LARP

Very large aperture dipoles for a "dipole first" IR

Shlomo Caspi

Port Jefferson

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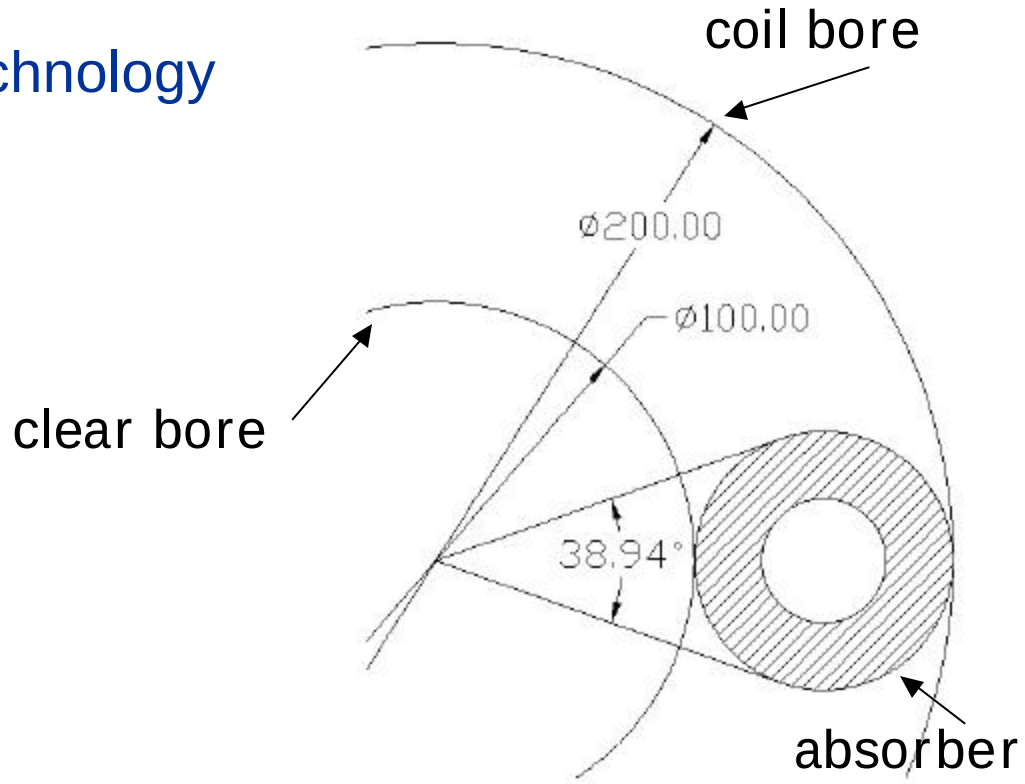
Why a large Bore ?

- Make room for internal absorbers
- Use “existing” magnet technology



Dipole First

- Operating field 13.6 T
- Nb_3Sn Technology
- Clear bore 100mm to accommodate beams
- Coil bore 200mm to accommodate absorbers

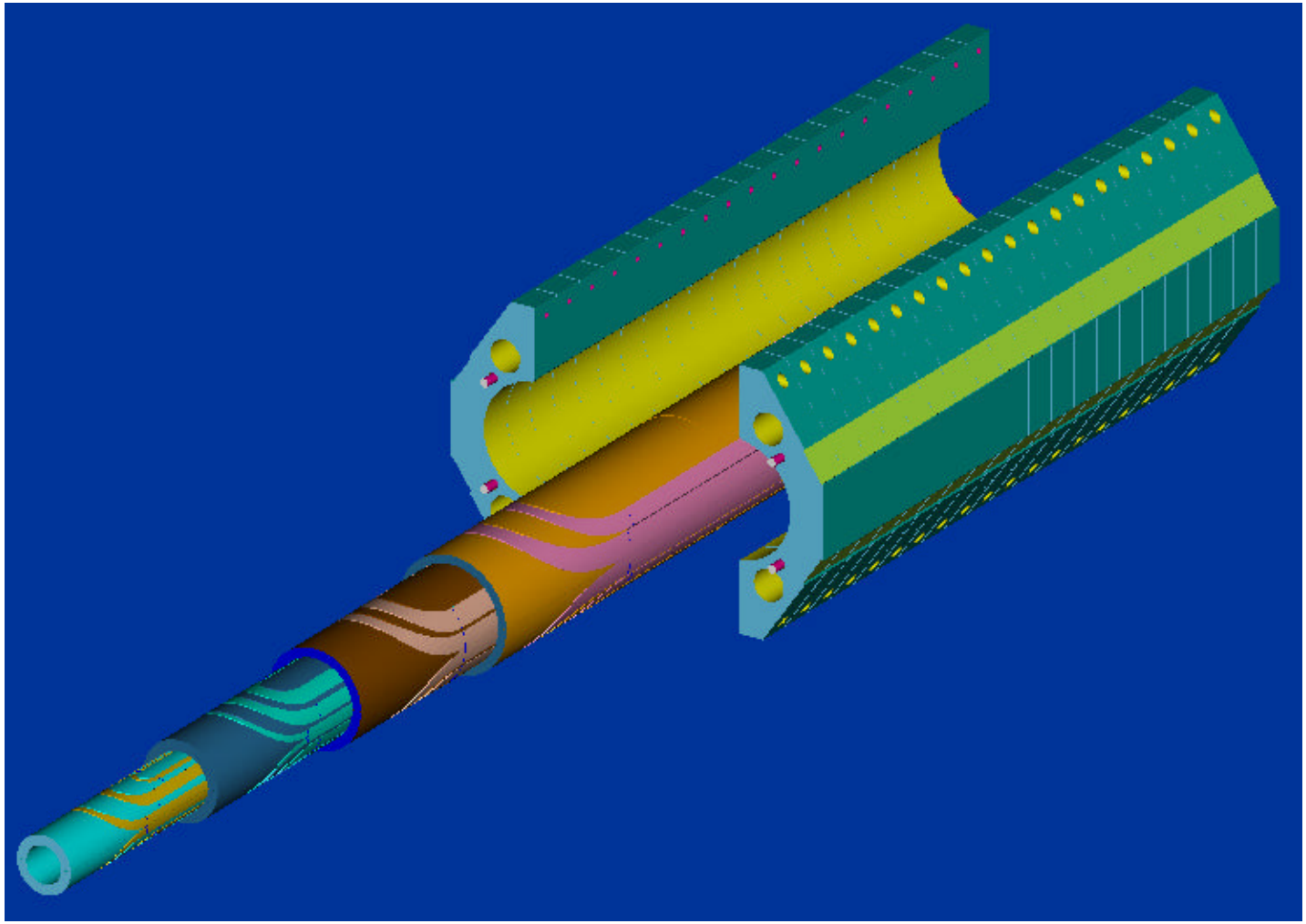
Approach

- Key and bladder assembly
- Two conceptual designs:
  - Shell-type
  - Block-type

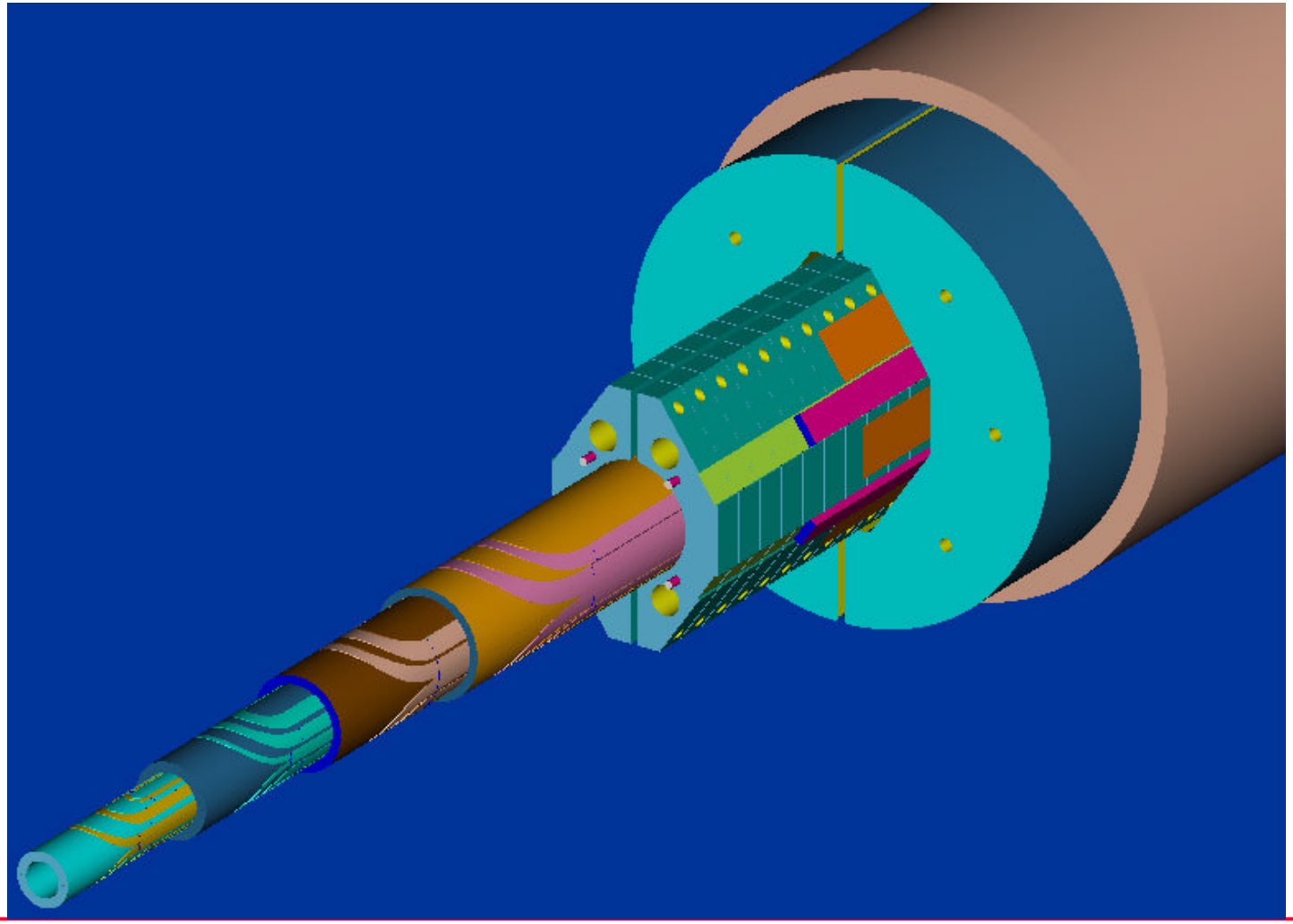
Shell type dipole - Conceptual

		Jc=2500±500 A/mm^2 4.2K 12T	
		T=4.2K	T=1.9K
		Margin (%)	
Bore Diameter (mm)	200		
Operating Field (T)	13.6	80±2%	74±2%
Number of Layers	3 double layers		
Cable width (mm)	17.0		
Outer coil radius (mm)	202		
Je (Amm^2)	215		
Operating Stress (MPa)	185		
Operating Stored Energy (MJ/m)	8.6		

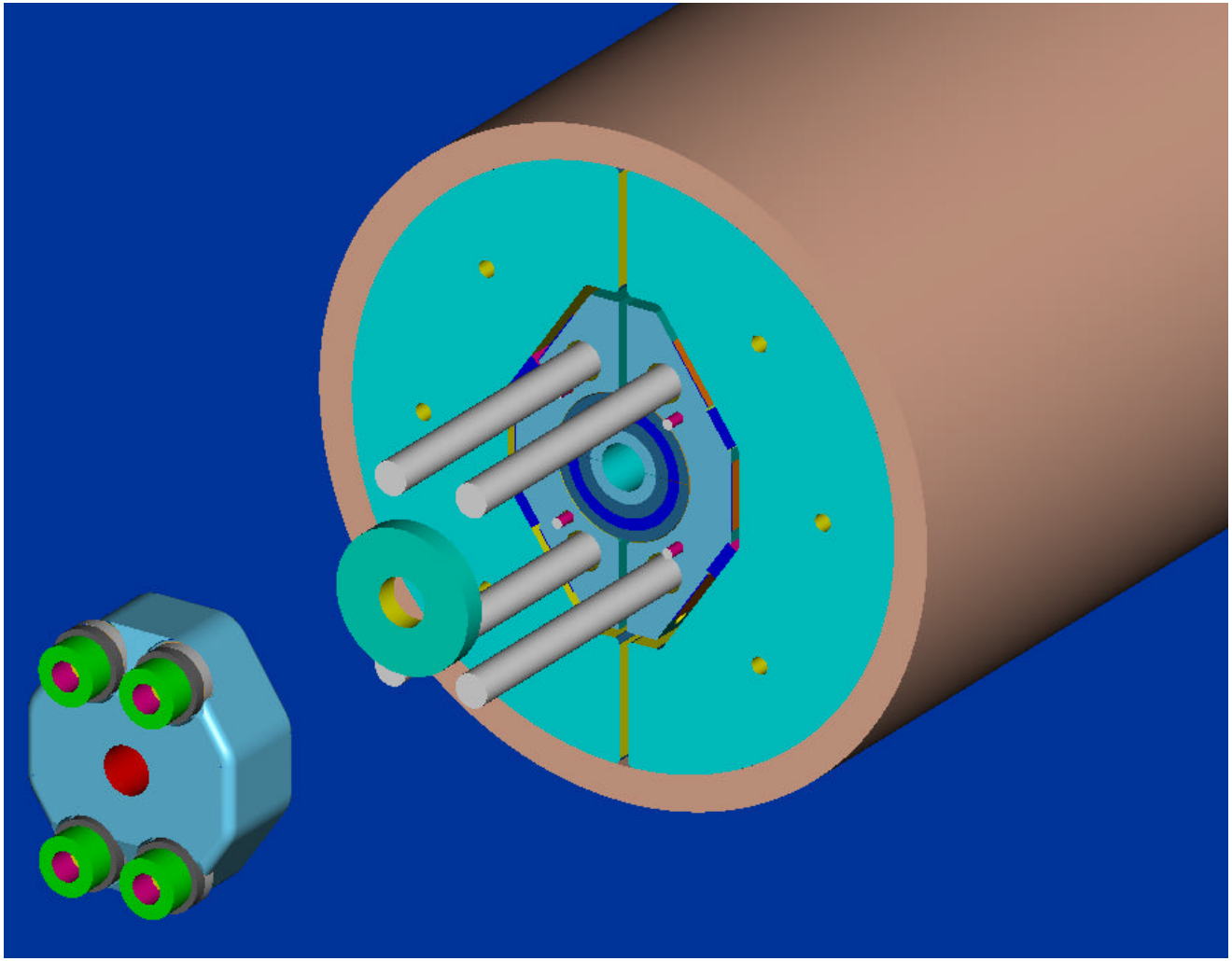
Coils Sub-Assembly



Coil and Structure



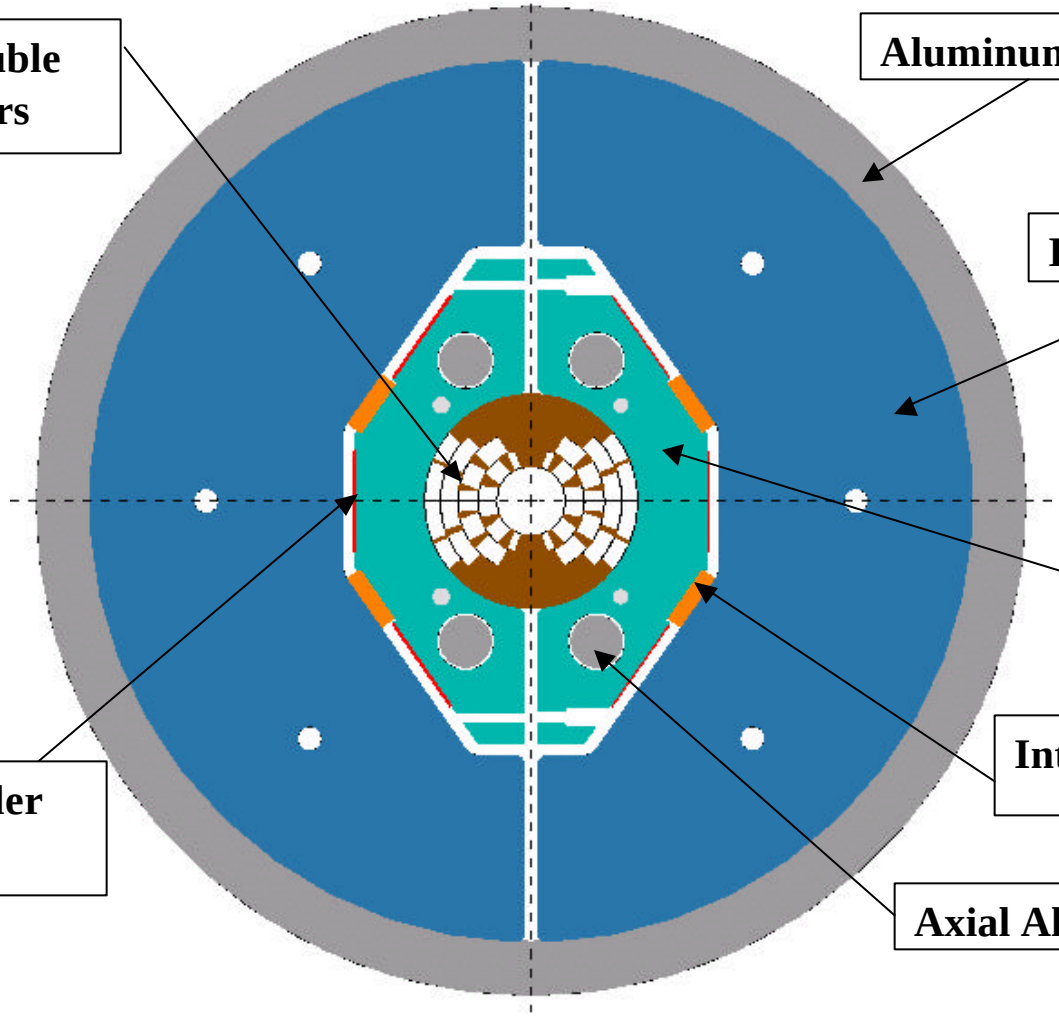
End Plate



Shell-type concept (not to scale)

(NAPA)

200mm bore
1.5m structure



Block type dipole - Conceptual

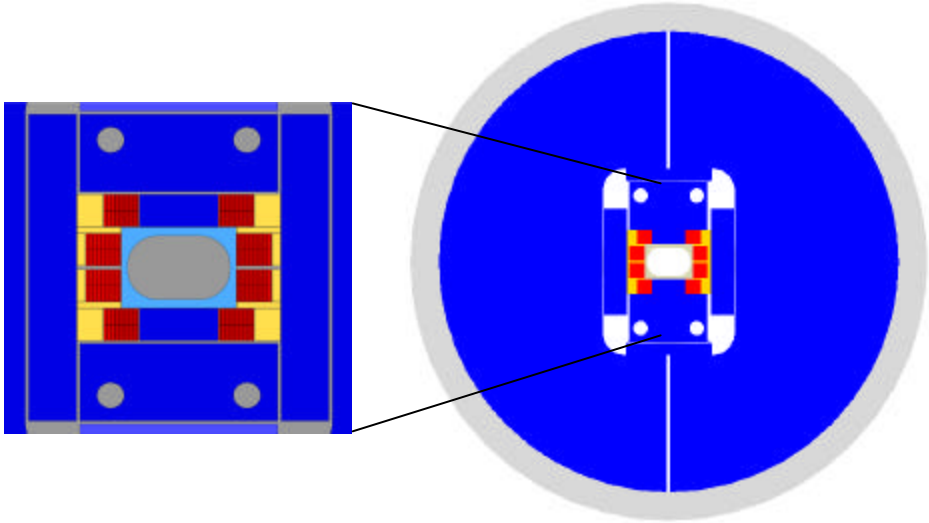
First iteration: LD-150 (Napa)

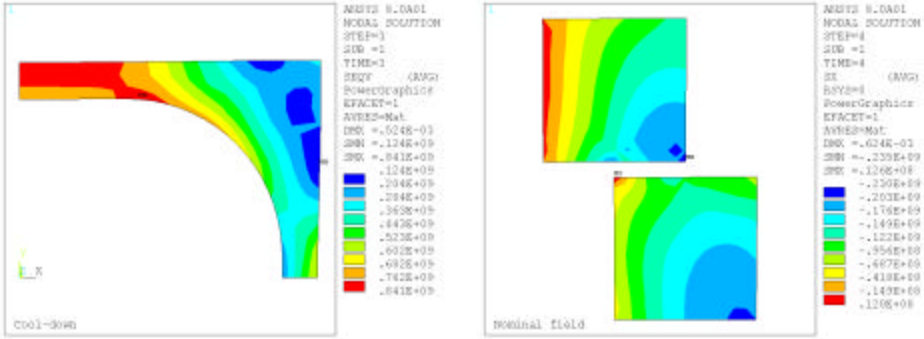
- Clear bore: 150 mm x 100 mm
- Horiz. coil aperture: 170 mm
- Al shell thickness: 100 mm
- Iron yoke, 1.6 m OD
- Bladder width: 100 mm

- Max. shell stress (4.3K): 170 MPa
- Max. bladder pressure: 50 MPa
- Max. bore stress: 850 MPa
- Max. coil stress: 150-200 MPa

- Field errors: < 0.2% @ R=50 mm

- Max. quench voltage: 340 V
- Max. coil temperature: 150 K





“LD-200” Features

Approach:

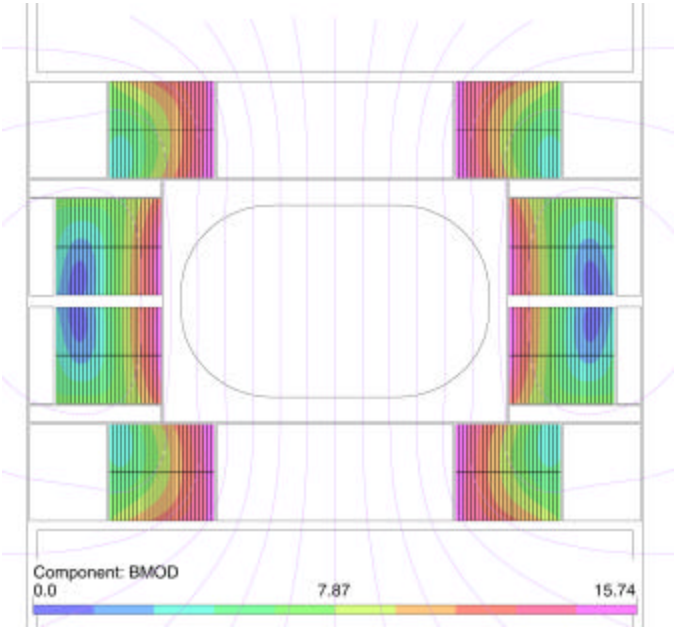
- scale LD-150 to 200 mm aperture
- compare key performance parameters

LD-200 design parameters:

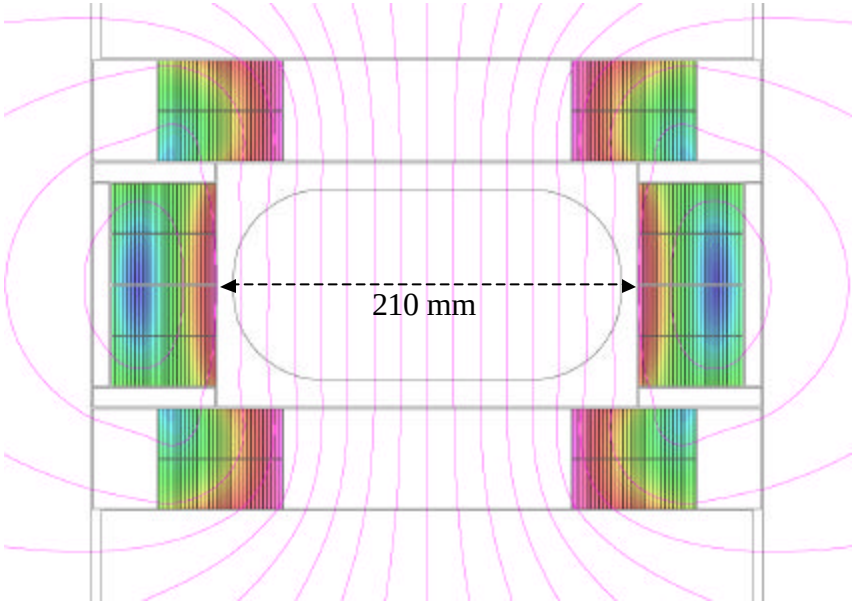
- Horizontal aperture (coil): 210 mm
- Clear bore: 190 (200) mm x 100 mm
- Target field: 15-16 T (4.2 K)
- Strand: 1 mm diameter (new OST with increased sub-elements)
- Iron insert in “pole” module, tilted ends in “midplane” module
- “Moderate” field quality

Coil Cross-sections

HD-150

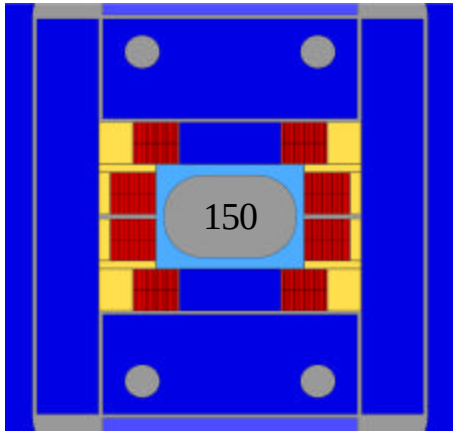


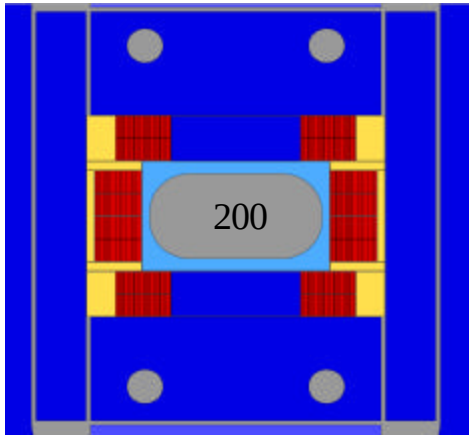
HD-200



- two double-layers racetracks for each pole
- no spacers (pending field quality optimization)
- need to define field quality volume & specs

Short-sample Parameters





Parameter	Unit	**LD200**	LD150	HD1
Bore field	Tesla	**15.5**	15.9	16.7
Coil field	Tesla	**16.9**	16.7	16.1
Max current	kA	**20.1**	20.2	11.4
Stored Energy	MJ/m	**7.5**	6.0	0.66
Inductance	MH/m	**37**	29	10
F_x (quadrant, 1ap)	MN/m	**14.6**	14.4	4.7
F_y (quadrant, 1ap)	MN/m	**-8.9**	-7.3	-1.5
Ave. stress (h)	MPa	**140**	140	150

Parameter	Unit	LD200	LD150	HD1
Strand diameter	mm	**1.0**	1.0	0.8
Ic (16 T, 4.2 K)	A	**503**	503	322
No. strands		**52**	50	36
No. turns/quadr.		**118**	108	69

Lorentz Forces and Stresses @ 15 T

HD-150

Layer 1+2
- Fx = + 5.0 kN/mm
  (coil stress: 102 MPa)
- Fy = - 1.9 kN/mm
  (coil stress: 40 MPa)

Layer 3+4
- Fx = + 7.9 kN/mm
  (coil stress: 146 MPa)
- Fy = - 4.5 kN/mm
  (coil stress: 89 MPa)

HD-200

Layer 1+2
- Fx = + 4.7 kN/mm
  (coil stress: 90 MPa)
- Fy = - 2.5 kN/mm
  (coil stress: 48 MPa)

Layer 3+4
- Fx = + 9.3 kN/mm
  (coil stress: 178 MPa)
- Fy = - 5.5 kN/mm
  (coil stress: 106 MPa)

- *An increase of cable width would help reduce the horiz. coil stress*
- *Strand diameters >1 mm should be pursued for this application*

Conclusions

- A 200mm bore, 13.6T dipole with internal absorbers
- Two conceptual designs – shell and block type
- Shell, block with operating margin: 75-80%, 80-90% respectively
- High but manageable pre-stress (185MPa)
- High but manageable stored energy (8.6 MJ/m)
- Nb_3Sn technology that can be applied today.
- Use 1m model for a short sample test facility.

<u>Next step</u>

- Complete magnetic and mechanical analysis
- Complete conceptual design