Insights from 3D Kinetic Simulations
+
Observational Constraints

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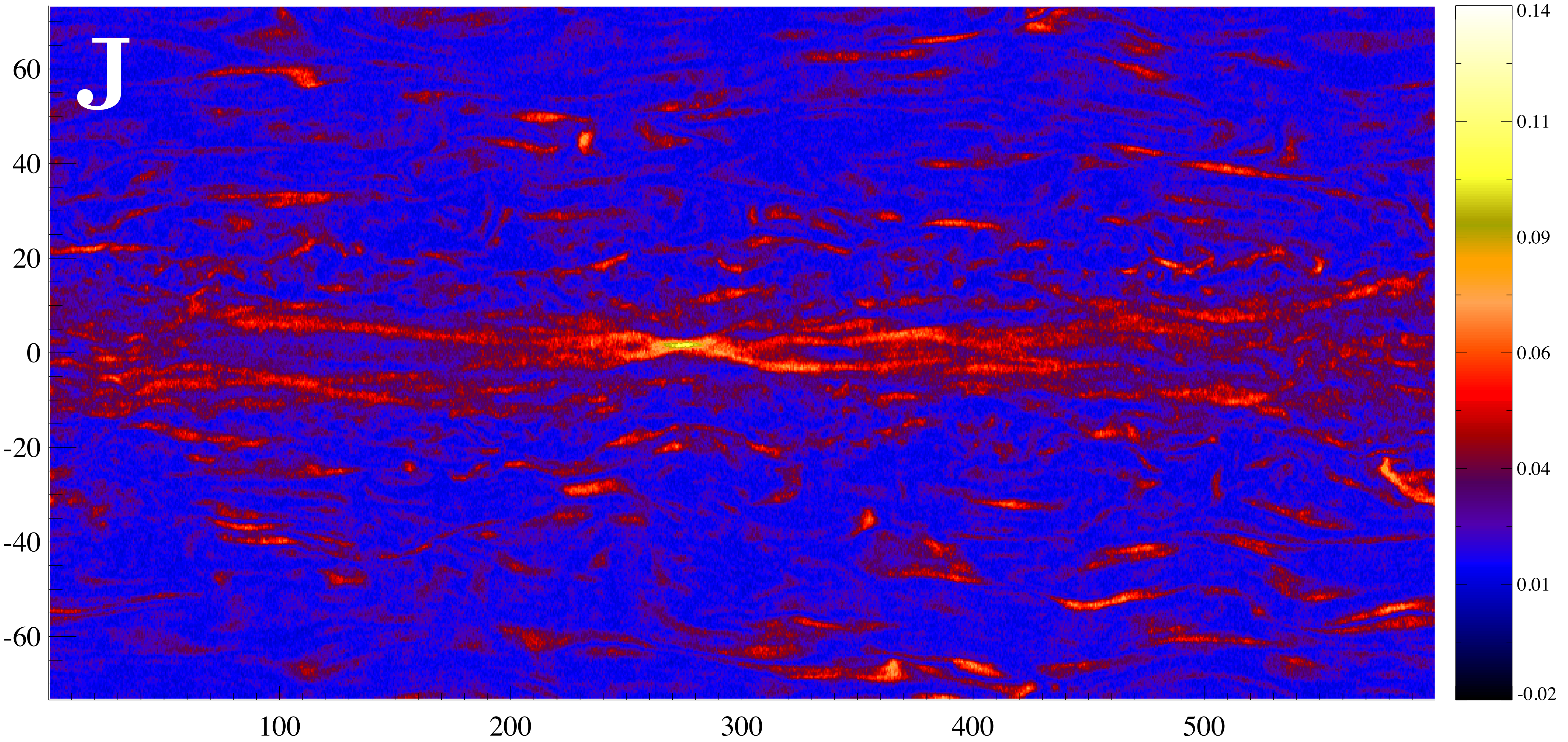
Key results emerging from kinetic studies

- Ion-scale current sheets develop turbulence spontaneously in 3D through various instabilities
  - Power-law spectra $\longrightarrow E_B \propto k_\perp^{-2} \rightarrow k_\perp^{-3}$
  - Chaotic 3D field structure
  - Rate remains very close to previous 2D results
  - Mechanism for breaking frozen-flux remains the same
  - Evidence of enhanced particle acceleration & mixing
- New setup considers thick current sheets with a spectrum of long-wavelength Alfvenic perturbations
- Very difficult to trigger any clear reconnection
- Above results are consistent with global hybrid studies and observations in magnetosphere + solar wind

Thick Current sheet + Waves



Large run on Blue Waters

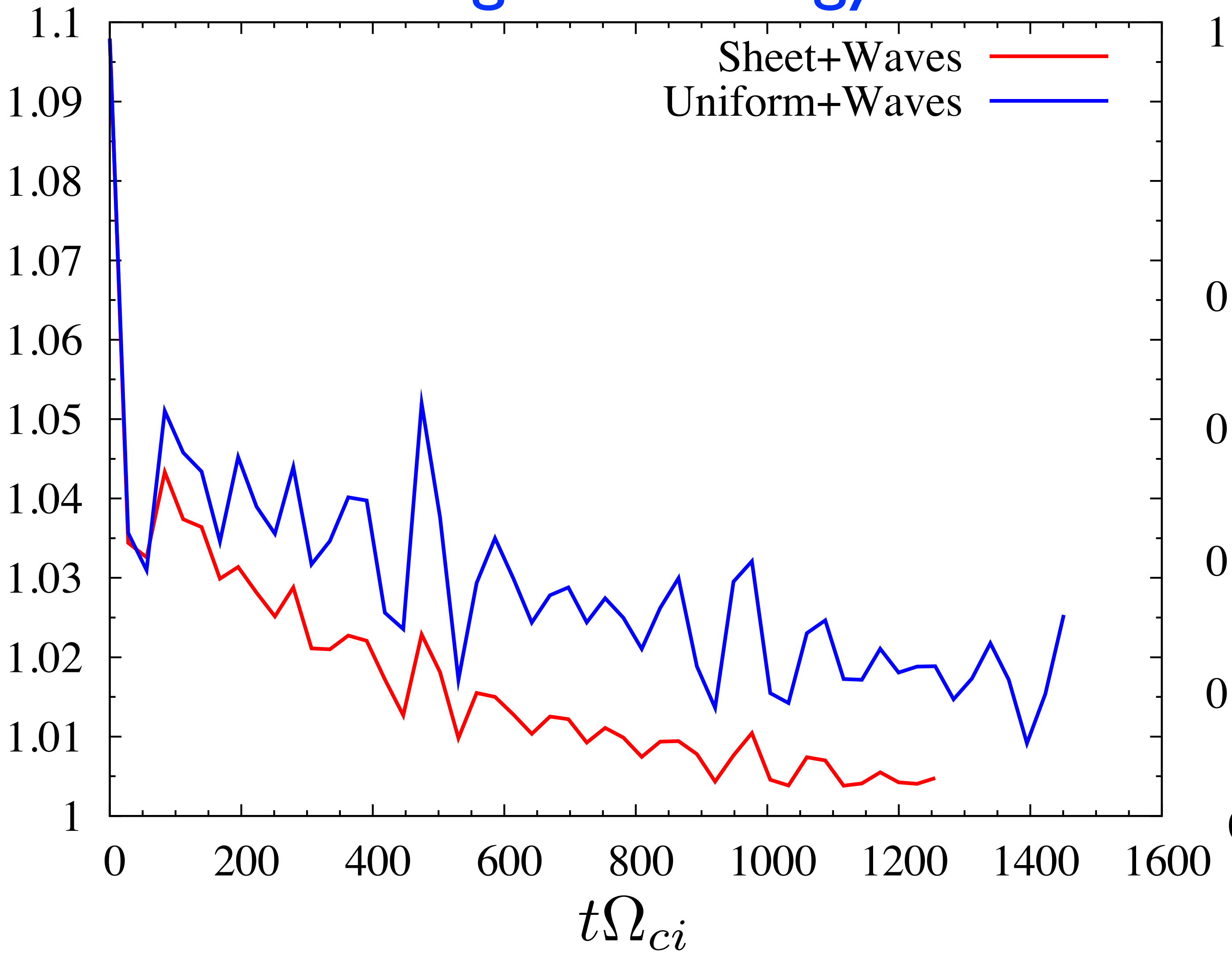
$\rightarrow$ $3072 \times 768 \times 768$ cells

$600d_i \times 150d_i \times 150d_i$

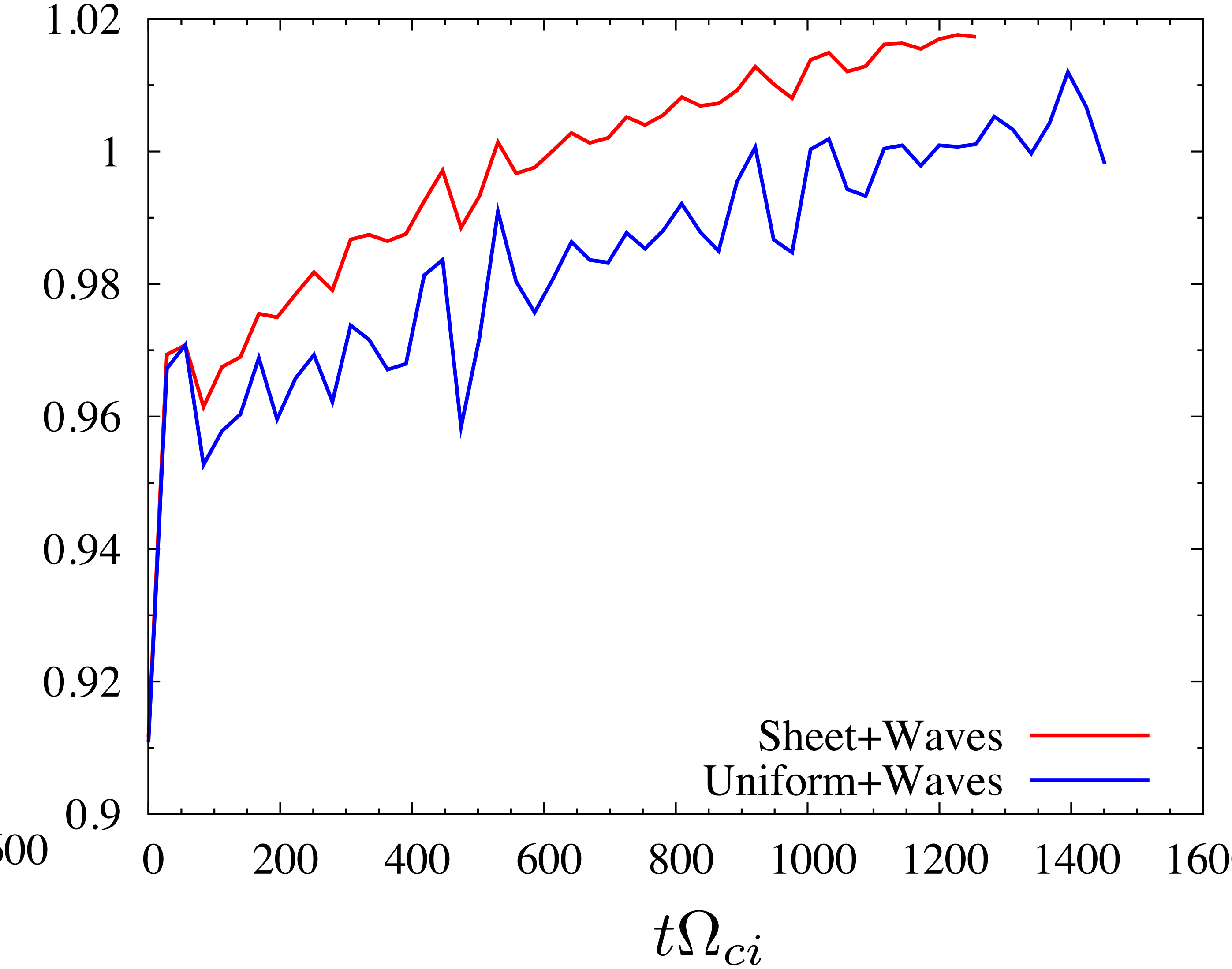
$v_{the}/c = 0.2 \rightarrow \beta_e = \beta_i = 0.32$

$\lambda = 15d_i$ Half-thickness of layer

Magnetic Energy

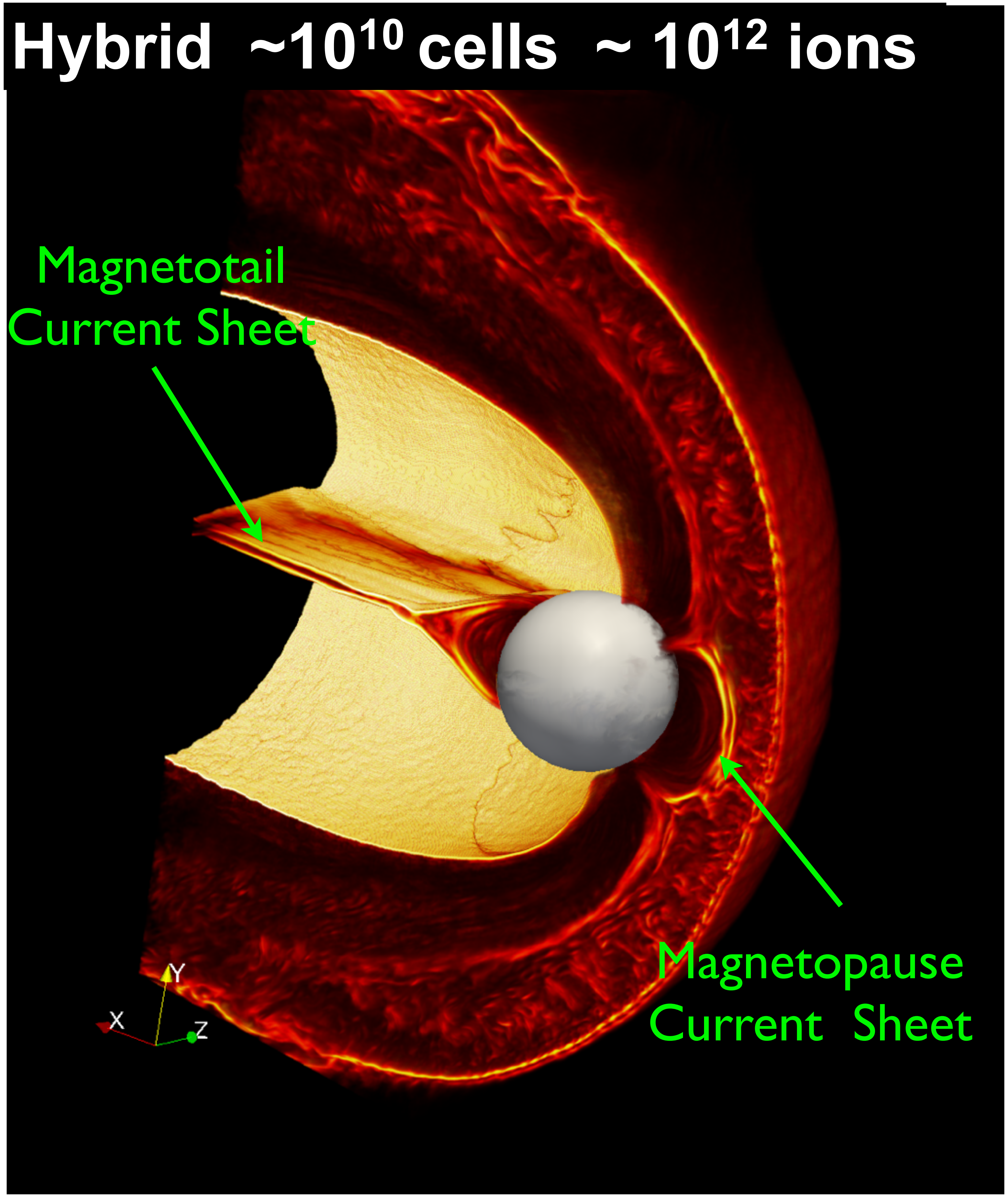


Kinetic Energy



To convert to Alfven times $\longrightarrow$ $\tau_A \Omega_{ci} \equiv \left(\frac{L}{V_A}\right) \Omega_{ci} = \frac{L}{d_i} = 150 \rightarrow 600$

Constraints from Global Hybrid + Observations



Observationally - reconnection is observed when the layers approach ion kinetic scale

Likewise, global hybrid simulations show the same thing

Observationally, there is some evidence this is also true in the solar wind - where there are current sheets + Alfenic turbulence

See Gosling, and Borovsky

This doesn’t of course rule out the concept of “turbulent reconnection” in thicker sheets.

However - it doesn’t appear easy either in the collisionless limit

May require asymptotically large systems, which are far beyond our ability to measure (or simulate) directly