

The EISCAT systems and how to run them

Introduction to hardware, control and data

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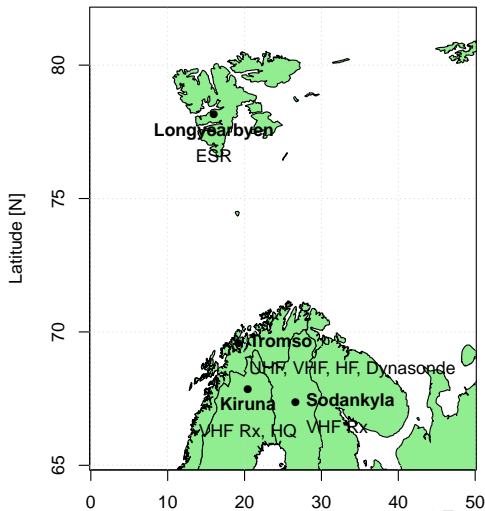


Radar School, Pikku-Syöte, Finland
August 2019

- 1 The EISCAT systems
- 2 EISCAT hardware and signal processing basics
- 3 EISCAT experiment configuration
- 4 EISCAT software control
- 5 EISCAT data

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EISCAT sites



EISCAT mainland radars

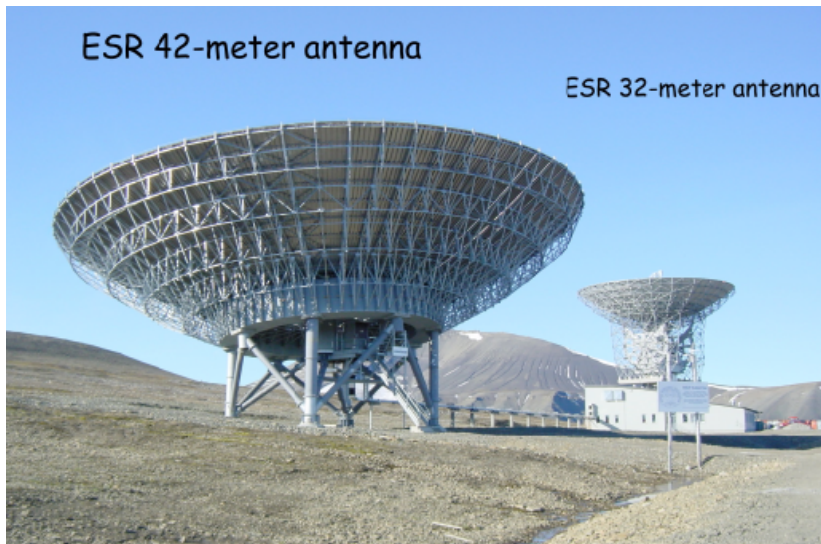


VHF 224 MHz



UHF 930 MHz

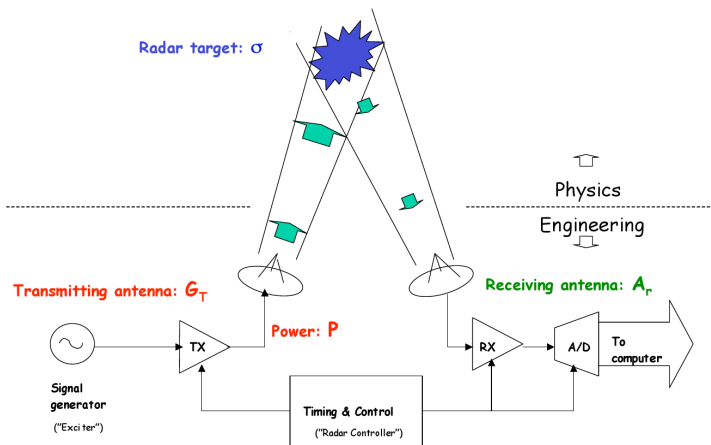
EISCAT Svalbard radar site near Longyearbyen 78° N



ESR 500 MHz

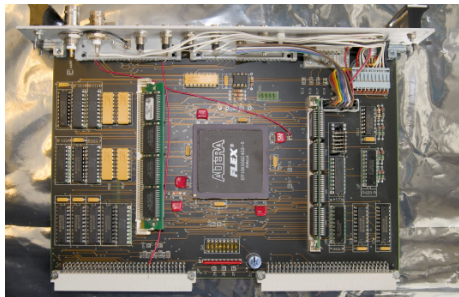
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A generic radar system



Transmitting a signal

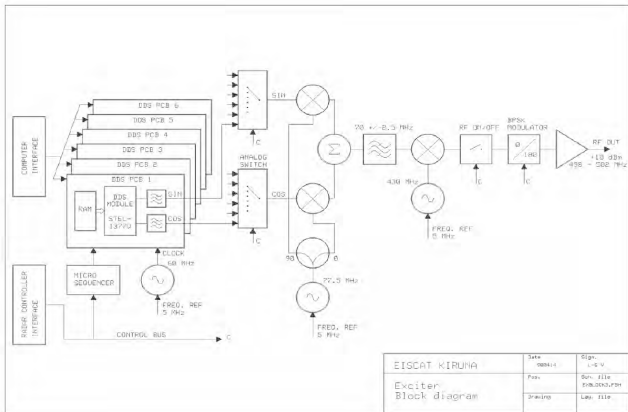
Radar controllers



- The hearts of the radars
- Handle fast synchronizations
- Memory banks containing sequences of bits
- 10 MHz resolution
- One for Tx and one for each Rx

Transmitting a signal

Exciter



- Generates the signal
- 0 and 180 degree phase flips

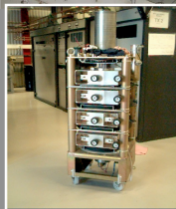
Transmitting a signal

Power amplifiers

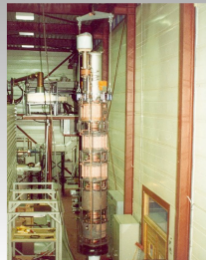
- Raise the output power
- ESR peak output 1 MW (average 250 kW)
- Waveguides to the antennas



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.

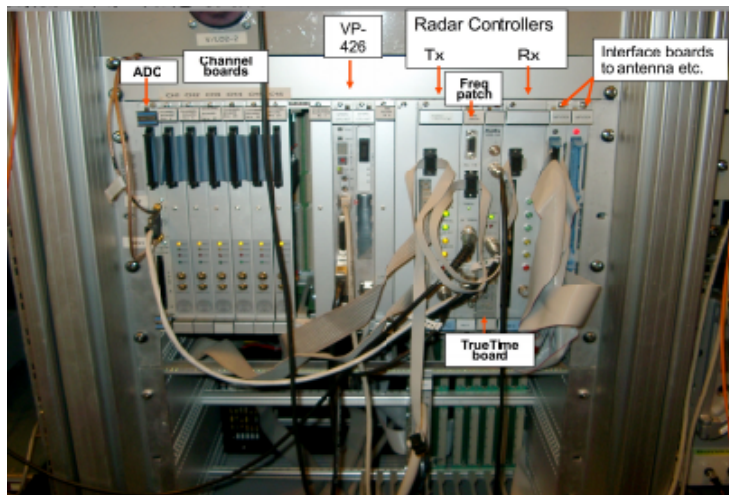
EISCAT

13 May 2013, Grana

EISCAT Radar School 2019

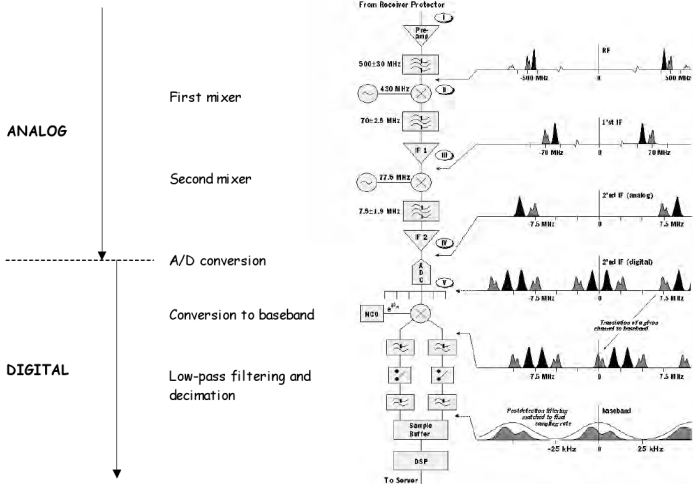
Receiving the scattered signal

Digital receiver (and radar controllers)



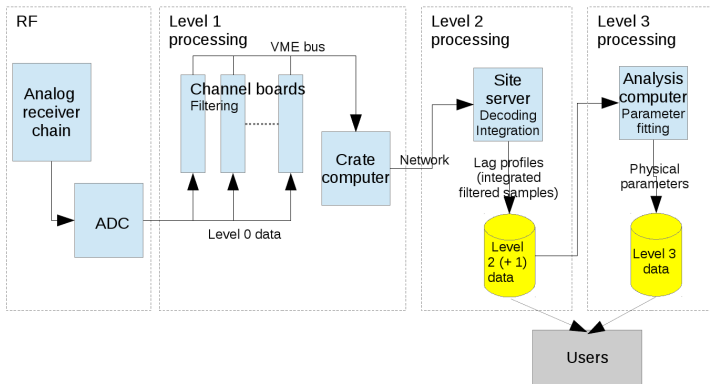
Receiving the scattered signal

Overview of EISCAT signal processing



Receiving the scattered signal

Schematic summary



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Definitions needed for an experiment

Pulse code

- Range resolution
- Time resolution
- Maximum range

Transmitter configuration

- Frequency/frequencies

Receiver configuration

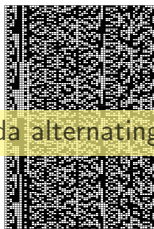
- Channels (Ion line, Plasma lines?, Background ...)
- Filters

Antenna scan

- Fixed or moving
- ESR single or dual antenna

EISCAT Experiments

Anders Tjulin
EISCAT Scientific Association
5th December 2018



Manda alternating code

<https://www.eiscat.se/scientist/document/experiments/>

- Transmitter, pulse code, receiver, decode → Radar program
 - ▶ manda
 - ▶ beata
 - ▶ folke
 - ▶ ...
- Antenna pattern (and ESR "slow" antenna switching) → Scan program
 - ▶ cp1
 - ▶ cp2
 - ▶ ...

Selecting a pulse code program

Mainland VHF

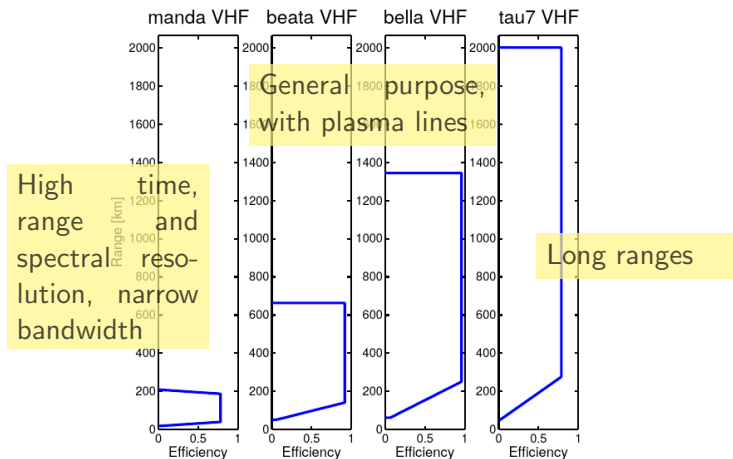


Figure 2: Overview of the ranges covered at the EISCAT VHF radar by the experiments used in the common programmes.

Selecting a pulse code program

EISCAT Svalbard radar

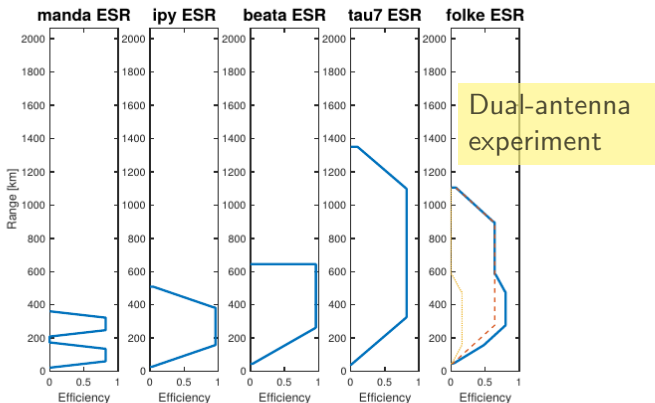


Figure 3: Overview of the ranges covered at the EISCAT ESR radar by the experiments used in the common programmes.

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The EISCAT Realtime Operating System (EROS)

- **Tcl** programming language with extensions
- Command line console
- Experiment definition file **experiment.elan**
- Antenna scan file(s) **scan.elan**
- Radar controller file **experiment.tlan**
- Channel board and decoder control: **.fil**, **.par** etc

Experiment file example

```
# bella.elan
...
BLOCK bella {{scan cp1} {owner CP} {height 270.0}} {
  # For ESR bella {{scan fixed42p} {owner CP} {ant 42m}} {
    ... lots and lots of definitions ...

    # Stop receiver --
    SYNC -10
    stopradar -rec
    if {[ISUHF]||[ISVHF]||[ISESR]} {
if {$enatra} {stopradar -trans}
    }
    if {[ISESR]} {
stopradar -pla
stopdata pla
    }
    stopdata
    # Load radar controller --
    if {[ISESR]} {
if { $ant=="42p" } {
    loadradar rec -loopc $Loopc -sync $Sync -file ...
    loadradar pla -loopc $Loopc -sync $Sync -file ...
    if {$enatra} {
loadradar trans -loopc $Loopc -sync $Sync -file ...
    }
}
...

SETTCR 0
%%% SUBCYCLE 1 %%%
AT 0.9 CHQPULS,RXSYNC,NCOSELO,AD2L,AD1R,STFIR
AT 1.9 1LOCH1SEL1,1LOCH2SEL1,2LOCH1SEL2,2LOCH2SEL2
AT 2 RXPROT,LOPROT
AT 32 BEAMON,F6
%%% RF TRANSMISSION %%%
AT 88 CH1,CH4,RFON,PHA180 %++
AT 178 PHAO %--
AT 268 PHA180 %+
AT 313 PHAO %-
AT 358 PHA180 %++++
AT 538 PHAO %--
AT 628 PHA180 %+
AT 673 PHAO %---
AT 853 PHA180 %+
AT 898 PHAO %--
AT 988 PHA180 %+
AT 1033 PHAO %-
AT 1078 PHA180 %+++
AT 1213 PHAO %---
AT 1348 PHA180 %+
AT 1393 PHAO %-
AT 1438 RFOFF,PHAO,BEAMOFF
AT 1528 CH1OFF,CH4OFF
AT 1538 RXPOFF
AT 1558 LOPOFF
%% SIGNAL RECEPTION: 192 samples
AT 1810 CH1,CH4,CH2,CH5,CH3,CH6
...

```

... and so on

The EROS console

The screenshot displays a Linux desktop environment with a red background. On the left, there is a sidebar with icons for 'debian-uxterm.desktop', 'RTG', 'Start eros', 'gnome-terminal.desktop', 'terminal', and 'Trash'. The main area contains several terminal windows:

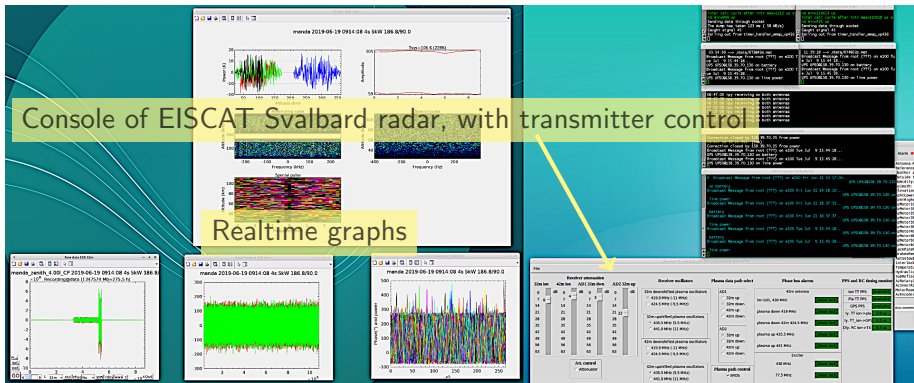
- Monitor (KIR) (on kserv)**: Shows the start of a monitor process with an interval of 107 ms.
- Vme (KIR) (on k4261)**: Shows a green prompt character.
- Correlator (KIR) (on k4261)**: Shows logs for cleaning up and stopping the correlator.
- Recorder (KIR) (on kserv)**: Shows logs for stopping the recorder.
- Elan (KIR) (on kserv)**: Shows an error message: "asn Failed to bring RDJ online while awaiting".
- Messages (KIR) (on kserv)**: Shows a list of messages including receiver resets and block words.
- EROS Console (KIR) @kserv (on kserv)**: Shows system status and experiment details. A yellow arrow points to the 'Command window' label, which is a yellow box containing the text 'Command window'.

At the bottom, there is a taskbar with icons for 'Vme (KIR)', 'Correlator (KIR)', 'Recorder (KIR)', 'Elan (KIR)', 'Monitor (KIR)', 'Messages (KIR)', and 'EROS Console (KIR) ...'. A tooltip at the bottom left says 'Click here to hide all windows and show the desktop.'

Console at a remote site (Kiruna)

Command window

The EROS console and the EISCAT realtime graph (RTG)



The RTG windows are where you monitor data during a run.
It is Matlab software, start separately from EROS (desktop icon)

Important EROS commands

`runexperiment` Load an experiment and start at specified time

`enablerecording` Start saving data

`printexperiment` Show experiment status

`printantenna` Show pointing

`stopexperiment`

- Commands can be abbreviated
- Online help is available
- EISCAT staff will assist you

EROS command cheat sheet

Start

```
runexperiment /kst/exp/beata/beata fm cp1 G1 [85]
enablerecording (When transmitter is up)
```

ELAN file Start time Associate code
[Tristatic altitude]

Scan

During experiment

```
printexperiment
printantenna
```

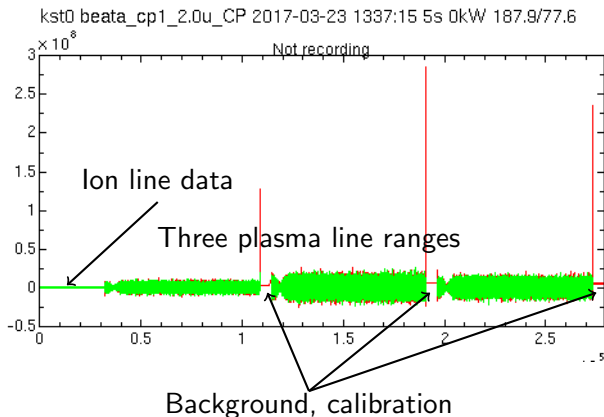
```
stopexperiment [22:00]
```

Outline

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Decoded data: The lag profile

Data in autocorrelation domain (lag, range)



How to access your data

Lag profile data EISCAT database of lag profile data

Analyze data 1 Download data and run GUISDAP

Analyze data 2 Online GUISDAP

Standard analysis Get from Madrigal

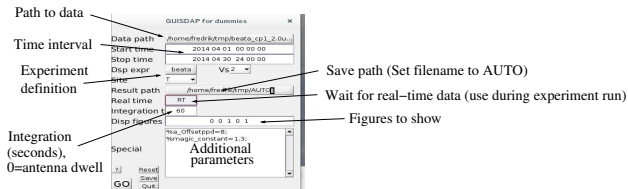
All the above accessible from **EISCAT Schedule**

<https://www.eiscat.se/schedule/schedule.cgi>

GUISDAP analysis basics

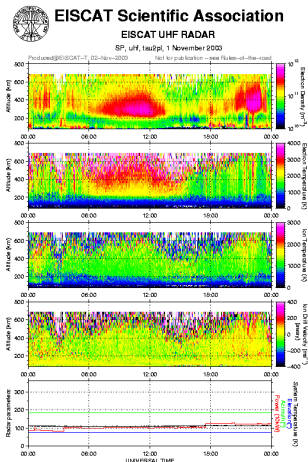
More in a later lecture

- Matlab software
- Will run online tonight
- `guisdap -a`



- Fits theoretic spectrum to data
- Uses atmospheric composition models: MSIS, IRI
- Takes care of transmitter power, geometry

- If you have Matlab, you can run GUISDAP on your laptop —
Download available from EISCAT web
- Otherwise, online analysis or analyzed data from Madrigal
- During the experiment and group work, EISCAT staff will assist you
- More details on Thursday



Electron density m^{-3}

Electron temperature K

Ion temperature K

Line of sight velocity m/s

Parameters

To create new plot: **vizu new VERBOSE** at GUISDAP prompt

Current status and limitations of EISCAT radars

NB!

Tromsø UHF Antenna cannot move. Fixed at field-aligned position.

Tromsø VHF Antenna pointing is a manual operation. By default vertical. Low elevation northward possible and has to be announced ≈ 1 h in advance.

EISCAT Svalbard radar Power line maintenance has been going on, but should be ready now

Experiment night planning

- Two groups will run in parallel
- Experienced EISCAT users and staff will assist
- The radar not used by the students will run a standard mode



<https://www.eiscat.se>



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