EuCARD 2nd annual meeting
WP7-HFM
Design of the FRESCA2 Dipole

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Acknowledgement

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  - @ CERN:
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    Shlomo Caspi
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    Pascal Labrune, Jean-François Millot (Saclay)
  - ESAC reviewers:
    Giorgio Ambrosio, Shlomo Caspi, Pasquale Fabbricatore, Yukikazu Iwasa, Tatsushi Nakamoto, Lucio Rossi

FRESCA2's Big Five

Magnet aperture

Magnetic field

Magnet length

Straight section

HTS insert

[1]

One year following the track…

03-2010 > Bending test with HFM copper cable [2]

05-2010 > Choice of the dipole design option [3]

Late 2010 > Conceptual & Engineering ‘Baseline’ design

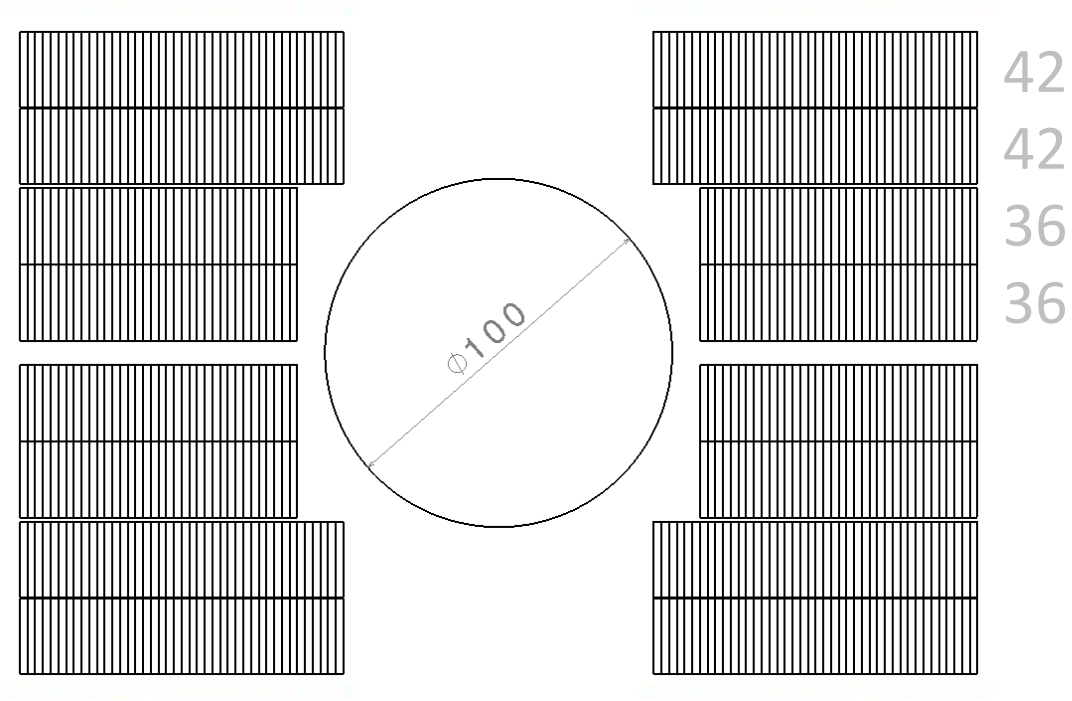
01-2011 > ESAC Review [4]

Early 2011 > Engineering ‘Optimised’ design

04-2011 > First drawings

Magnet cross-section

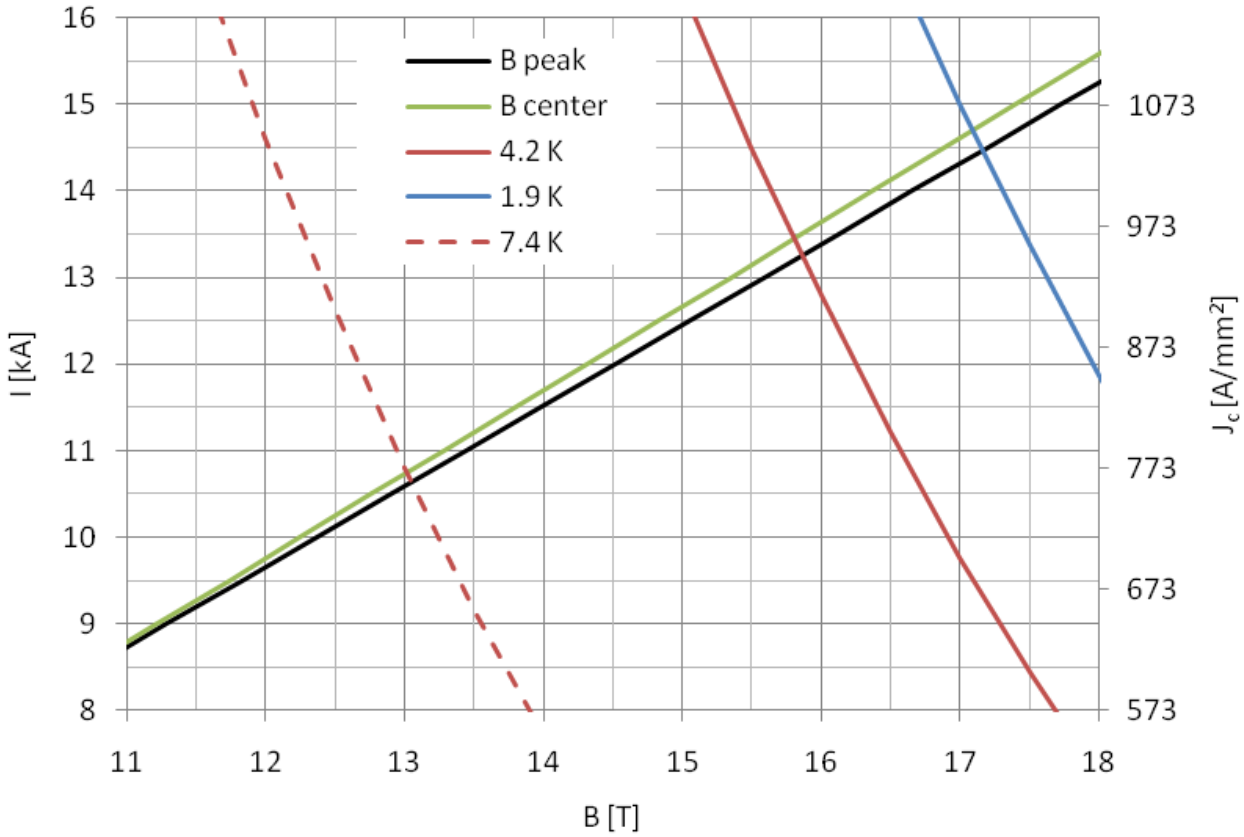
- Now in its final version [5]:



- 156 turns per pole
- Iron post
- B_{center} = 13.0 T
- I_{13T} = 10.7 kA
- B_{peak} = 13.2 T
- E_{mag} = 3.6 MJ/m
- L = 47 mH/m

Courtesy of Attilio Milanese

Load line



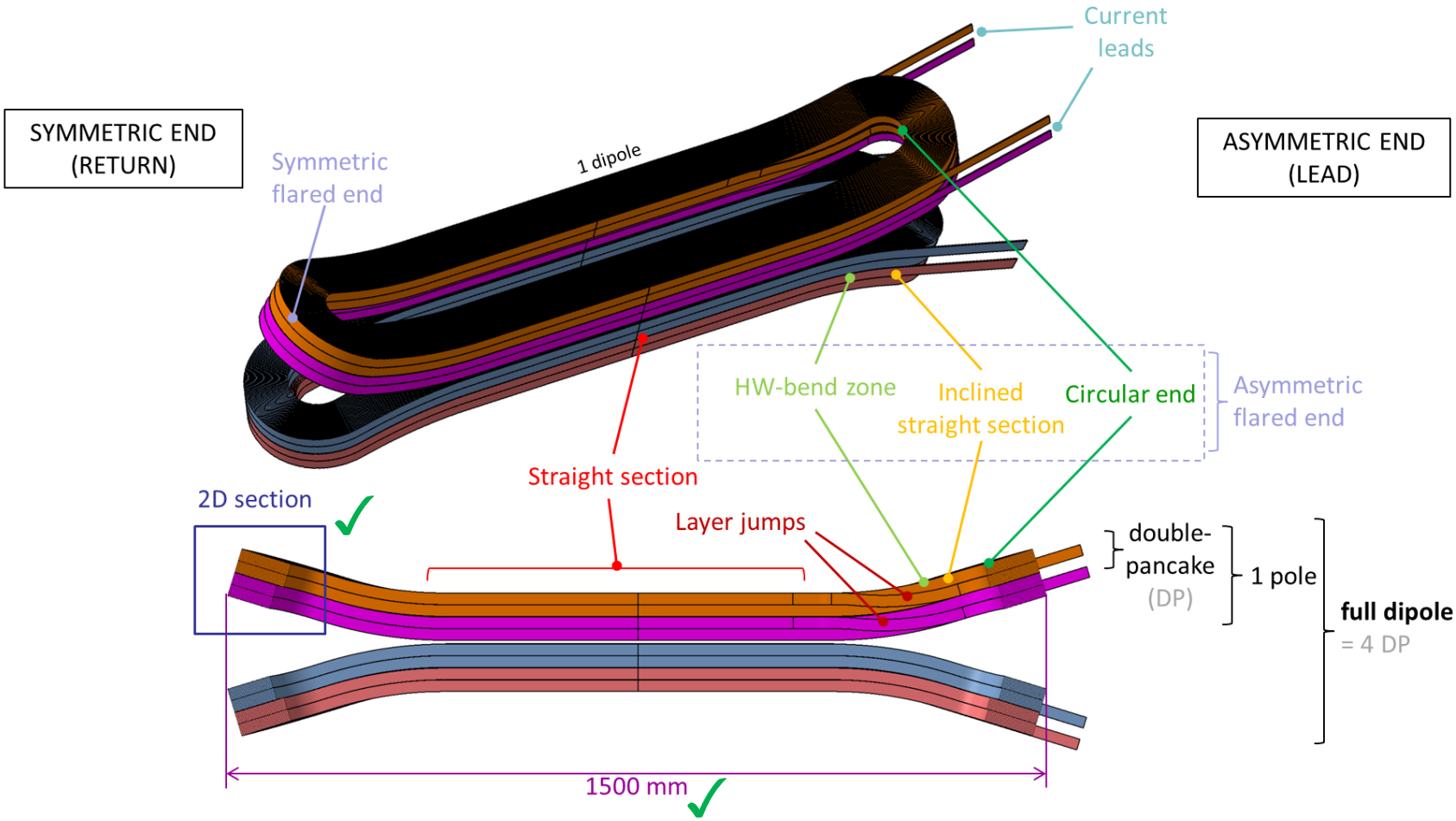
Position along the load line

- at 13 T: 83% @ 4.2 K, 76% @ 1.9 K
- at 15 T: 88% @ 1.9 K

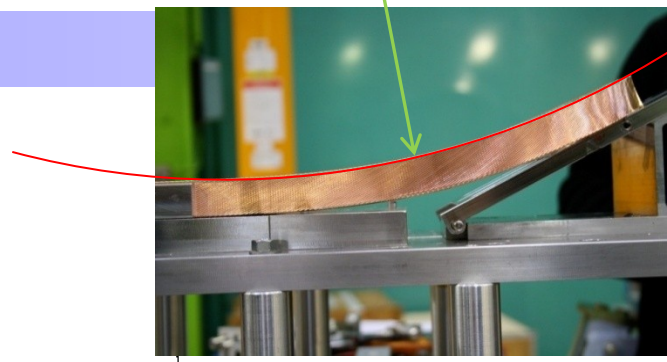
Courtesy of Attilio Milanese

3D layout

- 1.5 m – long
- Straight section length > 700 mm



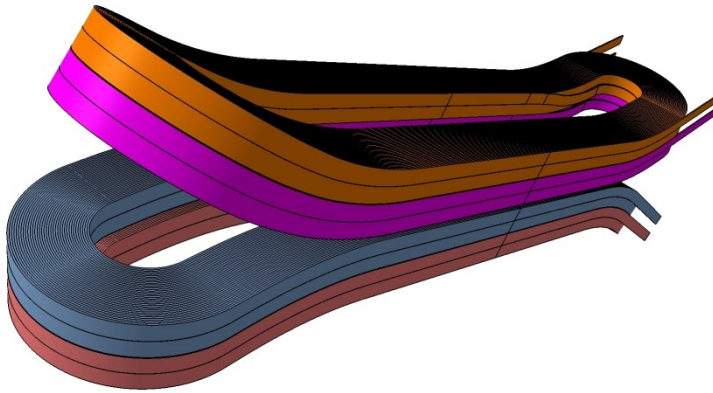
Ends details



- 17° ramp, R = 700 mm ☞ L_{ss} = 730 mm ✓
- Can be compared to HD2 [6]: 10° ramp, R ~ 350 mm
- Review ☞ Geometrical imperfections considered

Cable needs

- ~ 1 km of cable for the dipole
- ~ 50 km of strand

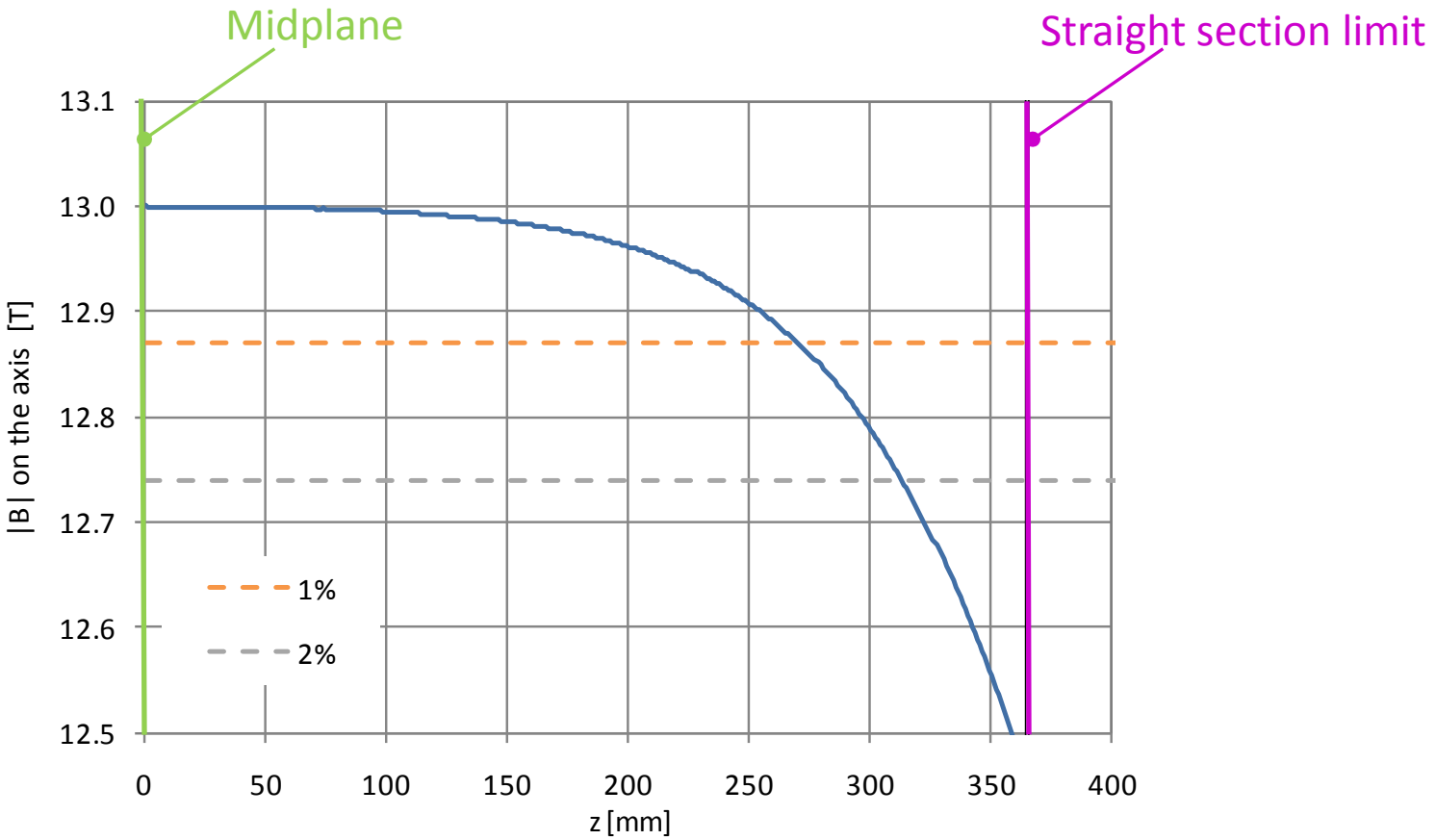


CABLE NEEDS		
Sub-element	Theoretical cable length (m)	+ 3% margin
Double-pancake 1-2	223	230
Double-pancake 3-4	253	260
1 POLE	476	490
FULL DIPOLE	**952**	**981**

in one piece

4 pieces of cable

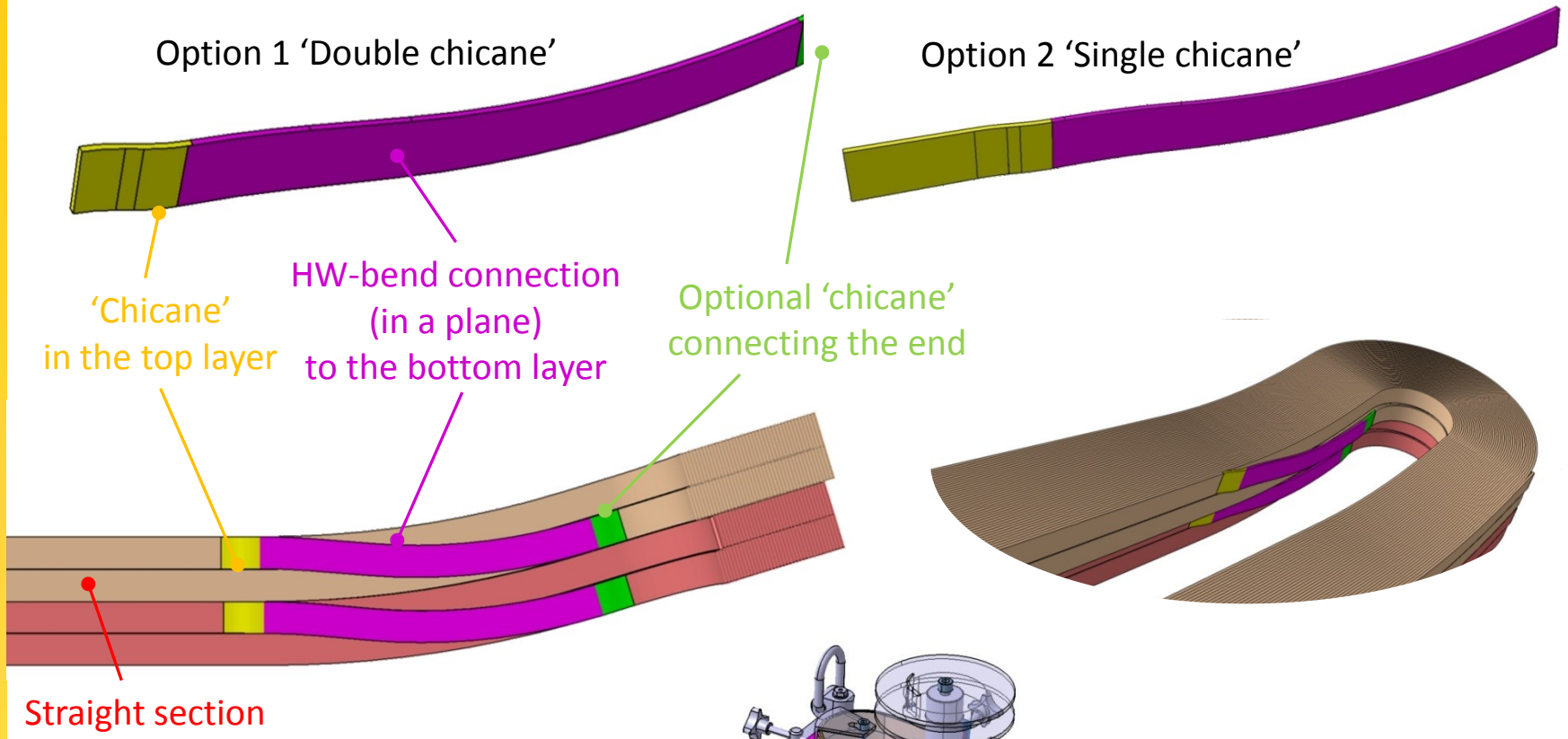
Field homogeneity

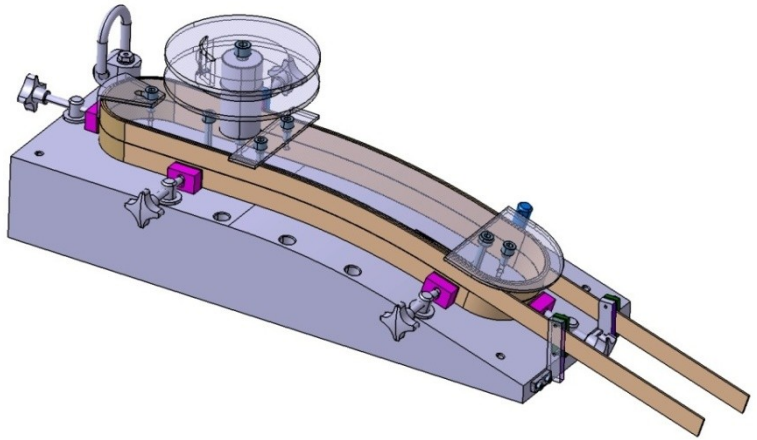


- Iron parts along the straight section
- 'Good field' zone along the axis (1% margin) ~ 540 mm

Courtesy of Attilio Milanese

Layer jump options

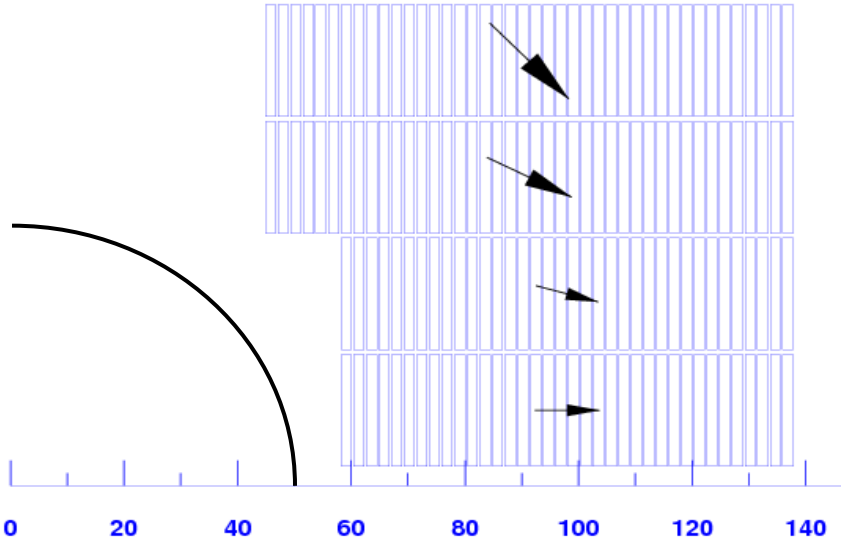




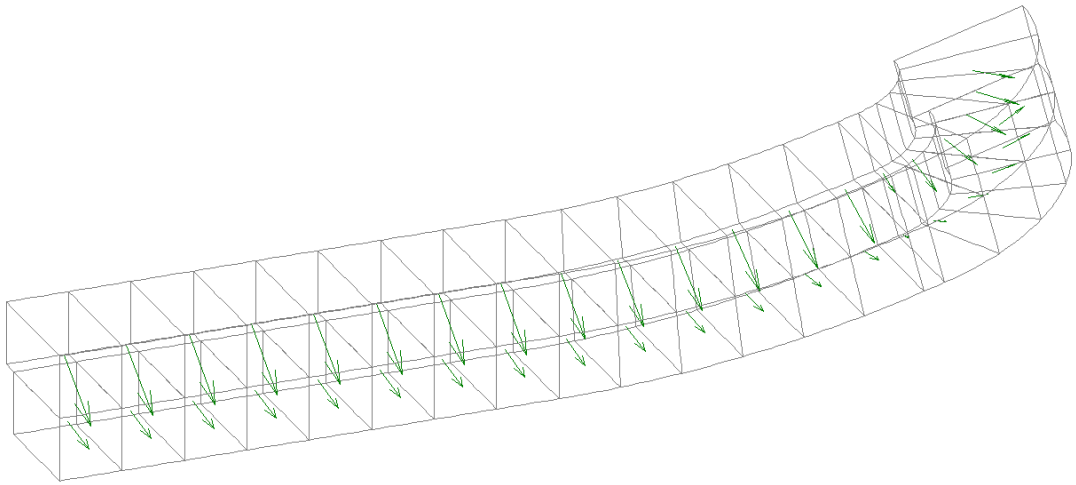
- Experimental setup under construction

Lorentz forces

- In 2D (per quadrant)
  - **F_x = 7.5 MN/m**
  - F_y = −3.9 MN/m

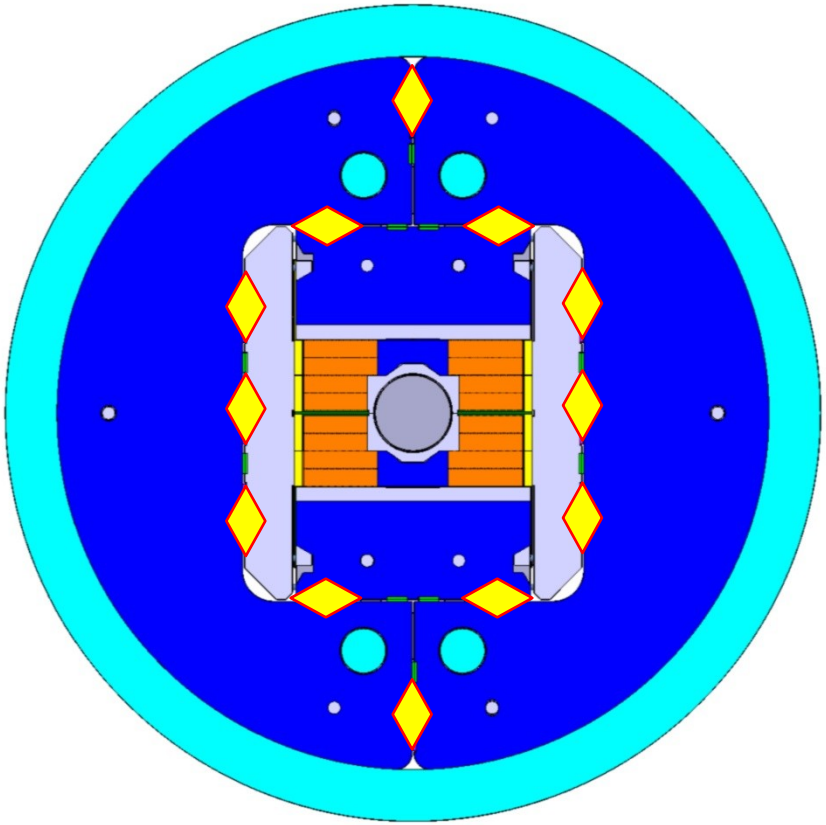


- In 3D (per octant)
  - F_x = 4.95 MN
  - F_y = −1.97 MN
  - F_z = 0.52 MN



Courtesy of Attilio Milanese

Structure cross-section



Bladder location

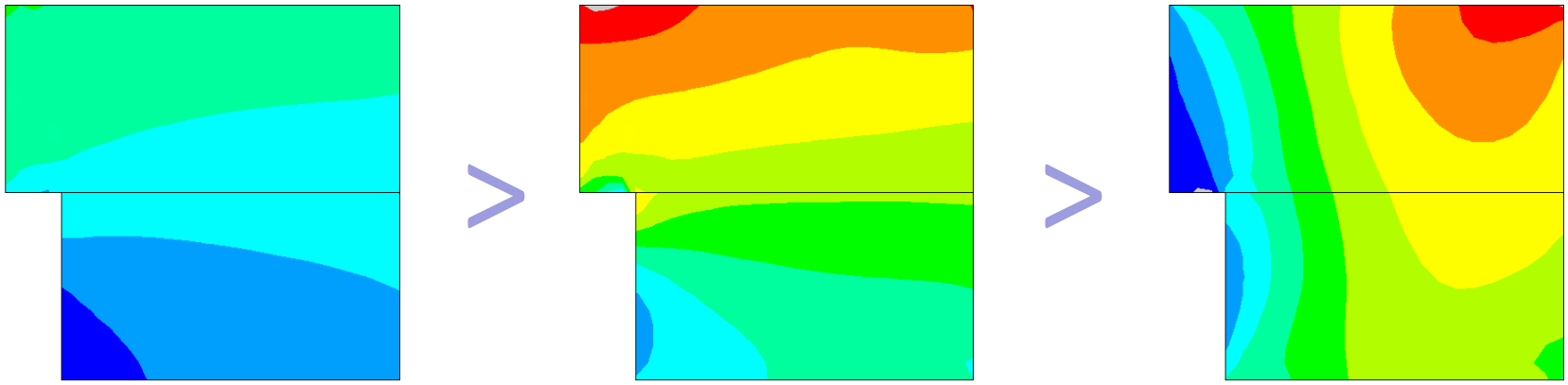
- Shell-based structure
- Dimensioned by 2D/3D FEA
- Bladders and keys
- no central tube
- outer diameter = 1030 mm
- shell thickness = 65 mm

Material colors:

Coil Steel Aluminum Iron Aluminum-Bronze Insulation

Stresses on the coil

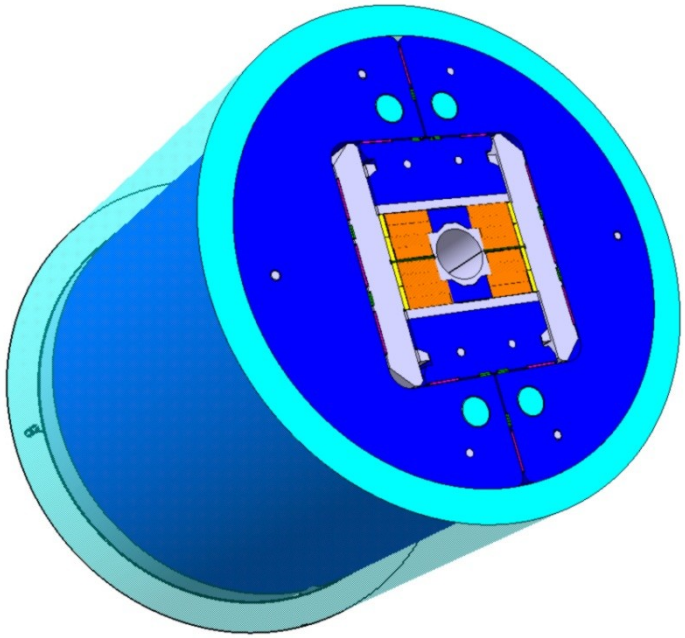
- σ_x not over 150 Mpa ✓
- High field and high stress regions do not overlap
- 2D and 3D analysis match

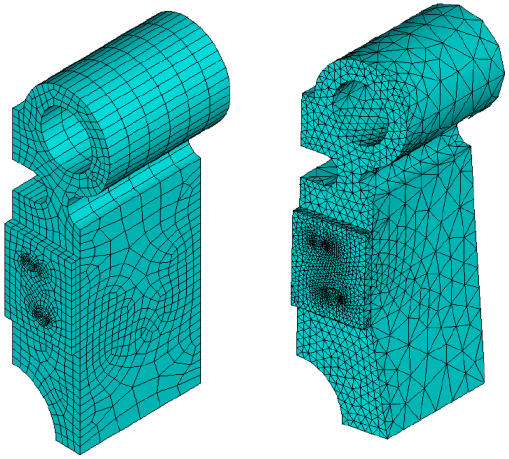


Courtesy of Attilio Milanese

Structure overview

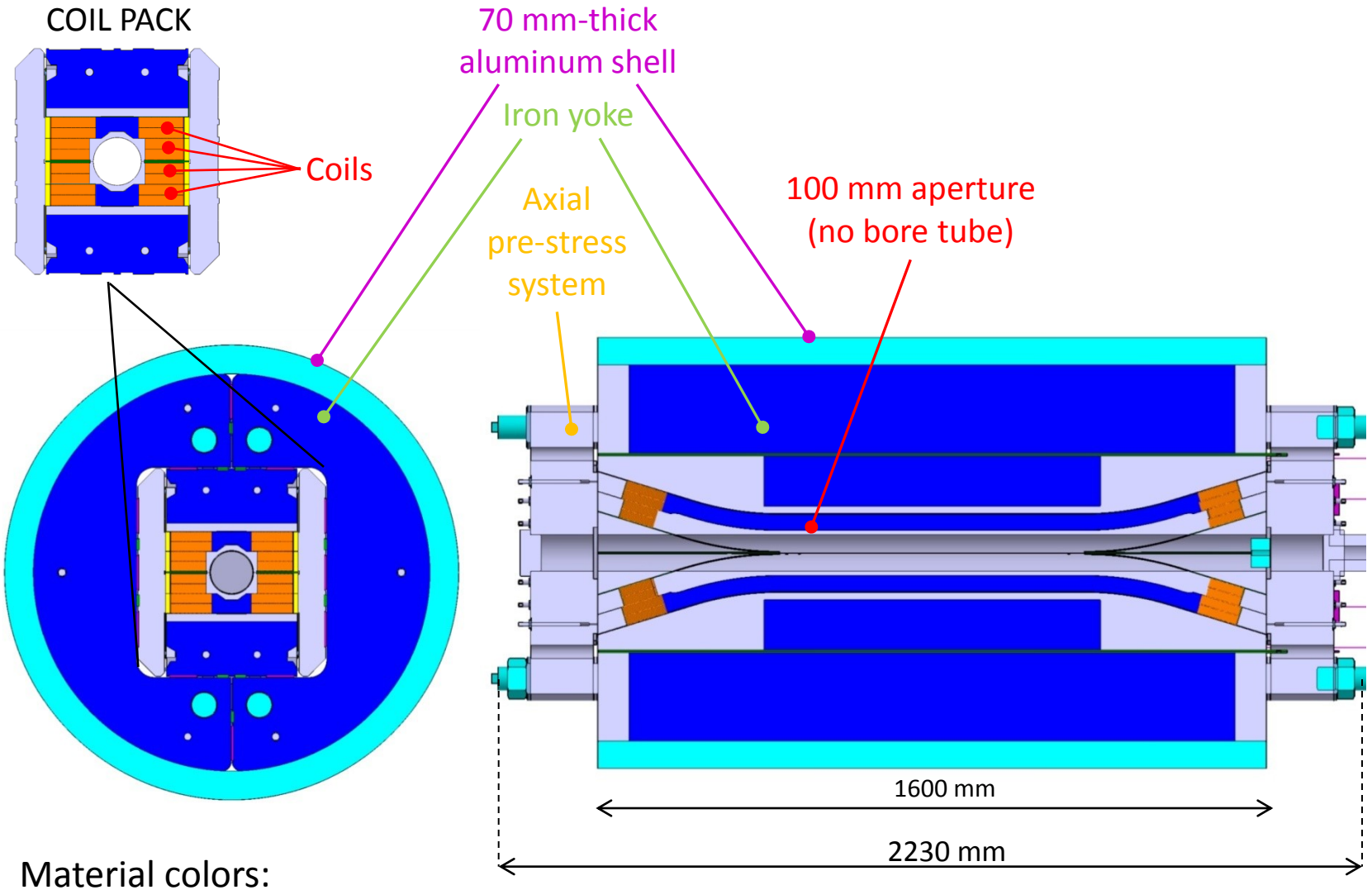
9 000 kg!





- Engineering design almost completed
- Connections to be studied
- Local verifications are still necessary

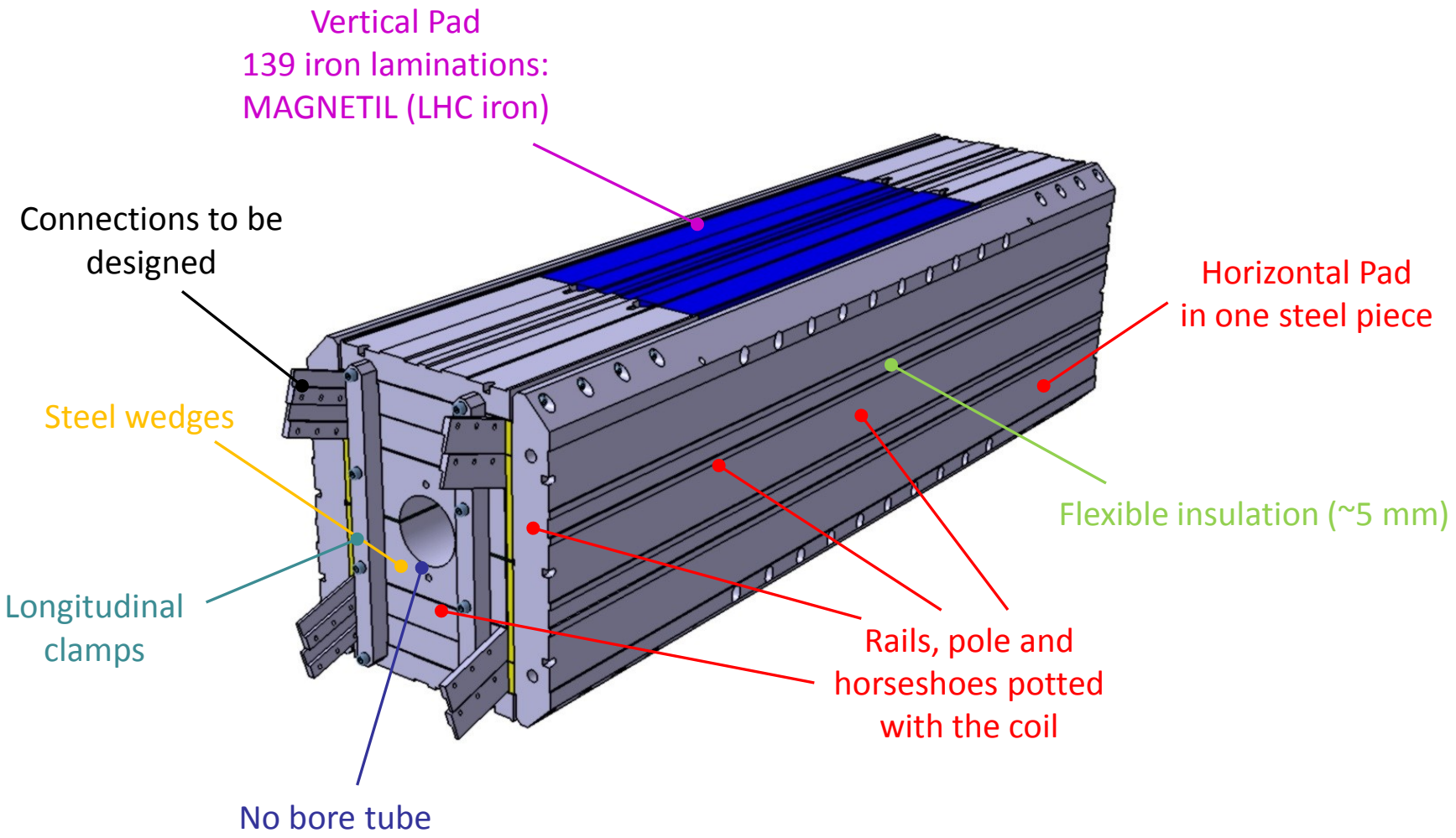
Structure: engineering design



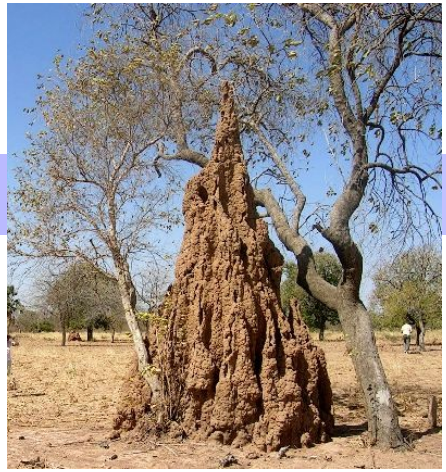
Material colors:

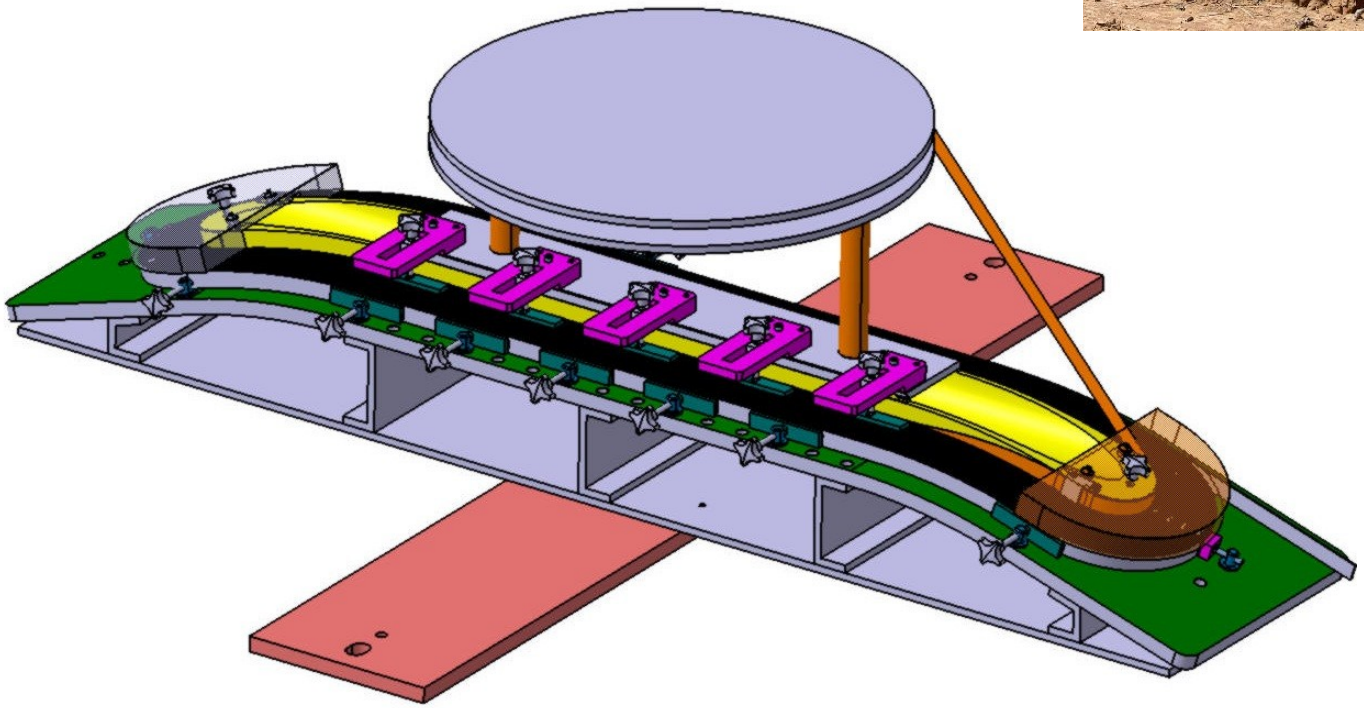
Coil Steel Aluminum Iron Titanium Aluminum-Bronze Insulation

Focus: coil pack



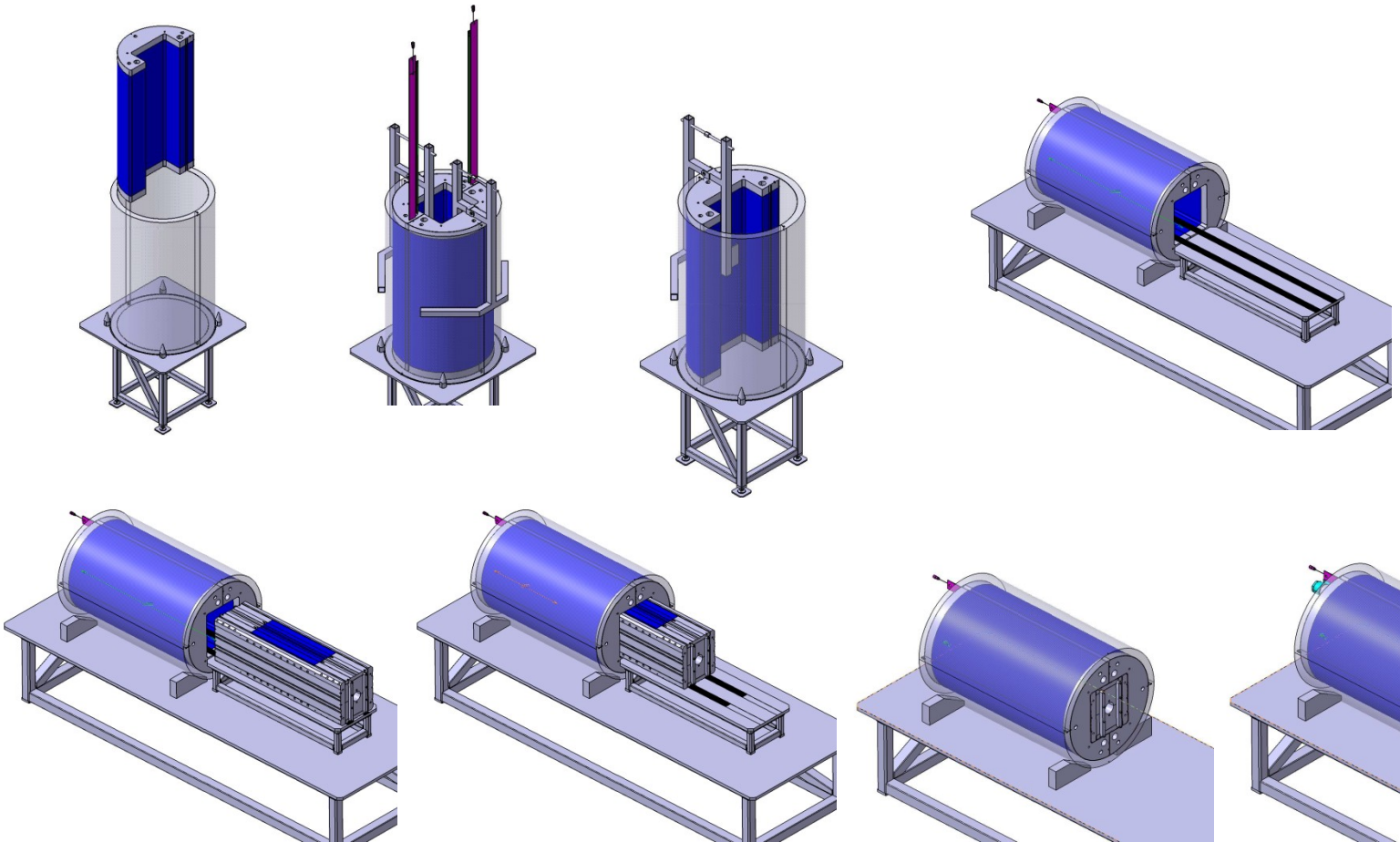
Fabrication process study





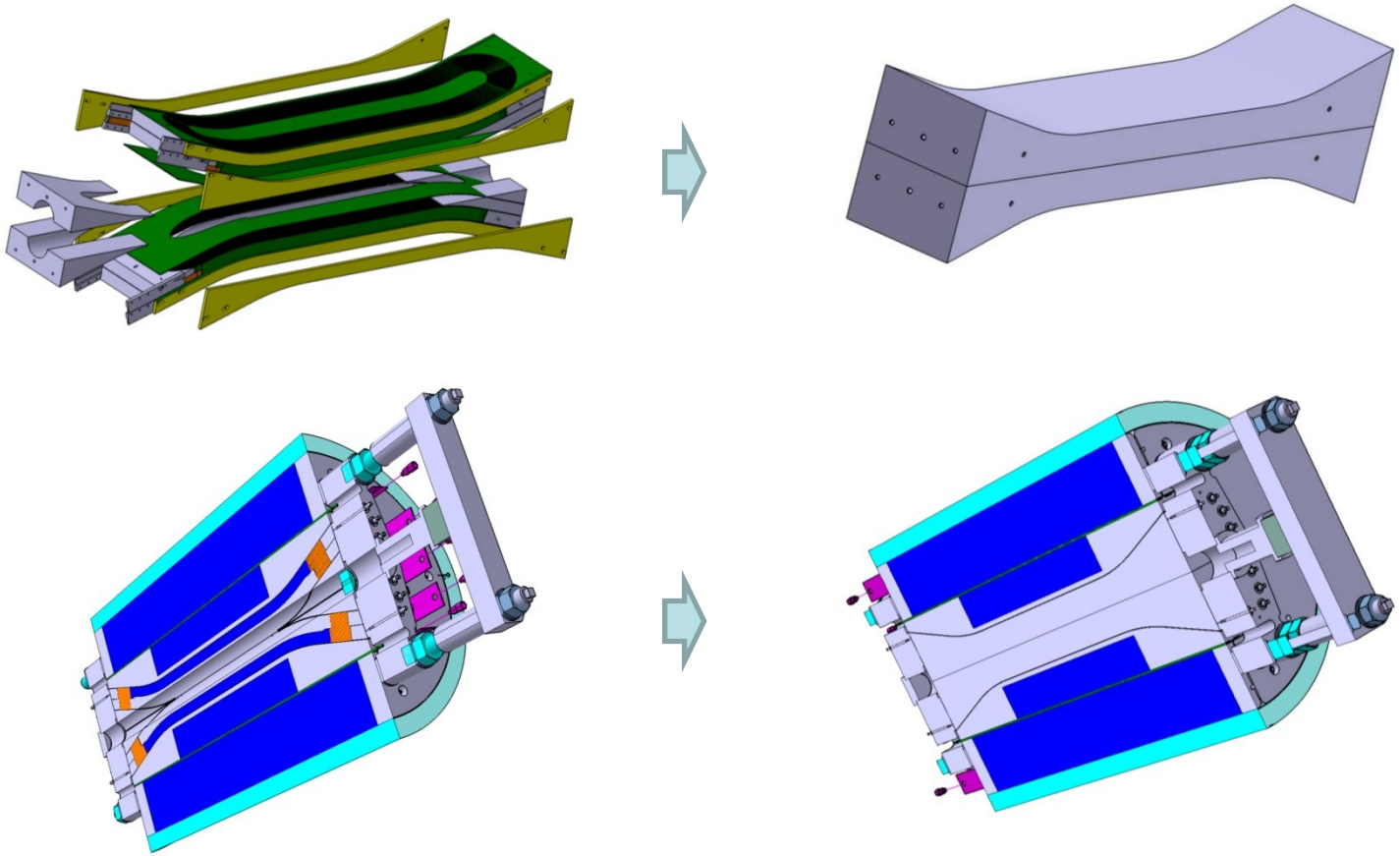
Assembly process study

- Vertical assembly of the yoke in the shell
- Horizontal assembly of the coil pack [7]



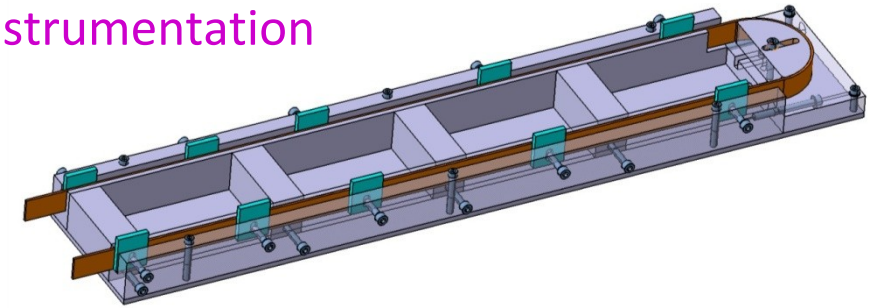
Coil pack mockup

- Drawings for structure fabrication are ready
- Structure validation with a coil pack mockup



Next steps

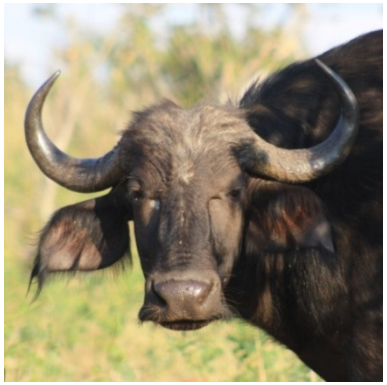
- Engineering design
  - Additional calculations
  - Fabrication method
  - Connection / protection / instrumentation



- Experimental tests
  - Layer jump test
  - Nb_3Sn longitudinal dilatation test (picture)
  - Winding tests

- Structure machining & testing

Thank you



References

[1] EuCARD-HFM dipole specification and baseline parameters

MPWG

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[2] EuCARD-HFM : Rapport sur les essais de cintrage des têtes de bobine en configuration bloc

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MPWG

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[4] Report of the EuCARD-HFM ESAC Review of the high field dipole design

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[5] Baseline conceptual design: the magnet we will build

A. Milanese

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[6] Design of HD2: a 15 Tesla Nb3Sn Dipole with a 35 mm Bore

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EFINOR

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