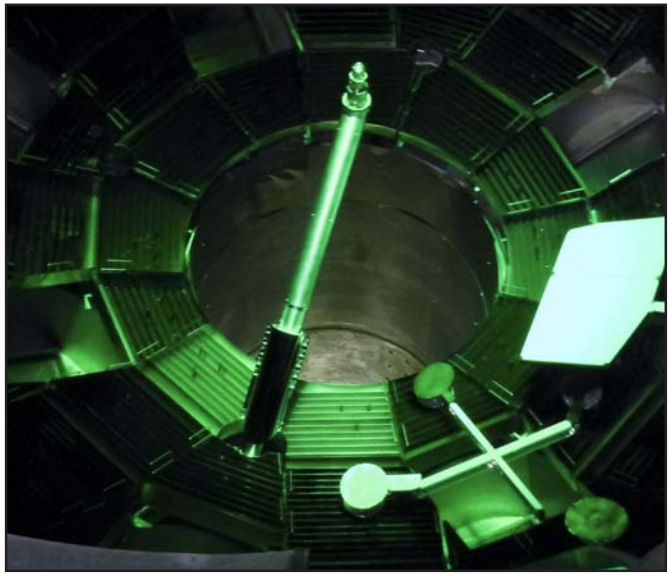
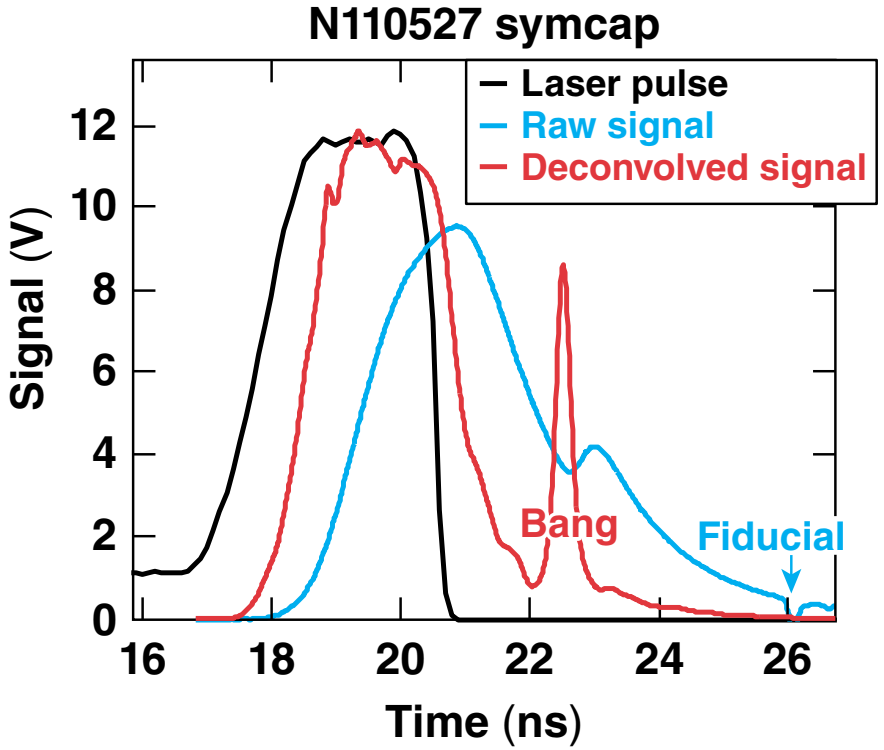
First Results from the South-Pole Bang-Time Diagnostic on the NIF





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Summary

The south-pole bang-time (SPBT) diagnostic provides a new x-ray bang-time measurement on the NIF

- The SPBT diagnostic has been operational on the NIF since mid-May 2011 and is now a standard measurement for the NIF ignition tuning campaign
- SPBT has been calibrated using short-pulse laser shots
  - the temporal-response function was measured offline using 10-ps pulses on the COMET laser
  - timing with respect to NIF system t_0 was calibrated *in situ* using 88-ps impulse NIF shots
- X-ray bang times are determined from the x-ray bang peak after deconvolution and hohlraum background signal removal
- Total error on the bang-time measurements is estimated at 39 ps

The SPBT diagnostic is a collaborative effort between LLE and NIF/LLNL

LLE

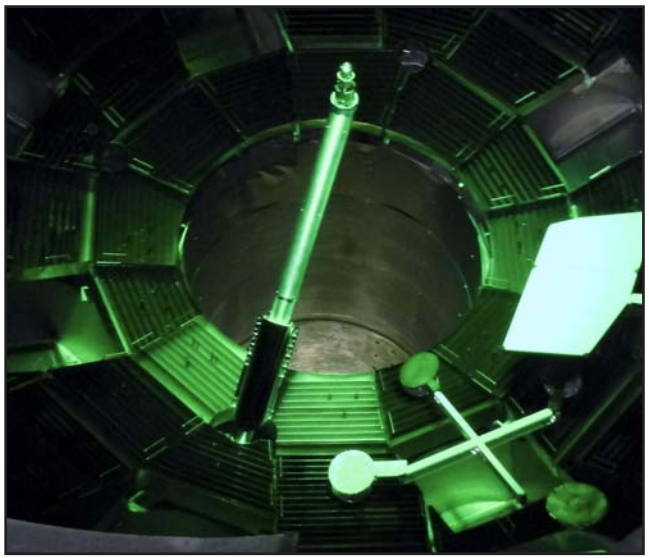
- J. Magoon
- T. C. Sangster
- M. J. Shoup III
- F. J. Marshall
- C. Stoeckl
- V. Yu. Glebov
- and others...

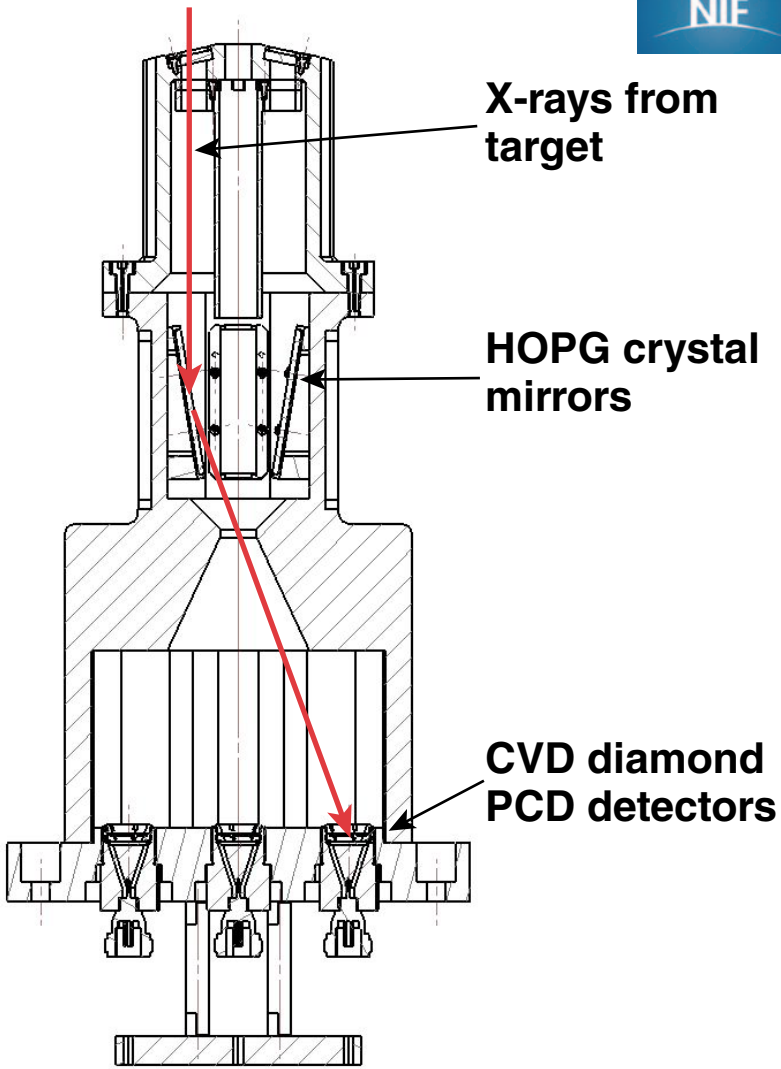
NIF/LLNL

- A. G. MacPhee
- S. Burns
- M. Eckart
- J. D. Kilkenny
- N. B. Meezan
- Z. Sober
- and many more...
- G. Krauter
- J. Celeste
- J. Kimbrough
- G. Lacaille
- J. Parker
- M. Thayne

SPBT has five chemical-vapor-deposition (CVD) diamond detectors that view the capsule through the south-pole laser entrance hole

- SPBT is not DIM mounted and has a permanent dedicated fixture
- HOPG crystal monochromators on four channels select 11 keV (near predicted capsule bang x-ray spectrum maximum)

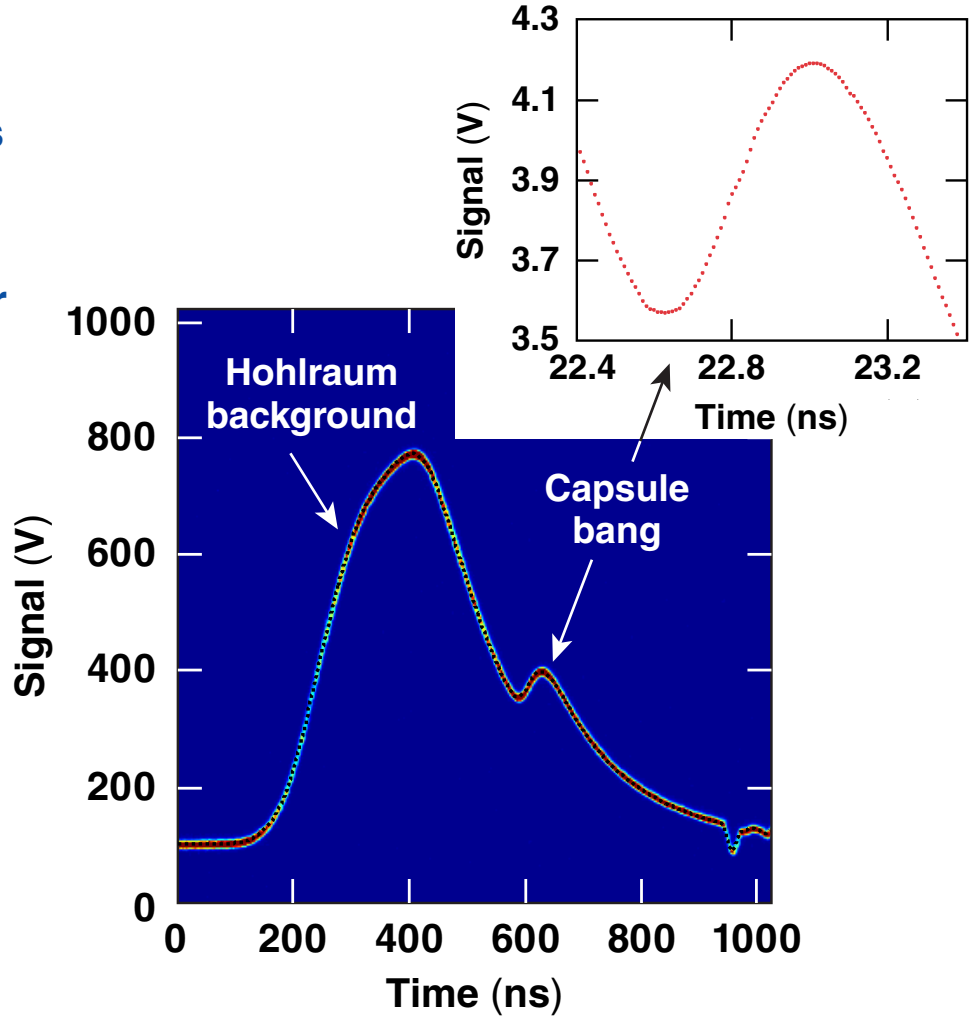




E20322

The SPBT signal is recorded by an FTD10000 scope with 10-ps time steps over a 10-ns window

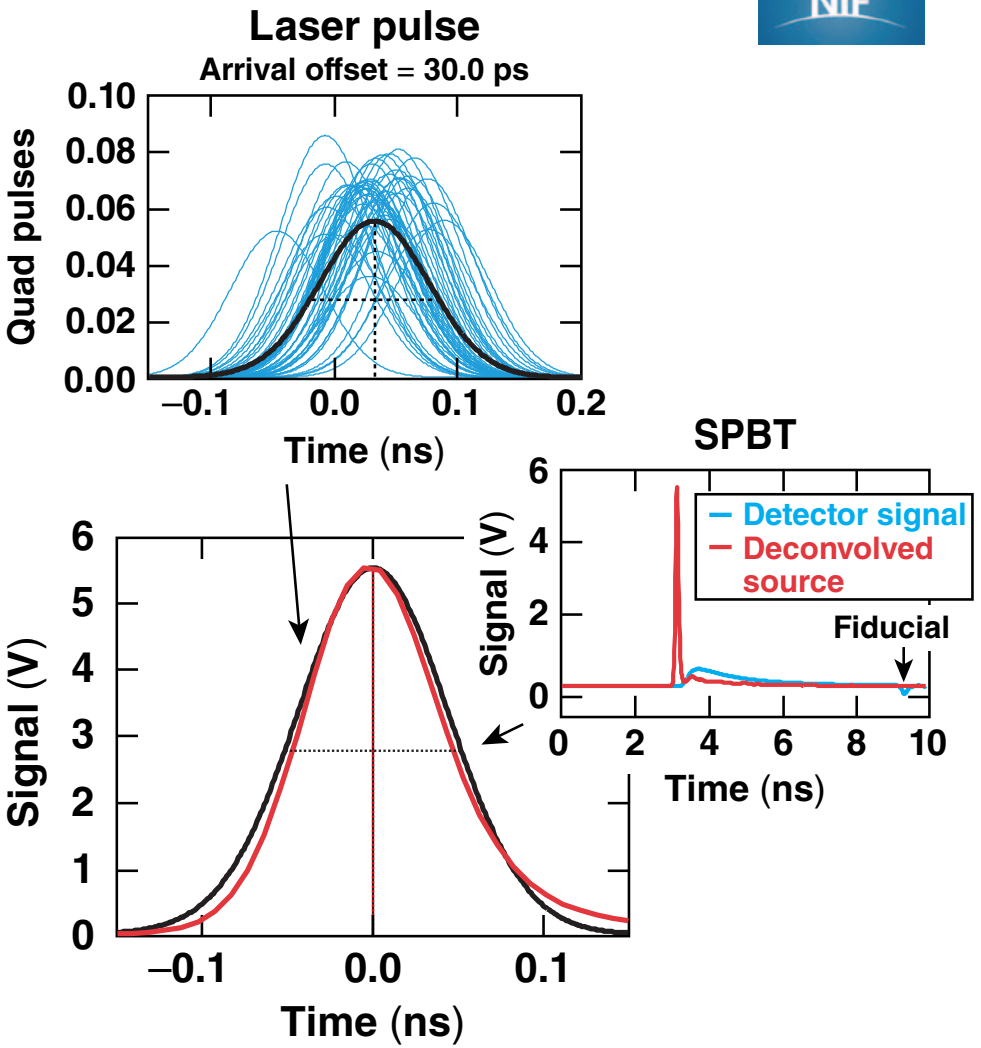
- FTD10000 is needed for a 10-ps sampling rate and damage resistance from high-voltage signals
- Low noise levels
- Background from hohlraum stronger than capsule bang (so far)
- Data postprocessing
  - time adjusted for the variable scope sweep speed on the FTD10000
  - signal height adjusted for nonlinear response due to finite bias voltage (small effect if $V_{signal} << V_{bias}$)



N110527 symcap, FTD10000 scope image

The SPBT detectors have been calibrated using impulse signals from a variety of laser systems

1. The temporal instrument response measured with 10-ps pulses from LLNL's COMET laser
2. Detector sensitivity (C/J) measured at LBL's Advanced Light Source (ALS)
3. *In-situ* timing measured on planar targets at the NIF TCC
   - 88-ps impulses from several quads
   - FWHM midpoints used as signal centers
   - timing calibrated by aligning x-ray signal with total laser pulse



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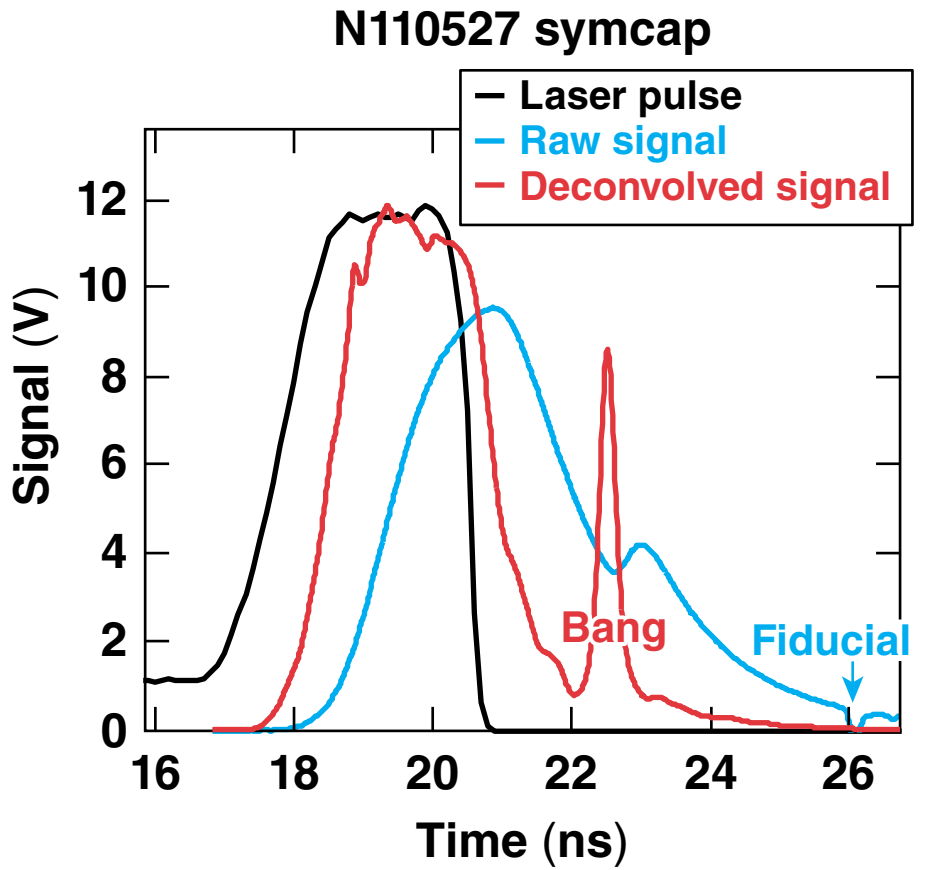
X-ray bang times are extracted from the deconvolved SPBT signals

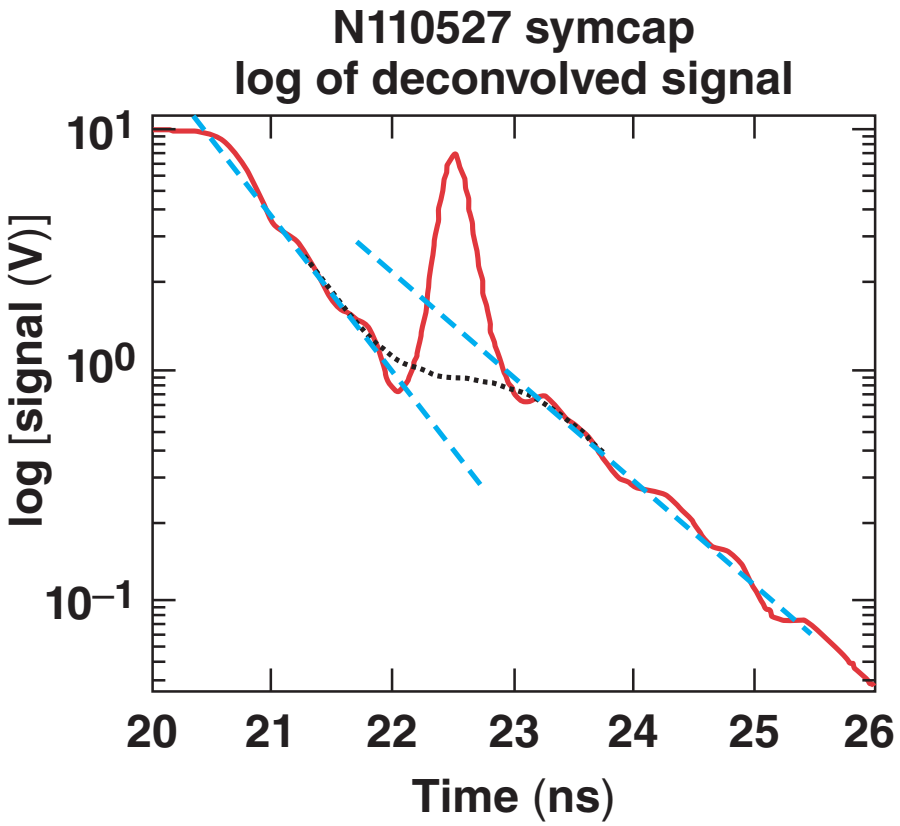
- The temporal response of SPBT signals are deconvolved using an iterative non-negativity enforcing algorithm*



*J. Nagy and Z. Strakoš, in *Mathematical Modeling, Estimation, and Imaging*, edited by D. C. Wilson *et al.*, (SPIE, Bellingham, WA, 2000), Vol. 4121, pp. 182–190.

X-ray bang times are extracted from the deconvolved SPBT signals

- The temporal response of SPBT signals are deconvolved using an iterative non-negativity enforcing algorithm*
- Capsule bang peak extracted from hohlraum background
  - can shift bang-time measurement by up to 20 ps for very small bangs
  - exponential decay before and after bang are NOT the same



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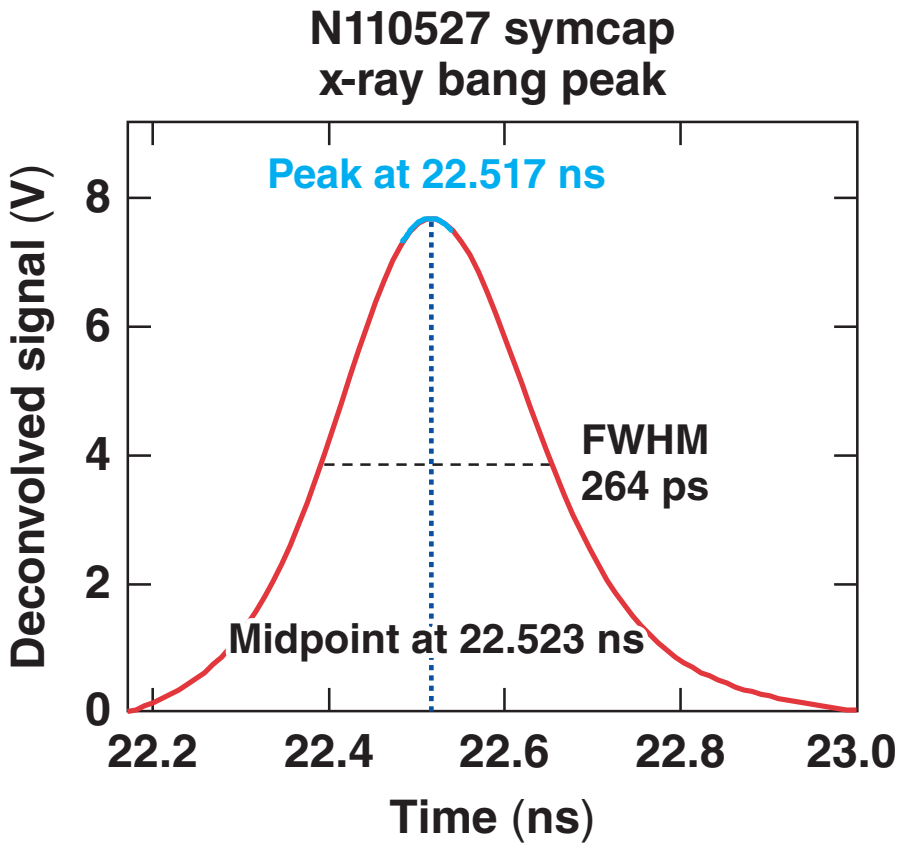
E20328

X-ray bang times are extracted from the deconvolved SPBT signals

- The temporal response of SPBT signals are deconvolved using an iterative non-negativity enforcing algorithm*
- Capsule bang peak extracted from hohlraum background
- Bang time taken as the time of peak x-ray emission
  - can differ by several pico seconds from the midpoint of the peak at FWHM
  - bang time error estimate ~39 ps



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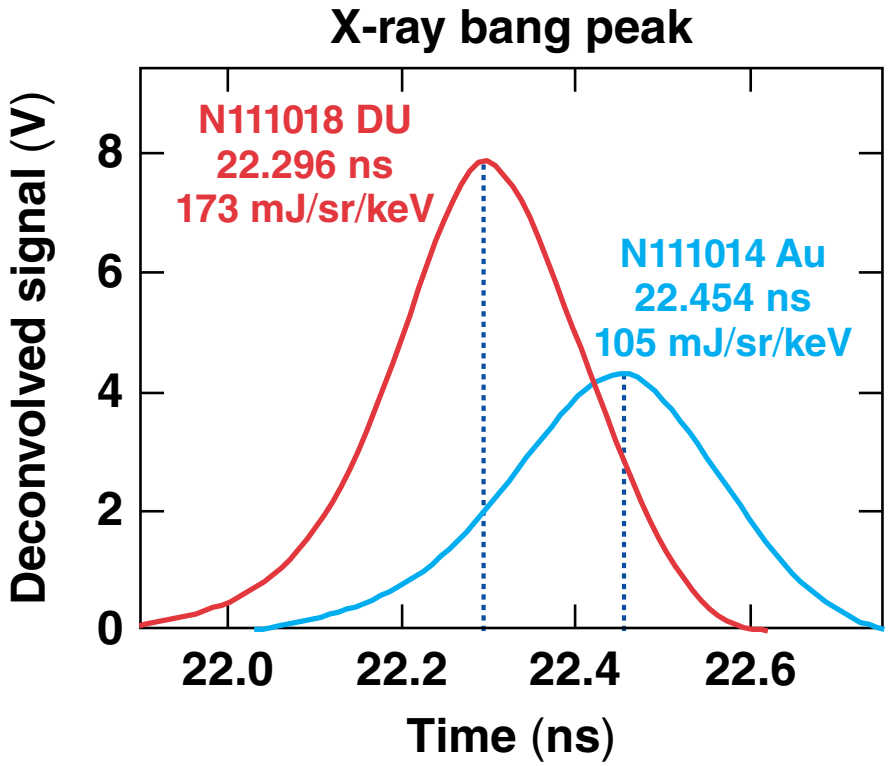
E20329

SPBT is now a standard diagnostic on NIF implosions

- SPBT has measured the x-ray bang time for many different NIF target implosions
  - DT and THD layered implosions
  - SymCaps
  - AblConv
- SPBT is currently part of the NIF campaign to tune implosion performance towards ignition



SPBT showed a clear improvement in implosion velocity (earlier bang time) and greater x-ray bang yield for DU versus Au hohlraums using similar laser pulse shapes and energies (1.2 MJ)

SPBT will evolve as a diagnostic on NIF

- SPBT has begun to measure the time integrated x-ray spectral radiant intensity (J/sr/keV)
  - the total charge collected from the bang peak can be translated into an x-ray yield measurement as SPBT is absolutely calibrated (to ± ~40%)
- SPBT can also measure the neutron bang signal
  - SPBT's central channel (without HOPG mirror) can record the neutron burst similar to the NTOF detectors → neutron bang time, T_i, etc.
- Optical-Electrical Mach-Zehnder fiber optic system will replace the long cable runs to the NIF diagnostic mezzanine, which should improve our instrument response

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