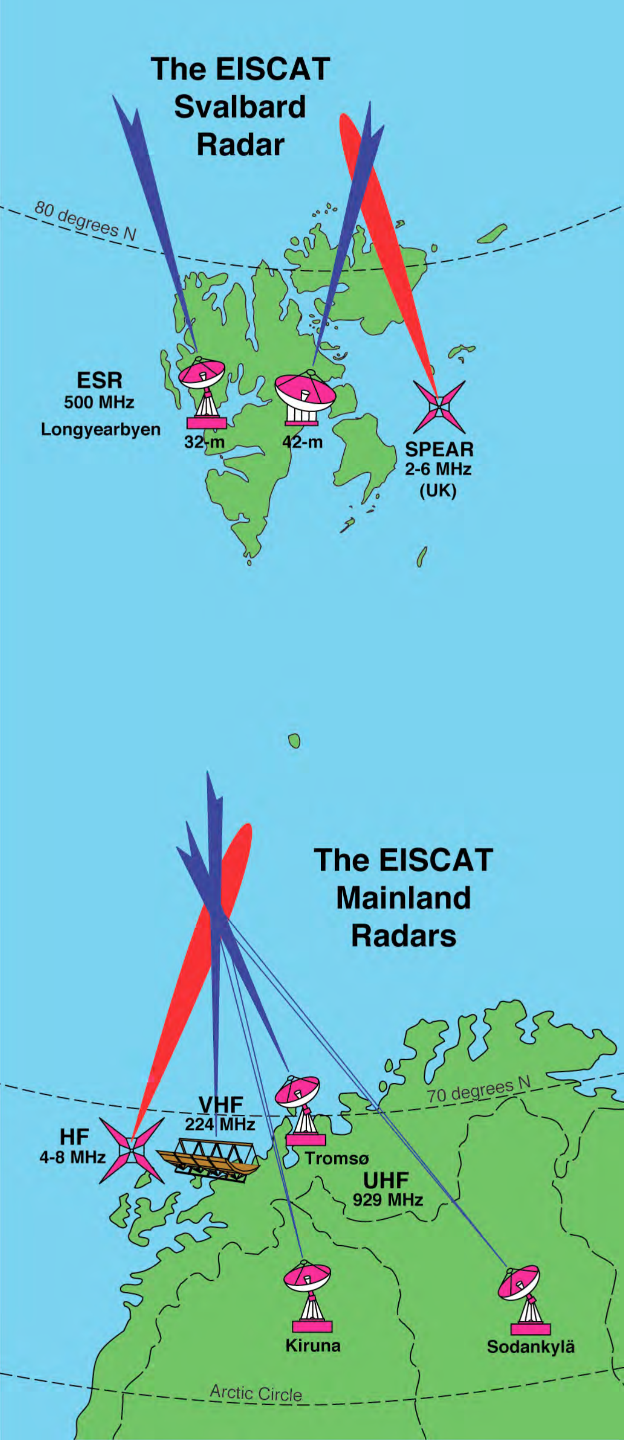
An Introduction to EISCAT_3D

Ingrid Mann

EISCAT Scientific Association, Kiruna, Sweden



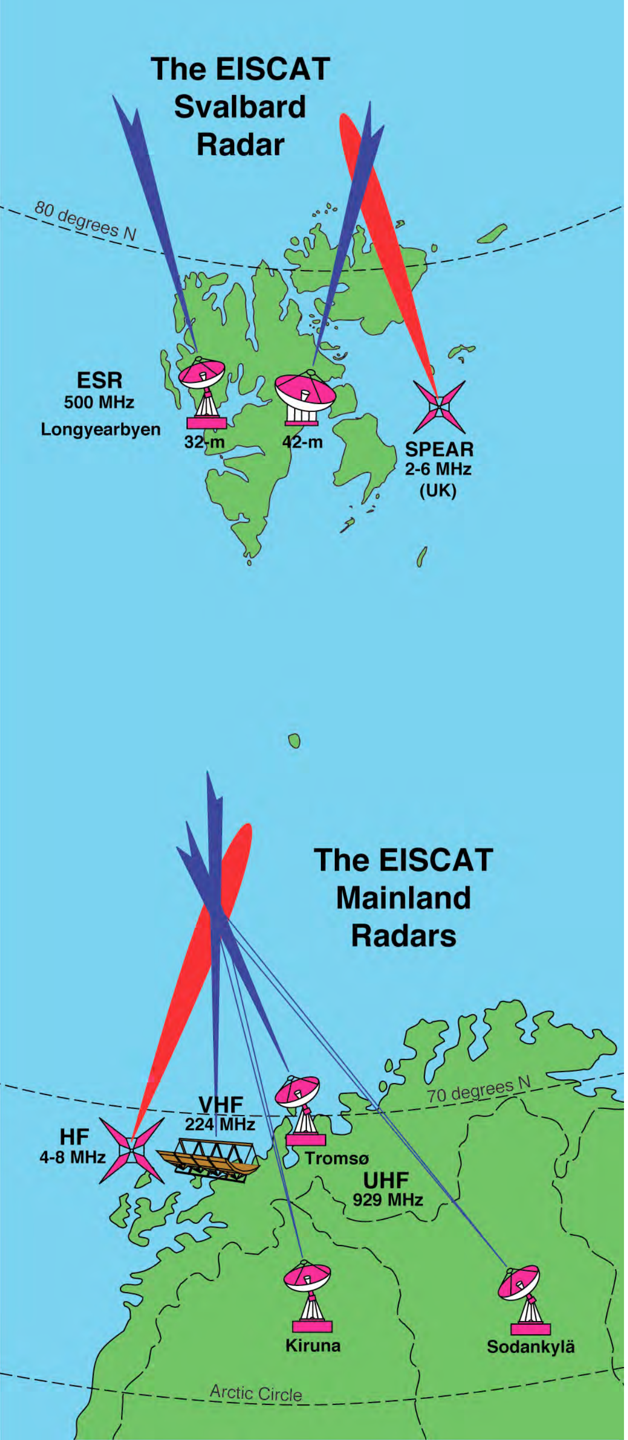
EISCAT Incoherent Scatter Radars

EISCAT scientific association

Incoherent scatter measurements

Example for other radar targets

EISCAT_3D project



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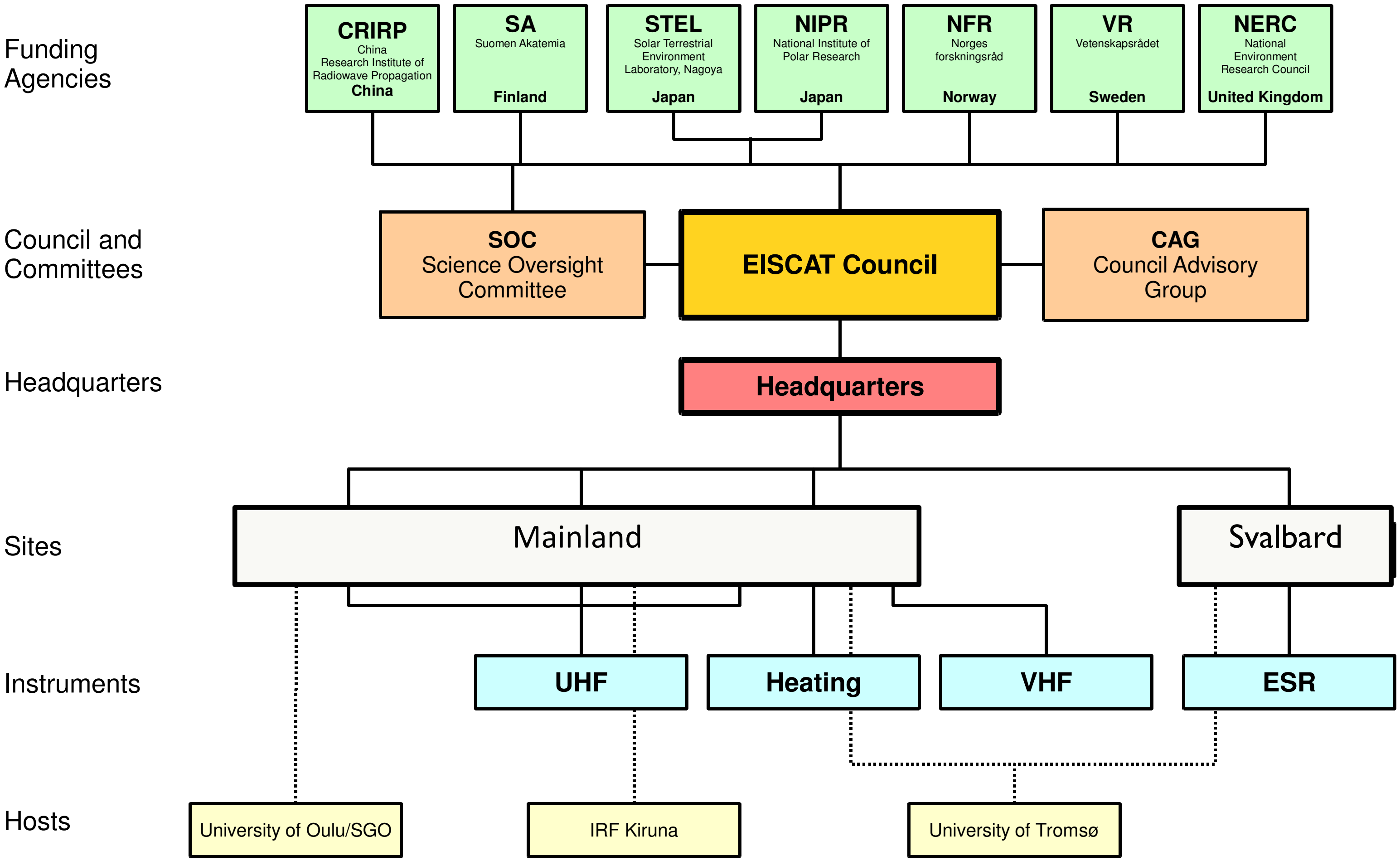
EISCAT_3D project


EISCAT
European Incoherent
Scatter Scientific Association

EISCAT Radars and Dynasondes

224, 500, & 928.4 MHz

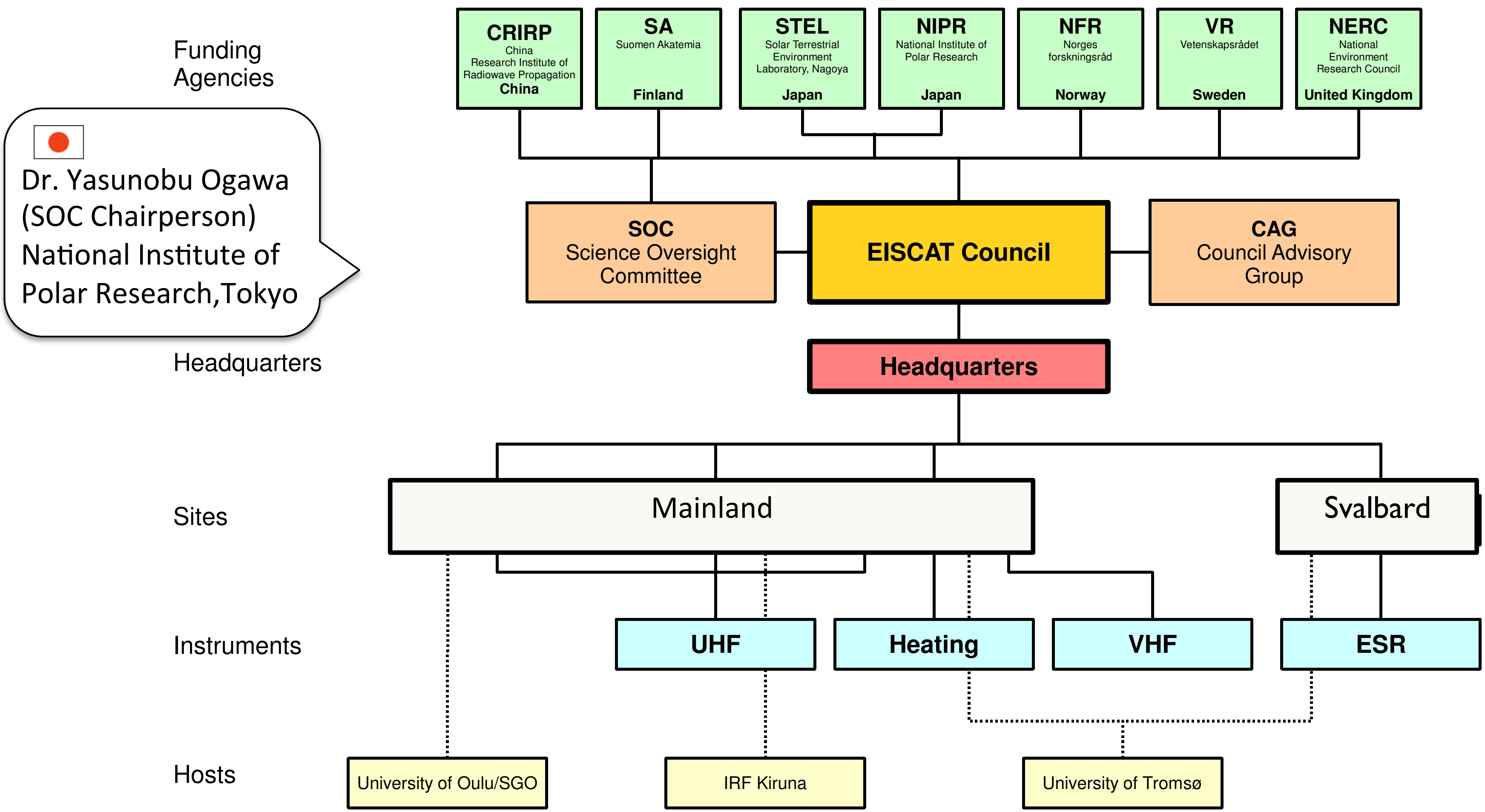
EISCAT Governance



EISCAT Governance

Dr. Hiroshi Miyaoka (Council Delegate)
National Institute of Polar Research, Tokyo

Dr. Satonori Nozawa (Council Member)
Solar Terrestrial, Environmental Lab. Nagoya University



EISCAT

participates in global measurement campaigns

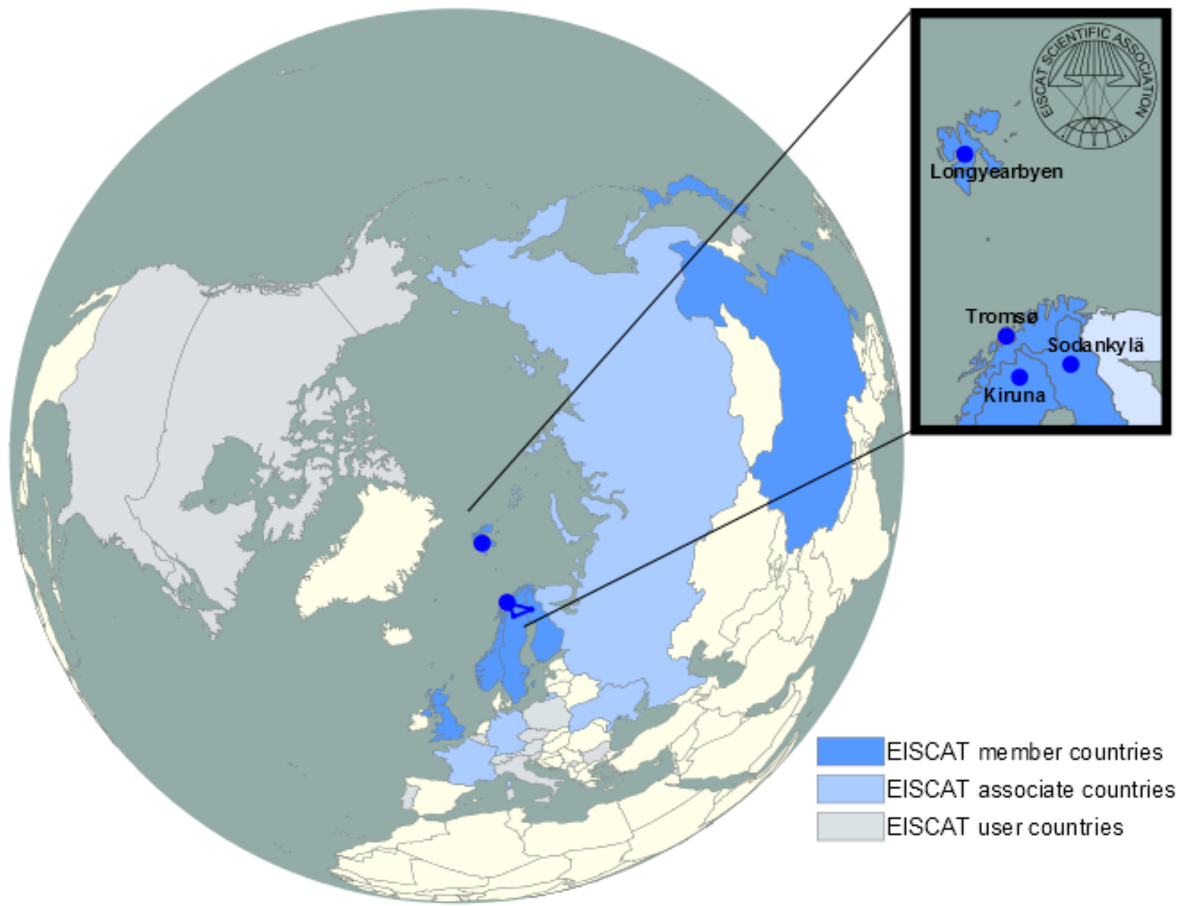
is used together with optical observations

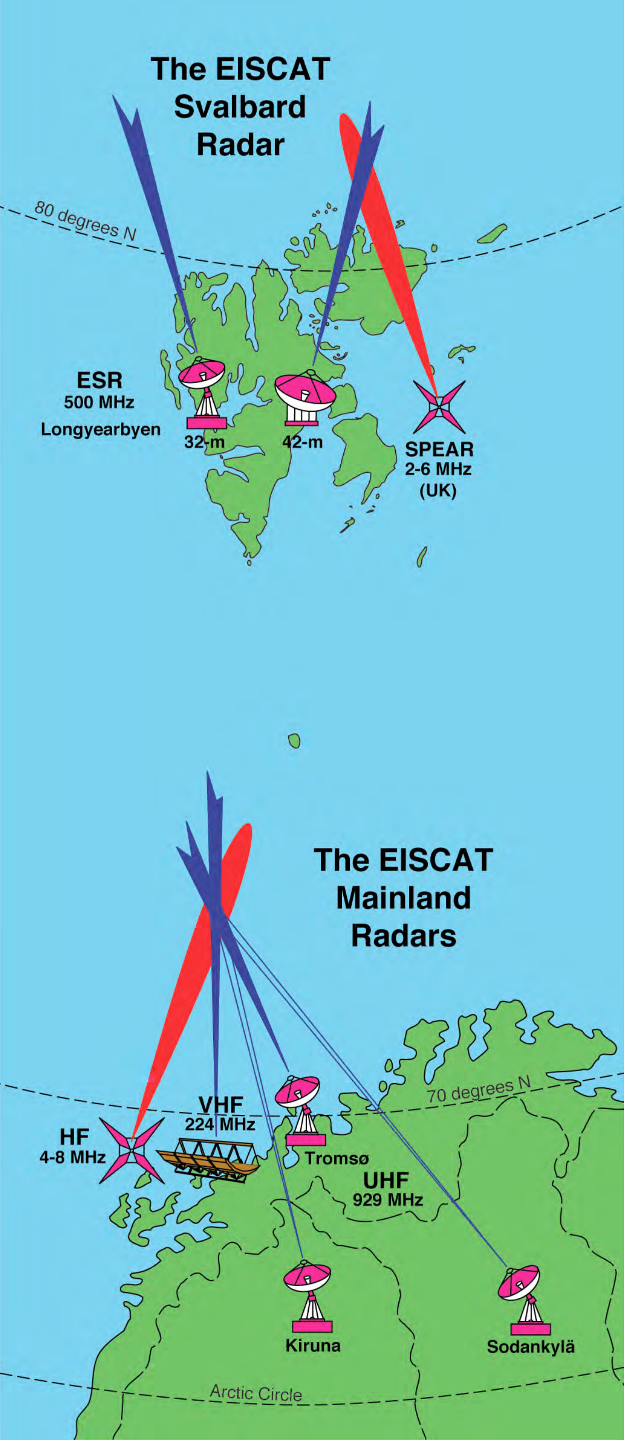
measures in conjunction with rockets & satellites

2013 Observations (est.):
1500 hrs Common
1200 hrs Special (200 Japan)

current members

- China
- Finland
- Japan
- Norway
- Sweden
- United Kingdom





EISCAT Incoherent Scatter Radars

derive from data:

electron density

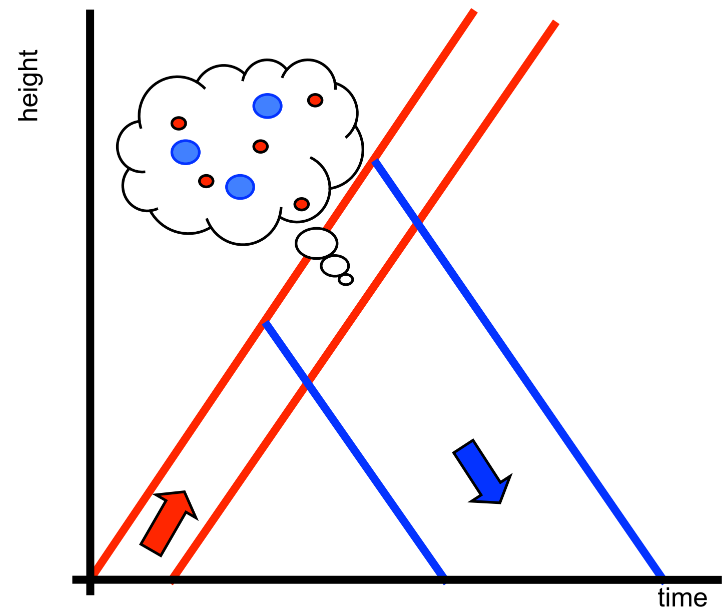
electron temperature

ion density

ion temperature

(.....)

Electrons scatter the radio wave:



observe scattering at electrons

electron oscillations “damped” by ions(& charged dust)

high power radio pulse 2 MW

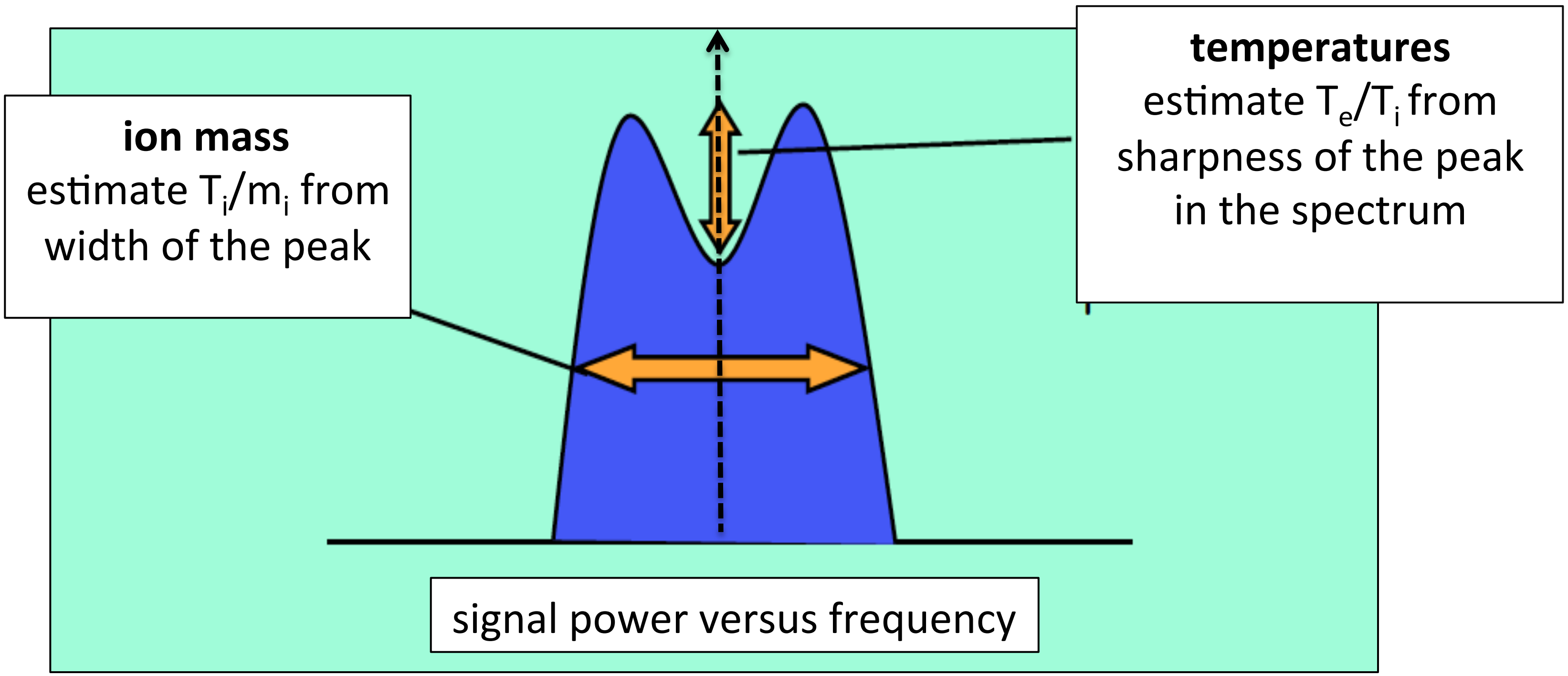
sensitive receiver signal 10^{-18}W

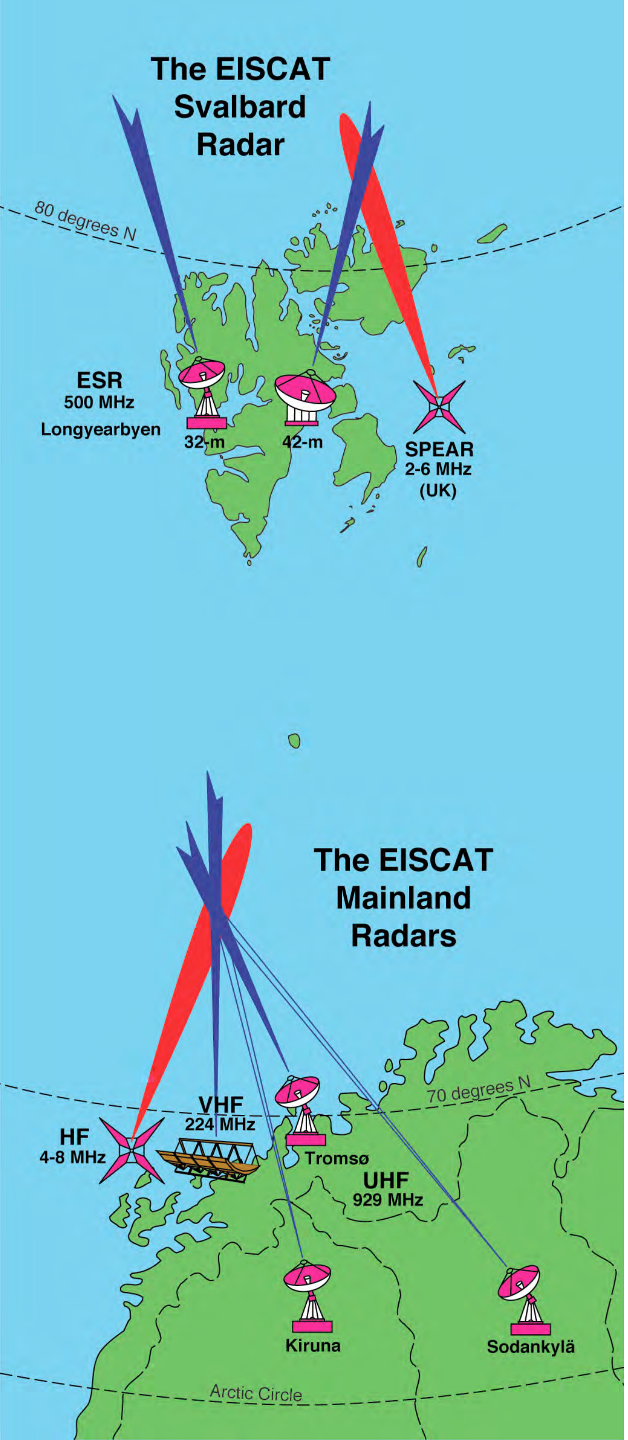
Some parameters found from scatter spectrum:

electron density (= ion) density from integrated back scattered signal

ion velocity from Doppler shift of frequency

altitude of scattered volume from time lag





EISCAT Incoherent Scatter Radars

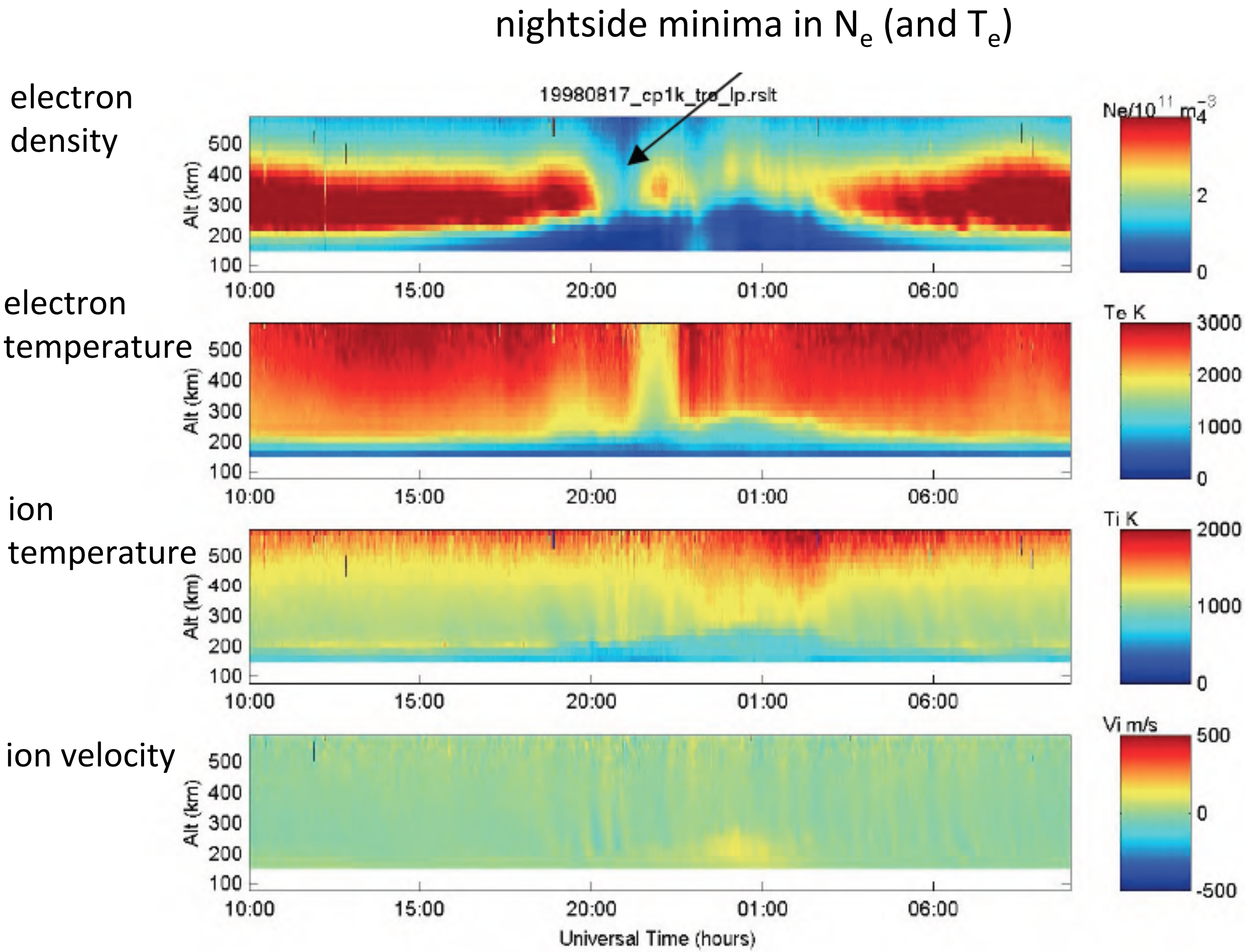
EISCAT scientific association

Incoherent scatter measurement

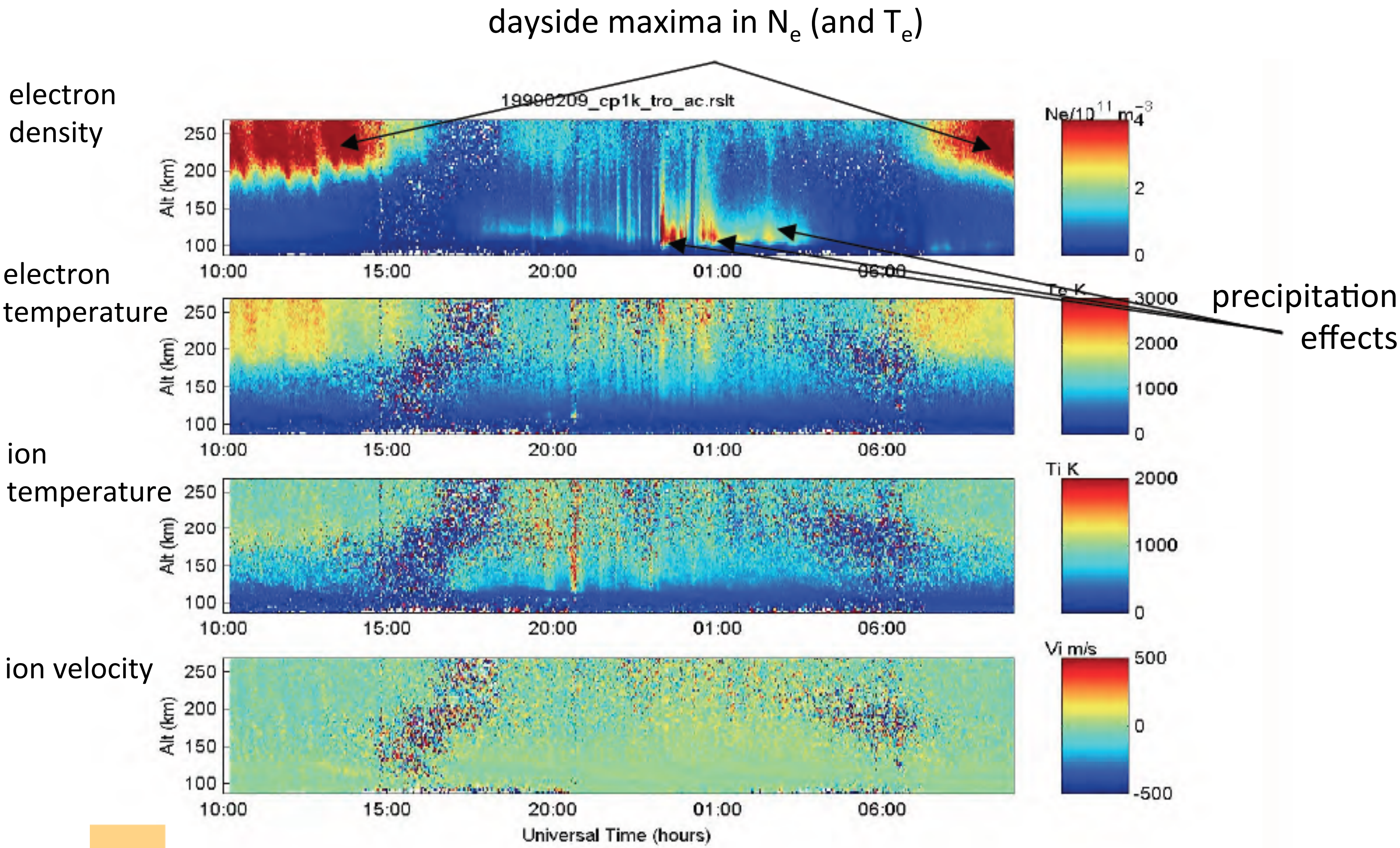
Example for other radar targets

EISCAT_3D project

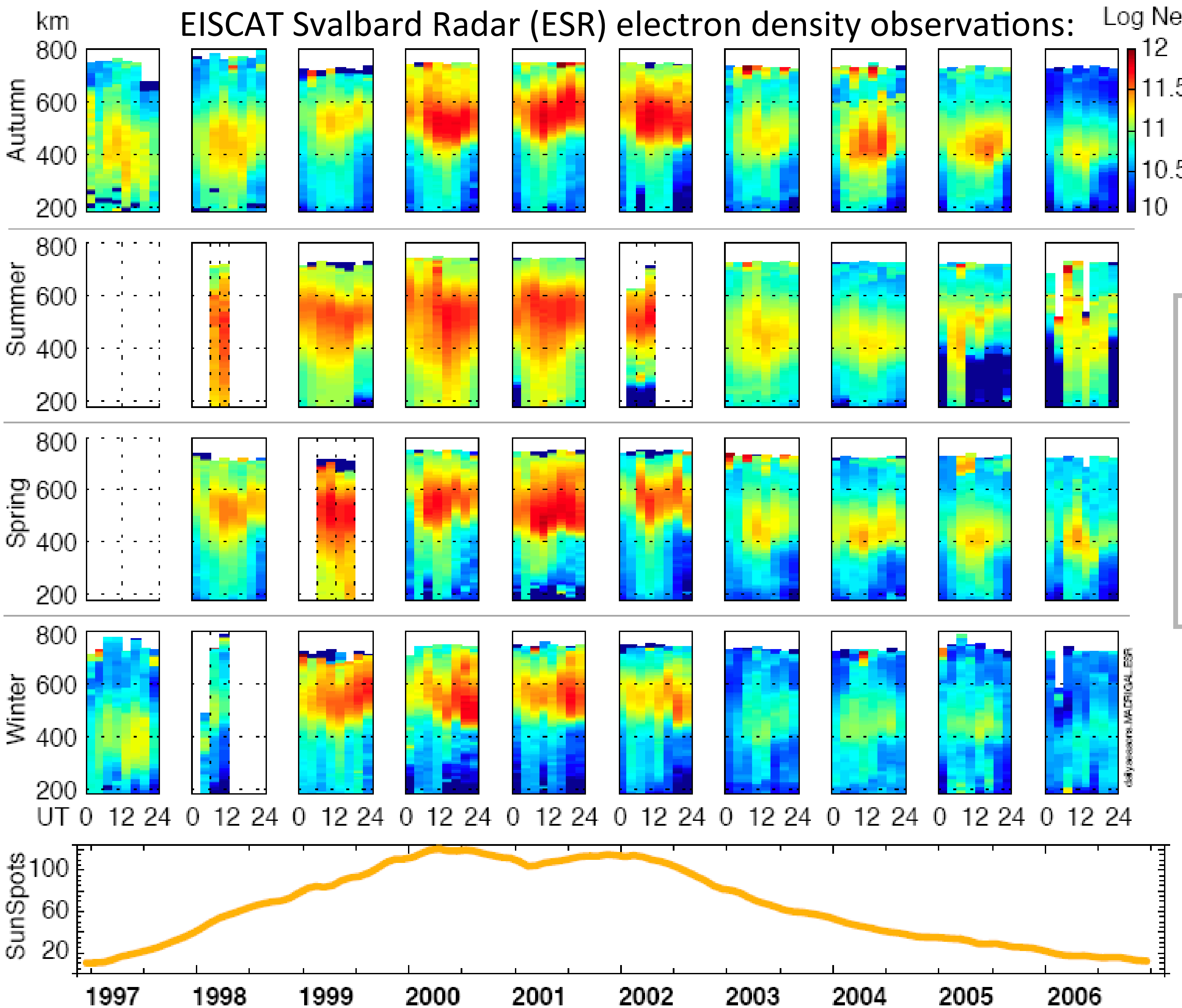
A typical summer day:



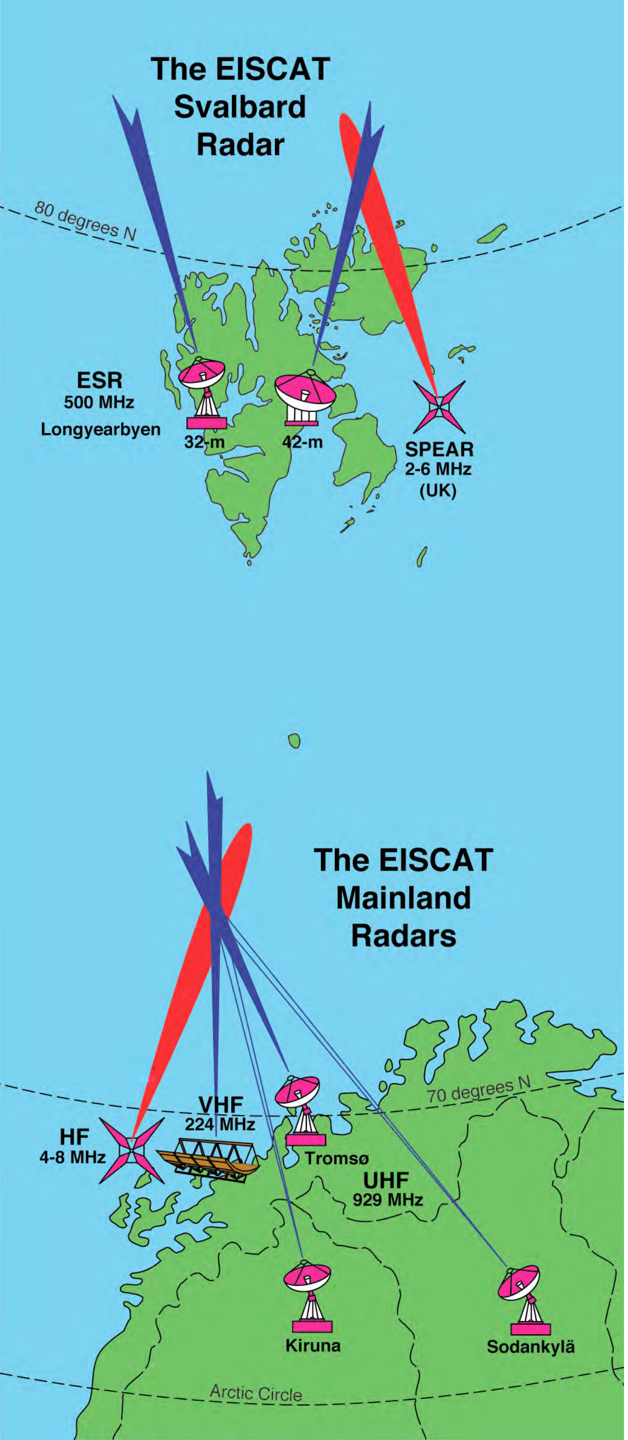
A typical winter day:



EISCAT Measurement During the Years



Daily 3-hour averages averaged over each season



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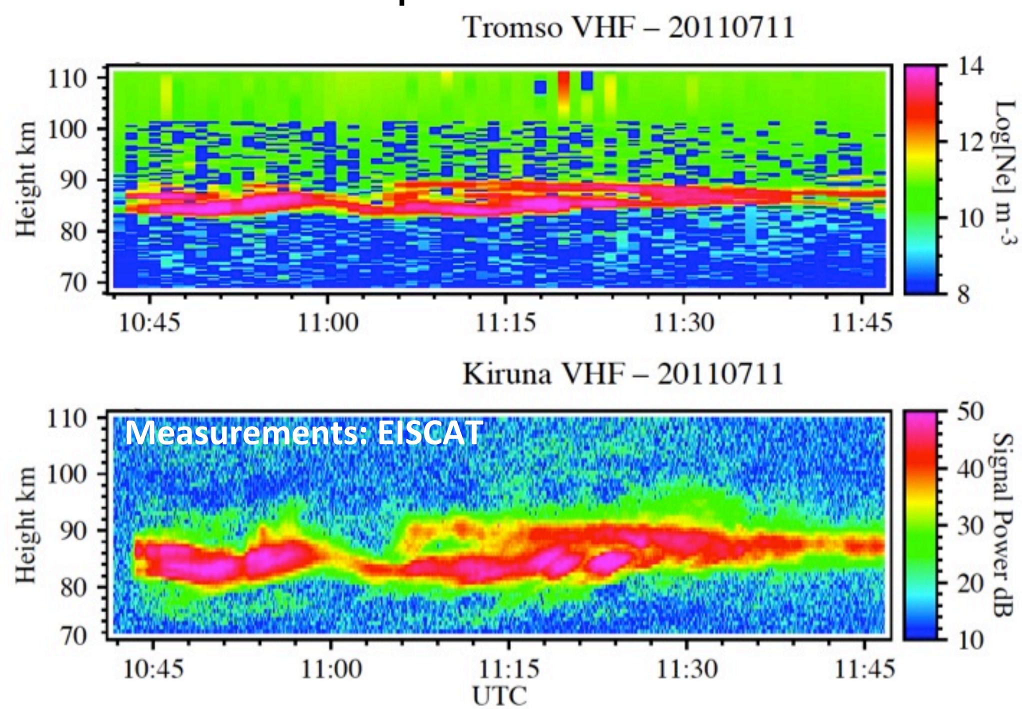
Examples for other radar targets

EISCAT_3D project

Dust Observations in Earth's Atmosphere

Noctilucent Clouds

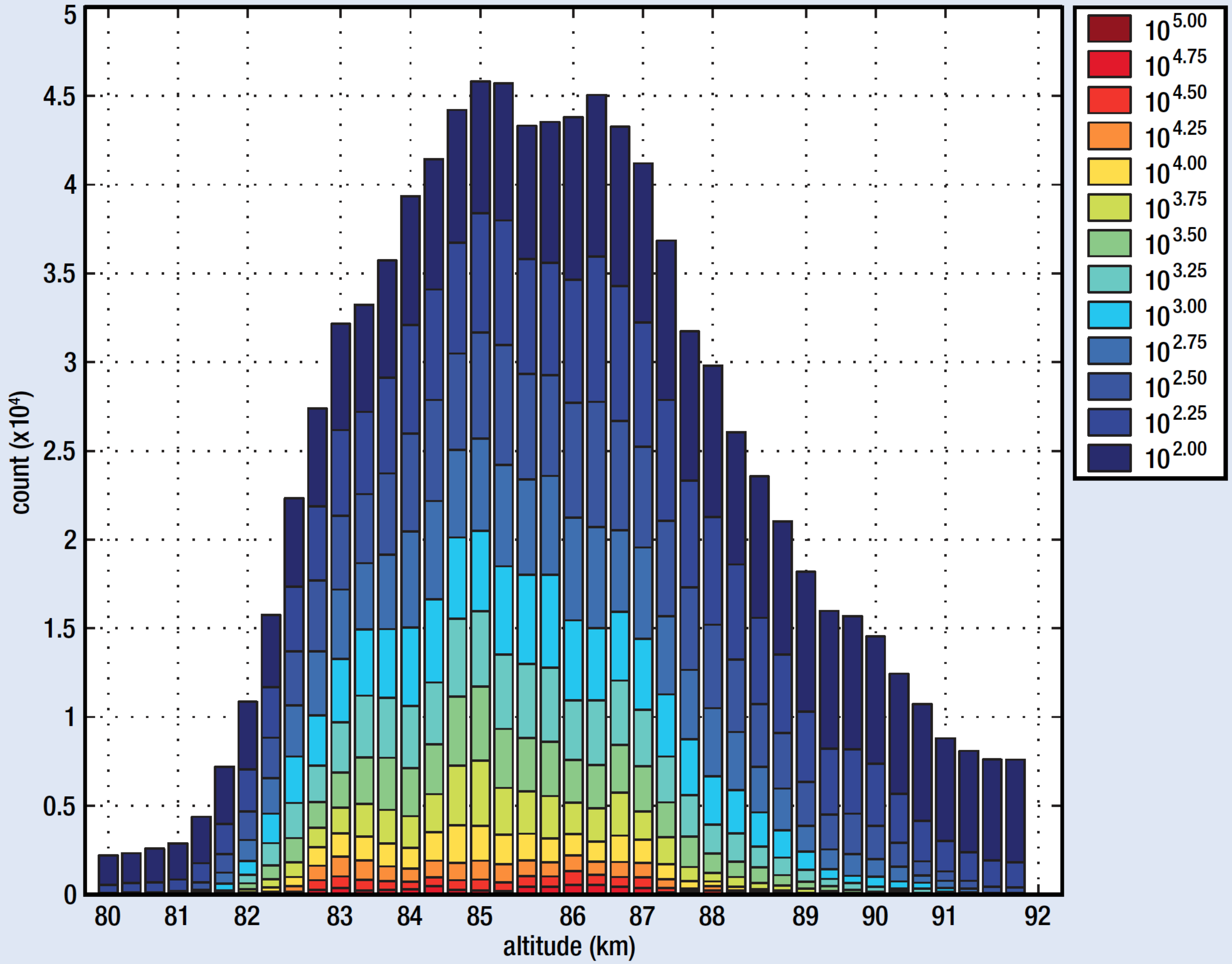
Polar Mesospheric Summer Echoes



Dusty Plasma Studies: example PMSE

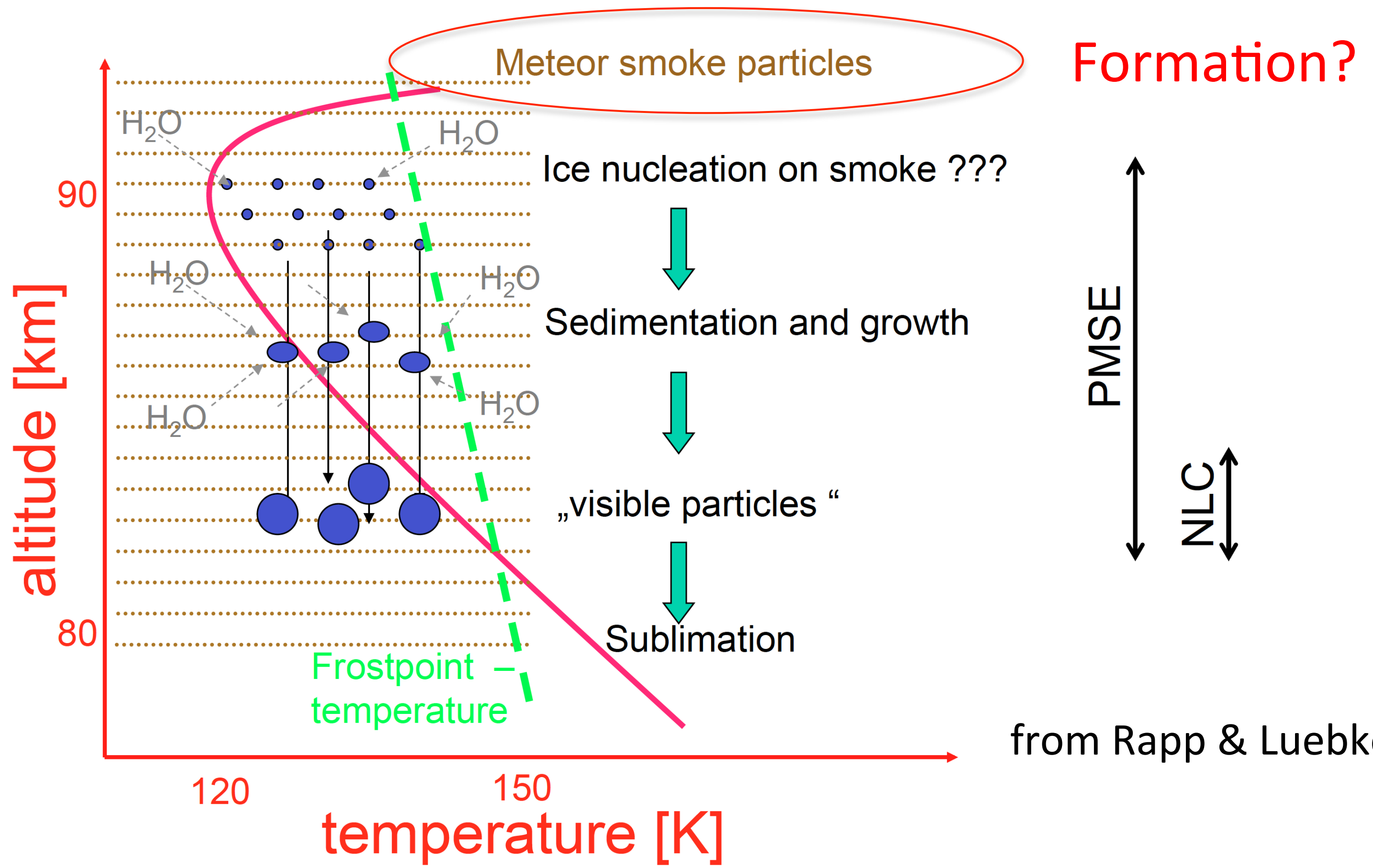
HARTQUIST *ET AL.*: POLAR MESOSPHERIC SUMMER ECHOES

2: PMSE occurrence rate as a function of height. PMSE relative strengths spanning a factor of 1000 have been assigned colours. Dark red indicates the strongest and dark blue the weakest PMSEs. The weak tail at 90 km and above is not due to PMSE backscatter. Instead it is caused by incoherent scattering on free electrons produced sporadically in high abundance by energetic particle precipitation. (From Naesheim 2008)



Dusty Plasma Studies: example PMSE

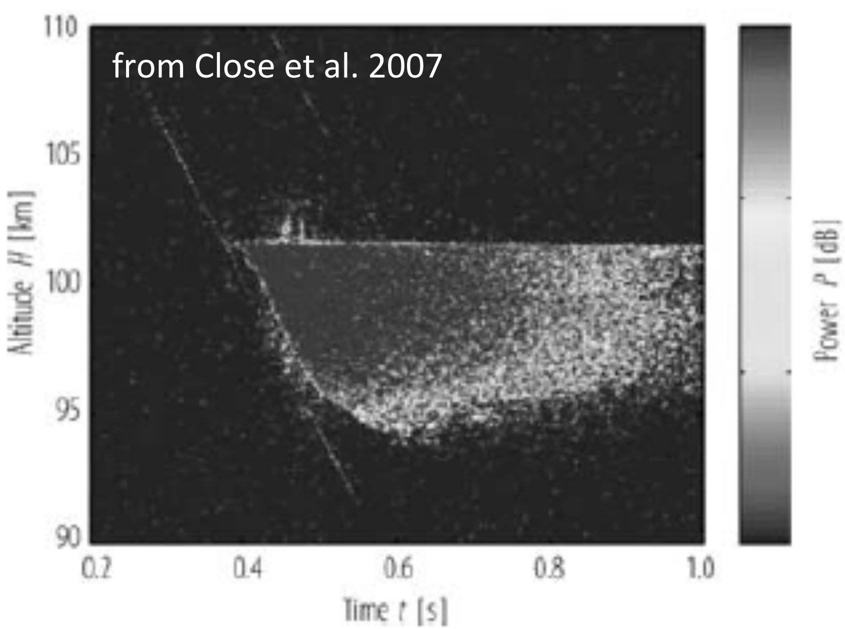
Formation Model

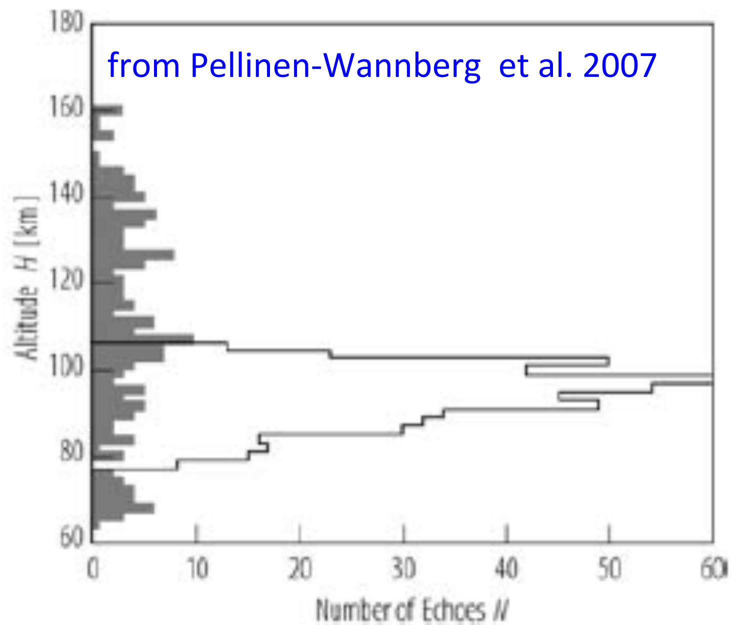


from Rapp & Luebken 2004

Solar System Studies: example meteor observations

(a) The intensity of a meteor radar signal as function of time and altitude measured with the ALTAIR VHF radar (160 MHz) [07Clo]. The diagonal line at the left is the head echo signal, while the signal on the right of this line that extends in altitude and time is the non-specular trail signal. **(b)** Altitude distributions of the meteor head echoes (open histogram) and trail echoes (filled histogram) recorded during the December 1990 and December 1991 observing periods with EISCAT [04Pel].



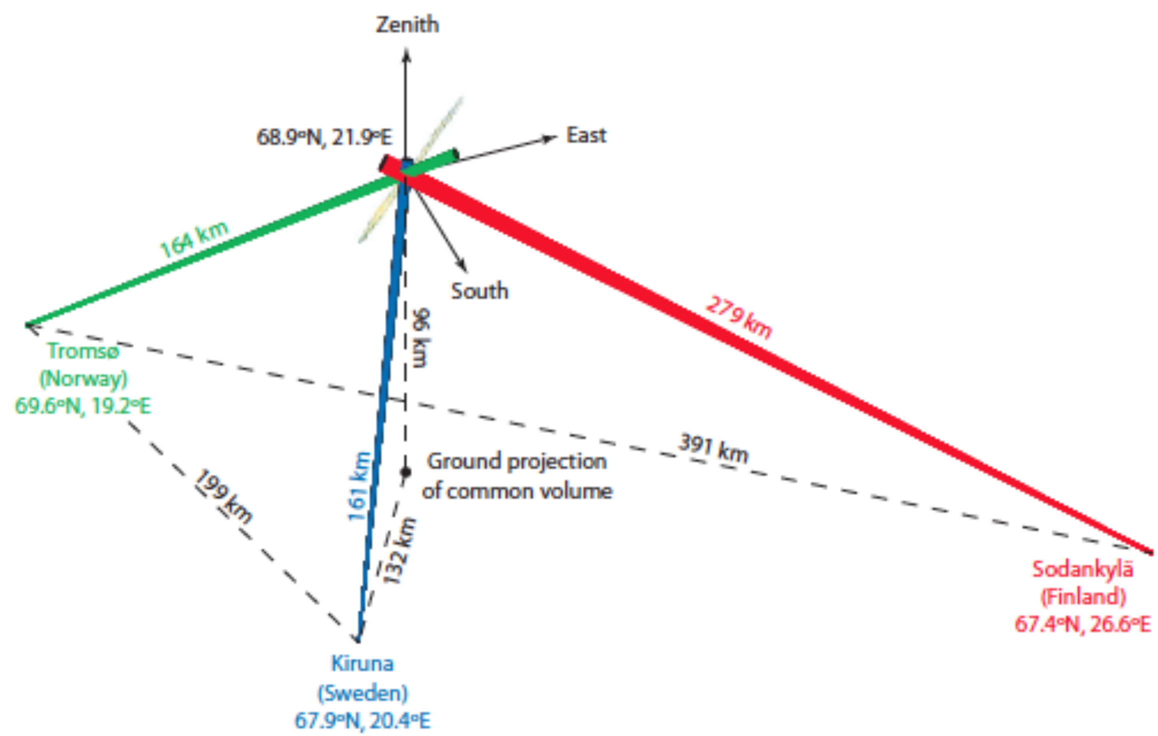


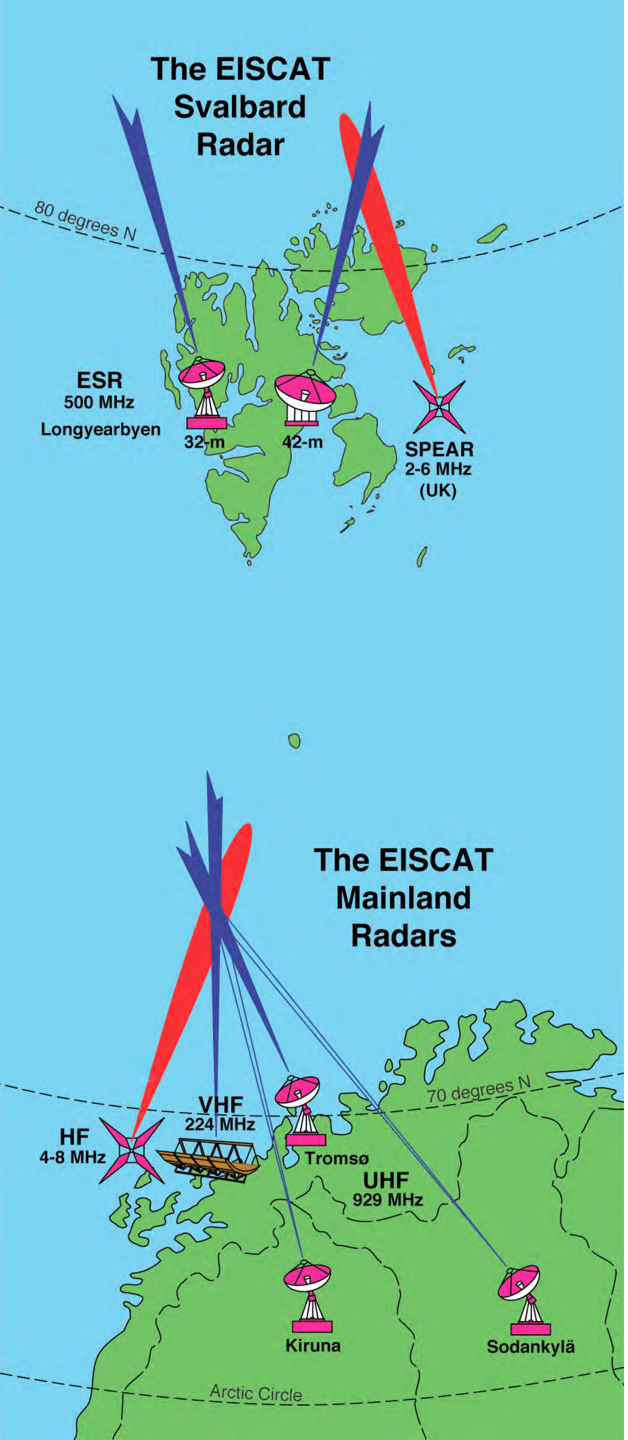
High-resolution meteor exploration with tristatic radar methods

Direct measurement of the meteor headecho velocity vector provides orbital information

Johan Kero

IRF Scientific Report 293, 2008





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Incoherent scatter measurements

Examples for other radar targets

EISCAT_3D project

February 2012 Project Plan

EISCAT_3D
Research infrastructure for incoherent scatter radar studies of the environment

Document prepared by EISCAT Scientific Association

27th February 2012

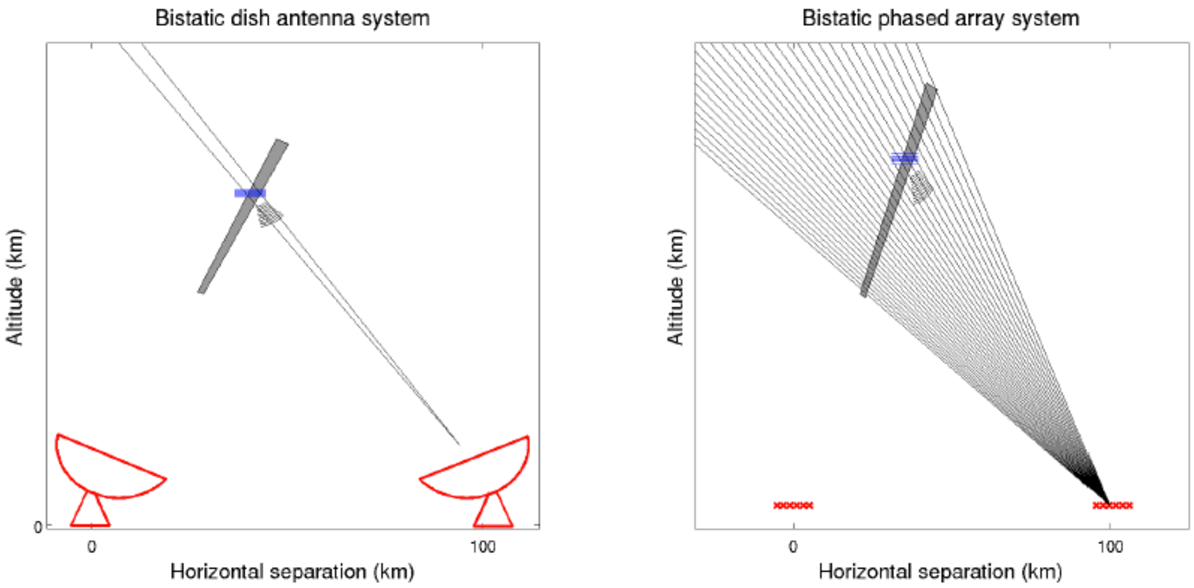
1 Executive Summary

EISCAT_3D will be a world-leading international Research Infrastructure, using the incoherent scatter technique to study how the Earth's atmosphere is coupled to space. EISCAT_3D will provide an advanced plasma physics laboratory for studying microscale phenomena, a key atmospheric monitoring instrument for climate and space weather studies and an essential element in international global multi-instrument campaigns for studying the environment.

EISCAT_3D concept

multi-static phased array radars
\+ advanced digital processing
= ______________________

continuous observations & high flexibility
beam steering & volumetric imaging



SEVENTH FRAMEWORK PROGRAMME

EISCAT_3D Baseline Design

System	
5 sites (including one with Tx~10 MW and one with Tx~1 MW), multiple outlying sub-arrays at all sites, arbitrary Tx/Rx polarisation	
Antenna Characteristics	
Type	Phased array
Average number of antenna elements per site	10,000
3 dB receive bandwidth	30 MHz
Gain	~50 dBi
Beam-width	0.8°
Transverse resolution at 100 km	< 50 m (depending on integration time)
Grating-lobe free radiation pattern	Down to elevations < 35°
Transmitter Characteristics	
Type	Pulsed
Duty cycle	≥ 25 %
Centre frequency	233 MHz
Modulation bandwidth	~5 MHz
Pulse length	0.25–3000 μs
Pulse repetition frequency	Arbitrary
Modulation	Arbitrary phase, polarisation and amplitude

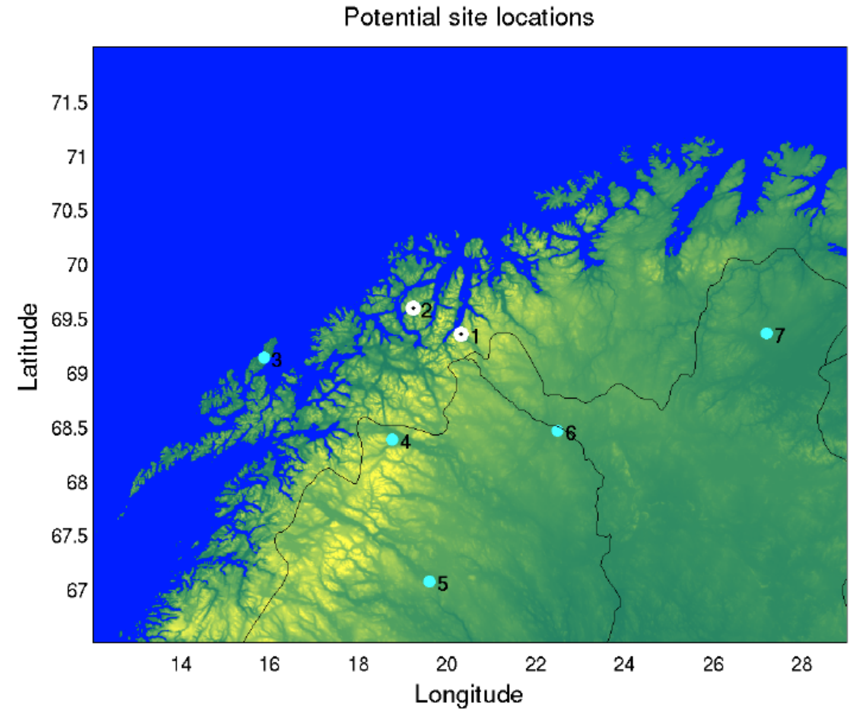
SEVENTH FRAMEWORK PROGRAMME

How will it look?

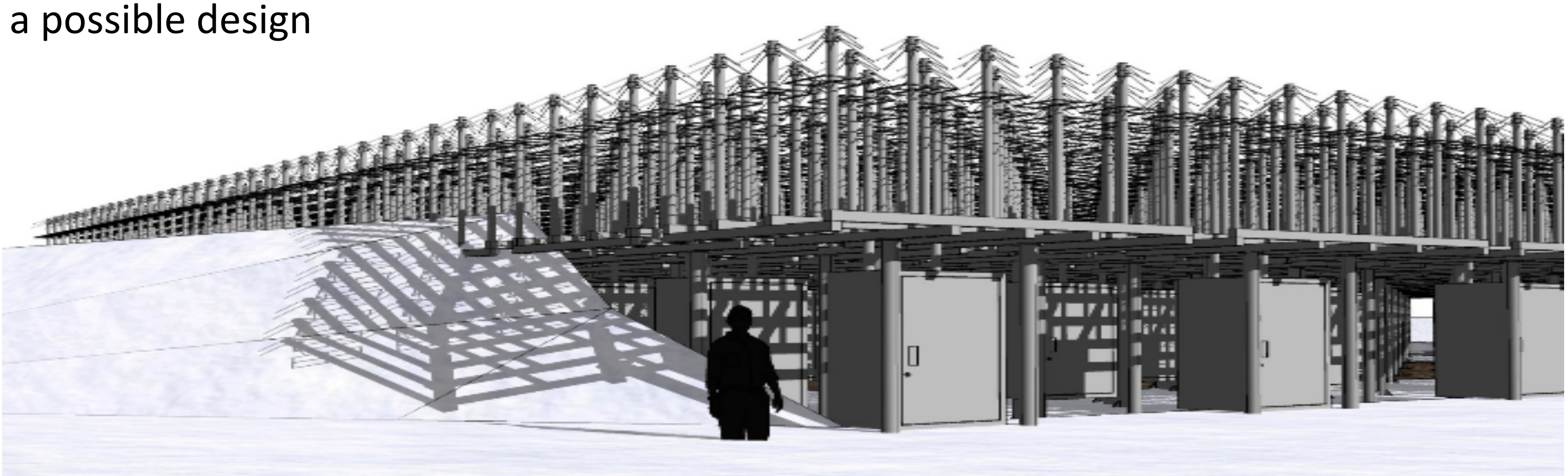
Baseline: core site & 4 remote sites

community agrees on list of 7 potential sites

will permit observations combined with rocket flights from Andoya (N) and Esrange (S)



a possible design



Design Plan

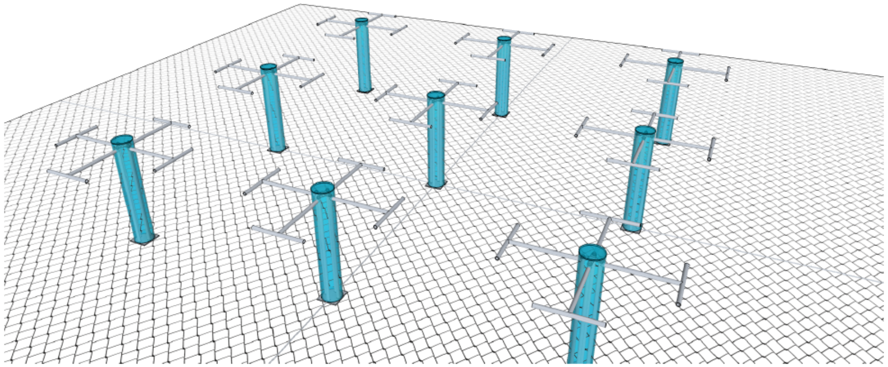


Figure 6: One possible design of the antenna elements. These elements are built with 2 crossed shortened dipoles with capacitive loads at the ends. This makes the antenna foot-prints smaller than half a wavelength. The antennas are mounted above a ground-plane mesh.

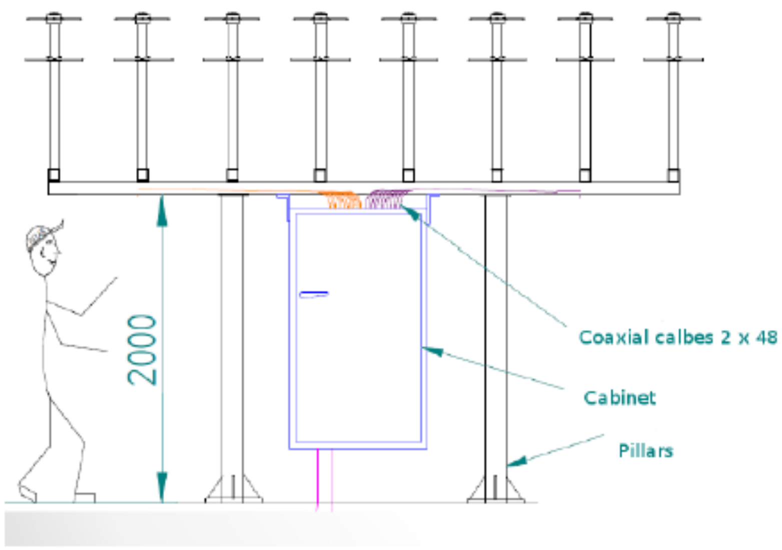


Figure 5: *The antenna-group structure, that makes up the unit building block for the arrays. The antenna elements are protected from varying ground conditions at the elevated plane. The electronics contained in the cabinet provide power, timing, signal processing and network for data transfer.*

Table 2*: Comparison of measurement capabilities between the current EISCAT UHF radar system and the future EISCAT_3D.*

Measurement type	Current UHF t(s)	Future EISCAT_3D t(s)		Improvement factor	
		3 sites	5 sites	3 sites	5 sites
Isotropic parameters at 110 km altitude	4.0	0.024	0.018	160	200
Isotropic parameters at 300 km altitude	15.0	0.3	0.17	50	85
Vector velocities at 110 km altitude	300	6	1	50	300
Vector velocities at 300 km altitude	1700	95	20	18	80
Monitoring data products as a function of altitude: electron density, electron and ion temperature, ion drift velocity:					
Other monitoring data products: Meteor influx and orbit parameters					
New Measurement capabilities: • Instantaneous, adaptive control of beam positions • Simultaneous multiple beams/interlaced beams with sub-pulses in different directions • High-resolution coding utilising phase, polarisation and amplitude • Aperture synthesis imaging – fine-scale 3-D imaging (sub-beam-width) • multi-beam volume imaging – large/small-scale 3D imaging (10 to 100s km horizontal coverage) • full-profile vector-wind measurements – large/small-scale 3D vector imaging • high-speed object tracking					

EISCAT_3D bottom up:

Preparatory Phase Project

Funded from October 2010 – September 2014

by European Commission / FP7 INFRASTRUCTURES call:

"Construction of new infrastructures"

Aim: ensure that the EISCAT_3D project will reach a sufficient level of maturity with **respect to technical, legal and financial issues** so that the construction of the EISCAT_3D radar system can begin **immediately after the conclusion of the phase.**

Participants: University of Oulu, Luleå University of Technology, Swedish Institute of Space Physics, University of Tromsø, Science and Technology Facilities Council (UK), the Swedish Research Council, National, Instruments, Uppsala University & EISCAT Scientific Association as the project coordinator.

EISCAT_3D **Budget & Funding Applications**

Investment: Baseline design 135 MEU

123 MEUR & 12 MEUR contingency

Annual budget ≈ 8 MEUR (69MKSEK) in 2022

14 % site operation, 35 % radar operation, 50 % staff cost

users in host countries N,S,F plan proposals for:
to start implementation in 2014 (proposals ≈ 80 MEU)

Time line:
Norway: funding proposal submitted October 2012
Sweden: funding proposal submitted March 2013
Finland: roadmap proposal to be submitted in 2013
Japan: roadmap proposal to be submitted in 2013

EISCAT_3D bottom up:

annual meeting of the preparatory phase project

annual EISCAT_3D user meeting

bi-annual EISCAT Scientific Symposium

bi-annual reports to Council and Oversight Committee

EISCAT_3D is Research Infrastructure for the Environment on ESFRI Roadmap

offers the link to other environmental research

helps extending user community

helps attracting new member countries

enhances chances for international collaboration for the association and for individual users

Development of Science case for the new system coordinated by Dr. Anita Aikio (Oulo Univ., Finnland) and Dr. Ian McCrea (STFC, United Kingdom)

EISCAT_3D users:

1 experienced EISCAT users

2 new users attracted by the enhanced conventional capabilities and/or by the capabilities that are inherent to the new system

3 environmental and space weather modellers and service providers ('continuous data sets')

4 occasional users interested in EISCAT_3D for short-duration research projects or as source of supporting data (campaigns)

EISCAT aims to expand its user community & membership

please check https://www.eiscat.se/eiscat2014

http://www.eiscat.se/

May 2013

EISCAT User Access and Membership Policy

EISCAT Scientific Association is currently aiming to invest in a cutting-edge EISCAT_3D radar system, to expand its user community and to expand its membership. EISCAT[1] is revising its statutes with the aim to open up access to all scientists in the field and seeks new members who wish to contribute to the progress of the Association. The Association is revising its user access and membership policy, and potential new members or users are strongly encouraged to discuss their aspirations with the EISCAT Council members or EISCAT executives. There are several ways for scientists to access EISCAT instruments and data: Associate Membership, Affiliate Membership and individual user access based on scientific merit.

EISCAT Associates provide the basic conditions for running the Association, take full responsibility for the Association and determine the overall direction of its development. They are expected to make a significant initial payment into the Association that is related to achieving its scientific and strategic goals and to contribute to the operational costs, maintenance, and decommissioning in a proportion that is related to their initial payment and that allows that the minimum required operation costs be covered by the Associates. It is understood that Associates intend to make a long-term commitment and that they give a 5-year notice before leaving the association. At present the initial payment from a new Associate should ideally amount to 5 % of the total investment currently planned for the new EISCAT instruments[2]. The Associates decide on a common observation program and on data formats, they have guaranteed observation time according to an agreed time-share formula and access to the archived data of the Association. Associates will normally be National Research Councils, their equivalents, or major national institutions.

EISCAT Affiliates can join the association on a smaller level of financial contribution responsibility, and other commitments. The Affiliates have guaranteed observation time according to an agreed time-share formula and access to the archived data of the association. The expected minimum payment of Affiliates to the association should grant observation time that permits the Affiliate to run at least one independent observation campaign per year[3]. Affiliates will normally be individual institutions or foundations.

The EISCAT Associates establish the governing EISCAT Council and its committees. Affiliates have vested membership in the EISCAT Science Advisory Committee and observer status in Council.

EISCAT encourages scientists to use its data and instrumentation for high-level research projects and grants observation time to external users through an open peer-review programme that is coordinated by a scientific committee established by the association. Associates and Affiliates are expected to distribute their observation time to individual users in a way that ensures that the EISCAT system is used for scientific work of the highest standard.

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[1] EISCAT is currently funded and operated by research councils of Norway, Sweden, and Finland and by funding bodies in Japan, China and the United Kingdom (EISCAT Associates). France, Russia and Ukraine are affiliated partners. The host institutes of the present EISCAT systems are Sodankylä Geophysical Institute (independent department of University of Oulu), University of Tromsø and Swedish Institute of Space Physics. EISCAT Scientific Association is a Swedish non-profit organization.

[2] EISCAT at present plans a major investment into the new EISCAT_3D system that is equivalent to approximately 1 100 MSek (130 MEUR).

[3] This corresponds at present to a minimum fee equivalent to 100 000 SEK (12 000 EURO).