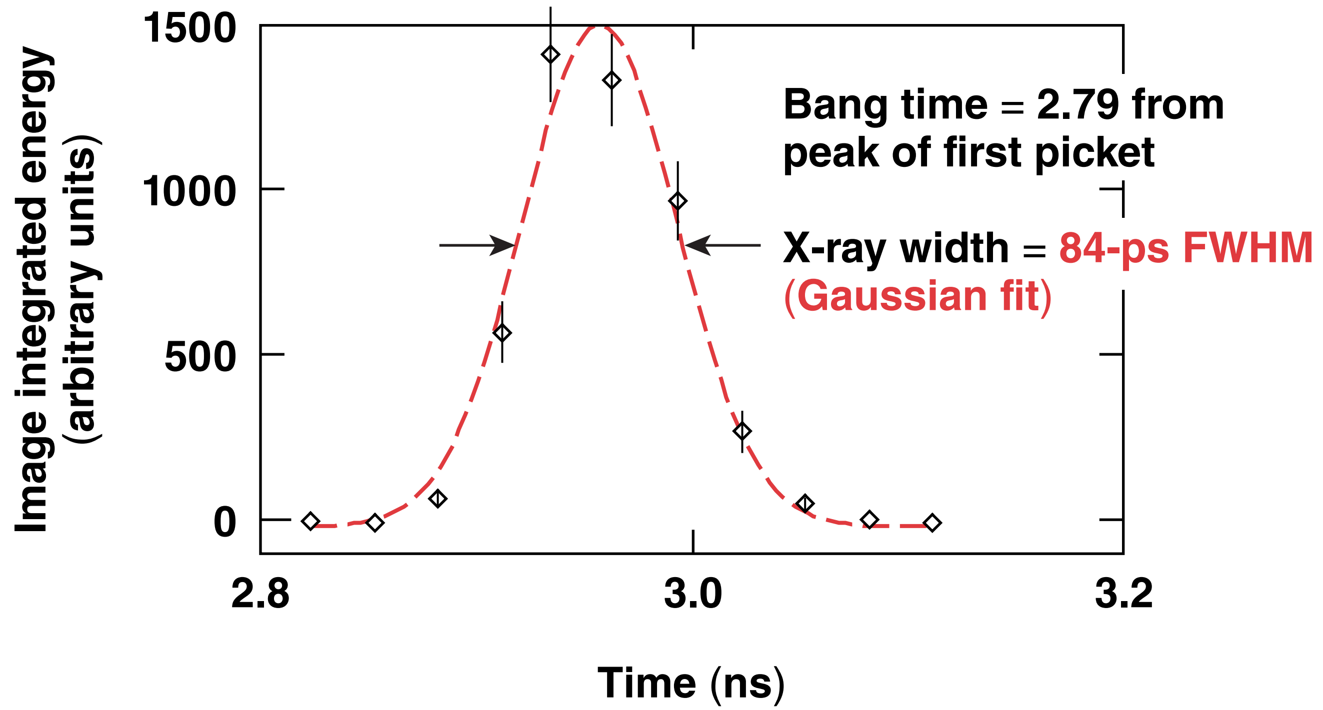
Time-Resolved Imaging of Cryogenic Target X-Ray Emission at Peak Compression on OMEGA



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Summary

Time-resolved x-ray imaging of cryogenic target core emission provides improved estimates of bang time, burn width, and peak core pressure

- Cryogenic DT target-implosion cores are imaged on OMEGA by a combination of a high-speed framing camera coupled to a pinhole array and by two time-integrating x-ray microscopes
- The time history of the core x-ray emission determined by the high-speed framing camera gives absolute values of the bang time and burn width
- The core pressure is inferred from the measured core size, ion temperature, neutron yield, and burn width
- The measured x-ray bang time and burn width agree favorably with *LILAC* 1-D hydrodynamic simulations of these experiments, while the inferred core pressure is lower

Collaborators

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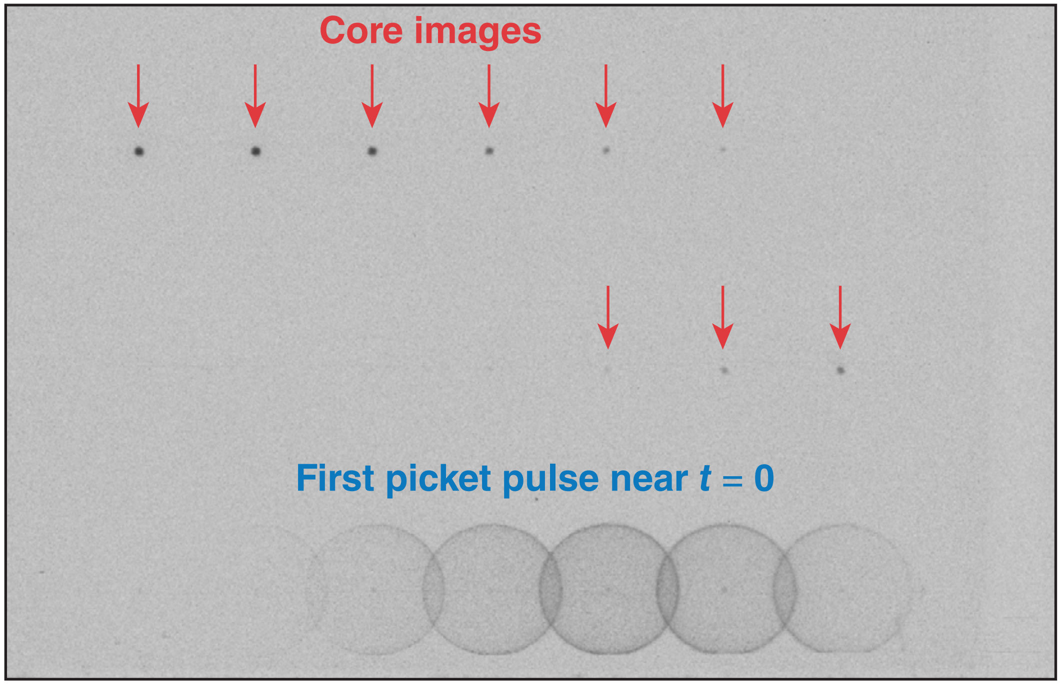
The framing-camera images determine the absolute x-ray bang time and burn width

OMEGA cryogenic target shot 74354

Strip 3
Δt = 2.9 ns

Strip 2
Δt = 2.7 ns

Strip 1
t = 0



0 — Time (ps) → — 200

Target:
7-μm CD shell
64-μm DT ice layer
865-μm diameter

Laser:
Double picket
α = 3.6 pulse
25 kJ
$I_{peak} = 9 \times 10^{14}$ W/cm^2
$V_{imp} = 3.5 \times 10^7$ cm/s

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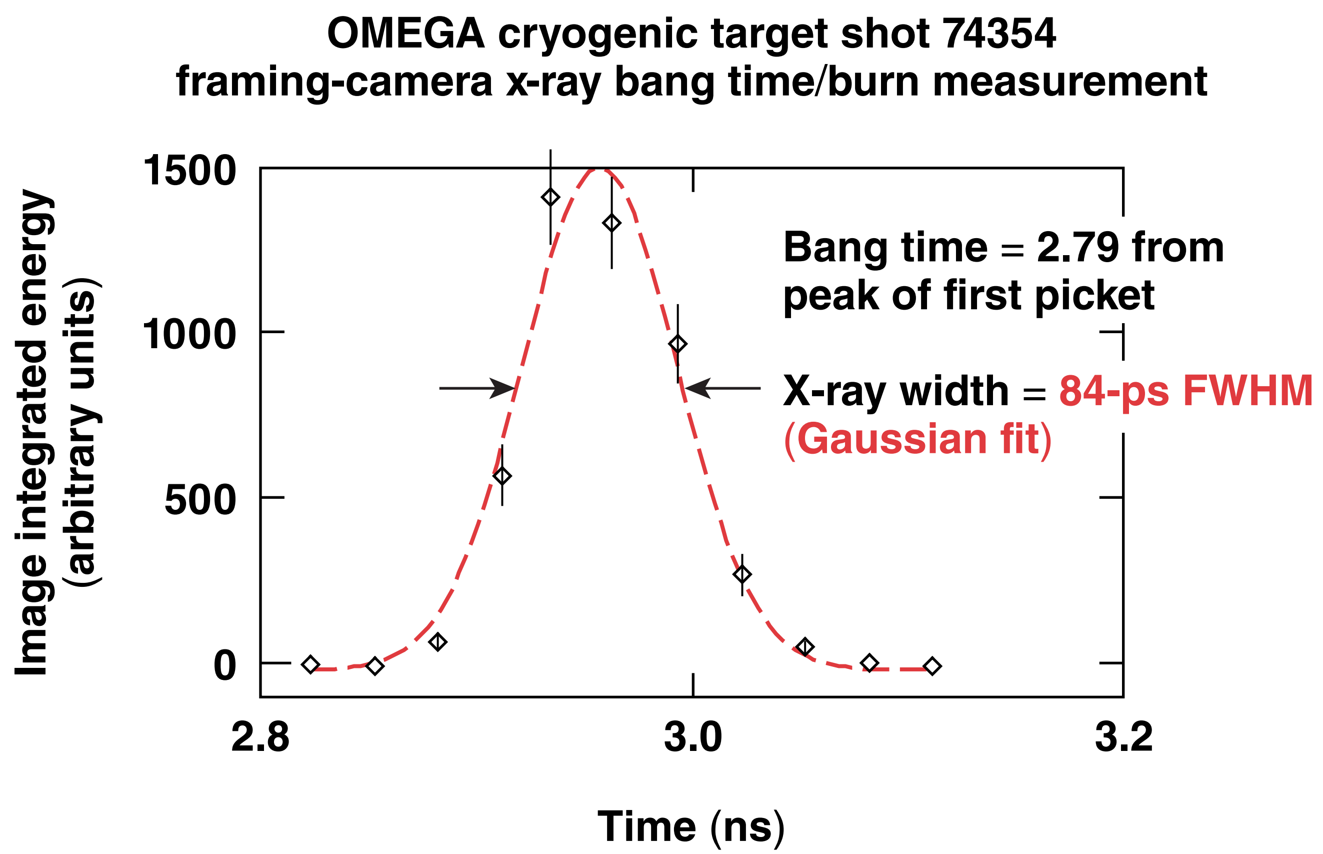

The framed pinhole images and time-integrated x-ray microscope images show a similar size stagnation region

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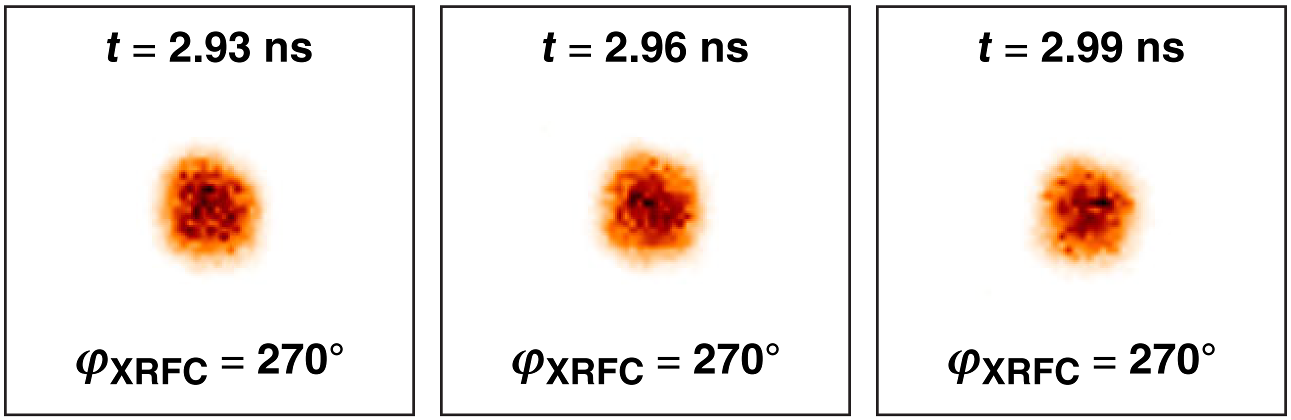
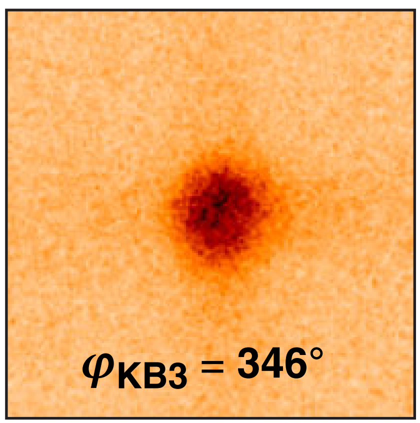
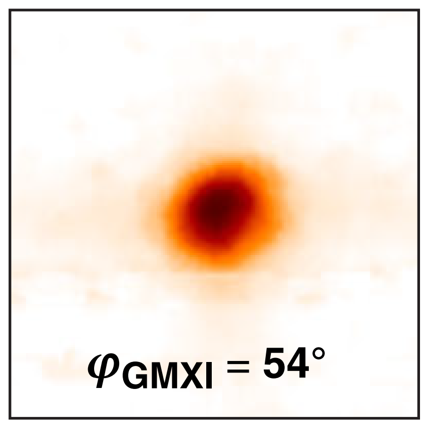
X-ray framing-camera (XRFC) images



Kirkpatrick–Baez KB3 image (time integrated)





Gated monochromatic x-ray imager (GXMI) image (time integrated)

All images are 200 $\times$ 200-μm regions

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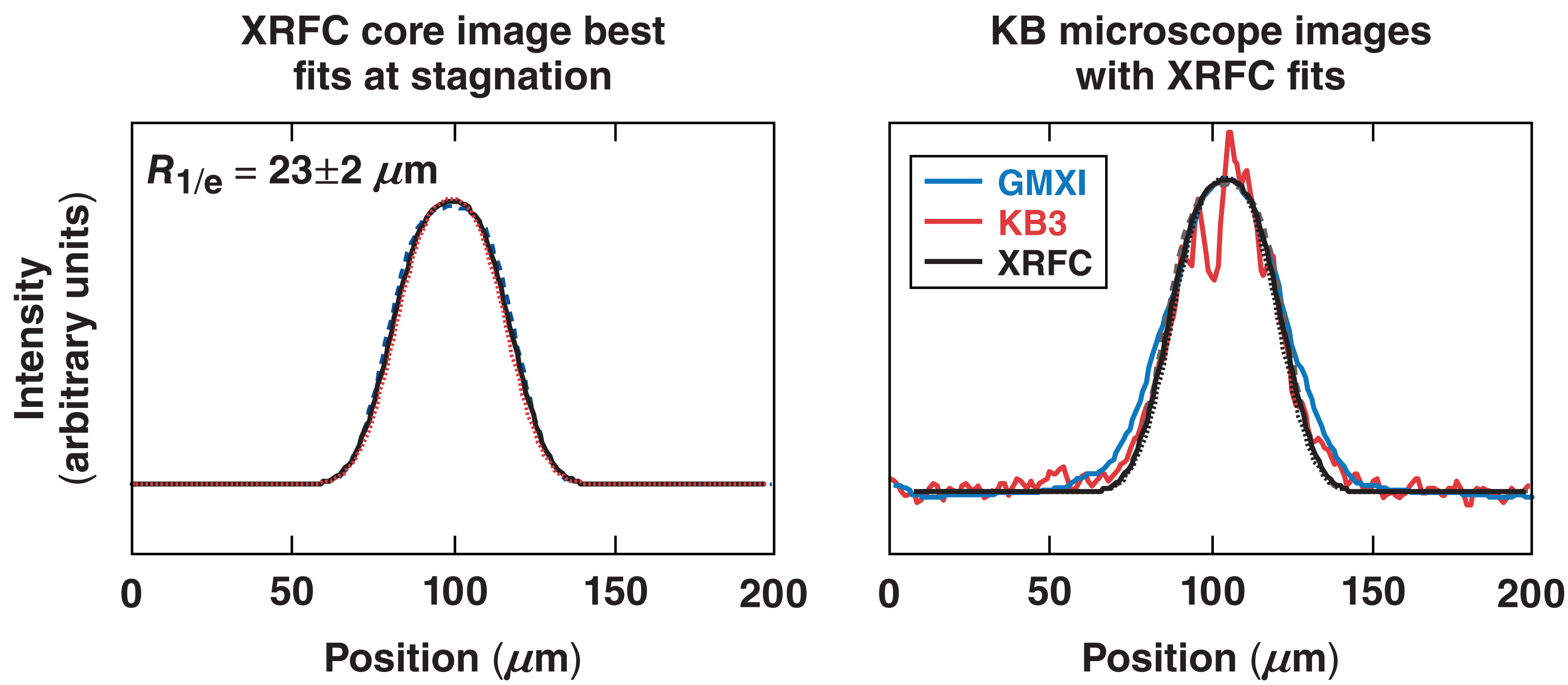
The framed pinhole images and time-integrated x-ray microscope images show a similar size stagnation region

OMEGA cryogenic target shot 74354



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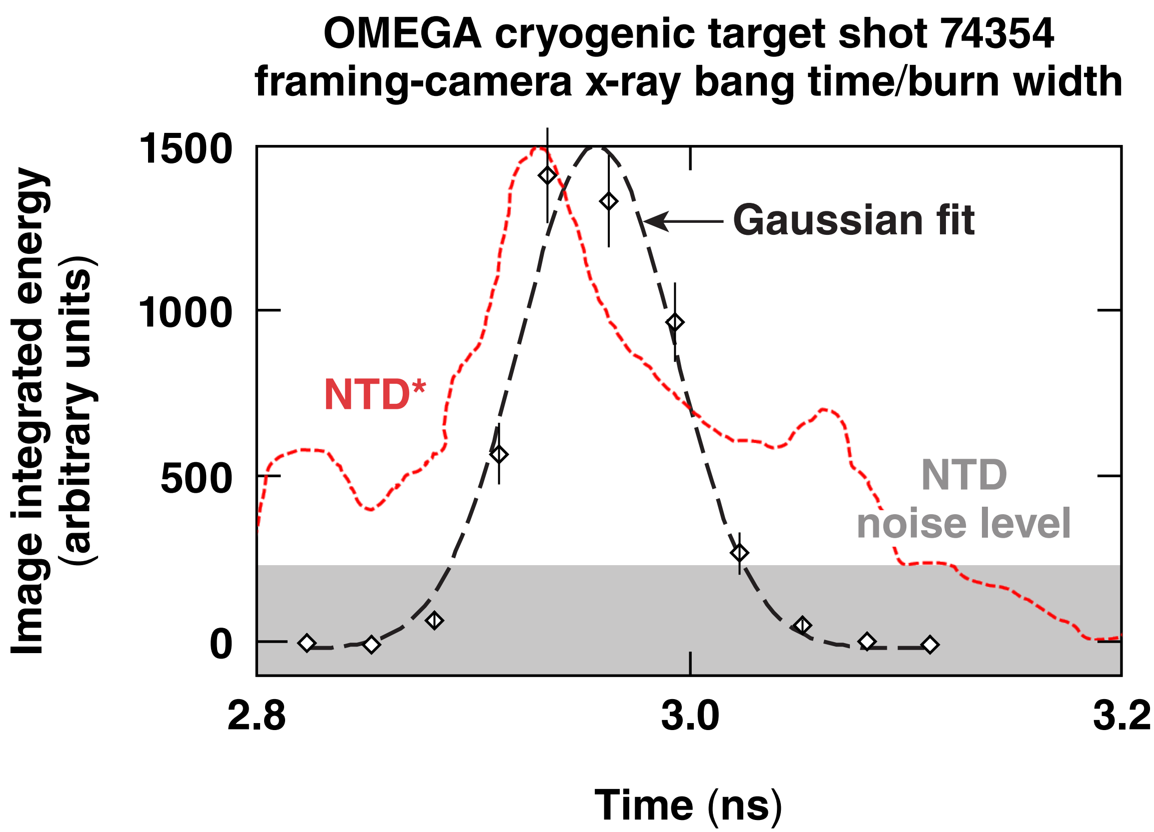
The framing camera determined bang time agrees with the neutron-measured bang time within errors



- Times from peak of first picket
  - $t_{x\ ray}$ = 2.79±0.03 ns
  - t_{NTD} = 2.72±0.05 ns
  - t_{LILAC} = 2.74 ns
  - $\Delta t_{x\ ray}$ = 84±10 ps
  - Δt_{NTD} = 117±25 ps
  - Δt_{LILAC} = 69-ps x ray, 60-ps neutron

*Neutron temporal diagnostic

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The hot-spot pressure and volume are inferred from the neutron yield, burn width, ion temperature, and core size

$$\langle p \rangle = \sqrt{\frac{Y_n / 10^{16}}{\xi(T) V_{hs} \tau}}, \text{ where } \xi(\mathrm{T}) \equiv \frac{1}{V_{hs}} \int V_{hs} \frac{\langle \sigma v \rangle}{\mathrm{T}^2} dV \text{ and } V_{hs} \approx \frac{4\pi}{3} R_{17\%}^3$$

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R_{17} = 26±2 μm (framed images + KB microscope images)
Y_n = (1.73±0.01) $\times 10^{13}$
τ = 78±10 ps (inferred x-ray burn width)
T_i = 3.3±0.4 keV
$\langle p \rangle$ = 25±5 GBar
$\langle p \rangle_{1\text{-D}}$ = 80 GBar

C. Cerjan, P. T. Springer, and S. M. Sepke, Phys. Plasmas 20, 056319 (2013);
R. Betti *et al*., Phys. Plasmas 17, 058102 (2010).

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Summary/Conclusions

Time-resolved x-ray imaging of cryogenic target core emission provides improved estimates of bang time, burn width, and peak core pressure

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