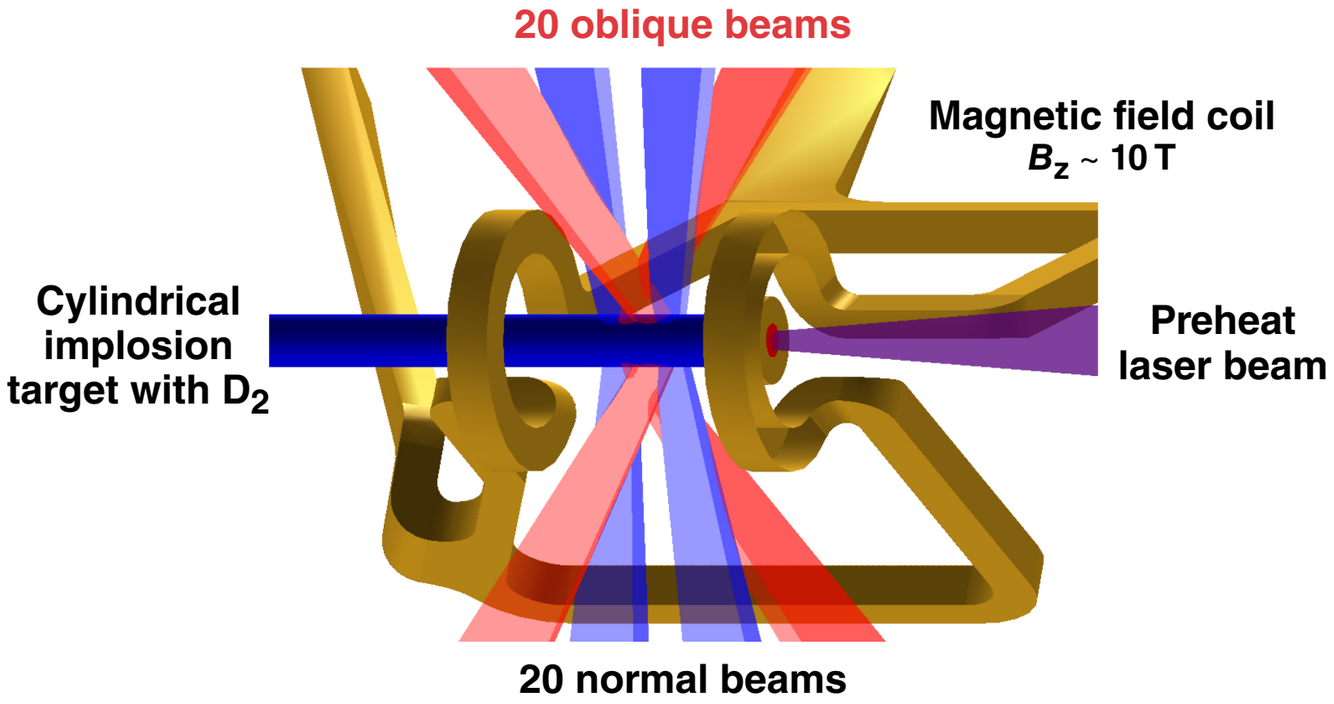
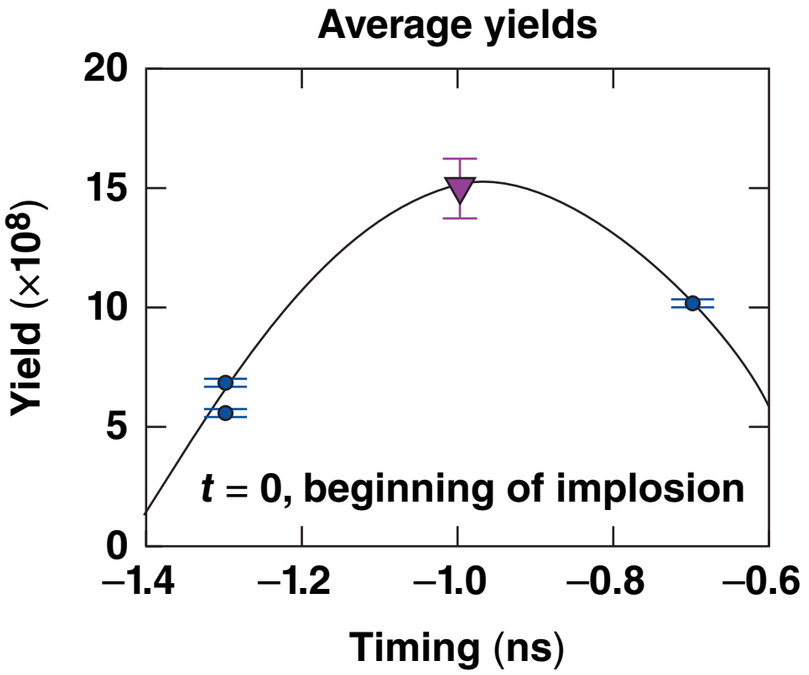
Neutron Measurements in Laser-Driven Magnetized Liner Inertial Fusion Experiments on OMEGA





V. Yu. Glebov
University of Rochester
Laboratory for Laser Energetics

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Summary

The suite of neutron diagnostics was developed for laser-driven magnetized liner inertial fusion (MagLIF) experiments on OMEGA

- Laser-driven MagLIF is being developed on OMEGA to study MagLIF scaling
- A new H15 nTOF detector was designed and fabricated to measure MagLIF yields from 1×10^7 to 5×10^9 and T_i from 2 to 8 keV
- The suite of neutron diagnostics measures the DD primary and DT secondary yields, ion temperature, and neutron bang time in MagLIF experiments on OMEGA

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Collaborators

D. H. Barnak, J. R. Davies, J. P. Knauer, C. Stoeckl, R. Betti,
S. P. Regan, T. C. Sangster, and E. M. Campbell

University of Rochester
Laboratory for Laser Energetics

MagLIF implosions on OMEGA provide a platform for studying the basic science and scalability of the concept

- A faster shot cycle allows for more shots, better statistics, and wider scans of the MagLIF parameter space
- Better diagnostic access allows for measurements that cannot be performed at the Z scale
  - magnetic-field/Nernst-effect measurements, shell trajectories
- OMEGA-scale experiments provide code validation over 1000× in energy
  - ultimately, we will have the confidence in extrapolating to ignition-scale designs

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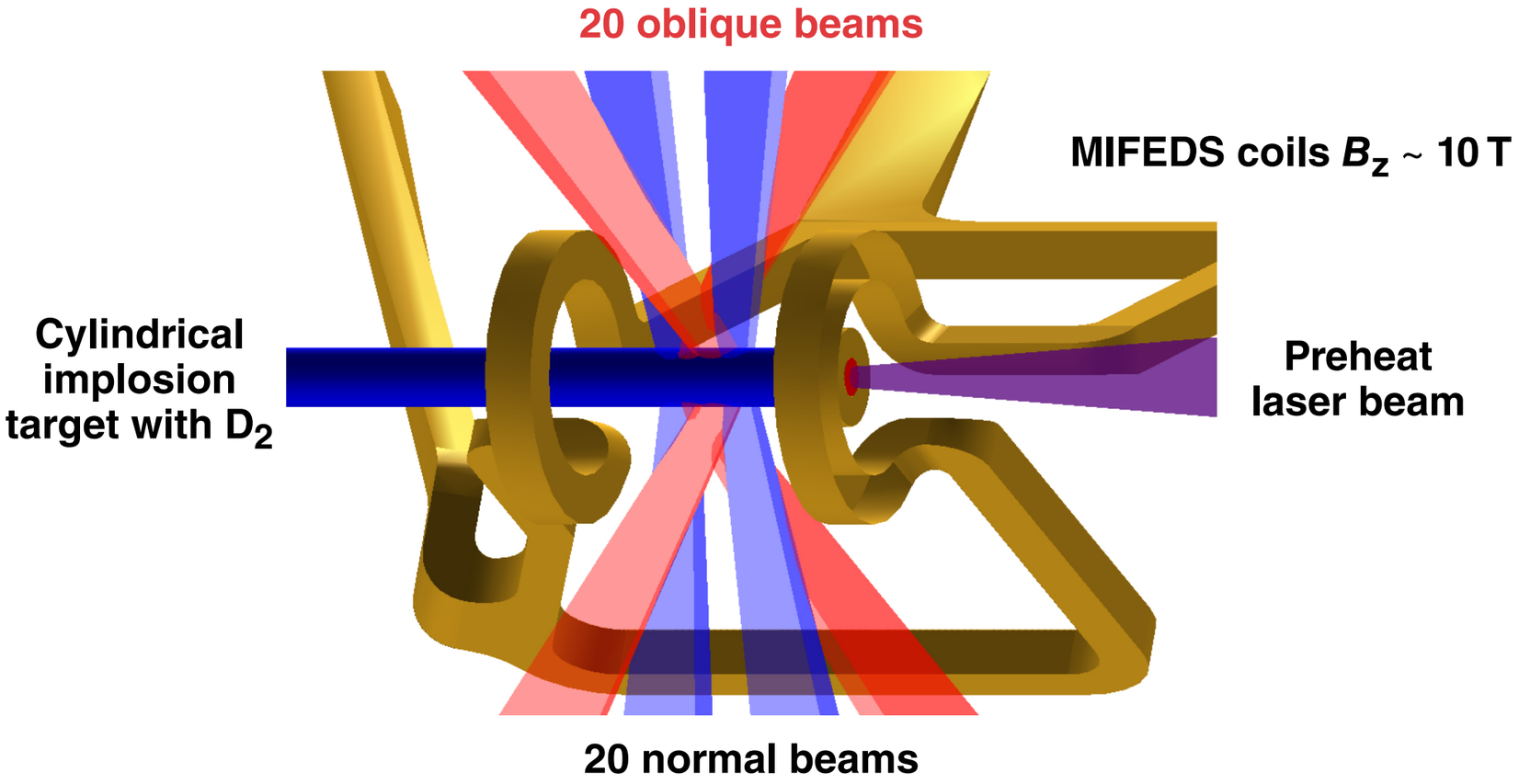
Laser-driven MagLIF is being developed on OMEGA to study MagLIF scaling



- DD-yield range—from 1×10^7 to 5×10^9
- T_i measurement range—from 2 keV to 5 keV

D. H. Barnak, KI2.00004, this conference (invited);
J. R. Davies *et al.*, CO8.00004, this conference.
MIFEDS: magneto-inertial fusion electrical discharge system

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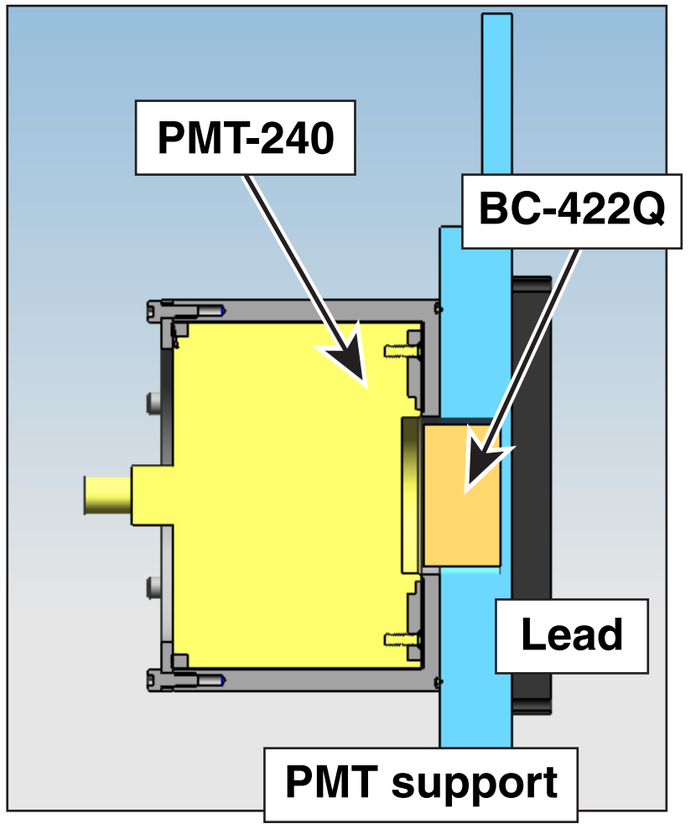
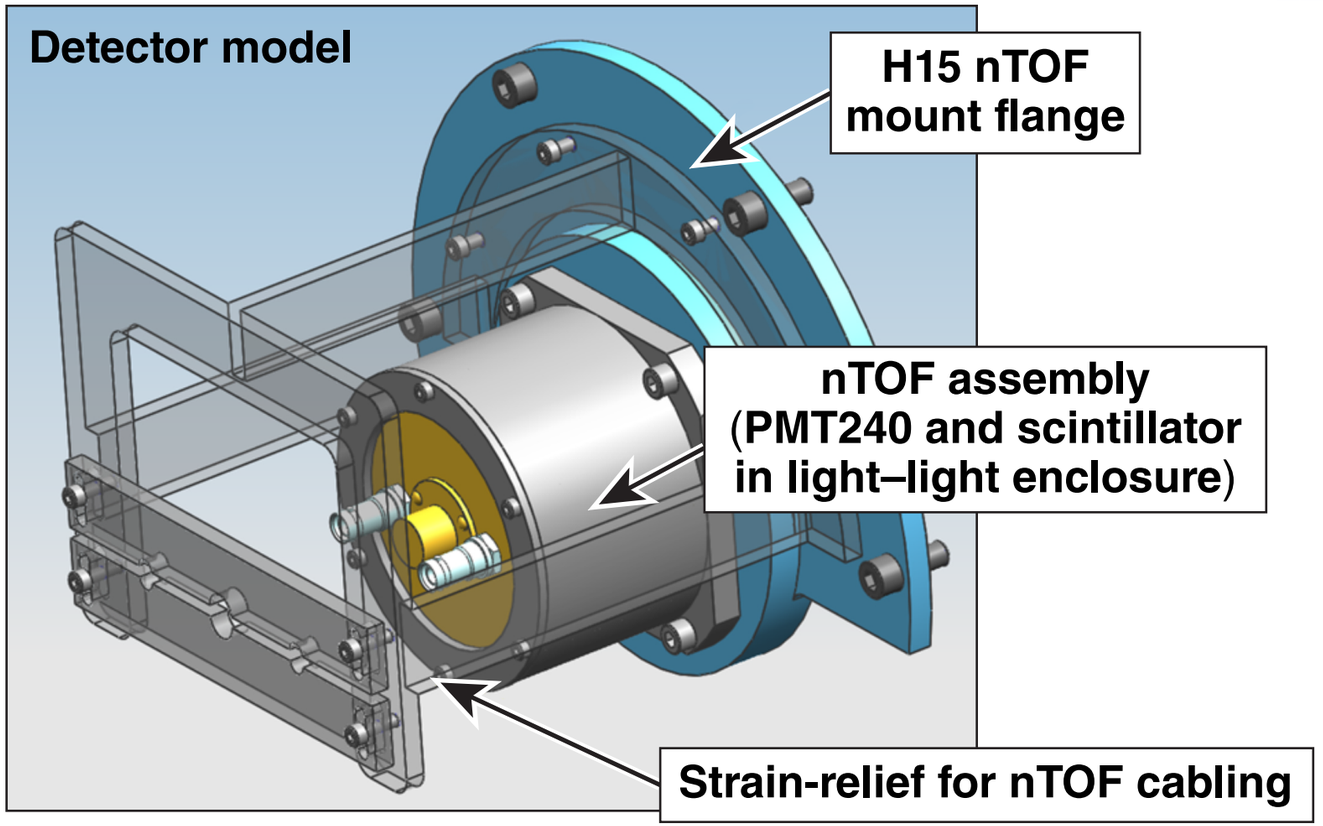
Several existing and one new neutron time-of-flight (nTOF) detector were used to measure neutrons in MagLIF experiments

Already existing nTOF detectors:				
Name	**Scintillator**	**Shielding**	**Yield range**	**T_i yields**
1.7-m nTOF	40 × 20-mm BC-422	50-mm Pb	1×10^7 to 2×10^9	NA
2 × 2	51 × 51-mm BC-404	12.7-mm Pb	5×10^6 to 1×10^9	NA
3-m nTOF	38 × 25.4-mm BC-422Q	25.4-mm Pb	5×10^8 to 1×10^{10}	2×10^9 to 1×10^{10}
5.4-m nTOF	38 × 25.4-mm BC-422Q	12.7-mm Pb	1×10^9 to 1×10^{11}	5×10^9 to 1×10^{11}

A new nTOF detector was needed for ion-temperature measurements in MagLIF experiments on OMEGA.

A new H15 nTOF detector has a Photek PMT-240 and a 40 × 10-mm BC-422Q scintillator shielded by 10 mm of Pb





The H15 nTOF detector assembly bolts to a H15D re-entrant tube flange and sits at 1.7 m from target chamber center (TCC).

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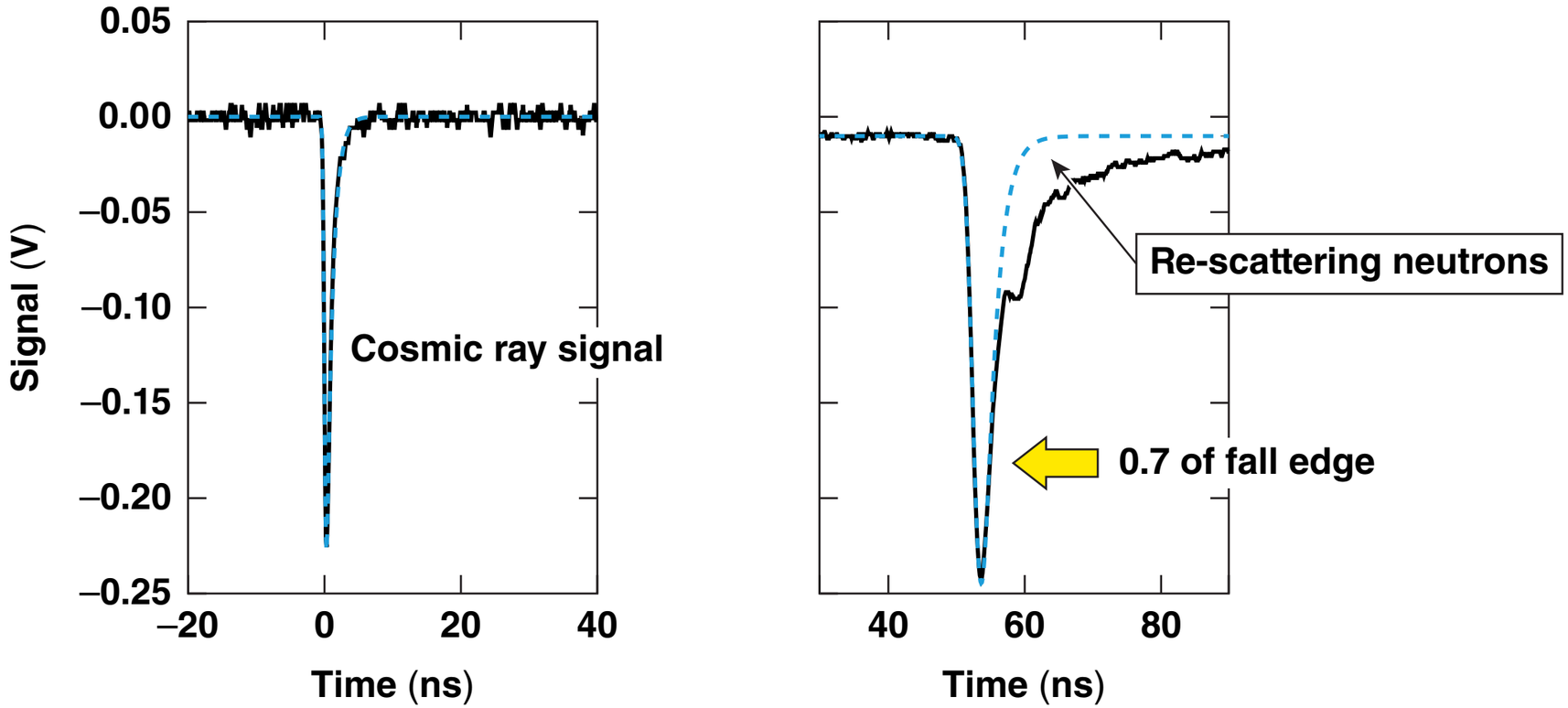
The H15 nTOF detector is capable of measuring T_i in MagLIF shots on OMEGA

H15 nTOF is fast!

MagLIF shot 82955
$Y = 7.5 \times 10^8$, $T_i = 2.7$ keV



In shots on OMEGA there is a tail from neutron re-scattering and (n, γ) interactions in target chamber walls that was removed by the special fit.

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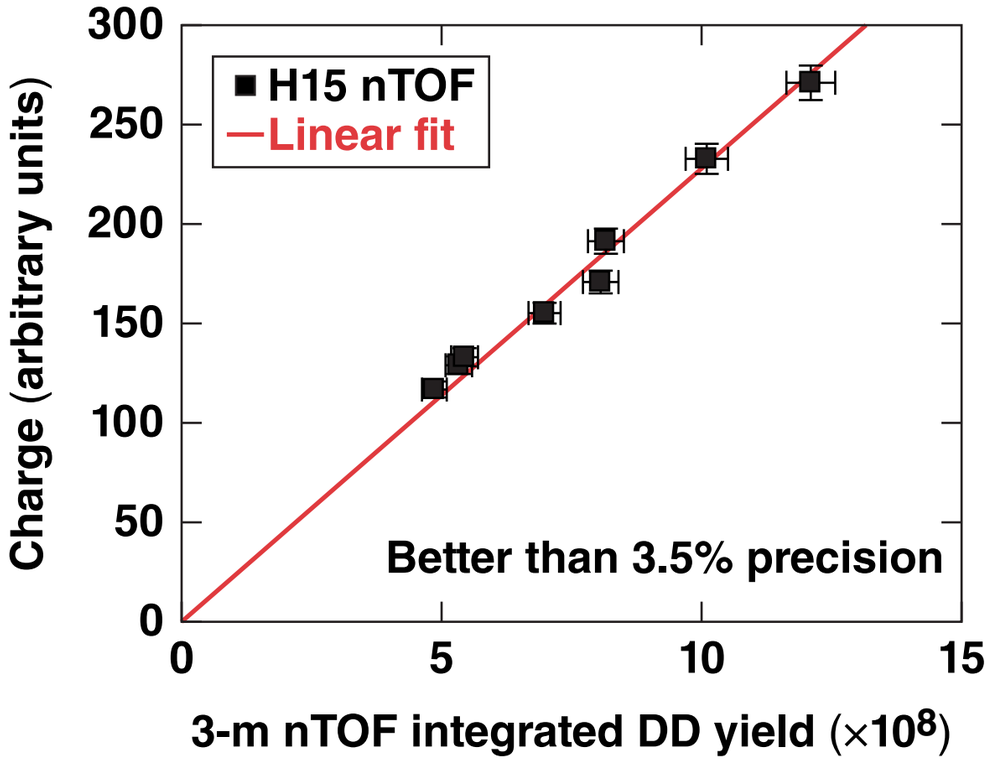
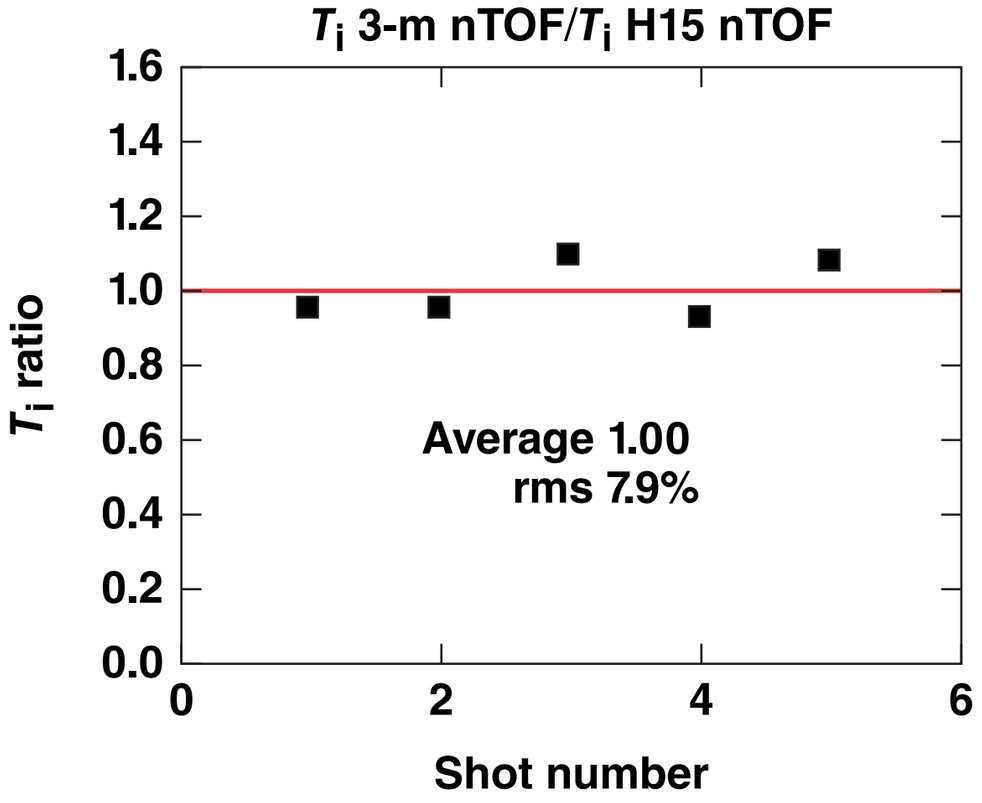
The H15 nTOF detector was calibrated in DD yield and ion temperature against a 3-m nTOF detector





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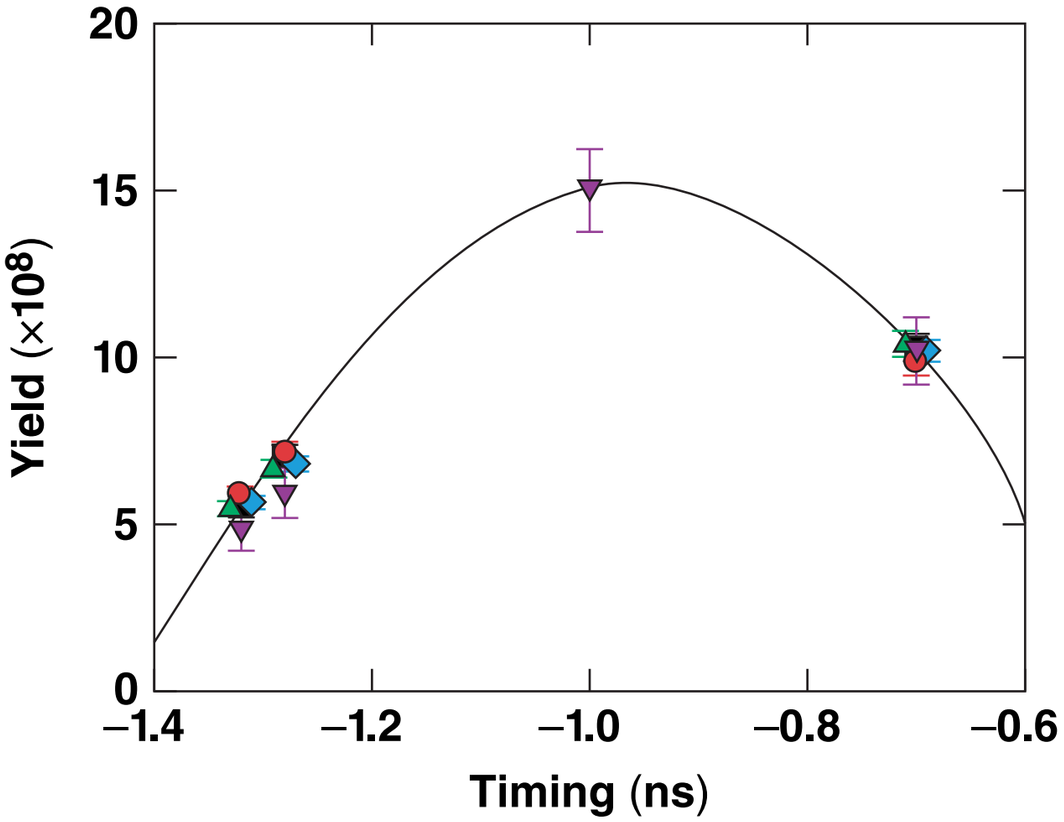
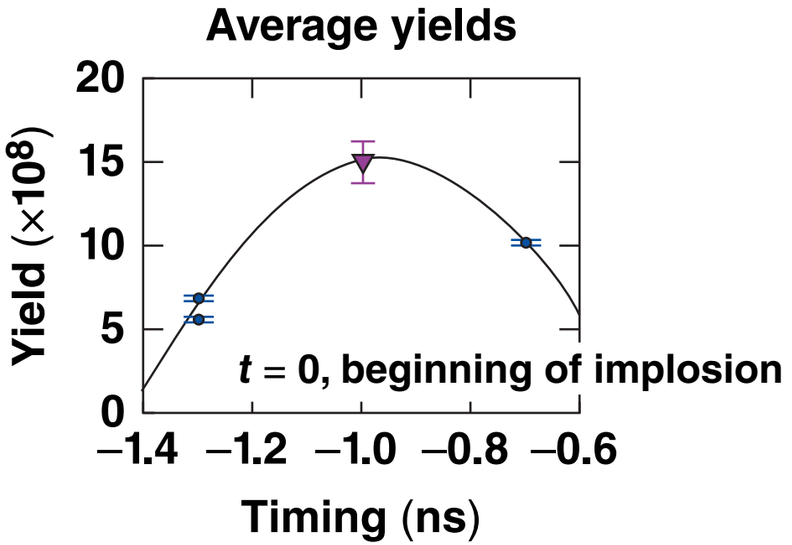
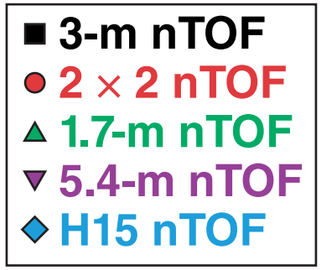
The nTOF diagnostics were used to optimize P9 3ω preheat beam timing







Averaging measurements from several nTOF detectors allows for an increase in the yield measurement precision.

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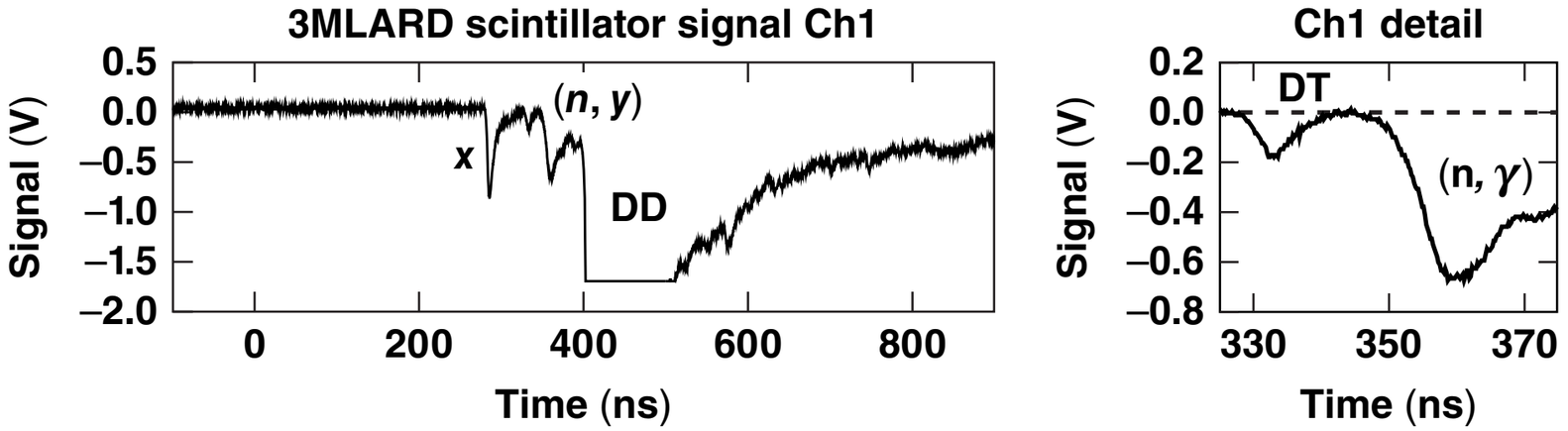
The secondary DT yield in MagLIF experiments is measured by the 3MLARD* detector

- The secondary neutrons are created in reactions:

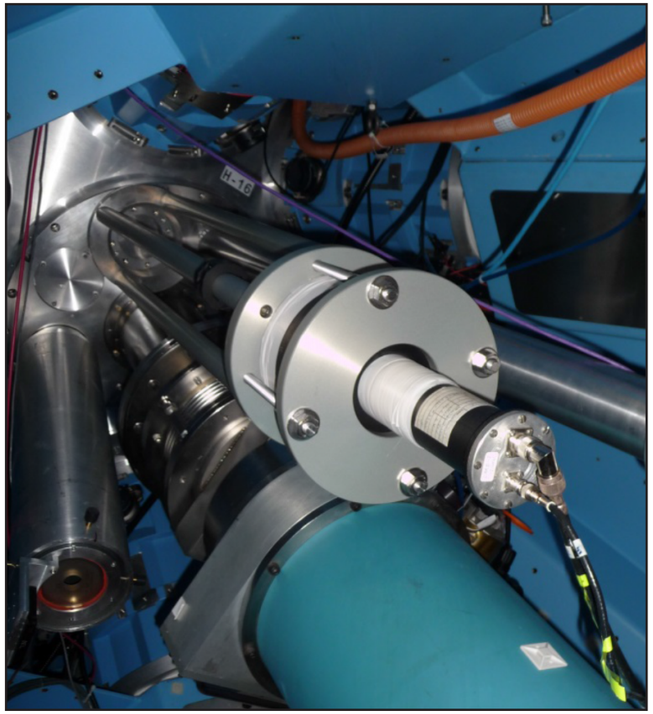
  $D + D \rightarrow p\ (2.5\ MeV) + T\ (1.01\ MeV)$

  $T\ (1.01\ MeV) + D \rightarrow \alpha + n\ (11.8\ to\ 17.1)$

MagLIF shot 82955, $Y_{DD} = 7.5 \times 10^8$, $Y_{DT} = 2.3 \times 10^5$



3MLARD detector



- The 3MLARD detector is installed on port H16B at 285 cm from TCC; it has a 17.78-cm-diam, 10-cm-thick Pilot-B scintillator coupled with an XP2020 photomultiplier tube (PMT); the 2.54-cm-thick lead plate is installed in front of the scintillator

*V. Yu. Glebov *et al.*, Rev. Sci. Instrum. 72, 824 (2001).

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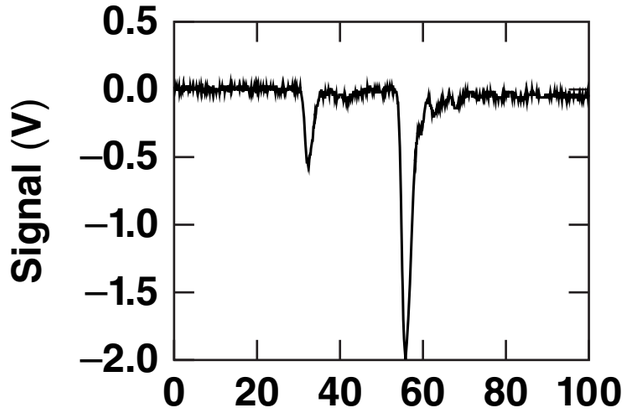
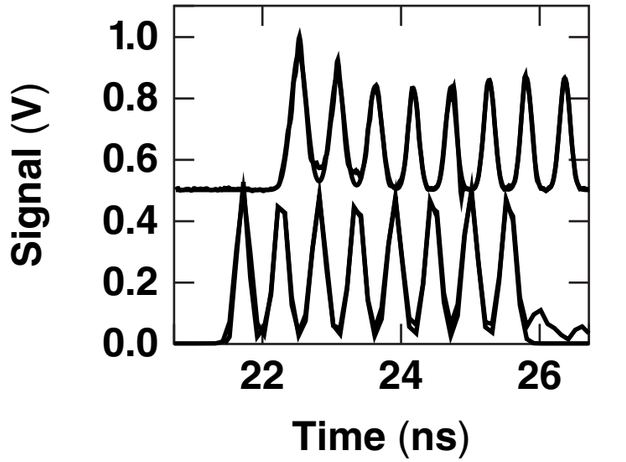
The neutron bang time was measured in MagLIF experiments by the LLE neutron bang time (NBT)* detector

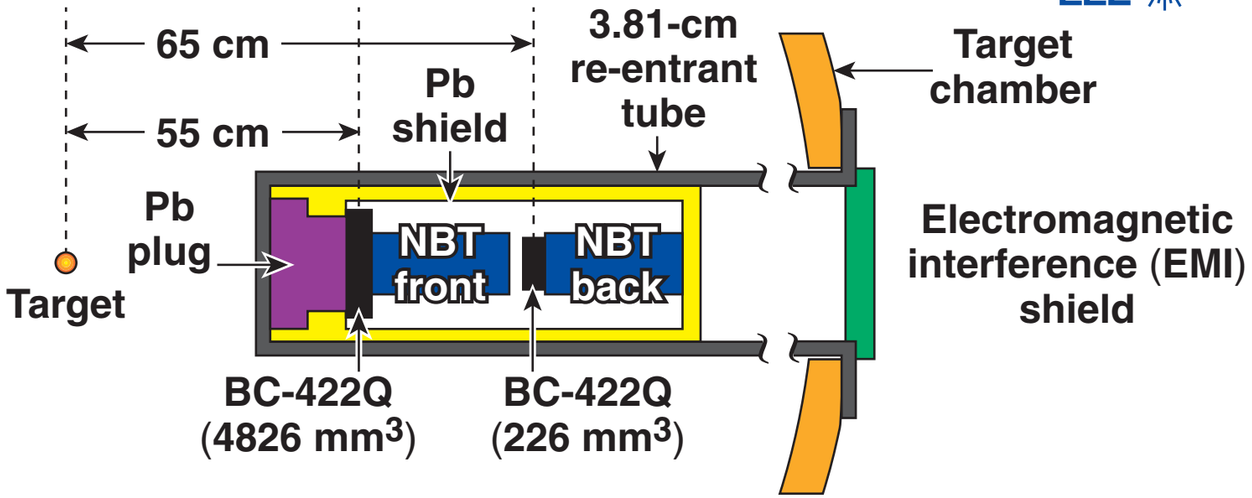
MagLIF shot 82957, $Y = 5.8 \times 10^8$

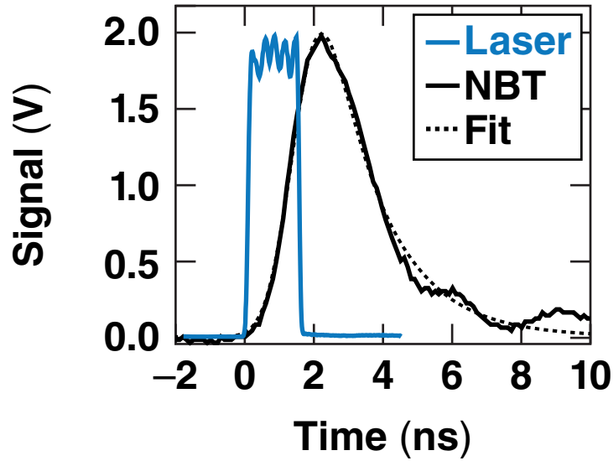
NBT front signal



NBT + P510 fiducials







NBT front and laser signals

*C. Stoeckl *et al.*, Rev. Sci. Instrum. 73, 3796, (2002).

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Summary/Conclusions

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