Status of the PHOENIX V3 ion source R&D

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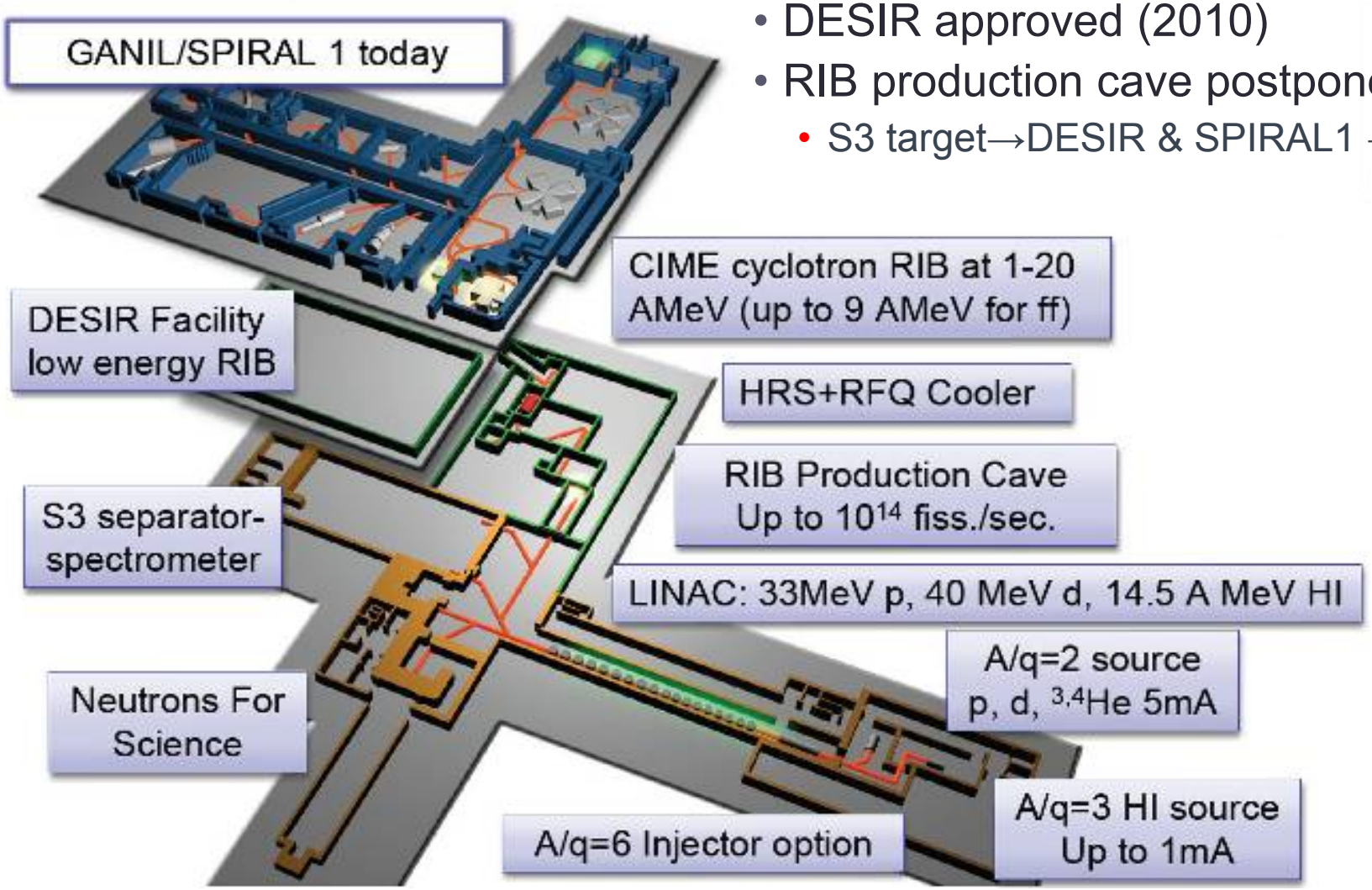
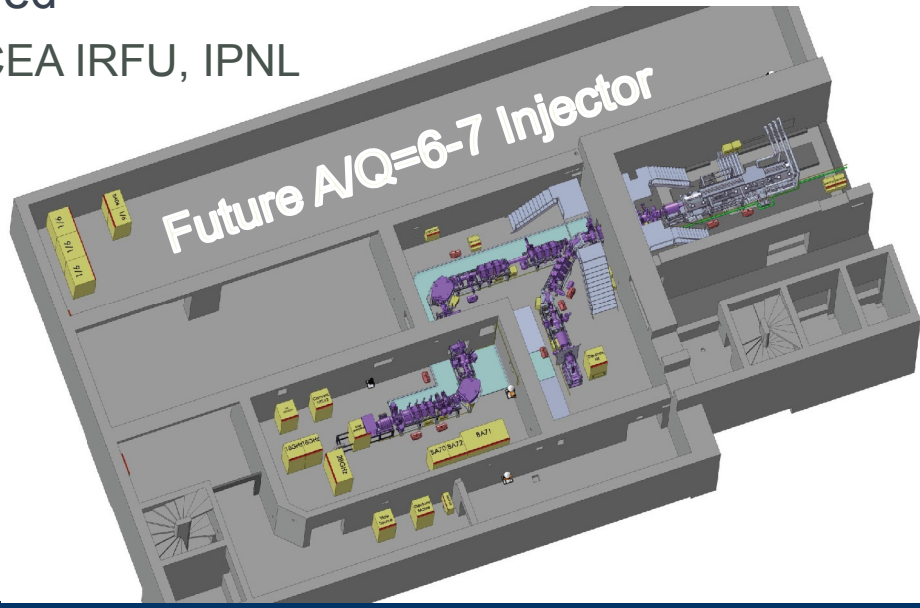
SPIRAL2

- Linac, S3, NFS approved (2008)
- DESIR approved (2010)
- RIB production cave postponed (2013)
  - S3 target→DESIR & SPIRAL1 →DESIR

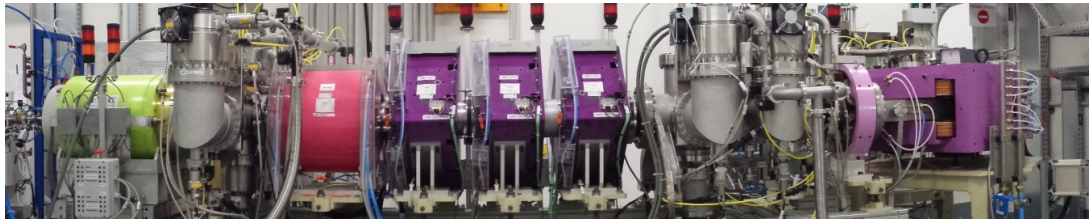


SPIRAL2 ECRIS Strategy with limited funding

- M/Q=3 for M<50
  - Starter ion source : PHOENIX V2
  - Upgrade granted by the EU CRISP contract : PHOENIX V3
- M/Q=6-7 for M up to uranium: prospect
  - New injector required + 2 extra linac cavities
  - New superconducting ion source required
    - collaboration foreseen : GANIL, LPSC, CEA IRFU, IPNL
  - No funding so far
  - The project will start once the DESIR hall will be granted (low energy RIB)

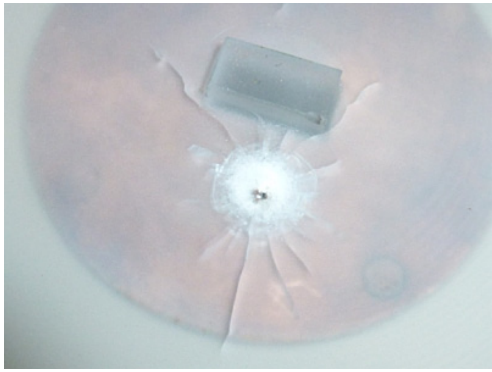


Recent Spiral2 heavy ion source activity



- At GANIL :
  - PHOENIX V2 is used to produce high intensity $^{4}He^{2+}$ beams to commission the RFQ
  - The source is now fully operationnal at 60 kV
    - It required many ground improvements to make it happen!
  - A new 4 mm thick quartz DC breaker was designed as the 2 mm version broke down
  - The new breaker has passed long term operation @ 60 kV and high RF power
- At LPSC :
  - Assembly of the PHOENIX V3 source
  - Full refurbishement of the local LEBT hosting the source

A supply complaining about HV breakdowns



Fused 2 mm DC breaker

Motivation for the PHOENIX V3 upgrade

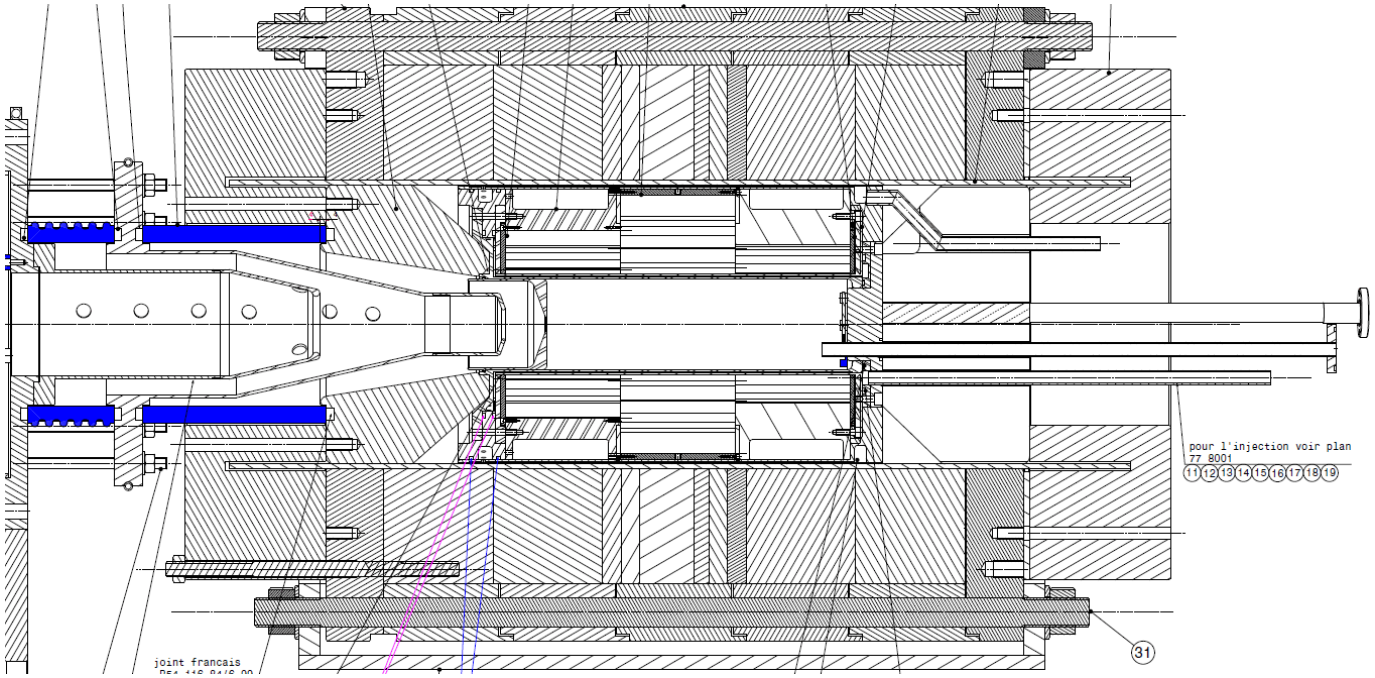
- CRISP EU collaboration : 200 k€ funding available
  - Funding sufficient to design an upgrade of PHOENIX V2, keeping the ion source hardware/supplies unchanged
    - Solenoid power supplies, RF, beam extraction, mechanical frames…

CRISP

SEVENTH FRAMEWORK PROGRAMME

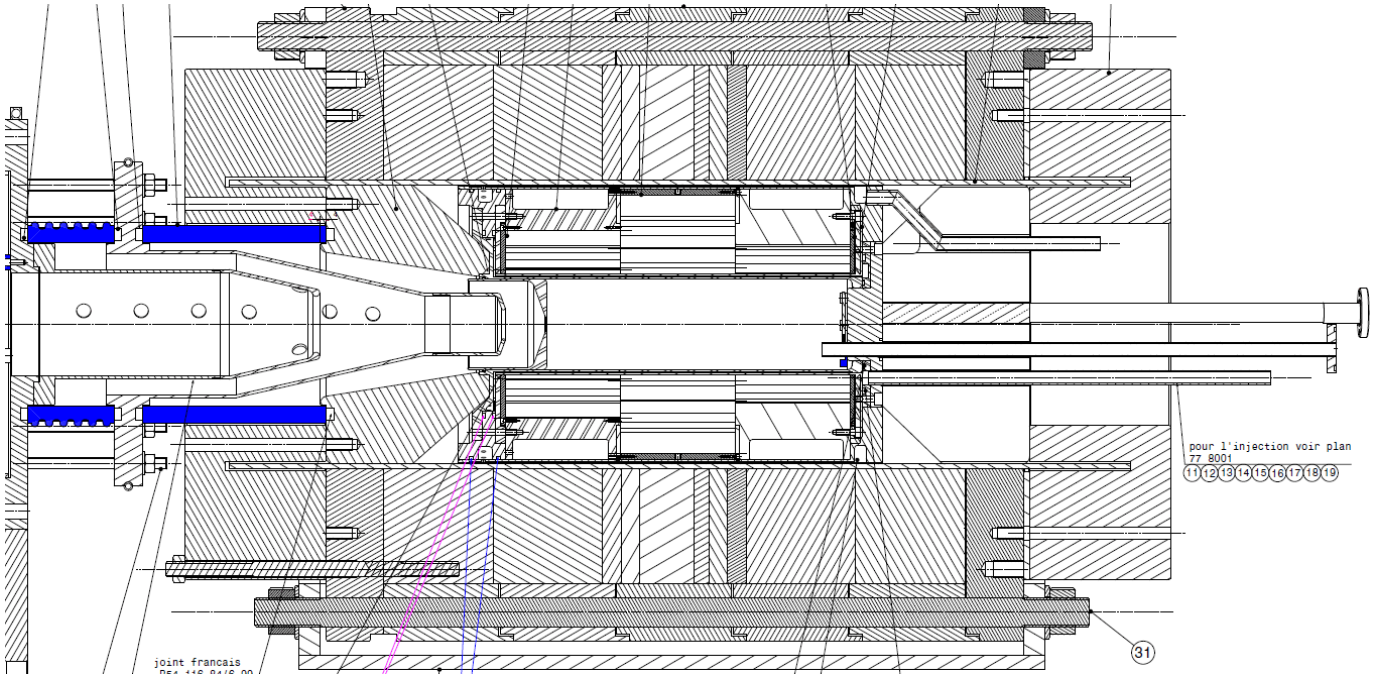
- Upgrade Goal : improve M/Q=3 beam intensities
  - Enhance the production rate of high charge states
  - Reduce the residual pressure in the plasma chamber
- How
  - Increase the plasma volume by increasing the plasma chamber radius
  - Keep the radial confinement intensity at wall ~constant
  - Keep the existing axial confinement system
  - Add a turbo pump at the injection

PHOENIX upgrade : V2→V3



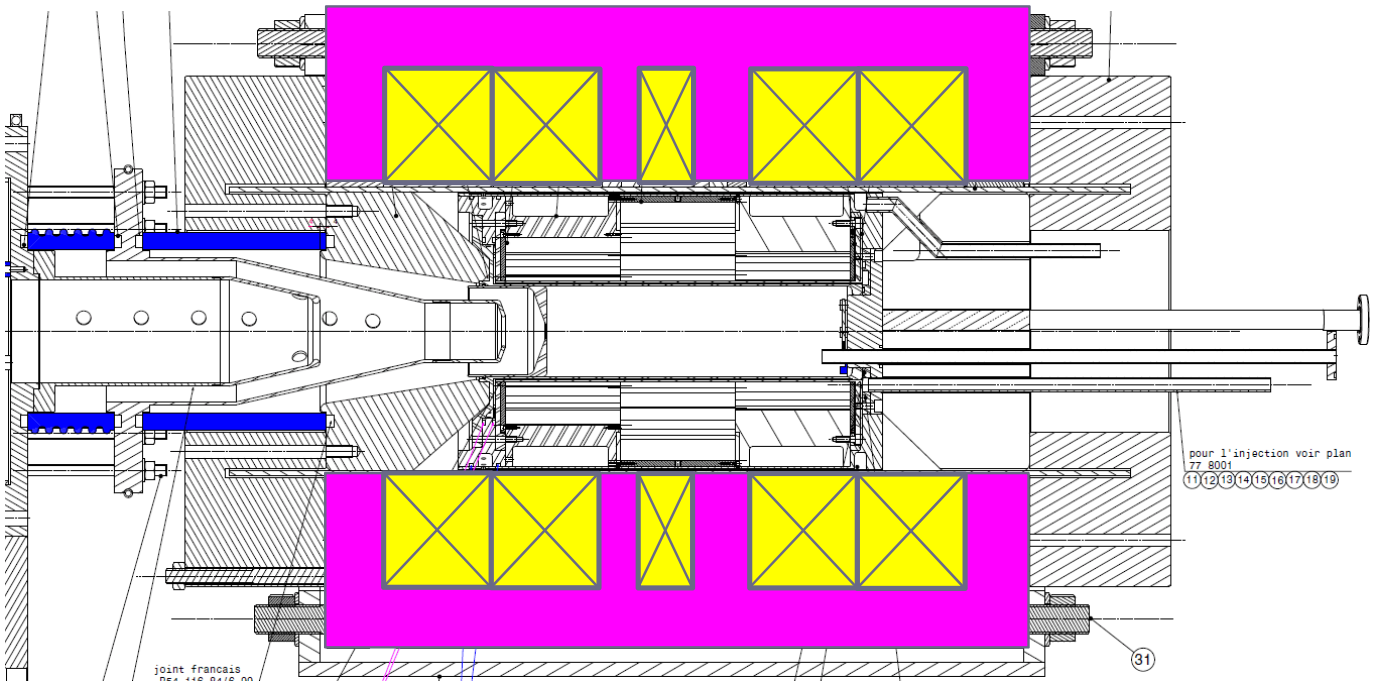
PHOENIX upgrade : V2→V3

Axial magnetic structure



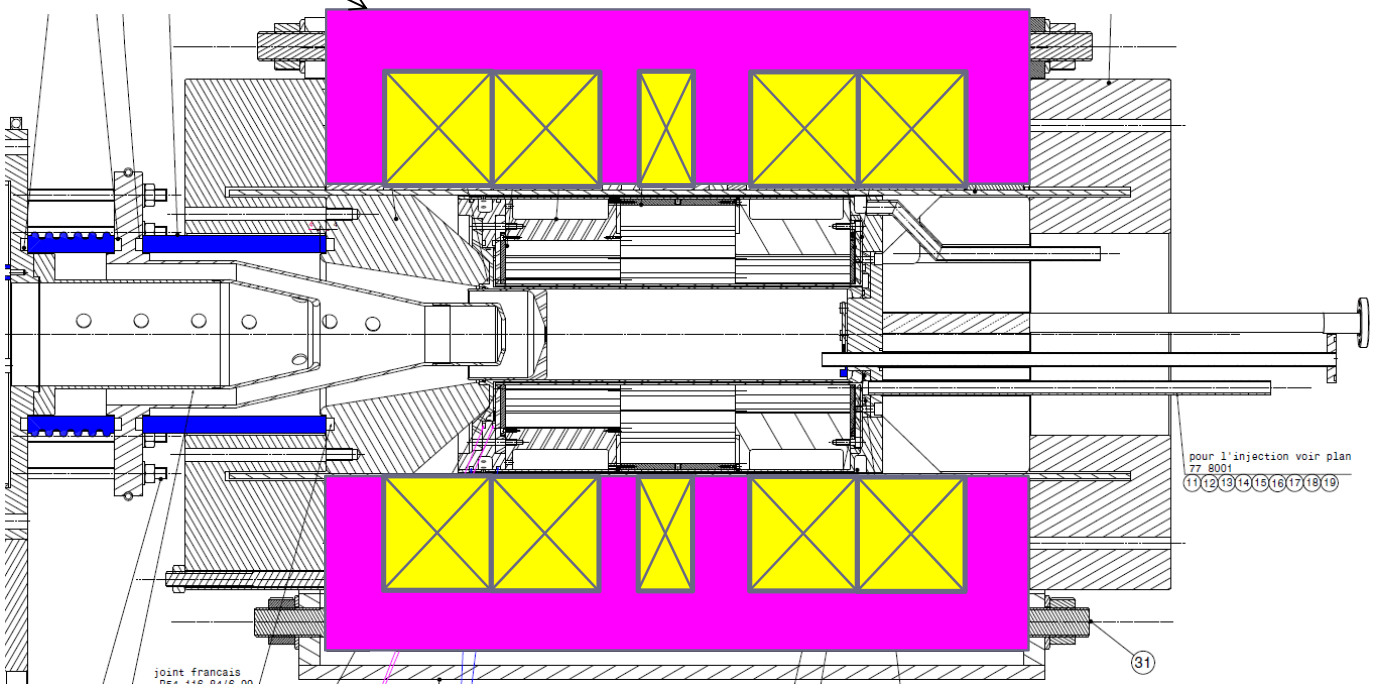
PHOENIX upgrade : V2→V3

Axial magnetic structure



PHOENIX upgrade : V2→V3

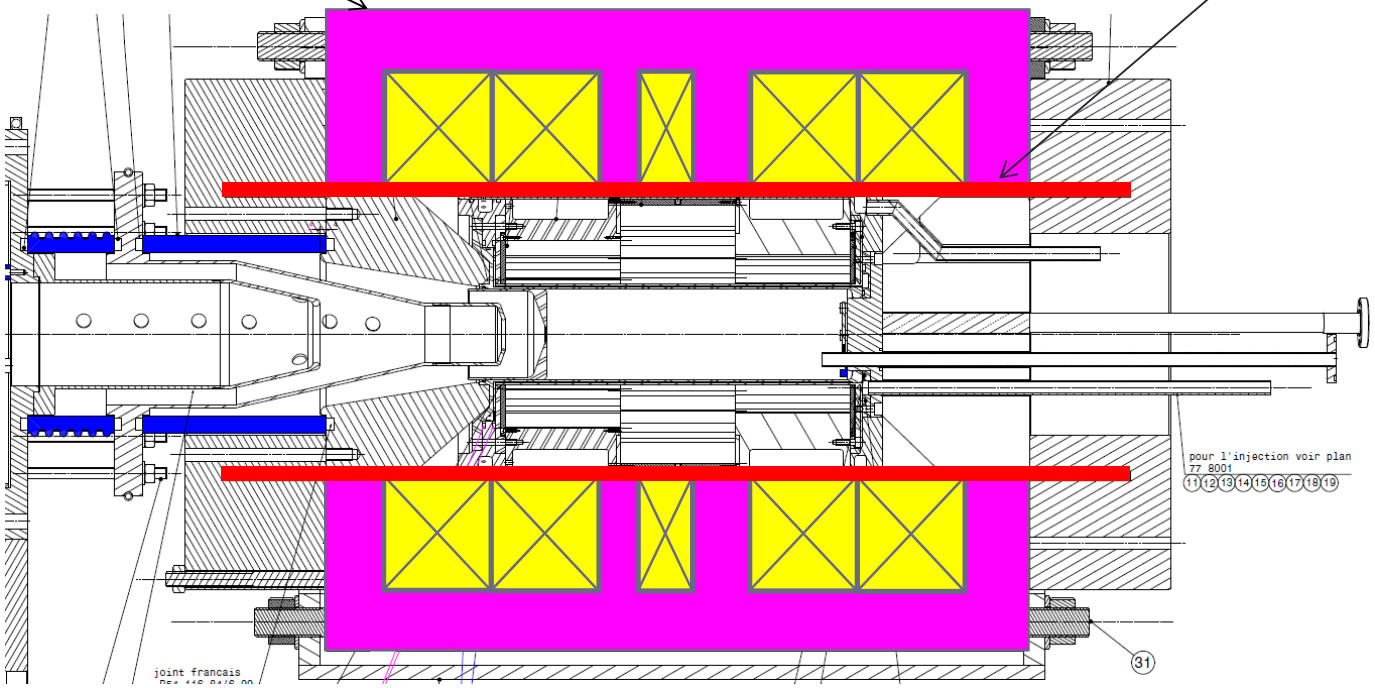
Axial magnetic structure



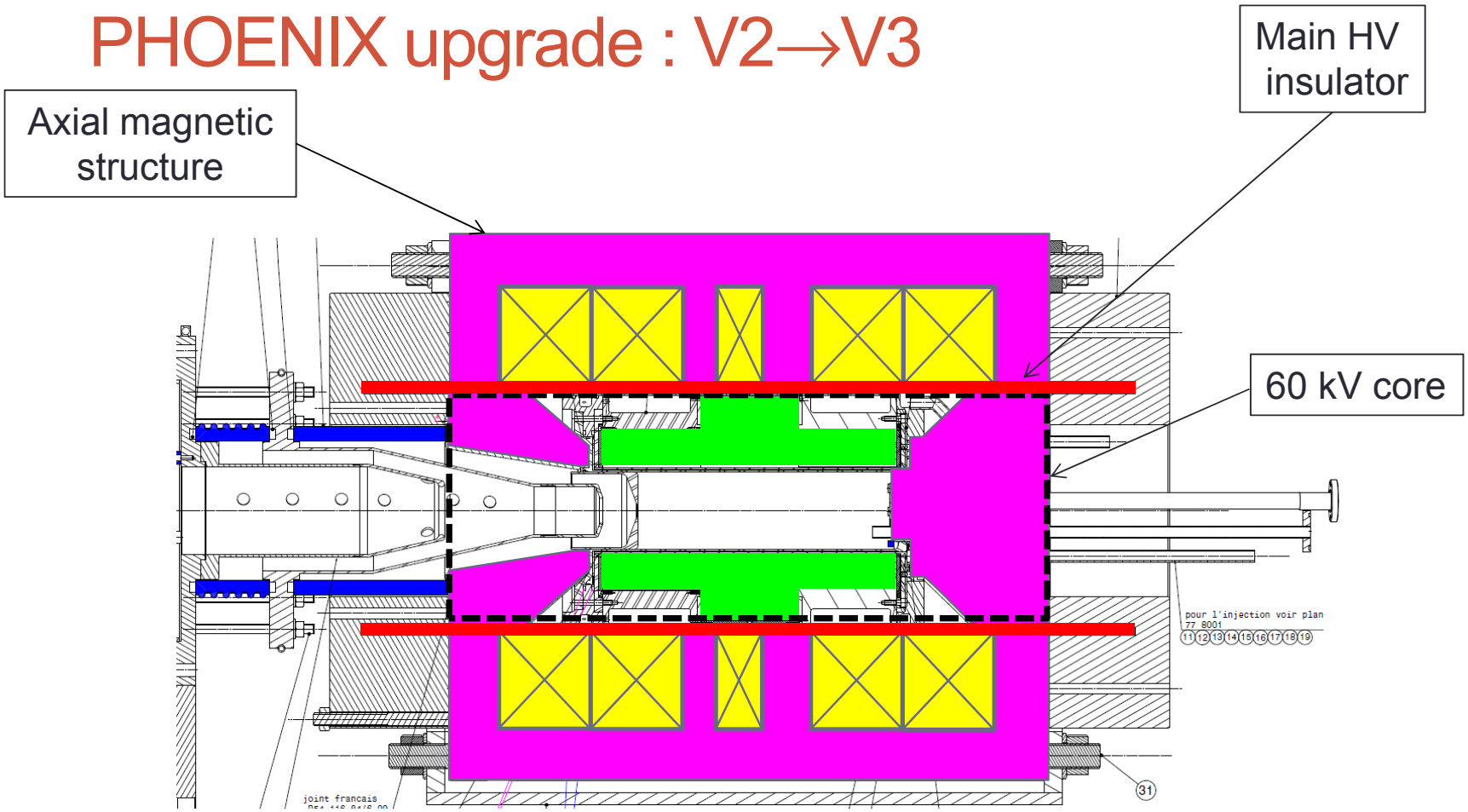
PHOENIX upgrade : V2→V3

Axial magnetic structure

Main HV insulator



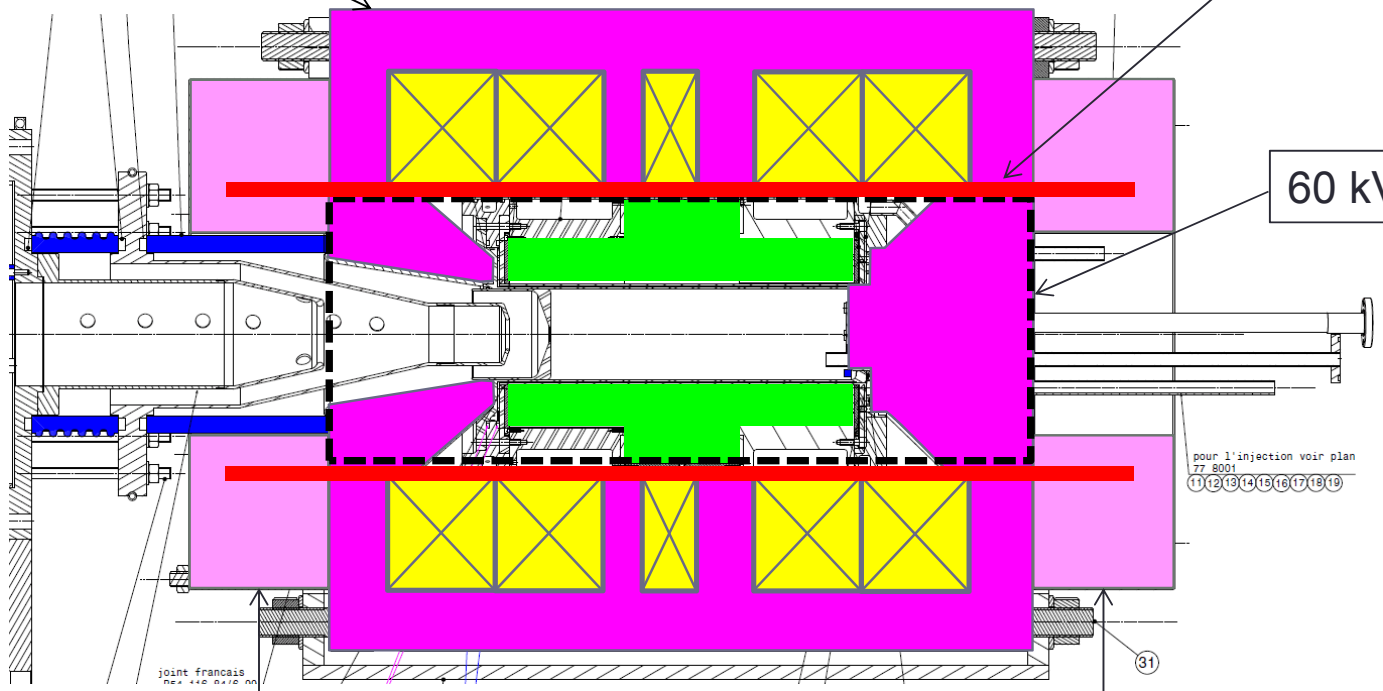
PHOENIX upgrade : V2→V3



PHOENIX upgrade : V2→V3

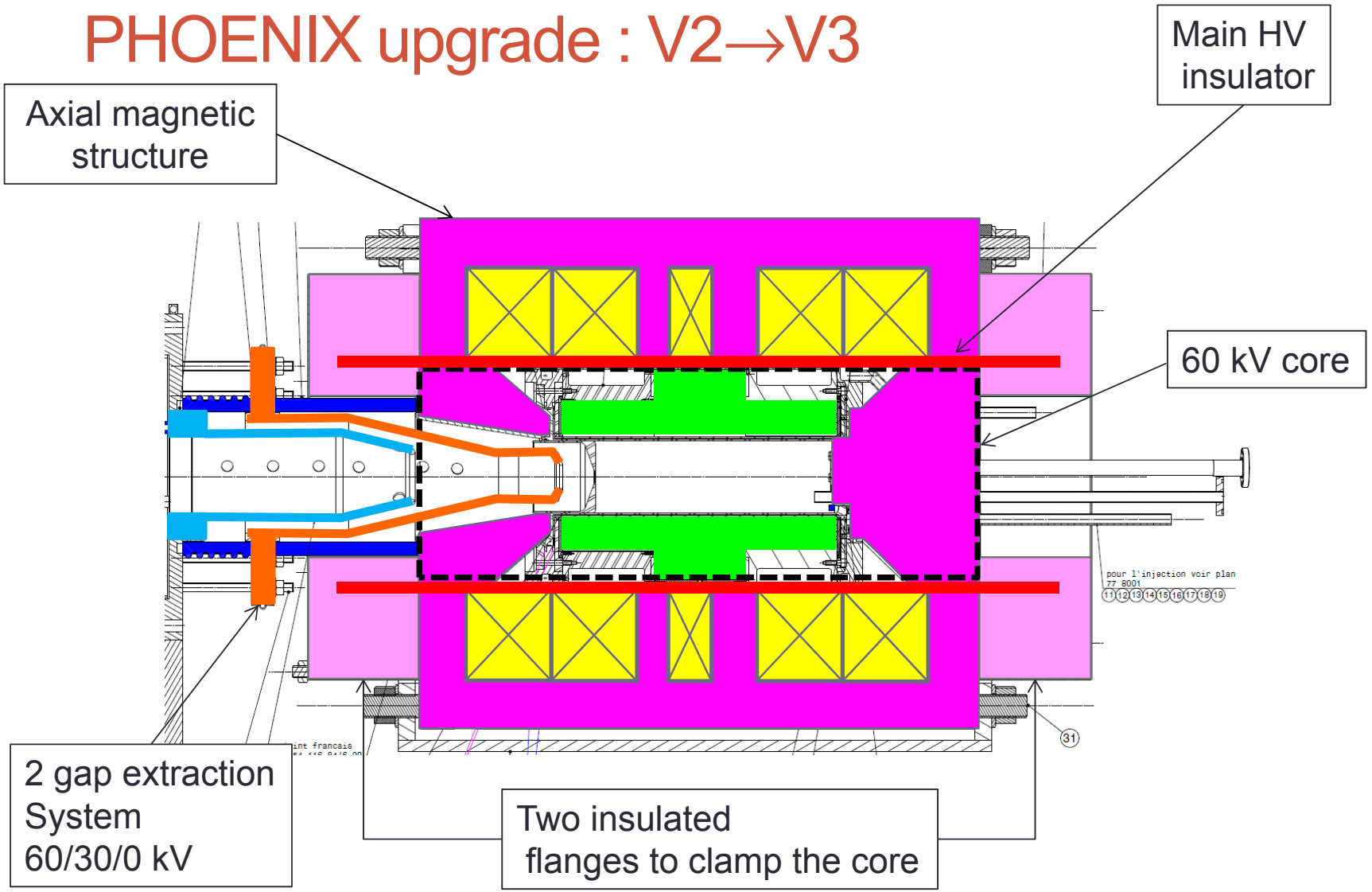
Axial magnetic structure

Main HV insulator



Two insulated flanges to clamp the core

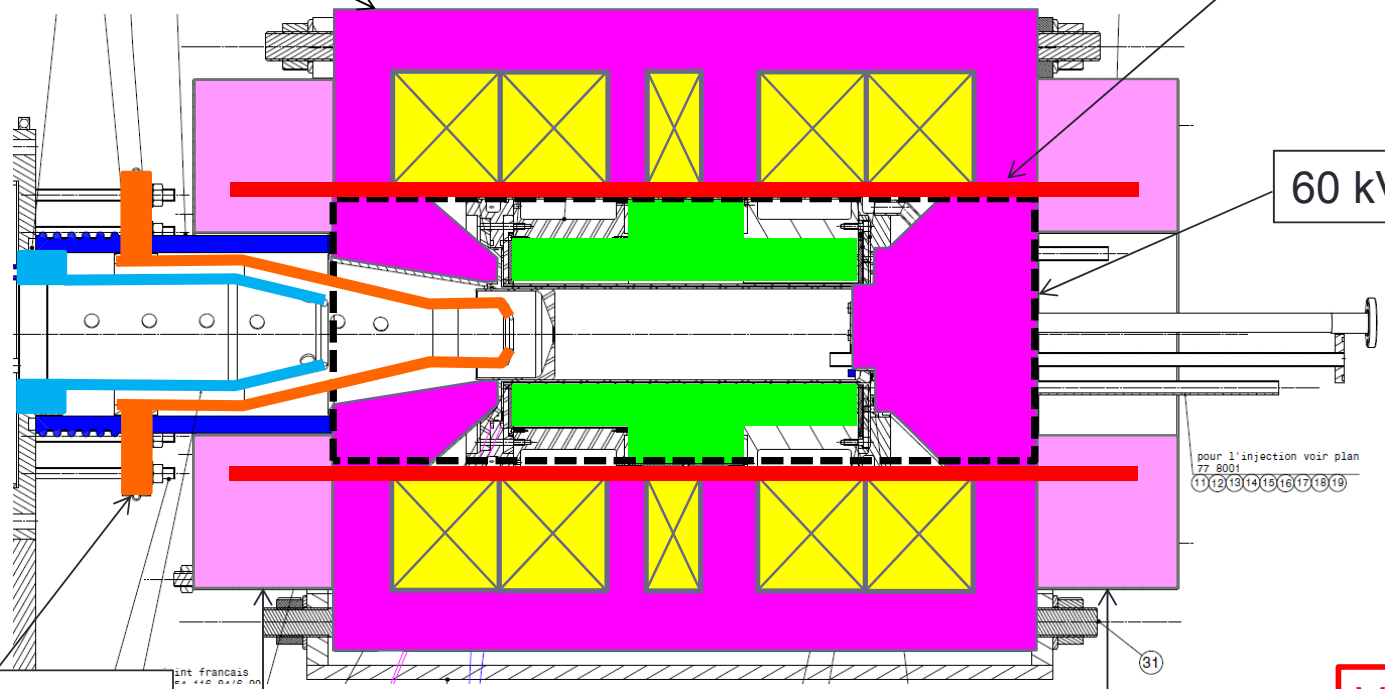
PHOENIX upgrade : V2→V3



PHOENIX upgrade : V2→V3

Axial magnetic structure

Main HV insulator



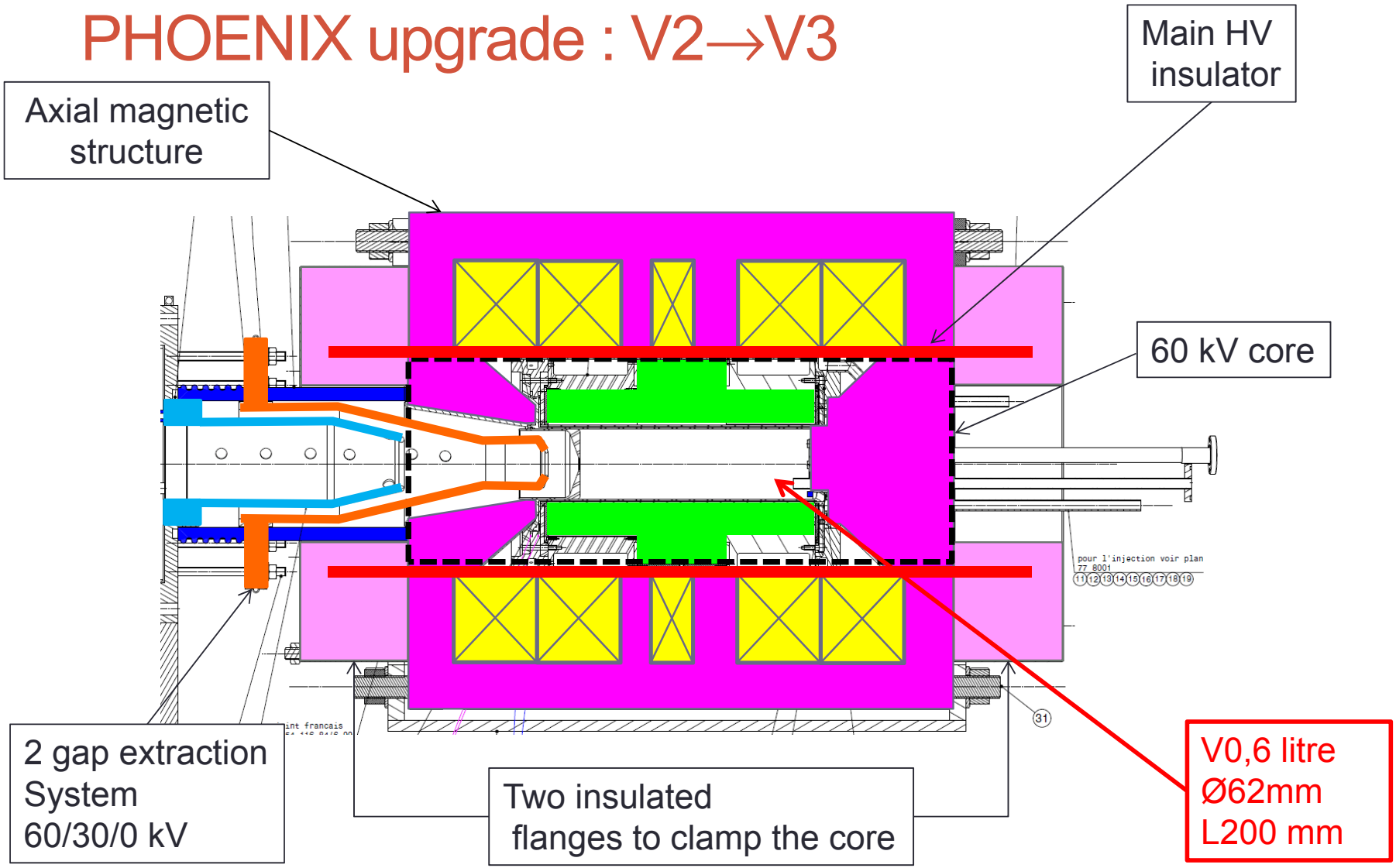
60 kV core

2 gap extraction System 60/30/0 kV

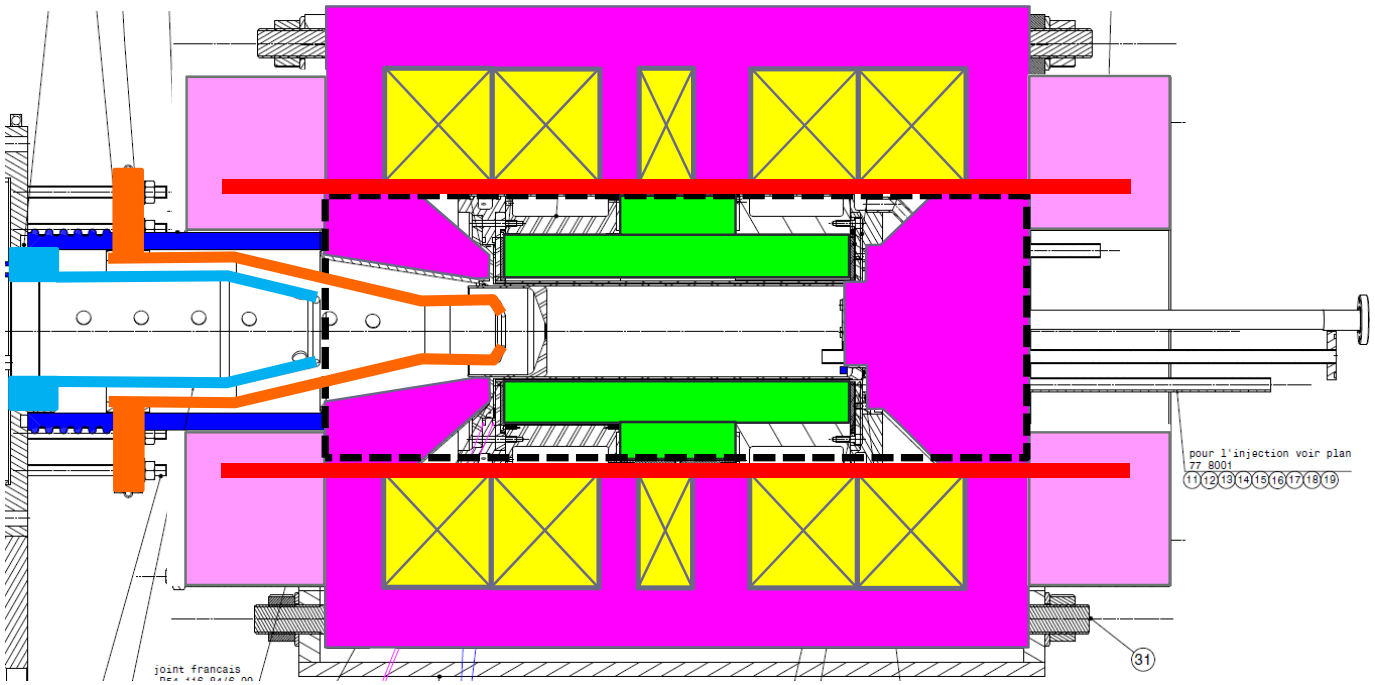
Two insulated flanges to clamp the core

V0,6 litre
Ø62mm
L200 mm

PHOENIX upgrade : V2→V3



PHOENIX upgrade : V2→V3



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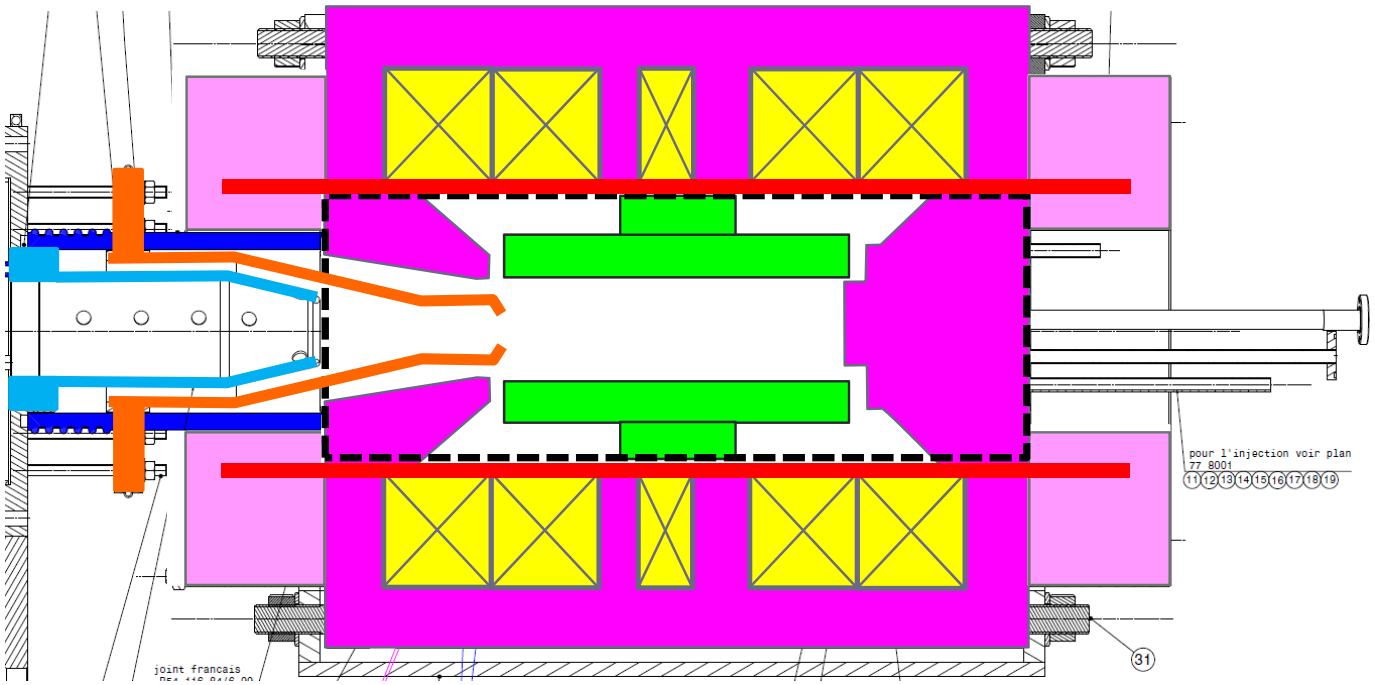
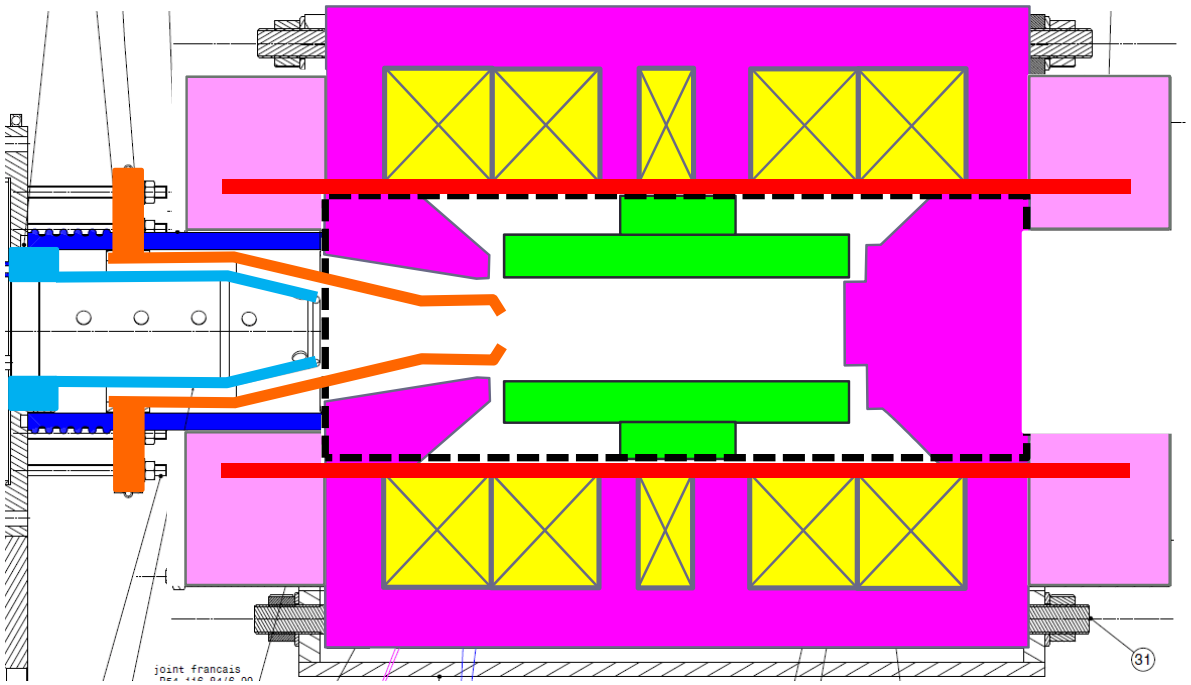


PHOENIX upgrade : V2→V3



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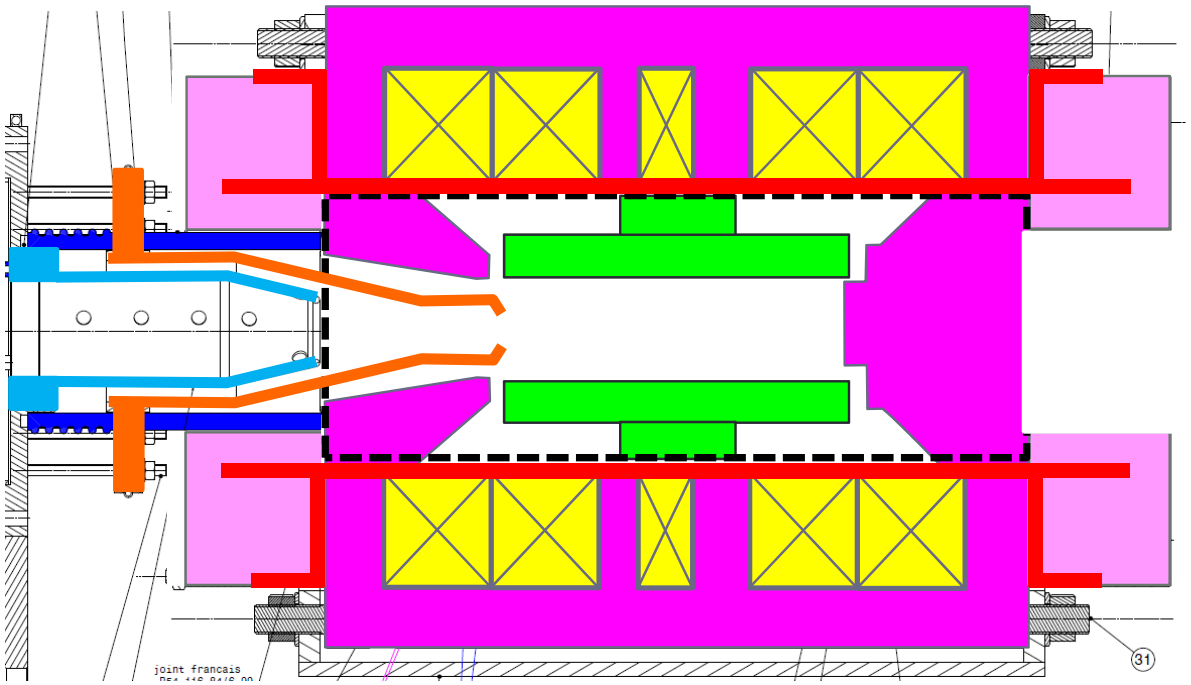
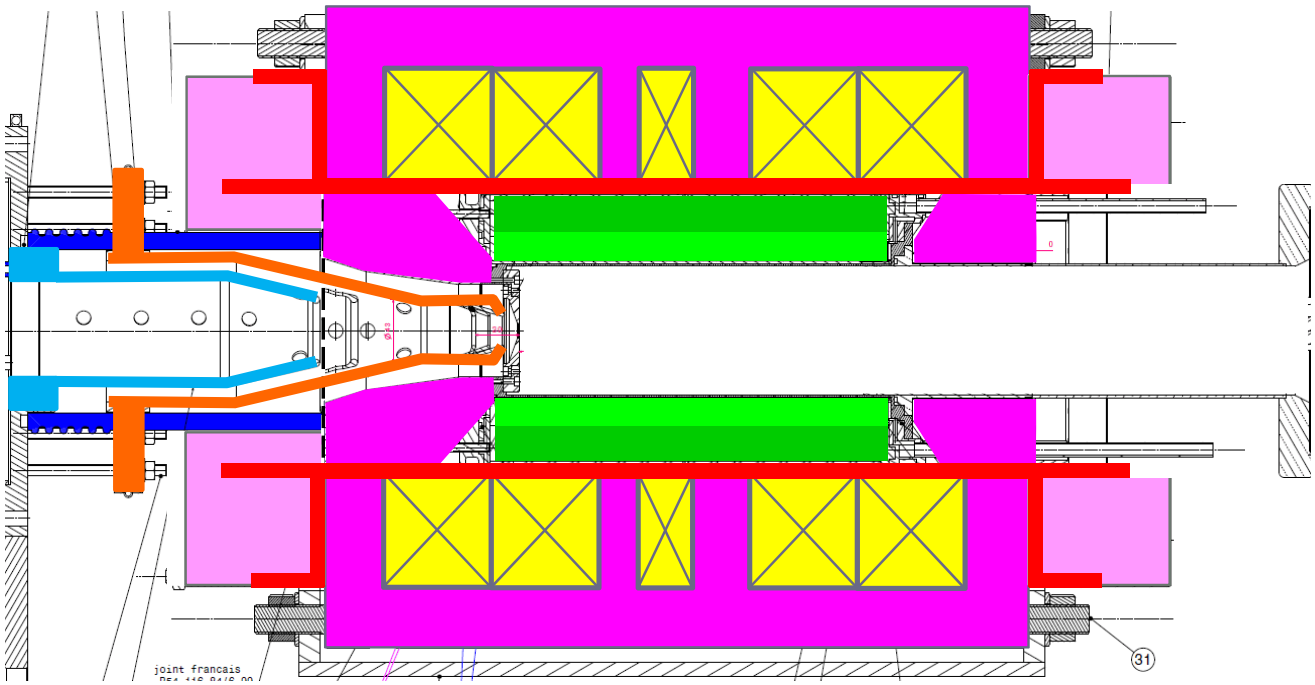
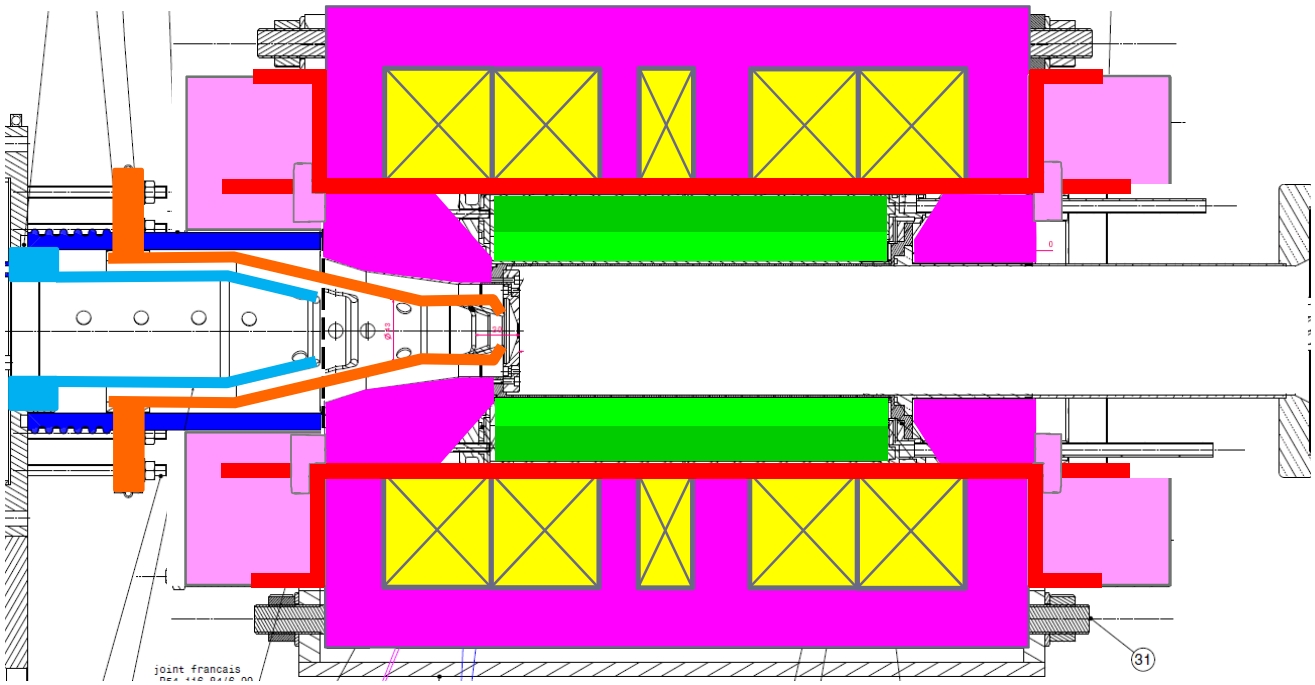


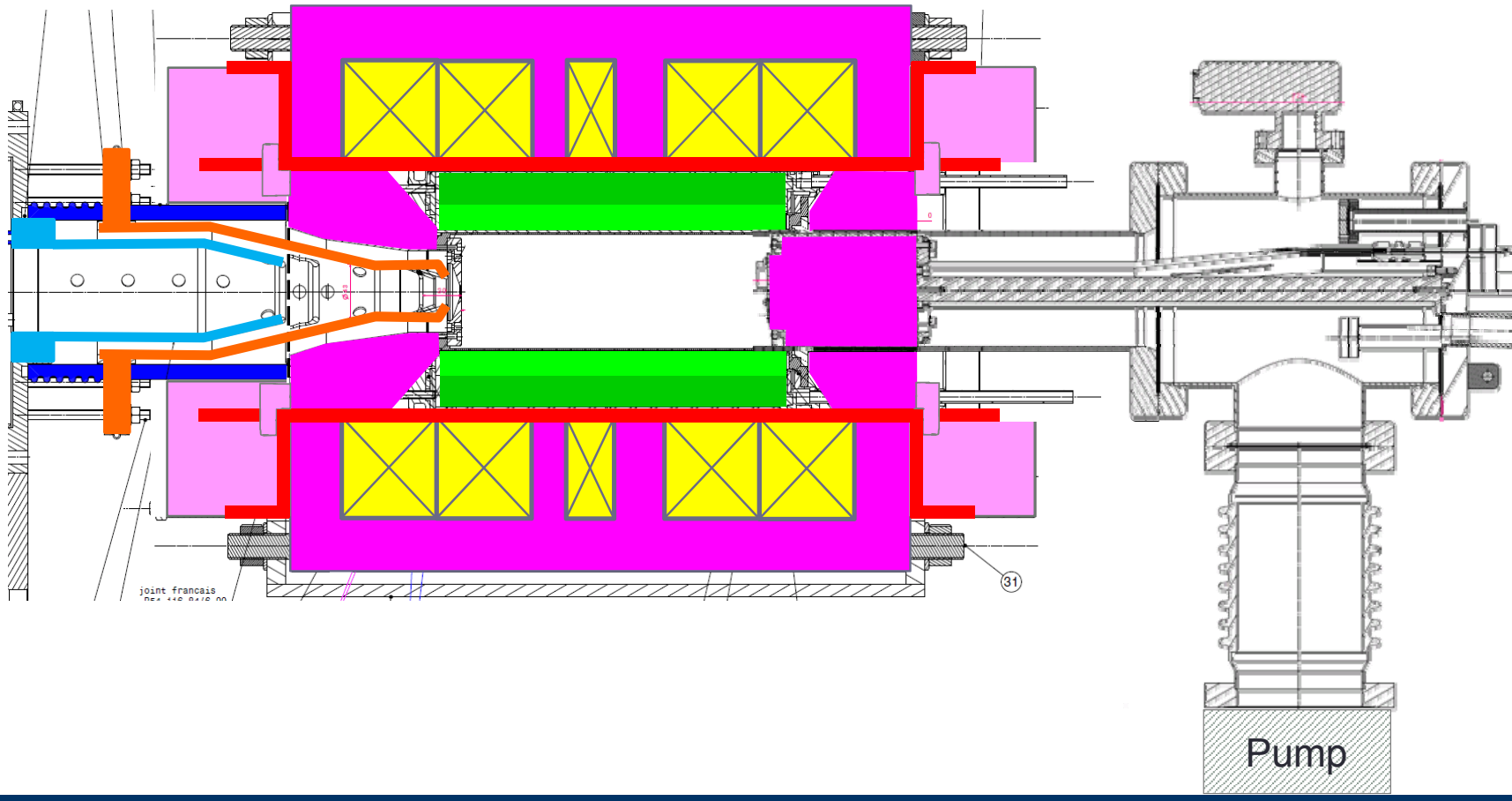
PHOENIX upgrade : V2→V3



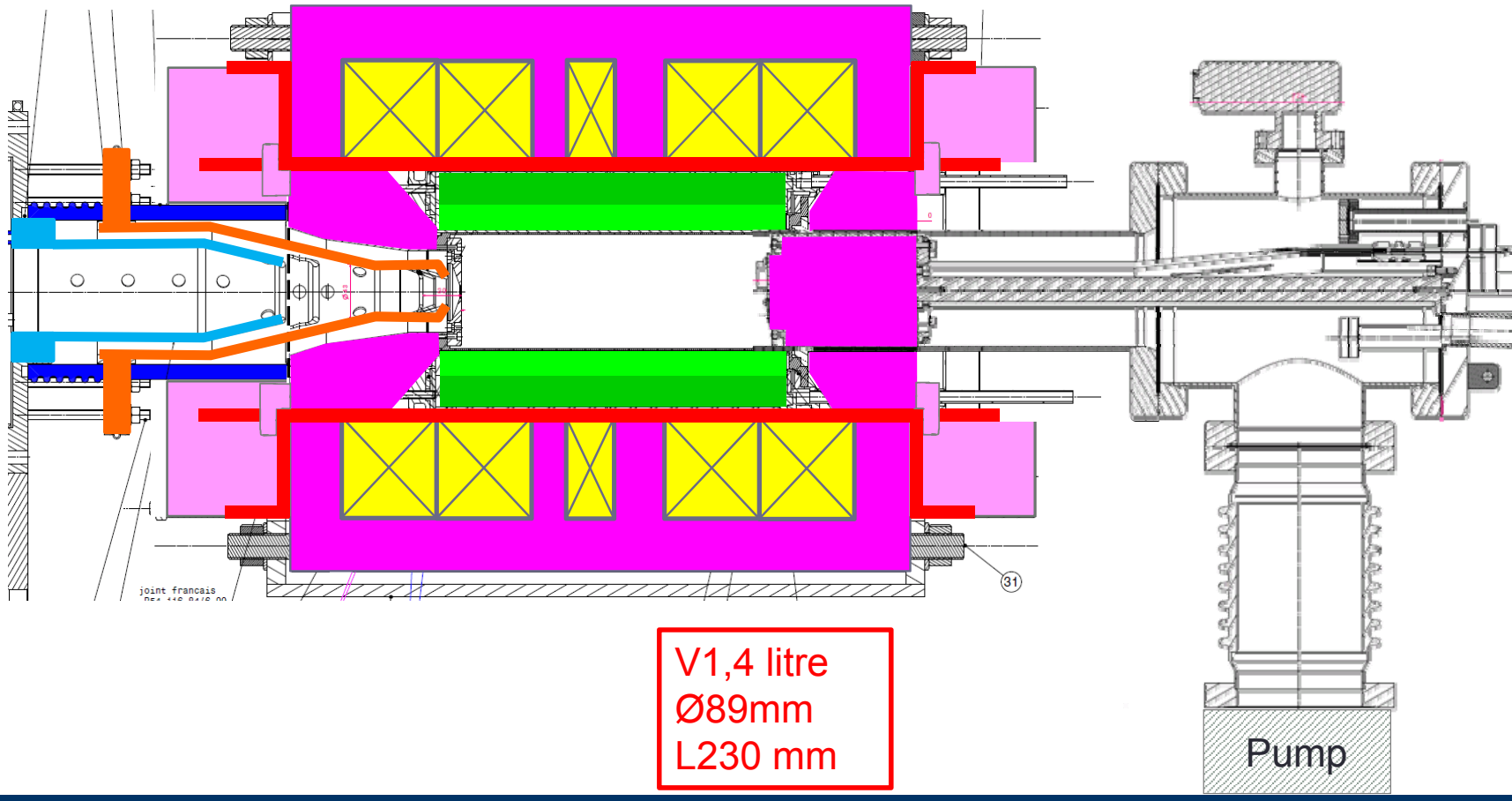
PHOENIX upgrade : V2→V3



PHOENIX upgrade : V2→V3

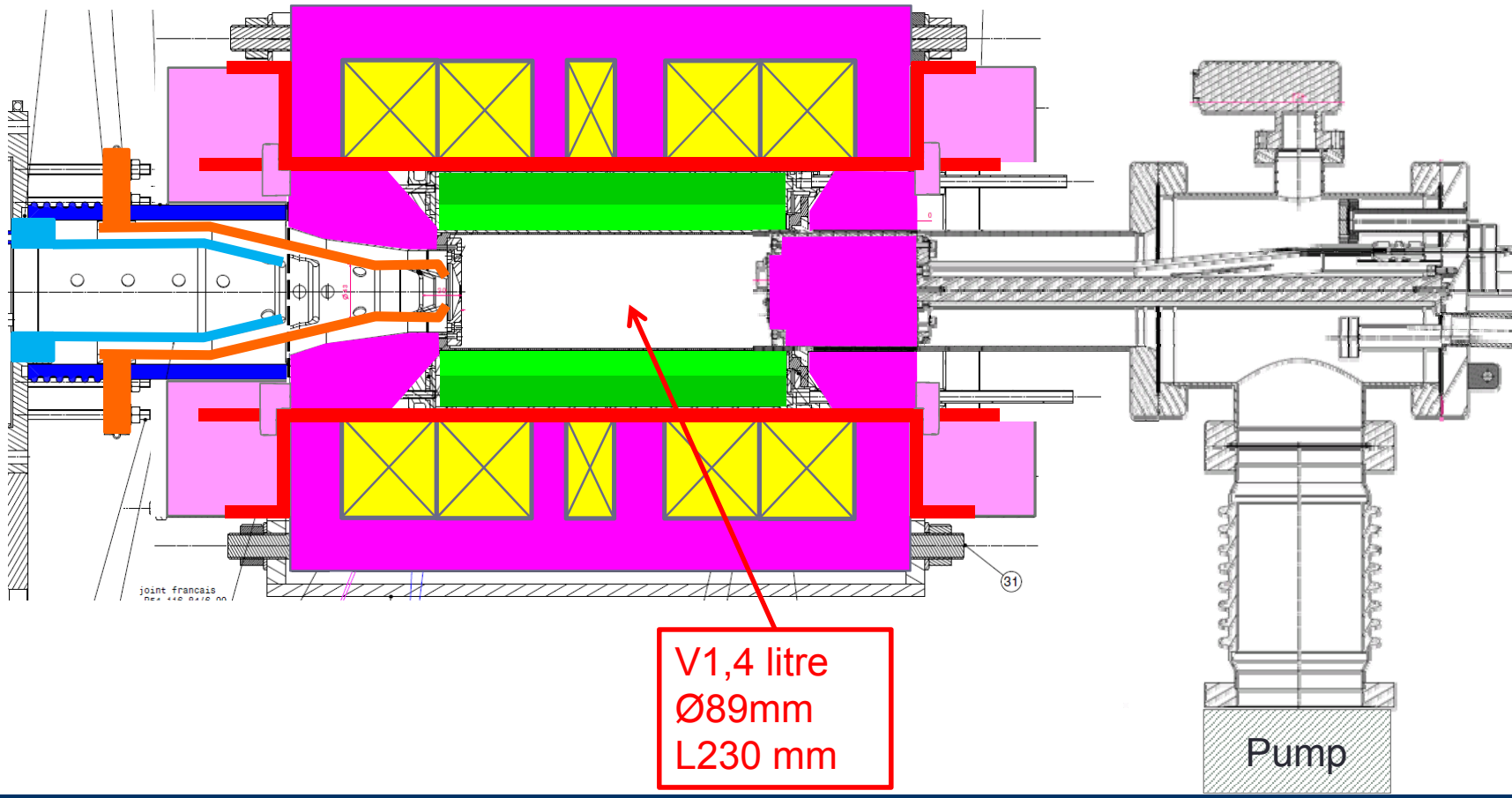


PHOENIX upgrade : V2→V3



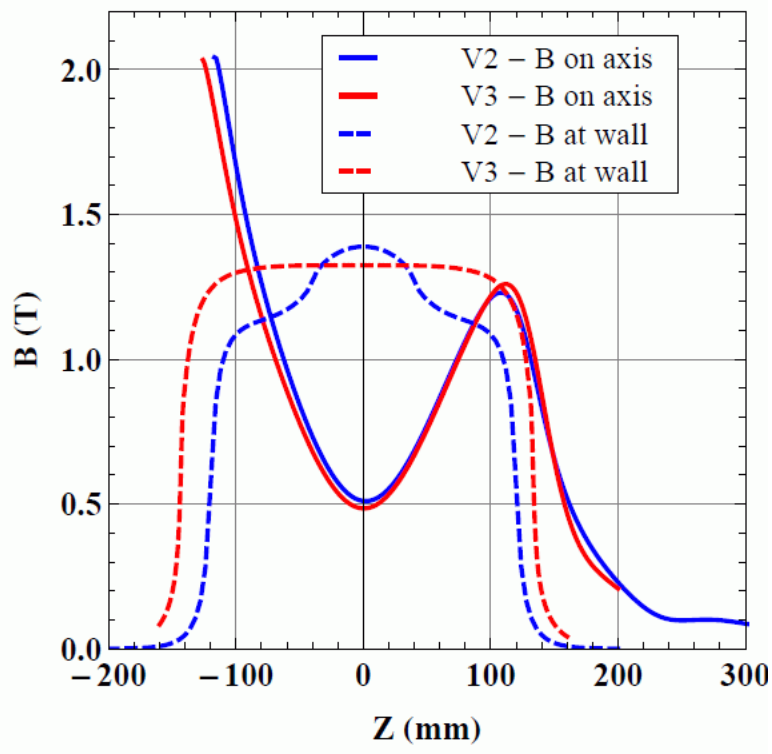
V1,4 litre
Ø89mm
L230 mm

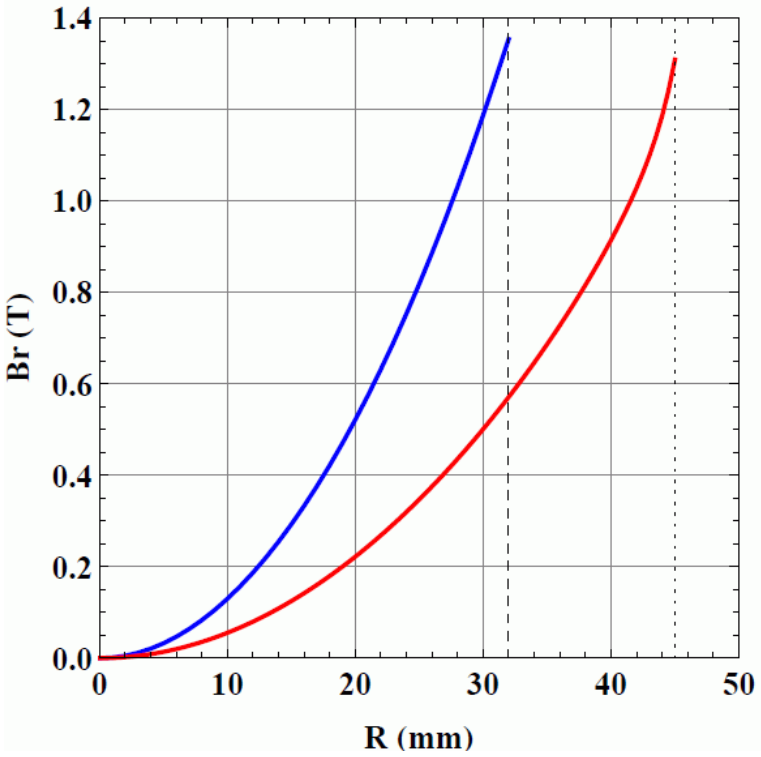
PHOENIX upgrade : V2→V3



Magnetic Field

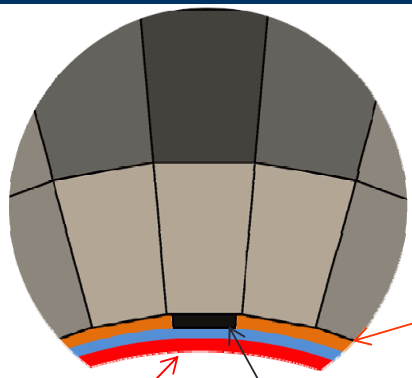
- Nearly an identical axial structure
- Almost a constant radial intensity at wall

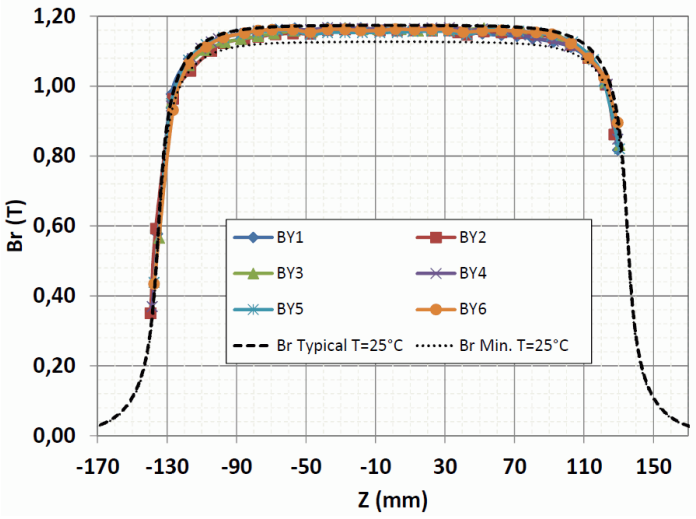


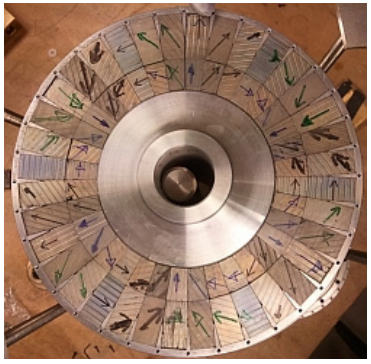


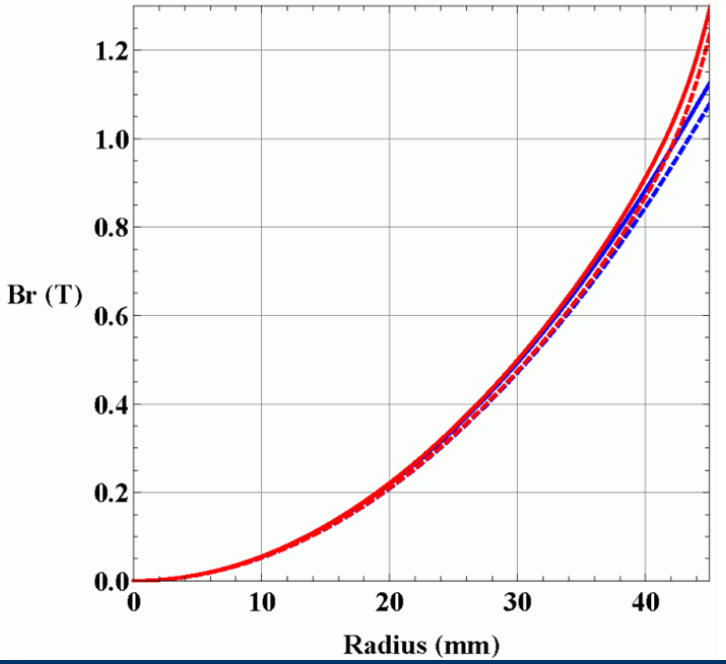
Hexapole

- Two configurations:
  - Bare hexapole Br~1.18 T
  - Iron strips to boost the field Br~1.25 T
- Nominal field measured



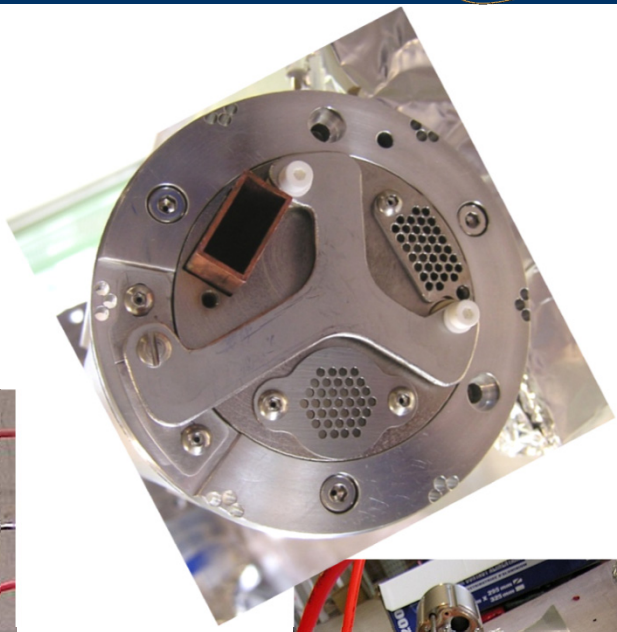


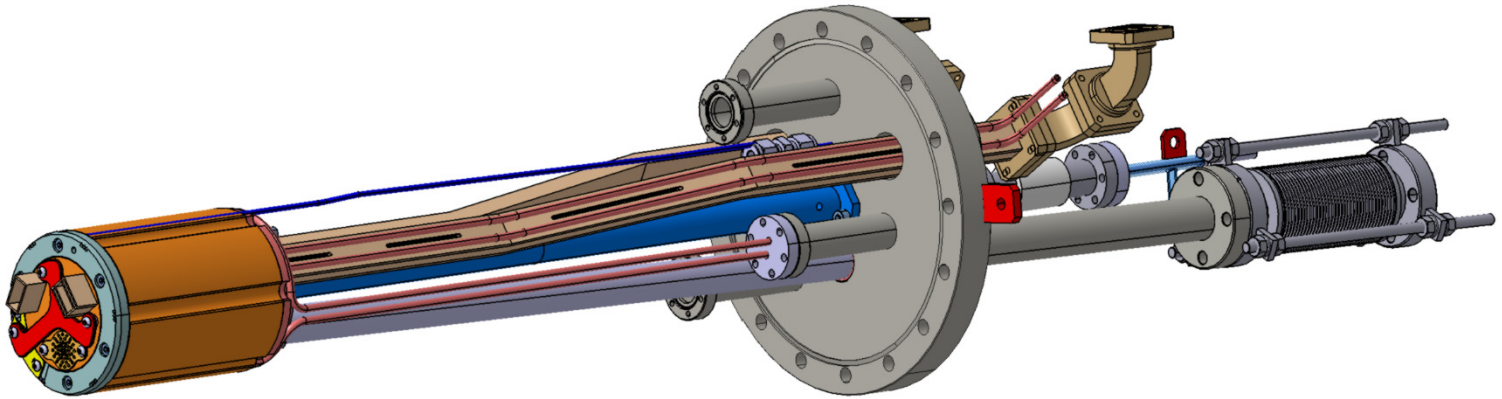


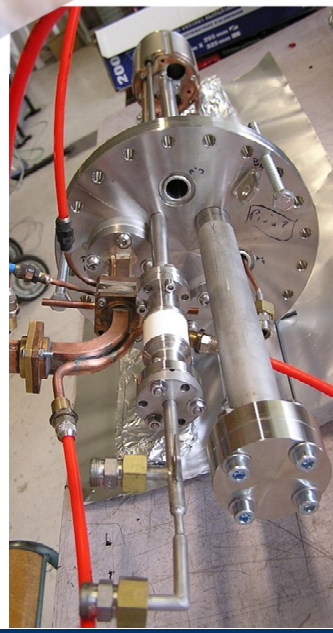


Mechanical hardware

- Injection assembly 1 (under test) :
  - Br~2T
  - Moderate pumping

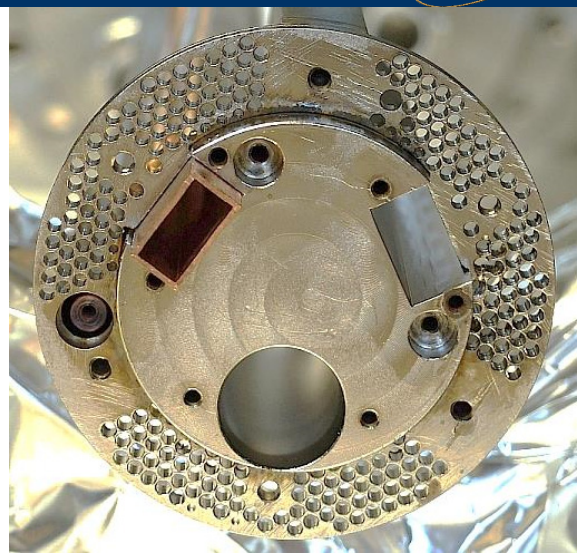


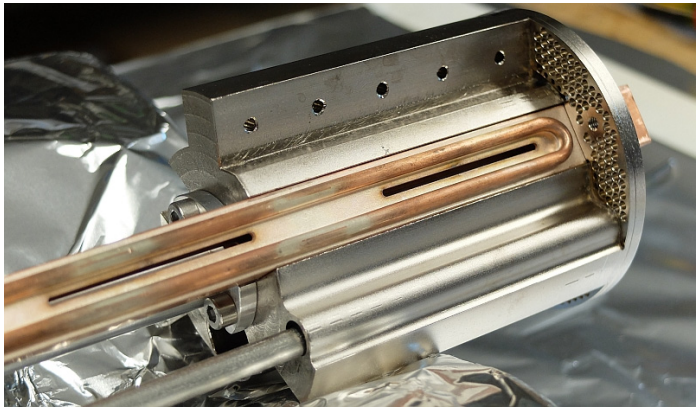


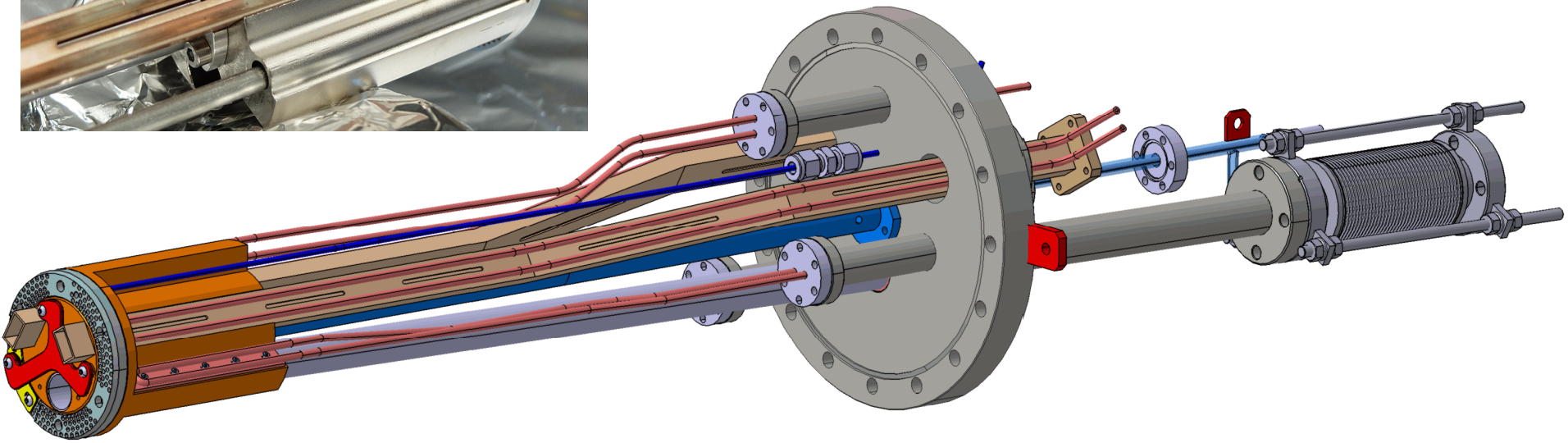


Mechanical hardware

- Injection assembly 2 :
  - Hollow iron plug Br~1.9 T
  - Enhanced chamber pumping

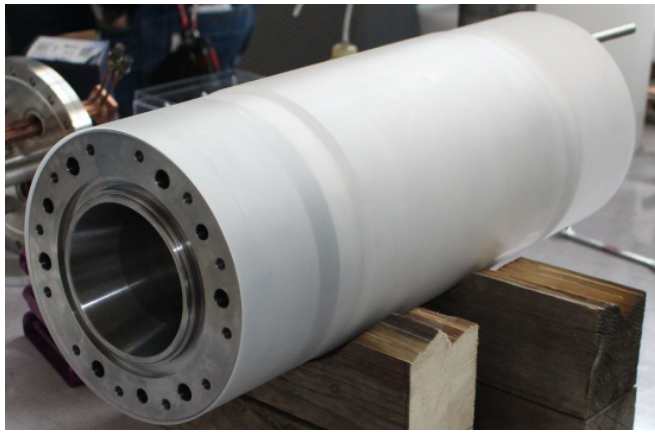


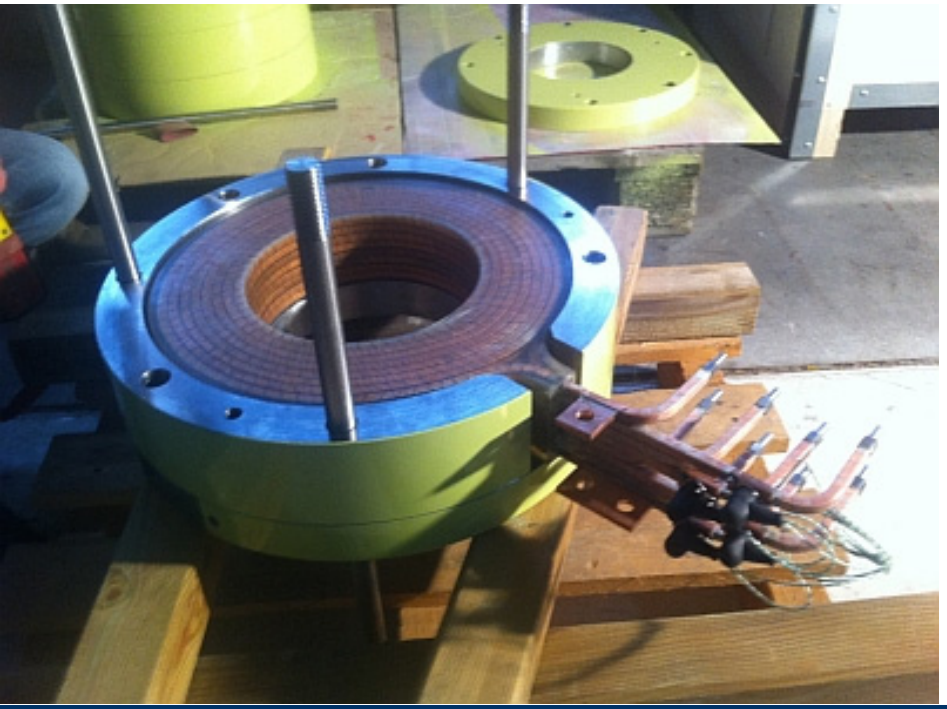


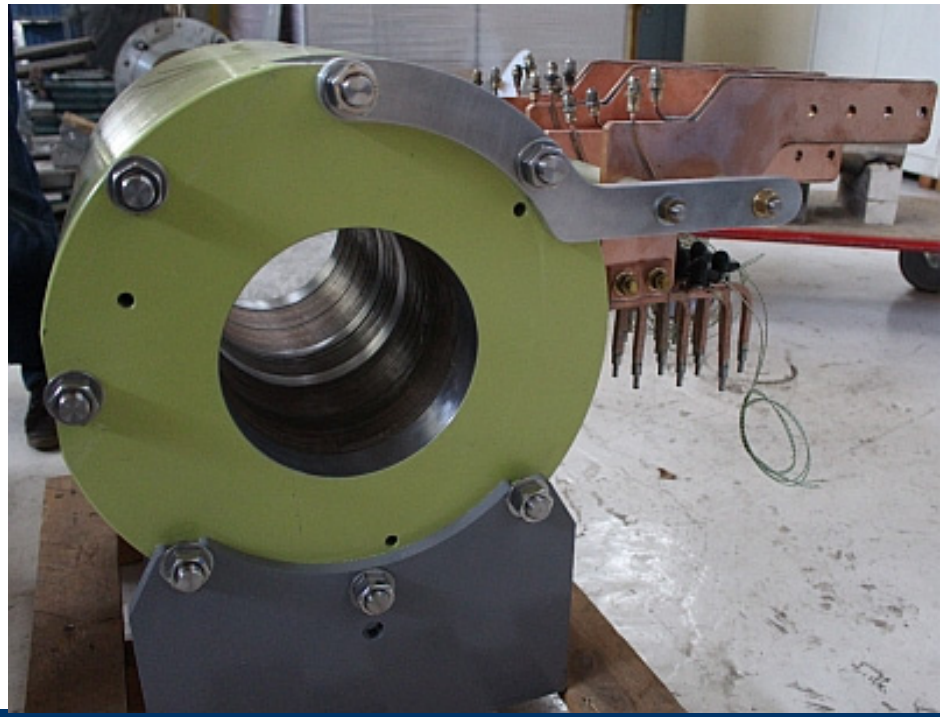


Source assembly

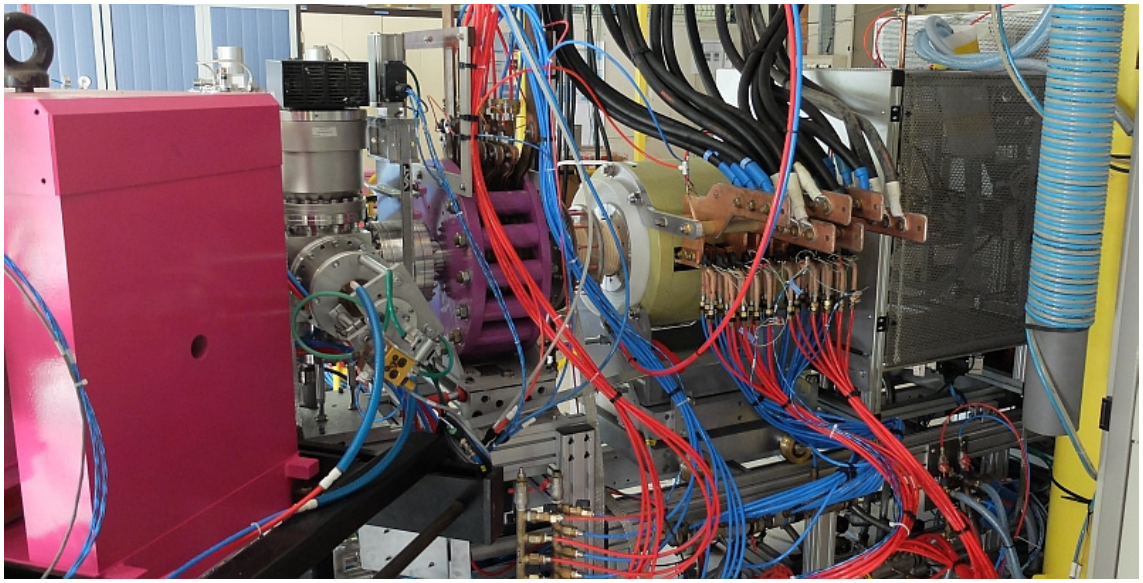
- Axial structure stack up
- HV core assembly in the insulator





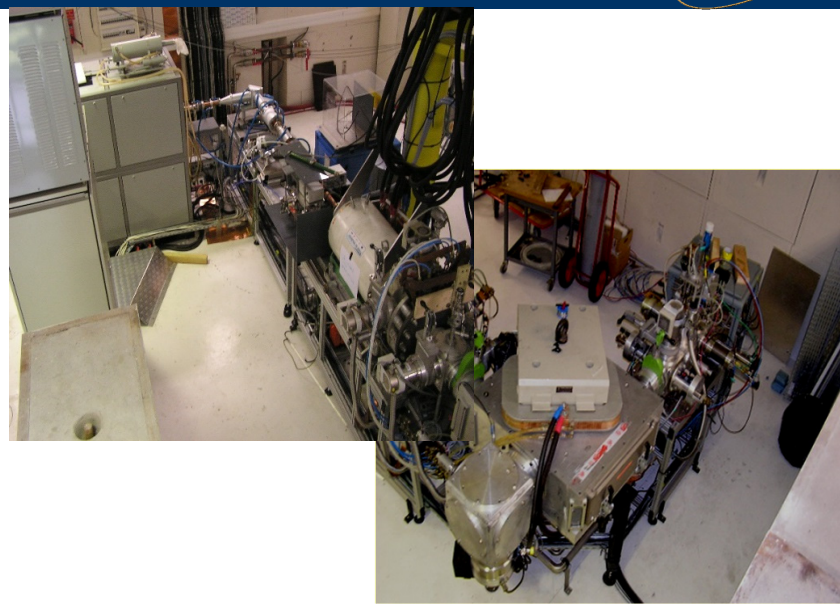


Source assembly



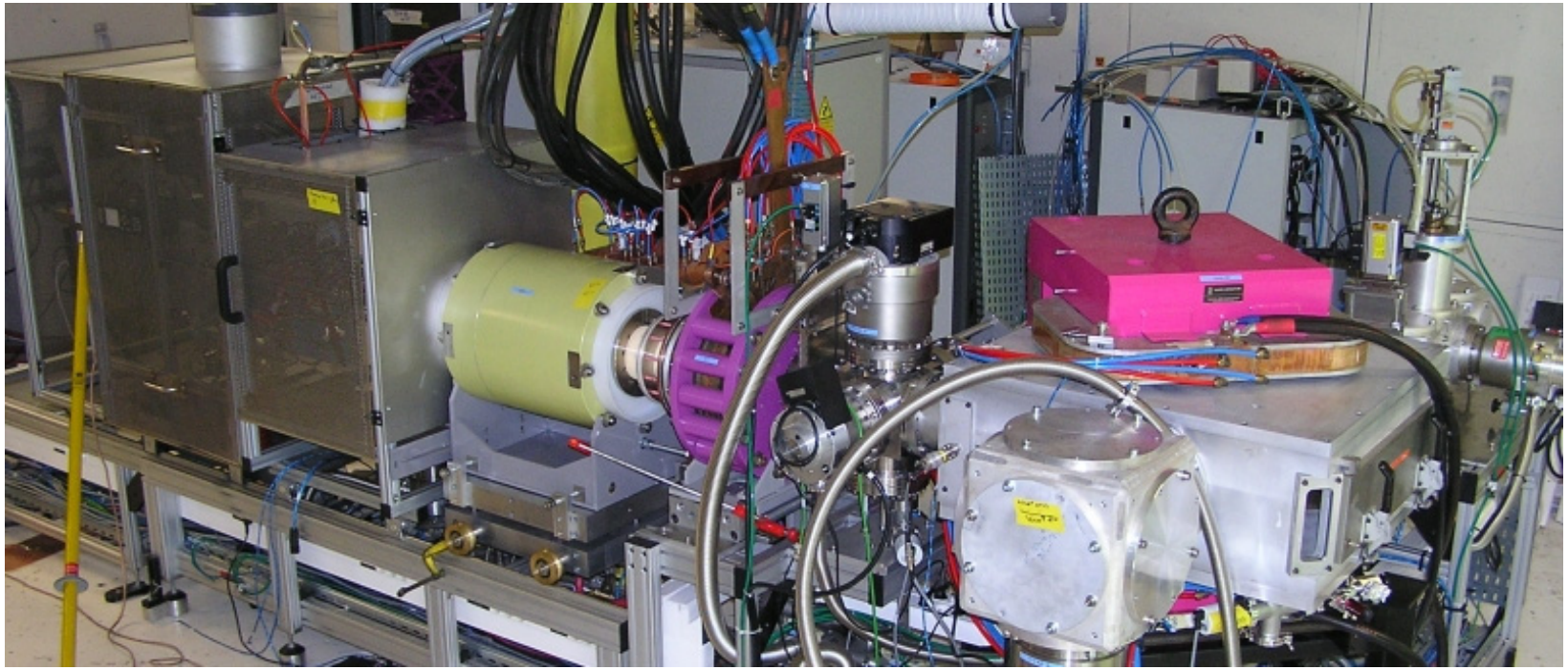
Difficult LEBT refurbishing

- Goal :
  - Clean the vacuum part to get rid of primary oil pump contamination
  - Improve the vacuum
  - Use dry scroll pumps
  - Improve beam optics
  - Rewire the whole LEBT instrumentation
  - Update the command control software
- Difficulties→ Large Delay
  - The LEBT industrial cleaning process turned into a nightmare
  - Aluminum corrosion (0.2 to 0.8 mm pitting)…
  - All the aluminum vaccum parts had to be resurfaced with sand paper!



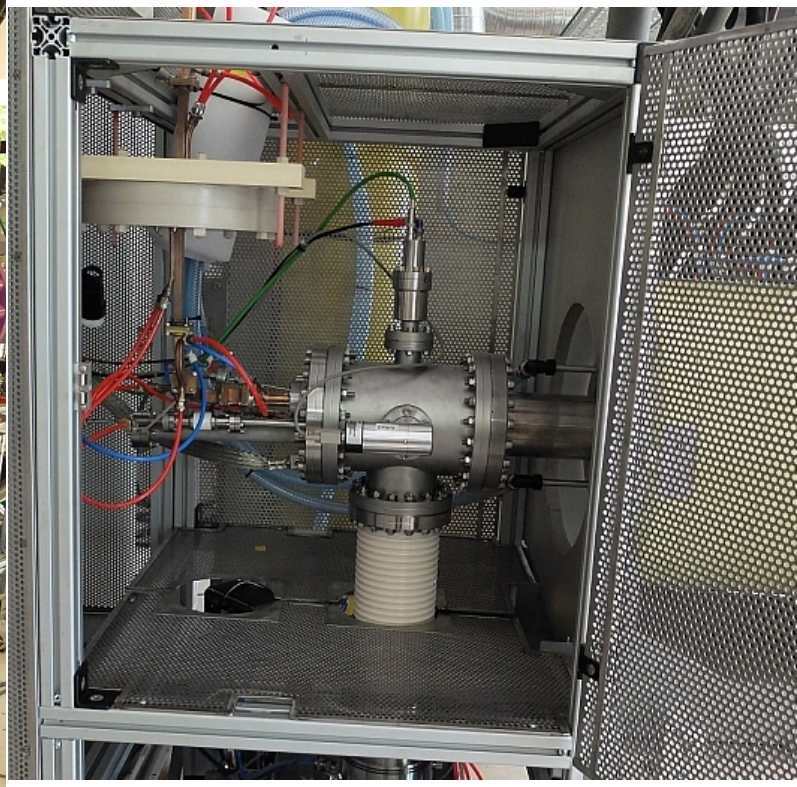
LEBT and source operational

- May 2016



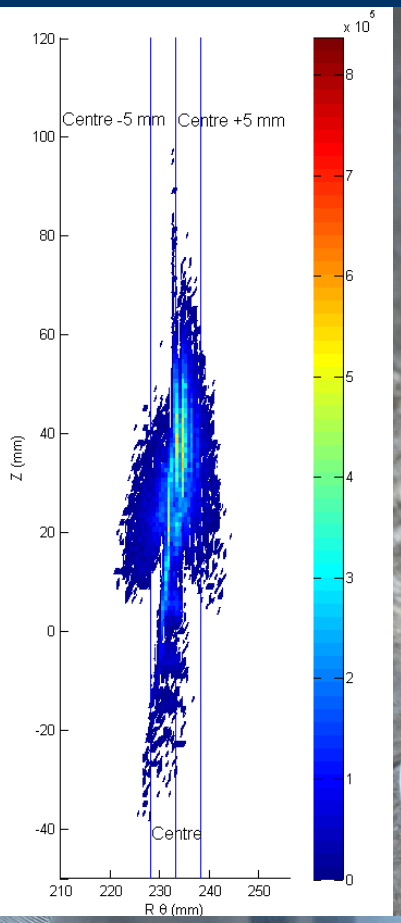
- Pressure at injection 2×10^{-8} mbar
- Pressure at extraction 6×10^{-8} mbar

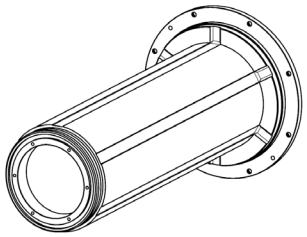
LEBT and source operational



Plasma chamber modification

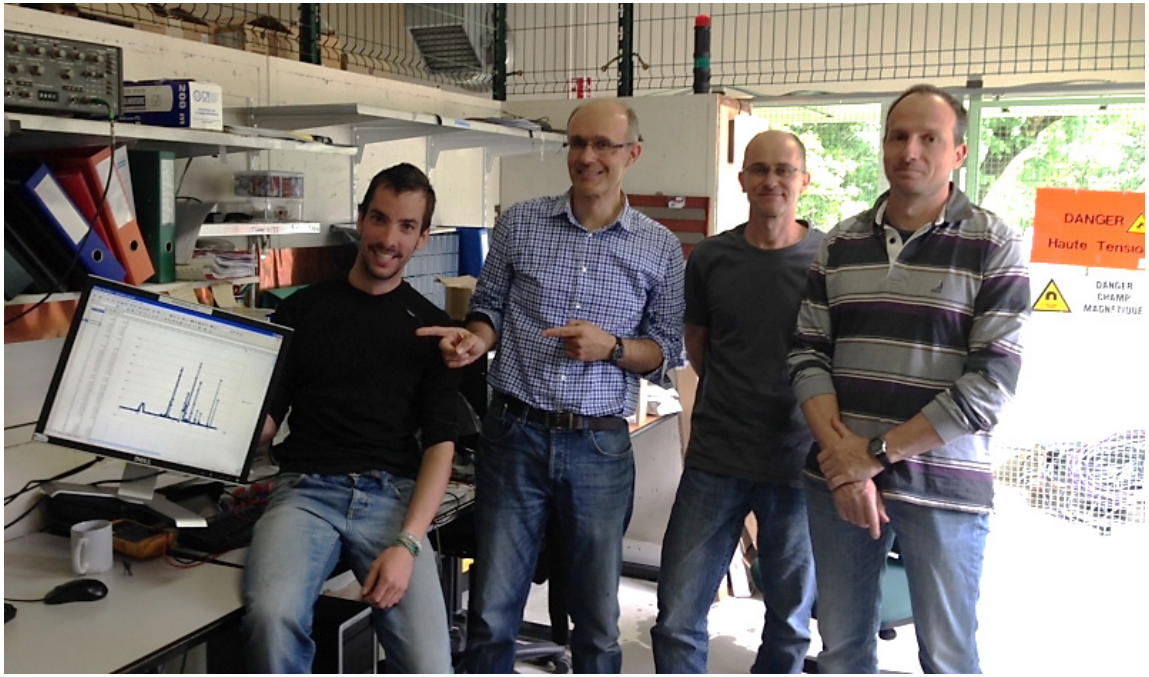
- A check before igniting the plasma revealed an insuficient water cooling of the chamber!
  - Experimental Water velocity was too slow
  - Re<2500 => laminar flow…
- Hot electrons simulation was done to locate the heat deposition
- The chamber mechanics was modified to increase the water velocity along the poles
  - 0.5x10 mm^2 slots
  - v=11 m/s in each channel
  - Re~10000 => definitely Turbulent



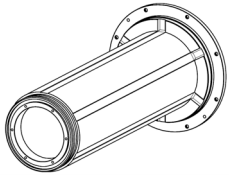


1st PHOENIX V3 plasma

- May, 9th 2016
  - 30 kV, low RF (to prevent any damage to the hexapole)



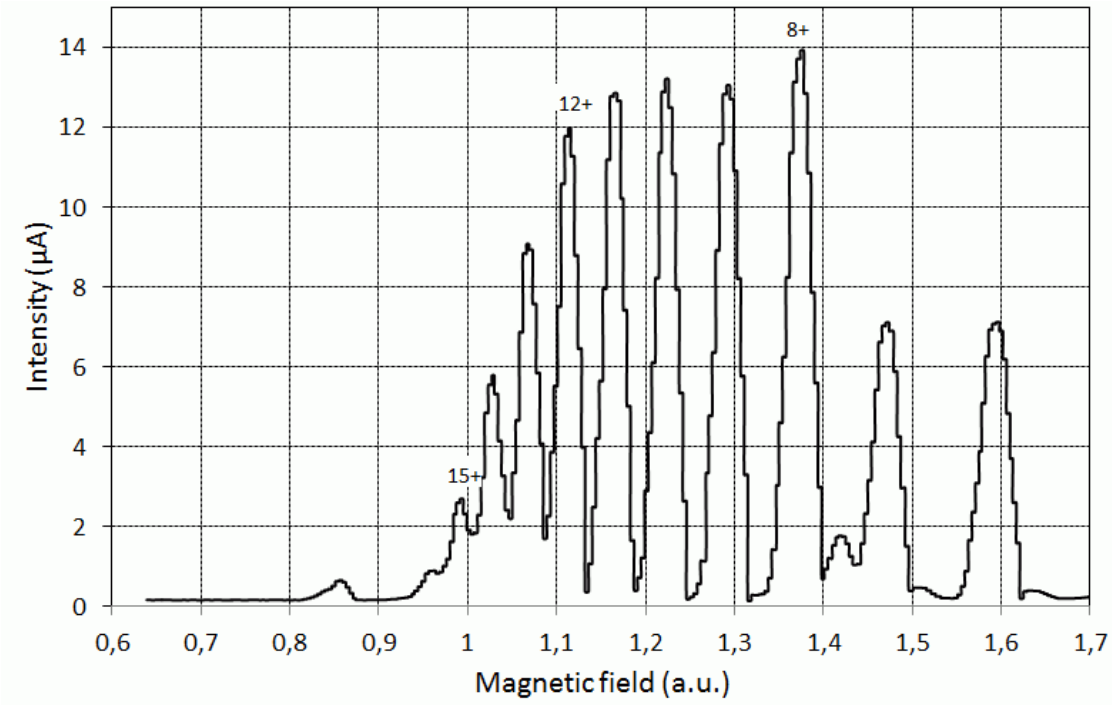
- New Plasma chamber installed in late July 2016
  - ~10 days of commissioning since



Low power commissioning under progress

- The source commissioning is normal so far
  - The RF coupling looks ok
  - The plasma mean charge state is enhanced with respect to V2
  - 45 kV reached (goal is 60 kV)

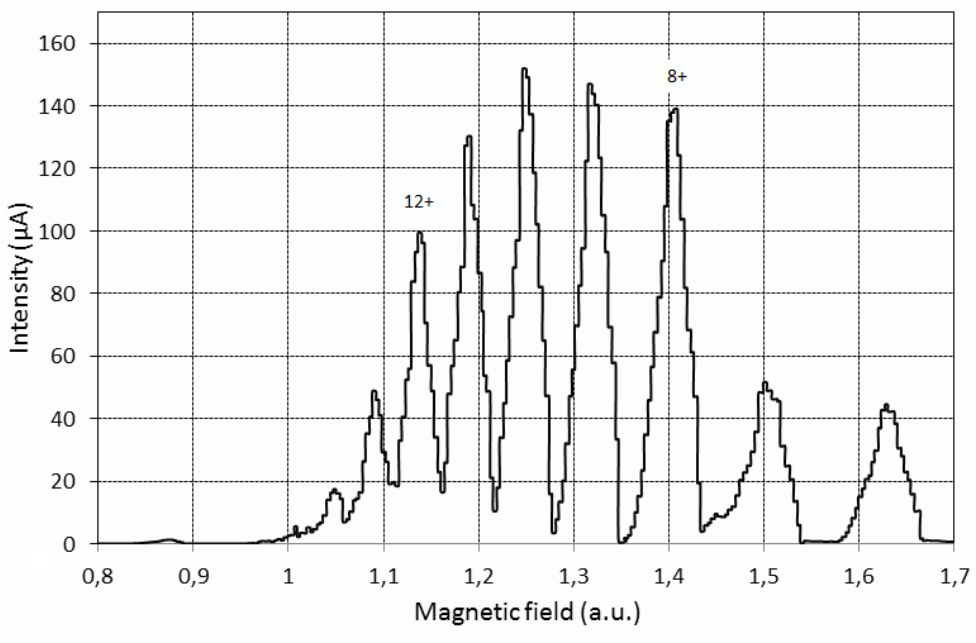
Argon spectrum – 180W RF – low pressure



Low power commissioning under progress

- The source performance is improving with time…
  - As of today @ 300 W RF: 110 µA Ar^{12+}, 450 µA Ar^{8+}, 400 µA O^{6+}
- Limitation by the 3 magnetic field power supplies
  - 35 years old , unused for 3 years, unable to deliver their nominal intensity (1100A instead of 1300A)
  - To be maintained soon

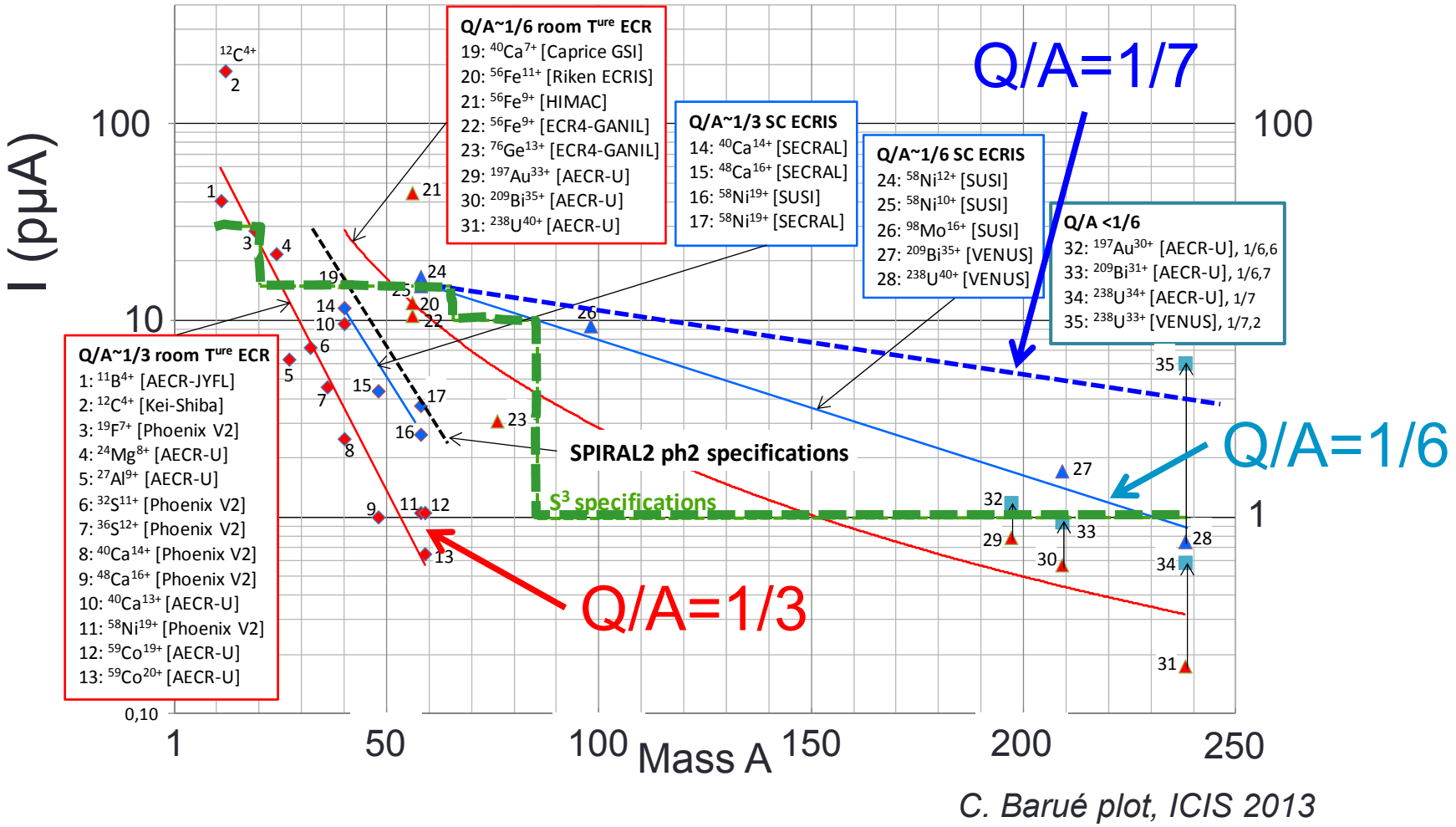
Finger crossed for the coming Tests!



THANK YOU FOR YOUR ATTENTION !

여러분의 관심 에 감사드립니다

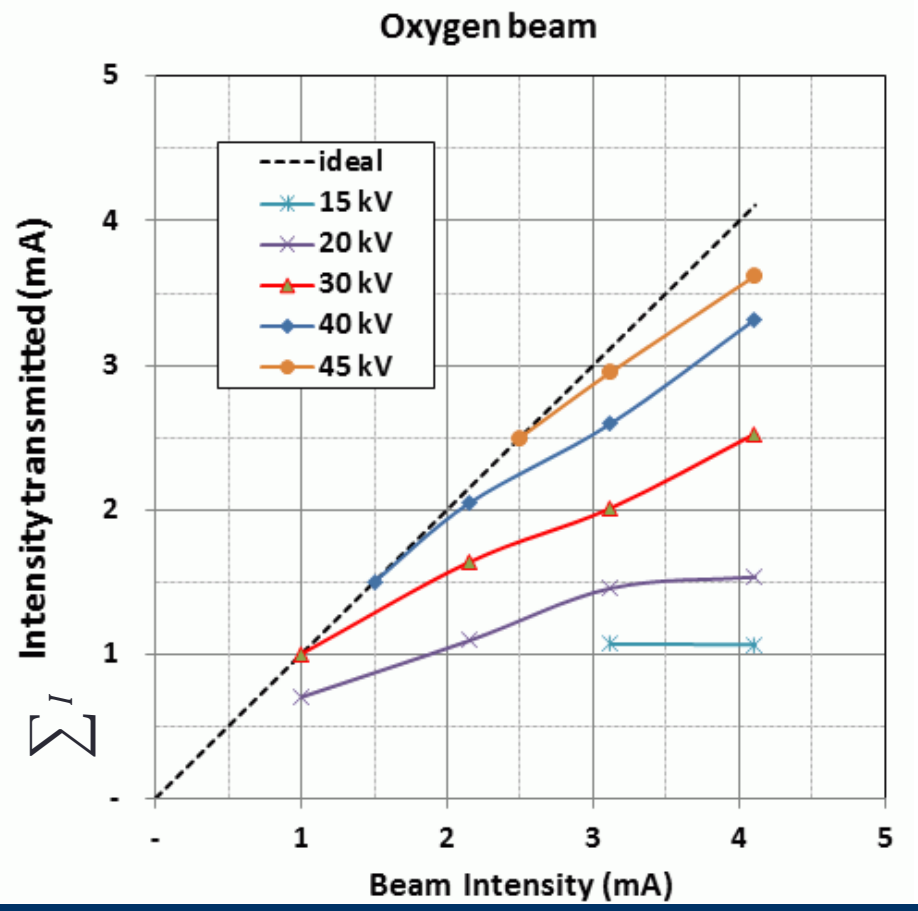
Updated beam requirements for S^3



C. Barué plot, ICIS 2013

LEBT transport investigation

- Oxygen « flat spectrum »



- High charge state transmission higher than low charge state
- An indirect evidence that high charge states are extracted on smaller radius