Outstanding Issues from Our Last Meeting at Berkeley

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PPPL

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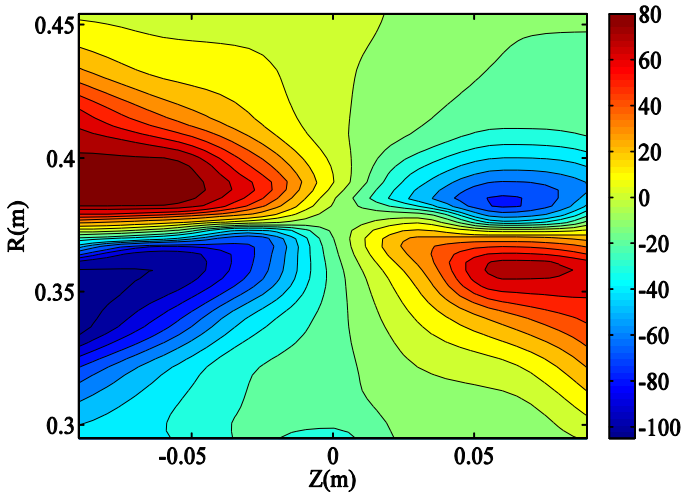
Frontier of Collisionless Reconnection Research

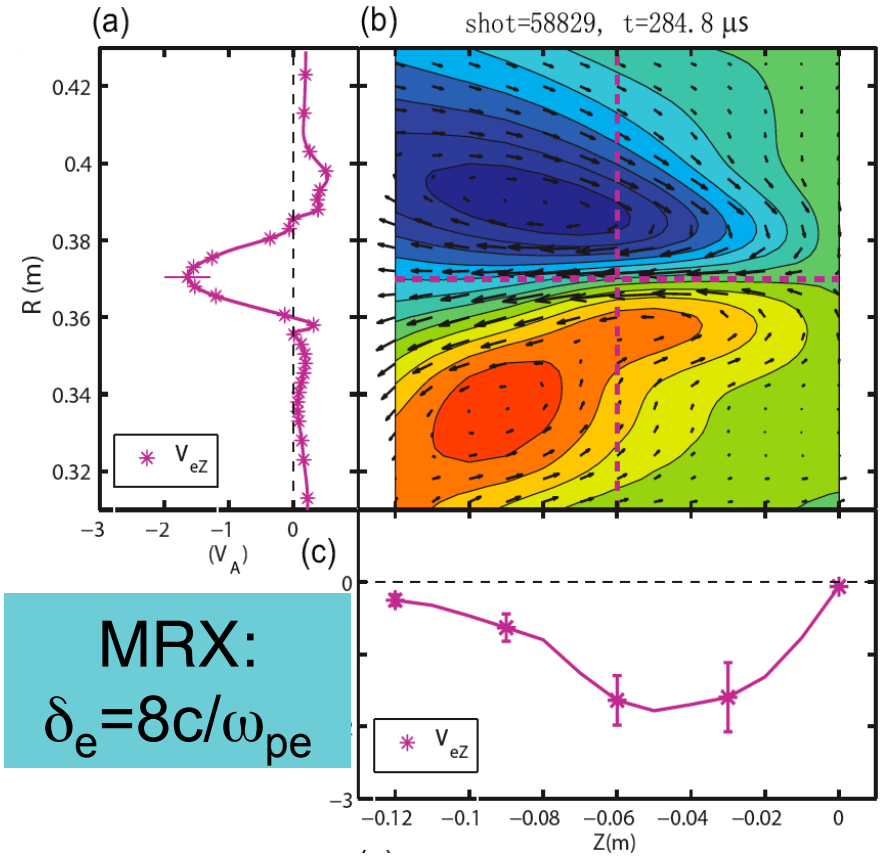
- Collisionless reconnection is dominated by two-scale dynamics: ion scale (c/w_{pi}) and electron scale (c/w_{pe}).
- Ion-scale physics largely understood around X-line.
- Electron-scale physics is the current frontier, a subject to be studied by MMS.



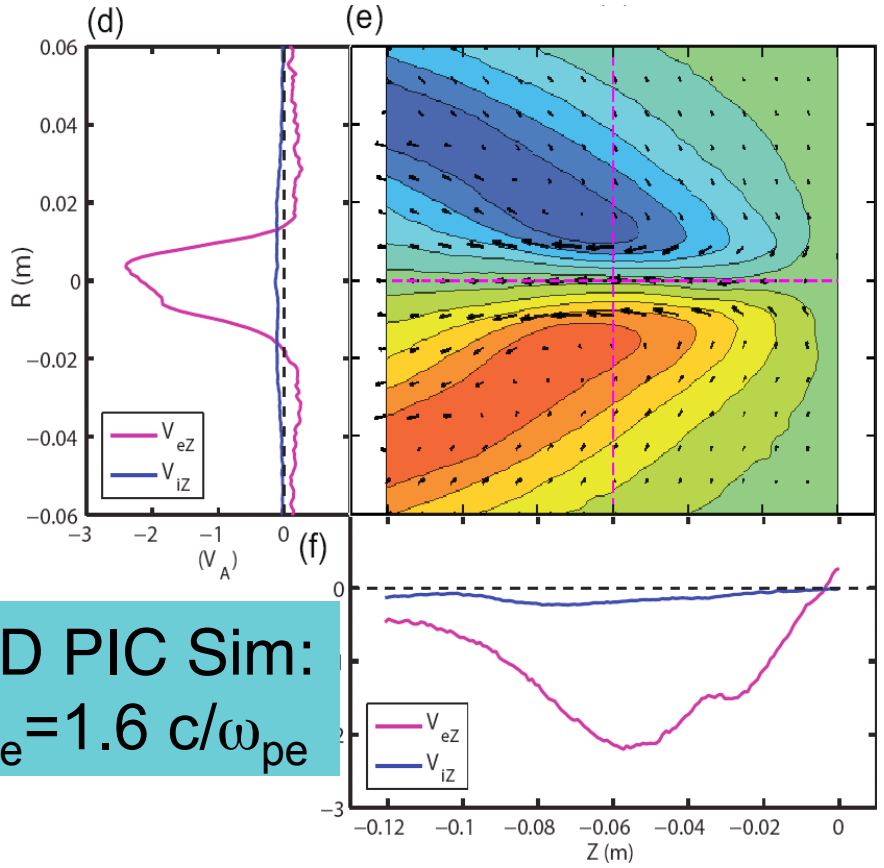
Yoo & Yamada, JGR (2012)

All Ion-Scale Features Are Reproduced By 2D PIC Simulations…

Ji et al. GRL (2008); Dorfman et al. PoP (2008); Roytershteyn et al. PoP (2010)



MRX: $\delta_e = 8c/\omega_{pe}$

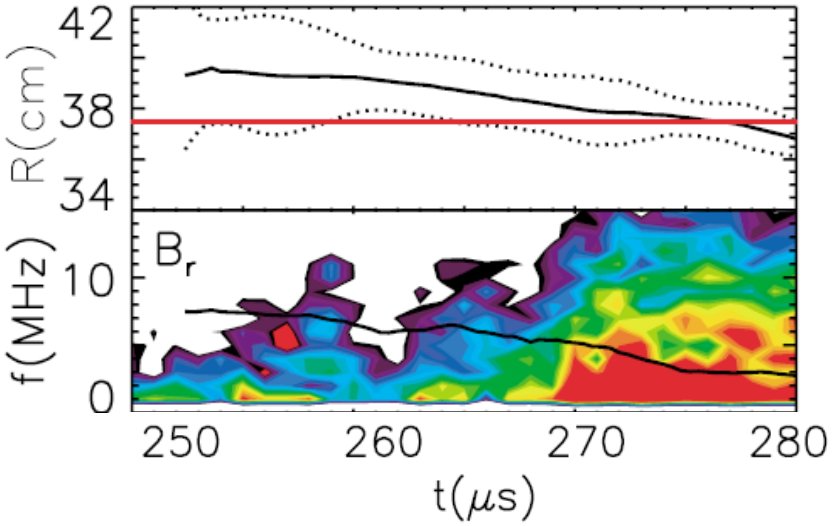


2D PIC Sim: $\delta_e = 1.6\ c/\omega_{pe}$

… but not on electron scales ➔ 3D effects!

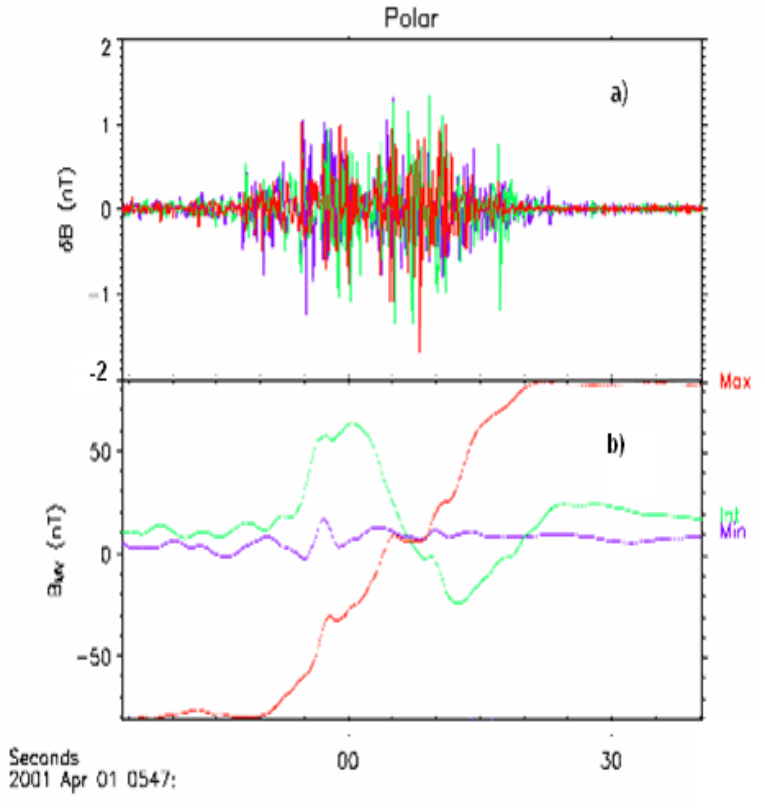
Electromagnetic Fluctuations Observed at the Current Sheet Center

MRX



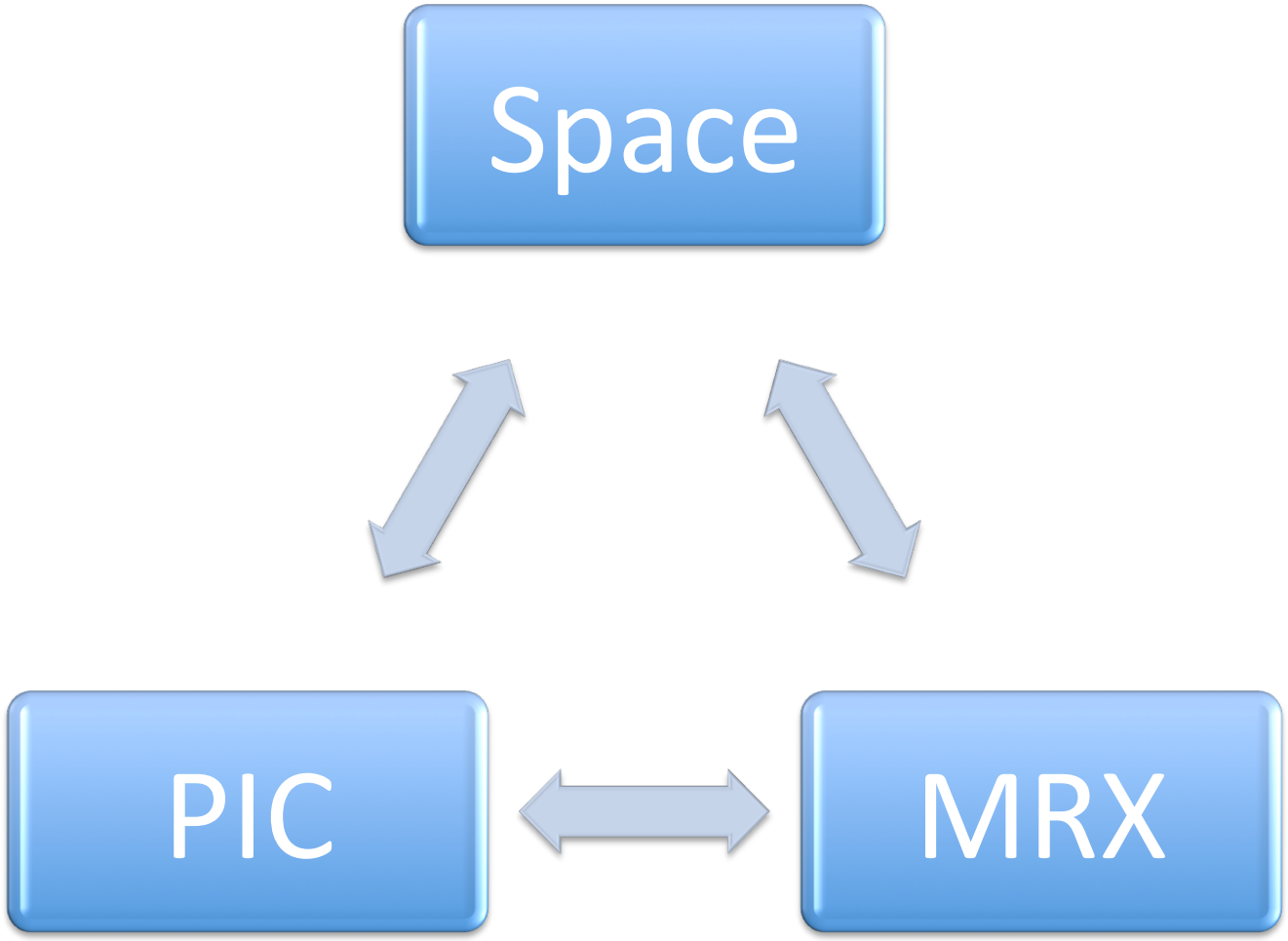
Ji et al. PRL (2004)

Polar Satellite



Bale et al. (2004)

Truly Collaborative Research Approaches



Major Questions: Electron Scale Dynamics around X-line

- What determines the electron layer thickness?
- What are the observed waves?
- Are these waves responsible for the thickened layers?
- How do particles get heated?
- How does a finite guide field change answers to the above questions?

Major Questions: Electron Scale Dynamics around X-line

2 years later:

- What determines the electron layer thickness?
- What are the observed waves?
- Are these waves responsible for the thickened layers?
- How do particles get heated?
- How does a finite guide field change answers to the above questions?

Publications

- 3 PRLs
  - Oieroset et al. 2011
  - Roytershteyn et al. 2012
  - Tharp et al. 2012
- 1 GRL
  - Dorfman et al. 2012 (submitted)
- 3 JGRs
  - Mozer et al. 2011
  - Pritchett et al. 2012
  - Yoo & Yamada 2012
- 4 PoPs
  - Roytershteyn et al. 2010
  - Mozer et al. 2011
  - Ji & Daughton 2011
  - Roytershteyn et al. 2012 (submitted)
- 1 Ph.D. Thesis
  - S. Dorfman (2011)

I. Current Sheet Dynamics

Simulation:

- Study effects due to probe
- Study wave characteristics and impact on reconnection, w/ and w/o collisions, in 3D symmetric and asymmetric reconnection
- Flux rope dynamics
- Measure the thickness as a function of the distance from the X-line in the outflow direction, in both 2D and 3D simulations

MRX:

- Study probe effects by measurements with and without a second probe nearby
- Obtain profiles by fast sweeping current sheet across probes
- Re-measure wave dispersion and compare to simulation
- Improve diagnostics for current sheet dynamics, including flux ropes
- Identified 3D current sheet disruption due to flux rope ejection as a cause of impulsive reconnection
- Flux rope dynamics
- Revisit electrostatic fluctuation measurements
- Explore high-f fluctuation measurements

Space:

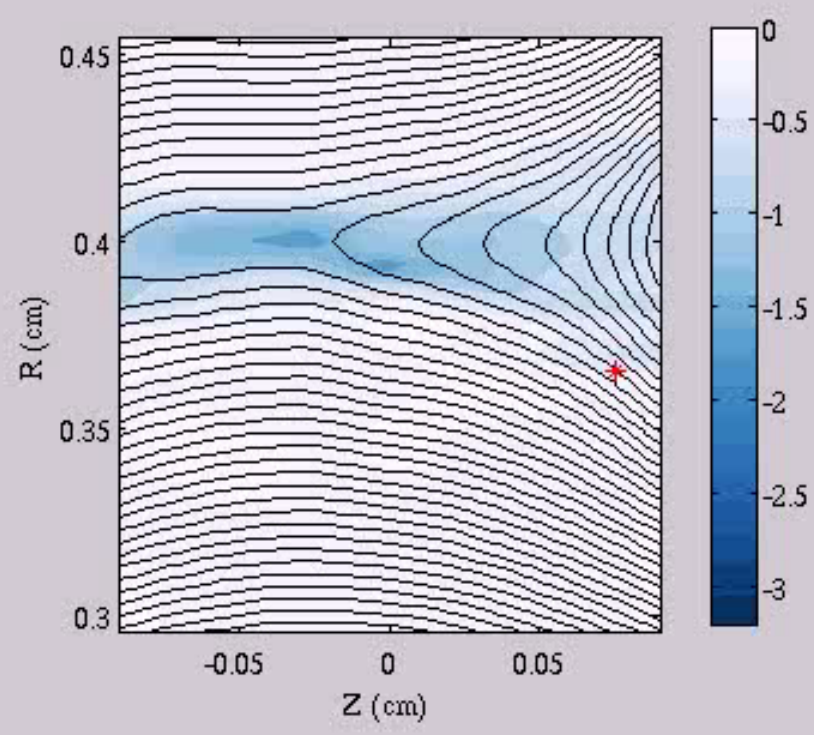
- Determine dependence of wave characteristics on local parameters, including reconnection electric field
- Geotail's best case: E_nongyrotropic can support E_reconnection?
- Wait/search for lucky events for satellites crossing current sheet near the X-line

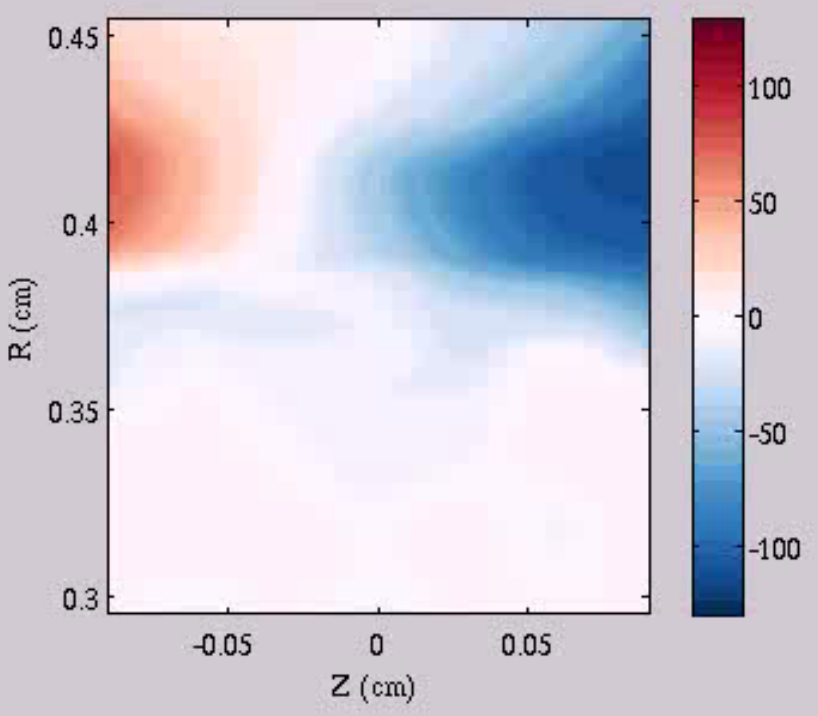
Resolution 1: Waves identified as long wavelength EM LHDI
Resolution 2: Waves can't support Ey or can't explain CS thickening

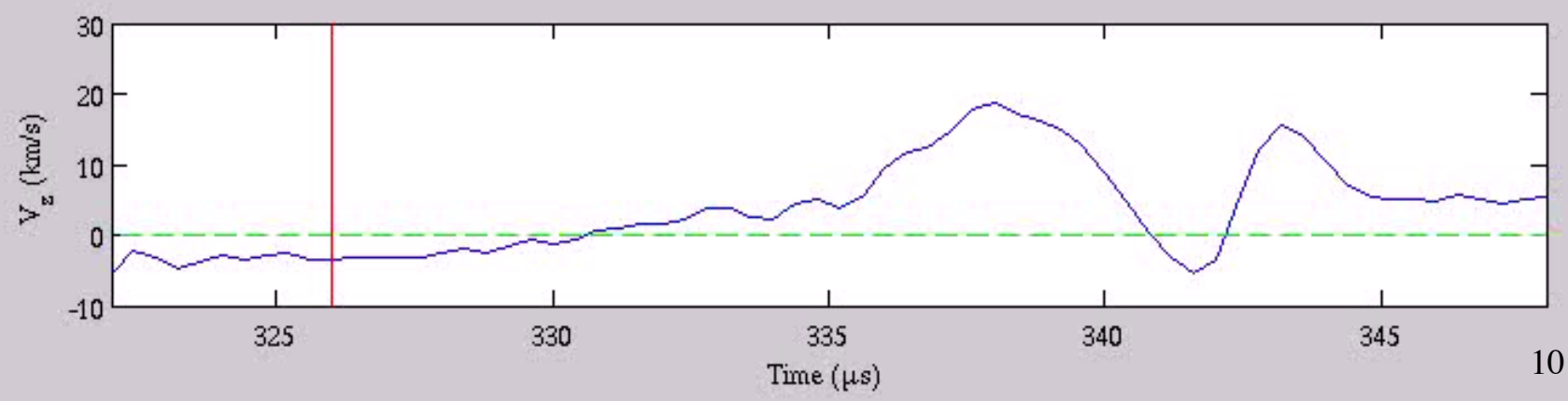
Hypothesis 1: Flux rope dynamics explain CS thickening
Hypothesis 2: "X-line spreading" + flux ropes explain impulsive rec.

Flux Rope Dynamics

J. Yoo (2012)







II. Electron and Ion Heating

Simulation:

- Include collisions

MRX:

- Improve Te measurements by revised Langmuir probes
- Spectroscopic measurements of neutral particle energy
- Improve Ti by revised IDSP and flow measurements by Mach probe
- Explore Te measurements by UV/EUV measurements

Space:

- Waves heating of ions and electrons
- Systematically determine the dependence of electron and ion heating/ acceleration on local parameters during reconnection

Hypothesis 1: waves important for (electron) heating
Hypothesis 2: potential structure important for ion heating

III. Guide Field Effects

Simulation:

- In a small system in MRX geometry
- Guide field enhancement in H. Karimabadi et al (1999)
- Guide field enhancement simulated by Huang and Bhattacharjee (2011)

MRX:

- Establish systematic dependence of reconnection rate, diffusion region structure, on guide field strength.
- Guide field enhancement detected
- Dependence of waves, heating/acceleration on guide field

Space:

- Guide field enhancement detected but with density depletion
- Systematically determine the dependence of reconnection rate, waves, electron and ion heating/acceleration on guide field strength

Resolution: guide field slows down reconnection
Hypothesis: global dynamics explain guide field enhancement