AstroBEAR

An Adaptive Mesh Refinement Code for Computational Astrophysics

AstroBEAR is a parallelized hydrodynamic/MHD simulation code suitable for a variety of astrophysical problems. AstroBEAR is designed for 2D and 3D adaptive mesh refinement (AMR) simulations, the current versioncode shows good scaling above thousands of processors. In addition, AstroBEAR comes with a number of multiphysical processes such as self gravity, thermal conduction and resistivity.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = \mathbf{0},$$

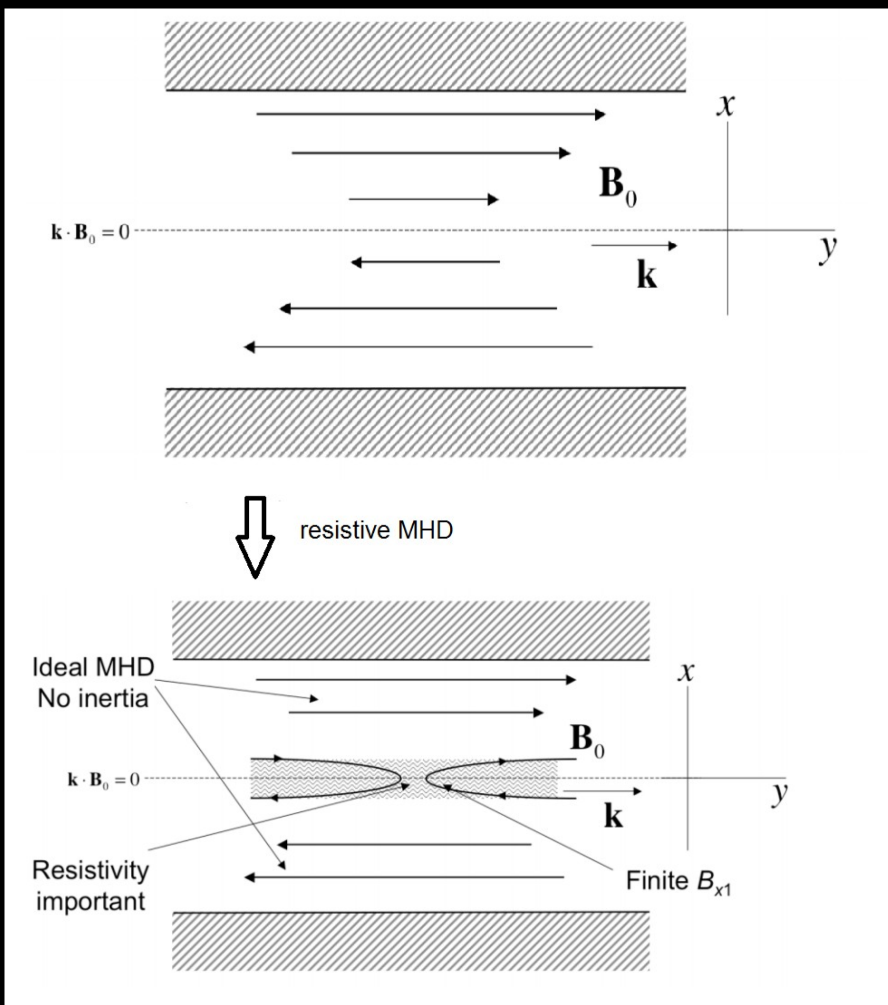
$$\frac{\partial (\rho \mathbf{v})}{\partial t} + \nabla \cdot [\rho \mathbf{v}\mathbf{v} + \mathbf{\Pi} + (\mathrm{p} + \frac{\mathrm{B}^2}{8\pi})\mathbf{I} - \frac{\mathrm{BB}}{4\pi}] = \mathbf{0},$$

$$\frac{\partial \mathrm{B}}{\partial t} + \nabla \times (\mathbf{v} \times \mathrm{B}) = \nabla \times (\eta \nabla \times \mathrm{B}),$$

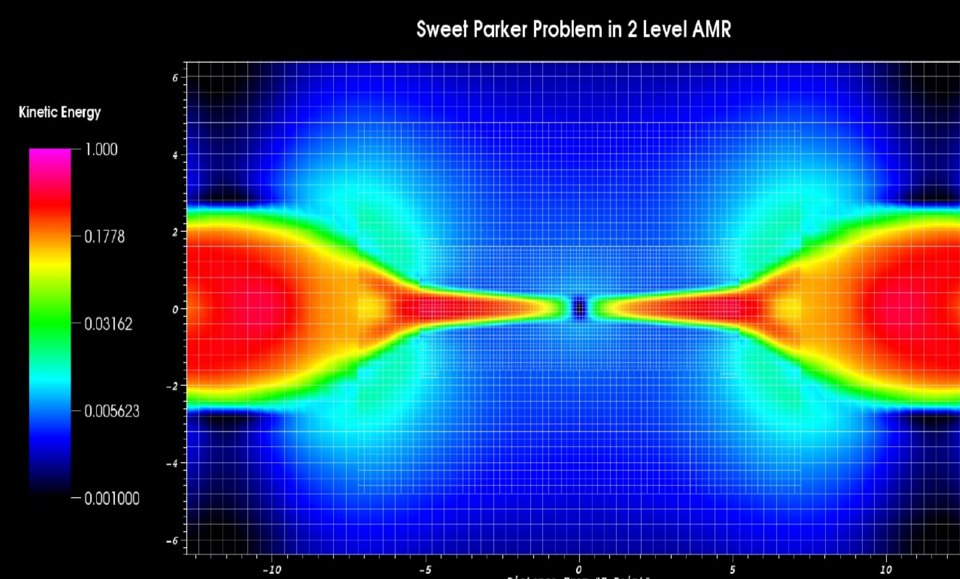
$$\frac{\partial E}{\partial t} + \nabla \cdot [\mathbf{v}(E + p + \frac{B^2}{8\pi}) - \frac{\mathrm{B}(\mathrm{B} \cdot \mathbf{v})}{8\pi}) + \mathbf{\Pi} \cdot \mathbf{v} + \mathbf{J}_\mathrm{d} \times \mathrm{B}] - \mathbf{\Lambda}(\mathbf{n}, \mathbf{T}) = \nabla \cdot (\kappa \cdot \nabla \mathbf{E}) + |\mathbf{J}_\mathrm{d}|^2 / \eta$$

Currently AstroBEAR deals with the multiphysics processes using an explicit approach.

Multiphysics Test: Sweet Parker Box

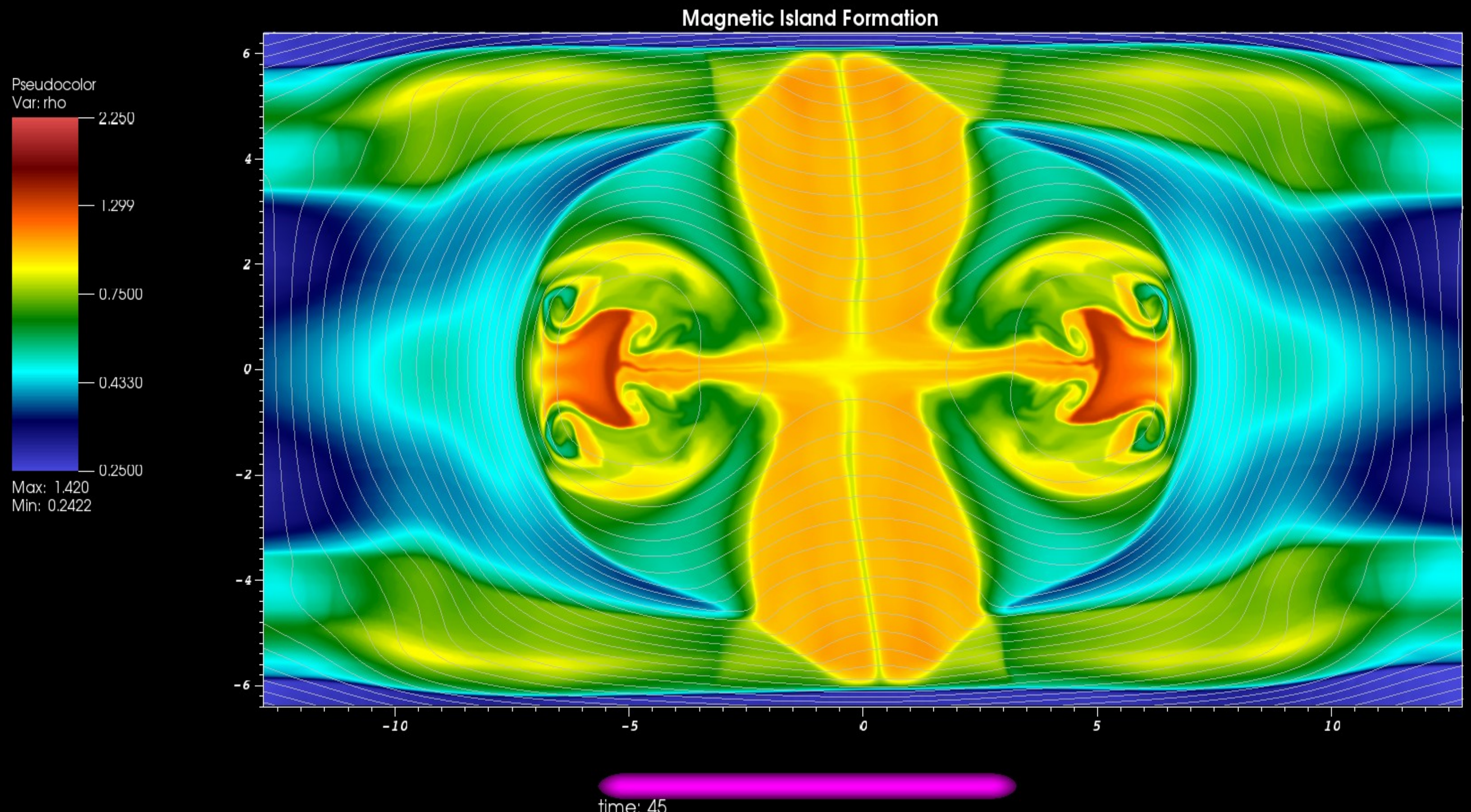


Magnetic field in a sheer pinch configuration can generate many resistive instabilities under perturbation.
To form Patschek shock in such a sheer pinch, we intentionally increase the resistivity at the center of the configuration (a certain point along y axis, according to the left figure). This allows the field lines to reconnect at this particular point faster than the rest therefore forming a region where field lines are continuously brought in and get annihilated. The energy generated from this reconnection forms a symmetric “outflow” along the y axis.

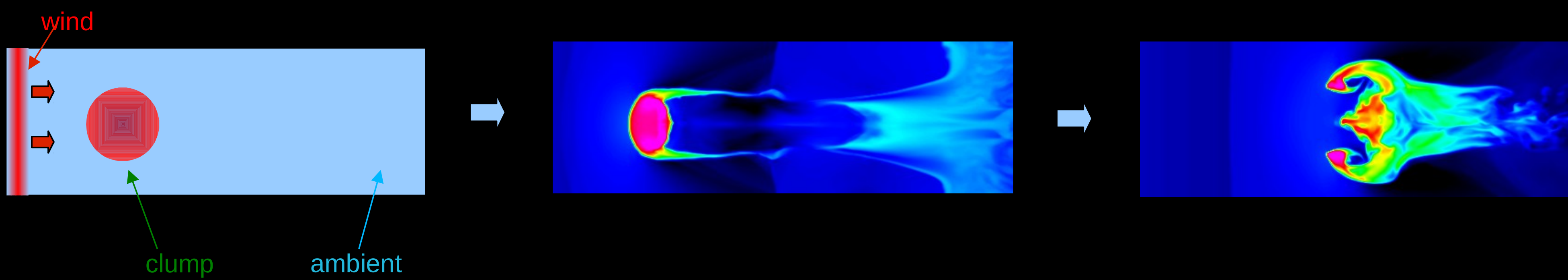


Multi-Physics Test: Magnetic Islands

The magnetic island formation is induced by perturbing the sheer pinch by a sinusoidal perturbation. X points and O points can form due to non zero resistivity, and dense regions separated by X and O points are formed, hence "islands". The growth rate and the size of the "islands" depend on resistivity and the strength of the perturbation. Notice that the formed "islands" are antisymmetric in this case because of the phase of the initial perturbation.



Problem Setup



ambient density = 1 mg/cc

atomic mass = 12 (carbon)

ambient temperature = 5 ev

density contrast = 100

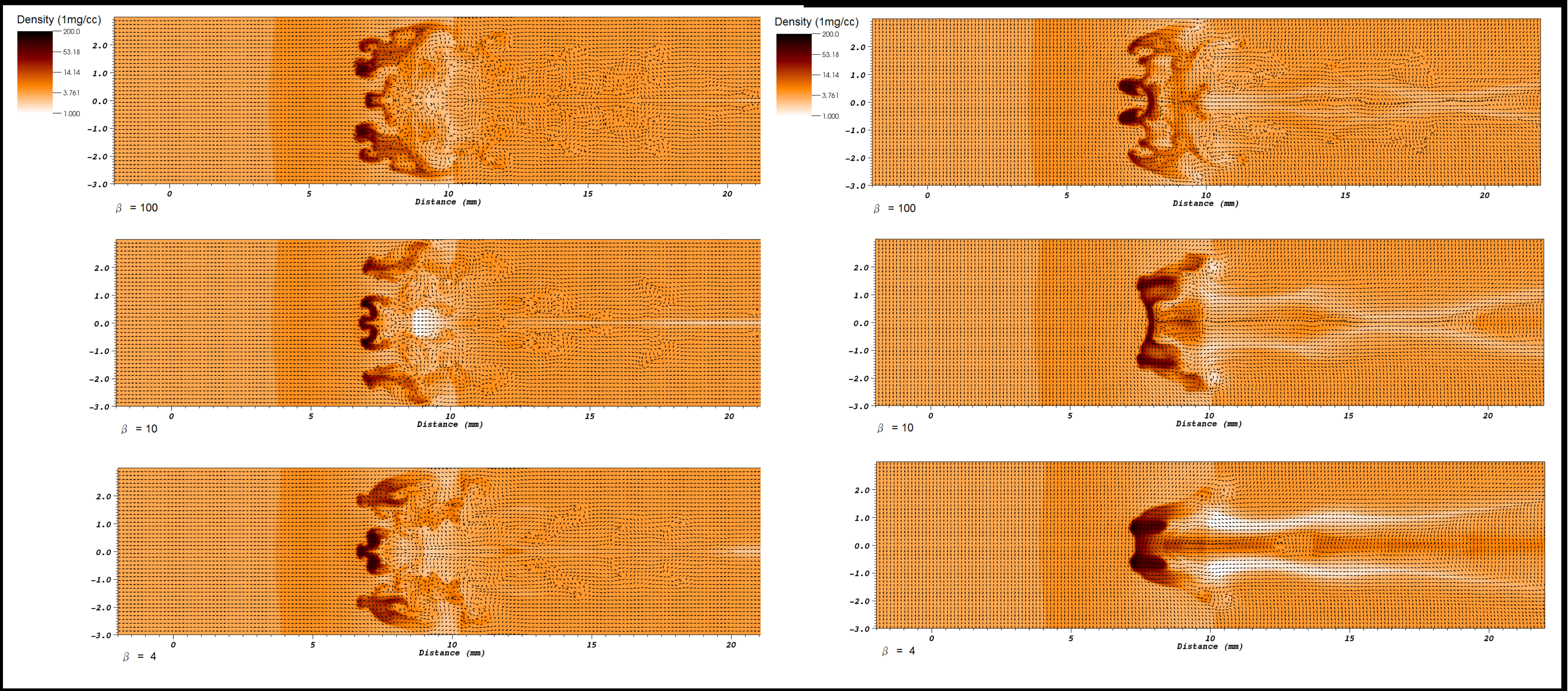
clump radius = 0.1 mm

tube radius = 0.3 mm

shock speed = 40 km/s (mach 5)

magnetic beta = 4

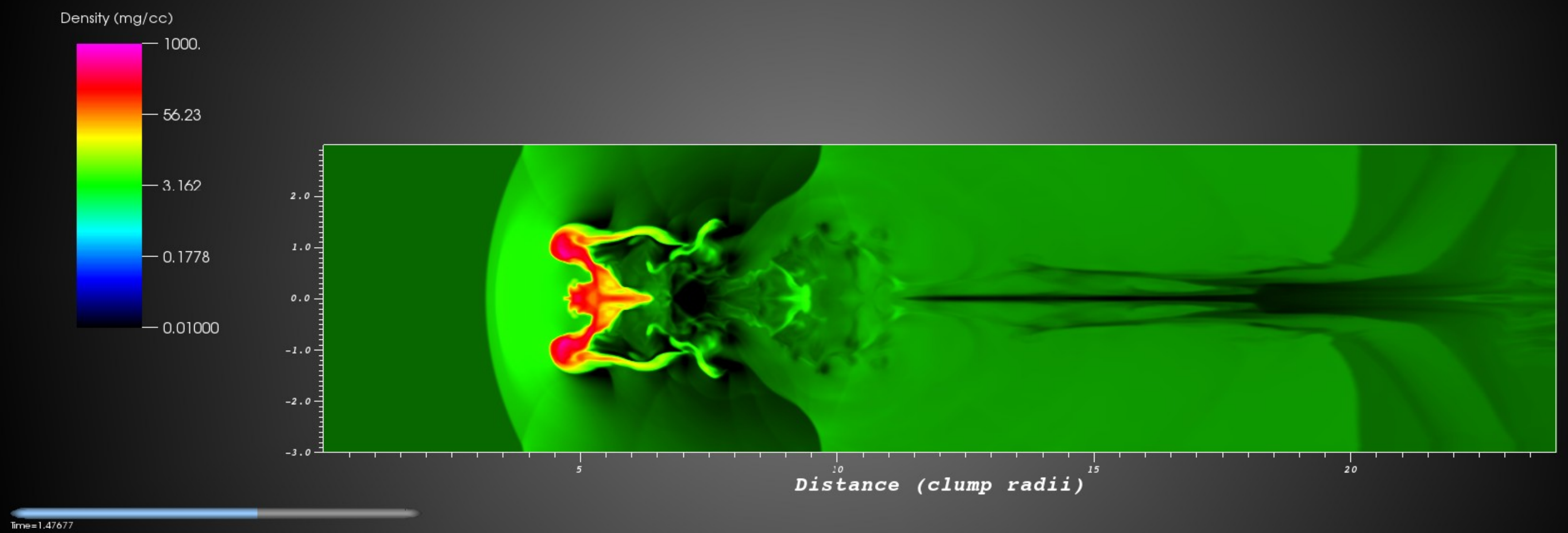
Shock-Clump Interaction with Uniform Global Field

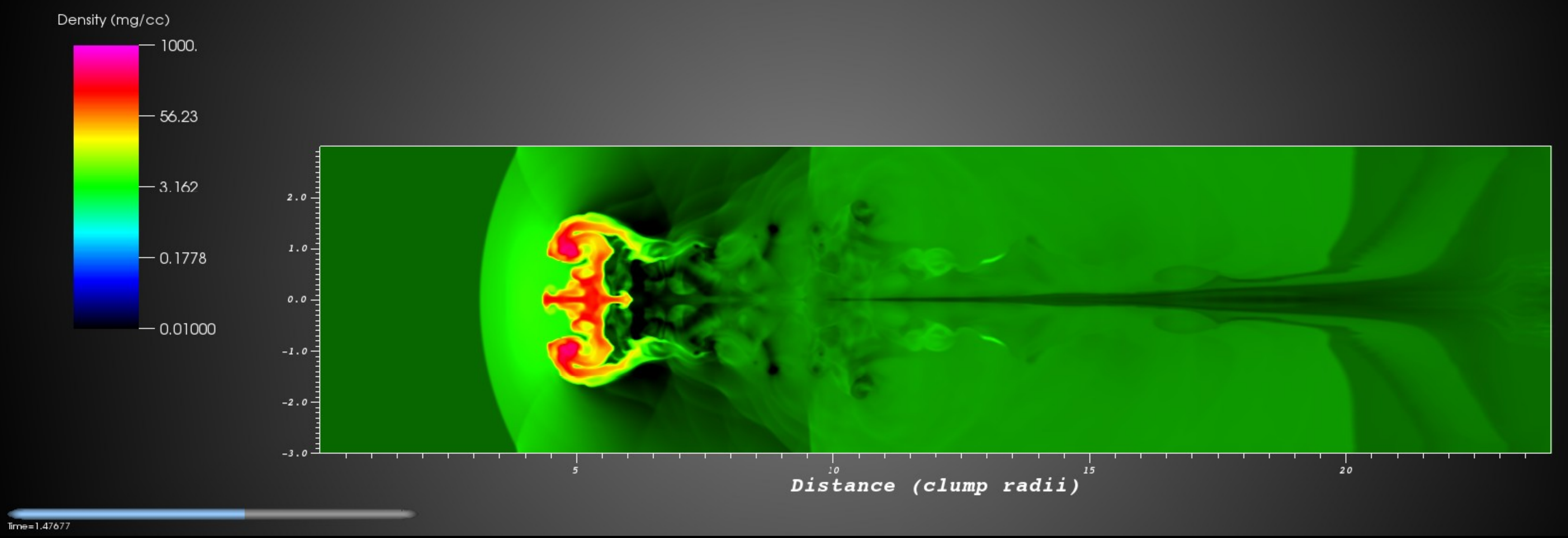


Movie:
http://www.pas.rochester.edu/~shuleli/0118_bx/

Simulation Results with Resistivity: Bx

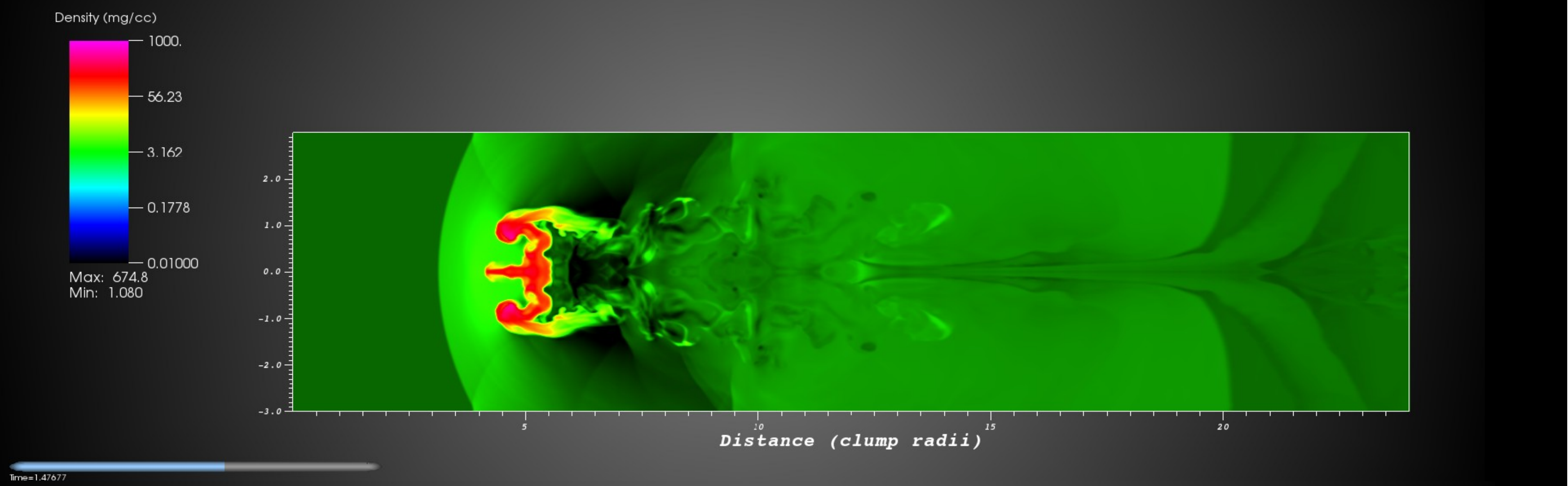
At 1.5 crushing time, Rm = inf, 1000

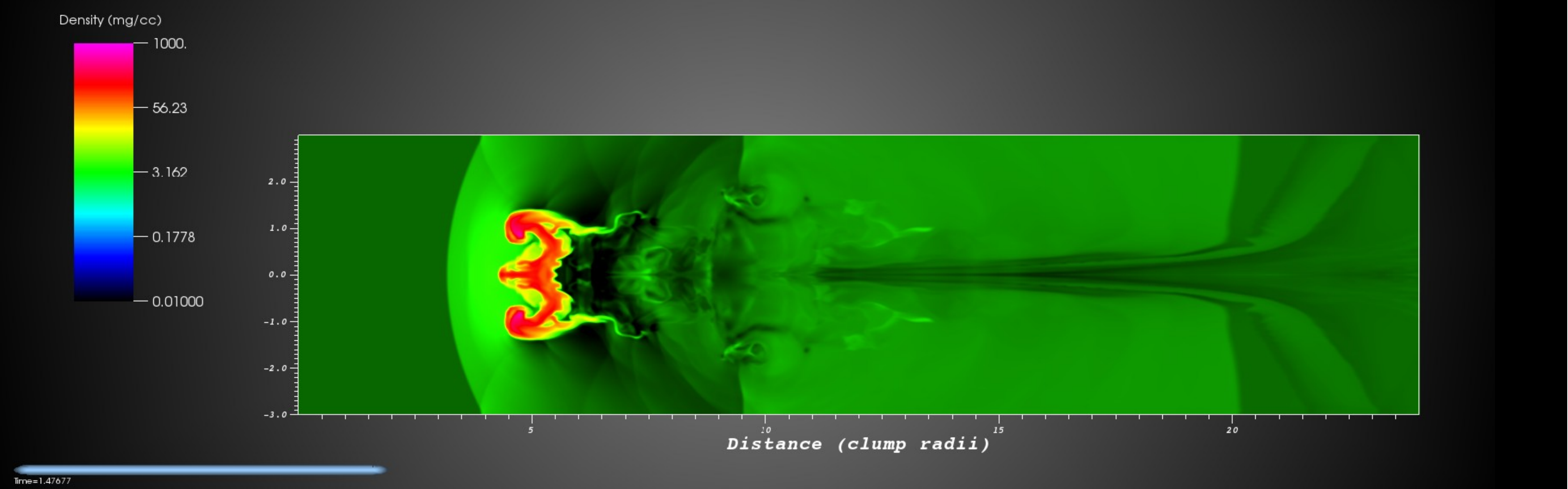




Simulation Results with Resistivity: Bx

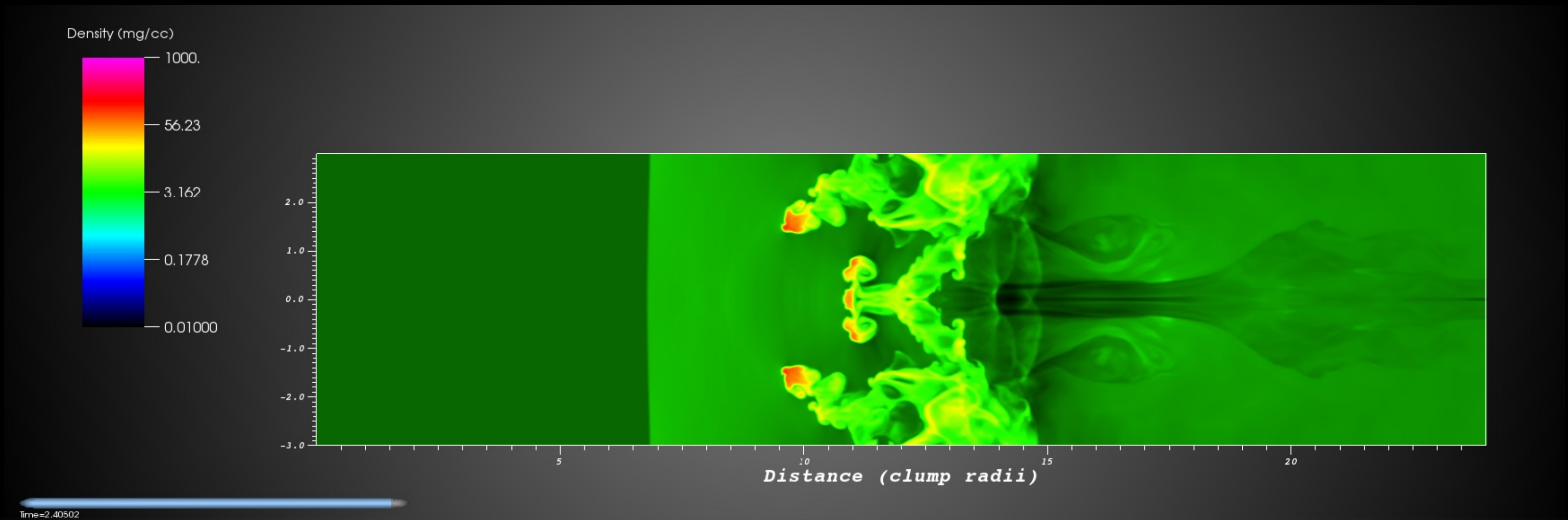
At 1.5 crushing time, Rm = 100, 10

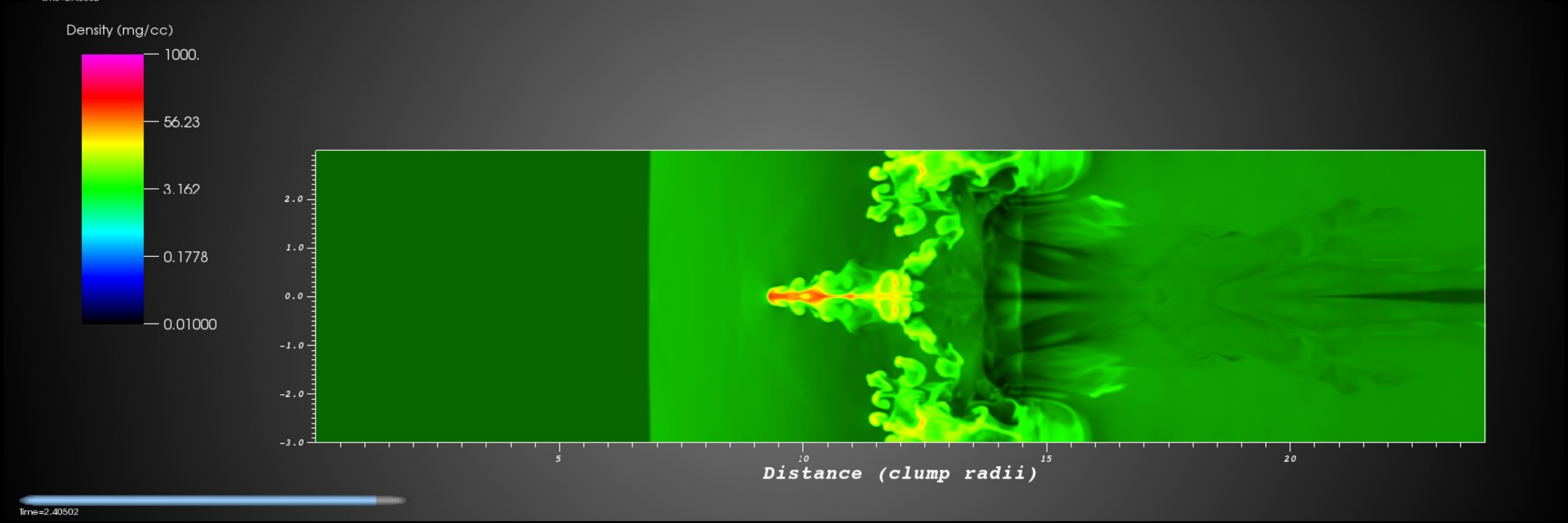




Simulation Results with Resistivity: Bx

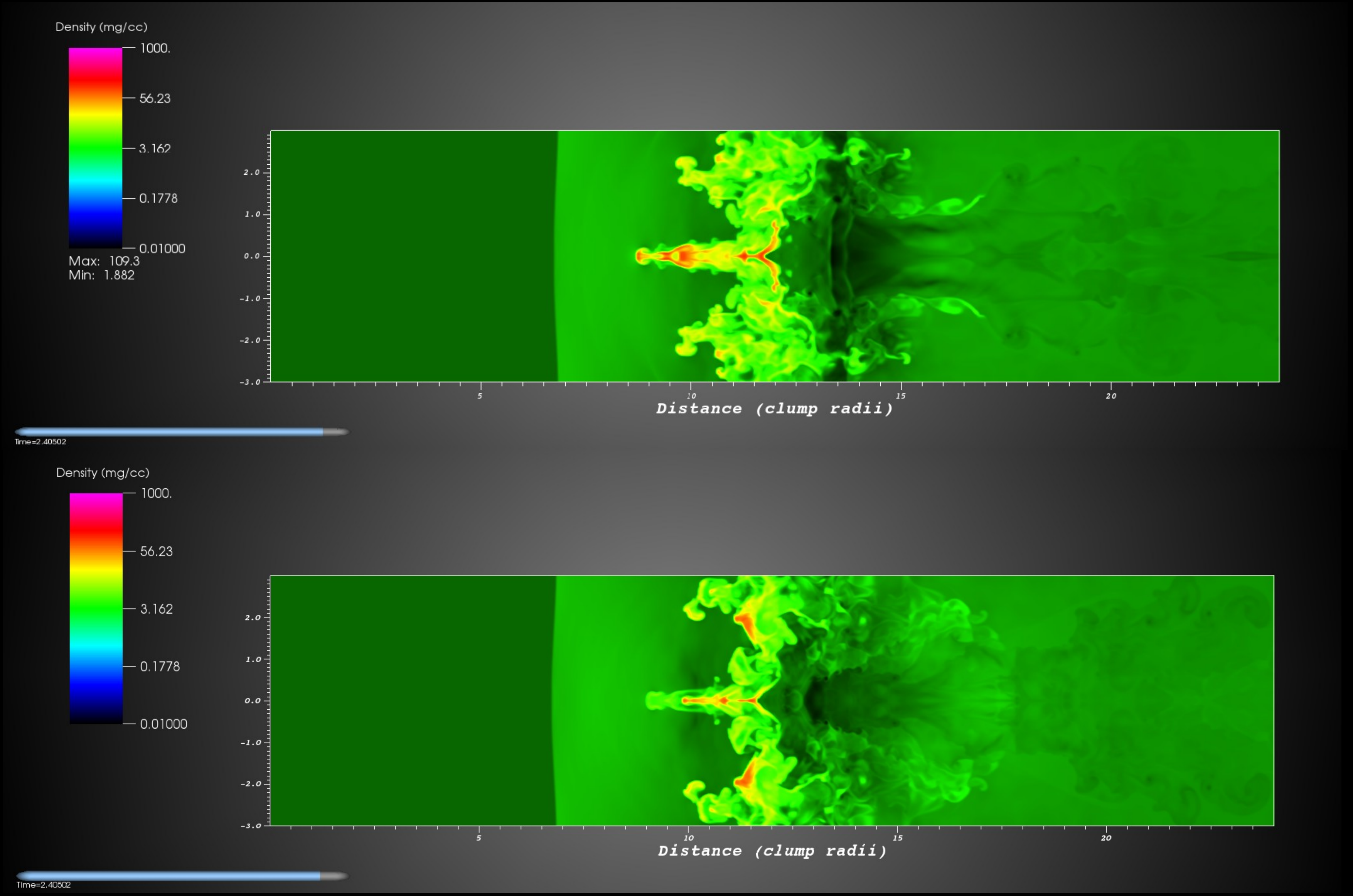
At 2.5 crushing time, Rm = inf, 1000





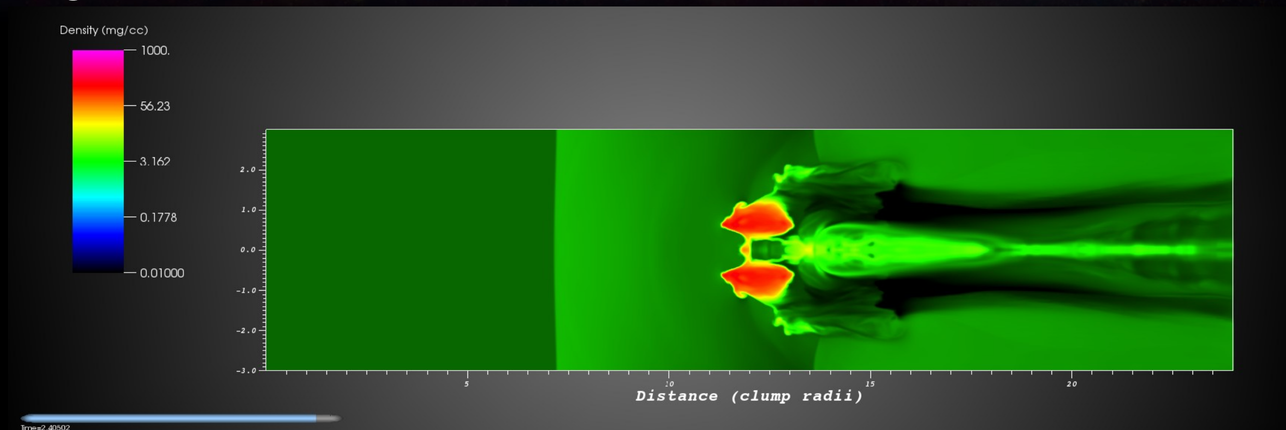
Simulation Results with Resistivity: Bx

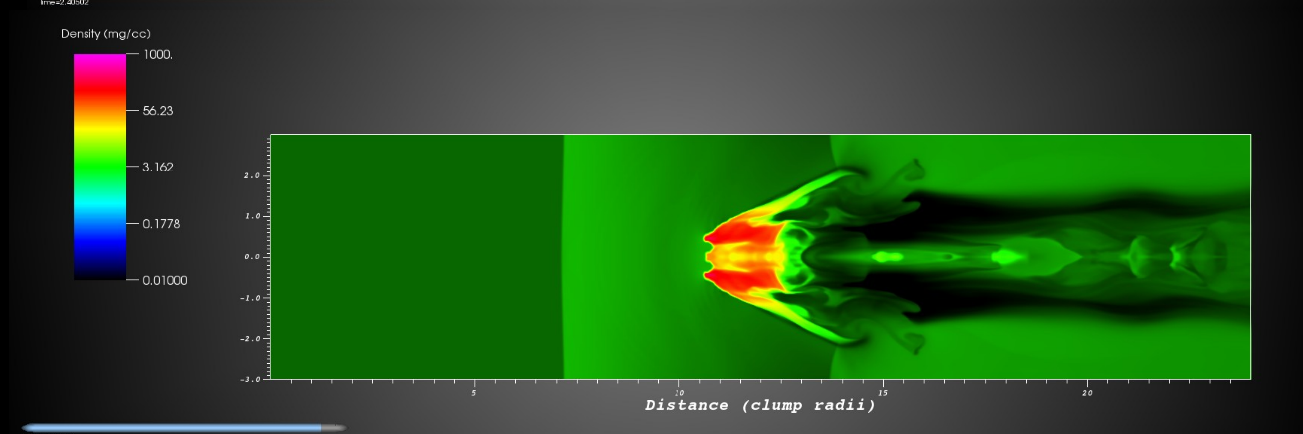
At 2.5 crushing time, Rm = inf, 1000, 100, 10

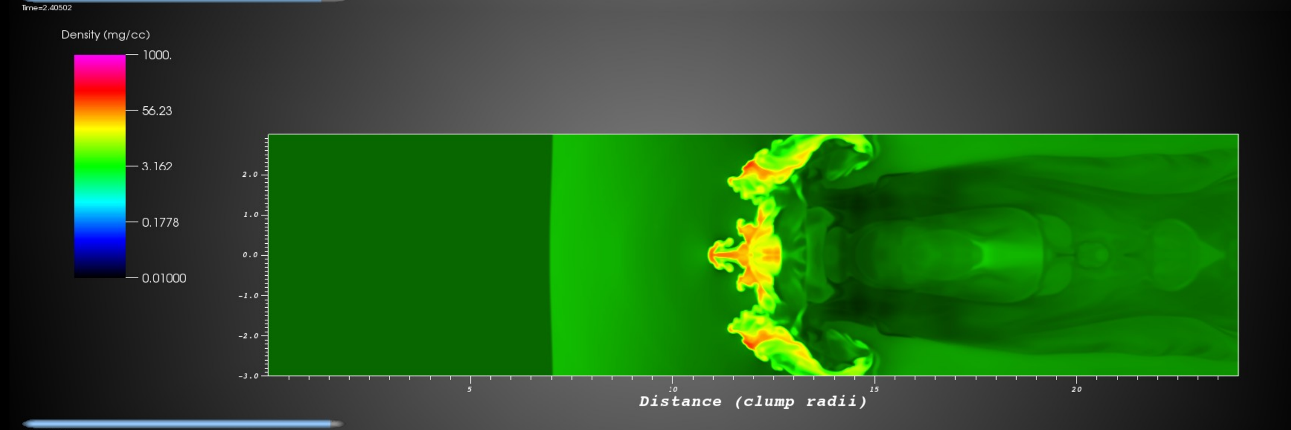


Simulation Results with Resistivity: By

At 2.5 crushing time, Rm = inf, 1000, 100

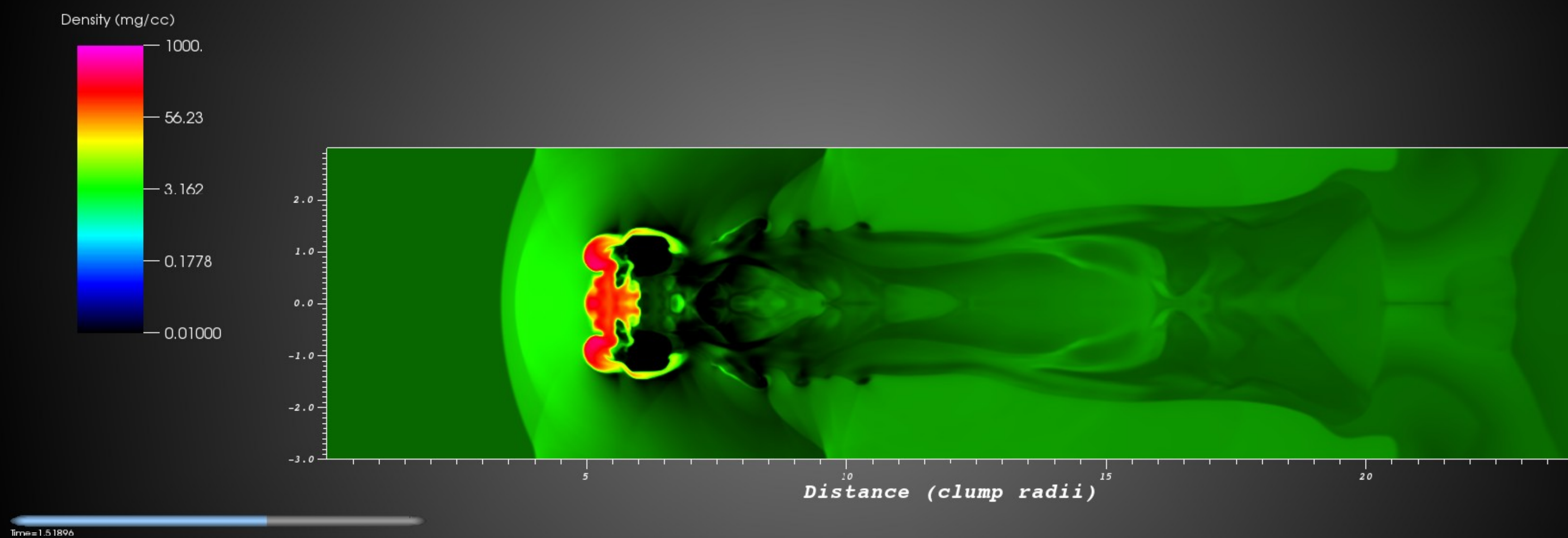


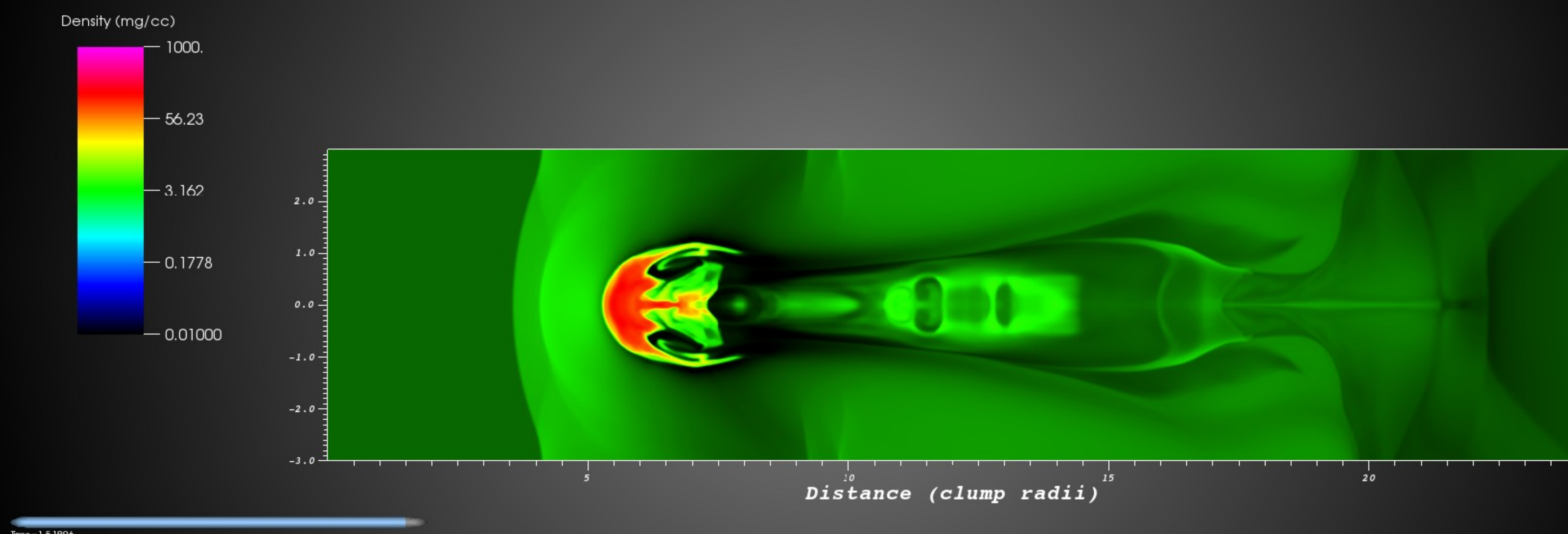




Simulation Results with Resistivity: Strong and Weak By

At 1.5 crushing time, beta 4 vs beta 1





Field Amplification: By