SPIRAL2 HM RIB Preseparator: Design and Expected Performances

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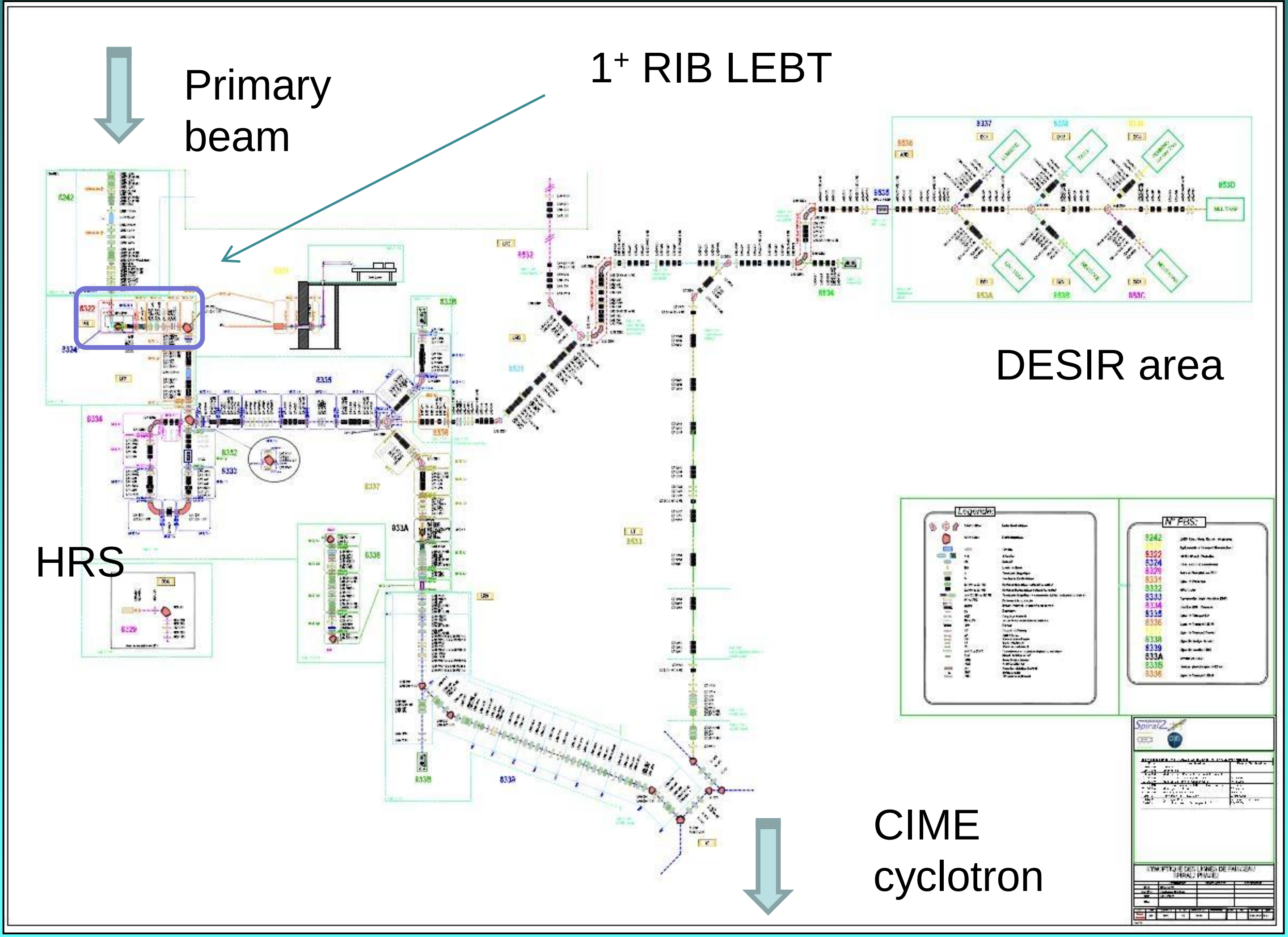
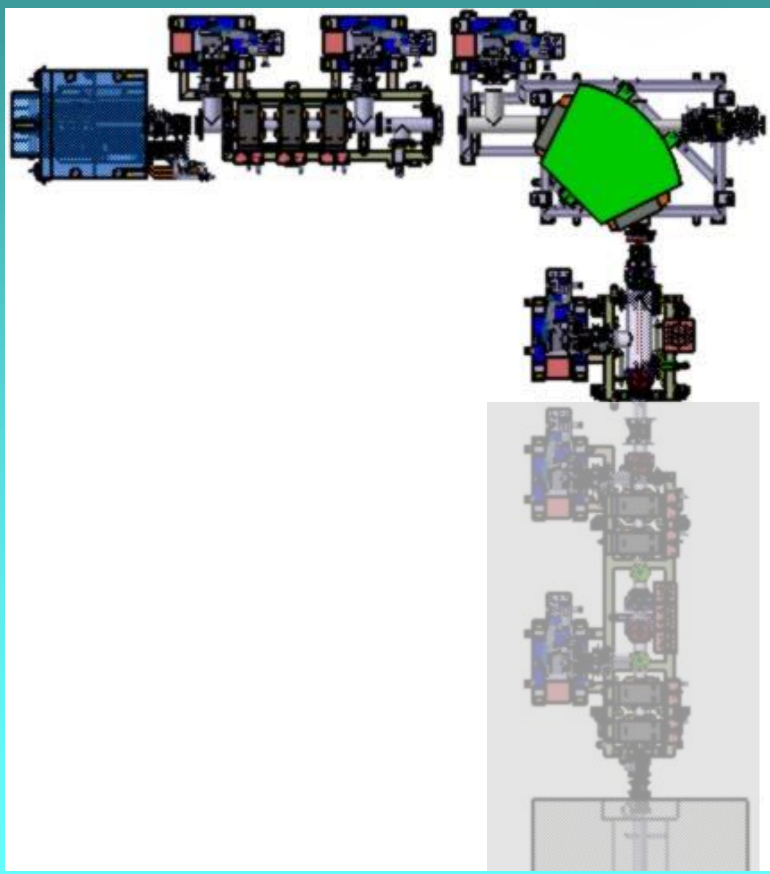
Outline

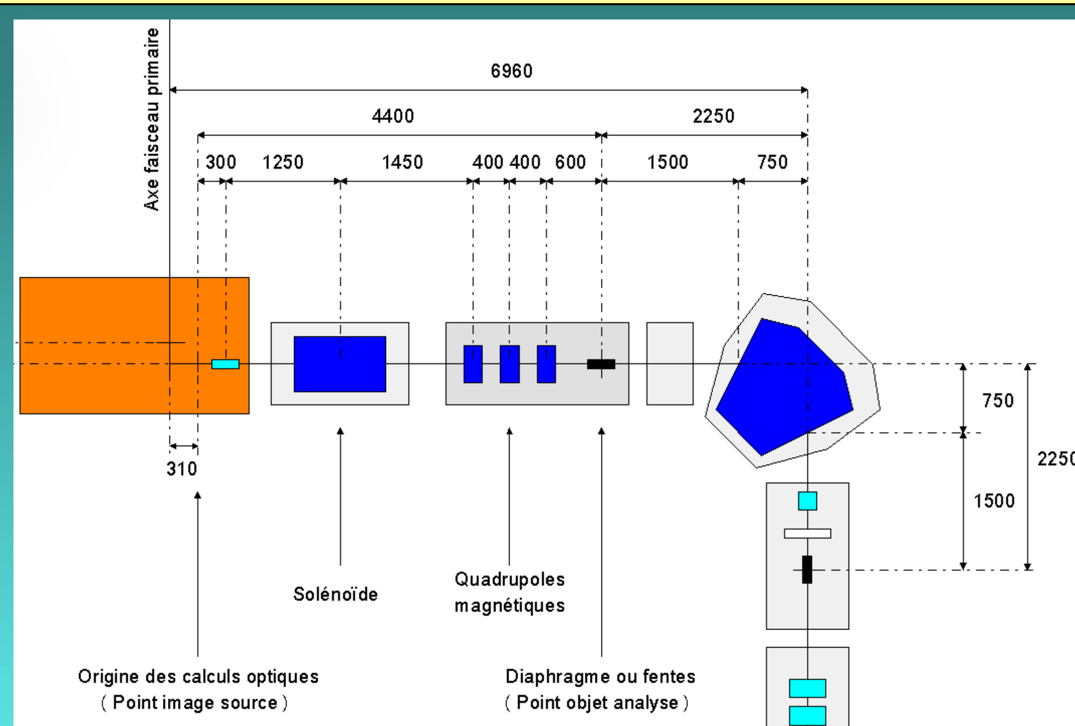
- Beam line layout, main components and issues
- What we have to consider, the compromise between beam transmission, rejection and safety
- Expected performances, the hypothesis and limitations
- Conclusion

Beam line layout

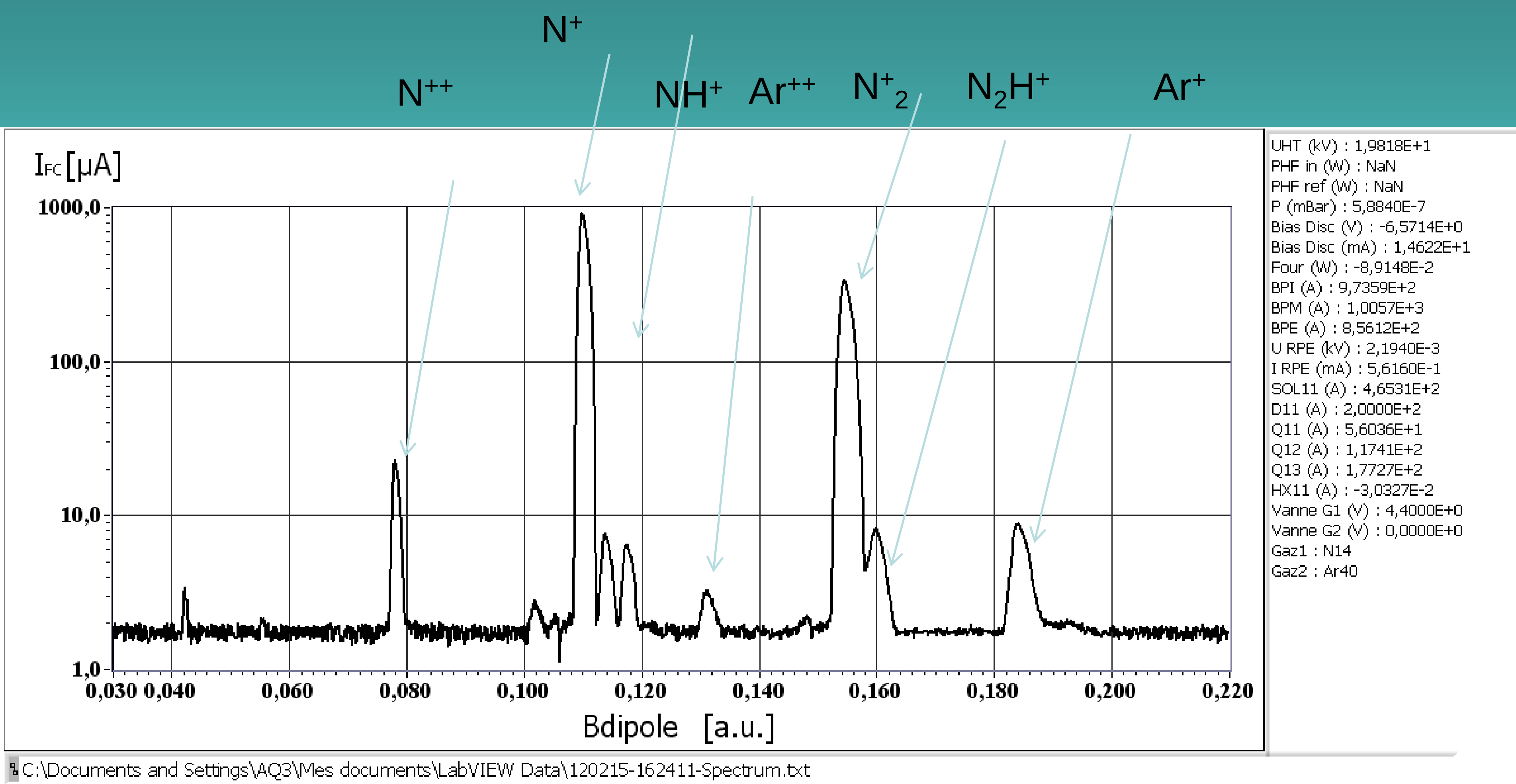


ISOL beam extraction





Typical mass analysis



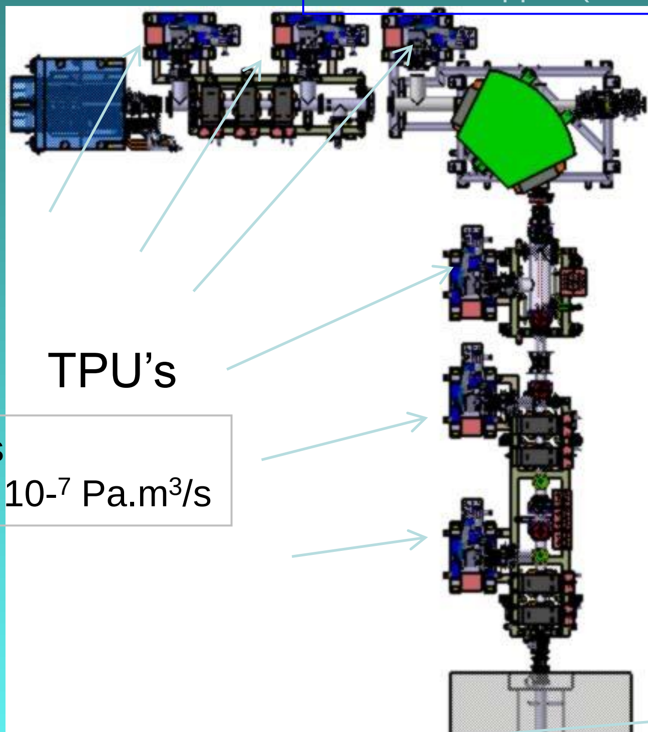
ECRIS Argon beam extraction with Nitrogen as supporting gas

Main issues

- HI-LEBT, space charge dominated regime
- Light-ion beam rejection with solenoid and magnetic triplet at front-end and mass separation of beam of interest
- Beam/environment interactions
- Beam diagnostics and tuning
- Safety and radiation monitoring (volatile species, decay products, pumping rates, trapping, transmission coefficients, collimation)
- Maintenance (remote handling)
- Costs (building, hot cell, technical services)

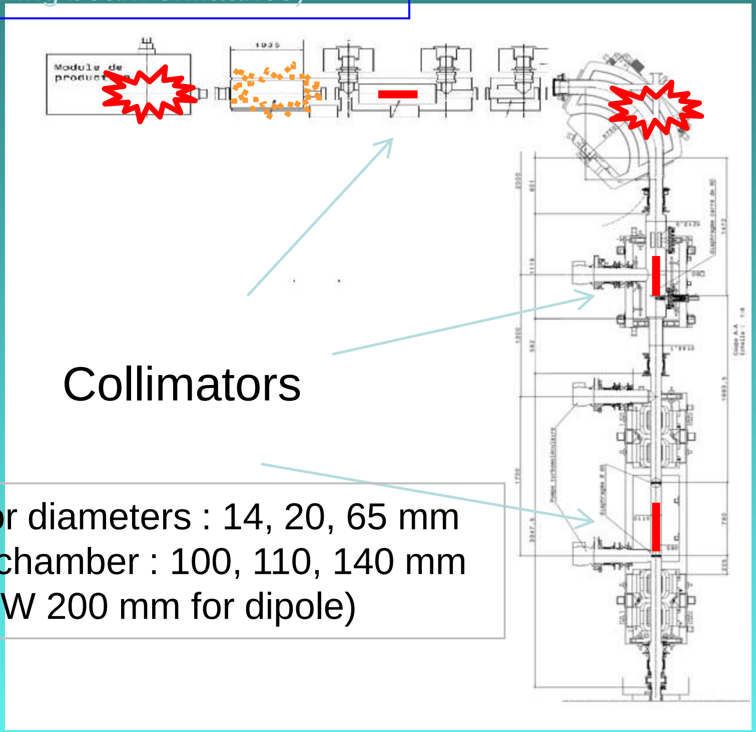
Confinement and pumping

>>>Different assumptions and incidental scenarii. Collimation and vacuum chambers dimensions are consistent with transverse beam enveloppes (line acceptance matching beam emittance)



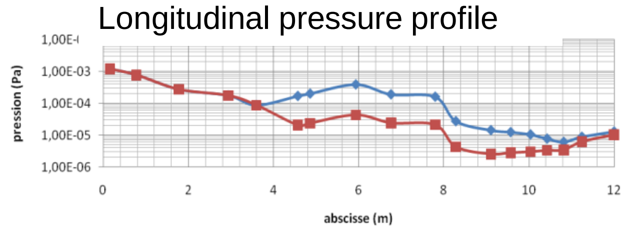
TPU's

550 l/s
10^{-4} – 10^{-7} Pa.m³/s



Collimators

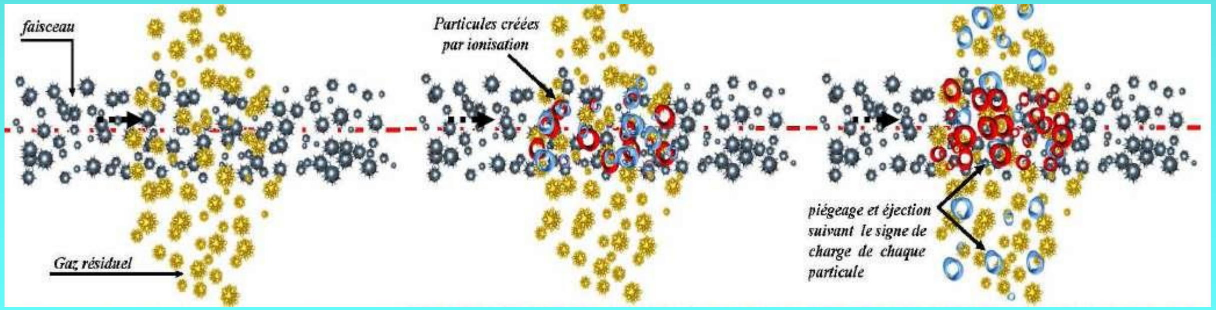
Collimator diameters : 14, 20, 65 mm
Vacuum chamber : 100, 110, 140 mm
(H 120 x W 200 mm for dipole)



Particle/gas transmission coef. : 10^{-6} before dipole – 10^{-3} after

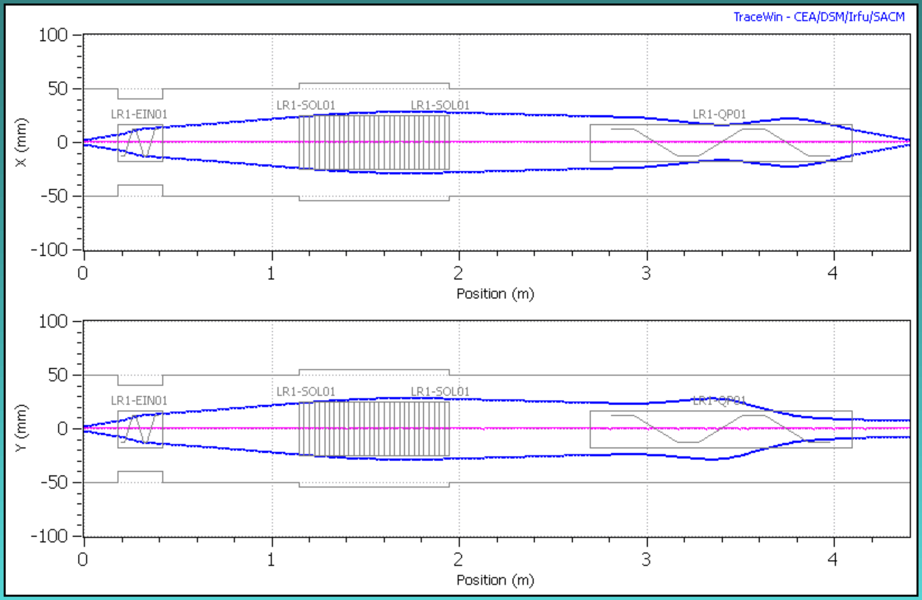
(Transmission and trapping coefficient calculation with Movak3D)

- ►Beam/residual gas interaction — To be done
- ► Beam/contaminants and supporting gas influence — Work in progress
- ► Beam/space charge/neutralization process — Work in progress
- ► Beam/environment losses — Work in progress

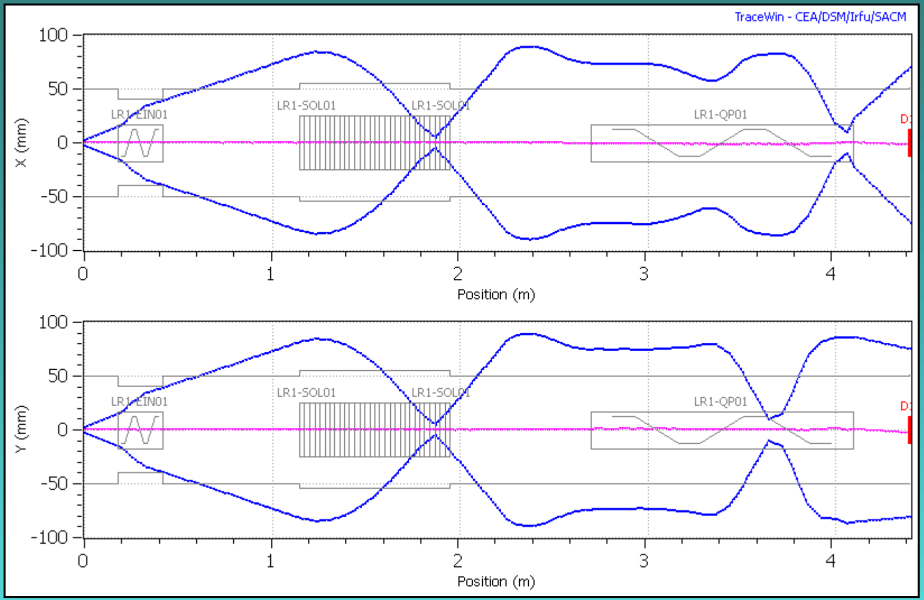


courtesy CEA/IRFU/SACM

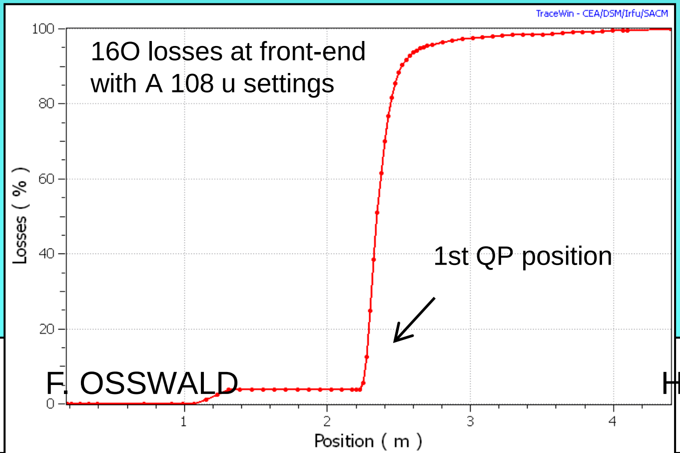
Beam rejection and losses

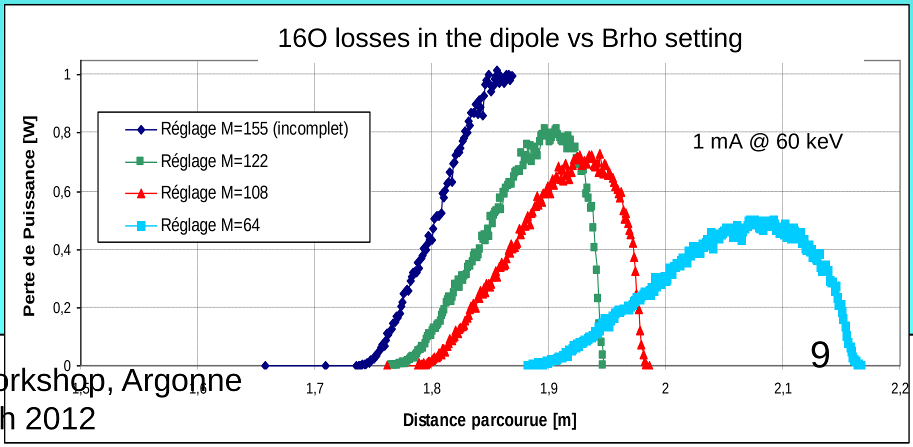


A 108 u
Spot +/- 2.25 mm
Emittance 80 pi mm mrad
Intensity 50 uA



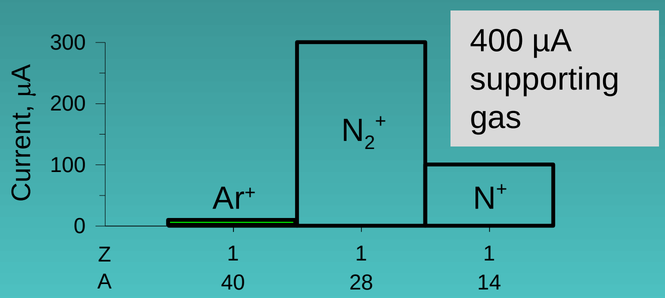
16O with A 108 u settings
Spot +/- 2.25 mm
Emittance 80 pi mm mrad
Intensity 1 mA
Beam losses 99.9 %

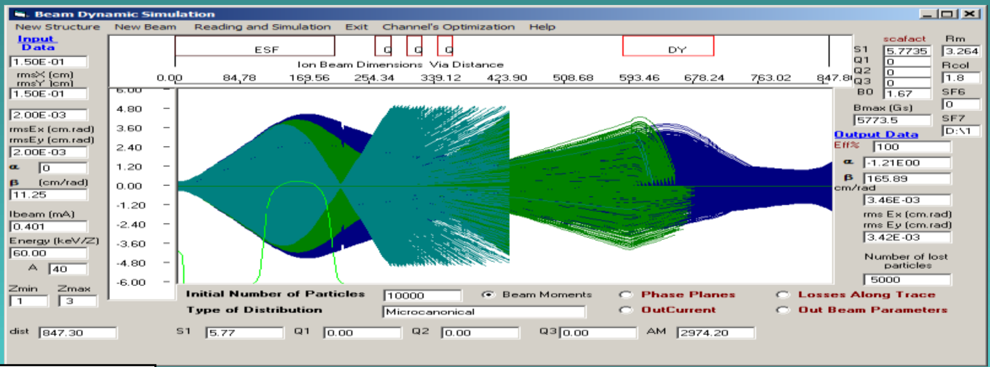




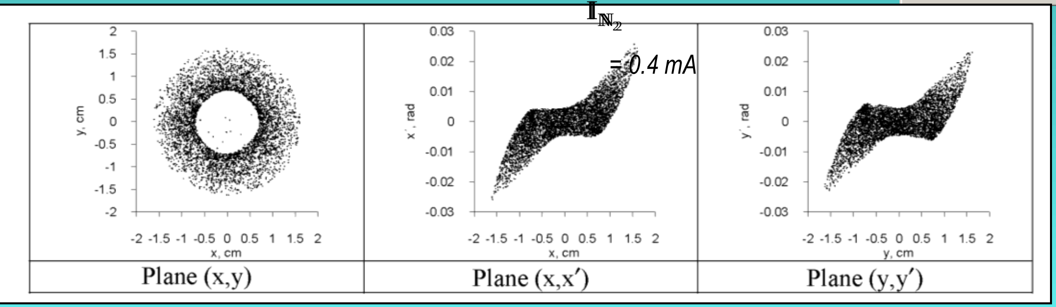
HI-LEBT with multispecies beam

ECRIS : influence of supporting gas and contaminants
Example of 0.4 mA $^{40}Ar^{+}$ beam extraction @ 60 keV

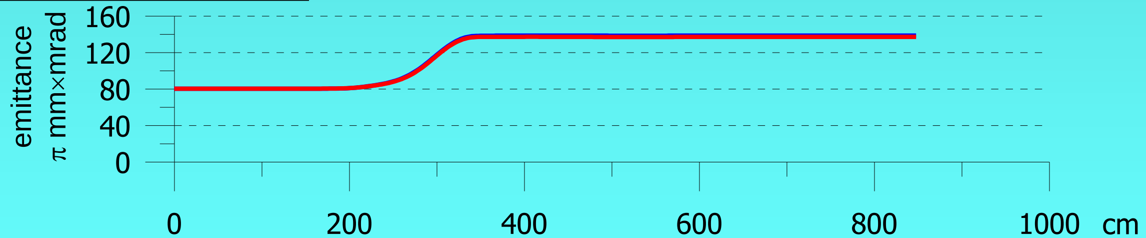




Multiparticle beam dynamics simulation



$^{40}Ar^{+}$ ions distribution on analyzing plane

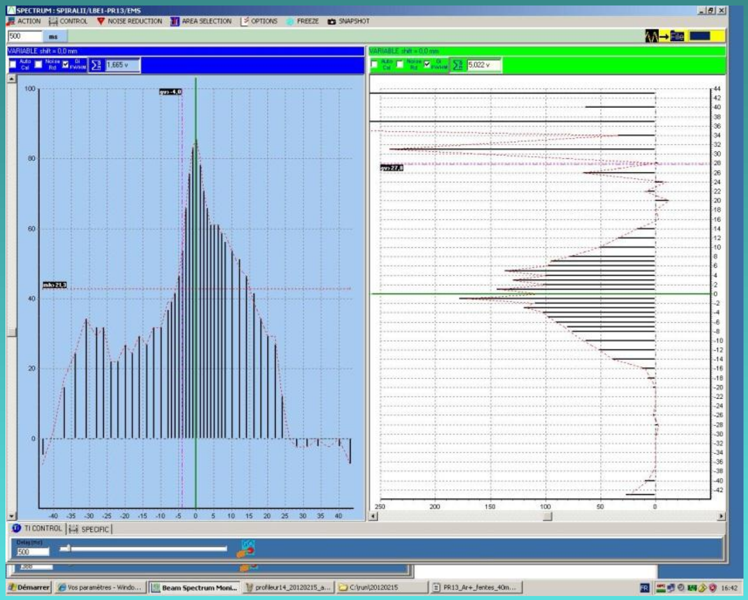


Emittance variation along axial direction

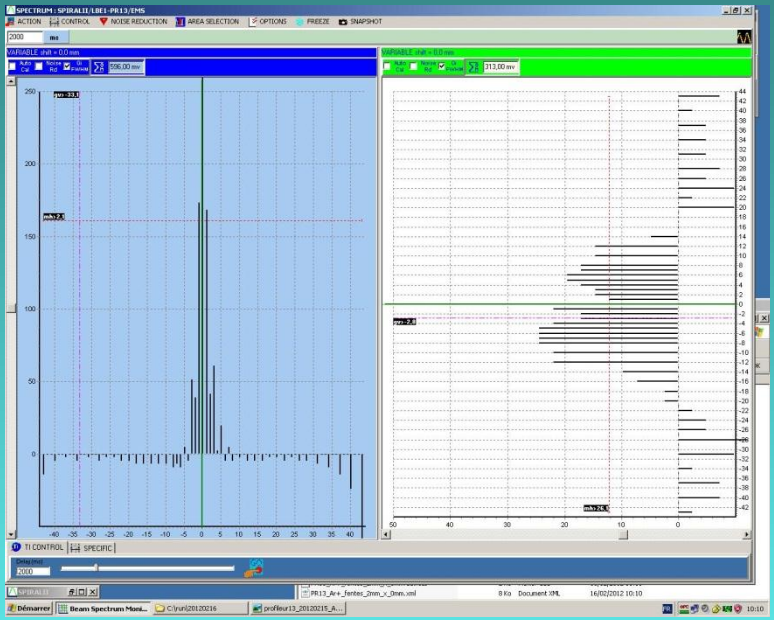
Courtesy FLNR/JINR

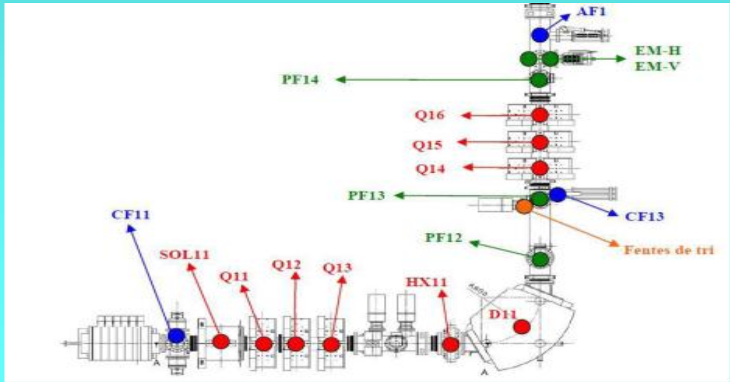
Hollow beam experiment

Standard profile



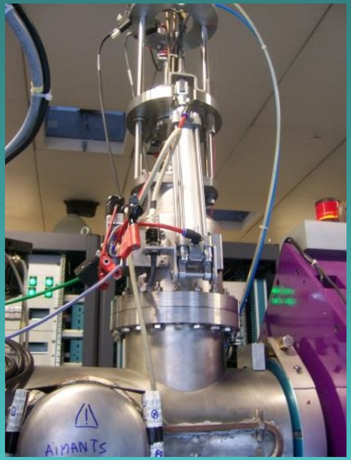
Hollow beam

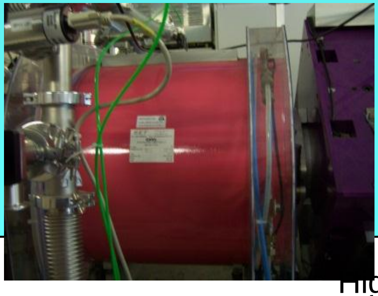


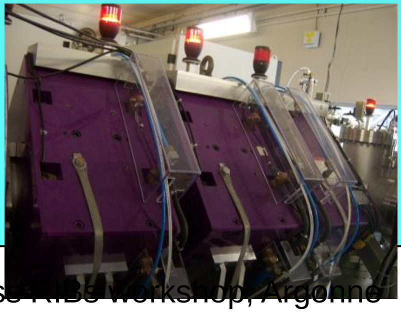


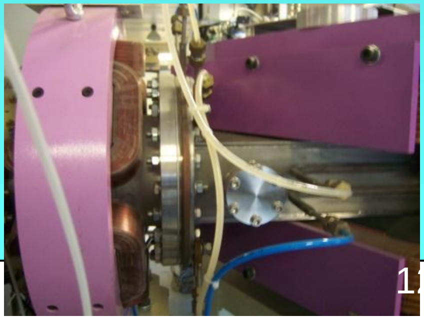
Experiment performed at LPSC with the support of IPNL and FLNR, February 2012

Conventional L-shaped extraction line

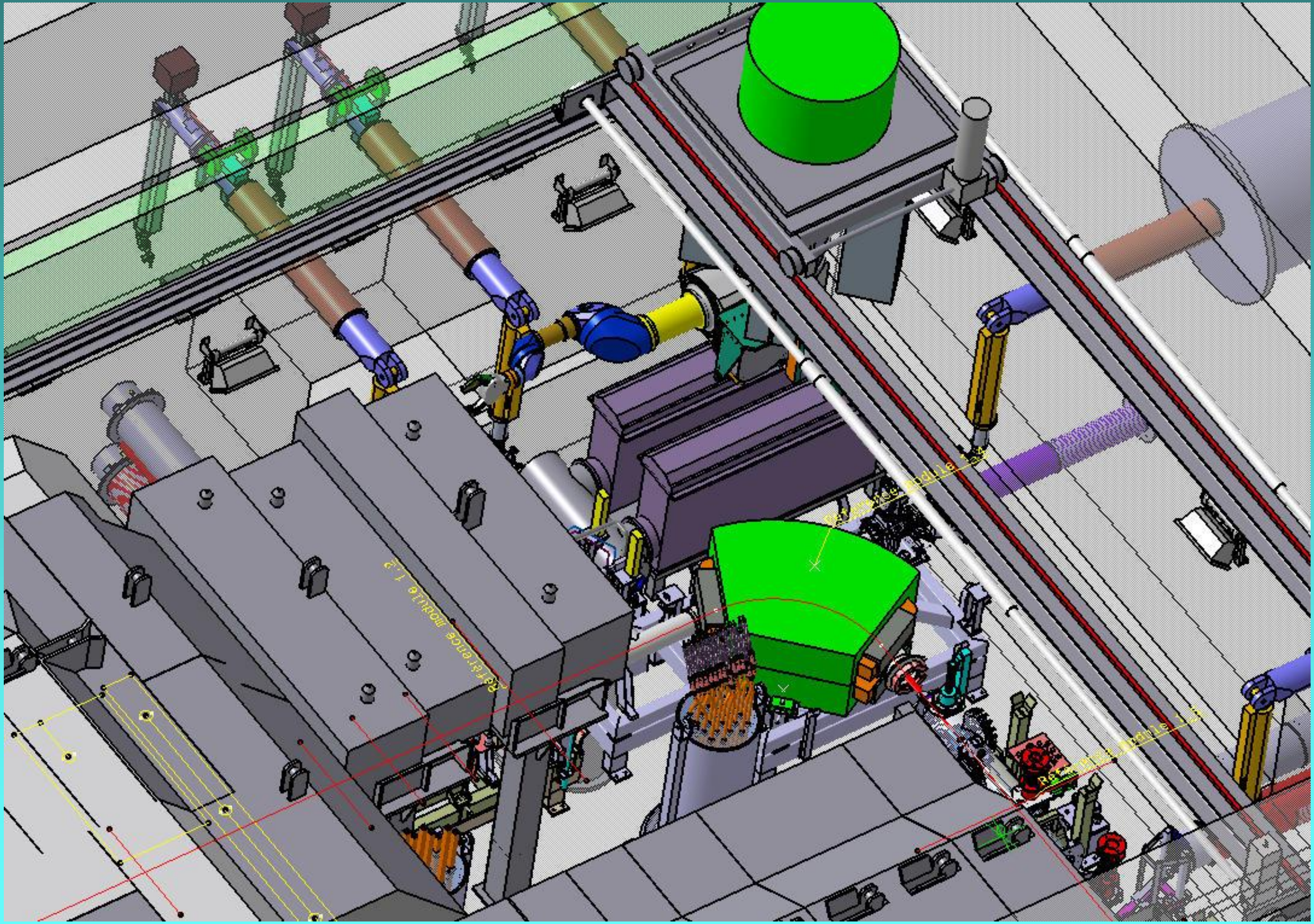








HI RIB line



Radiation issue

Max RIB current is not only a question of performance, it is also a safety issue due to limited dose rate in controlled access area (safety/economic ratio)

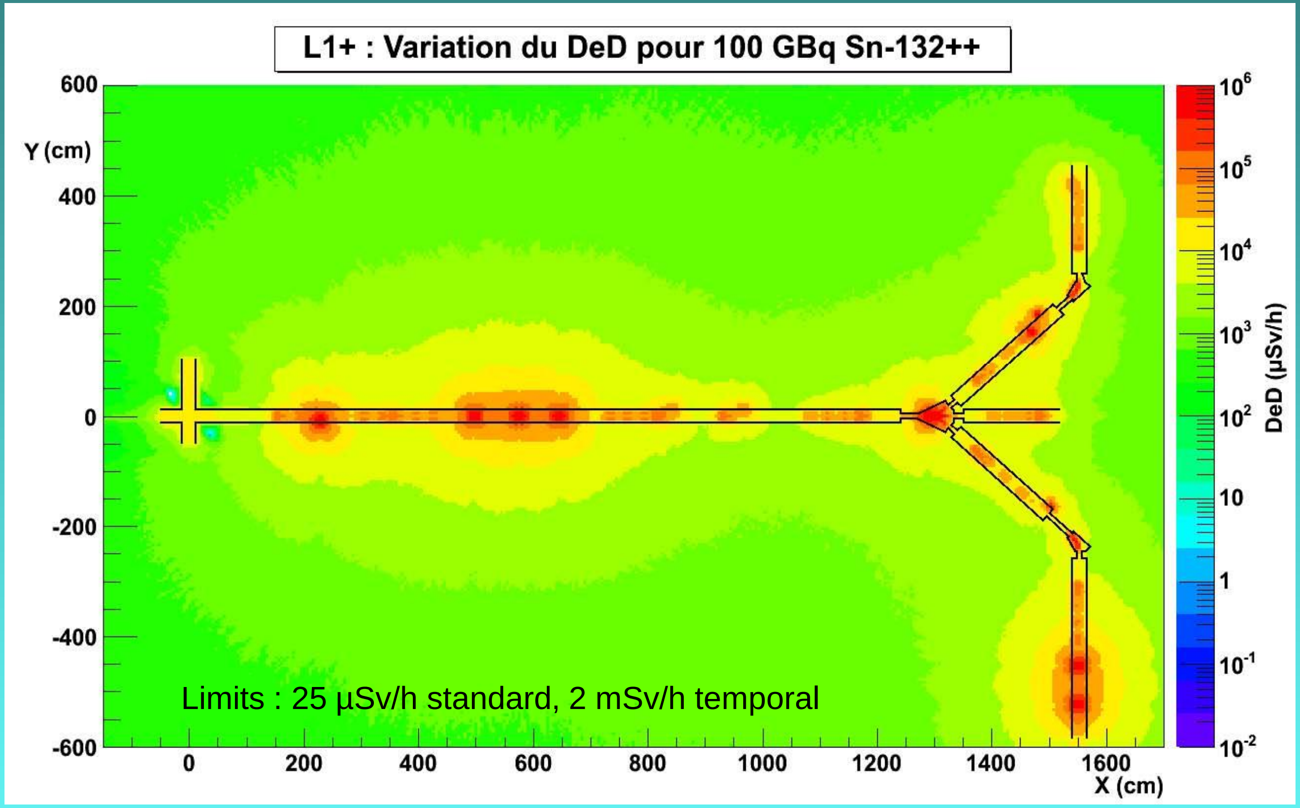
Max dose rate in the hot cell (Gy/Y)

	N+γ	γ_{fi} (X^{y+})	Resiliance	
			RadHard epoxy	MIC
Solenoid	10^4-10^6	$10^5/10^{8*}$	10^7	10^{11}
QP's	10^3	$10^5/10^{8*}$	10^7	10^{11}
Dipole	10^2	$10^5/10^{8*}$	10^7	10^{11}

* Averaged power/full power (200 kW, 10^{11} pps, 10^{14} fi/s)

- Source A : Converter + target
  - Neutron flux (direct + fission)
  - Gamma prompt radiation
- Source B : Radioactive beam
  - Gamma radiation (fission products)

Equivalent dose rate calculation



In order to assess the hot spots, to define maintenance procedure, safety distance of operation, shielding, time duration in respect of the ALARA principle (MCNPX model, during operation)

> The highest intensities may be limited due to safety issues (not only pps of beam but also contamination)…

Baseline performances

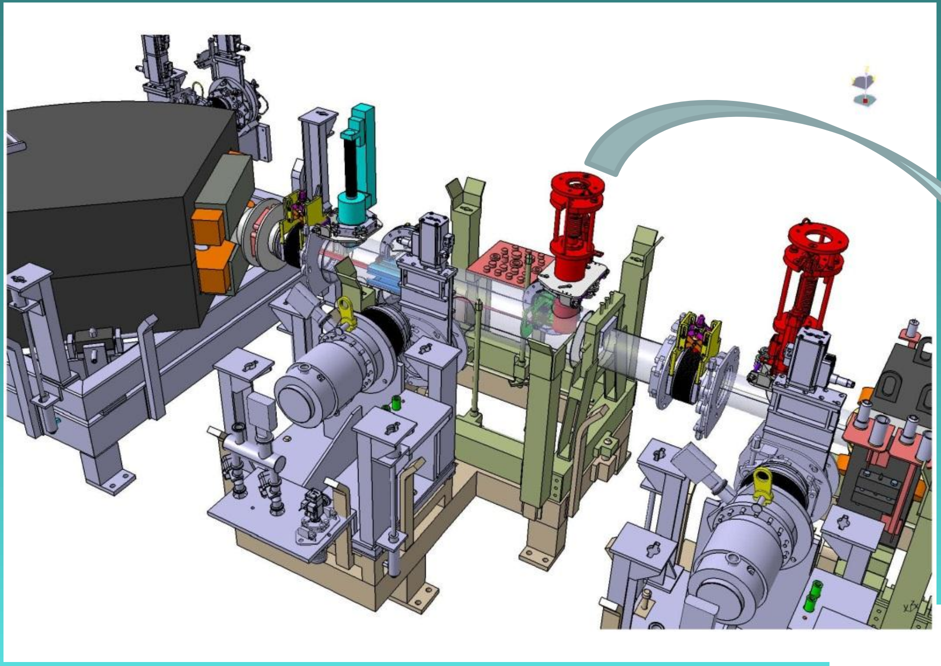
Transport of single charged ions
Beam intensity up to 5 mA
Highest transmission (rougthly 100 % at 1st order)
Up to 60 keV
3 ≤ A ≤ 240 amu
Emittance ≤ 80 π mm.mrad
Adapted angular and momentum acceptances
Mass resolution : 300 resolving power

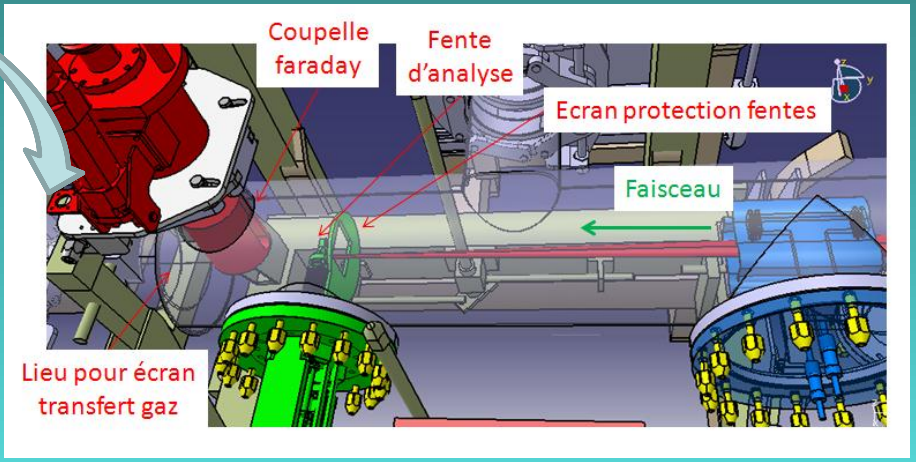
Beam controls mostly performed downstream - outside hot cell, difficult to control it inside (radiation, maintenance, mechanical integration) :

- Beam collimation, emittance limitation, transverse enveloppes matching
- Control of beam losses (BPM, pepperpots, FC)
- Radiation monitoring
- Beam purification with HRS (isobars suppression)
- Charge breeding
- Selective ions sources and adapted ECRIS settings (choice of supporting gas)

⇒ Serious commissioning required !

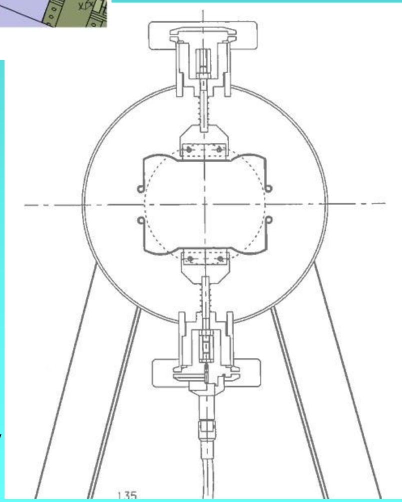
Example of beam diagnostic





FC : diam 30 mm

+



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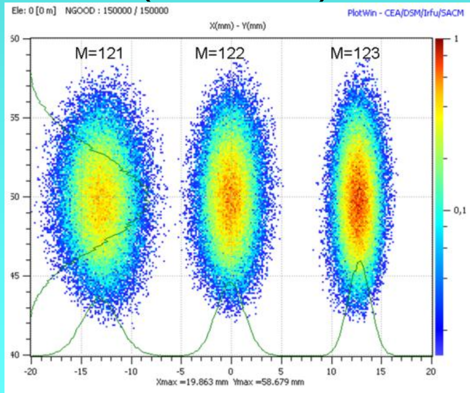
Mass separation on FC (simulation)



Pulsed beam extraction : +/- 1500 V (low duty cycle)

Collaborations : LEBT and nuclear BL

Thank you