

# Introduction to EISCAT

What you need to know to run an experiment

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EISCAT Scientific Association

Incoherent scatter radar school 2016, Sodankylä

- 1 Overview of EISCAT
- 2 Overview of EISCAT hardware and signal processing
- 3 EISCAT experiment configuration
- 4 Running EISCAT: EROS command line, real time graph and real time analysis
- 5 Summary and experiment design cookbook

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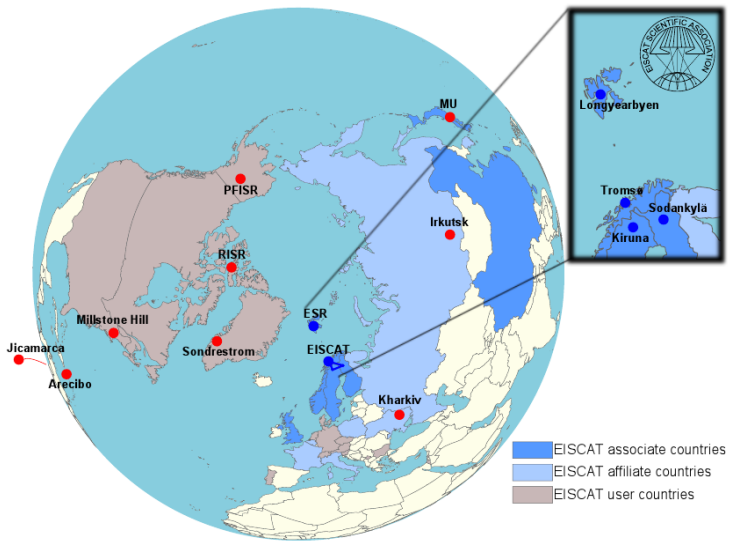
# What is EISCAT?

ESR 32-meter antenna

- Originally European Incoherent Scatter Scientific Association
- International organization based in Kiruna, Sweden
- Member institutes in six countries (FI, NO, SE, UK, JP, CN)
- Three incoherent scatter radars
- Ionosonde
- Ionospheric heater

<http://www.eiscat.se>

# EISCAT in the world



Map Anders Tjulin

# EISCAT Svalbard radar (ESR)

- 500 MHz band
- Longyearbyen, Svalbard,  $78^{\circ}09'11''$  N,  $16^{\circ}01'44''$  E
- Magnetospheric cusp and dayside auroral oval



From slides by Assar Westman

# EISCAT mainland radars

Nightside auroral oval, atmospheric dynamics, active heating. . .

- UHF, 930 MHz
- VHF, 224 MHz, tristatic



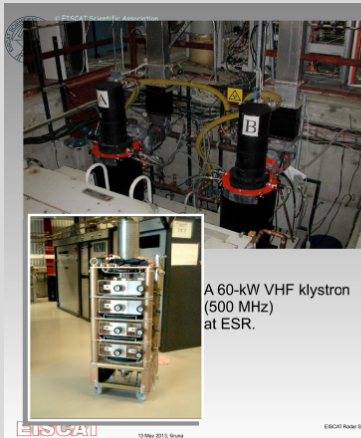
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# Transmitting a signal

## Power amplifiers

- Raise the output power
- Peak output 1 MW or more (average some 250 kW)
- Waveguides to the antennas



Two 1-MW UHF klystrons (930 MHz) at Tromsø.

A 1.5-MW VHF klystron (224 MHz) at Tromsø.

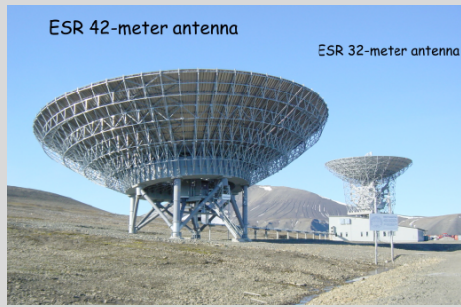


**NB: an operator must be on duty to turn on the transmitters!**

# Transmitting a signal

## Antennas

- Waveguide from klystrons
- ESR has antenna switch
- Polarizer
- Receiver protection



# Receiving the scattered signal

## Analog receiver chain

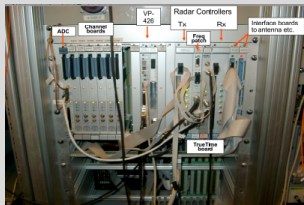
- Antennas: T/R switch, Receiver protector
- Low noise amplifiers
- Mixers
- Filters

## Digital receiver chain

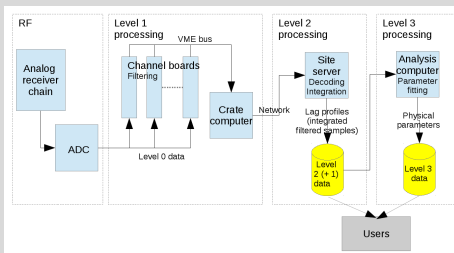
- A/D converter
- DSP boards
- Software

# Receiving the scattered signal

## Digital receiver (and radar controllers): the VME crate



## Schematic summary



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# Experiment considerations

[https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at\\_download/file](https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at_download/file)

## 1 Radar and antenna

### ▶ location

- ★ Svalbard
- ★ Mainland

### ▶ frequency

- ★ UHF
- ★ VHF

## 2 Pulse code program

- ▶ Altitude interval
- ▶ Range resolution
- ▶ Time resolution
- ▶ Plasma lines or not
- ▶ Raw data or not
- ▶ Svalbard: antenna switching

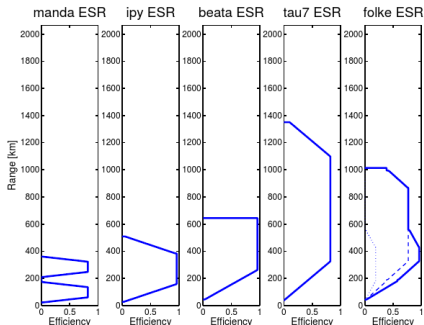


Figure 3: Overview of the ranges covered at the EISCAT ESR radar by the experiments used in the common programmes.

See document at URL above, courtesy Anders Tjulin

# Experiment considerations

[https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at\\_download/file](https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at_download/file)

## Antenna scan patterns

- UHF, ESR 32 m antenna: fixed position or scan (if possible)
  - ▶ Field aligned vs latitudinal coverage
  - ▶ Vector velocity: neutral wind or electric field
- ESR 42 m antenna: fixed field aligned
- VHF tilt **NB controlling this antenna is like moving a football field — time to change from vertical to low elevation is up to 20 minutes!**

This means: if VHF is to be moved, we will have to do so in advance before the experiment night

# Some recommended pulse code experiments

See documentation for which experiments available on which radar

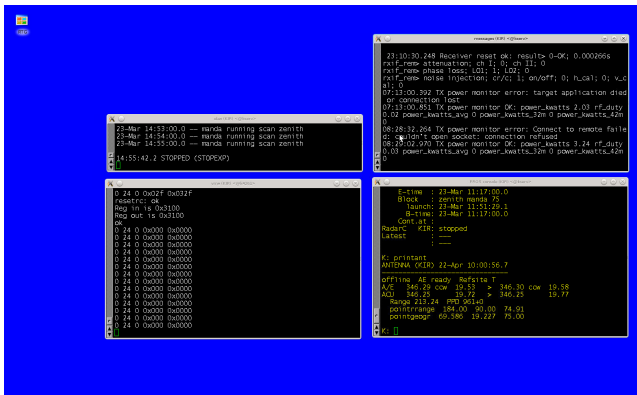
- manda** Middle atmosphere and D region, ion line only, high resolution, raw data
- beata** Standard experiment with plasma lines
- bella** Long baud length, for topside or low elevation, with plasma lines
- tau7** Longest baud length, topside or low elevation
- taro** Svalbard dual antenna
- folke** Svalbard dual antenna



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# The EROS console (Kiruna site)

## EISCAT Realtime Operating System



```
23-Mar 14:53:00.0 --- randa running scan zenith
23-Mar 14:54:00.0 --- randa running scan zenith
23-Mar 14:55:00.0 --- randa running scan zenith
14:55:42.2 STOPPED (STOPEXP)

0 24 0 0x02f 0x032f
resatrc: ok
Reg in 15 0x3100
Reg out 15 0x3100
ok
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
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0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000
0 24 0 0x000 0xb0000

23:10:30.248 Receiver reset ok: result= 0-OK; 0.000266s
rxrf_rese attenuation: ch 1; 0; ch 11; 0
rxrf_rese phase loss: L0; 1; L0; 0
rxrf_rese noise injection: cr/c; 1; on/off; 0; h/cal; 0; v_c
al; 0
07:13:00.392 TX power monitor error: target application died
or connection lost
07:11:00.851 TX power monitor OK: power_kwatts 2.03 rf_duty
0.02 power_kwatts_avg 0 power_kwatts_2m 0 power_kwatts_4m 0
08:28:32.264 TX power monitor error: Connect to remote failed:
couldn't open socket: connection refused
08:29:02.970 TX power monitor OK: power_kwatts 3.24 rf_duty
0.03 power_kwatts_avg 0 power_kwatts_2m 0 power_kwatts_4m 0

E-time : 23-Mar 11:17:00.0
Block : zenith manda 75
Launch : 23-Mar 11:11:29.1
B-time : 23-Mar 11:17:00.0
Cont.at :
RadarC : KIR; stopped
Latest : ---
K: printant
ANTENNA (GIR) 22-Apr 10:00:56.7
offFlng AE ready ReflctA T
A/E 346.29 cow 19.33 * 346.30 cow 19.58
AQU 346.25 19.72 * 346.23 19.77
Range 213.24 PPD 96140
pointrange 184.00 20.00 74.91
pointgeogr 69.586 19.227 73.00
K: ]]
```

The window titled **EROS console** is a command line interface where you run all EROS commands. The programs are written in an extension of the Tcl/Tk script language, called ELAN.

## Important EROS commands (see [http://sgo.fi/~jussi/eiscat/erosdoc/eros\\_commands.html](http://sgo.fi/~jussi/eiscat/erosdoc/eros_commands.html))

**runexperiment** Load and execute experiment ELAN file at specified time with specified parameters:  
<experiment file> <start time> <scan pattern> <associate code / CP> <any additional parameters>

### Example

```
runexp /kst/exp/beata/beata fm ip2 CP
```

Note: commands can be abbreviated!

**enablerecording** **Important:** enable data storage

**printexperiment** Show experiment status

**pointdir** (and other similar commands) Change antenna pointing

**printantenna** Show antenna pointing

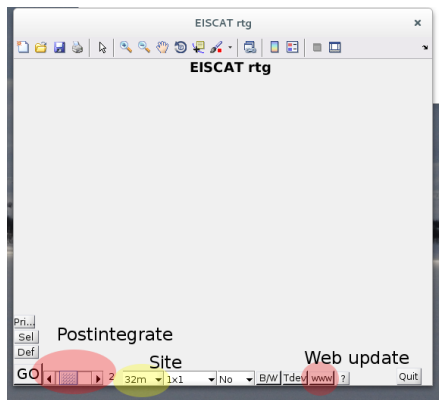
**stopexperiment** Stop the experiment

## RTG overview

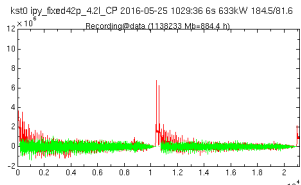
- Matlab software
- Reads data files
- Plots spectra and overviews
  - ▶ Selected in experiment's **rtg\_def.m**
- Plots can go to EISCAT web page

# RTG user interface

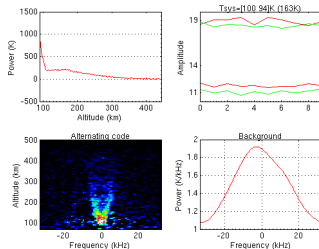
- Post-integration of data
- Site and other settings
- Plot geometry
- Enable WWW update



# Example of RTG output



ipy 2016-05-25 1029:36 6s 633k/W 1845/81.6



# Real-time analysis

- GUISDAP: Matlab software package
- `guisdap -a`
- Set parameters and go

Figures to show

Path to data

Time interval

Experiment definition

Select this

Integration (seconds), 0=antenna dwell

The screenshot shows the GUISDAP for dummies interface. The window title is "GUISDAP for dummies". The interface includes several input fields and buttons. Annotations with arrows point to specific elements: "Path to data" points to the "Data path" field; "Time interval" points to the "Start time" and "Stop time" fields; "Experiment definition" points to the "Dsp expr" field; "Select this" points to the "Real time" dropdown menu, which is currently set to "RT"; "Integration (seconds), 0=antenna dwell" points to the "Integration t" field. The "Disp figures" field contains the binary string "0 0 1 0 1". The "Special" section contains a text area with the code: `%a_Offsetppd=8;` and `%magic_constant=1.3;`. The text "Additional parameters" is overlaid on this section. At the bottom of the window are buttons for "?", "Reset", "Save", "GO", and "Quit".

Additional parameters

# GUISDAP output (vizu)

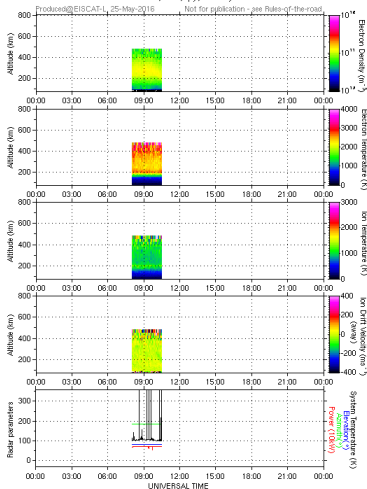
Realtime output also on EISCAT web page



EISCAT Scientific Association

EISCAT SVALBARD RADAR

CP, 42m, jpy, 25 May 2016





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# Designing **your** experiment

## What to do next

### Design your experiment

- 1 Decide on a scientific objective
- 2 Select a site and radar
- 3 Decide whether a certain time slot is preferred (when is “my” phenomenon most likely to occur?)
- 4 Required range, time resolution, etc. determine what pulse code to use
  - ▶ Consider e.g. **manda, beata, bella, tau7**
  - ▶ Check documentation for what code programs are available on “your” radar
- 5 Choose antenna pointing (or scan if required and possible)
- 6 Write a short proposal
  - ▶ Proposal is evaluated
  - ▶ Time is allocated (scheduling)

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# Designing **your** experiment

What to do next

## Run your experiment

- Be in Polaria lecture hall well in advance before your allocated radar time!
- EISCAT and SGO staff will assist you how to
  - ▶ start your experiment
  - ▶ contact the on site transmitter operators
  - ▶ save and analyze the data.
- **Be prepared to have a plan B!**



ESR 42-meter antenna

ESR 32-meter antenna

Questions?

## More information

- <http://www.eiscat.se>
- [https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at\\_download/file](https://www.eiscat.se/groups/Documentation/UserGuides/eiscat-experiments/at_download/file)
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