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# A New Neutron Time-of-Flight Detector for $D_2$ Yield and Ion-Temperature Measurements on OMEGA

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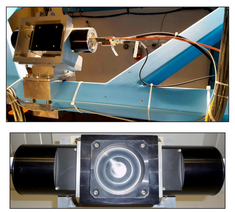
## Abstract

A new nTOF detector for $D_2$ yield and ion-temperature easurements on the OMEGA Laser System was designed, installed, and calibrated. The goal of this detector is to provide an additional line of sight for $D_2$ yield and ion-temperature measurements above the $1 \times 10^{10}$ yield range. The nTOF detector consists of a 90-mm-diam, 20-mm-thick BC-422 scintillator and a gated Photek photomultiplier tube (PMT)-240 photomultiplier tube. The PMT collects scintillating light through the 20-mm side of the scintillator without the use of a light guide. There is no lead shielding from hard x rays in order to allow the x-ray instrument response function of the detector. Hard x-ray signals generated in the implosion experiments are gated out by the PMT. There are slots for glass neutral-density filters between the scintillator and the PMT to avoid PMT saturation at high yield. The nTOF detector is installed in the OMEGA P8A sub-port line of sight at 5.3 m from the target chamber center (TCC) in the OMEGA Target Bay. In addition to $D_2$ measurements, the same detector is used to measure deuterium–tritium (DT) yield and ion temperature in the $5 \times 10^{10}$ to $1 \times 10^{12}$ yield range. The design details and the calibration results of this nTOF detector in both $D_2$ and DT implosions on OMEGA will be presented.

TC16076

## A new gated P8A 5.3-m nTOF detector was installed on OMEGA in P8A sub-port line of sight at 5.3 m from TCC

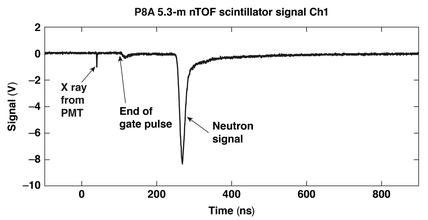


- P8A sub-port, 5.3 m from TCC
- Uncollimated line of sight
- BC-422 scintillator: 90 mm × 20 mm
- Up to two gated PMT-240's
- Slots for glass ND filters
- No lead shielding (x-ray IRF)
- HV - 4.4 kV, $2 \times 10^5$ gain for DD
- HV - 3.6 kV, $6 \times 10^3$ gain for DT
- Tektronix 1-GHz, 10-GS/s scope
- 20-m-long LMR-400 cable

ND: neutral density
IRF: instrument response function
HV: high voltage

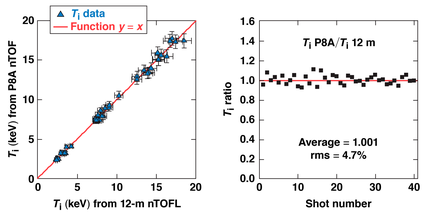
TC16078

## Example of the scope trace from the P8A 5.3-m nTOF detector for $D_2$ shot 98130 with yield $2.15 \times 10^{11}$



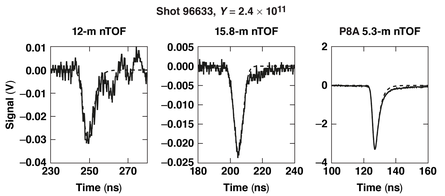

TC16080

## The P8A 5.3-m nTOF detector was calibrated in $D_2$ ion temperature against a 12-m nTOFL detector




TC16082

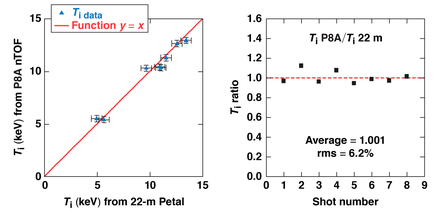
## The P8A 5.3-m nTOF detector is useful for low-yield DT shots on OMEGA




There are not enough nTOF detectors for low-yield DT in the range from $1 \times 10^{11}$ to $1 \times 10^{12}$ on OMEGA. The 12-m nTOFN and 15.8-m nTOF have low neutron statistics and high electromagnetic pulse (EMP) noise below $1 \times 10^{12}$. The P8A 5.3-m nTOF detector will cover the DT yield range from $5 \times 10^{10}$ to $1 \times 10^{12}$.

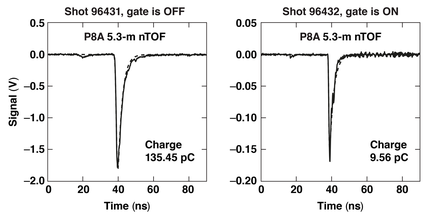
TC16084

## The P8A 5.3-m nTOF detector was calibrated in DT ion temperature against a 22-m nTOF Petal detector




TC16086

## Comparison of two shots with the same hard x-ray signal and PMT gate of the detector "OFF" and "ON"

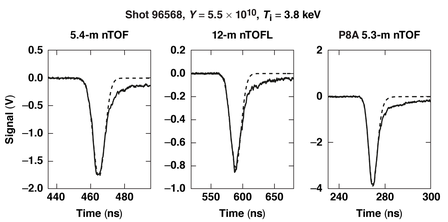



Only 7% (9.56/135.45) of hard x-ray signal is from direct interaction with the MCP inside the PMT.

MCP: microchannel plate

TC16079

## Comparison of neutron signals from three $D_2$ nTOF detectors




The P8A 5.3-m nTOF is more sensitive than the 5.4-m nTOF and 12-m nTOFL detectors.

TC16081

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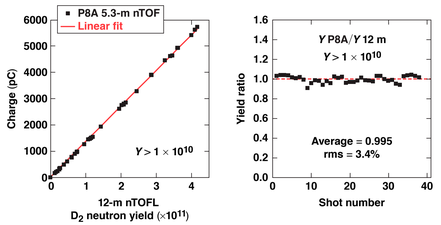
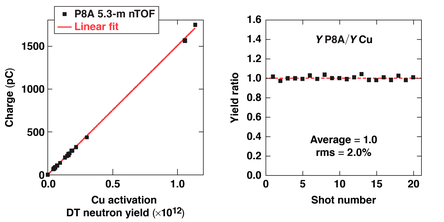



TC16083

## The P8A 5.3-m nTOF detector was calibrated in DT yield against a Cu activation yield




TC16085

Summary/Conclusion

## A new nTOF detector designed for $D_2$ and low DT neutron measurements was installed and calibrated on OMEGA

- A gated unshielded P8A 5.3-m nTOF detector is now operational in $D_2$ and low DT shots in uncollimated line of sight on OMEGA
- Gated x rays do not affect $D_2$ neutron measurements
- Calibration demonstrated good $D_2$ yield and $T_i$ precision above $1 \times 10^{10}$ yield
- The P8A 5.3-m nTOF detector is used at DT yields below $1 \times 10^{12}$

TC16087

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A new nTOF detector for $D_2$ yield and ion-temperature easurements on the OMEGA Laser System was designed, installed, and calibrated. The goal of this detector is to provide an additional line of sight for $D_2$ yield and ion-temperature measurements above the $1 \times 10^{10}$ yield range. The nTOF detector consists of a 90-mm-diam, 20-mm-thick BC-422 scintillator and a gated Photek photomultiplier tube (PMT)-240 photomultiplier tube. The PMT collects scintillating light through the 20-mm side of the scintillator without the use of a light guide. There is no lead shielding from hard x rays in order to allow the x-ray instrument response function of the detector. Hard x-ray signals generated in the implosion experiments are gated out by the PMT. There are slots for glass neutral-density filters between the scintillator and the PMT to avoid PMT saturation at high yield. The nTOF detector is installed in the OMEGA P8A sub-port line of sight at 5.3 m from the target chamber center (TCC) in the OMEGA Target Bay. In addition to $D_2$ measurements, the same detector is used to measure deuterium–tritium (DT) yield and ion temperature in the $5 \times 10^{10}$ to $1 \times 10^{12}$ yield range. The design details and the calibration results of this nTOF detector in both $D_2$ and DT implosions on OMEGA will be presented.

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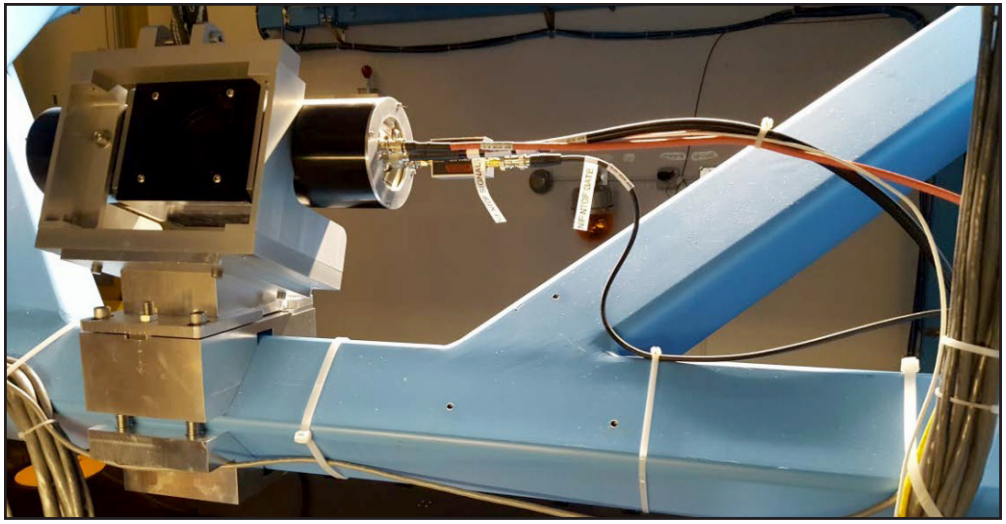

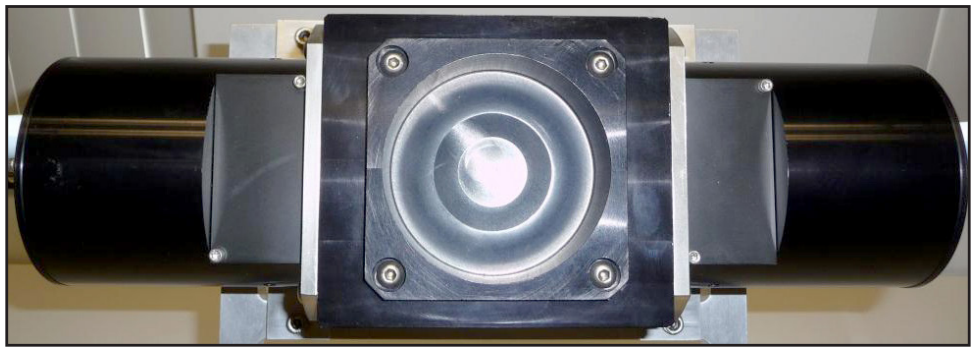

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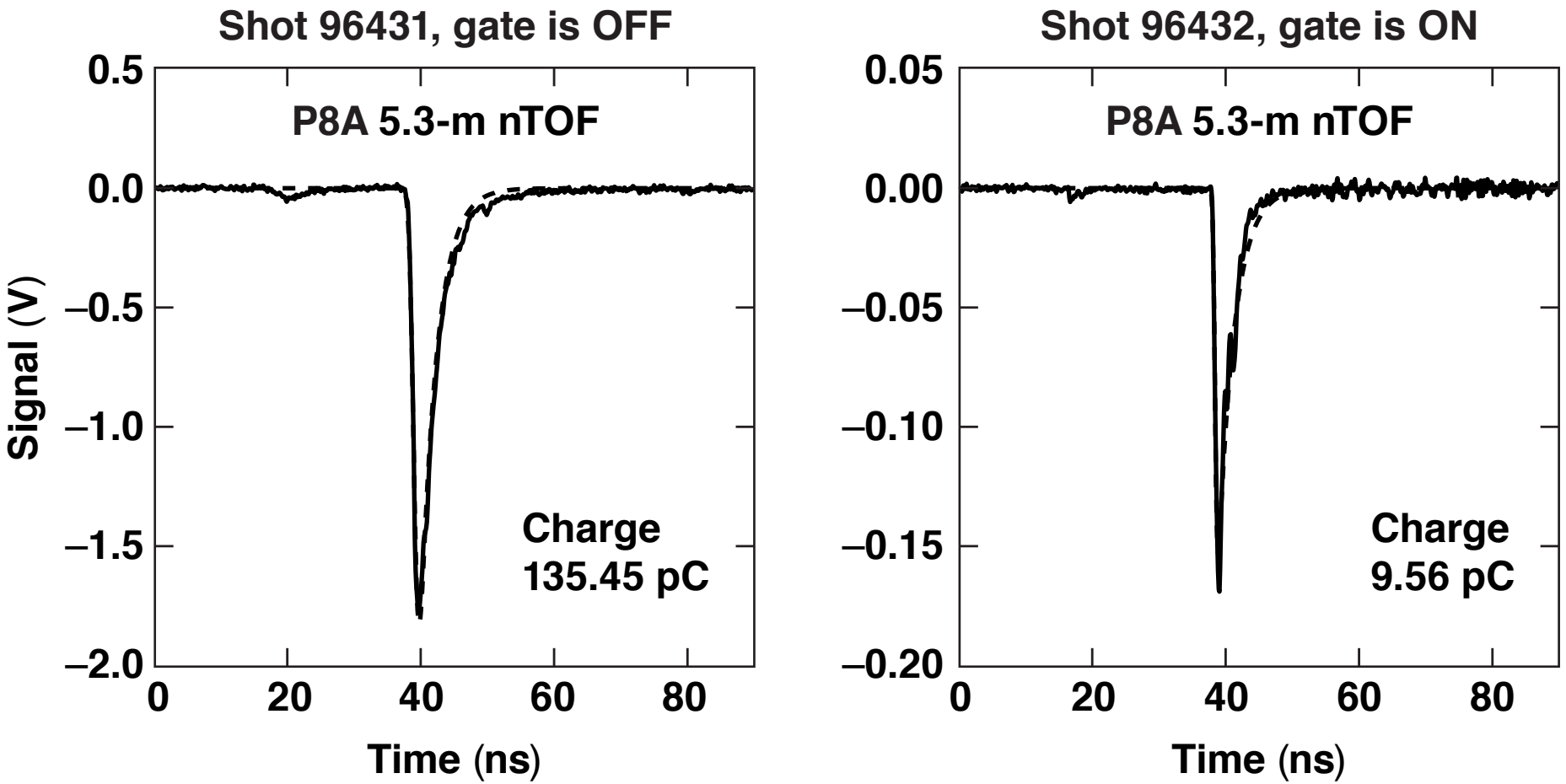


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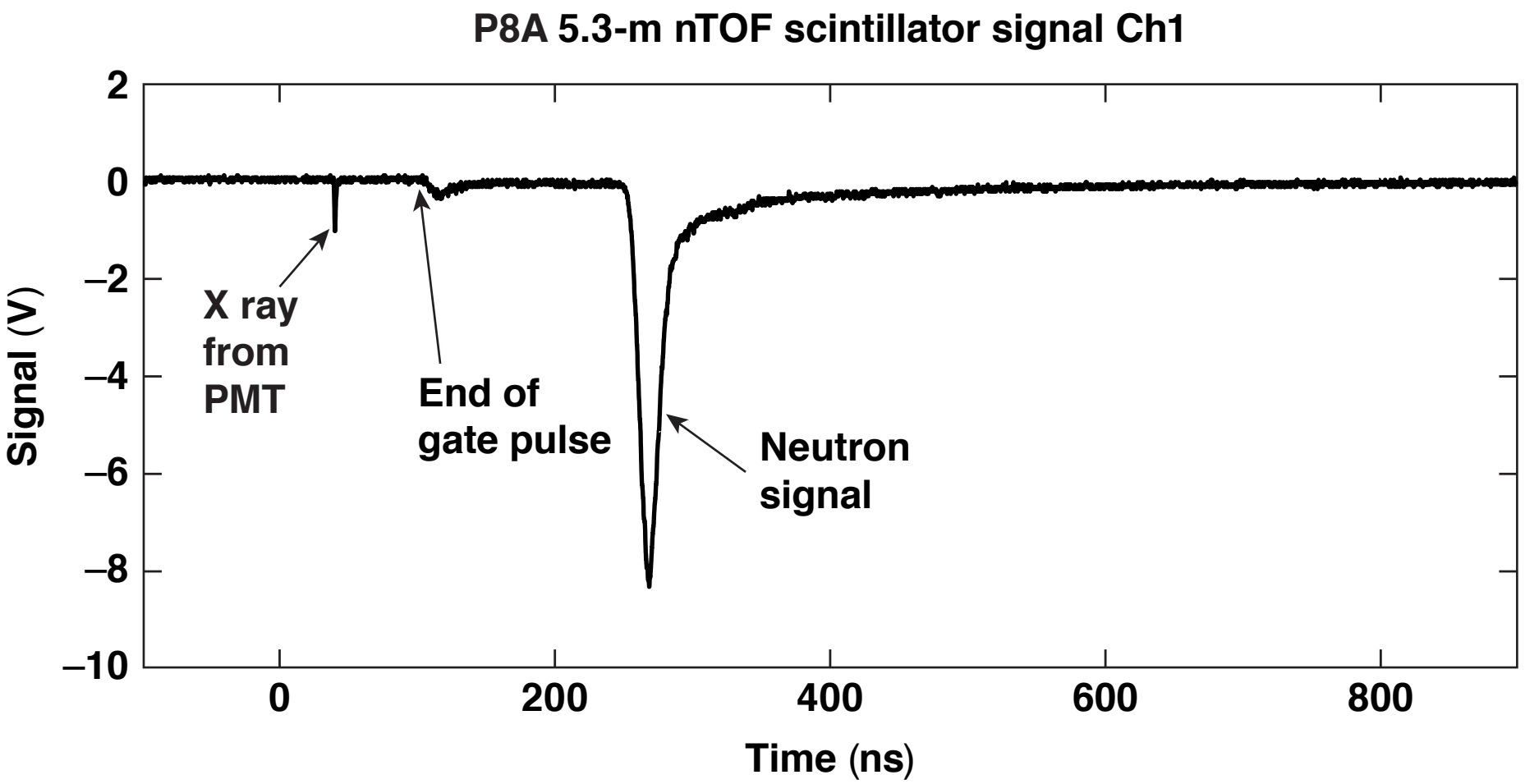
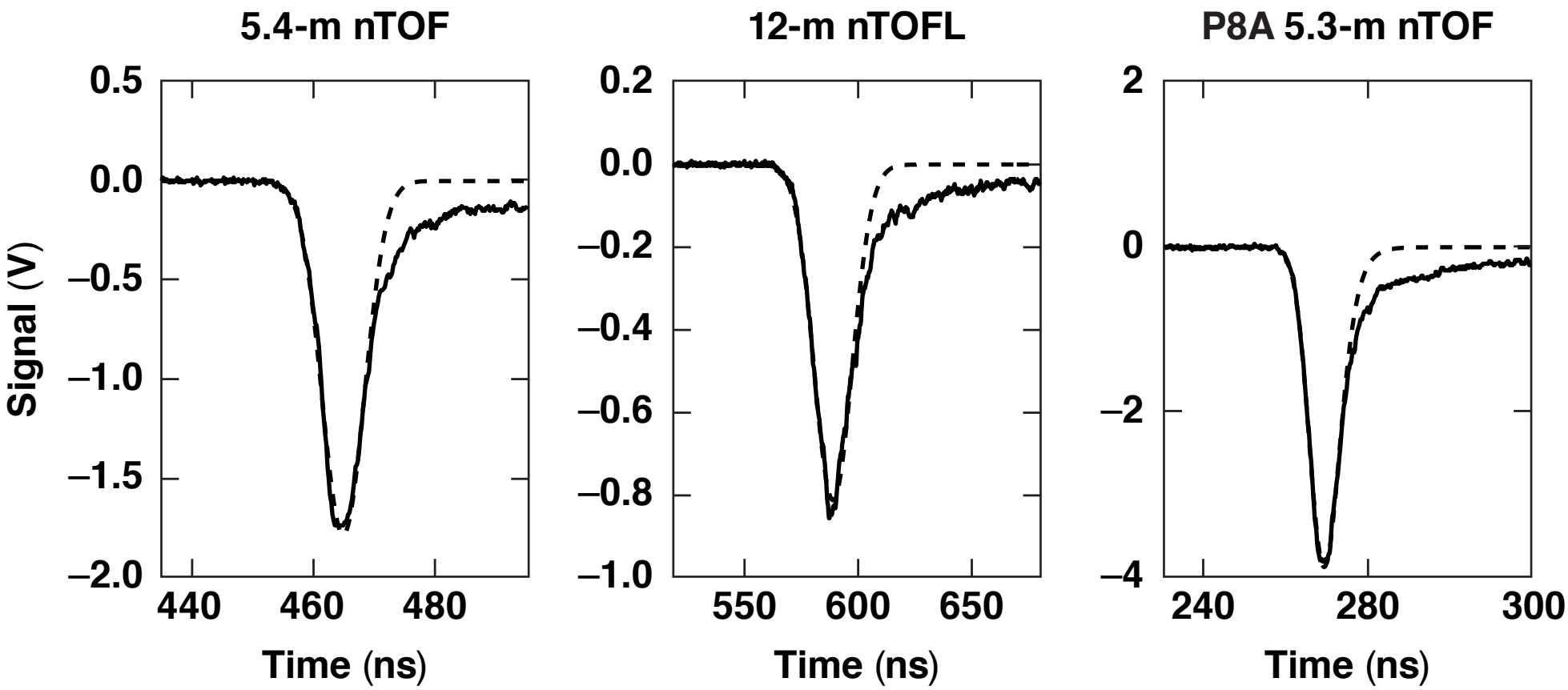



TC16080

# Comparison of neutron signals from three $D_2$ nTOF detectors

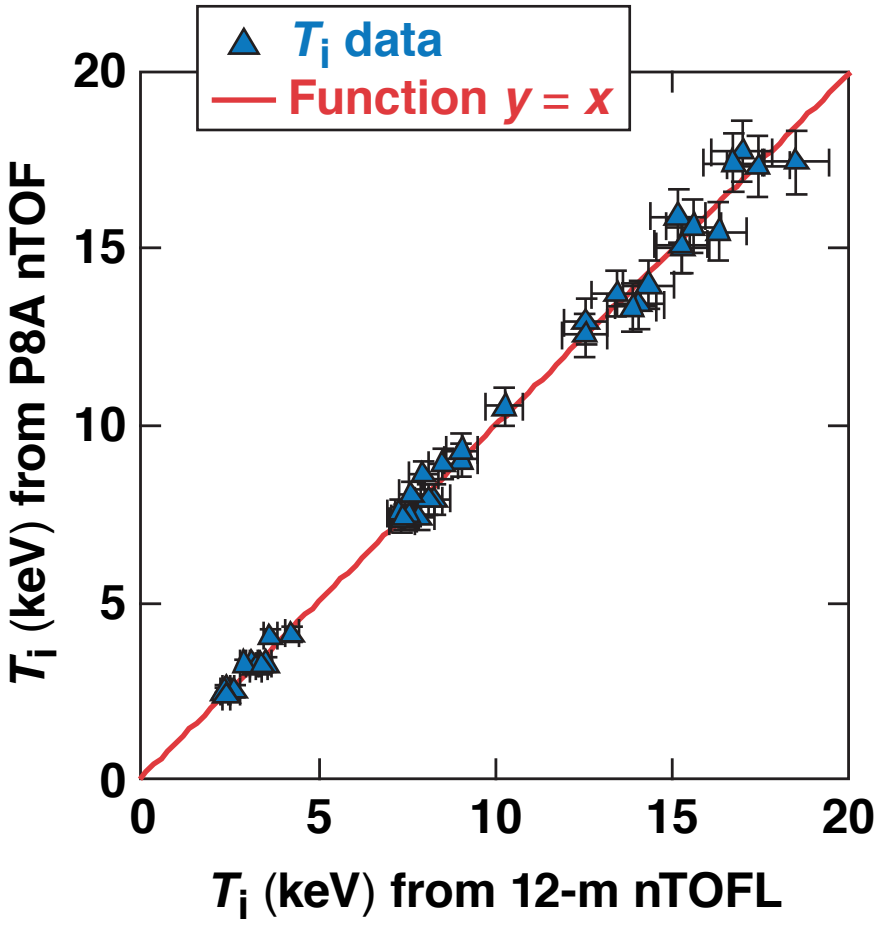
Shot 96568, $Y = 5.5 \times 10^{10}$, $T_i = 3.8$ keV

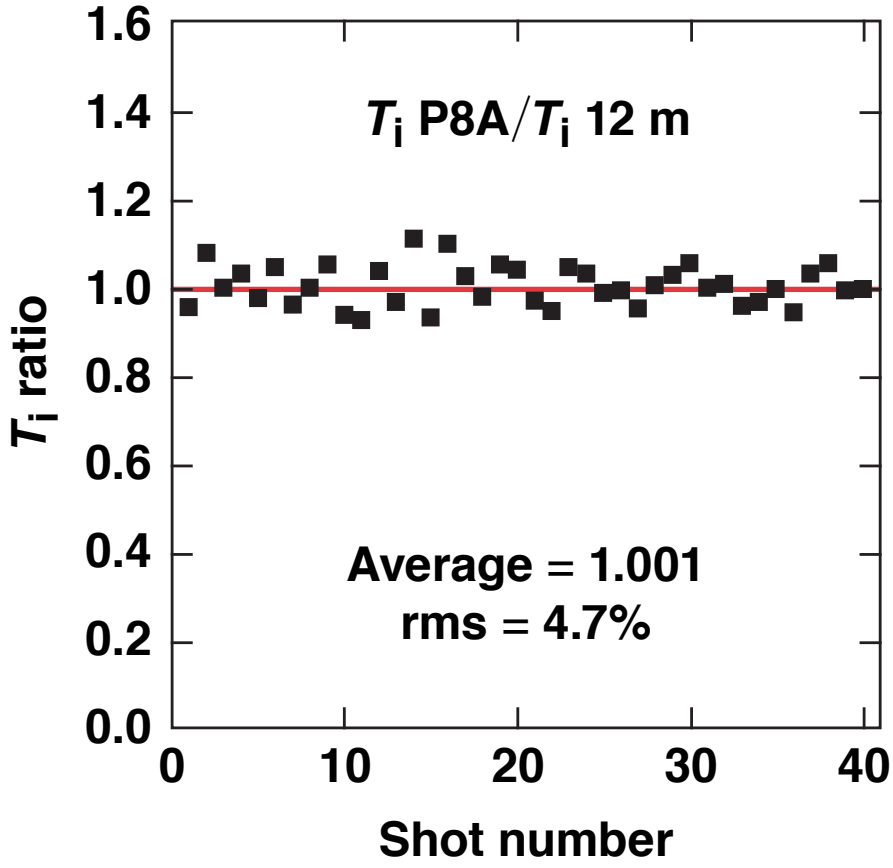



**The P8A 5.3-m nTOF is more sensitive than the 5.4-m nTOF and 12-m nTOFL detectors.**

TC16081

# The P8A 5.3-m nTOF detector was calibrated in $D_2$ ion temperature against a 12-m nTOFL detector




TC16082

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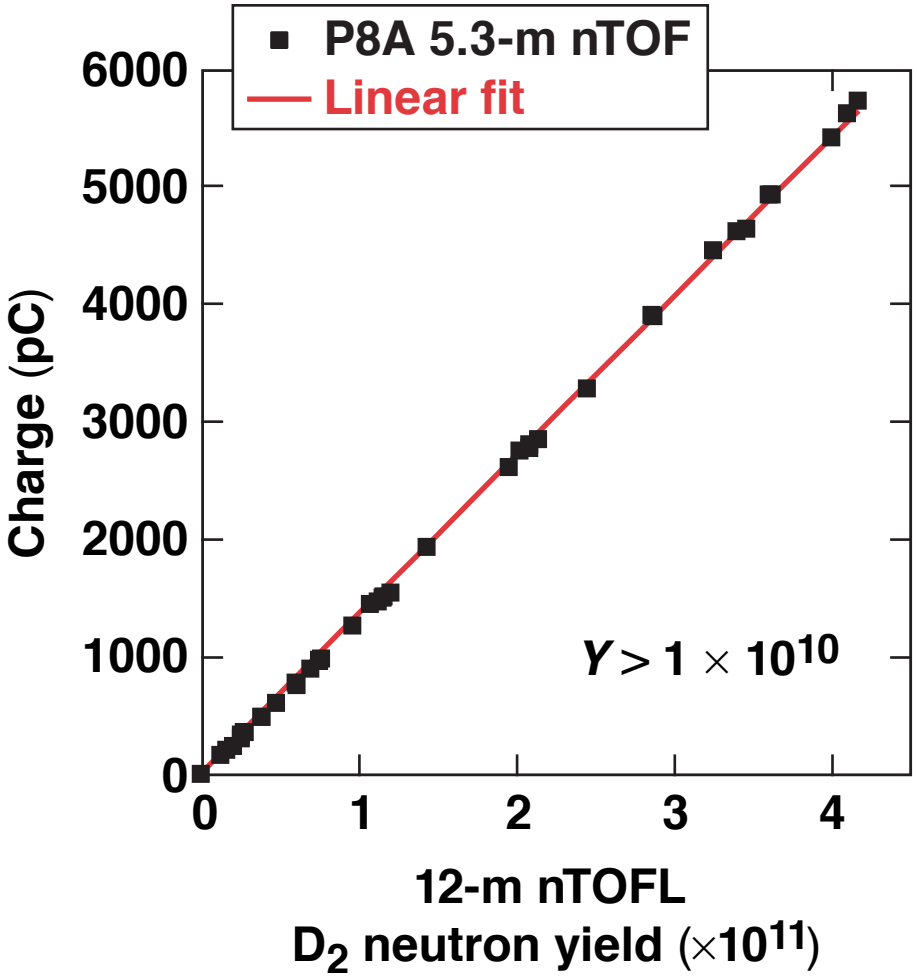
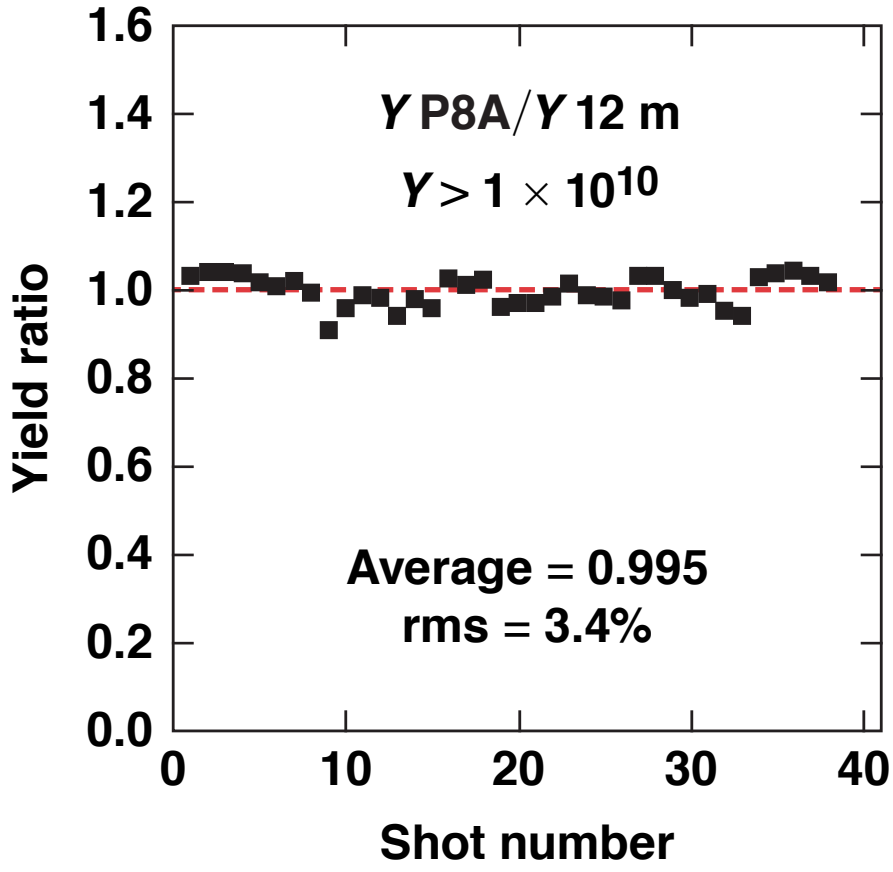
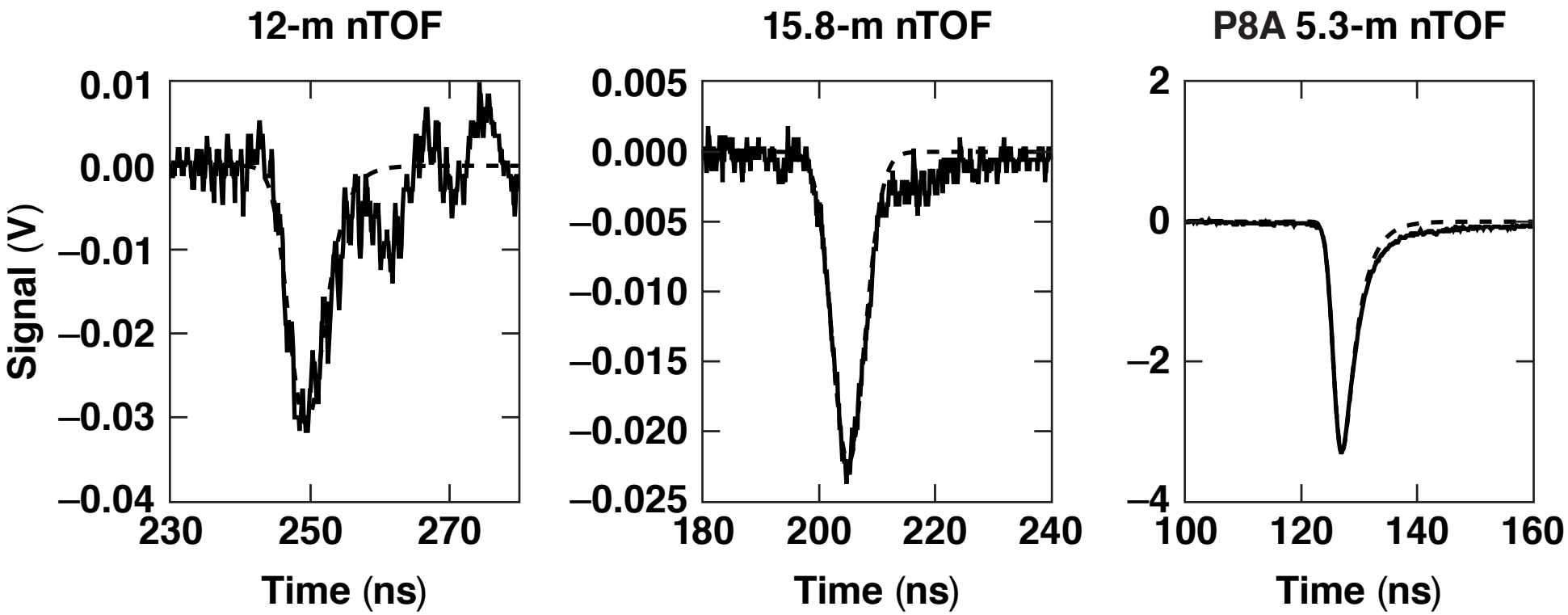



TC16083

# The P8A 5.3-m nTOF detector is useful for low-yield DT shots on OMEGA

Shot 96633, $Y = 2.4 \times 10^{11}$




There are not enough nTOF detectors for low-yield DT in the range from $1 \times 10^{11}$ to $1 \times 10^{12}$ on OMEGA. The 12-m nTOFN and 15.8-m nTOF have low neutron statistics and high electromagnetic pulse (EMP) noise below $1 \times 10^{12}$. The P8A 5.3-m nTOF detector will cover the DT yield range from $5 \times 10^{10}$ to $1 \times 10^{12}$.

TC16084

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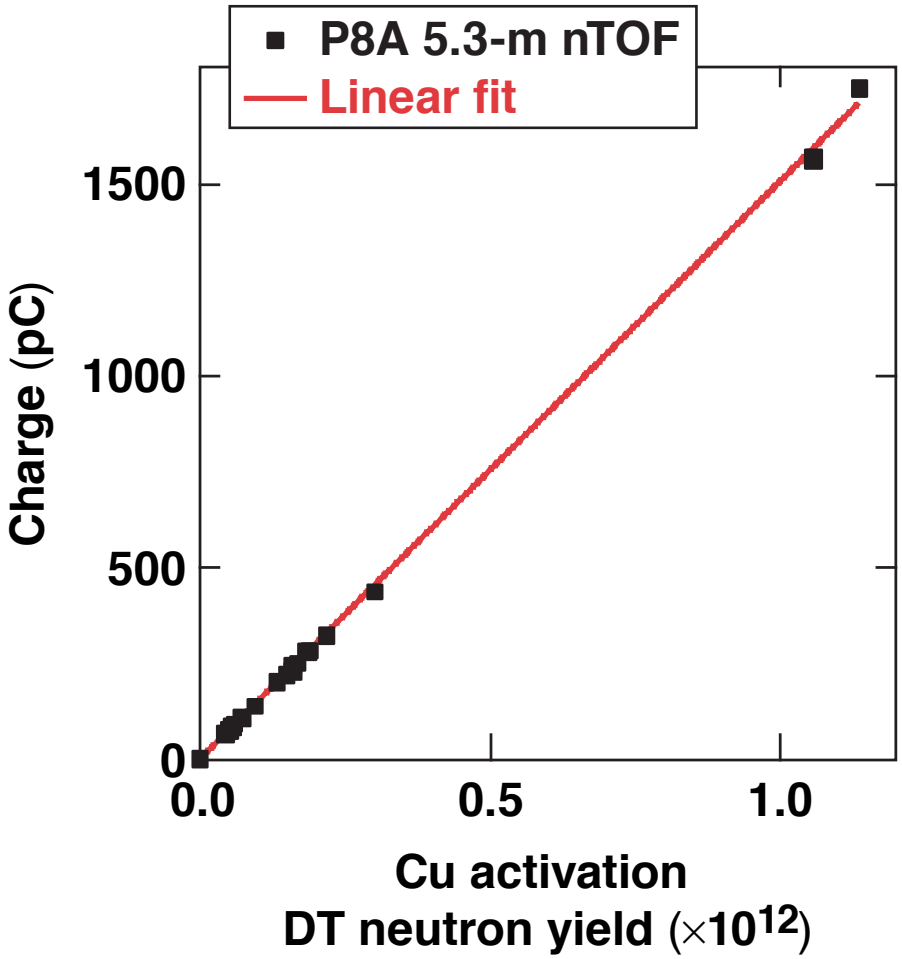
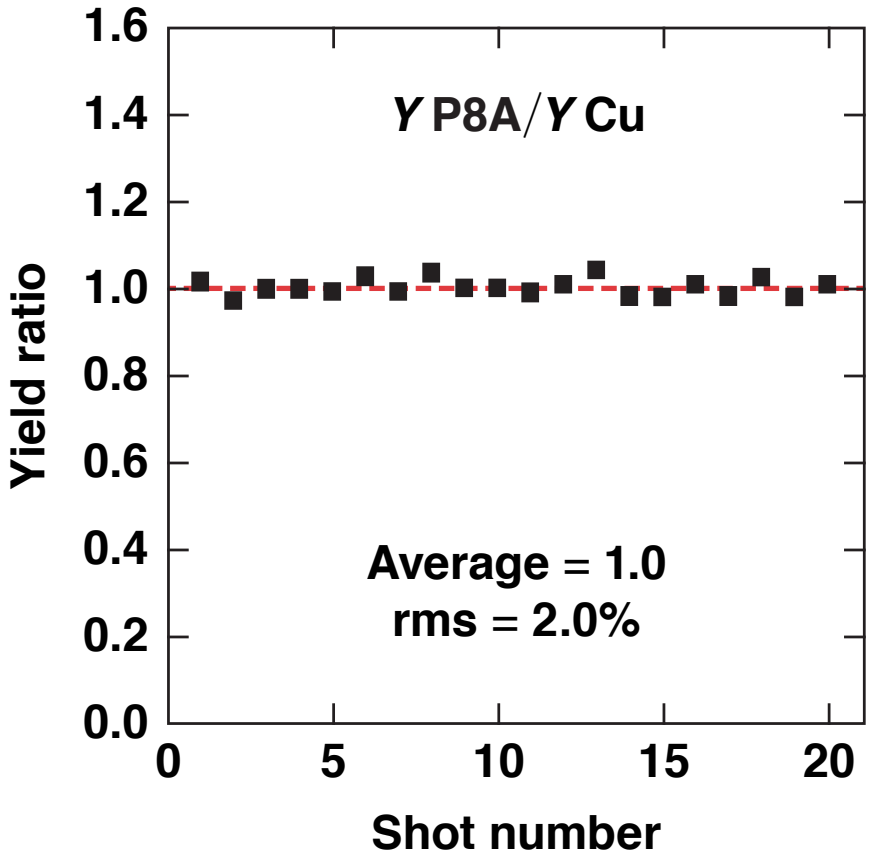
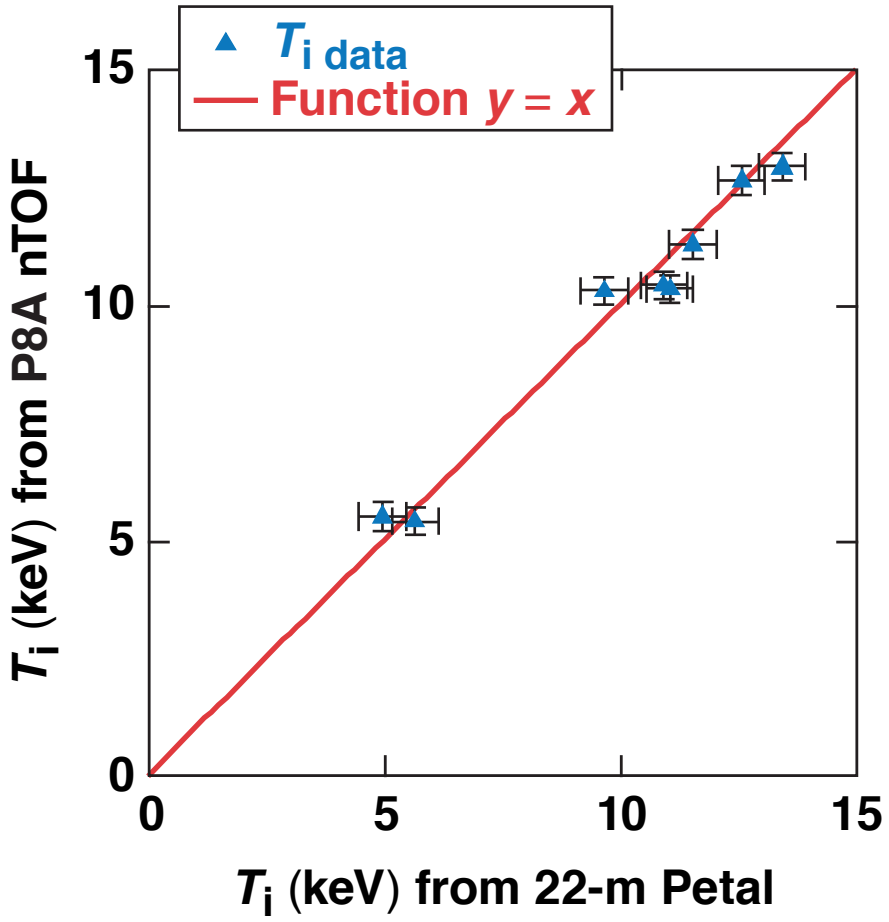
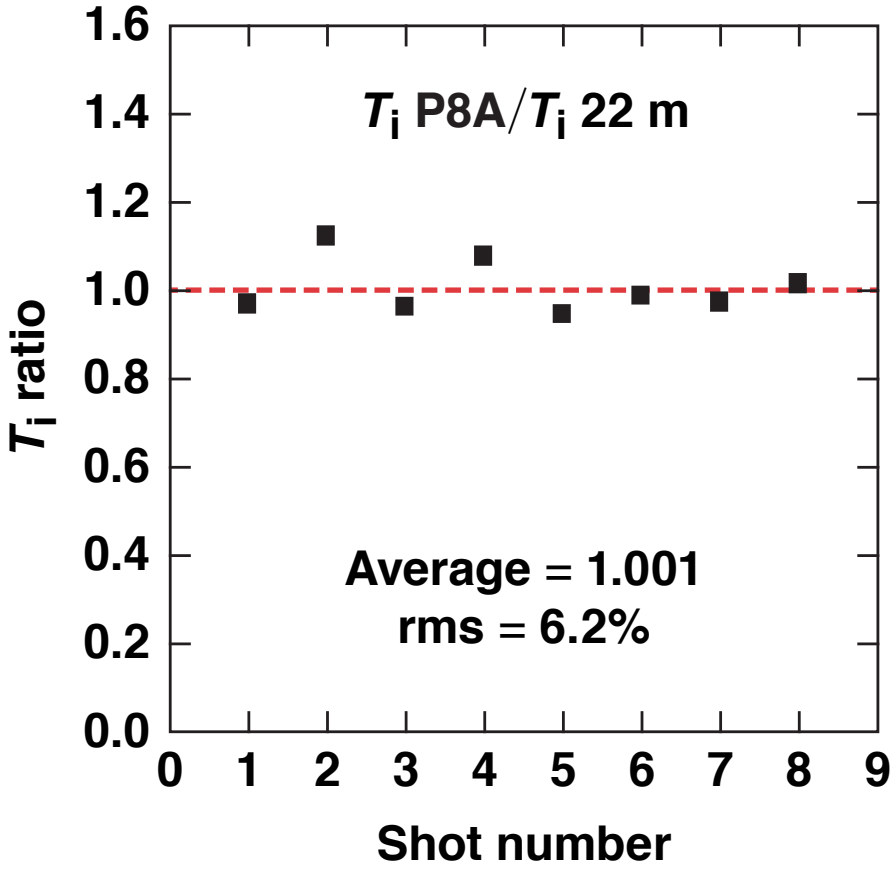



TC16085

# The P8A 5.3-m nTOF detector was calibrated in DT ion temperature against a 22-m nTOF Petal detector

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