HED magnetic reconnection experiments with externally applied magnetic field

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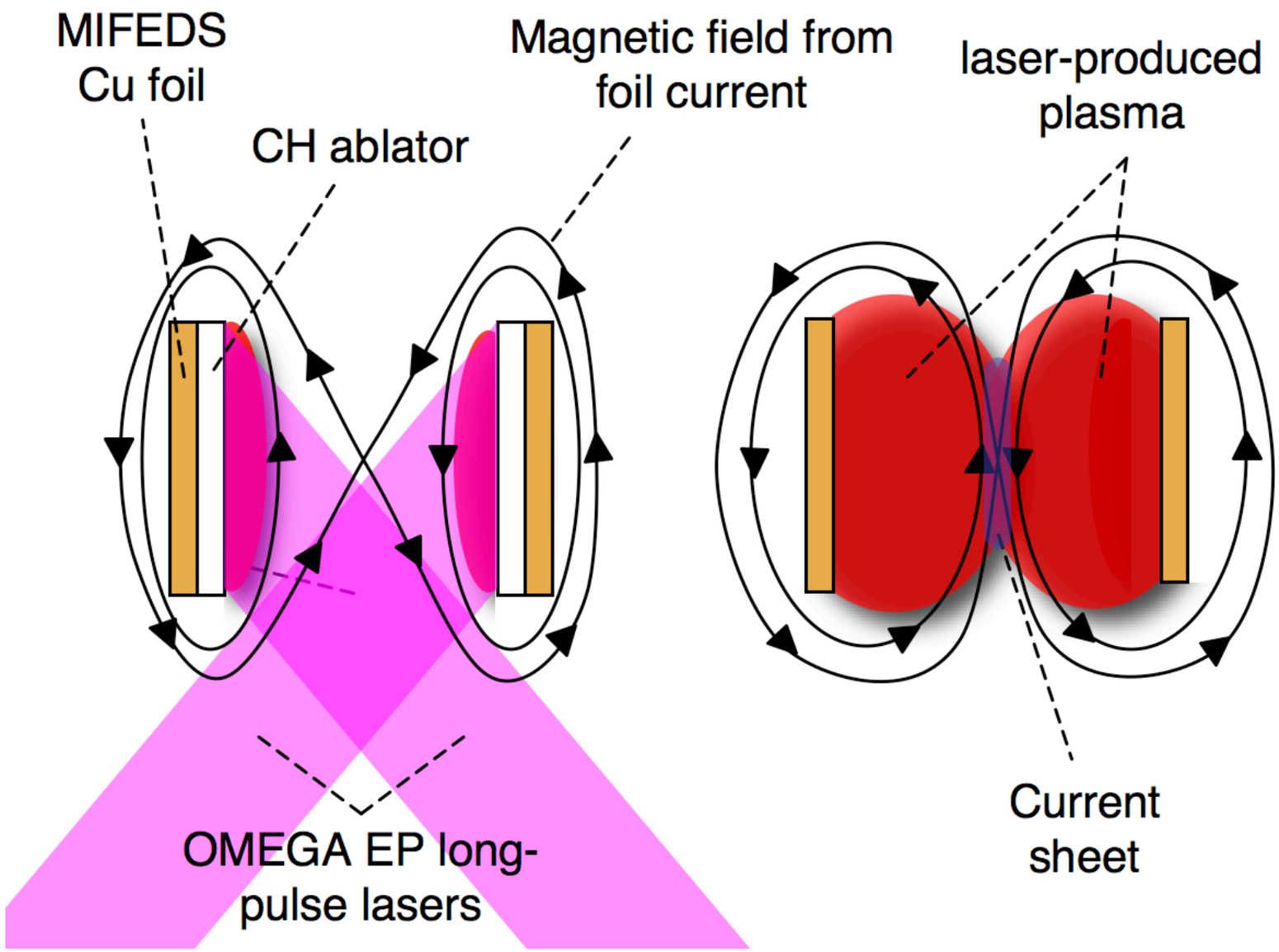
MIFEDS-based reconnection experiments (in collaboration with G. Fiksel, P. Nilson, S. Hu, P.Y. Chang, LLE)

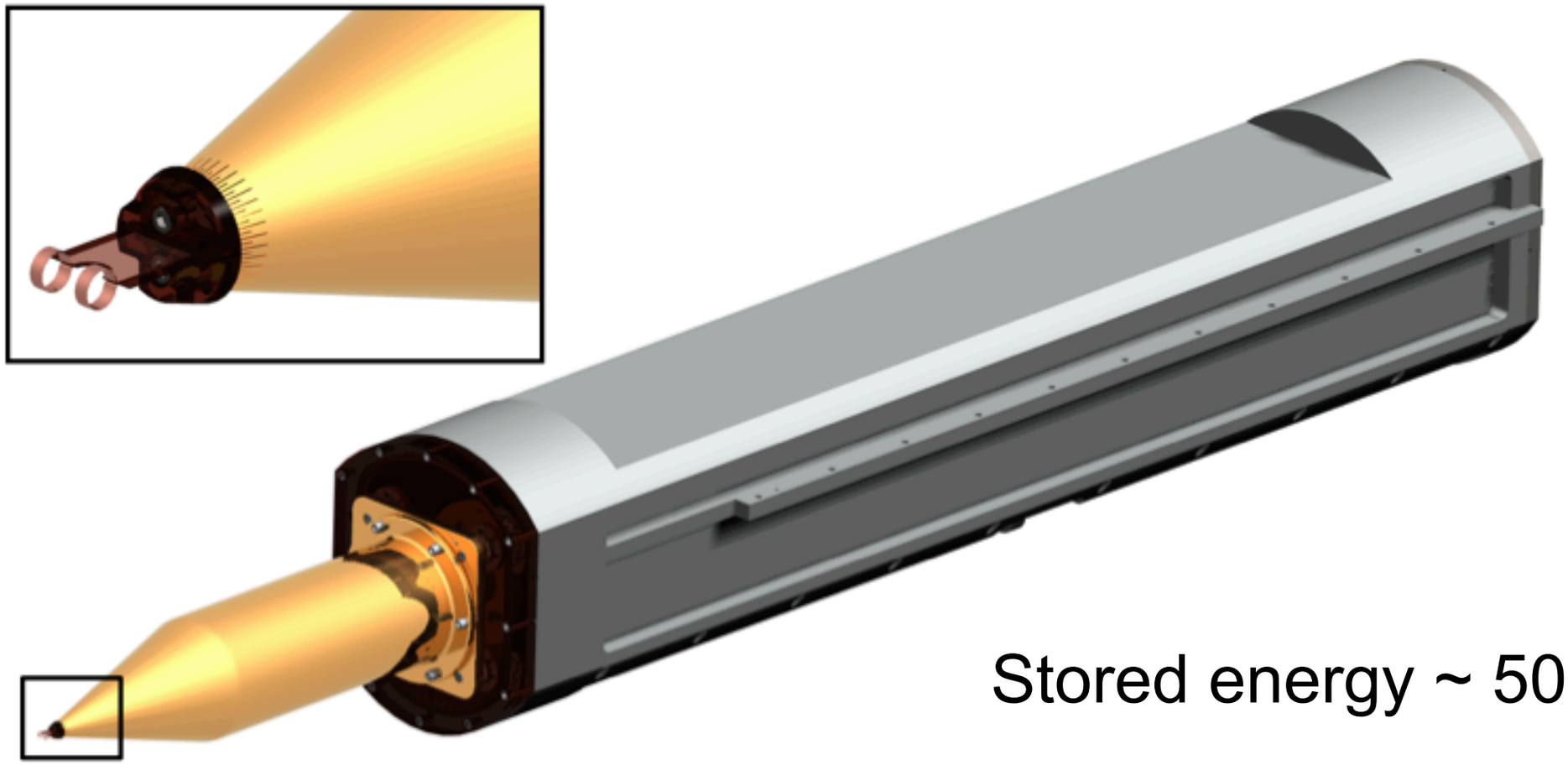


Outline

- Description and planning experiments for OMEGA EP based on MIFEDS for magnetic field generation
- Some first results from MIFEDS experiments
  - experiments at B=0 and B finite
  - magnetized “ribbons” of blowoff plasmas have been created and collided, B field destruction observed

MIFEDS II

(Magnetized Inertial-Fusion-Energy Delivery System)



Stored energy ~ 500 J

Ref: O. Gotchev, J. Knauer, P. Chang, et al, and R. Betti, RSI (2009).

Prospects for laser-driven reconnection experiments

- Possibility to reach and study reconnection in a wide range of L/di (maybe 100-200?) and high S regimes
- Test predictions of flux pile-up, island formation (will require further experimental and diagnostic creativity)

- MIFEDS-based experiment:
  - control magnetic flux available for reconnection (from 0 to more than available from Biermann fields)

- Further knobs (e.g. collisionality, separation) are being explored through further computation

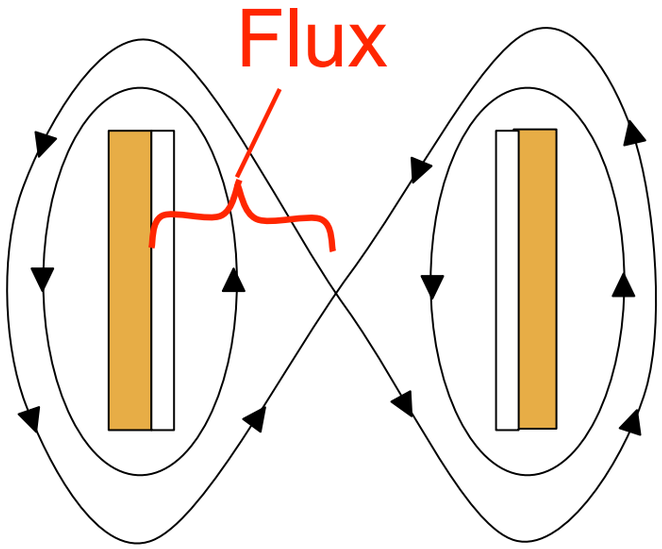
Comparison with previous bubble reconnection experiments

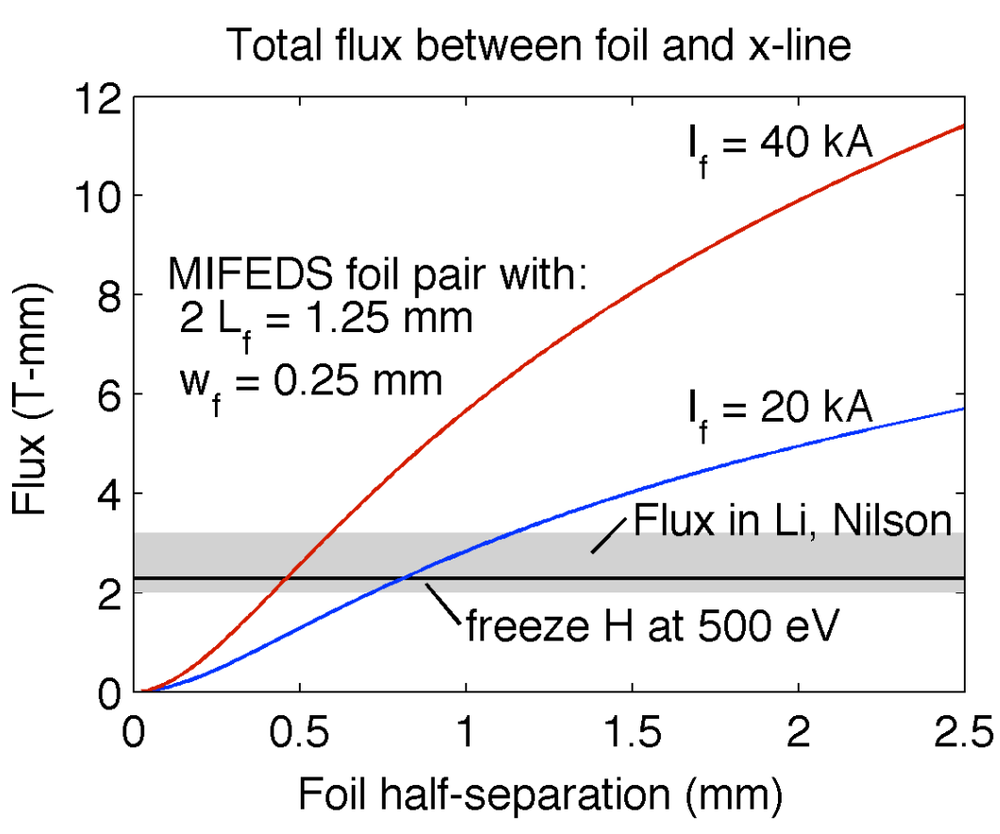
- Quasi-2d geometry

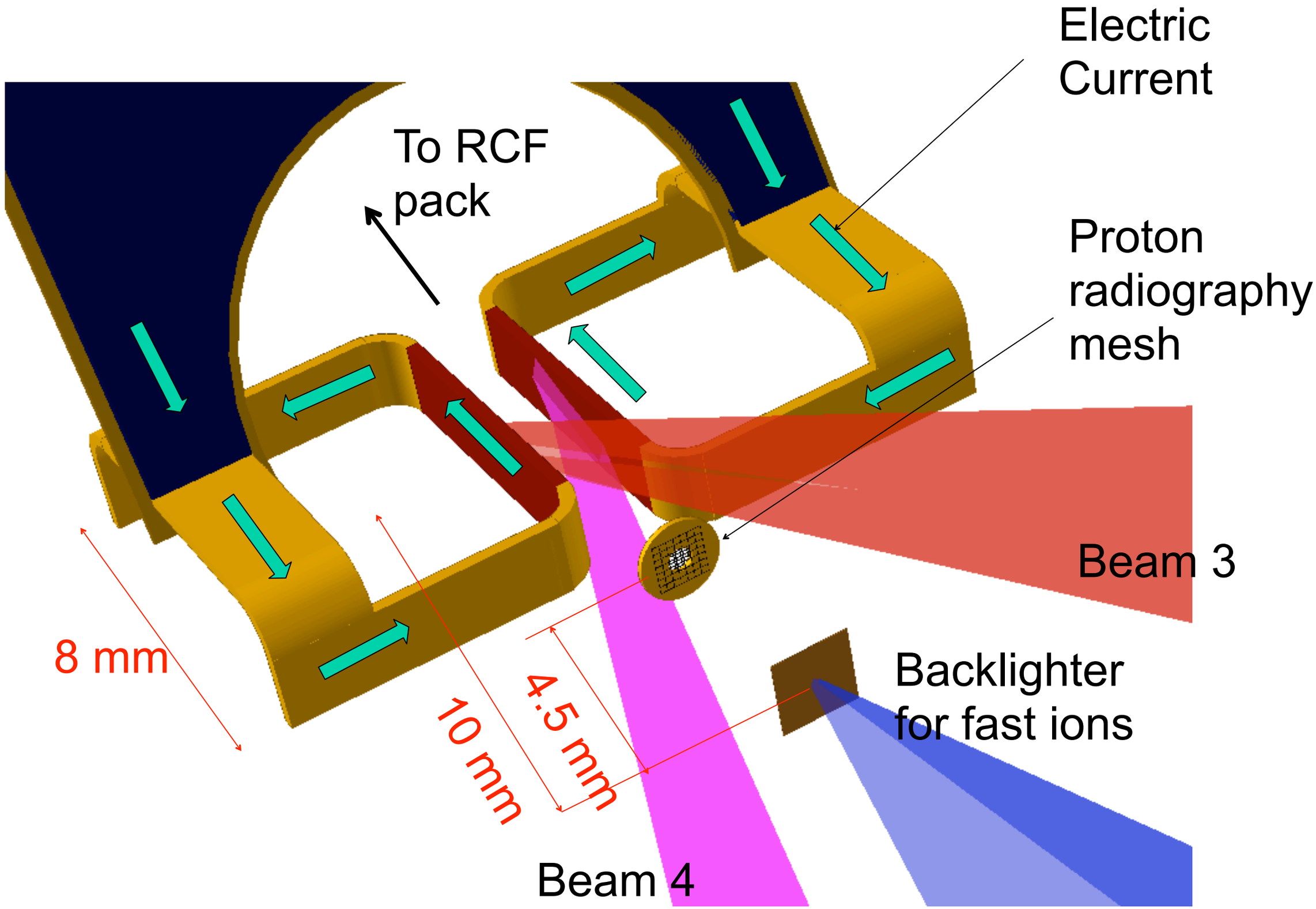
- MIFEDS: control, vary magnetic flux available for reconnection

- Null experiment: B = 0

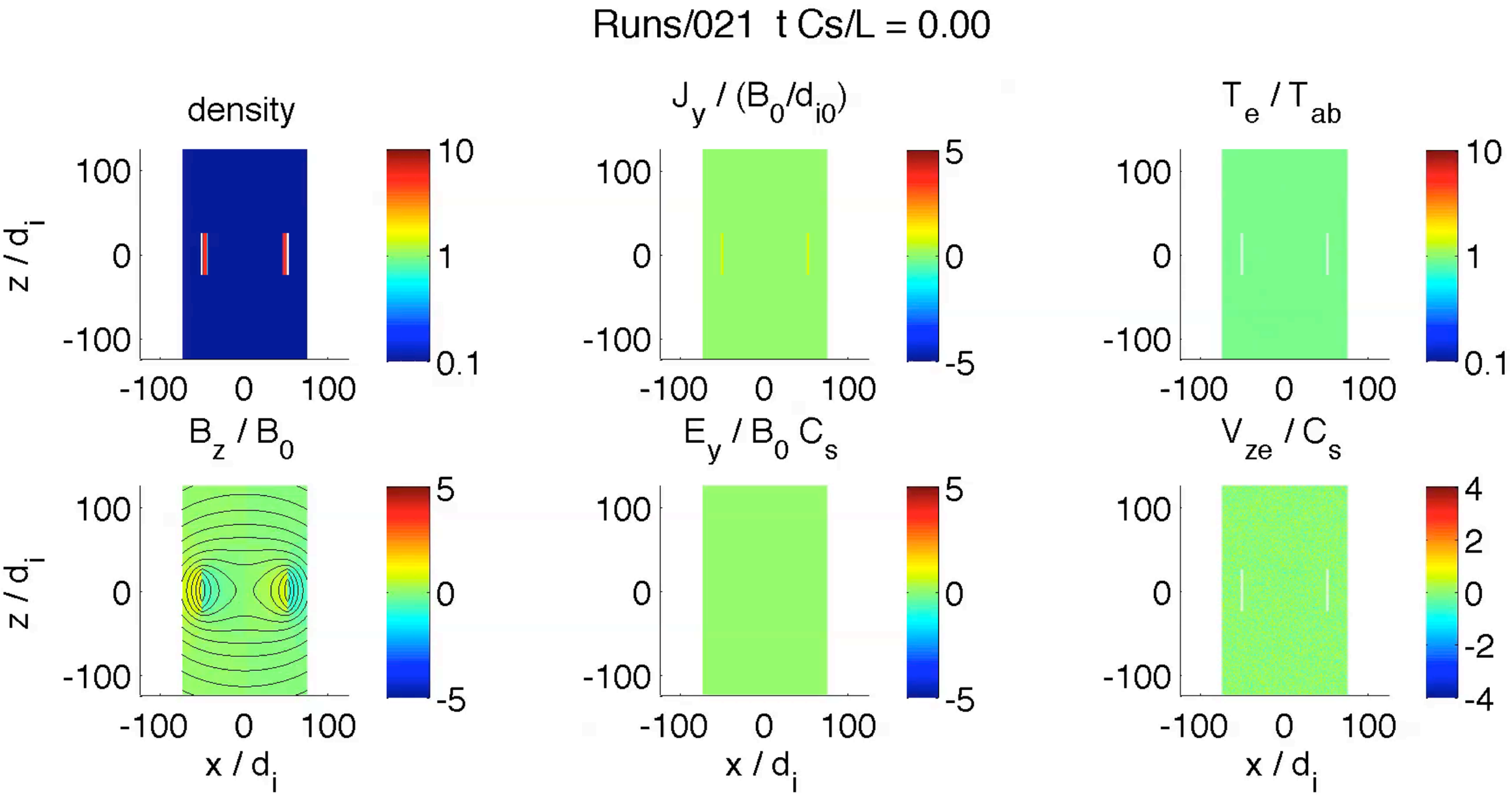
- Eventually study **guide field** reconnection.





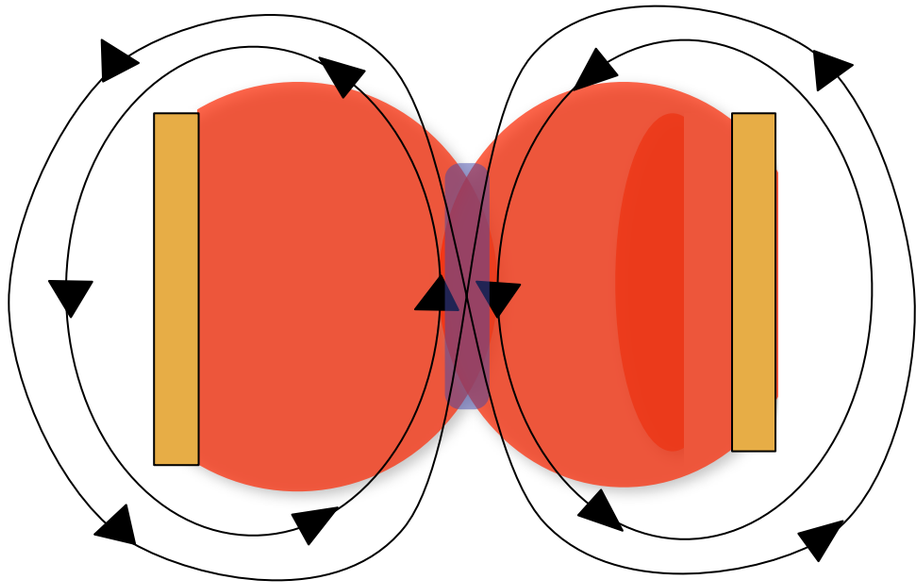

Electric
Current
To RCF
pack
Proton
radiography
mesh
Beam 3
8 mm
10 mm
4.5 mm
Backlighter
for fast ions
Beam 4

Example PIC simulation

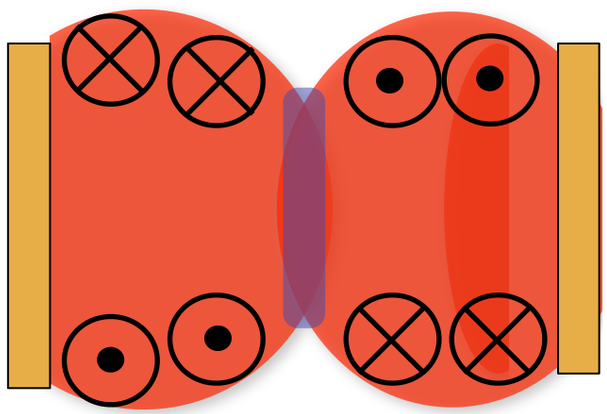


What about self-generated (Biermann) field?

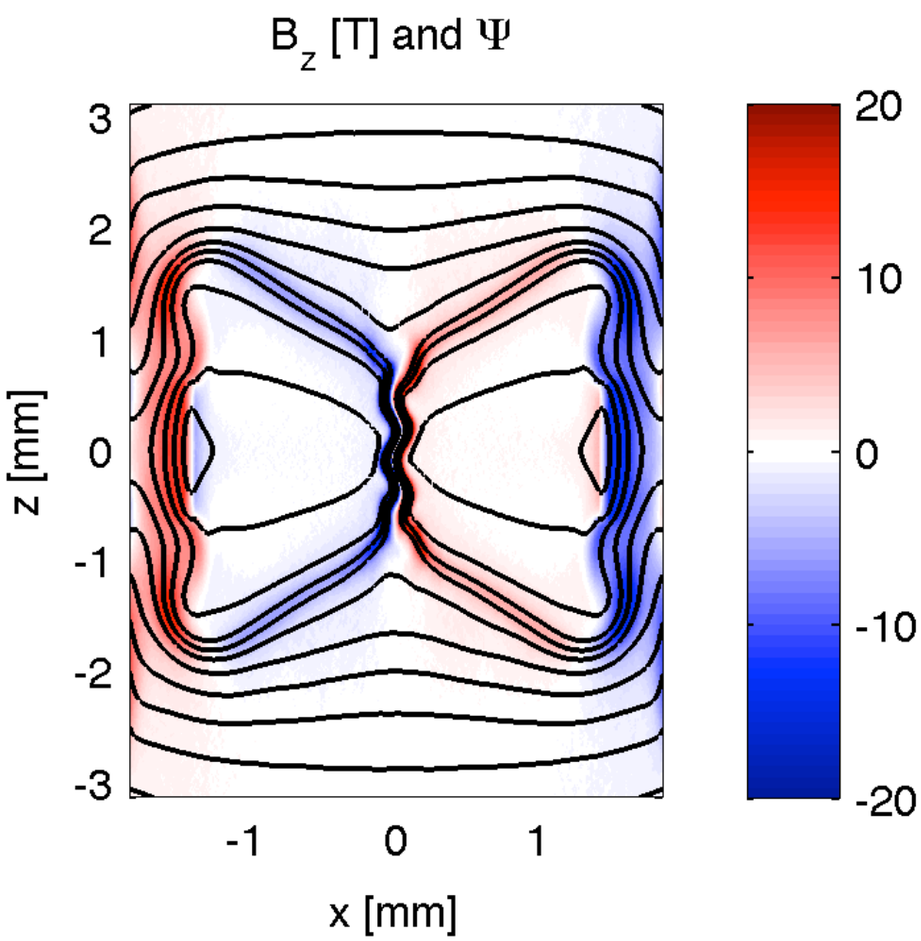
MIFEDS fields

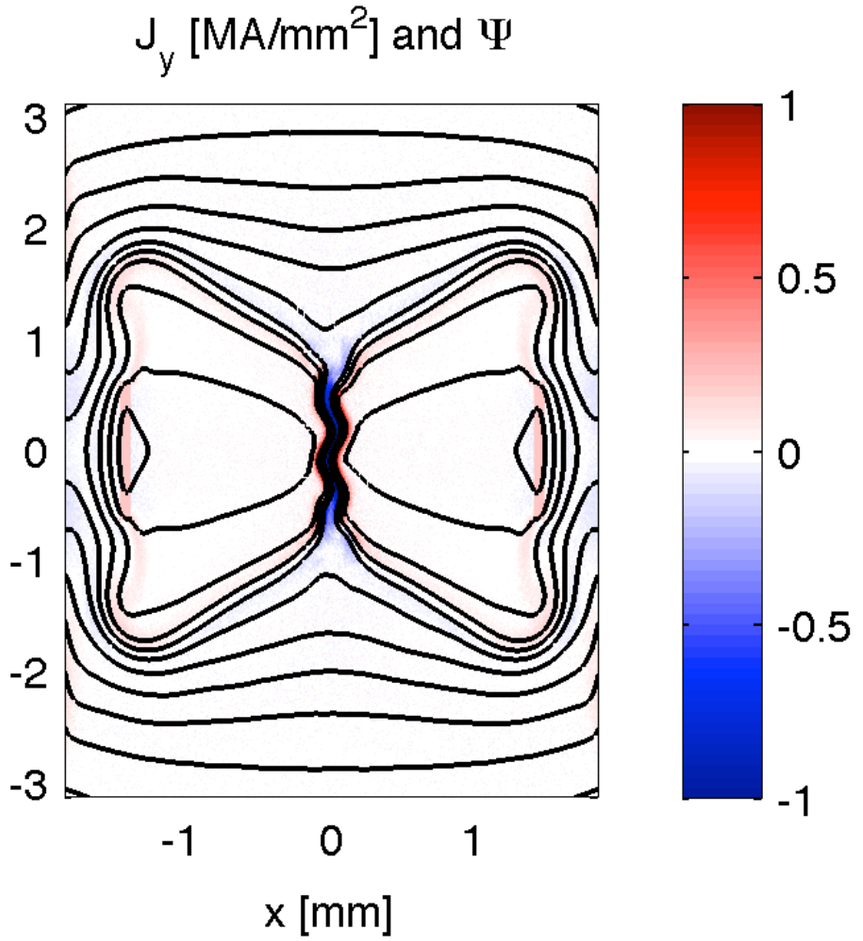


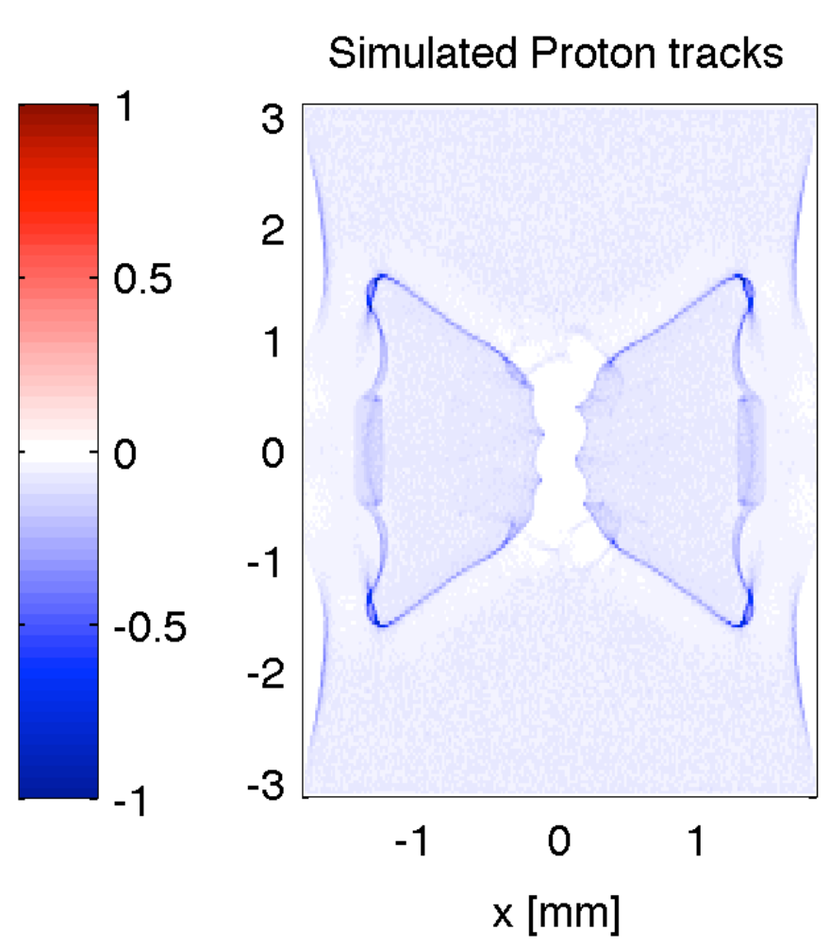
Biermann fields



Proton radiography simulated in post-processing



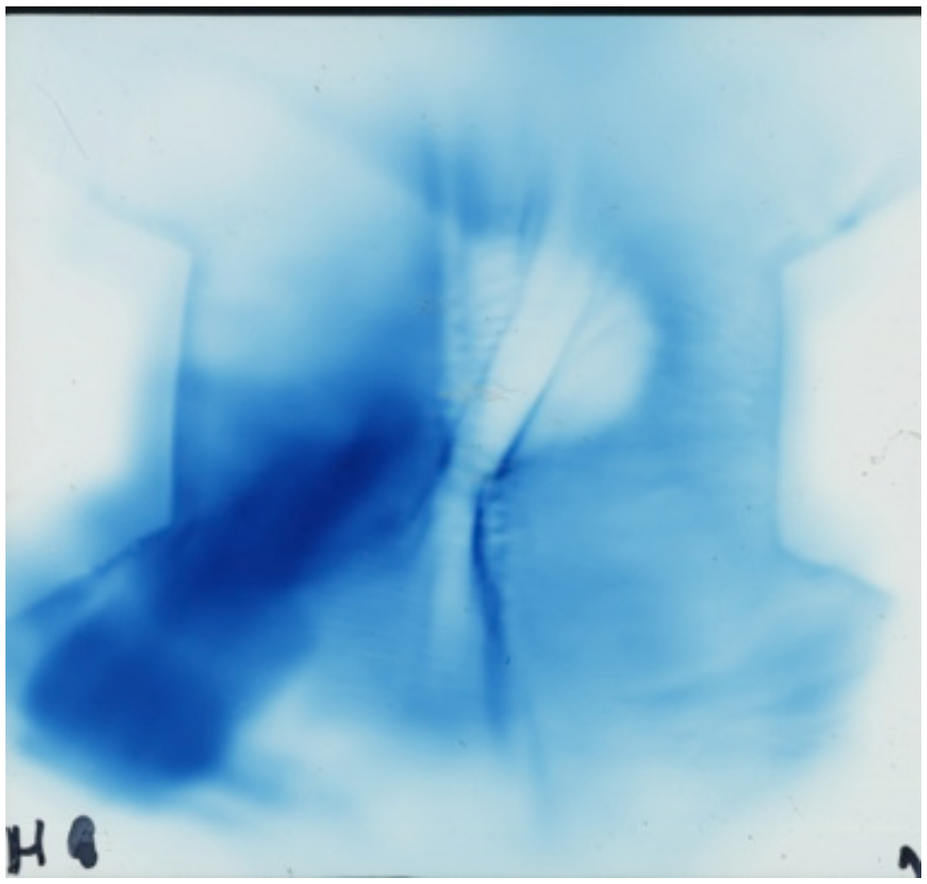




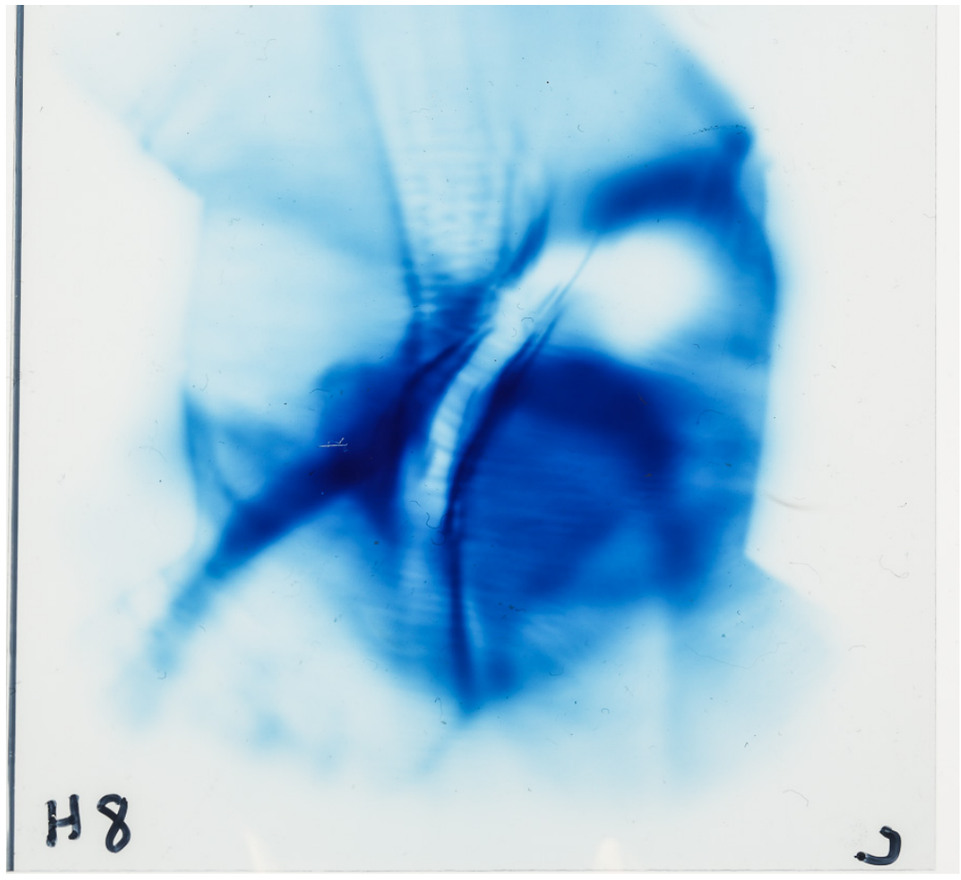
OMEGA EP Experiments

Simply applying MIFEDS does not produce a magnetized blowoff plasma

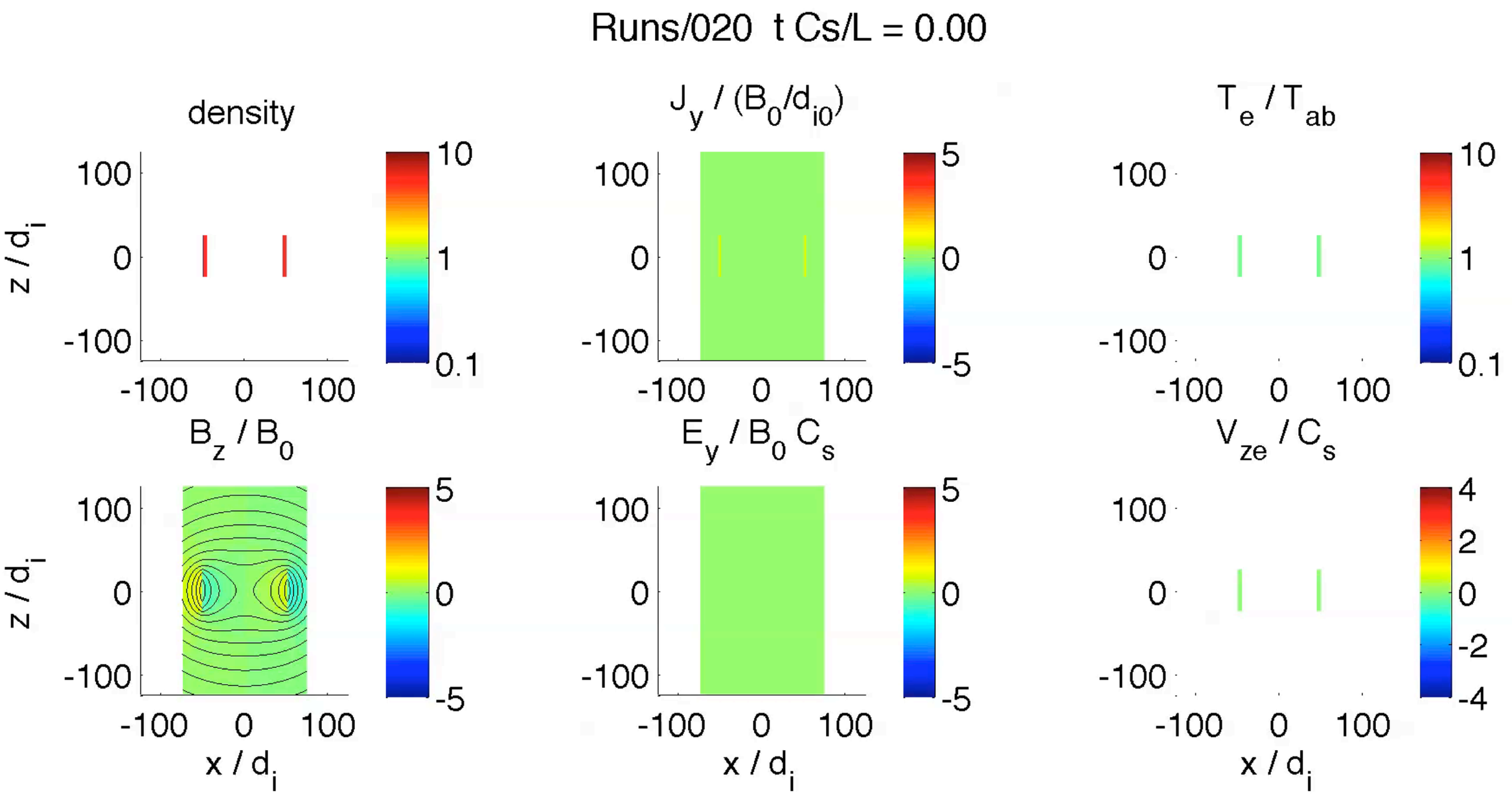
Sept, B_{mifeds} = 0
t = 2.8 ns



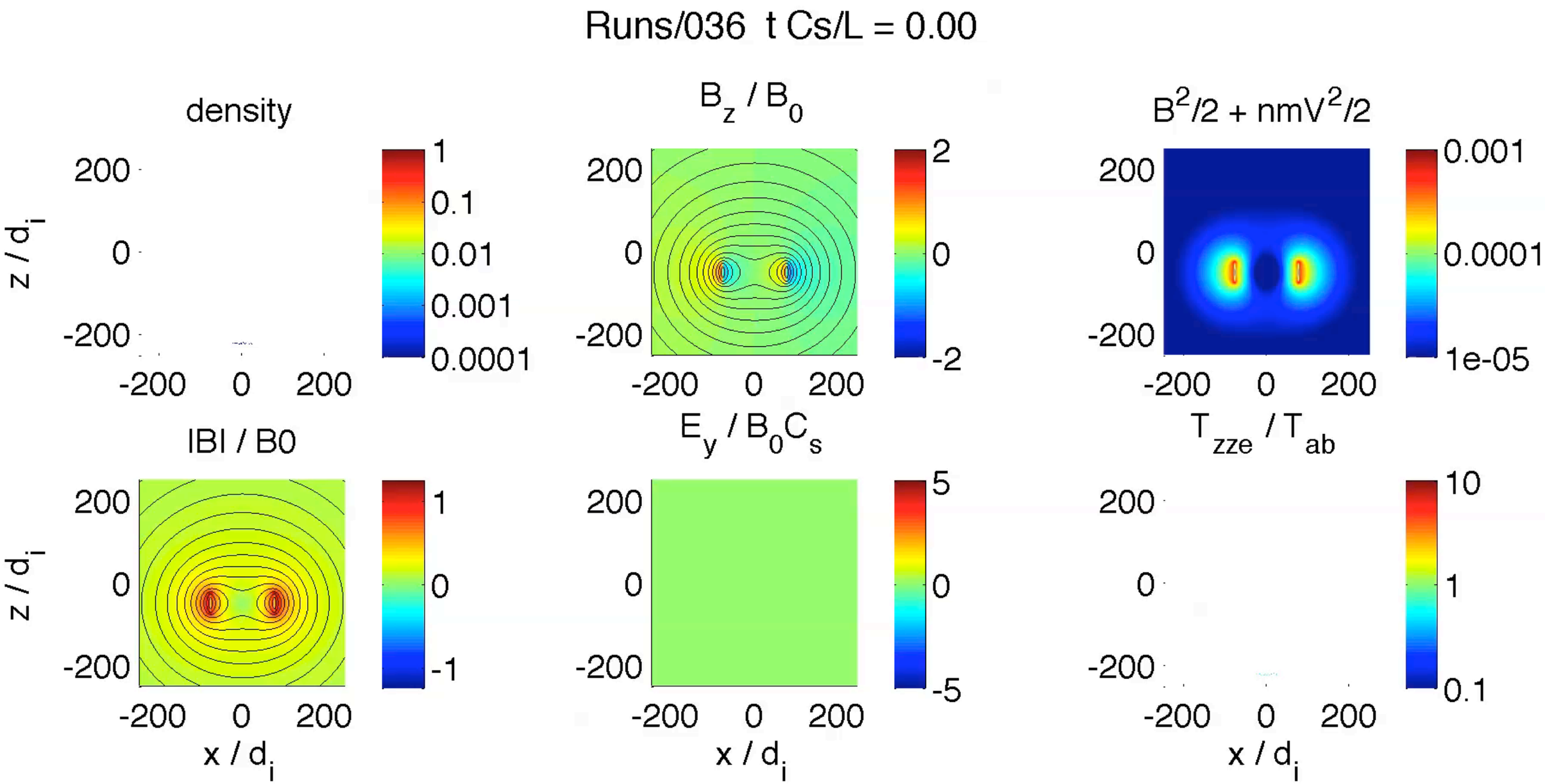
Dec, B_{mifeds} =6 T
t = 2.8 ns



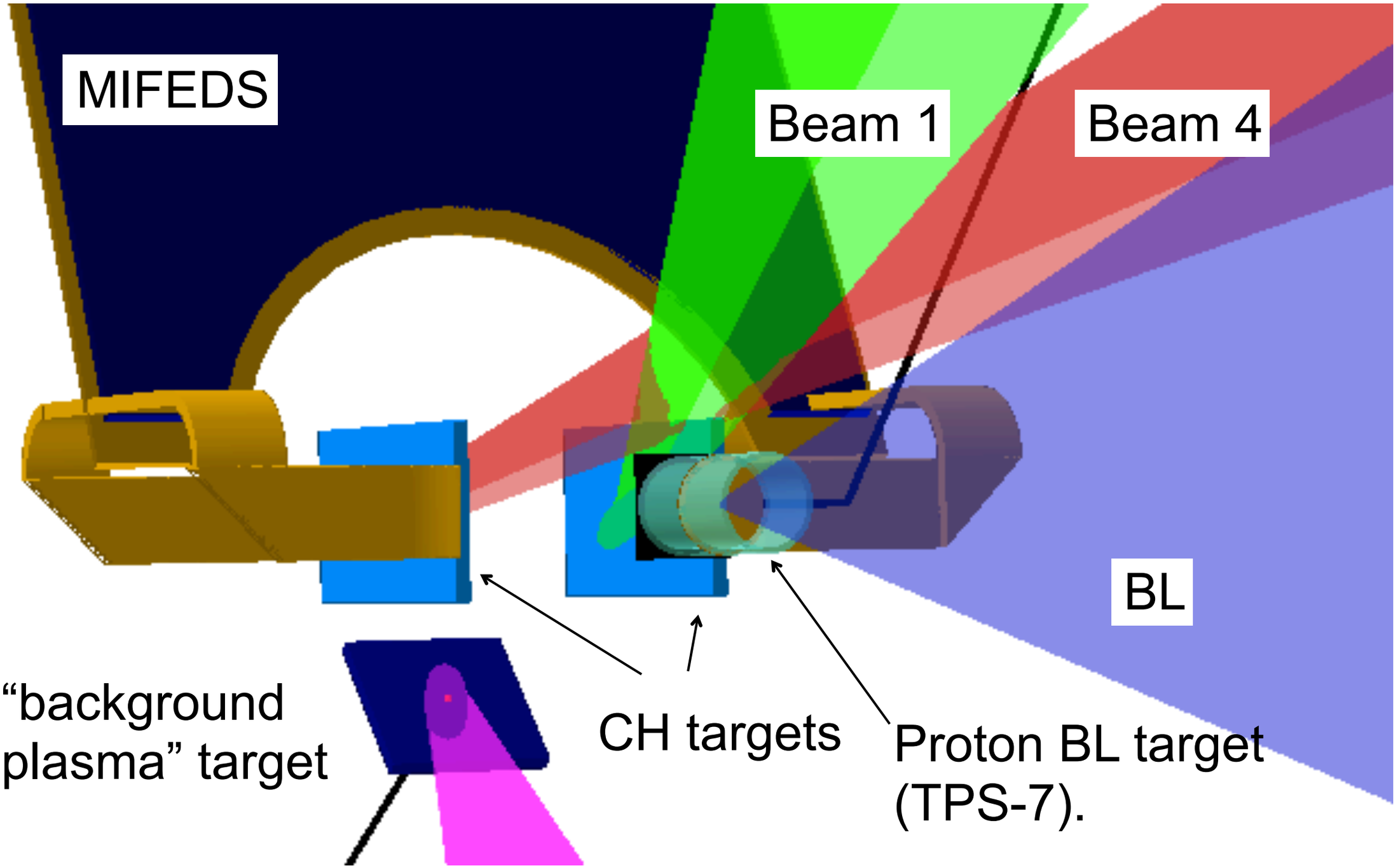
Ablation into vacuum MIFEDS field *does not* form a current sheet



“Background” plasma source enables blowoff plasma to be magnetized

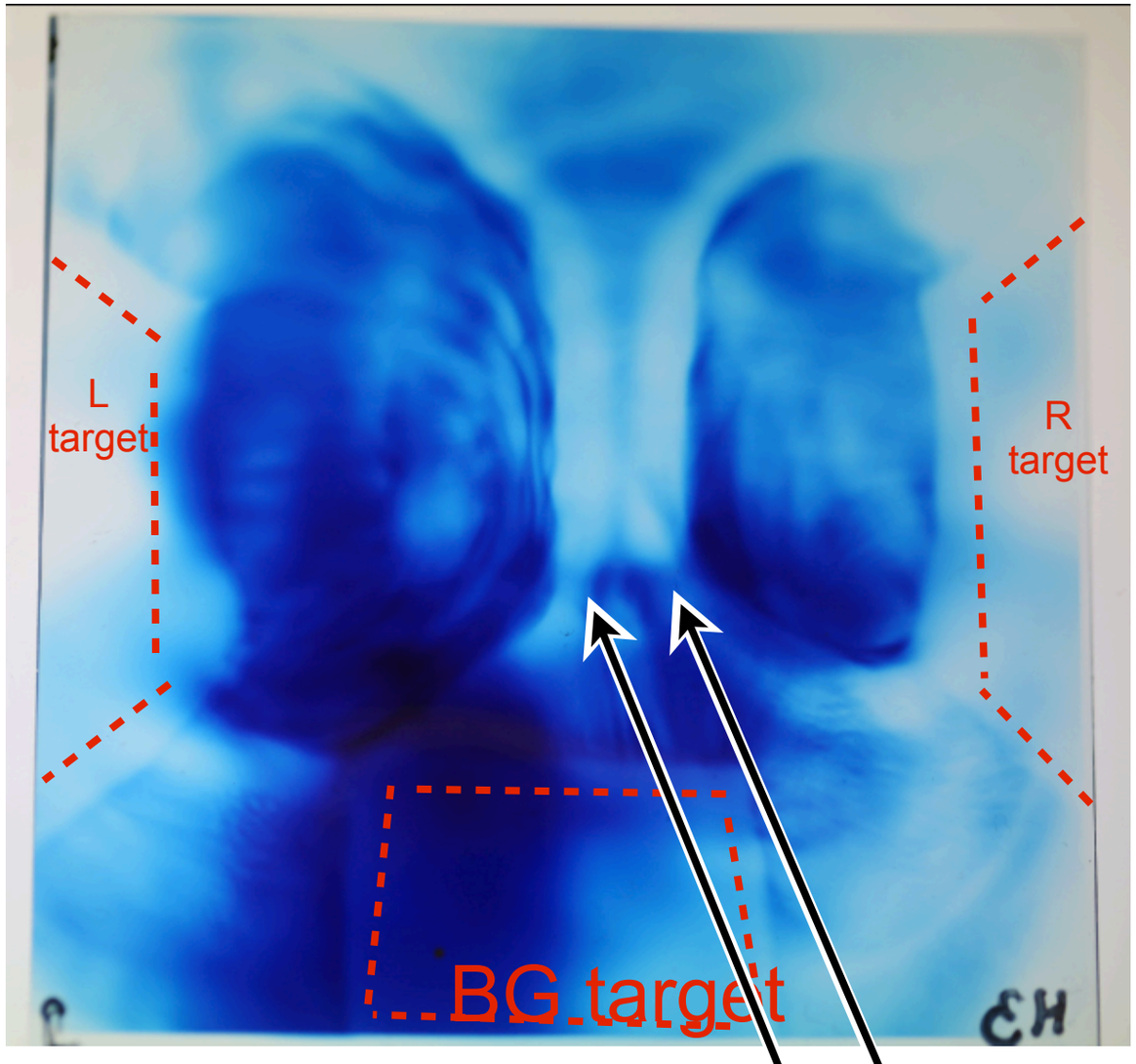


Experimental setup

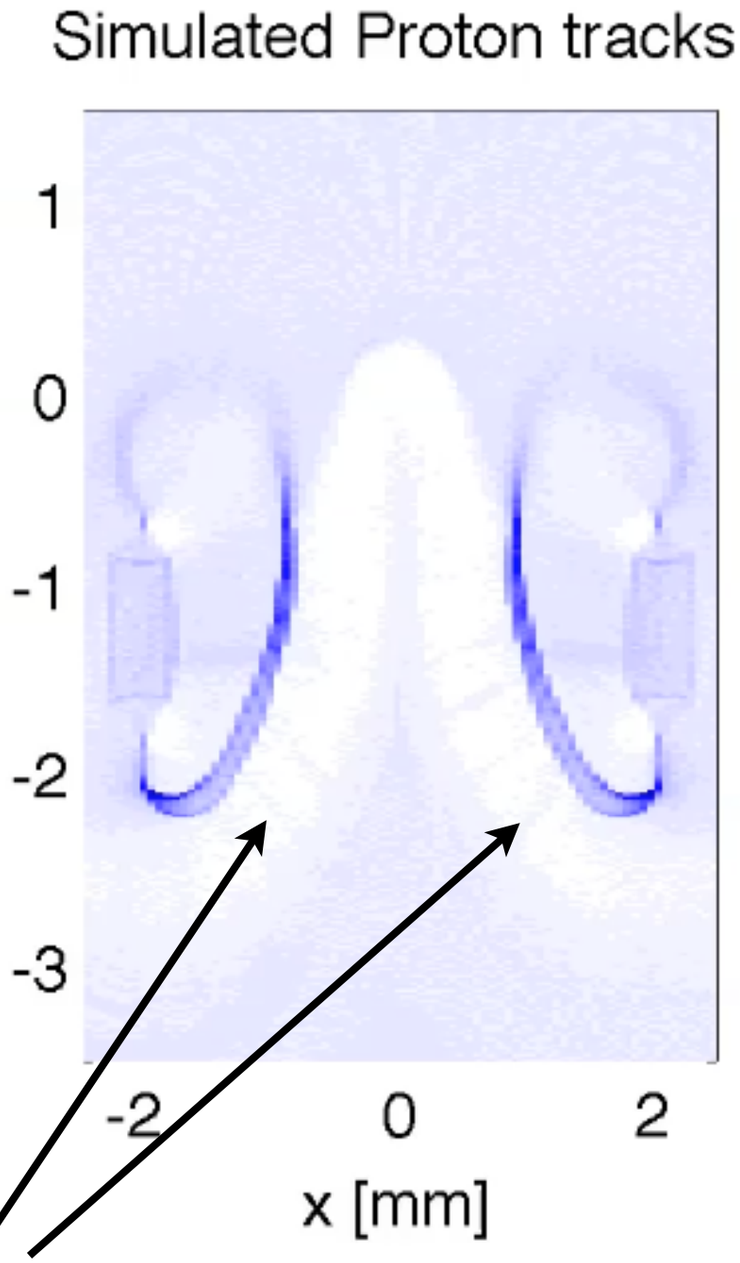


Presence of background plasma allows formation of propagating magnetized plasma with B-field “ribbon”

Shot 14250:
100 J bg plasma @ -15 ns
1.5kJ drive plasmas @ -3 ns



Particle-in-cell simulation with bg plasma source

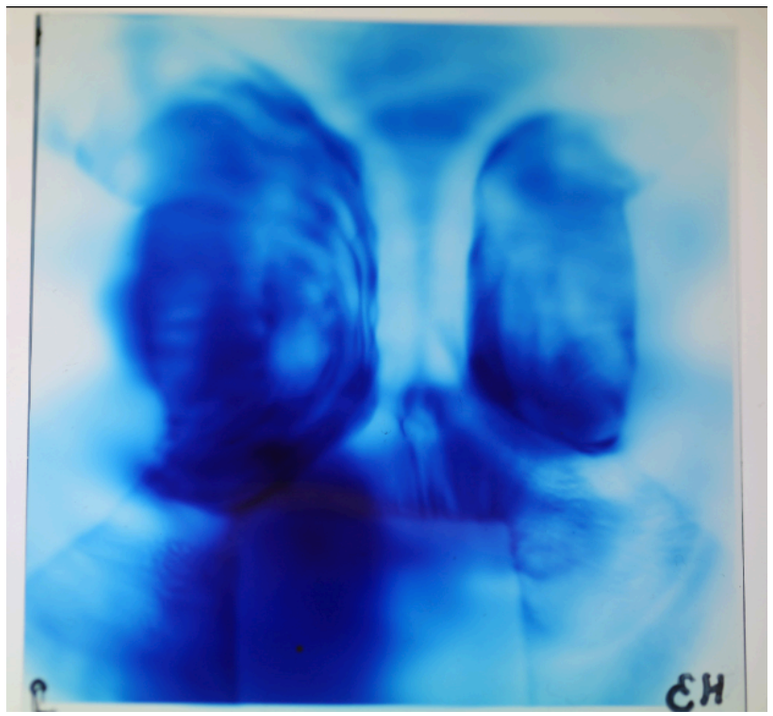


Ribbon of magnetic field scatters proton beam leading to observed proton void
(not observed with no background plasma, e.g. in previous shot-days with MIFEDS)

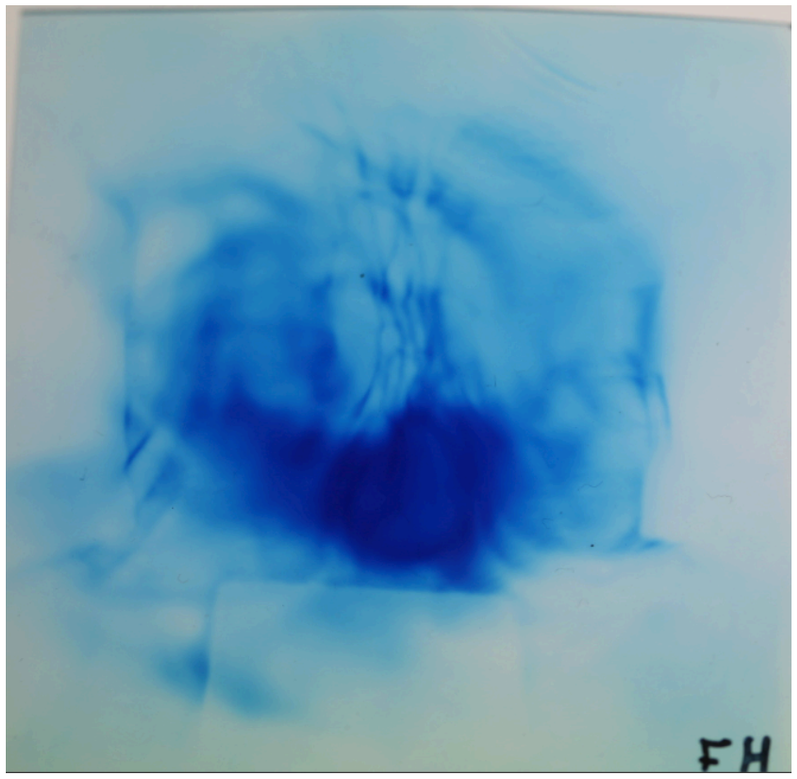
Collision of counterpropagating magnetized plasmas

Drive beams: UV beams 1&4, 1500 J, timing variable
Background plasma: UV Beam 3, 100 J, @ Drive -12 ns
Backlighter: 800 J at t=0

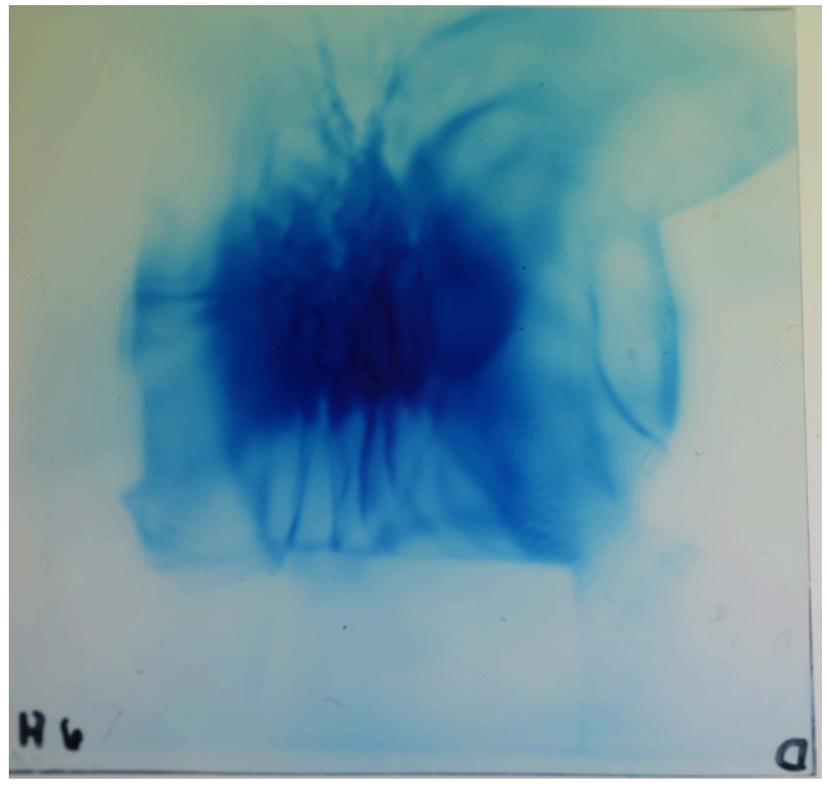
Shot 14250, Drive @ -3 ns



Shot 14252, Drive @-4 ns



Shot 14251, Drive -5 ns



Summary

- New experiments have been designed for OMEGA EP using MIFEDS for controlling B field involved in reconnection.
- Magnetized blowoff plasmas have been successfully produced and collided
  - low-density background plasma is key
  - magnetic field destruction observed