MeChanICs - Marie Curie Linking Industry to CERN

Mid Term Review 27th and 28th of September 2012

Fabrizio Rossi

My background

- Dec. 21st, 1981: Born (Milan, Italy)
- April 2006: M.Sc. in Mechanical Engineering (Politecnico di Milano, Milan, Italy)

  MFS: Machine design

- Dec. 2009: PhD in Mechanical System Engineering (Politecnico di Milano, Milan, Italy)

  MFS: Gears noise and vibrations

- Jan. 2010 - Feb. 2011: Post-Doc researcher for ENI S.p.A.

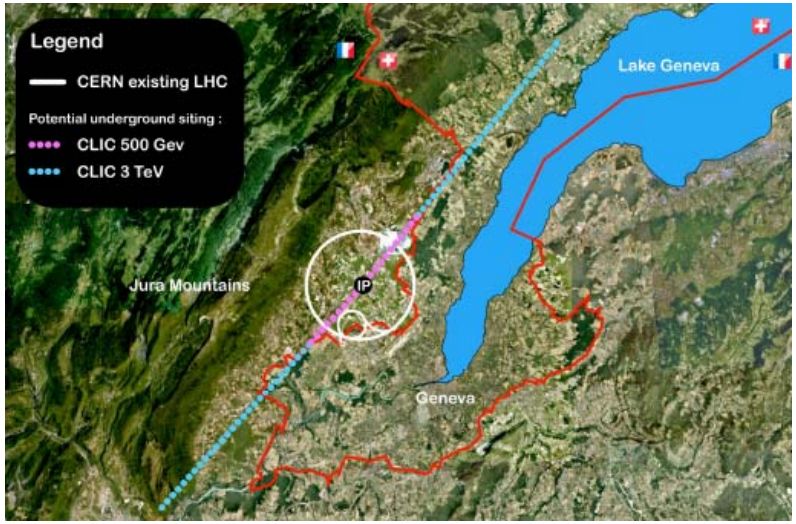
  MFS: Innovative casing design for off-shore oil drilling

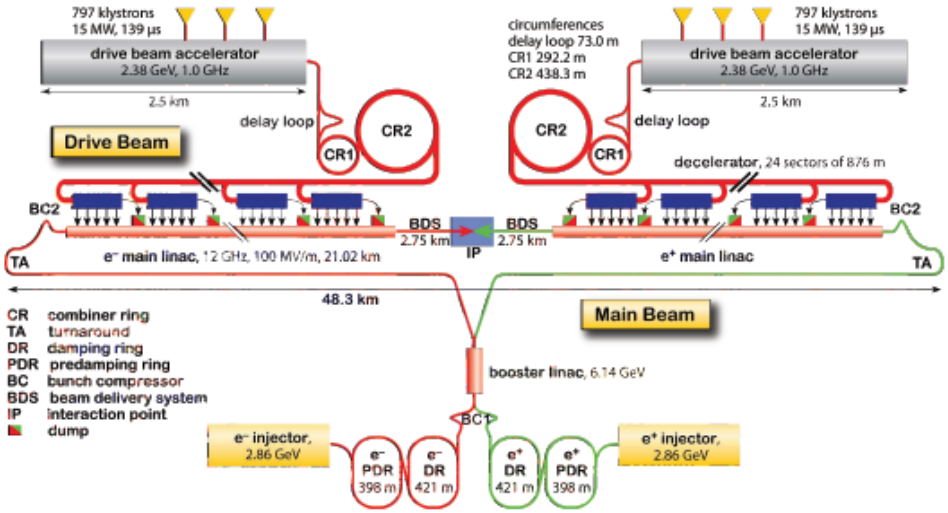
- Apr. 2011 - Now: Marie Curie Fellow at CERN

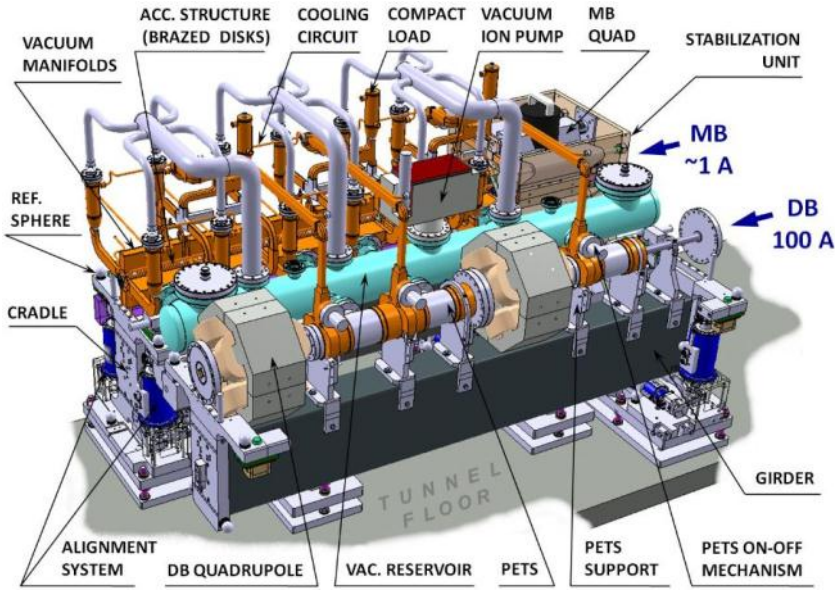
CLIC project: introduction

- CLIC (Compact LInear Collider) is a multi-TeV normal conducting electron positron collider, where the Main Beam (MB) passes through the Accelerating Structures (AS) and is accelerated by the RF power extracted from a low energy and high-intensity Drive Beam (DB) using Power Extraction and Transfer Structures (PETS).

- The total length of CLIC is about 48-km and both 21-km long main linacs are constituted of two meters long repetitive modular units.





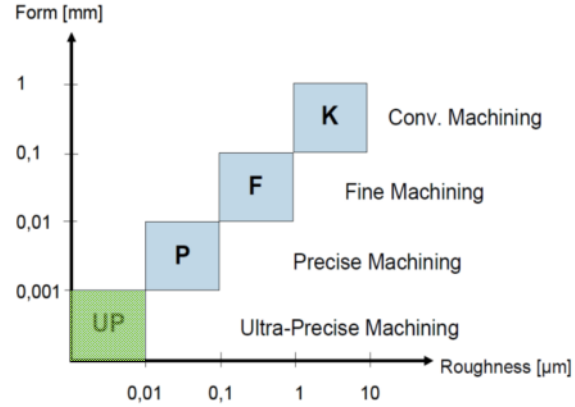


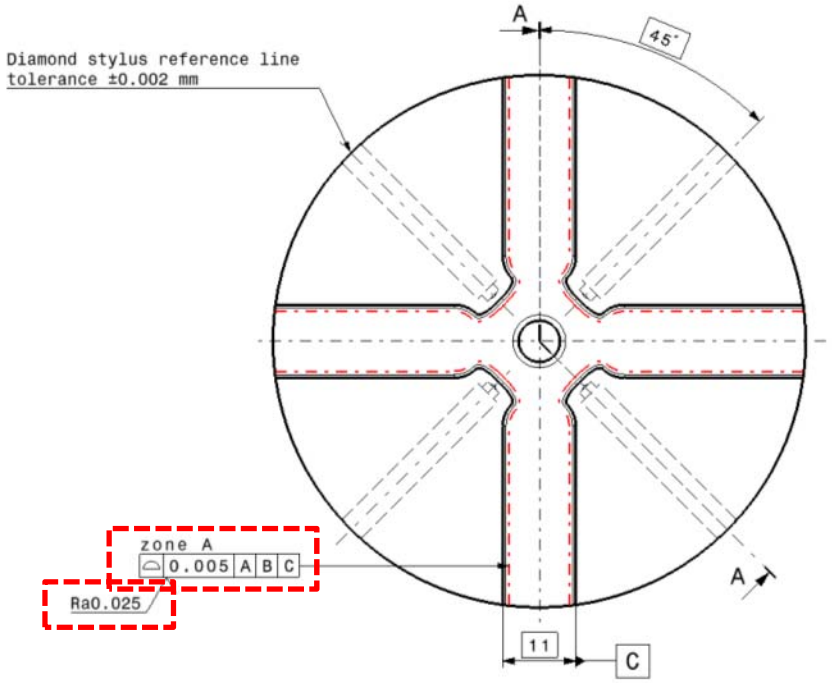
CLIC project: accelerating structure disks

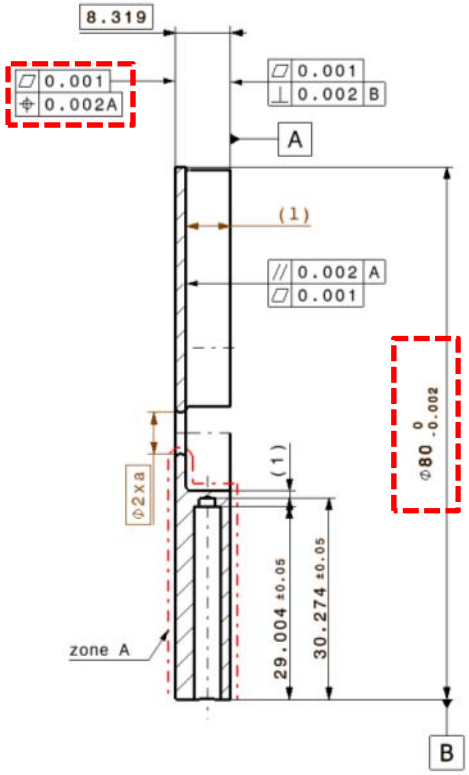
ACCELERATING STRUCTURE DISKS

- Ultra-precise machining
- Copper OFE

CLIC's requirements
shape accuracy: ± 2.5 µm
roughness Ra: 0.025 µm

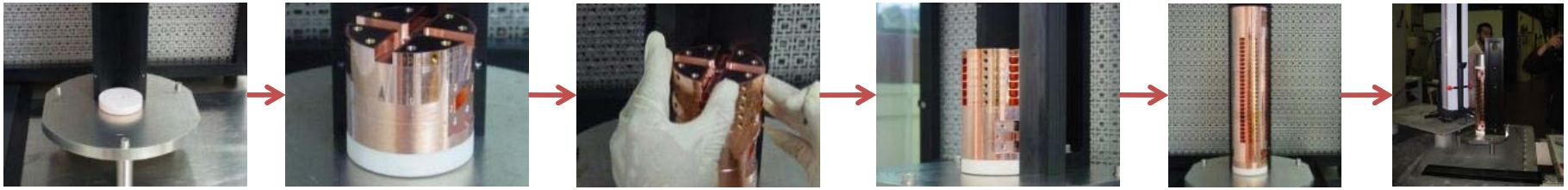






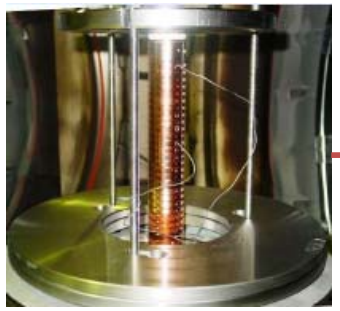
CLIC project: assembly of accelerating structures

ASSEMBLY AND ALIGNMENT CONTROL

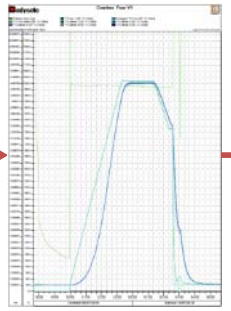


Alignment control

DIFFUSION BONDING PROCESS

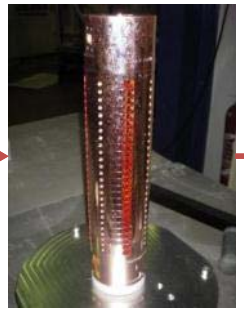


1. Load is applied to the disks stack using the load device and thermocouples are mounted to measure the temperature history during the heat treatment .



2. Bonding inside the furnace:
   - atmosphere: H_2
   - temperature: 1025 °C

Before each bonding cycle, a outgassing cycle is performed.

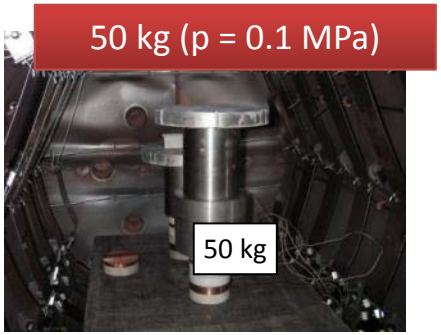


3. Bonded disks stack

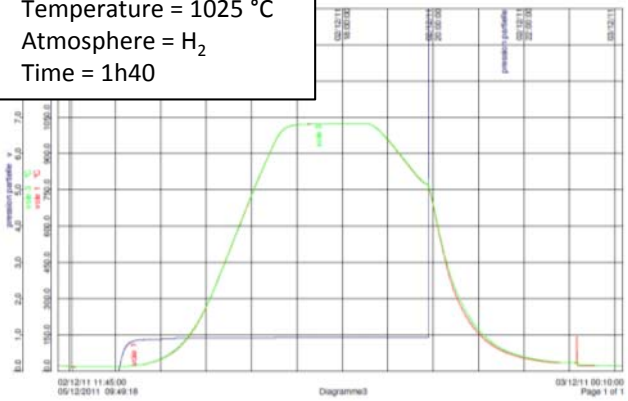
4. Particular of the grains aspect after the heat treatment. Grains size order of a few millimeters.

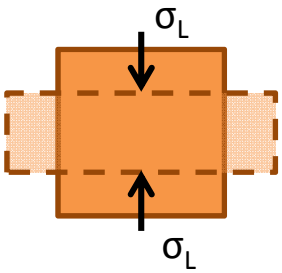
CLIC project: diffusion bonding process

- Modelling of diffusion bonding process to reduce final deformations



BONDING PARAMETERS
- Temperature = 1025 °C
- Atmosphere = H_2
- Time = 1h40





$\varepsilon_L = \sigma_L / E$

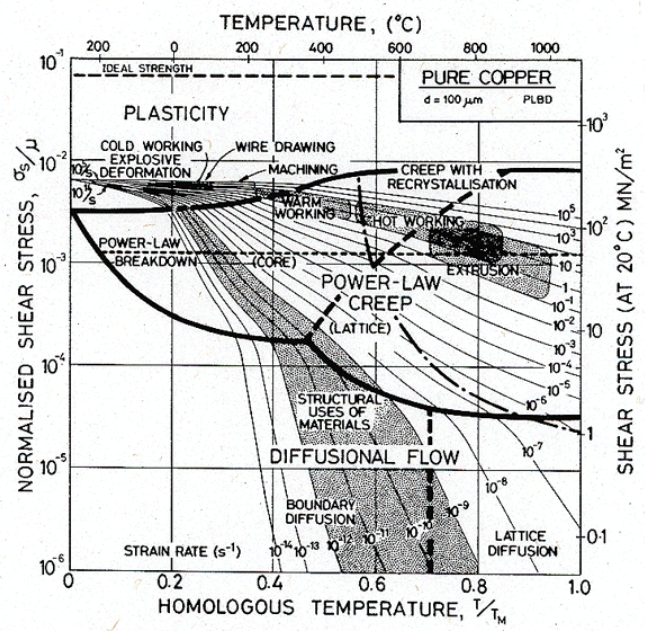
$\varepsilon_T = -\nu \cdot \varepsilon_L$

$$\dot{\varepsilon}_{L,Co} = A_{Co} \frac{\delta D_{gb} \Omega \sigma_L}{d^3 kT}$$

$$\dot{\varepsilon}_{L,NH} = A_{NH} \frac{D_1 \Omega \sigma_L}{d^2 kT}$$

$$\sigma_L, d, T \Rightarrow \dot{\varepsilon}_L \Rightarrow \varepsilon_L = \dot{\varepsilon}_L \cdot \Delta t \Rightarrow$$

$$\Rightarrow \varepsilon_T = -\nu \cdot \varepsilon_L \Rightarrow \Delta \emptyset = \varepsilon_T \cdot \emptyset$$



- <u>Measured</u> deformation of the external diameters (average): $\Delta\varnothing_{EXP}$ = +0.025 mm

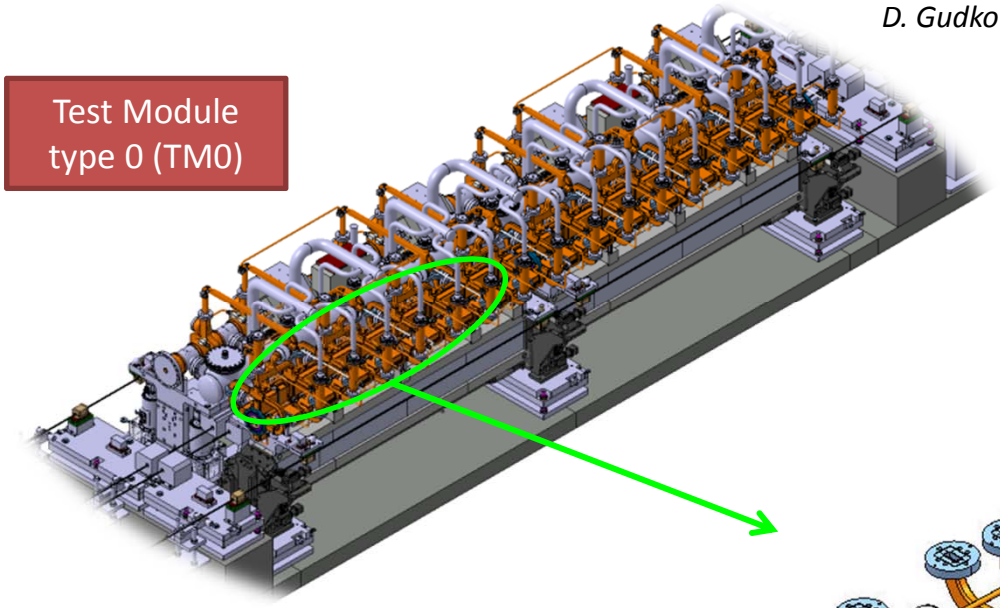
- <u>Predicted</u> deformation of the external diameters (d = 65 µm): $\Delta\varnothing_{THEO}$ = +0.025 mm
  - *Coble creep: +0.004 mm*
  - *Nabarro-Herring creep (A_{NH} = 17): +0.021 mm*

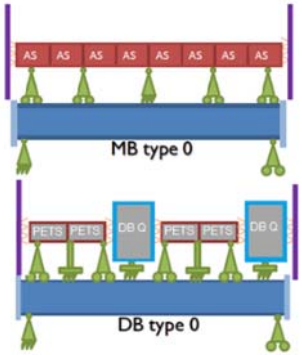
d [µm]	Δ_{THEO} [mm]
55	+0.036
65	+0.025
75	+0.018

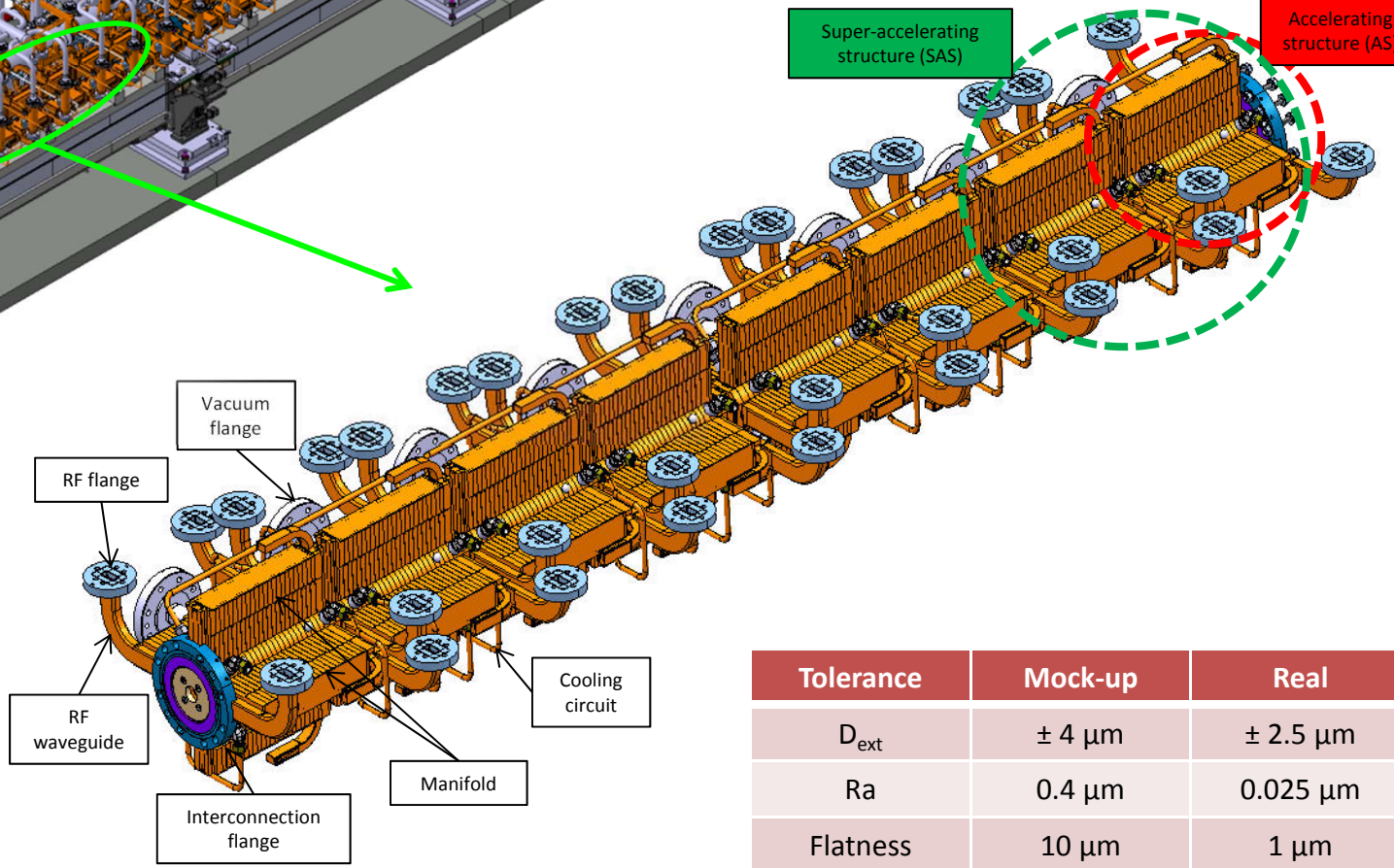
CLIC project: prototype modules

D. Gudkov

Test Module type 0 (TM0)

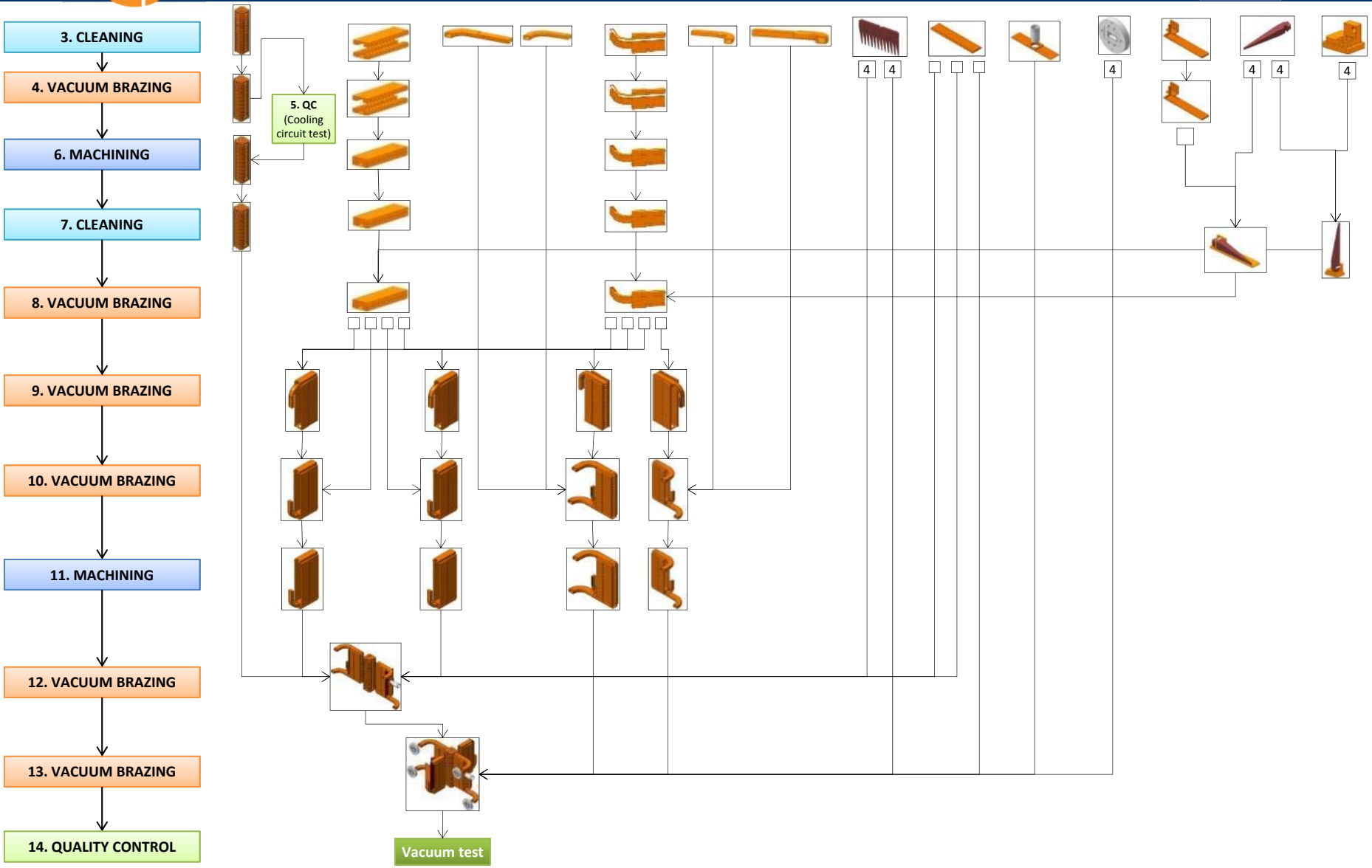




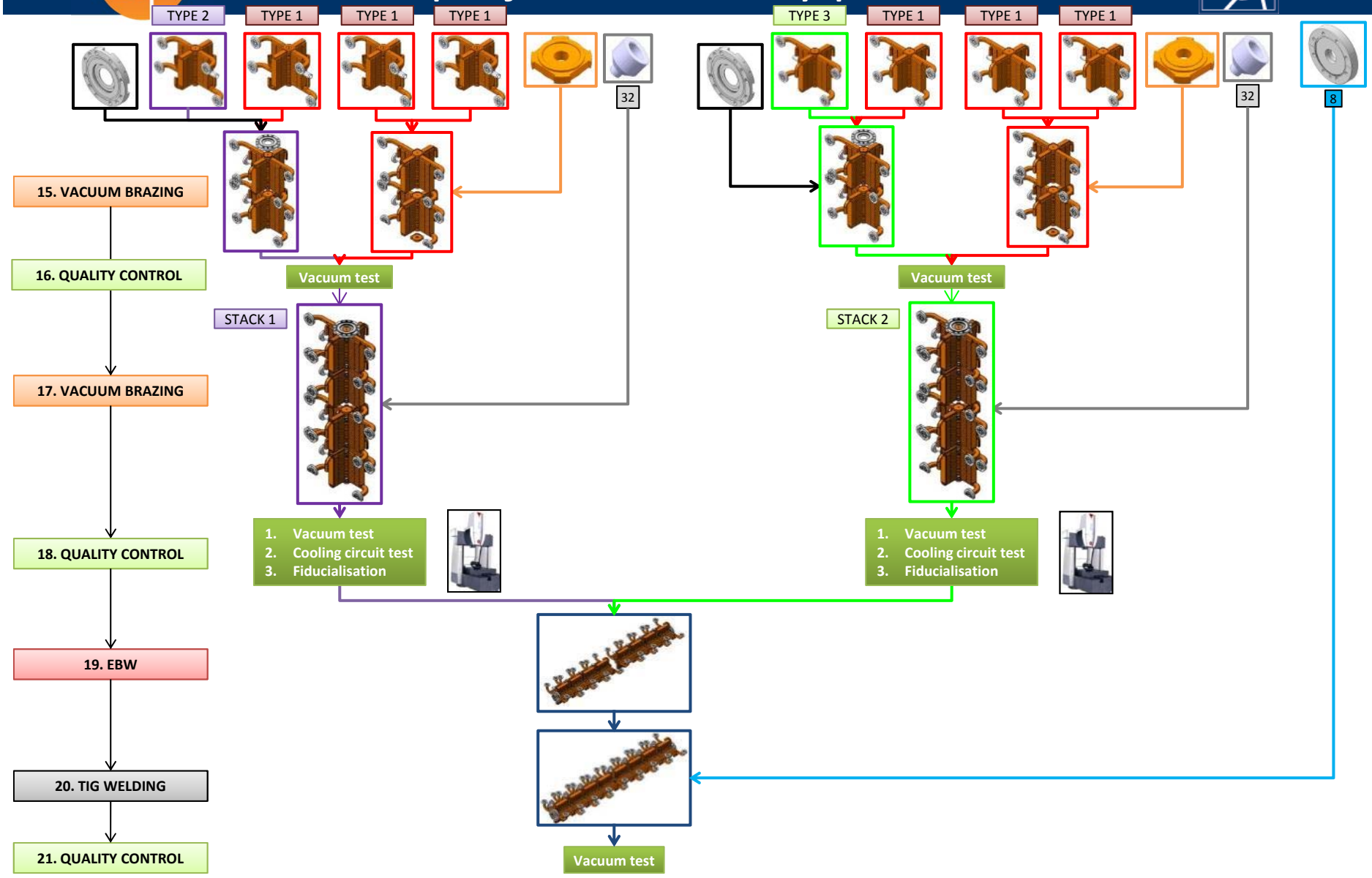


Tolerance	Mock-up	Real
D_{ext}	± 4 µm	± 2.5 µm
Ra	0.4 µm	0.025 µm
Flatness	10 µm	1 µm

CLIC project: assembly procedure

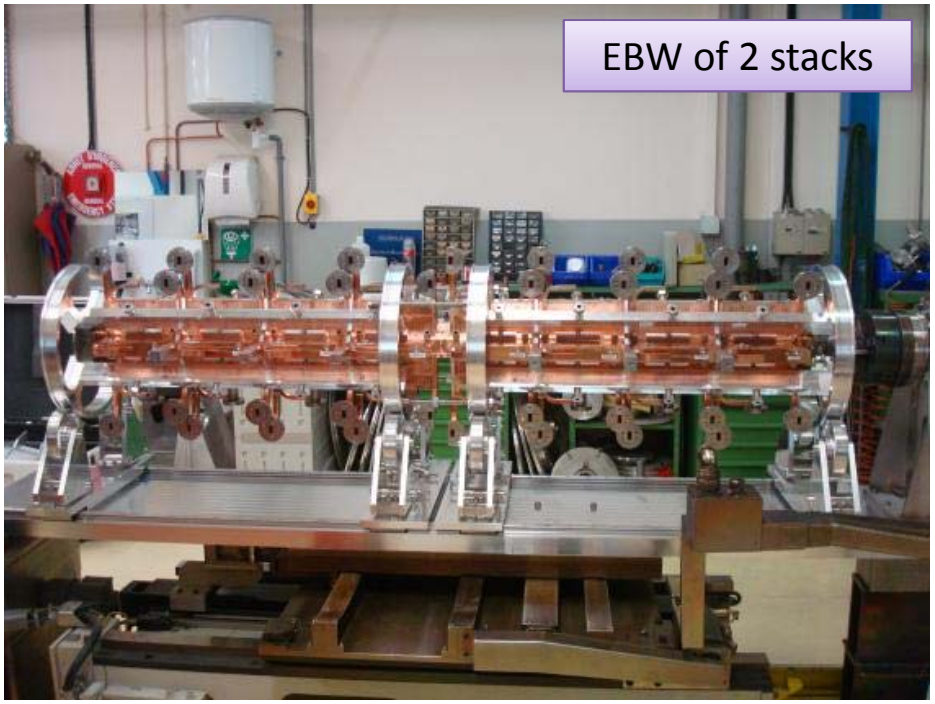


CLIC project: assembly procedure



CLIC project: prototype modules

- First CLIC prototype module type 0 READY
- Assembly of RF network, vacuum network, compact load, cooling system inside module, etc. in progress



CLIC project: numerical simulations

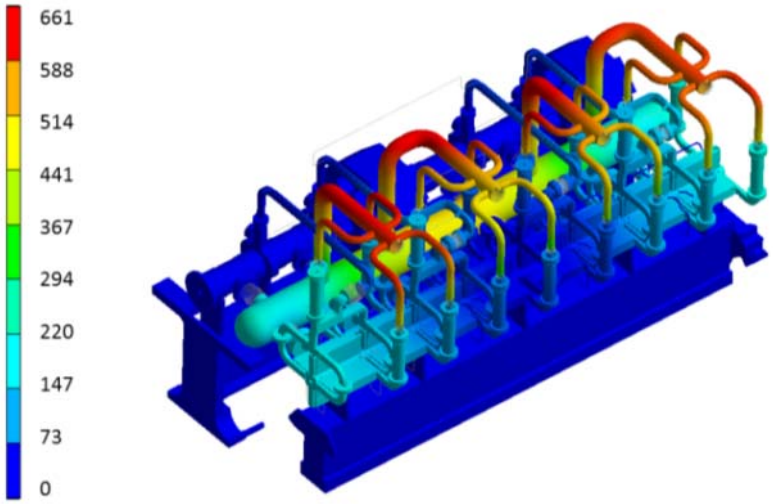
- Micron-level stability of CLIC two-beam modules, two-meter repetitive units constituting the main linacs, is one of the most important requirements to achieve the final luminosity target.

- High power dissipation during normal operation modes of modules will result in misalignments in and between different elements of the linacs, thus affecting the final resulting luminosity

Resulting displacements on the DB and MB lines due to thermal, vacuum and gravity loads

Displacements [μm] (location and load type)	**Prototype type 0**
MB (RF load)	183
DB (RF load)	47
MB (vacuum load)	30
DB (vacuum load)	131
MB (gravity load)	27
DB (gravity load)	40

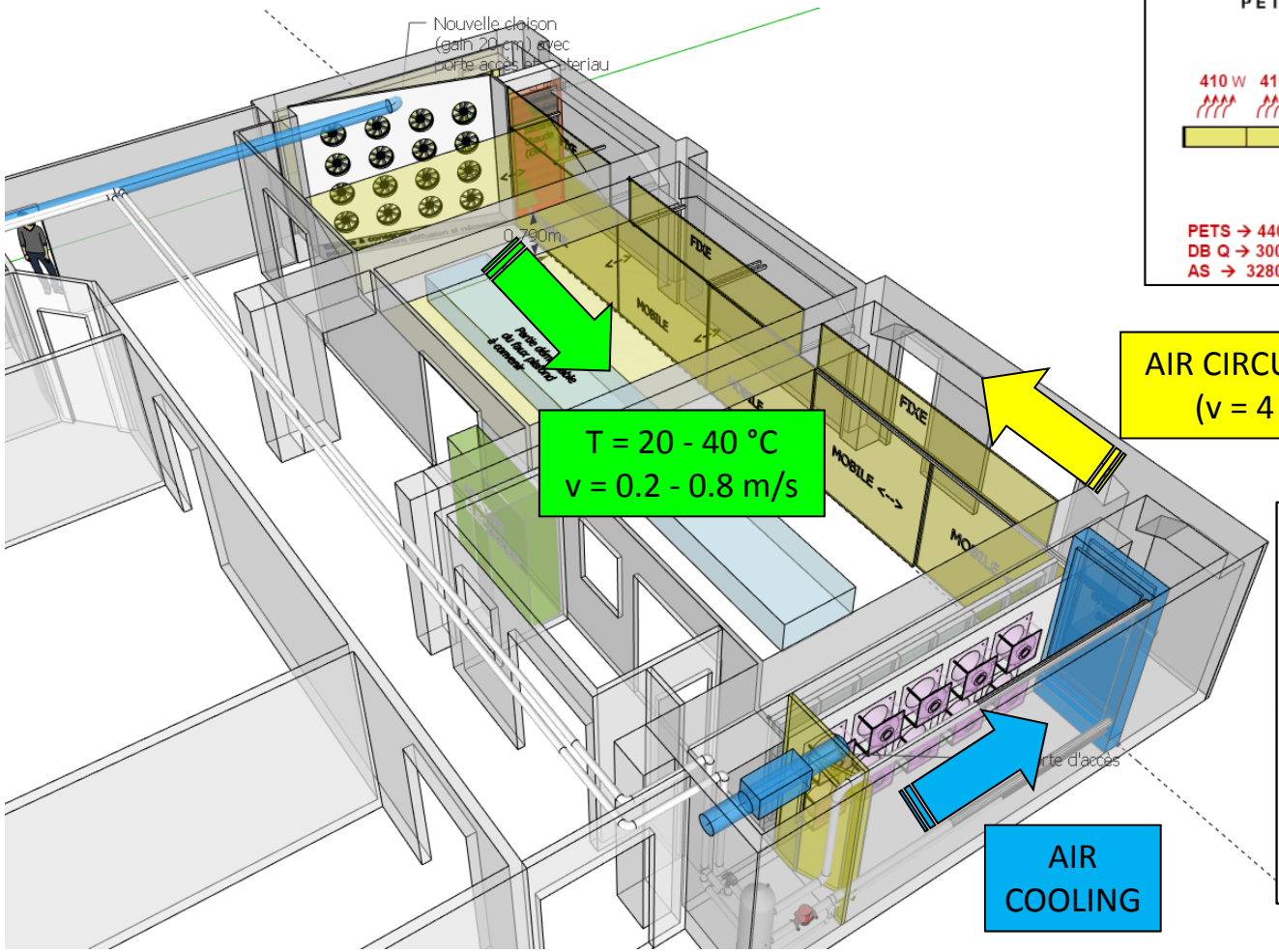
Deformed shape of prototype module type 0 due to applied thermal RF loads (values in μm)

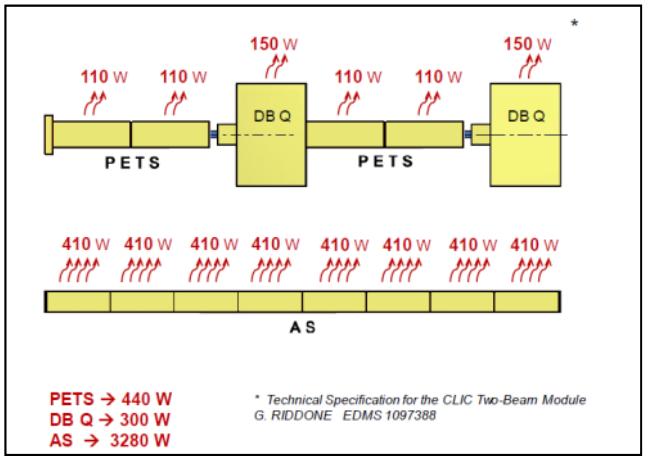


(SAS = 820 W, PETS unit = 78 W, T_{amb} = 25 °C)

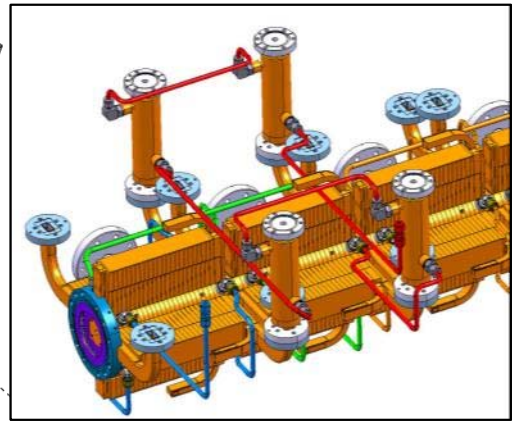
CLIC project: experimental tests

- Setup of a dedicated test bench for experimental validations of numerical analysis



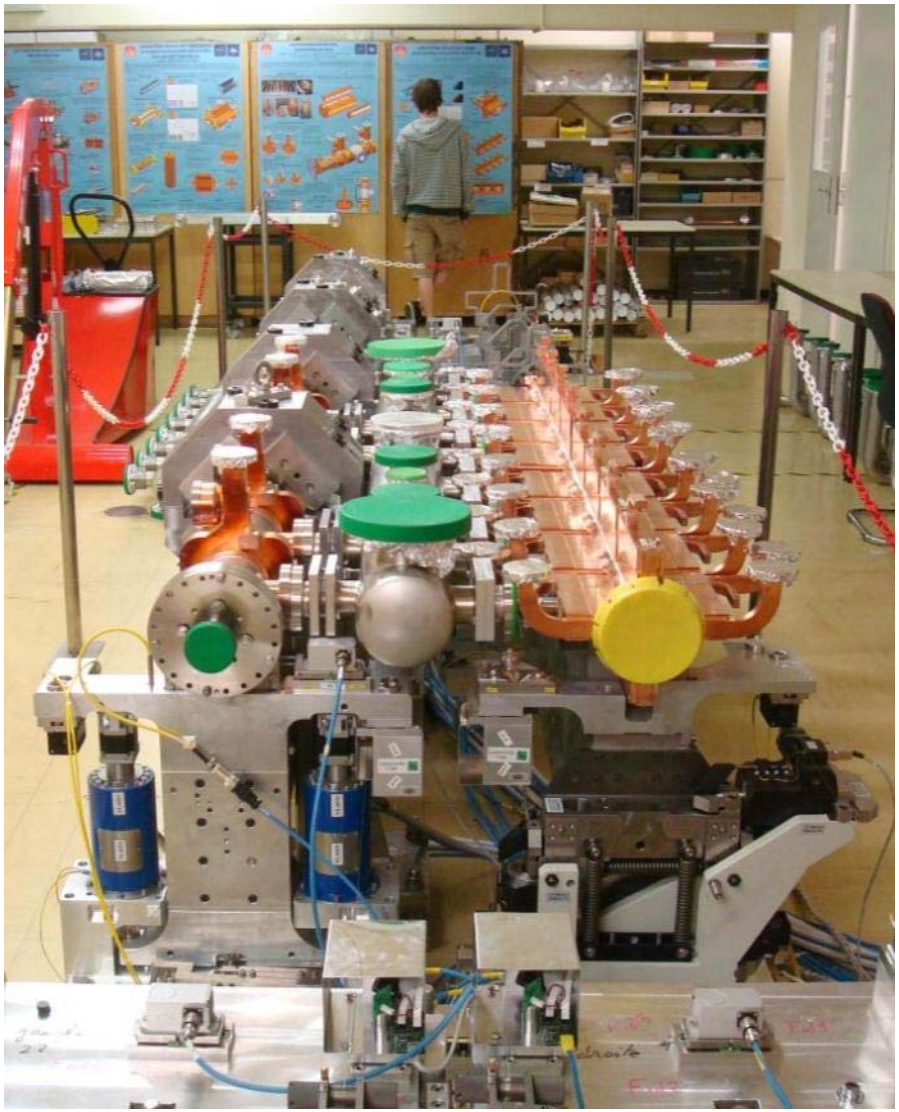


Heating system



Cooling system

MeChanICs projects: professional experience



- Supervision of technical and doctoral students
- Contacts with MeChanICs industrial partners:
  - ❑ Loval Oy (Loviisa, Finland)
    - ✓ *Bonding and brazing*
  - ❑ Lewel Group (Oulu, Finland)
    - ✓ *Design and finite element analysis*
  - ❑ Mectalent Oy (Oulu, Finland)
    - ✓ *Manufacturing of tooling*
  - ❑ Tarkmet Oy (Vaasa, Finland)
    - ✓ *Machining and laser welding*
- Secondment to Loval Oy: October – November 2012

MeChanICs projects: environment

- CERN is a truly unique organization. A genuine collaboration between countries, universities and scientists, driven not by profit margins, but by a commitment to create and share knowledge.
- People here are part of immense scientific discoveries, answering some of life's most complex questions and pushing the boundaries of understanding. Experts from every field come here to share in this ambition and the nature of this collaborative, international community creates a genuine atmosphere of trust.
- History's being made here – and the excitement is tangible. It is the only place in the world where you can do this work in this way.

CERN. Take part.

Passion

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Responsibilities

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