

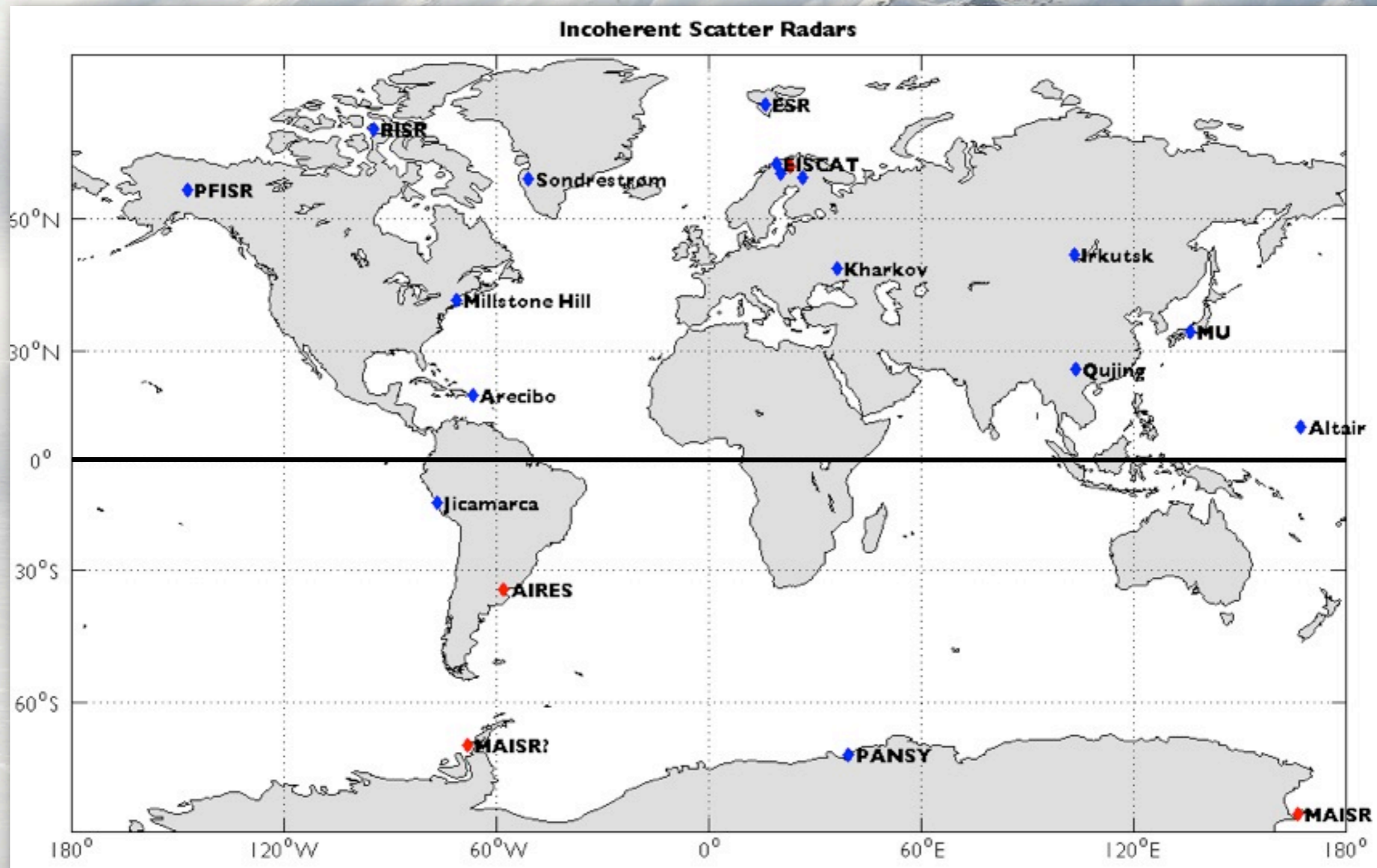
# EISCAT

Scientific Association

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Sodankylä, Finland  
thu@sgo.fi

• [www.eiscat.se](http://www.eiscat.se) • [www.eiscat3d.se](http://www.eiscat3d.se)  
[blog.eiscat3d.org](http://blog.eiscat3d.org)

# Incoherent Scatter Radars



# EISCAT

- Originally: ~~European~~ Incoherent SCATter.
- Since 1975.
- Operates 3 ISRs.
- Locations: Tromsø (NO), Kiruna (SE), Sodankylä (FI), Longyearbyen (Svalbard).
- Founding members: UK, DE, FR, NO, SE, FI.
- Members (2012):  
UK, NO, SE, FI, JP, CN (+RU, FR, (UA)).
- August 2011: 30 years of measurements.



Photo: Thomas Ulich.

# You can get Radar Time!

- EISCAT Peer-Review Programme
- EISCAT sets aside 200 hrs of radar time per year (at the moment).
- Everyone can apply!
- Decisions on basis of merit.
- If equal merit, new users and new countries have priority.

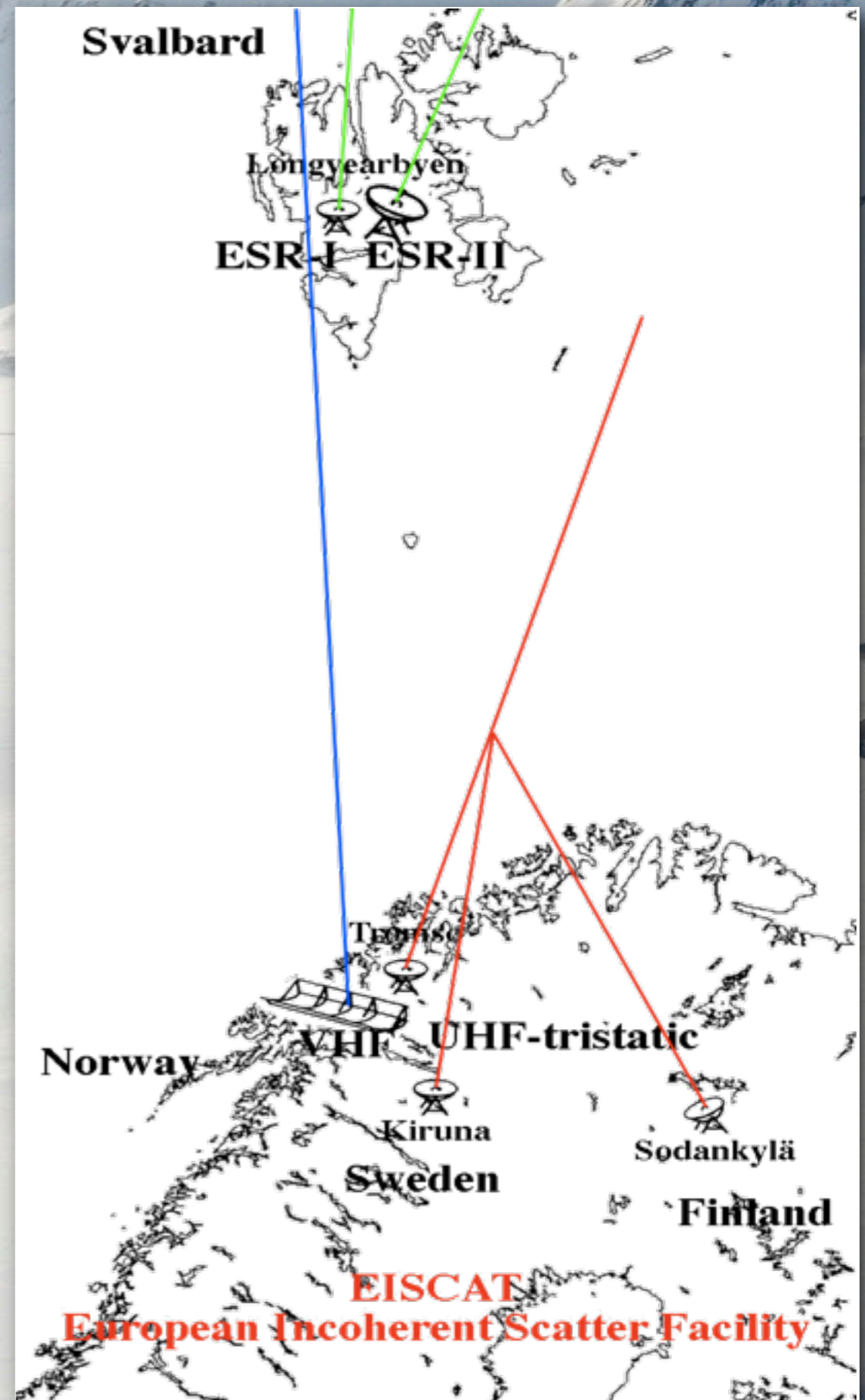
# You can get Radar Time!

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Next deadline anticipated  
1st November 2013

# Current EISCAT installations in Northern Scandinavia and Finland

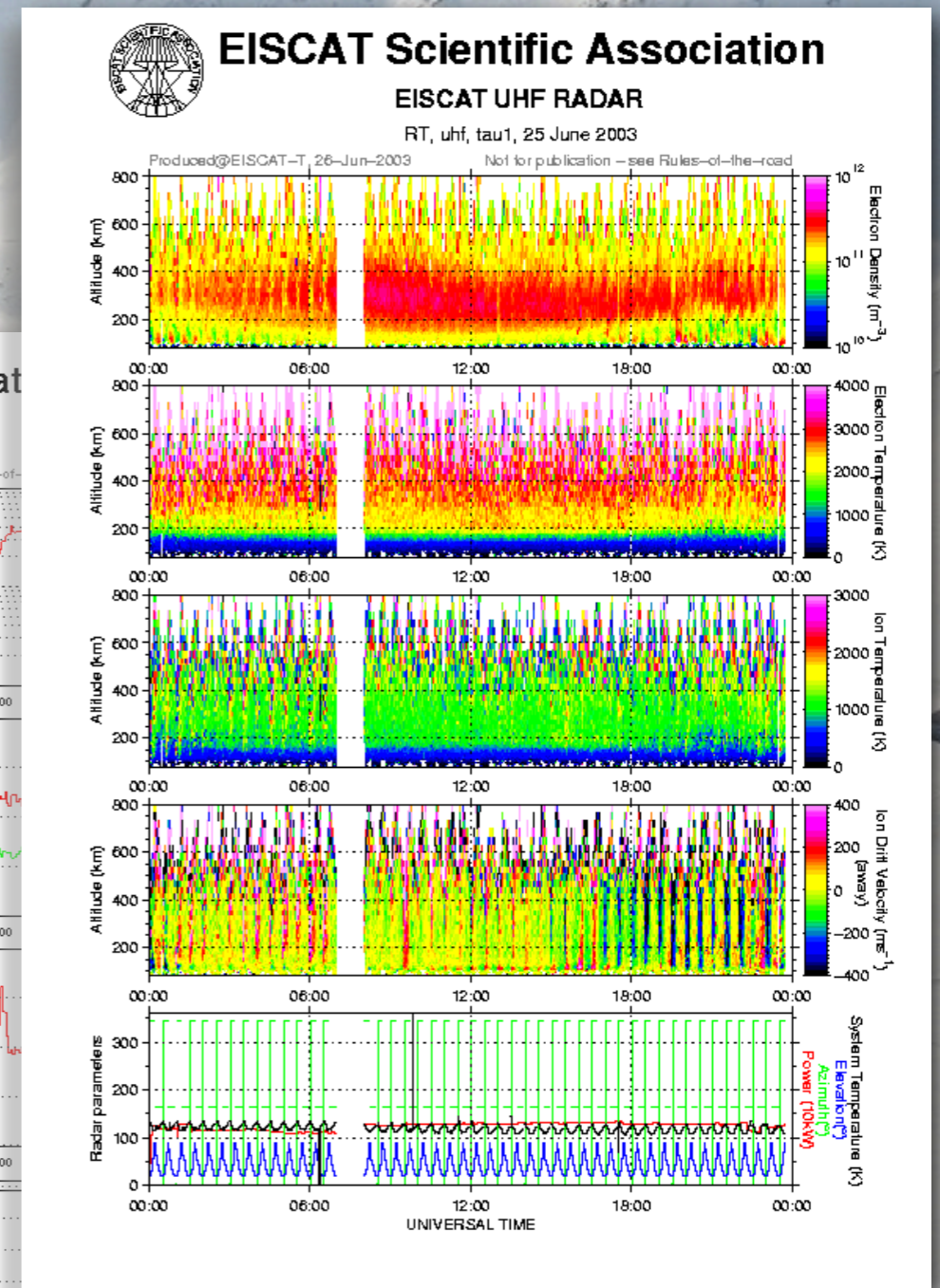
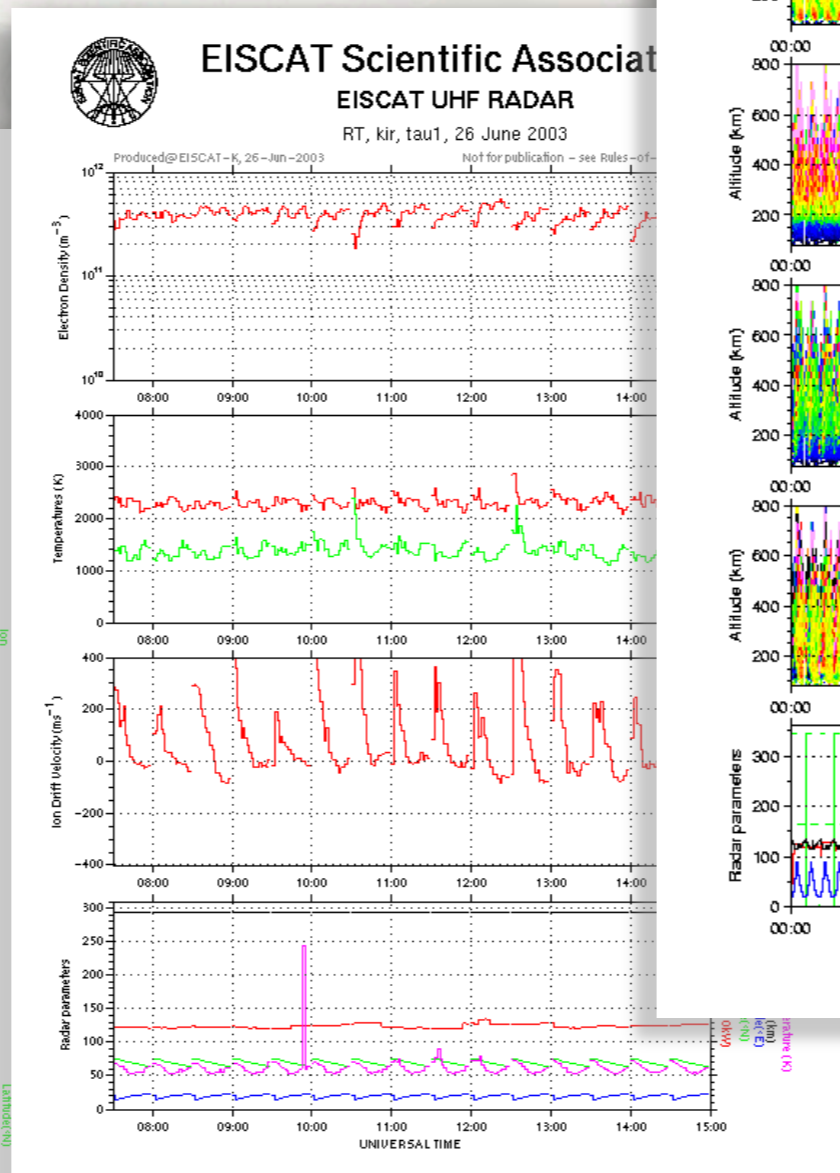
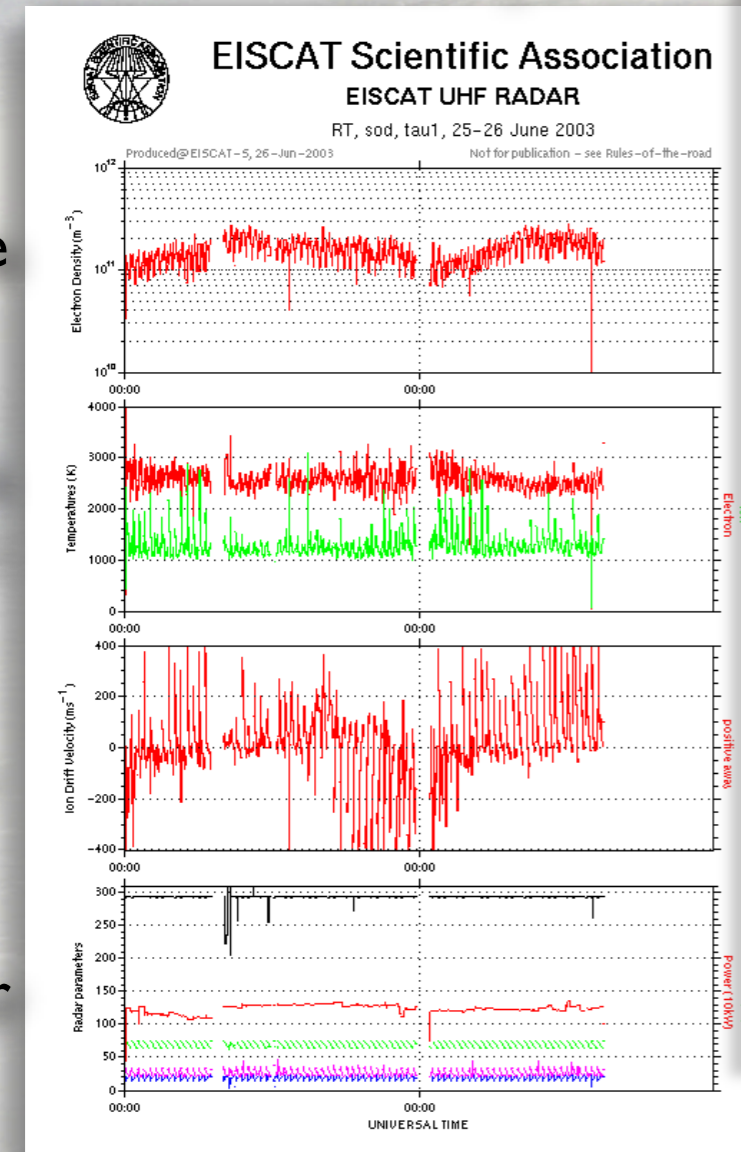
**Unique:** tristatic IS radar!



# Tri-static Data

Kiruna

Sodankylä



Tromsø

Ne

Te  
Ti

v

par

Ne

Te

Ti

v

par

# ISRs, Heater, Dynasondes



ESR, 500 MHz



VHF, 224 MHz

UHF, 930 MHz

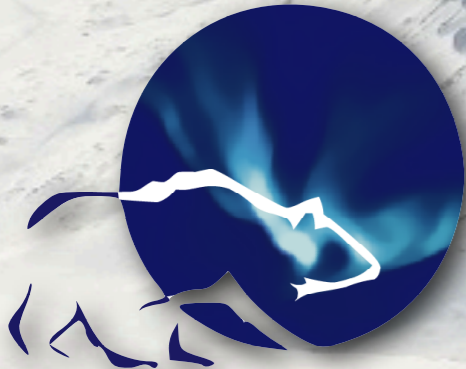




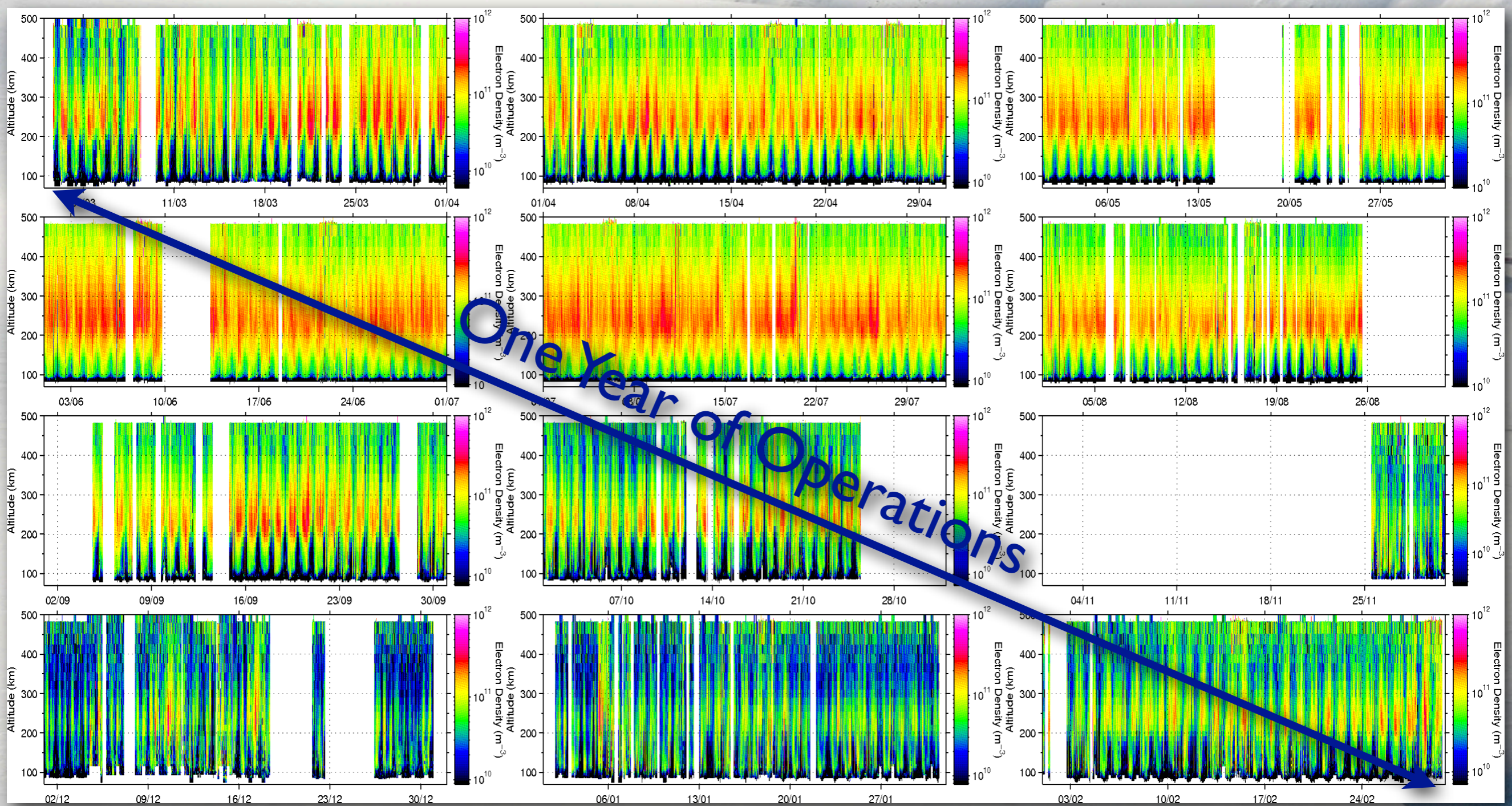
# EISCAT VHF



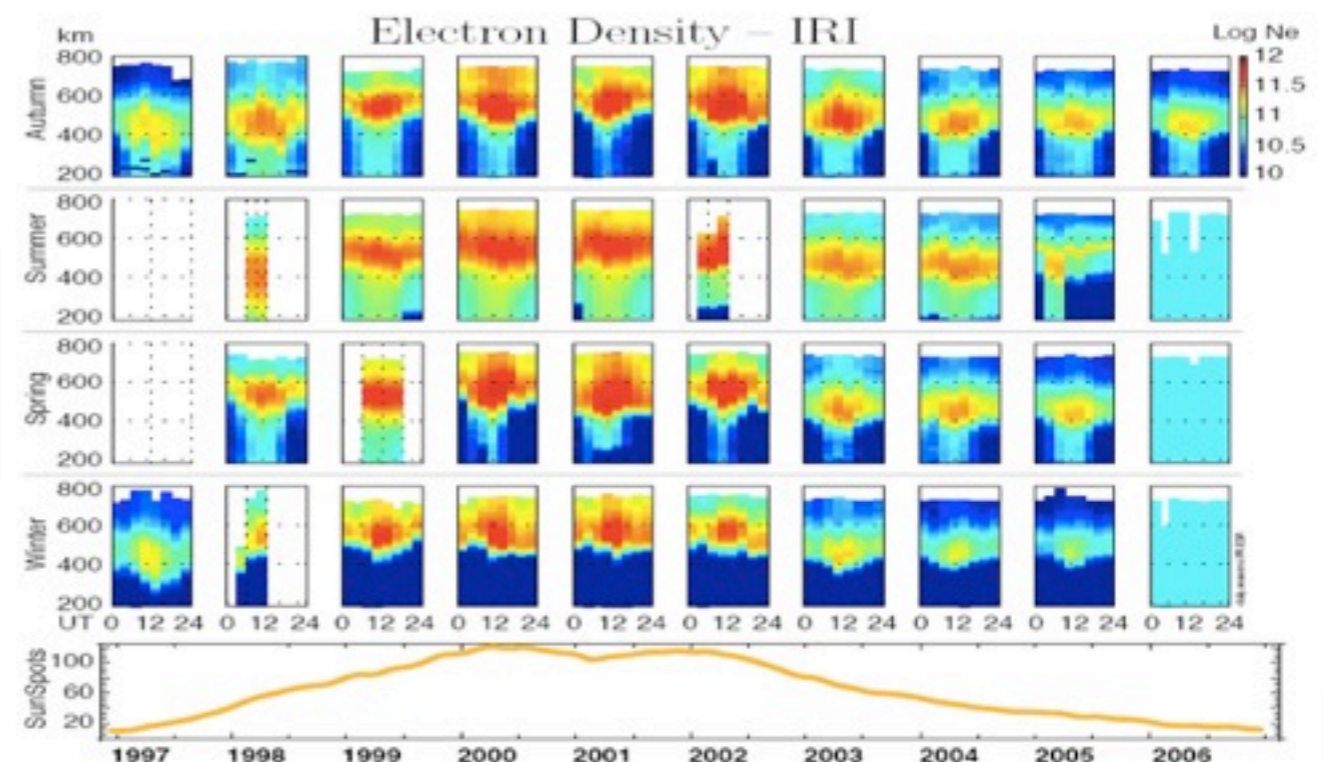
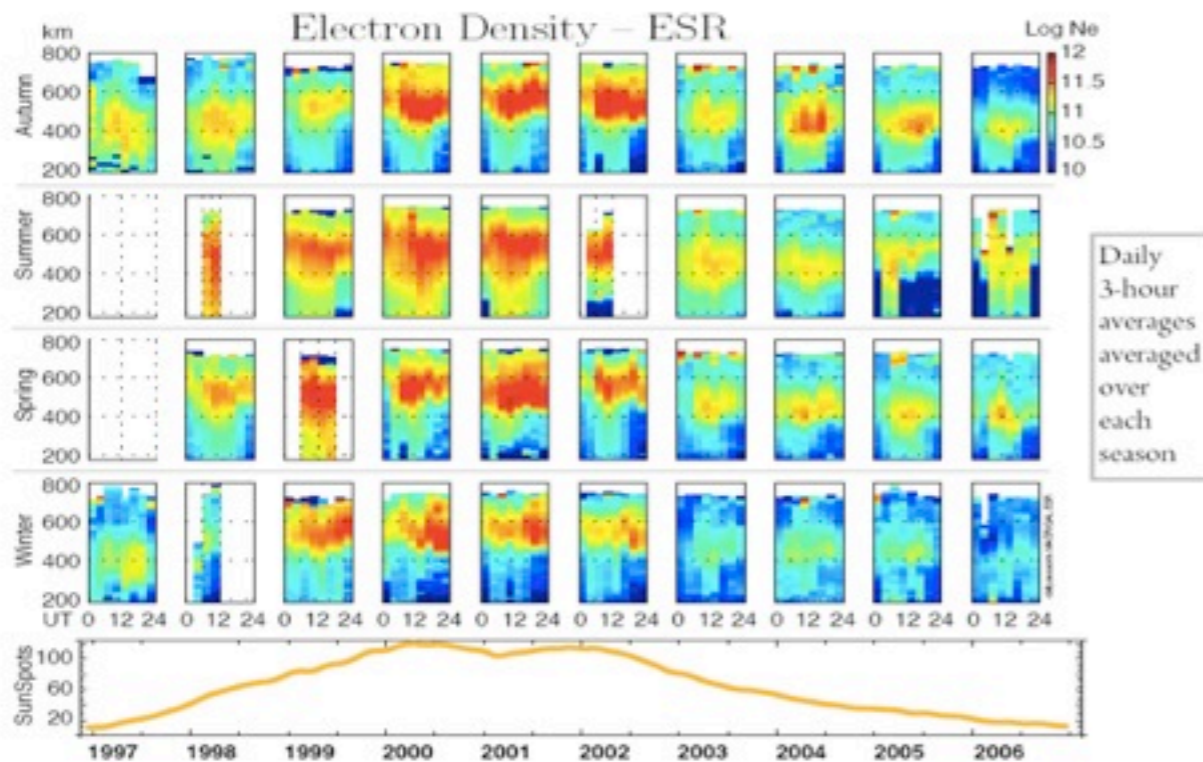
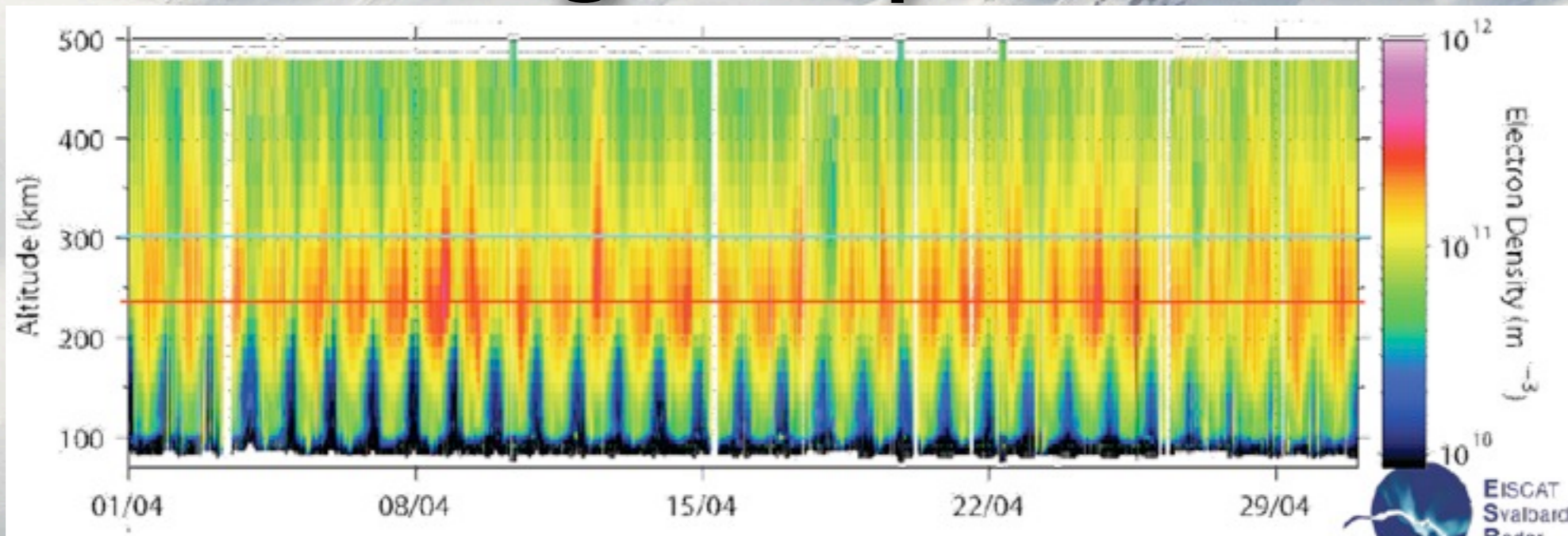
Brian McClave, Site-Eye Ltd, UK



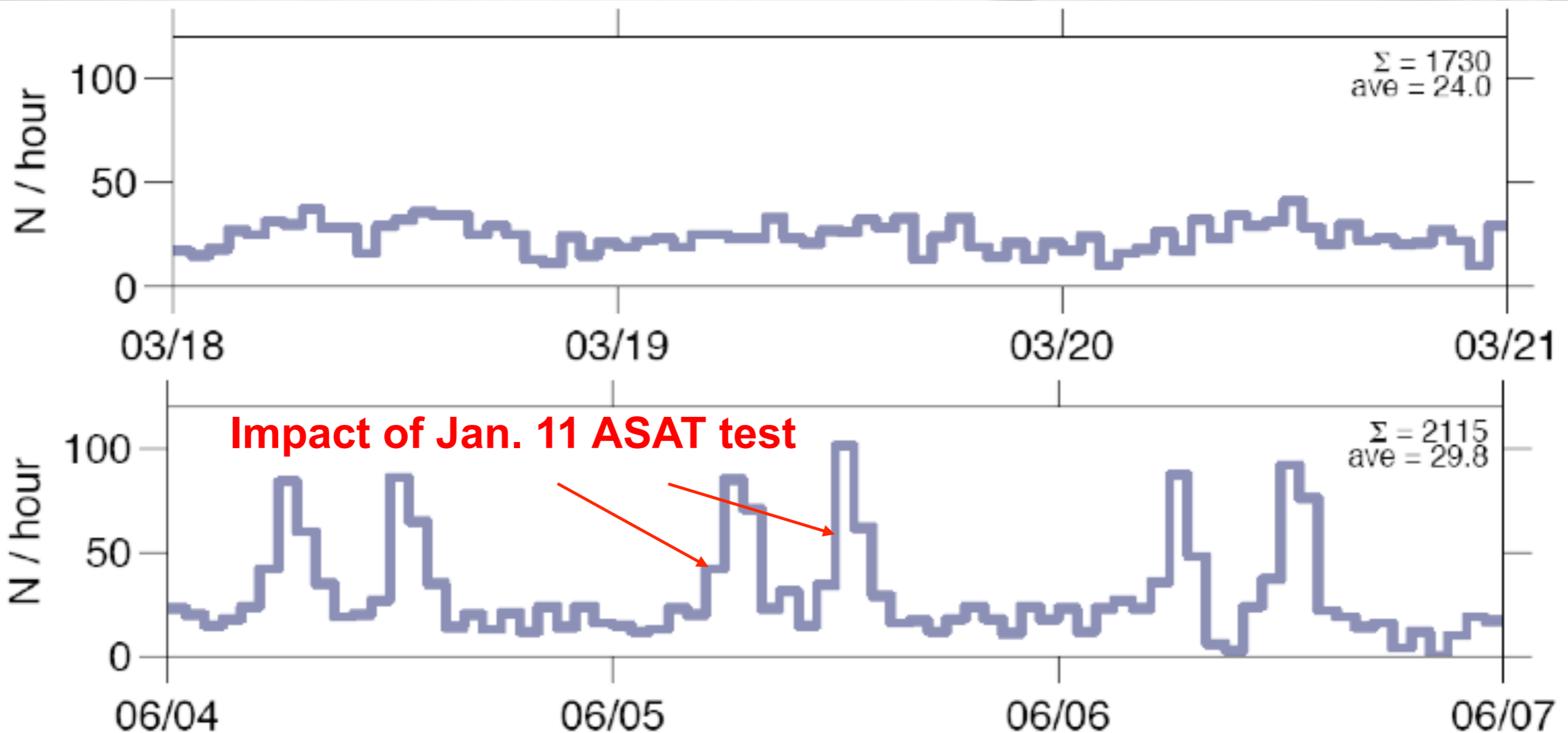
# EISCAT Svalbard Radar



# Space Weather: Modelling and predictions

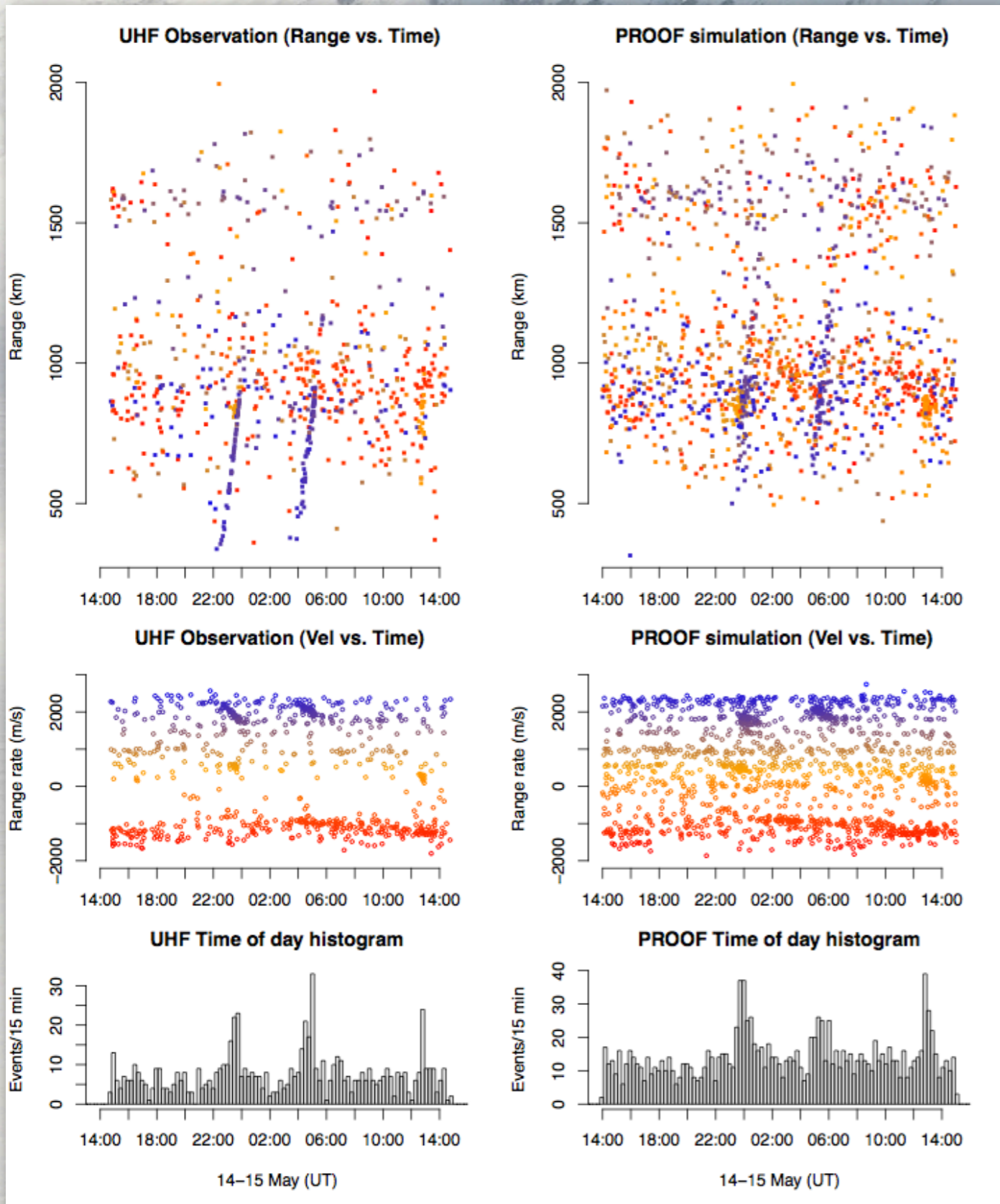


# EISCAT & Space Debris



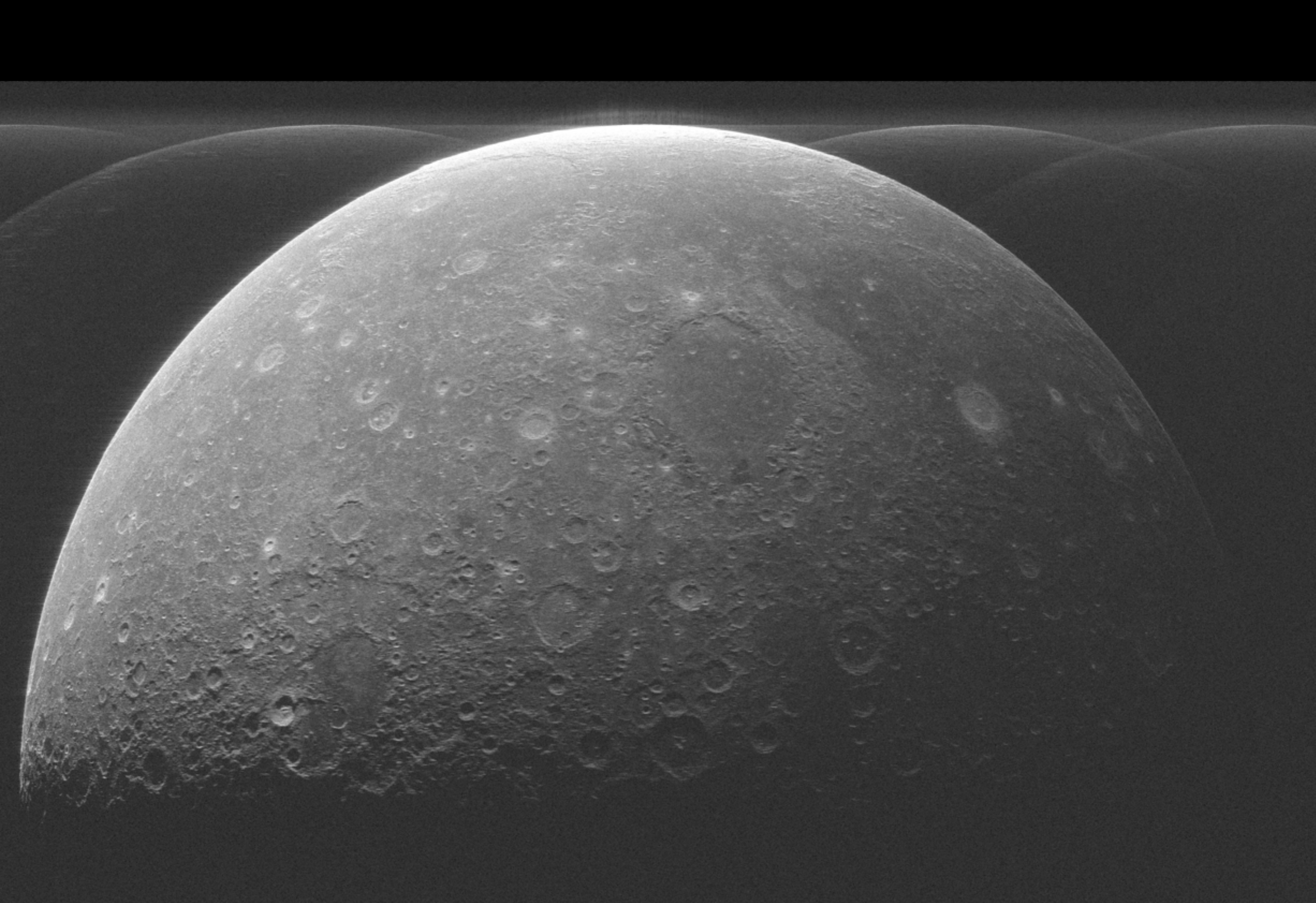
|| Jan 2007, Chinese anti-satellite missile test taking down Fengyun weather satellite.

# Iridium-Cosmos Collision seen by EISCAT UHF radar

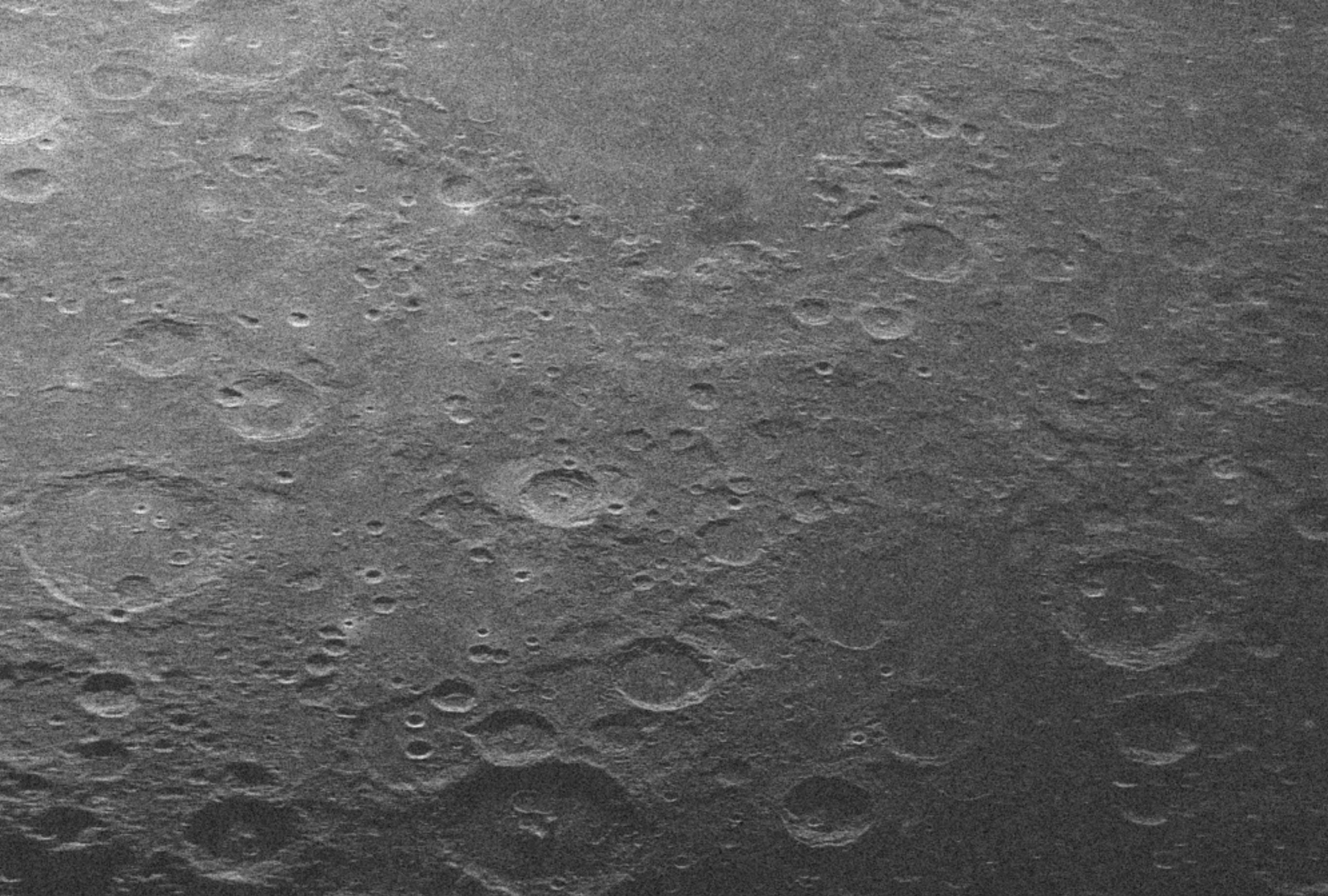


What happens when an unstoppable object hits an indestructible barrier?  
Here: 1.7 g Al sphere of 1.2 cm  $\varnothing$  at 6.8 km/s.

(Courtesy J Vierinen et al., 2009)



First radar image of the moon by EISCAT (J Vierinen & M Lehtinen)



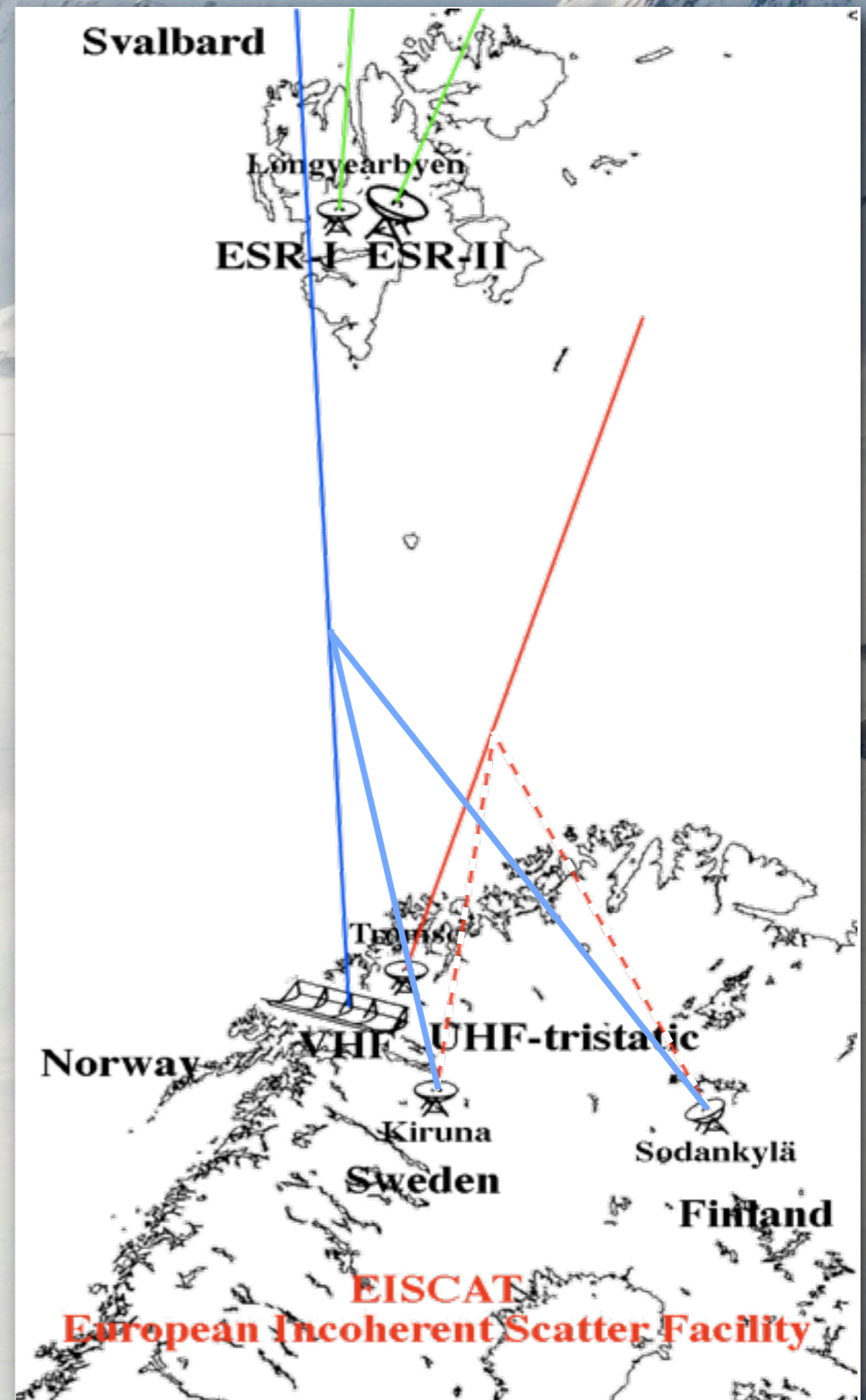
After focussing, 600m resolution. (J Vierinen & M Lehtinen)

**Unique:** tristatic IS radar!

**But:** UHF at 930 MHz; now too much GSM interference.

Intermediate measure: KIR & SOD converted to VHF!

**Also:** single point 3D only, leading to space-time ambiguities.





A dirt trail with tire tracks winds through a rocky, grassy landscape. The trail is the central focus, leading from the bottom center towards the upper right. The terrain is covered in green grass and scattered dark grey rocks of various sizes. In the background, a small stream flows through the landscape. The overall scene is bright and natural.

**Where to go from here?**

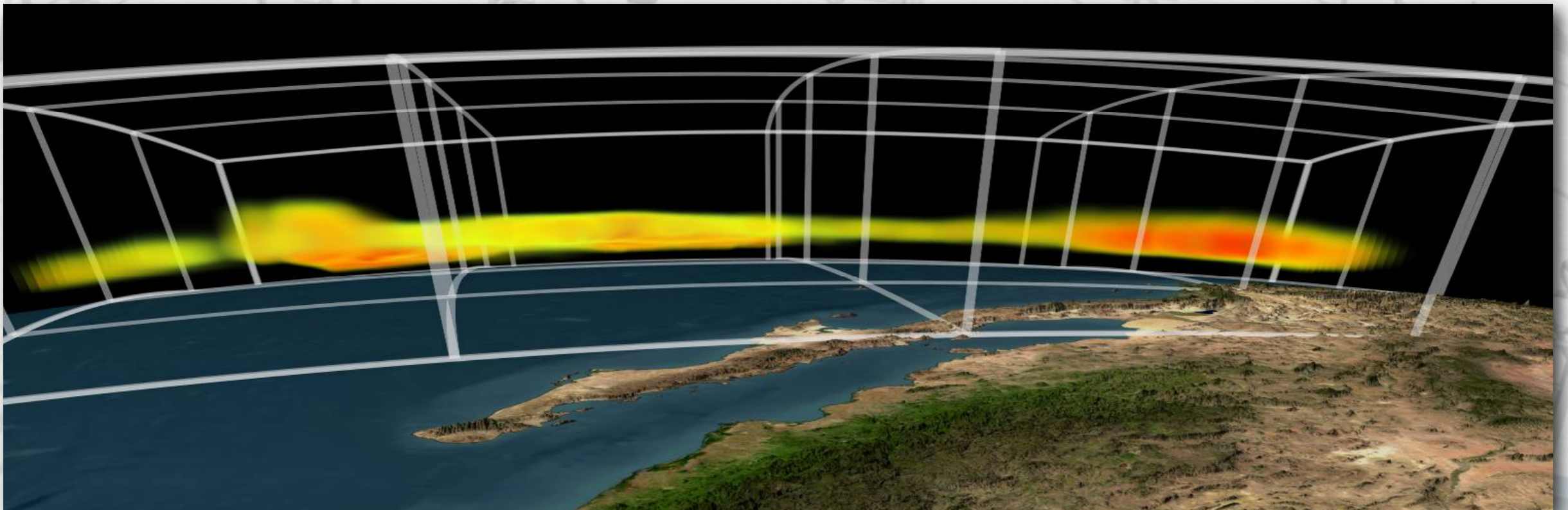
A large array of radar antennas in a field, with mountains in the background. The antennas are arranged in a grid pattern, and the background shows a range of mountains under a blue sky with some clouds.

# **EISCAT\_3D**

**The European 3-Dimensional Imaging Radar  
for Atmospheric and Geospace Research**

# EISCAT\_3D - The Idea

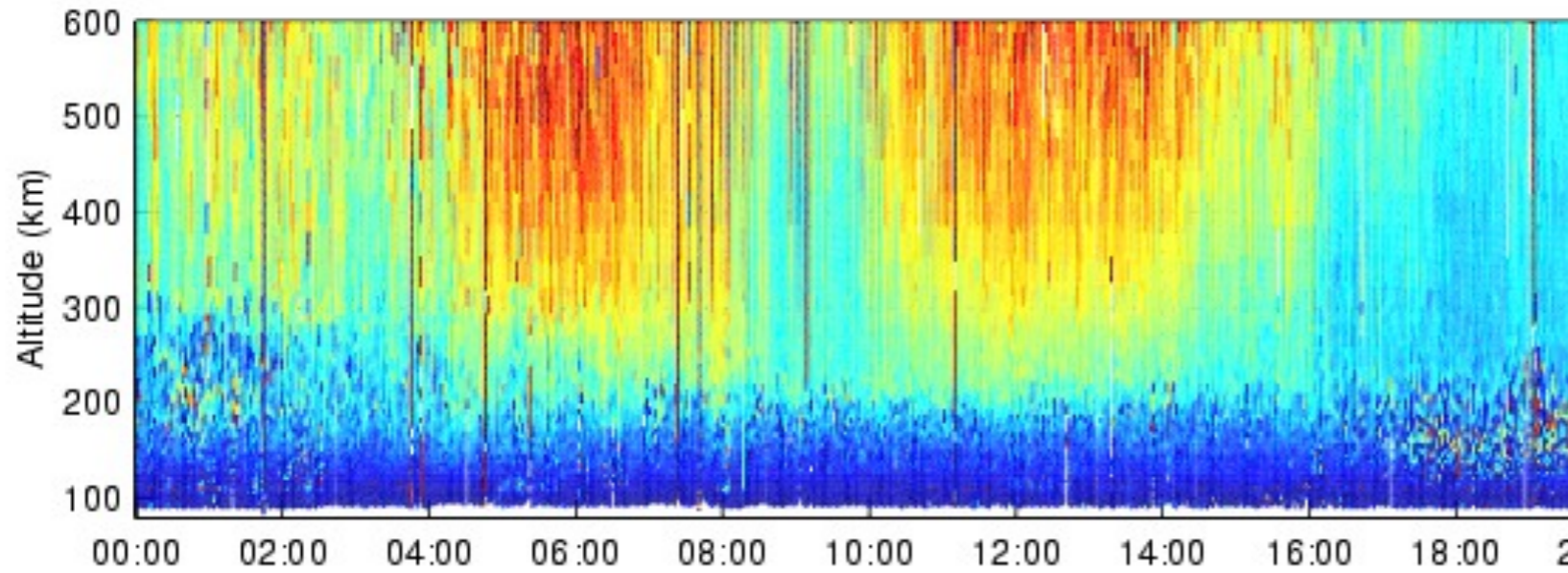
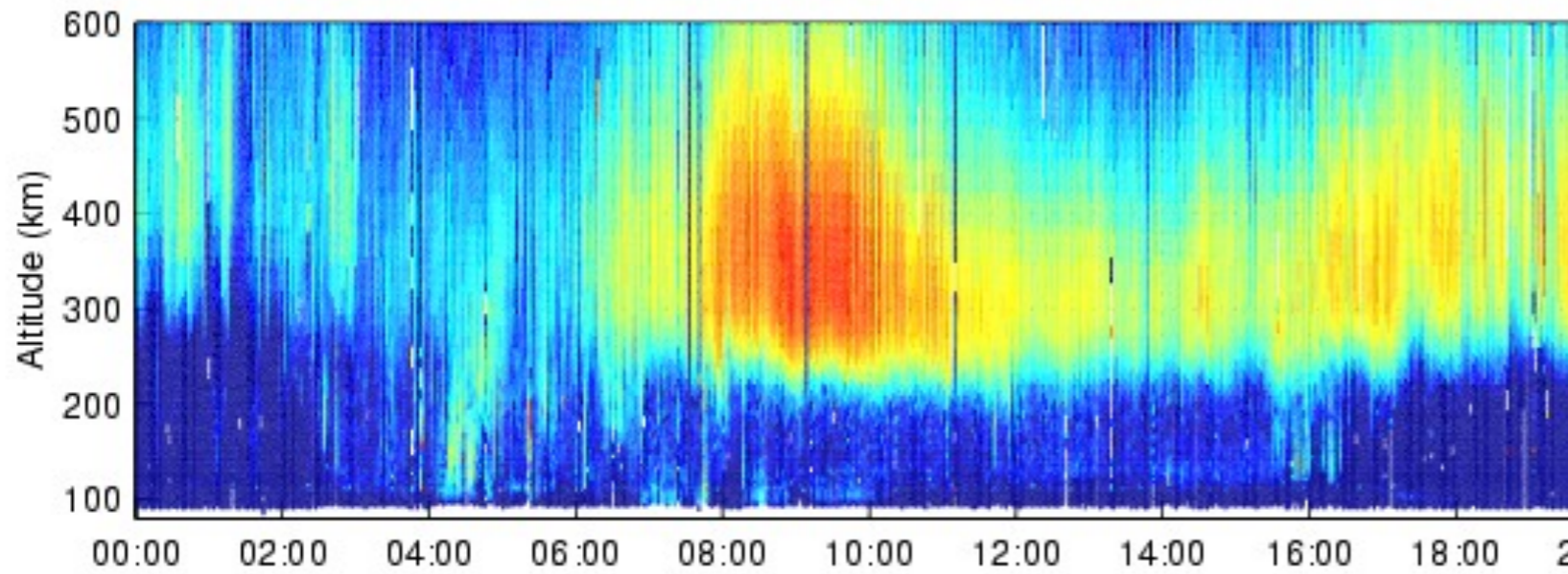
- EISCAT UHF: tristatic, but 1D
- AMISR: 1D volumetric
- EISCAT\_3D: 3D volumetric



# EISCAT\_3D - The Idea

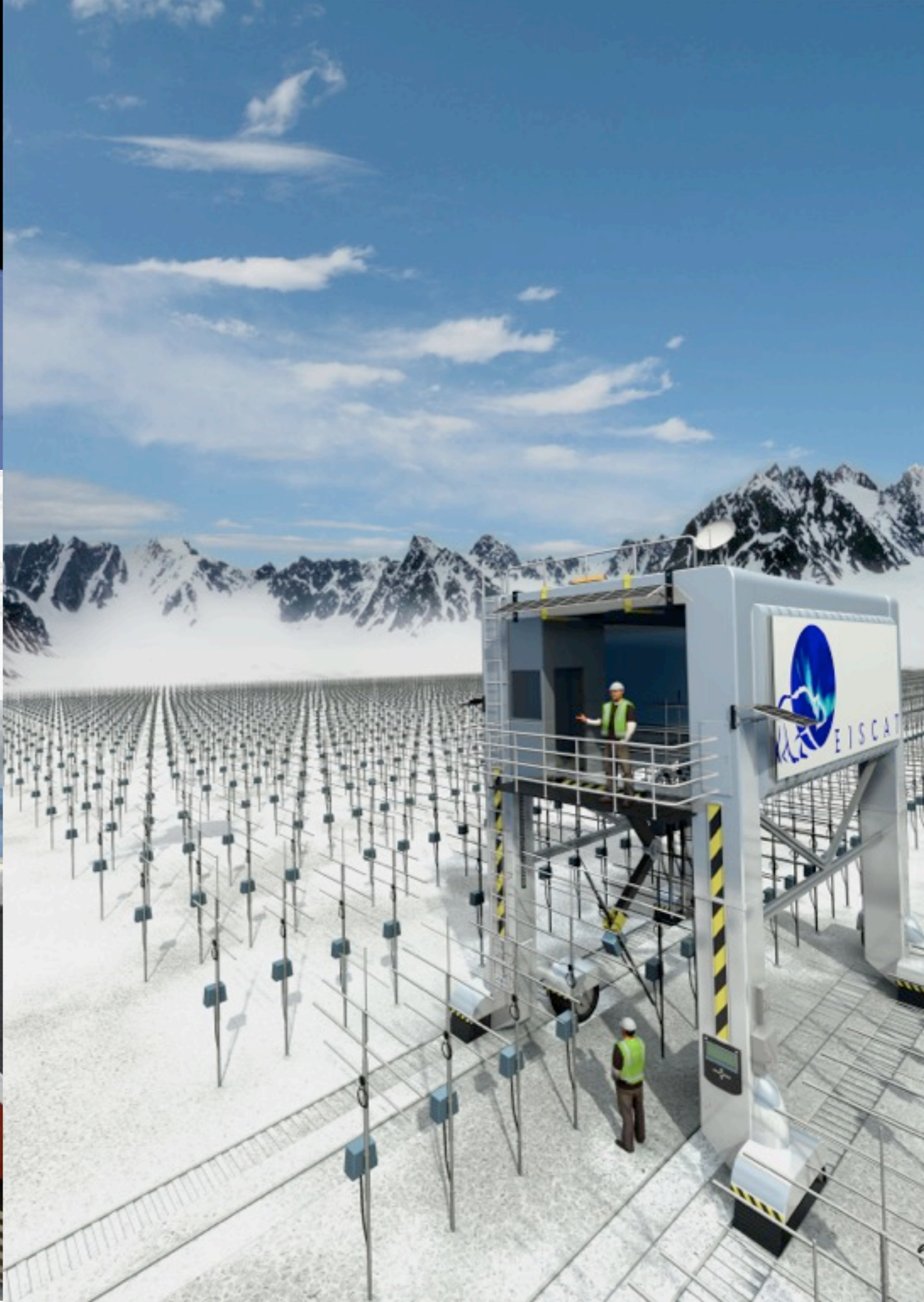
- Volumetric radar, capable of imaging an extended spatial area with
- simultaneous full-vector drift velocities,
- continuous operation modes,
- short baseline interferometry for sub-beamwidth scales,
- real-time data access.

# Space-Time Ambiguity



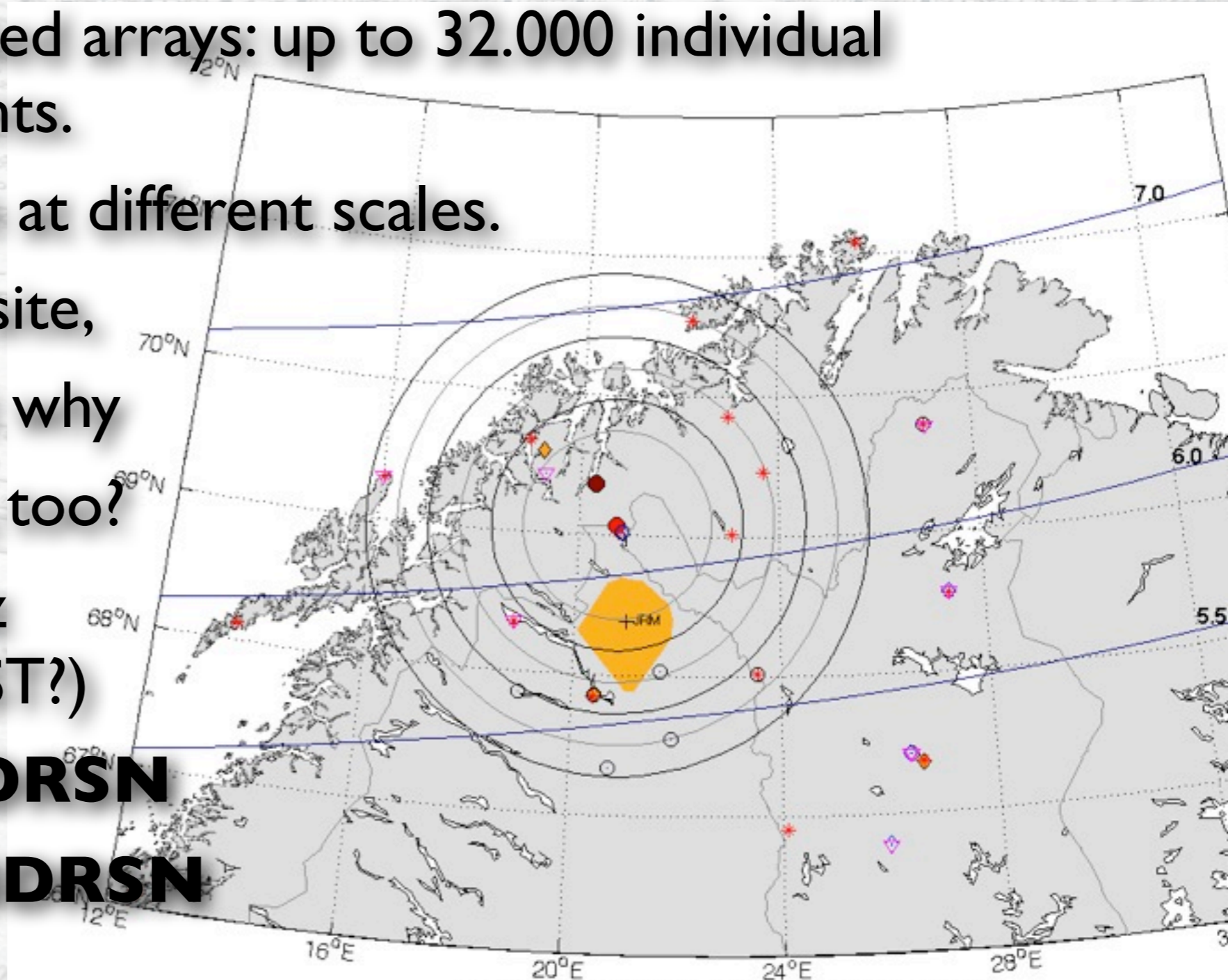


# EISCAT\_3D - Visions



# EISCAT\_3D - System

- Very large phased arrays: up to 32.000 individual antenna elements.
- Modular design at different scales.
- Central Tx/Rx site, remote Rx, but why not remote Tx, too?
- VHF  $\approx 230\text{MHz}$  (and MF for MST?)
- Locations **TBDRSN**
- Tech Specs **TBDRSN**



Think big! Think extendable! Think modular!

# EISCAT\_3D - Science

- Influence of natural solar-terrestrial variability on climate.
- Long-term anthropogenic change.
- Coupling between atmospheric layers.
- Space plasma physics, including active experiment.
- Measurements of the solar wind and solar corona.
- Effects of meteors and energetic particles on atmospheric chemistry.



# EISCAT\_3D - Science

- Development of radar and information technology.
- Monitoring of space weather.
- Space situational awareness.
- Ground-based support for future space missions.
- Orbit determination of space debris and meteors.
- Radar-mapping of near-Earth objects.

# EISCAT\_3D - Timeline

- 2005-2009: Design Study (completed)
- 2010-2014: Preparatory Phase
- 2015-2016: Start of Construction
- 2016-2045: Operation

# EISCAT\_3D 2015-2045+

- Continuous development.
- World-class high-latitude Space and Radio Science, space weather, radar technology
- State-of-the-Art Education of Space Scientists, Electrical & Radio Engineers, IT Engineers, Mathematicians at all levels.



A Finnish Radio Receiver in Support of EISCAT\_3D

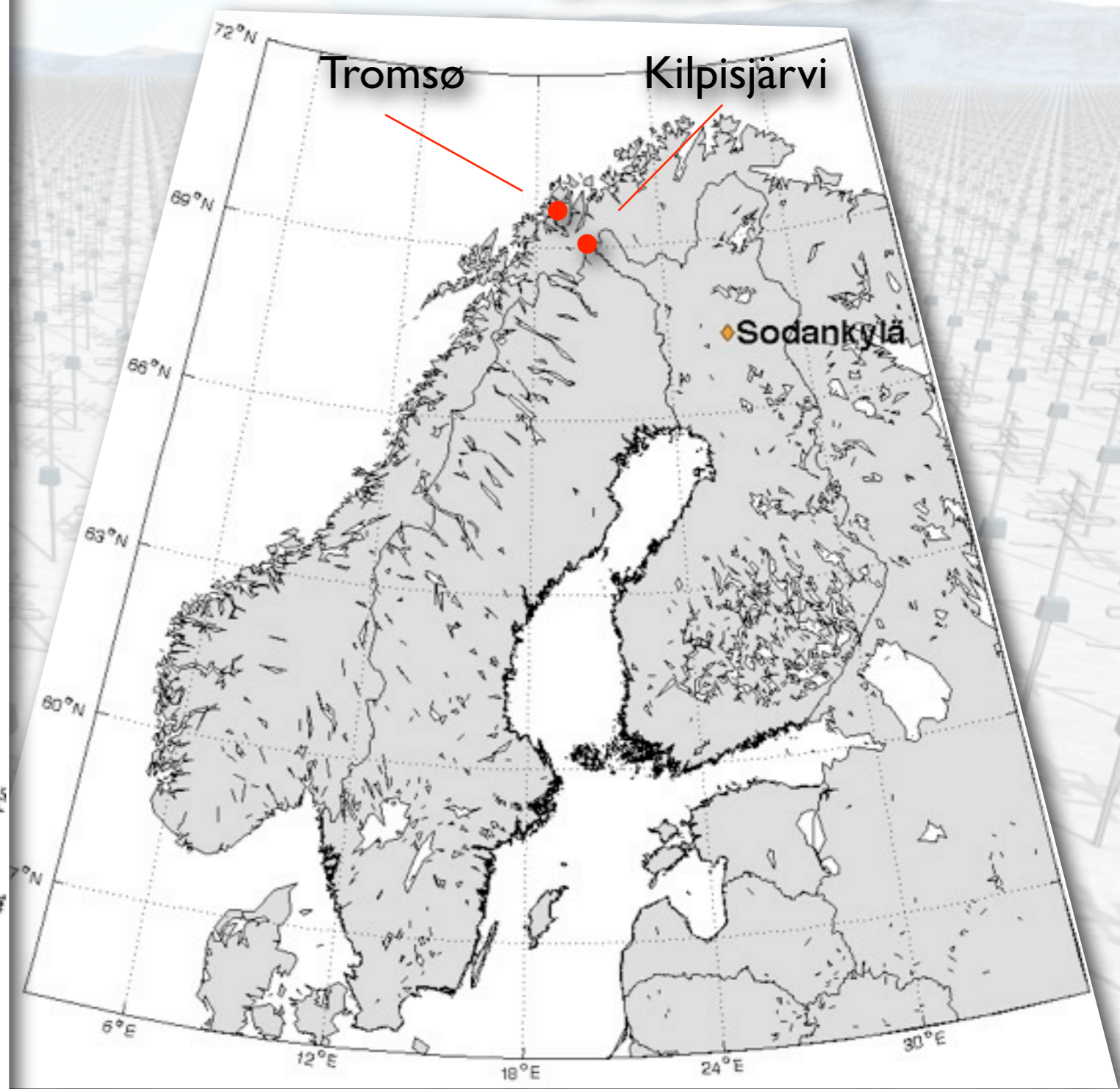
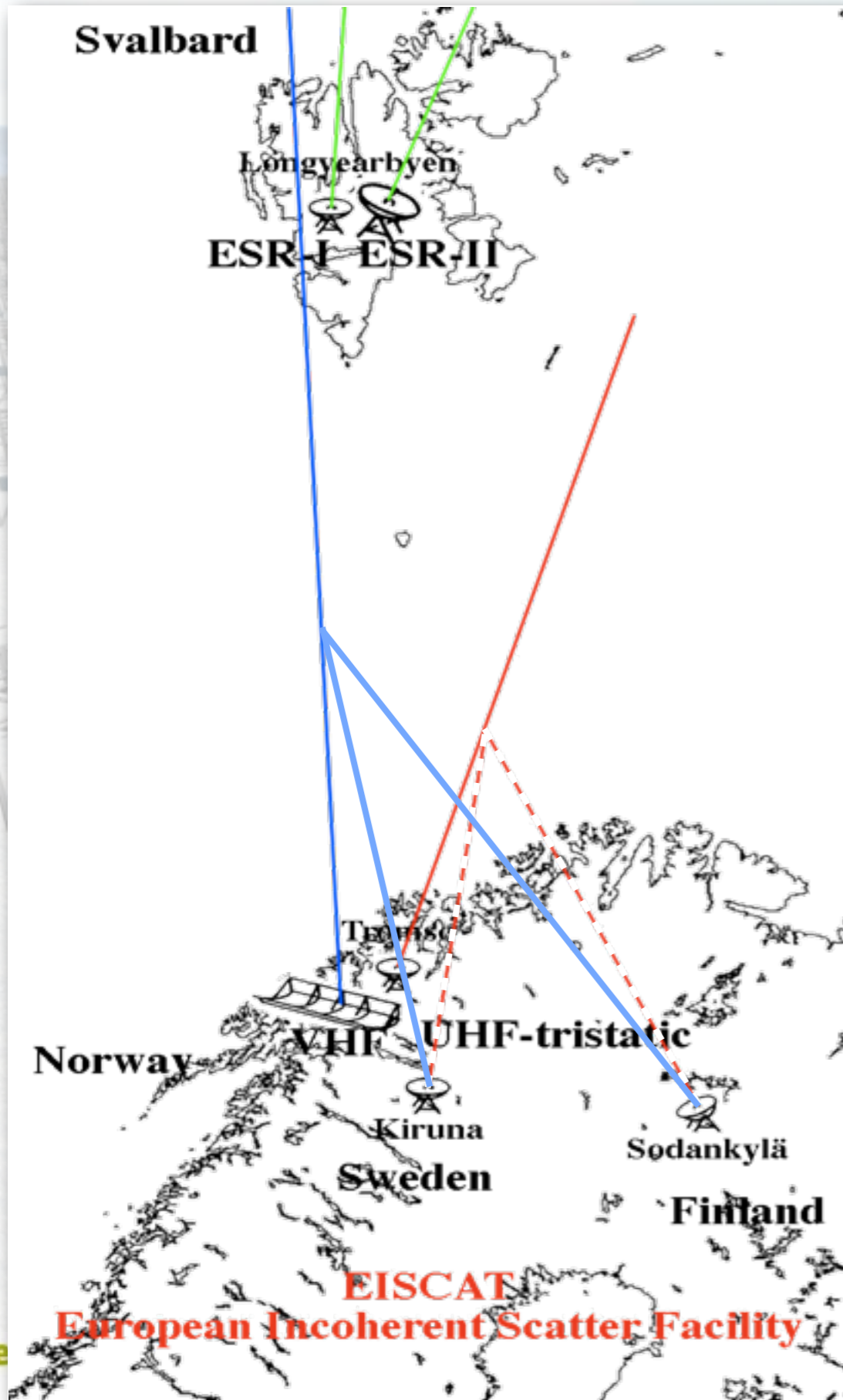


# KAIRA

Kilpisjärvi Atmospheric Imaging Receiver Array

- Dual VHF radio receiver array.
- Uses LOFAR technology.
- Funded by University of Oulu and European Regional Development Funds. (Total  $\approx 1.3\text{M}\text{€}$ ).
- Receiver for EISCAT VHF.
- Prototyping for EISCAT\_3D.
- Many applications in geophysics.

Closest inhabited place  
on Finnish territory



UNIVERSITY of OULU  
OULUN YLIOPISTO

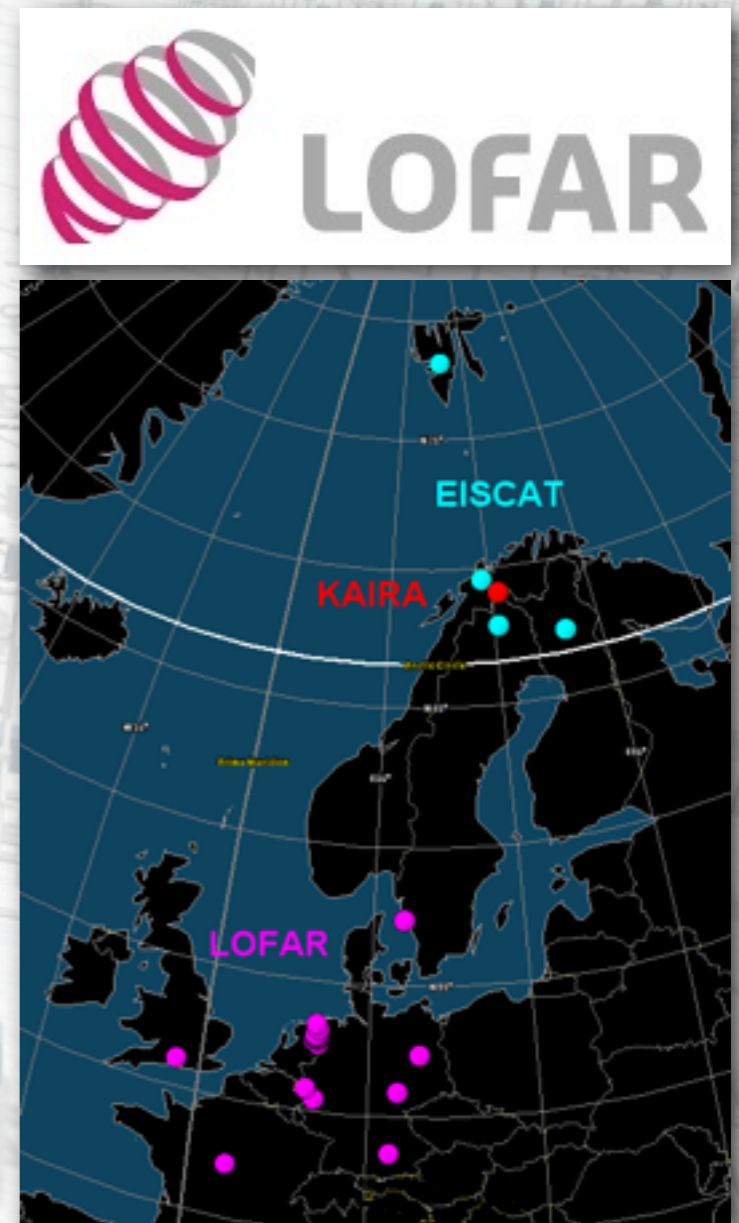


# EISCAT VHF



# LOFAR?

- LOFAR — Low Frequency Array.
- Pan-European Radio telescope.
- Observe universe at VHF frequencies.
- Designed, built and operated by ASTRON, the Netherlands Institute for Radio Astronomy.
- Multiple stations across Europe each of which typically has two arrays of antennas.





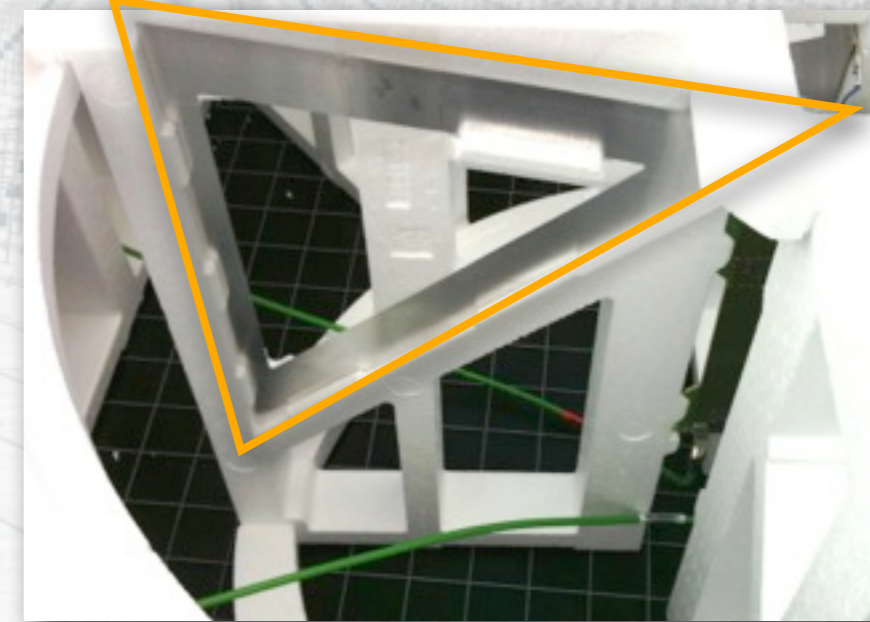
# LOFAR Technology

- LOFAR receiver array for the frequency range 120-250 MHz.
- Adaptable to work also as radar receivers.
- Advantages:
  - production channels exist, optimised for mass production.
  - several new applications (e.g. in astronomy) possible
- University of Oulu has bought and deployed a “LOFAR remote station” for evaluation.



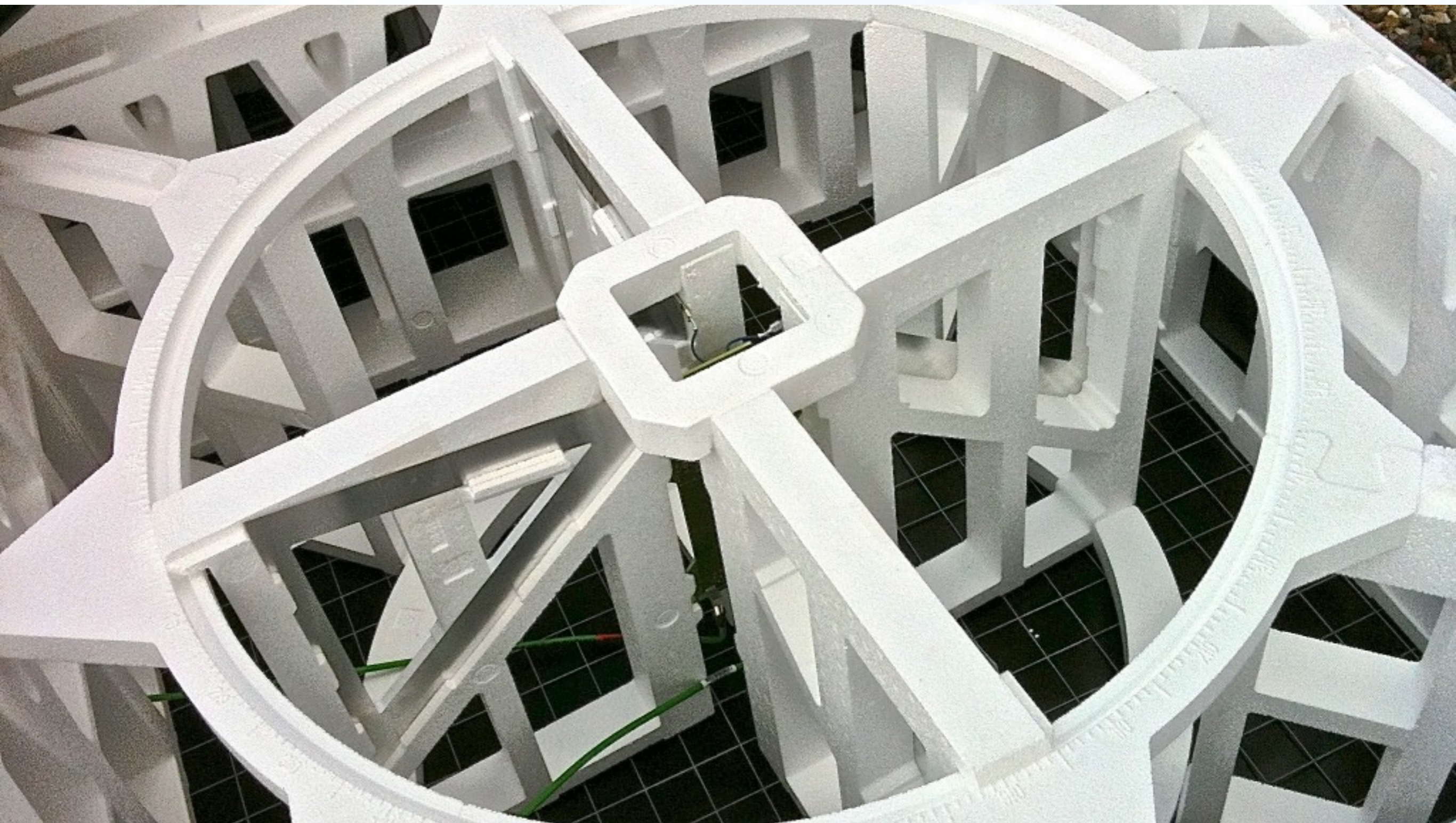
# LOFAR Station

- **High Band Array (HBA)**
  - 120 MHz - 240 MHz and more
  - 96 or 48 tiles (intern./remote station)
  - Polystyrene: 5m x 5m x 0.6m,  $\approx$  300 kg
  - 16 cells per tile with crossed bowtie antennae
  - KAIRA: 48 tiles = 768 cells = 1536 aerials
- **Low Band Array (LBA)**
  - 30 MHz and below - 80 MHz
  - 96 crossed dipoles in pseudo-random array





# High Band Array (110-270MHz)



Leverage from  
the EU  
2007-2013



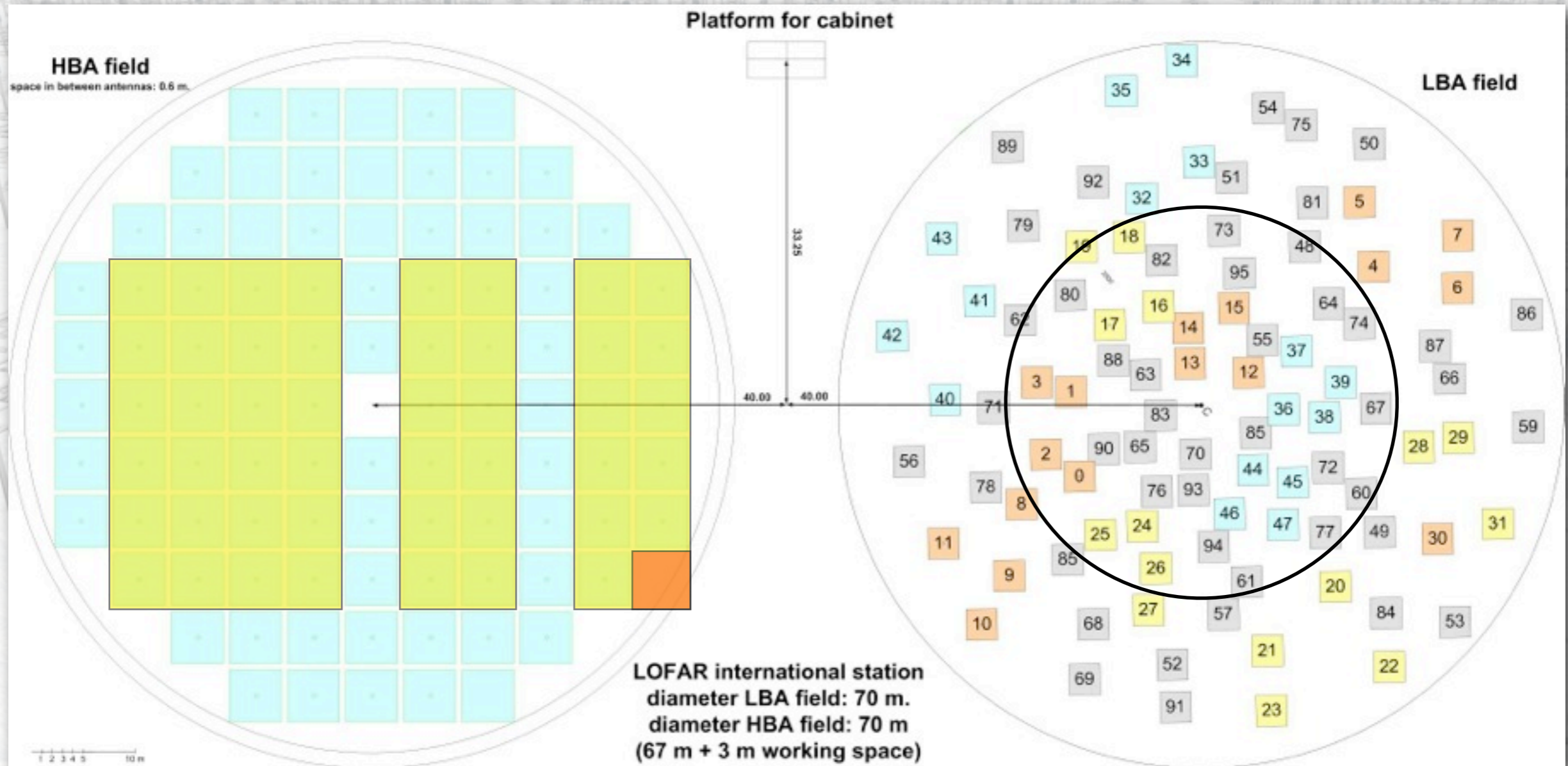
UNIVERSITY of OULU  
OULUN YLIOPISTO





# Low Band Array (30-80MHz)

# LOFAR Station



Full “international” station: 96 HBA + 96 HBA

**KAIRA:** 48 HBA + 96 LBA



# Winter Testing



Photos: Tero Raita, SGO.



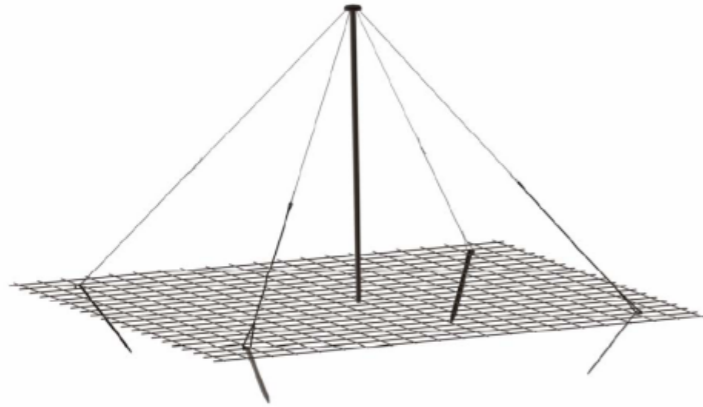
# How much snow?



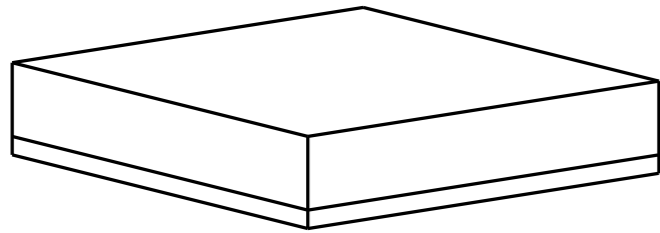
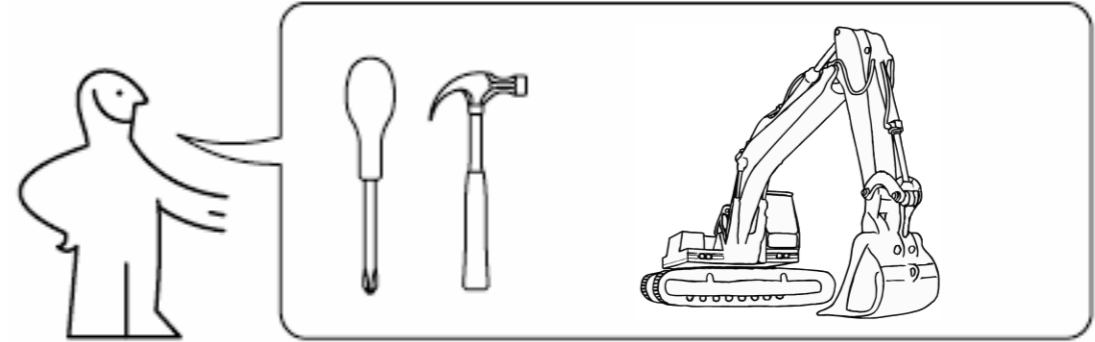




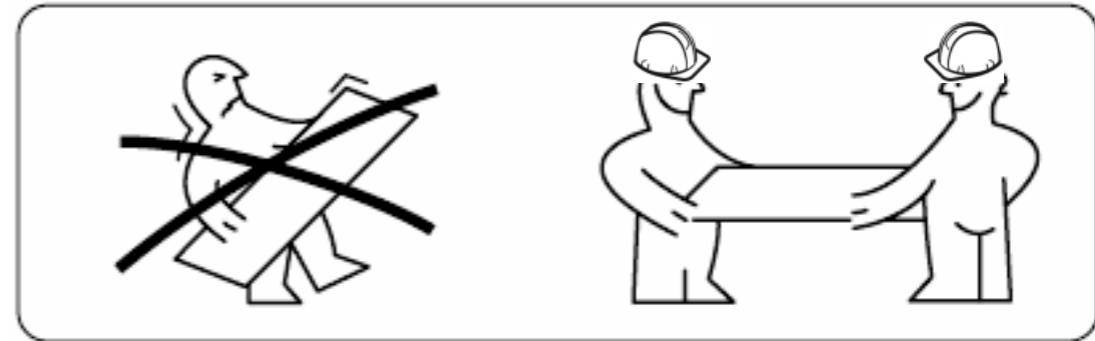
# LÖFÅR



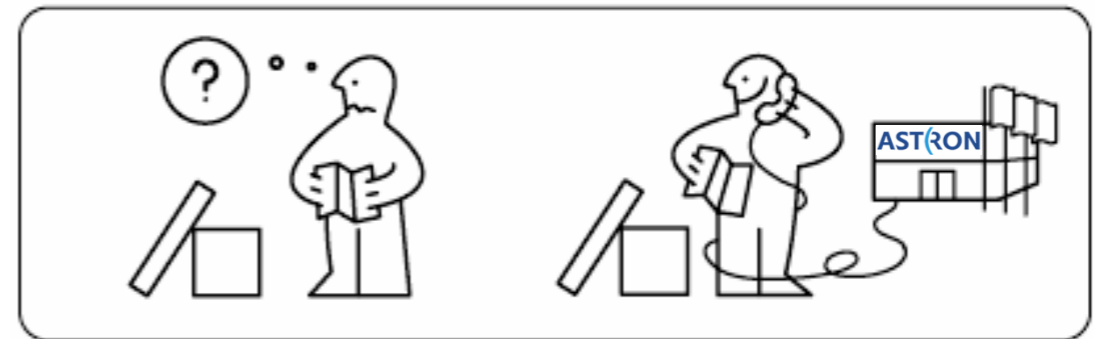
96x



48x



1x



# DEEP SPACE

Radio astronomy

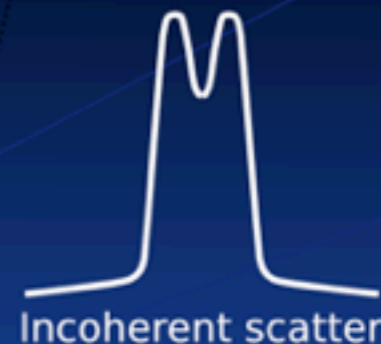
1 AU



1000 km



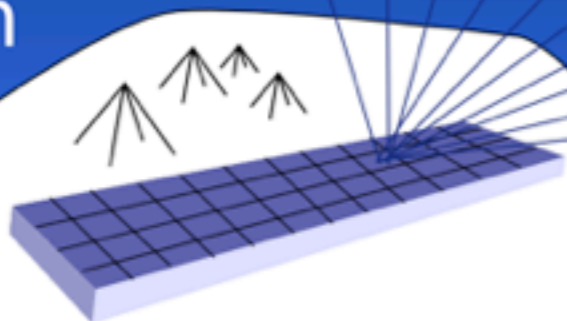
250 km



100 km



50 km



Nearby MST radars  
DAB transmitters  
and meteor radars

Tromsø  
ionospheric  
heater

Tromsø  
VHF

**KAIRA**

Kilpisjärvi Atmospheric Imaging Receiver Array

# Next Generation Radar for Next Generation Scientists!



Photo: Anja Strømme

**Get in touch now!**

[www.eiscat.se](http://www.eiscat.se)

[www.eiscat3d.se](http://www.eiscat3d.se)

[blog.eiscat3d.org](http://blog.eiscat3d.org)

Twitter:

[twitter.com/EISCAT\\_3D](https://twitter.com/EISCAT_3D)

Facebook:

[facebook.com/EISCAT3D](https://facebook.com/EISCAT3D)

**It's YOUR radar!**