Tritium-doped titanium foil production at CATS

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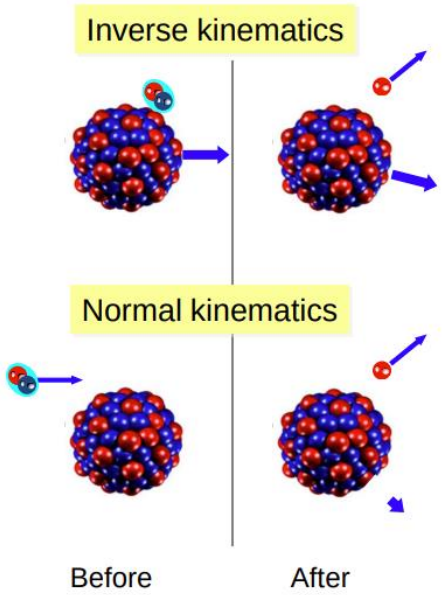
MOTIVATION

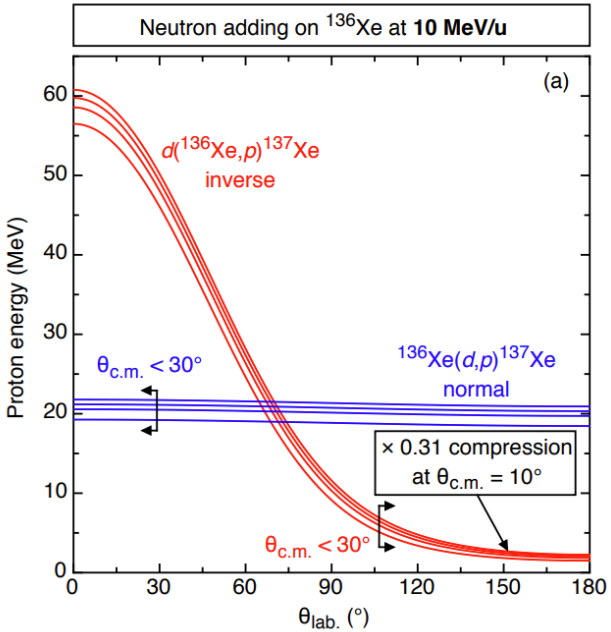
Needed for e.g. (t,p) reactions
Emerging triton beams, but limited to stable targets
Radioactive beams necessitate tritium targets

What are the constraints?

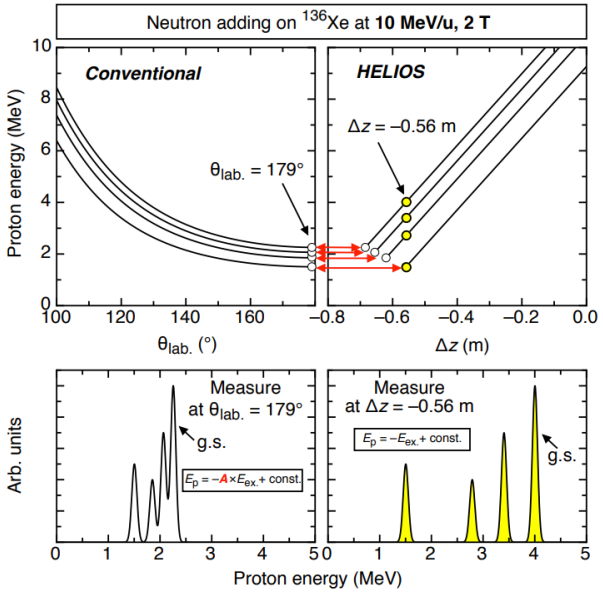
INVERSE KINEMATICS

Kinematic compression in inverse kinematics - resolution
Strong angle dependence - broadening





HELIOS APPROACH



Measured quantities

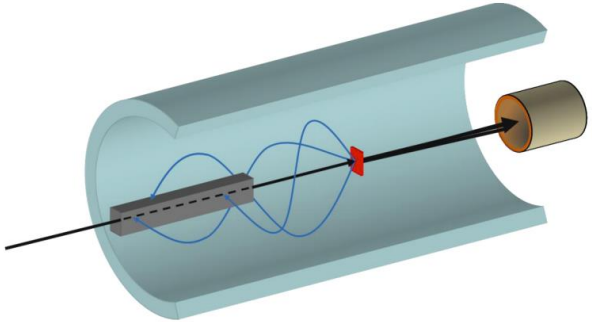
Flight time:	$T_{flight}=T_{cyc}$
Position:	z
Energy:	E_{lab}

Derived quantities

Part. ID:	m/q
Energy:	E_{cm}
Angle:	θ_{cm}

B=2T

Particle	T_{cyc} (ns)
p	34.2
$^3He^{2+}$	51.4
d, α	68.5
t	102.7



$$\frac{m}{q} = \frac{eB}{2\pi} \times T_{flight}$$

$$E_{cm} = E_{lab} + \tfrac{1}{2} m V_{cm}^2 - \frac{V_{cm} qeB}{2\pi} z$$

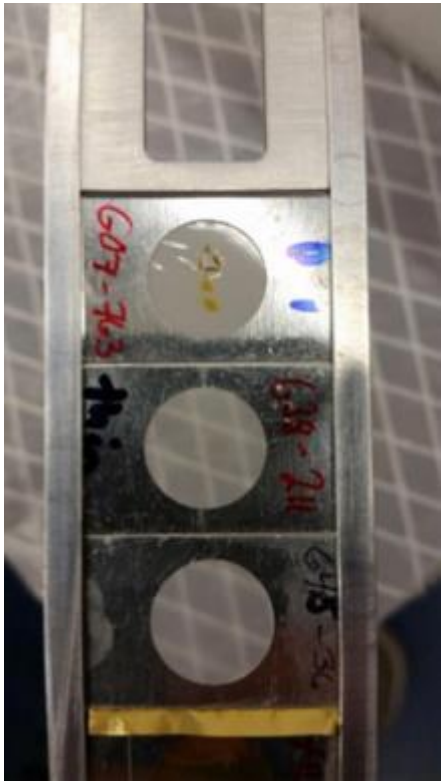
$$\theta_{cm} = \arccos\left(\frac{1}{2\pi} \frac{qeBz - 2\pi m V_{cm}}{\sqrt{2mE_{lab} + m^2 V_{cm}^2 - m V_{cm} qeBz/\pi}} \right)$$

DEUTERIUM TARGETS

- Usually deuterated polyethylene C_2D_4
- “easy” to produce
- High hydrogen content
- Contaminant carbon has low Z (stopping power)
- Can be produced 20µg/cm^2 or thicker
- Will degrade in beam

Not available for tritium, problem of destruction

American Radiolabeled Chemicals, Inc.



METAL HYDRIDES

- Storage of hydrogen in titanium, palladium, uranium …
- TiH_x can reach x=2.0 with diffusion above 300°C
- Same process industrially used for recovery of tritium (e.g. Trisorber manifold based on uranium)
- Minimal energy loss (low Z, thin, compromise 1µm Ti)

Material is brittle after hydration (welding between frames)

EARLIER ATTEMPTS

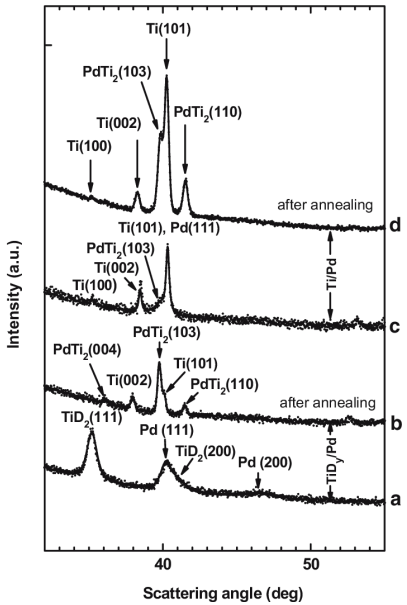
- Sodern (France) not reaching necessary loadings of tritium
- One existing target traveling the world, but decaying
- Collaboration with Moravek (California) after several attempts successful with Deuterium surrogate
- Targets characterized with Helios, theoretical maximum loading
- No tritium targets

SETUP AT ANL

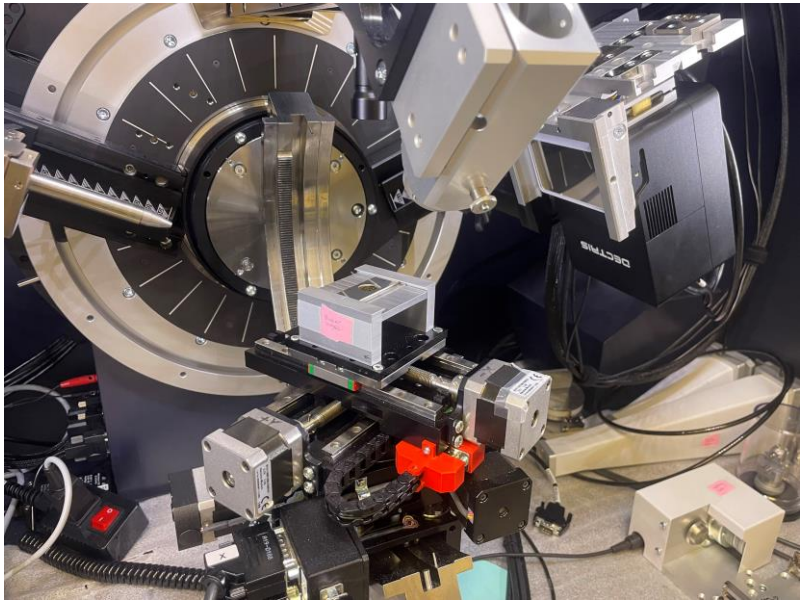
Small tube furnace with manifold for pumping, purging and hydrogen source
Tests with Deuterium as a surrogate (temperature, exposition time, pressure)

CHARACTERIZATION WITH XRD

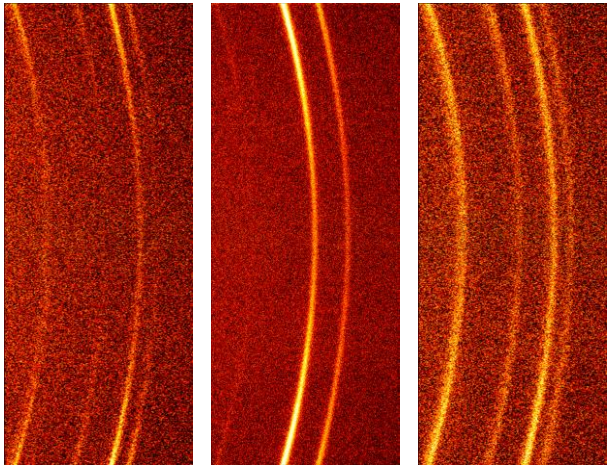
Small tube furnace with manifold for pumping, purging and hydrogen source
Tests with Deuterium as a surrogate (temperature, exposition time, pressure)

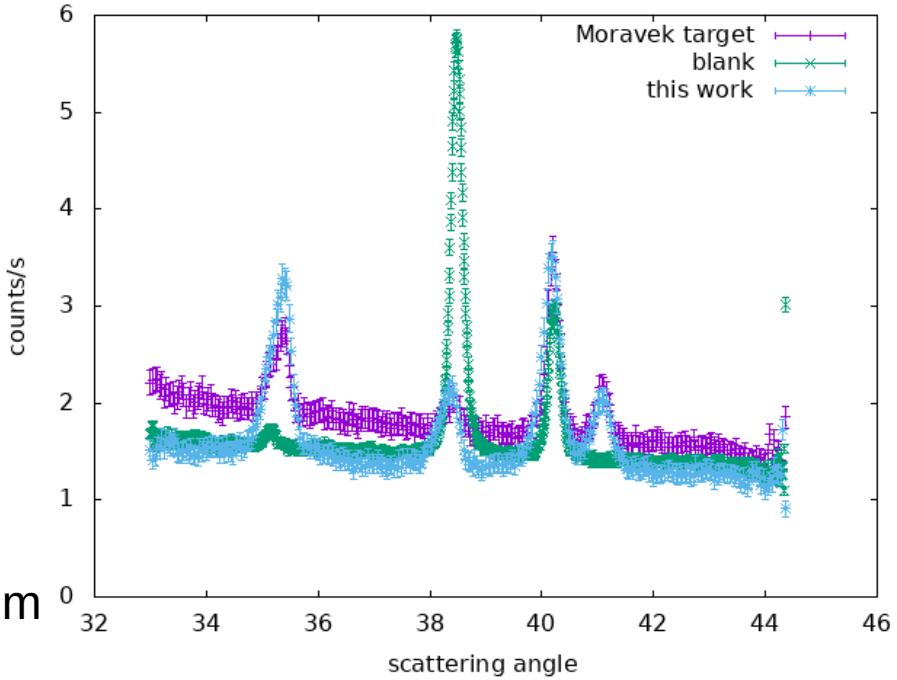


Lisowski, W., Keim, E.G., Kaszkur, Z. *et al. Anal Bioanal Chem* **389**, 1489–1498 (2007).



CHARACTERIZATION WITH XRD





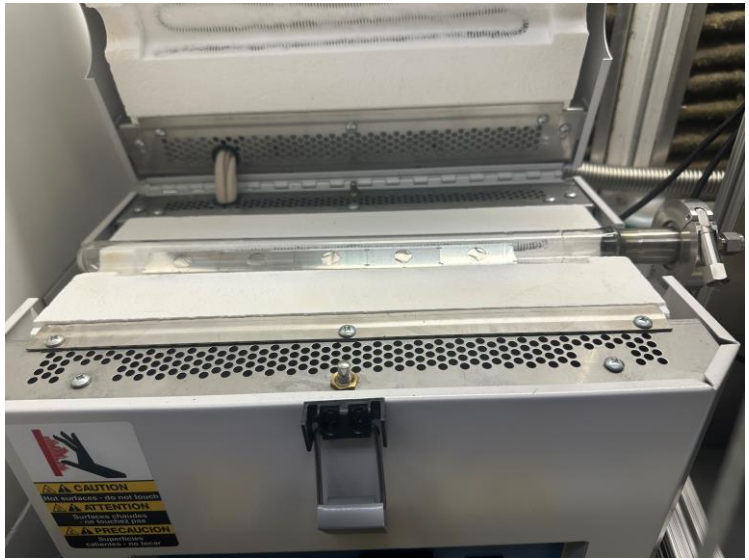
Powder diffractometry of standard (Moravek), blank, and deuterated titanium

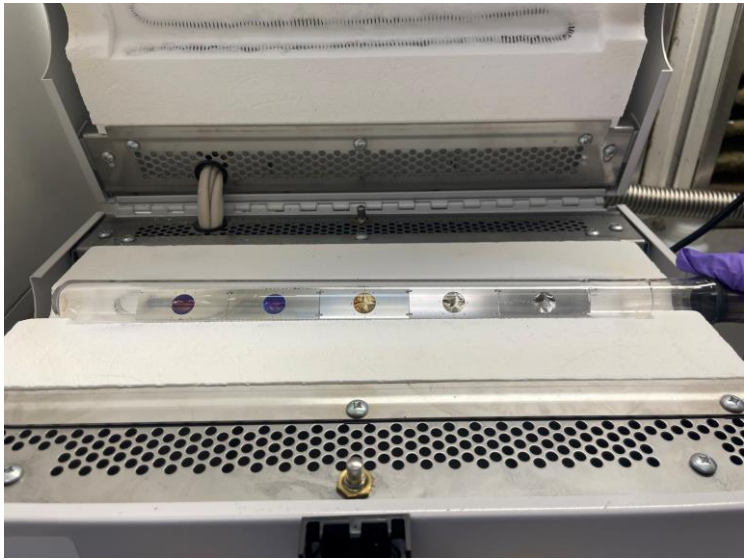
TRITIUM TARGETS

- 50Ci of tritium in a fume hood
- Similar parameters to D_2 test
- Dead volume can be reduced
- High loose contamination ~35Mdpm on frame
- Targets could be stacked to produce more at a time
- recovery necessary if demand indicates multiple repetitions

TRITIUM TARGETS

Interesting color change
Characterization to be done by ion beam scattering





SUMMARY/OUTLOOK

- Tritiated titanium foils successfully produced
- Loading factor to be determined
- Difference between the targets (color change) to be understood
- Recycling and reduction of dead volume are options for the future

Experiments at ANL, FRIB and CERN are waiting for any tritiated target

Tritiated polyethylene development will continue for low Z beams

Thank you for your attention!

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