MDI/Integration issues of GLD(c)

Yasuhiro Sugimoto
KEK

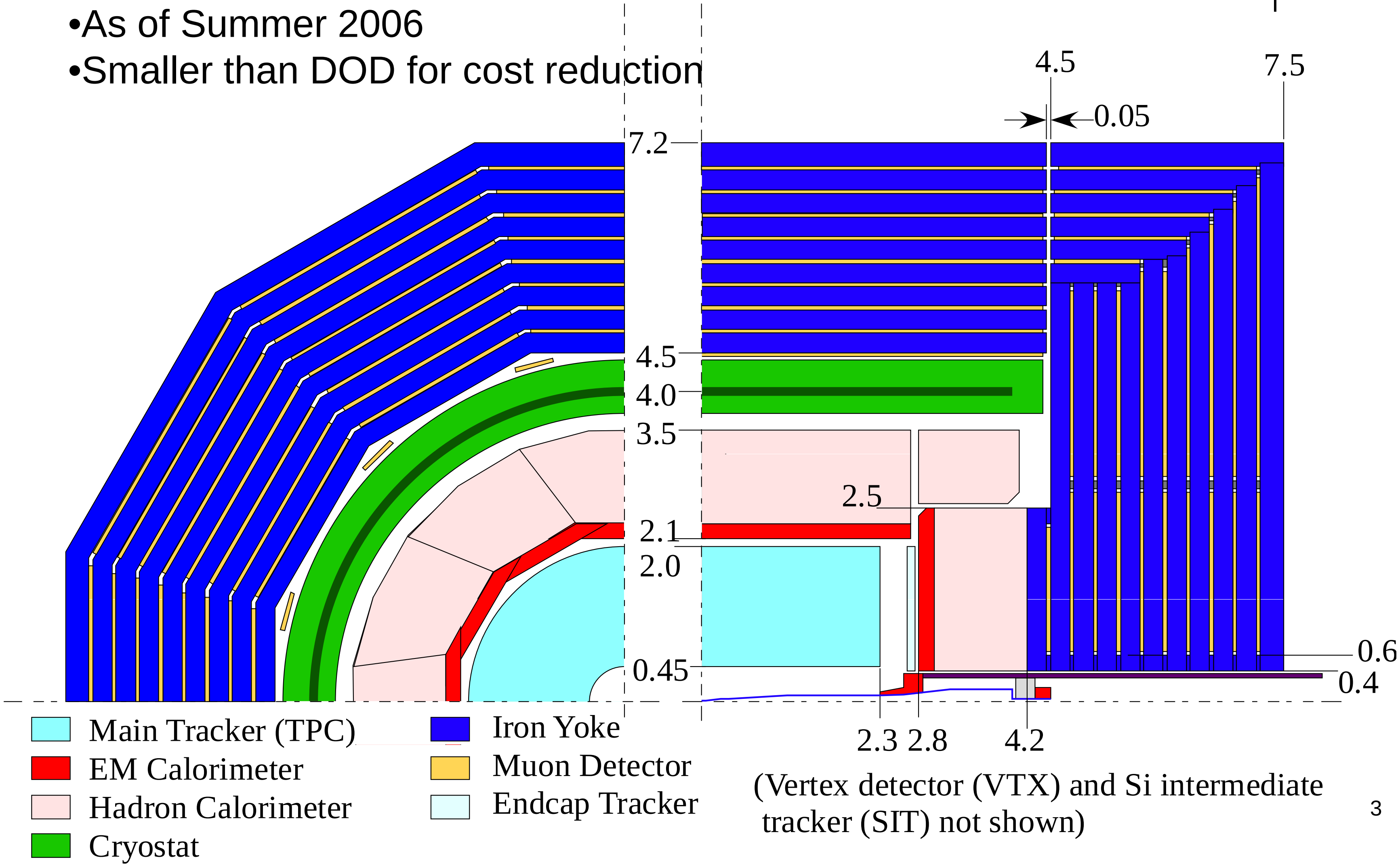
Jan. 15, 2008 @DESY-Zeuthen

Contents

- Global parameters
- Surface assembly
- Solenoid and return yoke
- End-cap design / opening-closing
- Beam pipe / Small angle region
- Beam background and VTX

Original GLD

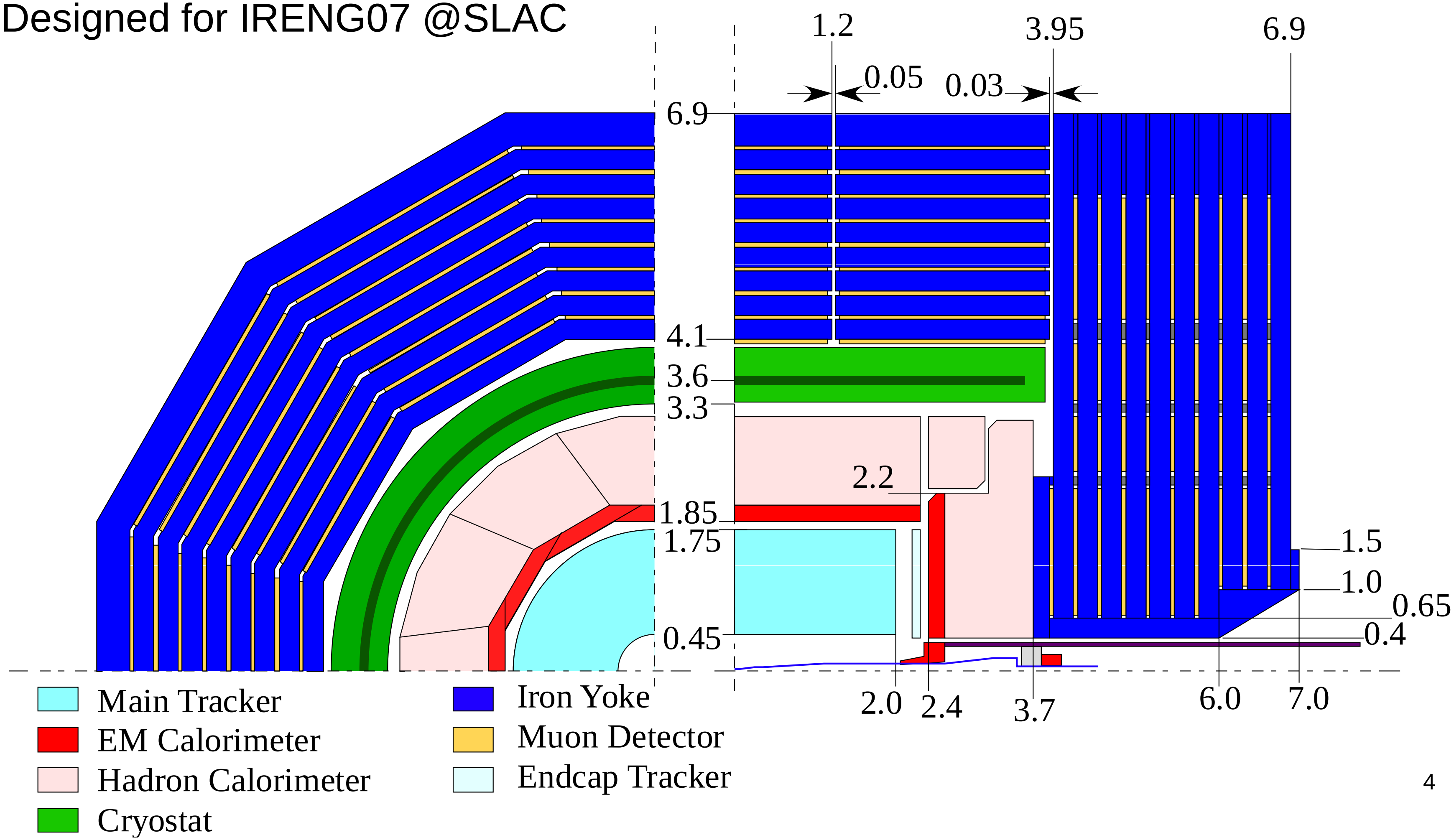
- As of Summer 2006
- Smaller than DOD for cost reduction



(Vertex detector (VTX) and Si intermediate tracker (SIT) not shown)

Compact GLD - GLDc

- GLDc ~ GLD' (Average of GLD and LDC)
- Designed for IRENG07 @SLAC



Parameters (1)

			GLD	GLDc
Iron Yoke	Barrel	Rout	7.2 m	6.9 m
		Rin	4.5 m	4.1 m
		Weight	6090 t	5080 t
	E.C.	Zin	4.2/4.5 m	3.7/3.95 m
		Zout	7.5 m	6.9 m
		Weight	3260 t / side	3050 t / side
Solenoid	B		3 T	3.5 T
	R		4 m	3.6 m
	Z		4 m	3.6 m
	Weight		~330 t	~300 t
	E		1.6 GJ	1.7 GJ
Stray field @Z=10m			70 G	120 G

Parameters (2)

			GLD	GLDc
TPC (active region)	Rin		0.45 m	0.45 m
	Rout		2.0 m	1.75 m
	Zmax		2.3 m	2.0 m
Barrel CAL	ECAL	Rin	2.1 m	1.85 m
		Rout	2.3 m	2.05 m
		$BRin^2$	**13.2 Tm^2**	**12.0 Tm^2**
	HCAL*	Rout	3.5 m	3.15 m
		Thickness	1.2 m	1.1 m
	Weight		1750 t	1130 t

* Pb/Scinti option

$BRin^2$=10.2 for LDC and 8.1 for SiD

Parameters (3)

			GLD	GLDc
EC CAL	ECAL	Zmin	2.8 m	2.4 m
		Zmax	3.0 m	2.6 m
	HCAL	Zmax	4.2 m	3.7 m
		Thickness	1.2 m	1.1 m
	Weight		270 t / side	270 t / side
CAL	Total weight		2290 t	1670 t
Detector weight	Barrel yoke + solenoid		6.4 kt	5.4 kt
	Barrel total		8.2 kt	6.5 kt
	Endcap total		3.5 kt/side	3.3 kt/side
	Total weight		**15 kt**	**13 kt**

Global shape

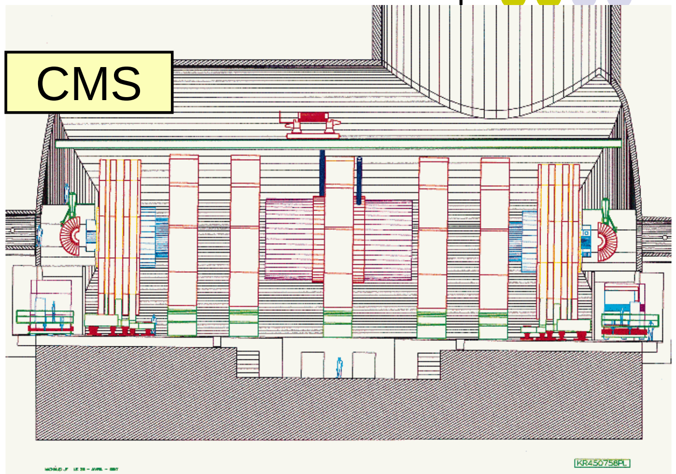
- Merits of dodecagonal shape
  - Reduction of unnecessary gaps

	8		12		16	
TPC-ECAL (R=2.1m)	17.3cm		7.4cm		4.1cm	
HCAL-Solenoid (R=3.5m)	8	16	12	24	16	32
	26.6cm	6.7cm	11.9cm	3.0cm	6.7cm	1.7cm
Solenoid-Yoke (R=4.5m)	37.1cm		15.9cm		8.8cm	

  - Reduction of size and deformation of iron plates by self weight
    - Length of a side at R=7m is 5.8m for octagon and 3.75m for dodecagon
    - Octagonal: δ~1mm / Dodecagonal: δ~0.2mm for 25cm thick iron of the outermost layer (R~7m)

Surface assembly

- GLD
  - Barrel part (Yoke+Sol.) > 6000 ton
  - For CMS style assembly (using 2000 ton crane to descend), it should be split into 5 rings and there will be many gaps
    - Large stray field
    - Difficulty in alignment of rings
  - In present design, GLD barrel yoke is split in R- and ϕ-direction into 24 pieces
  - 400-t cranes in the underground exp hall and surface assembly hall
- GLDc
  - Barrel part (Yoke+Sol.) < 6000 ton
  - Pure CMS style assembly can be done by splitting the barrel part into 3 rings and splitting each end cap part into two halves
  - 50~100-t crane underground, 2000-t crane for the shaft, and 80-t crane in the surface assembly hall
  - 3 barrel rings and 4 endcap halves can move separately using air pad



Solenoid

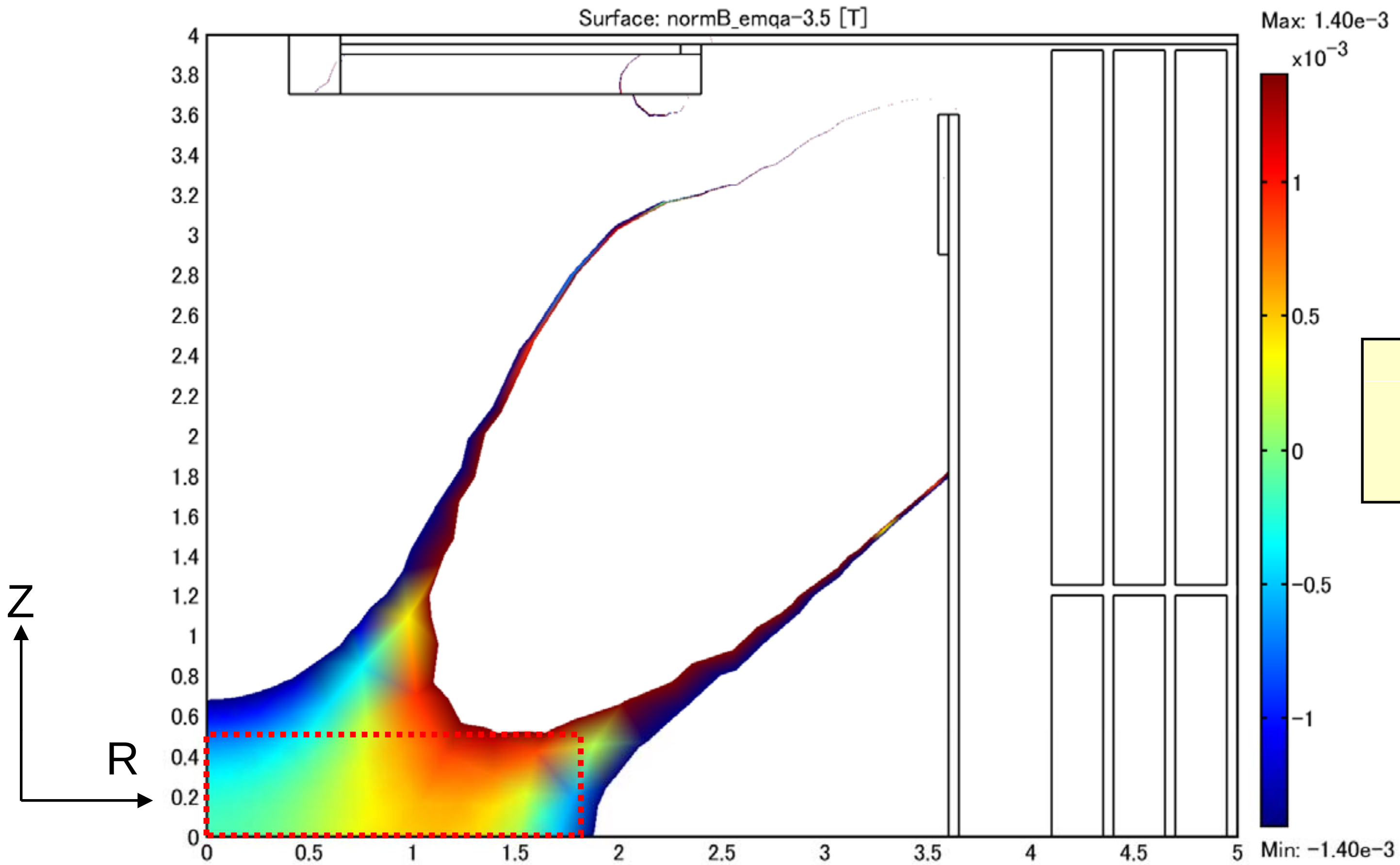
- Parameters of GLD (DOD) solenoid
  - Coil radius 4m
  - Coil half length 4.43m
  - Coil layers 2 (4 at both ends for uniformity)
  - Wire ATLAS type
  - Stored energy 1.6 GJ
  - Cold mass 78 ton
  - E/M 20 kJ/kg
- Cryostat
  - Wall should be thick enough (6cm SUS) to support inner detectors, particularly calorimeters
  - Rin=3.715m, Rout=4.4m
- Problem in GLD solenoid design
  - E/M of GLD is too large (ATLAS type wire has low mass)
  - New design/R&D of the superconducting wire is necessary

Iron return yoke

- Thickness – GLD:2.7m, GLDc:2.8m (LDC:2.15m)
  - GLD is designed to make stray field at Z=10m small enough (70/120 G for GLD/GLDc)
  - LDC design will cause large stray field outside the detector
  - If an electronics hut is built close to the detector, we should define a tolerable level of stray field (less than x gauss at $R>R_{det}+y$)
    - Electronics malfunction (saturation of ferrite core, etc.)
    - Safety (handling of tools, human health, etc.)
- Thickness of each iron slabs
  - GLD(c): 25~30cm (LDC: 10cm); No tail-catcher for GLD(c)
  - Deflection due to magnetic force/self weight should be estimated

B-field of GLDc

- Field uniformity

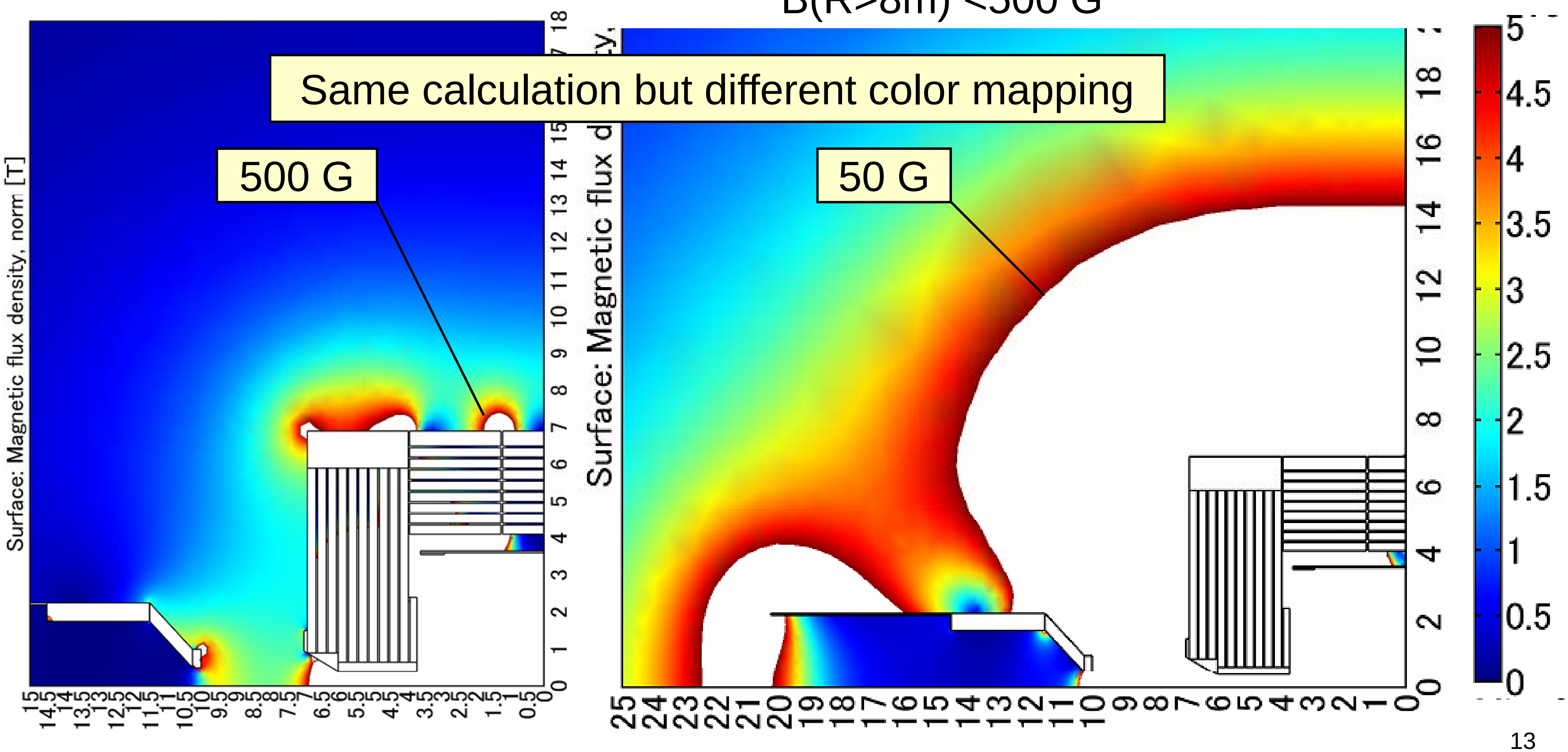


δB/B<4x10^{-4} for |Z|<50cm

B field of GLDc

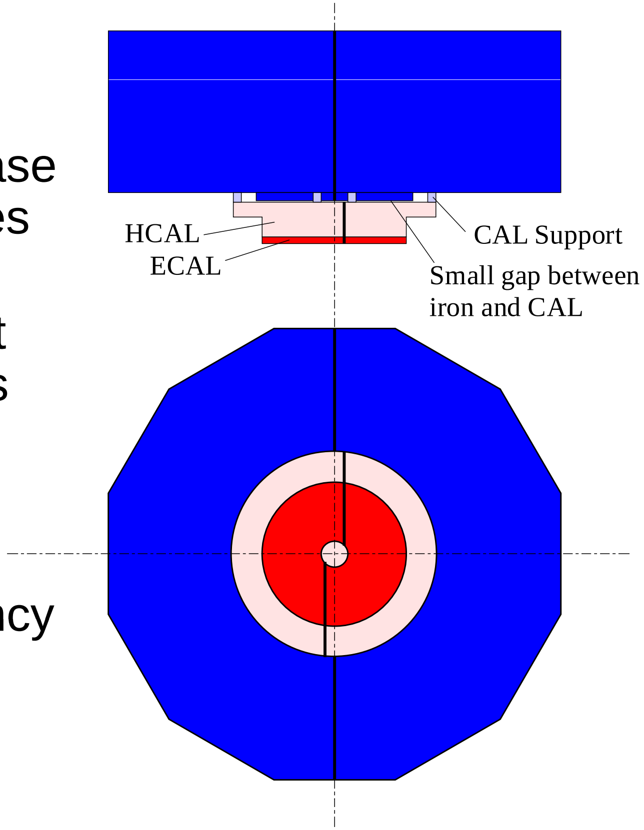
- Stray field

B_0=3.5 T
B(10.5m<Z<20m) <50 G
B(R>8m) <500 G



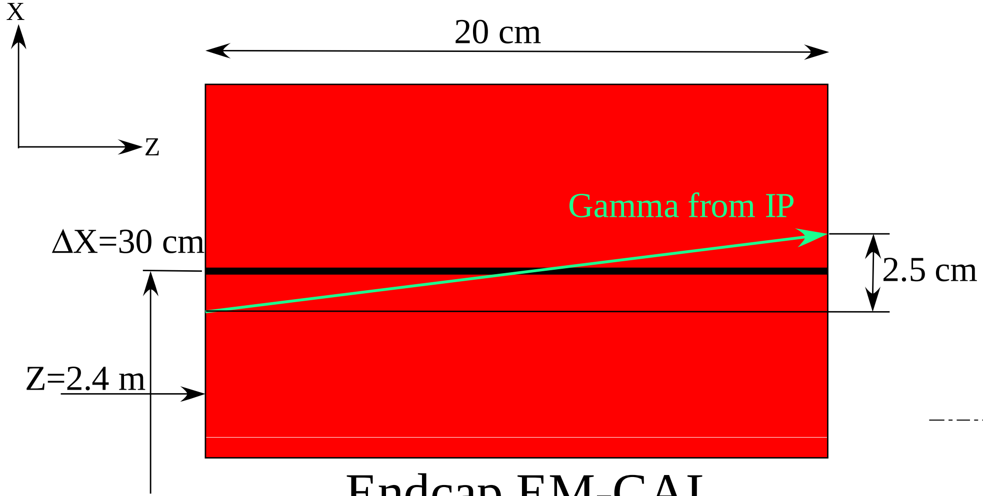
Design of GLDc Endcap

- GLD/GLDc endcap yoke is vertically split
- Installation and maintenance of Muon detectors are done from the splitting plane (X=0 plane) like Belle detector
- Support rings can be put between iron slabs to increase the rigidity of the endcap yoke (75mm-thick side plates are used for GLD)
- Usually two halves may be connected tightly and split only for installation and maintenance of sub-detectors
- Endcap calorimeters can be arranged without dead space
- Because hadrons make shower in the endcap iron, small gap of muon detectors does not make inefficiency of muon identification

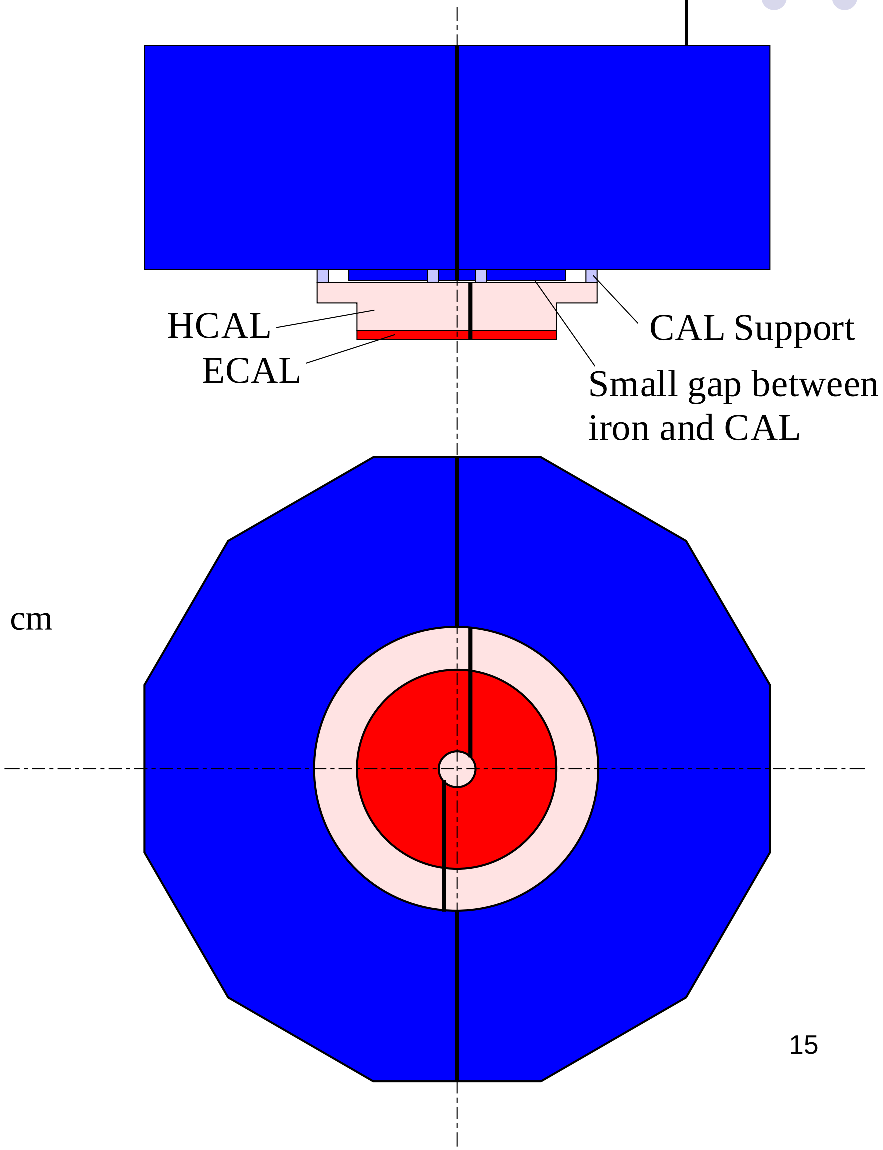


Gap in sub-detectors

- Endcap CAL



Endcap EM-CAL

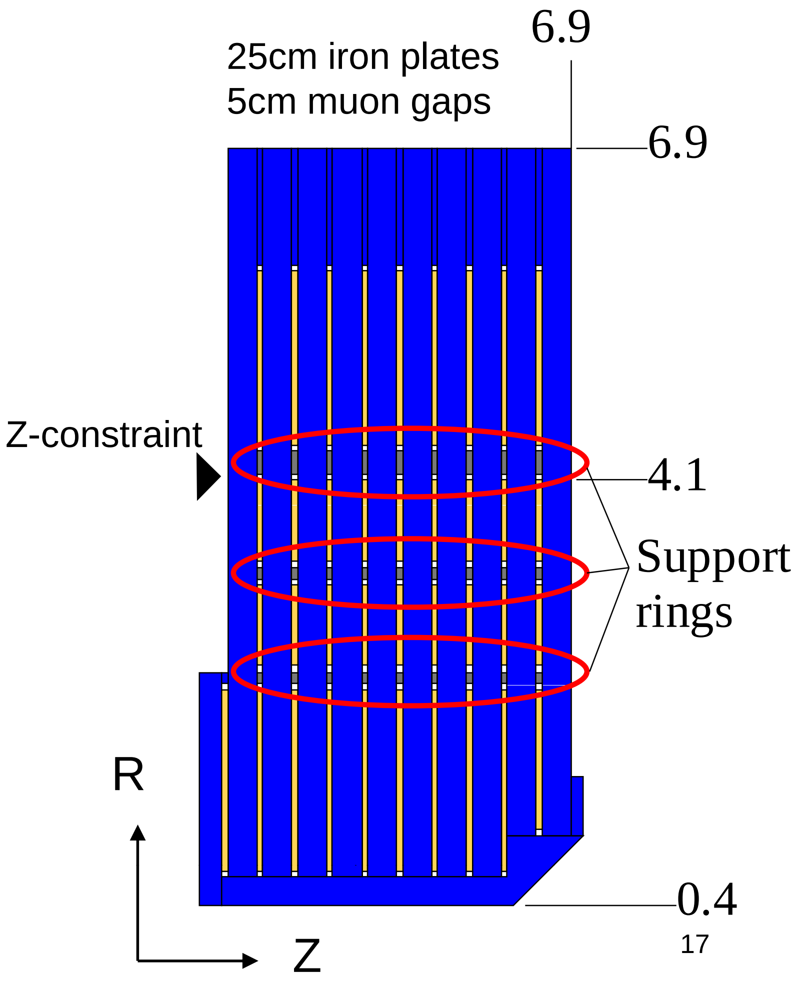


Diameter of endcap hole

- GLD: R=40cm
  - Not changed from 2001 (JLC detector)
    - QD0
    - Compensation (Anti) solenoid (7mrad crossing angle)
    - 10cm thick tungsten support tube
- LDC: R=30cm(?)
  - Designed for TESLA detector
    - No compensation solenoid (head-on collision)
- Information from BDS group is necessary
  - What is the design of the anti-solenoid?
  - Do we need extra space around QD0 for alignment mechanism?

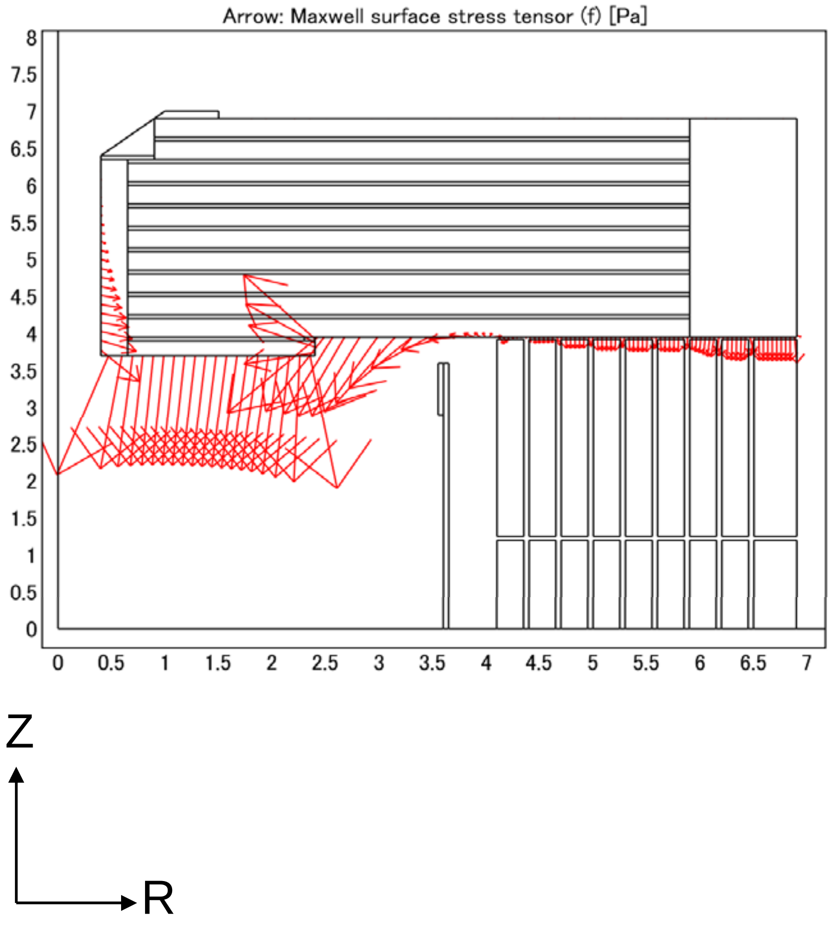
Endcap Deformation

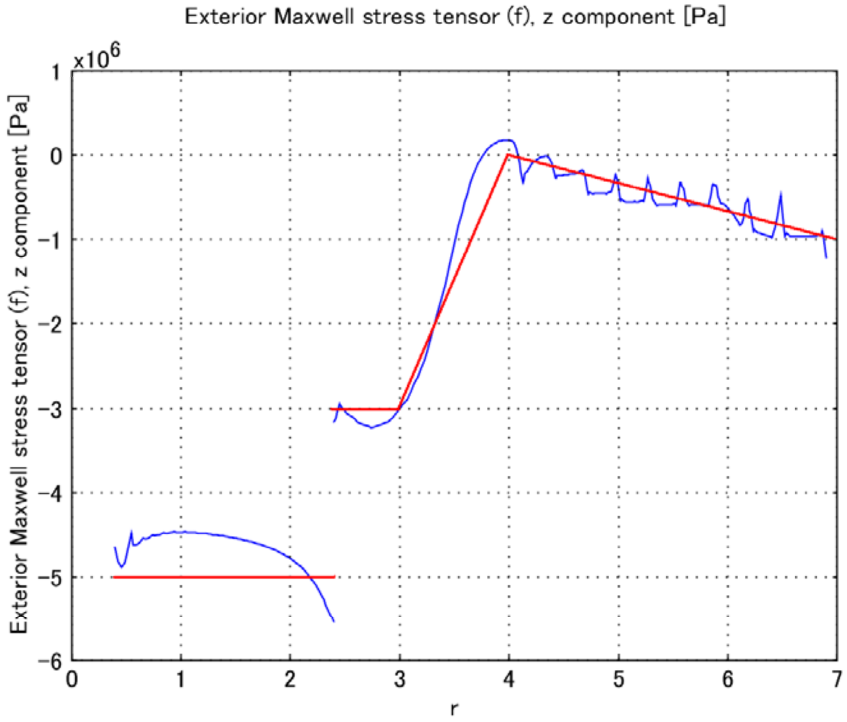
- Calculation by FEA method
  - In B-field calculation, endcap is treated as a whole and surface force is calculated
  - The surface force at the front surface of the endcap is obtained as a function of R, and parameterized by a simple function
  - This simple function is used for the calculation of the deformation
  - Z-constraint only at R=4.1m (Inner radius of barrel yoke)
  - 3D model calculation



Endcap Deformation

- Magnetic Force





Endcap Deformation

- Results

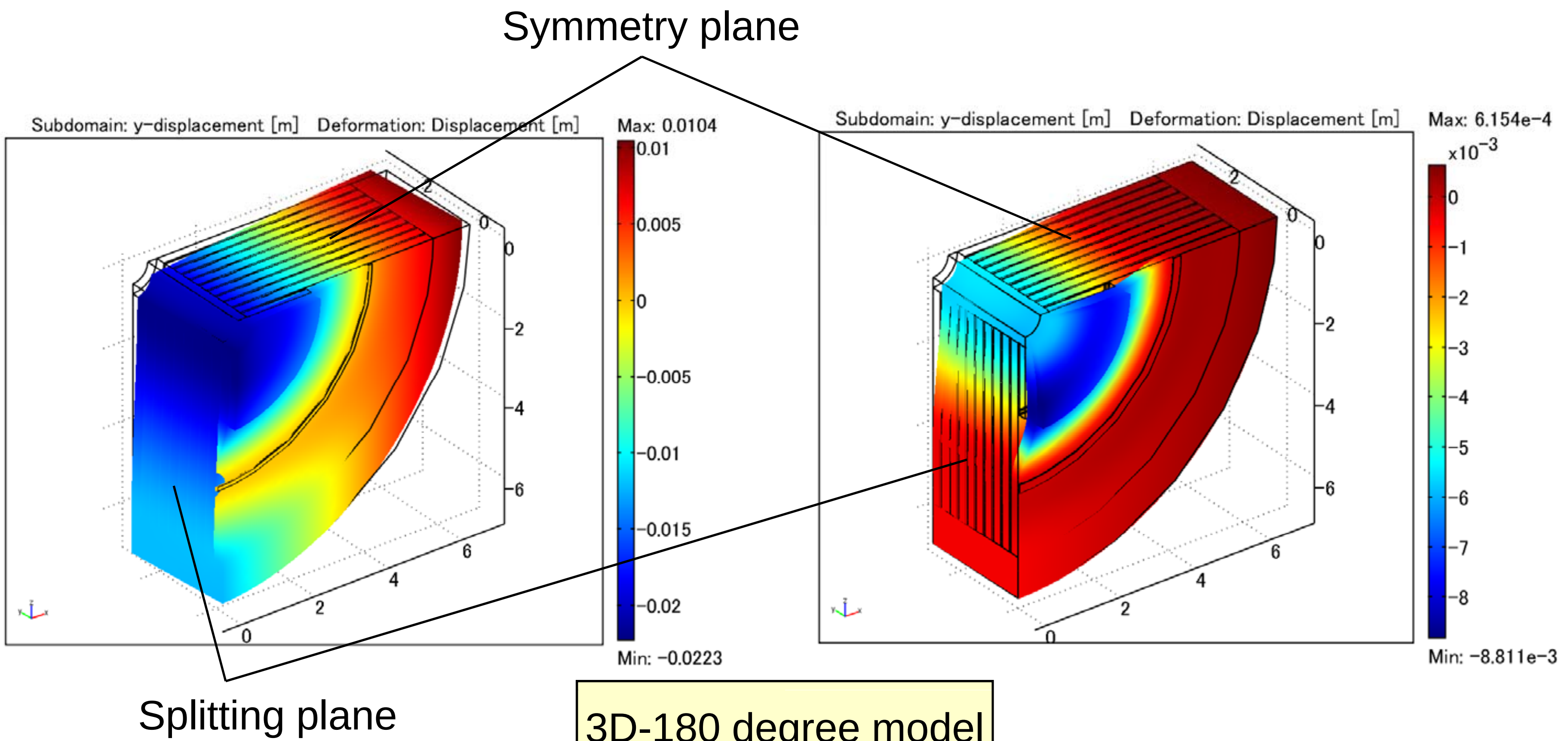
	Angle	Support ring	ΔZ		
			r=0.4 m	r=6.9 m	
3D	180	No	-21 mm	+11 mm	ϕ=0
			-23 mm	-13 mm	ϕ=90
3D	360	No	-12 mm	-3.9 mm	
3D	180	1 (r=4.1m)	-5.7 mm	-0.6 mm	ϕ=0
			-5.9 mm	-0.5 mm	ϕ=90
3D	360	1	-4.6 mm	-0.2 mm	
3D	180	2 (r=2.3, 4.1m)	-2.6 mm	+0.5 mm	ϕ=0
			-2.7 mm	-0.7 mm	ϕ=90
3D	360	2	-1.8 mm	-0.4 mm	
3D	**180**	**3 (r=2.3, 3.2, 4.1m)**	**-1.7 mm**	**+0.3 mm**	**ϕ=0**
			-1.8 mm	**-0.7 mm**	**ϕ=90**
3D	360	3	-1.1 mm	-0.4 mm	
2D	360	No	-90 mm	0 mm - Fix	SiD-like: 23x(10cm Fe + 5cm gap)

3D: 3-dimensional model
2D: Axial symmetric 2-dimensional model

180: Splitting endcap
360: Non-splitting endcap

Endcap Deformation

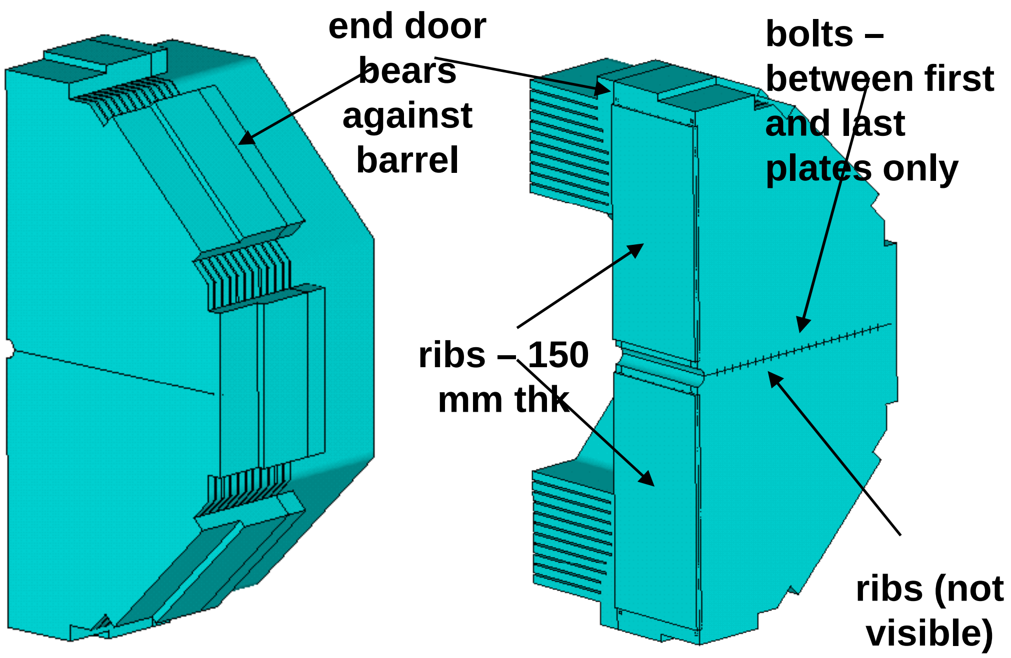
- No support ring
- One support ring/gap

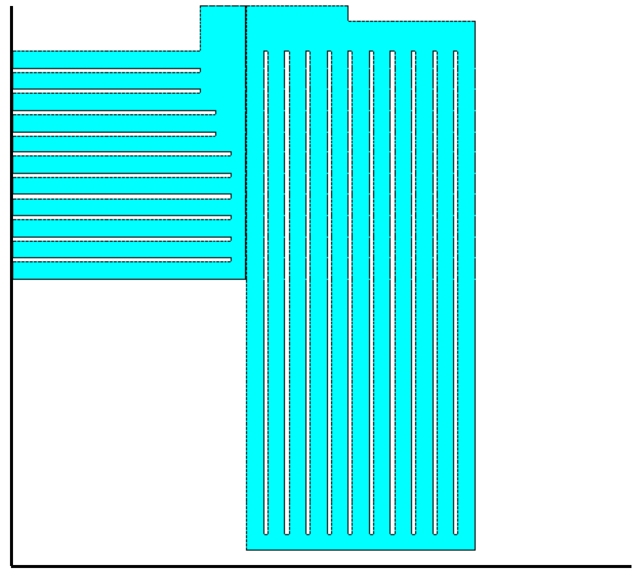


3D-180 degree model

SiD

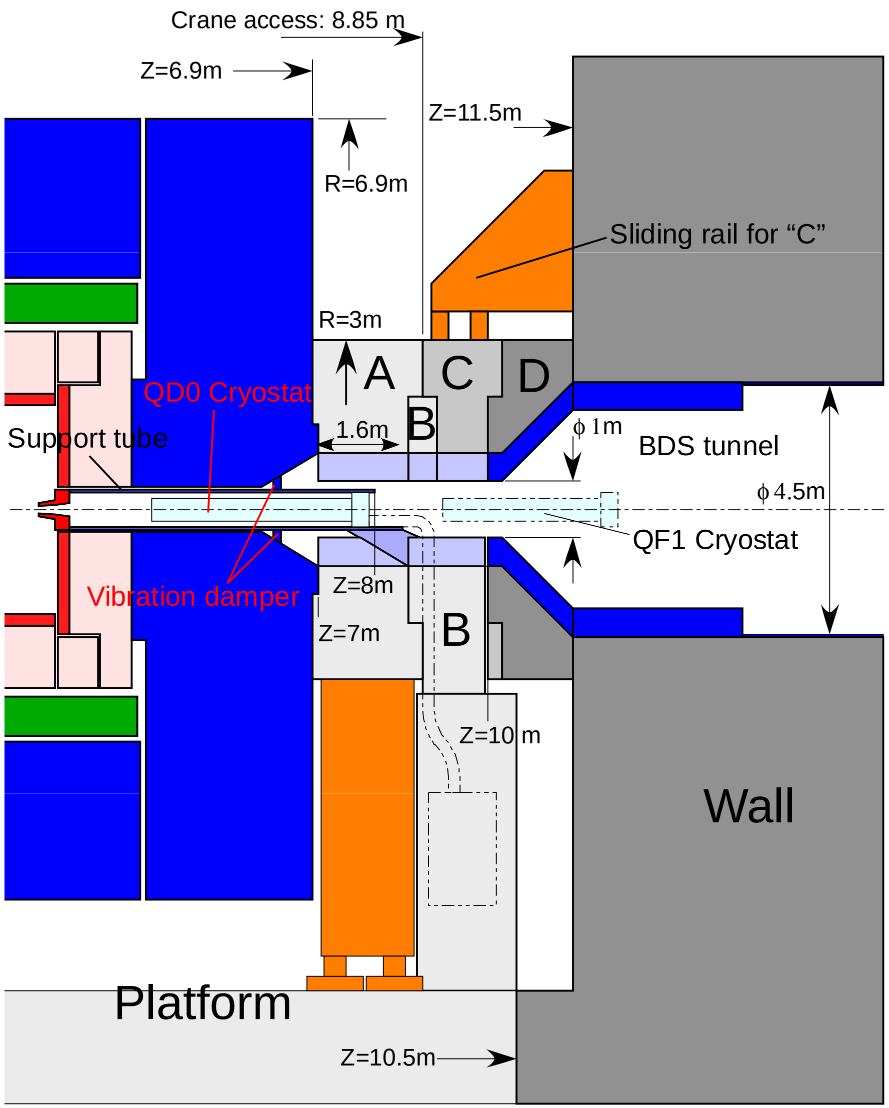
- Design shown at IRENG07 WS





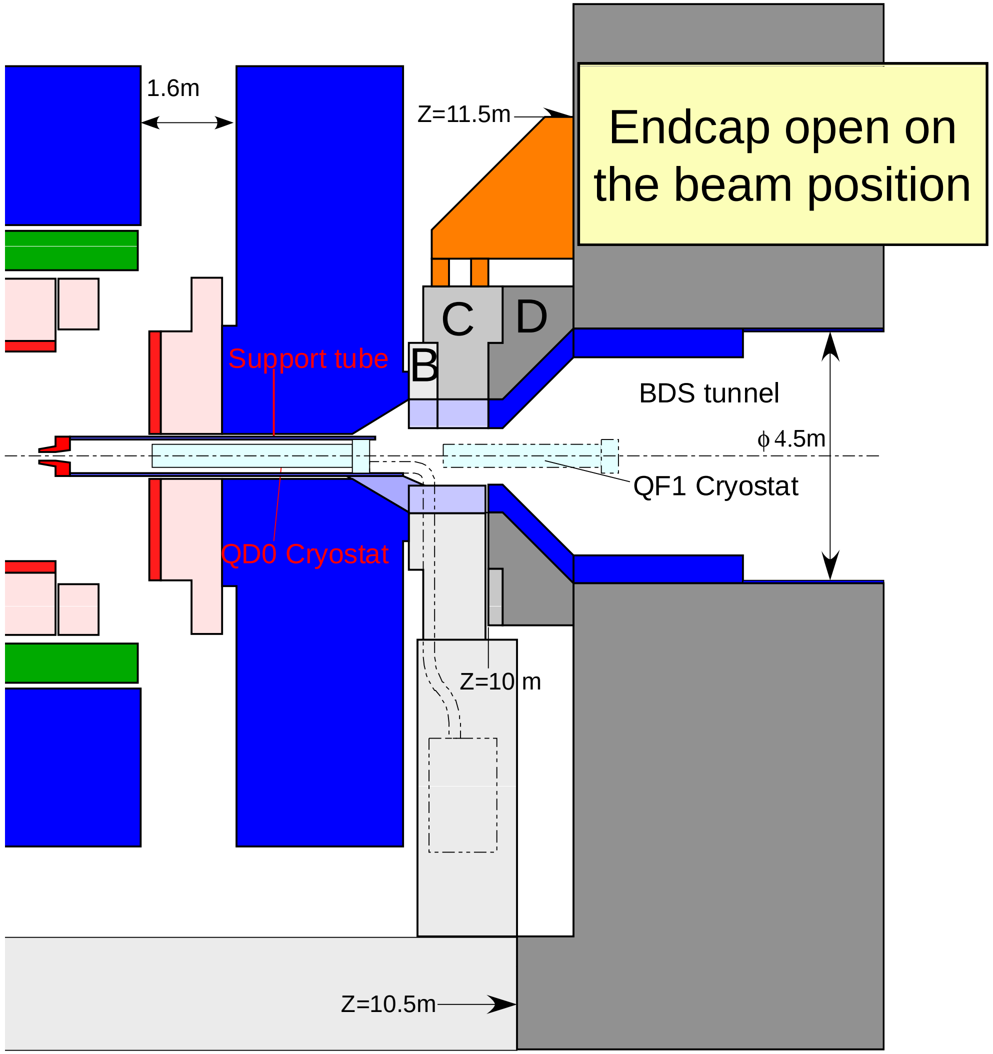
Similar to GLD!

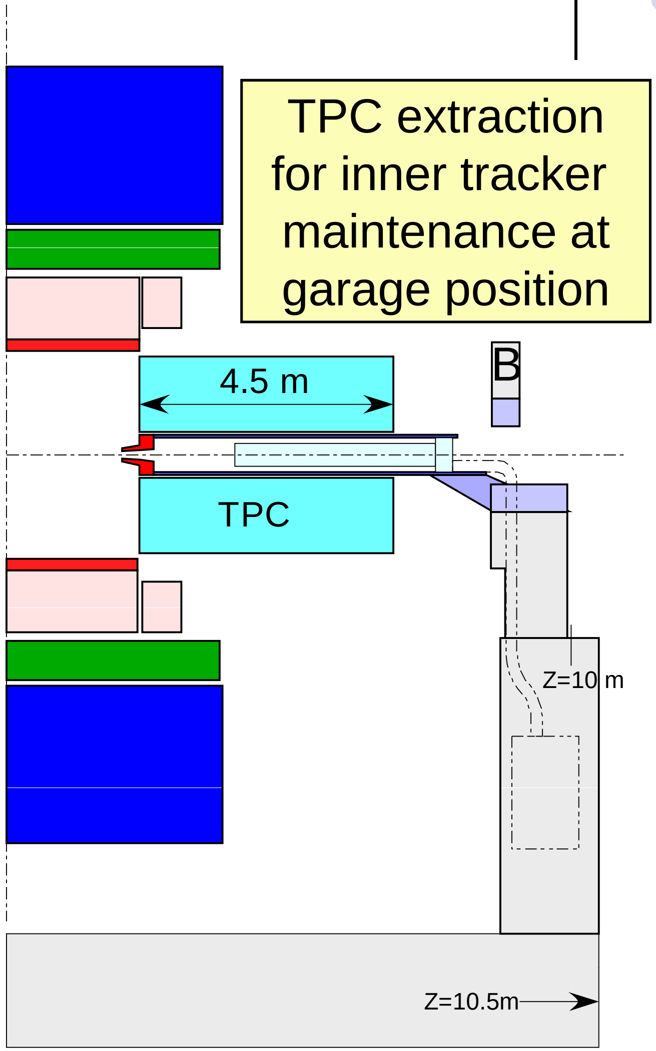
Pacman design and FD support



- A: slide sideway using air pad
- B: supported from the floor of platform
- **QD0 cryostat is supported by the support tube and the support tube is supported from B**
- We can put additional support for the support tube at the entrance of endcap yoke to damp the vibration, if necessary
- Upper part of B (~10 ton) must be removable by crane for installation and removal of the support tube
- C: slide along the wall (D) (common to both experiments) ~50 tonx2
- D: part of the wall
- Wall distance can be as small as 11.5 m from IP, if the crane can access to 2.65m from the wall
- Construction of C is done by a mobile crane (CMS style)
- Inner radius of pacman should be determined after design of gate valve etc. between QD0 and QF1 is fixed

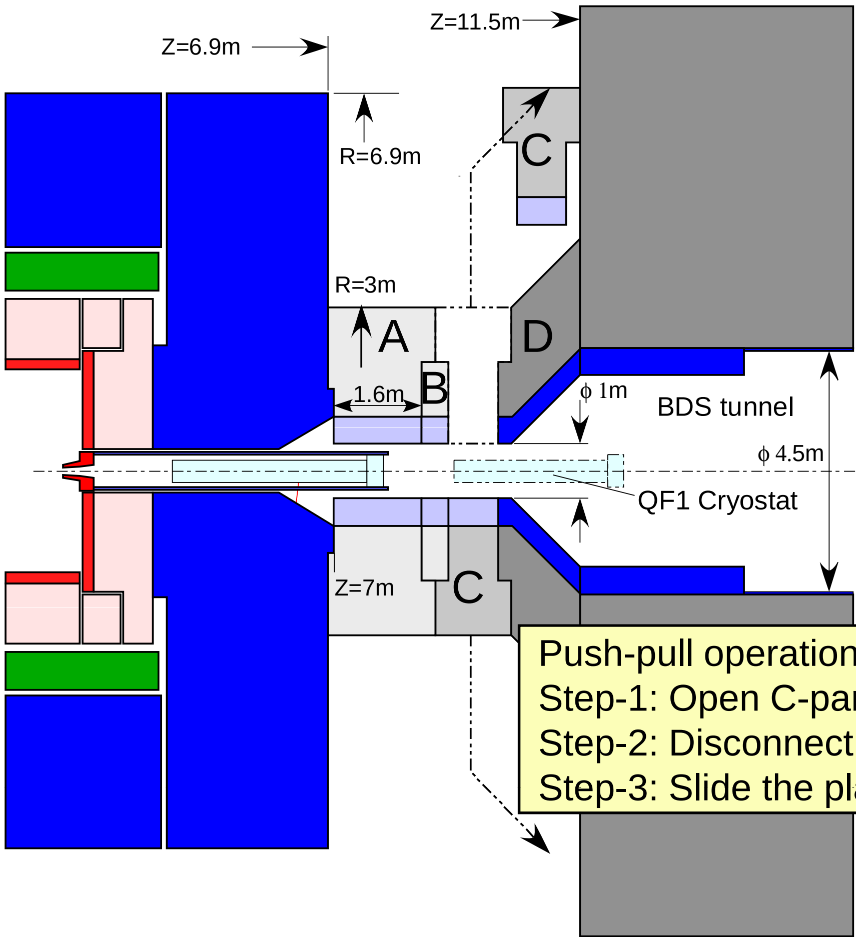
Pacman design and FD support





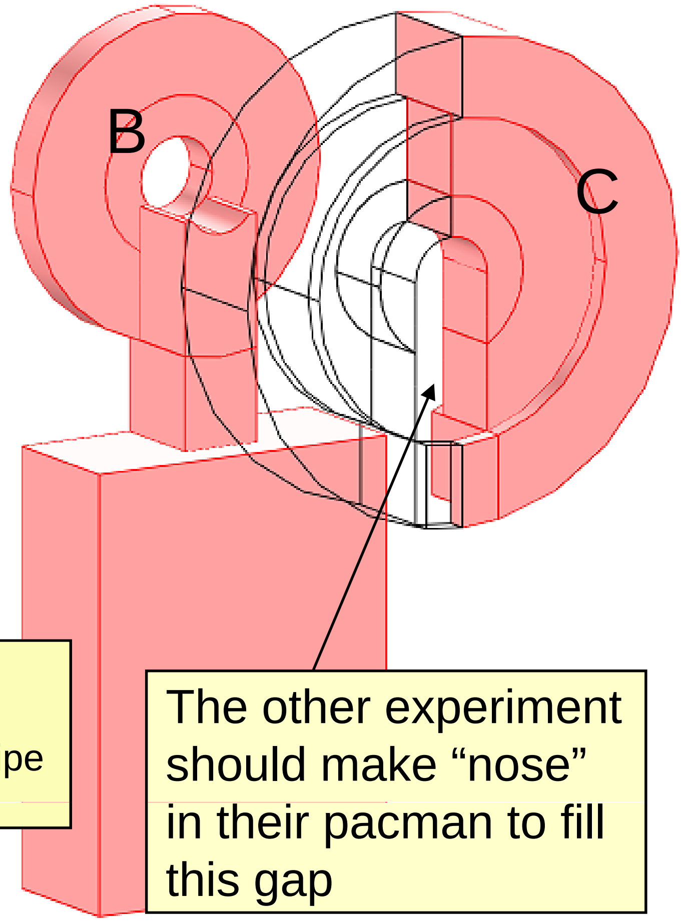
Pacman design and FD support

- Plan view



Push-pull operation:
Step-1: Open C-part
Step-2: Disconnect beam pipe
Step-3: Slide the platform

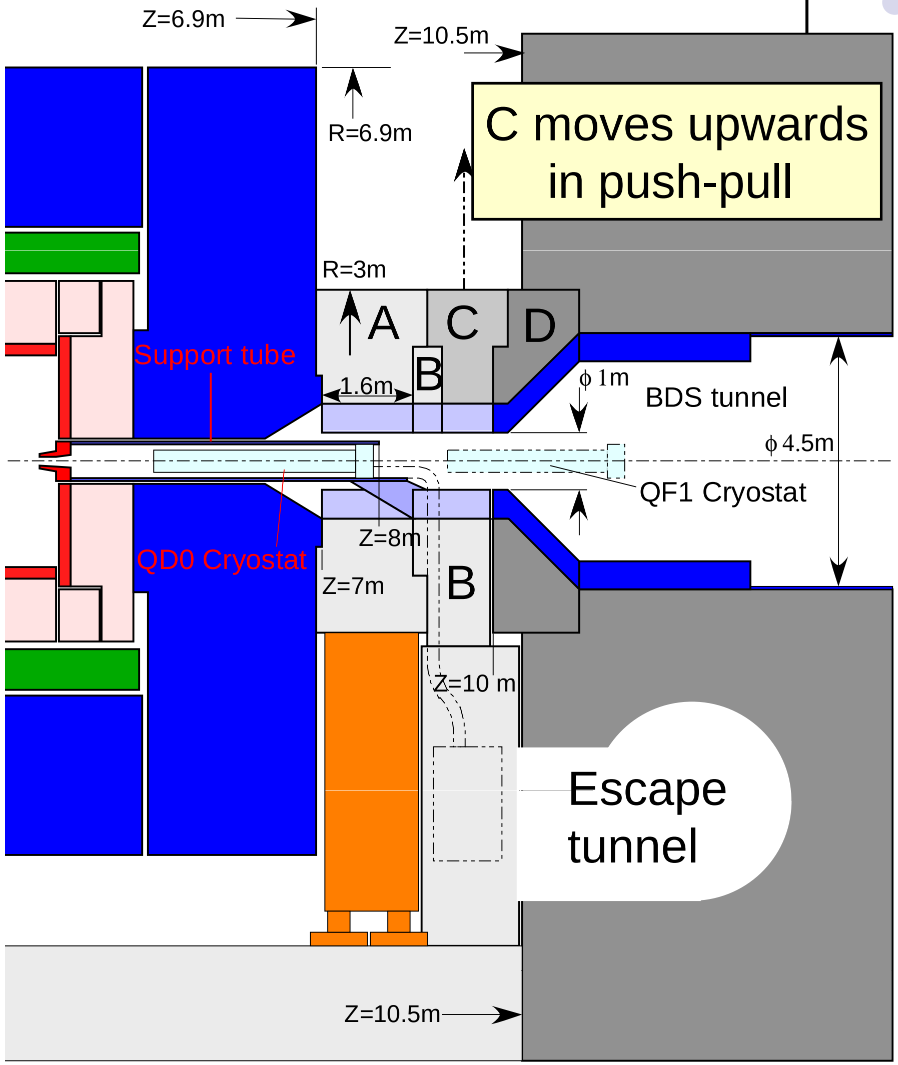
- 3D view



The other experiment should make “nose” in their pacman to fill this gap

Still smaller cavern option

- Forget about crane access
- Forget about safety issues
- Design with cavern floor width as small as 21m can be drawn with the support-tube scheme
  - Pacman "C" moves upwards (using a small gantry crane fixed to the wall?) in push-pull operation
  - There is no way for a person to run away from one side of the detector to the other side (escape tunnel ?)



L* for GLDc

Component	Start	Length
End cap yoke	3.7 m	
BCAL	3.8 m (note-1)	0.2 m
BPM	4.0 m	0.2 m (??)
QD0 cryostat	4.2 m	0.264 m
QD0 coil (L*)	4.464 m	

L* of ~4.5 m seems adequate

- note-1
  - By putting BCAL at Z>Zendcap, strength of anti-DID can be reduced because R-component of solenoid B-field near the hole of end cap yoke can help guiding low energy pair-background into the beam exit hole
  - If z-position of BCAL can be smaller, L* can be smaller than 4.5m
  - We need 3D field calculation including anti-solenoid and simulation study on backscattering from BCAL

Beam pipe shape

- GLD: Long straight section made of Al
- LDC: Long conical section made of Fe

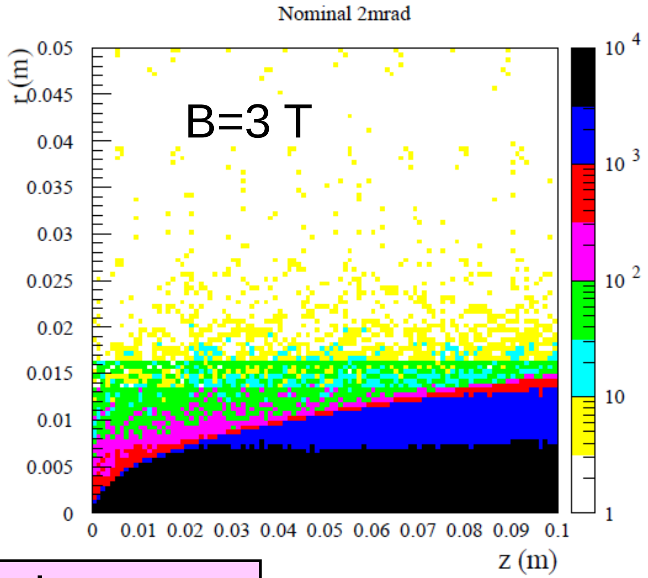
➔ We (FCAL group?) need

  - Estimation of the wall thickness needed to support the atmospheric pressure
  - Simulation study for lum. measurement

- Beam pipe near IP
  - Designed based on distribution of dense core of pair-background

Pair background and R_{VTX}

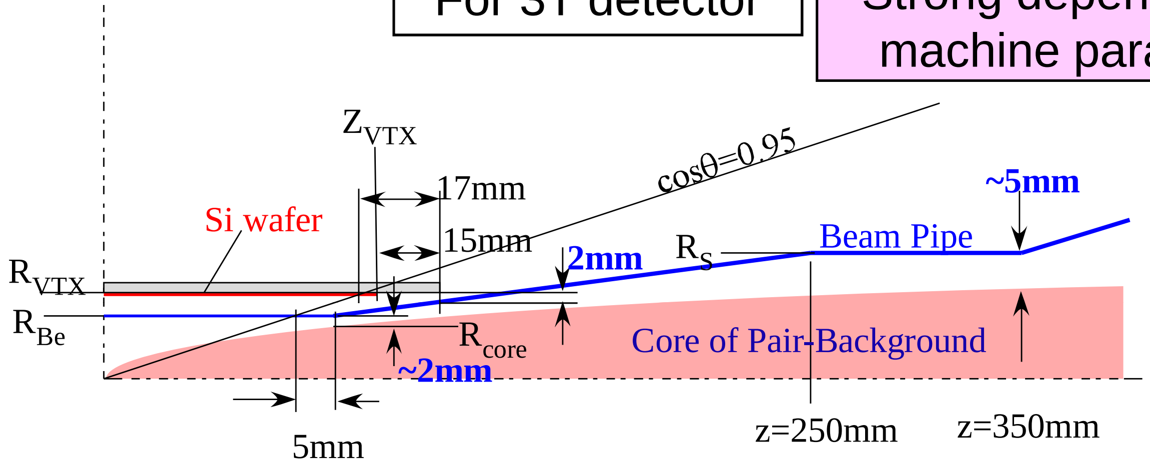
- VTX inner radius
  - Design criteria:
    Beam pipe should not be hit by dense core of the pair background



E_{CM}	Option	R_{bp}	R_{VTX}
500 GeV	Nominal	13 mm	17 mm
1 TeV	High L A1	15 mm	20 mm
500 GeV	High Lum	19 mm	24 mm

For 3T detector

Strong dependence on machine parameters



High Lum options are not included in RDR.
We should study again with new beam parameters of Nominal and **LowP** options for 250 and 500 GeV

Other Issues

- Issues not studied yet in GLD
  - Power consumption
  - Detector cooling
  - Cable/pipe extraction and handling
  - Detector alignment
  - Luminosity (run period) needed for track-based alignment
  - Support scheme of beam pipe/VTX/SIT
  - Vibration analysis
  - Seismic issues
  - Services for detector solenoid compatible with push-pull
  - Fire safety

Next step

- Some issues can be studied only after detector parameters are defined, but we should start immediately studying on many issues in order to make a common design of ILD
  - Tolerable stray field of the detector solenoid
  - Structure of return yoke
  - Diameter of endcap hole
  - Pair background study with new machine parameters
  - Global shape of the detector
  - …..
  - …..
- In order to establish a self-consistent detector integration scheme, discussions including all sub-detector groups are necessary. Please subscribe to the MDI/Integration working group mailing list (only 28 persons at present)