EuCARD Magnet R & D

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CERN

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The contribution of our American and European colleagues is acknowledged.

EuCARD WP7 High Field Magnets

European Coordination for Accelerator Research & Development

Superconducting High Field Magnets
for higher luminosities and energies

Task 1: Coordination and communication

Task 2: Support studies (thermal studies and insulation radiation hardness)

Task 3: High field model

Task 4: Very high field dipole insert

Task 5: High Tc superconductor link (powering links for the LHC)

Task 6: Short period helical superconducting undulator (ILC e^+ source)

April (September) 2009 – April 2013

EuCARD WP7 High Field Magnets

12 partners:

BRUKER

cea

CERN

cnrs
dépasser les frontières

Columbus Superconductors
GRUPPO MALACALZA

INFN

KIT
Karlsruher Institut für Technologie

Wrocław University of Technology

University of Southampton

Science & Technology Facilities Council

UNIVERSITÉ DE GENÈVE

TAMPEREEN TEKNILLINEN YLIOPISTO

EuCARD WP7: tasks 3 and 4

High field model: FRESCA2

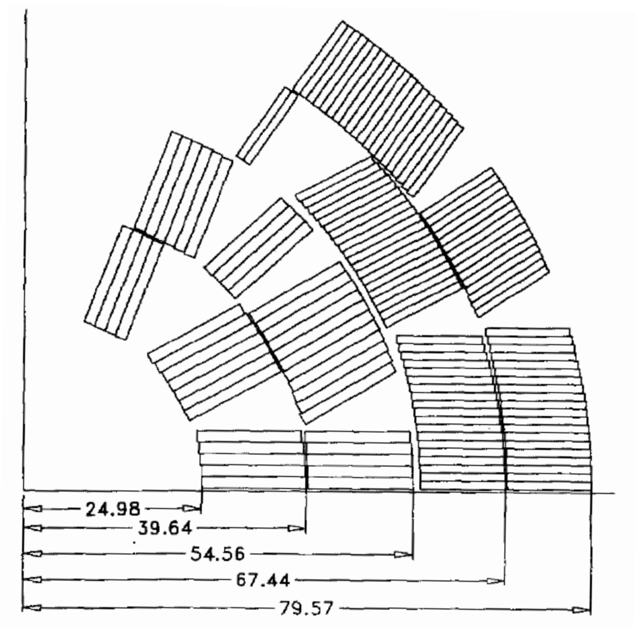
- Design, build and test a 1.5 m long, 100 mm aperture dipole model with a design field of 13 T using Nb_3Sn high current Rutherford cables. This magnet is intended to replace the present 10 T magnet in the FRESCA cable test station at CERN.

Very high field dipole insert:

- Design, build and test HTS solenoid insert coils for a solenoid background magnet aiming at a field increase up to 6 T to progress on the knowledge of HTS coils, their winding and behaviour. This is in intermediate step towards a dipole insert.
- Design, build and test an HTS dipole insert coil for a dipole background magnet aiming at a field increase of about 6 T.

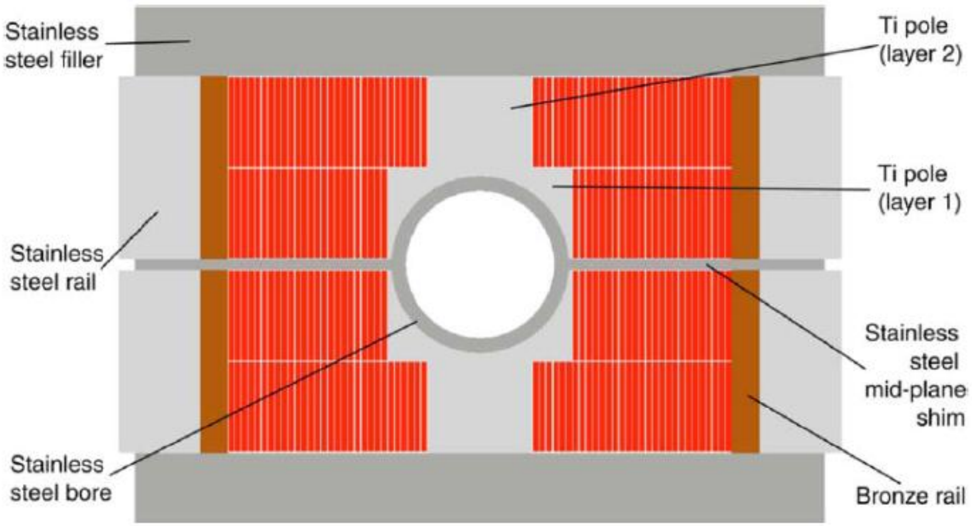
High field dipoles: two (main) designs

LBNL D20 (1996)



50 mm bore
reached 12.8 T
at 4.2 K

LBNL HD2 (2008)

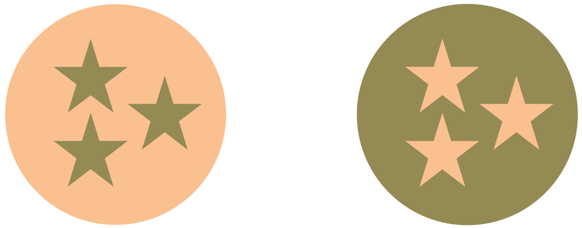


36 (43) mm bore
reached 13.8 T (13.4 T)
at 4.2 K

High Field Model: the conductor

Nb_3Sn strand

1 mm diameter
J_c = 2500 A/mm^2 @ 12 T, 4.2 K
J_c = 1250 A/mm^2 @ 15 T, 4.2 K
Cu / non-Cu ratio = 1.25
pilot orders placed with two vendors
EAS Bruker (PIT) and OST (RRP)



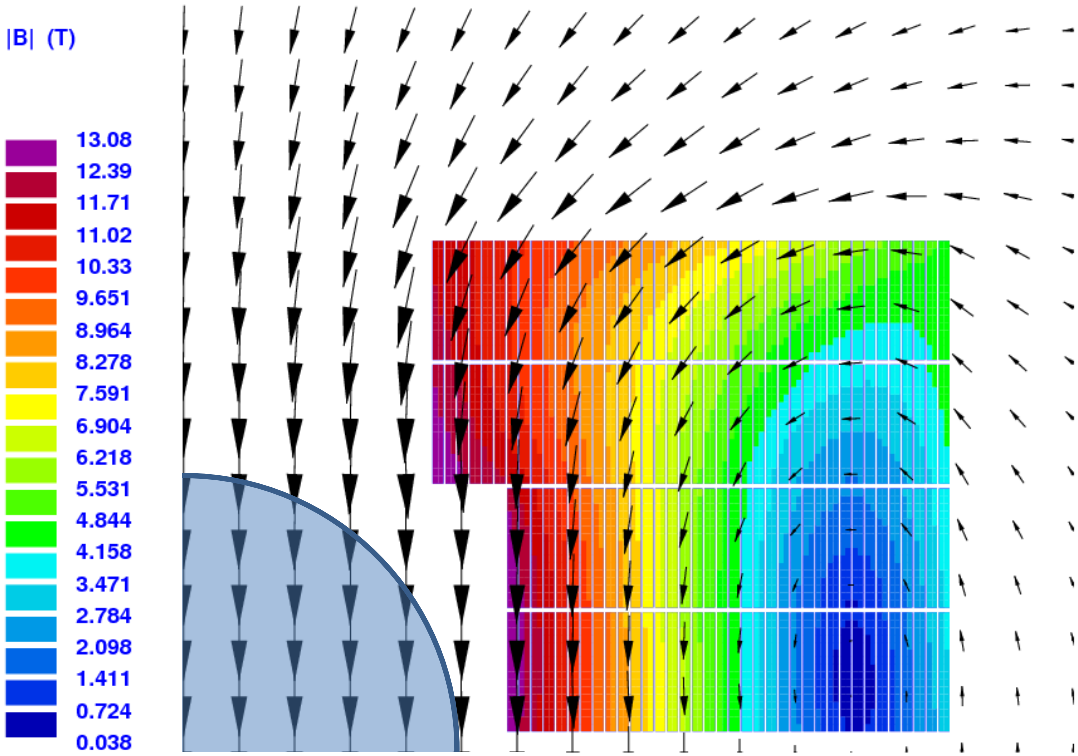
Rutherford cable

40 strands, rectangular, no core
21.4 x 1.8 mm bare
200 μm insulation
10% cabling degradation assumed

FRESCA2: cross section (Oct. 2010)

156 turns (per pole)

36 + 36 + 42 + 42



[15 T imply 87.0 % load line @ 1.9 K]

B_{center} = 13.0 T

I_{13T} = 10.2 kA

B_{peak} = 13.1 T

81.8 % load line @ 4.2 K

75.4 % load line @ 1.9 K

$F_{x,qua}$ = 7.61 MN/m

$F_{y,qua}$ = -3.41 MN/m

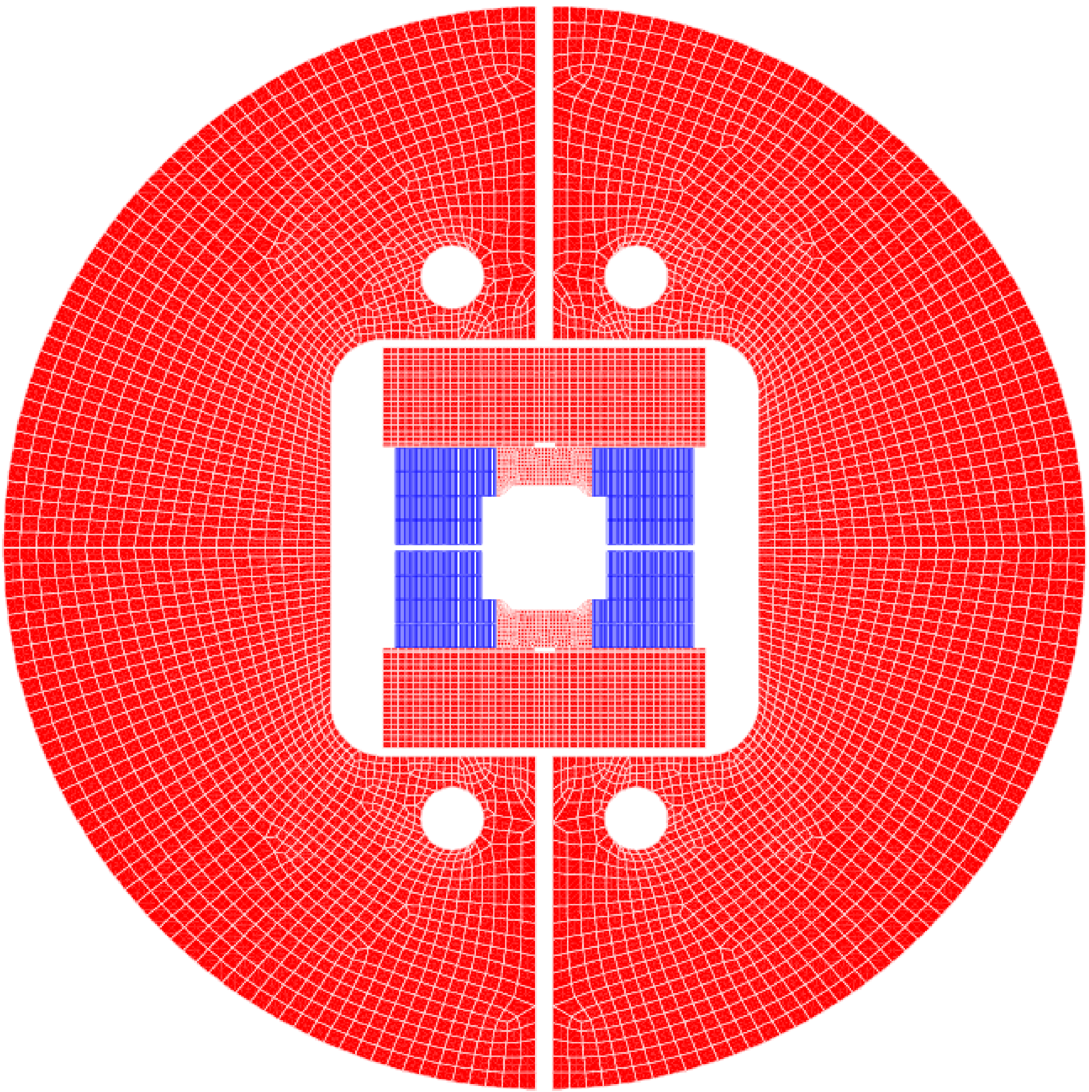
$\Delta B_y/B_{center} < 0.2$ %

for $B_{center} > 10$ T

E = 3.58 MJ/m

L = 46.8 mH/m

FRESCA2: iron (Oct. 2010)



D_{yoke} = 1.0 m

≈ 10 tonnes of iron

13 T in the bore imply:

<u>with iron</u>

81.8 % load line (4.2 K)

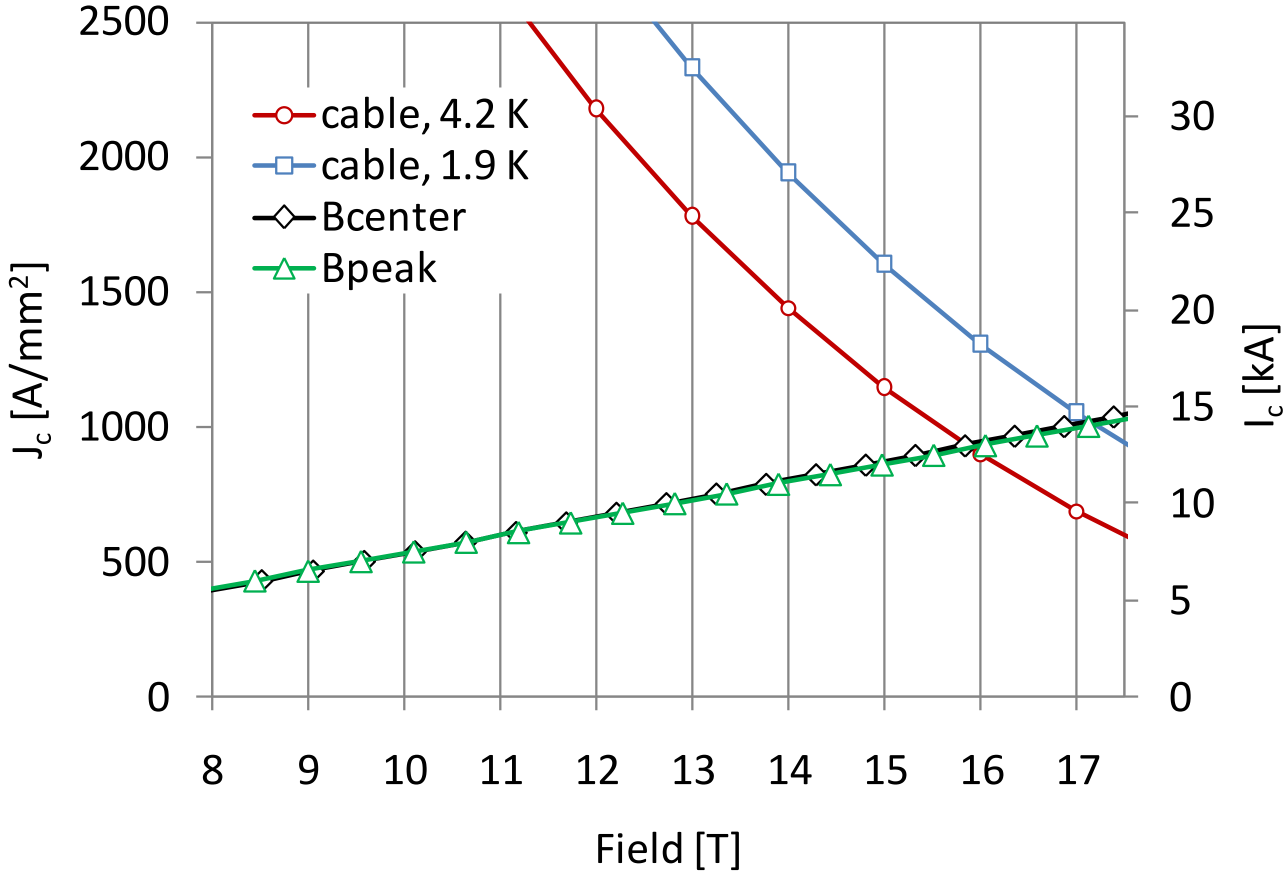
280 mT of stray field on outer shell

<u>without iron</u>

89.8 % load line (4.2 K)

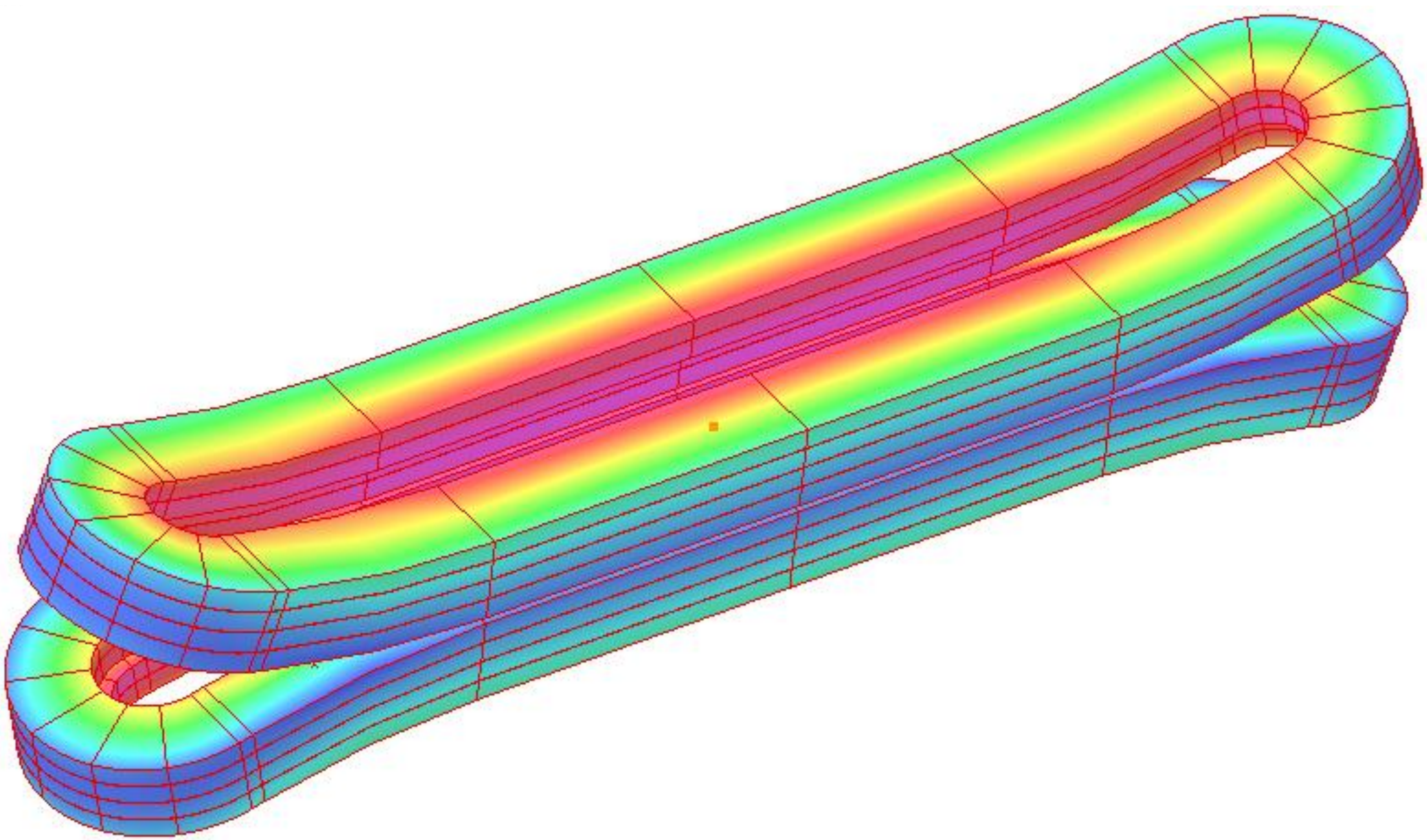
500 mT of stray field on outer shell

FRESCA2: load line (Oct. 2010)



[3000 A/mm^2 instead of 2500 A/mm^2 (12 T, 4.2 K) would give 0.3 T more at short sample, 4.2 K]

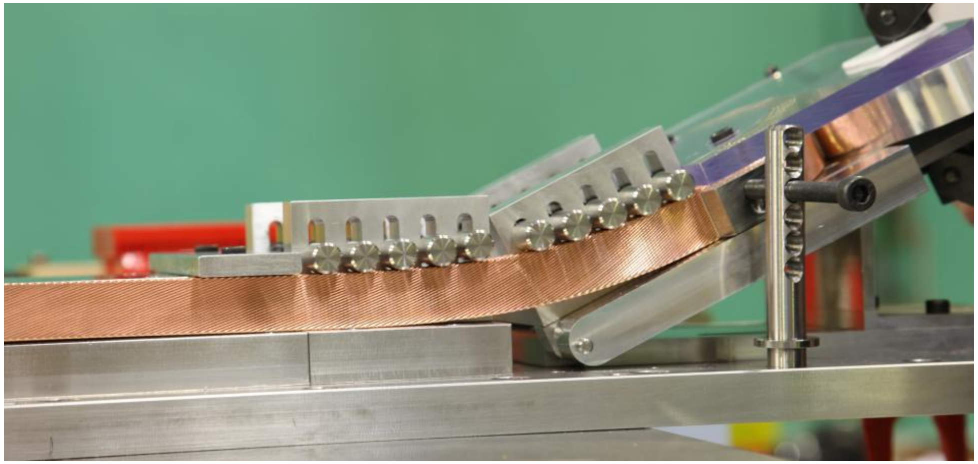
FRESCA2: flared ends (Oct. 2010)



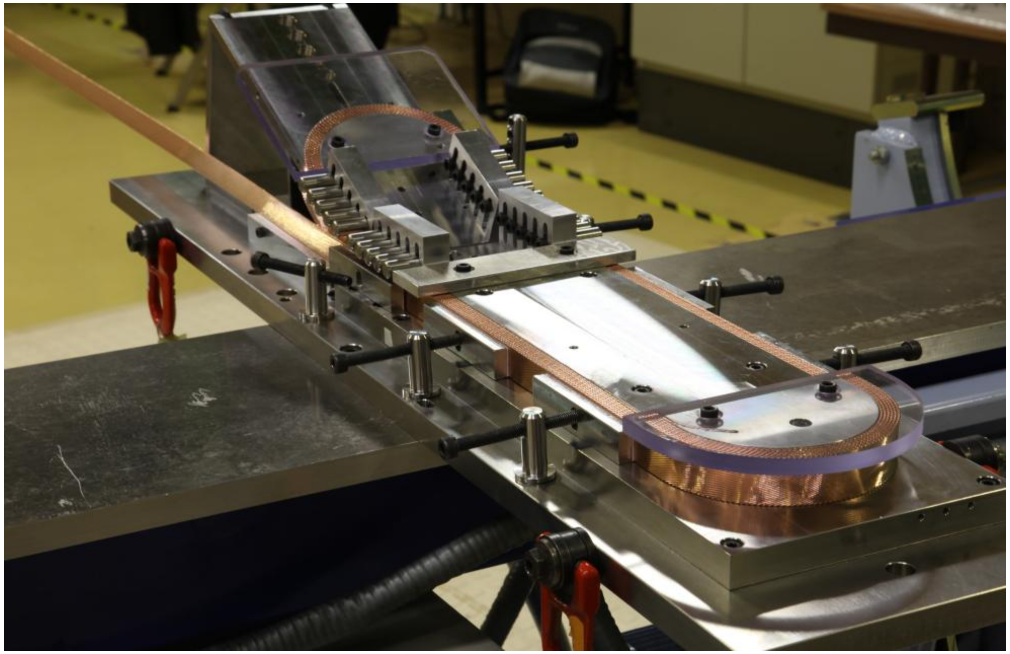
the peak field is in the straight section

optimization of the iron in the ends is ongoing

FRESCA2: flared ends

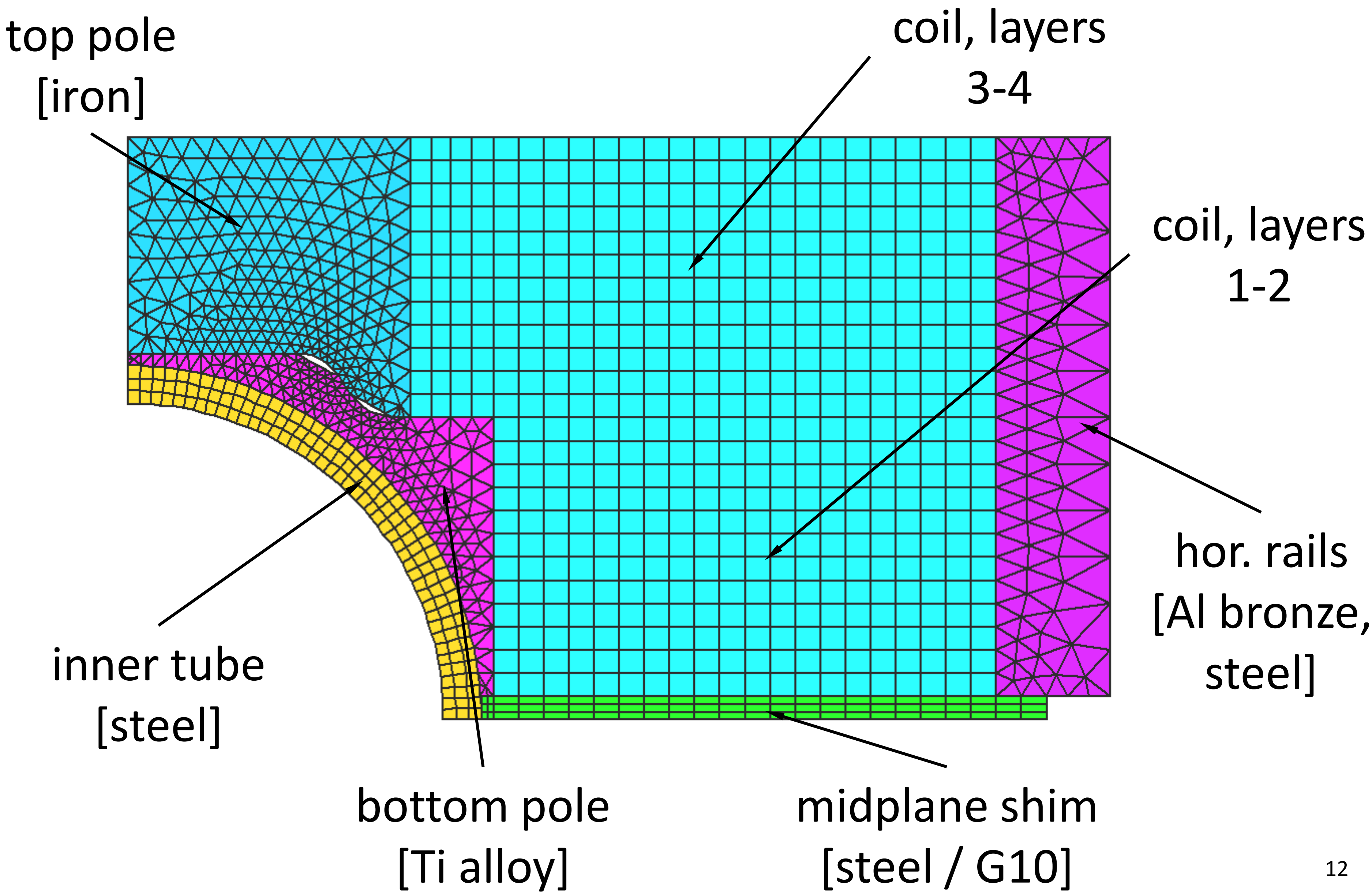


A first proof-of-concept winding test has been performed with copper cable in March 2010.



The result is that such an end design looks feasible.

FRESCA2: structure (Oct. 2010)



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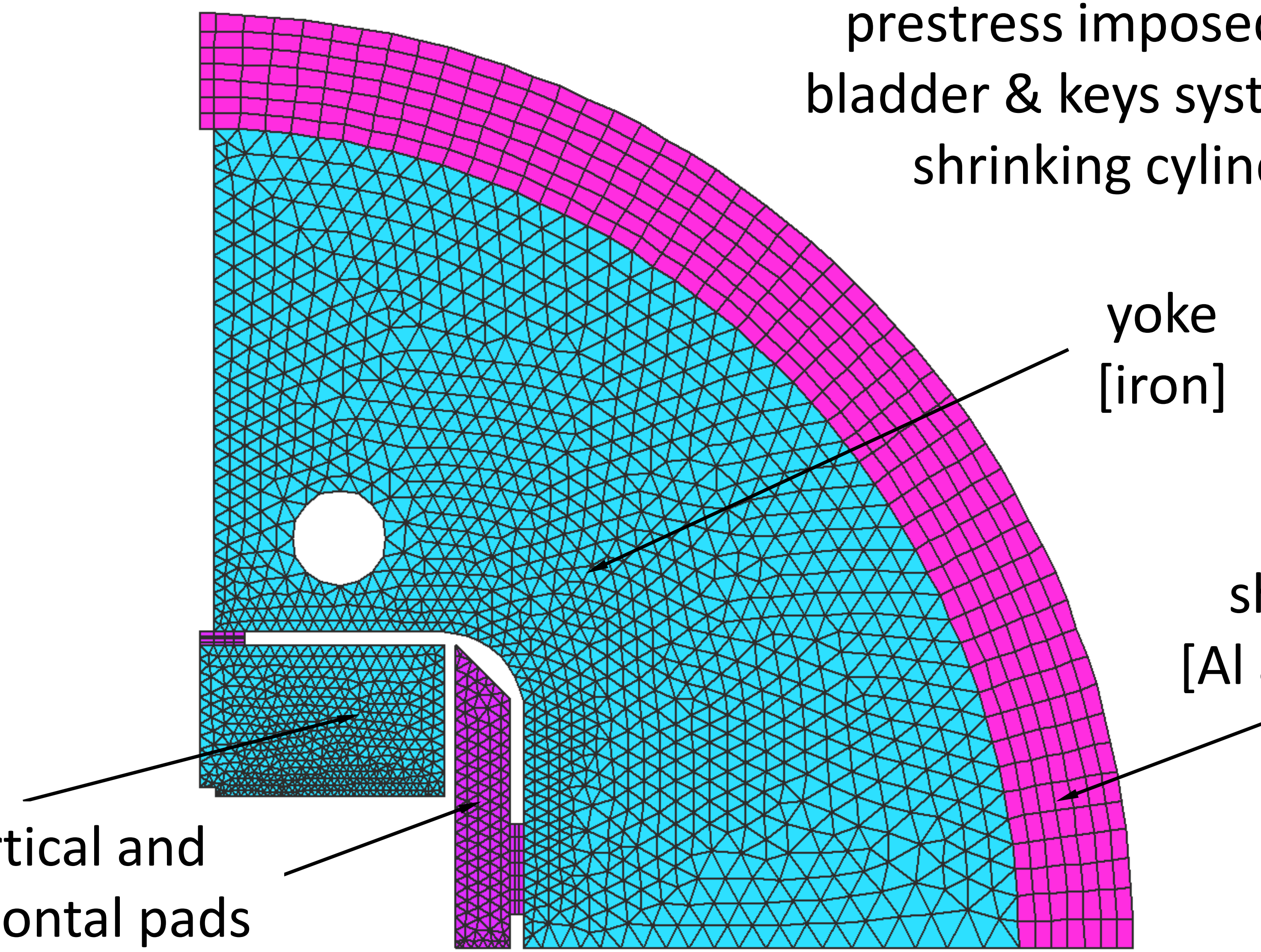

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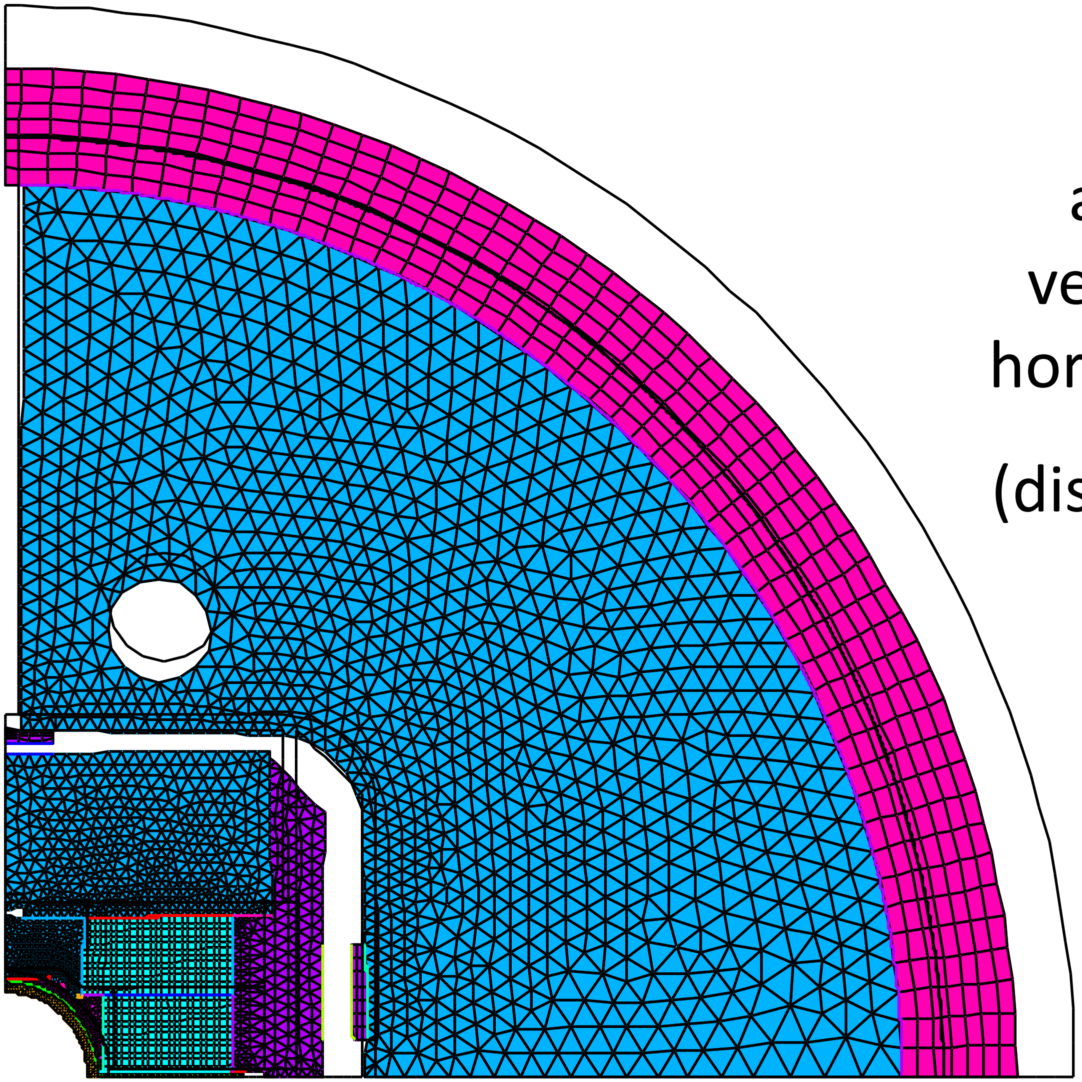


R_{yoke} = 500 mm
t_{shell} = 70 mm

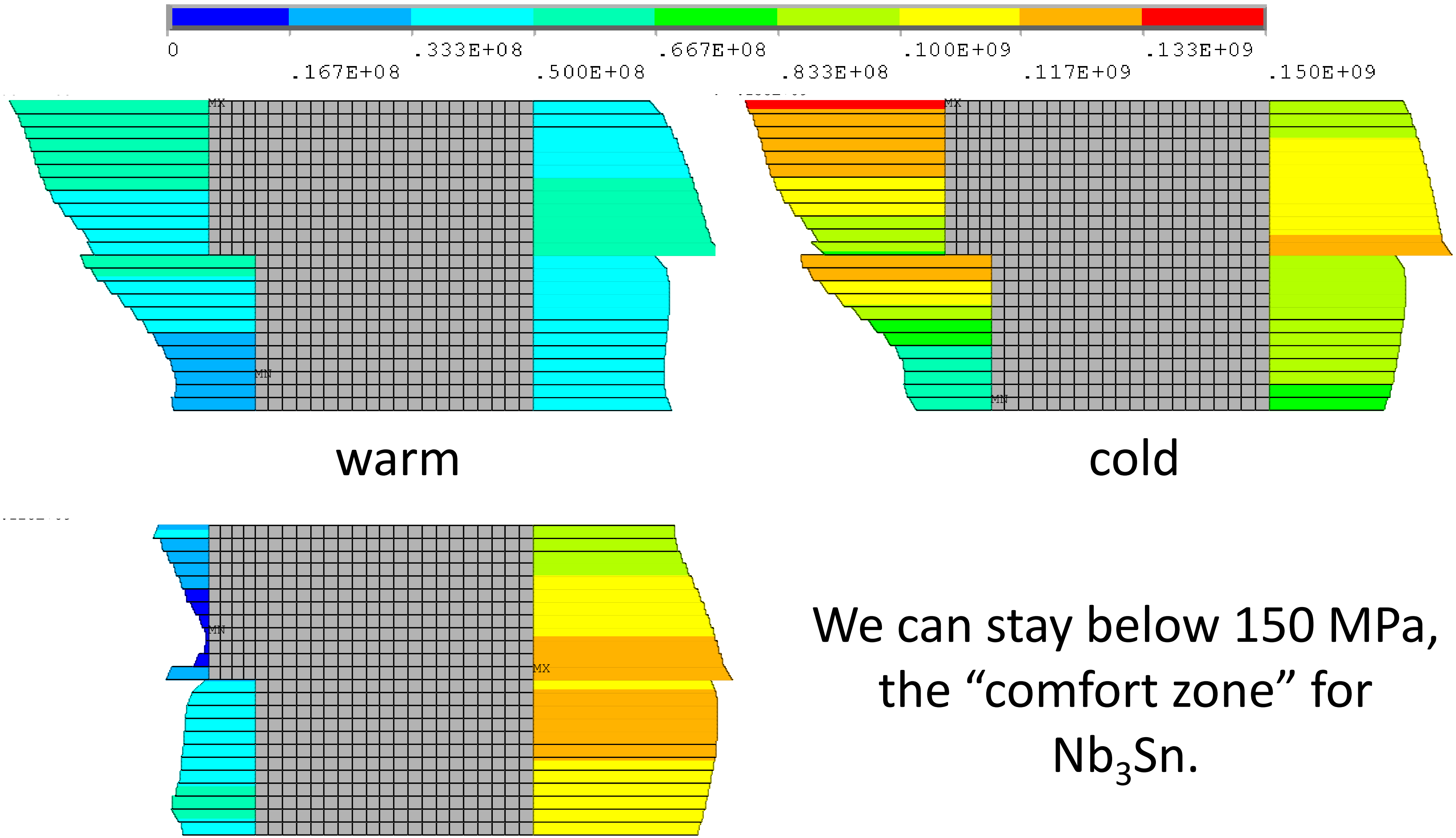
after cool down, with
vertical keys in (250 μm)
horizontal keys in (600 μm)

(displacement scaling x 25)

prestress on the coil

≈ 50 MPa at warm
≈ 60 MPa more at cold

FRESCA2: stresses on the coil



powered to 13 T

We can stay below 150 MPa, the "comfort zone" for Nb_3Sn.

FRESCA2: current planning

- Jan. 2011: detailed magnet design (20-21 Jan. 2011 design review)
- April/June 2011: structure tested in LN2 with dummy coil
- Conductor deliveries: Sept. 2010, Dec. 2010, March 2011, July 2011, Nov. 2011
- First double pancake coil wound (half pole): March 2012
- Magnet ready to be tested with first full coil: March 2013

The Short Model Coil program runs in parallel to prepare the technology, using 18 and 40 strand cables.

Thank you.