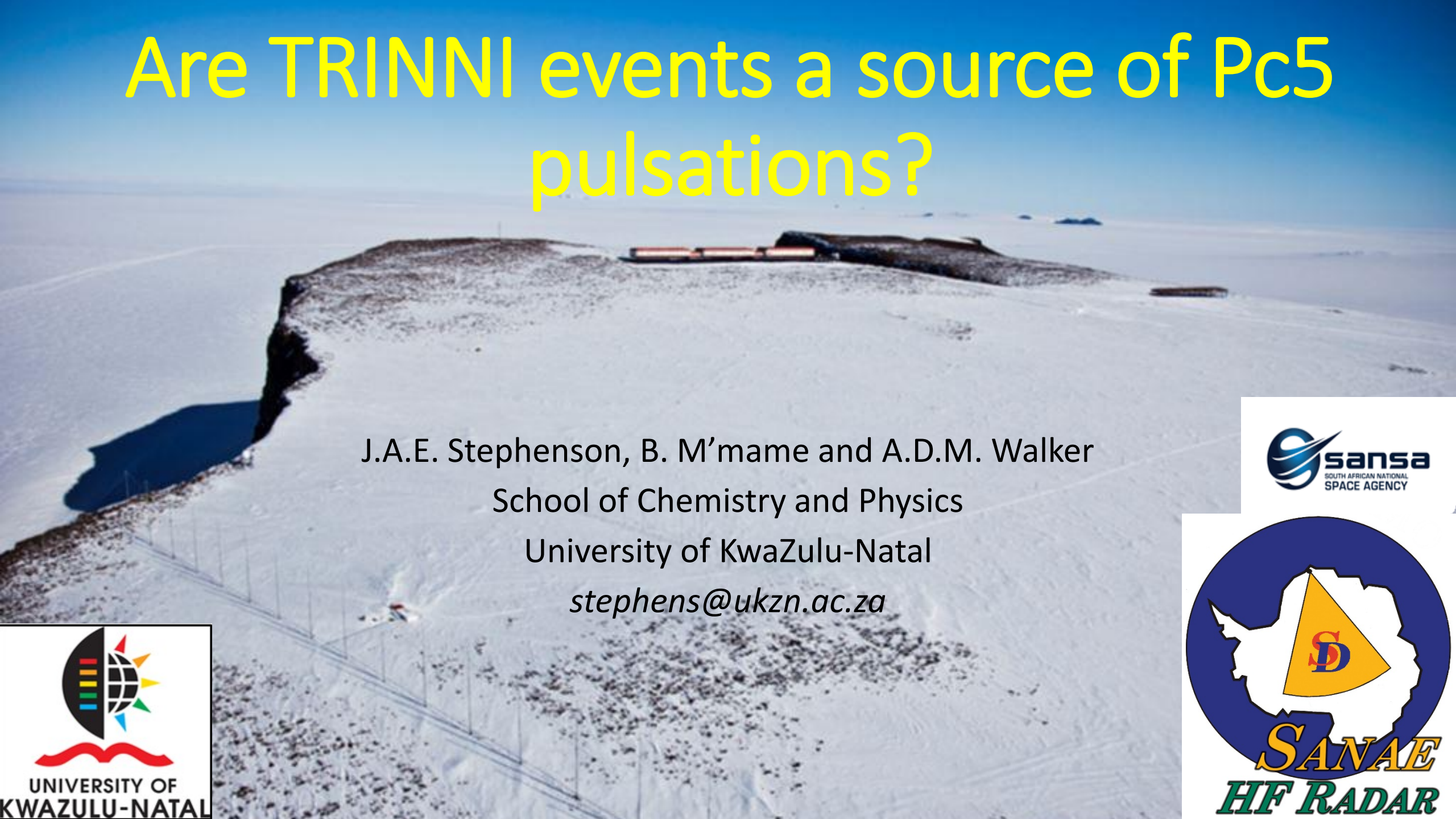
Are TRINNI events a source of Pc5 pulsations?



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SANAE HF RADAR

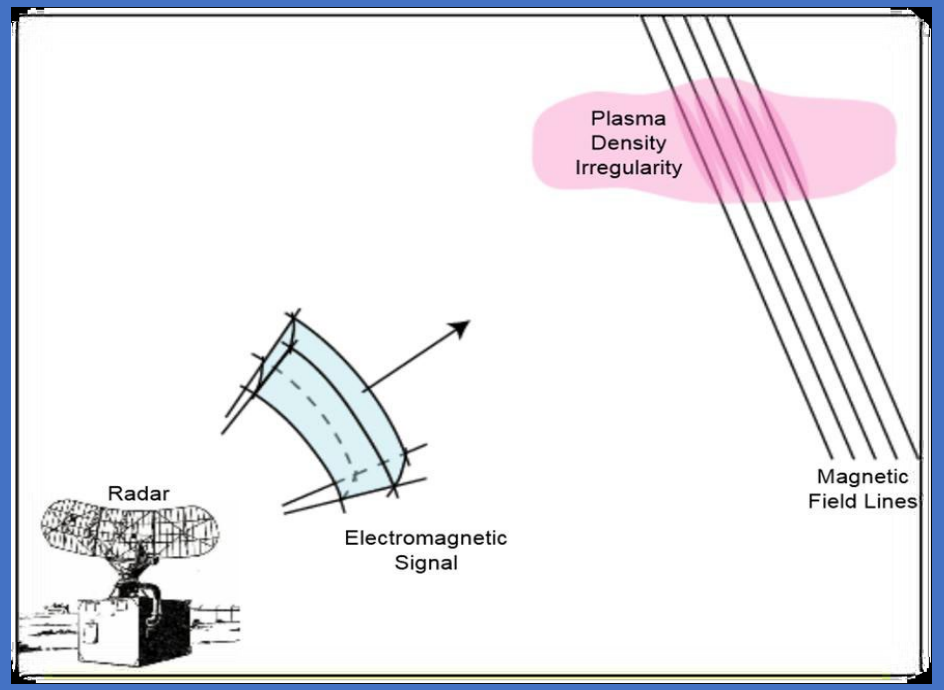
Outline

- What is a TRINNI and how do we detect a one? (Q1)
  - Sanae HF radar (SuperDARN HF radar network)
  - Brief tutorial on Geospace
- What are Pc5 pulsations and how do we detect them? (Q2)
  - Magnetometer chain
- Proposed scientific mechanism behind how a TRINNI could be a source of Pc5 pulsations and how we could detect this.
- Initial investigation employing SuperDARN radar the Greenland West Magnetometer chain
- Conclusions

Q1

The Sanae HF radar

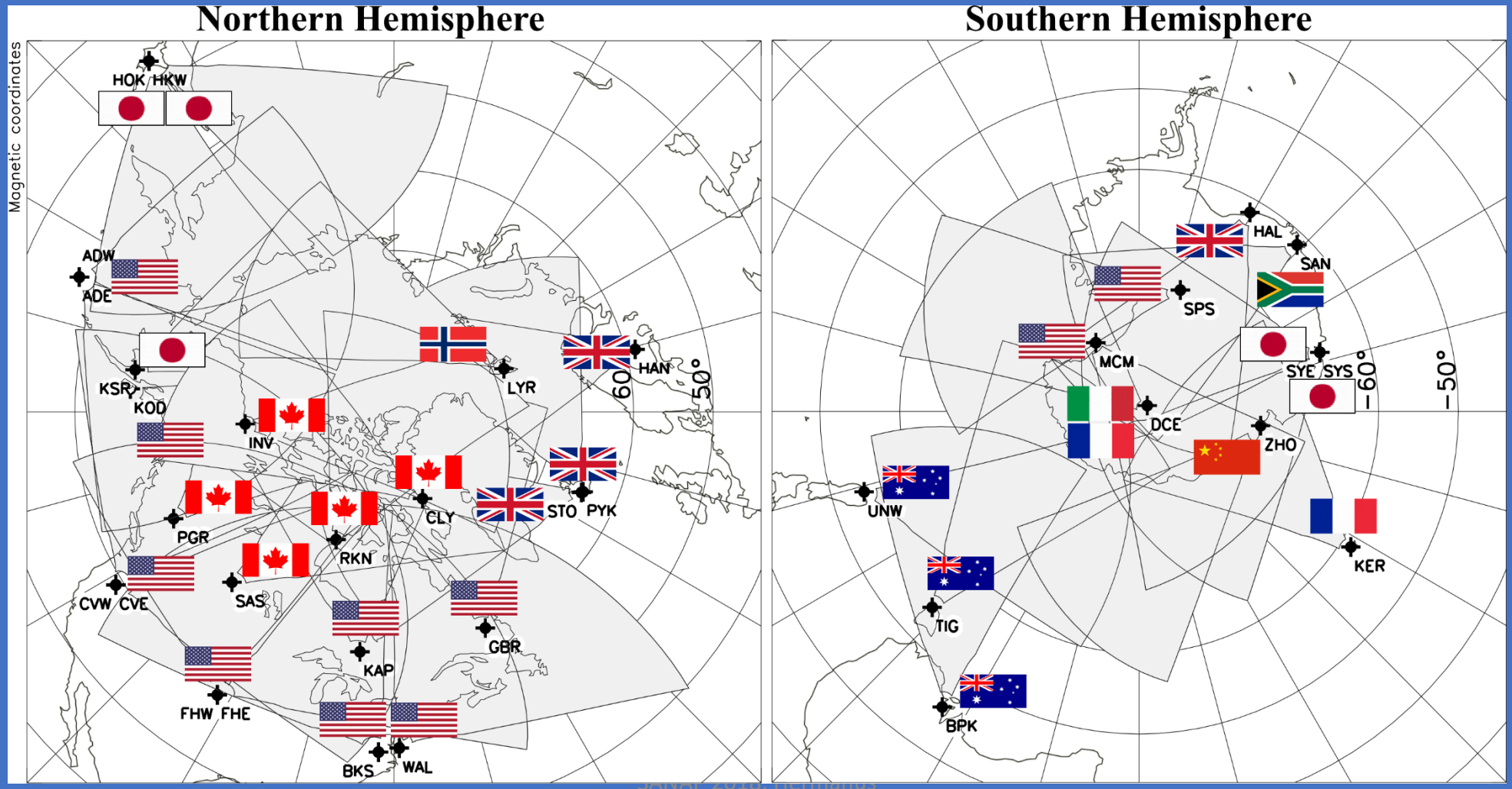
- Radar (RAdio Detection And Ranging)
- HF (8-20 MHz)
- Monitors Space Weather
- Reflects off ionospheric irregularities (~300km altitude) Ionosphere charged layer near the top of the neutral atmosphere (50 – 1000 km altitude). Lowest boundary of geospace.
- Primary Data Products:
  Backscattered power and Doppler velocity



Q1

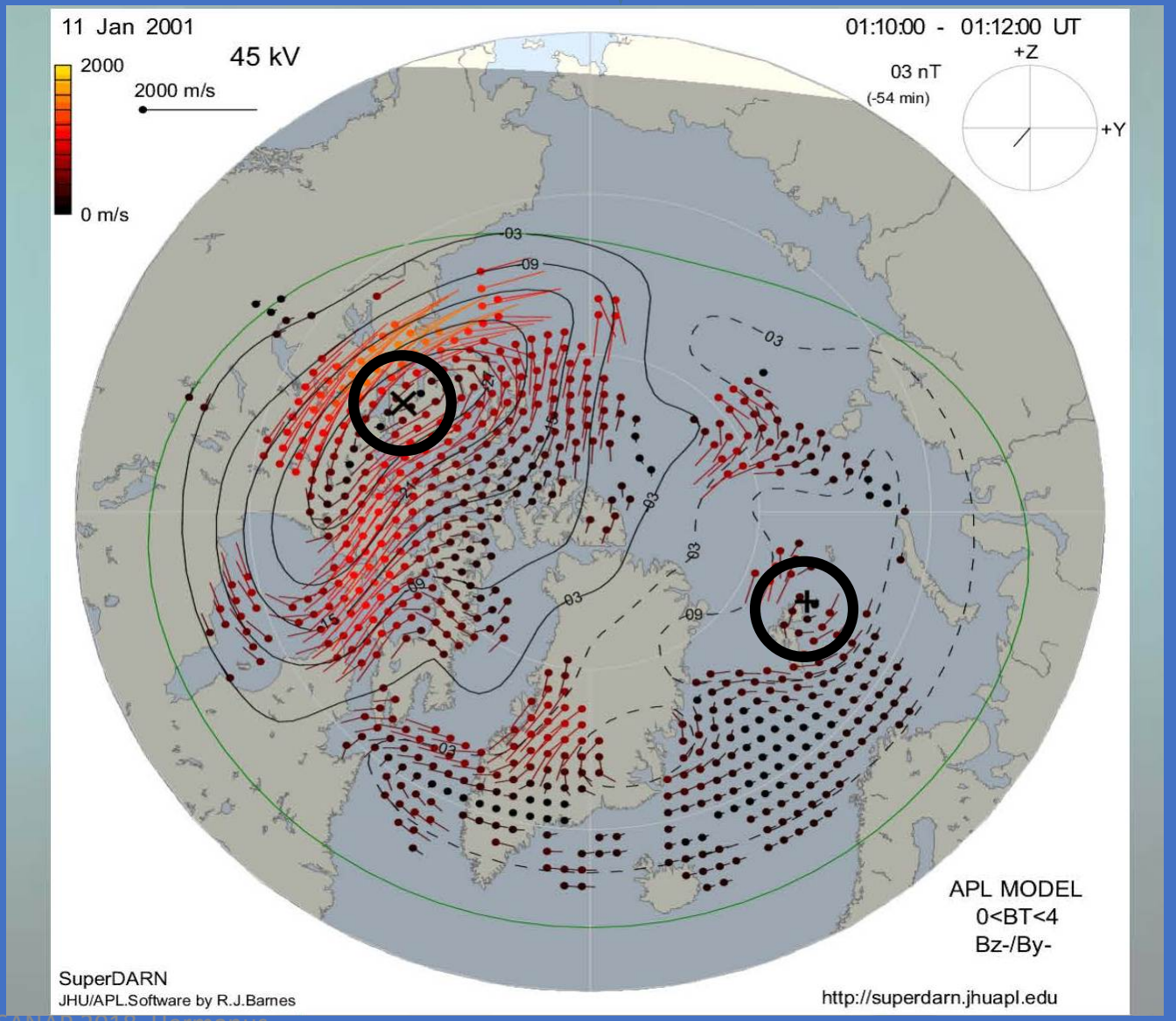
SuperDARN network (31 radars, 11 countries)

vt.superdarn.org



Q1 SuperDARN Convection Map

- Radar velocity vectors combined with a model to form a convection pattern.
- 2 Dungey convection cells. Over large scale length "frozen-in plasma" a good approximation. This means concurrent drift of plasma and magnetic field lines. This convection (both electrons and protons move in the same direction) is principally driven by magnetic reconnection.
- Lines of constant flow are lines contours of electrostatic potential. Cross Polar Cap Potential is the potential difference between + and – cells and a measure of the strength of the convection.



Q1

Interpretation of convection map

What is reconnection?

This is a process whereby magnetic field lines are cut and reconnect to other field lines, changing the magnetic topology and releasing vast amounts of energy

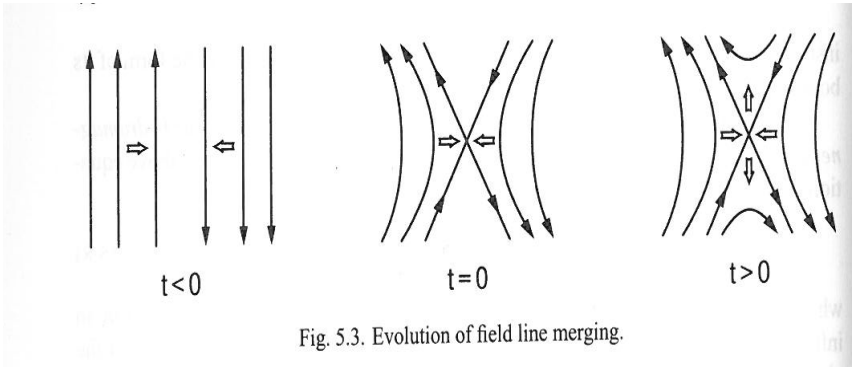
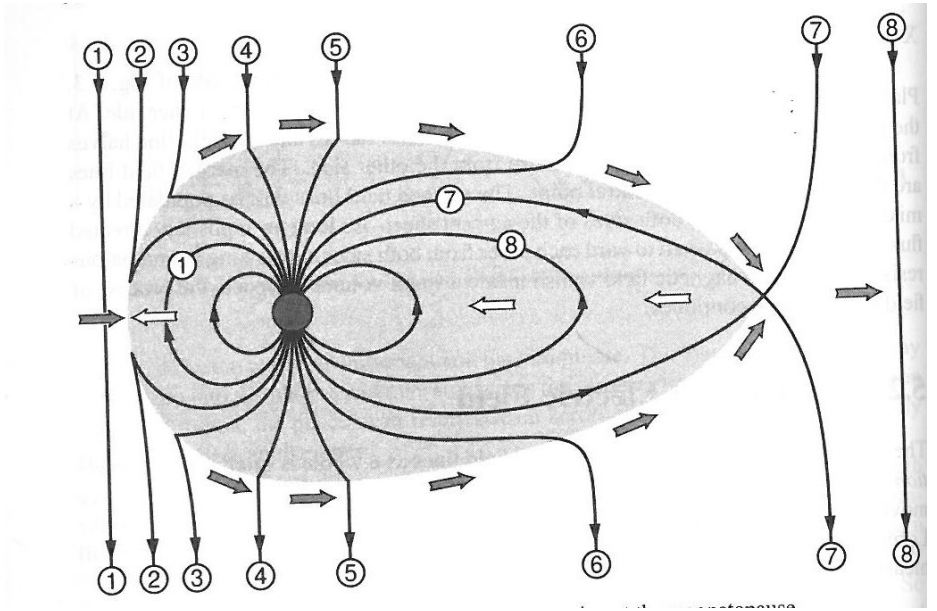


Fig. 5.3. Evolution of field line merging.

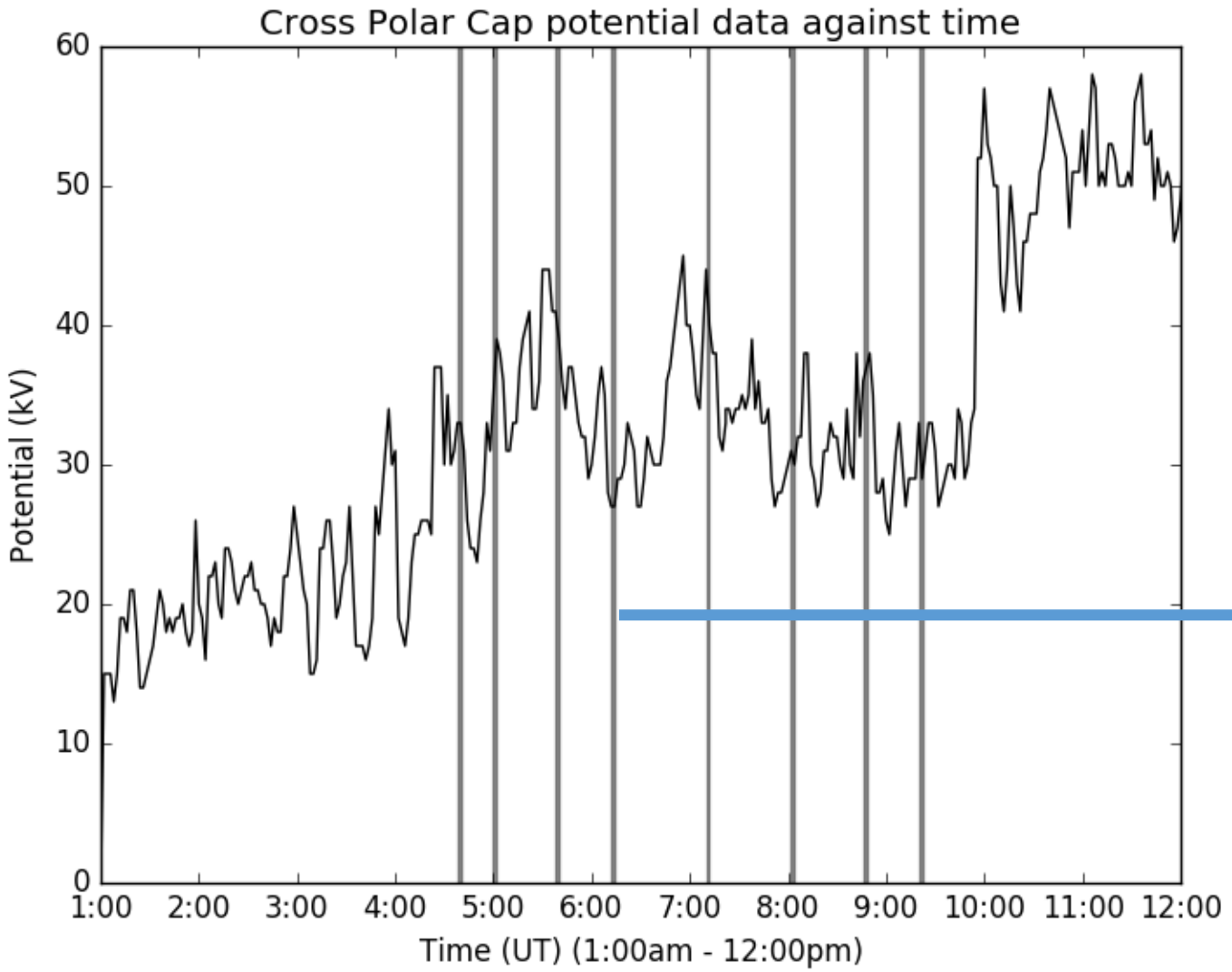
Convection in the polar regions is largely driven by an interaction between the Interplanetary Magnetic Field (IMF) in the solar wind and the Earth's magnetic field. Figure to the right illustrates reconnection when the magnetic field of the solar wind is opposite directed to the Earth's magnetic field. This occurs when the Sun is magnetically active. When this is prolonged it results in geomagnetic substorms and aurora.

Baumjohann and Treumann, 1996



Q1

Cross Polar Cap Potential (CPCP) 20 March 2002



What is a TRINNI? Tail Reconnection during IMF Northward- Non-substorm Interval. When reconnection occurs at the flanks of the magnetosphere this leads the tail being twisted (not stretched as for the substorm). This happens during magnetically quiet periods.

Each vertical line marks a TRINNI event where the tail untwists, driving greater convection. Each line is associated with an enhancement in CPCP of around 5-10 kV

Q2

Pc 5 pulsations

What are Pc5 pulsations?

- Dynamic processes in the near-Earth space environment often generate periodic small fluctuations in the Earth's magnetic field of nanoTesla to 100's of nanoTesla (<.1% of the main field). These pulsations have sources both outside the magnetosphere e.g. pressure pulses in solar wind and internal sources e.g Drift-bounce mechanism

- These fluctuations are magnetohydrodynamic (magneto-fluid) in nature and have periods ranging from 150-600s (frequency range 1-5 mHz). These structures can be observed on the ground by a variety of instruments, most commonly by magnetometers.

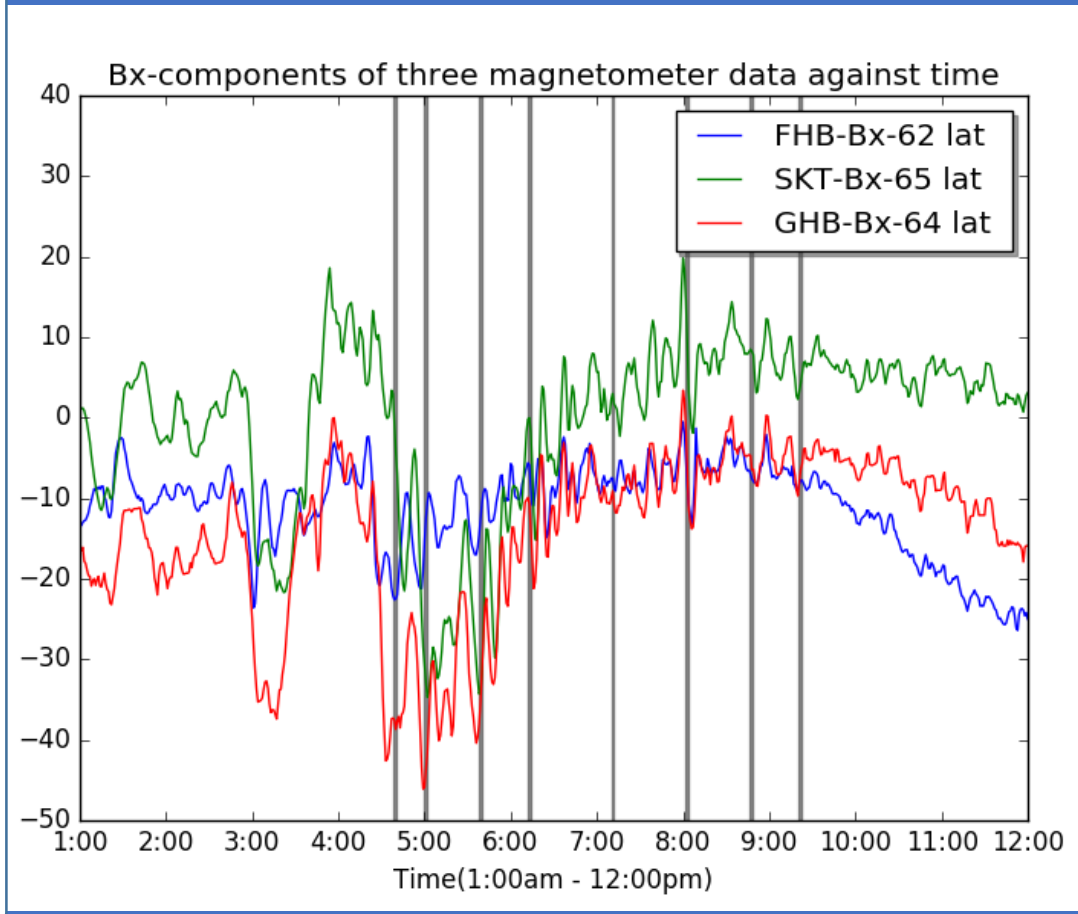
Why are they important?

- They distribute energy – both into and around the magnetosphere. They also have an influence on growth or decline of plasma populations.

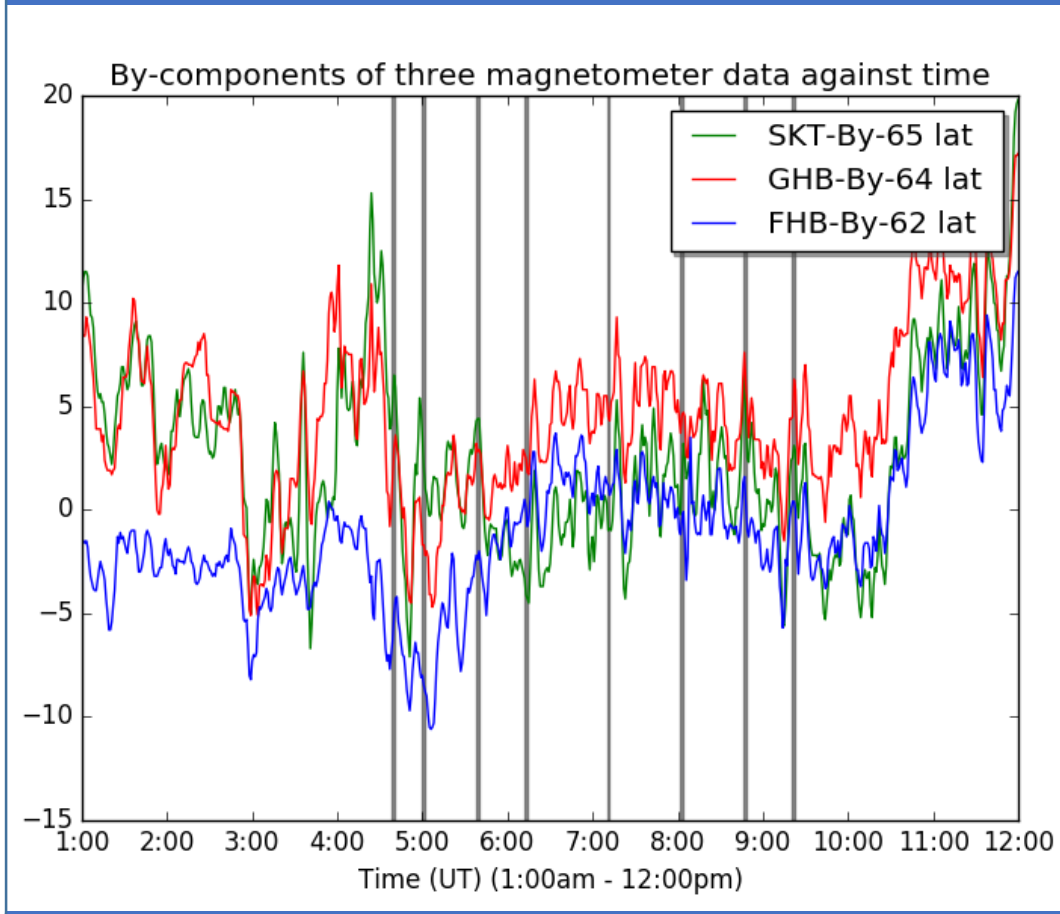
Q2

Magnetometer Observations of Pc5 pulsations

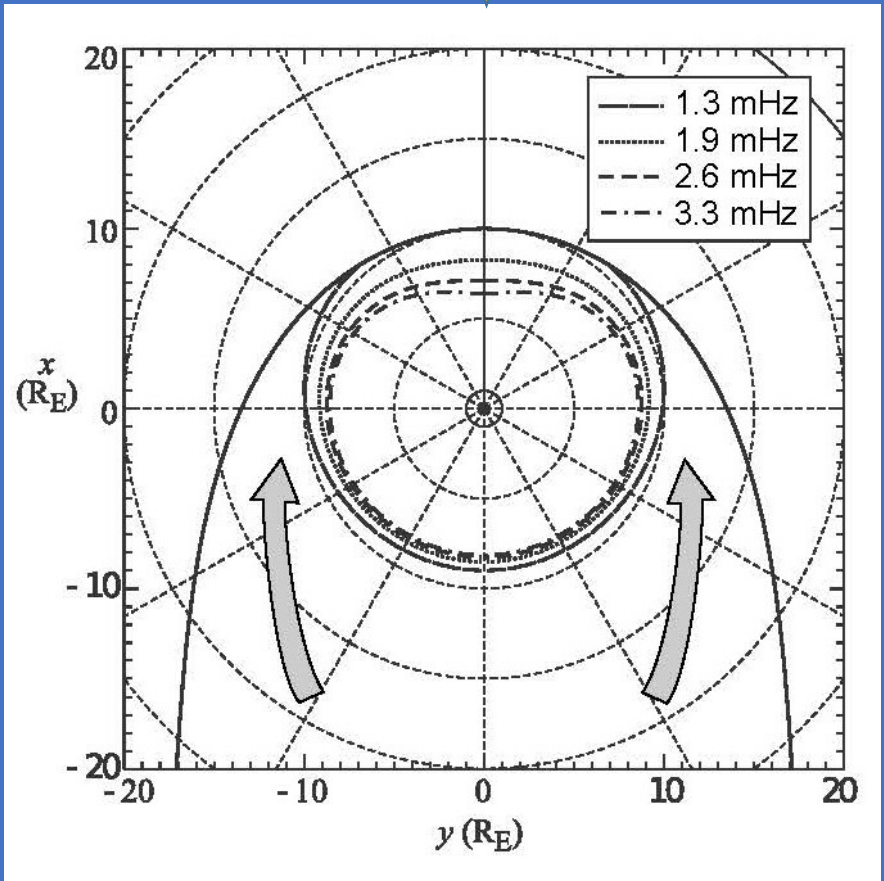
Bx (nT) direction Geographic North



By (nT) direction Geographic East



Proposed scientific mechanism



Turning point for various frequencies in the magnetosphere. (Walker, 2002)

As the TRINNI event occurs in the magnetotail (bottom of figure), associated Pc5 pulsations are released in the form of a fast MHD waves. The pulsations travel sunward in a waveguide (marked thick arrows) between the magnetopause and the turning point. If the pulsations have a frequency that matches the dimensions of the waveguide on the flanks of the magnetosphere, this resonance can grow. It can then excite the closed magnetic field line in the centre cavity whose natural frequency

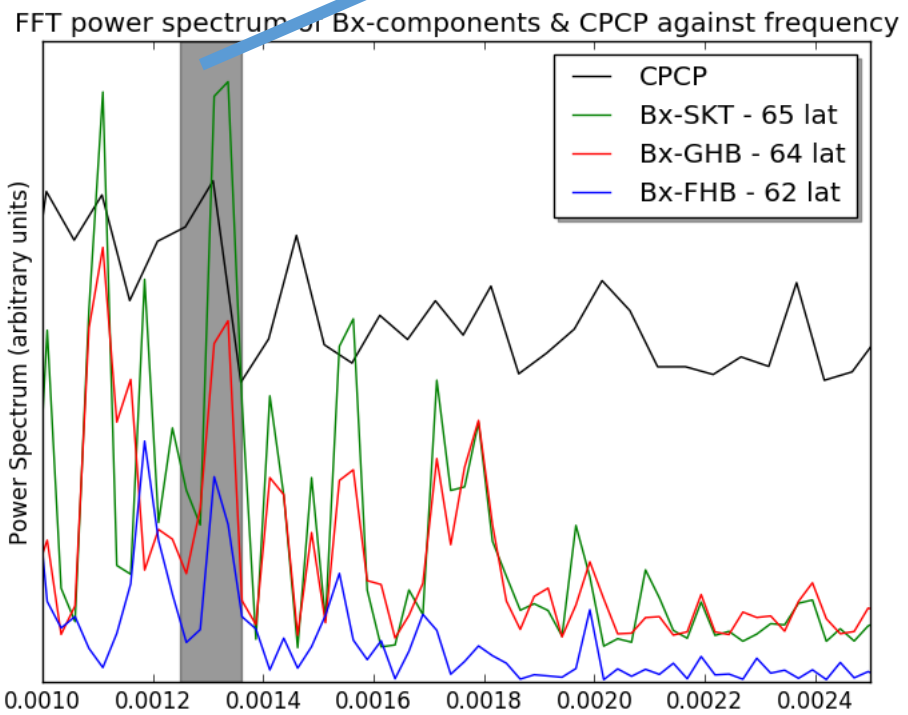
$$f = {}^{nB}\Big/_{2\,l\,\sqrt{(\mu_0 \rho)}}$$

B value magnetic field, *l* is the length and ρ is the plasma density of the line

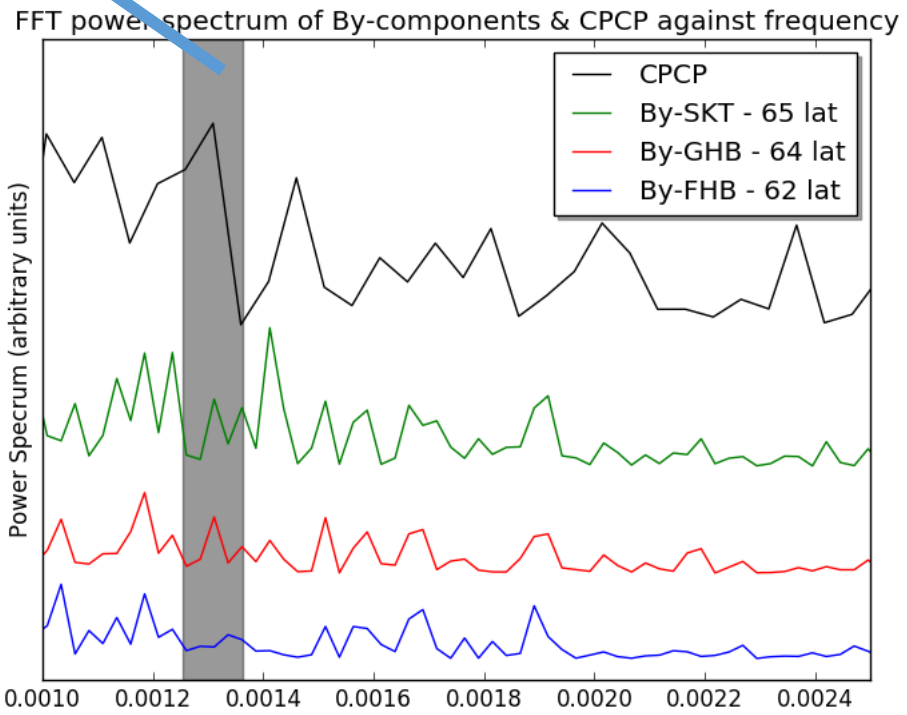
is the same, or a multiple *n* of the resonance in the waveguide. We can detect this with a magnetometer.

Fourier transforms of CPCP and Bx (left) and By (right) magnetometer data

1.25-1.36 mHz



Power

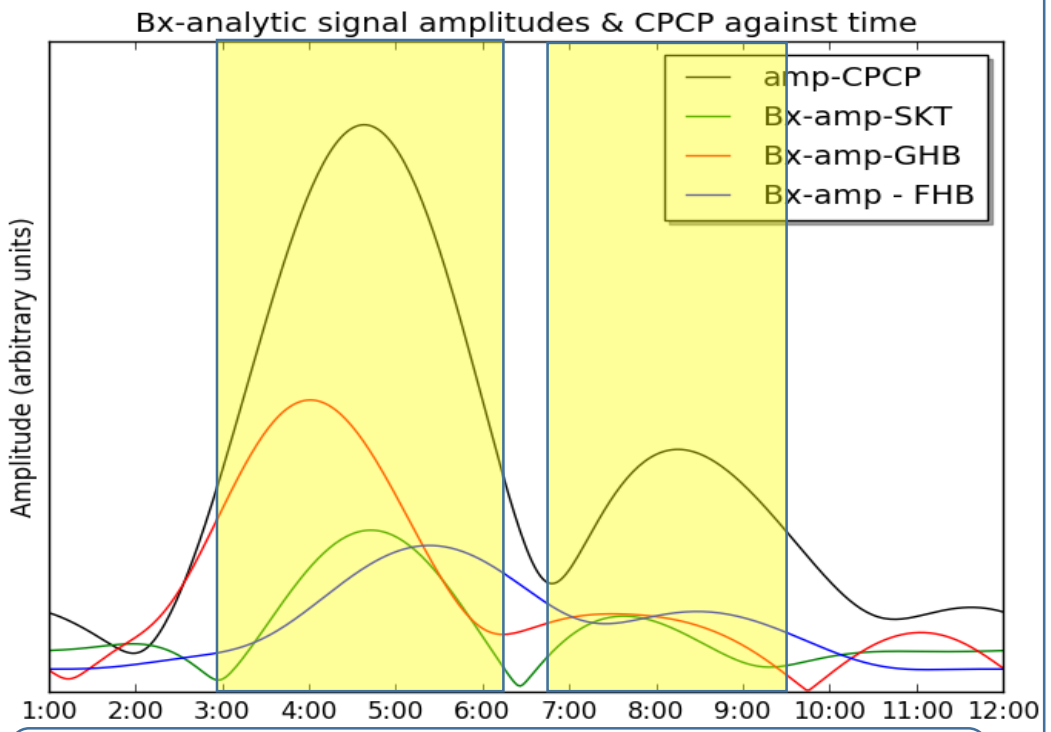


Frequency (mHz)

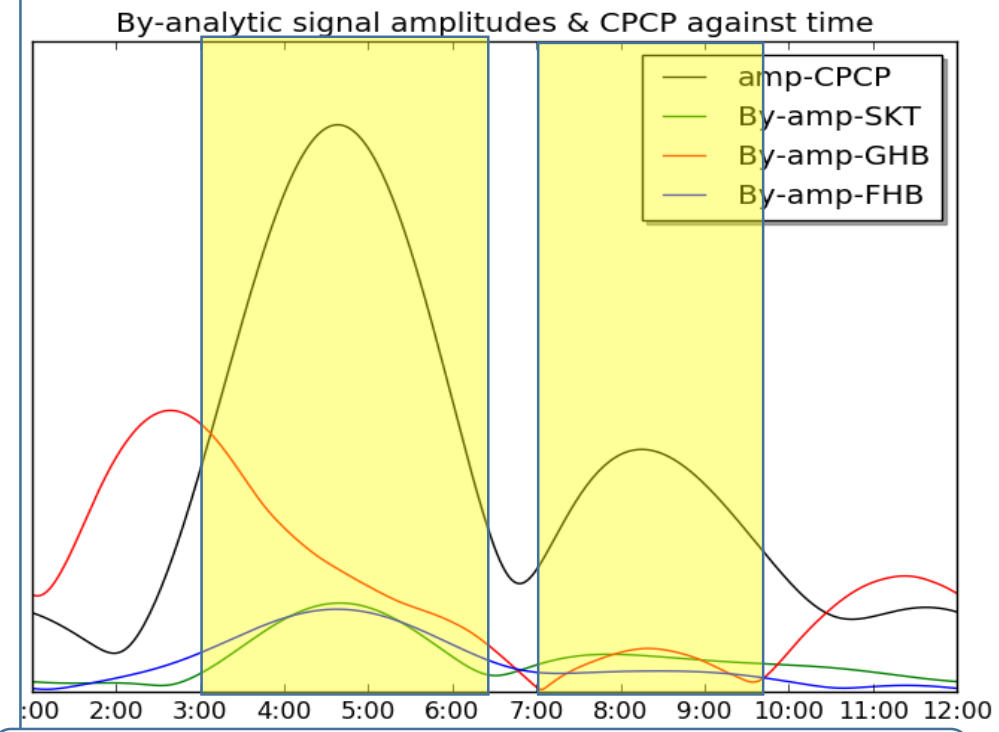
Frequency (mHz)

Analytic signals

- An analytic signal was computed of the broadband peak (1.25-1.34 mHz) in the previous spectra.
- An analytic signal may be regarded as an objective estimate of the instantaneous amplitude and phase of a broadband (and thus quasi-monochromatic) signal.

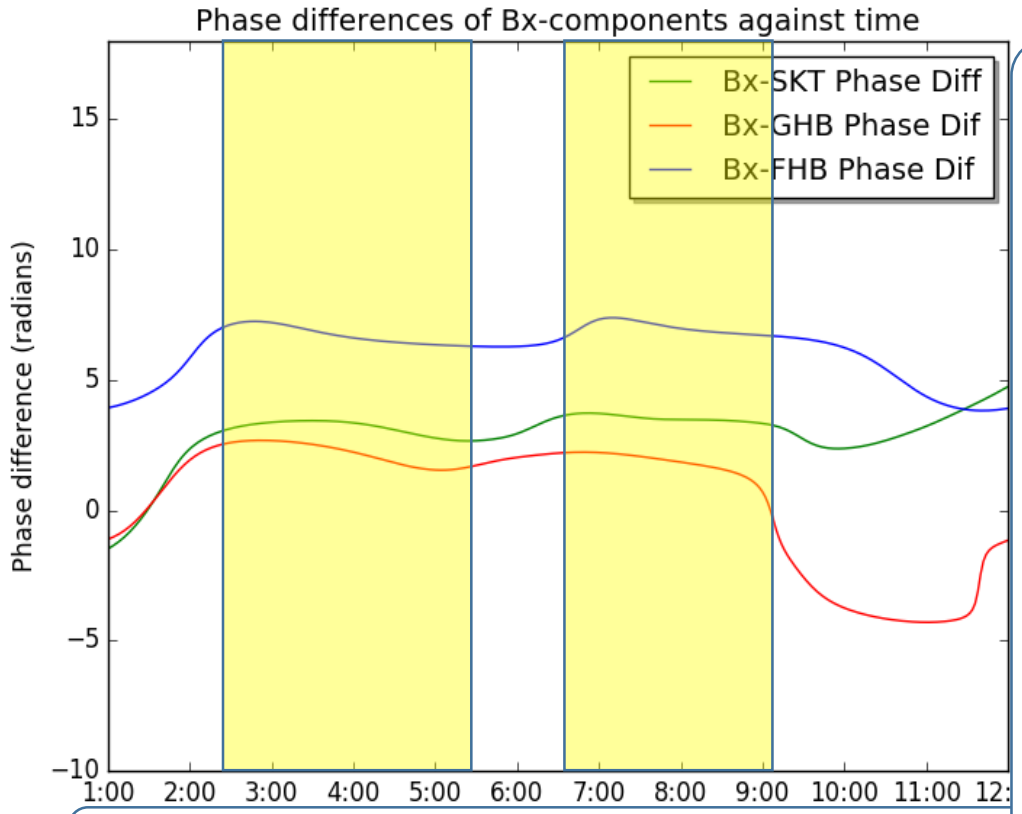


Amplitude

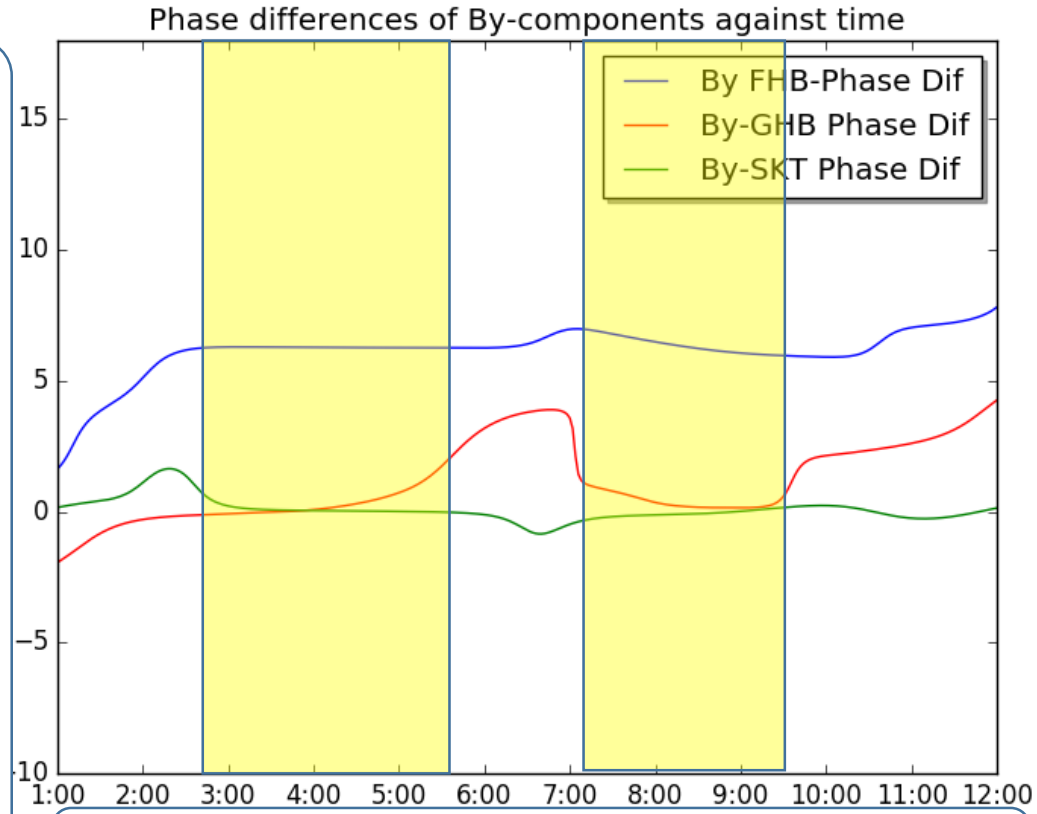


Phase of analytic signals

- Phase nearly constant during periods of maximum pulsation activity.
- Since their signals are relatively coherent, this implies there is a relationship between the TRINNI and Pc5 resonance



Phase difference (degrees)



Conclusions

- This preliminary analysis suggests that there is some coherence between the TRINNI events as measured in the CPCP of the SuperDARN radars and the Pc5 pulsations detected by the magnetometers.

However, to make an airtight case we need to do further analysis.
In particular:

- We need to pinpoint the source by determining the direction of phase velocity of the Pc5 pulsations in the waveguide i.e. it would need to be sunward.
- We would need to detecting Pc5 pulsations in the same frequency band *in situ* with satellite observations in the tail.
- To find other events “one swallow doesn’t make a summer”