Task 4 :
Technical developments for the insert

Jean-Michel Rey

Summary

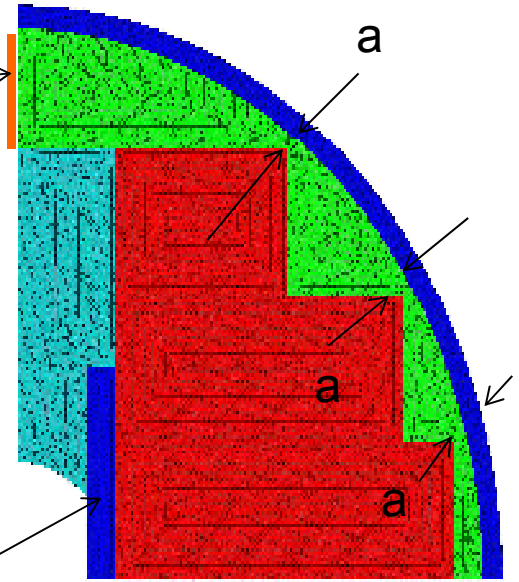
- Superconducting material
- Mechanical structure
- Winding scheme
- Superconductor
- Wire cutting of the jaws
- Electron beam welding of the jaws
- Reinforced stabilizer
- Electrical insulation
- External tube
- Mechanical structure

- What should we fear next ?

Mechanical structure

- Designed to withstand forces around 1000 tons/m
- Two independent structures to withstand the magnetic forces
  - The jaws – EB welded
  - The tube – thermally shrinked to have full contact with the jaws
- Highest load carried by the jaws

  Design criteria a = 1mm, not less
- Compression plates to limit the ovalization



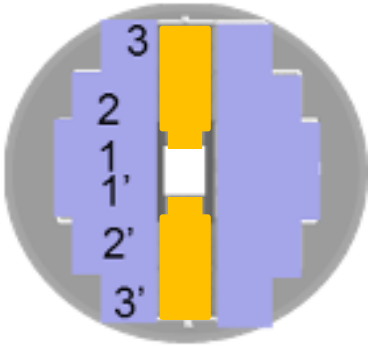
Winding scheme

- 3 double pancakes; 2 conductors co-winded
  - Mid point for each conductor on the straight part,

- One extra conductor thickness on the exit side of the winding on each pancake

Number of turns total: 335

35
60
73
72
61
34



34
61
72
73
60
35

Superconductor

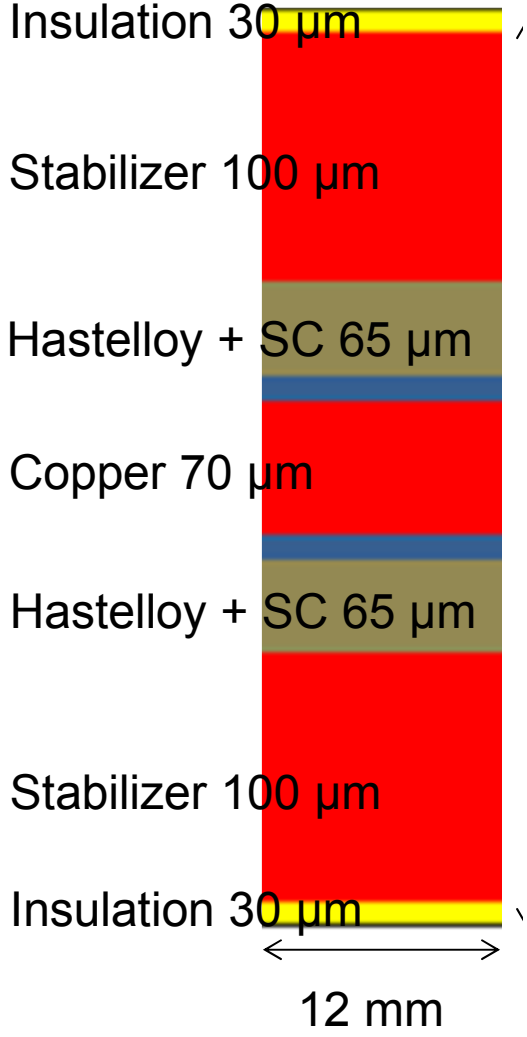
- SUPERPOWER YBCO based conductor.
  - ➢ Ref 2x12040 with copper shunt between the two YBCO faces,

- Nominal width 12 mm,

  but maximum value 12,19 mm

	Width (mm)	Thickness (mm)
Mean value	12,078	0,1988
Std dev	0,0709	0,0044

→ And we do not want to compress the conductor parallel to the faces.



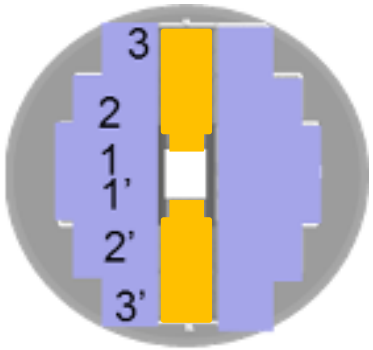
Mechanical structure

- Due to the width of the conductor we have:
  - a = 0,86
  - b = 0,97
  - c = 0,85

- Therefore we need to reduce the number of turns to:

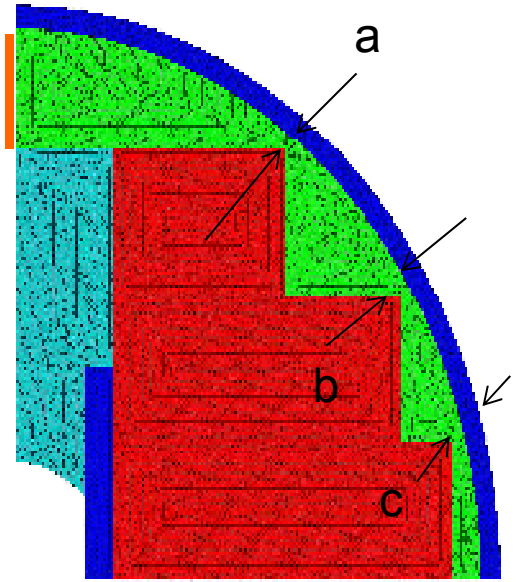
Number of turns total: 323

33
58
71
70
59
32



32
59
70
71
58
33

3,5 % turn reduction



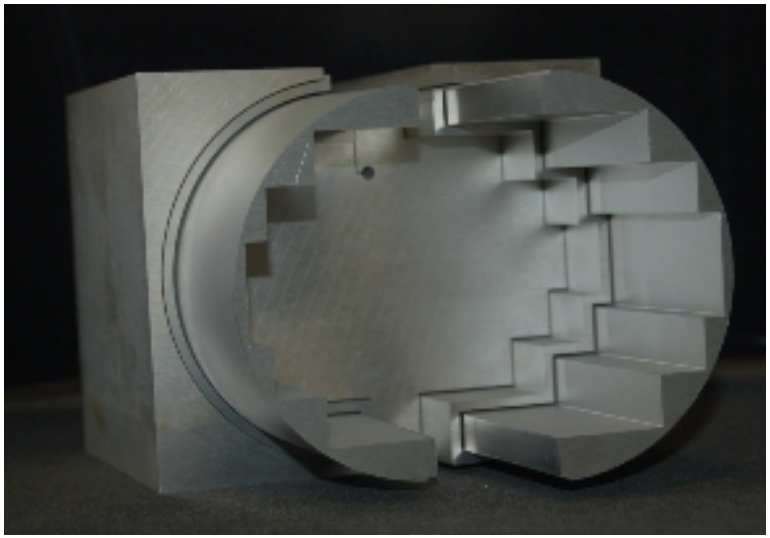
- To recover

a = 1,384; b = 1,854; c = 1,619 Acceptable !

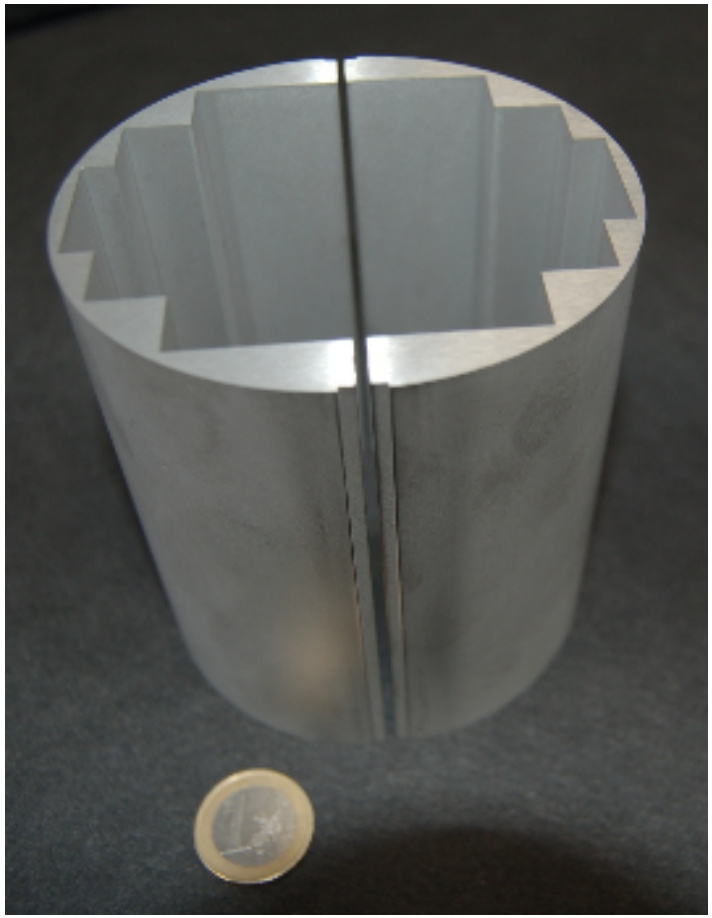
Wire cutting of the jaws

- Developed at LNCMI Grenoble using their experience on polyhelix cutting for high field resistive magnets.

- Tolerances within 0,02 mm

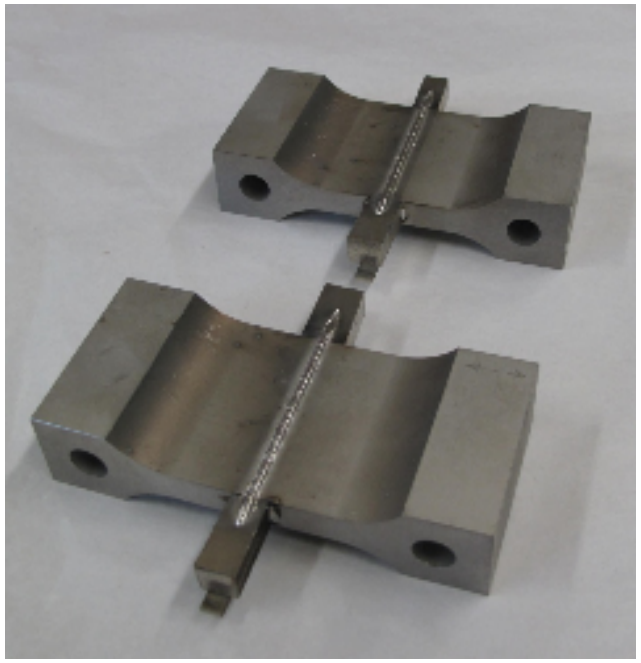


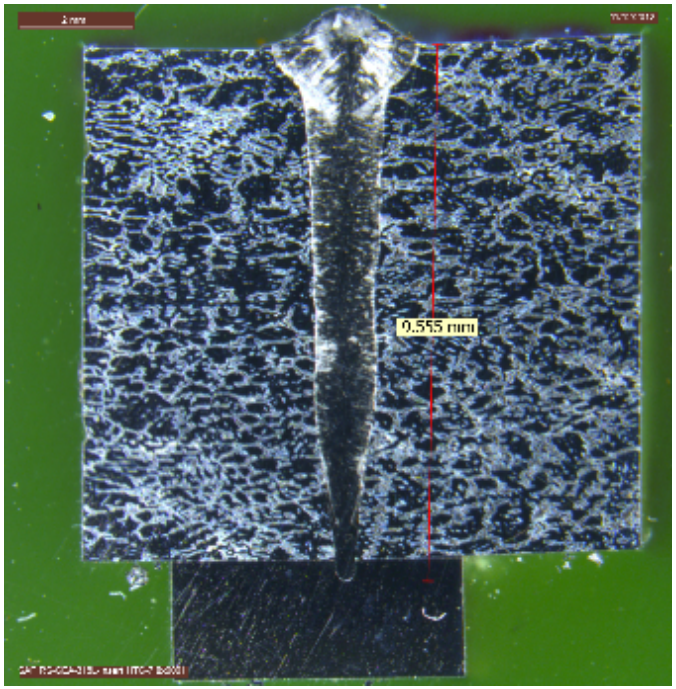
Thanks to Jean-Marc Tudela



Electron beam welding of the jaws

- Developed at CERN using their experience on accelerating cavities welding.
- Full penetration weld ending on a heel
- Next step: mechanical tests on welded samples



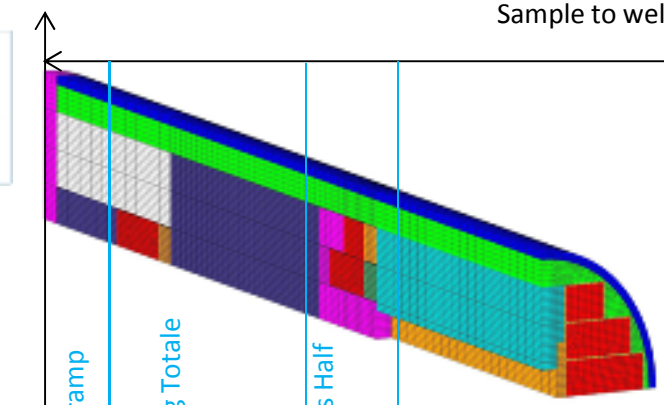


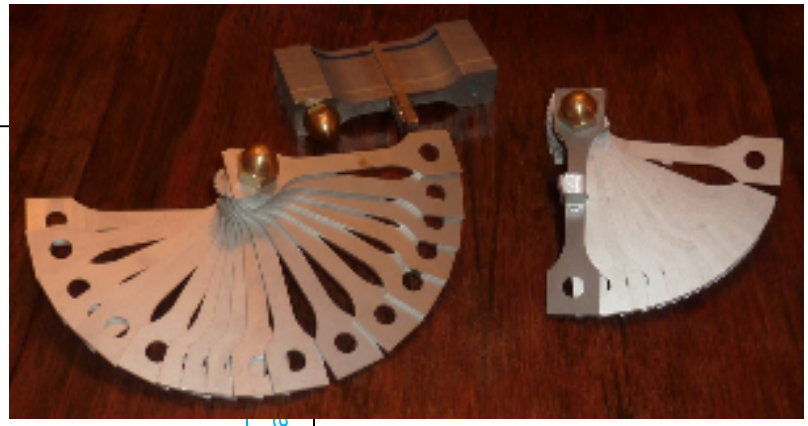
Thanks to Thierry Tardy, Gilles Favre, Francesco Bertinelli,

Electron beam welding of the jaws

- Testing at 4,2K, 77K and 300K foreseen at Saclay in the coming weeks.

- Welding sequence for the insert to be prepared and tested,





Reinforced stabilizer

- $CuBe_2$ used to reinforce Copper

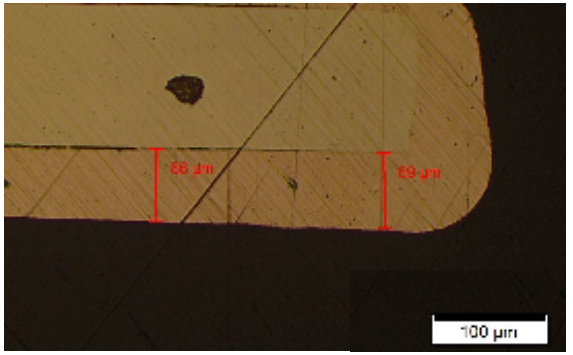
	Young modulus (GPa)	Ultimate strain (%)	Ultimate stress (MPa)
At room temperature			
CuBe2	47	16	677
CuBe2 heat treated	73	3	1260
At 77 K			
CuBe2	48	38	893
CuBe2 heat treated	73	8	1511

- It can be delivered already insulated

10 measures made

	Width (mm)	Thickness (mm)
Mean value	12,039	0,1696
Std dev	0,0288	0,00084

- Copper can be deposited by electroplating

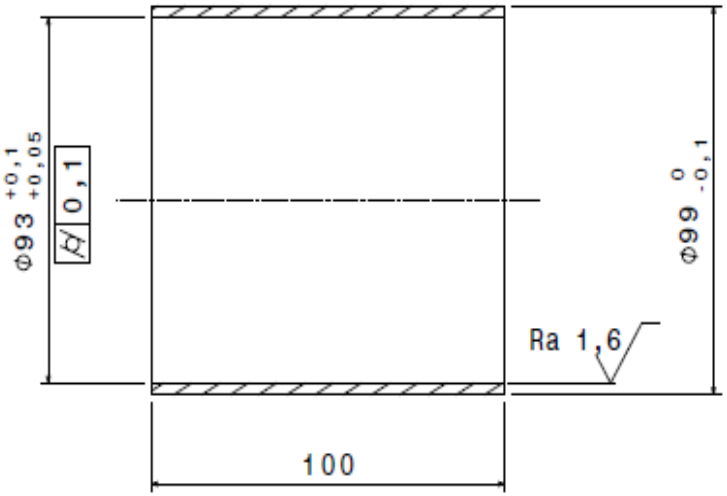


Electrical insulation

- Winding insulation: 30 μm Polyester tape applied directly on the CuBe face
  - Dielectric strength up to 1000 V for one 30 μm tape
  - Two polyester tapes facing each other in the winding
- Ground insulation: G10 foil 0,2 mm thick
- Intercoil (FRESCA II/ HTS INSERT) insulation : Kapton tape longitudinal gluing, 50% overlap

External tube

- To be mechanically efficient the tube needs to be in contact with the jaws,
- We may find some ovalization of the jaws due to the compression of the winding and the EB welding,
- To slide the tubes in place we will heat them to 450 C, allowing a 0,5 mm gap on the diameter.

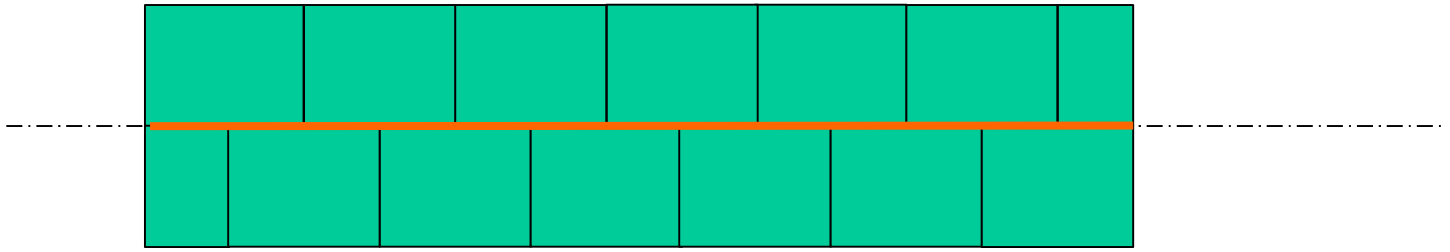


Mechanical structure

- Longitudinal structure

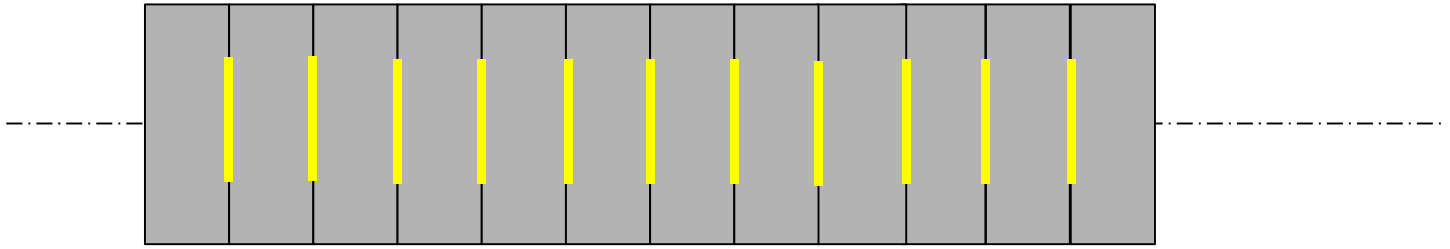
➢ On the jaws:

EB weld



➢ On the tubes:

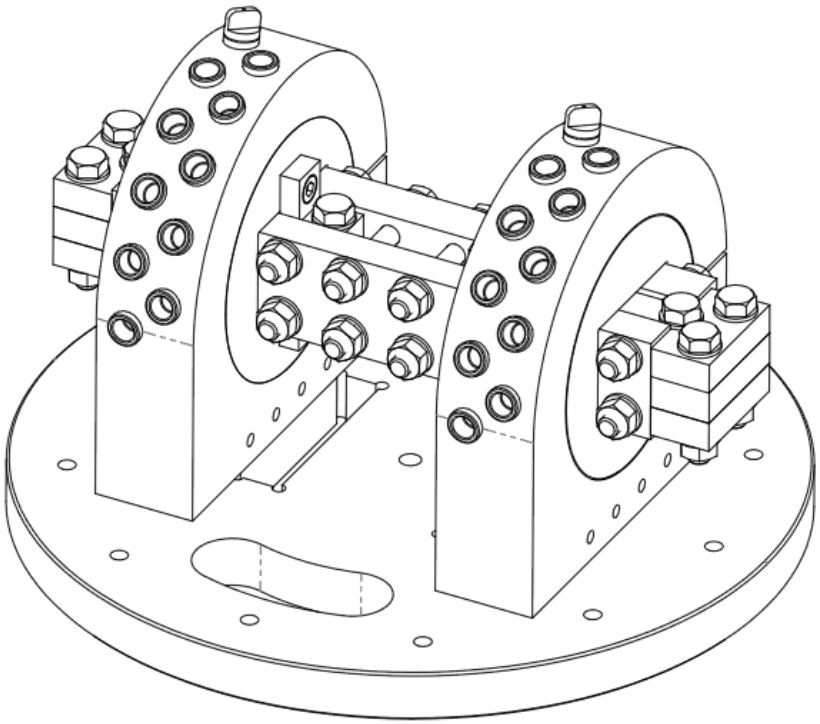
TIG weld

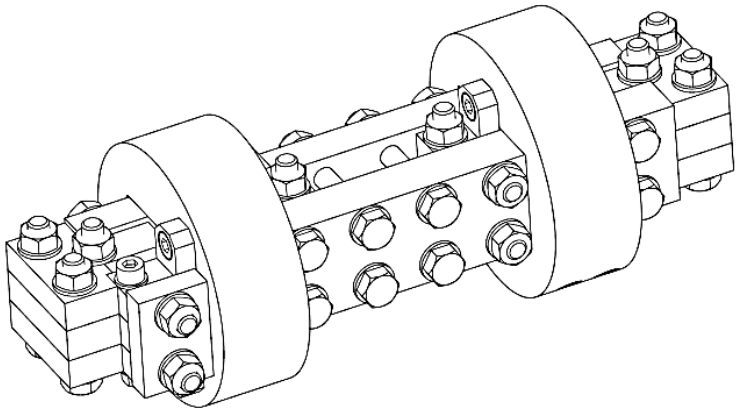


What should we fear next ?

- The critical points remaining are the critical current as a function of the magnetic field orientation and the corresponding quench propagation on the winding,
  - ➢ For this we need experiments

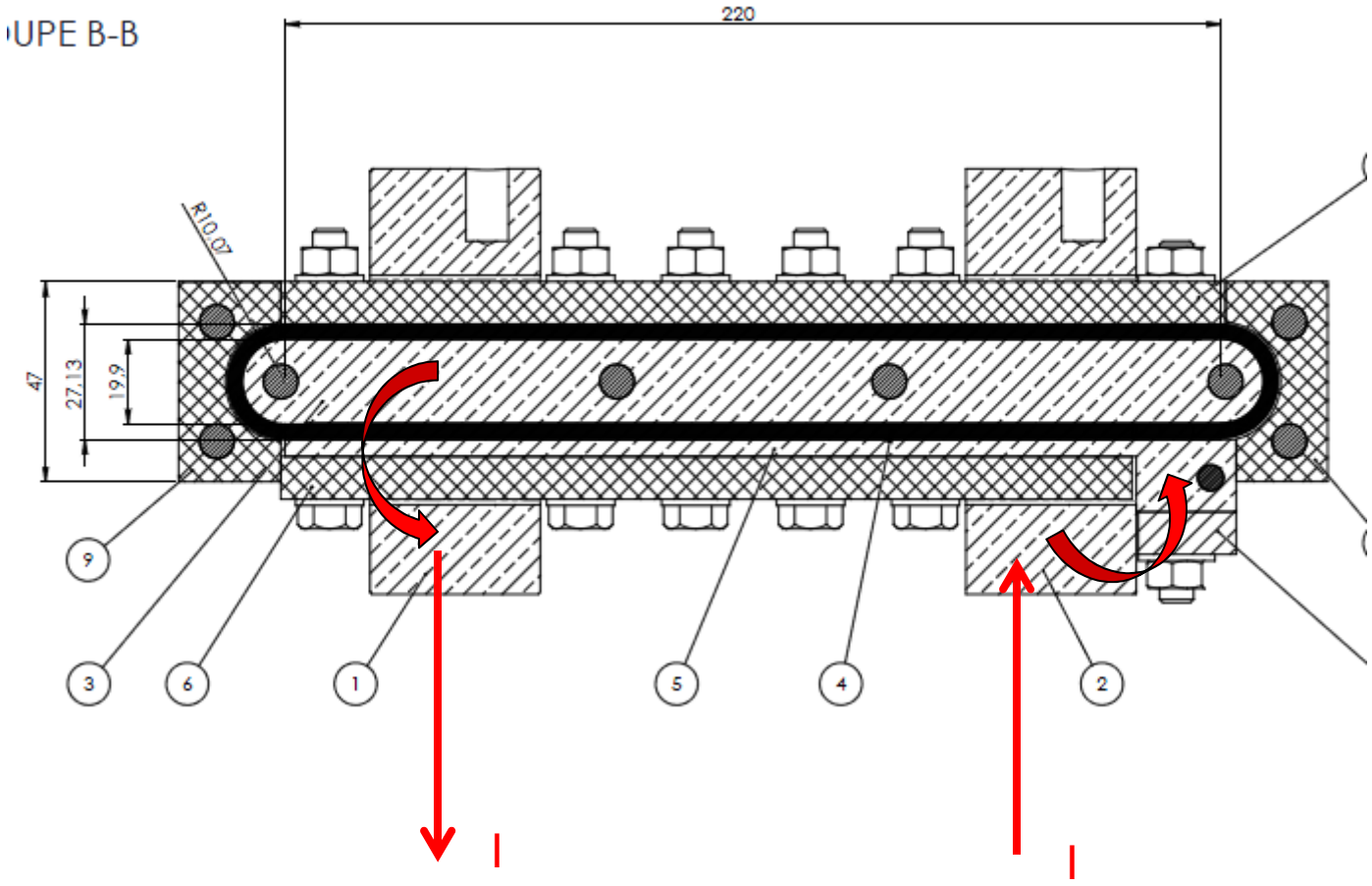
Therefore we have planned experiments !





What should we fear next ?

- 1 pancake of 10 turns fixed in two “camembert” like rotatable supports, having an angular indexation.



What should we fear next ?

- The reality:
  - Winding
  - Assembling
  - Welding
  - Etc…

As usual

Thank you for your attention