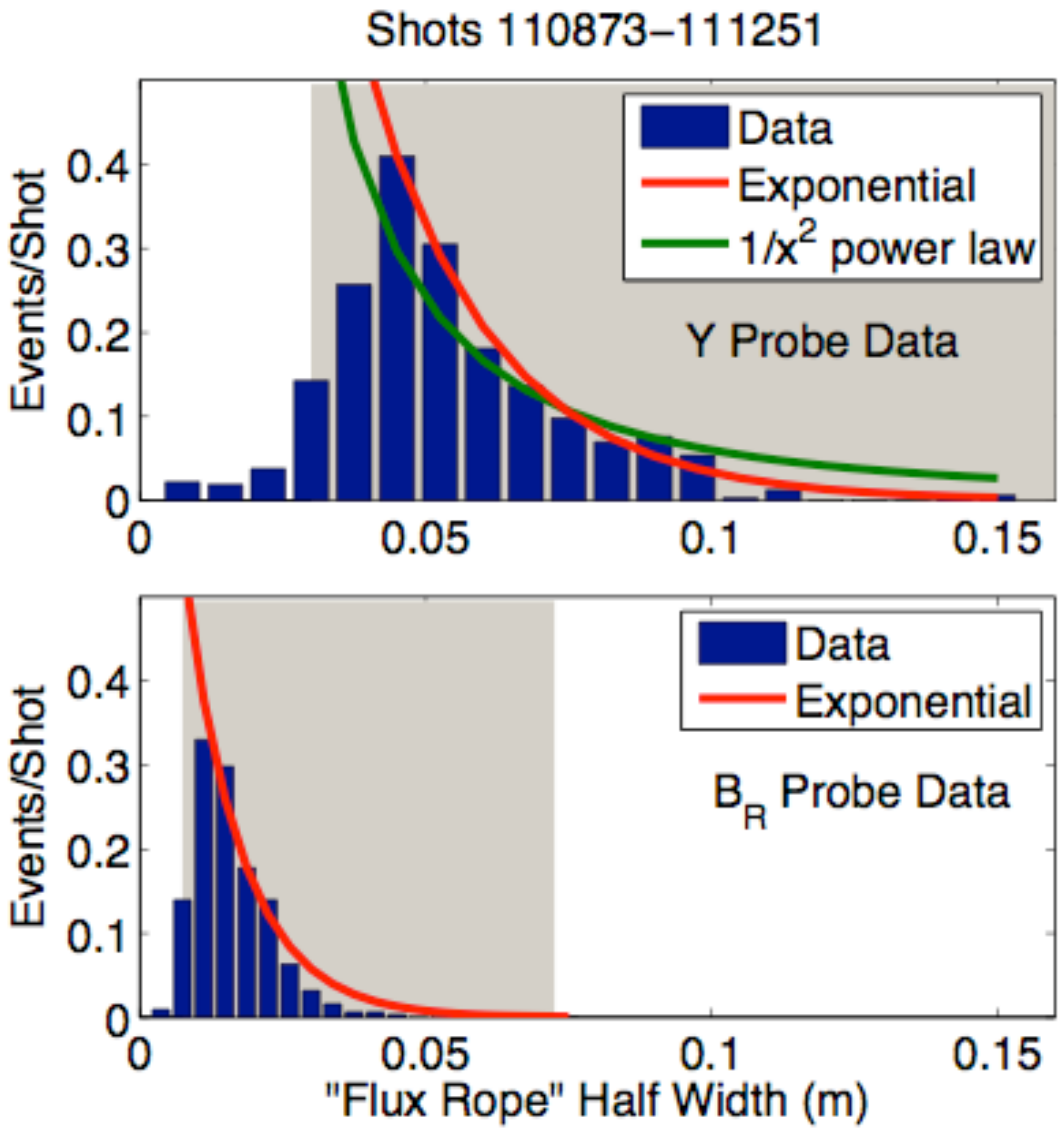
Planned Experiments on Reconnection

- Electron and ion heating
  - Guide field dependence
- Flux rope dynamics
  - Scan distance between 2 y planes
  - Guide field dependence
  - Statistics
- Electron acceleration (energetic tail?)
- Reconnection in partially ionized plasmas
- Solar flux rope experiment (C. Myers)
- Large Reconnection Experiment (LRX)

Statistics of Flux Rope Dynamics



Uzdensky et al. (2010):
1/x^2

Fermo et al. (2010):
exp(-x)

Huang & Bhattacharjee (2012):
1/x

S. Dorfman (2011)

Reconnection in Partially Ionized Plasmas

H. Ji, E. Lawrence, M. Yamada, and J. Yoo

Goals:

(1) To study the effects of partial ionization on magnetic reconnection
(2) To develop collaborations with solar physicists
(3) To submit a successful proposal to NASA

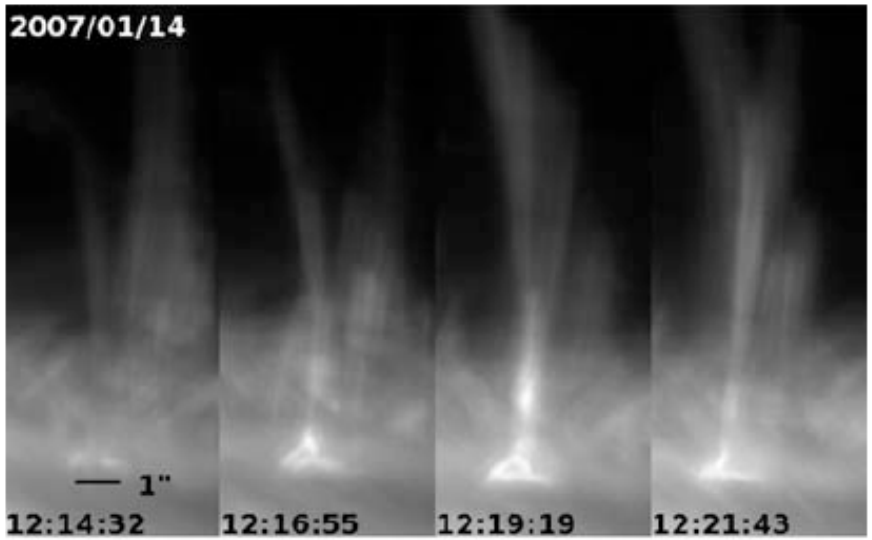
Progress:

(1) Neutrals do not alter the Hall current
(2) Neutrals slow reconnection due to slower outflow***
(3) Established collaborations with solar physicists
(4) Submitted a proposal to NASA Solar SR&T Program
(5) Submitted a paper to PRL (Lawrence et al. 2012)

Solar chromosphere is a dynamic place for magnetic reconnection

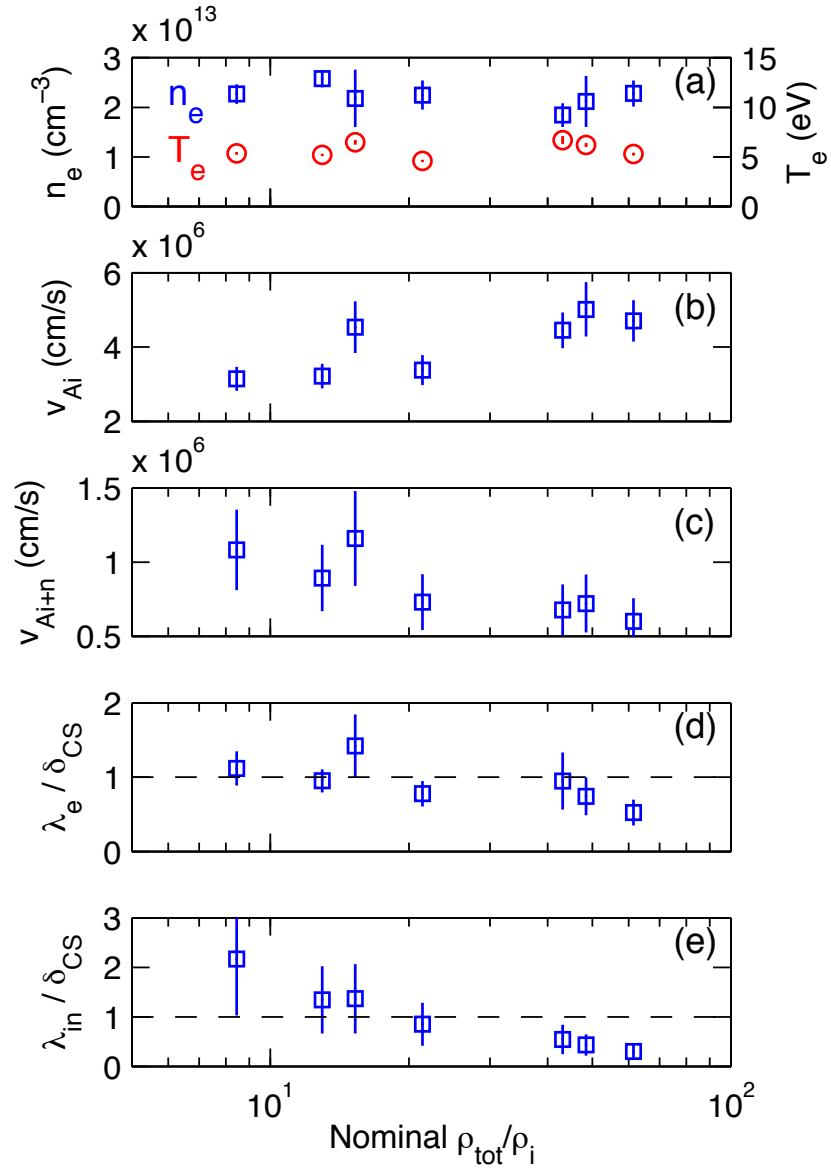
- Plasma is partially ionized (<1%)
- Corona-ward plasma jets are constantly observed, carrying sufficient energy for corona heating
- But how reconnection takes place in partially ionized plasmas? Faster due to e-n collisions or slower due to slower ion outflow?

Shibata et al., Science (2007)



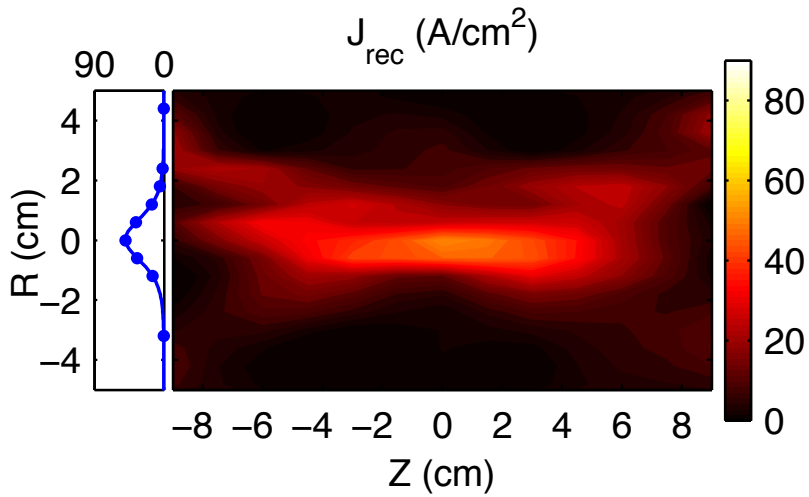
A Wide Range of Ionization Is Accessible

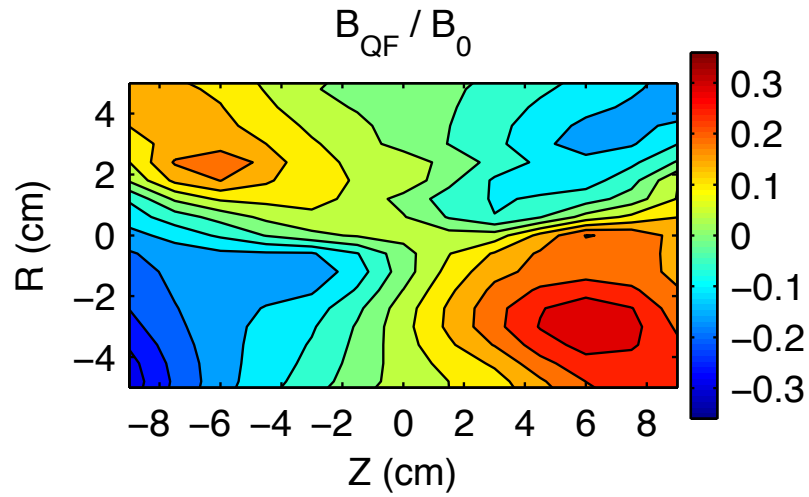
- Developed neutral density measurements spectroscopically
- Electron density and temperature kept constant
- Ions from uncoupled with neutrals to coupled



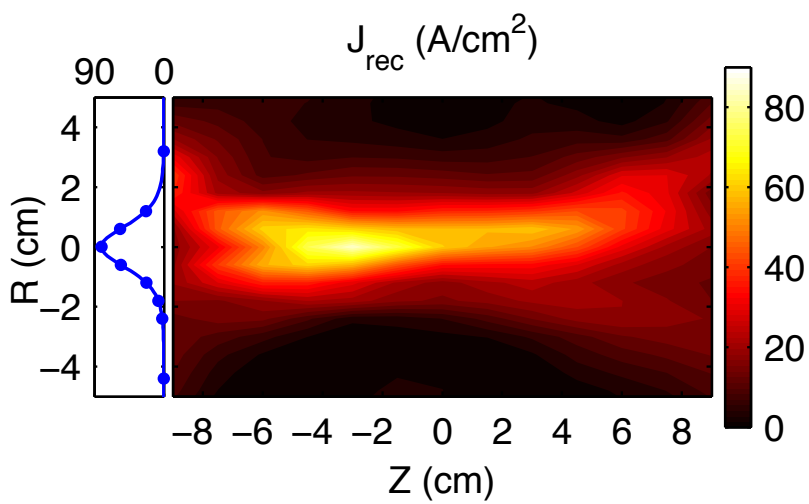
Current sheet and out-of-plane B field unaffected

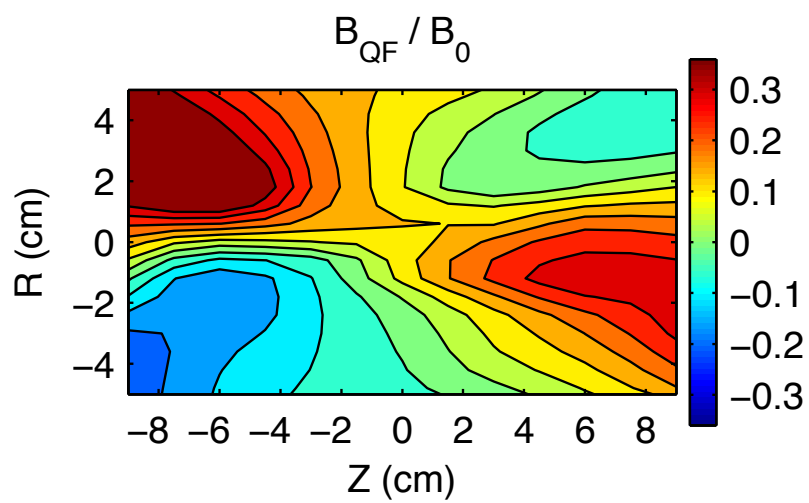
Ionized case (n_i/n_n~12%; η_{en}~0.5η_{ei}; ν_{en}, ν_{ei}<<ν_{ce})



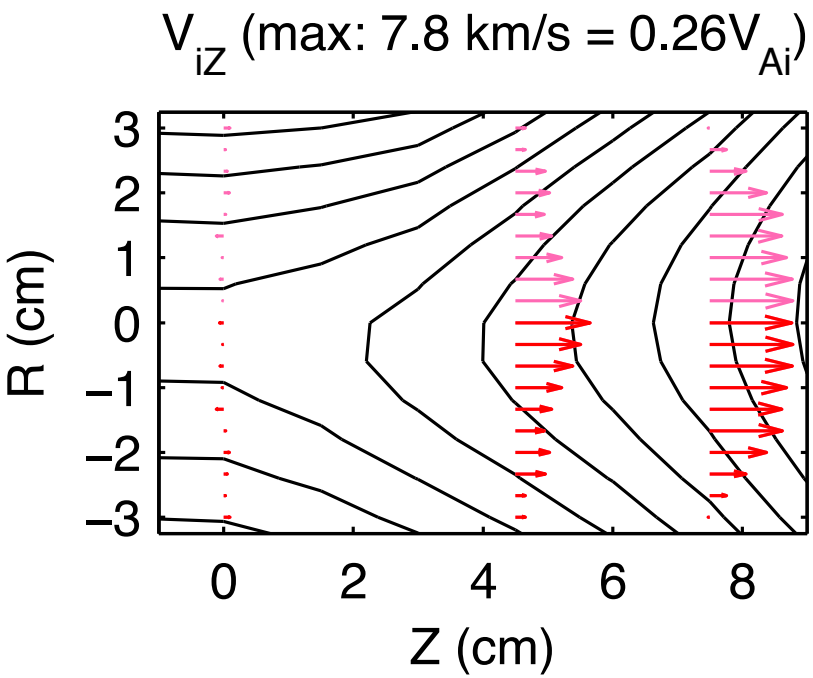


Weakly ionized case (n_i/n_n~0.9%; η_{en}~η_{ei}; ν_{en}, ν_{ei}<<ν_{ce})

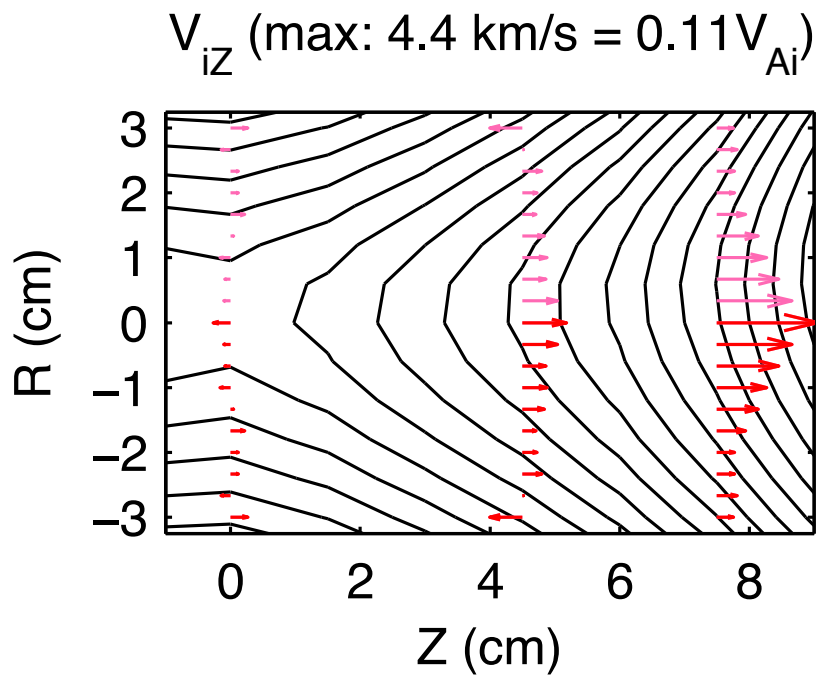




2D Ion Outflow Profiles

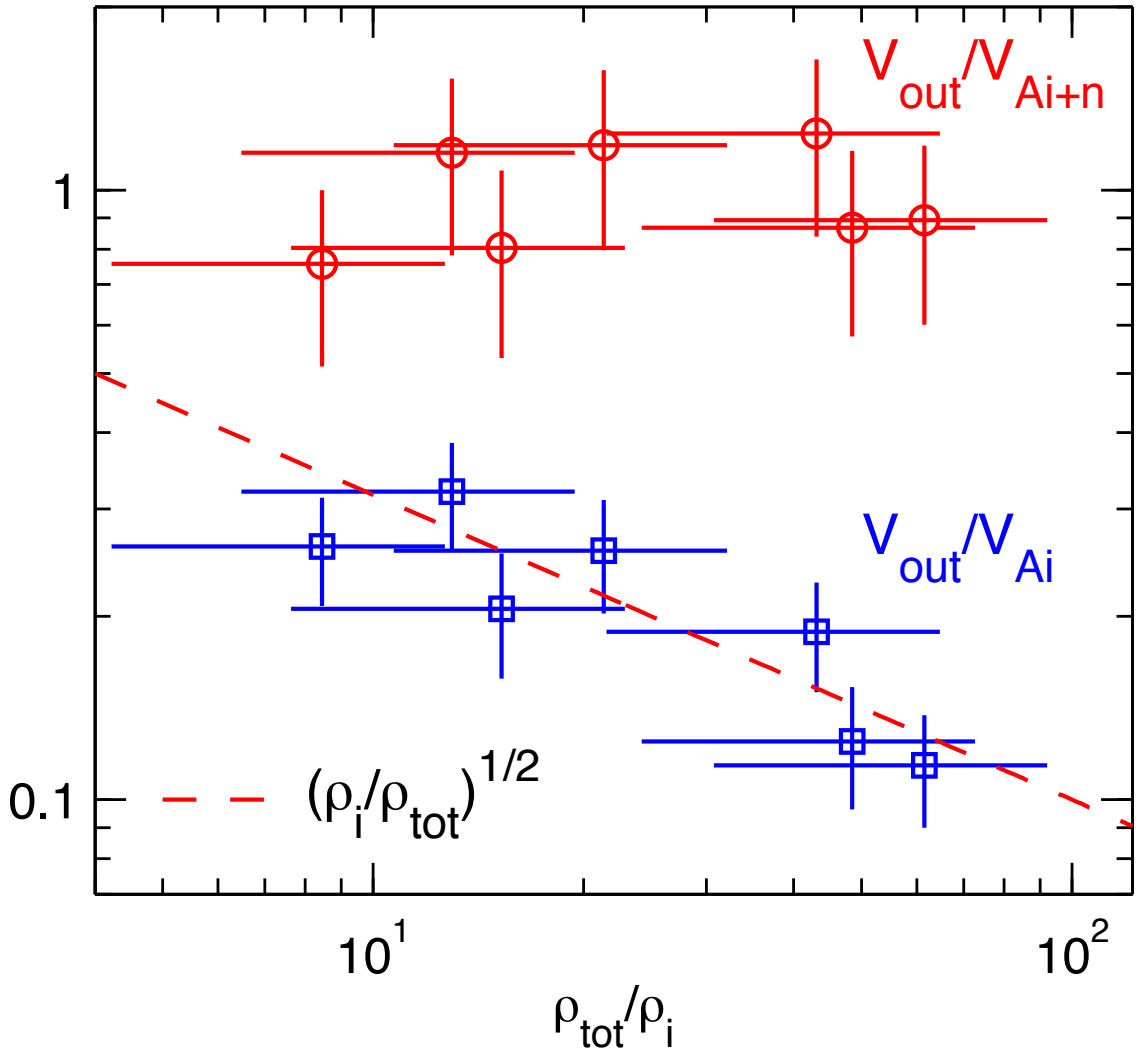


Ionized case (n_i~2×10^{13} cm^{-3}; n_i/n_n~12%; L/λ_{in}~0.5)

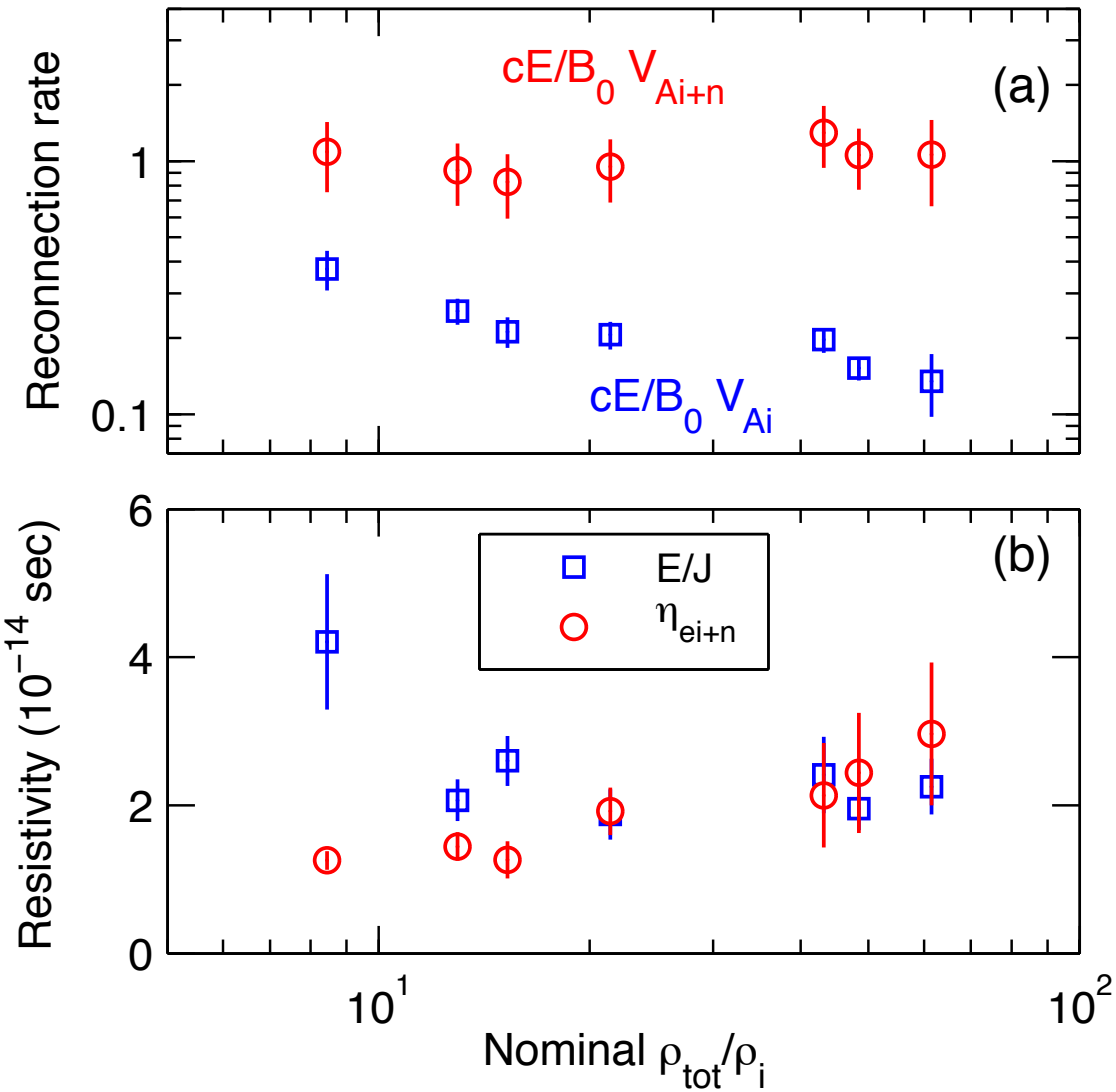


Weakly ionized case (n_i~2×10^{13} cm^{-3}; n_i/n_n~0.9%; L/λ_{in}~50)

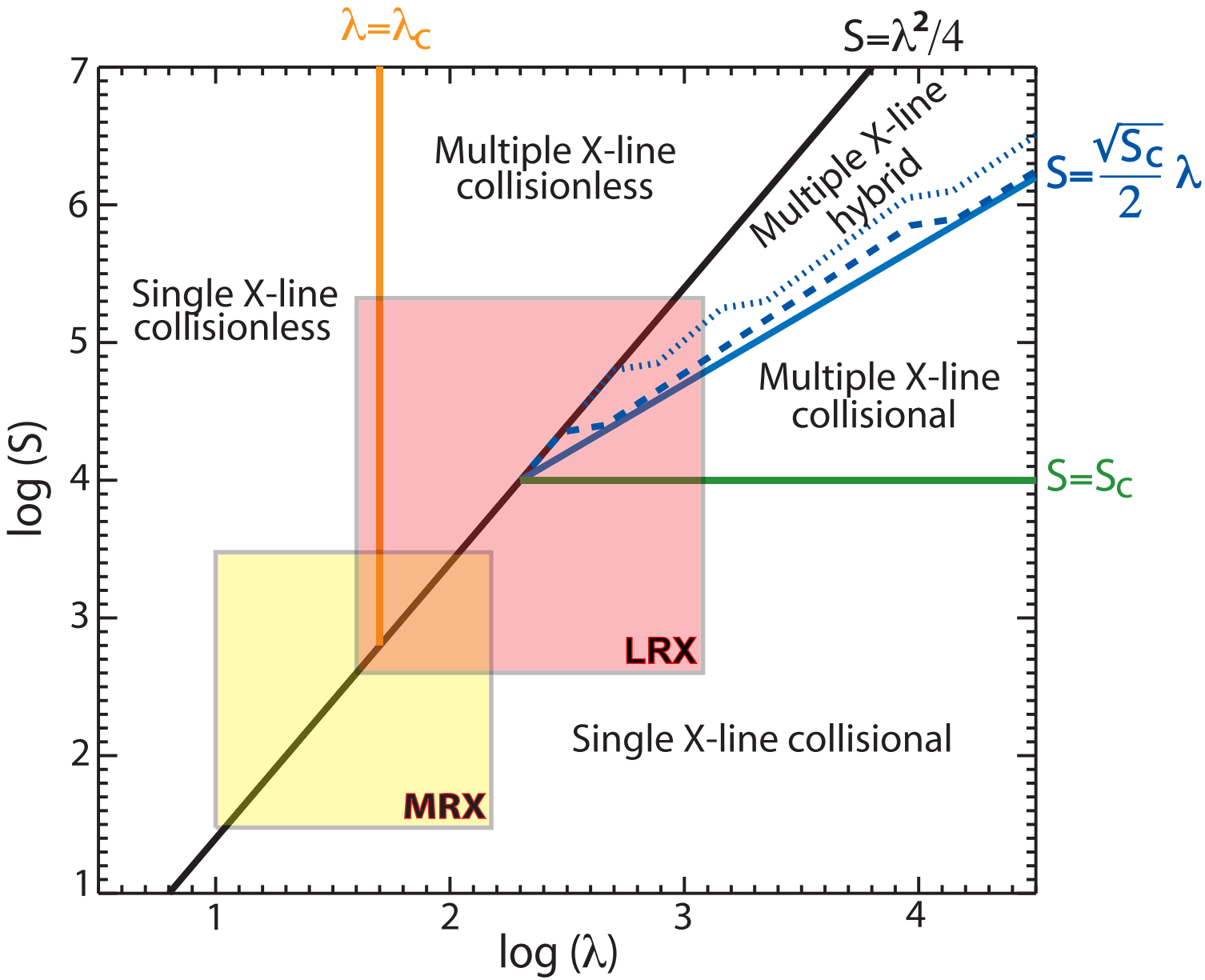
Ion outflow speed is reduced to Alfvén speed based on total (ion+neutral) mass density.



Reconnection rate is reduced due to lower ion flux, and is independent of resistivity: ions control reconnection rate



New Phases Provide Access to Astrophysical Reconnection

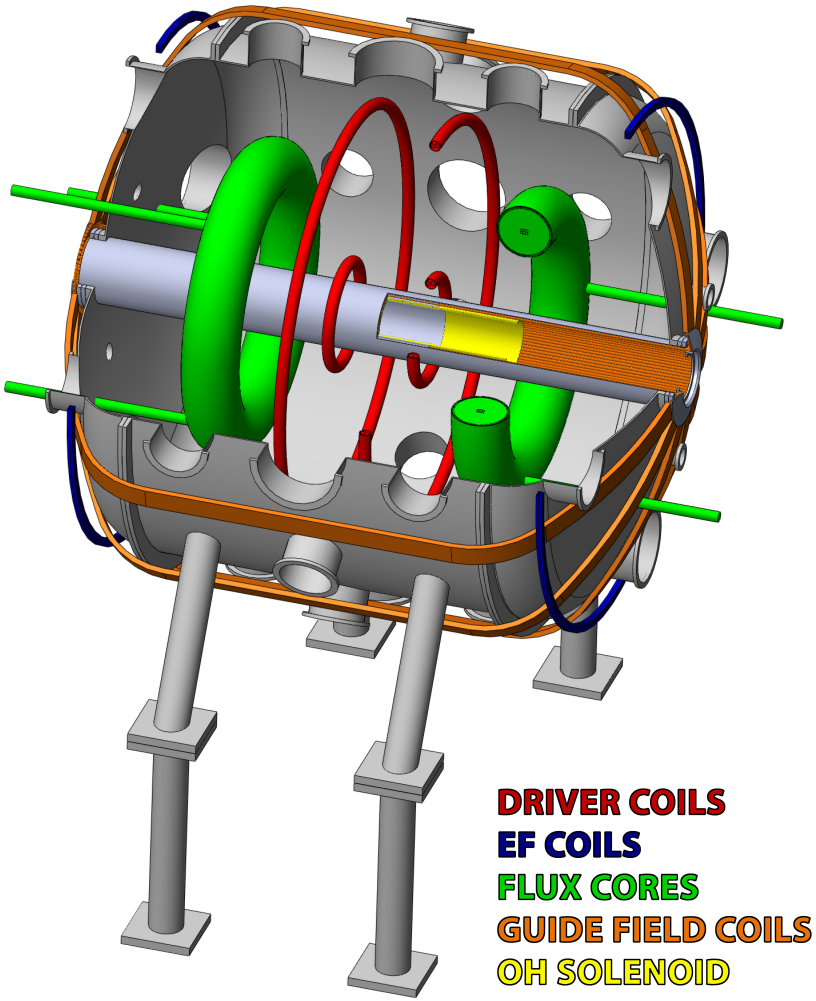


Large Reconnection Experiment (LRX)

- Justifications:
  - A small number of in-situ measurements in magnetosphere
  - Inability to resolve kinetic scales in solar and astrophysical plasmas
  - Limited diagnostic accessibility in laboratory fusion plasmas
  - Inability to use realistic parameters in numerical simulations
  - Small scale separations in existing laboratory experiments

- LRX can provide access to new regimes ($S=10^5$, $\lambda=10^3$) and with sufficient diagnostics capabilities

- Large-scale computation is a necessity

Conceptual Design Complete

Parameters	MRX	MRX-U
Device diameter	1.5 m	3 m
Device length	2 m	3.2 m
Flux core diameter	0.75 m	1.5 m
Stored energy	25 kJ	4 MJ
Plasma heating	No	OH (10MW)
S (anti-parallel)	600-1,400	5,000-16,000
$\lambda=(Z/\delta_i)$	35-10	100-30
S (guide field)	2900	100,000
$\lambda=(Z/\rho_S)$	180	1,000