DEPARTMENT OF PHYSICS

LSP Simulations of High Intensity Short Pulse Lasers Incident on Reduced Mass Targets

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Collaborators and acknowledgments

- K. U. Akli, R. R. Freeman, V. M. Ovchinnikov, and D. W. Schumacher

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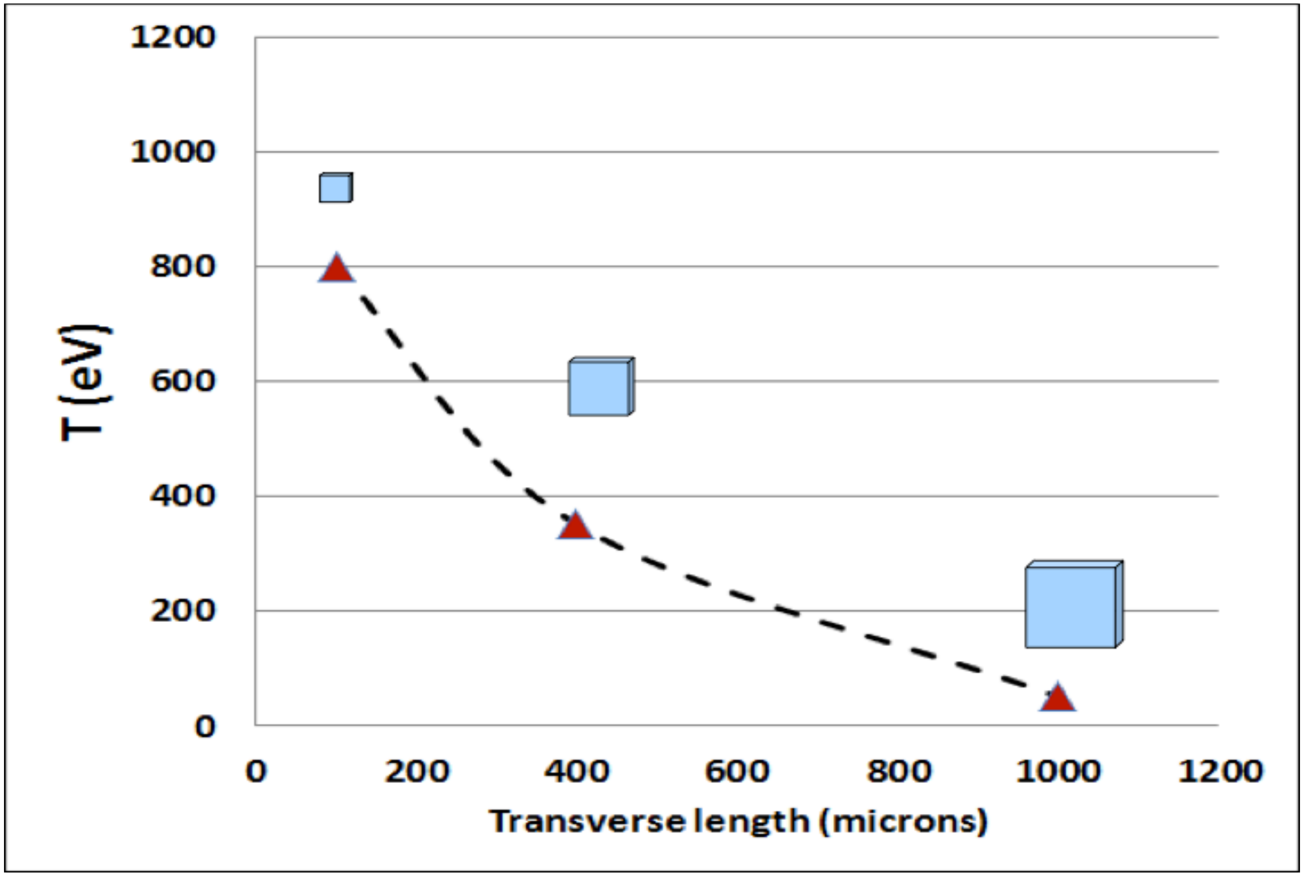
Outline

- Motivation for modeling Reduced Mass Targets (RMT)
- Simulation Goals and Results
  - 1 Dimensional Simulations
  - 2 Dimensional Simulations
- Conclusions

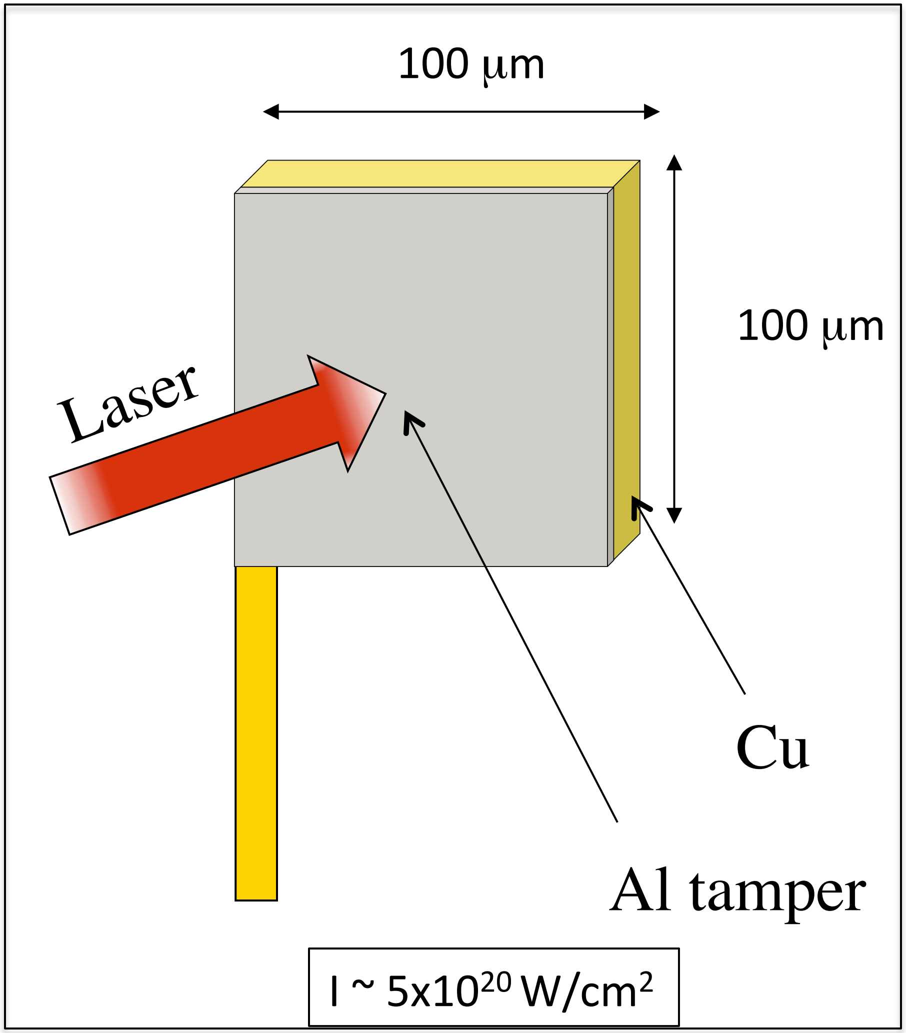
Motivation: Can we isochorically heat up RMT targets to high temperatures?

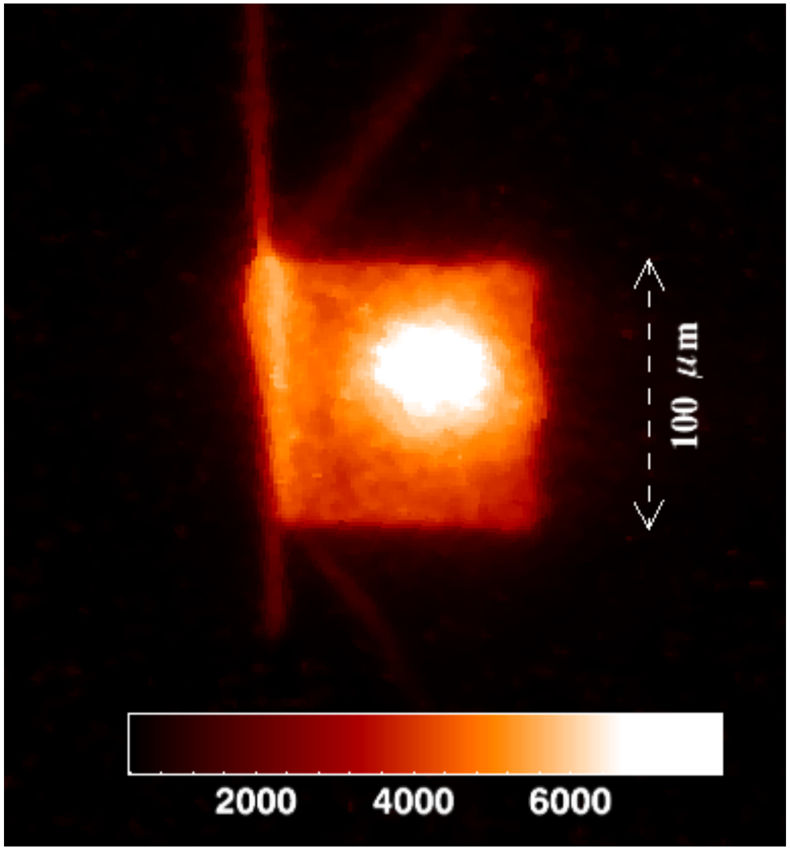


S. C. Wilks APS 2007

Considerable interest in isochoric heating of solid density plasmas to uniform temperatures for opacity, equation of state, and material properties measurements

Results from Experiments with the Vulcan laser





256 eV XUV image

[1] G. Gregori et al., Contrib. Plasma Phys. **45**, 284 (2005)
[2] K. U. Akli et al., Phys. Rev. Lett. **100**, 165002 (2008)

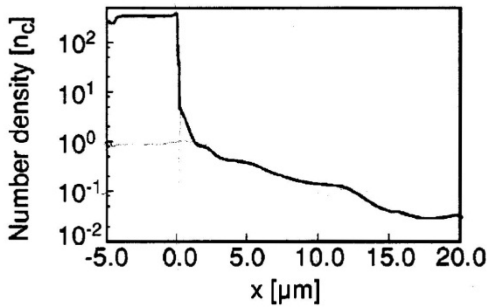
Simulation Goals

- We are studying how these parameters:
  - Laser Intensity
  - Preplasma Scale Length
  - Target Thickness
- Affect these physical phenomena
  - Average Target Ion Temperature
  - Target Temperature Uniformity
  - Above Solid Density Ion Shock

1D: Baseline Simulation Parameters

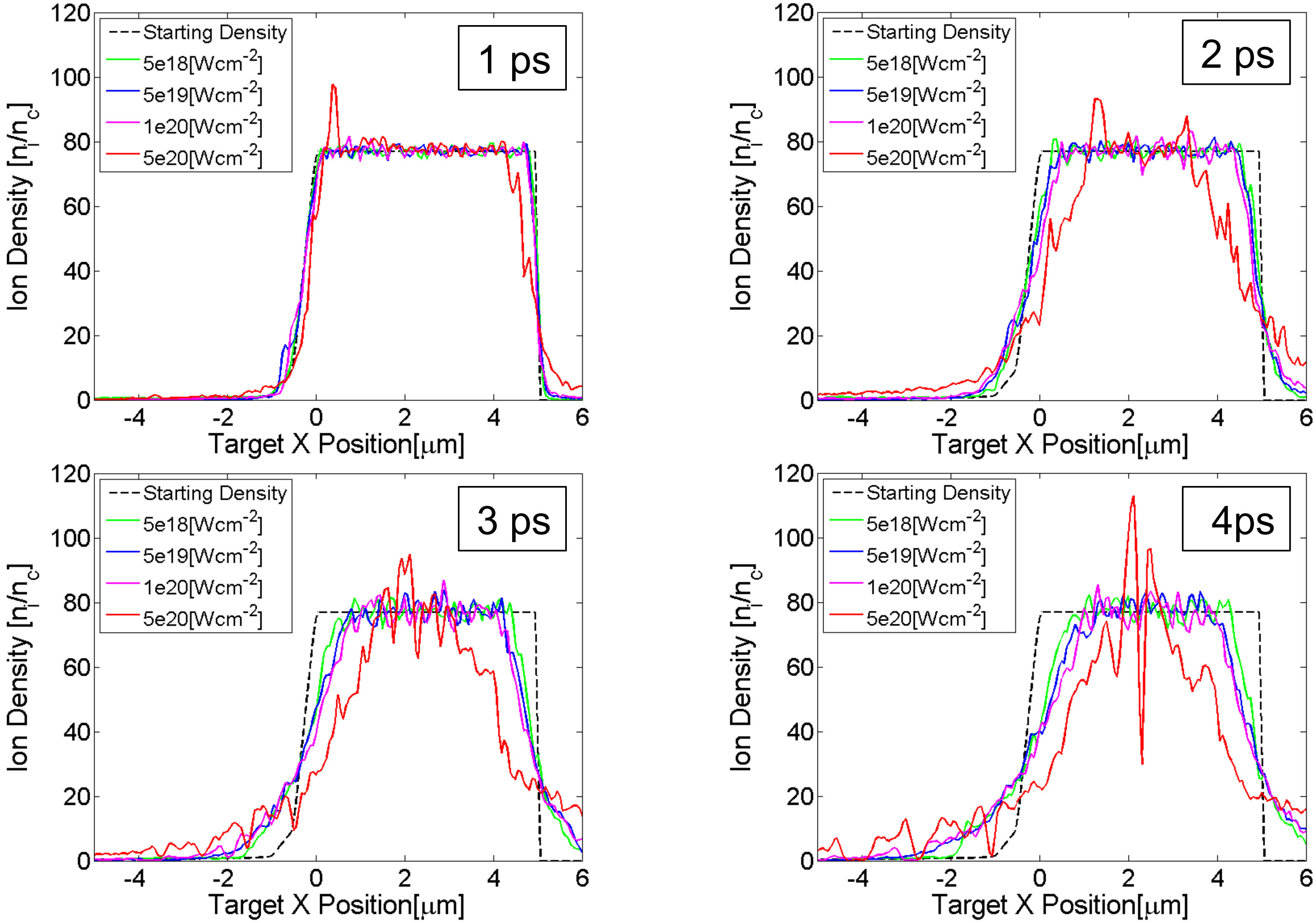
- LSP PIC modified by OSU HEPD group.
- All Particles Fully Kinetic
- Cell size λ/16 and 37μm long grid
- 6+ ionized copper 5μm target, with 20μm of preplasma of varying scale lengths including one from Habara et al.[3]
- λ= 1um, varying intensity, 1 ps duration Sin^2 pulse
- Timestep of 60 timesteps/optical cycle

Pre-Plasma From Habara et al.[3]



[3] Habara et al. *Phys. Rev. E* 70, 046414 (2004).

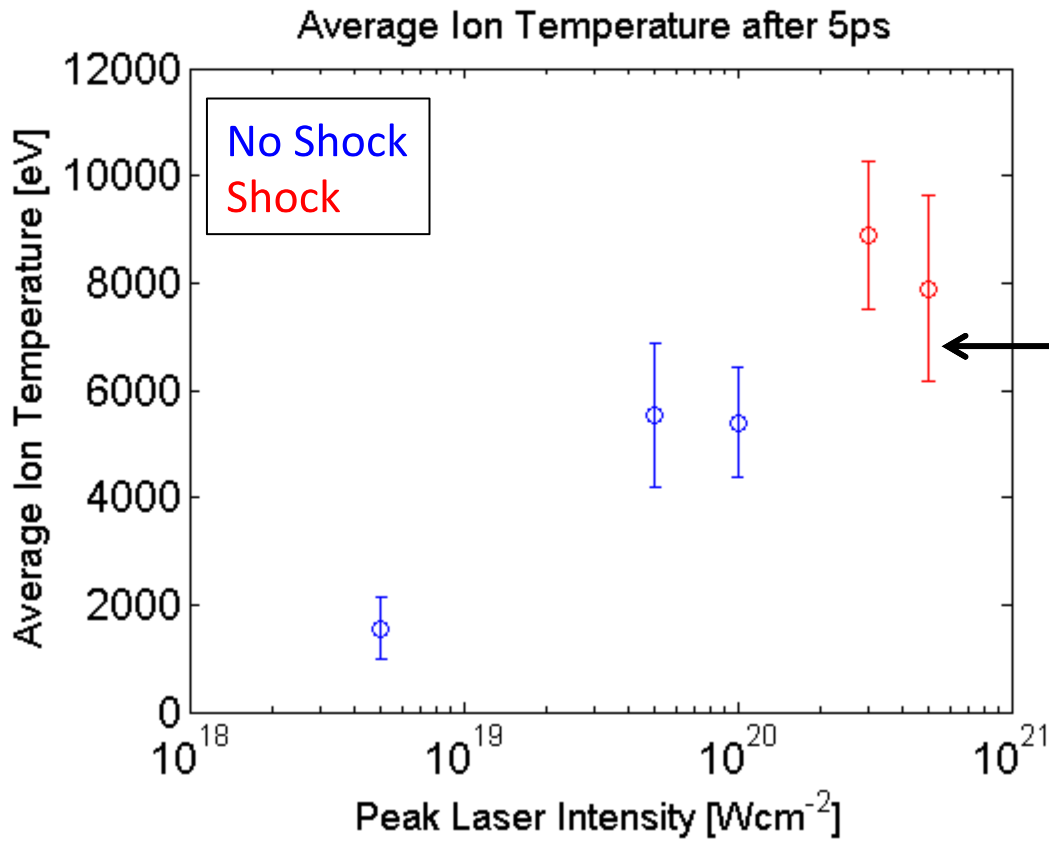
1D: Intensity Variation- 5μm Thick Target



Little density variation between intensities until a shock is generated.

[4]Sentoku et al., *Phys. Plasmas* (2009) [5]Silvia et al., *Phys. Rev, Lett.* (2004) [6]Wilks et al., Phys. Rev. Lett. (1992)

1D: Average Ion Temperature Vs. Laser Intensity



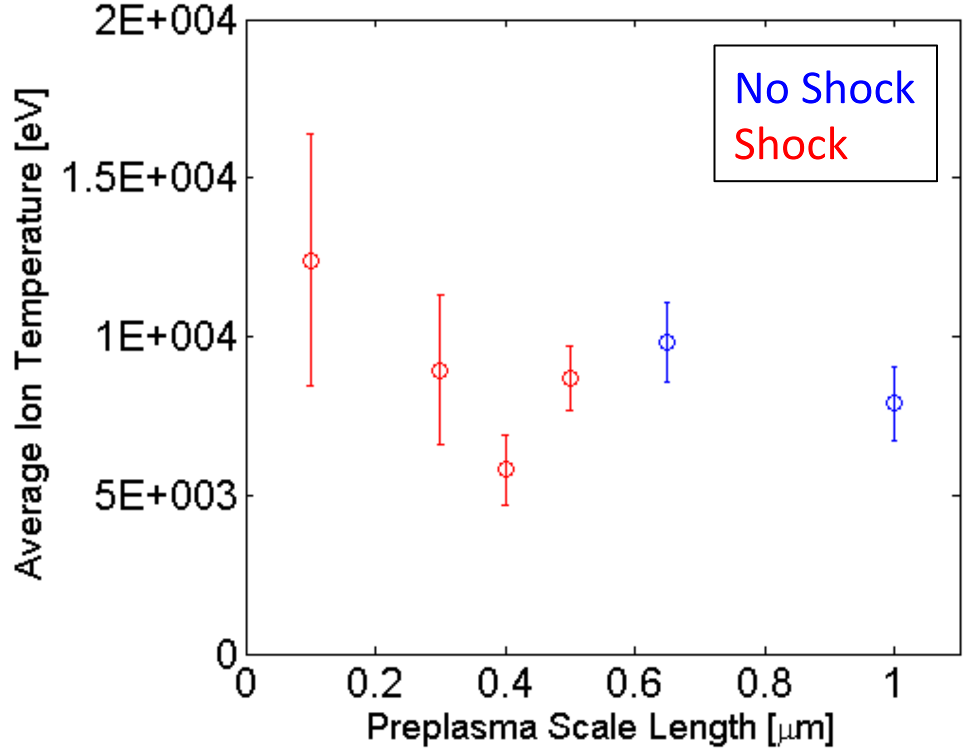
Bars show 1σ variation of target temperature

Large increase in intensity (energy) required to double temperature.

1D: Preplasma Scale Length Variation

Run at intensity of $5x10^{20}$

Average Ion Temperature at 5ps



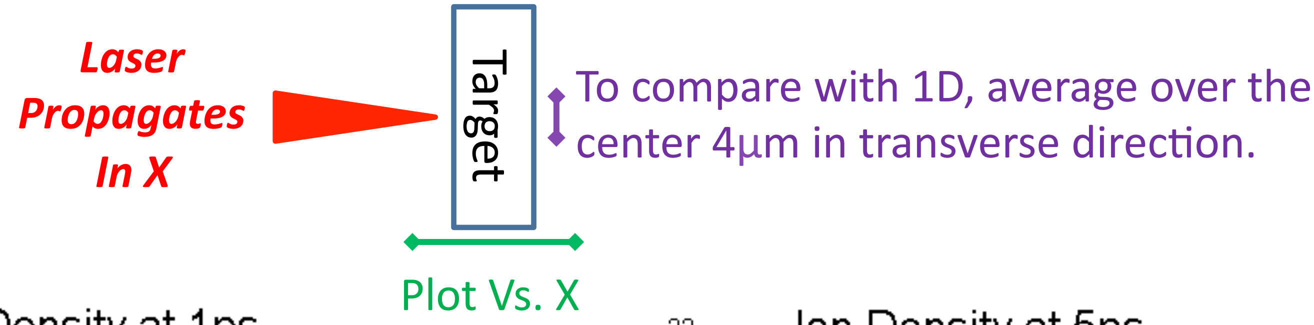
Bars show 1σ variation of target temperature

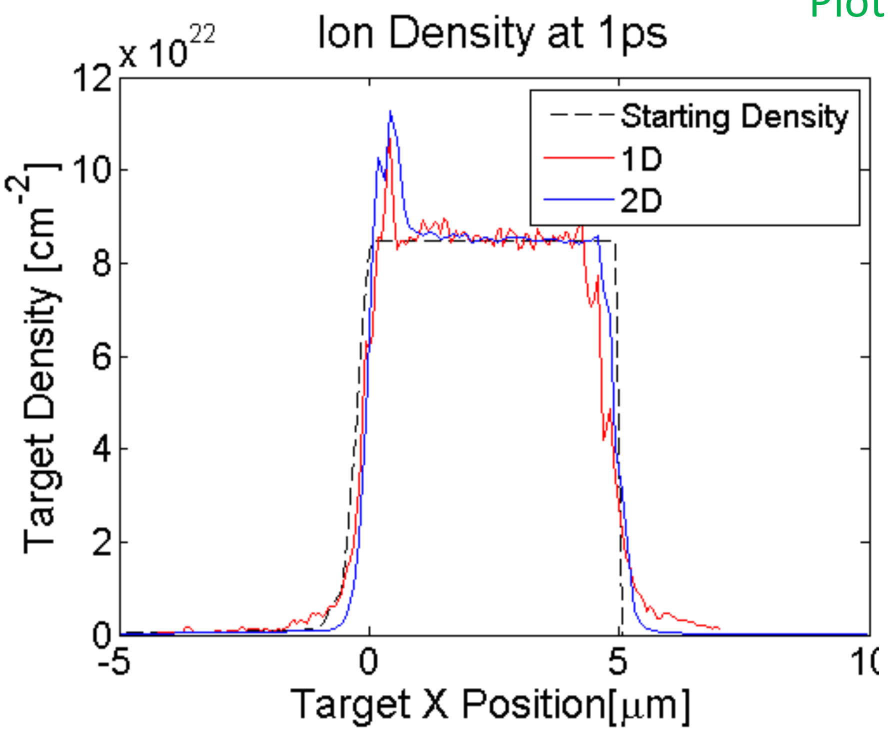
The scale length needs to be short to achieve the best heating

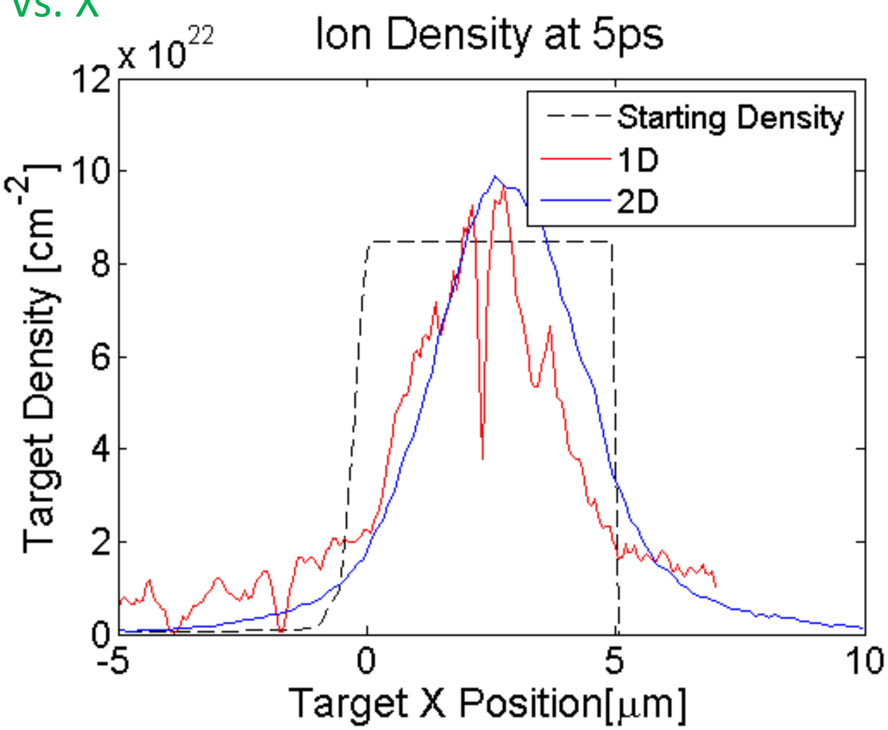
Moving From 1D To 2D

- The issue of heating uniformity is more realistically treated in 2D.
- 2D Simulation parameters
  - Cell size λ/16 for most of the grid including laser and target.
  - Target width 100μm in the transverse direction
  - Laser spot FWHM 5μm.
  - Preplasma from Habara et al. which is likely similar for the RAL experiment.

Compare 1D and 2D Target Center



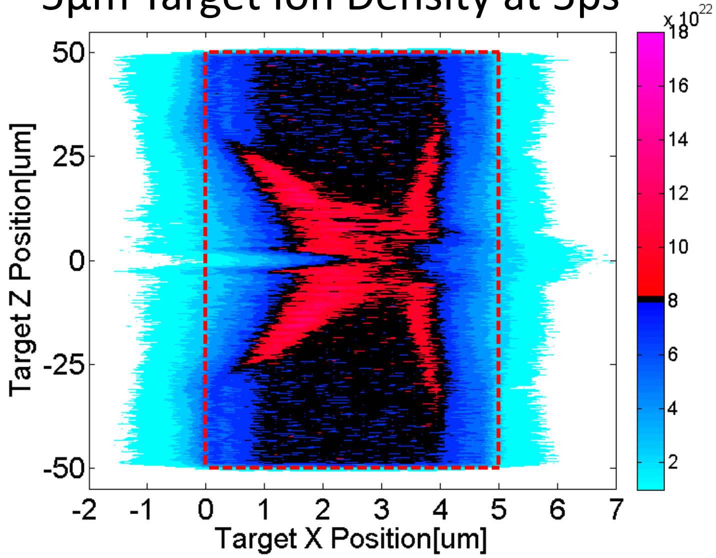




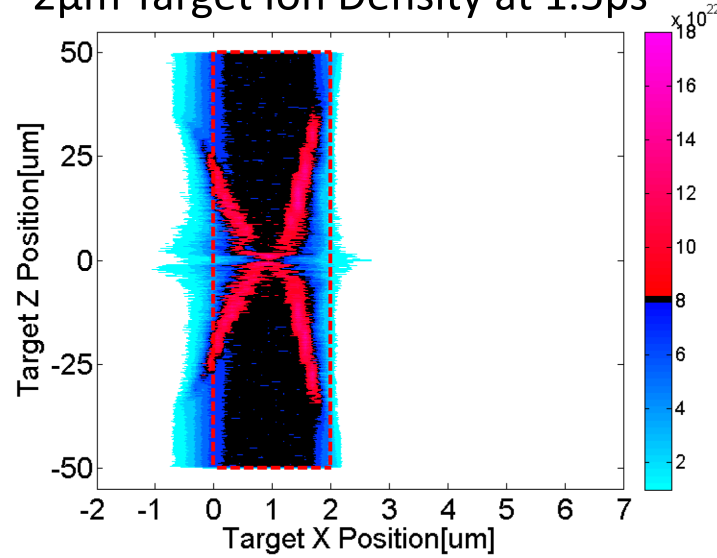
The center of the 2D target correlates well with the 1D target.
We see similar requirements of intensity, pre-plasma for a shock.

2D: Density Spatial Variation and Evolution

5μm Target Ion Density at 5ps

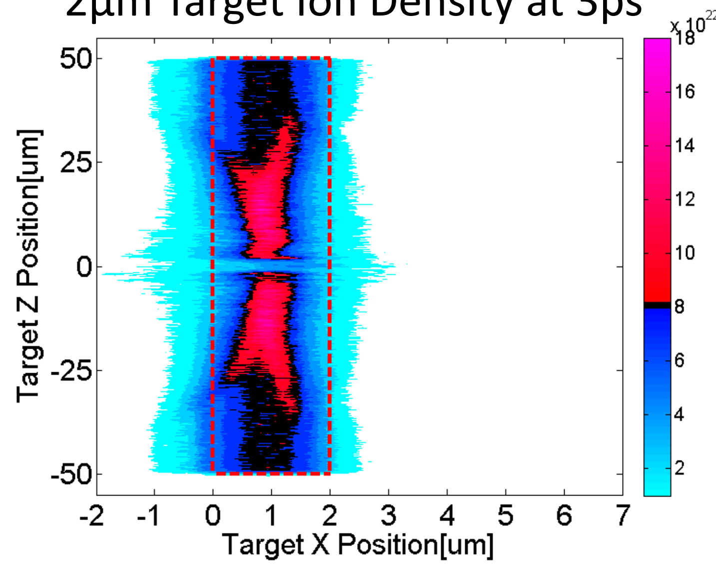


2μm Target Ion Density at 1.5ps

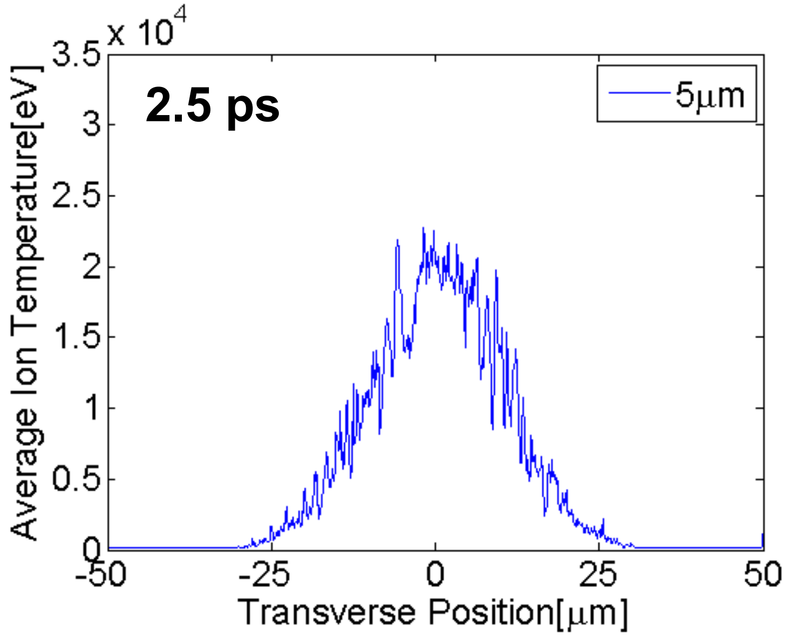


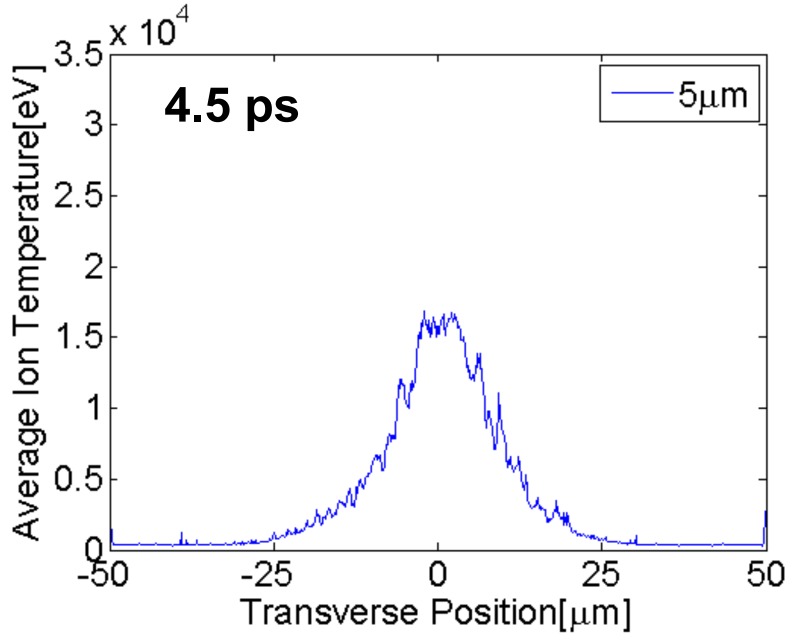
- Targets of different thicknesses appear to evolve similarly, but at different rates.
- Time-integrated diagnostics will average over this.

2μm Target Ion Density at 3ps

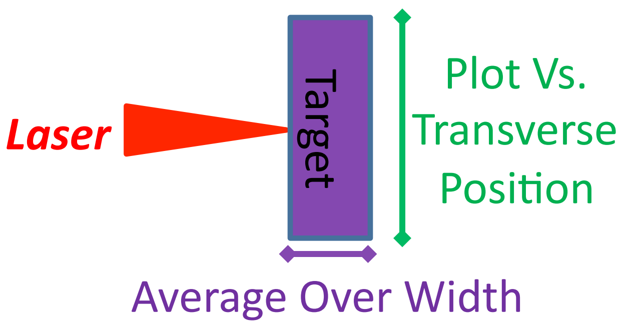


2D: Ion Temperature Vs. Transverse Position

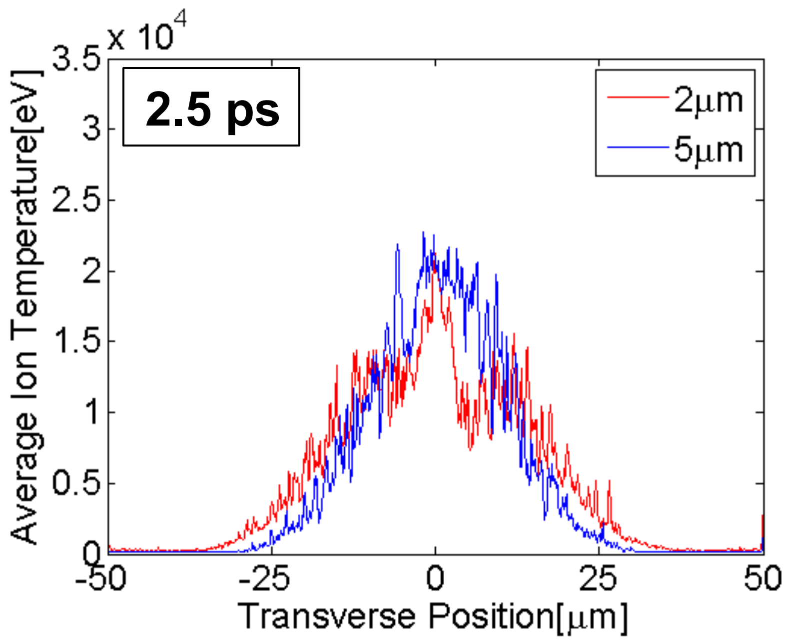


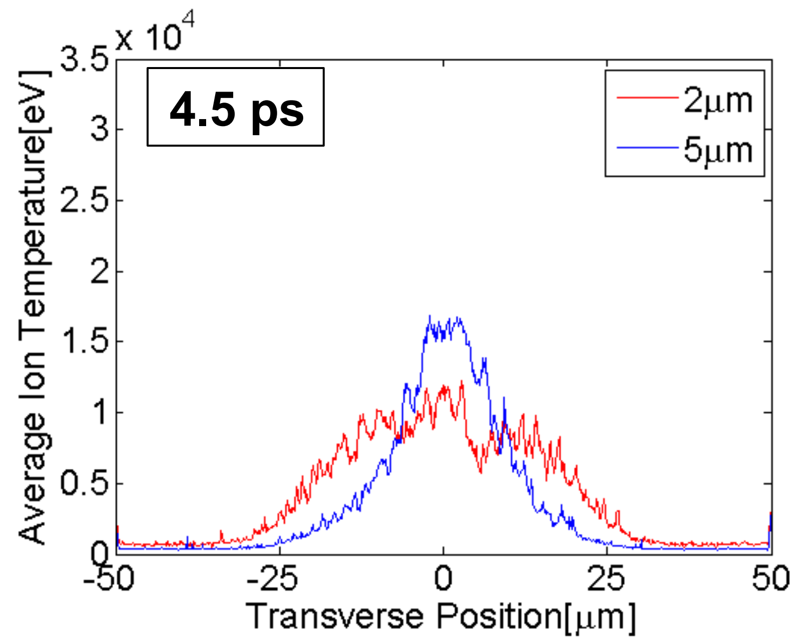


	5 μm	5 μm
Average Temp:	3500 eV	3300 eV
RMS:	5400 eV	4600 eV

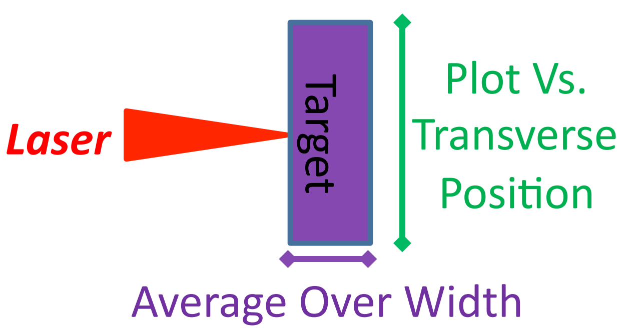


2D: Ion Temperature Vs. Transverse Position





	5 μm	2 μm	5 μm	2 μm
Average Temp:	3500 eV	5000 eV	3300 eV	3800 eV
RMS:	5400 eV	5300 eV	4600 eV	3500 eV



At all the times the thinner target has a higher average temperature. Relative RMS is smaller. It's hotter and more uniform

Conclusions

- Our simulations suggest that for a given laser pulse there is target size that achieves best heating of the target over the largest volume.
- Shocks play an important role in this process.
- We found 1D sims. show good correlation with the center of 2D targets, but there are phenomena that show up at later times in 2D that are not present in 1D.

Next:

- Can uniformity be improved?
- Improve simulations, run to longer times.
- Compare to hydro simulation using FLASH, HYDRA.