The GENEPI-3C accelerator for the GUINEVERE project

Maud Baylac, LPSC-Grenoble (France),

International topical meeting on nuclear research applications & utilization of accelerators, Vienna (Austria), May 4-8, 2009

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CNRS/IN2P3, France *SCK-CEN, Belgium* *CEA/DEN, France*

The GUINEVERE project

Generator of Uninterrupted Intense NEutrons at the lead VEnus Reactor

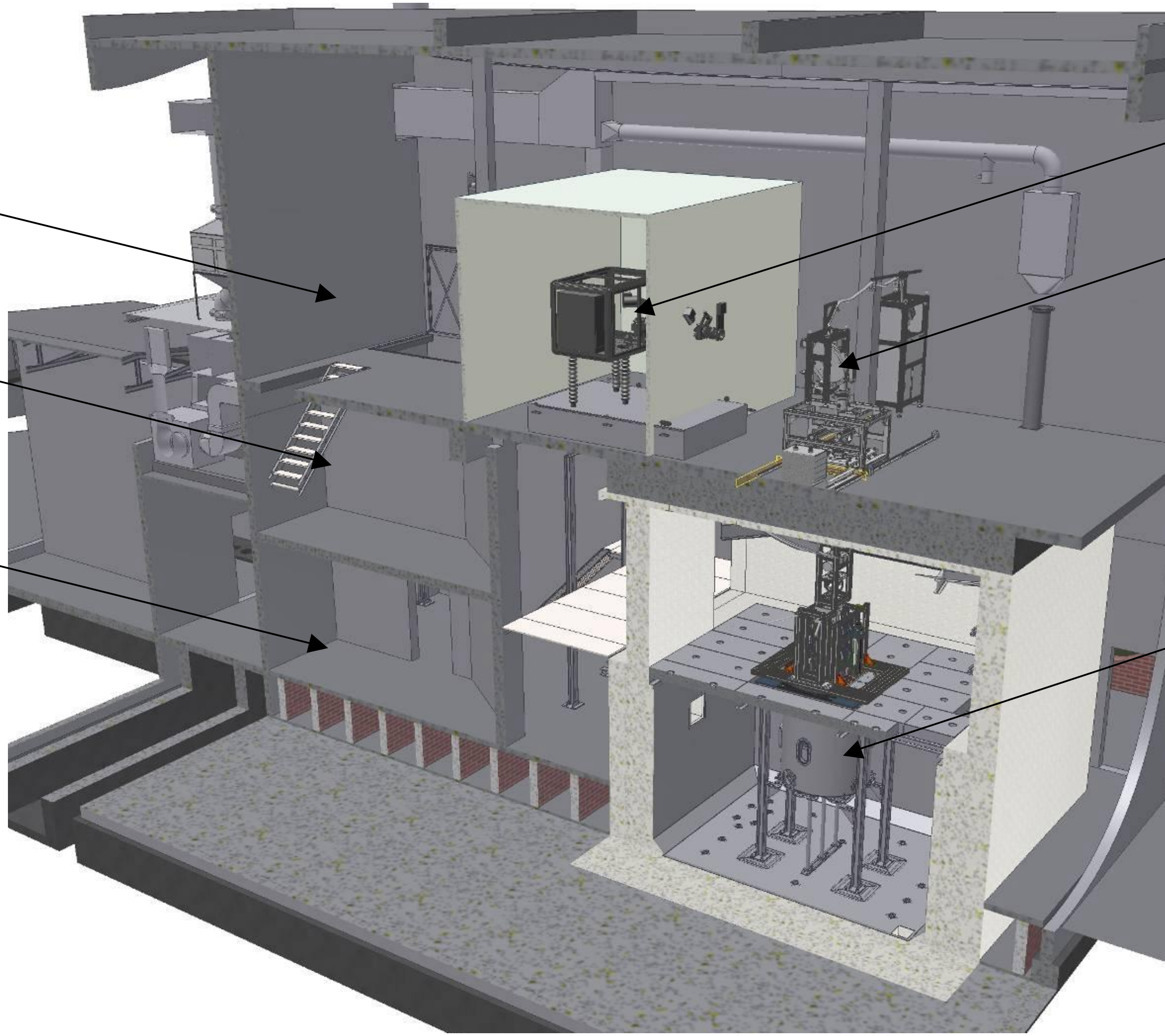
- Part of the Program IP-EUROTRANS (FP6), DM2 ECATS
- Provide a system representing an ADS demonstrator, continuing the MUSE-4 experimental program (FP5)
- Investigate on-line reactivity monitoring, sub-criticality determination & operational procedures in an ADS
- Collaboration CNRS/IN2P3 (France), SCK•CEN (Belgium) & CEA (France)
- **Zero(low)- power coupling of**
  - **a fast lead core reactor, VENUS-F**
  - **a neutron source, GENEPI-3C**

GUINEVERE's keypoints

- **Improving from MUSE4/GENEPI-1, new specifications**
  - **Vertical coupling**
  - Neutron source operated in **both pulsed and continuous mode**
- **Construction of a new neutron source (CNRS/IN2P3) : GENEPI-3C**
  - Intense & short pulses
  - Continuous operation with programmable beam interruptions
  - Mobile vertical beamline to be inserted into the core & out
- **Reactor (SCK•CEN) : VENUS-F**
  - Modify the water-moderated VENUS into a solid lead core
  - Fuel and lead rodlets provided by CEA (Cadarache)
  - Adapt building to accomodate the accelerator above the reactor

Talk given by A. Billebaud, Satellite meeting SM/ADS-08

GENEPI-3C coupled to VENUS-F



GENEPI-3C beam specifications

- **GEnerator of NEutrons Pulsed & Intense**
  - Electrostatic Deuteron accelerator (240 keV)
  - Neutron (14 MeV) production via $T(d,n)^4He$

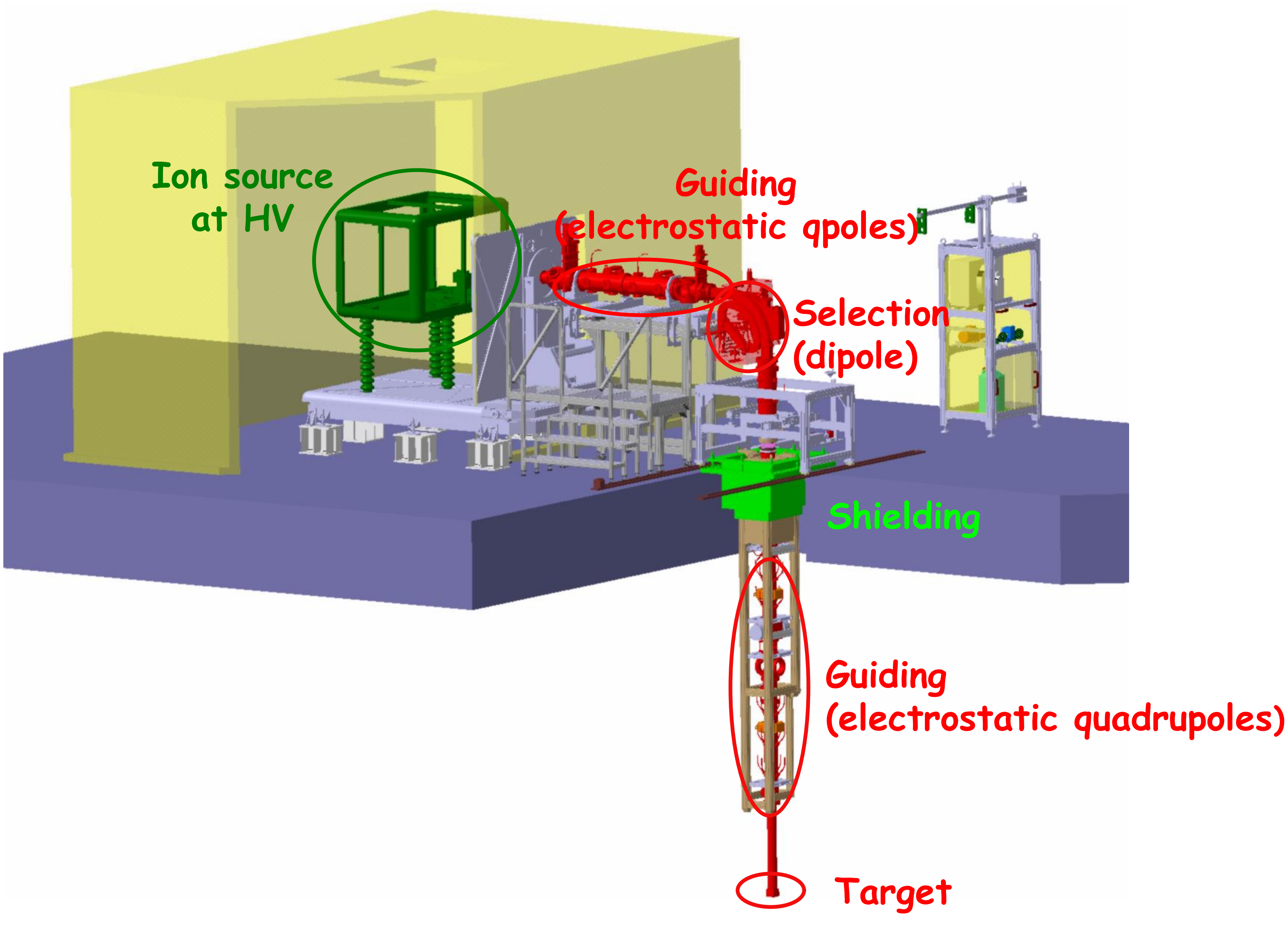
- Accelerator capable of producing **alternatively**
  - **Intense pulsed mode**
    40 mA peak current
    FWHM < 1 µs
    repetition rate : 10-5000 Hz
  - **Continuous mode**
    DC beam
    programmable beam trips

DC mode

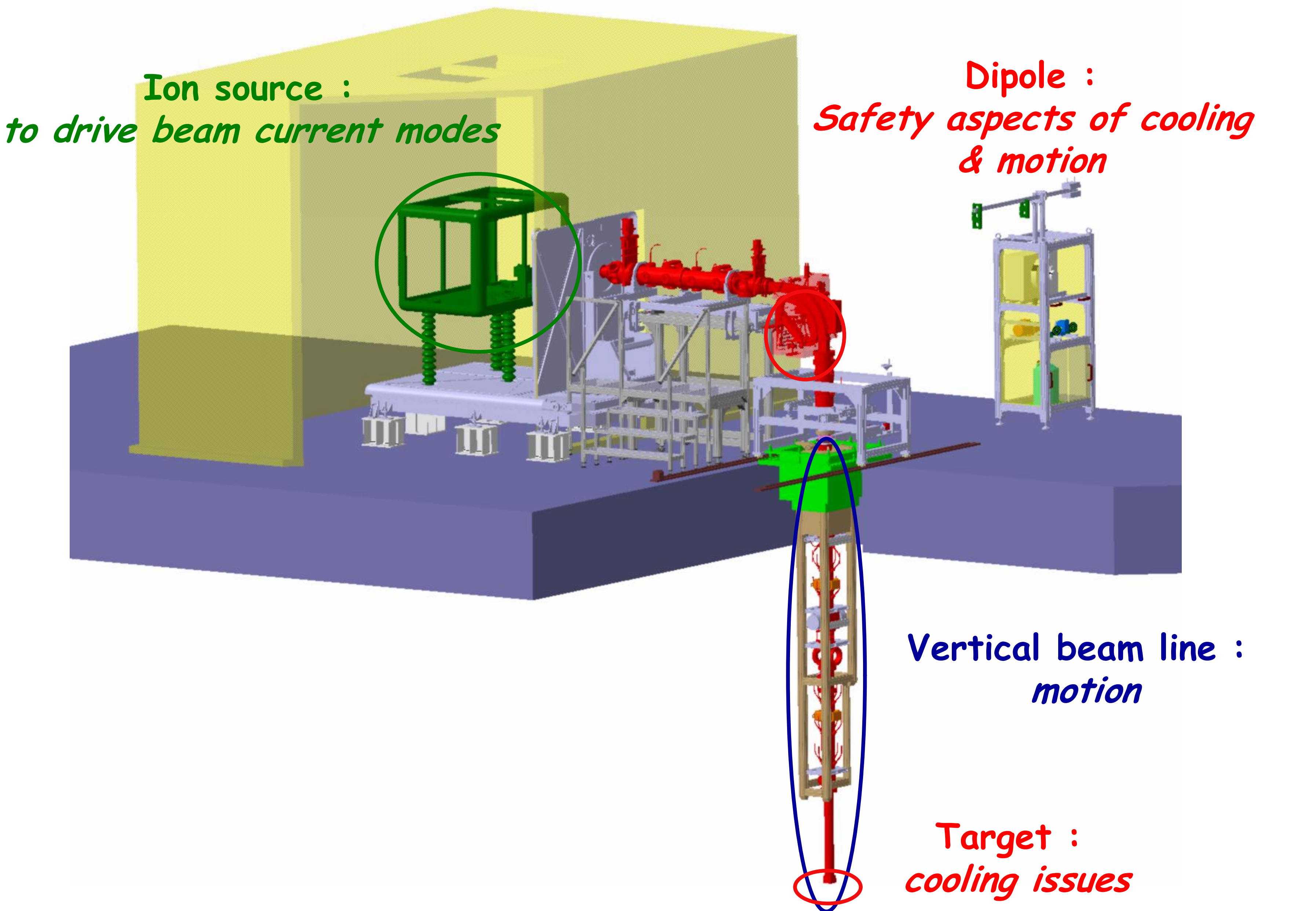
Mean current	160 µA to 1 mA
Beam trip rate	0.1 to 100 Hz
Beam trip duration	~ 20 µs to 10 ms
Transition edge	~ 1 µs
Beam spot size	Φ ~ 20-40 mm
Maximum n rate	$\sim 5\times10^{10}$ n/s
Pulse stability	~1%

- **Designed & built by CNRS/IN2P3 collaboration**
  IPN Orsay – LPC Caen – IPHC/DRS Strasbourg – LPSC Grenoble

Accelerator design



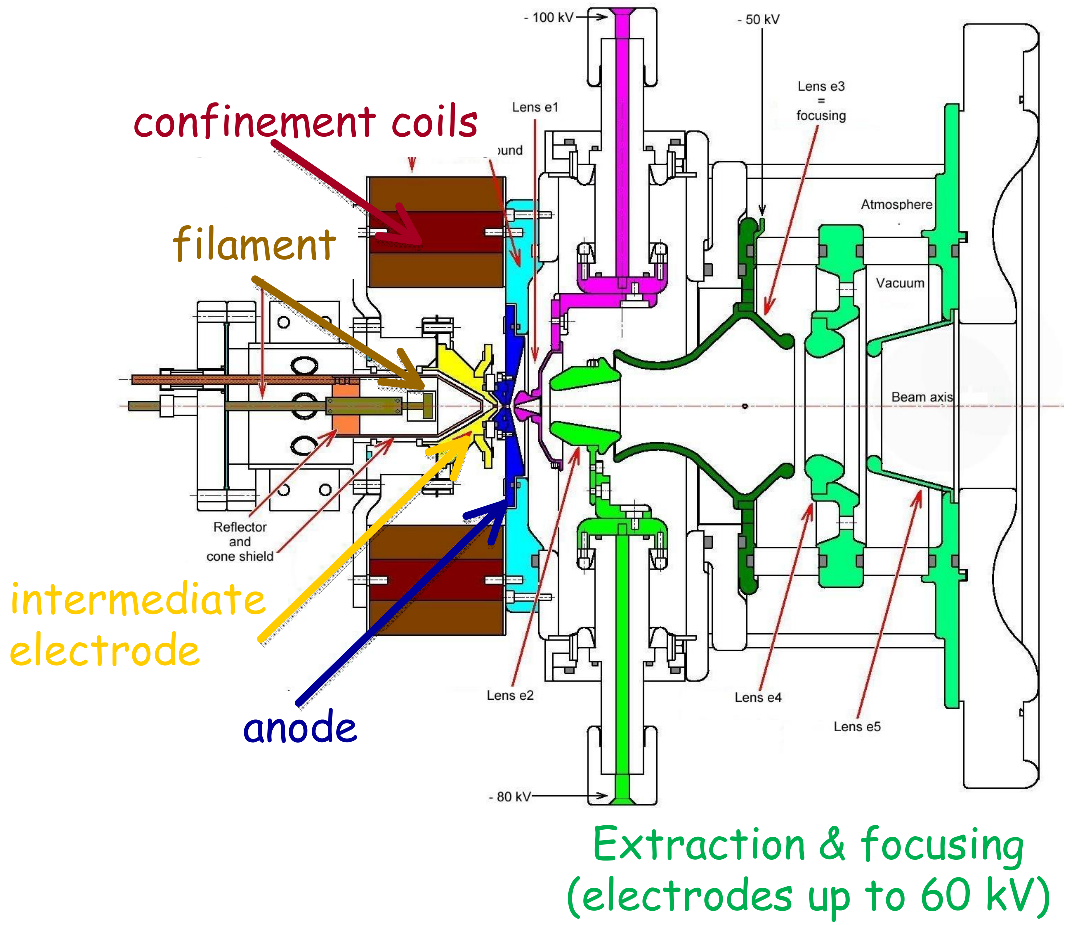
Accelerator specifities

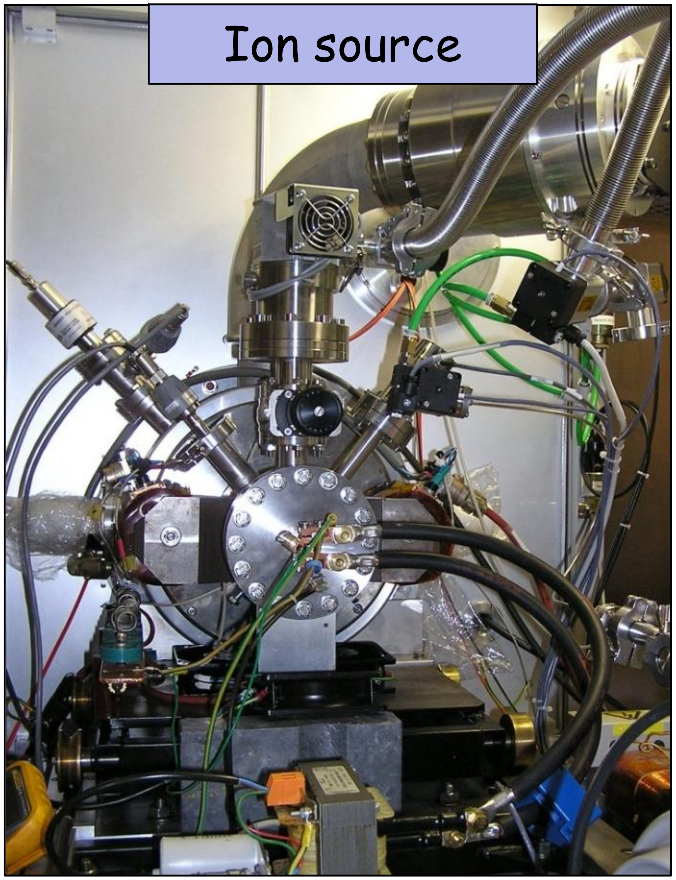


Ion source

- **Duoplasmatron** source to generate D⁺ beam
  - Well adapted for pulsed mode

- Goal : **one single source** to produce all current modes

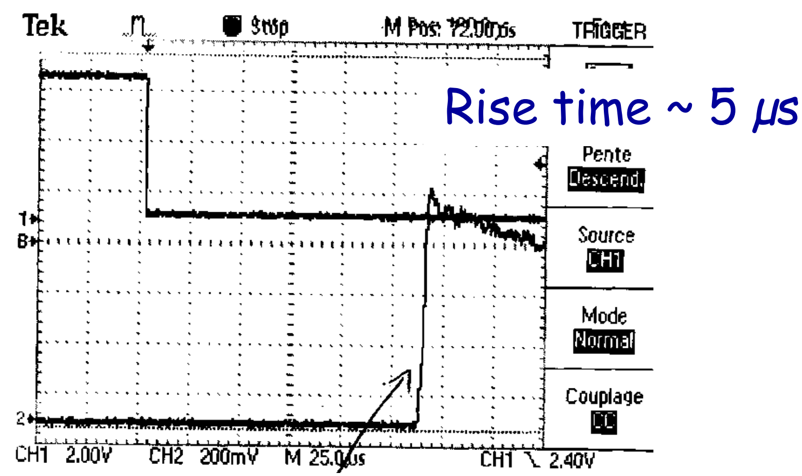


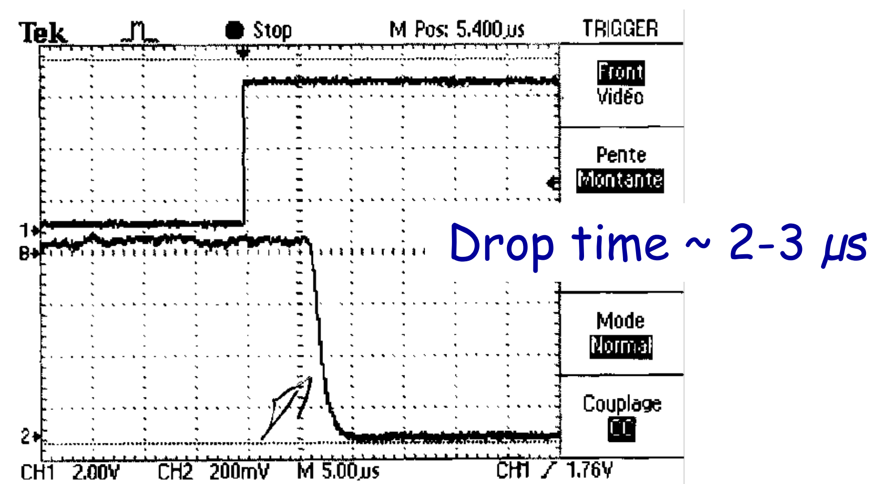


Ion source developments

- R&D on dedicated test bench to meet DC mode requirements
  - ionization efficiency for DC operation ~ 40%

- Main specifications reached
  - ✓ 1 mA D^+
  - ✓ beam interruptions
  - ✓ transitions ON/OFF ~ μs
  - adjustable trip rate : underway





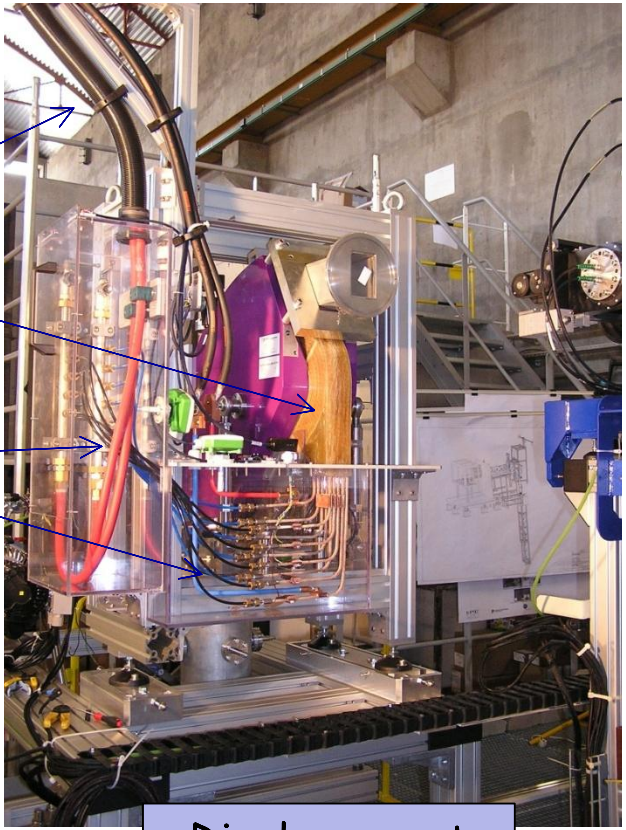
Dipole magnet

- Deflect the beam towards core & perform magnetic separation
- Magnet features : C design, 0.5 m radius, 0.2 T, 30° faces
- Translation system for dipole + short V line
- Water cooled with stringent precautions against leaks

  - Deported cooling unit
    away from bunker penetration

  - Coil, cooling system waterproof
    fiber glass ribbon & epoxy resin body

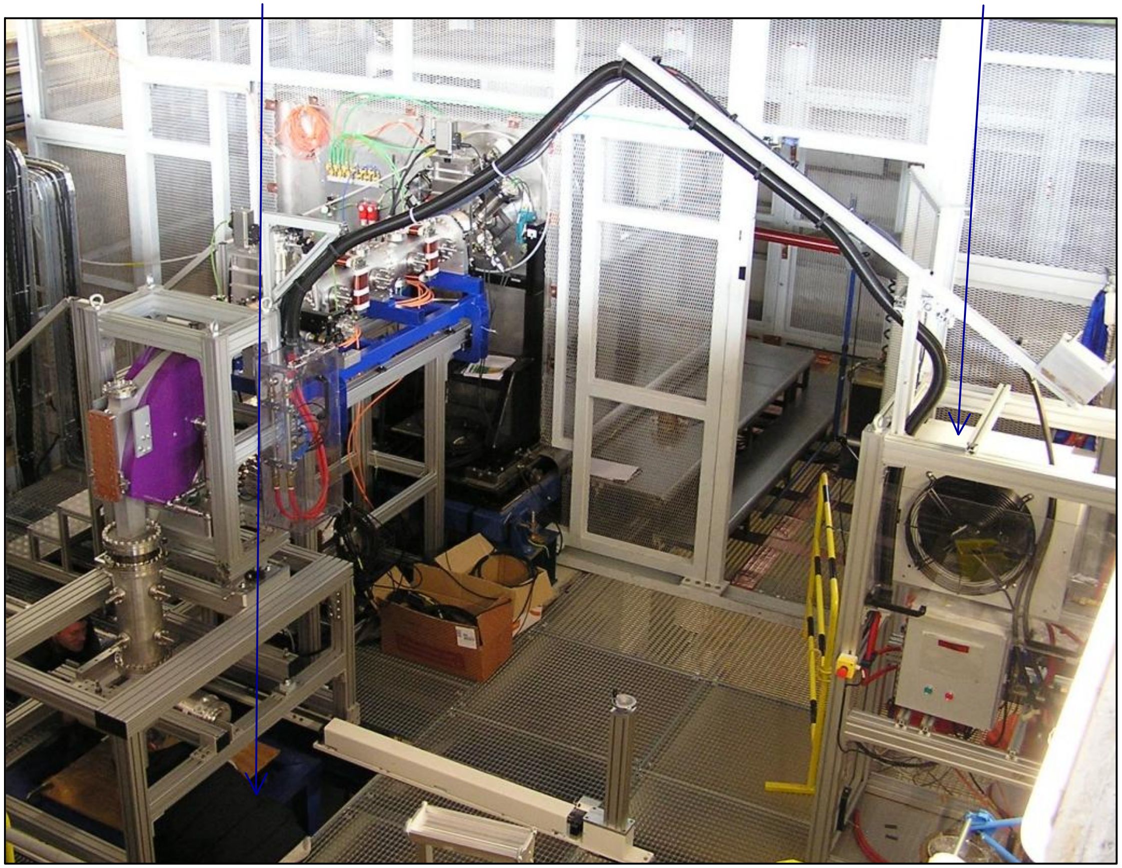
  - Water & electrical connections
    waterproof casing with leak detection



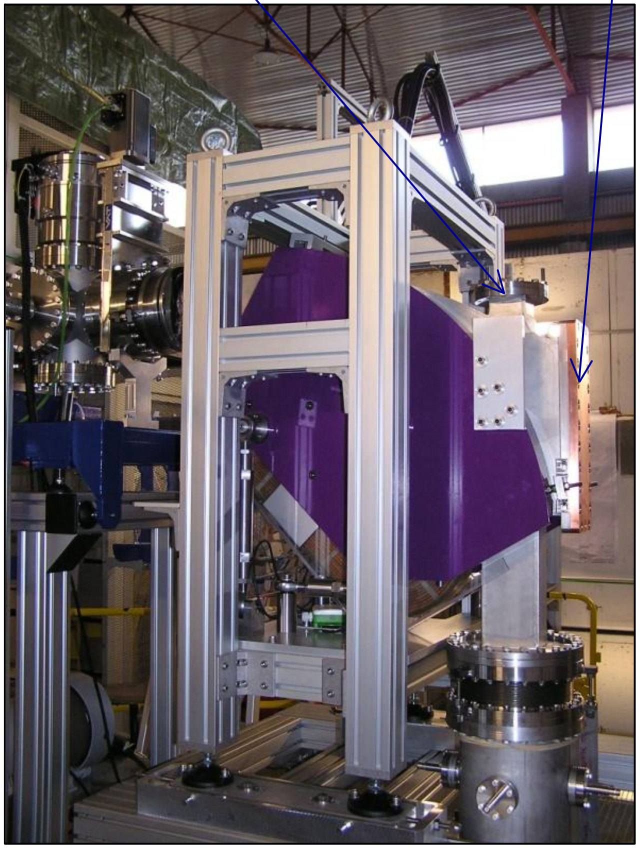
Dipole magnet
(out position)

Dipole magnet

- Ion collector connected to the chamber (D_2^+, D_3^+ out of source)
- Proton recoil telescope facing the target



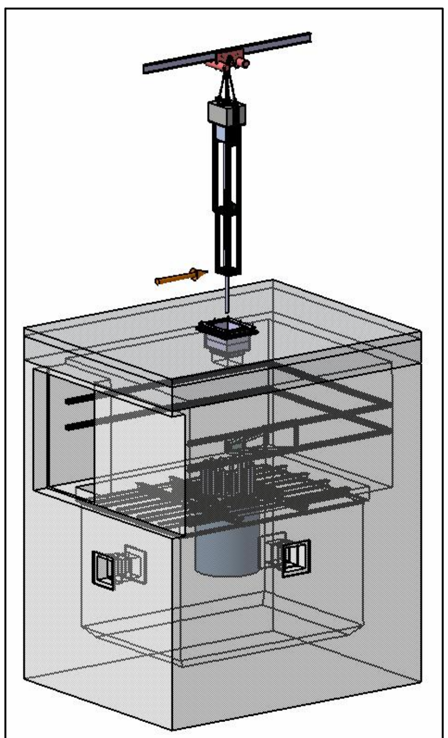
Dipole (in position) & cooling system

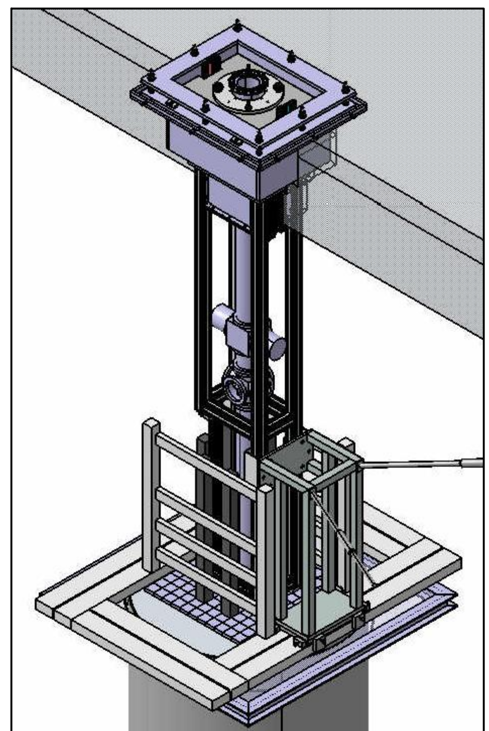


Dipole magnet

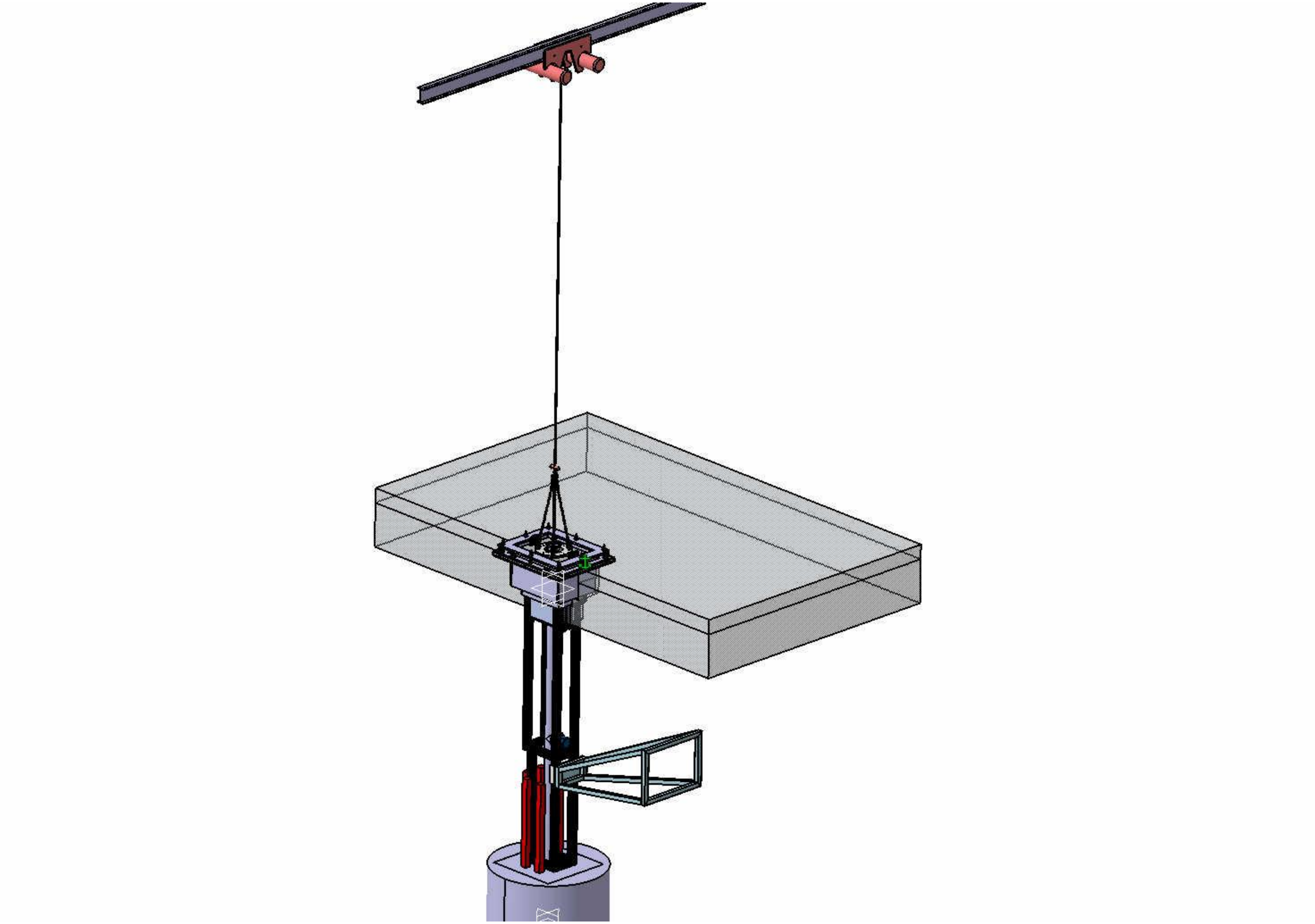
Beam line insertion

- Target within the thimble to be inserted at core center
- Machine sections mobile for periodic target changes & core maintenance
  - Dipole magnet to grant access to the V line
  - Vertical beamline to be lifted up
- Line & shielding embedded in support structure, guided upper & lower level

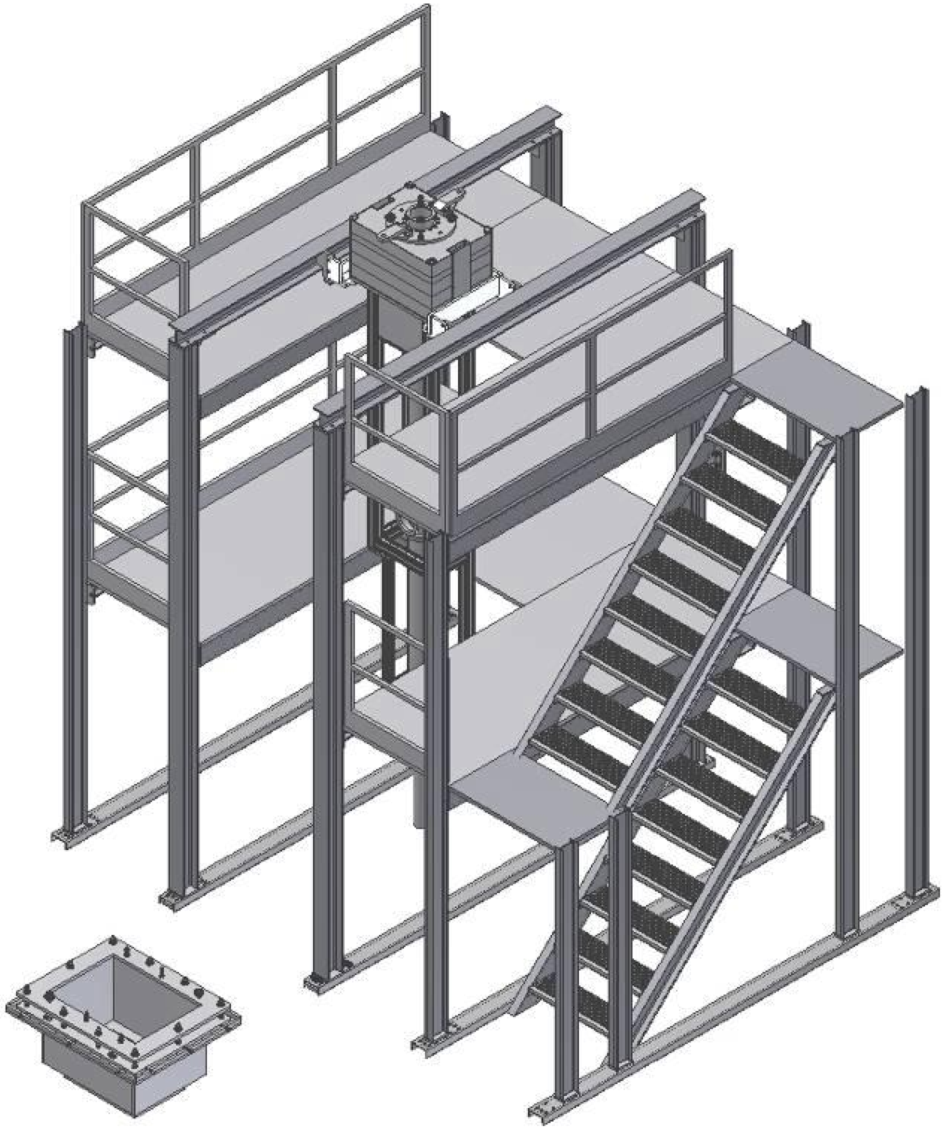




Vertical beam line motions

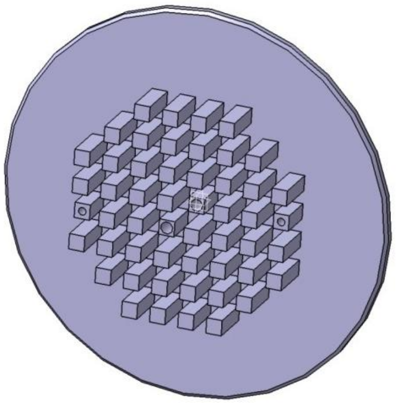


Vertical beam line storage



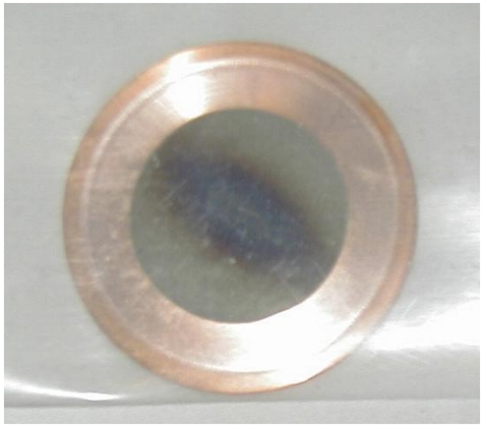
Tritium target

- Target holder : copper disk



- **Material:** high purity copper OFHC
- **Diameter:** 60 mm
- **Thickness:** 1.5 mm
- **Back side:**
    - -Pin fin size: 2.4x2.4x7 mm^3
    - -Diameter of pin area: 40 mm

- Thin layer of TiT (12 Ci)



- **Titane deposit:** 1100 $\mu g/cm^2$, **diameter:** 40 mm
- **Tritium loading (by impregnation):** 12 Ci
- **Titanium hydride** ρ=4.2 g/cm^2
- **T/Ti** ~ > 1.5

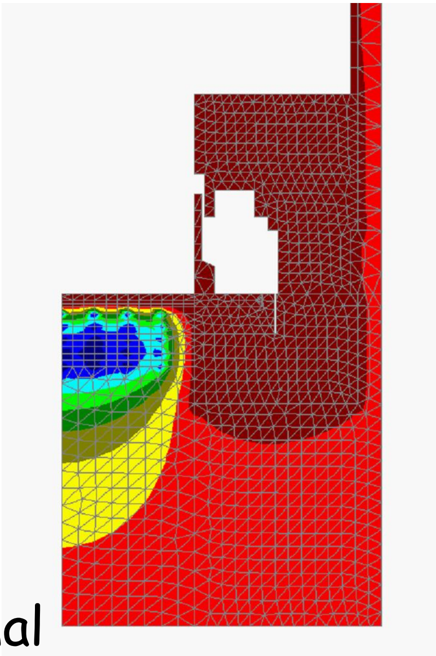
- Mounted on beamline termination (thimble)

Target cooling

- **Requirements**
  - Beam power to be evacuated **up to 250 W (DC mode)**
  - Reactor core not cooled : T~45° during operation
  - Temperature to be kept minimal to limit T desorption (<100 ° C)
  - **Hydrogen forbidden within core** (neutron slowdown in fast core)
  - Limited room available for cooling (2x2 FA)

- **Cooling system developed based on compressed air**
  - Cooler & drier system (6 bars)
  - Diffuser at target's back fed by 4 inlets
  - Simulations show that with adapted beam size

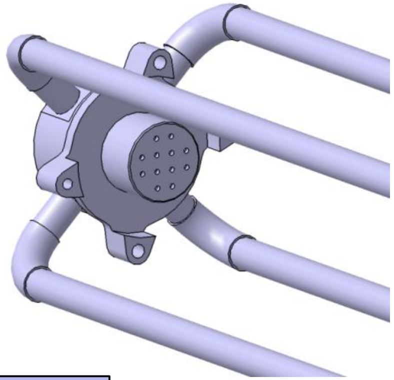
    $T_{max} < 60°$

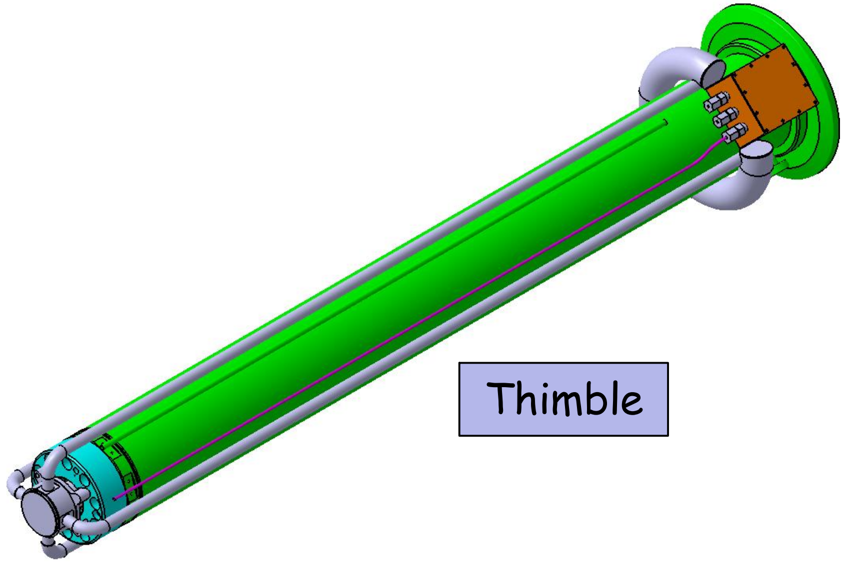


- Will be tested at LPSC with a mock-up of insertion canal

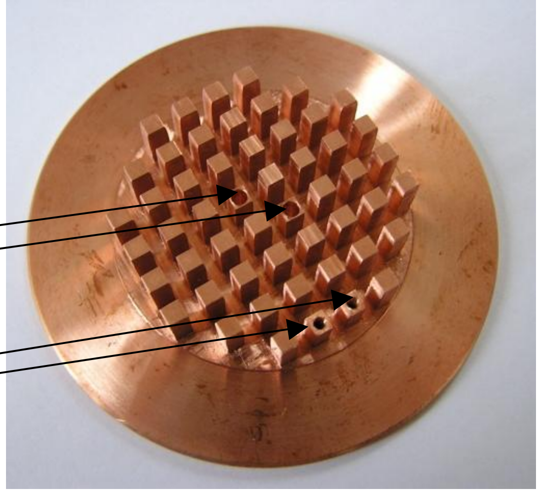
Target equipments

- Diffuser at thimble's end





- Current &temperature measured at back of target

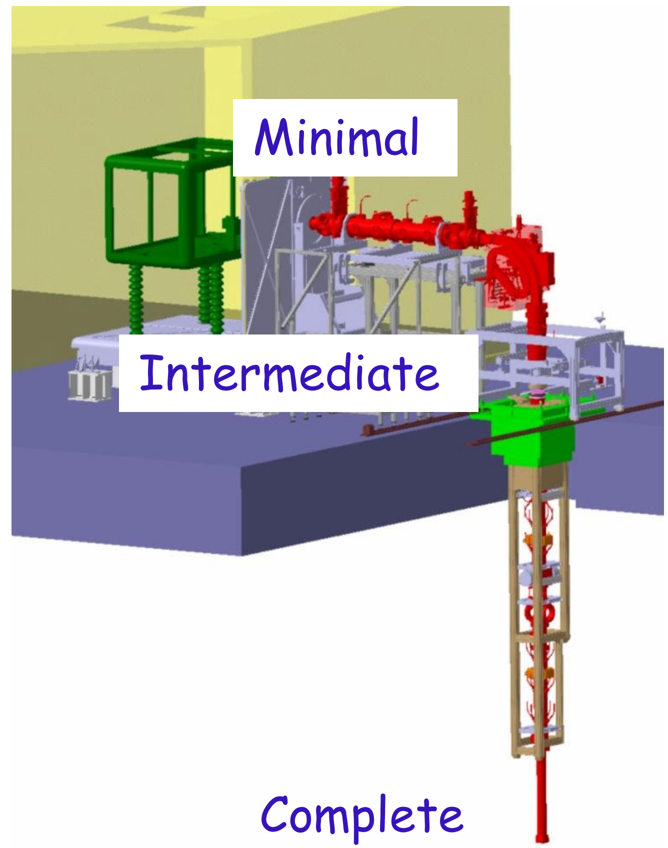


- Silicon detector at thimble front-end to monitor α recoil particles

Commissioning strategy

- Machine fully assembled & tested at LPSC before its transfer to Mol
- Developments on the ion source test bench for DC operation
- In parallel, pulsed mode to commission the accelerator at LPSC
- Along with machine construction, commission in 3 stages

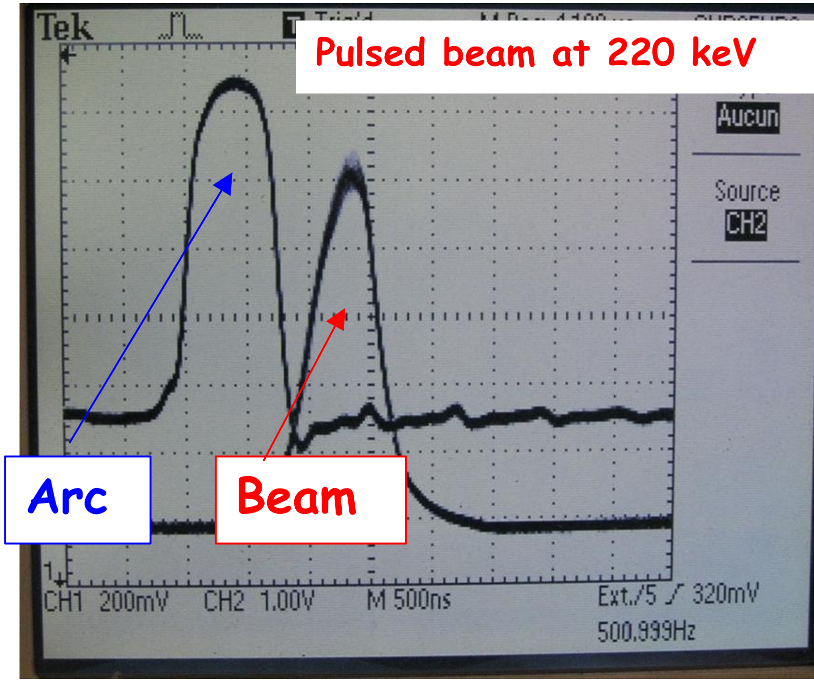
  - -Minimal beam line configuration
    ion source at HV
  - -Intermediate configuration
    adding H line, dipole, short V line
  - -Complete configuration
    Whole machine



Minimal configuration

- Assembly & tests : December 2008

  First pulsed beam at LPSC



After SEM correction in Faraday cup

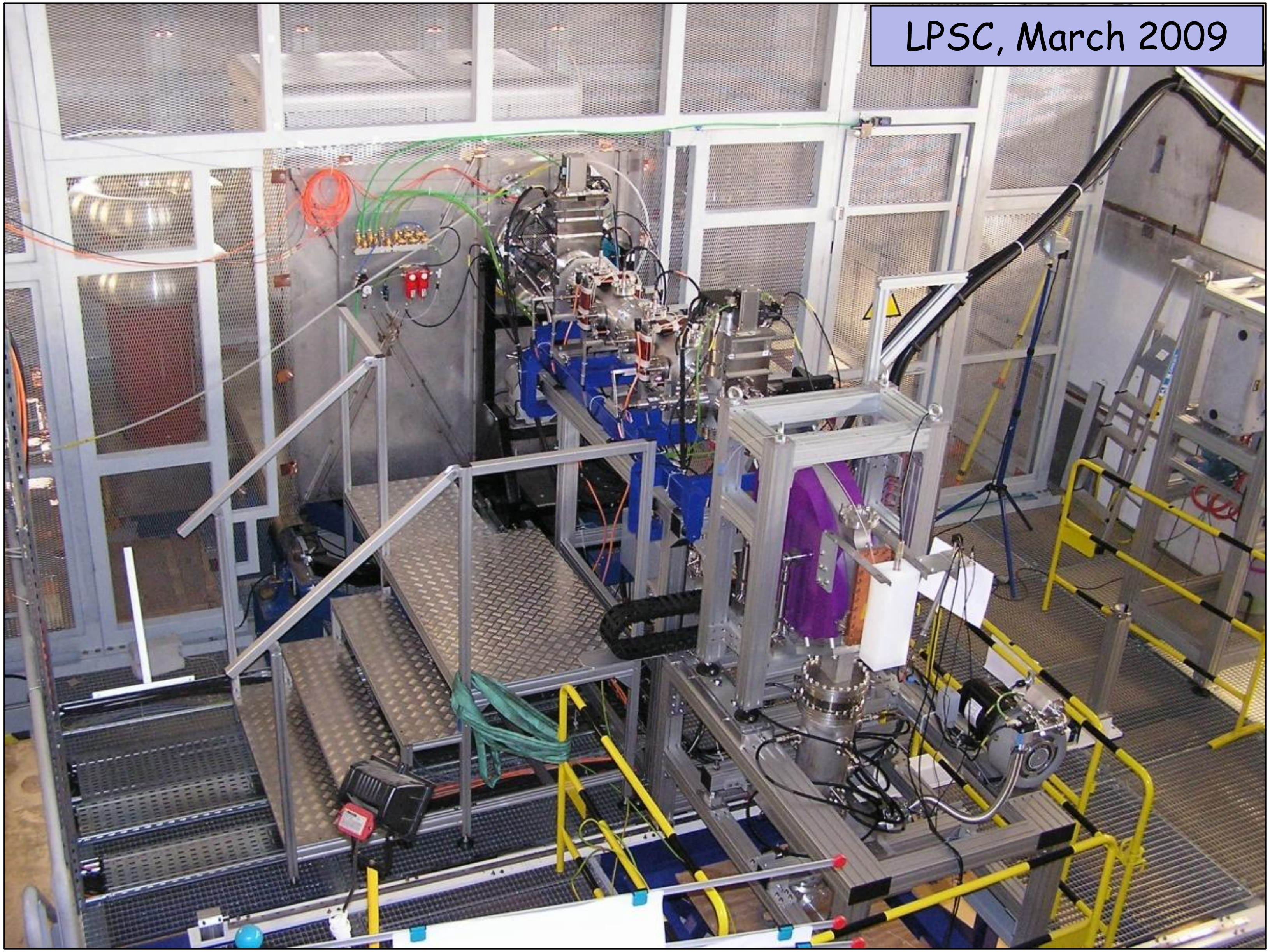
I peak ~ 70 mA

Similar to GENEPI-1

Total source output :

D^+ ~ 70-75% of total in pulsed mode

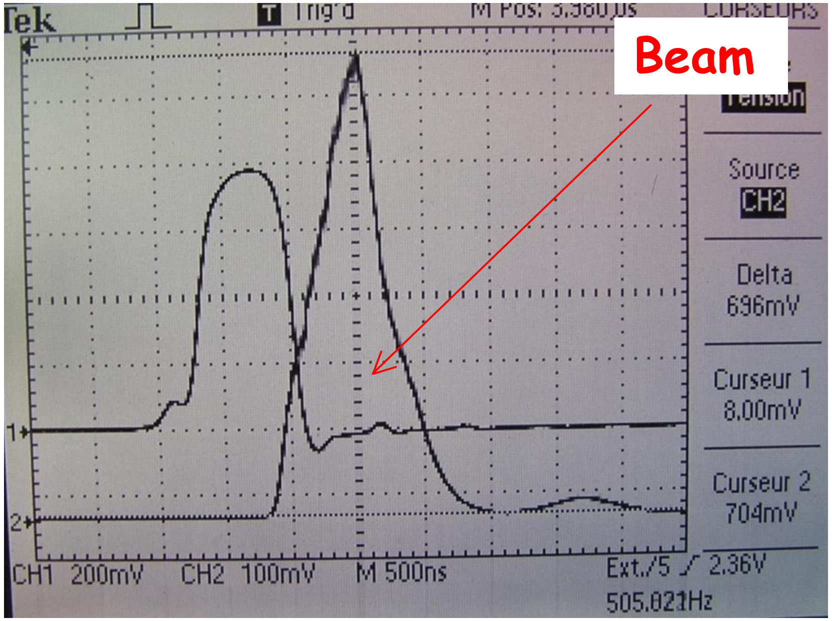
Intermediate configuration



Intermediate configuration

• After initial startup & debug (April 2)
beam by end of line at first try

• "Transmission" after magnetic selection
I(end)/I(source) ~ 70%
as expected in pulsed mode



• Equipment down to T2 output tested
• Some bugs corrected, few items to fix
• Interference checked between reactor measurement chains & GENEPI-3C : none
• Parasitic neutrons seen (ion collector)
• No temperature elevation of collector

• Beam current out of source reduced
Filament appears damaged ➔ conditioning of a new one underway

Summary & outlook

- **R&D remains on source**
  - DC mode with programmable interruptions
  - Current driving for coupling

- **Machine assembly & commissioning at LPSC underway**
  - Half of the machine tested & validated (April 2009)

- Assembly & commissioning (LPSC) : until summer 2009

- Machine assembly & tests (SCK-CEN) : September-October 2009

- Load VENUS & start physics program : December 2009

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