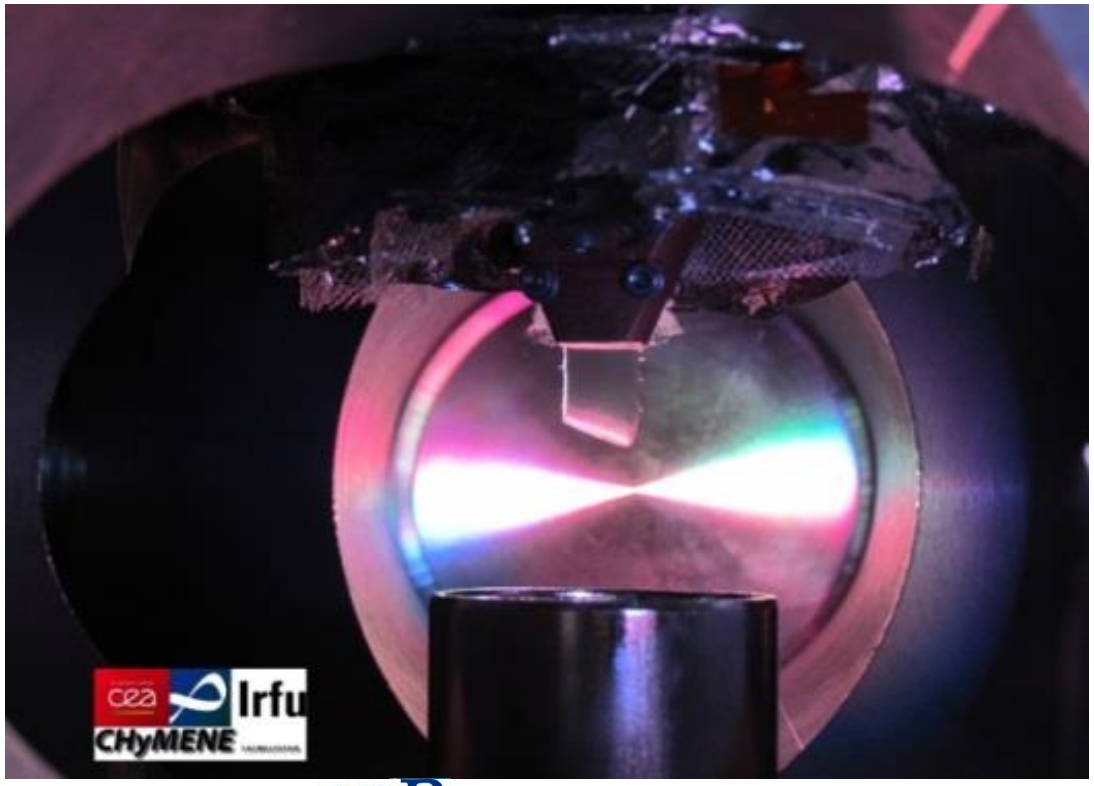


PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

FOR NUCLEAR STRUCTURE EXPERIMENT WITH UNSTABLE NUCLEI

CHyMENE PROJECT: Thin solid H_2 TARGET

GHELLER Jean Marc CEA/IRFU/DACM/LCSE
gheller@cea.fr

Project financing ANR

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

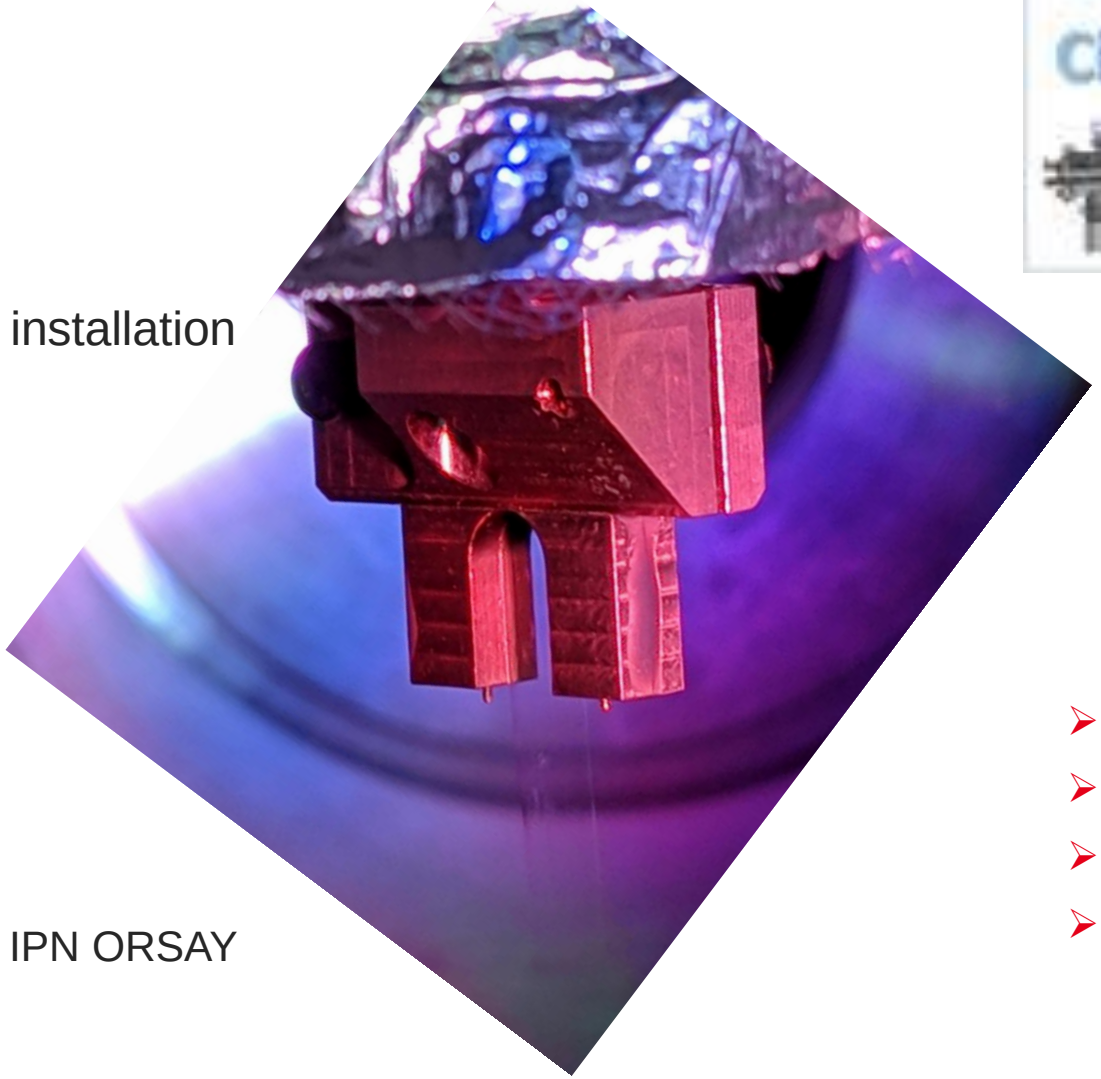
CHyMENE PROJECT

French acronym meaning:

Cible d'**Hy**drogène **M**ince pour l'**E**tude des **N**oyaux **E**xotiques

OUTLINE:

- The others targets
- Technical over view of CHyMENE installation
- Design
- How to make H_2 ribbon ?
- Pumping system
- IPNO experiment
- Nozzle Results & status, cost



keywords:

- **Cryocooler**
- **Extruder**
- **Pumping system**
- **Nozzle**

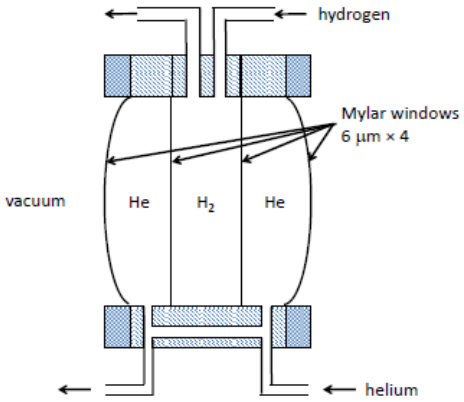
EPJA(2013) 15:155

Partners for the Project: CEA DAM, IPN ORSAY

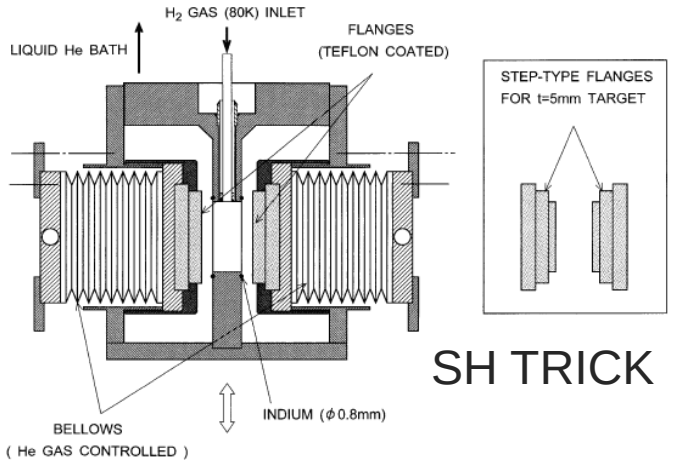
PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

Status of « solid target »

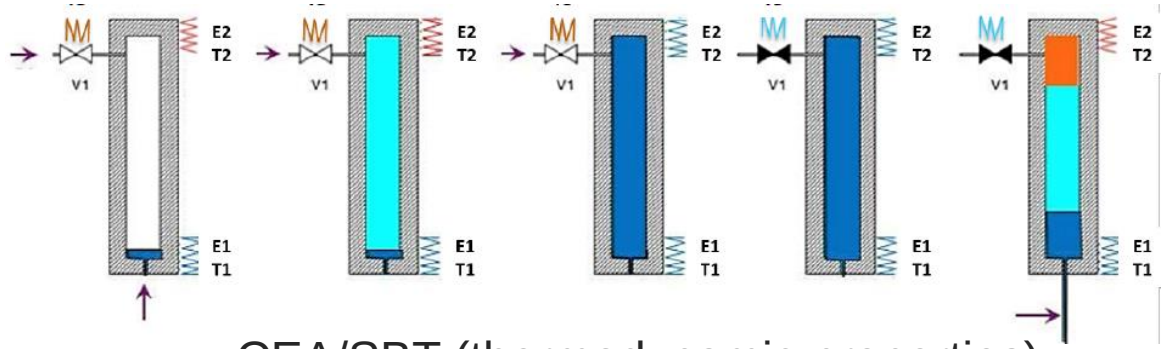
Targets	Ø	thickness	year	Comments
The Ganil	10 mm	1 mm	2006	
SH TRICK	25 mm	5 mm		Solid Hydrogen Target for Recoil detection In Coincidence with Inverse Kinematic
Target LMJ	2,4 mm		1996 - 2014	(CEA/SBT/DAM Cesta)
SLAC Target	1mm	Nano-µmetric	2000	liquid, speed> 100m/s, T° Solid
Targets Elise, Sophie		Ribbon 75 to 100 µm	2014-2018	CEA/SBT PALS (Prague) &RAL



The Ganil Target



SH TRICK



CEA/SBT (thermodynamic properties)

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

Status of « solid target »

Elastic & inelastic scattering

Knockout reaction

charge exchange reaction

Transfer reaction

nucleon transfer

Phase	Target	(p,p),(p,p')†	(p,Xγ)	(p,pN)†	N-transfer†	(p,n)
Gas	TPCs (ex. MAYA)	○	×	×	○	△
Liquid	GANIL liquid	×	△	×	×	△
	CRYPTA	×	○	×	×	○
	PRESPEC	×	○	×	×	△
	MINOS⋆	×	○	○	×	×
Solid	RIKEN solid	×	○	○	×	△
	GANIL solid	○	○	×	△	△
	RIKEN ultra-thin⋆	○	△	○	△	△
	CHyMENE⋆ (Rotation)	○	△	△	○	△
	CNS (pol)	○	△	○	×	○
	ORNL-PSI (pol)	○	△	△	○	△

Table 1. Domains of use for the different targets presented in this review. ○: designed for this type of reactions, △: can be used, ×: difficult or impossible to apply. Reactions marked with a † are understood as missing mass measurements.

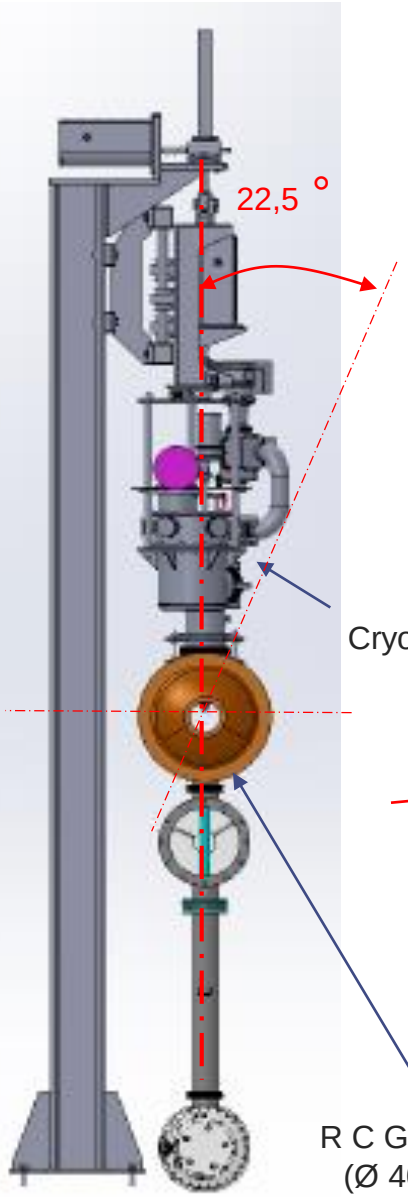
Courtesy of A. Obertelli & T.Uesaka

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

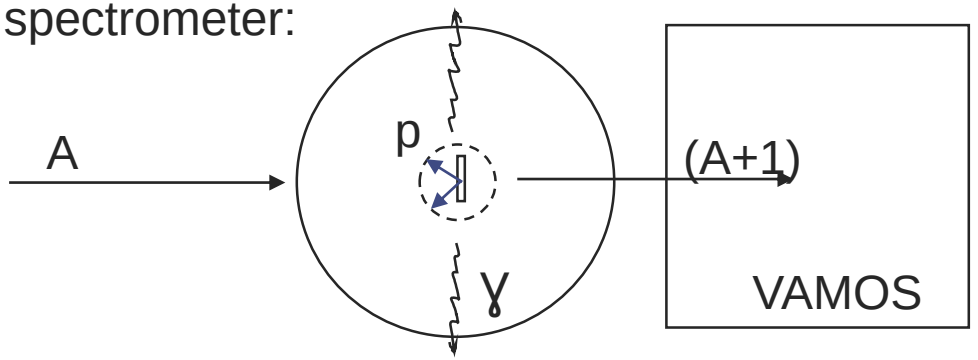
A.Obertelli[1] and T Uesaka[2]
[1] CEA, Centre de Saclay/IRFU DPhN F-91191 Gif/Yvette, France
[2] ROKEN Nishina Center, Saitama 351-0198 , Japan

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE PROJECT: AGATA/VAMOS

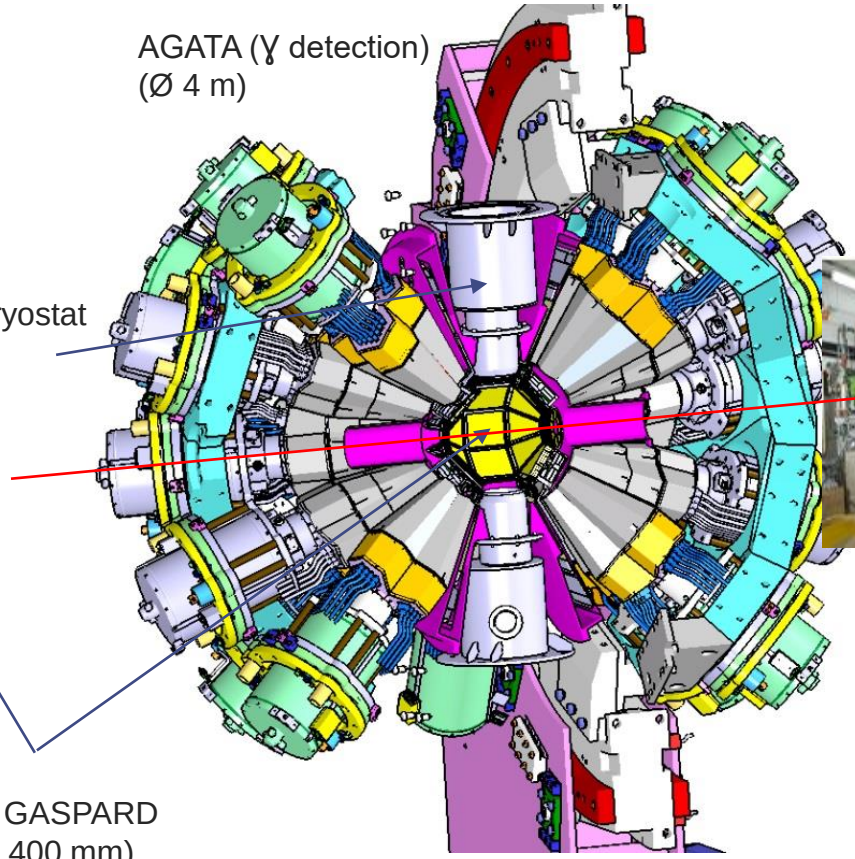


Transfer reaction AGATA+VAMOS spectrometer:
A(d, p) $^{+}$(A+1)



AGATA + GASPARD

Courtesy of A. Gillibert



neutron transfer reaction: ^{26}Ne (d,pγ) ^{27}Ne

(2006) Dol. target

Si

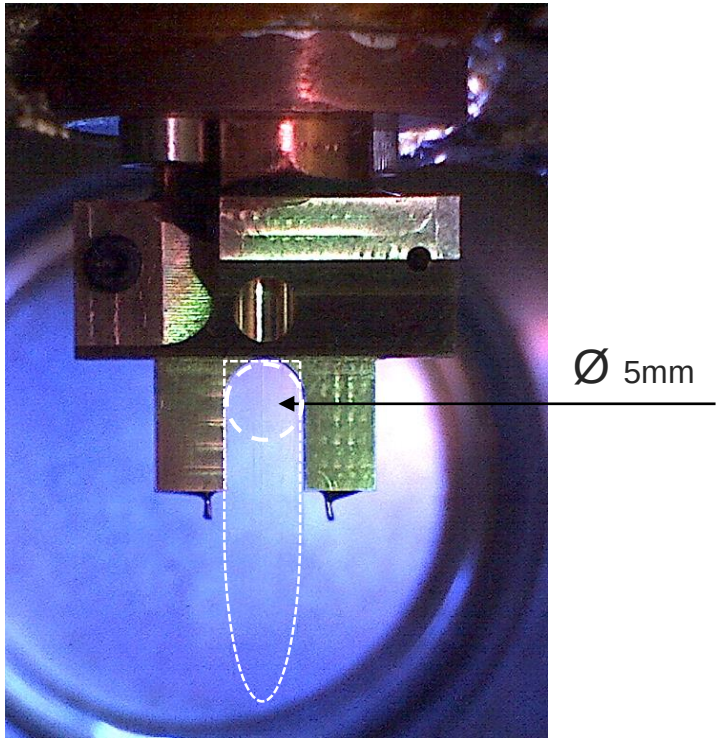
EXOGAM

VAMOS

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE PROJECT:TECHNICAL OVER VIEW OF THE INSTALLATION

Thin and pure solid windowless hydrogen or deuterium target.



Width from 2 to 10 mm and a thickness in the range of 20-100 µm (Thick VS width)

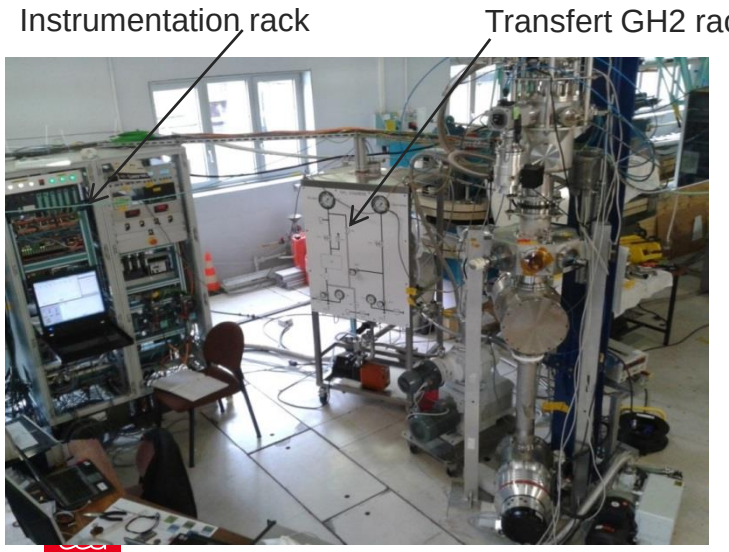
The adopted technique is continuous extrusion in the vacuum of a reaction chamber in collaboration with Pelin laboratory (supplier of the extruder).

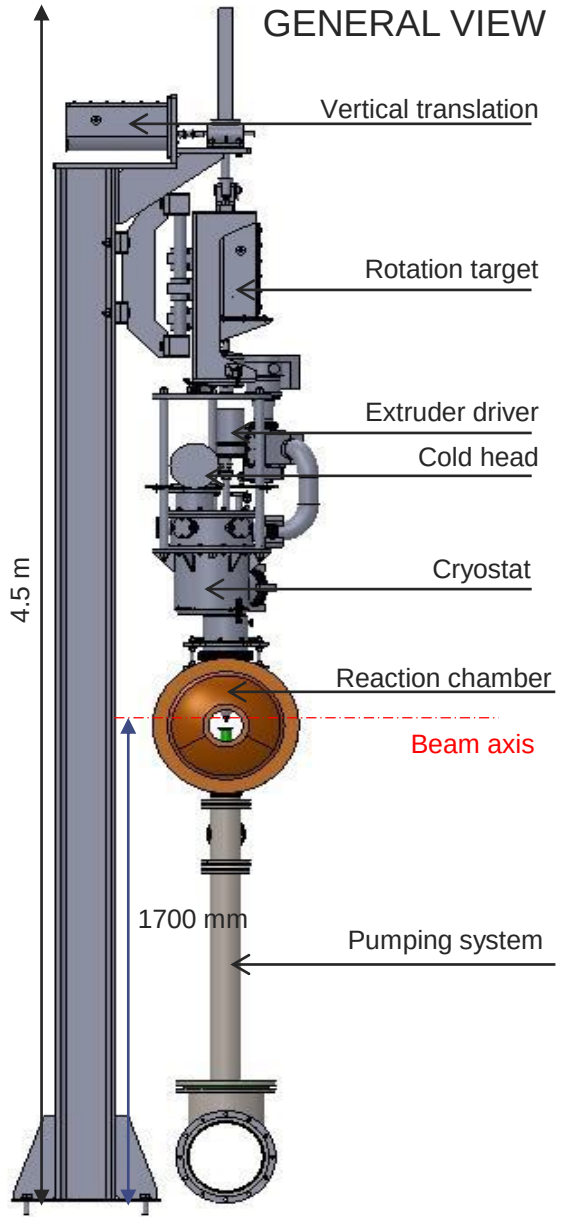
PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE PROJECT:TECHNICAL OVER VIEW OF THE INSTALLATION

Required Specifications:

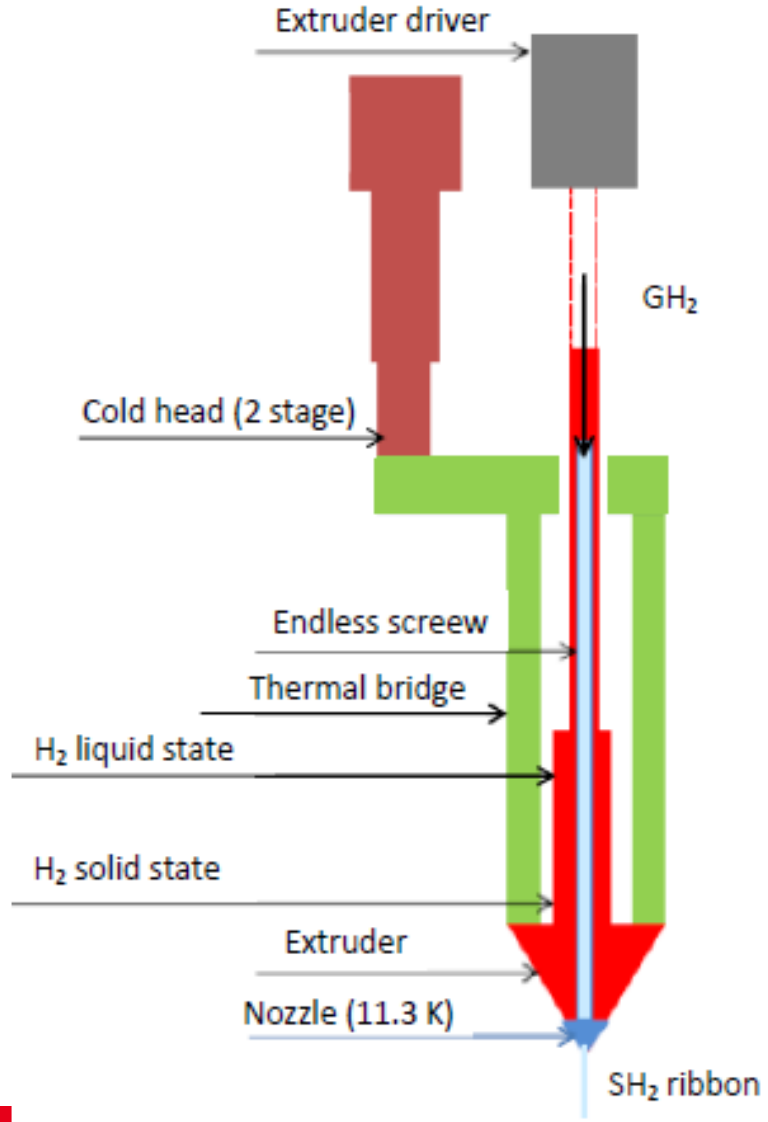
Cryogenic Power: 15 W at 12 K
Extrusion speed: 2 to 10 mm/s
Correct positioning of the ribbon
Vacuum reaction chamber: 5.10^{-5} mbar
Autonomy: At least 2 weeks
Target vertical translation: 100 mm
Target rotation: +/- 45 °
Needs: - air pressure (7bars)
- water (20 l/mn 20°C)
- 400V/63 A, 3 Ph +neutral+ ground



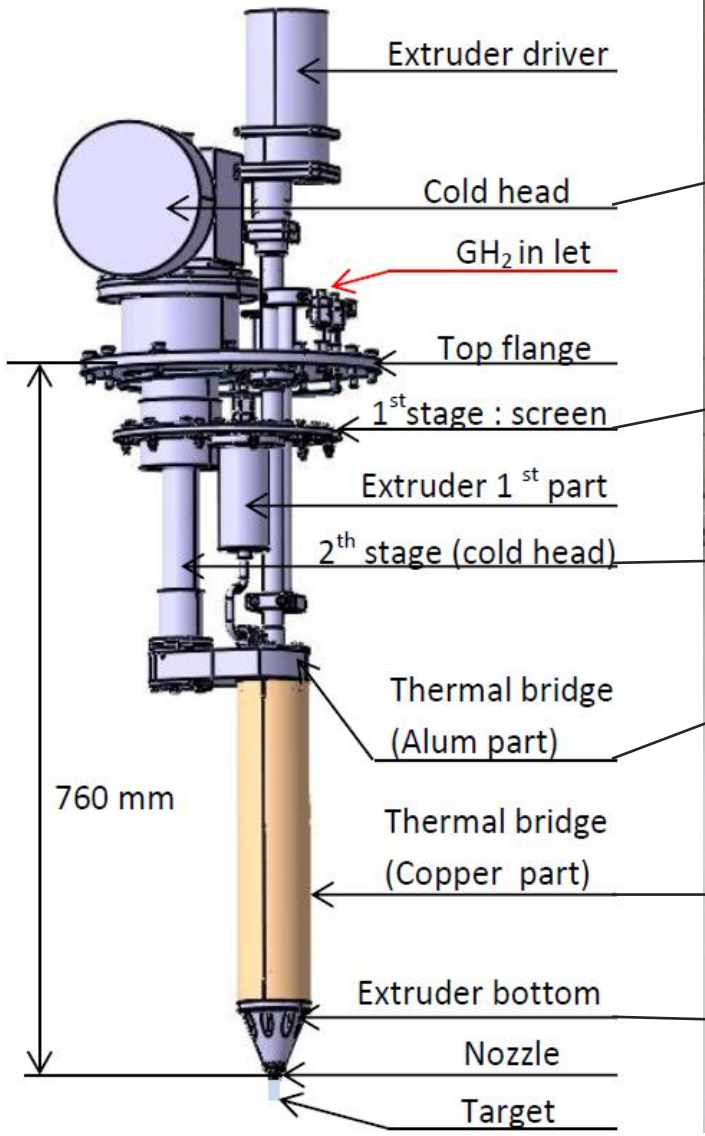


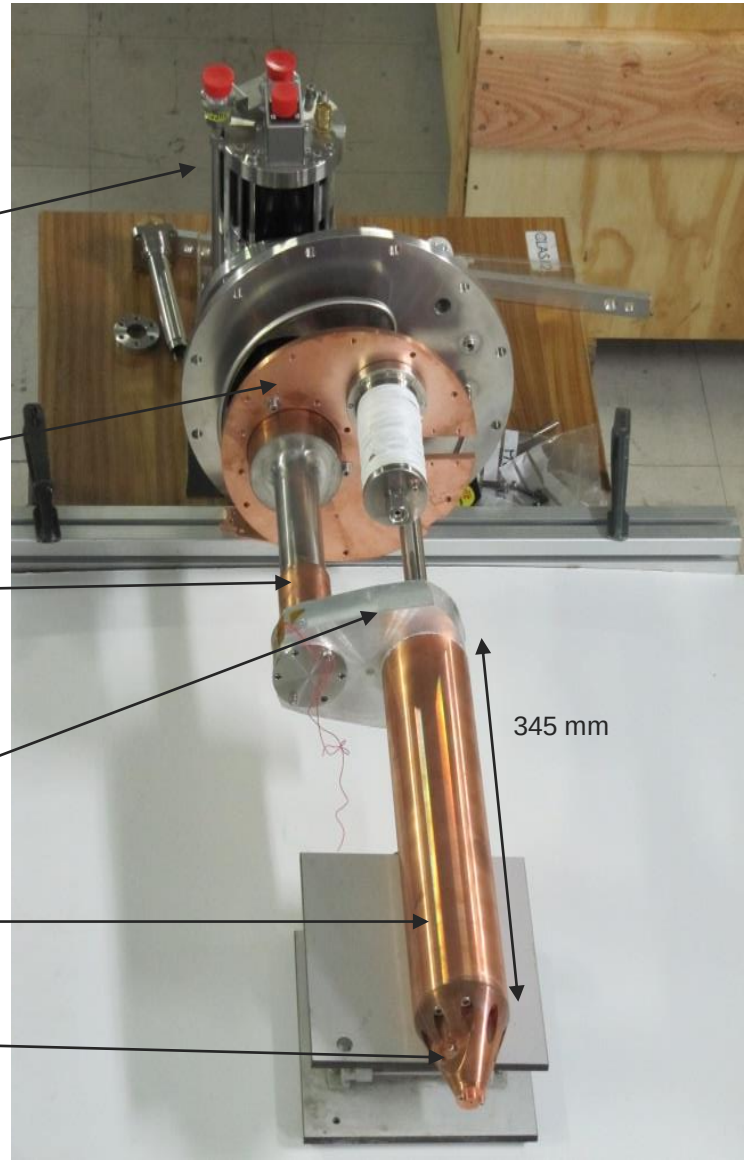
PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE PROJECT: different parts of the cryostat



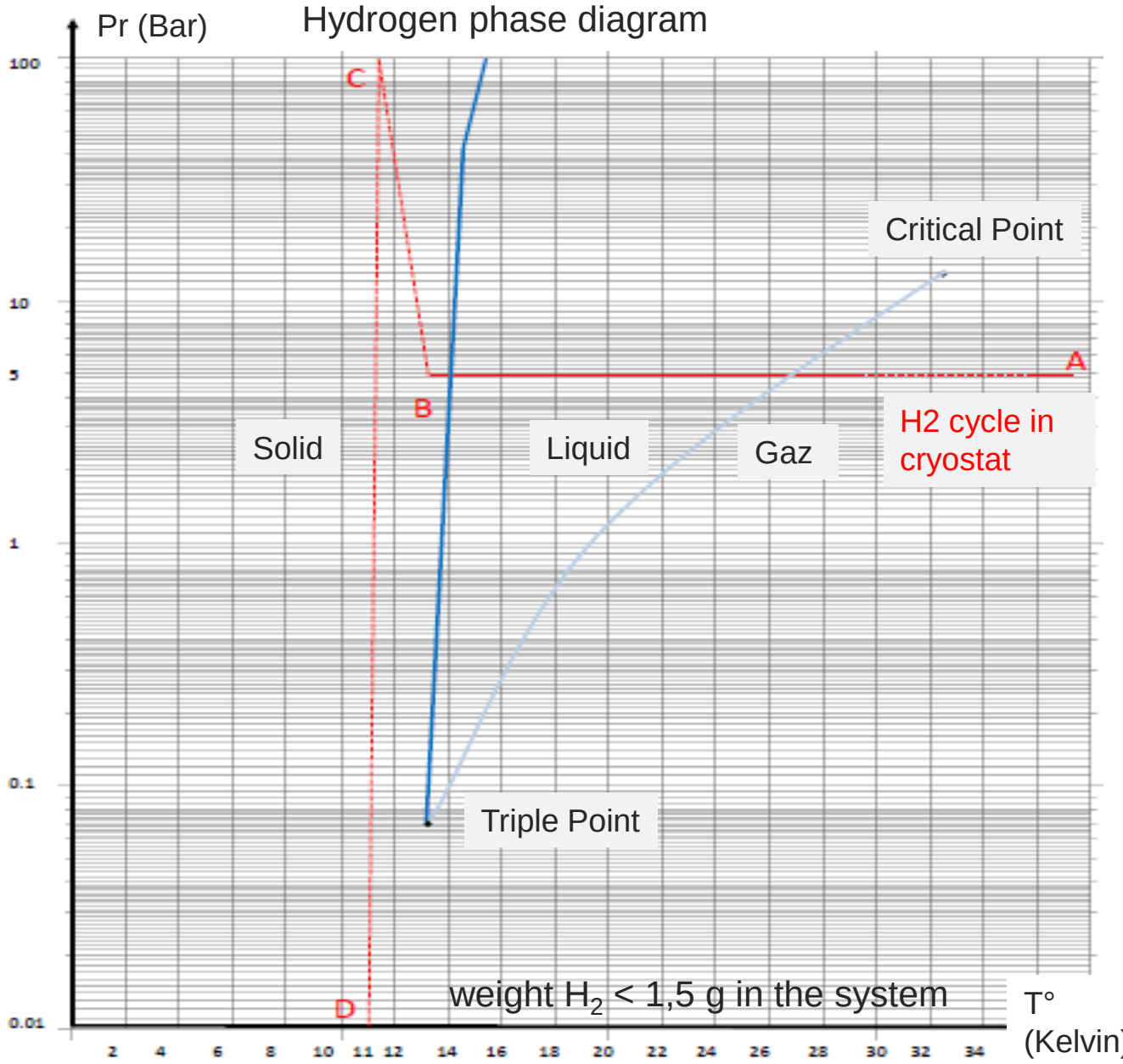
Cryogenic system in the cryostat

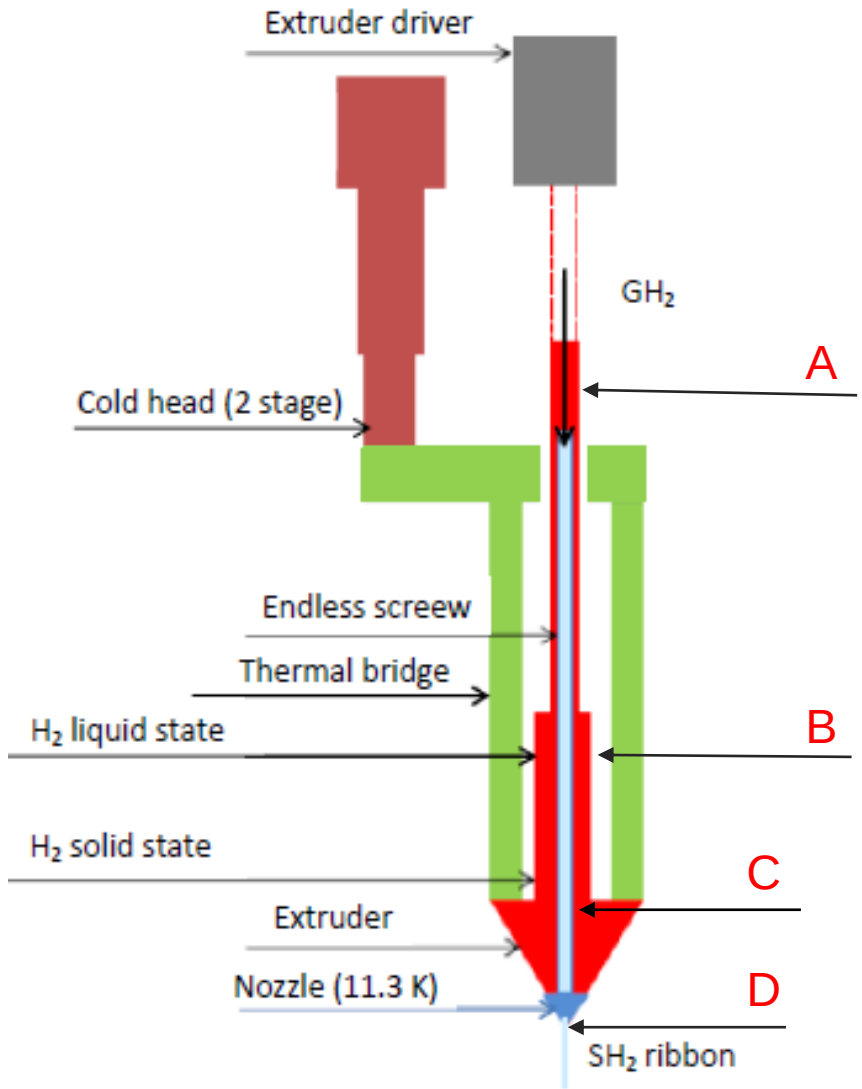




PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

❖ CHyMENE PROJECT: How to make H_2 ribbon ?





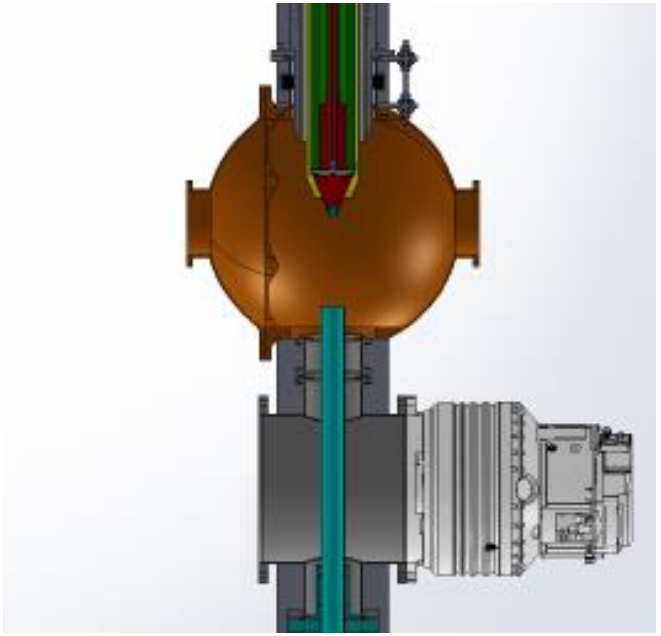
PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

❖ CHyMENE PROJECT: pumping system, contraints

Goal: vacuum of 5 x 10^{-5} mbar (the reaction chamber)

Qi = 5 x 10^{-9} m^3/s (Section: 50 µm x 10 mm)

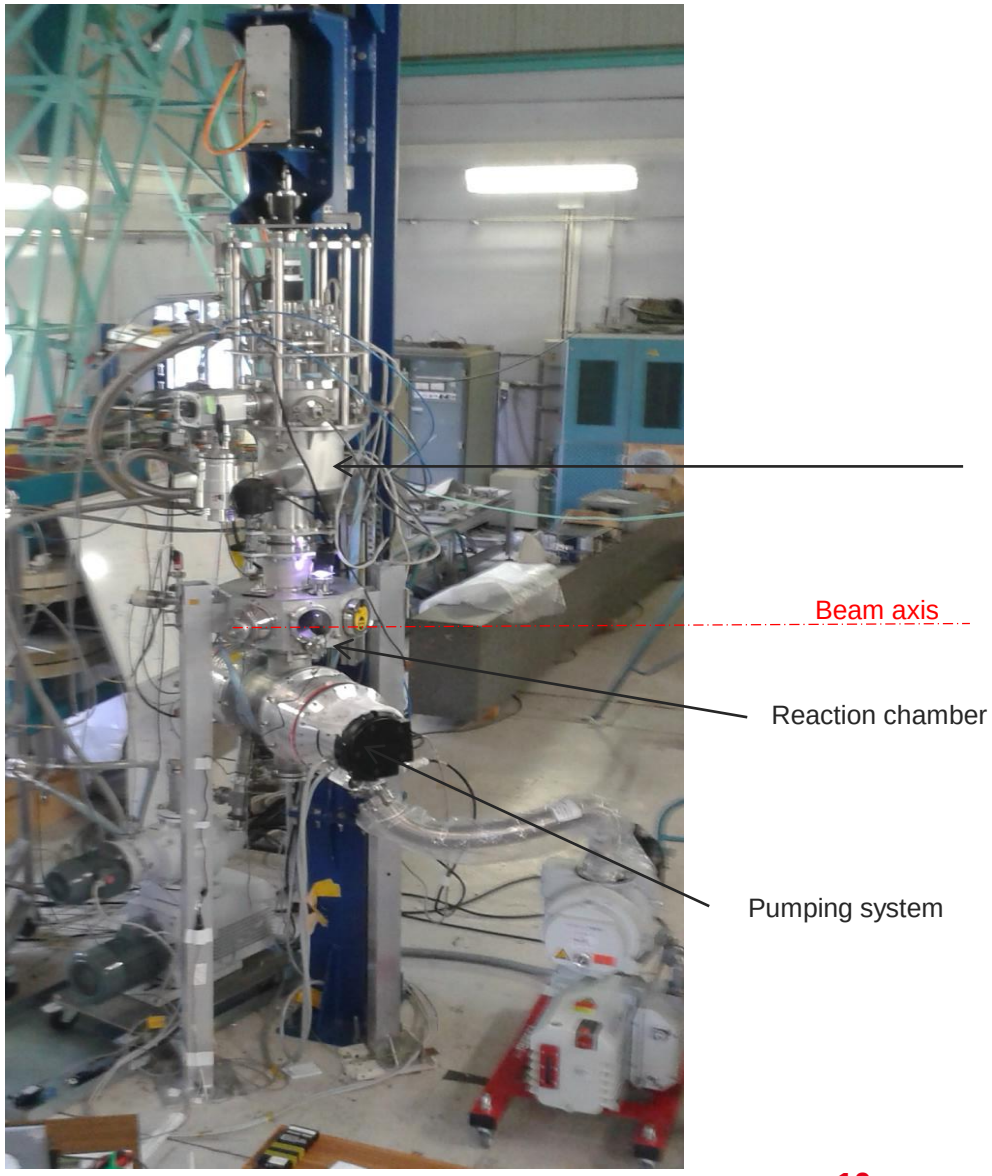
$\dot{m}$ = 4,1 x 10^{-4} g/s (ρ = 82 kg/m^3)



Equivalent leak: 5 mbar.l/s

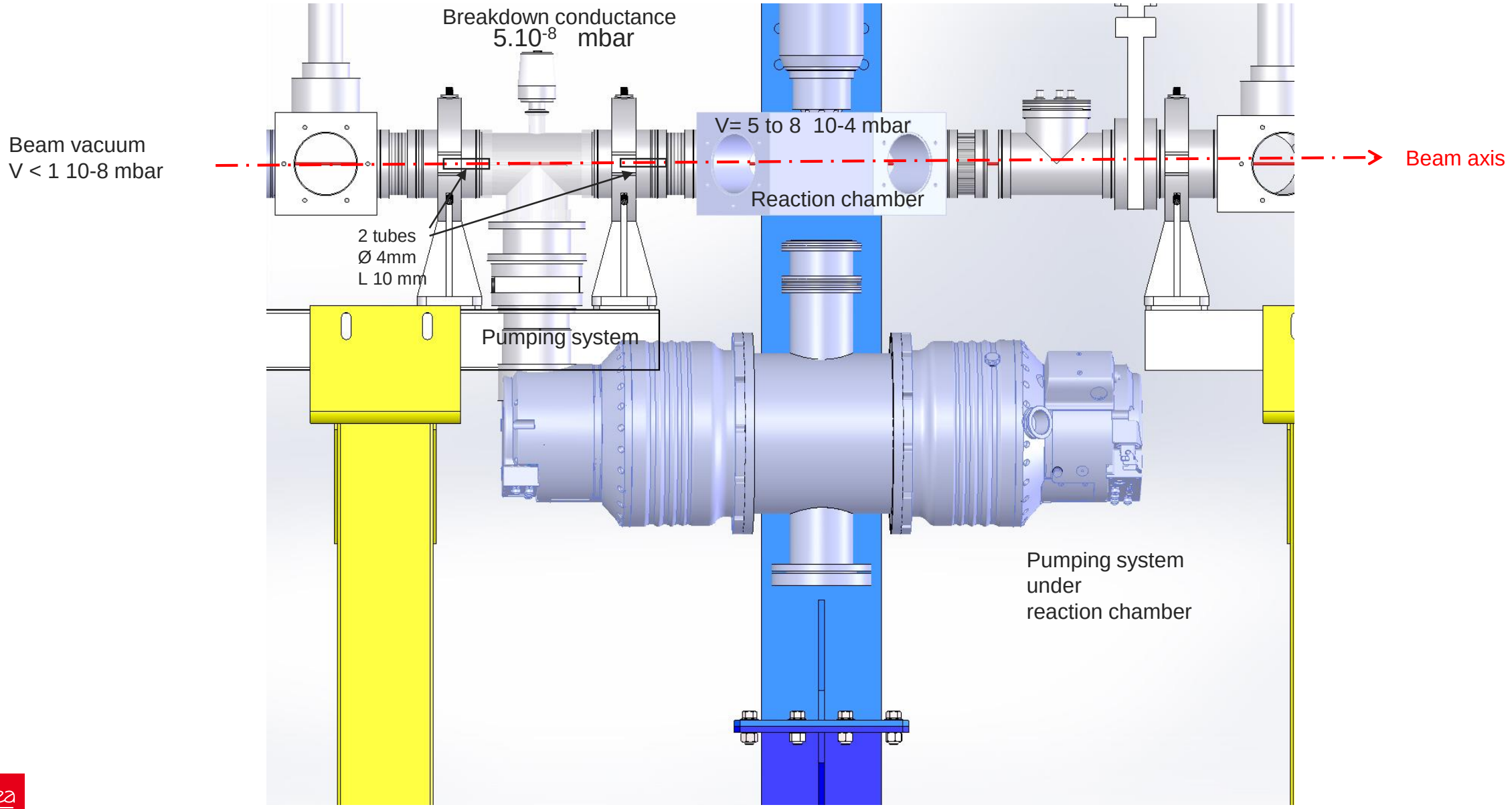
→ Need pumping
capacity:100 000 l/s

Unthinkable (not enough space and too expensive)



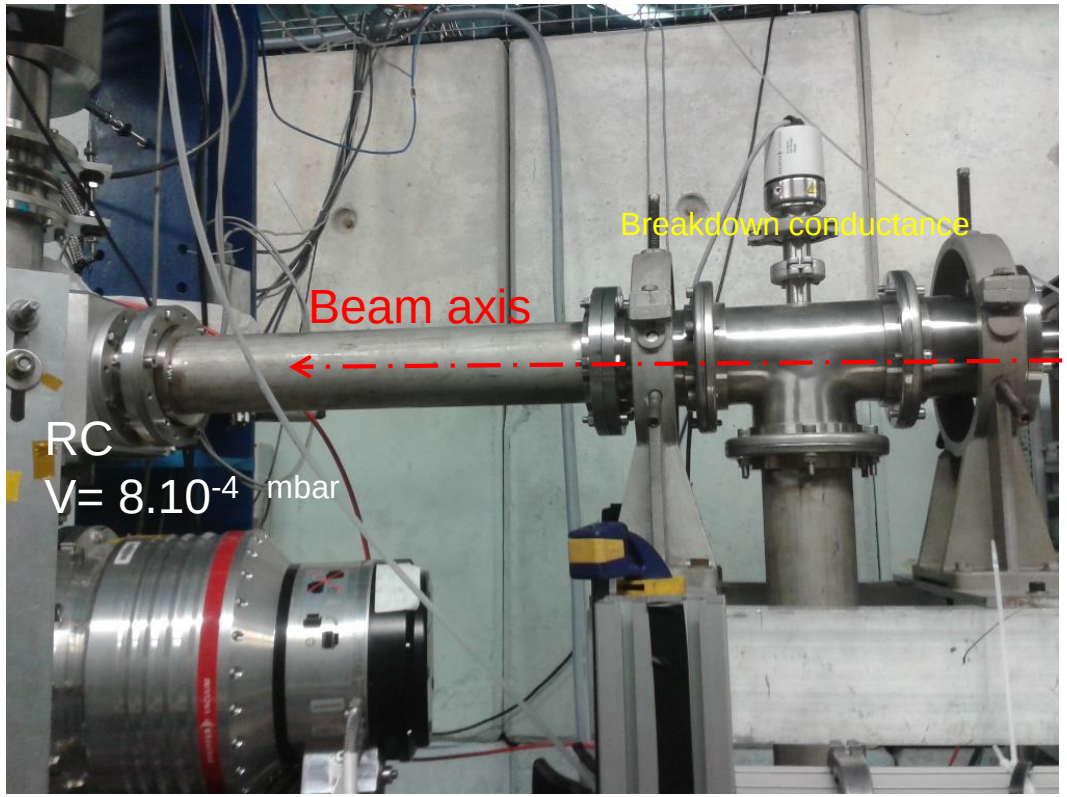
PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

❖ CHyMENE PROJECT: pumping system, contraints

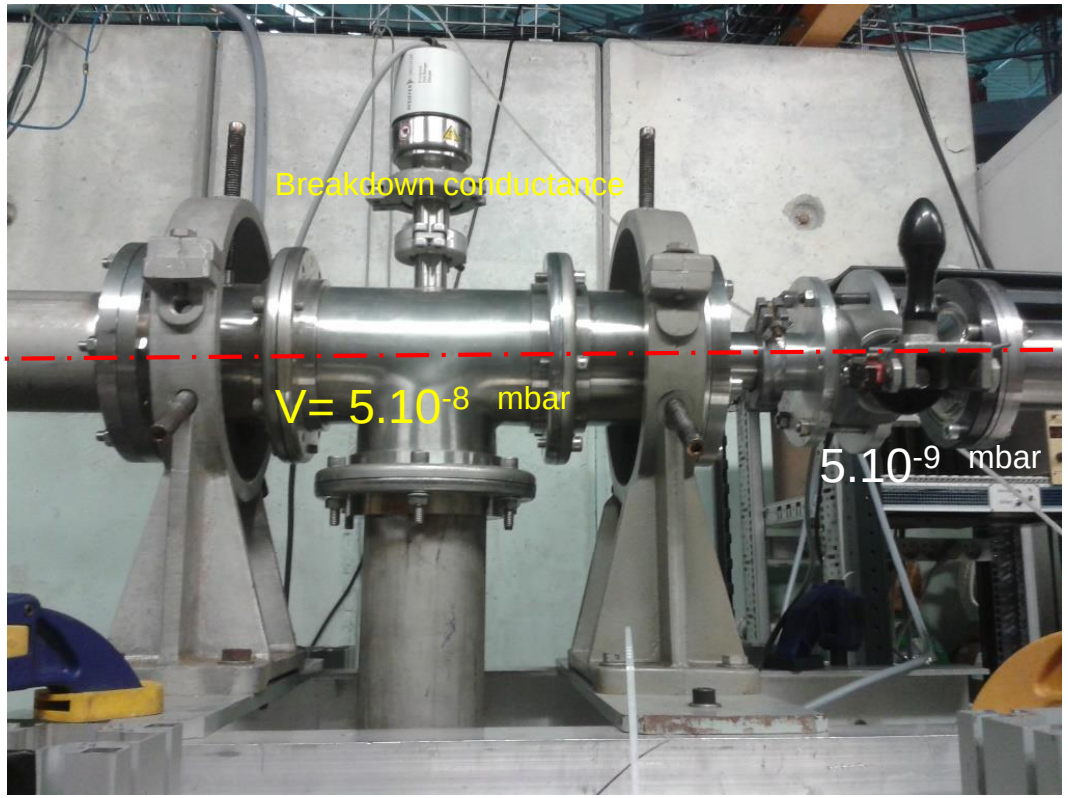


PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

❖ *CHyMENE PROJECT:* pumping system, contraints



Sprig 2019: IPNO Tandem



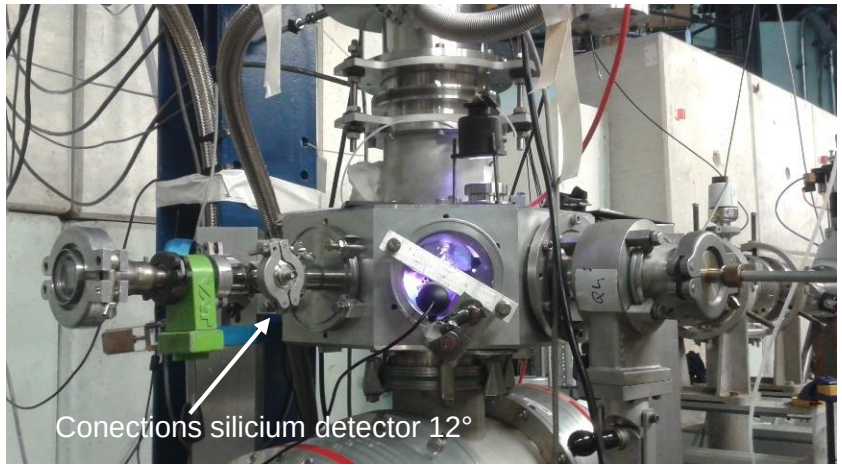
Spring 2019: IPNO Tandem

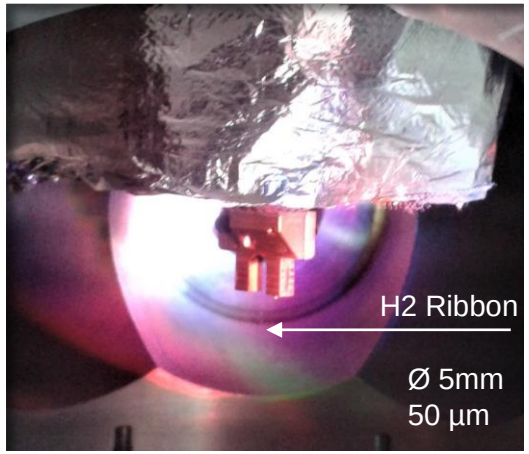
CONTRAINTS

- Beam alignment system (Room T° & Cold T°)
- Operators and experts beam

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

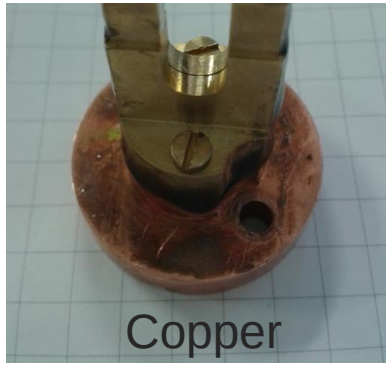
❖ CHyMENE PROJECT: IPNO Experiment Spring 2019

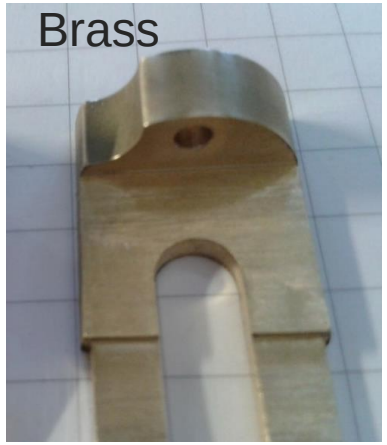


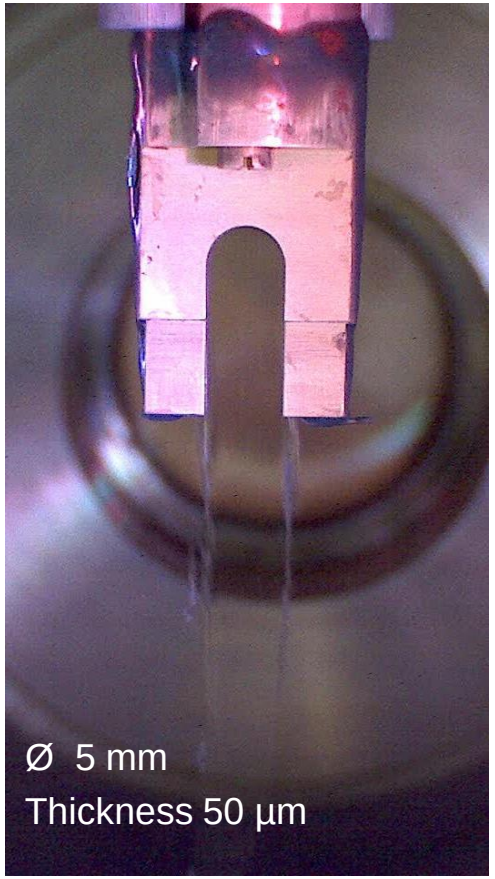


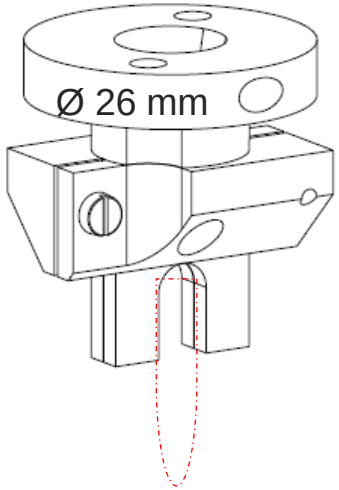
Desgin CEA: thickness 50/20 µm and less (latest generation)

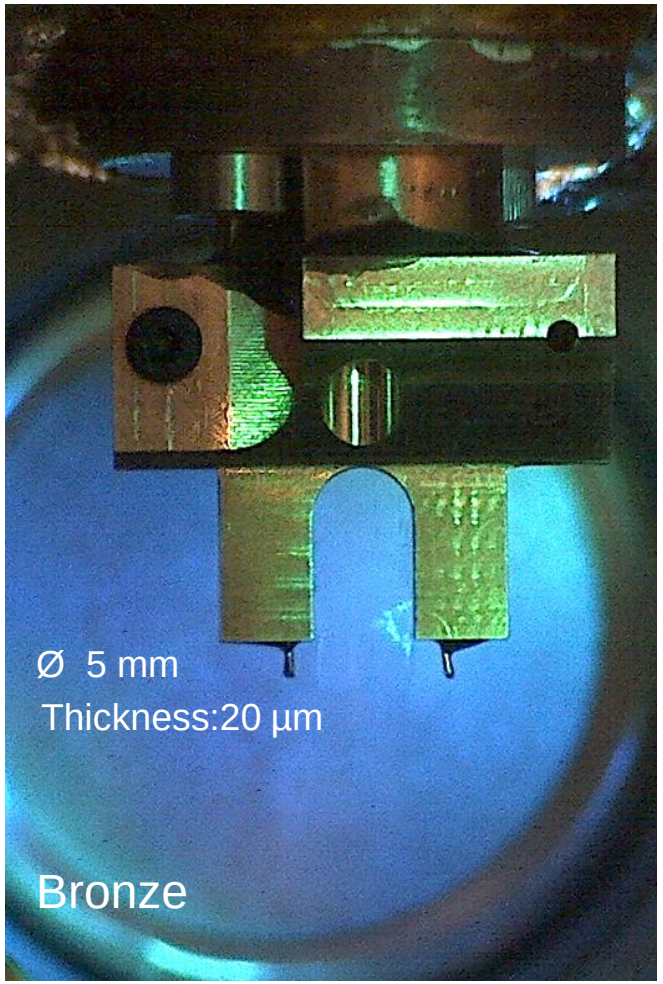
- ✓ 1 classical connection in copper
- ✓ 2 side guides for a vertical flow in brass or bronze (last version)





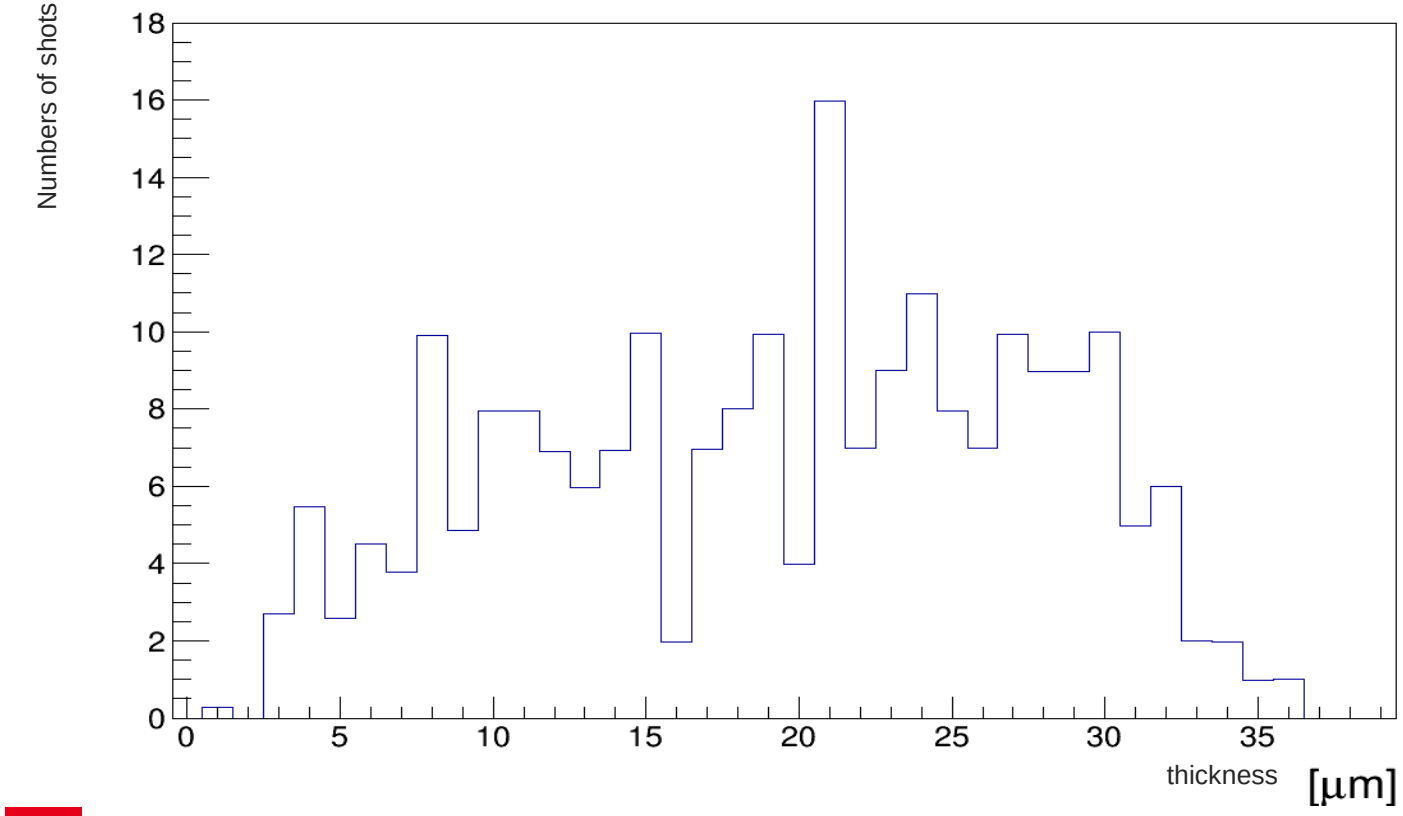


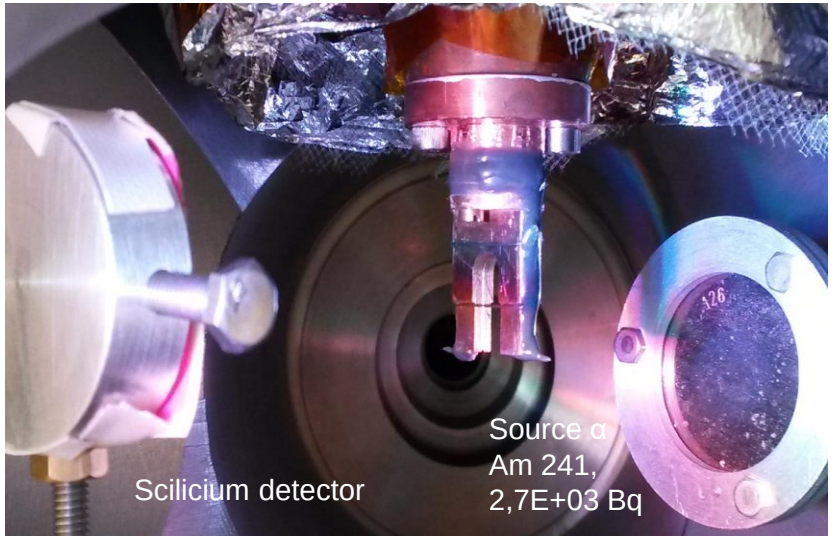


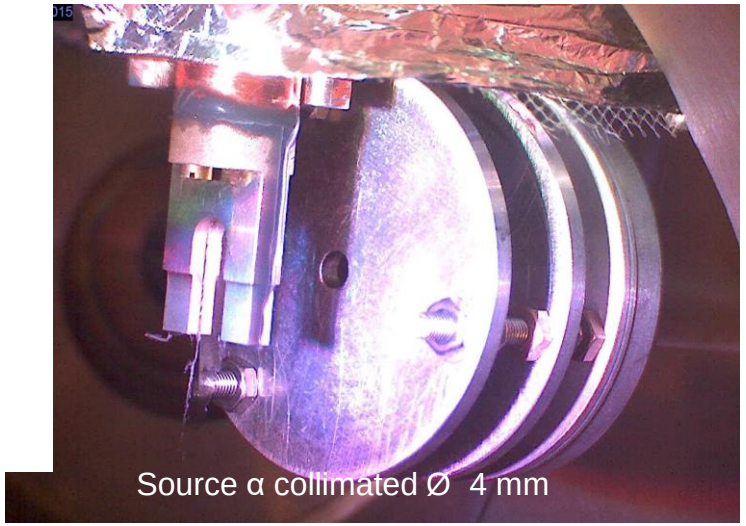


Measurement method:

Energy loss by α radiation associated with a silicon detector.







PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE PROJECT: Man Power, expertise, cost 2023

The tasks performed	2012	2013	2014	2015	2016	2019	2022	2023
Task 1 Design:	A1*: 0,8 m/y A2*: 0,5 m/y	- 1 cryogenic (A1) - 1 mechanical studies (A1) - 1 cryogenic/instrumentation/vacuum (A2)			expertise requested			
Task 2 Manufacturing		A1*: 0,8 m/y A2*: 1 m/y	- 1 cryogenic (A1) - 1 control-command/power supply studies (A1) - 1 cryogenic/instrumentation/vacuum/control-command/power supply (A2)			expertise requested		
Task 3: Tests H2 lab			A1*: 0,5 m/y A2*: 0,5 m/y	A1*: 0,5 m/y A2*: 0,25 m/y	A1*: 0,5 m/y	- 1 cryogenic (A1) - 1 cryogenic (A2)	expertise requested	
IPNO						A1*: 0,25 m/y A2*: 0,25 m/y	- 1 cryogenic (A1) - 1 cryogenic (A2)	
Deuterium					- 1 cryogenic (A1) - 1 cryogenic (A2)		A1*: 0,1 m/y A2*: 0,1 m/y	A1*: 0,2 m/y A2*: 0,4 m/y

Man power equivalent cost 2023 (Tasks 1 to 3): **430 k€**
(Taux T1 moyen DRF:ref DFP/DIR/22-047)

A1*: Engineer
A2*:Technicien

Cost equipment equivalent cost 2023: **700 k€**

- **+ reaction chamber cost**

PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

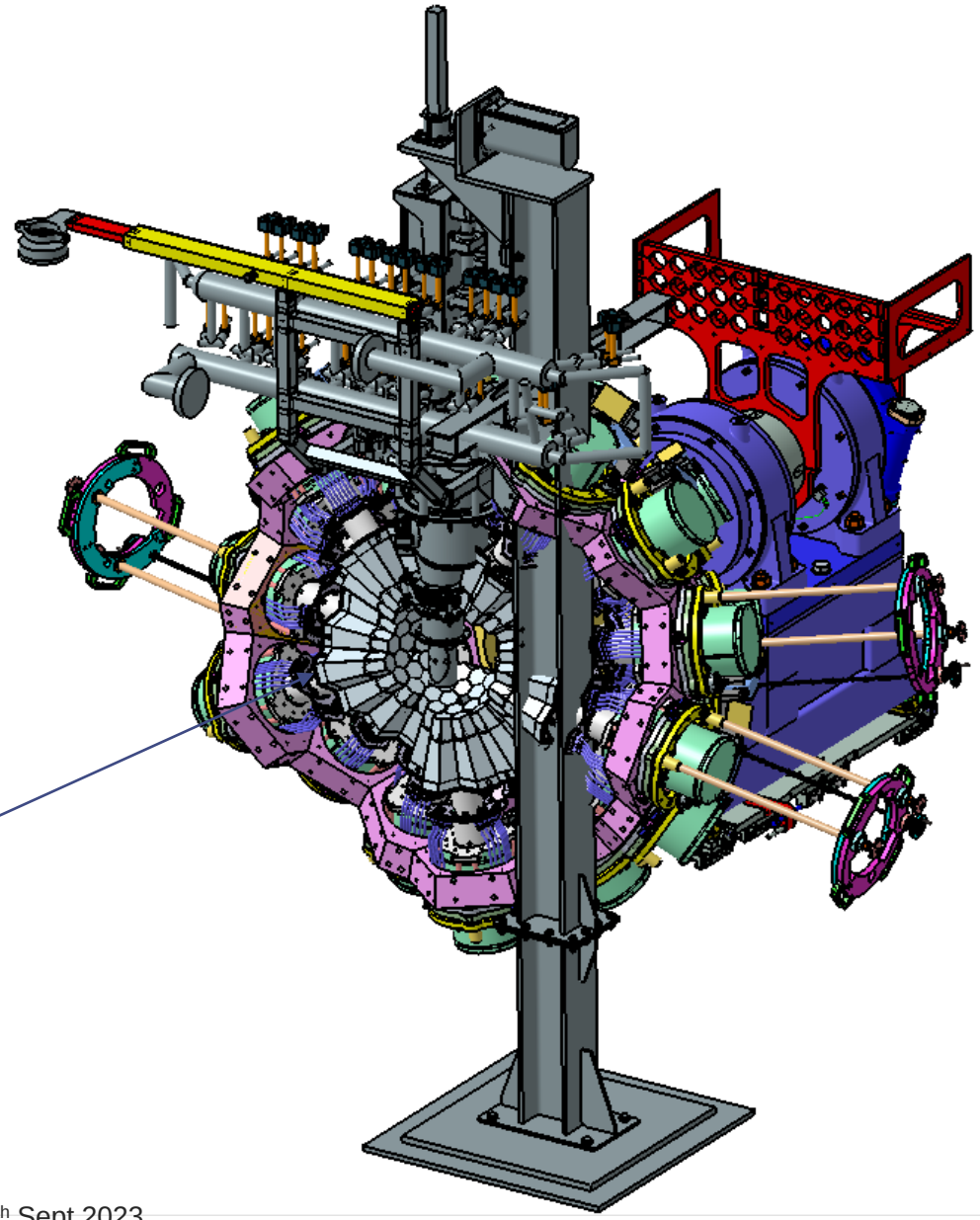
CHyMENE PROJECT:

Status

- ✓ Cryocooler validation
- ✓ Ribbon production 100 to 20 µm
- ✓ Hydrogen or deuterium target
- ✓ Vacuum 8 to 5 .10-4 mbar
- ✓ Confirmation of correct operation on beam
- ✓ System in standby mode

Future prospect

- ➢ Nozzle to study (4 G)
- ➢ Lower thickness
- ➢ Collaboration (Legnaro?) with Agata detector



PURE HYDROGEN TARGET DEVELOPMENTS AT CEA/IRFU

CHyMENE Project :
First production January 2014 at Saclay

G. Authelet, J. Brisset, R. Baudouin, C. Commeaux, P. Contrepois, A. Corsi, J-M. Gheller, A. Gillibert, P. Graffin, J-M. Joubert, E.C. Pollacco, A. Lukin, J. Relland, A. Roger, O. Roig, M. Sénoville, I. Vinyar,