A Statistical Study of Magnetopause Boundary Layer Electrons Using MMS

MMS Spring 2021 Science Working Team Meeting

S.N.F Chepuri[1], A.N. Jaynes[1], D.N. Baker[2], B.H. Mauk[3], I.J. Cohen[3], T. Leonard[2], D.L. Turner[3], J.B. Blake[4], J.F. Fennell[4]

[1]*Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, USA*
[2]*Laboratory of Atmospheric and Space Physics, University of Colorado Boulder, Boulder, Colorado, USA*
[3]*The Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA*
[4]*Space Science Applications Laboratory, El Segundo, California, USA*
Corresponding author's e-mail: sanjay-chepuri@uiowa.edu

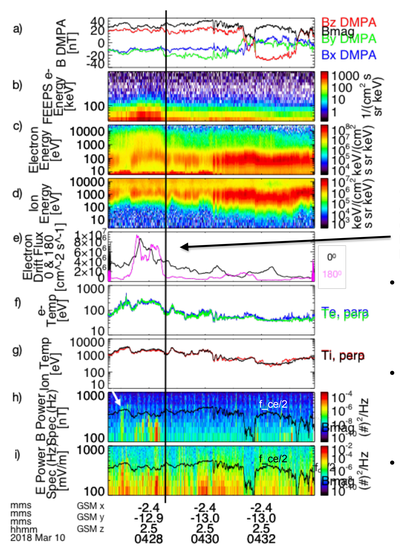
Abstract

We took a survey of boundary layer (or low-latitude boundary layer) crossings by the Magnetospheric Multiscale (MMS) mission. Out of 250 total crossings, about half showed enhancements of high-energy (>30 keV) electrons in the FEEPS sensor and a little less than half of those energetic electron events had whistler-mode waves present. Energetic electron enhancements were more likely to be present at magnetic local times closer to noon and at distances of less than about 20 Earth radii, but there was seemingly no correlation with magnetic latitude. For almost all of these events, the pitch angles of the FEEPS electrons were peaked at 90 or isotropic, not field-aligned. Almost all events had an elevated velocity moment within a few minutes of the whistler waves, suggesting reconnection nearby, but only a few showed reconnection jets within a few minutes. Overall, energetic electron enhancements are a fairly common occurrence and are likely associated with reconnection.

Objectives

- Look for enhancements in FEEPS energetic electrons in Boundary Layer crossings mentioned in SITL reports
  - Used data from 9/2016-4/2020
- Find whistler-mode waves near those FEEPS enhancements
- Examine how common these events were and any patterns in where they occurred
- Look for evidence of any nearby reconnection

Example Event



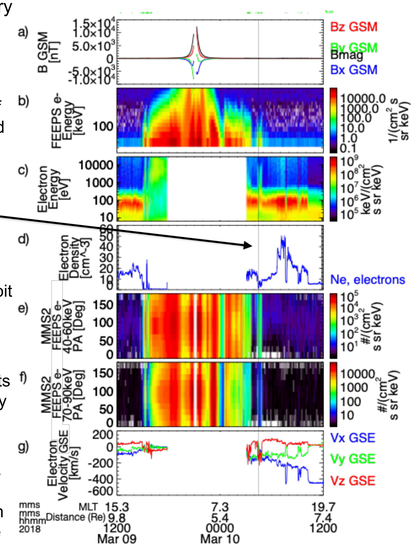
Identifiers of Boundary Layer:

- Slowly varying magnetic field
- Mixed population of magnetosphere and magnetosheath electrons and ions

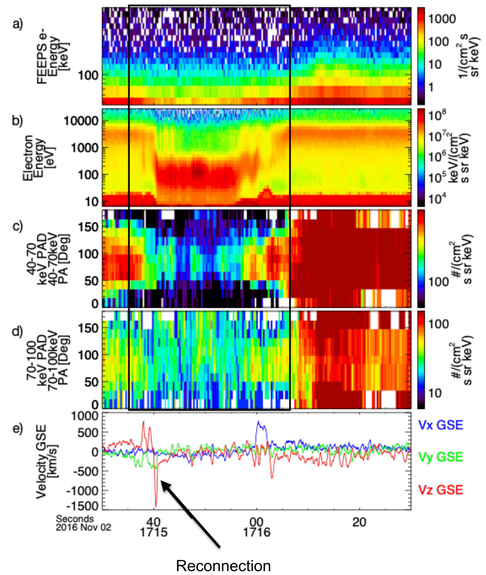
Where the spacecraft exits boundary layer

Where the zoomed in graph on the left starts

- Survey data of full orbit on right, burst data of boundary layer crossing on left
- FEEPS enhancements contained to boundary layer, so it's a local effect
- Whistler-mode waves at about half electron cyclotron frequency in boundary layer (white arrow)
- Little to no temperature anisotropy



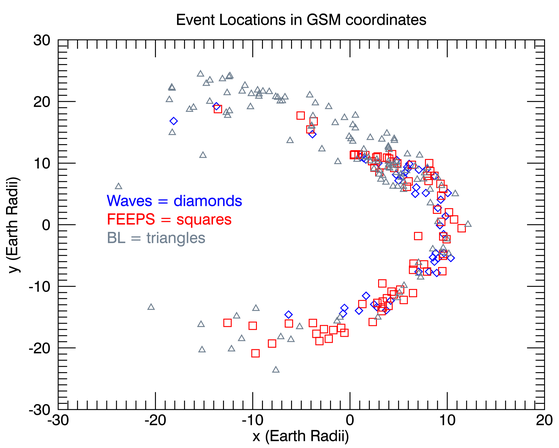
Reconnection Jet Example



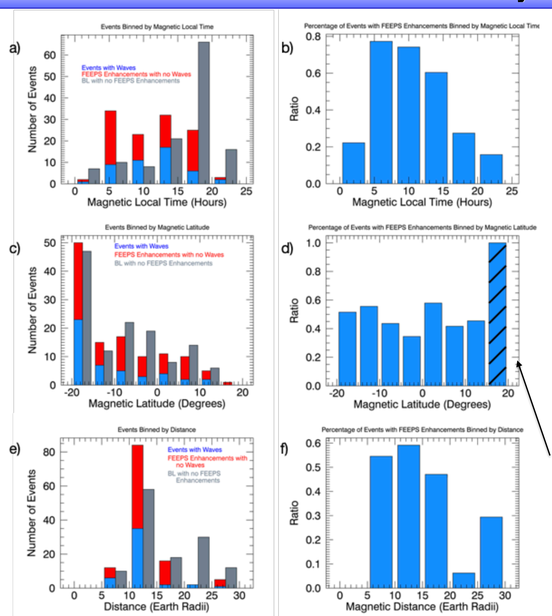
- Box shows beginning and end of boundary layer crossing
  - Goes in and out of layer inside the box
- FEEPS pitch angle distributions peaked at 90 for both lower and higher energies
- Jet in Vz suggests reconnection
- If no jet visible, then an elevated velocity moment without at jet in a single direction could indicate reconnection in the area
  - Jets would only be present very close to reconnection site, so very rare, but elevated velocity moments were quite common

Statistical Results

- 250 total events
- 121 (48%) with FEEPS enhancements
- 47 (19% of total events, 39% of FEEPS enhancements) with whistler-mode waves



Analysis of Statistical Results



- Graphs a), c), e) show raw numbers of events with FEEPS enhancements vs events without FEEPS enhancements for each quantity
  - For the purposes of this part of the study, we are not separating FEEPS enhancement events with and without waves
- Graphs b), d), f) show percentage of events in each bin with FEEPS enhancements
- More events with FEEPS enhancements on dayside
- No apparent correlation with magnetic latitude
- Events closer to Earth more likely to have FEEPS enhancements
  - Could be because the solar driving pushes magnetopause closer to Earth could also lead to more reconnection and more energetic electrons, but there was no meaningful difference in Dst index between event with and without FEEPS enhancements
  - Could also be because of asymmetries in the boundary layer
- Disproportionate number of events at certain magnetic latitudes because of 2017 orbit change
  - 2016 orbit had apogee near boundary layer so crossings more common then than after orbit change

Only one event in this bin, so the percentage is not meaningful

Summary/Conclusions

- Common to find energetic electrons in Boundary Layer, but far from universal
- Whistler-mode waves present less than half the time energetic electrons are
- Events more common on dayside and when boundary layer is closer to Earth
- Few field-aligned FEEPS pitch angle distributions, most peaked at 90 or isotropic
  - Several different possible methods of trapping electrons, including whistler waves and reconnection
- Few events had reconnection jets, but many had elevated velocity moments suggesting reconnection nearby
- Saw a temperature or beam anisotropy that could drive waves sometimes, but saw neither in most cases
- Phase trapping a possible method of accelerating these electrons
  - Simulations are being made from certain events to examine this mechanism

Submitted to *JGR:Space Physics*, 2021