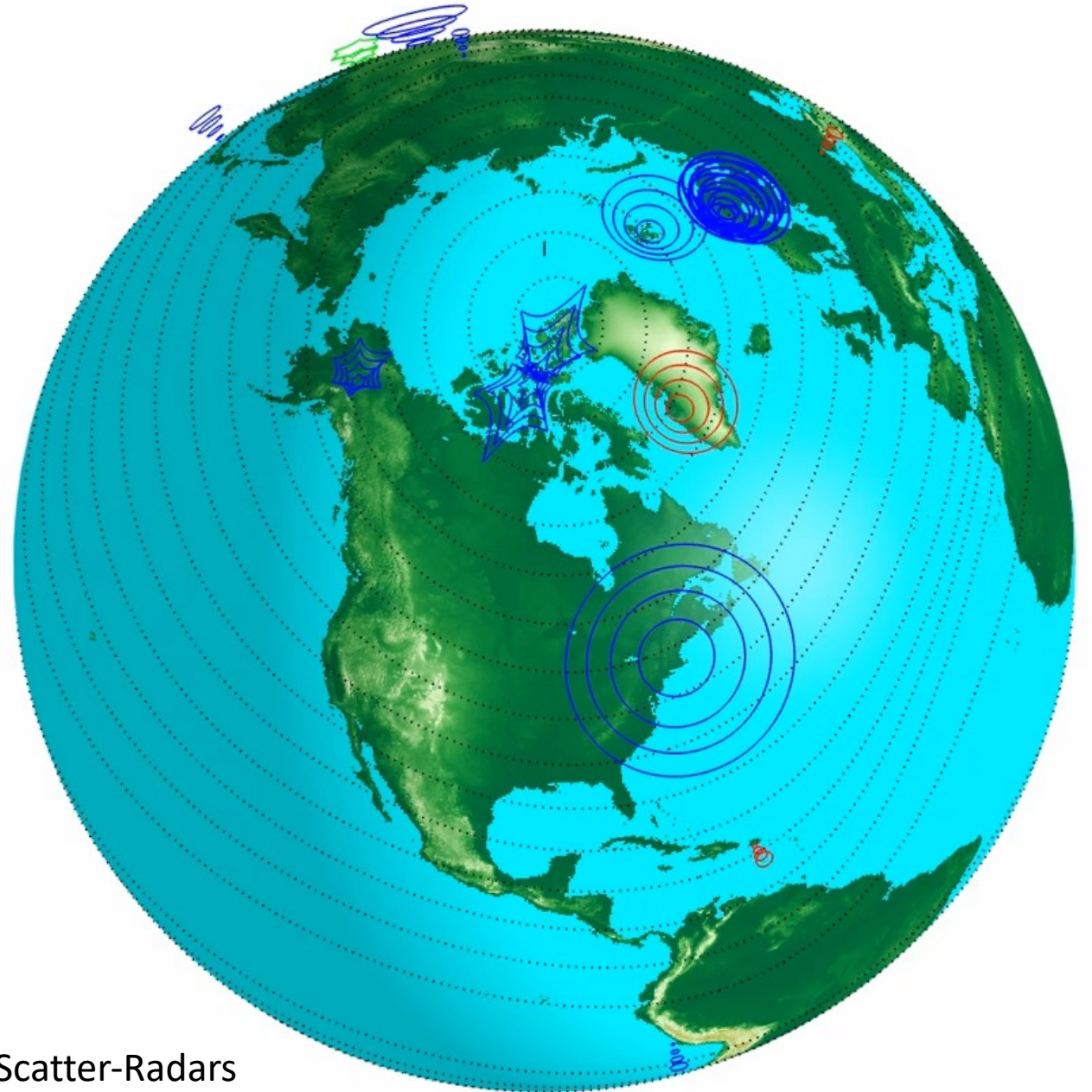


Advanced Phased Array EISCAT_3D

Craig Heinselman
University of Alaska Fairbanks

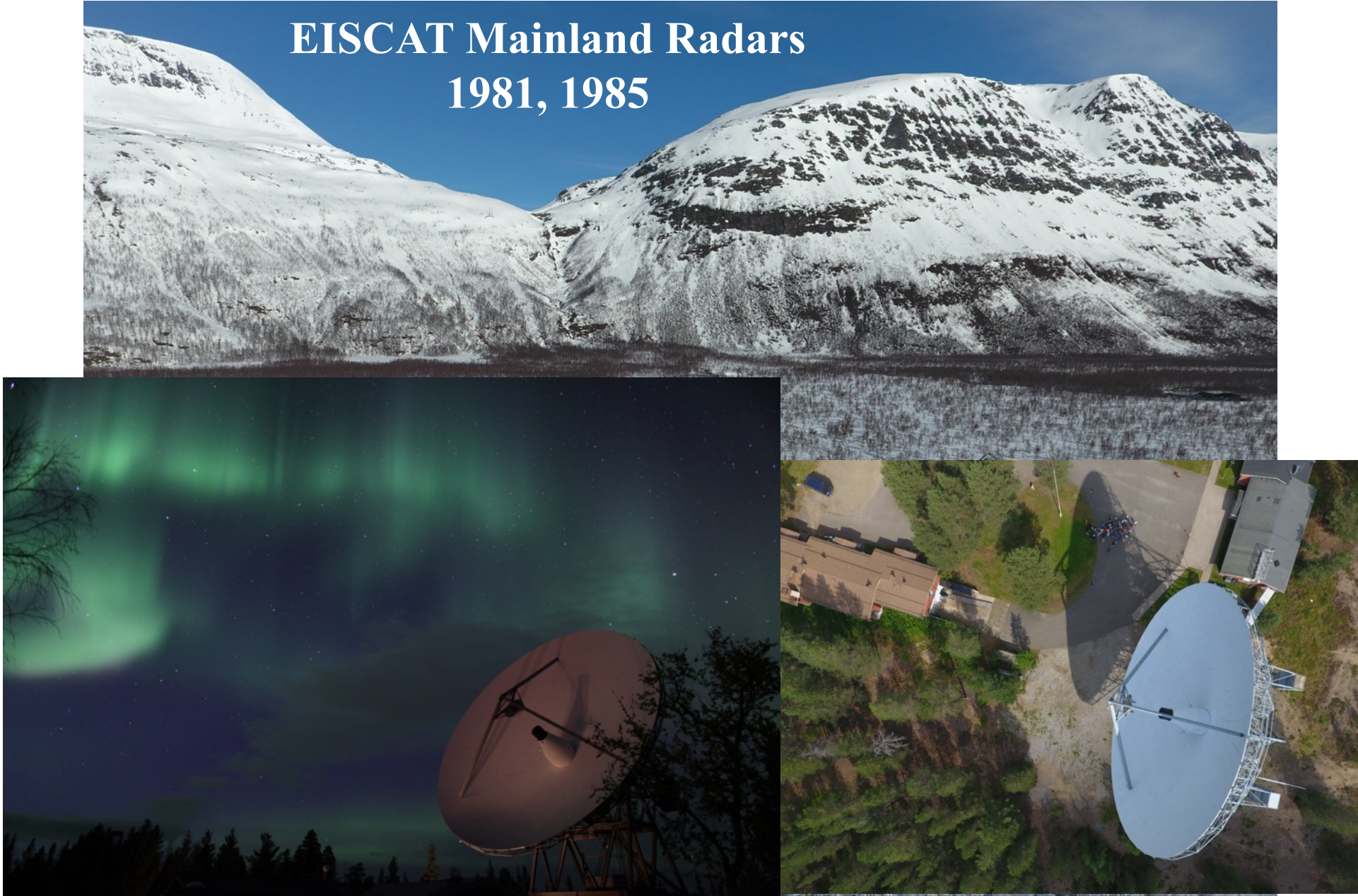


ISRs Past+Present

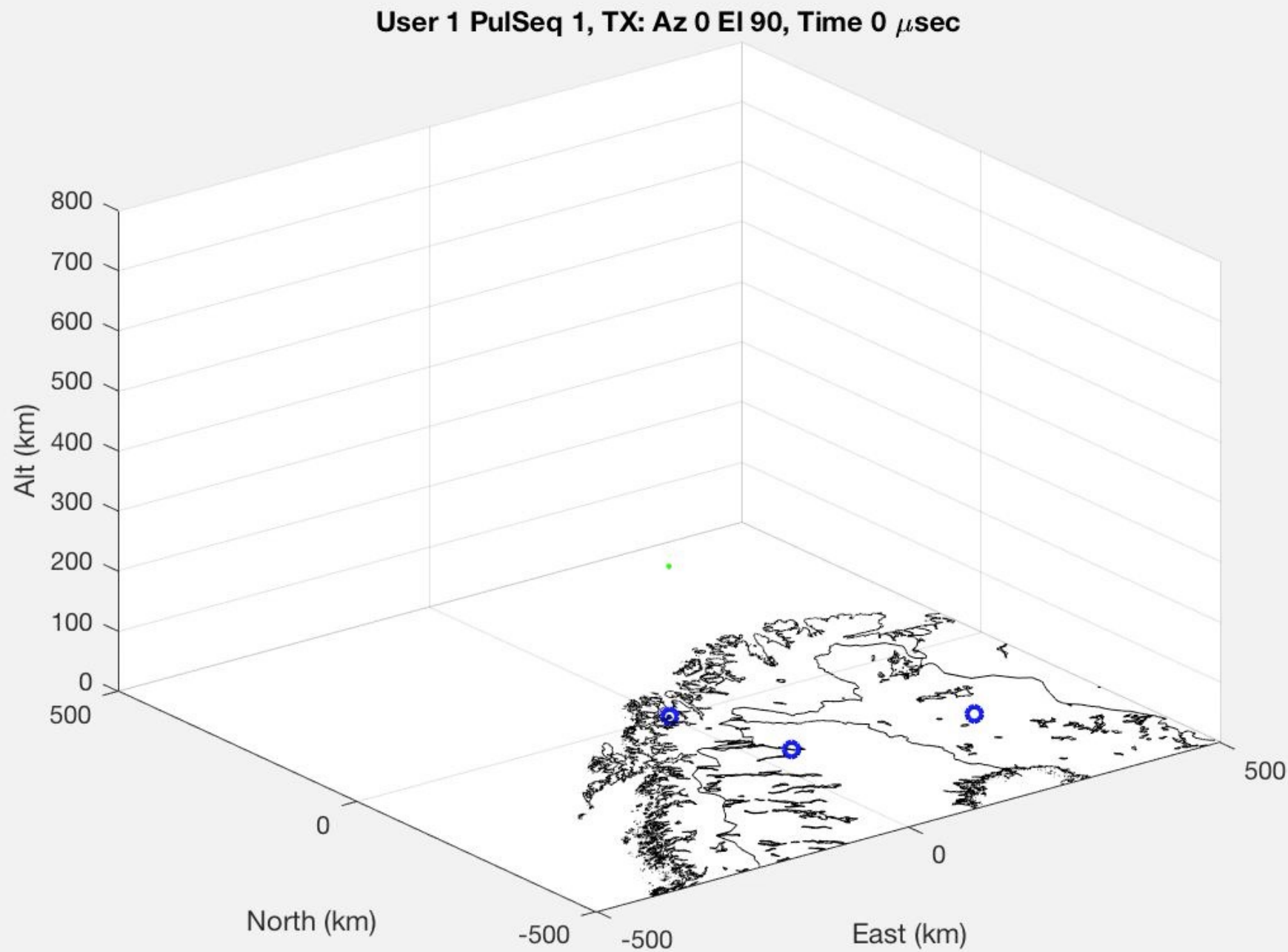


EISCAT Mainland

EISCAT Mainland Radars
1981, 1985



EISCAT Mainland



EISCAT UHF view of aurora

Power profile: 0.44 sec, 0.9 km range

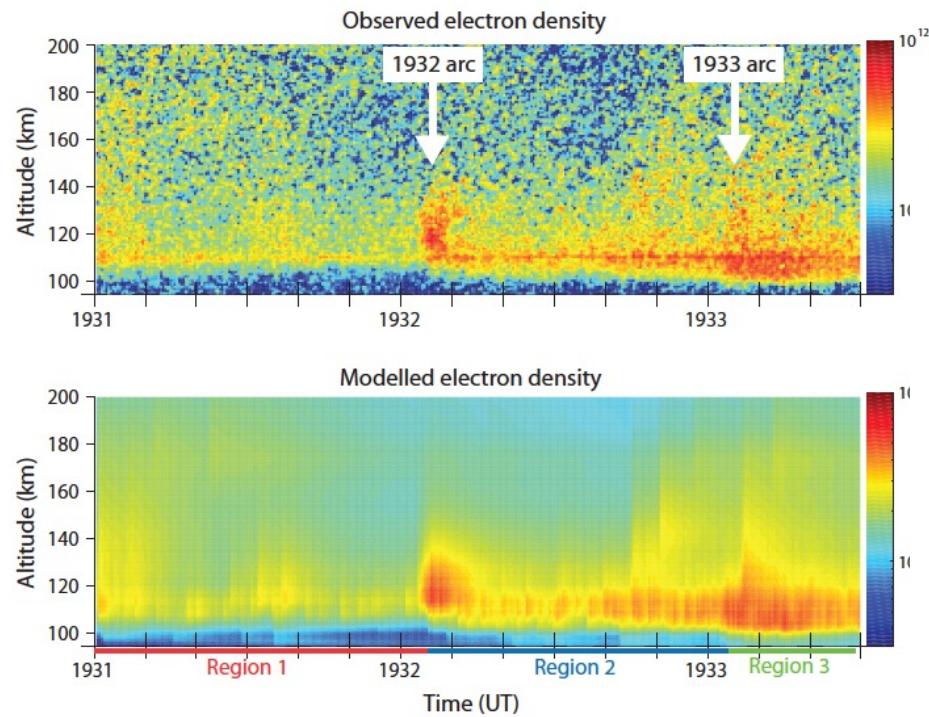


Fig. 7. Top: E-region enhancements in electron density corresponding to auroral arcs drifting over EISCAT. Bottom: modelled electron density.

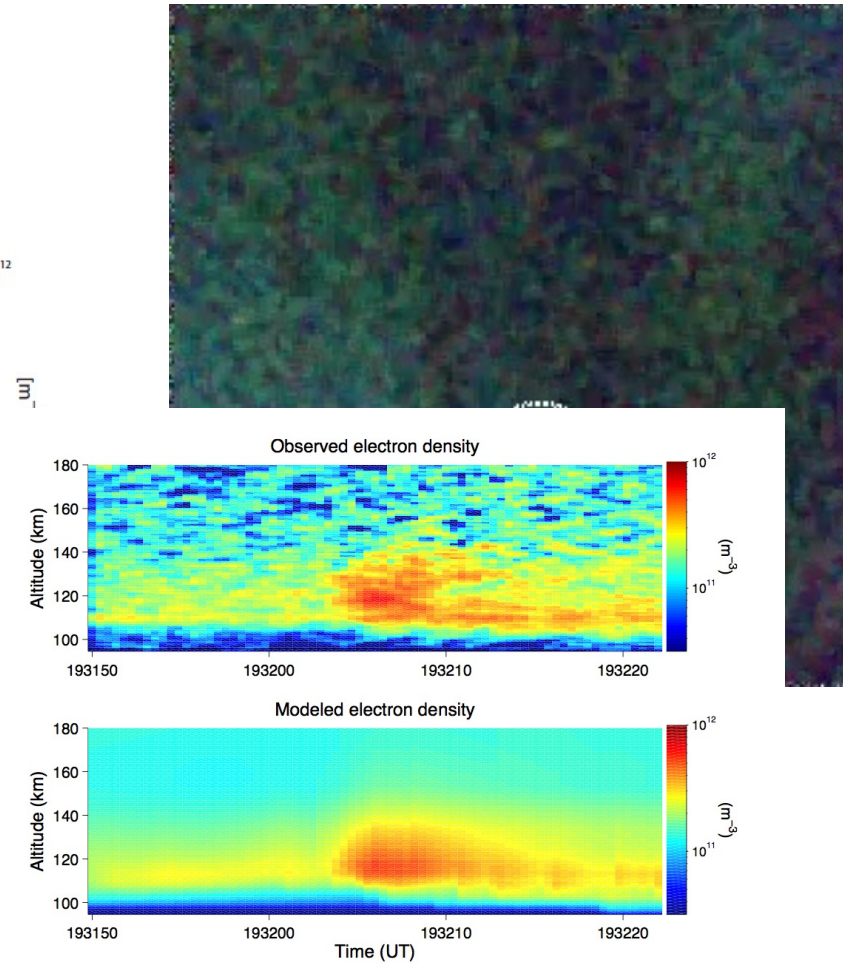


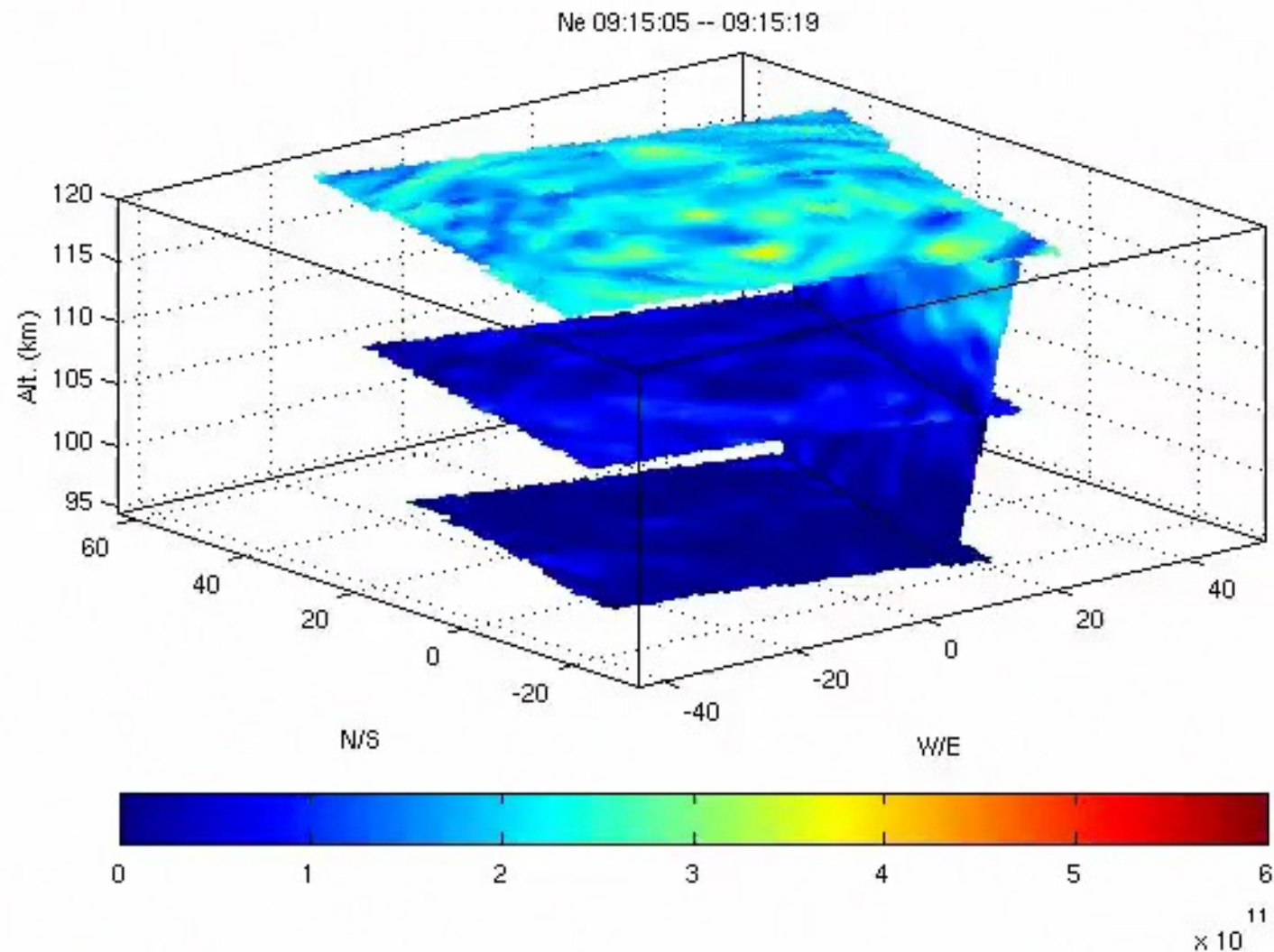
Fig. 12. Top: electron density profiles from EISCAT measurements, for the 1932 arc. Bottom: corresponding modelled electron density. The bite-out in the data at 19:32:10 UT is not reproduced by the model, and is believed to be caused by horizontal convection of plasma near the arc.

Sondrestrom view of aurora

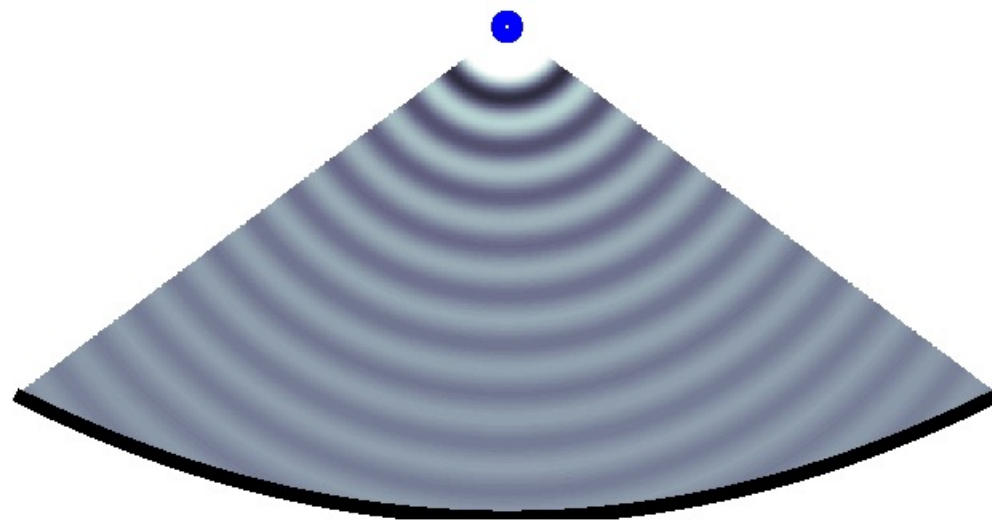


Time lapse movie by Anja Strømme

AMISR view of an aurora



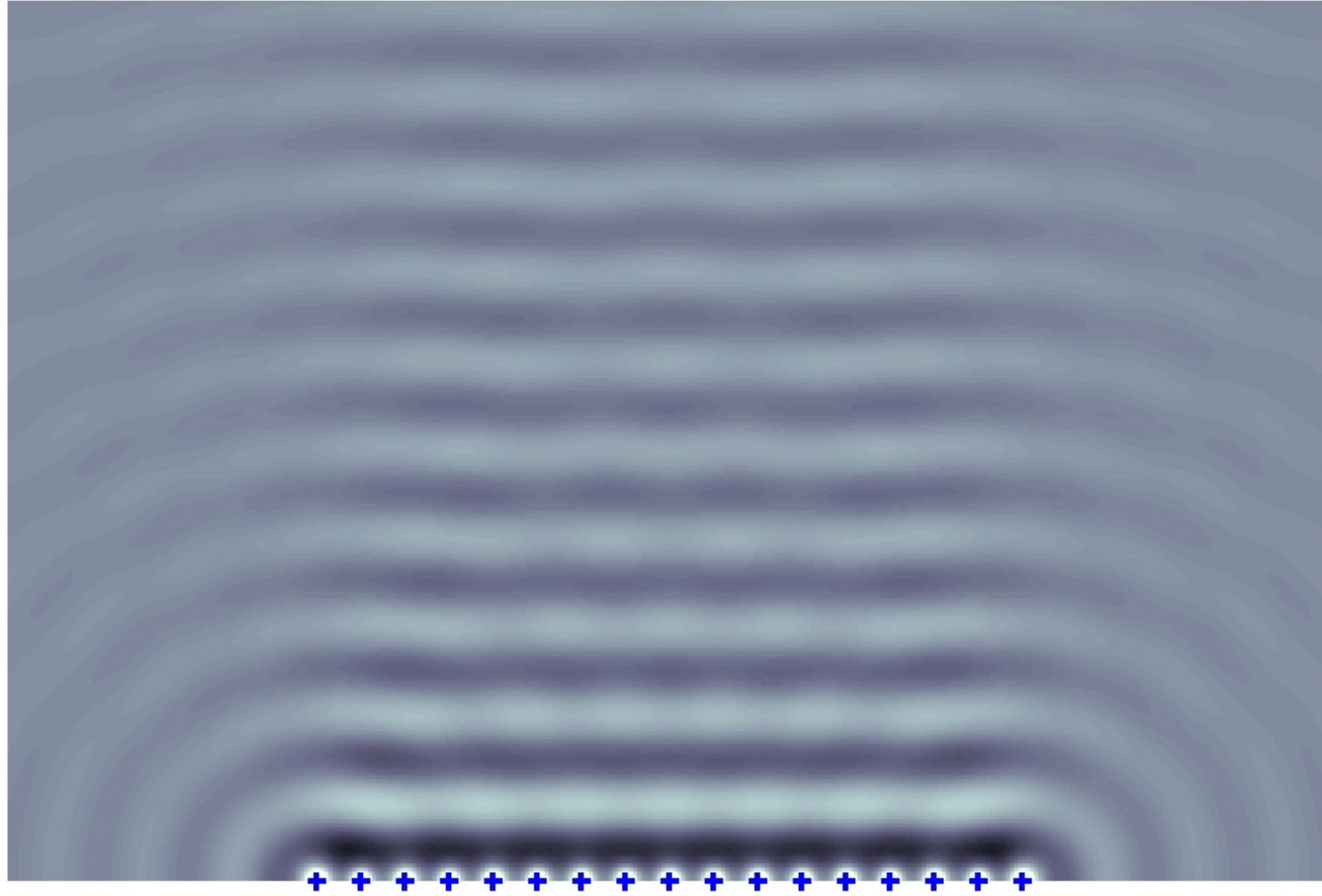
$$E_{\theta} \propto \frac{1}{r} e^{j(\omega t - k_0 r)}$$



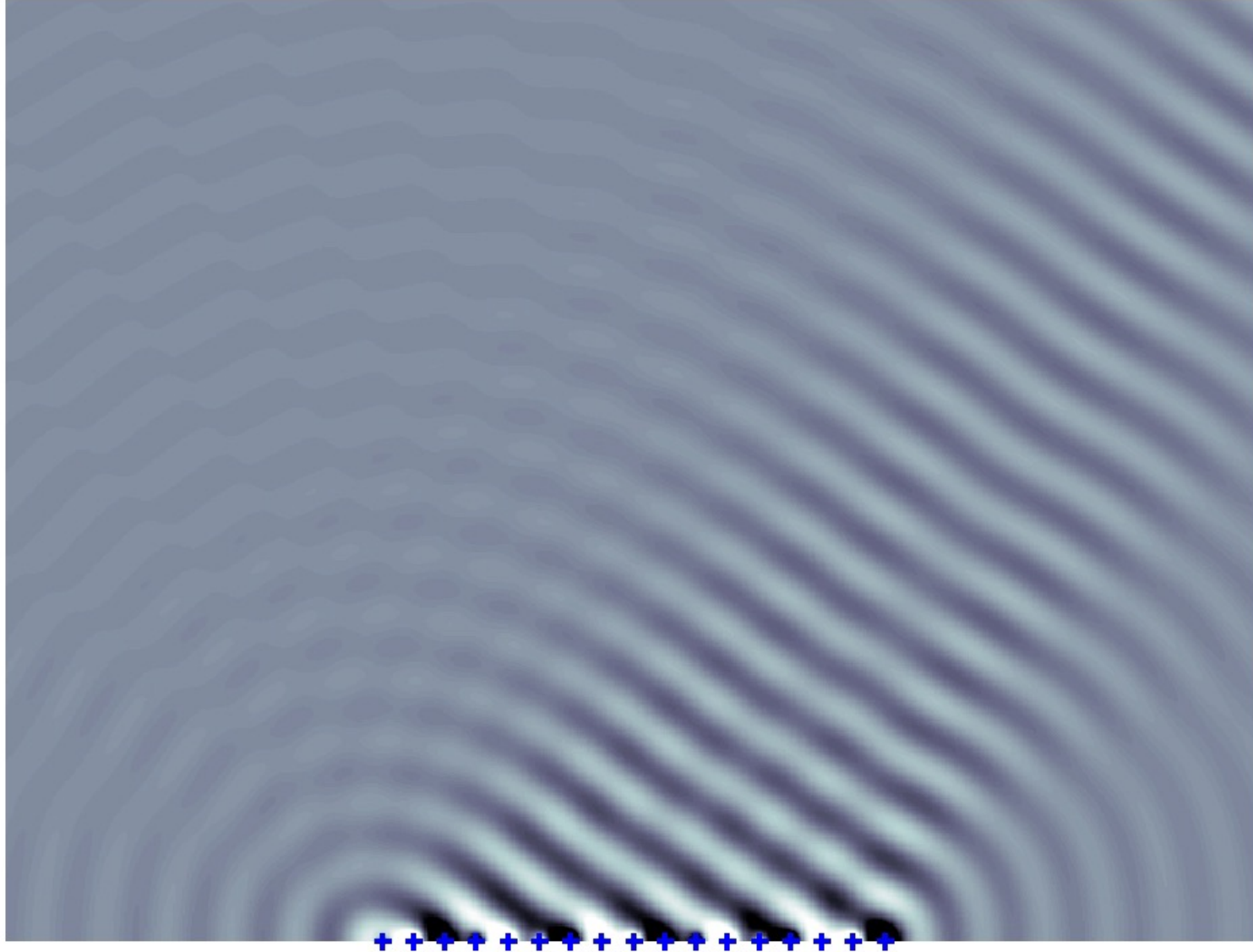
Phased Array Antennas



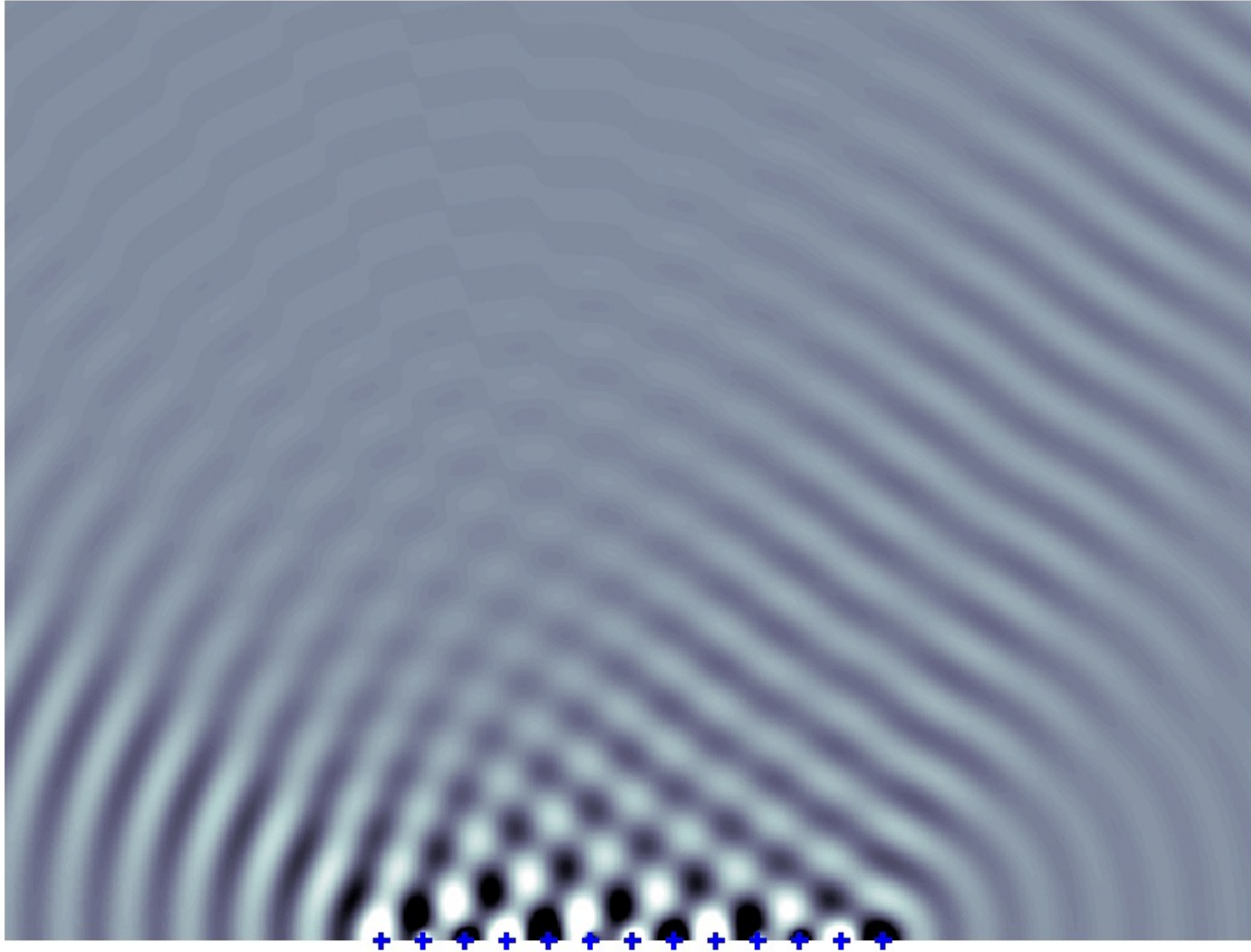
Phased Array, $\lambda/2$ spacing



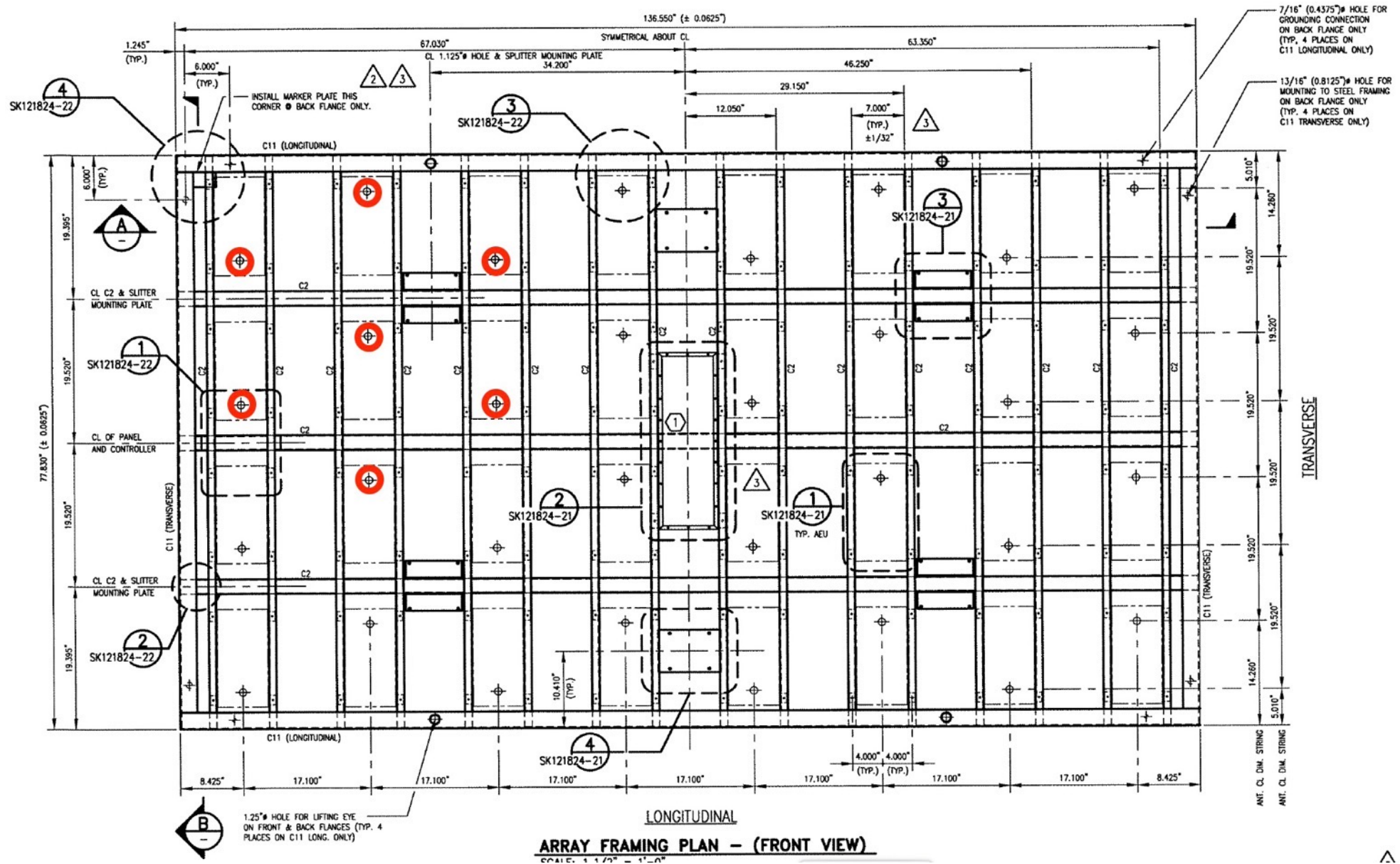
Phased Array, $\lambda/2$ spacing

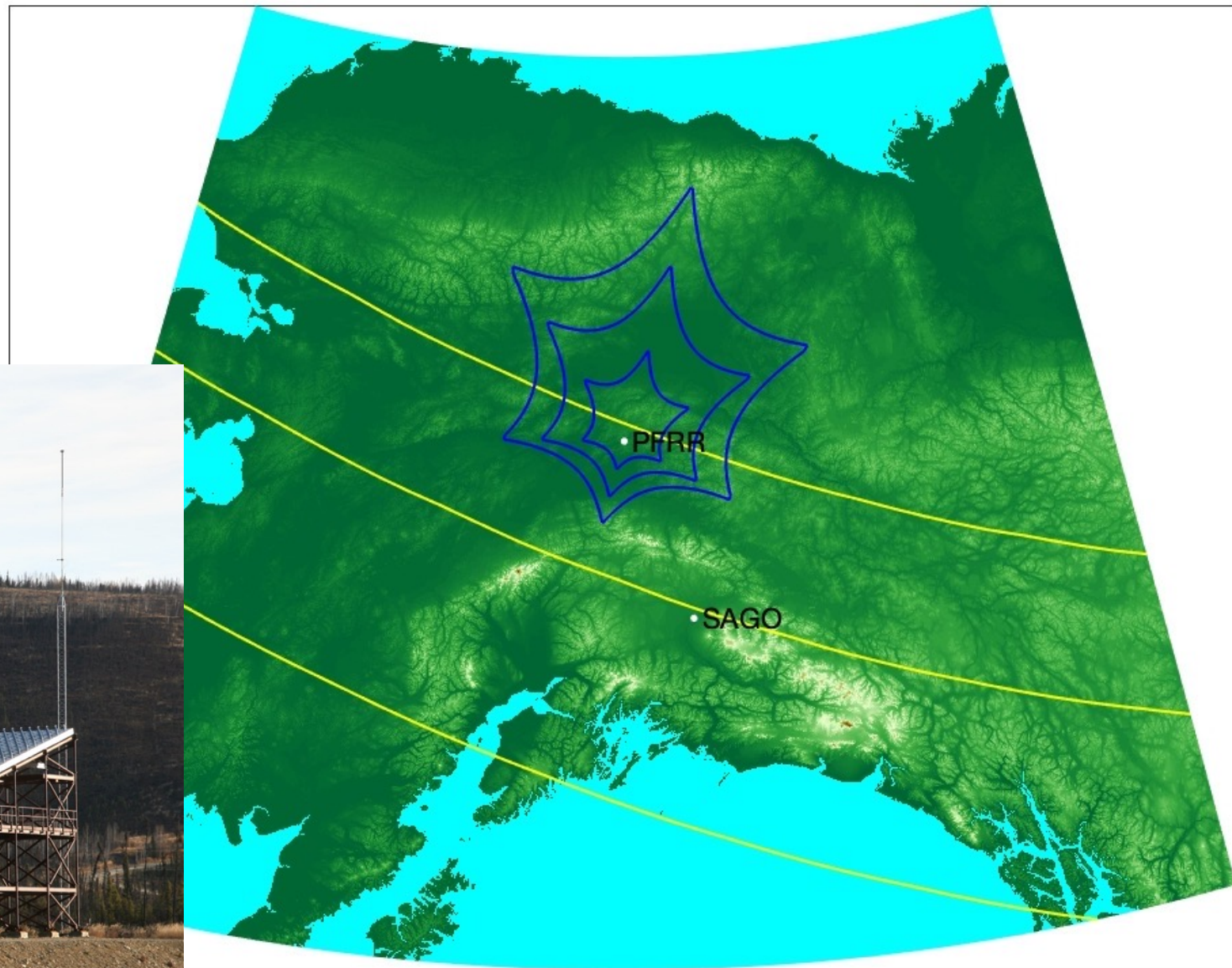


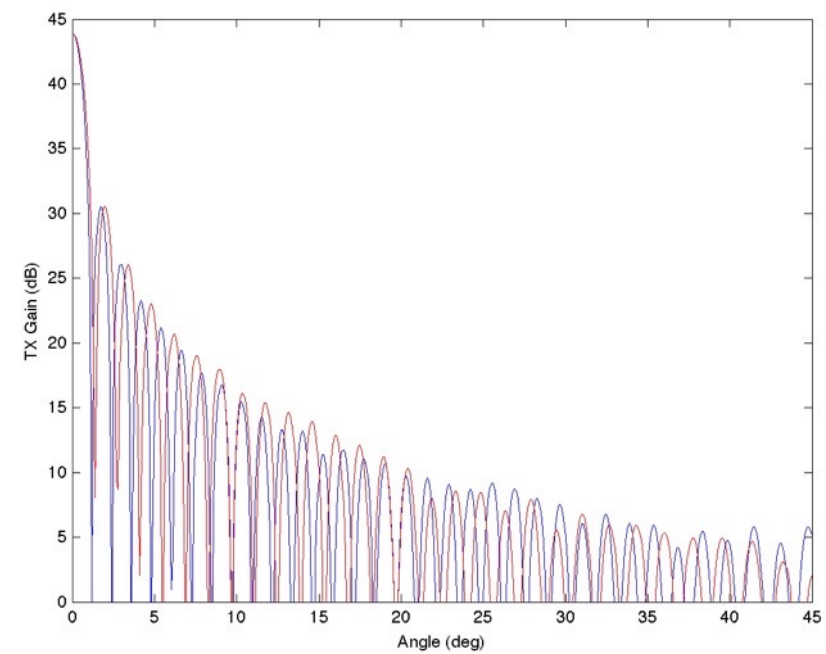
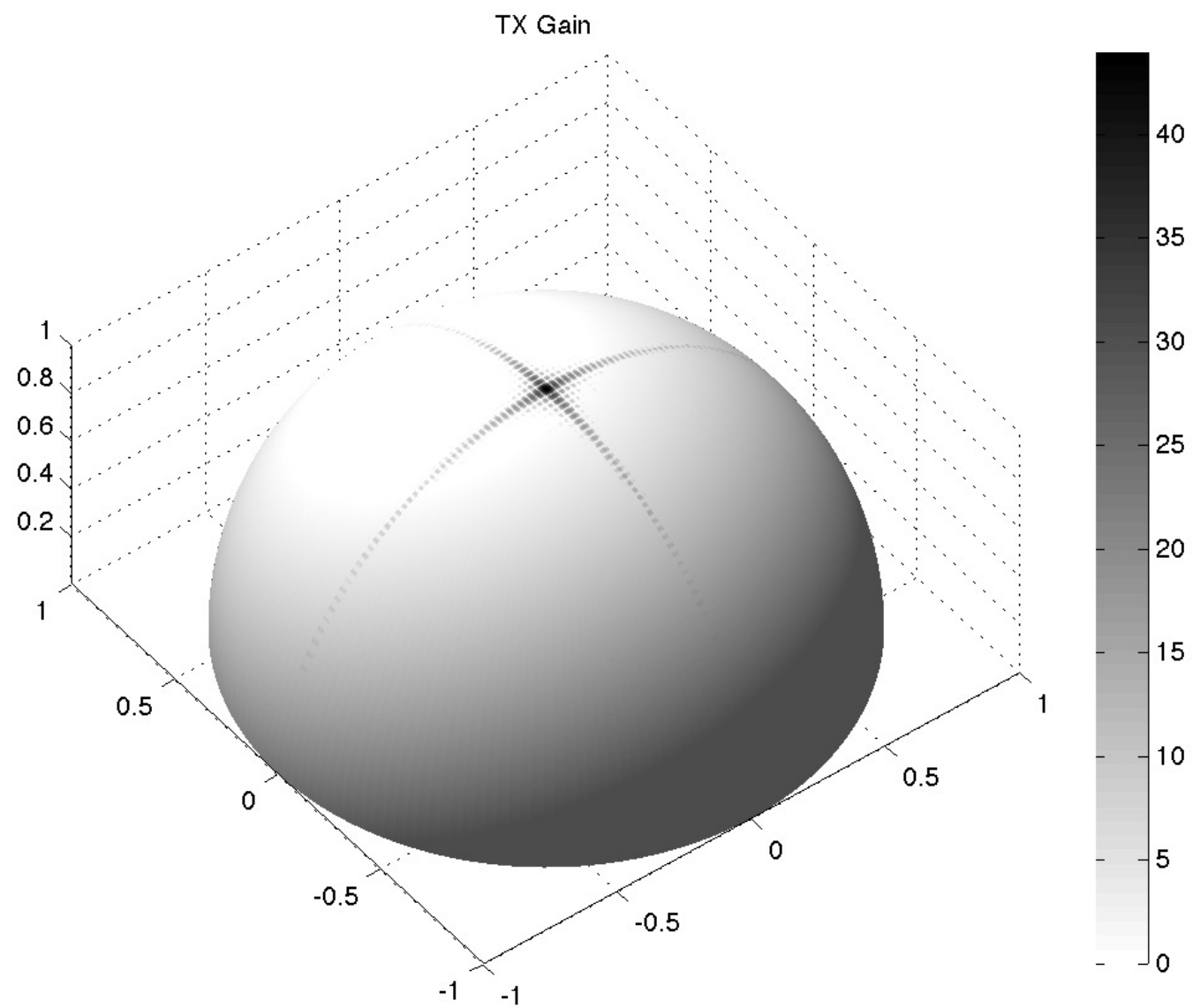
Phased Array, $2\lambda/3$ spacing

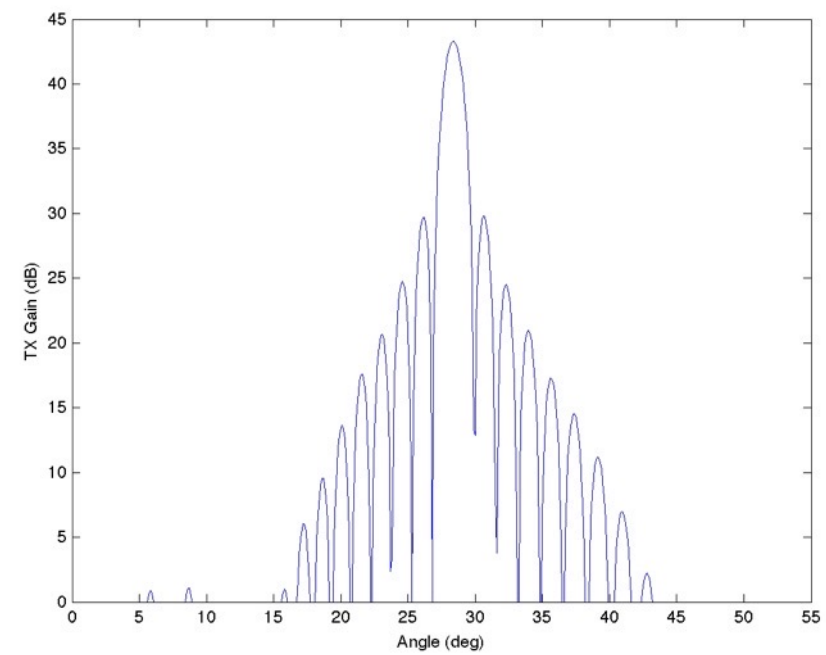
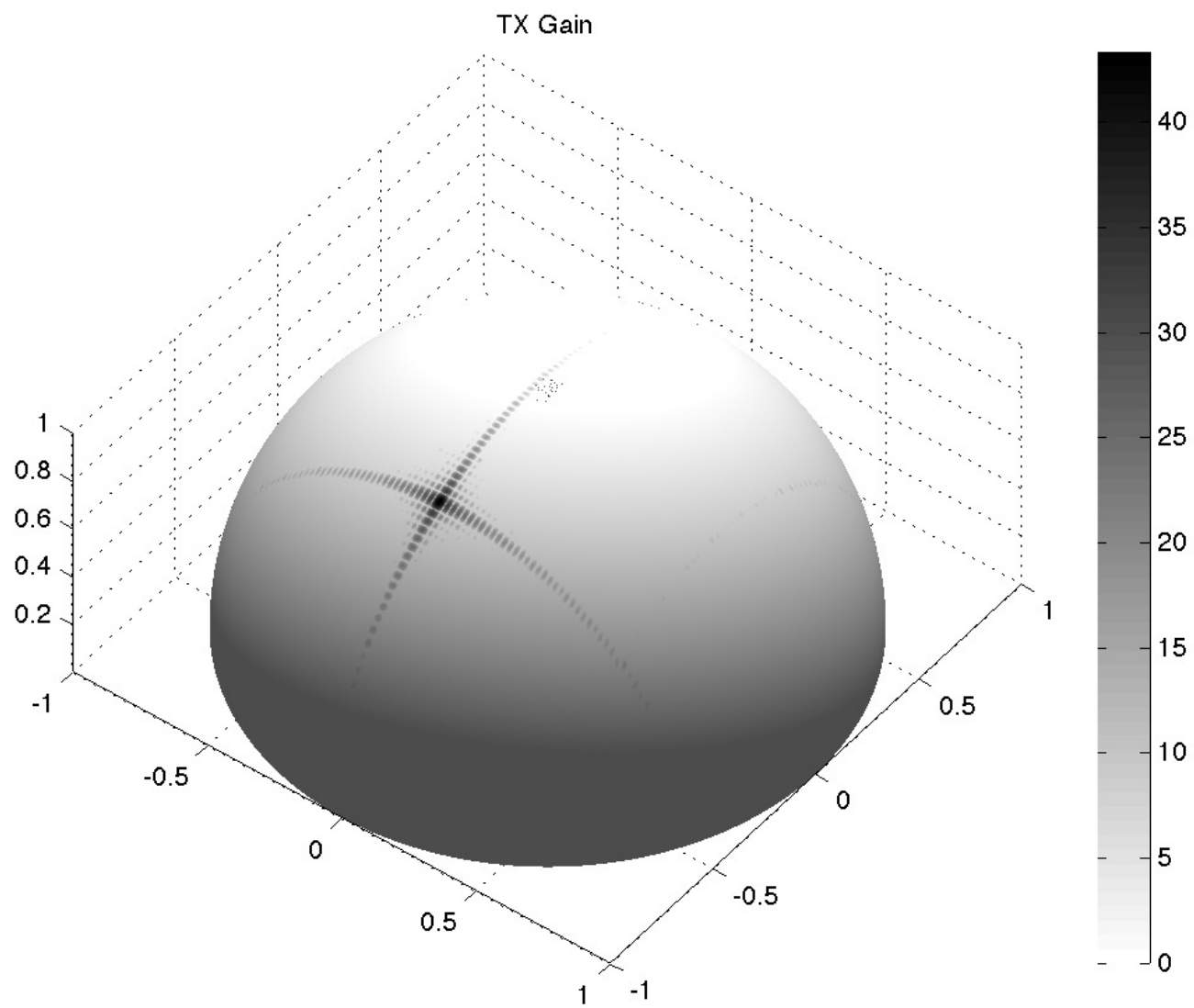


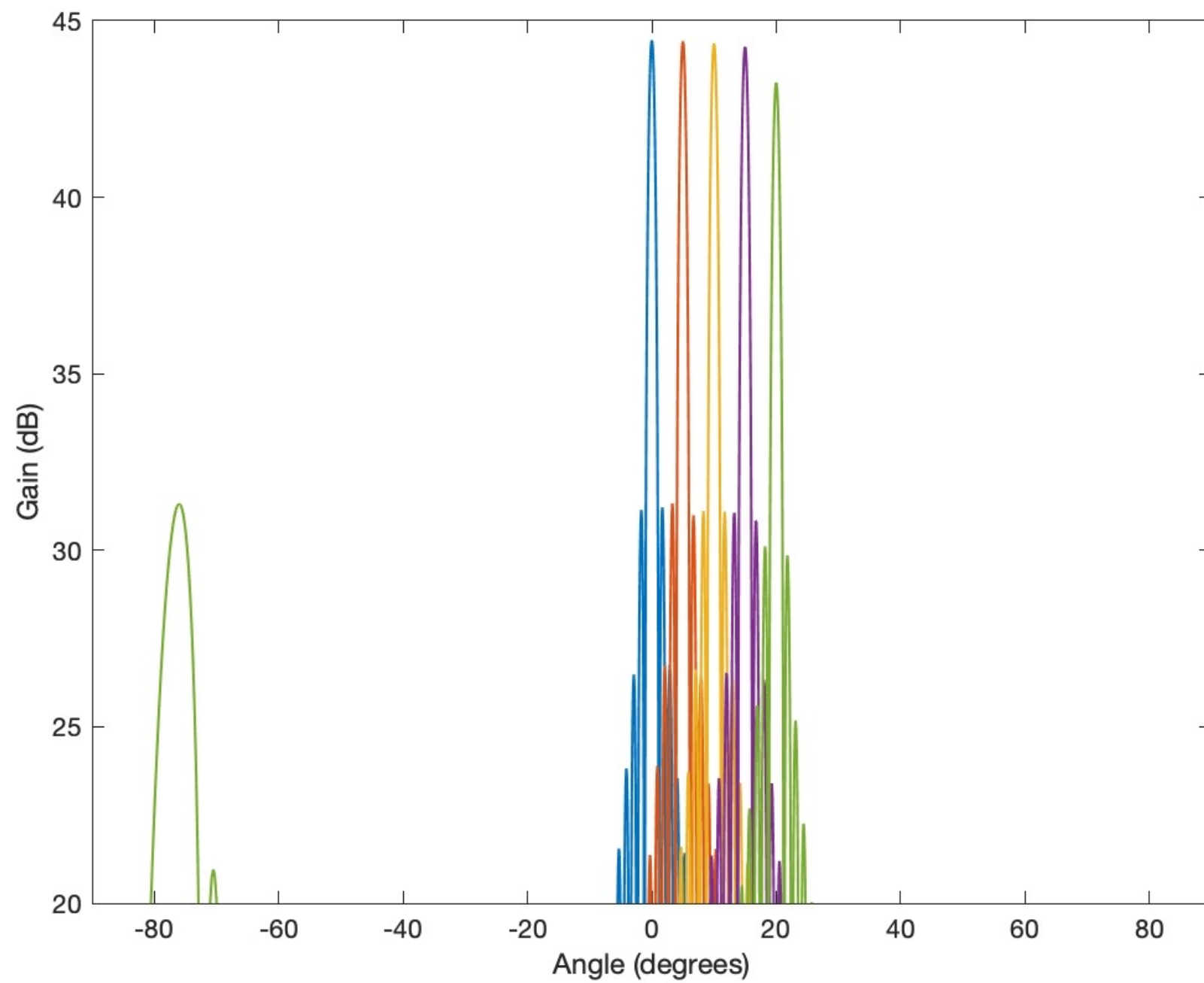
AMISR



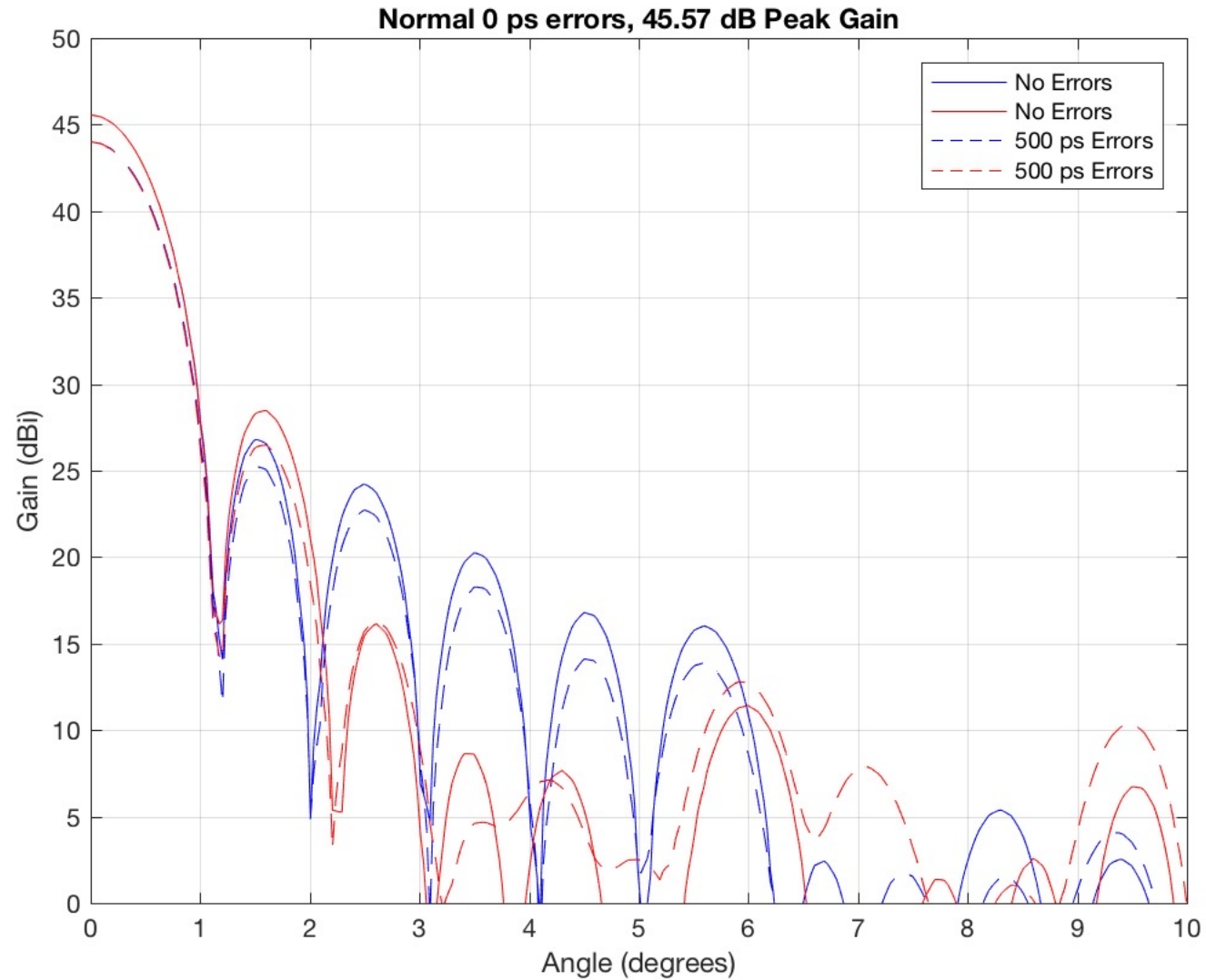




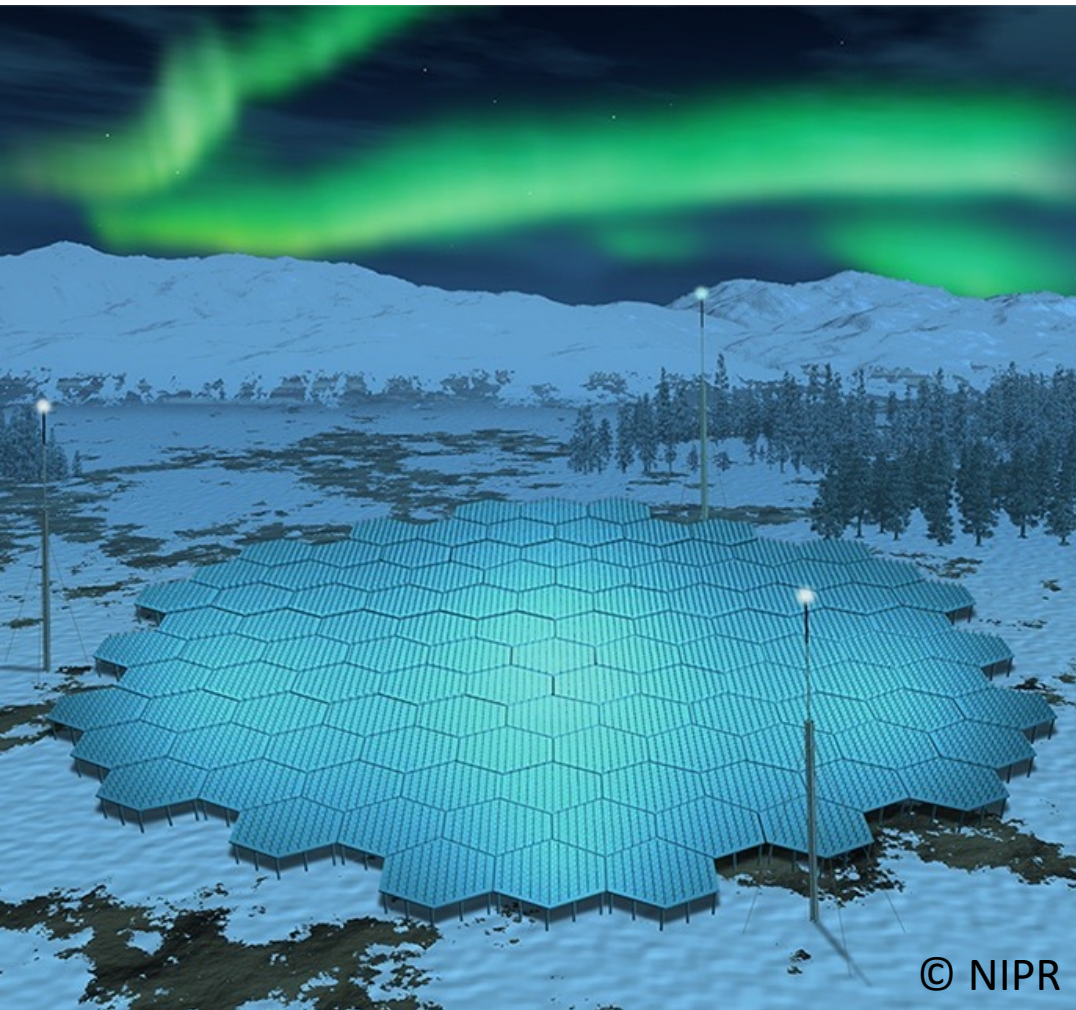




Errors in array phasing



E3D Science Case



REVIEW

Open Access



The science case for the EISCAT_3D radar

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Abstract

The EISCAT (European Incoherent SCATer) Scientific Association has provided versatile incoherent scatter (IS) radar facilities on the mainland of northern Scandinavia (the EISCAT UHF and VHF radar systems) and on Svalbard (the electronically scanning radar ESR (EISCAT Svalbard Radar) for studies of the high-latitude ionised upper atmosphere (the ionosphere). The mainland radars were constructed about 30 years ago, based on technological solutions of that time. The science drivers of today, however, require a more flexible instrument, which allows measurements to be made from the troposphere to the topside ionosphere and gives the measured parameters in three dimensions, not just along a single radar beam. The possibility for continuous operation is also an essential feature. To facilitate future science work with a world-leading IS radar facility, planning of a new radar system started first with an EU-funded Design Study (2005–2009) and has continued with a follow-up EU FP7 EISCAT_3D Preparatory Phase project (2010–2014). The radar facility will be realised by using phased arrays, and a key aspect is the use of advanced software and data processing techniques. This type of software radar will act as a pathfinder for other facilities worldwide. The new radar facility will enable the EISCAT_3D science community to address new, significant science questions as well as to serve society, which is increasingly dependent on space-based technology and issues related to space weather. The location of the radar within the auroral oval and at the edge of the stratospheric polar vortex is also ideal for studies of the long-term variability in the atmosphere and global change. This paper is a summary of the EISCAT_3D science case, which was prepared as part of the EU-funded Preparatory Phase project for the new facility. Three science working groups, drawn from the EISCAT user community, participated in preparing this document. In addition to these working group members, who are listed as authors, thanks are due to many others in the EISCAT scientific community for useful contributions, discussions, and support.

Keywords: EISCAT; EISCAT_3D; Radar; Incoherent scatter; Atmospheric science; Space physics; Plasma physics; Solar system research; Space weather; Radar techniques

Key features

- Tri-static phased array
 - ~10,000 crossed dipoles at the transmitter site
 - ~5,000 crossed dipoles at the receiver sites (upgradable to 10,000)
- Sensitivity >10x that of present EISCAT systems
- Full polarization control on transmit and receive
- Full steering to 30 deg elevation angle
- Multiple simultaneous beams on reception
- More than 2 MHz transmitter bandwidth (up to 5 MHz if possible)
- More than 20 MHz receiver bandwidth
- Interferometric imaging at the transmitter location
- Center frequency of 233 MHz
- Peak power ~3.5 MW initially with expansion to 10 MW (depending on future funding)

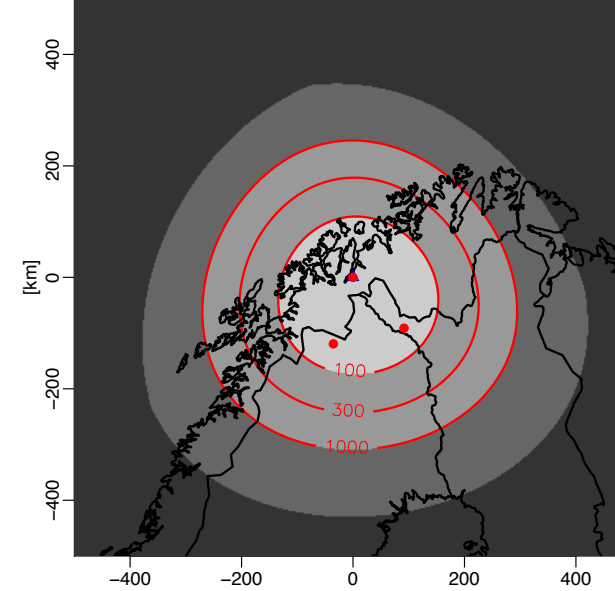
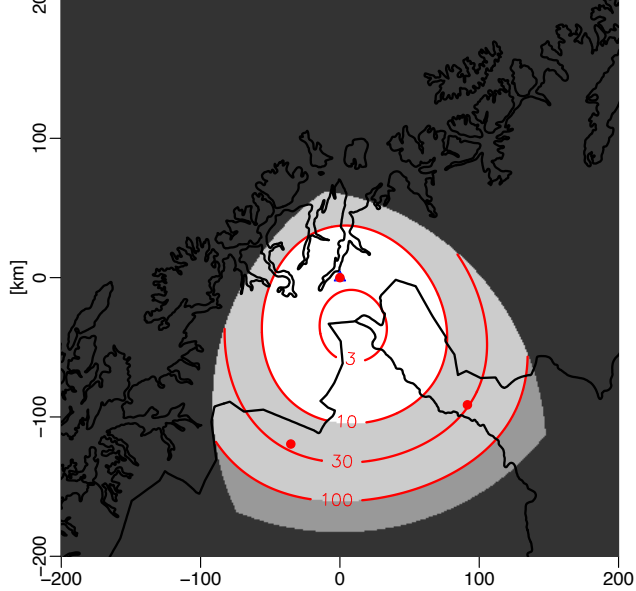
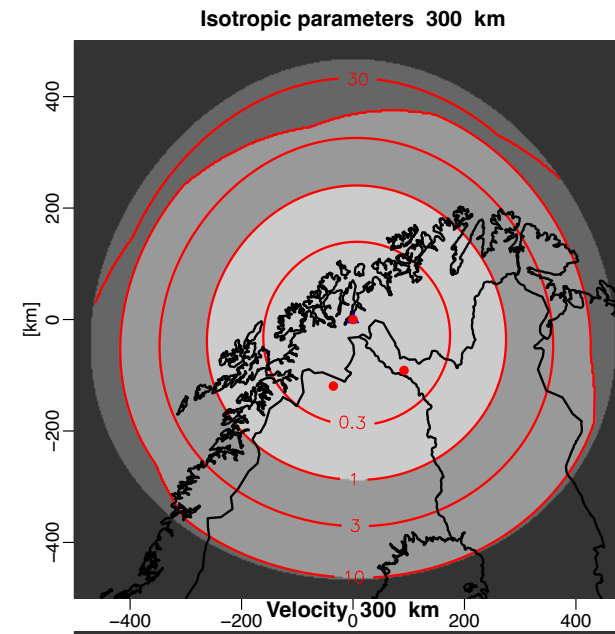
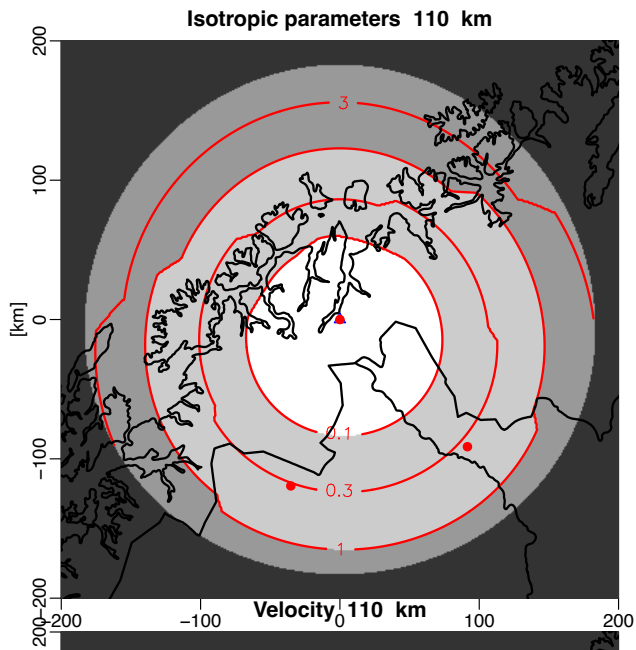


Tri-static Radar (unambiguous velocities)

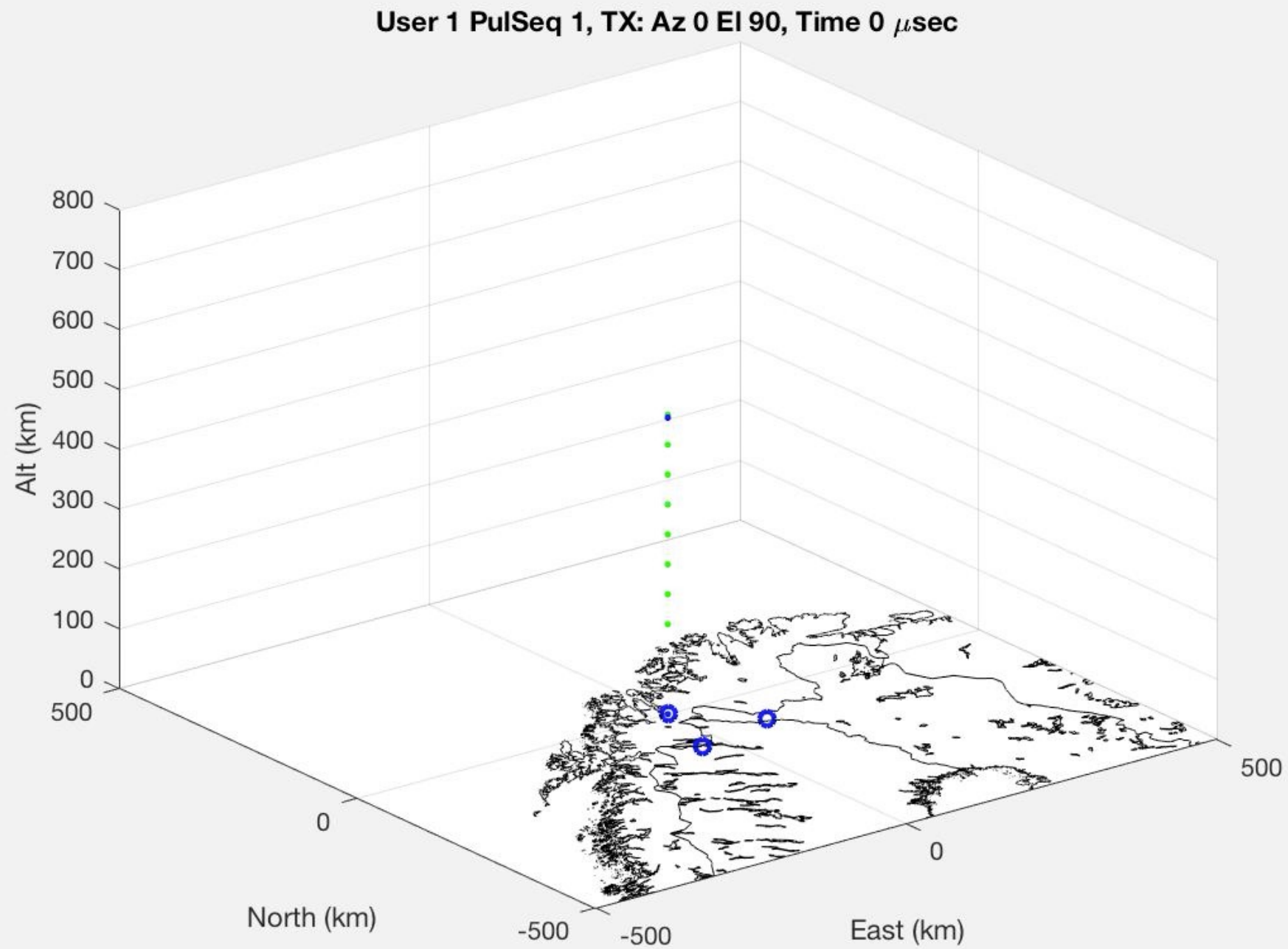


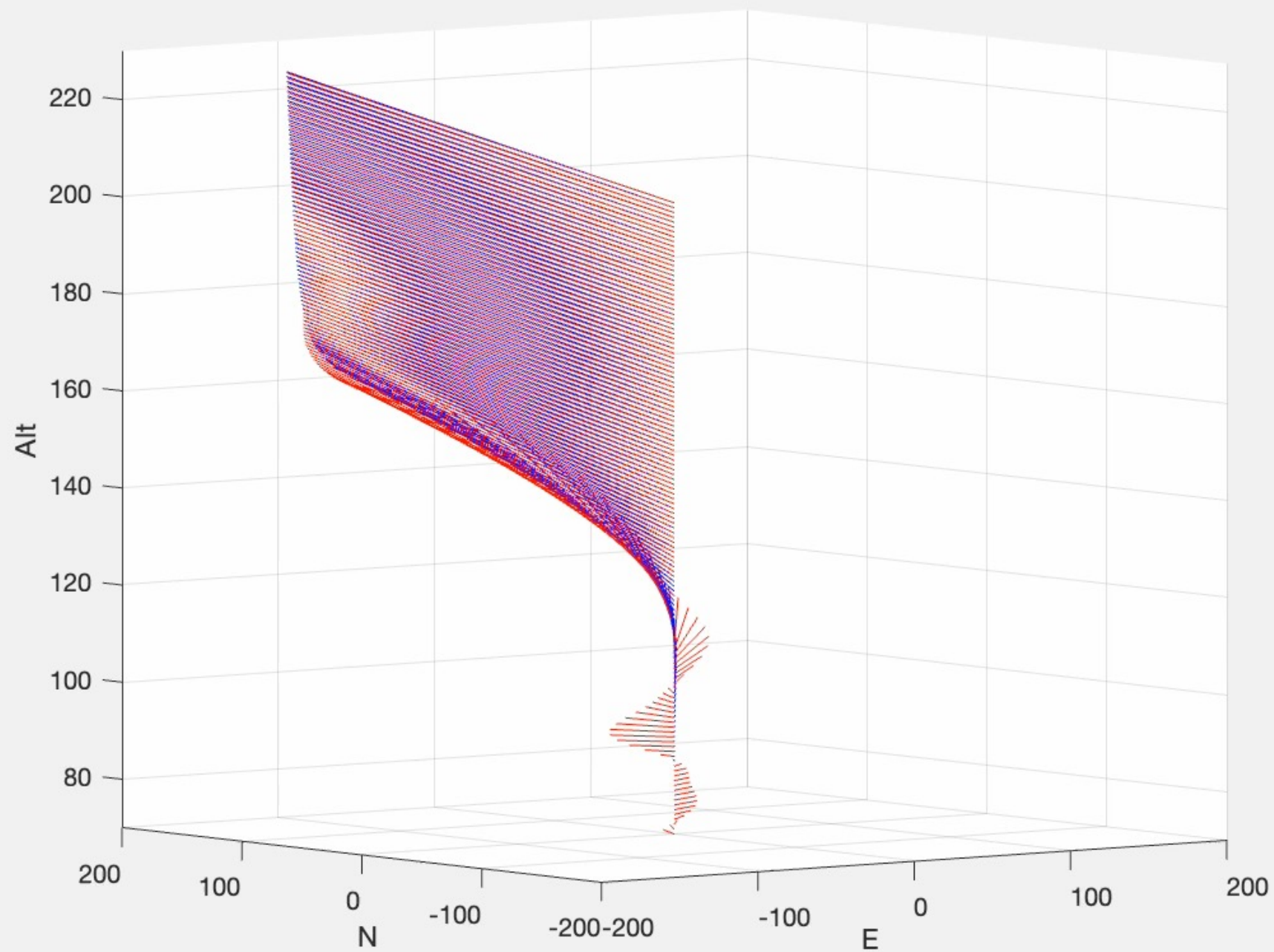
SENSITIVITY

(INTEGRATION TIMES FOR 5% ERRORS UNDER 'NORMAL' IONOSPHERIC CONDITIONS)

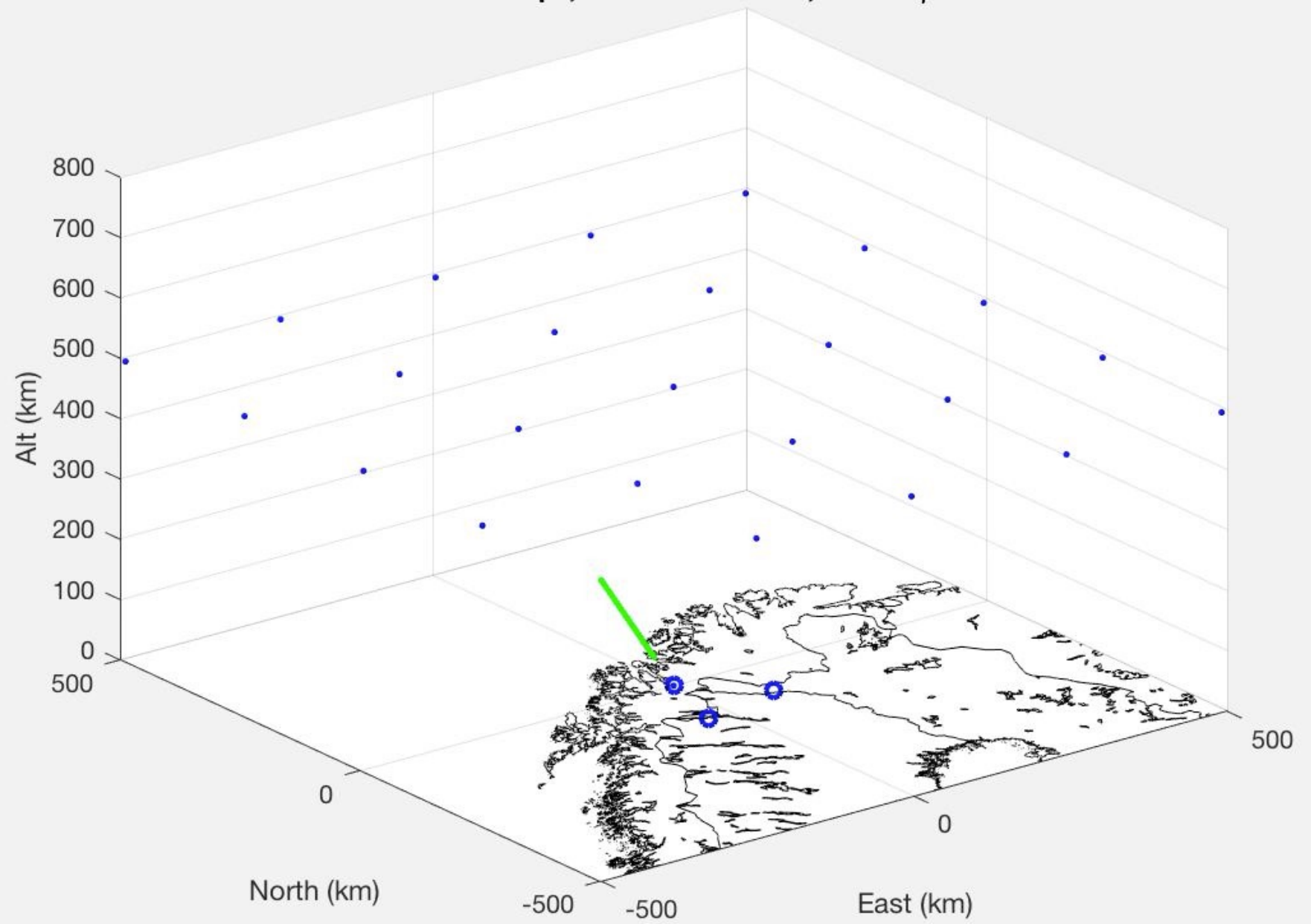


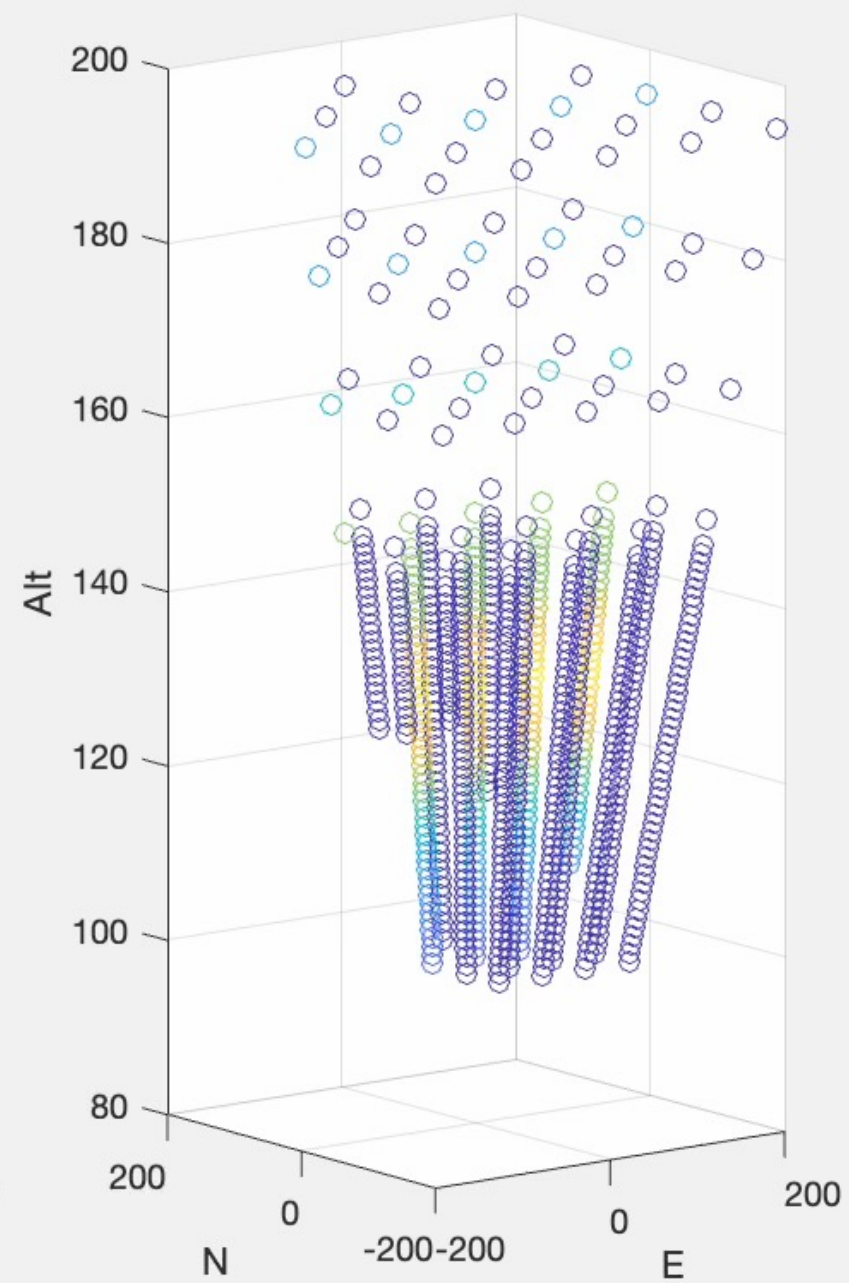
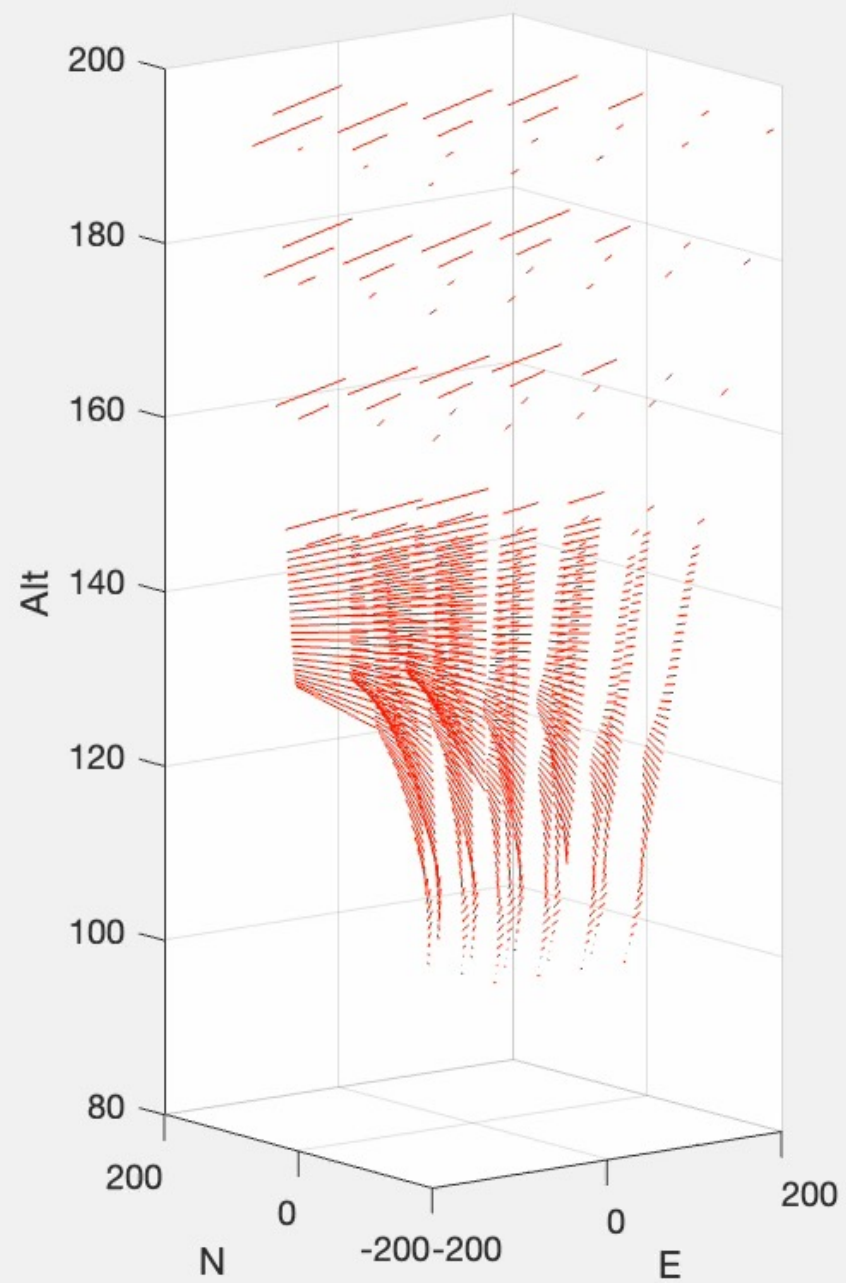
Tri-static



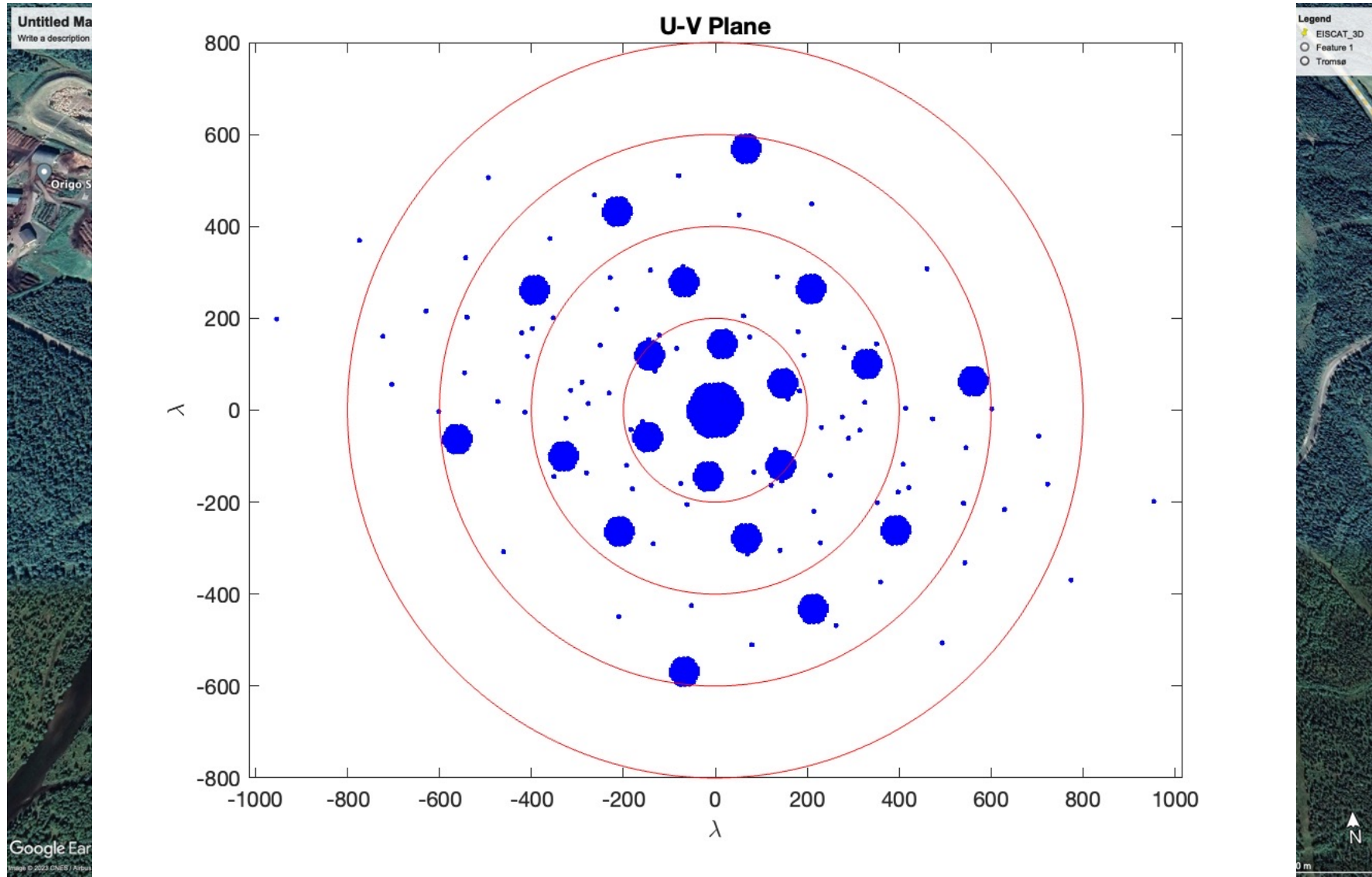


User 1 PulSeq 1, TX: Az -135 El 35, Time 0 μ sec





Interferometric Imaging



What does it take to build EISCAT_3D?



Skibotn was a challenging site to prepare



AU PRODUCTION



Movie by ECRIEE

FSRU PRODUCTION



FSRU serial production



Lower: FSRU testbench used during serial production

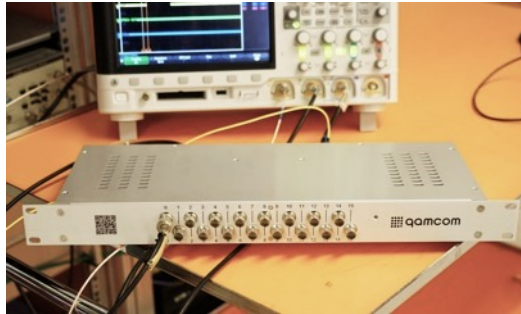
Photos by DA-Design

SAT PRODUCTION



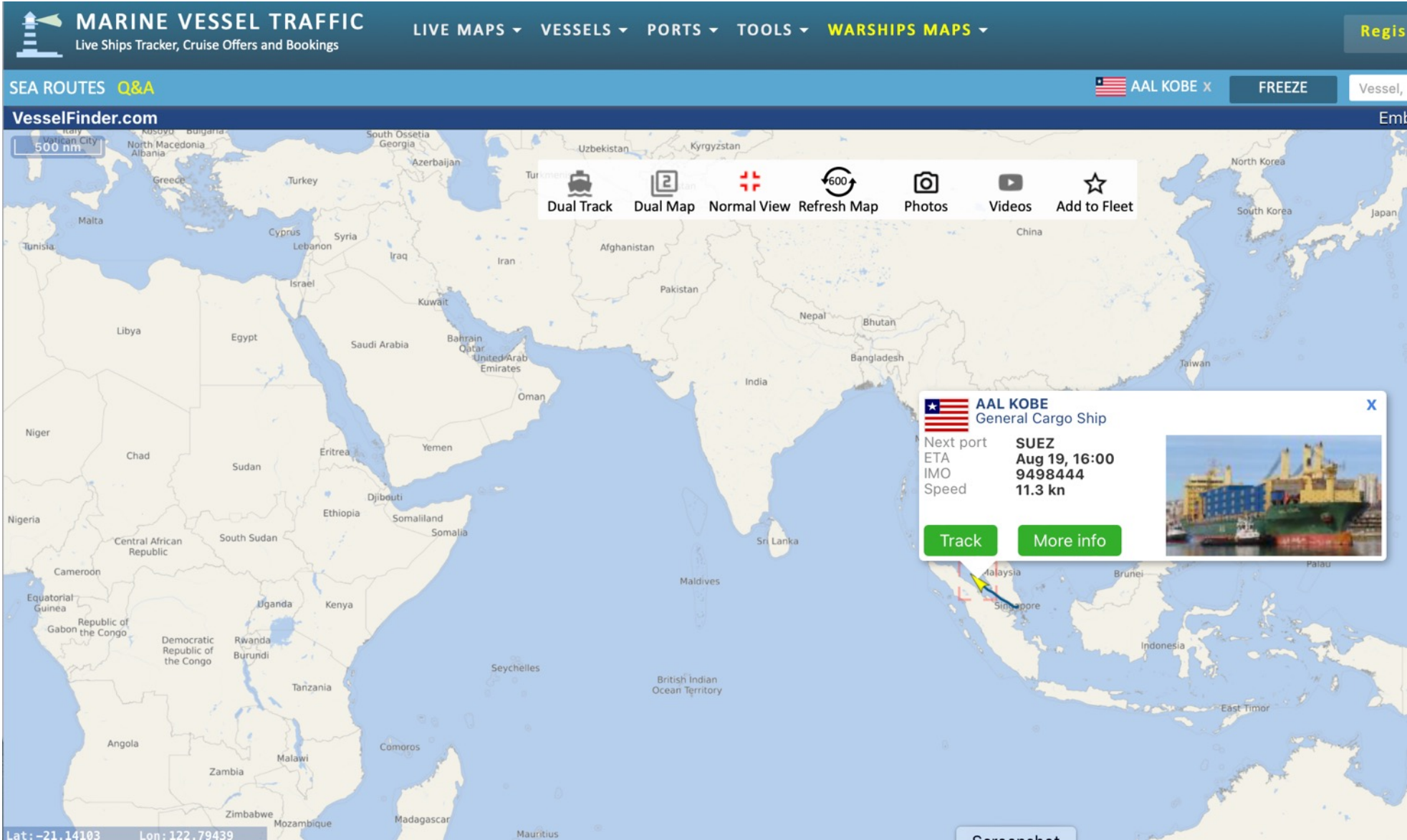
Photos by DA-Design

PSCU PRODUCTION AND DELIVERY



One PSCU unit has 16 channels that provide the analogue input signal for 16 SSPAs
All 444 PSCUs are delivered and stored in EISCAT facilities, Ramfjordmoen.

AU SHIPMENT



Antennas took a long trip to northern Norway



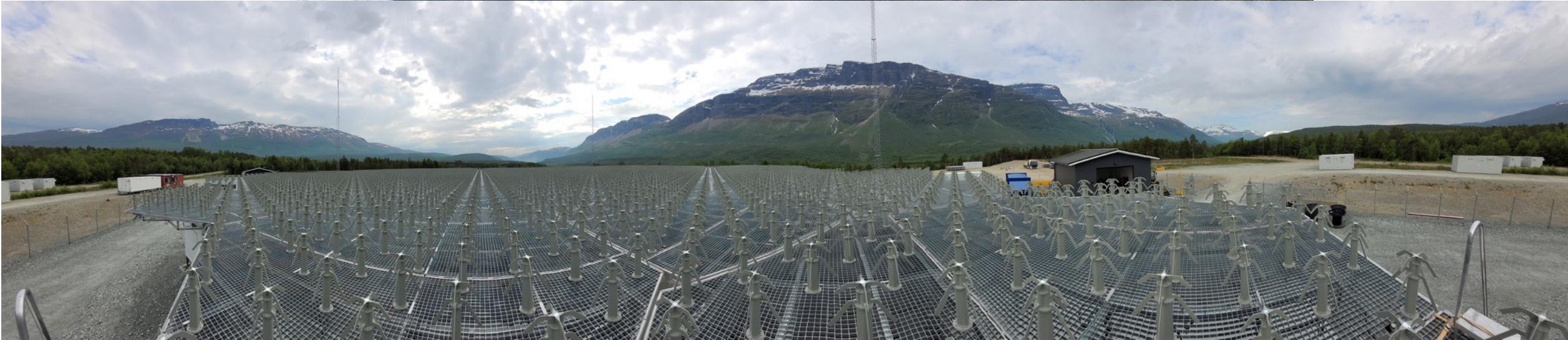
The last few hundred kilometers done!



Kaiseniemi assembly required fortitude (and warm jackets)



EISCAT_3D Skibotn, Norway

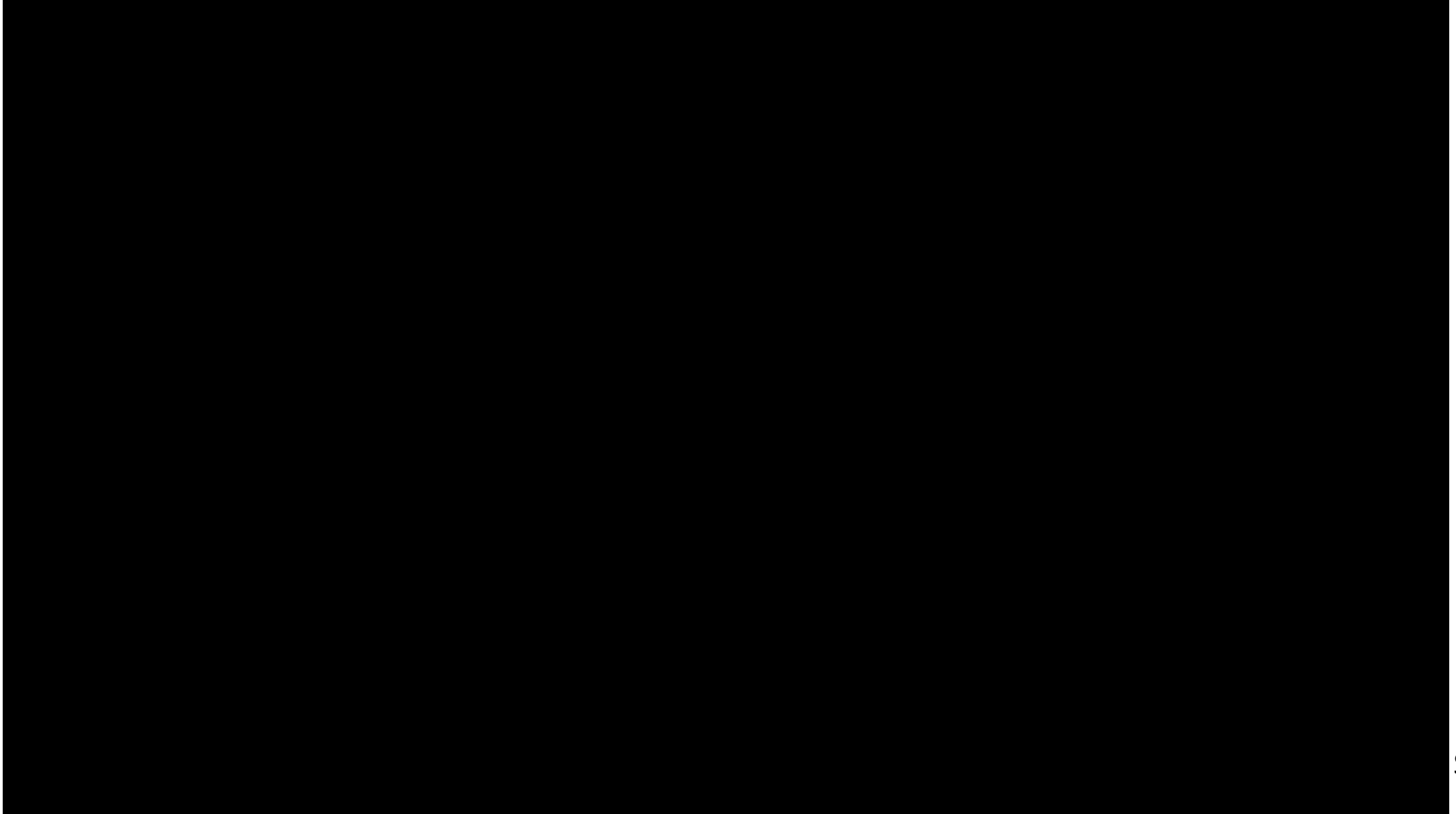


20 June 2023

Photo by Johan Svensson

10 May 2023

EISCAT_3D Karesuvanto, Finland



Status

- Skibotn, Norway
 - Antenna Units (AUs) installed
 - Power and fiber to Antenna Units installed
 - Site buildings in place
 - Awaiting permits to take the site into use (ground stability issues to be resolved)
- Kaiseniemi, Sweden
 - AUs installed
 - Power and fiber to AUs installed
 - Site buildings in place
 - Test AU is on-site
- Karesuvanto, Finland
 - AUs installed
 - Power and fiber to AUs installed
 - Site buildings in place



<https://heinselslug.smugmug.com/Professional/Meetings/ISR-School-2025-Fairbanks>