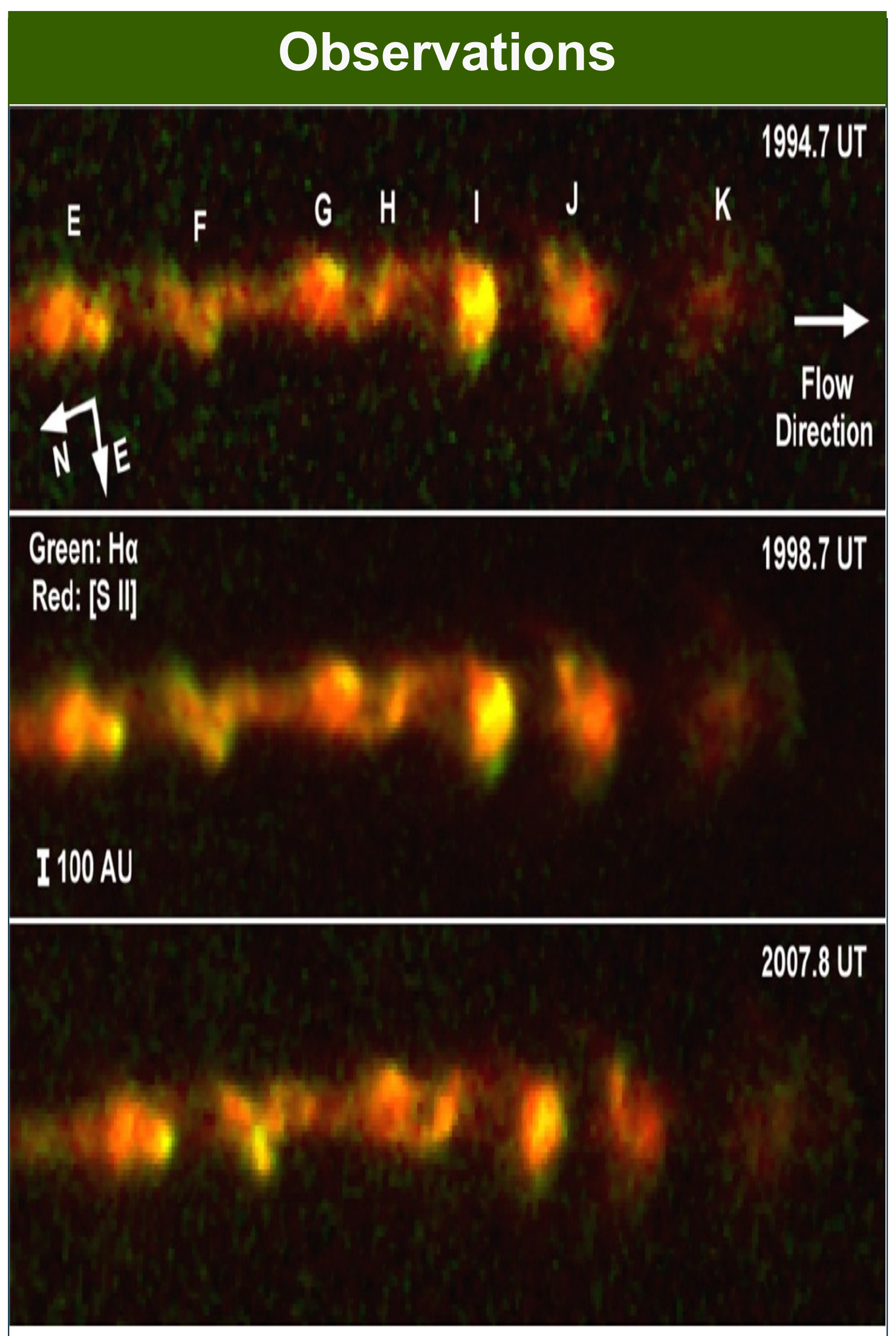
Emission from MHD Simulations of YSO Jets using AstroBEAR2.0

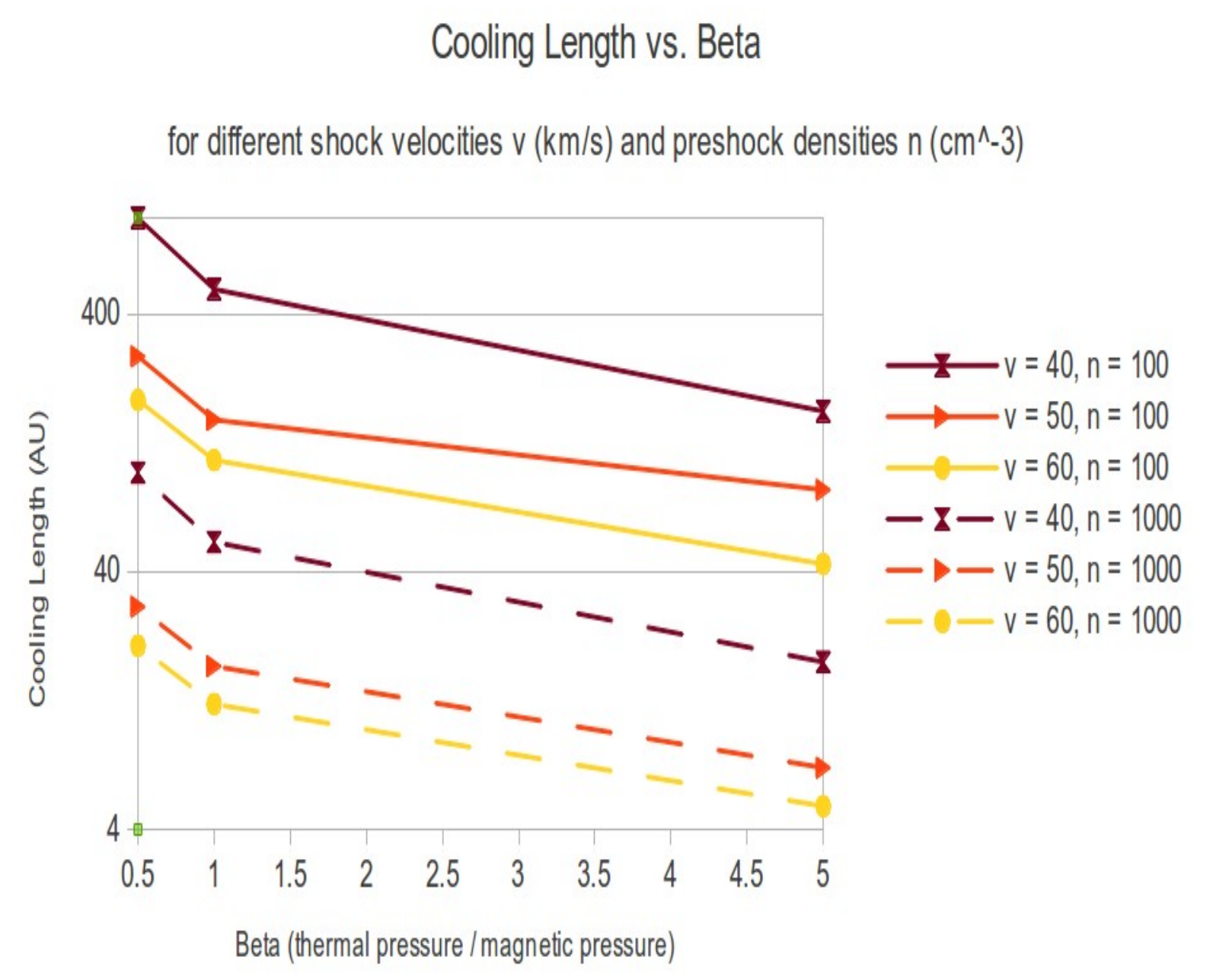
Eddie Hansen[1], Adam Frank[1], Pat Hartigan[2]

1 University of Rochester, Rochester, NY
2 Rice University, Houston, TX

Observations



HST images of the HH 34 jet [2]. Shocks heat the mostly neutral gas, and the gas emits Hα and ionizes. Ionized hydrogen recombines, the gas cools and emits [S II]. Magnetic fields broaden cooling zones (as evidenced in plot below).



Simulation Parameters

Ambient Density	100 1/cc
Jet Density	500 1/cc
Ambient Temperature	10,000 K
Average Jet Velocity	200 km/s
Jet Velocity Amplitude	50 km/s
Jet Velocity Period	50 yr
Total Run-time	500 yr
Jet Radius	5×10^{15} cm

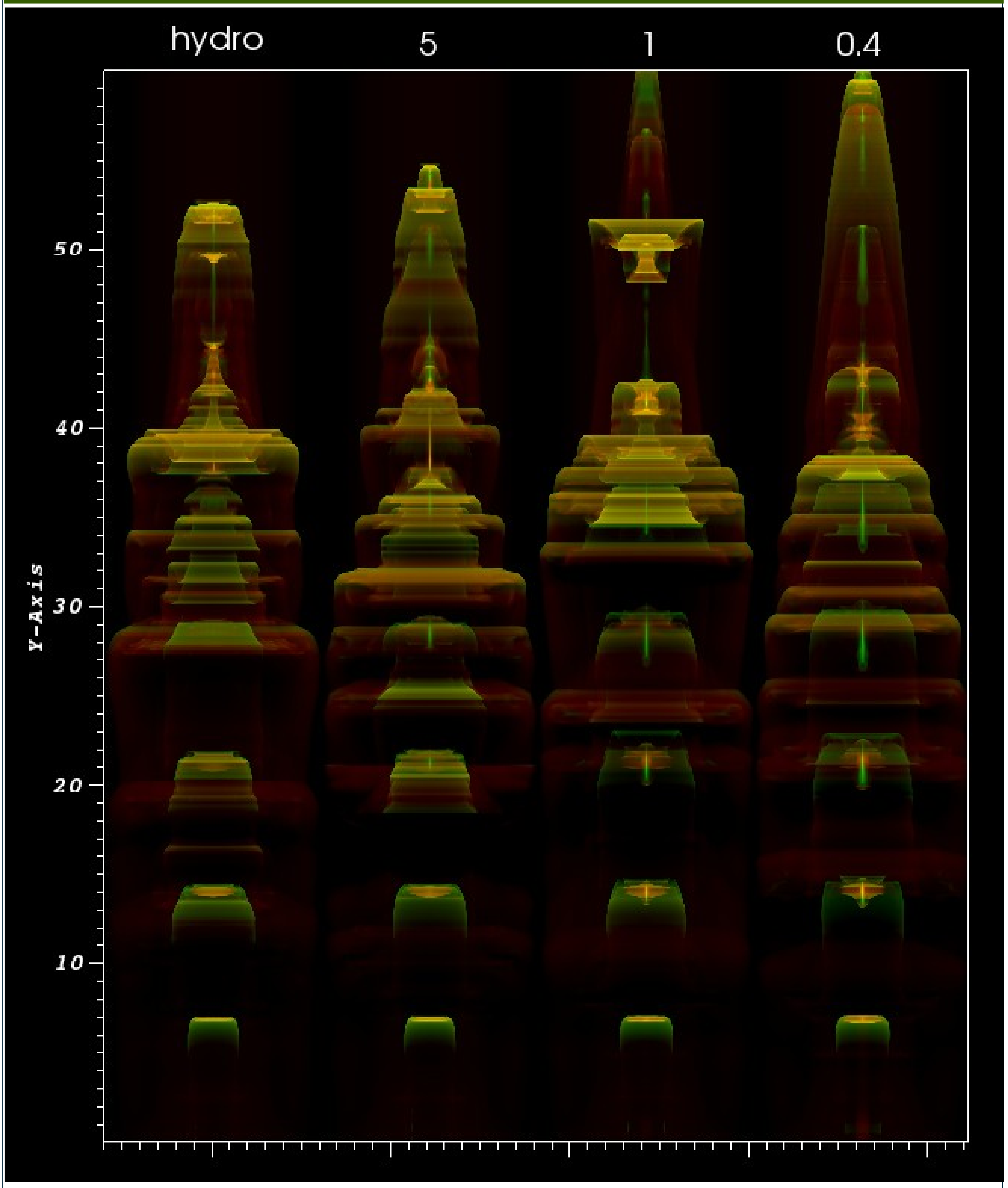
Numerical Model

Base resolution of 32 x 320 with 4 levels of AMR for a total effective resolution of 5.86×10^{13} cm/cell. Radial pressure and magnetic field profiles were used in order to achieve initial hydromagnetic equilibrium [1]. A total of four runs were completed with varying beta: infinity (hydro), 5, 1, and 0.4.

Introduction

These simulations are two-dimensional axisymmetric jets. They are based on those done by de Colle and Raga [1], The jets are pulsed via a sinusoidally time-dependent ejection velocity. A complicated structure of internal shocks and rarefactions is formed by the pulsations. The field inside these jets is purely toroidal. We have implemented hydrogen and helium ionization and recombination which enables us to produce and analyze emission maps of Hα and [S II]. Strong Hα emission typically marks shock fronts and strong [S II] emission occurs inside cooling regions behind shocks. Furthermore, an increase in field strength shows an increase in shock velocities, clump densities, and jet collimation. Simulations such as these are important to our understanding of observations of HH objects, and the ultimate goal is to develop a set of emission line diagnostics to measure magnetic field strength.

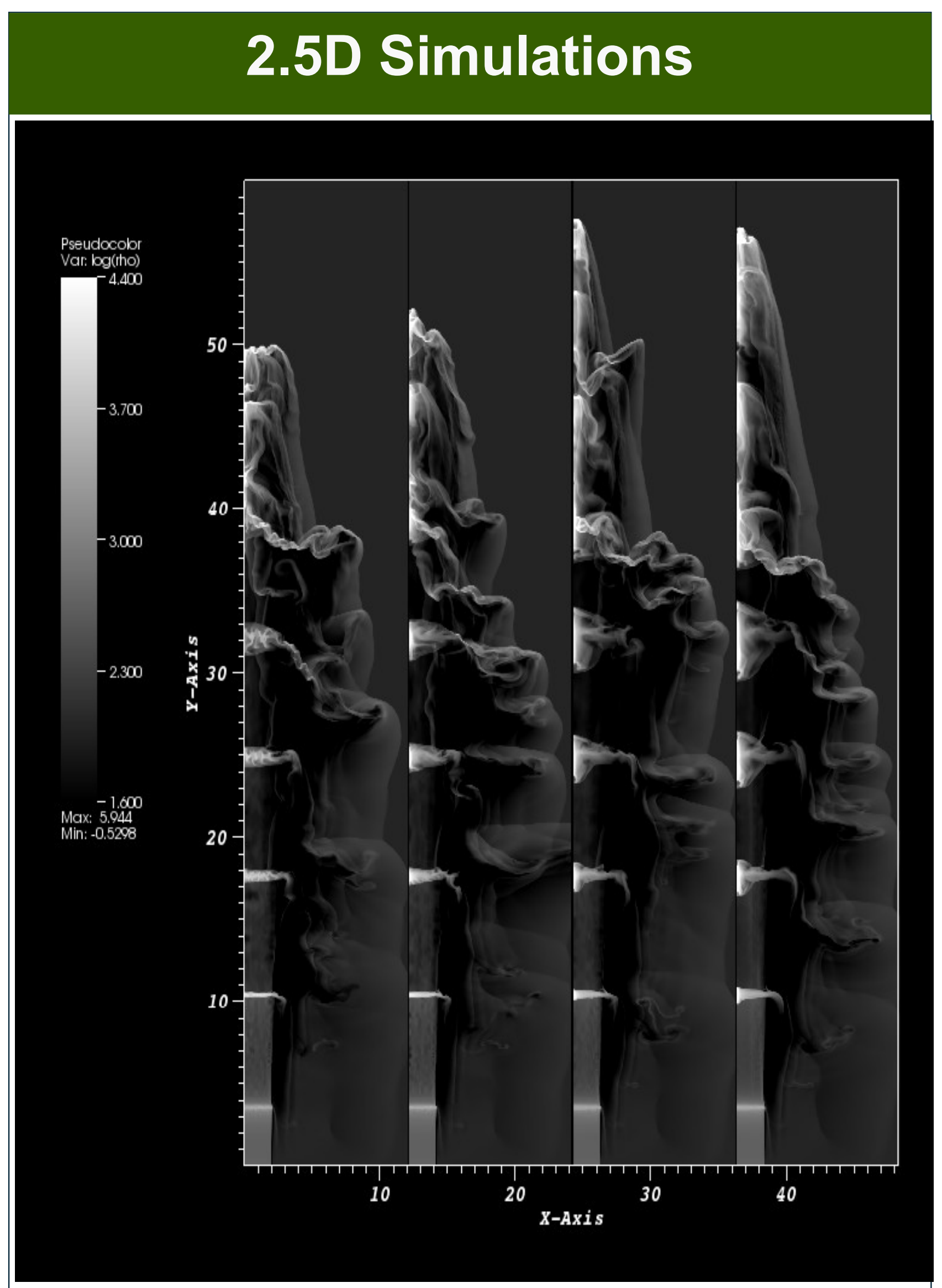
Synthetic Emission Maps



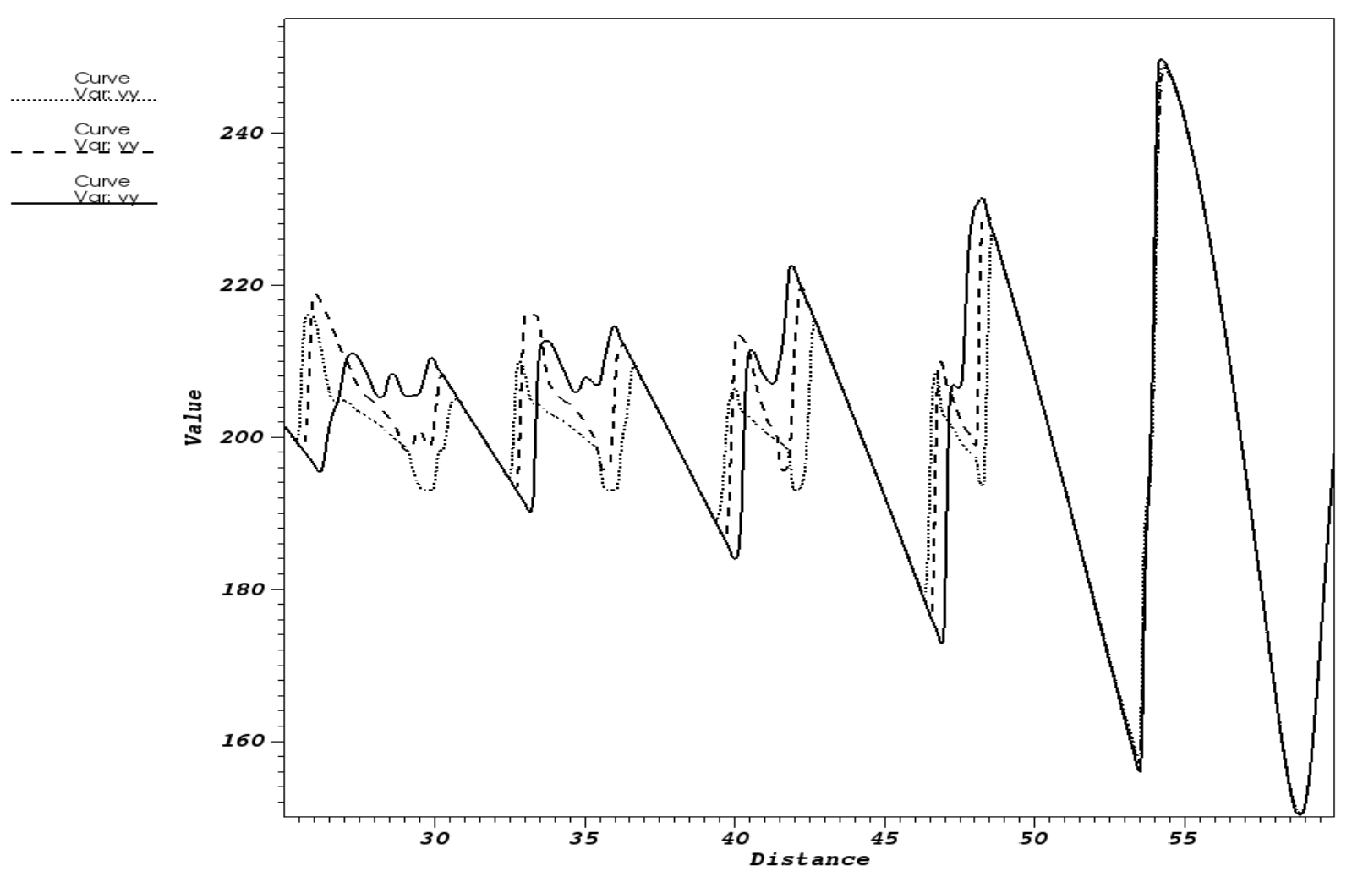
Conclusions

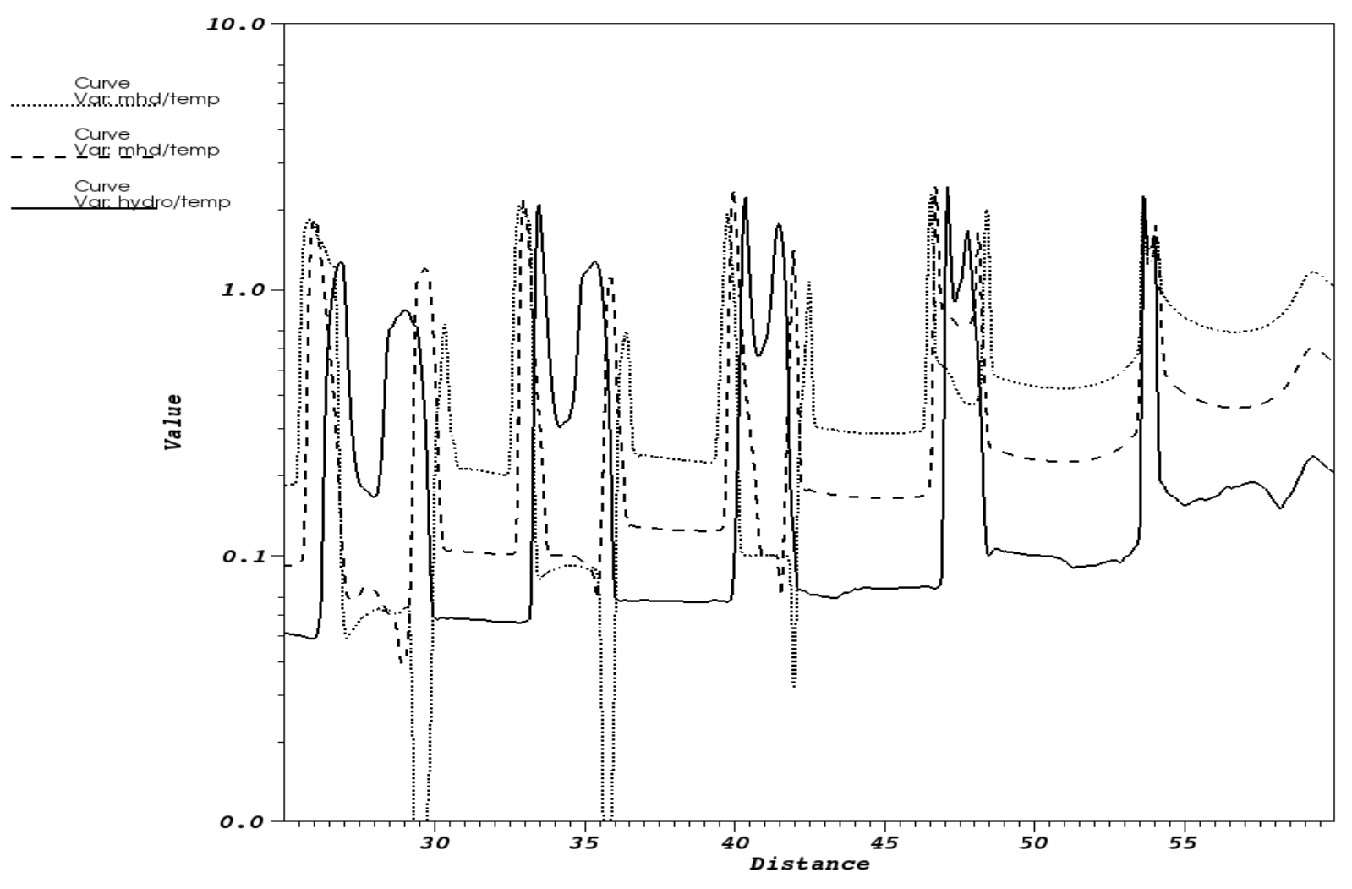
- Additional pressure from the magnetic field keeps the jet from expanding into the ambient, hence better collimation and denser clumps.
- The jets of the stronger field cases travel farther in the same amount of time and thus have higher velocities (an affect of the increased collimation).
- As the field strength is increased, the jet heads develop what are known as "nose-cones". It is believed that this might be an effect of the coordinate system and imposed symmetry. Therefore, 3D simulations are necessary to further explore the problem.
- These are the first simulations of this type to produce [S II] emission maps. It may also be useful to simulate other field geometries and produce synthetic emission maps for other lines.

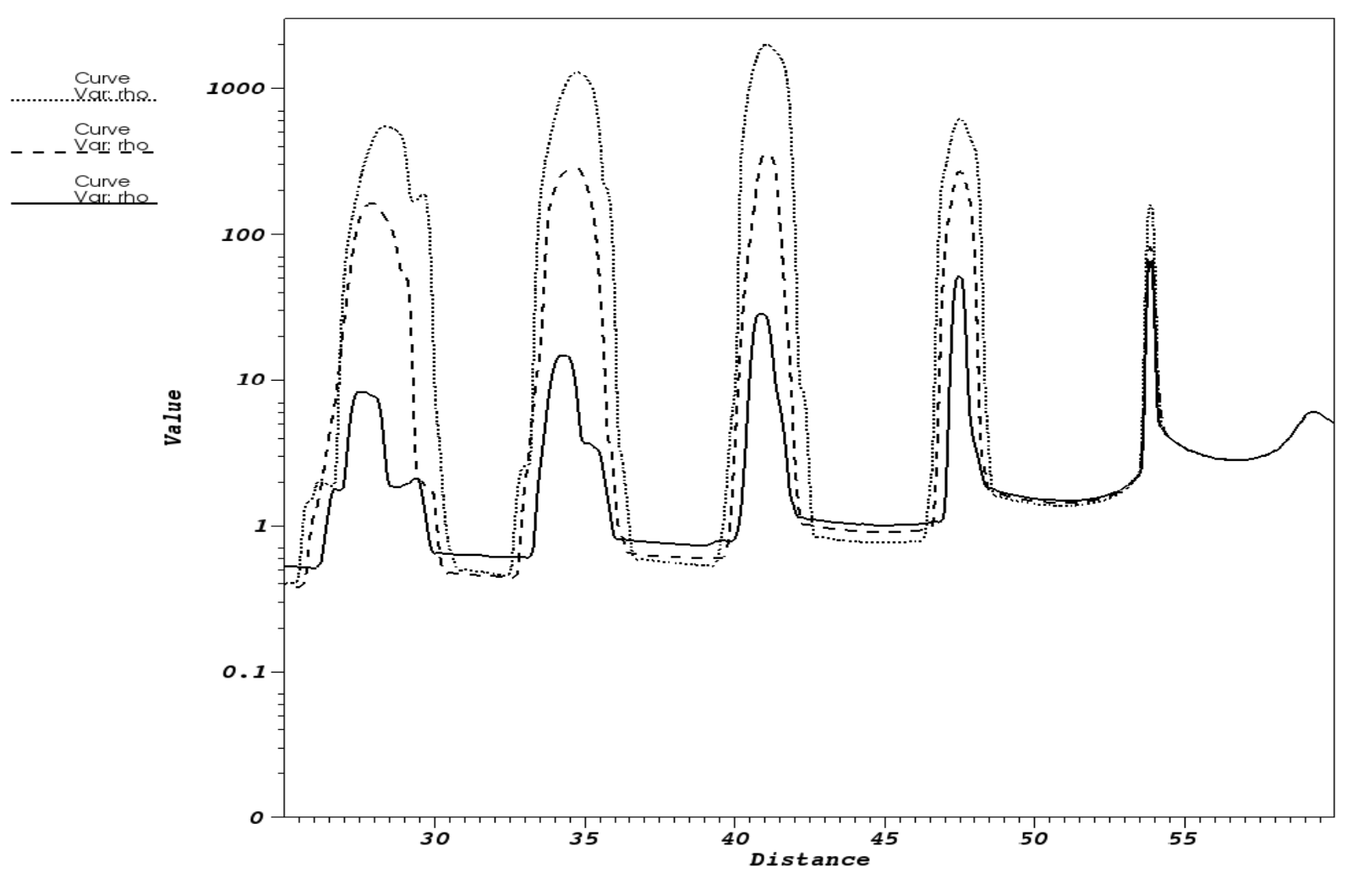
2.5D Simulations



The plots below show velocity, temperature, and density profiles along the symmetry axis. The direction of propagation is to the left, and the head of the jet is not included. The solid lines represent the hydro case, dashed is beta = 1, and dotted is beta = 0.4.







References

[1] De Colle, F., & Raga, A. C. 2006, A&A, 449, 1066

[2] Hartigan, P., Frank, A., Foster, J. M., Wilde, B. H., Douglas, M., Rosen, P. A., Coker, R. F., Blue, B. E., & Hansen, J. F. 2011, ApJ, 736:29 (20pp)