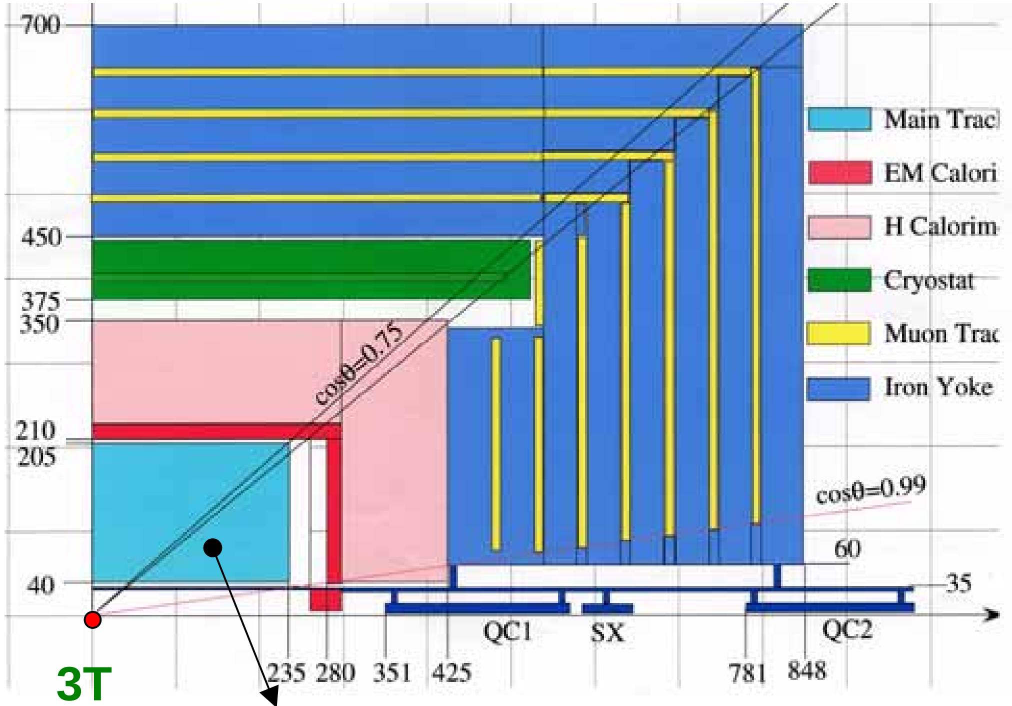
Nov. 10, '04

Support and magnet coil

KEK Hiroshi Yamaoka

Initial configuration of the iron yoke



$$\int_0^{Z_{max}} \frac{Br}{Bz} dz < 2mm$$

→ $$\int_0^{Z_{max}} \frac{Br}{Bz} dz = 2.3 - 8mm$$ → Too large!!

→ **Further amount of iron is necessary.**

→ <u>**Iron Yoke configuration is optimized!**</u>

Material for return yoke

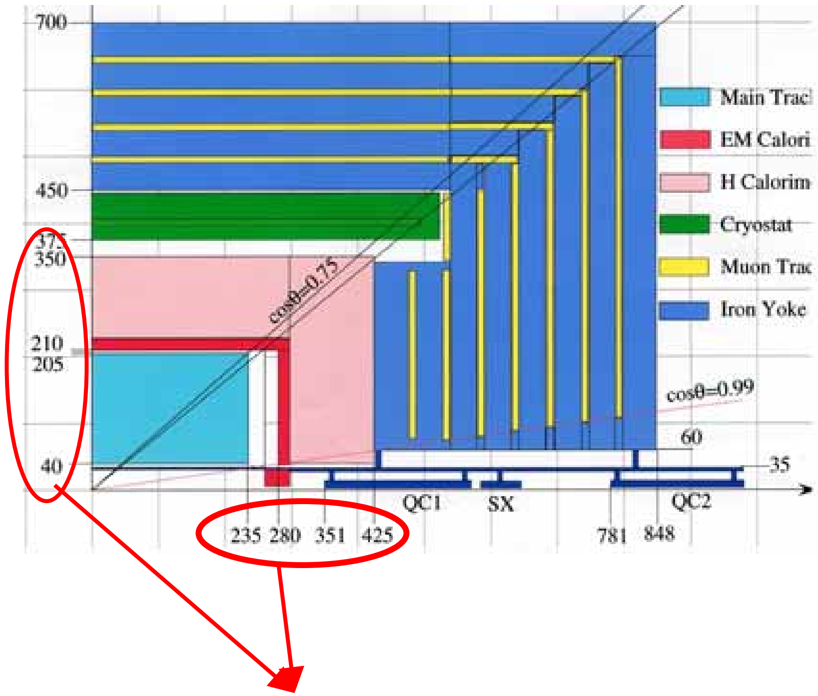
S10C(JIS)

Carbon= 0.1wt%

σ_t=310MPa

σ_e=205MPa

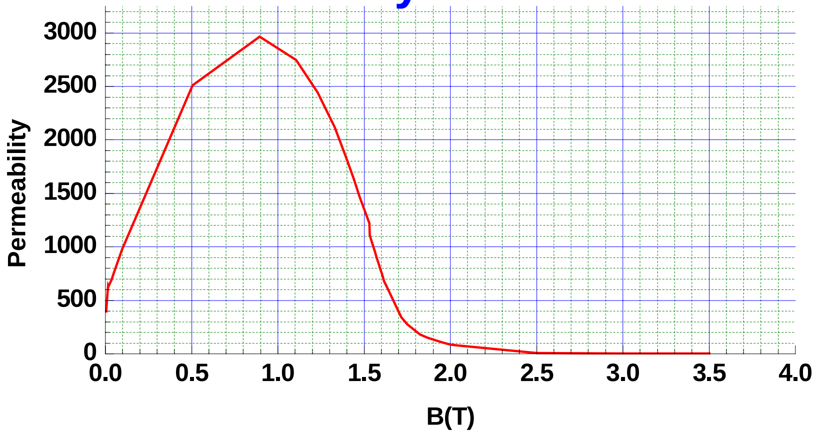
σ_{allow}=120MPa

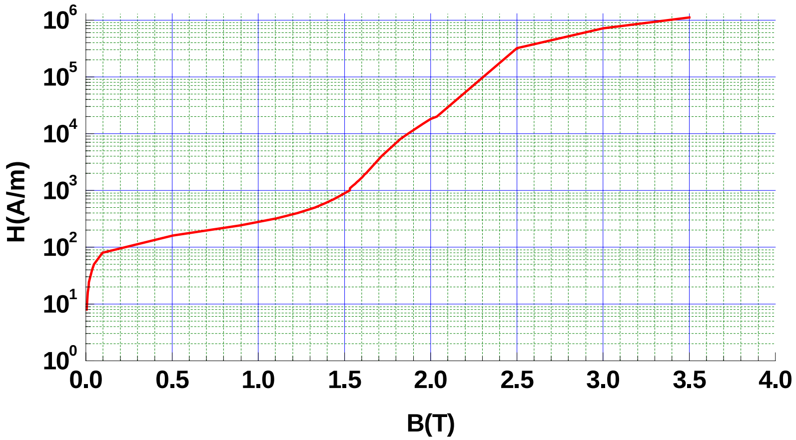


These dimensions are fixed,
Coil length, yoke dimensions are changed.

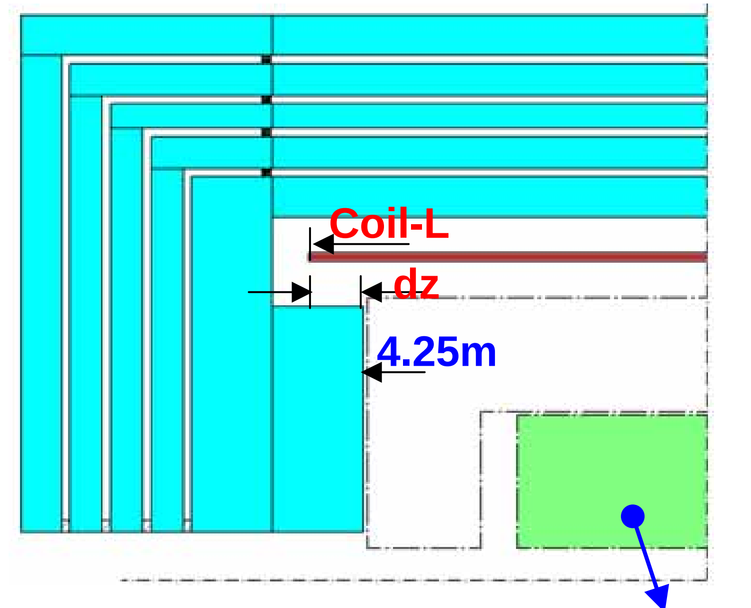
Belle

Permeability

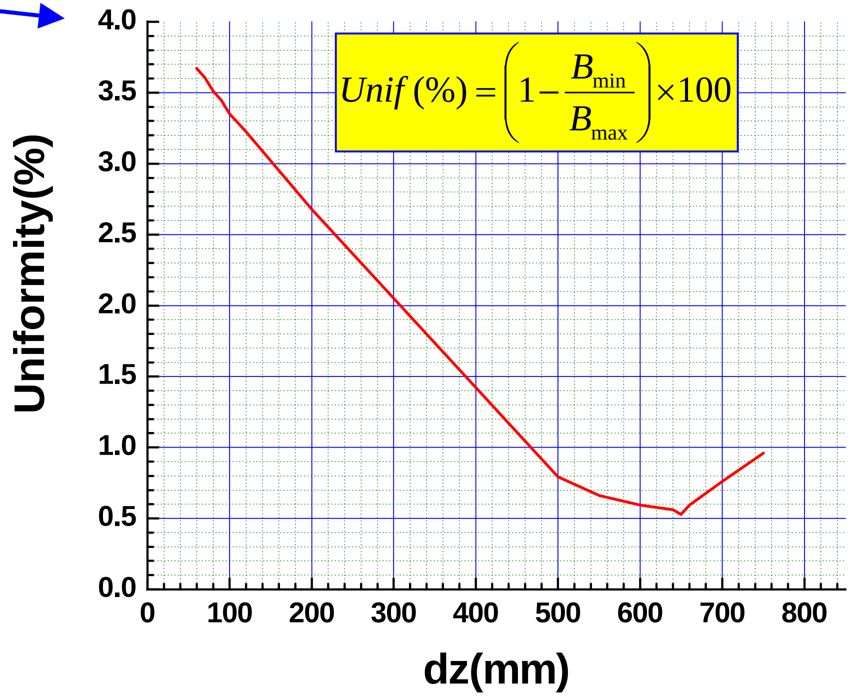


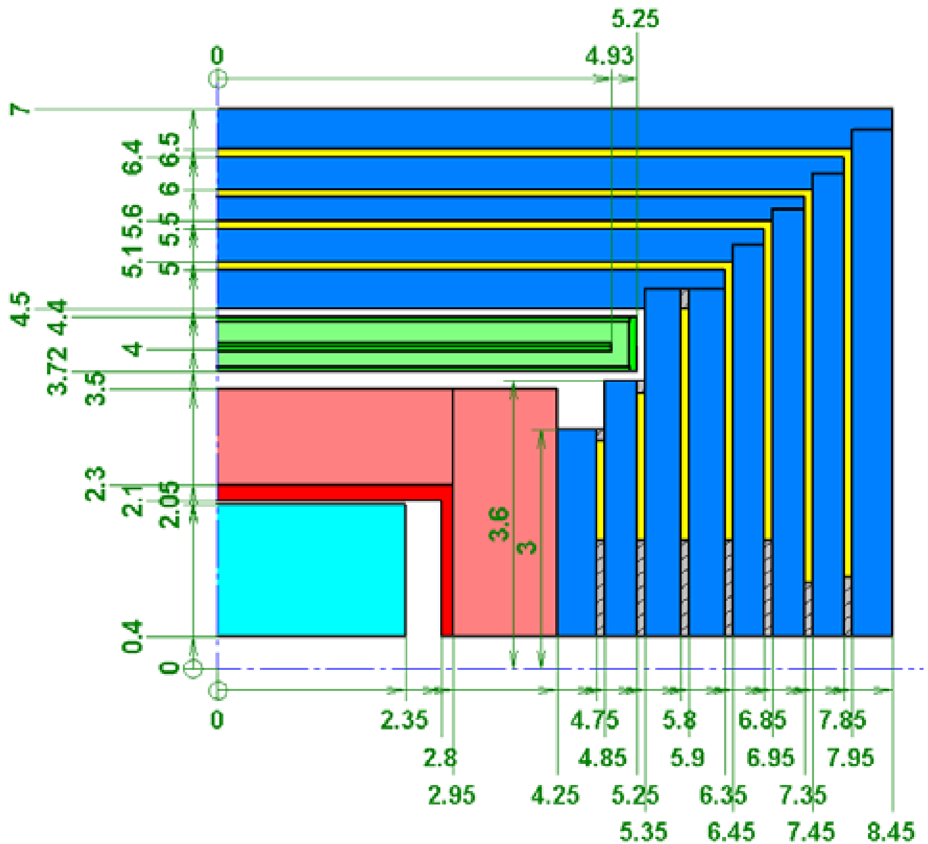


Calculations

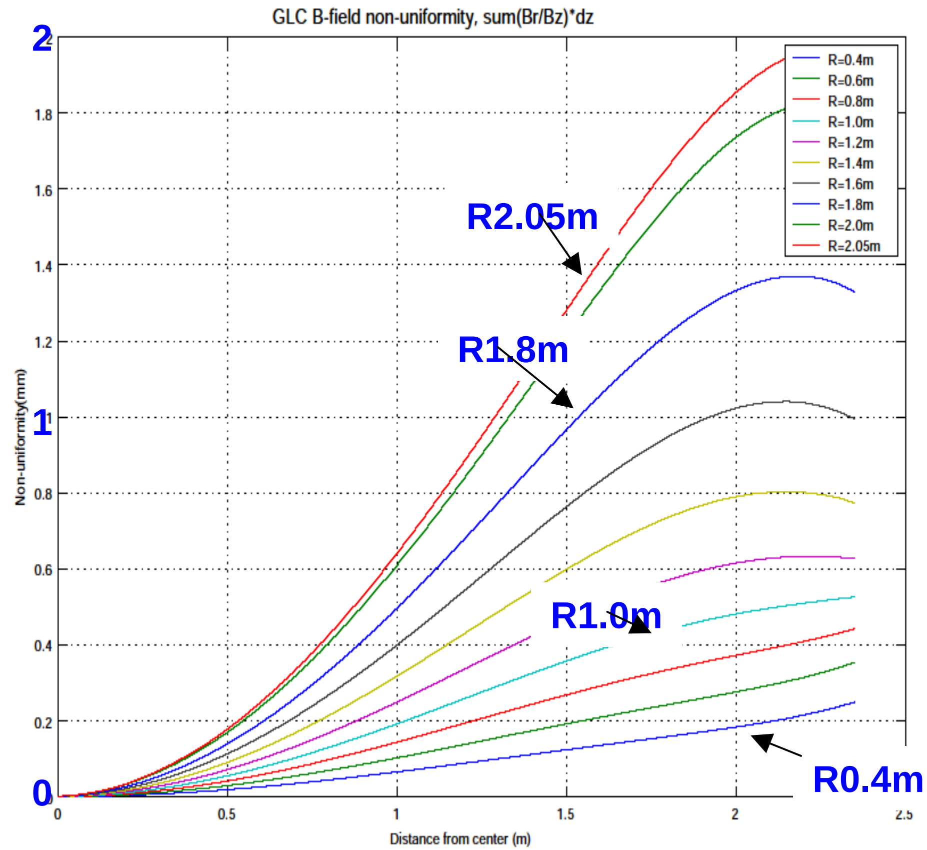


dz	Coil-L	Bmin	Bmax	Bc	Unif(%)
60	4.31	2.965	3.078	3.05	3.671
70	4.32	2.966	3.077	3.049	3.607
80	4.33	2.968	3.076	3.049	3.511
90	4.34	2.968	3.074	3.048	3.448
100	4.35	2.97	3.073	3.047	3.352
120	4.37	2.972	3.071	3.046	3.224
200	4.45	2.979	3.061	3.042	2.679
500	4.75	3.003	3.027	3.023	0.793
550	4.8	3.005	3.025	3.017	0.661
600	4.85	3.008	3.026	3.017	0.595
640	4.89	3.01	3.027	3.014	0.562
650	4.9	3.01	3.026	3.013	0.529
660	4.91	3.009	3.027	3.013	0.595
700	4.95	3.004	3.027	3.01	0.76
750	5	2.999	3.028	3.006	0.958



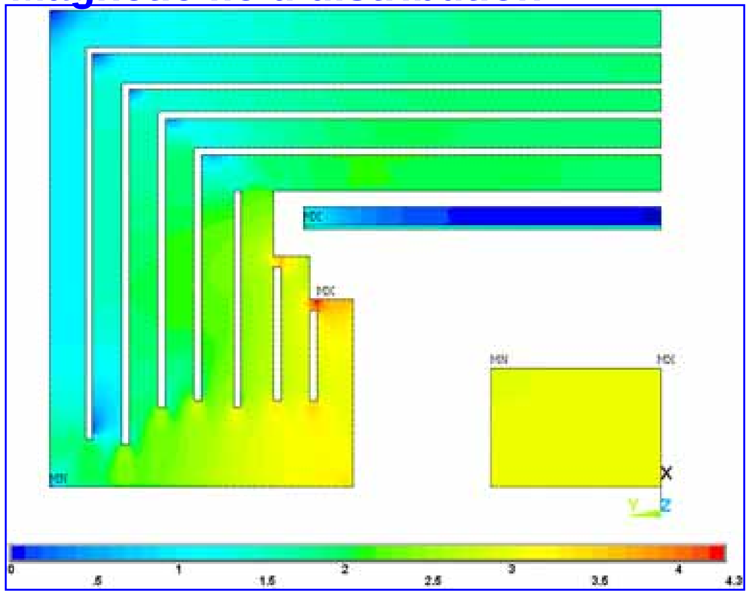


5.25
4.93
0
7
6.5
6.4
6
5.6
5.5
5.1
5
4.5
4.4
4
3.72
3.5
3.6
3
2.3
2.1
2.05
0.4
0
0
2.35
2.8
2.95
4.25
4.75
4.85
5.25
5.35
5.8
5.9
6.35
6.45
6.85
6.95
7.35
7.45
7.85
7.95
8.45

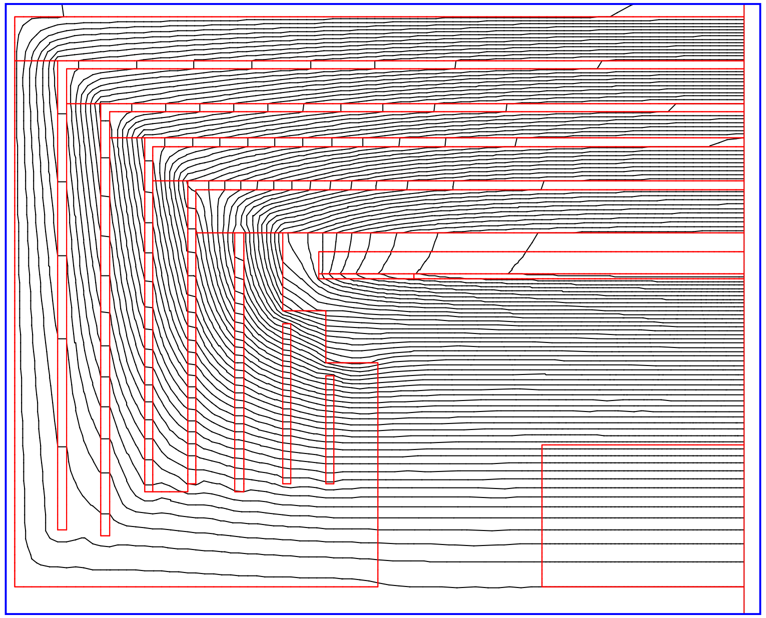


GLC B-field non-uniformity, sum(Br/Bz)*dz
Non-uniformity(mm)
Distance from center (m)
R=0.4m
R=0.6m
R=0.8m
R=1.0m
R=1.2m
R=1.4m
R=1.6m
R=1.8m
R=2.0m
R=2.05m
R2.05m
R1.8m
R1.0m
R0.4m
2
1
0

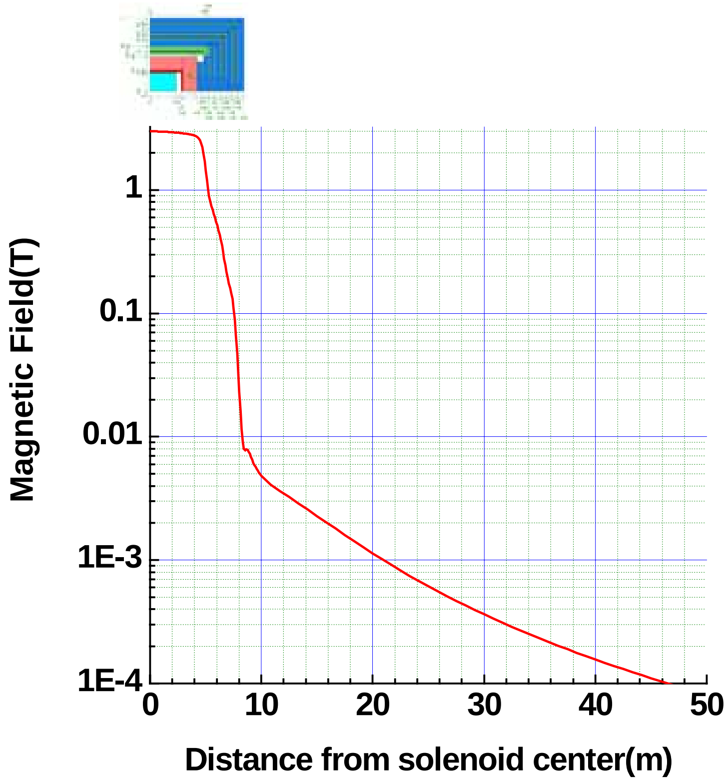
Magnetic field distribution



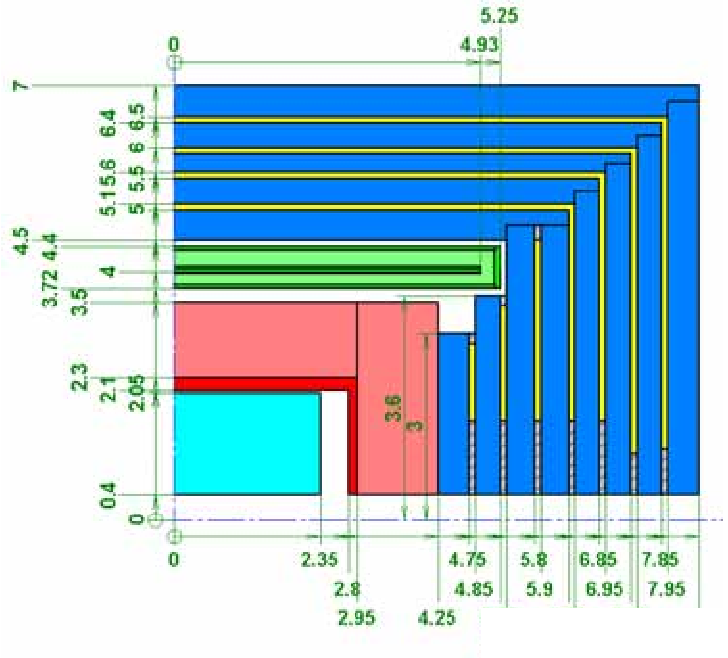
Flux line

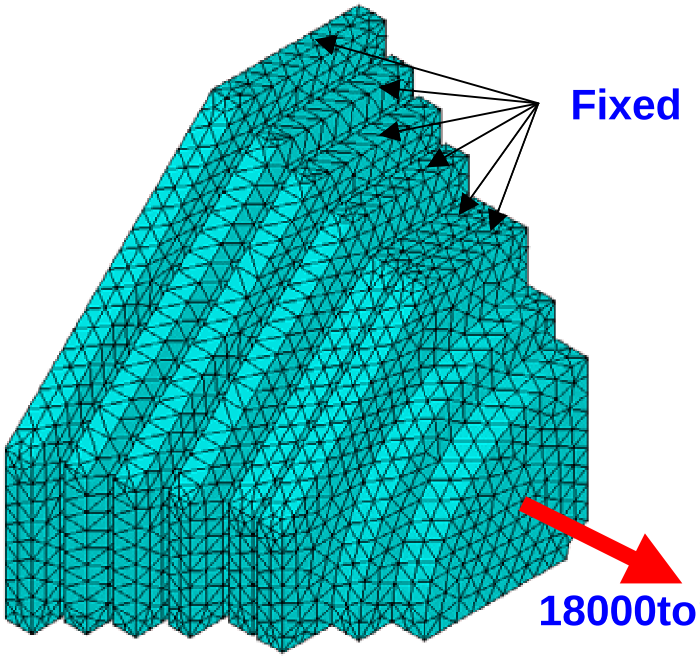


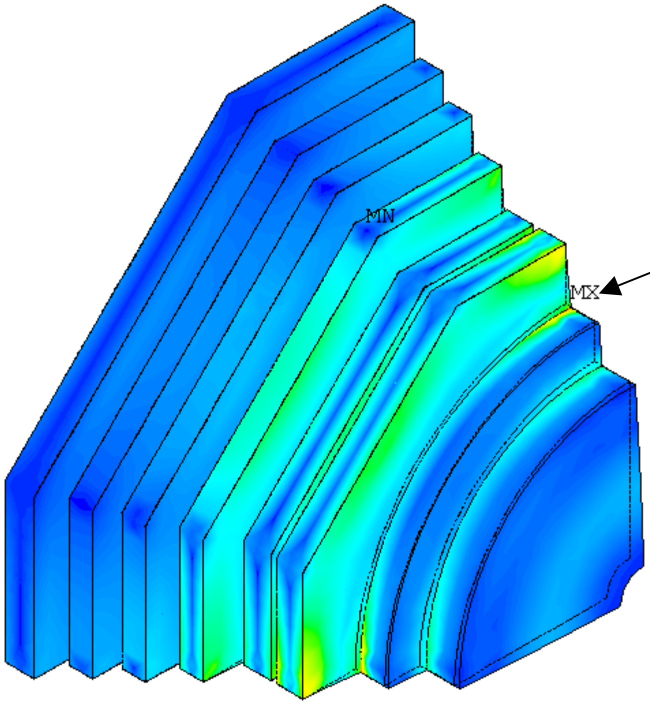
Fringe/Leakage field



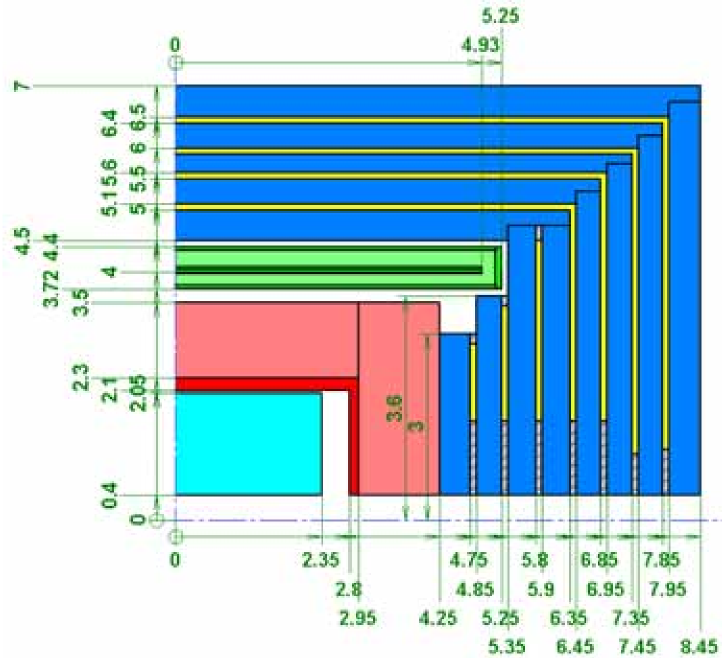
Stress/deformation of End Yoke

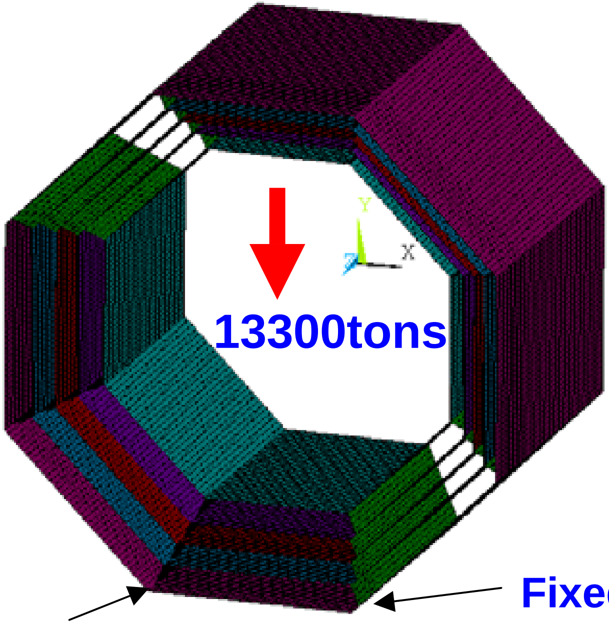


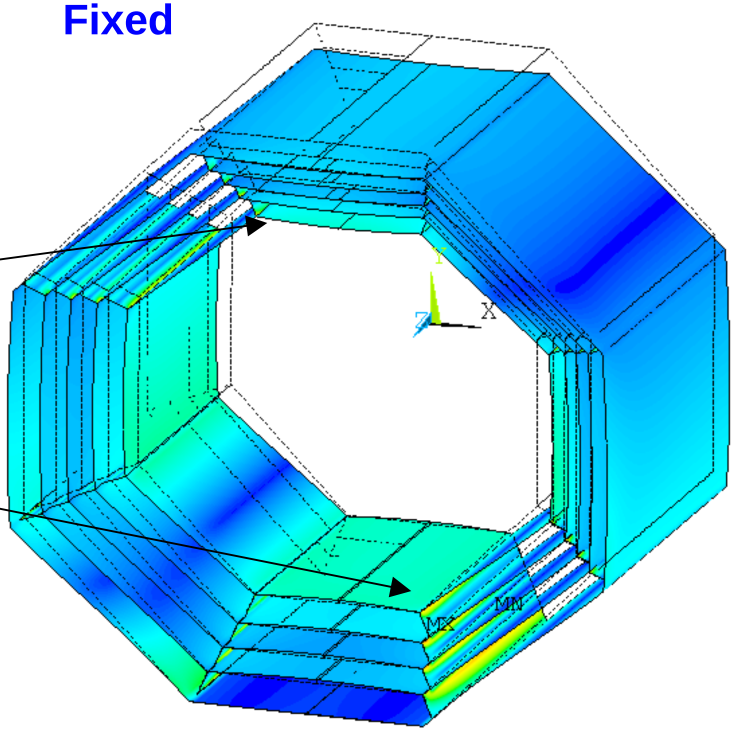




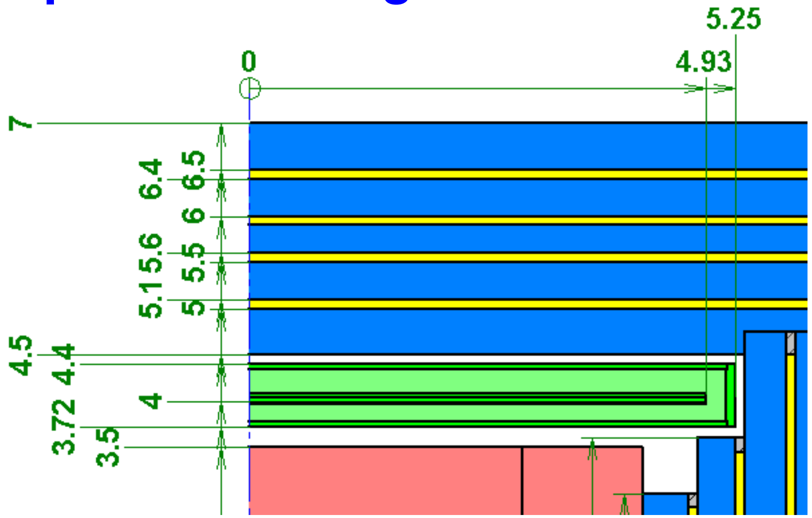
Stress/deformation of Barrel Yoke

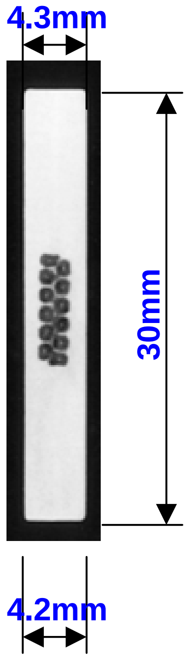






Superconducting Solenoid





(For ATLAS)

Cryostat	Inner radius	3.72m
	Outer radius	4.4m
	Half length	5.25m
Coil	Mean radius	4.0m
	Half length	4.93m
Central magnetic field		3T
# of turns(2 layers)		4576 turns
Current density		741A/mm^2
Nominal current		5338A
Inductance		81.0H
Stored Energy		1.8GJ

Aluminum stabilized superconductor

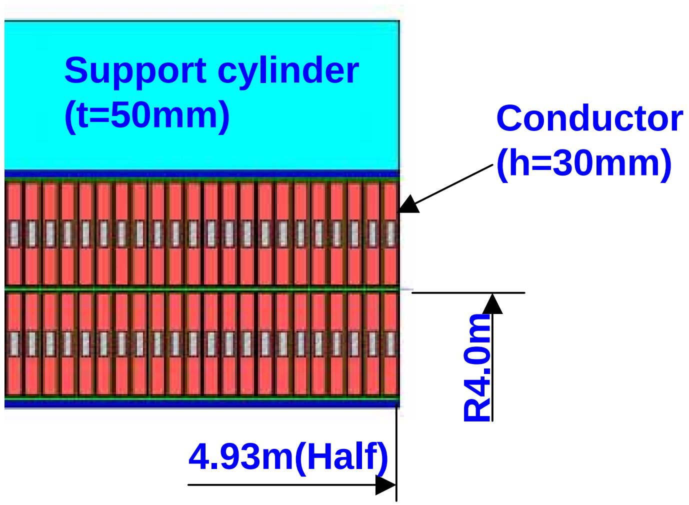
NbTi:Cu:Al= 1:0.9:15.6

Strand diameter: 1.23mm

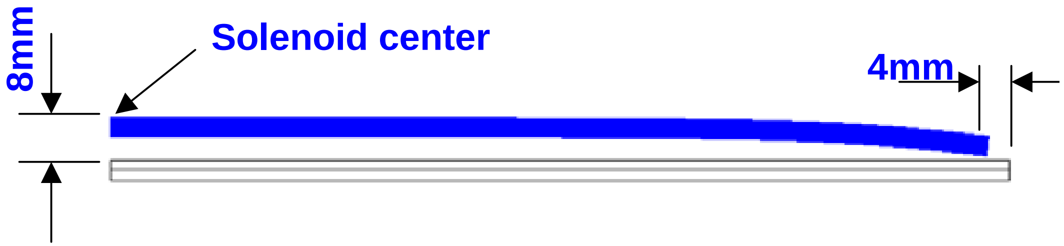
Filament diameter: 20μm

Jc in NbTi at 5T, 4.2K: > 2750A/mm^2

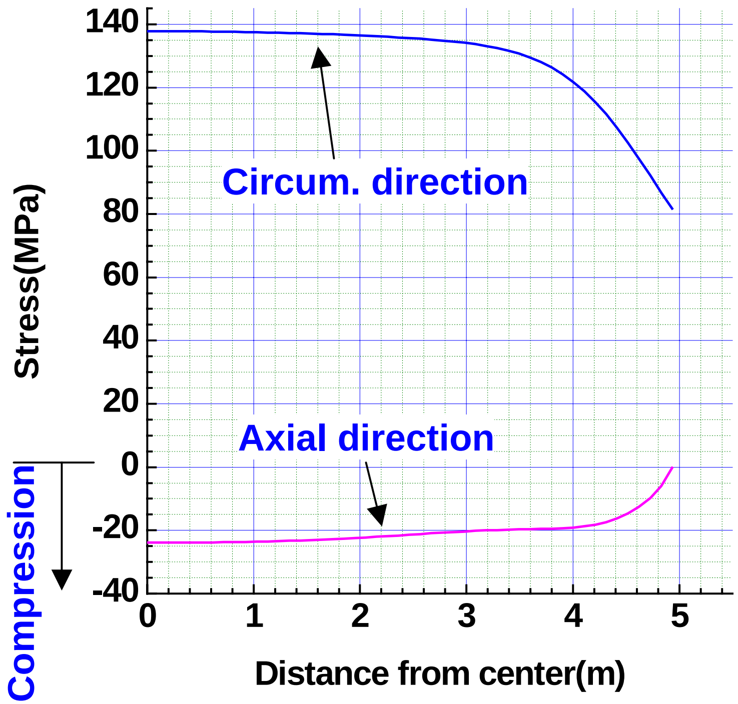
Ic at 5T, 4.2K: > 20300A



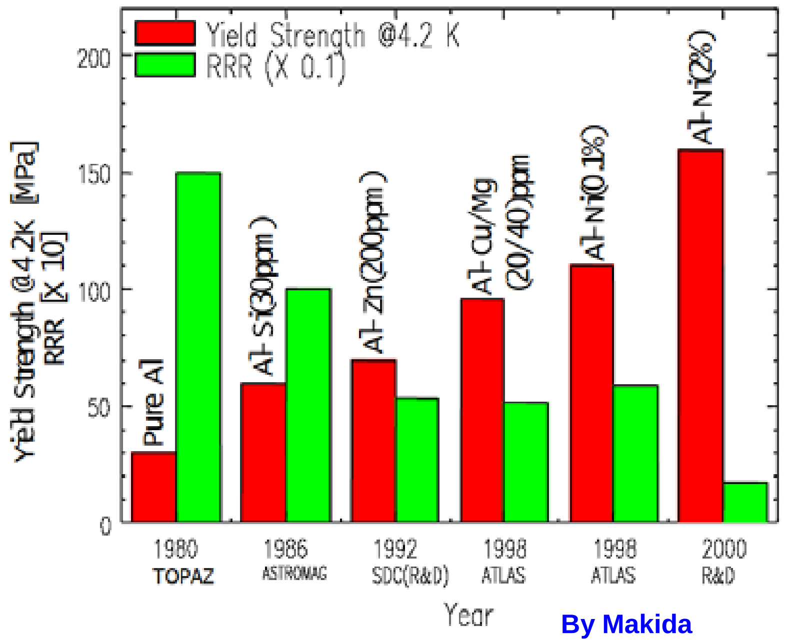
Deformation of the coil



Stress level in the coil

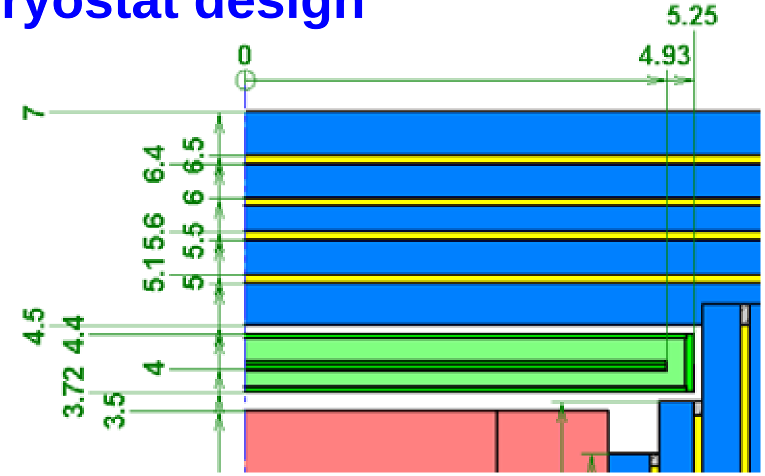


Development of High-strength Al

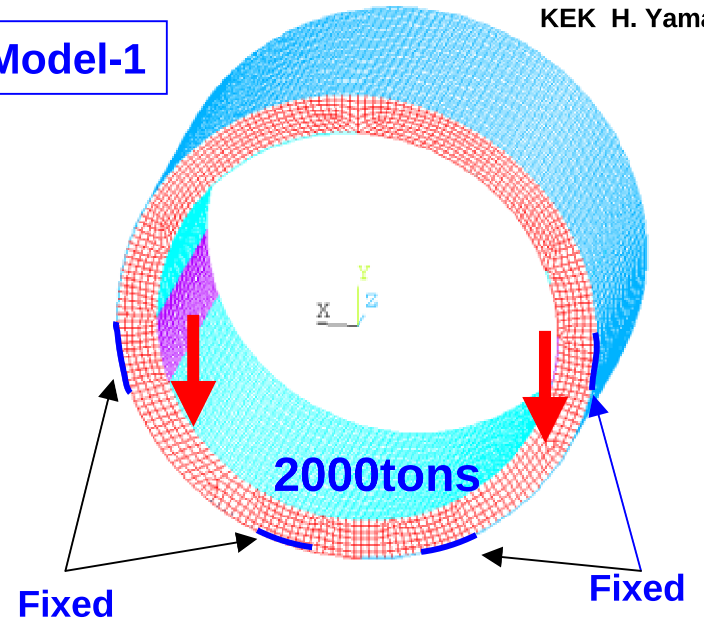


Oct. 29, '04
KEK H. Yamaoka

Cryostat design



Model-1



Load condition

- Weight of the calorimeter: 2000tons
- Weight of the solenoid : ~140tons
- Vacuum : 0.1MPa

⇒ Thickness of

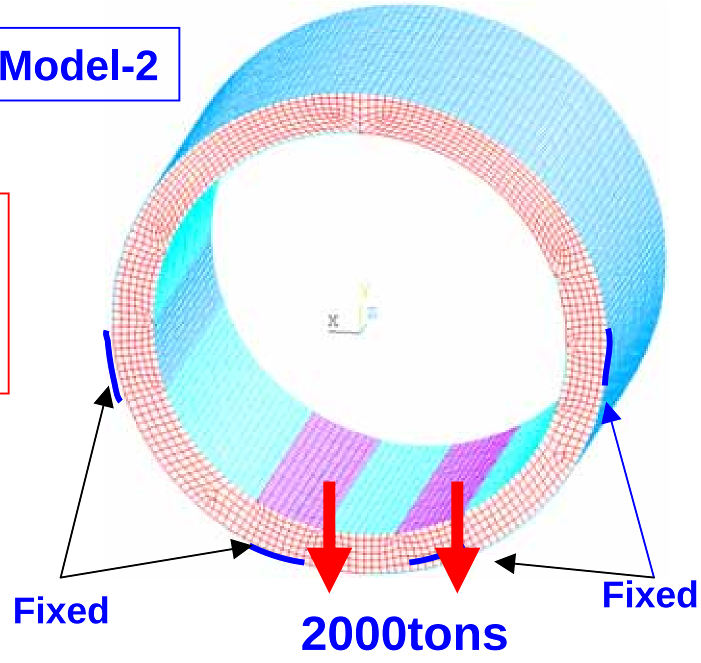
- Inner vacuum vessel
- End plates

were optimized.

SUS304

σ_t =530MPa
σ_y =210MPa
σ_{allow}=140MPa

Model-2

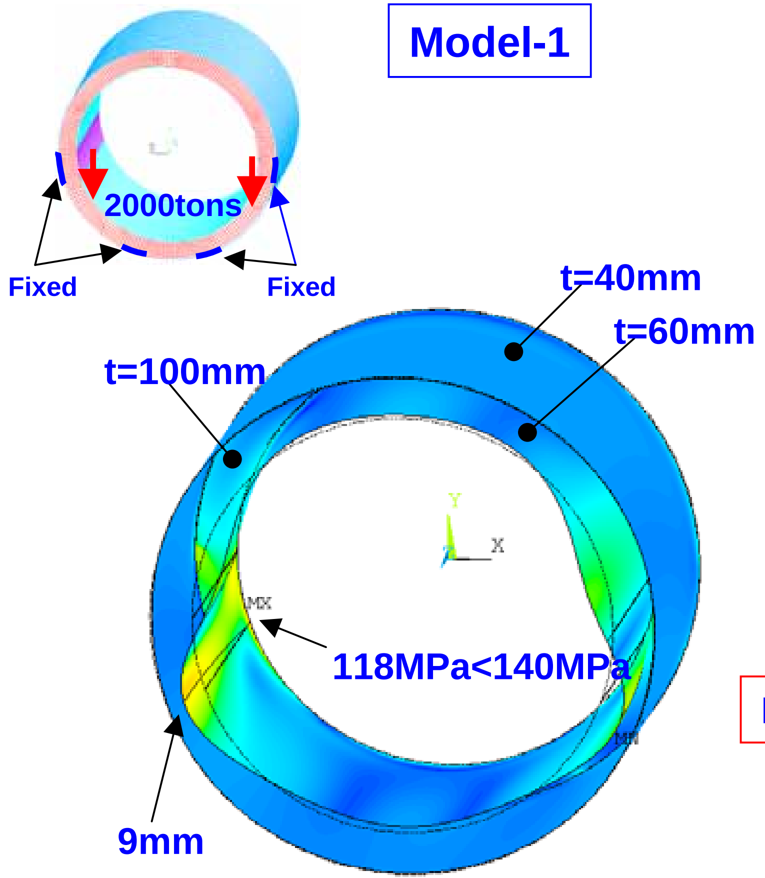


- Outer vac. vessel
  40mm thick ← t

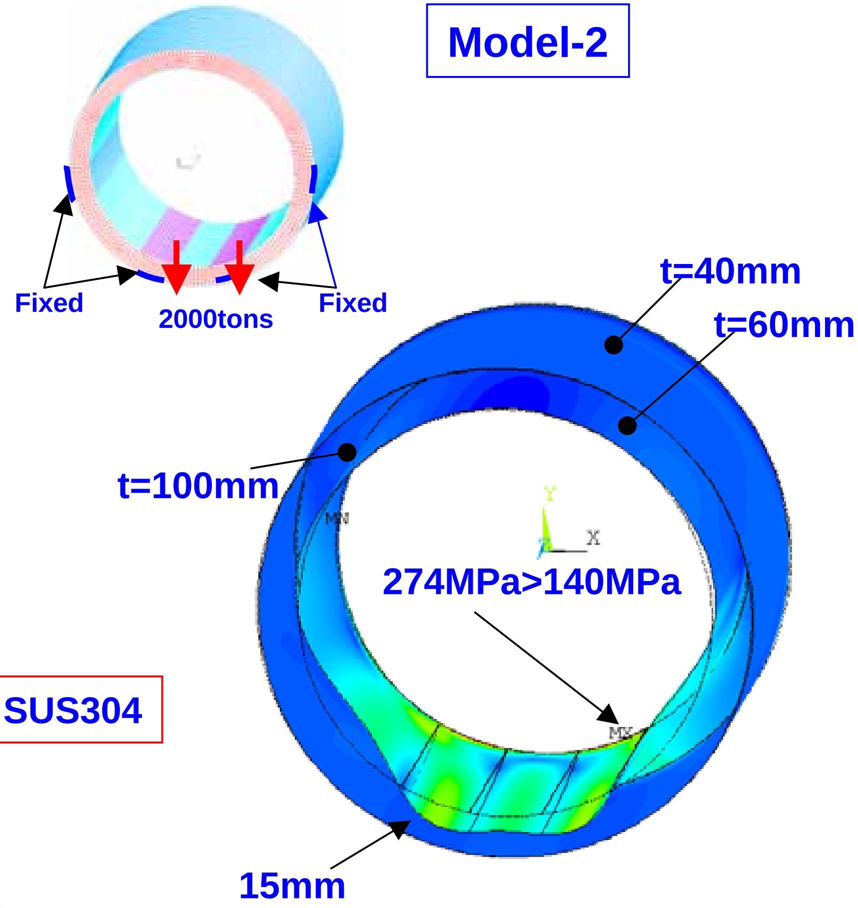
$$p = \frac{0.855}{(1-\mu^2)} \cdot \frac{0.75E}{\left(r/t\right)^{\frac{5}{2}} \cdot \left(L/r\right)}$$

p: Buckling pressure
0.1MPa x 2(safety factor)

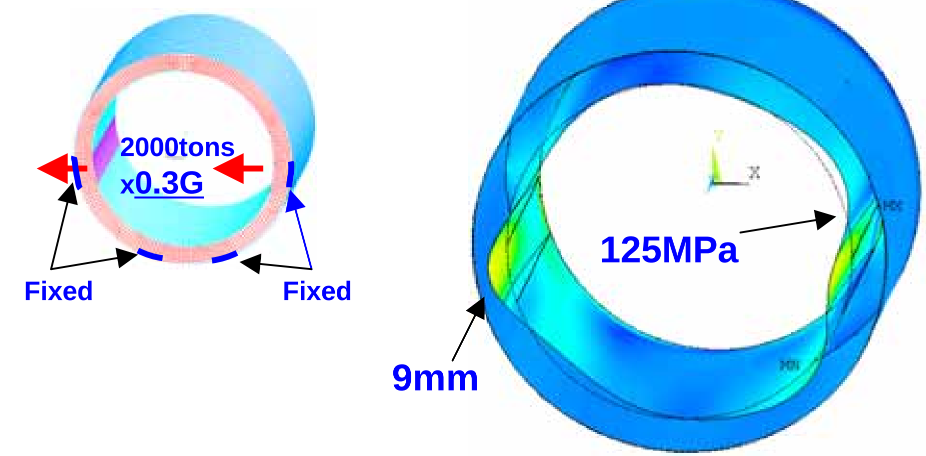
Model-1



Model-2



Material: SUS304

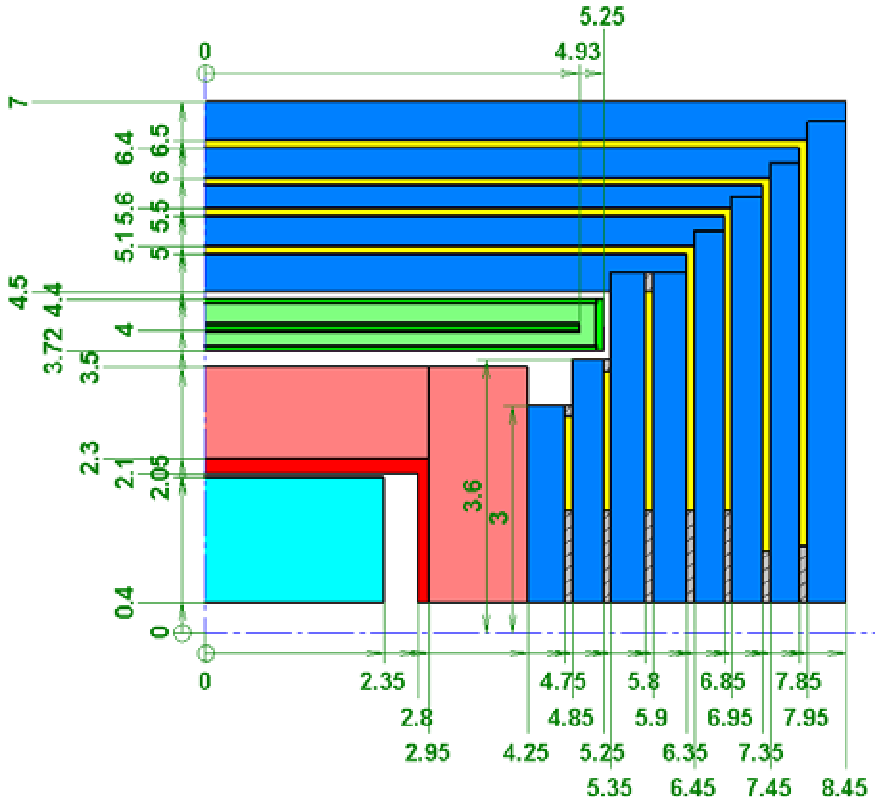


Stiffness: D

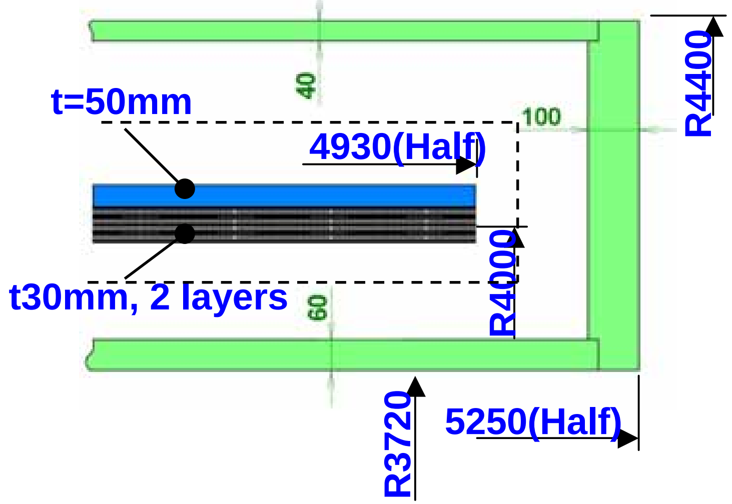
$$D = E \cdot I$$

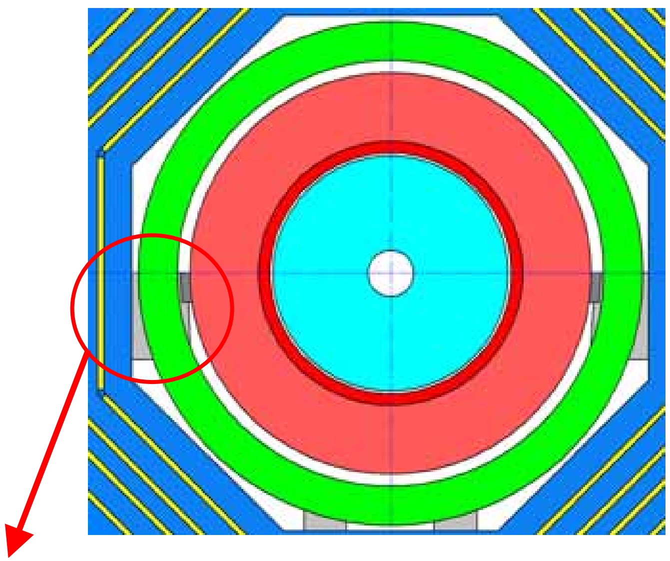
$$I = \frac{Width \cdot Hight^3}{12}$$

E: Young's modulus
I: Moment of Inertia



*Coil support system is not designed yet.

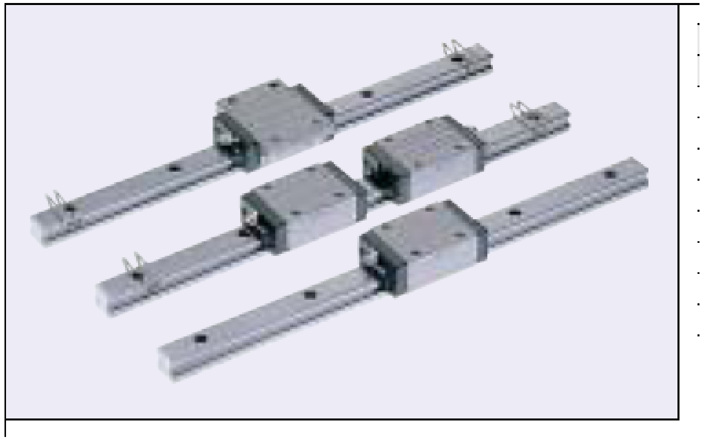


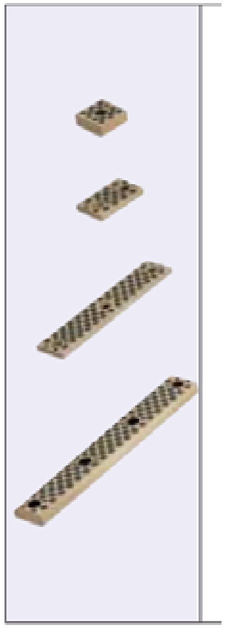


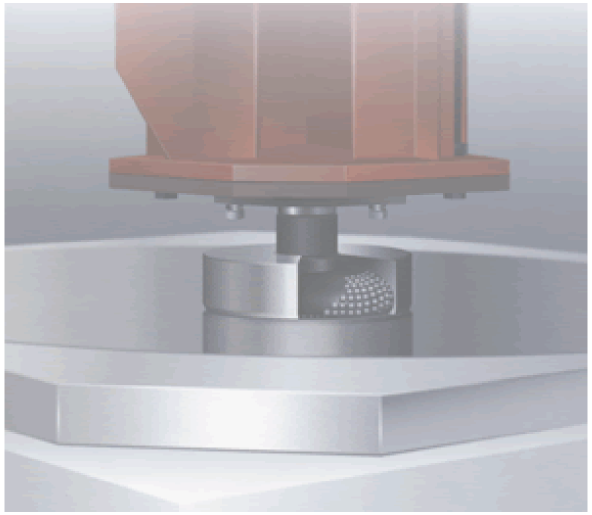
*Detail design is not yet done.

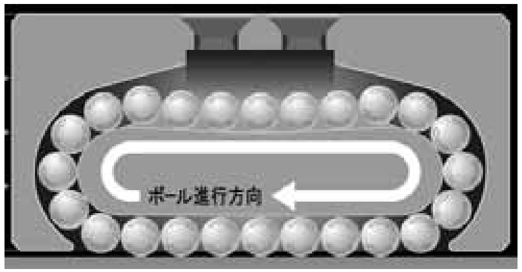
Requests to calorimeter structure;

- Calorimeter is divided to several pieces in the axial direction.
- One piece of calorimeter is stiff enough.








ボール進行方向

Feb. 14, '02 H. Y

Cost estimation of Return Yoke

Cost estimation of Solenoid

○ Law material

¥180/kg x 11000e3kg = ¥19.8 oku
+α(10%)
19.8x1.1=21.8 oku

○ Machining

Total area for machining of Barrel yoke
340m^2
End Yoke:
501m^2
Machining cost per 1m^2
¥200000/m^2
Total:
(340+501)m2x20万=16.8 oku
+α(10%)、
16.8x1.1=18.5 oku

○ Design cost

1 oku

○ Cost for QC

0.5 oku

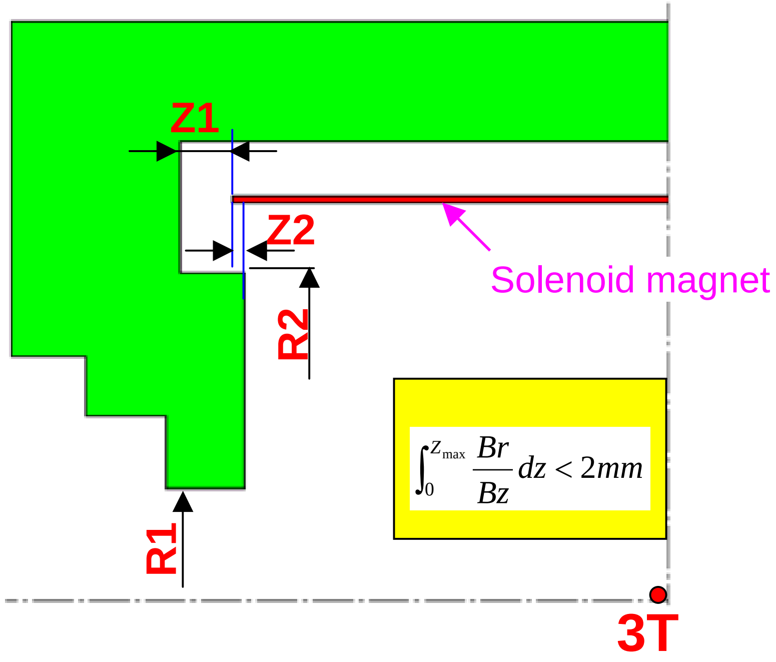
○ 利益率

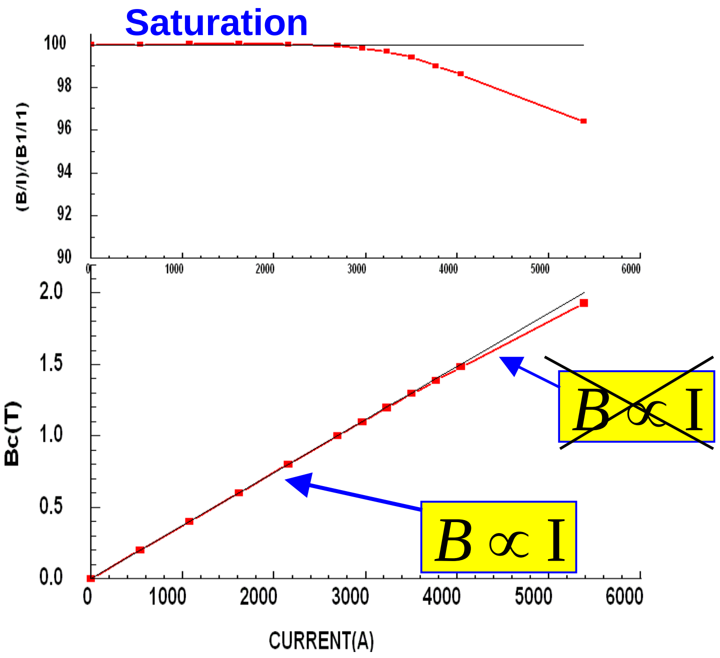
20%とすると、
41.8x0.2=8.4 oku

Total

50.2 okux1.05=52.7 oku

The way for improving field uniformity





- Plenty of amount of iron
- Minimize Z1,R1
- Optimize Z2,R2