EISCAT_3D

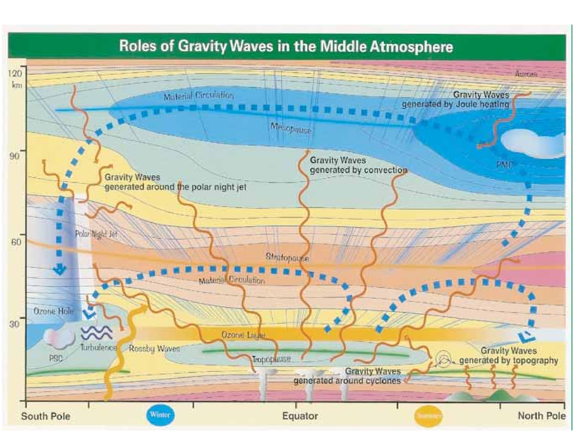
Next Generation Incoherent Scatter Radar in Europe

Introduction

EISCAT (European Incoherent Scatter) Scientific association operates three incoherent scatter radars in Tromsoe and Longyearbyen, Norway as well as additional receiver sites in Kiruna, Sweden and Sodankyla, Finland. Currently the EISCAT Associates comprise Finland, China, Germany, Japan, Norway, Sweden, and the United Kingdom, as well as supporting partners France and Russia. The radars observe the terrestrial plasma environment, measuring plasma densities, temperatures, and velocities amongst other parameters. EISCAT also monitors the solar wind, meteors and space debris, making the facilities a unique resource for geospace and climatologic monitoring.

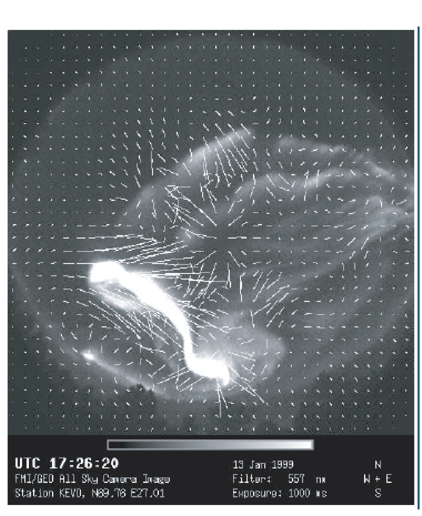
Over the last few years, a number of trends have appeared which have inevitably made it necessary for us to renew our current hardware. Most importantly, EISCAT science has moved into new areas, including more detailed studies of the energy coupling between the upper and lower atmosphere, the linkages among ionosphere, thermosphere, and magnetosphere, investigations of the importance of turbulence and small-scale structure, and sensitive detection of weak-coherence targets such as micrometeoroids, cm-scale space debris, as well as into planetary radar applications. These studies are not purely scientific, but also have practical importance for applications such as global positioning, communications, space situational awareness, and education. In turn this has presented a need for observations beyond the capabilities of the present systems, requiring capabilities such as greater sensitivity, faster scanning, multiple beams, volumetric imaging and interferometry, which no incoherent scatter radar is currently capable of providing. At the same time, EISCAT's existing radars are becoming older and harder to maintain, and the frequency bands which have been used for EISCAT operations in the past are coming under increasing pressure from UMTS 900 mobile telephones (in the case of our UHF frequencies) and digital audio broadcasting (in the case of our VHF frequencies). Another factor has been the recent inception of new incoherent scatter radars using phased array technology, such as the AMISR systems by National Science Foundation of USA. While these systems are admirable in many respects, the EISCAT community collectively felt that it was possible to go considerably further in developing phased array radar which was really unique, combining high sensitivity, volumetric imaging, interferometry and multistatic observations.

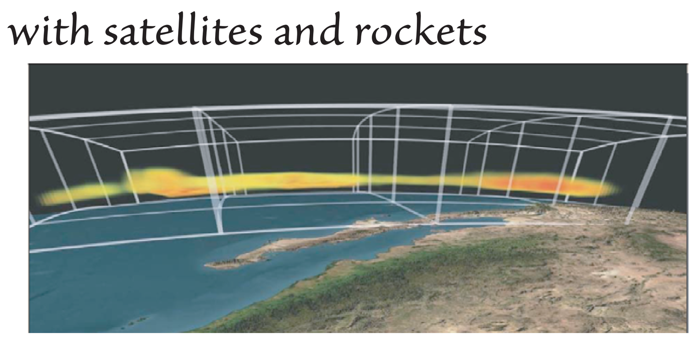
Key Science Drivers for EISCAT_3D

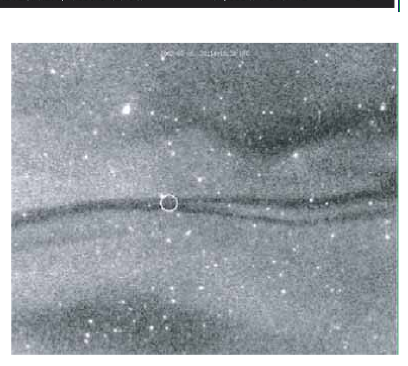


* 3D fine structures in the aurora
* Spatiotemporal meso-scale structures of the electromagnetic energy in the ionosphere
* Spatiotemporal meso-scale structures in the thermosphere
* Lower-thermospheric wind dynamics (atmospheric gravity waves, tides, planetary waves)

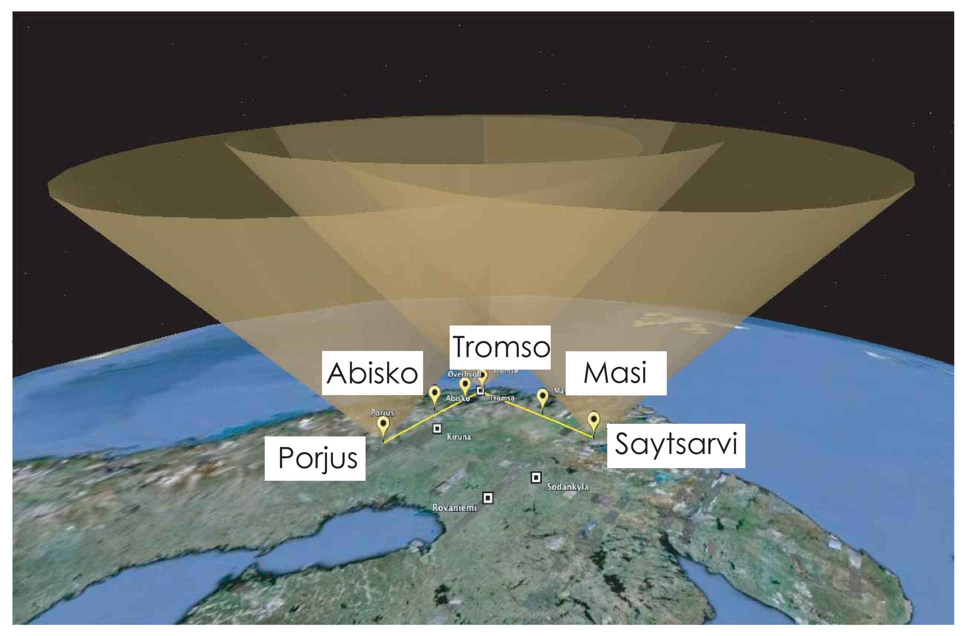
* Global effects of the polar ionospheric/thermospheric variations and feedback to the magnetosphere
* 3D current system
* Development of the methodology to estimate height-resolved ion composition in the whole ionosphere
* 3D structures of the naturally enhanced ion-acoustic and plasma lines
* ion out flow
* collaborative observation with Antarctic radars such as PANSY
* simultaneous observations with satellites and rockets



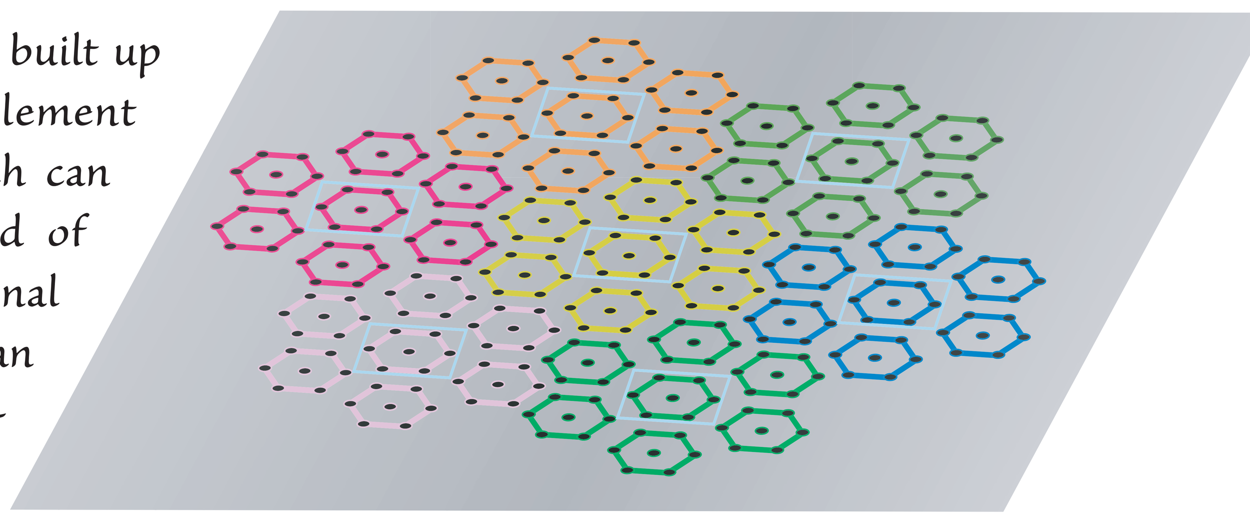




Specifications



The central core or the transmitter site is assumed to be located near the present Norwegian EISCAT site at Ramfjordmoen. The receiving sites located at four separated positions provide 3D coverage in the F region (over the 250-800 km height range) and in the E region (70-300 km height range).



The 3D core array will be built up from close-packed 49-element sub-groups, each of which can be regarded as composed of seven 7-element hexagonal cells. The figure shows an oblique view of a 343-element, approximately 18-m diameter array group, formed from seven sub-groups separated by different colors. The full core will comprise approximately 49 343-element groups. Each sub-group is served by a common, approximately 2m by 2m equipment container (indicated a square at the center of each sub-group) containing all RF, signal processing and control and monitoring electronics.

Transmitter parameters:

* Radar frequency in the 225-240 MHz range
* Power amplifiers utilising VHF TV power FETs
* Phased-array system with > 16K elements
* Peak power is over 2MW
* Equilateral triangular array configuration
* >3 outlier, Rx-only array modules for interferometry
* Fully digital, post-sampling beam-forming on receive
* Comprehensive interferometeric and imaging capabilities built-in

Receiver parameters:

* "Far-out" (~250 km baselines) sites dedicated to F2/topside work
* "Half-way" (100-110 km baselines) sites dedicated to F1/E/D region work
* Formed by approximately 8,000 antennae
* Medium gain (~10 dBi) element antennae
* Fully digital, post-sampling beam-forming
* Sufficient local signal processing power to generate at least five simultaneous beams
* 10 Gb/s connections for data transfer and remote control and monitoring
* Filled apertures, long enough to provide ~1 km beam resolution at E region altitudes above transmitter

Present Stage

Schedule

~ 2008:	design study ended
2009 ~ 2012:	funding call
2012 ~ 2015:	design & construction (2014: UHF closed)
2015 ~ 2045:	operation

Initial cost to assemble

* infrastructure of sites:	5.3 M Euro
* core site:	48.7 M Euro
* 4 remote sites:	63.0 M Euro
* data analysis etc:	0.5 M Euro
Total:	117.5 M Euro
Annual fee for operation:	2.9 M Euro

The European Strategy Forum on Research Infrastructures (ESFRI) selected EISCAT_3D for the Roadmap 2008 for Large-Scale European Research Infrastructures for the next 20-30 years. The facility will be constructed as a modular system by 2015.

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