Advanced Targetry for a ReA Solenoidal Spectrometer

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Reminder: why this is important

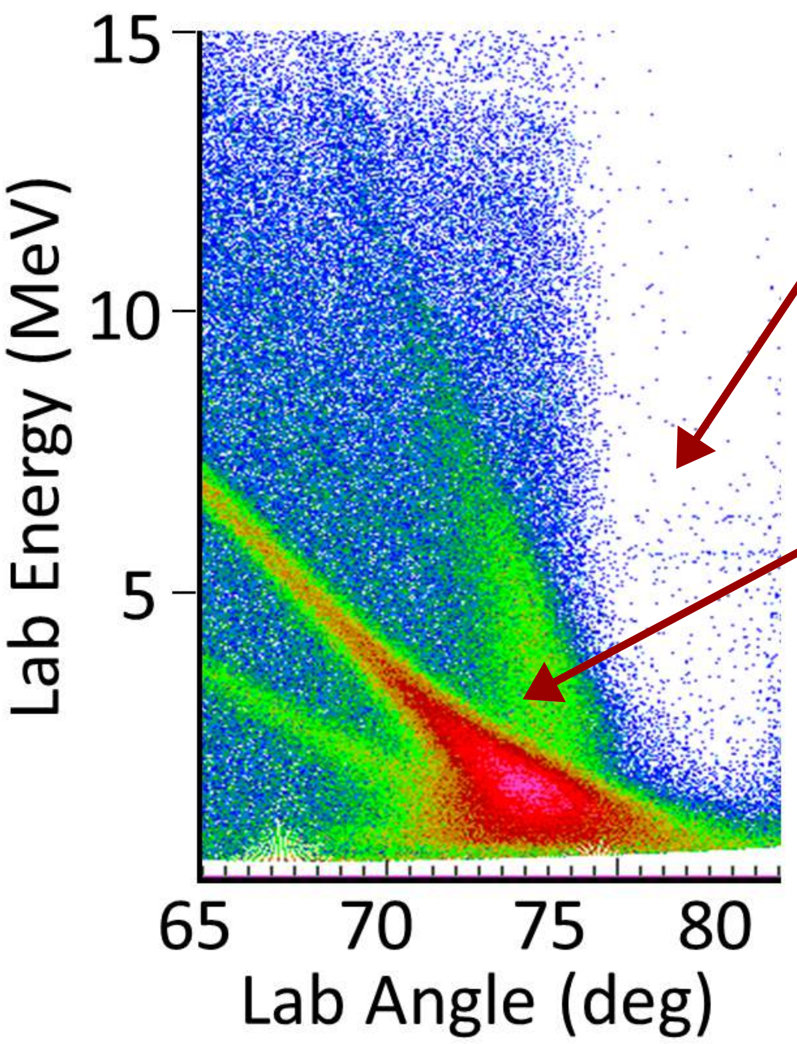
→ Three main ingredients: **beam**, **target**, **detectors**

→ Detector improvements can only balance issues with beam (cocktail beam, low intensity, large emittance, etc) to a limited extent

→ We want a target that is pure, homogeneous, the right balance of thick (density/ statistics) and thin (straggling/resolution), localized, robust

Reminder: why this is important

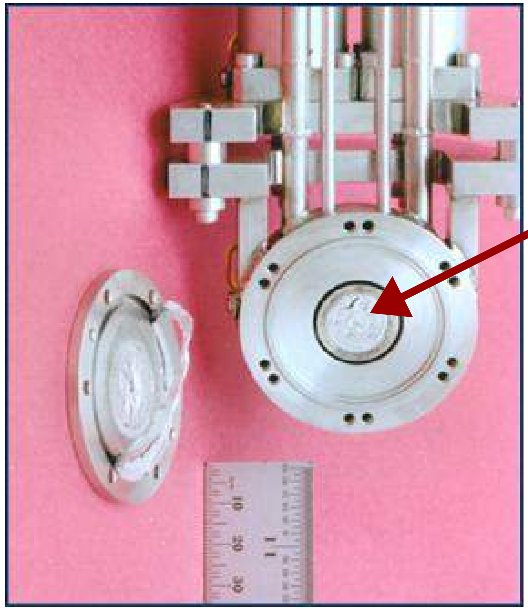
Are traditional targets really so bad?   ...Yes.



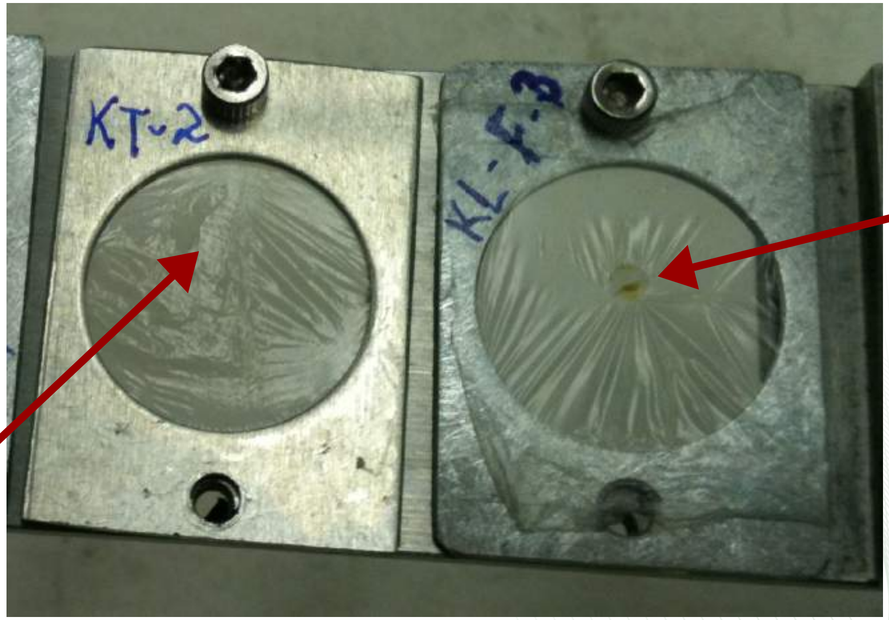
target ladder shadowing

background from stoichiometric contaminants

seriously this is just a glorified plastic bag



human-induced damage



beam-induced damage

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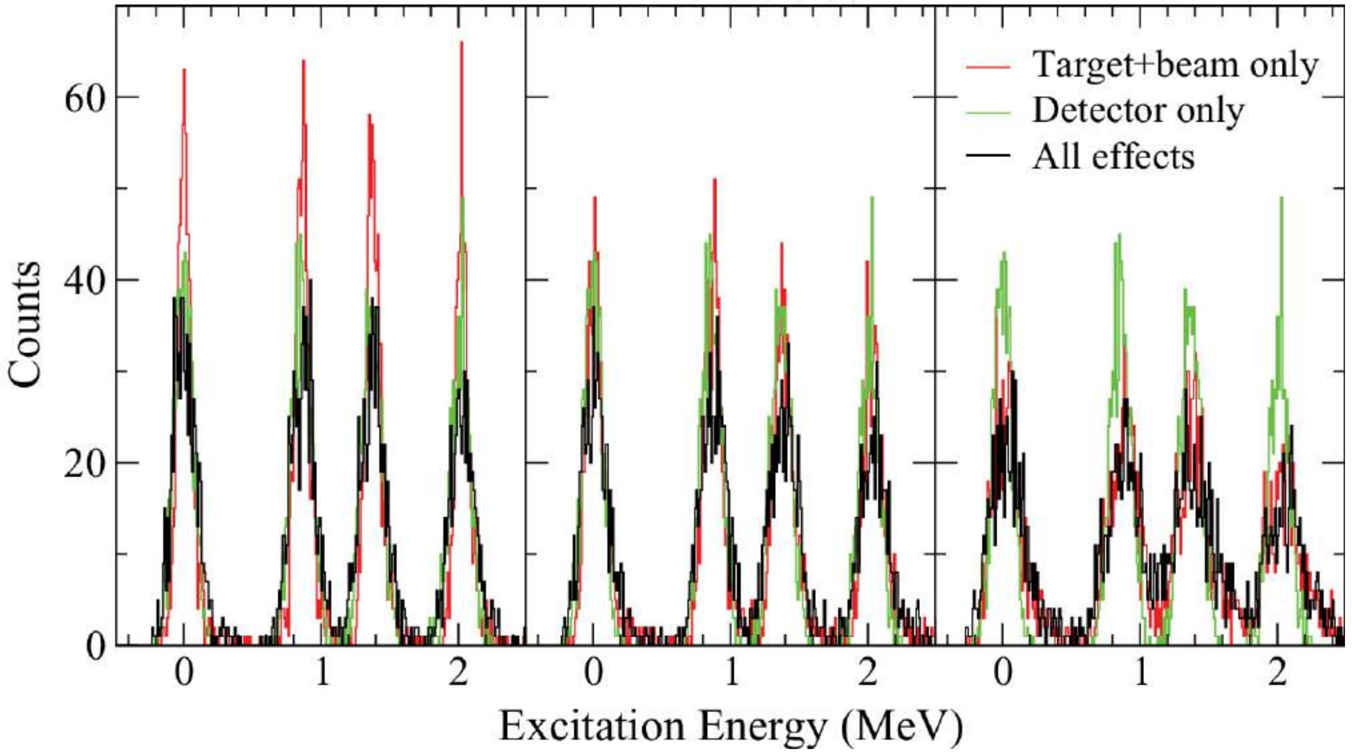
Reminder: why this is important

How bad is “so bad” then?

Consider the sims below: between 200 and 400 $\mu g/cm^2$ CD_2 target becomes dominating factor on experimental resolution



Simulations of the response of GODDESS silicon detectors for the $^{132}Sn(d,p)^{133}Sn$ reaction at 10 MeV/u to indicate the magnitude of effects from detector response (green) along with beam and target broadening (red) which contribute to the total resolution of the experiment, for 100, 200, and 400 ug/cm^2 CD_2, from Pain AIP Advances 4, 041015 (2014)

Other examples:

A 5 MeV alpha in polyethylene has a stopping power 2x higher and the lateral straggling is 2.5x higher as a percent of the total range (range is ~5x shorter) than hydrogen gas

Consider a 1cm long, 1” diameter gas cell with 1 atm of room-temperature helium and 2 μm nickel entrance and exit windows. The areal density of the target gas is 1/20th of the areal density of its windows

Adding just 5cm to the length (along beam axis) of an extended, differentially-pumped gas target can reduce the mass resolving power of the recoil separator behind it by nearly a factor of 2 (so imagine what it's doing to your angular resolution!)

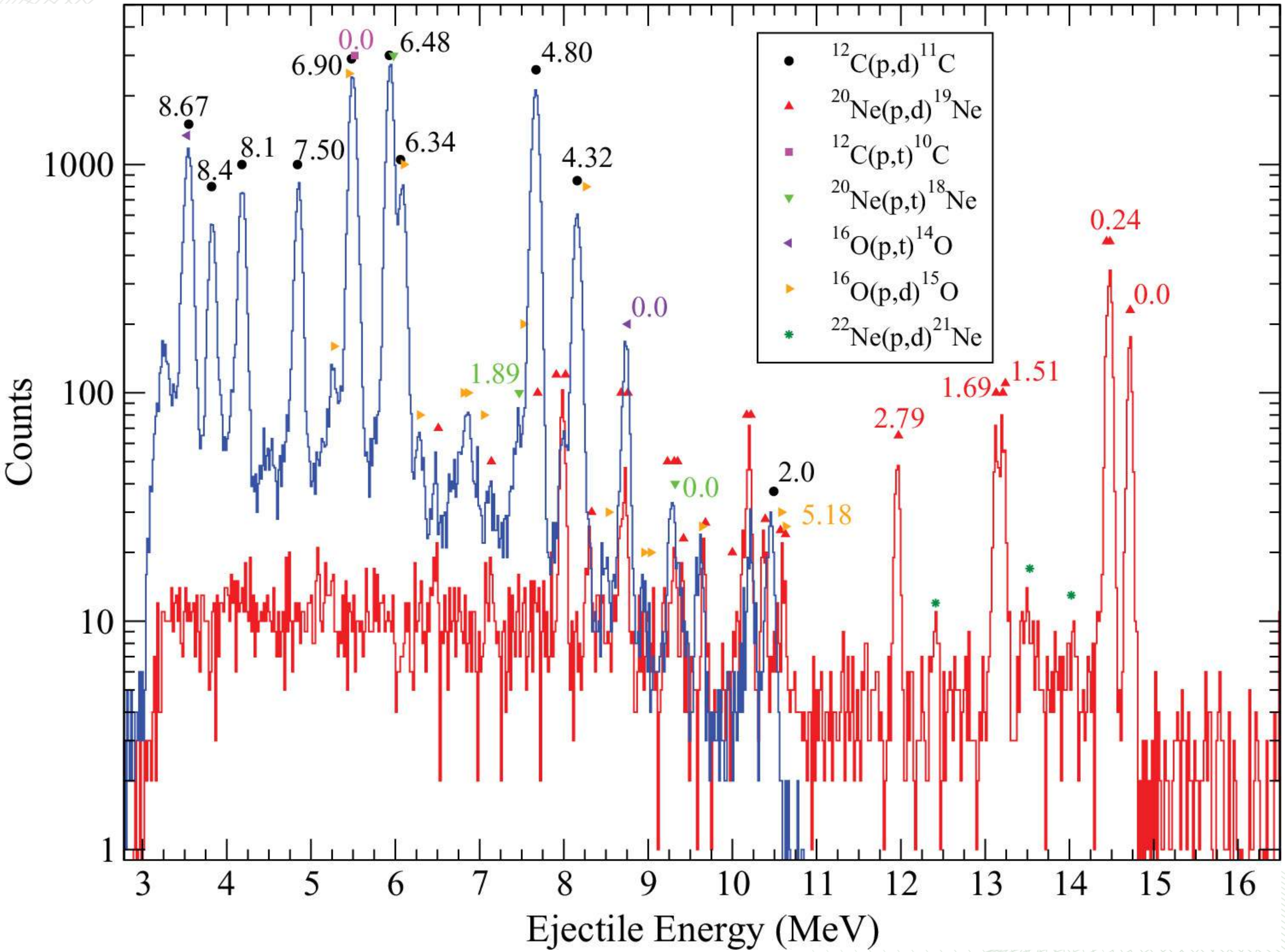
Fusion evaporation occurs at a ~5x lower beam energy for ^{30}P on carbon compound vs silver backing foil

A more concrete example: ^{20}Ne(p,d)^{19}Ne two ways

From Pain AIP Advances, comparison of the deuteron spectra from two normal kin measurements of ^{20}Ne(p,d) with the same detectors and ~same experimental setup (electronics, etc). Blue is a neon-implanted carbon foil; red is a jet of neon gas.

→ Factor of ~10 reduction in continuum background at higher excitation energies

→ Factor of ~2 improvement in energy resolution



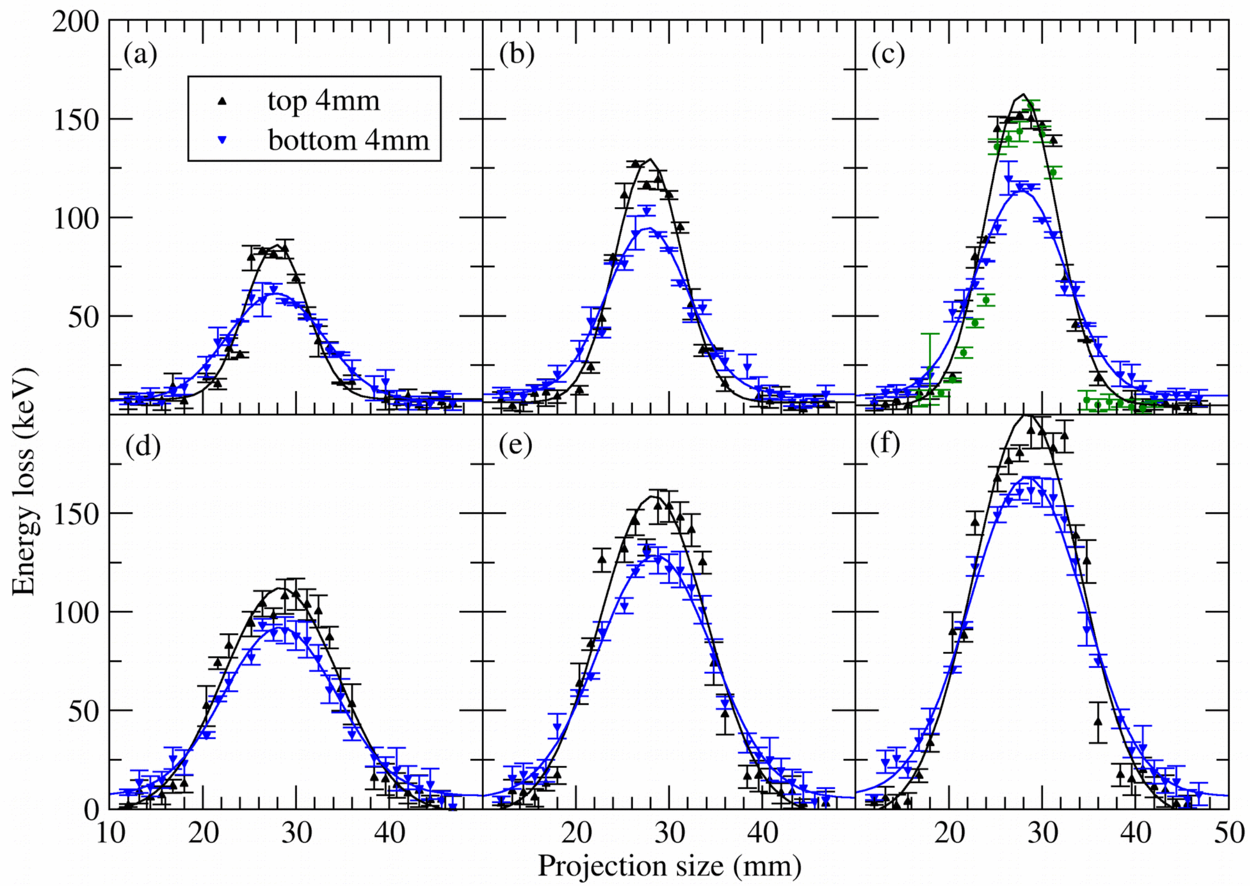
So what can we do?

1) Rely heavily on John Greene!

2) Build new&improved targetry for a ReAX solenoidal spectrometer

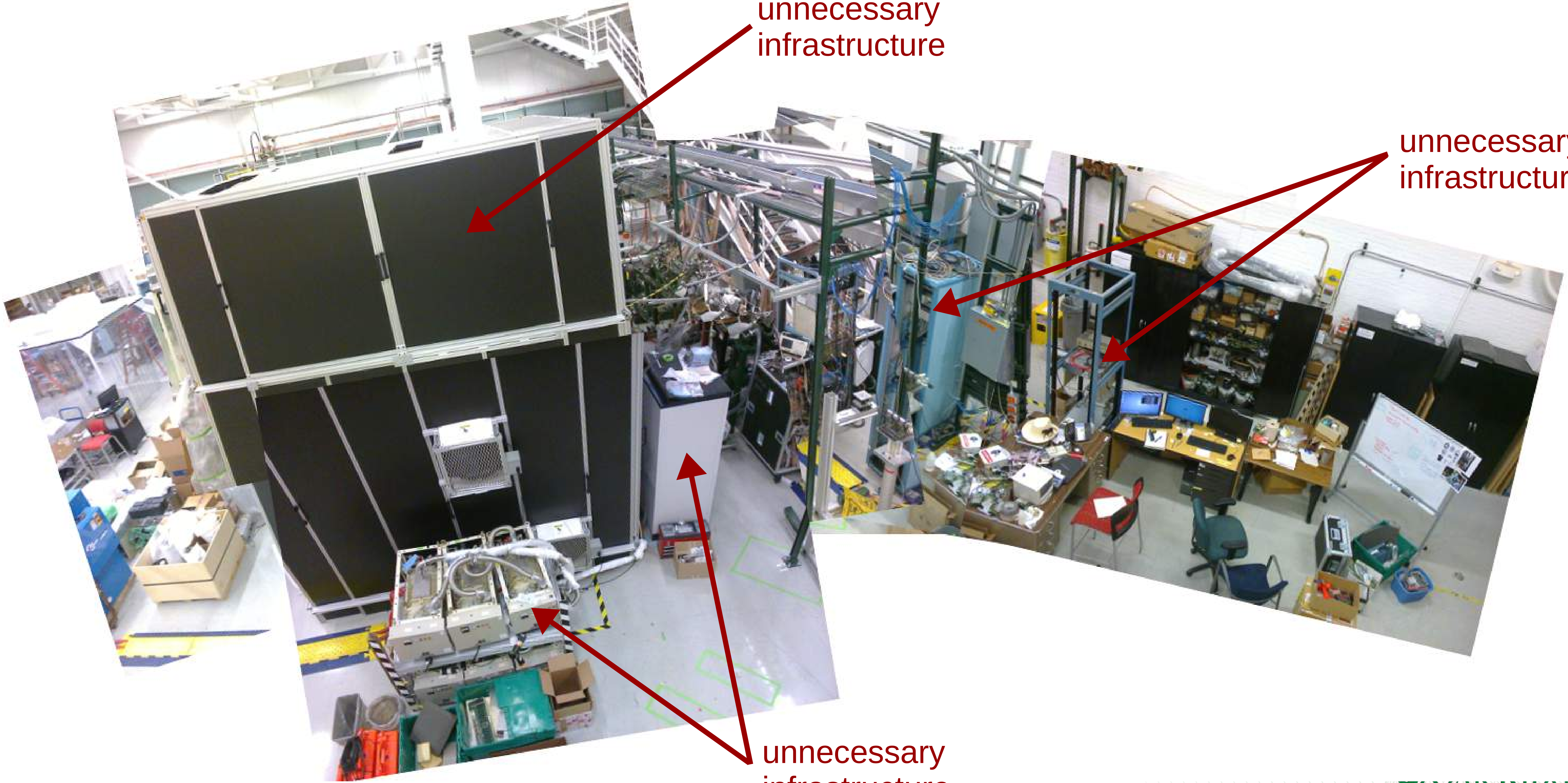
→ JENSA-like gas jet target
→ IRIS-like frozen hydrogen target
→ Something completely novel?

Option 1: JENSA-like gas jet target



Pros: high density, highly localized, pure, robust, can be varied in size and density quite a bit
Cons: large infrastructure requirements, absolute normalization very sensitive to beam/target overlap, non-negligible losses in solid angle coverage due to receivers

Option 1: JENSA-like gas jet target

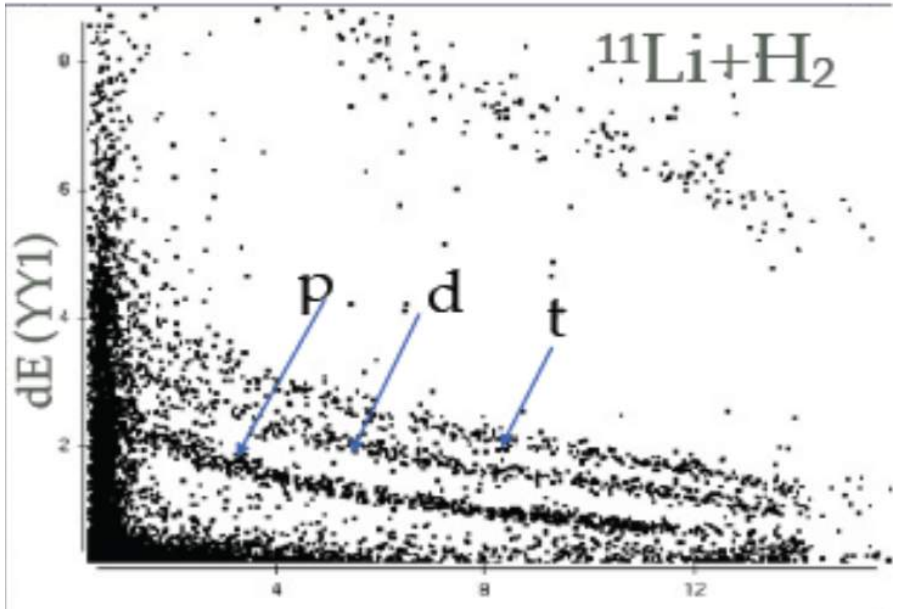


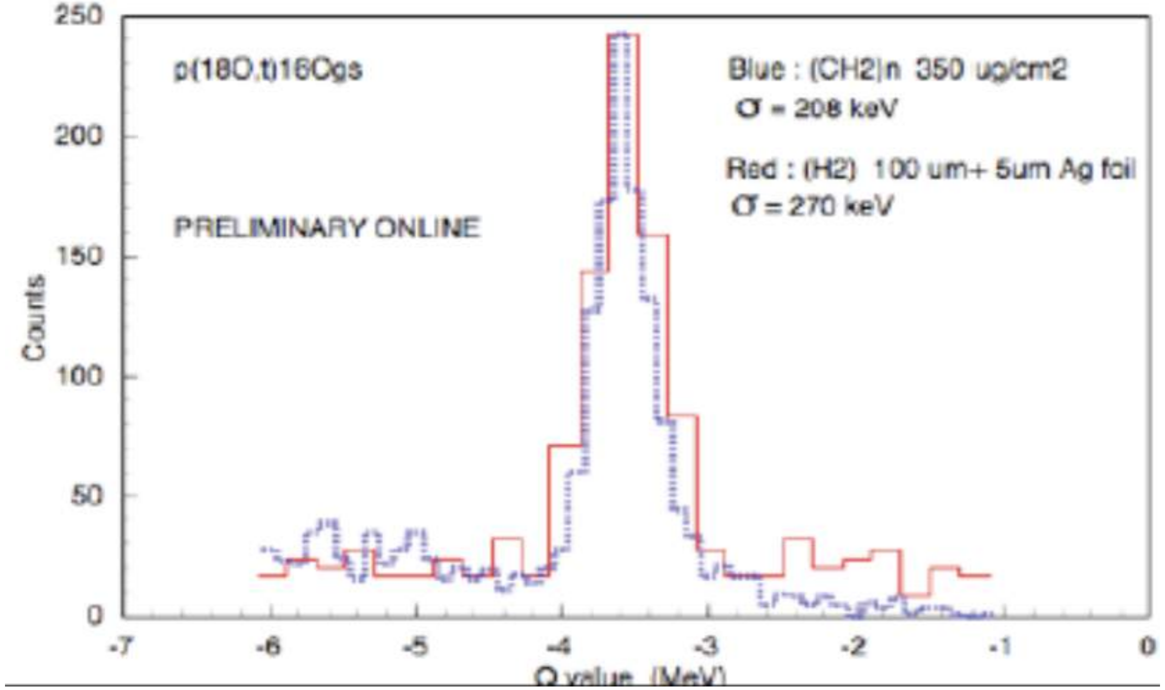
unnecessary infrastructure

unnecessary infrastructure

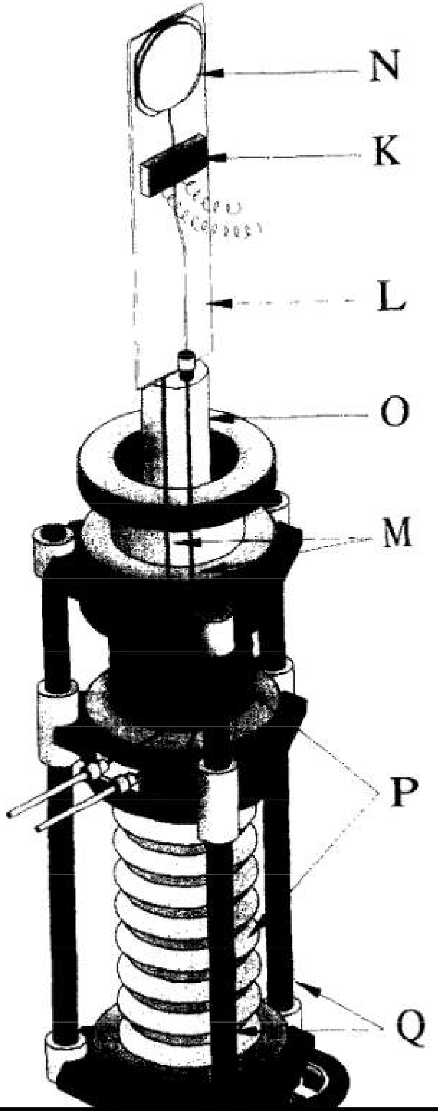
unnecessary infrastructure

IRIS-like frozen hydrogen target





P.E. Knowles et al. / Nucl. Instr. and Meth. in Phys. Res. A 368 (1996) 604–610 607



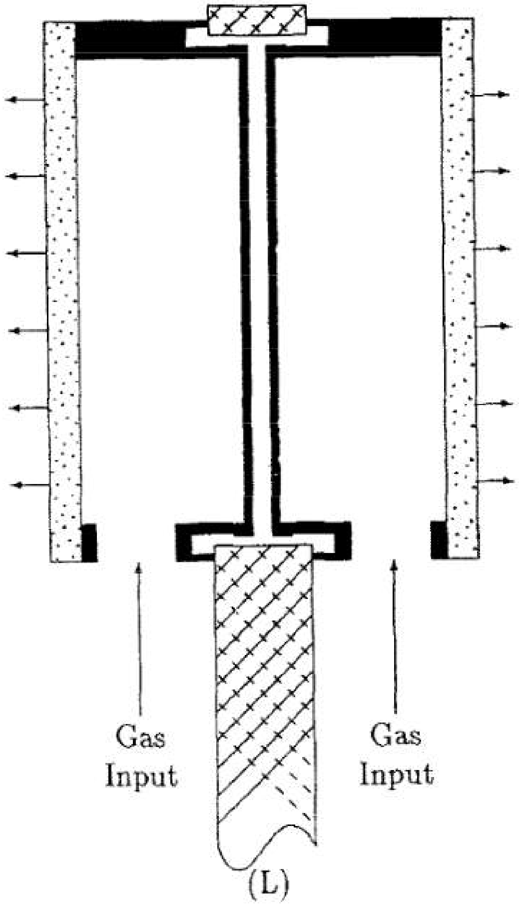
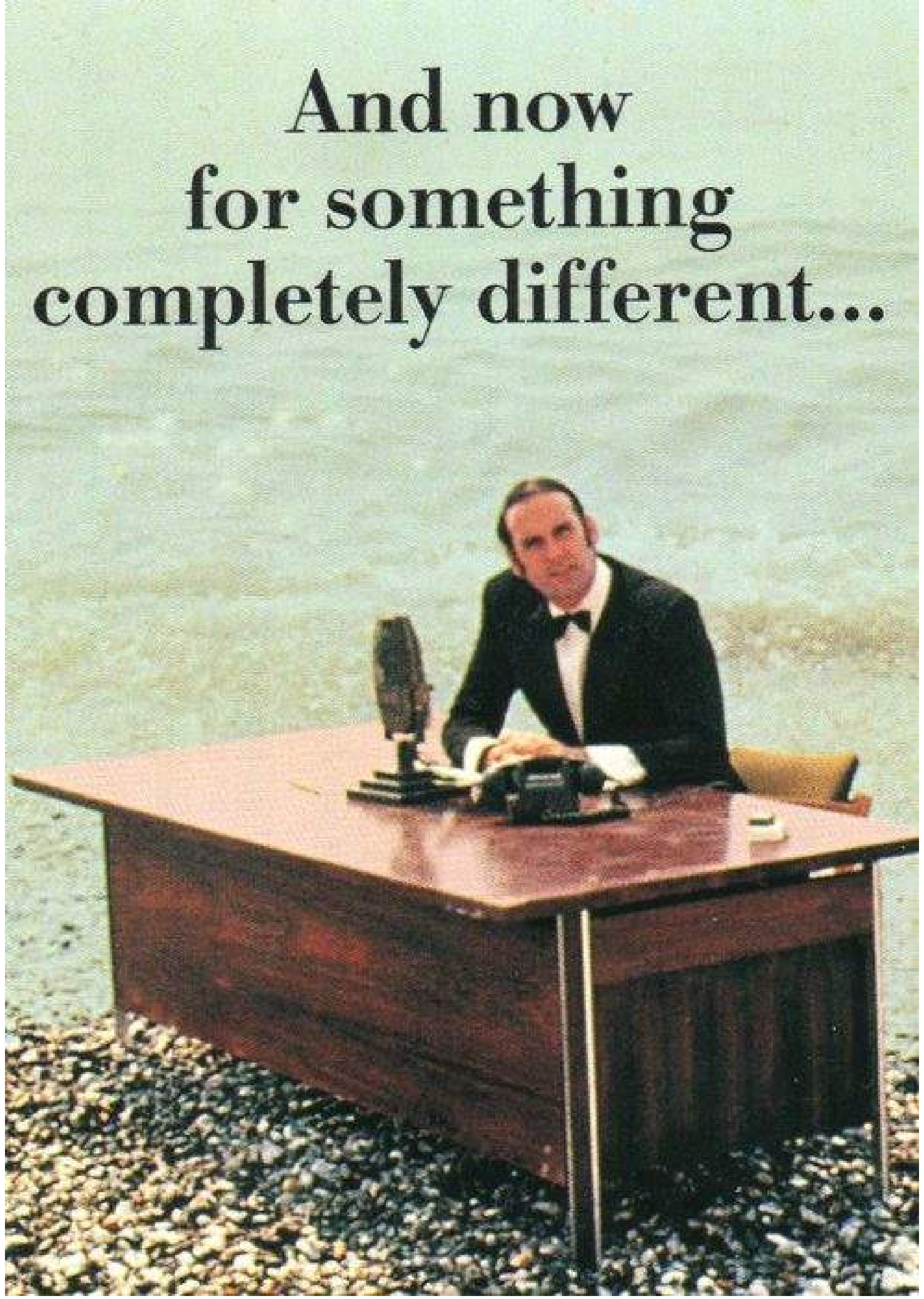


Fig. 4. A vertical-section view of the gas diffusion assembly. The *horizontal* size is magnified by a factor of 8 and the gas supply tubing has been removed for clarity. The top of the copper support, (L), is shown where the two diffusion chambers are mounted in recesses in the sheet. The gas flow path into the chamber and out through the sintered metal is illustrated.

Pros: variable density, backing foil is high Z and very thin so does not contribute as much background as carbon
Cons: backing foil worsens energy resolution, use of cryogenics (effort, safety)

Something completely different?



→ Active target inside magnetic field? (cf. Bazin, Raabe)
- reconstruction of spiral tracks through active medium
- magnetic field effects on Frisch grids, electric field lines
- size of active volume

→ Continuous CD_2 wheel?
- prevent/minimize beam-induced damage
- introduces additional failure points (moving parts)
- still just a glorified plastic bag

→ Use foil of an MCP as the target material? (cf. ND)
- combined target+beam tracking
- useful for in-flight beams
- MCP inside magnetic field

→ Other hydrogenated or deuterated compounds?

→ We already have HELIOS, so we can and should test ideas prior to implementing them with ReAX beams

Pros: ???
Cons: ???

Comparison and Conclusion

Question of which type of target to use will likely differ from measurement to measurement based on the goals

	CD_2 etc	Gas cell	Gas jet	H ice
Resolution	good	poor	great	good
Thicknesses (engineering limits)	large variation (10 ug/cm^2 – 50 mg/cm^2)	small variation (1-200 ug/cm^2)	small variation (1-100 ug/cm^2)	medium variation (400 ug/cm^2 – 1.3 mg/cm^2)
Infrastructure	minimal	medium	high	medium

Traditional targets are fine, but we can do better!

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