HITRI plus
Heavy Ion Therapy Research Integration

nimms

RTU accelerator technology students @CERN

Advancements of integration and mechanical design of gantries for ion-therapy

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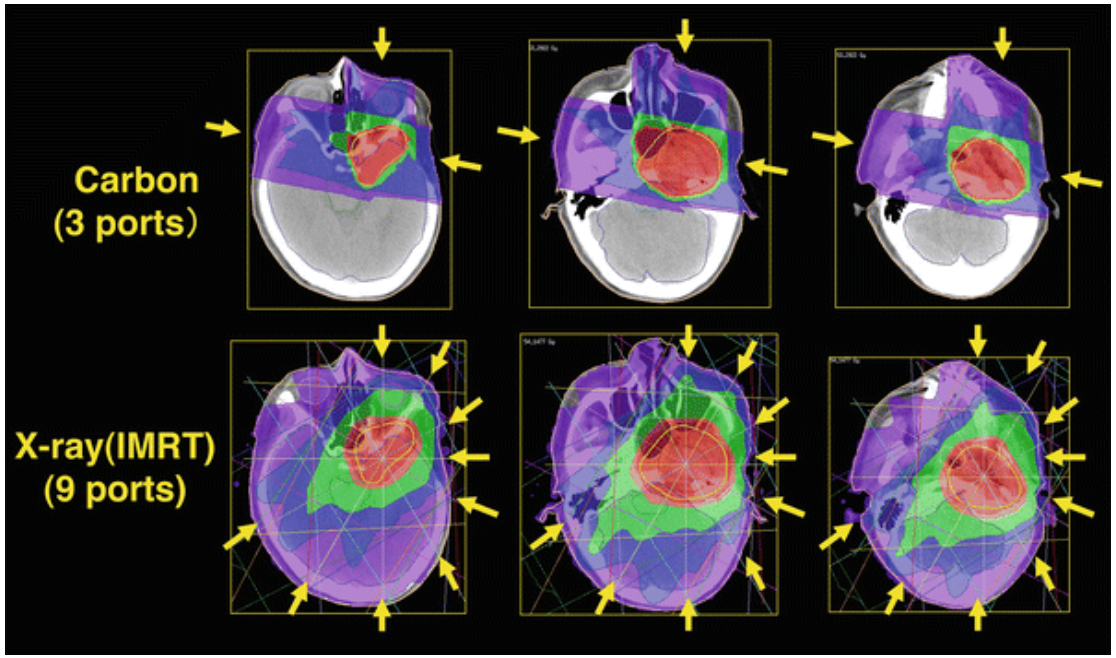
Task 7.5 - Integration of an innovative superconducting gantry: optics, mechanics, beam delivery (CNAO, CERN, SEEIIST, MEDA, RTU). Task Leader: M. Pullia

- 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/

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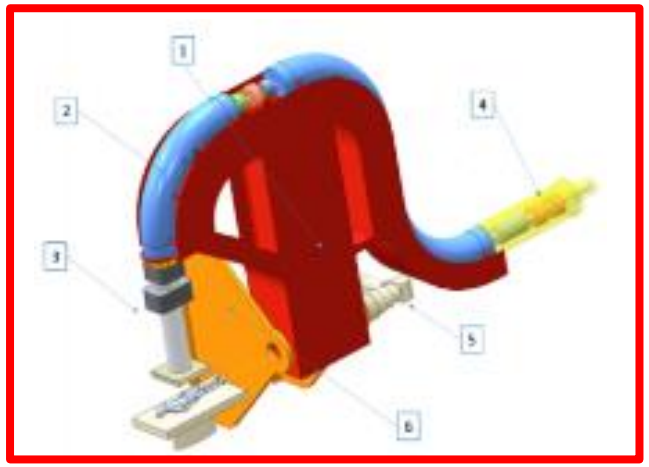
What is a gantry



The «SIGRUM» SC gantry

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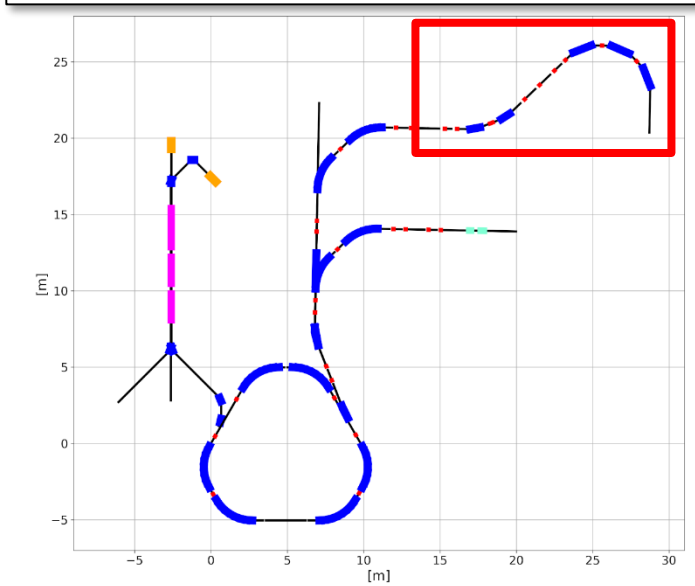
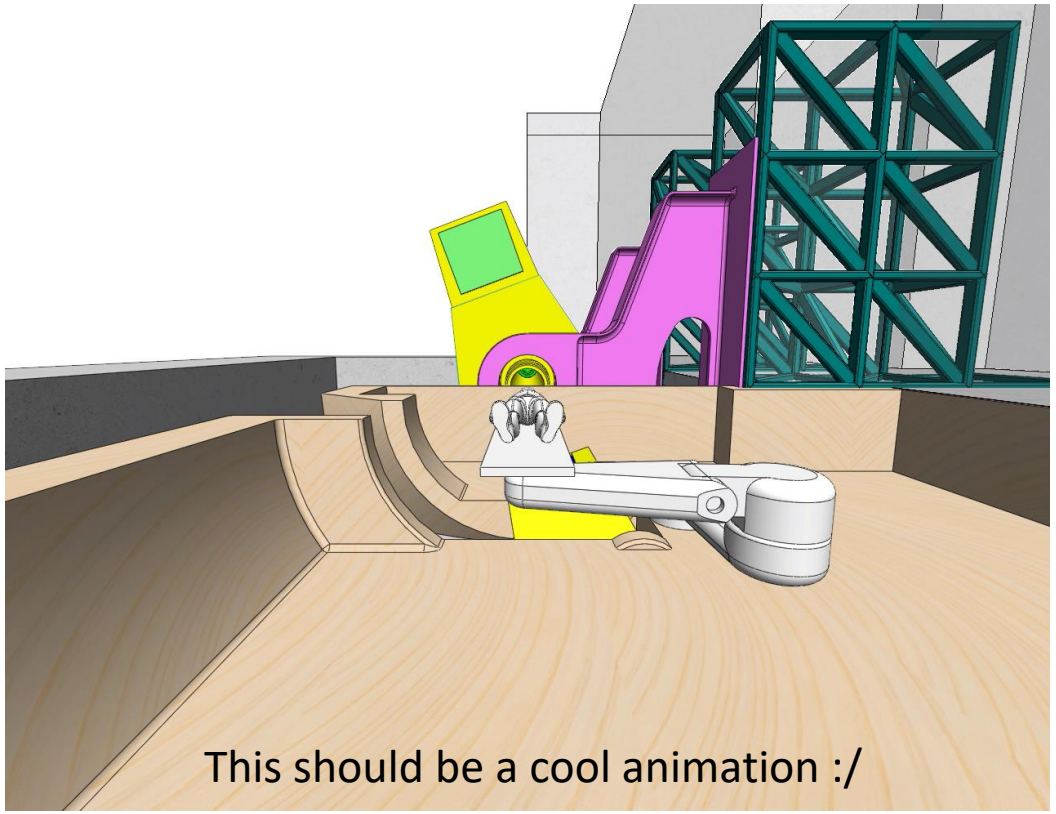
Advanced Particle Therapy center in the Baltic States



Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*



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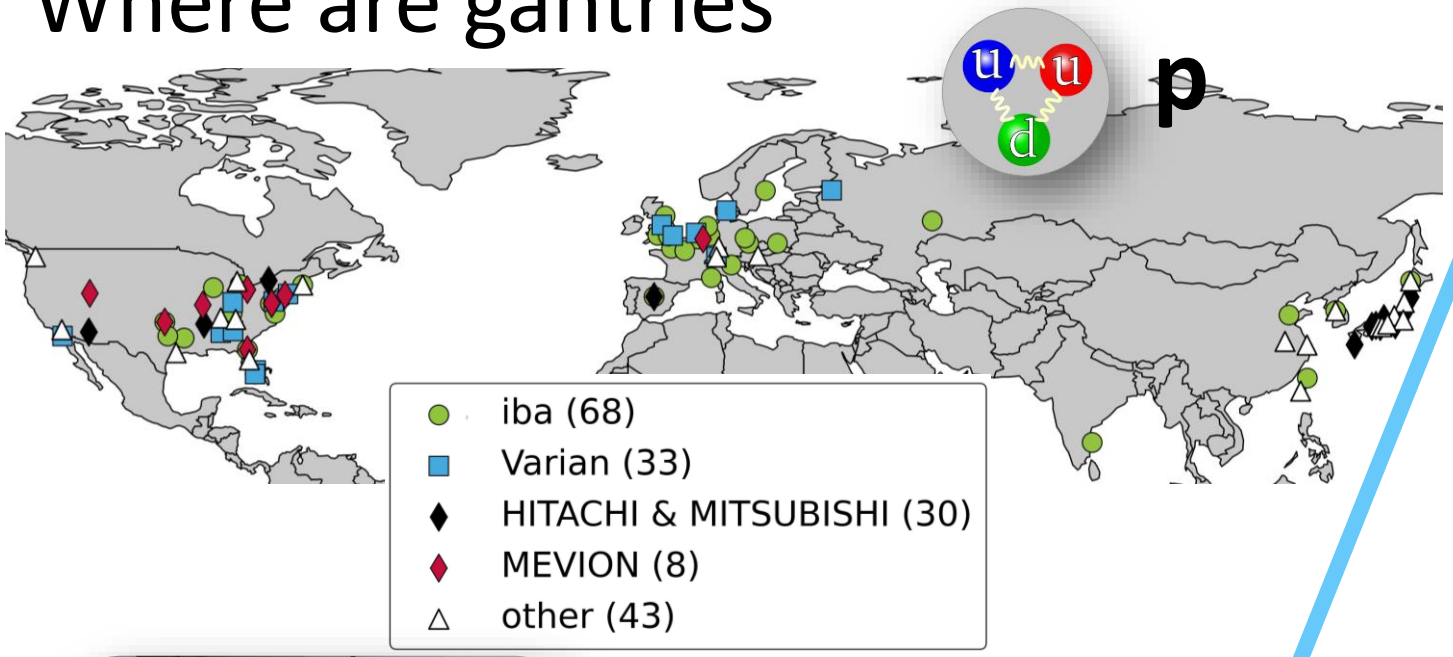
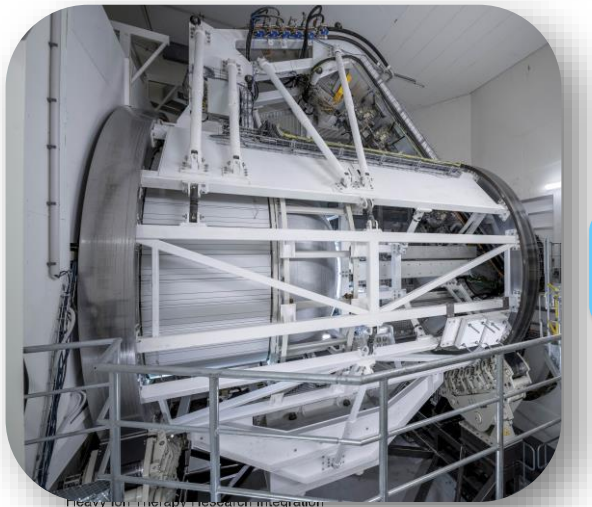
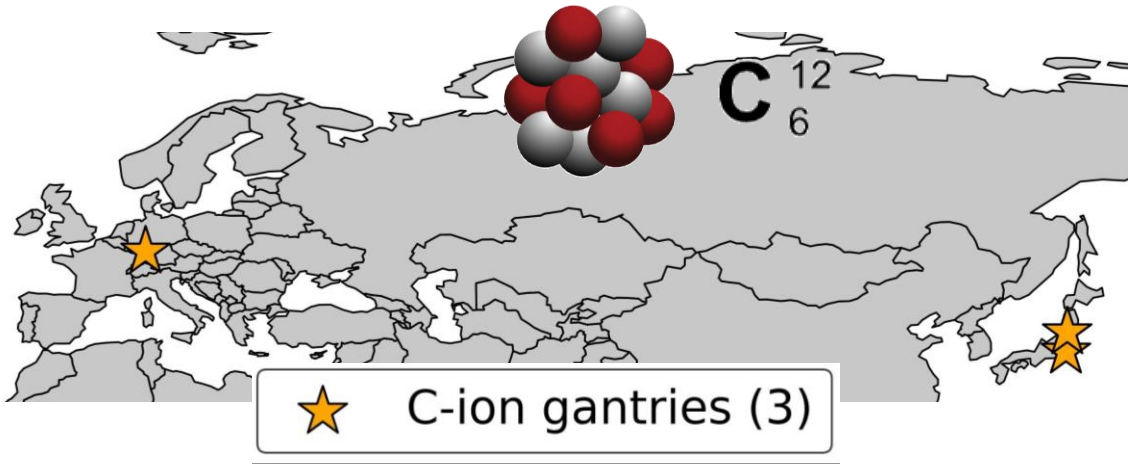
Where are gantries





≈ 100 tons

≈ 200 tons



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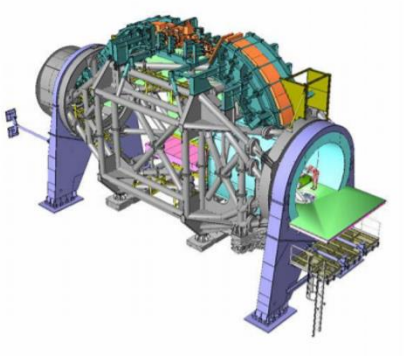
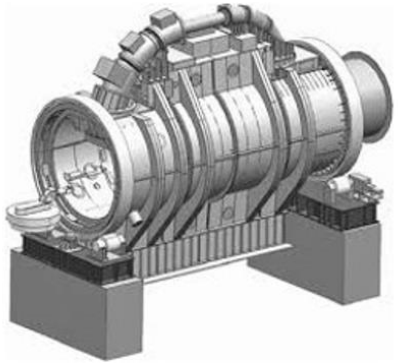
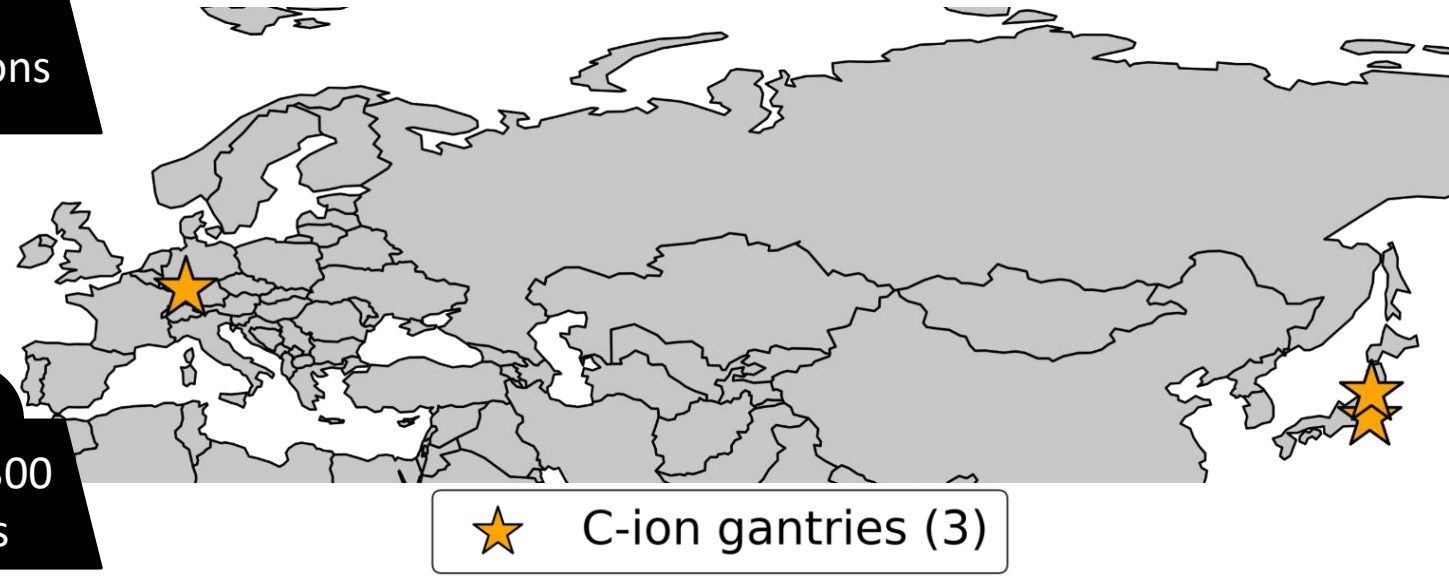
Where are gantries



Heidelberg (GE) 2008



Chiba (JP) and Yamagata (JP) **by TOSHIBA**



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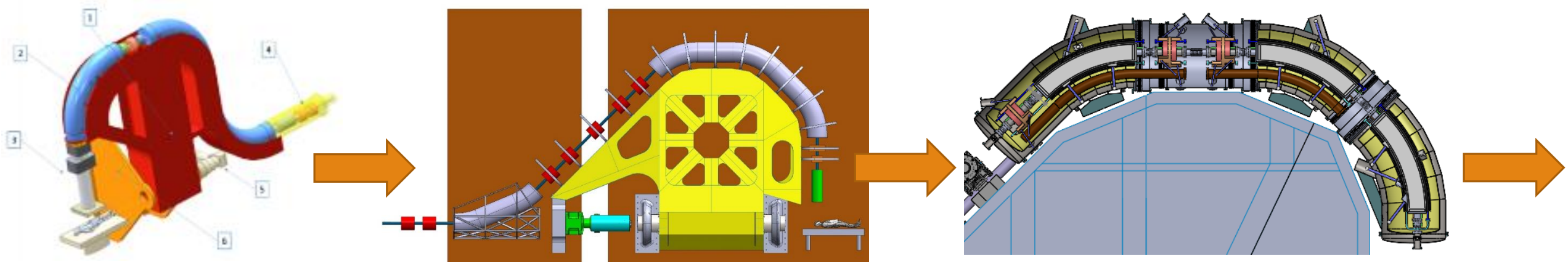
Studies evolution

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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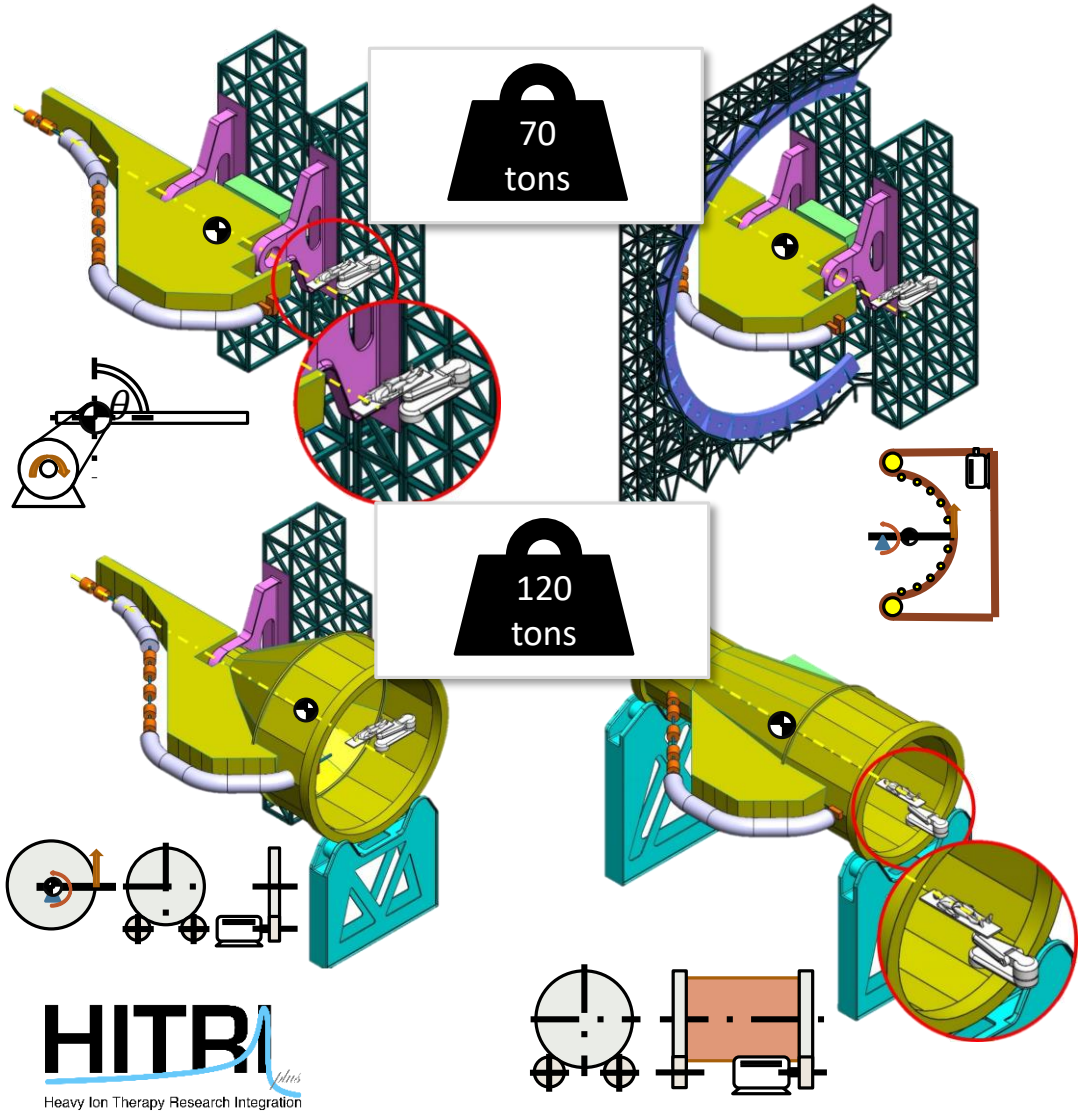
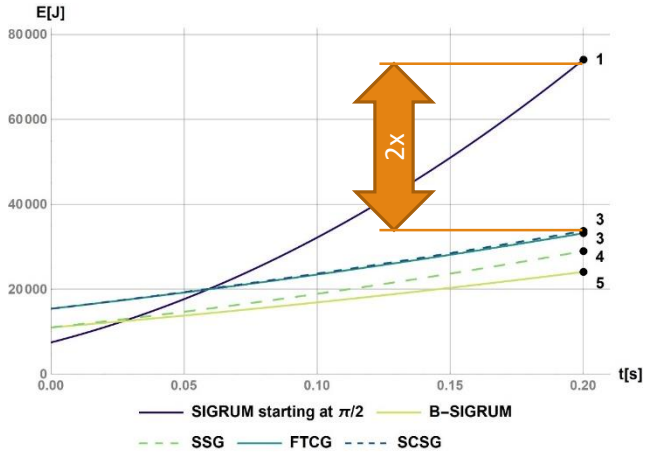
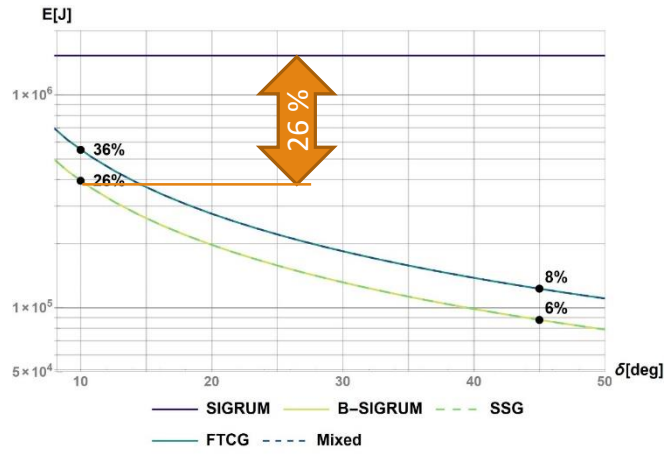
Proposal & comparison of conceptual designs



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





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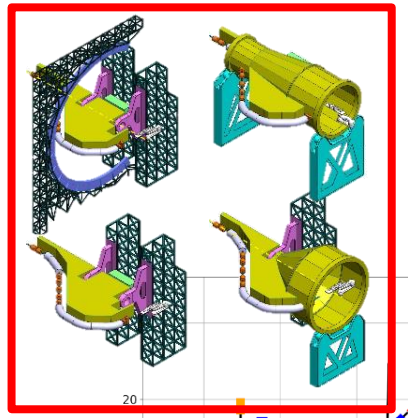
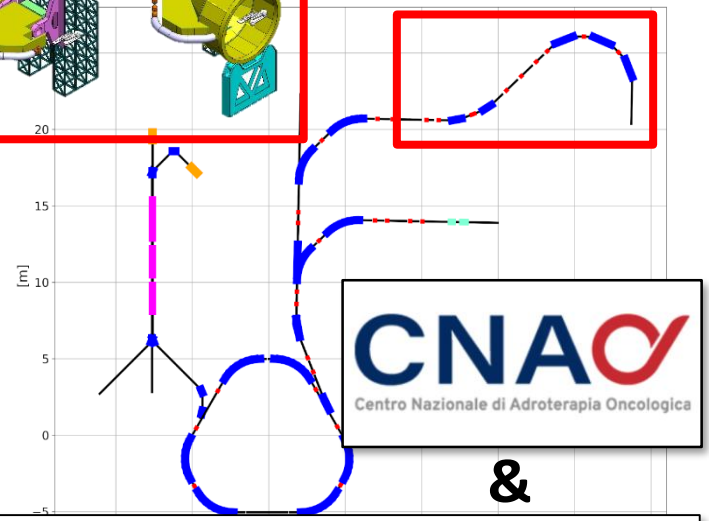
Proposal & comparison of conceptual designs

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**.
3. **FTG** is the only capable of providing **360°access**

CNAO
Centro Nazionale di Adroterapia Oncologica

&

Advanced Particle Therapy center in the Baltic States

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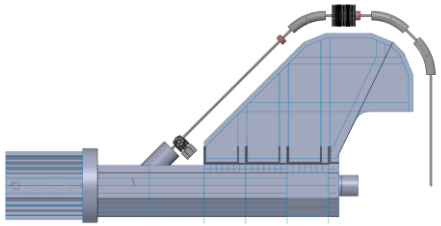
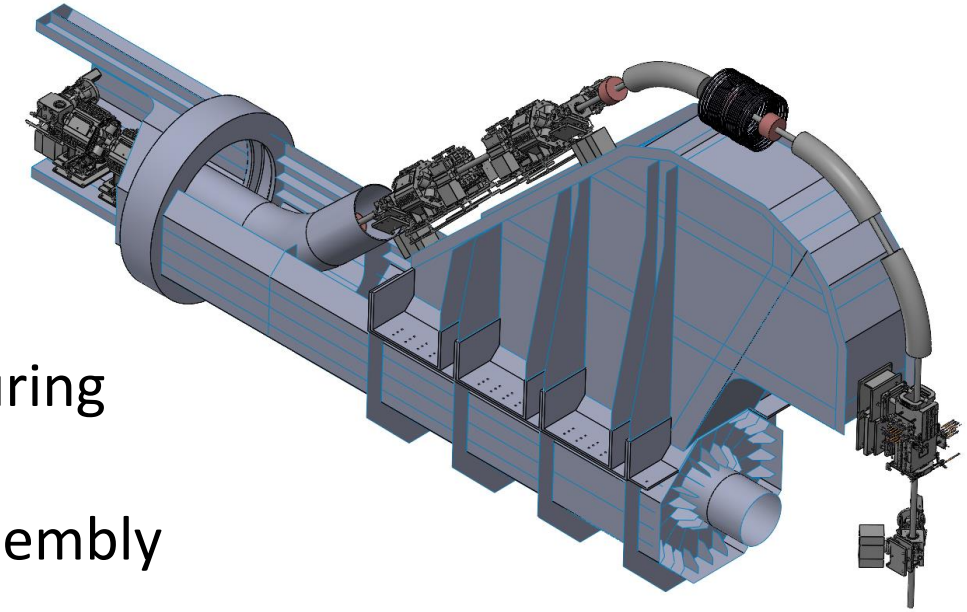
Future contributions

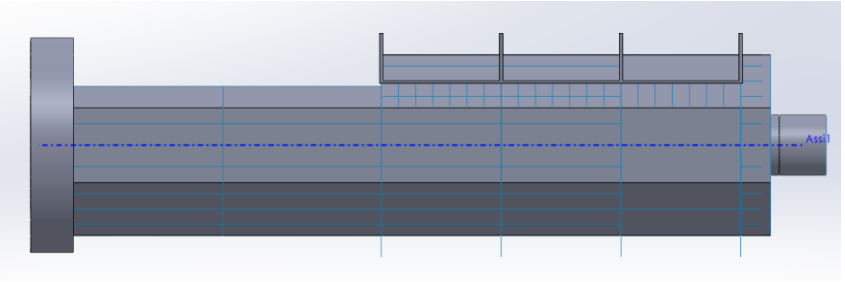
- **Main supporting structure design**



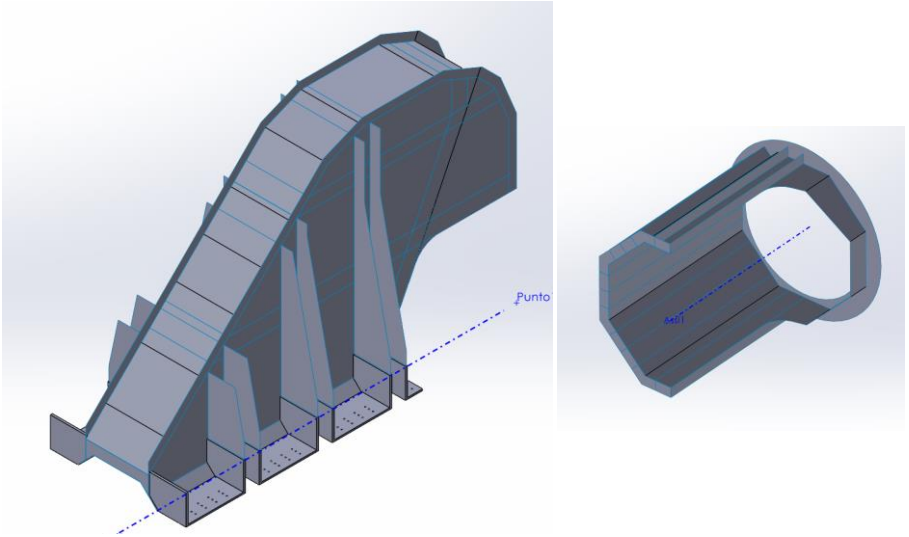


- Manufacturing
- Stiffness
- Ease of assembly

- Main axle: to achieve axis alignment



- Main and tail structural support of the transfer line



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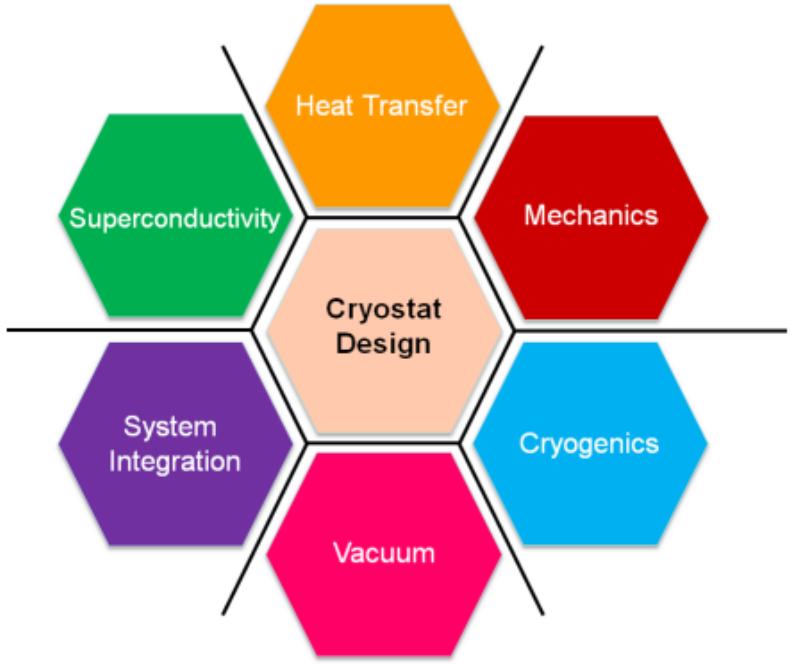
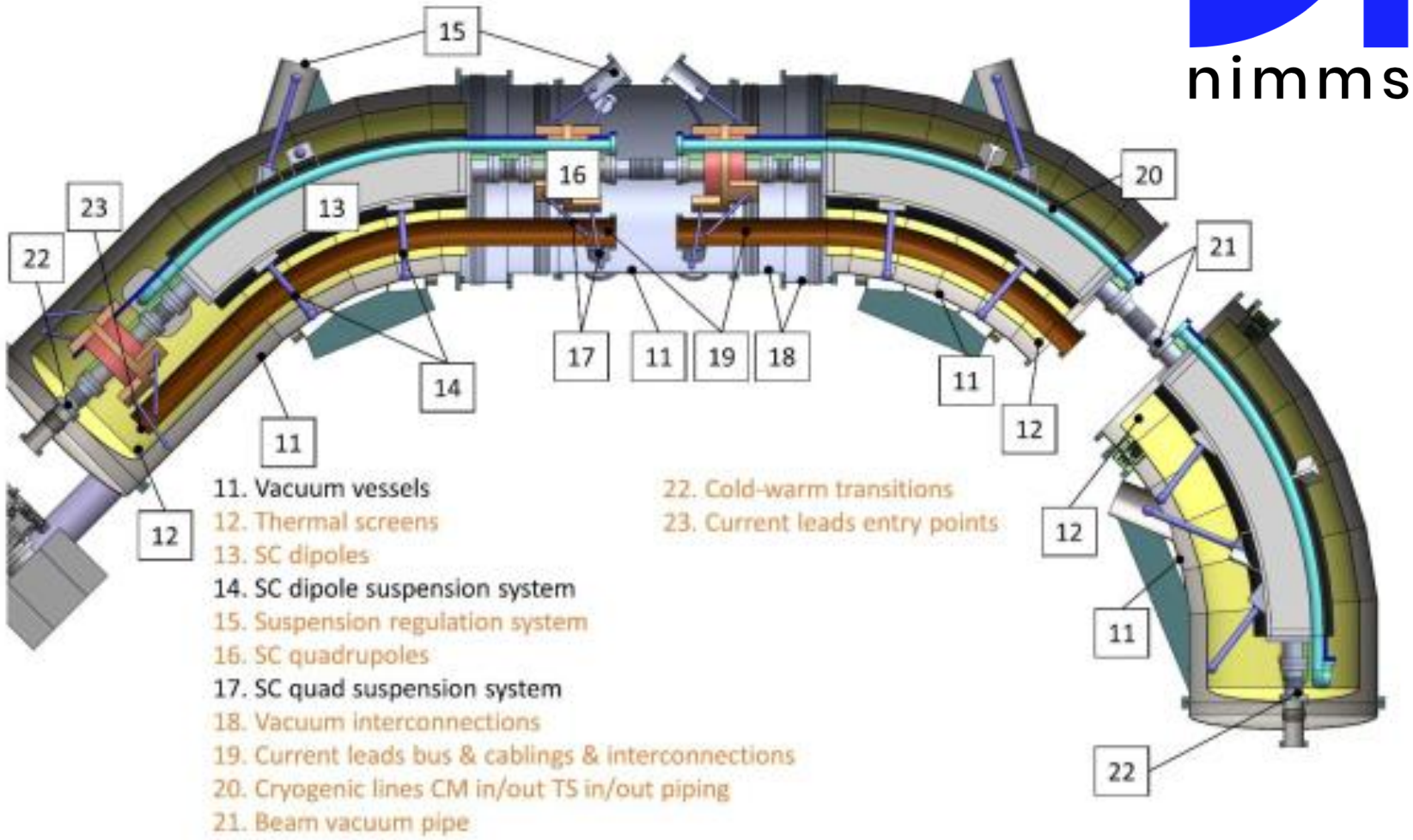
Future contributions

- **Integration**





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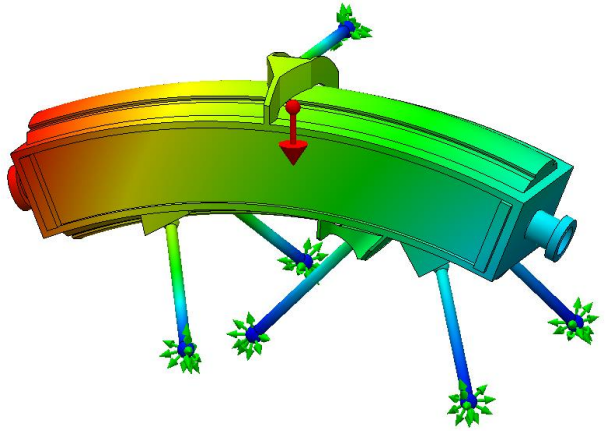
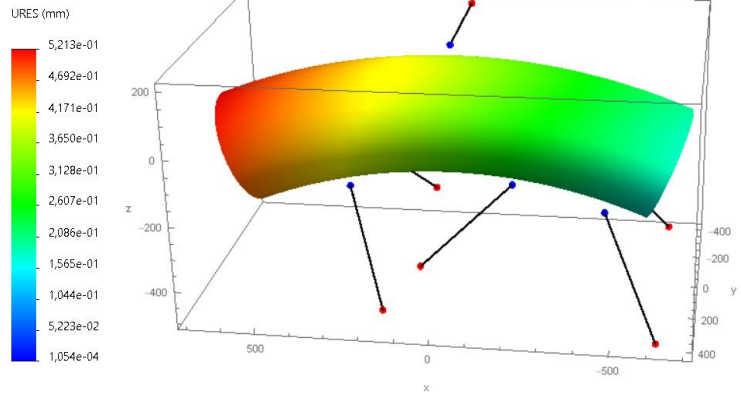
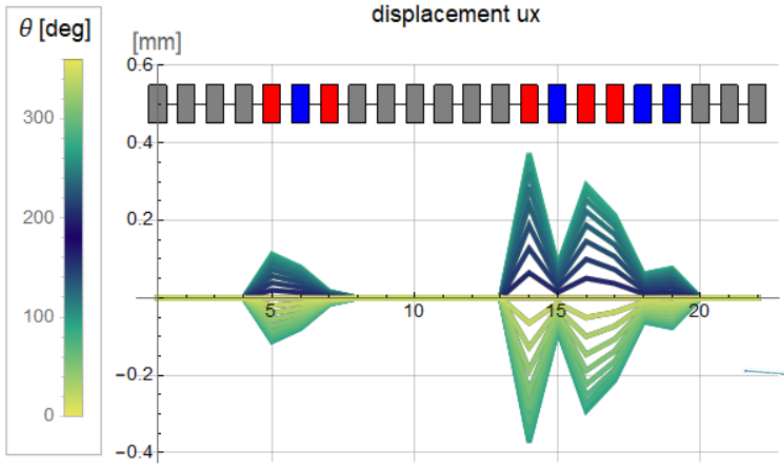
Future contributions

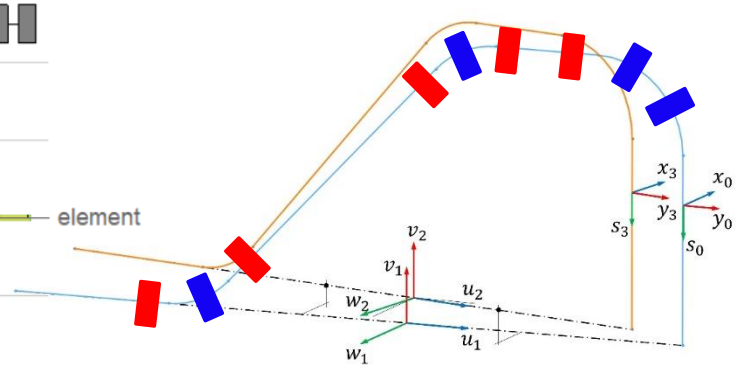
- **Analysis of a mathematical model to estimate the impact of mechanical errors on the pose (position and rotation) of the main optic components,**

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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Thank you!

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