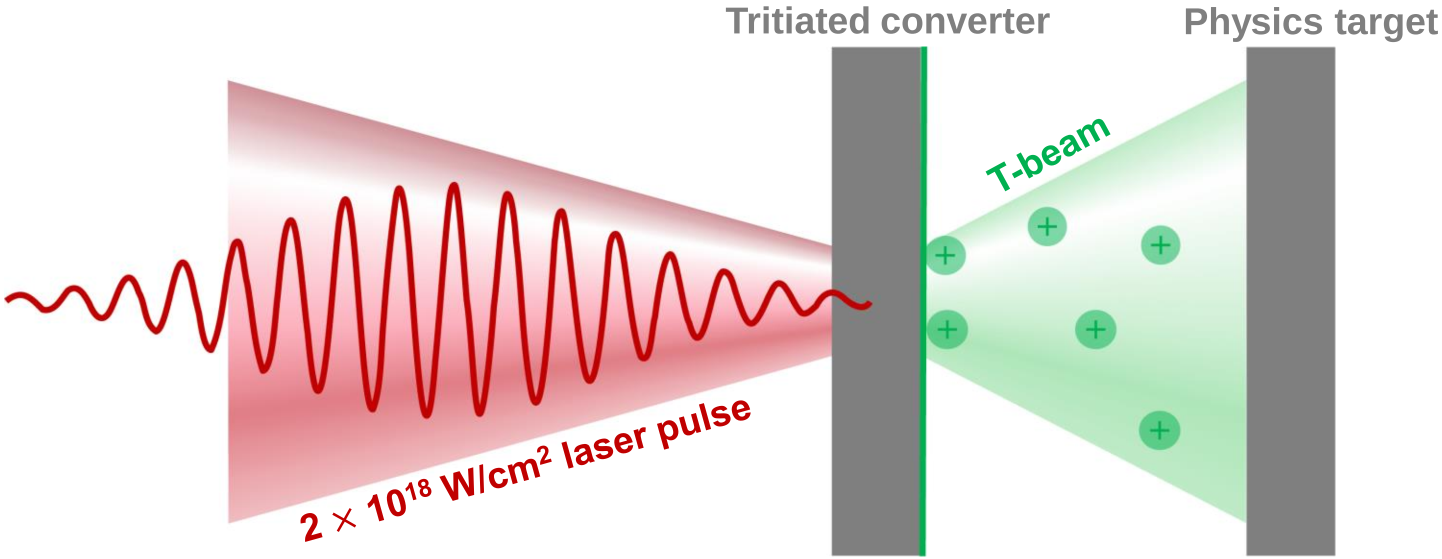
Recent developments at the OMEGA platform for deuterium and tritium beams



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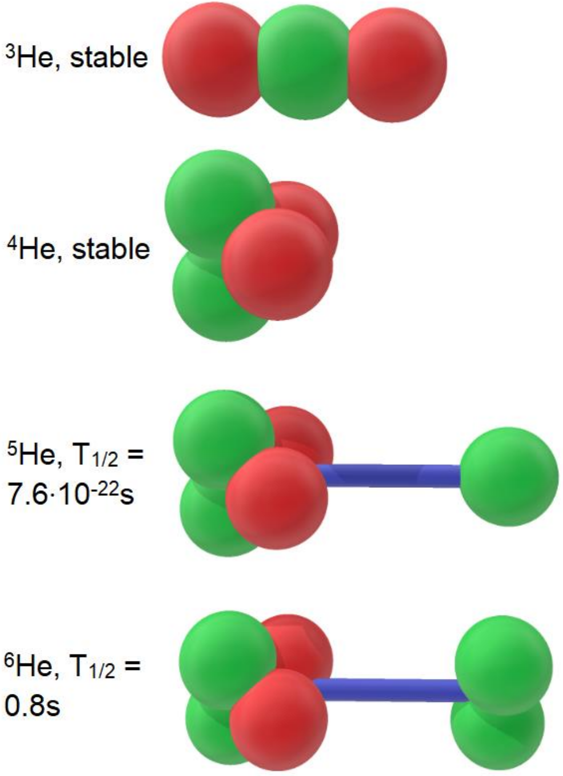
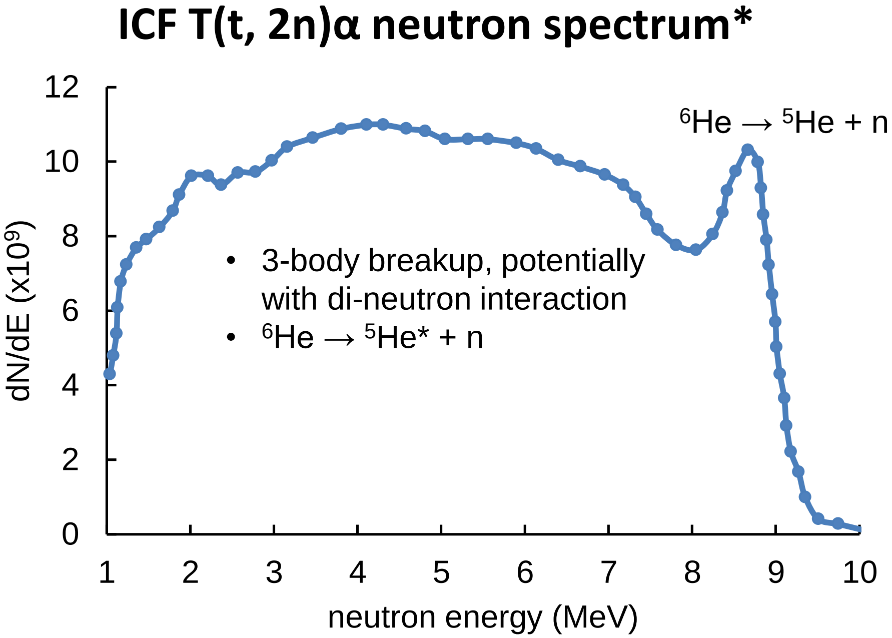
A platform for tritium beams is under development at OMEGA

- **Deuterium beams are strong enough to study reactions with cross sections around *100mb*, such as $^{9}Be(d,n)^{10}B$ and $^{7}Li(d,n)^{8}Be$**
- **Tritium beams are strong enough to induce $^{2}H(t,n)^{4}He$ (*5b*), but the yields are currently too low for other reactions**
- **Laser pulseshapes are developed to make more of the tritium in the targets accessible (10^{16} tritons are in the target but only 10^{12} in the beam)**
- **A new lithium activation diagnostic is being developed that can handle lower reaction yields**

Tritium reactions like T(t, 2n)α, ^{6}Li(t, p)^{8}Li and ^{9}Be(t, p)^{11}Be produce exotic neutron rich nuclei





*Reanalyzed data obtained by M. Gatu Johnson *et al*., Phys. Rev. Lett. 121, 042501 (2018).

Tritium reactions to be studied on this platform

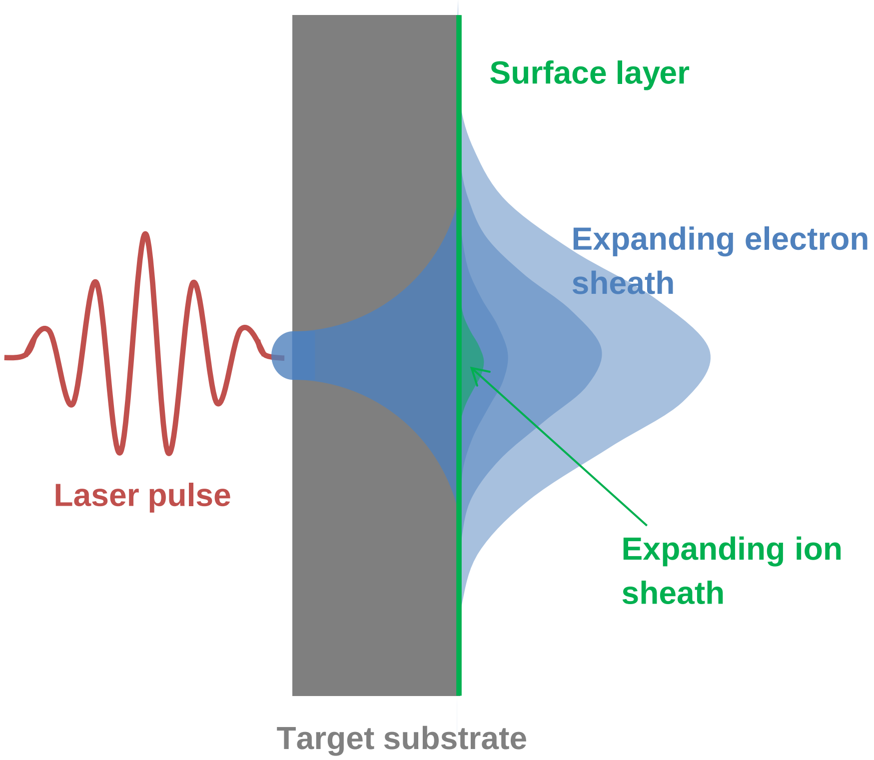
Reaction	Triton energies	To Be Measured	Interest
$^{3}H(t, 2n)^{4}He$	< 1 MeV 1 – 5 MeV	$d\sigma/dE_n$ $d\sigma(E_t)/dE_n$	Commissioning, neutron standard ^{6}He resonances
$^{6}Li(t, p)^{8}Li$	~1 MeV	$d\sigma(E_t)/dE_p$	Pair transfer, A=8 ab initio structure
$^{7}Li(t, \alpha)^{6}He^*$	> 6 MeV	$d\sigma(E_t)/dE_\alpha$	^{6}He resonances in p pickup
$^{6}Li(t, {}^{3}He)^{6}He^*$	> 6 MeV	$d\sigma(E_t)/dE$	^{6}He resonances in p pickup
$^{9}Be(t, p)^{11}Be$	~1 MeV	$d\sigma(E_t)/dE_p$	Pair transfer, A=11 ab initio structure
$^{197}Au(t, p2n)\,^{197}Au$	~10 MeV	$d\sigma(\theta, E_t)/dE_n$	t breakup, search for $^{3}H^*$ state
A(t, p)B	~1 MeV	$d\sigma/dE_n$	Neutron pair transfer

Target Normal Sheath Acceleration (TNSA) can generate multi-MeV ion beams with miniaturized setups

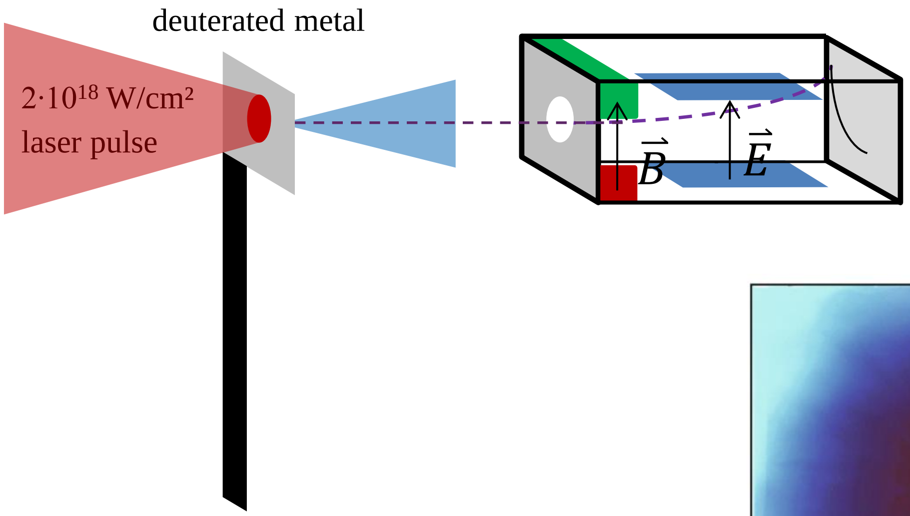
- **A target containing $\sim 10^{16}$ tritons is irradiated by a $\sim 10^{18}\ W/cm^2$ pulse**

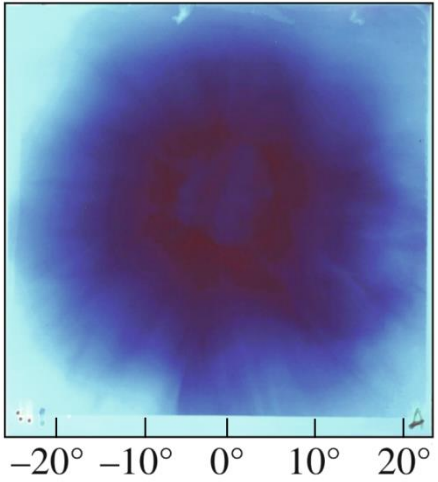
- **Several processes transfer energy from the laser to electrons and then to ions**

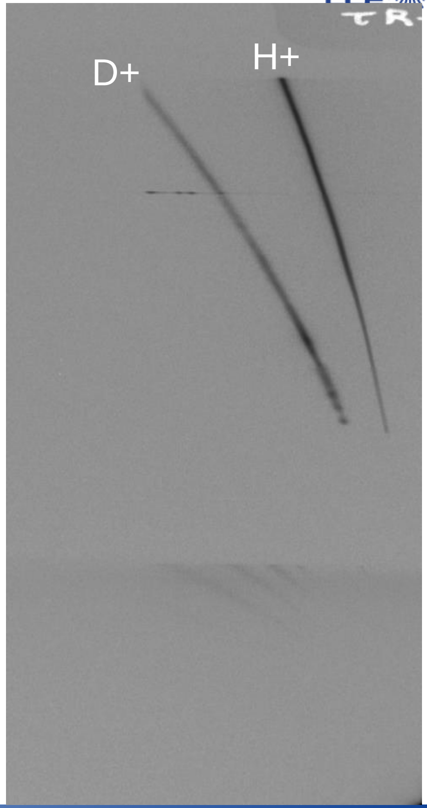
- **Studies with deuterated and tritiated targets have shown total yields around $\sim 10^{12}$ particles at energies of several MeV**



A Thomson Parabola and radiochromic film were used to characterize the beam





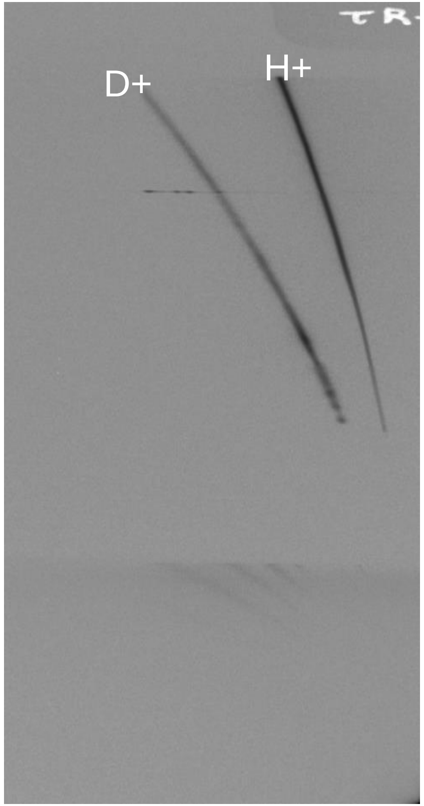


Our targets still predominantly accelerate protons, which reduces the deuteron acceleration

- Protons accelerate faster, thereby shielding heavier ions from electrons so most of the deuterium remains unused

- Even a short (<1s) ambient air exposure will grow a thin water-layer on the target

- Air exposure in the target chamber is unavoidable, therefore, the target has to be cleaned in-situ

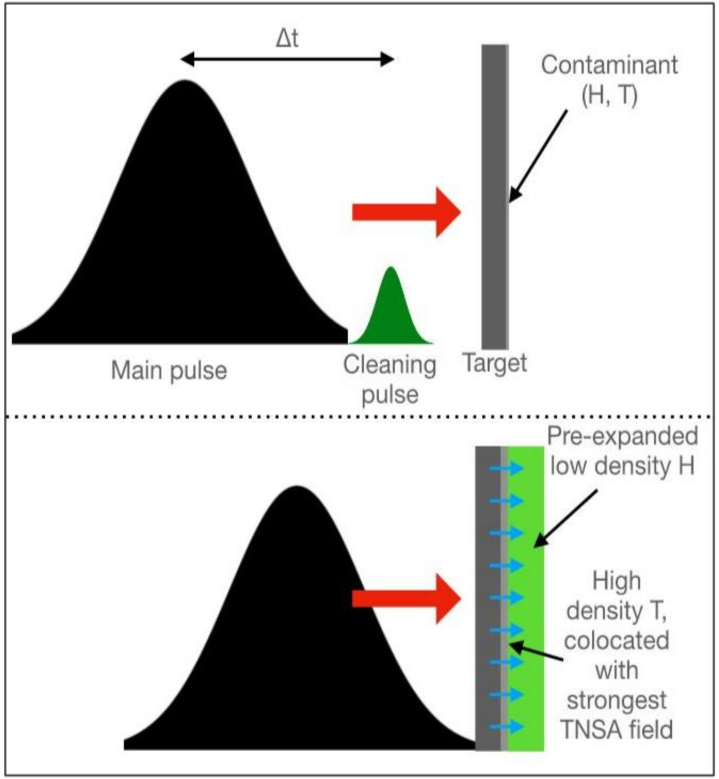


A custom pre-pulse has been developed for OMEGA-EP to clean our TiD_2 targets in-situ

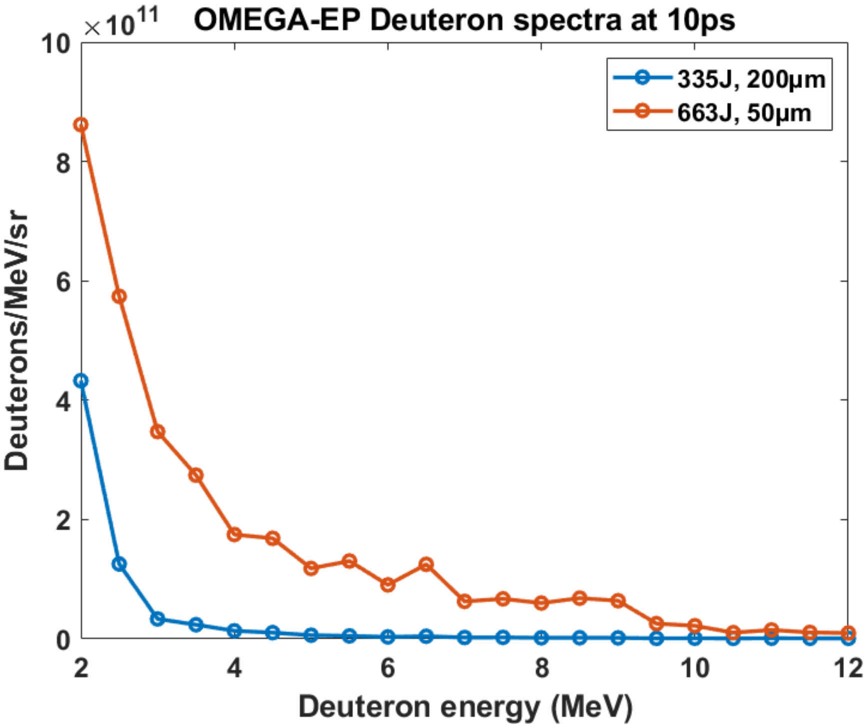
- A 0.7ps, 10^{17} W/cm^2 prepulse hits the target, creating ~100keV electrons

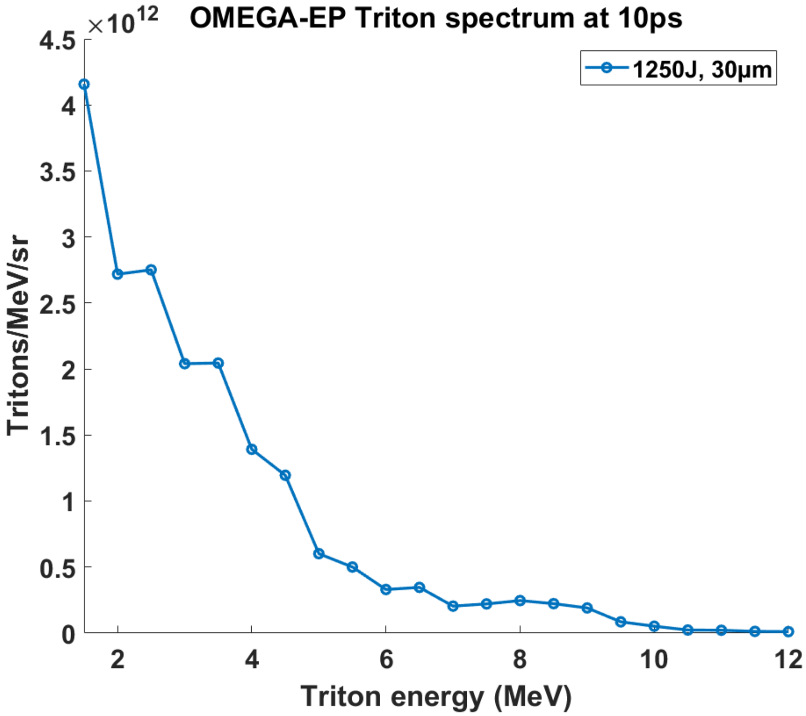
- This weak sheath accelerates the surface protons, leaving only the deeper sitting deuterium/tritium

- The main pulse (10ps, 10^{19} W/cm^2) hits 10ps later, when there is still a large density gradient at the target

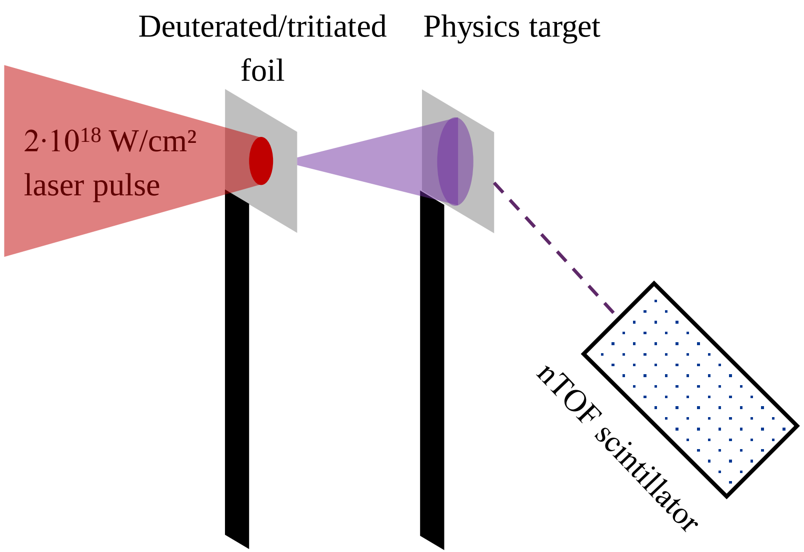


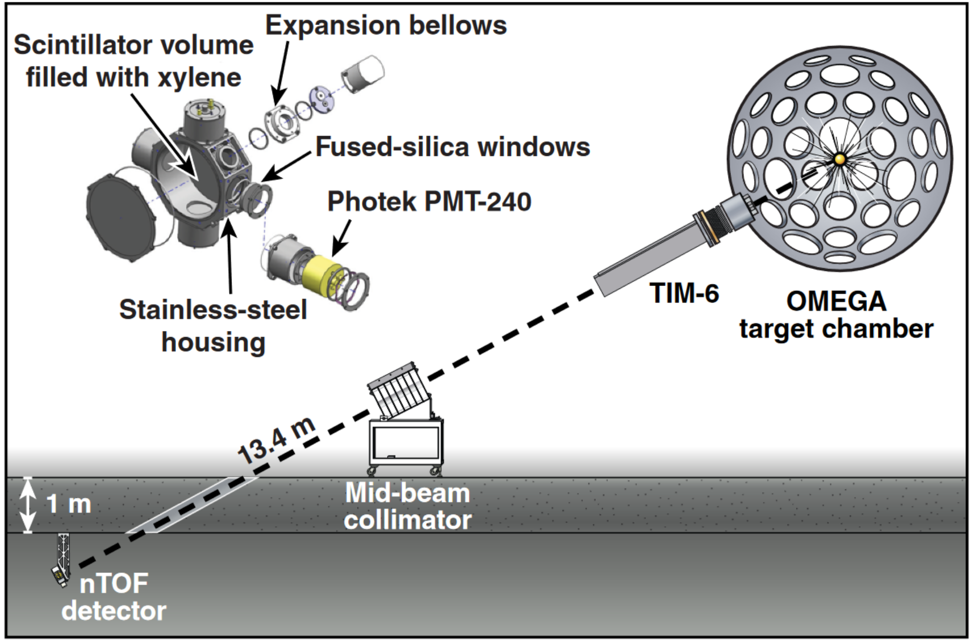
Deuteron and triton beam spectra are exponential with energies exceeding 10MeV



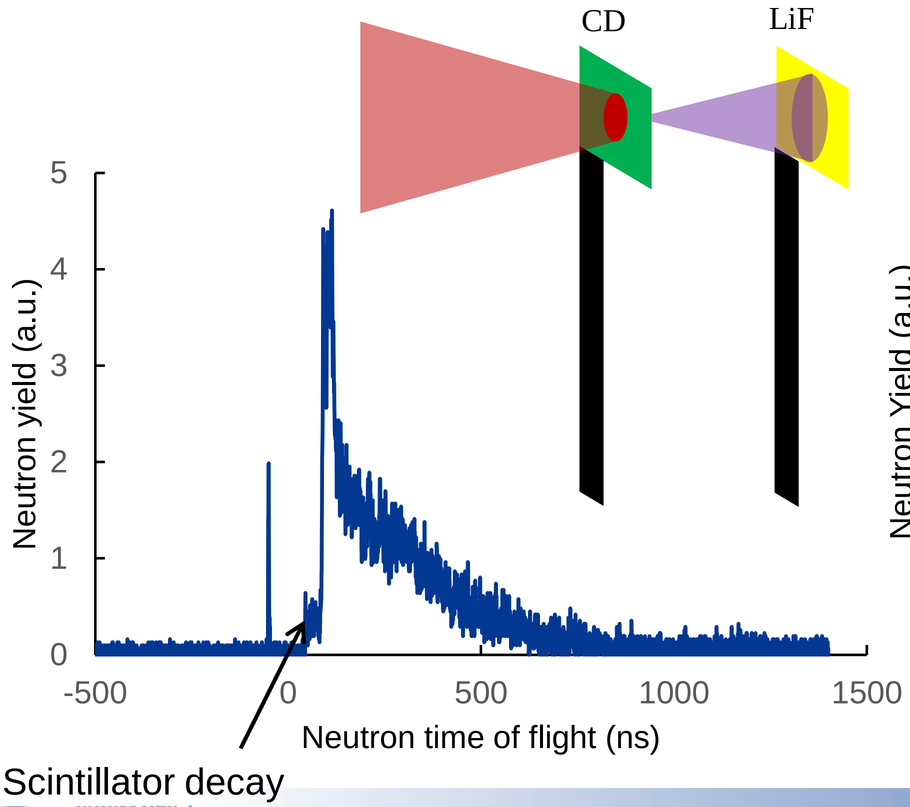


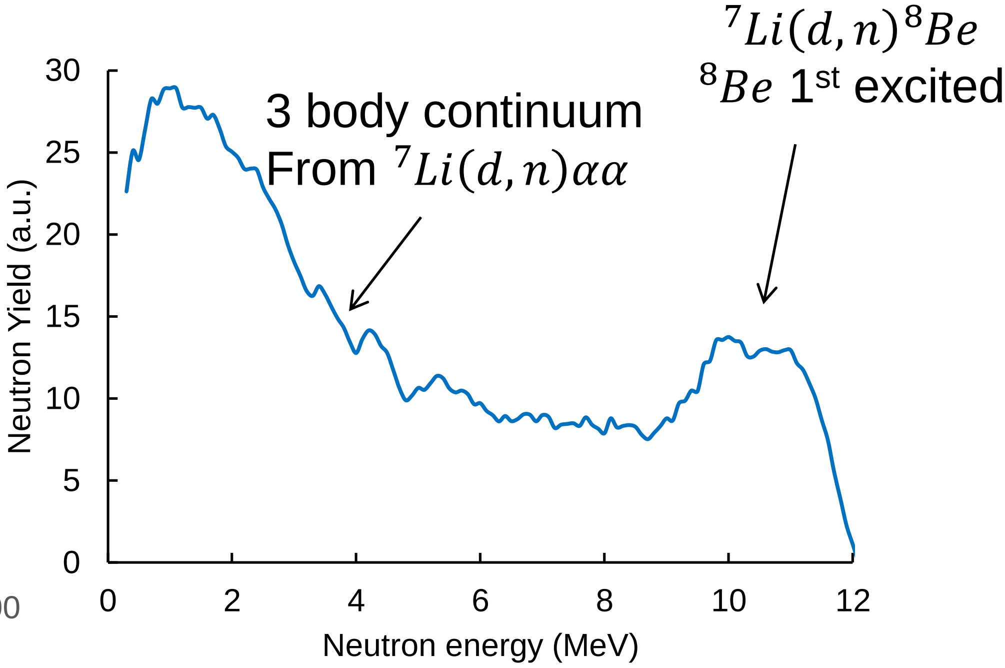
Neutrons from nuclear reactions are measured using the OMEGA/OMEGA-EP nTOFs



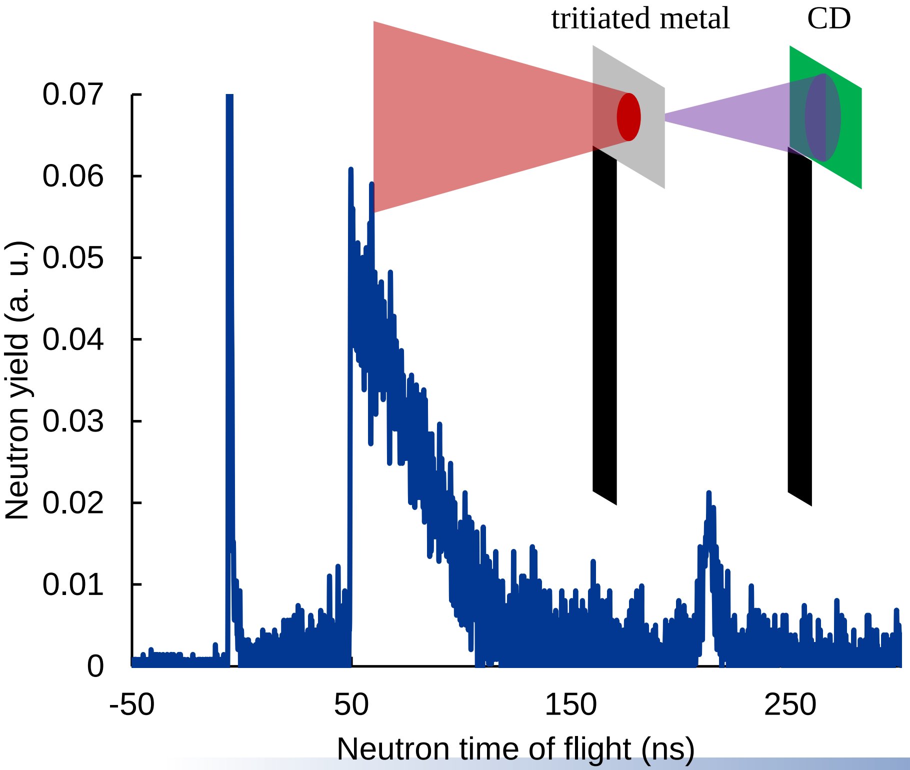


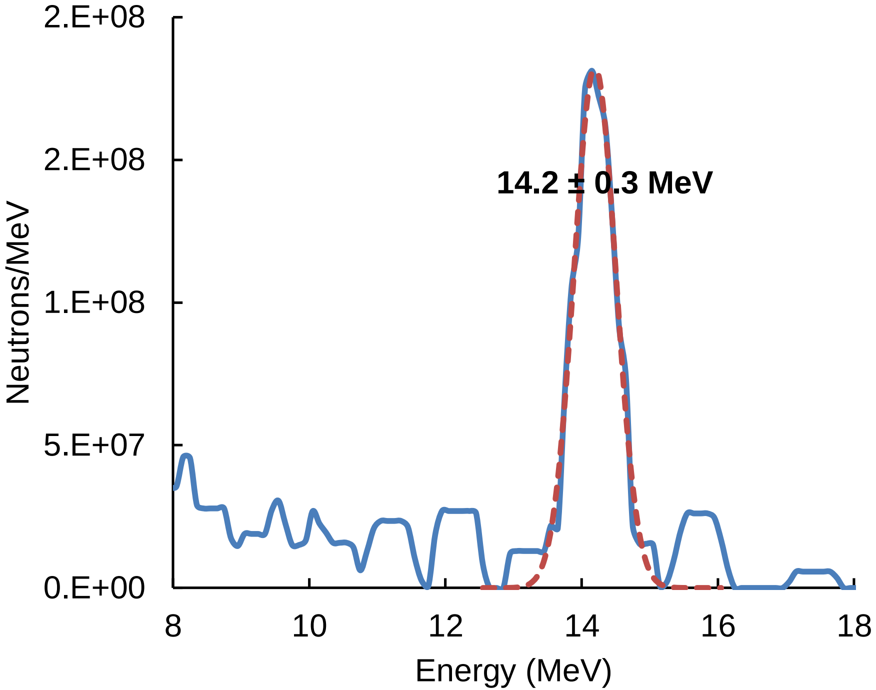
OMEGA deuterium beam on ^{7}Li produced a neutron spectrum with recognizable features





OMEGA tritium beam on deuterium produced the expected DT fusion neutrons

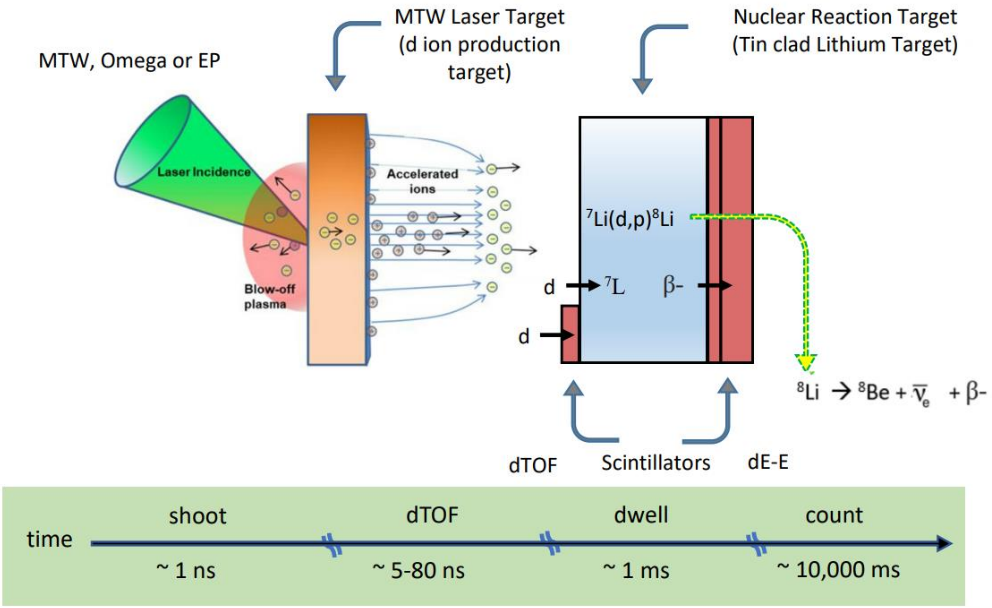




A new lithium activation diagnostic was designed to handle low-yield experiments

- The detector exploits the $^{7}Li(d,p)^{8}Li$ reaction with a cross section of ~150mb from 0.5 to 5 MeV

- Activation favors fast experiments since the nuclei do not have the time to decay, increasing signal/noise

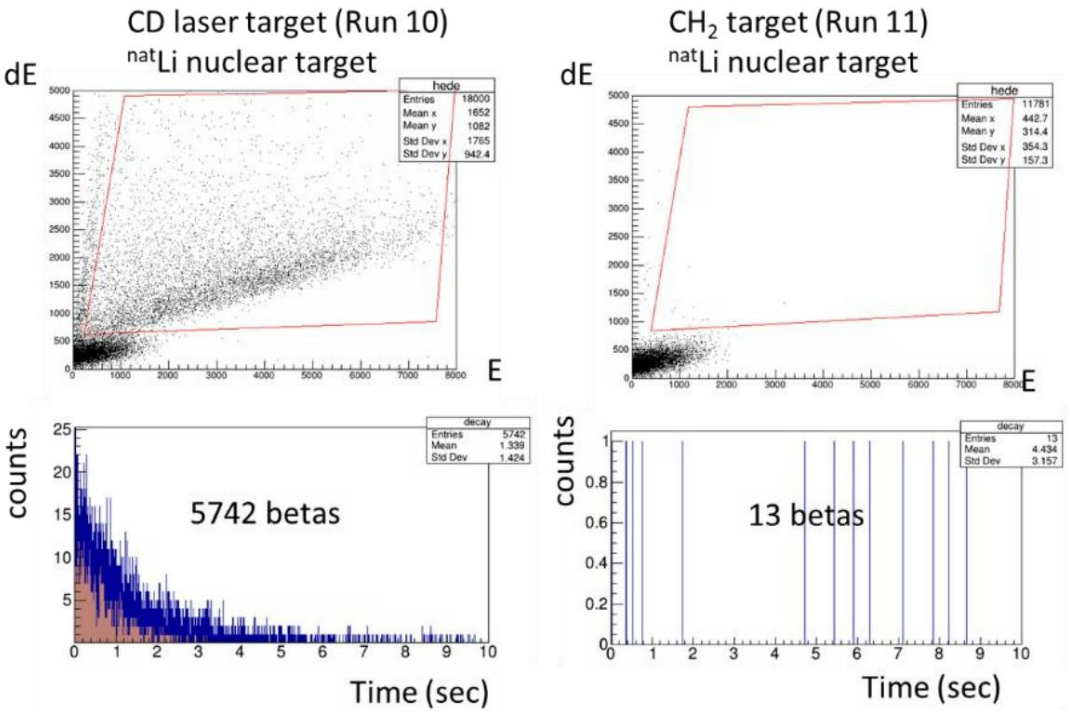


The new diagnostic was successfully tested on the downscaled MTW facility

- **CD targets were used to produce 10^{12} deuterons with mean energy ~0.8MeV**

- **6000 β events from the decay of ^{8}Li were detected**

- **Experiments on OMEGA with deuterium/tritium have been proposed**



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Backup

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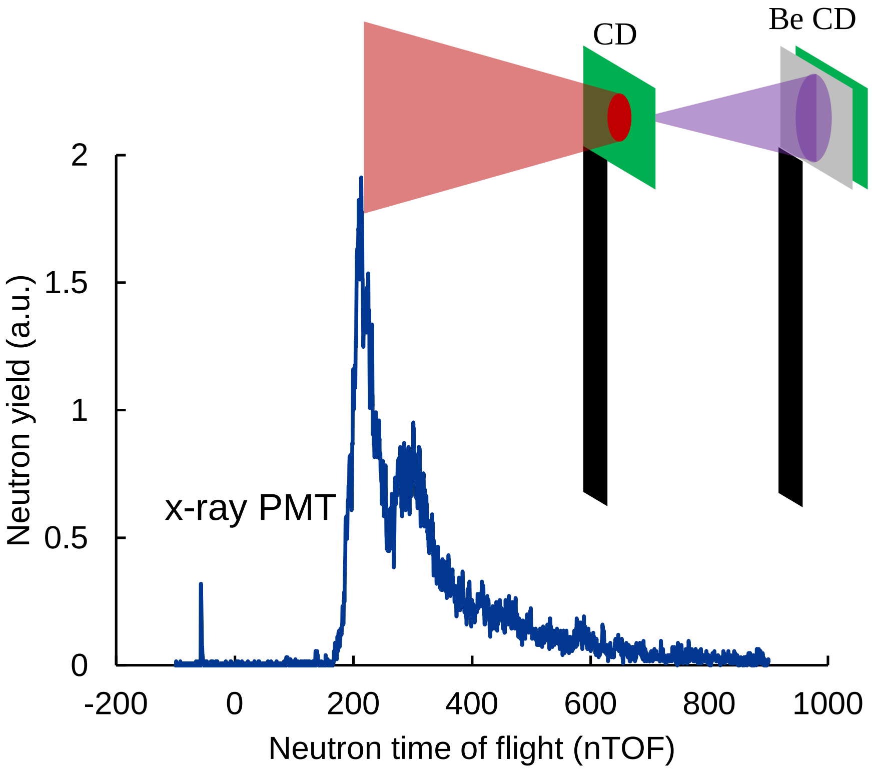
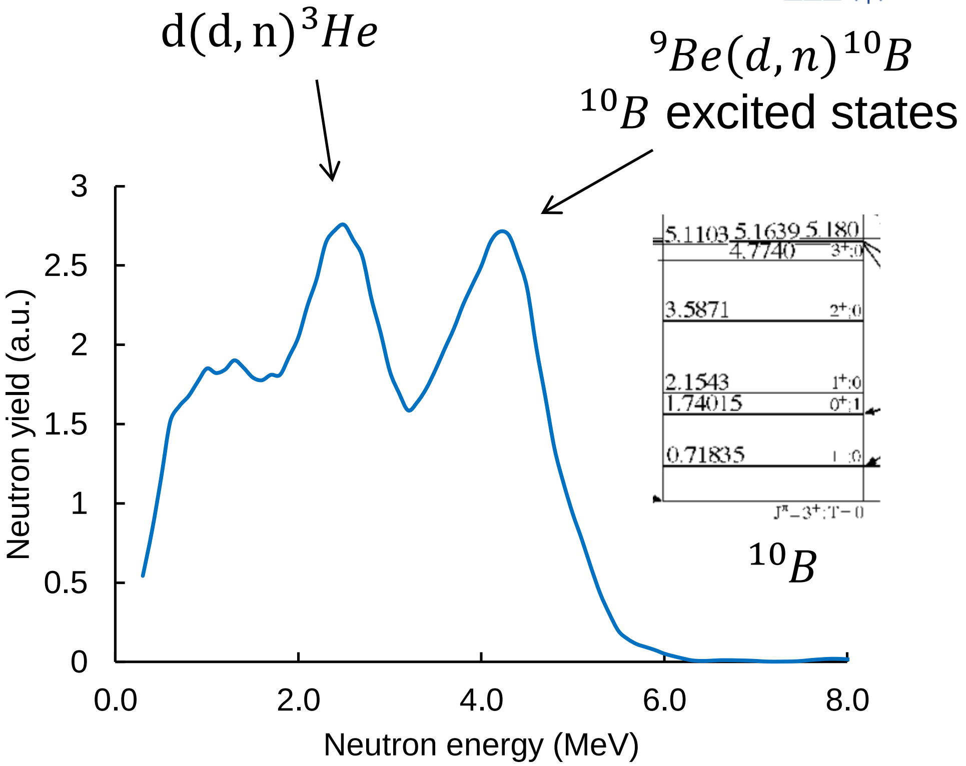
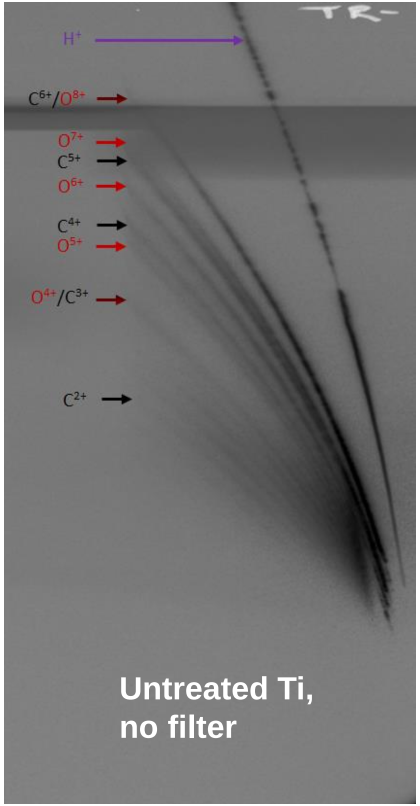
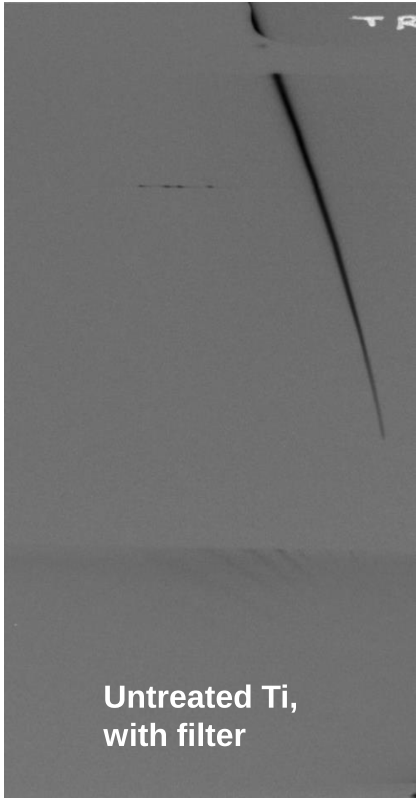
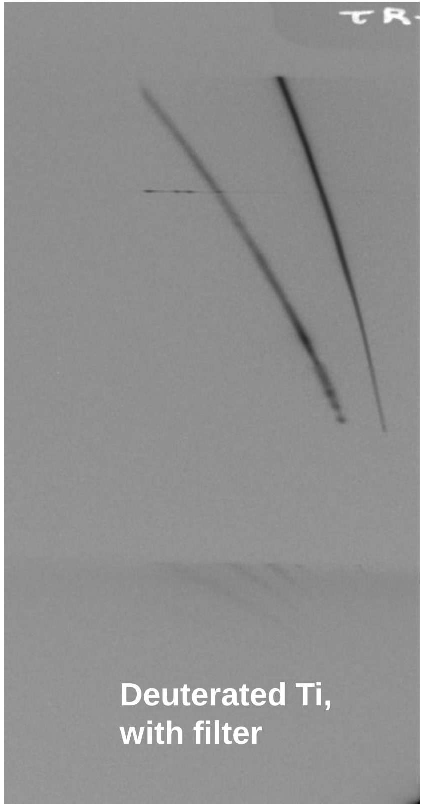




TPIE filter* effectively removed all heavy species







*A. Alejo *et al*., Review of Scientific Instruments 85, 9 (2014)