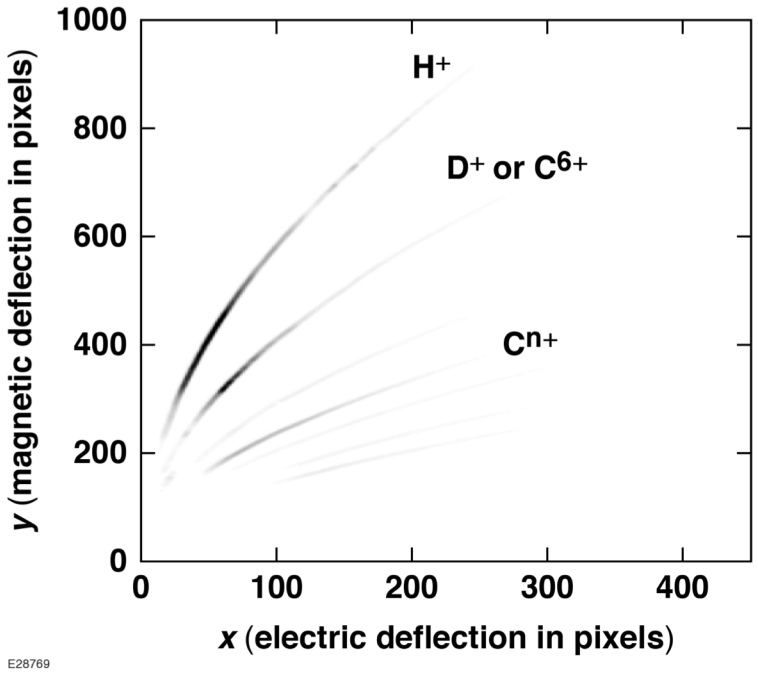
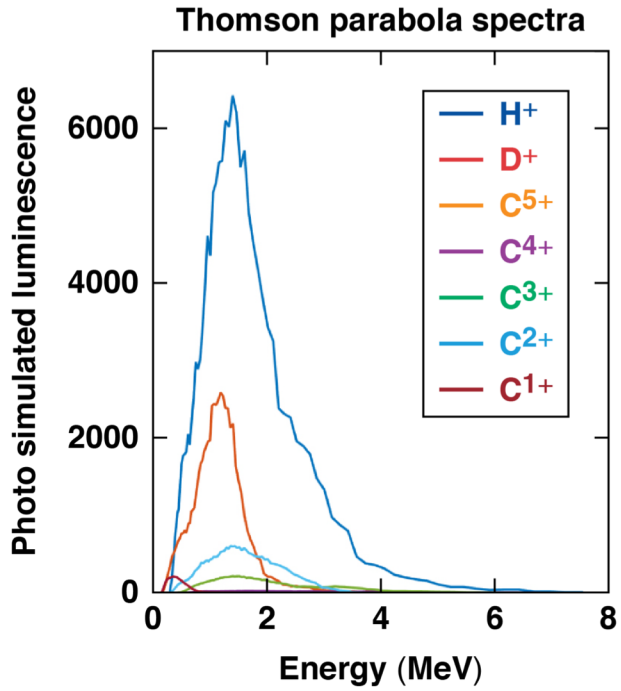
Using the Multi-Terawatt Laser at the Laboratory for Laser Energetics to Generate a High-Yield, 0.5-MeV Deuteron Beam





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American Physical Society
Division of Plasma Physics
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Summary

Ti foils charged with atomic deuterium demonstrate the highest TNSA yields

- Ti foils were prepared as TNSA targets in two different batches
  - additional Ti was evaporated onto the Ti foils under 1 m Torr D_2
  - Ti foils was exposed to atomic D^0 created by a filament in 1 m Torr D_2
- Two equivalent batches were prepared using Au foils as substrates
- All foils were irradiated with the Multi-Terawatt (MTW) laser (10 ps, 25 J, 10^{18} W/cm^2) to produce a deuteron beam
- A Thomson parabola ion spectrometer (TPIS) examined the abundance of different species in the TNSA beam and their energies

- Ti foils exposed to atomic D^0 had higher TNSA yields compared to Ti evaporation on Ti foils in D_2 gas
- The beam energy and width does not depend on the yield (target)
- Au foils have less contaminants (C, O), but also lower yields compared to Ti foils loaded the same way

Future experiments will duplicate this process with tritium to produce a tritium beam.

TNSA: target-normal sheath acceleration

Collaborators

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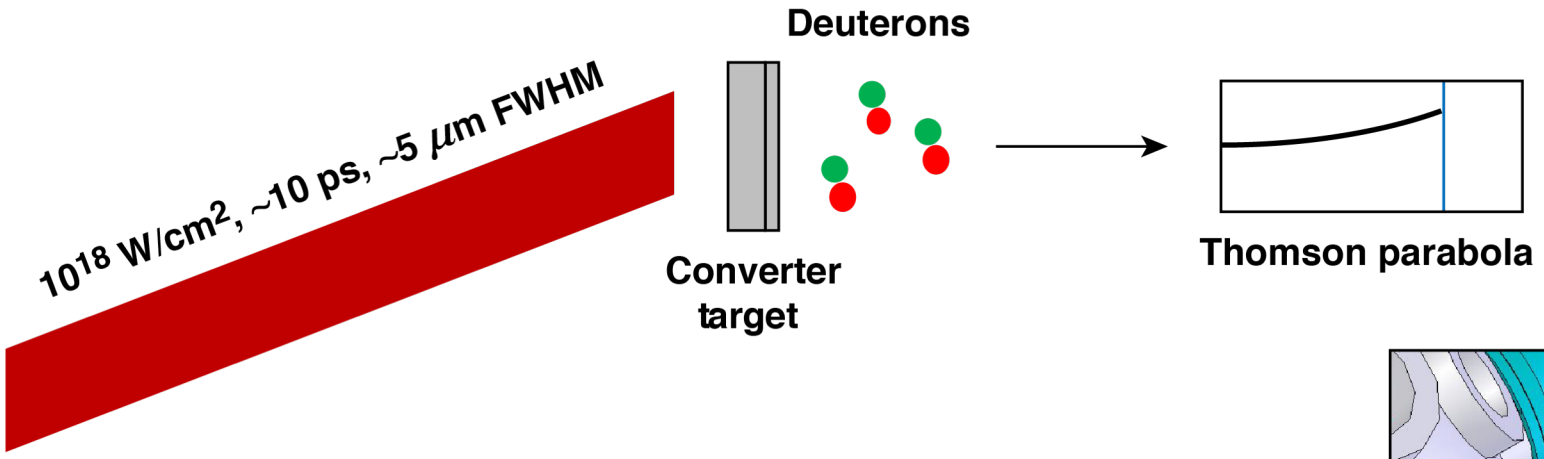
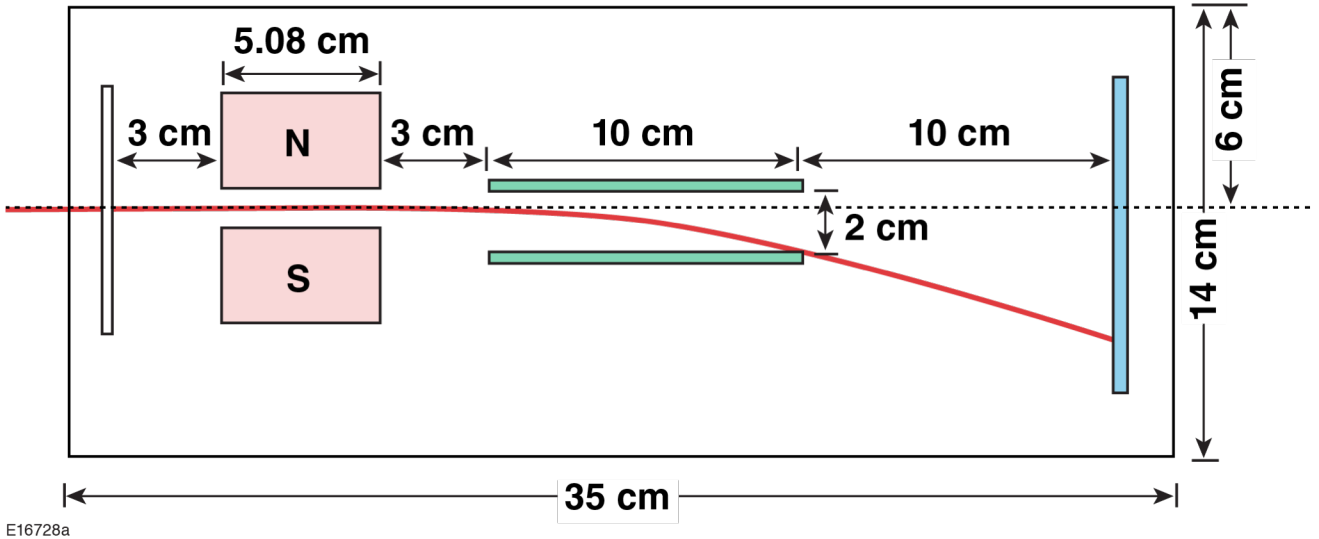
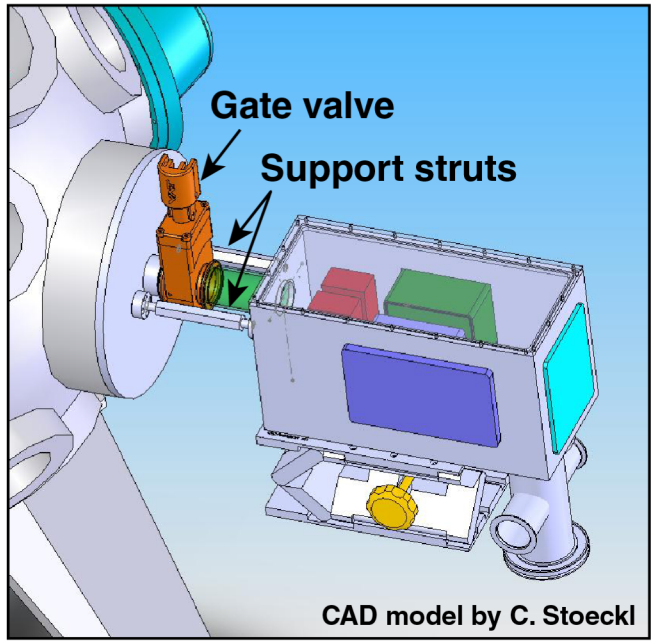
***Department of Physics and Chemistry**

The MTW laser accelerates deuterons from a deuterated Ti foil toward a Thomson parabola

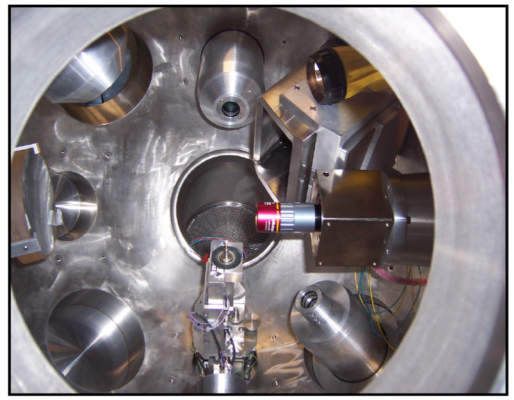


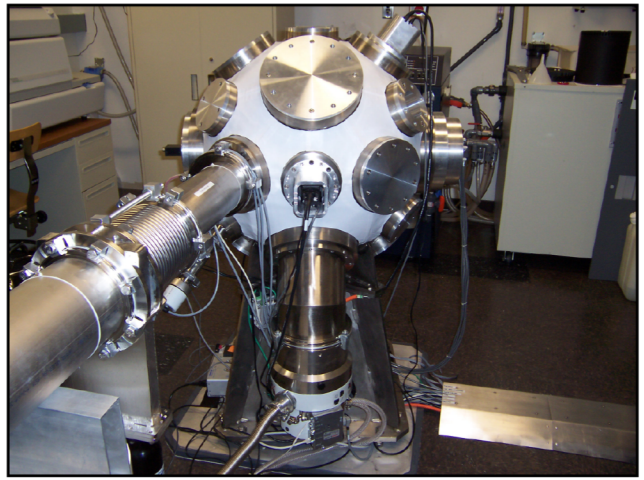




The MTW laser at LLE provides a flexible mid-scale capability for nuclear science experiments

- Low energy (~20 J) but high intensity
- 20-min shot cycle
- → parameter scans





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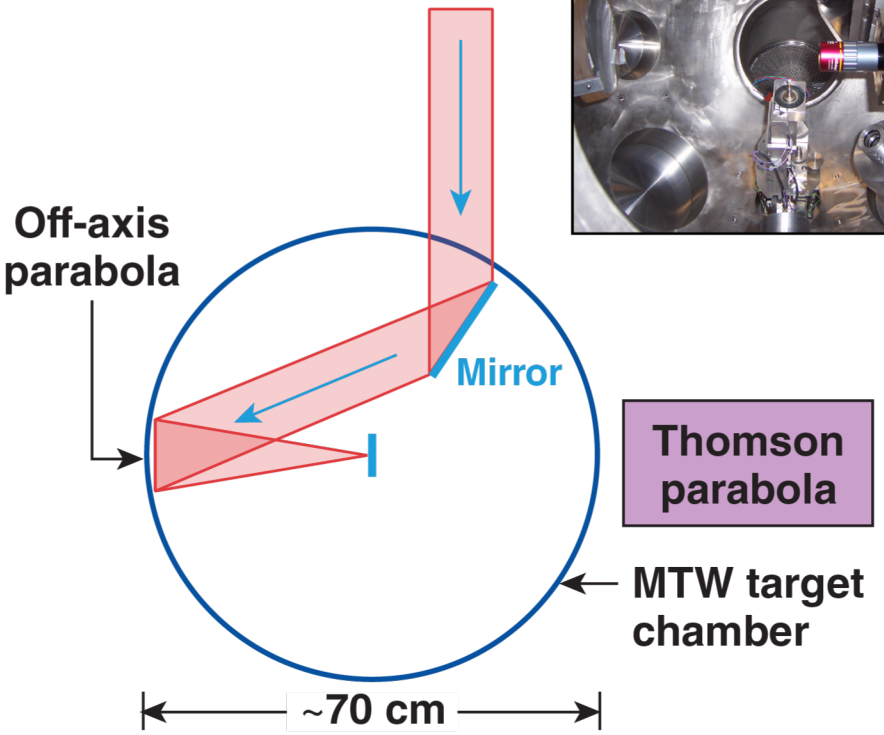


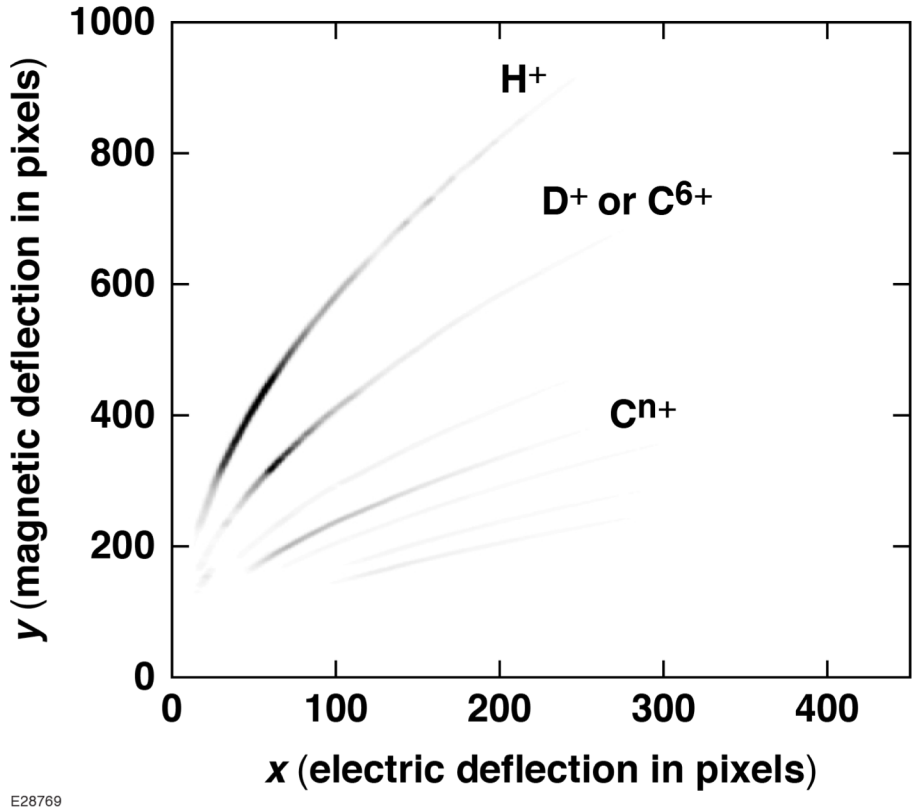
LLE: Laser at the Laboratory for Laser Energetics

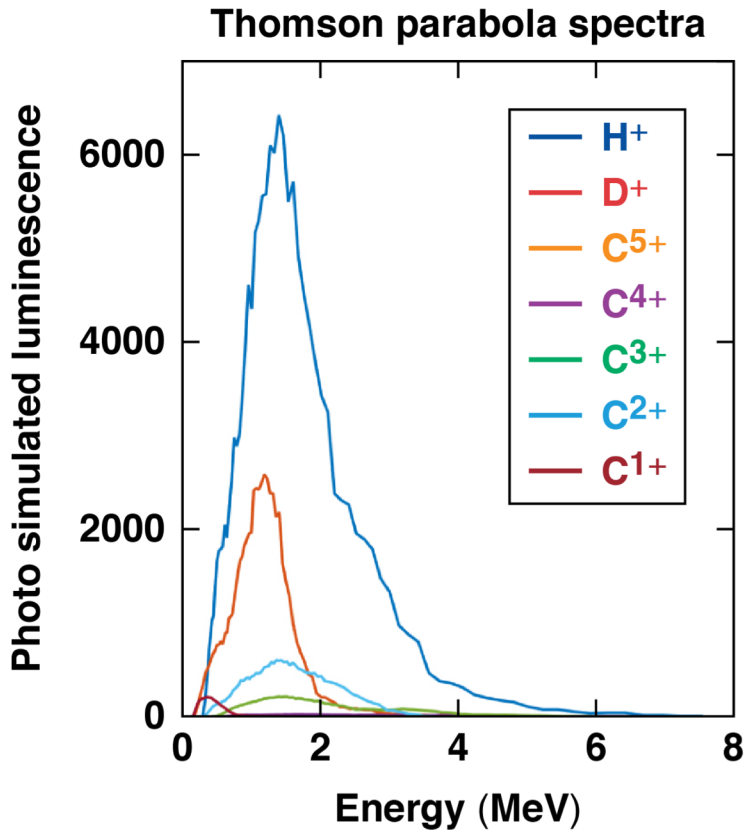
A total of 50 targets were shot, differing in backing material and deuterium exposure

Evaporate Ti onto Ti foil, 1 m Torr D_2	Expose Ti to 1 m Torr D_2 with atomic D^0
0 nm (as received)	0 h (as received)
470 nm TiD_2	22 h D^0
890 nm TiD_2	46 h D^0
1000 nm TiD_2	98 h D^0
1600 nm TiD_2	193 h D^0

Each target has a different inventory of deuterons.

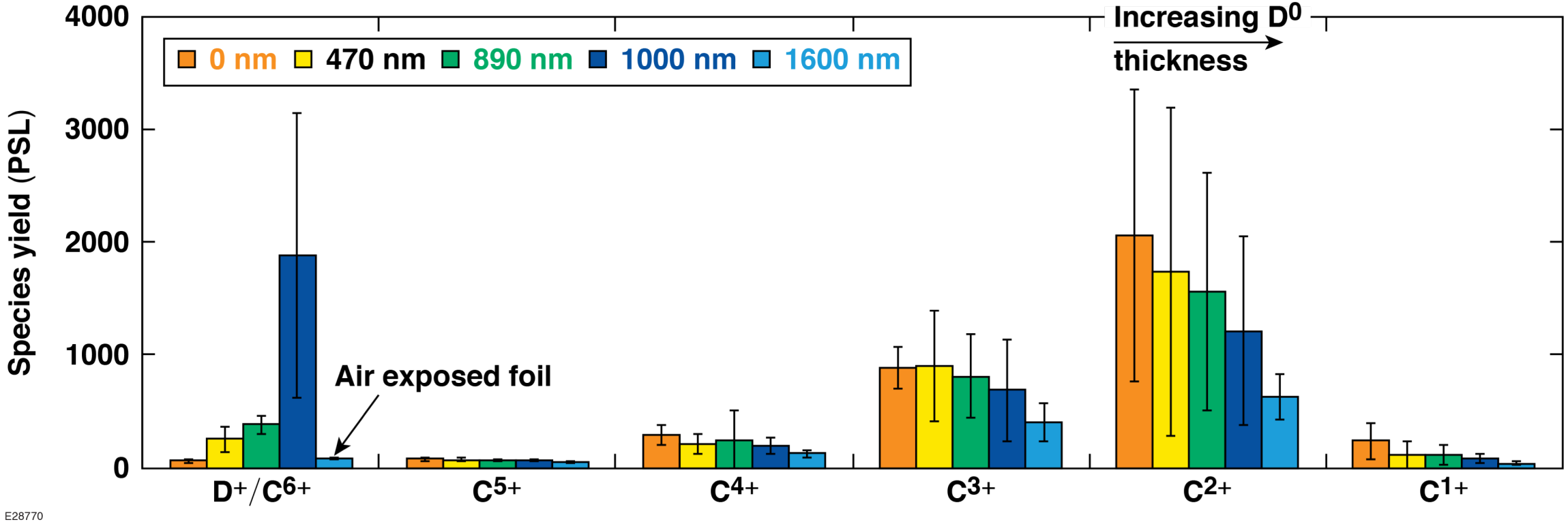
For each individual shot, the image plate is digitized and intensity is binned along each trace to obtain a spectrum





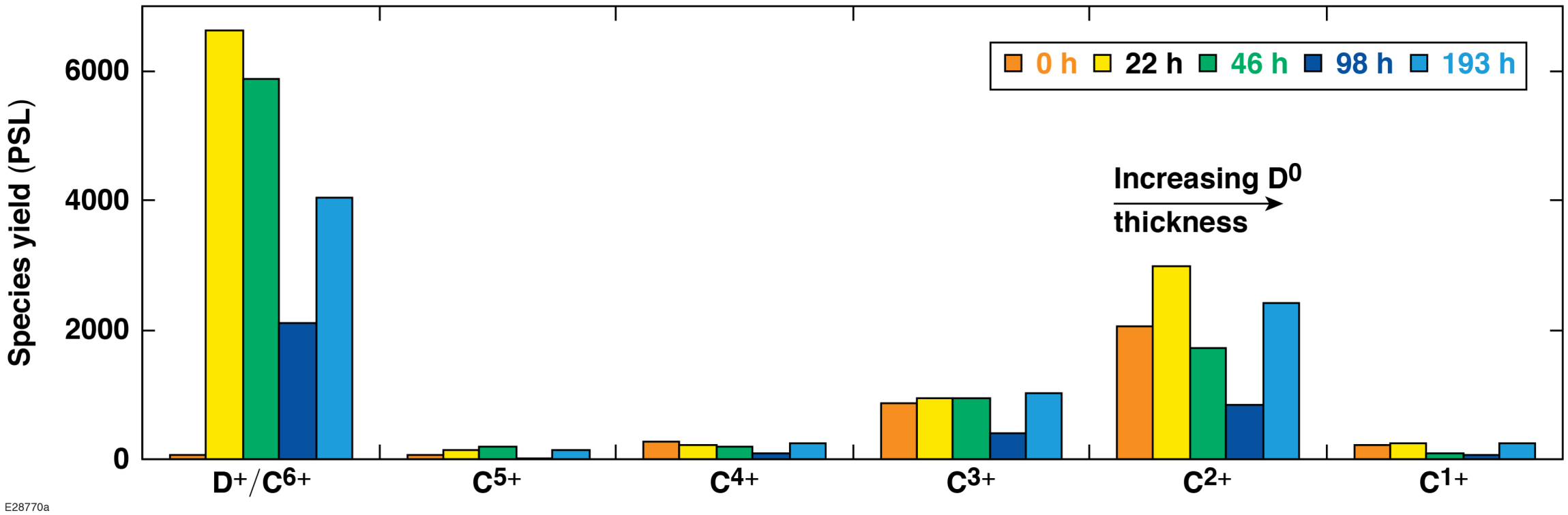
Ti with 46-h D^0 exposure produced an intense, 1±0.5-MeV deuteron beam.

TiD_2-loaded targets show and increase in deuteron yield and a decrease in carbon yield with increasing thickness



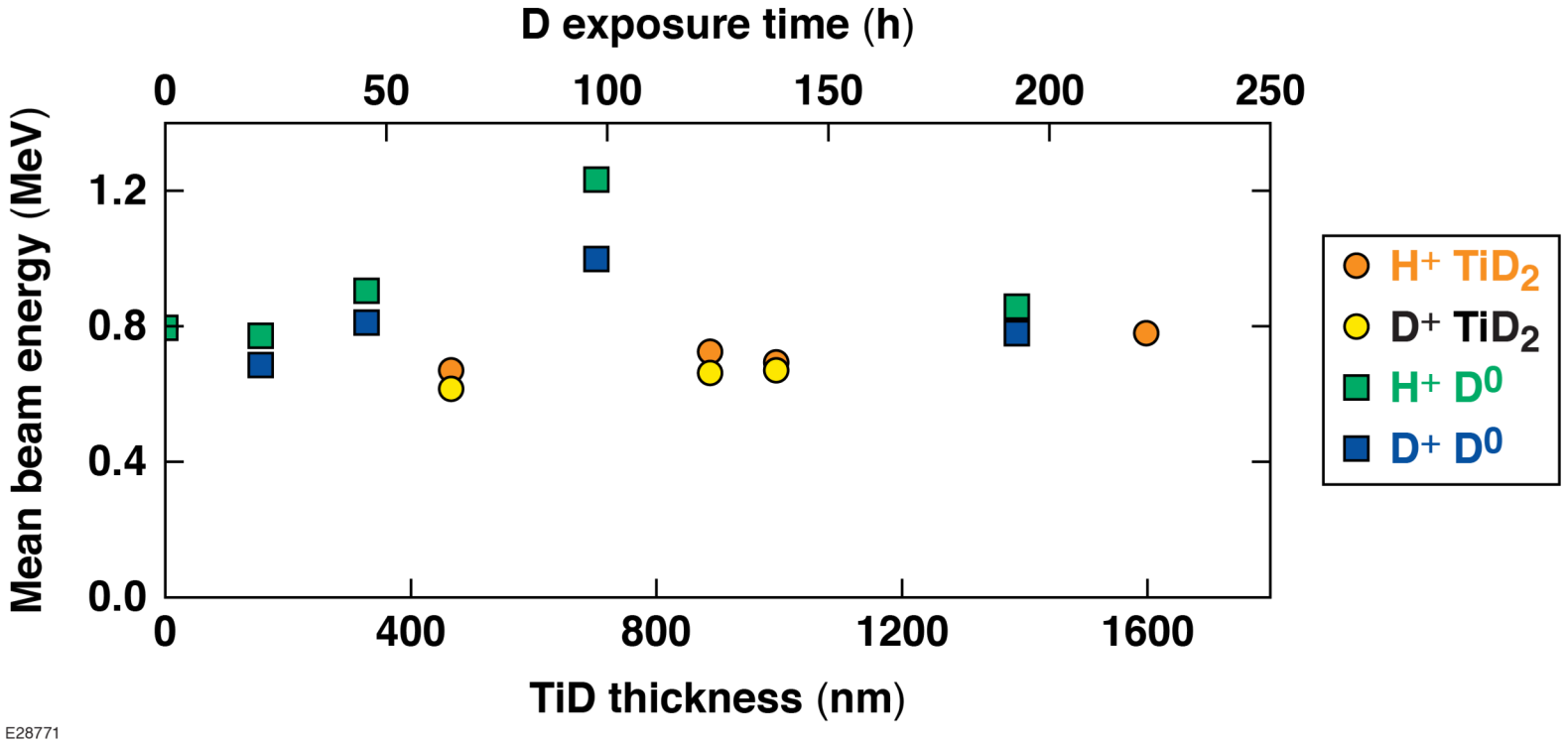
Relative abundances of C-ions follow expectations from atomic physics, → the extrapolated C^{6+} (D^+ background) should be low.

D^0 loaded targets show no clear trend between any species yield and exposure time, steady state seems to be reached quickly



D^0 loaded targets show 3× higher yields than TiD_2 targets.

Ti targets show no clear trend between the mean beam energy and surface finish



Summary/Conclusions

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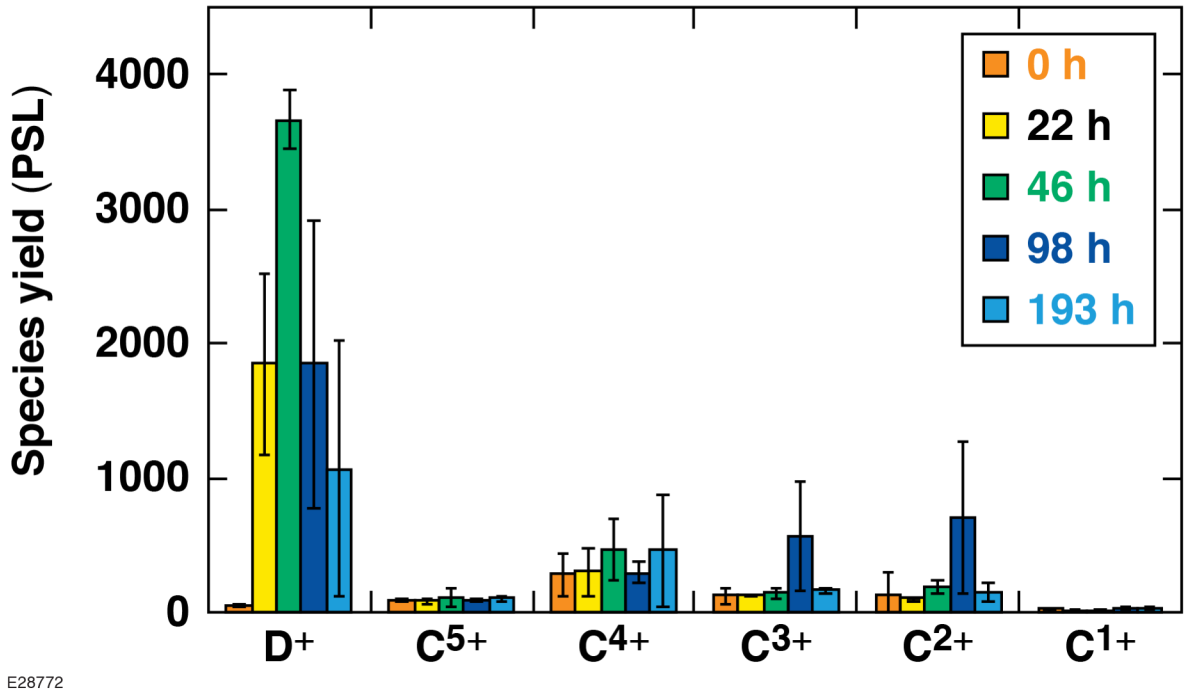
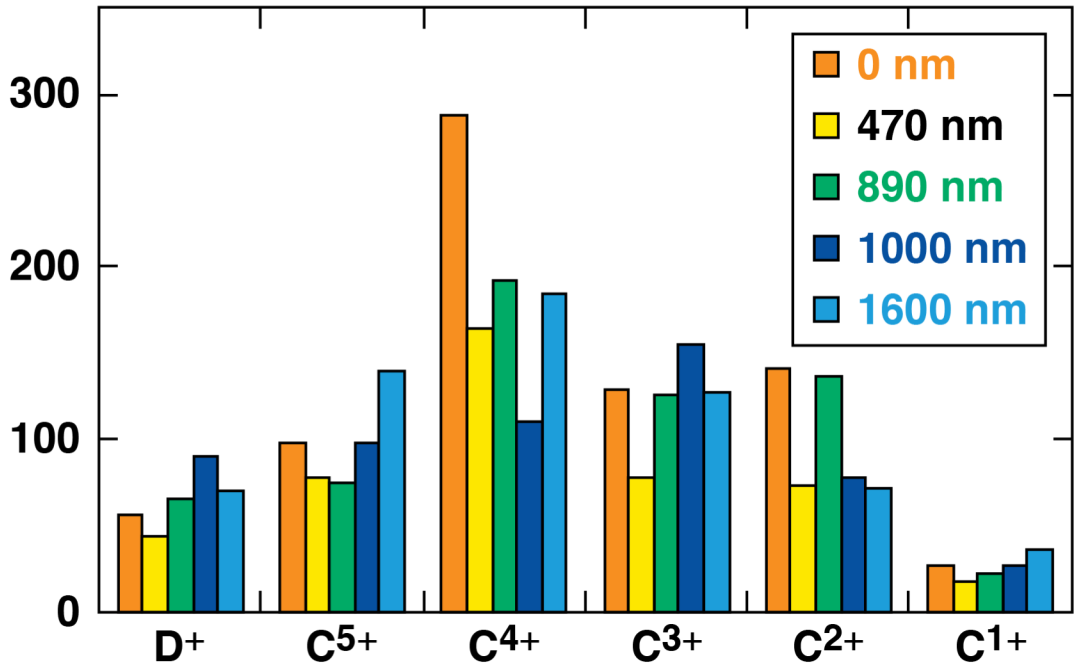
Backup

Ion species analysis for the gold foils

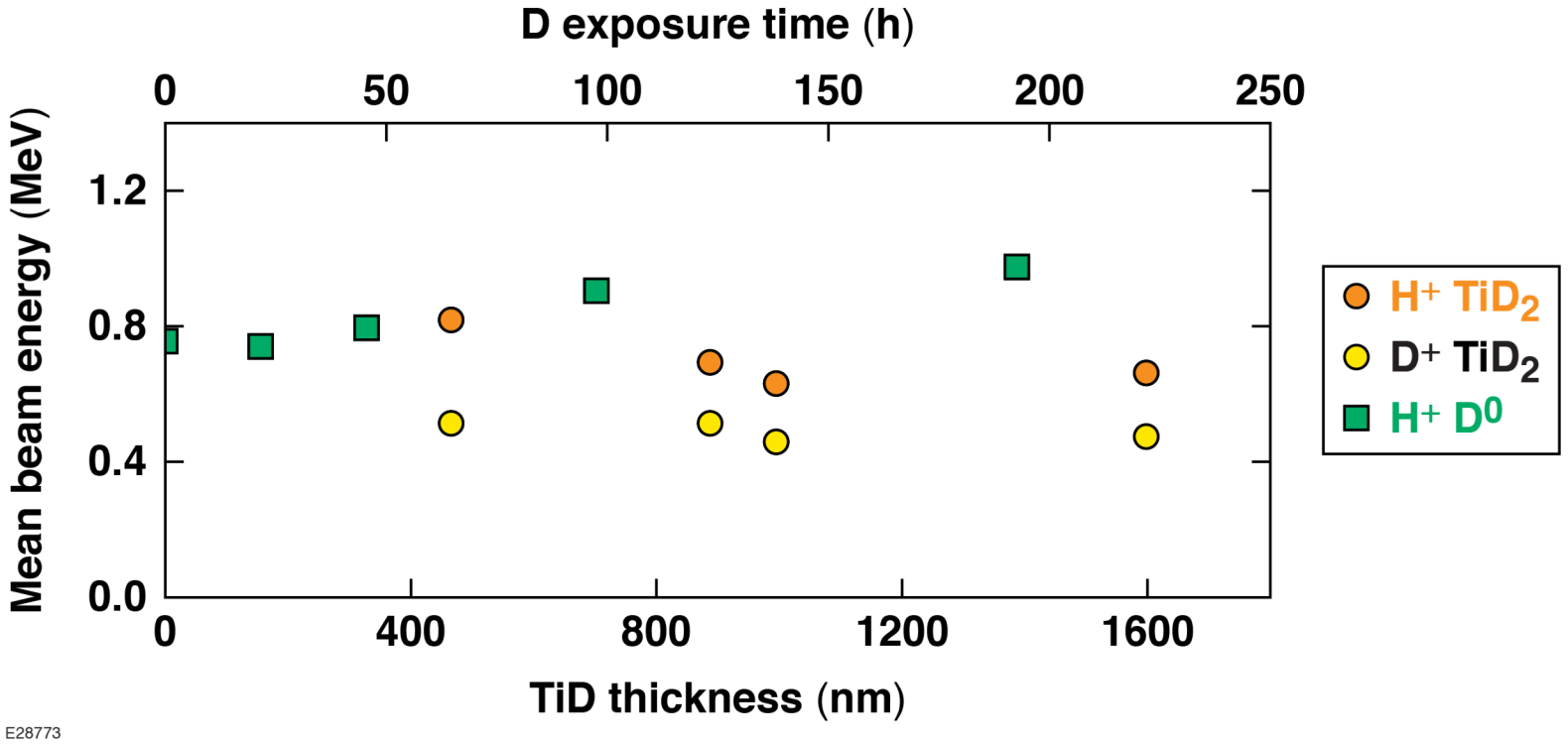




D^0 loaded targets show a maximum deuteron yield after 46-h; exposure, all C-ions are suppressed and follow no clear trend.

TiD_2 loaded targets show a very low deuteron yield hidden in the C-ions noise. Potentially, the TiD_2 does not bind to Au.

Beam analysis for the gold foils



D⁰ loaded targets show no clear trend between the mean beam energy or width and the surface finish.

TiD_2 loaded targets had a too low deuteron signal to yield a meaningful spectrum.