



EISCAT Scientific Association

The EISCAT_3D phased- array radar for research into the arctic ionosphere

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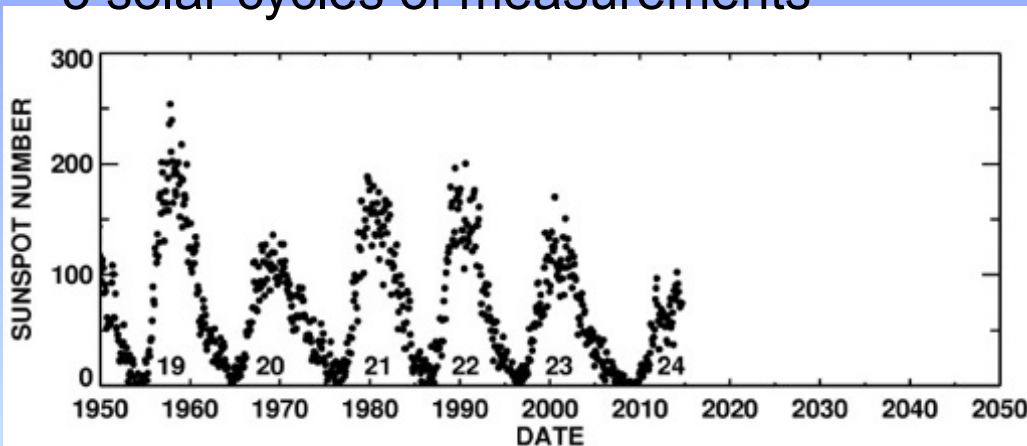
Assar Westman

EISCAT Scientific Association



EISCAT

- Originally: European Incoherent SCATter
- Founded in 1975, operational 1981
- Operates 3 Incoherent Scatter Radars
- Locations: Tromsø (NO), Kiruna (SE), Sodankylä (FI), Longyearbyen (Svalbard)
- Members (2014):
 - Associates – NO, SE, FI, UK, JP, CN
 - Affiliates - RU, FR, UA
- 3 solar cycles of measurements





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EISCAT Mainland Radars

Tromsø, Norway

Four 30x40 m VHF

32 m UHF

VHF: 224 MHz
UHF: 930 MHz



32 m VHF

Kiruna, Sweden

T-K 196 km, 165 deg
T-S 389 km, 125 deg
K-S 268 km, 99 deg



32 m VHF

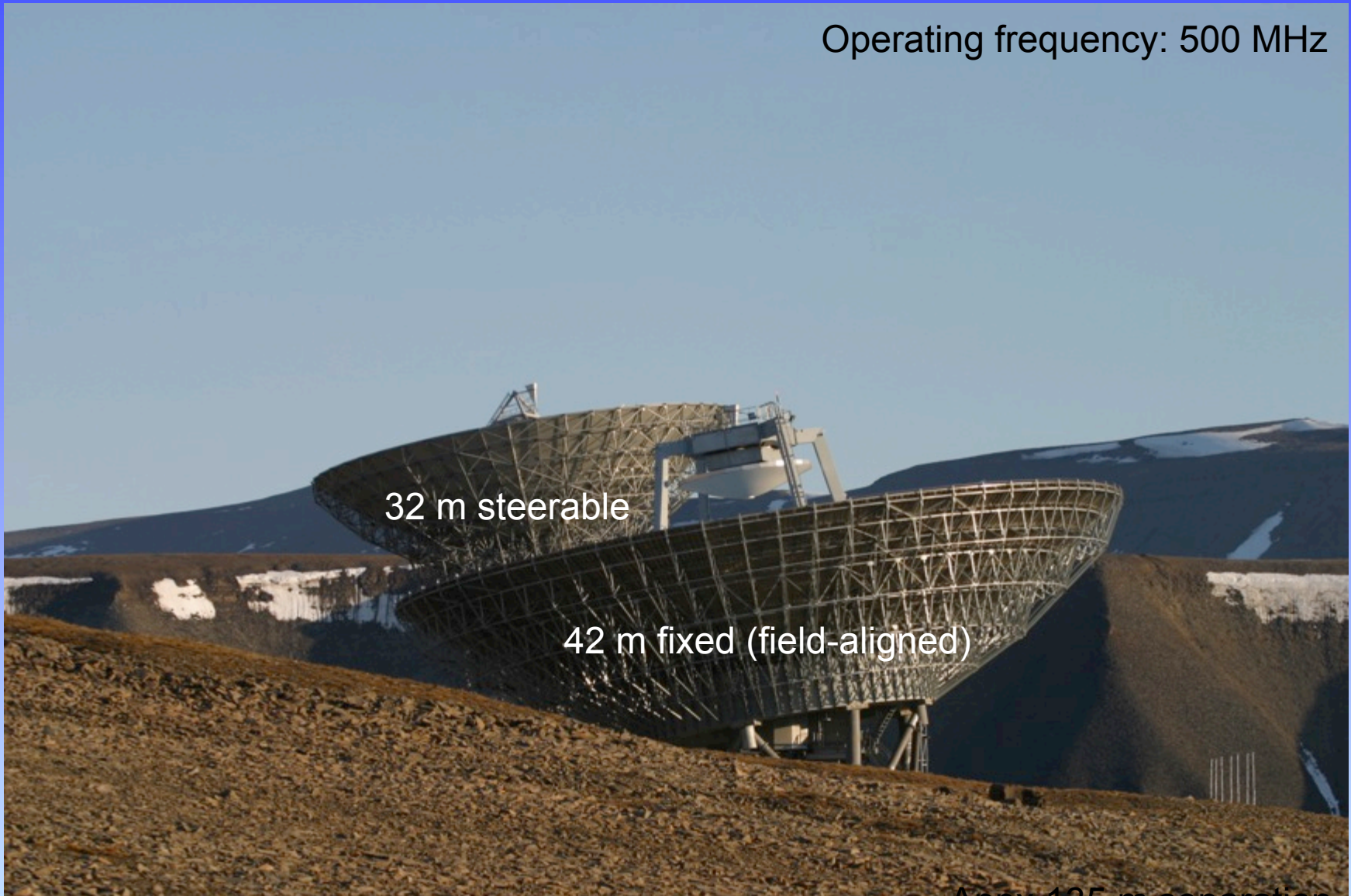
Sodankylä, Finland



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EISCAT Svalbard Radar

Operating frequency: 500 MHz



32 m steerable

42 m fixed (field-aligned)

Appx 135 m separation



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EISCAT Science

How is Earth's atmosphere coupled to space?

Space weather effects

Micrometeors

Near-Earth objects

Climate change

Space debris

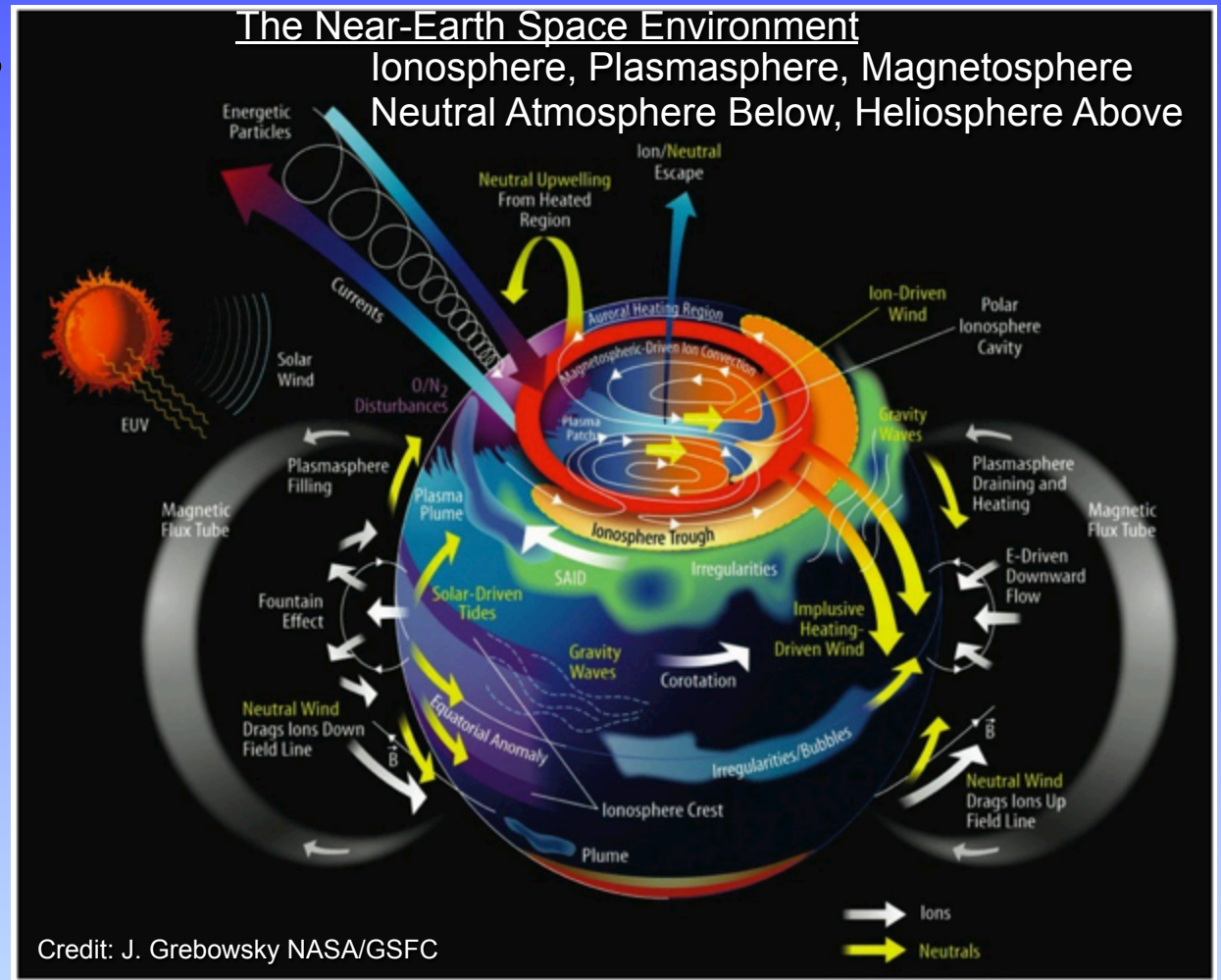
Interplanetary

Scintillations

Basic plasma physics

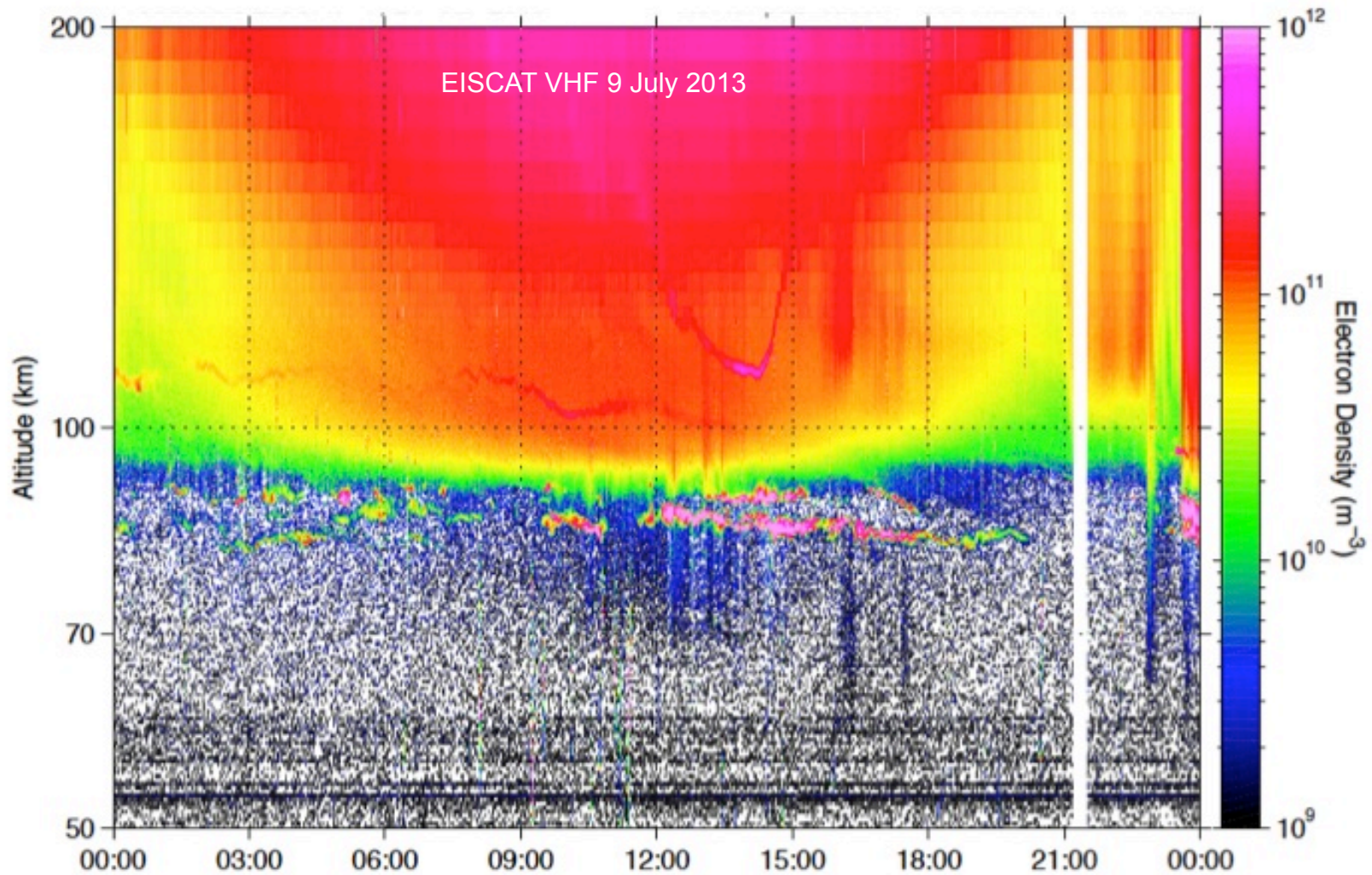
via active

experiments





A Summer Day



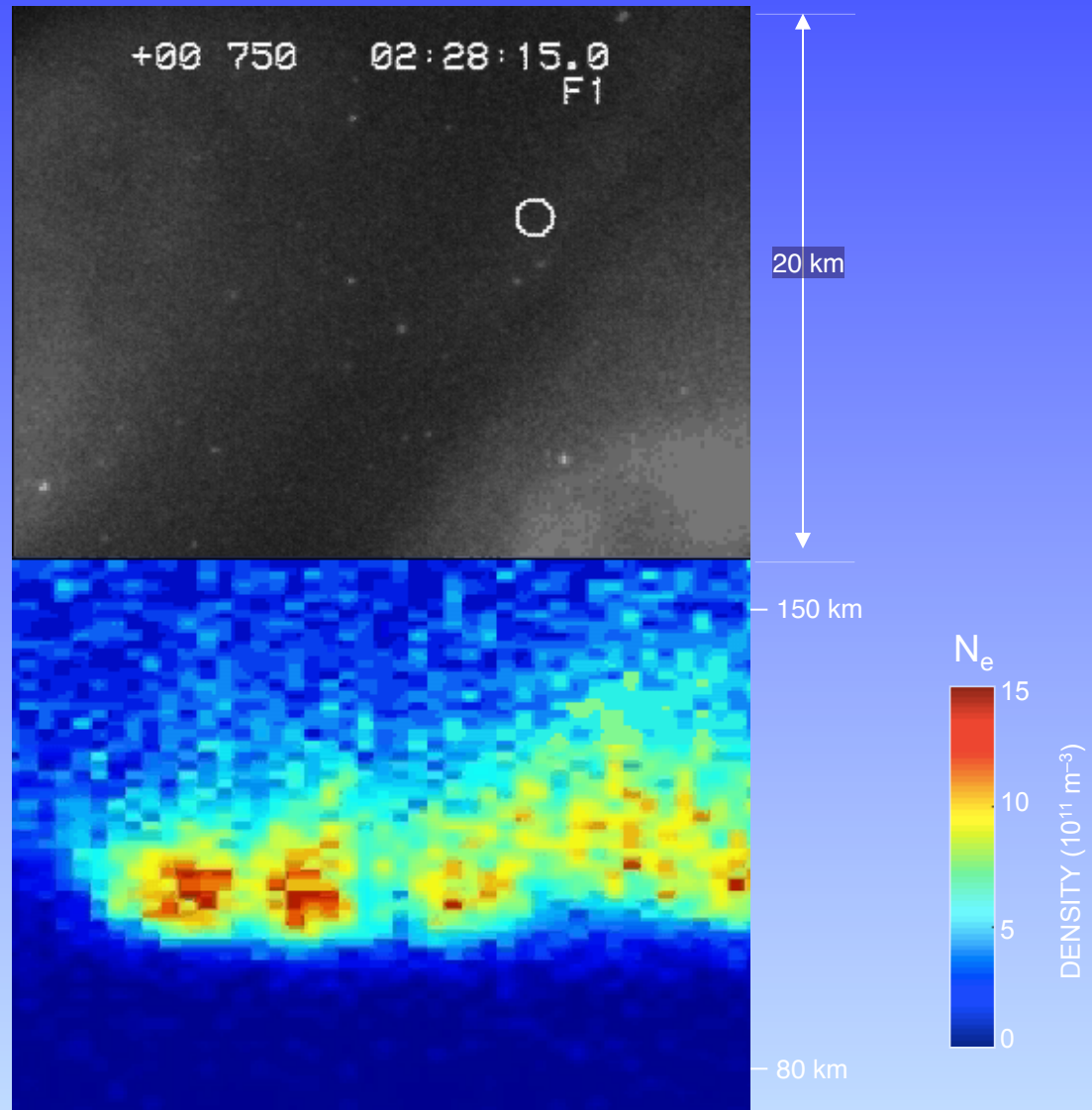


Aurorae create both visible emissions and ionization

High Speed Intensified Auroral Imaging

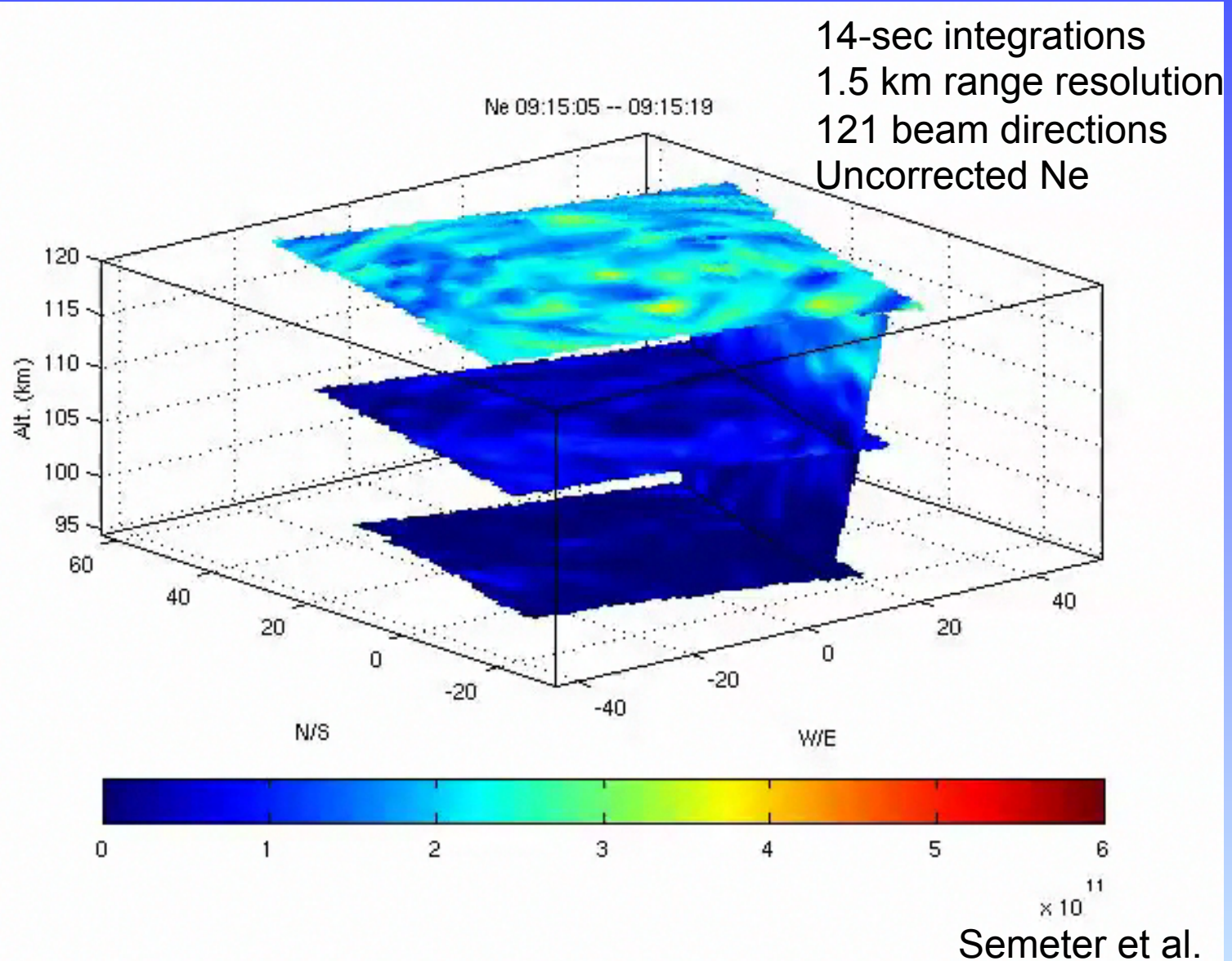
- **Narrow-field camera**
 - 25 frames/sec
 - > 640 nm
 - 21 x 26 km at 110 km
- **Sondrestrom IS radar**
 - Electron density
 - 1 km x 1.2 sec

J. Semeter





3-D radar (AMISR) view of an aurora





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EISCAT_3D Preparatory Phase

2010-2014

- EISCAT
- University of Oulu
- University of Tromsø
- Luleå University of Technology
- Rutherford Appleton Laboratory
- Swedish Institute of Space Physics
- Swedish National Infrastructure for Computing
- National Instruments
- Swedish Research Council

European Strategy Forum on
Research Infrastructures (ESFRI)
roadmap since 2008



EISCAT_3D

A European Three-Dimensional Imaging Radar for
Atmospheric and Geospace Research

ESFRI Roadmap Project



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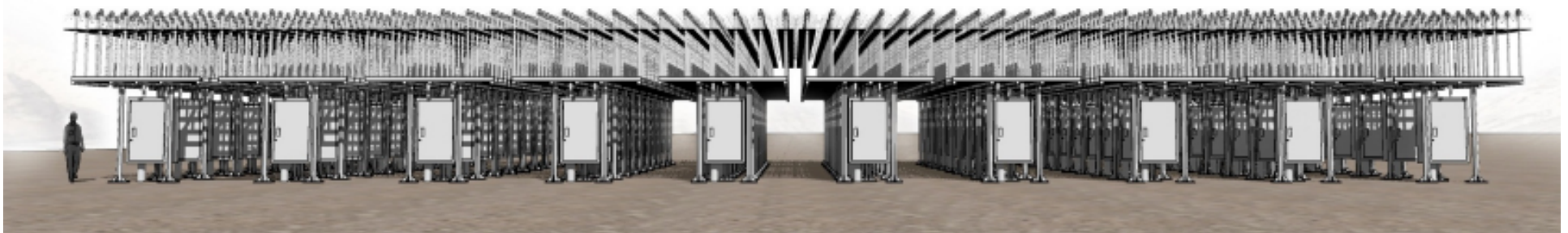
EISCAT_3D

EISCAT_3D will be a volumetric **vector**-imaging radar for studying the geospace environment

It represents a revolutionary upgrade to the existing EISCAT mainland facilities, utilizing multi-static, phased-array technologies

It will support continuous measurements of the space environment via unattended operations

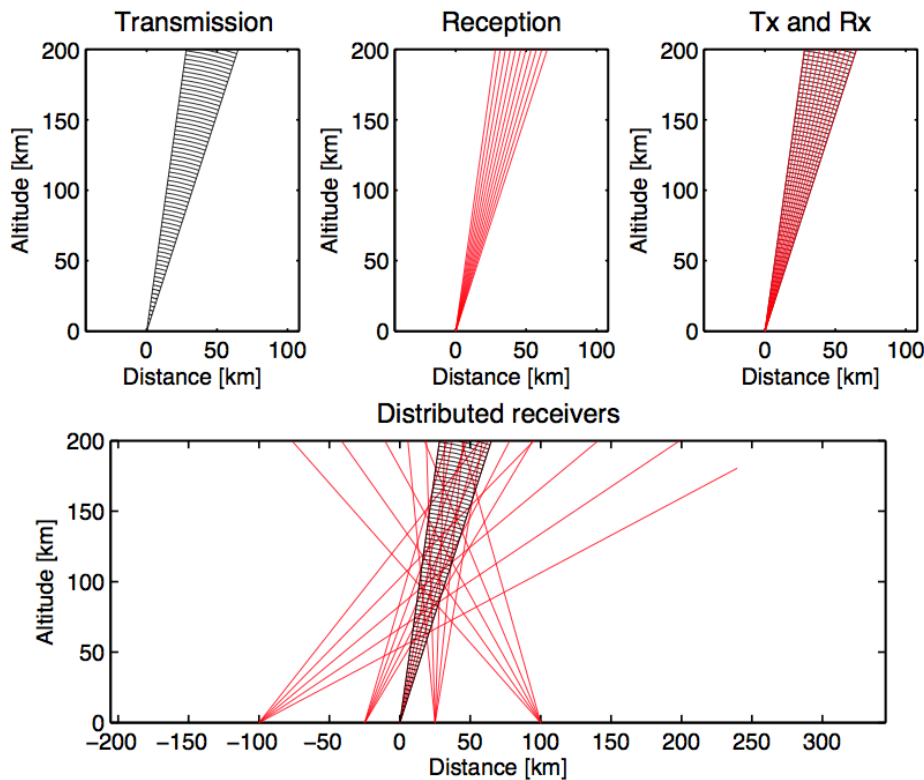
EISCAT_3D will have the sensitivity needed for ionospheric measurements at better than 100 msec time scales and 100 meter spatial scales (order of magnitude improvements over current systems)





Multistatic Phased Array

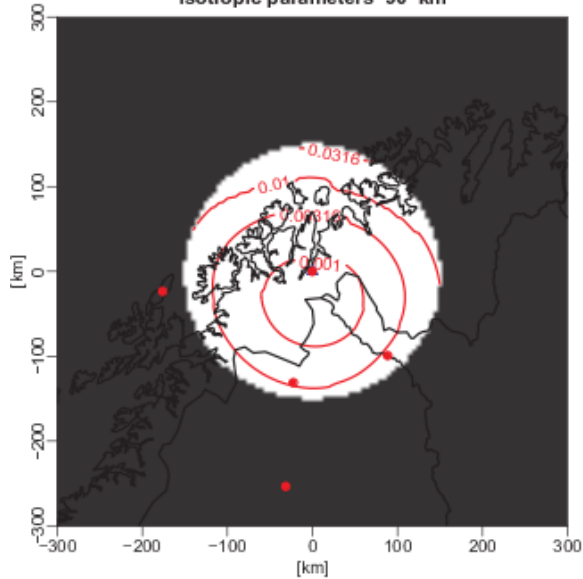
VHF: 233 MHz
Transmit Bandwidth 5 MHz
Receive Bandwidth 30 MHz
Transmit Bandwidth -> range resolution
Antenna coding -> greater sensitivity
Antenna coding -> beam shape changes



Synchronization challenge: all sites must know what the transmitter is doing all the time

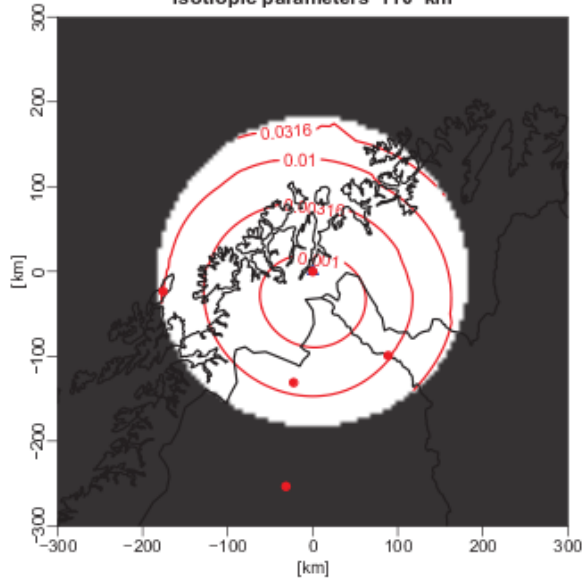
Baselines to Skibotn:	
Bergfors	133 km
Karesuvanto	127 km
Andøya	178 km
Jokkmokk	256 km

Isotropic parameters 90 km



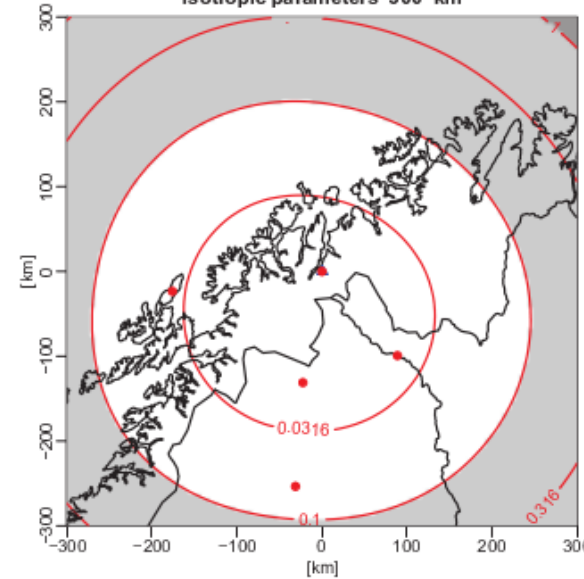
$\log_{10}(\text{integration time [s]})$

Isotropic parameters 110 km



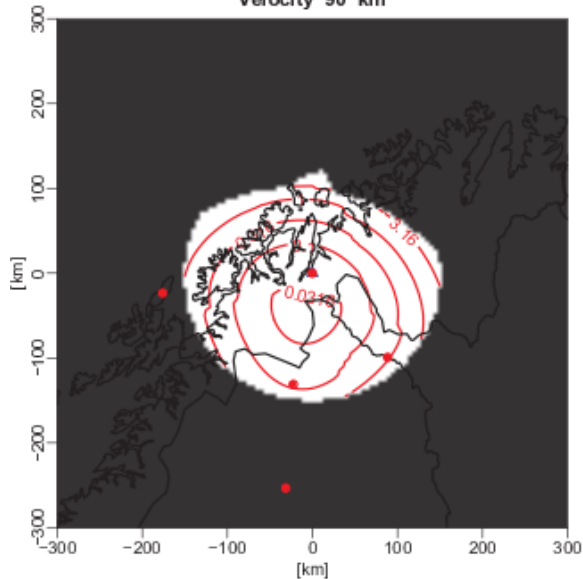
$\log_{10}(\text{integration time [s]})$

Isotropic parameters 300 km



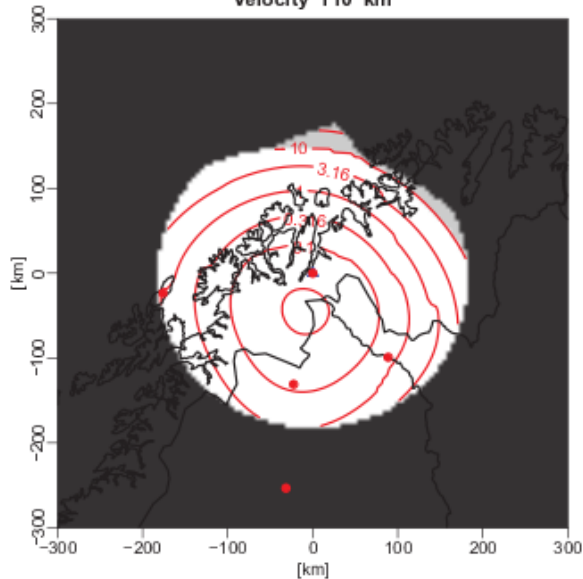
$\log_{10}(\text{integration time [s]})$

Velocity 90 km



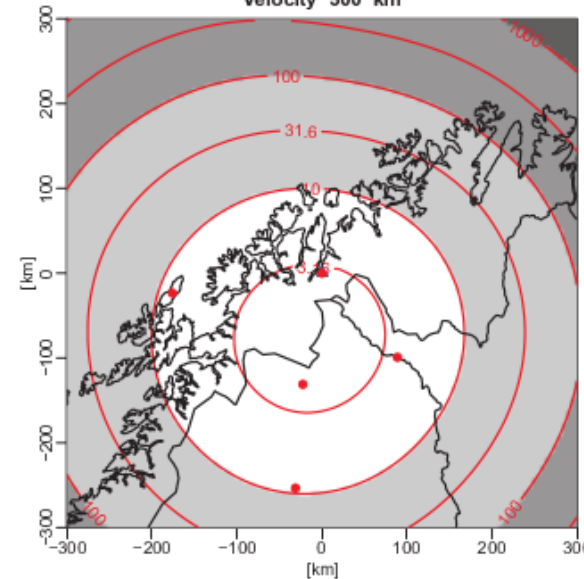
$\log_{10}(\text{integration time [s]})$

Velocity 110 km



$\log_{10}(\text{integration time [s]})$

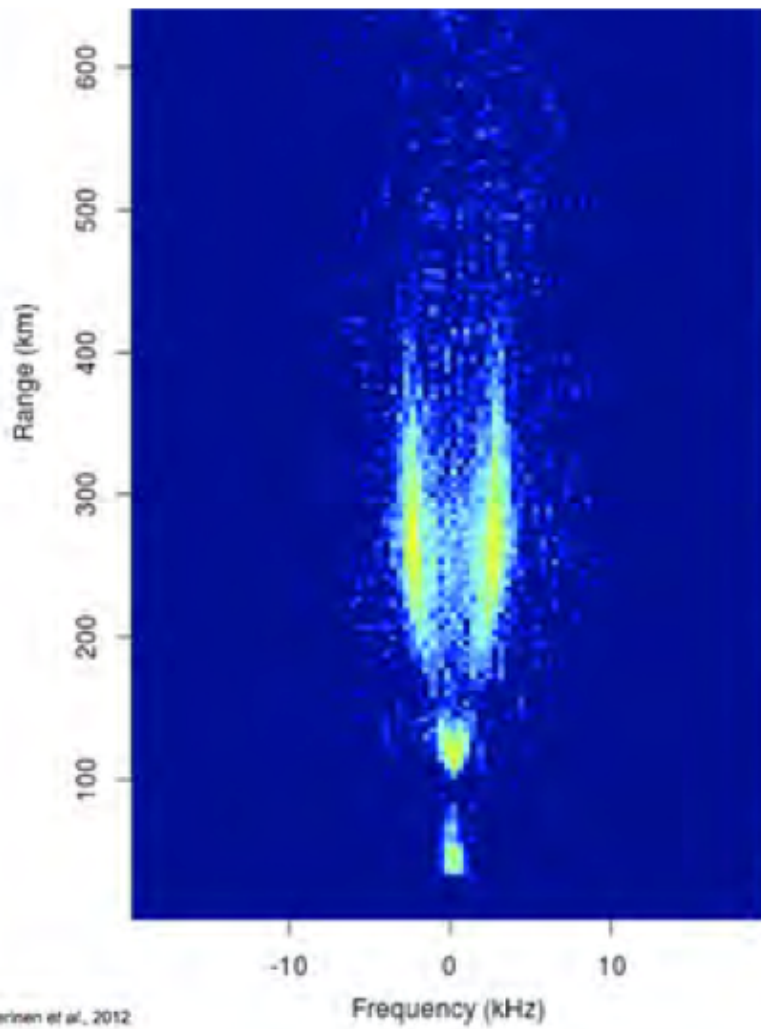
Velocity 300 km



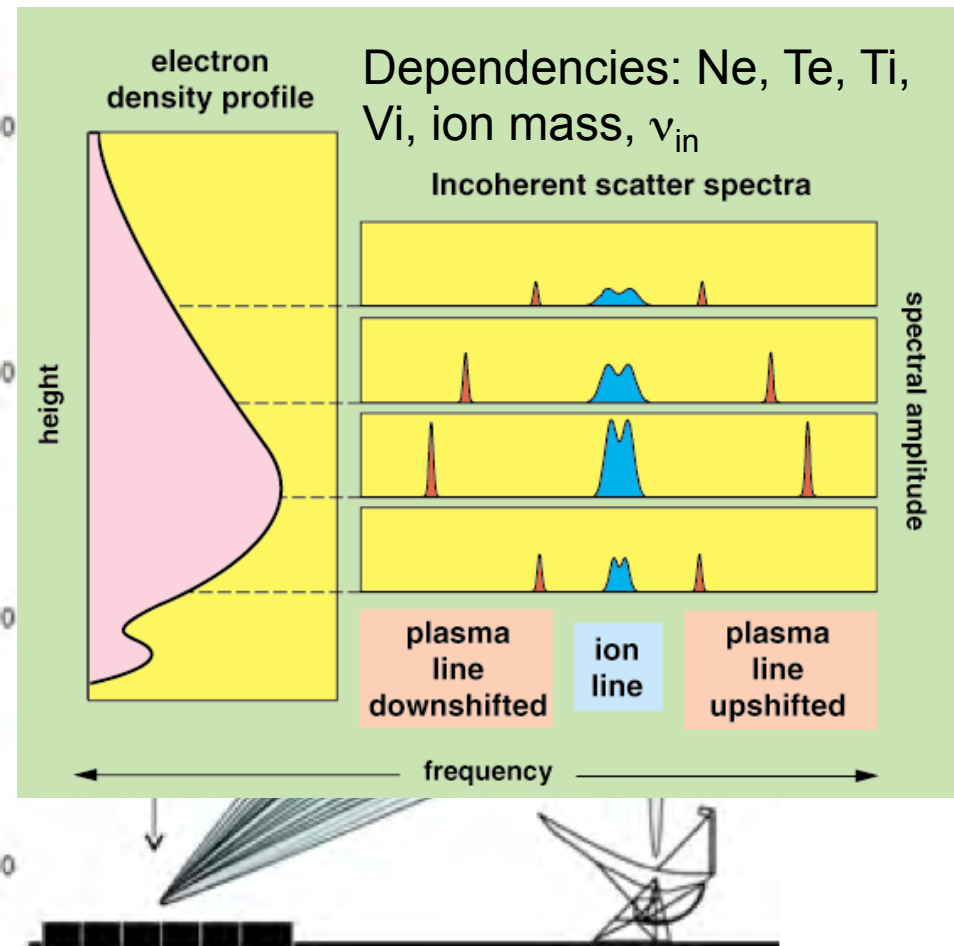
$\log_{10}(\text{integration time [s]})$



First multibeam receiver data analysis, KAIRA receiving EISCAT VHF



Verinen et al., 2012



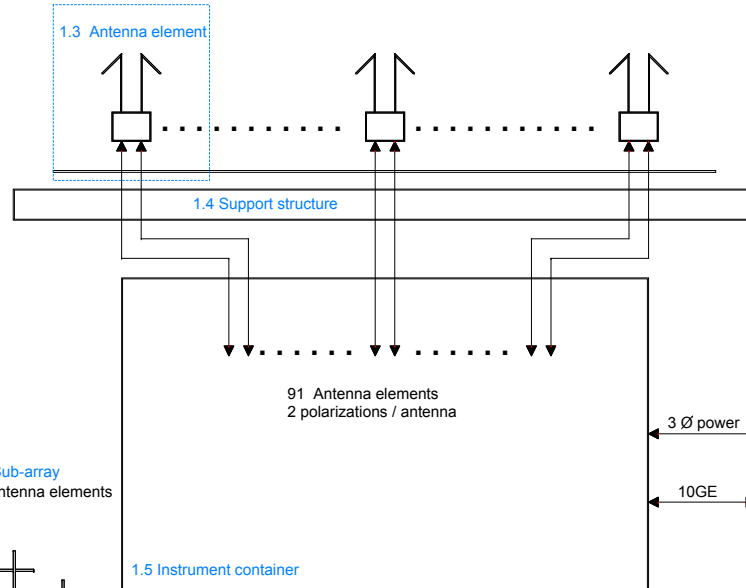
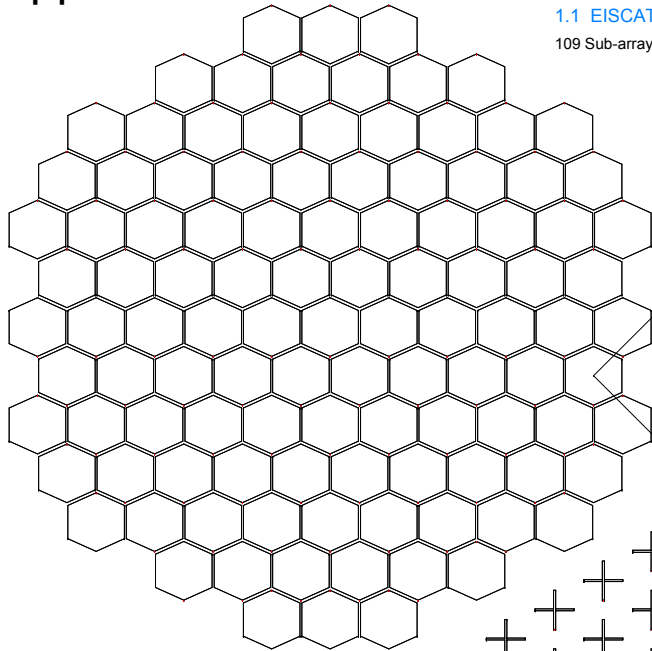
LOFAR-based: 48 HBA tiles

Vue graph from M. Lehtinen



9919 antennas per site

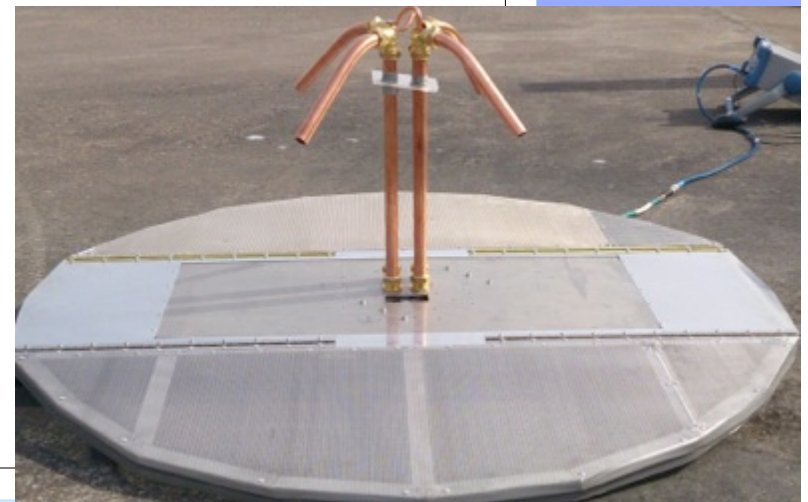
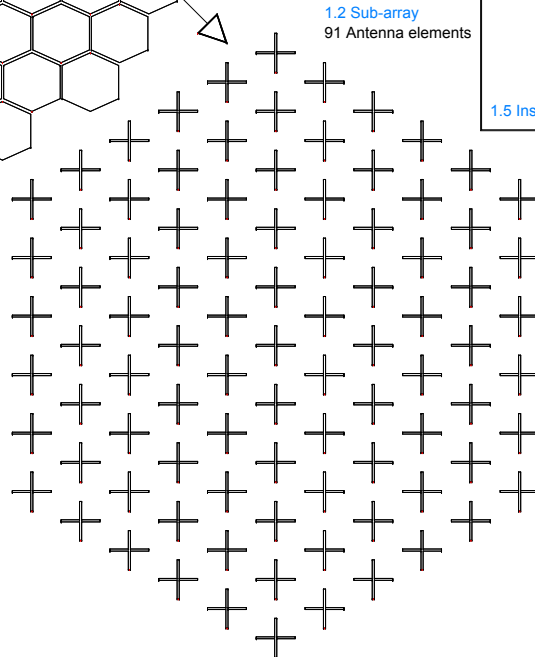
Appx 70 m diameter



Additional sub-arrays for aperture synthesis imaging

Antennas must be robust to arctic conditions over the 20+ year lifetime

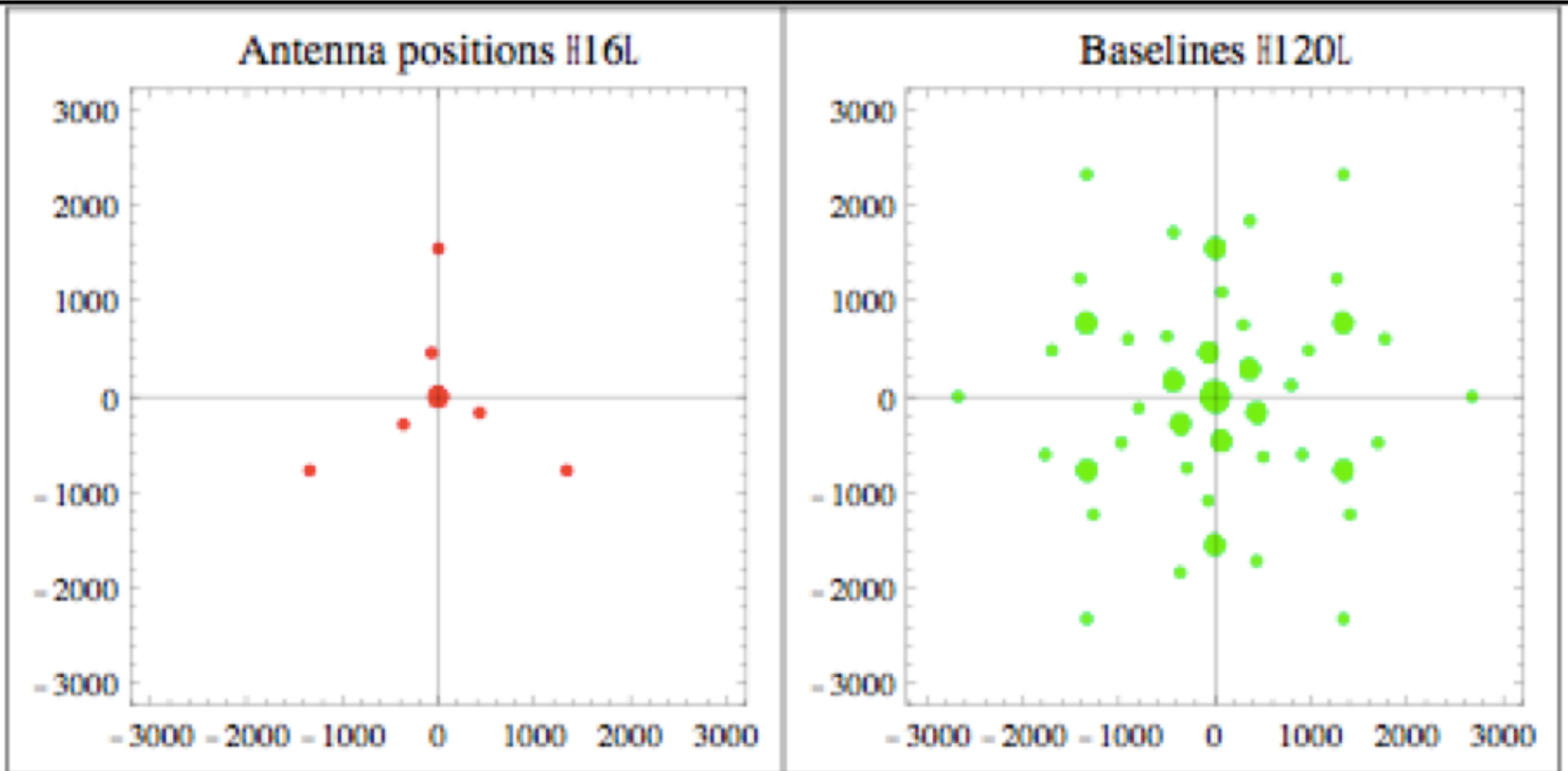
Calibration necessary for both transmit and receive





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Potential Layout for Aperture Synthesis Imaging



Unfortunately, we need to rethink the layout due to land acquisition limitations

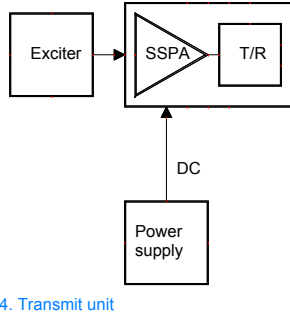
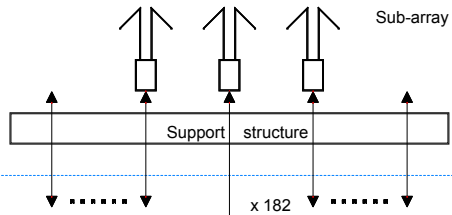


Component Modules

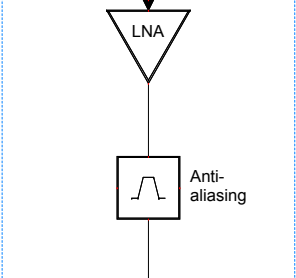
Timing:
within a site <100 ps
between sites <100 ns

1. EISCAT_3D Radar Array

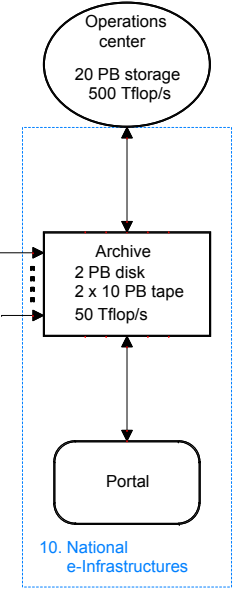
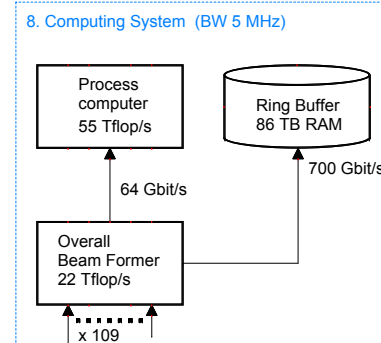
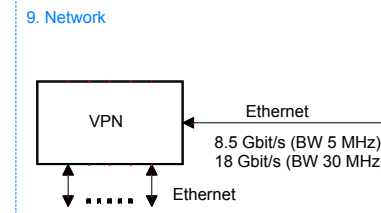
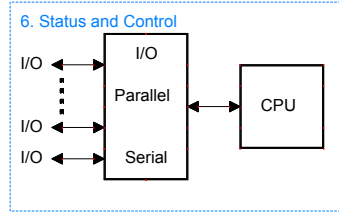
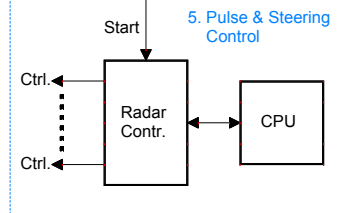
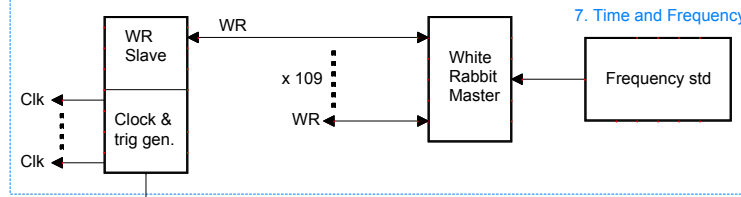
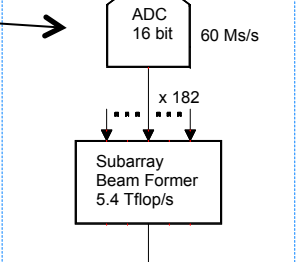
109 Sub-arrays
91 Antenna elements/Sub-array
Dual polarization, crossed dipoles
182 dipoles / Sub-array



2. Front end unit



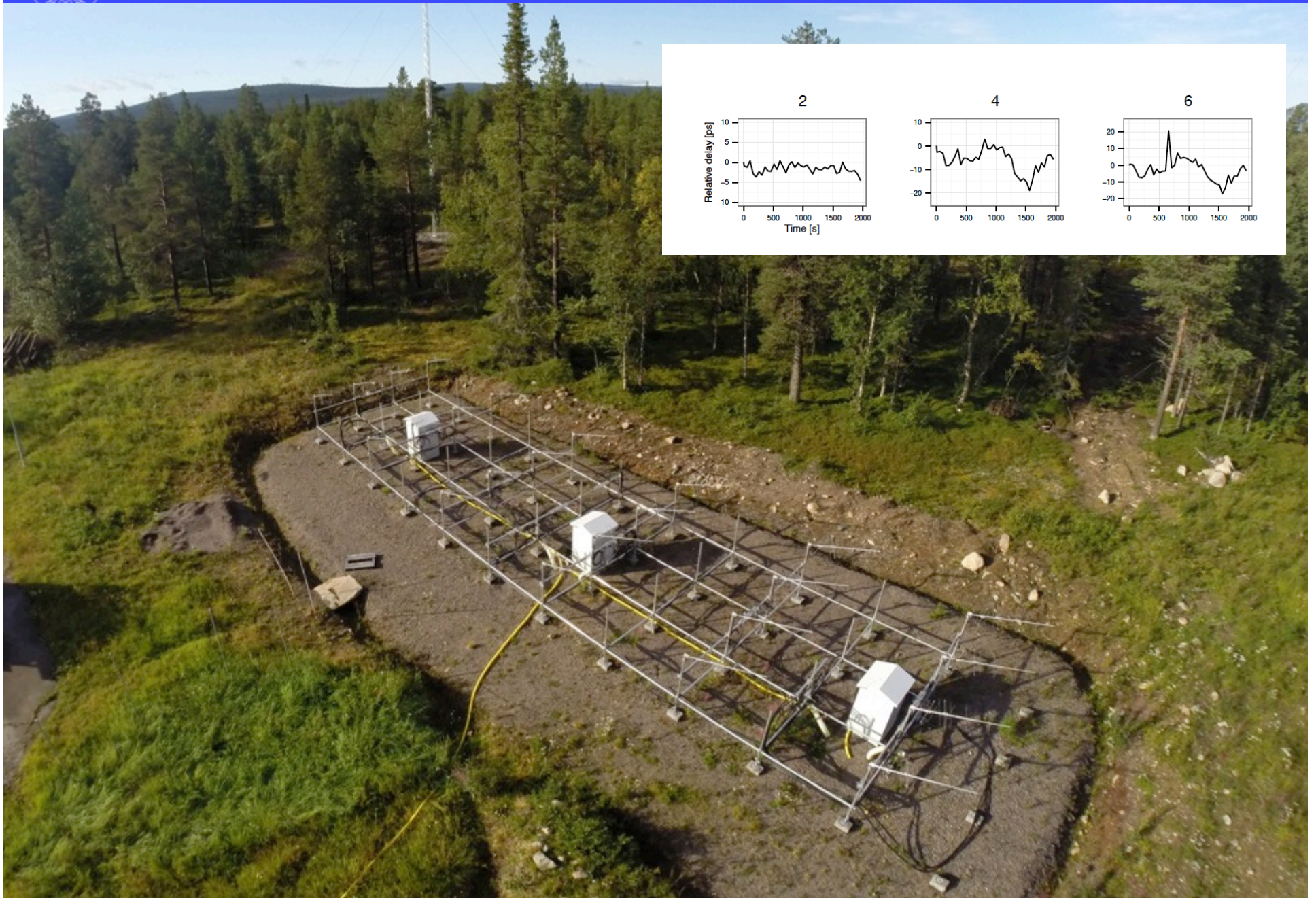
3. Sub-array Beam former (BW 30 MHz)



Bandwidth is modest but dynamic range critical, agc not possible

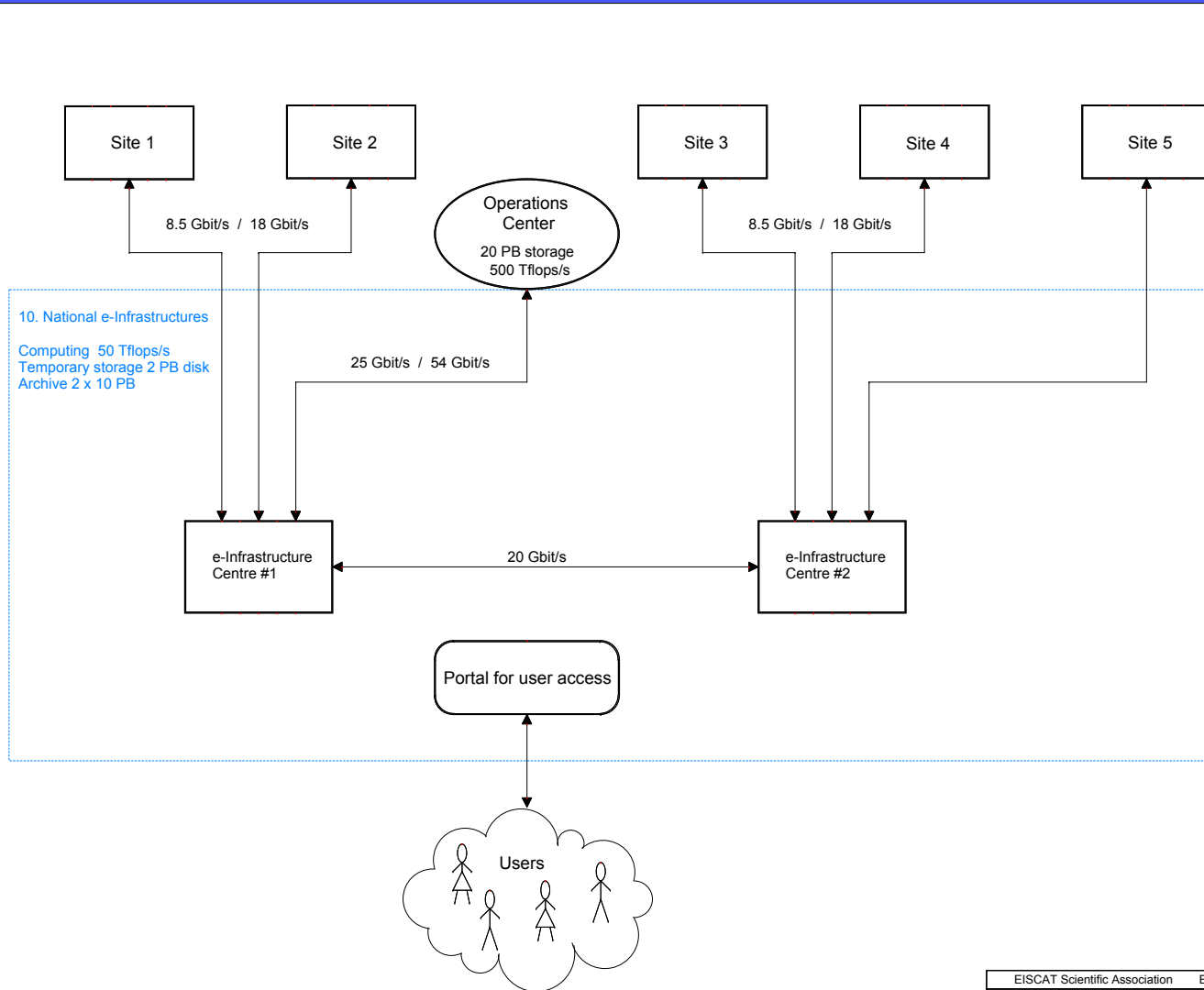
6.3 Gbit/s (BW 5 MHz)
38 Gbit/s (BW 30 MHz)

EISCAT Scientific Association		EISCAT_3D project	
File: EISCAT_3D Block diagram 0. top level			
Size: 421x298	Document Number: ver. 2014-02-20	Rev	
Date: Thursday, February 20, 2014	Sheet: 0	of 10	





EISCAT_3D



EISCAT Scientific Association		EISCAT_3D project	
10. National e-Infrastructures			
Size	Document Number	ver.	Rev
4168294		2014-02-20	
Date:	Thursday, February 20, 2014	Sheet	10 of 10



Network/Data Challenges

Planned EISCAT 3D sites are located in “remote” locations (except for Andøya). They have been chosen near internet infrastructure, but very wide bandwidths are not in the cards.

The networking needs include both bandwidth (for data transfer) and latency (for synchronized control) constraints.

Shipping out data from sites should ideally be done as early as possible in the processing. However, the amount raw data produced at each site is several orders of magnitude larger than infrastructure supports, requiring substantial on site processing (beamforming, bandwidth reduction, triggers etc.).

Realistic requirement for the first 10 years of EISCAT 3D is in the range 10-100 Gbit/s for each site (and maybe a little bit more for the connection between the storage sites, and to and from the operations center).

Data volumes should be on the order of a few PB/year, increasing over time.



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Additional News and Information

www.eiscat3d.se

The screenshot shows a web browser window with the URL <https://www.eiscat3d.se>. The page features a large 'EISCAT 3D' logo at the top. A navigation menu on the left lists various sections like 'EISCAT_3D', 'Description and status', 'The Science', 'The Project', 'Documents', 'The EISCAT_3D Blog', 'Appearances', 'Publicity Material', 'Press', 'News Archive', and 'External Links'. The main content area displays a news article titled 'Application for EISCAT_3D funding in Norway submitted' dated 'Thu, 2014-10-16 11:14' by 'anders'. The article text states: 'The Norwegian EISCAT community has submitted an applications for funding from the Research Council of Norway (Forskningsrådet). The application is for funding towards construction of EISCAT_3D.' Below the article is a screenshot of the Norwegian Research Council website showing a confirmation message: 'Your application has been submitted. Back to the list of existing applications.' The right sidebar contains contact information for the EISCAT Scientific Association, including a phone number (+46-980-79150), a fax number (+46-980-79159), and an email link. It also includes a search bar and a link to join the 'EISCAT_3D mailing list' with a small European Union flag logo below it.

The picture above shows a screen capture the moment after Cesar La Hoz at

This project has received



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Thank you