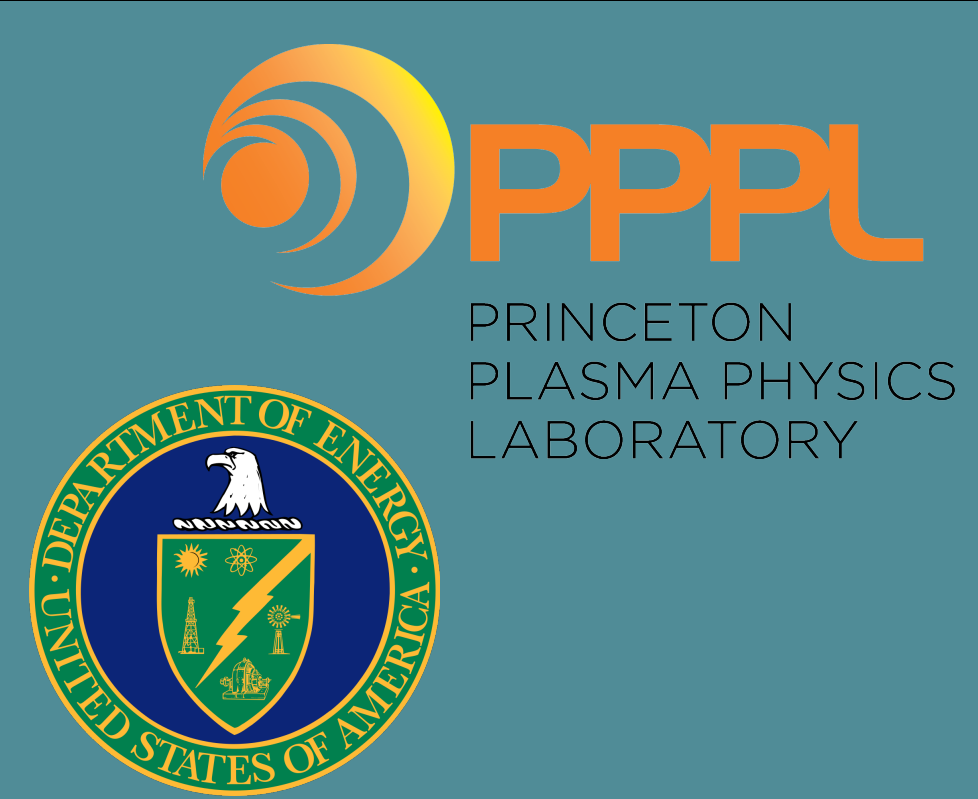




Whistler Wave Generation due to Electron Temperature Anisotropy in Asymmetric Magnetic Reconnection and B-Dot Probe Construction for F.L.A.R.E



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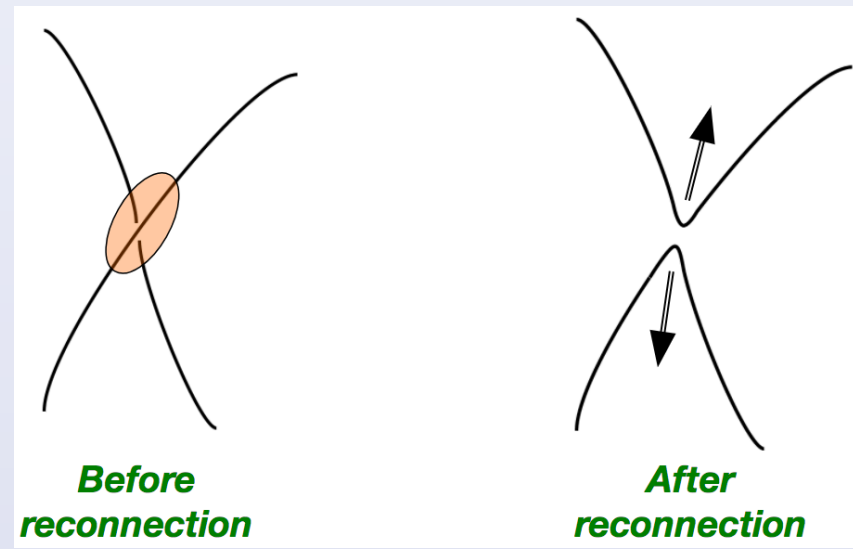
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Objectives

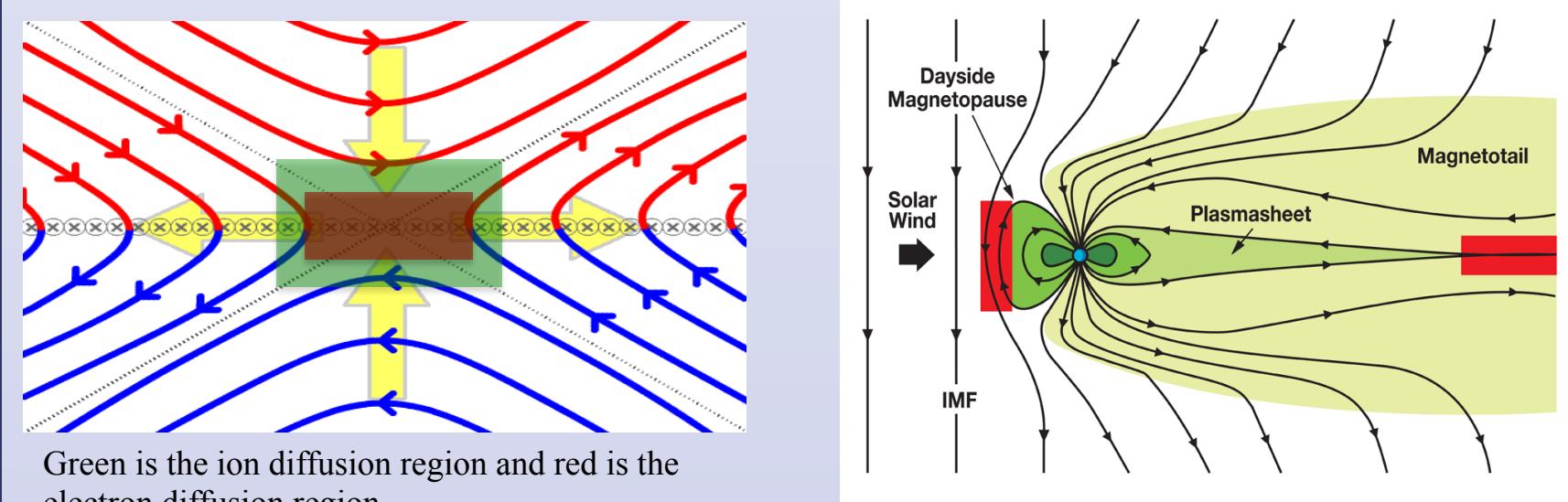
- Determine whether the parallel or perpendicular components of electron temperature anisotropy are the drivers for whistlers waves observed during asymmetric reconnection in space.
- Discussion on the construction of B Dot probes for FLARE.

Magnetic Reconnection

A topological rearrangement of the magnetic field lines.



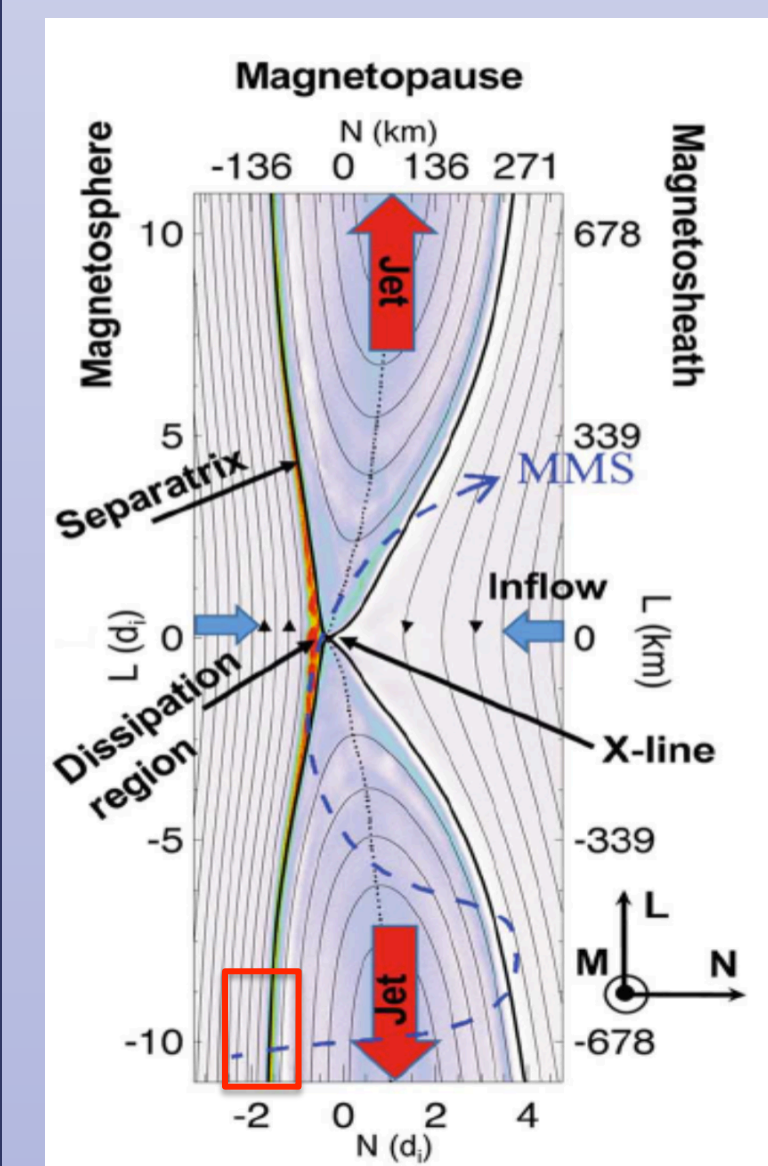
Magnetic reconnection is known as the driver for many explosive phenomena such as solar flares, sawtooth instabilities, and substorms.



Magnetic reconnection leads to rapid transfer of magnetic energy to plasma kinetic energy. Thus understanding reconnection can be helpful in both astrophysical plasma and fusion reactor plasmas.

The MMS (Magnetic Multiscale) experiment looks at reconnection in space.

MMS: An Asymmetric Reconnection Event Measured from 13:05:28 to 13:05:48 (UT)



Symmetric reconnection happens when the two plasmas interacting have similar plasma properties such as density, temperature, and magnetic field strength. The magnetosheath plasma is cold and dense and the magnetosphere plasma is hot and tenuous. Thus, reconnection events at the dayside magnetopause are classified as asymmetric reconnection.

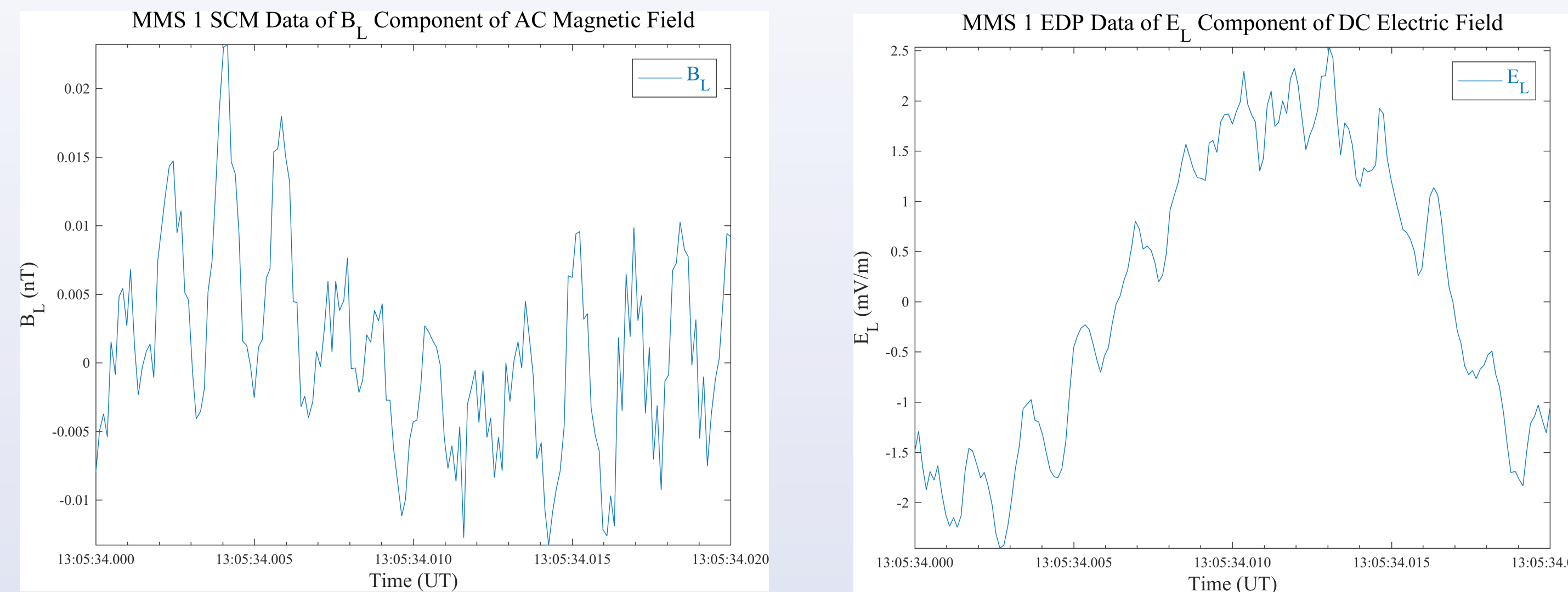
Whistler Waves

Whistler waves are right hand circularly polarized electromagnetic waves in the frequency range of:

$$f_{\text{lower hybrid (lh)}} \leq f_{\text{whistler}} \leq f_{\text{electron cyclotron (ec)}}$$

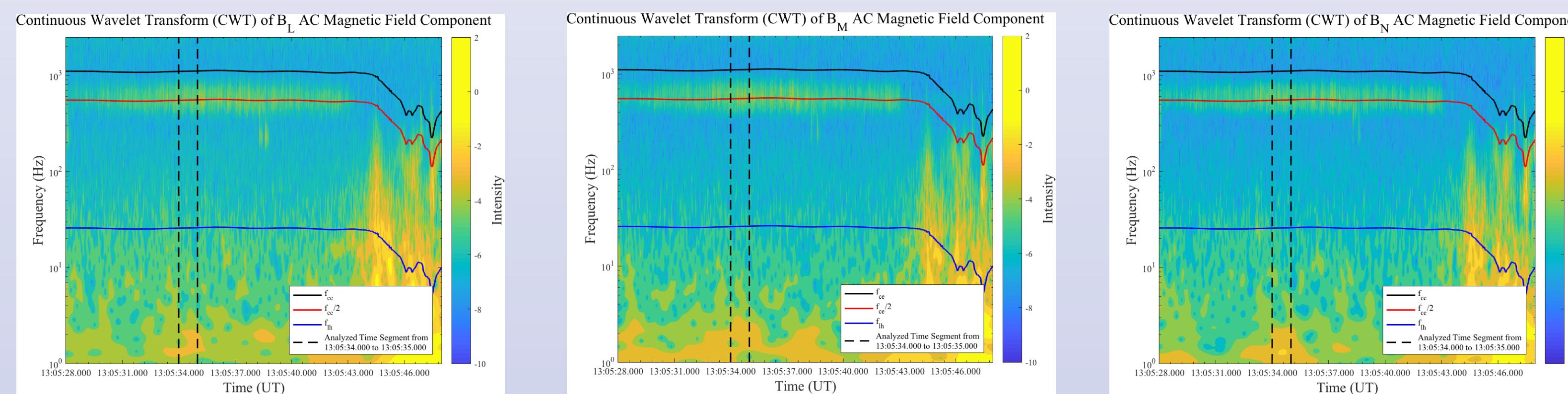
Although whistlers waves can be generated by many different mechanisms, electron temperature anisotropy is thought to be the reason for whistlers waves near the separatrices on the magnetosphere side.^{[1] [2]}

Whistler Waves in the Asymmetric Reconnection Event



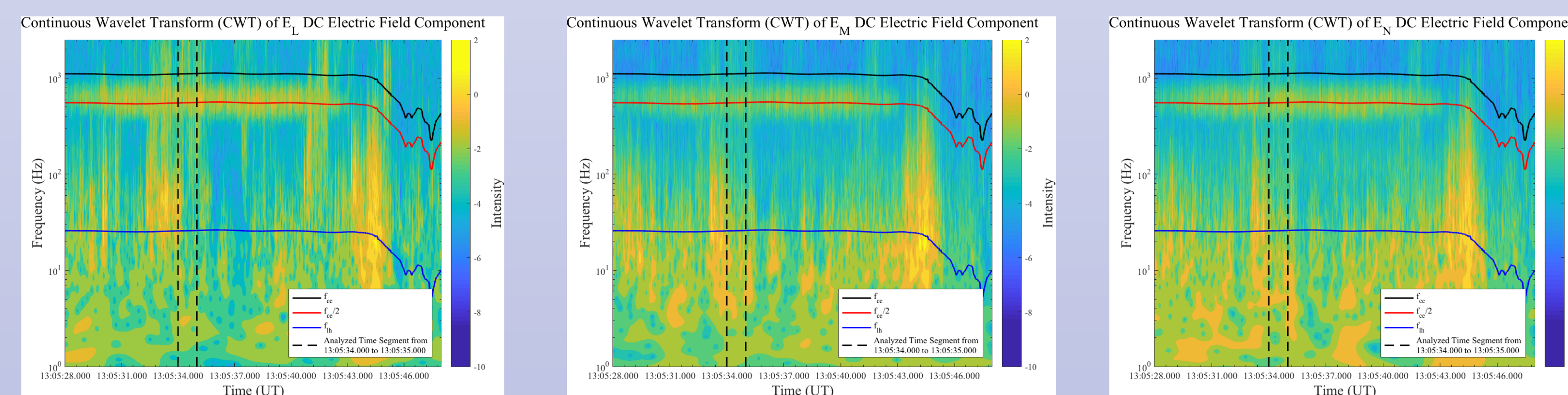
Both magnetic and electric fields show low amplitude and high frequency signals before passing through the separatrix. For a 1/50th of a second time interval both signals oscillate ~10 times. This is on the scale of a ~500 Hz signal that is expected to be a whistler wave.

SCM: AC B Field



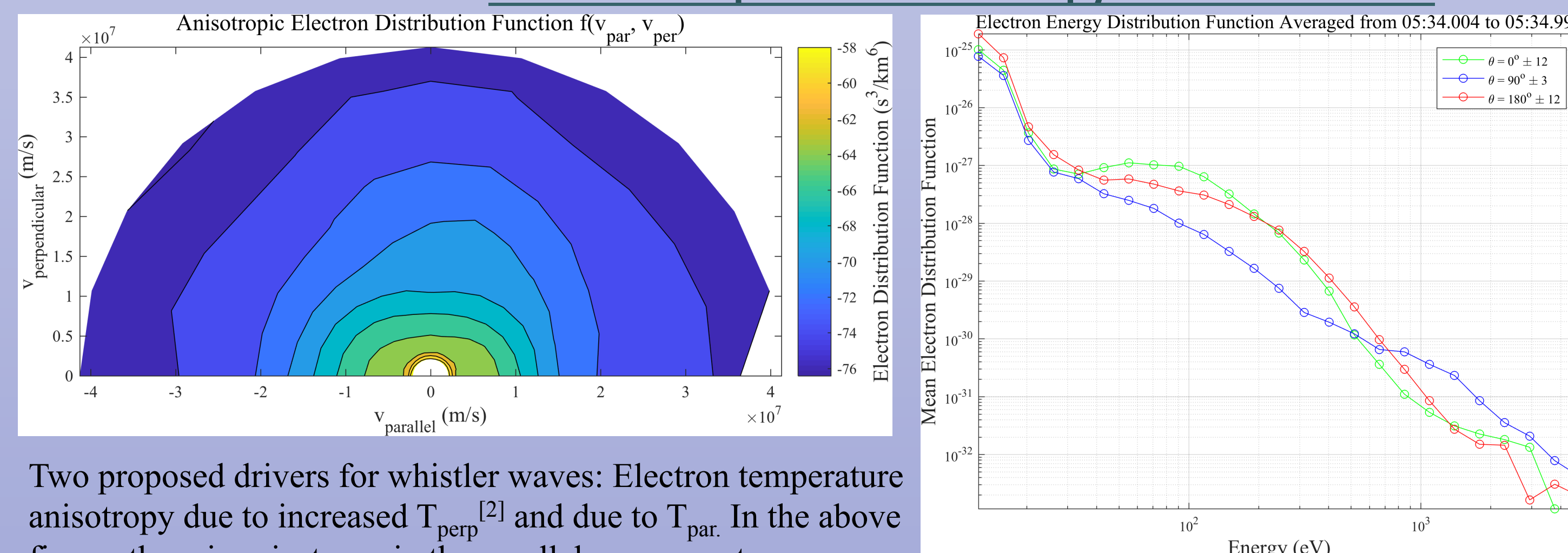
The blue, red, and black lines represent f_{ce} , $0.5f_{ce}$, f_{lh} respectively. There is greater intensity signal near $0.5f_{ce}$ before MMS passes through the separatrix. These EM fluctuations have the right-handed polarization, which is characteristic of a whistler wave.

EDP: DC E Field



The blue, red, and black lines represent f_{ce} , $0.5f_{ce}$, f_{lh} respectively. There is a greater intensity signal near $0.5f_{ce}$. This mode is electromagnetic as it is seen in both magnetic and electric field data which is another characteristic of whistler waves. As well, it aligns with expected findings of Graham et al.^[1] and Le Contel et al.^[2]

Electron Temperature Anisotropy and Future Work



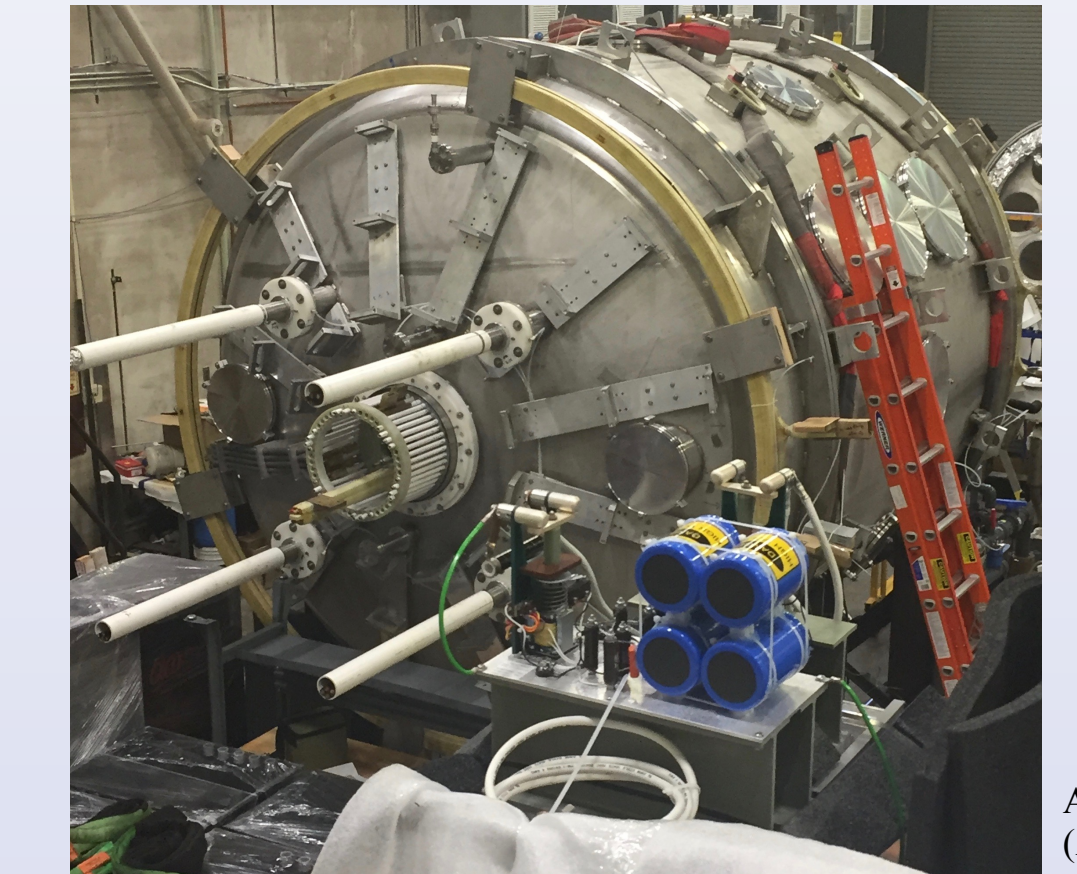
Two proposed drivers for whistler waves: Electron temperature anisotropy due to increased T_{perp} ^[2] and due to T_{par} . In the above figure, there is anisotropy in the parallel component.

Next, we will fit the pitch angle distribution function to a sum of Maxwellians in order to use the WHAMP code and get the dispersion relation to compare to theoretical results. This will prove what the driver for these whistler waves is.

FLARE

(Facility for Laboratory Reconnection Experiment)

FLARE aims to study regimes of magnetic reconnection related to astrophysical, solar, and fusion plasmas. It will allow users to perform experiments in the MHD, ion, and electron scales.



A picture of FLARE (August 2017)

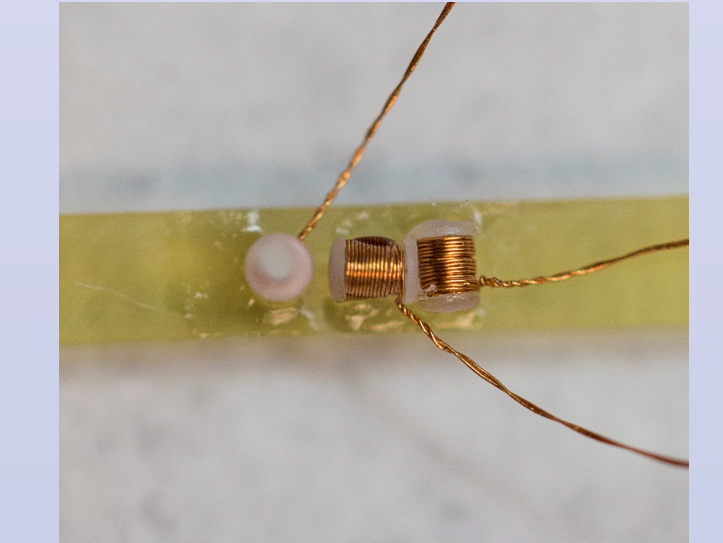
B-Dot Probe Construction

A probe used to measure time varying three dimensional magnetic fields.

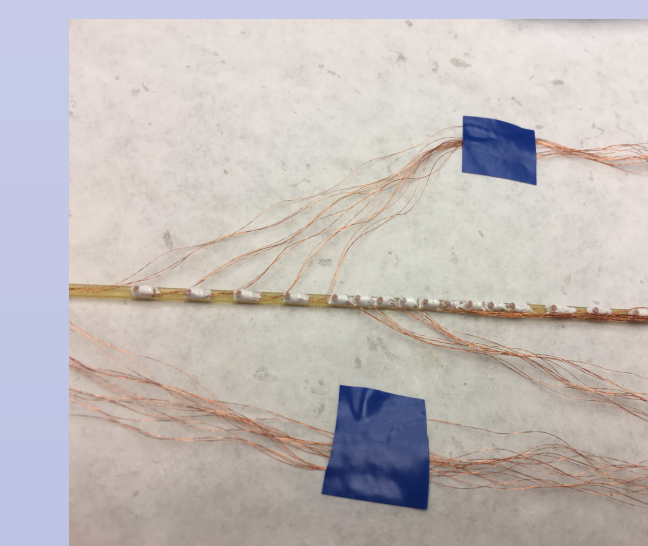
The probes are one meter in length and contain 43 measurement points. Each measurement point contains three pick up coils for a total of 149 pick up coils and sets of leads for each probe. All of the pick up coils are attached and soldered by hand.



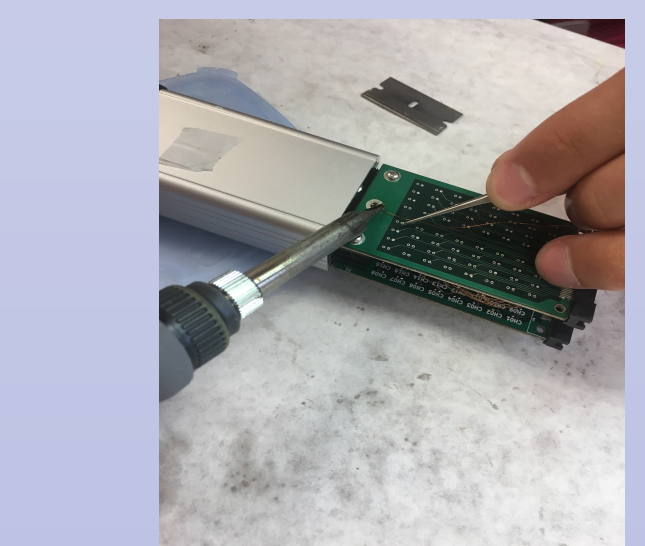
One coil placed on a dime for scale.



One triplet of perpendicular coils glued into the jig.

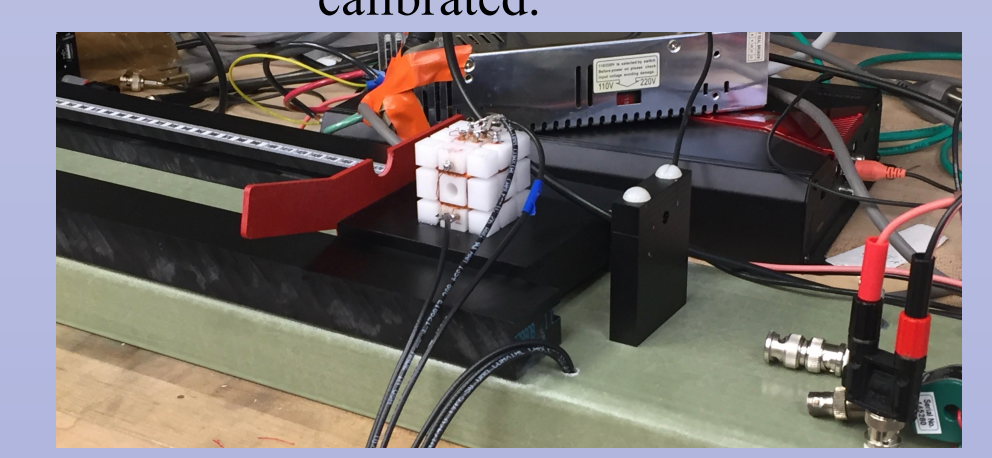


Multiple triplets glued into place along the jig.



128 leads are soldered to the two PCBs. The probe is ready to be calibrated.

Future work will include creating a procedure for calibrating each probe individually before the first plasma. Using a Helmholtz coil cube for controlled directional magnetic fields.



A completed probe – currently 15 have been constructed. Calibration will begin very soon.

References:
 [1] Graham, D. B., A. Vaivads, y. v. Khotyaintsev, and M. André (2016). Whistler emission in the separatrix regions of asymmetric magnetic reconnection. *J. Geophys. Res. Space Physics*, 121, 1934-1954, doi:10.1002/2015JA021239.
 [2] Le Contel, O., et al. (2016). Whistler mode waves and Hall fields detected by MMS during a dayside magnetopause crossing. *Geophys. Res. Lett.*, 43, 5943-5952, doi:10.1002/2016GL068968.