Iphi

Irfu

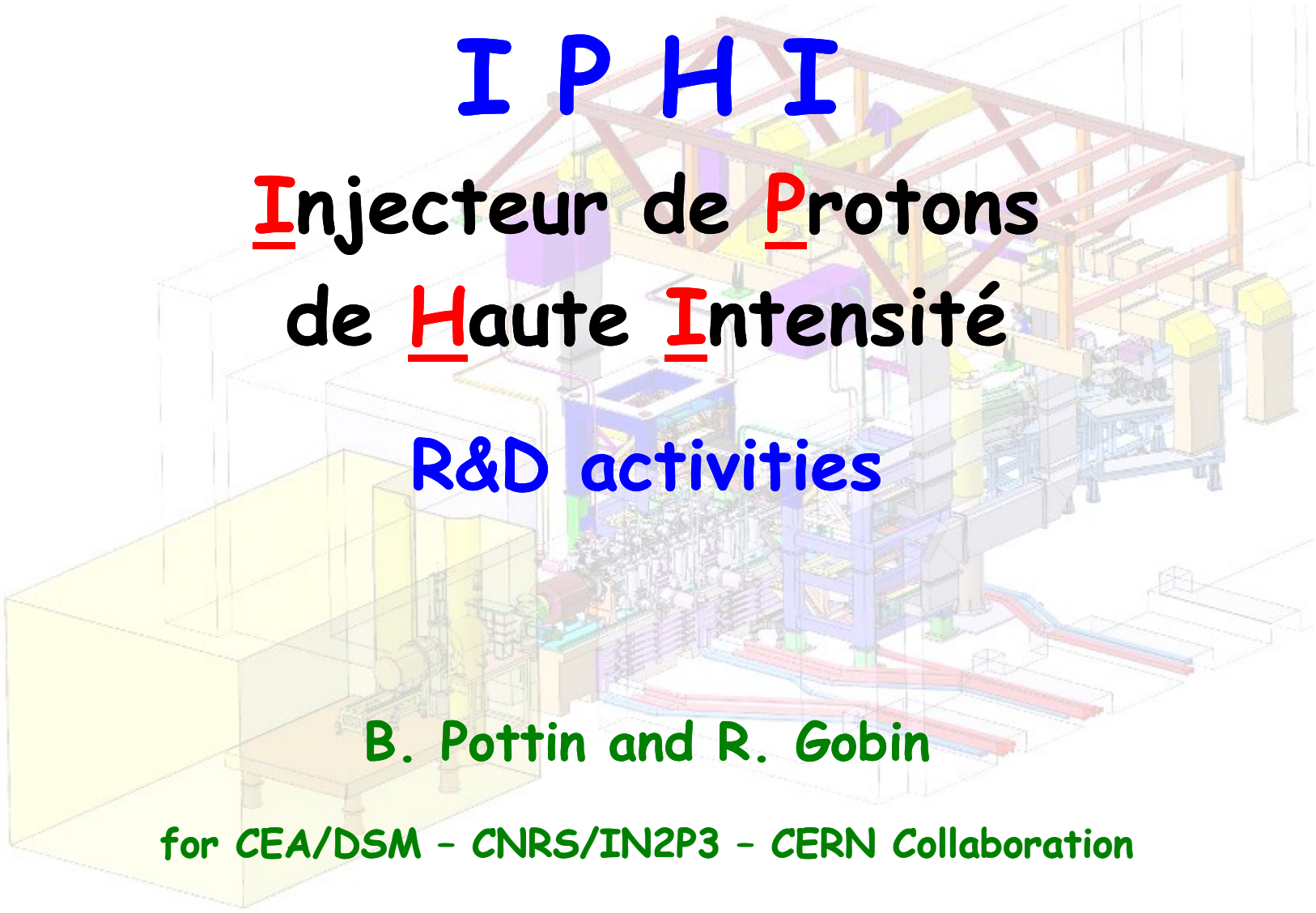
cea

saclay

I P H I

Injecteur de Protons de Haute Intensité

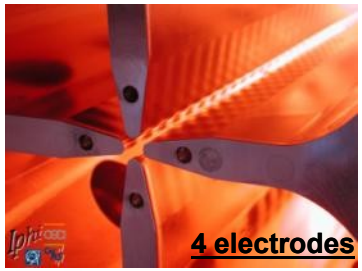
R&D activities



B. Pottin and R. Gobin

for CEA/DSM – CNRS/IN2P3 – CERN Collaboration

IPHI: low energy HPPA demonstrator



RFQ
100mA/3MeV/352MHz

Diagnostic Line
100mA/3MeV/CW

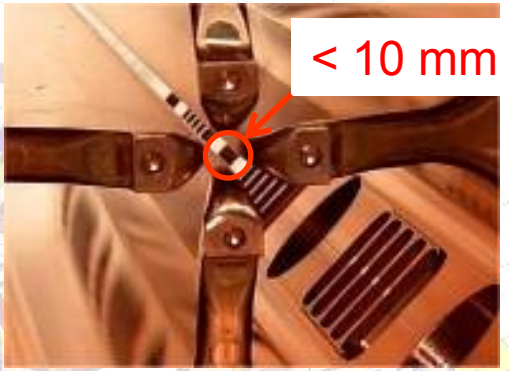
SILHI source
100mA/95keV/CW

Developments and construction started at the end of 90's.

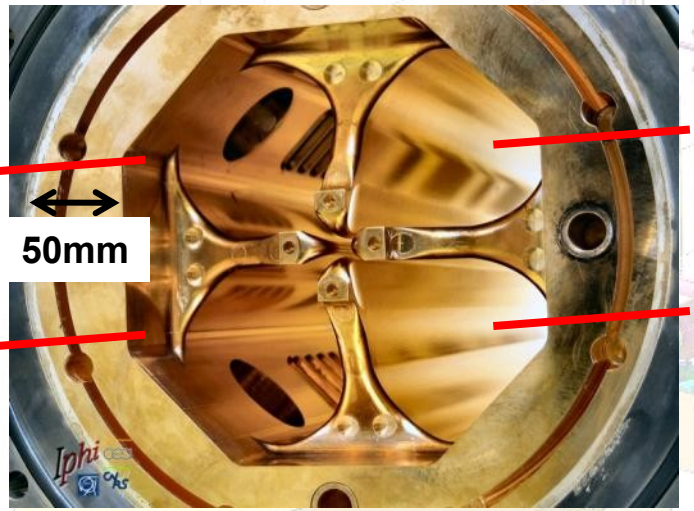
RFQ module construction

6 m long RFQ made of 6 modules…
Each module is built in 4 parts corresponding to 4 electrodes
with very tight tolerances : few microns/1m.

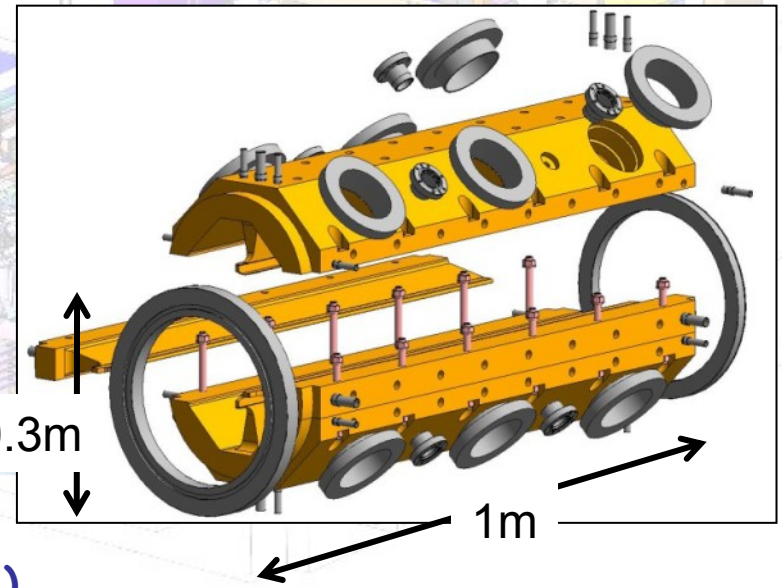
→ machining and alignment are very important.



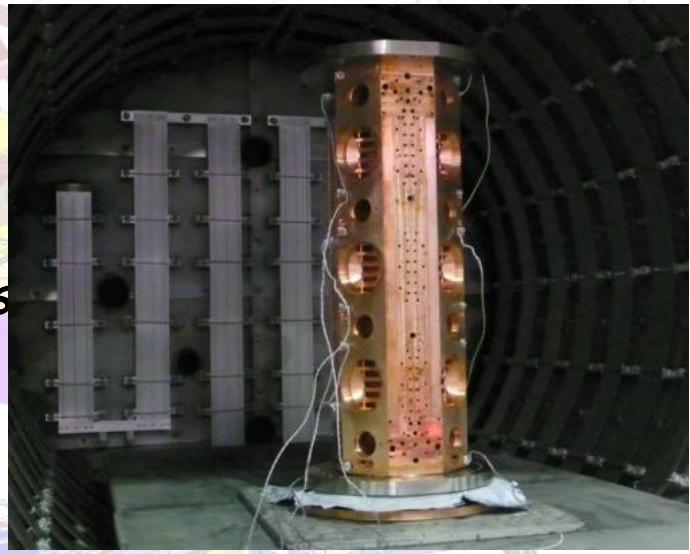
ASSEMBLY by BRAZING



surface of the brazing plans
(cleanliness, flatness, roughness…)
is critical.



RFQ assembly challenges

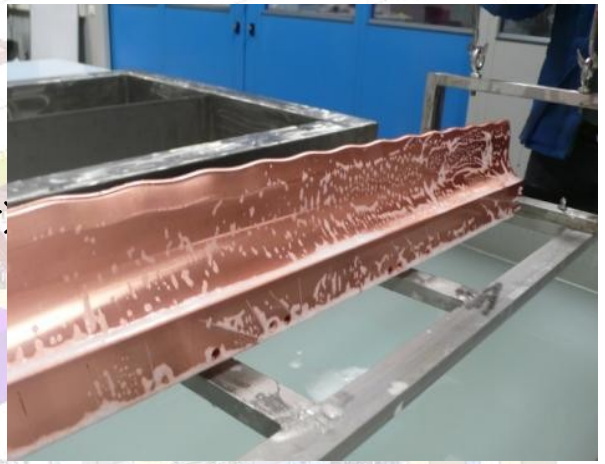


- **Vacuum challenge**
  - *P = 10^{-7} mbar*
  - *No leak with 268 cooling pipes*
  - *Numerous ports (60 pumping ports 4 RF ports, 96 tuners)*
  - *75 crossings through the brazing plan for each module (cooling pipes)*
- **No pollution**
  - *brazing surface*
- **Deformation of geometry after brazing <10µm** with elongation of about 16mm @ 800°C during the brazing process (brazing material is AgCuPd)

  → **Thermal treatments before final machining**

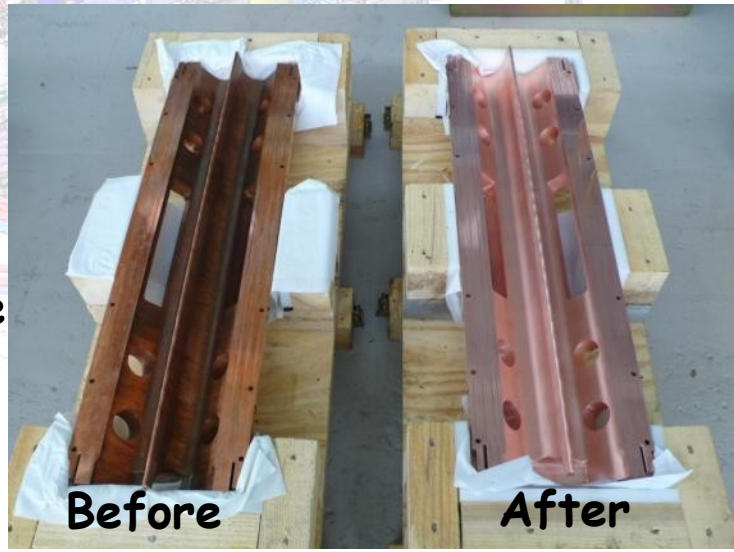
Brazing preparation

- **Creation of a cleaning laboratory**
  - To test different chemical solutions
  - To test different cleaning procedures with:
    - Ultrasonic bath (warming or not)
    - Rinsing method with demineralized water (warming or not)



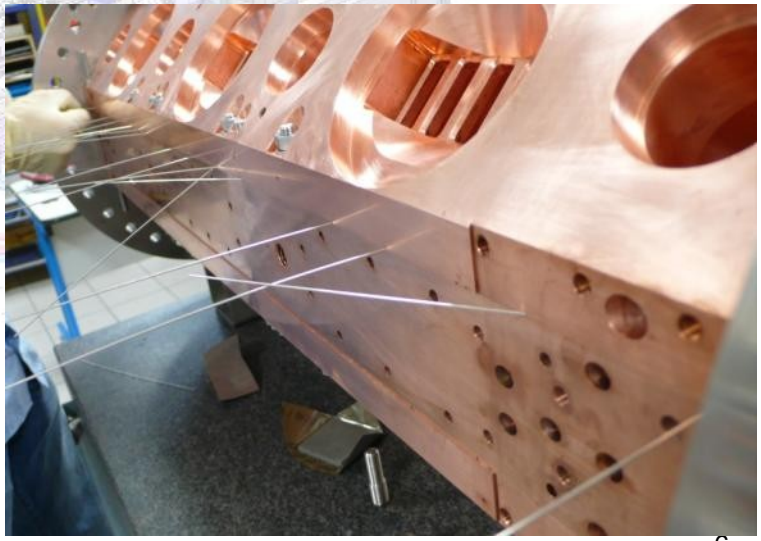
- **Cleaning of several materials:**
  - Copper, stainless steel, molybdenum…

- **Storage with N_2 saturated atmosphere**
- **Cleanliness of the surfaces to avoid oven pollution**



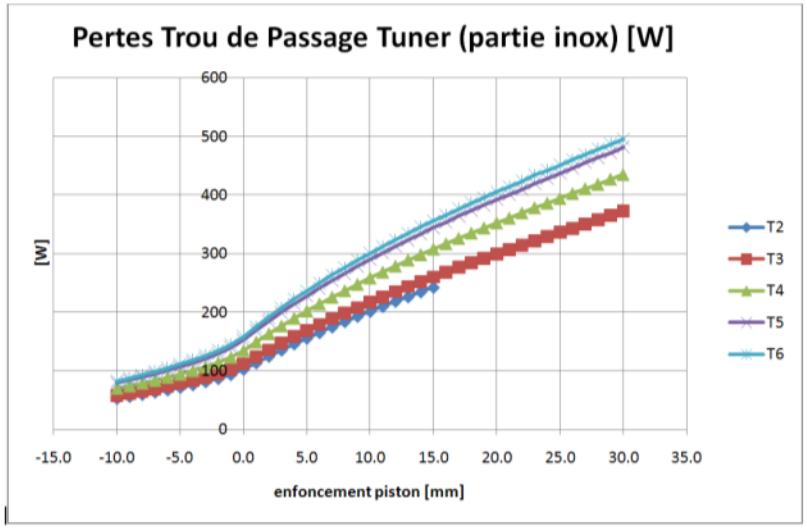
Horizontal or vertical brazing

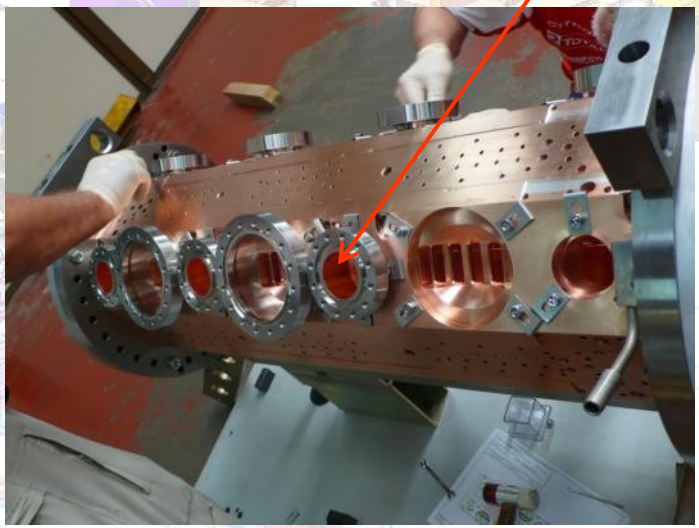
- **Brazing groove design depends on module brazing position:**
  - Longitudinally for horizontal brazing
  - Fish bones shape (with external access) for vertical position
- **R&D activities allowed us obtaining better results with the vertical brazing solution :**
- **- less deformations**
- **- possibility to repair with a second brazing** (fish bones grooves are empty after the brazing)
- **For both cases, specific local grooves for the extremities and cooling pipes**



R&D in layer deposition

- The RF adjustments are done by modifying the volume inside the cavity by tuners → RF feeding leads to cavity thermal heating.
- To help cooling of the tuner flanges, copper layer deposition is needed.

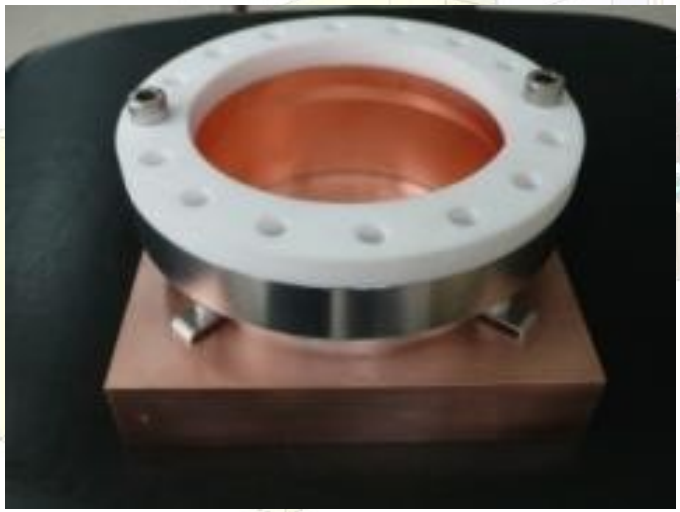


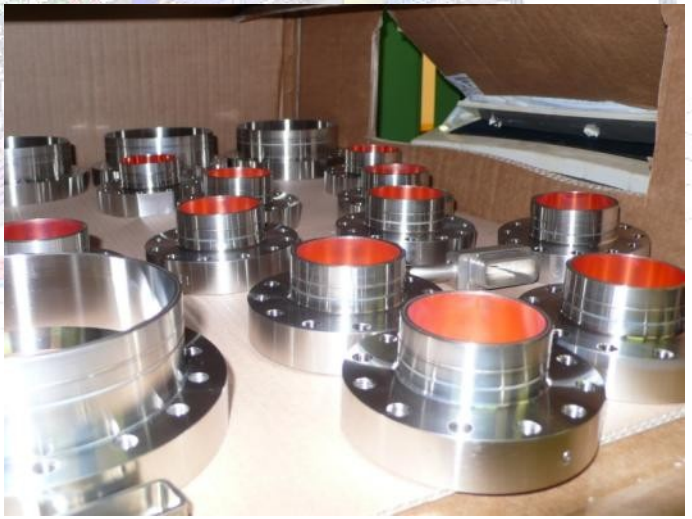


R&D in layer deposition

- material deposition needed for:
  - 2µm thick Nickel (brazing stainless steel with copper)
  - 25µm thick Copper (thermal transfer)

- Developments (with external company) of new tools and process to get reproducible thickness



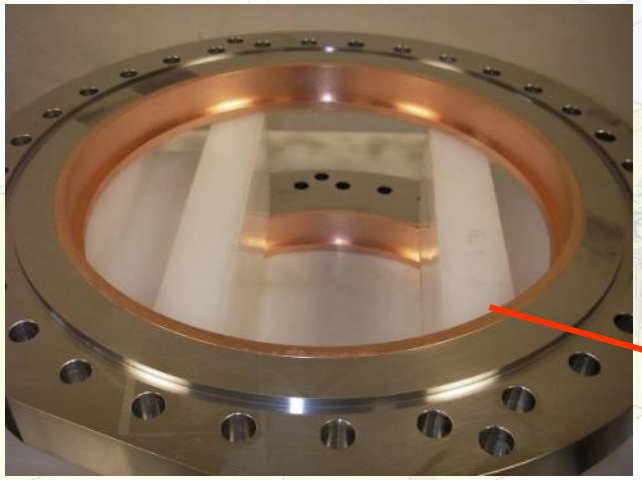


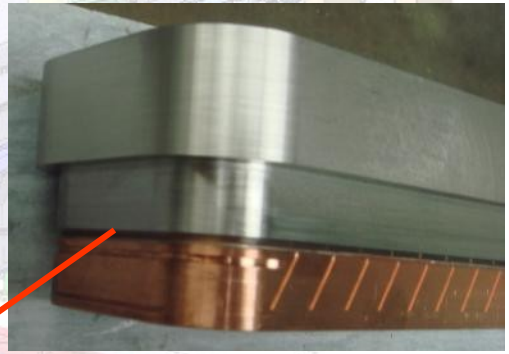
R&D on bi-material pieces

WHY ?

- a vacuum leak appeared between stainless steel flange and copper of the module after 2nd brazing of module 6
  - Looks to be caused by the fragility of the nickel layer
- decision to use bi-material pieces with high temperature brazing (AuNi) between stainless steel and copper without nickel

  → followed by classical brazing copper-copper

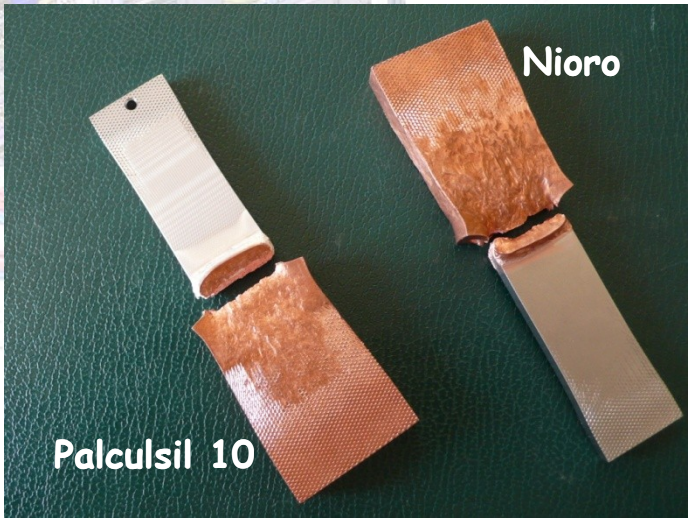




R&D : brazing for different assembly

- Face to the cost of AuNi brazing technique, general R&D program is in progress to qualify the mechanical resistance of different material assemblies after brazing.
- The aim is to be able to decide wich brazing material is appropriate versus the mechanical application.
- The following brazing materials are under test:

  - *Cusil : 72%Ag + 25%Cu – 780°C*
  - *Palcusil 10 : 58%Ag + 32%Cu + 10%Pd – 852°C*
  - *Nioro : 82%Au + 18%Ni – 955°C*
  - *50Gold50Copper : 50%Au + 50%Cu – 970°C*
  - *35Gold65Copper : 35%Au + 65%Cu – 1010°C*

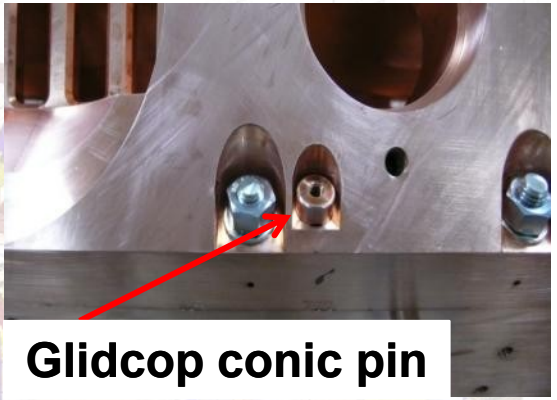


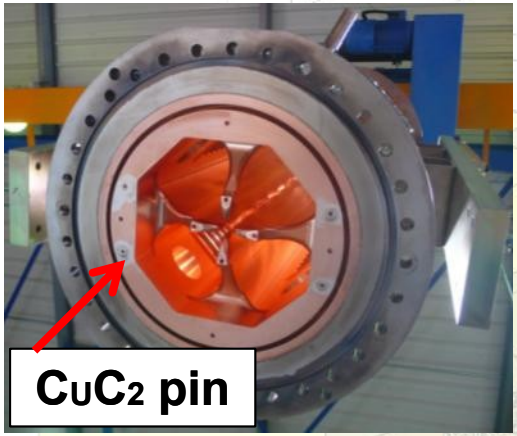
Brazing with no displacement…

To prevent possible displacements:

- Longitudinal displacement :

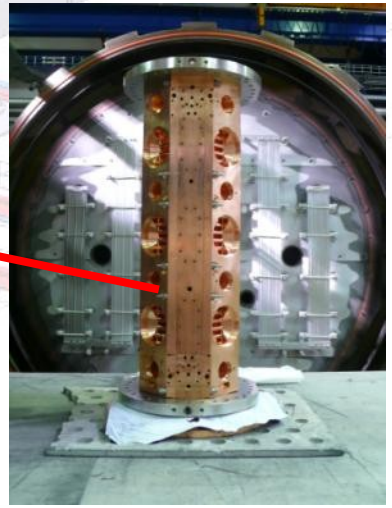
  a glidcop conical pin (same expansion than copper) to help the mechanical assembly and to keep mechanical resistance during the brazing





- Transversal displacement :

copper pin brazed to get correct expansion and minimize leak risks in the brazing plan



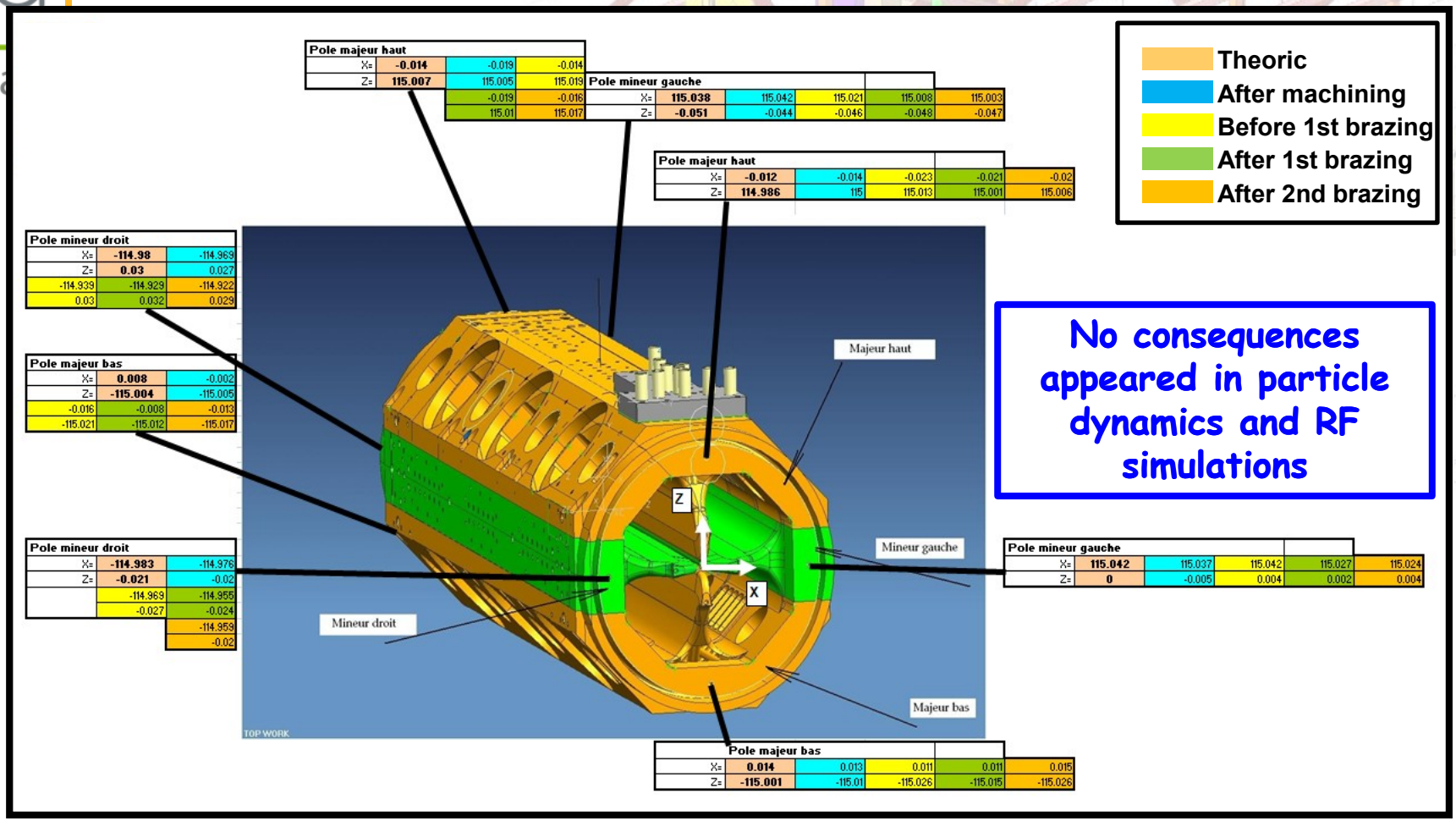
- General brazing:

Clamping with Molybdenum rods, stainless steel nuts and inconel "belleville" washers with arrangement validated by preliminary tests

Displacements after brazing

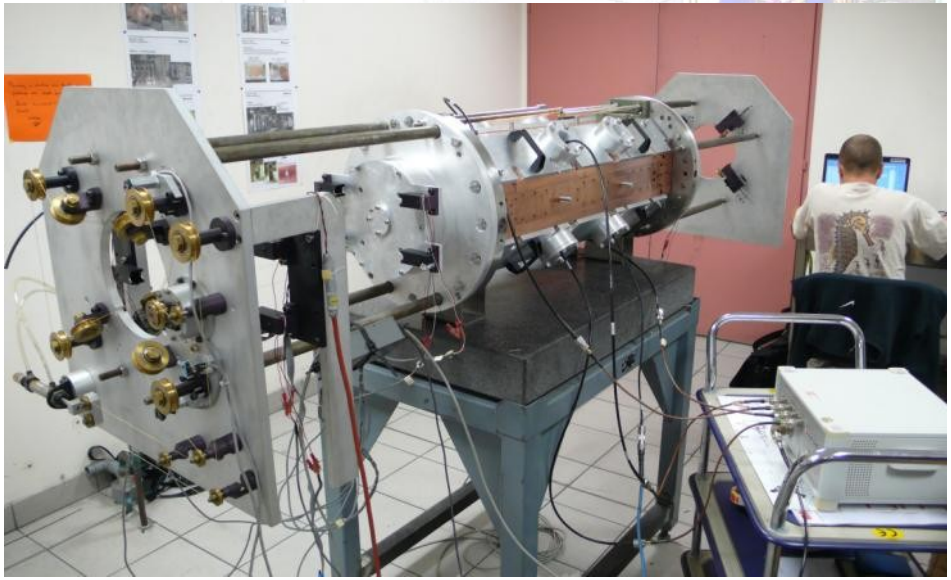
IPHI's module 6th :

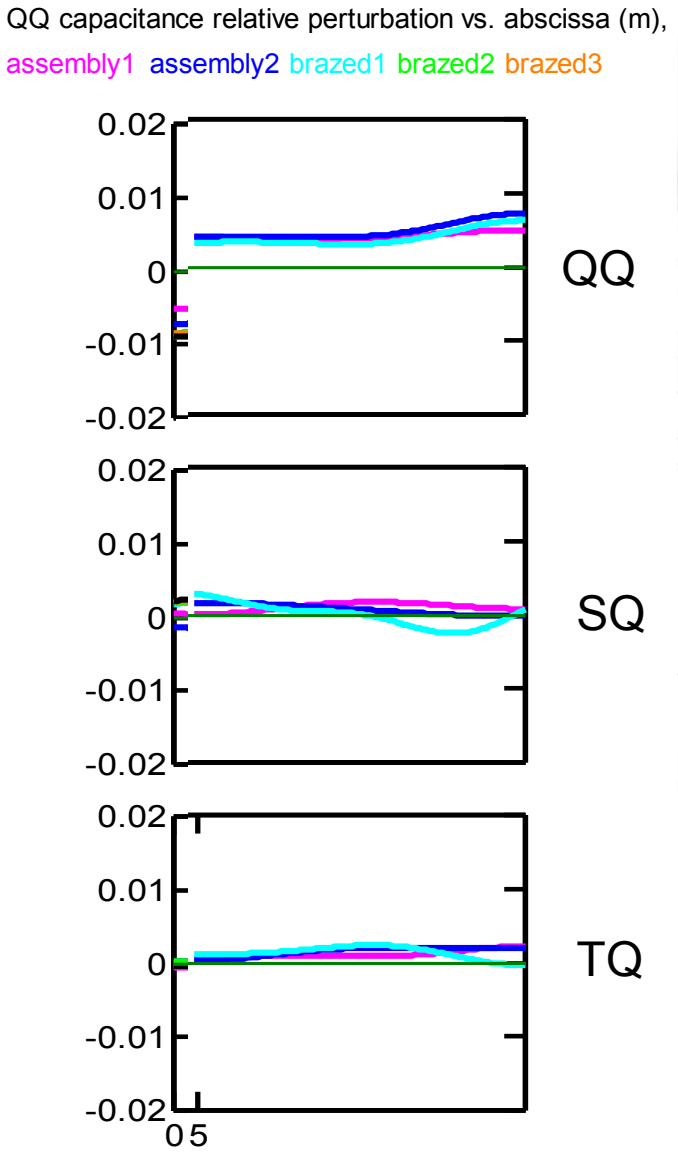
- **Maximum displacement of 35 µm has been observed at the extremity of left minor pole (compare to machining)**
- **Average displacements of 15 µm**



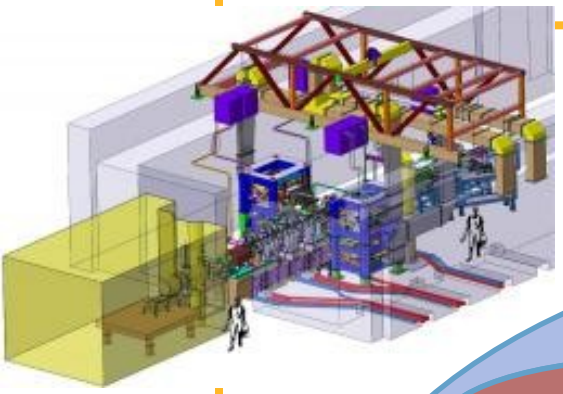
RF measurements

- Bead pull measurement method has been developed and qualified with the IPHI project
- It allows qualifying geometric defaults lower than 50 µm and adjusting the stub tuner dimensions

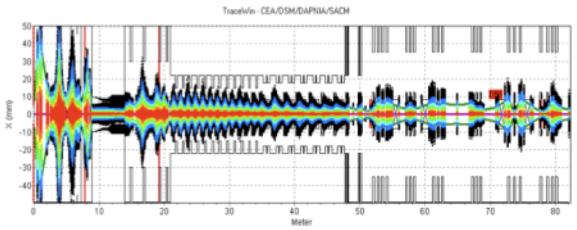




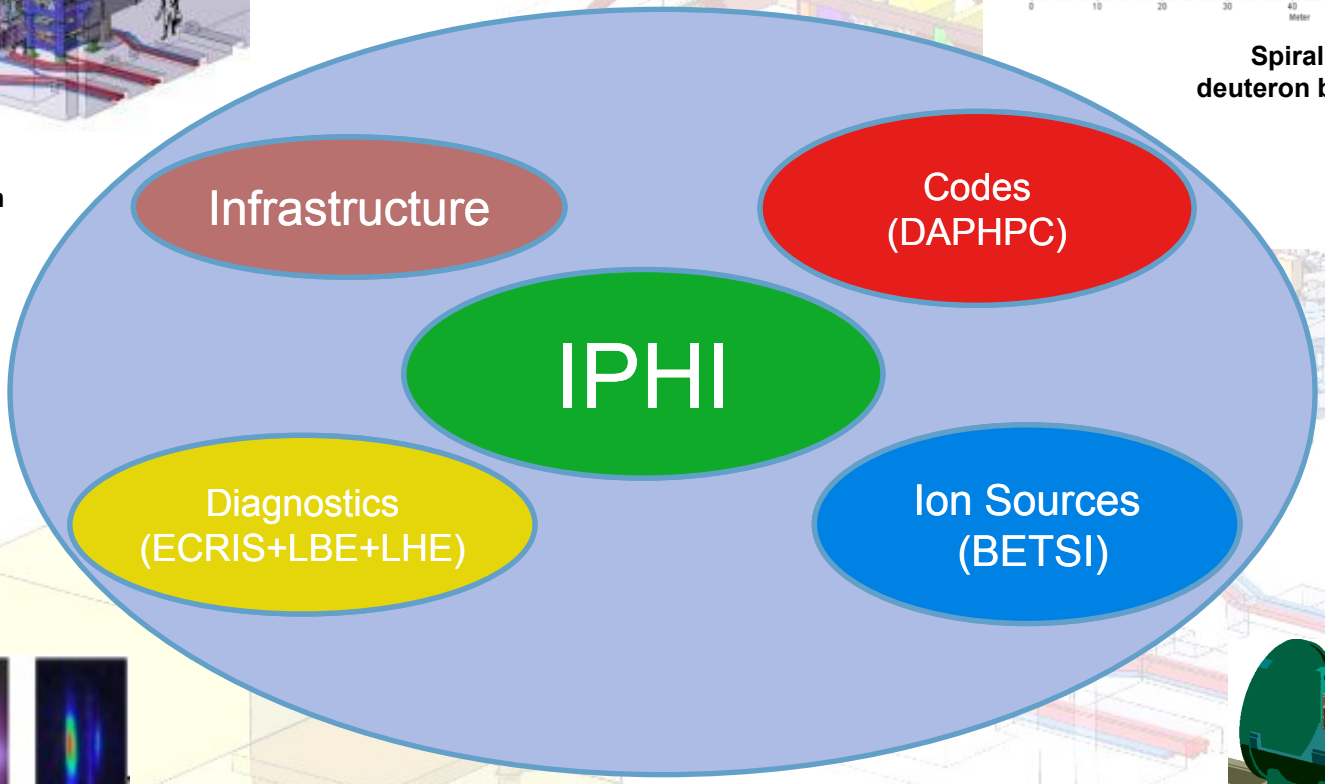
Developments around IPHI

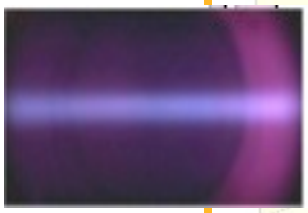


IPHI installation



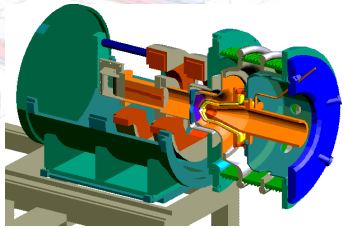
Spiral 2 end to end deuteron beam simulations





Beam profile with CCD camera

Doppler



3D view of the SILHI source

SILHI source and LEBT

ECR Source ➔ Resonance zone:

$\omega = e B / m$

ω, pulsation

e, electron charge

B, magnetic field

m, electron mass.

2.45 GHz ➔ 875 Gauss

Since 1996, SILHI produces H+ beams with good characteristics:

H+ Intensity > 100 mA at 95 keV

H+ fraction > 80 %

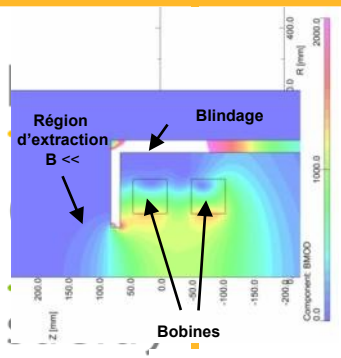
Beam noise < 2%

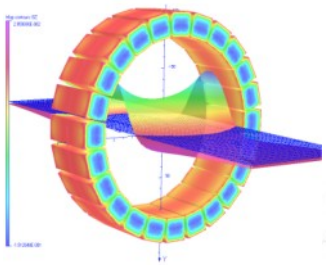
95 % < Reliability < 99.9 %

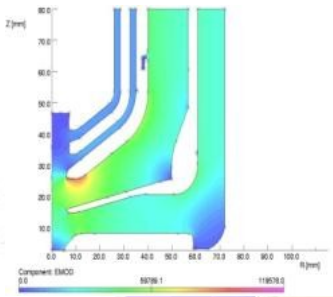
Emittance < 0.2 π mm.mrad

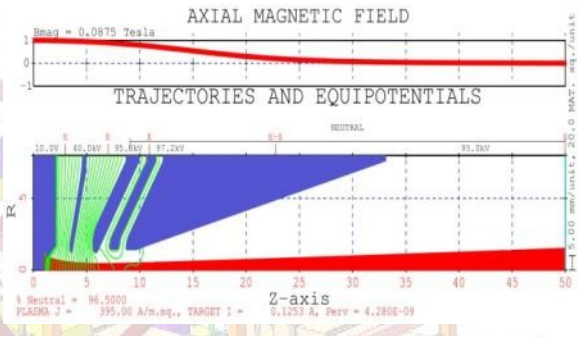
CW or pulsed mode operation

From SILHI to new sources

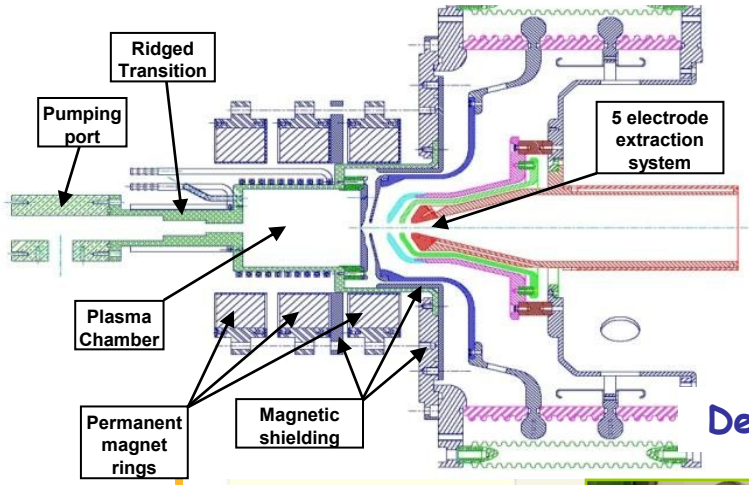




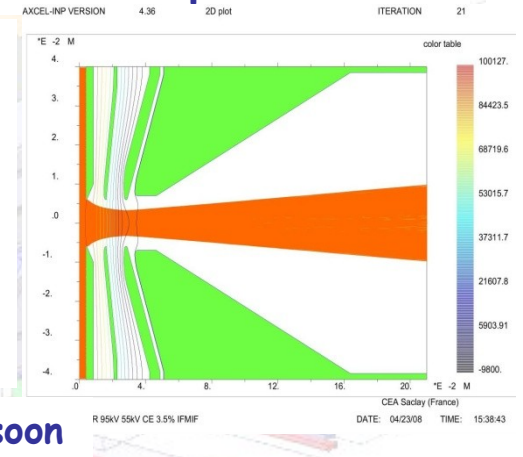




Source design and developments are based on simulations and experiments.

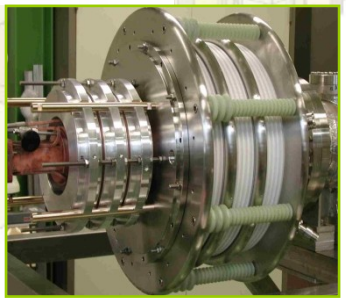


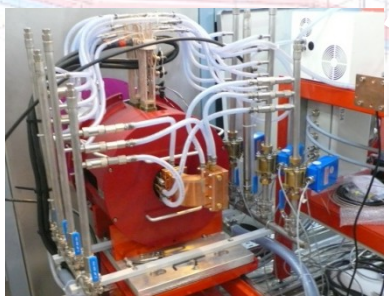
Permanent magnet source for Spiral 2 (5 mA – 40 keV D+ beam) and 4 electrode extraction system for IFMIF Injector (140 mA – 100 keV D^+ beam).

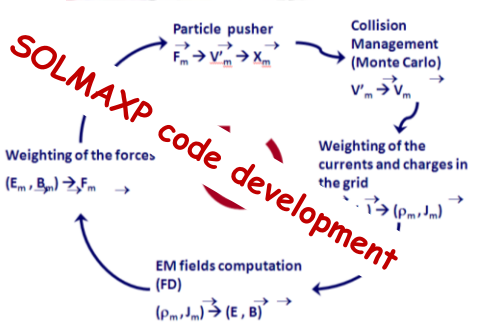


Design of FAIR injector will start soon

More than 100 mA H+ beam has been extracted from a permanent magnet source.



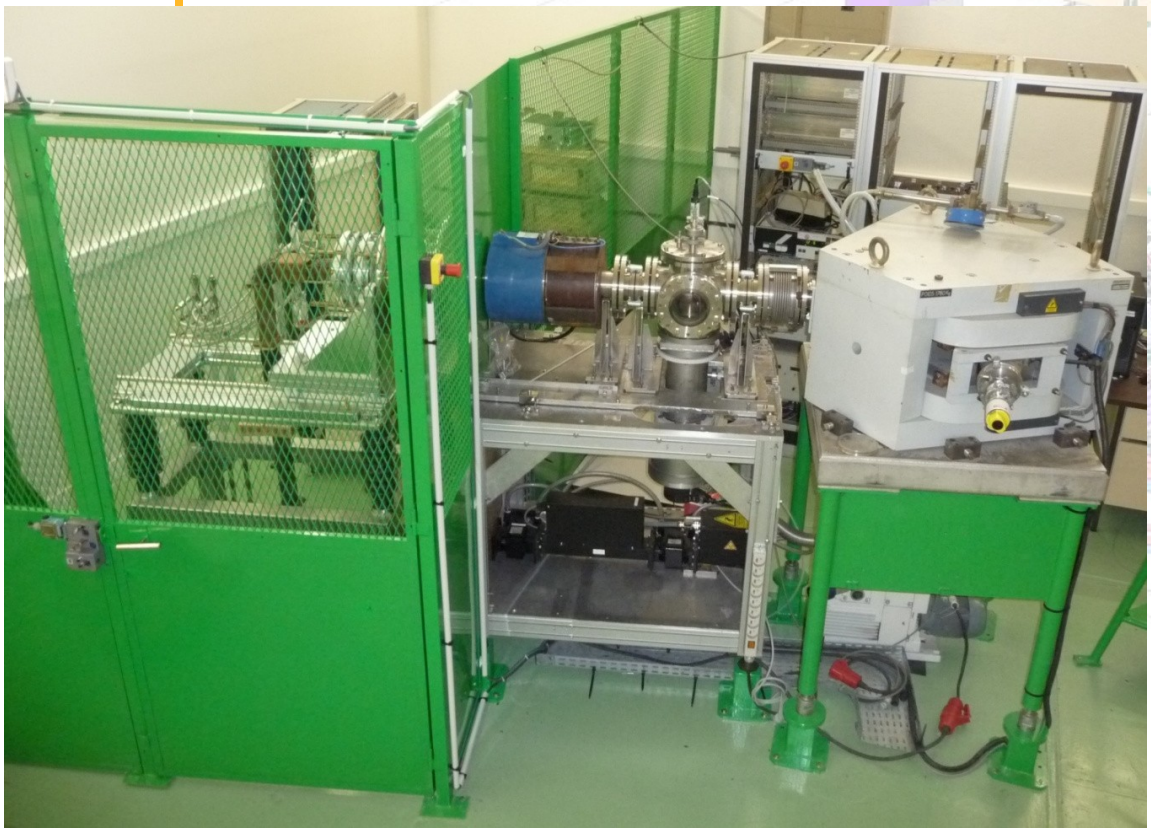


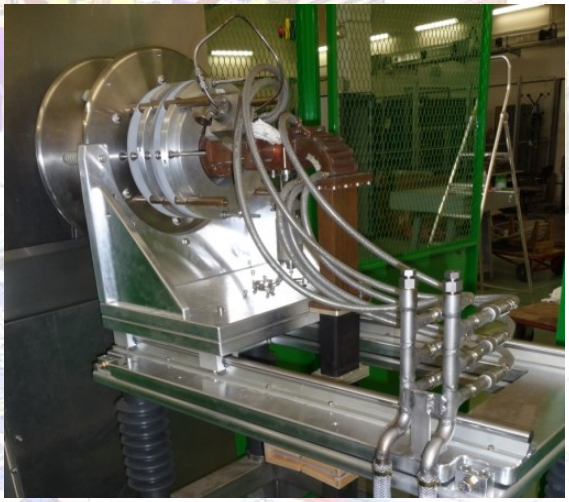


BETSI test bench

In parallel, R&D activities are carried out for better source and beam knowledge.

- Magnetic structure studies (thesis started Oct. 2009)
- Analysis of RF coupling to plasma
- Diagnostic development (ex: tomography within DITANET network)





New source (ALISES) under construction to be tested end 2011

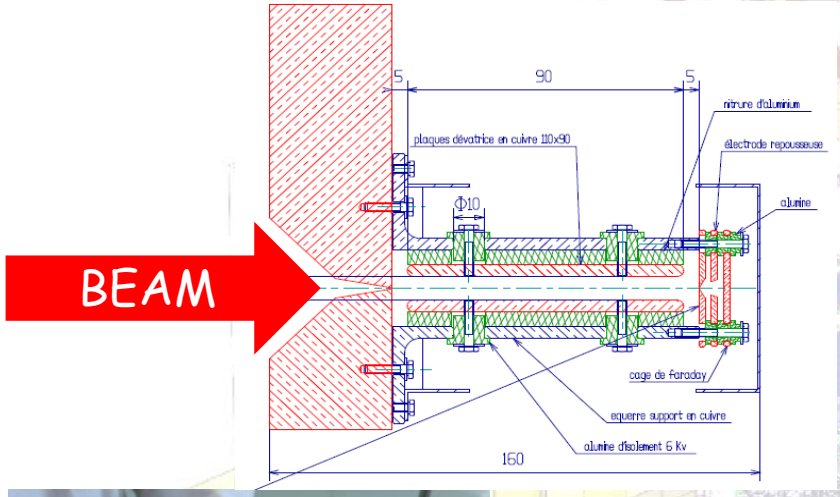
Patent n° FR1060578

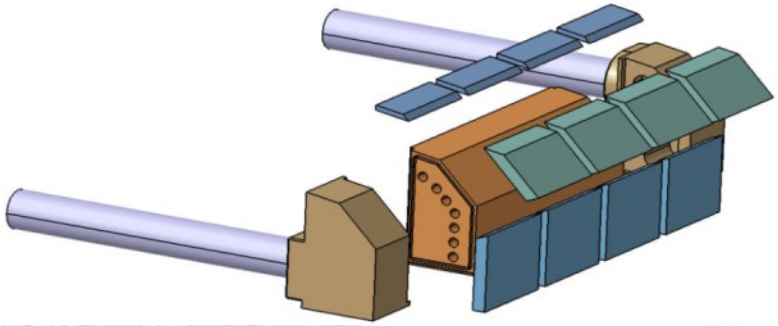
ALISES: Advanced Light Ion Source Extraction System

LBE Emittance scanner

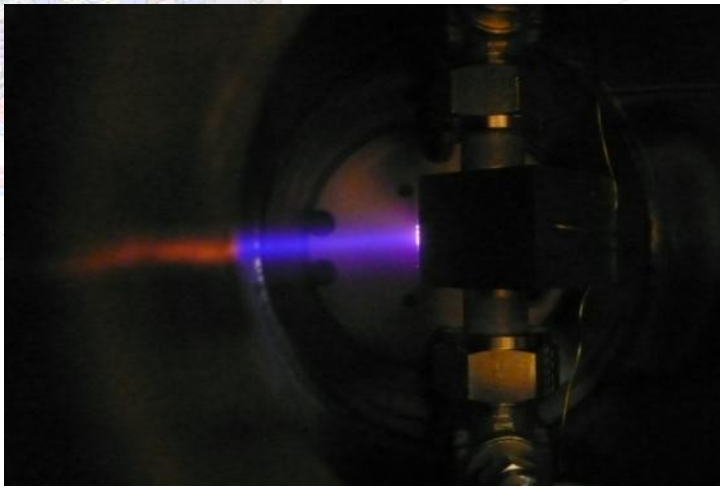
Allison scanner to characterize a 17 kW beam with high power density (1 to 2 kW/cm²) is developed

- Cu block covered with W tiles by brazing
- Water cooling system to assume the heating due to the beam power





Prototype for brazing (W-Cu) technique validation

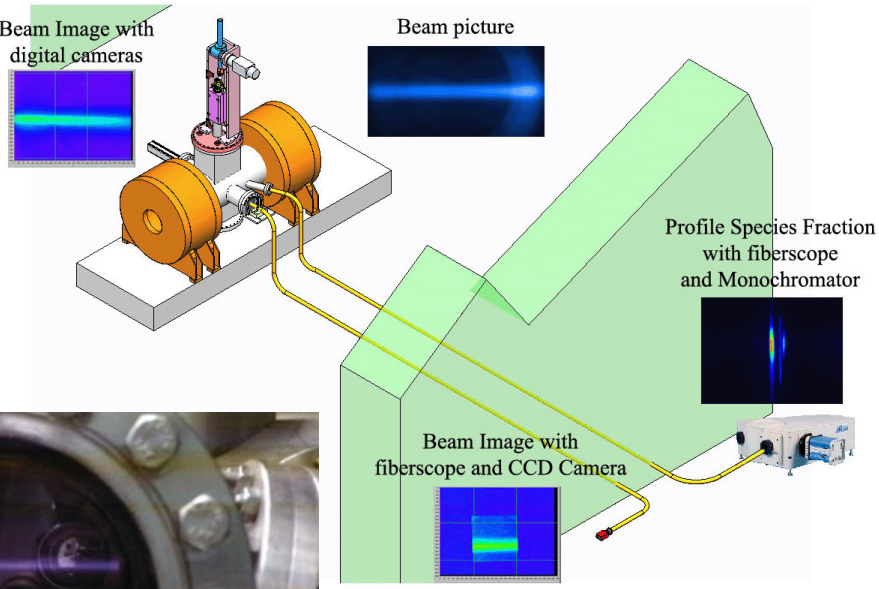


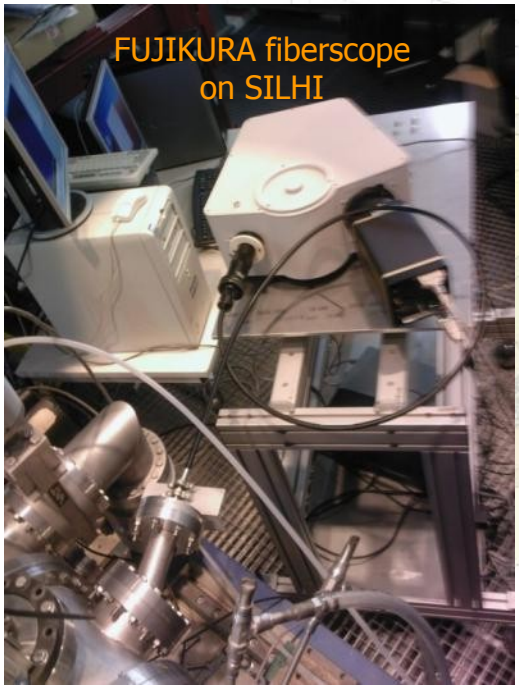
Species fraction analysis with fiberscope

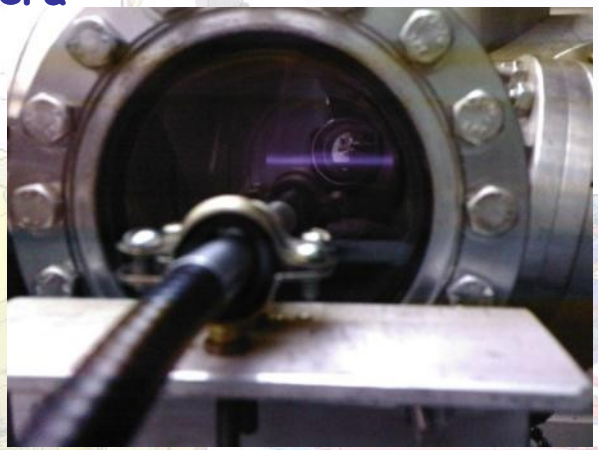
- **Optical diagnostics development**

Measurement of species fractions (and associated beam profiles) with Doppler shift method:

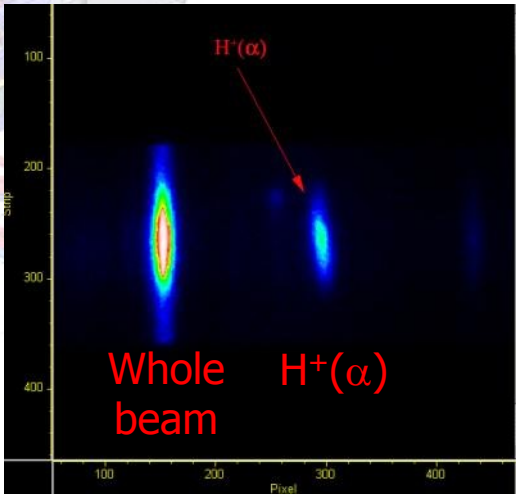
Beam image carrying with fiberscope outside the vault to a monochromator associated to a CCD camera





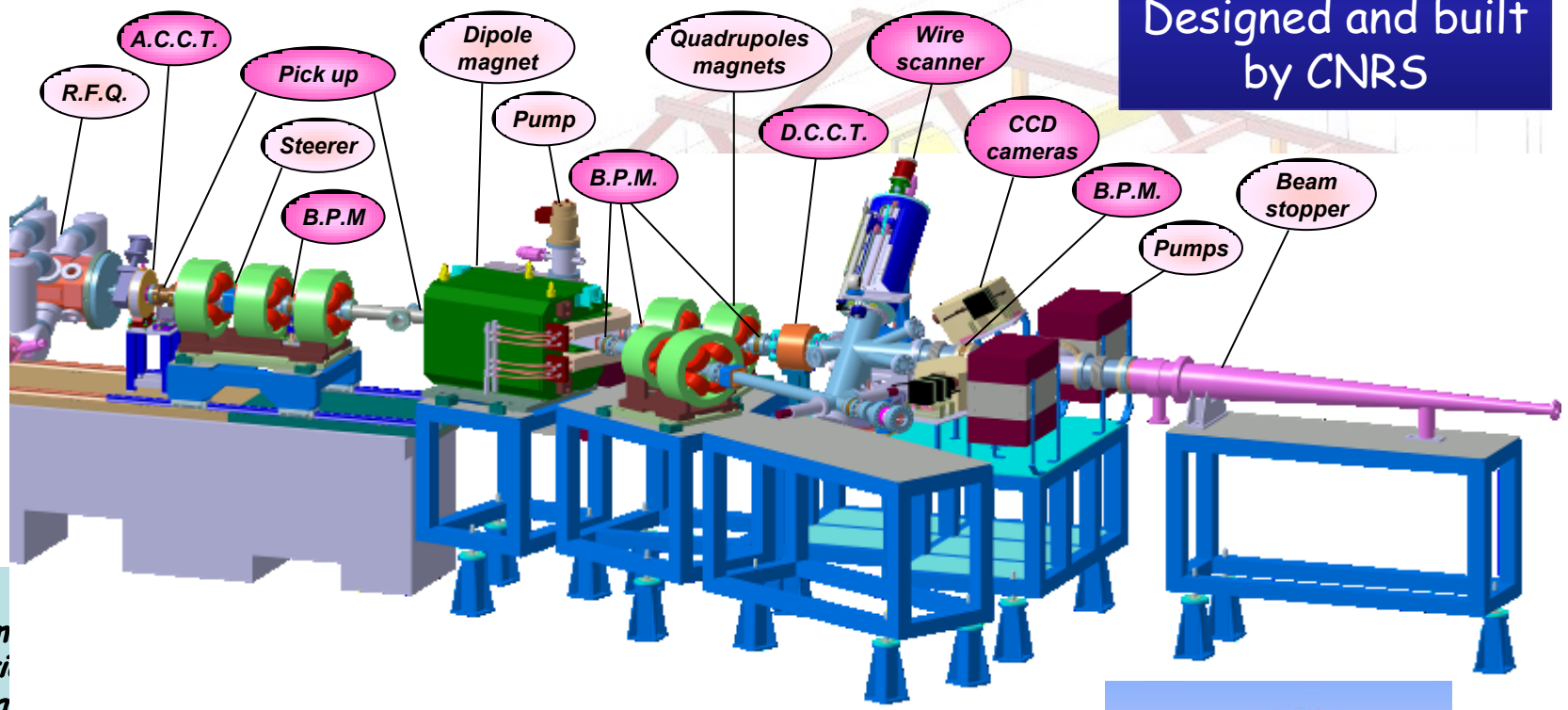


Species fraction observation with Doppler shift method using FUJIKURA fiberscope



IPHI Diagnostic Beam Line

Irfu cea saclay

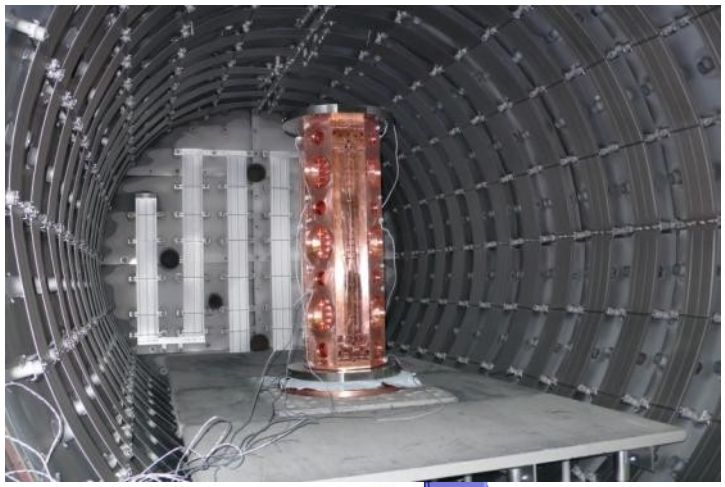


Designed and built by CNRS

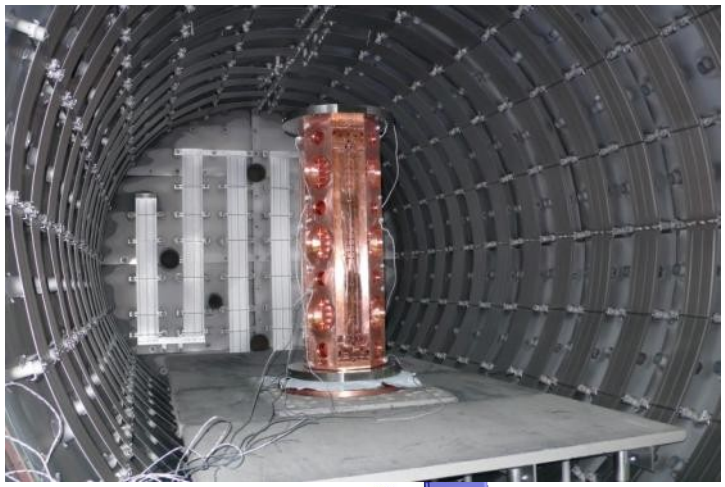
Diagnostics:

- *Intensity m*
- *Beam Positi*
- *Energy mea… : 3 F.C.*
- *Energy spread measurement: 2 slits + 1 F.C.*
- *Transverse profiles:*
  1 W.S., optical measurements, backscattered protons
- *Temperature measurements of the beam pipe (thermocouples)*
- *Optical diagnostics*

R&D activities carried out at IPN Orsay for BPM and WS diagnostics.



Thanks!



Thanks!

Schedule of IPHI project

- *Summer 2011* :
  - Modules reception
- *End 2011* :
  - RFQ assembly
- *Summer 2012* :
  - Conditionning
- *End 2012* :
  - First proton beam