DE LA RECHERCHE À L'INDUSTRIE

cea

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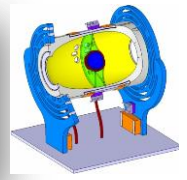
THE MEGAJOULE LASER: TARGET FABRICATIONS

CRYOGENIC TARGET DEVELOPMENT

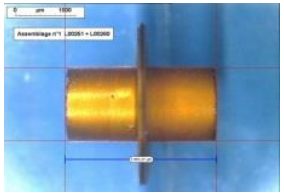
CEA-DAM, VALDUC (+ LE RIPAULT / R&D Materials)

CEA- DRF-INAC-SBT

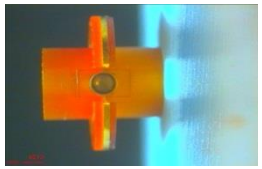
Target fabrication for all CEA – DAM experiments



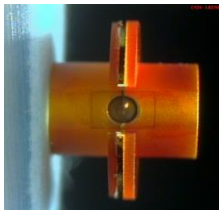
LMJ progressive power increase program



(Empty hohlraum)



(Foam ball – empty hohlraum)



(Plastic shell with gas in empty hohlraum)

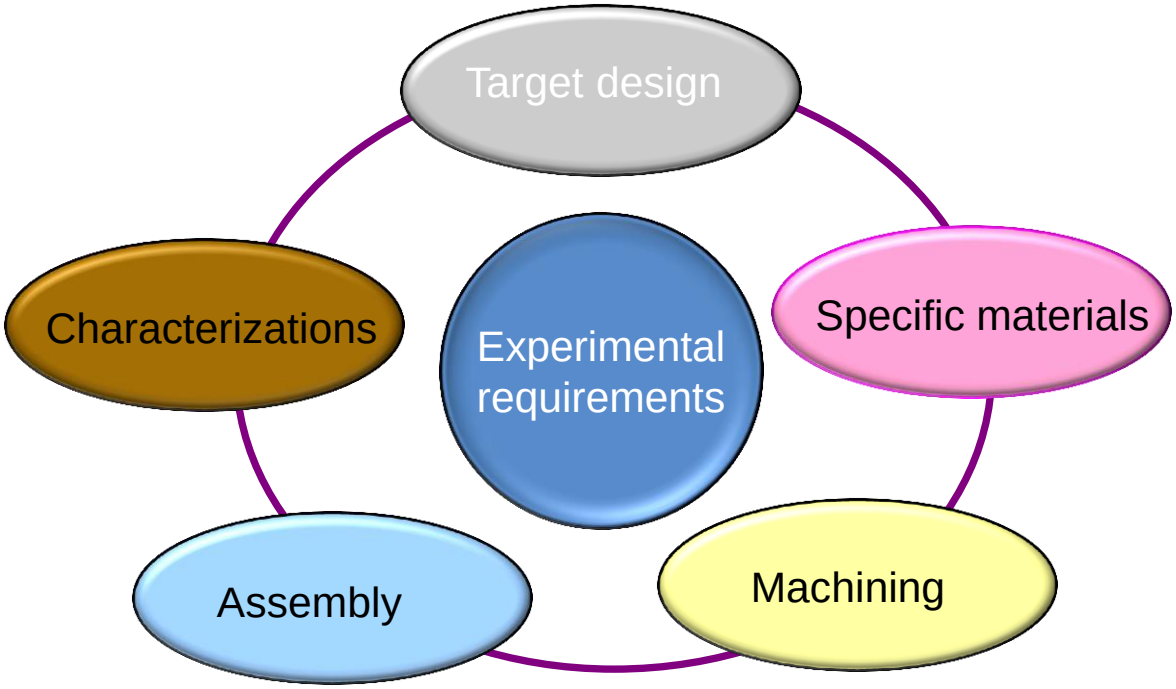
(Plastic shell with gas in hohlraum with gas)

Ignition targets will be experimented later.

Centimetric to millimetric sizes
Micrometric tolerances
Nanometric characterizations

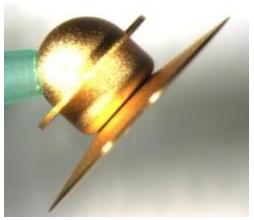
Mainly focused on HED physics targets.

Target fabrication tool

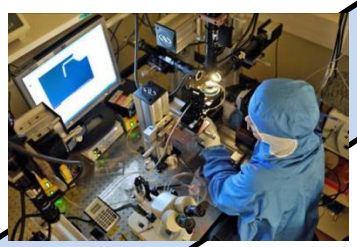


Target design

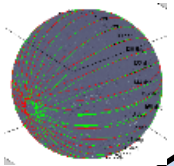
The final target



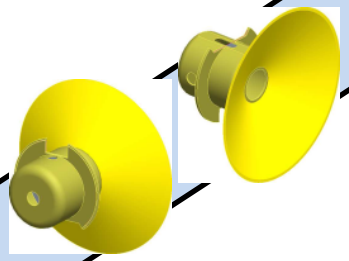
Assembly



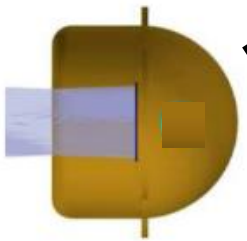
Characterizations



The CAD



The concept



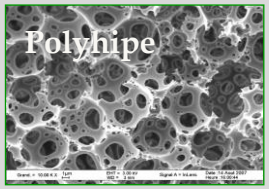
Centimetric to millimetric sizes
Micrometric tolerances
Nanometric characterizations

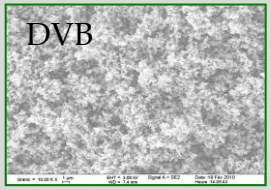
The target design is particularly important:
- To define the feasibility
- To determine the materials
- To estimate the tolerances
- To prepare and optimize the assembly synoptic

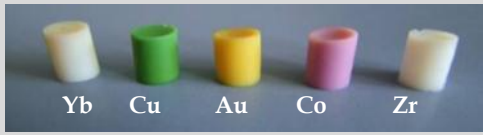
Specific Materials

Foams & Aerogels

Organic foams and aerogels

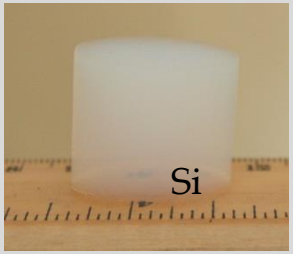




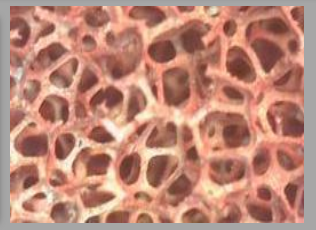


Inorganic aerogels

Silica based aerogel
Tantalum based aerogel

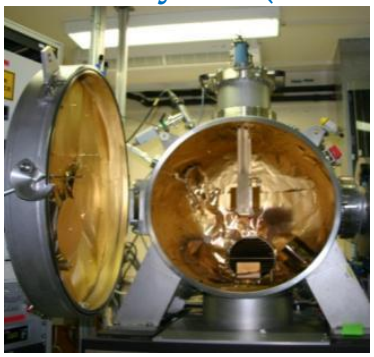


Metal foams (Cu, Au, Pt)



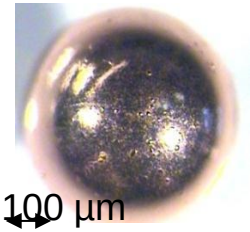
Metals

Thin layers (PVD coatings)



(Au, Cu, Ta, Ti, Zn, Al, SiO2…)

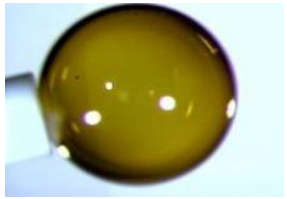
Metallic capsules (PVD + galvanometry)



Copper capsule

GDP

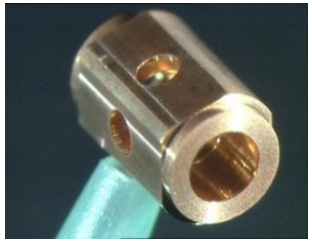
PAMS mandrels



Machining

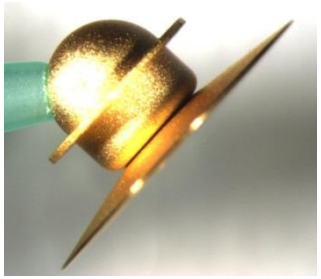
Ultra-Precision

Monobloc “multi” hohlraums and multipart gold holhraums

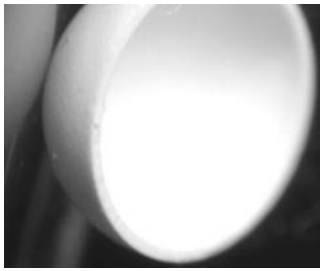


Cylindrical holhraums

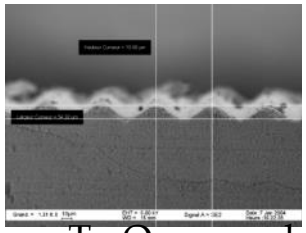
Gold / polymer holhraum



Foams & aerogels

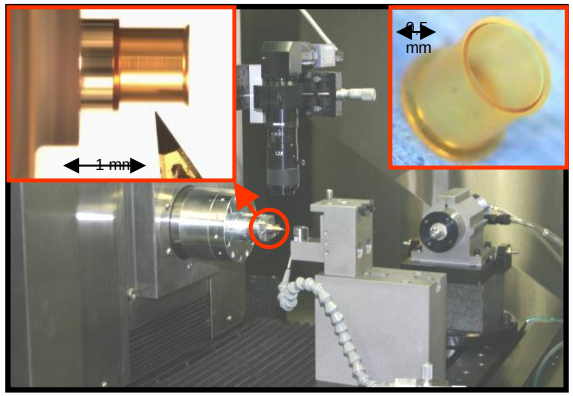


Foam hemisphere



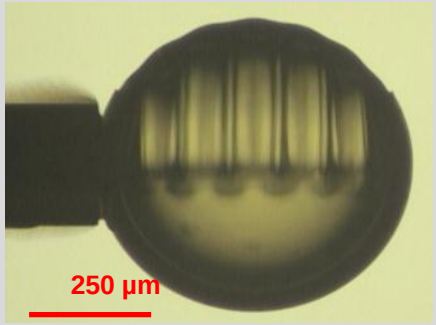
Ta_2O_5 aerogel
Modulation in aerogel

Plastics



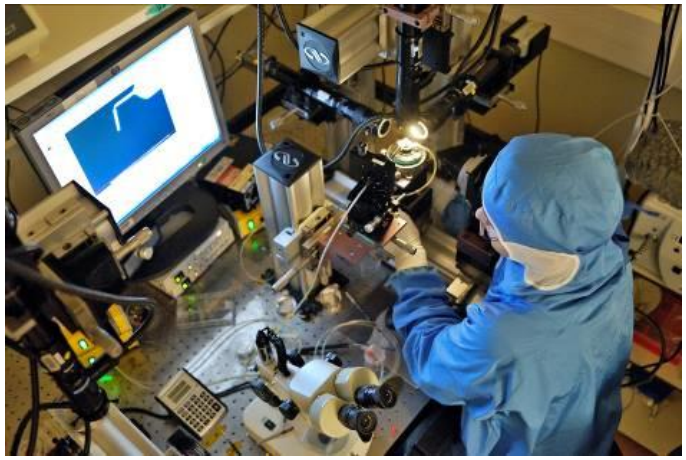
Laser

Femtosecond laser Ti:Sa
(120 fs – 1 KHz)

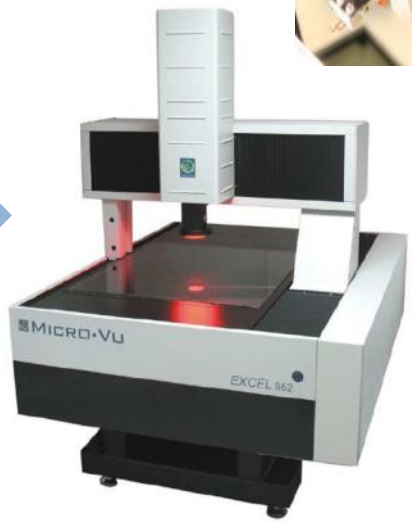


Assembly

Piezo-gripper

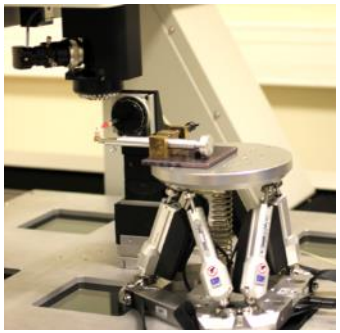


Totally manual assembly



3D characterization machine

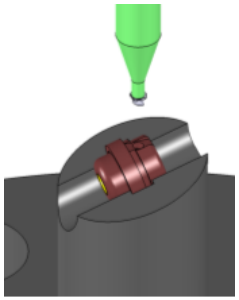
Automated hexapod & strength gauge



& specialized A-team

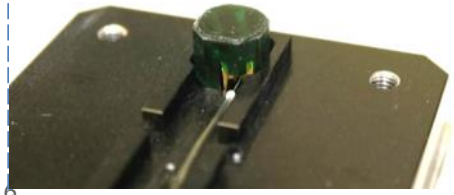
Additive manufacturing

Holders and vacuum systems



Small assembly tools

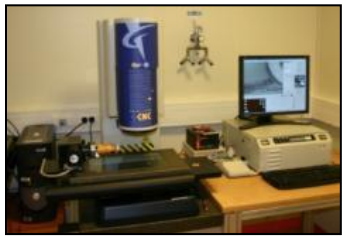
Transportation box



Characterization

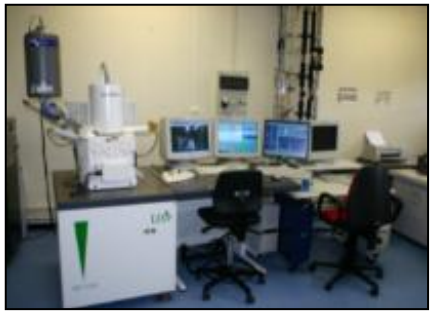
For one target, many characterizations are needed.

Smartscope (3D optical sensor)



Telecentric Microscopy

SEM



Holographic Microscopy

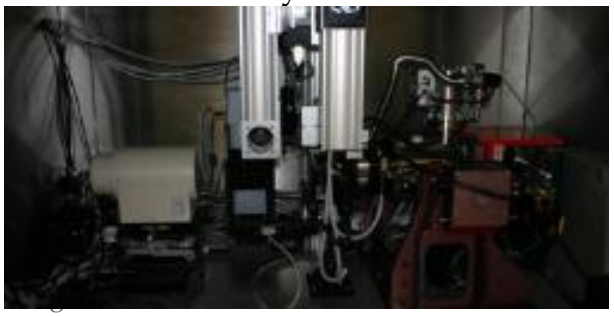
X-ray tomography

Confocal microscope

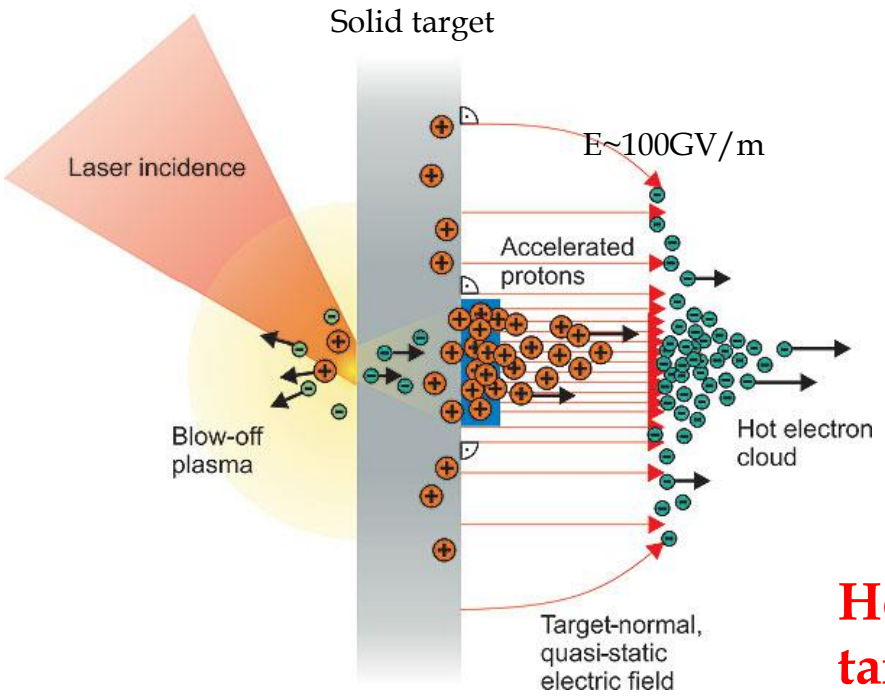
AFM

Precision balance

Numerical X-rays sensor



Context: LASER/PLASMA ACCELERATION

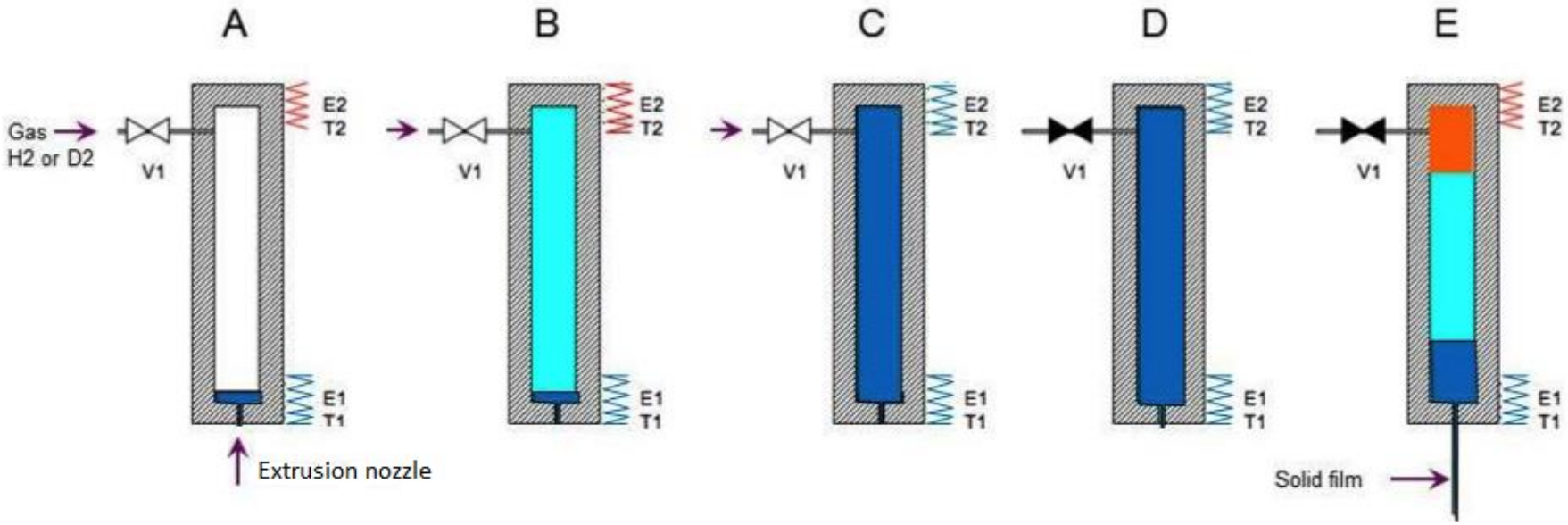


Very thin solid Hydrogen target should be interresting to produce protons beams of high energy.

But,

How to produce pure solid Hydrogen target?

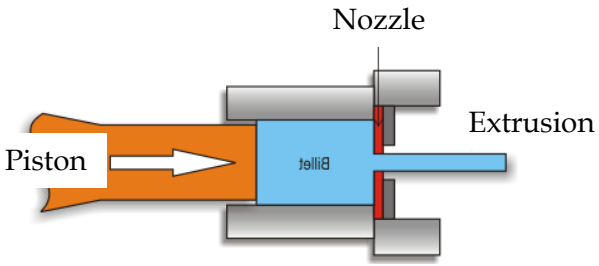
Extrusion: our concept

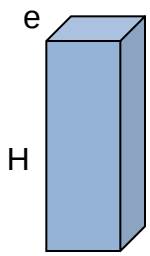


- Without mobile part
- Use of thermodynamic properties of the fluid
- Patented by CEA-SBT « EP 2 682 695 A1 »

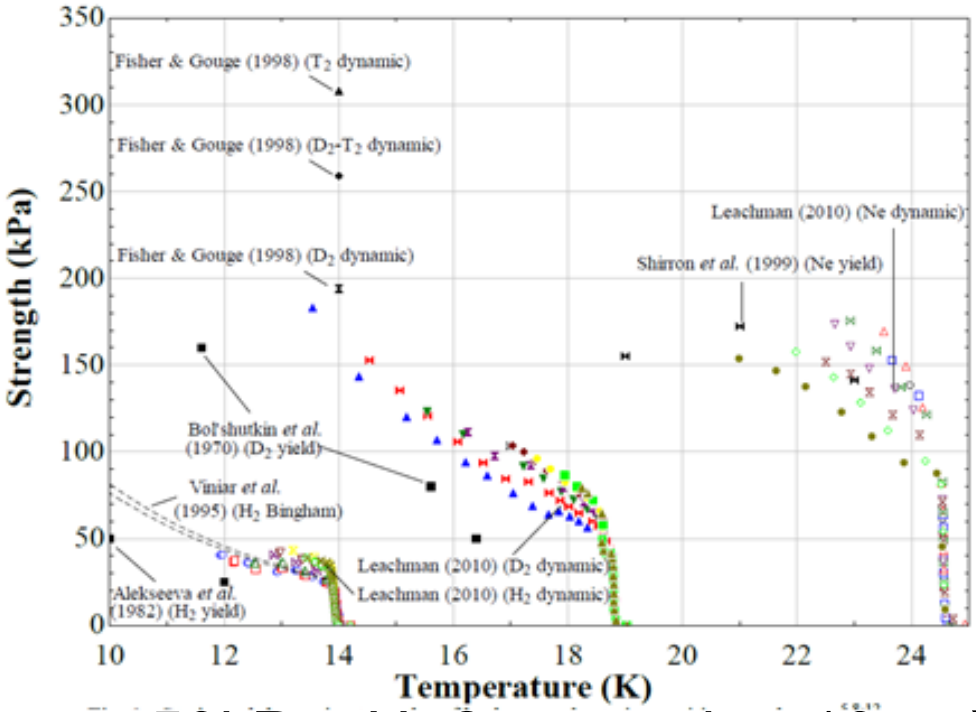
Extrusion

Thermomechanical process where a compressed material is forced to cross a nozzle having the section of the piece to be obtained.





High pressures are required to overcome the shear strength



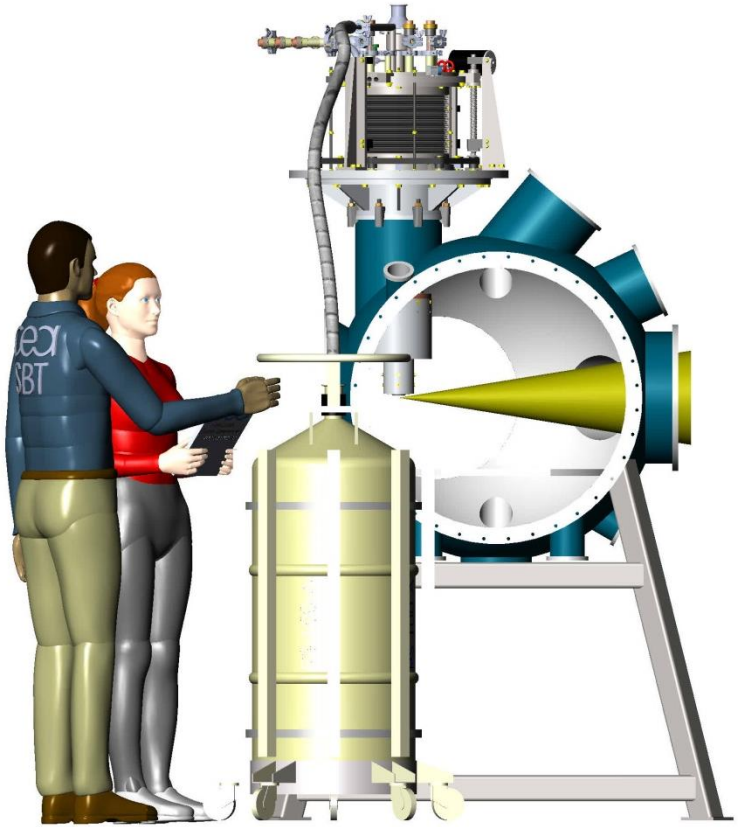
P=2*σ*H/e (200bars for σ=50kPa, H=2mm and e=10µm)

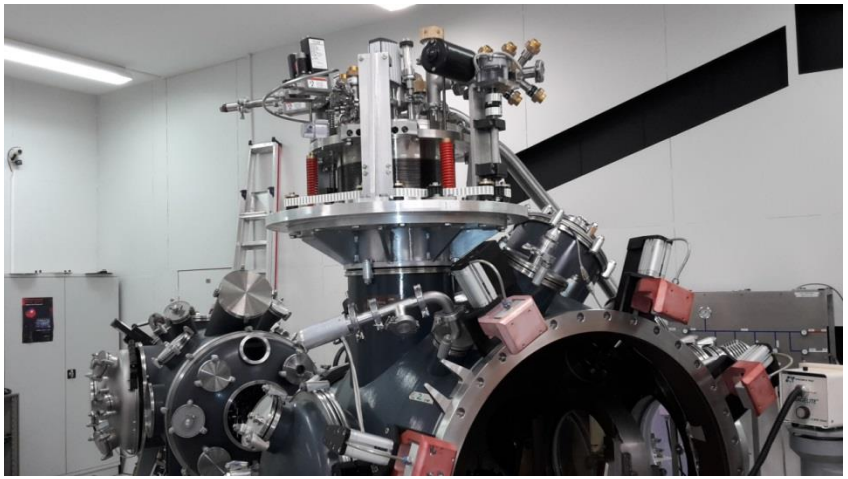
Fabrication of the first prototype

PHD (LANEF)
Stéphane Garcia

Cryostat Elise

(**E**xperiment on **L**aser **I**nteraction with **S**olid hydrog**E**n targets)

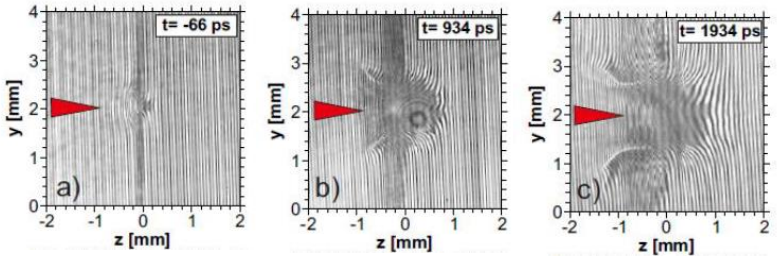




- A cryostat « *laser-compatible* »

Experimentation on PALS

1kJ – 330ps – 3TW (dec 2015)



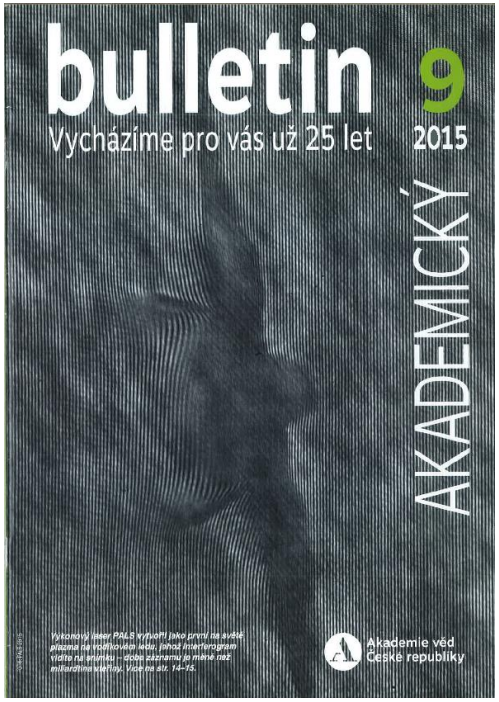
30 tirs à 600J. Protons à ~5MeV
$n=5.10^{16}$ protons et 3.10^{19} cm^{-3}

PALS News

For the first time ever: Protons accelerated in the plasma produced from hydrogen ice by a laser

High-energy protons find application in medicine for irradiation of tumors as well as in many other science and technology fields (such as proton radiography). Very efficient acceleration of protons occurs in the hot plasma produced by a high-power laser beam focused on a target containing hydrogen. The thicker the target and the more hydrogen in it, the more accelerated protons. The ideal would be to have a laser target of pure hydrogen frozen into a solid state at temperatures as low as -261°C.

"Combining the ultra-cold and the ultra-hot for laser-plasma proton acceleration"
D. Margarone et al.
physical review x

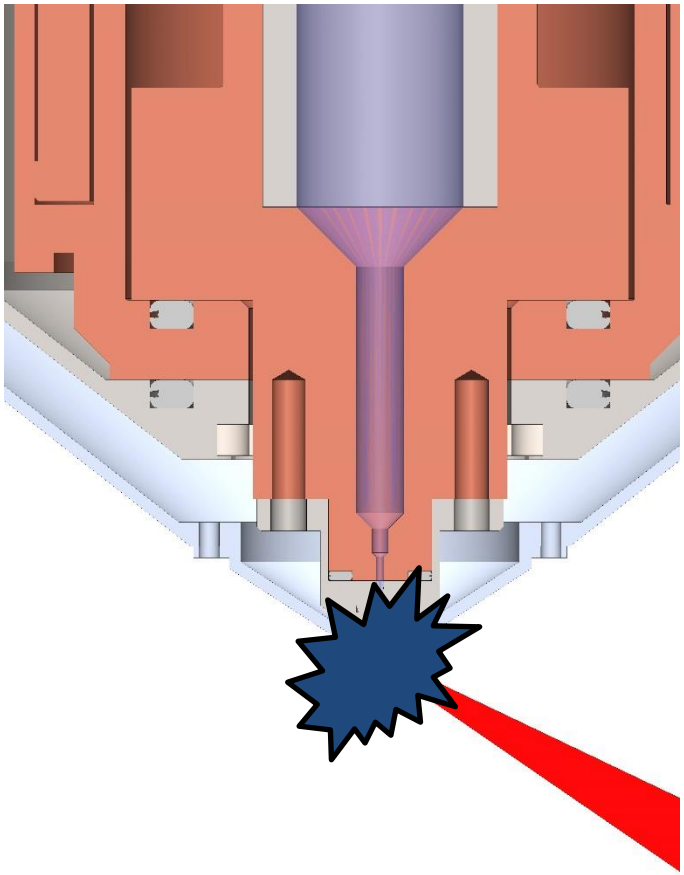


Expérimentation on ELFIE

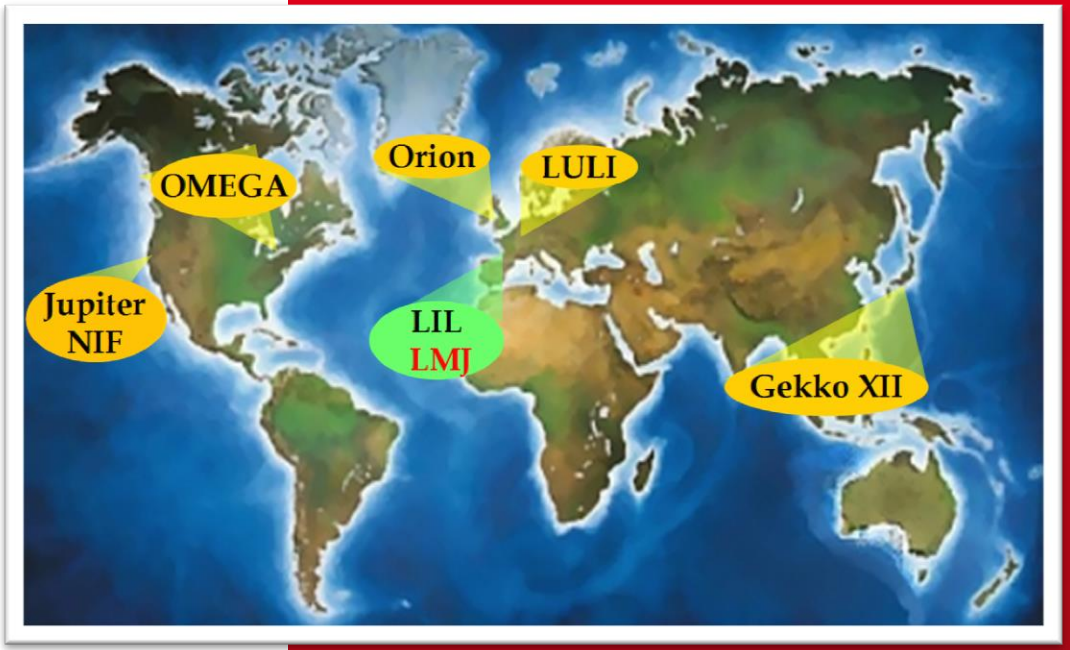
20J – 200fs – 100TW (Fev 2016)

40 tirs . Protons ~ 15MeV

The Emptying of the Cell after a Shot



The heat generated by the hot plasma makes the temperature of the cell increase and this causes the emptying of the cell.
DATA are required to design a nozzle for high frequency shot



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Direction des applications militaires
Direction des armes nucléaires