

# 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

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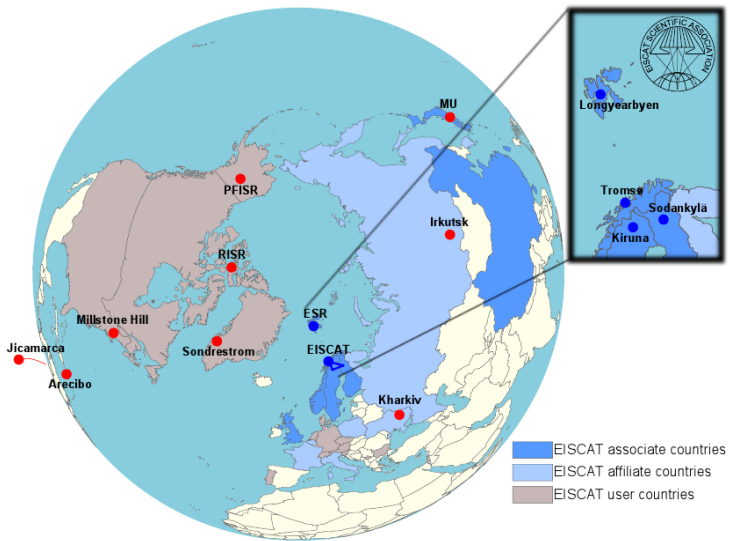
# What is EISCAT?

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
- Cusp and dayside auroral oval



From slides by Assar Westman

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



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

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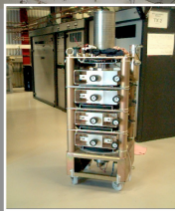
# Transmitting a signal

## Power amplifiers

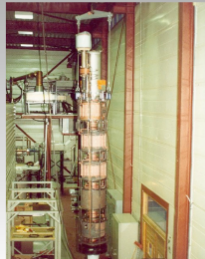
- Raise the output power
- Peak output 1 MW or more (average some 250 kW)
- Waveguides to the antennas



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



A 60-kW VHF klystron (500 MHz) at ESR.



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

EISCAT

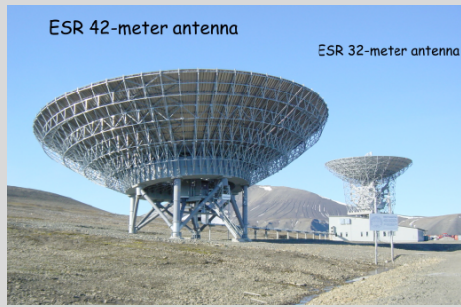
13 May 2013, Grana

EISCAT Radar School 2013

# Transmitting a signal

## Antennas

- Waveguide from amplifiers
- ESR has antenna switch
- Polarizer, mode converter
- Receiver protection



# Receiving the scattered signal

## Analog receiver chain

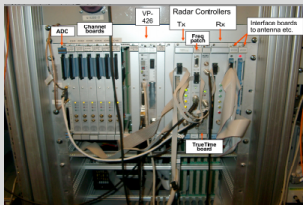
- Antennas: T/R switch, Receiver protector
- Low noise amplifier
- Mixers
- Filters

## Digital receiver chain

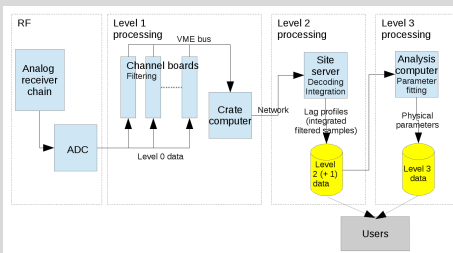
- A/D converter
- DSP boards
- Software

# 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

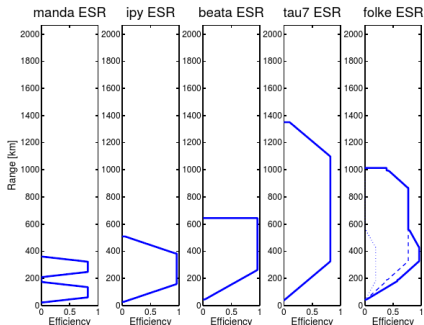


Figure 3: Overview of the ranges covered at the EISCAT ESR radar by the experiments used in the common programmes.

See document at URL above, courtesy Anders Tjulin

# Experiment considerations

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## Antenna scan patterns

- UHF, ESR 32 m antenna: fixed or scans
  - ▶ Latitude coverage
  - ▶ Vector velocity, 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 about 15 minutes!**

This means: if VHF is to be moved, do so in advance before experiment night or during UHF experiment

# 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



# EISCAT Realtime Operating System (EROS)

<http://sgo.fi/~jussi/eiscat>

- Handles all “slow” configurations
- Consists of several UNIX processes
- Based on **Tcl** script language
- Loads all configurations; VME crate computer talks to
  - ▶ antenna control unit
  - ▶ VME boards
  - ▶ ESR exciters

## ELAN (extended Tcl/Tk) files

### 1 Main program

- ▶ Loads all radar configurations including pulse code program
- ▶ Synchronization
- ▶ Starts experiment **but not data recording**

Names are usually acronyms: **beata, bella, manda...**

### 2 Antenna scan program

- ▶ ELAN subroutine loaded from main program
- ▶ Runs pointing commands in a synchronized manner

Names are typically intended Common Program use: **cp1, cp2, cp3...**

## Data correlation (voltage to ACF domain)

- VME crate computer: **lag\_wrap**
  - ▶ Configuration: `.fil` file
  - ▶ Reads out data from channel boards
  - ▶ Sorting, preformatting, cross products
  - ▶ Reads transmitter power
- Main computer: **decodump**
  - ▶ Decoding: configuration `.DECO` file
  - ▶ Other processing also possible
  - ▶ Final time integration
  - ▶ Adds parameter block
  - ▶ Stores to files compatible with Matlab

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# The EROS console (Kiruna site)

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

0 24 0 0x02f 0x032f
resetrc: ok
Reg in 1s 0x3100
Reg out 1s 0x3100
ok
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
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0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000
0 24 0 0x000 0x0000

E-time : 23-Mar 11:17:00.0
Block : zenith manda 75
Taunch: 23-Mar 11:51:29.1
B-time: 23-Mar 11:17:00.0
Cont.at :
RadarC_KIR: stopped
Latest : ---

K: printant
ANTENNA (KIR) 22-Apr 10:00:56.7

-----
offLine AE ready RefSite T
A/E 346.29 cow 19.53 > 346.30 cow 19.58
ACU 346.25 19.72 > 346.25 19.77
Range 213.24 RPD 961.0
pointrrange 184.00 90.00 74.91
pointgsqr 69,586 19,227 75.00

K: ]
```

The window titled **EROS console** is a command line interface where you run all EROS commands.

## 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

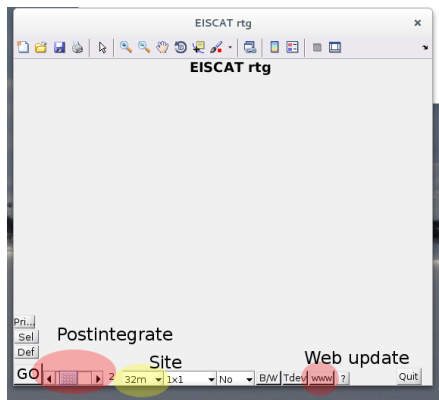
**stopexperiment** Stop the experiment

## RTG overview

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

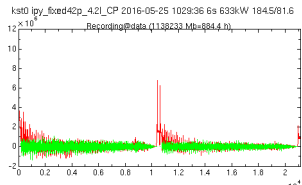
# RTG user interface

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

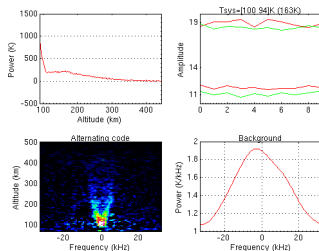




# Example of RTG output



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. It includes fields for Data path, Start time, Stop time, Dsp expr, Site, Result path, Real time (highlighted with a red box and the text 'Select this'), Integration time, and Disp figures. A 'Special' section contains additional parameters like `%a_Offsetppd=8;` and `%magic_constant=1.3;`. Arrows point from the text labels to the corresponding fields in the GUI.

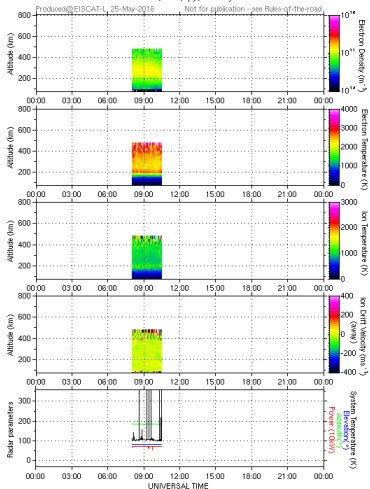
Additional parameters



## EISCAT Scientific Association

EISCAT SVALBARD RADAR

CP, 42m, ipy, 25 May 2016



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)
- [http://sgo.fi/~jussi/eiscat/erosdoc/eros\\_commands.html](http://sgo.fi/~jussi/eiscat/erosdoc/eros_commands.html)