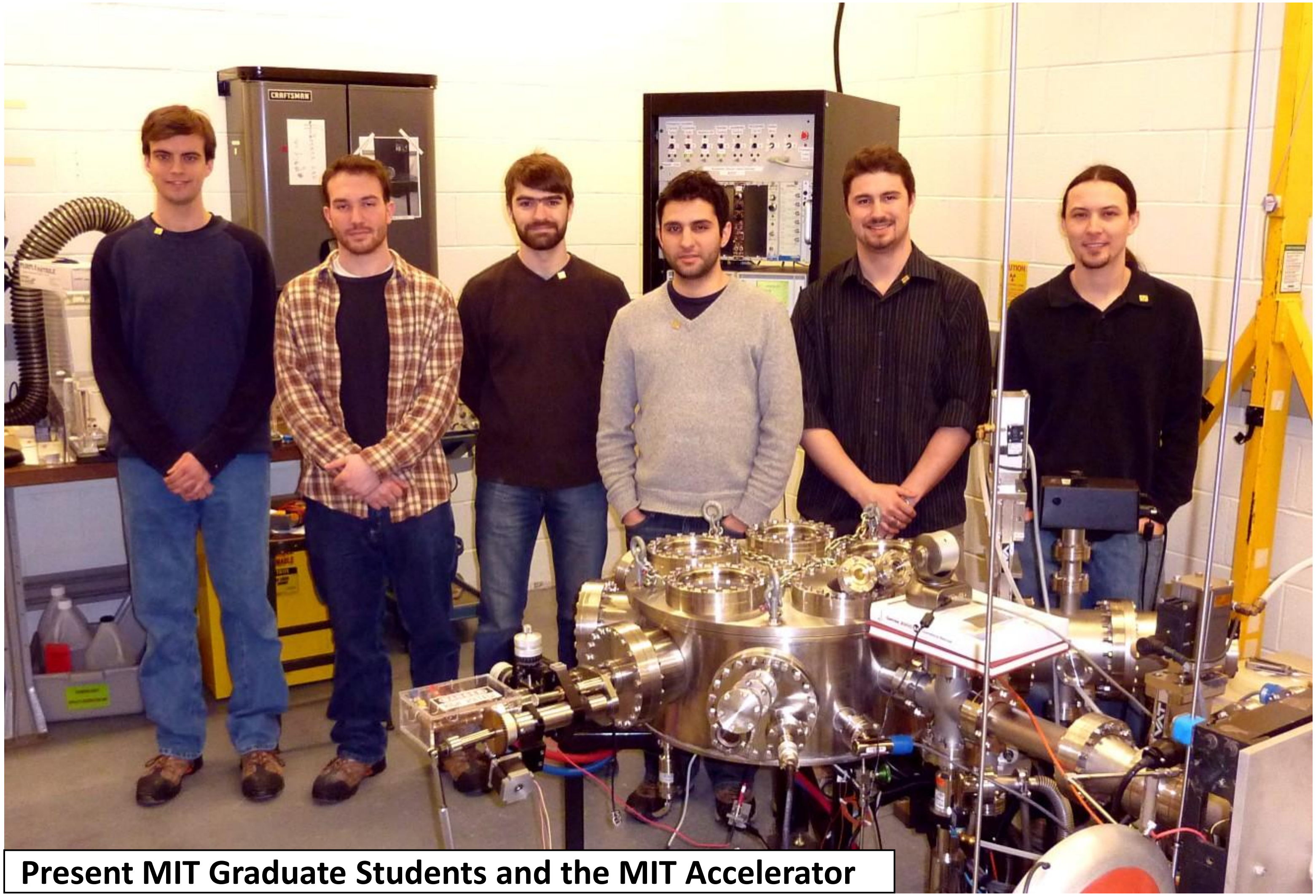
Introduction

The MIT Accelerator for development of ICF diagnostics at OMEGA / OMEGA-EP and the NIF



Present MIT Graduate Students and the MIT Accelerator

Collaborators

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Summary

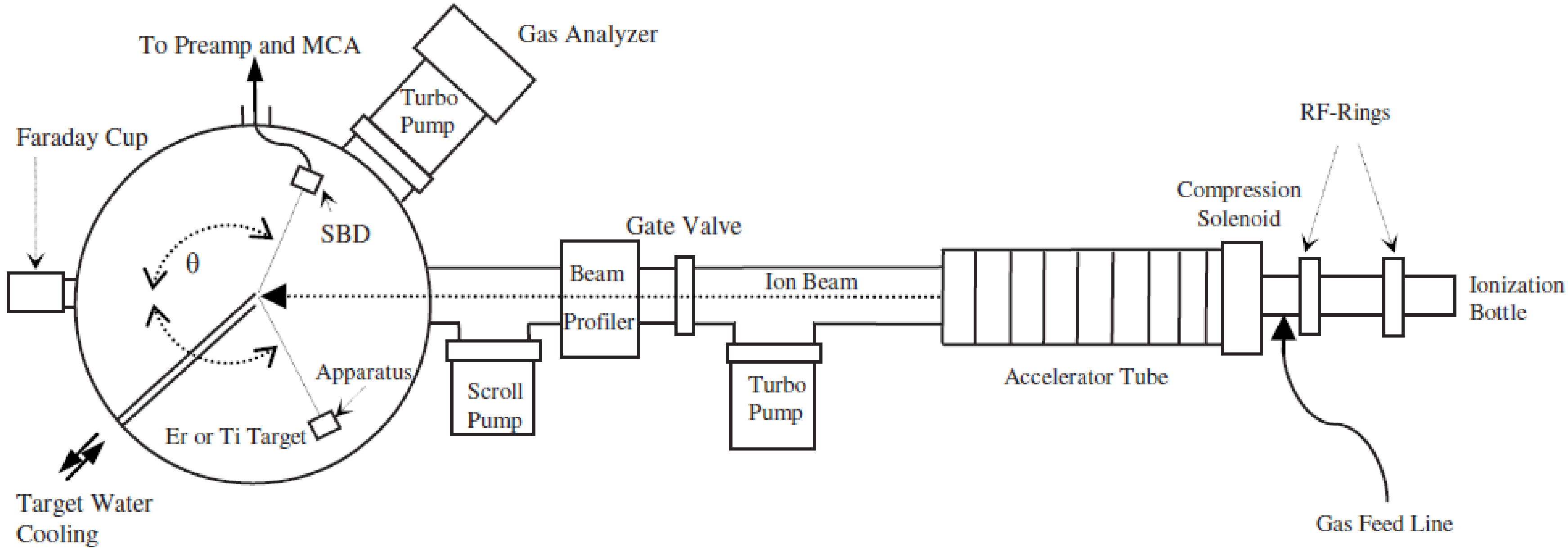
- The MIT accelerator generates fusion products relevant for three NIF nuclear diagnostics based on CR-39:
  - DD-n yield diagnostic
  - Wedge-range-filter Proton Spectrometer
  - MRS Neutron Spectrometer

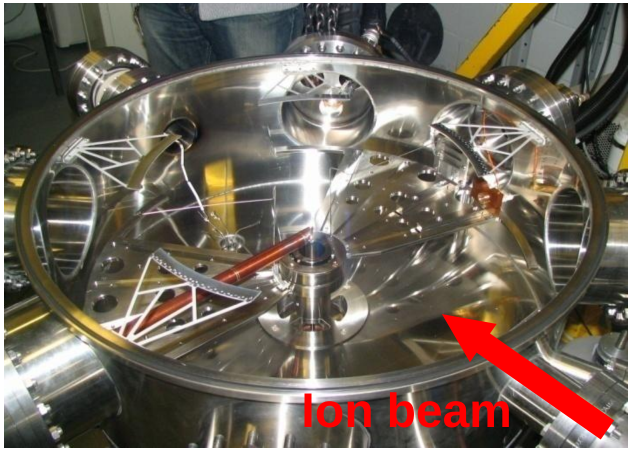
- It is currently used to support the development and calibration of new and existing diagnostics for use at OMEGA, OMEGA-EP and the NIF.

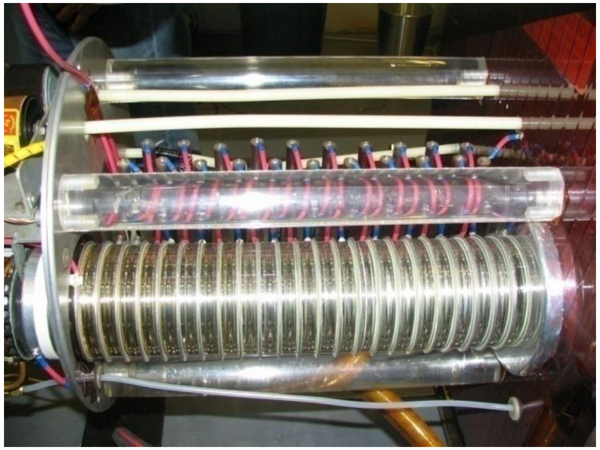
PSFC UR LLE NIC The National Ignition Campaign

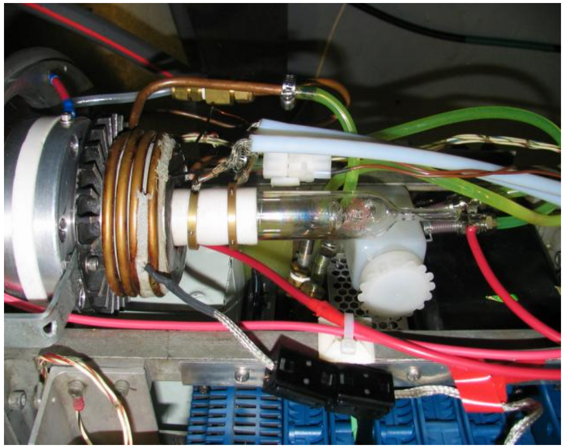
F.H. Séguin *et al.*, Rev. Sci Instrum 74, 975 (2003).
S. McDuffee et al., Rev. Sci Instrum 79, 043302 (2008)

The MIT accelerator is capable of producing fusion products and beam ions relevant for ICF diagnostics development









Fusion products produced by the accelerator

The accelerator is capable of producing several fusion products and beam ions

Primary products (kinematics not included):

D + D → T (1.01 MeV) + p (3.02 MeV)

D + D → n (2.45 MeV) + ^{3}He (0.82 MeV)

D + ^{3}He → α (3.6 MeV) + p (14.7 MeV)

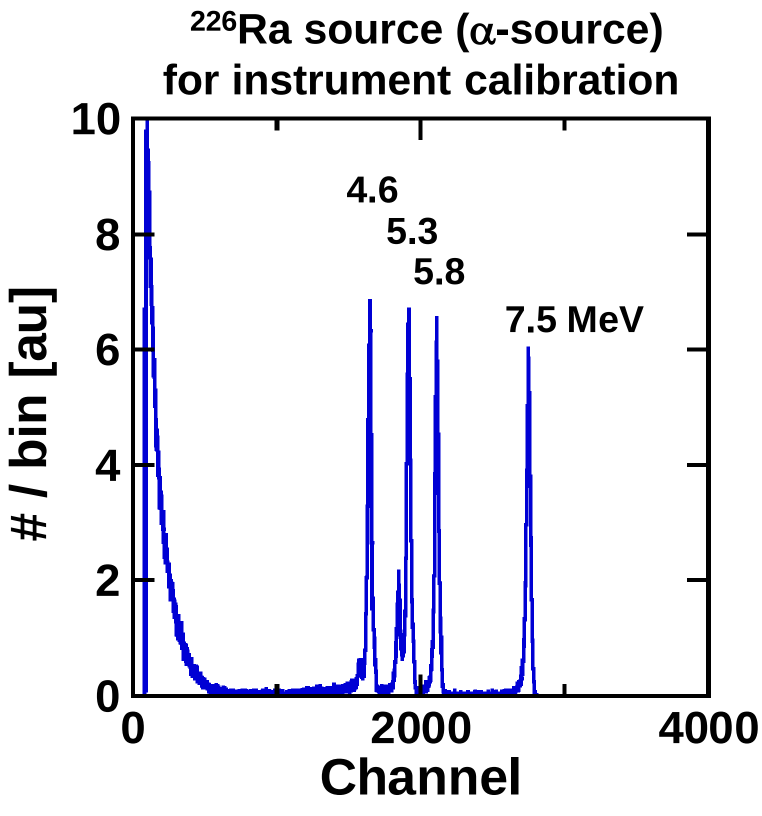
Beam ions:

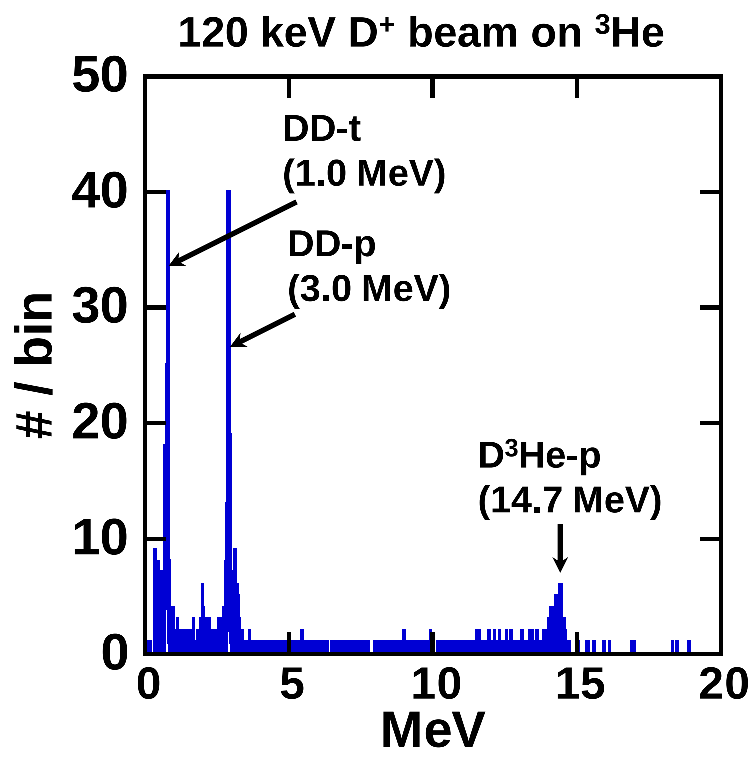
D^+ (<150 keV)

$^3He^+$ (<150 keV)

$^3He^{2+}$ (<300 keV)

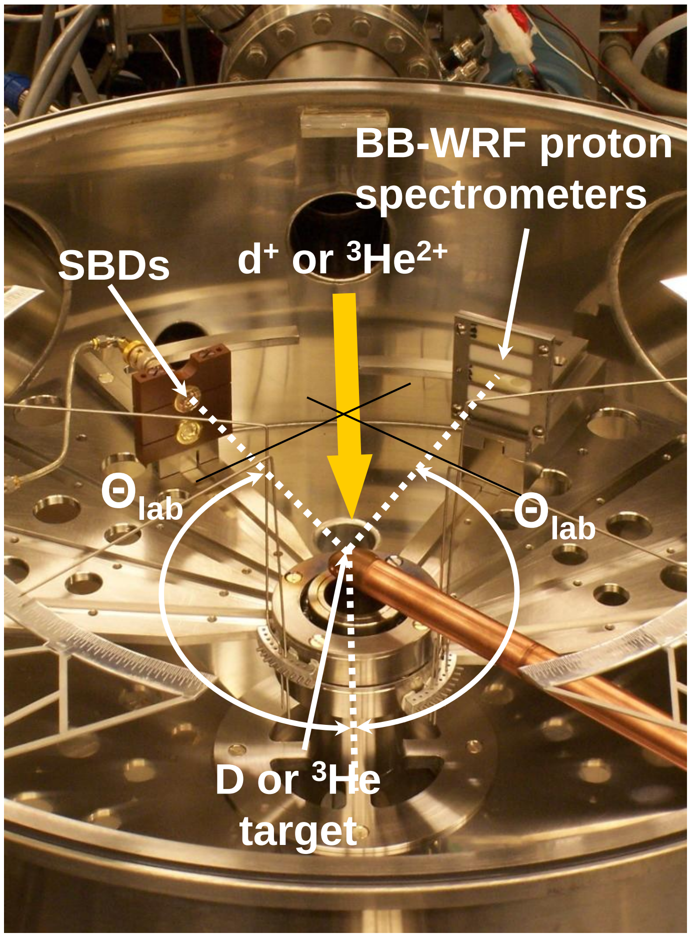
Radioactive sources and kinematic calculations are used to characterize the energy of the fusion products

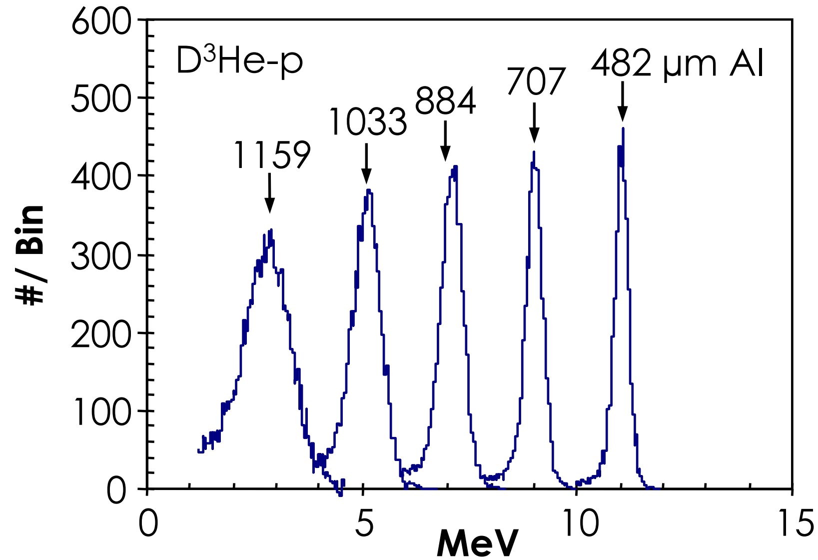


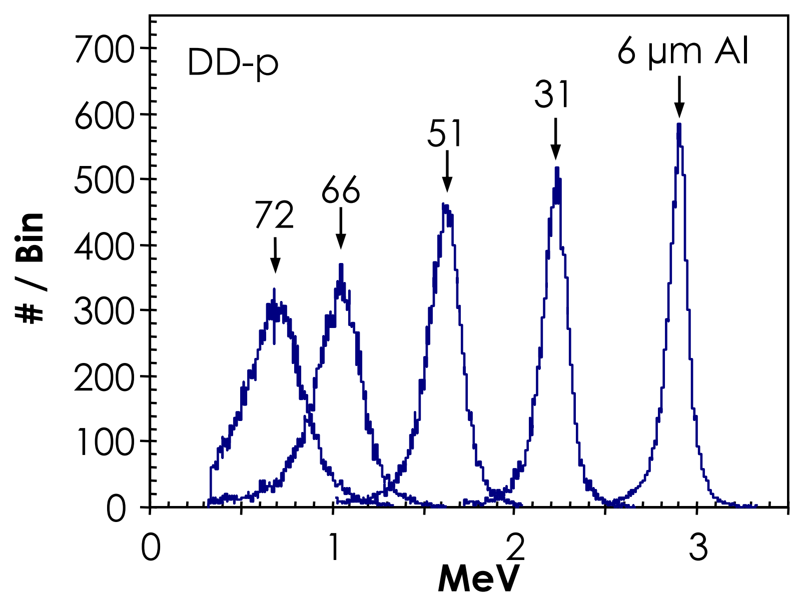


Fusion product rates up to ~10^7/s are readily achieved

Kinematic effects and ranging filters are exploited to provide fusion products with a large range of energies

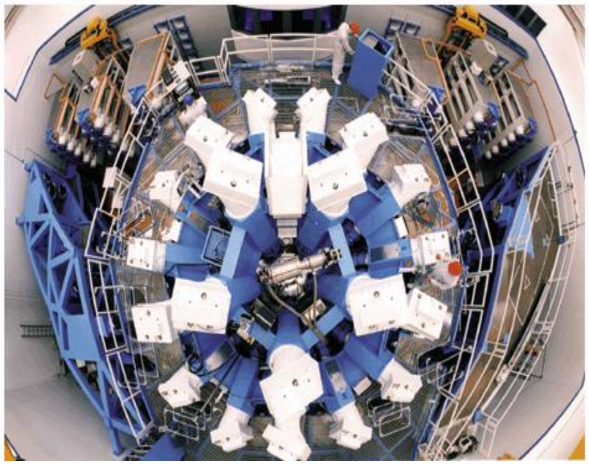


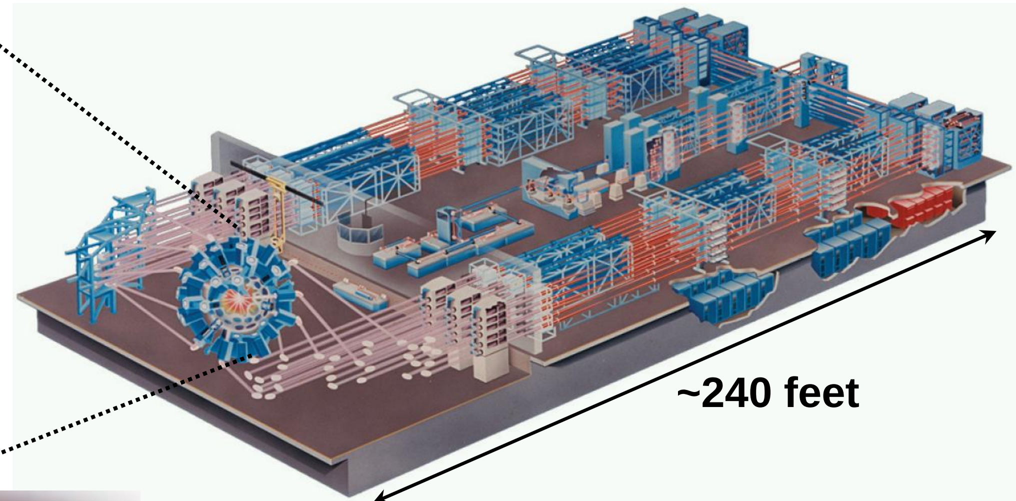


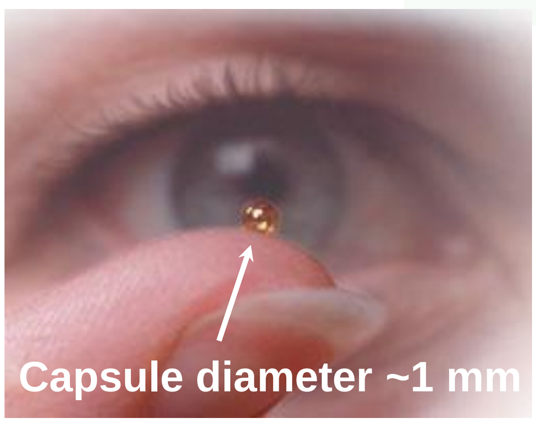


Primary Objectives…

The objective with the accelerator is to design and characterize instruments for diagnosing ICF plasmas at OMEGA, OMEGA-EP…

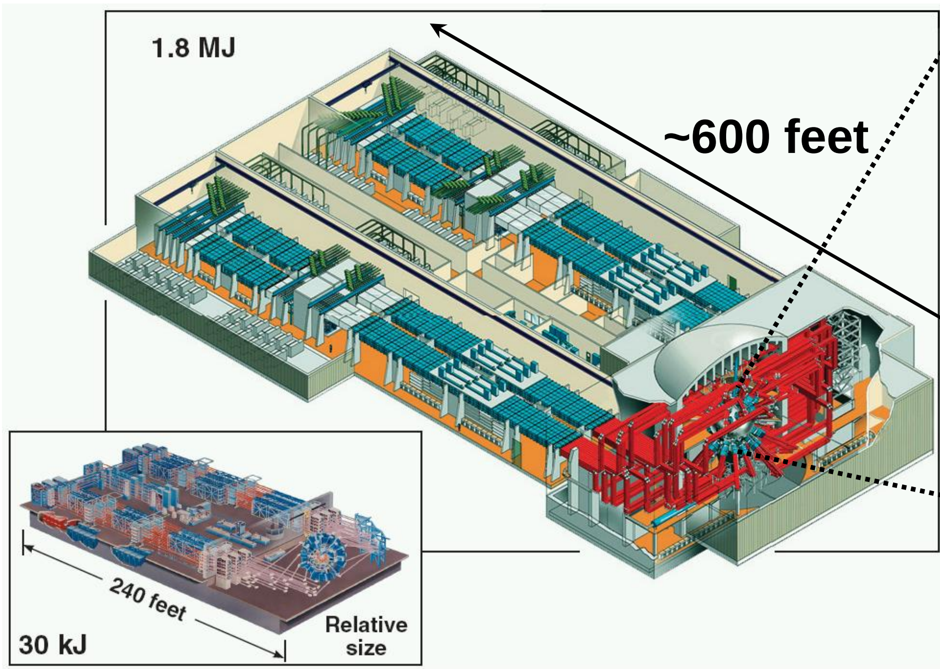


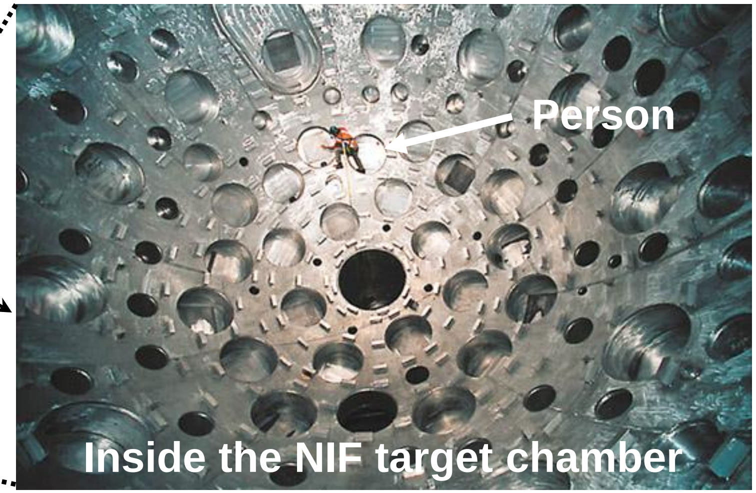


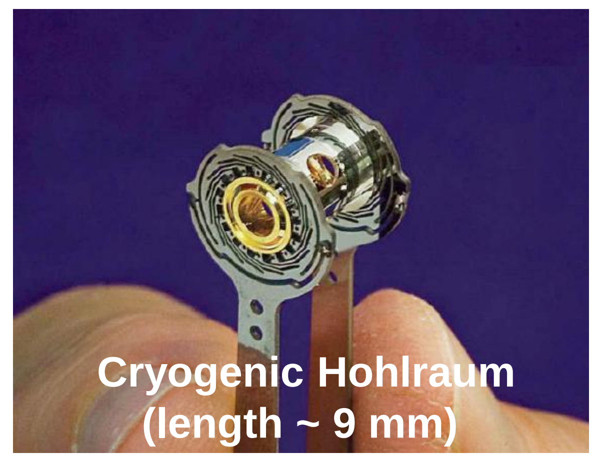


- **60 laser beams delivering 30 kJ on capsule in ~1 ns**
- **Direct or indirect drive**

…and the National Ignition Facility (NIF) at LLNL



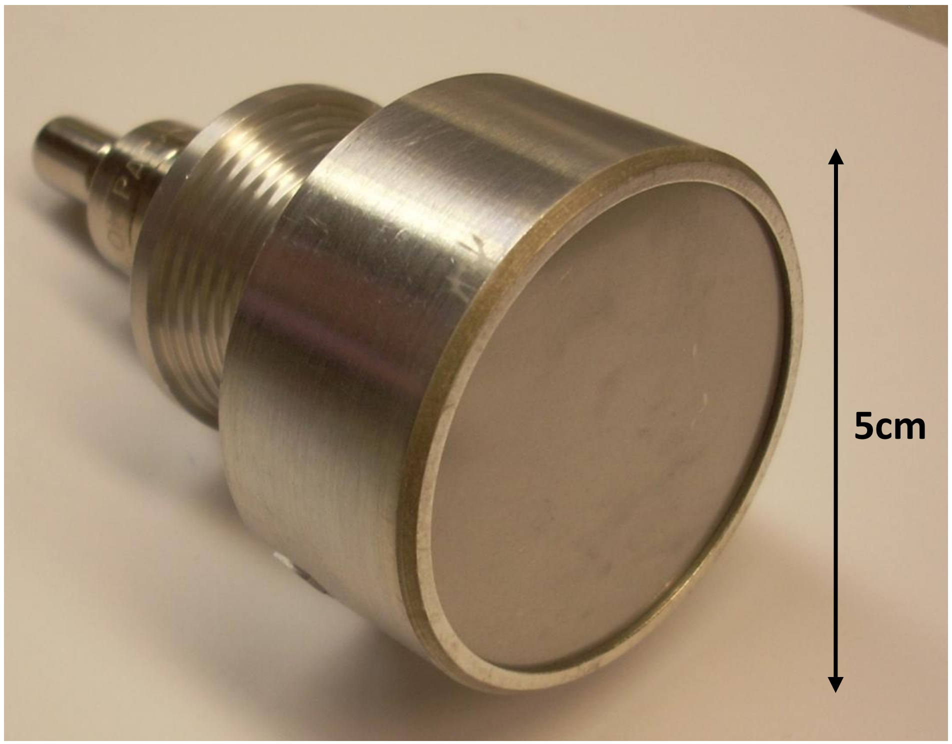


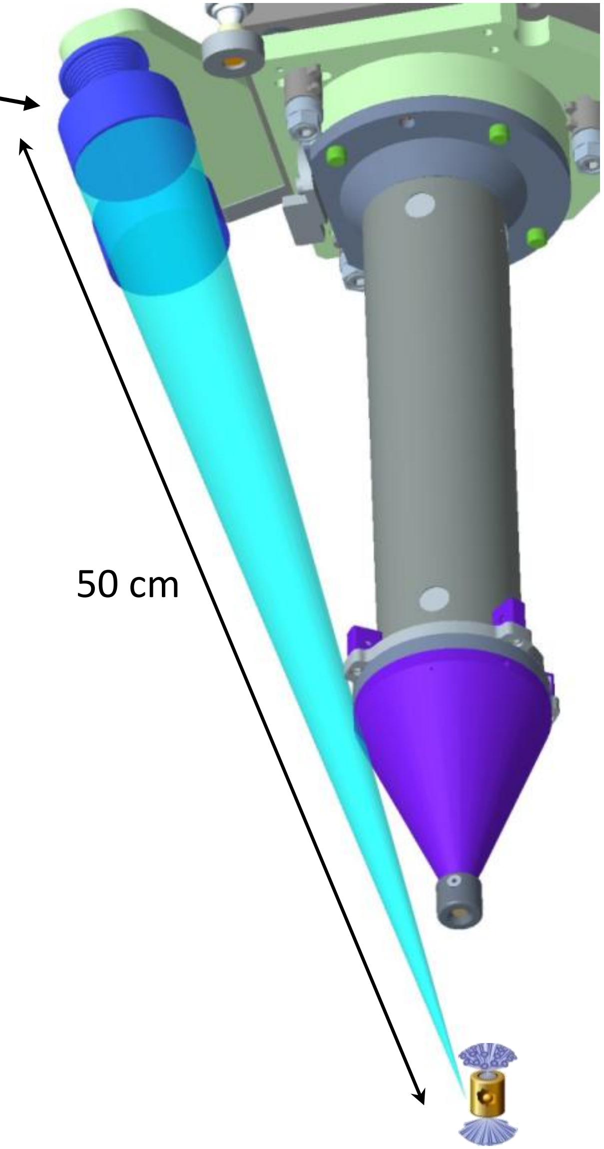


- 192 Laser Beams delivering 1.8 MJ on capsule
- Indirect drive or direct drive
- First credible ignition experiments ~2010

Diagnostic #1: CR-39-based neutron yield detector

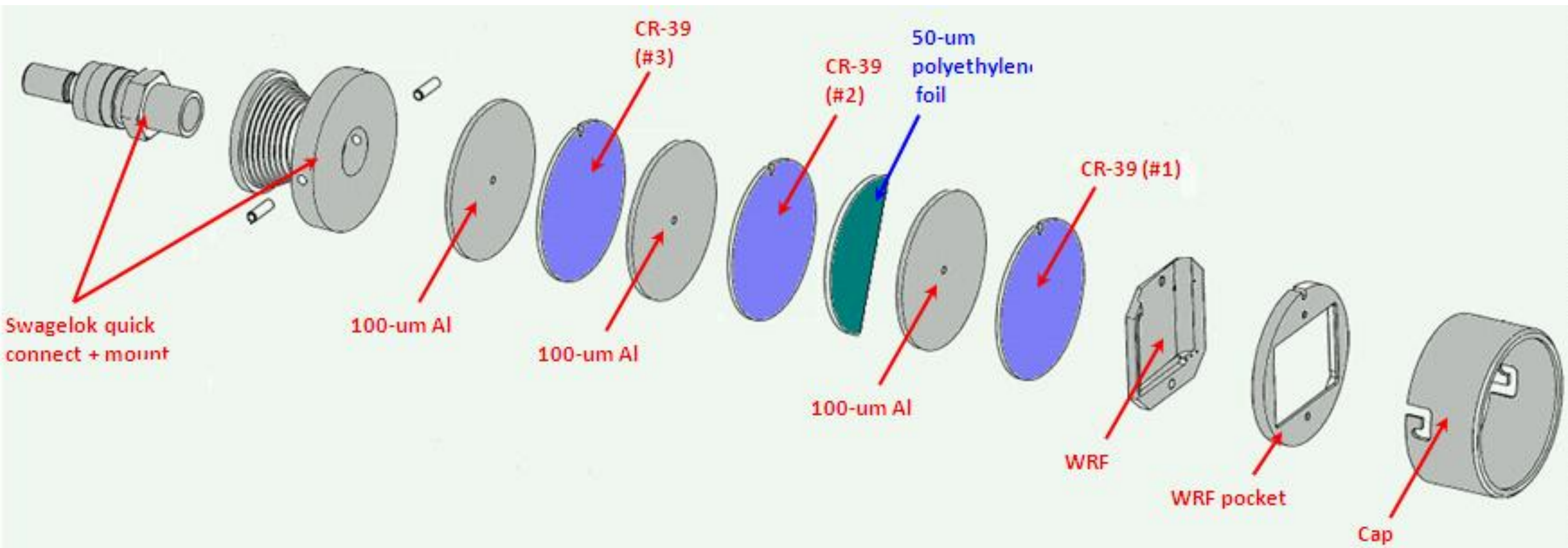
Compact, CR-39 based DD-n detectors





Compact, CR-39 based DD-n detectors have been fielded on the NIF

The accelerator has been used to measure the CR-39 efficiency for detection of DD-neutrons at OMEGA and the NIF



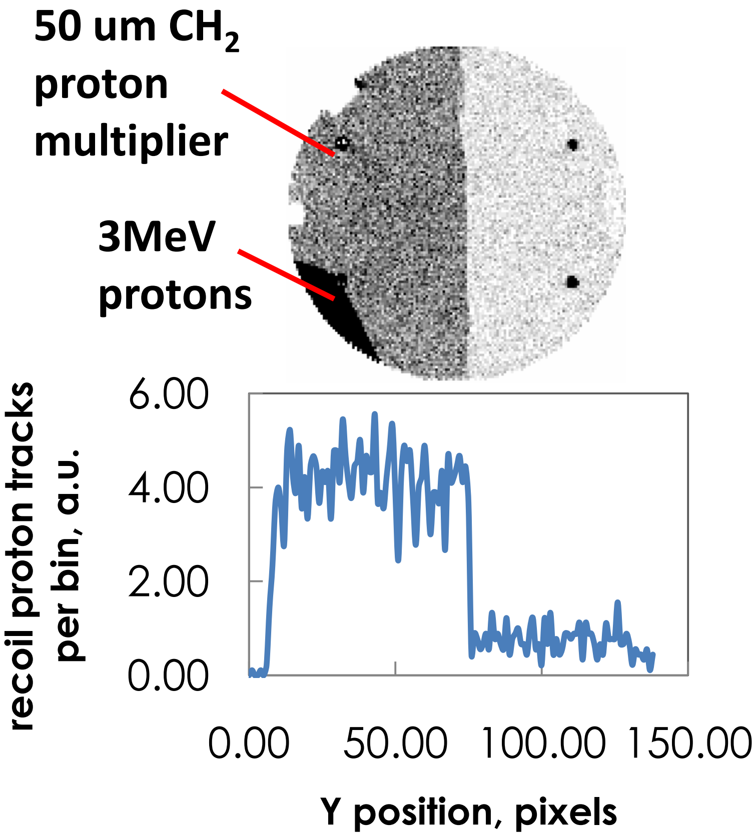
Shown here is detector package for both neutron and secondary proton measurements

The detection efficiency determined from the accelerator is applied to OMEGA and NIF data

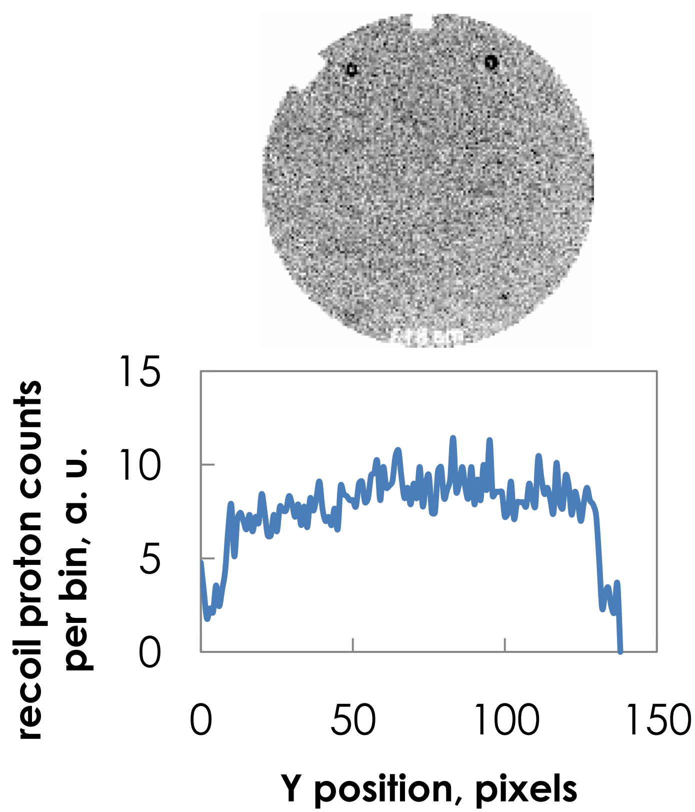
J.A. Frenje et al., Rev. Sci. Instrum. 73 (2002).
F. H. Seguin, et al. (to be submitted)
M. Manuel et al. (this session)

CR-39 has been exposed to known fluences of neutrons on the MIT accelerator

Front Side

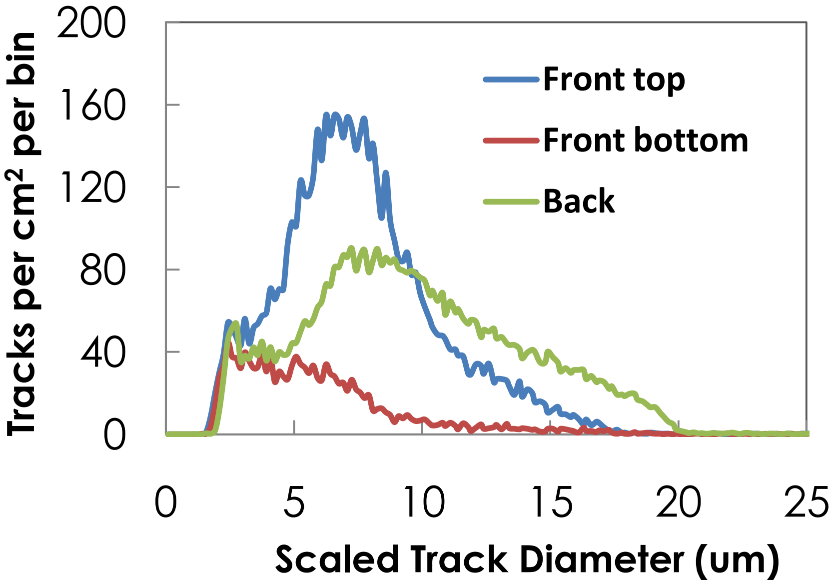


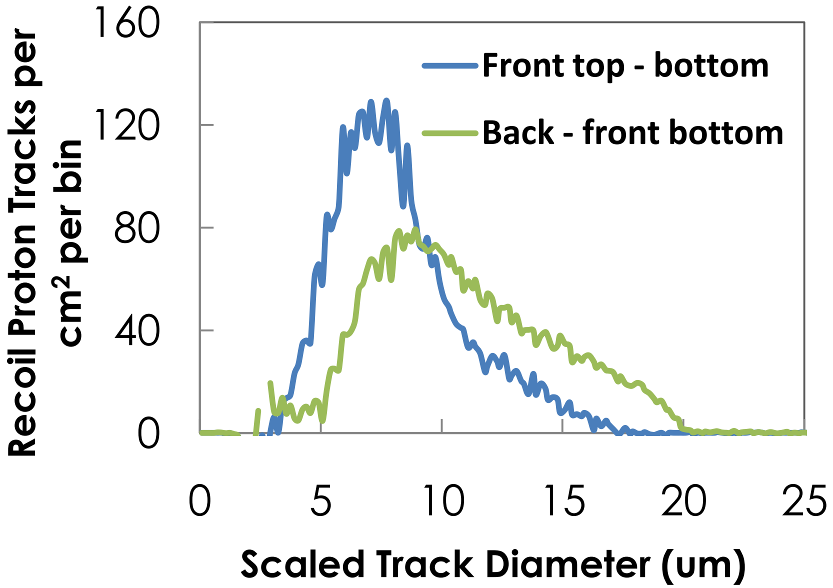
Back Side



Silicon barrier diodes (SBDs) were used to measure the associated particle fluence (3MeV protons)

Detection efficiencies were determined for different yield processing techniques

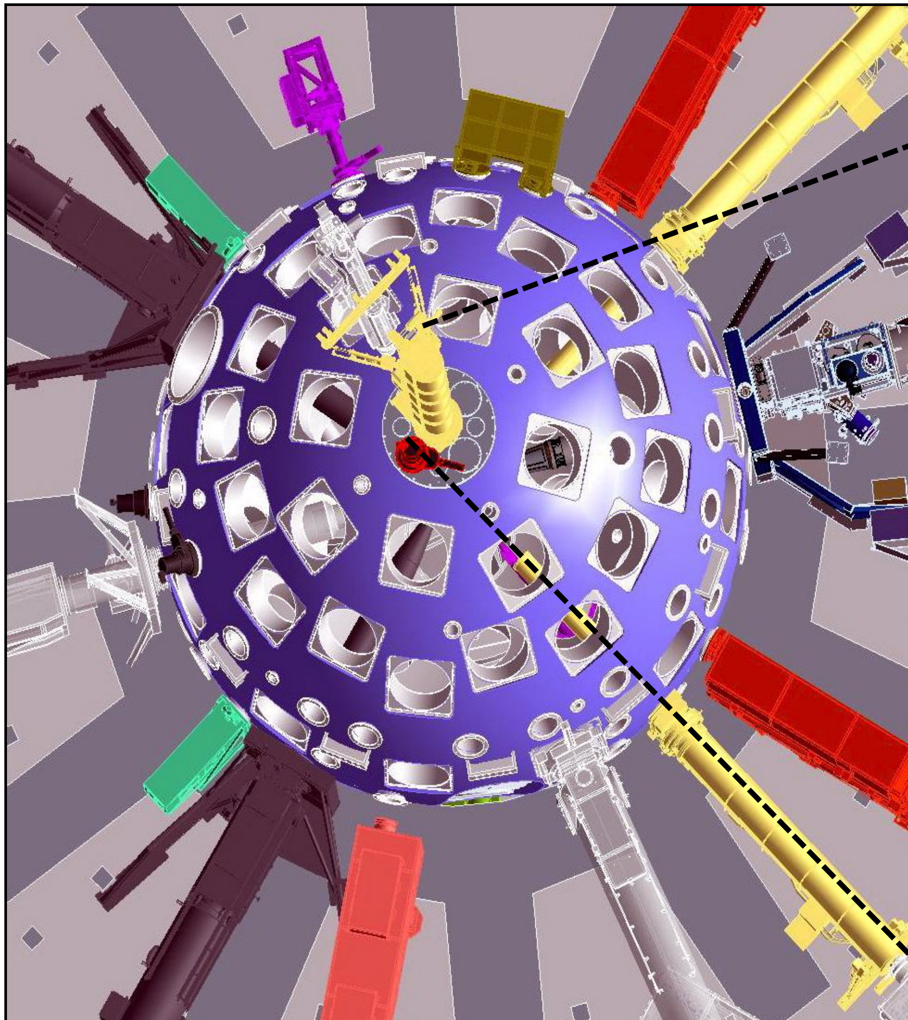


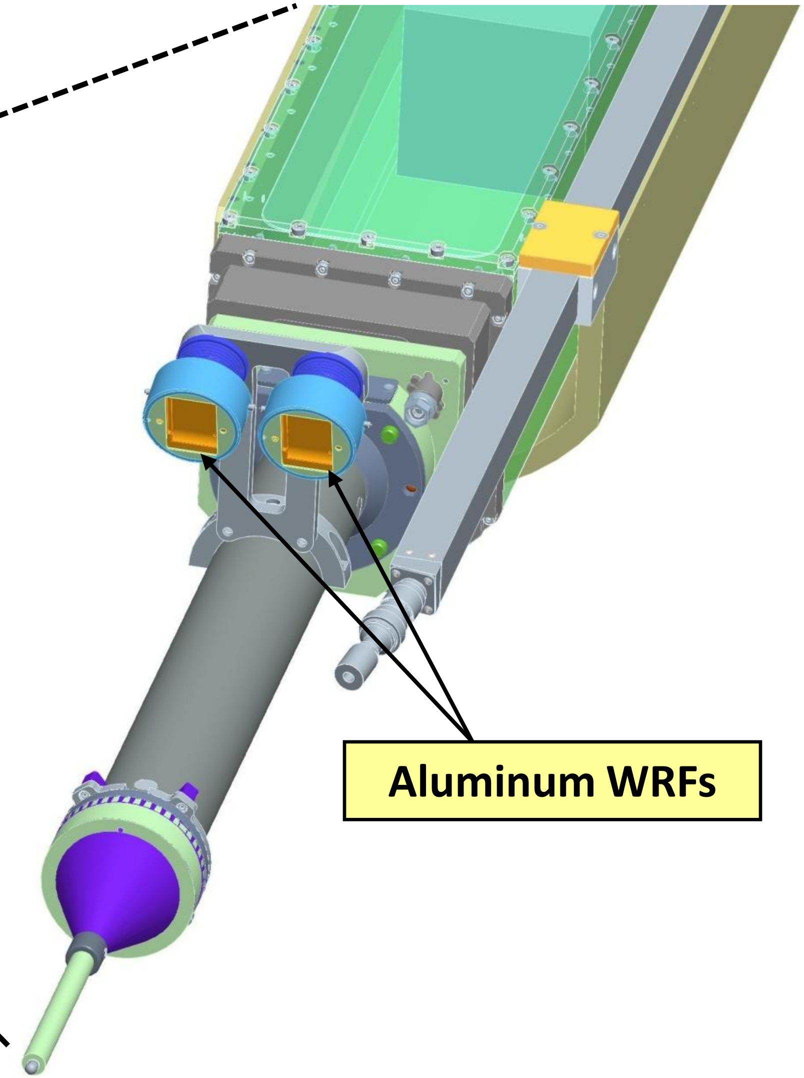


Detection efficiencies of DD-n of order 10^{-4} have been determined

Diagnostic #2: Wedge-Range-Filter (WRF) Proton Spectrometer

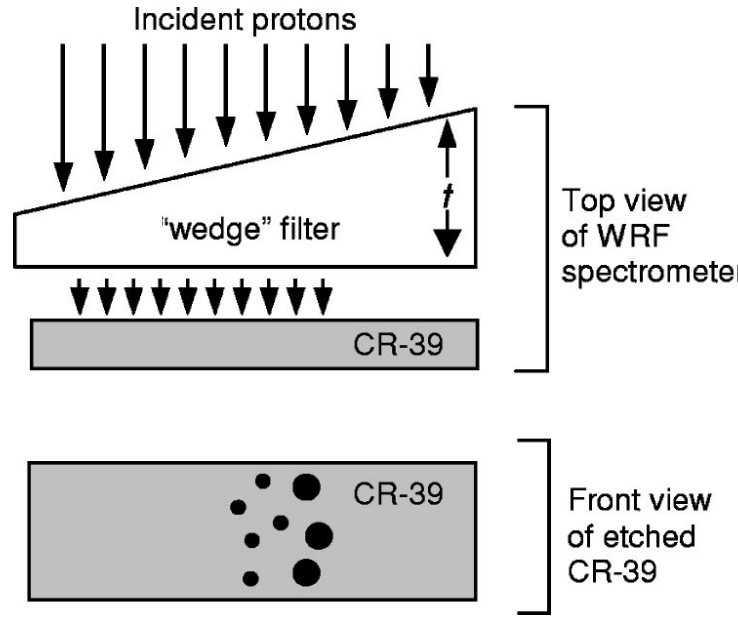
WRF proton spectrometers have been fielded in the polar and 90-45 DIM on the NIF





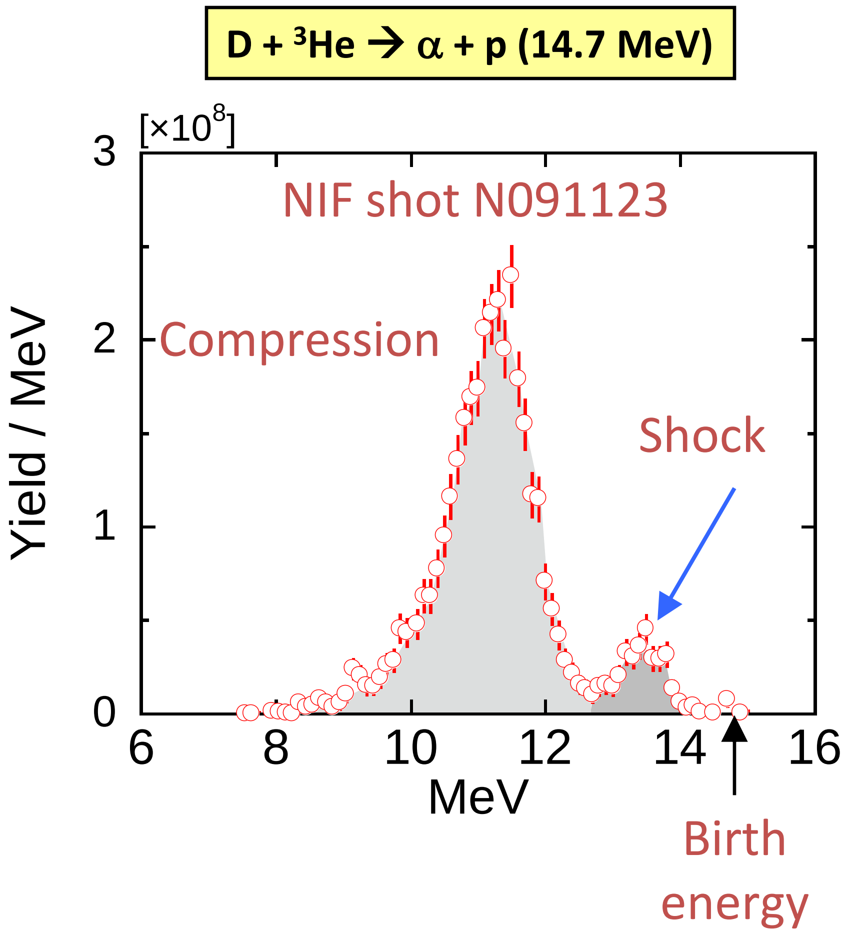
The accelerator has been used to calibrate WRF spectrometers for the measurements of D-3He protons at OMEGA and the NIF

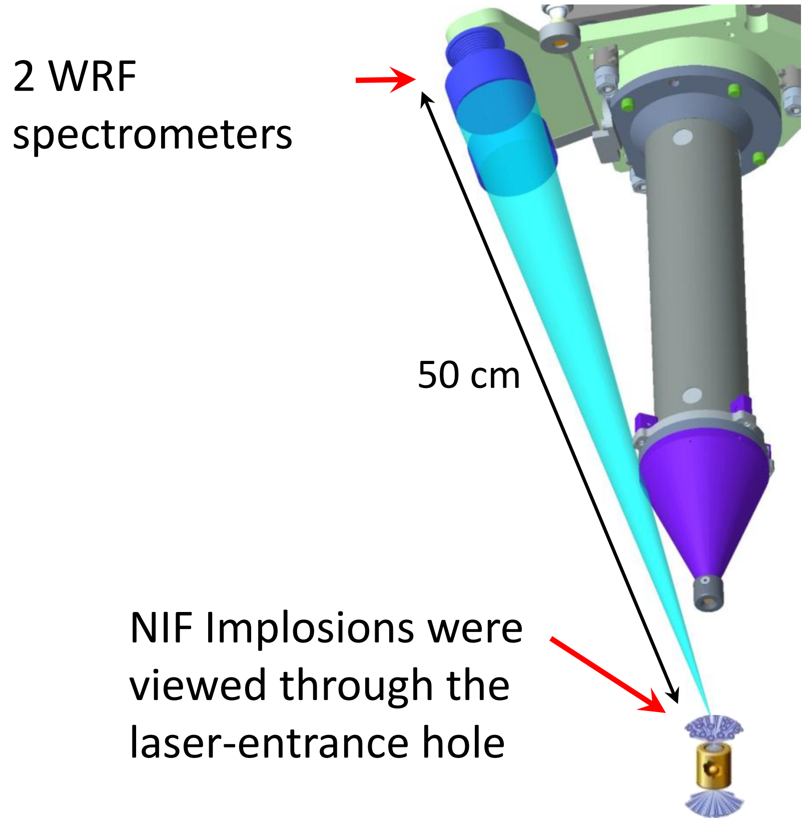
Aluminum (left) and Zirconia (right) WRFs have been used on the recent NIF campaign



F.H. Séguin *et al.*, Rev. Sci Instrum 74, 975 (2003).

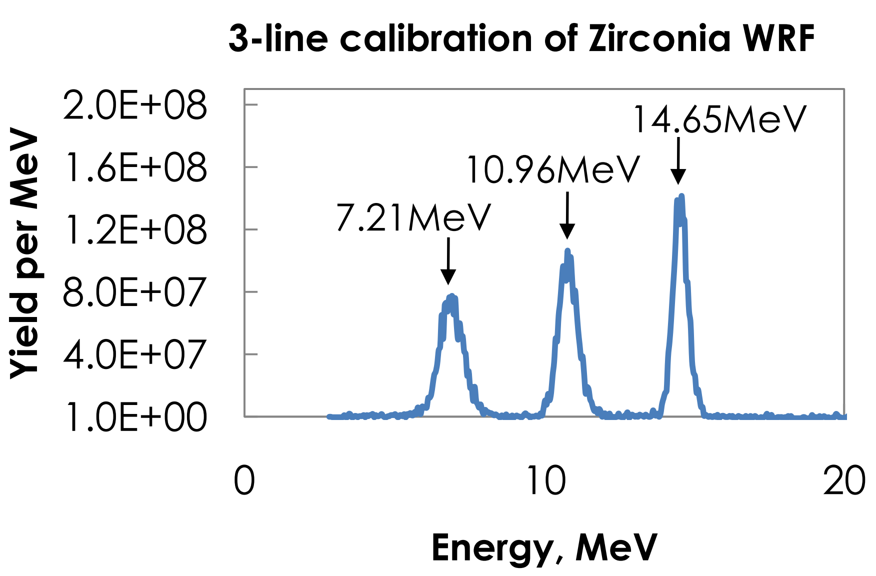
The WRF spectrometers have been used at OMEGA and the NIF for diagnosing ρ*R* and ρ*R* asymmetries in a wide range of implosions through measurements of D-3He protons

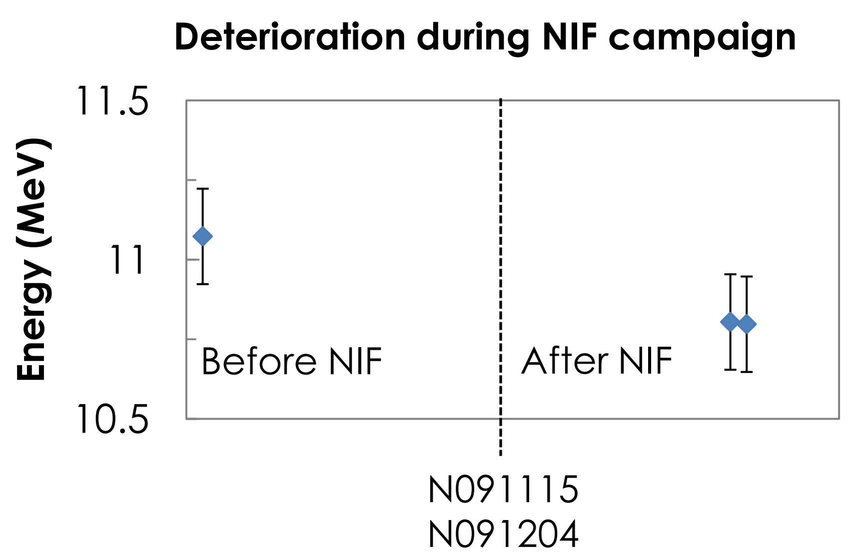


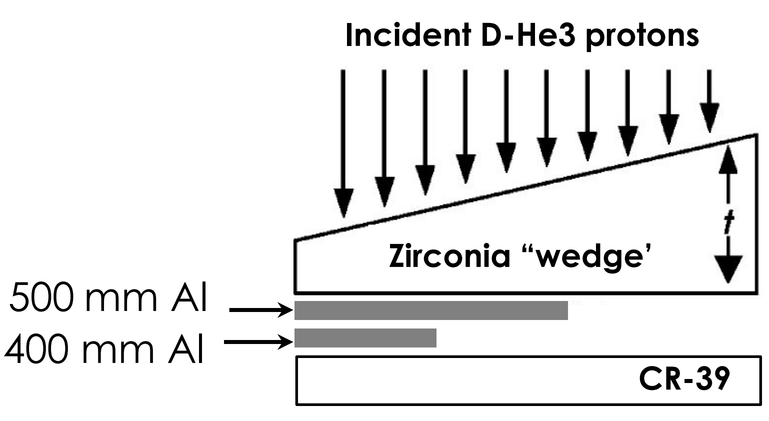


** F.H. Séguin *et al.*, Rev. Sci Instrum 74, 975 (2003).

Calibration of new WRFs and recalibration of WRFs used on the NIF have been conducted on the accelerator





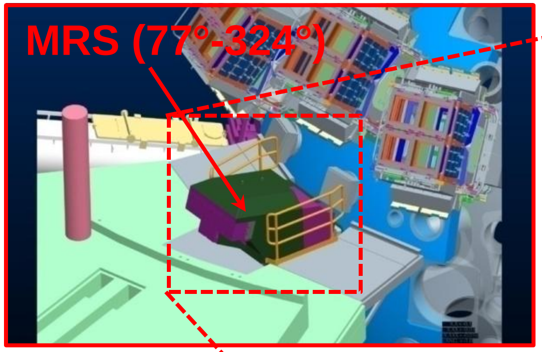


Both Aluminum and Zirconia WRFs showed no significant deterioration

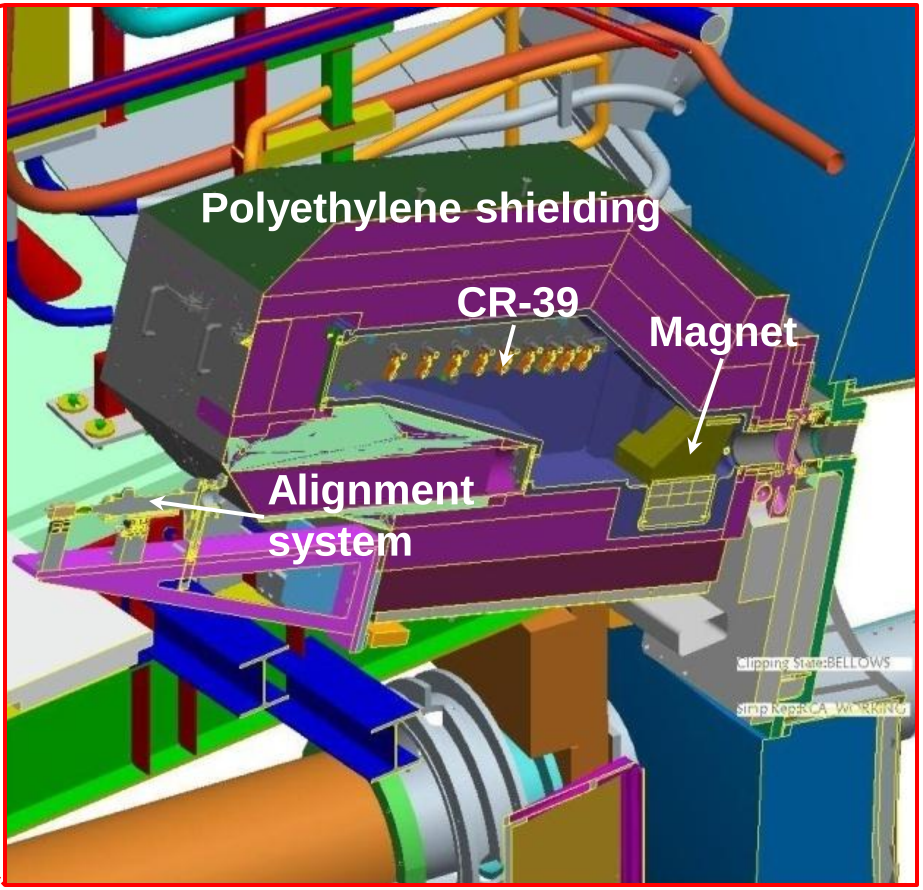
Diagnostic #3: The Magnetic Recoil Spectrometer (MRS)

An MRS is currently implemented on the NIF for measurements of the ICF-neutron spectrum

MRS on the NIF target chamber

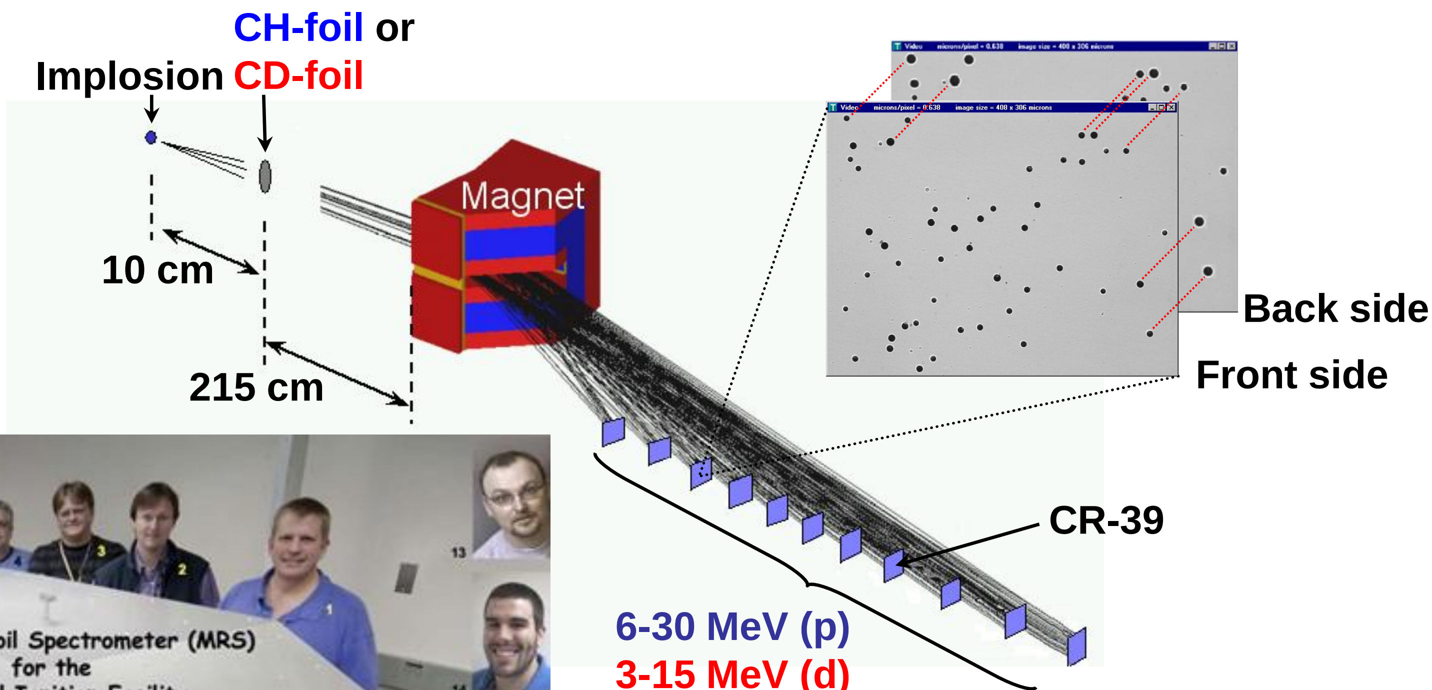


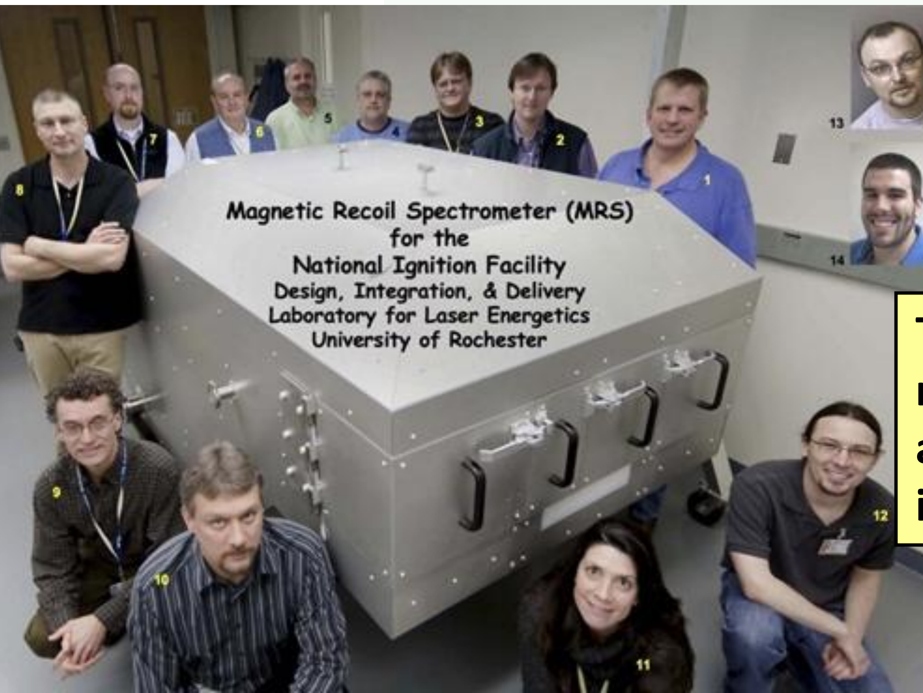
Graduate student Dan Casey and the NIF MRS



Cross-section of the MRS for the NIF

The MRS' on OMEGA and the NIF are using CR-39 for detecting recoil protons or deuterons

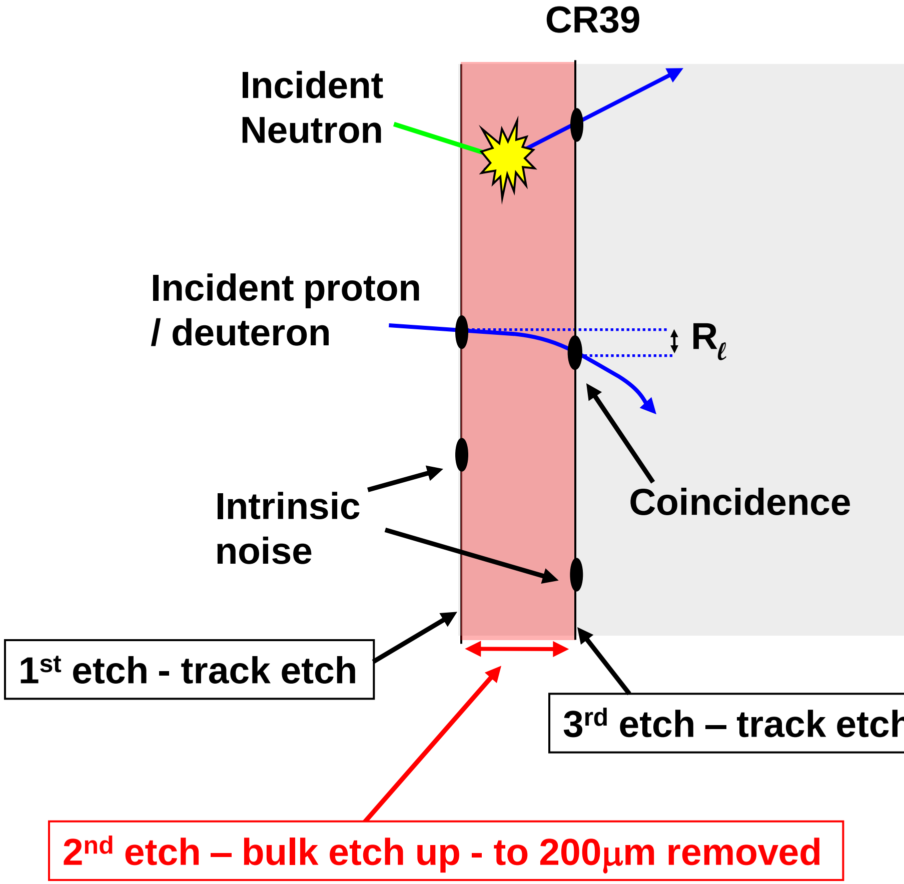


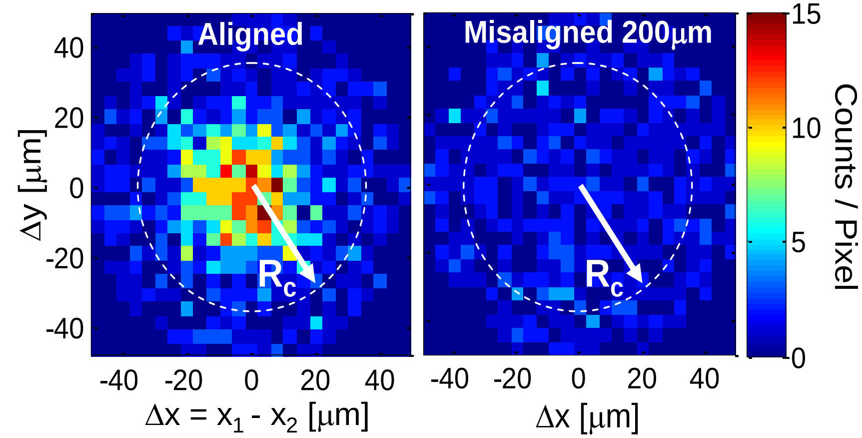


This spectrometer measures the absolute neutron spectrum (6-30 MeV) from which ρR, T_i and Y_n can be determined for a large range of implosions.

** J.A. Frenje *et al.*, Rev. Sci. Instrum. 72, 854 (2001).
J.A. Frenje *et al.*, Rev. Sci. Instrum. (2008).

The coincidence counting technique (CCT) for the MRS at OMEGA was developed and optimized using the accelerator



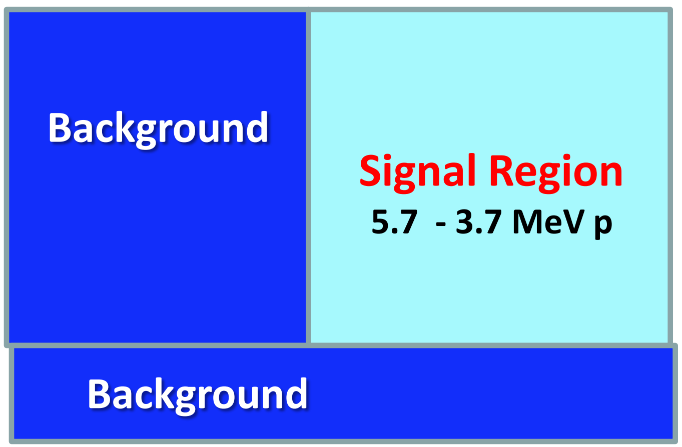


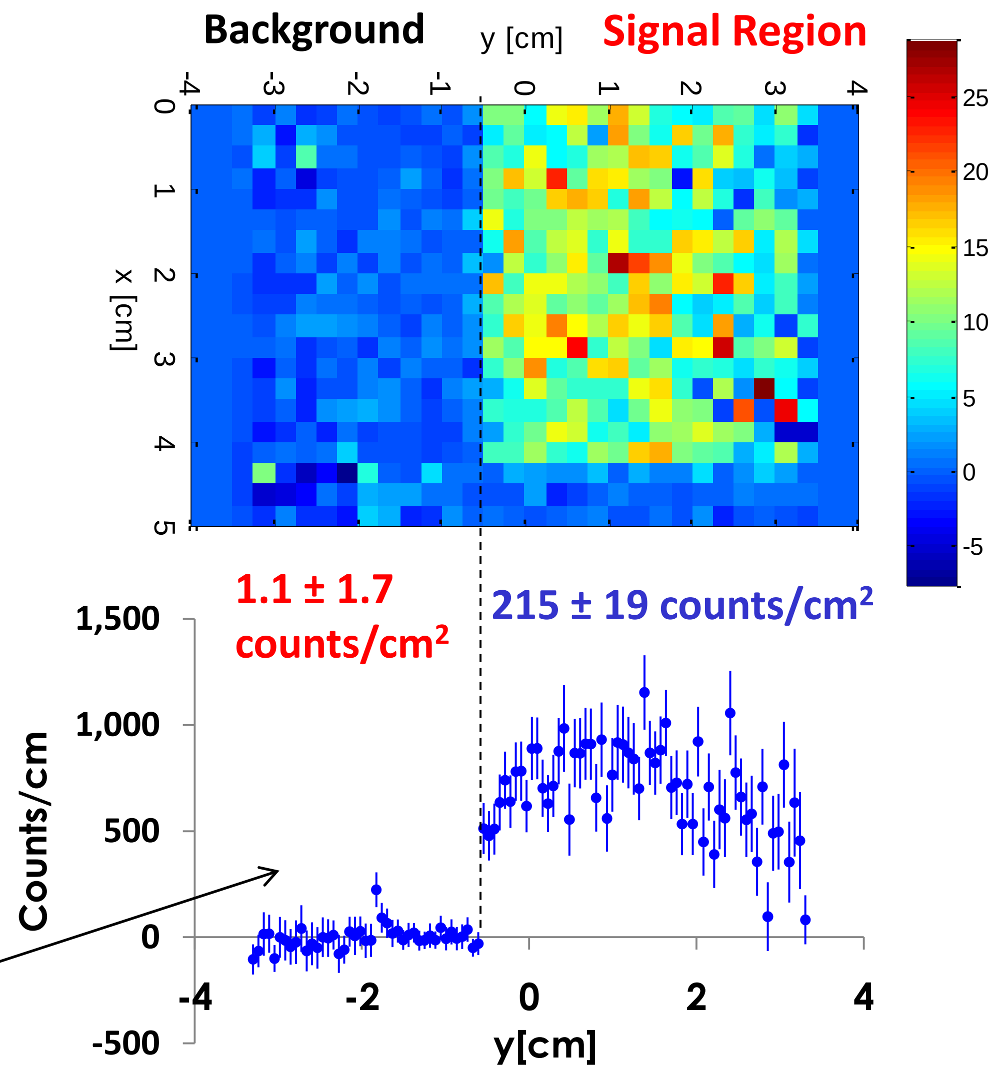
By applying the CCT, *S/B* is enhanced orders of magnitude*

* D.T. Casey *et al.* , to be submitted to Rev. Sci. Instrum. (2008).

** J.A. Frenje *et al.* , Rev. Sci. Instrum. 72, 2597 (2002).

DHe^3 protons were used to test the CCT and to show that it properly subtracts background with a 200um bulk etch





The background region is effectively zero, showing the CCT properly subtracts the background

Some important references…