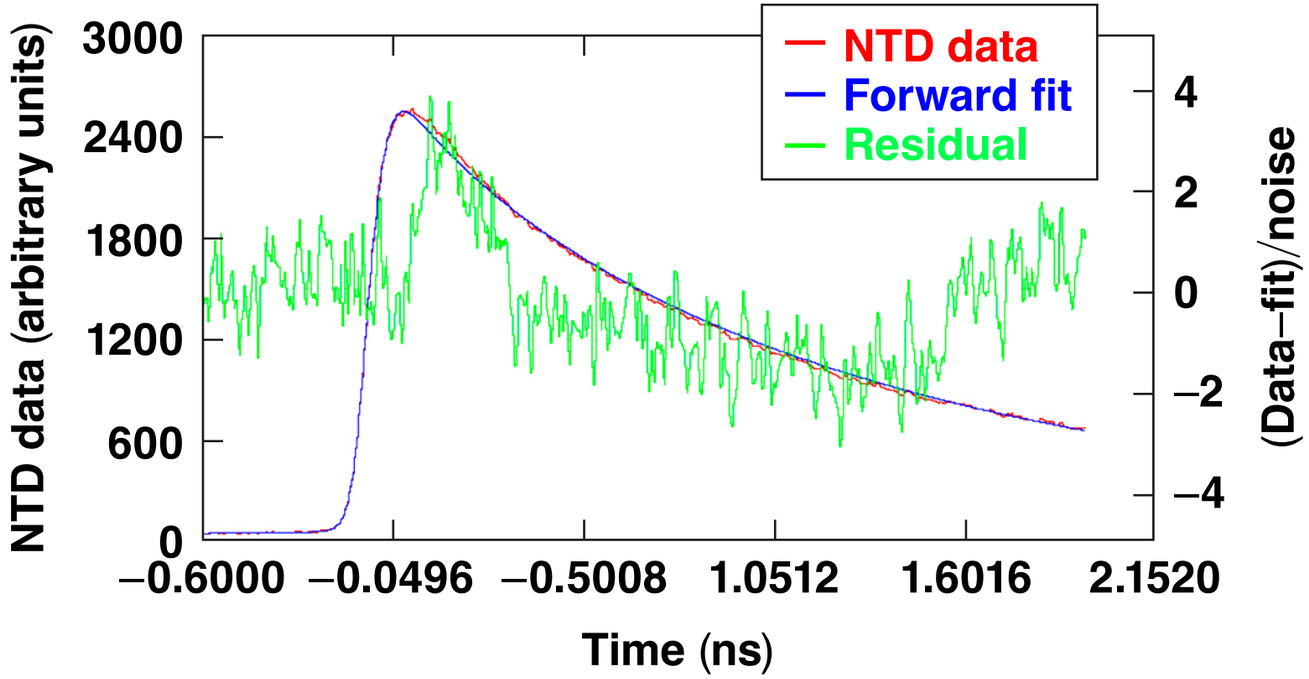
Burn-Rate Measurements from the High-Performance Cryogenic Implosion Campaign on OMEGA



J. P. Knauer
University of Rochester
Laboratory for Laser Energetics

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Summary

Data from the neutron temporal diagnostic (NTD) is used to show how the emission rate changes from implosion to implosion

- A forward-fit analysis has been developed for the NTD data to reduce noise
  - an instrument-response-function (IRF) is constructed from NTD timing-calibration data
    - IRF needs ion temperature to obtain the correct IRF rise time
    - 15.8 m (P2) nTOF T_i used
- A six-parameter model is used for the modeled emission rate (dY/dt)
  - the model represents emission from two times with two widths
- The fitted dY/dt is used to study the burn rate shape
  - implosion properties relate to how neutron emission is distributed

nTOF: neutron time-of-flight

Collaborators

C. Stoeckl, R. Betti , V. Gopalaswamy, K. S. Anderson, D. Cao, M. J. Bonino, E. M. Campbell, T. J. B. Collins, C. J. Forrest, V. Yu. Glebov, V. N. Goncharov, D. R. Harding, J. A. Marozas, F. J. Marshall, P. W. McKenty, P. B. Radha, S. P. Regan, T. C. Sangster, and R. C. Shah

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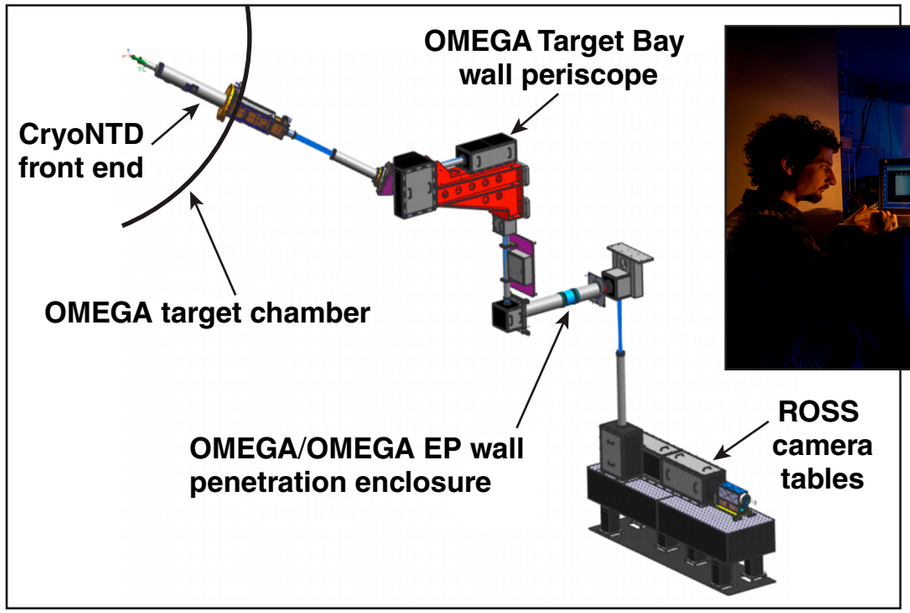
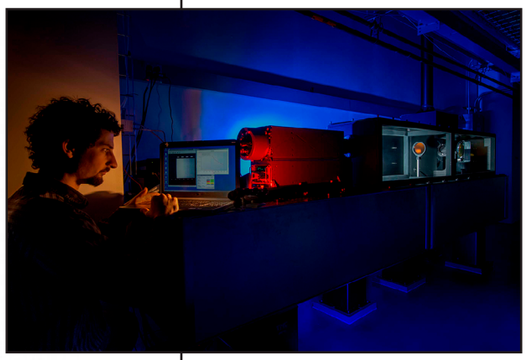
Laboratory for Laser Energetics

The P11-NTD delivers the instrument performance required to support the LLE cryogenic campaign





Performance metric	Performance status
Minimum burnwidth	50 ps
Bang-time measurement accuracy	±50 ps
Detectable DD neutron-yield range	5×10^{9} to 1×10^{13}
Detectable DT neutron-yield range	5×10^{10} to 1×10^{15}

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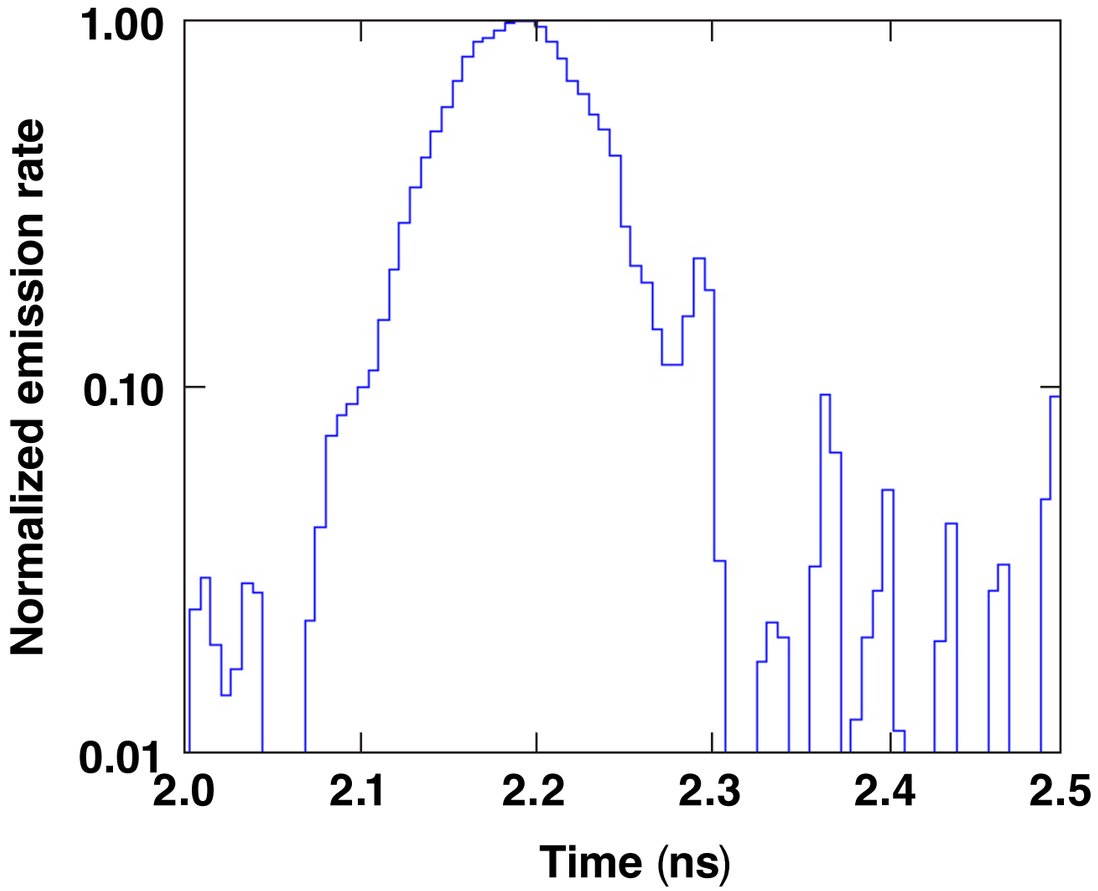
ROSS: Rochester optical streak system

Current NTD analysis deconvolves a decaying exponential from the streak-camera data and then adjusts the resultant width



- Current analysis
  - noise from deconvolution increases with time
  - finite bandwidth only compensated for in width (quadrature subtraction)
- Forward-fit analysis
  - noise is constant over time
  - finite bandwidth adjustment is applied to the entire signal

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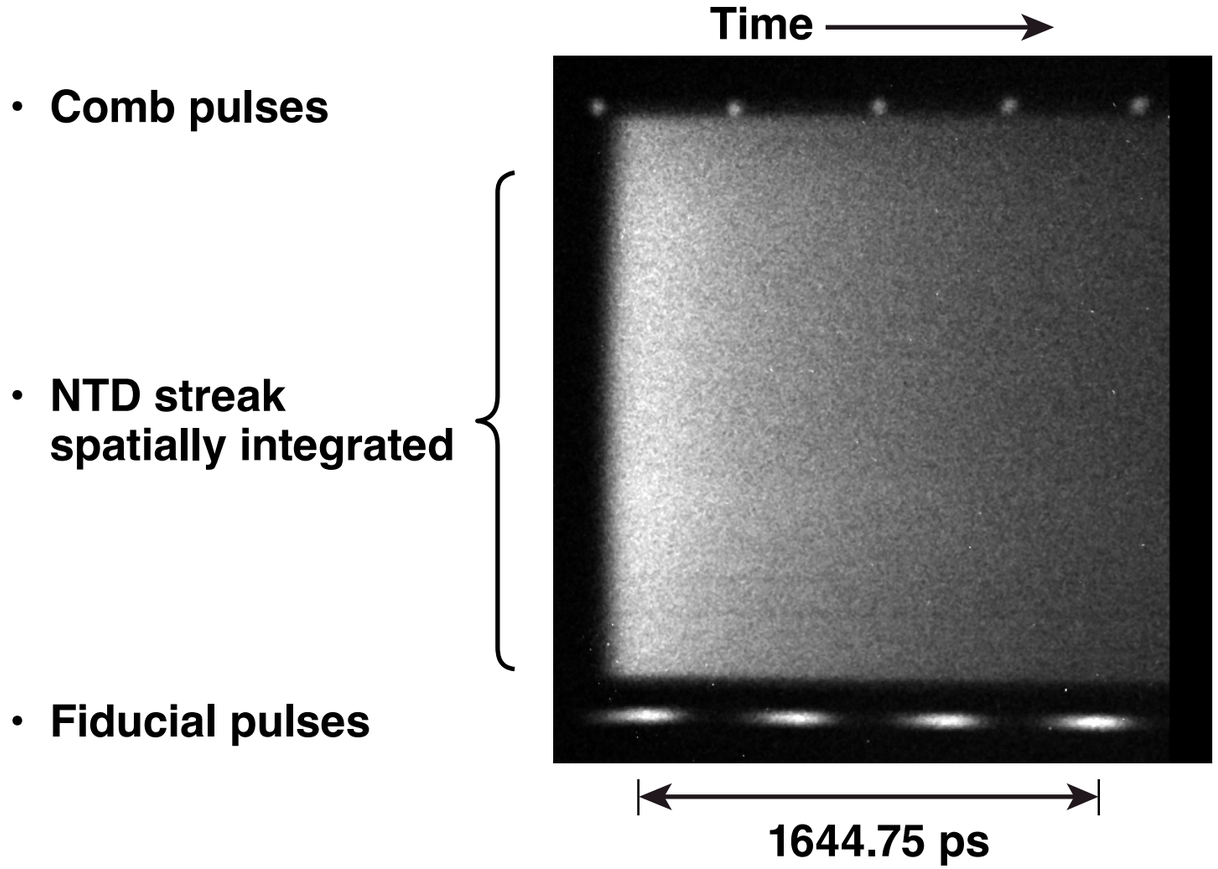
NTD data start as a streak-camera image



Comb and fiducial pulses are used to compensate for streak-camera distortions.

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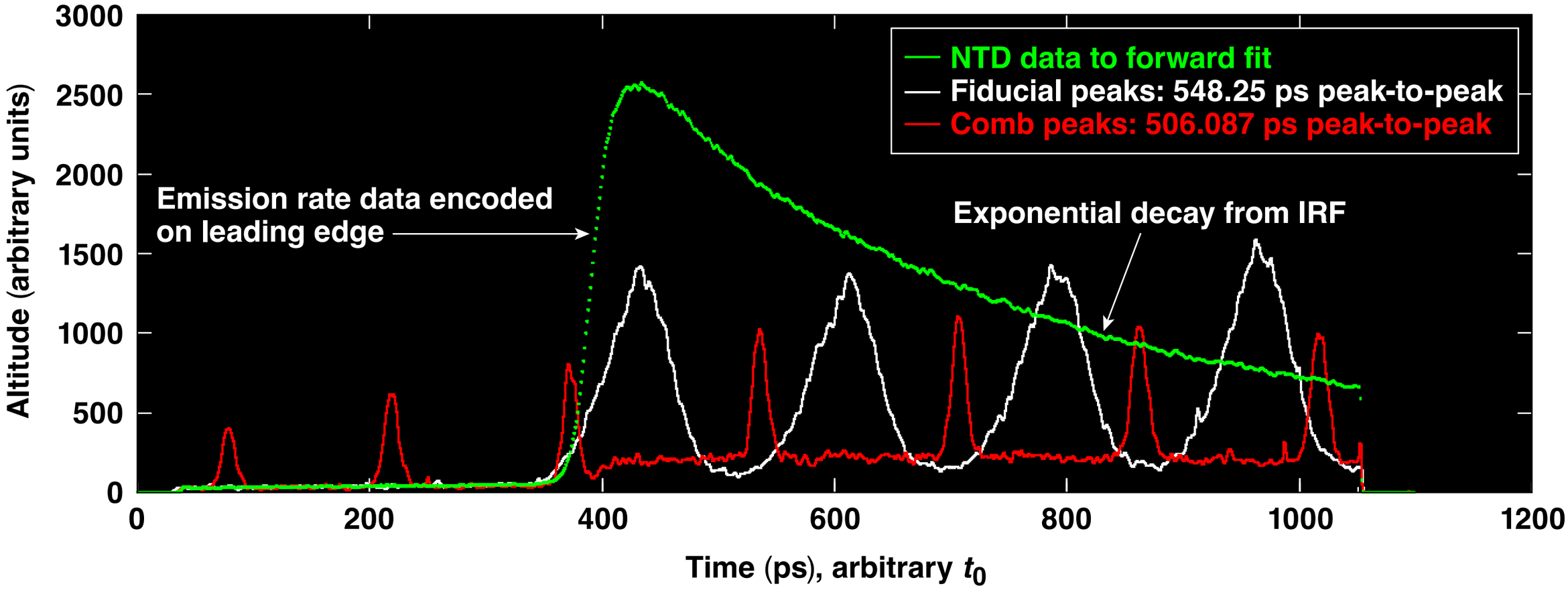
Comb, fiducial, and NTD data are extracted from the streak-camera image after distortion corrections



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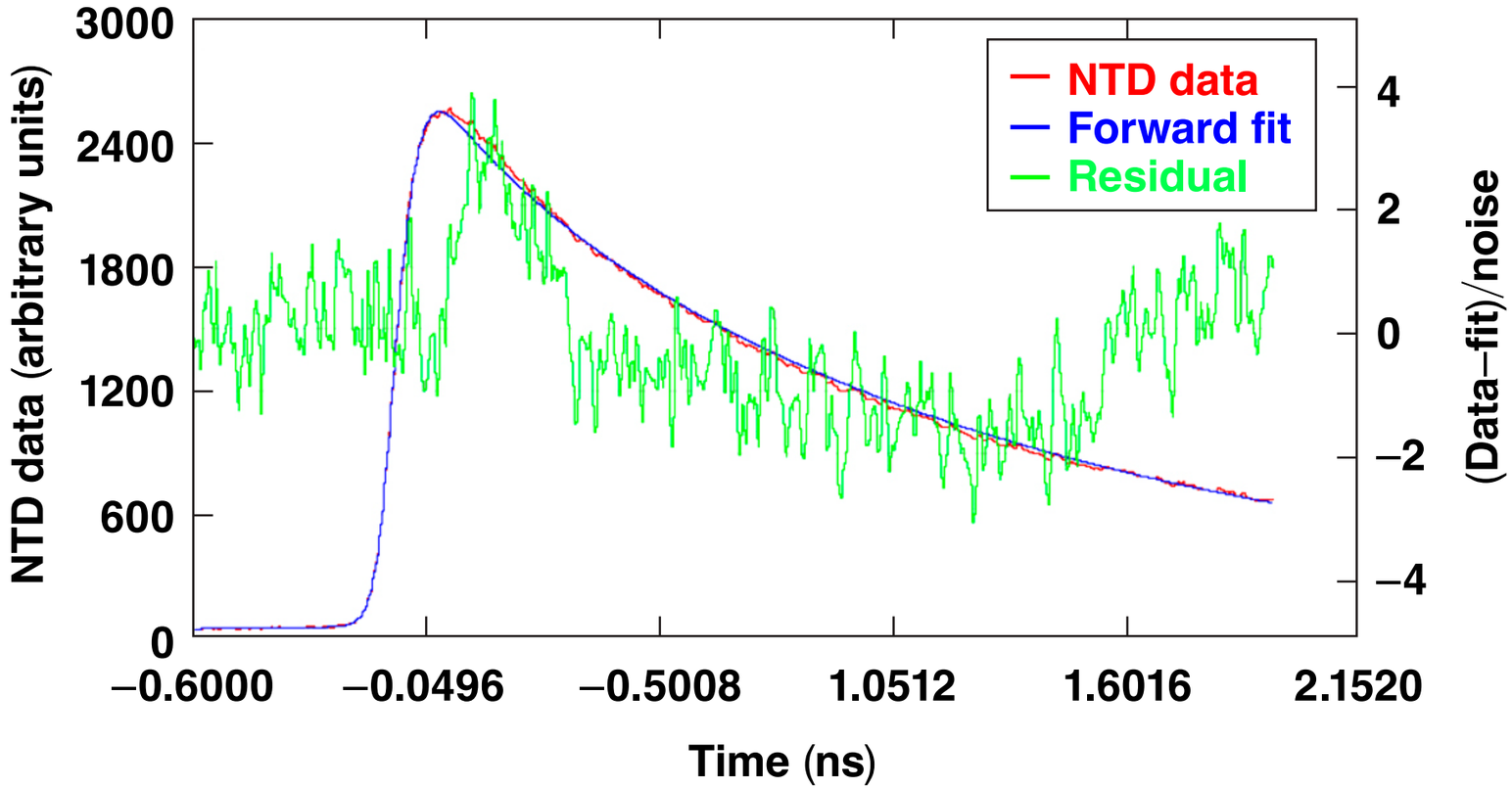
An IRF is convolved with a model for the neutron emission rate and fitted to the NTD data

$$\mathrm{NTD}(t) = \int_{-\infty}^{t} \mathrm{IRF}(kT, t - t_1) \otimes \left[\frac{\mathrm{d}}{\mathrm{d}t} Y(\text{parameters}, t_1)\right] \mathrm{d}t_1$$ **Convolution integral**

$$\frac{\mathrm{d}}{\mathrm{d}t} Y(I_0, t_0, \sigma_0, I_1, t_1, \sigma_1) = I_0 \cdot e^{-\frac{1}{2}\left(\frac{t - t_0}{\sigma_0}\right)^2} + I_1 \cdot e^{-\frac{1}{2}\left(\frac{t - t_1}{\sigma_1}\right)^2}$$ **Six-parameter model**

The emission rate is modeled as two Gaussians

Model fit and residuals are calculated over the entire data region



NTD model compares well with the measured data; $0.5 < \chi^2_{DoF} < 2.0$.

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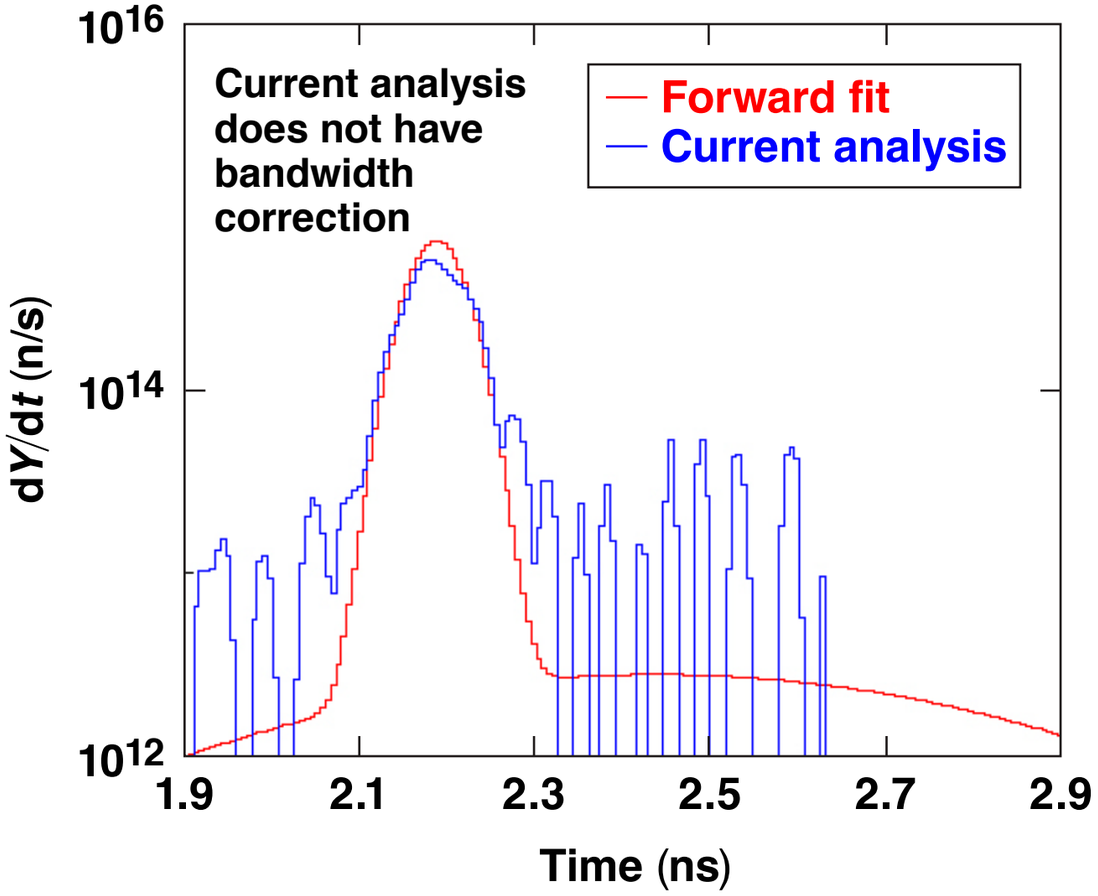
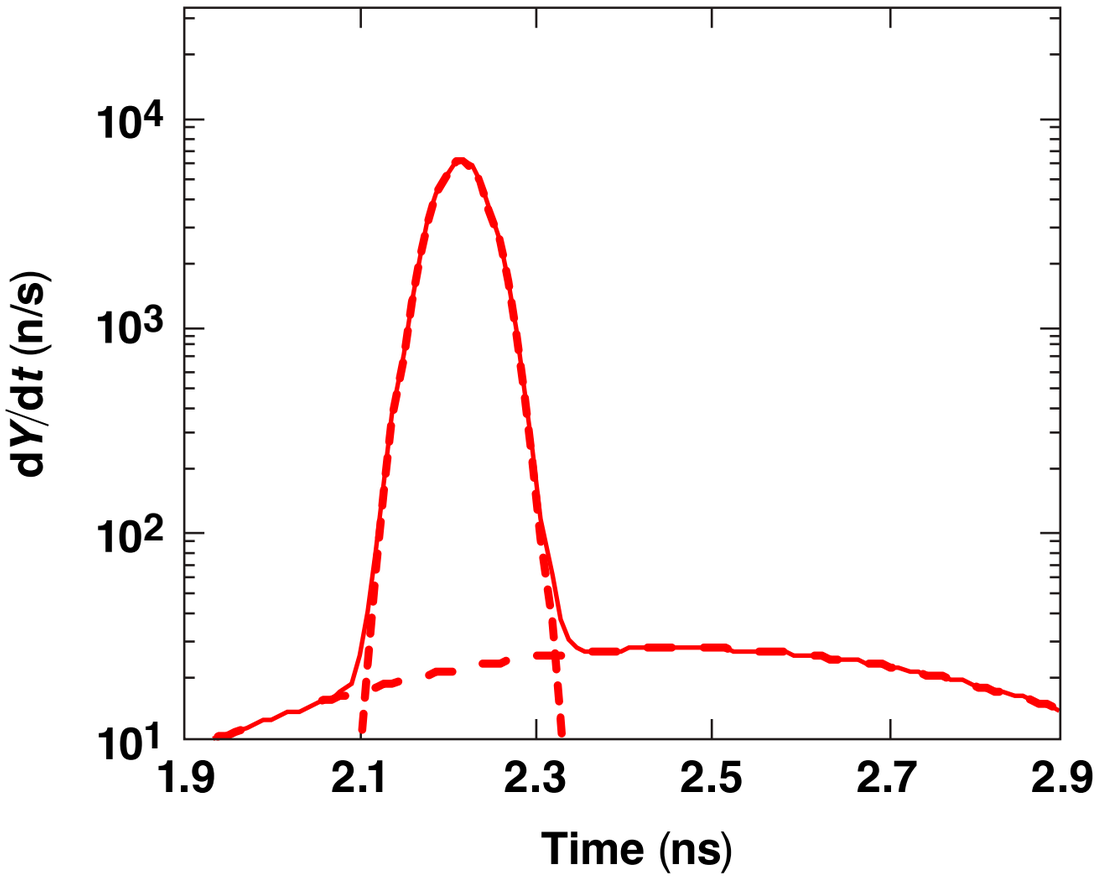
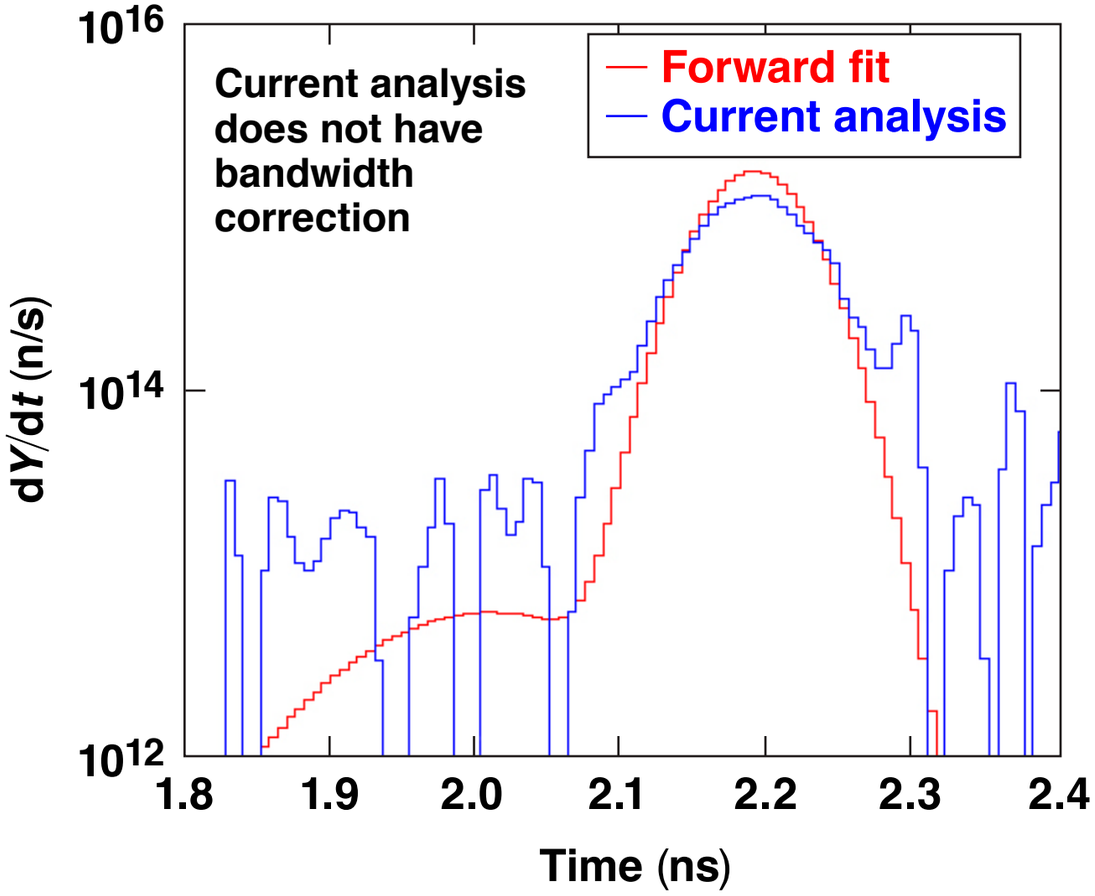
NTD data from a low-yield (5.4×10^{13}) implosion has emission rate early in time, indicating little compression yield

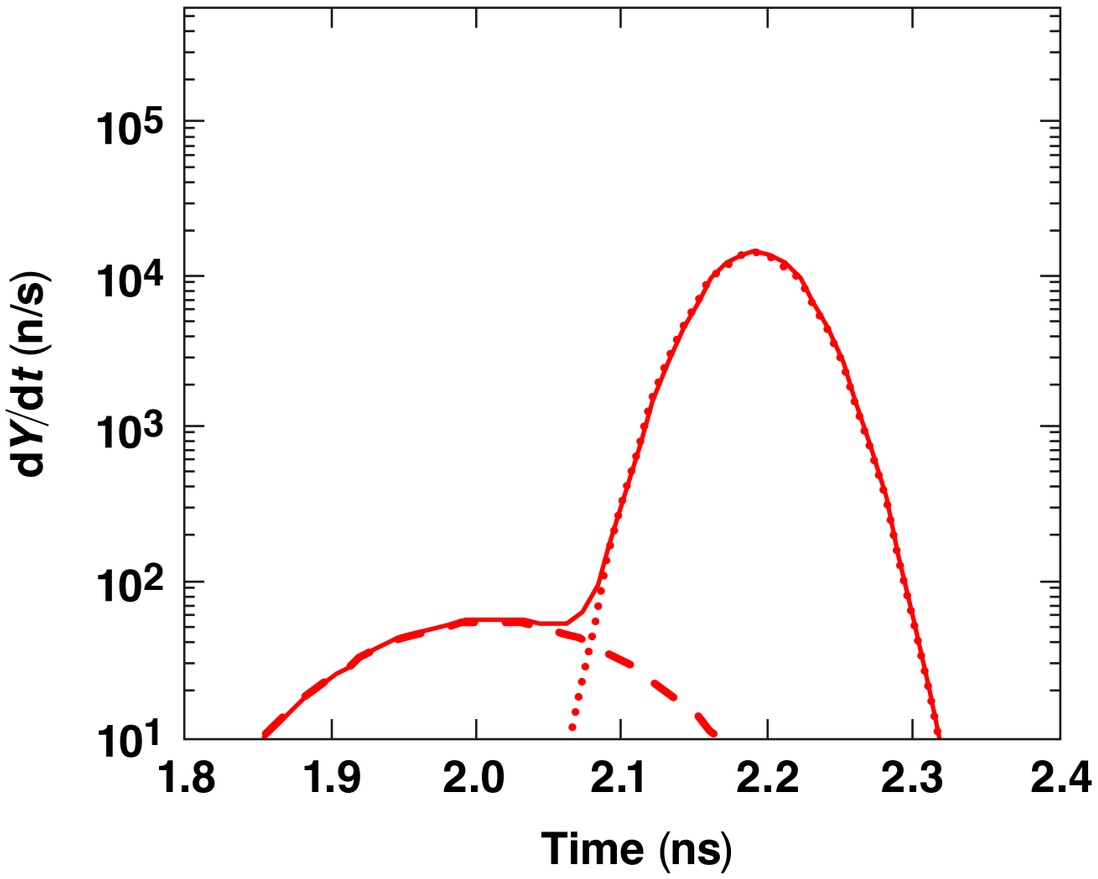




E28108

NTD data from a high-yield (1.6×10^{14}) implosion has emission rate late in time, indicating compression yield





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Summary/Conclusions

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	Uncorrected	Corrected	Forward Fit
Shot 89996	87 (ps)	70 (ps)	78 (ps)
Shot 90291	94 (ps)	78 (ps)	81 (ps)
Error	5 (ps)	5 (ps)	5 (ps)

nTOF: neutron time-of-flight

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