EISCAT_3D: A European Three-Dimensional Imaging Radar for Atmospheric and Geospace Research

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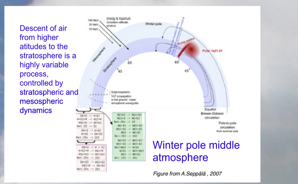
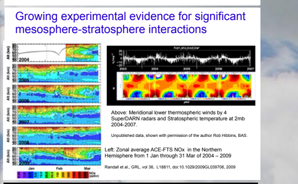
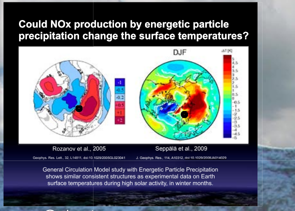
EISCAT_3D will be Europe's next-generation radar for the study of the high-latitude atmosphere and geospace. The facility will be located in northern Fenno-Scandinavia, with capabilities going well beyond anything currently available to the international research community. Several very large active phased-array antenna transmitter/receiver arrays, and multiple passive sites will be located across three countries. EISCAT_3D will be comprised of tens of thousands, up to more than 100000, individual antenna elements.

EISCAT_3D combines several key attributes which have never before been available together in a single radar, such as volumetric imaging and tracking, aperture synthesis imaging, multistatic configuration, improved sensitivity and transmitter flexibility. The use of advanced beam-forming technology allows the beam direction to be switched in milliseconds, rather than the minutes which it can take to re-position dish-based radars. This allows very wide spatial coverage to be obtained, by interleaving multiple beam directions to carry out quasi-simultaneous volumetric imaging. It also allows objects such as satellites and space debris to be tracked across the sky. At the passive sites, the design allows for at least five simultaneous beams at full bandwidth, rising to over twenty beams if the bandwidth is limited to the ion line, allowing the whole range of the transmitted beam to be imaged from each passive site, using holographic radar techniques.







The Science Objectives

- **What is the influence of natural variability in the solar-terrestrial system on climate?**
- How are atmospheric layers coupled?
- Support for space-borne science studies.
- Space weather monitoring.
- Space surveillance.
- Orbital element determination of space debris, meteors and asteroids.
- Effects of meteoritic deposit on atmospheric chemistry.
- Magnetospheric and ionospheric plasma physics.
- Mapping of near-Earth objects.
- Solar wind and solar coronal measurements.
- Development of radar and information technology.

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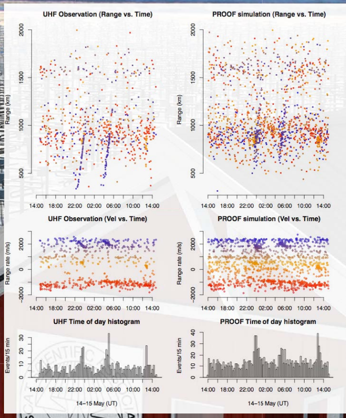


Space debris detected using the EISCAT UHF system on May 14-15th 2009, afew months after the Iridium-Cosmos satellite collision.The Iridium cloud orbital plane passes are visible at about 00:00 and 13:00 UT; and the Cosmos cloud pass at about 00:00 and 06:00 UT. The figure also compares the measurement with a statistical debris model called PROOF.

Differences show that the model could be improved by using the EISCAT measurements.

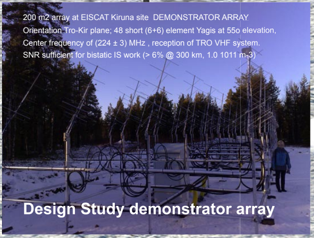
(from J. Vierinen et al., 2009)

Concept of the Design Study

- at least 4 remotes and 1 core site
- resolution at 100 km 1s/100m
- 3D coverage: stratosphere - 800 km
- core site range up to 2000 km

The time line:

- 2005-2009: Design Study, completed
- 2010-2013: Preparatory Phase
- 2014-2015: Construction
- 2015-2045: Operation



Design Study demonstrator array

SCALE: 10's of thousands of antennas
RESOLUTION: 10 times better time and spatial resoution than present radars
CAPABILITY: EISCAT_3D will be a volumetric radar capable of imaging an extended spatial area with simultaneous full-vector drift velocities, having continuous operation modes, short baseline interferometry capability for imaging sub-beamwidth scales, real-time data access for applications and extensive data archiving facilities.
EISCAT_3D is open to Global and Asian participitation
During the preparatory phase 2010-2013 the development of technical concepts according to science criteria will be done via user community workshops and dedicate work groups.
If your institute is interested to use EISCAT_3D, please send us a request to be included as an Associate Partner. Associate partners are invited to user meetings and workgroups.

See handout document at http://www.eiscat3d.se/drupal/material

EISCAT_3D has a modular configuration, which allows an active array to be split into smaller elements to be used for aperture synthesis imaging. The result will be an entirely new data product, consisting of range-dependent images of small sub-beamwidth scale structures, with sizes down to 20 m. EISCAT_3D will be the first phased array incoherent scatter radar to use a multistatic configuration. A minimum of five radar sites, consisting of two pairs located around 120 km and 250 km from the active site respectively, on baselines running East and South from the active core, is envisaged. This provides an optimal geometry for calculation of vector velocities in the middle and upper atmosphere. The gain of the EISCAT_3D antennas and the large size of the active site arrays will deliver an enormous increase in the figure-of-merit relative to any of EISCAT's existing radars. An active site of 5,000 elements would already exceed the performance of the current EISCAT VHF system, while an active site comprising 16,000 elements, as suggested in the Design Study carried out from 2005 to 2009, will exceed the sensitivity of the present VHF radar by an order of magnitude. Each transmitter unit will have its own signal generator, allowing the generation and transmission of arbitrary waveforms, limited only by the available transmission bandwidth and spectrum allocation by the frequency management authorities.

Implementation of all currently used and envisaged modulation schemes and antenna codings (such as polyphase alternating codes, array tapering, orbital angular momentum beams) is possible, as well as adaptation to any kind of future codes. In addition, it will allow advanced clutter mitigation strategies such as adaptive null steering and null shaping.

The science case of EISCAT_3D is versatile, ranging from global change related studies of the atmospheric energy budget and coupling of atmospheric regions to space plasma physics with both small-scale structures and large-scale processes, as well as planetary and meteor radar applications. Additional societal value is in opportunities for continuous geospace environment monitoring and possible service applications to users needing information on space debris and space weather.

Modular construction, several sites

ESFRI Roadmap project

- The Swedish Research Council proposed EISCAT_3D on the ESFRI Roadmap
- ESFRI accepted the proposal in December 2008.
- The ESFRI EISCAT_3D proposal emphasizes modular construction of a large distributed radar facility with a possibility to have several active sites

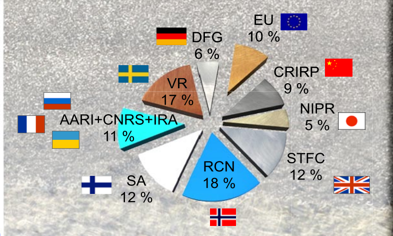
Operation 2015-2045
Estimated costs: Preparation: 6 MEUR
Construction: 60 MEUR one active site
250 MEUR all sites
Operation: 4-10 MEUR/year
Decomissioning: 10-15% of construction

Website: http://www.eiscat3d.se/

EISCAT *is an International Association with current members from China, Finland, Germany, Japan, Norway, Sweden, and Great Britain, as well as supporting partners from France, Russia and Ukraine.*

EU funding of mobility and

EISCAT Scientific Association



2009 Budget 34 MSEK / 3.3 MEUR

EISCAT Scientific Association operates currently three incoherent scatter radars in Northern Scandinavia. The current facilities include the 2-dish monostatic radar at 500Mhz at Longyearbyen, Svalbard, the 224 MHz monostatic VHF radar in Tromsø, Norway, a tristatic UHF radar at 930 Mhz with transmitter/receiver in Tromsø and receivers in Kiruna, Sweden and Sodankylä, Finland, a high-power HF heating facility in Tromso, as well as 2 dynasondes in Tromso and at Svalbard.

Incoherent scatter radar (ISR) is known to be the most versatile ground-based remote sensing method of the upper atmosphere and near-Earth space, being able to measure 4 parameters, electron density, electron temperature, ion temperature and line-of-sight plasma velocity simultaneously. With assumptions, even more parameters can be deduced. Also weak coherent targets, such as meteors and very small space debris can be measured since the ISR is essentially a high-power, large-aperture radar.

EISCAT Incoherent Scatter radars