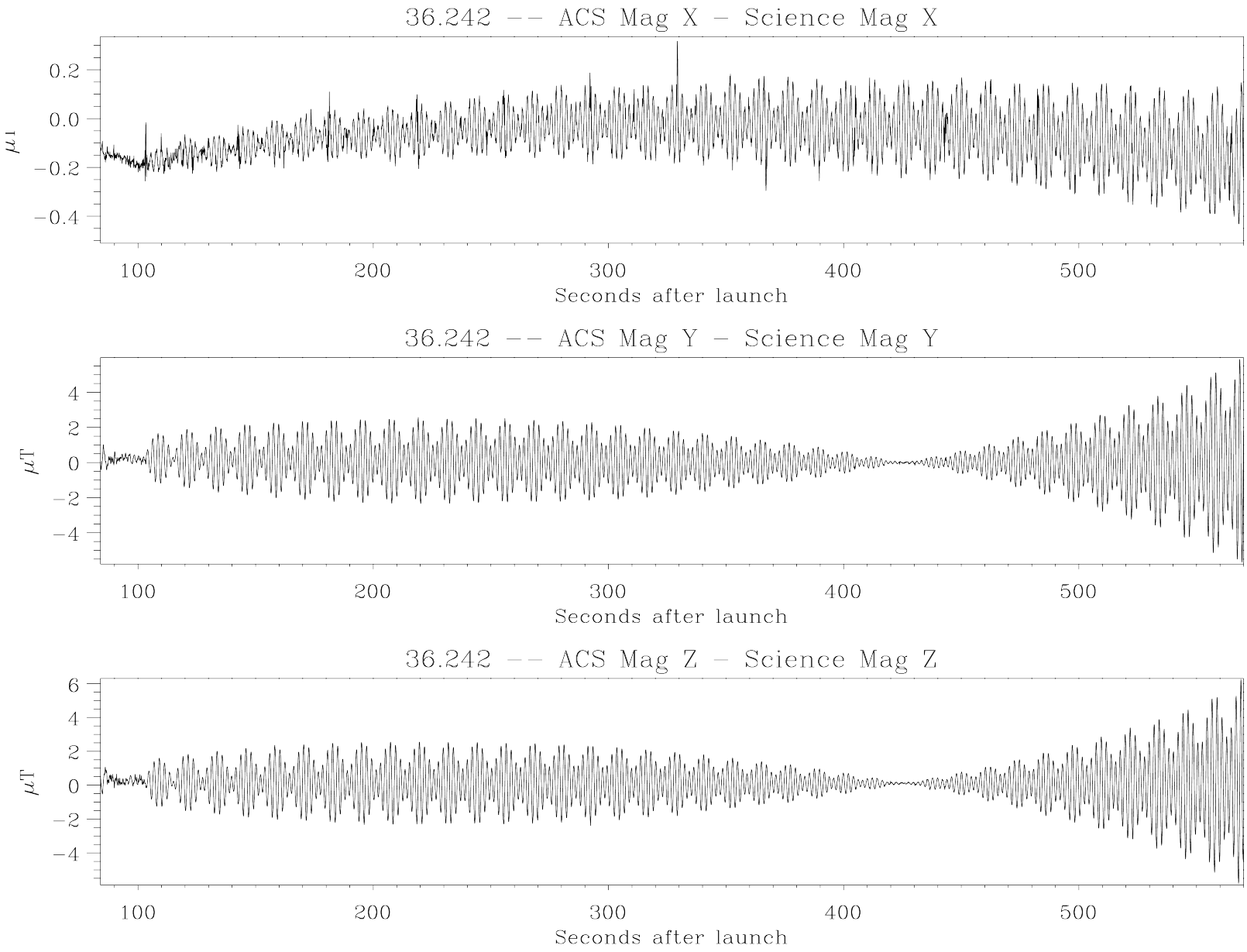

36.242 -- Science Mag (BLACK), IGRF (RED)
Δattitude = 2.9, 2.5, −30.2°
mean error = 0.66 μT
B_X (μT)
56
54
52
50
48
10
5
0
−5
−10
100
200
300
400
500


36.242 -- Science Mag (BLACK), IGRF (RED)
Δattitude = 2.9, 2.5, −30.2°
B_X (μT)
56
54
52
50
48
10
5
0
−5
−10
10
5
0
−5
−10
300
320
340
360
380
400


36.242 -- Mean Error: Science Mag/IGRF (no corrections)
μT
0
1
2
3
4
100
200
300
400
500
Seconds after launch


36.242 -- Angle: Science Mag/IGRF (no corrections)
Degrees
0
1
2
3
4
5
6
7
100
200
300
400
500
Seconds after launch

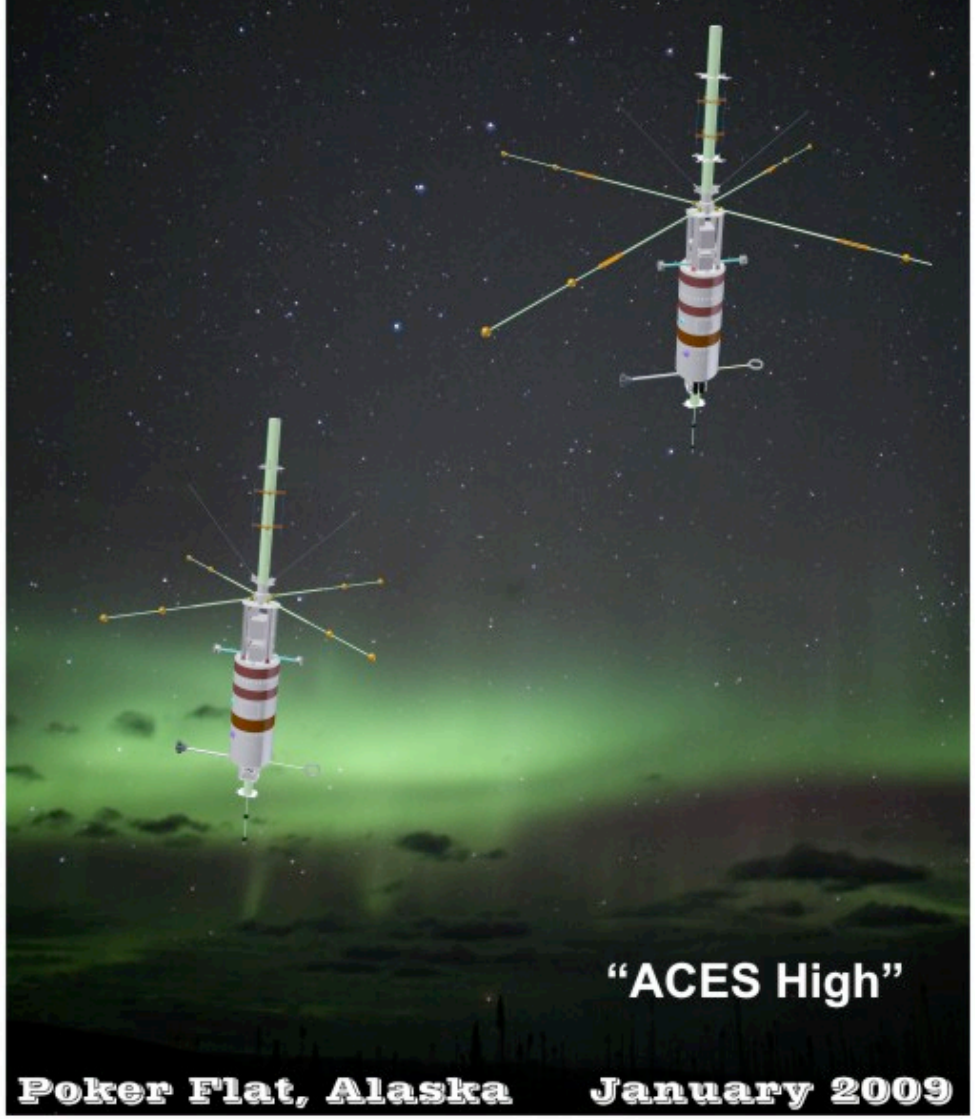

36.242 -- Mean Error, Mag/IGRF (Attitude Offsets: 2.8,2.5,−29.8°)
2.0
1.5
1.0
0.5
0.0
μT
200
300
400
500
Seconds after launch
36.242 -- Mean Angle, Mag/IGRF (Attitude Offsets: 2.8,2.5,−29.8°)
4
3
2
1
0
degrees
200
300
400
500
Seconds after launch


36.242 -- ACS Mag X - Science Mag X
0.2
0.0
−0.2
−0.4
μ1
100
200
300
400
500
Seconds after launch
36.242 -- ACS Mag Y - Science Mag Y
4
2
0
−2
−4
μT
100
200
300
400
500
Seconds after launch
36.242 -- ACS Mag Z - Science Mag Z
6
4
2
0
−2
−4
μT
100
200
300
400
500
Seconds after launch

ACES “High” -- 36.242

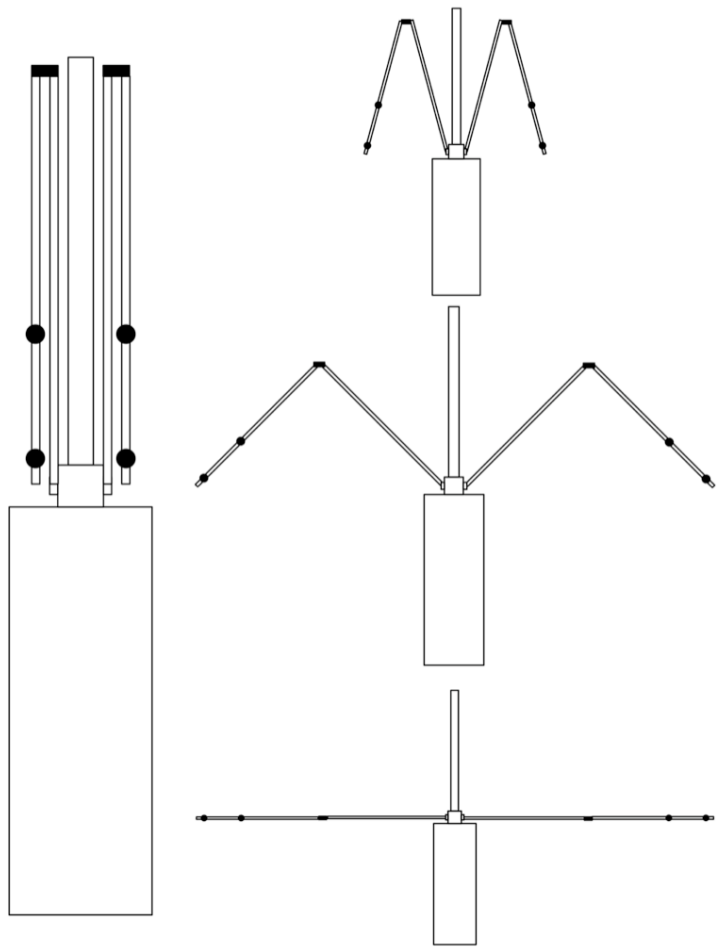
DC Electric Field Measurements

Auroral Current and Electrodynamics Structure (ACES) Sounding Rockets 21.139 & 36.242



Poker Flat, Alaska January 2009

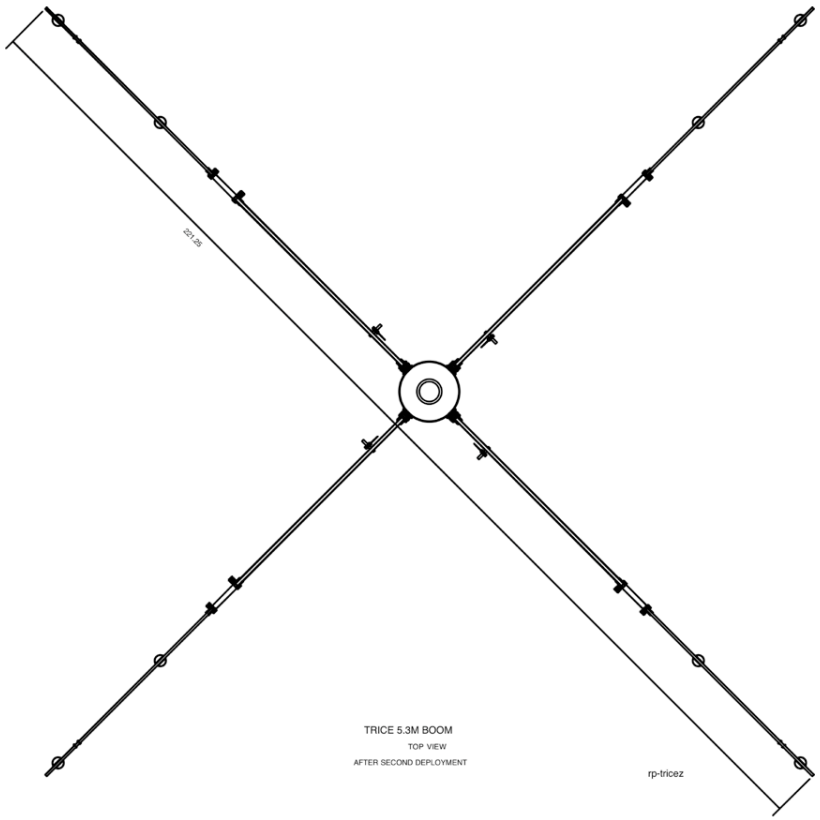
Plan "A" for ACES-HIGH Double-Articulated booms



Single-stage deployment. Two keeper decks, one pyro event fires two pairs of pyros, one pair on each keeper deck (paired for redundancy). Springs in the boom help "kick" out the outboard element. Deck is cut away in a "ski jump" to permit full deployment, even if boom does not open up before "phase A hinge" deploys fully.

Decision to go with Plan A will be based on successful deployment tests on the WFF spin table by the end of June.

5.3 m tip to tip articulated fiberglass Booms after "Phase B" deployment



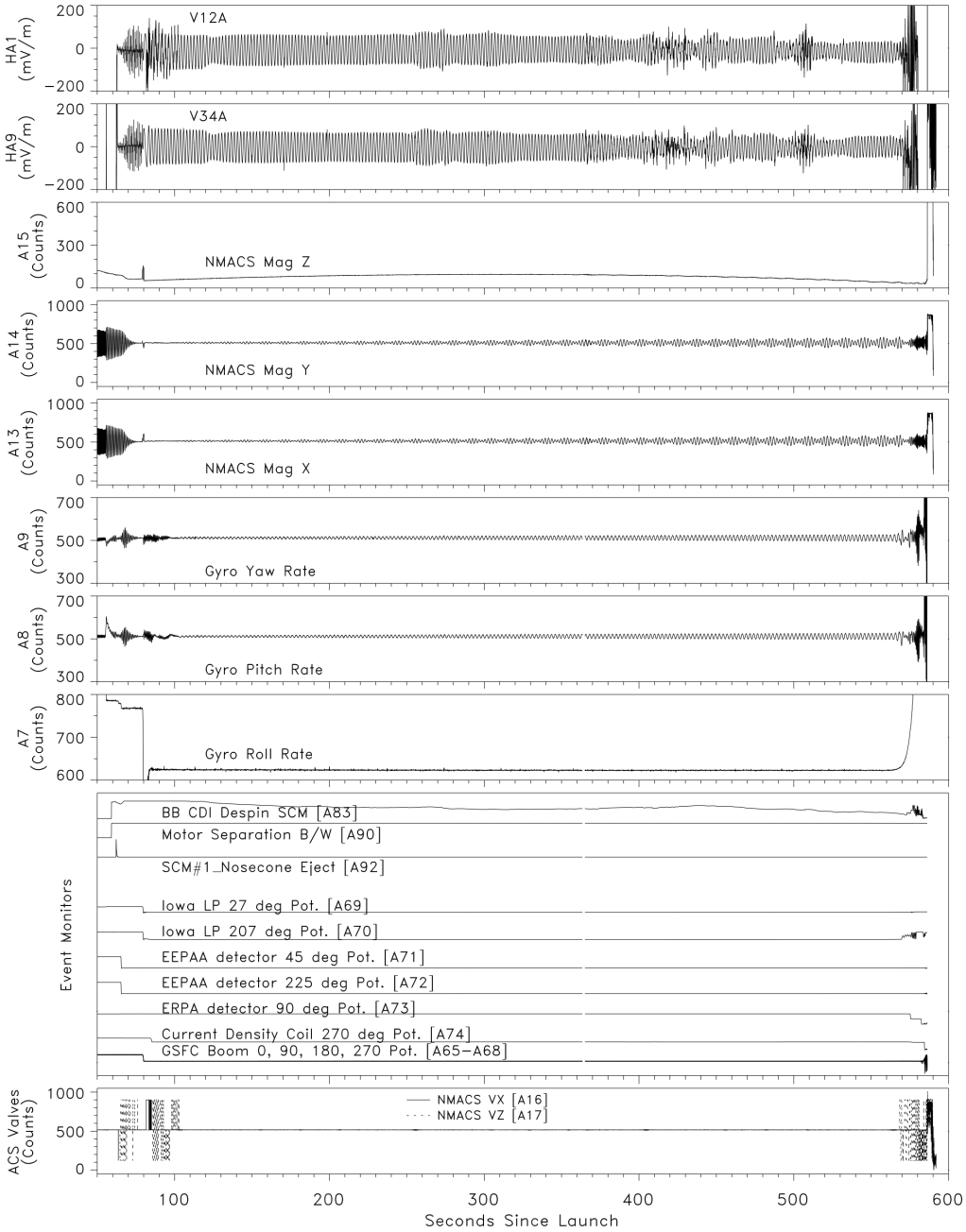
5.3 m tip to tip fiberglass Booms after "Phase A" deployment"

Articulated booms have 2 folding deployments. Initially, they are stowed along the spin axis around the fiberglass mast.

Poker Flat, Alaska -- 36.242 (ACES High)

29 January 2009, 09:49:41.0 U.T.

Event Monitor Study



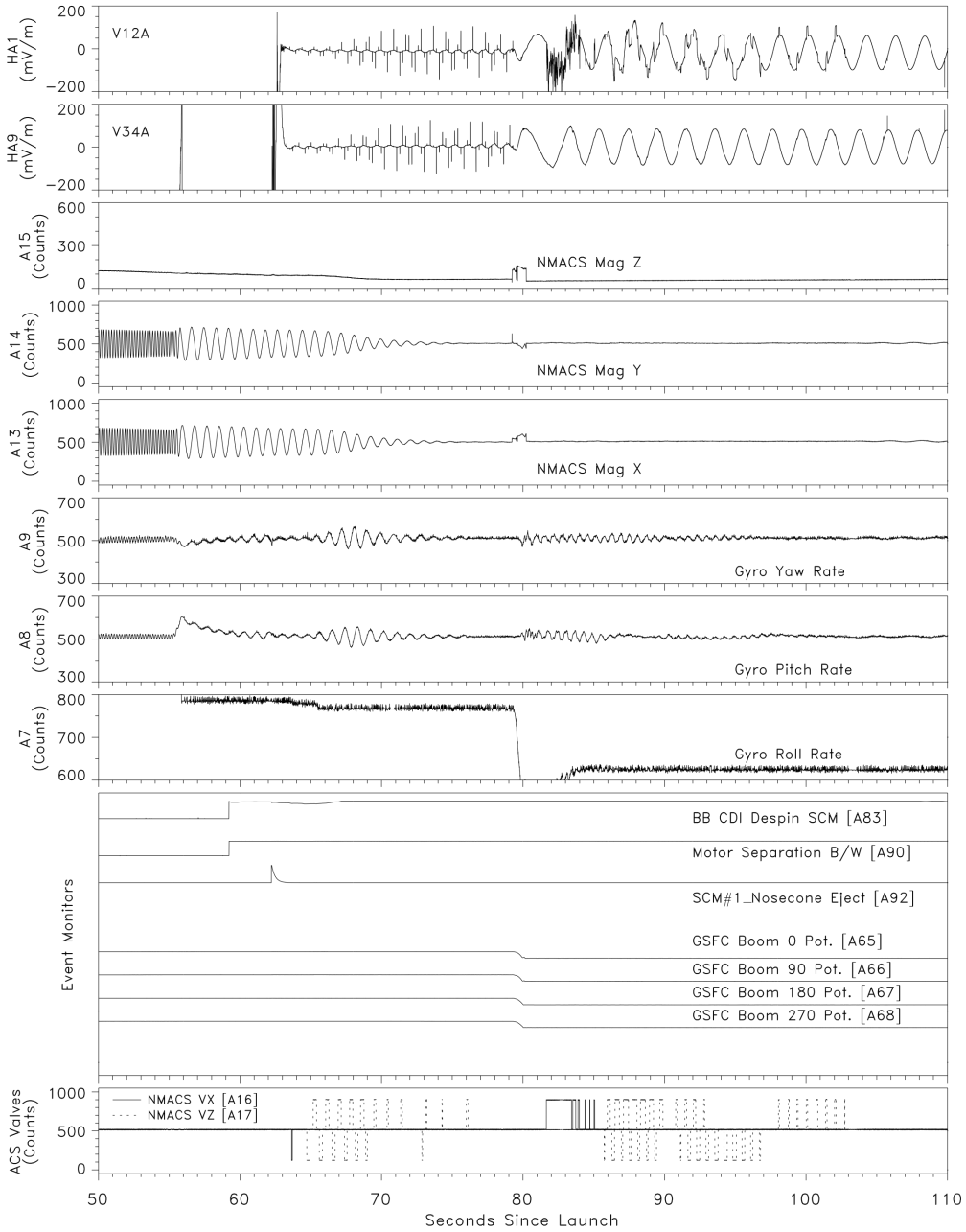
36242_BoomMonitorEvents_A65-A74_50sec-LOS.ps

SCM Mon Feb 9 14:41:14 2009

Poker Flat, Alaska -- 36.242 (ACES High)

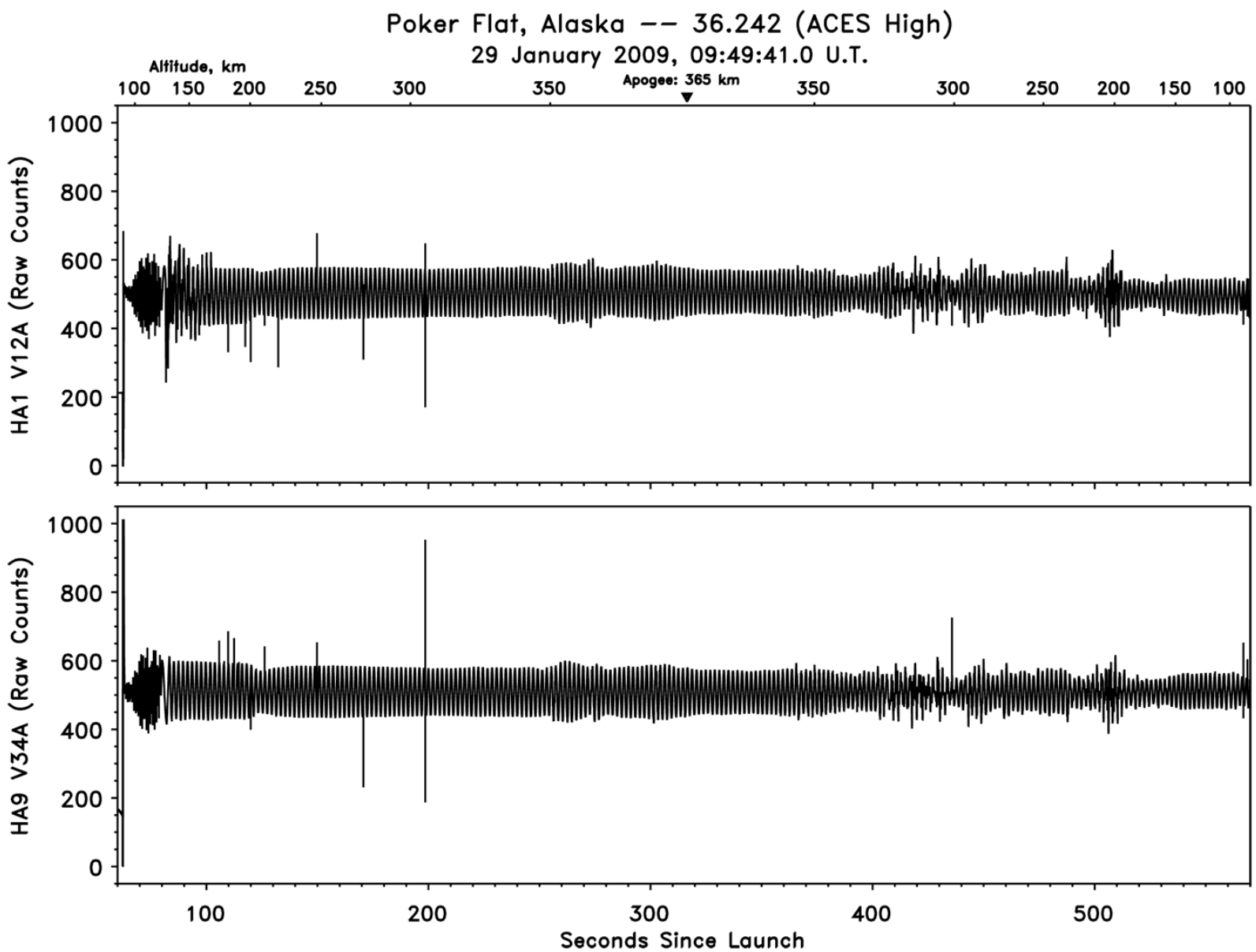
29 January 2009, 09:49:41.0 U.T.

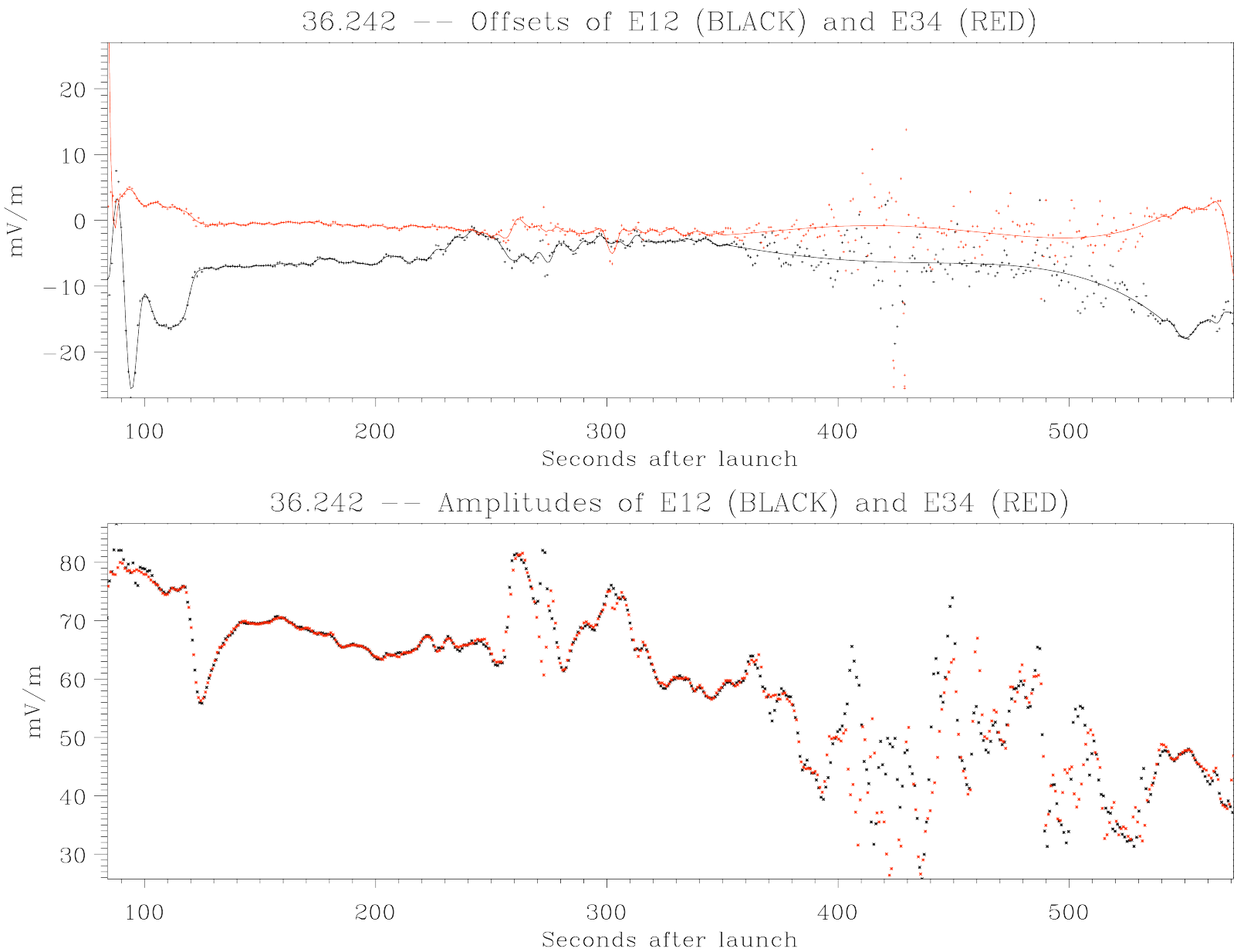
Event Monitor Study

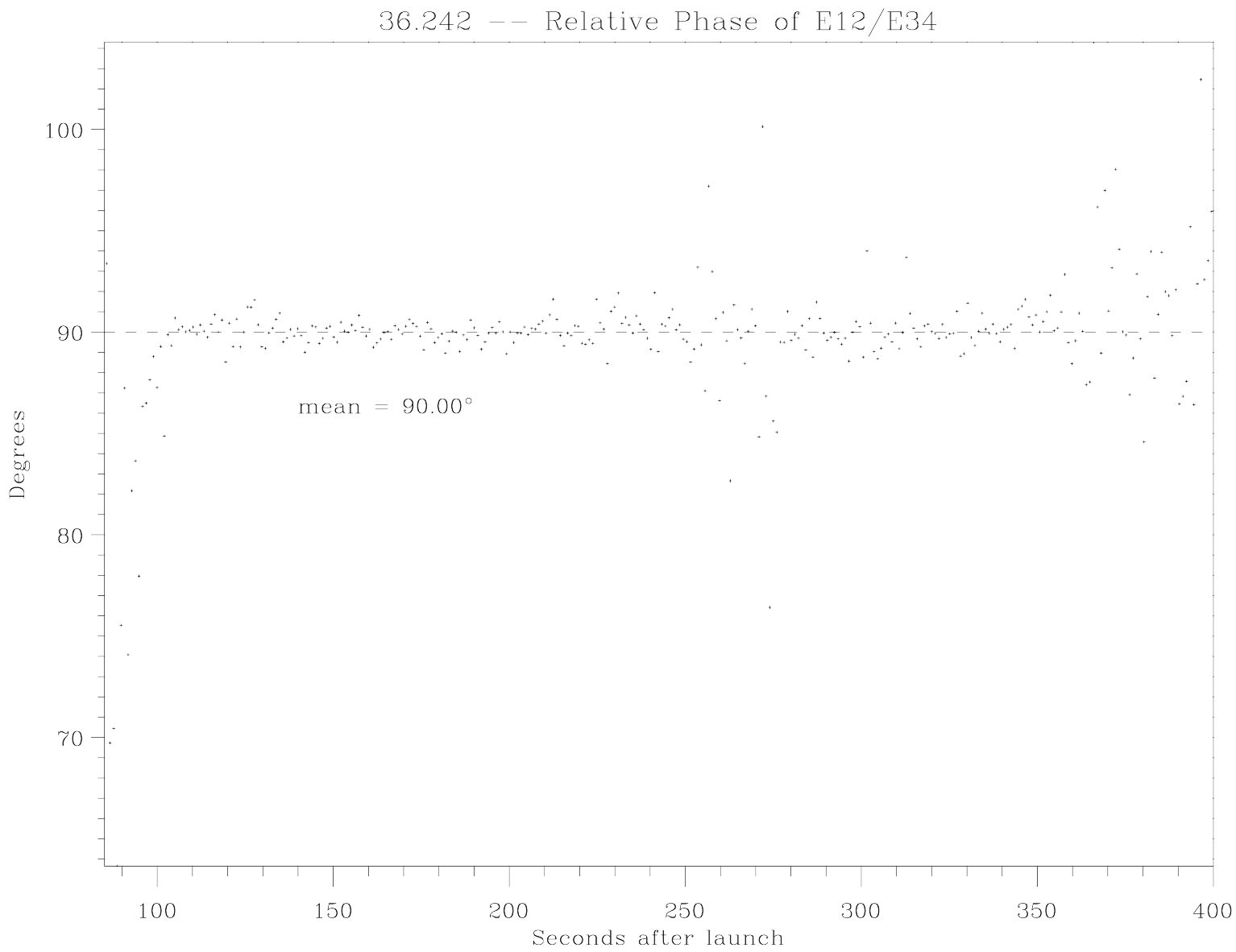


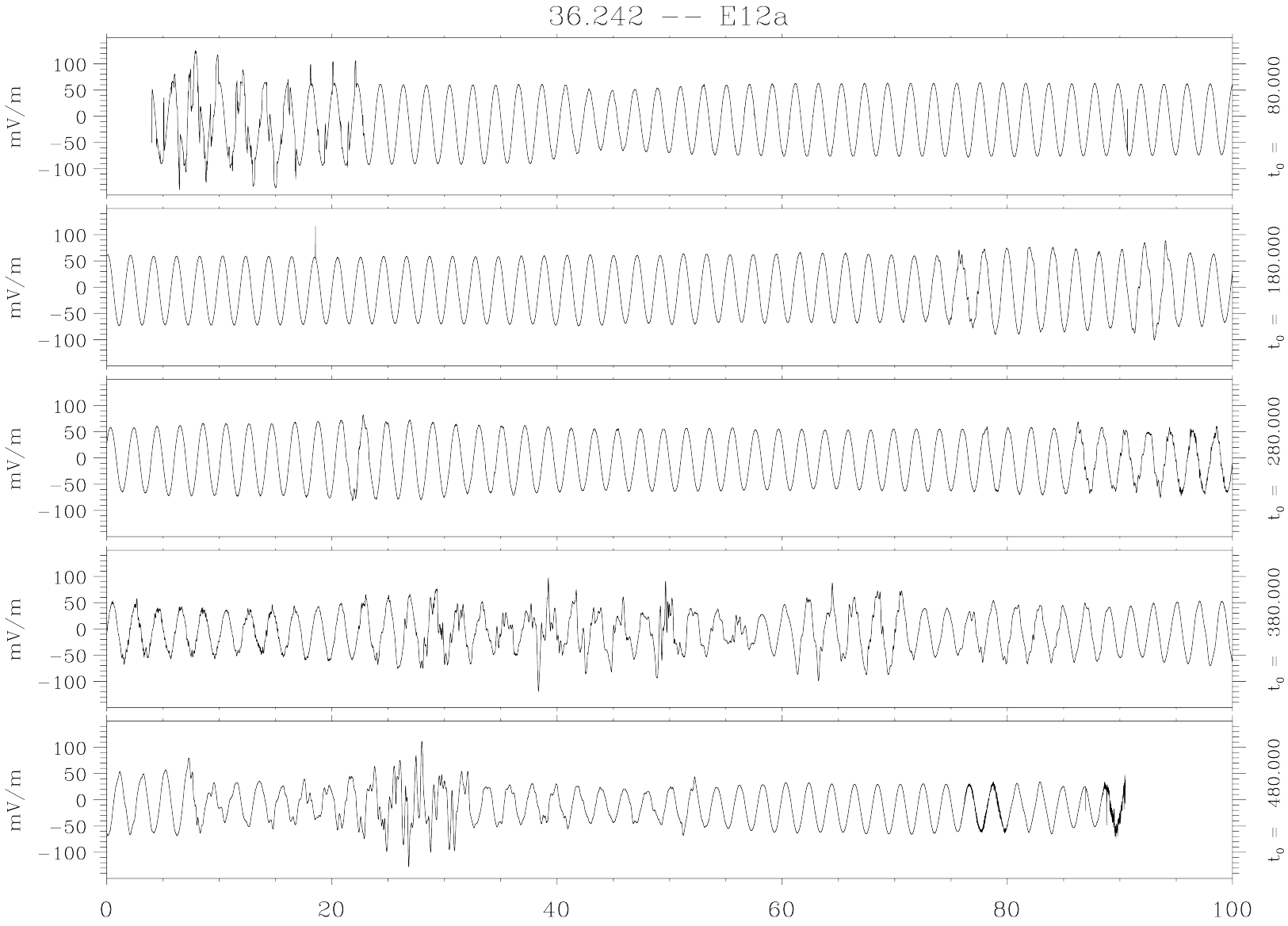
36242_BoomMonitorEvents_50-110sec.ps

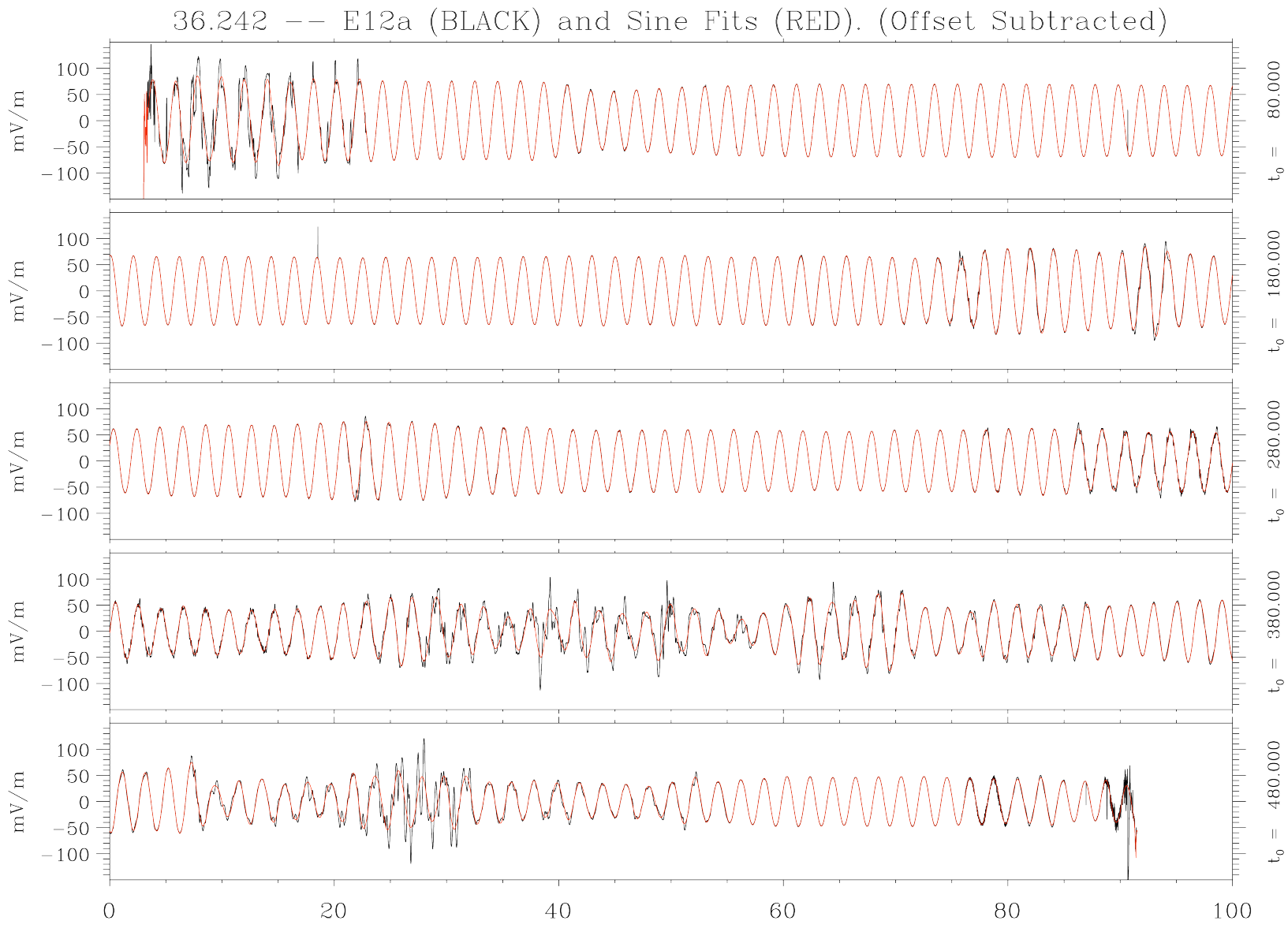
SCM Mon Feb 9 14:55:36 2009

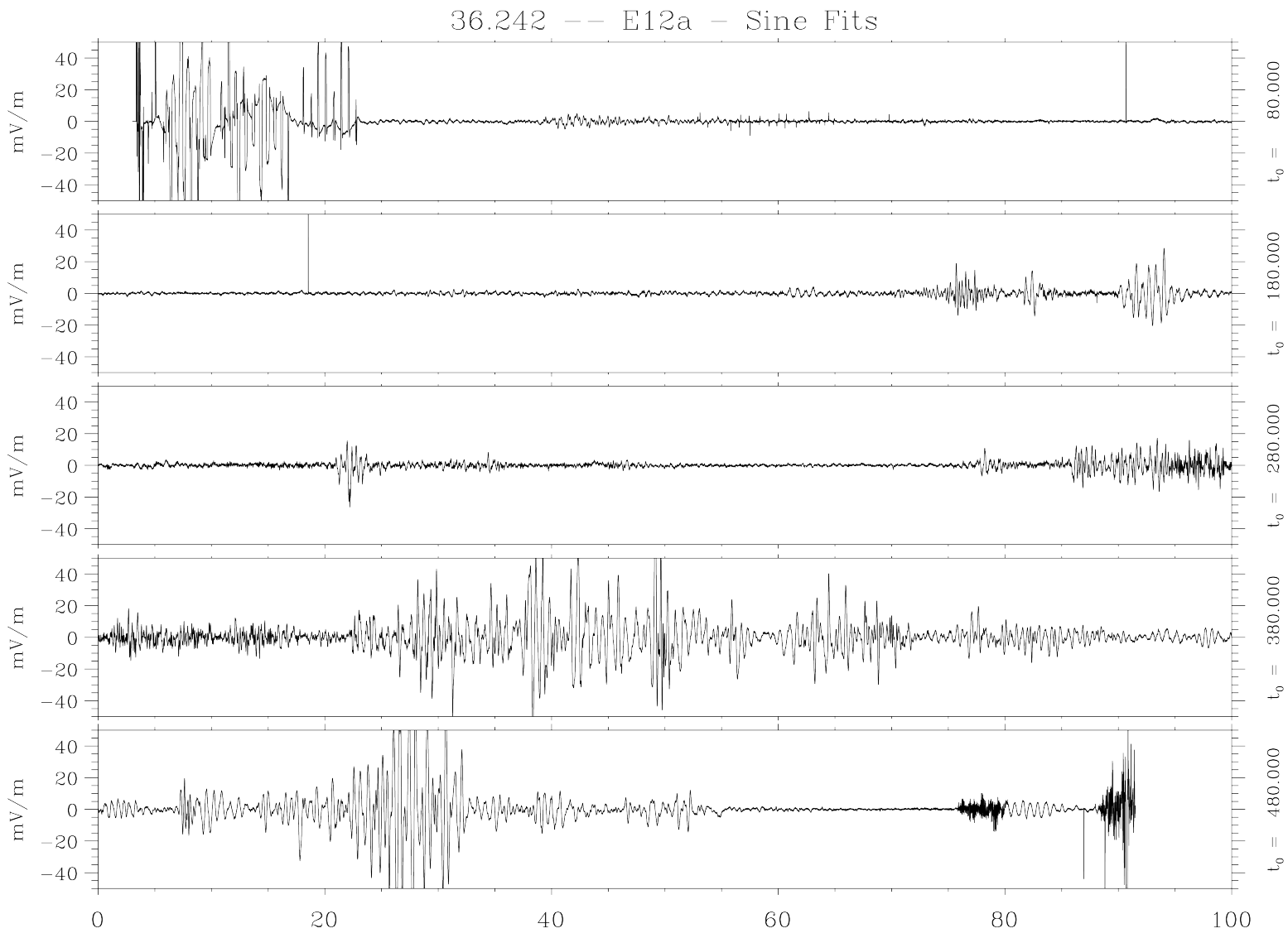

Poker Flat, Alaska -- 36.242 (ACES High)
29 January 2009, 09:49:41.0 U.T.
Altitude, km
100 150 200 250 300 350 Apogee: 365 km 350 300 250 200 150 100
HA1 V12A (Raw Counts)
HA9 V34A (Raw Counts)
0 200 400 600 800 1000
100 200 300 400 500
Seconds Since Launch

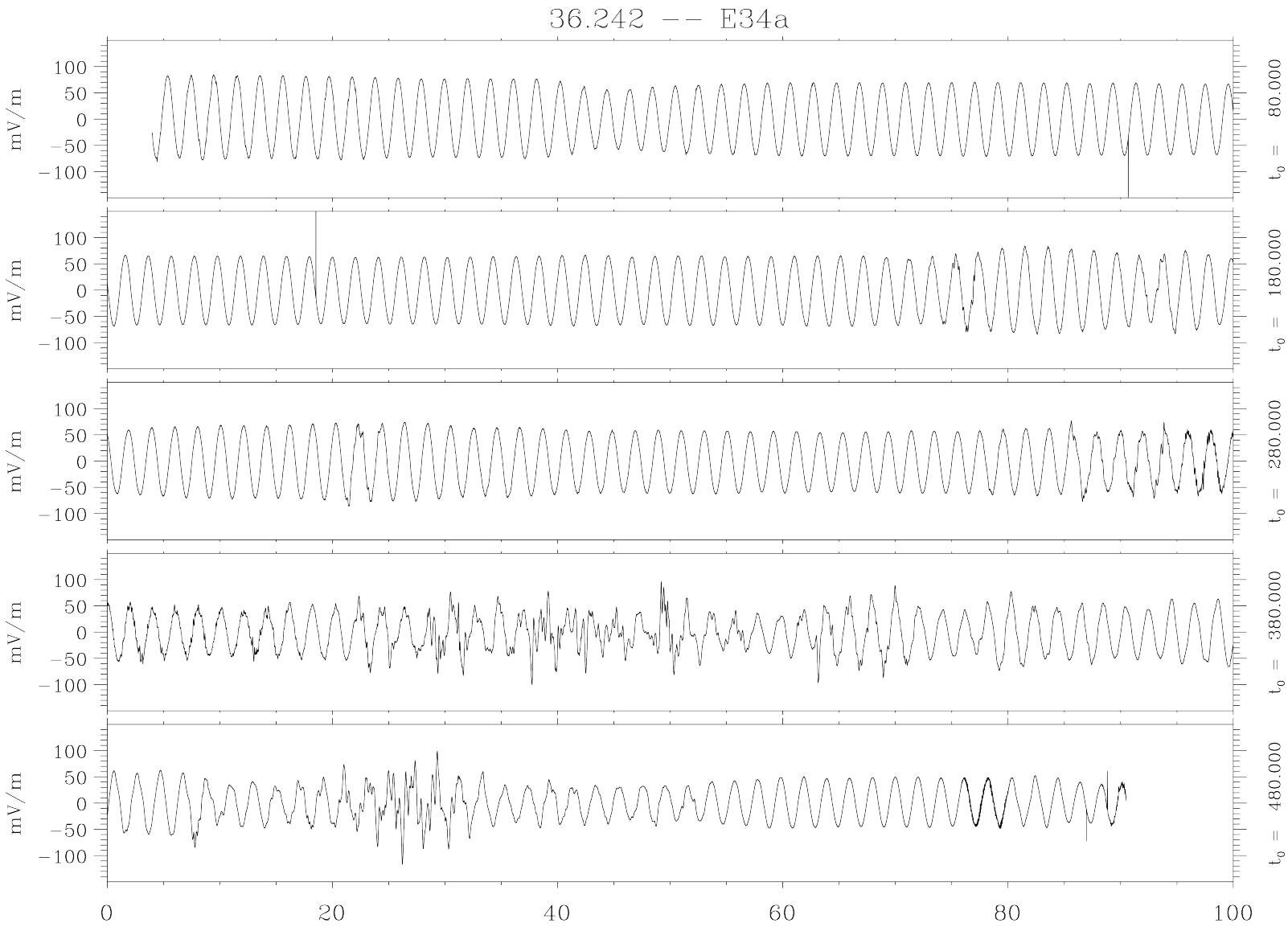

36.242 -- Offsets of E12 (BLACK) and E34 (RED)
mV/m
20
10
0
−10
−20
100
200
300
400
500
Seconds after launch
36.242 -- Amplitudes of E12 (BLACK) and E34 (RED)
mV/m
80
70
60
50
40
30
100
200
300
400
500
Seconds after launch

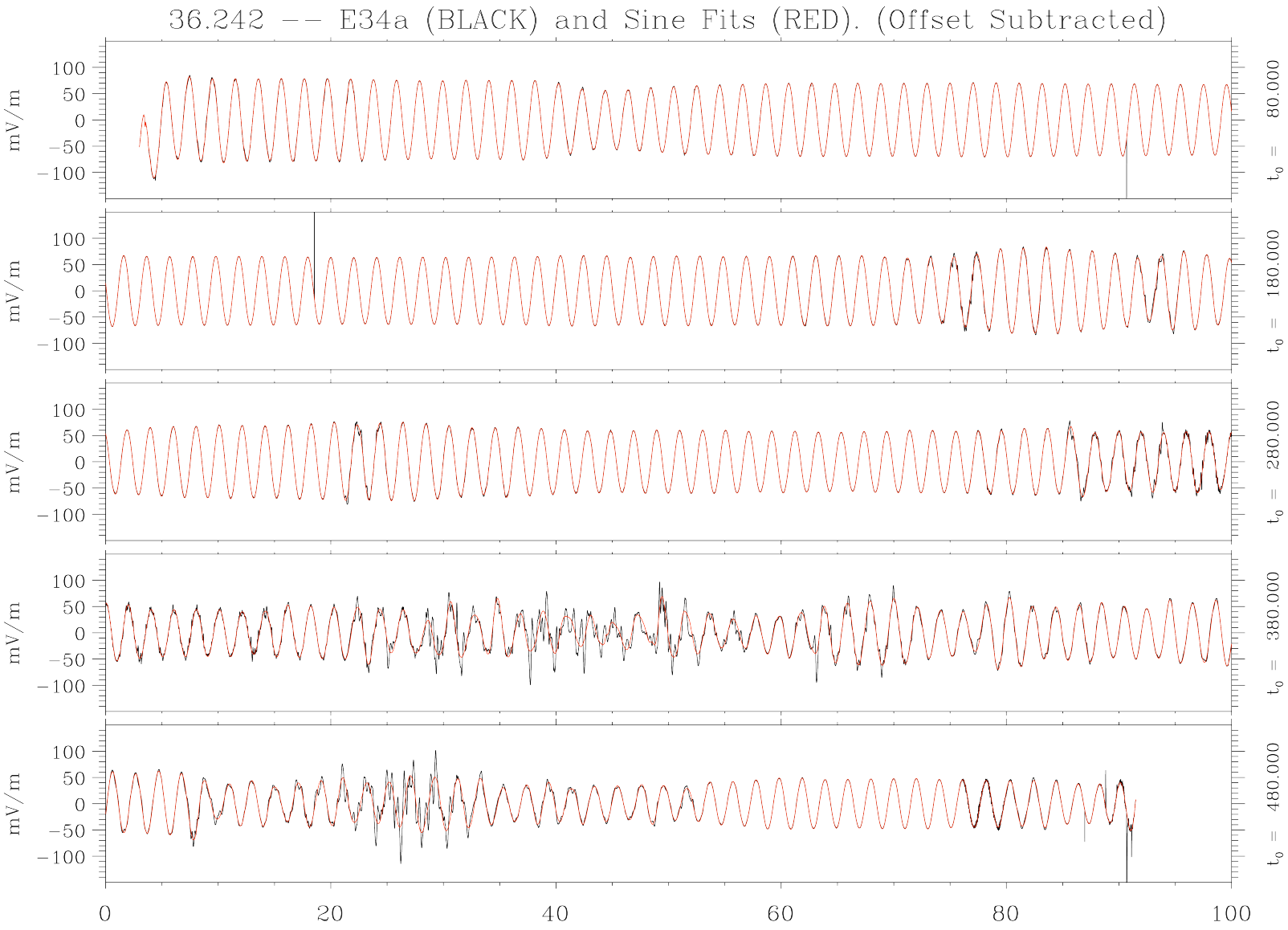

36.242 -- Relative Phase of E12/E34
100
90
80
70
Degrees
mean = 90.00°
100
150
200
250
300
350
400
Seconds after launch

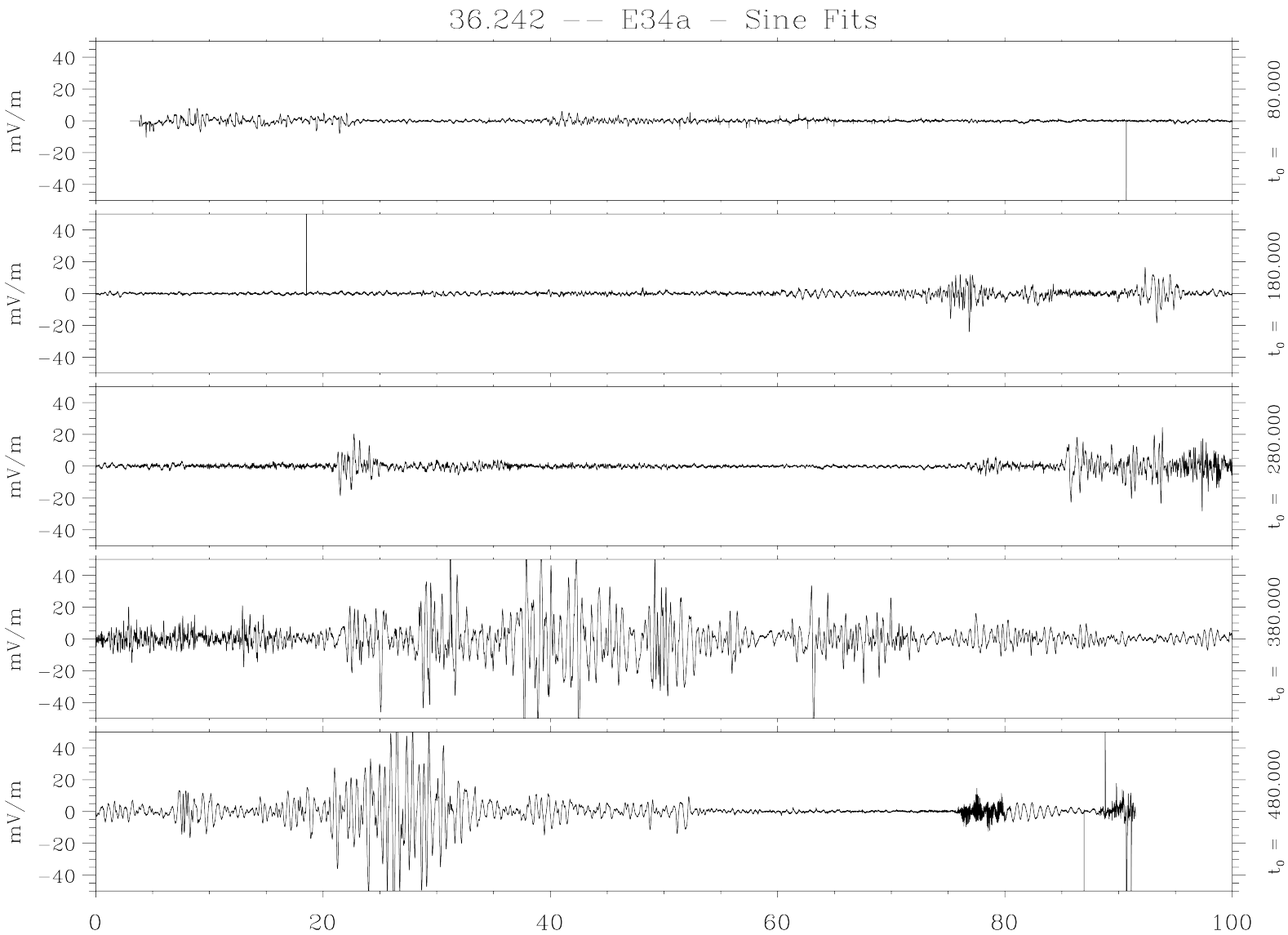

36.242 -- E12a
mV/m
100
50
0
−50
−100
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100

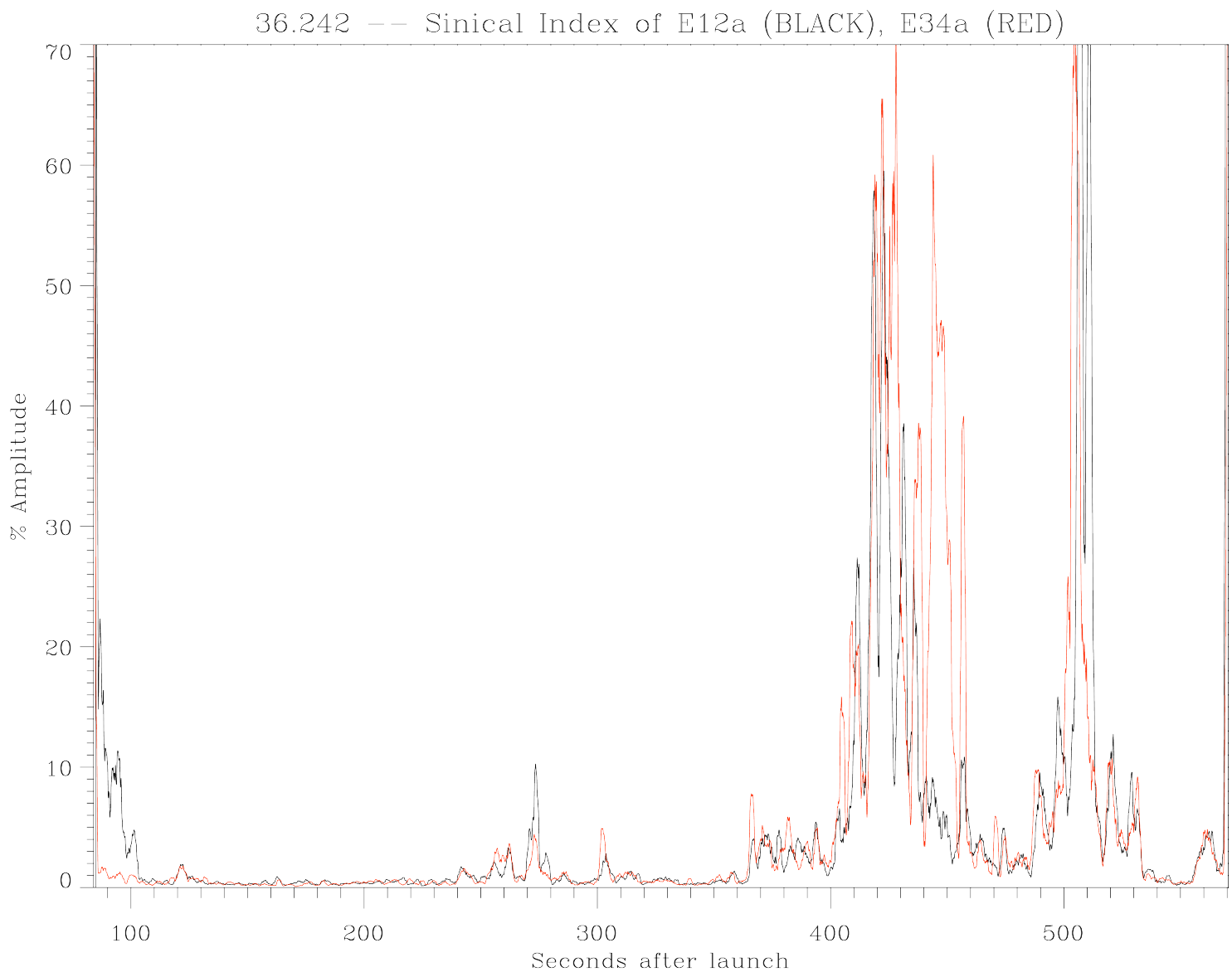

36.242 -- E12a (BLACK) and Sine Fits (RED). (Offset Subtracted)
mV/m
100
50
0
−50
−100
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100

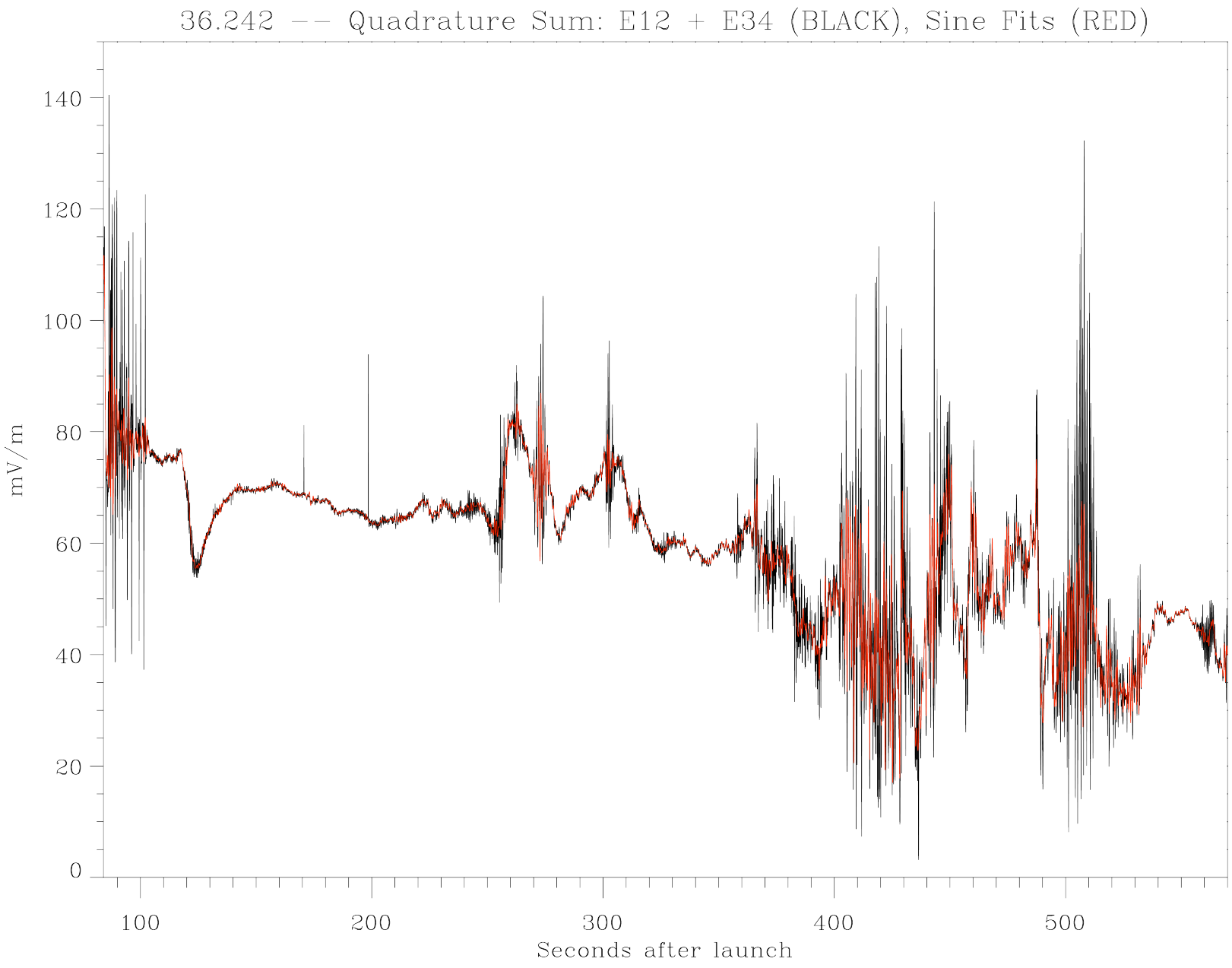

36.242 -- E12a - Sine Fits
mV/m
40
20
0
−20
−40
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100


36.242 -- E34a
mV/m
100
50
0
−50
−100
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100

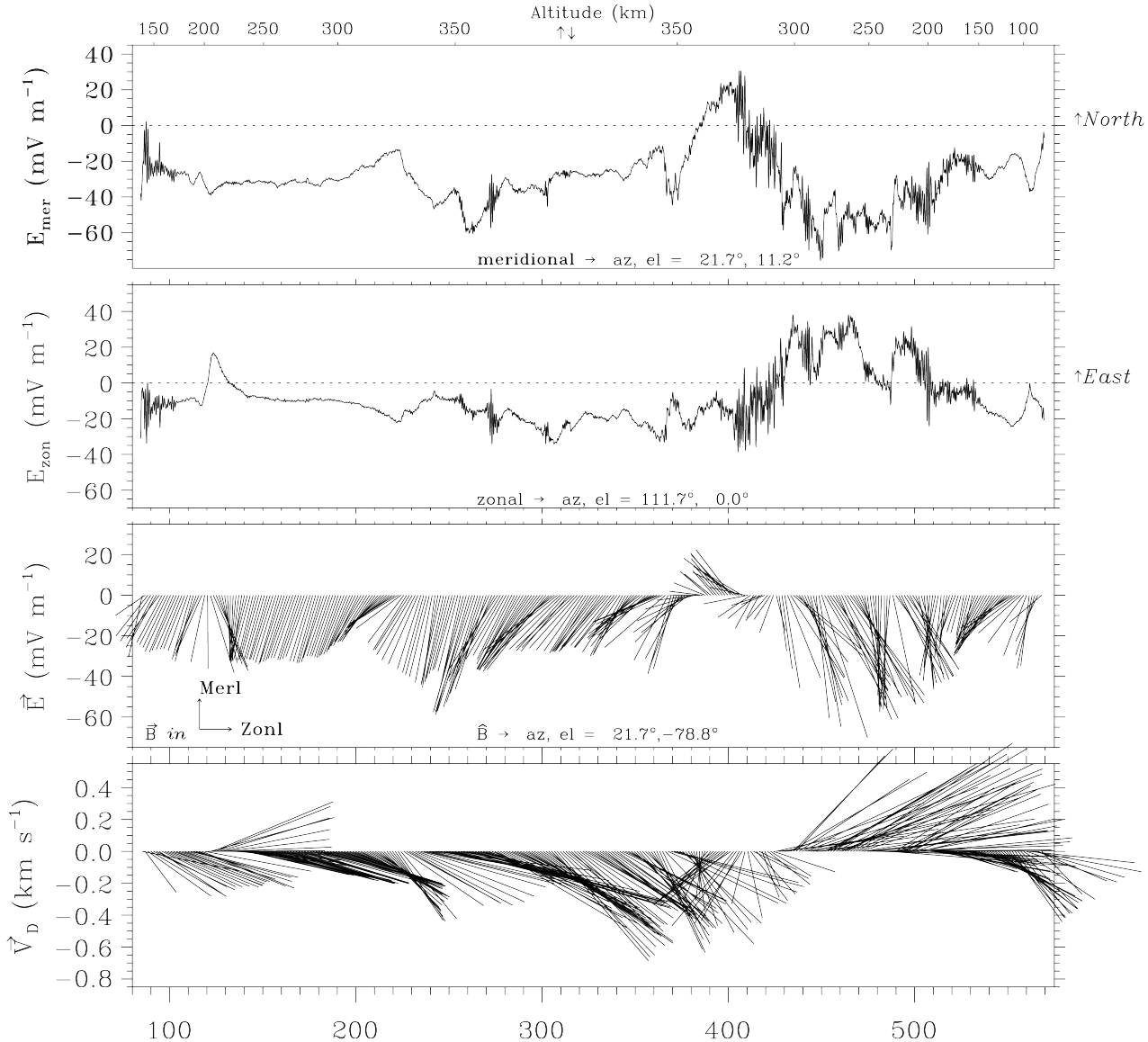

36.242 -- E34a (BLACK) and Sine Fits (RED). (Offset Subtracted)
mV/m
100
50
0
−50
−100
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100


36.242 -- E34a - Sine Fits
mV/m
40
20
0
−20
−40
t_0 = 80.000
t_0 = 180.000
t_0 = 280.000
t_0 = 380.000
t_0 = 480.000
0
20
40
60
80
100


36.242 -- Sinical Index of E12a (BLACK), E34a (RED)
% Amplitude
0
10
20
30
40
50
60
70
100
200
300
400
500
Seconds after launch


36.242 -- Quadrature Sum: E12 + E34 (BLACK), Sine Fits (RED)
mV/m
0
20
40
60
80
100
120
140
100
200
300
400
500
Seconds after launch

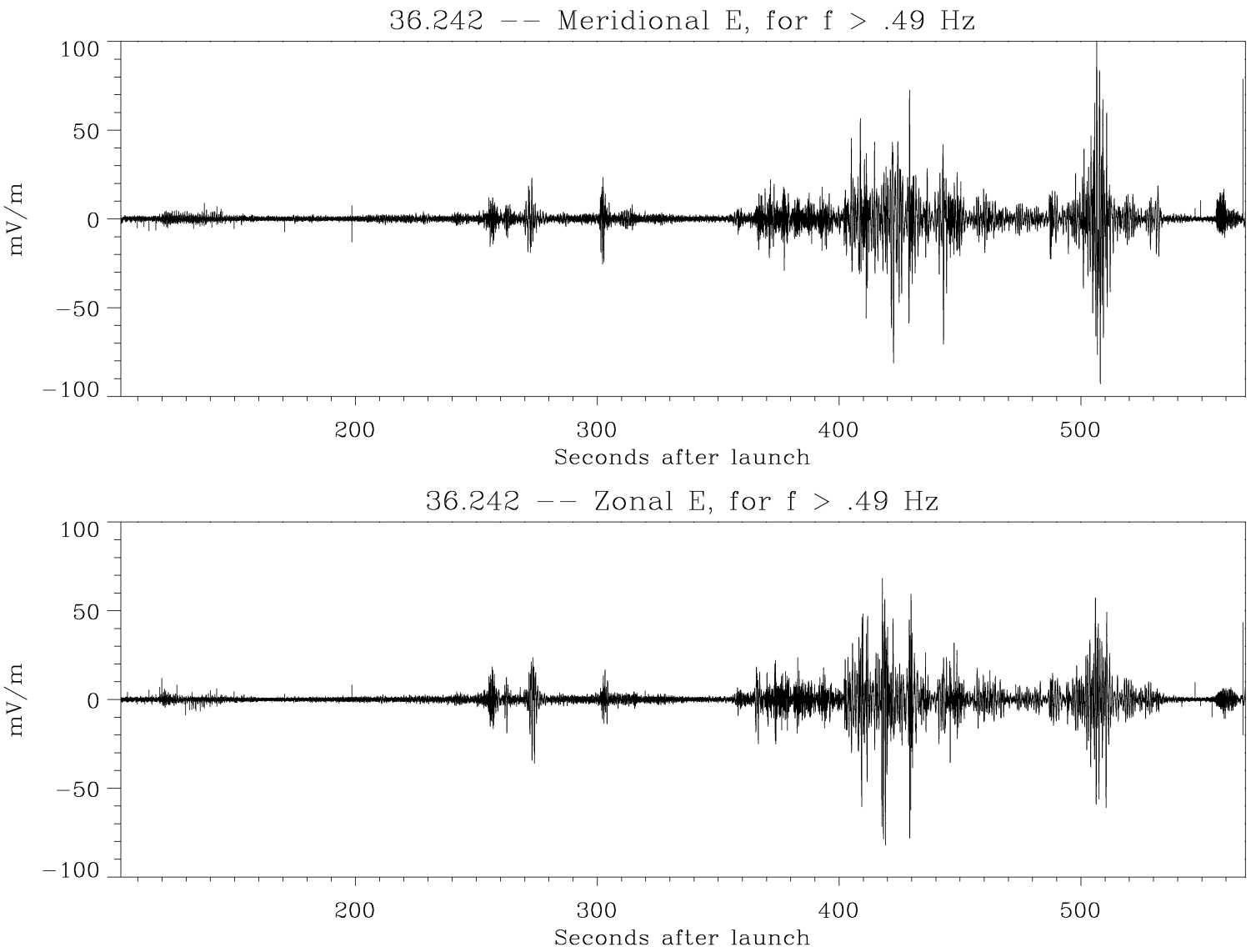
DC Electric Field Solution -- ACES “High” (36.242)



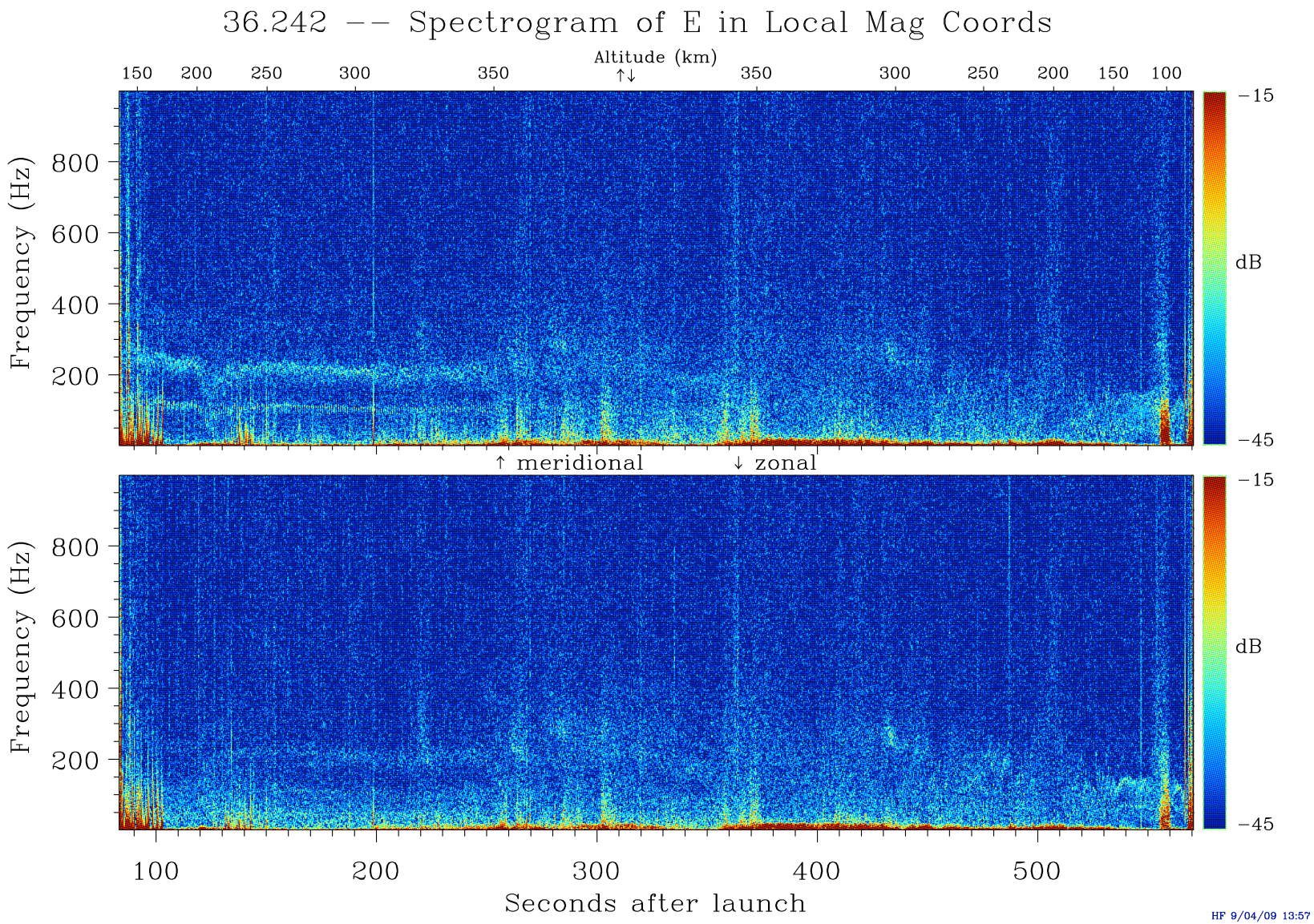
Seconds After Launch (09:49:40 UT)

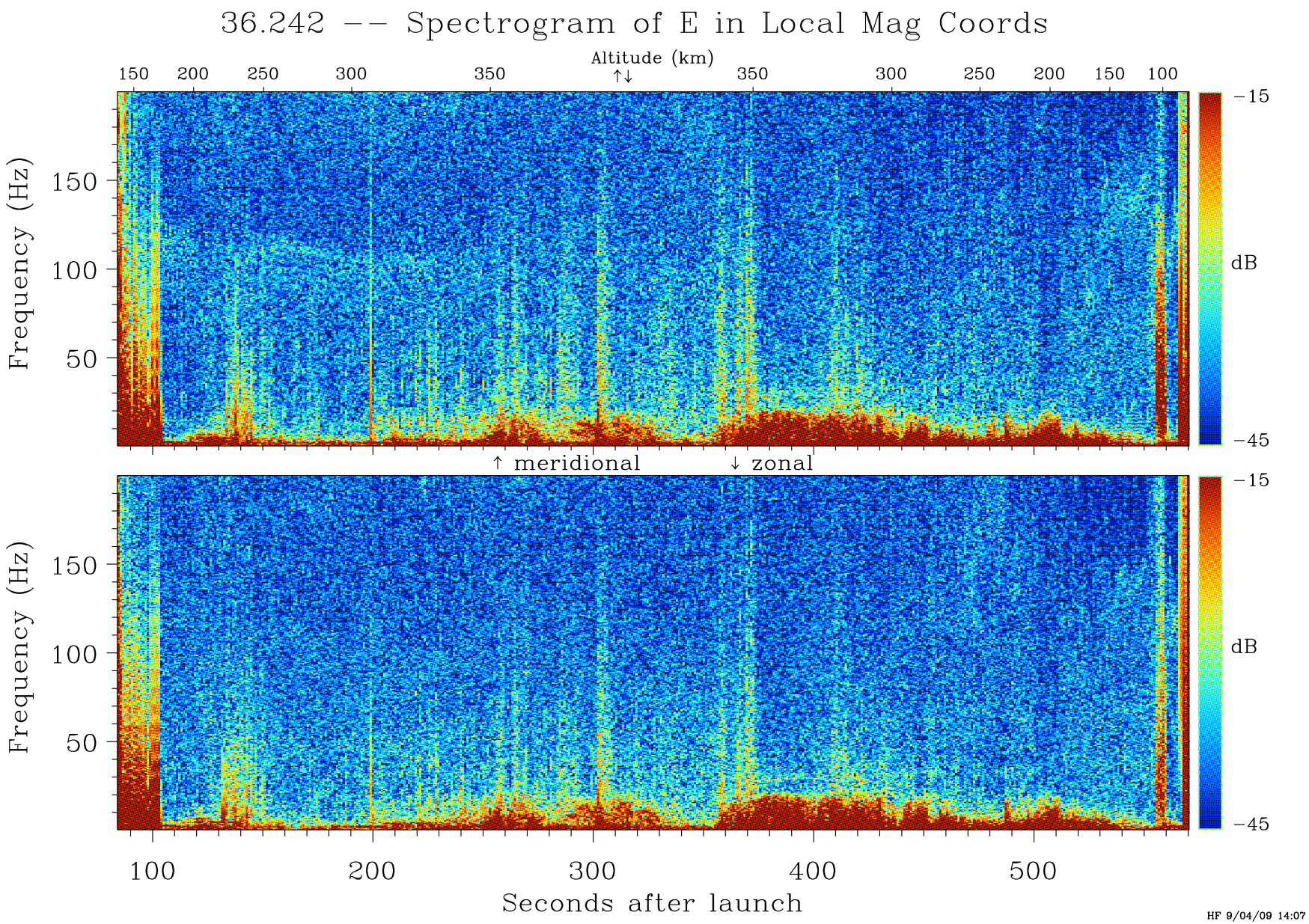
ACES “High” -- 36.242

ELF Electric Field Measurements



HF 9/04/09 14:15

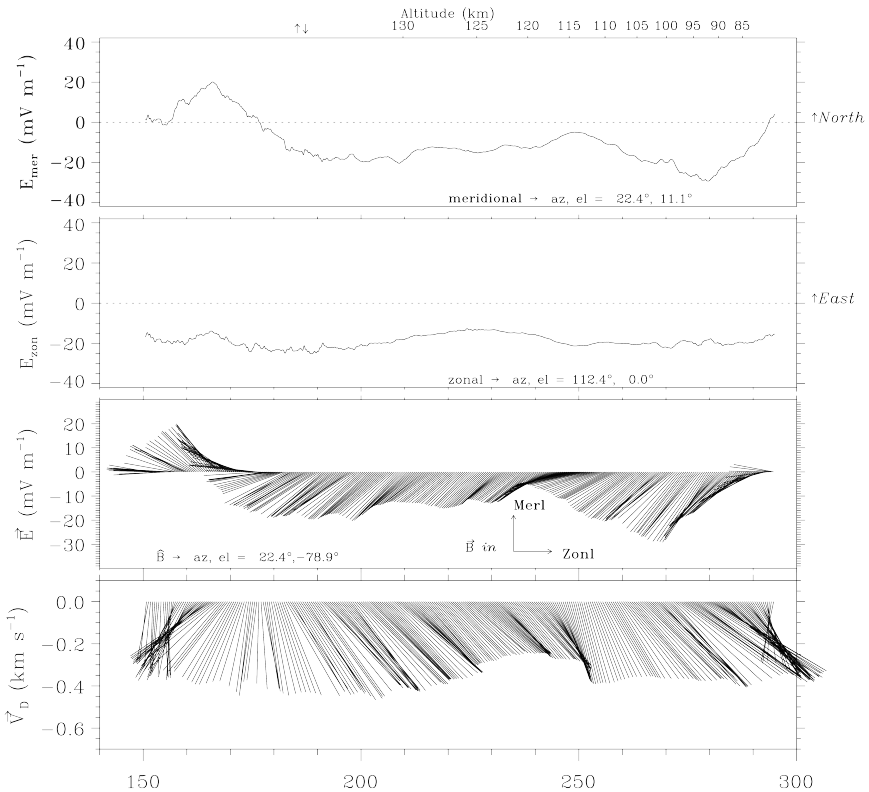

36.242 -- Spectrogram of E in Local Mag Coords
Altitude (km)
150 200 250 300 350 ↑↓ 350 300 250 200 150 100
Frequency (Hz)
800
600
400
200
−15
dB
−45
↑ meridional
↓ zonal
Frequency (Hz)
800
600
400
200
−15
dB
−45
100 200 300 400 500
Seconds after launch
HF 9/04/09 13:57


36.242 -- Spectrogram of E in Local Mag Coords
Altitude (km)
150 200 250 300 350 ↑↓ 350 300 250 200 150 100
Frequency (Hz)
150
100
50
−15
dB
−45
↑ meridional
↓ zonal
Frequency (Hz)
150
100
50
−15
dB
−45
100 200 300 400 500
Seconds after launch
HF 9/04/09 14:07

Comparison of E x B Drifts on Two ACES Rockets

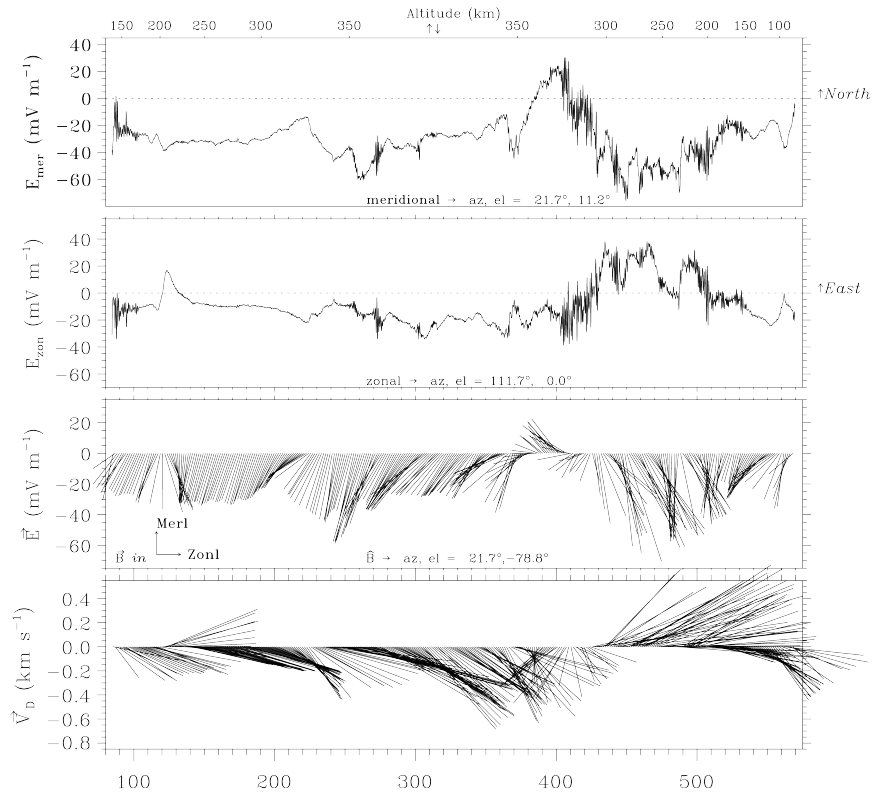
DC Electric Field Solutions -- Comparisons -- ACES “High and Low”

ACES “Low” (21.139)

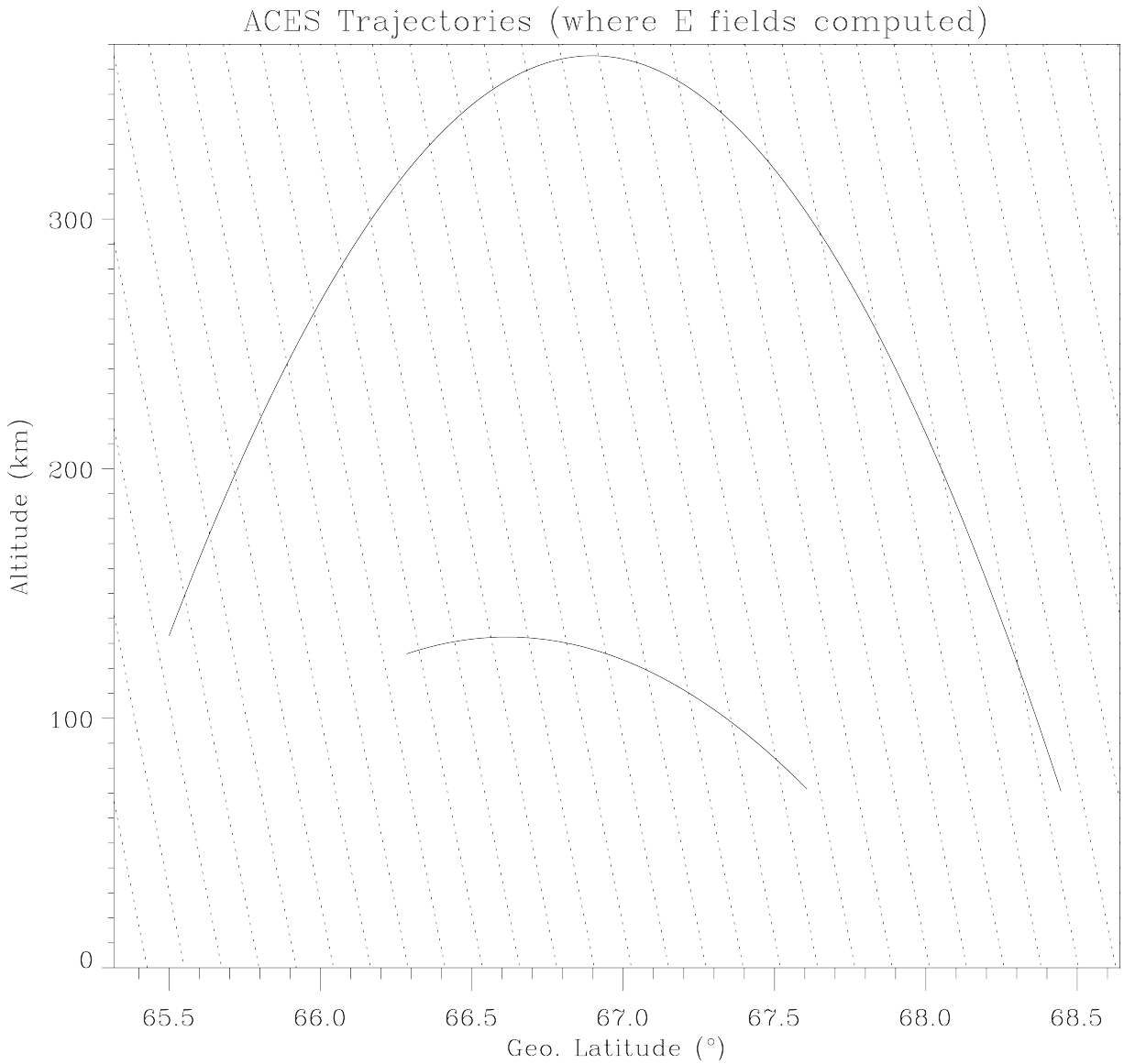


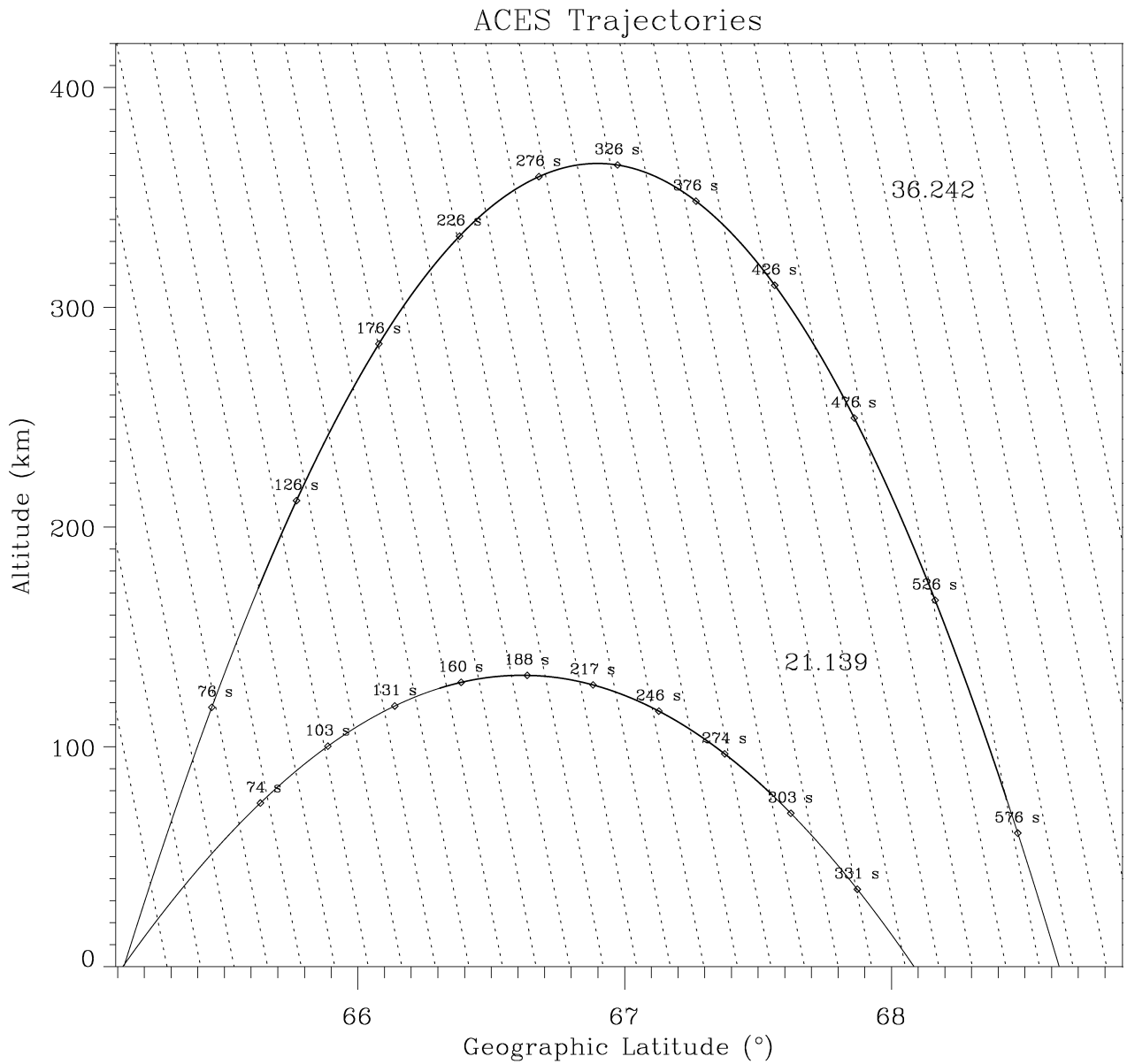
Seconds After Launch (09:51:10 UT)

ACES “High” (36.242)

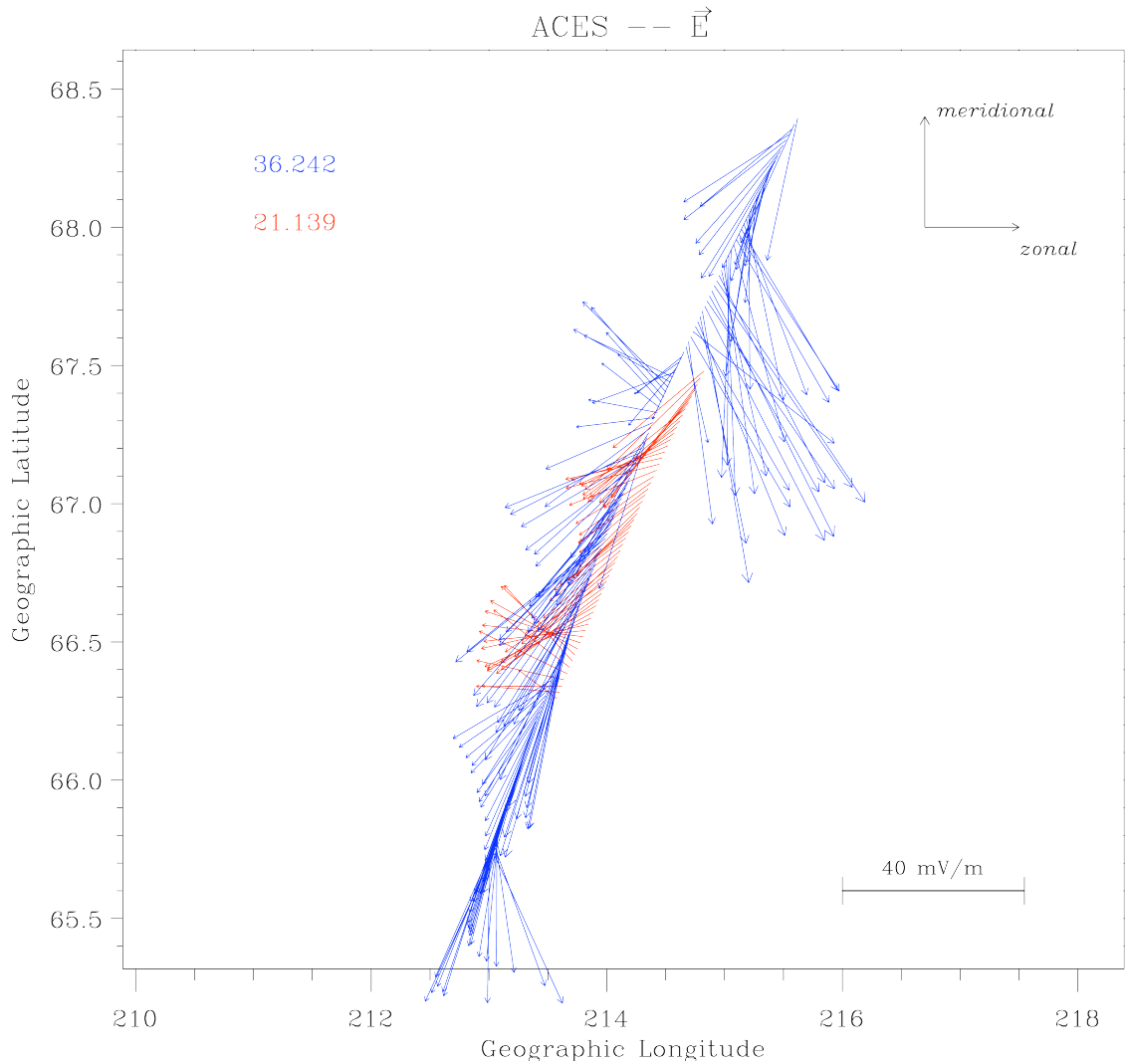


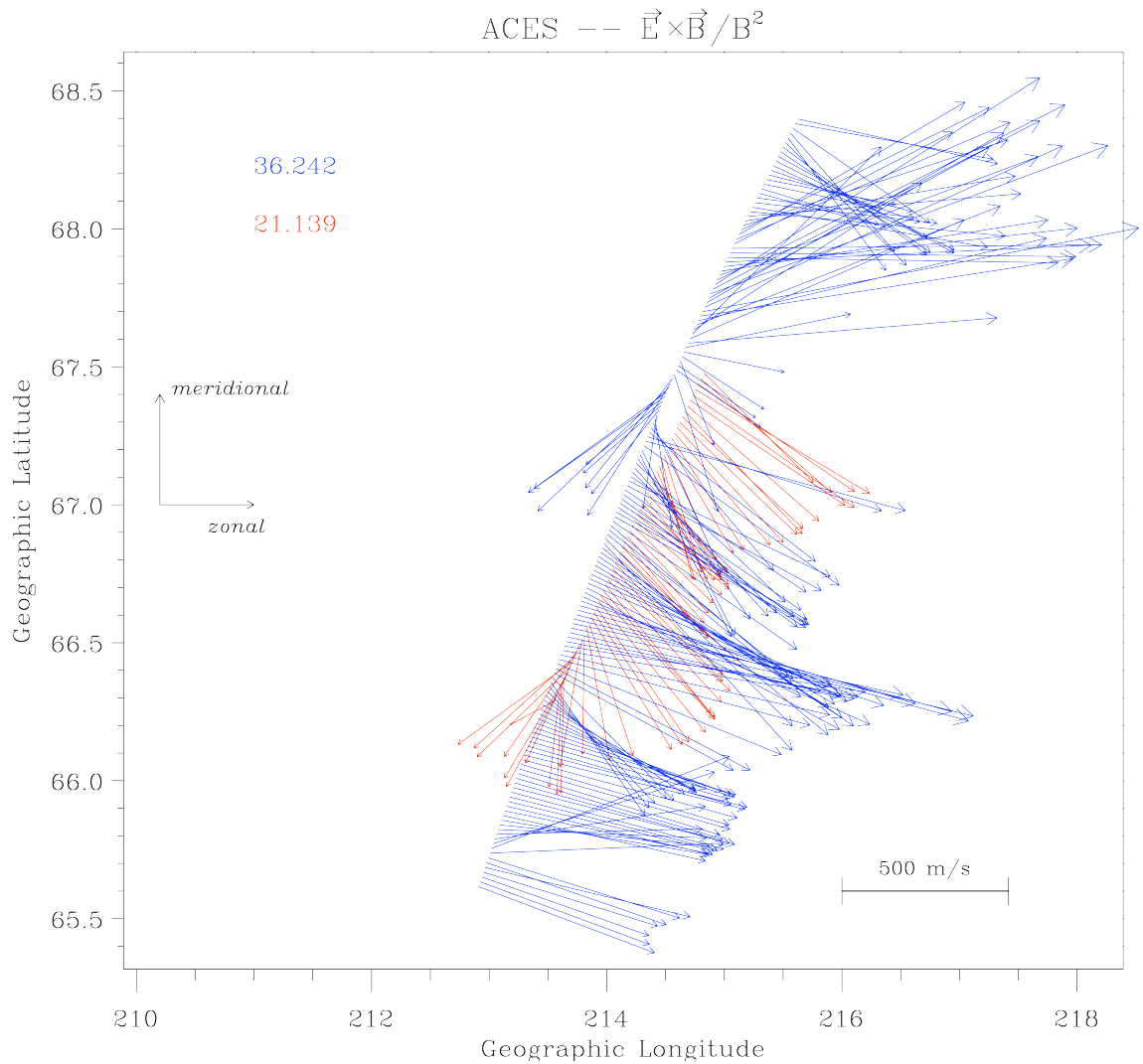
Seconds After Launch (09:49:40 UT)

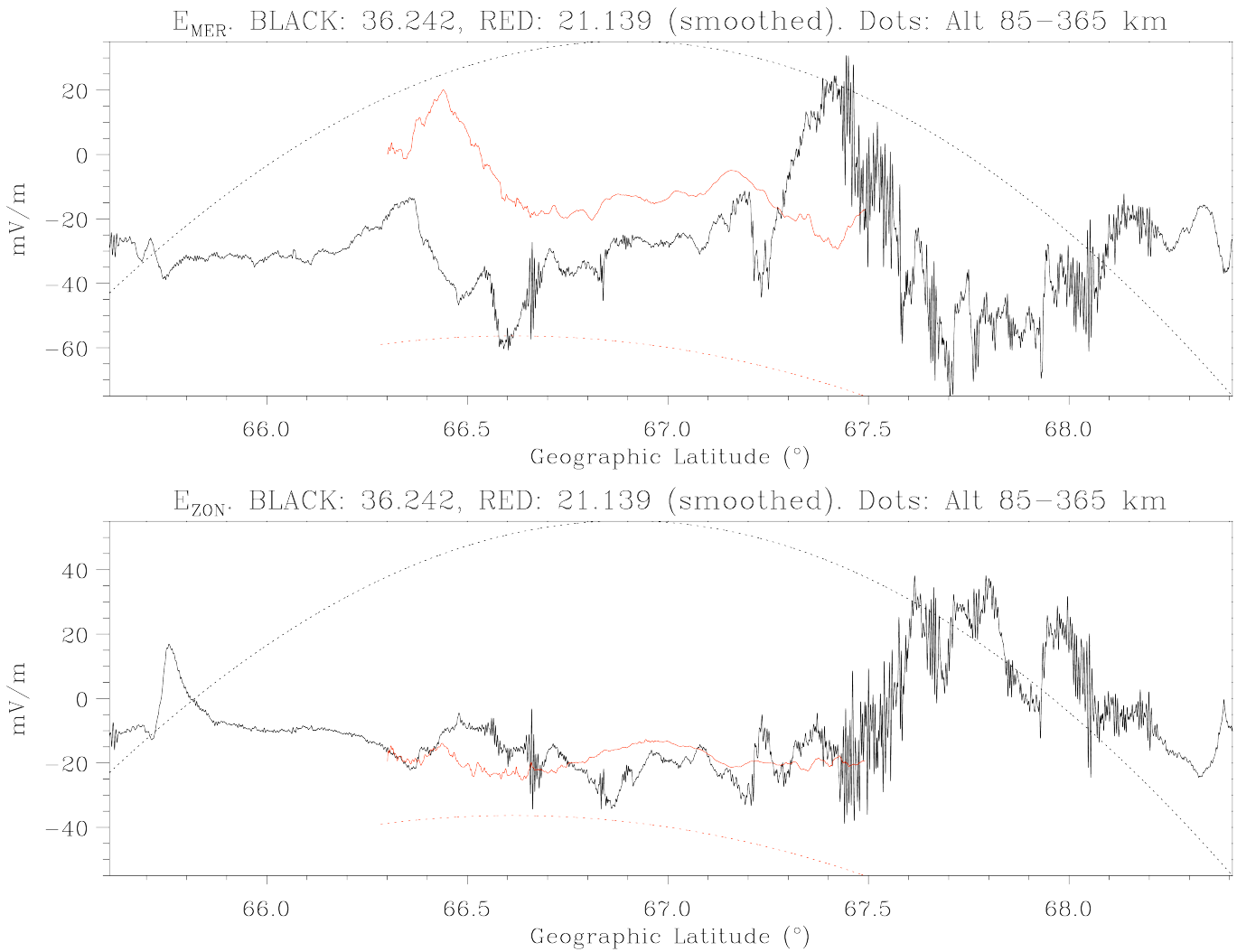

ACES Trajectories (where E fields computed)
Altitude (km)
0
100
200
300
65.5
66.0
66.5
67.0
67.5
68.0
68.5
Geo. Latitude (°)



HF 9/04/09 17:55


ACES -- $\vec{E}$
36.242
21.139
meridional
zonal
40 mV/m
68.5
68.0
67.5
67.0
66.5
66.0
65.5
Geographic Latitude
210
212
214
216
218
Geographic Longitude


ACES -- $\vec{E}\times\vec{B}/B^2$
36.242
21.139
meridional
zonal
500 m/s
68.5
68.0
67.5
67.0
66.5
66.0
65.5
Geographic Latitude
210
212
214
216
218
Geographic Longitude

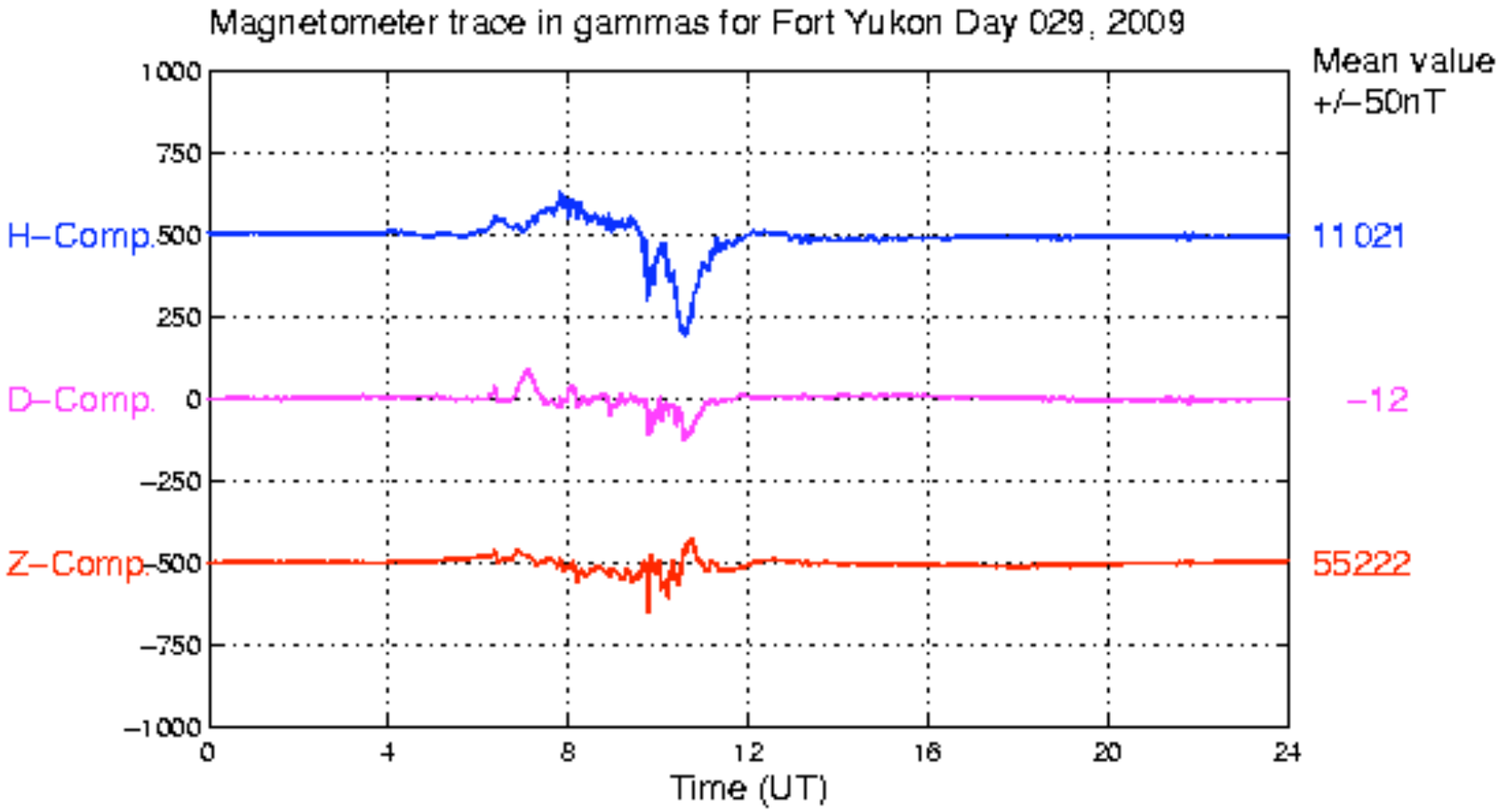

E_MER. BLACK: 36.242, RED: 21.139 (smoothed). Dots: Alt 85−365 km
mV/m
20
0
−20
−40
−60
66.0
66.5
67.0
67.5
68.0
Geographic Latitude (°)
E_ZON. BLACK: 36.242, RED: 21.139 (smoothed). Dots: Alt 85−365 km
mV/m
40
20
0
−20
−40
66.0
66.5
67.0
67.5
68.0
Geographic Latitude (°)

Ground-Based Measurements Related to E x B Drifts

Magnetometer and PFISR Data

Ft. Yukon -- Ground-based Magnetometer

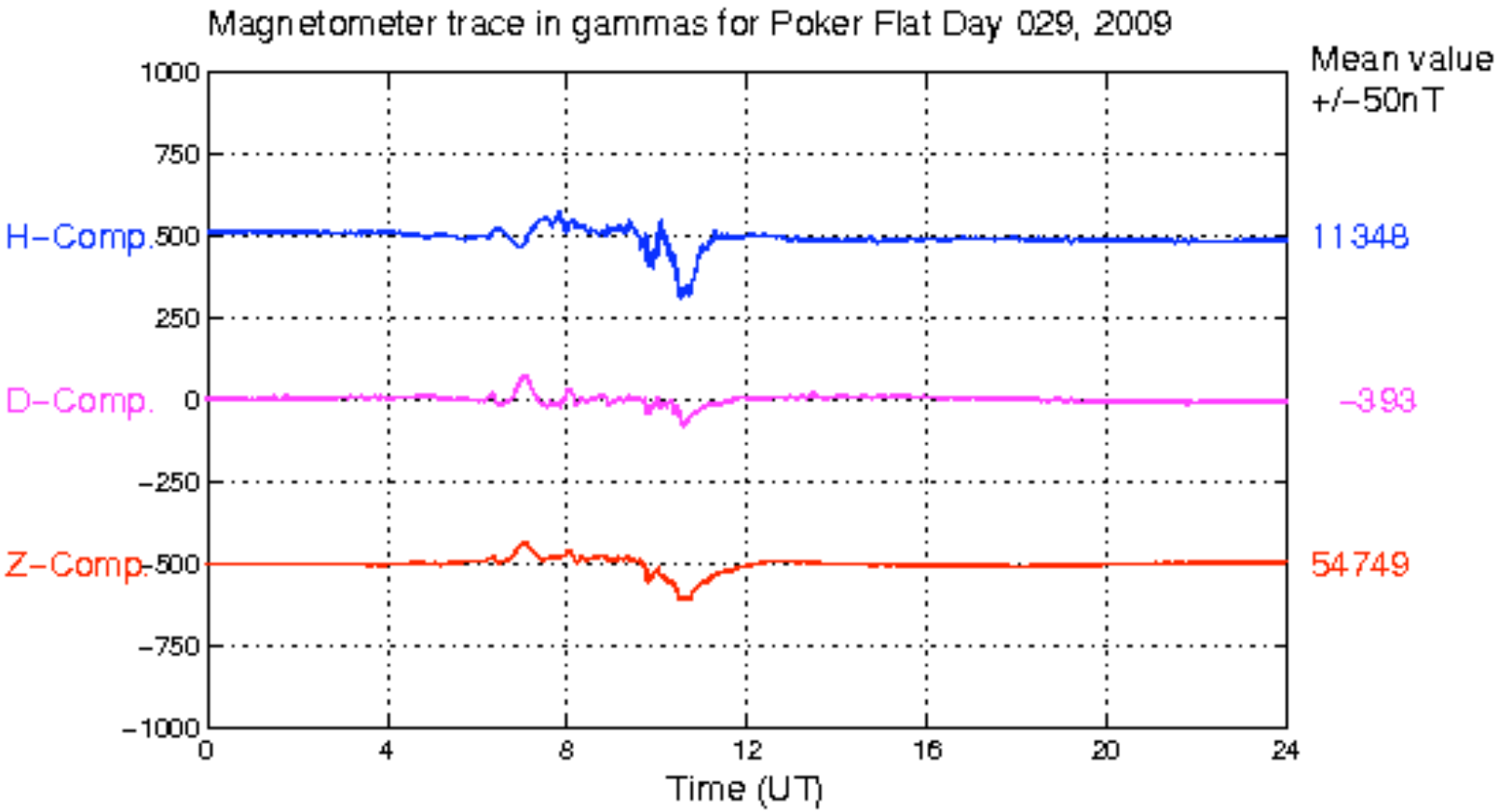
Launch T-zeroes: 09:49:40 UT, 09:51:10 UT



Courtesy, PFRR

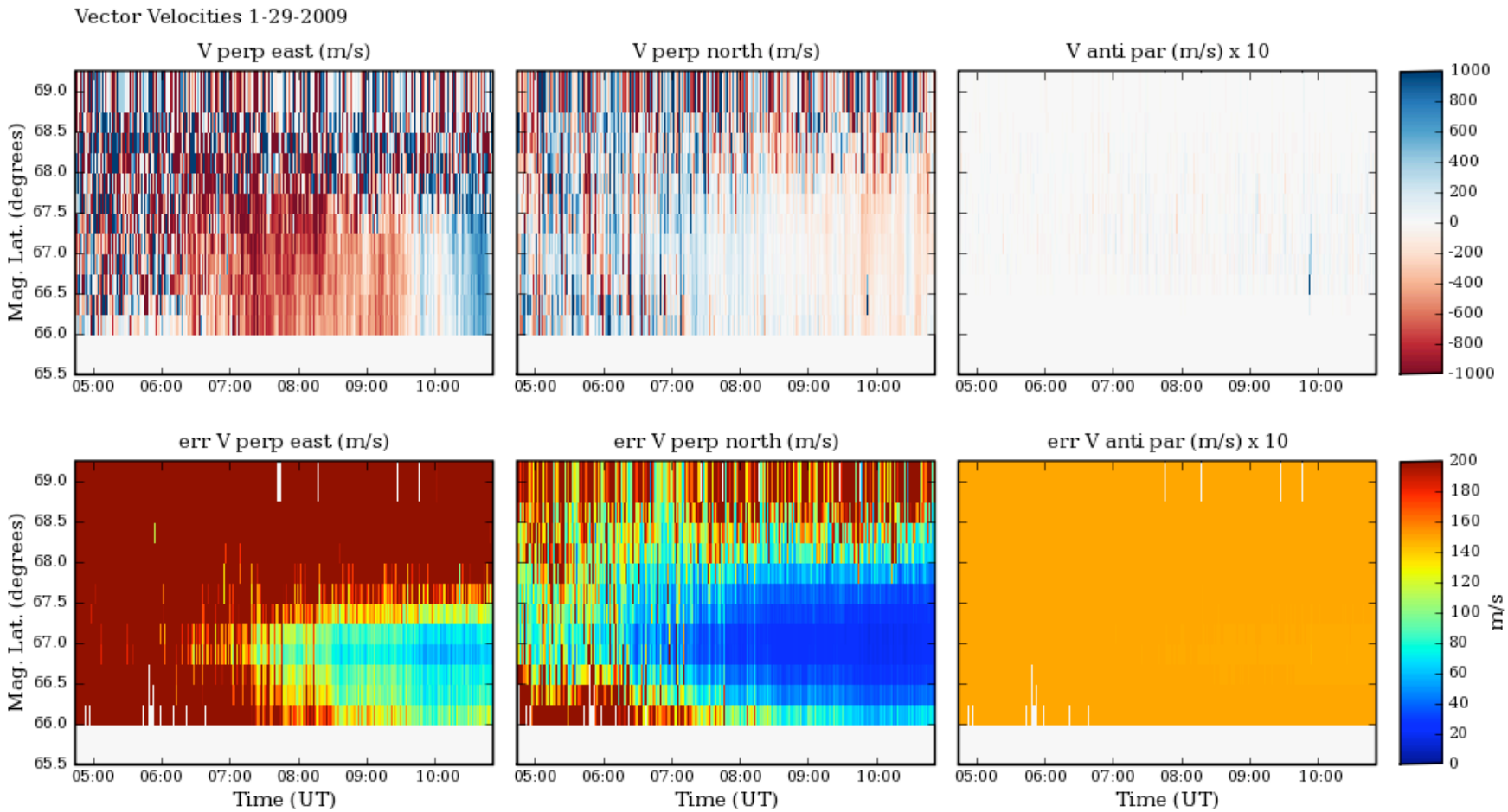
Poker Flat -- Ground-based Magnetometer

Launch T-zeroes: 09:49:40 UT, 09:51:10 UT



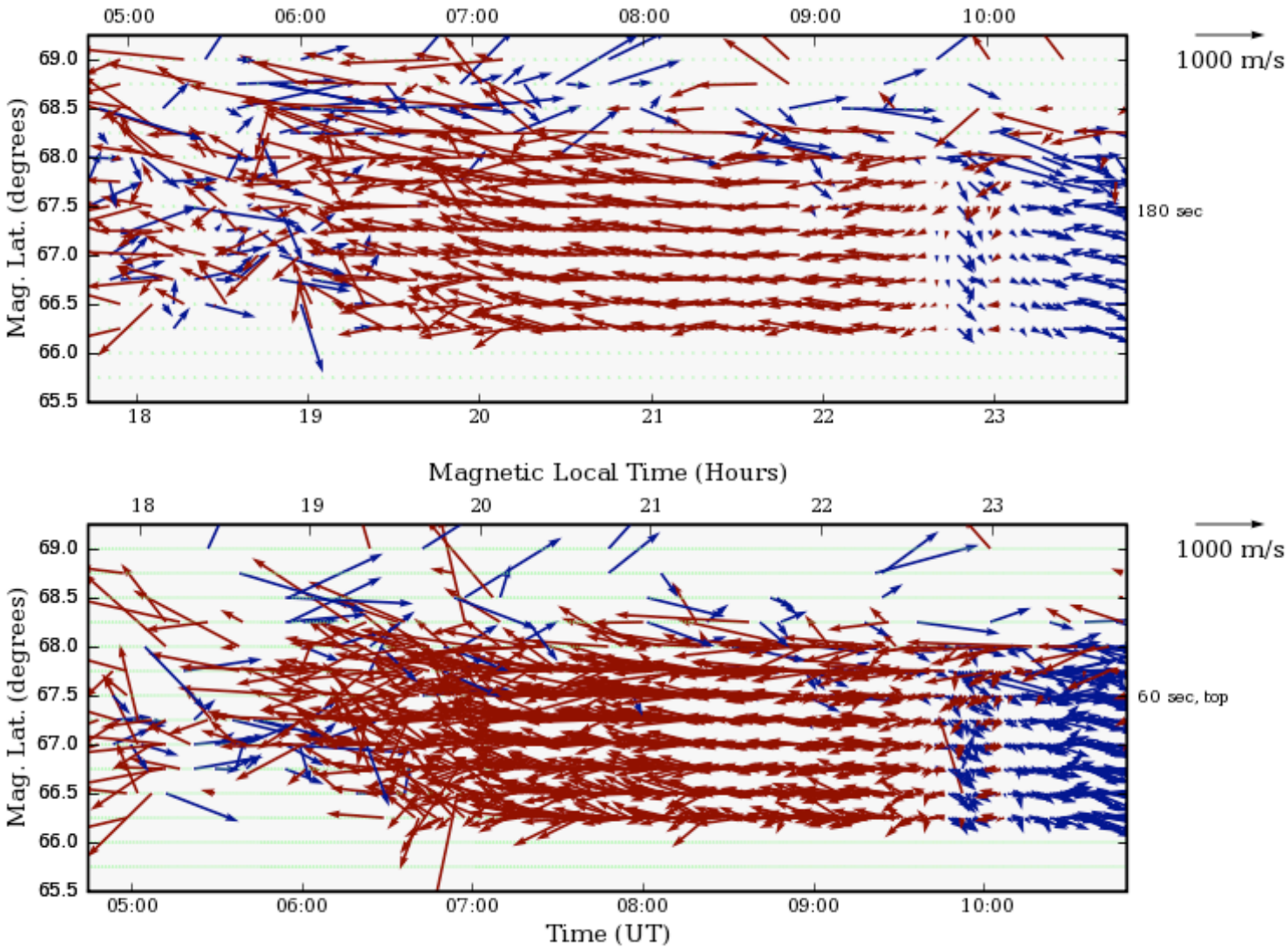
Courtesy, PFRR

PFISR -- Overview Drifts -- January 29, 2009



Courtesy, M. Nicolls, C. Heinselman

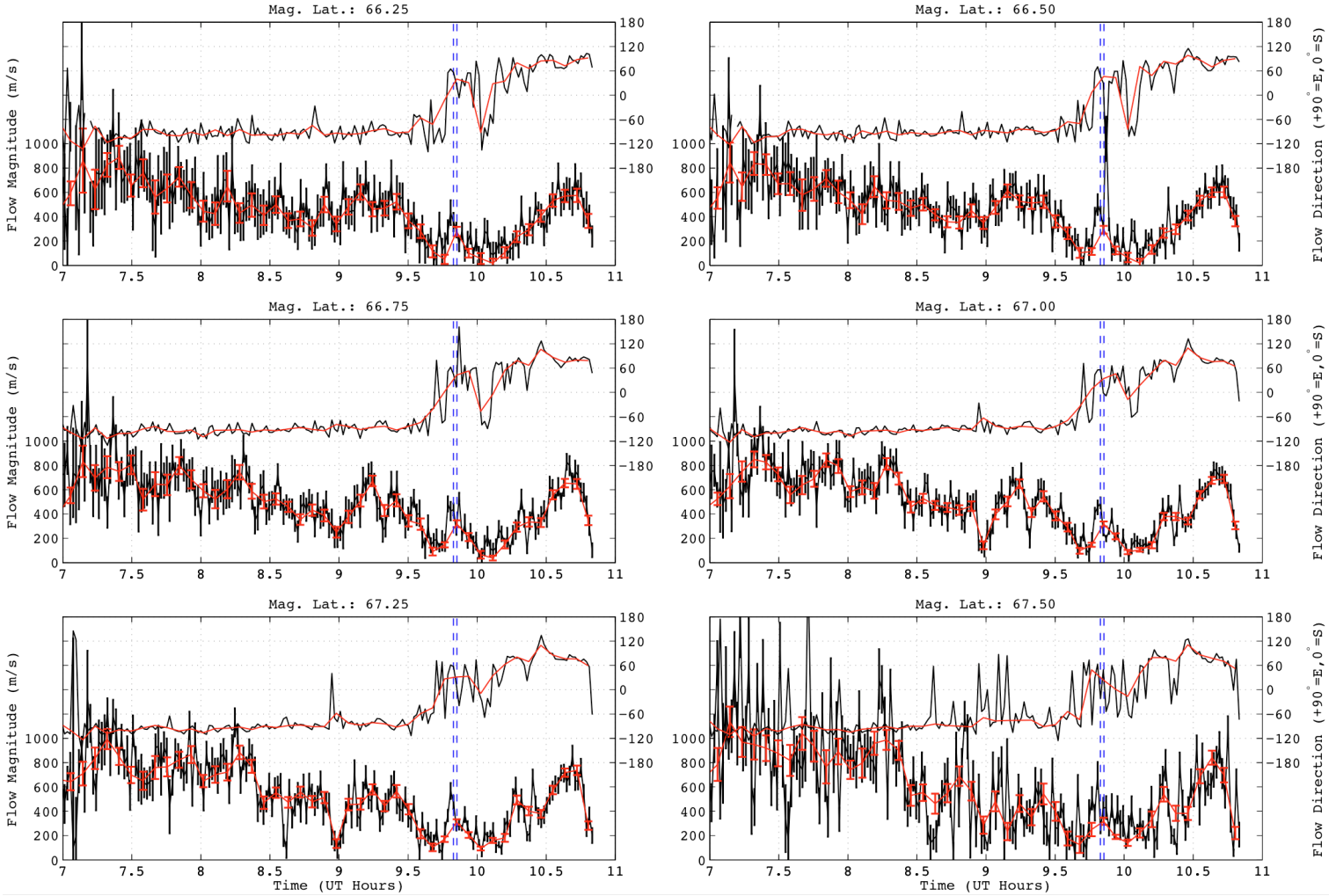
PFISR -- Overview Drifts -- January 29, 2009



Courtesy, M. Nicolls, C. Heinselman

PFISR -- Detailed Flow Drifts along 6 Beams -- January 29, 2009

1 min resolution = black, 5 min resolution = red



Courtesy, M. Nicolls, C. Heinselman