



**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 (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
```

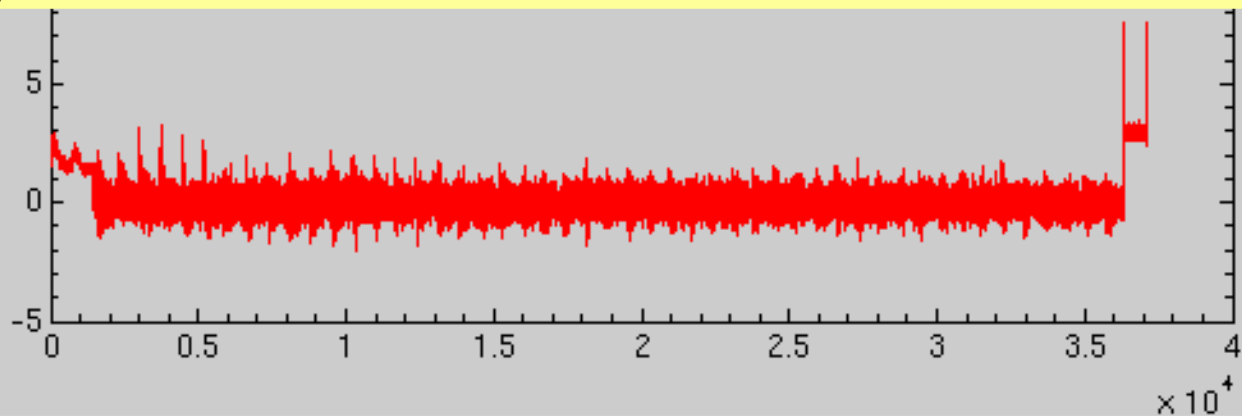
Grand total is 37191 elements using 594192 bytes

```
>> 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

### HQ Operations, August 2006

Year: <input type="text" value="2006"/>	<input checked="" type="checkbox"/> Scheduled	<input checked="" type="checkbox"/> VHF radar	<input checked="" type="checkbox"/> Tristatic UHF	<input checked="" type="checkbox"/> Tromsø UHF	<input type="button" value="Query"/>
Month: <input type="text" value="August"/>	<input type="checkbox"/> Requested	<input checked="" type="checkbox"/> Kiruna receiver	<input checked="" type="checkbox"/> Sodankylä receiver	<input checked="" type="checkbox"/> Svalbard radar	
	<input checked="" type="checkbox"/> Archived data	<input checked="" type="checkbox"/> Heating	<input type="checkbox"/> SPEAR		

	00UT	04UT	08UT	12UT	16UT	20UT	24UT
2006:08:01 Tue	.	.	.	.	.	AA	vhf AA ( 1.0h) <a href="#">tau8v_lowel 1.11 AA</a>
2006:08:01 Tue	.	.	.	.	.	AAA	32m AA ( 1.0h) <a href="#">hildel_vhfcross 1.01 AA</a>
2006:08:01 Tue	.	.	.	.	.	111	ESR <a href="#">steffe AA AA(4)</a>
2006:08:01 Tue	.	.	.	.	.	111	VHF <a href="#">taul AA AA(4)</a>
2006:08:02 Wed	AAAAAAA	.	.	.	.	.	vhf AA ( 3.0h) <a href="#">tau8v_lowel 1.11 AA</a>
2006:08:02 Wed	AAAAAAA	.	.	.	.	.	32m AA ( 3.0h) <a href="#">hildel_vhfcross 1.01 AA</a>
2006:08:02 Wed	111111	.	.	.	.	.	ESR <a href="#">steffe AA AA(4)</a>
2006:08:02 Wed	111111	.	.	.	.	.	VHF <a href="#">taul AA AA(4)</a>
2006:08:03 Thu	.	.	.AA	.	.	.	42m NI ( 0.9h) <a href="#">steffel_fixed42m 2.00 SP</a>
2006:08:03 Thu	.	A	.	.	.	.	42m NI ( 0.1h) <a href="#">steffel_fixed42m 2.00 TEST</a>
2006:08:03 Thu	.	.	.	.	AAAAAAAAA	.	uhf GE(44)NO(25)CN(25)EI(6) ( 5.3h) <a href="#">arc_dlayer_htu_zenith 1.00 NO</a>
2006:08:03 Thu	.	.	AA	.	.	.	32m NI ( 1.0h) <a href="#">hildel_anv 1.01 SP</a>
2006:08:03 Thu	.	.	.	.	AA AAAAAAA	.	vhf GE(44)NO(25)CN(25)EI(6) ( 5.1h) <a href="#">arc_dlayer_hvt_zenith 1.00 NO</a>
2006:08:03 Thu	.	.	1111	.	.	.	ESR <a href="#">Reimei ESR NI(10)</a>
2006:08:03 Thu	.	.	.	.	111111111111	.	HEA <a href="#">pmse NO(20),EI(5),GE(35),CN(20)</a>
2006:08:03 Thu	.	.	.	.	111111111111	.	TRO <a href="#">pmse NO(20),EI(5),GE(35),CN(20)</a>
2006:08:03 Thu	.	.	.	.	111111111111	.	VHF <a href="#">pmse NO(20),EI(5),GE(35),CN(20)</a>
2006:08:04 Fri	.	.	.	.	AAAAAAAAA	.	vhf GE(44)NO(25)CN(25)EI(6) ( 5.8h) <a href="#">arc_dlayer_hvt_zenith 1.00 NO</a>
2006:08:04 Fri	.	.	.	.	111111111111	.	HEA <a href="#">pmse NO(20),EI(5),GE(35),CN(20)</a>
2006:08:04 Fri	.	.	.	.	111111111111	.	VHF <a href="#">pmse NO(20),EI(5),GE(35),CN(20)</a>
2006:08:05 Sat	A	.	.	.	.	.	vhf GE(44)NO(25)CN(25)EI(6) ( 0.0h) <a href="#">arc_dlayer_hvt_zenith 1.00 NO</a>
2006:08:06 Sun	.	.	.	.	.	.	.
	00UT	04UT	08UT	12UT	16UT	20UT	24UT
2006:08:07 Mon	.	.	.AAA	.	.	.	sod NI(33)NO(33)3P(34) ( 1.0h) <a href="#">scinti hires</a>
2006:08:07 Mon	.	.	.AAA	.AAA	.	.	kir NI(33)NO(33)3P(34) ( 1.0h) <a href="#">scinti hires</a>
2006:08:07 Mon	.	.	.AAA	.AAA	.	.	uhf NI(33)NO(33)3P(34) ( 2.0h) <a href="#">scinti hires</a>
2006:08:07 Mon	.	.	PP	.	.	.	UHF <a href="#">SSEOS NI(5),NO(5),3P(5)</a>
2006:08:07 Mon	.	.	.	PP	.	.	UHF <a href="#">SSEOS NI(5),NO(5),3P(5)</a>
2006:08:08 Tue	.	.	.	.	.	AAA	vhf AA ( 1.1h) <a href="#">tau8v_lowel 1.11 AA</a>
2006:08:08 Tue	.	.	.AAA	.AAA	.	.	uhf NI(33)NO(33)3P(34) ( 2.0h) <a href="#">scinti hires</a>
2006:08:08 Tue	.	.	.AAA	.AAA	.	.	kir NI(33)NO(33)3P(34) ( 1.0h) <a href="#">scinti hires</a>
2006:08:08 Tue	.	.	.AAA	.	.	.	42m NI ( 0.9h) <a href="#">steffel_fixed42m 2.00 SP</a>
2006:08:08 Tue	.	.	.AAA	.	.	.	sod NI(33)NO(33)3P(34) ( 1.0h) <a href="#">scinti hires</a>
2006:08:08 Tue	.	.	.	.	.	AA	32m AA ( 1.0h) <a href="#">hildel_vhfcross 1.01 AA</a>
2006:08:08 Tue	.	.	1111	.	.	.	ESR <a href="#">Reimei ESR NI(10)</a>
2006:08:08 Tue	.	.	PP	.	.	.	UHF <a href="#">SSEOS NI(5),NO(5),3P(5)</a>
2006:08:08 Tue	.	.	.	PP	.	.	UHF <a href="#">SSEOS NI(5),NO(5),3P(5)</a>
2006:08:08 Tue	.	.	.	.	.	111	ESR <a href="#">steffe AA AA(4)</a>
2006:08:08 Tue	.	.	.	.	.	111	VHF <a href="#">taul AA AA(4)</a>
2006:08:08 Wed	AAAAAAA	.	.	.	.	.	vhf AA ( 2.0h) <a href="#">tau8v_lowel 1.11 AA</a>

- 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

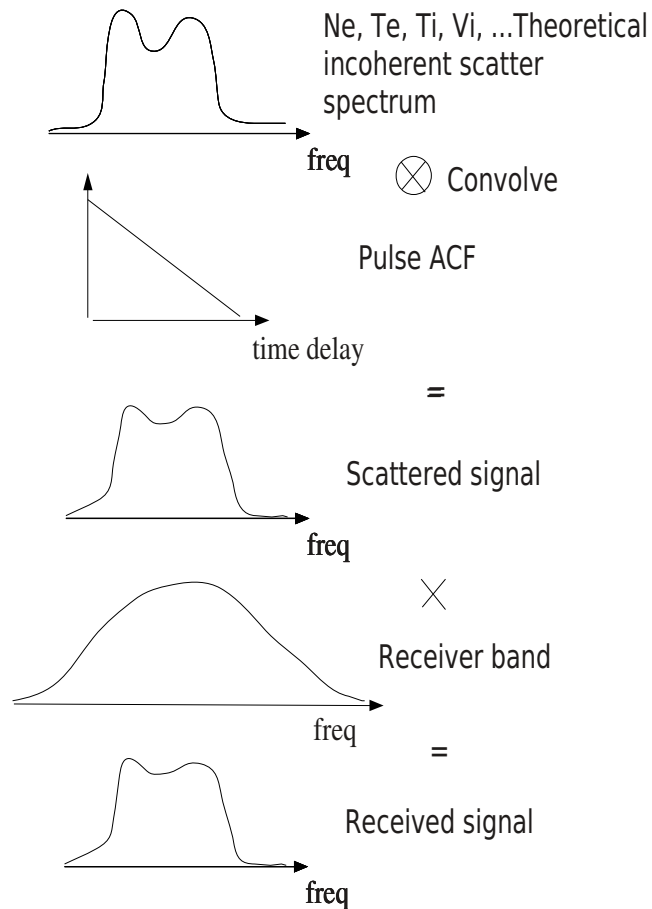
- Within GUISDAP
  - Display, calibrate, vectors...

# 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

# GUIDDAP

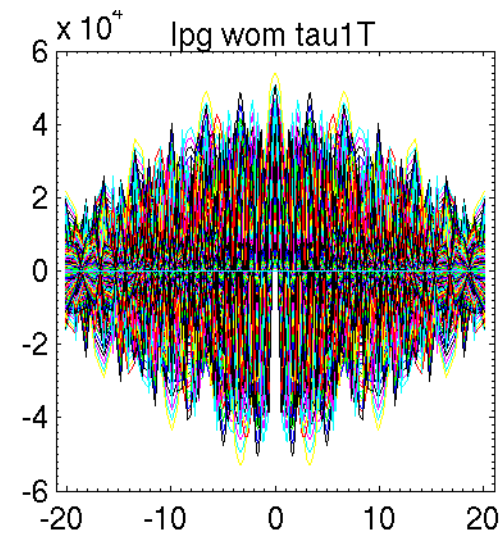
## Classic analysis



Compare this with the measurements, after proper transformation

## Guidap 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;`

Data path: /data1/tau2pl\_r\_cp1\_1.10\_SP@kir  
Start time: 2003 11 02 01 00 00  
Stop time: 2003 11 02 09 00 00  
Dsp expr: tau2pl Vs 1  
Site: K  
Result path: /analysis/results/AUTO  
Real time: RT  
Integration time: 60  
Disp figures: 0 0 1 0 1  
Special: %a\_Offsetppd=8;  
Buttons: ?, GO, Reset, Save, Quit

# Fitted Parameters

<b>Parameter</b>	<b>Unit</b>	<b>Fitted quantity</b>	<b>Min</b>	<b>Max</b>
Electron density	$\text{m}^{-3}$	$\log(N_e/N_0)$	$10^6$	$10^{14}$
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	$\text{ms}^{-1}$	$\text{asinh}(v_i/v_0/2)$	-20000	20000
Composition		$p_i$	-0.01	1.01
Dcspike	K	$\text{asinh}(D/2)$	-100	10000
Broadband	K	$\text{asinh}(B/2)$	-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

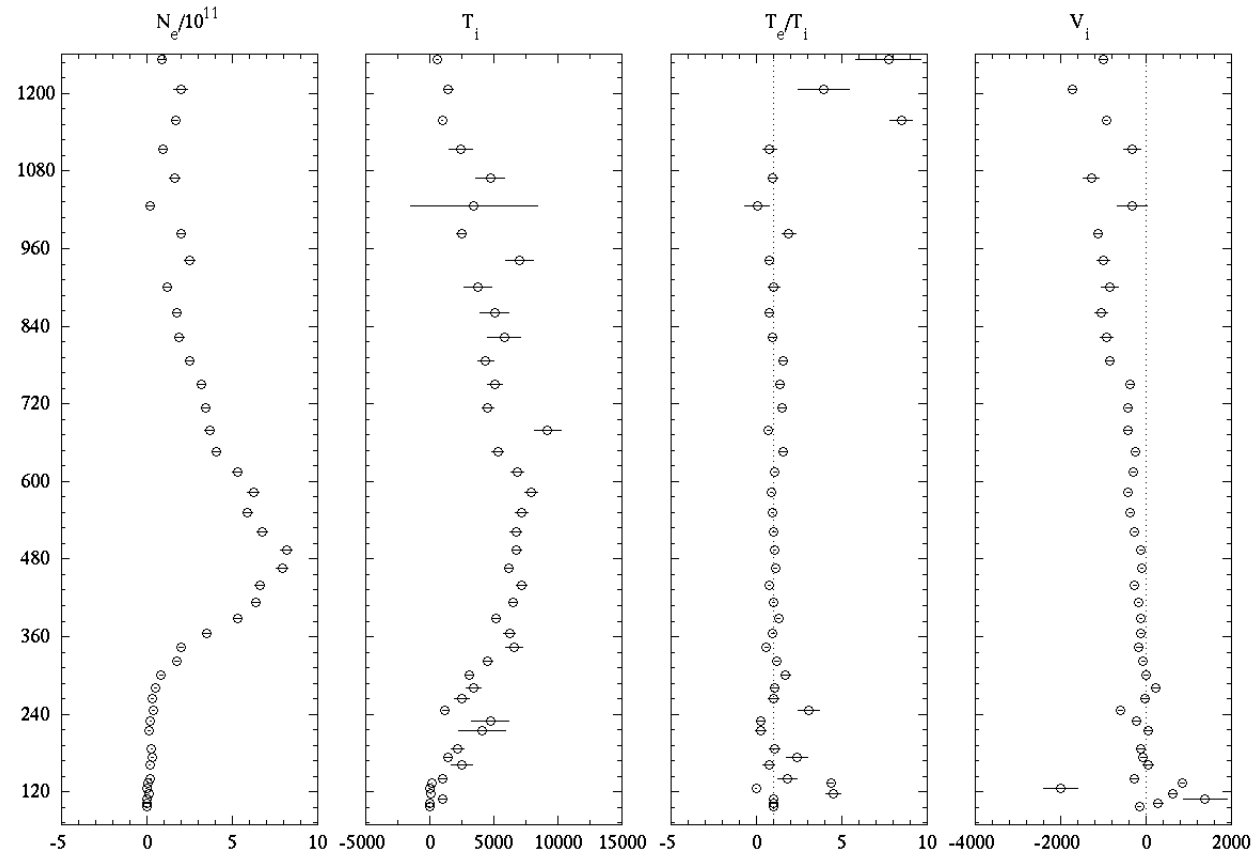
Can be changed by `fit_altitude` variable

`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 it 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



2002-02-01 1032:00 - 2002-02-01 1033:49 (El=81.6 deg) [tau0:L]



# EISCAT Scientific Association

## EISCAT UHF RADAR

CP, uhf, tau2pl, 12 March 2004

Produced@EISCAT-T, 12-Mar-2004

Not for publication - see Rules-of-the-road



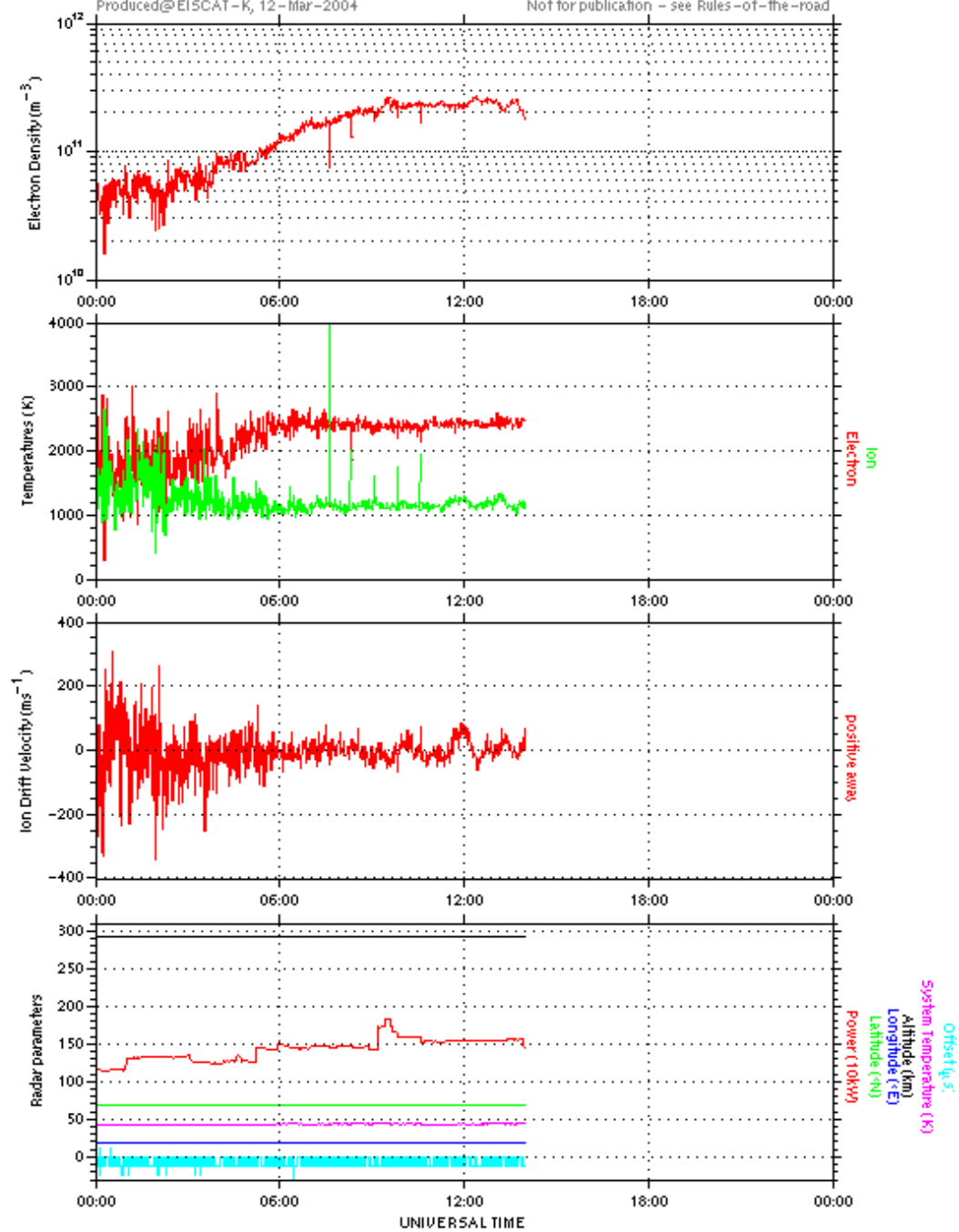
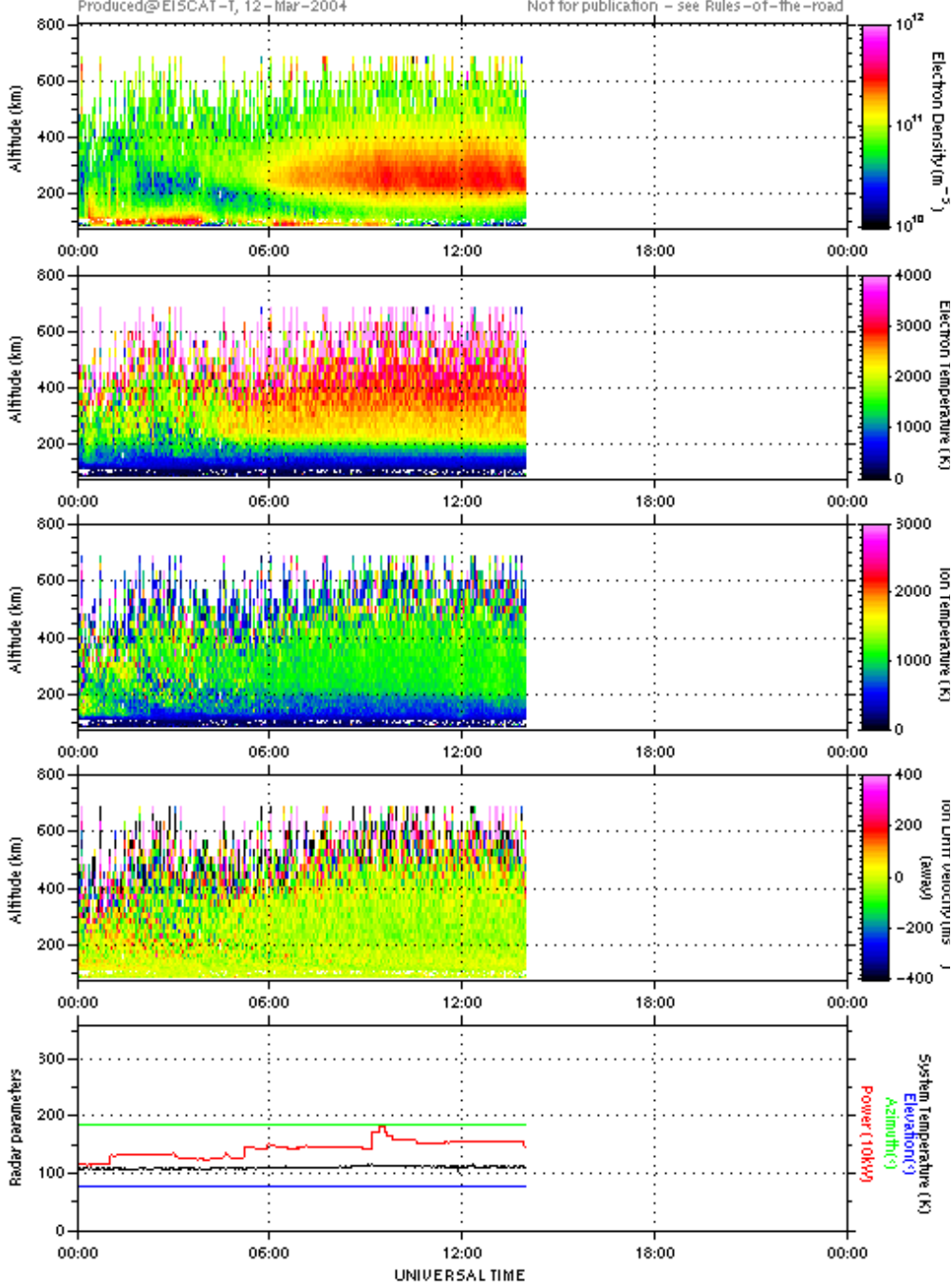
# EISCAT Scientific Association

## EISCAT UHF RADAR

CP, kir, tau2pl, 12 March 2004

Produced@EISCAT-K, 12-Mar-2004

Not for publication - see Rules-of-the-road



# Result file

<i>variable</i>	<i>size</i>	<i>contents</i>
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, $p_1 \dots p_n$ , 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: $\Delta p_1 \dots \Delta p_n$ , $\text{Corr}(p_1, p_2)$ , $\text{Corr}(p_2, p_3)$ , $\text{Corr}(p_3, p_4) \dots \text{Corr}(p_1, p_n)$
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 $p_1 \dots p_n$
r_apriorierror	(Ng,1)	a priori errors for $p_1 \dots p_n$
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 ( $\mu\text{s}$ )
r_Magic_const	(1,1)	magic constan used
r_spec	(Ng,:)*	inverted measured spectra

# Result file

<i>variable size</i>	<i>contents</i>
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) residual, measured error/expected error;
r_res (Ng,1)	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;
        '];
```

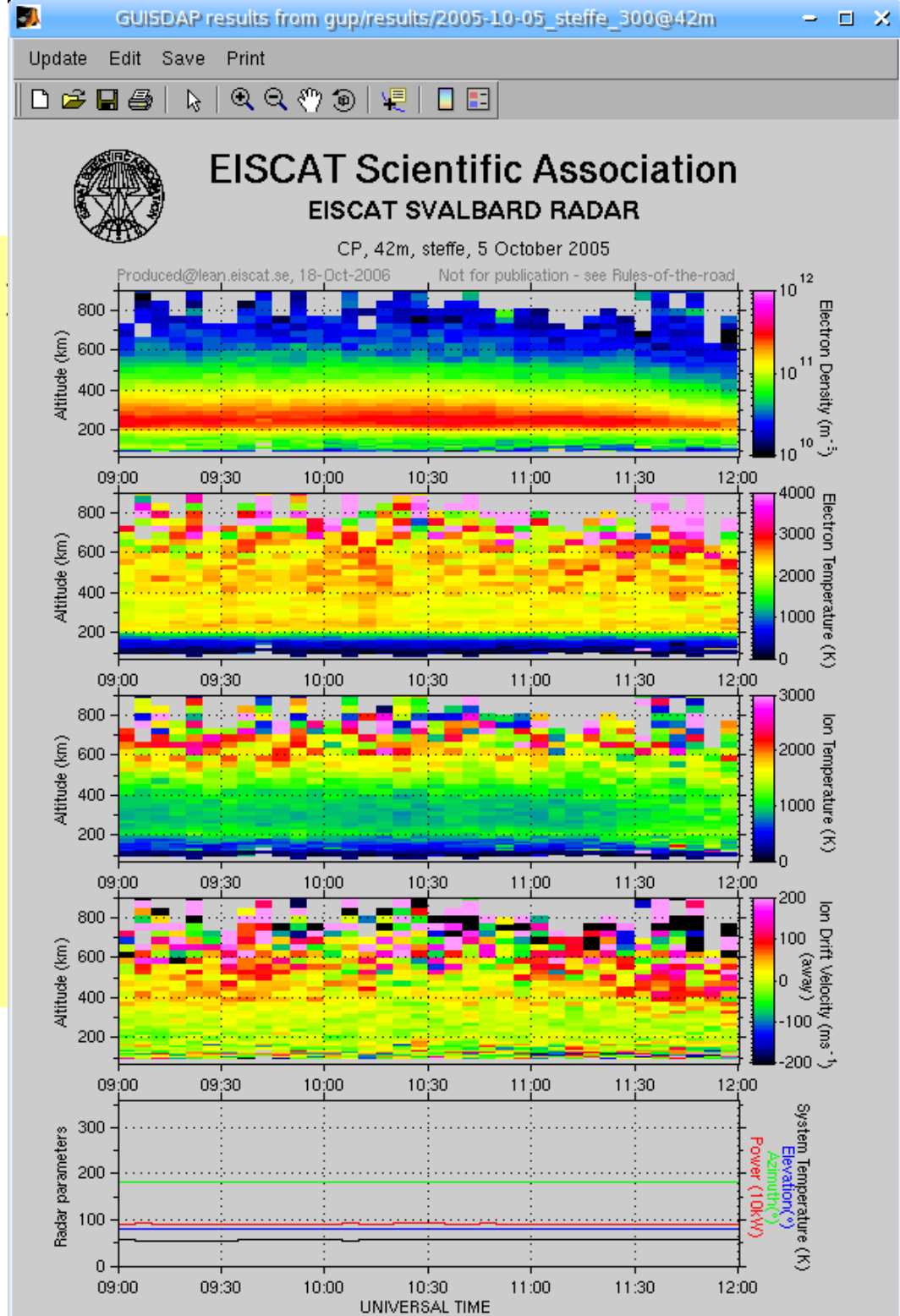
# vizu plotting routine

- 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

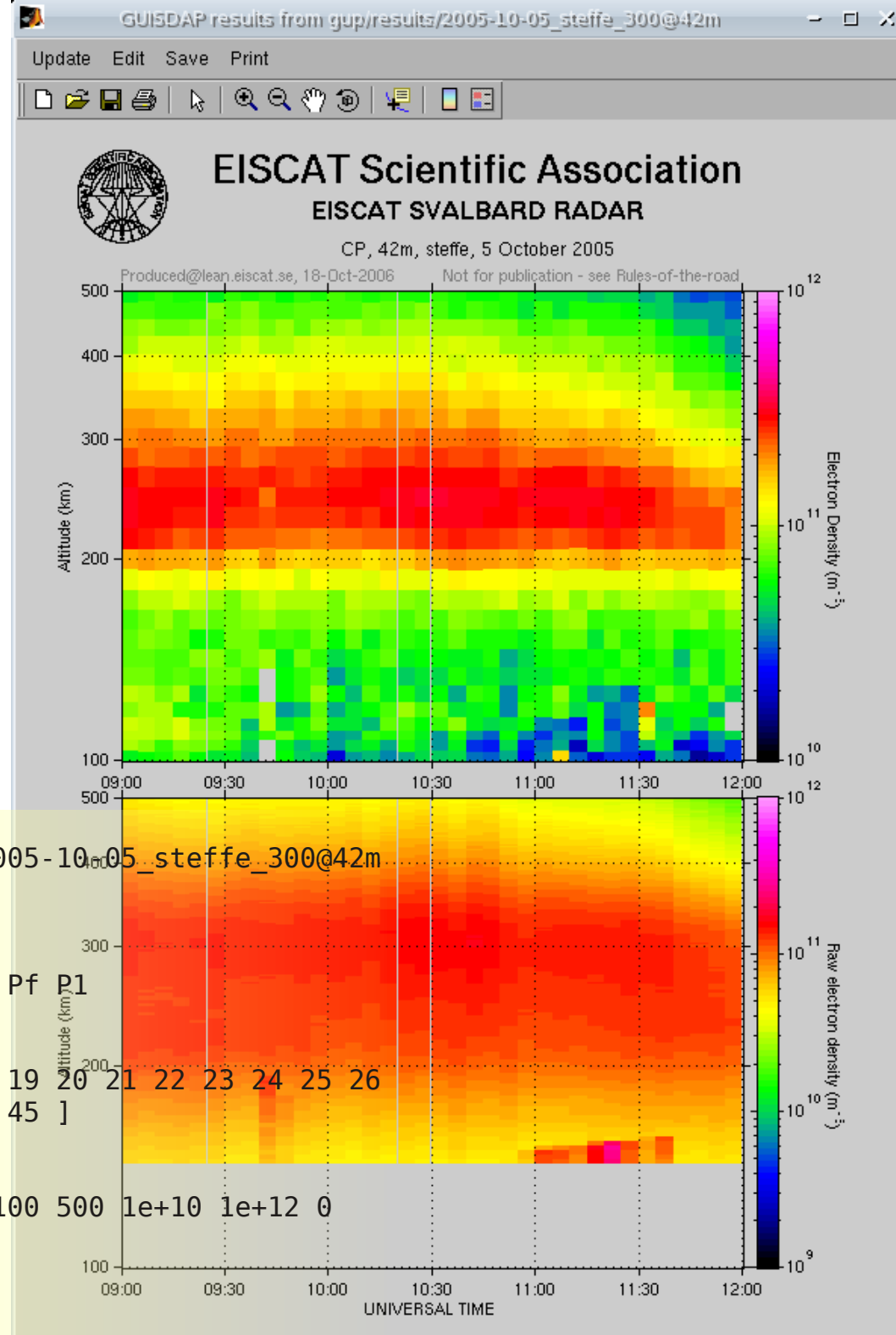
```
>> vizu verbose
Data path? [/home/ingemar/gup/results/
gup/results/2005-10-05_steffe_300@42m
Start time? [ 2005 10 5 6 32 27 ]
End time? [ 2005 10 5 12 0 2 ]
Altitude scale? [ 70 900 ]
Parameters: Ne Te Ti Vi AE TT LL Rs 0+
Co Nr Lf L1 Ls Pf P1
Choose? [Ne Te Ti Vi AE]
Type of experiment? [CP]
>>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



# 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 0+ 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 ]
Stretch secs? [ 65 ]0
```



# Calibration

- calib\_ne
  - to calibrate against ionosond (rather vertical)

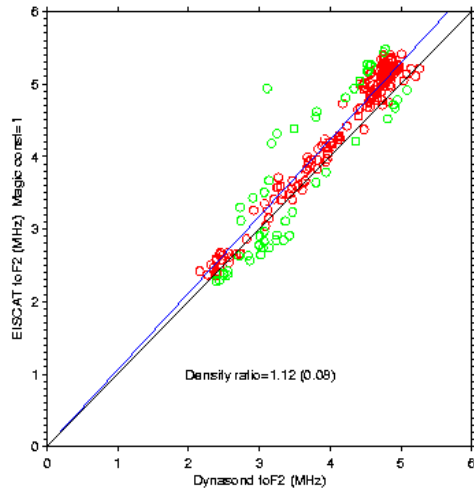
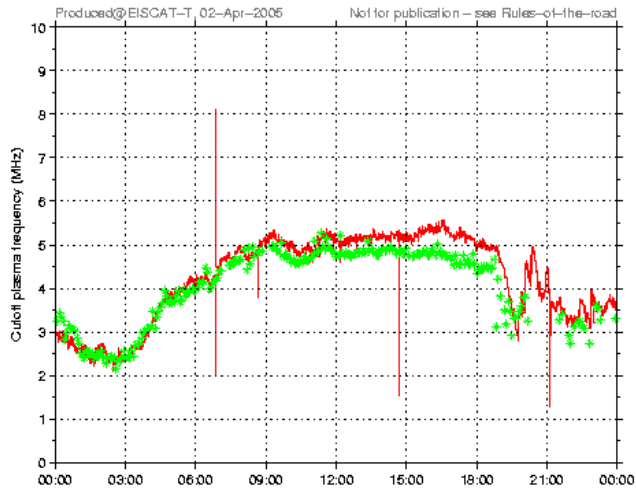
- calib\_pl\_ne
  - to calibrate against measured plasma lines



**EISCAT Scientific Association**

**EISCAT UHF RADAR**

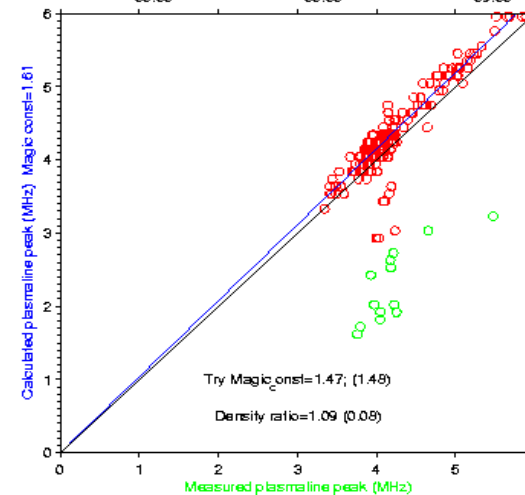
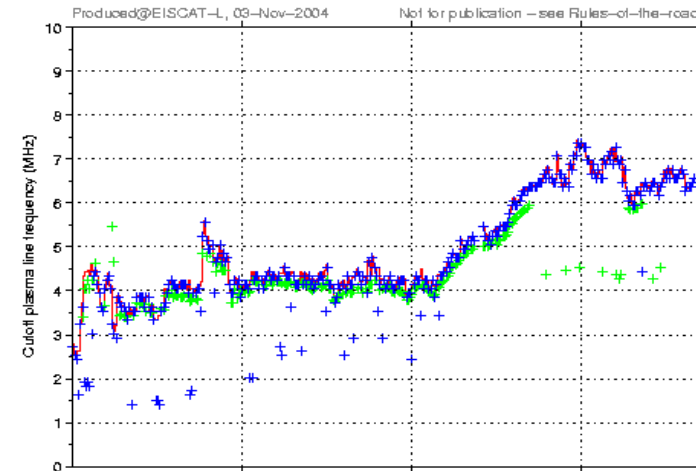
CP, uhf, tau2pl, 1 April 2005



**EISCAT Scientific Association**

**EISCAT SVALBARD RADAR**

CP, 42m, steffe, 27 October 2004



# Web analysis

HQ data archiver: Tape Contents - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.eiscat.se/raw/schedule/

## HQ data archiver: Tape Contents

Tape number:  or search by date:  
Experiment:  Year:  Month:  Day:  Hour:   
 [Site summaries](#)

---

The Data Archive has the following entries for data at 20060815:  
RAID disk storage

<input type="checkbox"/>	Type	Start date & time	End date & time	Experiment
<input checked="" type="checkbox"/>	data	2006-08-15 08:28:40	2006-08-15 09:00:00	CH uhf tau2plu_fixed_1.10HF_CH (63338 kB)
<input checked="" type="checkbox"/>	data	2006-08-15 09:00:00	2006-08-15 10:00:00	CH uhf tau2plu_fixed_1.10HF_CH (82778 kB)
<input checked="" type="checkbox"/>	data	2006-08-15 10:00:00	2006-08-15 11:00:00	CH uhf tau2plu_fixed_1.10HF_CH (121549 kB)
<input checked="" type="checkbox"/>	data	2006-08-15 11:00:00	2006-08-15 11:20:40	CH uhf tau2plu_fixed_1.10HF_CH (41604 kB)
<input checked="" type="checkbox"/>	info	2006-08-15 00:00:00		CH uhf tau2plu_fixed_1.10HF_CH (16 kB)

Select the data sets that you want to download.

MATLAB files are individually compressed with bzip2.

Be sure to read the [rules](#) regarding access and use of this data.  
For example, data younger than one year can only be downloaded by the experimenter.

---

Prepared at 08:04 UT Wed Oct 18, 2006

Powered by MySQL version 4.0.18

Done

# 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

