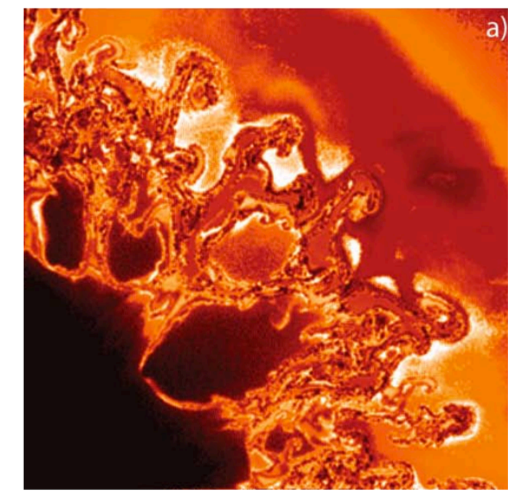
Rayleigh Taylor Growth relevant to Supernova Explosions

Jennifer Cosens[1], Matthew Trantham[2], Carolyn Kuranz[2]
[1]Undergraduate Research Opportunity Program, [2]Department of Climate and Space Sciences and Engineering



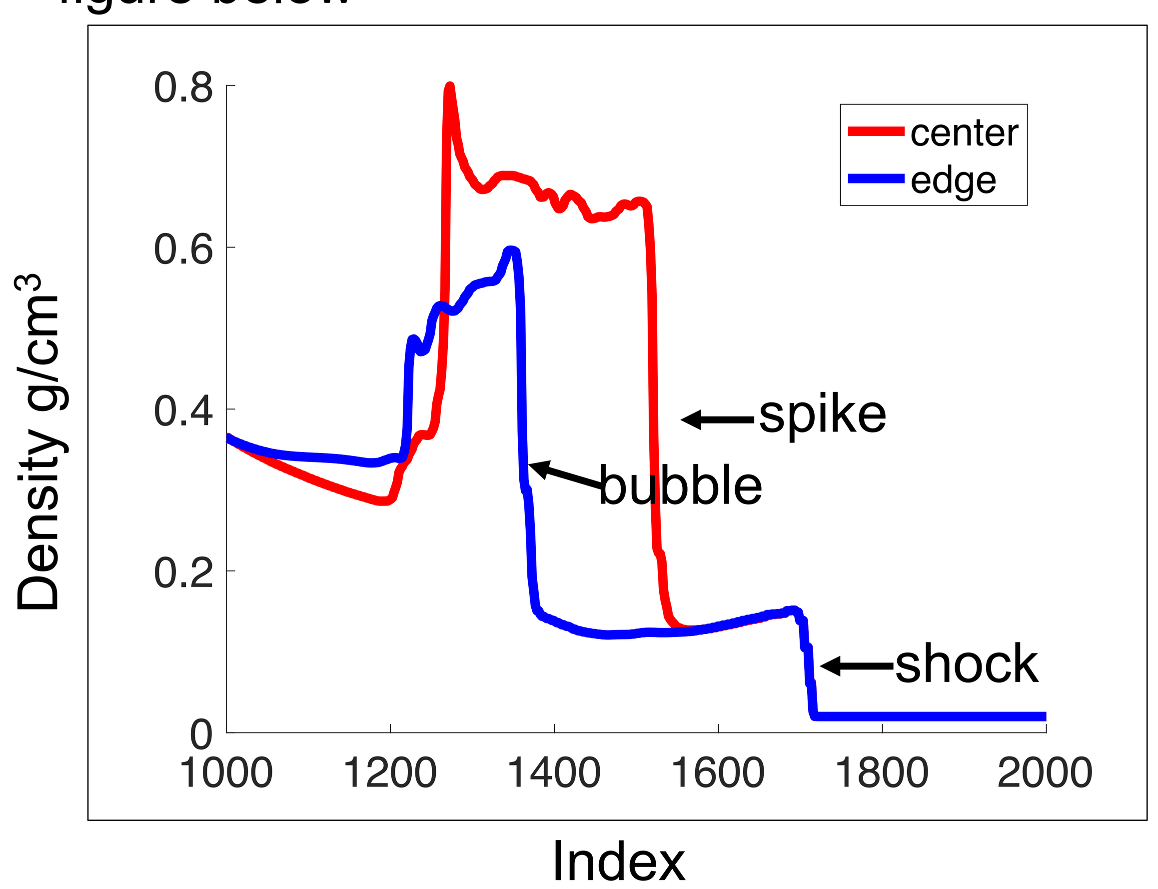
Picture from E. Muller et al.[2]

BACKGROUND

This study focuses on the effects of radiation on the growth of the Rayleigh Taylor Instability relevant to supernova explosions. Rayleigh Taylor is an instability caused by two fluids of different densities under acceleration. The lighter density is pushing into the denser fluid which creates an instability. Within supernova explosions, the lighter fluids are pushed through the higher density fluids as the shock moves through the layers of the star. Simulations of this phenomenon are carried out with the Center for Radiative Shock Hydrodynamics (CRASH) software. CRASH is a multidimensional Eulerian code that models multi-material radiation hydrodynamics. This produces data that can be analyzed in Matlab. Due to high cost of experimentation, the purpose of this study is to simulate the experiments and find the conditions that will produce the most useful results.

METHODS

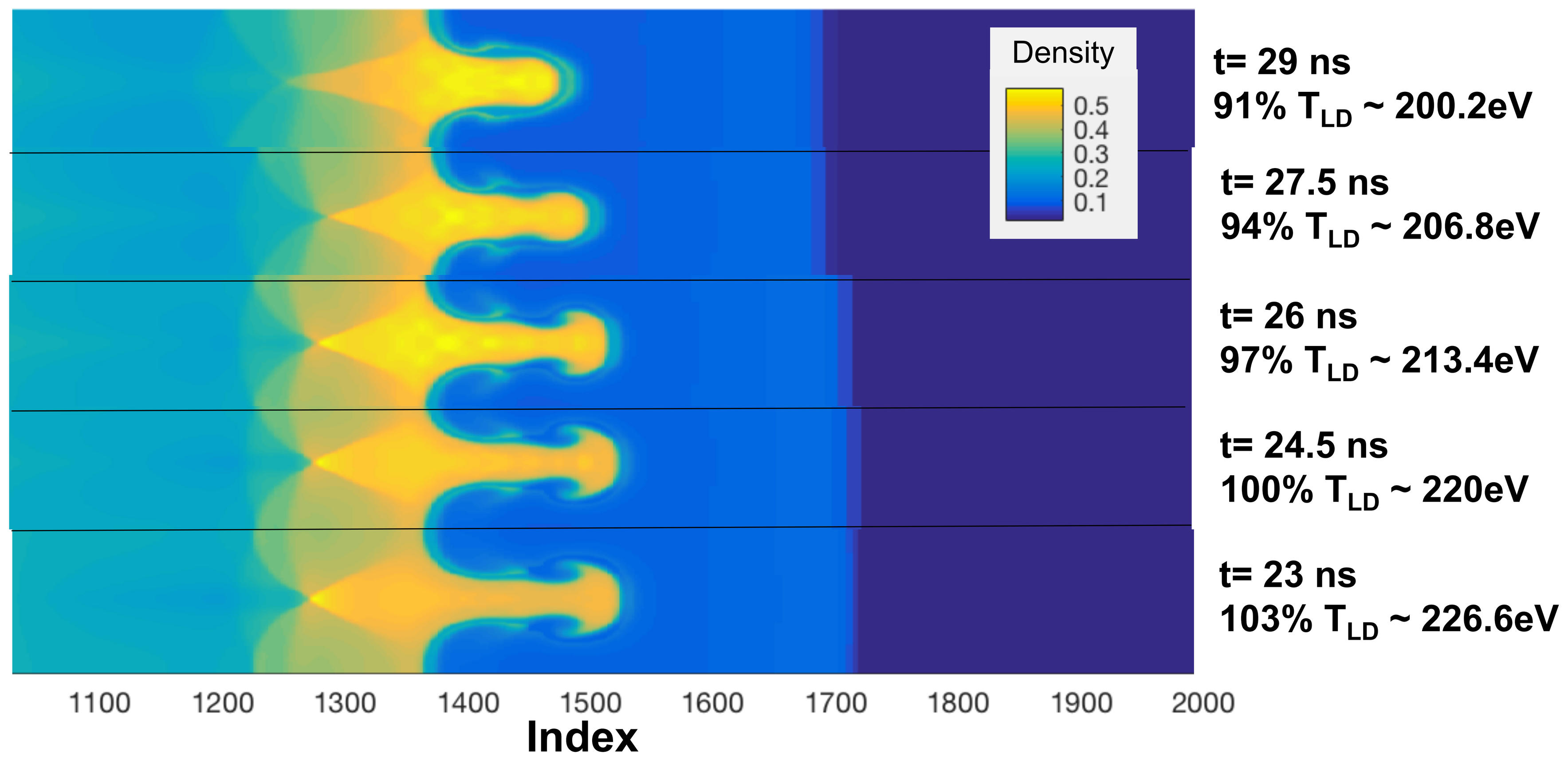
- Experiments resembling supernovae are conducted in lab using lasers to produce a large amount of energy in a microscopic target
- Simulations of these experiments are conducted with CRASH code
- Two scenarios were run— high drive (high radiation environment) and low drive (low radiation environment)
- This data is then analyzed through Matlab
- Three data points are analyzed— the shock, spike, and bubble
  - •These points are found by taking derivatives of the density profile to find large changes as seen in the figure below



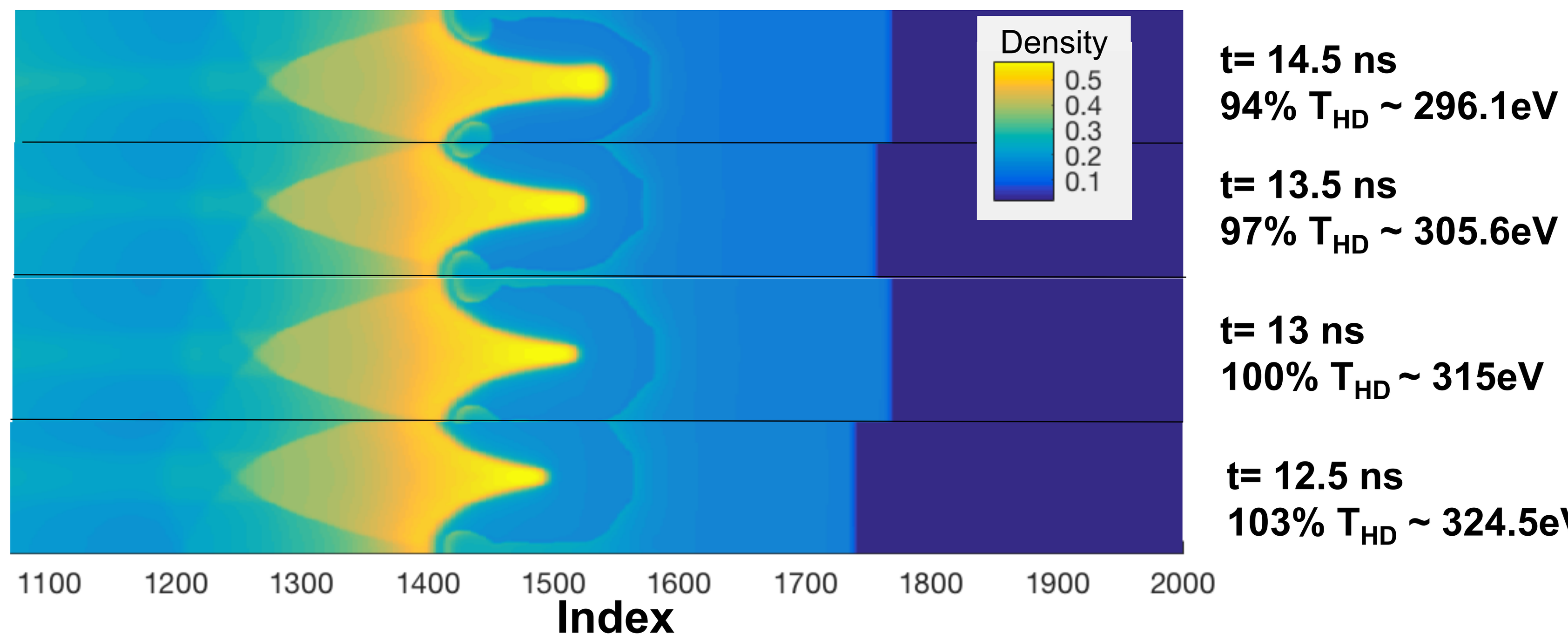
A graph of densities on the edge and center of the growth.

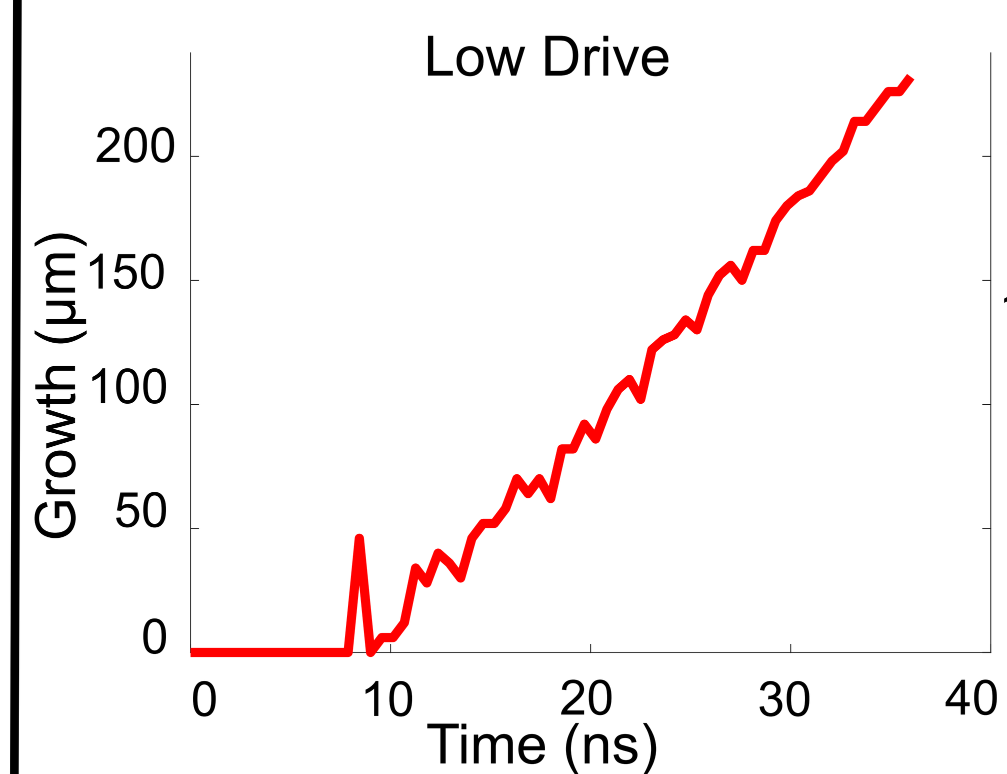
RESULTS & DISCUSSION

Contour graphs presenting the density in the Low Drive Rayleigh Taylor Instability at T_{LD} = 220 eV

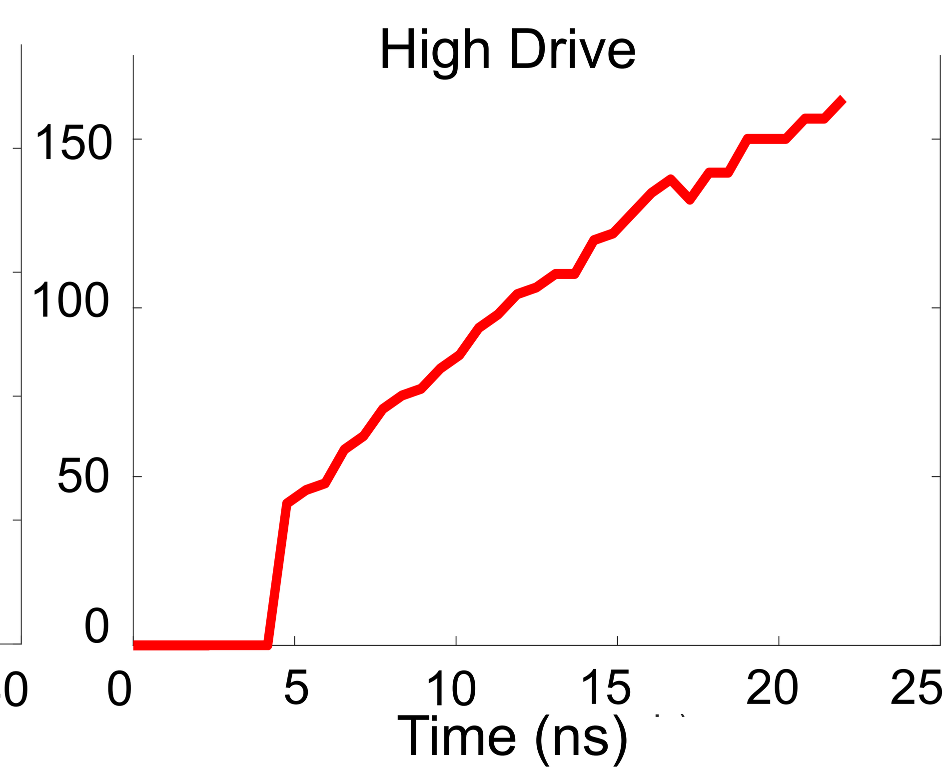


Contour graphs presenting the density gradient in the High Drive Rayleigh Taylor Instability at T_{HD} = 315 eV

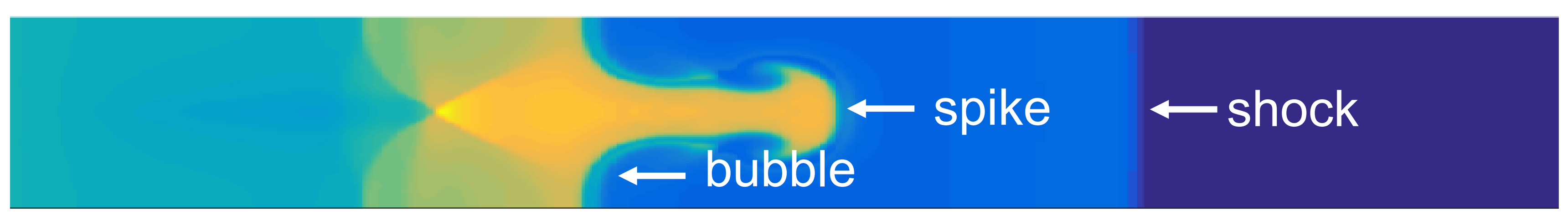




The growth length of the instability-- found by subtracting the spike position by the bubble position of the low drive over 40 ns.

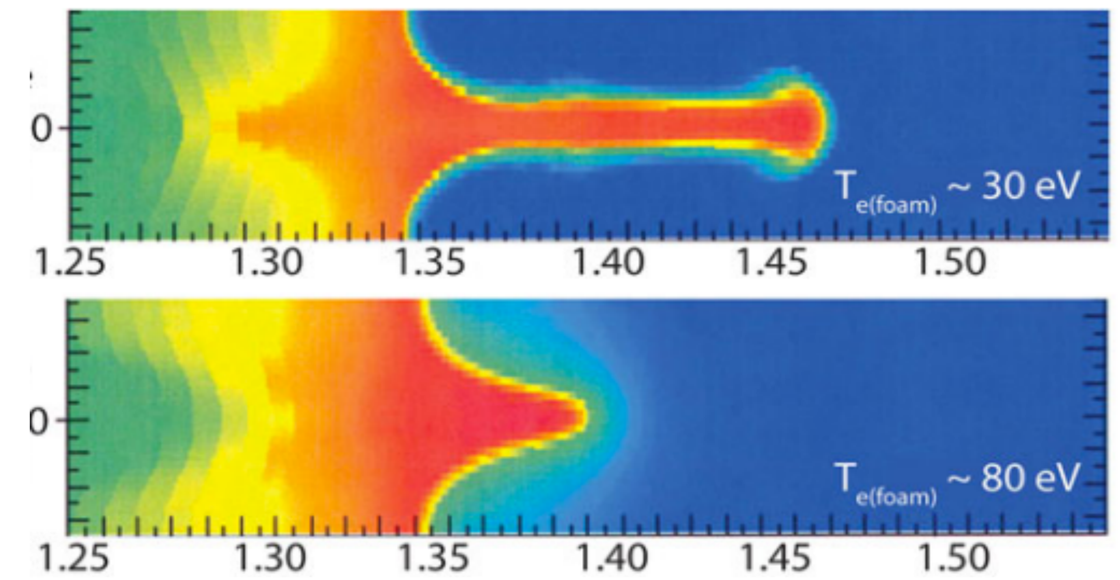


The growth length of the instability of the high drive over 22 ns.



CONCLUSIONS

- The low drive's instability is minimally affected by the radiation
- The high drive's instability is greatly affected by the radiation- the growth produces a blunted spike
- This is due to the vaporization of the spike from high temperatures
- The high drive's trial time is also approximately half the trial time as the low drive



2D ARES simulation performed at LLNL presenting the high drive and low drive spikes (C. Kuranz et al[1]).

FUTURE DIRECTIONS

- In future experiments, the effects of the high and low drive trials can be used to understand which conditions should be used to produce useful results
- The times of each trial will be used to know which times to record data during actual experimentation

ACKNOWLEDGEMENTS AND REFERENCES

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References:

[1]Kuranz, C. et al., Astrophysically relevant radiation hydrodynamics experiment at the National Ignition Facility. Springer Science Business Media. **2011**, 336, 207-211.

[2]Muller, E.,Fryxell B., Arnett D., Instability and Clumping in SN 1987A. Astronomy and Astrophysics. **1991**, 251, 505-514.