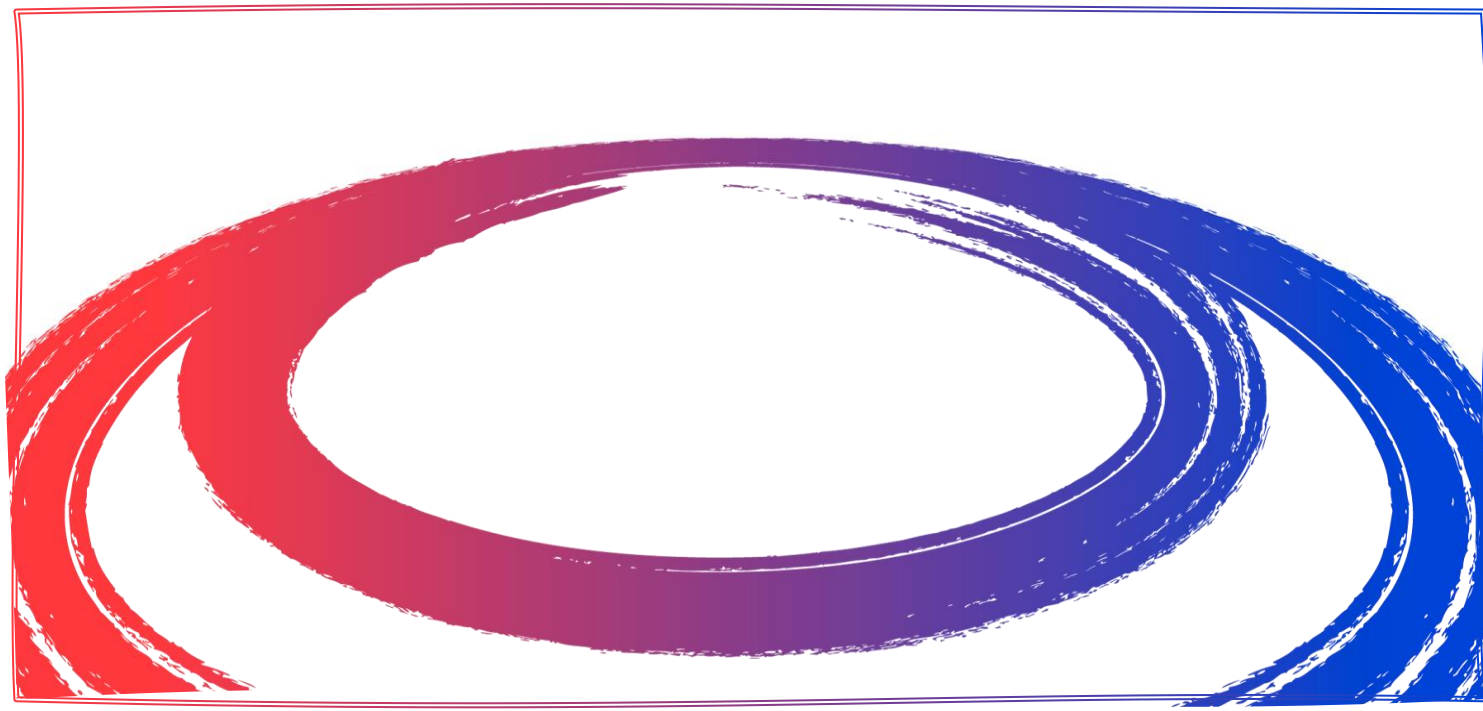
Dipole Magnets for Collider Ring



Workshop on Muon Collider Superconducting Magnet Design

Milano, 07/10/2024

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[5] *University of Milan*
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Outline

1. Requirements & assumptions

2. Structure

4. Stress

5. Open points

Requirements

Parameter	Value	U.M.
Bore diameter	140	mm
Bore field	16	T
Operating temperature	20	K
Temperature margin	2.5	K

Requirements and assumptions

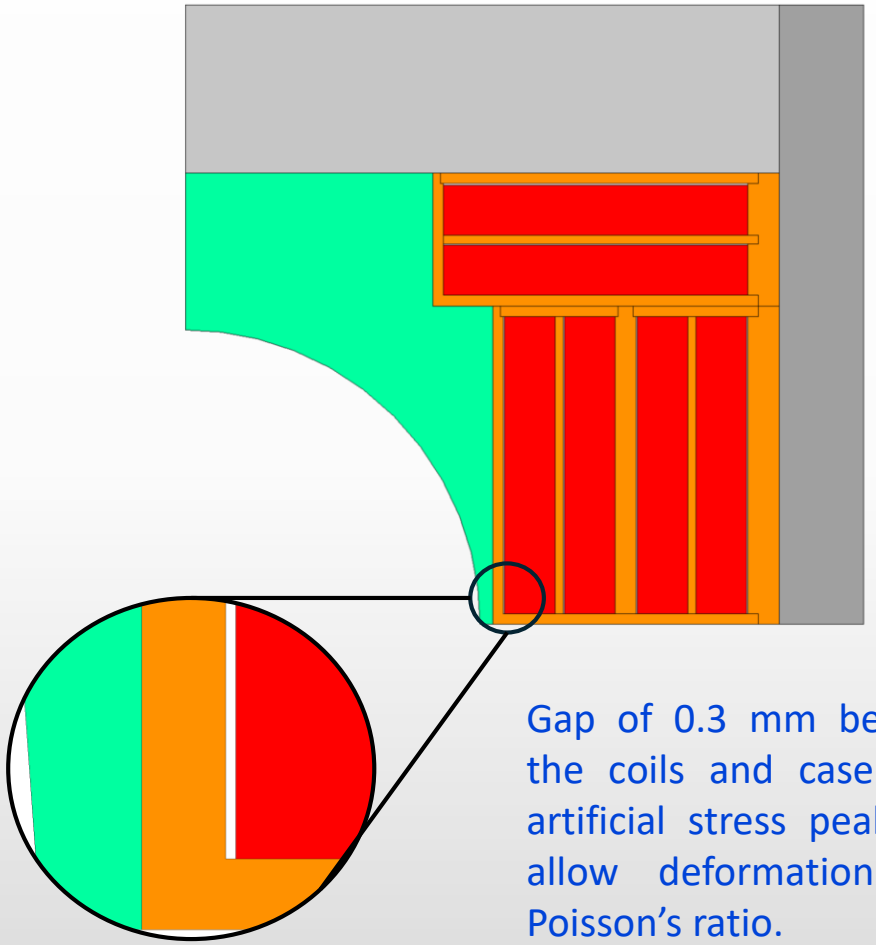
Goal: evaluation of stresses in the conductors due only to Lorentz forces (No cool-down and energization)

Assumptions

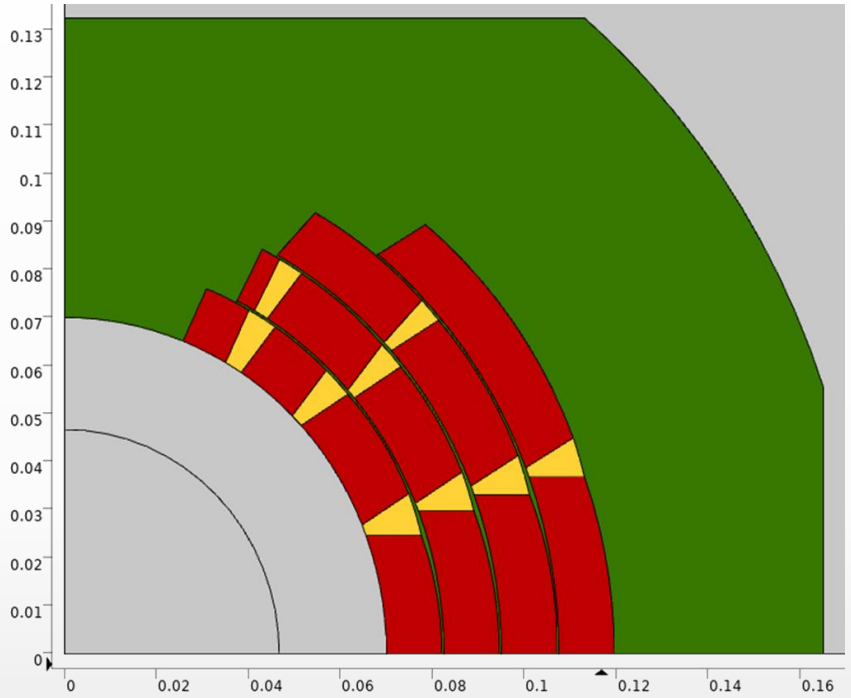
- Infinitely rigid structure (nodal displacement = 0)
- Standard type contact without friction between coils and mechanical structure
- $E_{coils} = 174\ GPa$[1]
- $\upsilon_{coil} = 0.3$

[1] C. Barth *et al., Electro-mechanical properties of ReBCO coated conductors from various industrial manufactures at 77 K, self-field and 4.2 K, 19 T,* 2015, *Supercond. Sci. Technol.* **28** 045011

Structure



Gap of 0.3 mm between all the coils and case to avoid artificial stress peaks and to allow deformation through Poisson's ratio.

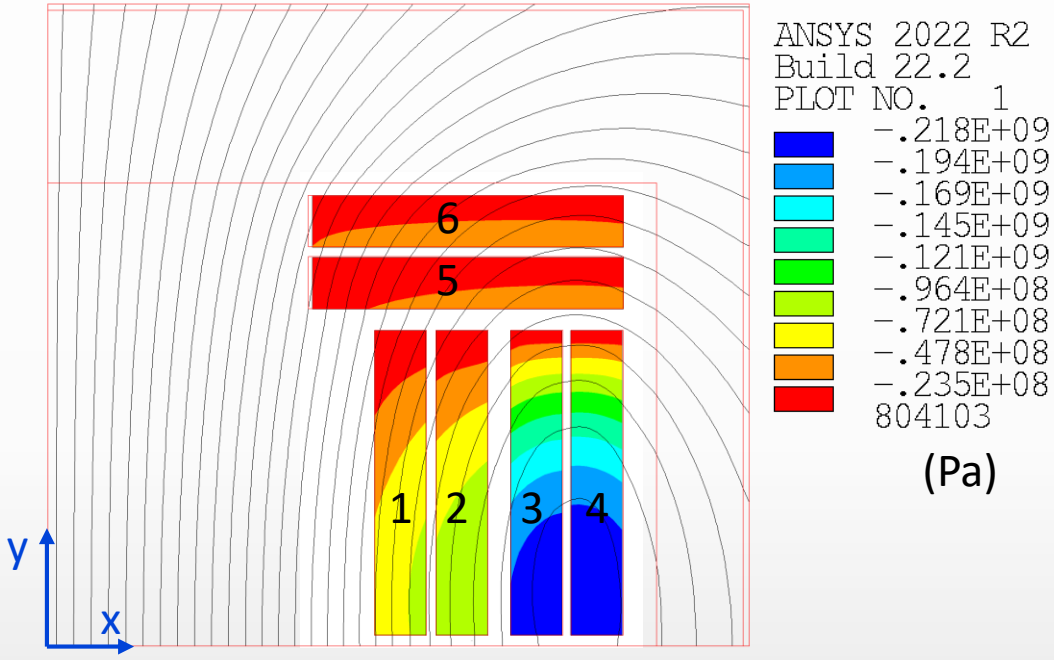


Wedges material: copper (Cu)

Y-stress VS Azimuthal stress

1. Requirements
2. Structure
3. Stress
4. Open points

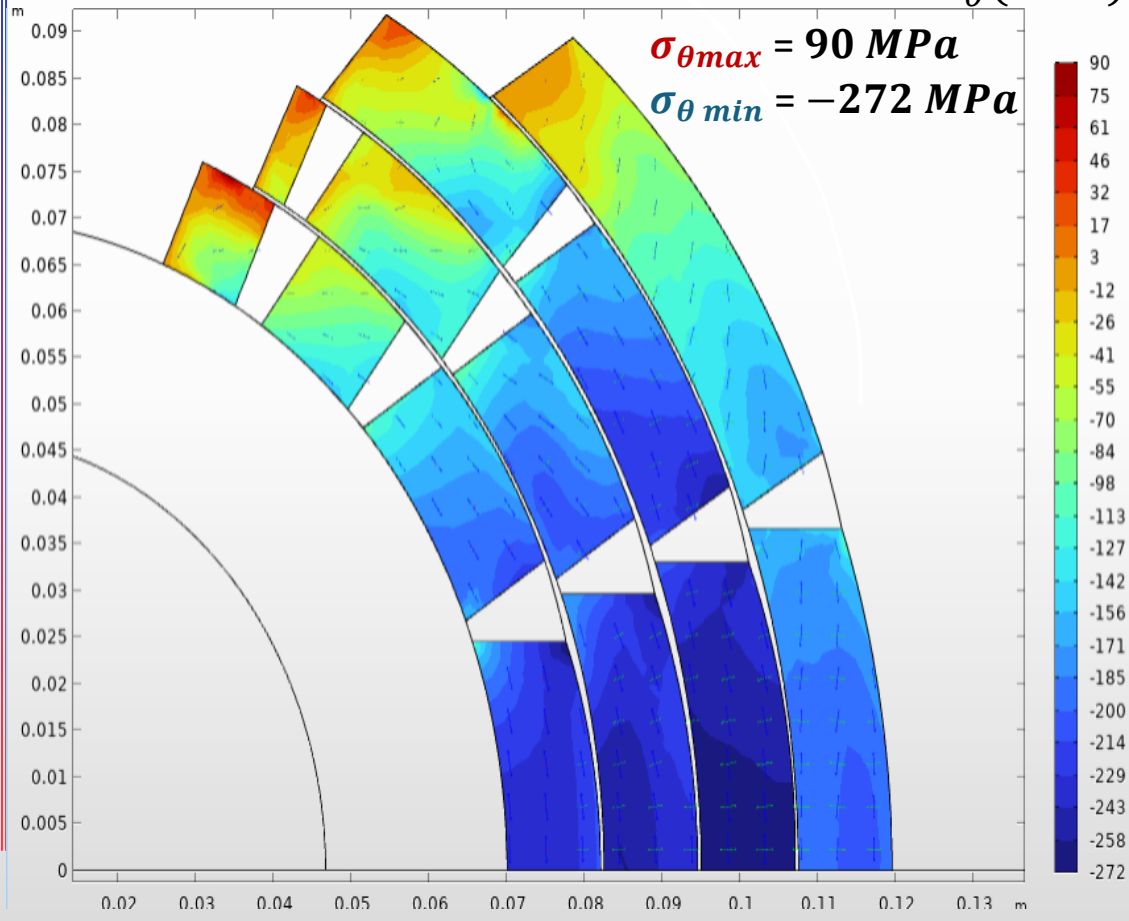
Y-stress



σ_{y_max}	Value	U.M.
σ_{y1}	-79.2	MPa
σ_{y2}	-94.3	MPa
σ_{y3}	-213.6	MPa

σ_{x_max}	Value	U.M.
σ_{y4}	-217.9	MPa
σ_{y5}	-42.3	MPa
σ_{y6}	-46.8	MPa

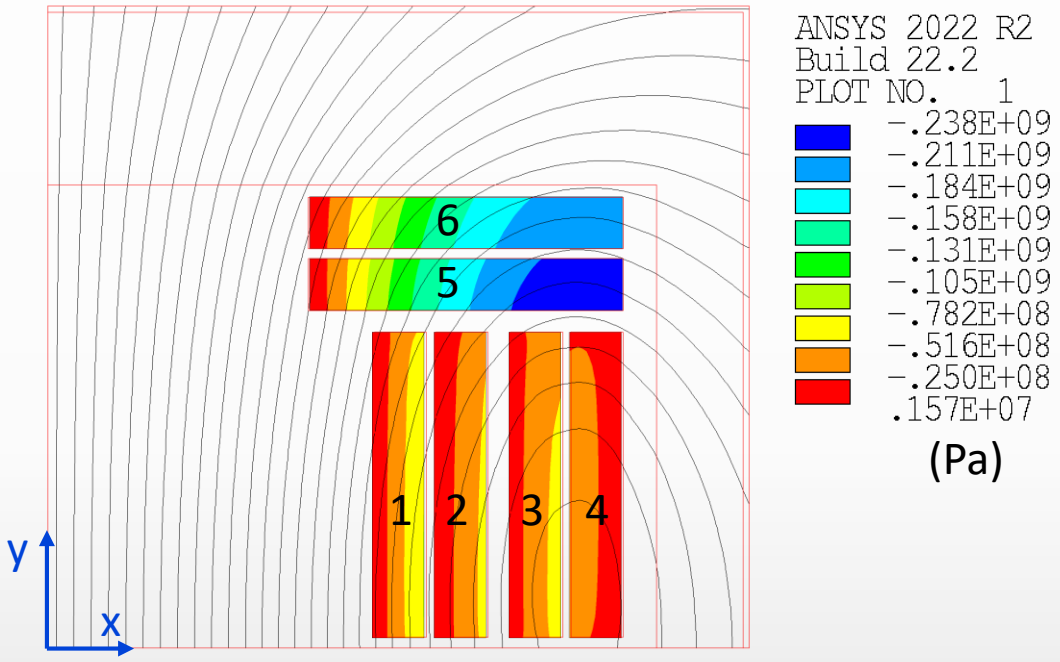
Azimuthal stress



X-stress VS Radial stress

1. Requirements
2. Structure
3. Stress
4. Open points

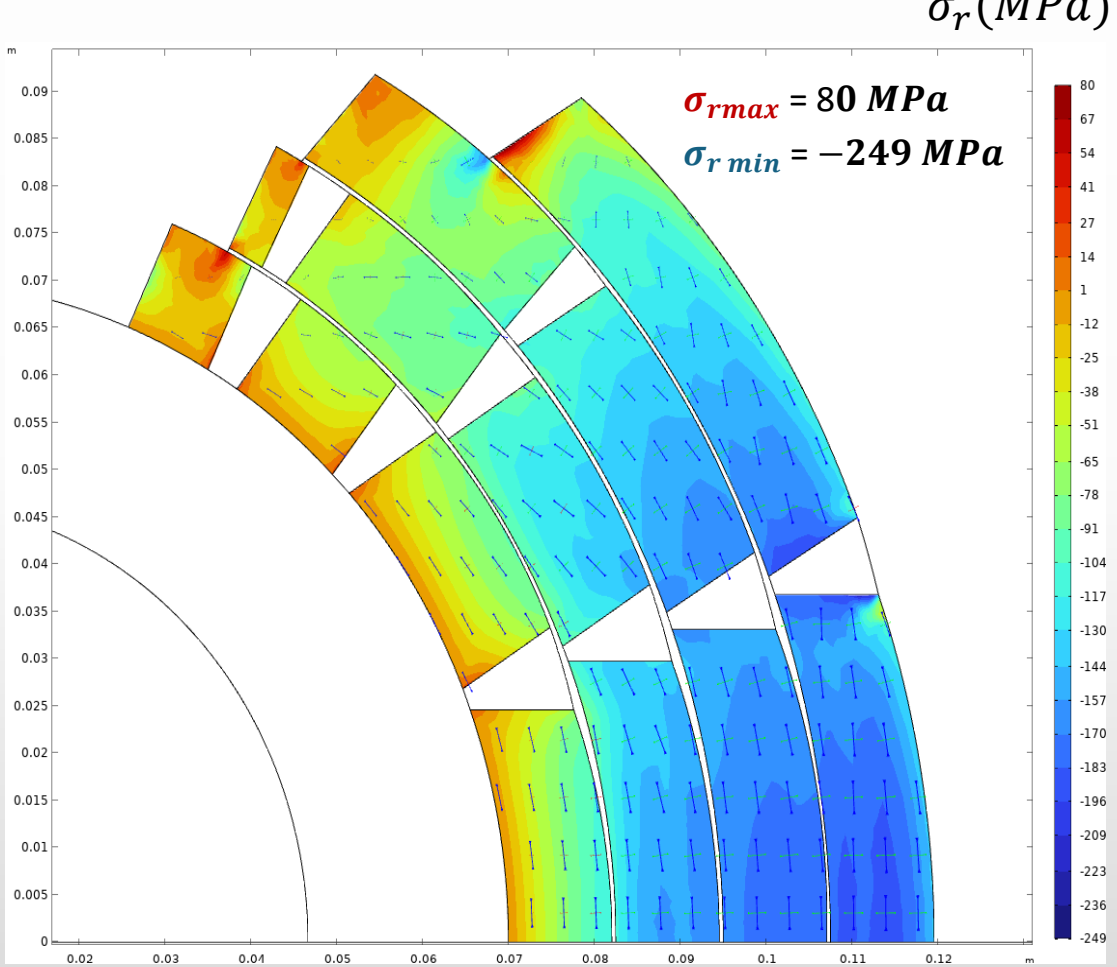
X-stress



σ_{x_max}	Value	U.M.
σ_{x1}	-79.4	MPa
σ_{x2}	-59.6	MPa
σ_{x3}	-58.2	MPa

σ_{x_max}	Value	U.M.
σ_{x4}	-32.9	MPa
σ_{x5}	-237.6	MPa
σ_{x6}	-207.3	MPa

Radial stress



Max stresses comparison

Max compressive stress

σ_{max}	Value	U.M.
σ_{x_max}	-237.6	MPa
σ_{y_max}	-213.6	MPa

Max tensile stress

σ_{max}	Value	U.M.
σ_{x_max}	0	MPa
σ_{y_max}	0	MPa

No tensile stress

Max compressive stress

σ_{max}	Value	U.M.
σ_{r_max}	-249	MPa
σ_{ϑ_max}	-272	MPa

Max tensile stress

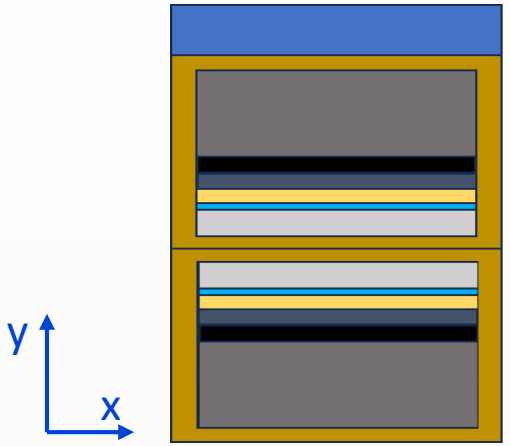
σ_{max}	Value	U.M.
σ_{r_max}	80	MPa
σ_{ϑ_max}	90	MPa

Max allowable stresses for ReBCO

Max compressive stresses

σ_{max}	Value	U.M.
σ_{x_max}	-100[1,2]	MPa
σ_{y_max}	-400[1,2]	MPa

[1] Value related to RT



Max tensile stresses

σ_{max}	Value	U.M.
σ_{x_max}	?	MPa
σ_{y_max}	?	MPa
σ_{z_max}	600[2]	MPa

All the stresses seen before are below the max. allowable stress

[2] Superconductor Business Development Division Fujikura Ltd., "Introduction of Fujikura re-based high temperature superconductor," Fujikura Global, Tech. Rep., 2024

Open points

What will be the goal for the mechanics study ? Similar to NbTi or Nb3Sn coil ? Do we impose a maximum displacement of the coils ?

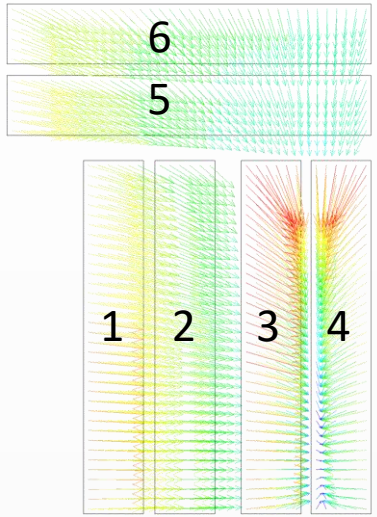
Is it OK to study a mechanical structure with case around the coils ?

What mechanical properties do we use ? What Young's modulus, Poisson's ratio etc. ?

Goal: study the field quality in Roxie

Backup Slides

Lorentz forces



σ_{y_max}	Value	U.M.
F_{x1}	5.36	MN/m
F_{x2}	3.96	MN/m
F_{x3}	3.84	MN/m
F_{x4}	-2.08	MN/m
F_{x5}	2.61	MN/m
F_{x6}	2.34	MN/m
F_{xTOT}	16.03	MN/m

σ_{y_max}	Value	U.M.
F_{y1}	-0.81	MN/m
F_{y2}	-1.02	MN/m
F_{y3}	-2.44	MN/m
F_{y4}	-2.52	MN/m
F_{y5}	-2.37	MN/m
F_{y6}	-2.97	MN/m
F_{yTOT}	-12.13	MN/m