

# Proposal to increase the extracted beam power from the LNS-INFN Superconducting Cyclotron

101° congresso della Società Italiana di Fisica

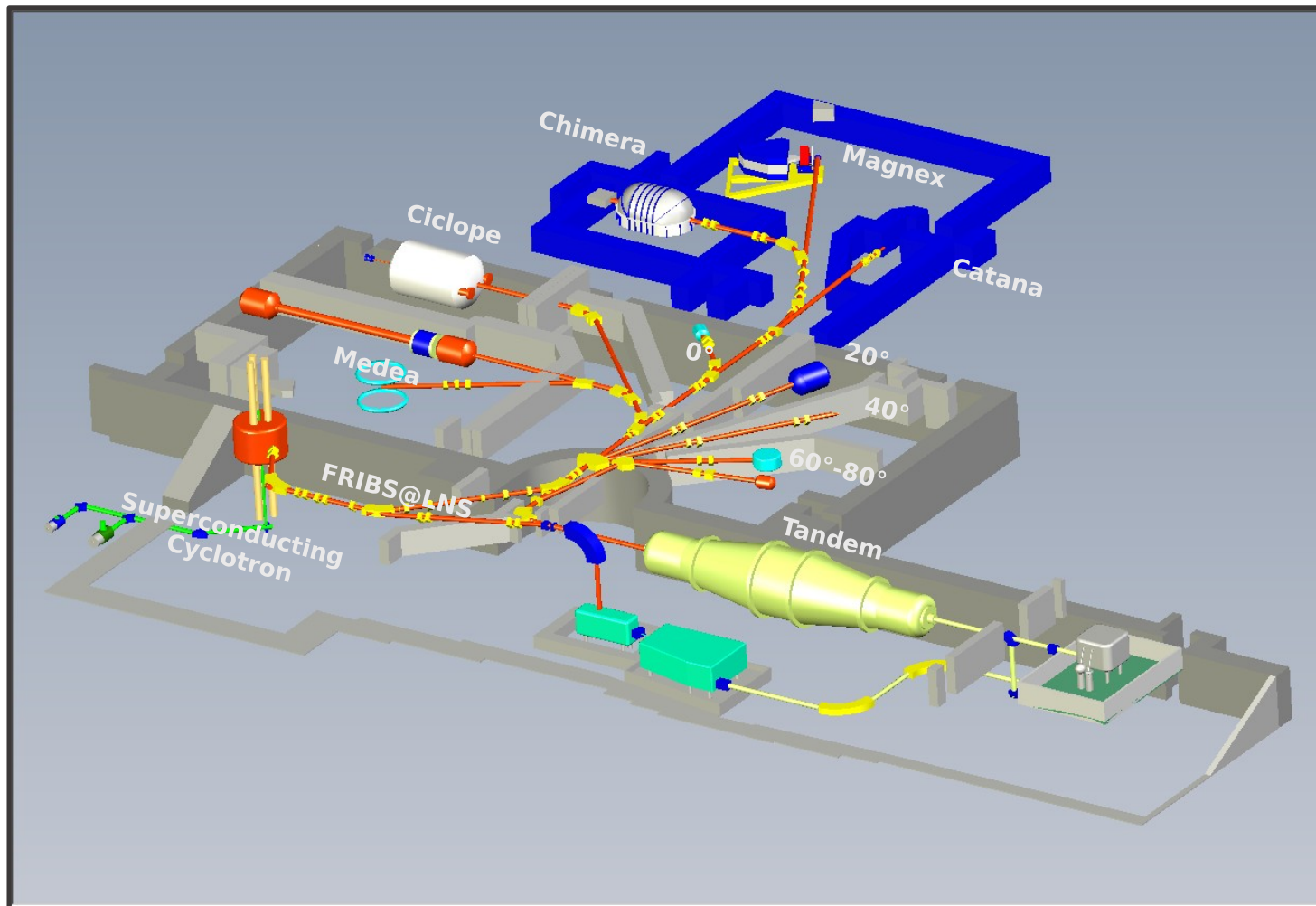
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# Overview

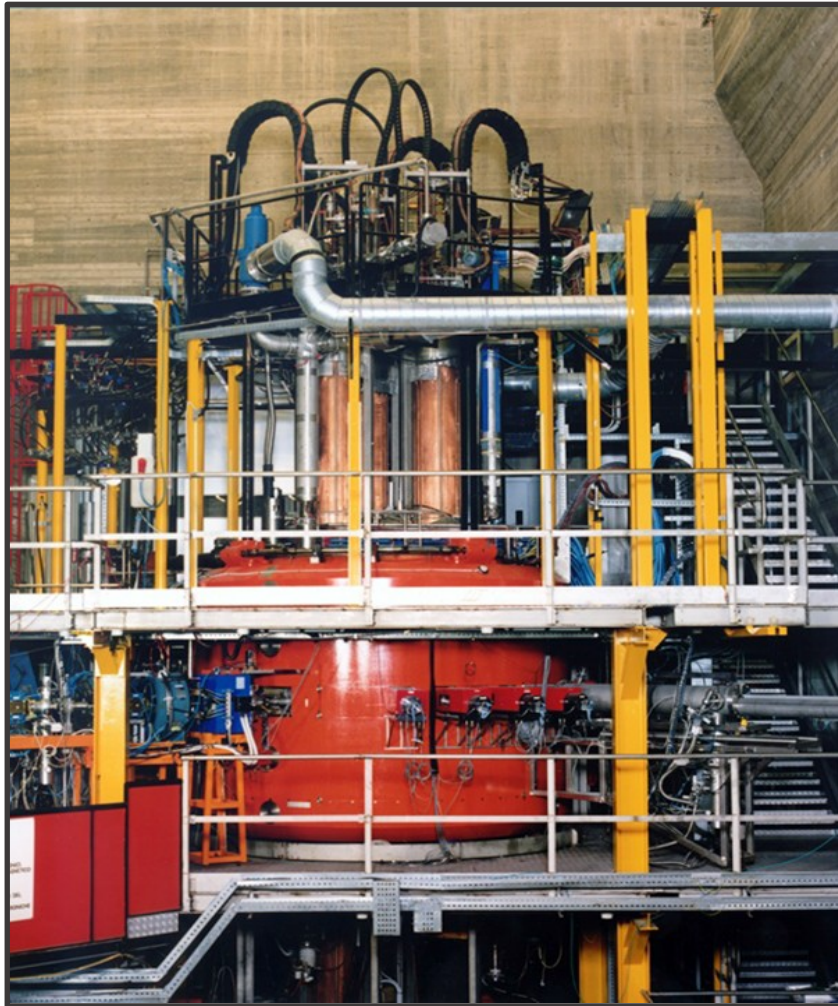


- Presentation of LNS-INFN accelerators: focus on the CS
- New requests for high power beams: NUMEN
- Possible upgrades to increase the extracted power
- Feasibility study for the extraction by stripping
- Beam dynamics results

# INFN -LNS Laboratories



# LNS-INFN Superconducting Cyclotron



## Cyclotron features

n° of accelerating cavities	3
Harmonic	2
RF frequencies	15-48 MHz
Magnetic field on the mp	2.2-4.8 T
Pole radius	90 cm
External radius	190.3 cm
Total height	286 cm
Weight	196 tons
K bending	800
K focusing	200

**Energy = 10-80 AMeV**  
**Able to accelerate up to the Uranium**



# New requests for high power beams: NUMEN



2 test-run done in October 2014  
and February 2015

$^{40}\text{Ca}$  ( $^{18}\text{O}$ ,  $^{18}\text{Ne}$ )  $^{40}\text{Ar}$ :

$^{18}\text{O}$  at 15 & 25 AMeV @ 6 enA

**too low statistics.**

Next run:

$^{116}\text{Sn}$  ( $^{18}\text{O}$ ,  $^{18}\text{Ne}$ )  $^{116}\text{Cd}$

Energy 15- 30 AMeV

Intensity needed 60 eμA

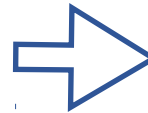
-> P ≈ kWatt

# CS Upgrade

## CS Upgrade:

We need to increase the extracted beam power to 5-10kWatt for  $^{12}\text{C}$   $^{18}\text{O}$   $^{20}\text{Ne}$

All the other beams now accelerated will be still available

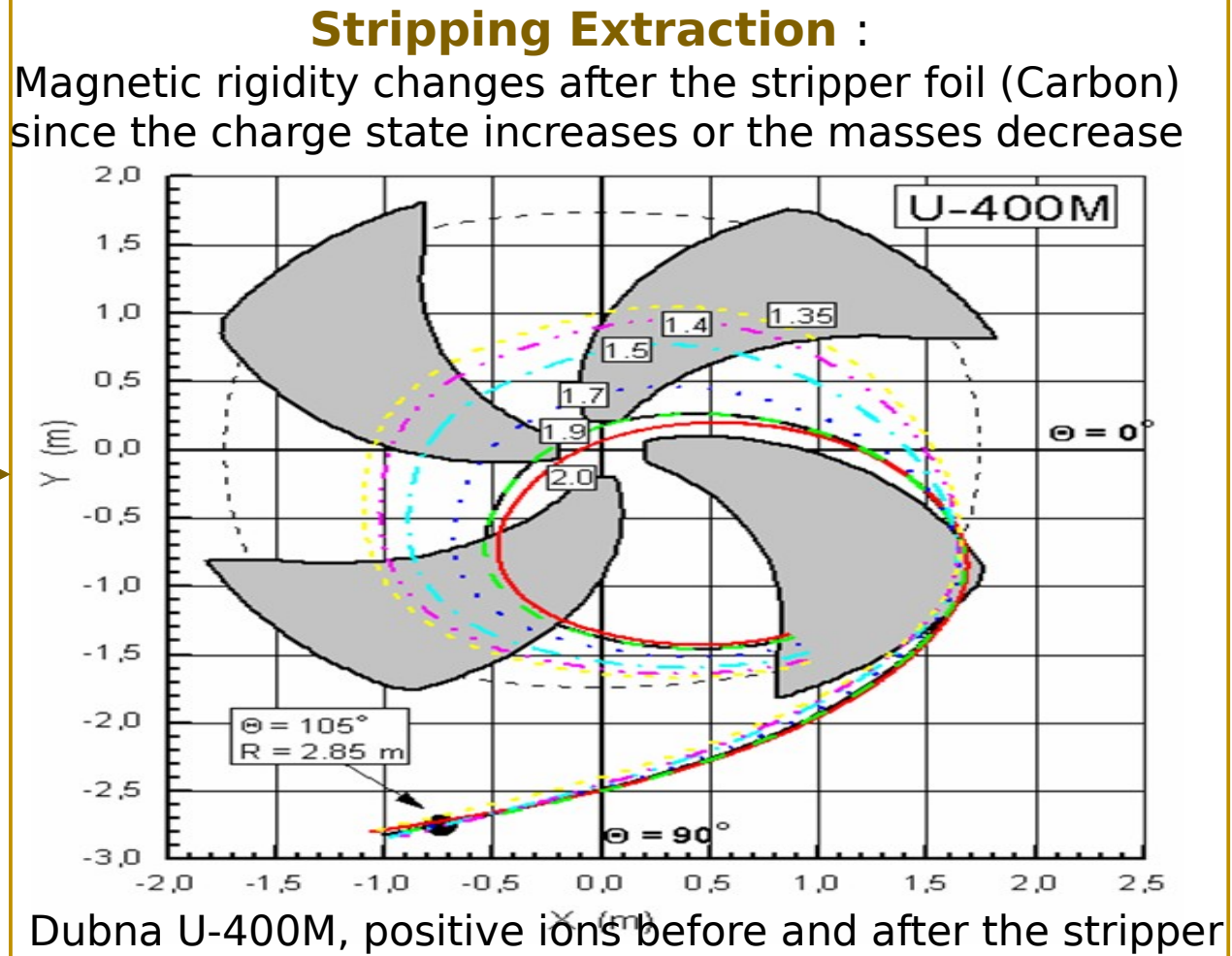
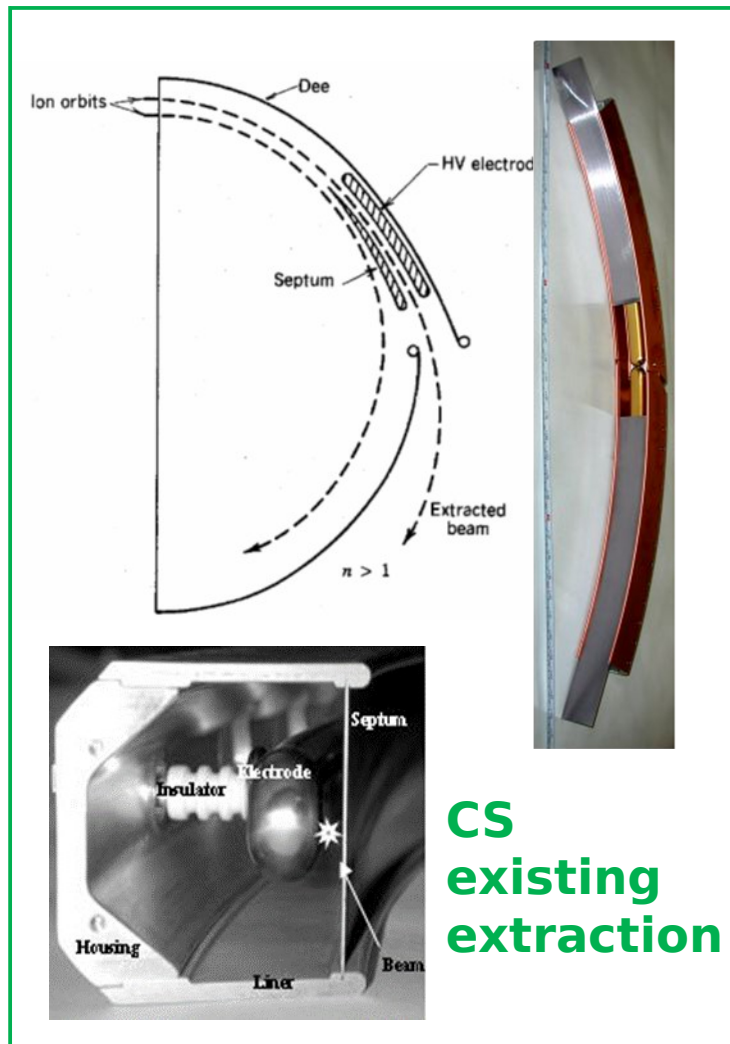


## New extraction mode with a stripper foil:

Today efficiency extraction through the electrostatic deflectors  $\varepsilon \approx 50\%$ . Max extracted power is 100 Watt and only 100 Watt is the power that can be lost inside the cyclotron. It is necessary increase the efficiency.

# What is stripping extraction?

**Expected  
extraction  
efficiency  
99%**

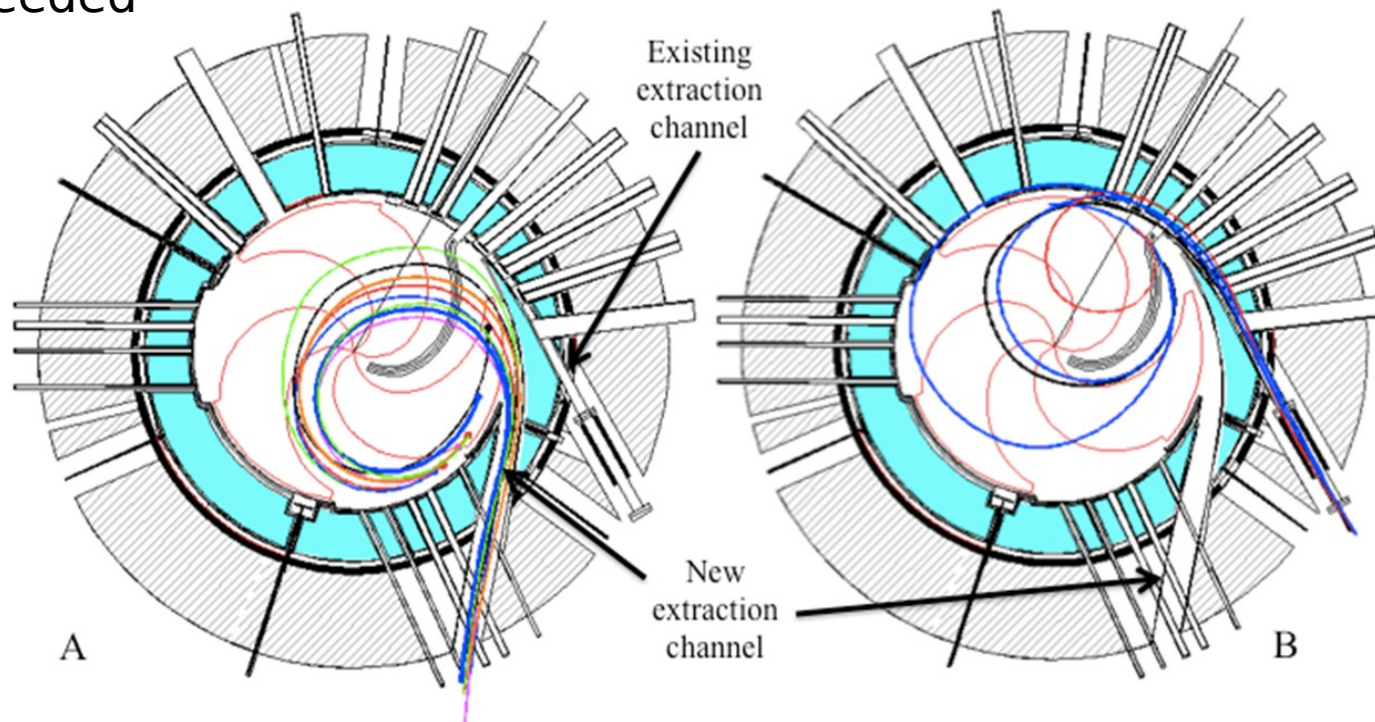


# Two extraction channels

Overview of all extraction orbits:

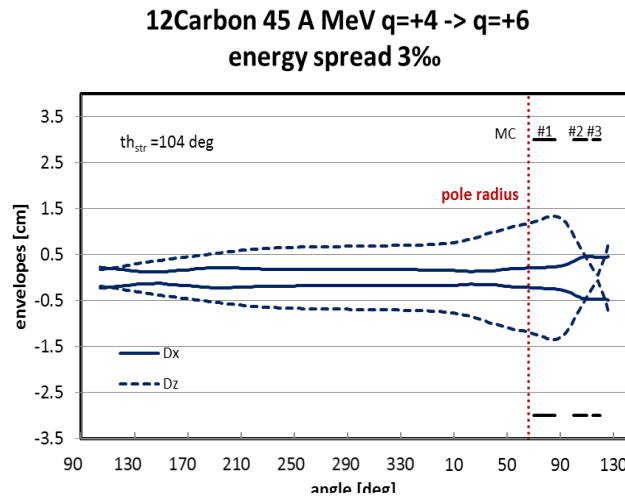
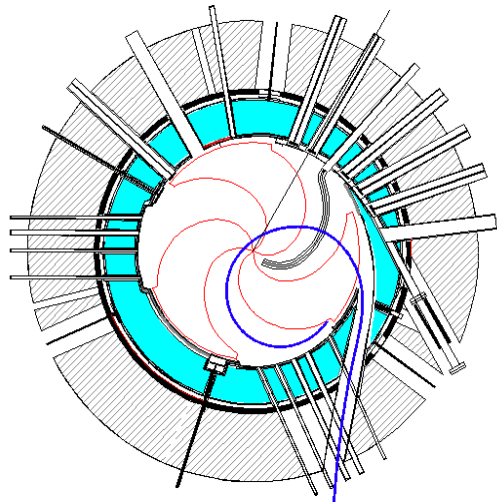
a new extraction channel, 30 deg away simplify the extraction system for a lot of ions.

That means smaller radial and axial envelopes and less and weaker magnetic corrections needed

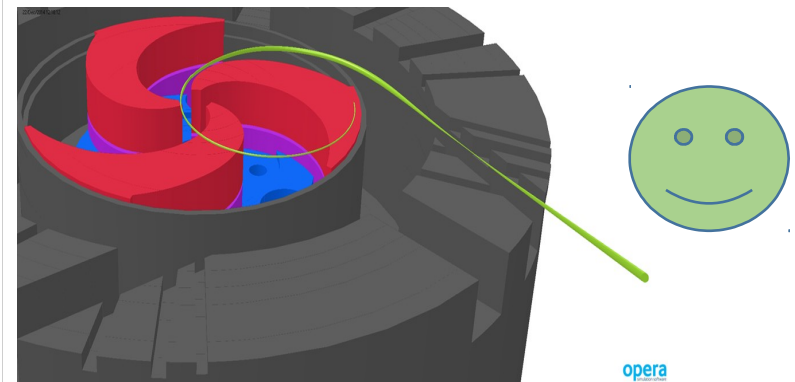
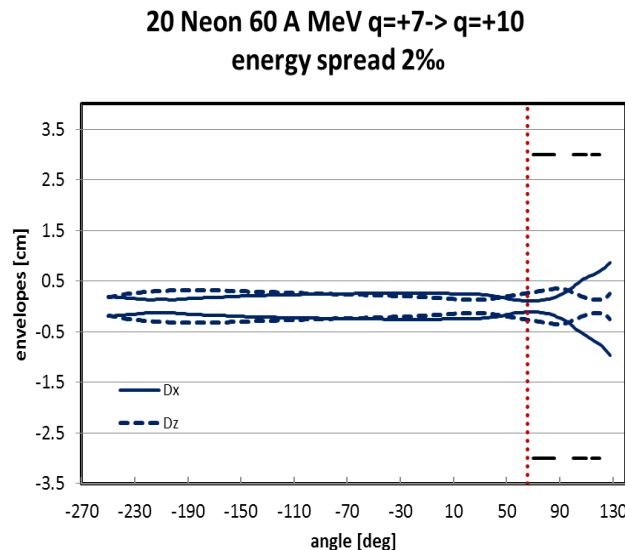
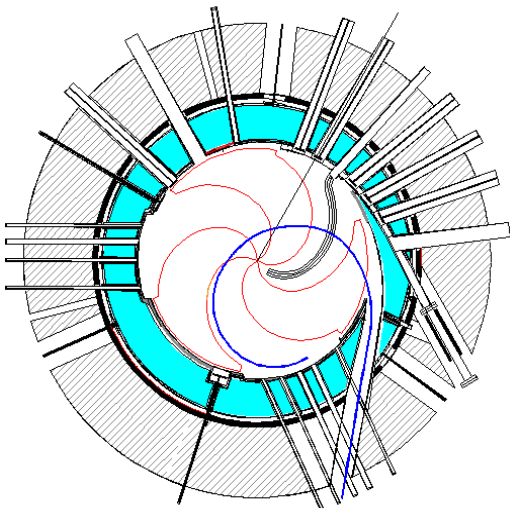




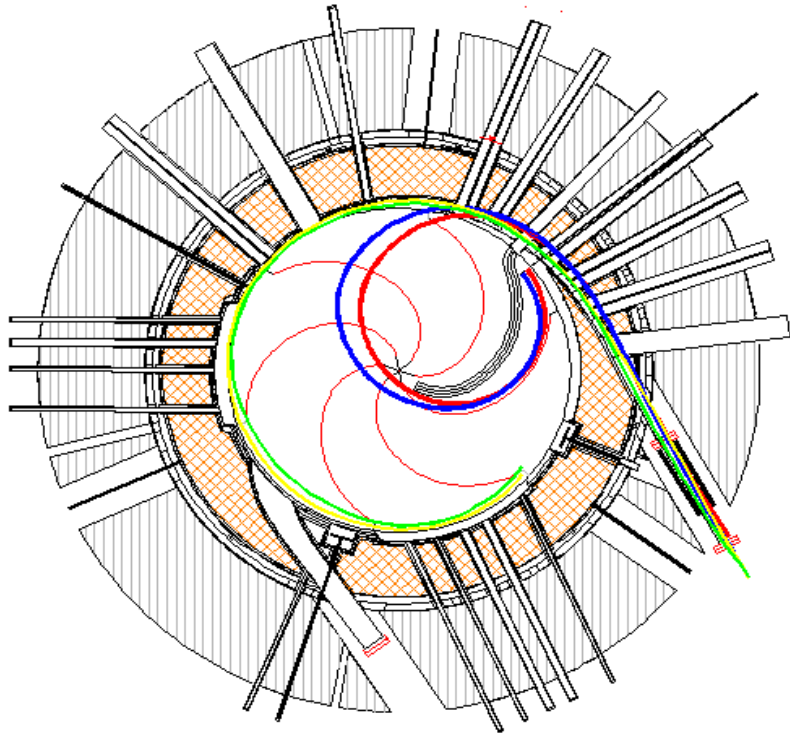
# Radial and axial enveloppes including energy spread



2 examples of extraction through the **NEW EXTRACTION CHANNEL:**  
3 Magnetic channels after the pole radius are enough



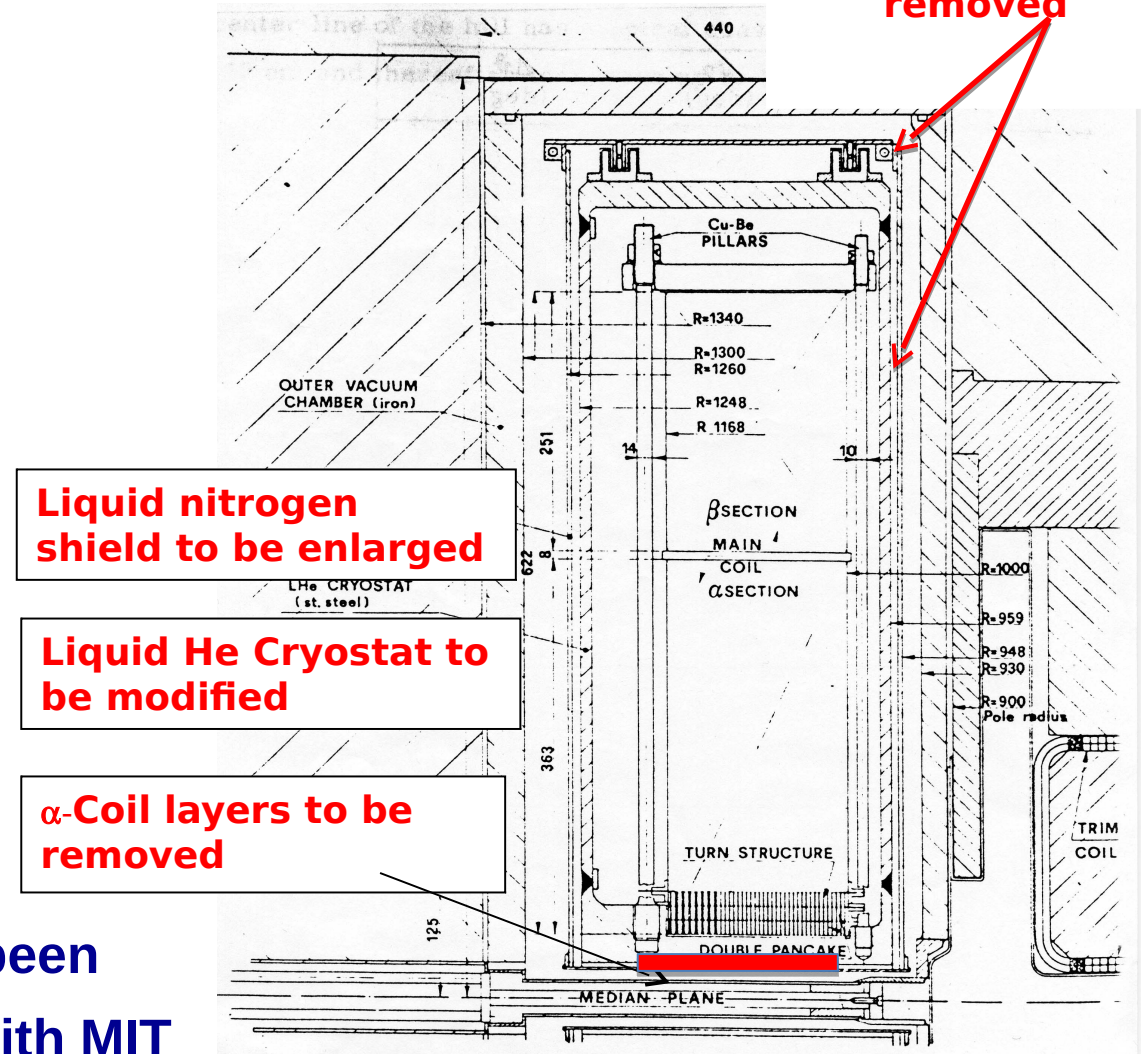
# From electrostatic extraction to extraction by stripping



**A new set of superconducting coils and a new cryostat**

**A conceptual design study has been accomplished in collaboration with MIT**

**Inner CuBe pillars removed**

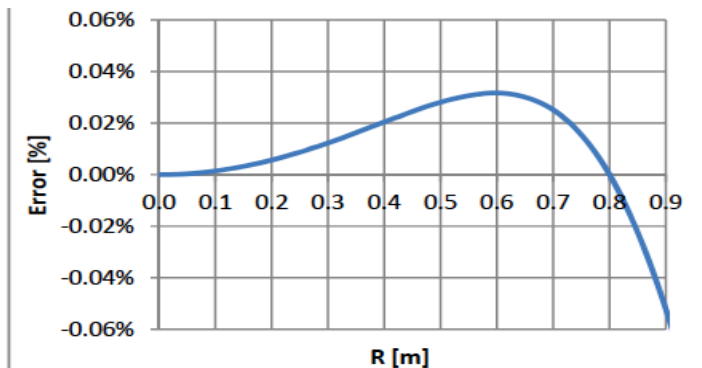
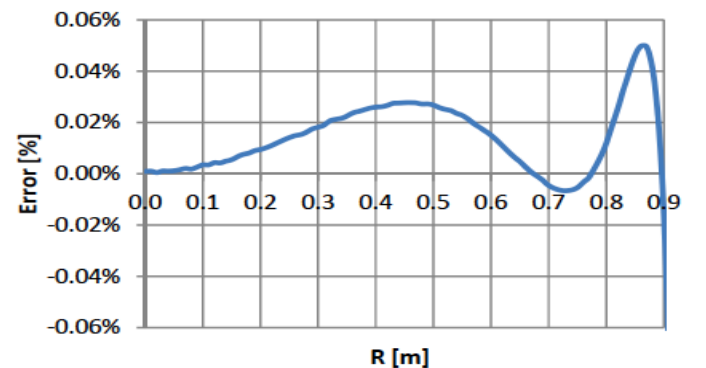
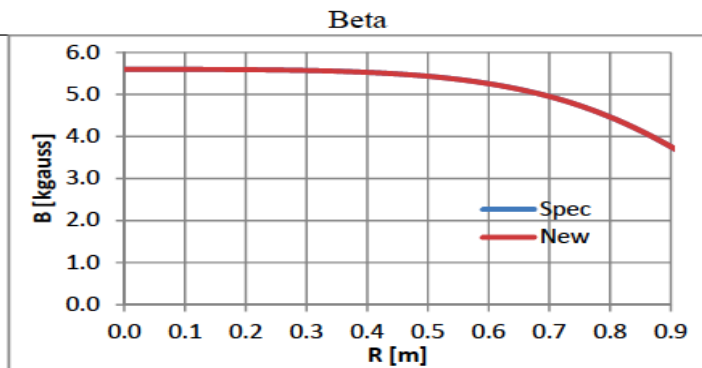
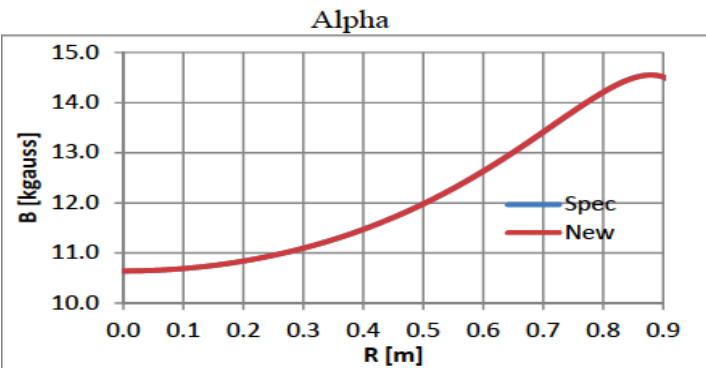


# Parameters of the existing coils and of the new proposed coils

Parameter	Units	alpha-old	beta-old	alpha-new	beta-new
Rmin	m	1.000	1.000	1.027	1.000
Rmax	m	1.168	1.168	1.162	1.147
Zmin	m	0.062	0.434	0.090	0.433
Zmax	m	0.426	0.686	0.385	0.684

New and old coils form factors.

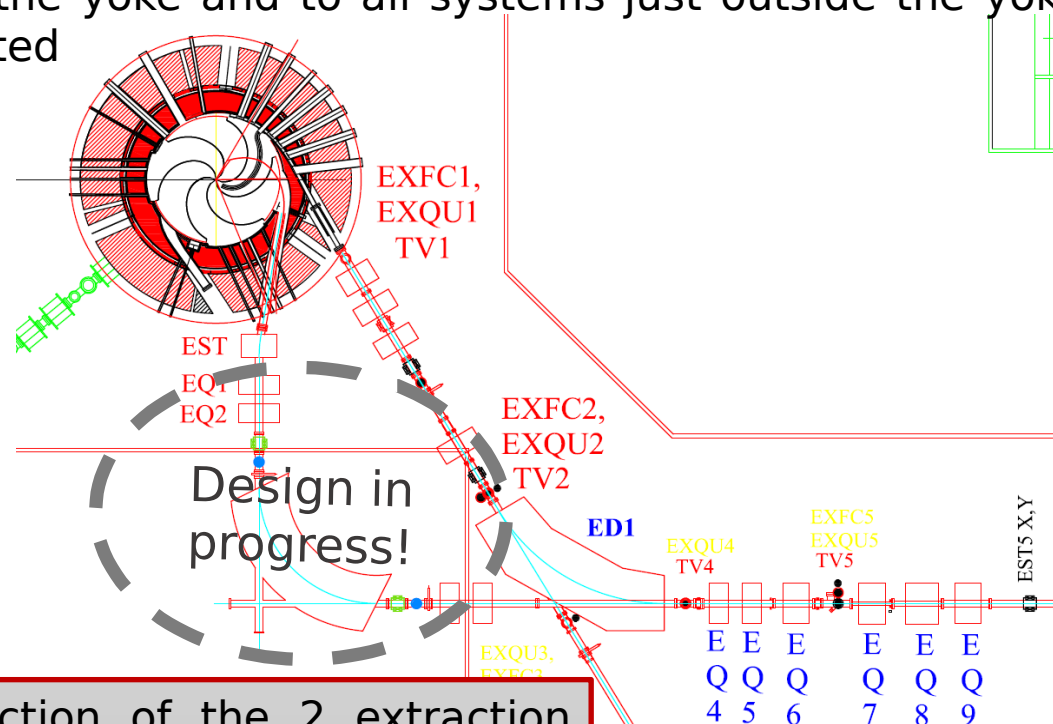
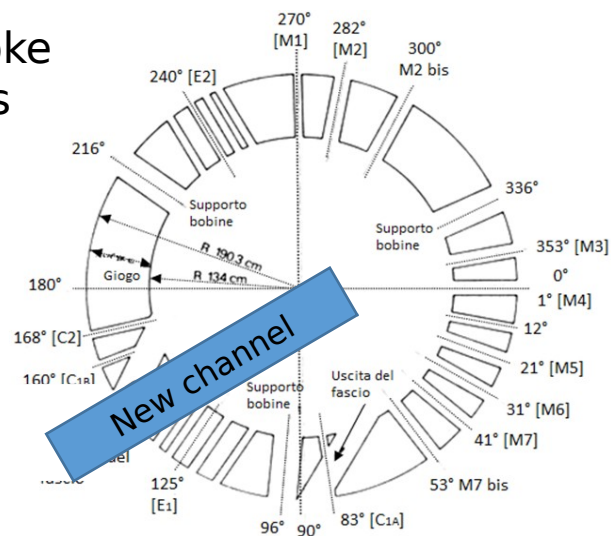
The difference is 0.06%!



# Further considerations

More studies are on going and both solutions are under investigation. The new channel is definitely more appealing from a beam envelope point of view, but the mechanical constraints and modifications to the yoke and to all systems just outside the yoke are important and need to be carefully evaluated

All actual yoke penetrations



With the new beam powers, the cross-section of the 2 extraction channels has to be broadened respect to the one we have now and a cooling system has to be designed.

**A NEW CRYOSTAT IS MANDATORY IN ANYCASE**



# FIRST CONCEPTUAL DESIGN OF THE NEW CRYOSTAT



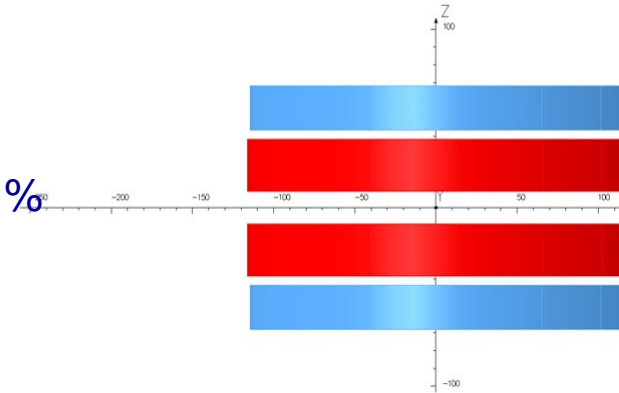
## Specifications

- Form factor equal to the actual in 0,1%
- Broaden the cross-section of the extraction channel
- Nitrogen and helium consumption lower than the actual ones
- Magnetic, thermic and structural computation
- Cost estimation

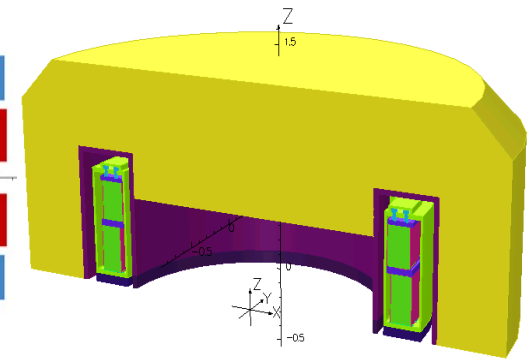


**MIT CONCLUSION:  
Feasible**

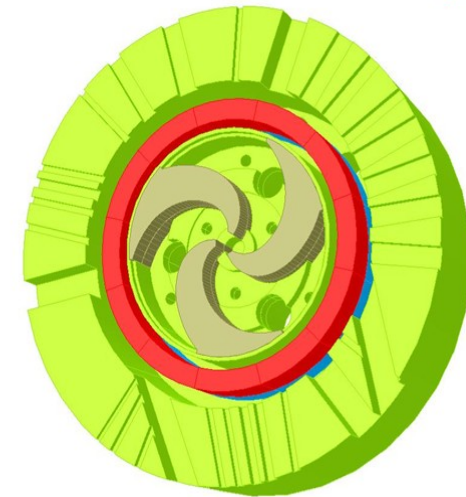
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opera  
simulation software



# CONCLUSIONS



- Feasibility study of beam extraction

**OK (LNS)**

- Preliminary study of the new cryostat

**OK (MIT)**

- Detailed forecast of costs and time schedule for the full upgrade

**On going ( AS-G + LNS)**

- New design of the spiral inflector, central region and new extraction line

**On going (LNS)**

**To reach few kWatt of beam extracted  
power from the CS is feasible**

**Thanks**