Turbulence, selective decay, and merging in the SSX plasma wind tunnel

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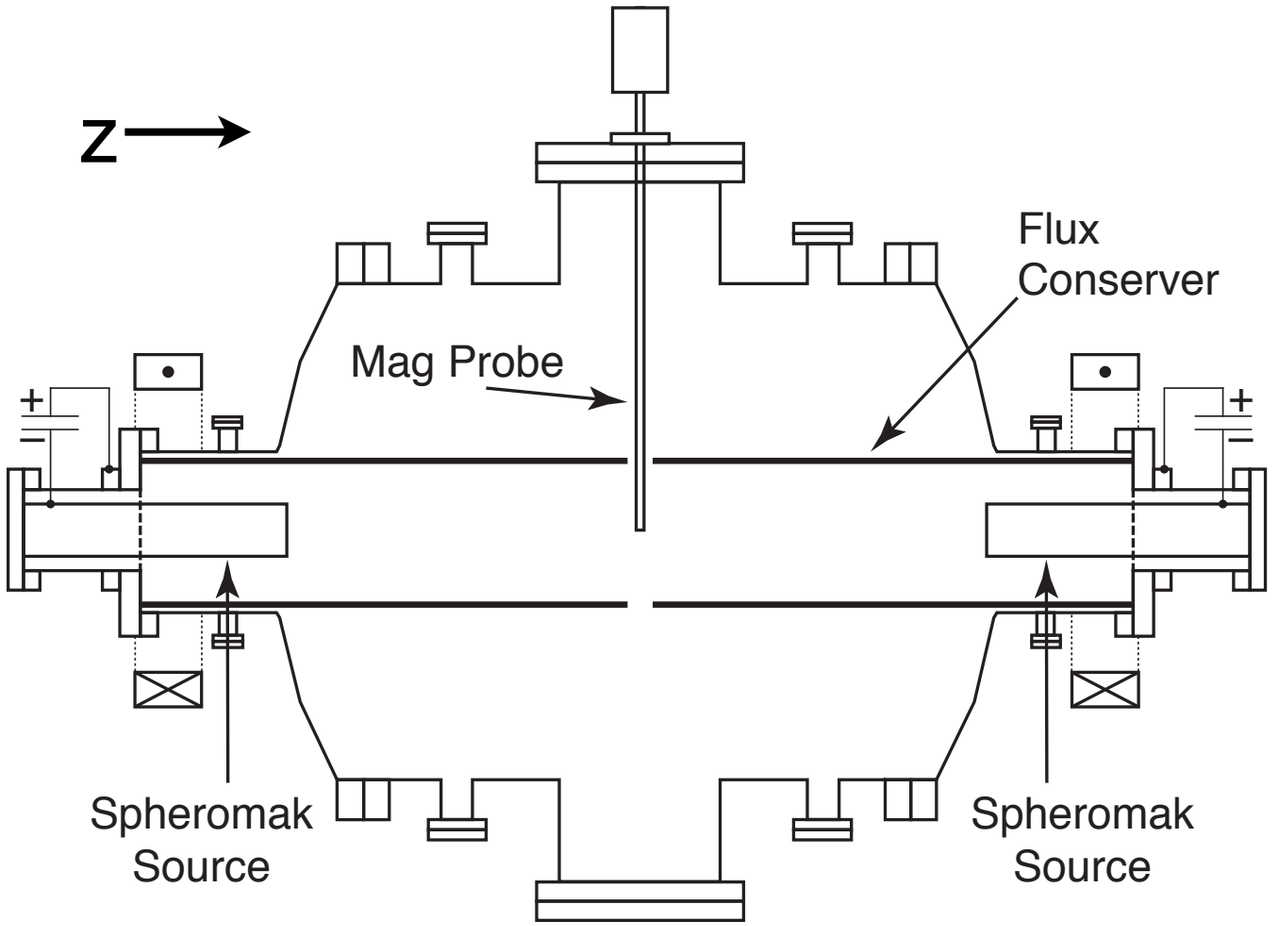
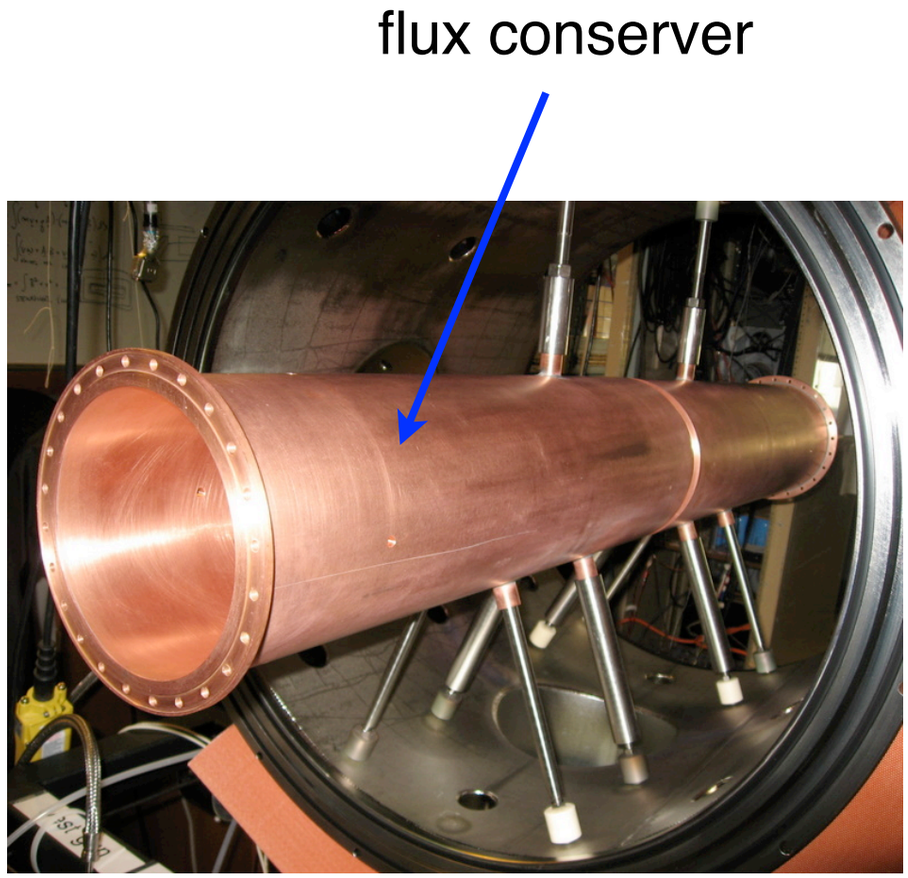
Wind tunnel setup

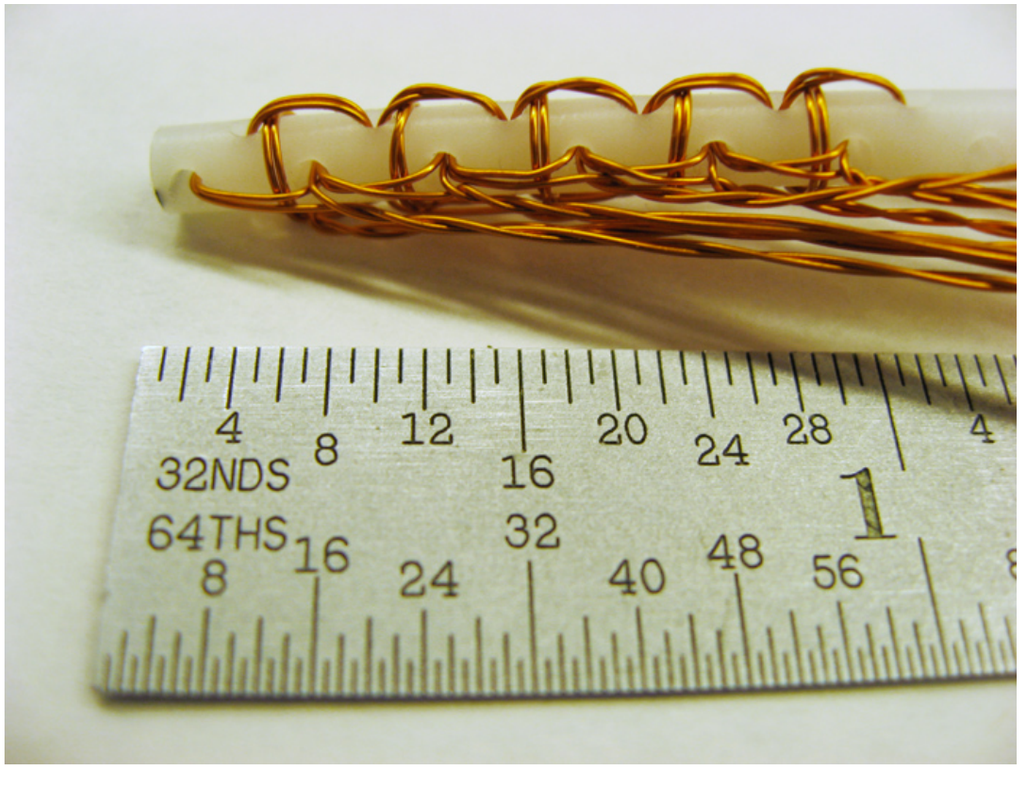


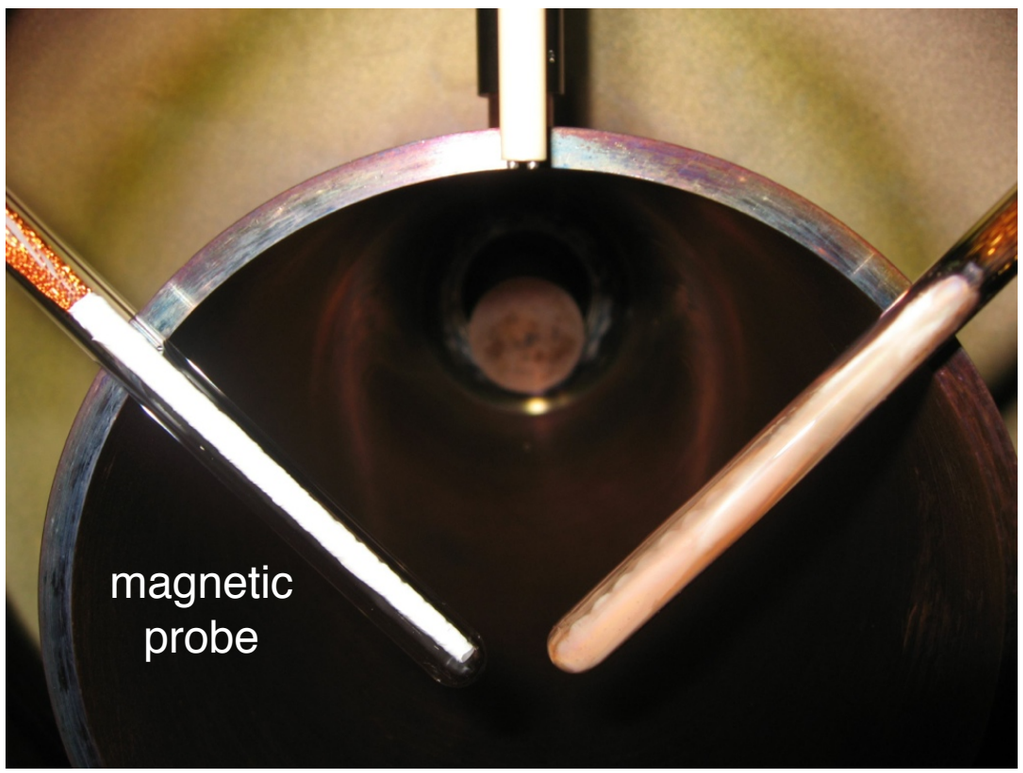


- Copper flux conserver defines boundary for plasma
- 10:1 aspect ratio (L/r)
  - 84 cm long with a radius of 8.4 cm
- Radial magnetic probe at midplane
- Diagnostic access provided for at the mid-plane by gap between two flux conserver halves

New high resolution magnetic probes

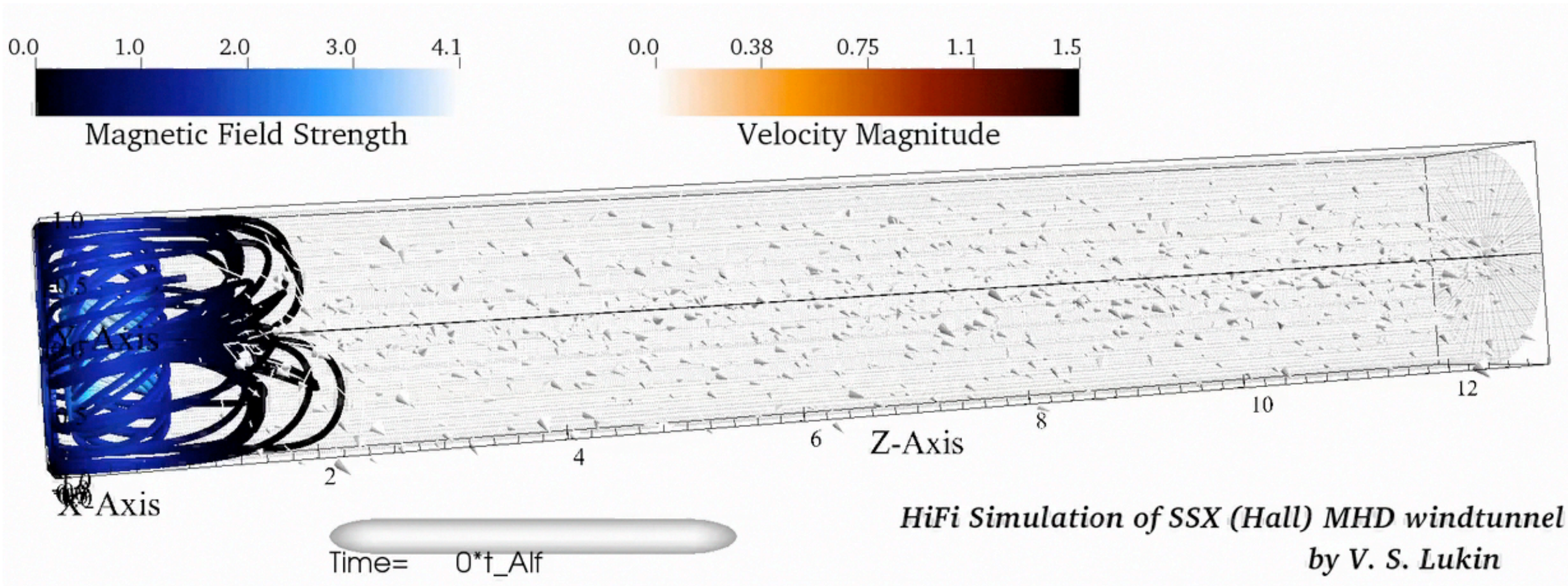
- 16 channels of triplets
- 4.5 mm spacing
  - ~ ρ_i = 3-5 mm
- 1- and 2-turn coils
  - high bandwidth
- not hardware integrated
- 96 channels of 65 MHz digitizers
  - 14 bit - 4 decades of resolution
- Measure B-dot at high spatial and temporal resolutions





HiFi simulation

final state



V. S. Lukin

Merging

- In past merging experiments, merging progresses quickly after initial contact, taking about 20 μs
- In current experiments, large reconnection events are observed 20-35 μs after initial contact is made
- What triggers events is unclear:
  - Associated with delayed merging of the plasmas? Are the plasmas stagnating at the mid-plane for some period of time before reconnecting?
  - Or are they immediately reconnecting, and we are observing a relaxation event of partially or fully merged plasmas?

Merging scenarios

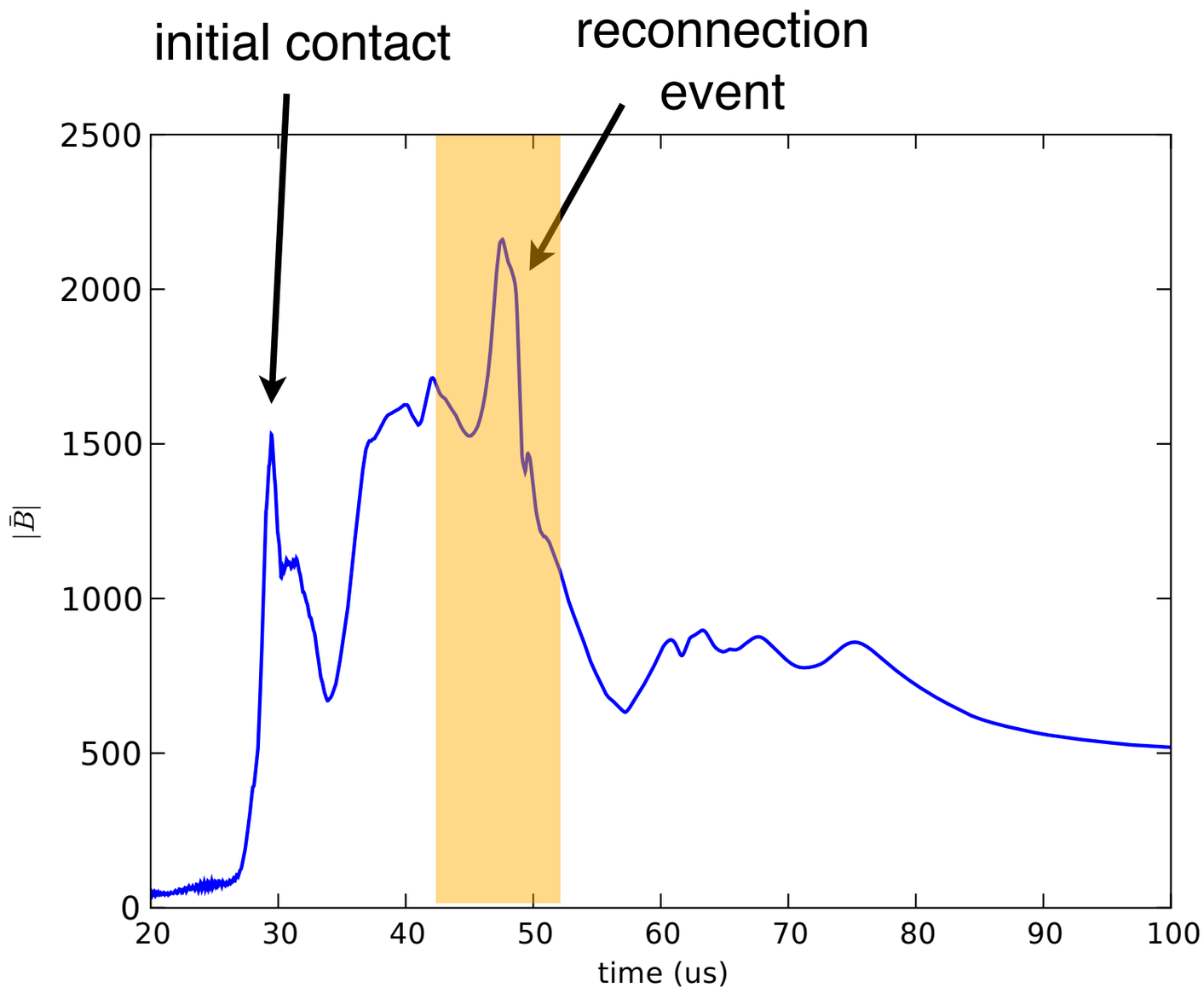
Head on, aligned

Head on, rotated

Slip past each other

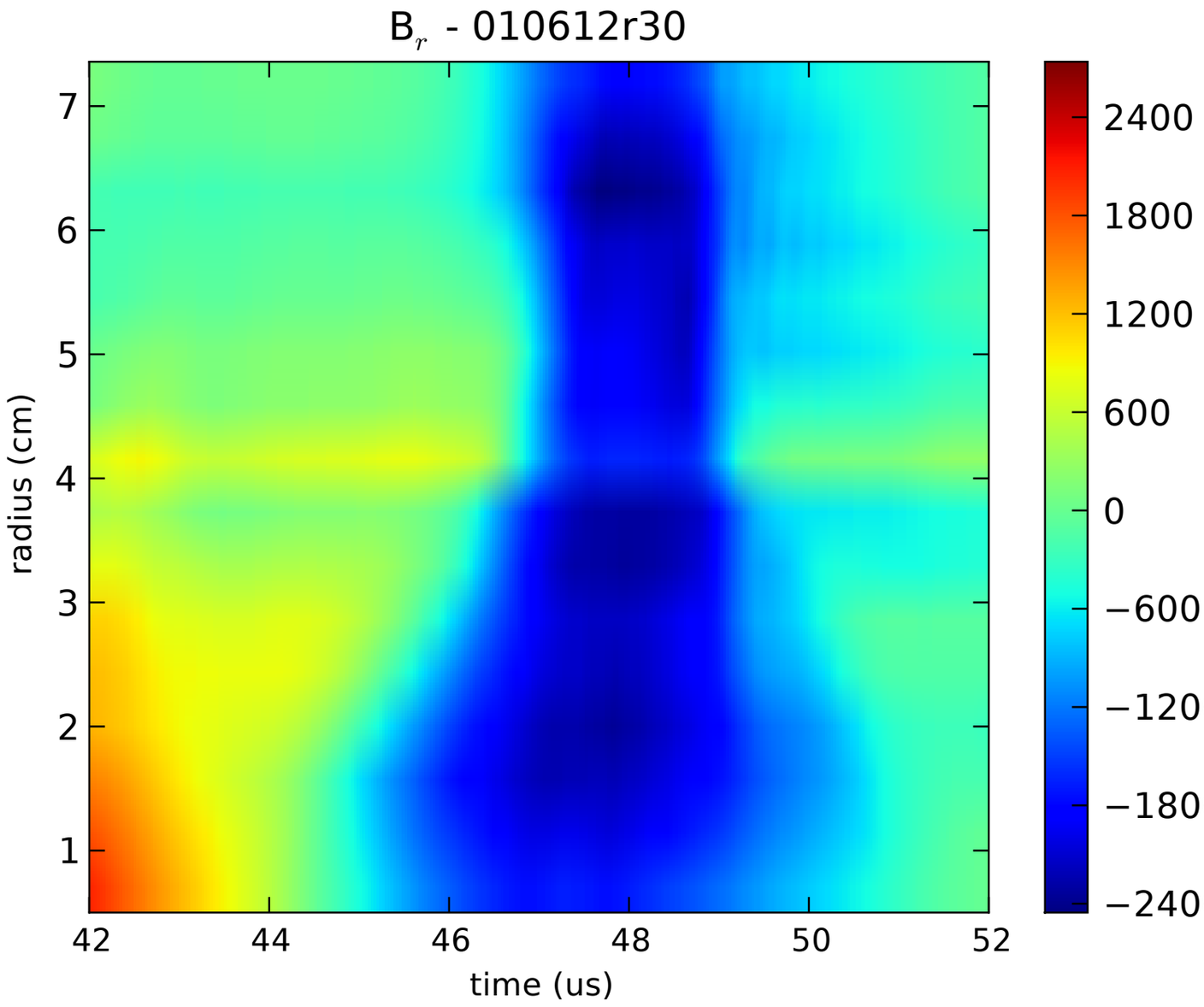
Reconnection event, late in time

- After initial contact of the two plasmas (~ 30 μs), large reconnection event occurs 20-30 μs later



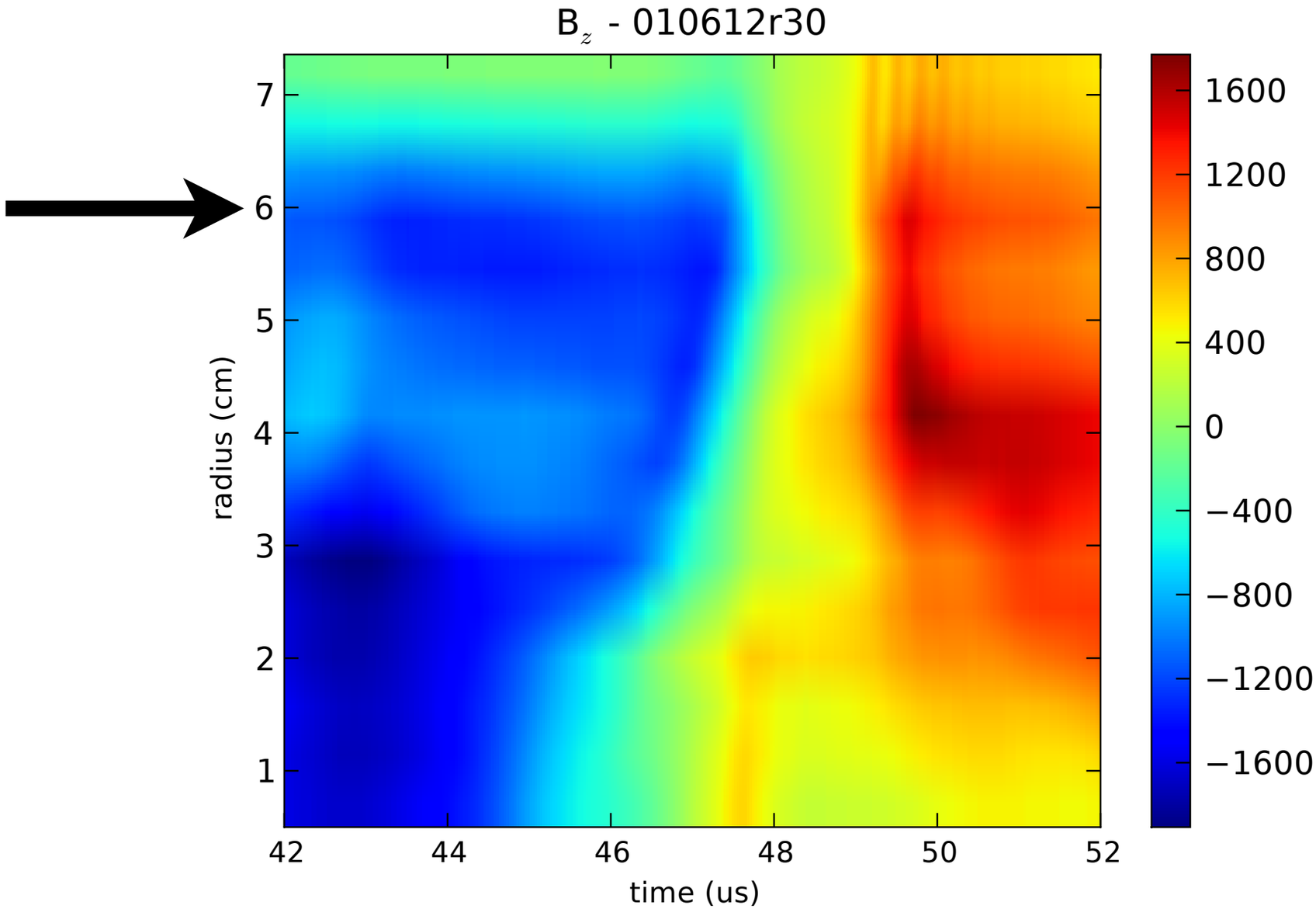
B-field signature - radial

- Strong radial B-field

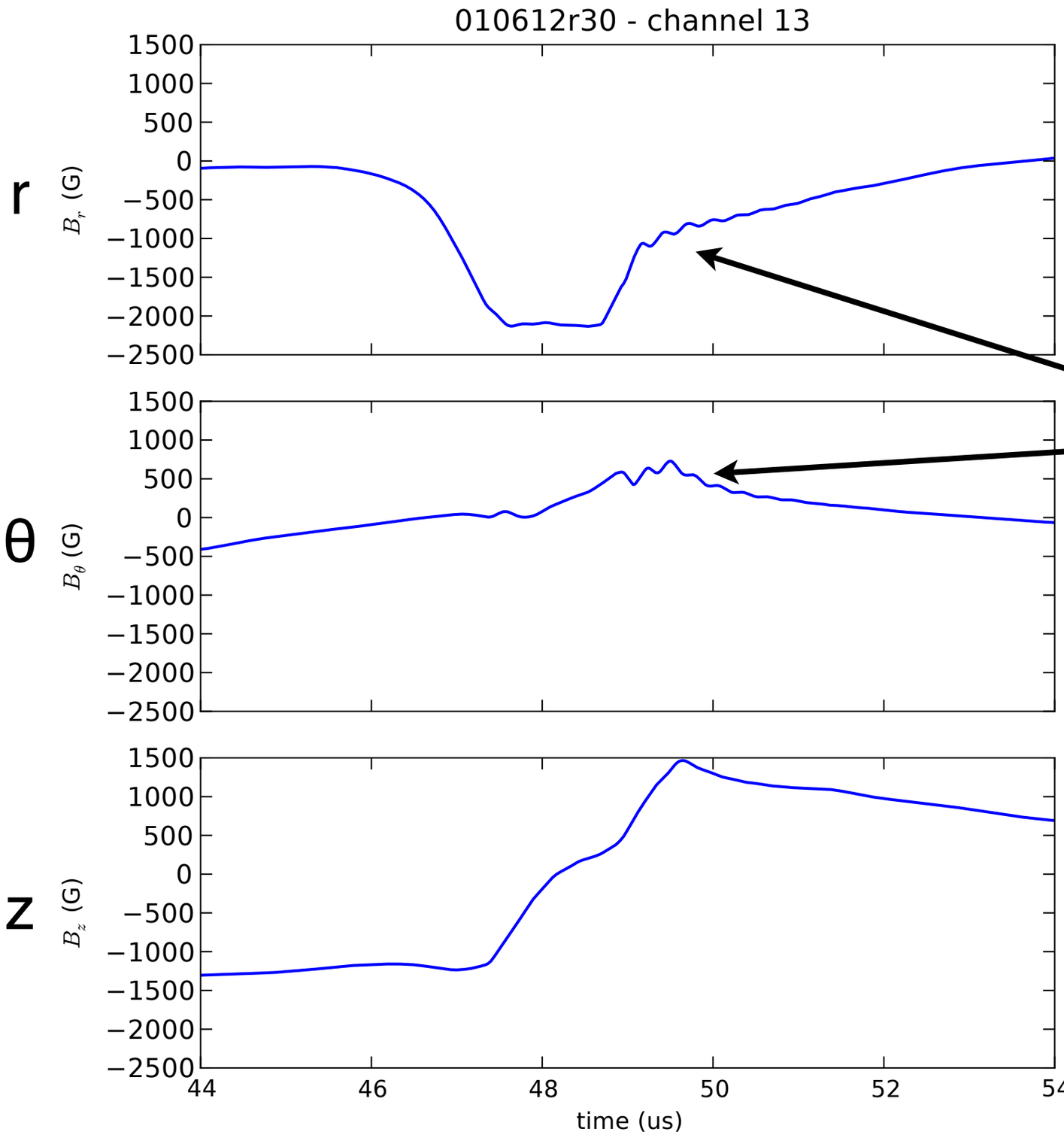


B-field signature - axial

- Reversal in axial B-field (z direction)



B-field signature



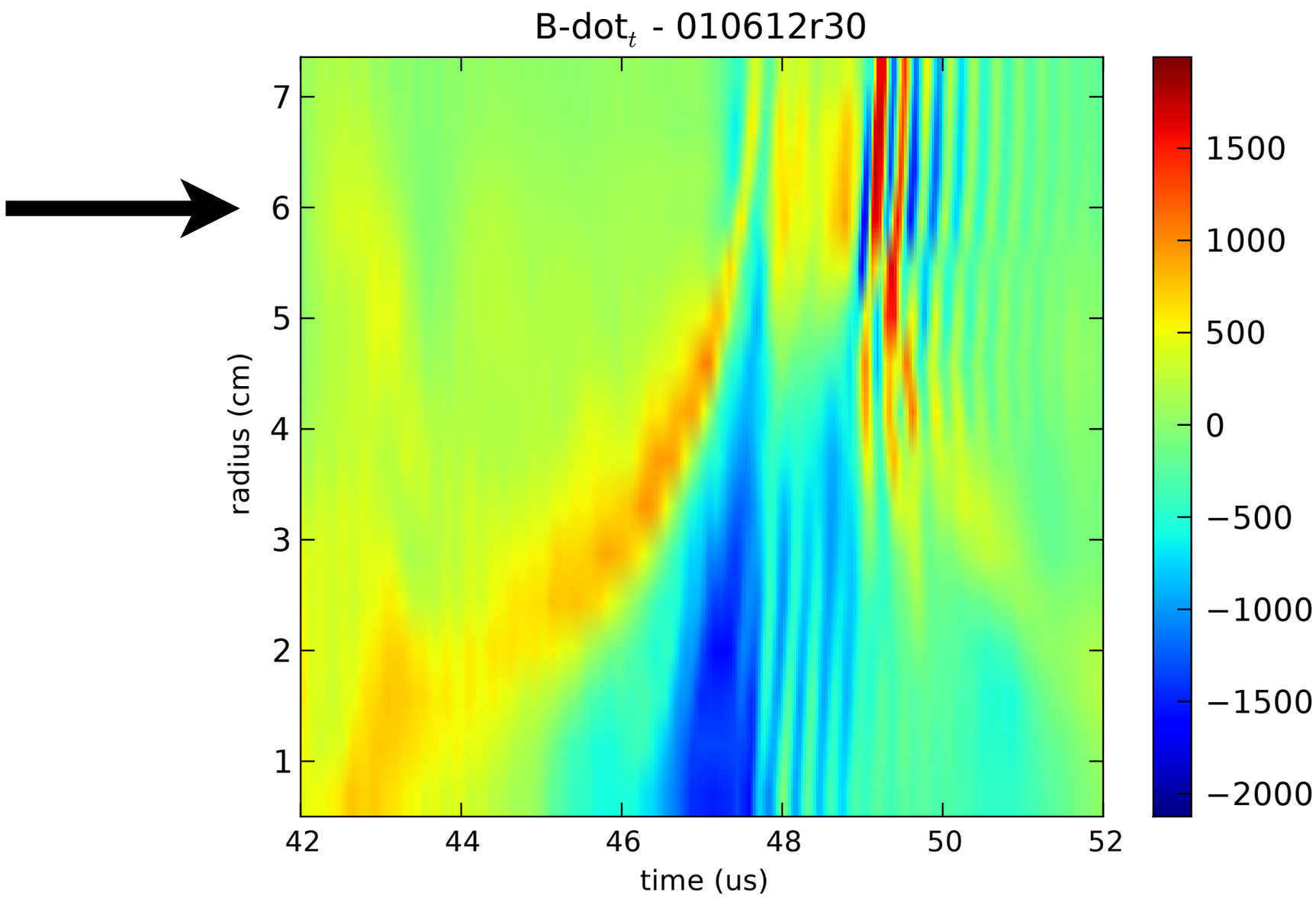
strong radial field

oscillations

field reversal

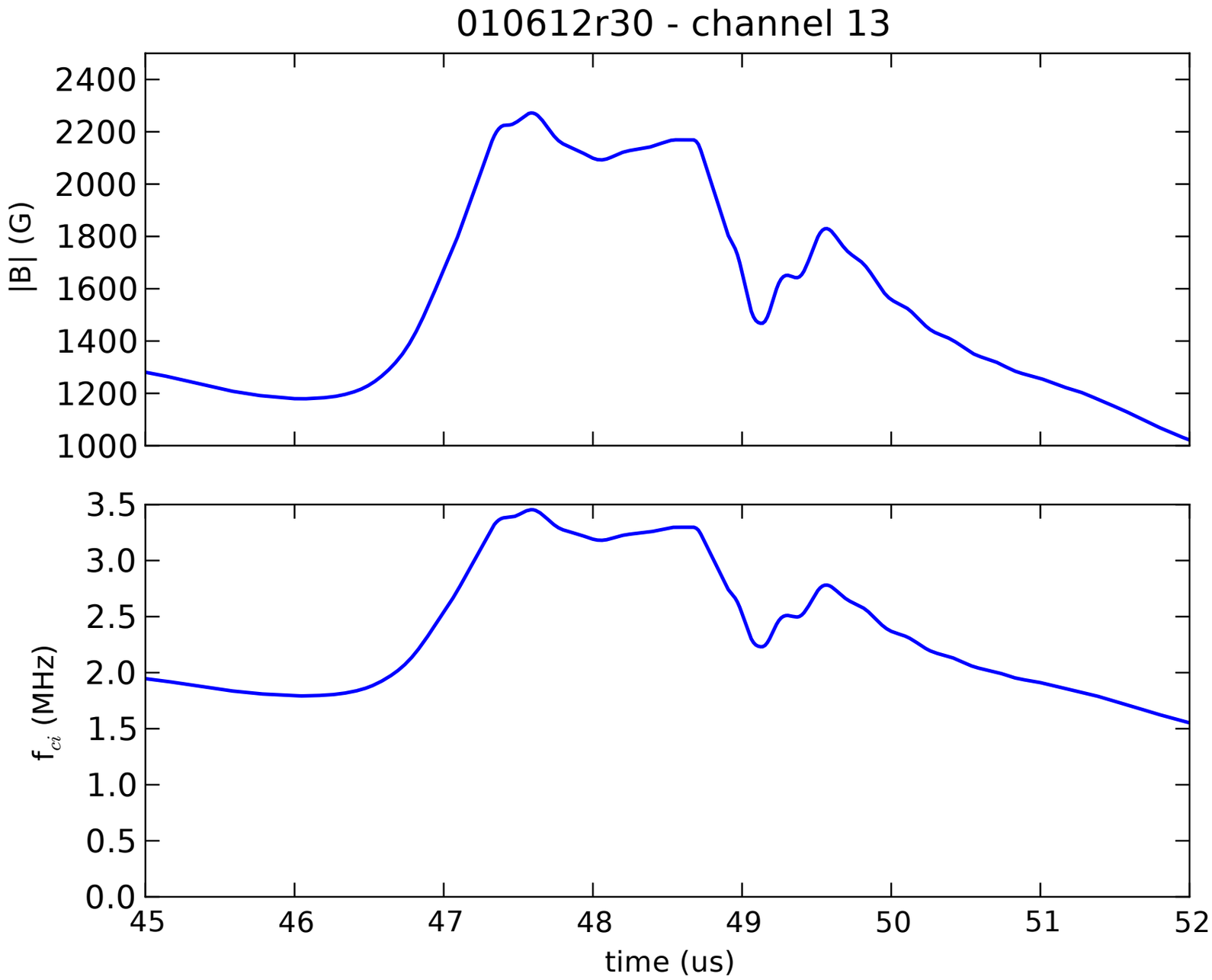
B-dot oscillation

- Strong oscillation observed at end of event
- 3.5 MHz
- Very localized - extends 1-2 ρ_i radially

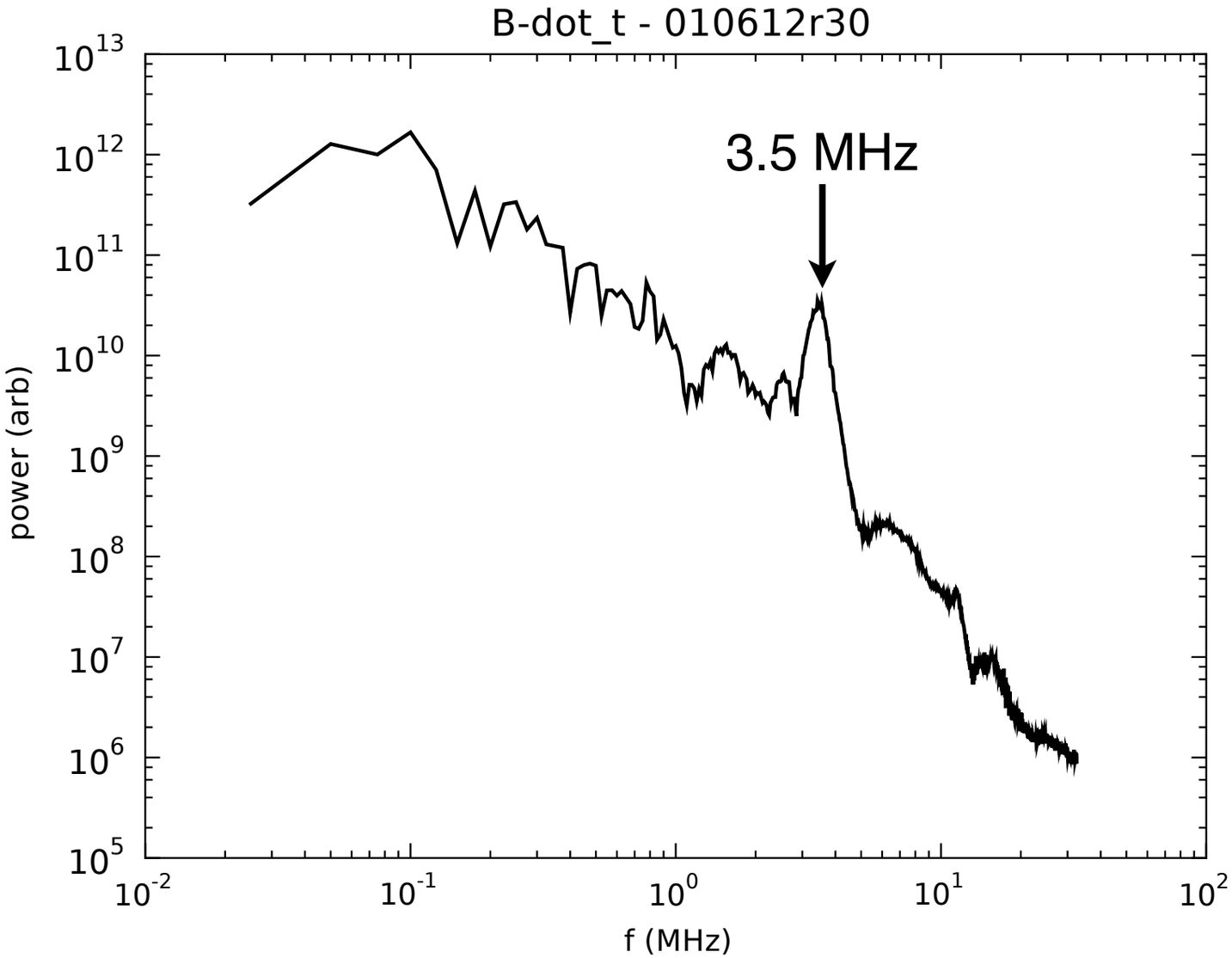


Oscillation at ω_{ci}

- ω_{ci} is ~3.5 MHz for the local B-field where the oscillations are observed

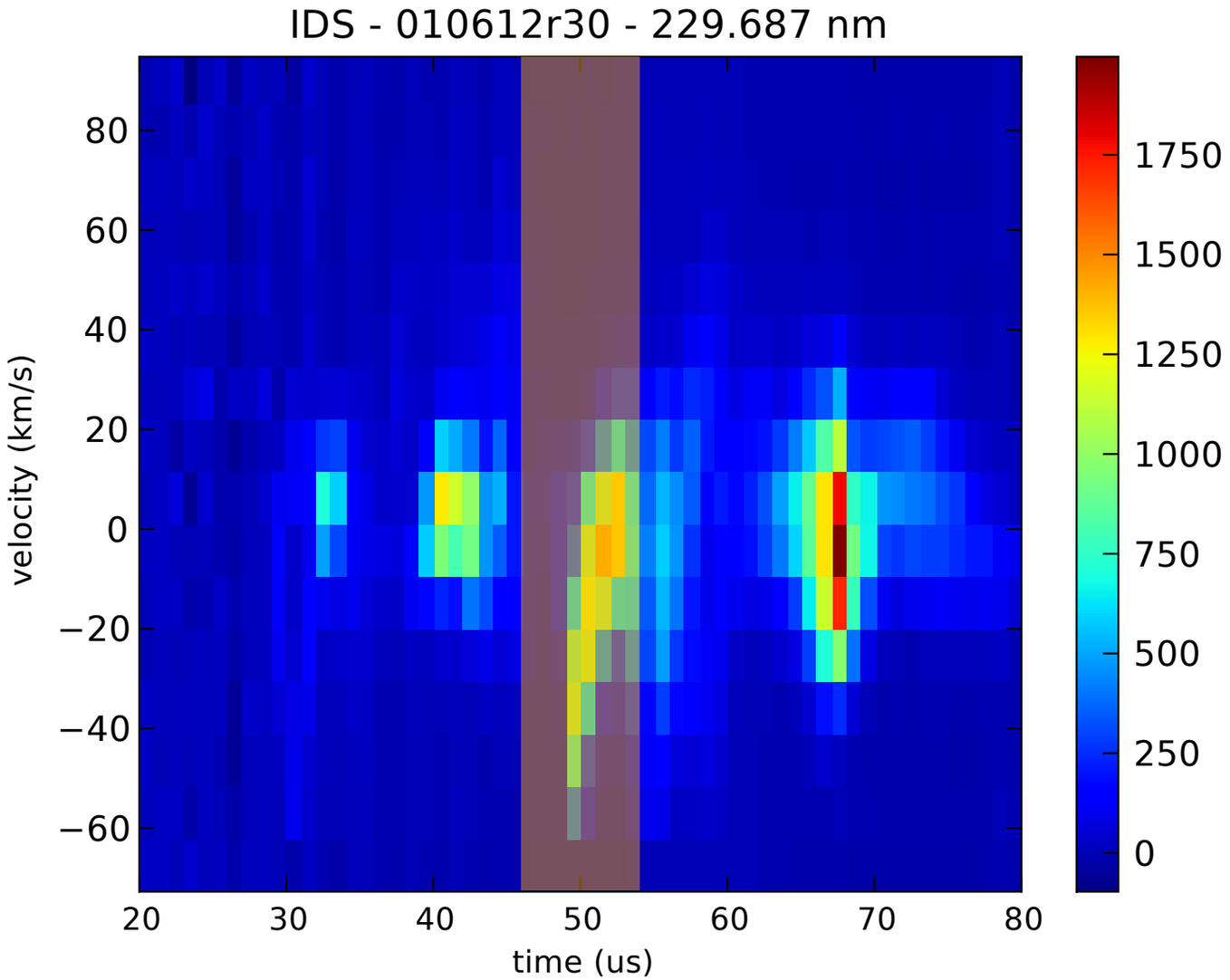


MHD instability → kinetic instability



- Even though oscillations last a few μs, they provide a large contribution to the power spectrum.
- Current sheet is driving ion cyclotron instability? [Drummond & Rosenbluth, 1962]

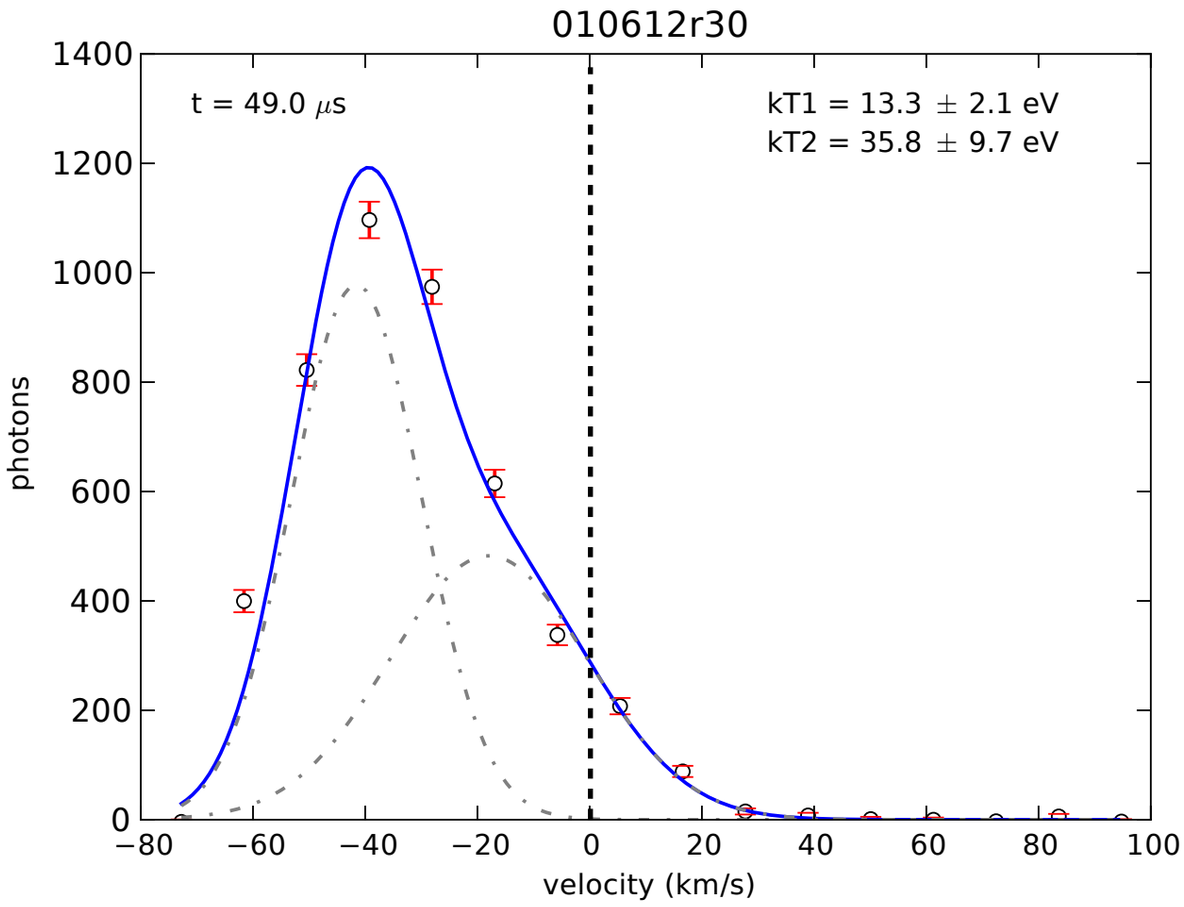
IDS activity correlated with reconnection event

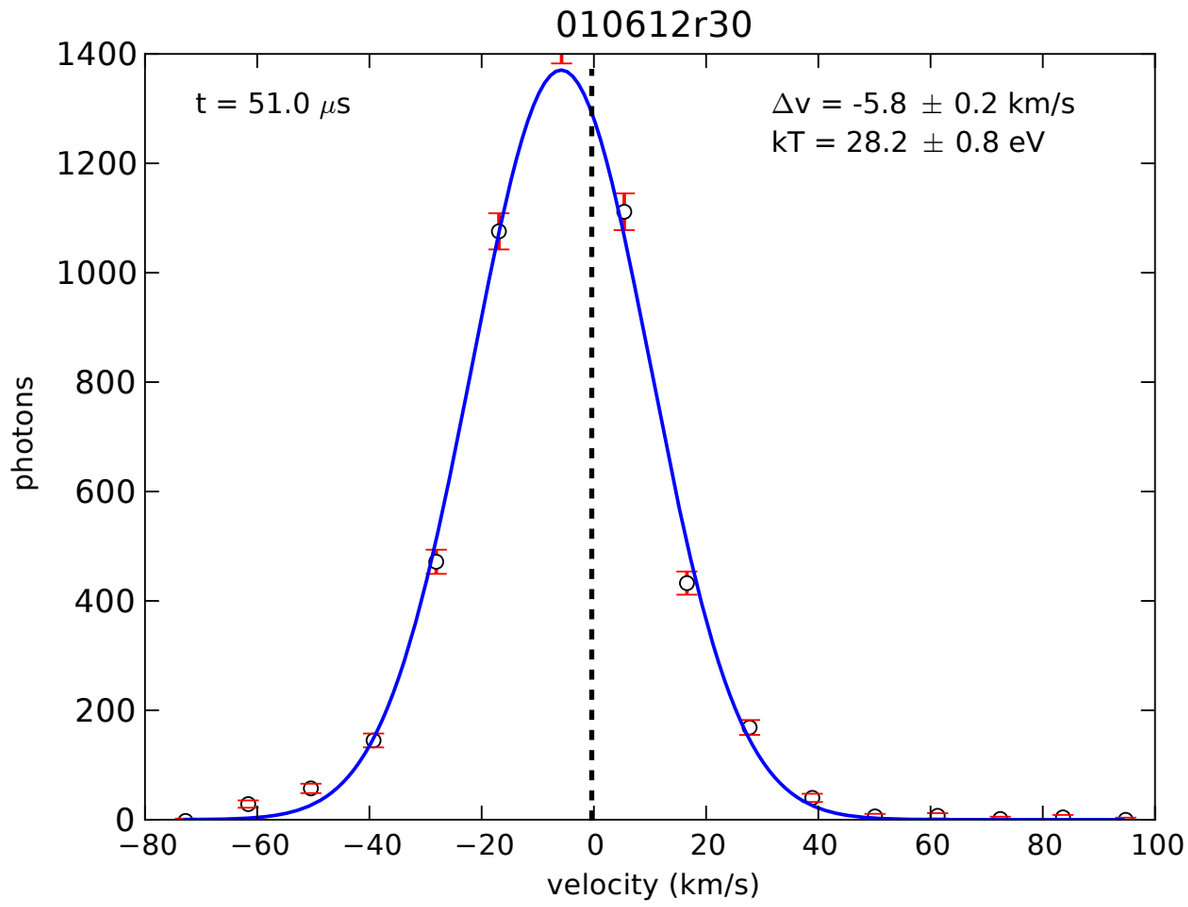


- IDS activity bursty, correlated with reconnection events
- Often a total absence of signal before event
- Flow away from diagnostic at beginning of event

IDS activity correlated with reconnection event

- Immediately after event, large flows away from IDS
- Hotter ions (30-40 eV) at first with rapid cooling
- Driven by observed waves?





Proposed plasma accelerator

- 4 stage acceleration via theta pinch coils
- Designed to accelerate plasmas from 50 km/s to 100 km/s
  - increase in kinetic energy from ~50 J to 200 J
- Driven merging should produce smaller scale coherent structures and fluctuations than currently achievable in SSX