The technological challenges for the EISCAT_3D Phased Array Radar system

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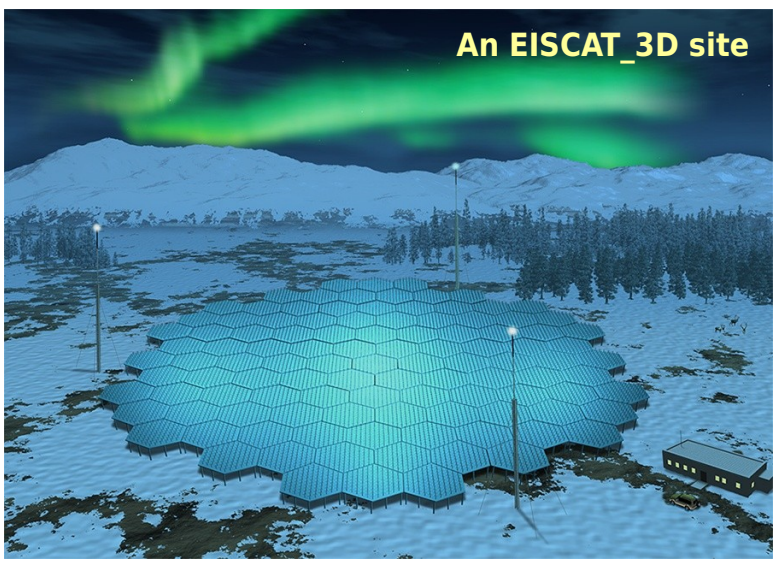
EISCAT_3D

A flexible **multi-static phased array radar** for incoherent scatter and other radar studies in the polar atmosphere.

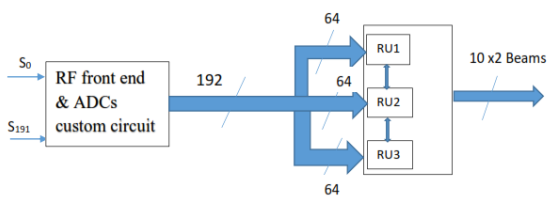
The EISCAT_3D Science Case covers

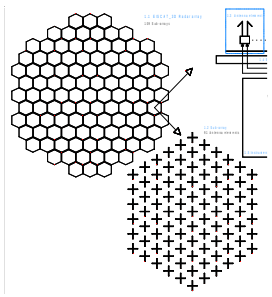
- atmospheric physics and global change;
- space and plasma physics;
- solar system research;
- space weather and service applications;
- radar techniques, new methods for coding and analysis.



Beamformer

The first beam former will take the digitised signal from each antenna element at 100 MHz speeds, delaying the signal at 10 ps resolutions to steer the beam (look direction), mixing the signal down to base band, and filter it and re-sample it. The delays are individual for each antenna and ten simultaneous look directions are formed. This process performed with FPGAs and requires very accurate timing given by the White Rabbit protocol. Beams are formed for each of the 109 subarrays, and the data is sent over high speed network into a central site server with the second beam forming unit. This is based on a 10^4 core CPU cluster, where the 10 beams from all subarrays are further narrowed down, making a total of 100 simultaneous look directions.





Subarray characteristics	
Number of Antennas	91
Number of polarizations	2
Sample rate	104 MHz
Bandwidth	30 MHz
Dealy filter type & length	36-tap DSP-FIR
Filter Resolution	18 bits
Group & phase delay error combined	≤ 5.8 ps
Computing requirement	5 - 32 Tflop/s
Network requirement per sub-array	64 Gbit/s

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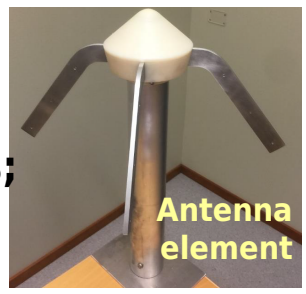
Challenges

All sites will receive the scattered signal from the transmitted radio pulses, and the signal will be digitised at each antenna element. This enables pointing the whole collective antenna into 100 different directions simultaneously.

The data will go through several steps before it's ready as a scientific product, each of them demanding large resources: two stages of beam forming, a 1D profiling with first analysis results, a 3D profiling with a full analysis with selection processes for the archiving of data.

EISCAT_3D capabilities

- Simultaneous **multiple beams;**
- Instantaneous, **adaptive control of beam position;**
- High-resolution phase, polarisation and amplitude coding;
- Full-profile **vector measurements;**
- Small-scale (sub-beam-width) imaging;
- High-speed **object tracking.**



Online data processing for Real-Time radar control

The data from the radar sites will be processed online at the Operations Centre, estimated for 500 Tflop/s processing and 20PB buffer storage. The challenge for this Operations Centre computing is to combine the data online from multiple sources into three-dimensional data products using tightly-coupled high-throughput computing. These data products must then be used to control the radar operation.

The Operations Centre computing must be able to react and adapt between the science cases in real-time as natural phenomena occur randomly and are not repeatable.