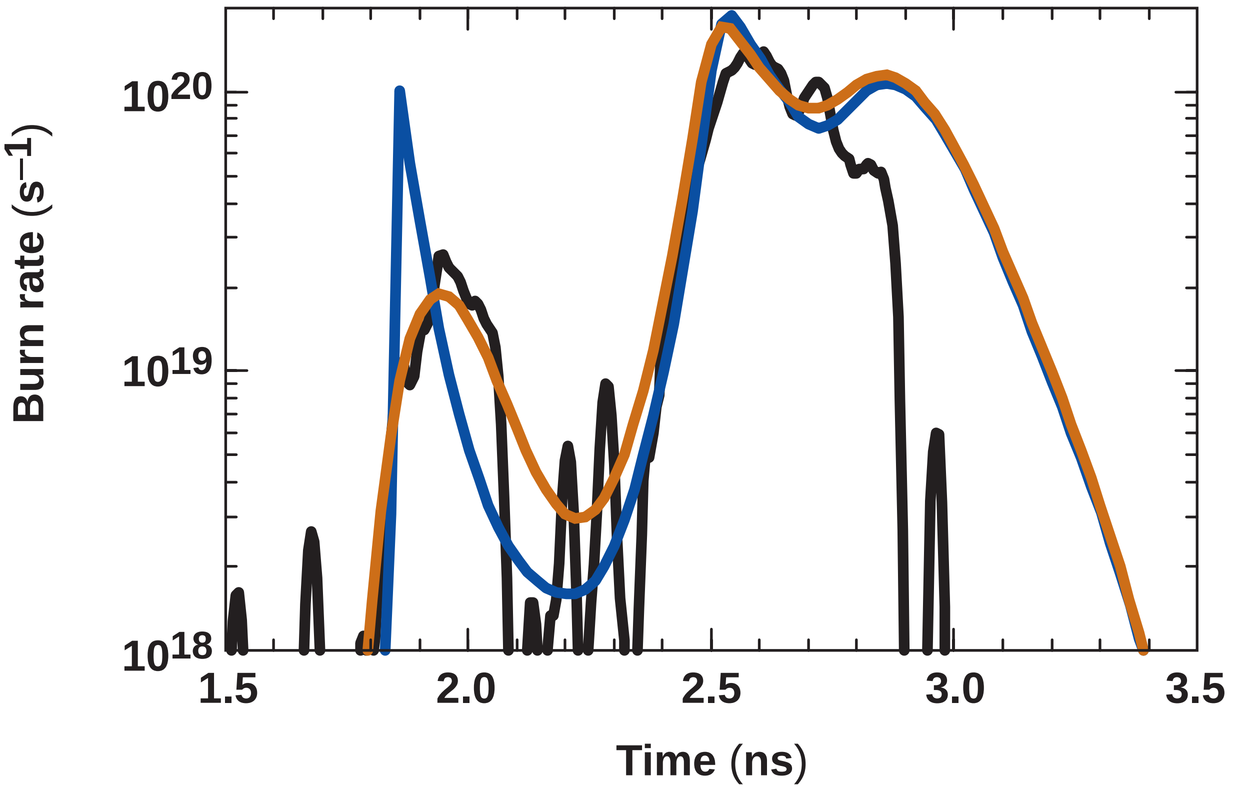
Comparison of Neutron Burn History Measurements with One-Dimensional Hydrodynamics Simulations



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Comparison of Neutron Burn History Measurements with One- and Two-Dimensional Hydrodynamic Simulations

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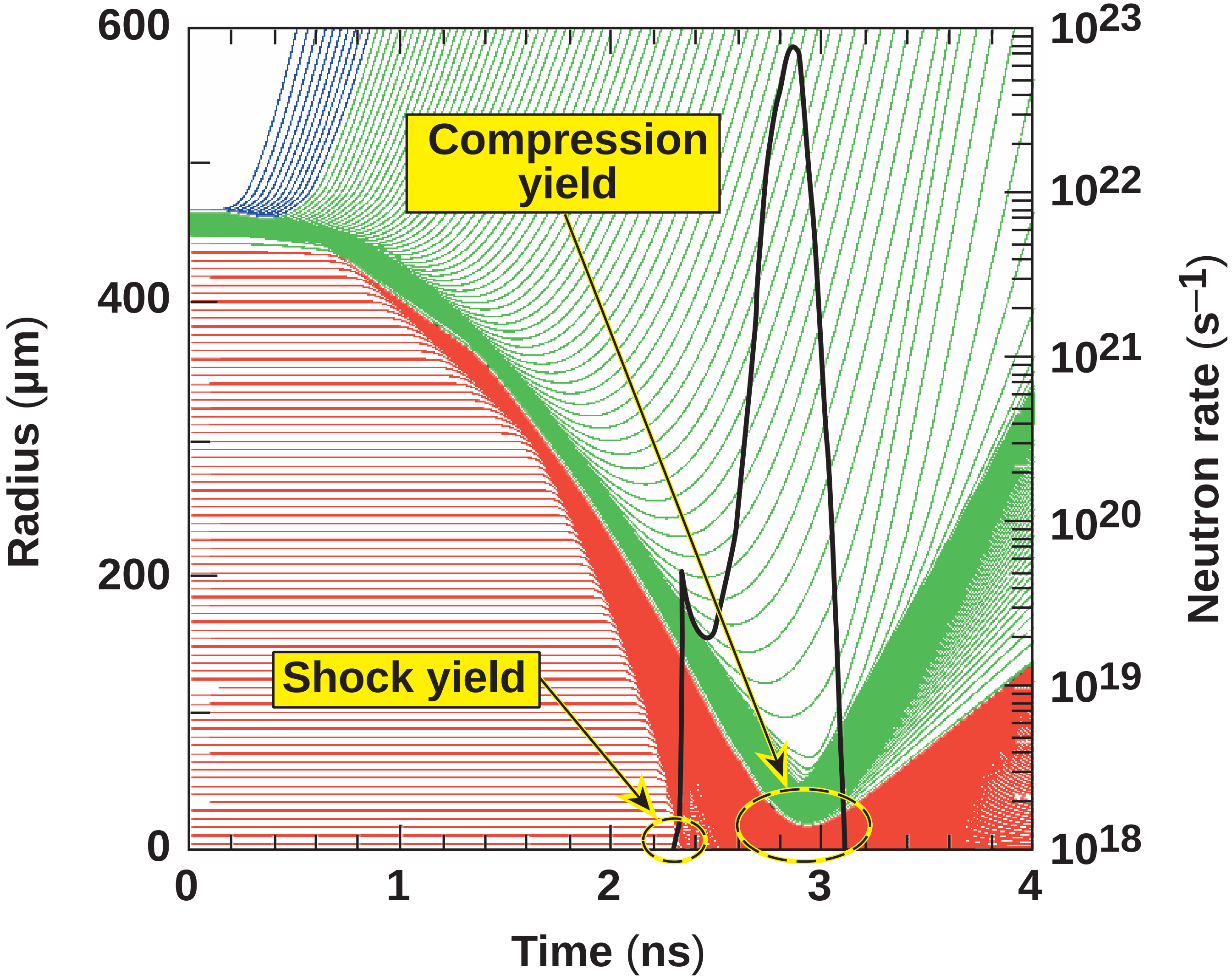
The fast scintillator-based neutron temporal diagnostic (NTD) measures the burn histories of direct-drive spherical targets on OMEGA. NTD has a time resolution of 20 ps and a jitter below 50 ps. Experimental burn histories from both DD- and DT-filled capsules are compared with burn predictions from one- and two-dimensional hydrodynamic simulations. Analysis of the most stable implosions [implied by experimental yields >50% of the calculated one-dimensional (1-D) yield] shows good agreement between experiment and the 1-D code calculations. Examples from the extensive database of burn histories, recorded under a variety of different laser and target conditions, will be shown, illustrating the use of NTD data as a guide in the refinement of future simulations. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

The neutron burn history shows details of the shock arrival and the stagnation phase of the implosion



Compression yield

Shock yield

E9260a

Summary

Burn history measurements reveal capsule implosion dynamics

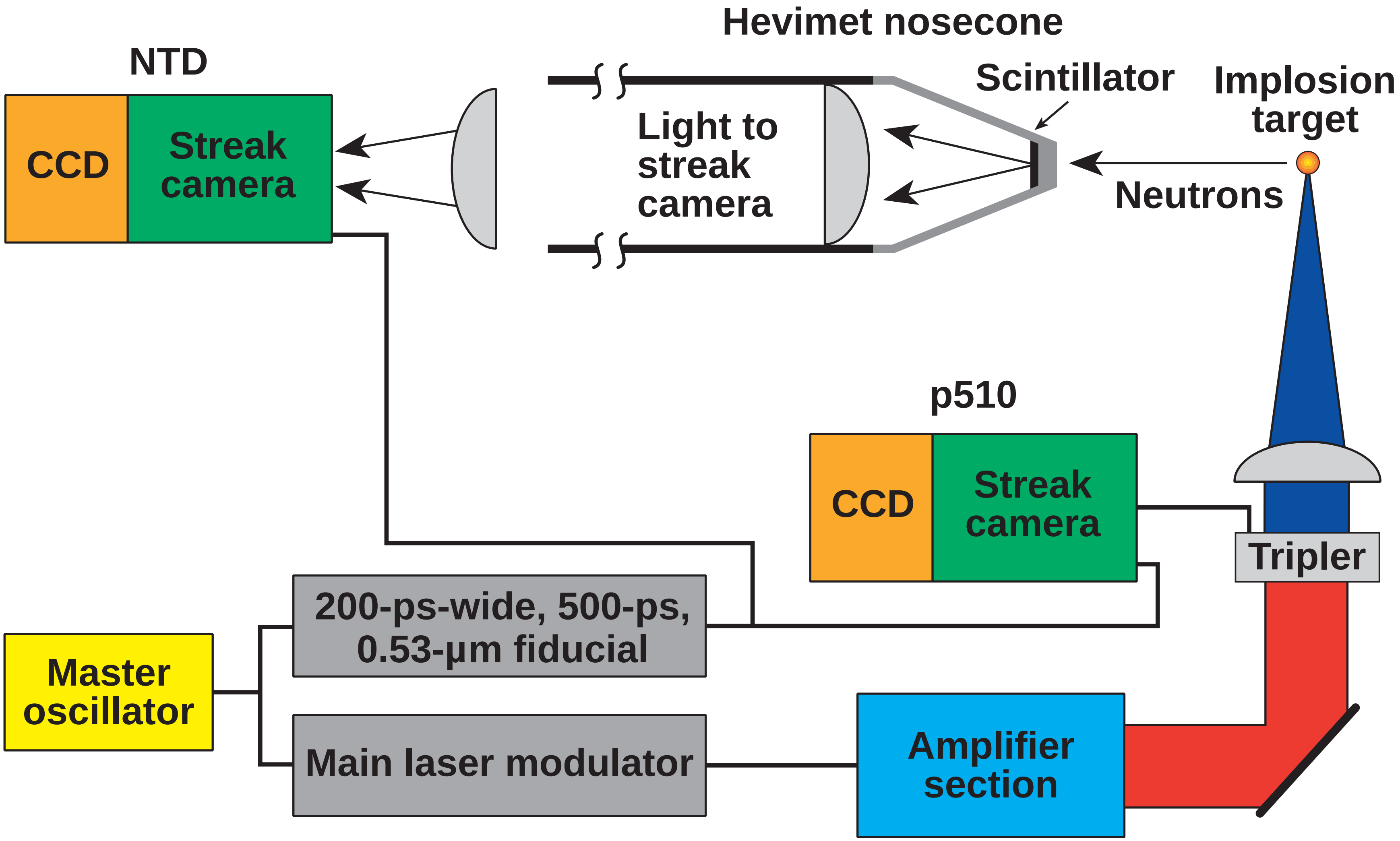
- Precise measurement of the neutron burn history shows many details of the shock arrival and the stagnation phase of a capsule and provides valuable input to compare with hydrocode calculations.

- A scintillator/streak-camera-based neutron temporal diagnostic (NTD) measures the neutron burn history with 25-ps time resolution and better-than-50-ps absolute timing accuracy.

- The measured bang time puts stringent limits on both the incident energy and the flux limiter used in the hydrocode calculations.

- The differences observed between experiment and the hydrocode calculations lead to a better understanding of mix processes that quench the observed neutron yield.

Setup of the neutron temporal diagnostic (NTD)*



*R. A. Lerche, Rev. Sci. Instrum. 66, 1 (1995).

Summary of NTD operational parameters

Temporal resolution

- Plasma temperatures, target scintillator distance

$$\Delta t_{ps} = \left\{\begin{matrix} 7.78 \\ 1.28 \end{matrix}\right\} \times \sqrt{T_{keV}} \times d_{cm} \left\{\begin{matrix} \mathrm{DD} \\ \mathrm{DT} \end{matrix}\right\},$$

$$\text{for} \quad \begin{matrix} \Delta t & \leq 20\ \text{ps} & & \\ d & \leq 2.5\ \text{cm}, & 1.1\ \text{cm}, & \text{DD neutrons} \\ d & \leq 15.6\ \text{cm}, & 7.0\ \text{cm}, & \text{DT neutrons} \end{matrix} \left.\begin{matrix} \\ \\ \end{matrix}\right\}, \ T = 1\ \text{keV},\ 5\ \text{keV}$$

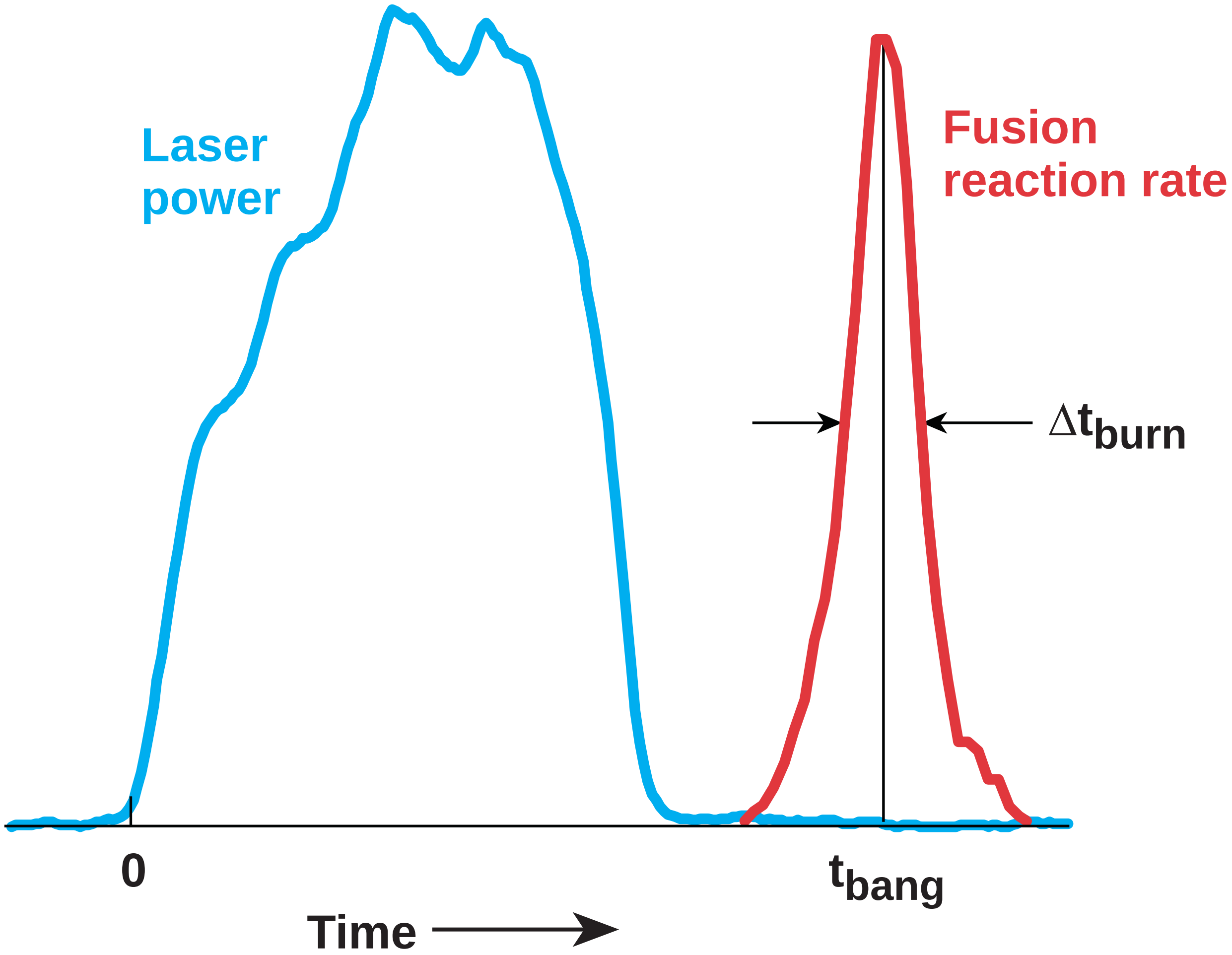
- Scintillator thickness

$$\Delta t = \frac{\Delta x}{v_n} = \left.\begin{matrix} 46\ \text{ps, DD neutrons} \\ 19\ \text{ps, DT neutrons} \end{matrix}\right\}, \ 1\text{mm scintillator}$$

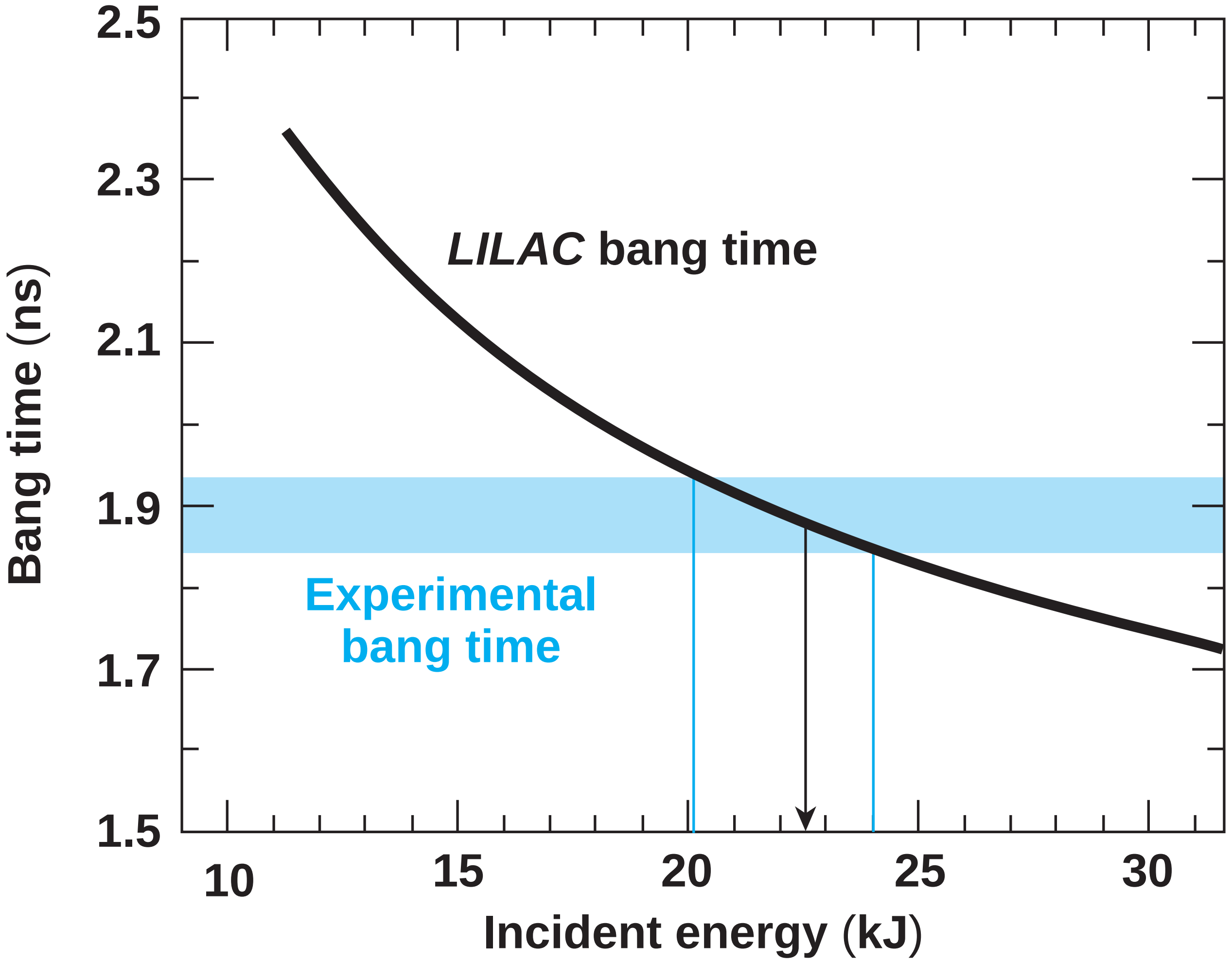
Timing stability

- Mechanical stability of setup
  <20 ps over a period of 3 months of operation

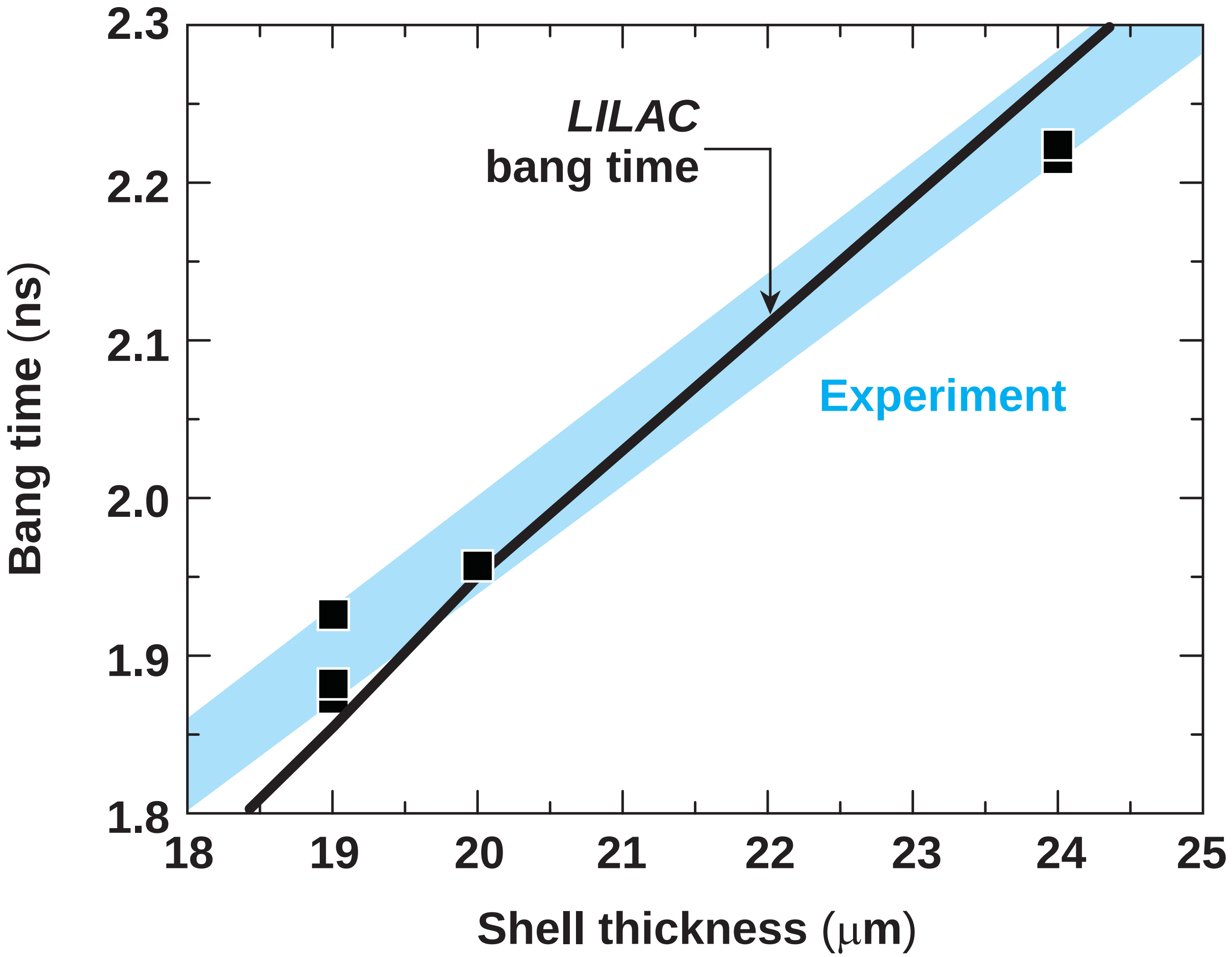
The neutron bang time is defined relative to the 2% point of the laser power history



The measured bang time puts limits on incident energy



Measured and calculated bang times are in good agreement for various shell thicknesses



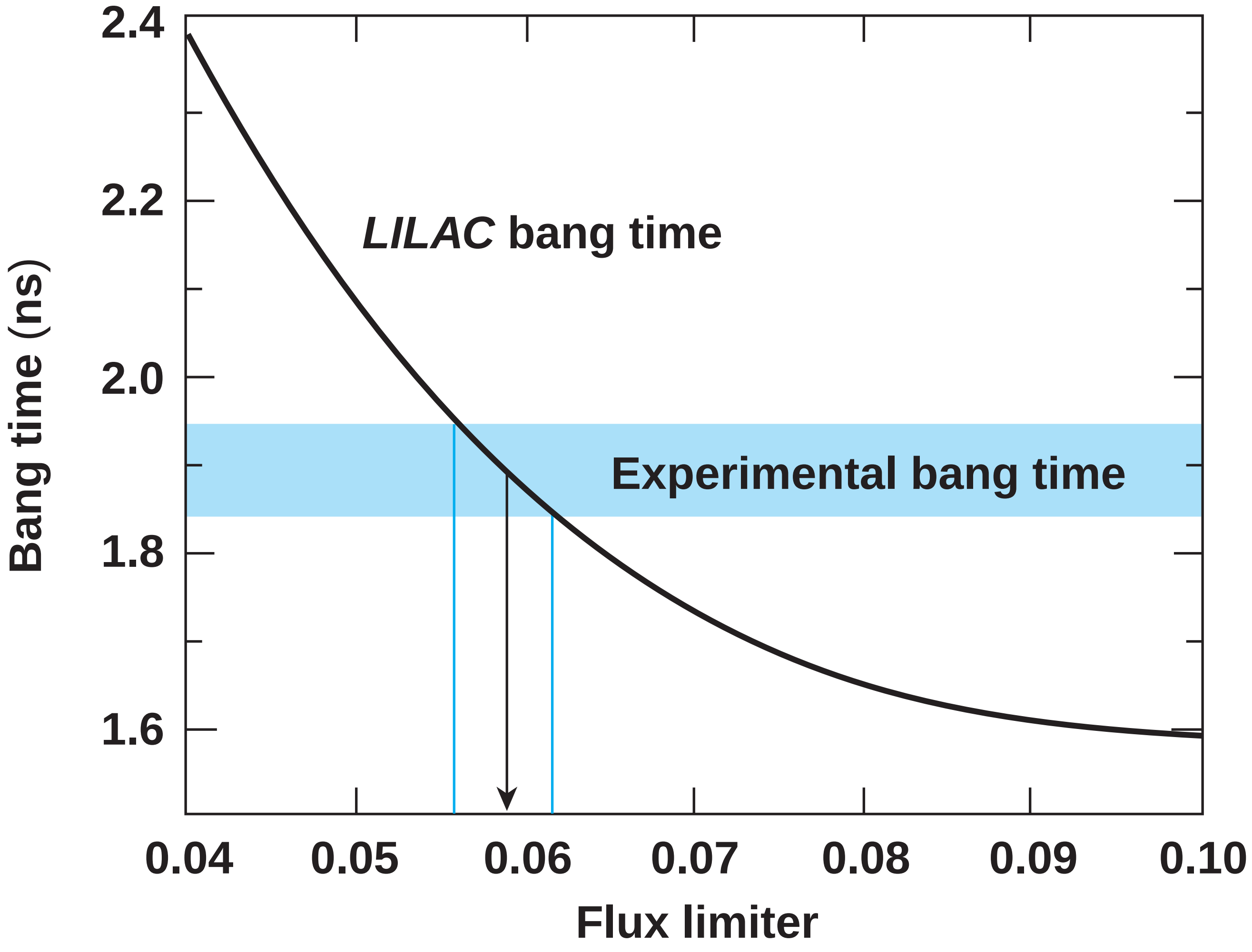
Capsule:

- 1-mm diam.
- 15 atm DD

Laser:

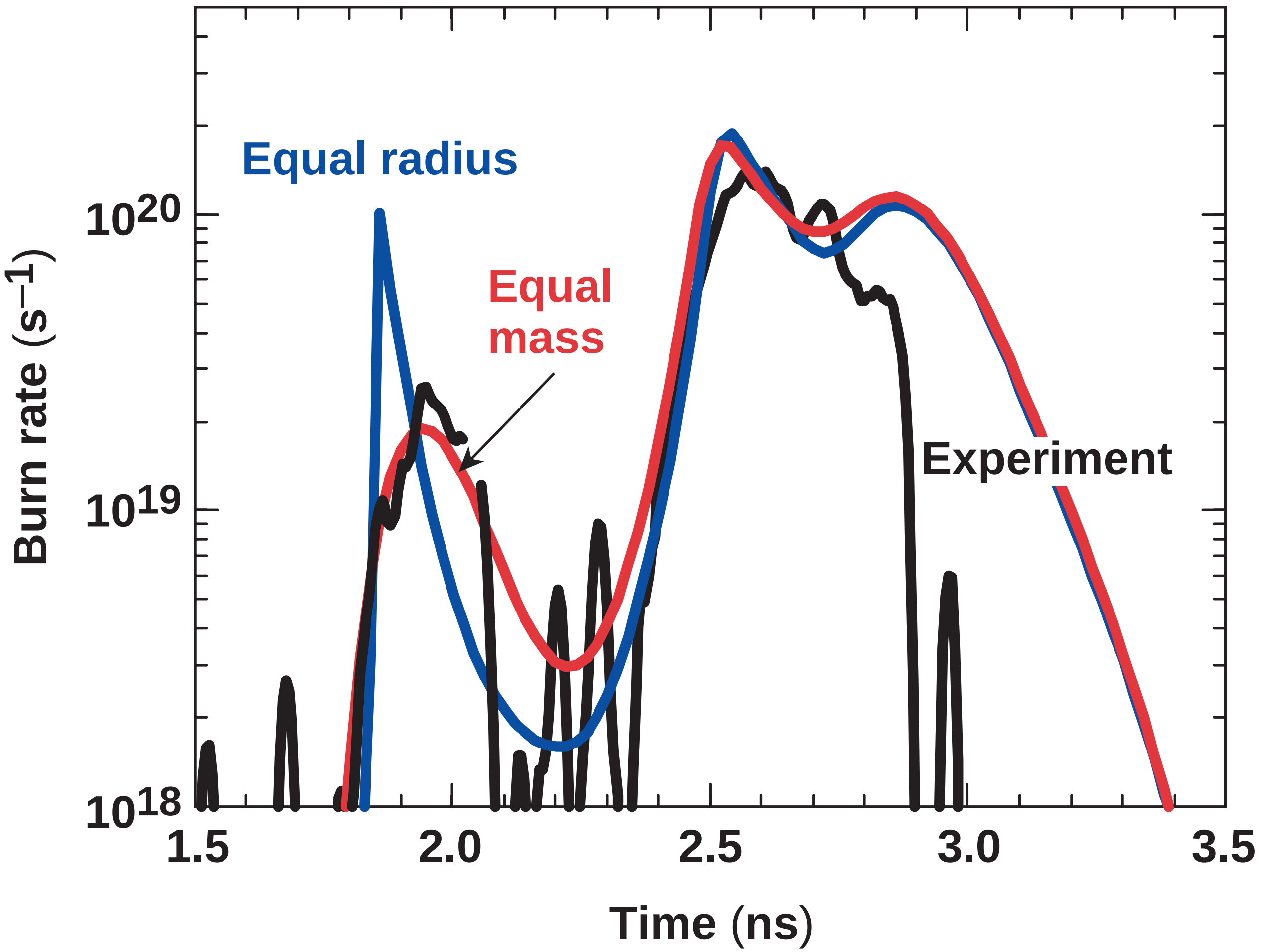
- 1 ns square
- 1-THz SSD
- 23 kJ
- DPP
- Polarization smoothing

The measured bang time puts stringent limits on the value of the flux limiter (sharp cut-off model*)



*C. E. Max *et al*., Phys Fluid 8, 1645 (1980).

Experiments where shock and compression are well separated show the importance of adequate zoning



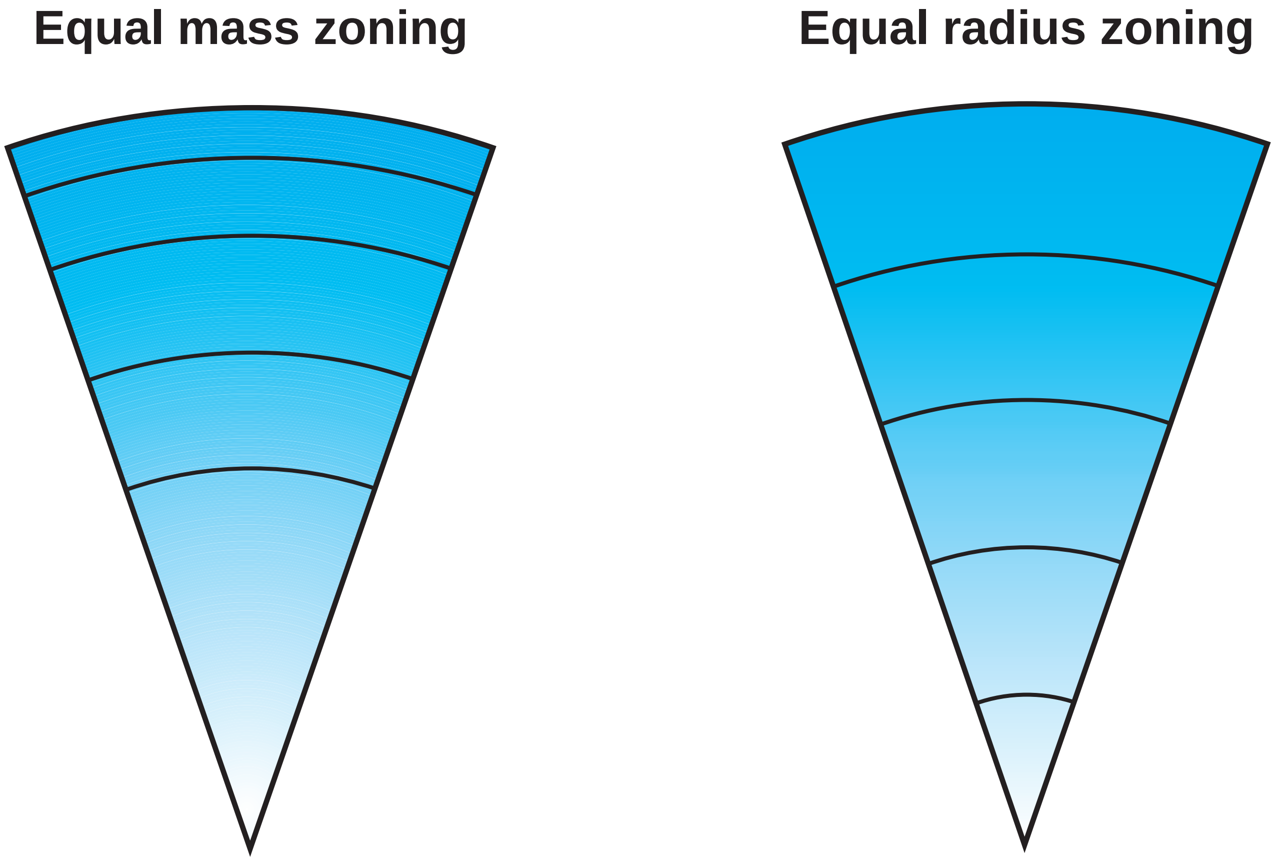
Capsule:

- 1-mm diam.
- 20 μm CH
- 20 atm DT

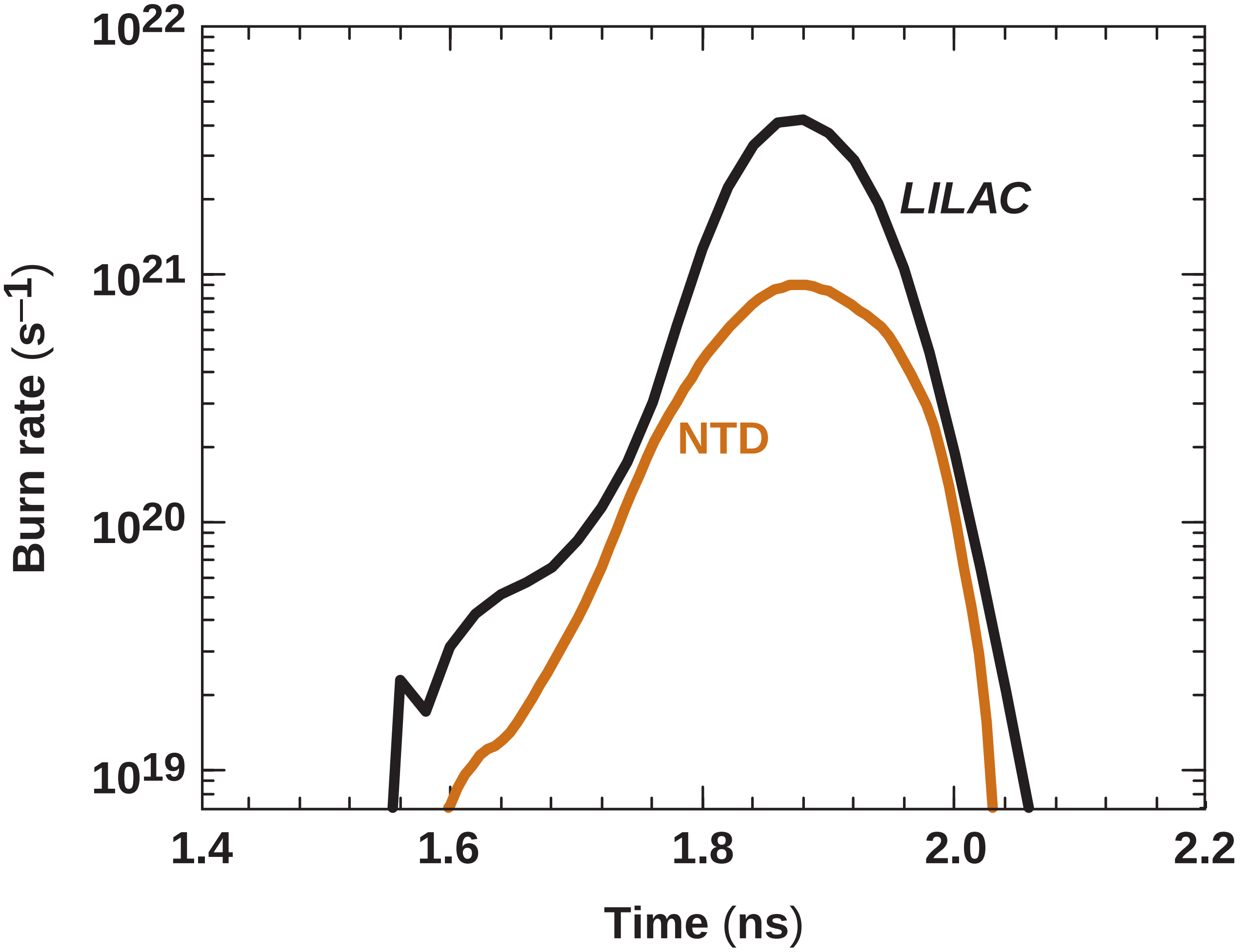
Laser:

- 400-ps square
- 9 kJ
- 0.25-THz SSD
- DPP

Two different zoning schemes are possible when using the hydrocode *LILAC*



Experiments with a 1-ns square laser pulse show no truncation of the neutron yield



Capsule:

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Summary/Conclusions

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