

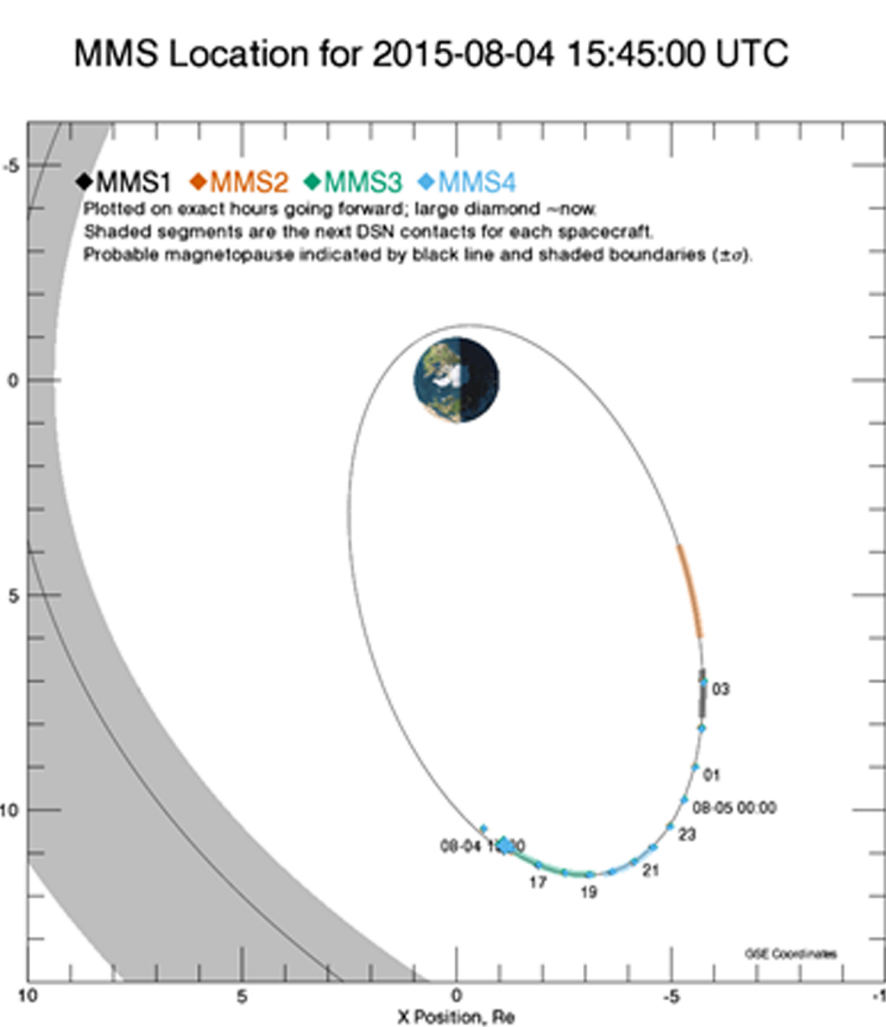
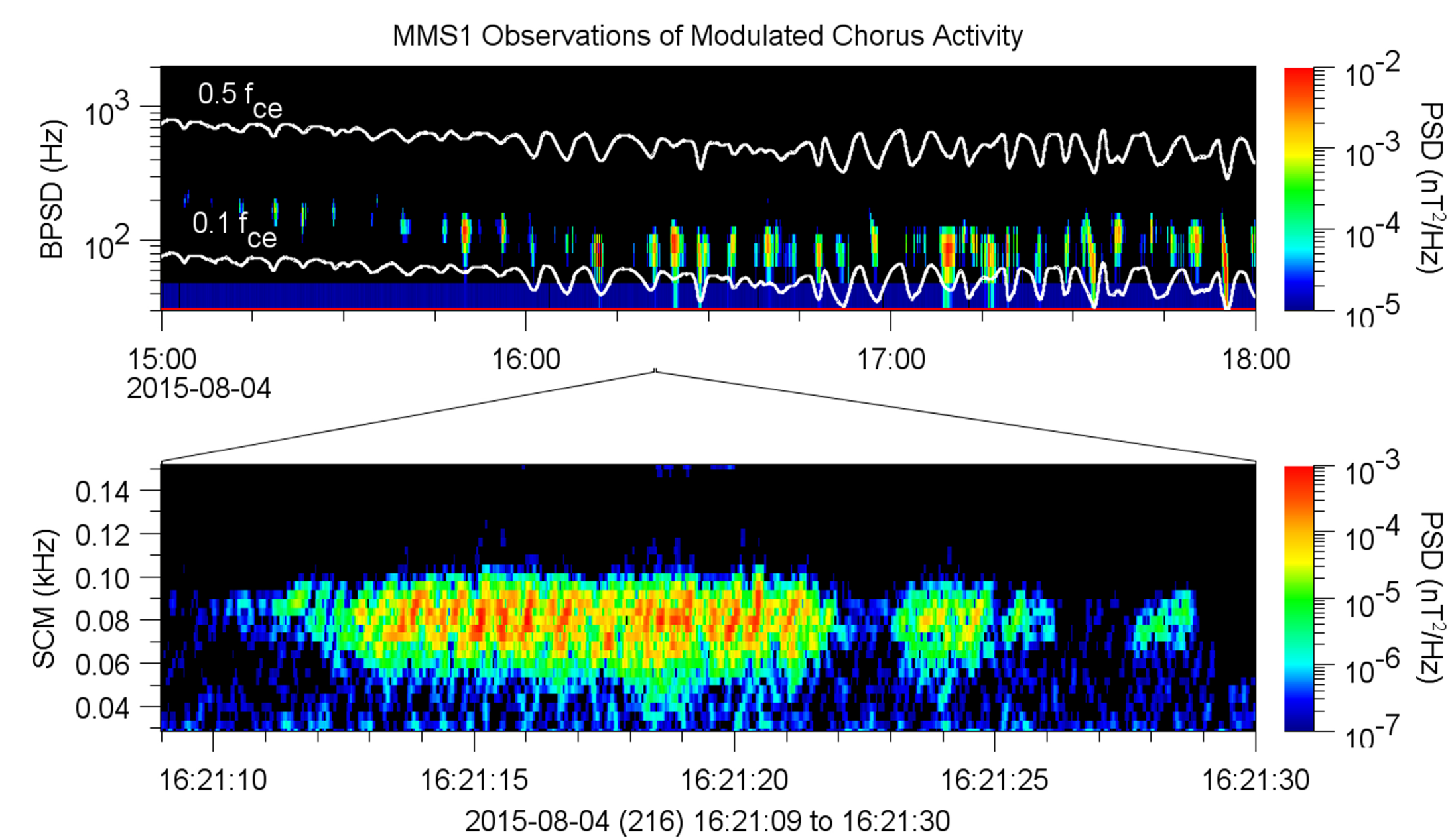
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## Abstract

We present here direct observations of chorus-wave modulated quasi field-aligned electrons using the Electron Drift Instrument (EDI) on board the Magnetospheric Multiscale mission. These events demonstrated fluctuations in the count rates of 500 eV electrons exhibiting the same spectral characteristics as simultaneously observed whistler-mode chorus waves using the on-board search coil magnetometer.

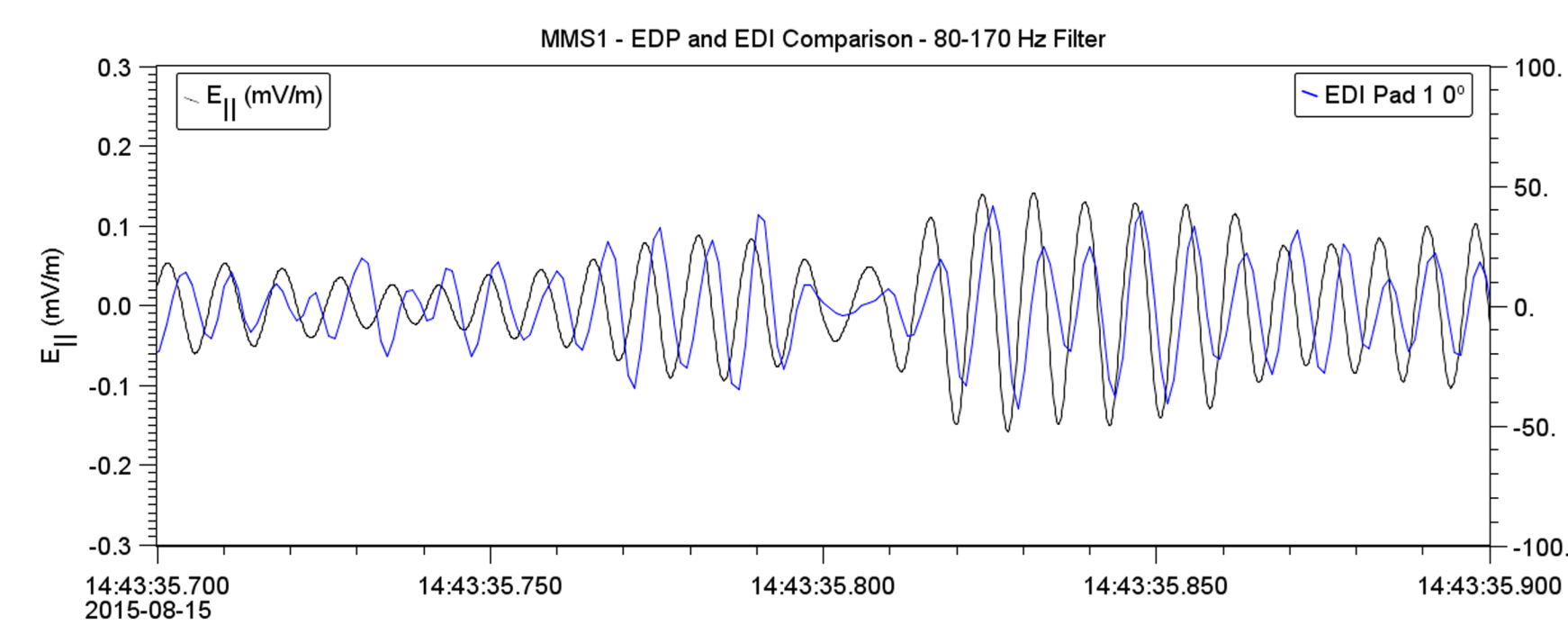
We use the multiple look directions of EDI close to the alignment direction in combination with the sweep of the instrument as the spacecraft spins to generate both pitch angle and gyrophase plots of the fluctuating counts in the wave perturbation frame of reference. We identify periods of gyrophase bunching suggesting active wave-particle interactions. These periods of wave activity were additionally observed to be modulated by Pc5-frequency magnetic perturbations, some of which have been identified as mirror-mode structures. The spacecraft encountered these mirror-mode structures just inside of the duskside magnetopause.

## Lion Roars

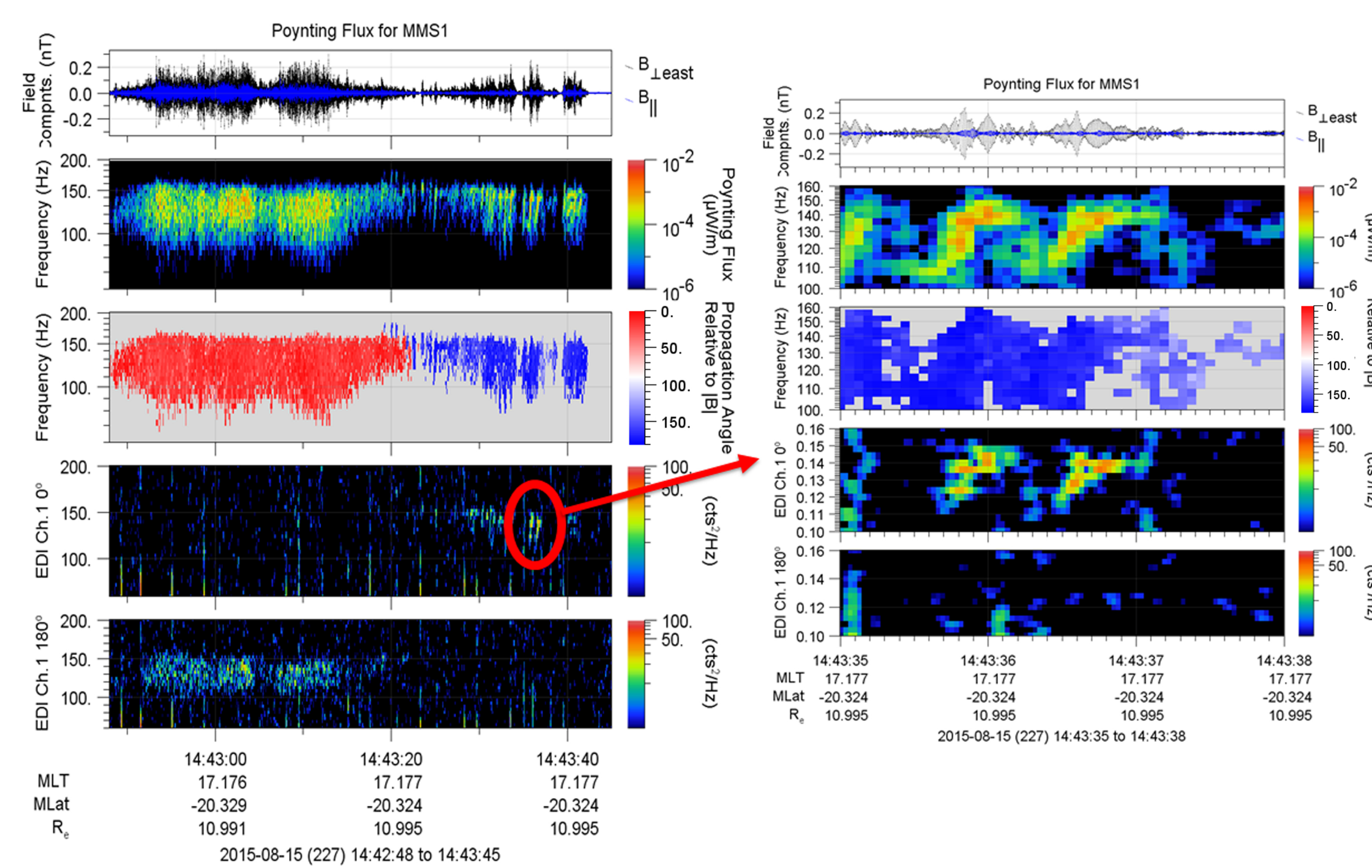


- Lower Band chorus activity modulated by Pc5 fluctuations
- Dips in magnetic field strength drive resonant particle energy down to thermal range
- MMS encountered trains of Pc5 activity lasting several hours at duskside magnetopause

## Electron Oscillations

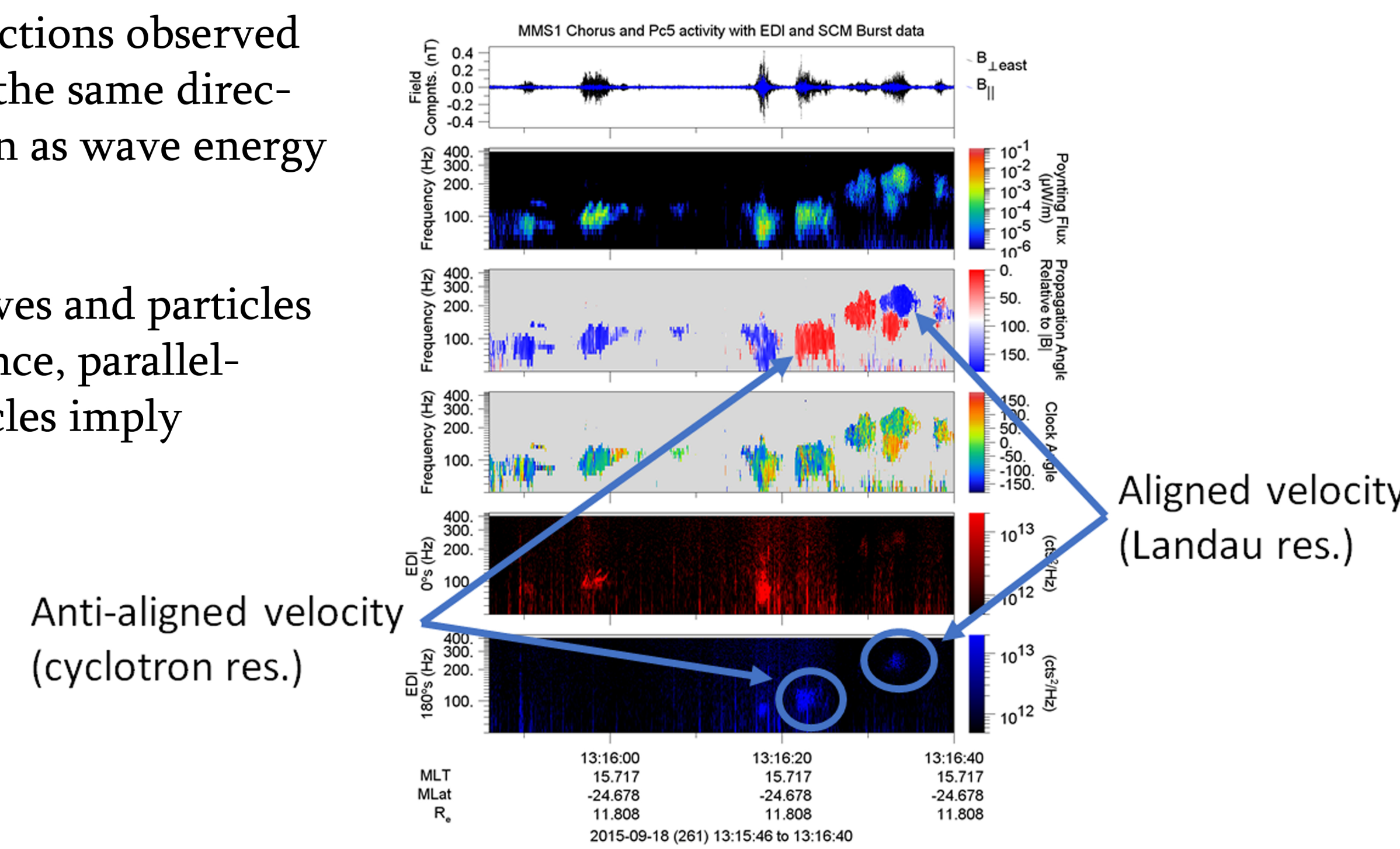


- Particle fluctuations demonstrate same spectral characteristics as wave events
- Wave propagation directions determined by local field deviations
- Right, only counter-streaming electrons demonstrate resonant fluctuations



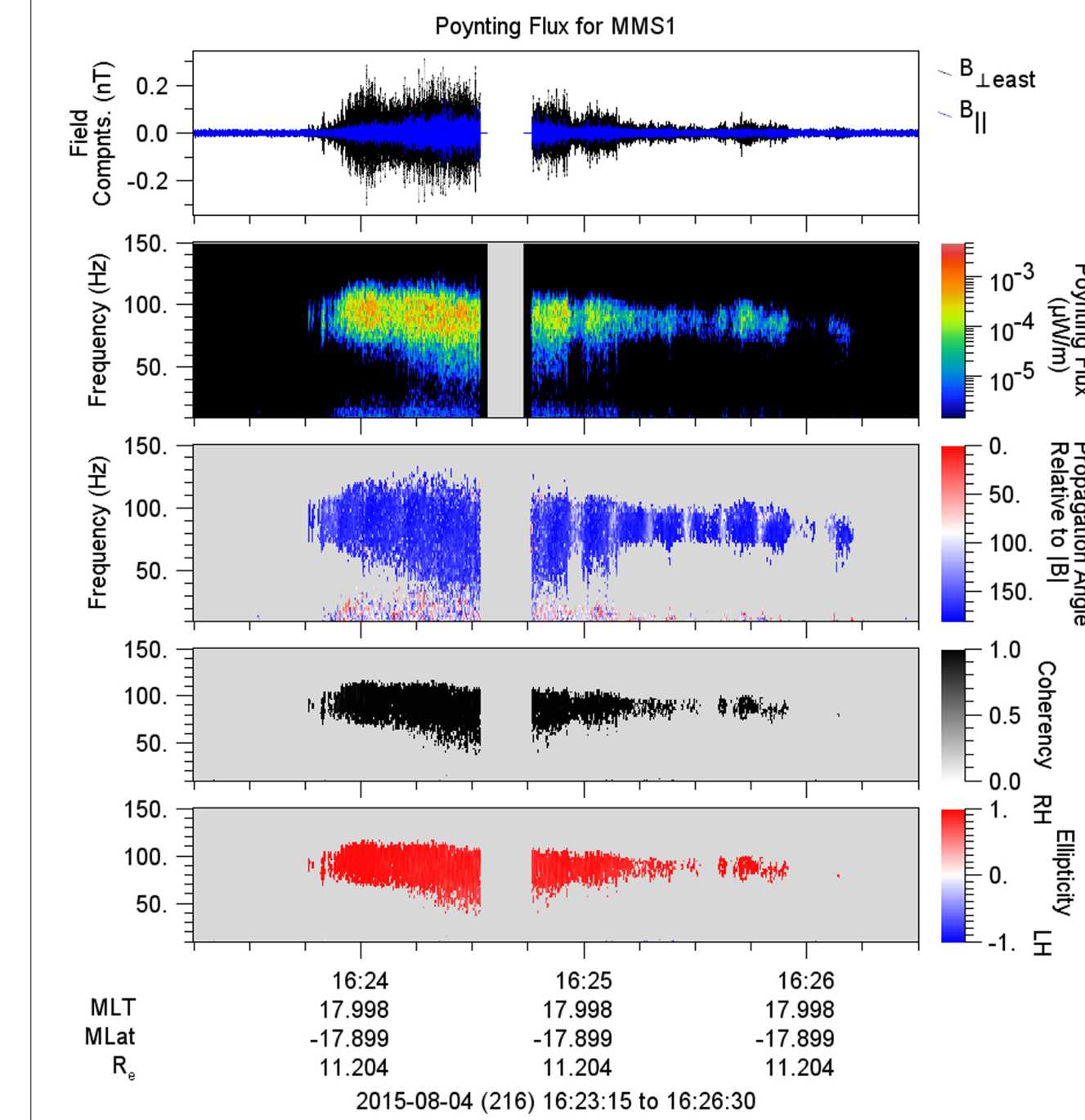
## Cyclotron vs Landau

- Resonant electron interactions observed in cases both traveling in the same direction and opposite direction as wave energy
- Oppositely-traveling waves and particles indicate cyclotron resonance, parallel-traveling waves and particles imply Landau resonance.

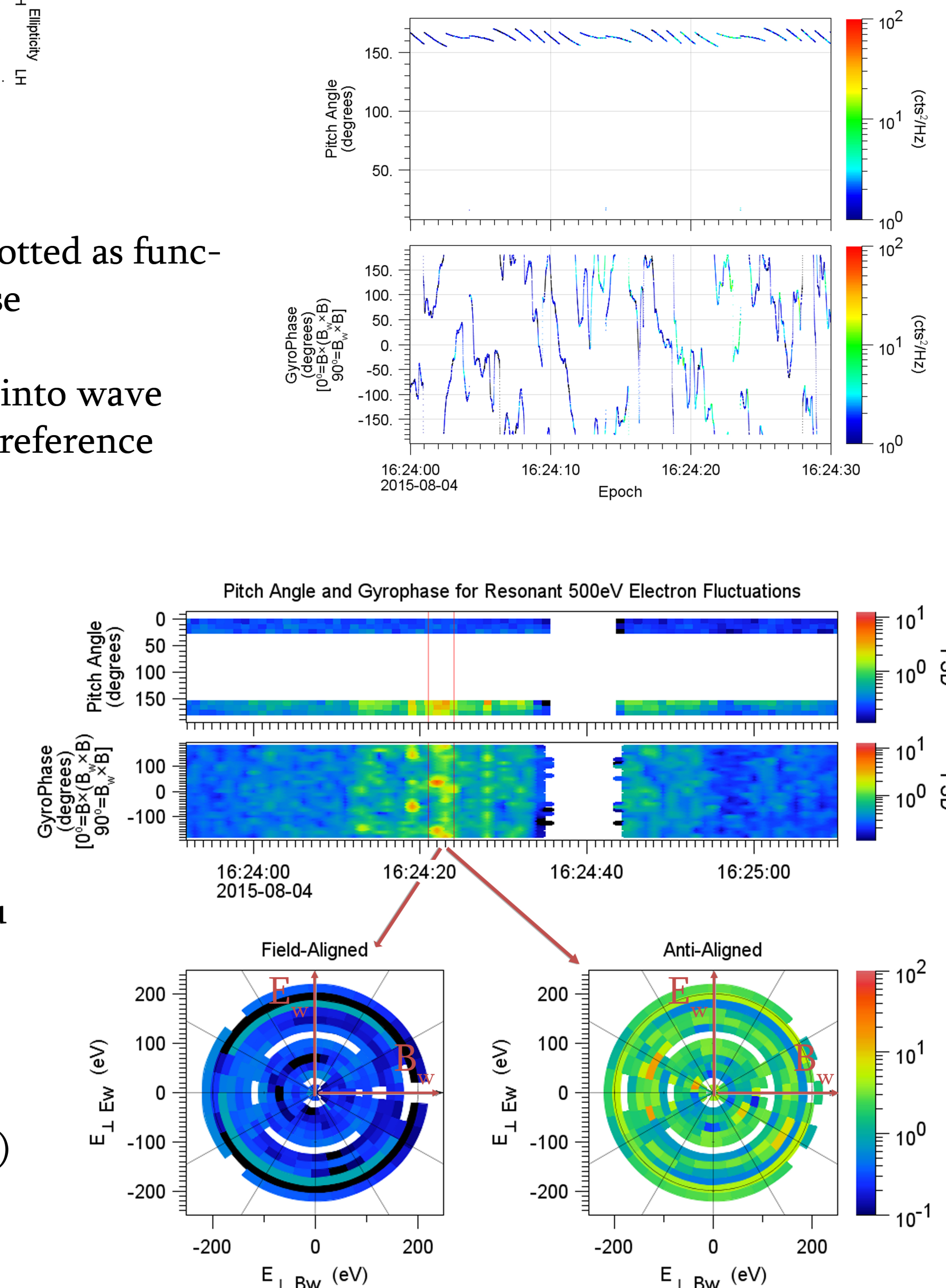


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## Gyrophase Bunching



- In ambient mode, 8 total detectors record 500 eV electron counts
- EDI samples 1024 /s in both field-aligned (0°) and anti-aligned (180°) directions
- Resonant electrons oscillate at same frequency as wave perturbations
- Wave event highly coherent and strongly right-hand circularly polarized
- Poynting Flux directed opposite background field direction
- Electron oscillations recorded simultaneously with wave activity at ~16:24:20 at wave frequency
- PSD of electron fluctuations plotted as function of pitch angle and gyrophase
- Gyrophase orientation rotated into wave magnetic perturbation frame of reference
- Enhancements of electron PSD by gyrophase indicate bunching of resonant electrons in wave train
- Electron fluctuations only in 180° channels
  - Same direction as wave propagation, implying Landau resonance
- Particle oscillations bunched around gyrophase angle of 30° and -150° (B<sub>w</sub> at 0° and E<sub>w</sub> at 90°)



## Conclusions/Discussion

The high sample rate of EDI allows us to directly observe in situ wave/particle interactions by comparing fluctuations in 500 eV electron counts to simultaneous lower band chorus activity.

We have identified electron populations resonantly fluctuating with chorus wave field vectors. This occurs both when particles and waves are aligned as well as counter-streaming, implying both Landau and cyclotron resonance, respectively. In one particular cases we have observed gyrophase bunching of resonant particles demonstrating active interaction between waves and particles.