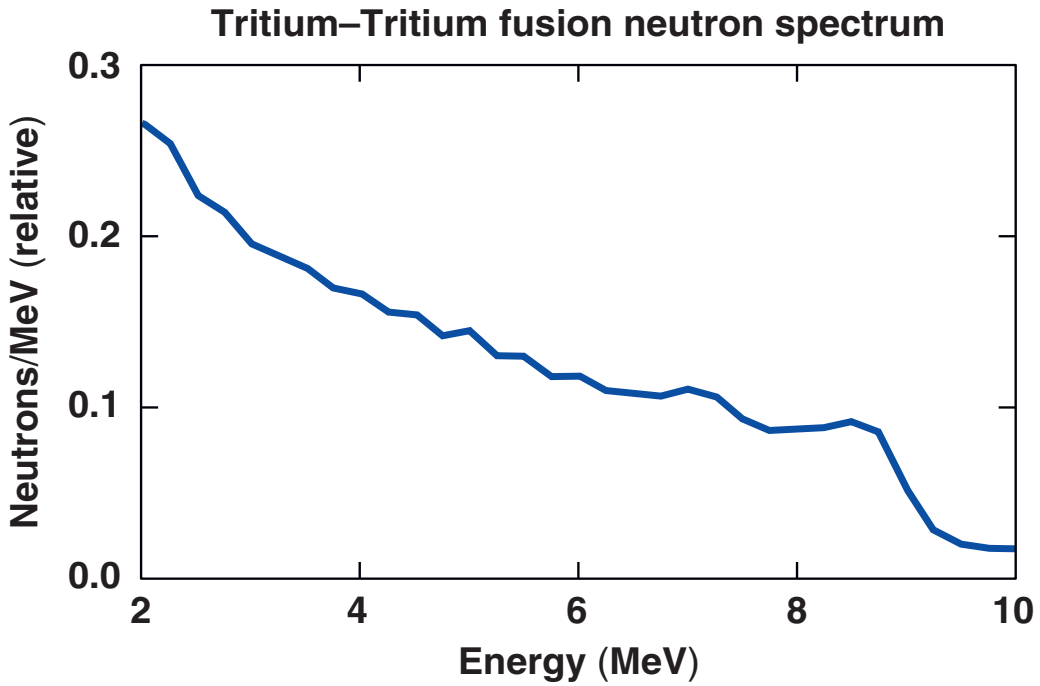
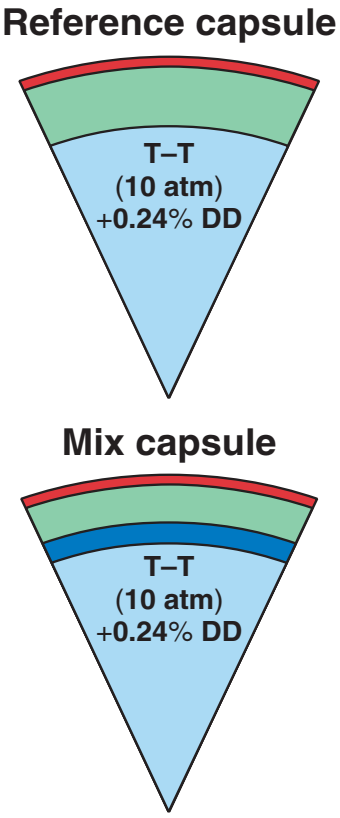
T–T Fusion Neutron Spectrum Measured in Inertial Confinement Fusion Experiment





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

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Summary

Neutron energy spectra were measured in T–T inertial confinement fusion on OMEGA

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- Plastic capsules filled with high-purity (99.67%) tritium gas were imploded on OMEGA.
- The neutron spectra were measured by an absolutely calibrated neutron time-of-flight (nTOF) scintillator detector.
- The T–T neutron spectrum in ICF is similar to the neutron energy distribution from a muon-catalyzed T–T fusion reaction.
- The measured T–T neutron energy distribution can be implemented in numerical models calculating neutrons for NIF and LMJ.

Collaborators

T. C. Sangster, P. B. Radha, W. T. Shmayda,
M. J. Bonino, and D. R. Harding

University of Rochester
Laboratory for Laser Energetics

D.C. Wilson, P. S. Ebey, and A. Nobile, Jr.

Los Alamos National Laboratory

R. A. Lerche and T. W. Phillips

Lawrence Livermore National Laboratory

Measuring the neutron energy spectrum in T–T implosions was part of a mix study campaign*

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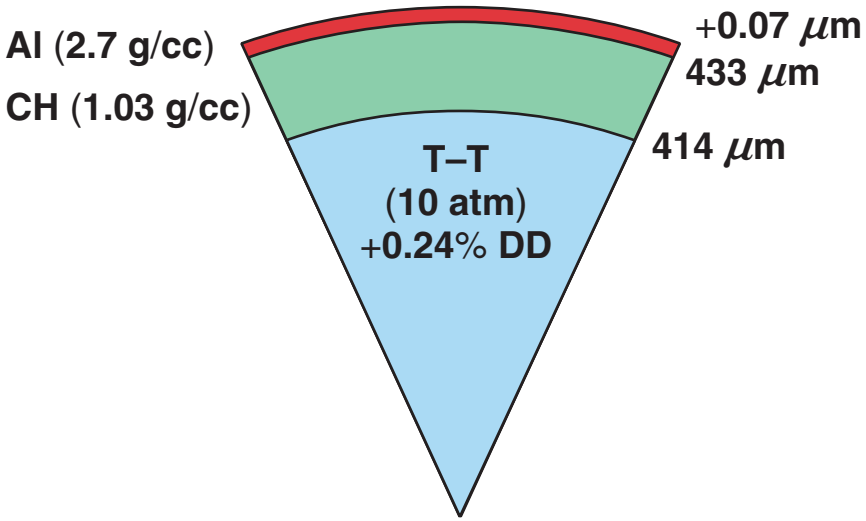
Reference capsule

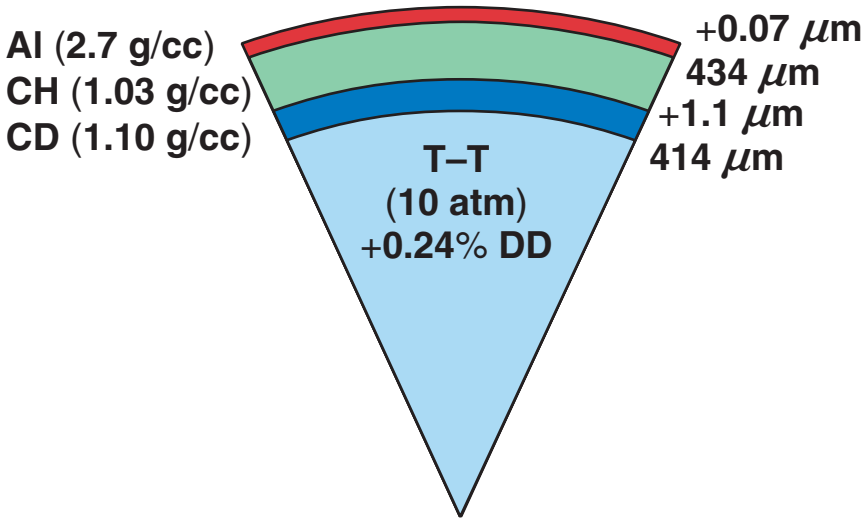


23-kJ laser energy

Background DT yield 3.5×10^{10}

T–T neutron yield 1.7×10^{10}

Mix capsule



23-kJ laser energy

DT yield from mix 2.0×10^{12}

T–T yield was not measured

E15130

*D. C. Wilson *et al.*, "Nearly Pure Tritium Filled Capsule Implosions to Measure the Time Dependence of Mix," Bull. Am. Phys. Soc 50, 312 (2005).

Fabricating and handling pure tritium targets is especially challenging

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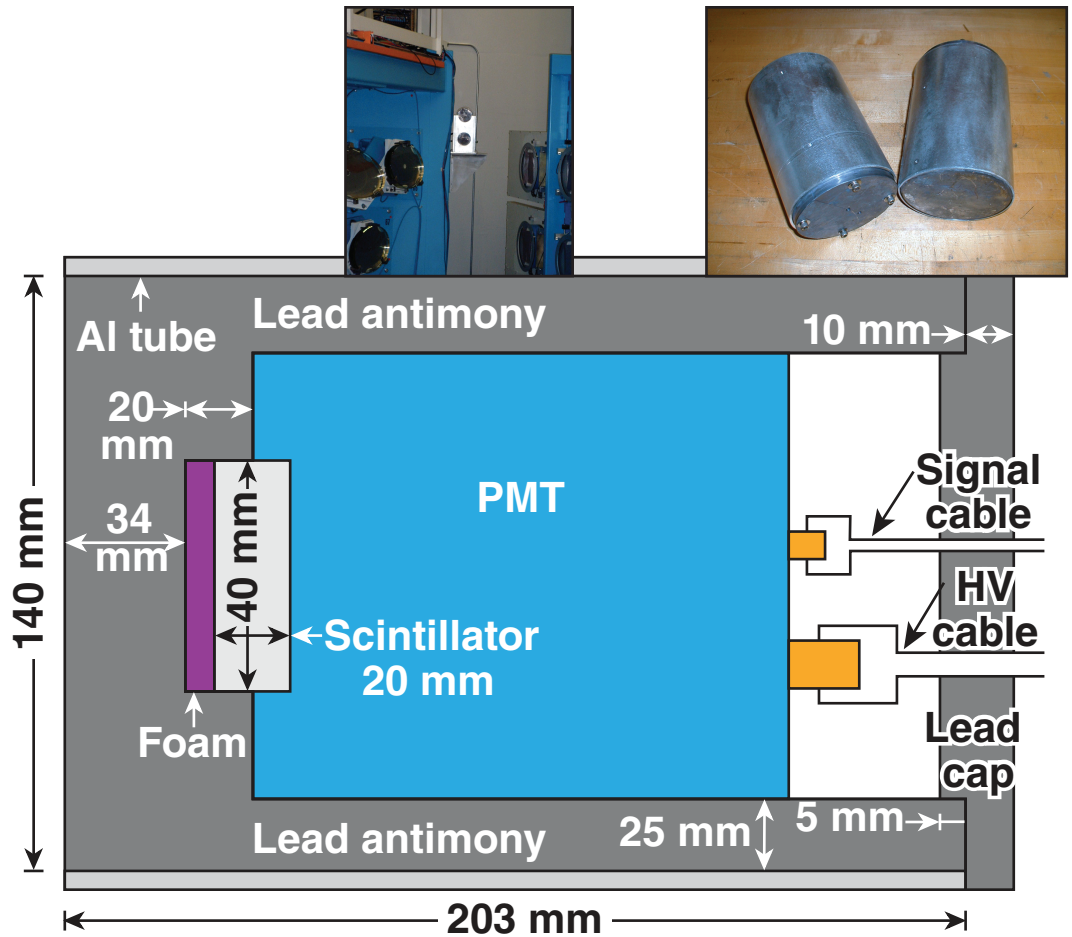
- A dedicated fill system had to be built[1] at Los Alamos National Laboratory to keep deuterium contamination low.
- To limit diffusion loss through the walls, capsules had to be kept at near-liquid-nitrogen temperatures during and after transport between Los Alamos and Rochester.
- Stalk or fiber mounting in a glovebox was done after cryogenic storage at LLE.

More than two years was needed between concept and first delivery.

[1] P. S. Ebey *et al.*, LA-UR-06-6892.

DT and T-T neutrons were measured by two similar nTOF detectors located 12.4 m from the target

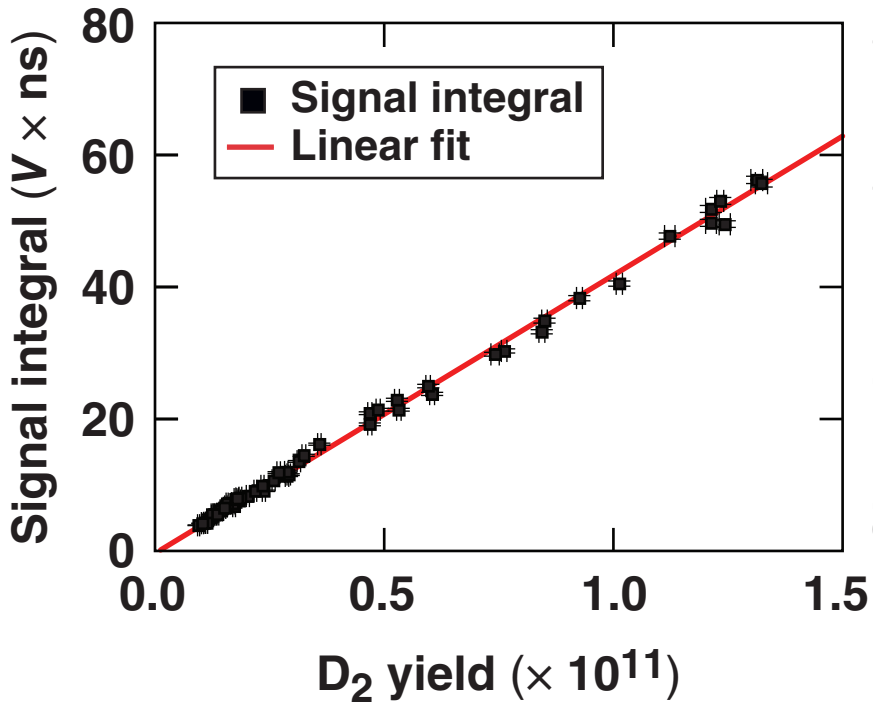


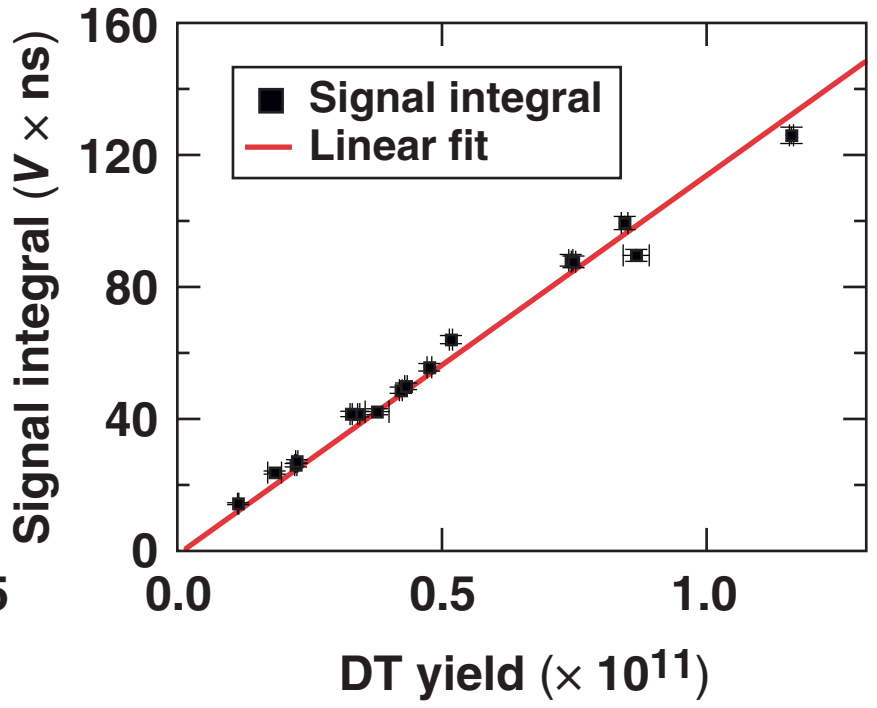
nTOF detector: BC-422 scintillator
Photek PMT-240, gain 1×10^5

E15132

V. Yu Glebov *et al.*, Rev. Sci. Instrum. 75, 3559 (2004).

The nTOF detector was absolutely calibrated by D_2 (2.45 MeV) and DT (14.1 MeV) neutrons on OMEGA





Both D_2 and DT neutron calibrations have an accuracy of 10%.

The nTOF detector sensitivity between 2.45 MeV and 14 MeV was calculated by the Monte Carlo model

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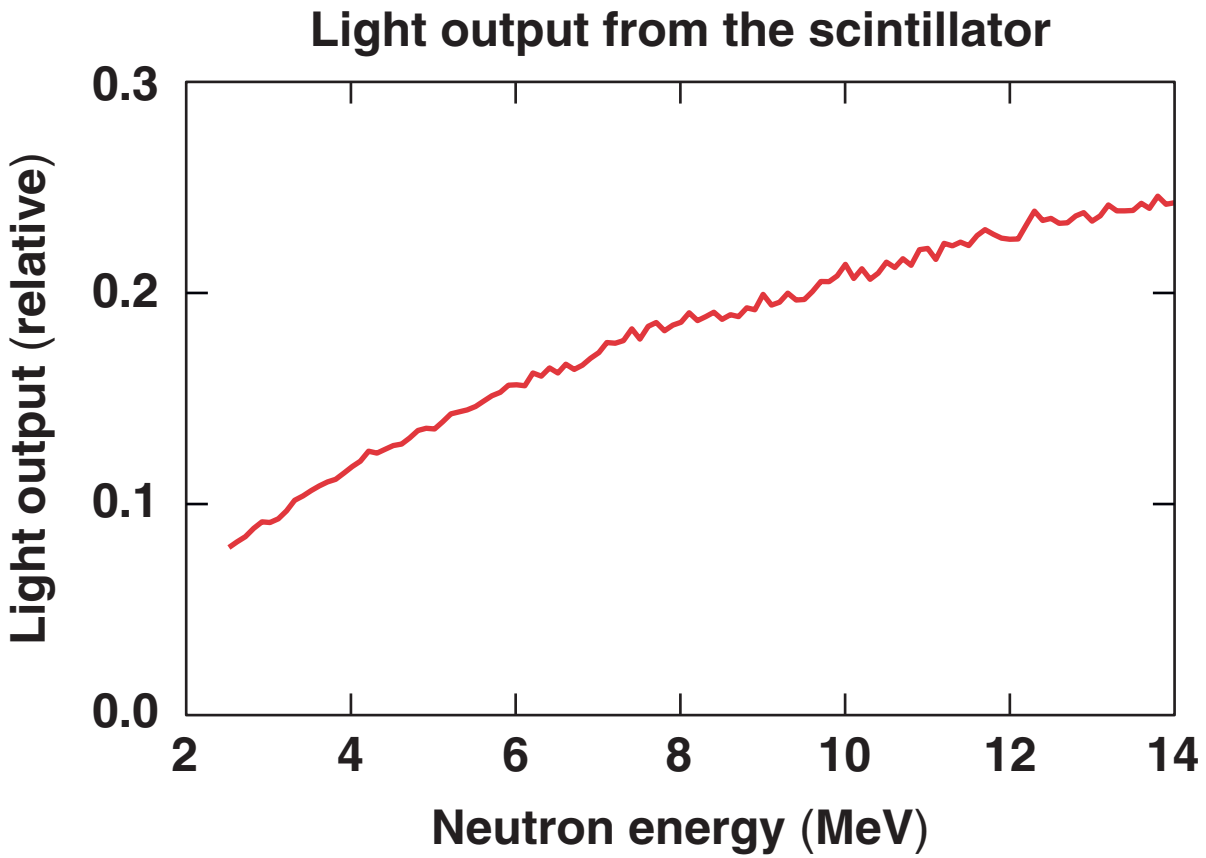

Monte Carlo model* calculates light output from 2 × 2-cm BC-422 scintillator.

E15134

*R. Cecil *et al.*, Nucl. Instrum. Methods 161, 439 (1979).

Both DT neutron signals (from residual D_2 gas) and T–T neutrons can be seen in raw data

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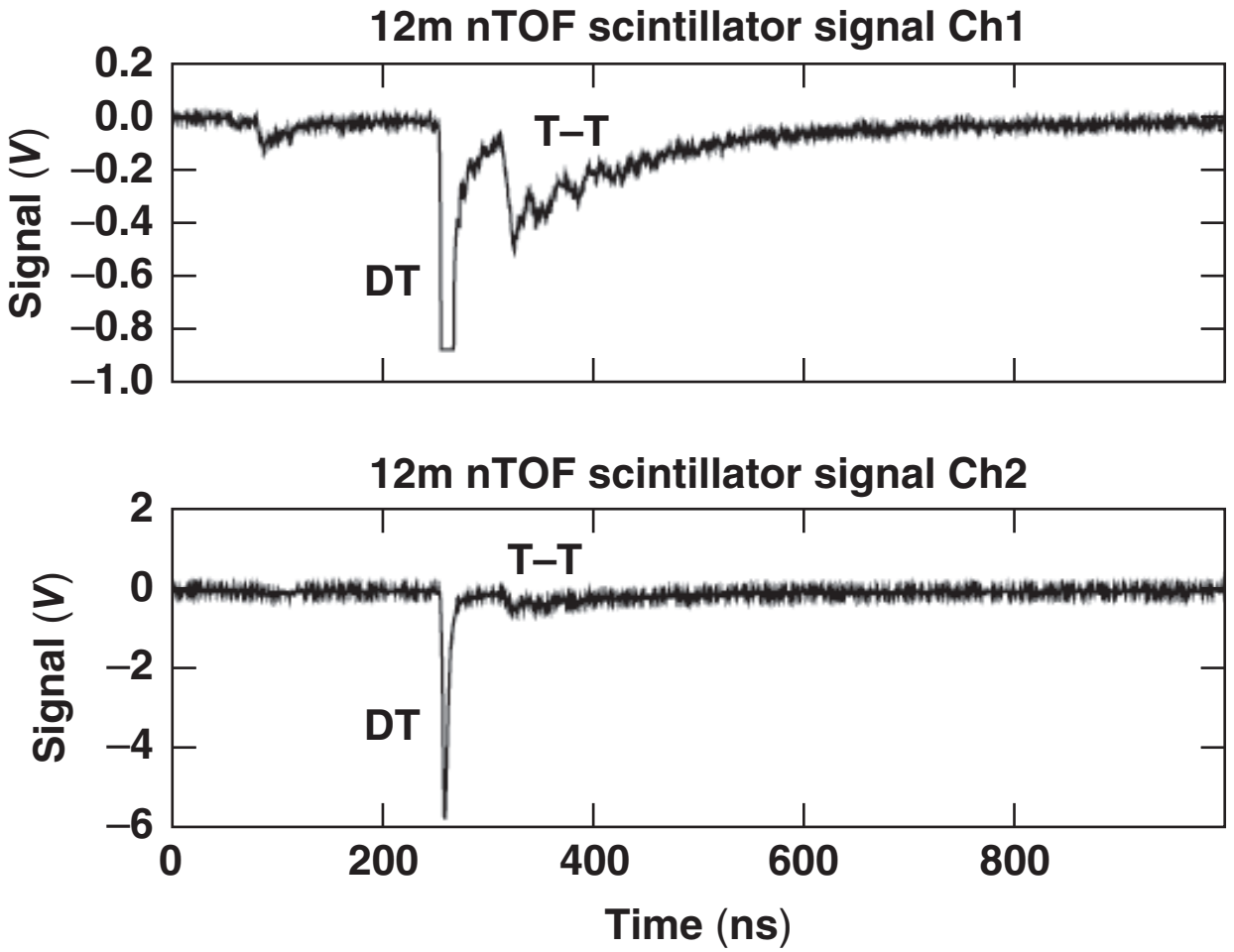
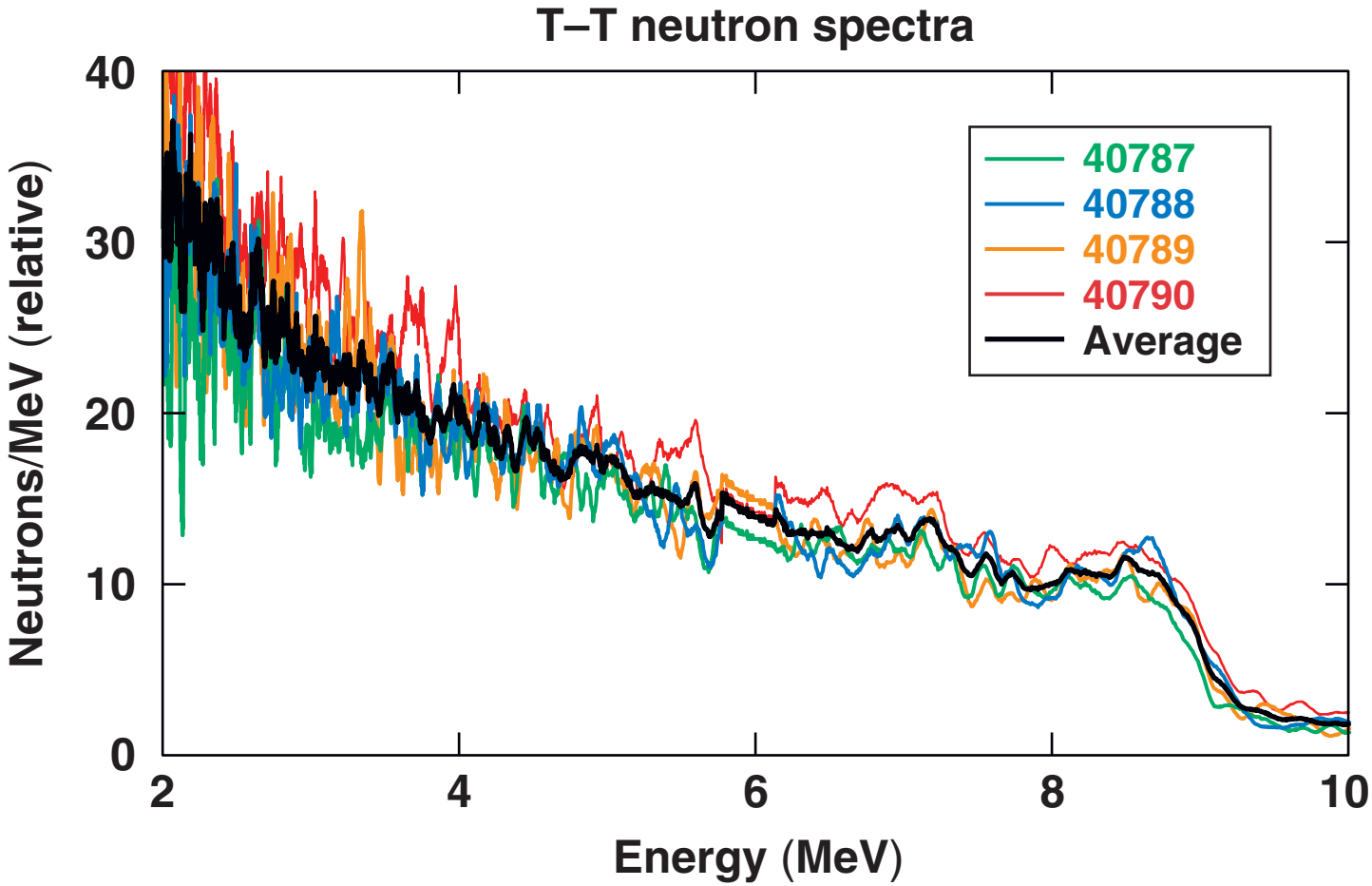
Shot 40788, TT(10)CH[19], 1-ns square laser pulse, 23.3 kJ



E15135

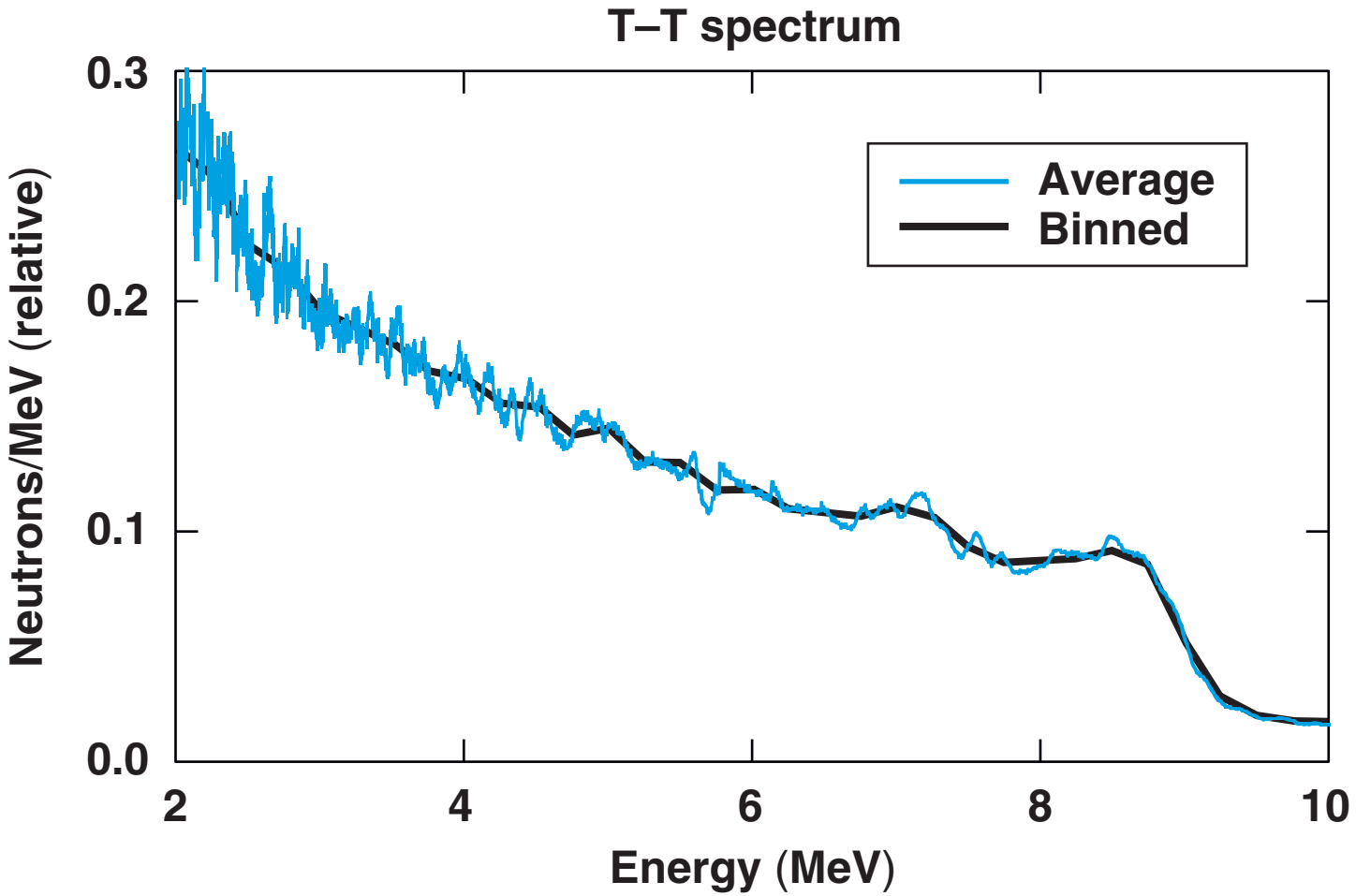
Experimental data from four nominally identical TT(10)CH[19] shots agree well with each other



The raw data were normalized by yield and transformed from time to energy domain.

E15136

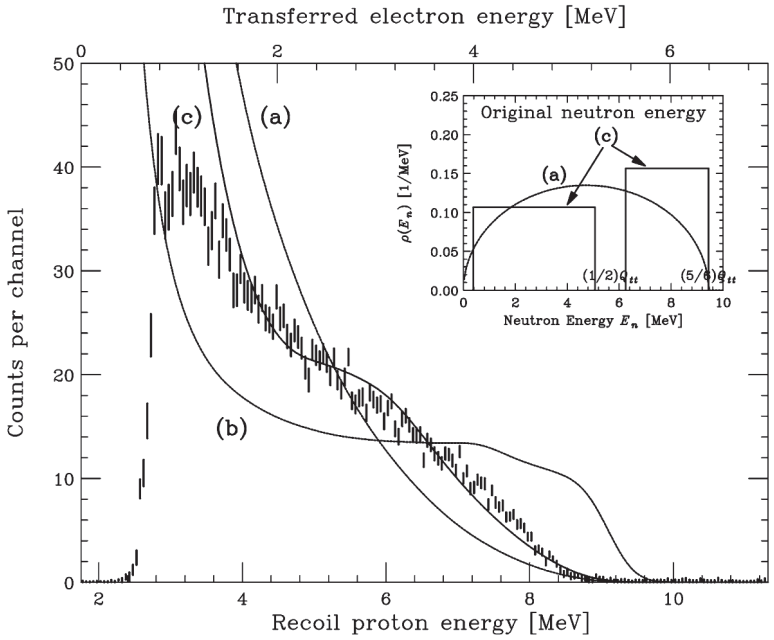
The final T–T neutron energy spectrum was obtained by averaging and binning four identical shots

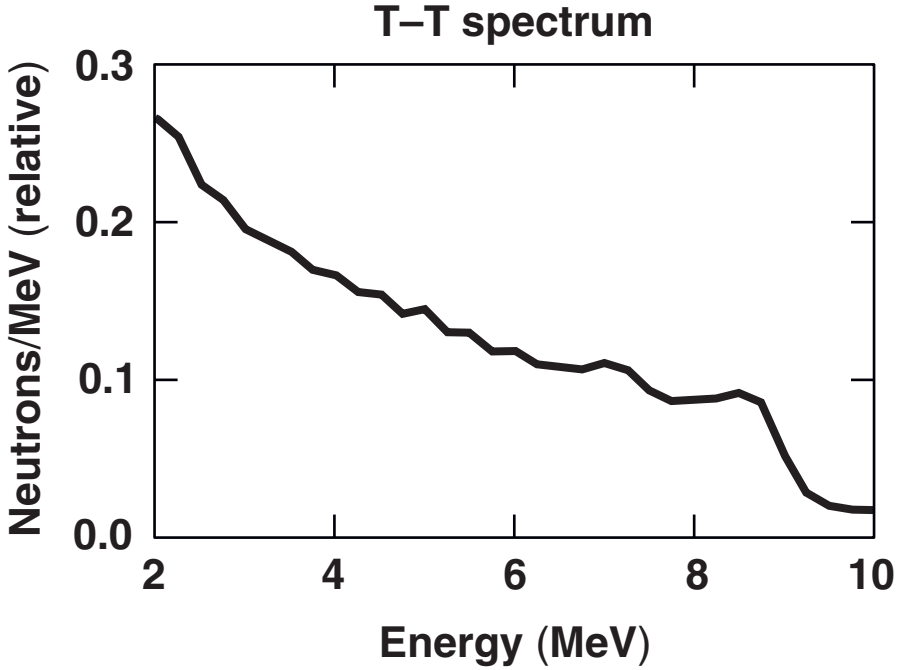


E15137

The measured T–T neutron spectrum is similar to the energy distribution from muon-catalyzed T–T fusion[1]

[1]T. Matsuzaki, Phys. Lett. B



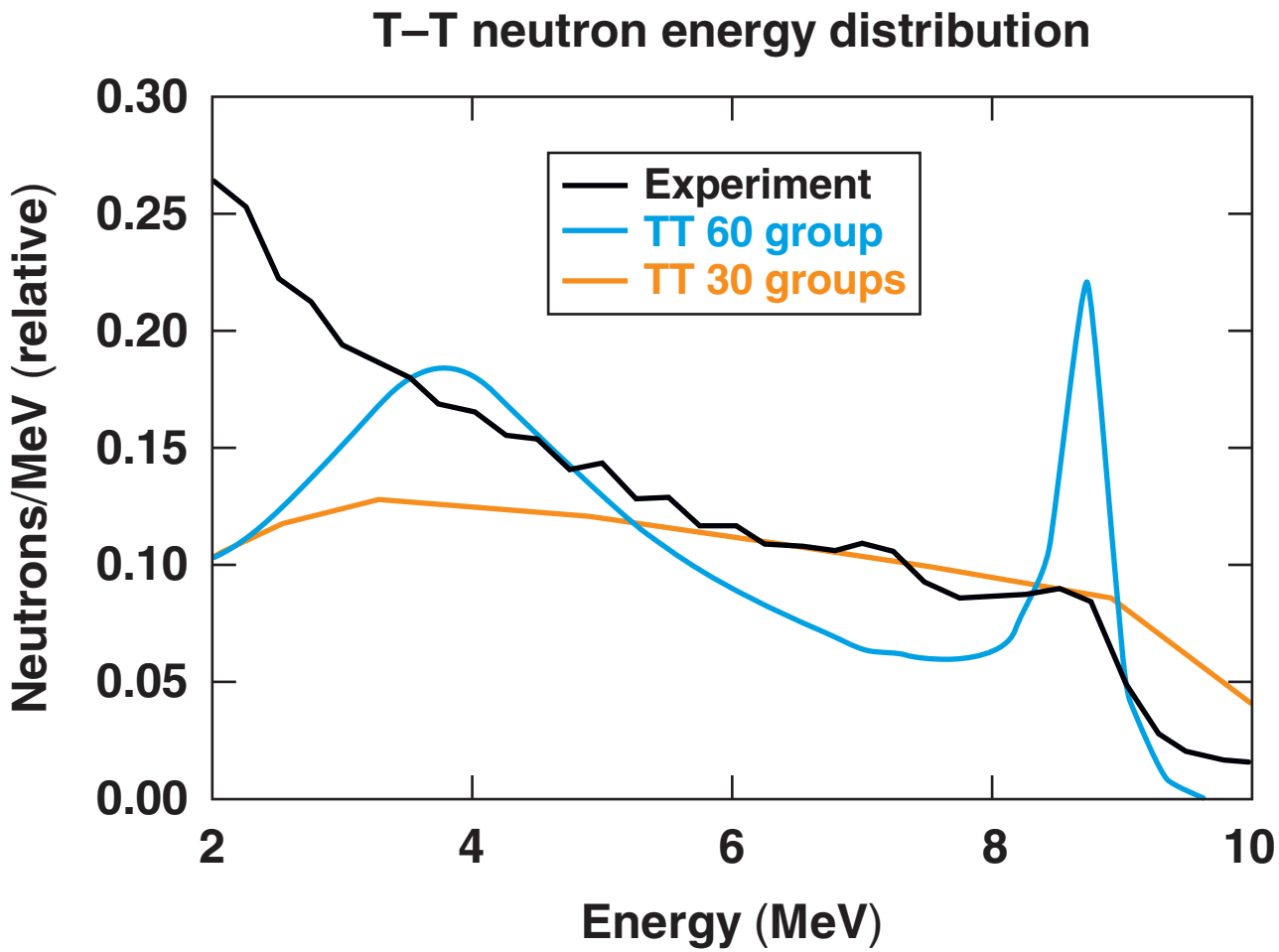


Our data are better described by model (b) in Ref. 1: *n-n* correlation only; as if decay were $t + t \rightarrow \alpha + 2n$

E15138

[1]T. Matsuzaki *et al.*, Phys. Lett. B 557,176 (2003).

The measured T–T neutron energy distribution can be implemented in a numerical simulation



LANL NDI Multigroup Neutron Library T16_2003.

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