Commissioning the P11 Neutron Temporal Diagnostic for High-Neutron-Yield Implosions

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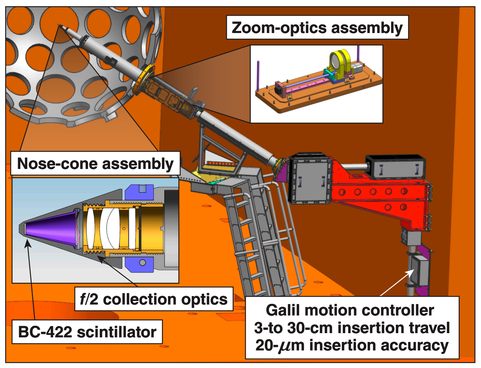
University of Rochester, Laboratory for Laser Energetics

Summary

- The P11 neutron temporal diagnostic (NTD) provides precision neutron burn rate and bang-time measurements for high-yield cryogenic implosions
- Port selection at P11 allows for a 9-cm scintillator insertion depth on cryogenic implosions to improve available signal levels and measurement bandwidth
- A 200× reduction in neutron noise levels relative to the H5-NTD was achieved by locating the streak camera behind the OMEGA shield wall, 11.4 m from target chamber center (TCC)
- A 16-m optical-path-length image-relay system transports scintillator light from inside the target chamber to the streak camera
- Data is recorded using a Rochester Optical Streak System (ROSS) P5100 streak camera with 15-ps temporal resolution

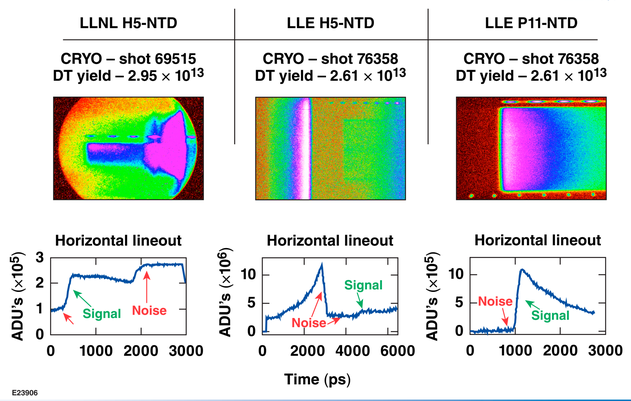
E23899

The OMEGA Target Bay section includes the scintillator-transport mechanism, zoom-optics assembly, and image-relay hardware



E23903

The P11-NTD provides superior data quality on high-yield implosions compared to previous NTD diagnostics



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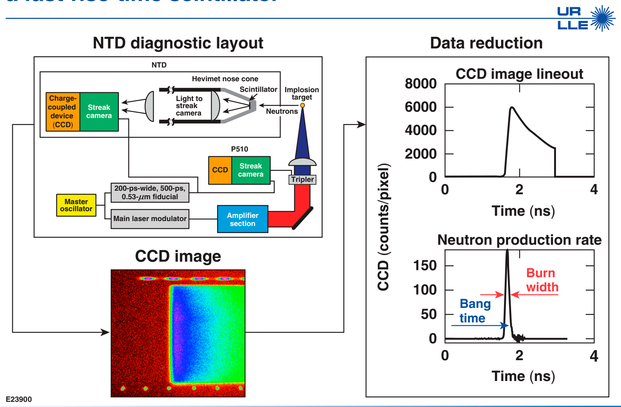
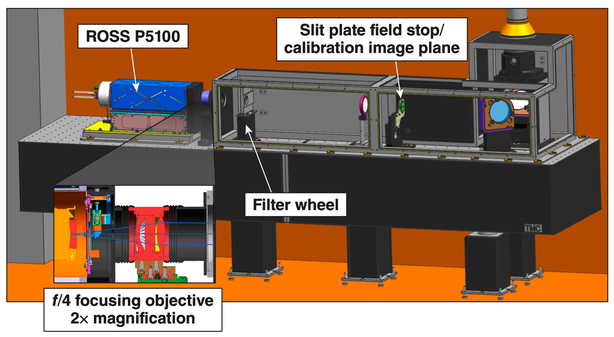
The NTD measures the neutron burn rate and bang time relative to the OMEGA laser T-0 using a fast-rise-time scintillator



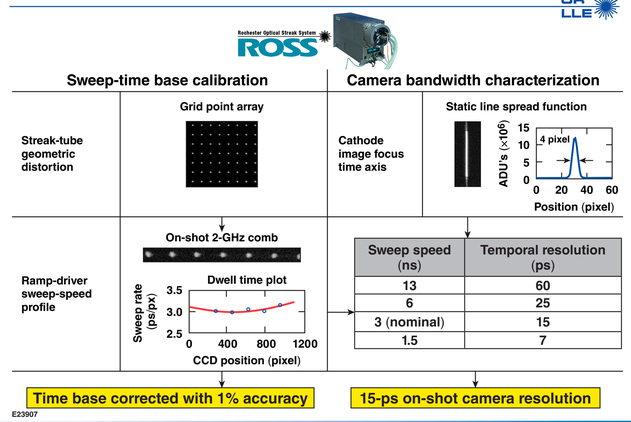
E23900

The final image relay section includes focusing optics, a remote-controlled filter wheel, and the ROSS streak camera



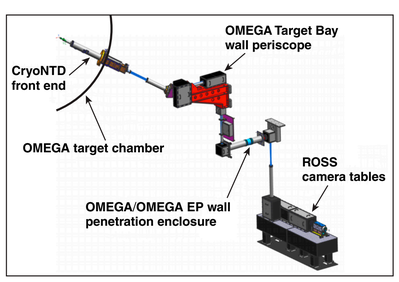
E23904

The P11-NTD leverages the power of the ROSS streak-camera platform to provide a well-characterized camera response



E23907

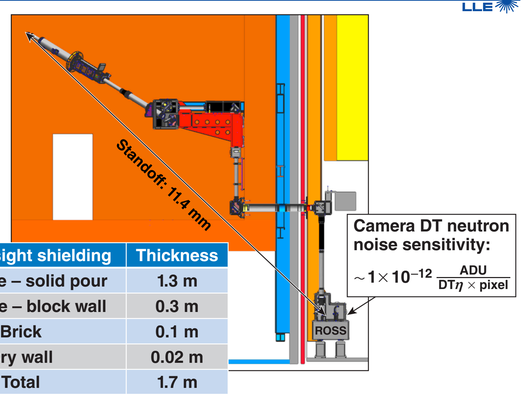
The P11-NTD delivers the instrument performance required to support the current and future LLE cryogenic campaign



Performance metric	Performance status
Minimum burn width	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}

E23902

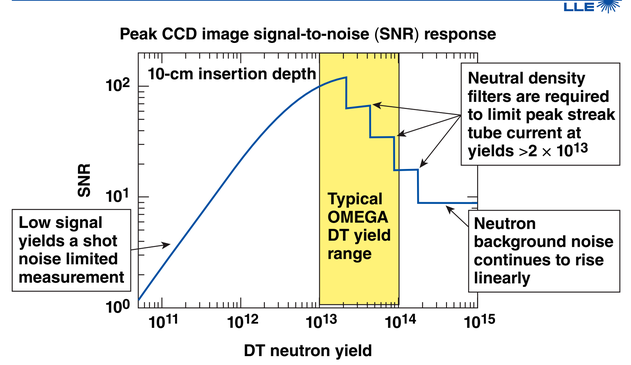
Neutron noise was minimized by placing the streak camera ~11 m from TCC with ~170 cm of line-of-sight shielding



Line-of-sight shielding	Thickness
Concrete – solid pour	1.3 m
Concrete – block wall	0.3 m
Brick	0.1 m
Dry wall	0.02 m
Total	1.7 m

E23905

The P11-NTD maintains excellent CCD image signal-to-noise ratios throughout the typical OMEGA DT neutron yield range



E23919

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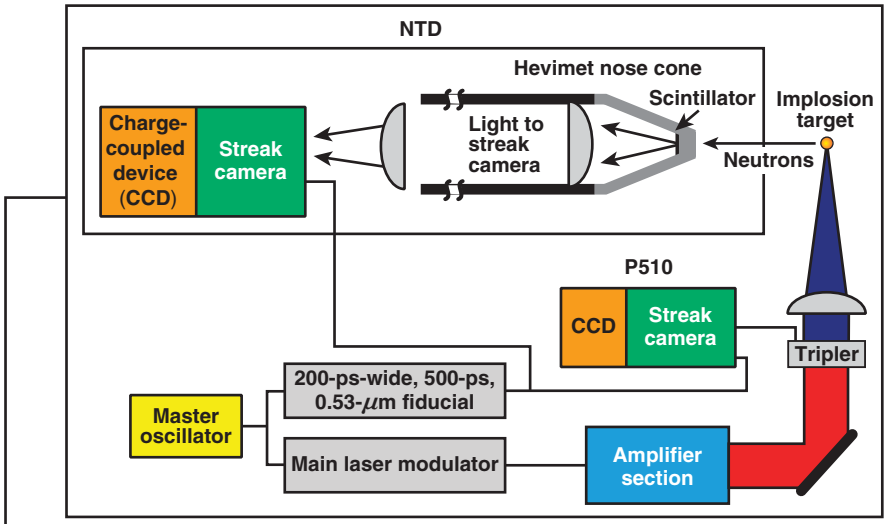
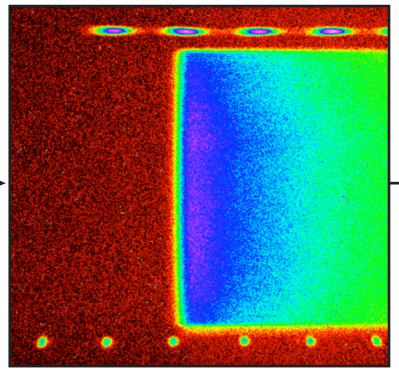
UR LLE

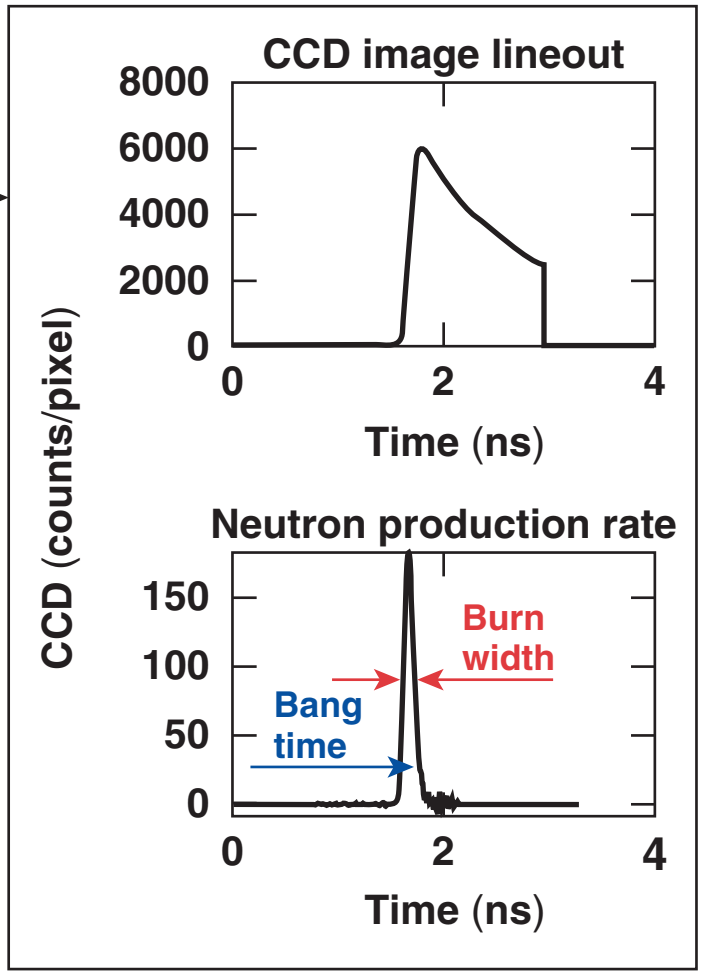
NTD diagnostic layout



CCD image



Data reduction



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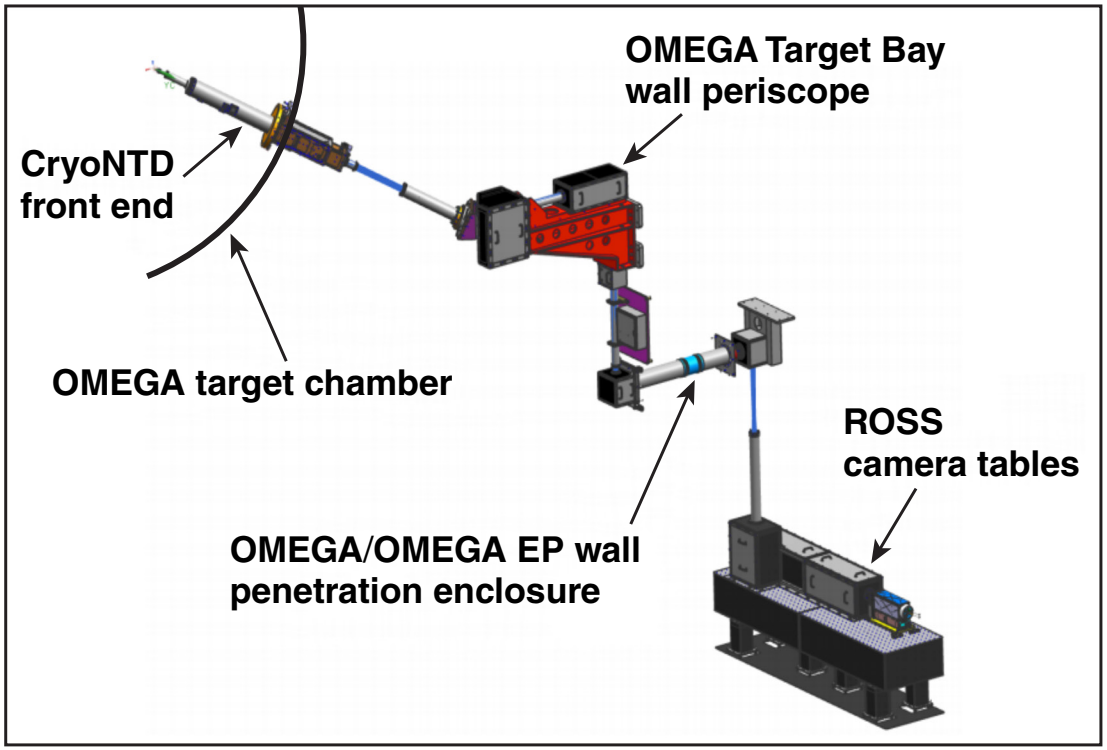

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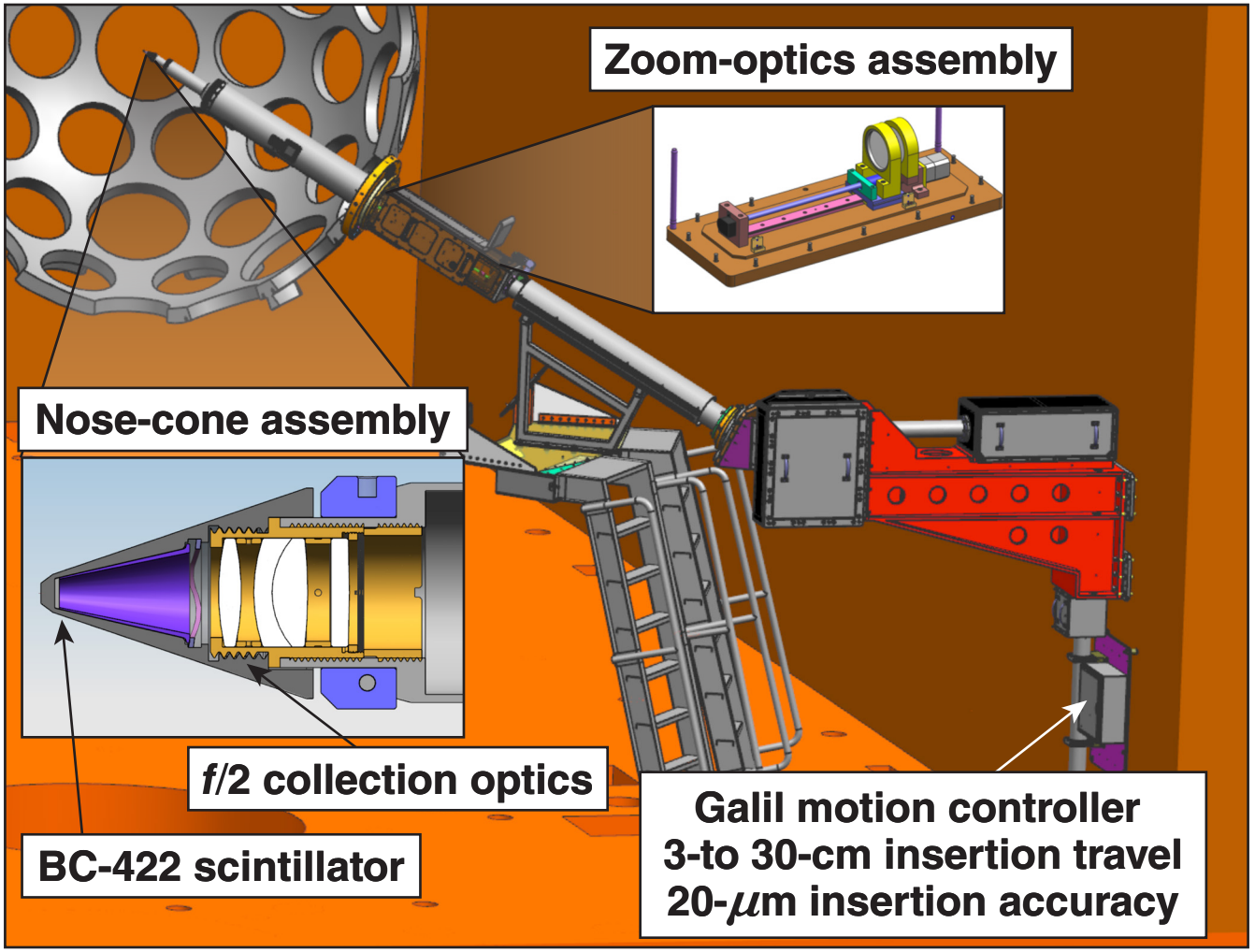

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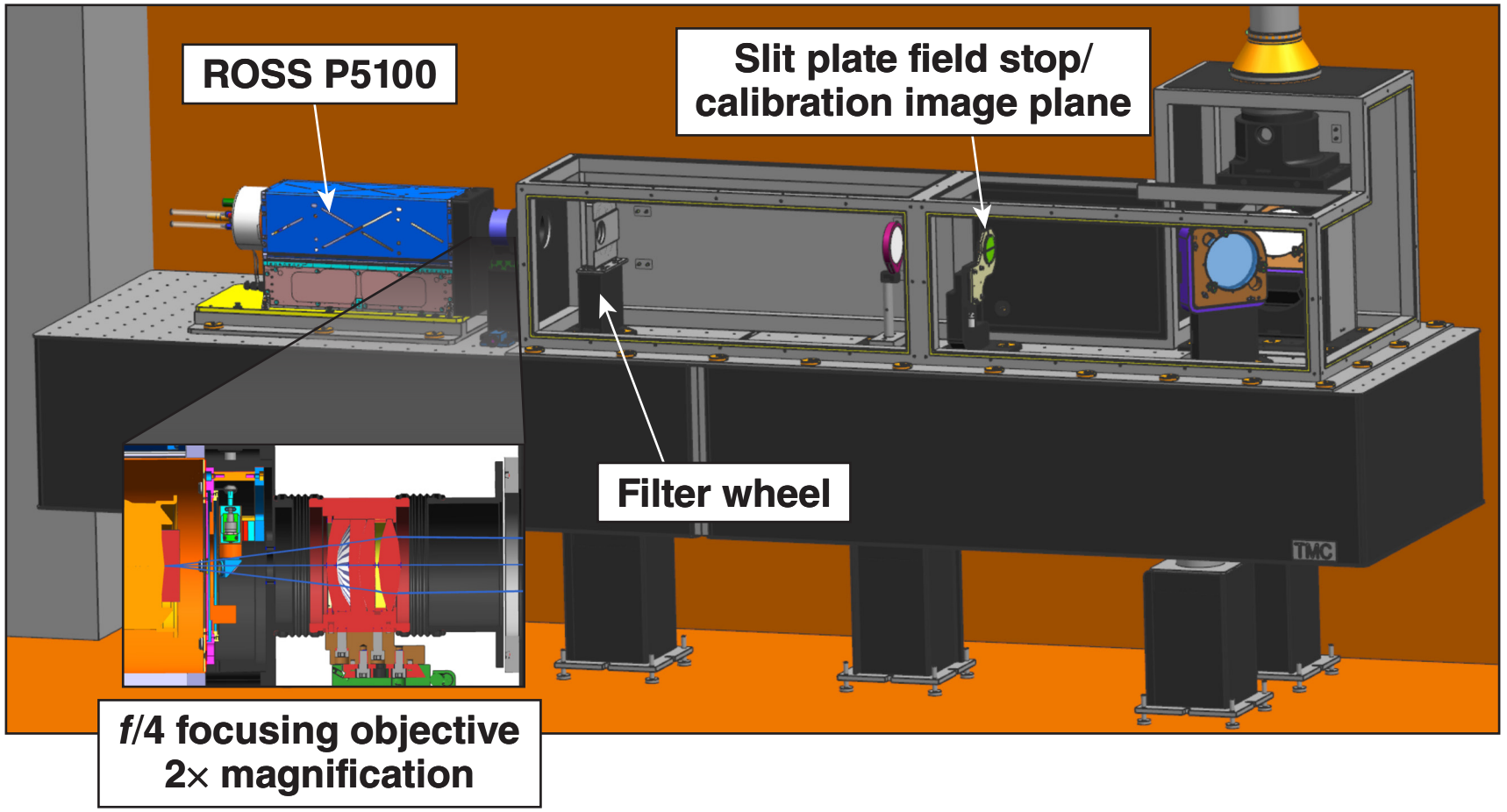

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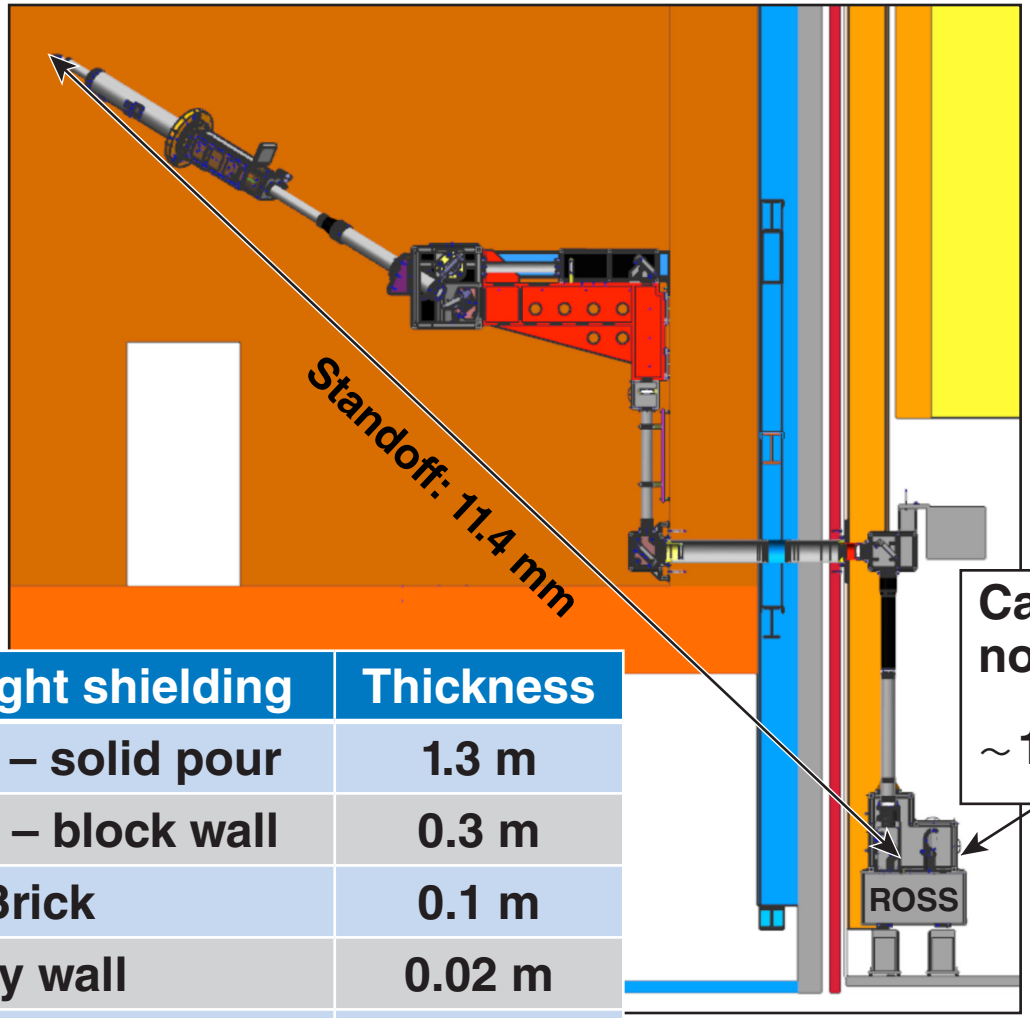

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Camera DT neutron noise sensitivity:

$$\sim 1 \times 10^{-12} \frac{\text{ADU}}{\text{DT}\eta \times \text{pixel}}$$

E23905

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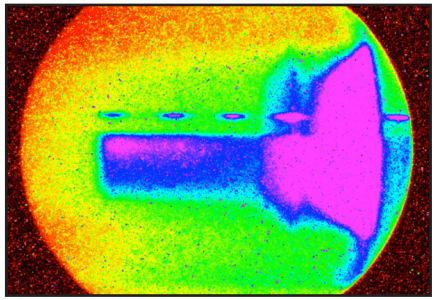
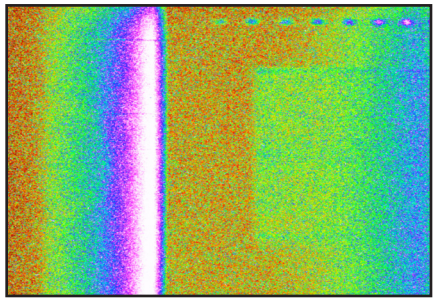
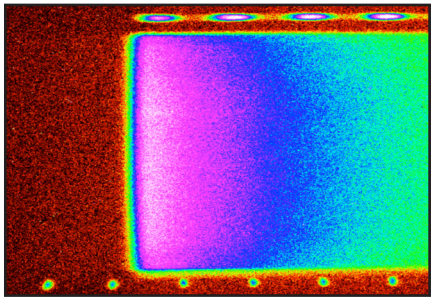
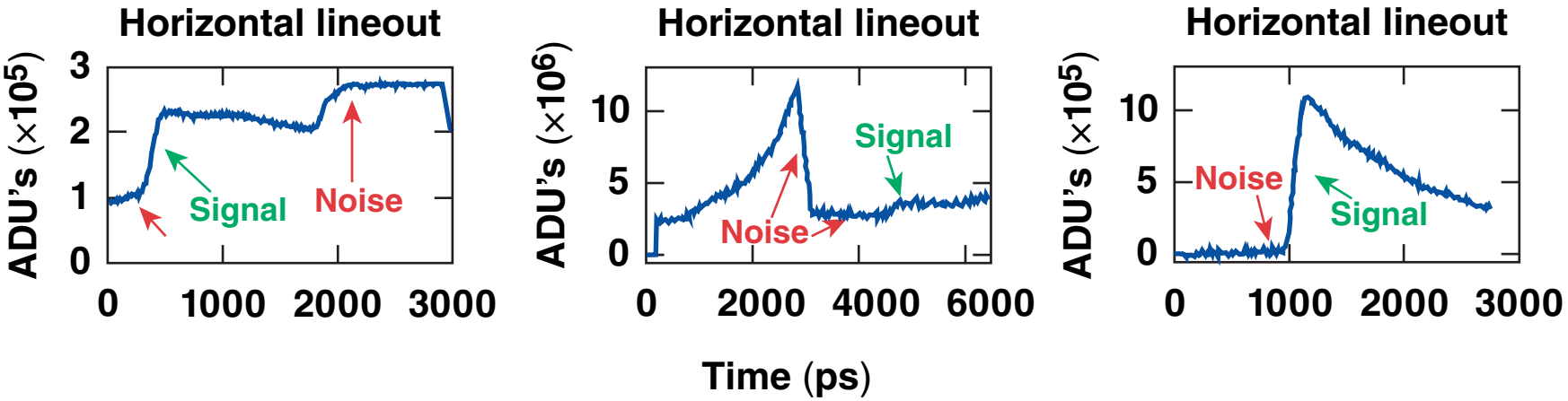
UR LLE

LLNL H5-NTD	LLE H5-NTD	LLE P11-NTD
CRYO – shot 69515 DT yield – 2.95×10^{13}	CRYO – shot 76358 DT yield – 2.61×10^{13}	CRYO – shot 76358 DT yield – 2.61×10^{13}









E23906

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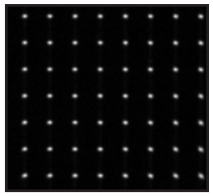
Rochester Optical Streak System
ROSS

Sweep-time base calibration

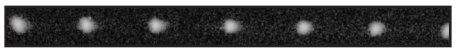
Streak-tube geometric distortion

Grid point array

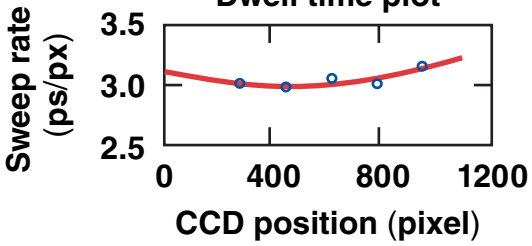


Ramp-driver sweep-speed profile

On-shot 2-GHz comb



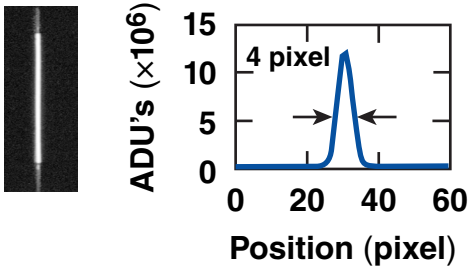
Dwell time plot



Camera bandwidth characterization

Cathode image focus time axis

Static line spread function



Sweep speed (ns)	Temporal resolution (ps)
13	60
6	25
3 (nominal)	15
1.5	7

Time base corrected with 1% accuracy

15-ps on-shot camera resolution

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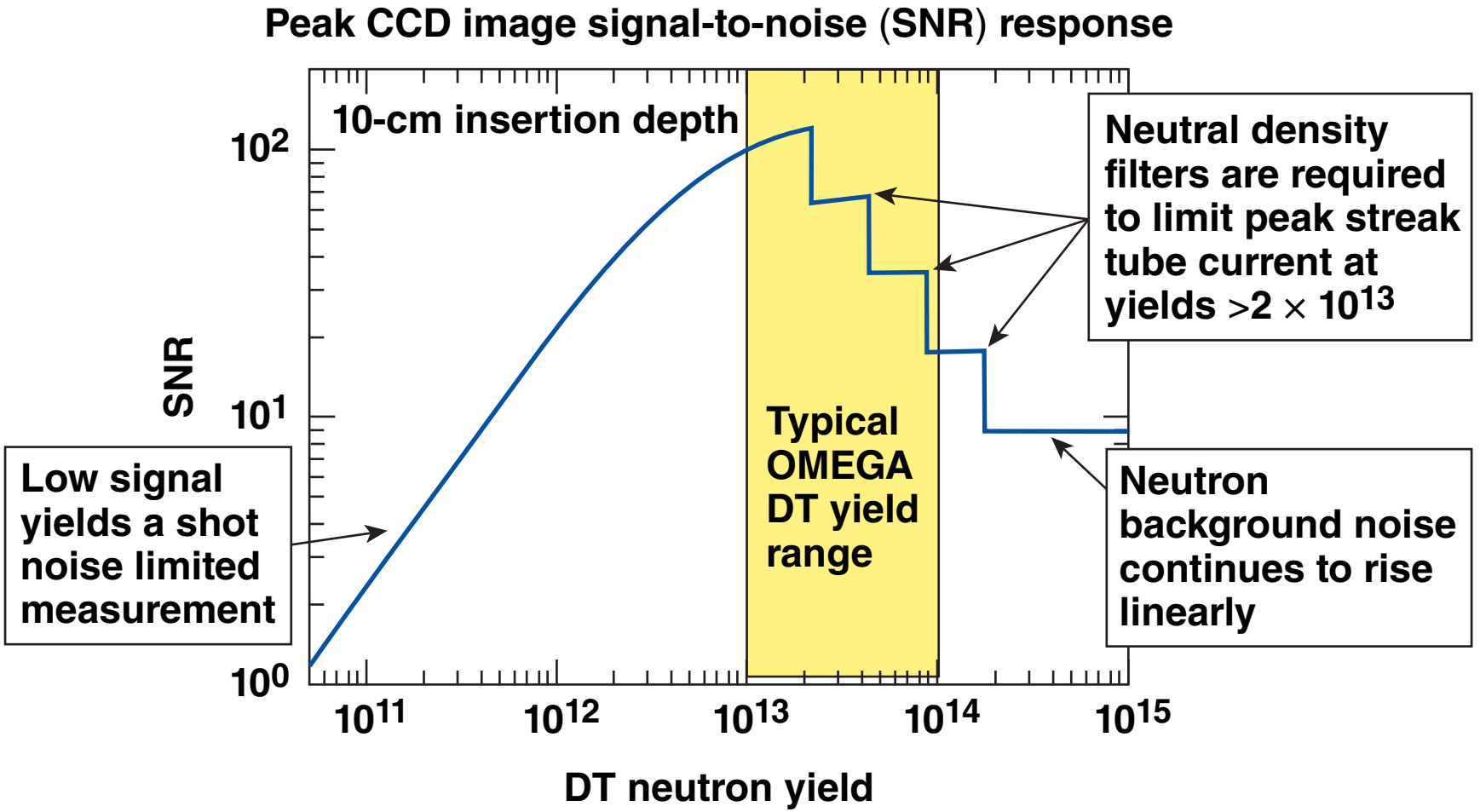

E23919