Advanced Phased Array EISCAT_3D

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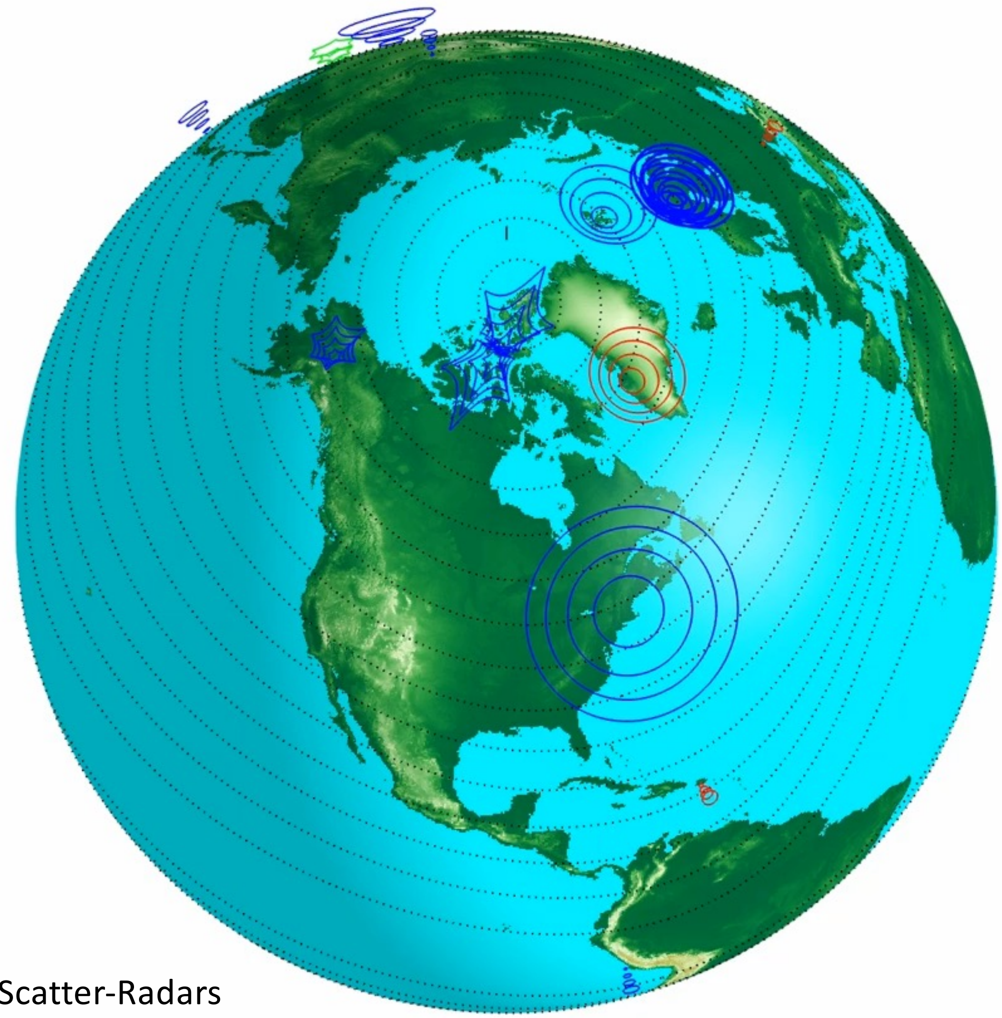
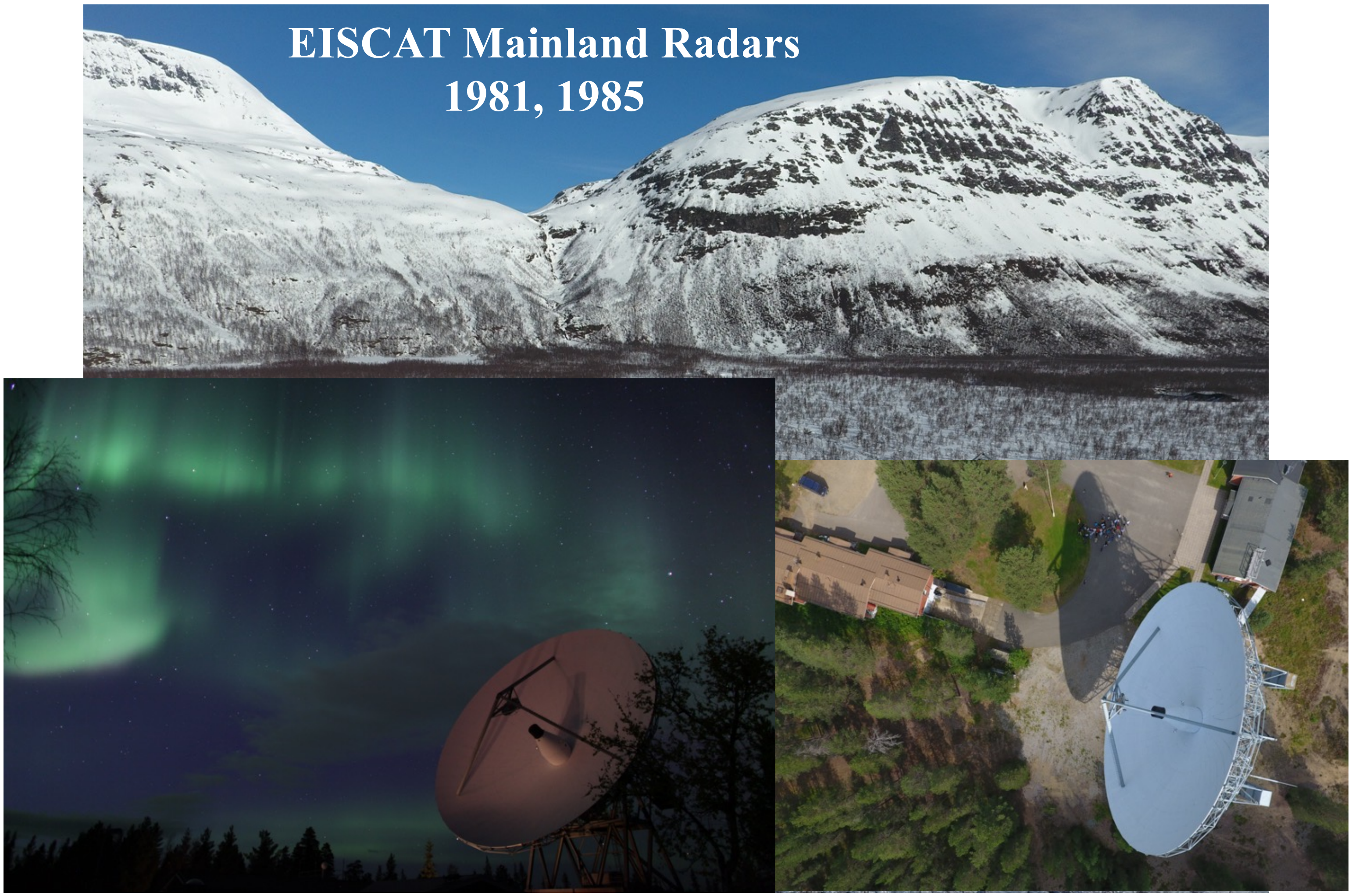
University of Alaska Fairbanks

ISRs Past+Present

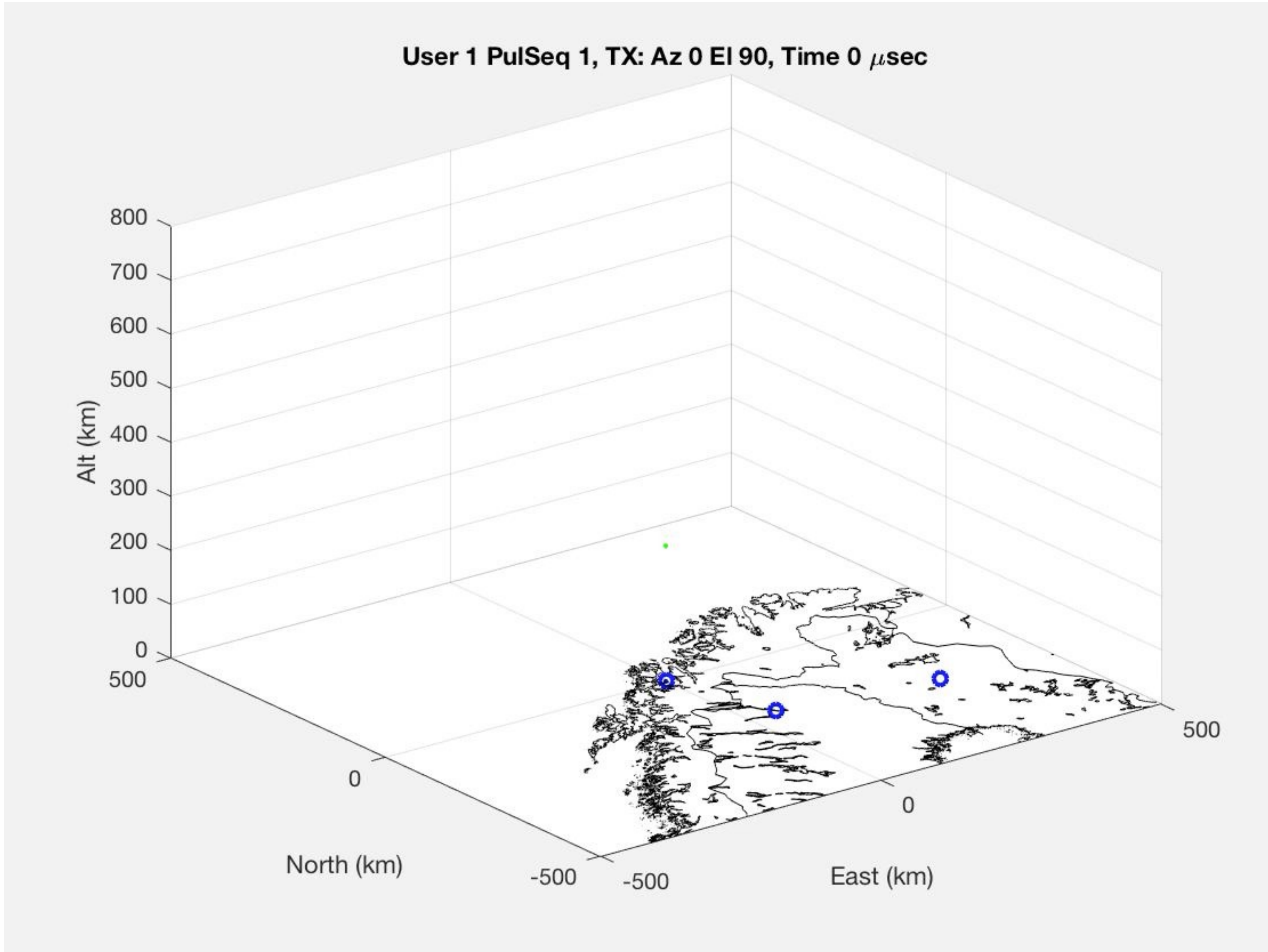
https://heinselslug.smugmug.com/Professional/Incoherent-Scatter-Radars



EISCAT Mainland



EISCAT Mainland



EISCAT UHF view of aurora

Power profile: 0.44 sec, 0.9 km range

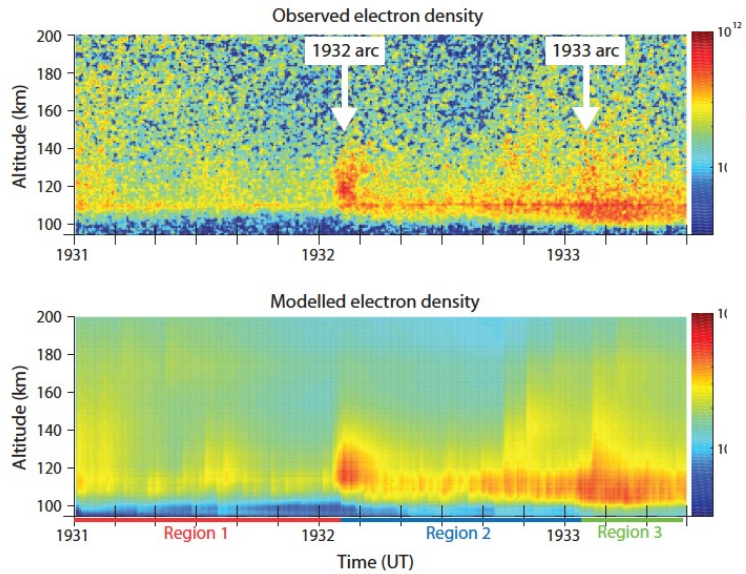
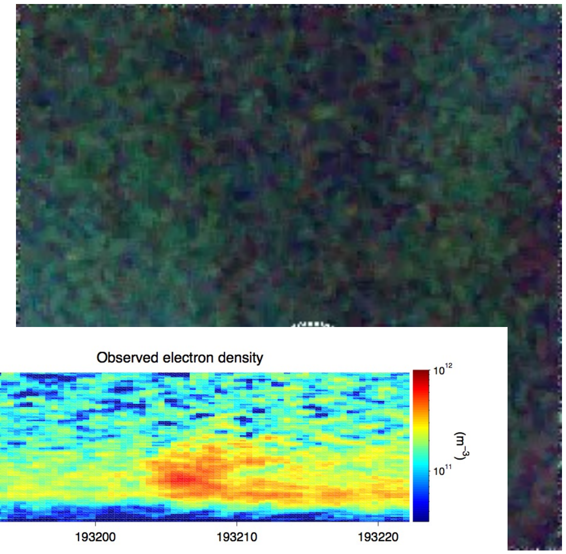


Fig. 7. Top: E-region enhancements in electron density cc sponding to auroral arcs drifting over EISCAT. Bottom: mode electron density.



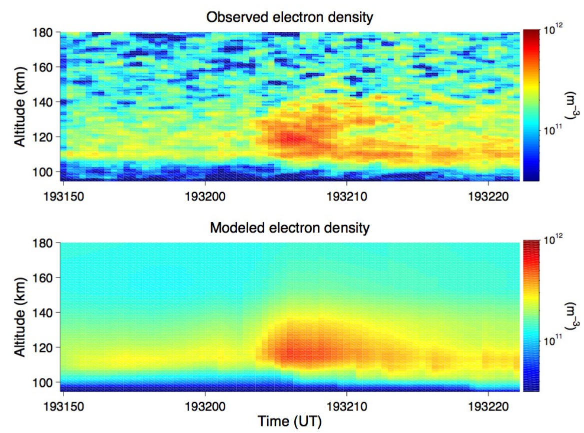
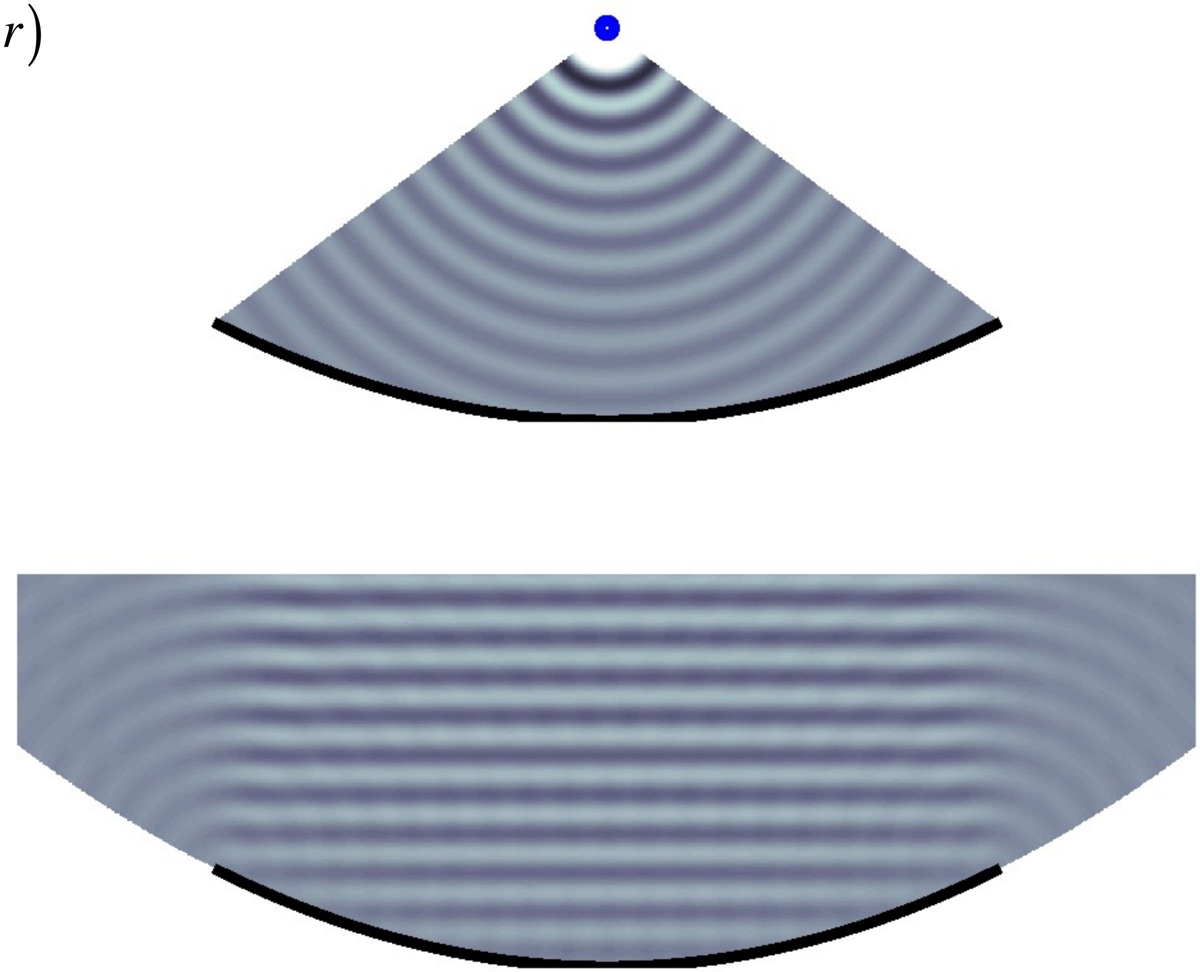


Fig. 12. Top: electron density profiles from EISCAT measurements, for the 1932 arc. Bottom: corresponding modelled electron density. The bite-out in the data at 19:32:10 UT is not reproduced by the model, and is believed to be caused by horizontal convection of plasma near the arc.

Dahlgren et al., 2011

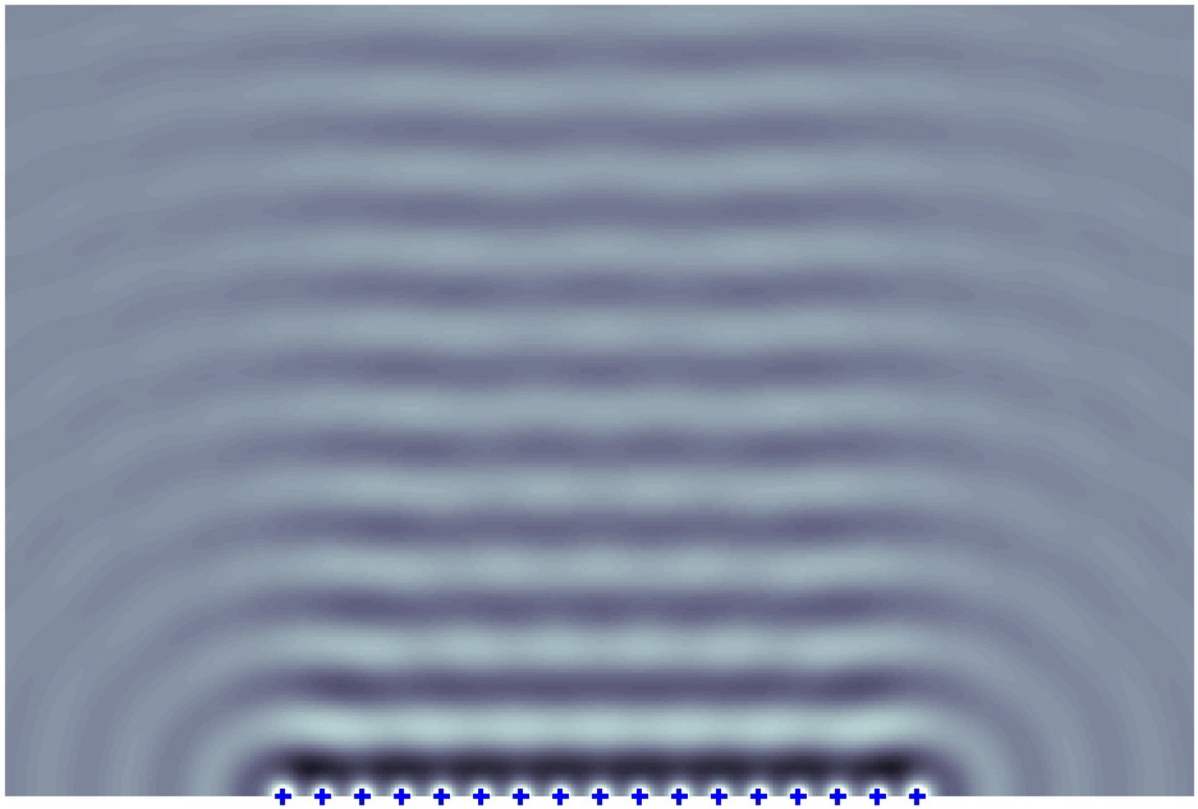
Sondrestrom view of aurora

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

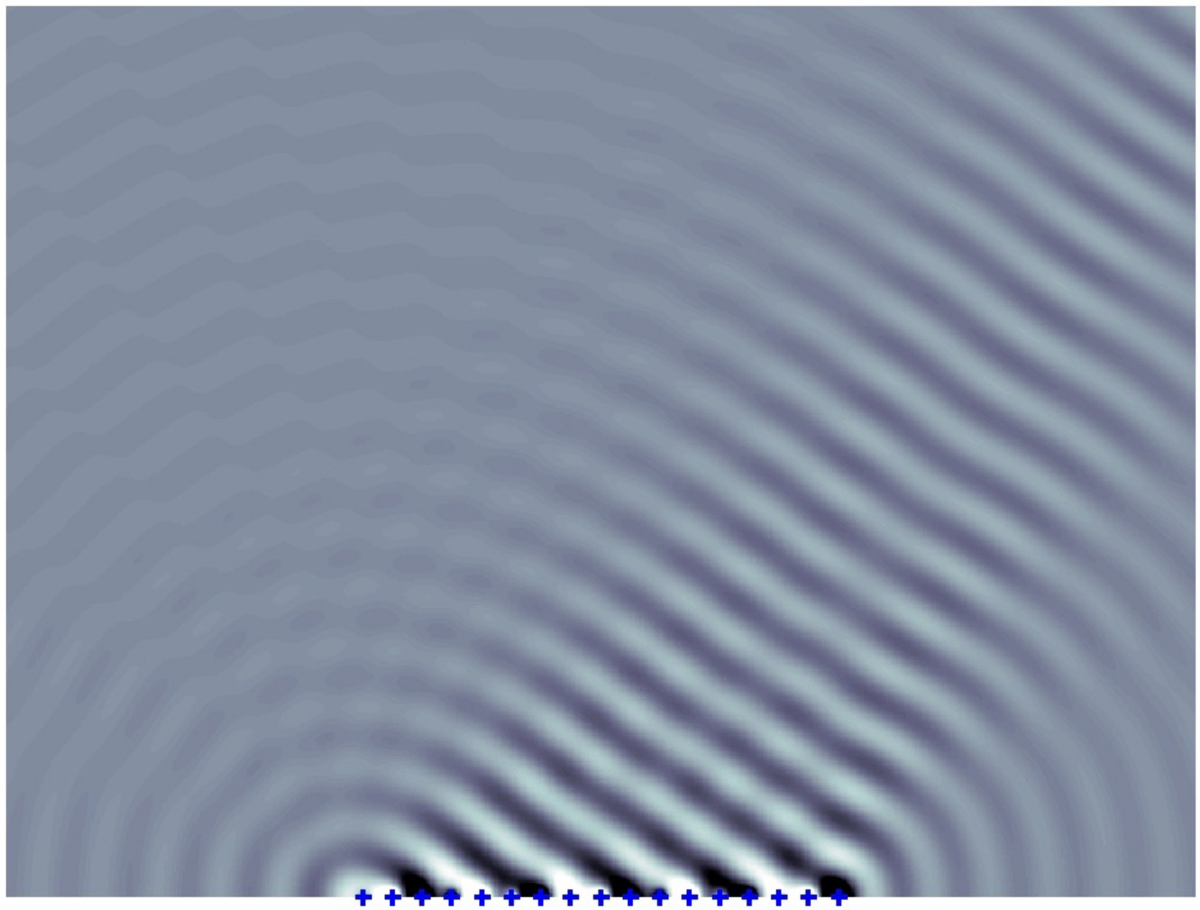


Phased Array Antennas

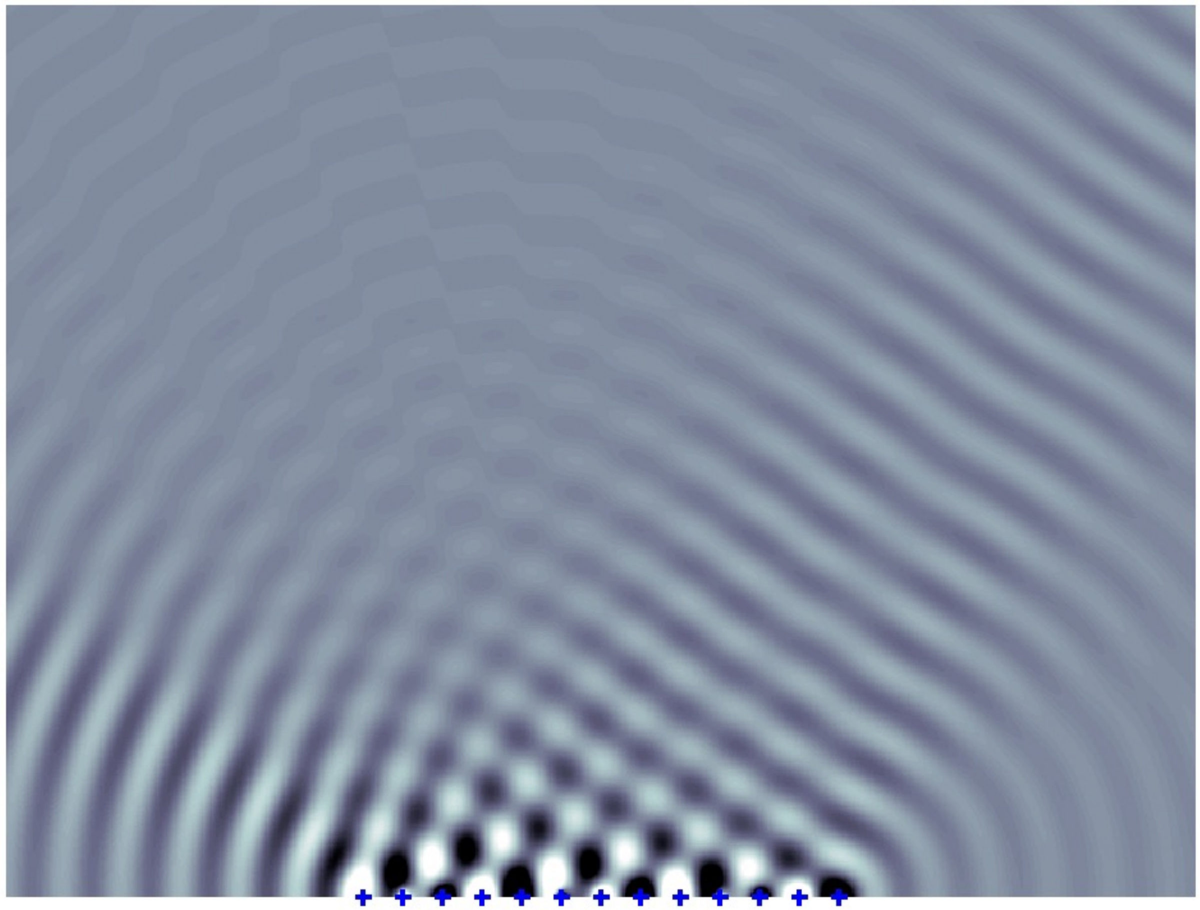
Phased Array, $\lambda/2$ spacing



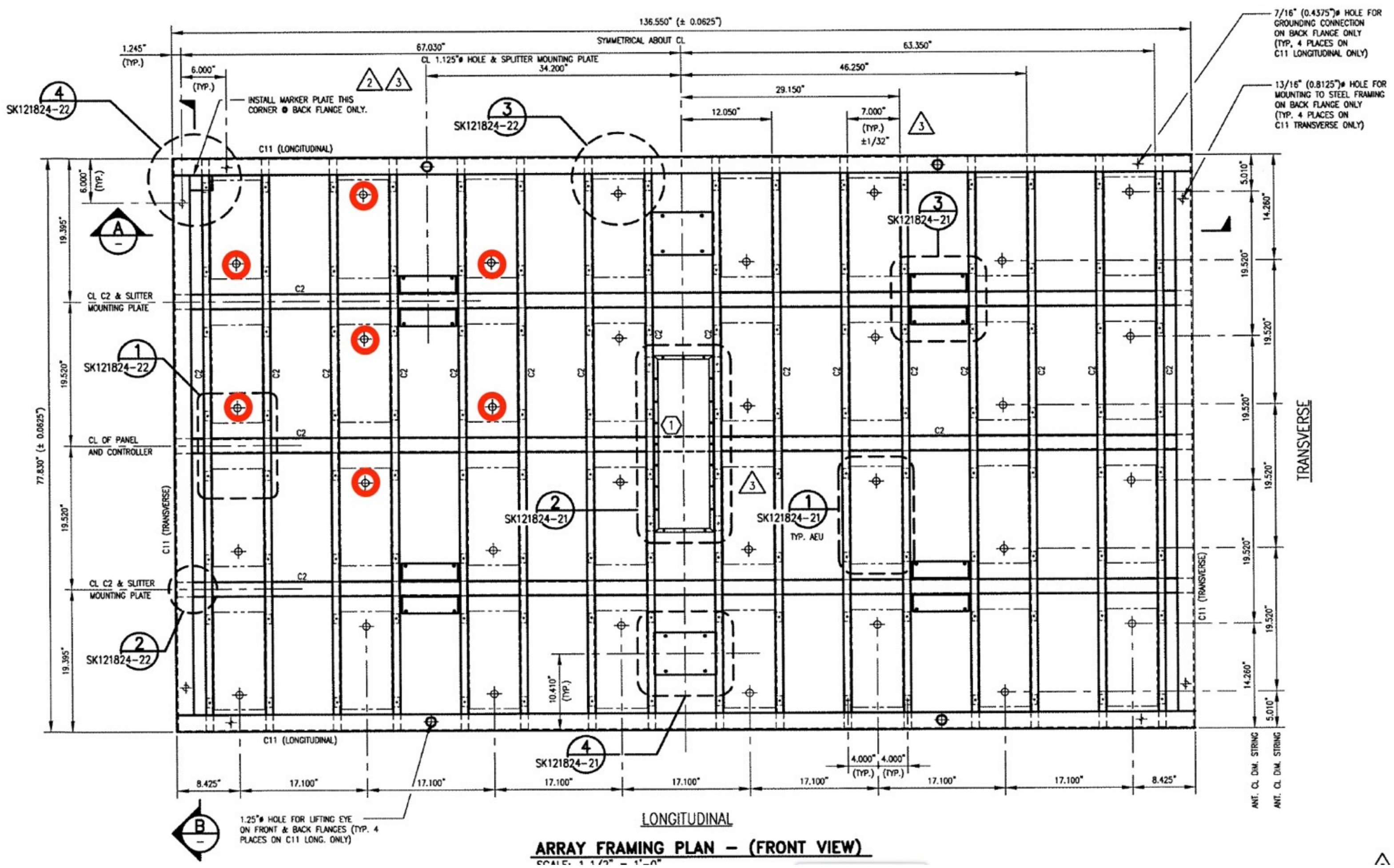
Phased Array, λ/2 spacing



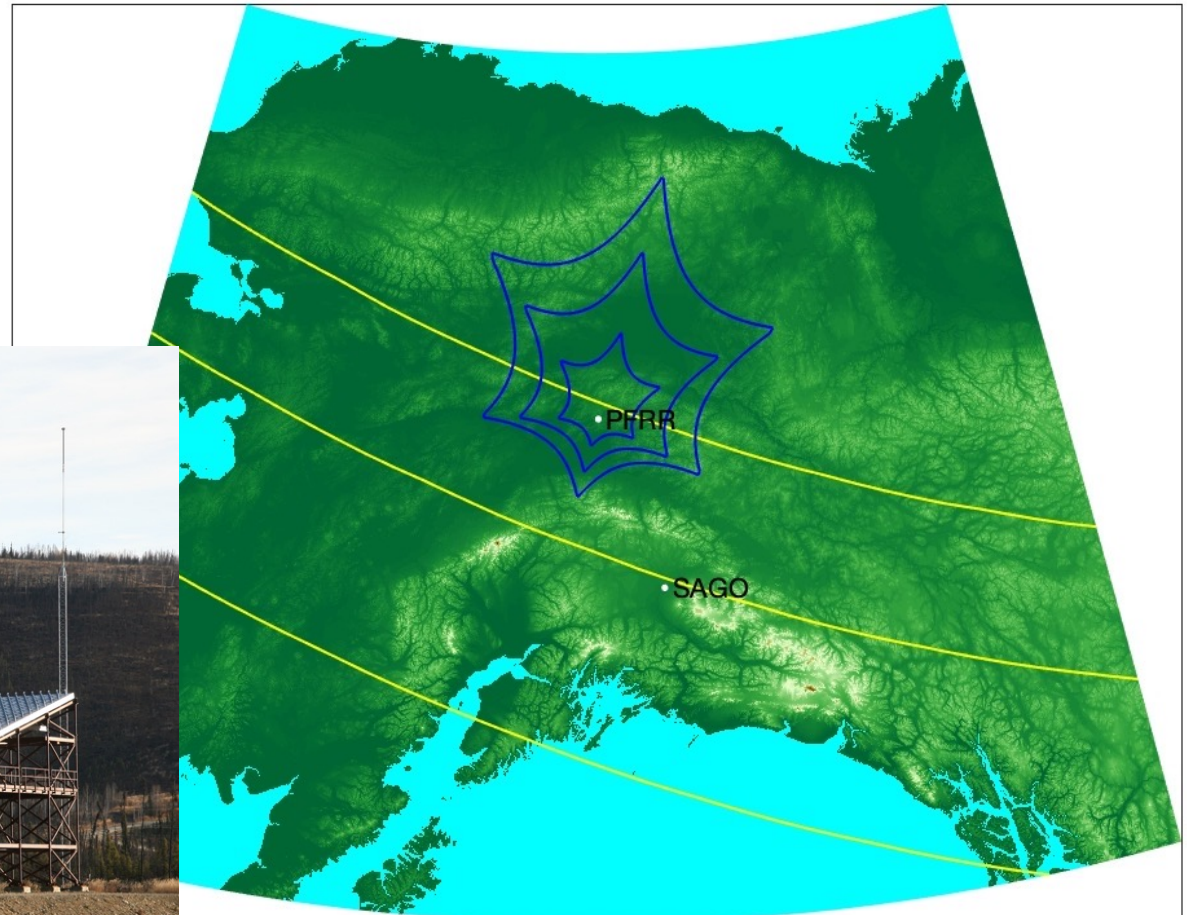
Phased Array, $2\lambda/3$ spacing

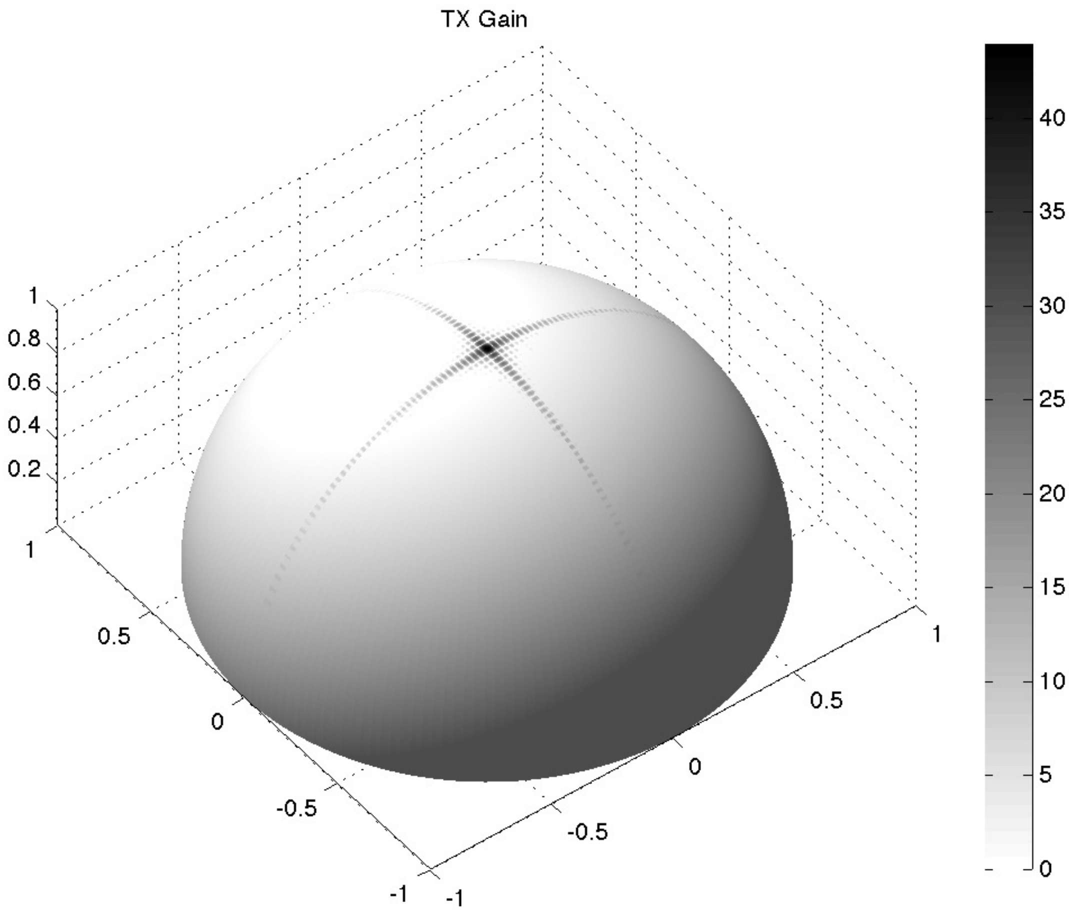


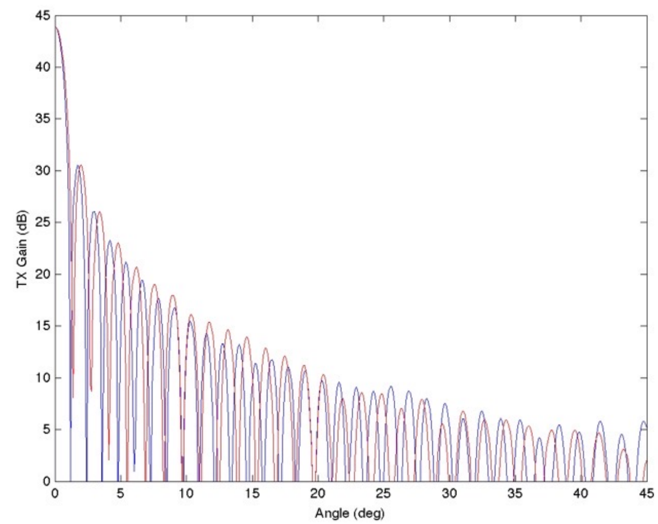
AMISR



136.550" (± 0.0625")
SYMMETRICAL ABOUT CL
67.030"
63.350"
CL 1.125"ø HOLE & SPLITTER MOUNTING PLATE
34.200"
46.250"
29.150"
12.050"
7.000" (TYP.) ±1/32"
1.245" (TYP.)
6.000" (TYP.)
INSTALL MARKER PLATE THIS CORNER @ BACK FLANGE ONLY.
7/16" (0.4375")ø HOLE FOR GROUNDING CONNECTION ON BACK FLANGE ONLY (TYP. 4 PLACES ON C11 LONGITUDINAL ONLY)
13/16" (0.8125")ø HOLE FOR MOUNTING TO STEEL FRAMING ON BACK FLANGE ONLY (TYP. 4 PLACES ON C11 TRANSVERSE ONLY)
SK121824-22
SK121824-21
C11 (LONGITUDINAL)
C11 (TRANSVERSE)
C2
CL C2 & SLITTER MOUNTING PLATE
CL OF PANEL AND CONTROLLER
TYP. AEU
77.830" (± 0.0625")
19.395"
19.520"
5.010"
14.260"
10.410" (TYP.)
TRANSVERSE
8.425"
17.100"
4.000" (TYP.)
ANT. CL DIM. STRING
1.25"ø HOLE FOR LIFTING EYE ON FRONT & BACK FLANGES (TYP. 4 PLACES ON C11 LONG. ONLY)
LONGITUDINAL
ARRAY FRAMING PLAN – (FRONT VIEW)


PFRR
SAGO


TX Gain
1
0.8
0.6
0.4
0.2
1
0.5
0
-0.5
-1
-1
-0.5
0
0.5
1
40
35
30
25
20
15
10
5
0


TX Gain (dB)
Angle (deg)
45
40
35
30
25
20
15
10
5
0
0
5
10
15
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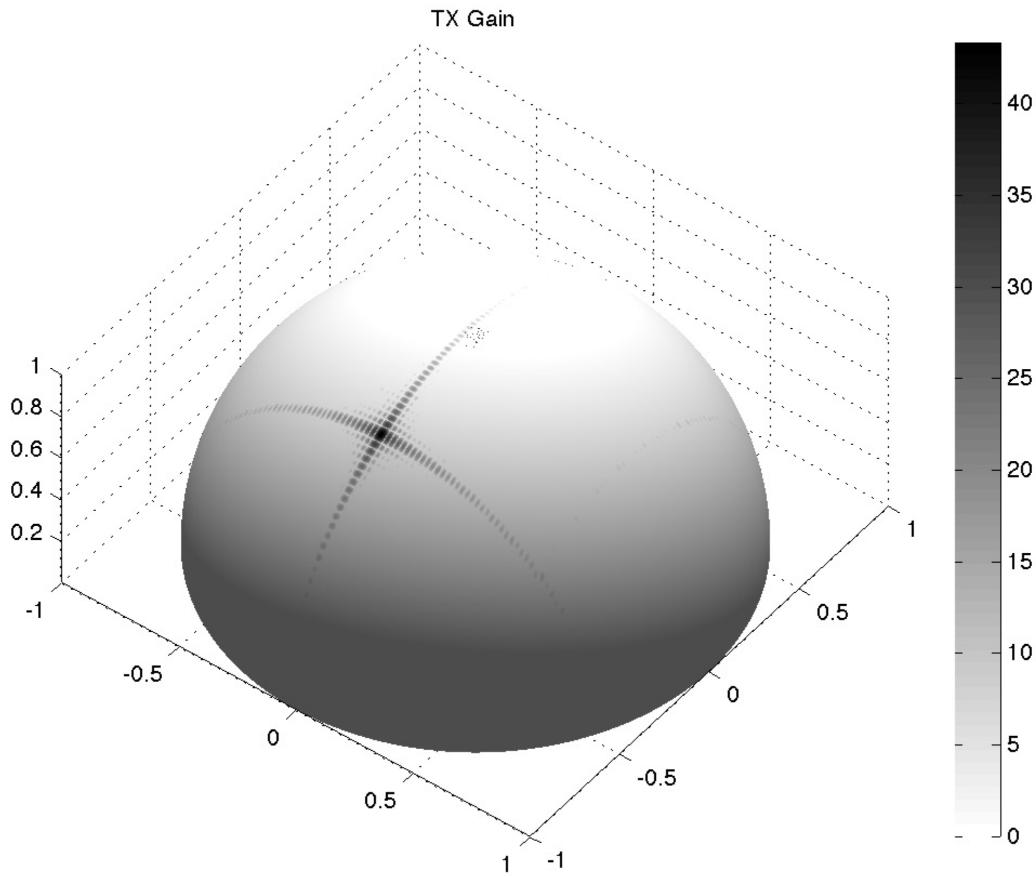
25
30
35
40
45


TX Gain
1
0.8
0.6
0.4
0.2
-1
-0.5
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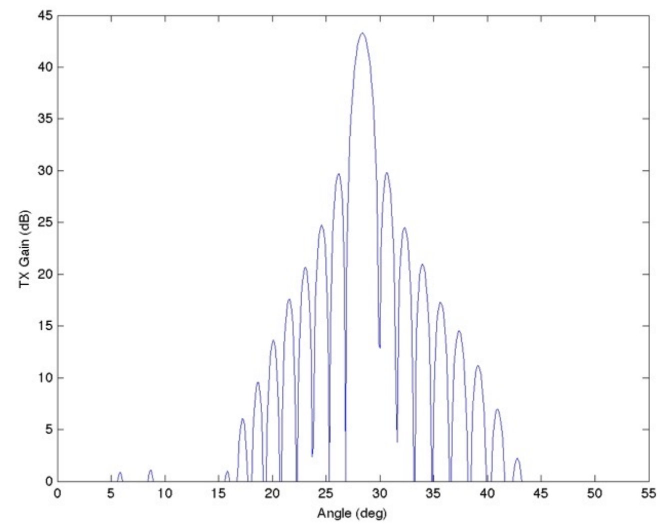
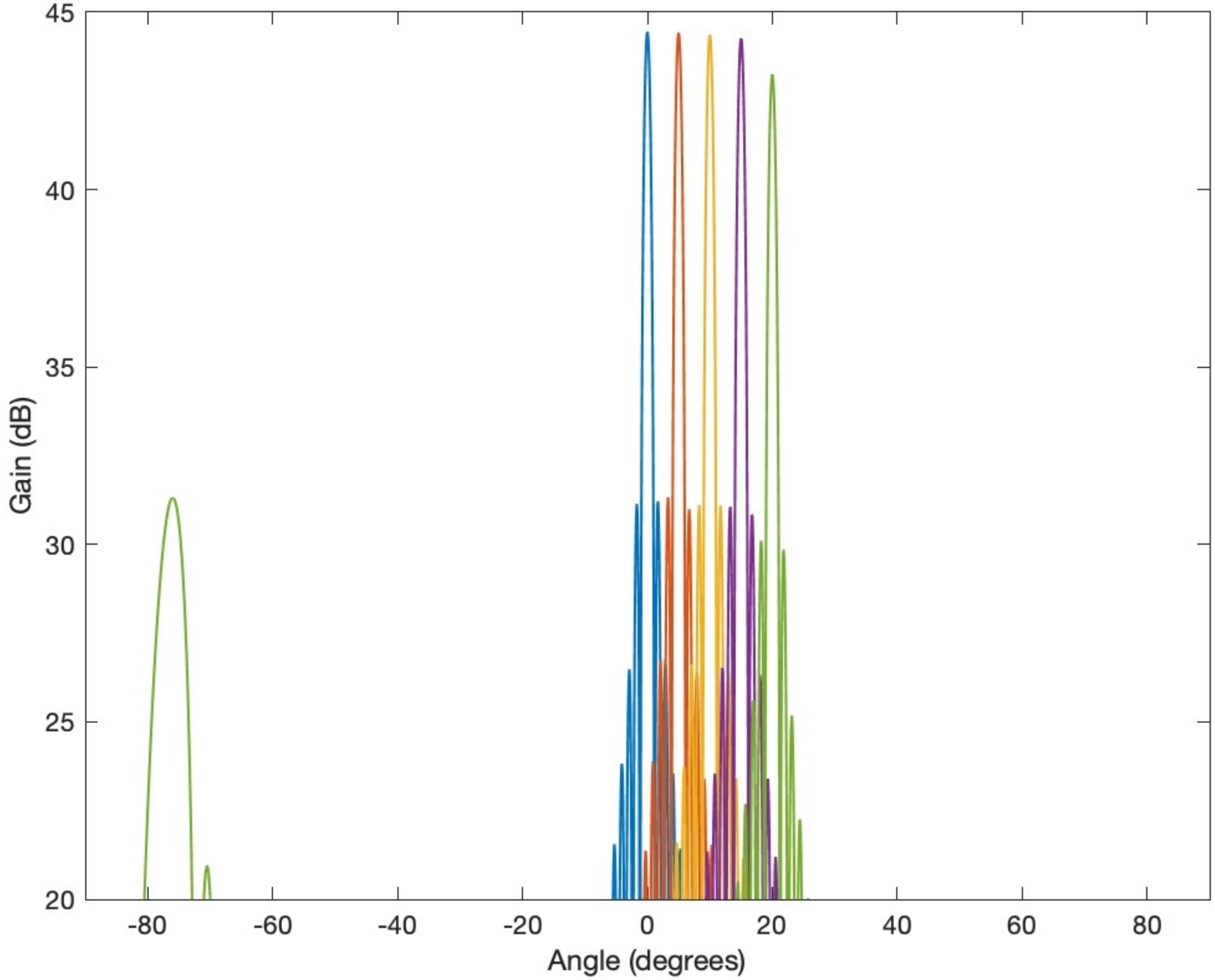
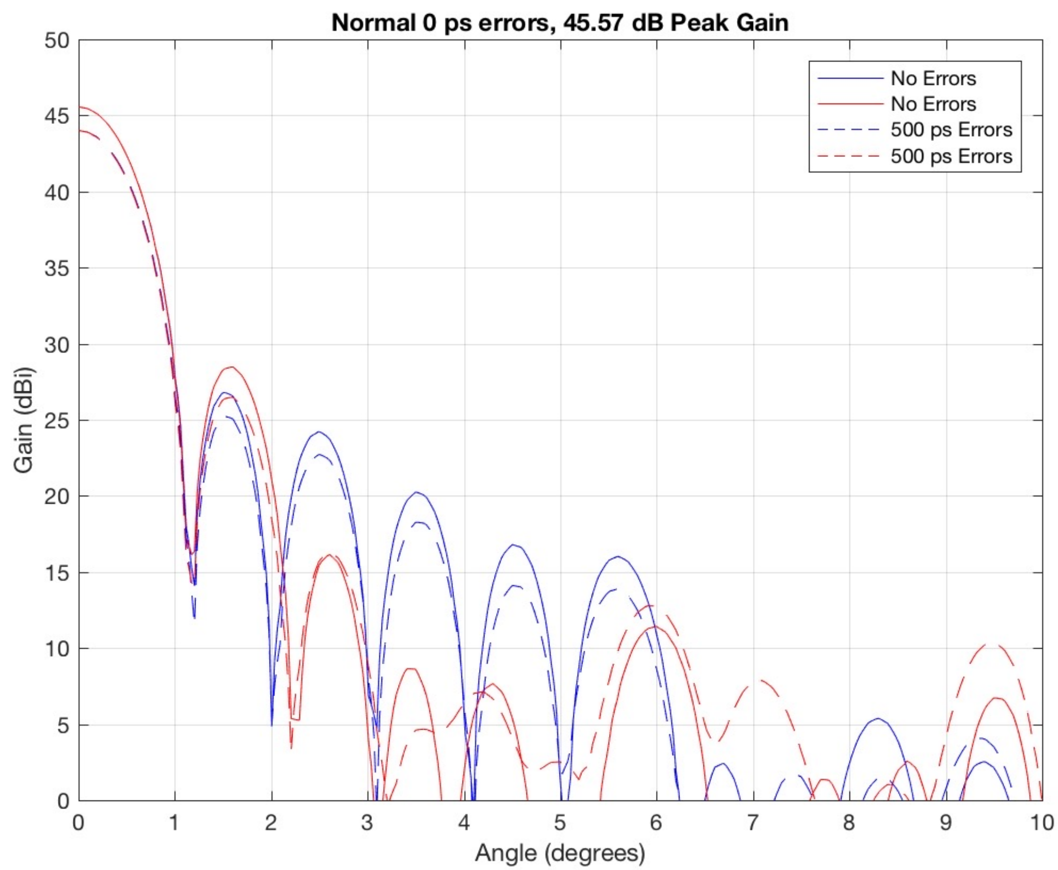
0.5
1
-1
-0.5
0
0.5
1
0
5
10
15
20
25
30
35
40


TX Gain (dB)
Angle (deg)
0
5
10
15
20
25
30
35
40
45
50
55

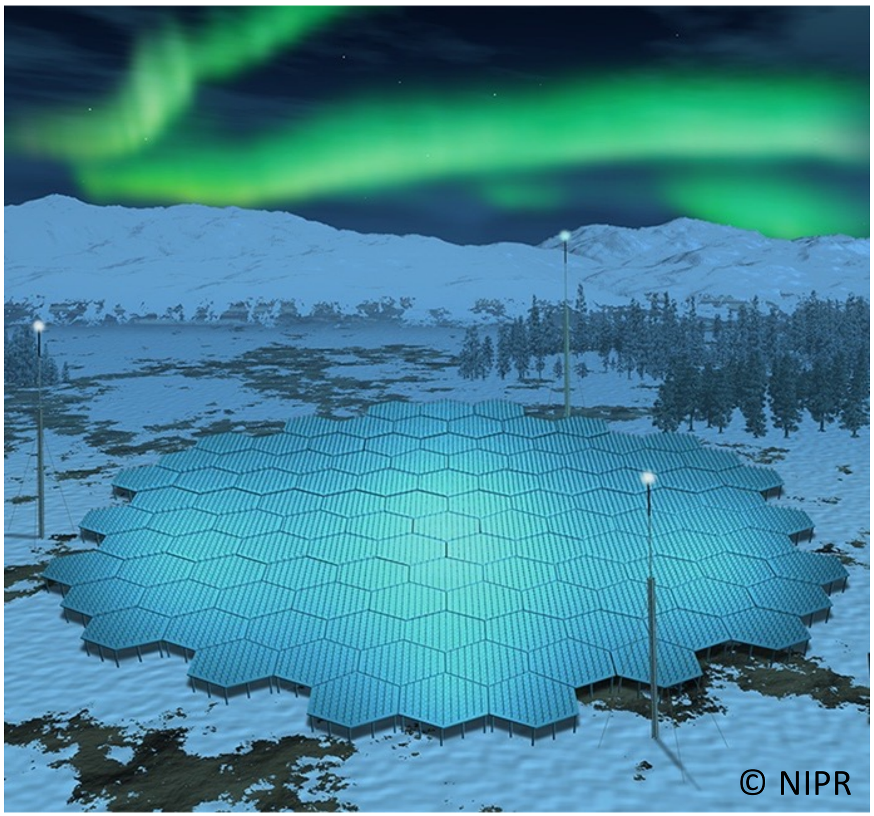


45
40
35
30
25
20
Gain (dB)
-80
-60
-40
-20
0
20
40
60
80
Angle (degrees)

Errors in array phasing



E3D Science Case



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Progress in Earth and Planetary Science
a SpringerOpen Journal

REVIEW Open Access

The science case for the EISCAT_3D radar

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Abstract

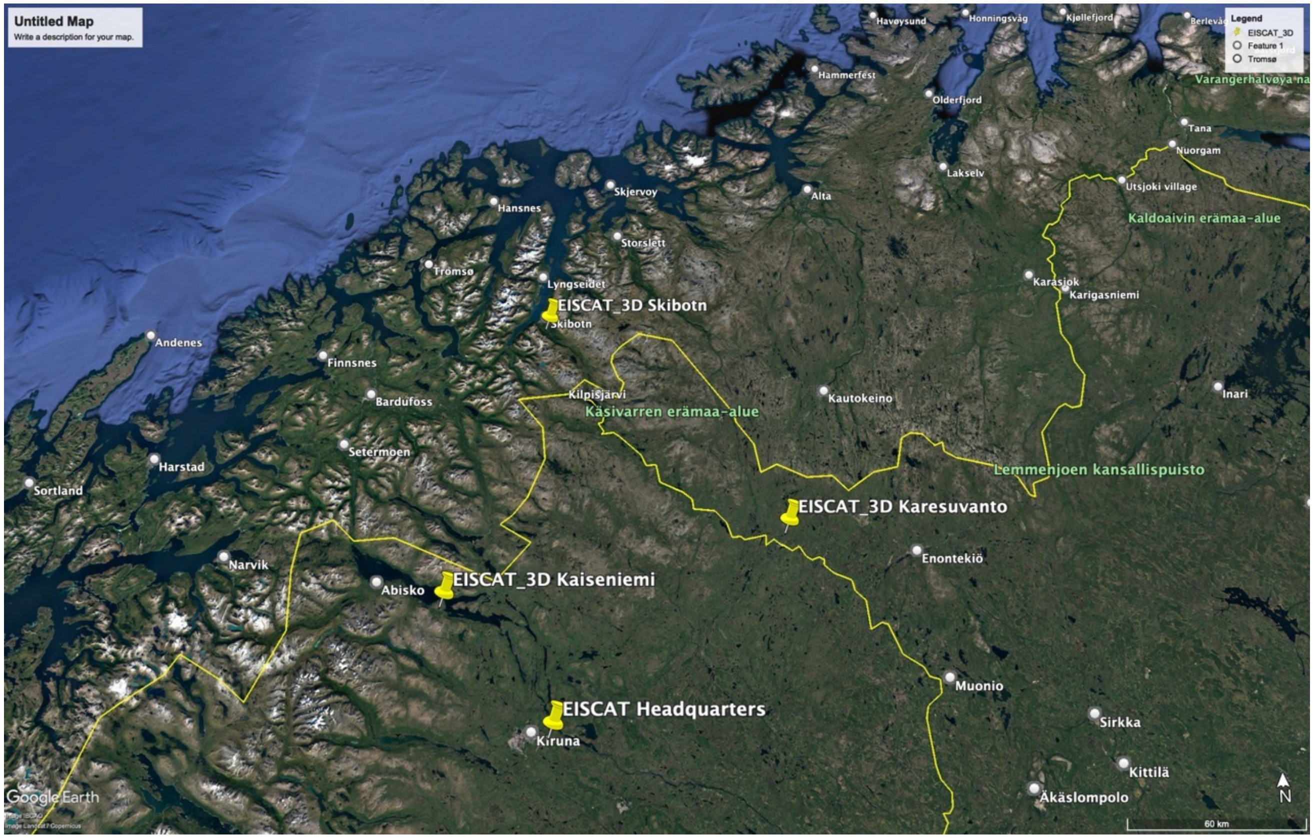
The EISCAT (European Incoherent SCATer) Scientific Association has provided versatile incoherent scatter (IS) radar facilities on the mainland of northern Scandinavia (the EISCAT UHF and VHF radar systems) and on Svalbard (the electronically scanning radar ESR (EISCAT Svalbard Radar) for studies of the 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 facilitatefuture 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

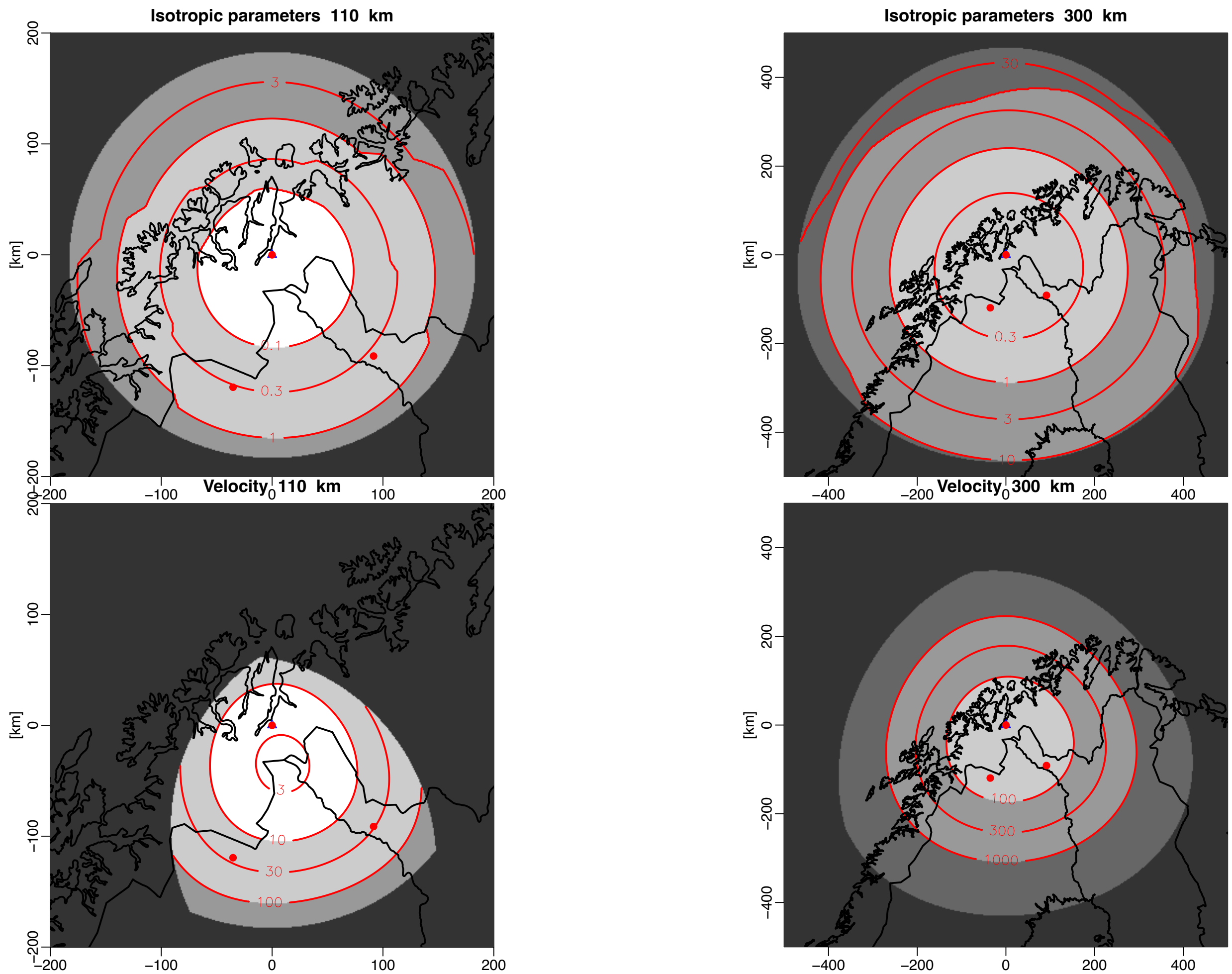
Key features

- 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)

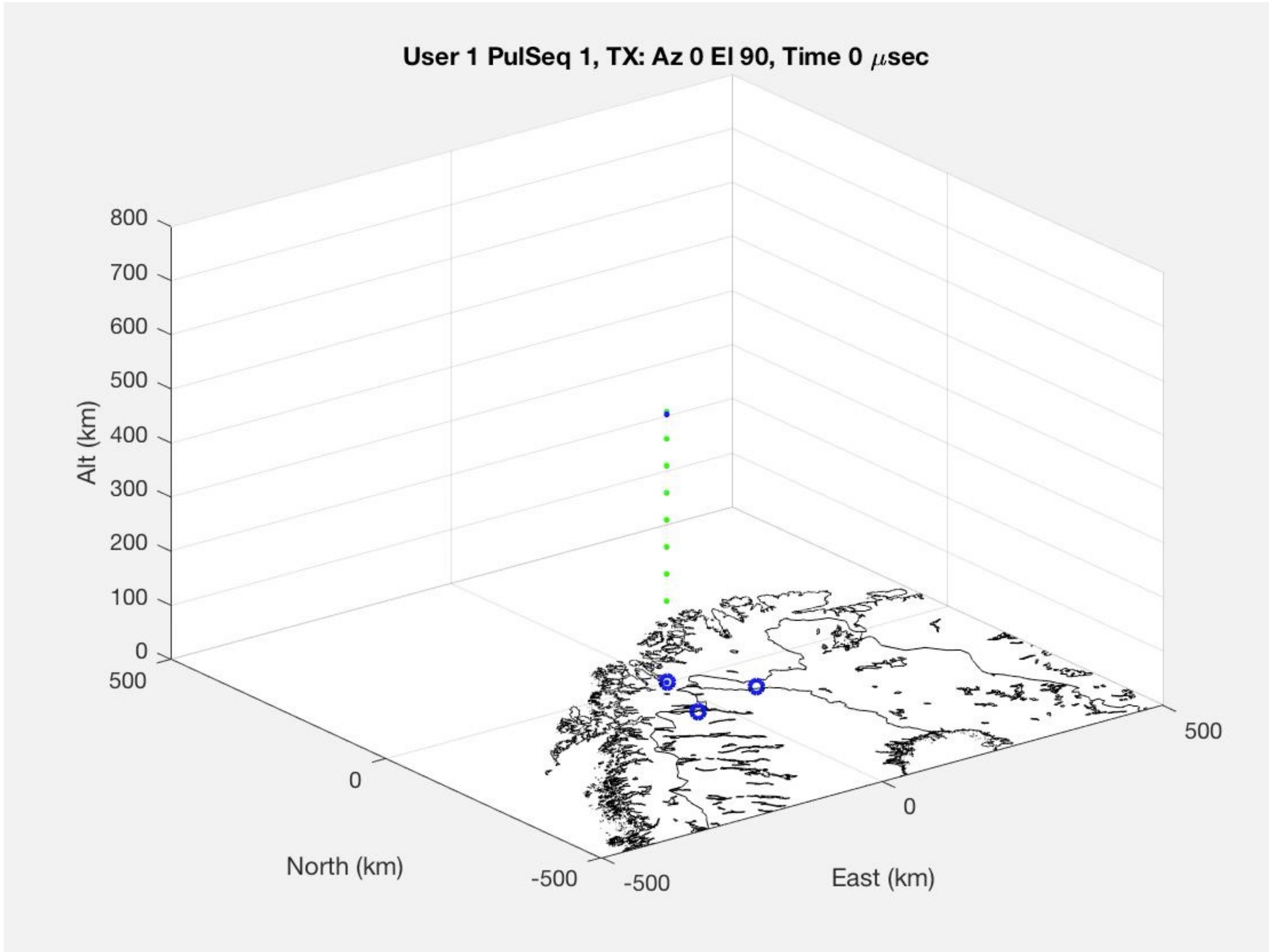
Tri-static Radar (unambiguous velocities)



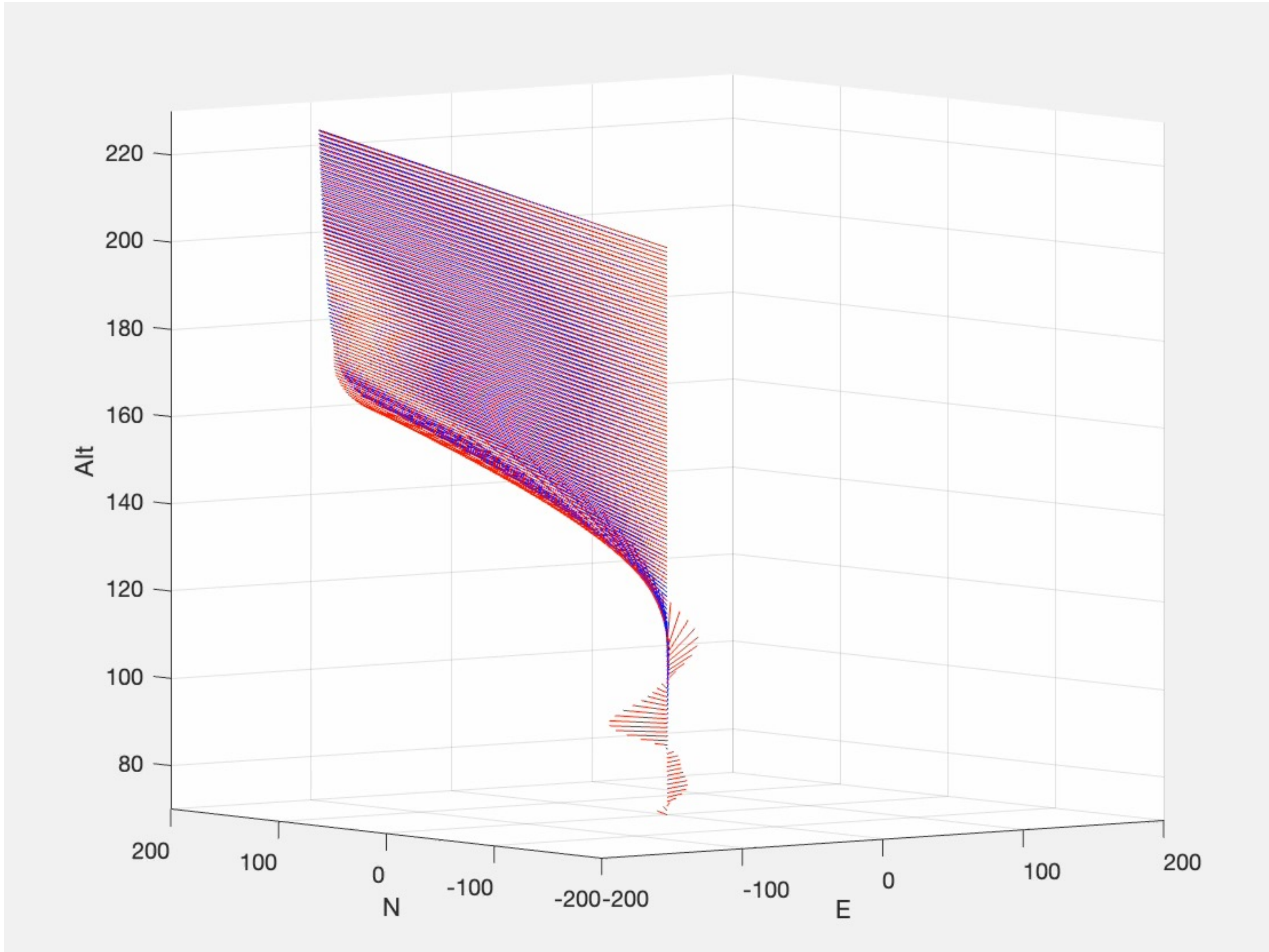
SENSITIVITY
(INTEGRATION TIMES FOR 5% ERRORS UNDER ‘NORMAL’ IONOSPHERIC CONDITIONS)



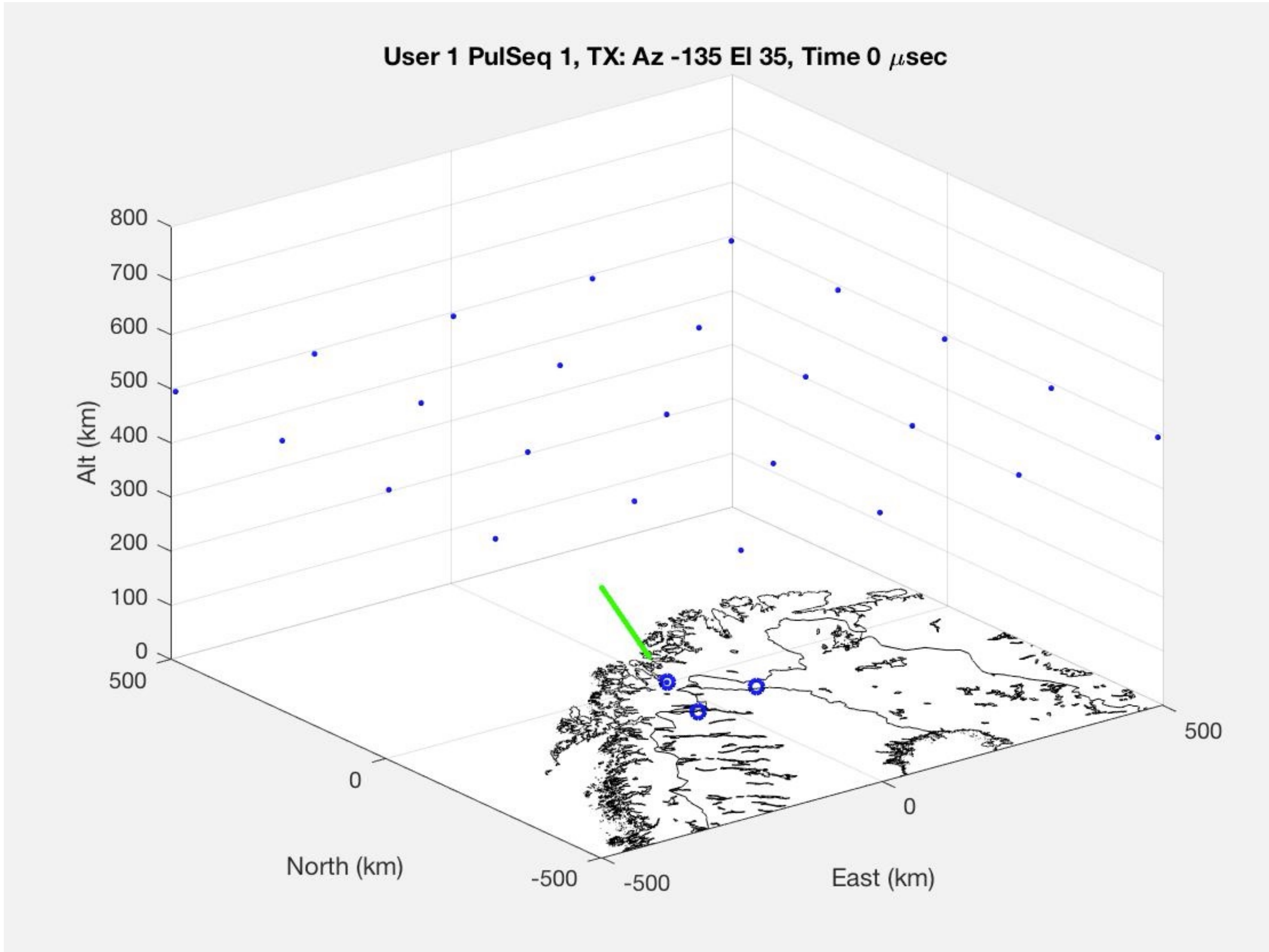
Tri-static

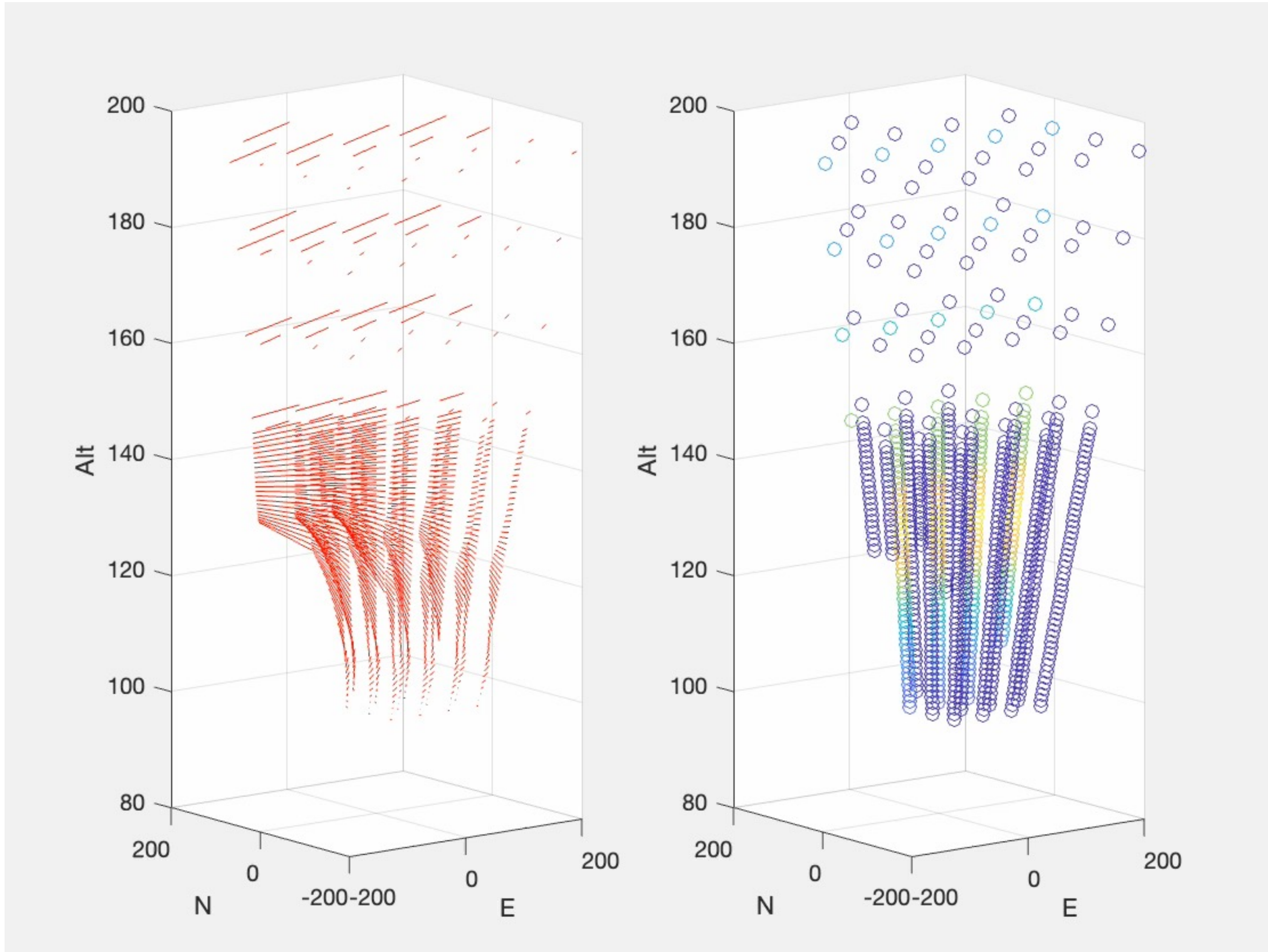


User 1 PulSeq 1, TX: Az 0 El 90, Time 0 μsec
Alt (km)
800
700
600
500
400
300
200
100
0
500
0
-500
North (km)
-500
0
500
East (km)

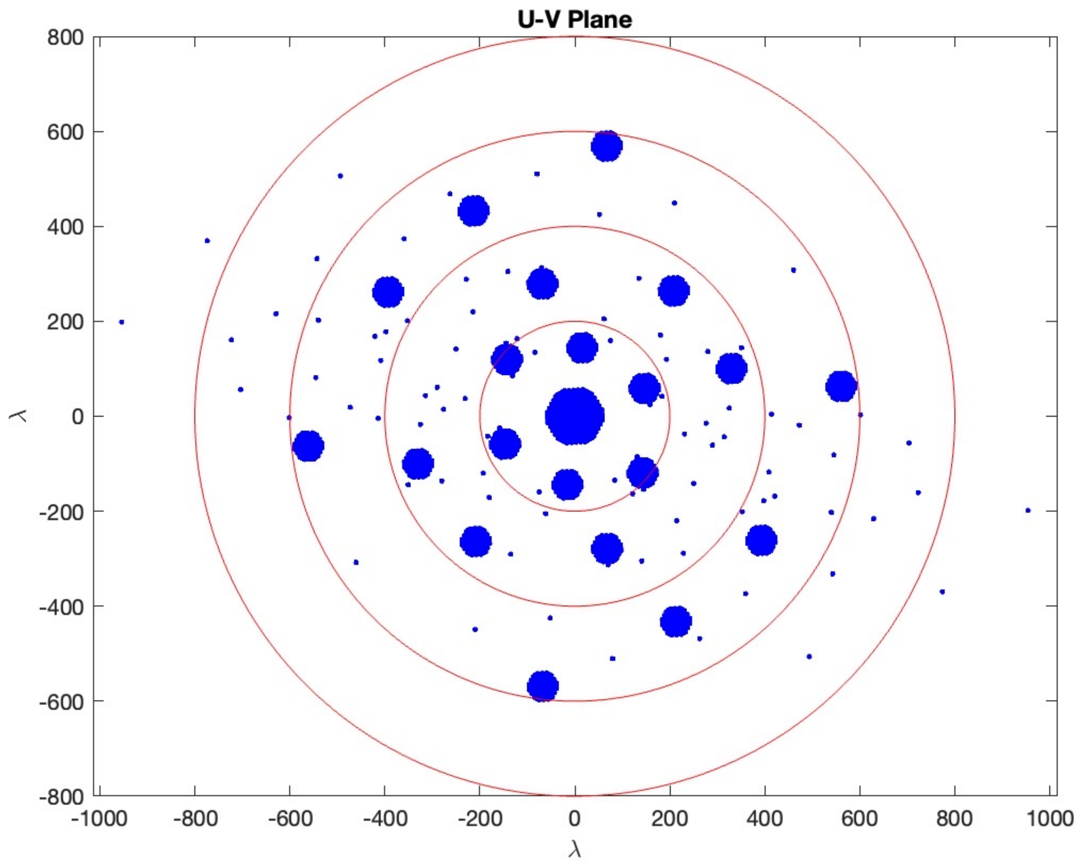


Alt
220
200
180
160
140
120
100
80
N
200
100
0
-100
-200
E
-200
-100
0
100
200


User 1 PulSeq 1, TX: Az -135 El 35, Time 0 μsec
Alt (km)
800
700
600
500
400
300
200
100
0
500
0
-500
North (km)
-500
0
500
East (km)

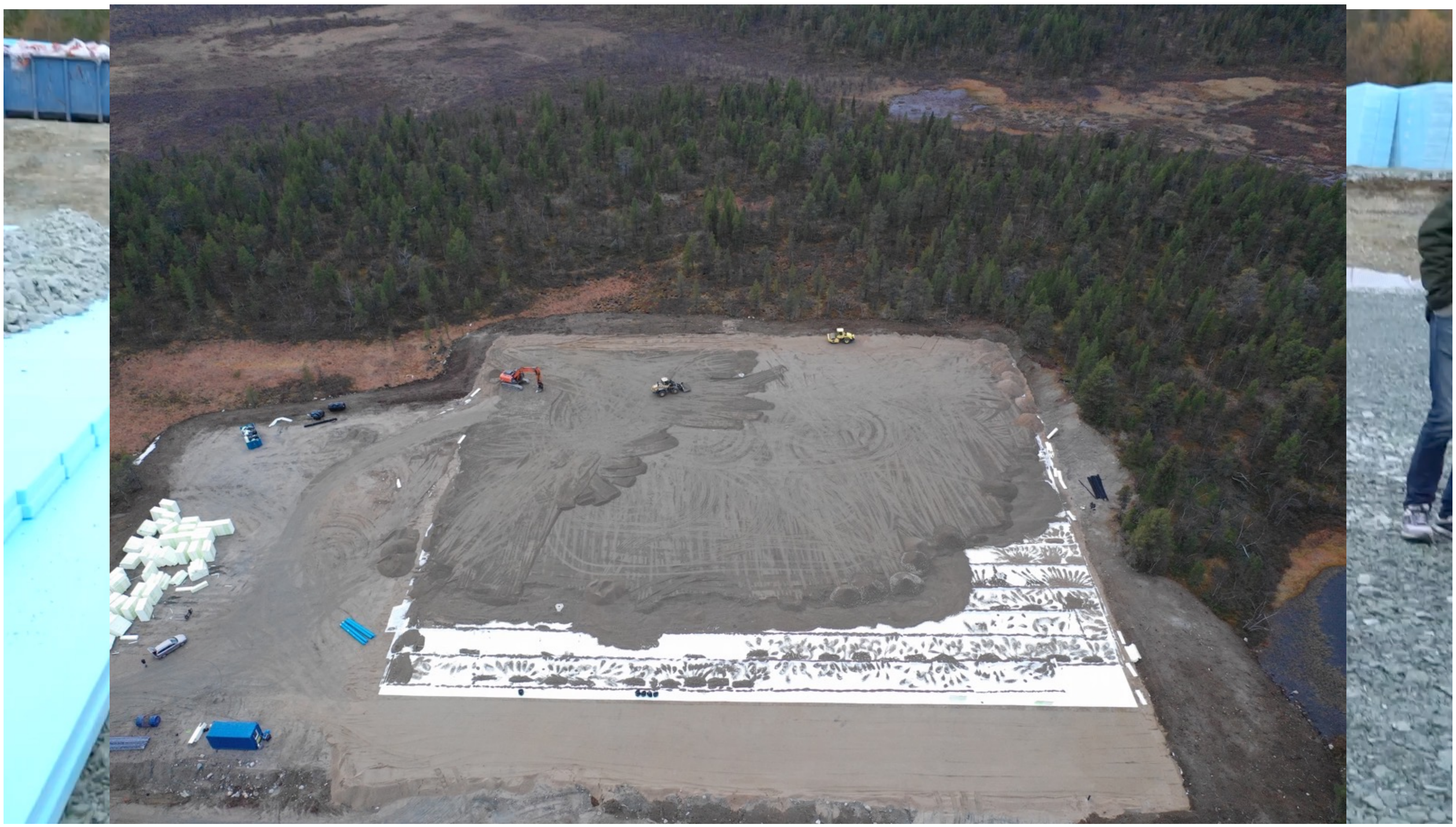

200
180
160
140
120
100
80
Alt
200
0
N
-200-200
0
200
E
200
180
160
140
120
100
80
Alt
200
0
N
-200-200
0
200
E

Interferometric Imaging



What does it take to build EISCAT_3D?

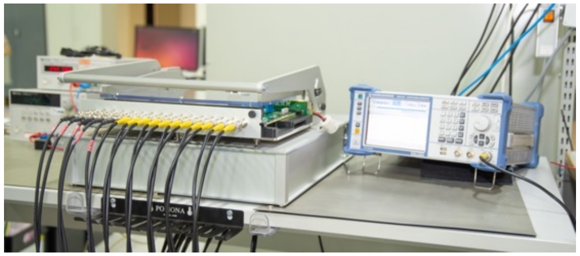
Skibotn was a challenging site to prepare



AU PRODUCTION

FSRU PRODUCTION

FSRU serial production



Lower: FSRU testbench used during serial production

Photos by DA-Design

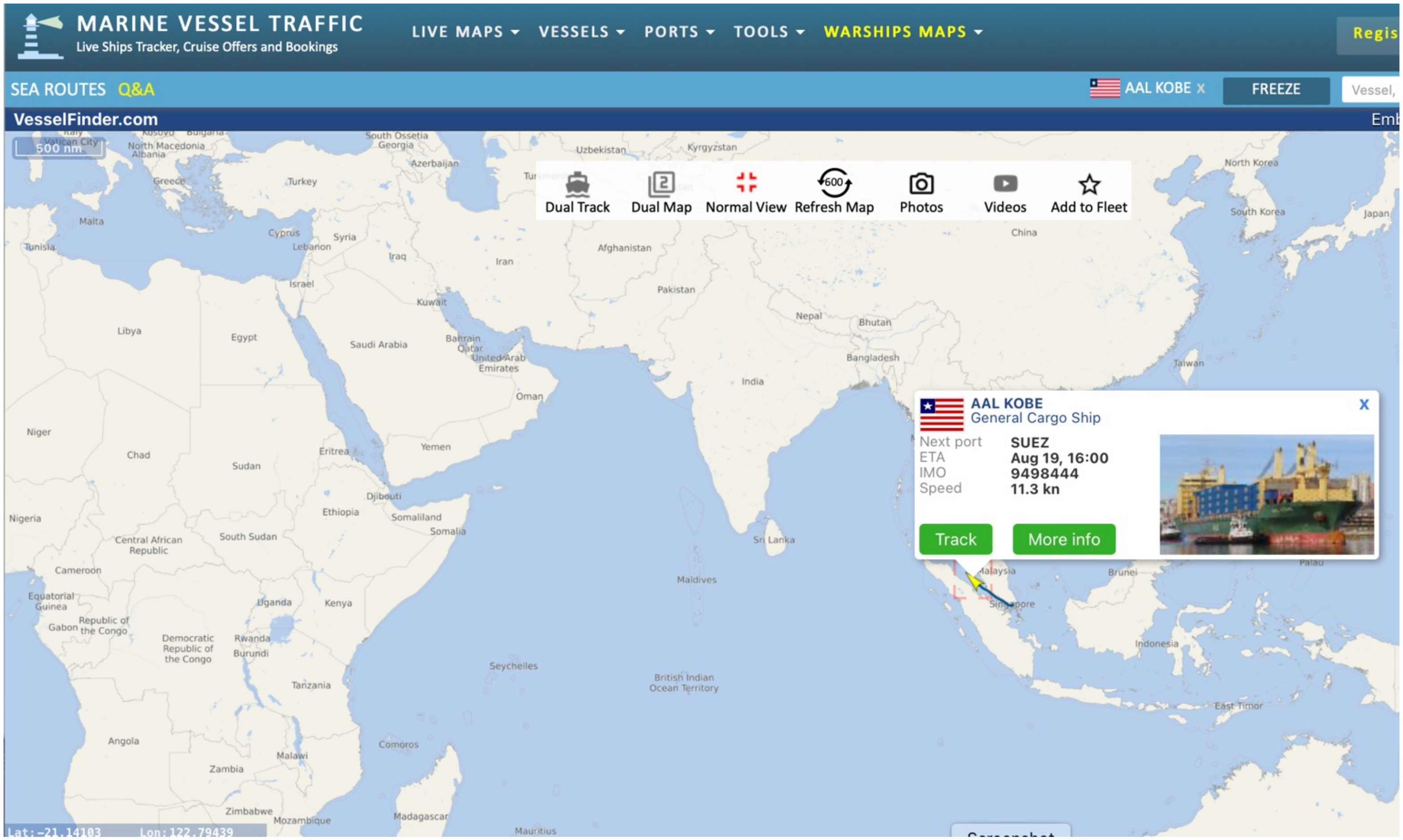
SAT PRODUCTION

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

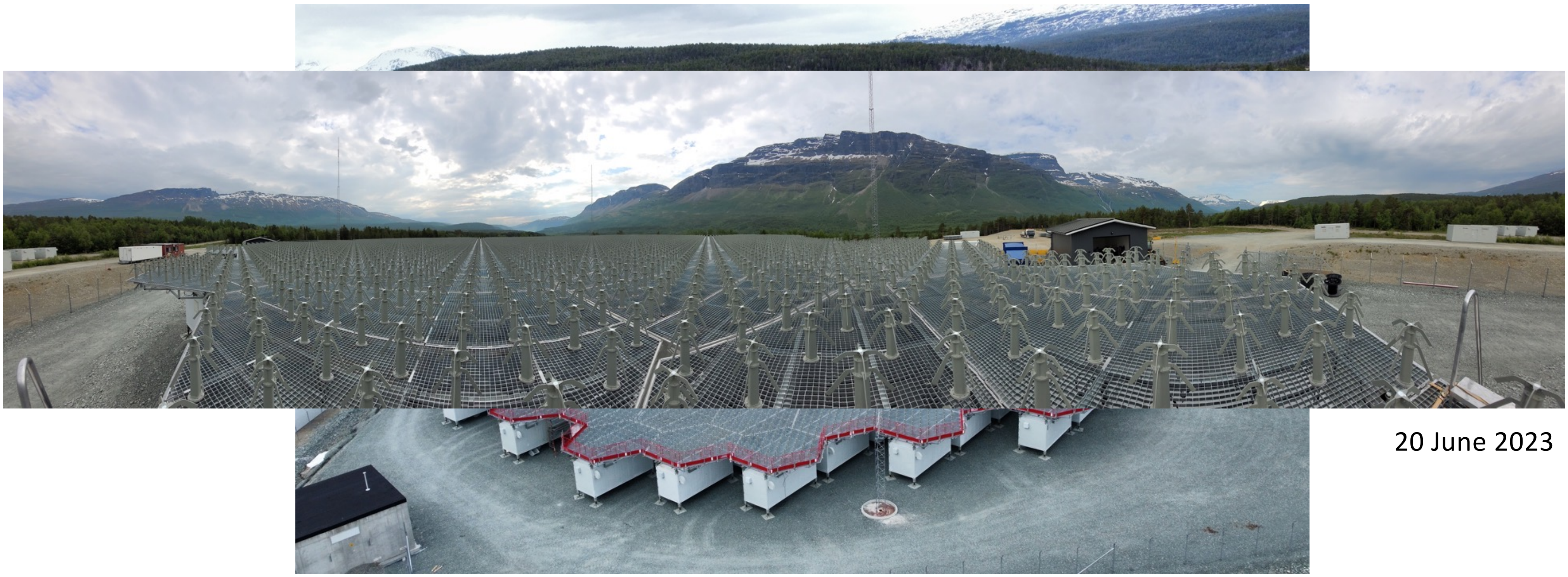

MARINE VESSEL TRAFFIC
Live Ships Tracker, Cruise Offers and Bookings
LIVE MAPS
VESSELS
PORTS
TOOLS
WARSHIPS MAPS
SEA ROUTES
Q&A
AAL KOBE
FREEZE
VesselFinder.com
Dual Track
Dual Map
Normal View
Refresh Map
Photos
Videos
Add to Fleet
AAL KOBE
General Cargo Ship
Next port SUEZ
ETA Aug 19, 16:00
IMO 9498444
Speed 11.3 kn
Track
More info

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

Svensson

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
  - Some electronics installed (7 AUs)
  - Test AU is on-site
- Karesuvanto, Finland
  - AUs installed
  - Site buildings in place
- Hoping for inauguration ~November 2025

https://heinselslug.smugmug.com/Professional/Meetings/ISR-School-2024-Boston