HITRI plus
Heavy Ion Therapy Research Integration

nimms

Scientific seminar for the RTU accelerator technology students @CERN

LUCA PIACENTINI

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

VPP Valsts pētījumu programma

VPP-IZM-CERN-2020/1-0002

Collaboration on Gantry mechanical desgin

- Prof. Toms Torims
- Dr. Andris Ratkus
- M.Sc Luca Piacentini
- M.Sc Jānis Vilcāns

- Dr. Maurizio Vretenar ATS-DO
- Dr. Diego Perini
- Dr. Luca Dassa

- Dr. Marco Pullia

- Prof. Stefano Uberti

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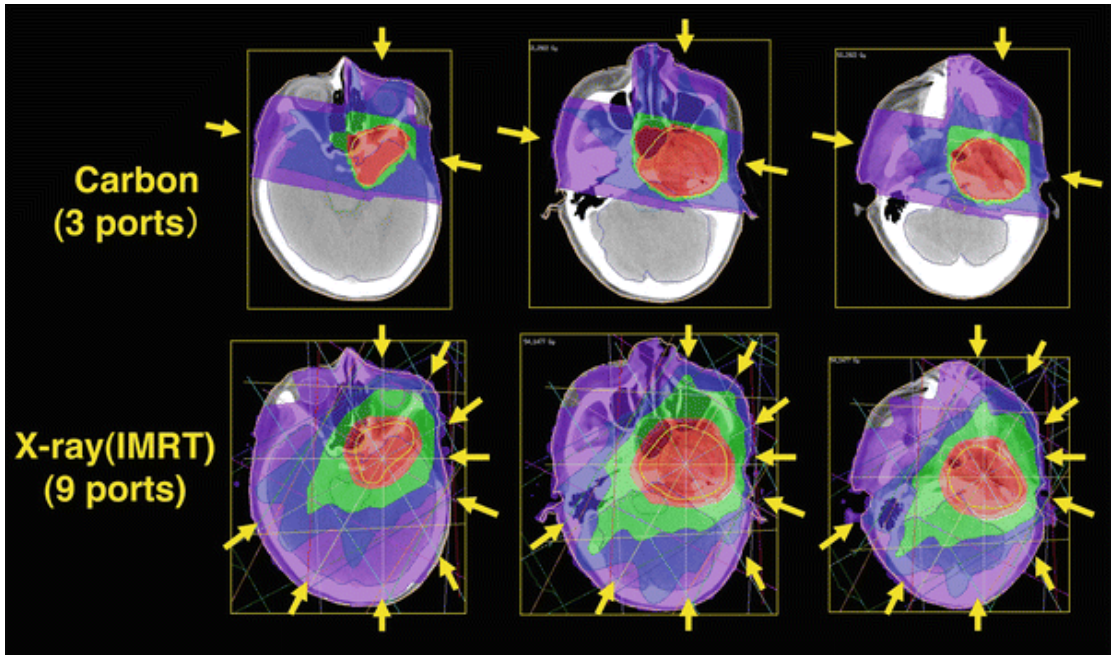
Task 7.5 - Integration of an innovative superconducting gantry: optics, mechanics, beam delivery (CNAO, CERN, SEEIIST, MEDA, RTU). Task Leader: M. Pullia

- Sub-Task 7.5.1, **Basic structure and mechanical design**: After having identified the baseline conceptual design, the mechanical structure and the technical solutions of the beam transport and the magnets will be investigated in detail. This sub-Task will start from a **general mechanical** and optics **design of the gantry** to integrate actual magnet designs, beam instrumentation, dose delivery, cryogenics aspects, etc. into a detailed mechanical design. (CNAO, RTU, CERN).

The «SIGRUM» SC gantry

Courtesy of U. Amaldi and E. Benedetto



https://radiologykey.com/the-characteristics-of-carbon-ion-radiotherapy/

Courtesey of M. Vretenar

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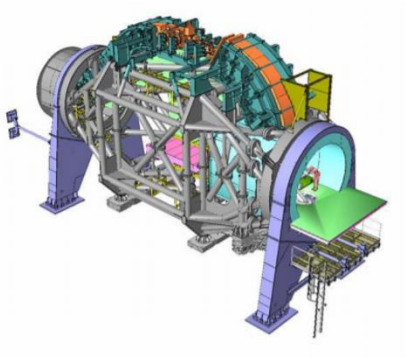
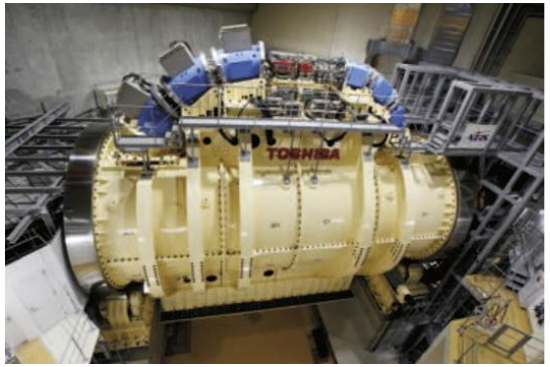
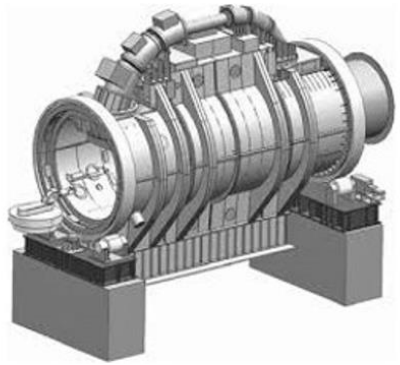
What is a gantry



600 tons

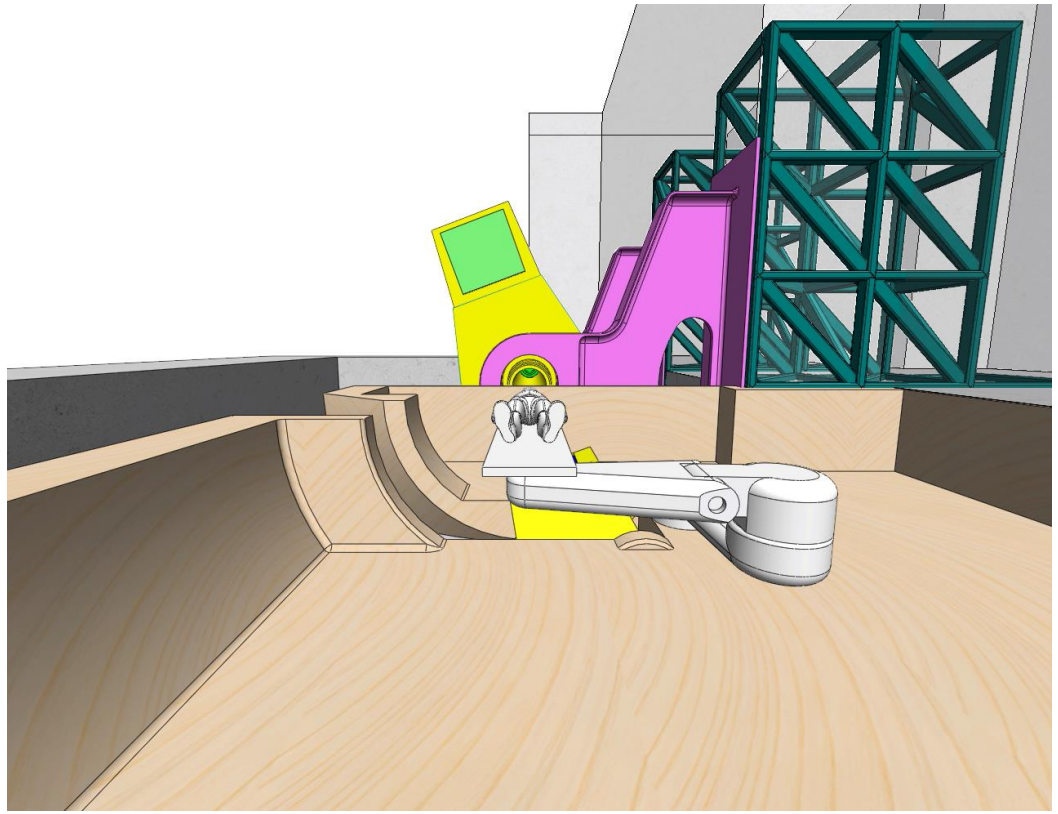
Heidelberg (GE)





100 -300 tons

Chiba (JP) and Yamagata (JP)



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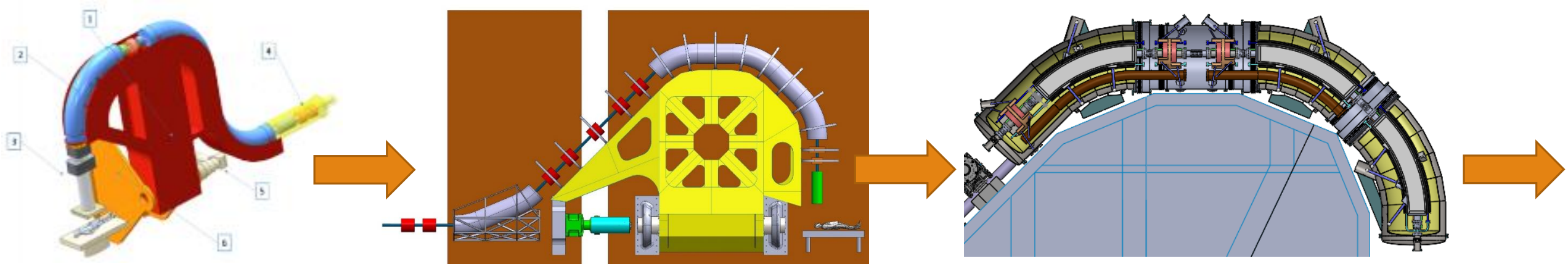
Studies evolution

Conceptual design [1][2] **Further conceptual mechanical studies [3]** **Integration studies**



[1] Amaldi, U et al D. SIGRUM - A SUPERCON-
DUCTING ION GANTRY WITH RIBONI'S UNCONVENTIONAL MECHANICS. (2021,6),
http://cds.cern.ch/record/2766876
[2] E. Benedetto et al. "A Carbon-Ion Superconducting Gantry and a Synchrotron Based on Canted Cosine Theta Magnets". In: (2021). arXiv: 2105.04205 [physics.med-ph].
[3] Piacentini, L. Project Development of a Rotating Transferring Line for Carbon Ions Used for Medical Scope. Master's Thesis, Università degli Studi di Brescia, Brescia, Italy. Unpublished work, 26 March 2021.

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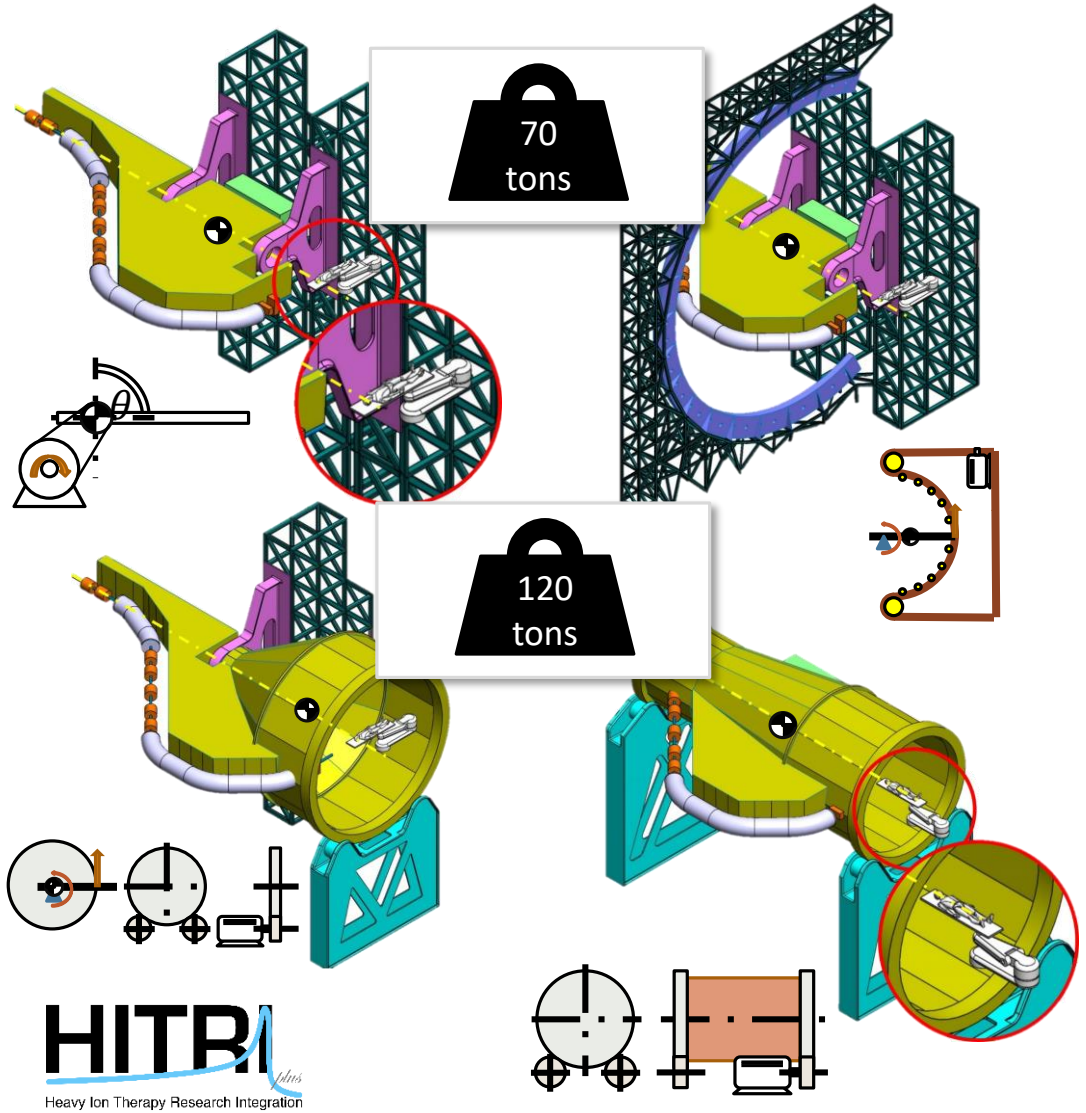
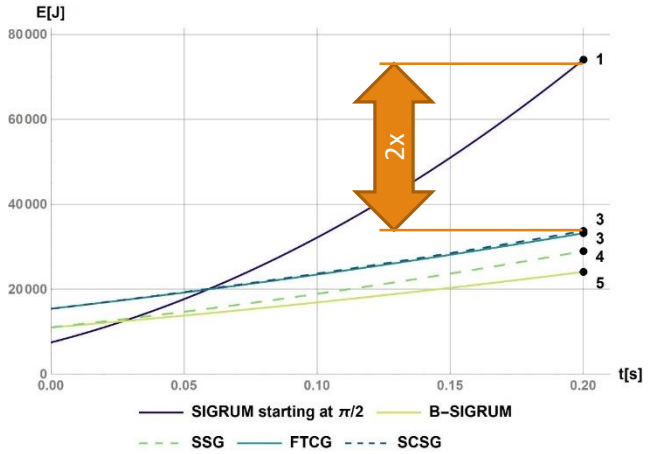
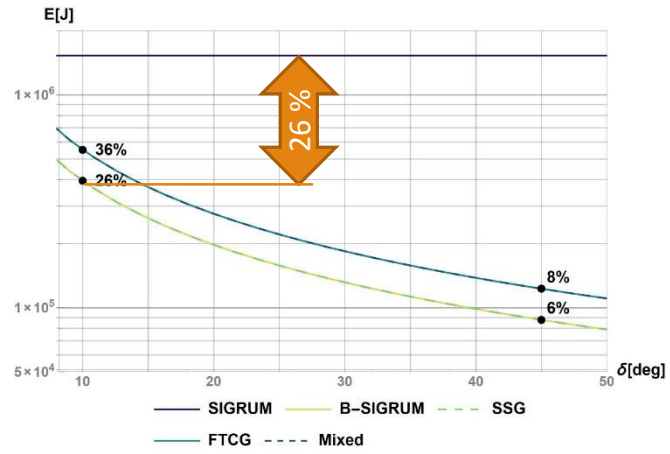
Proposal & comparison of conceptual designs



- **Robustness of the design**
  - Failure scenarios
- **Performances**
  - Deformations
- **Costs**
- **Size**





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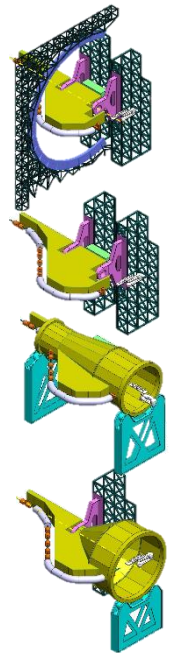
Proposal & comparison of conceptual designs

Robustness of the design			Size	Lightness and complexity		Performances: deformation and precision					Costs		Environmental	
Failure possibility	Possible safety brakes position	Number of systems to brake	Room space requirements	Complexity	Weight and inertia	Tolerances	Deformation performaces (structure)	Improvement margin of structure deformation	Deformation performaces (supports)	Load properties	Cost of manufacturing components	Cost of the driving system	Minimized energy consumption	
4	5	5	3	3	5	5	5	5	3	4	4	5	5	**SSG**
5	3	5	5	5	5	5	5	3	3	4	4	1	5	**B-SIGRUM**
3	4	5	1	4	3	4	5	4	5	5	2	4	4	**FTG**
3	4	5	5	4	3	4	5	4	4	3	2	4	4	**SCSG**



1. Comparative study has been performed in the **comprehensive** manner, following **unified methodology** providing **objective results**.
2. **All four scenarios are suitable for further gantry conceptual design** it is up to community to make a choice based on evaluation results of this study.
3. **All proposed scenarios are safe**, however the **safest** is evaluated to be **SSG**;
4. **SSG** and **B-SIGRUM** are estimated to be **twice cheaper** than **FTG** and **SCSG**;
5. **FTG** is the only capable of providing **360°access**

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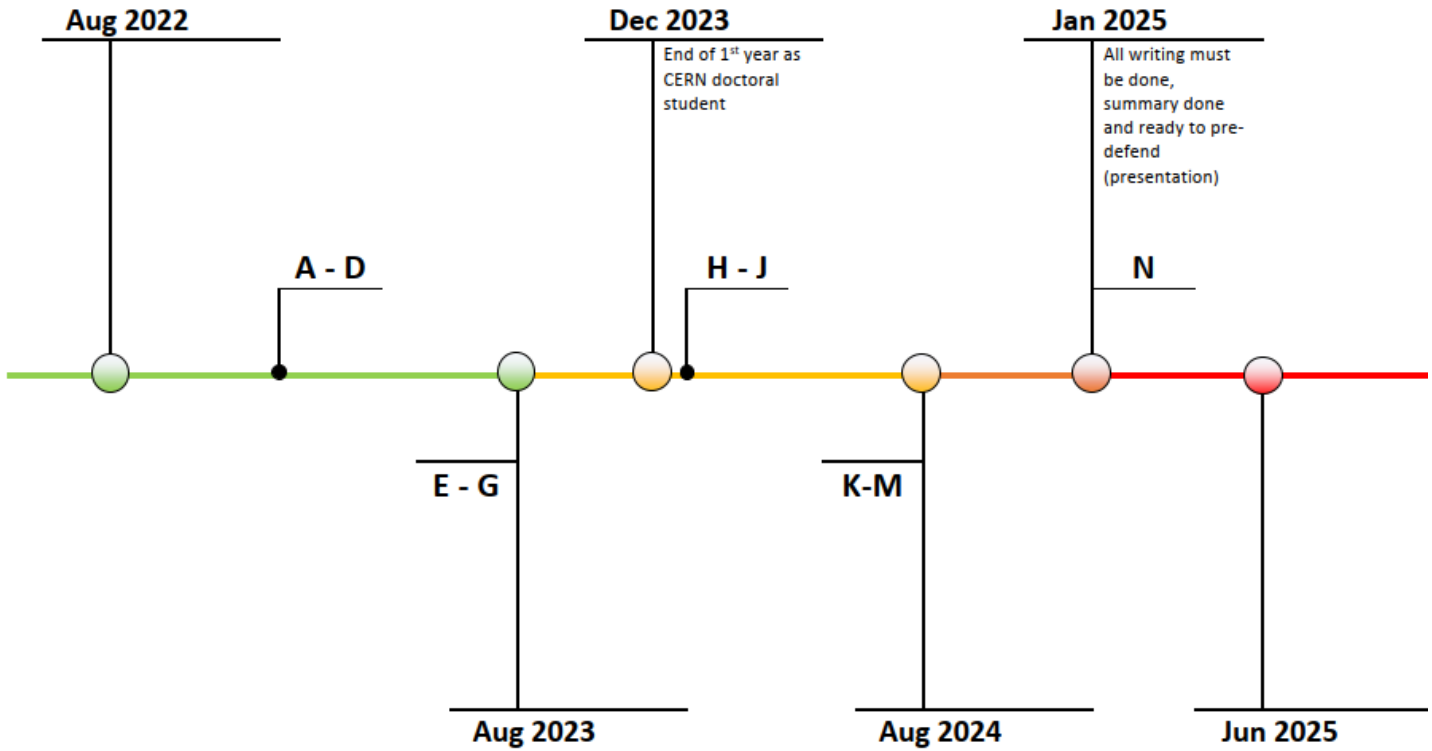
Future contributions

- **Analysis of a mathematical model to estimate the impact of mechanical errors on the pose (position and rotation) of the main optic components,**

A. Literature review on errors in mechanical engineering
B. Comprehensive correction and measuring strategy
C. Error list formalization for each strategy
D. Analysis of necessary numerical input parameters
E. Integration completion **(minimum necessary to answer point D)**
F. Analysis of error concatenation strategies
G. Code writing and code optimization **(python or maxima implementation)**
H. Data acquisition (computing power necessary)
I. Data analysis conclusion
J. Experiment planning
K. Experiment design
L. Experiment build
M. Data collection experiment
N. Conclusions



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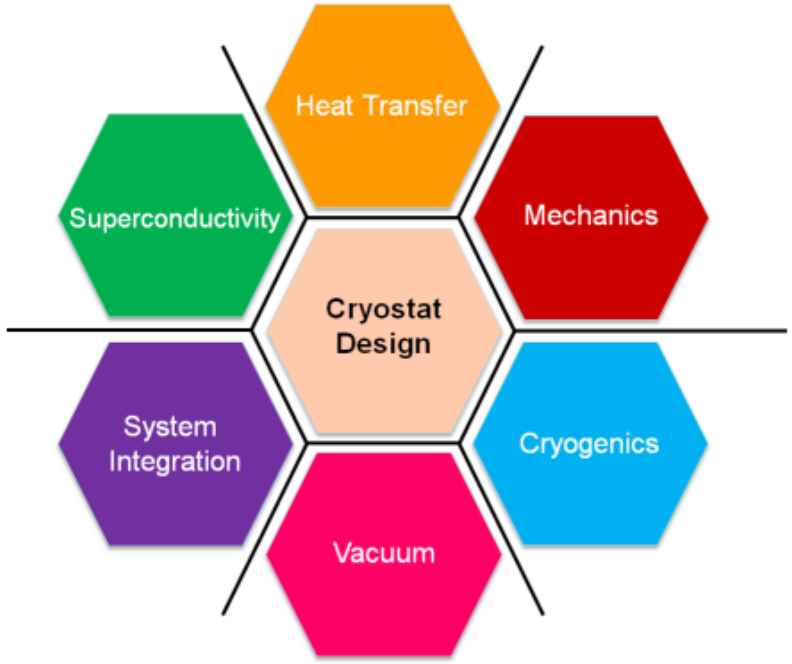
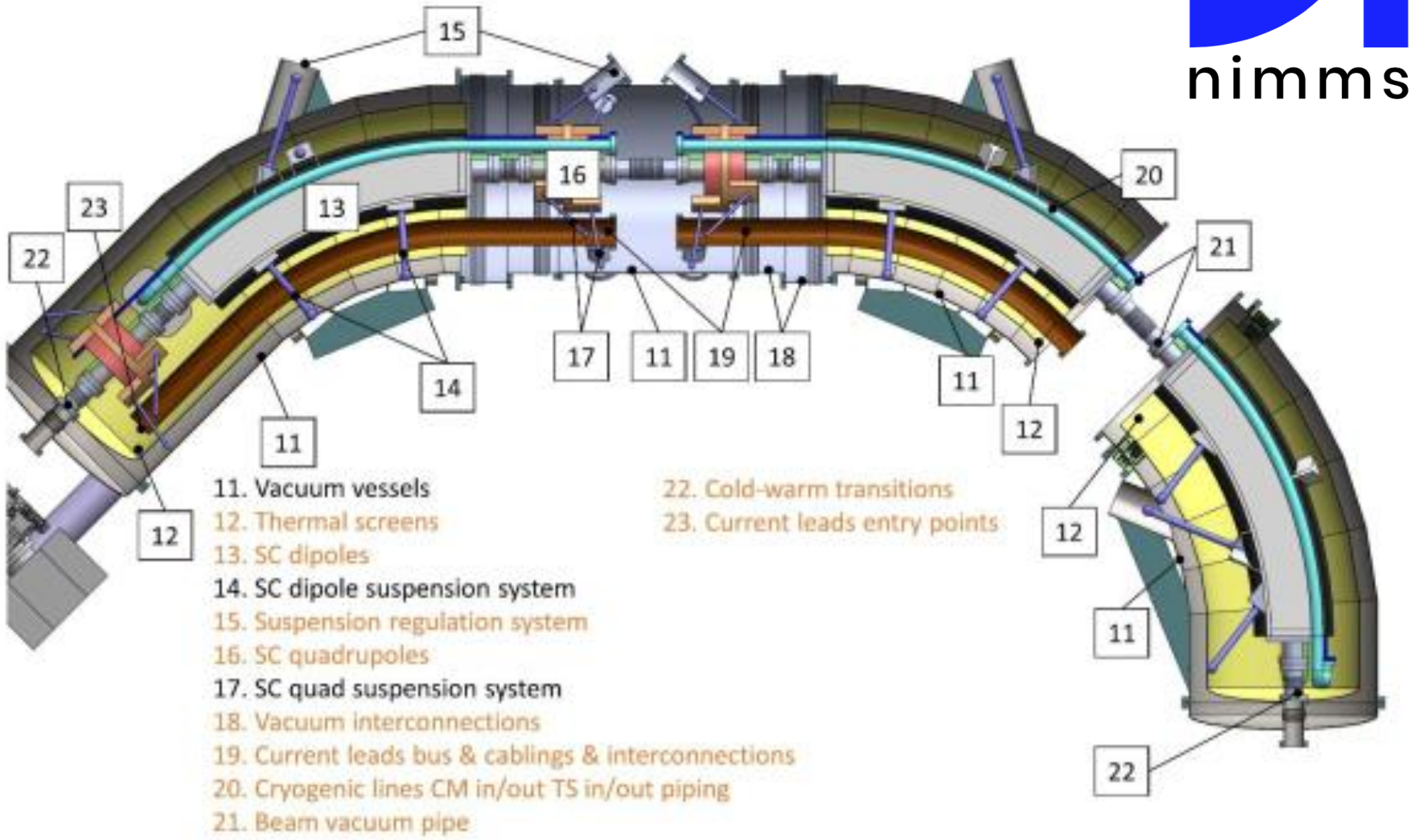
Future contributions

- **Integration**





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Thank you!

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1st Year PhD progresses

Plan of Doctoral thesis and it's implementation for the 1st study year

From October, 2021 until October, 2022.

1. EXAMS		
No.	**Subjects (course code, name of the course, CP)**	**Semester**
1.	Acceleretor Technologies, 8	*2nd*
2.	Particle Detectors, 2	*1st*
3.	Computing and Programming for Physics, 2	*1st*
4.	Statistical Methods in Data Analysis, 2	*1st*
5.	Radiation Safety, 1	*2nd*
6.	Introduction to Particle Physics, 2	*1st*
7.	Mathematics for Particle Physics, 4	*1st*
8.	Relativity and Cosmology, 4	*2nd*
9.	Research work, 23	*1st-2nd*
Total	48	

- **All Courses have been followed and relative exams passed.**
- **Participation with oral presentation at NIMMS 25/02/2022:** Joint NIMMS-SEEIIST Meeting #78 (25 February 2022) · Indico (cern.ch)
- **Publication on international scientific journals:**
  - Preliminary Design of the Support Structure for a Rotating Carbon-Ion Transfer Line for Medical Applications (published 27/11/2021) https://doi.org/10.3390/instruments5040034 **Reviewed**
  - Comparative study on scenarios for rotating gantry mechanical structures https://doi.org/10.12688/openreseurope.14683.1 **awaiting peer review**
- **Mobility: Work from CERN from 1st of December 2021 – today**

- **Thesis general introduction**
- **Choice of the mechanical structure**
- **Analysis job:**
  - **Conceptual design of possible structures and evaluation of pros & cons**
  - **Conceptual integration of necessary elements**

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