On the relationship between auroral absorption, electrojet currents and plasma convection

Adam C. Kellerman

Roman A. Makarevich

Department of Physics

La Trobe University

Victoria 3086, Australia

Outline

- **Introduction**
  - **Auroral absorption**
  - **Auroral electrojet current system**
  - **Electron heating**
- **Experimental Setup**
- **Observations**
  - **Point by point comparisons for the entire dataset**
  - **Point by point comparisons for different time sectors**
  - **Hourly correlation study**
  - **High correlation period study**
  - **Irregularity velocity and tristatic ion velocity**
- **Conclusions**

Auroral Absorption

Free electrons absorb EM radiation and reradiate it until they collide with a heavier ion or neutral resulting in Cosmic Noise Absorption or CNA

CNA is measured on the ground by riometers

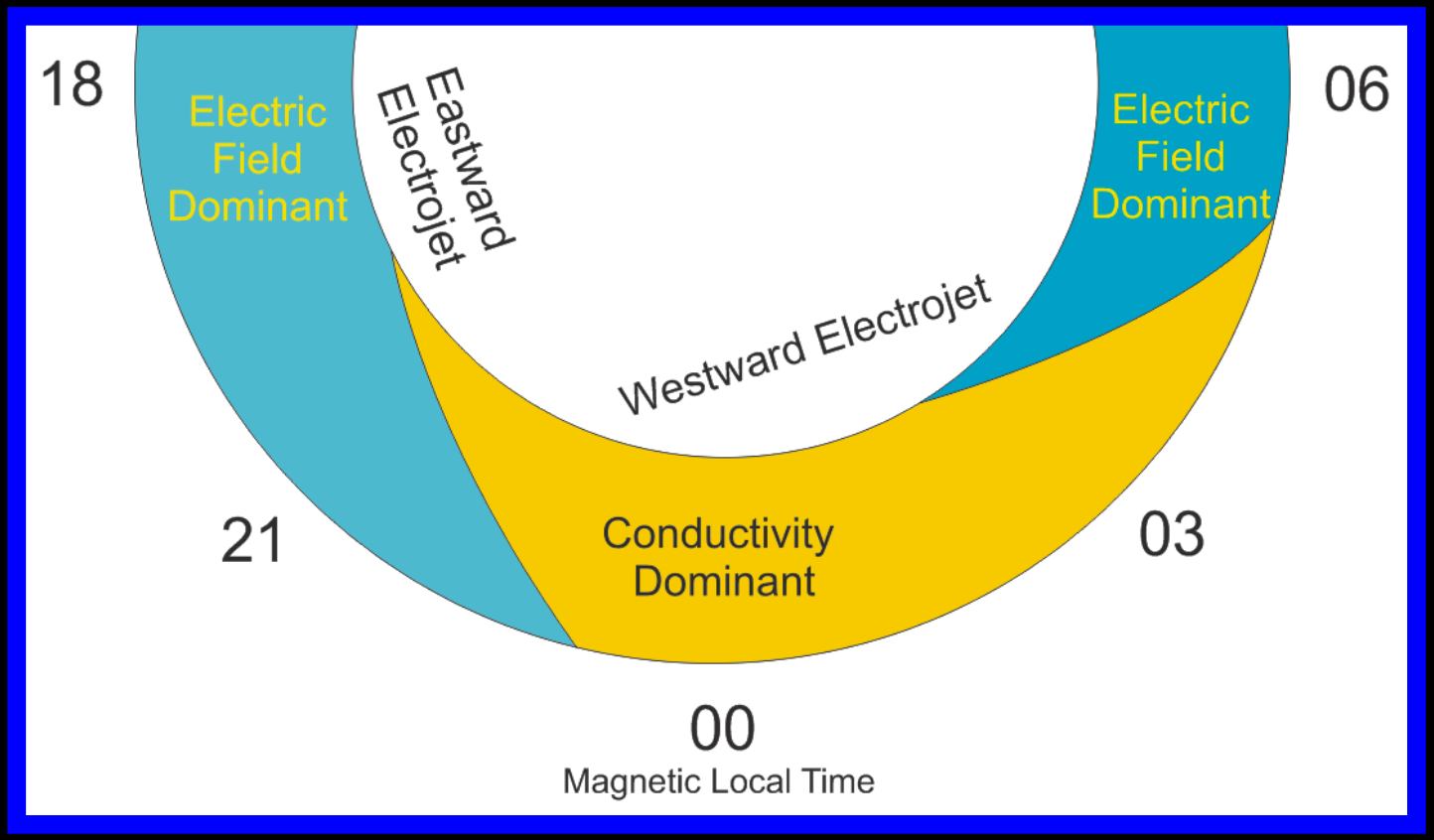
Enhanced ionisation due to precipitation also produces enhanced conductance and hence electric currents

Absorption is closely related to conductance [*Senior et al.*, 2007]

$$A \propto \int_h N\nu / f(\nu)\, dh \qquad \Sigma \propto \int_h N\nu / g(\nu)\, dh$$

Obj 1: Evaluate the potential of riometers in studies involving conductance estimates

Auroral Electrojet Current System



Adapted from *Kamide and Vickrey* (1983)

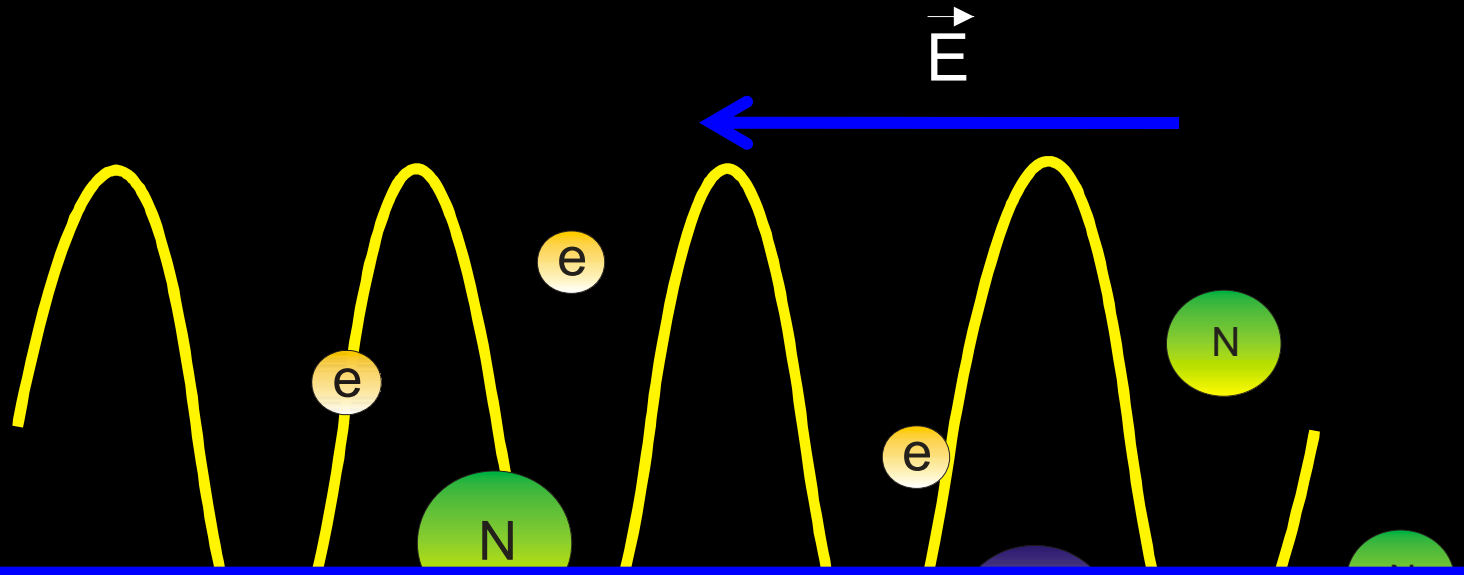
Obj 2: Study the relative importance of the electric field and conductance in all time sectors including the dayside

Electron Heating Absorption

Strong electric fields drive two stream plasma waves that increase electron energy and temperature

$$\nu \cong \nu_{en} = 5.4\times10^{-10} n_n T_e^{1/2}$$

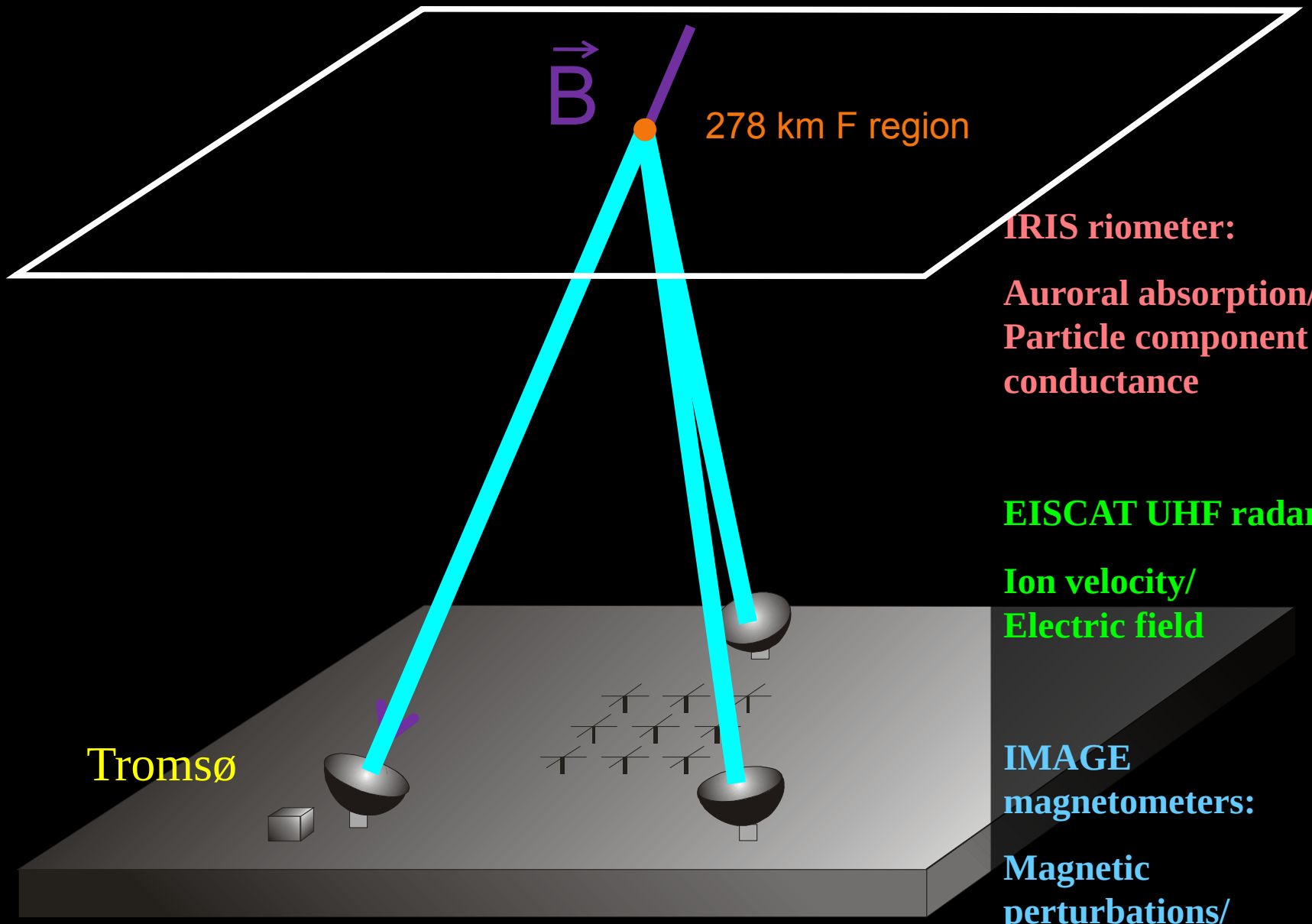
$$A \propto \int_h N\nu / f(\nu)\, dh$$



Obj 3: Investigate the electric-field-absorption relationship and to determine whether electron heating absorption events are observed in the auroral zone

Experimental Setup

Experiment Setup



IRIS riometer:

Auroral absorption/ Particle component of conductance

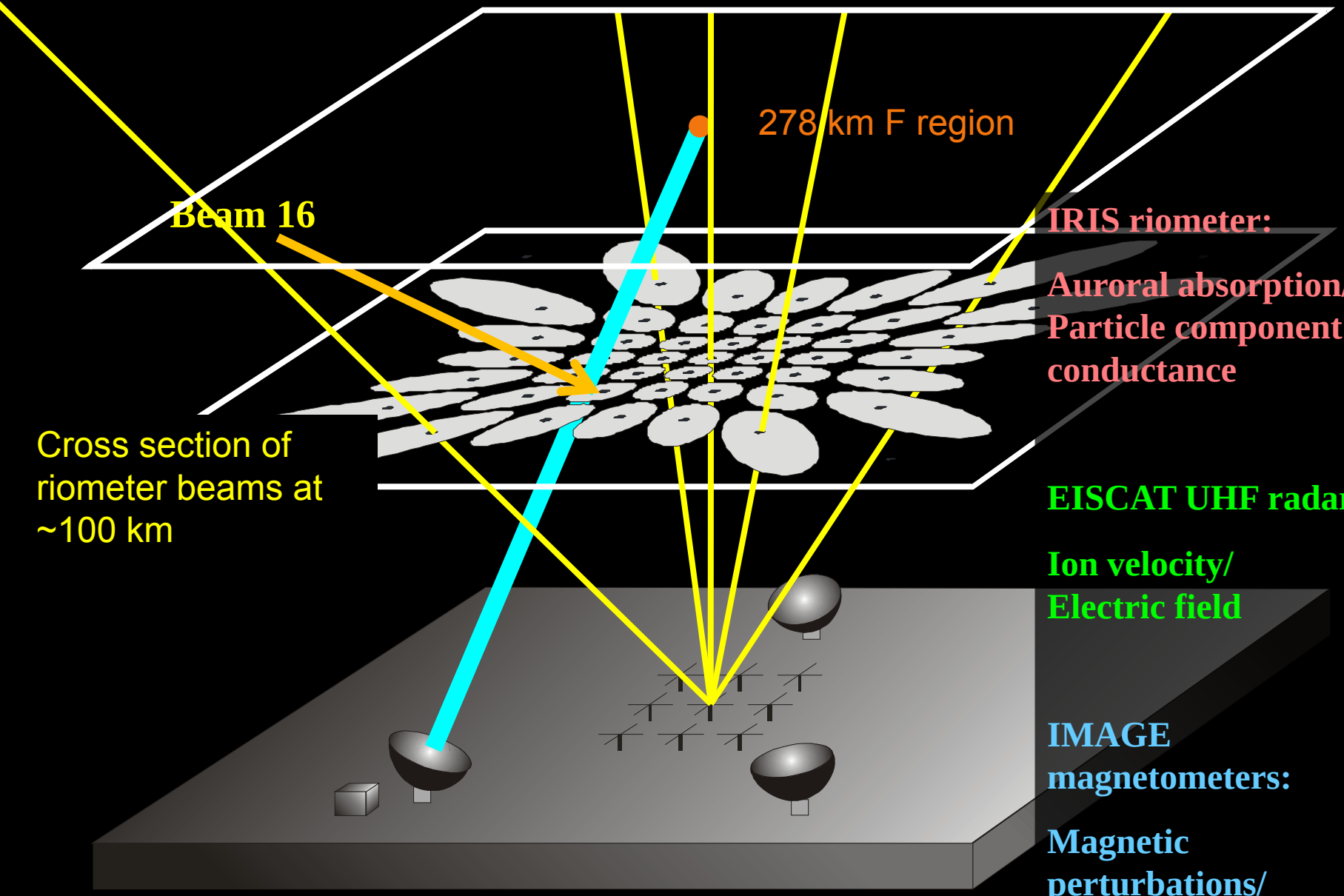
EISCAT UHF radar:

Ion velocity/ Electric field

IMAGE magnetometers:

Magnetic perturbations/ Electric Hall currents

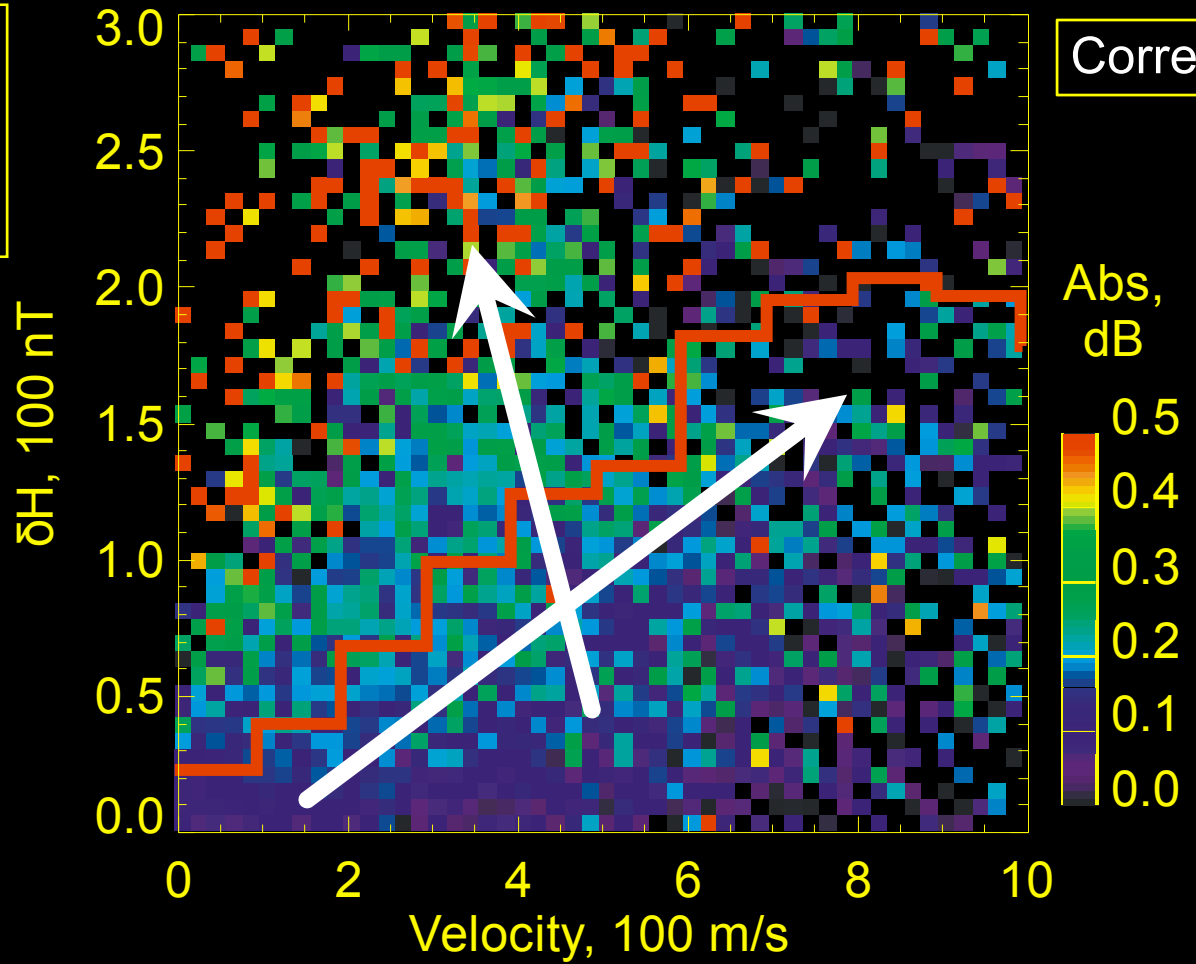
Experiment Setup




Observations

Point by Point Comparisons: δH vs E-field

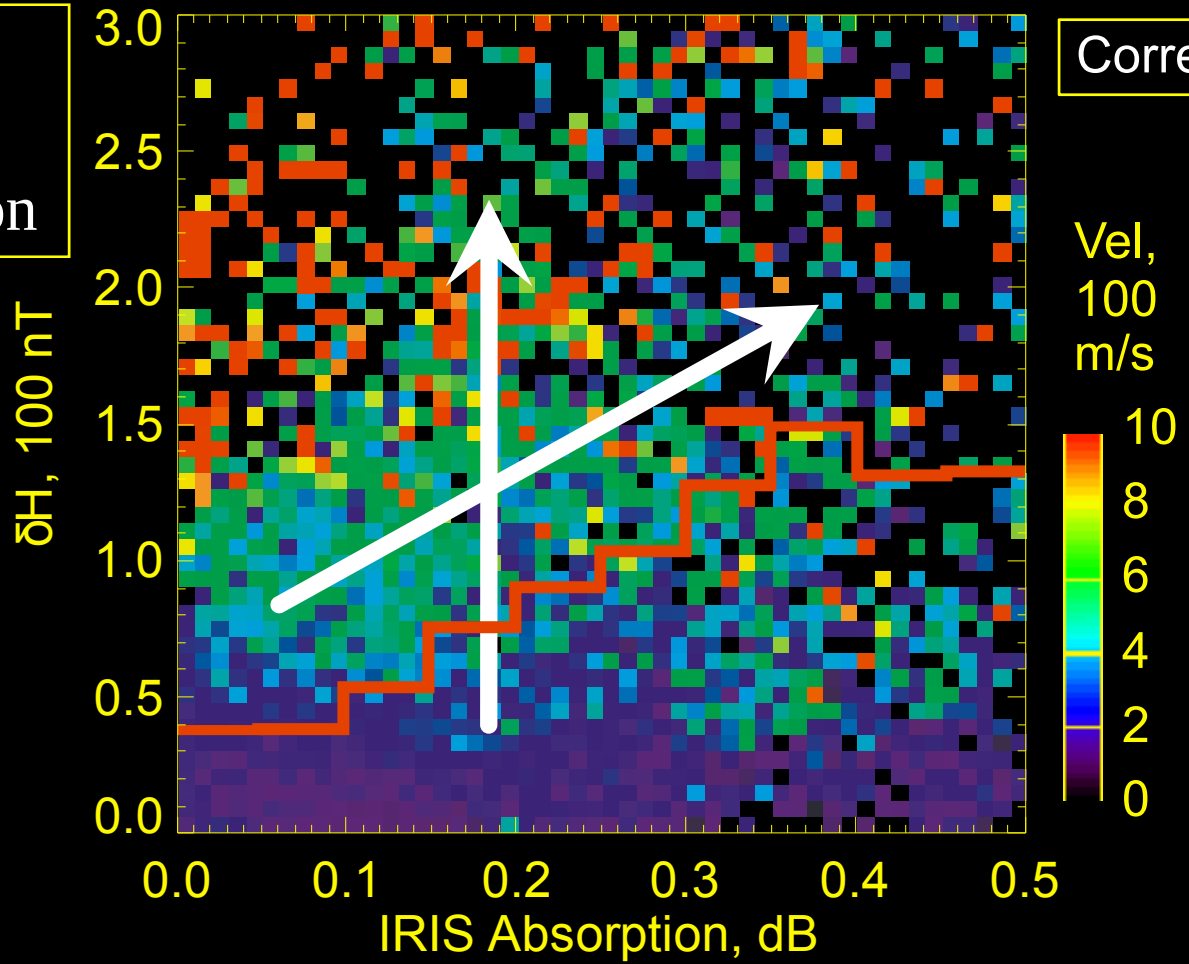
Increase of perturbation with velocity



Structuring in colour indicative of an absorption influence on the current

Point by Point Comparisons: δH vs absorption

Increase of perturbation with absorption

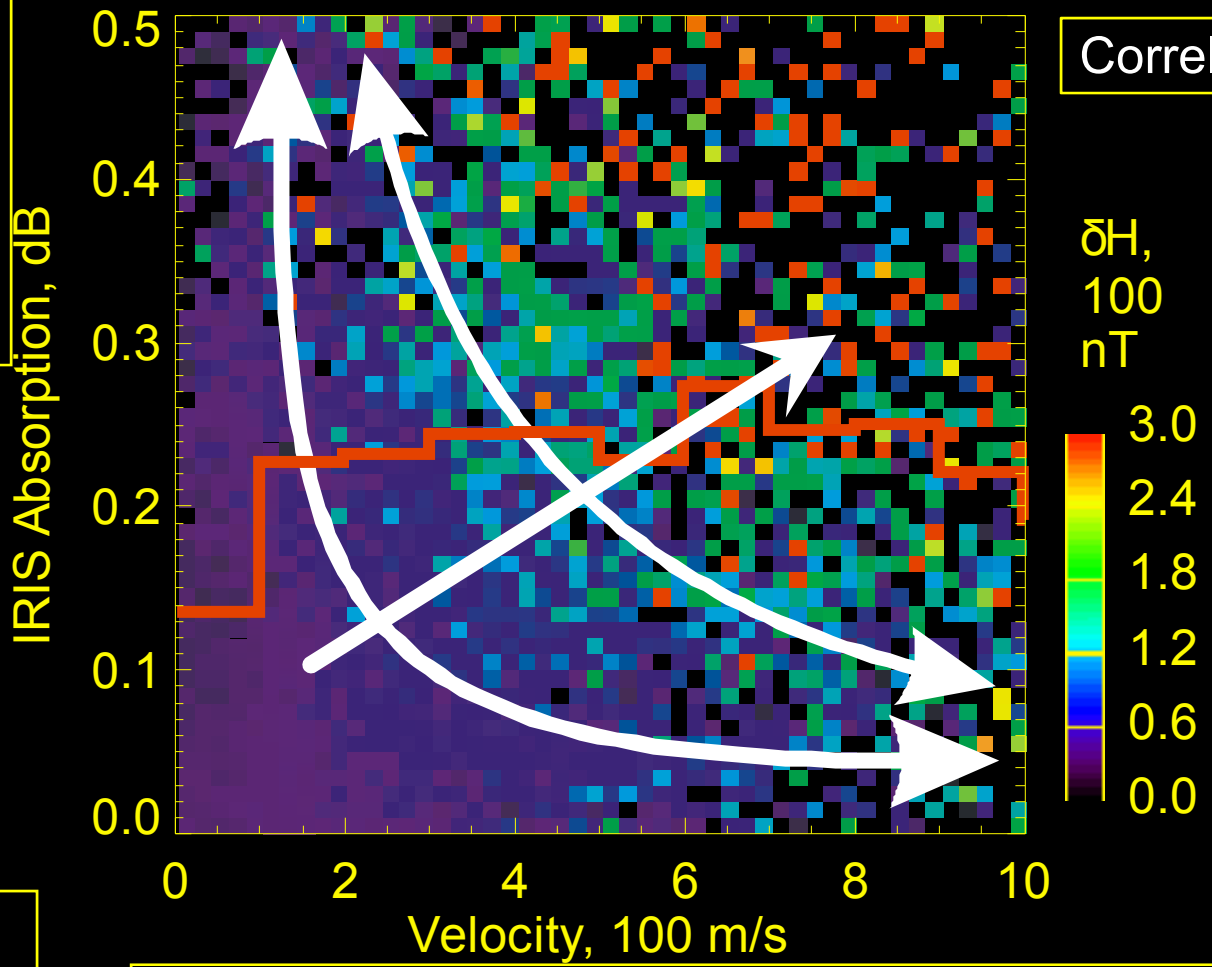


Correlation: 0.32

Stronger structuring in colour indicative of a higher E-field influence on the current

Point by Point Comparisons: Absorption vs E-field

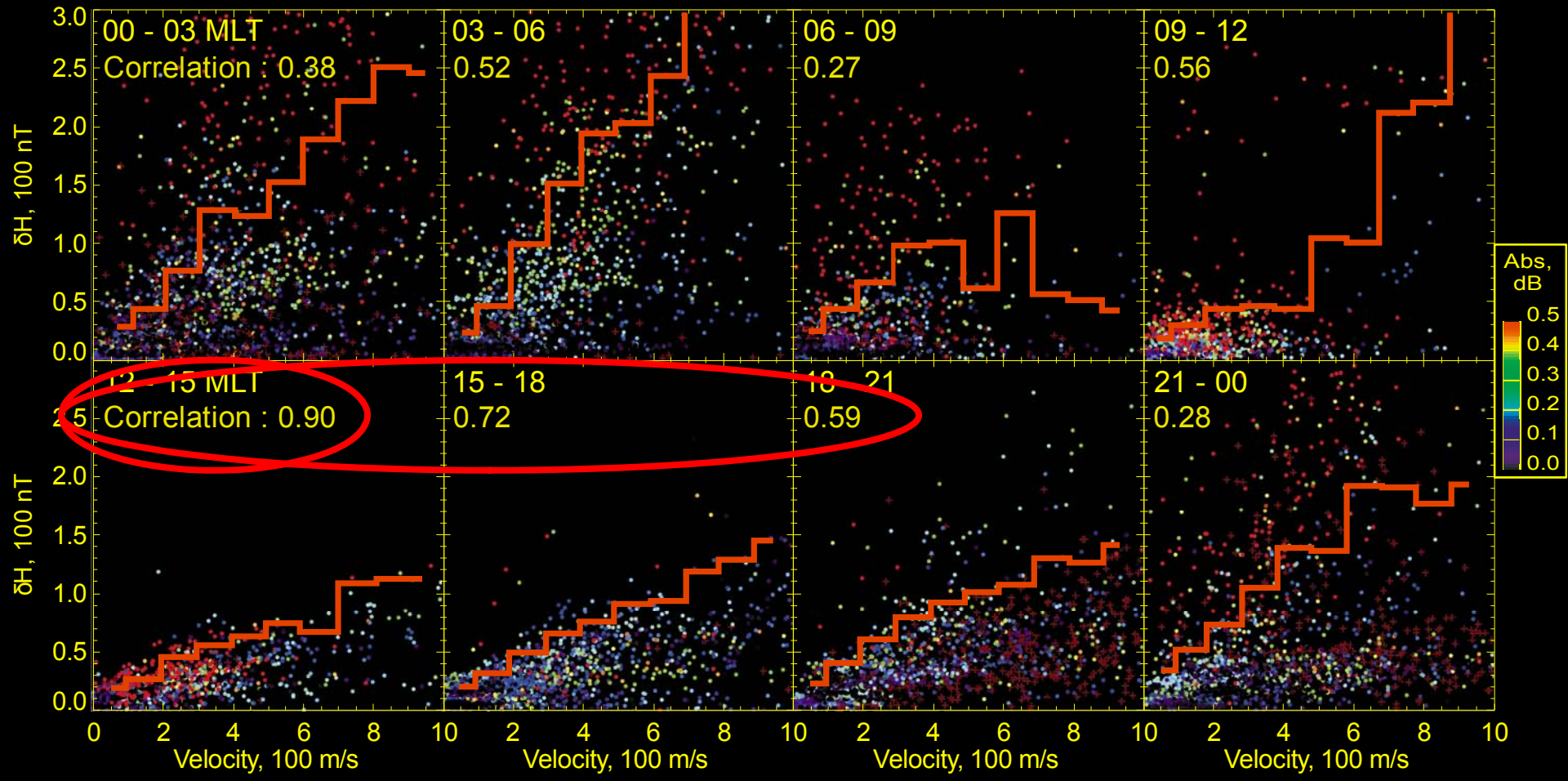
No clear relationship between absorption and E-field



Inverse proportionality in absorption vs E-field

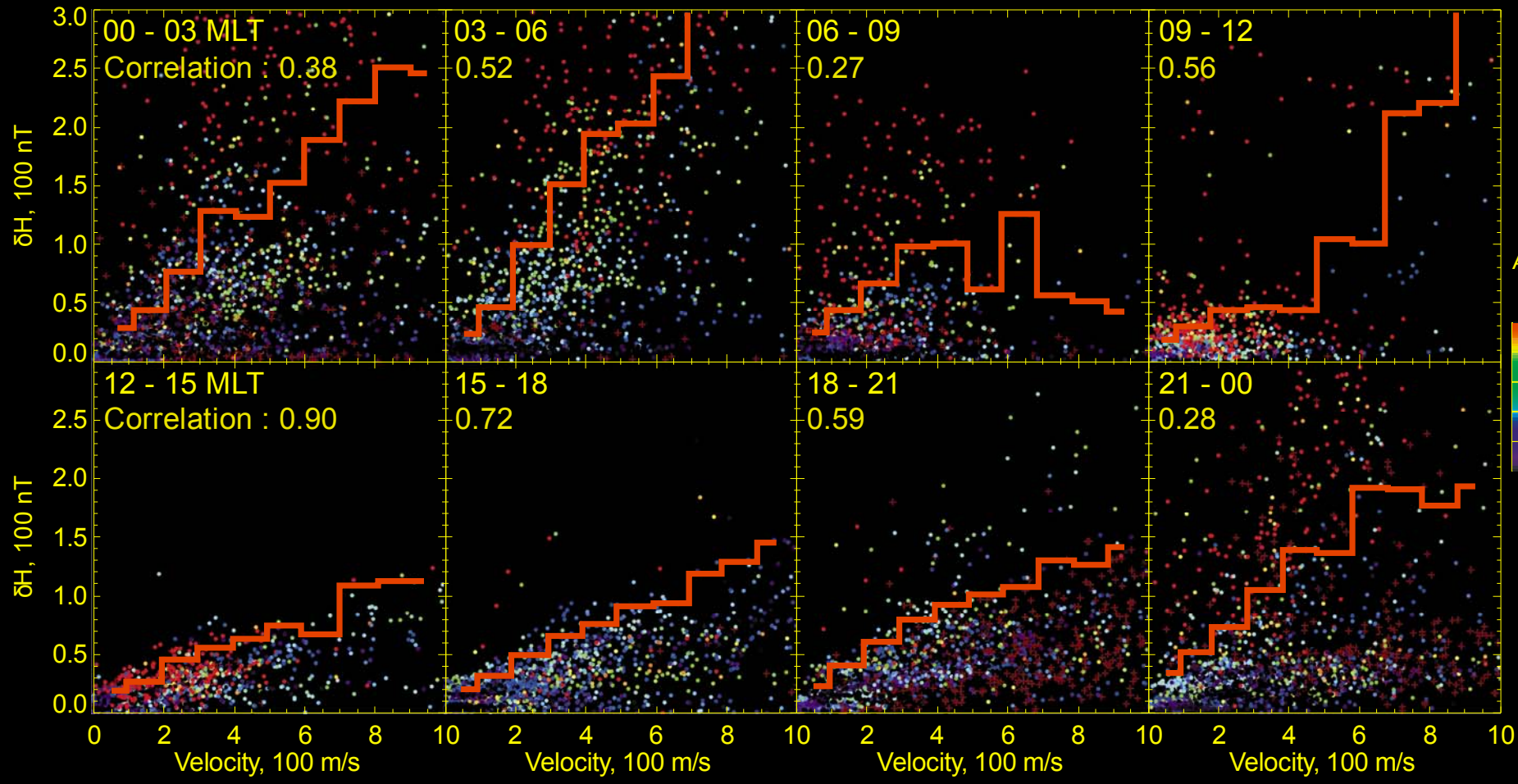
Strong structuring in colour indicative of the combined influence of E-field and absorption on the current.

Point by Point Comparisons: δH vs E-field MLT



Sharp increase in δH vs E-field correlation at 12 MLT and high during afternoon

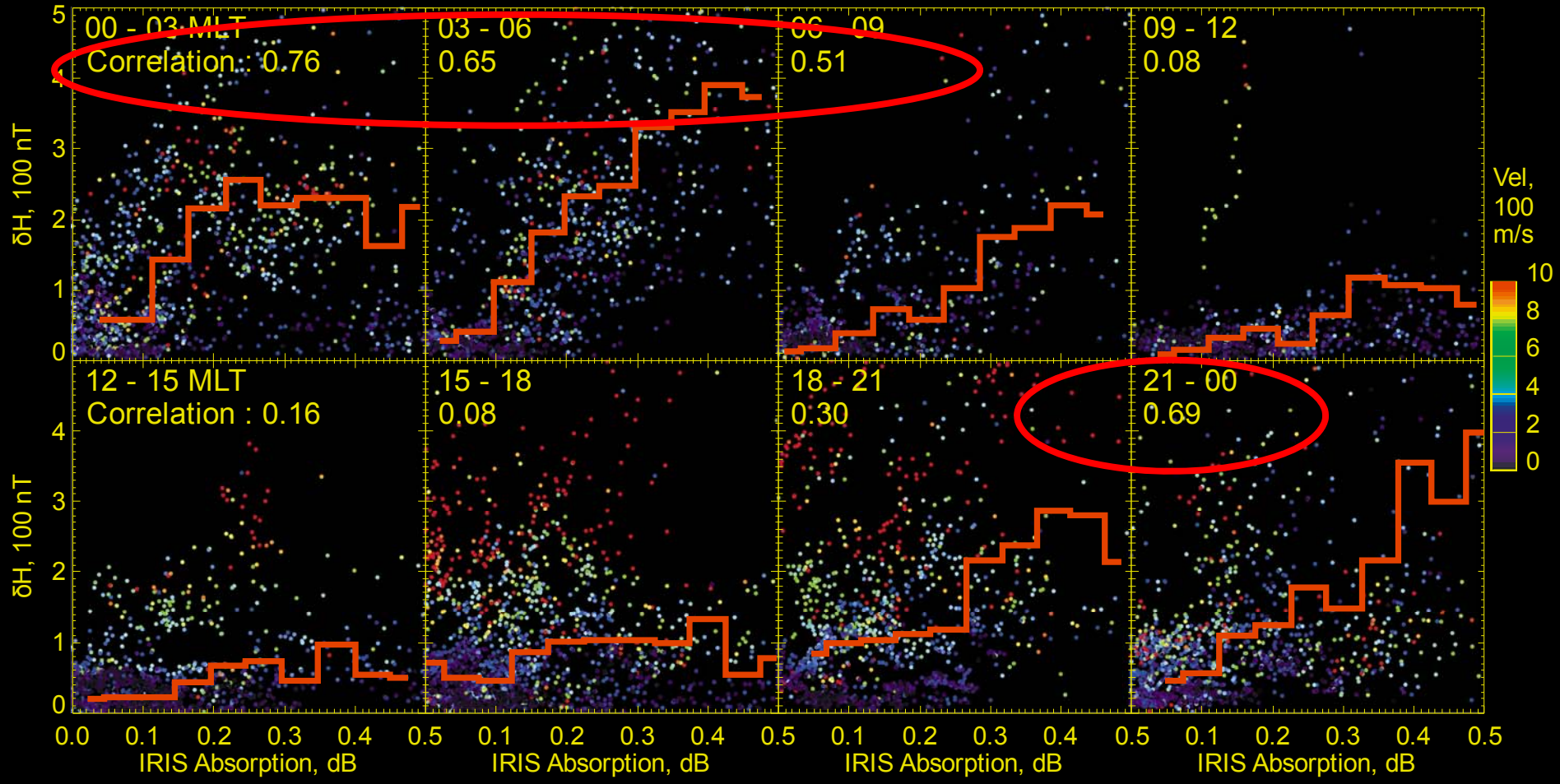
Point by Point Comparisons: δH vs E-field MLT



Sharp increase in δH vs E-field correlation at 12 MLT and high during afternoon

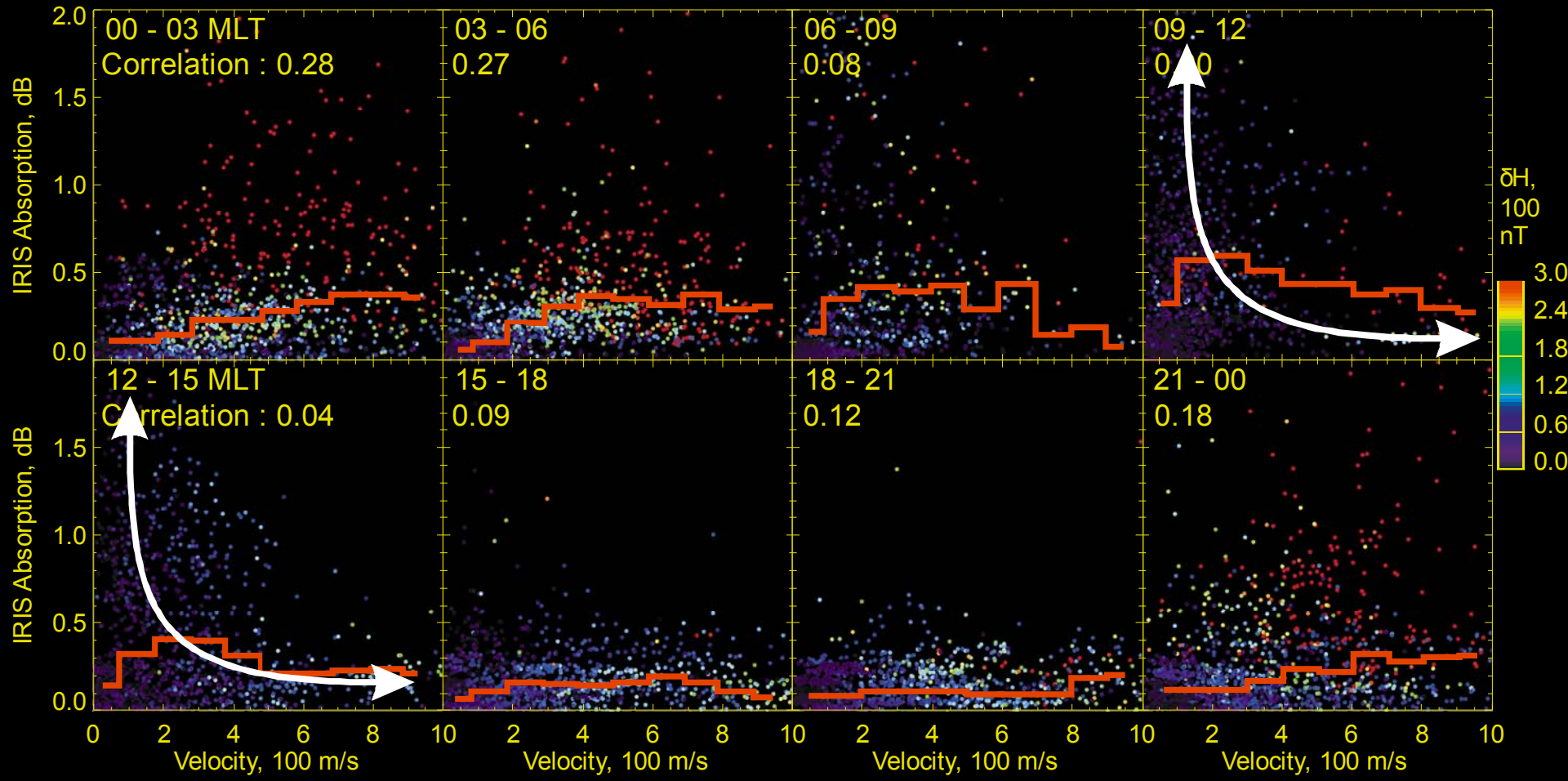
Structuring in colour representative of an absorption influence on the current near midnight

Point by Point Comparisons: δH vs abs MLT



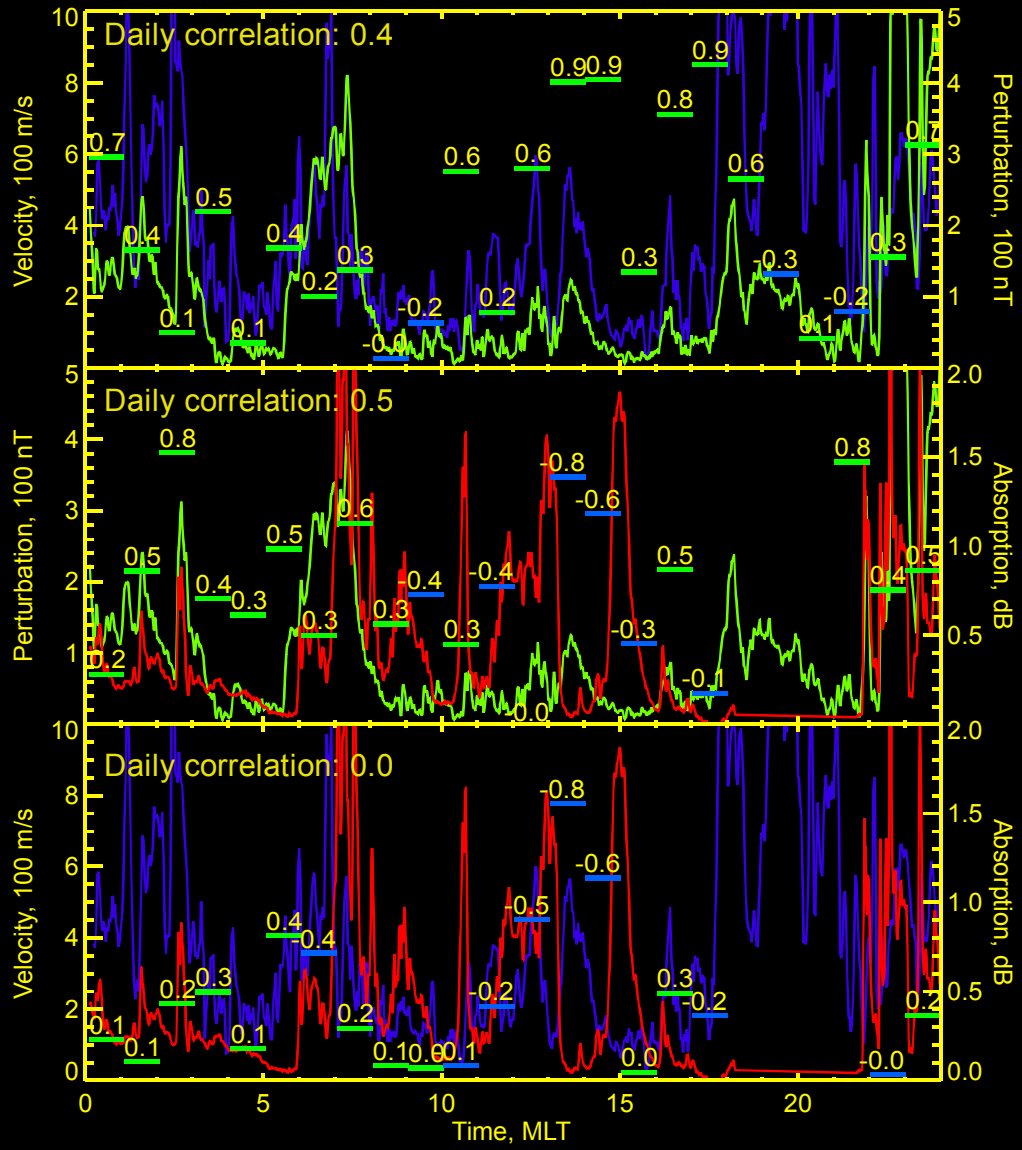
Sharp increase in δH vs absorption correlation at 21 MLT and slow decline through morning

Point by Point Comparisons: Abs vs E-field MLT



Inverse proportionality observed between absorption and E-field from 9 – 15 MLT

Hourly correlation analysis



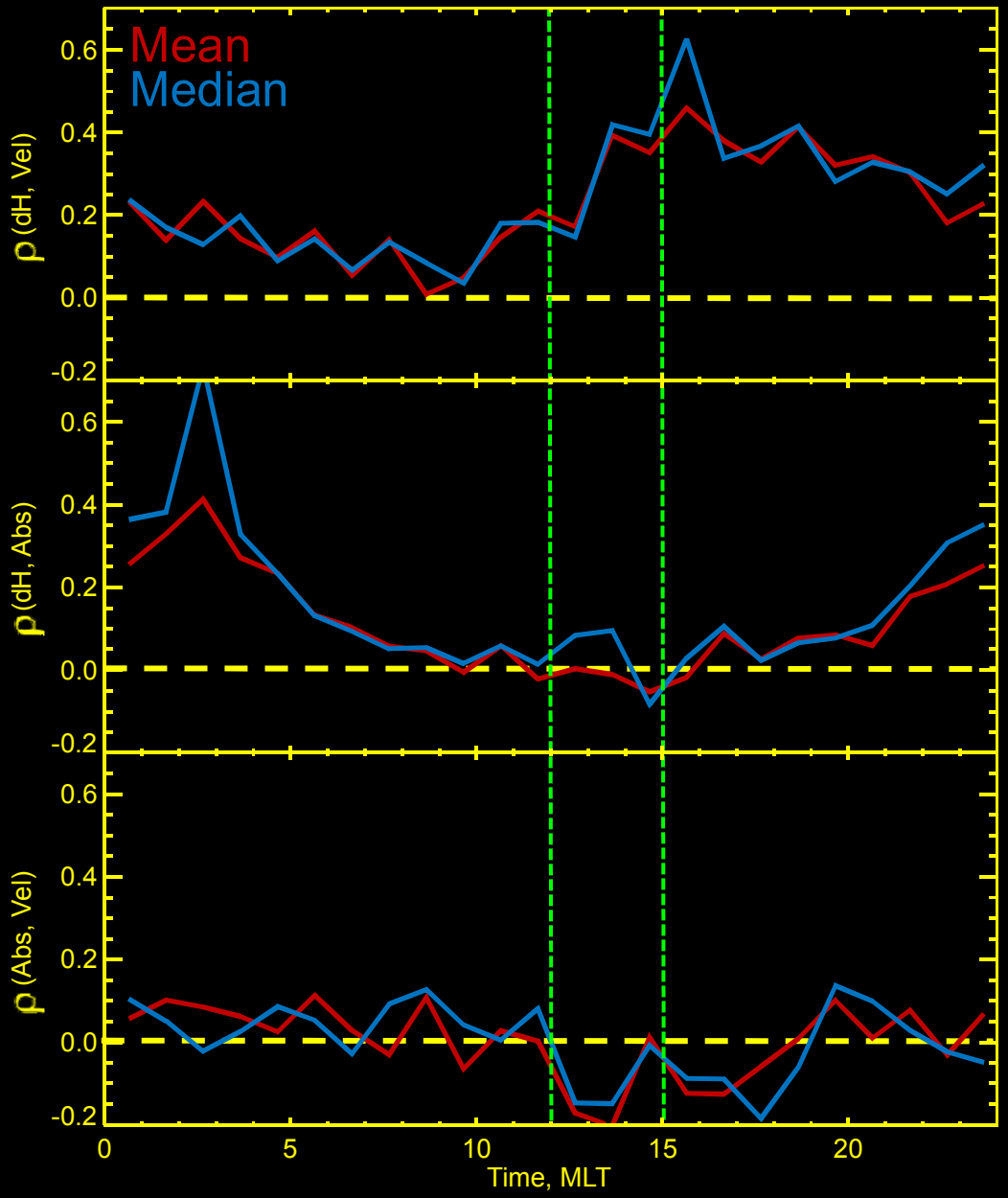
- Correlations were calculated for each hour and each day

Velocity

Perturbation

Absorption

Hourly correlation analysis



- Correlations were calculated for each hour and each day
- Similar variation observed throughout the day for both ρ(δH, Vel) and ρ(δH, Abs) in comparison to the previous analysis
- A small anti-correlation is observed for the ρ(Abs, Vel) during the 12–15 MLT sector

This analysis largely confirms the results of the previous analysis

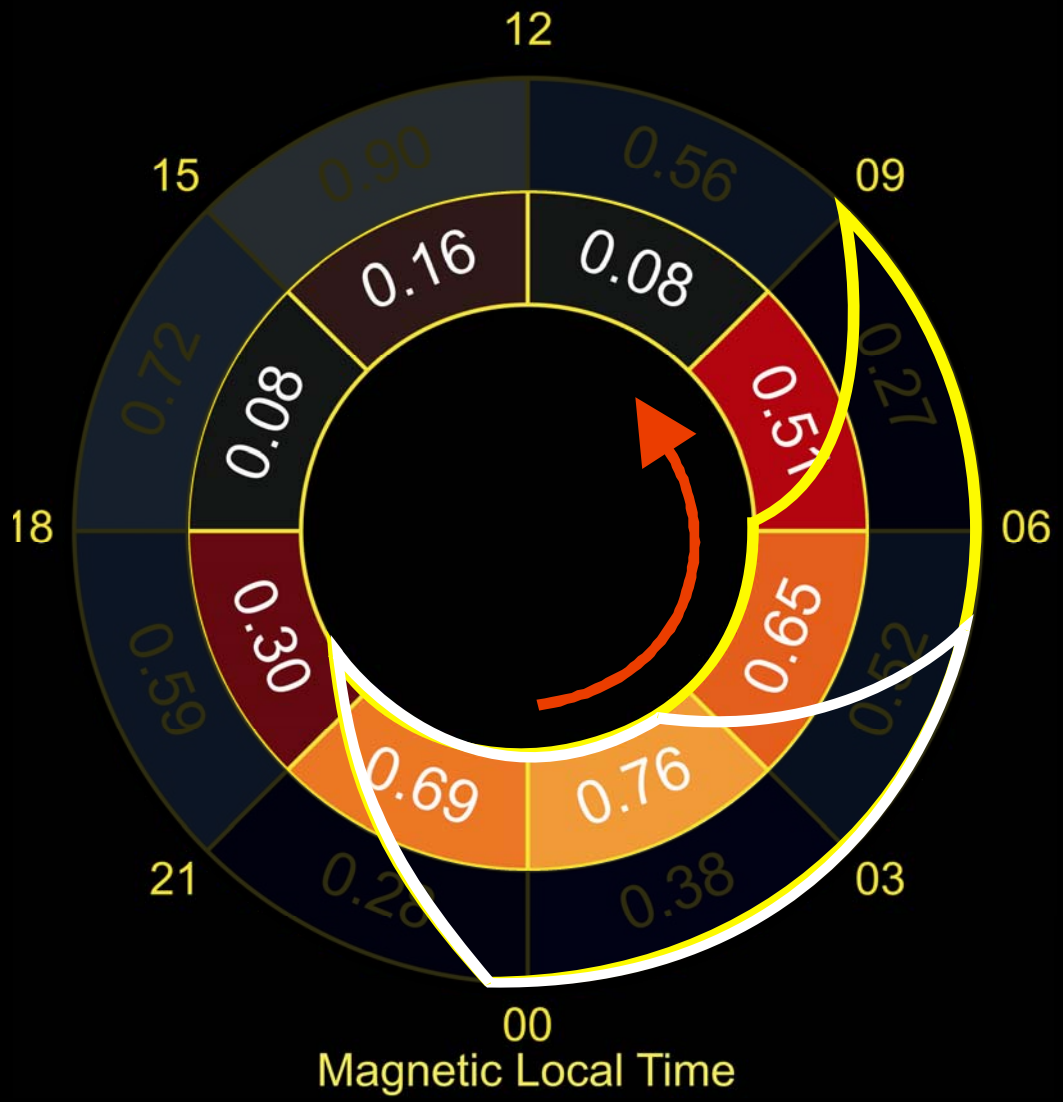
Conductivity-Dominant Region

Previously:

- Is at 21 – 06 MLT [Kamide and Vickrey, 1983]
- It may extend to 08 MLT [Sugino et al., 2002]

This study:

- Extends from 21 to 09 MLT with correlation declining with MLT after 00 MLT
- The depletion of electron clouds slowly drifting around the Earth eastward could be a responsible mechanism [Stauning, 1996a]



Electric-Field-Dominant Region

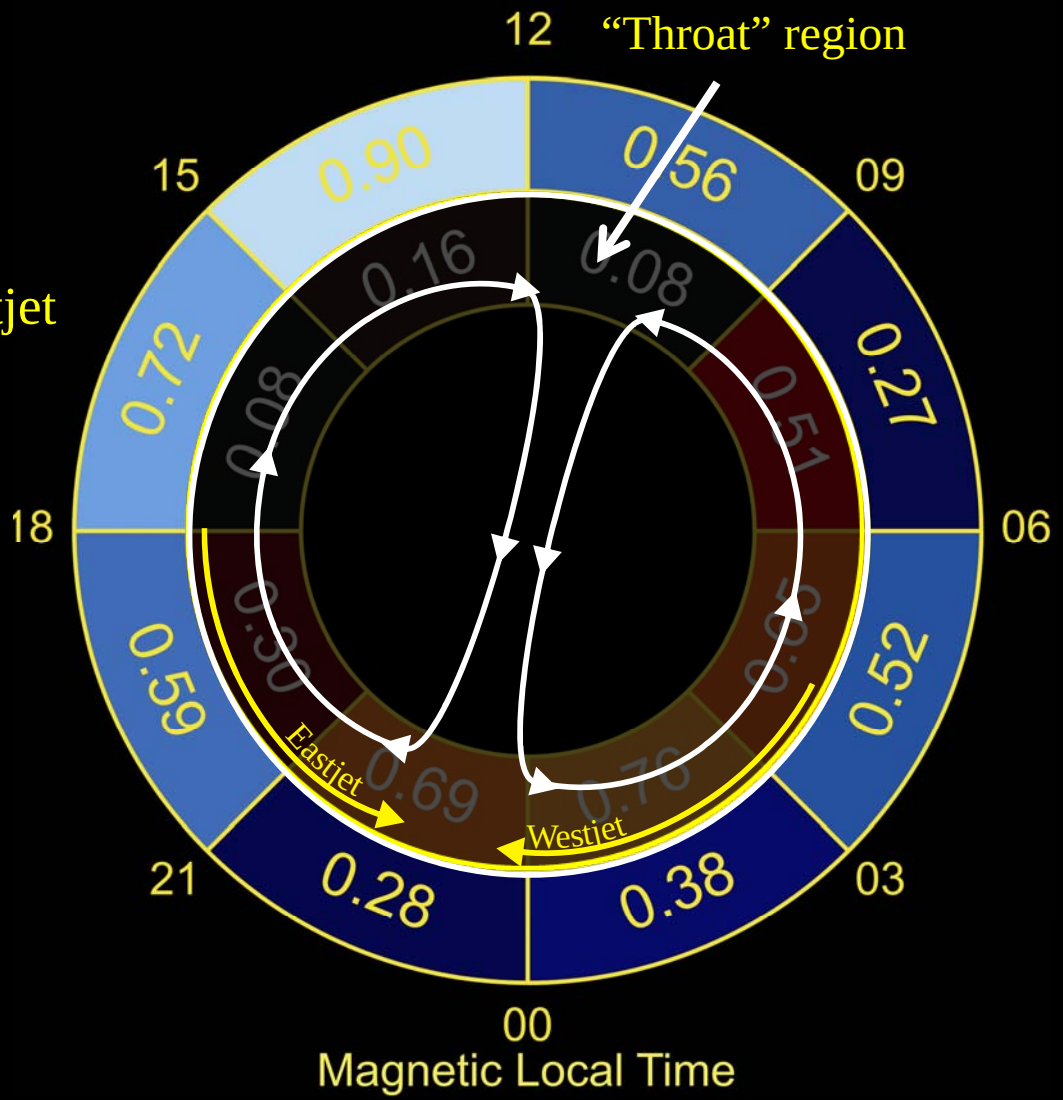
Previously:

- Is associated with nightside eastward electrojet [Kamide and Vickrey, 1983]

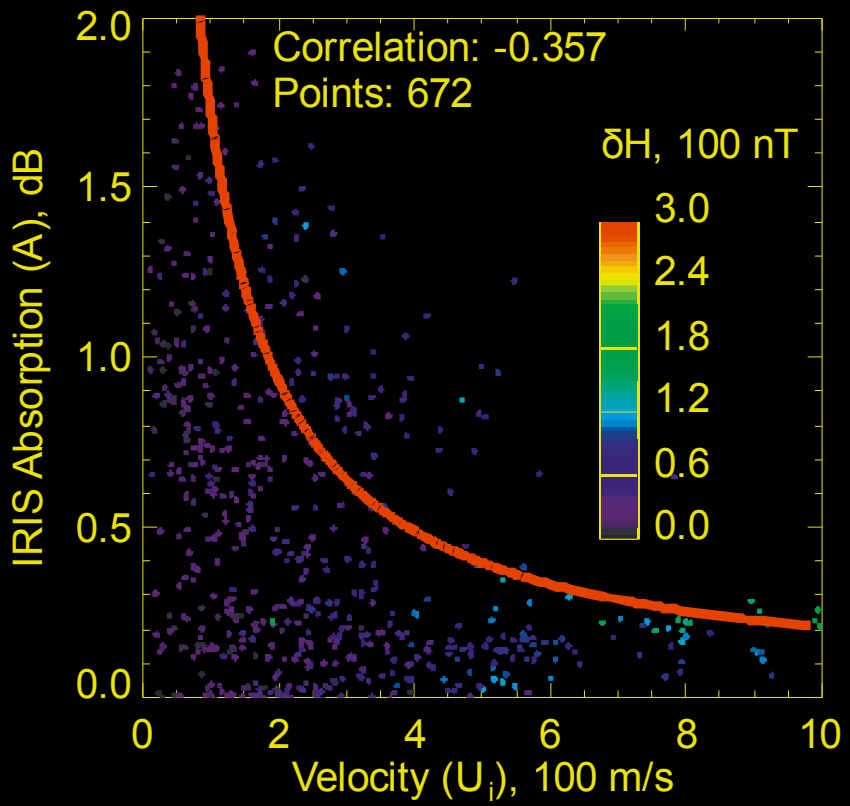
Eastjet

This study:

- The region of high current-electric-field correlation is asymmetric wrt to 00-12 MLT line
- Rotation may be related to a lack of mirror symmetry between the positive and negative B_y effects [Kustov et al, 1998; Ruohoniemi and Greenwald, 2005]



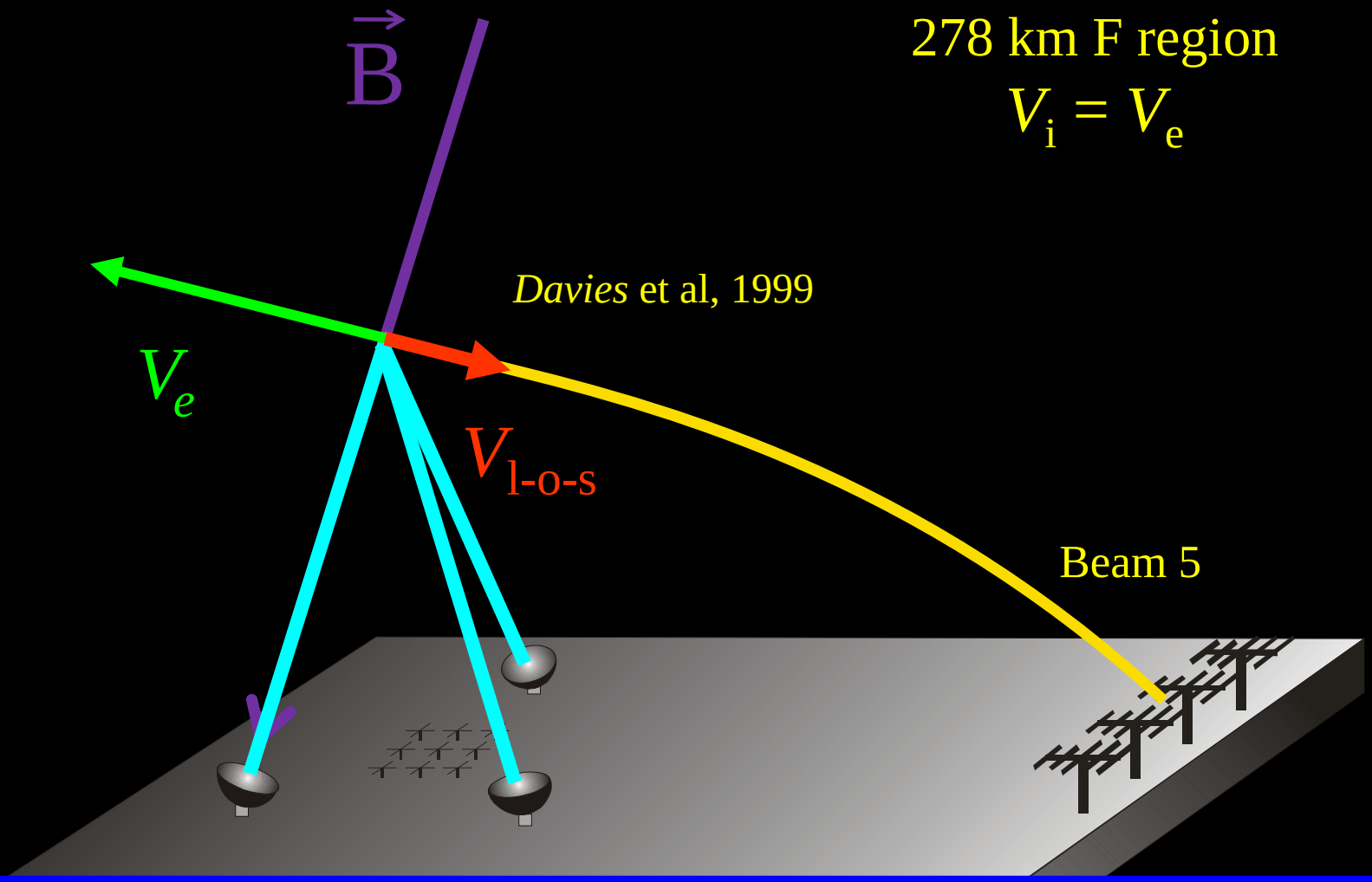
Perturbation/E-field High Correlation Periods



- A 3 hr period was chosen from 9 days exhibiting high correlation.
- The period 12-15 MLT showed the highest correlation over these days and indeed the entire 46 day data set as previously shown.

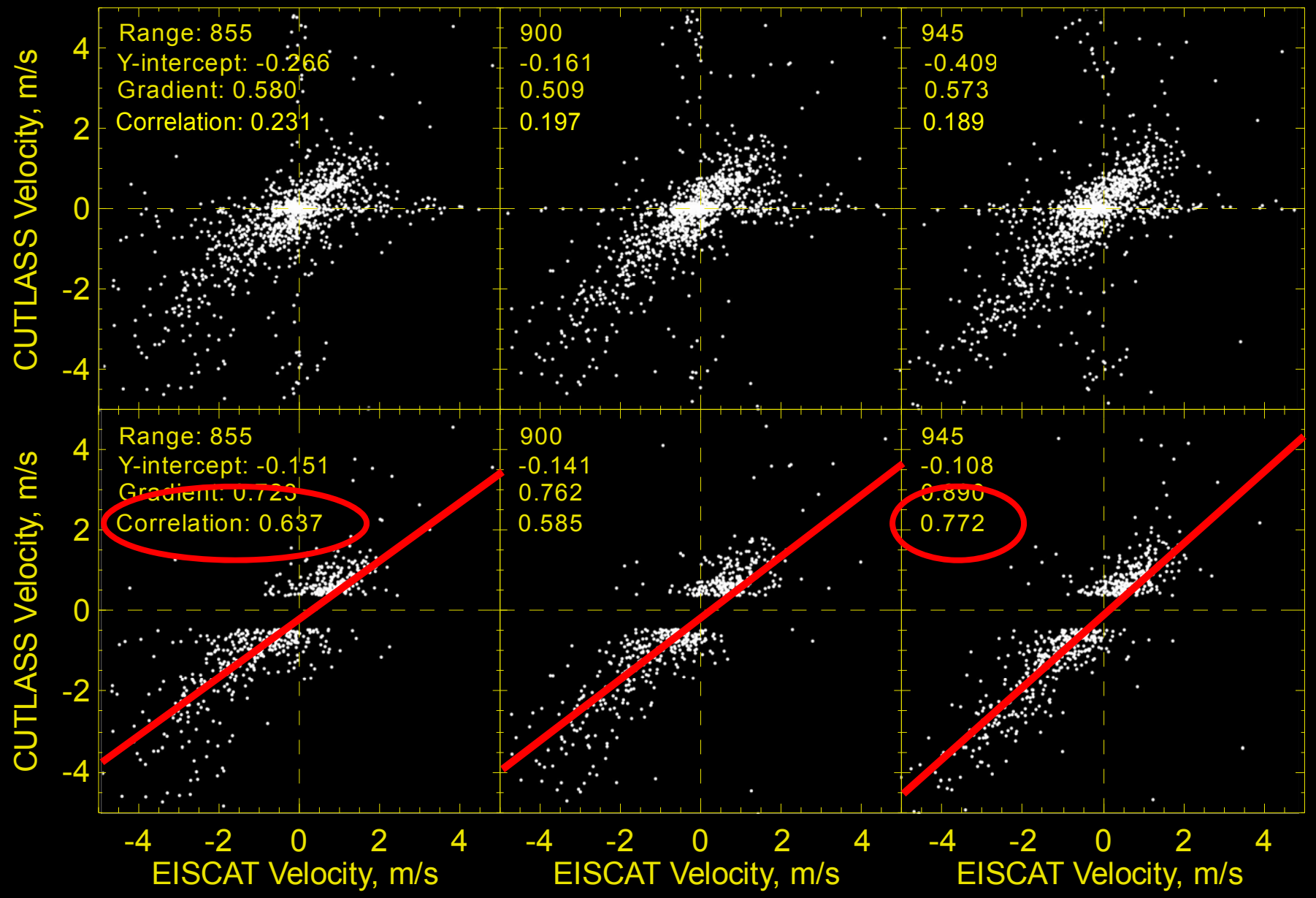
An approximately inverse proportionality b/w A and Ui was observed for the high correlation period in agreement with the magnetospheric generator idea

Irregularity velocity and tristatic ion velocity

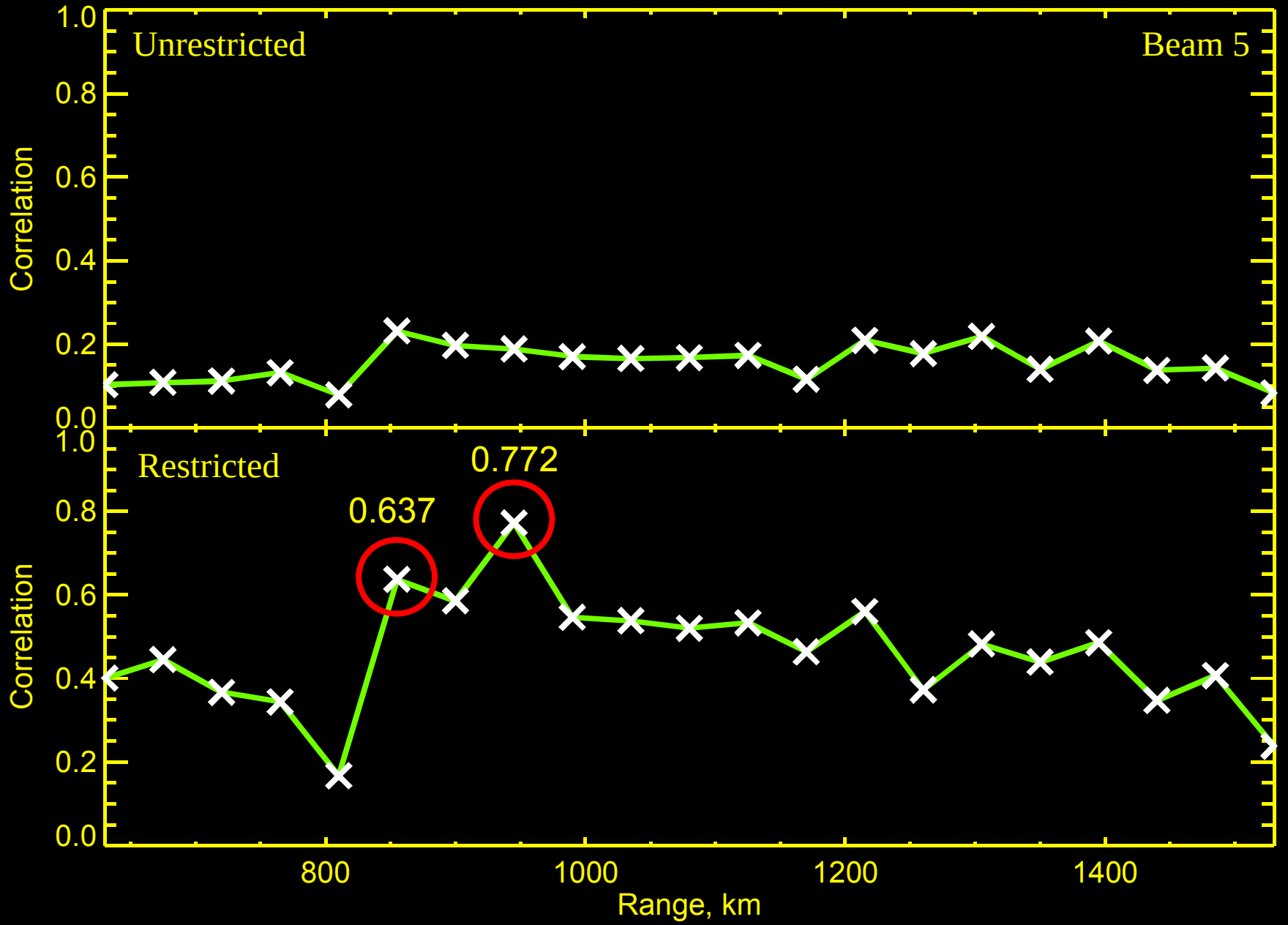


Compare EISCAT and CUTLASS velocities to evaluate the potential of riometer/HF radar in statistical studies

Irregularity velocity and tristatic ion velocity



Irregularity velocity and tristatic ion velocity



Conclusions

1. This study demonstrated the excellent potential of riometers for studies of current-conductance-E-field relationships, particularly in combination with magnetometers, as both types of instruments operate nearly continuously providing data under most conditions
   a. An asymmetry was found with respect to the 00-12 MLT meridian possibly due to a rotation of the "throat" region
   b. Conductance-dominant region extends to 09 MLT

2. No electron heating events were found. Instead, an inverse proportionality was found between conductance and electric field on the dayside, which was attributed to a limit on the Pedersen current imposed by the magnetospheric voltage generator

3. The correlation between EISCAT and CUTLASS F-region velocities is high when outliers are excluded; it maximises at 855 and 945 km on a statistical basis