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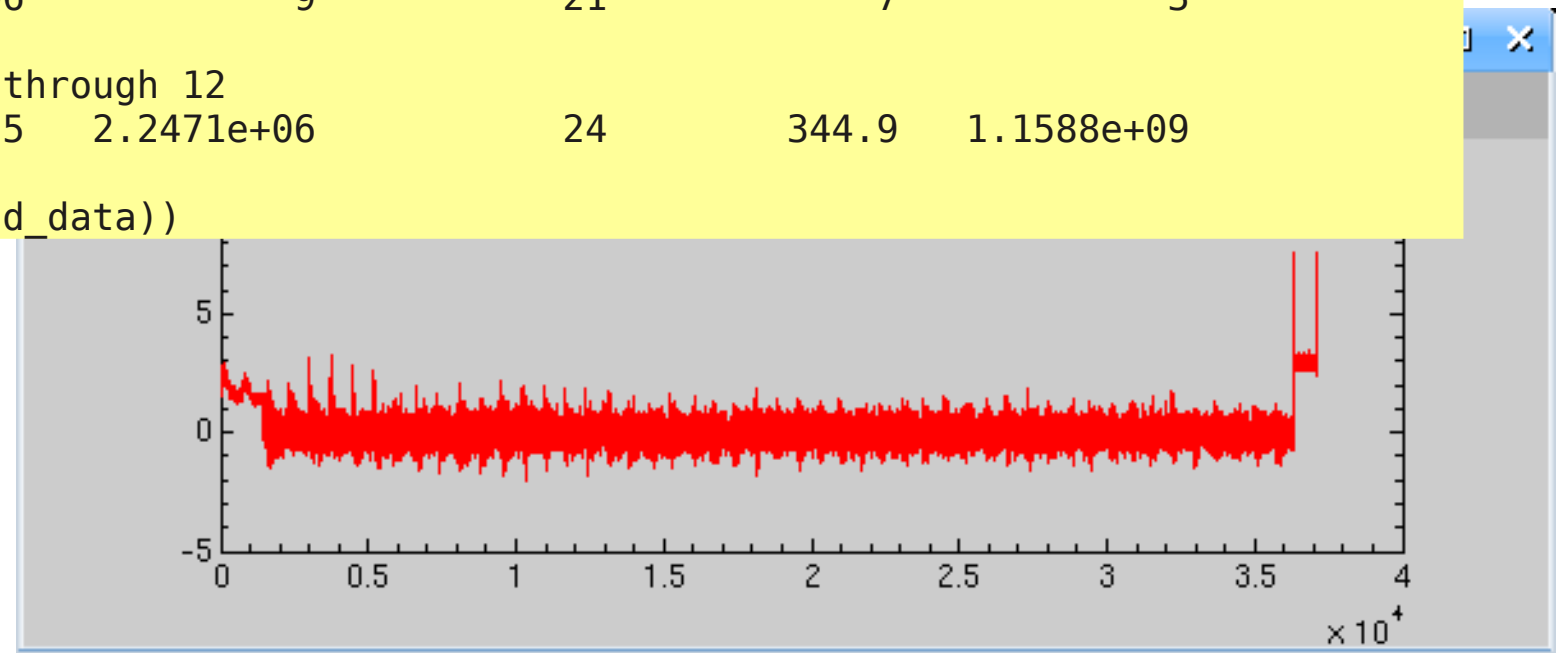
EISCAT HQ

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 (metadata)
  - d_parbl (real vector)
    - Time, antenna and transmitter parameters (metadata)
  - d_data (complex vector)
    - Lagprofiles (rangeprofiles of summed/decoded lagged products)
      - one to thousands
      - Correlations of received samples
        - Depends on transmitter code and decoding procedure
  - d_raw (complex vector)
    - Raw amplitude samples
      - Transmitter code

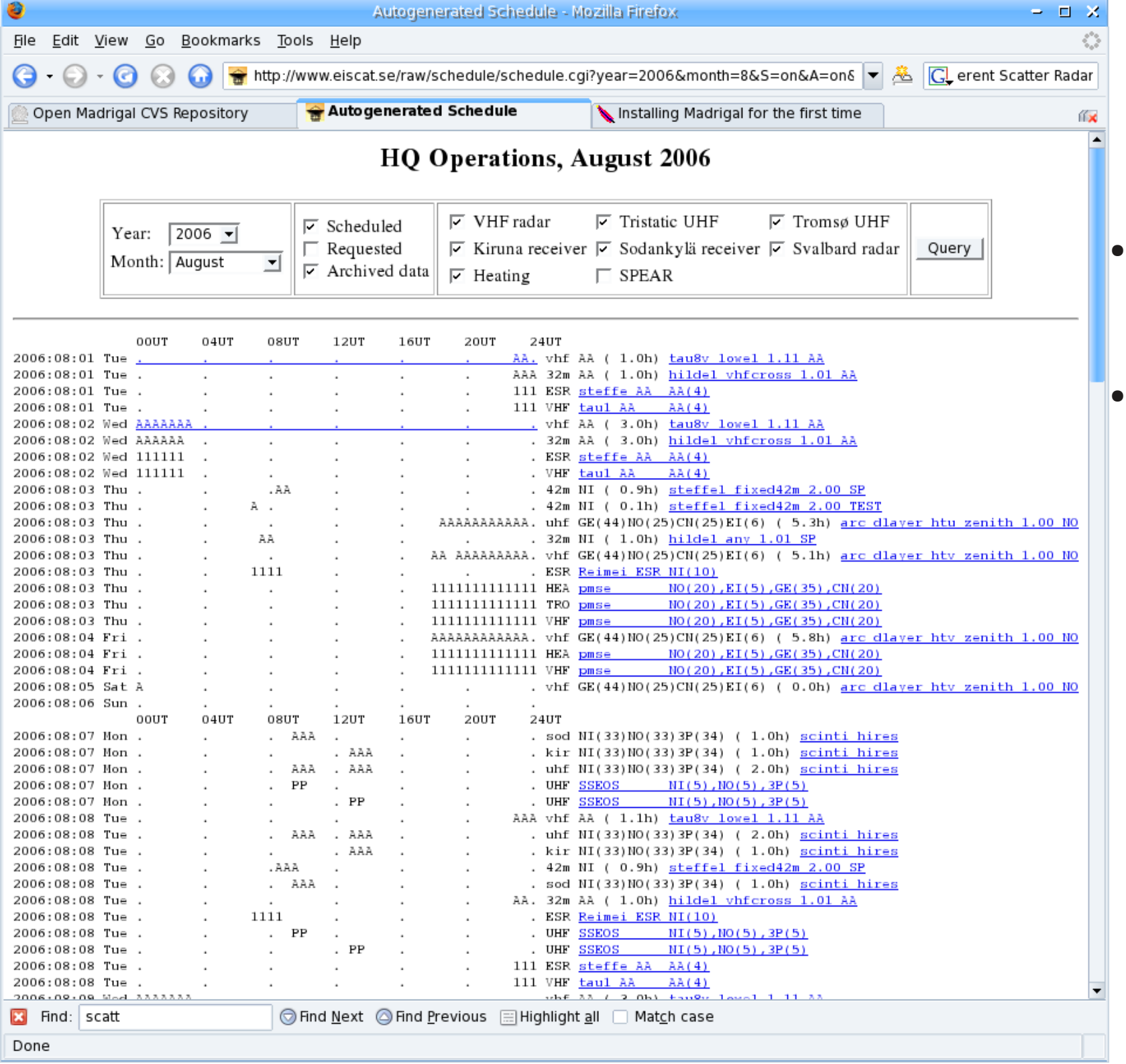
Raw data

```
>> 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 analysis

- GUISDAP
  - To analyse data and reduce into physical quantities
  - To integrate
  - Use the setups to understand the data layout for own analysis procedures
  - Matlab toolbox
    - Download at

http://www.eiscat.se/groups/Documentation/UserGuides/GUISDAP

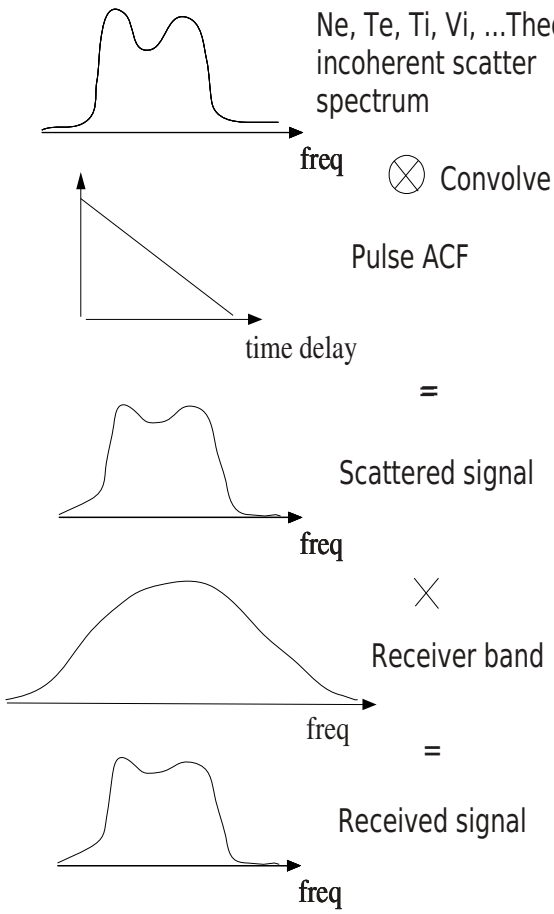
- Analysed data
  - Within GUISDAP
    - Display, calibrate, vectors...

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

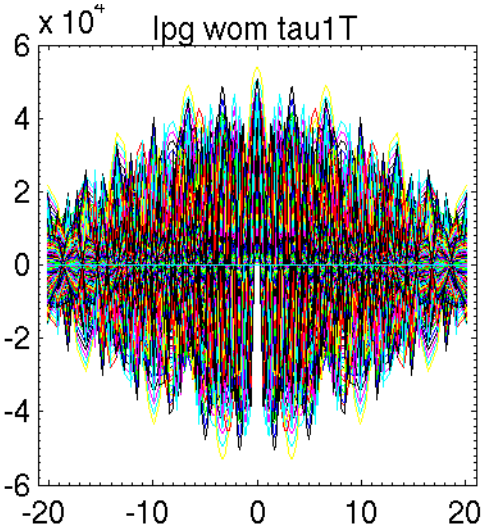
Classic analysis



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 ambiguity vectors

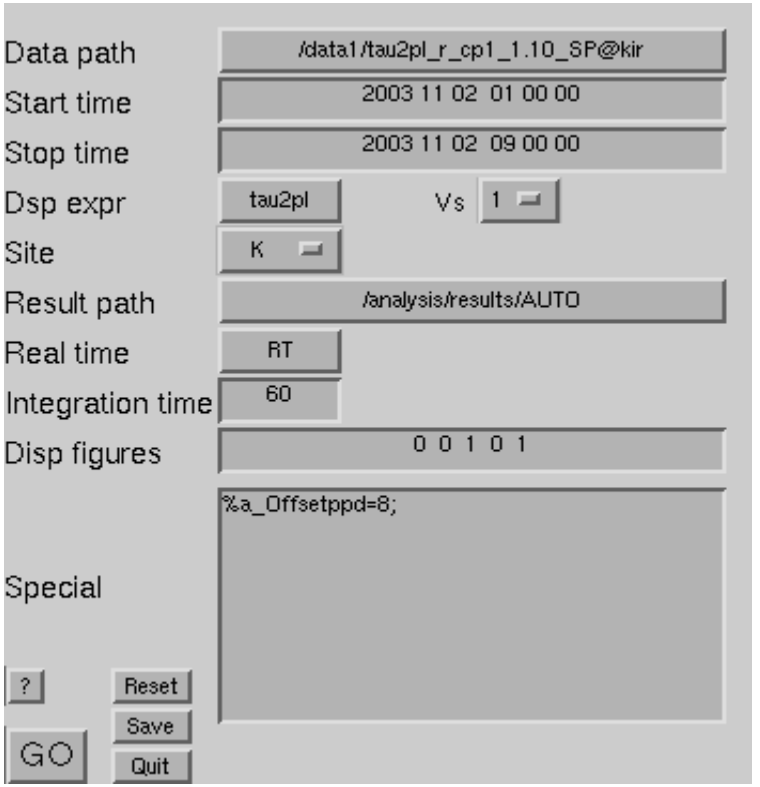
- Spectral ambiguity function
  - lpg_wom
  - Used in fitting process
- Range ambiguity function
  - lpg_wr
  - Space debris detection
  - Bistatic volumes

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}	$\mathrm{asinh}(v_i/v_0/2)$	-20000	20000
Composition		p_i	-0.01	1.01
Dcspike	K	asinh(D/2)	-100	10000
Broadband	K	asinh(B/2)	-100	10000

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

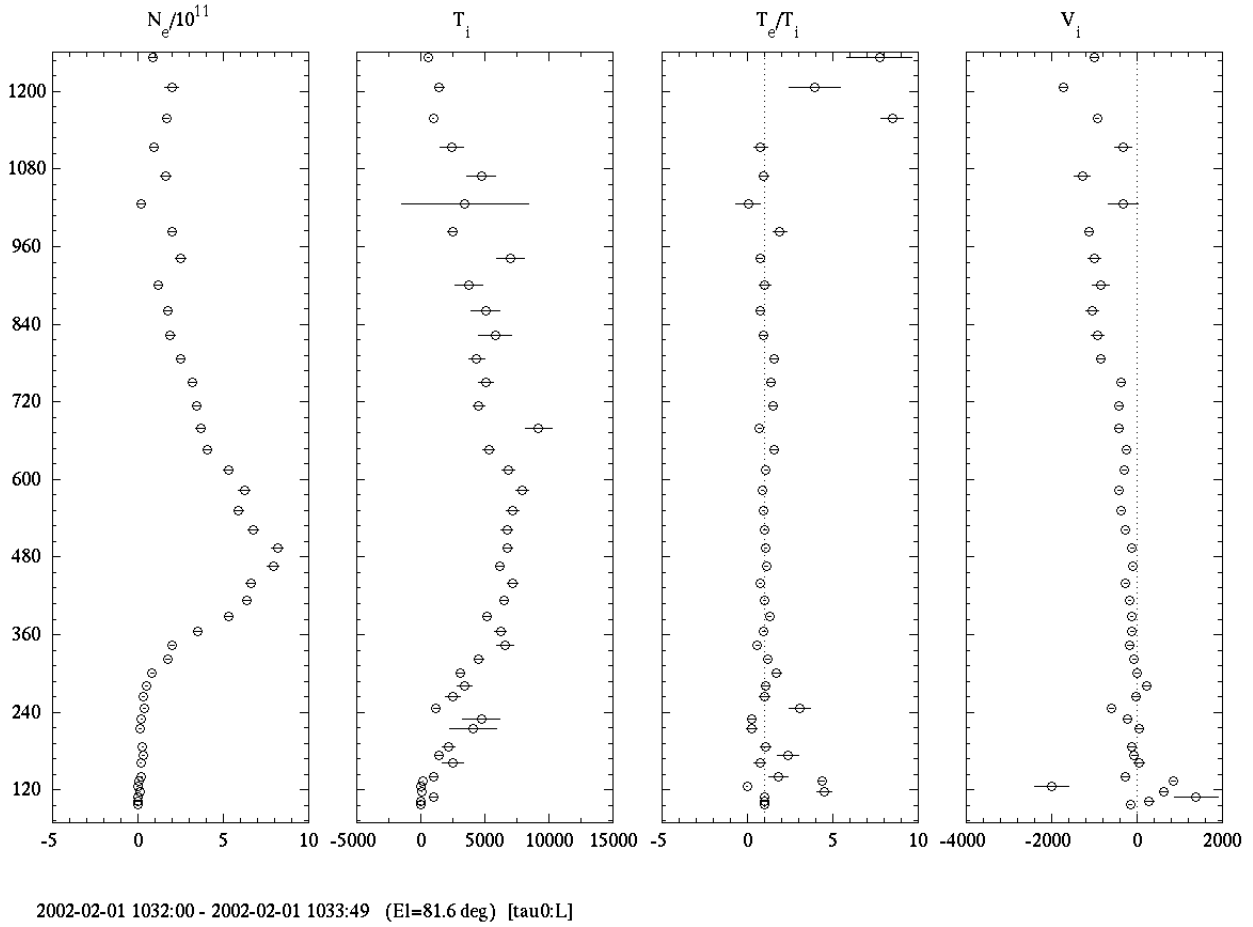
Can be changed by fit_altitude variable

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

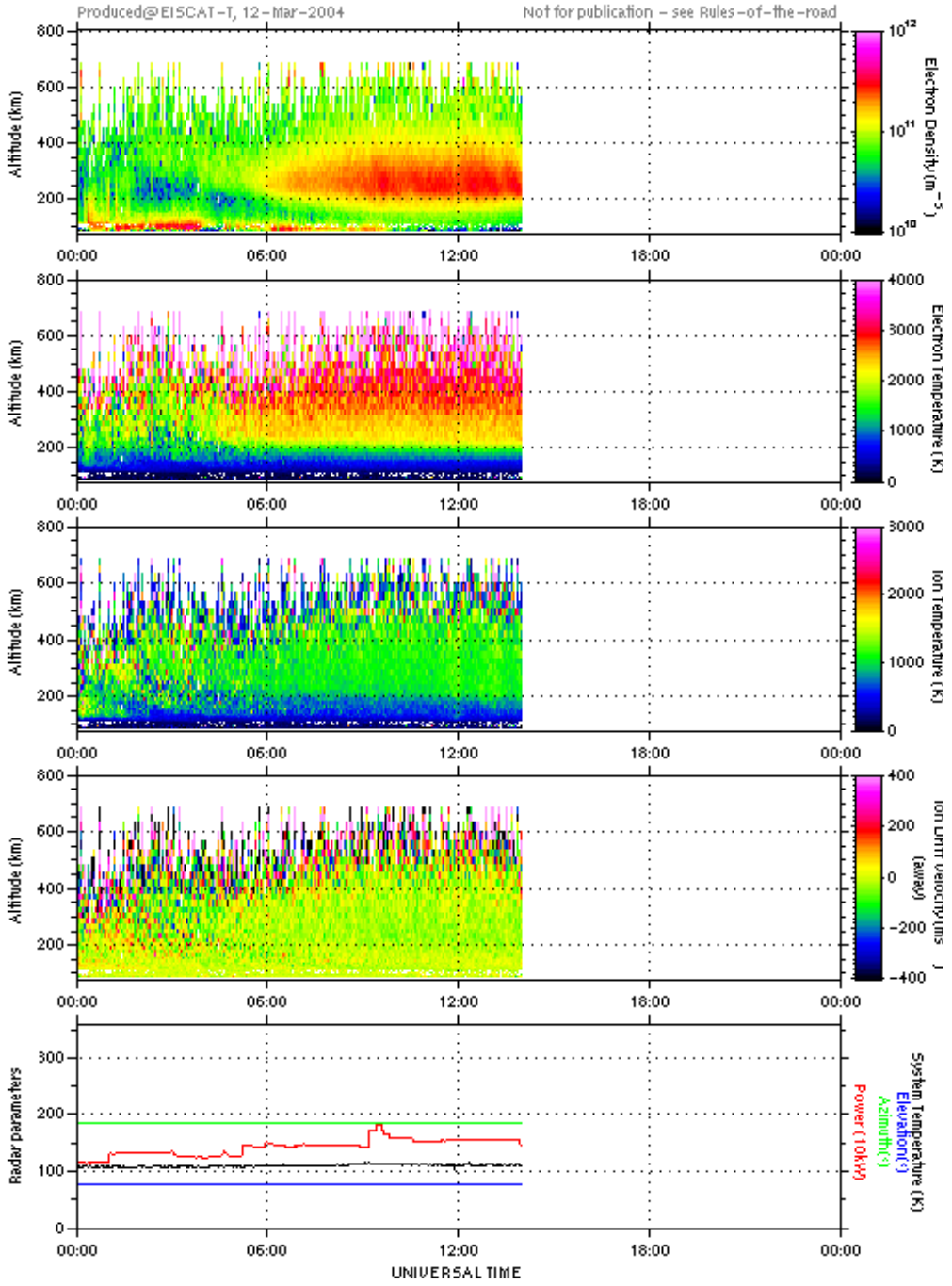
- Correlator dump
  - Plot of used part of the dump
  - Calibrated
  - Check that is corresponds to the data dump
- Power profile (Not remote)
  - Check that the densities are in proper range
- Fits
  - Plots the measurements versus the best theoretical fit
  - used parts of lag profiles (-1: spectra, 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

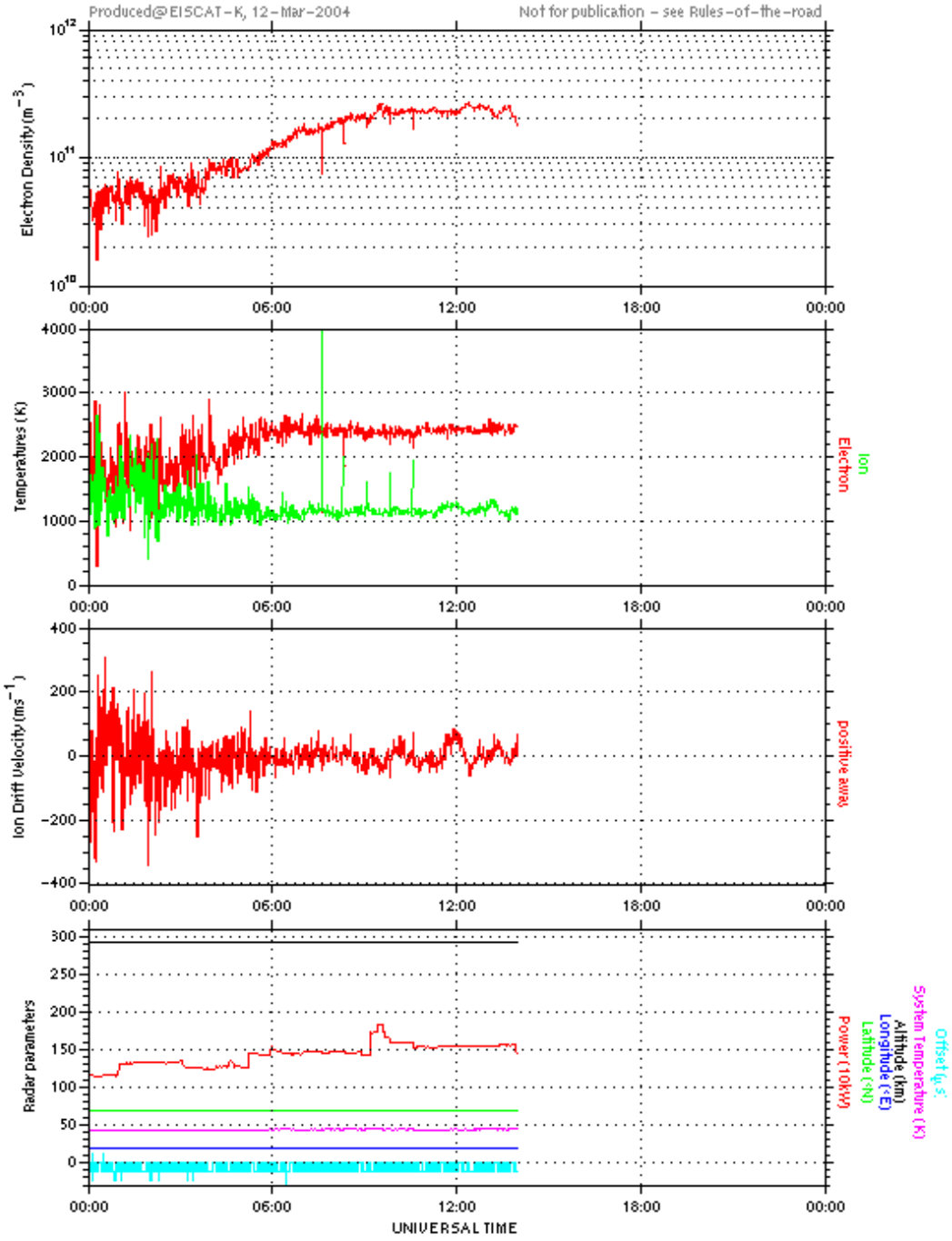
CP, uhf, tau2pl, 12 March 2004



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,n(n+1)/2)	errors and correlations of the parameters, order: $\Delta p_1 ... \Delta p_n$, $Corr(p_1, p_2)$, $Corr(p_2,p_3)$, $Corr(p_3,p_4) ... Corr(p_1,p_n)$
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 offset (μs)
r_Magic_const	(1,1)	magic constan used
r_spec	(Ng,:)*	inverted measured spectra

Result file

variable	*size*	*contents*
r_param	(Ng,n)	density, ion temperature, temperature ratio, collision frequency, ion specie contents, (DC spike, broadband noise)
r_error	(Ng,n(n+1)/2	Errors (covariance matrix)
r_res	(Ng,1)	residual, measured error/expected error; Variance properly estimated or assumptions valid ??
r_status	(Ng,1)	status of the fit

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;                           '];
```

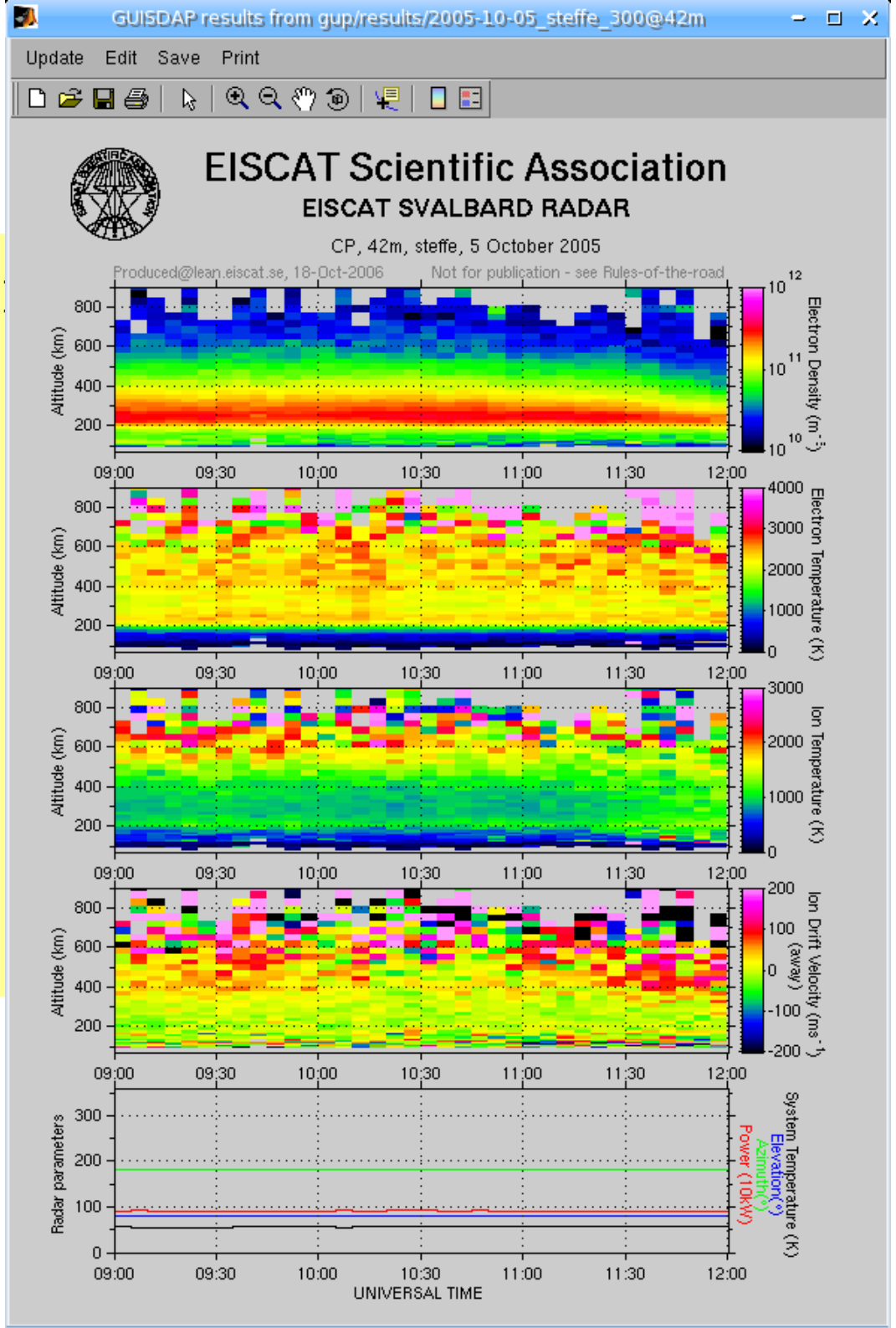
vizu plotting routine

- 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

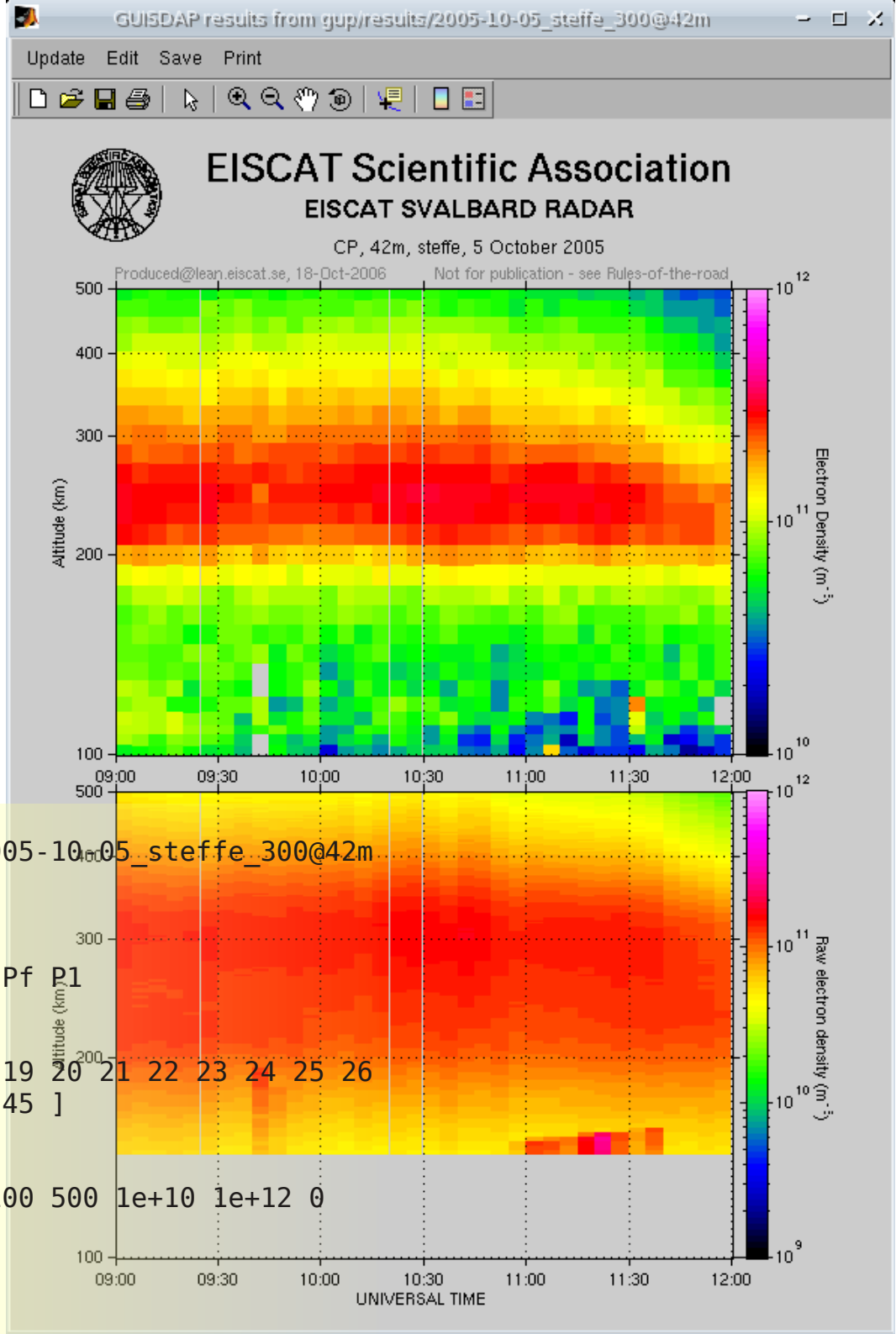
```
>> vizu verbose
Data path? [/home/ingemar/gup/results/]
gup/results/2005-10-05_steffe_300@42m
Start time? [ 2005 10 5 6 32 27 ]
  End time? [ 2005 10 5 12 0 2 ]
Altitude scale? [ 70 900 ]
Parameters: Ne Te Ti Vi AE TT LL Rs O+
Co Nr Lf L1 Ls Pf P1
Choose? [Ne Te Ti Vi AE]
Type of experiment? [CP]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



vizu

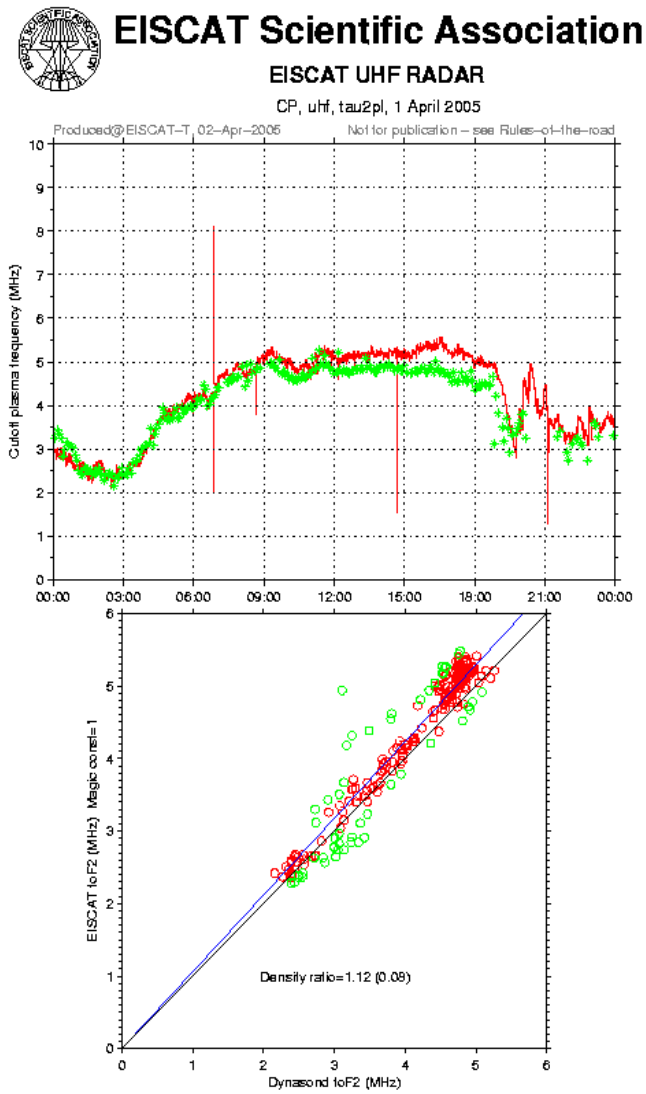
- Maximum verbose mode

```
>> 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
```

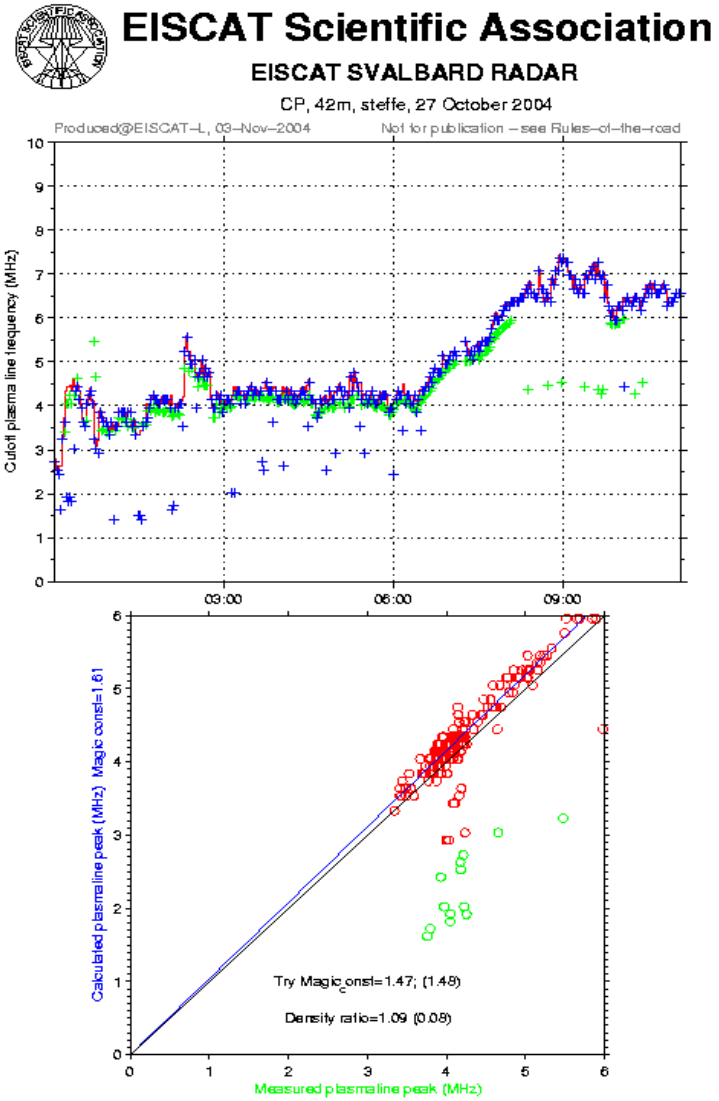


Calibration

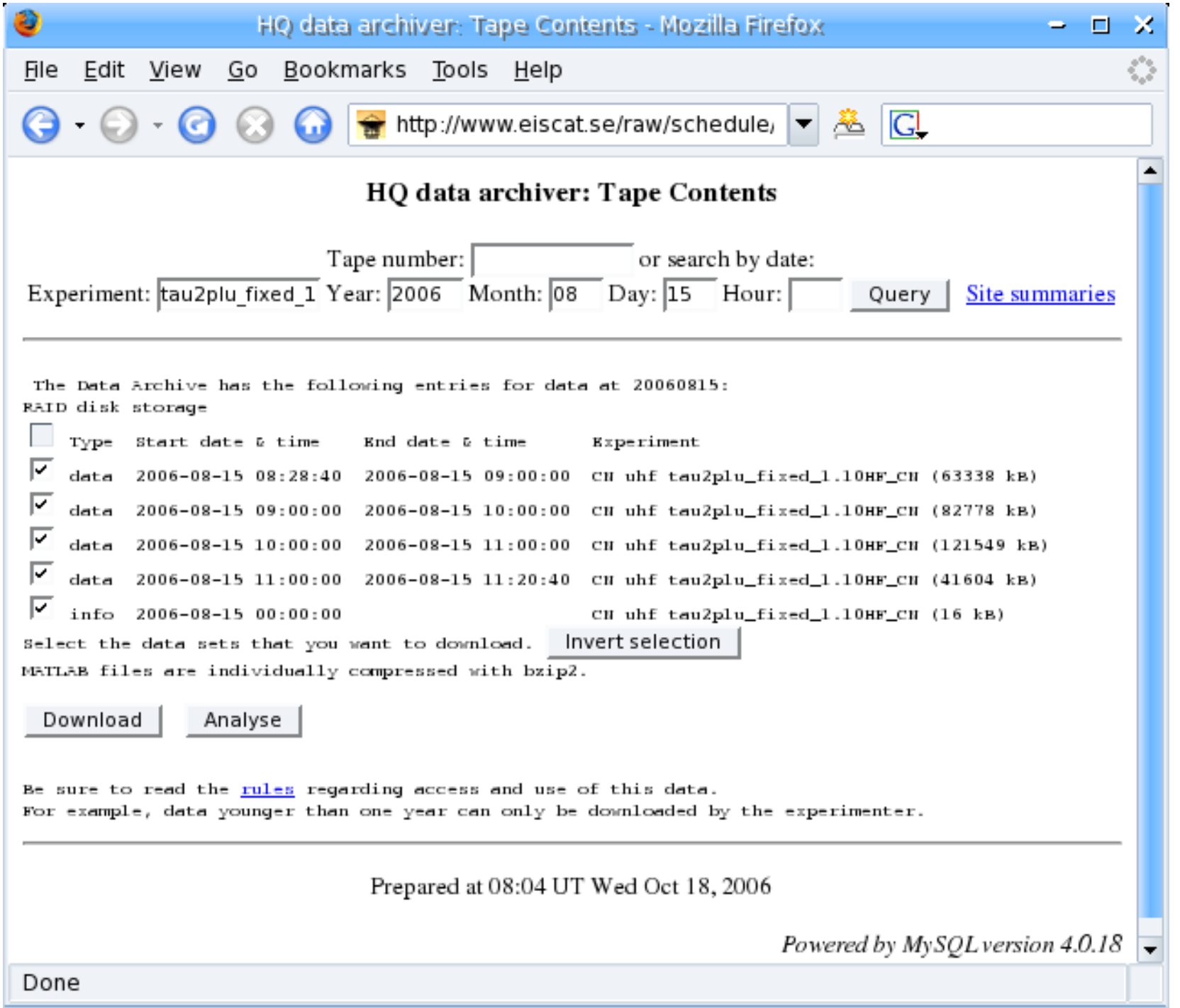
- calib_ne
  - to calibrate against ionosond (rather vertical)



- calib_pl_ne
  - to calibrate against measured plasma lines



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