THE FIRST CYCLOTRON-BASED MULTI-ION THERAPY SYSTEM

PROJECT STATUS, PERSPECTIVES AND CHALLENGES

Authors

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Knowledge Transfer Seminar CERN, 21-23th of January 2025

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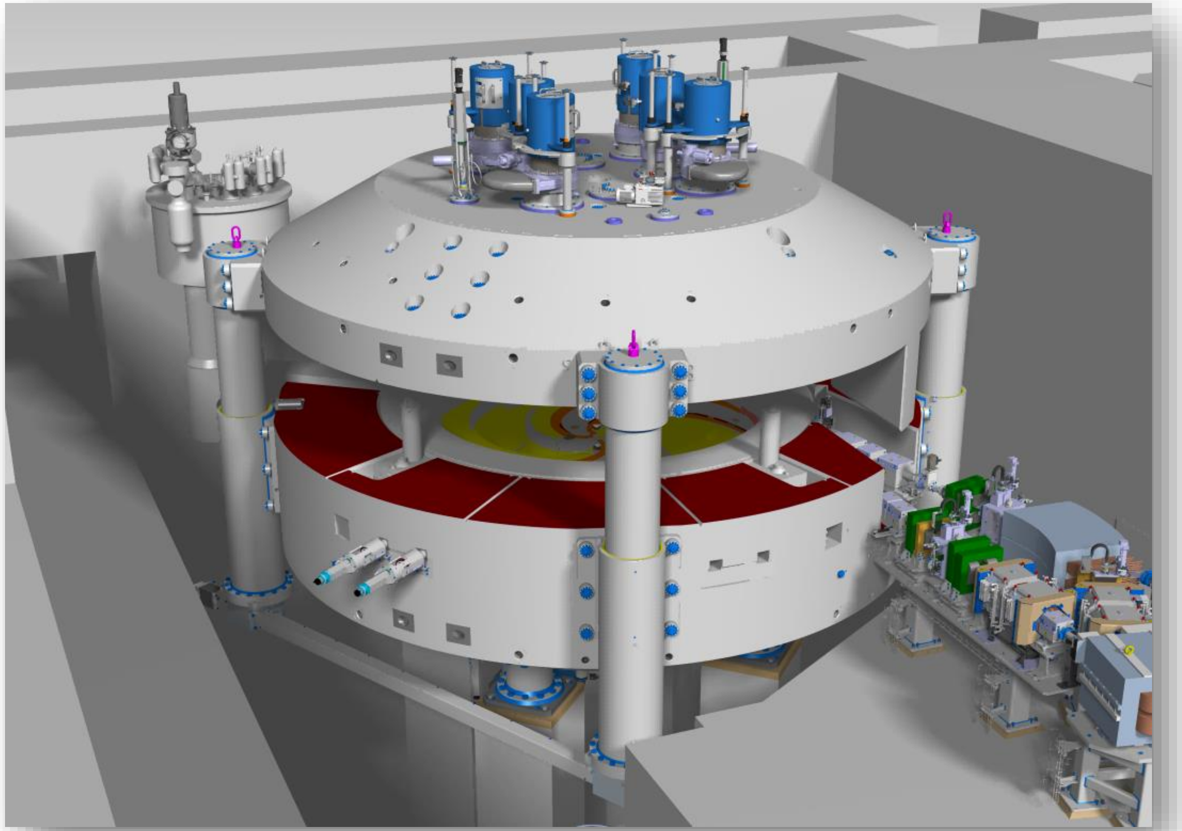
Layout of the presentation

1. The clinical context
2. Presentation of the C400IONS
3. Recent developments: design & production
4. Installation status

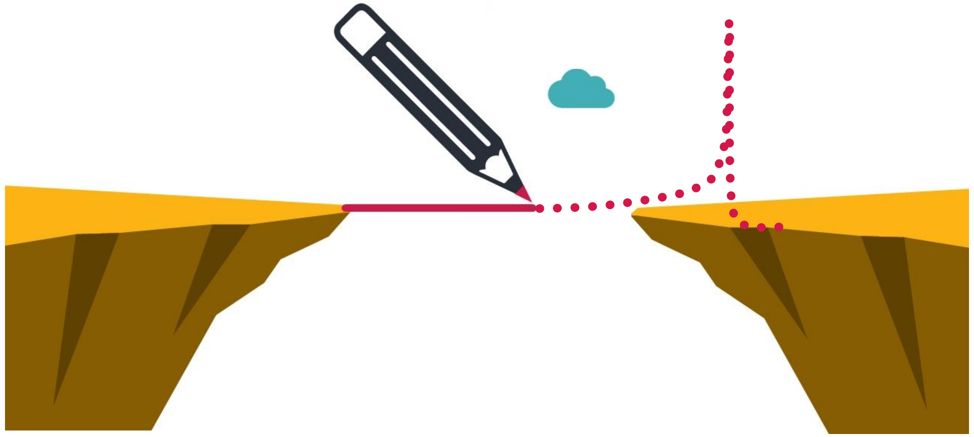


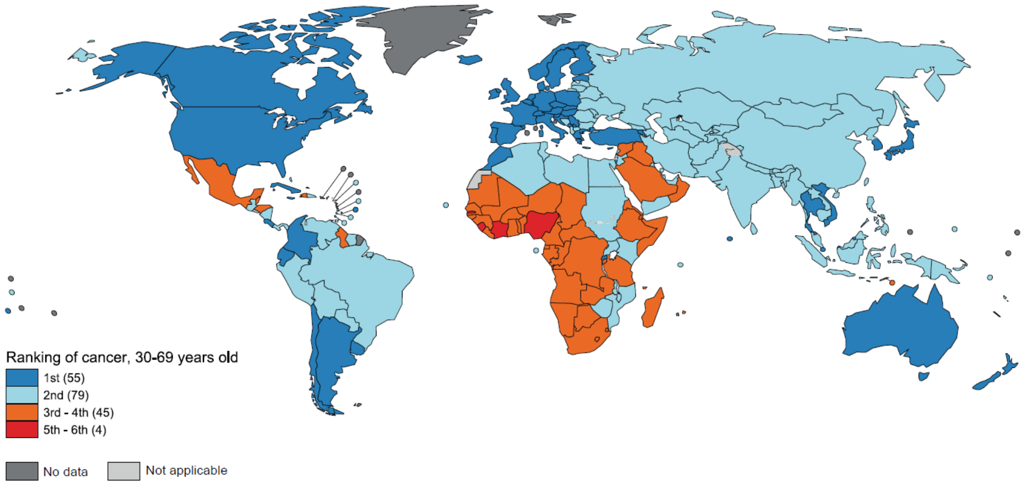
Let’s bridge the PT gap

Estimated number of patients who may benefit from carbon ion radiation therapy is about 1-4% of new cancer cases [1]

So about 200 000 to 800 000 new patients per year based on the 19M to 28M new cancer incidence worldwide in 2022 and 2040 respectively[2]

Less than 7 000 patients (0,04%) were treated with carbon in 2023 [3]

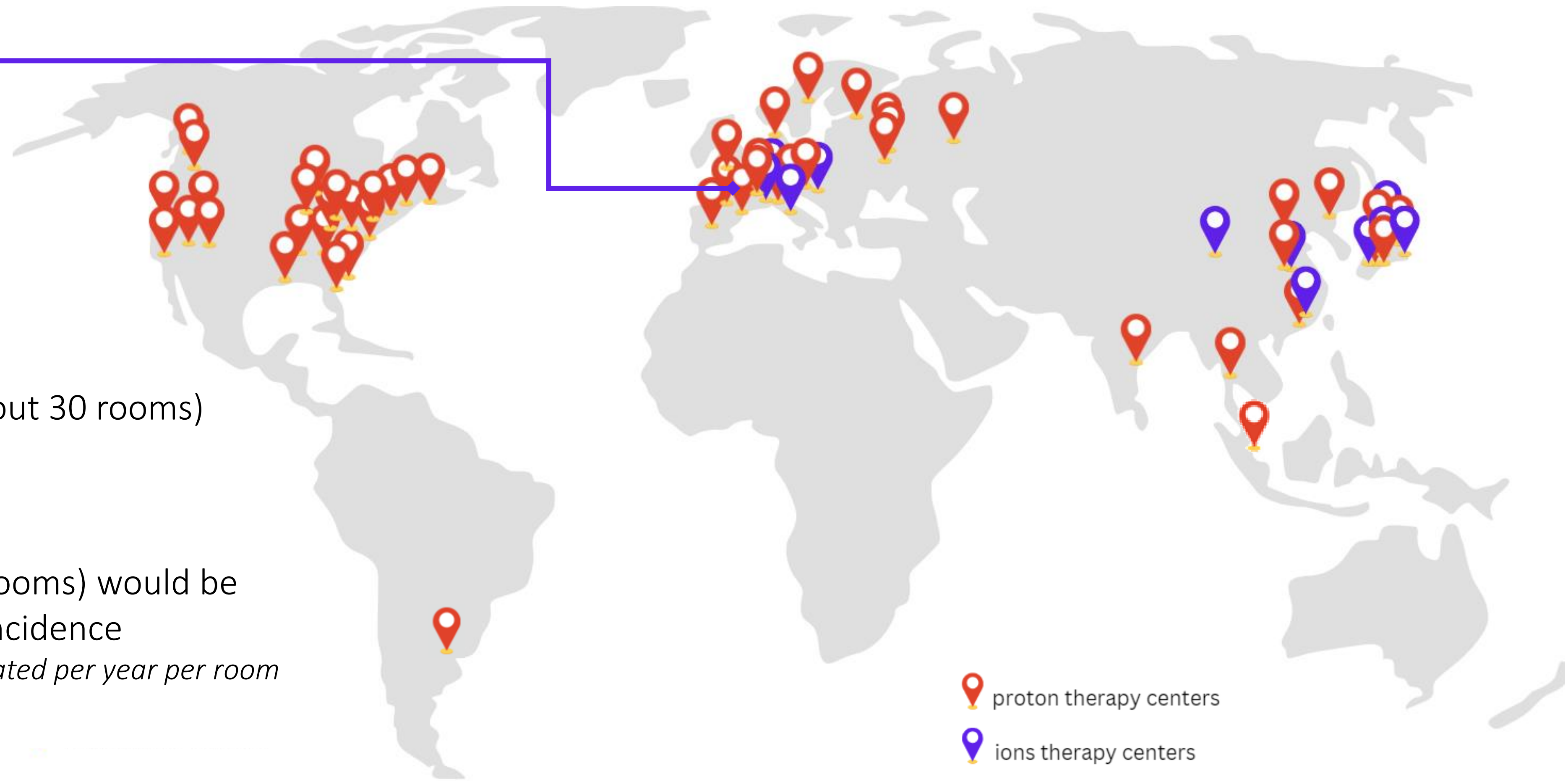




Source: [1] SEER database / Ahern et al., 2023
[2] IARC
[3] PTCOG

Operational Ion Therapy around the World

1st C400 IONS INSTALLATION
at Cyclhad



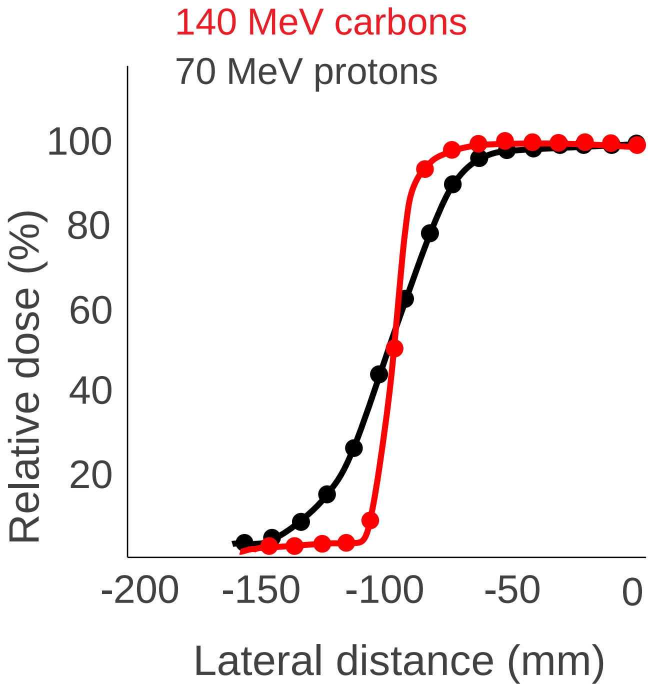
- ✓ **100 proton** therapy centers
  30 under construction
- ✓ **16 ions** therapy centers (about 30 rooms)
  4 under construction

- ➢ **700 centers** (roughly 1400 rooms) would be needed to treat 1% of the incidence
  Assumption of 350 patients treated per year per room

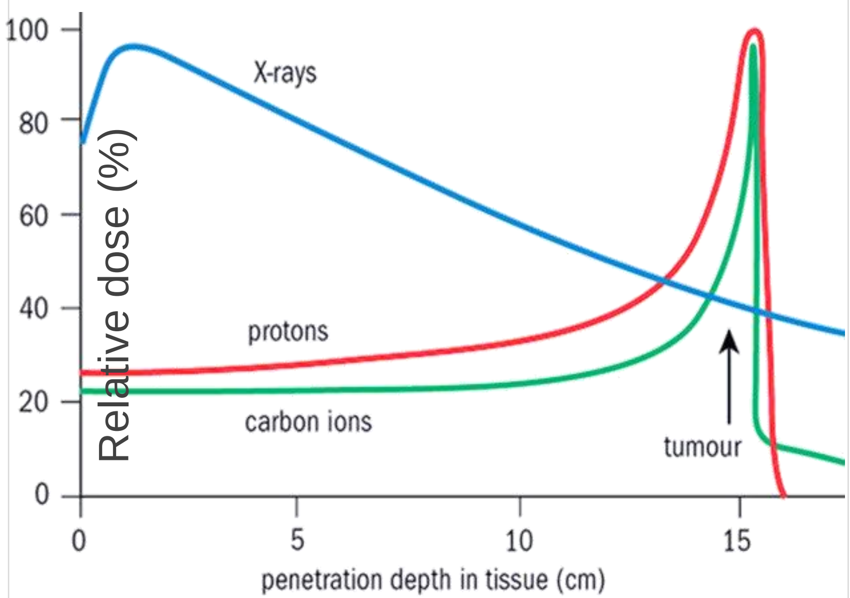
Why Ion Beam Therapy?

NHa NORMANDY HADRONTHERAPY

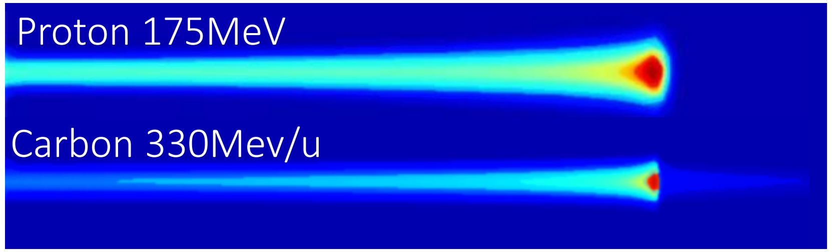
Small lateral penumbras	Thin Bragg Peak	Reduced spot size in tissue

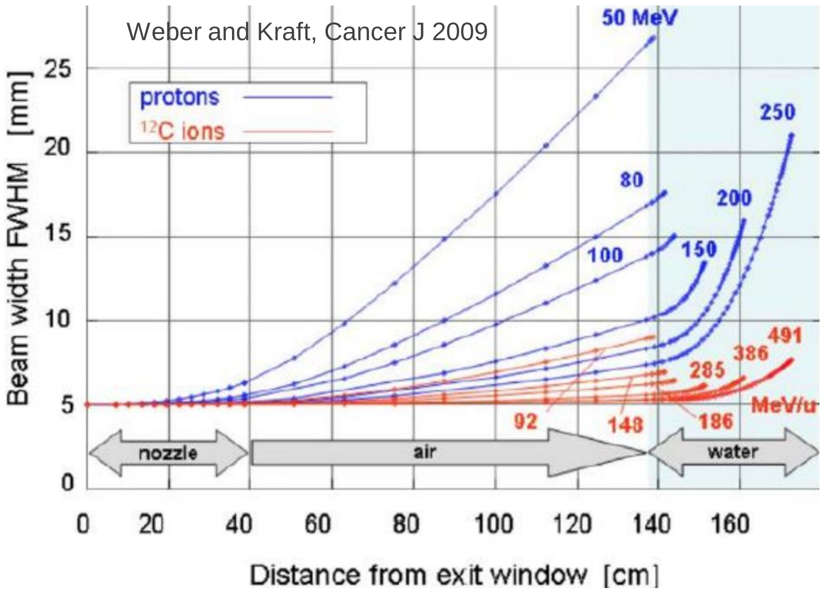


Courtesy of G. Kraft
GSI, Darmstadt



Courtesy of Johannes Gutleber
CERN, Geneva



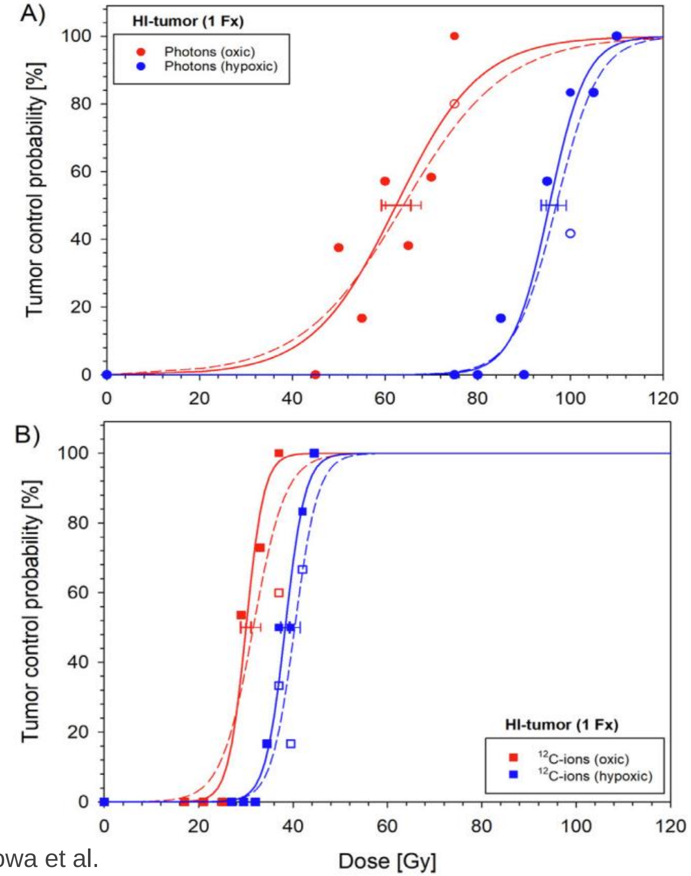


Sharper dose distribution

Why Ion Beam Therapy?

NHa NORMANDY HADRONTHERAPY

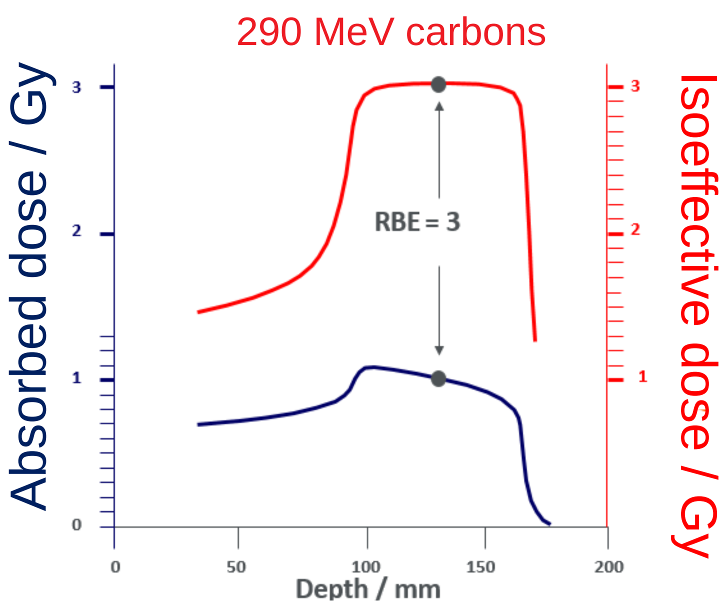
Efficient for radioresistant cells

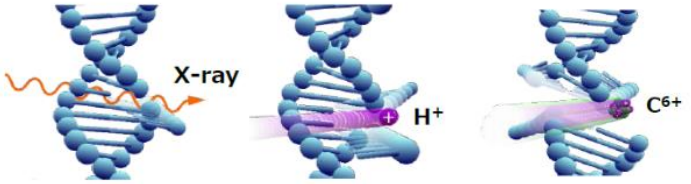


2024 Glowa et al.

Hypoxic tumor response

High LET and RBE



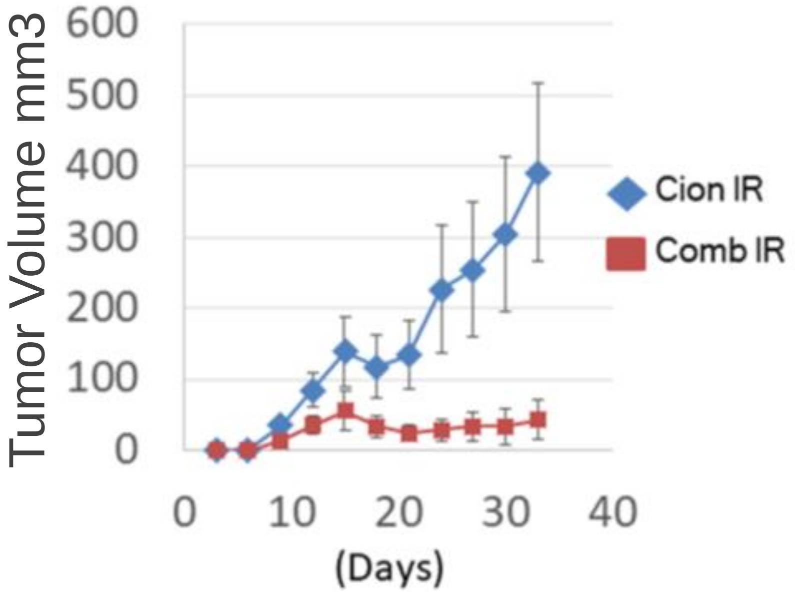


Modified Kraft et al 2000

DNA Double strand break

Combined with immunotherapy

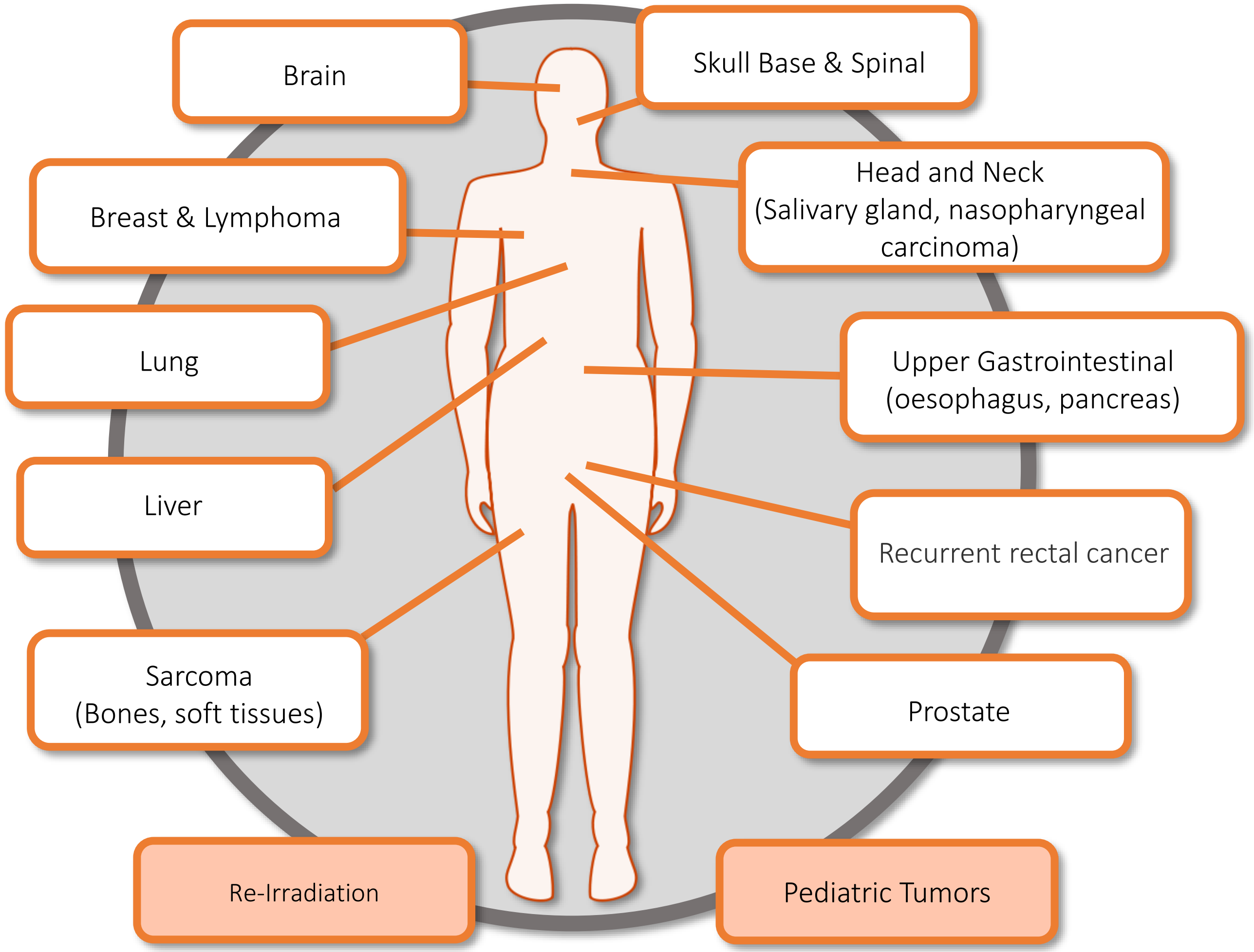
Enhanced tumor efficacy
with immune checkpoint inhibitors



Takaashi et al Oncotarget 2019,

Apoptosis effect activation

Possible Indications

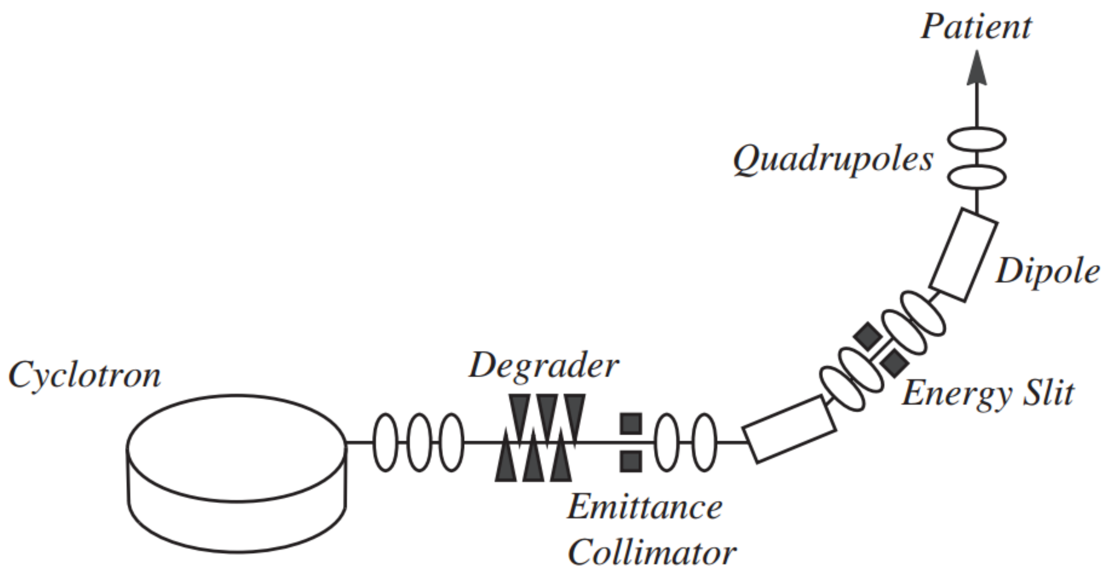


The C400 IONS project

Bring all the advantages of the cyclotron-based PT system to hadrontherapy, starting with Carbon and Helium beams

Strong points of cyclotrons technology relative to existing solutions:

- **Continuous beam**
  - Easier beam delivery
- **Compact layout**
  - A factor ~3 in footprint layout compared to current synchrotron-based systems
- **Simple system**
  - Less equipment, less complex magnet, no injector, etc.
  - Fixed B-field, fixed RF
- **Cost efficient**
- **Easy to maintain**
  - expect ~15 technicians for site maintenance (3 rooms)
- **High beam current**
  - Interesting opportunity for FLASH and minibeams
- **Technology very well known and mastered**
  - C400 developed in close collaboration with IBA (>600 accelerators, incl. >70 PT solutions, 120000+ patients treated worldwide)



NHa in few words

NHa NORMANDY HADRONTHERAPY

- Designs and produces its own C400 IONS treatment system
- Designs the superconducting cyclotron 400MeV/u
- Designs the treatment rooms with fixe beamline / couch / chair
- Markets the C400 IONS treatment system

iba

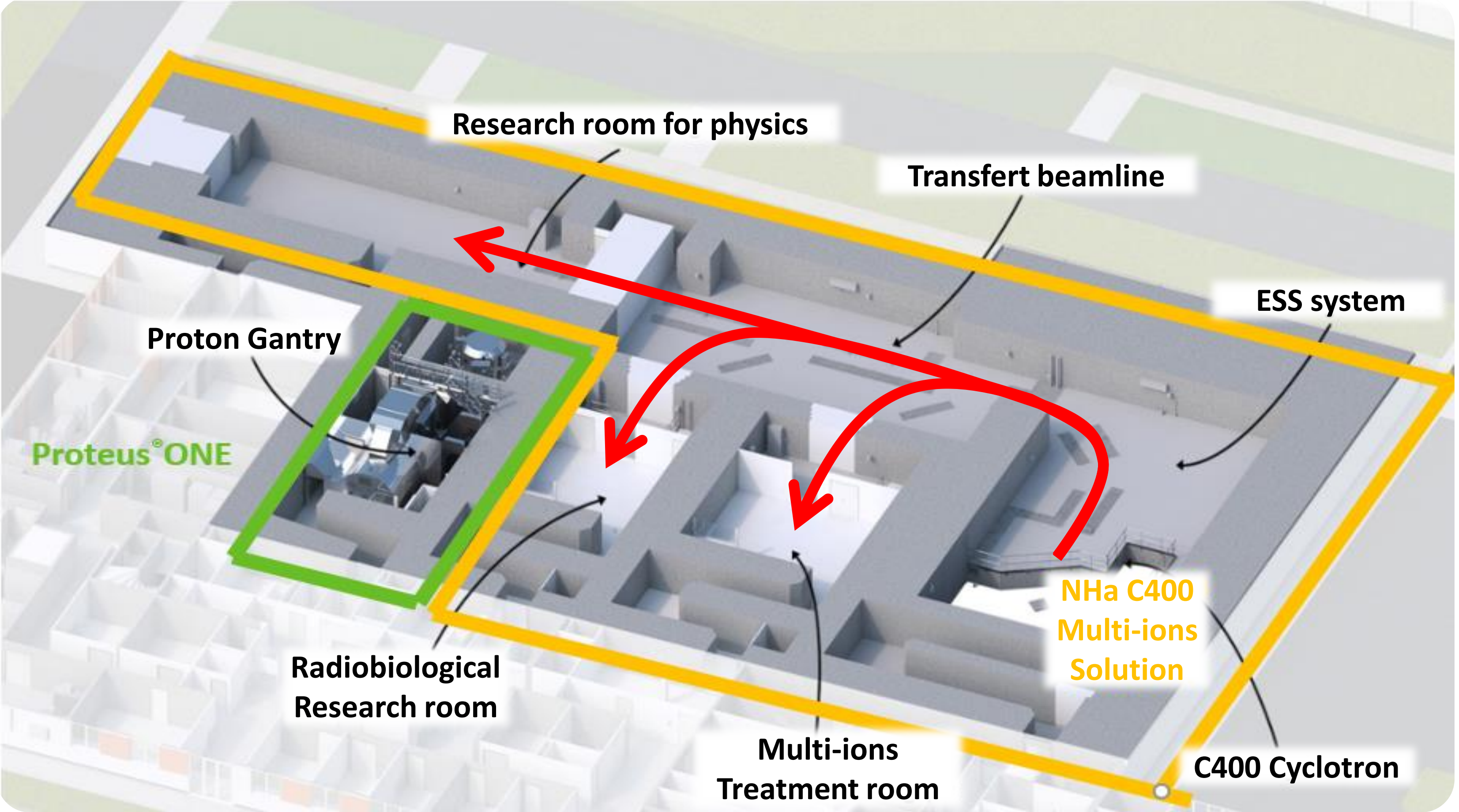
- Accelerators technology is IBA's DNA
- Supports design of the C400 heavy ion cyclotron and beamline
- Treatment room equipment based on IBA software and hadware
- Supports market the new heavy ion system

Cyclhad center in Caen - France

NHa NORMANDY HADRONTHERAPY

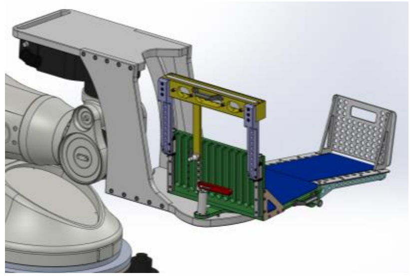
1st patient treated with protons in August 2018 (Proteus one)

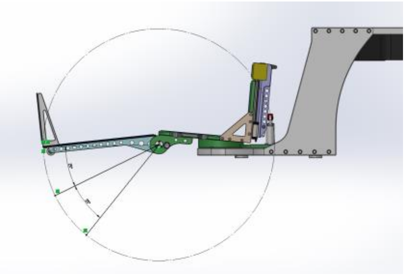
Bunker ceiling open for the rigging of the C400 in 2024

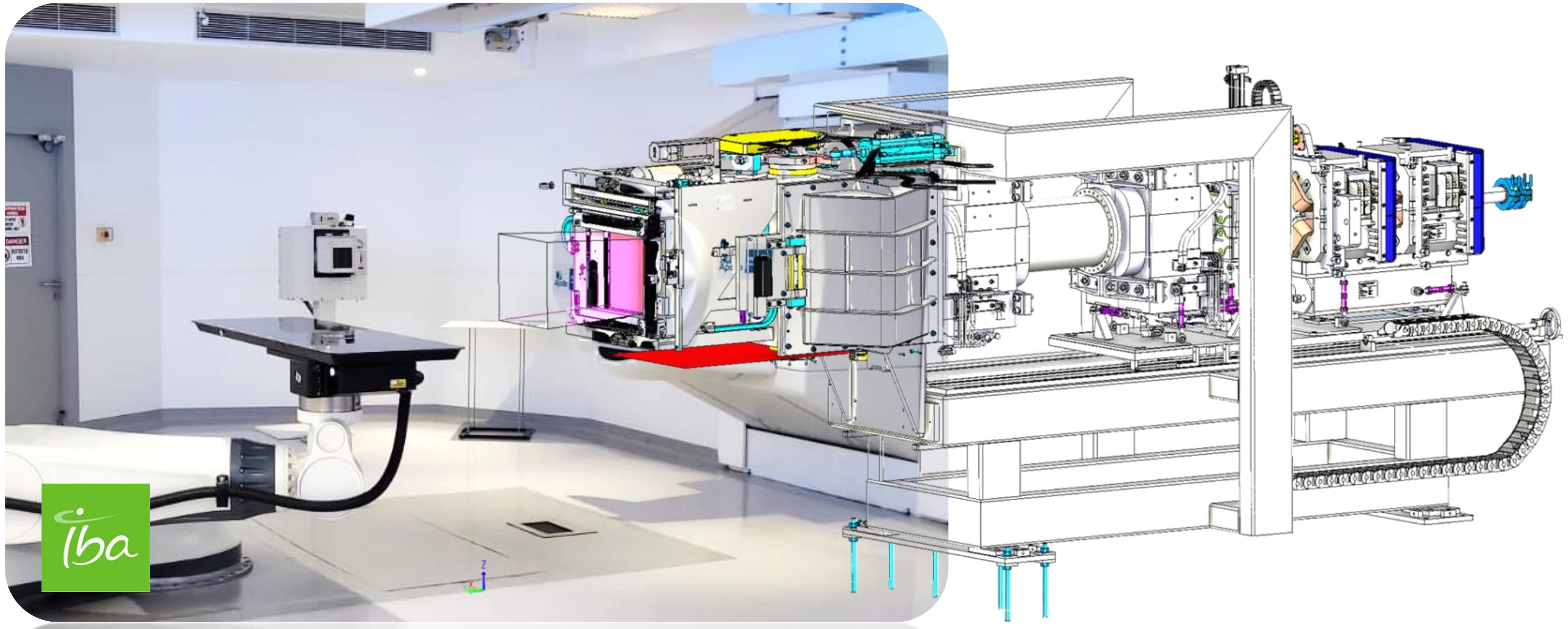


Multi-particles – fixed beam treatment room

- Taking advantage of know-how and experience from IBA
- High performance beam delivery and dosimetry:
    - Pencil beam scanning technology
    - 6D PPS robotic system
    - 2D PPVS flat panel with 3 X-ray tubes
    - Accessories to optimize irradiation range & treatment
    - Nozzle bottom clearance improved for a chair
    - Particle Quick switching
- Innovative chair currently in development







Courtesy of IBA: Chennai site, India

Isocenter performances

Clinical Beam Performance Specifications	Unit	Carbon	Proton	Helium
Maximum range	g/cm²	≥ 27	≥ 32	
Beam position accuracy at isocenter	mm	≤ 0.5		
Beam spot size @ max range (1σ)	mm	≤3	≤ 3.6	≤3.6
Beam spot size @ min range (1σ)	mm	≤ 4	≤ 8	≤ 6
Maximum Field size	cm²	≥ 20x20	≥ 30x30	≥ 28x28
SAD X/Y	cm	296 / 330		
Average dose rate (homogeneous cube of a 10 cm × 10 cm × 10 cm)	Gy/min	≥ 2		

Patient Positioning and Alignment Specifications	Unit	Couch	Chair
Treatment volume (L x W x H)	cm	100 x 50 x 40	32 x 23 x 55
Yaw rotation for prescription / correction	°	± 90 / ± 5	± 180 / ± 5
Pitch and roll range for prescription / correction	°	± 10 / ± 5	

Challenges, perspectives and partnerships

NHa NORMANDY HADRONTHERAPY

Helium ions PBS ready

Third party CBCT, SGPT compatible

Carbon Flash research - 2x2x2cm²

High dose rate treatment

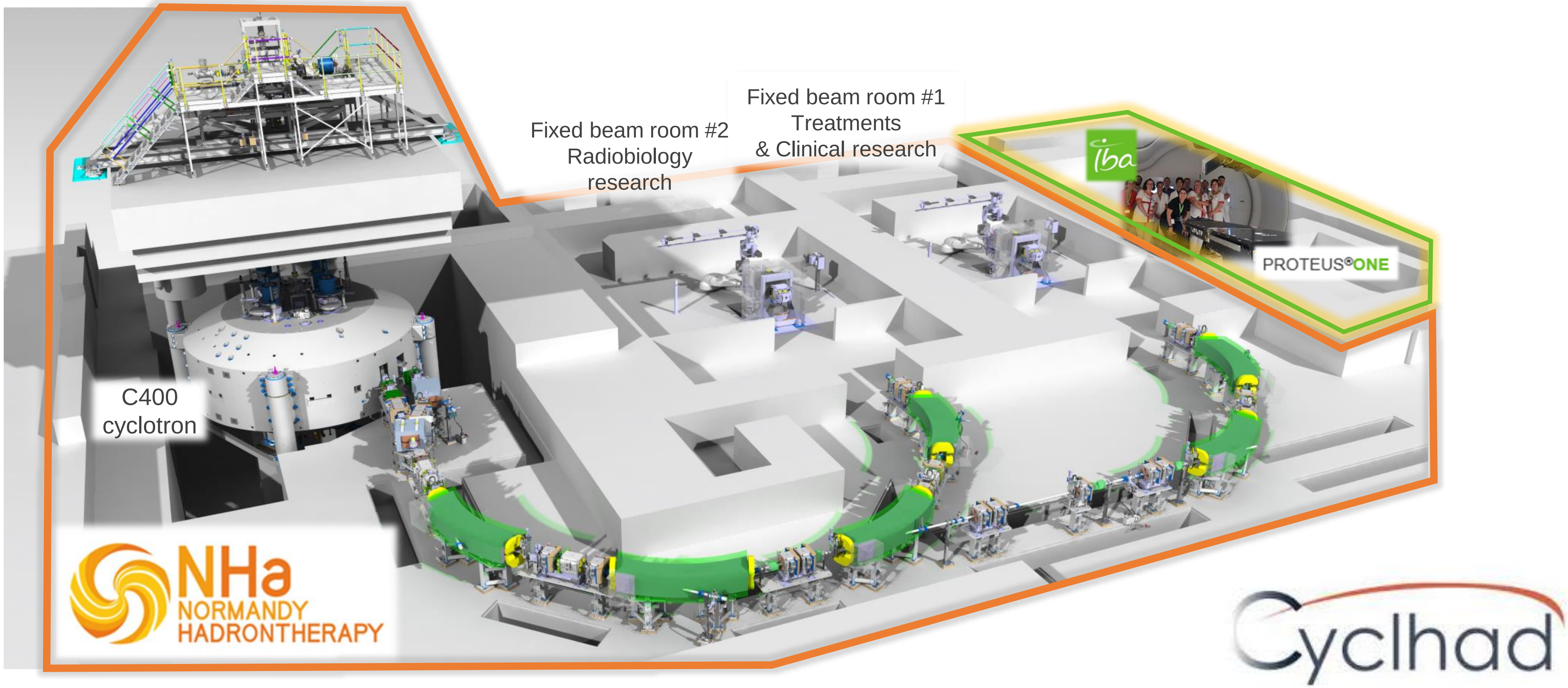
Conformal Hadron Flash therapy

Helium imaging

Gantry based technology (Arc, CBCT…)

New ions like **Oxygen…**

First site: CYCLHAD (Caen, France)



The C400 cyclotron

REMINDER: Initial accelerator design is based on a IBA-JINR collaboration from 2009, reviewed by experts of our community.

Table B1: Summary of the C400 cyclotron Main parameters

General properties		
accelerated particles	=	H_2^+, $^4He^{2+}$, ($^6Li^{3+}$), ($^{10}B^{5+}$), $^{12}C^{6+}$
Injection energy	26 kV ←	25 keV/Z
final energy of ions,	=	400 MeV/amu
protons	260<<270 ≈	265 MeV/amu
extraction efficiency		70 % (by deflector)
number of turns	~2100 ←	~1700
Magnetic system		
total weight	737 Tons ←	700 tons
outer diameter	7m ←	6.6 m
height	=	3.4 m
pole radius	=	1.87 m
valley depth	=	60 cm
bending limit	=	K = 1600
hill field	≈	4.5 T
valley field	≈	2.45 T
RF system		
radial dimension	≈	187 cm
vertical dimension	≈	116 cm
frequency	=	75 MHz
operation	=	4th harmonic
number of dees	=	2
dee voltage		
center	~60 kV ←	80 kV
extraction	~150 kV ←	170 kV

- **IBA experts (Jérôme Mandrillon, Vincent Nuttens, Willem Kleeven *et al.*) did an extra pass on all subsystems with substantial modifications and additions**
- **Let's mention also the mechanical engineering experts: Laurent Koffel, Sebastien Deprez and Yohakim Otu that led the nice developments presented here.**

Design Report of Superconducting Cyclotron C400 for Hadron Treatment

JINR
V. Aleksandrov, G. Shirkov, E. Syresin,
G. Karamysheva, N. Kazarinov, S. Kostromin, N. Morozov, E. Samsonov, V. Shevtsov, A. Tusikov, V.Romanov

IBA
Y. Jongen,
W. Kleeven, S. Zaremba, D.Vandeplassche, F. Stichelbaut,
S. Deneuter, S Déprez, W. Beeckman

SIGMAPHI & co
J-L. Lancelot,
W. Beeckman, F. Forest, M.N. Wilson, C. Monroe

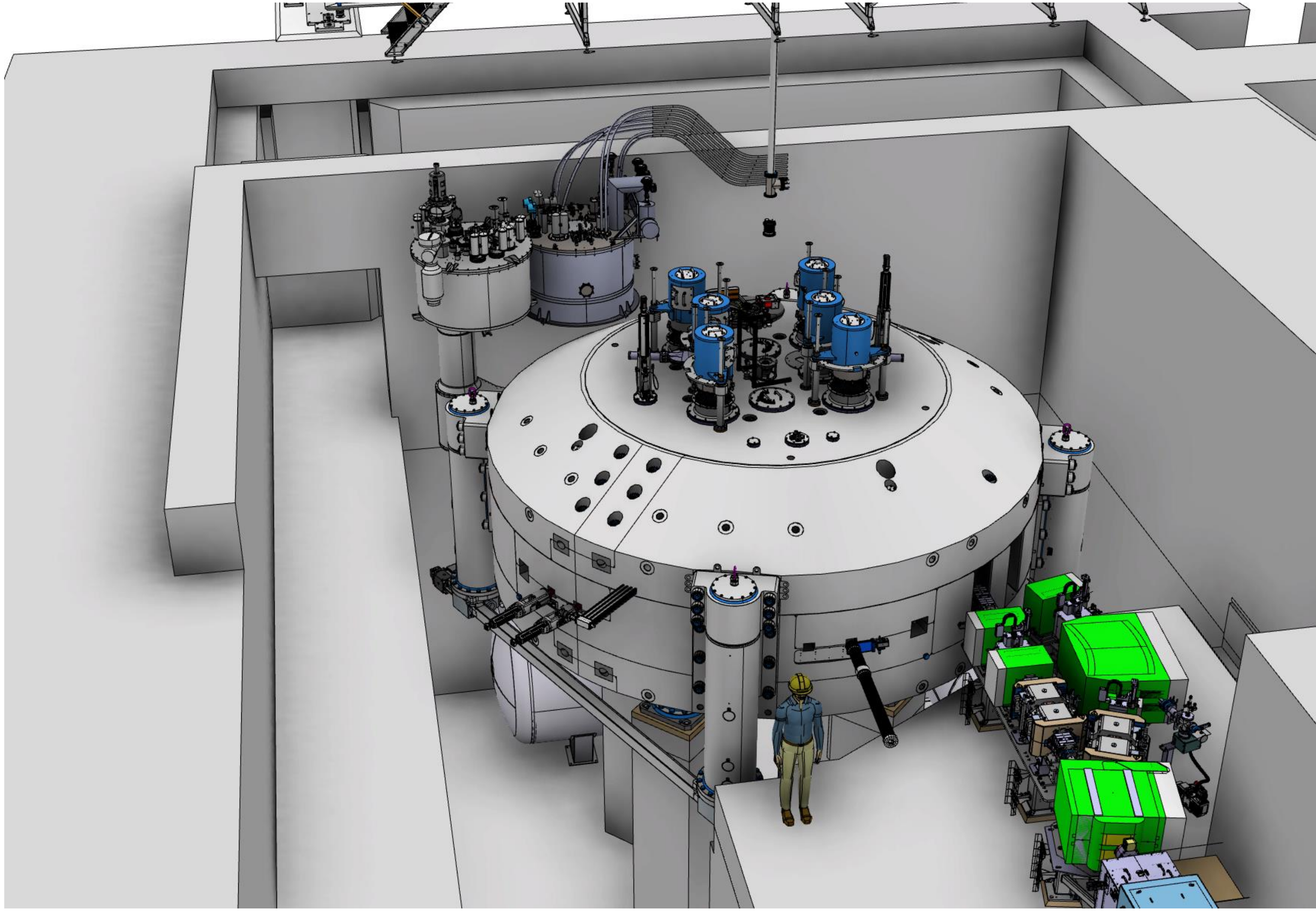
International Experts Design Review
Louvain-la-Neuve
22 & 23 April 2009

ΣΦ SIGMAPHI

C400 Design review April 2009 IBA Confidential

General overview of the C400 cyclotron

Main technical features:



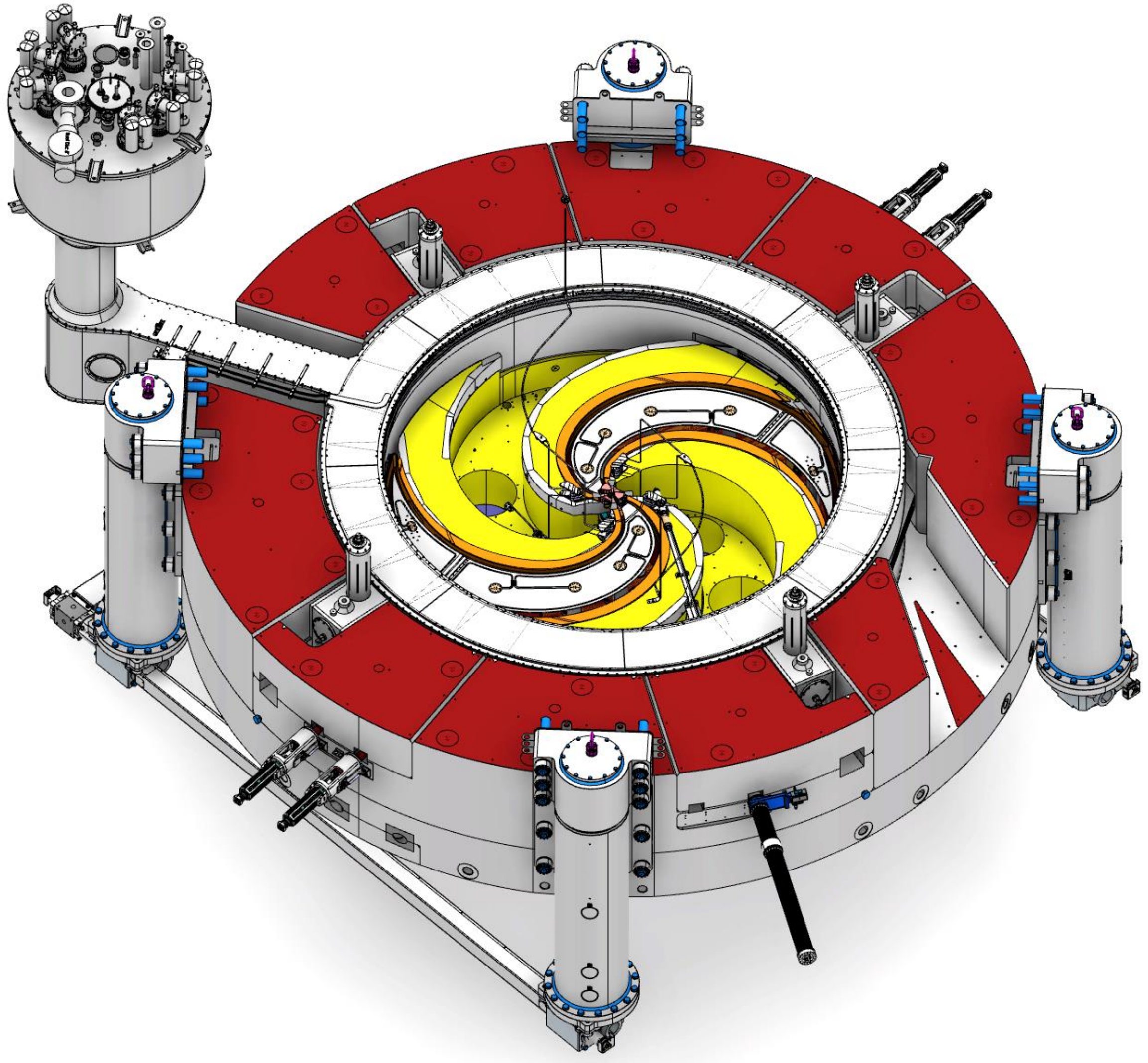
General overview of the C400 cyclotron

Main technical features:

- "Compact" magnet

  740 Tons – 7m diameter yoke - pole radius 1.87m
  pole is 4-fold symmetry / Elliptical gap / Spiralized poles
  can accelerate q/m = ½ particles

- **RF**: 75MHz for $^{12}C^{6+}$, 75.6MHz for H_2^+, Harmonic #4



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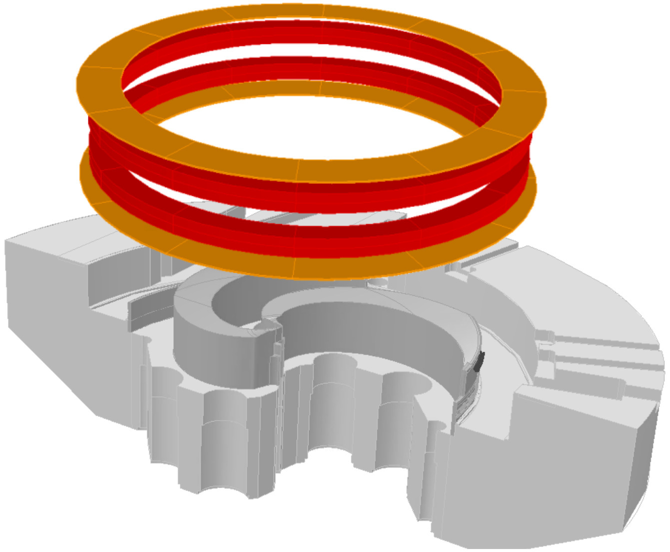
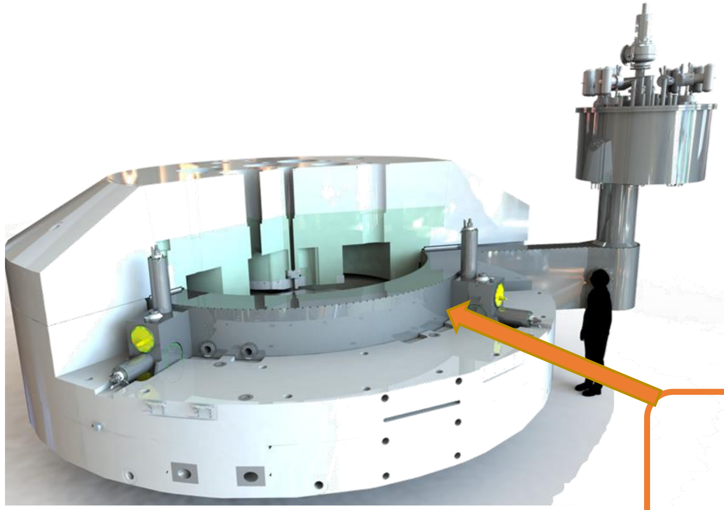
- Cryogenic coils
  - max field 4.5T
  - coils in liquid He bath
  - 2 sub-coils/coil to adapt field to particle masses discrepancies.





Coils

Ramping time : 2 hours

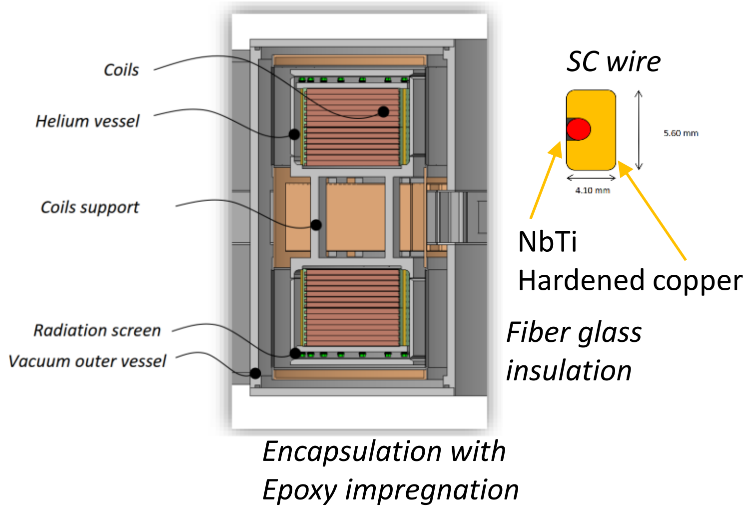
Time to switch between particles : < 15 min

Stored energy: ~55.6 MJ

turns per coil : 1344

Supra material : NbTi

Critical current: 2800 A @ 4,5 T @ 4,2 K



Cryostat

Outer diameter: 4.8m

Liquid helium bath T°: 4.3 K

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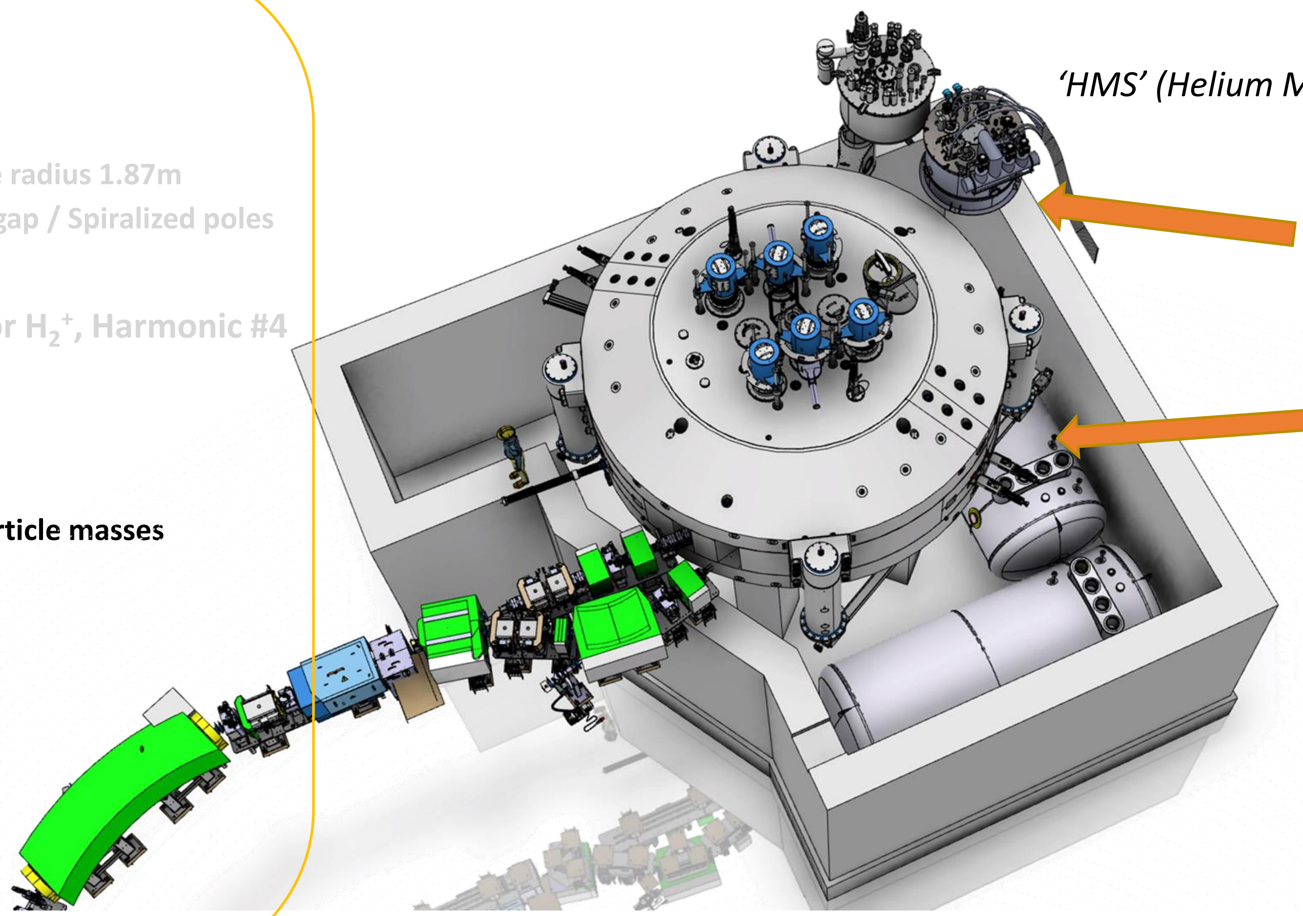

‘HMS’ (Helium Management System)

Cryogenic system

First cooling from GHe to LHe with closed loop liquifaction system

Cooling power : 6 cryocoolers / 14 W cooling power @ 4.3 K

Highly instrumented for quench management (Temperatures / Voltages / pressures, strain gauges, quench heaters)

2x large tanks for complete He recovery & reliquefication on site
→ Cost saving and environment friendly

General overview of the C400 cyclotron

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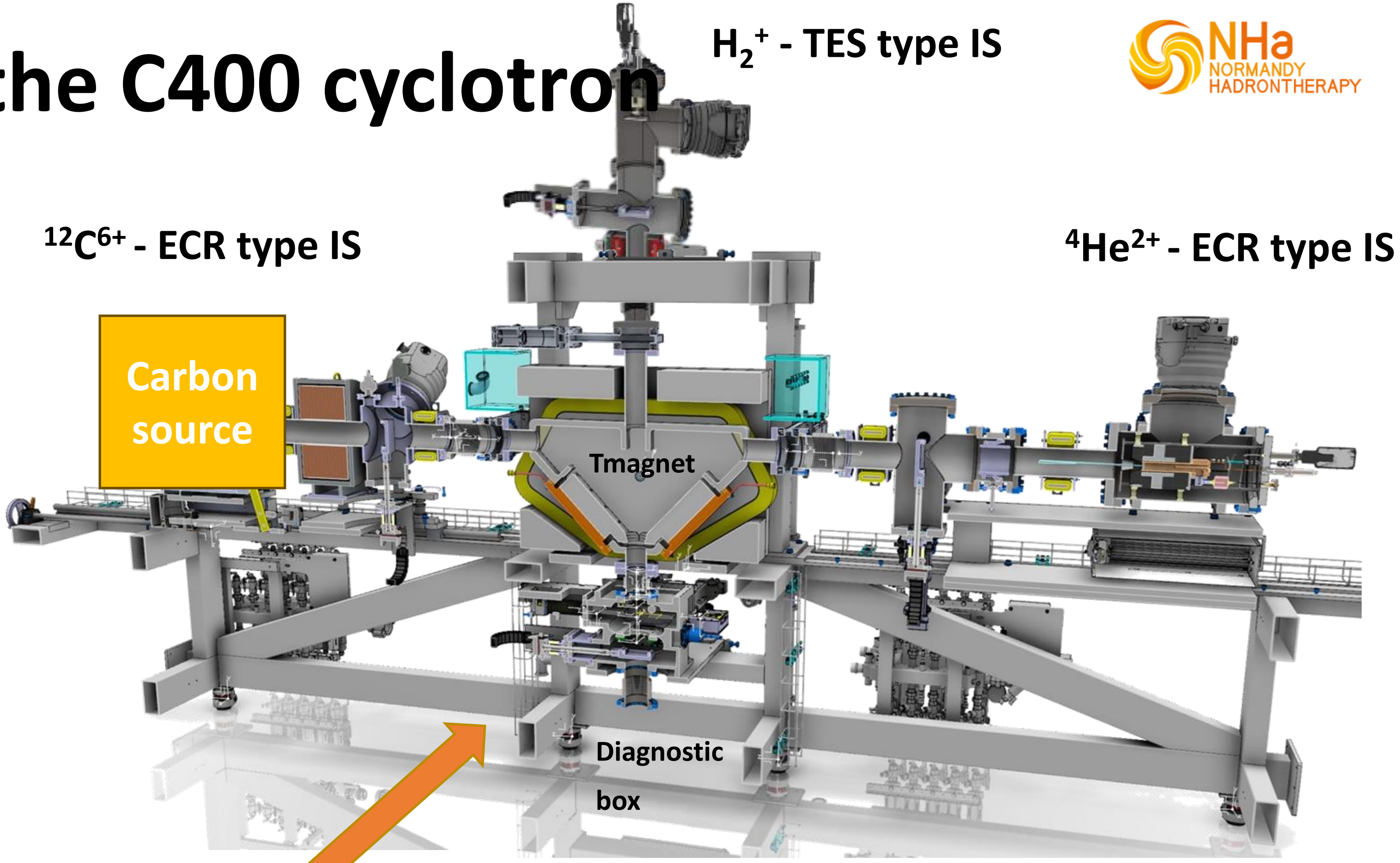
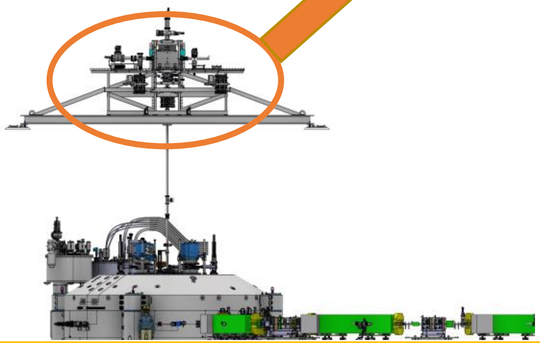
  - 2 sub-coils/coil to adapt field to particle masses discrepancies.
- Injection line
  - 3 sources: H_2^+, $^4He^{2+}$ & $^{12}C^{6+}$
  - Beam optics controls, buncher & diagnostics





ECR sources

He and H2 sources are commercial items (Polygon Physics) specifically tuned for the C400 IONS injection line

The Carbon source is a novel in-house developments with up-to-date methods and technology

Transport line

layout & equipment designed to maximize transmission and injection into cyclotron

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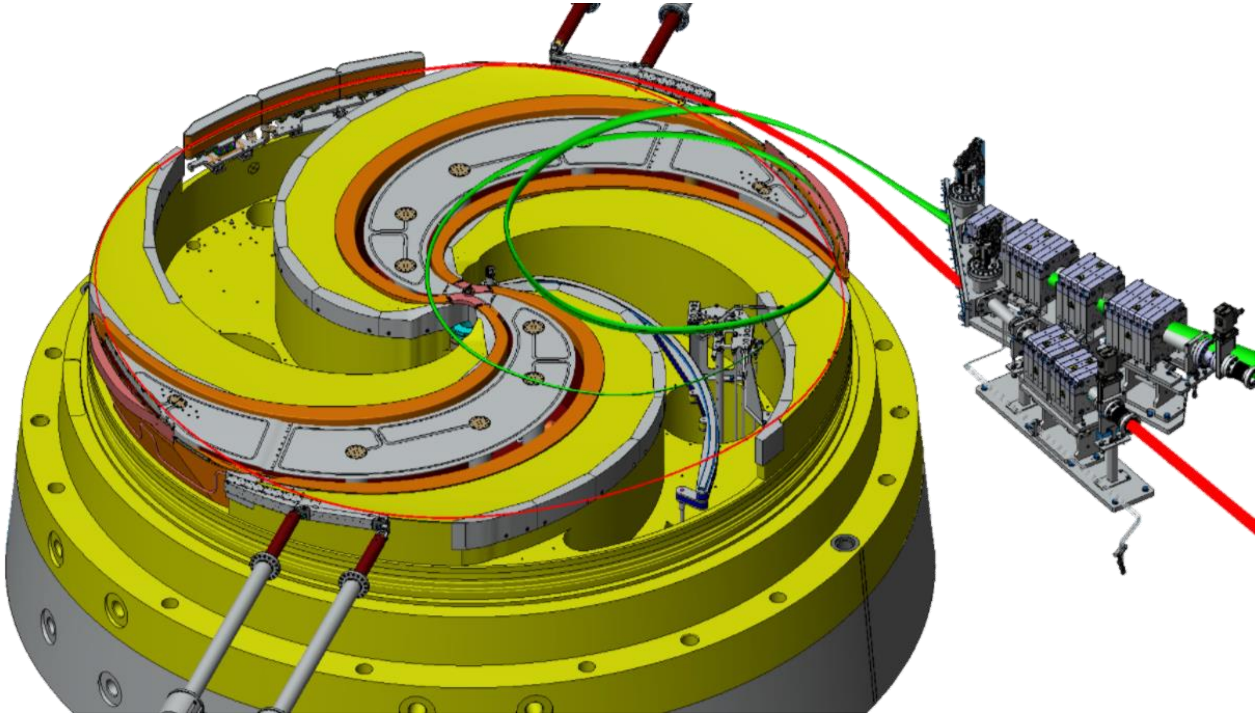
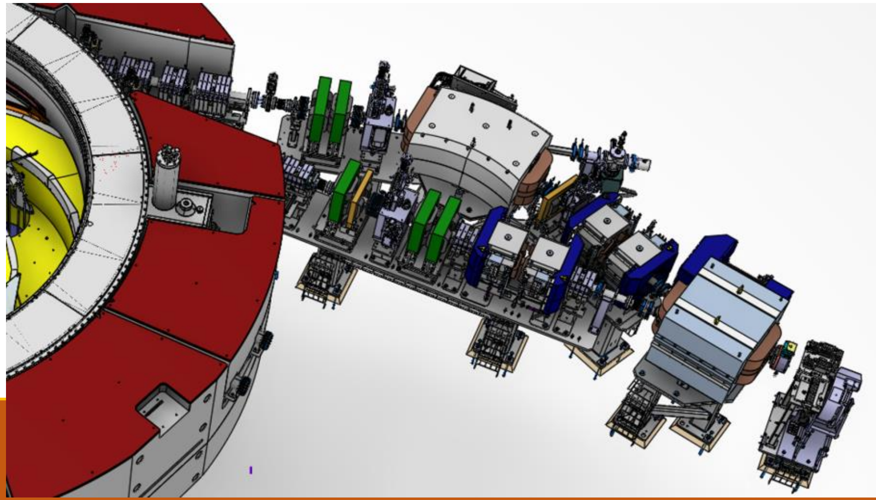
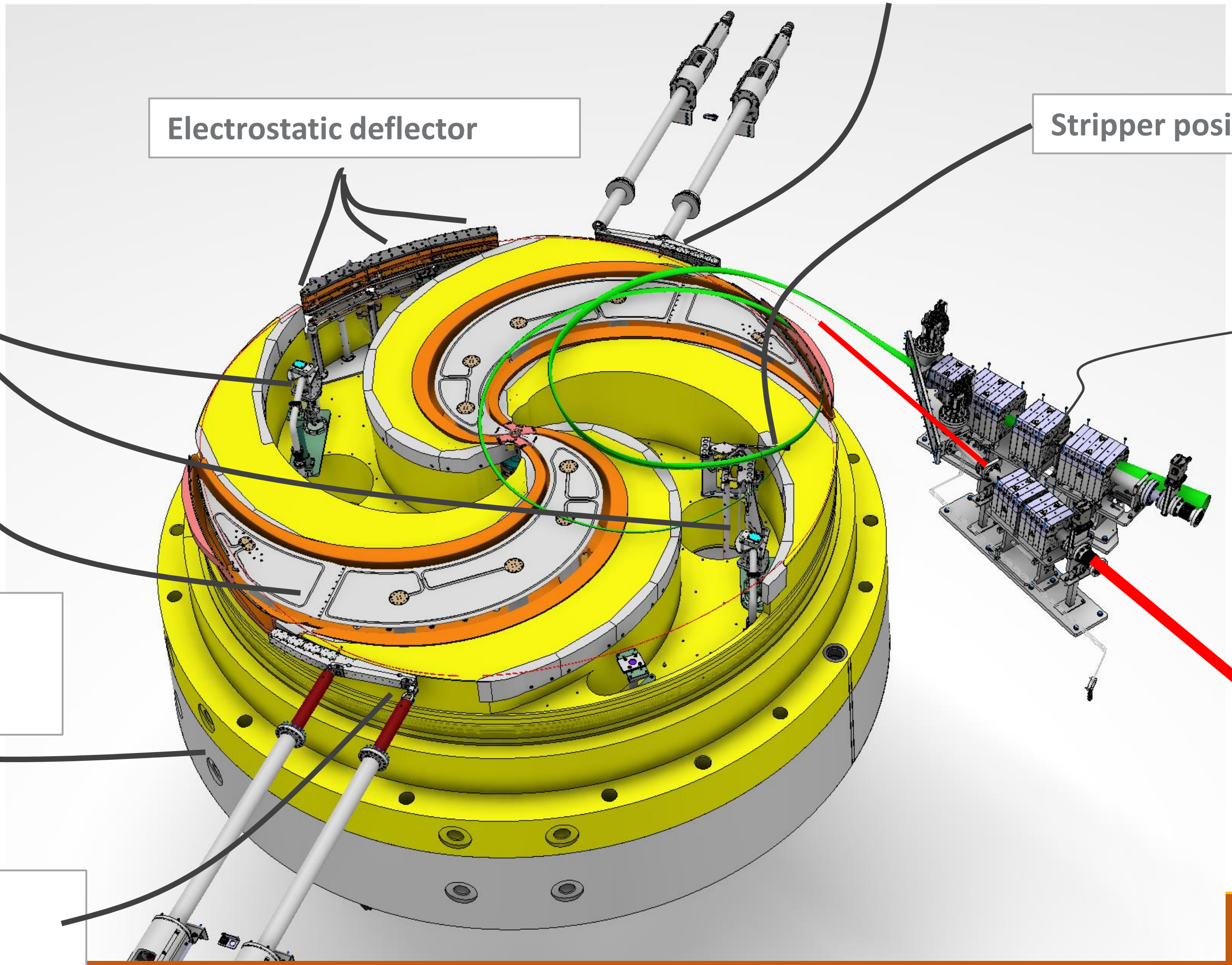
- Injection line
  - 3 sources: H_2^+, $^4He^{2+}$ & $^{12}C^{6+}$
  - Beam optics controls, buncher & diagnostics
- **Dual extraction:**
  - H_2^+ @ ~265 MeV/u: protons extracted via stripping
  - $^4He^{2+}$ & $^{12}C^{6+}$ @ 400 MeV/u: via electrostatic deflector





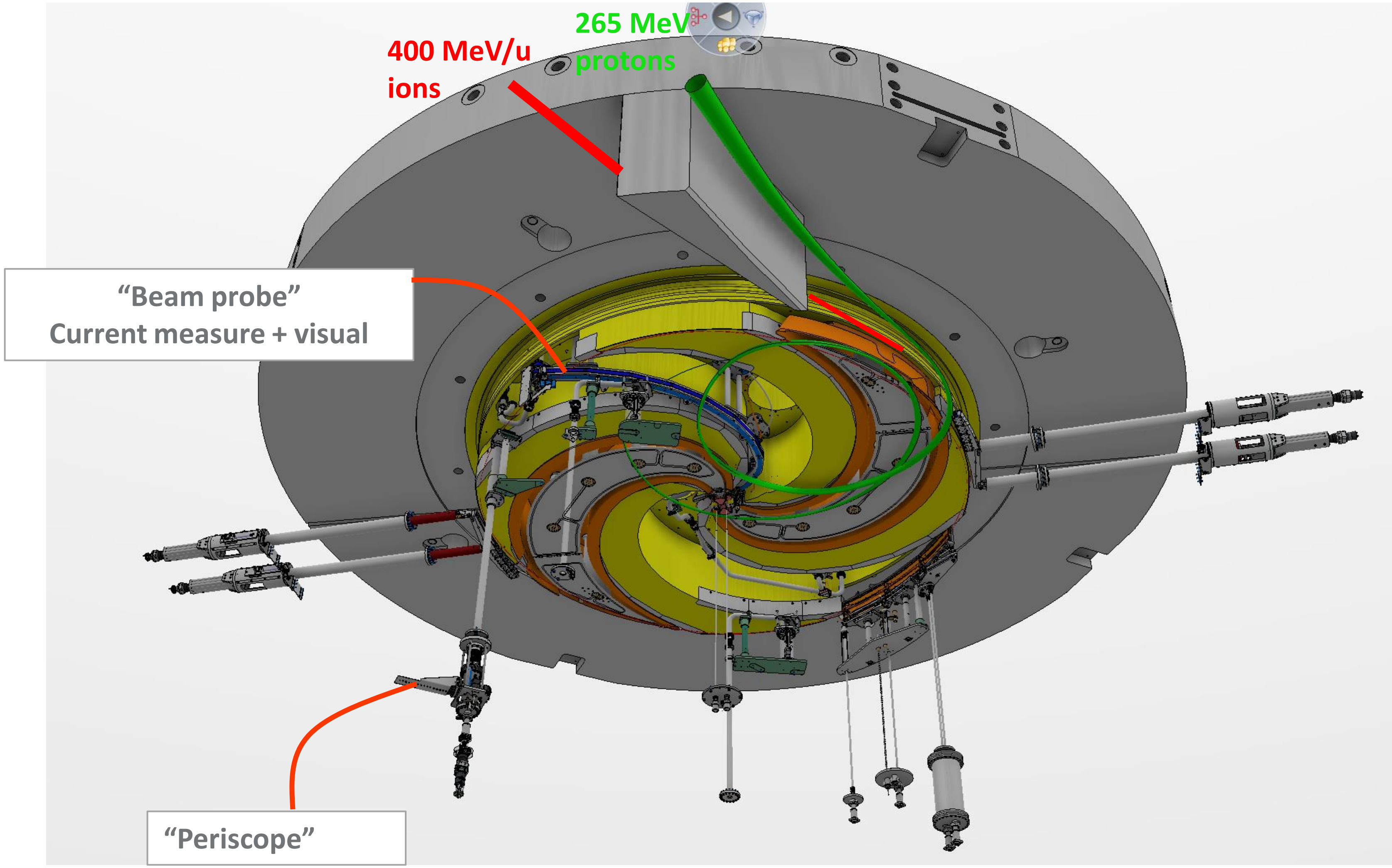
General overview of the C400 cyclotron

C400 – Inside view on BOTTOM pole:



General overview of the C400 cyclotron

C400 – Inside view on TOP pole:

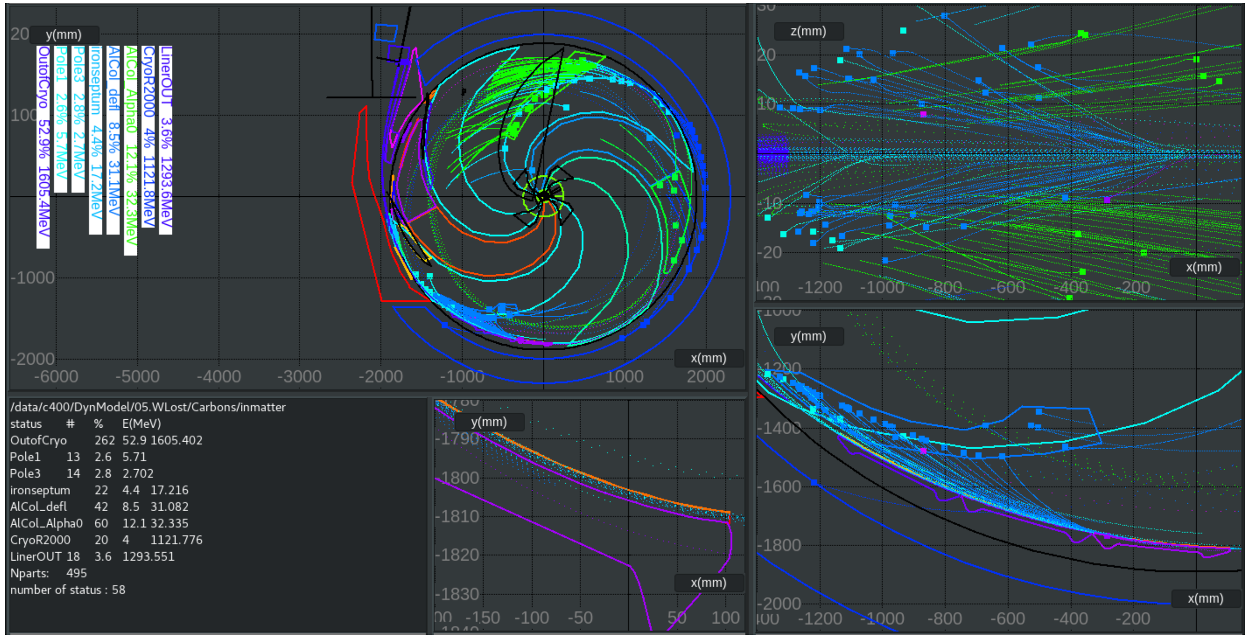


Beam losses management

- <u>Why?</u>
  - High energy & current ⇨ large energy deposition spread inside the cyclotron
  - Activation ⇨ Dose received to personnel
  - Power transmitted on SCC cryostat ⇨ Quench risk

- <u>Principles:</u>
  - Computation of particle tracking of the lost particles inside matter

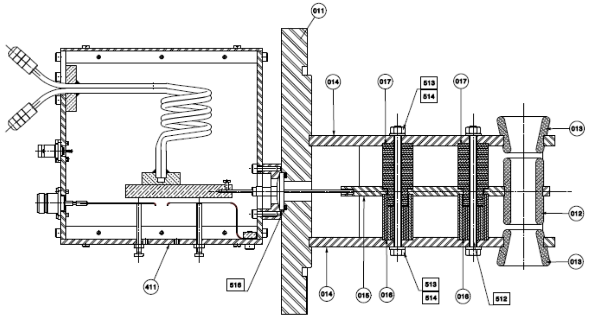
- <u>Mitigations:</u>
  - 1. Optimize injection
  - 2. Tune beam in the central region
  - 3. Addition of collimators at high radius

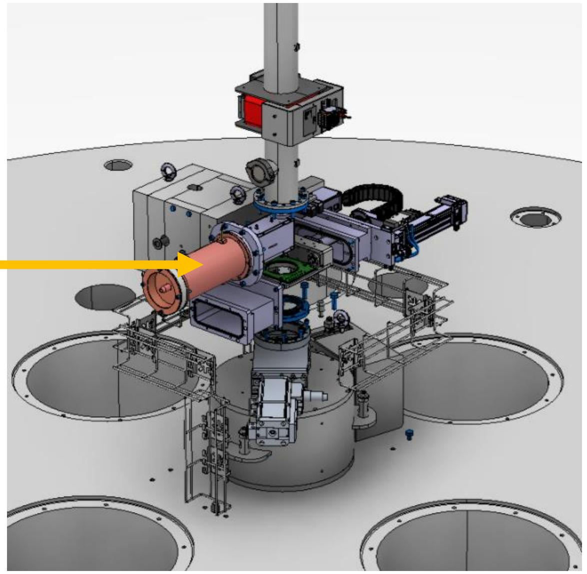


Beam losses management

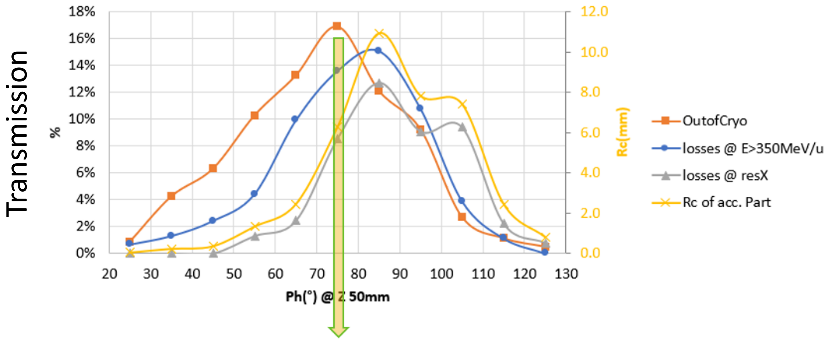
1. Optimize injection: make use of the buncher in the injection line

2 gaps – single harmonic buncher of known design

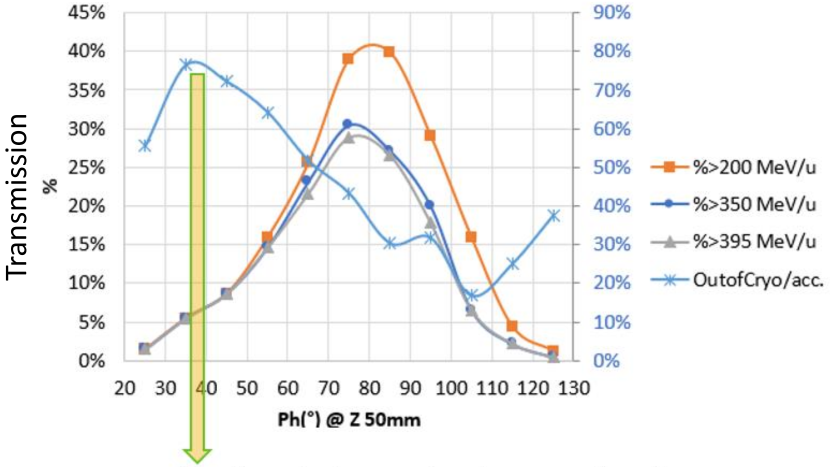




"outofCryo": meaning particles reaching cryostat exit port



Optimal phase for max current



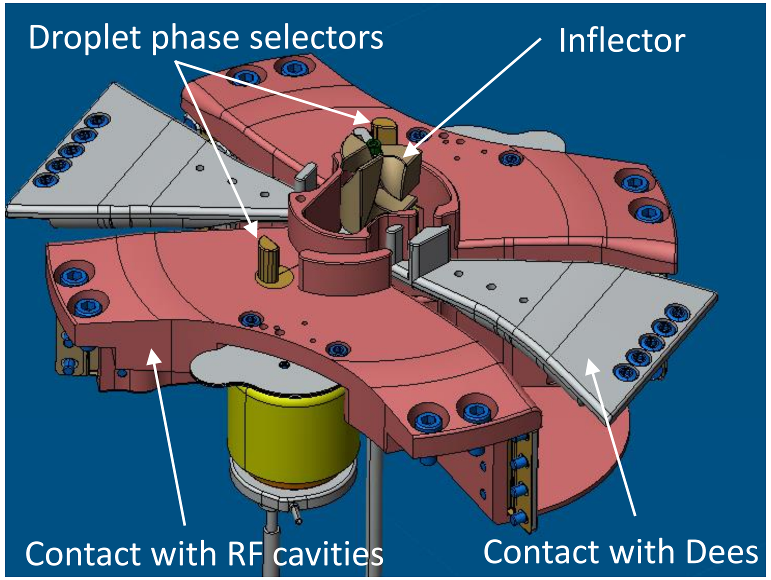
Optimal phase for less activation

Depending on the settings of the buncher, we can get either:
- an activation reduction by a factor ~2
- OR a max current multiplication by a factor ~4

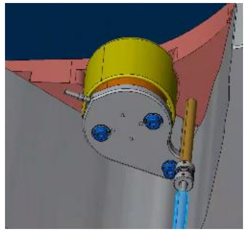
Final settings and use will be defined by tests during commissioning

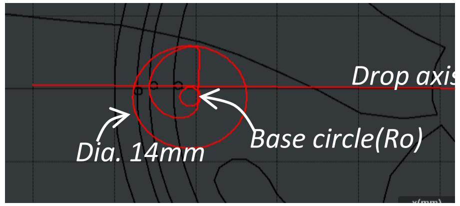
Beam losses management

2. Tune beam in the central region: ‘droplet’ shaped phase selector

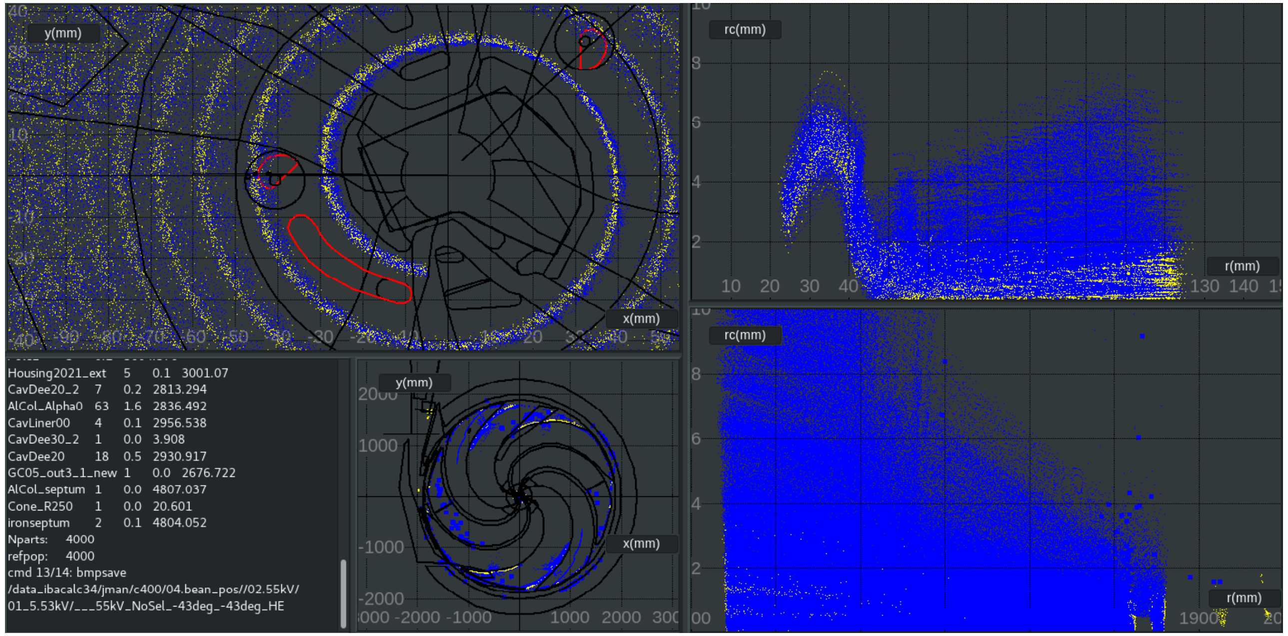


Actuated from outside the cyclo





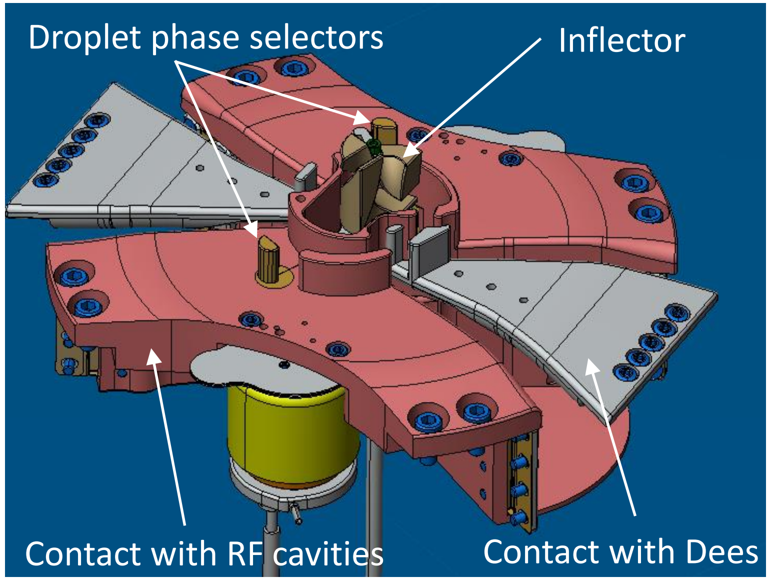
NO HIT DETECTION ON SELECTOR



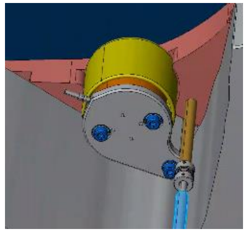
“outofCryo”: meaning particles reaching cryostat exit port
Blue: High energy losses: losses post central region: in resonance & in extraction

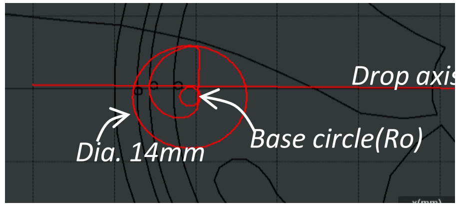
Beam losses management

2. Tune beam in the central region: 'droplet' shaped phase selector

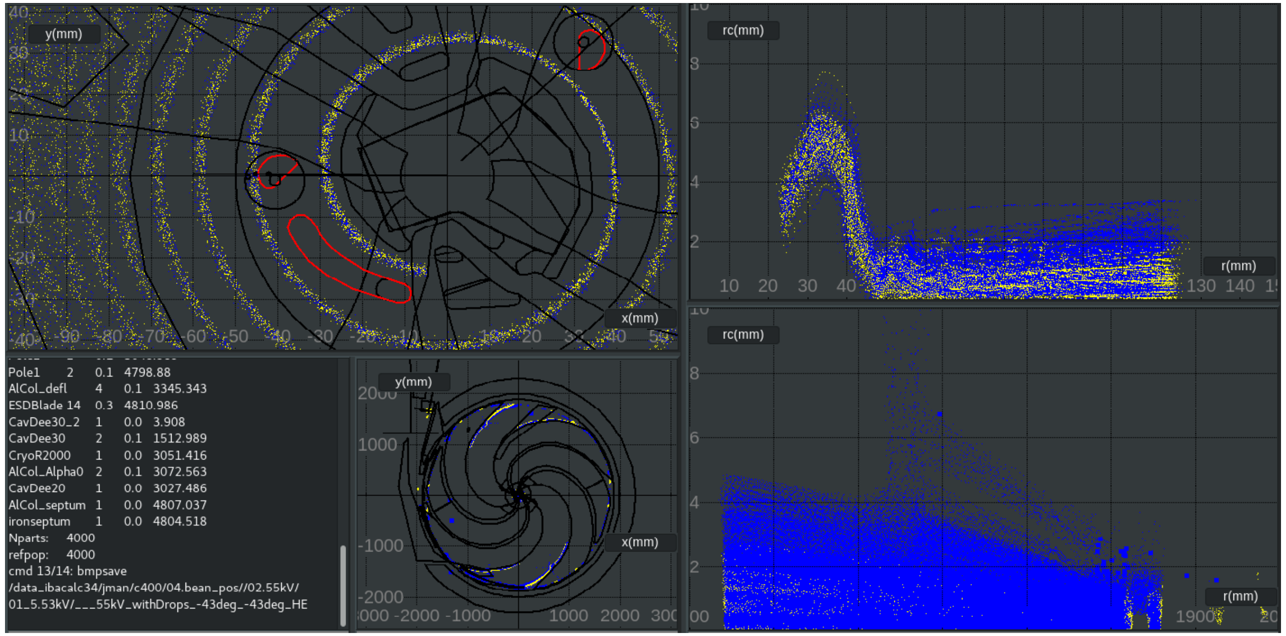


Actuated from outside the cyclo





HIT DETECTION ON SELECTOR (θ = -43°)

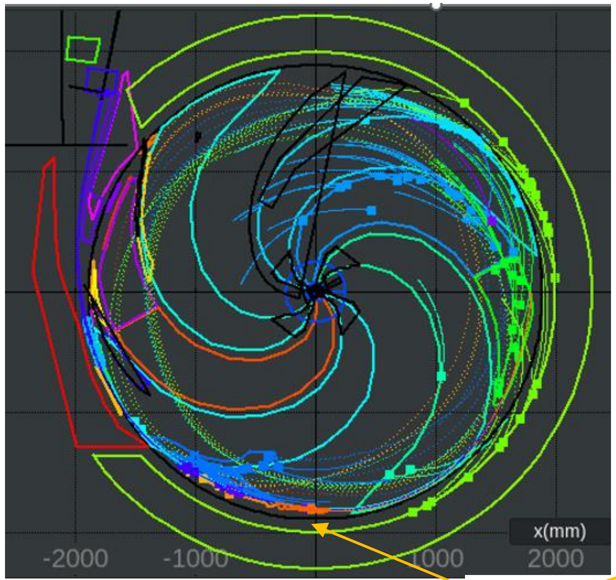


"outofCryo": meaning particles reaching cryostat exit port

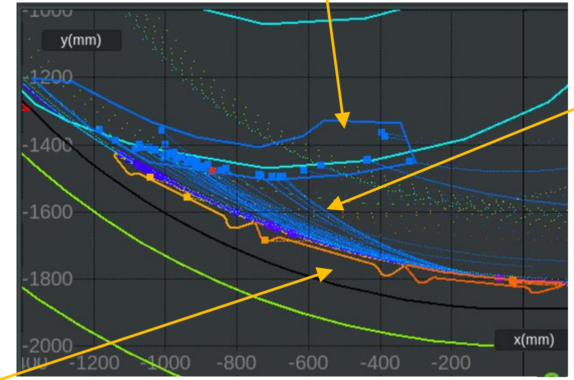
Blue: High energy losses: losses post central region: in resonance & in extraction

Beam losses management

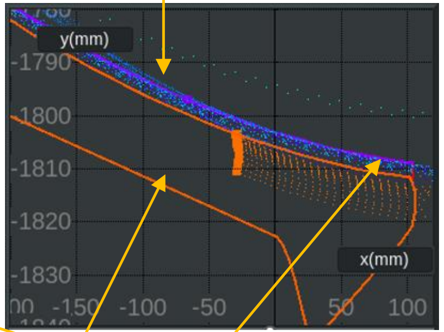
3. Addition of collimators at high radius

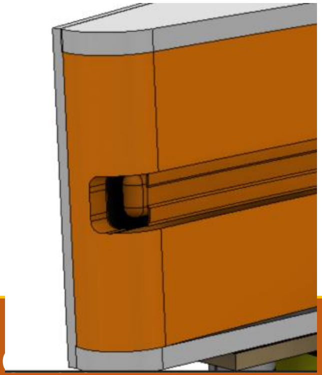


Added a low Z material (Al) volume to stop the tracks as much as possible

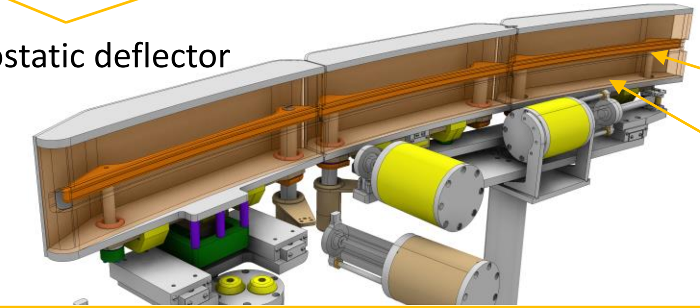


Extraction channel capture parts of several orbit turns
Energy losses in the septum generate a "particle shower" of variable radii downstream





Electrostatic deflector

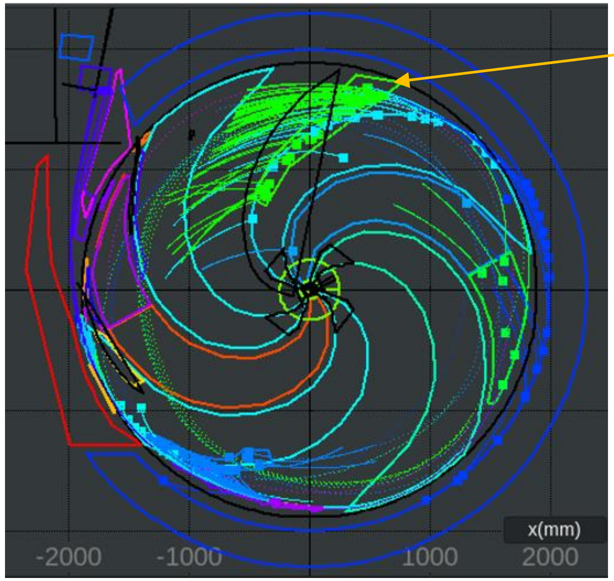


HV electrode

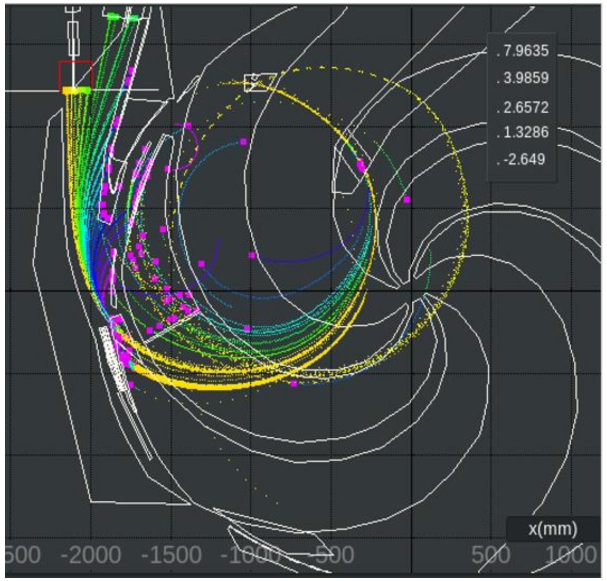
septum

Beam losses management

3. Addition of collimators at high radius

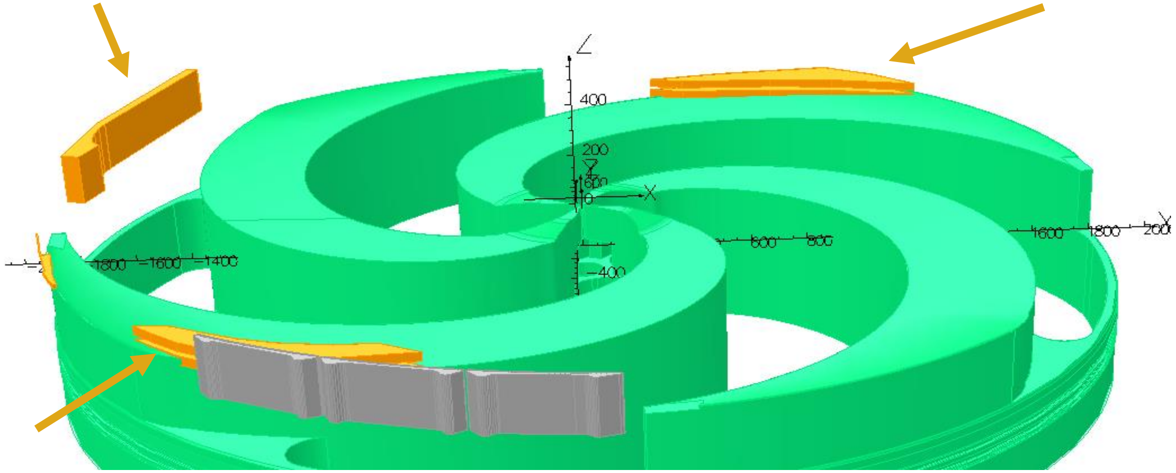


Second piece of collimators to stop remaining particles that going to be lost



4th piece deals with proton losses during the 2-turns extraction

Pre-septum of the gradient corrector to protect it from carbons and heliums



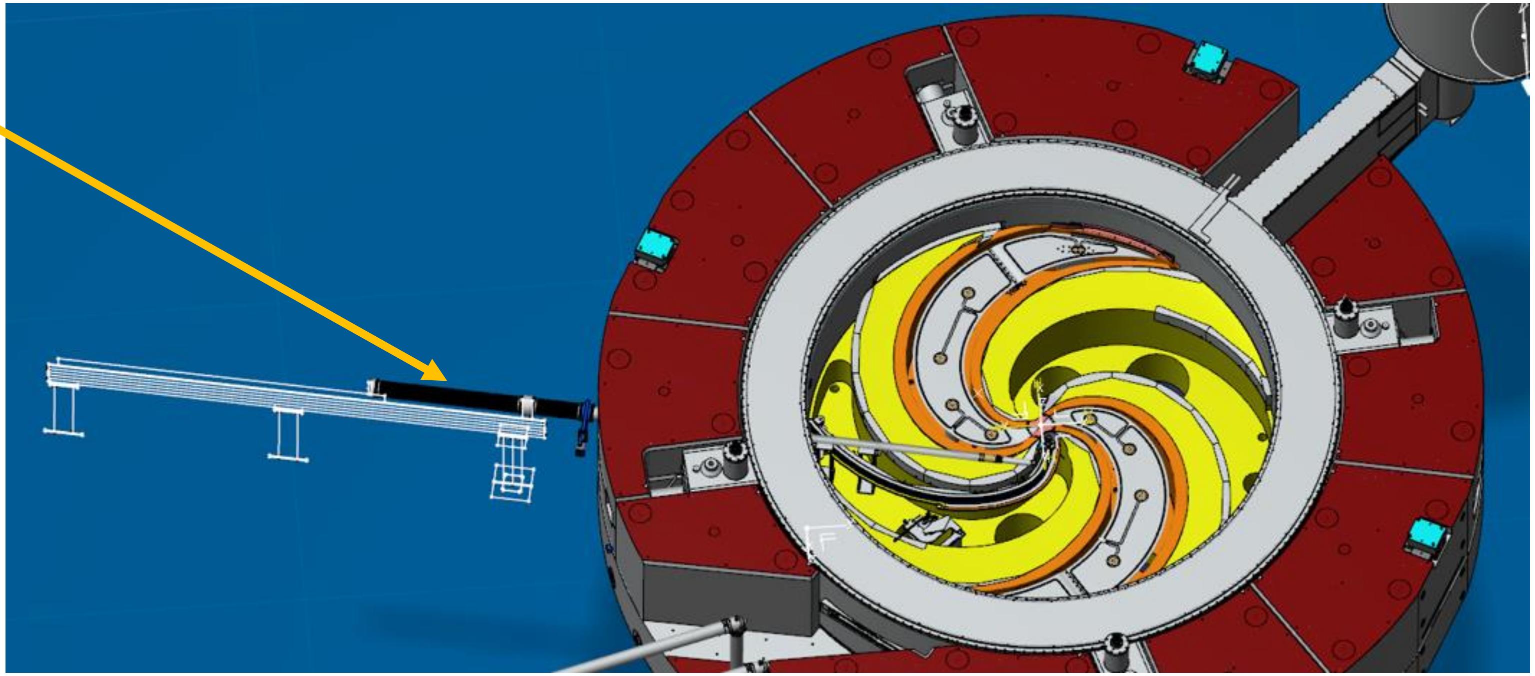
Beam probes

Design Requirements:

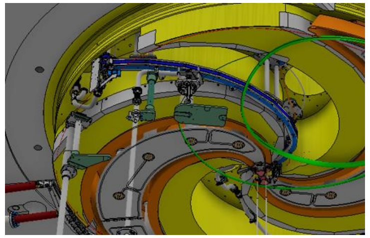
- measure beam current & shape at all orbits, mechanical accuracy (1mm), non magnetic+vacuum compatible
- Cooling, signal extraction, shielding from RF noise
- relatively fast: 2/3 minutes for a full track

"Usual radial probe" used on IBA cyclotron
Not suited for C400

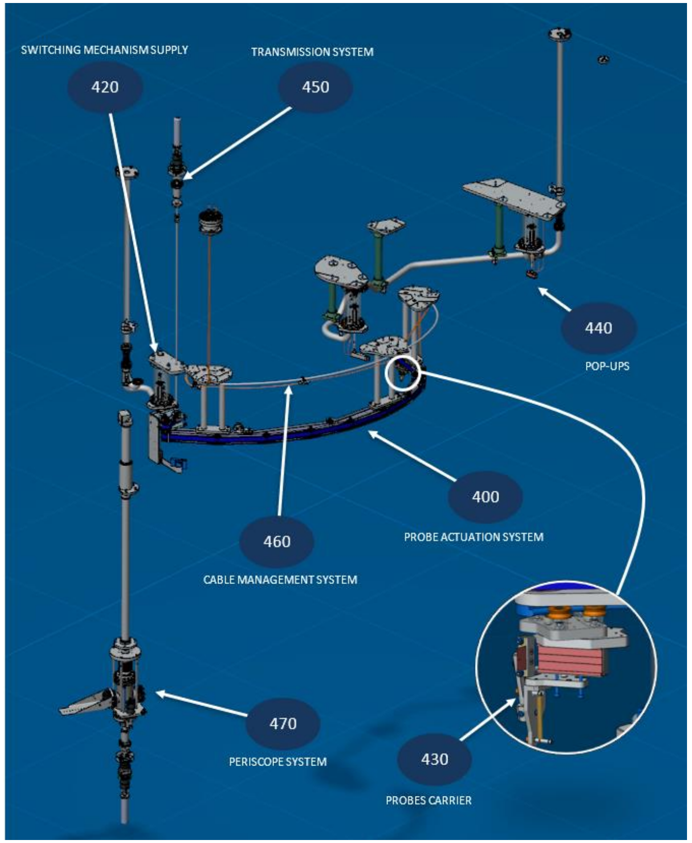
→ Did not allow for the optimum angle between beam and probe (90°)



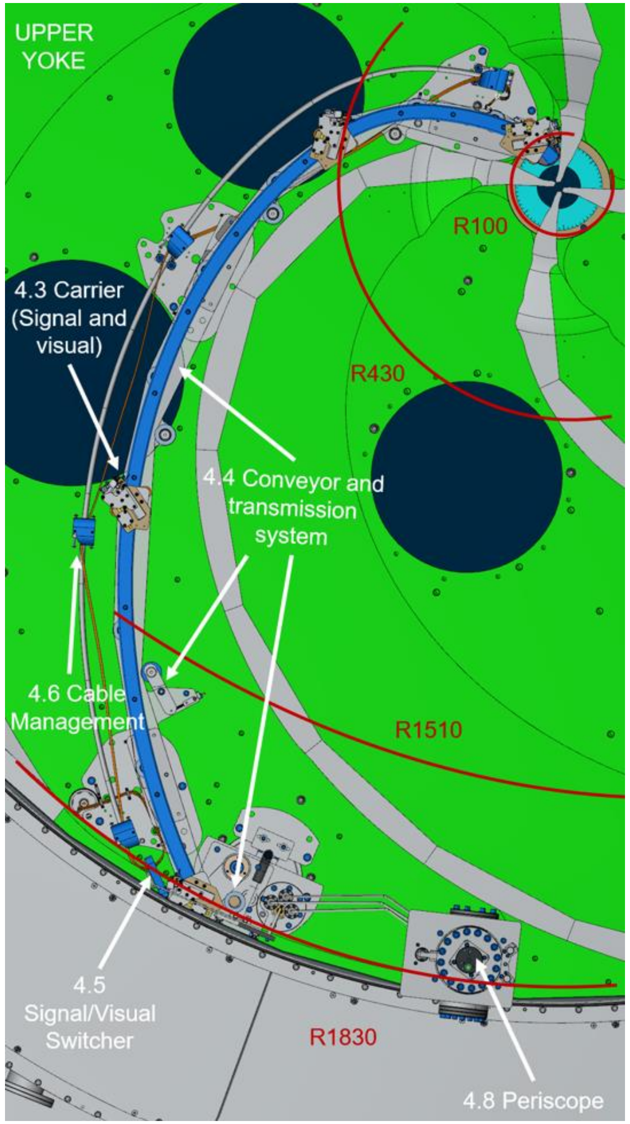
Beam probes



Chosen design:
curvilinear rail system + periscope +pops-ups

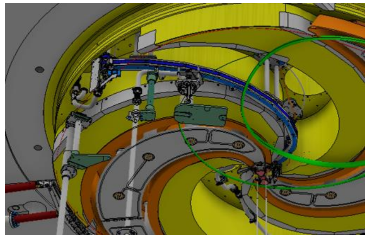


Features:
- suspended from upper yoke because of space optimization
- Curve parameterized to match almost perfect 90° between probe and beam down to R< 430mm
- Maximal reach R~100mm



Recent developments: Design progress

Beam probes



<u>Chosen design:</u>
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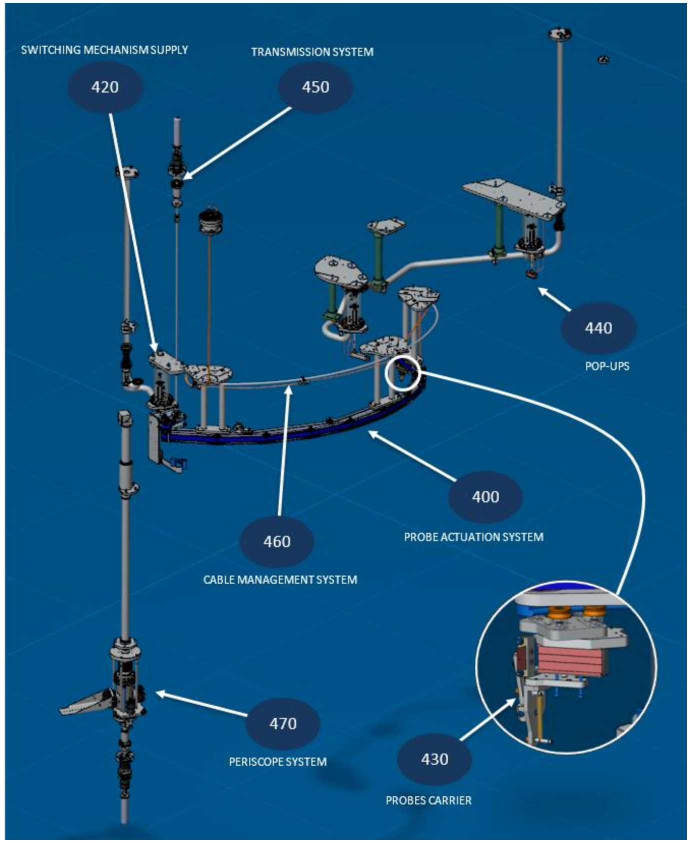
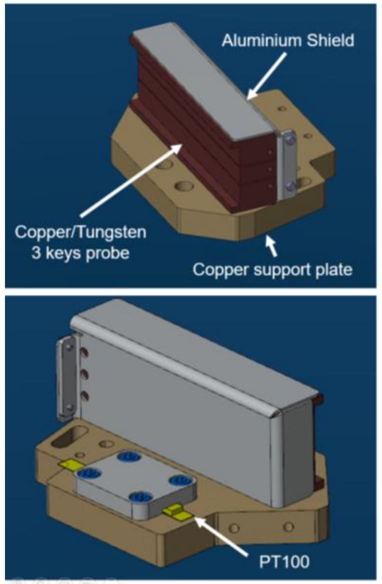
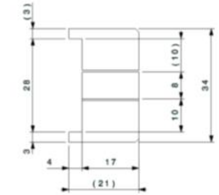
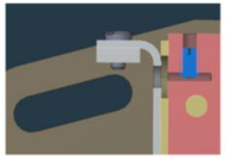


Beam current measurement:

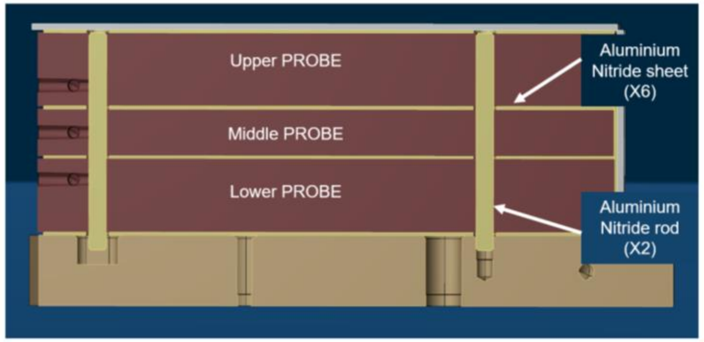




Profile of the 98 mm long probe

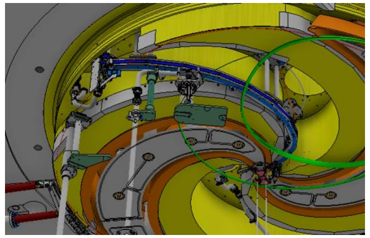


Cable connection

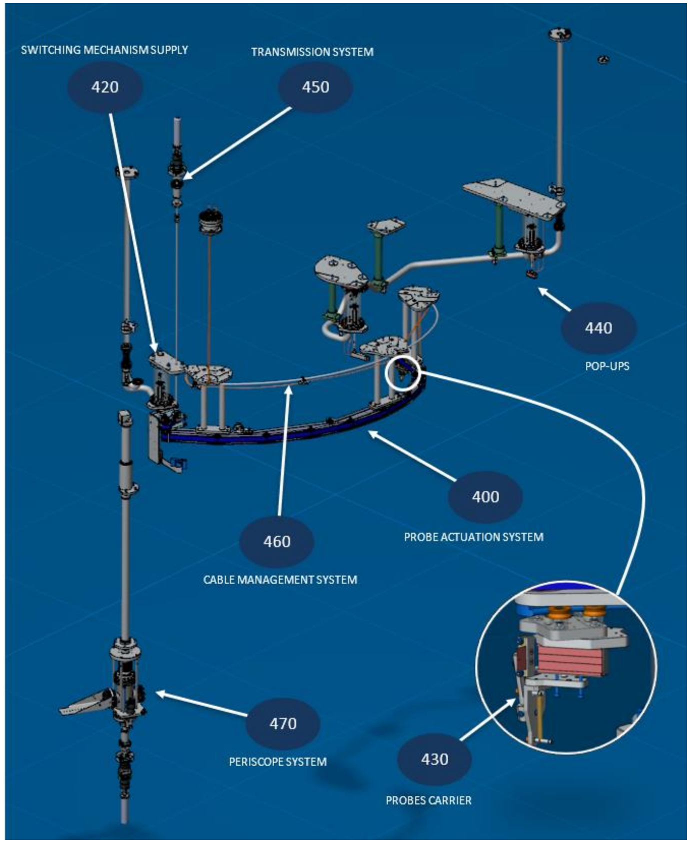


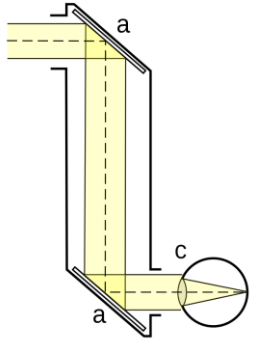
Recent developments: Design progress

Beam probes



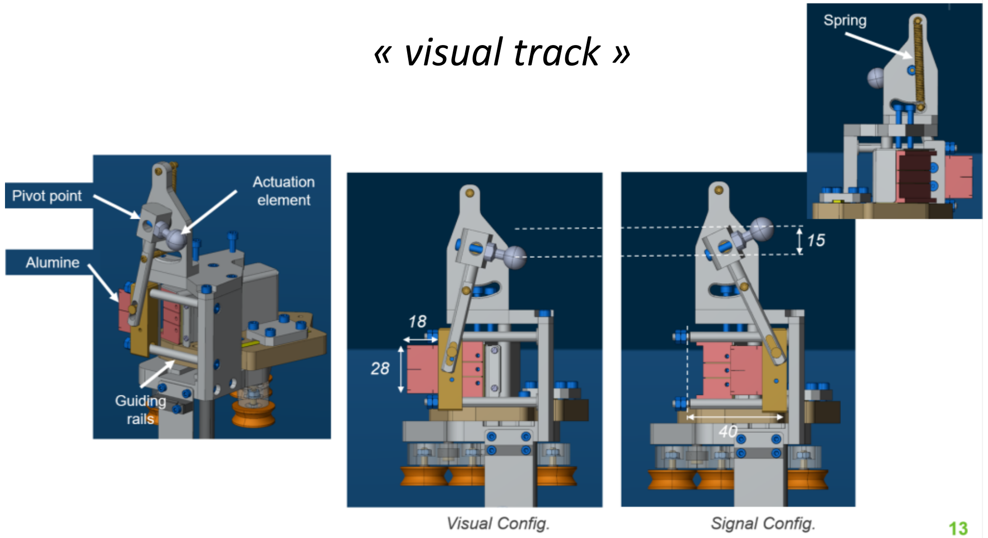
Chosen design:
curvilinear rail system + periscope +pops-ups

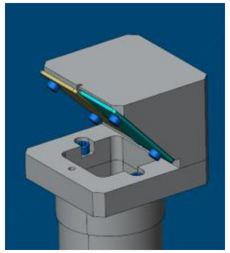




Beam shape measurement:

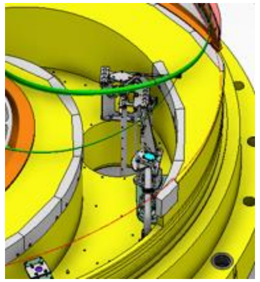
« visual track »





Recent developments: Design progress

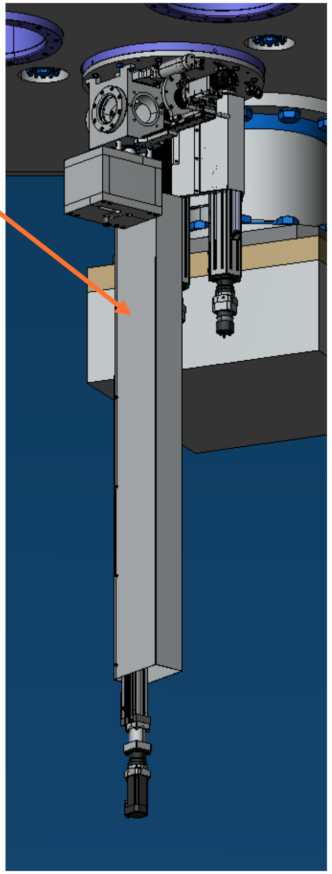
Proton stripper



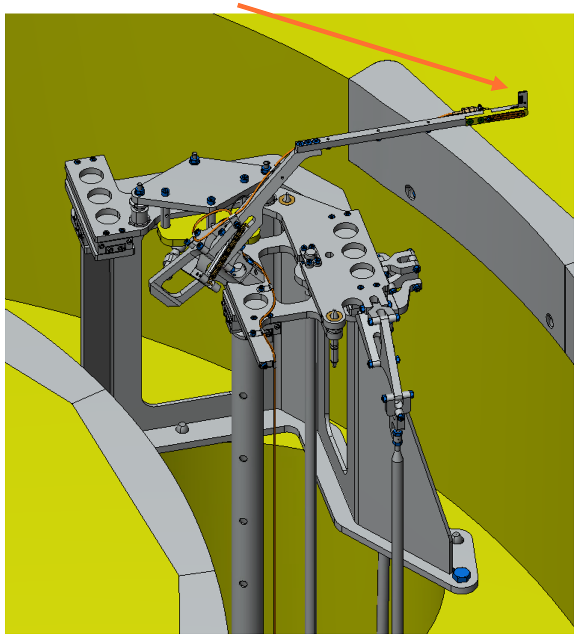
Main requirements:
- Accuracy and reliability of stripping foil position (affect beam properties)
- Fast particle switching proton/ions
- Replacement of stripping foil without cyclotron opening

Docking station:
- with isolated vacuum volume
- automated airlock sequence

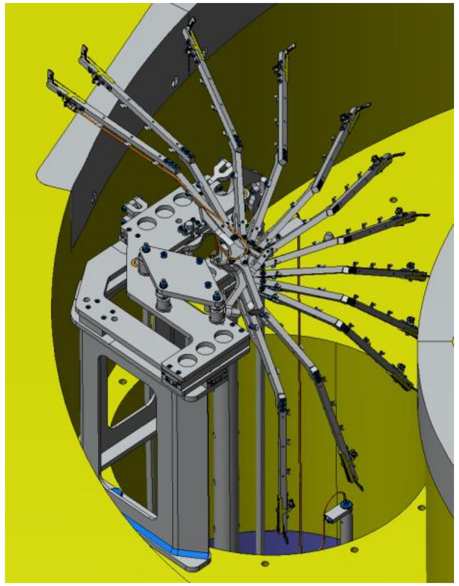
1400 mm stroke (with bellow)

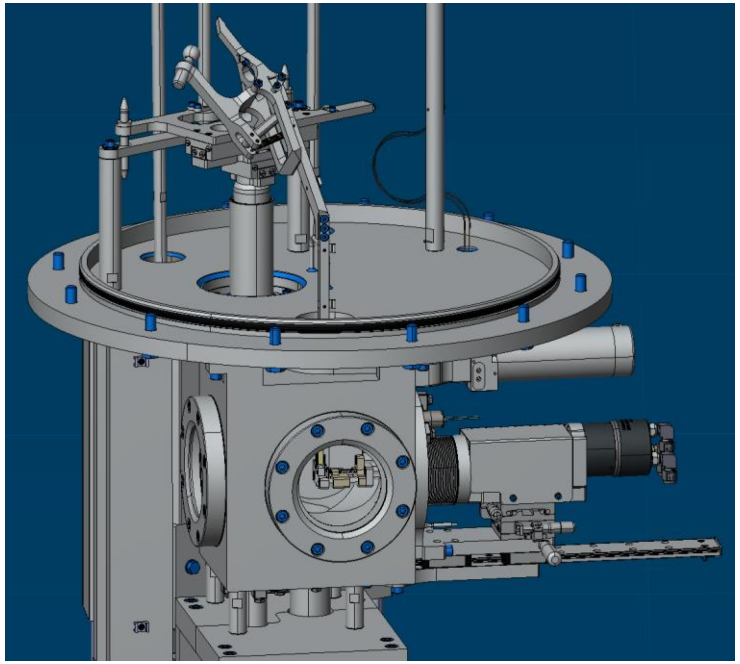


Stripping foil in nominal position



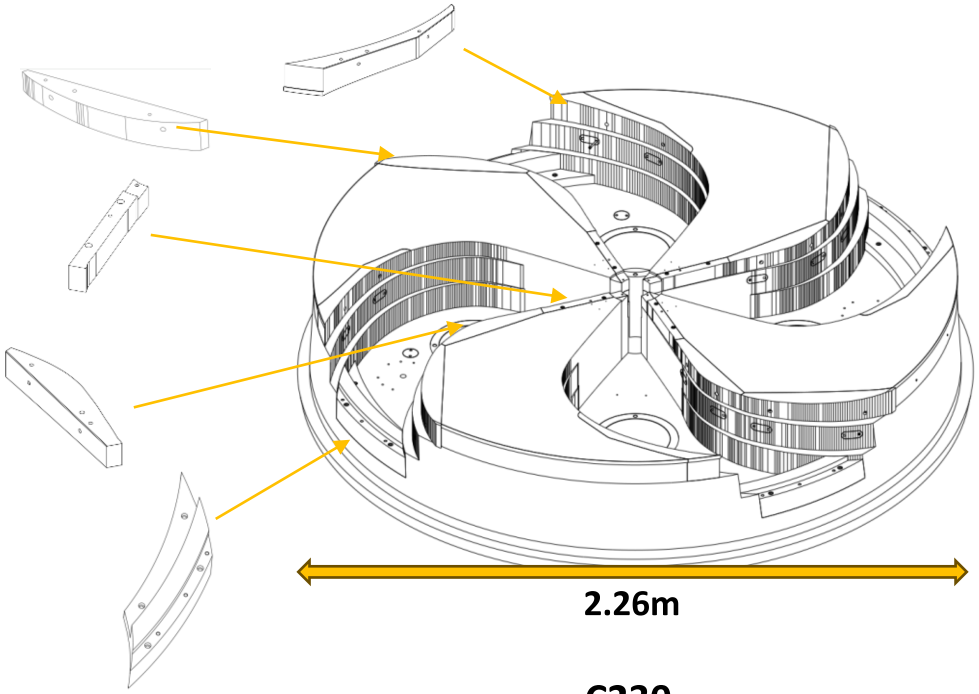
Stripper motion for extraction

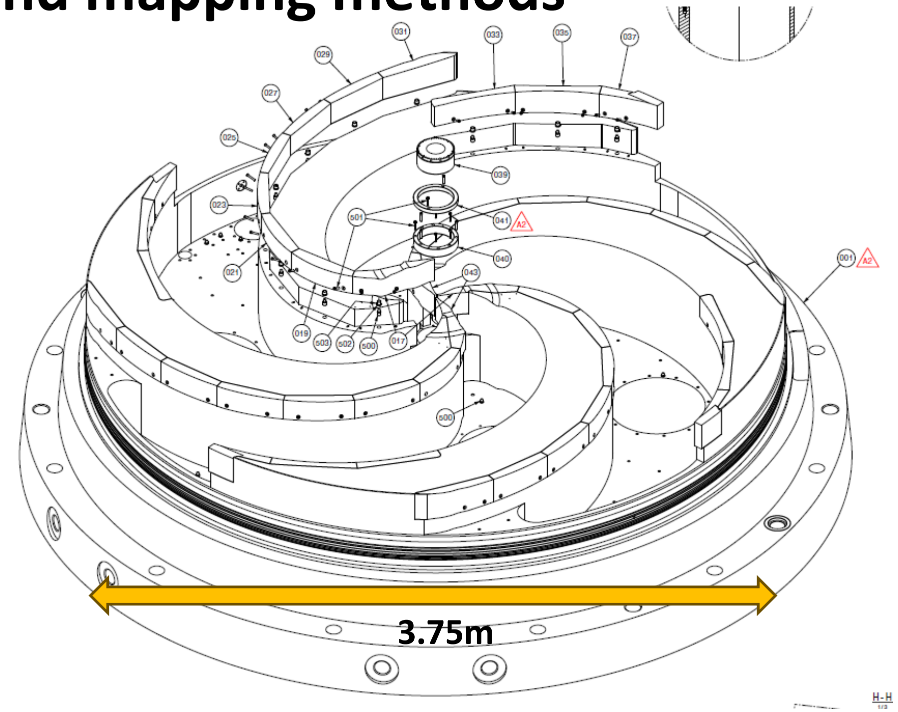




➡ **System and test bench Design finished, production starts soon**

Upscaling from C230: in need of new probes and mapping methods





C230

- 40 pole edges with 5 different shapes
- pole edge weights: max 25 kg
- Median plane: dia=2.26m → surface to cover: 4 m2
- Min-max B field: 1 - 2.8 T

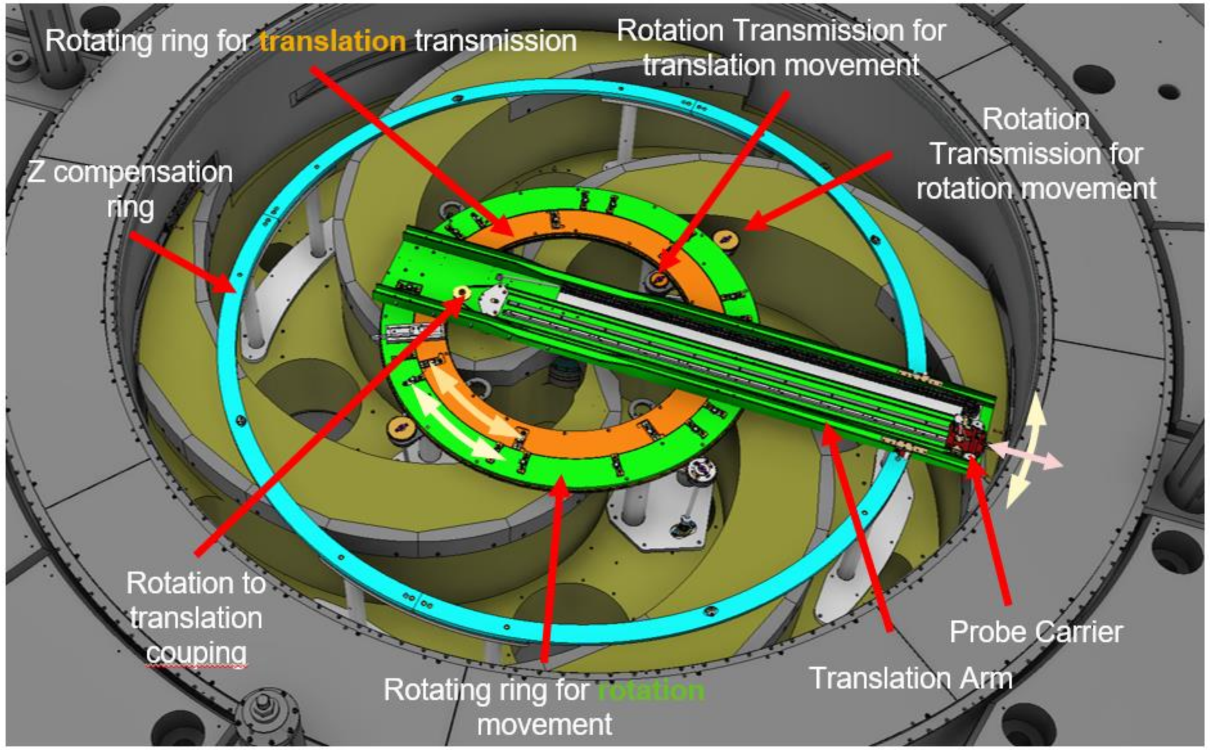
C400

- 88 multi-part forming the pole edges with 11 different profiles
- Parts weight: 21-44 kg
- Median plane: dia=3.75m → surface to cover: 11 m2
- Min-max B field: 2.5 - 4.5 T

C230 → C400

- Higher risk of accident/damages and mixing errors with pole edge handling
- Much larger surface to cover
    - **Significantly increase mechanical & measurement accuracy challenges**
      Position: ± 0.1mm repeatability & accuracy, B field: Aim for 10ppm absolute precision (~5G at B=4.5T max)
    - **Time challenge: Goal= Keep a full mapping under 24h**
- Take into account impact of pressure force on magnetic field → mapping directly under vacuum

Magnetic mapping wheel

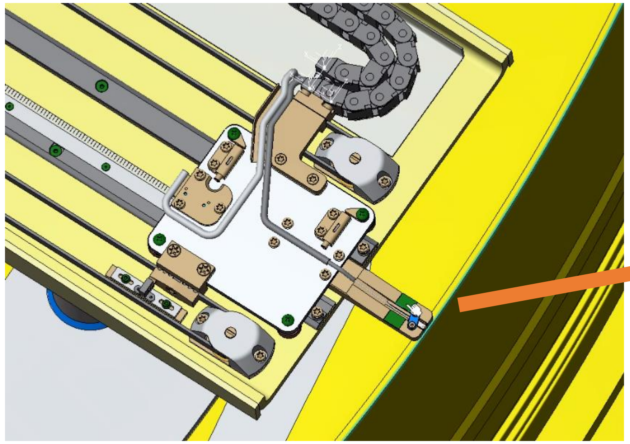


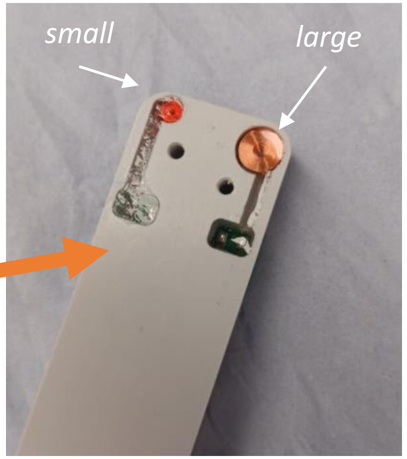
Key characterics:

- Full nonmagnetic environment, no induction, no thermal dilatation
  → Use of polymers, composites
- Vacuum compatible: remote electronics
- High speed of the mechanical arm: up to 0.5 m/s radial , >3 m/s azimuthal at max radius
- Multi-probes: Hall probe + NMR + custom-made high precision search coils

Search coil probes advantages:

- Measurement signal proportional to field gradient
  - Independent of field value: full precision in C400 field 2.5 -> 4.5 T
- Dynamic measurement – making use of the high speed of the mechanical arm
- Very high measurement accuracy, depends only on the acquisition setup and electronic chain of measurement



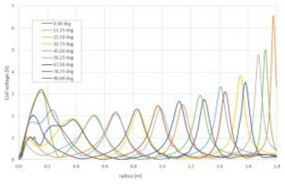


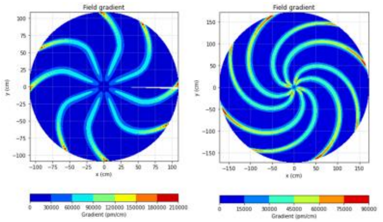
	model	
	small	large
diameter (mm)	3,8	7,4
wire dia (um)	13	20
coil height (mm)	2,6	5
number of turns	~10k	~18k
eff surface (m2)	~0,045	~0,375

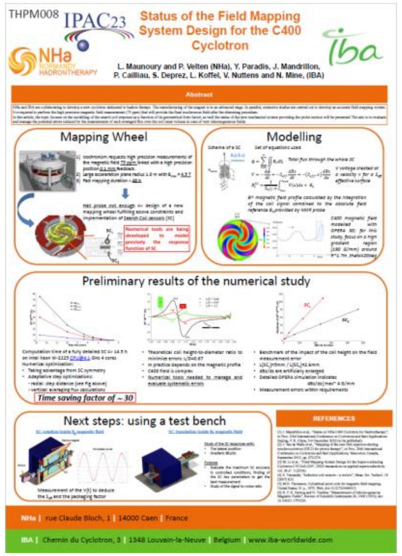
Recent developments: Design progress

Magnetic mapping wheel

Search coils commissioning sub-project



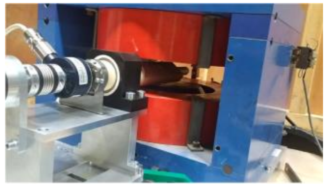




Steps:

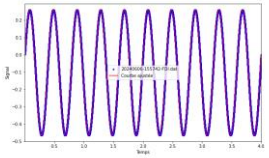
- Search coil(s) design: ✓
  - Geometry: height, inner/outer diameter
  - Sensitivity: wire thickness, number of turns
- Modelling of the probe response function
  - Analytical simulation ✓ → L. Maunoury & Ph. Velten et al., poster presented at IPAC23
  - Determine the acquisition setup ✓ → METROLAB FDI 2056 – top class digital integrator

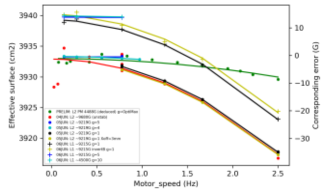
- Manufacture the coils ✓ → Manufactured by AUDEMARS (manufacturer of Swiss luxury watches!)
- Probe calibration ✓ → Performed at IBA with C230 mapping probe calibration dipole + dedicated rotative & translation setup



- Data analysis and systematic effect mastering ✓ → In-depth analysis revealed a small but significant impedance mismatch between coils and integrator
  -> confirmed by METROLAB expert
- Mapping strategy
- Commissioning tests

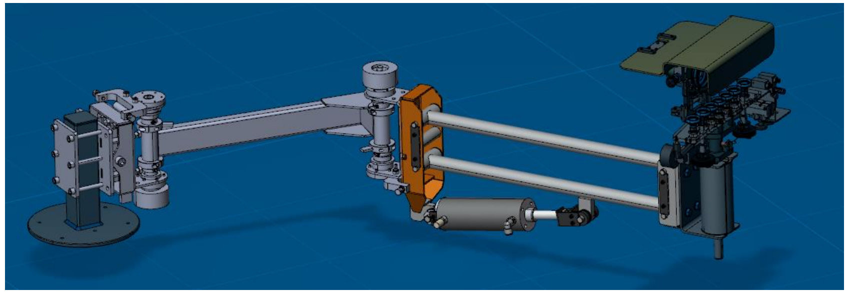
On-going works with strong support of IBA experts
Goal: Mapping Wheel ready for deployment mid 2025





Recent developments: Design progress

Pole edges handling arm

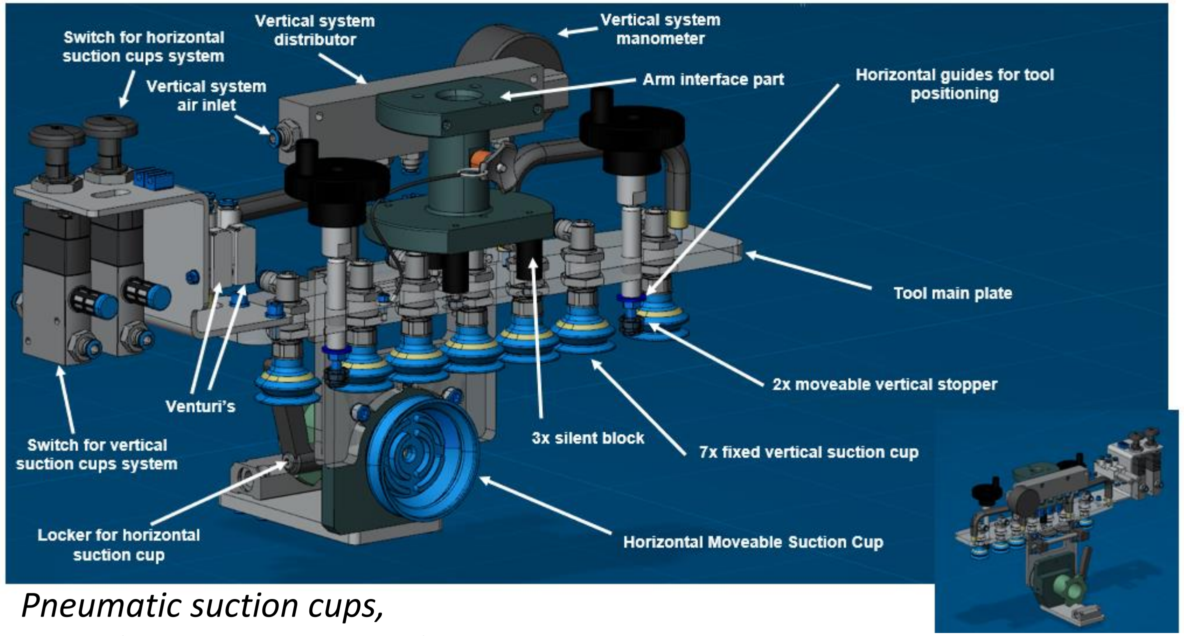


Zero gravity actuated arm (commercial item)
Allows reversal for upper & lower pole edge manipulation

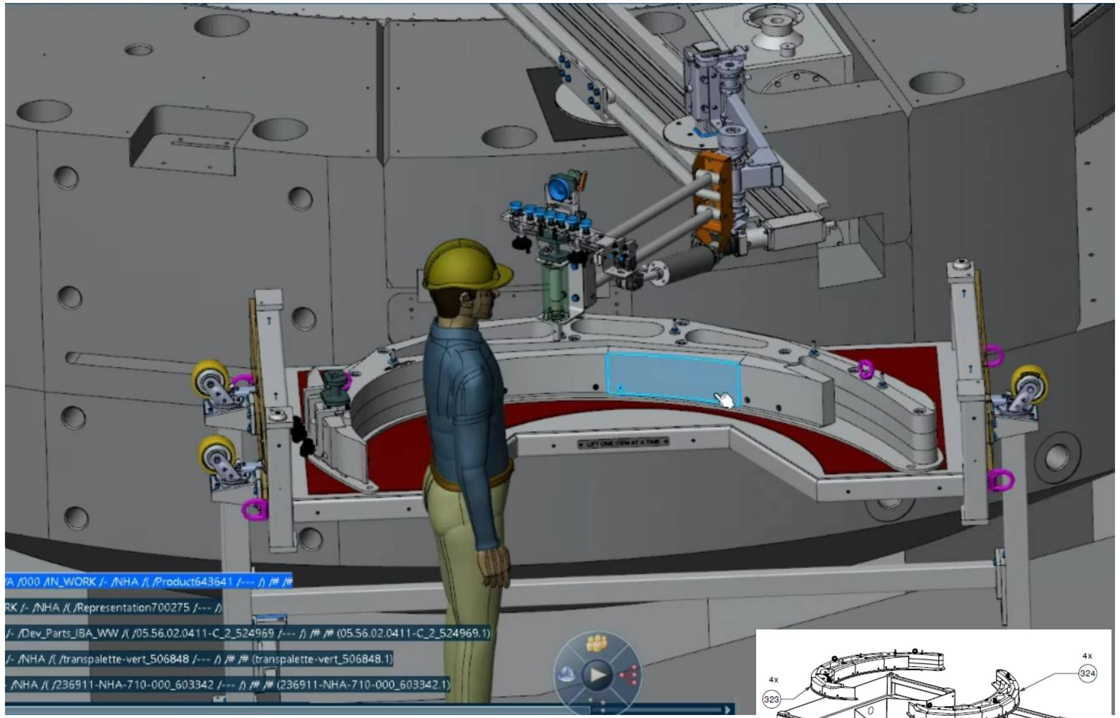
Design requirements:

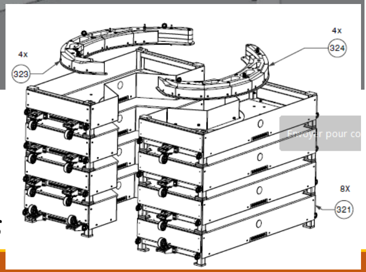
- Minimize risks of accident/damage and mixing errors during handling
- Speed-up overall process
- Facilitate pole edge machining iterations

tool head



Pneumatic suction cups,
allow fitting on all types of pole edges

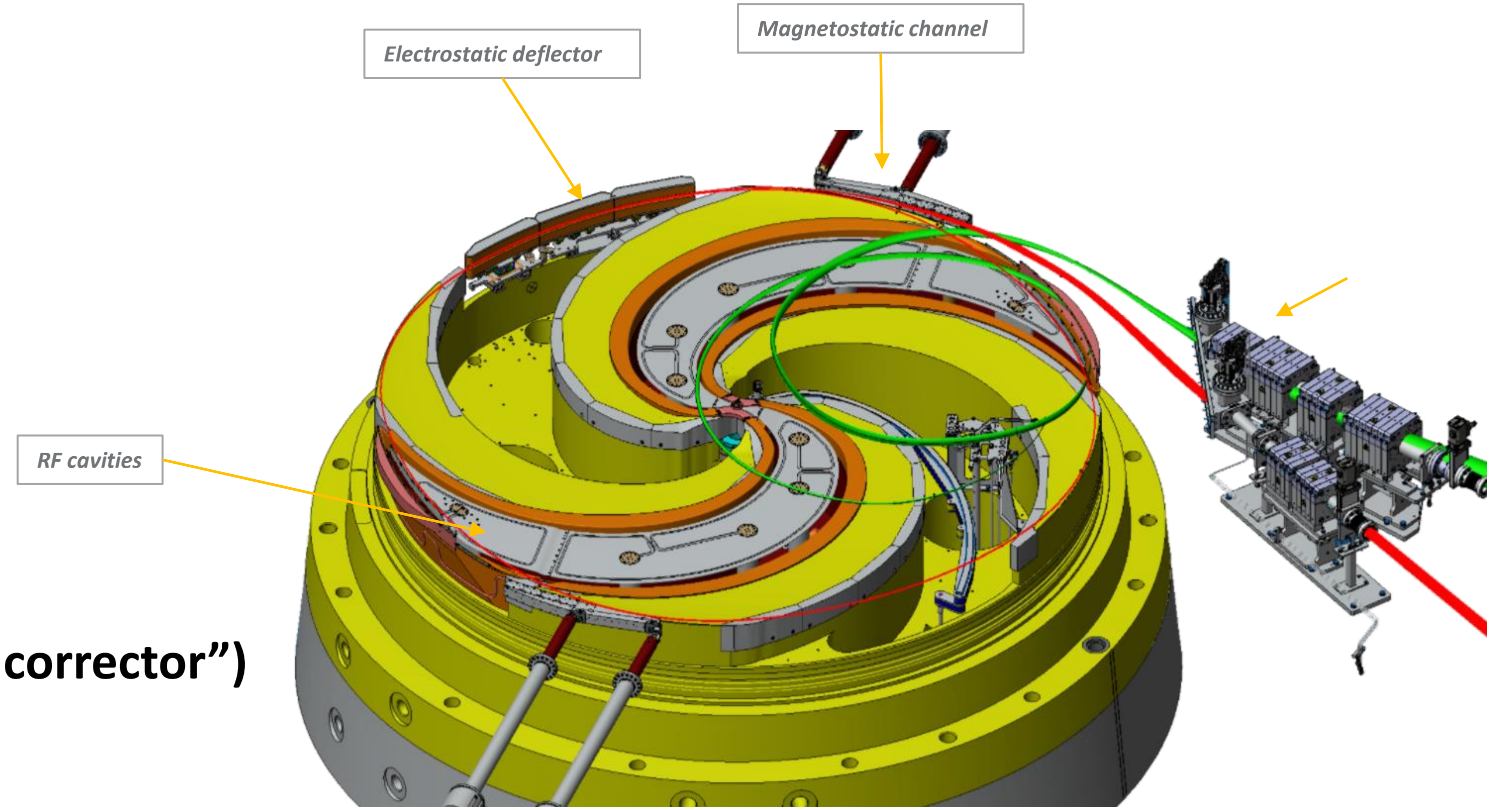




Docking station + transport chassis

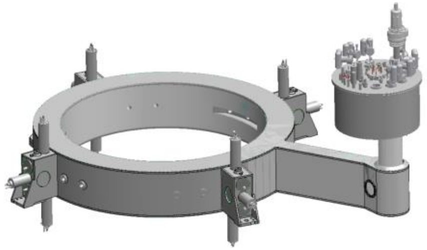
Recent developments

- Design progress:
  - Beam losses management
  - Beam probes
  - Proton stripper
  - Magnetic mapping wheel
  - Pole edges arm
- **Production status:**
  - **SCC & cryostat**
  - **RF cavities**
  - **Electrostatic deflector**
  - **Magnetostatic channel ("gradient corrector")**

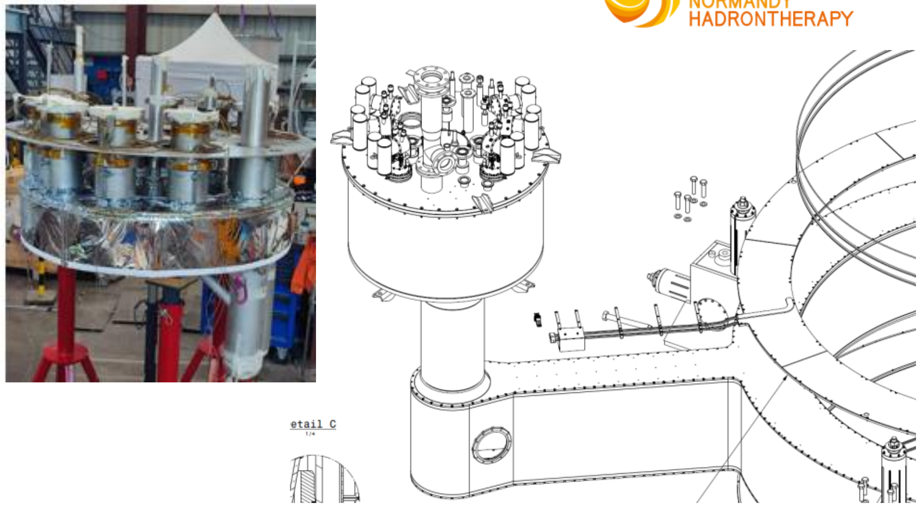


SCC & cryostat

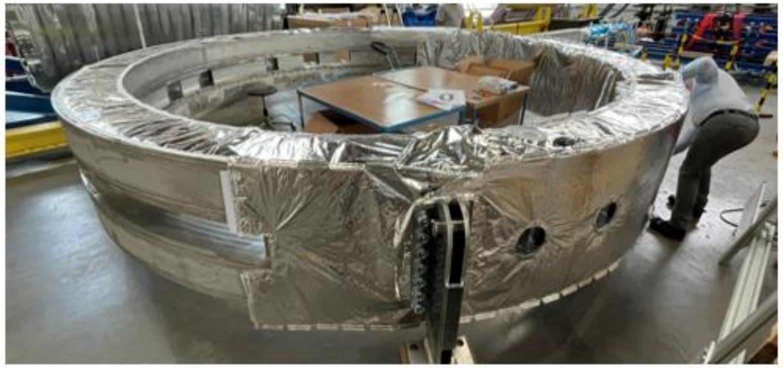
Conception & commissioning outsourced to SigmaPhi company



August 24: Cryostat vacuum (coils volumes) successfully tested at 10-6 mbar



Last step before delivery: Service turret commissioning (leak tests + functionality)

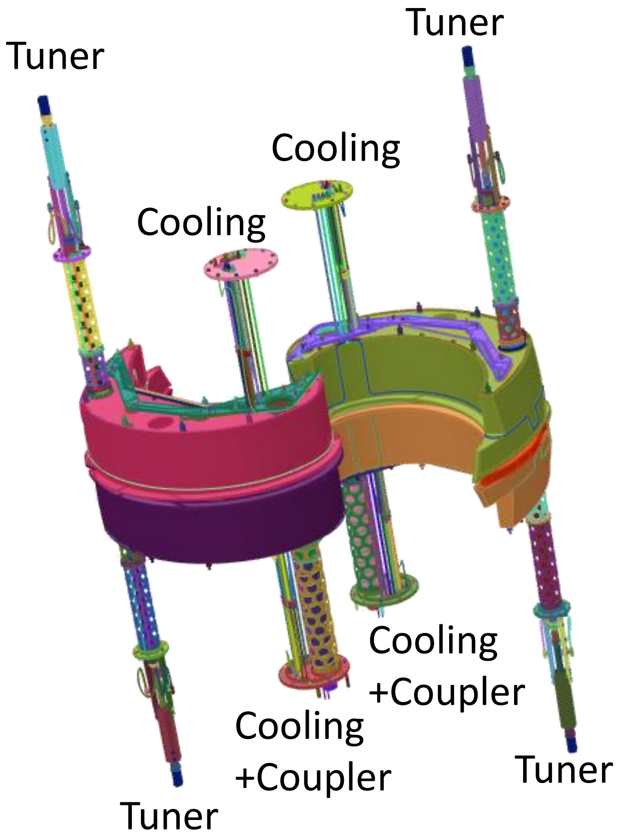


Outer vessel: equipped with radiation + N2 active cooldown

October 24: FAT @100K

Recent developments: Production status

RF cavities

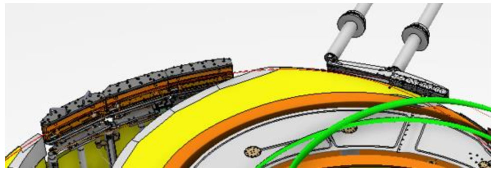


Process:

- 12mm thick pure copper plates, dimensions around 2,5m x 1,5m x 0,6m, around 585 kg
- Challenging Sheet metal work (boiler), MIG/TIG welding (Preheating 300°C!), re-machining

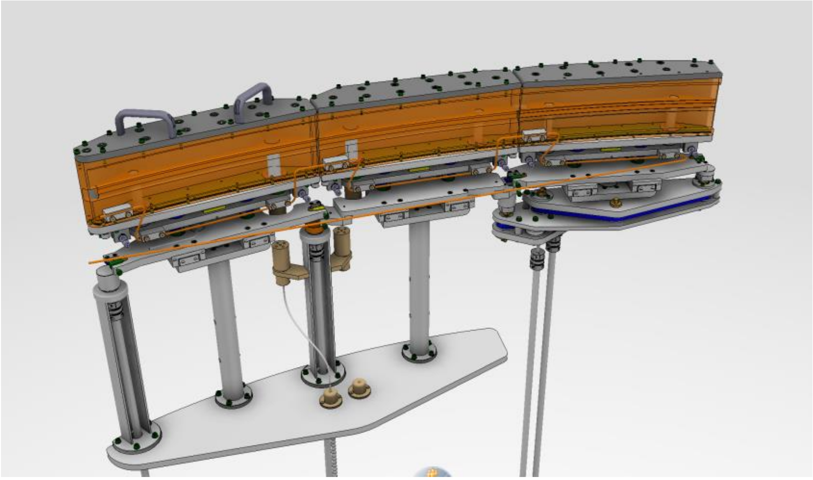
1 cavity set fully finished + FAT, ready for delivery
3 others: production under way

Recent developments: Production status



Electrostatic deflector

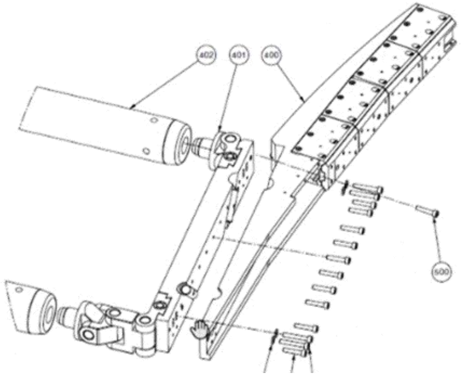
- Entrance position, exit position, gap are adjustable
- Curvature can be adjusted
- ≈1.20m total length (0,6m on C230)
- Foreseen operating voltage: <50 kV



➡ RFQ on-going with suppliers

Magnetostatic channel

- Entrance position, exit position are adjustable



➡ Production and FAT finished, including motorized movement tests

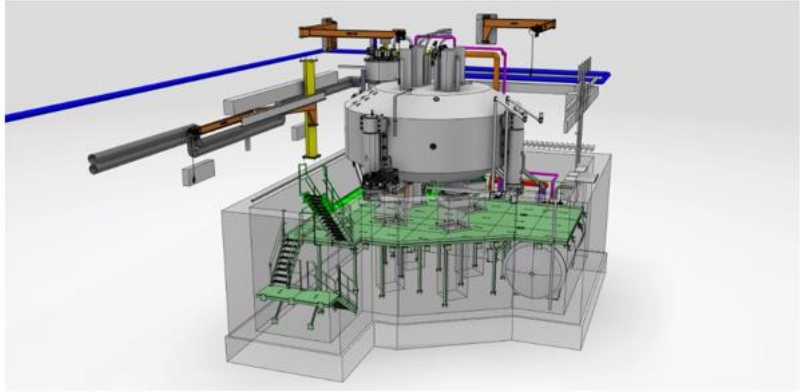
➡ Not yet installed in the cyclotron

Project delivery status

DOB - partial	Aménagement Cyclhad Aménagement Sogea	✓
phase 1 DOB - final	Rigging quench tanks Rigging lower catwalk Rigging lower Yoke installation Rigging Beam Line Rigging HMS	✓
PHASE 2	Rigging SCC Rigging upper Cyclo HMS connection Pipping	
PHASE 3	Test SCC	
PHASE 4	Magnetic mapping EIS Test Bench	
PHASE 5	Cyclo post mapping installation EIS RF commissioning and test	
PHASE 6	Cyclo Beam test Beam On Degrader	
PHASE 7	Transfer BL & Nozzle Aménagement Patient Room	

Phase 1 rigging – February 2024

Quench tanks for He recovery



Project delivery status

DOB - partial	Aménagement Cyclhad Aménagement Sogea	✓
phase 1 DOB - final	Rigging quench tanks Rigging lower catwalk Rigging lower Yoke installation Rigging Beam Line Rigging HMS	✓
PHASE 2	Rigging SCC Rigging upper Cyclo HMS connection Pipping	
PHASE 3	Test SCC	
PHASE 4	Magnetic mapping EIS Test Bench	
PHASE 5	Cyclo post mapping installation EIS RF commissioning and test	
PHASE 6	Cyclo Beam test Beam On Degrader	
PHASE 7	Transfer BL & Nozzle Aménagement Patient Room	

Phase 1 rigging – February 2024

Beamlines

Power cabinets

Water cooling groups

Project delivery status

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Phase 1 rigging – February 2024

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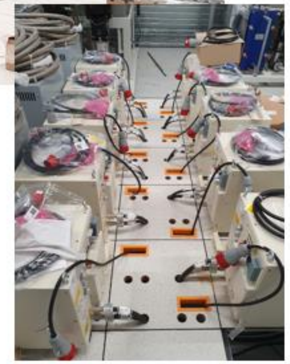
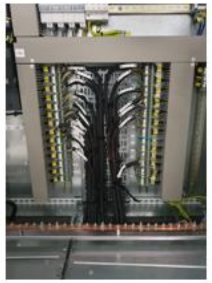
✓ **Auxiliaries installation: Mid 2024 - Present**

✓ *Installation, connection, conditioning, boot-up of various sub-systems…*

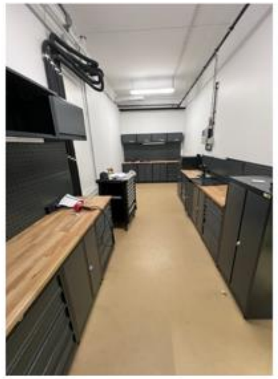
Water cooling groups



Cryo-coolers



IT servers, etc.



Technical rooms equipment

Power supply room

Project delivery status

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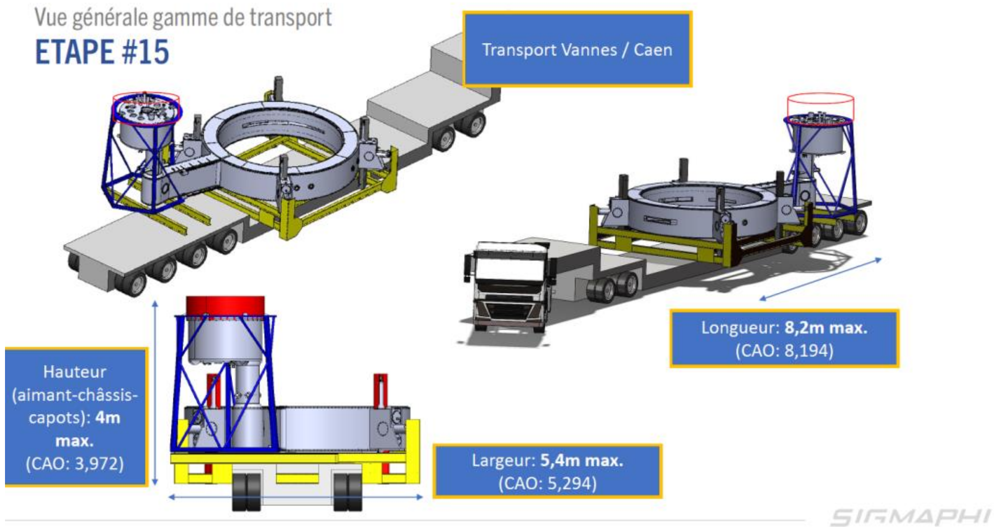
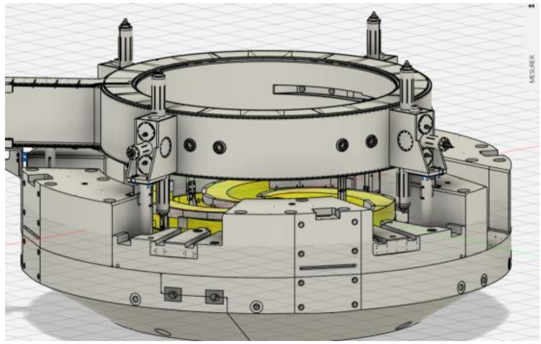
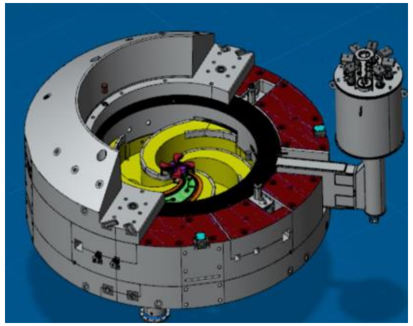
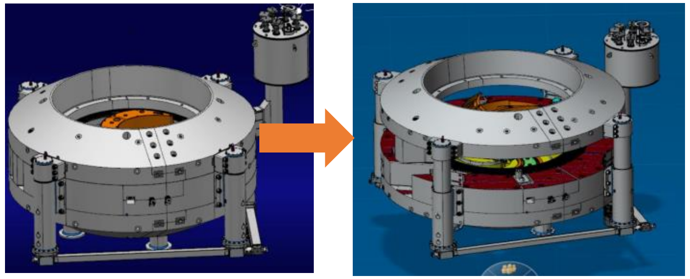


SCC Delivery Sigmaphi -> CYCLHAD


SCC Rigging


Upper yoke rigging


Yoke Lifting system validation

Project delivery status

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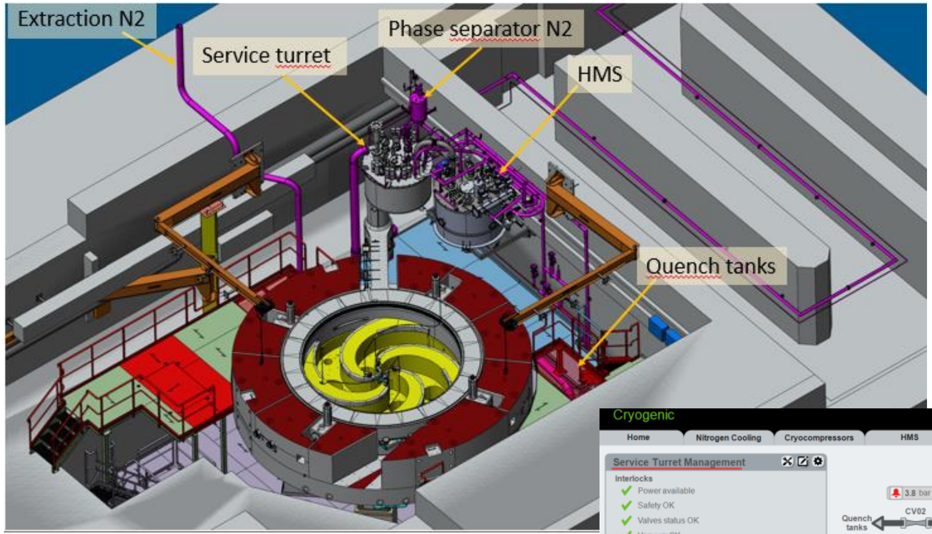
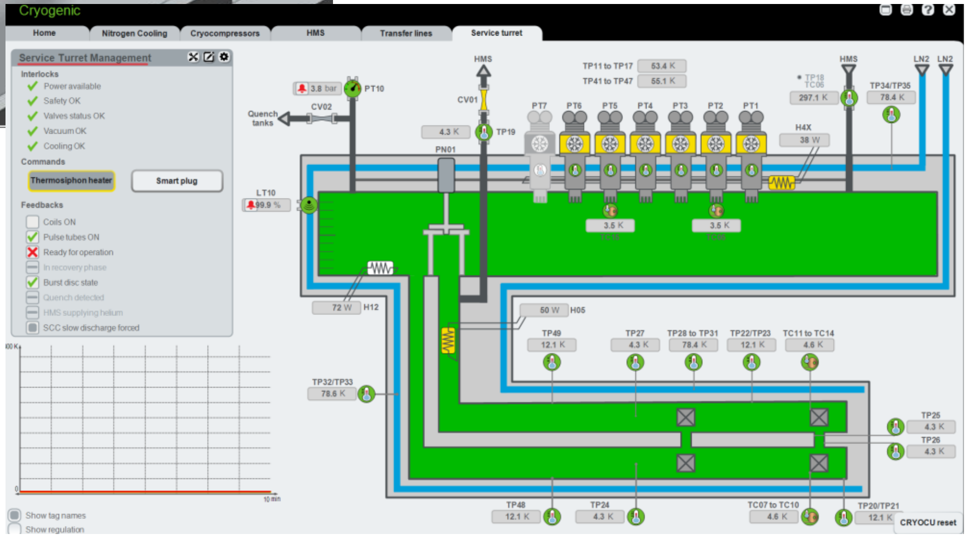
Commissioning the cryogenic system



General view



Screen interface

Project delivery status

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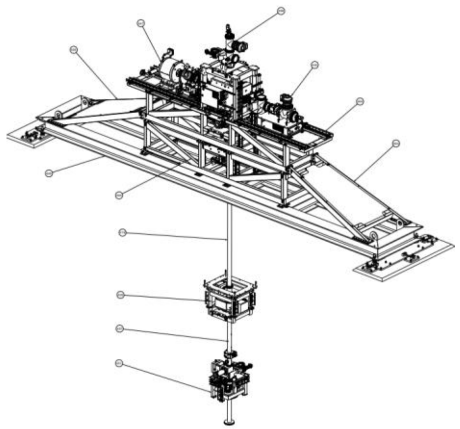
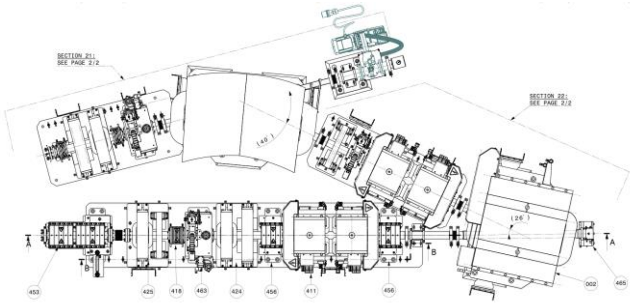
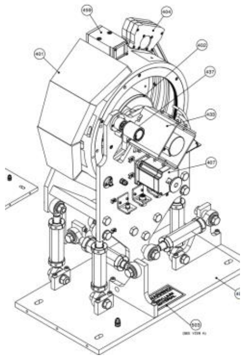
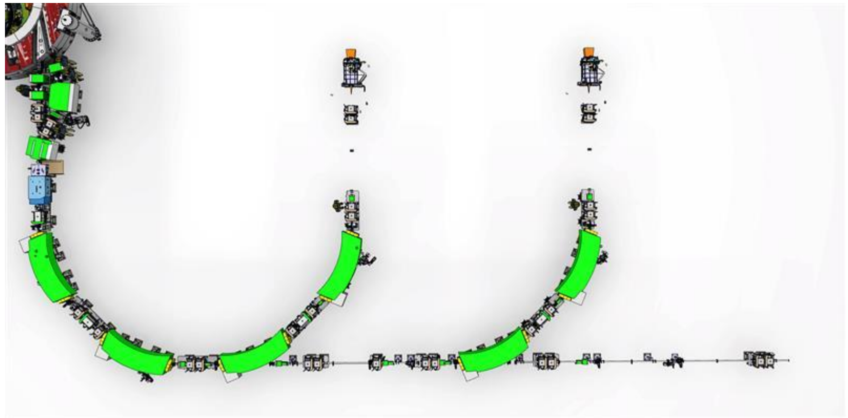
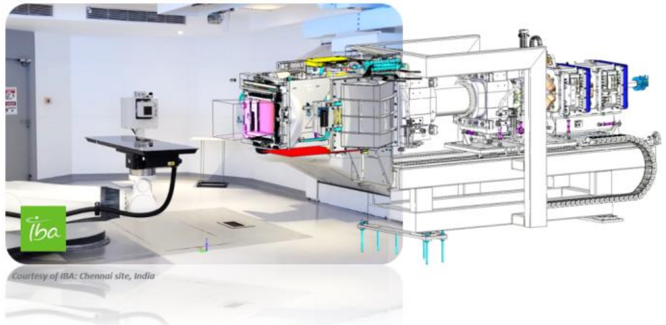

External Injection System


Extraction line


Degrader assembly

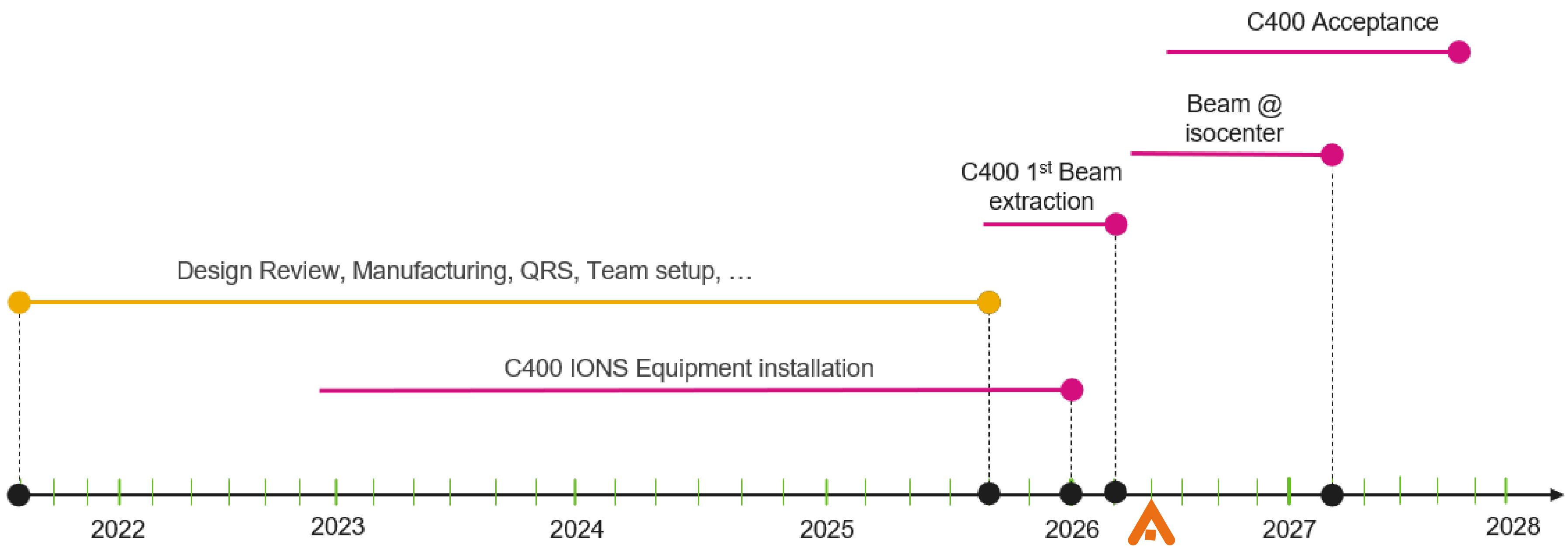

ESS and Transport beamlines

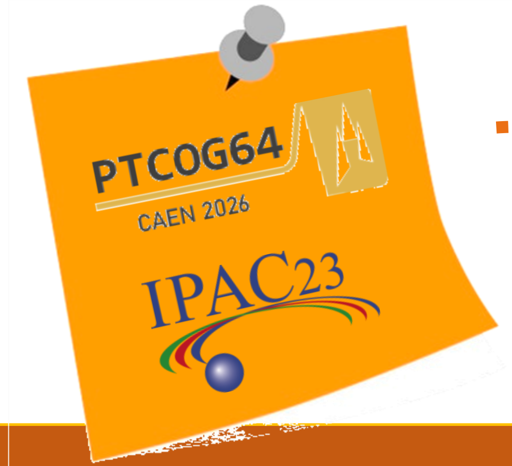


Beam delivery and treatment room equipment

Project delivery status: Perspectives

Timeline





Important Dates

International Particle Accelerator Conference, Ganil 05/2026 Caen
Particle Therapy Co-Operative Group, François Baclesse 06/2026 Caen

Challenges, perspectives and partnerships

NHa NORMANDY HADRONTHERAPY

Helium ions PBS ready

Third party CBCT, SGPT compatible

Carbon Flash research - 2x2x2cm²

High dose rate treatment

Conformal Hadron Flash therapy

Helium imaging

Gantry based technology (Arc, CBCT…)

New ions like **Oxygen…**

Thank you for your attention

NHa
NORMANDY HADRONTHERAPY

Introducing …

Normandy Hadrontherapy (NHa) located in Caen, France

- 2 main shareholders: **IBA** & **SAPHYN** (Normandy Region).
- Several other industrial and institutional partners joined the project

Owning about **40%** of the shares, **IBA** is:

- (i) the largest equity stakeholder
- (ii) industrial shareholder of NHa.

IBA:

- Accelerators technology is in IBA DNA
- Design of the C400 heavy ion cyclotron (Based on IBA design – Transfer of IP)
- All the other element(s) of the treatment rooms (IGPT, workflow and integration) using IBA technology
- Largest equity shareholder of NHa and authorized partner to market the new heavy ion system

NHa NORMANDY HADRONTHERAPY:

- Design, produce and market C400 IONS system
- Build a multiple heavy ions particle Radiation Oncology department in Caen with research capacity (Biology and Physics)
- Supported by the Normandy Region (French state) already hosting GANIL to become a leading European center for research and treatment in hadrontherapy

sfpi fpim, VINCI, Colombe Investment, GROUPE TREUIL, ÉFINOR, SRIW INVESTMENT & GROWTH, SIGMAPHI ACCELERATOR TECHNOLOGIES

iba, RÉGION NORMANDIE, Saphyn NORMANDIE SANTÉ

NHa NORMANDY HADRONTHERAPY

Design, produce and market the ion therapy system

SC coils & cryostat

Coils

Ramping time : 2 hours

Time to switch between particles : < 15 min

Stored energy: ~55.6 MJ

Cold mass at 4.3K: 14.6 tons

turns per coil : 1344

Supra material : NbTi

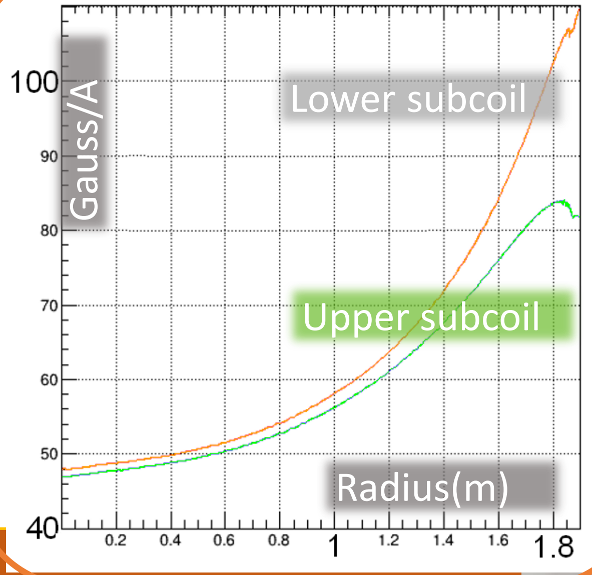
Critical current: 2800 A @ 4,5 T @ 4,2 K

Conductor peak field: 3.9T

Current density : ~31 A/mm²

Coils current:

- PS1 ~1034 A (on all 4 sub coils)
- PS2 (max 120A) (only on 2 sub coils)



Cryostat

Outer diameter: 4.8m

Liquid helium bath T°: 4.3 K

Liquid helium thermosyphon circulation system

Cooling power : 6 cryocoolers / 14 W cooling power @ 4.3 K

Highly instrumented for quench management (Temperatures / Voltages / pressures, strain gauges, quench heaters)