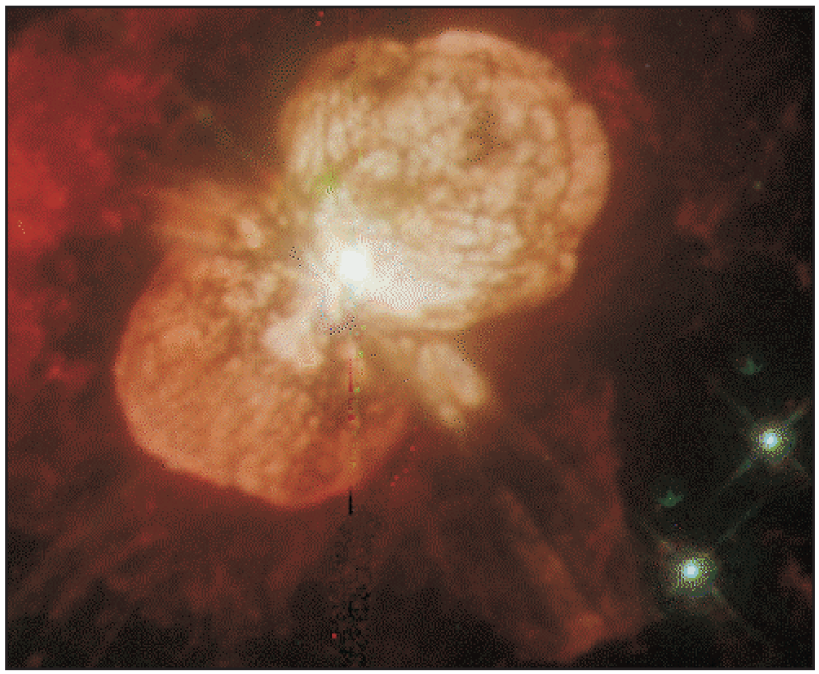
Development of a Test Bed for Astrophysical Jet Hydrodynamics



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Summary

A test bed for astrophysical jet hydrodynamics is being developed on OMEGA

- Jet structures in supernovae can be studied with a laser-generated blast wave.
- The propagation of ejecta through a medium displays jet-like features and can be studied with a laser-driven target.
- A point-projection backlighter has been developed to measure the evolution of hydrodynamic jets over large distances.

Outline

Development of a test bed for astrophysical jet hydrodynamics

- Point-projection-backlighter development
- Supernovae jet targets
- Ejecta-propagation targets

Supernovae jets (SNJ) are scaled to targets with fluid flow from the rear of a target into a foam medium

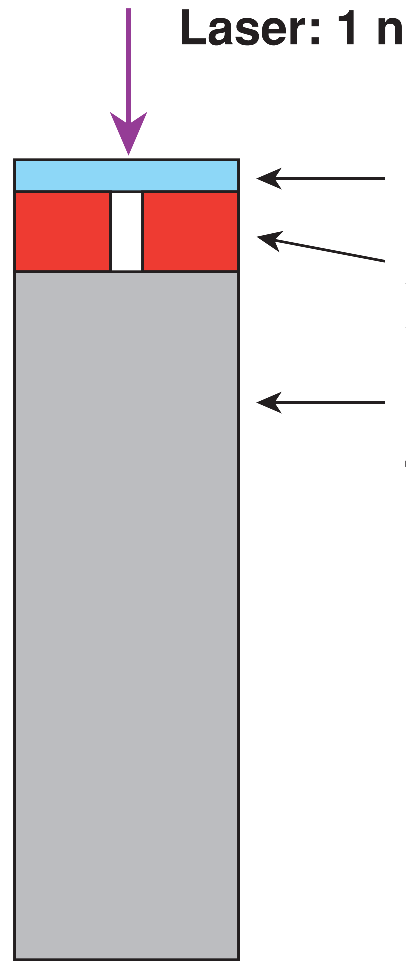
Decaying shock wave (blast wave) propagates through Mg foil.

Rear surface releases fluid stream toward medium.

$v_{fluid} \sim 30$ to 50 μm/ns

Mach # = 1 to 3

$\rho_{fluid}/\rho_{medium} \sim 10$



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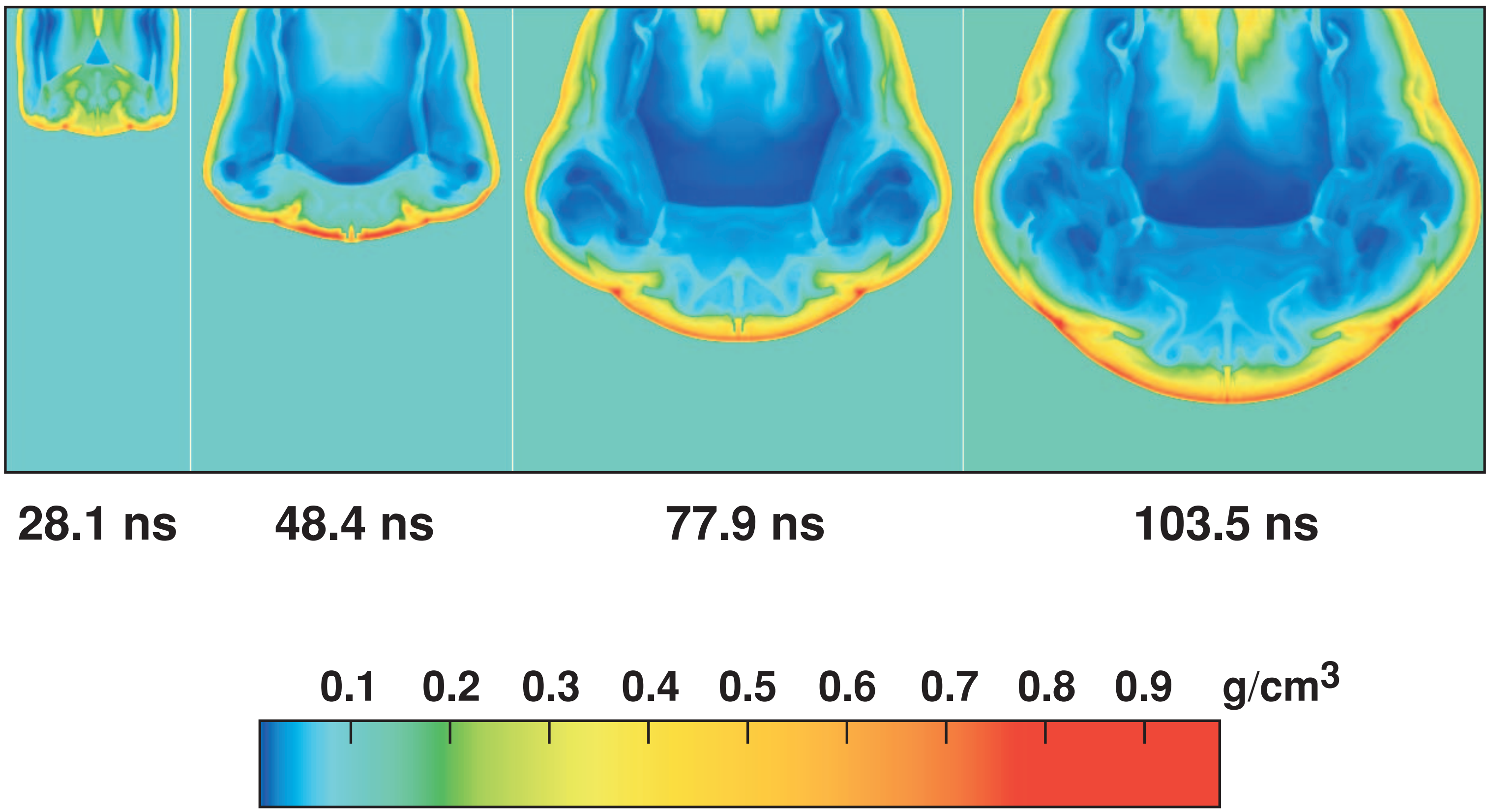
The SNJ targets have been simulated with a PPM 2-D hydrodynamic simulation

Density contours



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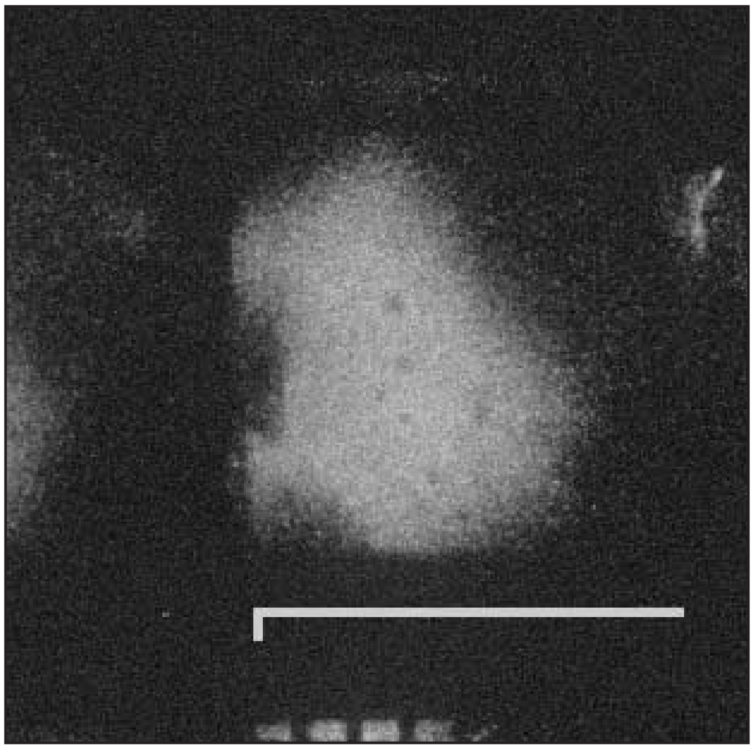
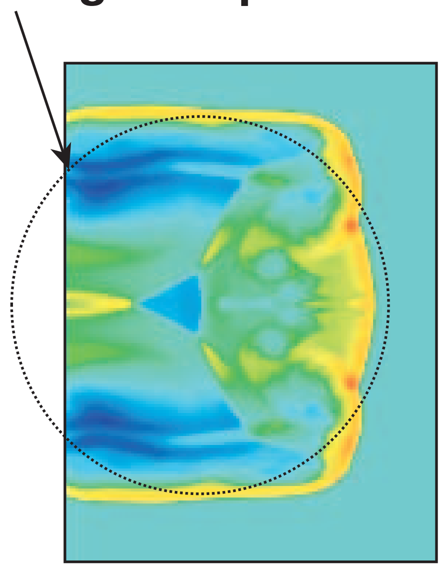
Area backlighting limits the size of the observable jet structures to ~ 1 mm



X-ray radiograph

Backlighter spot ~ 1-mm diameter



Density contours from 2-D hydrodynamic simulation

Targets to study the evolution of ejecta propagation into a medium are similar to the SNJ targets

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Ejecta velocity:
80 to 100 μm/ns

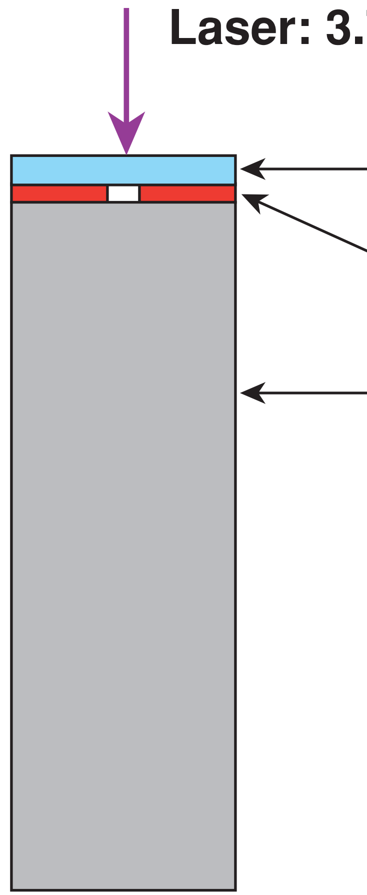
Mach # 5 to 10

$\rho_{ejecta}/\rho_{medium} \sim 100$

$t_{hydro} \sim 10$ ns

t_{cool}
radiation ~ 5 ns
conduction ~ 8 ns

$t_{cool}/t_{hydro} \sim 0.4$



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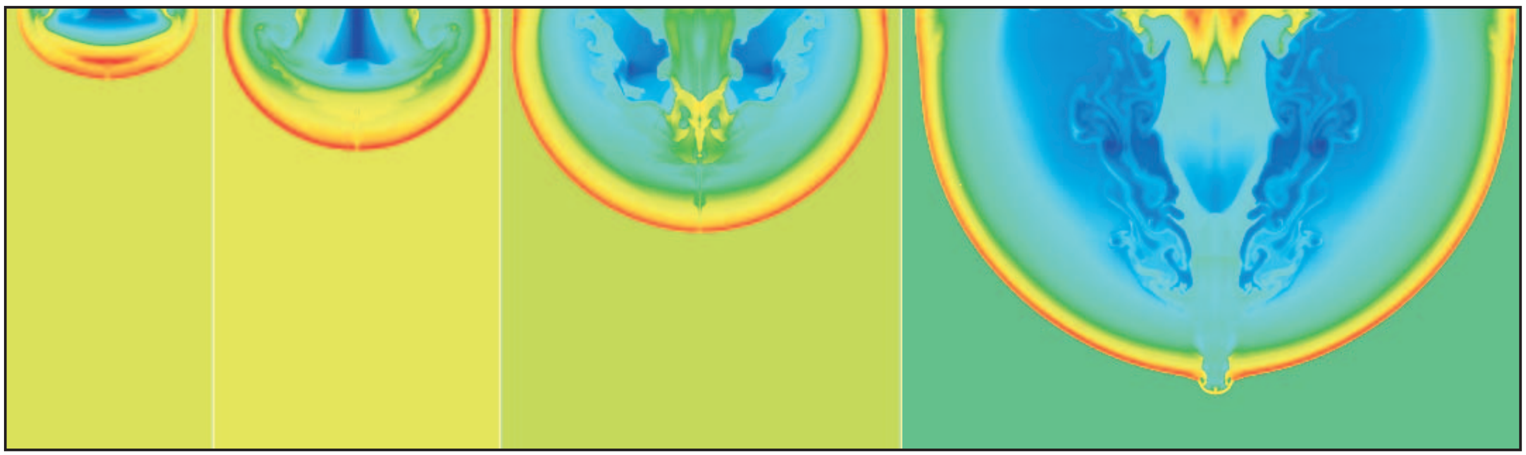
Propagation of ejecta through a medium has been simulated with the same PPM hydrodynamic code

Density contours



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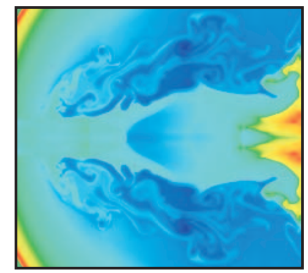
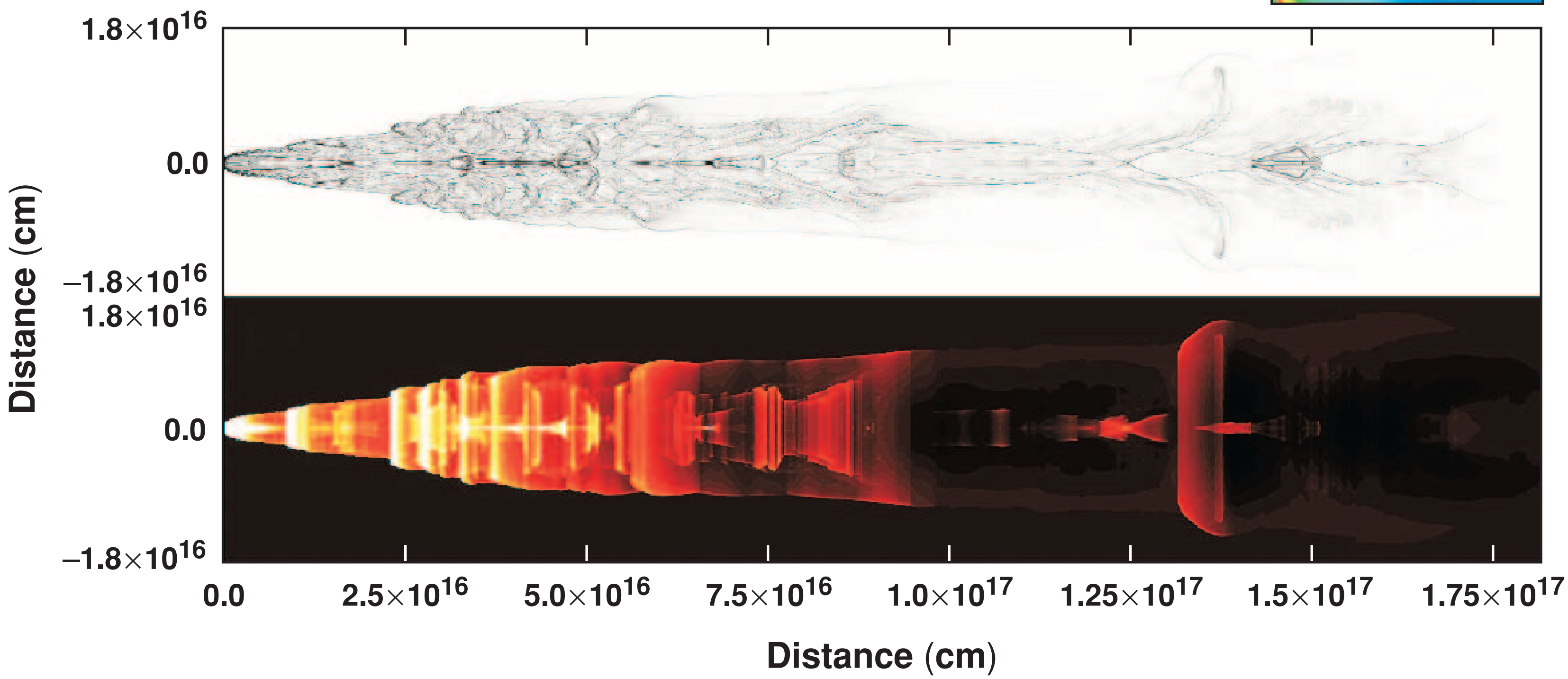
Simulations of the propagation of ejecta into a medium are similar for astrophysical objects and laboratory targets

Simulation of ejecta flow in η Carinea[1]

[1] A. Y. Poludenko, A. Frank, and S. Mitran, submitted to the Astrophysical Journal.





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The point-projection backlighter is constructed from a pinhole in Ta, CH absorbers, and the x-ray emitter

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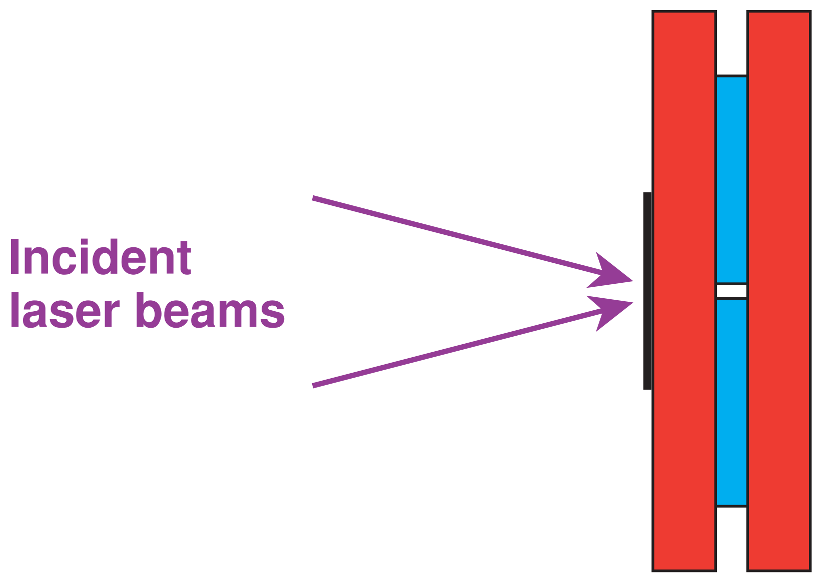
Ta substrate: 50 mm thick; 25-mm hole
CH: 100 mm thick
Thin x-ray emitter (PVDC, Ti, V, Fe)



The rear-surface temperature when the shock wave breaks out is high enough to melt the surface so no debris is directed toward the diagnostic.

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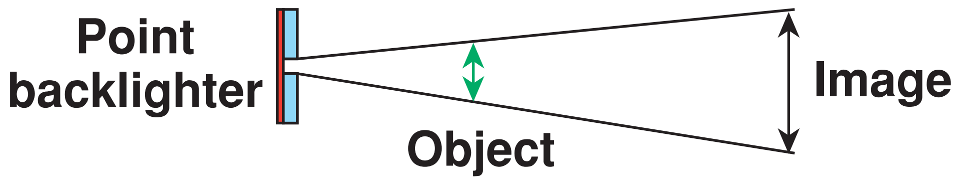
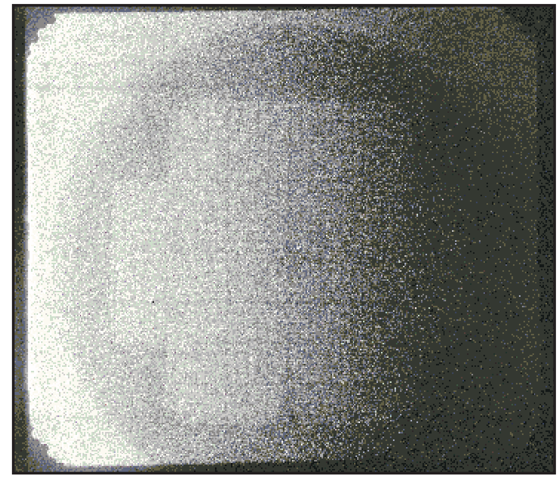
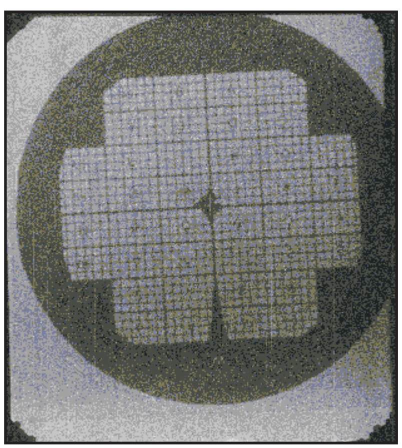
Development of point-projection backlighting is needed to resolve jet features over a large field of view





- Initial results were good[1] but subsequent usage has been difficult.
  - Resolution and contrast were poor.
  - Diagnostics were damaged by debris.

[1]D. K. Bradley *et al.*, Opt. Lett. 27, 134 (2002).



- Recent experiments have helped to understand the characteristics of a point-projection backlighter.
  - Resolution and contrast have been improved.
  - Diagnostics are no longer damaged.
  - X-ray spectra from 1.5 to 25 keV are being measured for Cl, V, Ti, and Fe sources.
  - Two view systems are under development.

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Summary/Conclusions

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