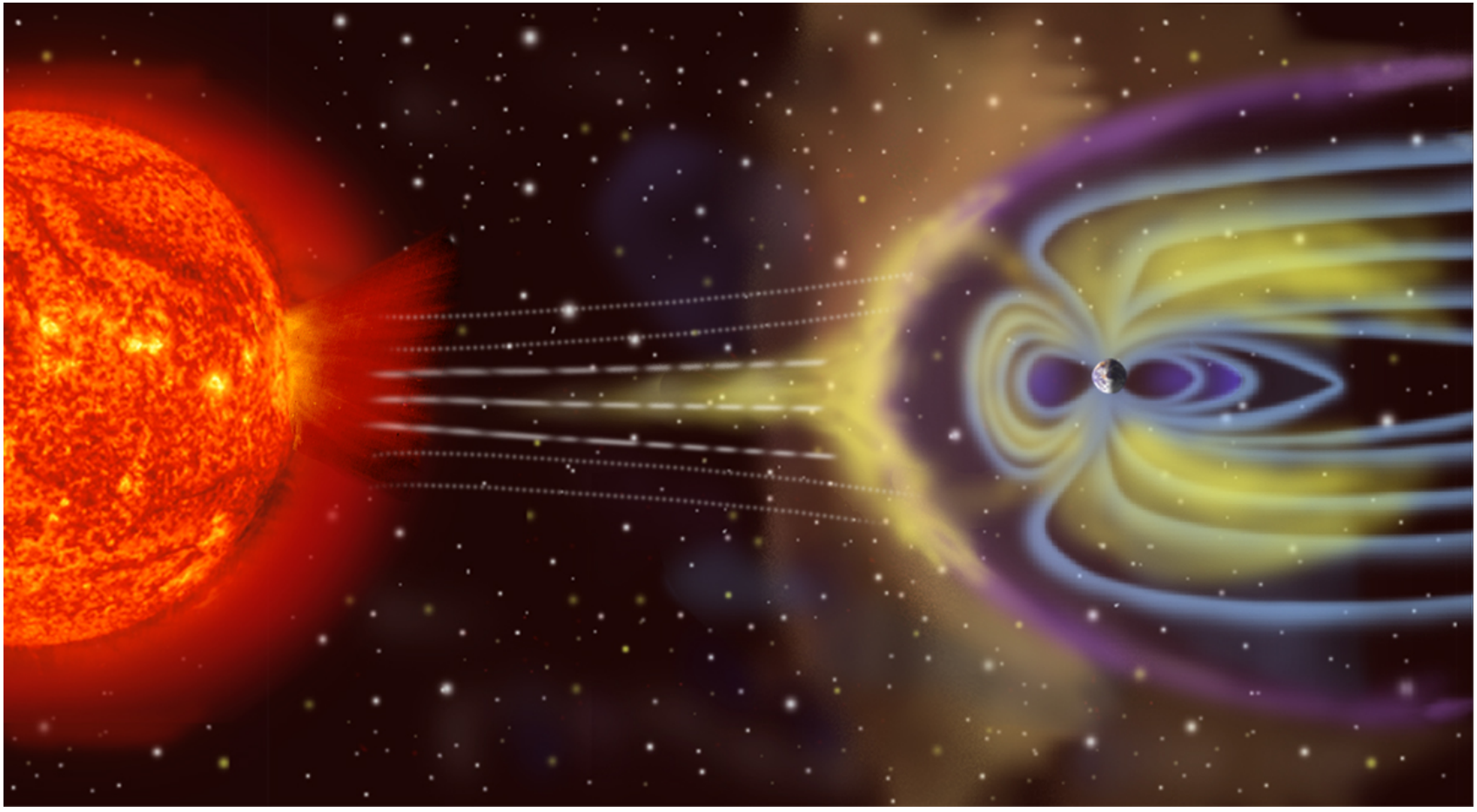
EISCAT_3D Nordic Computing Challenge

John White *NeIC*
for the E3DS project.

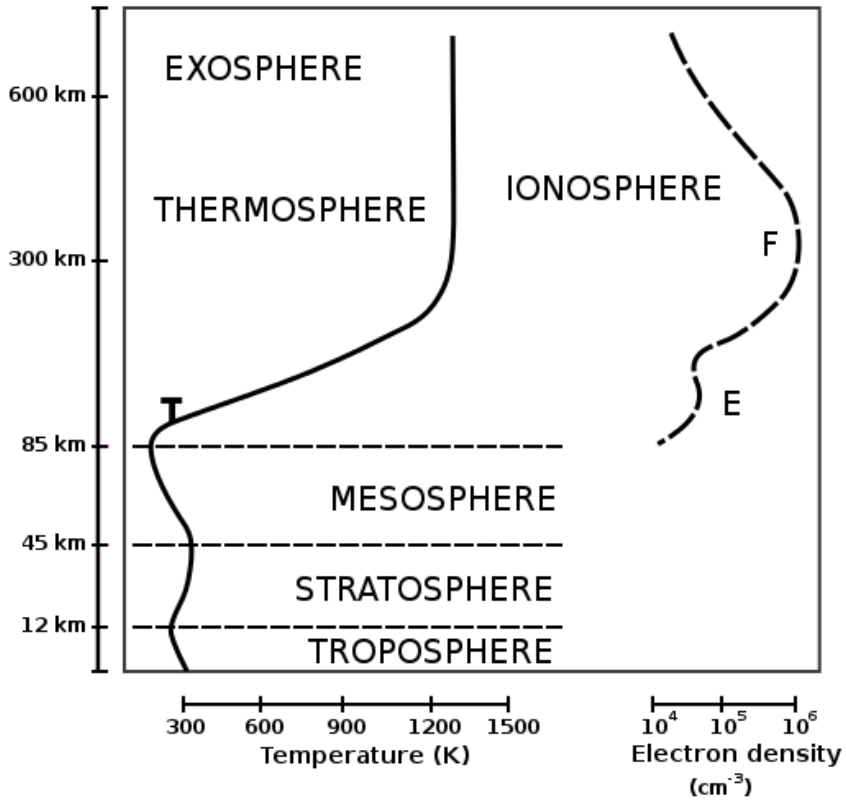
Introduction

- Solar-terrestrial connection and EISCAT
- EISCAT_3D project
- EISCAT_3D Support Project (E3DS)
- EISCAT_3D Computing
- EISCAT_3D Network Plan
- EISCAT_3D Integrated Computing

Solar wind and magnetosphere



Earth's Atmosphere



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Atmosphere

- "E" region absorbs x-rays.
- "F" region absorbs UV.
- Aurora 90-200 km altitude.

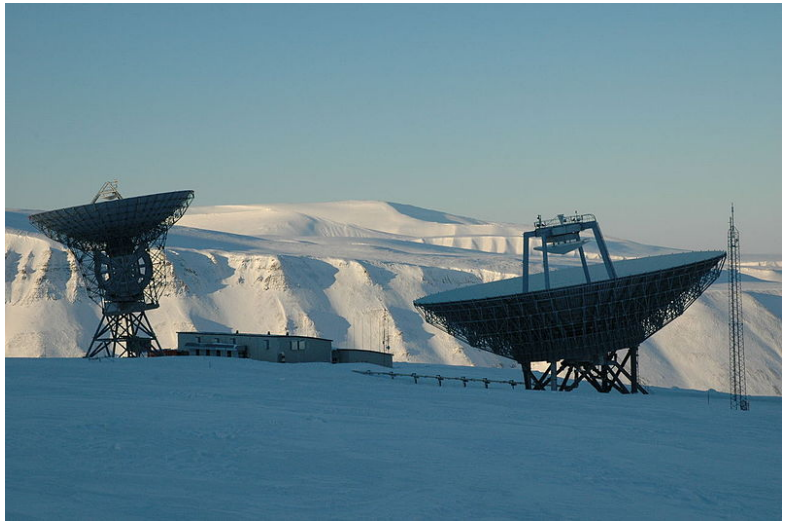
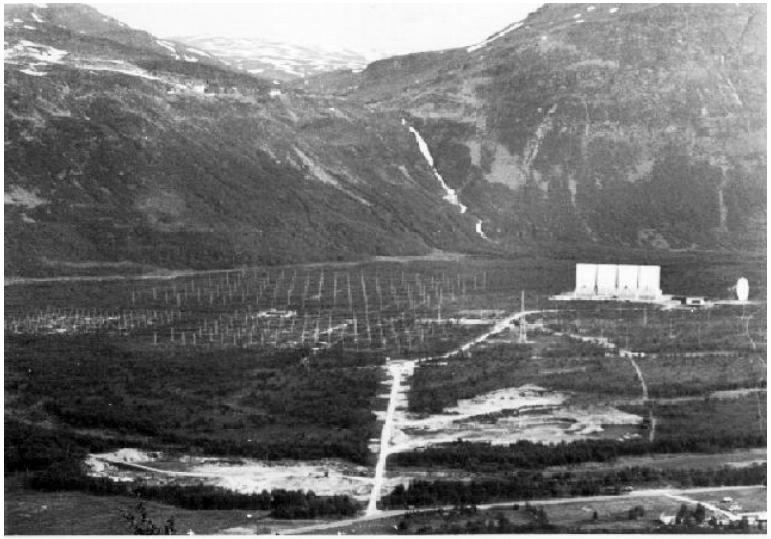
Incoherent scatter radar

- Ionospheric electron density
- Ion and electron temperature
- Doppler velocity of ions

EISCAT

European (originally) **I**ncoherent **SCAT**ter Scientific Association

Current EISCAT radars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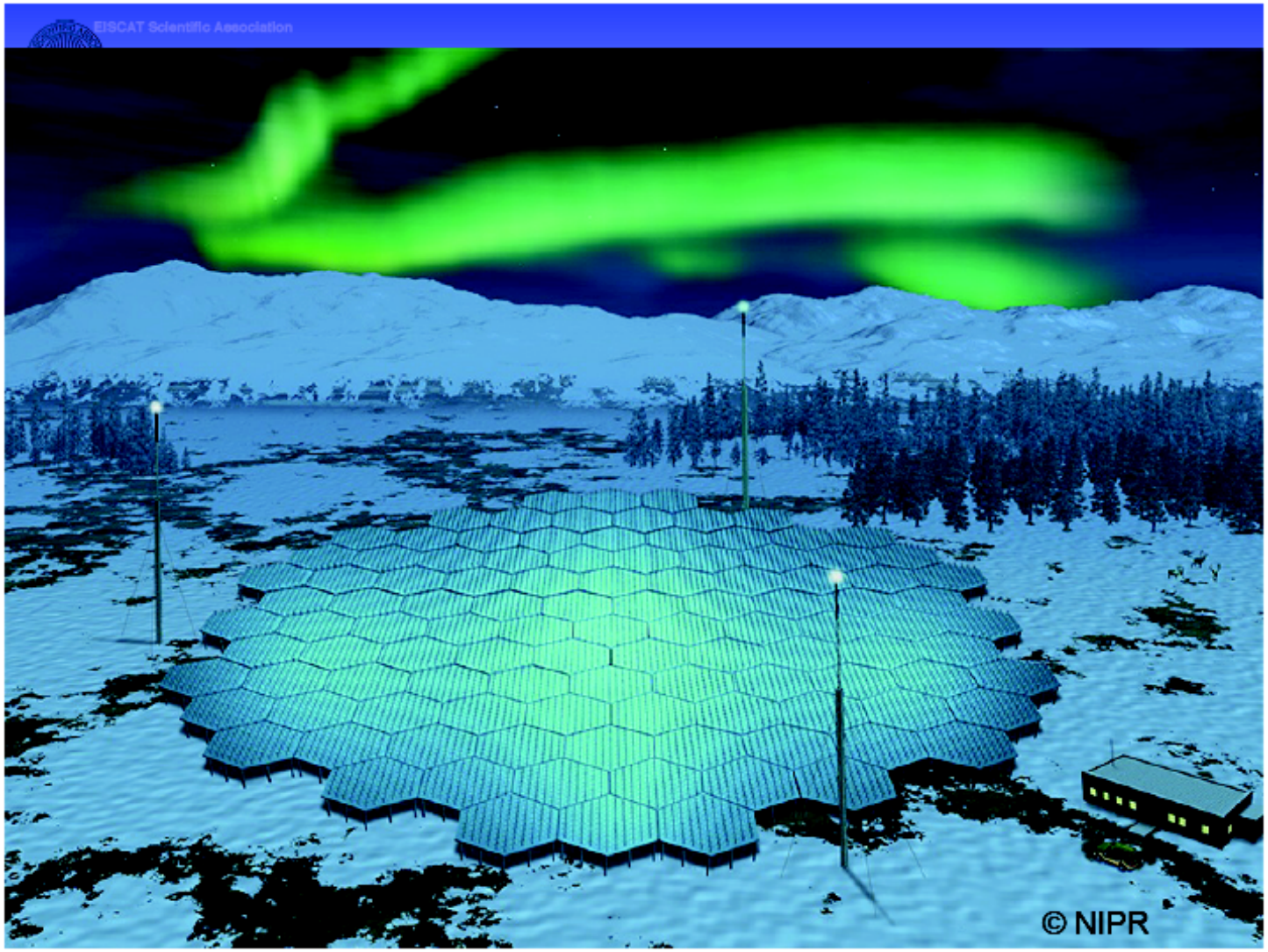
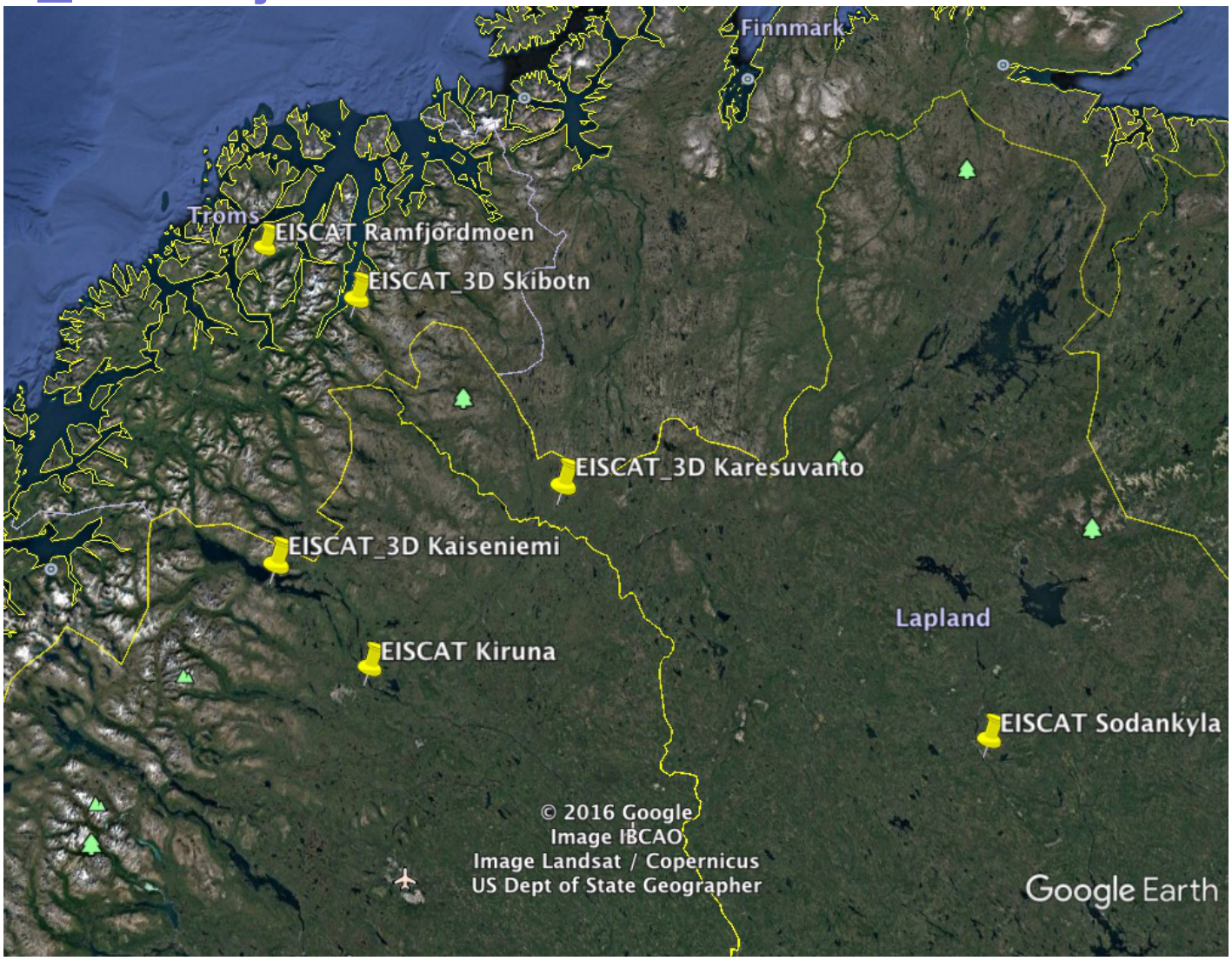
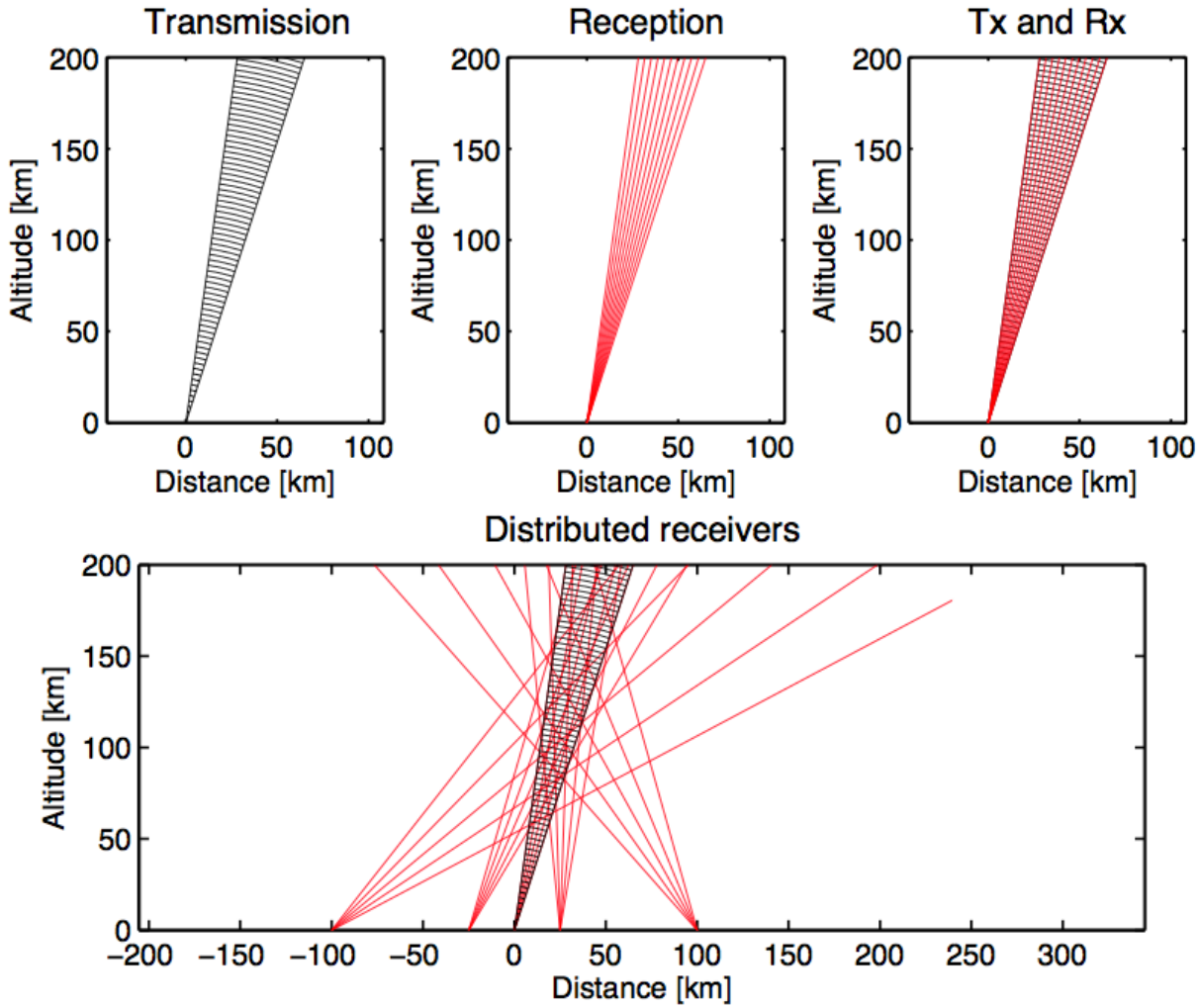
EISCAT_3D Project



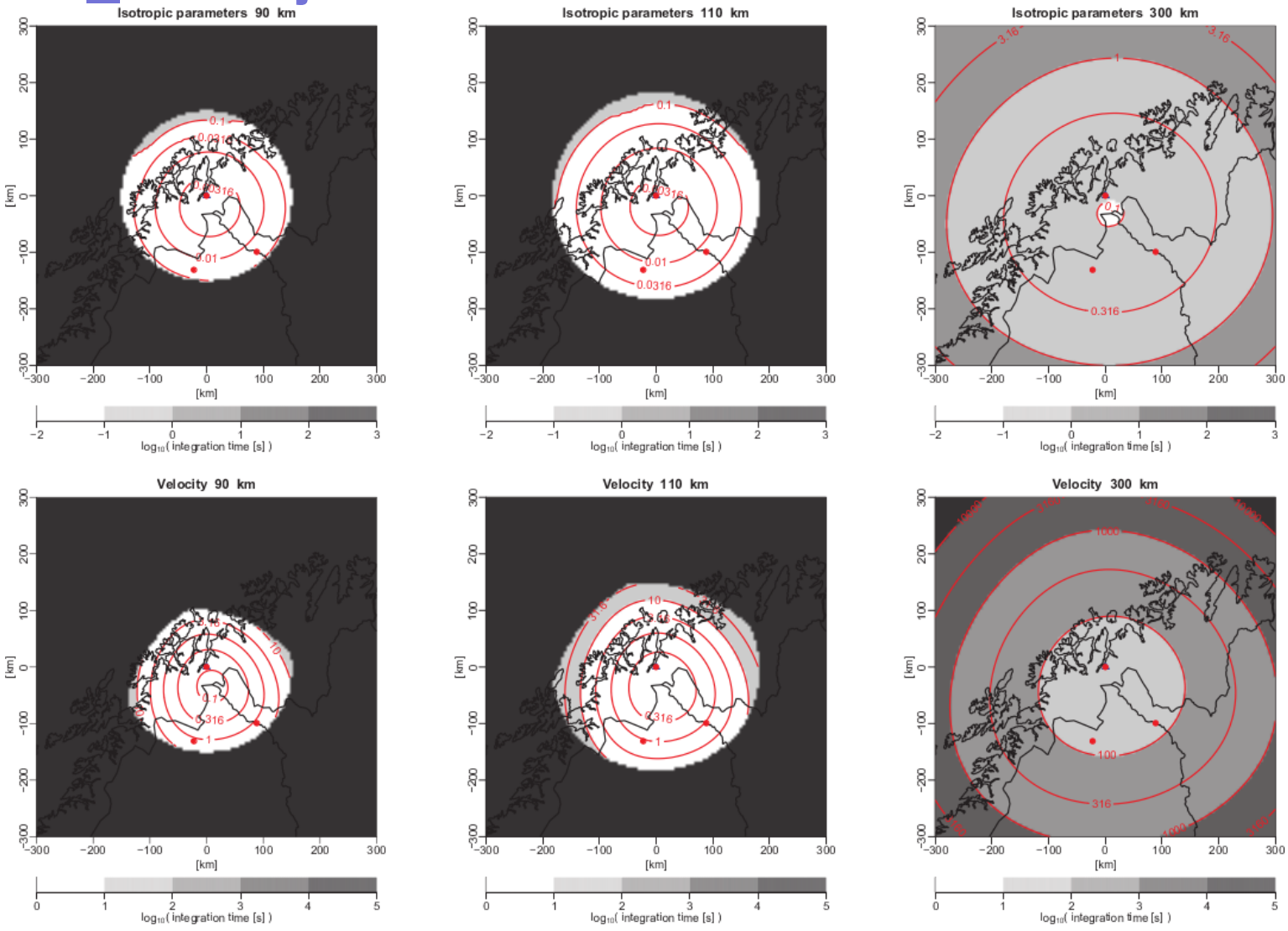
EISCAT_3D Project



EISCAT_3D Project

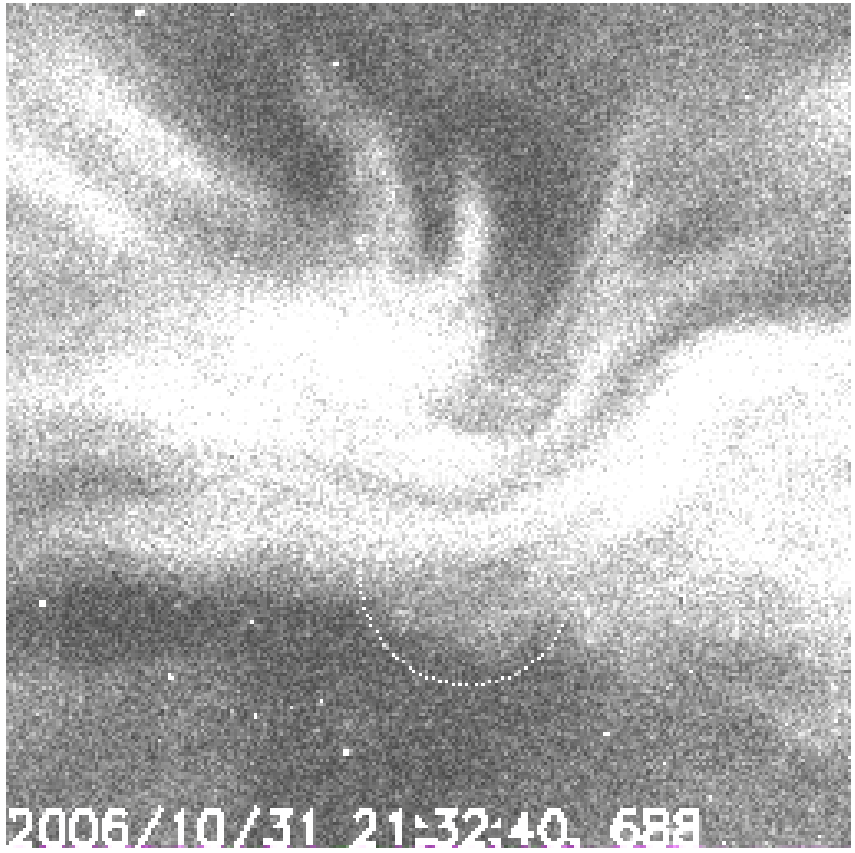


EISCAT_3D Project



Current EISCAT radars

Fine structure of aurora in real time



ASK 3×3 degrees 31 Oct 2006 Hanna Dahlgren, KTH

EISCAT_3D Project

https://heinselslug.smugmug.com/Professional/EISCAT/2017-06-Ramfjordmoen/

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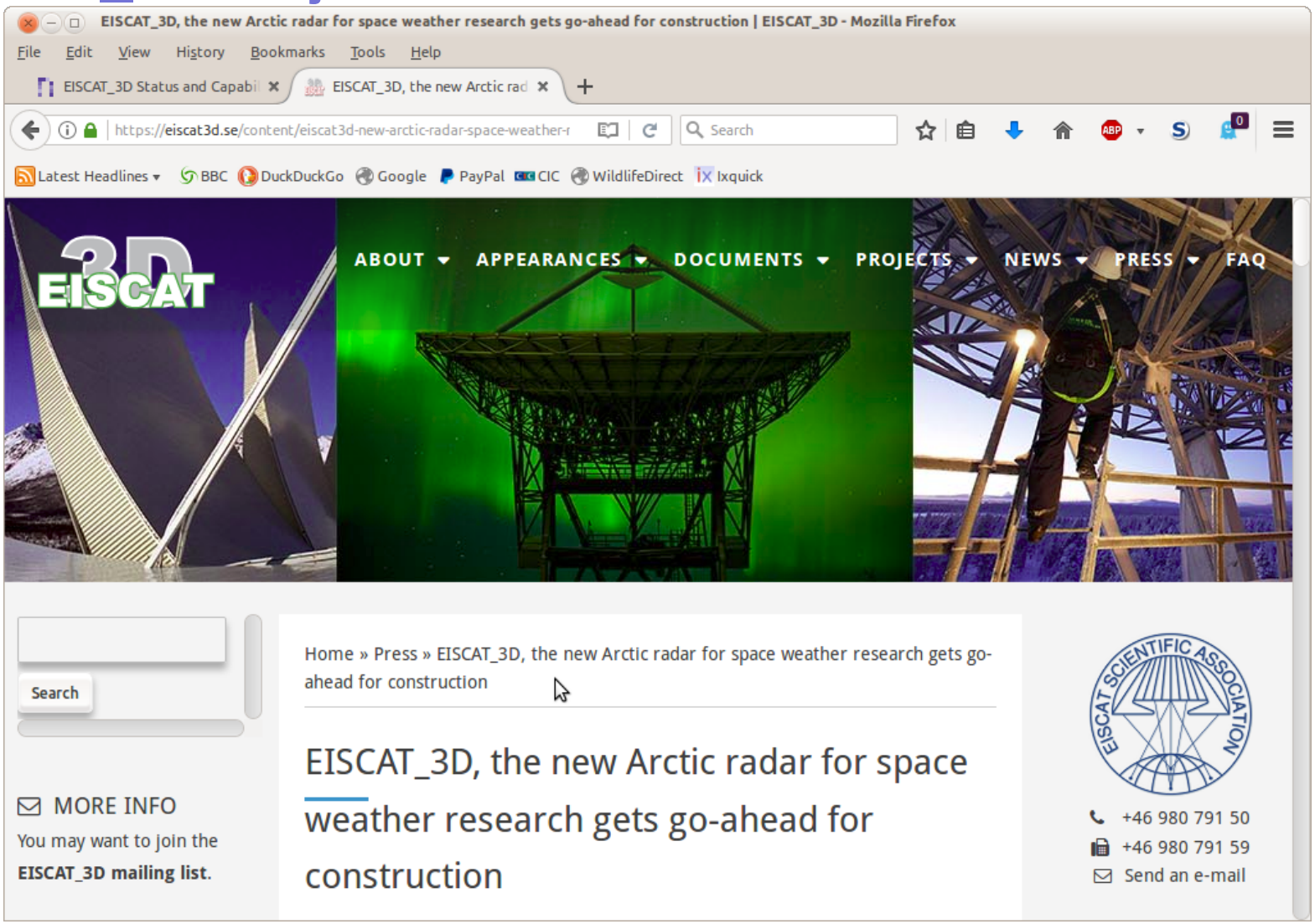


NeIC EISCAT_3D Support Project (E3DS)

- Project started January 15th 2015.
  - Basis: Letters of Interest to NeIC from EISCAT (2012, 2014)
  - Decision to launch project by NeIC Board (2014)
- Resources committed to project: EISCAT and NeIC
  Also, CSC, Tromsø and Umeå
- Steering group (representing partners that have committed resources):
  - Yasunobu Ogawa, EISCAT-Japan, (NIPR)
  - Craig Heinselman, EISCAT
  - Tomasz Malkiewicz, NeIC (CSC)

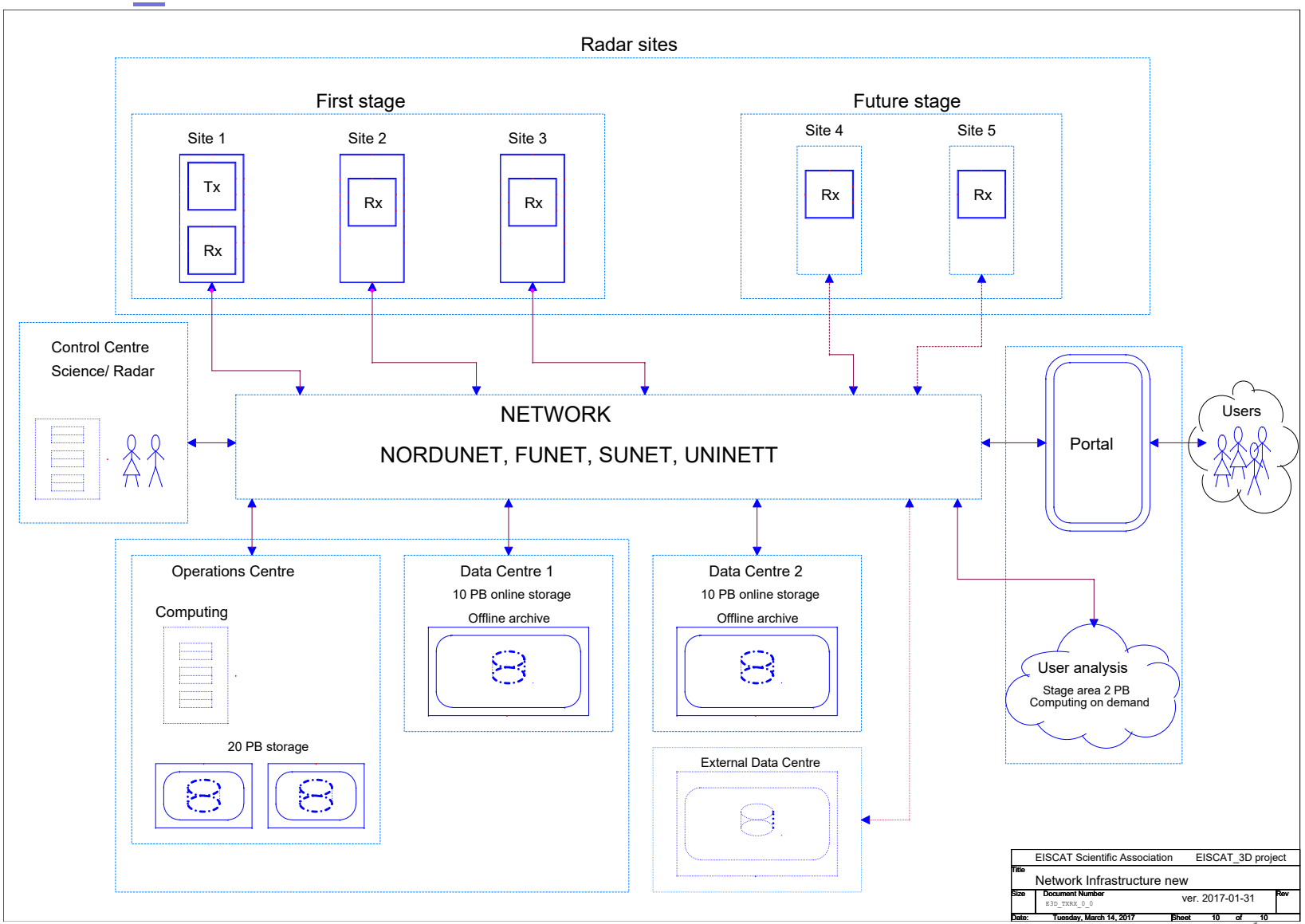
NeIC EISCAT_3D Support Project (E3DS)

- Project participants:
  - **Project manager (0.5 FTE)**: John White, NeIC.
  - Ingemar Häggström, EISCAT, Kiruna
  - Anders Tjulin, EISCAT, Kiruna
  - Assar Westman, EISCAT, Kiruna
  - Carl-Fredrik Enell, EISCAT, Kiruna
  - Sathyaveer Prasad, EISCAT, Kiruna
  - Tor Johansen, University of Tromsø
  - Harri Hellgren, EISCAT, Kiruna
  - Ari Lukkarinen, CSC
  - Sari Lasanen, University of Oulu
  - Mattias Wadenstein, University of Umeå
  - Åke Sandgren, University of Umeå
  - Juha Vierinen, University of Tromsø
  - Ilkka Virtanen, University of Oulu
  - Ulf Tigerstedt, CSC

E3DS Project Goals

- Find workable and cost-efficient solutions for the EISCAT_3D computing, storage and archive.
- Facilitate an effective dialogue on the implementation of EISCAT_3D with the stakeholders in the Nordic countries.
- Make best use of the existing expertise in the Nordic countries for implementing (the e-Infrastructure of) EISCAT_3D.

EISCAT_3D Wide-Area Schematic



EISCAT_3D computing

- On-site computing infrastructure (per radar site):
  - Reduce data rates to manageable levels (**19 Tb/s** $\rightarrow$ **53 Gbit/s);**
  - Two stages of beam forming.
    - Sub-arrays **109** $\times$ **5.0 TFLOPS**. (FPGA)
    - Overall beam former **22 TFLOPS**.
  - **86** TB RAM/SSD ring buffer.
  - Process computer (standard data products) **55 TFLOPS**.
- Off-site data-processing:
  - Operations Centre will coordinate the radar operations and observation modes;
  - Monitor production of standard data products from sites;
  - Generate non-standard products, multi-static data products and meta-data;
  - Eventually requires $\approx$ **500 TFLOPS.**
  - Located within existing e-infrastructure?
- Control centre located functionally within Operations Centre.
  - At Skibotn during commissioning, subsequently at Kiruna.

EISCAT_3D Network Traffic Matrix

	From								
To (below)	Ops Centre	Data 1	Data 2	Skibotn	Bergfors	Karesuvanto	Jokkmokk	Andoya	Sum
Ops Centre	N/A	1	1	53	53	53	53	53	267
Data 1	2	N/A	0.5	0	0	0	0	0	3
Data 2	2	0.5	N/A	0	0	0	0	0	3
Skibotn	1	0	0	N/A	0	0	0	0	1
Bergfors	1	0	0	0	N/A	0	0	0	1
Karesuvanto	1	0	0	0	0	N/A	0	0	1
Jokkmokk	1	0	0	0	0	0	N/A	0	1
Andoya	1	0	0	0	0	0	0	N/A	1
UK (RAL)	0	1	1	0	0	0	0	0	2
Japan (NIPR)	0	1	1	0	0	0	0	0	2
Sum (Out)	9	3.5	3.5	53	53	53	53	53	

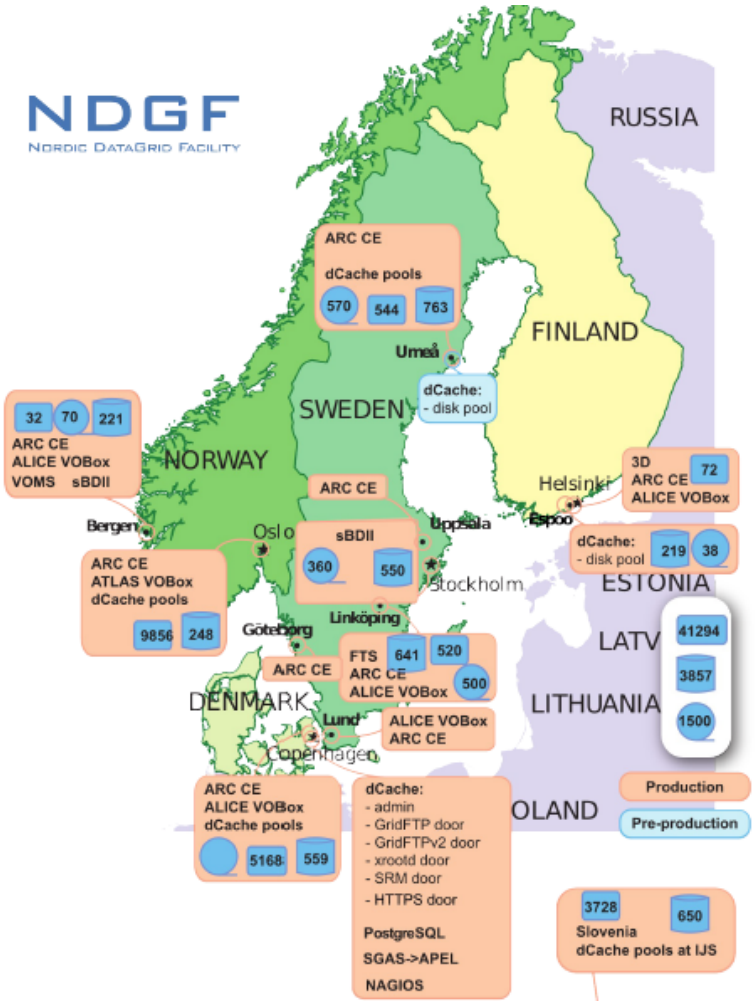
All numeric values are in Gb/s. A red (green) box indicates a (non) redundant path. Orange data transferred outside the Nordic area.

EISCAT_3D Integrated computing

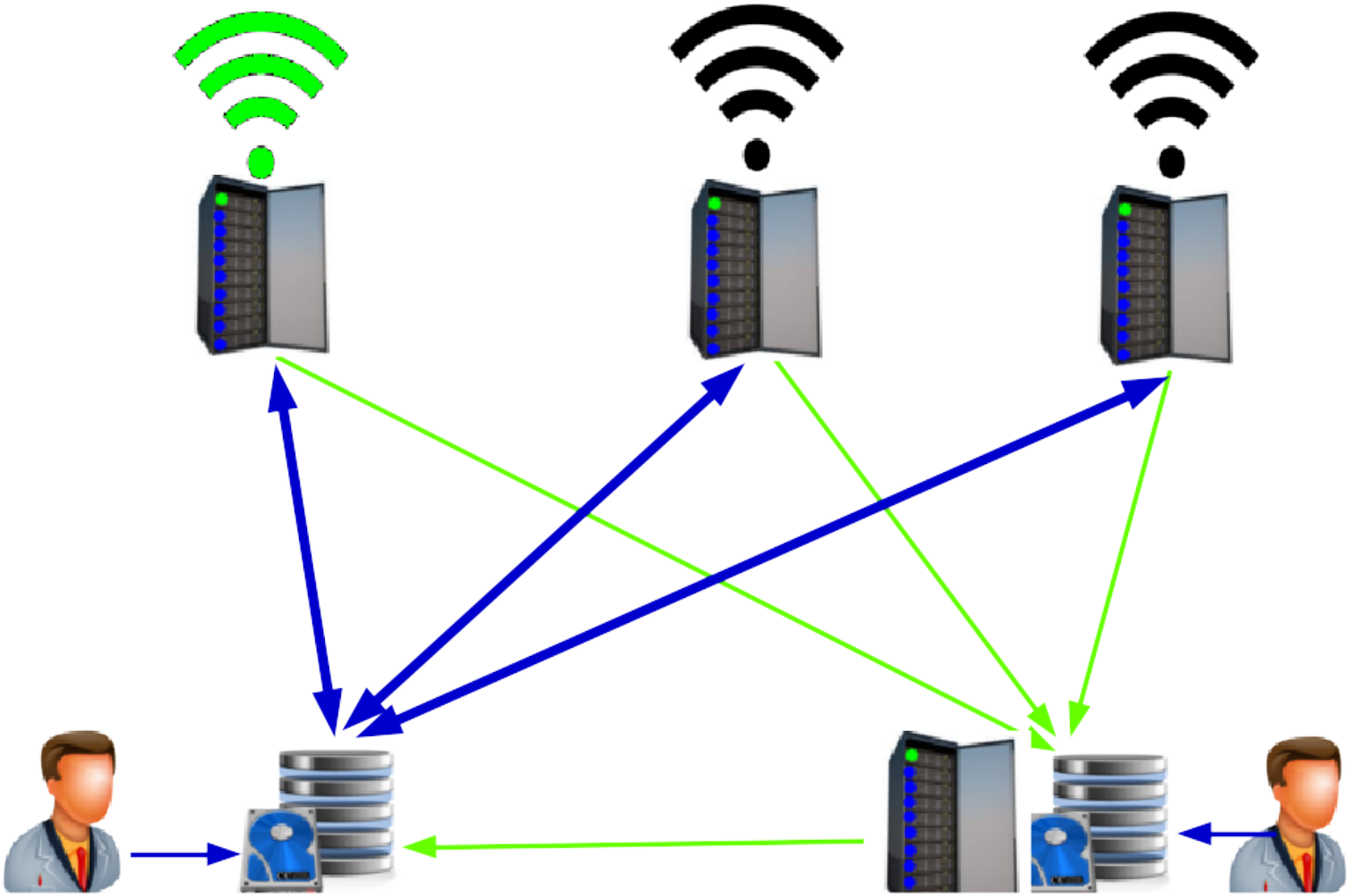
- **Site computing:**
  - Virtualized cluster: ≈ 80 TFLOPS
  - Beam forming containers/VMs.
  - Process computing containers/VMs.
  - User analysis computing containers/VMs.
- **Operations Centre computing:**
  - Virtualized cluster: ≈ 500 TFLOPS
  - 3D operations containers/VMs.
  - User analysis computing containers/VMs.
  - "Controller" node for virtualized cluster.
- **User analysis computing:**
  - User analysis containers/VMs distributed through Operations Centre and sites.
  - User analysis jobs interruptible by radar state.
  - Analysis computing profiles matched bycontainer/VM.
- **Virtualized e-infrastructure run by national provider(s).**

Nordic Tier-1 (NT1)

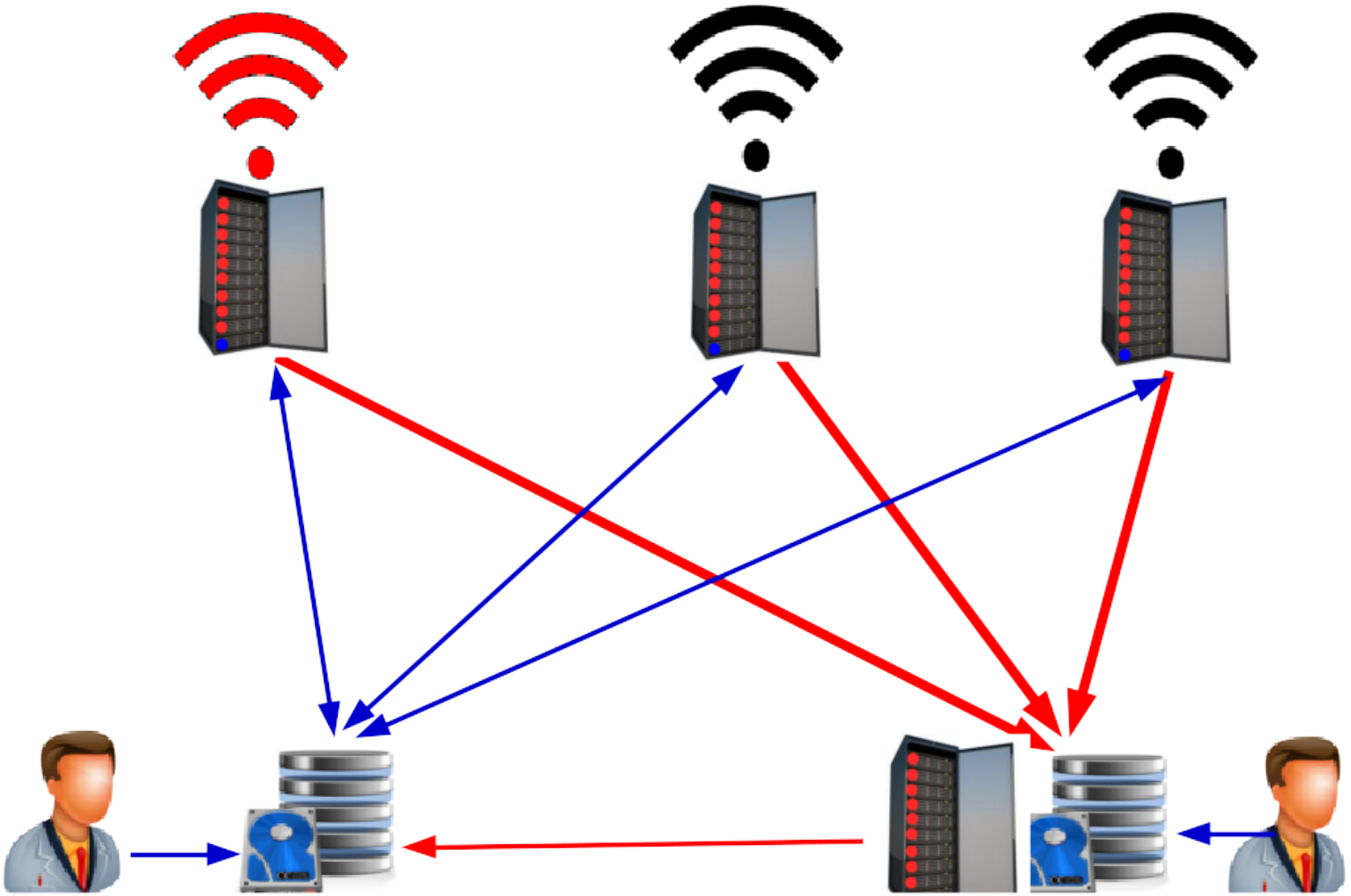
- CERN/LHC Tier 1 computing in the Nordic countries. Distributed site.
  - Bergen, Oslo
  - Umeå, Linköping
  - Copenhagen, Helsinki
- Project hosted within **NeIC**.
  - ≈ 12 people. 50% average.
  - Since 2010, part of **EGI**.
  - Serves ALICE, ATLAS.
  - **Compute** and **Storage** resources.
  - Networking by NorduNet.



e-infrastructure 3-D Operations: Low power



e-infrastructure 3-D Operations: High power



Concluding Remarks

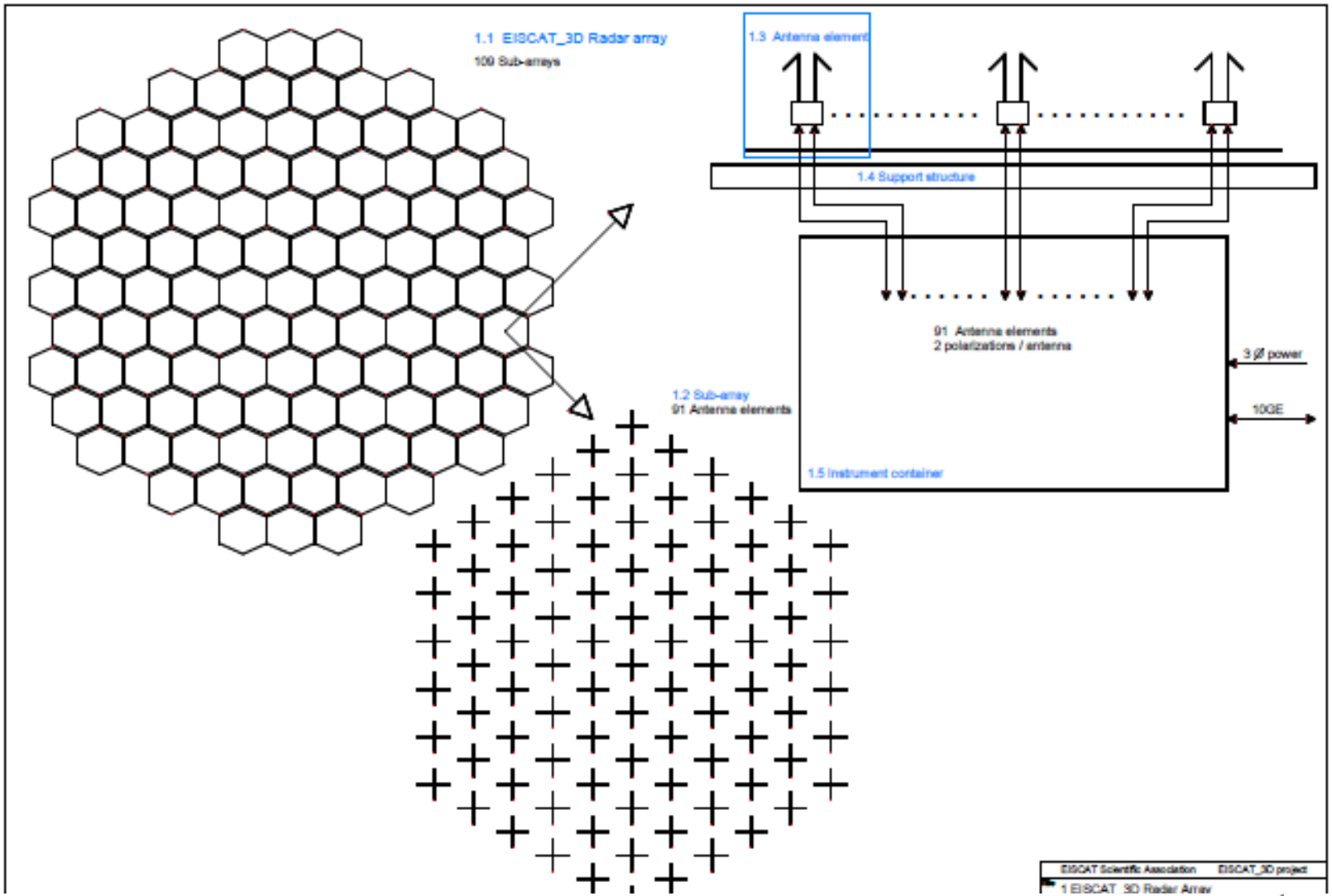
- **EISCAT_3D project on schedule.**
  - Test sub-array this summer 2017
- **E3DS project has aided in requirements for:**
  - **Operations Centre**
  - **Data Centre**
  - **Site and Operations Centre computing:**
    - Take advantage of virtualization to operate as single cluster.
    - Cluster operations by national provider(s).
    - EISCAT_3D relieved from cluster operations.
    - Spare cycles used for EISCAT_3D user analysis or other.
- **Use existing expertise to aid EISCAT_3D to perform science.**

Thank you

Questions?

Written in LaTeX

EISCAT_3D sub-arrays detail



E3DS Project Documents

- Project documents released:
  https://wiki.neic.no/wiki/EISCAT_3D_Support#Documents
  - MA-1: Requirements and their implications for EISCAT_3D data handling and processing at the operations centre
  - MA-2: Requirements and their implications for EISCAT_3D data handling and processing at the data centre
  - MA-3: EISCAT_3D Wide-Area Network Plan
  - MA-4: Recommended solutions for the operation and data centres.
  - MB-1: On-site computing requirements for EISCAT_3D test sub-array
  - MB-2: Consultation on selecting architecture/technology for the on-site computing related to a test-subarray
  - MB-4: Consultation on the procurement plan for EISCAT_3D core site test-subarray in particular to ensure its compliance with the overall high level computing architecture of the EISCAT_3D system.
  - MC-1: Test sub-array sub-systems and interfaces
  - MD-3: "Report on solutions for the data archive, including a description on how users can get access to adequate computing facilities"