Simulations of a stable helical shear-flow stabilized plasma jet

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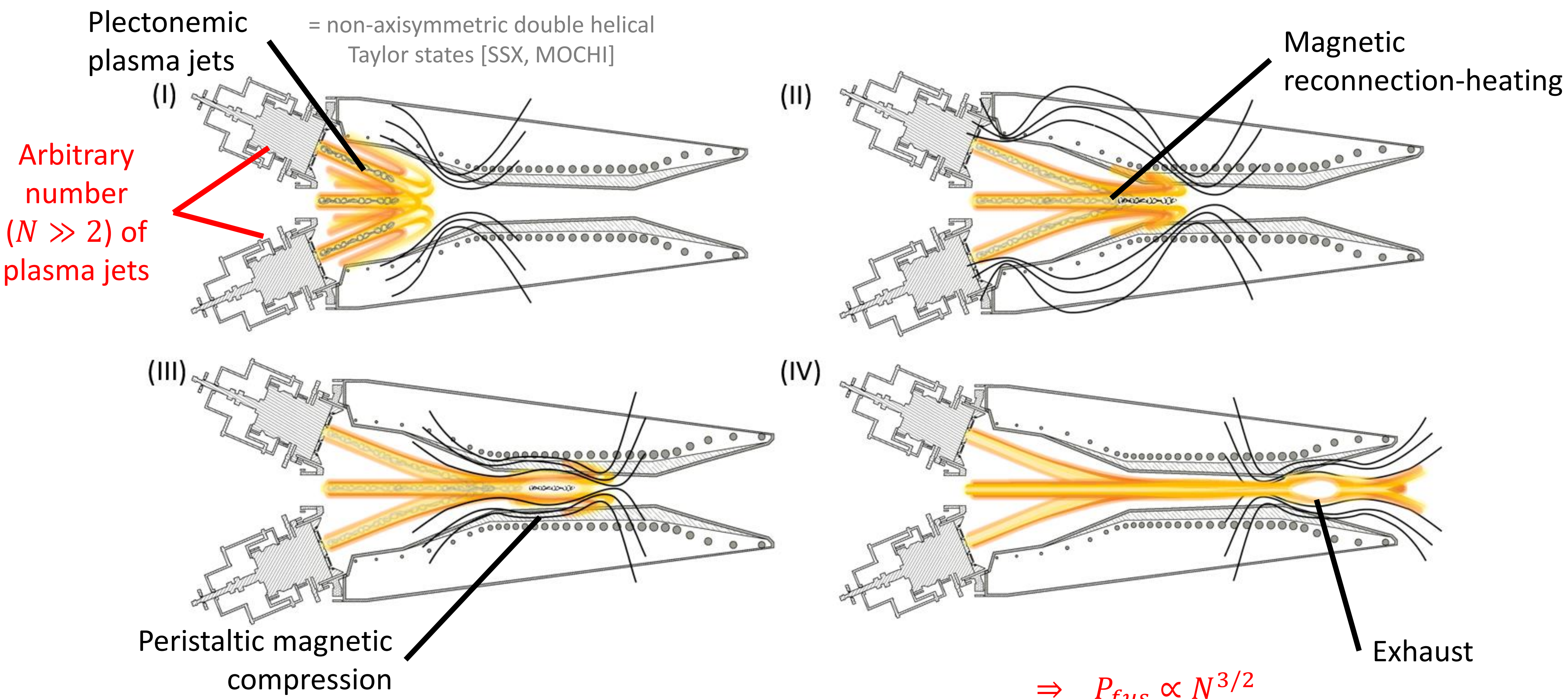
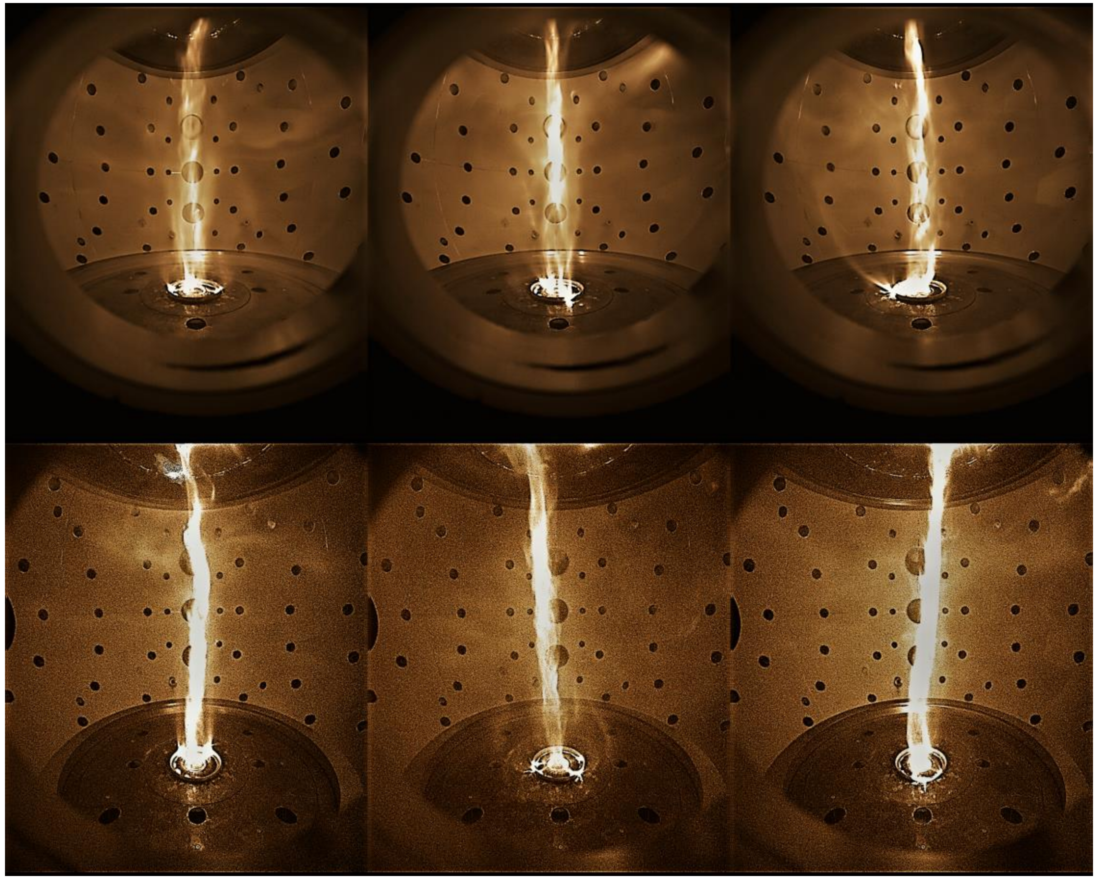
Helicity Drive magneto-inertial fusion concept



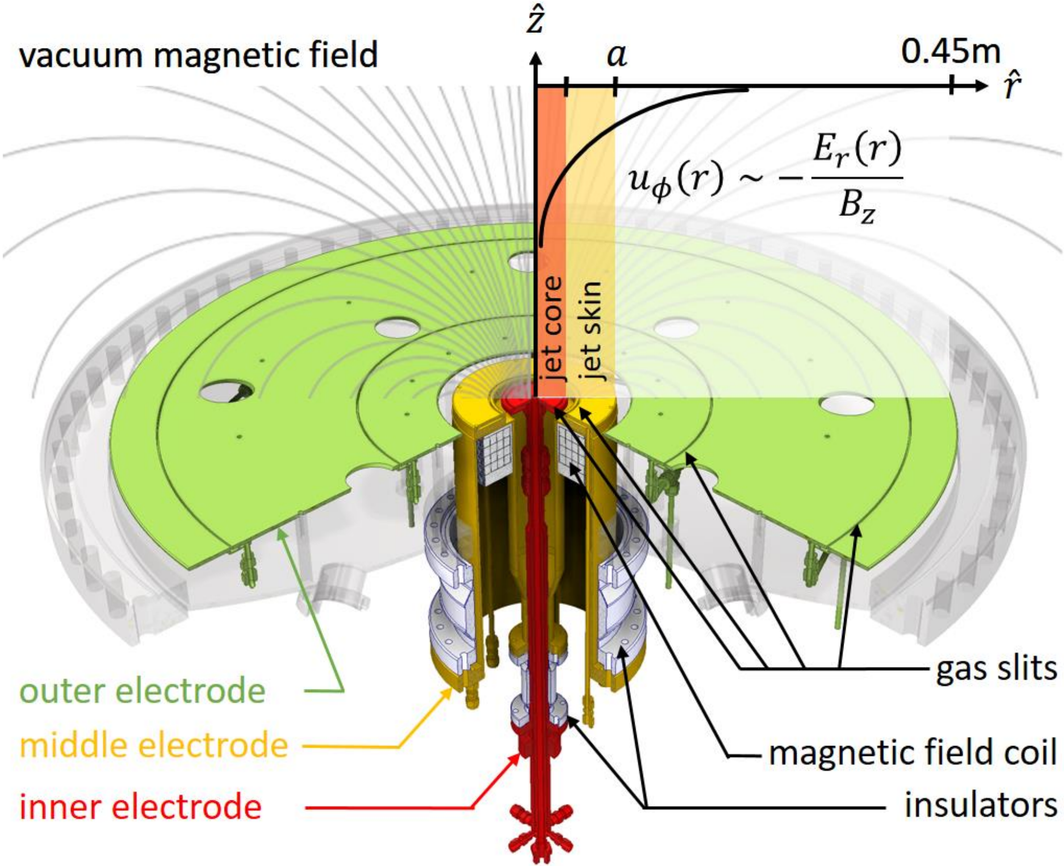
$\Rightarrow \quad P_{fus} \propto N^{3/2}$

S. You, AIAA Propulsion & Energy Forum, AIAA- 2020-3835, Aug. 24-28, 2020.

Experimental foundation for (I)



Dense plasma jets formed in MOCHI experiment.

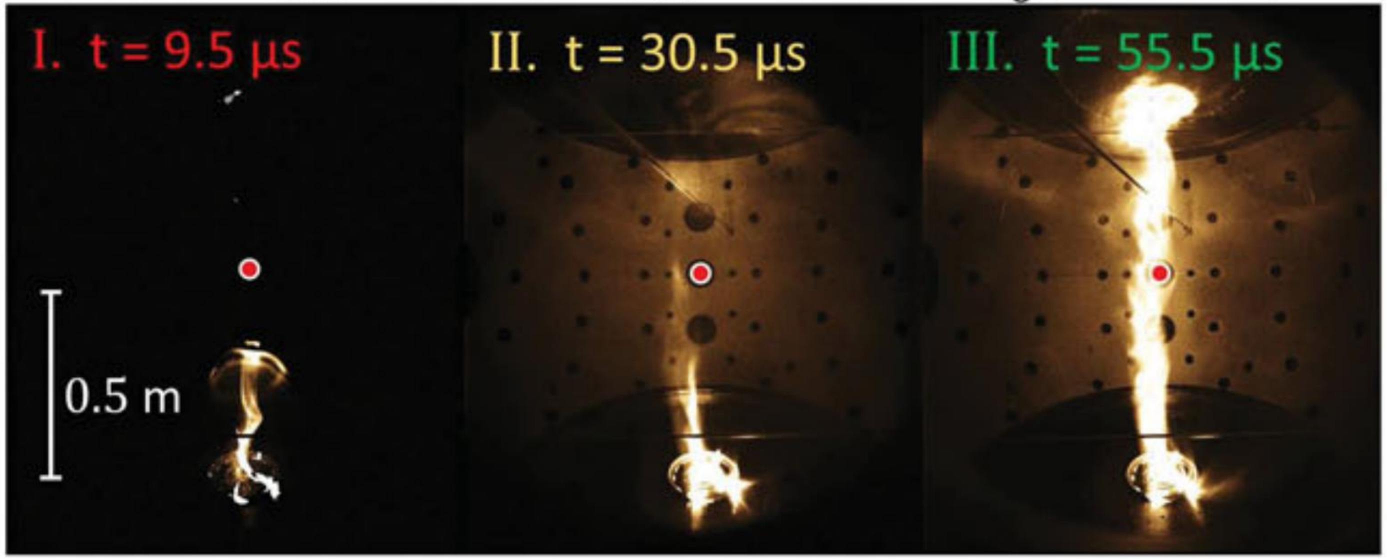


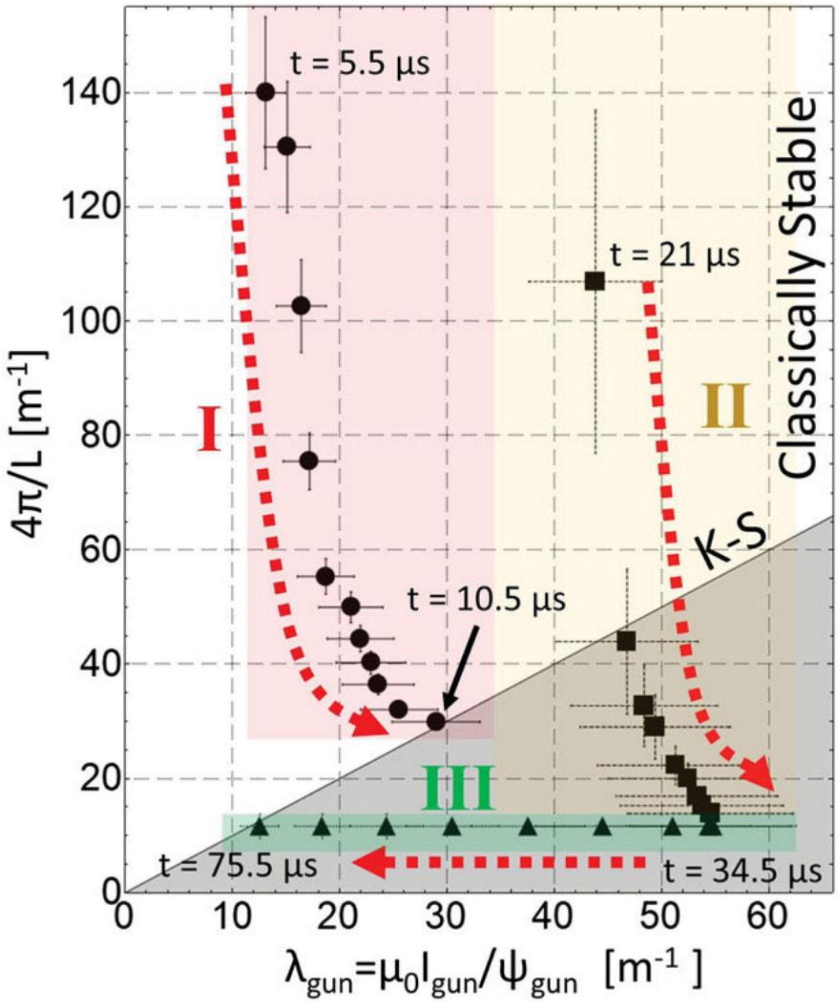
Plasma gun design of MOCHI experiment

S. You *et al*, Astrophys. J. Suppl. S., **236,** 29 (2018)

Jet is stable beyond classical Kruskal-Shafranov threshold

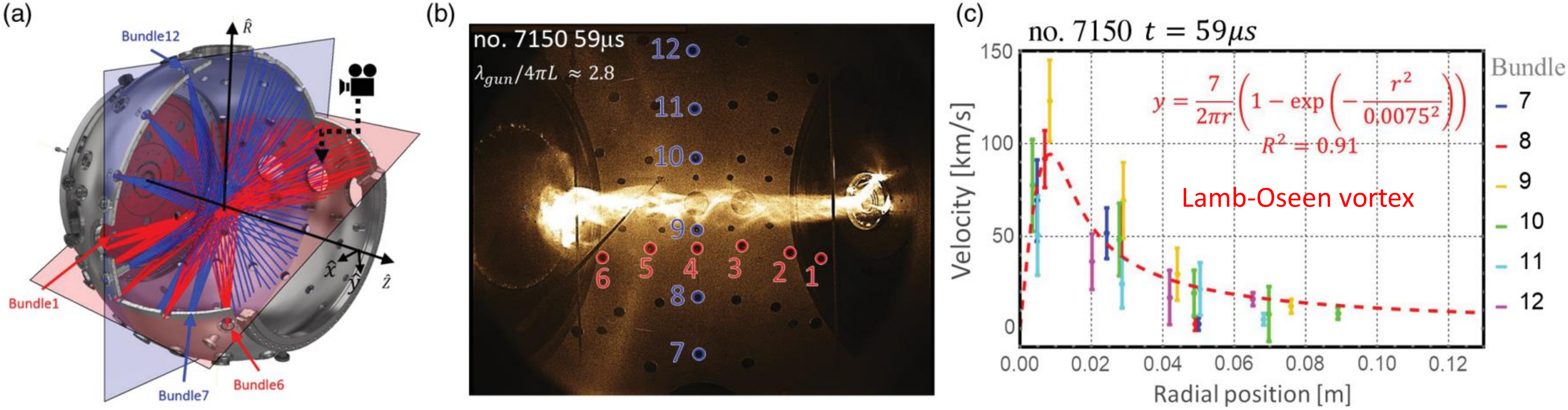
no. 7150: V_{core} = -6.1 kV; V_{skin} = -5.7 kV; ψ_{gun} = 4 mWb





E. S. Lavine & S. You, Phys. Rev. Lett., **123**, 145002 (2019)

Jet is stable beyond classical Kruskal-Shafranov threshold with helical shear flows



E. S. Lavine & S. You, Phys. Rev. Lett., **123**, 145002 (2019)

LA-COMPASS 3D MHD Simulations of MOCHI

Ideal MHD region (open boundaries)

Engine region

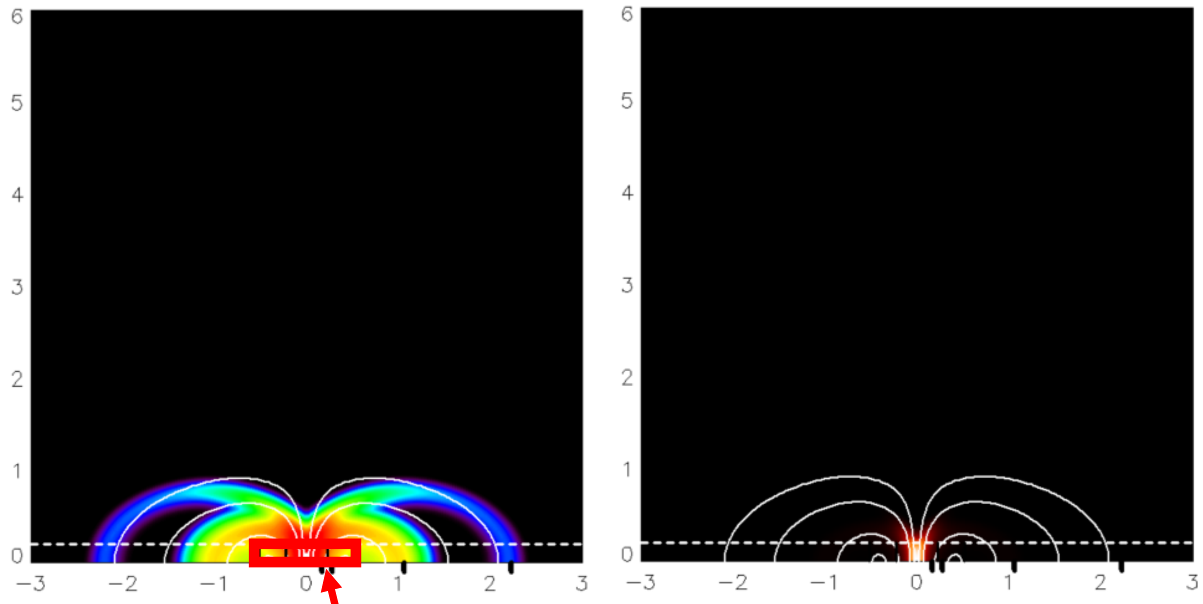
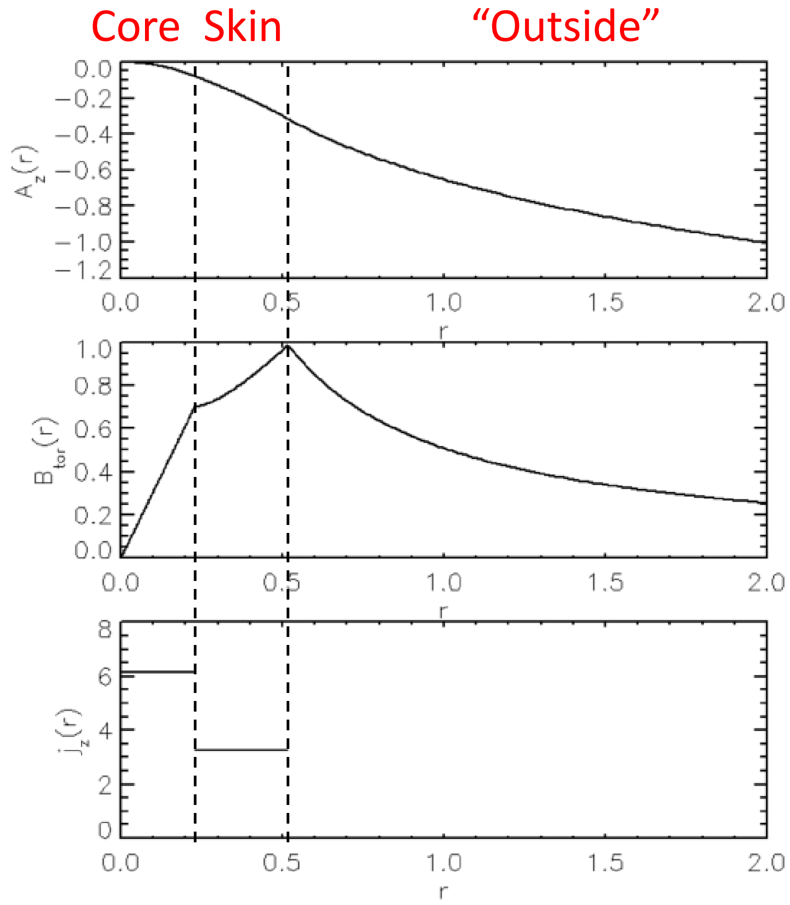


Figure 1. (a) Log(n) contours. (b) n^2 plot which simulates light emission ($\propto n^2$).



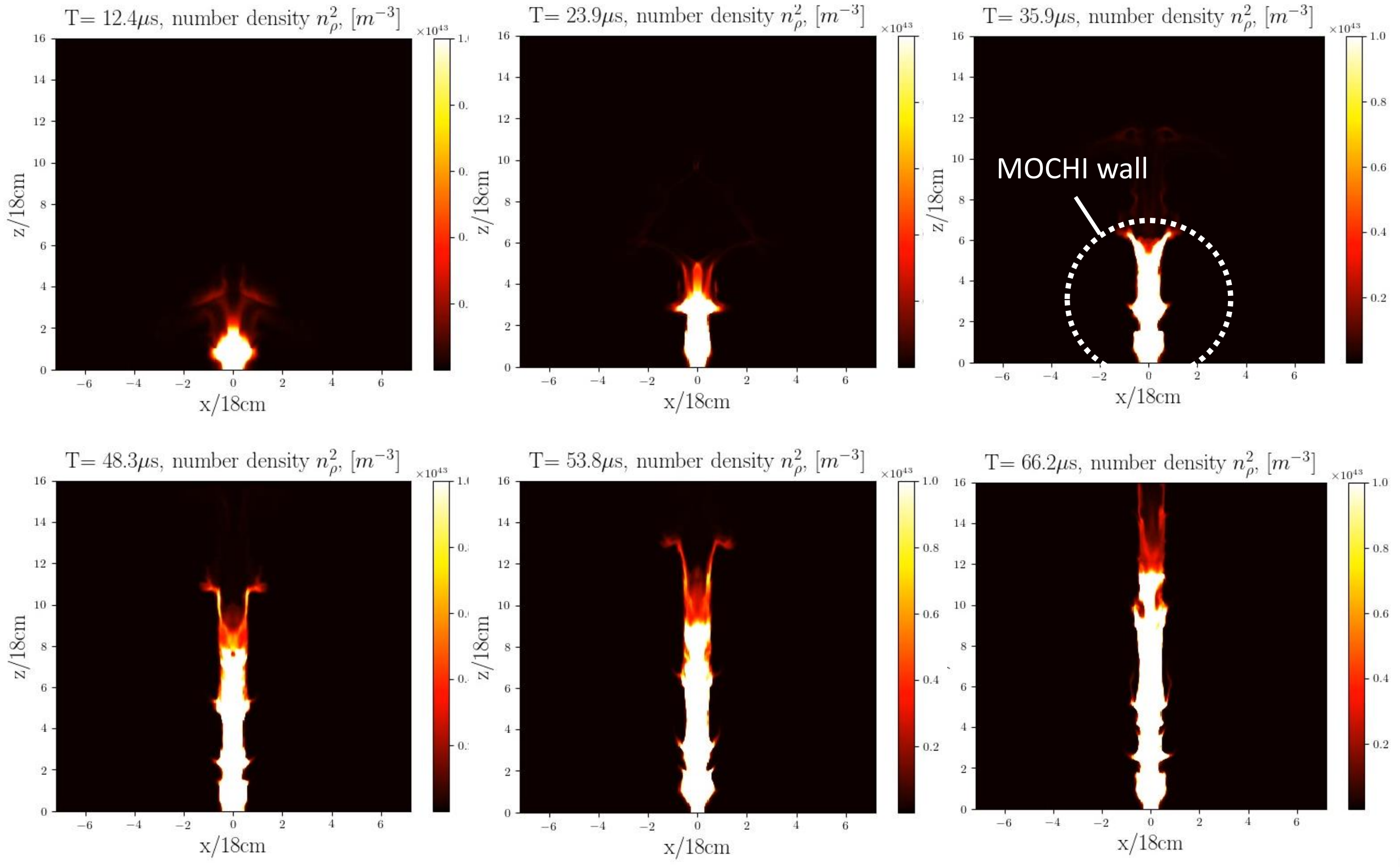
(a) Peaked current density with $I_a = 1.0, I_b = 2.2, a = 0.2278, b = 0.5167$.

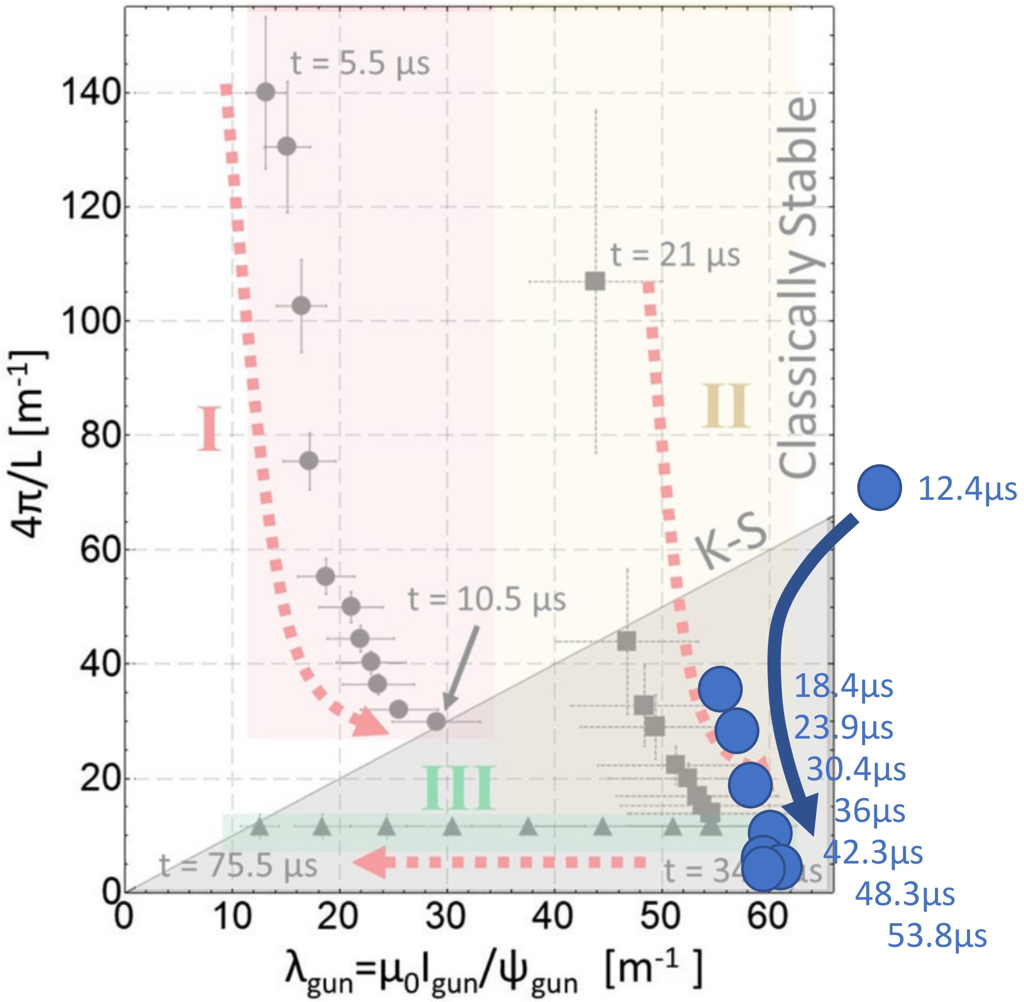
Imposed Core and Skin profiles in Engine Region:

1) Mass injection ($\dot{m}$) imposed
2) Kinetic energy (v_z) imposed
3) Current profile ($\dot{B}_{tor}$) imposed

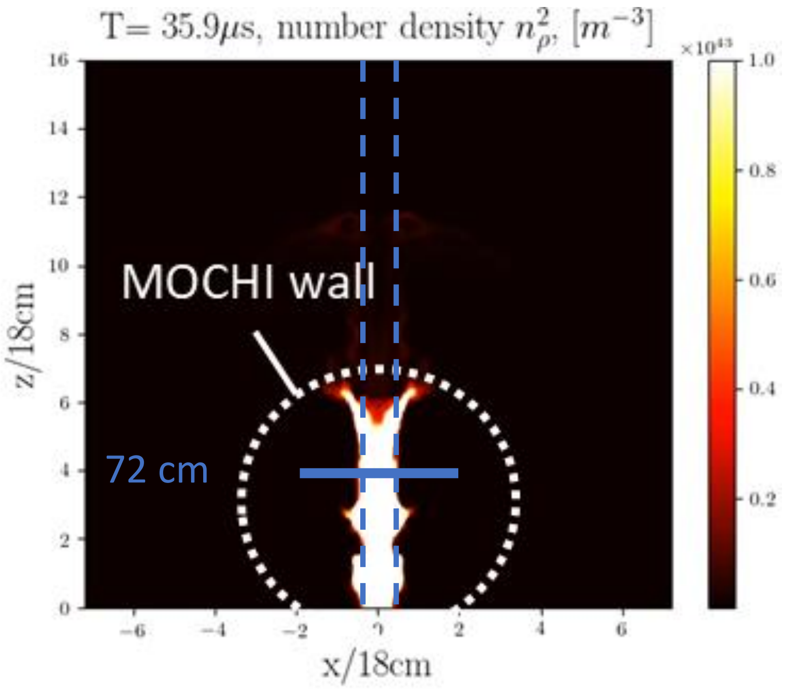
LA-COMPASS code: X. Zhai, H. Li, P. M. Bellan, S. Li, Astrophys. J., **791**, 40 (2014)

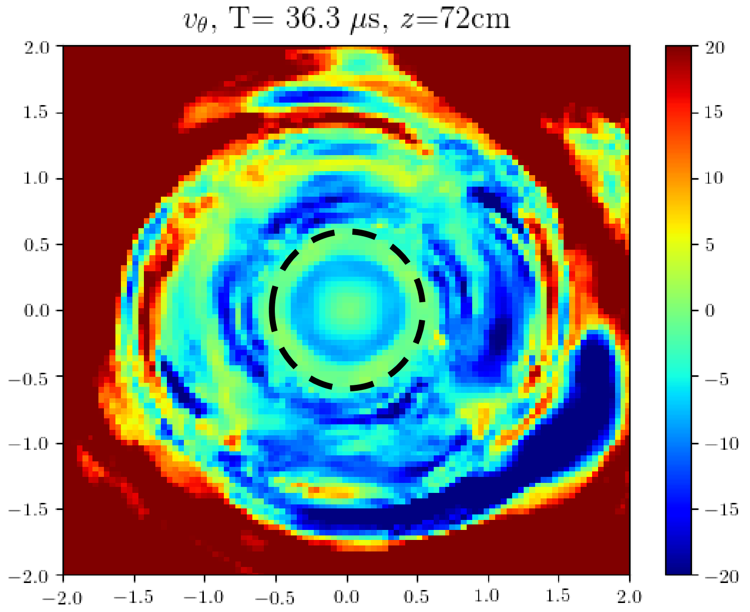
Simulation confirms long(er!) stable jet

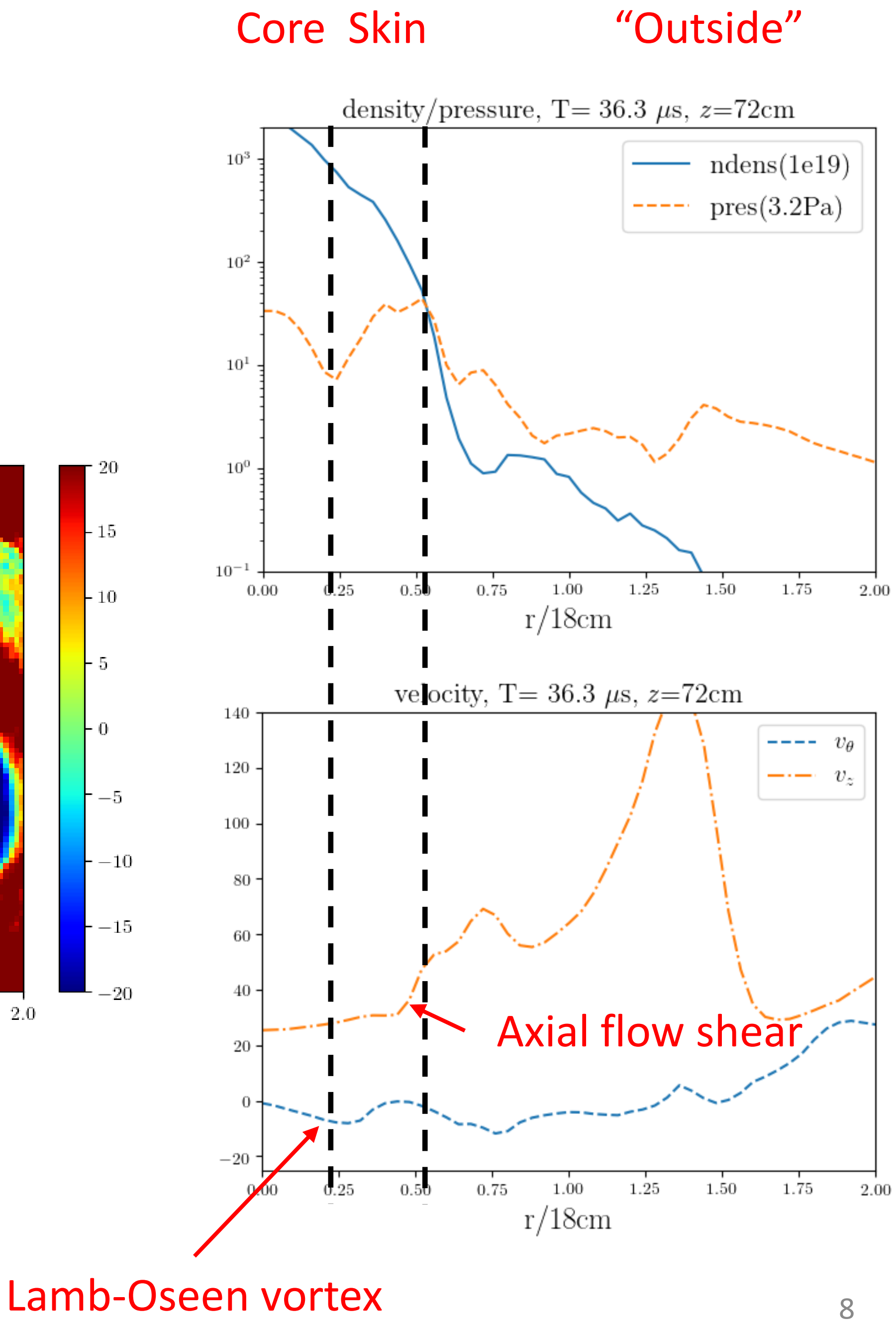




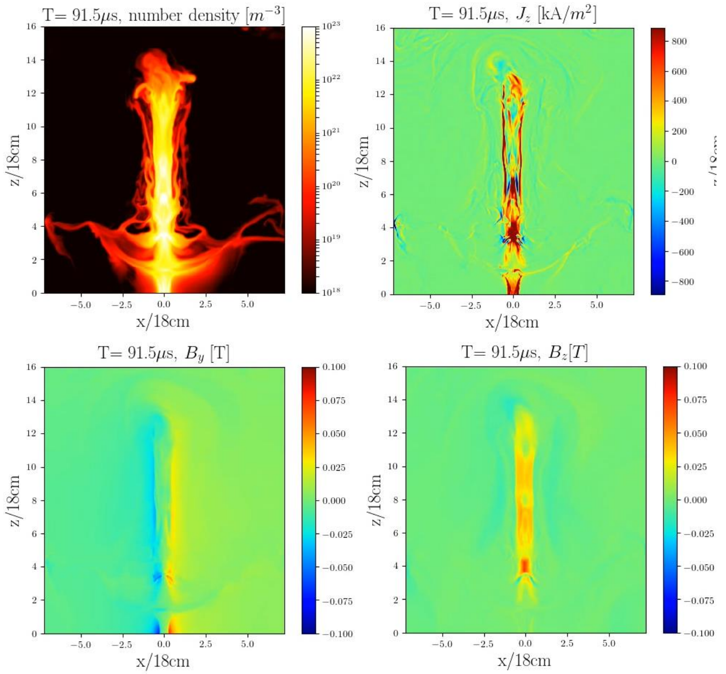
Simulations confirm helical flow shear



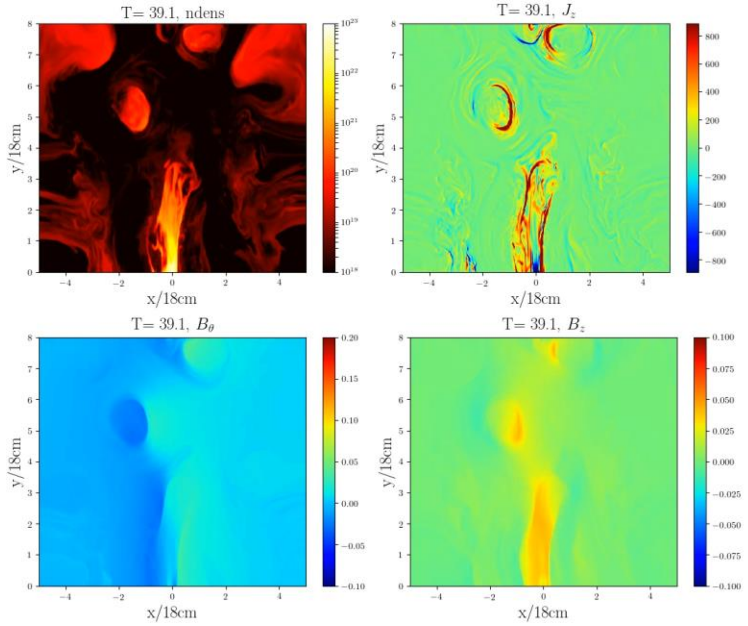




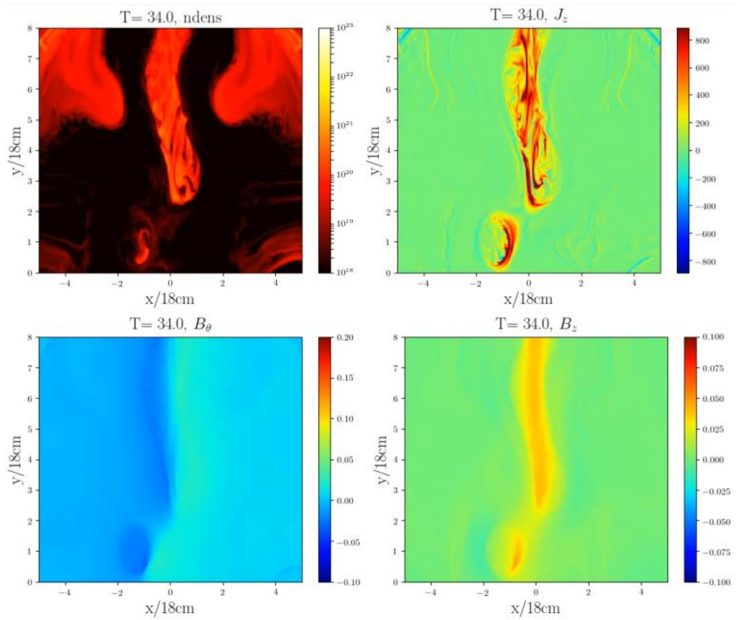
Without the 3 key ingredients, unstable jets.



No current profile
With mass injection
With v_z flow injection

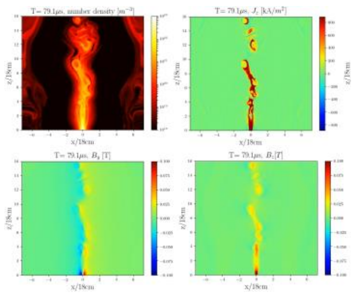


No v_z flow injection

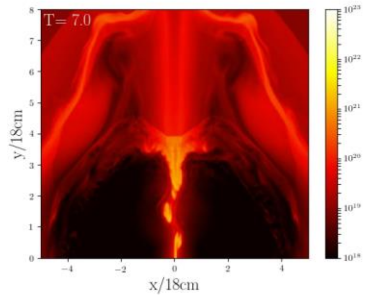


No mass injection

With current profile
With mass injection
No v_z flow injection



With current profile
No mass injection
No v_z flow injection



Thank you