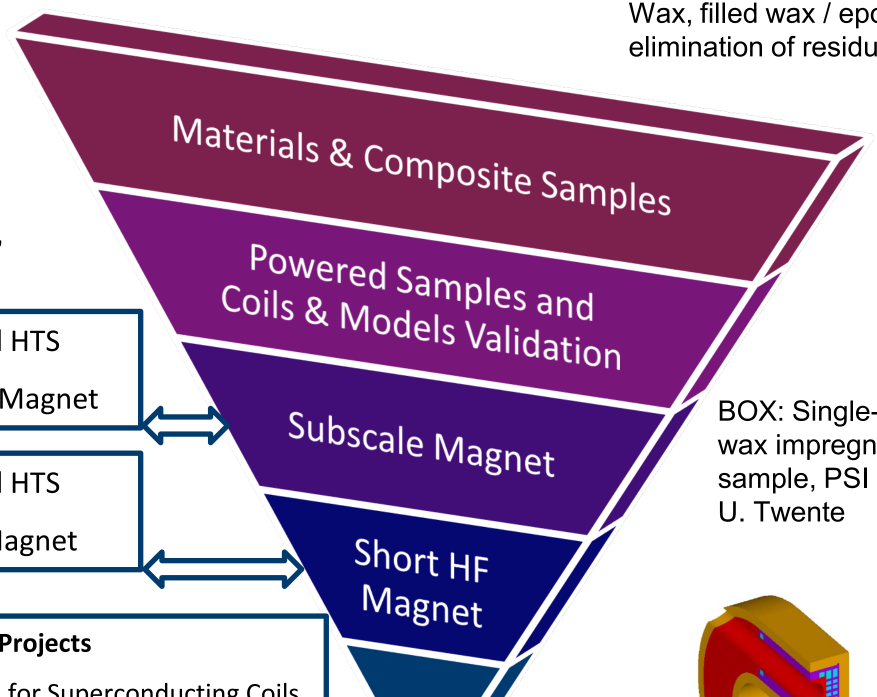
PAUL SCHERRER INSTITUT PSI

LTS & Hybrid Roadmap Outlook

D. Sotnikov,
H. Garcia



Hybrid HTS Subscale Magnet

Hybrid HTS Short Magnet

CHART Mag Projects

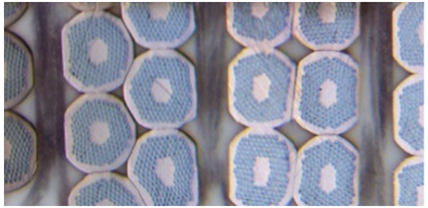
MagAM: AM for Superconducting Coils

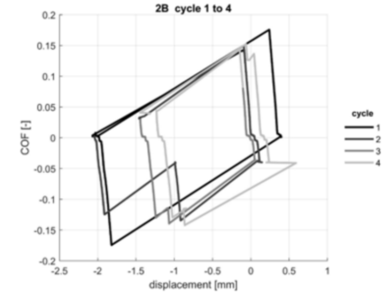
MagRes: Optimized resin system

MagComp: Cable modelling and caracterization

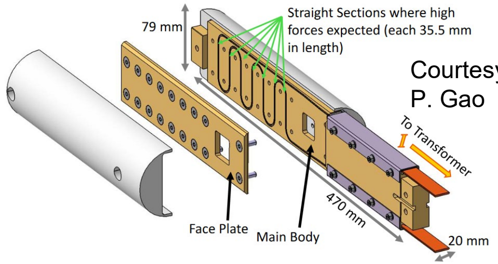
MagNum: Modelling & Optimization

Wax, filled wax / epoxy process development, HT elimination of residues and sliding interfaces, A. Brem

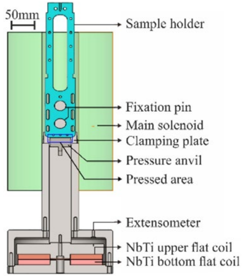




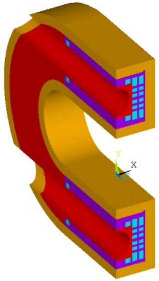
BOX: Single-turn wax impregnated sample, PSI & U. Twente

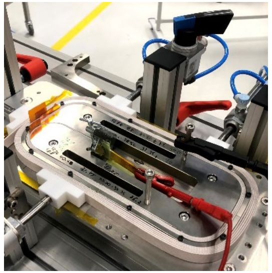


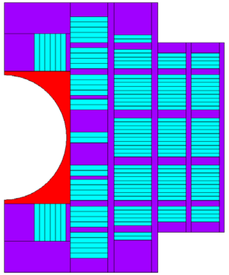
Courtesy P. Gao



Subscale Stress-Managed Common-coils







High-Field Stress-managed common coils

D. M. Araujo

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Swiss Accelerator
Research and
Technology

Douglas Araujo on behalf of the CHART Team :: Paul Scherrer Institute

Stress-Managed Asymmetric Common-Coils (SMACC) Conceptual Design

3rd Joint Common-Coils Meeting

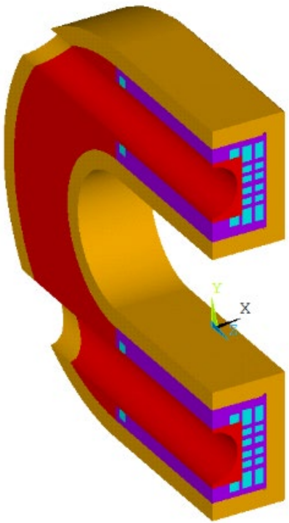
Work supported by the Swiss State Secretariat for Education, Research and Innovation SERI.
This work was performed under the auspices and with support from the Swiss Accelerator Research and Technology (CHART) program

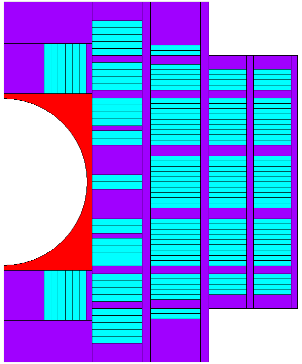
Motivation

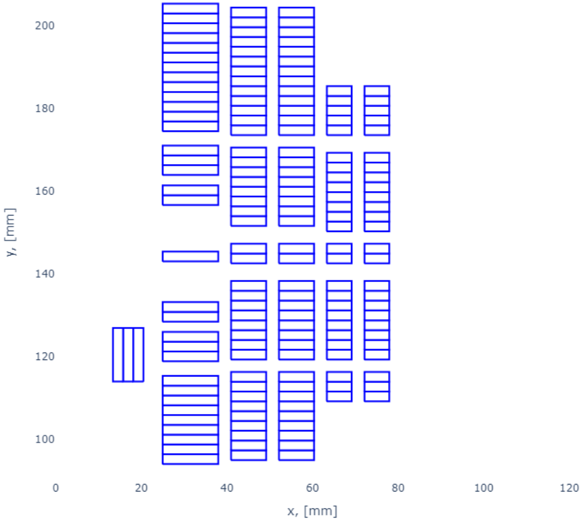
In respect to a standard common-coils magnet, we would like to propose improvements on how to:

- deal with high Lorentz forces
- simplify the common-coils architecture for accelerator magnets

allowing a full common coils architecture and reacting & winding







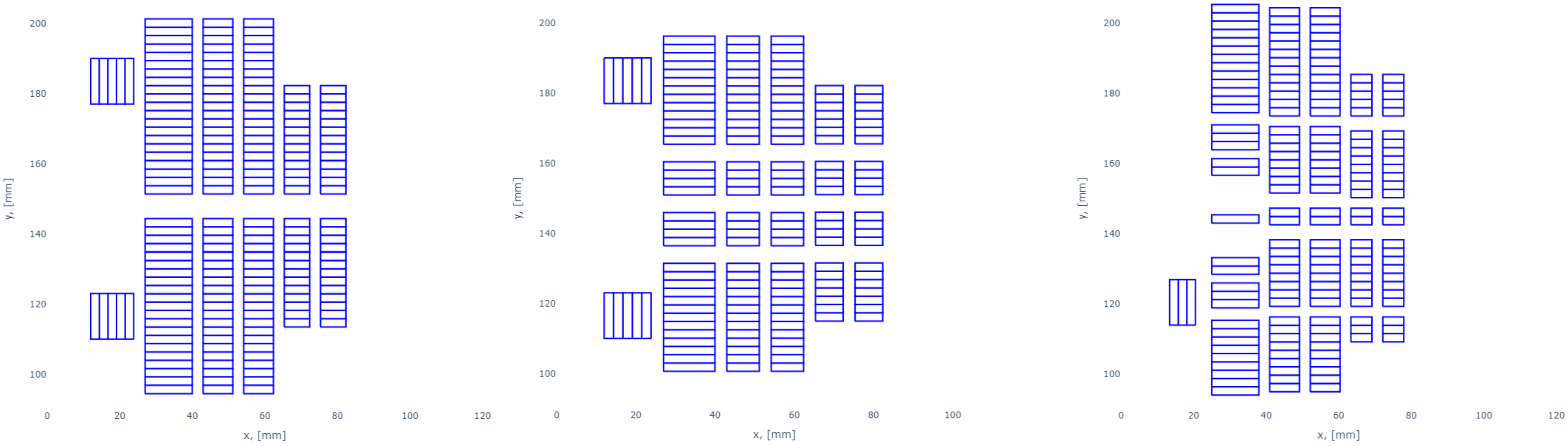
Magnetic Design

Let's consider two typical common-coils turns distribution, with racetracks on the top and bottom of apertures for field quality correction (a and b). C shows a third design without racetracks / clover-leaf coils, with an additional common-coil on the hard-way bend direction.

a: racetracks / clover-leaf coils and wide blocks

b: racetracks / clover-leaf coils and thin blocks

c: only common-coils and thin blocks



Stress-management with spars, but high vertical load

Stress-management with spars and ribs

Asymmetric design

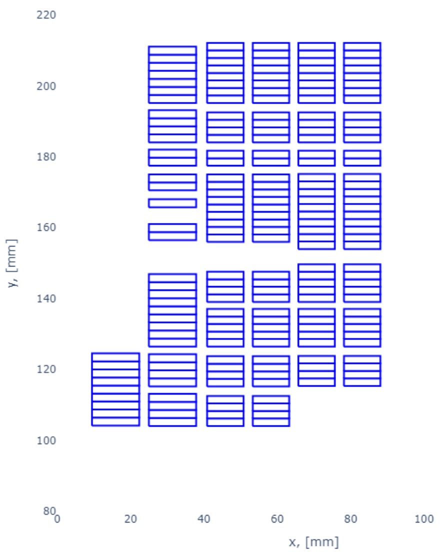
Magnetic Design

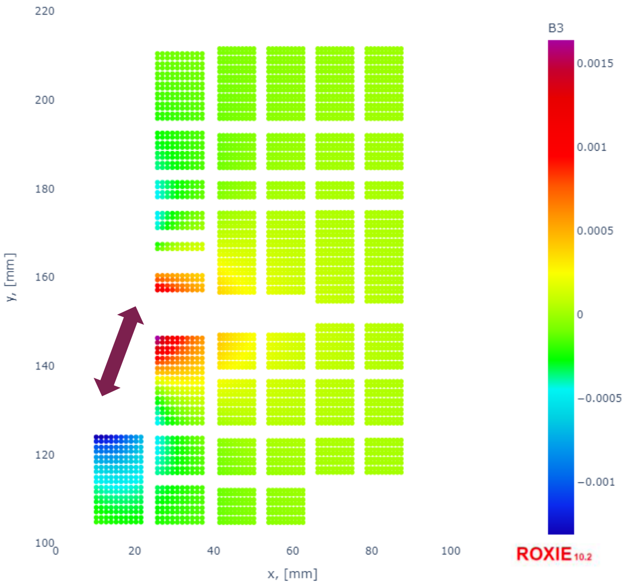
We can further simply option C, by having only easy-way bend common-coils

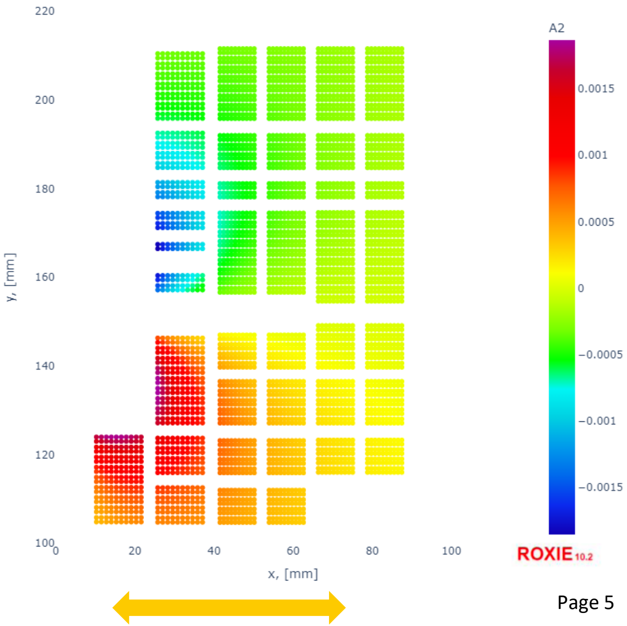
Layers 1 and 2 with 21 x 1.1 mm RRP® strand cu/noCu 0.9 and layers 3 to 6 with 18 x 1.0 mm RRP® strand cu/noCu 1.3 for protection purpose.

b3 & **a2** compensation

Layers: 1 2 3 4 5 6

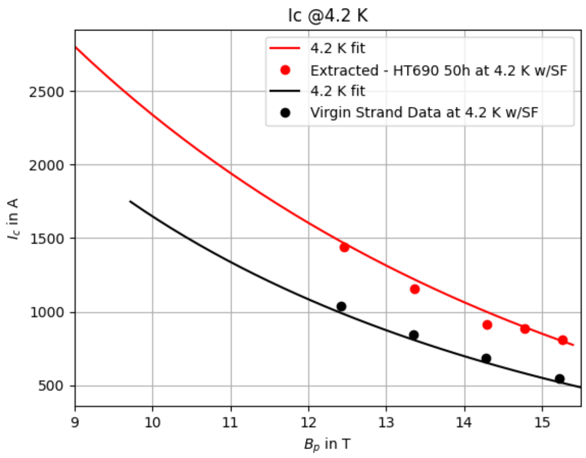




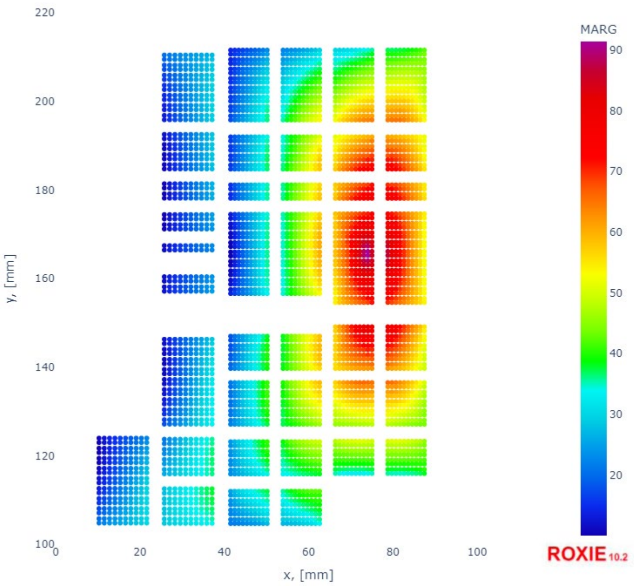


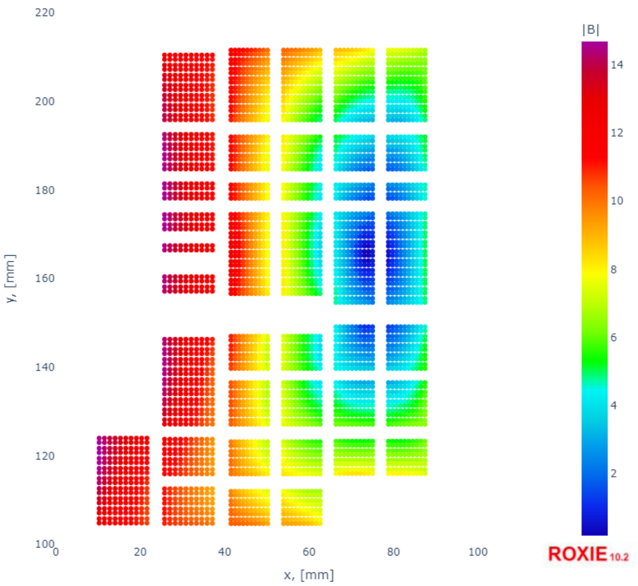
Magnet Parameters

Ribs and spar thickness were optimized for mechanics and to have the same margin in layers 1, 2 and 3.
Field quality is < 15 units spread between injection and 14 T (10% margin at 4.2 K) nominal field operation and < 15 units at nominal (to be further optimized after the final cable definition).



High-Field and **Low-Field** strand fitting





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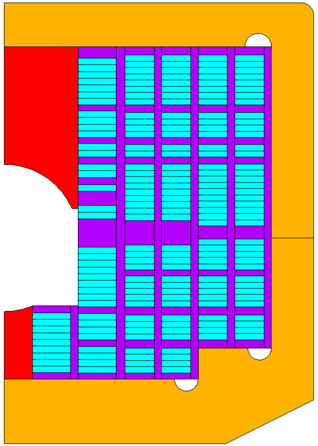
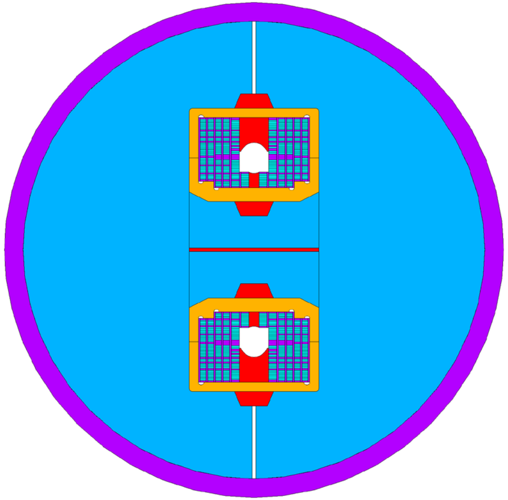
Cross-Section



The asymmetric common-coils magnet was designed with a intra-beam distance of 300 mm, 50 mm **bore**, **yoke** diameter of 740 mm and 30 mm thick stainless steel **shell.**

The magnet has 4 different types of coils (layer 1, layer 2, layer 3,4 and layer 5,6) and 12 coils in total (for a double aperture magnet). The coils are placed in the stress-management **formers**. The preload is transferred towards the inner-most layers through the **ribs**.



The massive **iron pole,** combined with the asymmetric concept, helps on the balance vertical force balance.

The load, due to Lorentz forces, is distributed between **pads** and **shell**, which limits the thickness of the **shell**.

The magnet concept is based on bladder & keys technology for room temperature preload. The structure is loaded, but thanks to the stress-management formers, the coil stress after loading and after cooling is < 40 MPa.

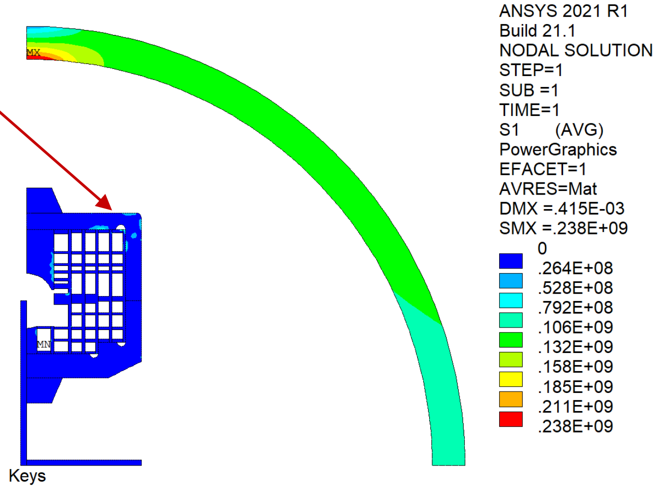
Mechanical Analysis

Pre-load with 0.5 mm interference on the keys.

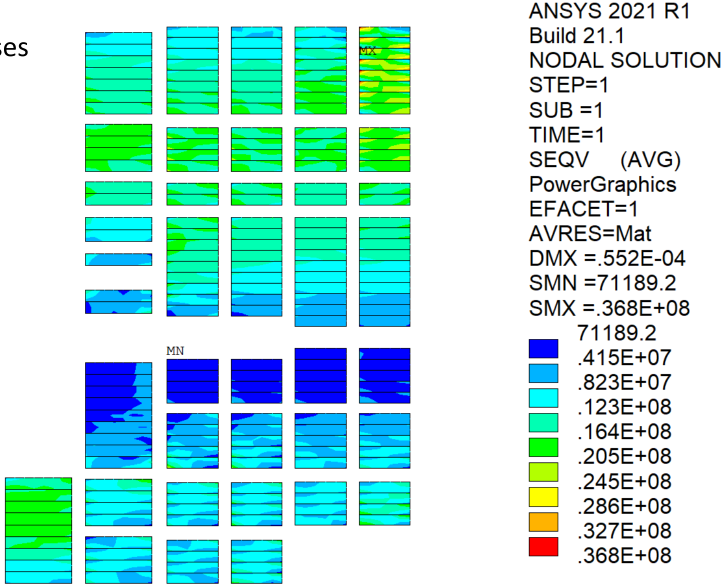
Low stress on coils: 37 MPa

424 MPa (compression) on the pads

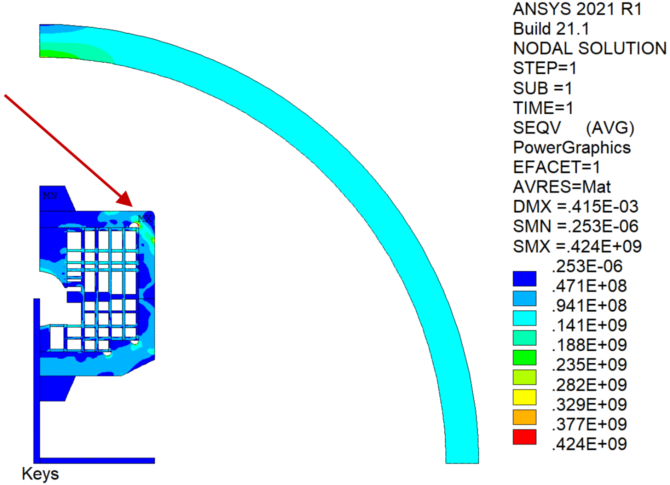
Maximum principal stress



Von-Mises



Keys



Von-Mises

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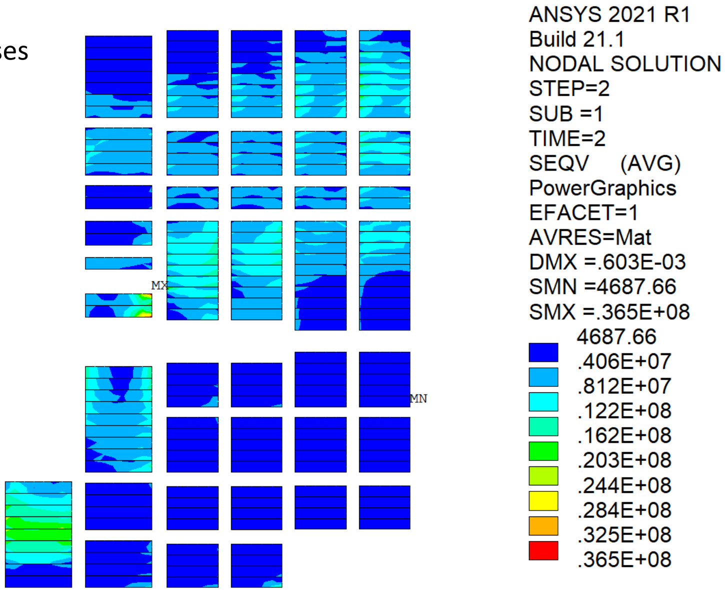
Mechanical Analysis

Pre-load with 0.5 mm interference on the keys and cooling-down.

Low stress on coils: 37 MPa

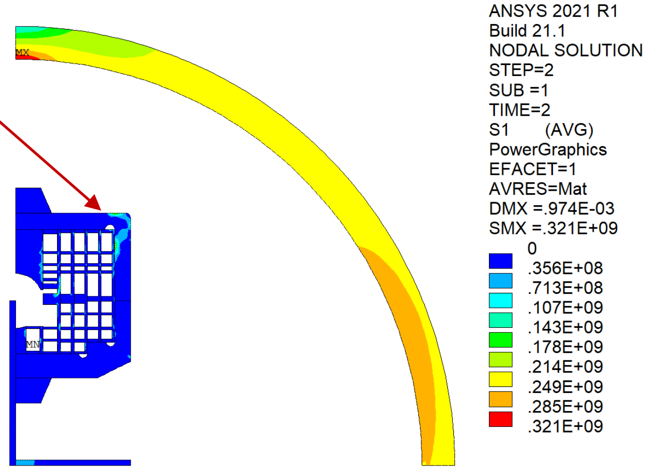
647 MPa (compression) on the pads

Von-Mises

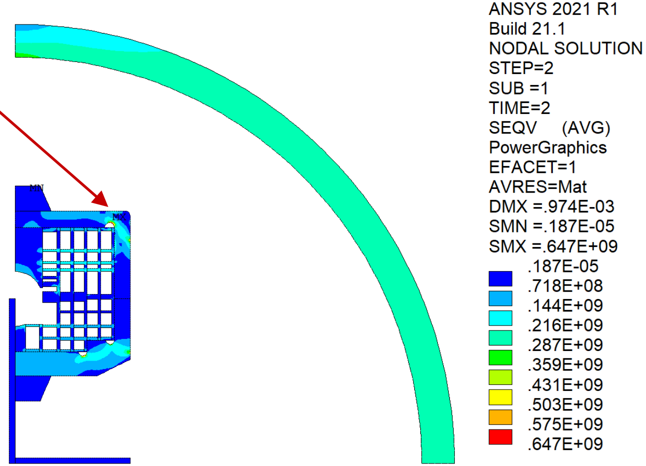


Cool-down

Maximum principal stress



Cool-down



Von-Mises

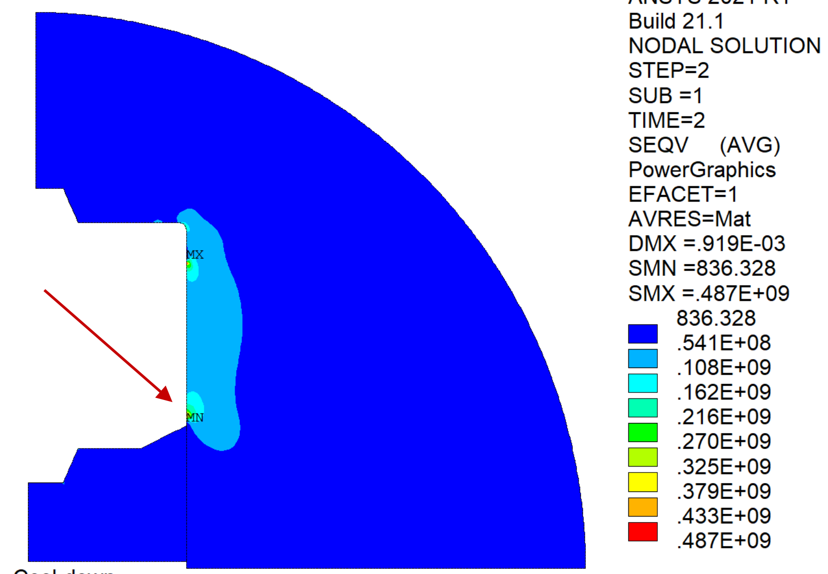
Cool-down

Mechanical Analysis

Pre-load with 0.5 mm interference on the keys and cooling-down.

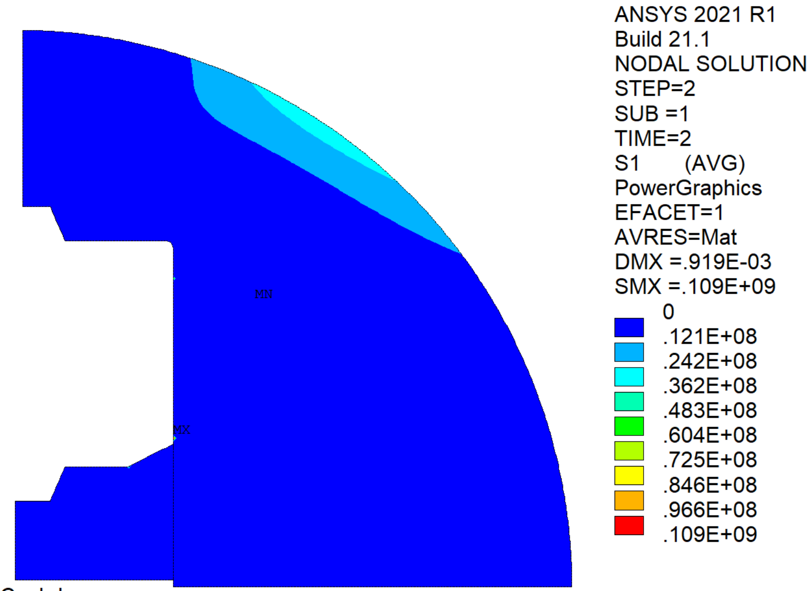
Stress on iron: **487 MPa in one node,** other else < 200 MPa

Von-Mises



Cool-down

Maximum principal stress



Cool-down

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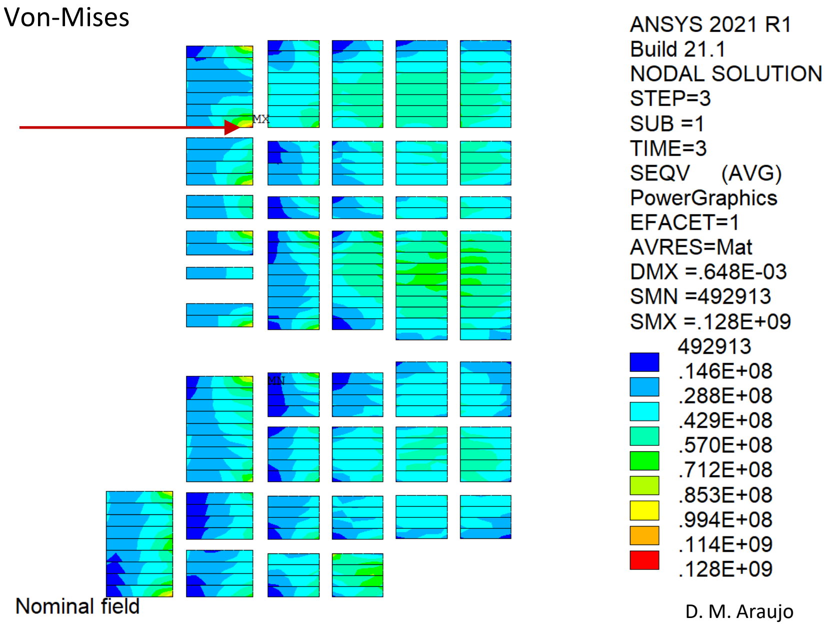
Mechanical Analysis

14 T operation (10% margin at 4.2 K)
Stress on coils: **128 MPa on corners,** other else < 100 MPa

15.1 T operation (10% margin at 1.9 K)
Stress on coils: **143 MPa on corners,** other else < 110 MPa



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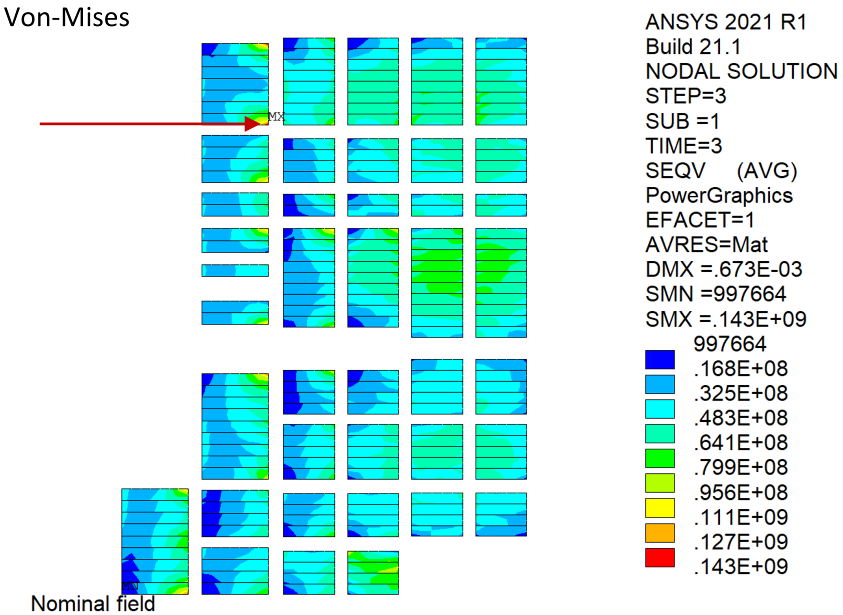

Mechanical Analysis

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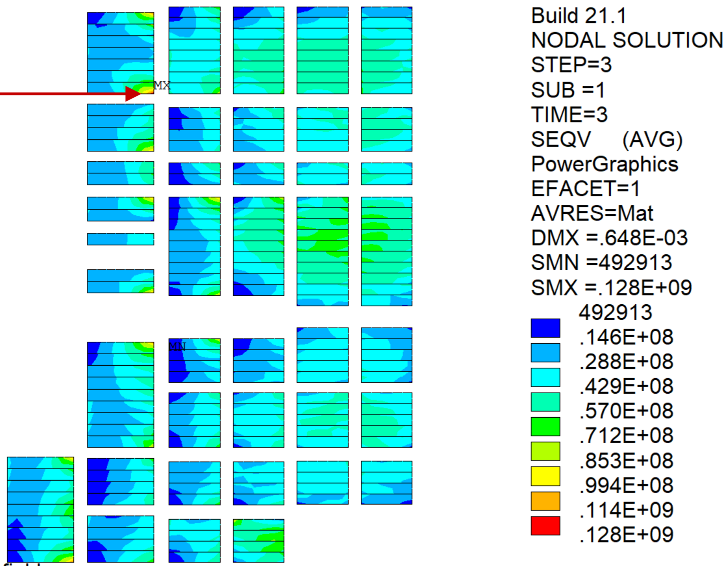
14 T operation (10% margin at 4.2 K)

Stress on coils: **128 MPa on corners,** other else < 100 MPa

< 30% engineering margin on the peak of stress regions.

Von-Mises



Nominal field

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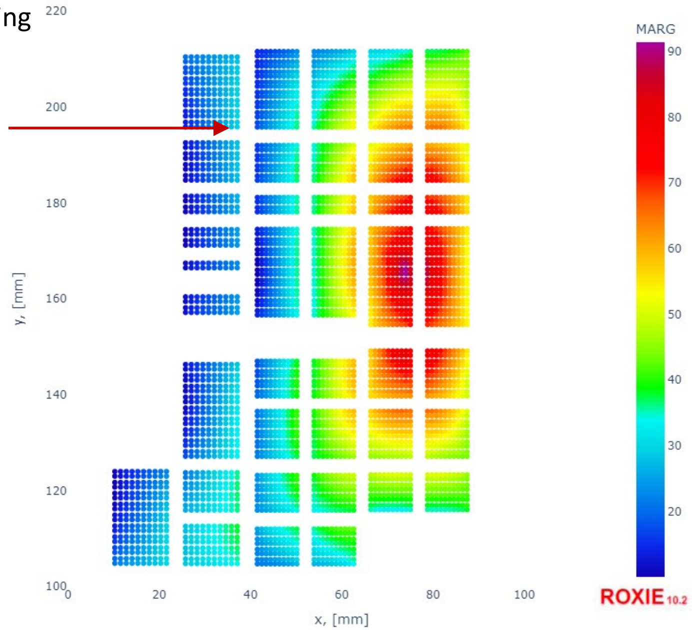
Engineering margin



Mechanical Analysis

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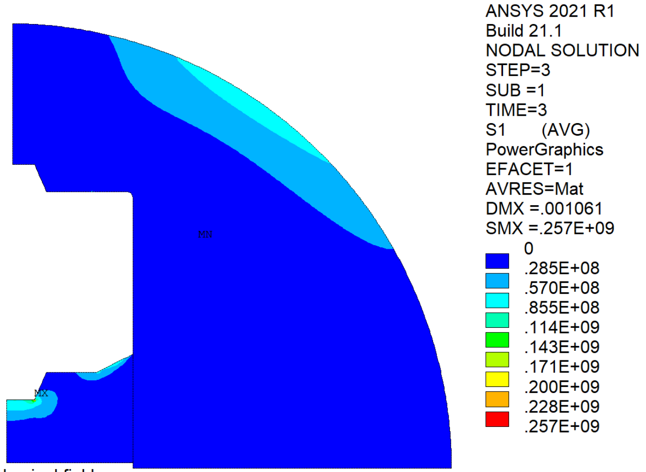
15.1 T operation

Peak of **692 MPa** on the formers

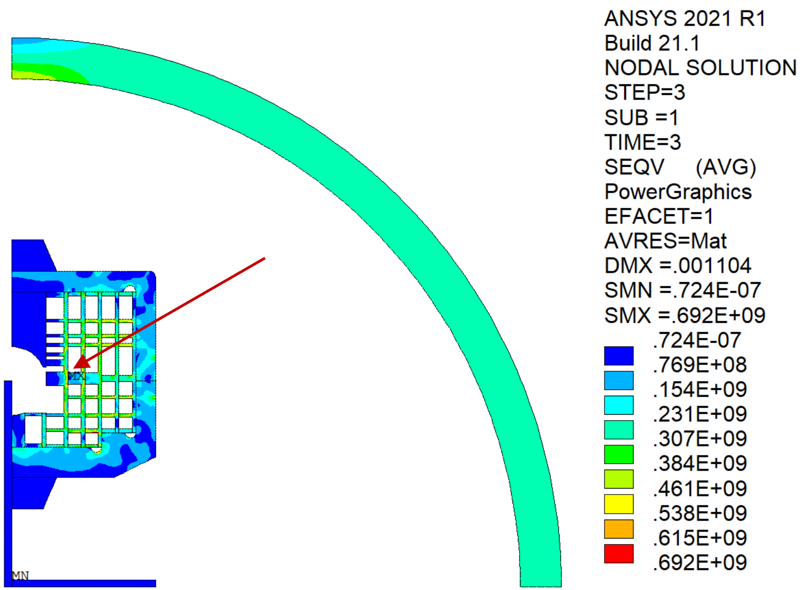
Stress on iron: **526 MPa in one node,** other else < 350 MPa

Maximum principal stress

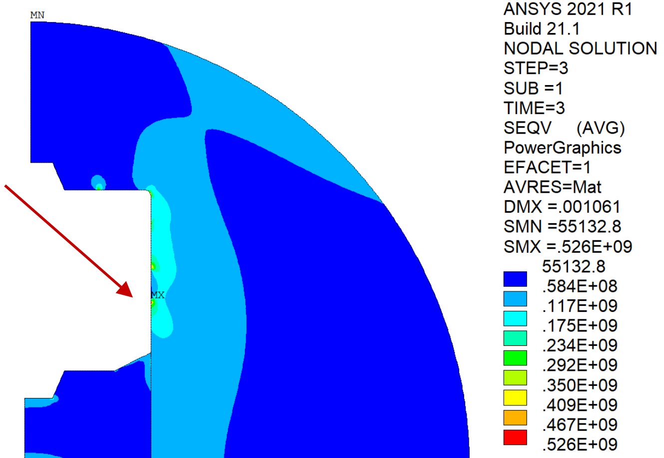


Nominal field

Von-Mises



Nominal field



Von-Mises

Nominal field

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Summary

Introduction of

- Stress-Managed Common-Coils Concept
- Asymmetric Common-Coils Concept

Possible advantages are

- Lower margin operation due to the low stress on high-field regions
- Pure common-coils (no need for racetrack / clover-leaf/… correctors)
- Possibility of implementing Reaction & Winding technique