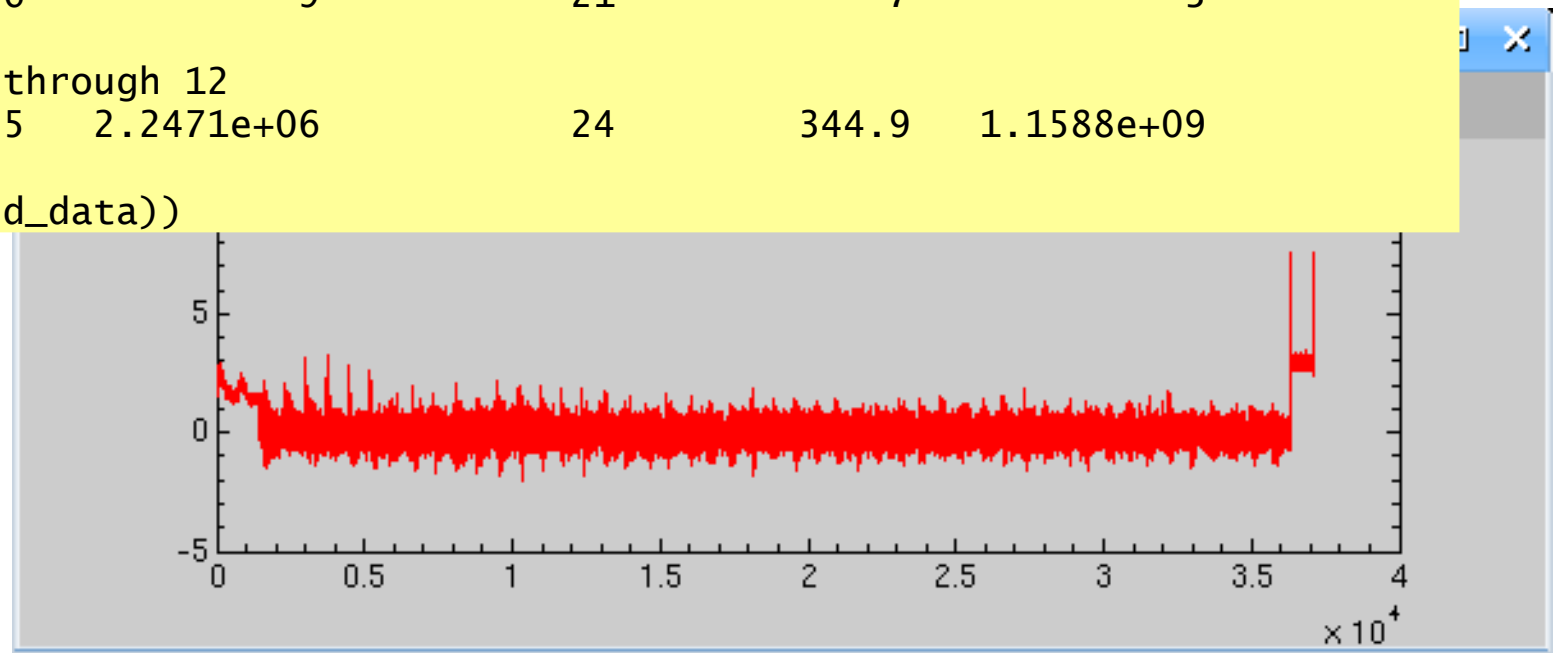

Ingemar Häggström
EISCAT HQ

EISCAT data

- Raw data (.mat files) Compatible with matlab, binary files
  - Name of the data file is the end time of the record in seconds from the beginning of year.
    - 8 characters long (padded with zeroes)
      - New Years Day at 1 UT -> 00003600.mat
  - d_ExpInfo (text string)
    - Experiment name, scan, owner
  - d_parbl (real vector)
    - Time, antenna and transmitter parameters
  - d_data (complex vector)
    - lagprofiles
      - one to thousands
      - Correlations of received samples
        - Depends on transmitter code and decoding procedure
  - d_raw (complex vector)
    - Raw amplitude samples
      - Transmitter code

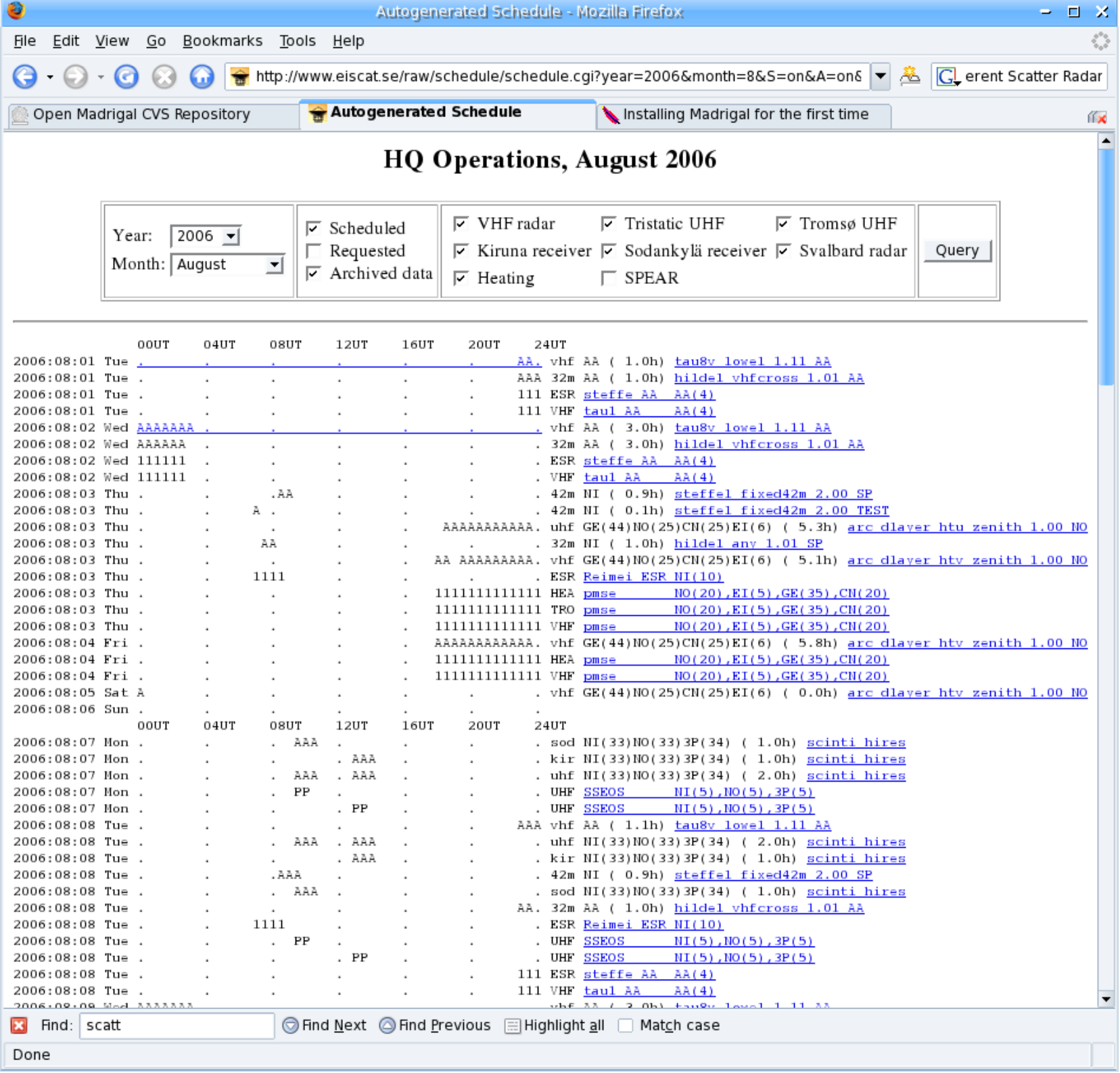
Raw data

```
>> whos
  Name             Size                     Bytes  Class

  d_ExpInfo        1x24                        48  char array
  d_data       37101x1                     593616  double array (complex)
  d_parbl          1x66                       528  double array

Grand total is 37191 elements using 594192 bytes

>> d_ExpInfo
d_ExpInfo =
kst0 tau1u_cp3nk_1.30_CP
>> d_parbl(1:12)
ans =
  Columns 1 through 6
        2006           9          21           7           3
19.993
  Columns 7 through 12
           5   2.2471e+06          24       344.9   1.1588e+09
11560
>>plot(real(d_data))
```



EISCAT data access

- Raw data
  - Stored at the data base in Kiruna, Sweden
  - Downloadable via the web schedule
    - http://www.eiscat.se/schedule/schedule.cgi
      - Choose 'Archived'
    - Older data (>1 year) and Common Programmes
      - Allowed for all EISCAT countries
    - Recent data
      - Only accounted countries



- Common
  - CP UP AA
- Special
  - Country codes
  - SW,CN,FI..

EISCAT data utilities

- Raw data
  - Real time graph (RTG)
    - The run-time display feature
    - To read/integrate data and plot profiles/spectra
  - GUISDAP
    - To analyse data and reduce into physical quantities
    - To integrate
    - Use the setups to understand the data layout for own analysis procedures
- Analysed data
  - Within GUISDAP
    - Display, calibrate, vectors...

RTG on the web

EISCAT Tromsø UHF Real Time Graph - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.eiscat.se/rtg/rtg.cgi?T

Loading...

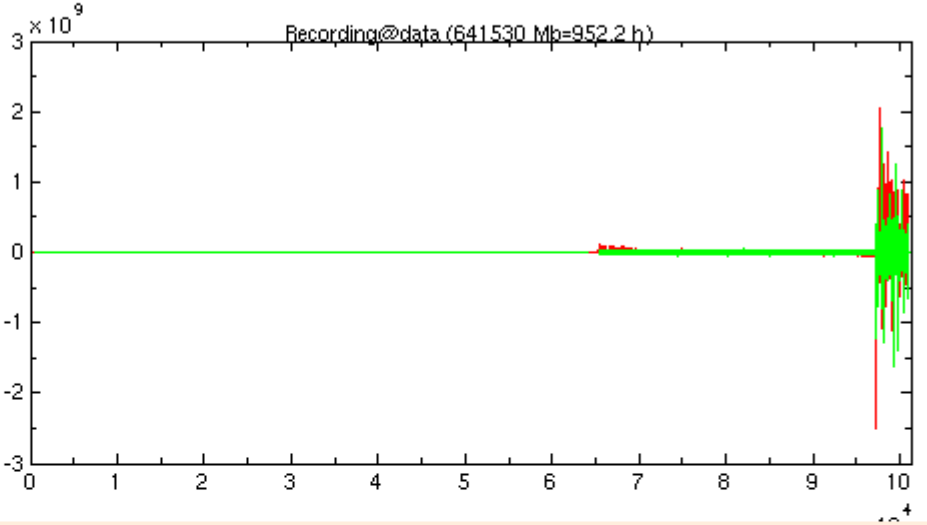
EISCAT SCIENTIFIC ASSOCIATION

Schedule
Real time graphs
» **Tromsø UHF**
» Tromsø VHF
» Sodankylä
» Kiruna
» ESR 32m
» ESR 42m
» ESR 32m PL
» Tromsø HF
» Real Time Graph
Latest analysis results
Madrigal
EISCAT 3D

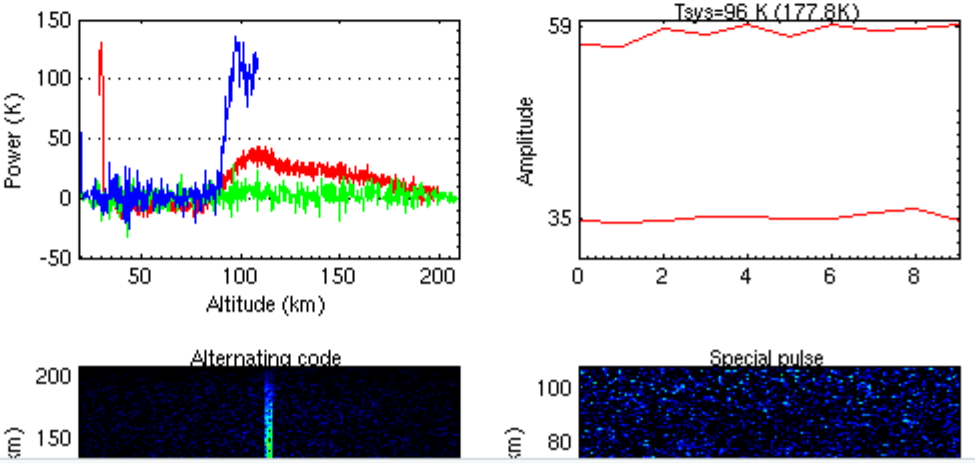
[remove menu for printing] [compact menu]

Last modified Thursday 09 December

kst0 manda_zenith_4.00u_SP 2011-07-21 0959:31 4.8s 1318kW 184.0/90.0



manda 2011-07-21 0959:31 4.8s 1318kW 184.0/90.0



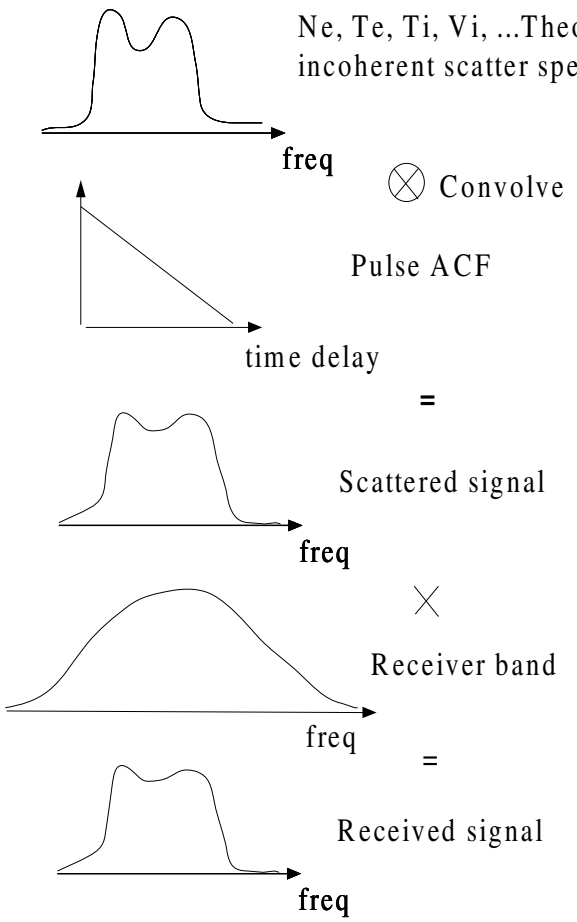
Transferring data from www.eiscat.se...

Received signal

- Incoherent scatter theory very exact
  - Spectrum depends on ionospheric parameters
- Received signal
  - Transmitted waveform
    - Pulse coding
  - (Direction – only for directions close to perpendicular)
  - Receiver filters
- Analysis
  - Compare theoretical with measured
    - Need to correct for the waveform and receiver filter

GUISDAP

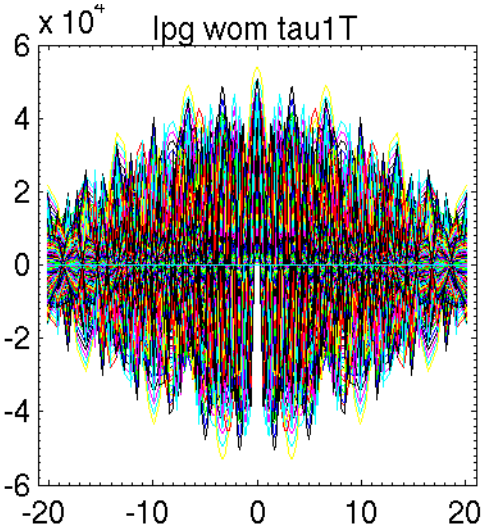
Classic analysis



Compare this with the measurements, after proper transformation

Guisdap analysis

Initialisation calculates the spectral ambiguity function for all points in the data dump, lpg_wom
This contains the transmitting pulse shape (pulse ACF), receiver band and transformations



The initialisation file

Describes the radar experiment in full detail

Initialisation simulates the experiment

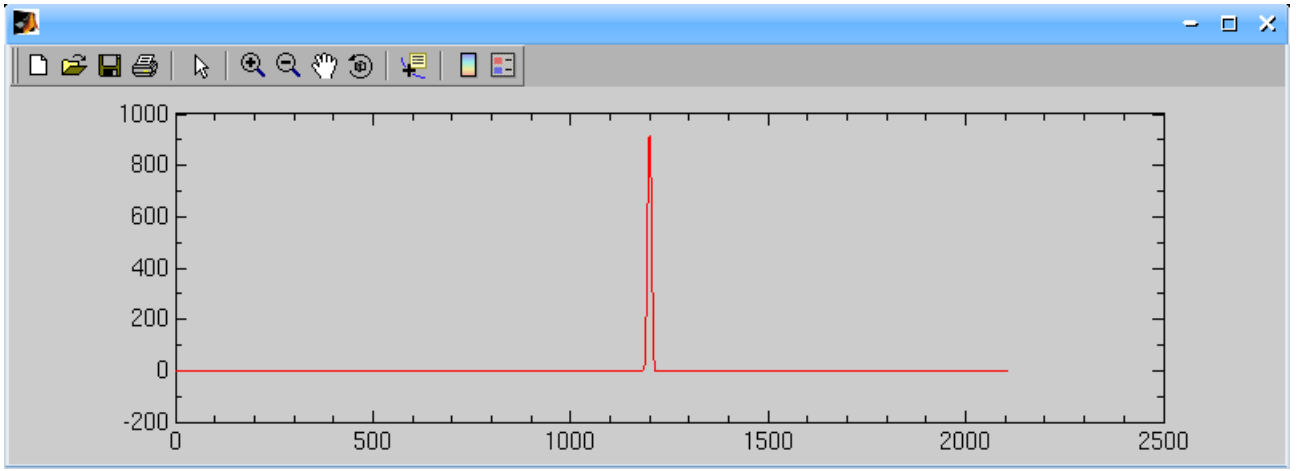
Only the correlated part (the lag profiles) – analysis in time domain

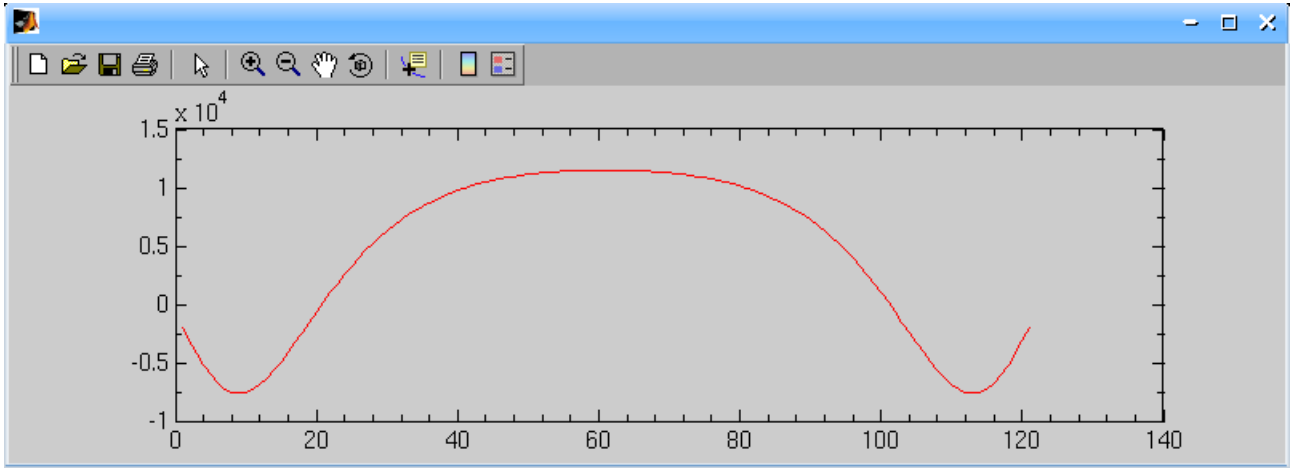
```
>> load /opt/guisdap8/exps/tau1/tau1Tinit
>> who

Your variables are:

GUP_iniver    lpg_cal       lpg_nt        p_N0          p_om0         vcg_penv
ch_fradar     lpg_code      lpg_ra        p_R0          vc_ch
   vcg_penvabs
ch_gain       lpg_dt        lpg_ri        p_RECloc      vc_group
lp_vc         lpg_h         lpg_w         p_T0          vc_penvo
lpg_ND        lpg_lag       lpg_wom       p_XMITloc     vc_routine
lpg_T         lpg_lpdata    lpg_wr        p_dtau        vcg_Aenv
lpg_bac       lpg_lpend     nameexpr      p_m0          vcg_Ap
lpg_bcs       lpg_lpstart   p_D0          p_om          vcg_Apenv
```

- lpg_
  - Lag profile **group**
  - Each lpg contains several lag profiles (1-1000s)
    - The lag profile is formed in a 'mini-experiment' within the exp (1 tx, 1 rec, 1 cal)
  - The lpg_ parameters describes each point in the data file (d_data)
    - lag, range, extent, type, background, calibration, injected noise, sampling interval, number of additions, group, range distribution, filter,....

The initialisation file

```
>> [lpg_ND(17) lpg_T(17) lpg_bac(17) lpg_bcs(17) lpg_cal(17) lpg_code(17)]
ans =
   960     0     0   115   629     1
>> [lpg_dt(17) lpg_h(17) lpg_lag(17) lpg_nt(17) lpg_ra(17) lpg_ri(17) lpg_w(17)]
ans =
          12         1200           12          657         1526            1
   14.598
>> plot(lpg_wr(:,17))
>> plot(real(lpg_wom(17,:)))
```





The ambiguity vectors

- Spectral ambiguity function
  - lpg_wom
  - Used in fitting process
- Range ambiguity function
  - lpg_wr
  - Space debris detection
  - Bistatic volumes

Analysis

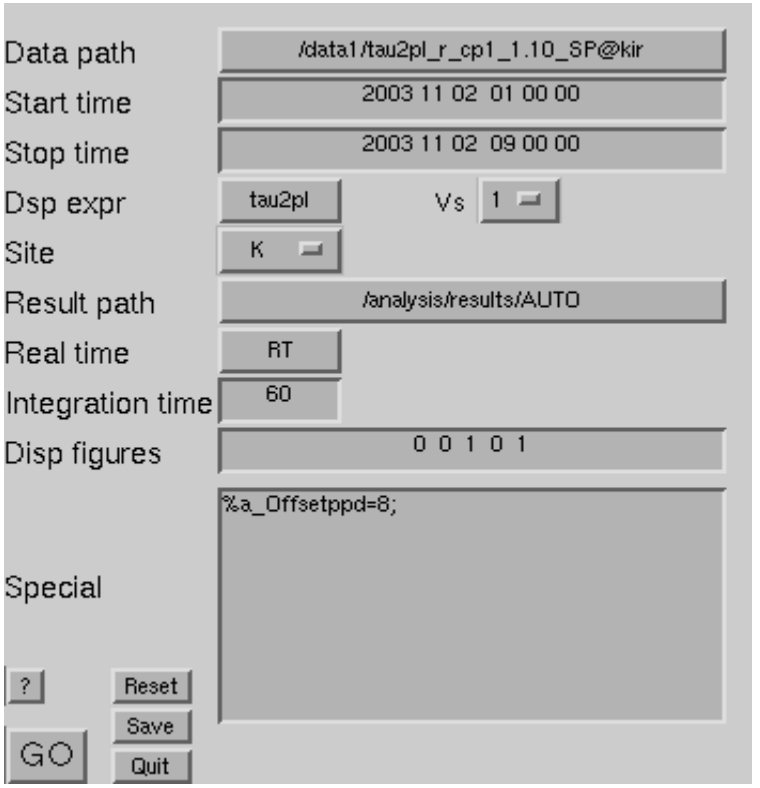
GUISDAP

% guisdap -a
• or
% guisdap
> analyse

Brings up the gfd setup window

Detailed instruction also at
http://www.eiscat.se/GUISDAP/howto.html

•Special
- Hundreds of parameters to tune if wanted
- display_analysis_pars=1;



Fitted Parameters

Parameter	Unit	Fitted quantity	Min	Max
Electron density	m^{-3}	$\log(N_e/N_0)$	10^6	10^{14}
Ion temperature	K	$\log(T_i/T_0)$	1	20000
Temperature ratio		$\log(T_e/T_i)$	0.01	100
Collision frequency	Hz	$\log(\nu_i/\nu_0)$	1	10^9
Ion drift velocity	ms^{-1}	$\text{asinh}(v_i/v_0/2)$	-20000	20000
Composition		p_i	-0.01	1.01
Dcspike	K	asinh(D/2)	-100	10000
Broadband	K	asinh(B/2)	-100	10000

GUISDAP vocabulary

- name_
  - experiment, site
- analysis_
  - parameters to set before analysis
    - range gating, integration time, antenna cycling
  - most transferred to a_ to override defaults
- d_
  - parameters that comes from the data
    - time, parameter block, data dump, variances
- ad_
  - parameters for specific addresses in the dump
- ch_, (radar_)
  - parameters specific to the data channel (radar)
    - gain, efficiency, frequency, tx power, direction
- p_
  - physical parameters
    - ion masses, scale parameters
- r_
  - result parameters
    - time, position, densities, temperatures
- local.
  - localitites
    - printername, hostname

Analysis defaults

- ionospheric model, (iono_model)
  - IRI-2007 (International Reference Ionosphere)
  - Sets initial values of parameters
- Gated analysis
  - analysis_altit
    - A vector defining heights to group the data together
      - Increased spacing with height
    - Assumes all points inside each interval describing the same plasma
  - analysis_maxwidth
    - Data points covering too large height interval will be skipped
      - Set to the gate spacing

Fit parameters

Default fit parameters and heights

Parameter	UHF (930 Mhz)	VHF (224 Mhz)	ESR (500 MHz)
Electron density	All heights	All heights	All heights
Ion temperature	Above 80 km	Above 100 km	Above 90 km
Temperature ratio	107-1500 km	120-1500 km	113-1500 km
Collision frequency	90-107 km	Never	Never
Ion drift velocity	All heights	All heights	All heights
Ion composition	Never	Never	Never

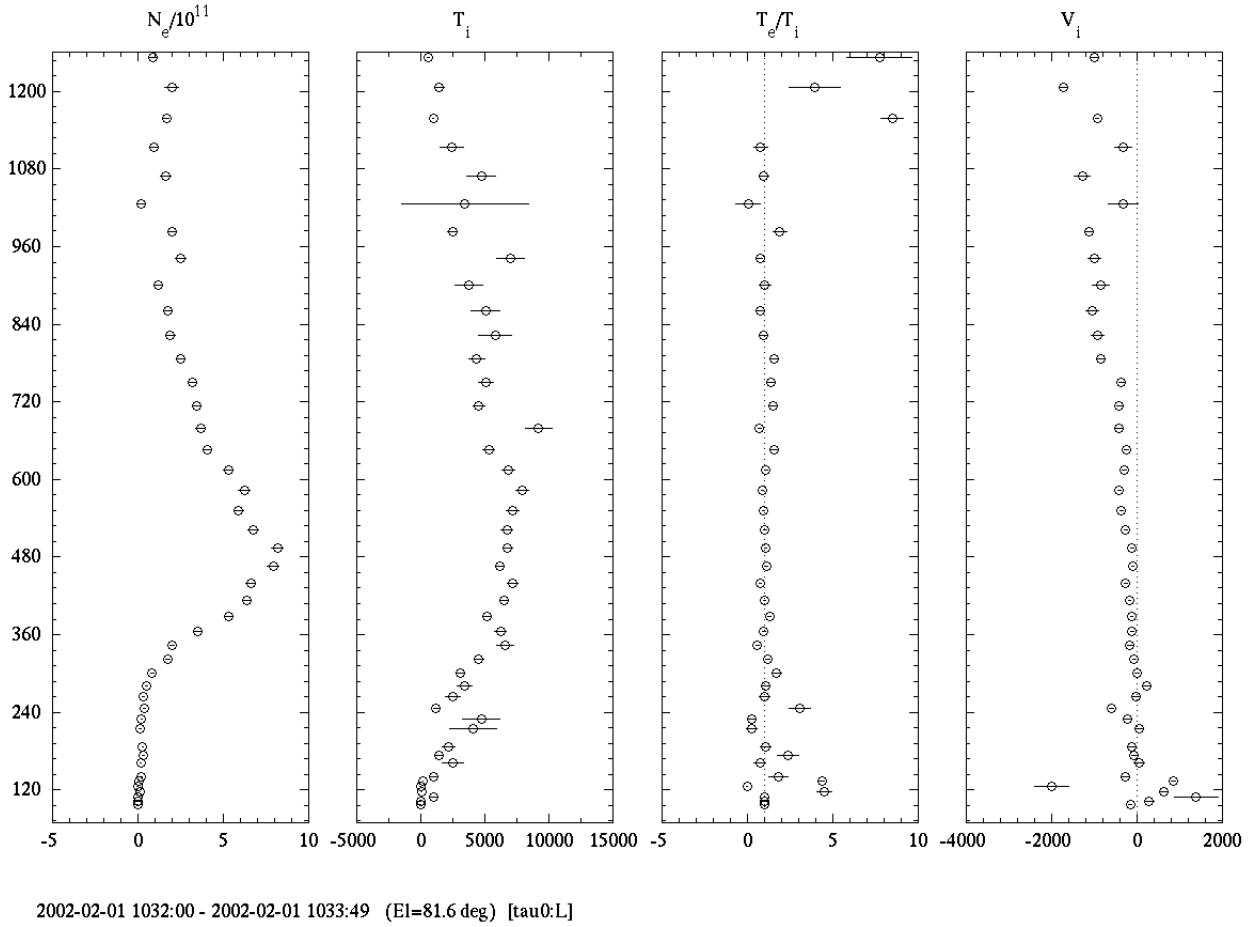
Can be changed by fit_altitude variable

fit_altitude([Ne Ti Tr Coll Vi Comp1 Comp2],[h1 h2 dh a_priori_error rel_error_flag])

```
fit_altitude=[0  Inf 0 1e2 1
              80  Inf 0 1e4 0
             107 1500 0 1e1 0
              90  107 0 1e2 1
               0  Inf 0 1e5 0
               0    0 0   1 0
               0    0 0   1 0];
```

Plots

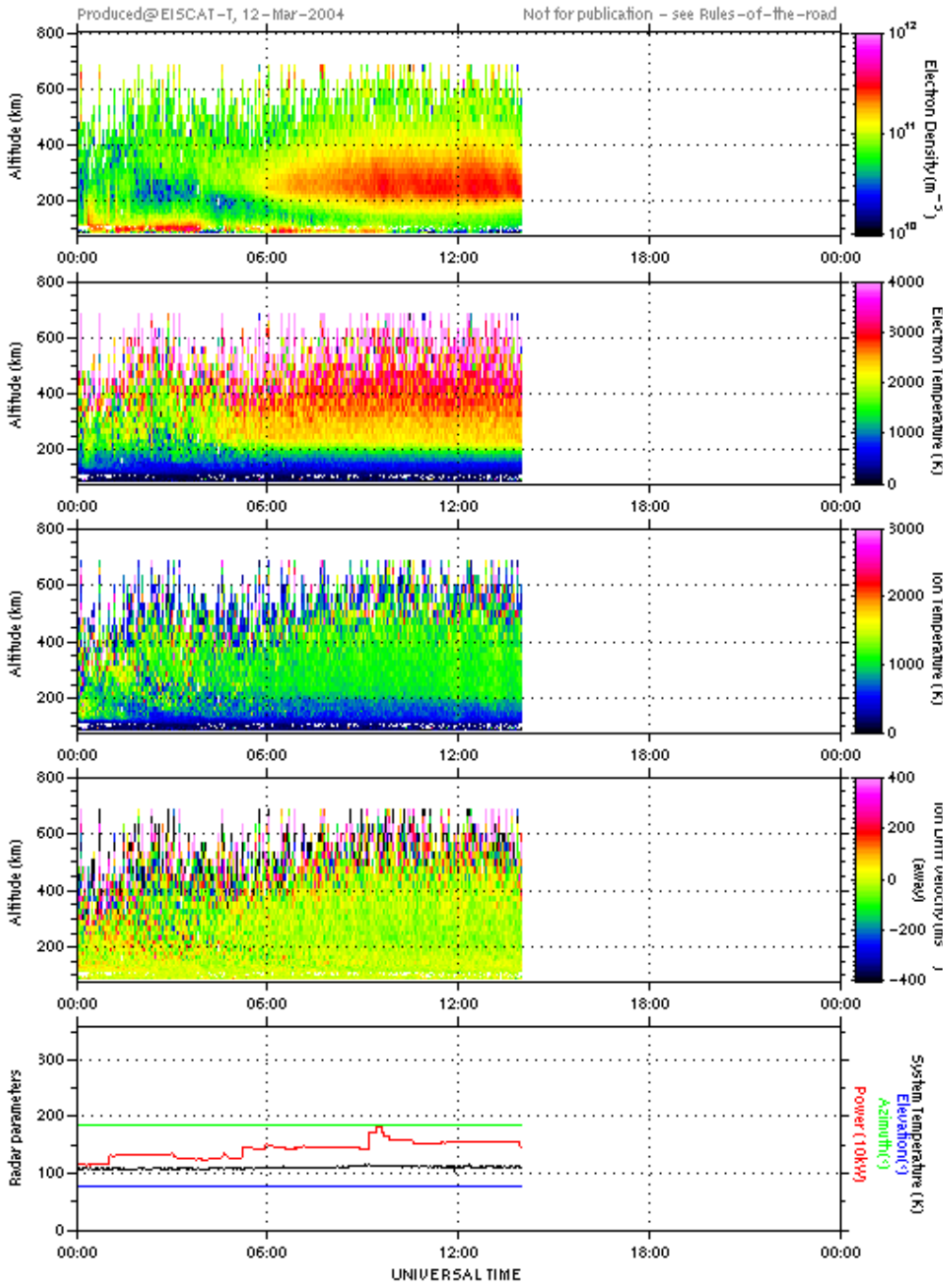
- Correlator dump
  - Plot of used part of the dump
  - Calibrated
  - Check that is corresponds to the data dump
- Power profile (Not remote)
  - Check that the densities are in proper range
- Fits
  - Plots the measurements versus the best theoretical fit
  - used parts of lag profiles (-1: spectra, inversion might need adjustment)
- Altitude profiles (Not remote)
  - -1 spectra
- Vizu
  - Summary plot of all analysed parameters
  - final check that experiment/analysis is correct



EISCAT Scientific Association

EISCAT UHF RADAR

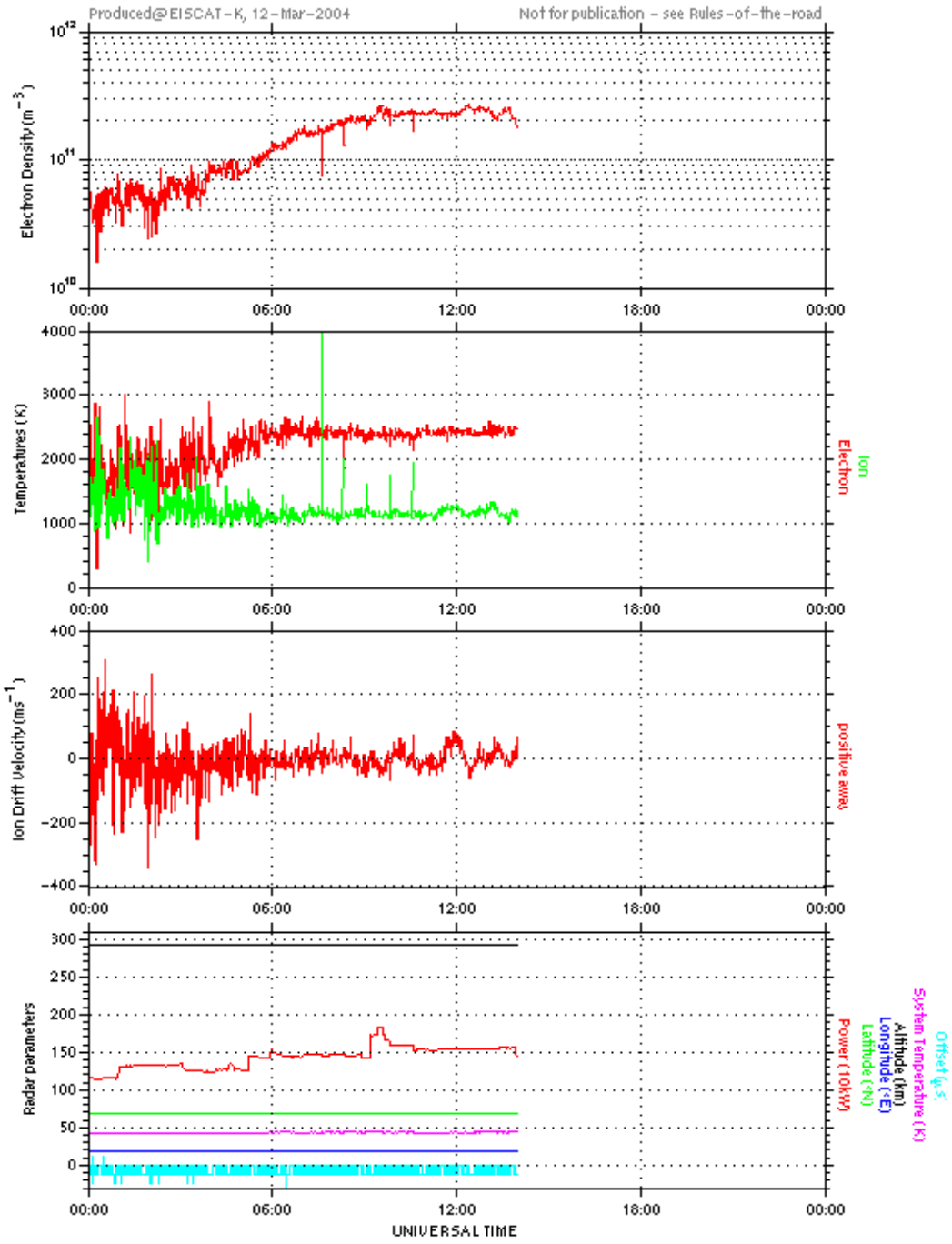
CP, uhf, tau2pl, 12 March 2004



EISCAT Scientific Association

EISCAT UHF RADAR

CP, kir, tau2pl, 12 March 2004



Result file

variable	*size*	*contents*
r_ver	(1,1)	version number of the GUISDAP program
name_expr	(1,:)	Name of the experiment
name_site	(1,1)	measurement site
name_ant	(1,3)	measurement antenna
r_time	(2,6)	start and end times of the integration period in order: year, month, day, hour, minutes, seconds
r_az	(1,1)	antenna azimuth (from parameter block)
r_el	(1,1)	antenna elevation (from parameter block)
r_Pt	(1,1)	power of the transmitter (from parameter block)
r_m0	(1,1..3)	masses of ions in the fit in atom mass units
r_range	(Ng,1)	range in km to the scattering volume
r_h	(Ng,1)	altitude in km of the scattering volume
r_param	(Ng,n)	result of the fit, $p_1 \ldots p_n$, order: density, ion temperature, temperature ratio, collision frequency, ion specie contents, DC spike, broadband noise
r_error	(Ng,1)	errors and correlations of the parameters, order: $\Delta p_1 \ldots \Delta p_n$, Corr($p_1$, p_2), Corr(p_2,p_3), Corr(p_3,p_4)...Corr(p_1,p_n)
r_res	(Ng,1)	residual of the fit with standard deviation
r_status	(Ng,1)	status of the fit, values: 0 = fit OK 1 = max number of iterations exceeded 2 = No fit done, because data too noisy 3 = Fit fail (outside limits)
r_dp	(Ng,1)	ion composition [0+]/ N,
r_apriori	(Ng,1)	a priori values for $p_1 \ldots p_n$
r_apriorierror	(Ng,1)	a priori errors for $p_1 \ldots p_n$
r_pp	(:,1)*	uncorrected densities (T_e, T_i)
r_pprange	(:,1)*	uncorrected densities ranges
r_XMITloc	(1,3)	transmitter location, order: Latitude(deg), longitude(deg), height (km)
r_RECloc	(1,3)	receiver location, order: Latitude(deg), longitude(deg), height (km)
r_SCangle	(1,1)	scattering angle, rad
r_Tsys	(1,:)	System temperatures (K)
r_Offsetppd	(1,1)*	estimated ppd offsets (μs)
r_Magic_const	(1,1)	magic constan used

Setup parameters

- Saved at
  - $TMPDIR/.gup
    - load -mat $TMPDIR/.gup
  - *result_path*/.gup
  - *result_path*/gfd_setup.m
    - executable script
- Next session starts with the same setups
  - Easy to correct
  - Use 'Reset' button to clear
- Rerun with
  - > go_on *setupfile*

gfd_setup.m

```
name_expr= 'steffe';
siteid= 5;
data_path= '/mnt/nfs/steffe_l_fix2_1.00_CP@32m';
result_path= '/home/ingemar/tmp/AUTO/';
t1=[ 2003 9 1 0 0 0];
t2=[ 2003 9 30 24 0 0];
rt= 0;
intper= 0;
path_exps= '/opt/guisdap8/exps/';
figs=[ 1 1 1 1 1];
extra=[ '%a_Offsetppd=8;                          '
 '%d_saveintdir="/home/ingemar/tmp/intdata";'
 '%analysis_altit=[];                          '
 '%analysis_do=0;                               '
 'a_satch.skip=40;                             '];
```

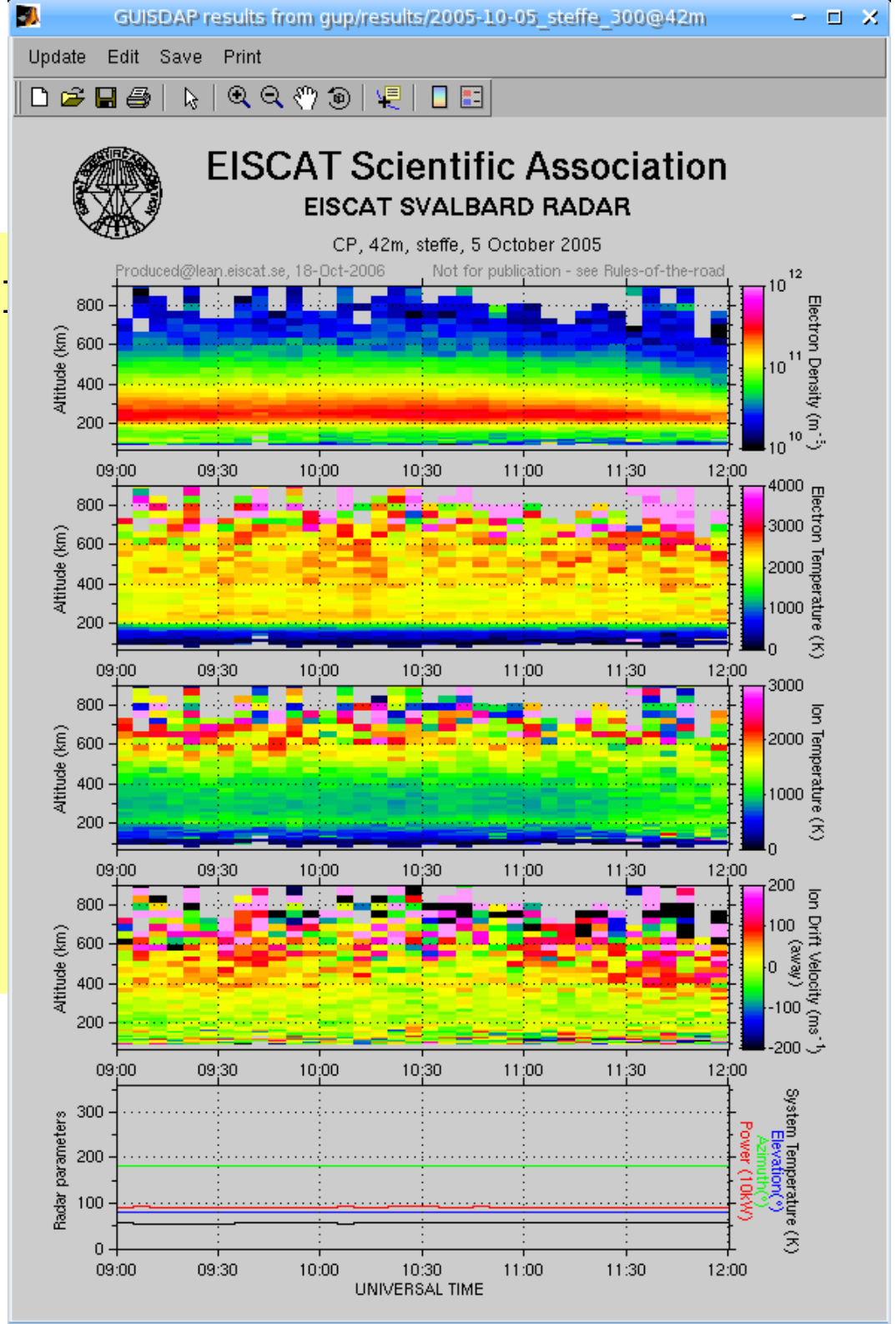
vizu plotting routine

- Main display routine for the GUISDAP output
- Default panels
  - Electron density
  - Electron temperature
  - Ion temperature
  - Ion drift velocity
  - Radar parameters
    - Tx, Pointing, System

```
function [varargout]=vizu(action,a2,a3)
% Plot GUISDAP results
% To plot with default dir names:
% >> vizu
% To plot without interaction:
% >> vizu dir exp_type antenna
% To update the plot with new files:
% >> vizu update
% To send the figure to the default printer:
% >> vizu print [printer]
% To save the current figure in .eps and
.png %  formats:
% >> vizu save [extra tail]
% To get more selection possibilities
% >> vizu verbose
% To get even more selection possibilities
% >> vizu VERBOSE
% To run realtime inside guisdap
% >> vizu rtgup
% To reset and start over:
% >> vizu new [action]
```

vizu

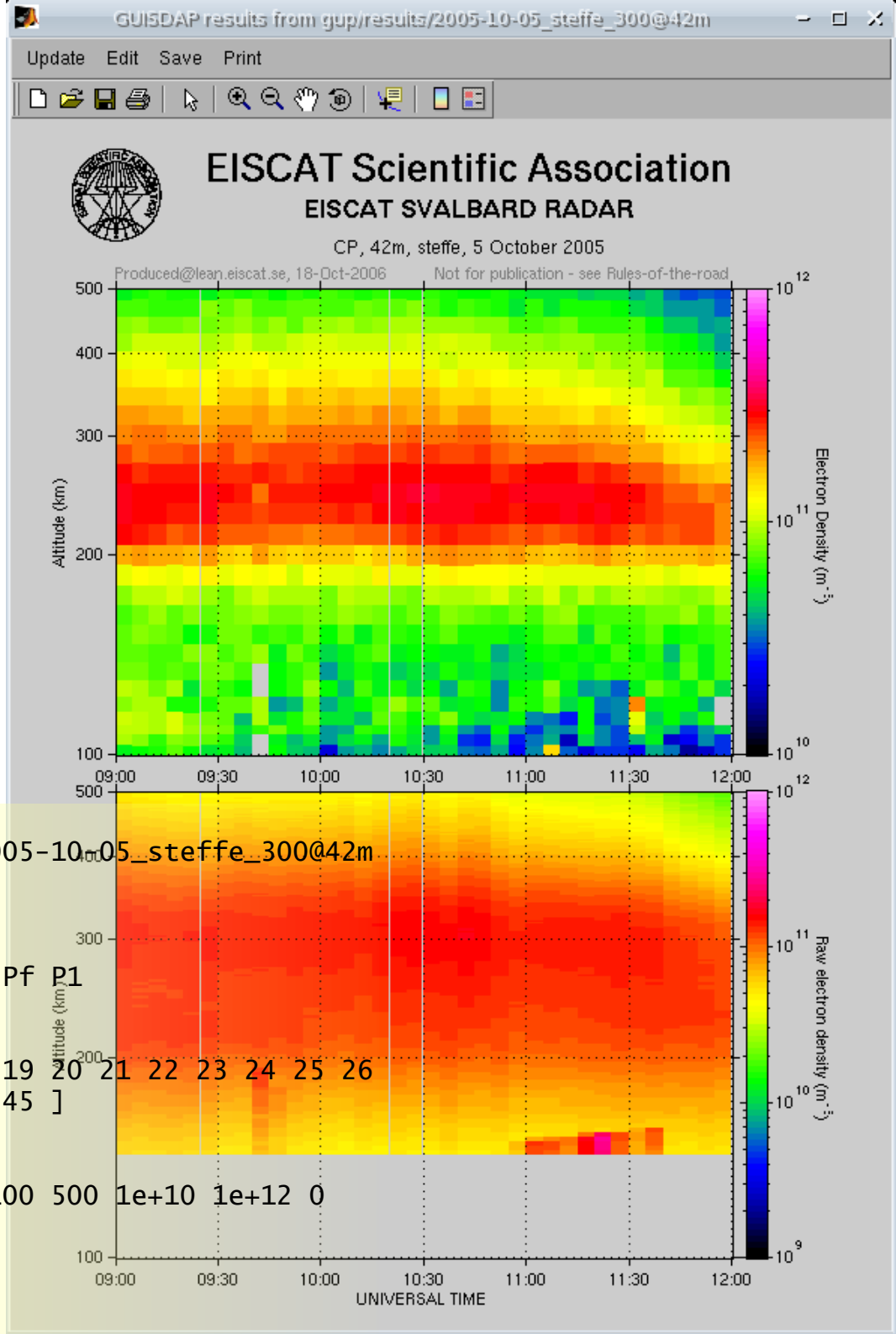
```
>> vizu verbose
Data path? [/home/ingemar/gup/results/]
gup/results/2005-10-05_steffe_300@42m
Start time? [ 2005 10 5 6 32 27 ]
  End time? [ 2005 10 5 12 0 2 ]
Altitude scale? [ 70 900 ]
Parameters: Ne Te Ti Vi AE TT LL Rs O+
Co Nr Lf L1 Ls Pf P1
Choose? [Ne Te Ti Vi AE]
Type of experiment? [CP]
>>
```



vizu

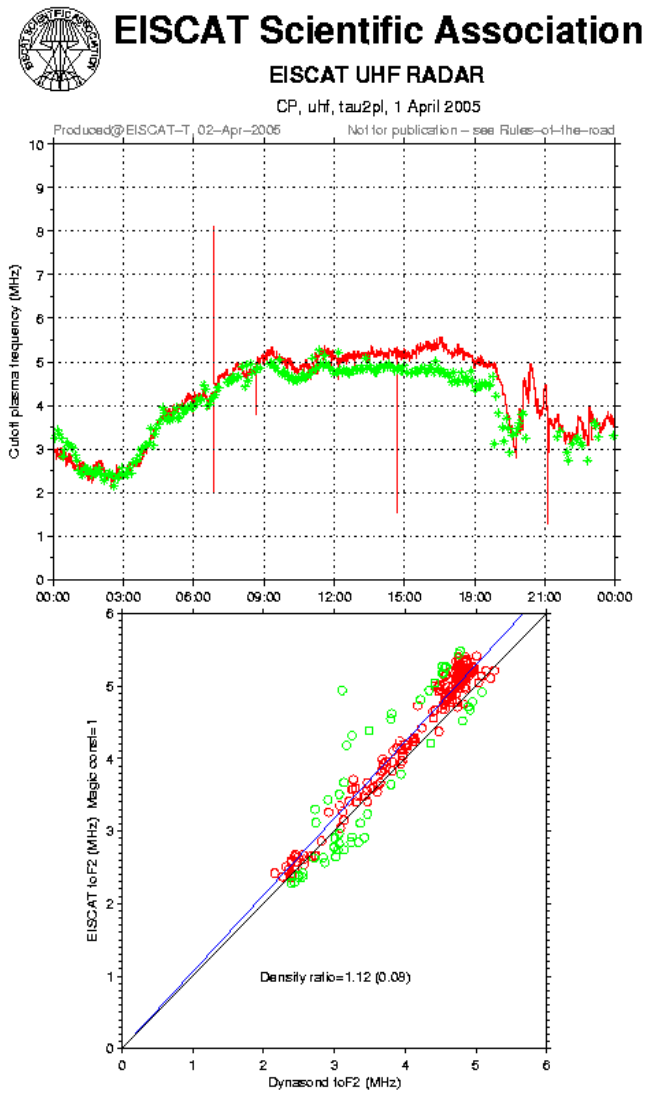
- Maximum verbose mode

```
>> vizu new VERBOSE
Data path? [/home/ingemar/gup/results/] gup/results/2005-10-05_steffe_300@42m
Start time? [ 2005 10 5 6 32 27 ]2005 10 5 9 0 0
  End time? [ 2005 10 5 12 0 2 ]
Altitude scale? [ 70 900 ]100 500
Parameters: Ne Te Ti Vi AE TT LL Rs O+ Co Nr Lf L1 Ls Pf P1
Choose? [Ne Te Ti Vi AE] Ne Nr
Type of experiment? [CP]
Gates? [ 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 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 ]
Y parameter (Ran-1 Alt-2 Lat-3)? [ 2 ]
Y scale type? [linear] log
Scales (Ran Alt Ne Te Ti Vi Coll Comp Res)? [ 50 900 100 500 1e+10 1e+12 0
4000 0 3000 -200 200 1 100000 0 1 0.1 10 ]
Scale (rawNe)? [ 1e+09 1e+12 ]
Strech secs? [ 65 ]0
```

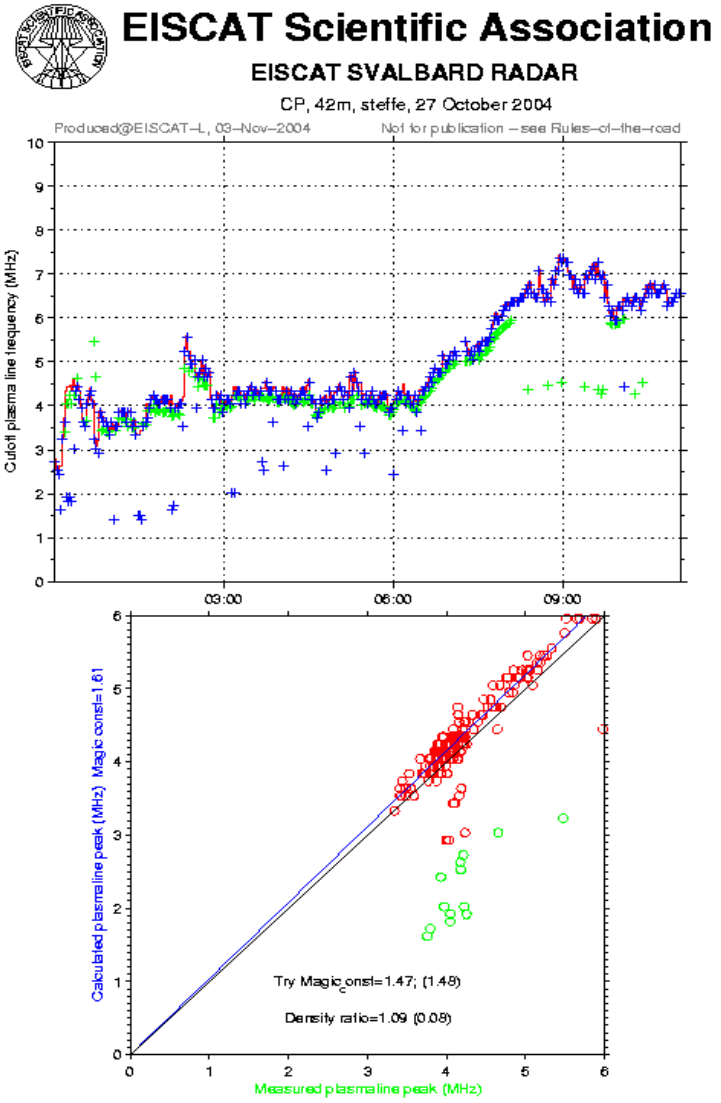


Calibration

- calib_ne
  - to calibrate against dynasonde (rather vertical)

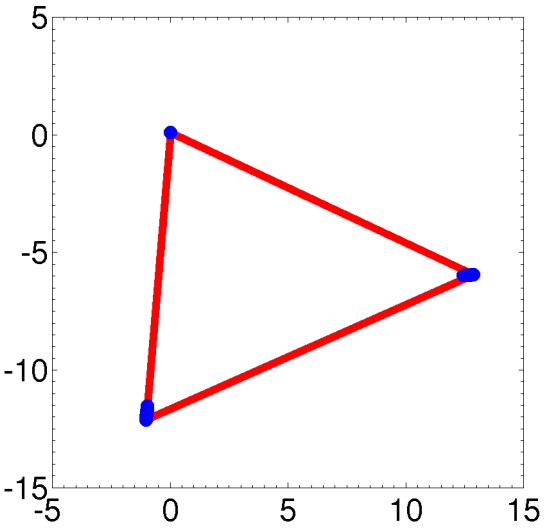


- calib_pl_ne
  - to calibrate against measured plasma lines

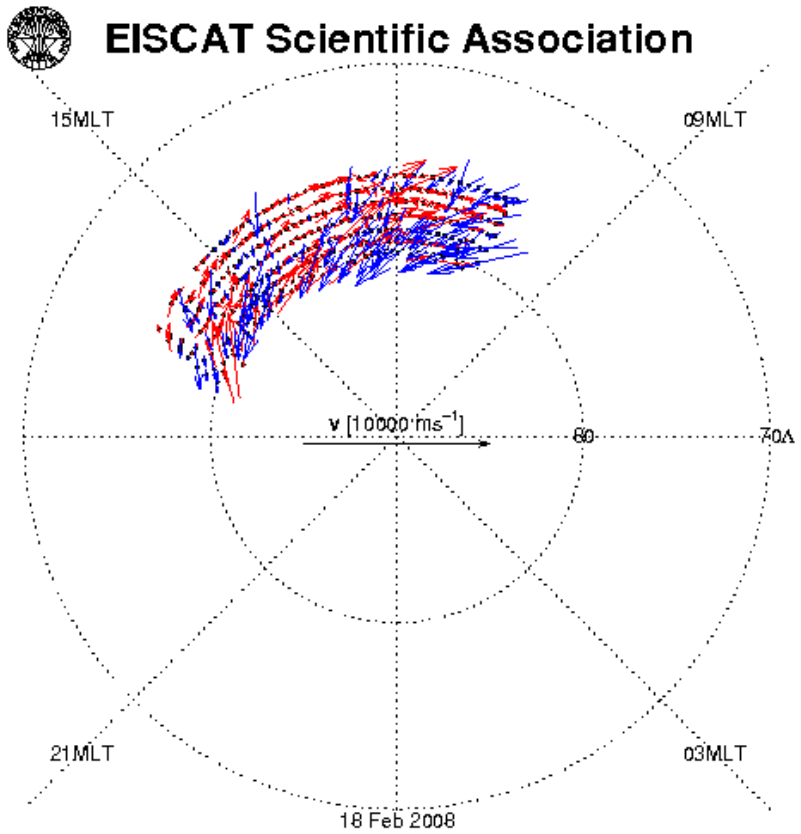


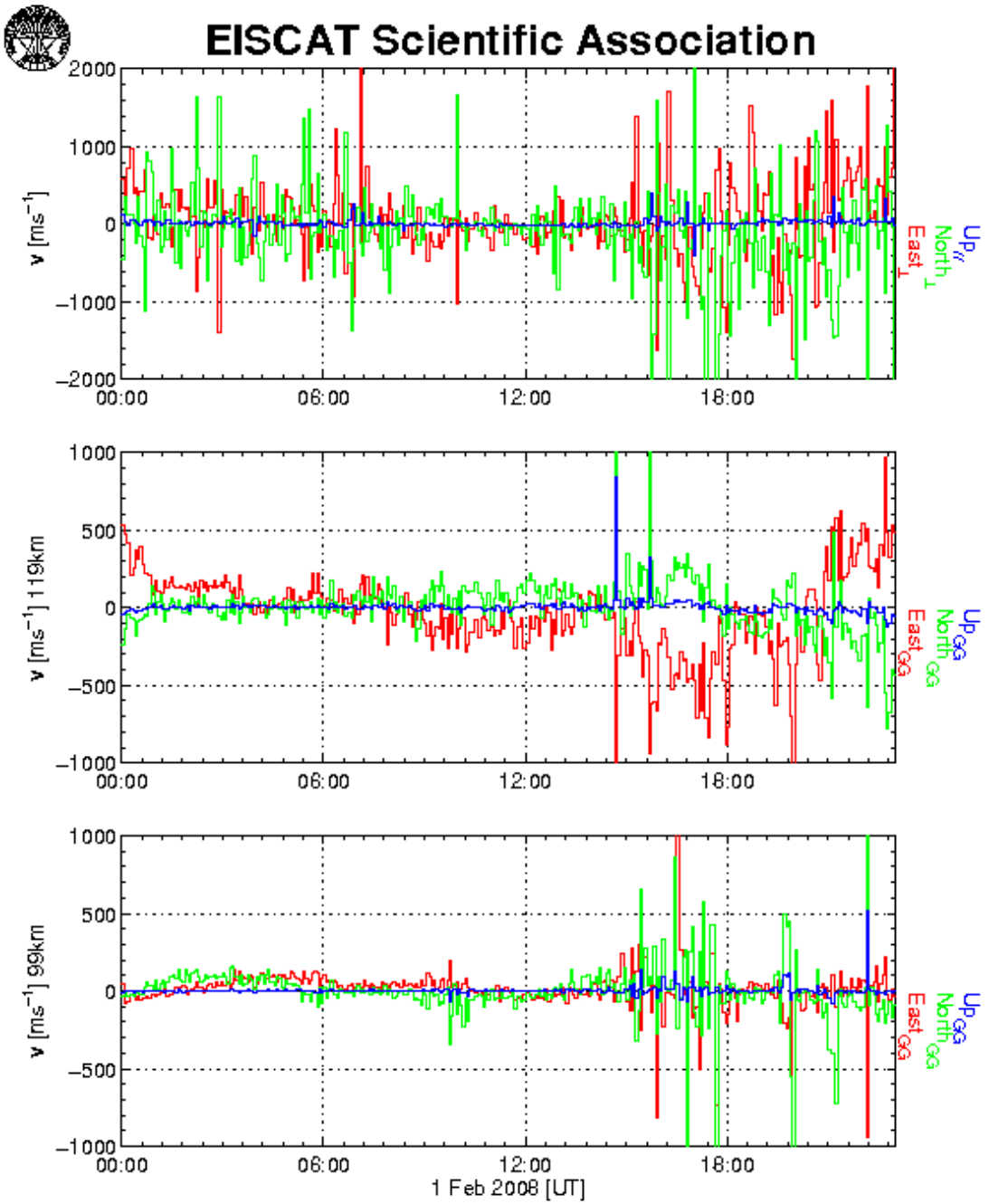
Vector velocities

- mono- and bi- and multistatic
  - Beamswing, sweeping
  - VHF/ESR
  - Normal KST tristatic
- Define regions in time and space
    - Collect data to make vectors
- “Goodness”
  - convex hull of directions (>3)
    - Area > 10° triangle
  - Covariance matrix
- Geographic coordinates

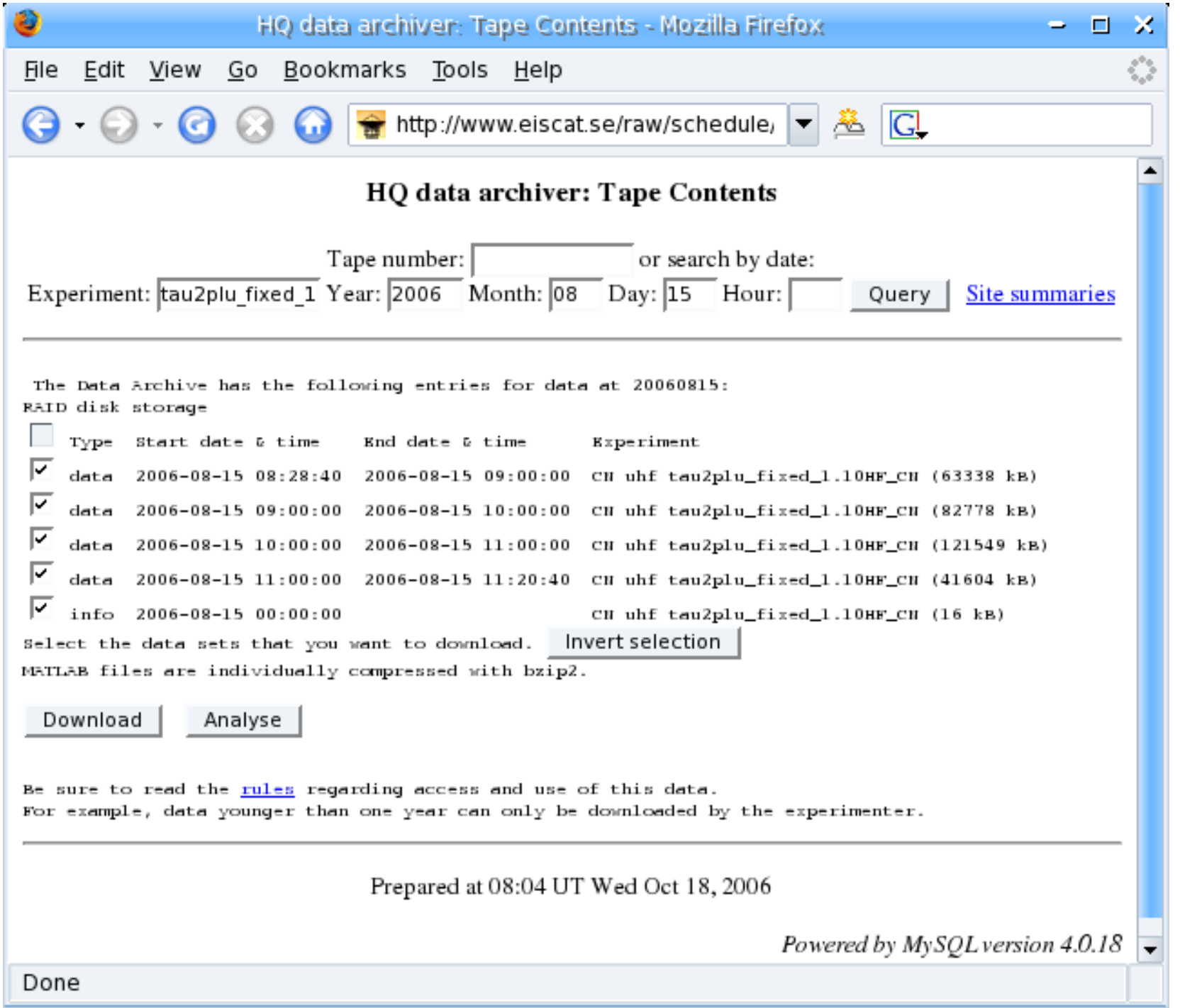


- Vectors


EISCAT Scientific Association
15MLT
09MLT
v [10000 ms^{-1}]
80
70Λ
21MLT
03MLT
18 Feb 2008


EISCAT Scientific Association
v [ms^{-1}]
2000
1000
0
−1000
−2000
00:00
06:00
12:00
18:00
Up⊥
North⊥
East⊥
v [ms^{-1}] 119km
1000
500
0
−500
−1000
UpGG
NorthGG
EastGG
v [ms^{-1}] 99km
1 Feb 2008 [UT]

Web analysis



Web analysis

- Very similar to matlab
- Results sent by e-mail
  - NCAR file, vizu plots, guisdap output
- Pros
  - don't have to download large data sets
  - don't need matlab license
  - latest GUISDAP version
- Cons
  - hard to find problems