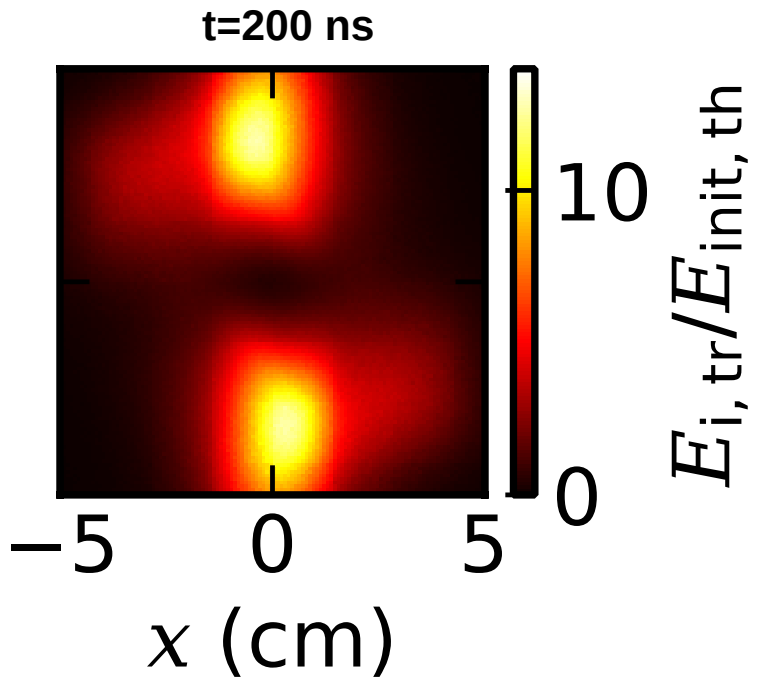
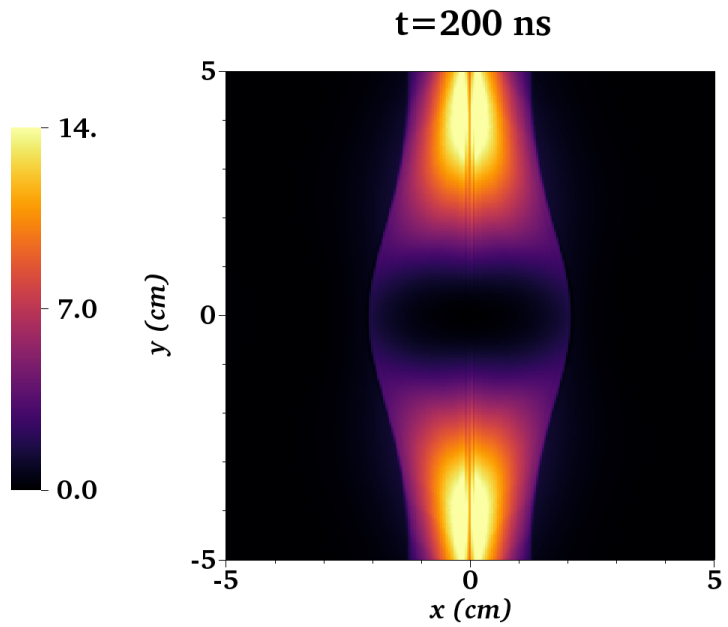
PIC Simulations of Colliding Plasma Jets in Plasma Liner Experiment

OSIRIS



FLASH



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Collaborators

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**See also CO08.00007, E. Hansen et al.
Extended MHD in the FLASH code**

Summary

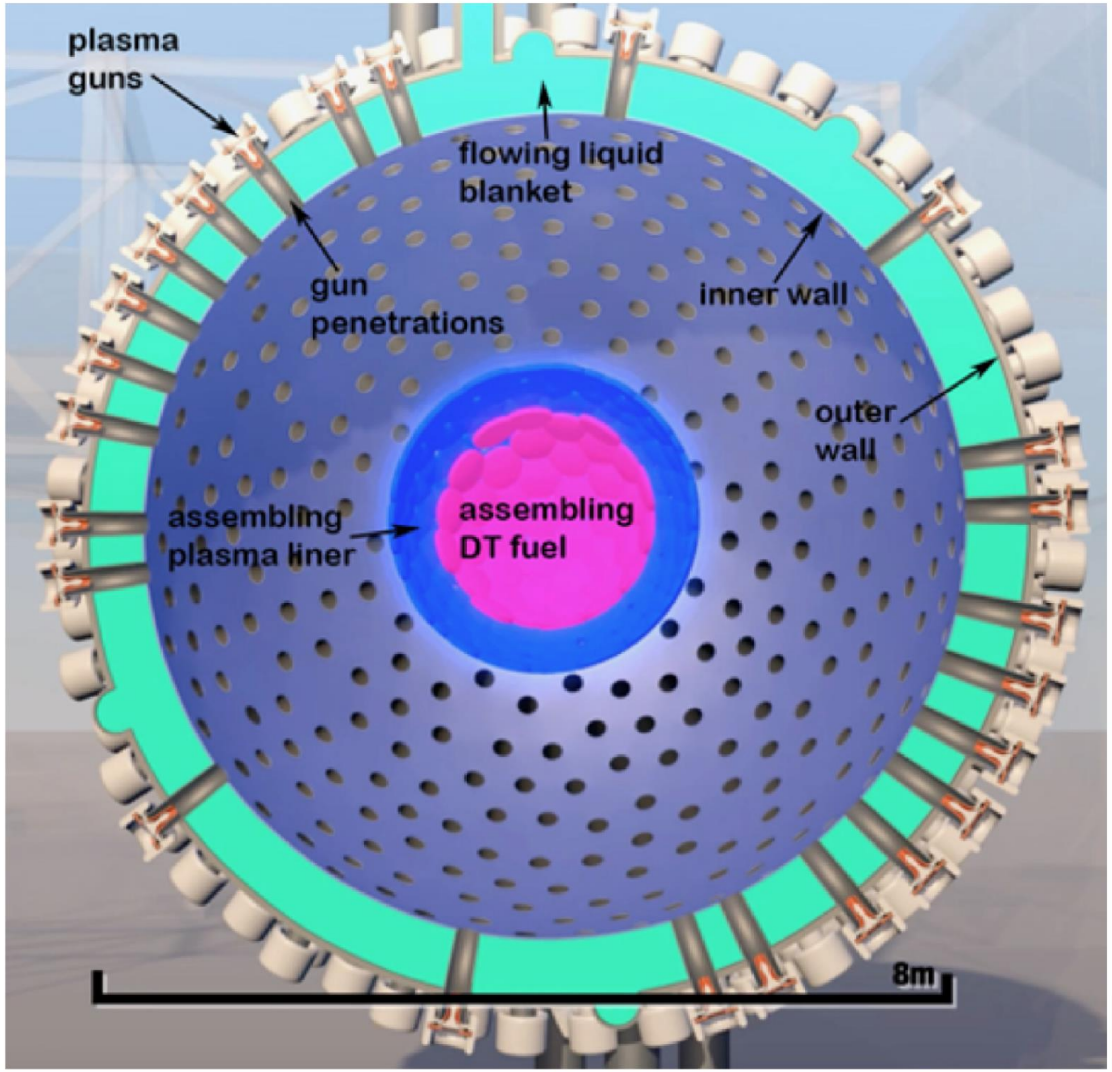
Colliding magnetized plasma jets were modeled with PIC to study Plasma Liner Experiments*

- Jets interpenetration was found to be mitigated by Modified Two-Stream Instability (MTSI)
- Colliding jets formed a plasma of $\chi_{i,e}$>1
- The results justified using single-fluid code FLASH to model target formation in PLX

* Hsu et al. IEEE Transaction on Plasma Science 40, 1287 (2012)

Plasma-Jet Driven MIF (PJMIF) investigates a "reactor-friendly" approach using spherical compression

- Target assembled from plasma jets launched from a "standoff" distance
  - No repetitive hardware destruction in all-gas / plasma architecture
- Spherical compression allows dramatic improvement in pressure scaling
  - $P \sim CR^5$ vs $CR^{3.33}$ (Cylindrical)
- PLX with 36 liners and 1.5 MJ stored energy aims to generate cm/μs/Mbar plasmas*



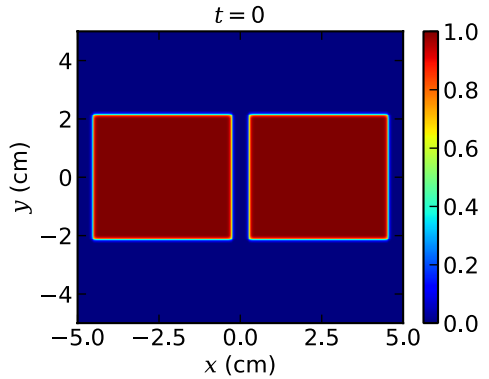
Courtesy of S. Langendorf, LANL

* Hsu et al. IEEE Transaction on Plasma Science 40, 1287 (2012)

Colliding magnetized jets is key physics in PLX target formation

- **Typical parameters of colliding jets**
  - **V=140 km/s, n=10^{14}/cm^3, T=5 eV, B=500 G**
  - **Proton MFP is ~1 m >> system size**

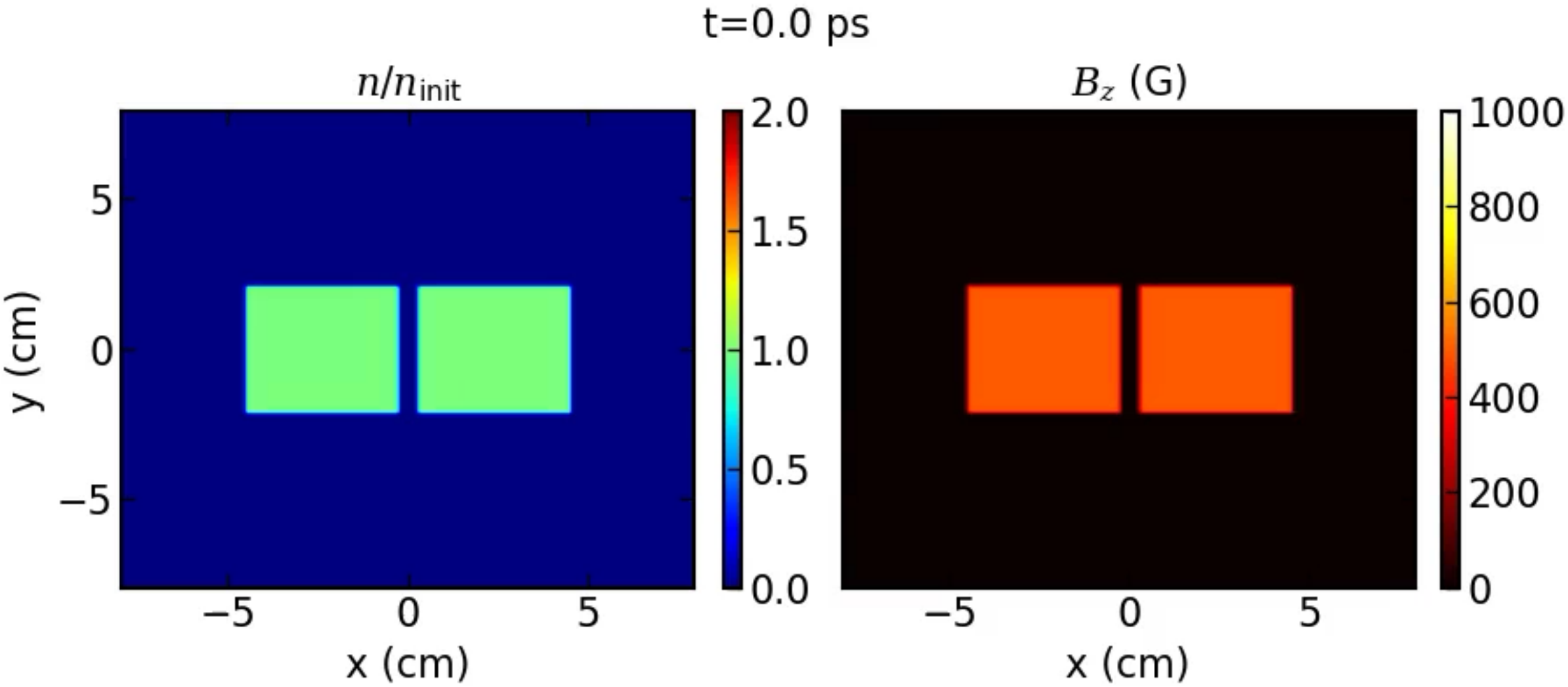
- **Can the process be modeled by single-fluid MHD codes?**
  - **Need to assess the degree of interpenetration**



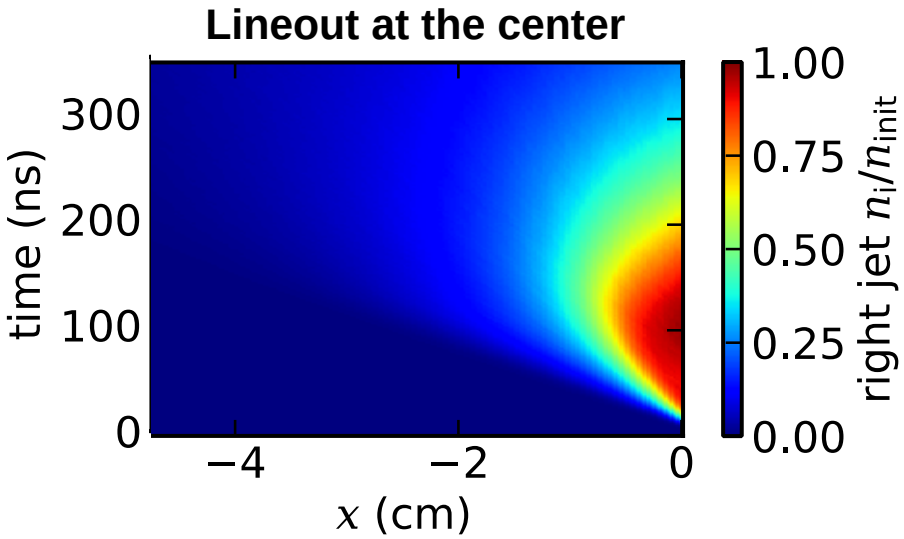
We justify use of FLASH with OSIRIS* simulations

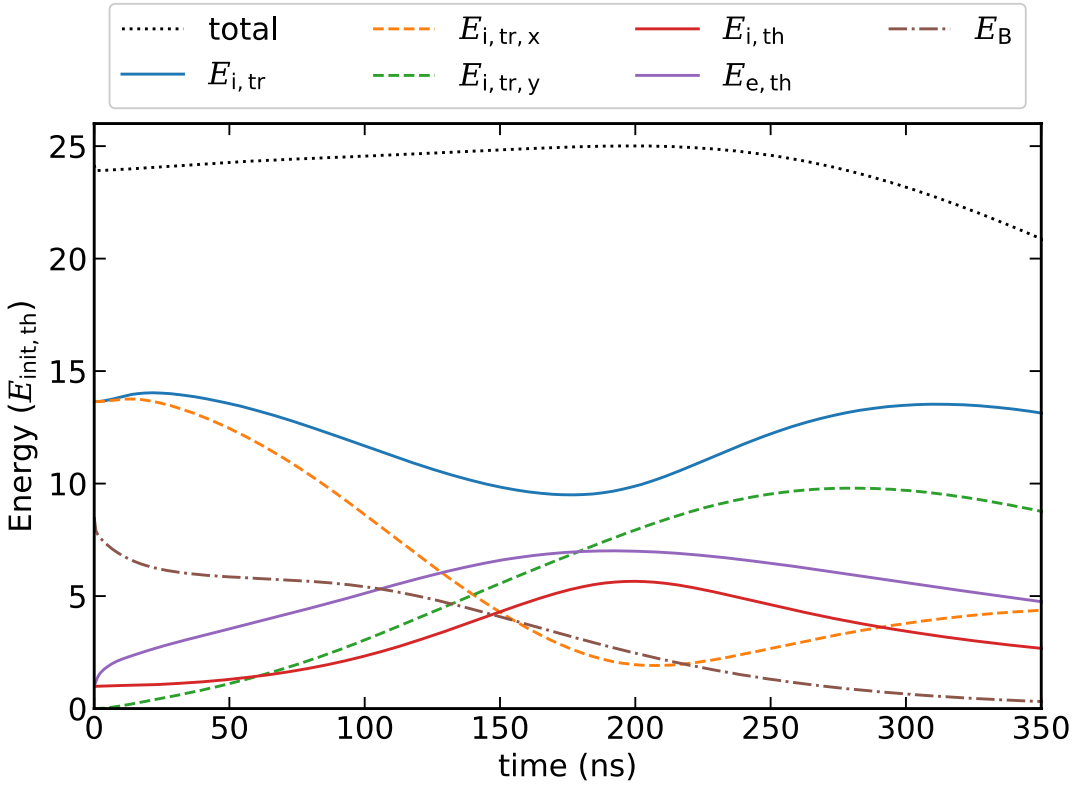
* Fonseca et al. "OSIRIS: A three-dimensional, fully relativistic particle in cell code for modeling plasma based accelerators." International Conference on Computational Science. Springer, Berlin, Heidelberg, 2002.

Jet colliding were successfully modeled by OSIRIS



The jets were largely stopped with limited interpenetration

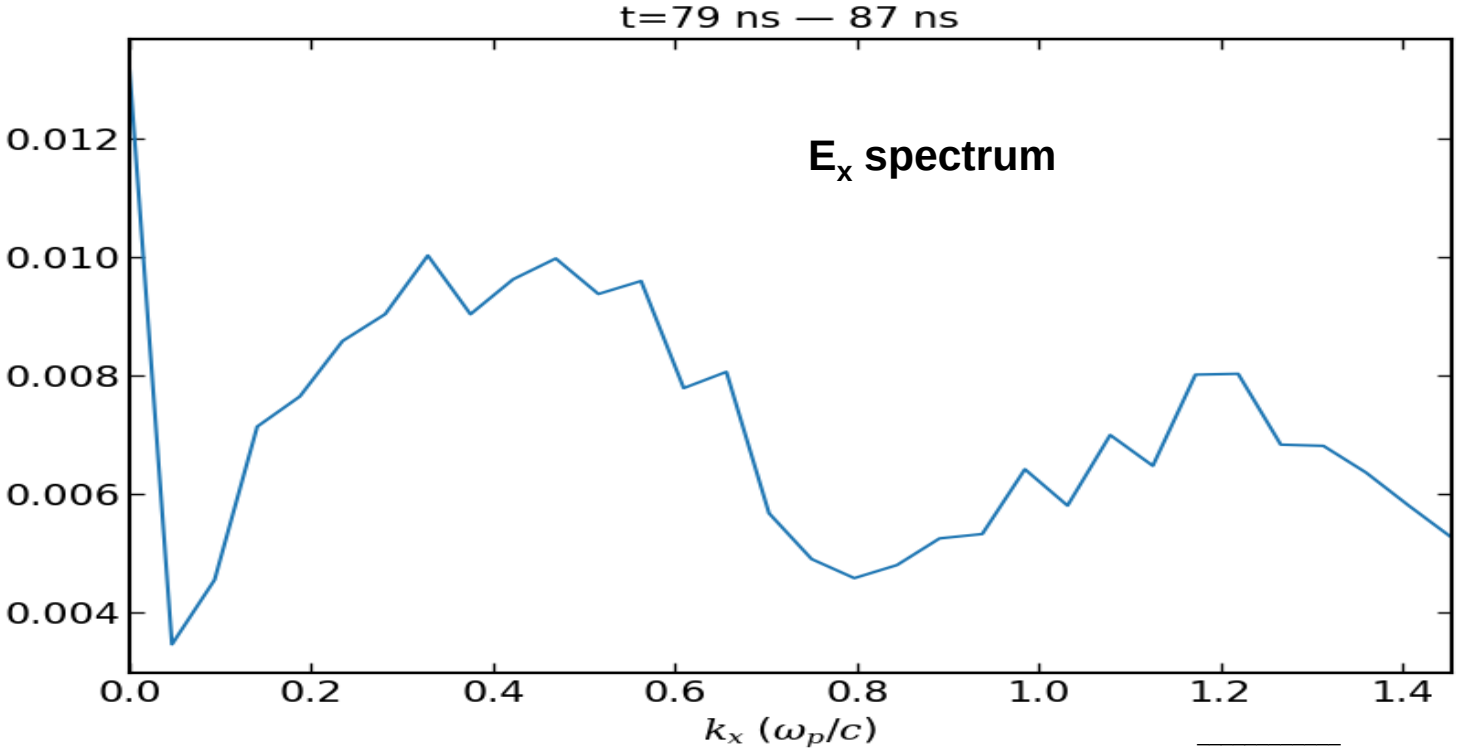




The plasma heated up before dispersing

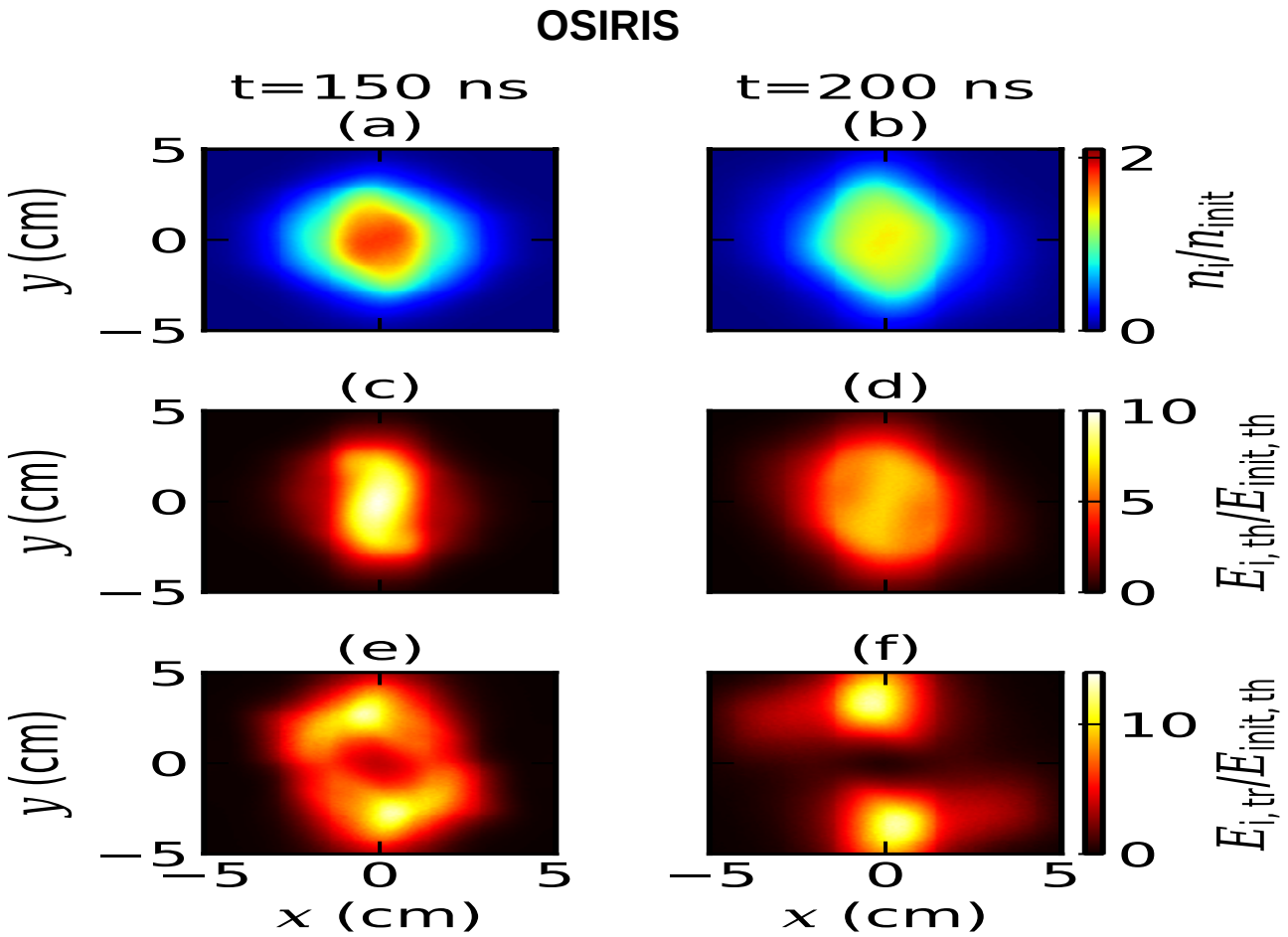
MTSI may play a role in jets stopping

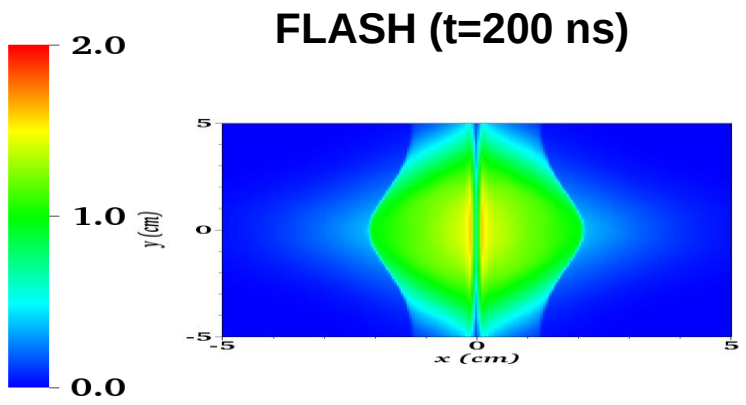
- **MTSI is a two-stream instability in a magnetic field*,****
  - $\gamma_{MTSI} \sim \omega_{LH} \sim 6.9 \times 10^{-2} ns^{-1} \sim 10^{3} \nu_{ie}$
  - **Maximum growth at $k = 0.49\omega_{pe}/c$**

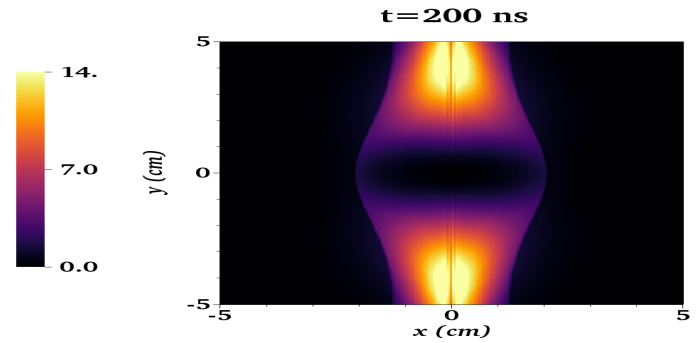


* Gary, Theory of Space Plasma Microinstabilities, Cambridge University Press (1993)
** McBride *et al.*, Phys. Fluids **15**, 2368 (1972)

The jets were largely stopped before dispersing sideways

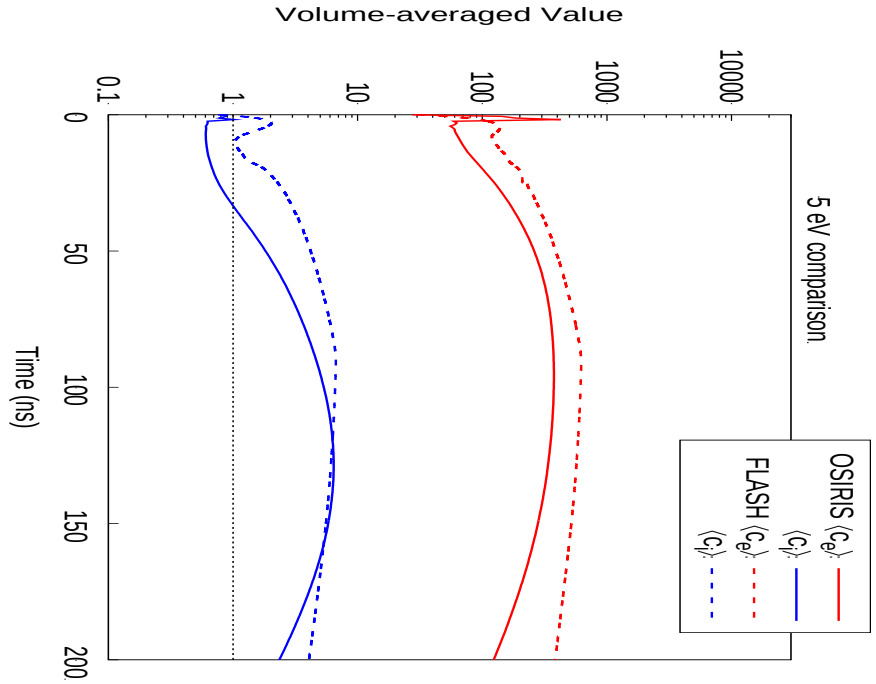






OSIRIS and FLASH saw similar behaviors

These results justified the use of FLASH for integrated modeling



Both simulations showed $\chi_{i,e}$>1

Summary

Colliding magnetized plasma jets were modeled with PIC to study Plasma Liner Experiments*

- Jets interpenetration was found to be mitigated by Modified Two-Stream Instability (MTSI)
- Colliding jets formed a plasma of $\beta \sim 1$ and $\chi_{i,e} > 1$
- The results justified using single-fluid code FLASH to model target formation in PLX

* Hsu et al. IEEE Transaction on Plasma Science 40, 1287 (2012)