

LLE Diagnostic Resource Team for the Advancement of Innovative Fusion Concepts

FUSION Diagnostics Program Review (Virtual) March 5, 2021

J. R. Davies, LLE, University of Rochester

C. Forrest, V. Glebov, J. Knauer, H. McClow, LLE, University of Rochester

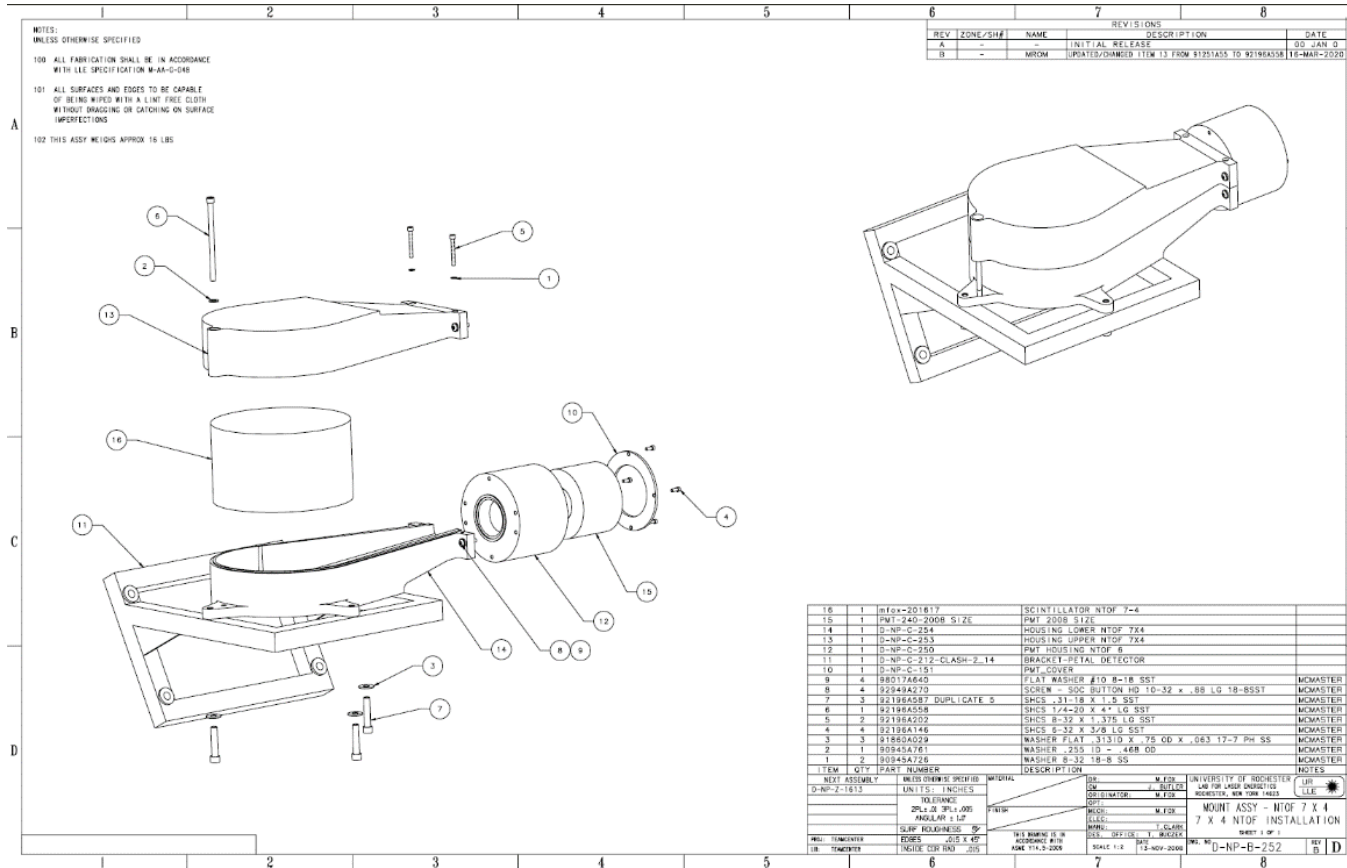
Team members and roles

- ▶ Jonathan Davies (PI)
 - Liaison with concept teams
- ▶ Chad Forrest (co-PI)
 - Head of nuclear diagnostic group at LLE
 - Responsible for neutron spectrometer
- ▶ Vladimir Glebov (co-PI)
 - Responsible for nTOF design and calibration
- ▶ Jim Knauer (co-PI)
 - Assist with nTOF design, calibration and deployment
- ▶ Hannah McClow (new hire)
 - Responsible for diagnostic deployment

A resource team for neutron diagnostics

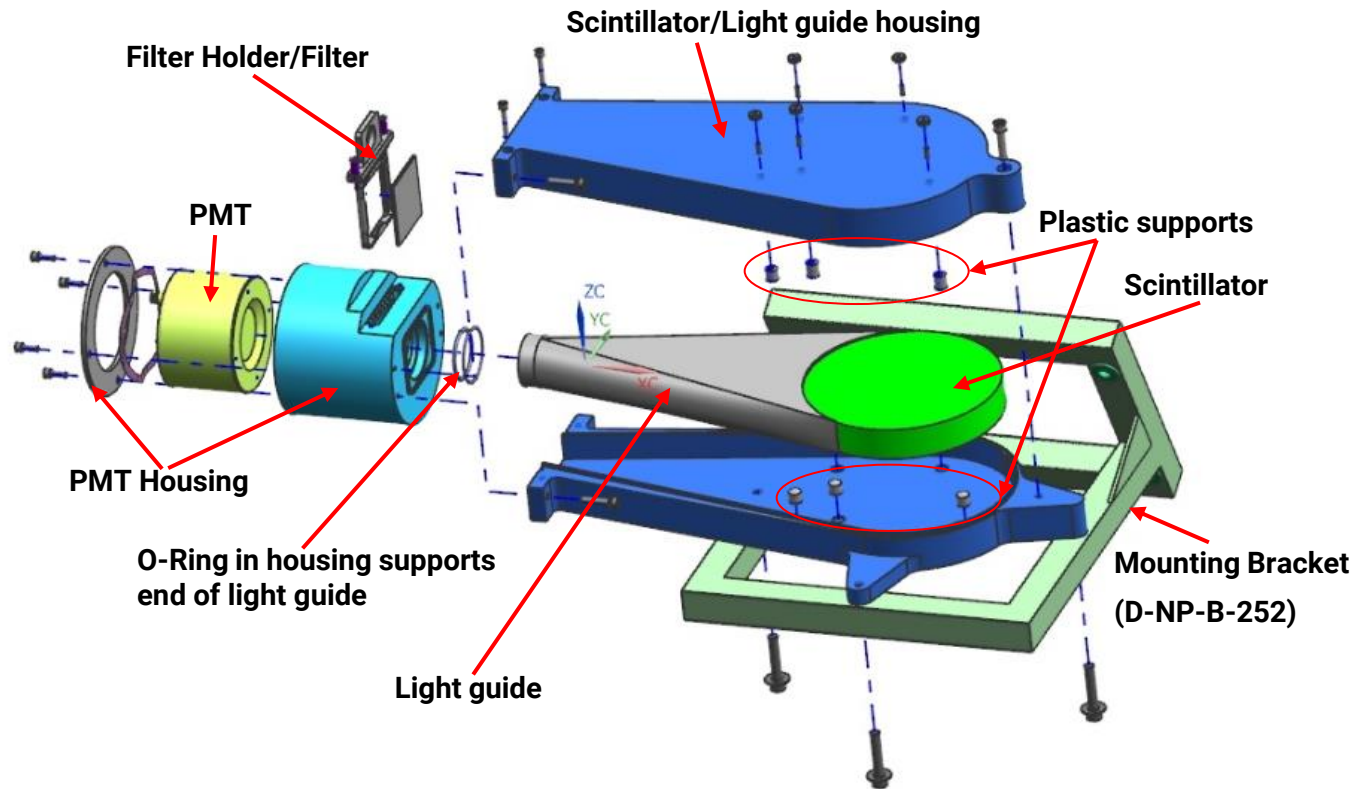
- ▶ Three dedicated DD neutron time of flight (nTOF) detectors
 - Side-on scintillator for x-ray shielding, PMT, HV supply, 10 m cables, 6-channel scope
 - 7x4 nTOF: yield for $> 10^2$ *incident* neutrons
 - Large ARPA-E nTOF: yield for $> 10^3$ *incident* neutrons
 - Fast ARPA-E nTOF: yield and ion temperature for $> 10^4$ *incident* neutrons
- ▶ Activation detectors
 - Counter for Cu (DT) and In (DD) activation available when not in use on OMEGA ($> 10^6$ incident neutrons, geometry dependent)
- ▶ DD neutron spectrometer
 - Single hit detection of knock-on D or H to infer neutron spectrum ($> 10^4$ *incident* neutrons)
 - Designed and under construction
- ▶ Diagnostic calibration
 - OMEGA routinely generates bursts of $> 10^9$ DD and DT neutrons with keV temperature
 - DD neutron generator producing a beam of up to 10^6 n s⁻¹
 - CF-252 source with an activity of 700-dps (0.01 μCi)
- ▶ Neutron diagnostic consultants

The 7x4 nTOF uses a 7" diameter, 4"-thick Pilot B scintillator



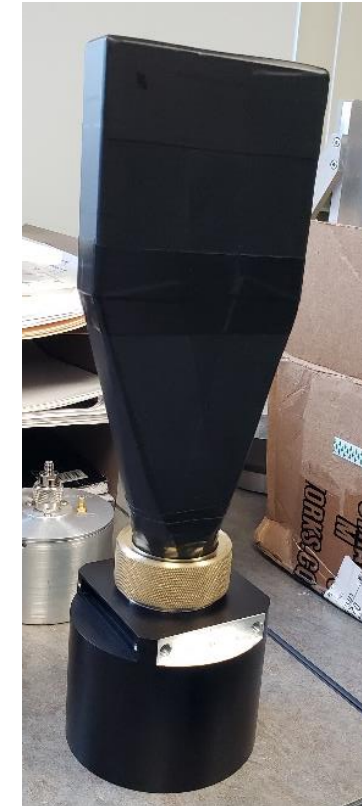
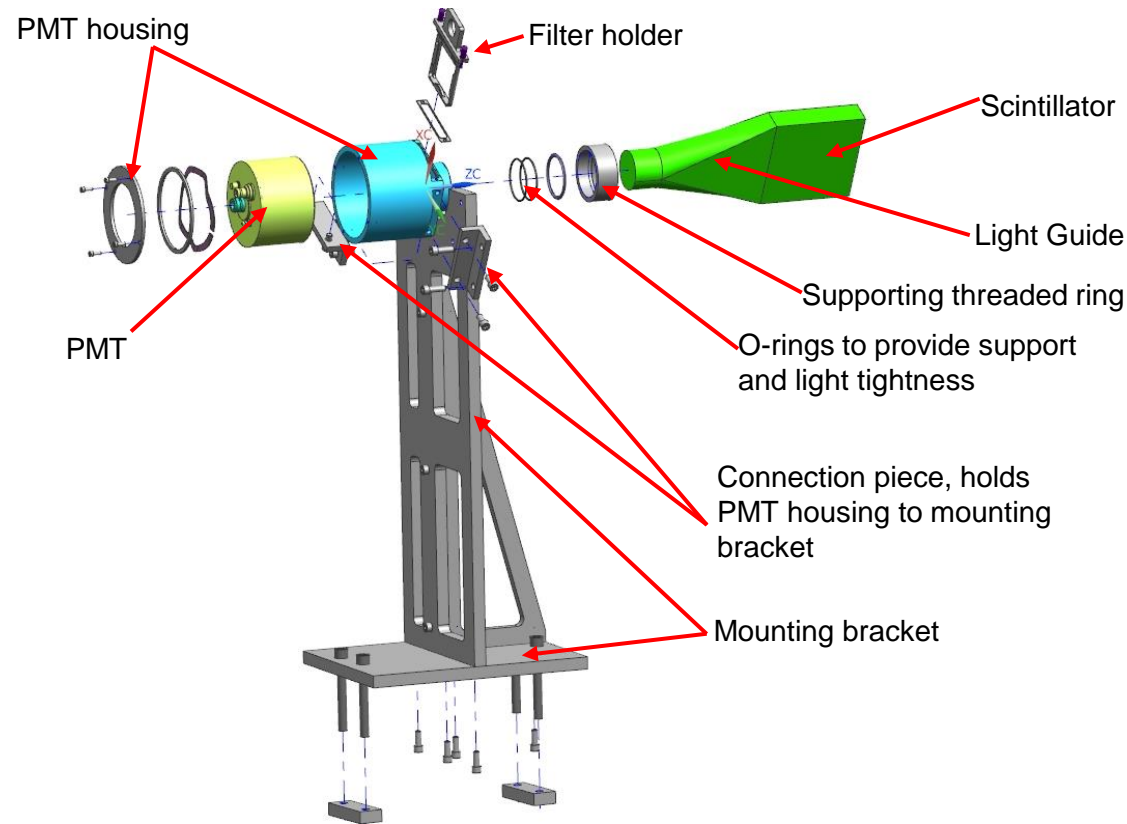
Mounting will need to be provided by the concept team

The Large ARPA-E nTOF uses a 15 cm diameter 2.5 cm thick BC420 scintillator



Mounting will need to be provided by the concept team

The Fast ARPA-E nTOF uses a 10×10×2.5 cm EJ-232Q scintillator: less light per neutron but a narrower IRF than the other detectors



Mounting will need to be provided by the concept team

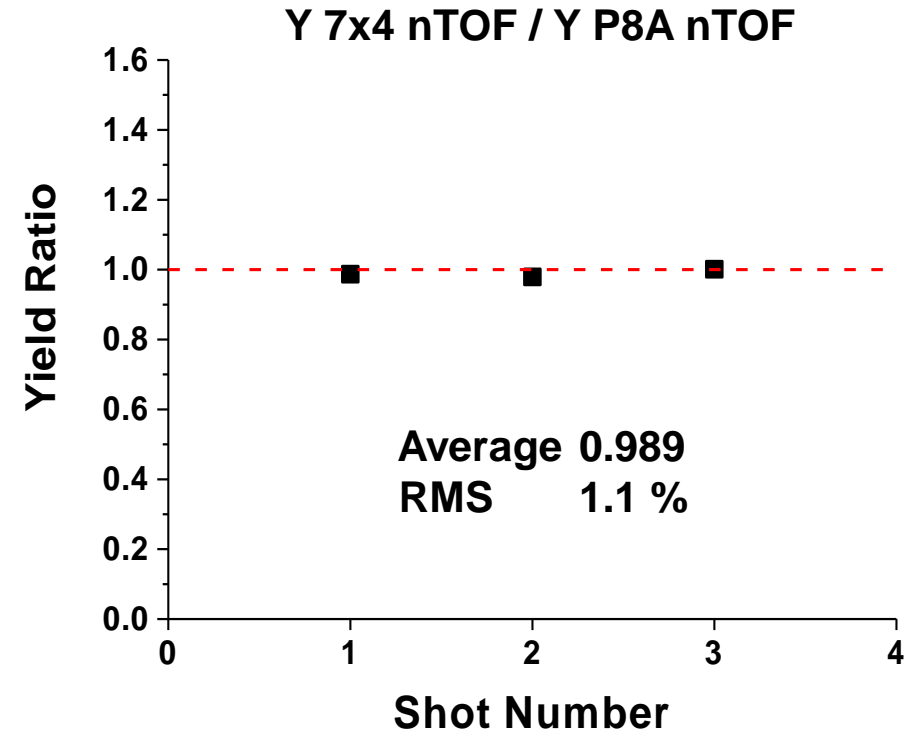
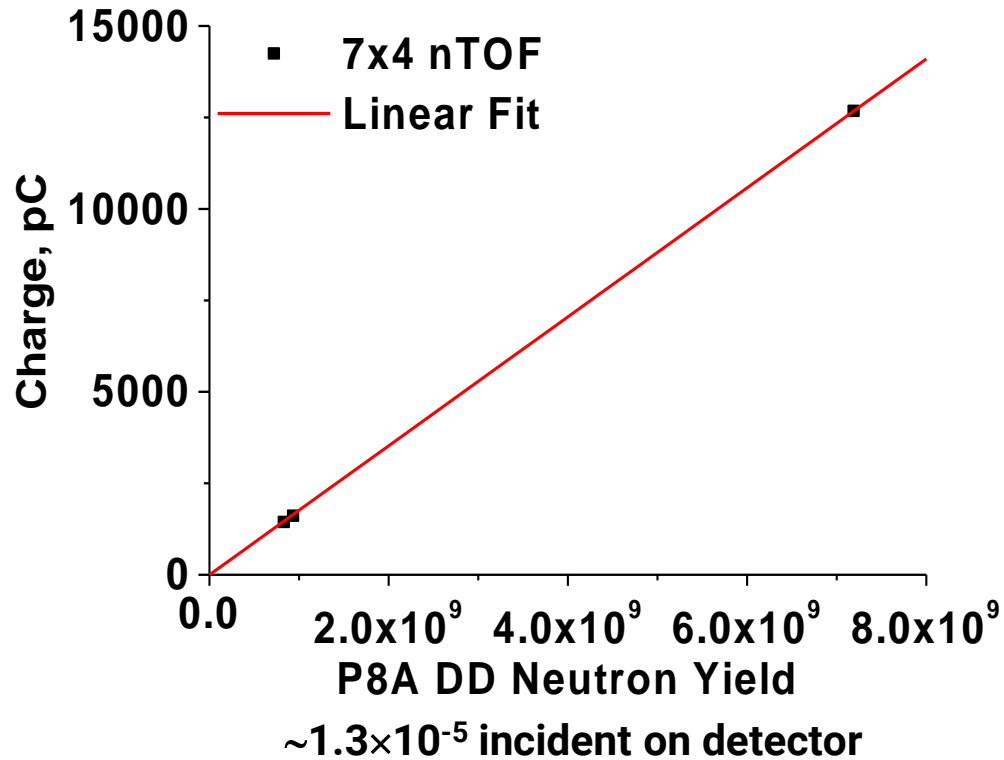
MIFTI sent two nTOFs built by Eljen to their design for calibration on OMEGA



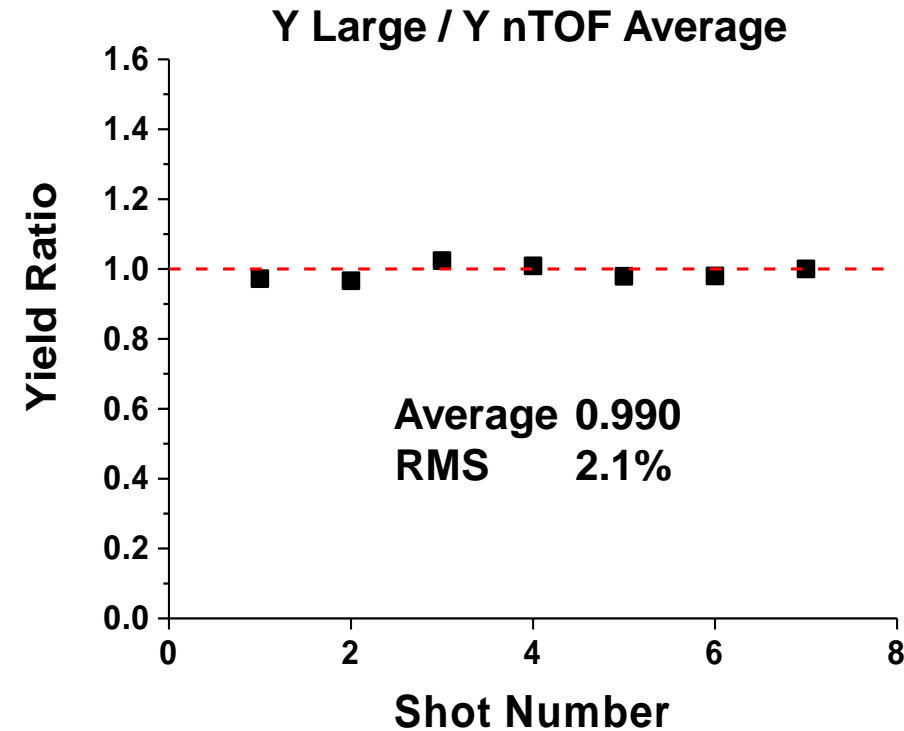
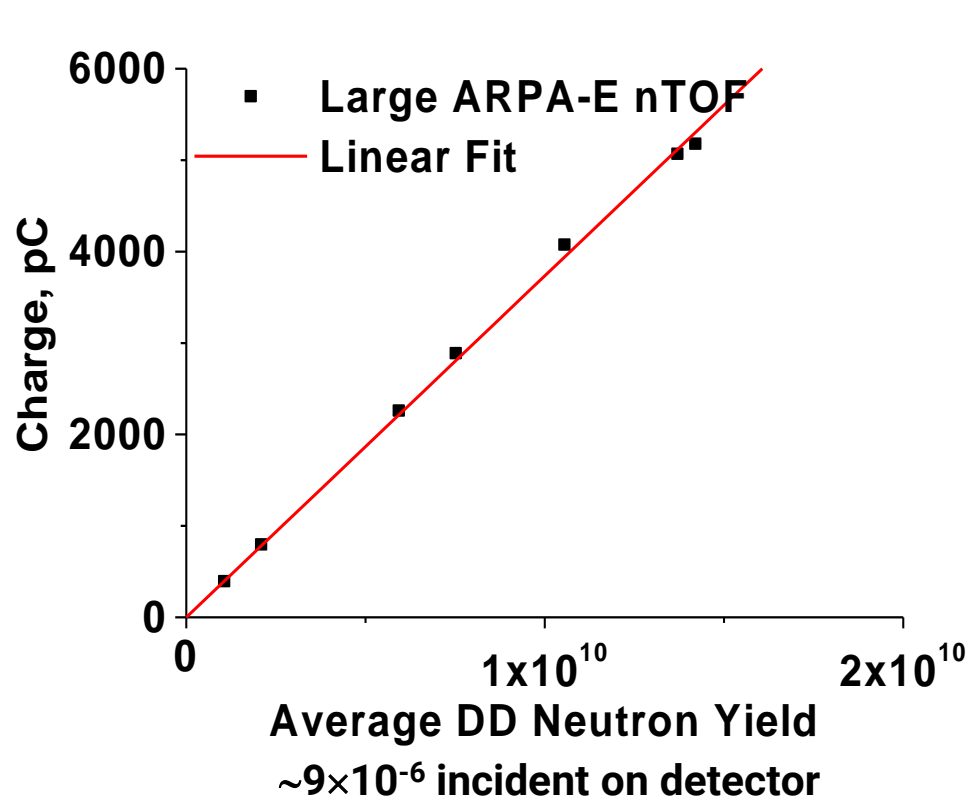
Current and planned work with concept teams

- ▶ Signed a collaborative agreement with MIFTI
- ▶ Calibrated two MIFTI nTOF detectors
- ▶ Providing design review for NK Labs neutron detector for muon catalyzed fusion experiments
- ▶ Plan to calibrate NK Labs detector
- ▶ In contact with ZaP Energy Inc.
 - The 7x4 nTOF is intended to measure DD yield on their experiment
- ▶ In contact with Compact Fusion Systems to advise on neutron diagnostic deployment
- ▶ Any other concept teams in need of neutron diagnostics?

The 7x4 nTOF detector was calibrated in DD yield against the P8A nTOF detector on OMEGA

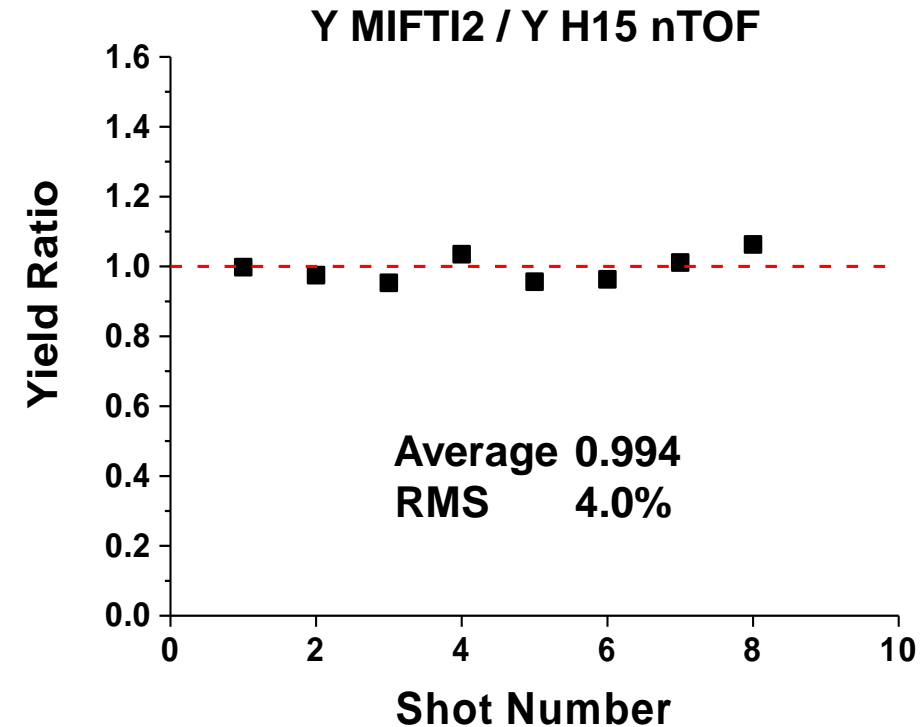
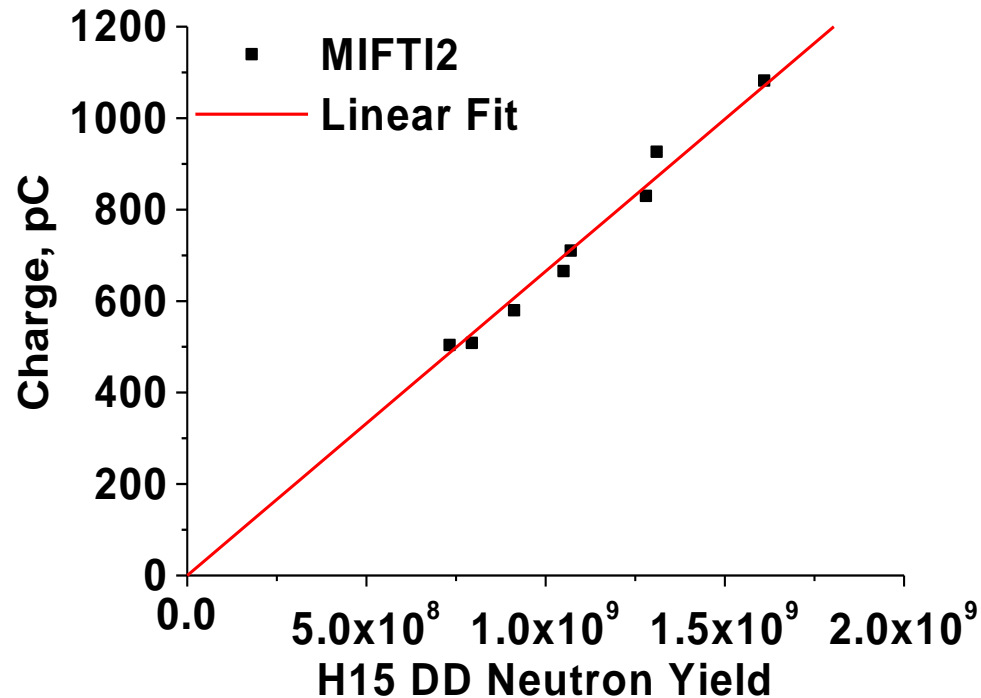


The Large ARPA-E nTOF detector was calibrated in DD yield against the mean of three nTOF detectors on OMEGA

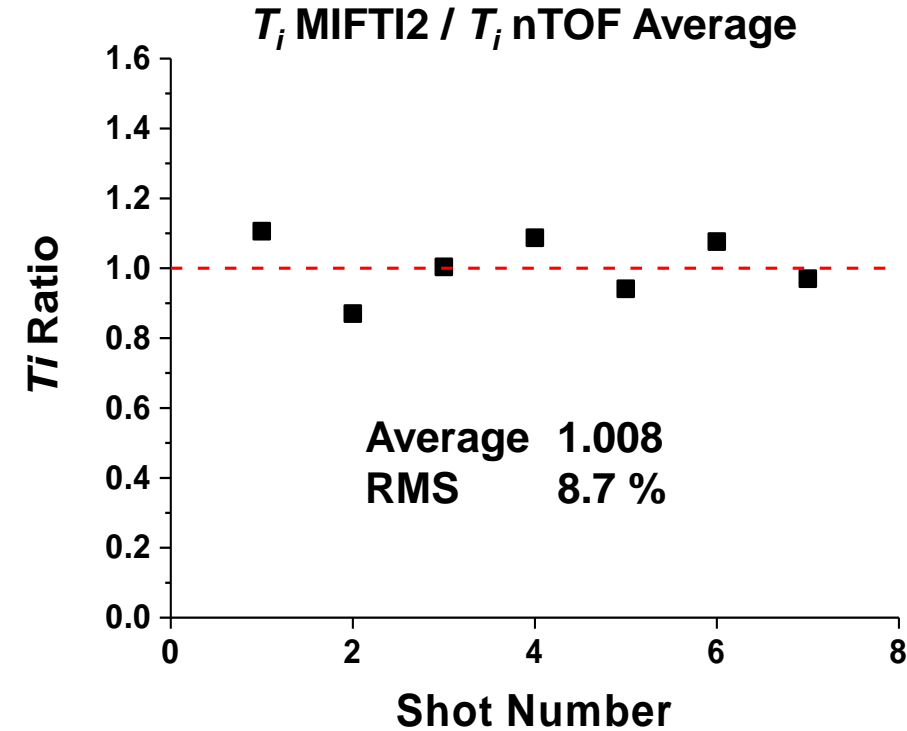
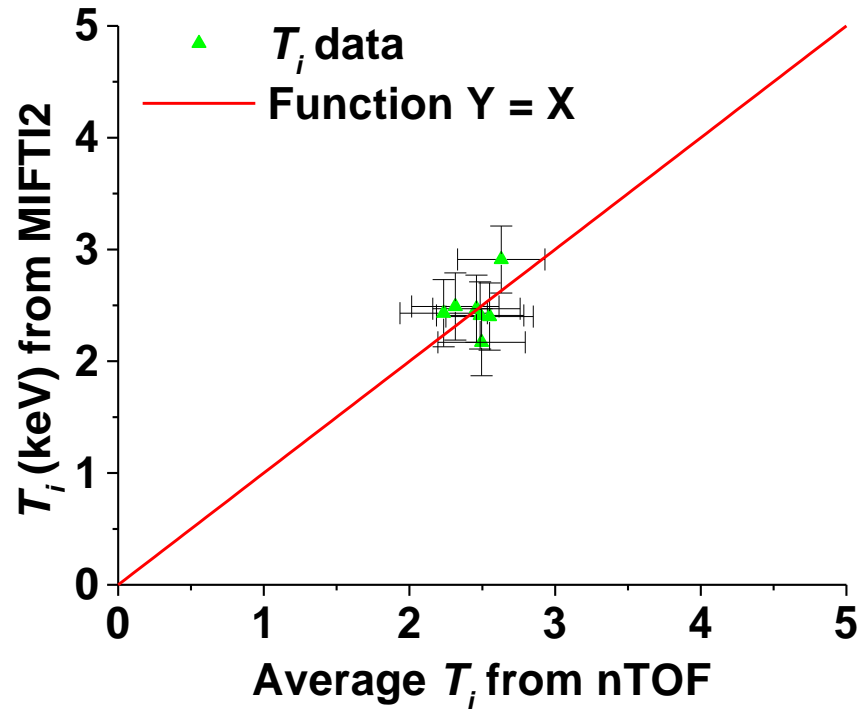


The Fast ARPA-E nTOF will be calibrated in yield and ion temperature in future shot days

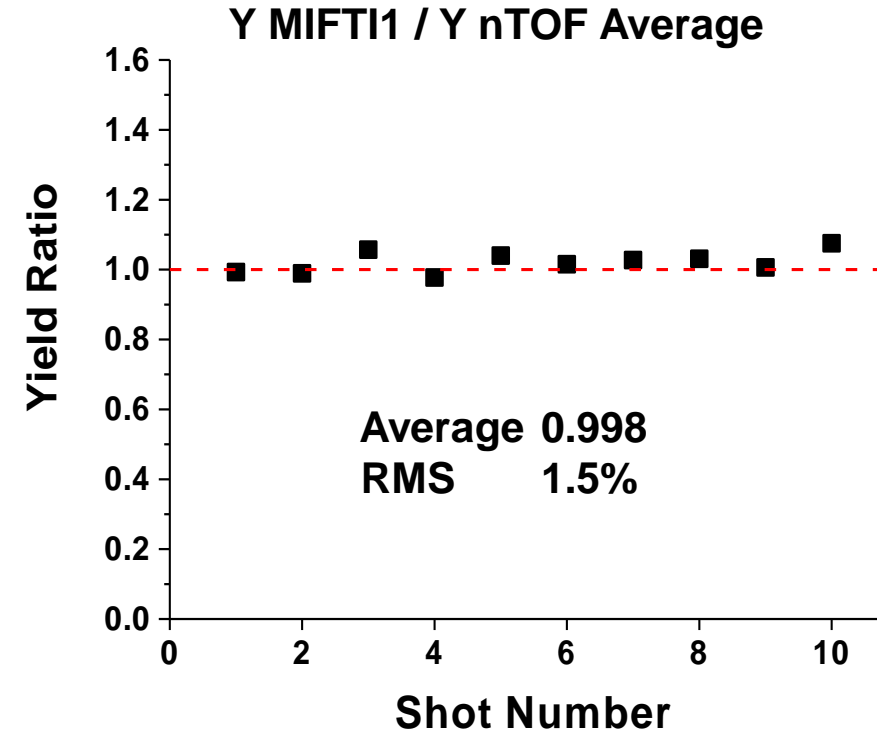
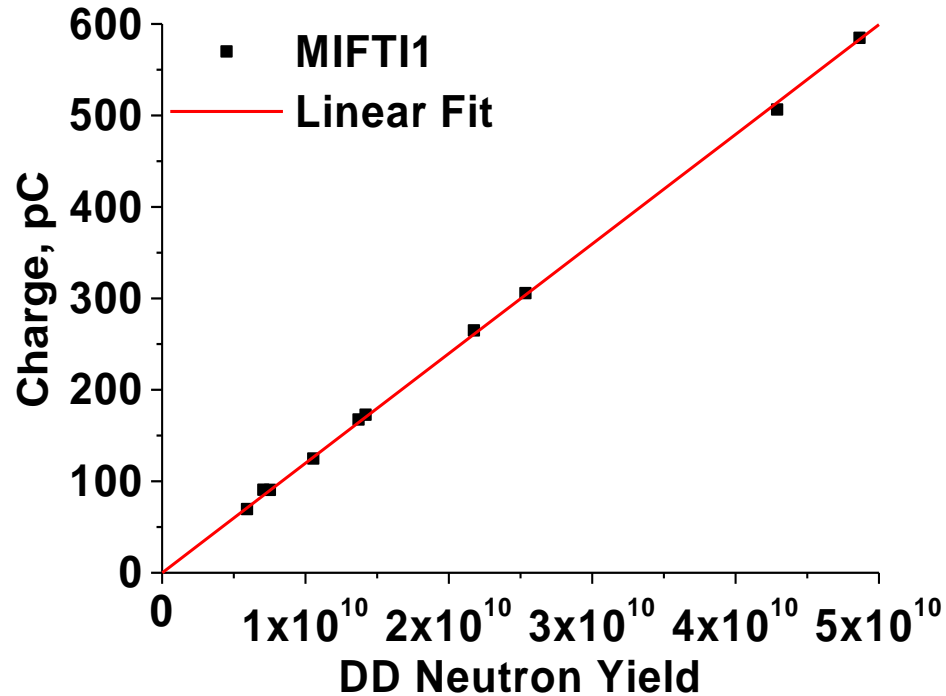
The MIFTI2 nTOF detector was calibrated in DD yield against the H15 nTOF detector on OMEGA (built for the ALPHA program)



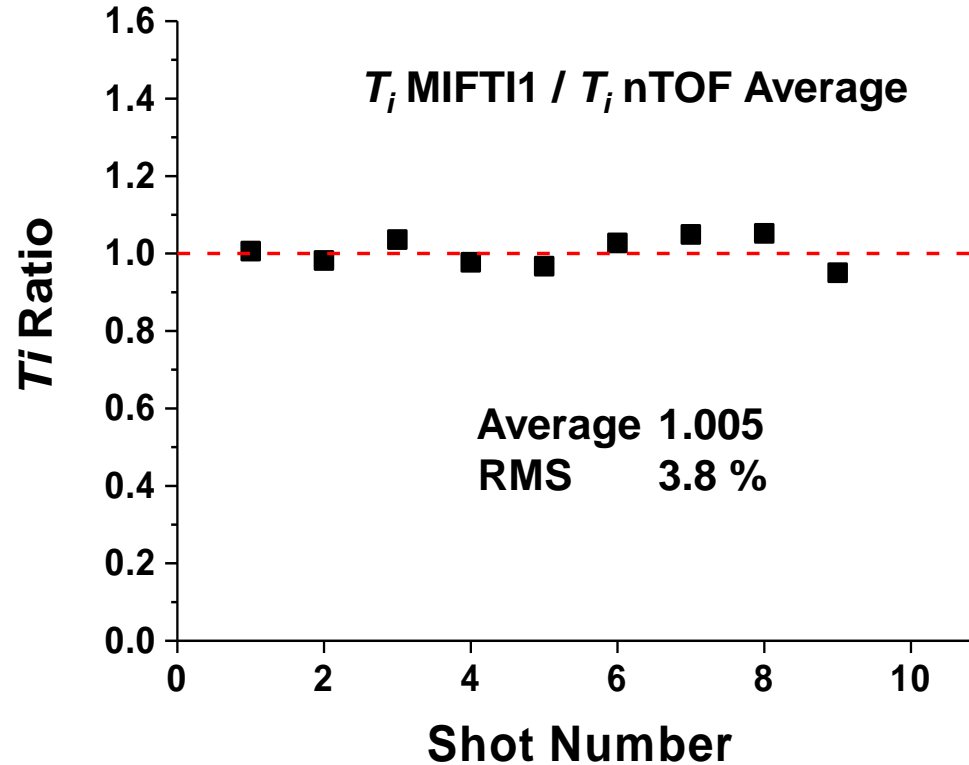
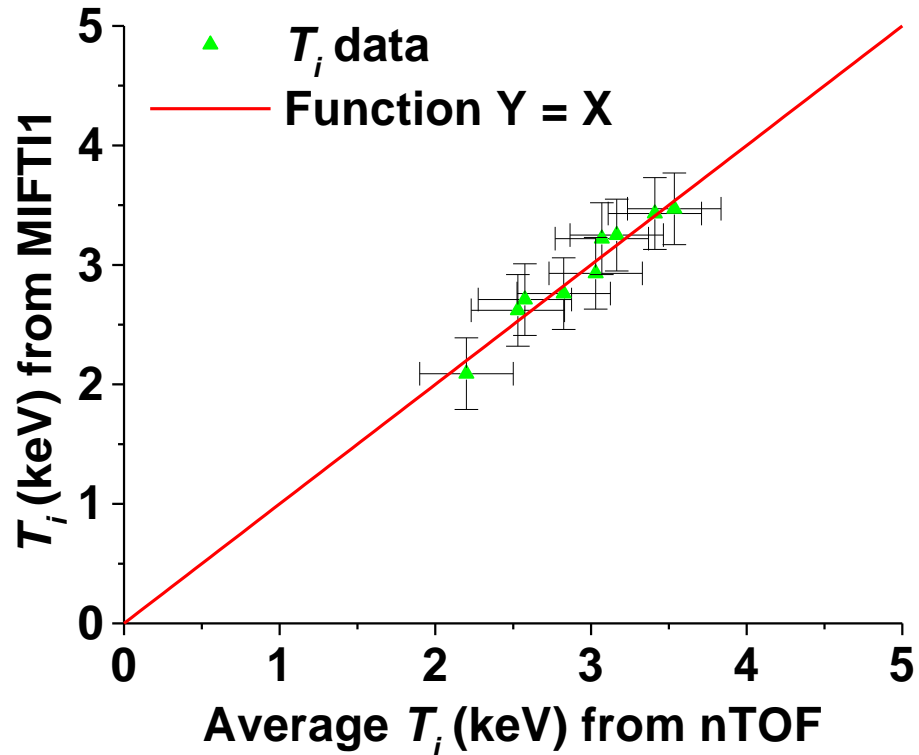
The MIFTI1 nTOF detector was calibrated in ion temperature against the mean of two nTOF detectors on OMEGA



The MIFTI1 nTOF detector was calibrated in DD yield against the mean of two nTOF detectors on OMEGA



The MIFT11 nTOF detector was calibrated in ion temperature against the mean of two nTOF detectors on OMEGA



Beyond the Fusion Diagnostics Program

- ▶ Inclusion of the LLE in the INFUSE program
- ▶ Diagnostic resource team for LaserNetUS
- ▶ Any companies interested?