# コメント

行松@極地研

## Syowa update

- **imaging radar**
  still preparing....
- **antenna maintenance**
  better way to maintenance to reduce expedition members burden...
- current minor/major problems
  etc...

## Iceland obs update

- new mode with iqwrite

# 中緯度SDによるplasmapauseに関する観測

行松＠極地研

# SD research

- **identify geophysical boundary regions**
- **mapping of geophysical regions**

  **only by SD Doppler spectrum data**

**cusp / LLBL**

**OCFLB / spectral width boundary**

**plasmapause?**

# SD P.P. research

## Hokkaido

Progress report on Hokkaido HF radar

**5. Study of ULF waves in the mid-latitude ionosphere**

Observation of the **ULF waves near the P.P**. (~60° geomag. lat.) is very important in order to **monitor the plasmasphere**. Moreover, it is thought that the **ULF waves** play very important roles in **plasma heating and energy conversion processes in the I.M.** However, the continuous 2-D E obs. in this region is not fully operational.
In this research topic, the **characteristic and dynamics in the plasmasphere** are studied by observing the ULF waves continuously over **subauroral to mid-lat. region** by the new radar, and the **unsolved problems of plasma heating and energy conversion process in the I.M.** are approached.

**6. Study of the generation mechanisms of plasma irregularities in the mid-lat. ionosphere**

Ionospheric plasma irregularities are important in order for the HF radar to observe ionospheric backscatter echoes. Although it turns out that these irregularities may exist over a large latitudinal extent, **many unknown points are left befind about their generation mechanisms**.This research topic **investigates the conditions of ionospheric irregularity generation** from observation of ionospheric echoes, and aims at clarifying their generation mechanism.

# SD P.P. research

## **TIGER** Research

Plasmapause Phenomena

The **plasmapause** is the outer boundary of the ionosphere-plasmasphere system, and like all boundaries in nature, it is **a region where waves are generated, reflected and dissipated.** Therefore the plasmapause plays an important role in **controlling energy transfer from auroral latitudes to middle and equatorial latitudes**. The region can be explored comprehensively by TIGER. SuperDARN radars are able to identify the electromagnetic structure of hydromagnetic resonances in the high-latitude ionosphere, but the occurrence in the region of the **plasmapause** has not been explored with this technique. **Low latitude pulsations** are thought to be **generated by ULF energy that propagates in the fast wave mode from the magnetopause, through the plasma trough and across the plasmapause into the inner magnetosphere.** Theoretical studies predict wave reflection points so that the fast mode wave is resonant in the magnetospheric cavity. These cavity/waveguide modes couple to localised field line resonances. TIGER will be used:

- * to search for **evidence for these waveguide modes**;
- * to **differentiate between modes (i.e surface, cavity and field line resonance)**

TIGER can obtain high spatial and time resolution measurements of the following phenomena:

- * the **dynamics of the establishment of a new plasmapause boundary** after substorm activity,
- * the **evolution of the global plasmapause shape** during **plasma erosion and the formation of the boundary at a new location**,
- * **ULF wave signatures of the plasmapause**. This includes studies of the **field resonance mode with plasmapause dynamics and the investigation of plasmapause surface waves**.

# SD P.P. research

## US Research

Plasmapause Phenomena

### FAI related to P.P. - TGI

Greenwald et al., GRL, 2006.
Ruohoniemie et al., AGU 2009.

# FAI@P.P.

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L18105, doi:10.1029/2006GL026581, 2006



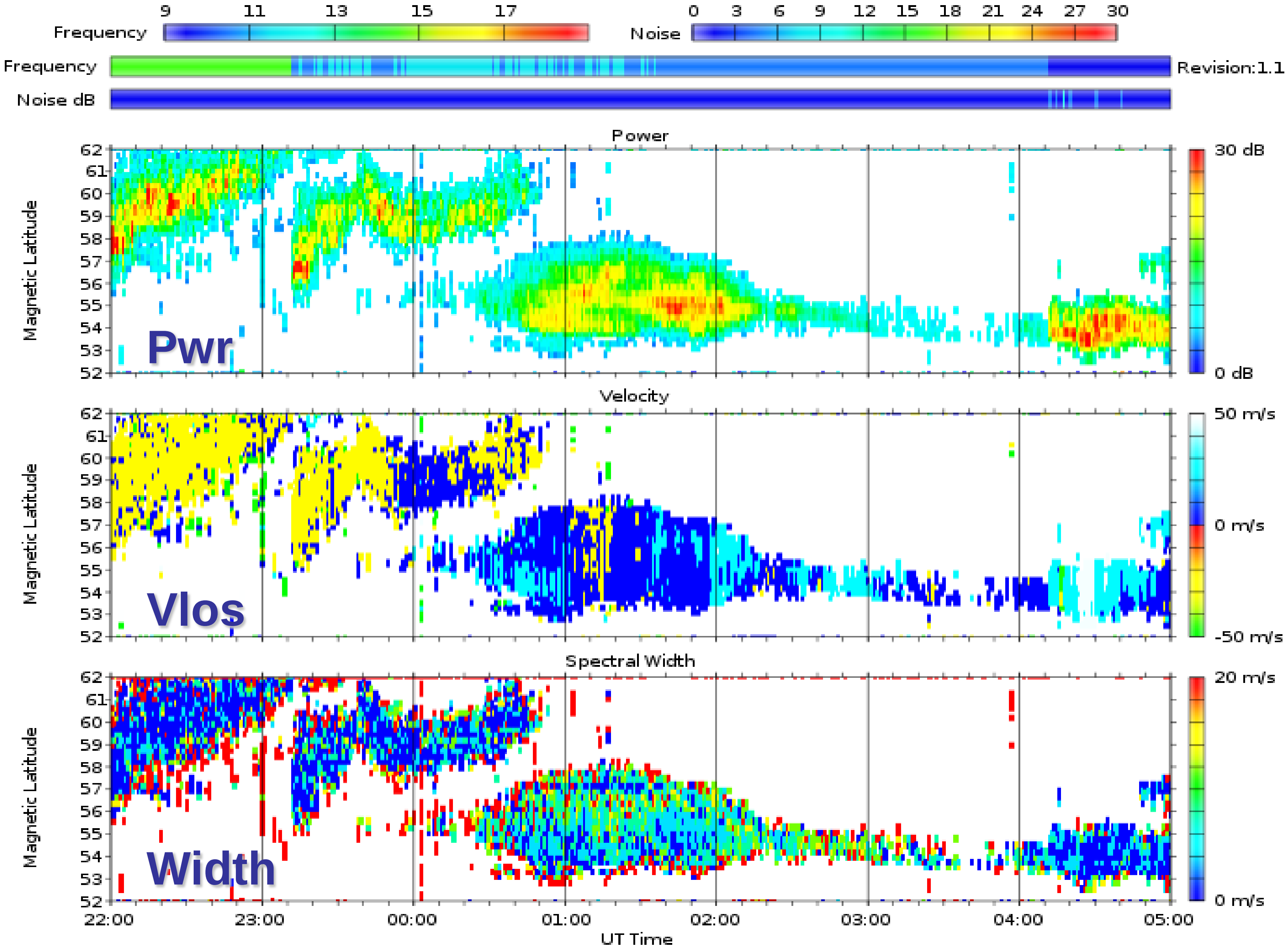
## Identification of the temperature gradient instability as the source of decameter-scale ionospheric irregularities on plasmapause field lines

Raymond A. Greenwald,[1] Kjellmar Oksavik,[1] Philip J. Erickson,[2] Frank D. Lind,[2]
J. Michael Ruohoniemi,[1] Joseph B. H. Baker,[1] and Jesper W. Gjerloev[1]

Received 12 April 2006; revised 21 July 2006; accepted 31 July 2006; published 21 September 2006.

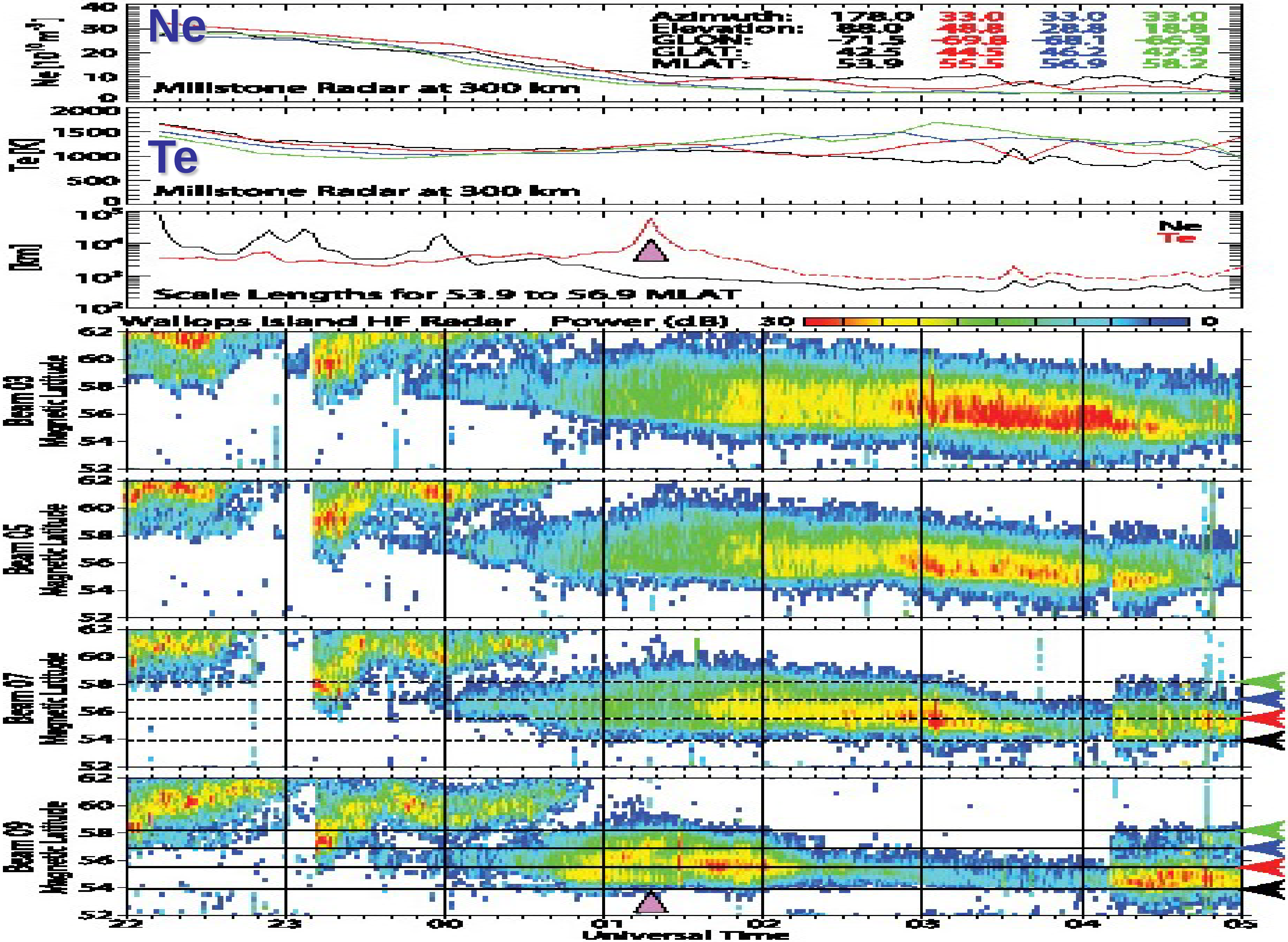
**Greenwald, et al., GRL, 2006**

# FAI@P.P.

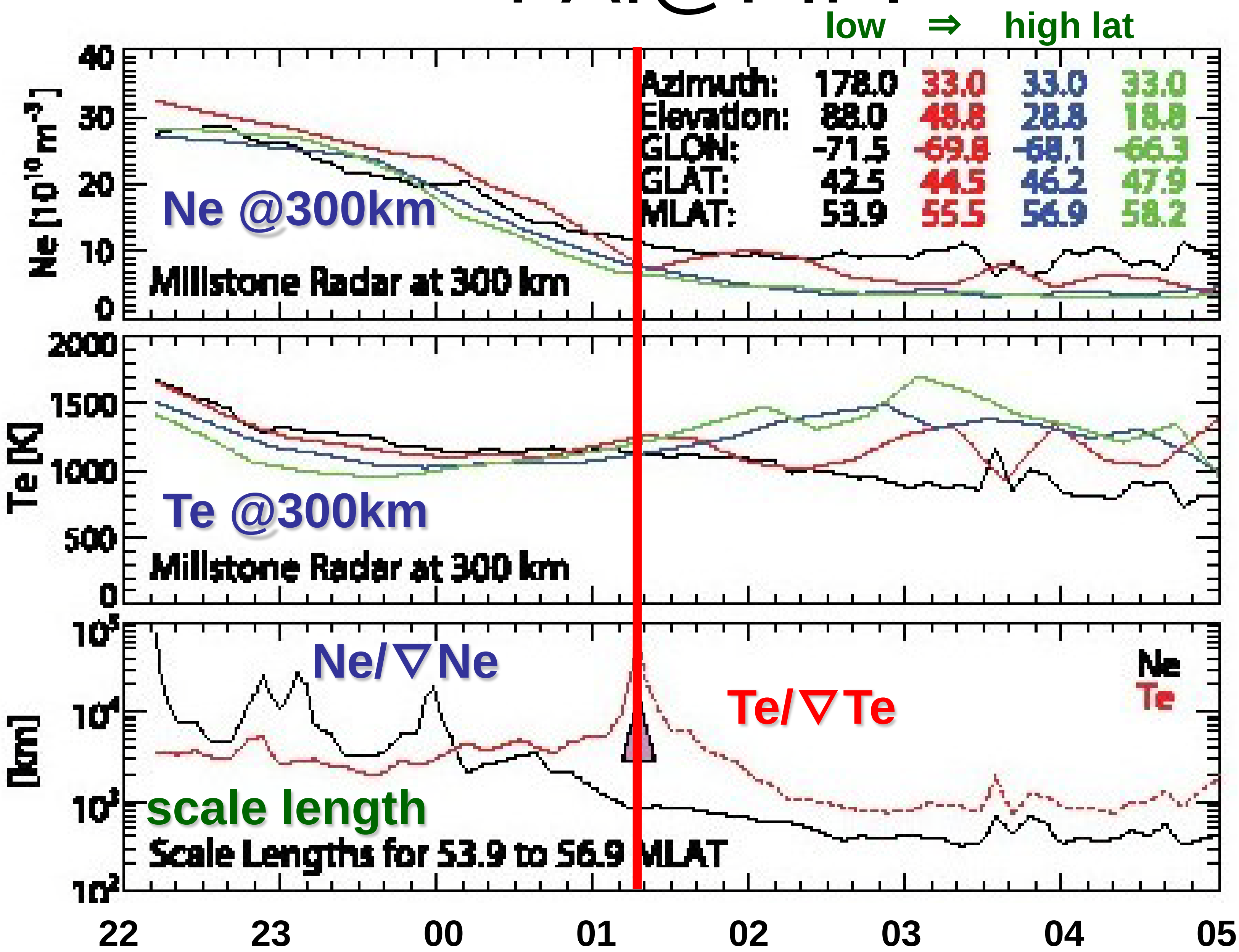


Frequency
9 11 13 15 17
Noise
0 3 6 9 12 15 18 21 24 27 30
Frequency
Revision:1.1
Noise dB
Power
30 dB
0 dB
Pwr
Velocity
50 m/s
0 m/s
-50 m/s
Vlos
Spectral Width
20 m/s
0 m/s
Width
Magnetic Latitude
62 61 60 59 58 57 56 55 54 53 52
22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00
UT Time

# FAI@P.P.


Ne
Azimuth: 178.0 33.0 33.0 33.0
Elevation: 88.0 48.8 28.8 18.8
GLON: -71.5 -69.8 -68.1 -66.3
GLAT: 42.5 44.5 46.2 47.9
MLAT: 53.9 55.5 56.9 58.2
Millstone Radar at 300 km
Te
Millstone Radar at 300 km
Scale Lengths for 53.9 to 56.9 MLAT
Ne
Te
Wallops Island HF Radar Power (dB) 30 0
Beam 03 Magnetic Latitude
Beam 05 Magnetic Latitude
Beam 07 Magnetic Latitude
Beam 09 Magnetic Latitude
Universal Time

# FAI@P.P.

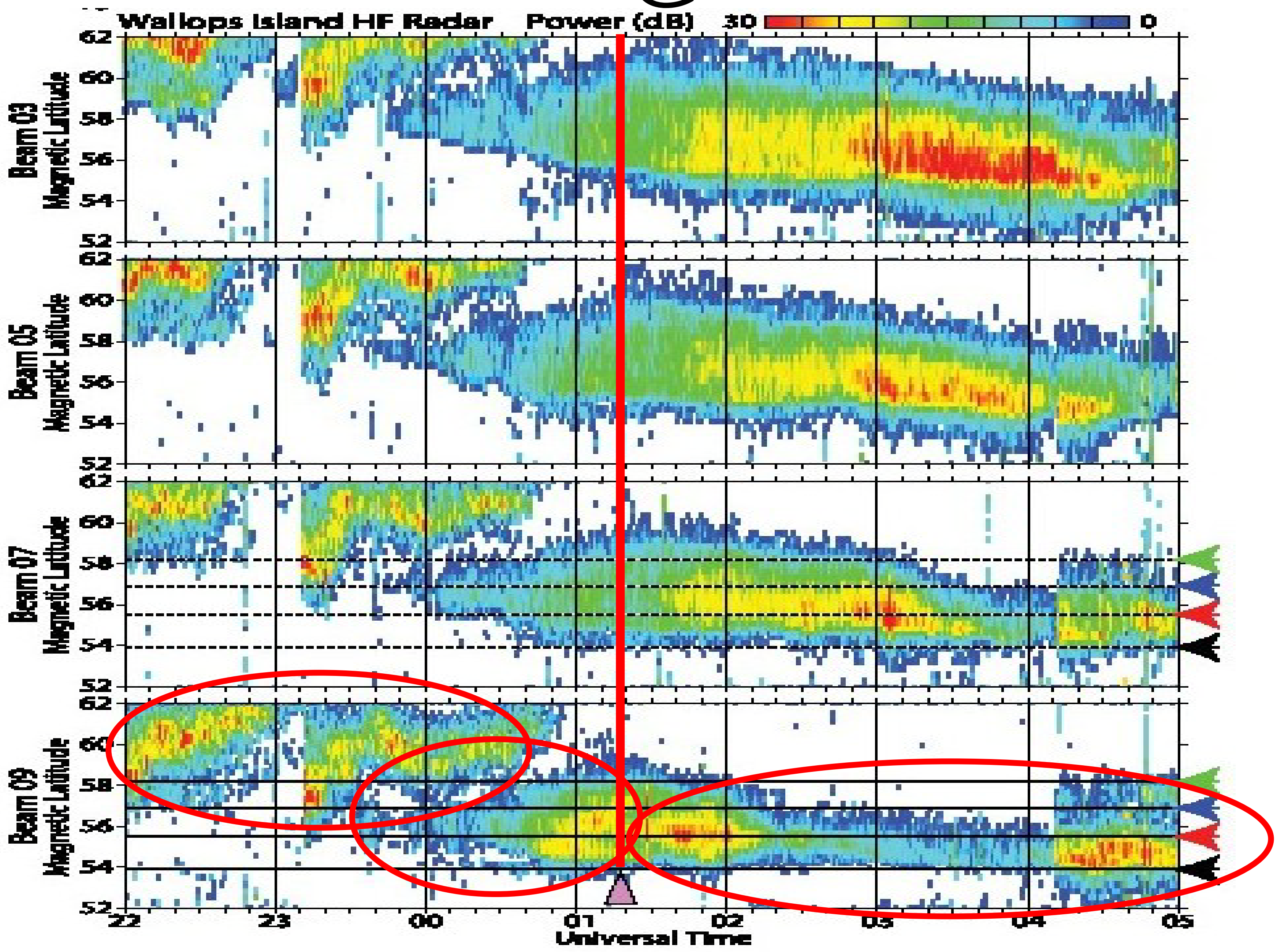



01:15～
∇Ne大

01:15～
∇Te
反転

且つ、
Kp小で
Ne
小@E
層

# FAI@P.P.


Wallops Island HF Radar
Power (dB)
30
0
Beam 03
Beam 05
Beam 07
Beam 09
Magnetic Latitude
62
60
58
56
54
52
22
23
00
01
02
03
04
05
Universal Time

# FAI@P.P.

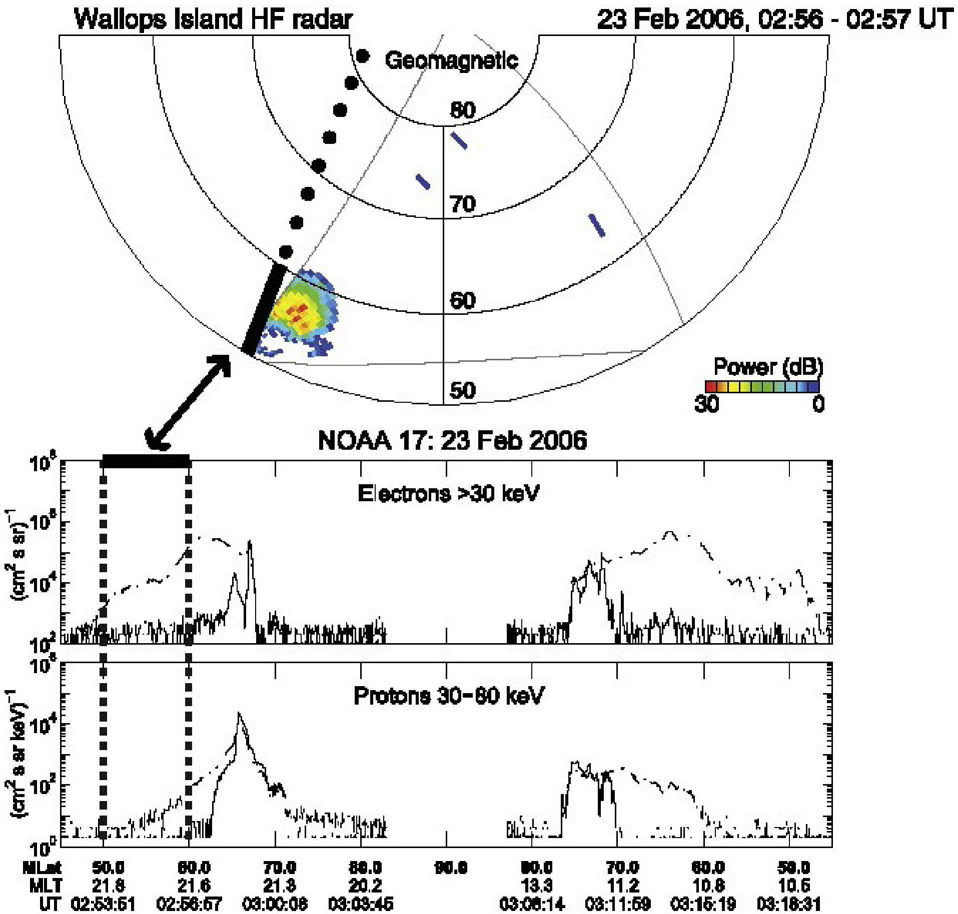



**Figure 2.** Overflight of NOAA 17 adjacent to the field of view of the Wallops radar at ~0256 UT on 23 February 2006. The backscattered signals are observed from 54°<Λ<59° in a region where there is a positive poleward gradient in trapped energetic particle fluxes (indicated by dot-dashed lines). There are no discernible precipitating particle fluxes (solid lines) in this region.

**NOAA17 & SD**

**high energy trapped particles**
**∇density > 0**
**precipitated HE particles : rare**

**high-lat heat source is due to Coulomb collisions btw the mirroring energetic particles and cold ionospheric electrons.**

# FAI@P.P.

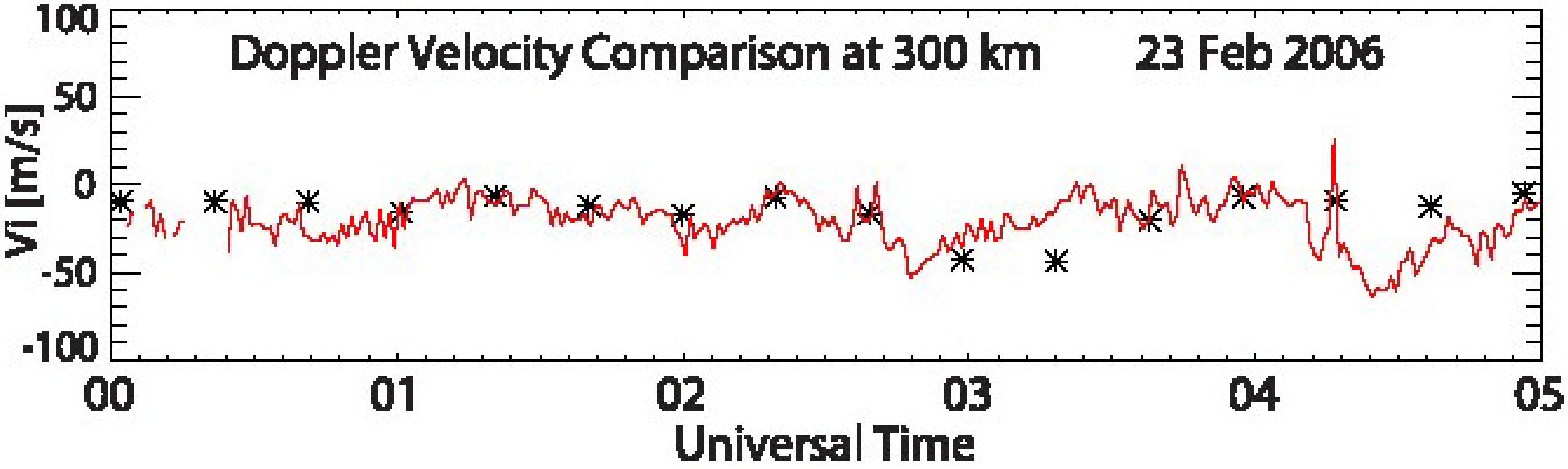



**Figure 3.** Comparison of irregularity Doppler velocities (red line) with plasma Doppler velocities (asterisks) at 300 km altitude for 00–05 UT on 23 February 2006.

**Doppler velocity comparison btw SD vs Millstone Hill ISR**
**fairly consistent!**
**SD data NOT ground scatter!**

# FAI@P.P.

[1] Recent observations with the new mid-latitude SuperDARN HF radar located at Wallops Island, Virginia have identified a class of ionospheric irregularities that is prevalent in the nightside sub-auroral ionosphere under low-to-moderate *Kp* conditions. These irregularities can be observed for many hours and generally exhibit very low Doppler velocities. A recent collaborative experiment using the Wallops radar and the Millstone Hill incoherent scatter radar has determined that these irregularities are located at the ionospheric footprint of the plasmapause and in a region of opposed electron density and electron temperature gradients. We conclude that the irregularities are produced by the temperature gradient instability (TGI) or by turbulent cascade from primary irregularity structures produced from this instability. This is the first experimental confirmation that the TGI is effective in producing decameter-scale ionospheric irregularities. **Citation:** Greenwald, R. A., K. Oksavik, P. J. Erickson, F. D. Lind, J. M. Ruohoniemi, J. B. H. Baker, and J. W. Gjerloev (2006), Identification of the temperature gradient instability as the source of decameter-scale ionospheric irregularities on plasmapause field lines, *Geophys. Res. Lett.*, *33*, L18105, doi:10.1029/2006GL026581.

**Millstone Hill ISRとWallopsとNOAAでP.P.でのFAI、Ne、Teを観測。**

**low~moderate Kp**
**night – several hours**
**low VLOS < 100 m/s**
**(ground scatterとの区別が困難!!)**

**footprint of P.P. (52° < Λ < 59° )**
**opposed $\nabla Ne \Leftrightarrow \nabla Te$**
**TGI requirement!!!**
**(Hudson and Kelley, 1976)**
**(Yizengaw & Moldwin, 2005)**

**TGI (temp. grad. instability, within general class of collisional drive wave instabilities ) or tubulent cascade from primary irregularity stductures (by TGI)**

**First experimental confirmation of decameter-scale ionospheric FAI effectively produced by TGI**

# FAI@P.P.

## ●P.P. 近傍でTeがLと共に増大する理由

**1. Coulomb collisions btw thermal electrons & mirroring energetic electrons or ions on the inner edge of the proton ring current.**

**2. Landau damping of electromagnetic ion cyclotron waves again located on the inner edge of the proton ring current [Cornwall et al., 1971]**

**3. coolong of thermal electrons on the plasmasphere side of the gradient through molecular conduction.**

**・3rd process : significant after sunset (indicated by the declining electron temperatures on the zenith antenna of the Millstone Hill ISR).**

# SD@P.P.

**・AGU 2009 fall meeting**

**M. Ruohoniemi – TGIのglobalな統計的分布**

**★Ground scatterとの区別**

**Vlosの特徴的な変化のみで可能か？**

**Spectral width etcに特徴は？**

**★how to identify the location of P.P. (only by SD)?**

**deduce Ne distribution/variation along L**

**using ULF/FLR**

# SD ULF

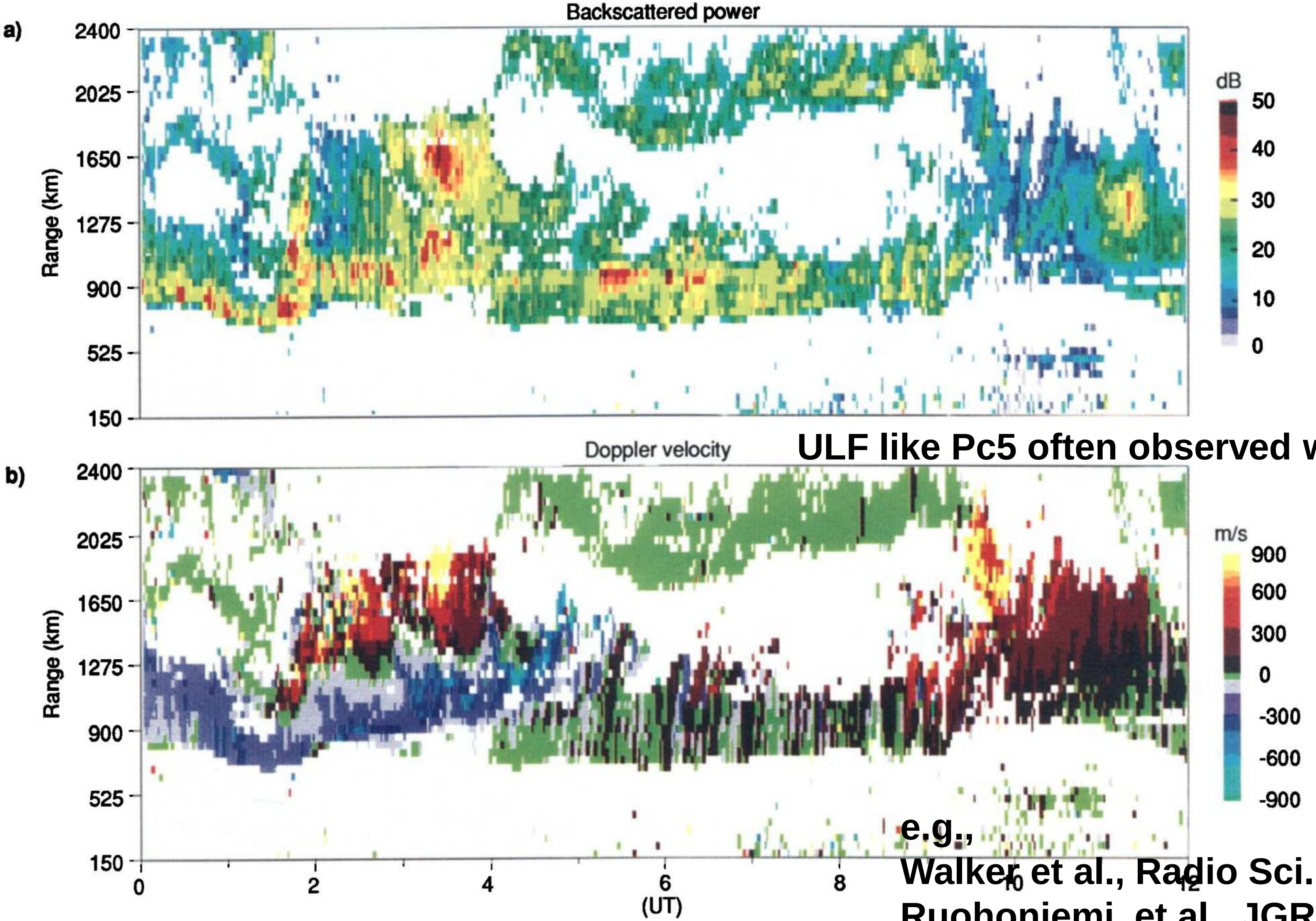
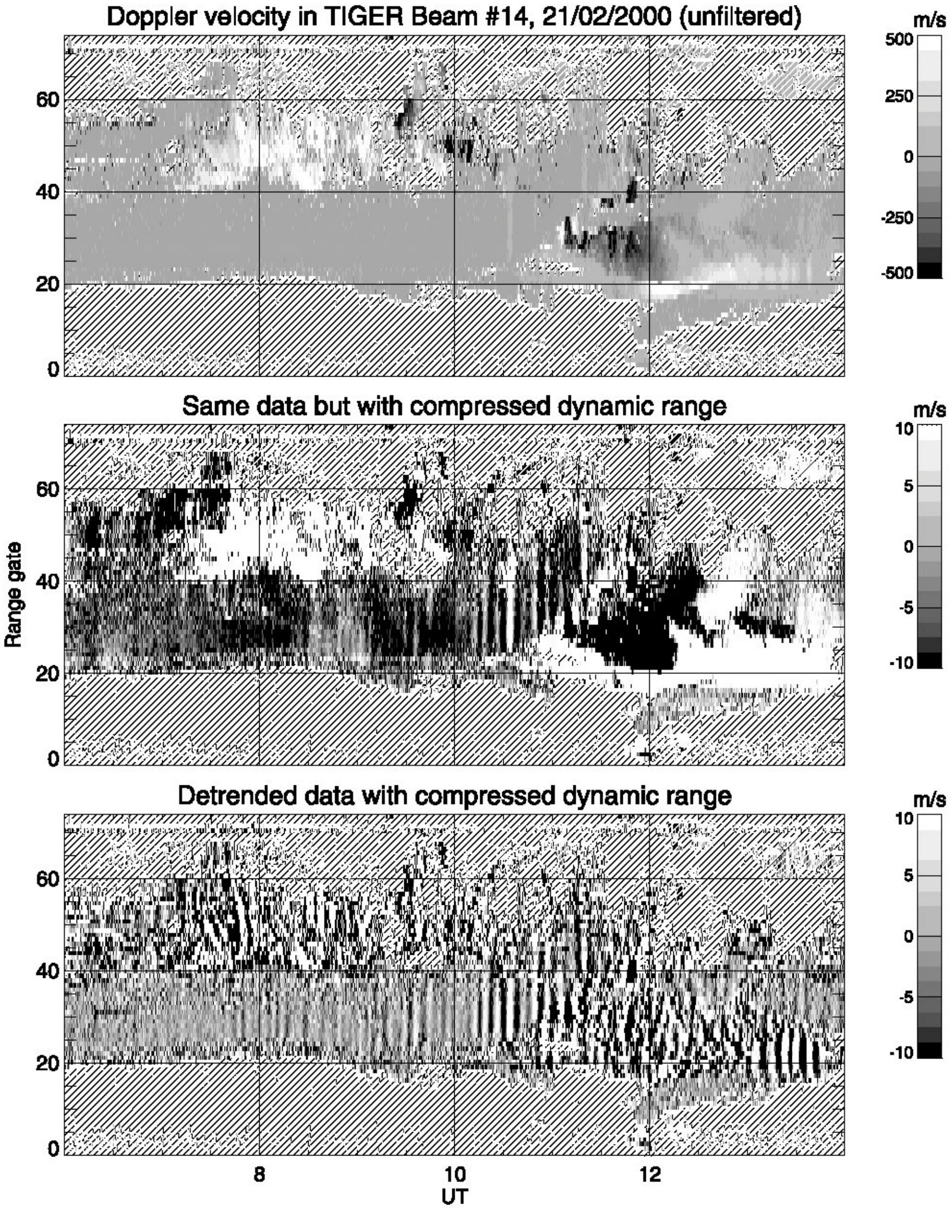



Plate 2. (*a*) Range-time plot of the backscattered power recorded on beam 8 during the period 0000–1200 UT on January 11, 1989. (*b*) The corresponding plot of the line of sight velocity. Note the periodic oscillations in the velocity sign between 0400 and 0900 UT in the 650–1150 km range interval.

**ULF like Pc5 often observed with SD**

**e.g.,**
**Walker et al., Radio Sci., 1987**
**Ruohoniemi, et al., JGR, 1991**

# SD ULF




**Panomarenko, GRL, 2003**

**not only ULF pulsation phenomena found in ionospheric data,**

**Abundant ULF records in ground/sea scatters**

**⇒Mid-Lat SD**

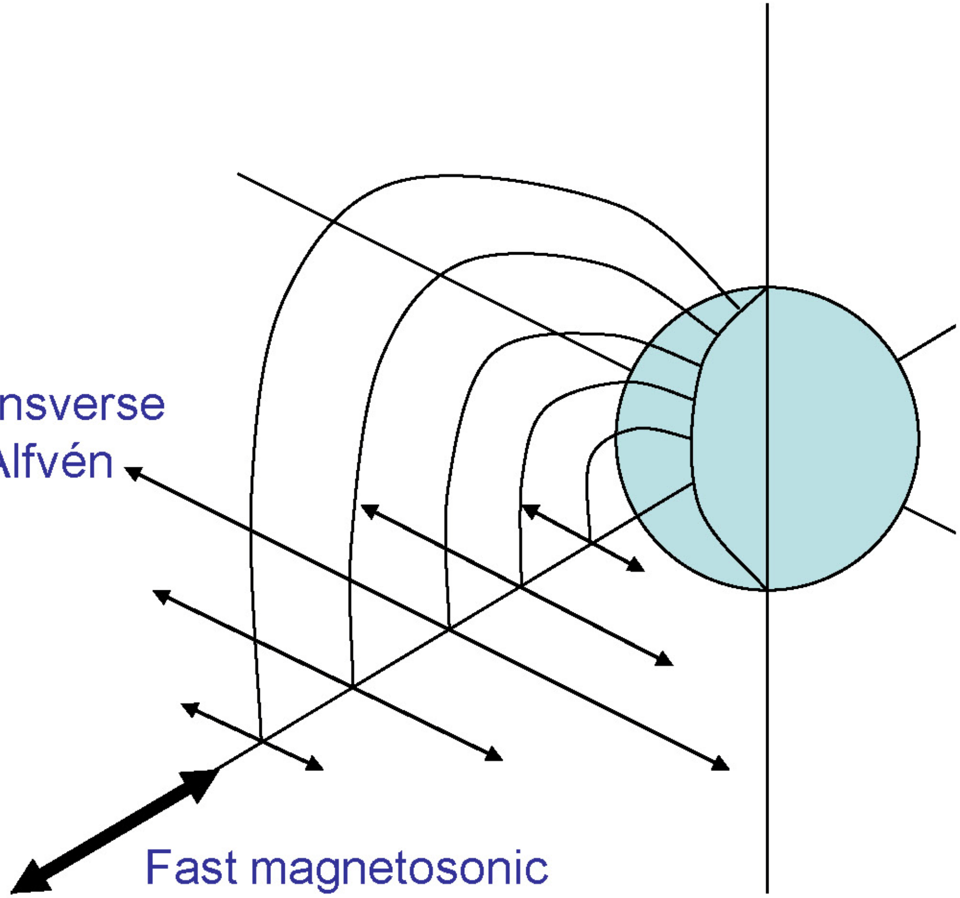
HMO

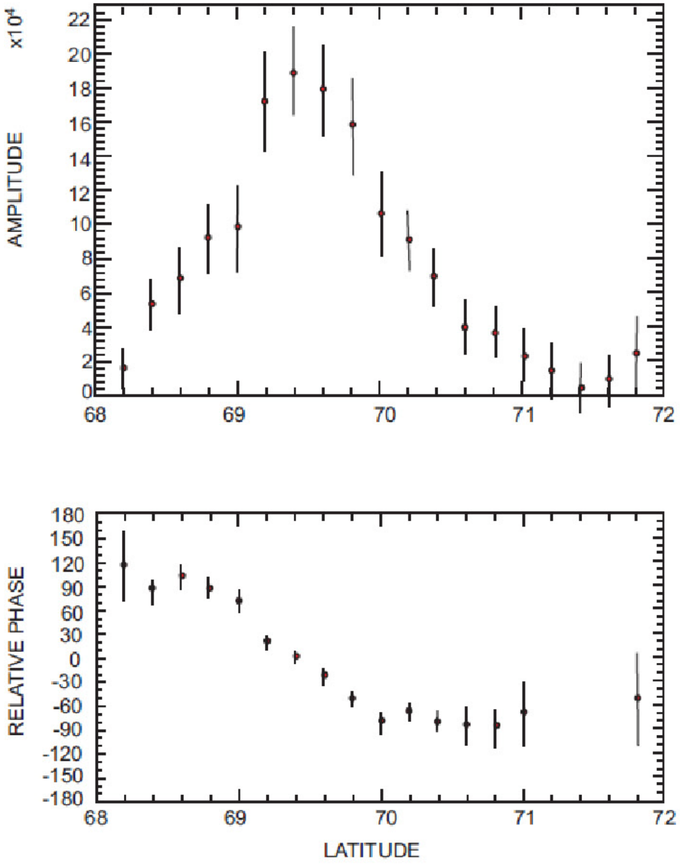
# Towards Realtime magnetospheric plasma densities from observations of Pc5 pulsations in SD data

Lindsay Magnus – magnus@hmo.ac.za

SuperDARN Workshop - 2009

# Pulsation characteristics
# What is FLR?

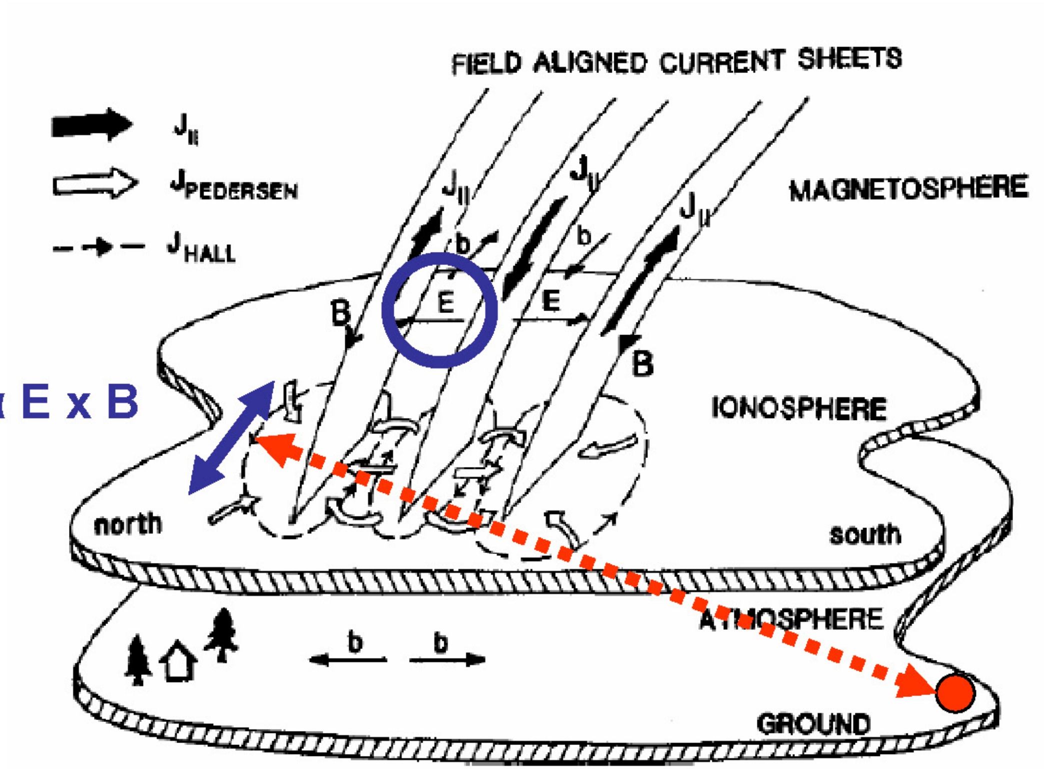


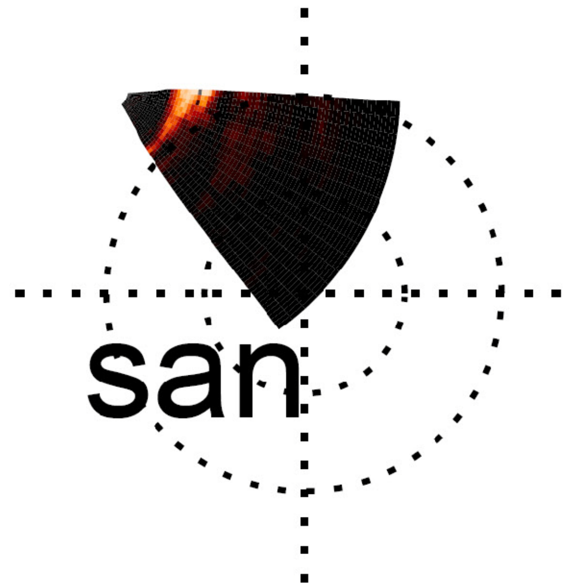




Fast magnetosonic waves will resonate with field lines with the same natural frequency

# Pulsation characteristics
# What does the radar see?

v α E x B

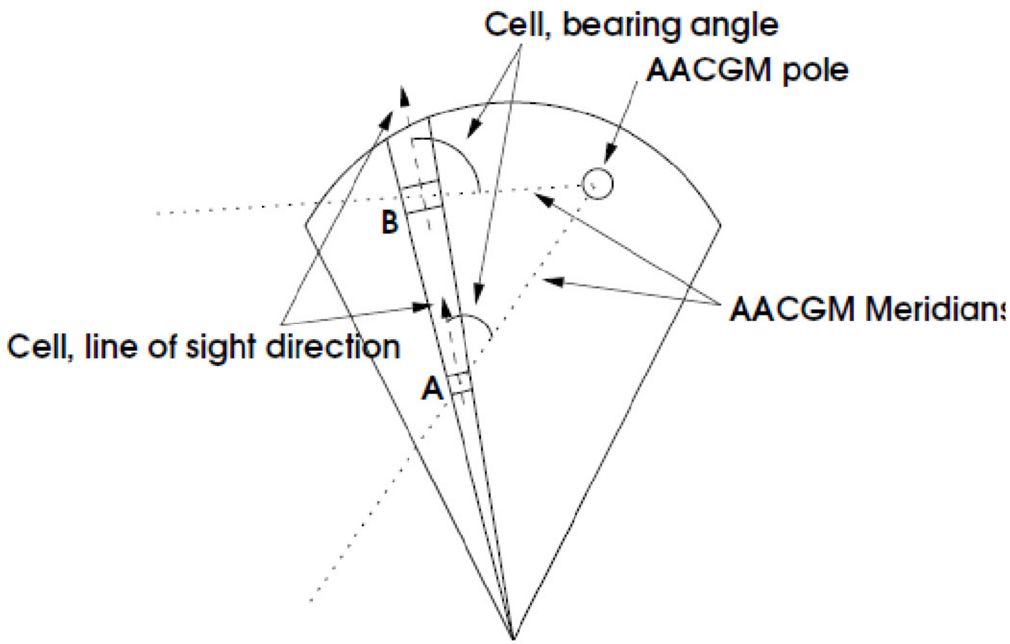


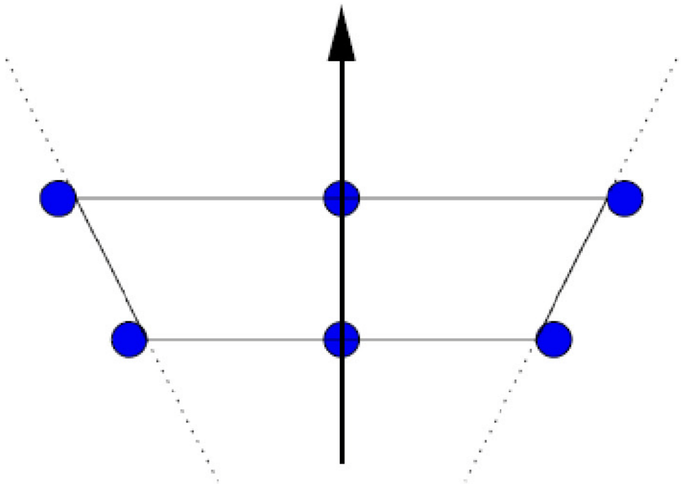




$$v_{radar} = v \cdot \overline{\mathrm{LoS}}$$

**FLR characteristics can only be observed in beams that are directed east-west**

# Magnetic bearing Definition

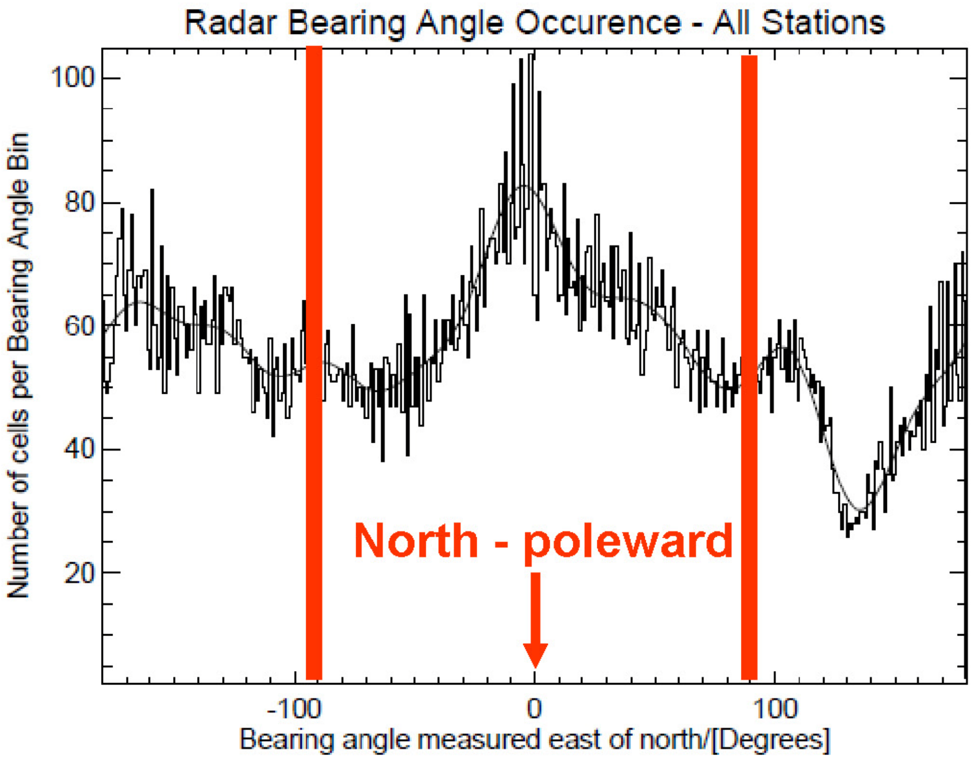


The magnetic bearing can be calculated for each cell in the network. The velocity that is measured by the radar is then the dot product of the bearing of the cell and the direction of the plasma motion.

**Cells in the same beam will not necessarily have the same magnetic bearing**

# Magnetic bearing
# SuperDARN characterisitics

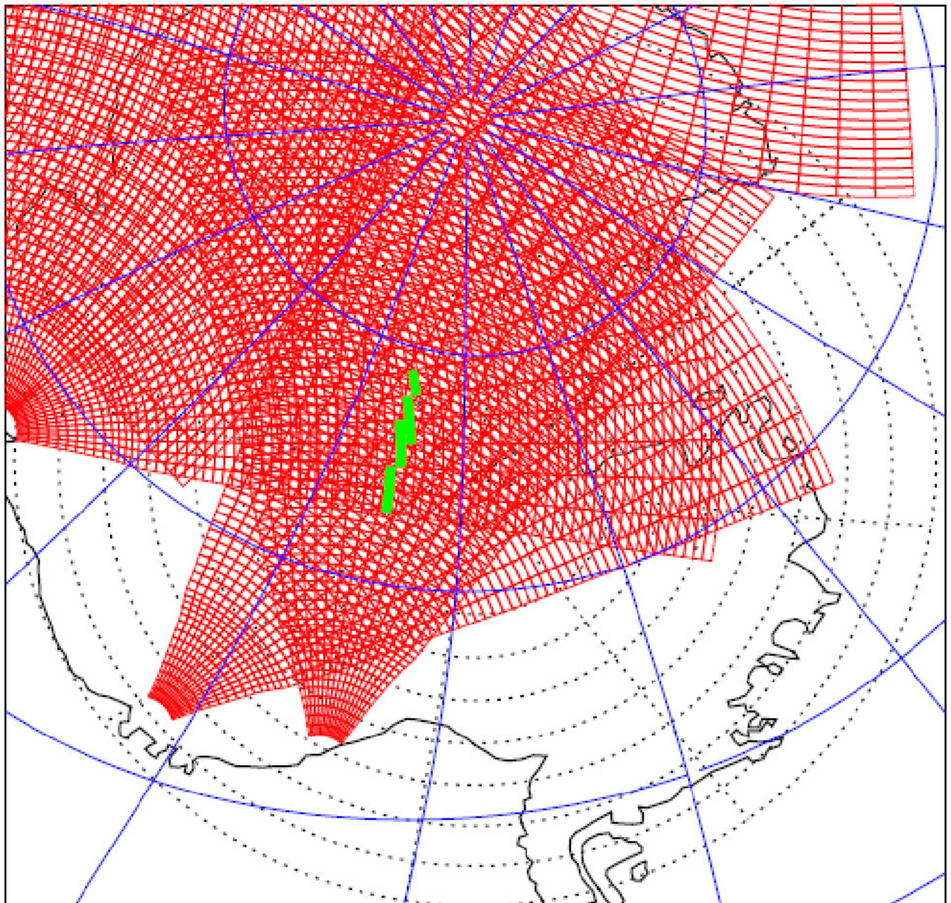



Most of the cells in the network are directed poleward (north or south) meaning that they are not suited for FLR observations

**More cells in the network are directed poleward**

# Magnetic bearing
# Suitable cells in the network

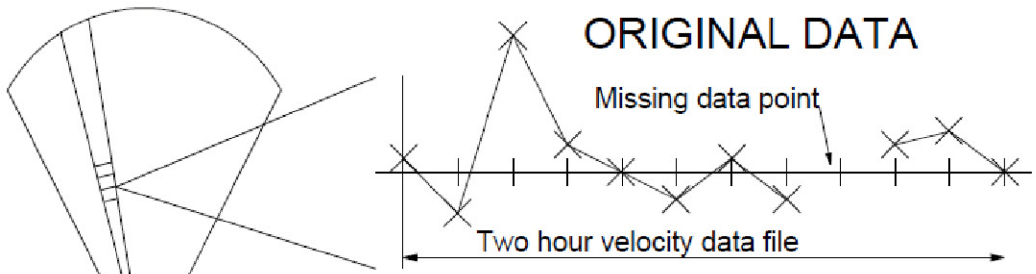
## Matching cells for AACGM Lon= 31°

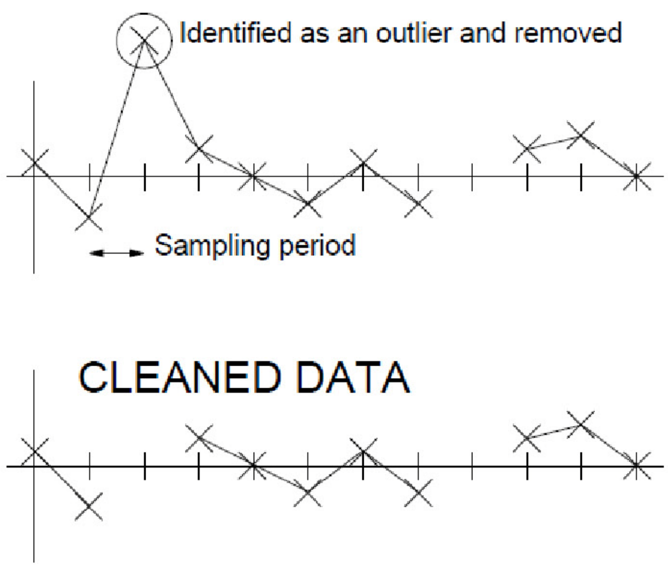


There are only a few cells in the network that will satisfy the strict bearing conditions to only observe the Transverse Aflven part of the pulsation. Further most of these cells are inside the OCFB which makes them useless for FLR observations.

**Cells can be identified that are perpendicular to lines of AACGM longitude**

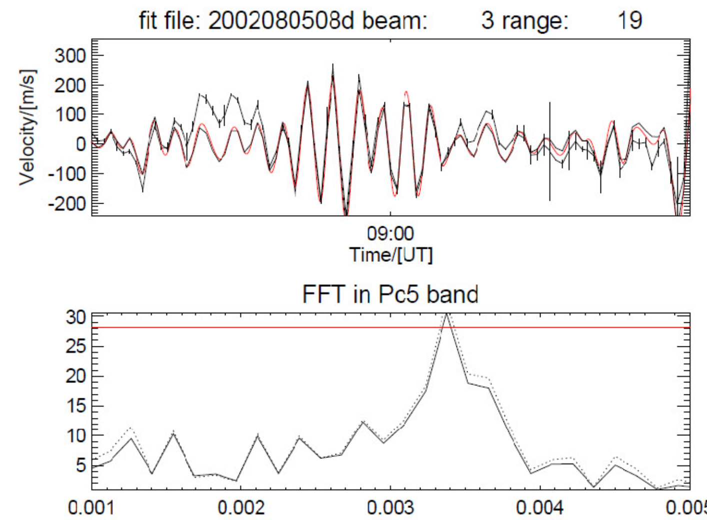
# Pulsation finder
# How it works




The data from a cell is expanded for a two hour record and is shown on the right

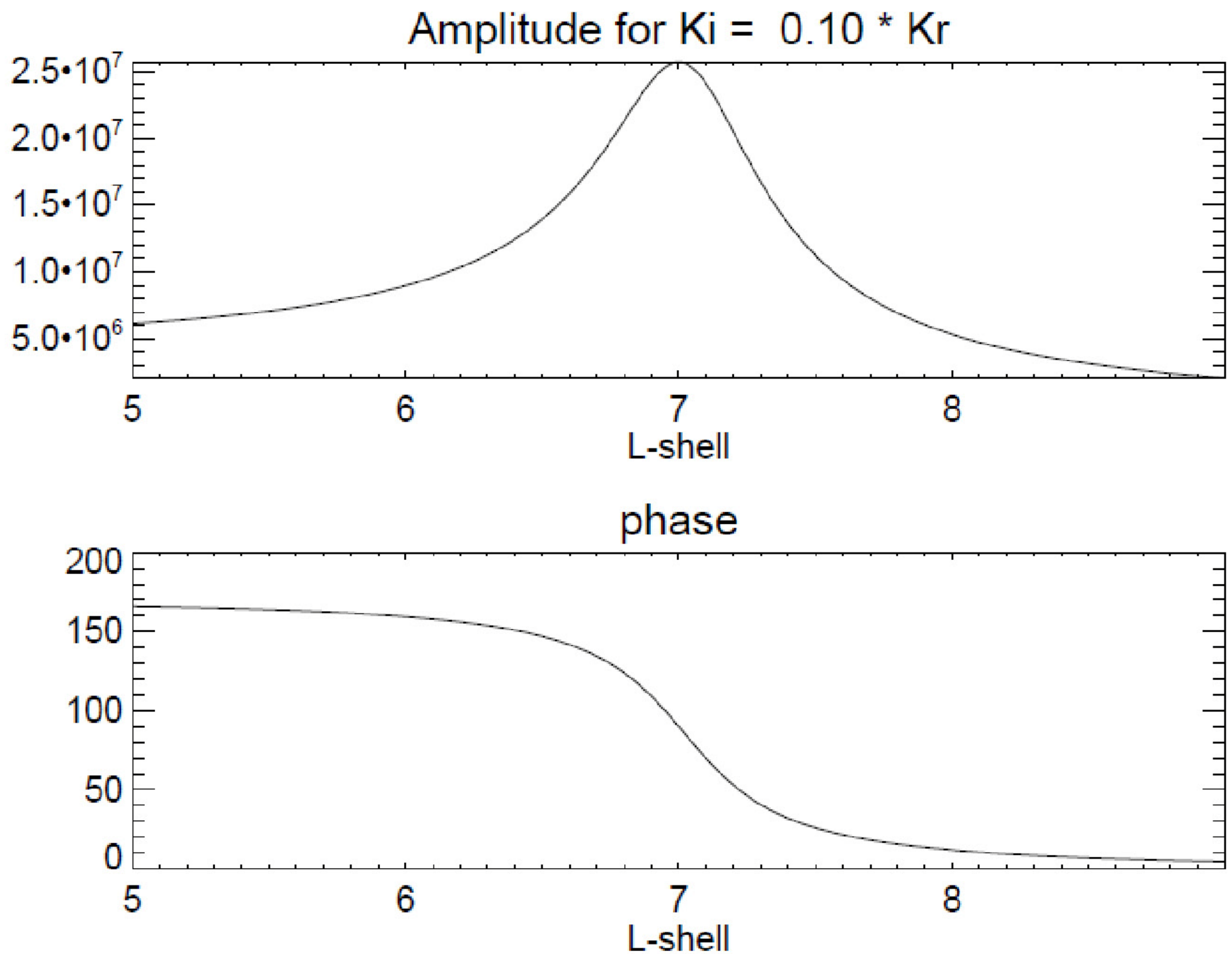
This gives a clean scatter percentage on 10/12 = 83% for this cell




Each cell in the network produces a two hour record of Doppler velocity data that are tested to determine if there is a periodic signal present with a peak in the Pc5 band. This is an automated process.

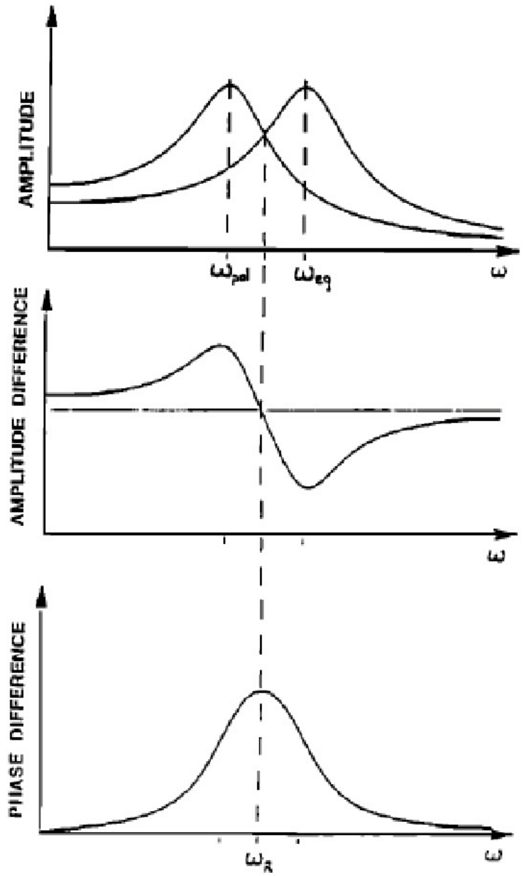
**The pulsation finder will indicate if Pc5 signals are present in a cell of interest**

# Simulated latitudinal variation

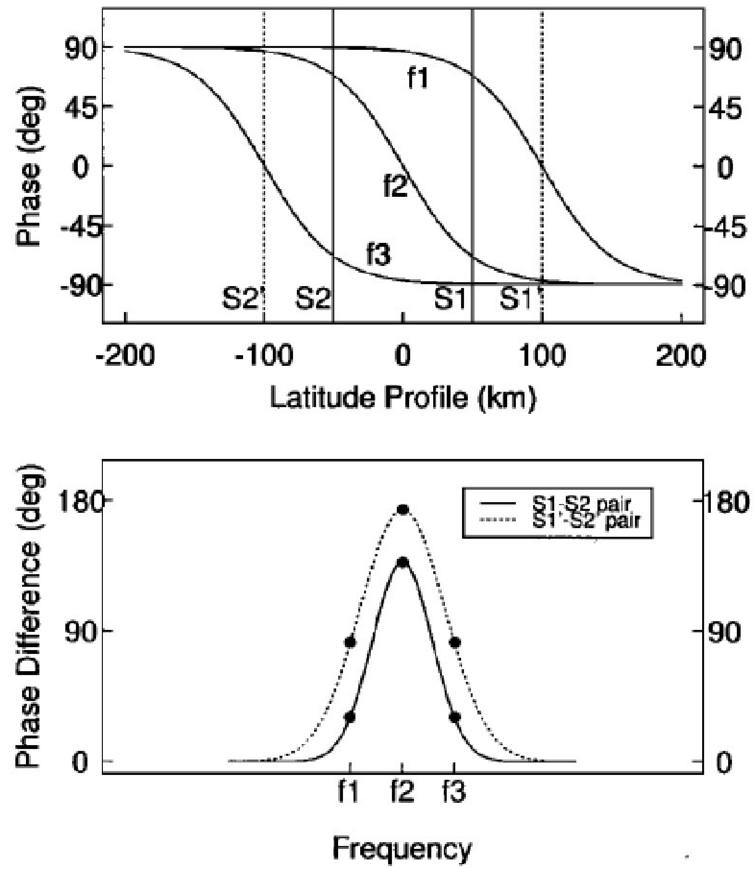



The variation is similar to a driven damped harmonic oscillator

# Cross phase analysis



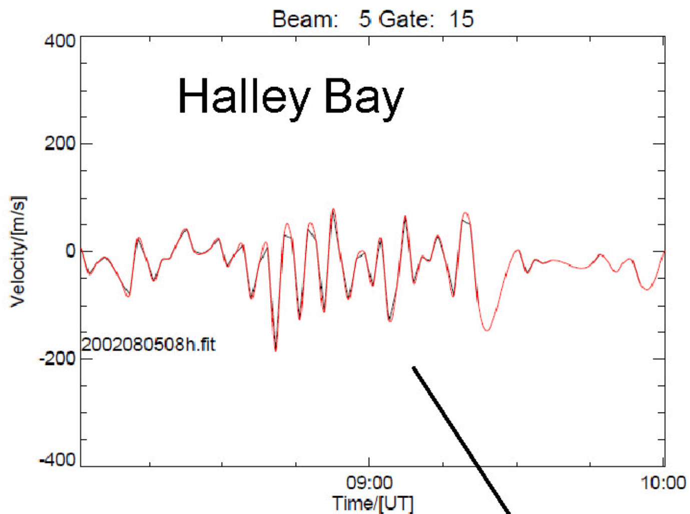

Waters et al, 1995, JGR

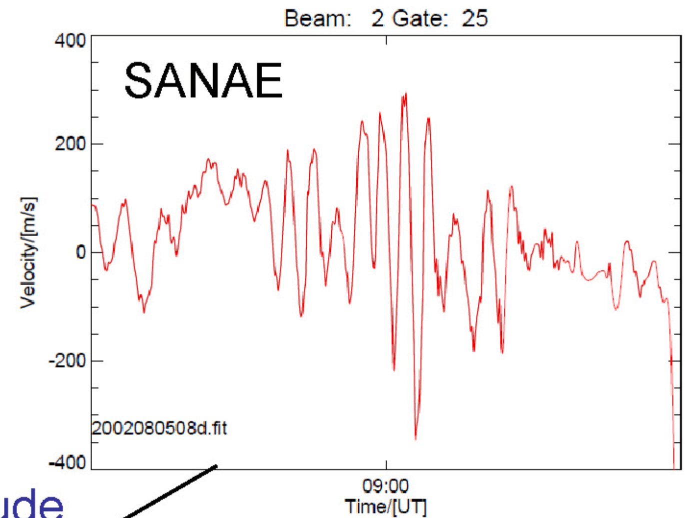


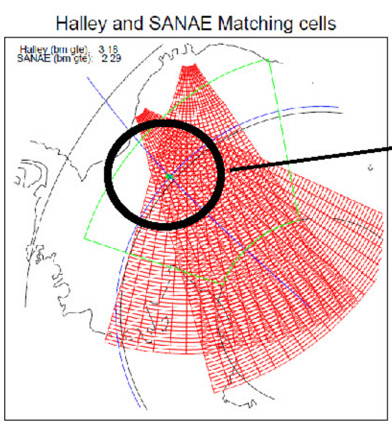

Chi and Russell, 1998, GRL

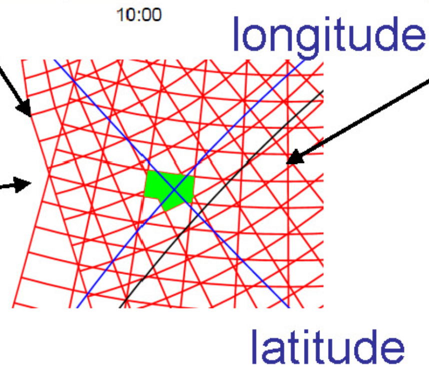
**Cross phase analysis has been used to infer plasma densities before**

# Results
# A FLR event



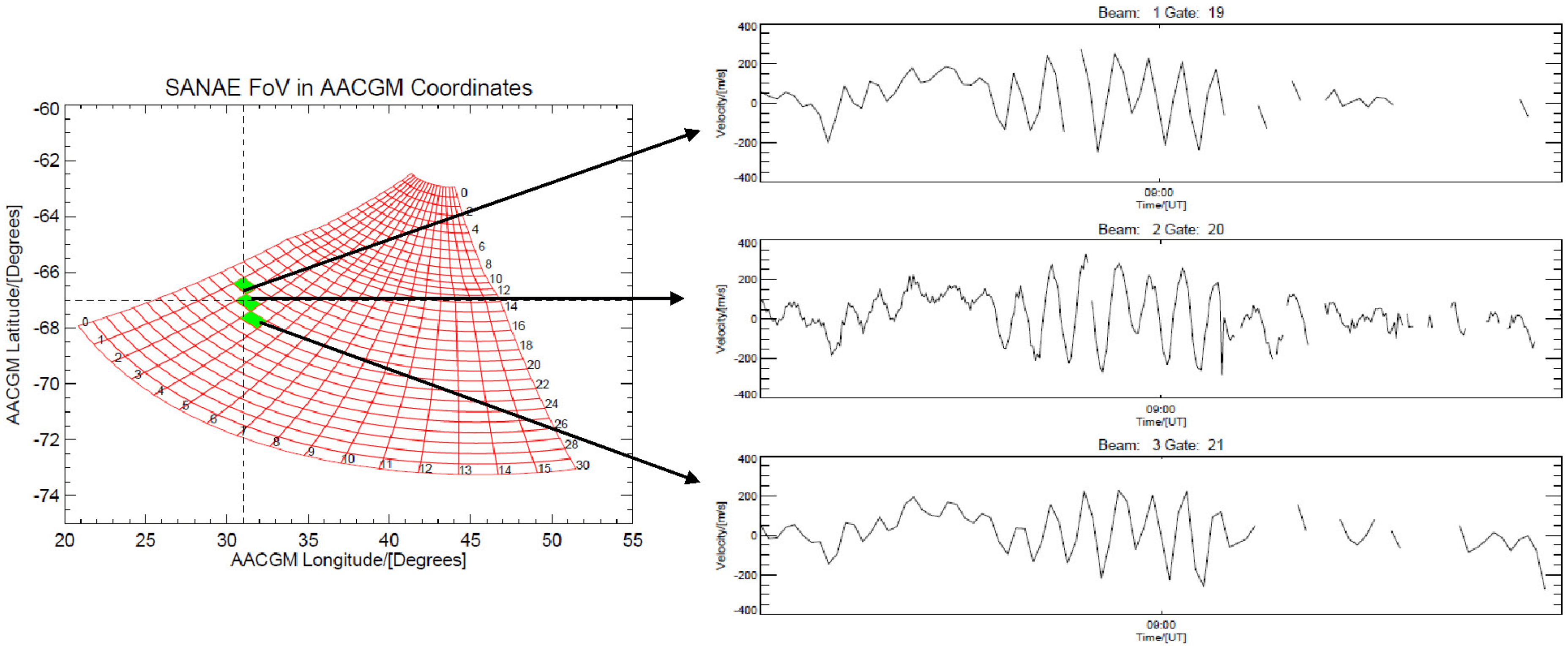




**To confirm that this was a FLR event we compared the pulsation from Halley Bay (more poloidal) and SANAE (more torroidal). The pulsations are from overlapping cells and the SANAE data is twice as large as the Halley Bay**

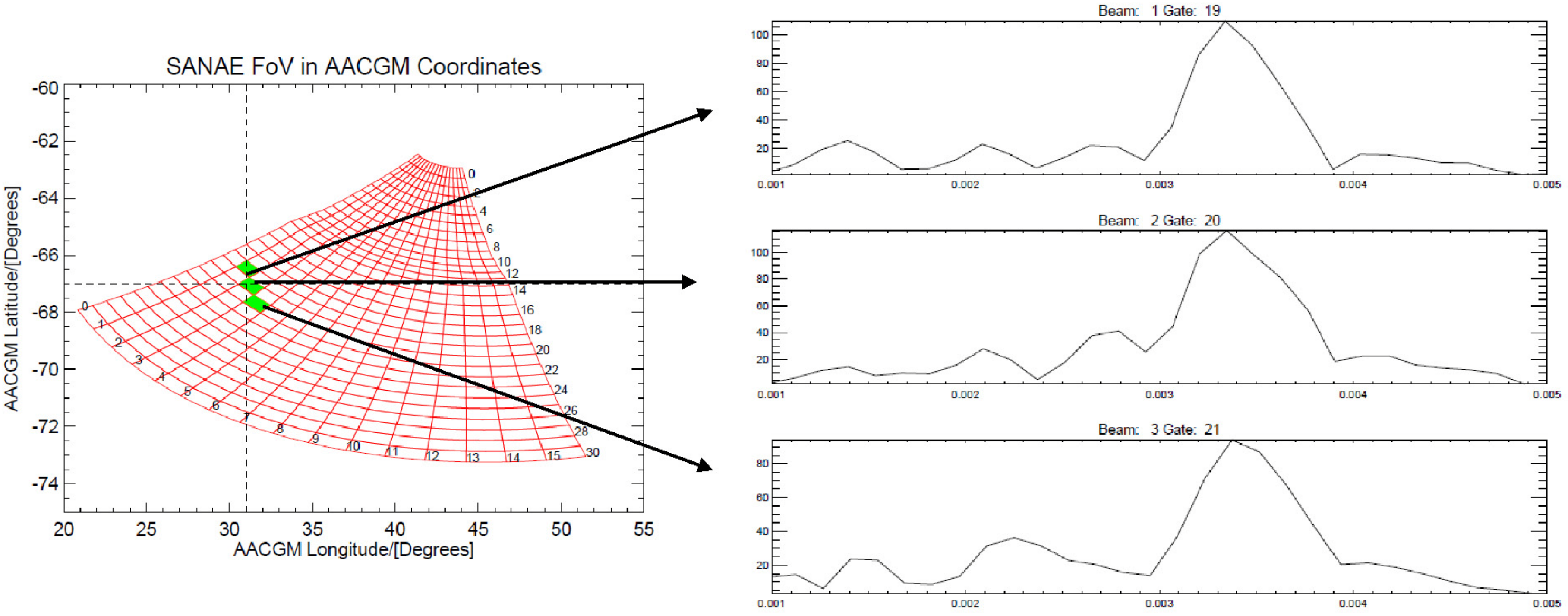
**The poloidal beam has a smaller amplitude than the torroidal beam**

# Which cells to process?



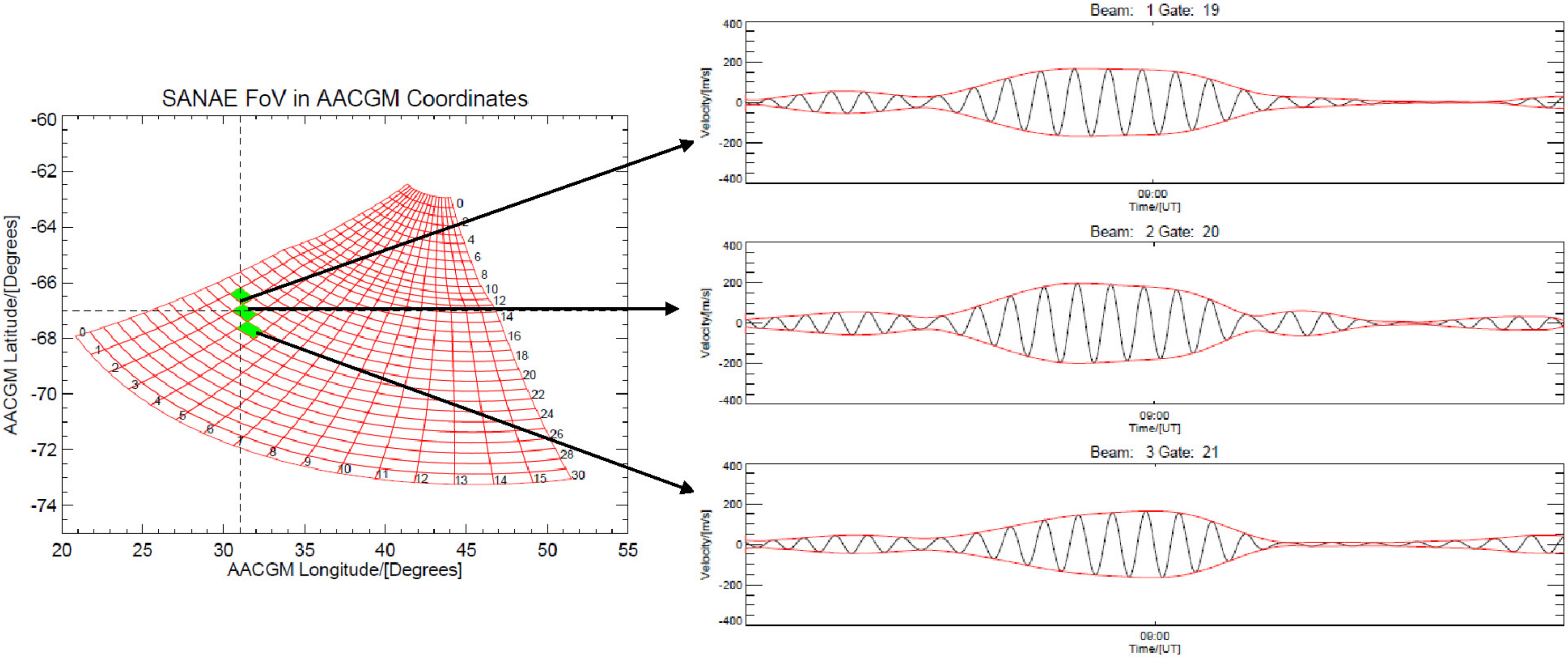

**Pulsations on a line of magnetic longitude**

# Which cells to process?



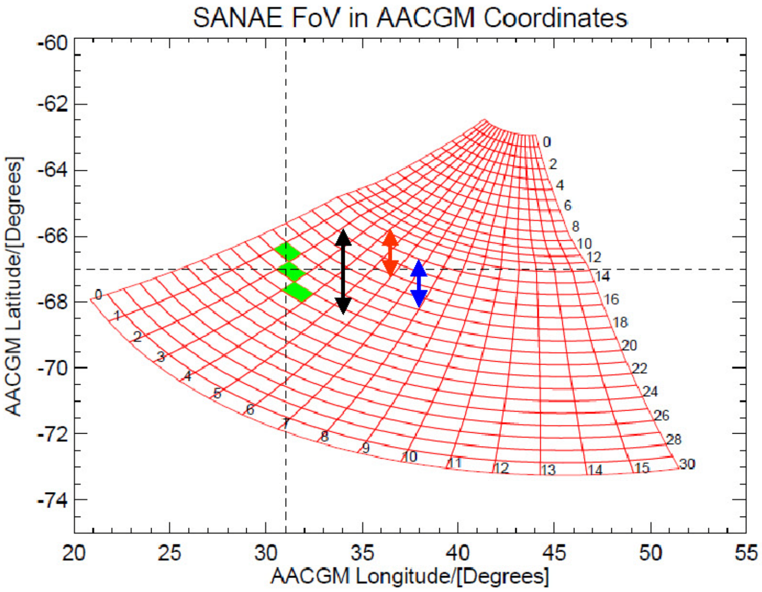

**Spectra give a peak between 3 and 4 mHz**

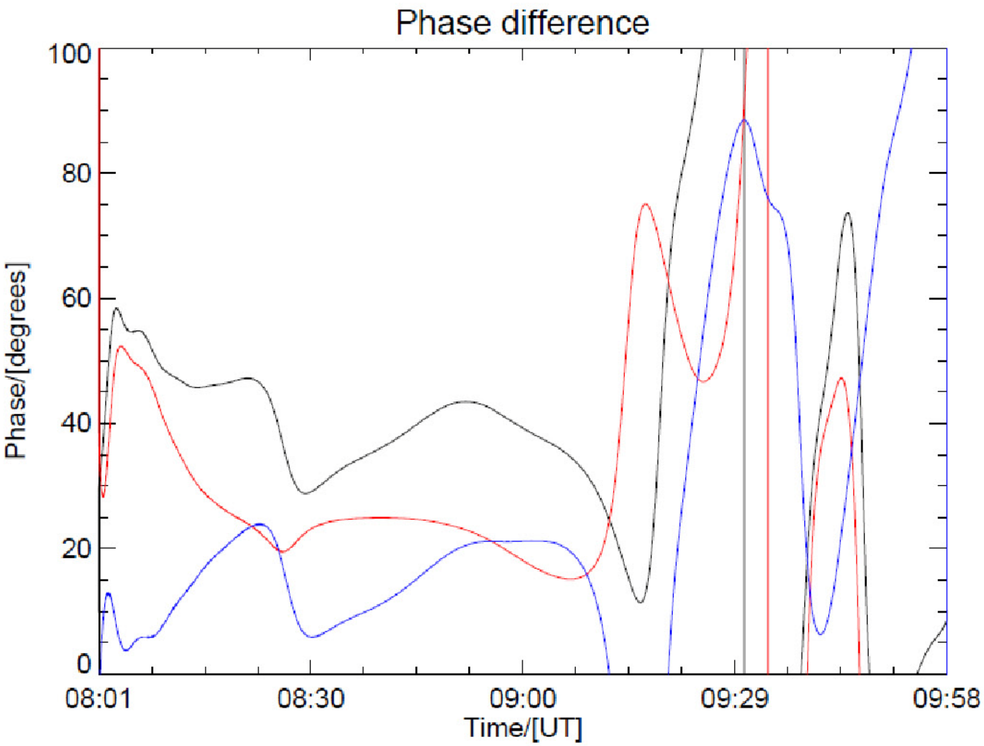
# Which cells to process?




**Data filtered between 3 and 4 mHz for the calculation of the analytic signal**

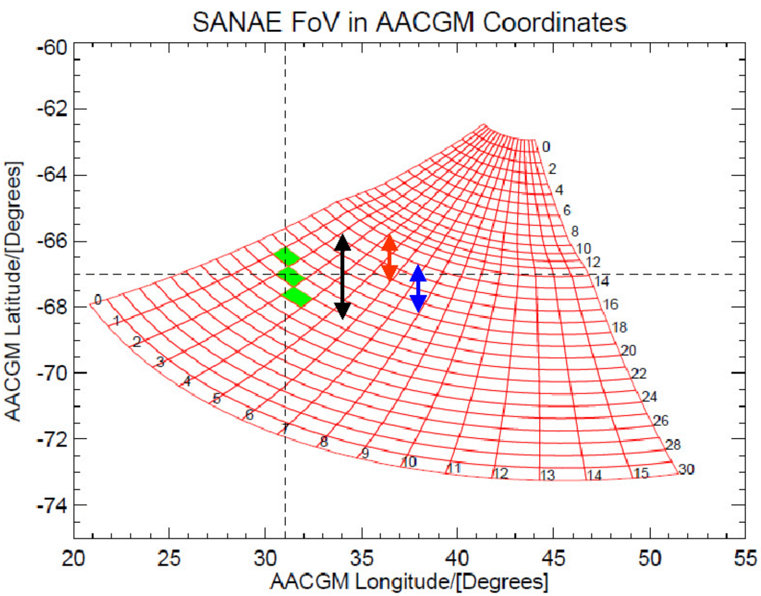
# Cross phase

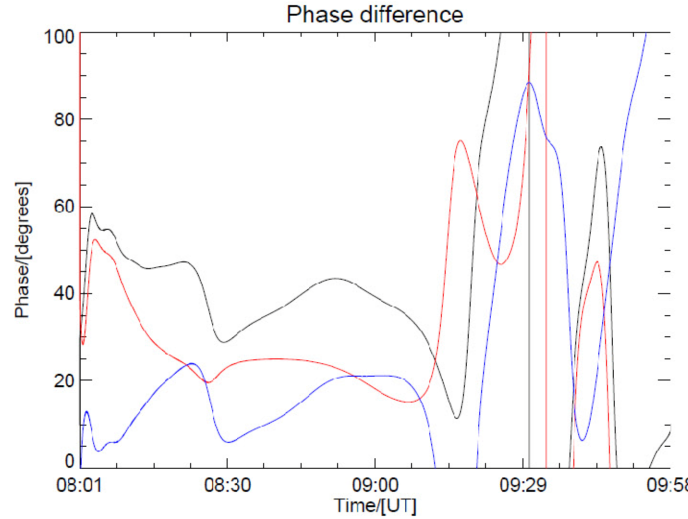


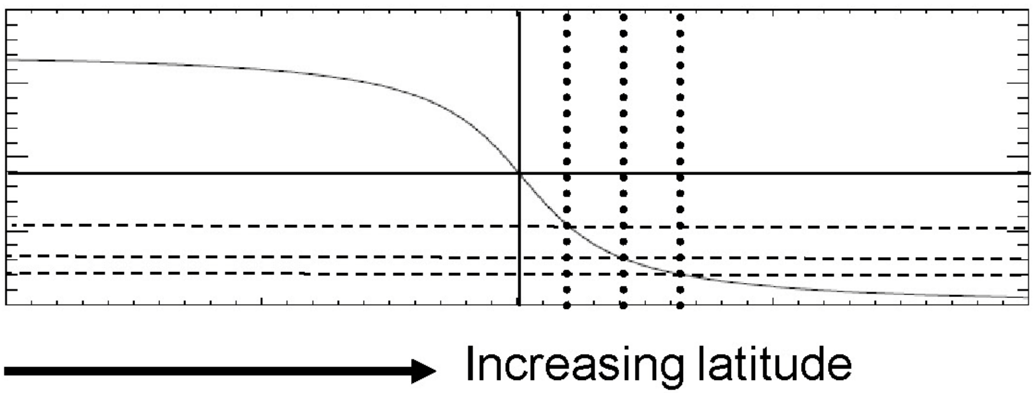




**The instantaneous phase difference from the analytic signal**

# Cross phase

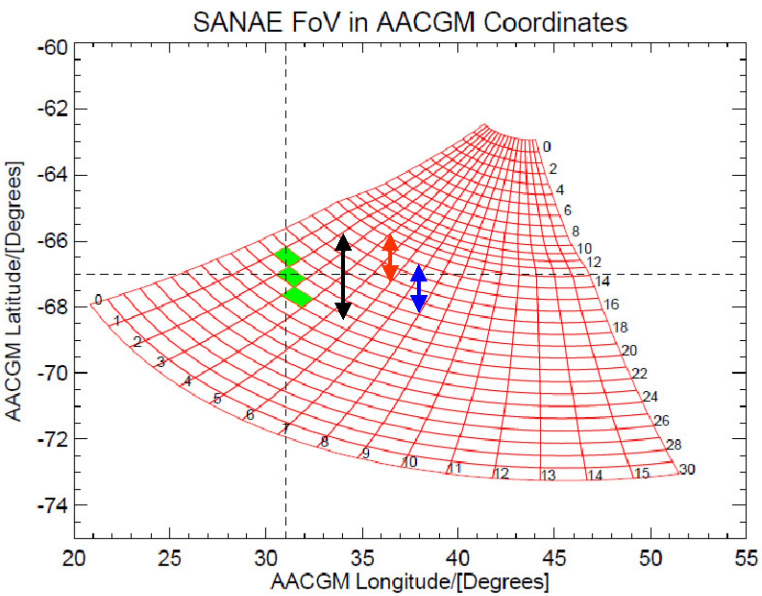


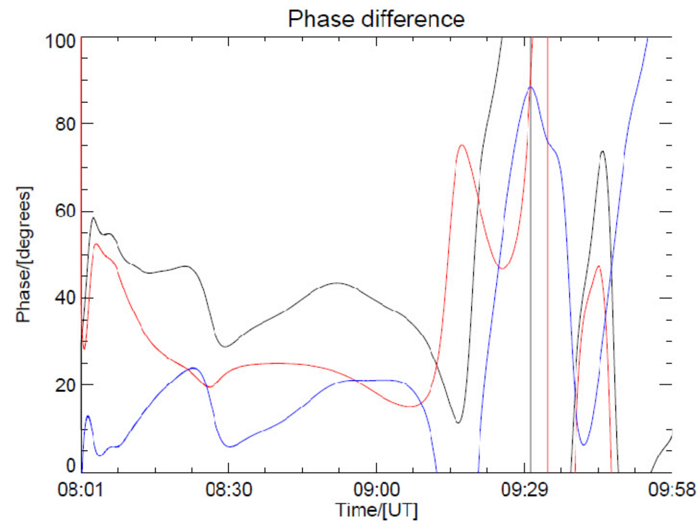



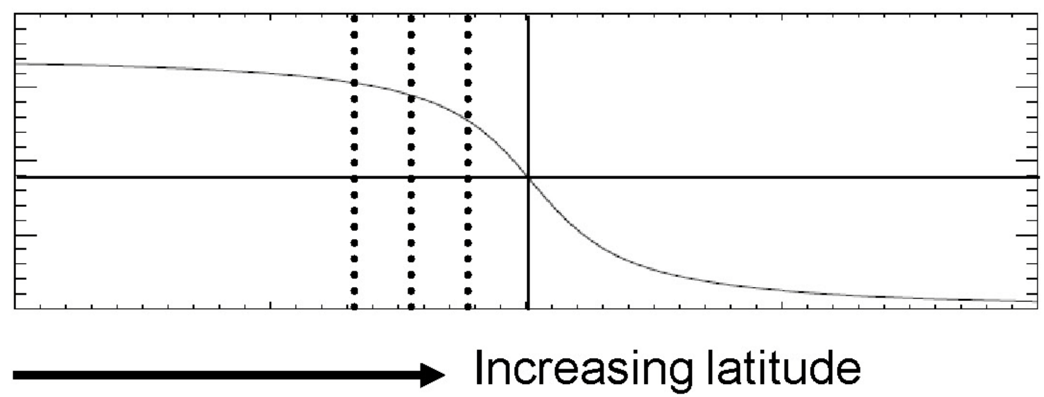




**The phase difference tells us that these cells are poleward of the resonoance**

# Cross phase



Increasing latitude

**The phase difference tells us that these cells are poleward of the resonoance**

# Real-time implementation

HMO

1. Decide on which cells should be used for detecting resonance;
   1. equatorward of the OCFB
   2. have a bearing of 90
   3. lie on a line of magnetic longitude

   ……………………………………………………………………………
2. Set the pulsation finder to scan each of these cells to determine if a pulsation is present
3. Calculate the cross phase spectra and determine the resonant frequencies if possible
4. Use a magnetic field model to infer the plasma densities for the field lines

Simple !!!

# FAI@P.P.

**★how to identify the location of P.P. (only by SD)?**
**deduce Ne distribution/variation along L**
**using ULF/FLR**

**⇒北海道レーダー等mid-latSDで**
**ULF(Pc5 etc)／FLR／P．P．やりましょう。**

**まずは、ULFデータ（のevents）探しから**

**九大河野氏とSD2010目標に始めつつあります。**
**ERG...**

# 大学間連携関連

~~2/26~~ 大学間連携：
2/25 Thu! 「SuperDARN/EISCAT/れいめい衛星データ解析講習会」
SuperDARNは、英国Leicester大Adrian Groccot氏を招き、
データ解析ソフトの講習会を行います。

~~2/27~~ EISCAT研究集会
2/26 Fri!

ご参加お待ちしています。