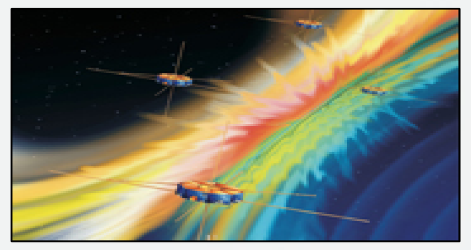
Plasma Energization in Asymmetric Magnetic Reconnection at the Dayside Magnetopause During Magnetic Storms

Jason R. Shuster[1] (jrf63@wildcats.unh.edu), **Li-Jen Chen**[1], **Arianna Zrzavy**[2], **Sita Mishra**[3], **Matthew R. Argall**[1], **Guanlai Li**[1], **Christopher Mouikis**[1], **William S. Daughton**[4], **Roy B. Torbert**[1], **Jongsoo Yoo**[5], **Masaaki Yamada**[5]

[1]Space Science Center, University of New Hampshire, Durham, NH 03824, U.S.A. [2]Contoocook Valley Regional High School, Peterborough, NH 03458, U.S.A. [3]Law and Government Academy at Hartfort Public High School, Hartford, CT 06105, U.S.A. [4]Los Alamos National Laboratory, Los Alamos, NM 87545, U.S.A. [5]Princeton Plasma Physics Laboratory, Princeton, NJ 08540, U.S.A.

SM13B-2147

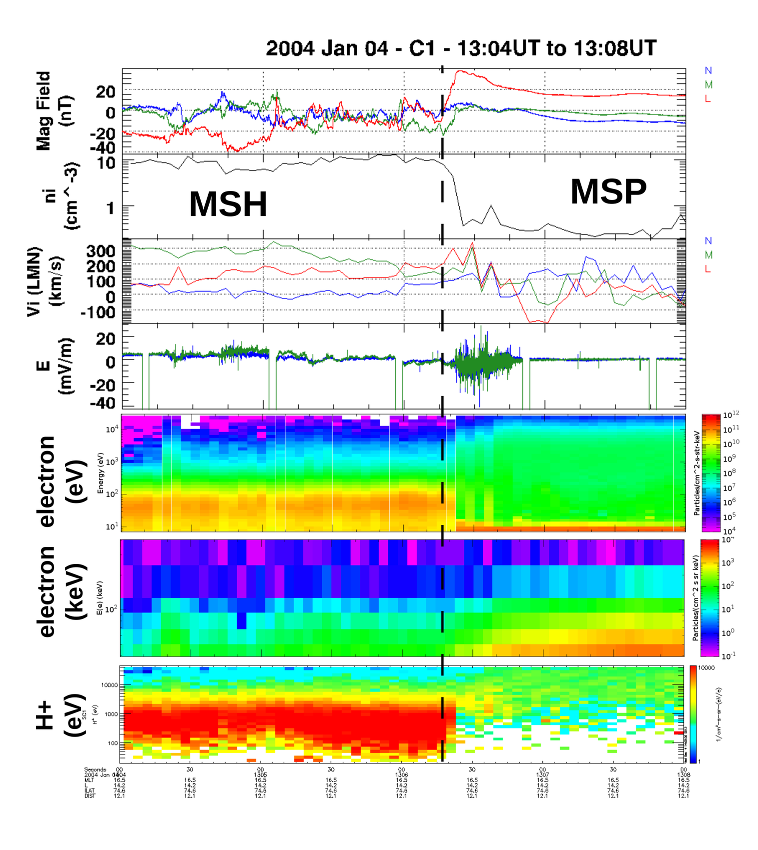


NASA's Magnetospheric Multiscale

Motivation and Context

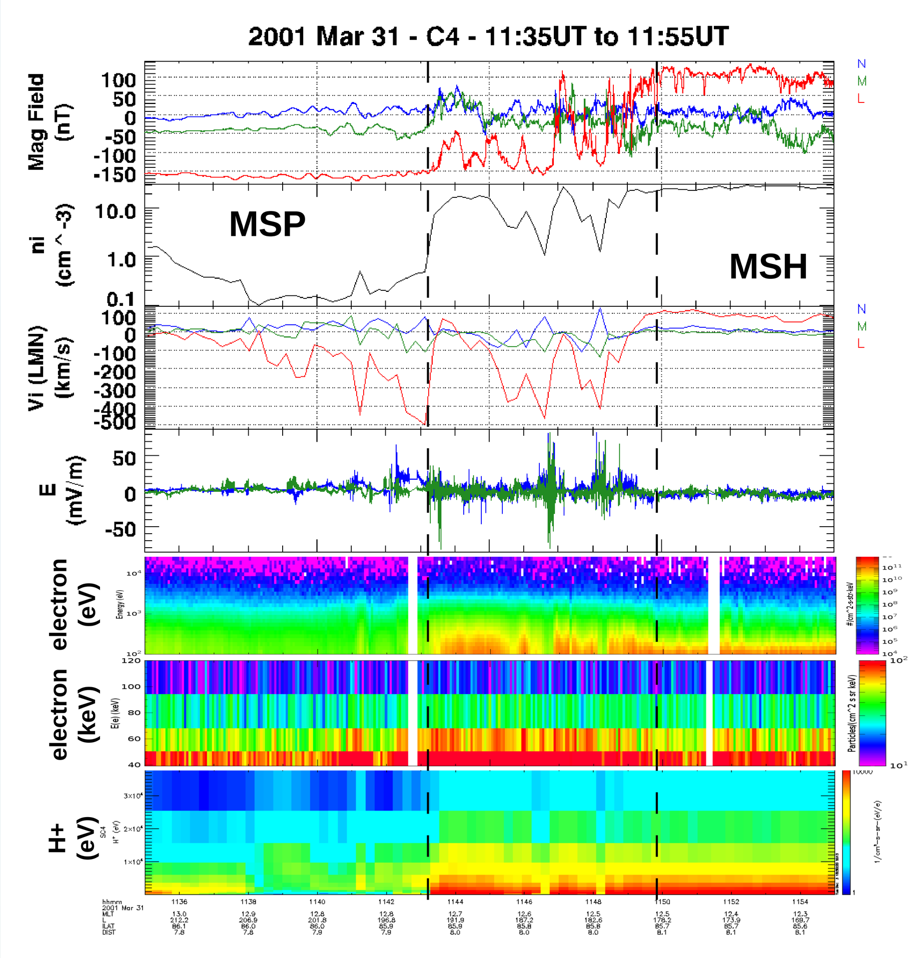
- The purpose of this poster is to investigate asymmetric magnetic reconnection at the magnetopause during magnetic storms. This study focuses on plasma energization. Our research goal is to establish an observational basis for characterizing storm-time, asymmetric reconnection.
- Reconnection at the magnetopause is *asymmetric*, occurring with gradients in plasma parameters such as the density, temperature, and magnetic field strength across the reconnection plane [1,2,3], whereas in *symmetric* reconnection these parameters are equal. During non-storm-time, magnetospheric (MSP) plasma is the most energetic while magnetosheath (MSH) plasma is the least energetic. Magnetopause reconnection can heat MSH plasma [4], but typically not to energies exceeding MSP energies. During the storm-time reconnection events featured in this poster, we find that plasma is most energetic in the exhaust region between the MSP and MSH. The events featured in this study have minimum Dst indexes ranging from -42nT (small storm) to -368nT (massive storm).

Non-Storm-Time Event: Dst ~ -20nT



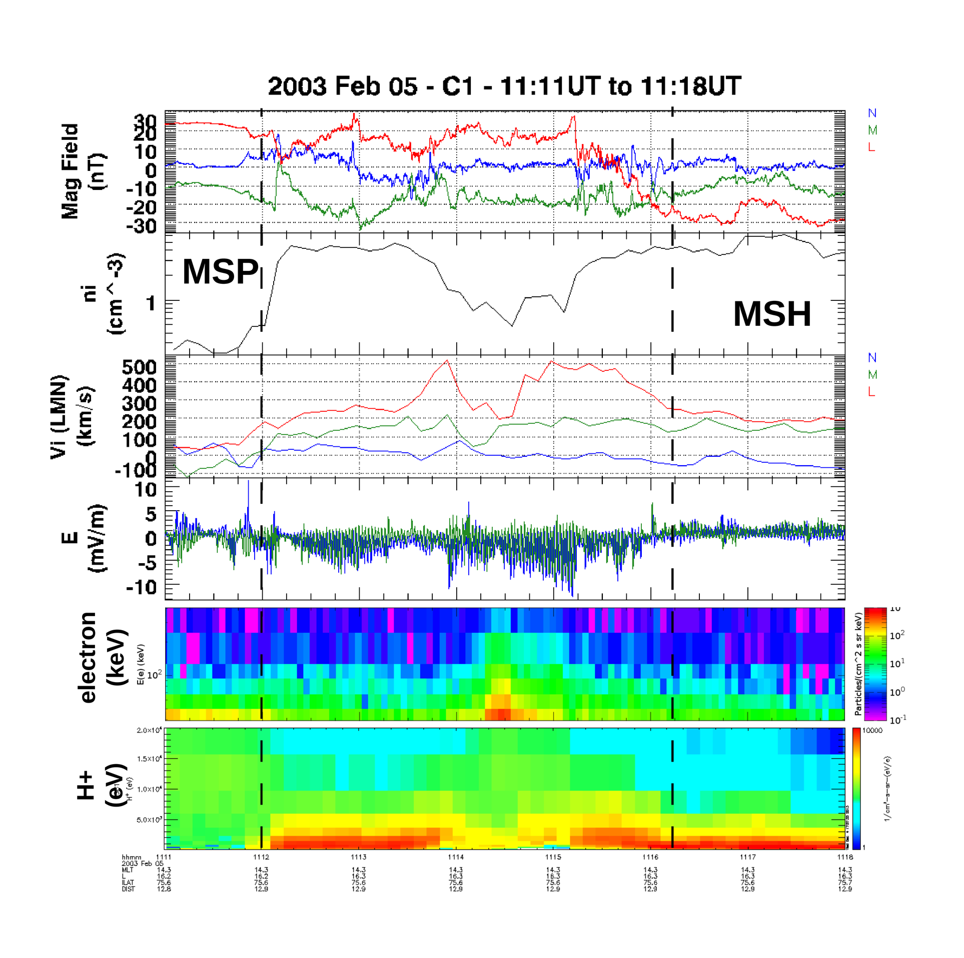
- Density gradient occurs at B_L transition and marks the increase in electron (e-) and ion (H+) energies from MSH to MSP.
- No evidence of plasma energization at magetopause.
- E-fluctuations localized to the H+ flow reversal region and close to the density transition.

Storm-Time Events



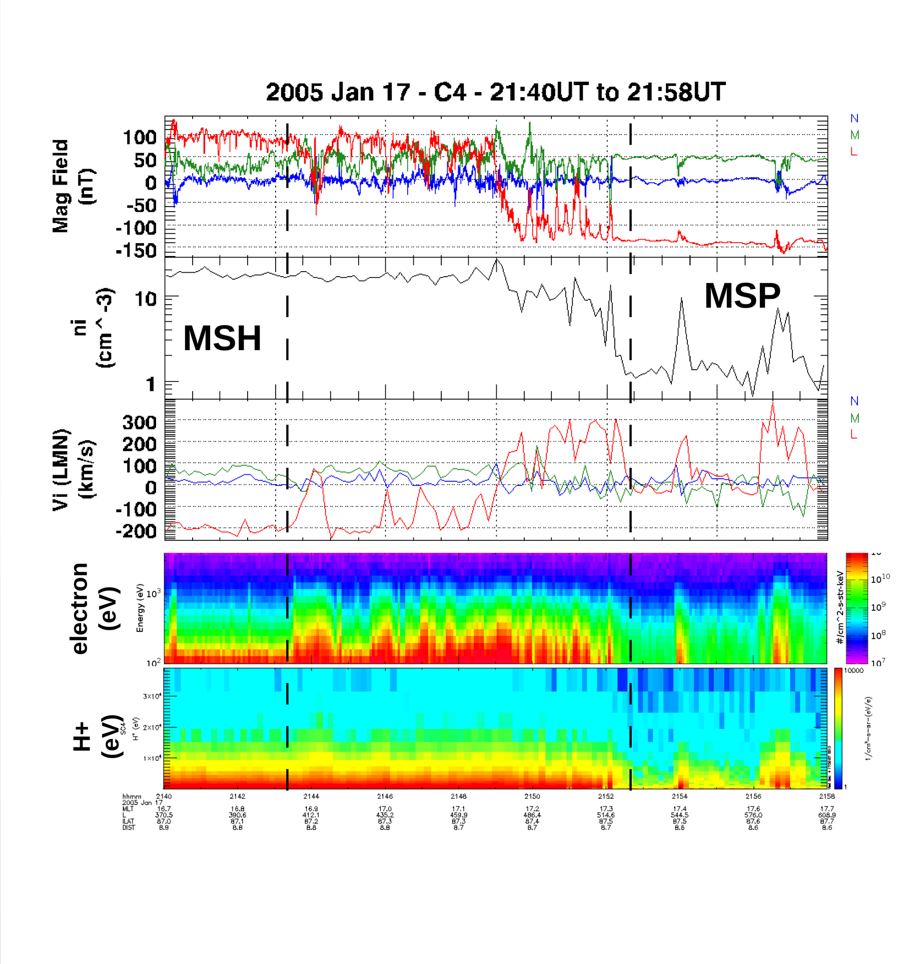
Event 1: Dst ~ -368nT (massive storm, for interplanetary signatures, see [5])

- Plasma energization occurs in region between B_L transition and density gradient.
- Plasma in exhaust region more energetic than both MSP and MSH plasamas.
- Electrons energized (~3 keV) preferentially on the MSP side of the B_L transition toward the density gradient.
- Enhanced 50 keV to 90 keV electron flux.
- H+ energization (~2.5 keV), strongest near density gradient.
- Strongest E-fluctuations throughout exhaust region.



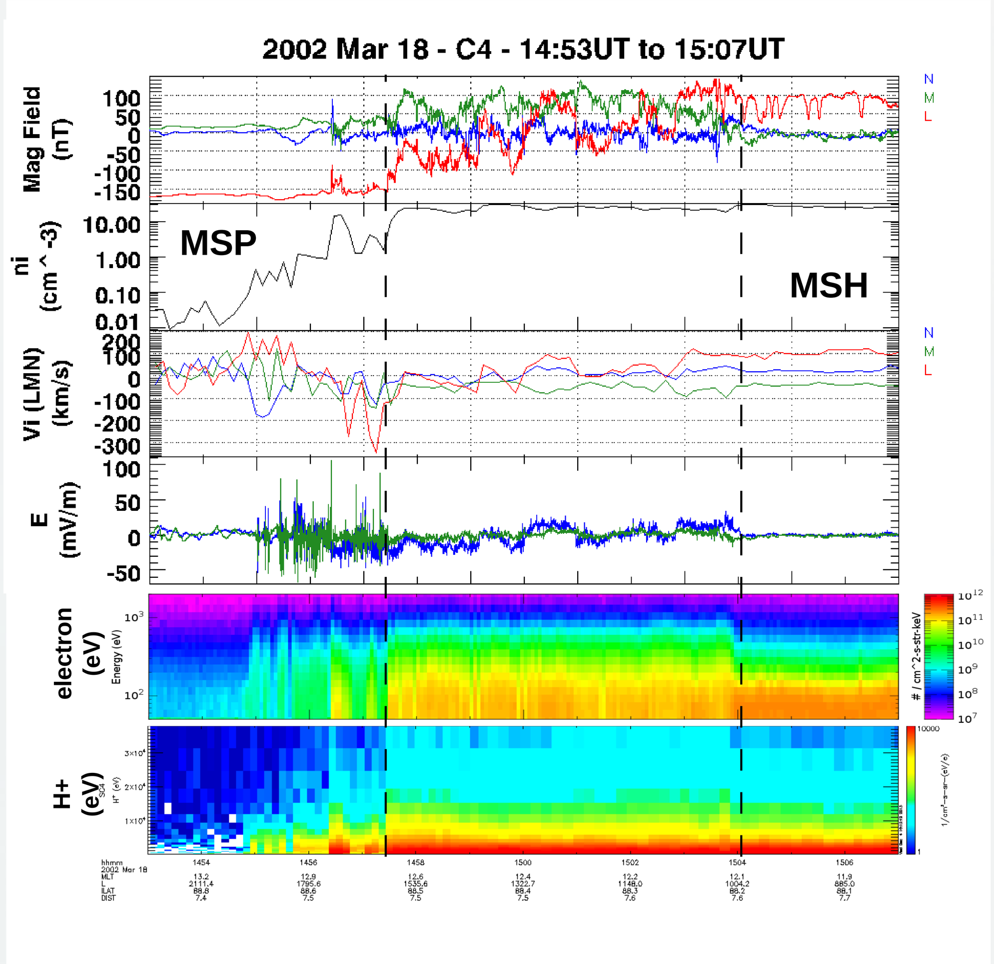
Event 3: Dst ~ -75nT (moderate storm)

- Burst of 300 keV electrons, significantly more energetic than MSP electrons, occurring in a density depletion region.
- 500km/s ion outflow jets in energized exhaust.
- E-fluctuations throughout plasma energization region.
- Enhanced 10 keV ion flux with MSP-like energies at the time of the 300 keV electrons.



Event 2: Dst ~ -122nT (large storm)

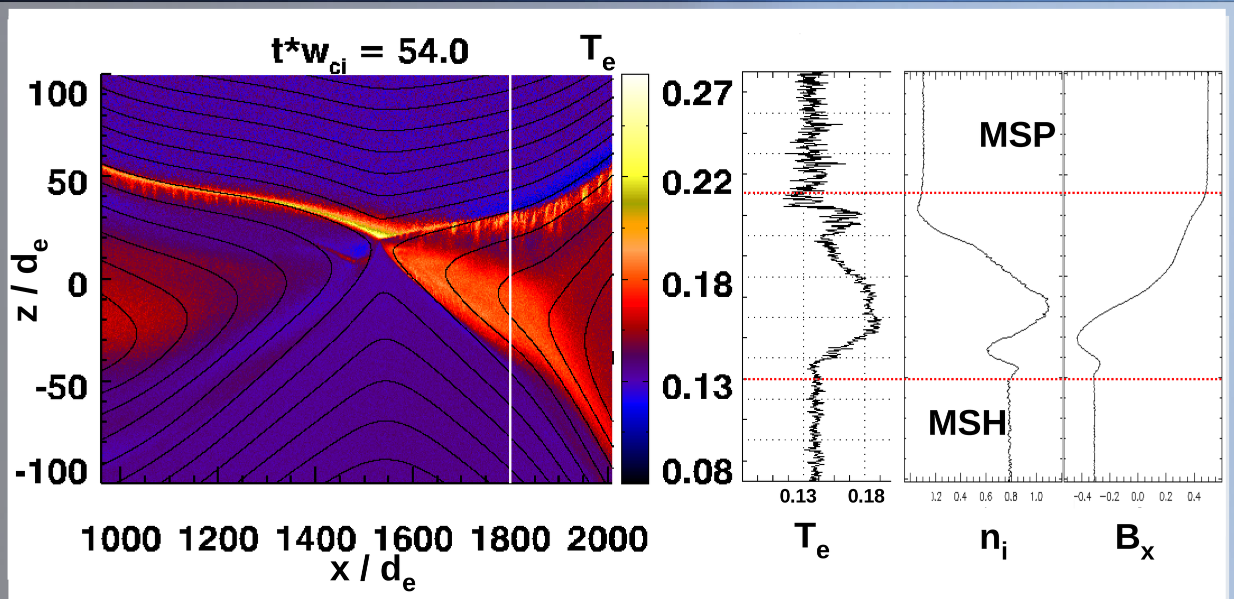
- Plasma energization begins at the density gradient and extends beyond the B_L reversal and flow reversal into MSH.
- Exhaust electrons more energetic than both MSP or MSH electrons.
- B_L transition coincides with the ion flow reversal, occurring on the MSH side of the density gradient.
- Electron energization up to 2 keV, strongest near ion flow reversals.
- Slightly enhanced 40 keV ion flux near flow reversal.



Event 4: Dst ~ -42nT (small storm)

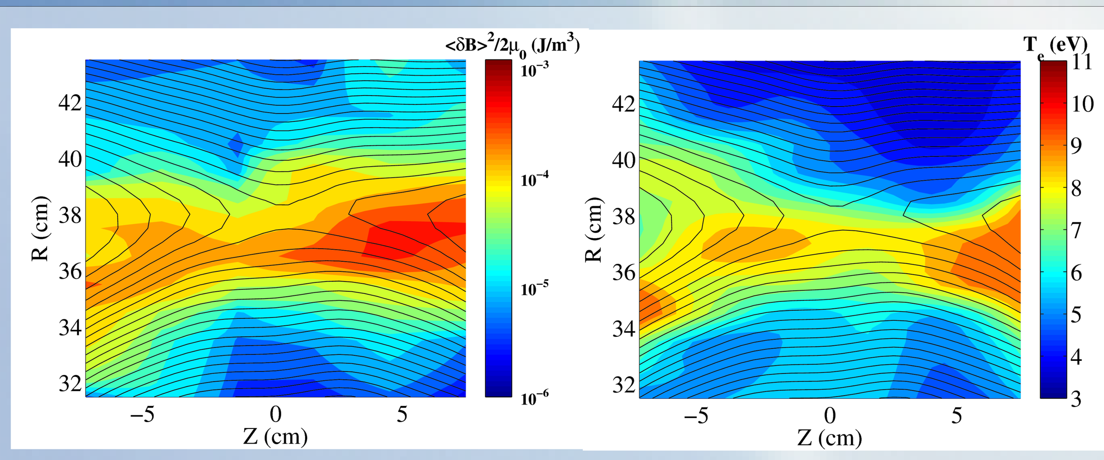
- Electrons energized up to 1 keV, more energetic than both MSH and MSP electrons.
- 40 keV ion flux enhancements strongest near the density gradient and B_L reversals, higher than MSH or MSP ions.
- Plasma energization in region with multiple B_L reversals on the MSH side of the density gradient.
- DC electric field components in energization region.
- Strongest E-fluctuations during ion flow reversal and density transition.

Asymmetric PIC Simulation:



- Electron heating in the entire exhaust during ni and B_x transition.
- Initial upstream asymmetry ratios: $B_{x,MSH} / B_{x,MSP} = 0.7$, $n_{MSH} / n_{MSP} = 10$

Magnetic Reconnection Experiment (MRX)



- Asymmetric reconnection experiment shows electron heating within the entire exhaust.
- Preferential heating on low-density side of B_L transition, consistent with storm-time events.
- Future work to compare B and E fluctuations to spacecraft data.

Conclusions

- During the four storm-time events reported here, electrons in the exhaust region between the B_L transition and density gradient attain energies even higher than MSP electrons, consistent with PIC results, while for non-storm-time events MSP electrons are typically the most energetic [4,6].
- For the most violent storm (Event 1), maximum electron energization occurs close to the density gradient, consistent with MRX results.
- H+ ions are most energetic in the exhaust during storm-time, except for Event 3.

REFERENCES:

[1] Cassak et al., Phys. Plasmas, **16**, 055704, 2009.
[2] Mozer et al., J. Geophys. Res., **113**, A00C03, 2008.
[3] Pritchett et al., J. Geophys. Res., **114**, A11210, 2009.
[4] Phan et al., Geophys. Res. Lett., **40**, 4475-4480, 2013.
[5] Farrugia et al., J. Geophys. Res., **111**, A11104, 2006.
[6] Lindstedt et al., Ann. Geophys., **27**, 4039-4056, 2009.

ACKNOWLEDGEMENTS:

Research at UNH is supported in part by NSF grants PHY-0903923 and AGS-1202537. We wish to thank CIS, FGM, EFW, and PEACE teams and the ESA Cluster Active Archive for providing data.