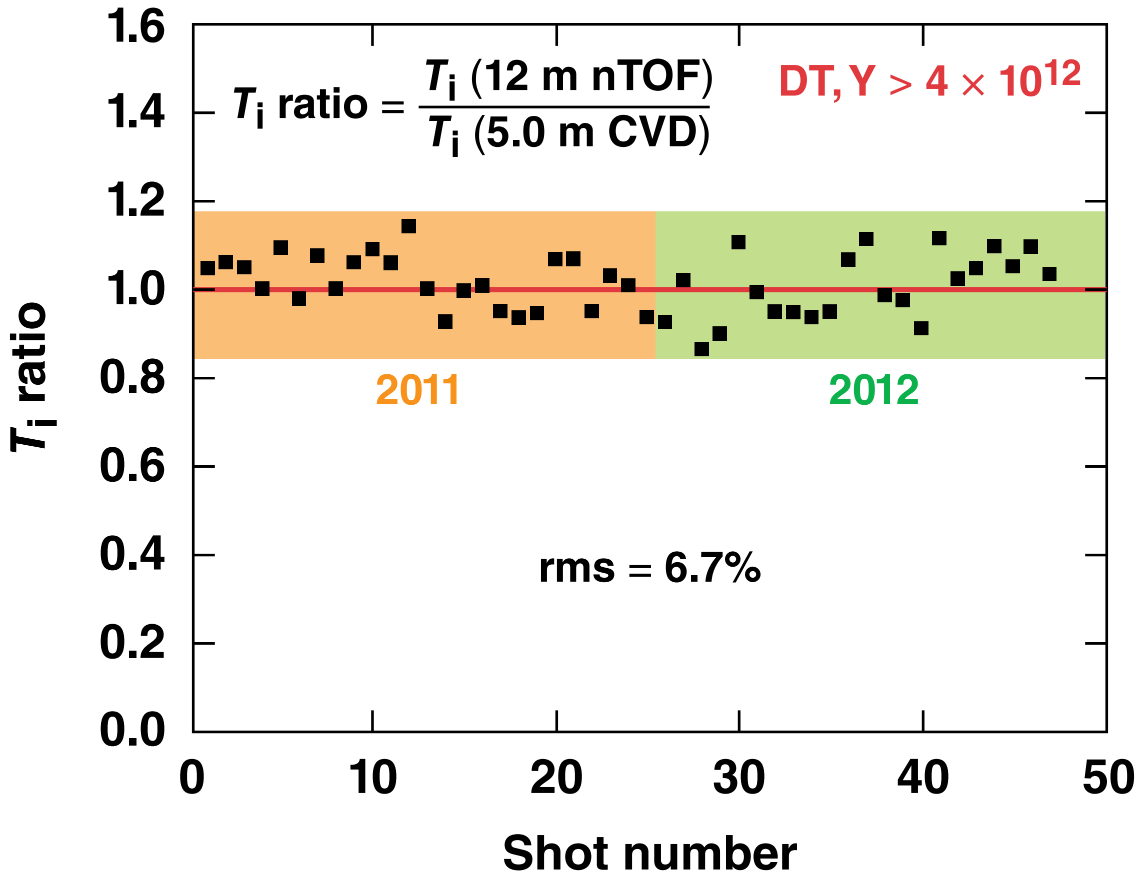
Absolute Ion-Temperature Measurements in Inertial Confinement Fusion (ICF) Implosions on OMEGA



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Summary

The ion temperature in D_2 and DT implosions on OMEGA is measured with better than 10% accuracy

- Several neutron time-of-flight (nTOF) detectors with different instrumentation, sensitivity, and distance from a target are used on OMEGA to measure ion temperature
- The instrument response function (IRF) for D_2 neutrons was constructed from x-ray measurements with better than 10% accuracy
- The instrument response function (IRF) for DT neutrons was measured directly with better than 5% accuracy

Collaborators

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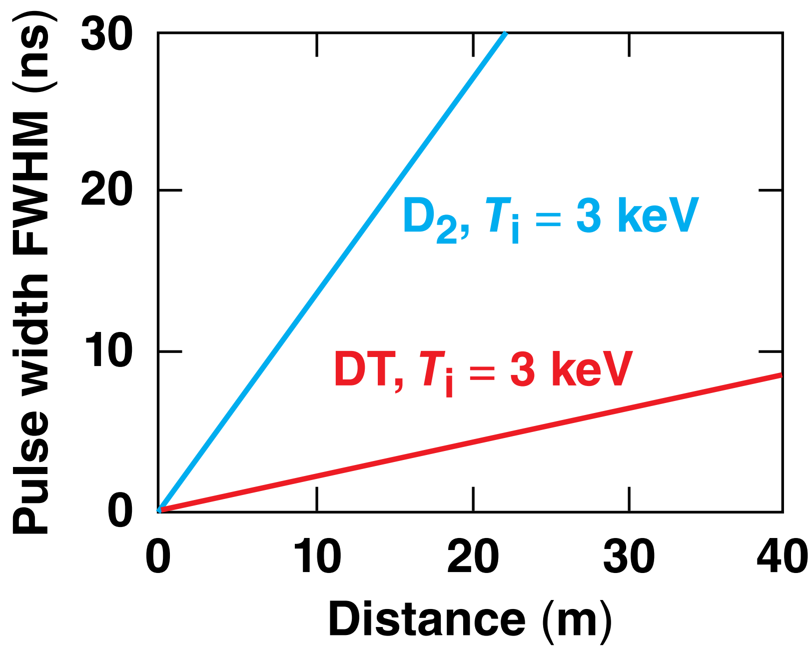
Many factors contribute to ion temperature measurements by neutron time-of-flight (TOF) detectors

- Ion temperature transforms by TOF into temporal width Δt (ps) that depends on*
  - ion temperature, T_i (keV)
  - detector distance, d (meters)
  - neutron type

    DT $\Delta t = 122 d \sqrt{T_i}$

    D_2 $\Delta t = 778 d \sqrt{T_i}$

- Fast detectors, large distances, and high neutron statistics are required for ion temperature measurements



Precision measurement or construction of instrument response function (IRF) is necessary for absolute measurement of T_i.

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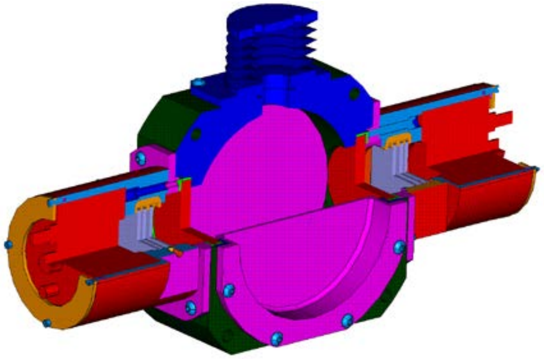
*H. Brysk, Plasma Phys. 15, 611 (1973).

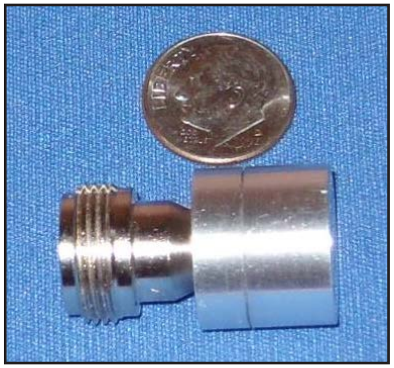
The OMEGA nTOF system consists of several detectors based on three different techniques

- Plastic scintillator (BC-422 or BC-422Q) coupled with a gated photomultiplier tube (PMT) or photodiode

- Oxygen-saturated liquid scintillator with gated PMT

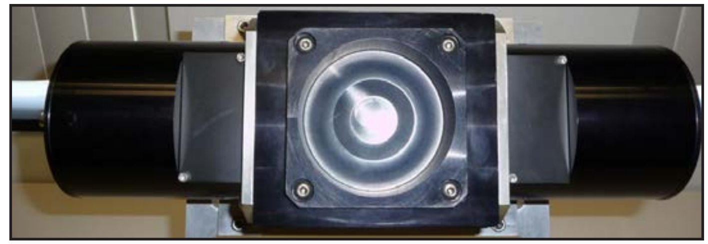


- Detectors based on chemical-vapor-deposition (CVD) diamonds

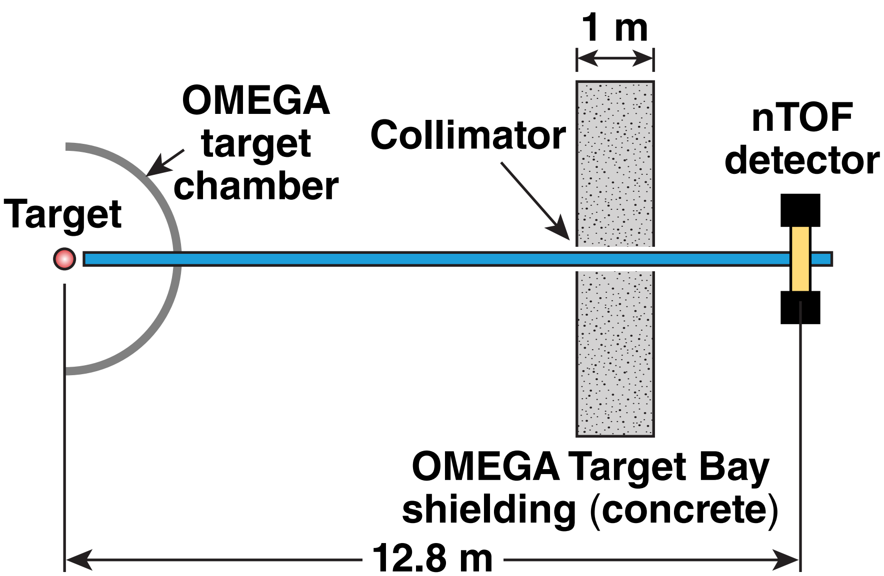


The nTOF3.5×1 detector was used for ion temperature measurements in D_2 implosions

- 90 × 20 mm BC-422 plastic scintillator
- Two gated PMT-240 for D_2 measurements
- Short (4 m) LMR-600 cables
- Two DPO 7104 scopes with 100 ps sampling
- No shielding, can measure x ray IRF



The nTOF3.5×1 detector can be installed in TIM6 collimated LOS



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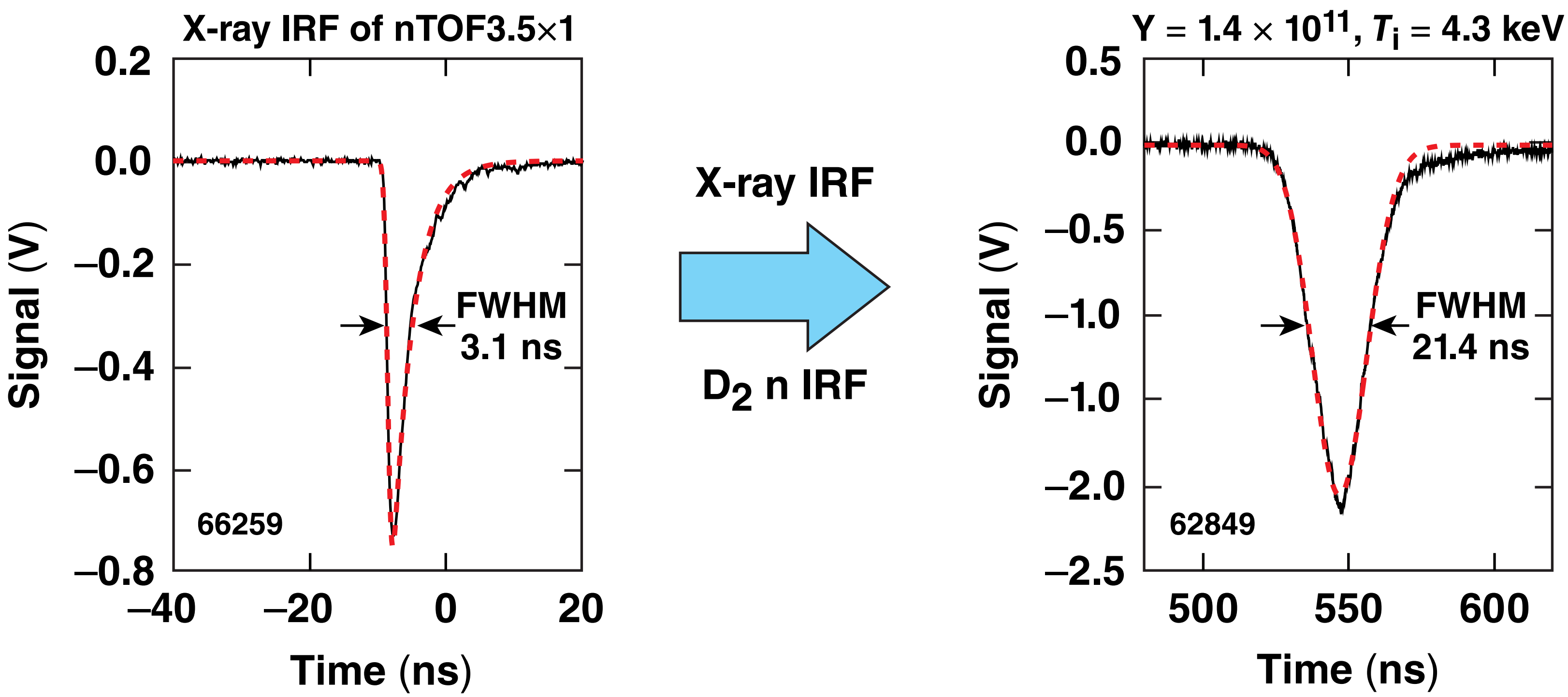
The IRFs of nTOF detectors for D_2 ion temperature measurements were constructed in multiple steps

- The x-ray IRF for nTOF3.5×1 detector was measured with an 100 ps x-ray pulse
- The x-ray IRF was converted to neutron IRF with propagation corrections
- Ion temperature was measured with nTOF3.5×1 detector
- The IRF of 12m nTOFL was adjusted to match nTOF3.5×1 T_i values



Estimated error of this multi-step process is ~ 8%.

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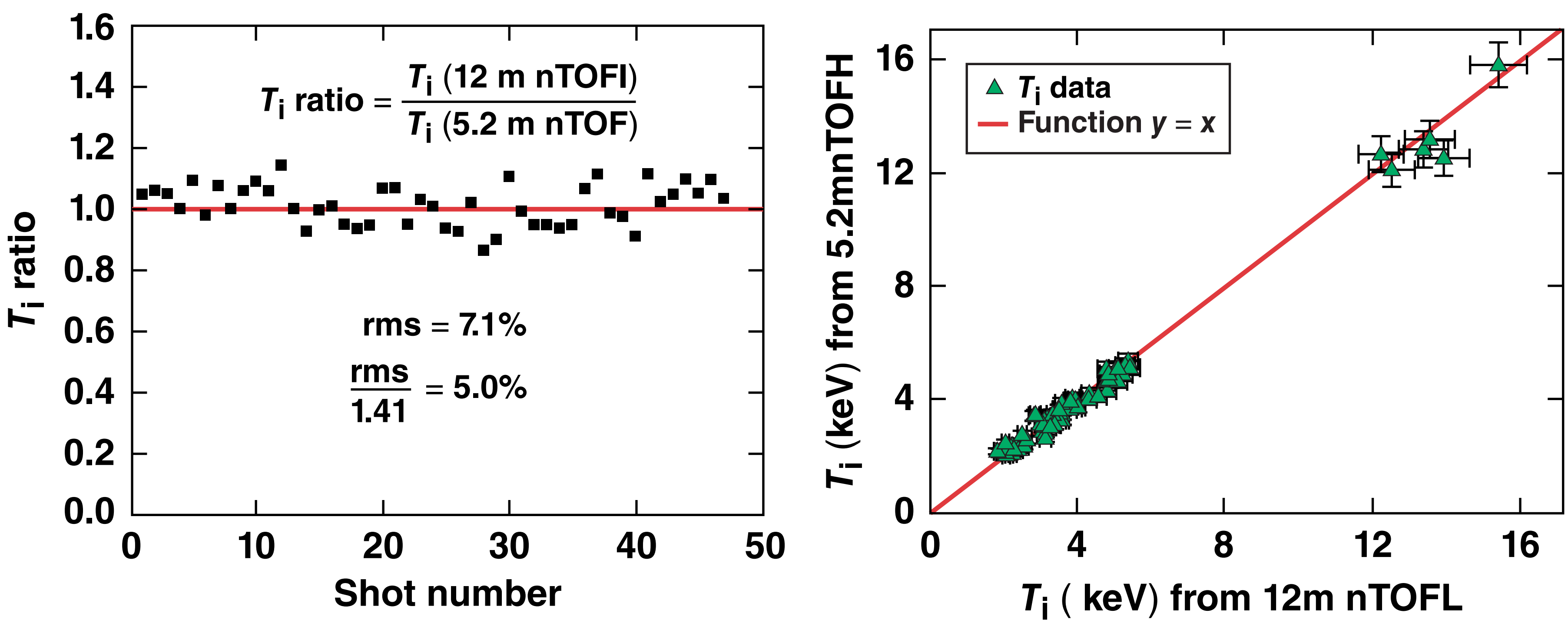
The independently measured D_2 ion temperatures are consistent with precision of 5%

D_2 shots with yields > 1×10^{10}



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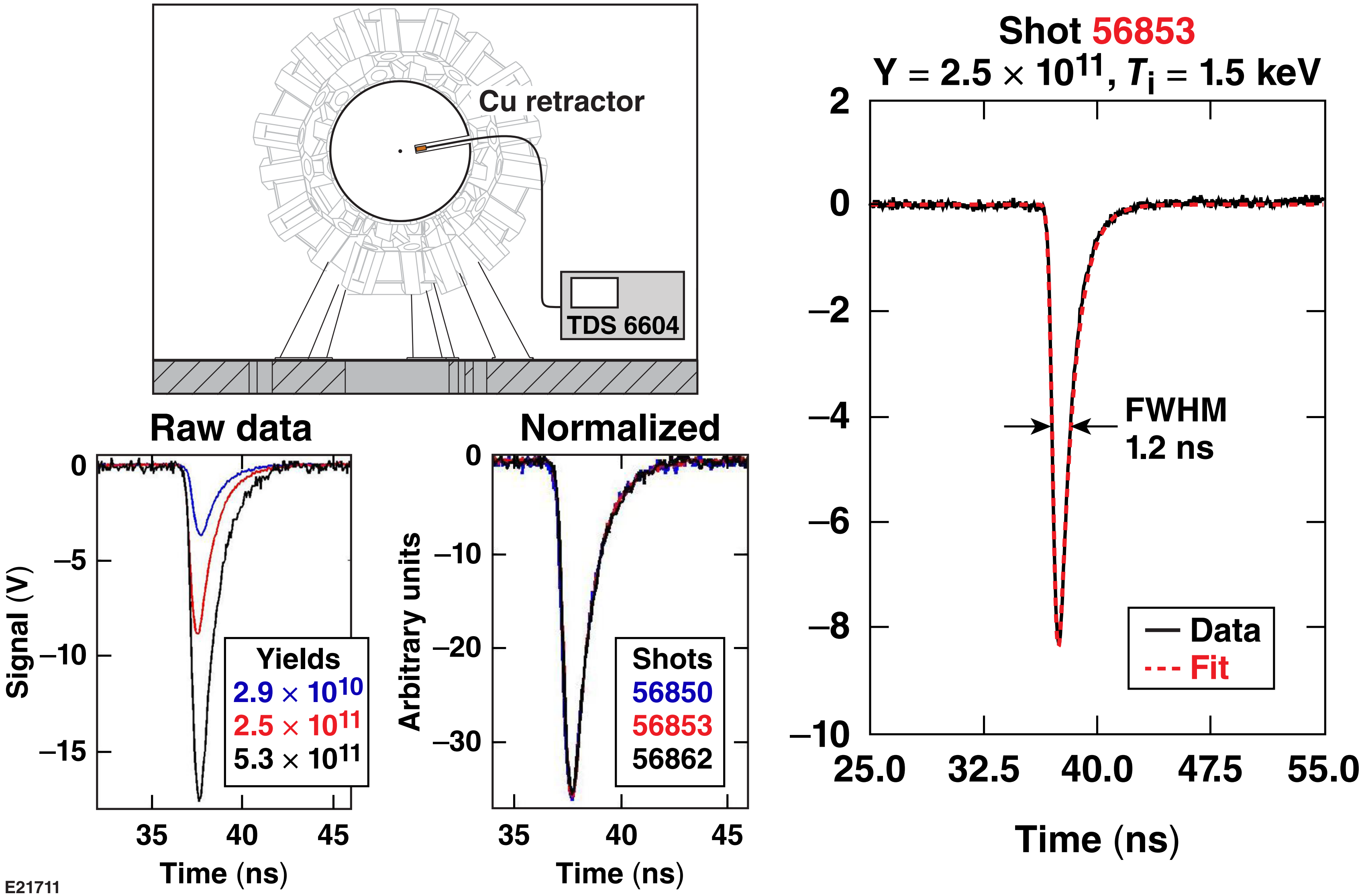
The neutron IRF of 5.0mCVD detector was directly measured in low T_i, low yield DT shots at 40 cm from TCC



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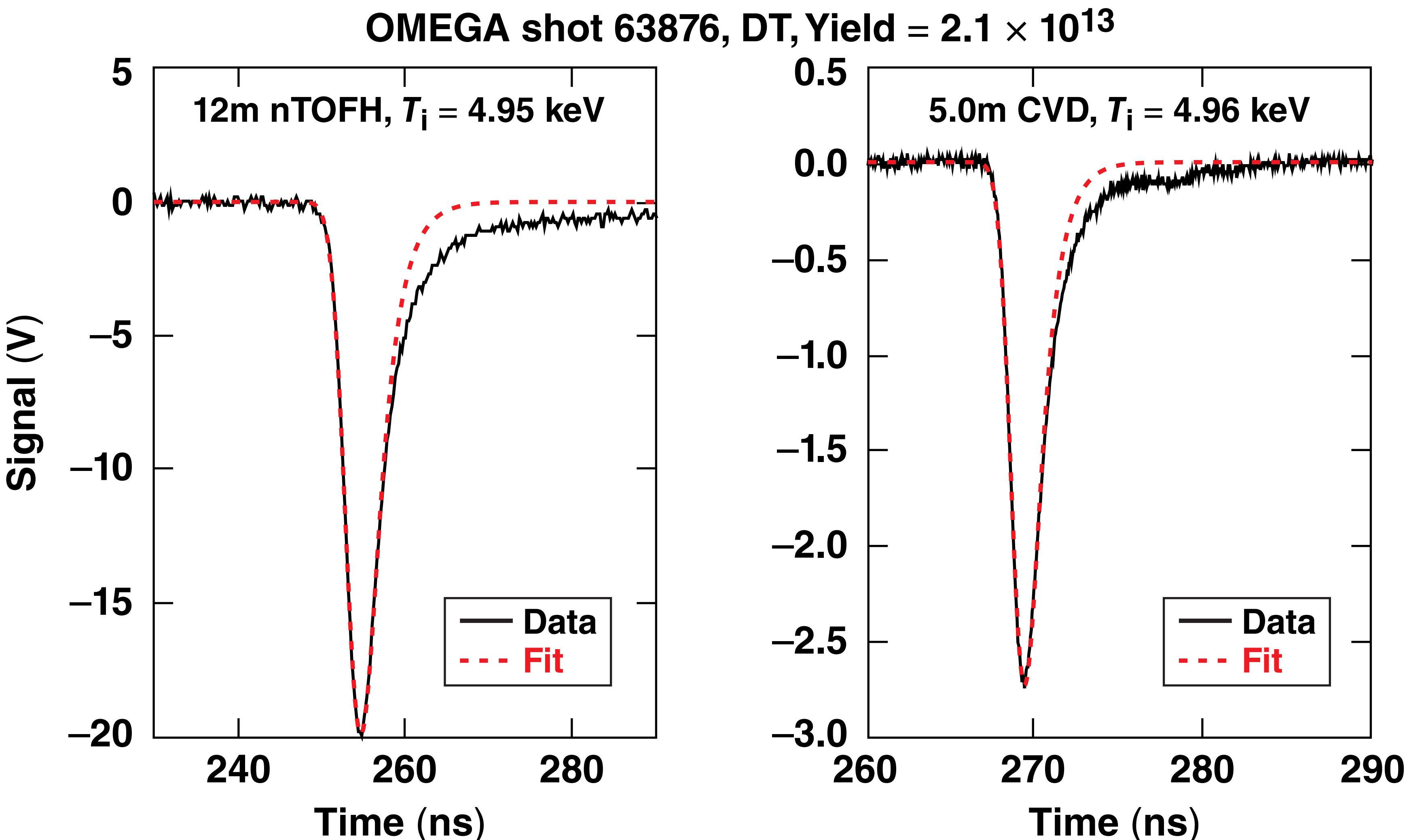
The DT yield and ion temperature are independently measured on OMEGA by at least two nTOF detectors



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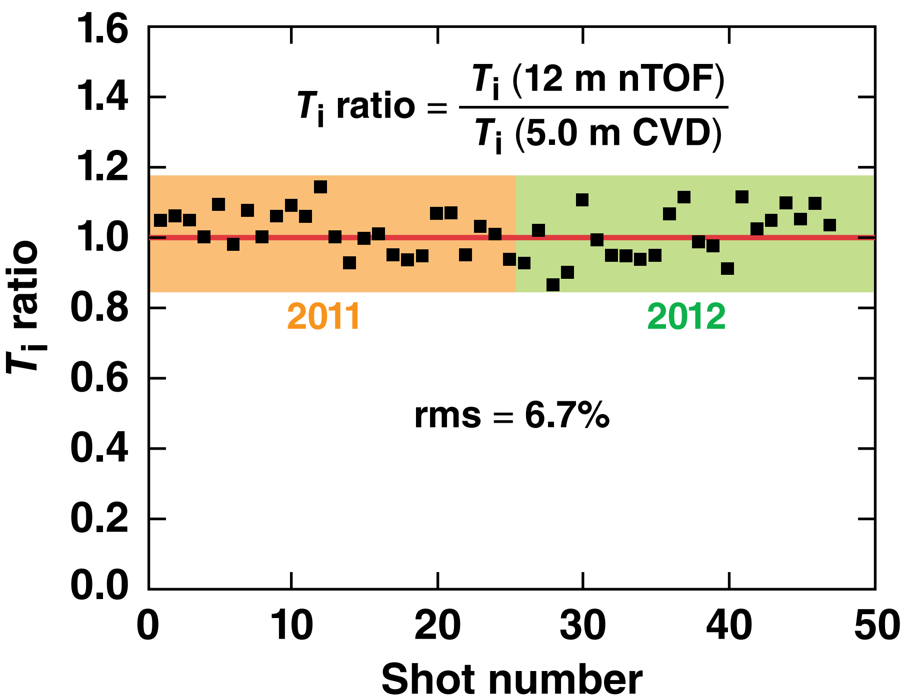
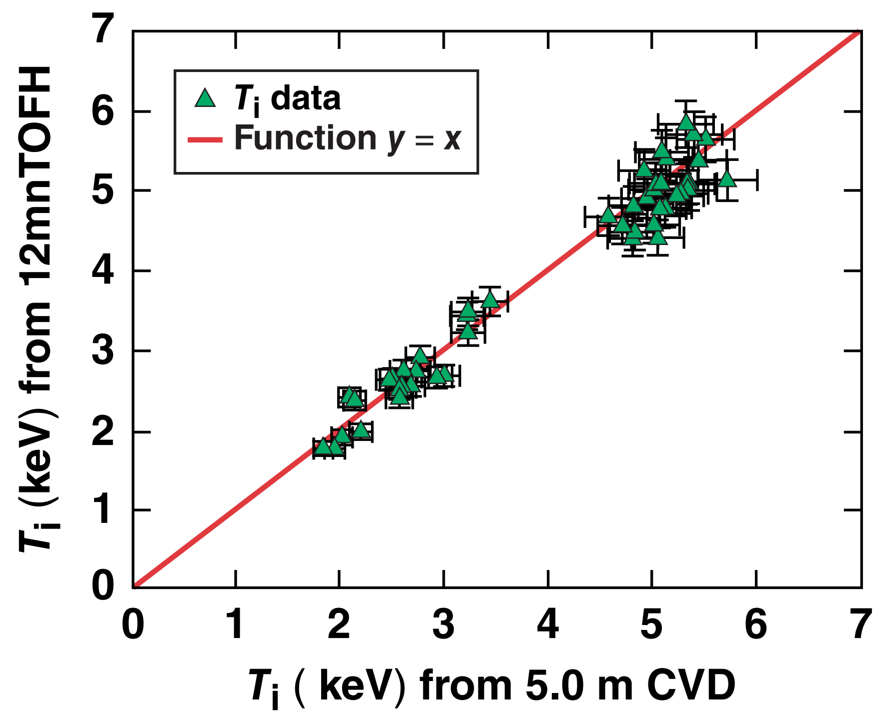
The independently measured DT ion temperatures are consistent with accuracy better than 5%

DT shots with yields > 4.0 × 10^{12}





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Summary/Conclusions

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