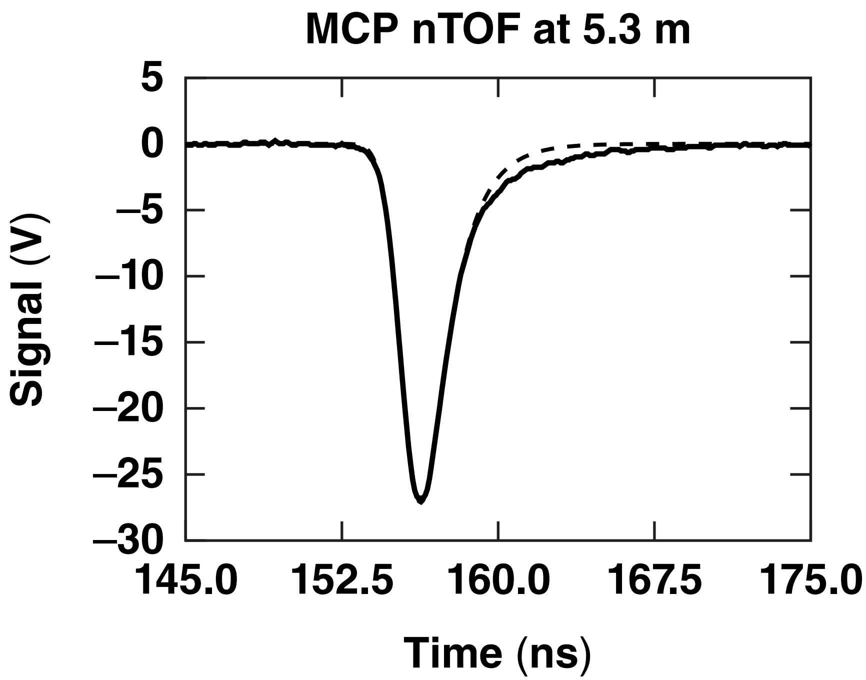
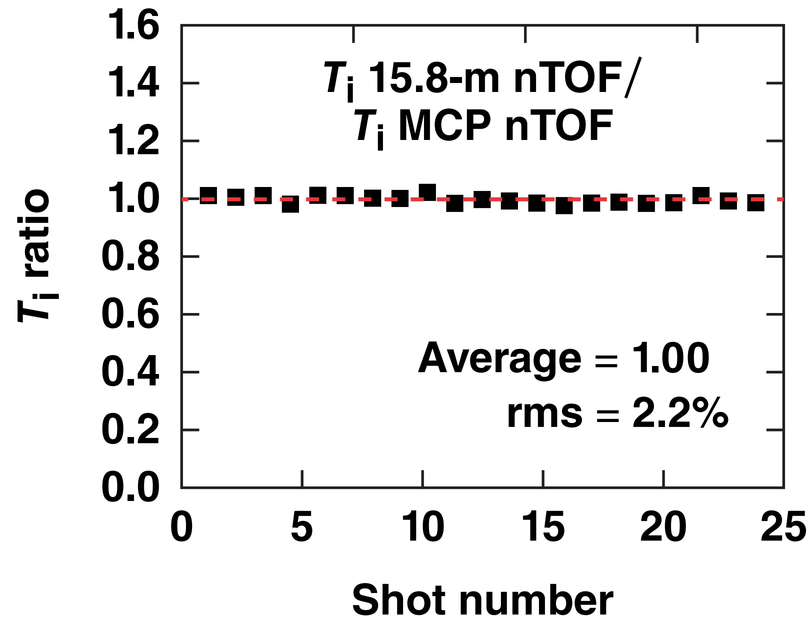
A New Microchannel-Plate Neutron Time-of-Flight Detector





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Summary

A new microchannel-plate neutron time-of-flight (MCP nTOF) detector was developed and tested on OMEGA

- The MCP nTOF has only a MCP photomultiplier tube without a scintillator; the signal is produced as a result of direct neutron interaction with the MCP
- Eliminating the scintillator removes the scintillator decay from the instrument response function (IRF) and makes the detector faster; the MCP nTOF is the fastest nTOF detector currently in use on OMEGA
- The MCP nTOF is practically insensitive to DD neutrons and can be used only for yield and ion-temperature (T_i) measurements in high-yield DT shots
- The MCP nTOF was tested 5.3 m from the target, but will be permanently moved to 15.9 m to improve T_i measurement precision

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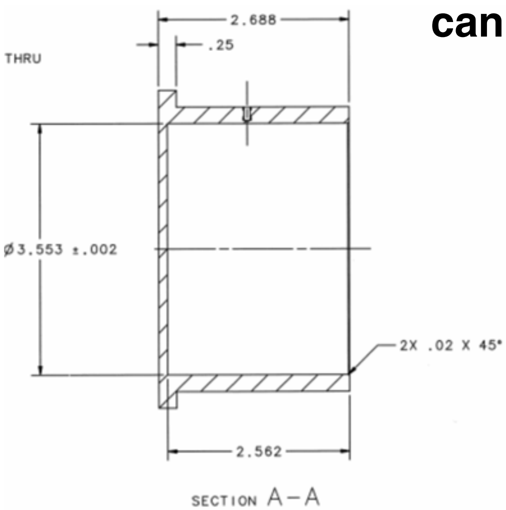
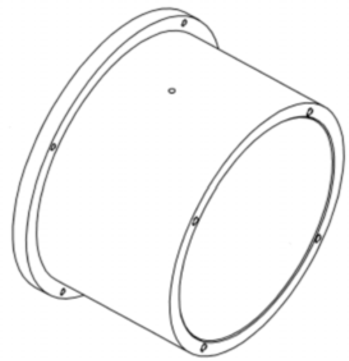
The MCP nTOF consists of a thin Al housing with a Photek* PMT140 photomultiplier

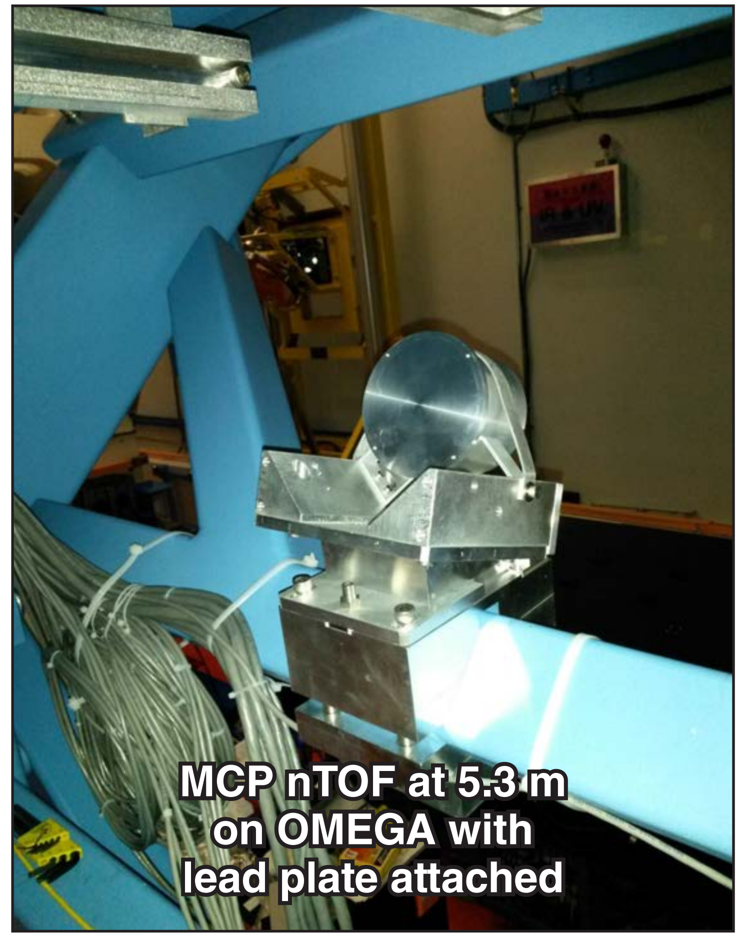


A 10-mm-thick lead plate can be attached in the front



Photek PMT140 single-stage MCP

- Hamamatsu MCP parameters
  - effective diameter: 42 mm
  - pore diameter: 10 μm
  - pore pitch: 12 μm
  - thickness: 0.5 mm



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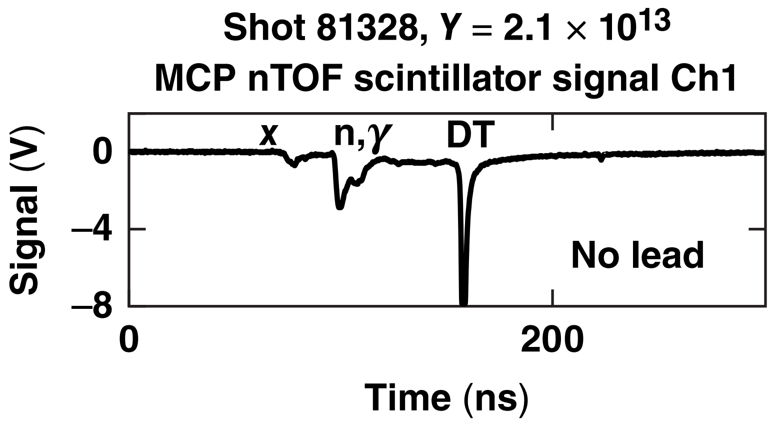
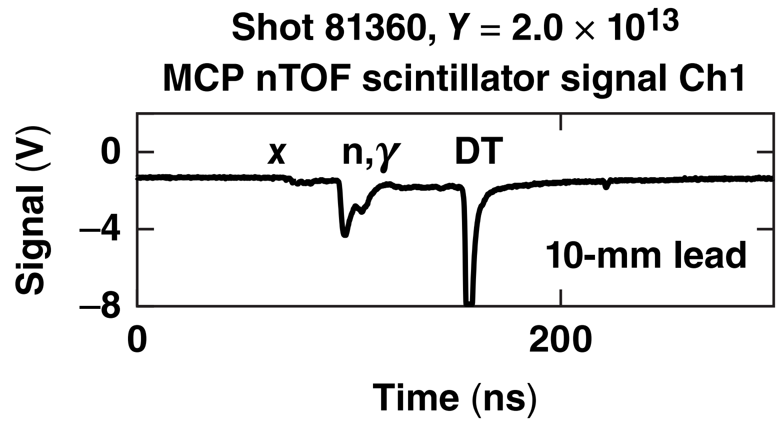
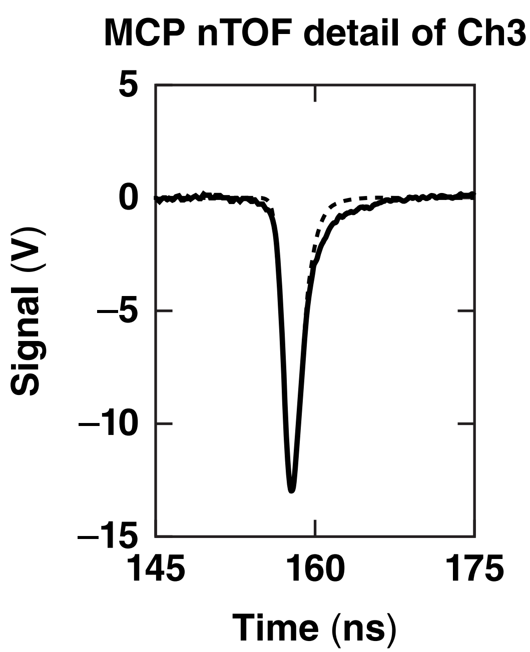
*Photek Ltd., East Sussex, UK TN38 9NS, see http://www.photek.com.

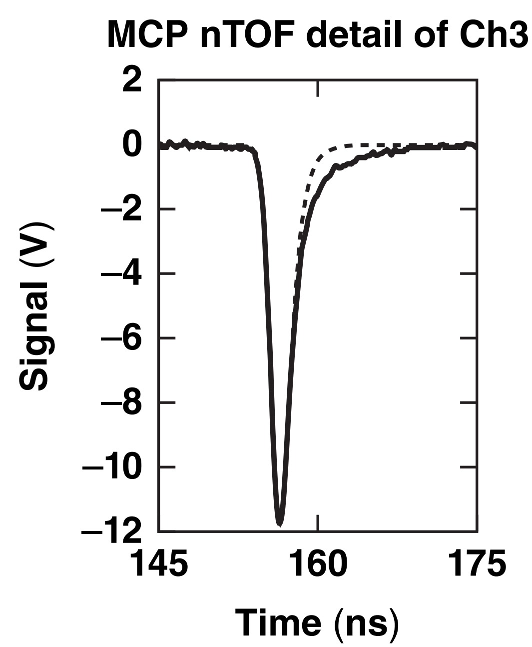
The MCP nTOF was tested on OMEGA at 5.3 m from the target with and without lead shielding







The MCP nTOF will be used with 10-mm lead shielding



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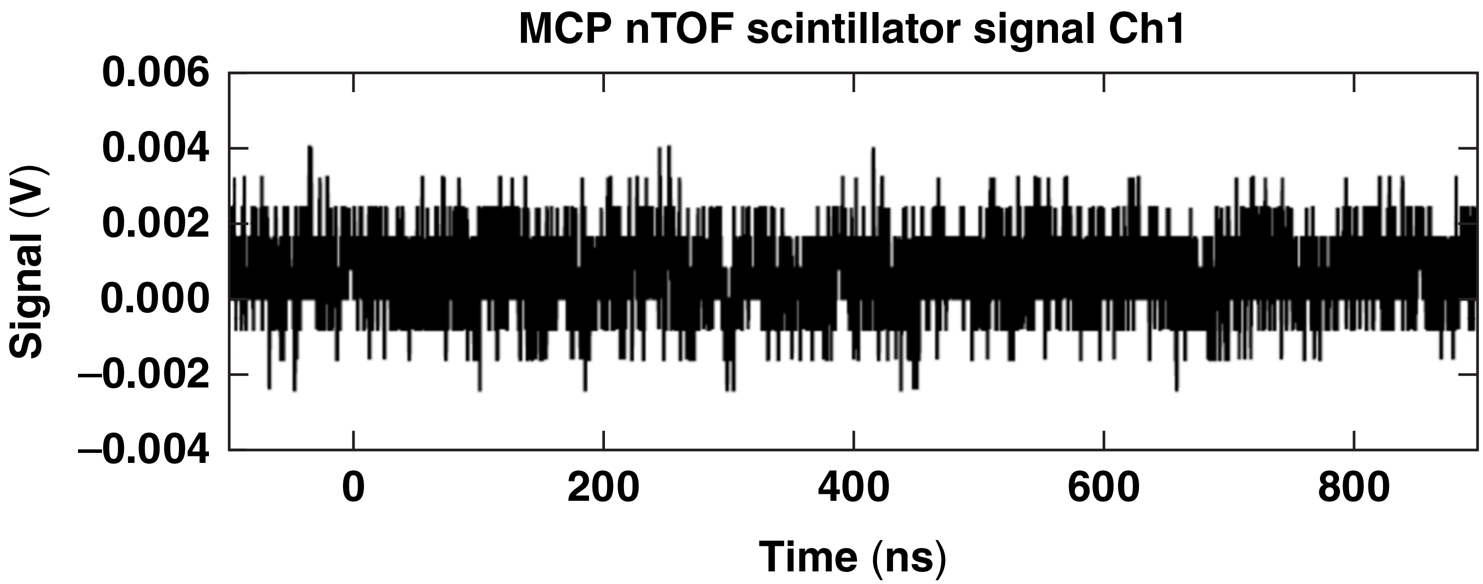
The MCP nTOF is practically insensitive to DD neutrons

Shot 81374 with a DD yield of 1.7×10^{11}



- The typical MCP lead glass* is 48% Pb, 25% O, and 18% Si
- Neutrons produced charge particles through (n, p) and (n, α) reactions
- For Pb, O, and Si threshold of proton and alpha production are above 2.5 MeV

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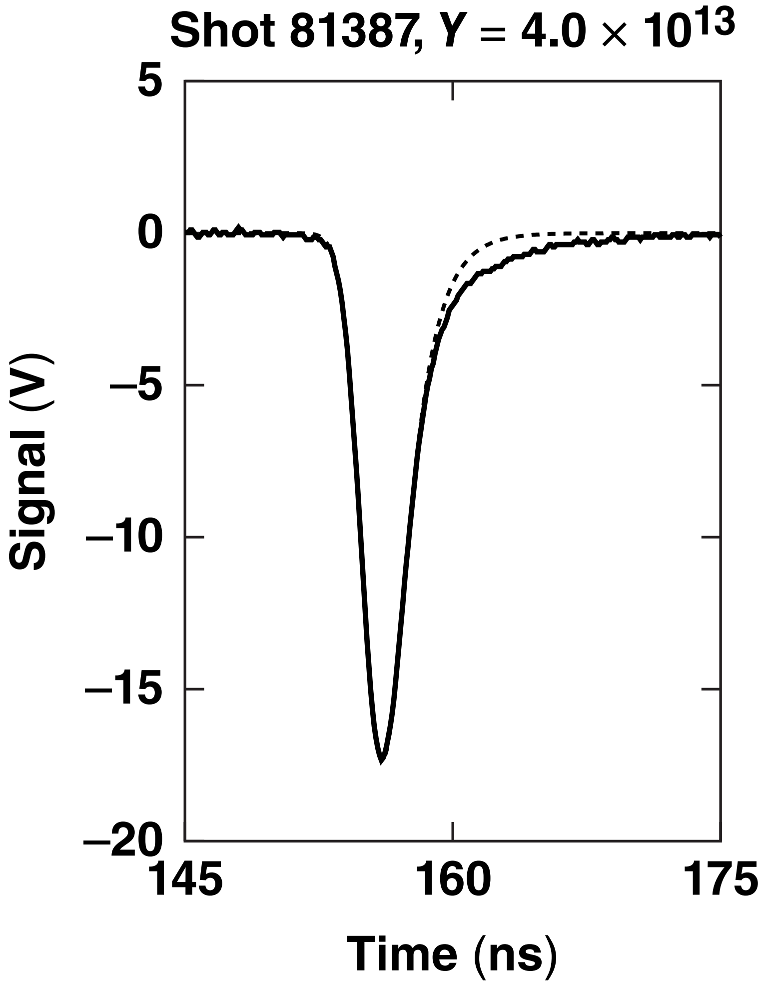
*S. S. Medley and R. Persing, Rev. Sci. Instrum. 52, 1463 (1981).

The MCP nTOF signal is fitted by a convolution of a Gaussian and an exponential decay function



- The PMT140 was run at –3.5 kV with a gain of ~40
- The signal was split into four channels of a DPO 7104 scope
- 20 m of LMR-400 cable was used
- The fit was used up to 50% of the falling slope

$$m(t) = \frac{A}{2\tau}\exp\left[-\frac{(t-t_1)}{\tau}\right]\times\exp\left(\frac{\sigma^2}{2}\right)\left\{1+\mathrm{erf}\left[\frac{(t-t_1)-\sigma^2/\tau}{\sqrt{2\sigma^2}}\right]\right\}^*$$

*T. J. Murphy *et al.*, Rev. Sci. Instrum 86, 610 (1997).

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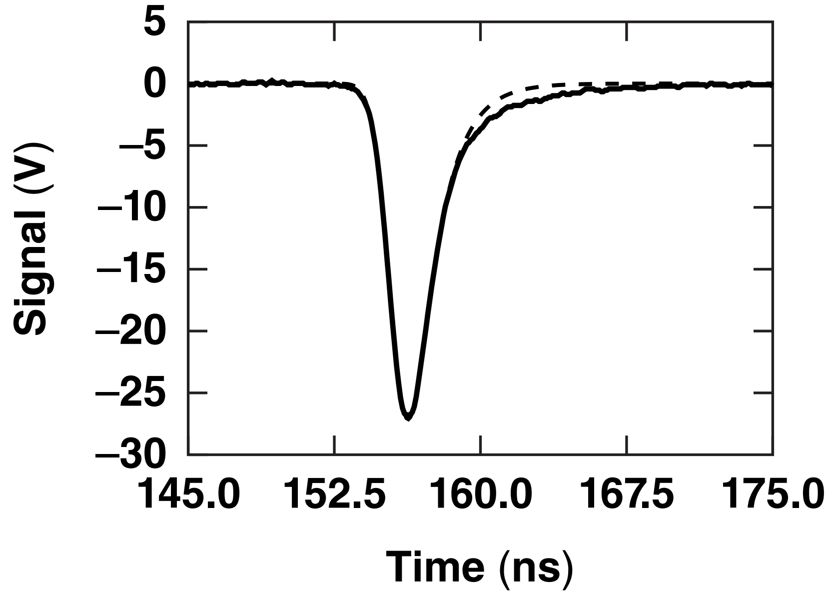
The current configuration of the MCP nTOF is the fastest nTOF detector on OMEGA

Shot 80552, DT, $T = 9.75 \times 10^{12}$, $T_i = 2.65$ keV

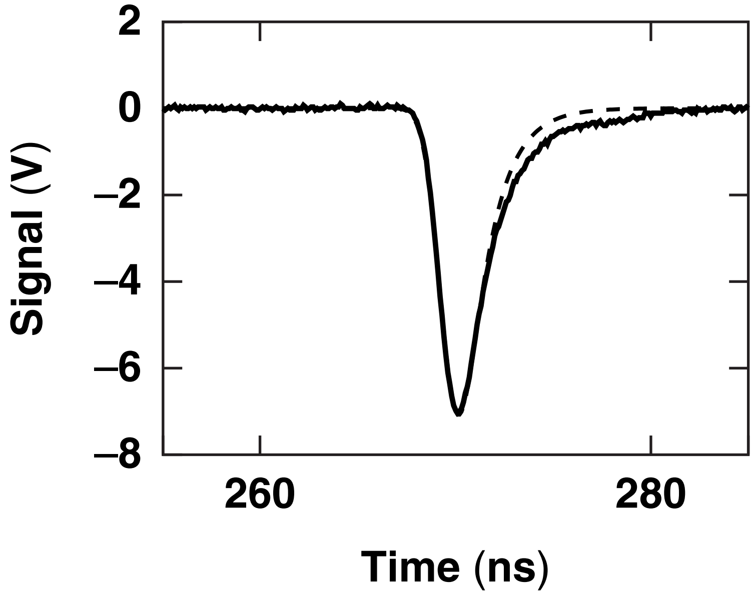
MCP nTOF at 5.3 m



Signal	Rise	Fall	FWHM**	Time
–61.58	0.76	1.33	2.50	155.554

$\chi = 0.13$	Response = 0.35 ns
$T_i = 7.41$	Charge 1 = 1638.13 pC

5.0-m CVD*



Signal	Rise	Fall	FWHM	Time
–15.92	0.75	1.33	2.60	269.426

$\chi = 0.41$	Response = 0.60 ns
$T_i = 7.39$	Charge 1 = 423.59 pC

*CVD: chemical-vapor deposition
**FWHM: full width at half maximum

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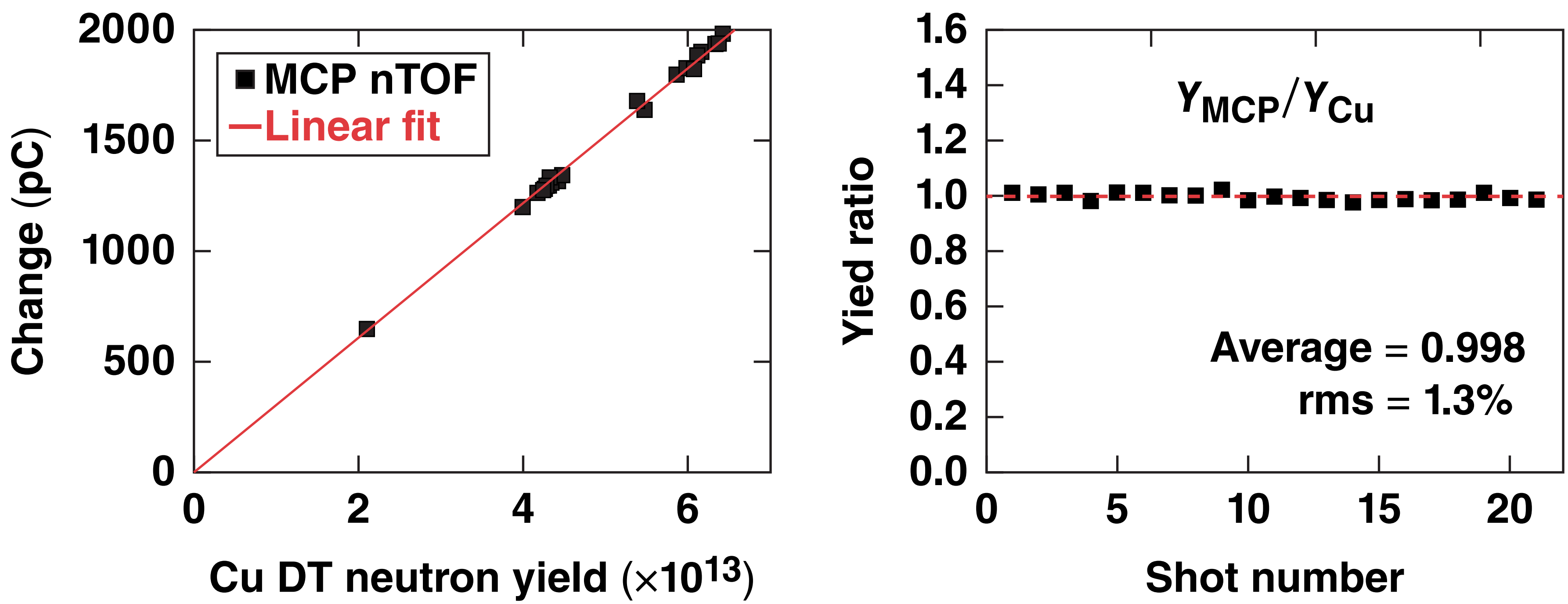
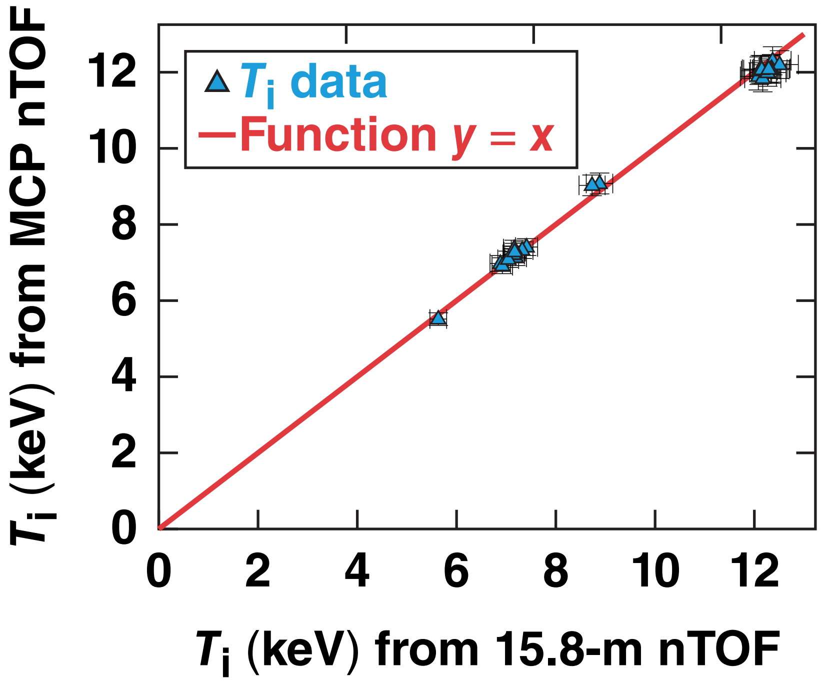
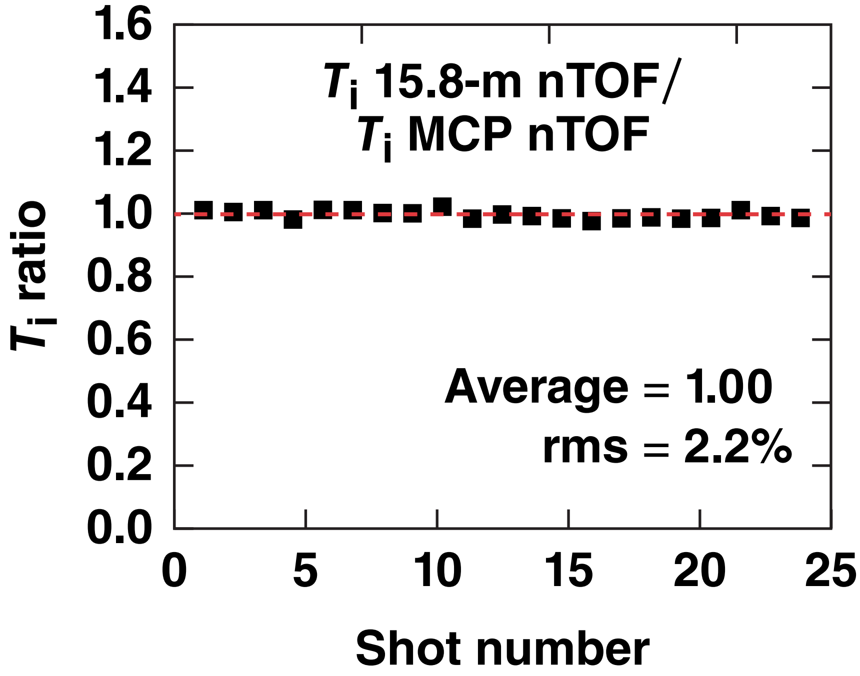
The yield inferred from the MCP nTOF was calibrated against the Cu activation diagnostic



All data are from the implosion of glass shell targets filled with DT.

The IRF of the MCP nTOF was adjusted to match the T_i of the 15.8-m nTOF detector





The MCP nTOF is a promising detector for T_i measurements.

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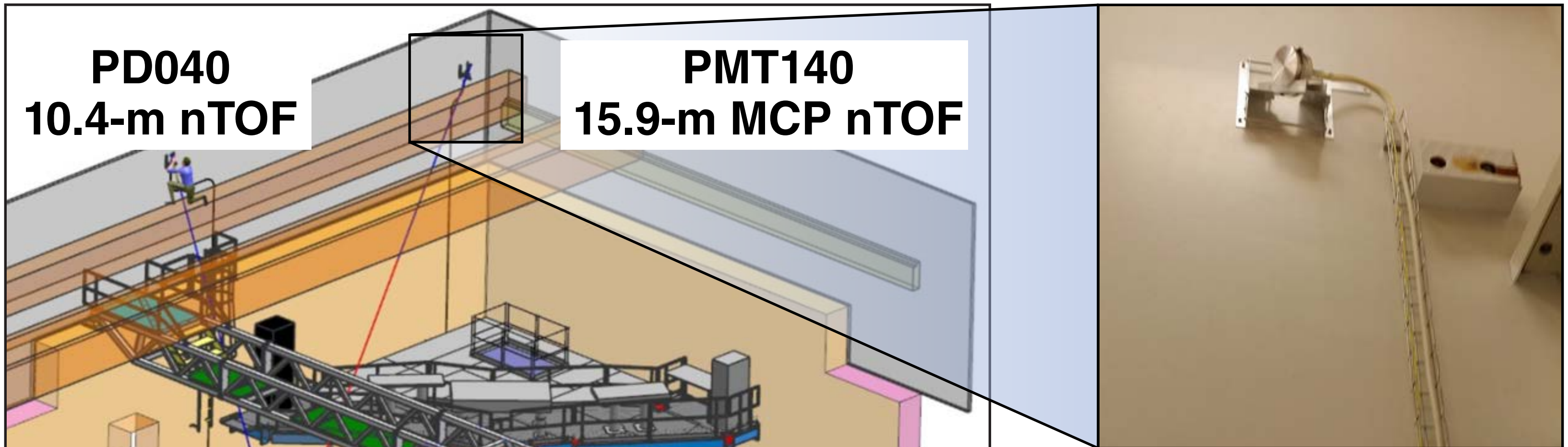
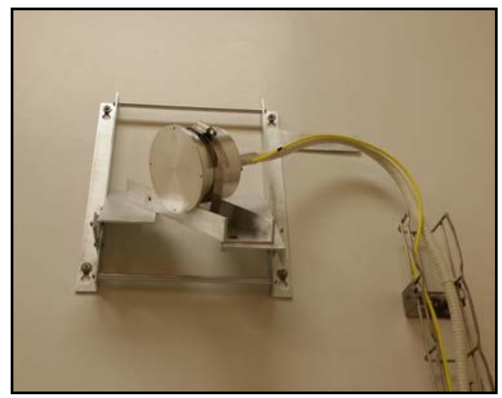
In May 2016 the MCP nTOF was permanently relocated to 15.9 m from target chamber center (TCC) in the P4F line of sight



OMEGA Target Bay



MCP nTOF installed

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Summary/Conclusions

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