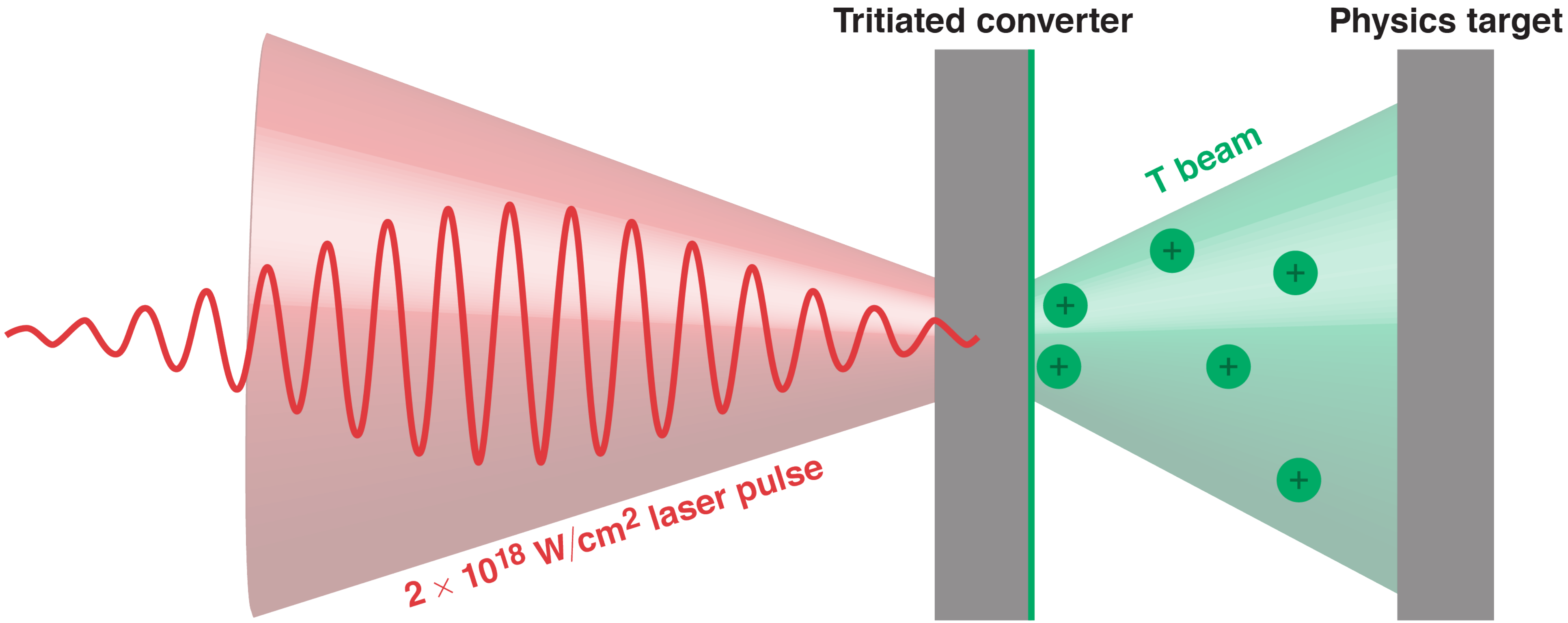
# First Demonstration of a Triton Beam Using Target Normal Sheath Acceleration

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Summary

# Target normal sheath acceleration (TNSA) can generate multi-MeV triton beams with miniaturized setups

- Deuterated and tritiated targets were shot on MTW and OMEGA EP
  - 25-$\mu$m-thick titanium was tritiated by gas exposure
  - The ion beams were examined using Thomson parabolas
  - The triton beam was used for pitcher – catcher nuclear experiments
- Key discoveries
  - The ion energy spectrum can be manipulated with the laser energy
  - The world's first TNSA triton beam contained $10^{12}$ tritons up to 10MeV and induced D–T fusion ($10^8$ DT neutrons)

MTW: Multi-Terawatt laser

# Collaborators


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OMEGA-EP, MTW Facilities

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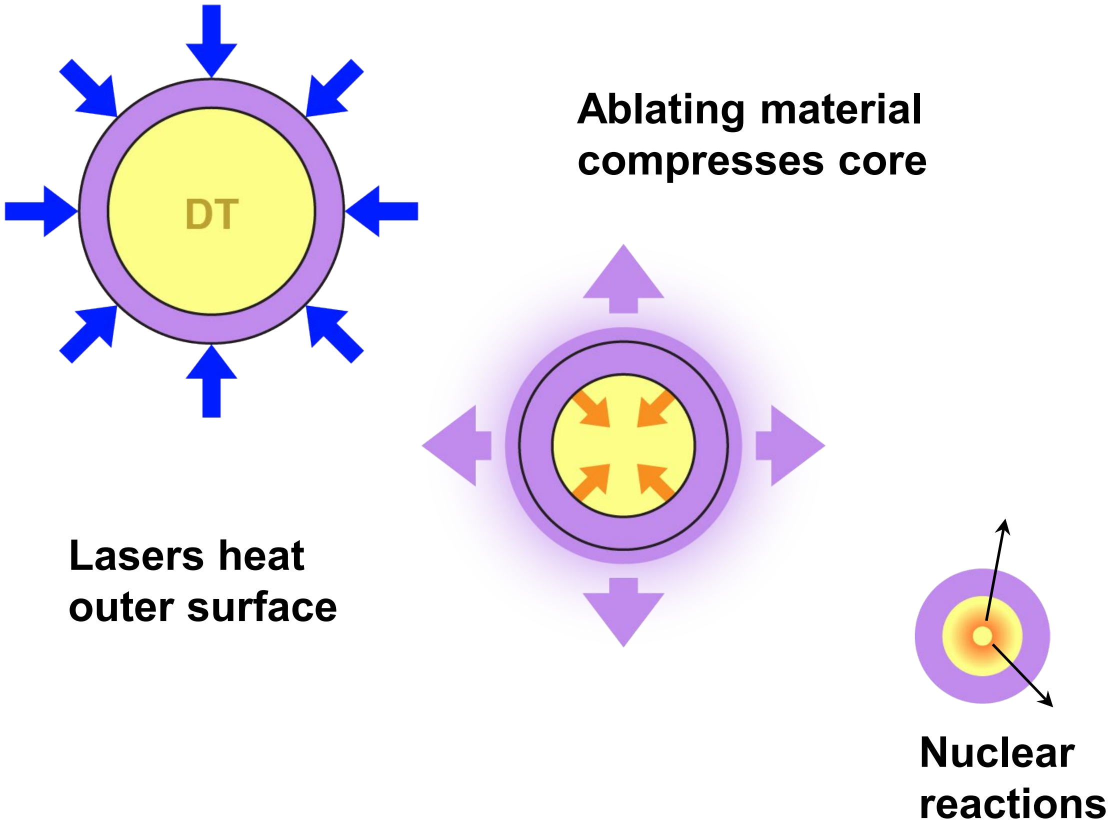
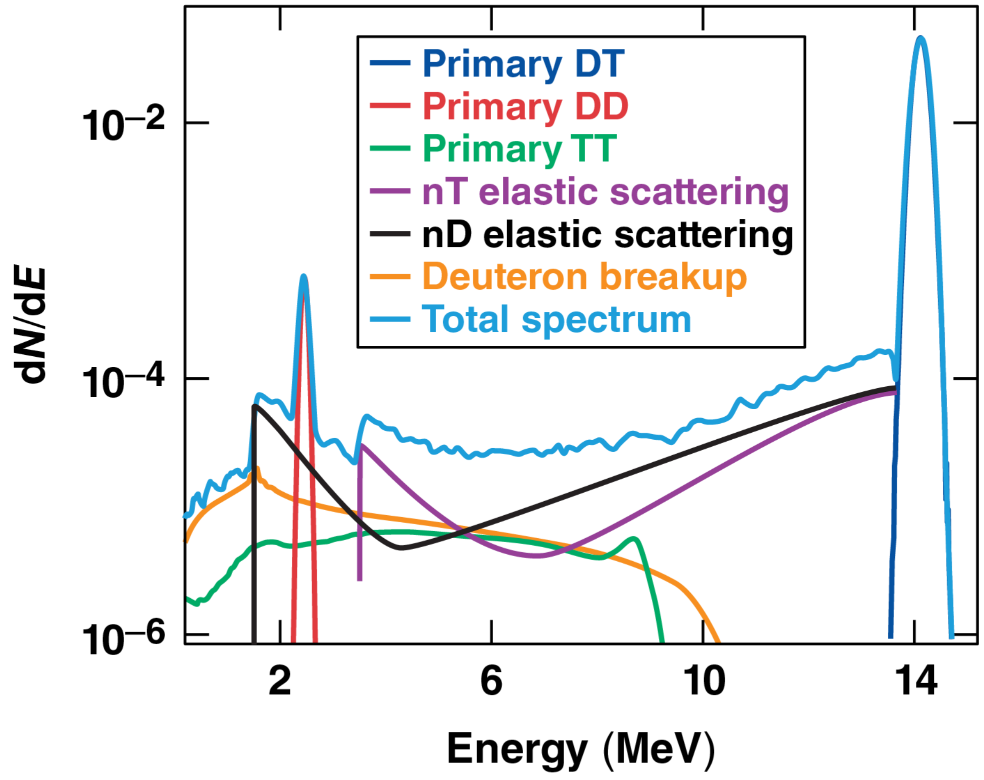
University of Rochester

# Inducing T(t, 2n)$\alpha$ with a controllable beam provides a "bare-reaction" standard for ICF without plasma effects

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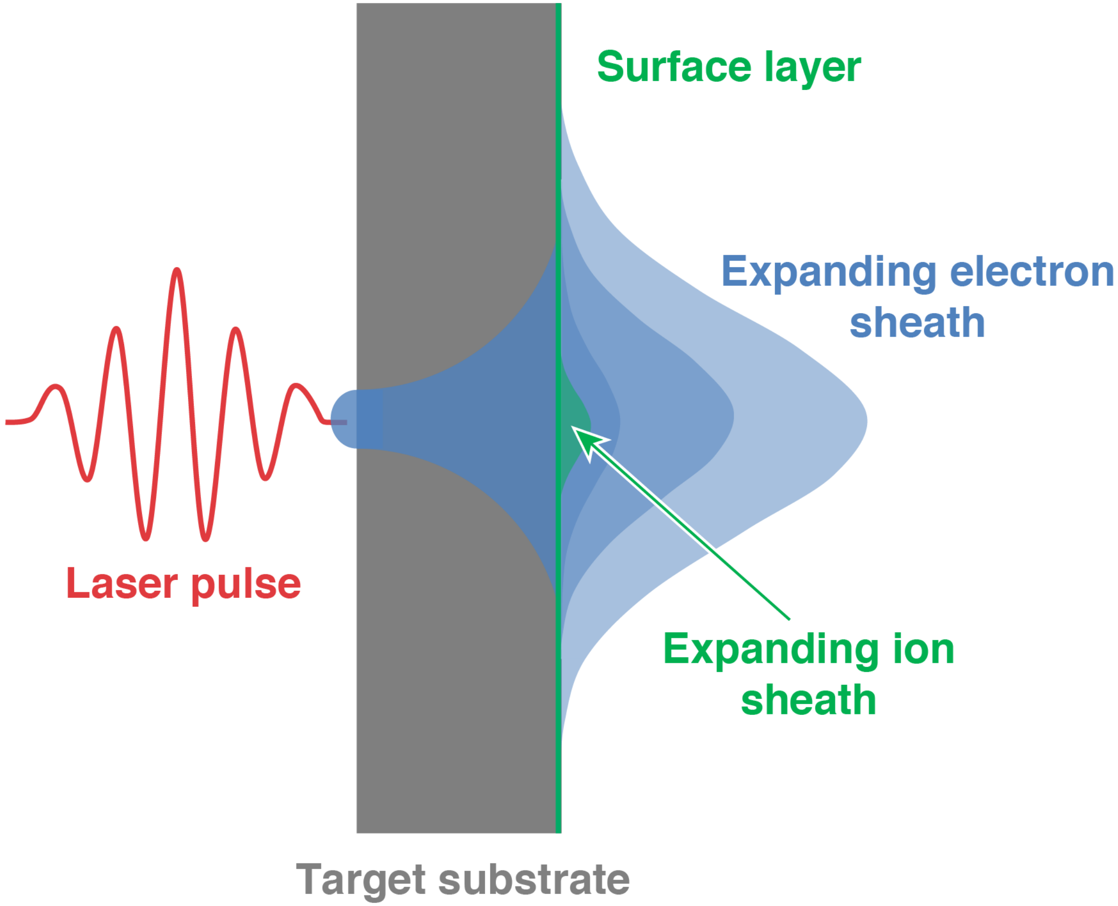
ICF: inertial confinement fusion

# TNSA can deliver radioactive beams that are challenging to handle for accelerators

- A 25-$\mu$m thick target contains ~$10^{16}$ tritons
- The laser produces a hot (~1-MeV) electron cloud at the target rear
- The electrons accelerate a cloud ("beam") of ~$1 \times 10^{12}$ tritons
- The energy spectrum can be manipulated with the laser

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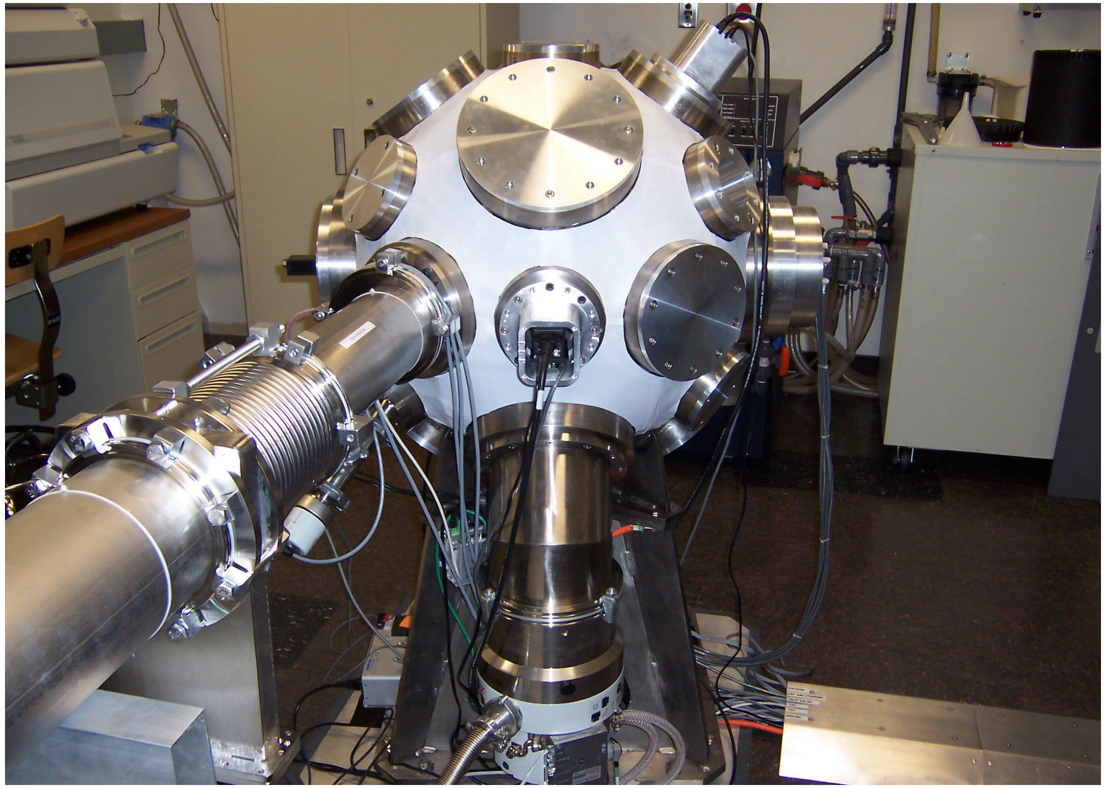
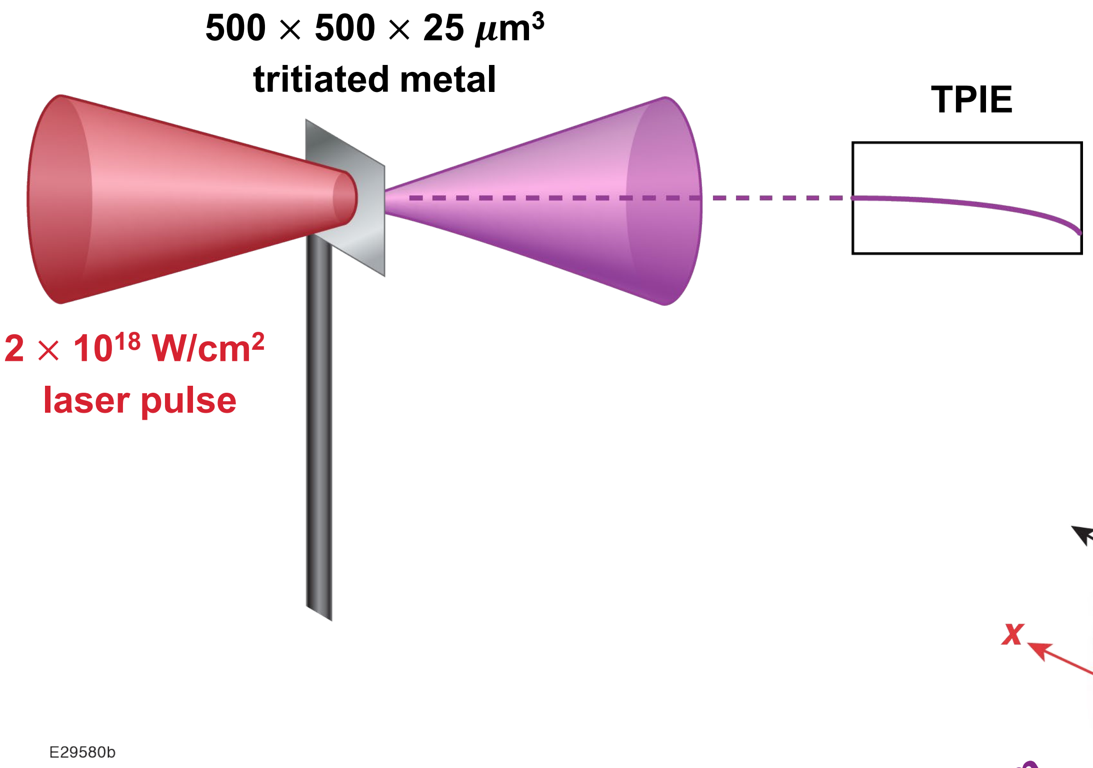
# Small-scale MTW experiments were conducted to guide the large-scale OMEGA/OMEGA EP deuteron and triton campaigns

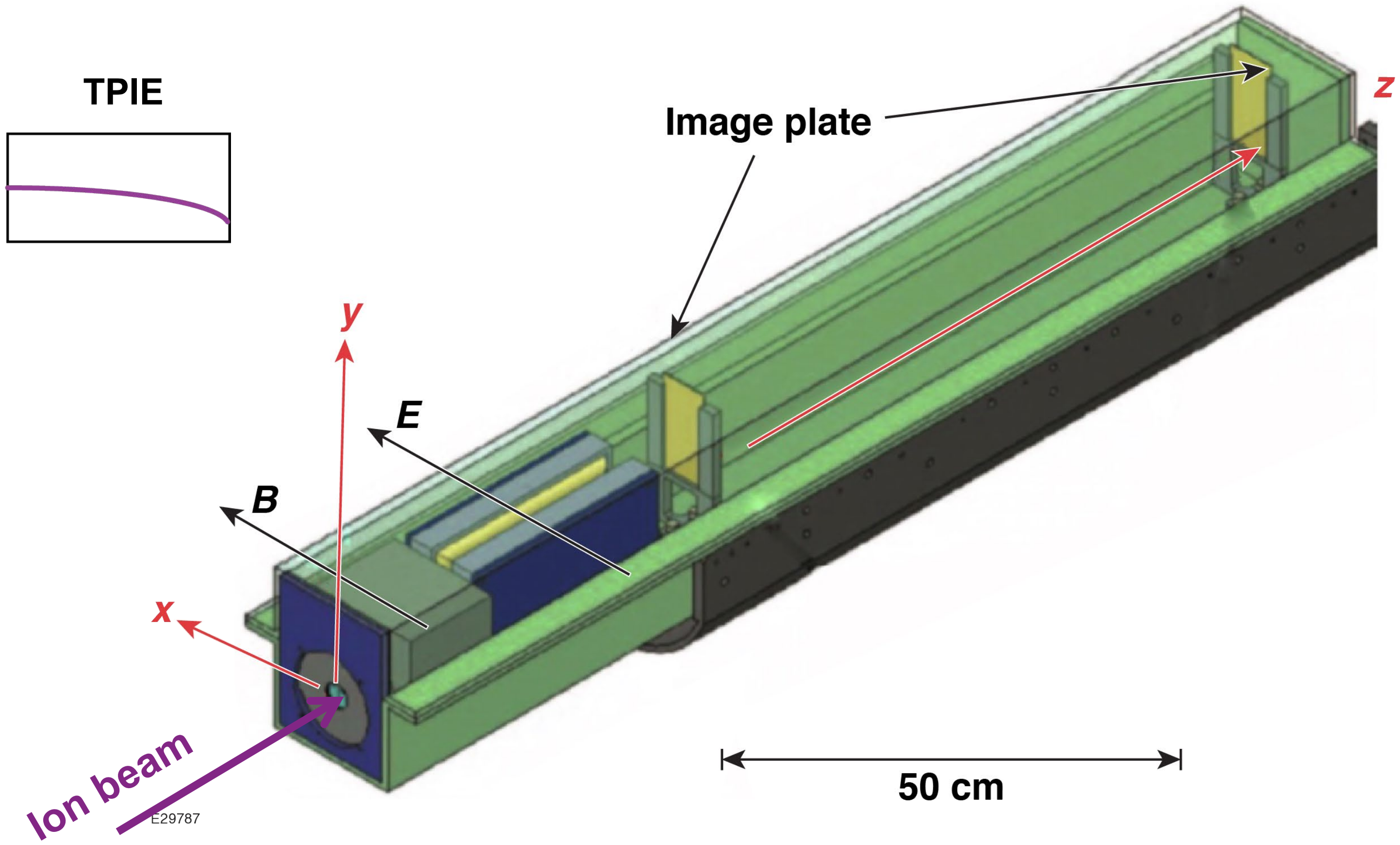


Multi-Terawatt facility, LLE

OMEGA facility, LLE

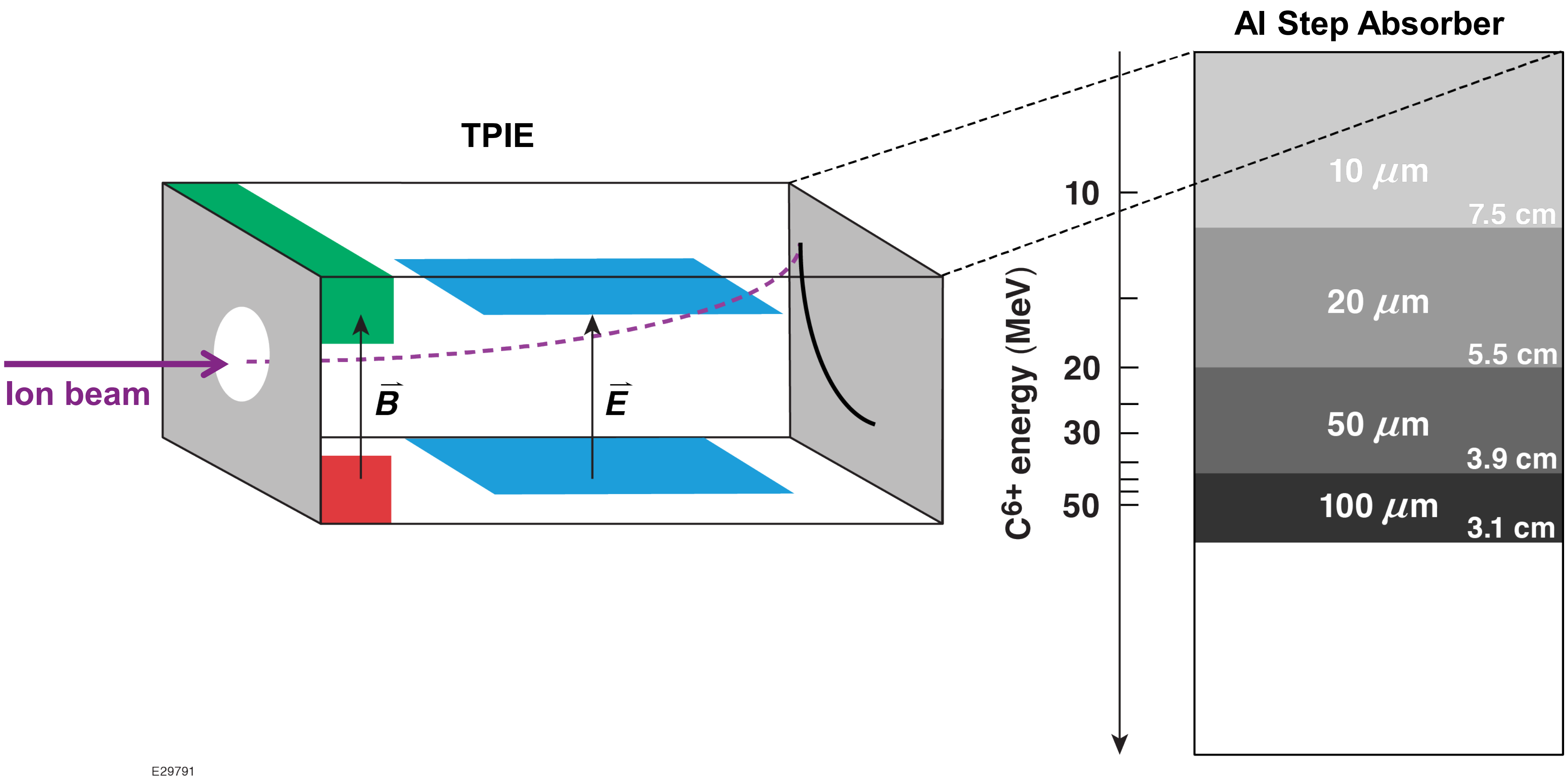
# A Thomson parabola (TPIE*) was used to resolve ions of different *q*/*m* and energies



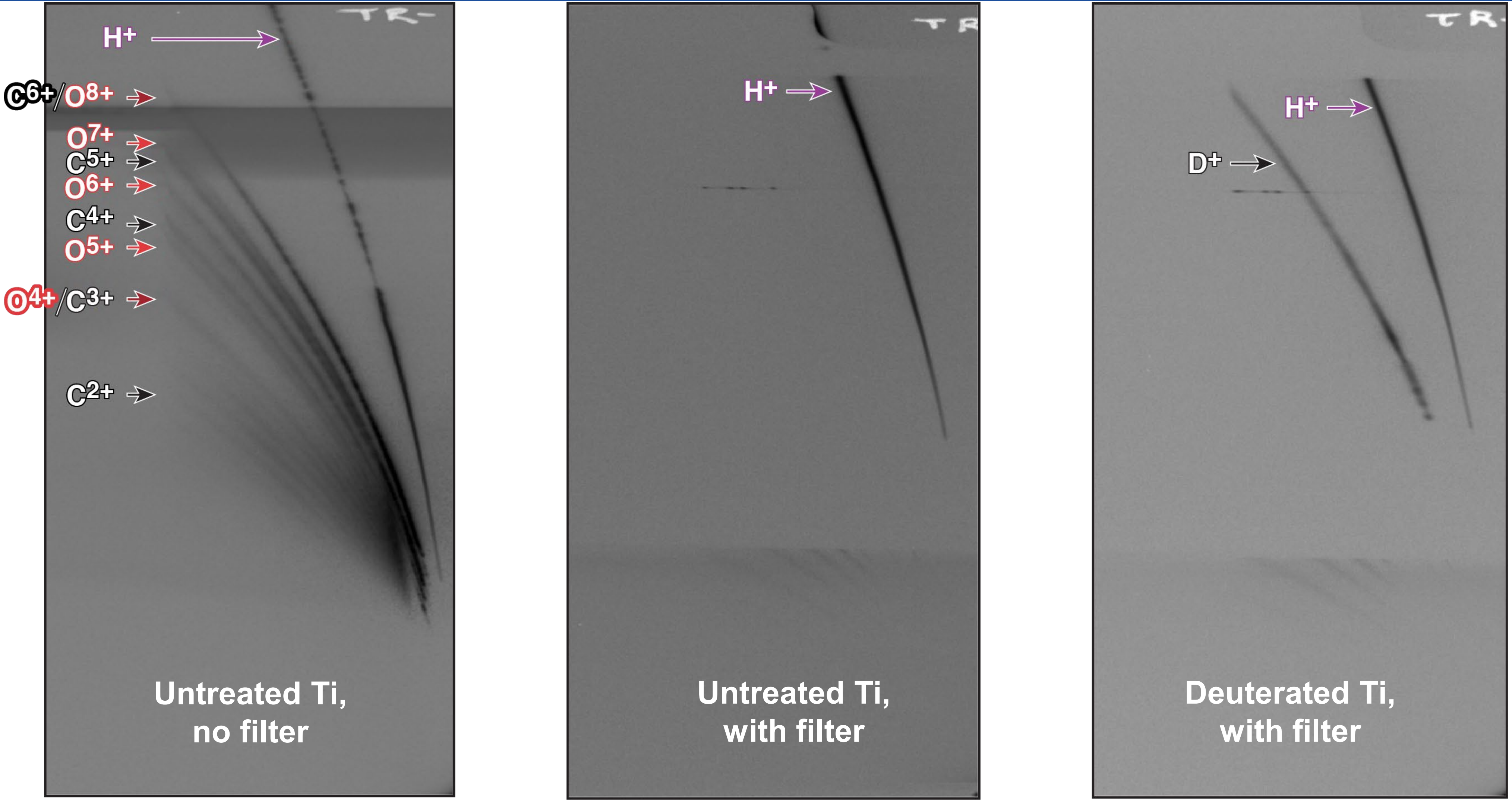

* Cobble *et al*., RSI 82 (2011).

# The Thomson parabola was equipped with a custom absorber* to eliminate heavy contaminants




* A. Alejo *et al.*, Rev. Sci. Instrum. 85, 093303 (2014).

# A custom TPIE filter effectively removed all heavy species

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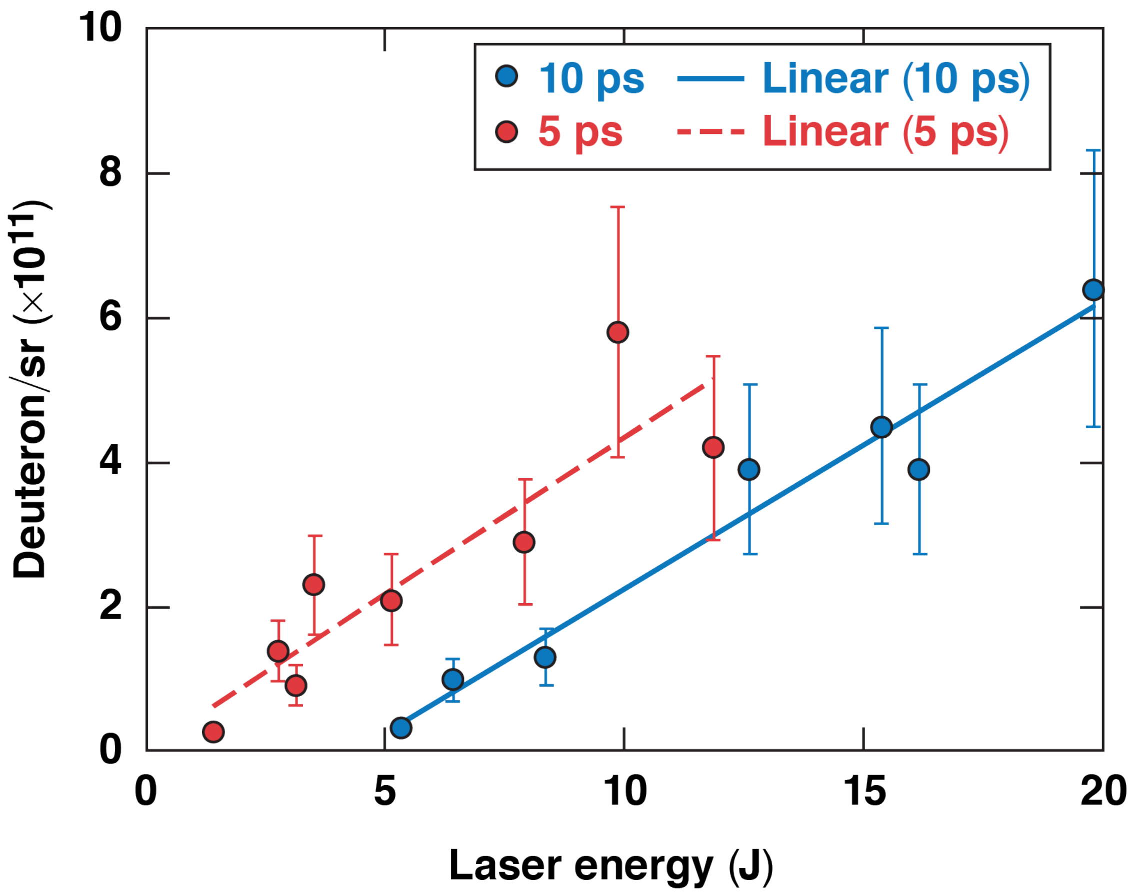
# Deuterium beam spectra transition from exponential to quasi-Gaussian with increasing laser energy

- **Higher laser energies increase the number of deuterons in the beam**

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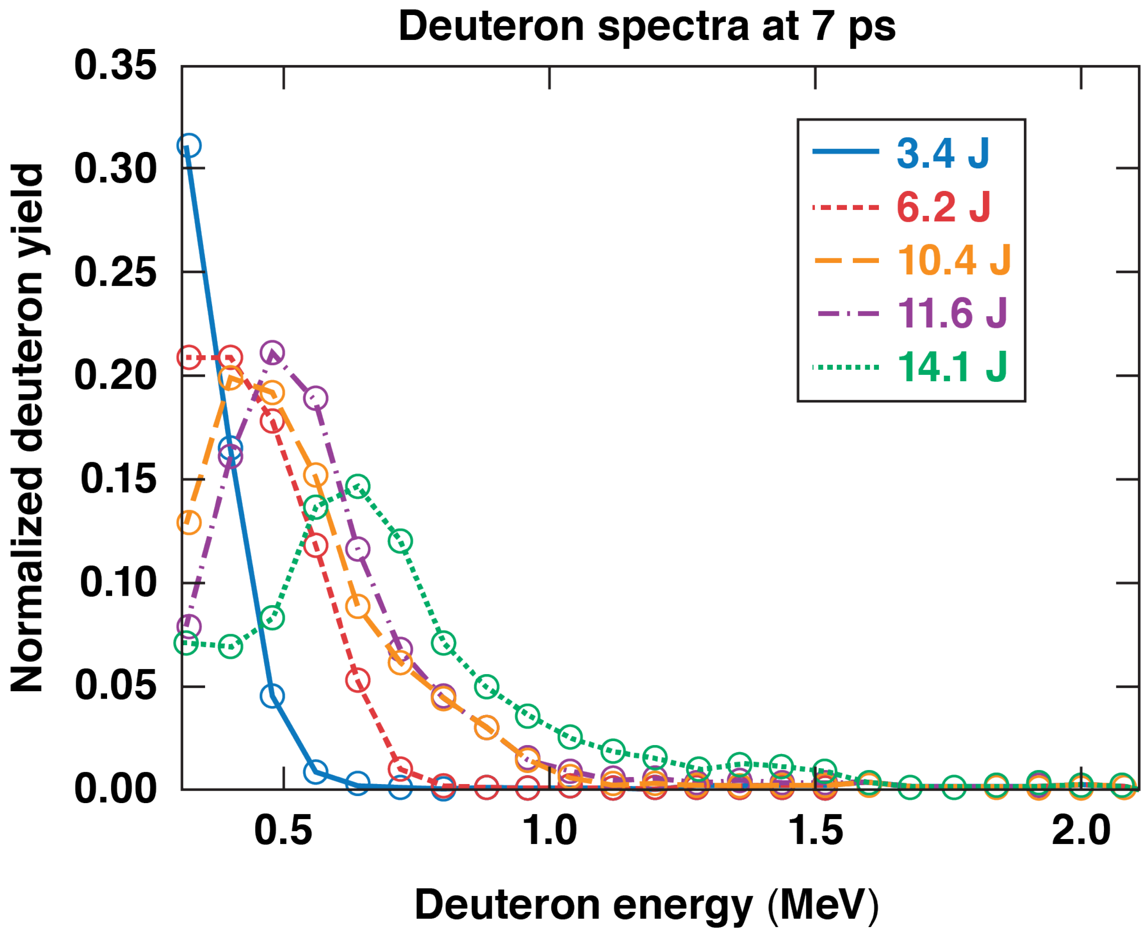
# Deuterium beam spectra transition from exponential to quasi-Gaussian with increasing laser energy

- **Higher laser energies increase the number of deuterons in the beam**
- **Low laser energies produce exponential, higher energies quasi-Gaussian spectra**

**Large ion populations repel so low energies are suppressed.**

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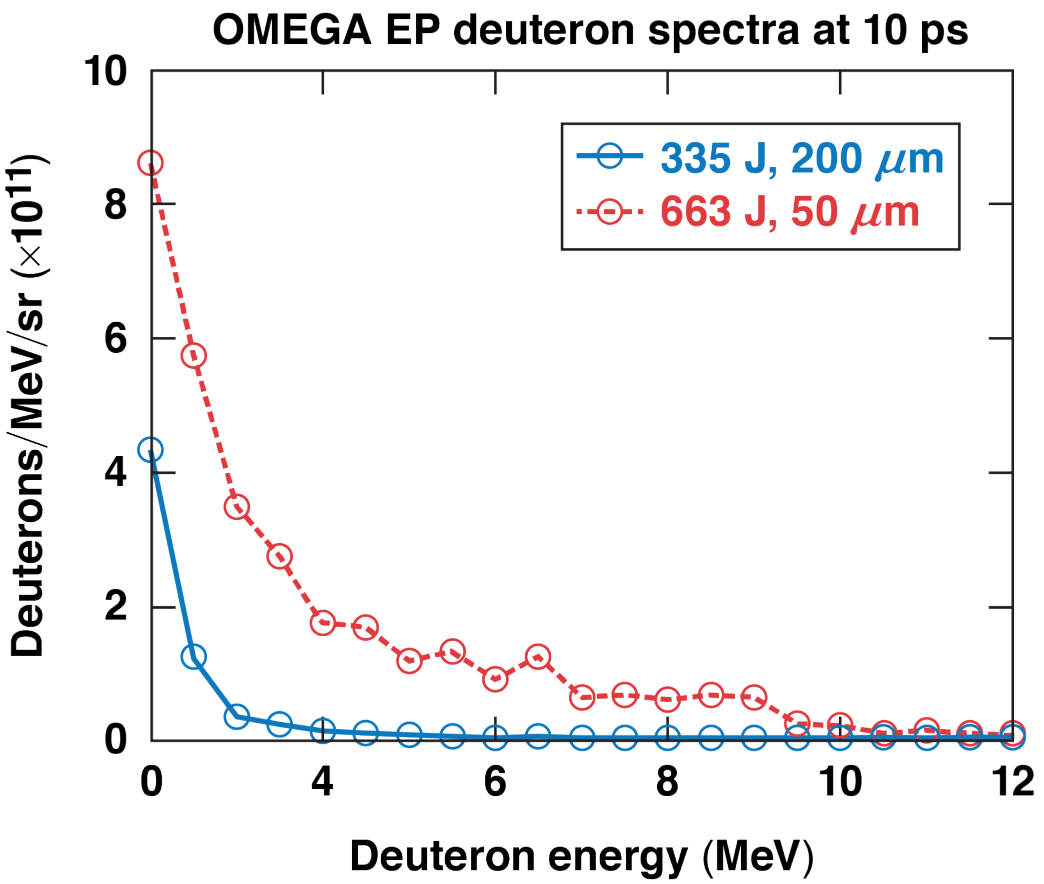
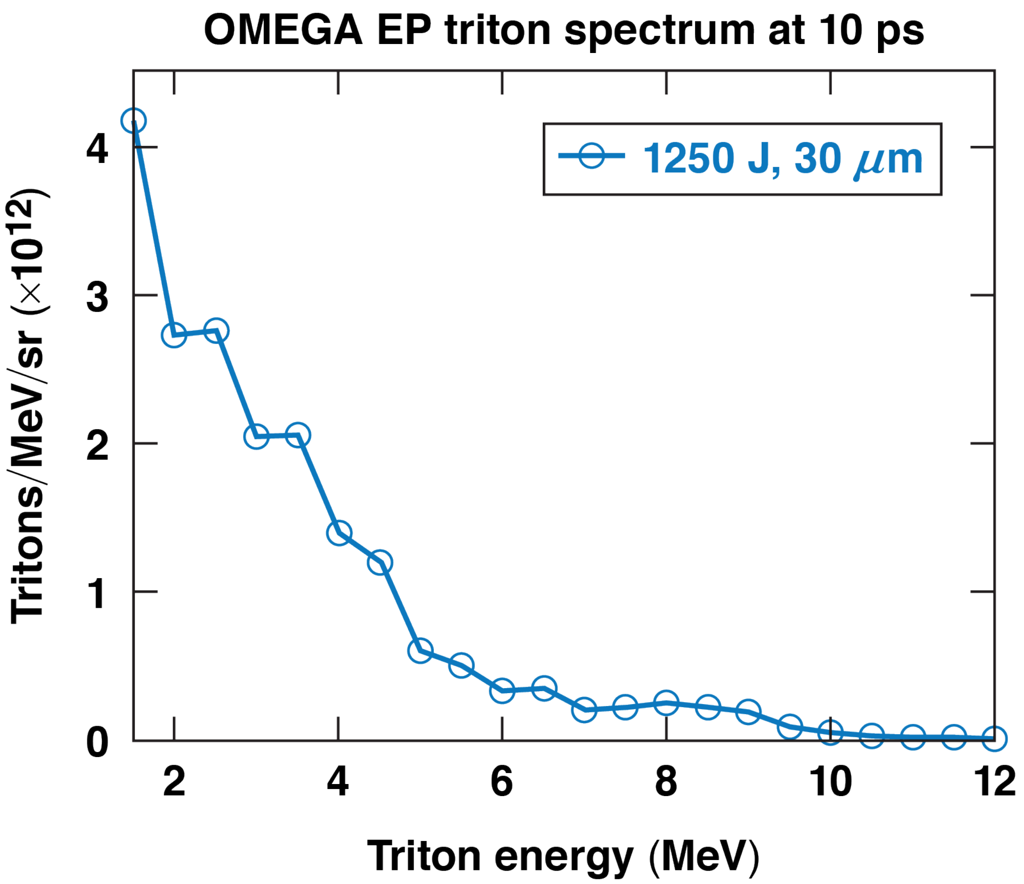
# Deuteron and triton beam spectra are exponential with energies exceeding 10 MeV

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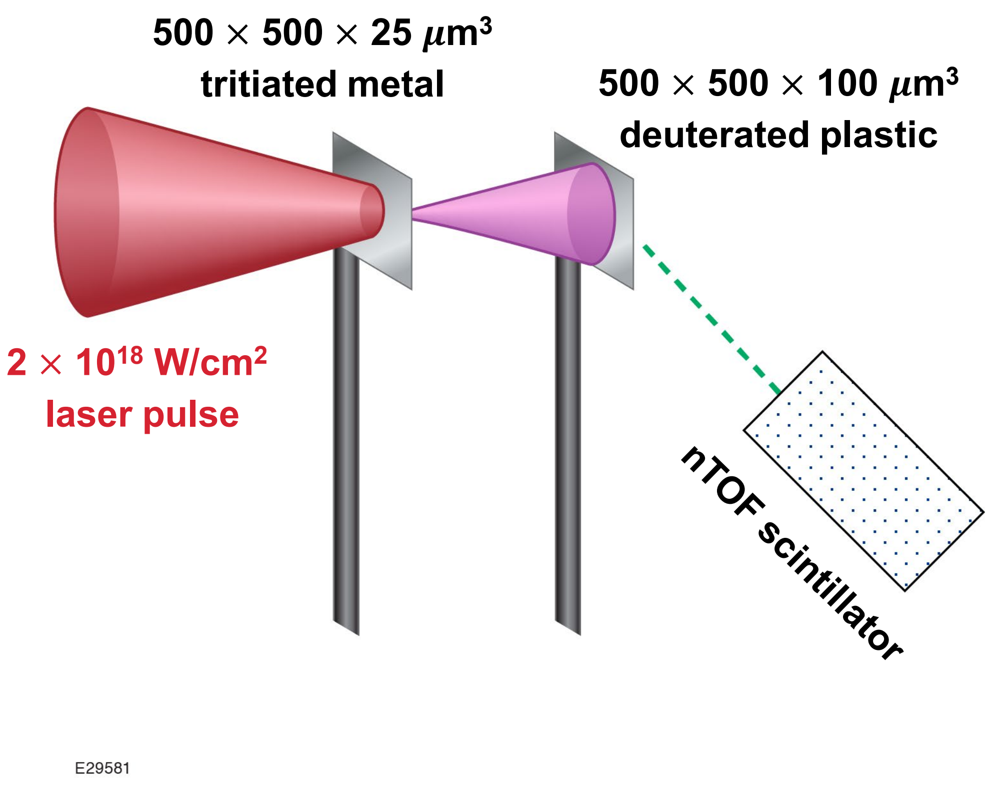
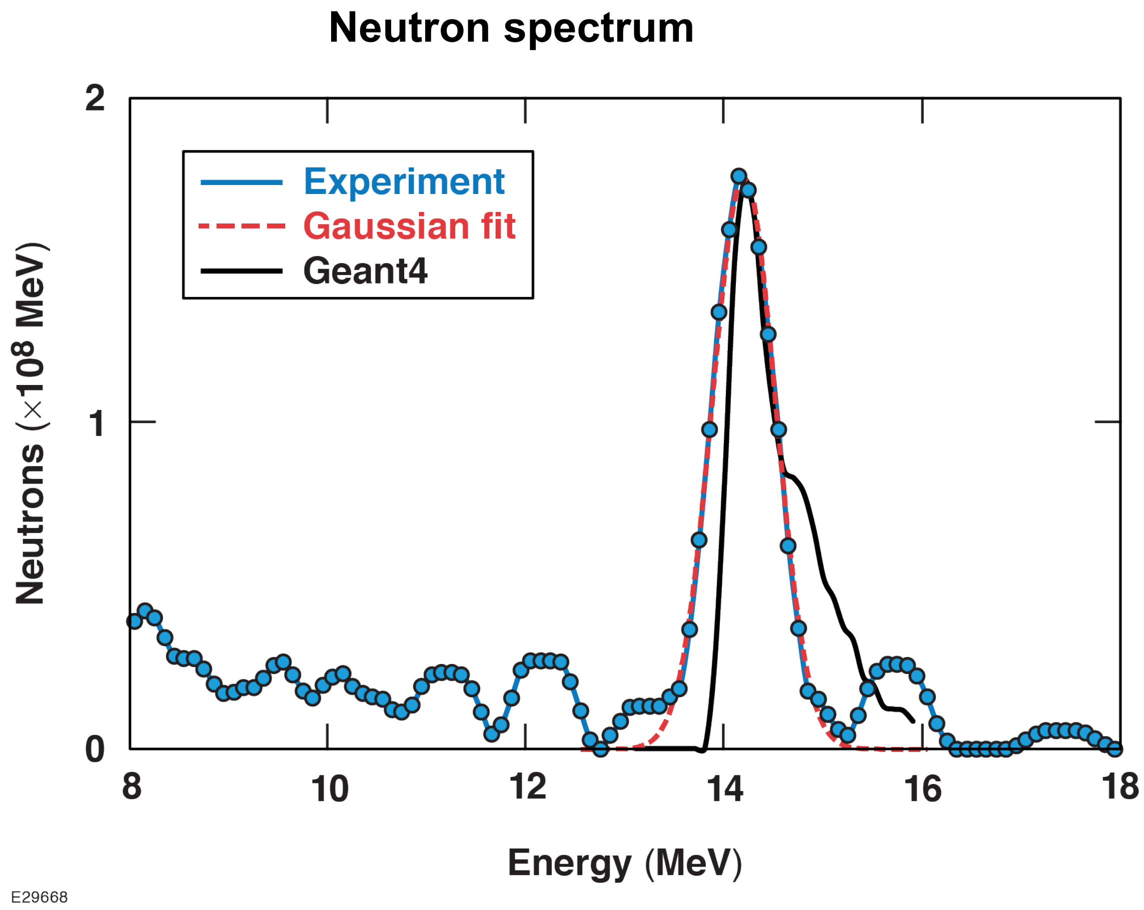
# The world's first TNSA triton beam contained $10^{12}$ tritons up to 10MeV and induced D–T fusion ($10^8$ DT neutrons)



# Target normal sheath acceleration (TNSA) can generate multi-MeV triton beams with miniaturized setups

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MTW: Multi-Terawatt laser

Backup

# Advantageous kinematics produce a peaked neutron spectrum even with a broad triton spectrum