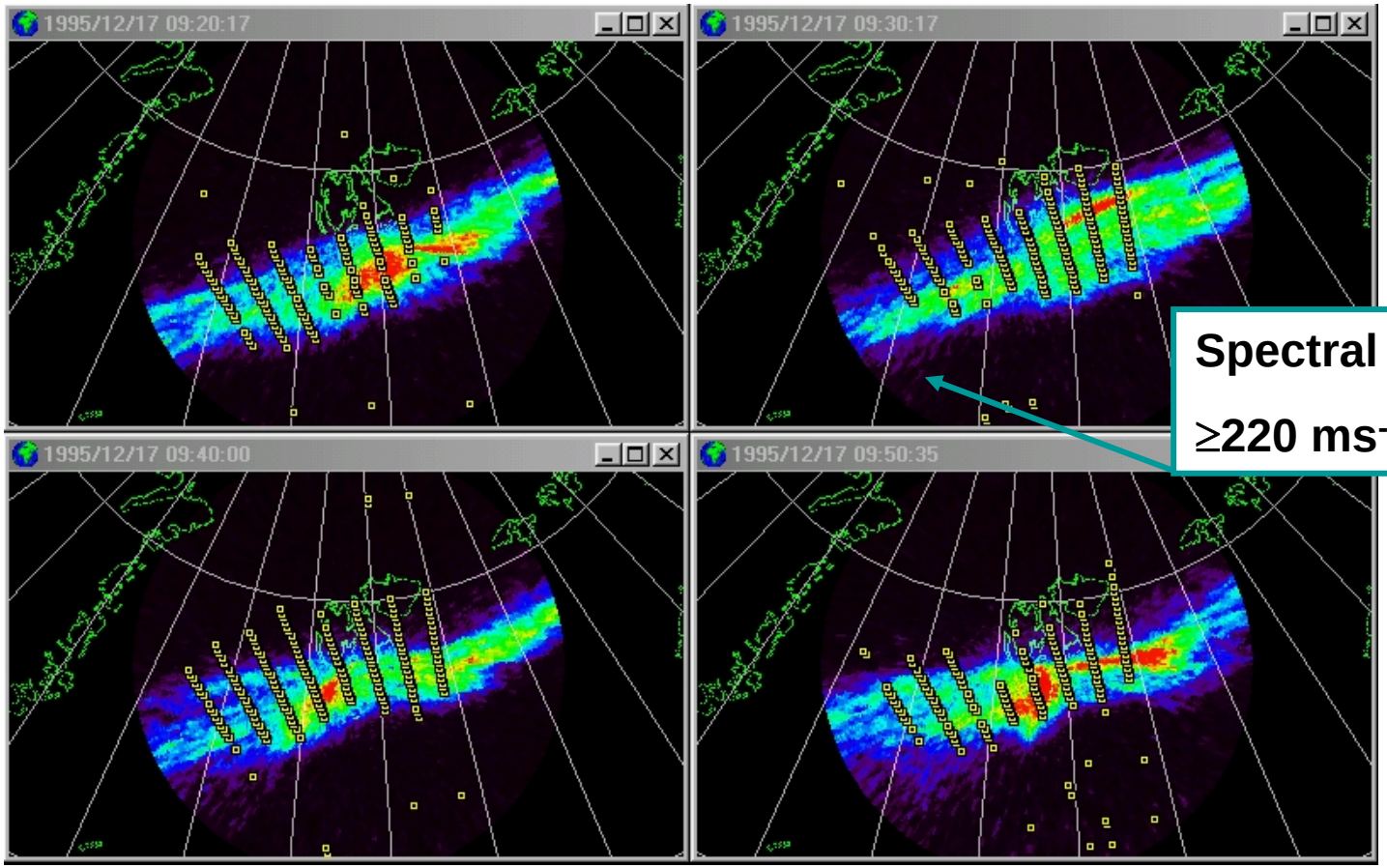
On the ICI-series of sounding rockets (2009-2014)

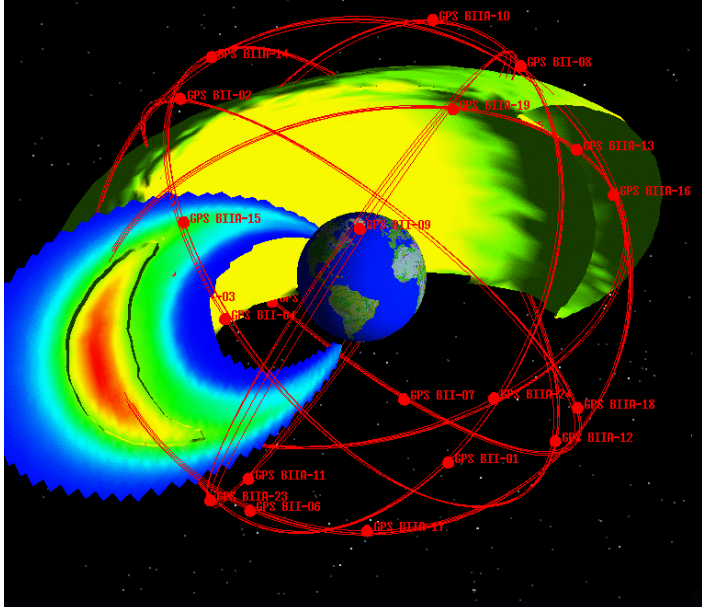
Jøran Moen

The observational relationship between the optical cusp and HF radar cusp is well documented.

!! However, we are lacking verification on how HF backscatter irregularities form!!

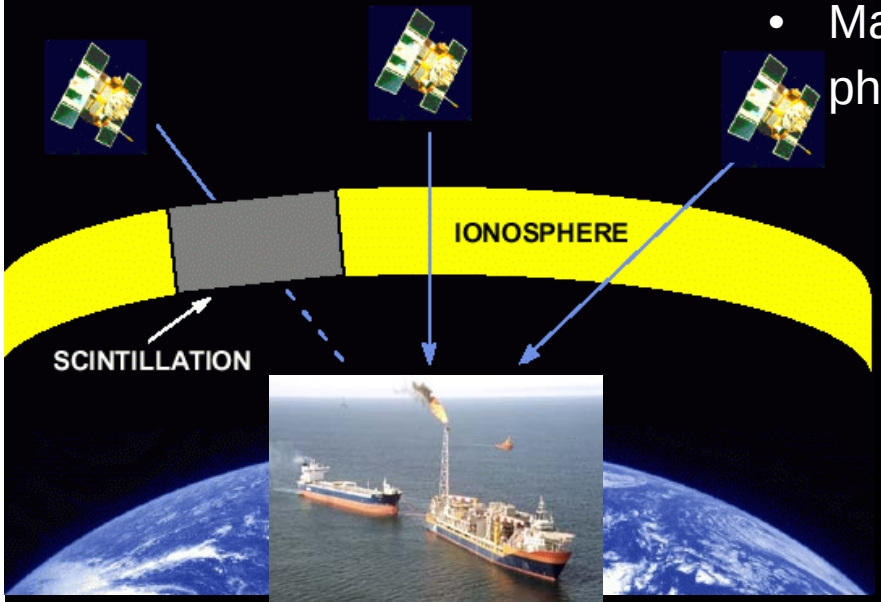


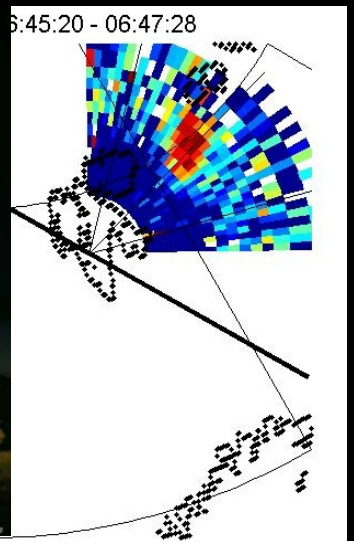
Moen et al., Ann. Geophysicae, 2000



ICI-work is very relevant for GPS navigation

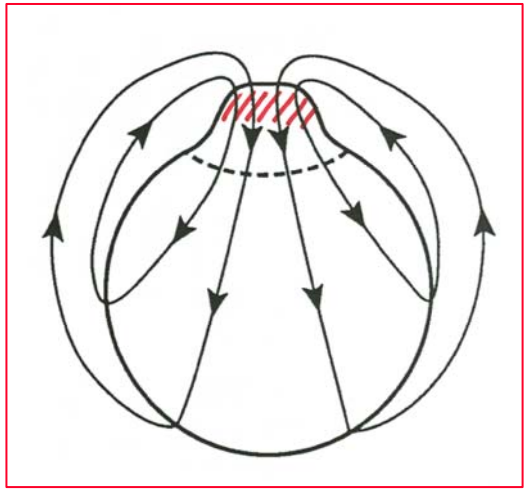
- Turbulence and irregularities in the ionosphere give rise to scintillations in the satellite to ground signal
- The Total Electron Content (TEC) along the path of a GPS signal can introduce a positioning error (up to 100 m)
- There will be an increasing demand for high-accuracy satellite navigation in polar areas.
- Maybe the most important space weather phenomenon for Norway.

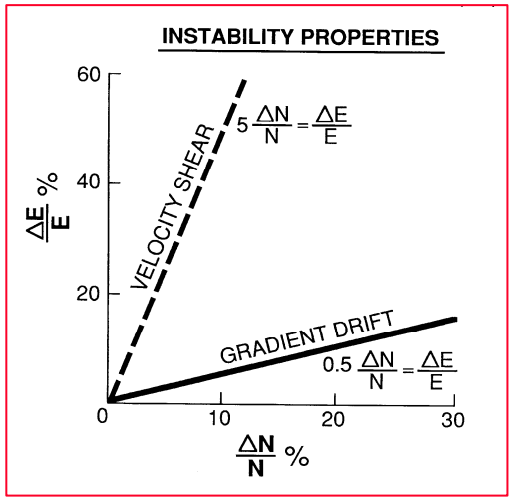




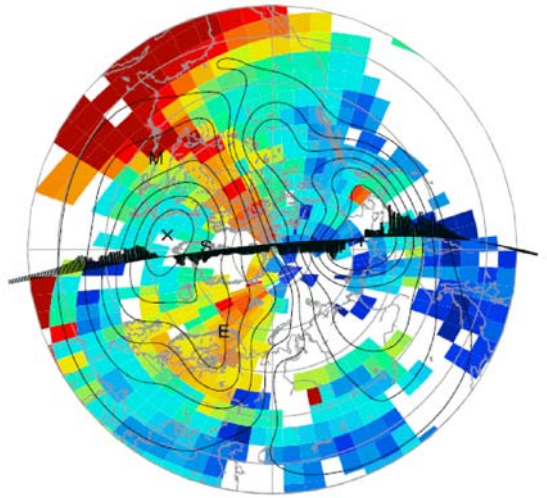
Two Primary Modes of F-region instabilities/irregularitues in the cusp/polar cap

- **Gradient drift instability**
- **Velocity shear instability**





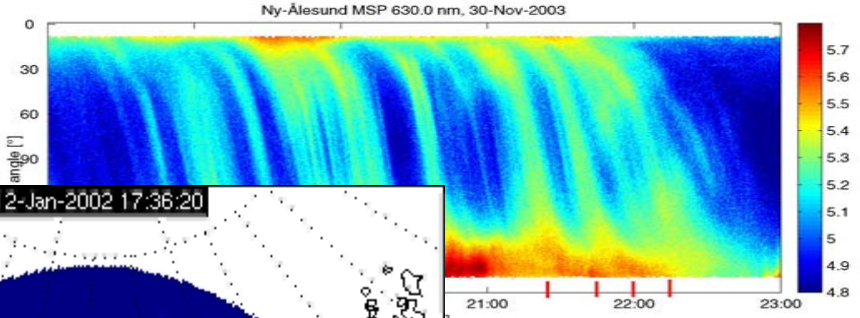
From Basu et al. (1988; 1992)



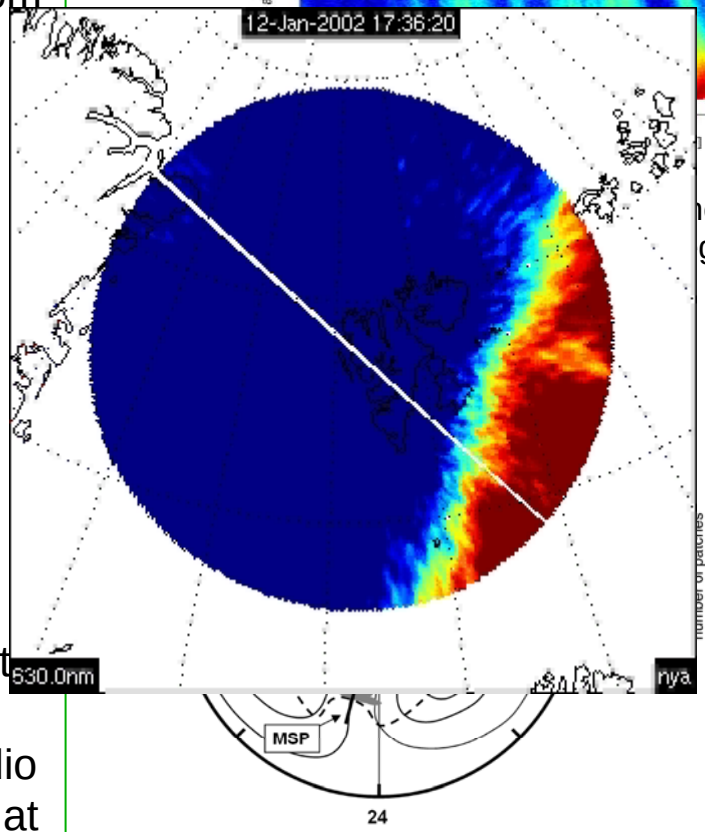
TEC image demonstrating transport of EUV ionized plasma extends into the polar cap (Foster et al., 2005)

Electron density patches and F-region irregularities are related phenomena:

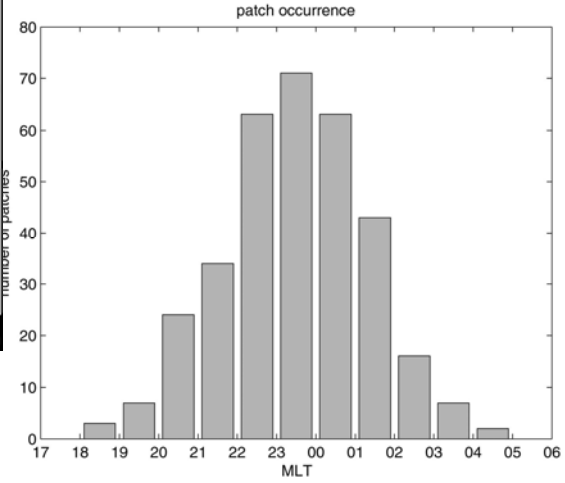
- Eight years of meridian scanning photometer data from Ny-Ålesund, Svalbard have been analyzed to study the occurrence of F-region polar cap patches at night
- About 60% of the patches exit the polar cap from 22-01 MLT, but patches was observed in the entire MLT range from 18:00-05:00.
- This patch occurrence statistics is an important new result of particular relevance t theoretical and empirical modeling, and forecast of radio wave propagation conditions at high latitudes.



he magnetic meridian from north
gral signs in the keogram.



Electron density patches drifting across the polar cap from day to night

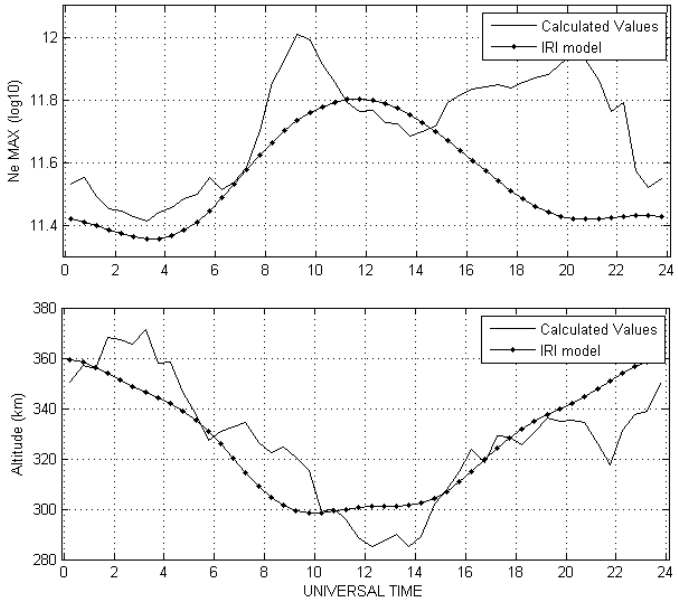


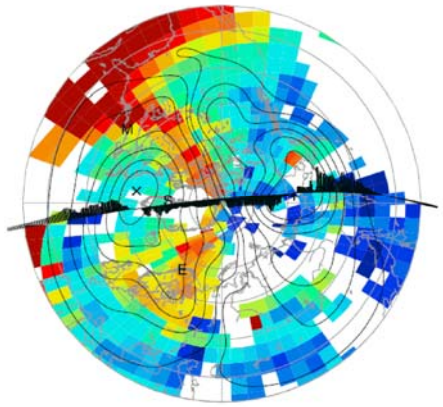
Occurrence statistics

Moen et al., *Geophys. Res. Lett.*, 34, L14113, doi: 10.1029/2007GL029632, 2007

Comparison with the IRI-model ionosphere

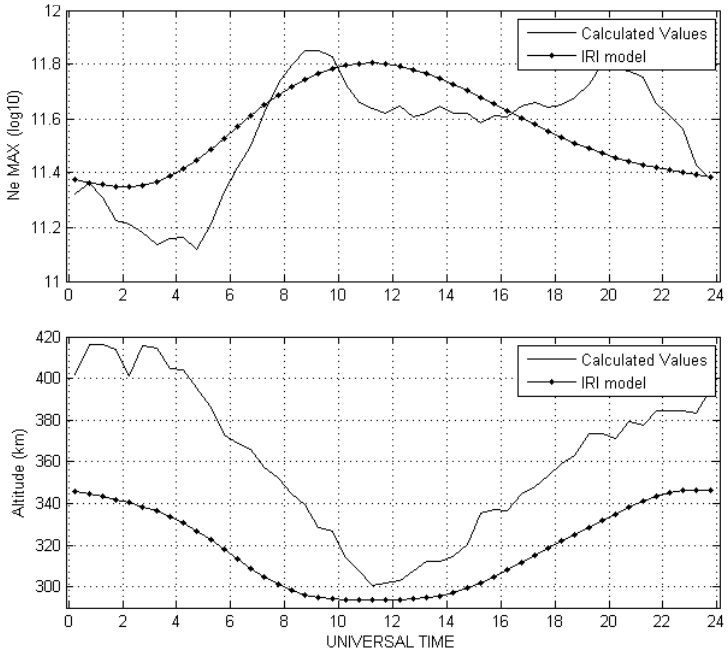
30 min averages, Feb 2001





GPS-map

30 min averages, Oct 2002



From Moen et al. Ann. Geophys., 26, 2427-2433, 2008

Team effort on patches:

Carlson, H. C., K. Oksavik, J. Moen, A. P. van Eyken, and P. Guio, ESR mapping of polar-cap patches in the dark cusp, Geophys. Res. Lett, 29, 10, 10.1029/ 2001GL014087 2002

Lorentzen, D. A., N. Shumilov, and J. Moen, Drifting airglow patches in relation to tail reconnection, Geophys. Res. Lett., 31 (2), L02806, doi:10.1029/2003GL017785, 2004

Carlson, H. C., K. Oksavik, J. Moen, and T. Pedersen, Ionospheric patch formation: Direct measurements of the origin of a polar cap patch, Geophys. Res. Lett., 31 (8), L08806, doi:10.1029/2003GL018166, 2004.

Lockwood, M., J. Davies, J. Moen, A. P. van Eyken, K. Oksavik, I. W. McCrea and M. Lester, Motion of dayside polar cap boundary during substorm cycles: II. Generation of poleward-moving events and polar cap patches by pulses in the magnetopause reconnection rate, Ann. Geophysicae, 3513-3532, 2005.

Carlson, H. C., J. Moen, K. Oksavik, C. P. Nielsen, I. W. McCrea, T. R. Pedersen, and P. Gallop, Direct observations of injection events of subauroral plasma into the polar cap, Geophys. Res. Lett., 33, L05103, doi:10.1029/2005GL025230, 2006.

Oksavik, K., J. M. Ruohoniemi, R. A. Greenwald, J. B. Baker, J. Moen, H. C. Carlson, T. K. Yoeman, and M. Lester, Observations of polar cap patches by the EISCAT Svalbard and SuperDARN Finland radars, J. Geophys. Res., 111, A05310, doi: 10.1029/2005JA011400, 2006.

Moen, J., Carlson, H.C. Carlson, K. Oksavik, C. P. Nielsen, S. E. Pryse, H. R. Middleton, I. W. McCrea, and P. Gallop, EISCAT observations of plasma patches at sub-auroral cusp latitudes, *Ann. Geophysicae, 24,* 2363-2374, 2006.

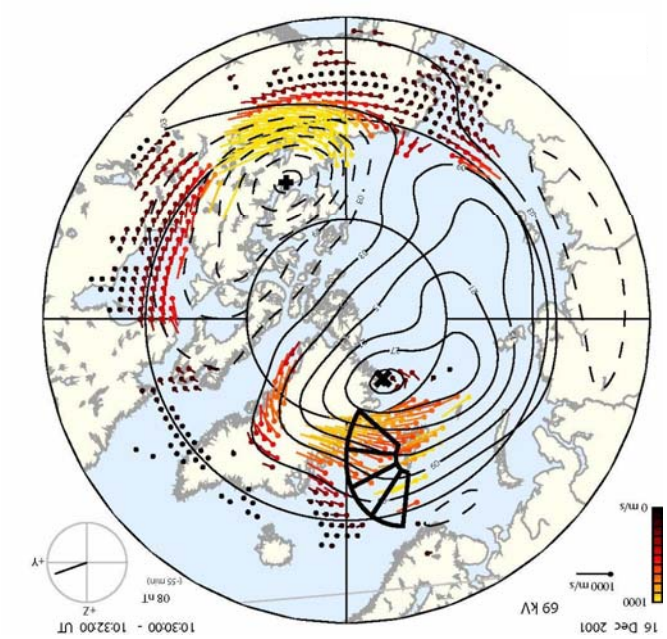
Moen, J., N. Gulbrandsen, D. A. Lorentzen, and H. C. Carlson, On the MLT distribution of F-region polar cap patches at night, *Geophys. Res. Lett*., 34, L14113, doi: 10.1029/2007GL029632, 2007

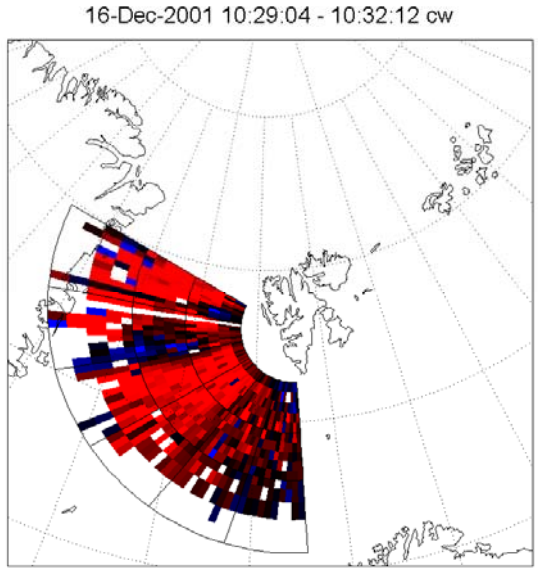
Carlson, H.C, T. Pedersen, S. Basu, M. Keskinen, J. Moen, Case for a new process, not mechanism, for cusp irregularity production, *J. Geophys. Res., 112*, A11304, doi:10.1029/2007/JA012384, 2007.

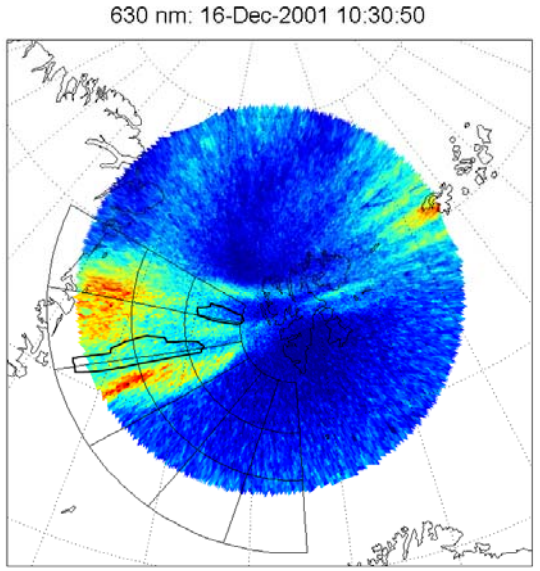
Moen, J., X. C. Qiu, H. C. Carlson, R. Fujii, and I. W. McCrea, On the diurnal variability in F2 – region plasma density above EISCAT Svalbard Radar, Ann. Geophys., 26, 2427-2433, 2008.

EISCAT SVALBARD RADAR : SP-NO-FASM

- A new category of flow channels opposing the large-scale background flow:
- First discovered by ESR
- Associated with strong flow shears which may turn upside down the way we think about ionospheric instabilities
- And generation of HF backscatter irregularities.







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OF OSLO

Team effort on RFEs:

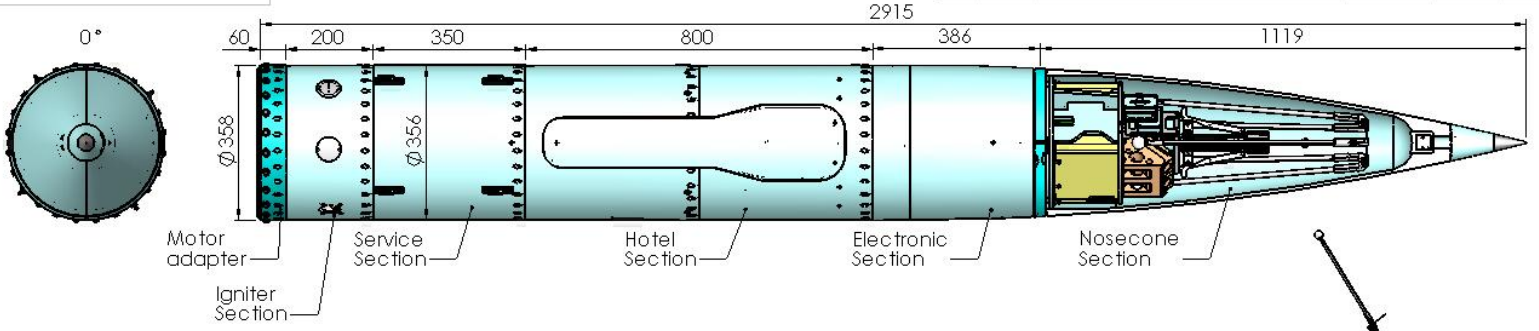
- Oksavik, K., J. Moen, and H. C. Carlson, High-resolution observations of the small-scale flow pattern associated with a poleward moving auroral form in the cusp, Geophys. Res. Lett., 31 (11), L11807, doi:10.1029/2004GL019838, 2004.
- Oksavik, K., J. Moen, H. C. Carlson, R. A. Greenwald, S. E. Milan, M. Lester, W. F. Denig, and R. J. Barnes, Multi-instrument mapping of the small-scale flow dynamics related to a cusp auroral transient*, Ann. Geophysicae, 23, 2657-2670, 2005.*
- *Rinne, Y., J. Moen, K. Oksavik, and H. C. Carlson, On the occurrence of Reversed Flow Events in the Cusp Ionosphere Observed by the European Incoherent Scatter (EISCAT) Svalbard Radar, J. Geophys. Res., 112, A10313, doi: 10.1029/2007JA012366, 2007.*
- *Moen, J., Rinne, Y., Carlson, H. C., Oksavik, K, Fujii, J., Opgenoorth, On the releationship between Birkeland current arcs and recersed flow channels in the winter cusp/cleft ionosphere, J. Geophys. Res., doi: 10.1029/2008JA013061, 2008.*

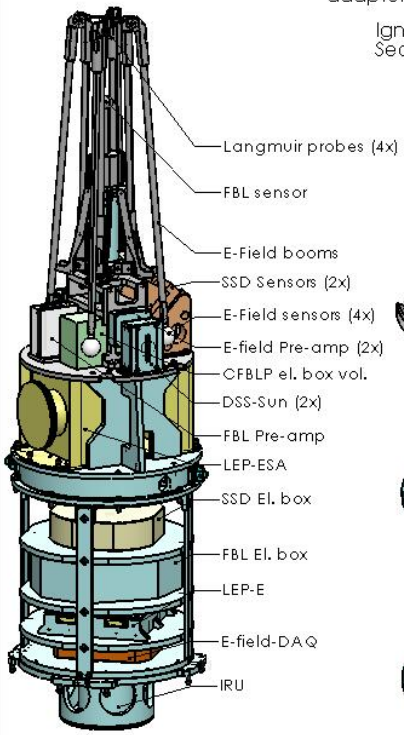
ICI-3 objectives:

Our main objective is to obtain a better physical description of instabilities and wave phenomena driven by the newly discovered Reversed Flow Events (RFEs) in the winter cusp ionosphere.

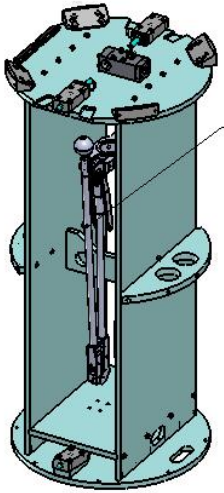
- Test whether the RFEs are associated with a tangential discontinuity (frozen into plasma) or a rotational discontinuity (indicative of reconnection).
- Test whether the RFE-Birkeland current

REV.	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED
E	15.01.08	Update	Jack Hvassing	G. Hansen	K. Haugland
F	07.05.08	Update	Jack Hvassing	H. Wold	G. Hansen
H	29.09.08	As built	Jack Hvassing	E. Saether	G. Hansen
D	04.01.08	Update	Jack Hvassing	G. Hansen	K. Haugland

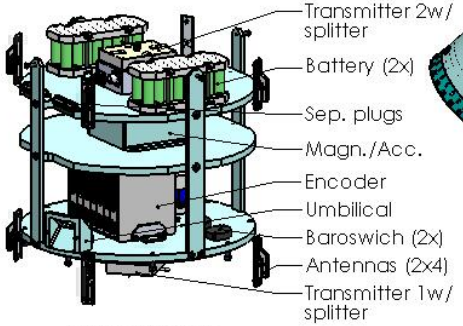




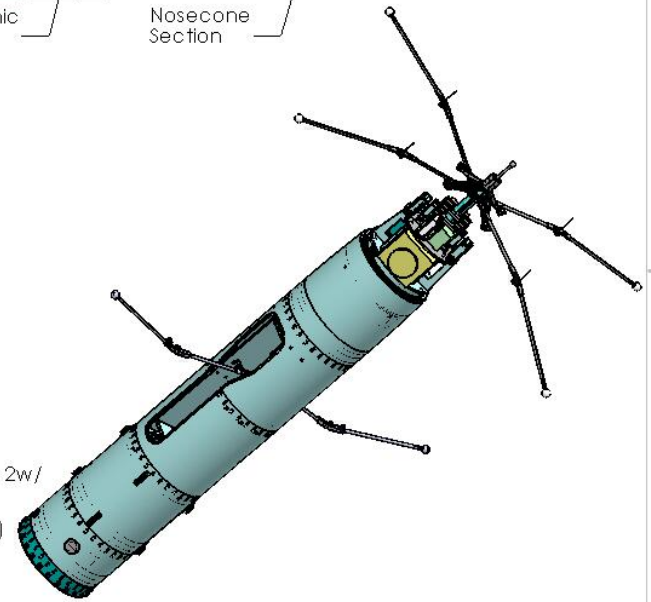
Electronic Section



Hotel Section



Service Section



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM. TOLERANCES ARE: MACHINED SURFACES NS-ISO 2768-m H	TOTAL WEIGHT: 142.90 Kg	P.O. Box 54 N-8483 Andenes	
	DEVELOPED BY: G. Hansen	Tel. +47 76 14 44 00 Fax. +47 76 14 44 01	
PROJECTION ANGLE	CAD DRAWING BY: J.Hvassing SolidWorks	www.rocketrange.no	
	PROJECT: Payload Design		
SIZE: A3	SCALE: 1:10	Document No.: Overview 203 ICI-2	

ANDØYA ROCKET RANGE

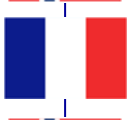
INSTRUMENTATION on ICI-3

FBP : Fixed Bias Langmuir Probe – ISAS/JAXA

m-NSLP : multi -Needle&Sphere Langmuir Probe system – University of Oslo

LEP-ESA : Low Energy Particle spectrometer (10eV-10keV), ISAS/JAXA

EFW : Electric Field and Wave Experiment, University of Oslo.



ADM : AC/DC Magnetometer - LPP.

SRADS: Sounding Rocket Attitude Detection System (UiO)

Studies of Fluctuations, Turbulence and Transport requires:

High resolution measurements of electron density, electron temperature, electrical and magnetic fields and cross correlation between these parameters

~10 kHz sampling rate

ICI-3 LAUNCH WINDOW: (Sun <-10; Moon <+10)

28 November – 11 December, 2010 (14 days)

26 November – 6 December 2011 (11 days!!)

07-12 UT, 08-13 LT, 10-15 MLT

OPTIMAL LAUNCH CONDITIONS:

1) Clear sky and active cusp placed over the nominal trajectory
2) HF radar echoes placed over the nominal trajectory
3) Discrete arc + RFE

REQUIREMENT STEP DOWN VERSUS TIME:

Day 1-4: 1), 2) and 3) have to be met.

Day 5-8: 2) and 3) have to be met

Day 9-14: Either 2) or 3) has to be met

ICI-2 : The New Work Horse ready for launch at Ny-Ålesund

APOGEE 340 km +/-10 km

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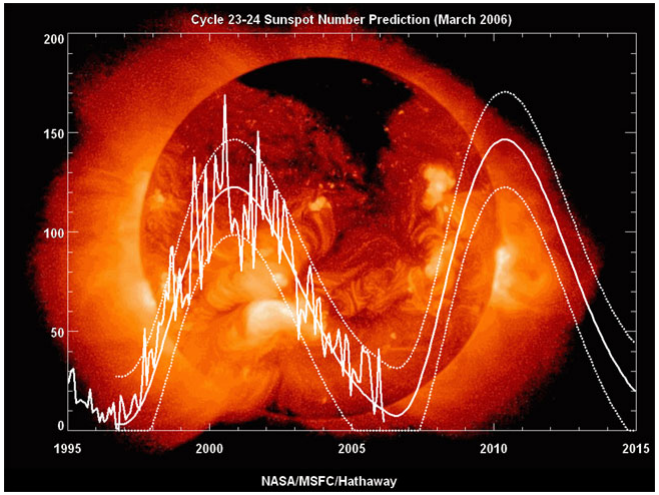
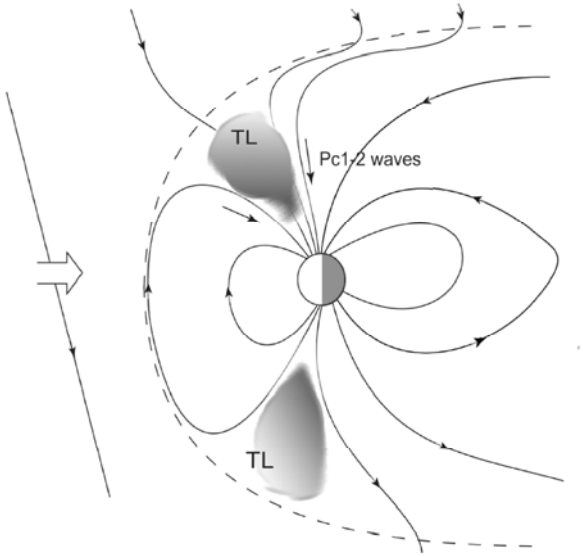


Tentative schedule:

- ICI 2 2008 Winter
- ICI 3 2011 Winter
- ICI 4-5 2014 Winter (Solar Max?)
- ICI 6-7 2016 Summer/Equinox

All rockets from Svalbard!

The ionospheric cusp: a challenging region



Turbulence gives rise to anomalous conductivity and damping of Alfven waves: Pilipenko et al. (in JGR review, 2007).

Pc-1,2 waves do not propagate to ground in the ionospheric cusp: Dyrud et al. (JGR, 1997); Engebretson et al. (JGR, 2005)

Open Questions:

Why is cusp a turbulent layer all the way down?

What are the dominant instability mechanisms, wave particle interaction and damping mechanisms?

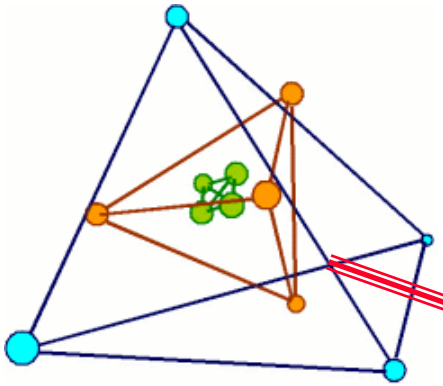
What is the finest scale of an electron beam (FAC), and what is the controlling factor of this thickness?

Inverted V structures and Alfvén wave shocks

Ion outflow

Challenges in future space research

- Keywords: Shocks, turbulence, reconnection
- The need for simultaneous measurements on MHD, ion and electron scales
- In the auroral ionosphere: This means a combination of ground measurements and in-situ measurements (rocket + dozens of daughters)



Cross scale mission/ SCOPE