Cryogenic targets for fragmentation beams (production?)

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p and α target for inverse kinematic reactions

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Review

Hydrogen targets for exotic-nuclei studies developed over the past 10 years

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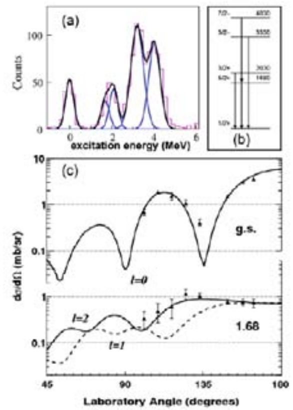
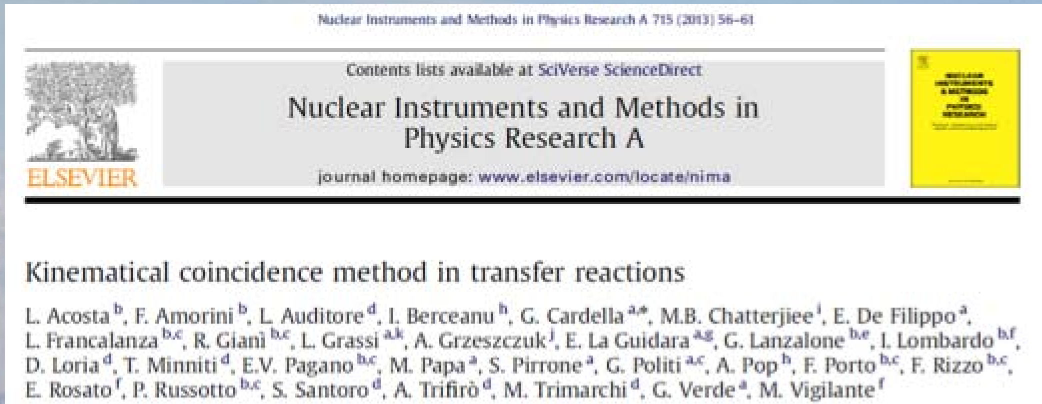


Fig. 2. (Color online) (a) Excitation-energy spectrum of ^{25}Ne obtained from the one-nucleon transfer measurement ^{24}Ne(d, p)^{25}Ne at 10 MeV/nucleon in inverse kinematics [1]. (b) Level scheme obtained from triple particle-gamma-residue coincidences. (c) Angular distributions in coincidence with the ground state and the first excited state at 1.68 MeV in ^{25}Ne. The sensitivity to the transferred angular momentum ℓ is obtained from the angular distributions for a given populated state. Courtesy W.N. Catford (University of Surrey).

Recent results from CHIMERA



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Kinematical coincidence method in transfer reactions

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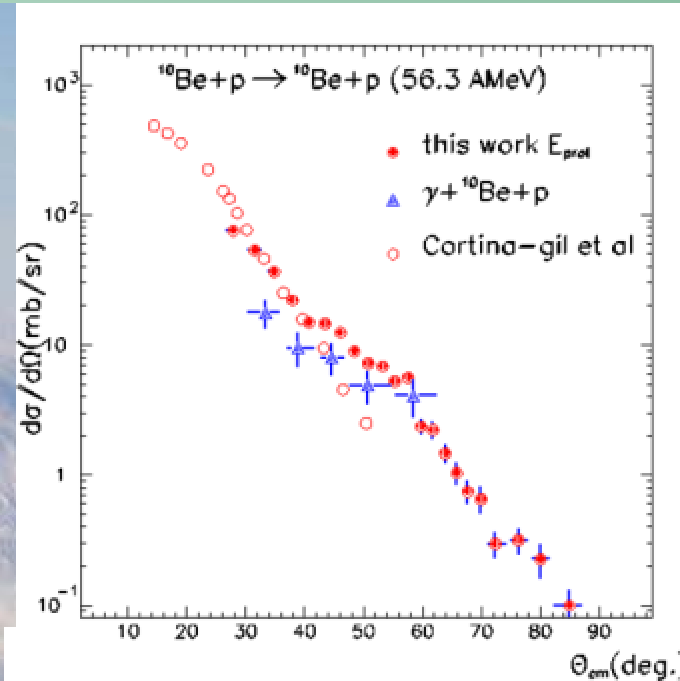
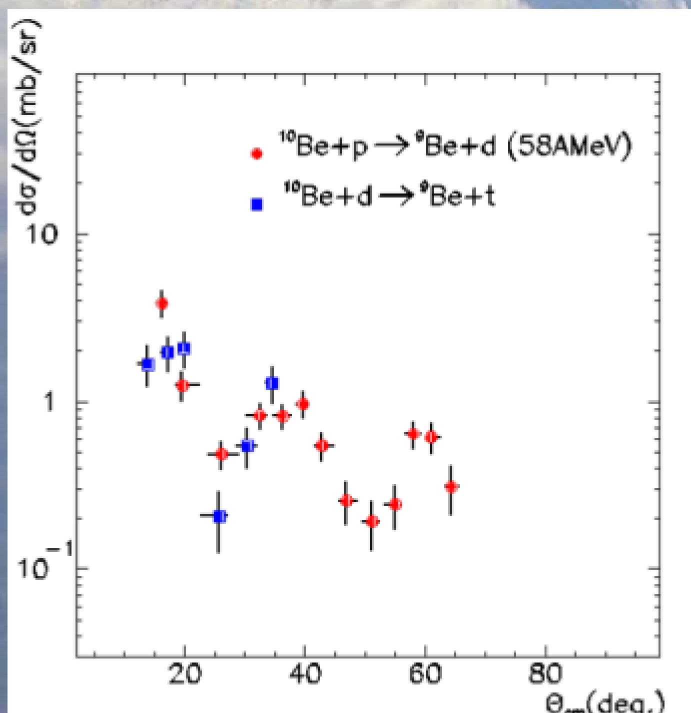
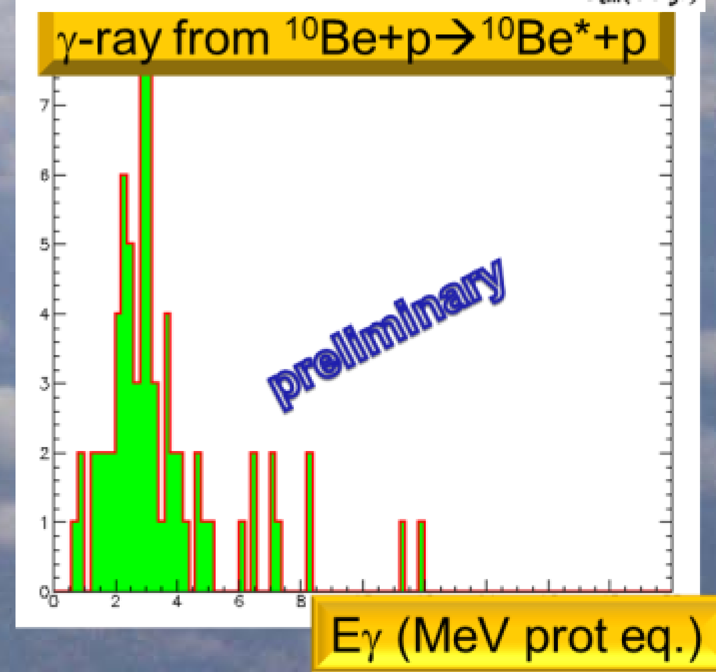






The ChyMeNe project (Orsay-Spiral2)

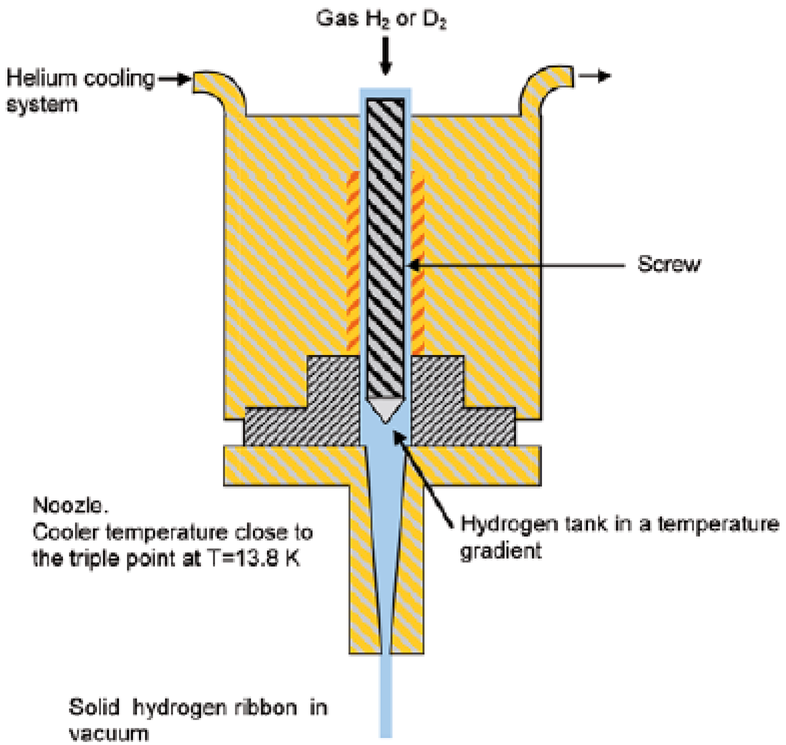


Fig. 12. Scheme of the extrusion technique of the CHyMENE project.

Concept simple:

Hidrogen flux pushed by a screw
In a liquid helium bath

Extruded by a nozzle with the desired size

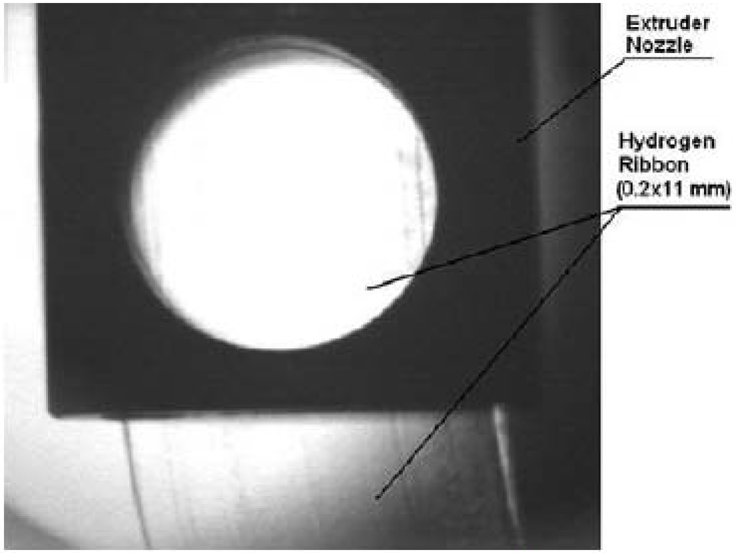
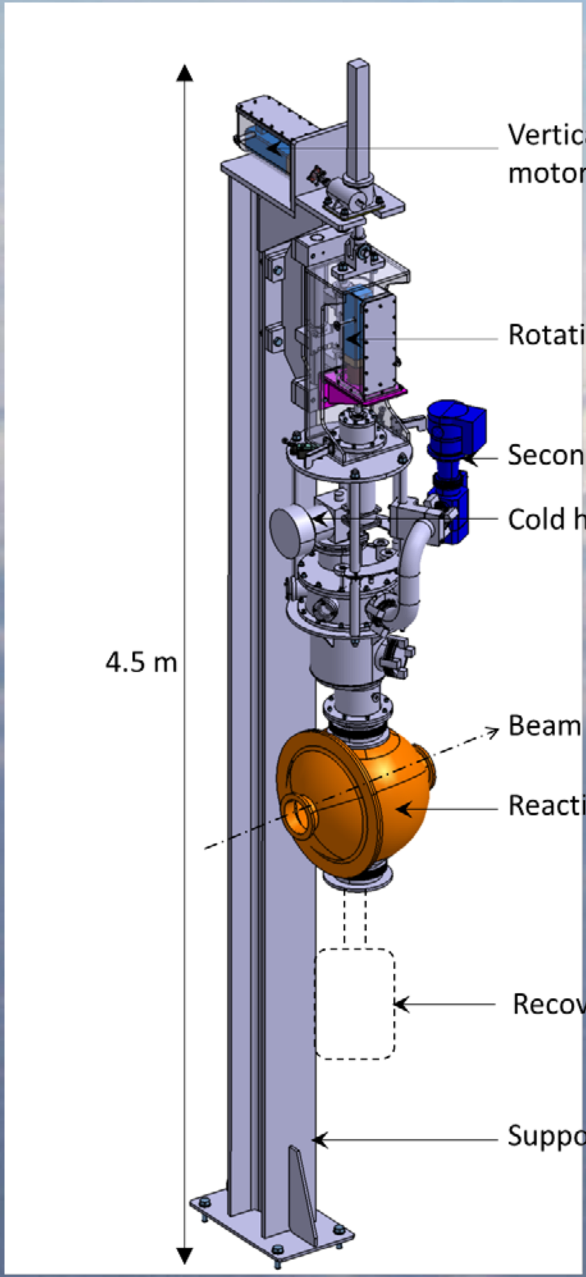


Fig. 13. Picture of a 200 μm thick H_2 film extruded at 10 mm $\cdot$ s^{-1} in a reaction chamber. The film width is 11 mm.

Clearly a large pumping is needed to evacuate hidrogen and enough cooling power for the Helium bath

The ChyMeNe project (Orsay-Spiral2)



The target appears in the form of a quasi-solid hydrogen ribbon (10 mm wide, 50 µm thick), which flows continuously using an extrusion technique in a vacuum inside a reaction chamber in front of the ion beam. This target is developed in collaboration with the the Pelin laboratory, which supplies the extruder, the IPN in Orsay, which is responsible for the extrusion nozzle and IRFU, which is in charge of the overall design of the mechanical and cryogenic system. This assembly comprises a cryostat in a vacuum, providing for vertical movement of 100 mm and a 100° rotation of the target, so as to give 90° analysis angles, with respect to the beam. The cryostat is made up of a cold head providing the power needed (15 W at 11 K) to solidify the hydrogen in the lower part of the extruder. The cryogenic power is transmitted from the source to the extruder by conduction via metals with very high thermal conductivity (10,000 Wm-1K-1 at 11 K). In the cryostat, the gaseous hydrogen at an initial pressure of 8 bar is first liquefied in the upper part, then is partially solidified and compressed to 100 bar in the cooled extruder before the solid film is expelled through the nozzle in the center of the reaction chamber. The paste obtained then falls by gravity into a recovery tank where it sublimes. The gas is then pumped and evacuated into a dedicated line. An Instrumentation and Control system controls all equipment, and manages the thermal regulation and safe state of the cryostat.

Hydrogen Thickness

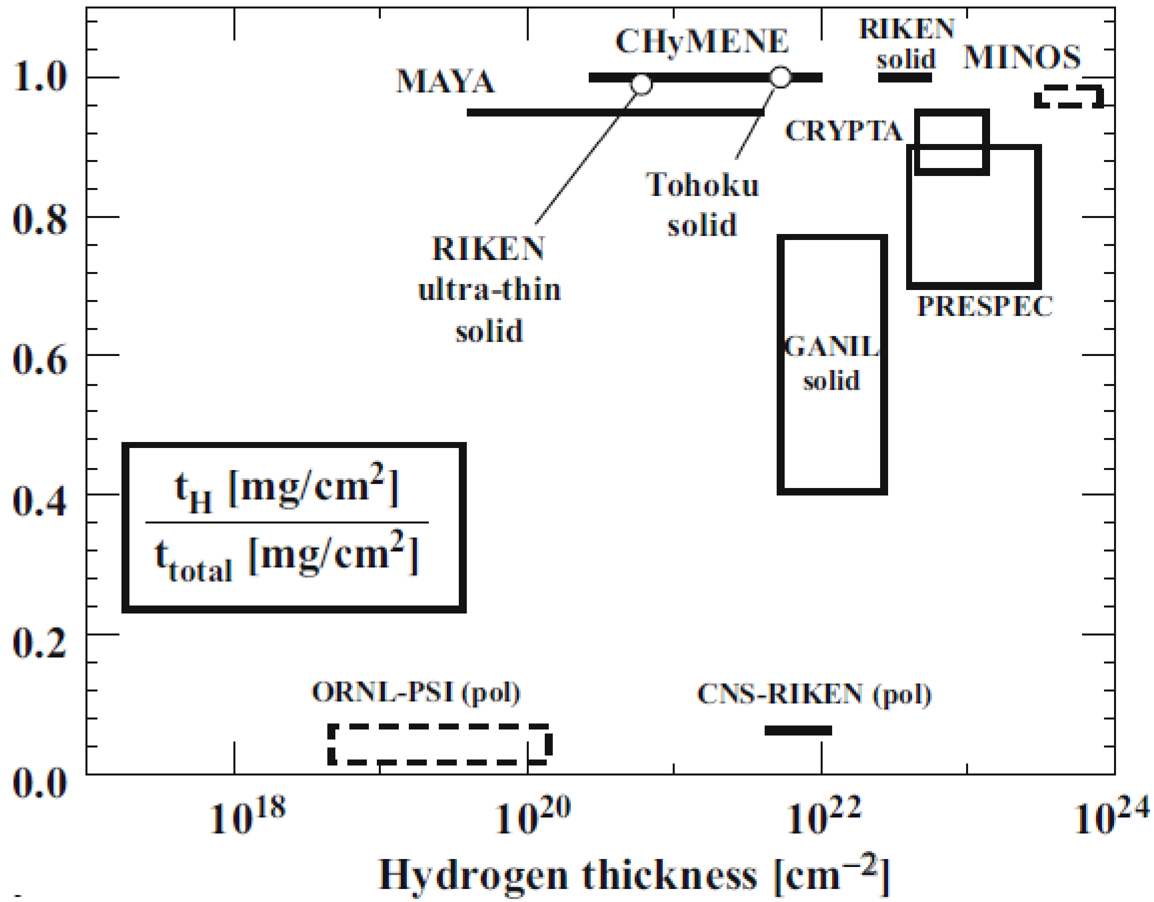


Fig. 28. Comparison of the thickness and purity of targets discussed in the present review. Existing targets are indicated with continuous lines or circles whereas the dashed symbols are used for targets still in R&D phase.

Can be used for fragmentation beam production?

Usually we produce fragmentation beams with a 9Be target, the smallest mass, relatively simple to handle, metallic target

Why small mass is better? To allow kinematical focusing of reaction products having larger collection efficiency (Higher beam intensity !!)

Proton or alpha targets are smaller targets and using them we could get an even better focusing increasing the beam intensity

For H target one could use a CHYMENE like system with continuous supply of H while for alpha to a liquid helium target with thin windows
(kapton?)

Can be used for fragmentation beam production?

beam	prymary	yield be9 target (kHz)	yield H target (kHz)	yield Helium target (kHz)	yield D target kHz
^{9}C	^{10}B 50MeV/A	1.9	3.6	2.7	
^{8}He	^{10}B 50MeV/A	2.7	4.1	4.1	5.7
^{16}C	^{18}O 50 MeV/A	170.	290.	273.	420.
^{38}S	^{40}Ar 40 MeV/A	253.	507.	424.	683.
^{68}Ni	^{70}Zn40 MeV/A	119.	319.	245.	398.
^{80}Ge	^{86}kr 40MeV/A	2.1	6.1	4,8	8.4
^{128}Sn	^{136}Xe 35MeV/A	0.27	8.1	2.4	8.8

Can be used for fragmentation beam production?

It is obvious that we should be able to give more cooling power than the energy dissipated by the primary beam on target (around 20W)

The target uniformity is crucial for a good beam transmission

The amount of money necessary for such a target it is not so small but it is still to be quantified
Could be two ? Or could be transportable to be used also as a final target

Up to now the study was just based on LISE however one should verify production cross sections also with some experimental campaign

This could be a subject for a future money request (premiale? –firb? –prin?-ERC Grant?) if a consensus is attained perhaps including also other improvements of fragmentation beam like the new chopper