The need for a next generation reconnection experiment

The successes of ongoing dedicated reconnection experiments

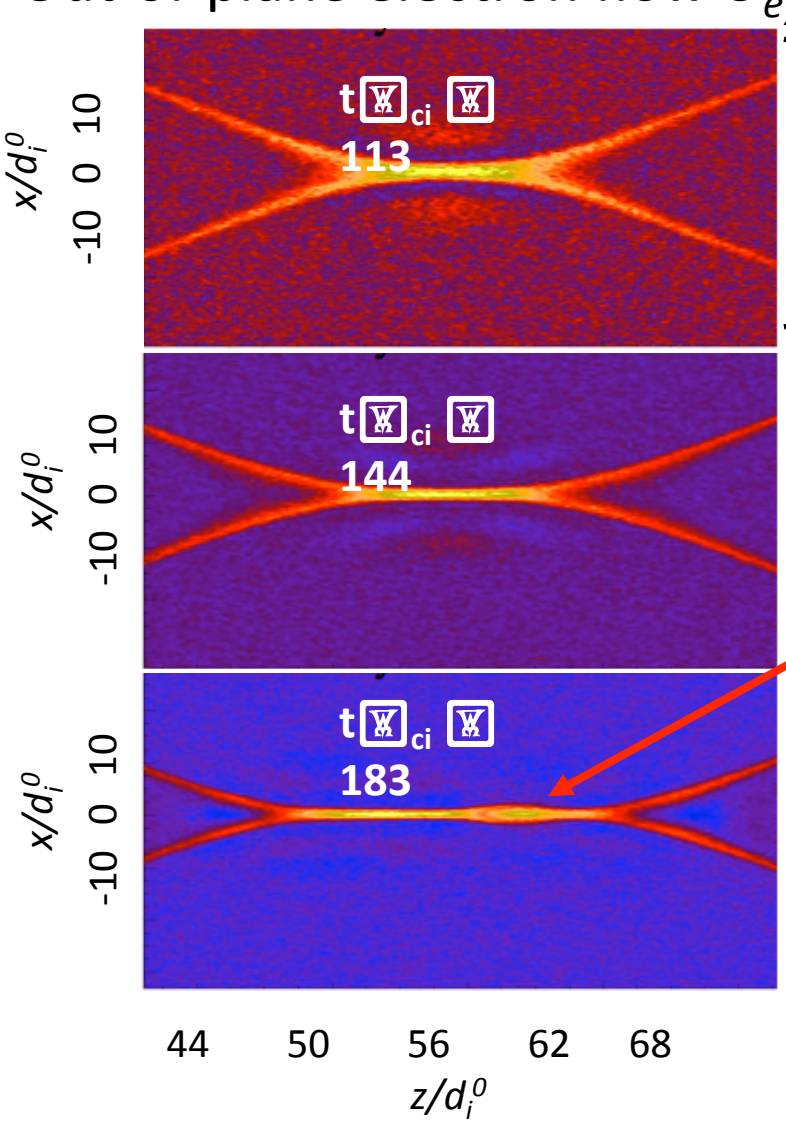
- The existing dedicated laboratory reconnection experiments have made major contributions to the physics basis of reconnection
  - Explored the transition from collisional to collisionless reconnection
  - Studied the structure of the Hall magnetic fields and the reconnection driven current layer
  - Ongoing exploration of the role of turbulence in the dissipation region
  - Contributed evidence of ion heating in reconnection outflows

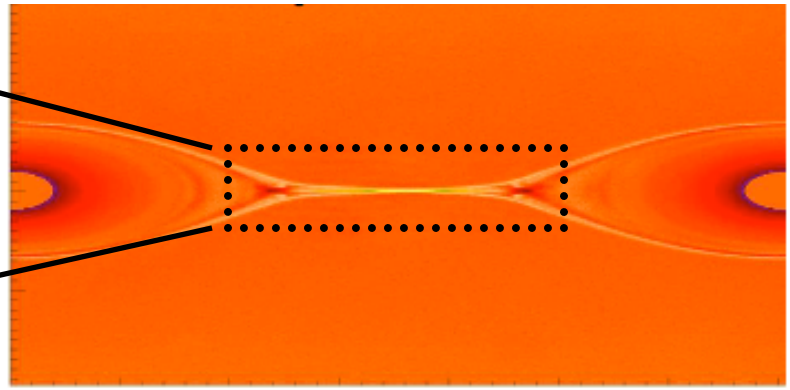
Scientific needs for a new experiment

- Because of size constraints existing experiments have been unable to explore key scientific issues
  - What is the structure of the boundary of the reconnection exhaust?
    - It a slow-mode shock as predicted by Petschek?
    - Simulations do not reveal a “switch-off” shock. Why?
    - Satellite observations have not resolved the issue.
  - How are electrons and ions heating in the outflow exhaust?
    - A key issue for understanding particle heating
    - Does a slow shock or a pickup mechanism cause the temperature jump in the outflow exhaust?
  - What controls the length of the dissipation region in the collisionless regime?
    - Some models suggest that secondary islands limit the length of the diffusion region
    - Others suggest that secondary islands are not necessary
    - Present experiments are too constrained to study multi island reconnection

What is the role of secondary islands in limiting the dissipation region?

Out-of-plane electron flow U_{ey}





- Layers continuously elongate, eventually become unstable against plasmoid formation

- Other simulations reveal steady reconnection with no secondary islands
- Need guidance from reconnection experiments

Scientific needs for a new experiment (cont.)

- Because of size constraints existing experiments have been unable to explore key scientific issues
  - Broad theoretical agreement that reconnection with a guide field intrinsically leads to multi-island interactions
  - Understanding the remarkable efficiency of particle acceleration during reconnection requires the exploration of particle dynamics in a multi-island system
  - Simulations are at present severely constrained because of the 3-D kinetic nature of the problem
  - It is doubtful that satellite observations alone will provide the necessary data
- Need a dedicated experiment of sufficient size and the right geometry to explore the multi-island regime and associated particle acceleration

Moving forward on a national level reconnection experiment

- An experiment to address multi-island issues and particle heating and acceleration would require significant resources
  - Should be a national facility
- Propose the formation of a national study group to explore the geometrical options and size requirements for a multi-island reconnection experiment
  - The first task would be to articulate the scientific need for such an experiment
  - An innovative design would be necessary to make the best use of resources
  - Similar to NASA's Science Definition Team for proposed satellite missions
- A critical question course is who would fund such an experiment

Key recommendations of the recent NAS study Plasma 2010

"A new generation of reconnection experiments at large scale will be critical to further progress in this important area"

"The plasma physics community and relevant federal government agencies should initiate a periodic evaluation and consultation process to assess the need for, and prioritization of, new facilities to address basic plasma science at the intermediate scale."