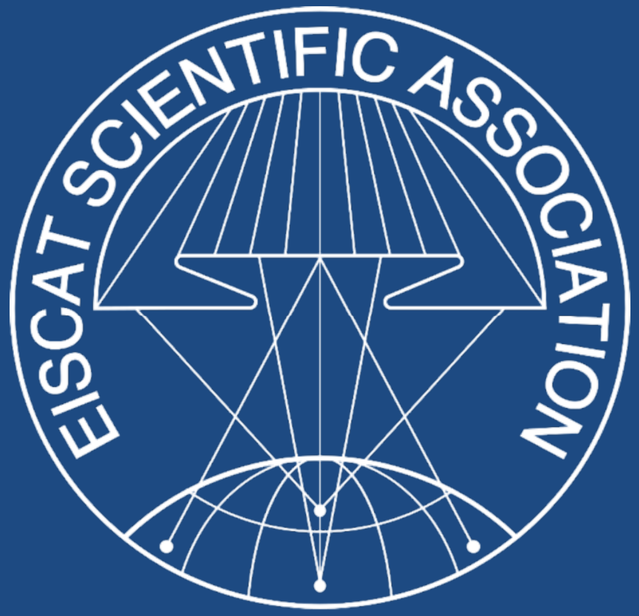


EISCAT_3D

Volumetric Phased-Array Incoherent Scatter Radar in the European Arctic

Th Ulich, I Häggström, A Steuwer, A Tjulin, C-F Enell, M Mihalikova, and the EISCAT Staff

EISCAT Scientific Association

- Founded in **1975**, first operations 1981, first Svalbard operations 1996.
- Research infrastructure for incoherent scatter radar observations of the high-latitude ionosphere & upper atmosphere.
- "The aim of the Association is to provide access to radar, and other, high-latitude facilities of the highest technical standard for non-military scientific purposes".
- User Facility (ESFRI Landmark).
- Founding Associates: France, Germany, UK, Norway, Sweden, Finland.

First EISCAT Council meeting, Kiruna, Sweden, January 1976

- Current Associates: China, Finland, Japan, Norway, Sweden, UK.
  Current Affiliates: DLR (DE), METI (USA), KOPRI (KR), KASI (KR), UKSA (UK), Neuraspace (PT), IRA-NASU (UA).

EISCAT Mainland Radars

Sodankylä and Kiruna

Photo: Thomas Ulich, Feb 2024.

Photo: Thomas Ulich, Oct 2023.

Last chance to see…

EISCAT Svalbard Radar

- 32m Antenna:
  new motor and gearbox being installed,
  antenna cannot yet be moved!
- Power now from Diesel
- Mine7: still planned to be close in 2 years,
  challenge regarding road & electricity

Baddeley *et al.*
Progress in Earth and Planetary Science (2023) 10:53
https://doi.org/10.1186/s40645-023-00585-9

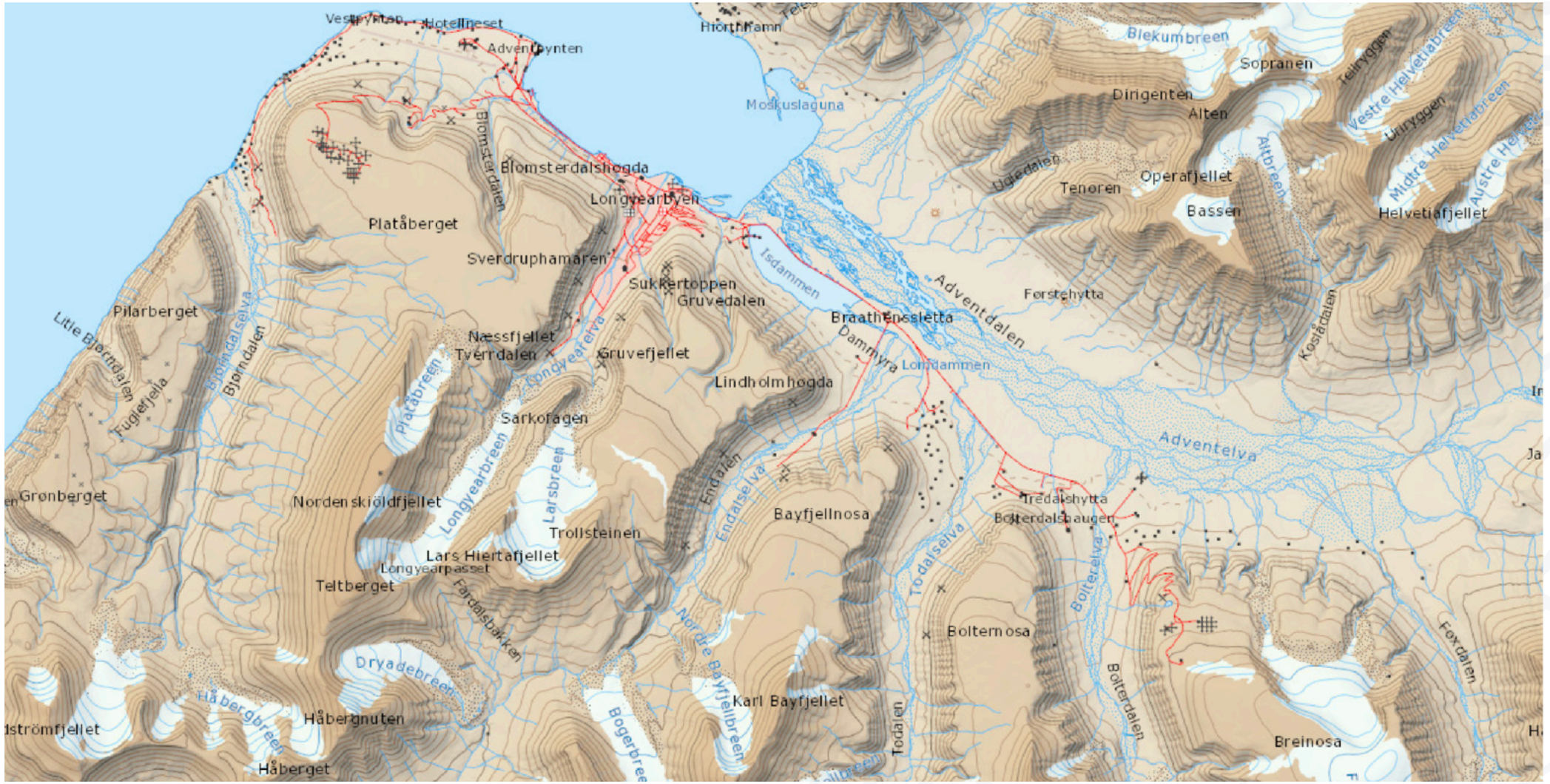
Progress in Earth and Planetary Science

REVIEW Open Access

Space and atmospheric physics on Svalbard: a case for continued incoherent scatter radar measurements under the cusp and in the polar cap boundary region

Lisa Baddeley[1,3*], Dag Lorentzen[1,3], Stein Haaland[1,3], Erkka Heino[2], Ingrid Mann[2], Wojciech Miloch[4], Kjellmar Oksavik[1,3], Noora Partamies[1,3], Andres Spicher[2] and Juha Vierinen[2]

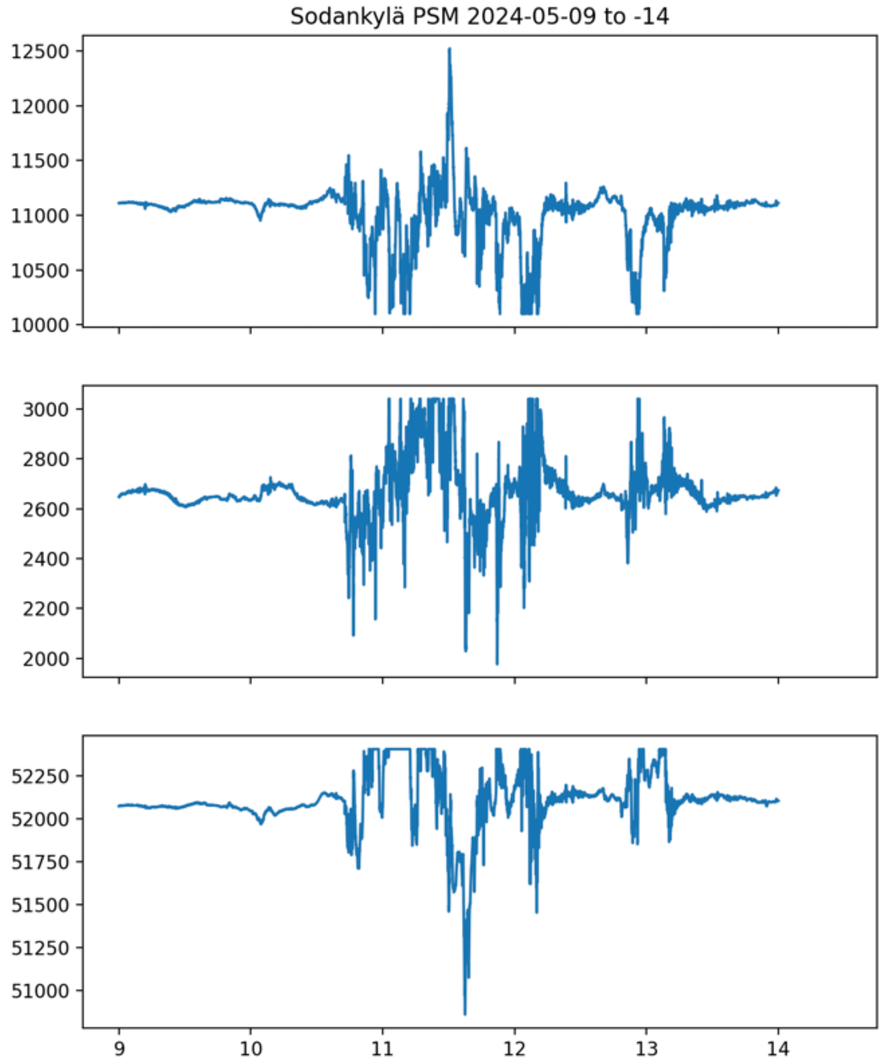
Breinosa Wind Park?

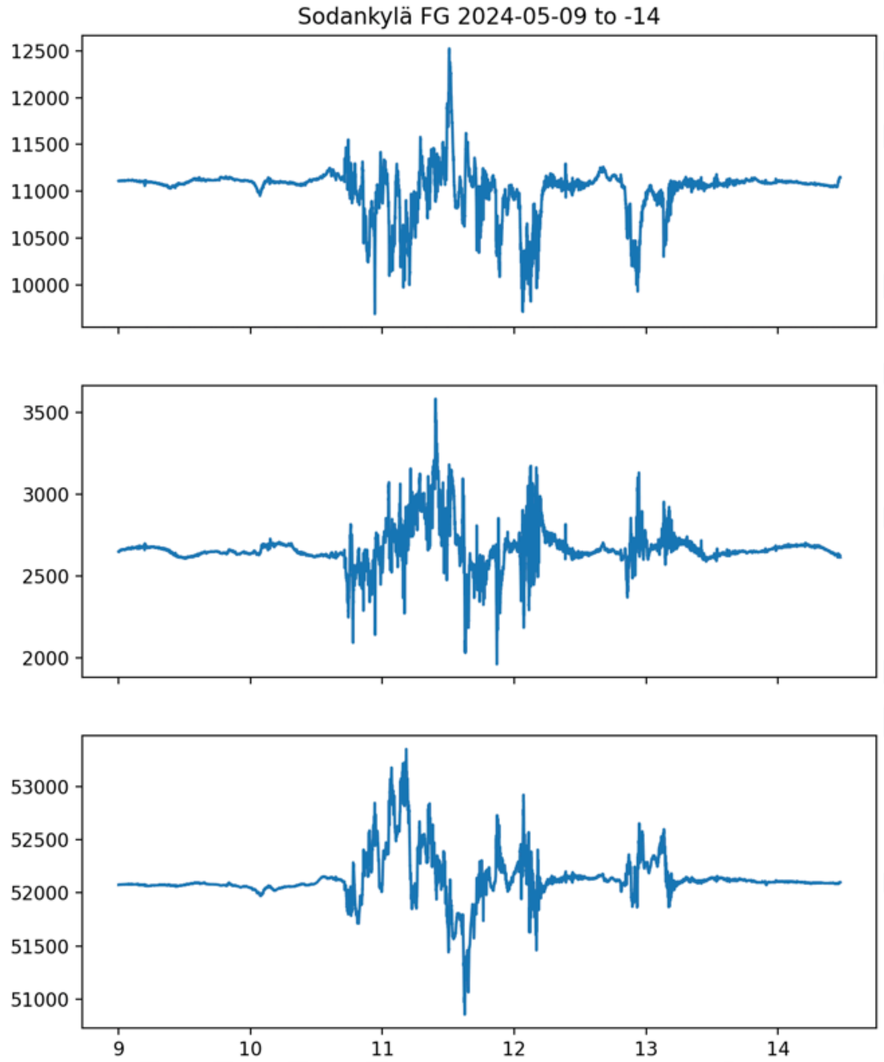


EISCAT Scientific Association

- “EISCAT AB” – See Viktoria Mattsson’s talk tomorrow at 10:00!
- New Affiliates:
  - UK Space Agency (UKSA)
  - Neuraspace

The Big Storm™



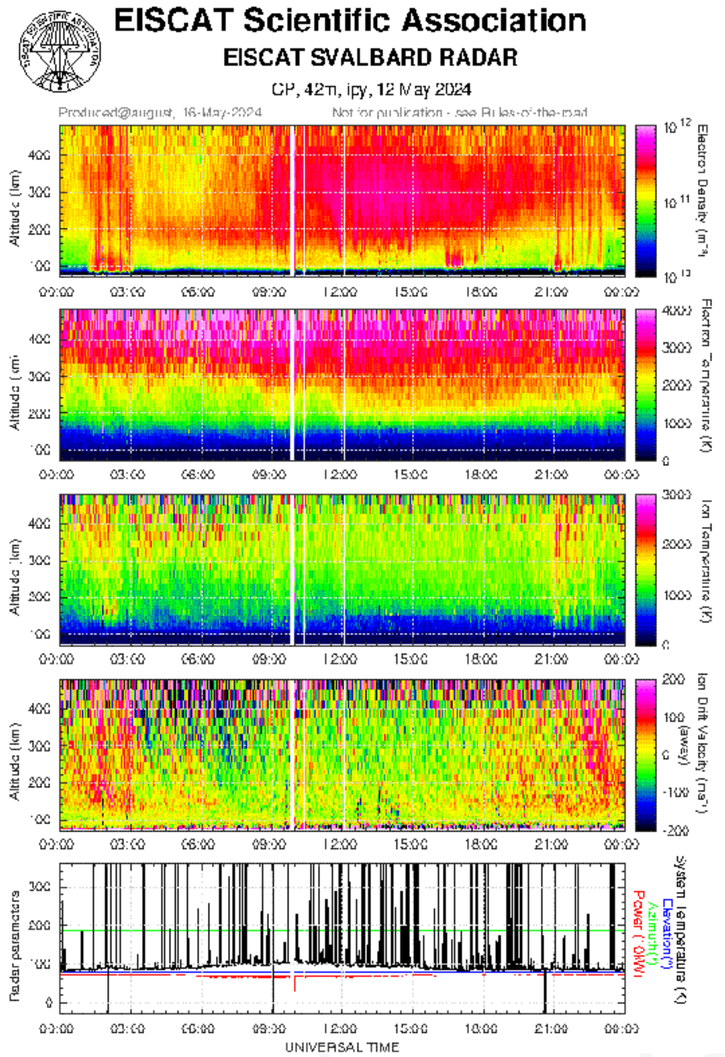


ESR and The Big Storm™

	00UT	04UT	08UT	12UT	16UT	20UT	24UT	Data archive
2024:05:06 Mon	.	.	.	.	.	.	.	
2024:05:07 Tue	.	.	.	.	.	.	.	
2024:05:08 Wed	.	.	.	.	.	.	.	
2024:05:09 Thu	.	.	.	.	.	.	.	
2024:05:10 Fri	.	.	.	.	A	A	A.	**42m** CP1 (11.0h) ipy_fixed42m_4.1l_CP
2024:05:10 Fri	.	.	.	.	A	A	A.	**32p** CP1 (11.0h) ipy_fixed42m_4.1l_CP
2024:05:11 Sat	A	A	A	A	A	A	A.	**42m** CP1 (24.0h) ipy_fixed42m_4.1l_CP
2024:05:11 Sat	A	A	A	A	A	A	A.	**32p** CP1 (24.0h) ipy_fixed42m_4.1l_CP
2024:05:12 Sun	A	A	A	A	A	A	A.	**42m** CP1 (24.0h) ipy_fixed42m_4.1l_CP
2024:05:12 Sun	A	A	A	A	A	A	A.	**32p** CP1 (24.0h) ipy_fixed42m_4.1l_CP

	00UT	04UT	08UT	12UT	16UT	20UT	24UT	Data archive
2024:05:13 Mon	A	A	A	A	A	A	A.	**42m** CP1 (24.0h) ipy_fixed42m_4.1l_CP
2024:05:13 Mon	A	A	A	A	A	A	A.	**32p** CP1 (24.0h) ipy_fixed42m_4.1l_CP
2024:05:14 Tue	A	A	A	A	A	.	.	**42m** CP1 (12.0h) ipy_fixed42m_4.1l_CP
2024:05:14 Tue	A	A	A	A	A	.	.	**32p** CP1 (12.0h) ipy_fixed42m_4.1l_CP
2024:05:15 Wed	.	.	.	.	.	.	.	
2024:05:16 Thu	.	.	.	.	.	.	.	
2024:05:17 Fri	.	.	.	.	.	.	.	

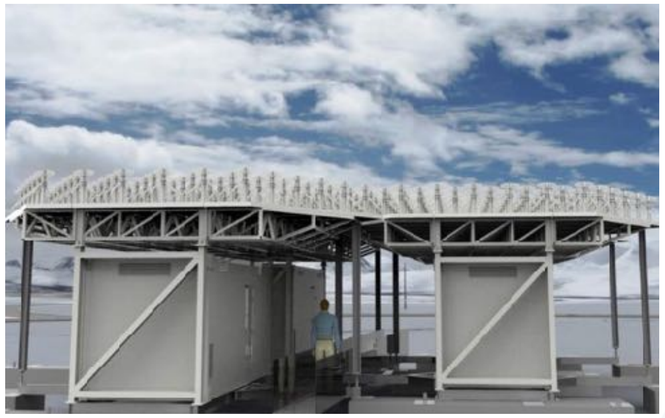
Thanks to the ESR Crew, the radar ran from Fri 10th May, 1300 UTC to Tue 14th May, 1200 UTC.

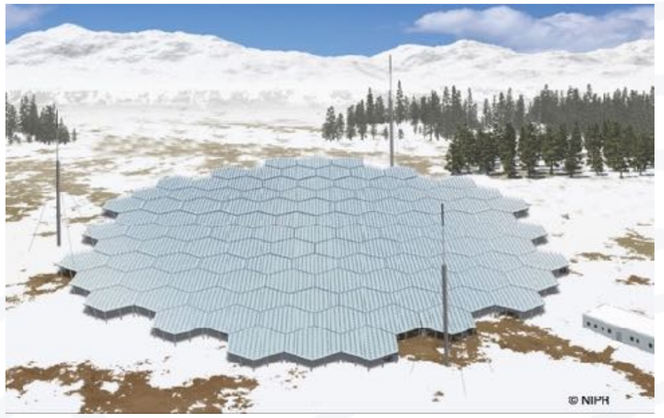


EISCAT_3D

EISCAT_3D Sites

EISCAT_3D – Phased Array Radar





An extremely versatile and largely **software-defined** instrument

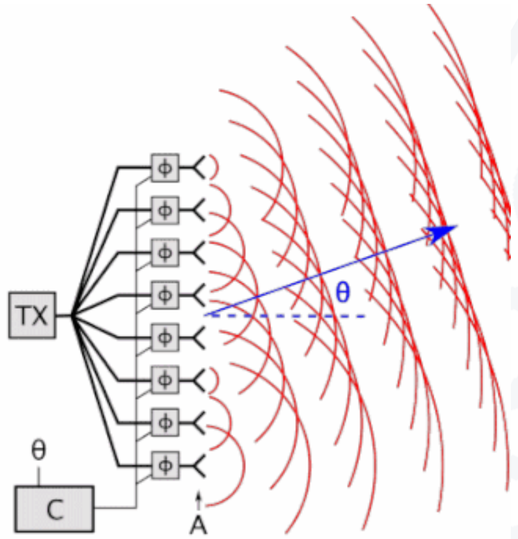
Multi-user capability

Easy expansion to new fields

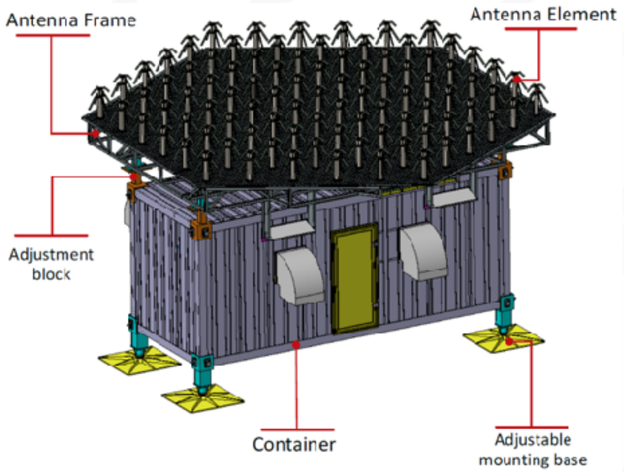
Tri-static, 3.37 MW, 233 MHz

10k (Tx/Rx) + 5k (Rx) +5k (Rx) antennas

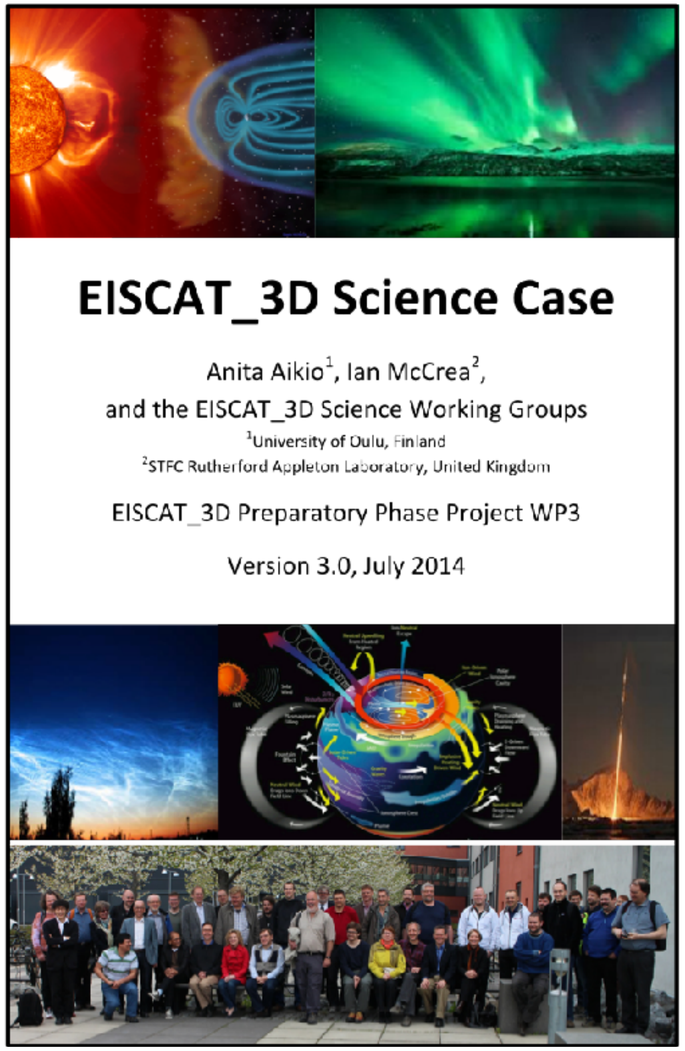
ESFRI Landmark Facility



User “Chetvorno”, Wikipedia, CC0.



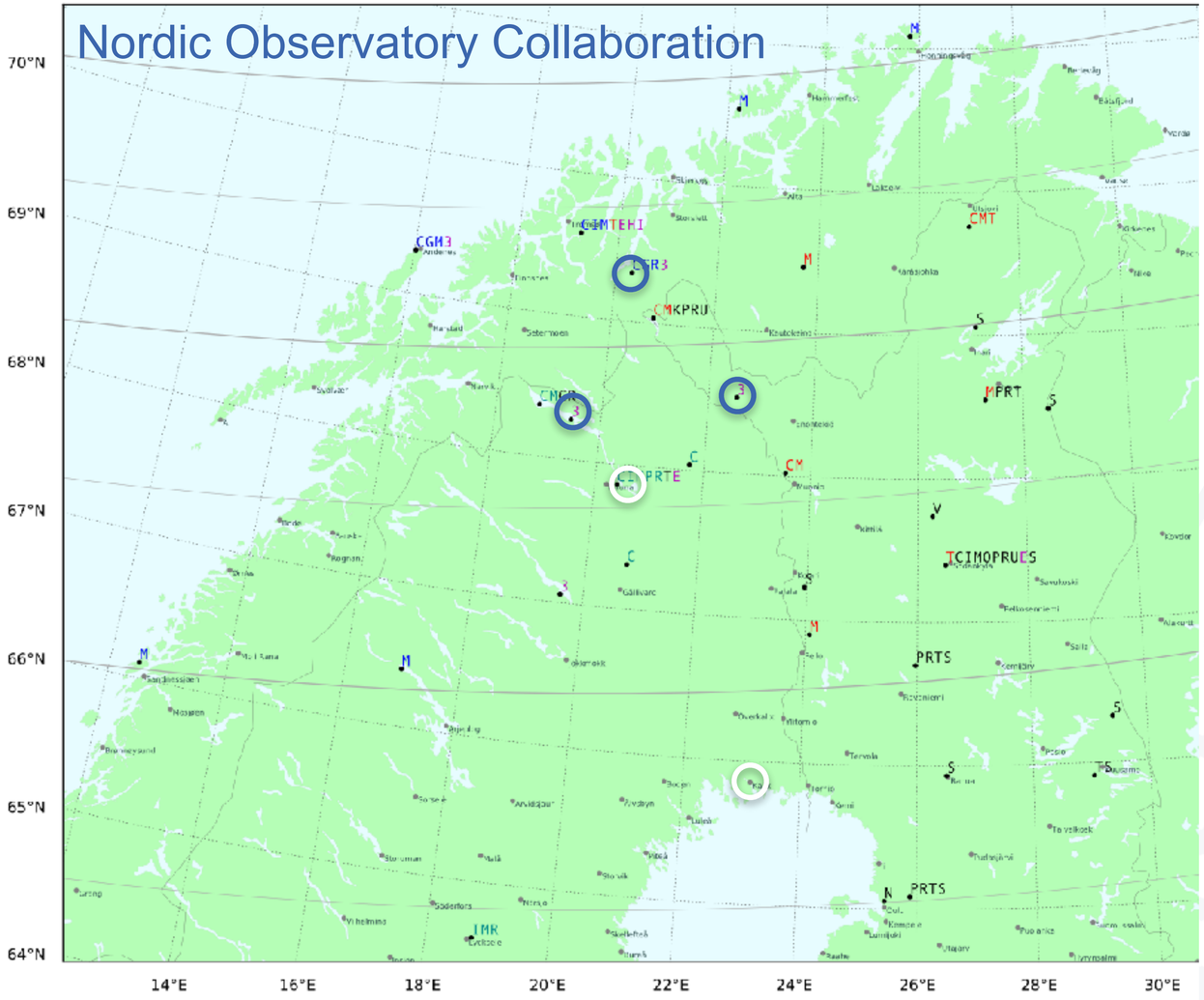
EISCAT_3D Science Case



Science Case document from Preparatory Phase:
www.eiscat.se -> EISCAT_3D -> Document Archive -> 2005-2017 -> Preparatory Phase -> WP3

Science Case as a paper:
https://doi.org/10.1186/s40645-015-0051-8

EISCAT_3D in Nordic Science Landscape



Blue circle:
EISCAT_3D site

White circle:
EISCAT HQ, Kiruna
DC Orion, Kalix

- Established 2018
- Current signatories:
  - Kiruna Atmospheric and Geophysical Observatory
  - Tromsø Geophysical Observatory
  - Sodankylä Geophysical Observatory
  - Kjell Henriksen Observatory
  - Finnish Meteorological Institute
  - Institute of Space-Earth Environmental Research (U Nagoya)
  - (Polar Geophysical Institute; collaboration on ice)

Swarm and Arase

ERG footprints near EISCAT

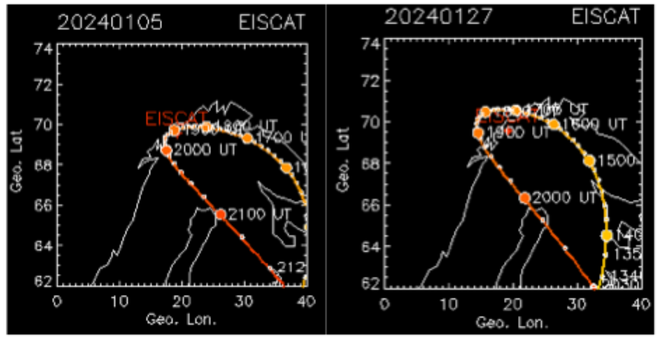
(Candidates of AA observations between Jan and Apr 2024)

- 2024-01-03 16-20 UT (Swarm B, 17 UT)
- 2024-01-05 17-21 UT (Swarm B, 18 UT)
- 2024-01-14 16-20 UT (Swarm B, 17 UT)
- 2024-01-16 16-20 UT (Swarm B, 17 UT)
- 2024-01-25 16-20 UT
- 2024-01-27 16-20 UT (Swarm B, 17 UT)
- 2024-02-05 16-20 UT
- 2024-02-07 16-20 UT
- 2024-02-16 14-18 UT
- 2024-02-18 14-18 UT (Swarm B, 15 UT)
- 2024-02-27 14-18 UT
- 2024-02-29 14-18 UT (Swarm B, 14 UT)
- 2024-03-09 13-17 UT
- 2024-03-11 13-17 UT
- 2024-03-22 12-16 UT
- 2024-04-02 12-16 UT
- 2024-04-13 11-15 UT

- Dark ionosphere in the night/dusk sides.
- Good conjunctions with Swarm satellites (14~18 UT) during the time intervals.

→ ~8 conjunctions (~32 hours) would be preferable for Arase-Swarm AA.

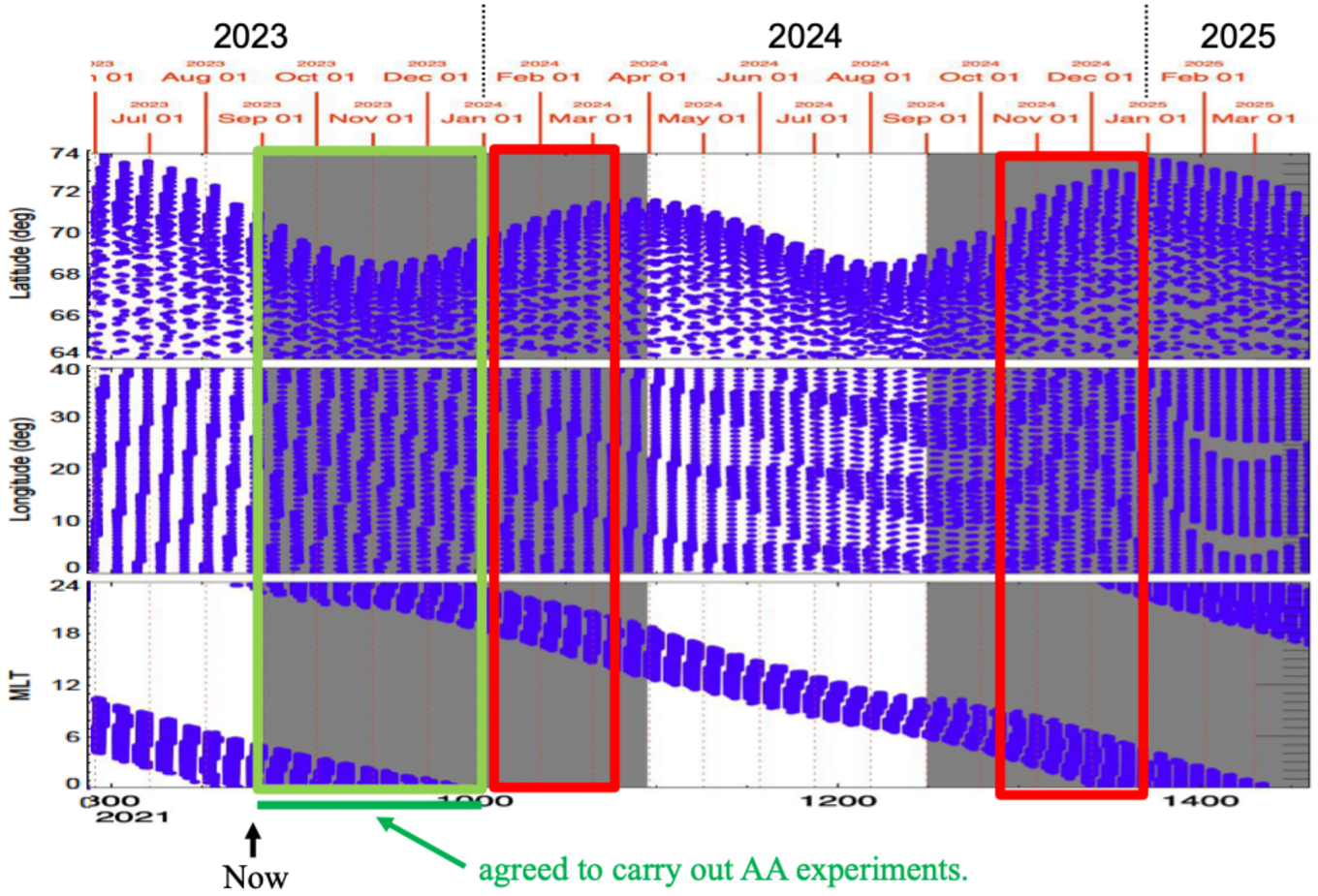
- We will have good conjunctions in the dawn side between October and December 2024 again.



Courtesy: Yasunobu Ogawa, NIPR

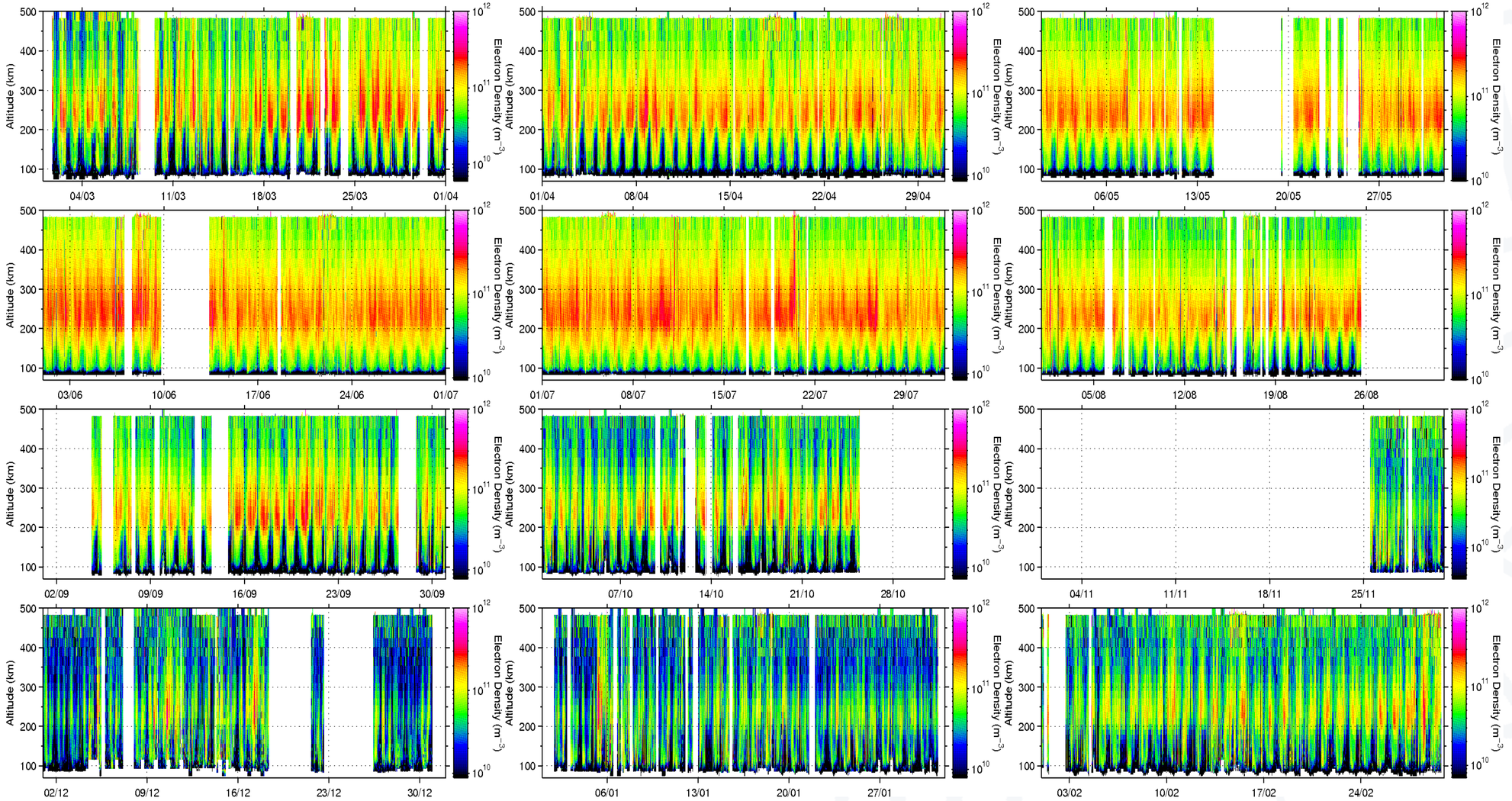
ARASE (ERG)

Prediction of ERG footprints for observations in 2023-2024



Courtesy: Yasunobu Ogawa, NIPR

Long Observations



Will be easier with EISCAT_3D – but needs special funding! – User action needed!

EISCAT Heating

Future of Heating? – Needs action from interested users!

The Sites

Skibotn, Norway

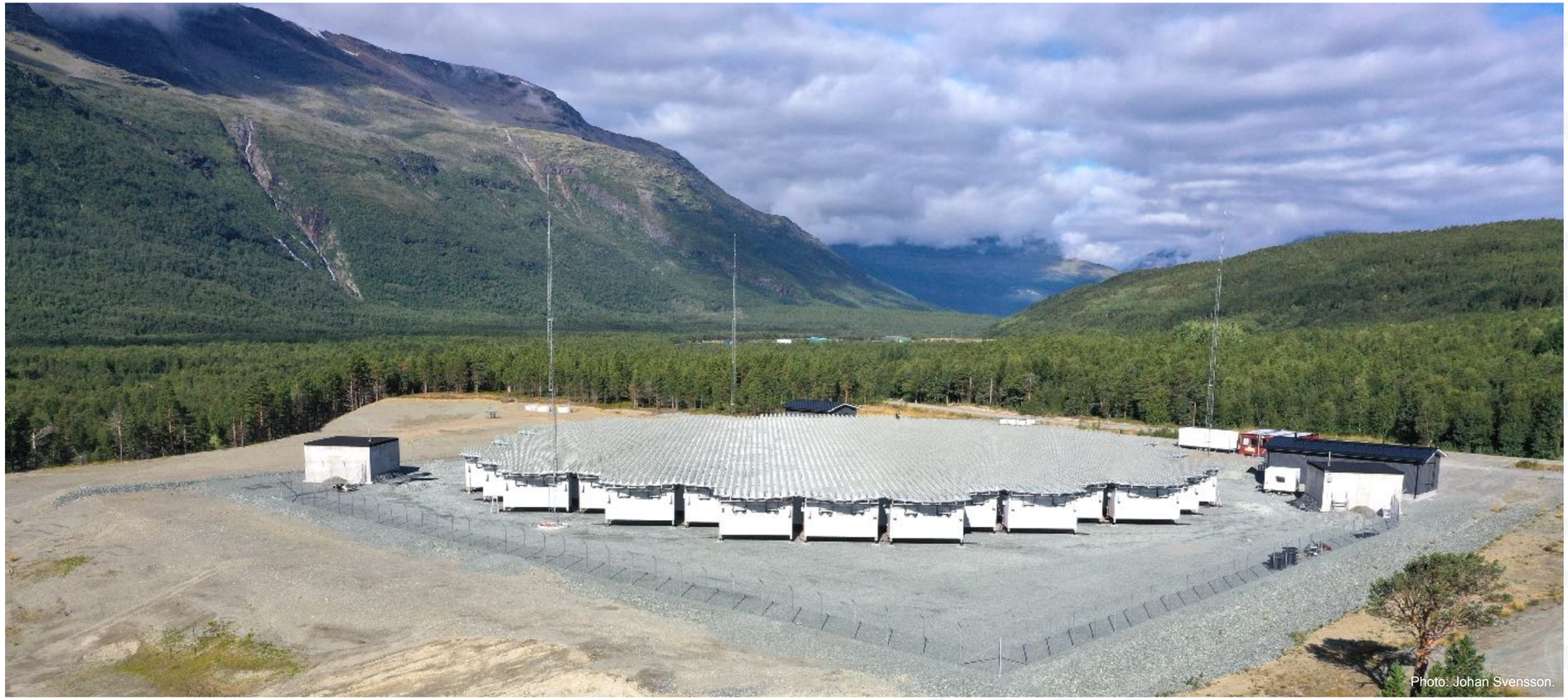


Photo: Johan Svensson.

Completed:

– All 109+10 Antenna Units are installed

– Site buildings and calibration towers completed

– Power and fibre distribution completed

– Start permit missing

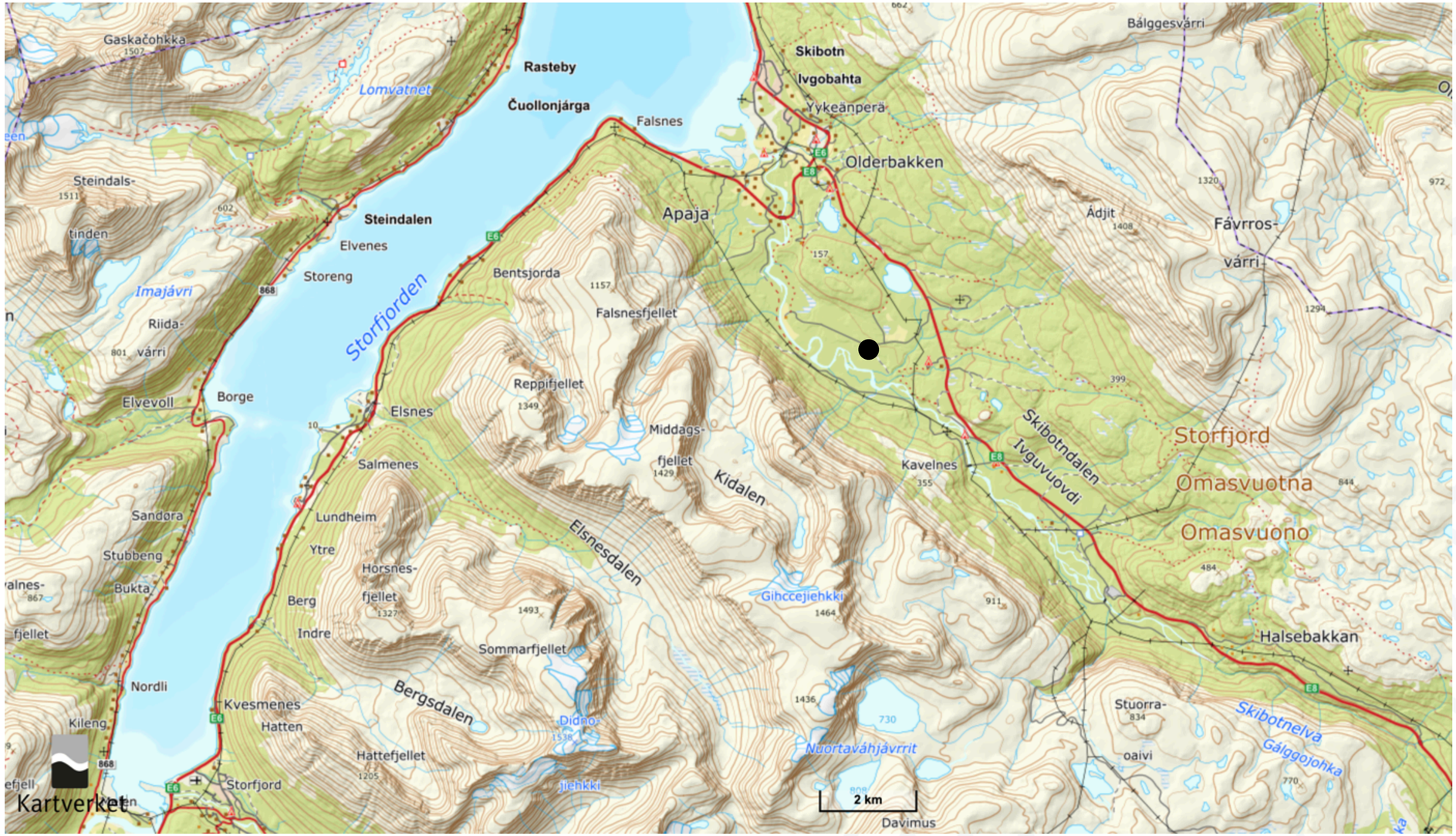
On-going:

– RF-fence detailed design. Installation starts in June.

Next steps

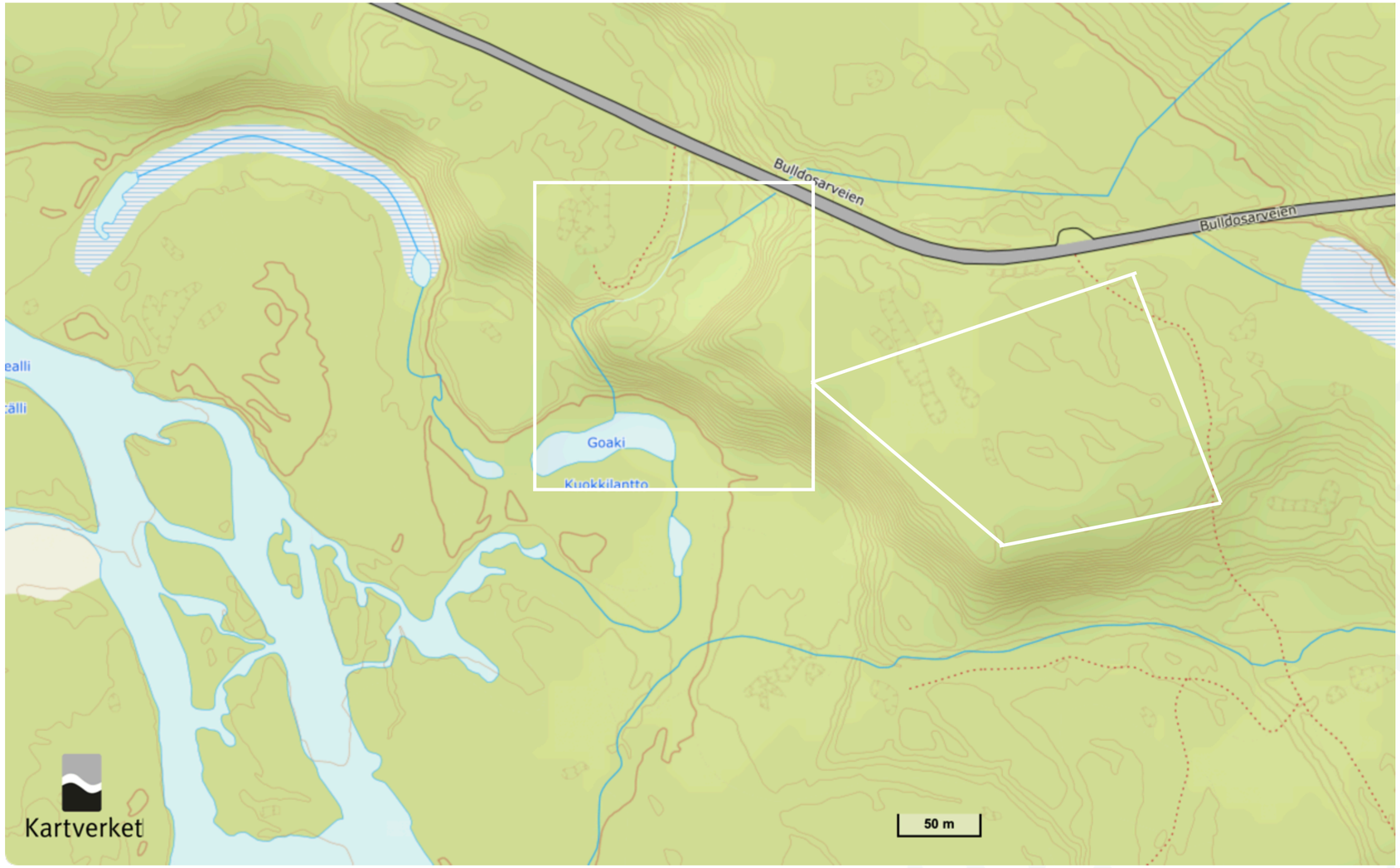
– NO-7 installation: 7 Transmit/Receive AUs, 637kW

Skibotn – Setting



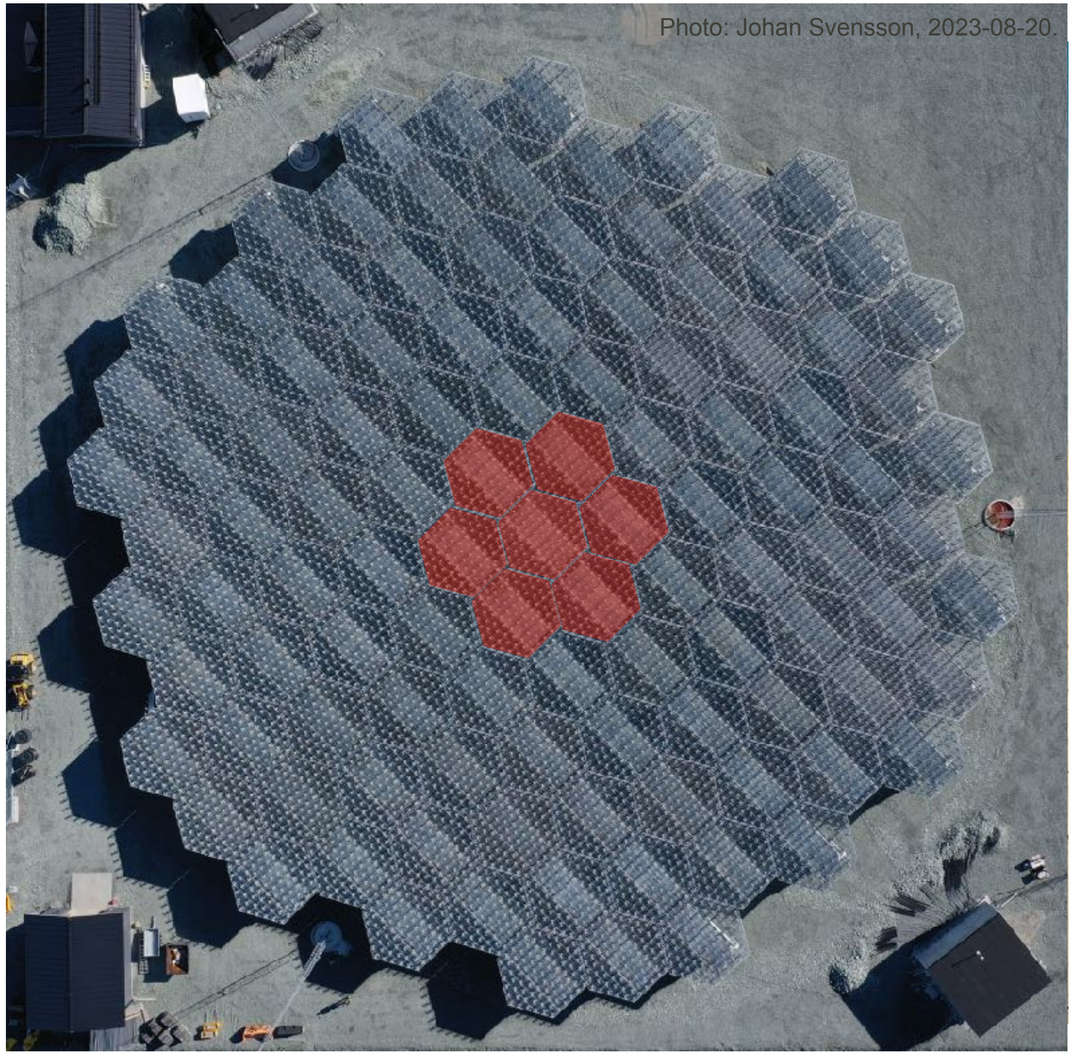
Skibotn – Area zoomed in

Skibotn – Slopes



Production, Engineering & Testing

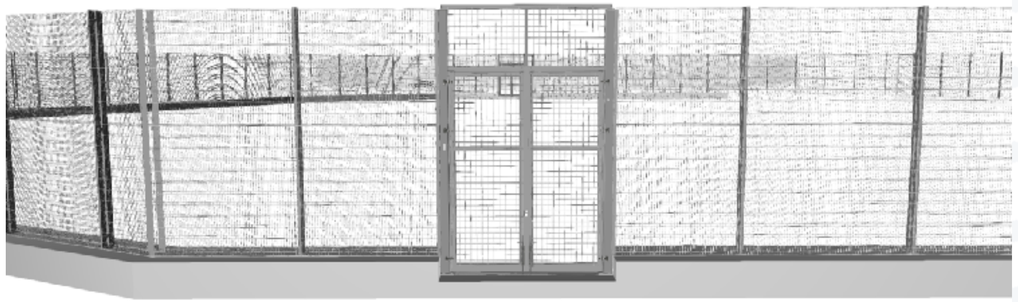
- **PET–7**:
  - 7 x 91 antennae x 2 channels
  - 500 W per channel
  - total: 637 kW
  - transmit–receive
- New code name: **NO–7**
  - Distinguish from **SE–7** and **FI–7**

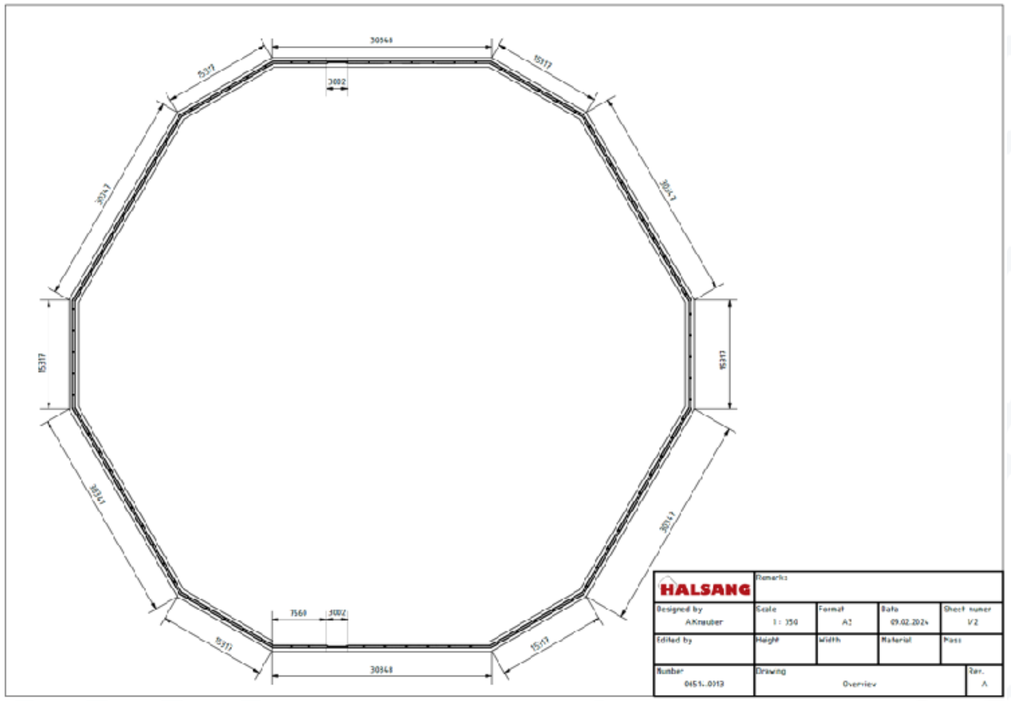


Skibotn Outrigger Receivers

RF Fence

- For personal safety – reducing field-strength levels from the MW transmitters down to secure levels.
- 5-meter-high double-fence with an approximate diameter of 87 meter that encloses the whole core antenna field in Skibotn
- Tested in CAD system





Kaiseniemi, Sweden

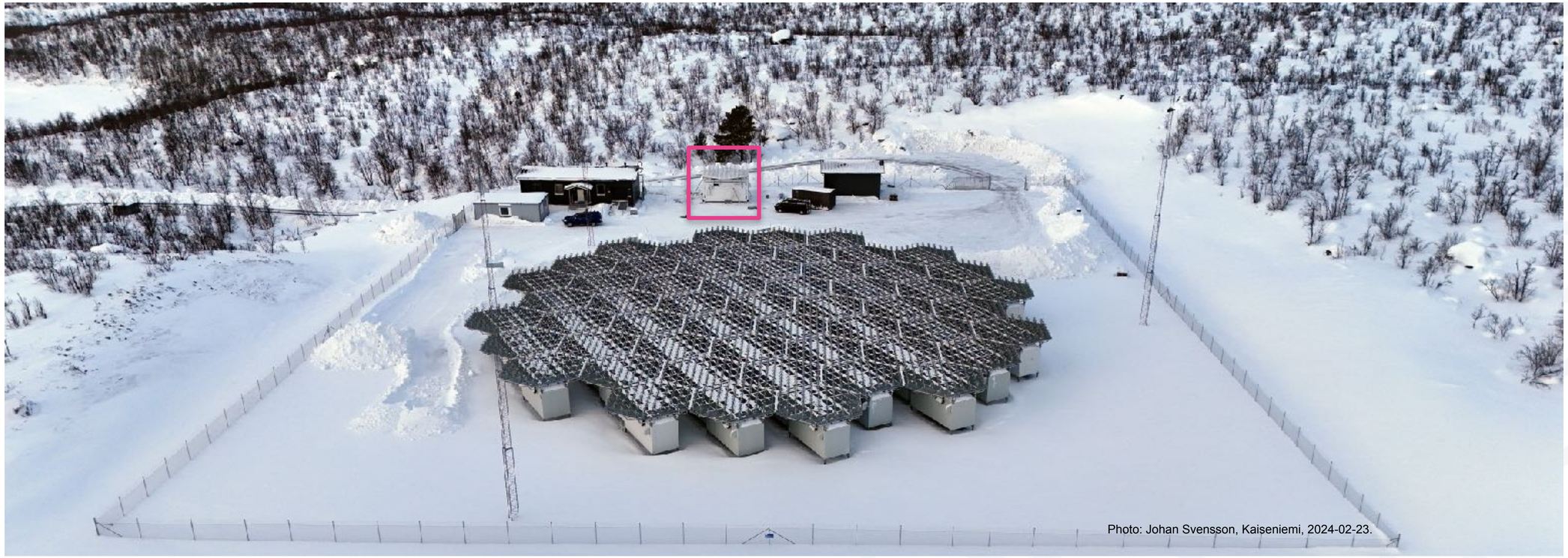


Photo: Johan Svensson, Kaiseniemi, 2024-02-23.

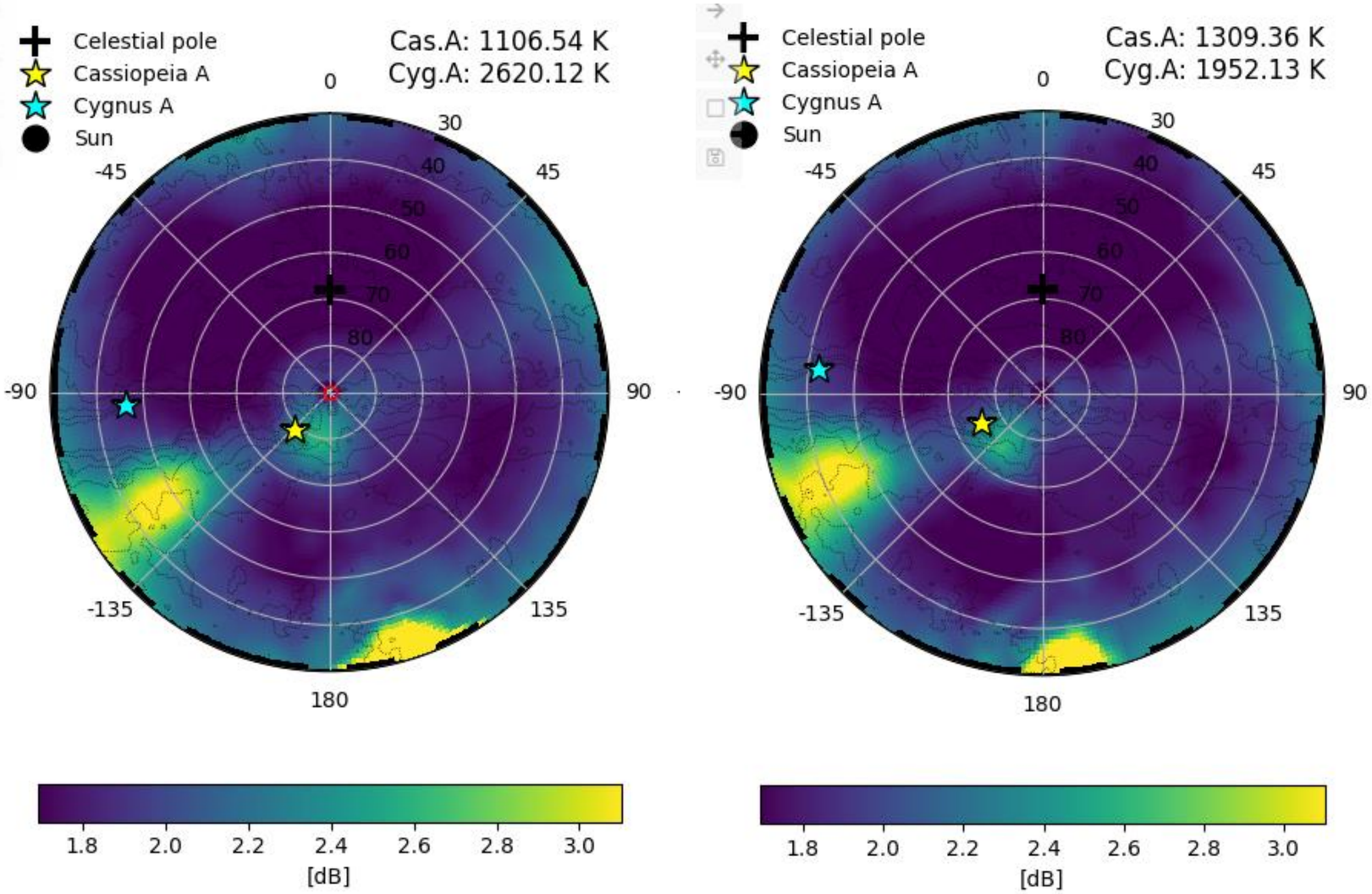
Completed:

- All 55, 54 Antenna Units (AU)
- Site buildings
- Transformer installations
- Calibration towers
- Kaiseniemi: 1 First-Stage Receiver Unit (FSRU) installed
- PET transferred from Kiruna to Kaiseniemi
- AU power and fibre connections

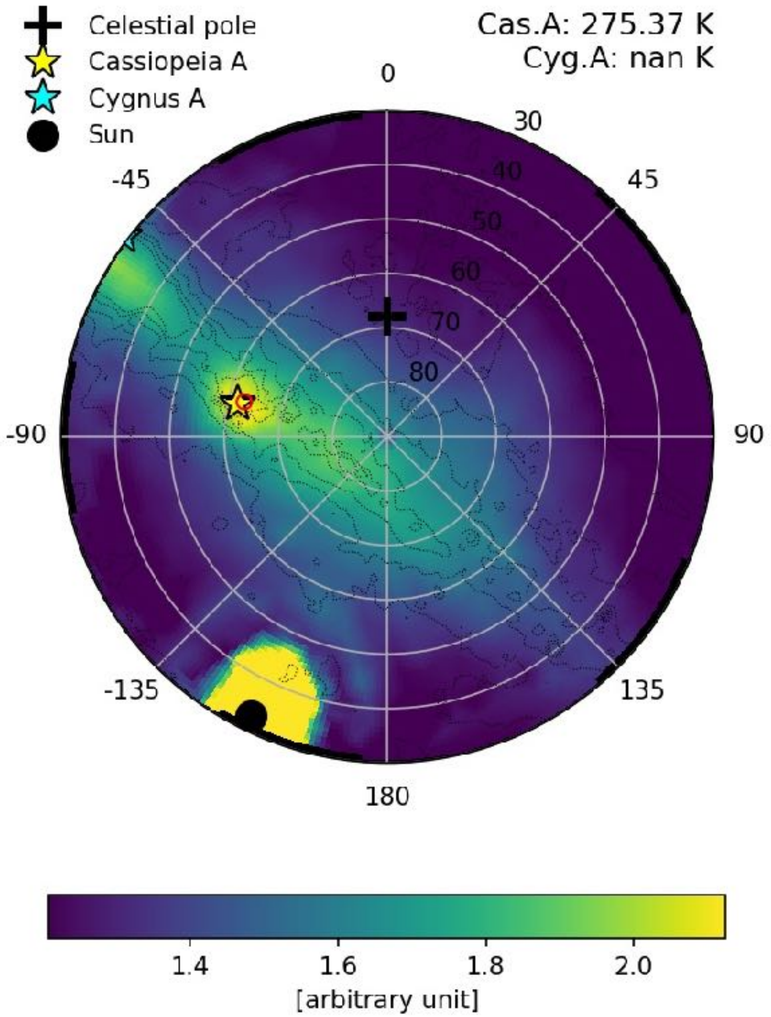
Next:

- Local SE–7 receiver configuration
- Installation of First-Stage Receiver Units (FSRUs; on-going)

PET Skymap 2024-03-19



SE–2 Skymap 2024-04-23



Karesuvanto, Finland

Photo: Th.Ulich, 2023-10-06.

Karesuvanto

Photo: Thomas Ulich, Karesuvanto, 2023-05-15.

Photo: Thomas Ulich, Karesuvanto, 2023-10-06.

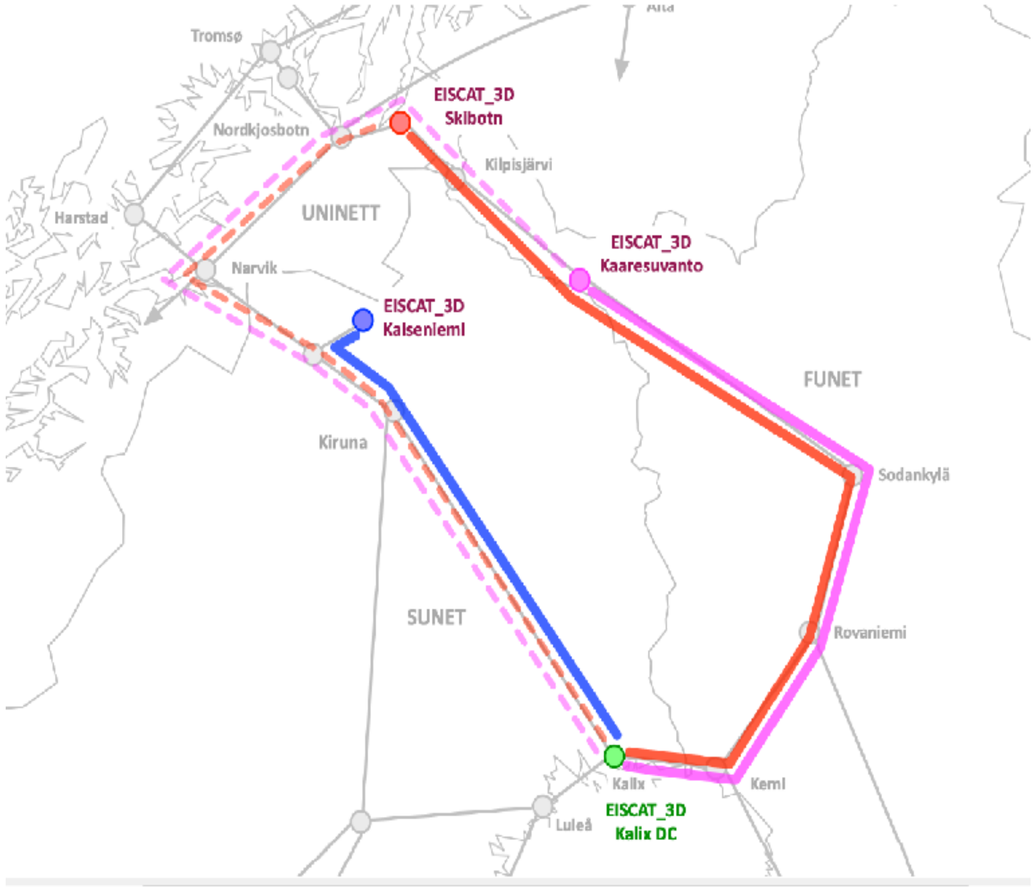
Open Doors Event: 2024-05-30

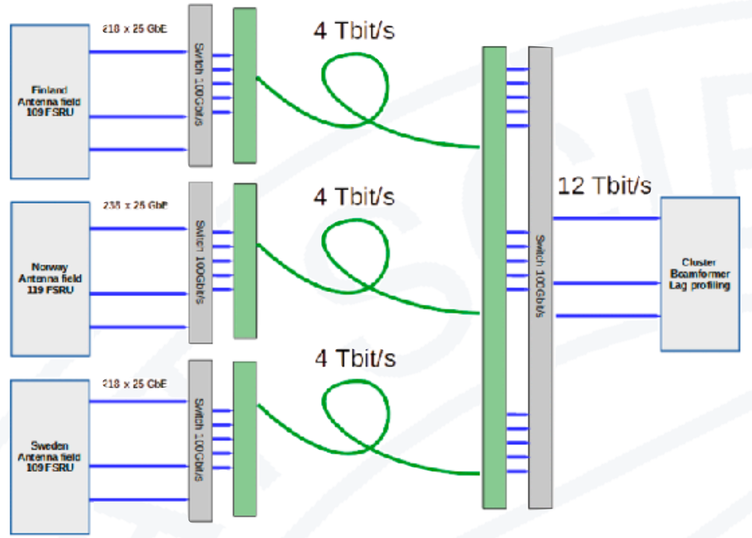
We are on Google Earth!

Kaiseniemi, Sweden, Google Earth, 2023-08-26

Karesuvanto, Finland, Google Earth, 2023-06-30

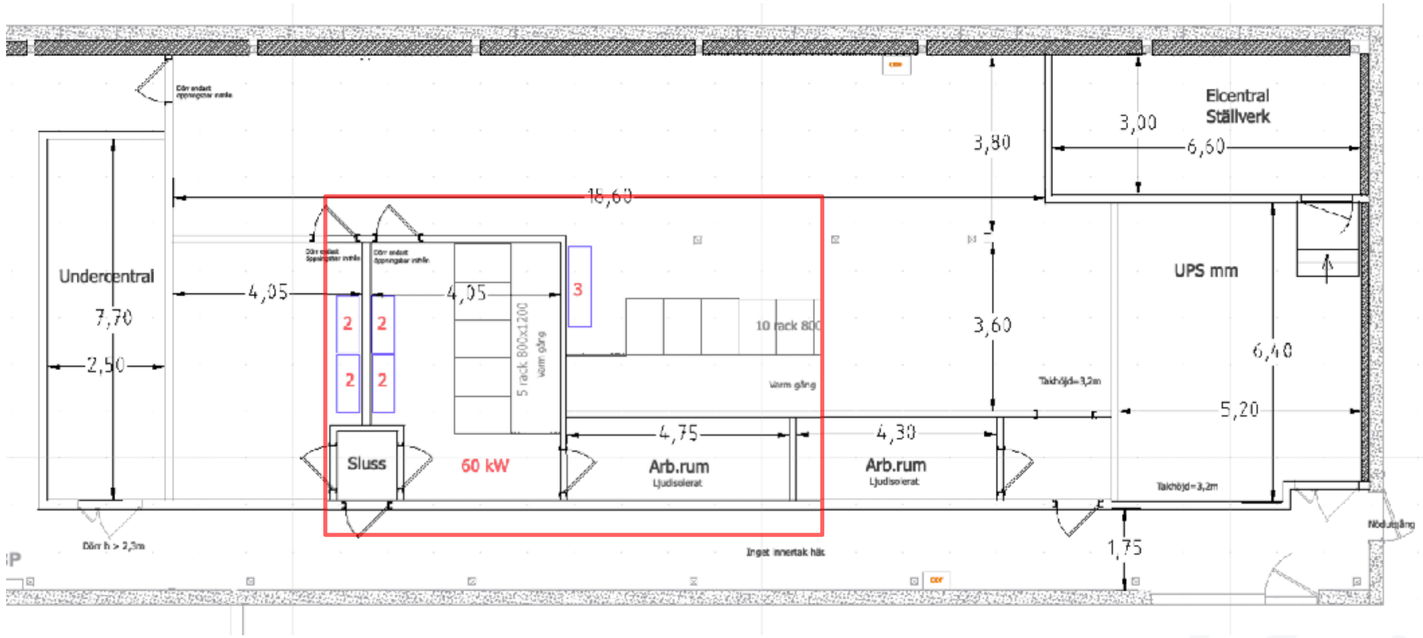
EISCAT_3D Network

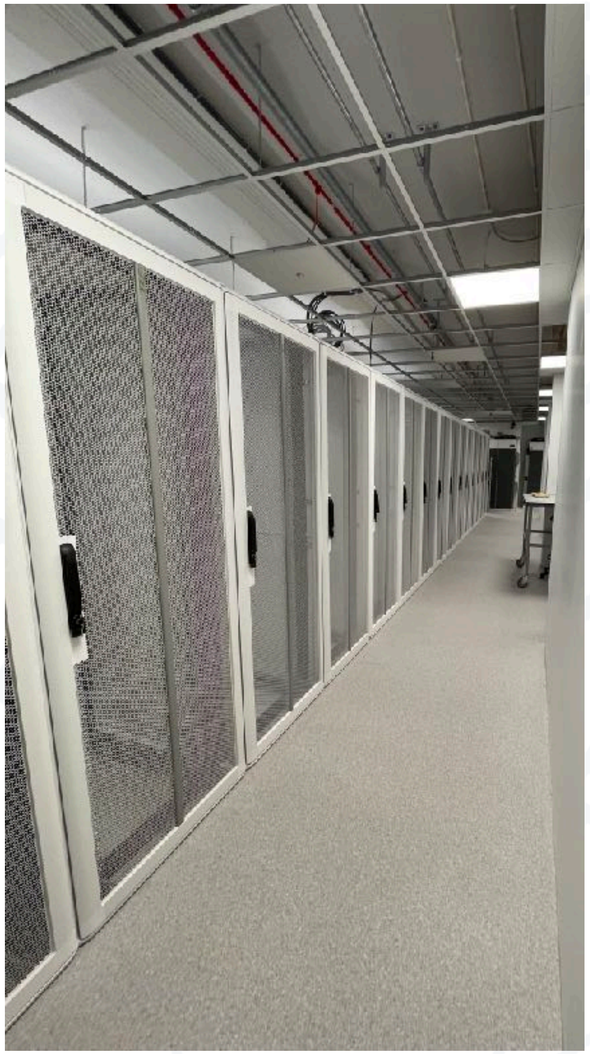




- 4 Tbit/s from each site to DC Orion (Kalix, SE).
- Network can be equipped with filters so that White Rabbit signal can transfer through network.
- Now GNSS clocks at each site but future maybe synchronise to external White Rabbit source.

DC Orion – SUNET





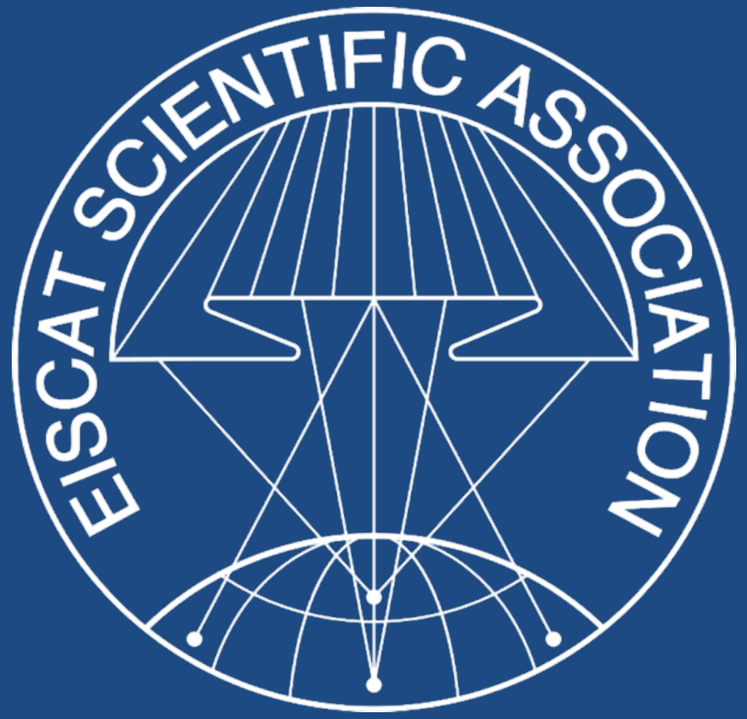
Commissioning

PET (Tx/Rx)	NO–7	SE–7	FI–7	VHF
Tx/Rx				
Rx				Tx
Tx		Rx		
		Rx		Tx
			Rx	Tx
		Rx	Rx	Tx
	Rx			Tx
	Tx/Rx (first light)			

Final Words

- Upcoming Meetings:
  - International EISCAT Symposium and 48th Annual European Meeting on Atmospheric Studies by Optical Methods
    Tromsø, Norway, 27 Jul – 2 Aug
  - International EISCAT Radar School
    Kilpisjärvi, Finland, 12–16 Aug
  - European Space Weather Week
    Umeå, Sweden, 27–31 Oct 2025

Thank you!


EISCAT SCIENTIFIC ASSOCIATION