GLD and GLDc

Oct. 23, 2007

Y. Sugimoto

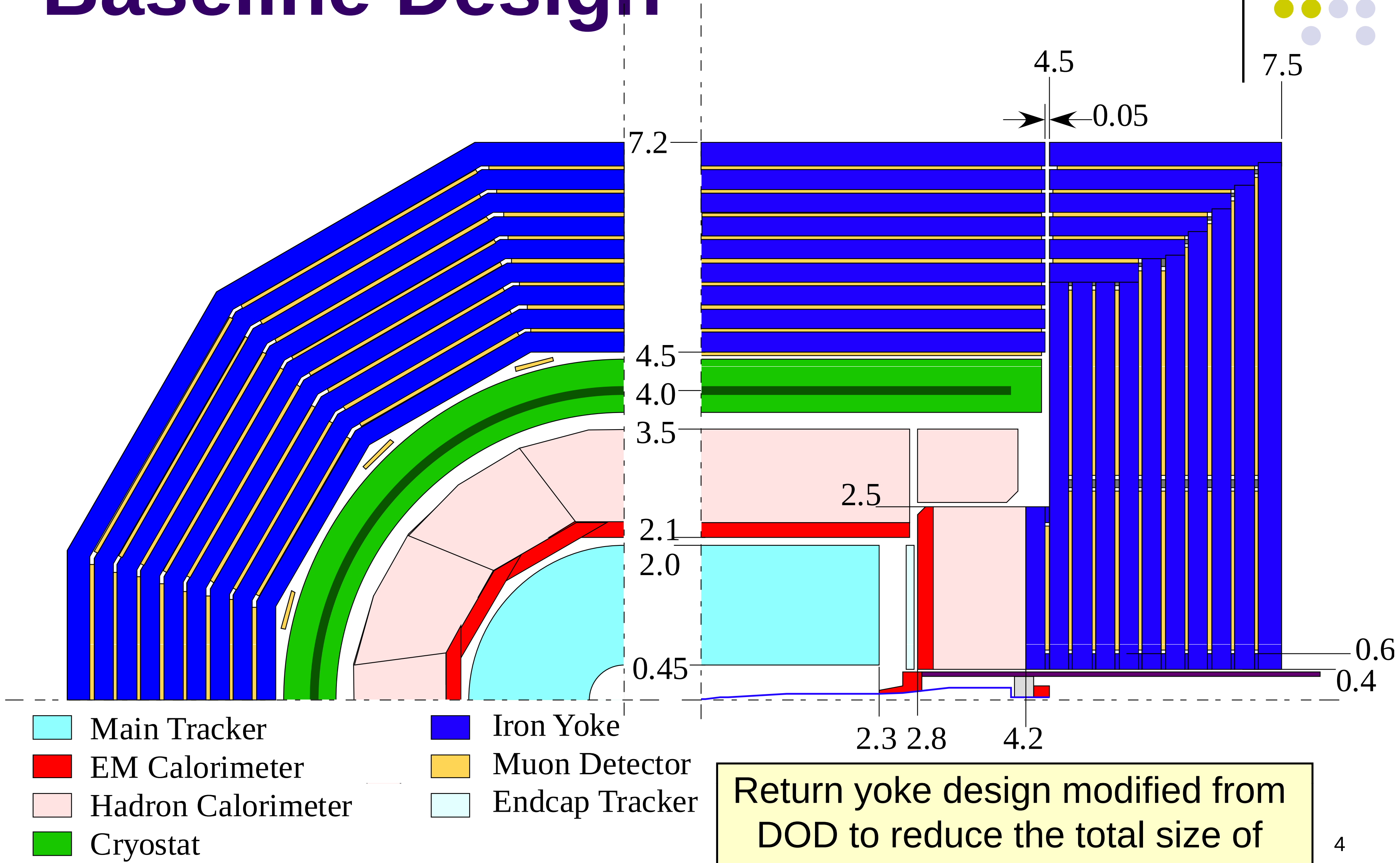
KEK

Part-I. GLD

GLD Baseline Design

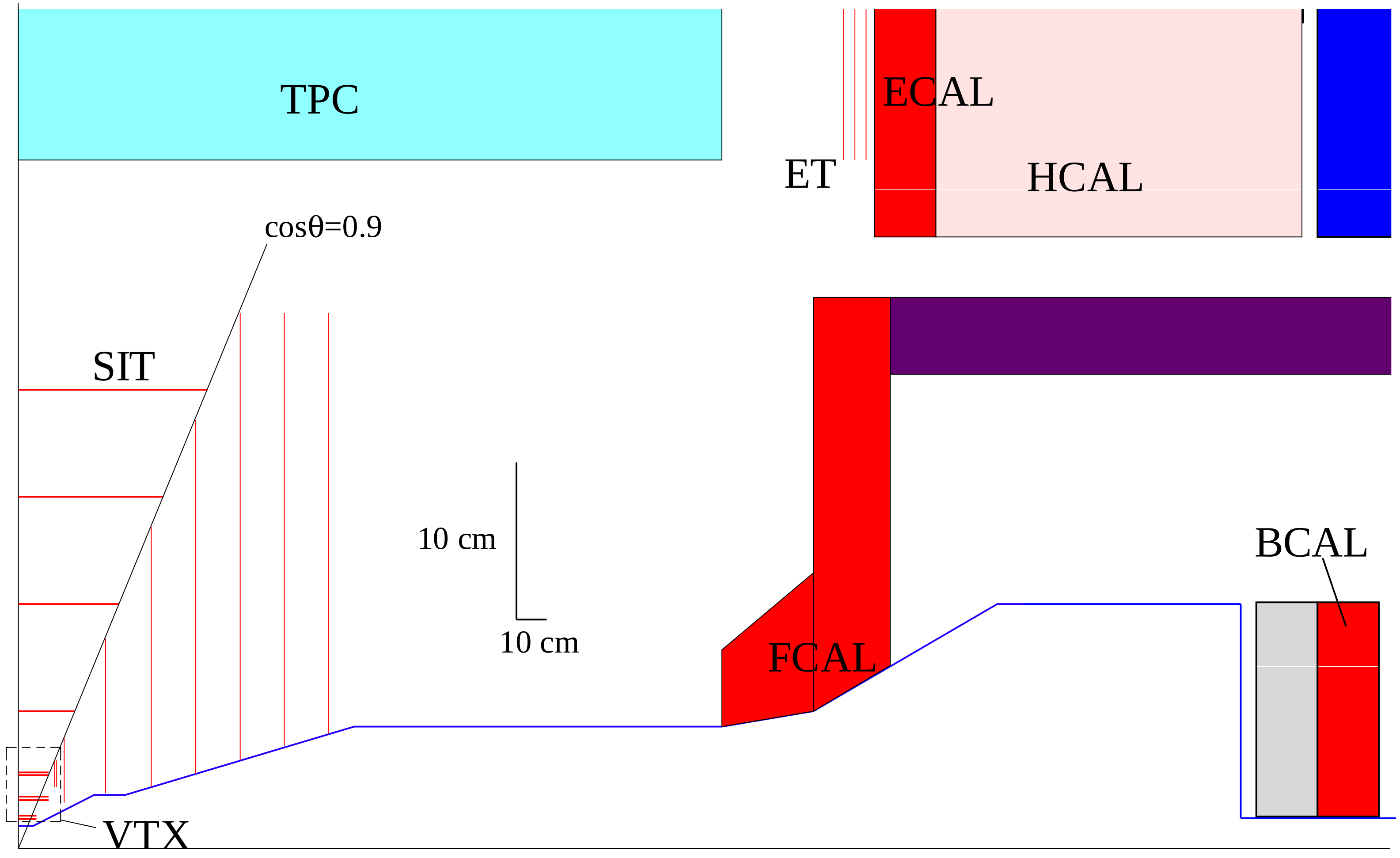
- Large gaseous central tracker; TPC
- Large-radius, high-granularity ECAL with W/Scinti sandwich structure
- Large-radius, medium granularity, thick (~6λ) HCAL with Pb(Fe)/Scinti. sandwich structure
- Forward CAL (FCAL and BCAL) down to 5mrad
- Precision Si micro-vertex detector
- Si inner tracker (barrel and forward)
- Si endcap tracker (?)
- Si outer tracker between TPC and ECAL (??)
- Beam profile monitor in front of BCAL
- Muon detector interleaved with iron plates of the return yoke
- Moderate magnetic field of 3T

Baseline Design

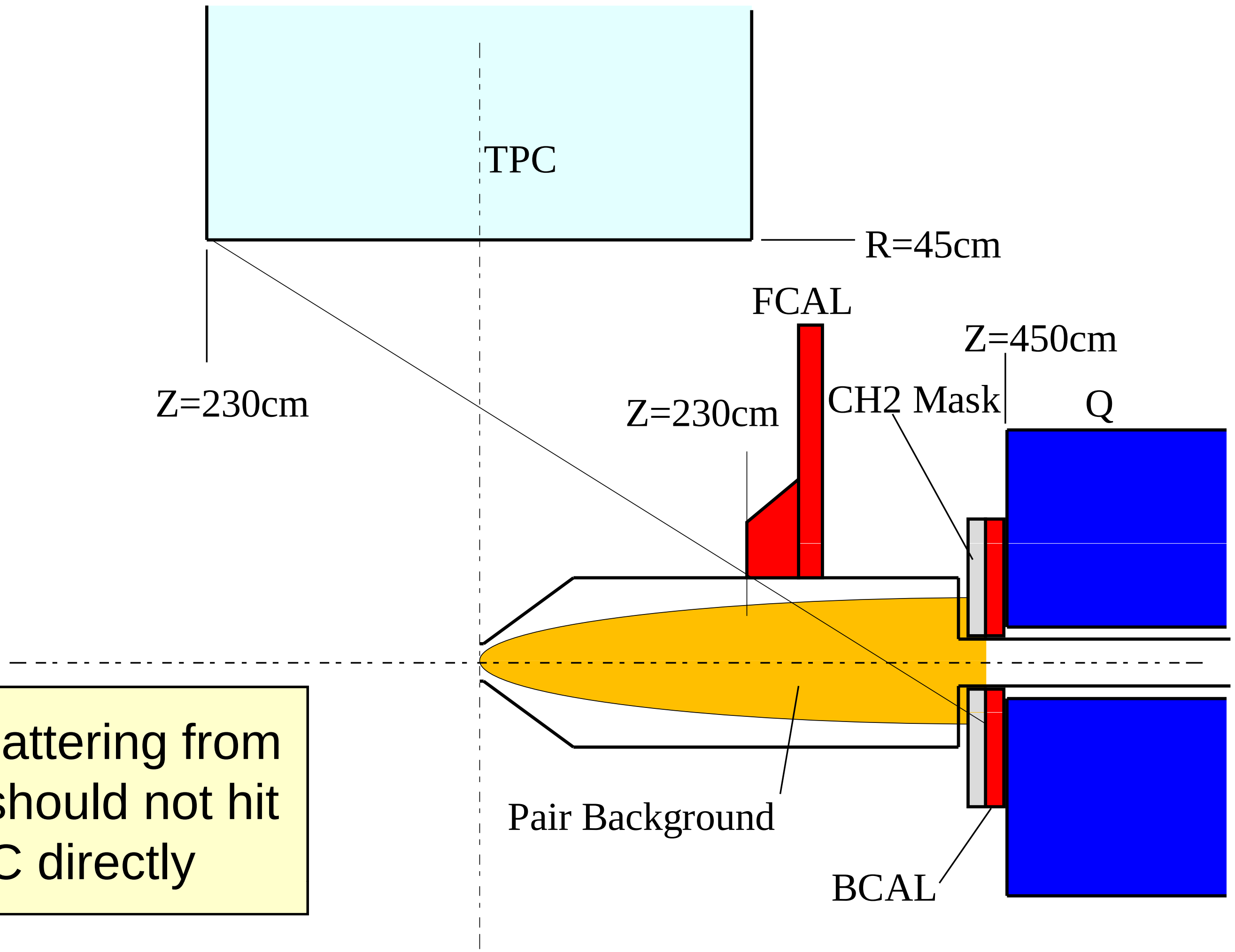


Return yoke design modified from DOD to reduce the total size of the detector and exp-hall size

Baseline Design



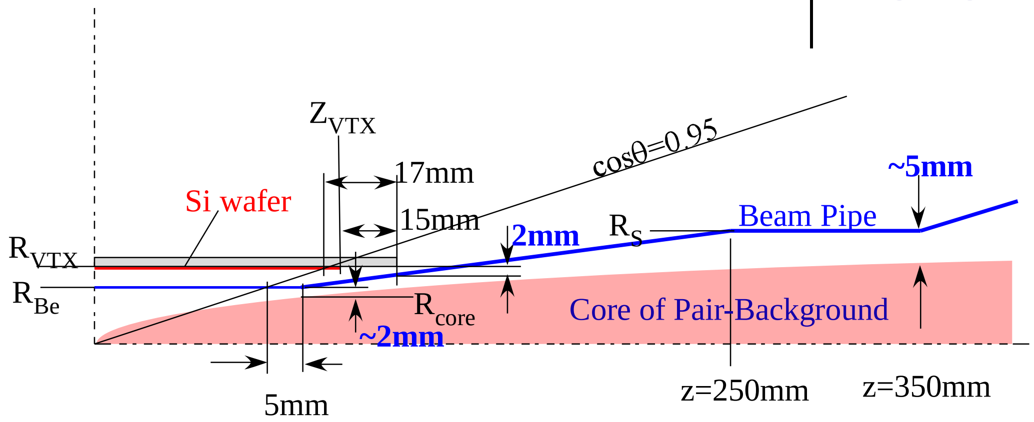
Baseline Design

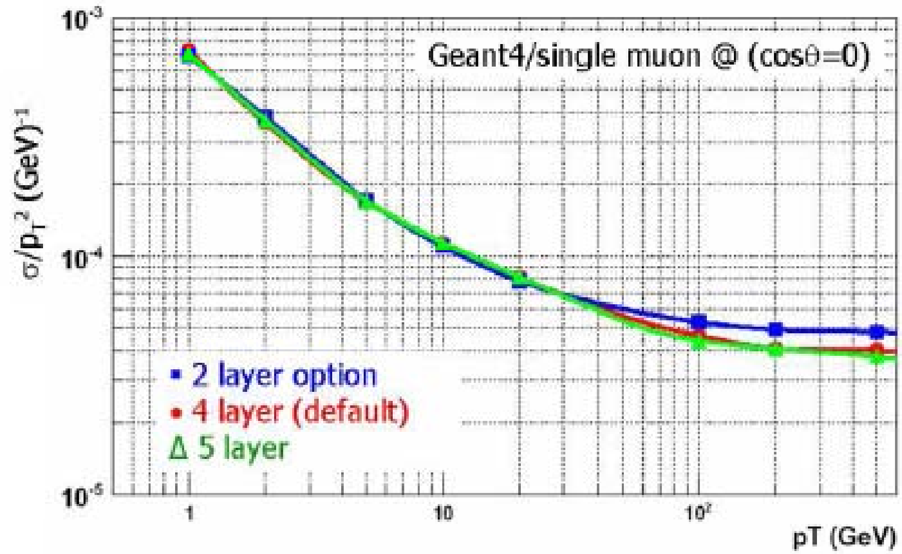


Back-scattering from BCAL should not hit TPC directly

Detector Parameters

- VTX
  - 6 layers (3 doublets)
  - R=20(18) mm – 50 mm (Strongly depends on machine parameters)
  - Fine pixel CCD as the baseline design
- SIT
  - DSSD, 4 layers, R=9 - 30 cm
  - 7 discs in forward region, Z=15.5 - 101.5cm
  - Bunch ID capability
- TPC
  - R=45 cm – 200 cm
  - Z=230 cm





Detector Parameters

- ECAL
  - W/Scintillator/Gap = 3/2/1 mm
  - 33 layers
  - 1cmx4cm scintillator strips, w.l.s. fiber+MPPC (SiPM) readout
  - 2cmx2cm scintillator tile as an option
  - 26 X_0, 1 λ
- HCAL
  - Pb(Fe)/Scinti./Gap = 20/5/1 mm
  - 46 layers
  - 1cmx20cm scintillator strips + 4cmx4cm scintillator tile, w.l.s. fiber+MPPC readout
  - 5.7 λ
- Muon detector
  - 8/10 layers in 4-cm gaps between 25-30 cm thick iron slabs of return yoke
  - X-Y scintillator strips with w.l.s.fiber+MPPC readout

Detector Parameters

- PFA

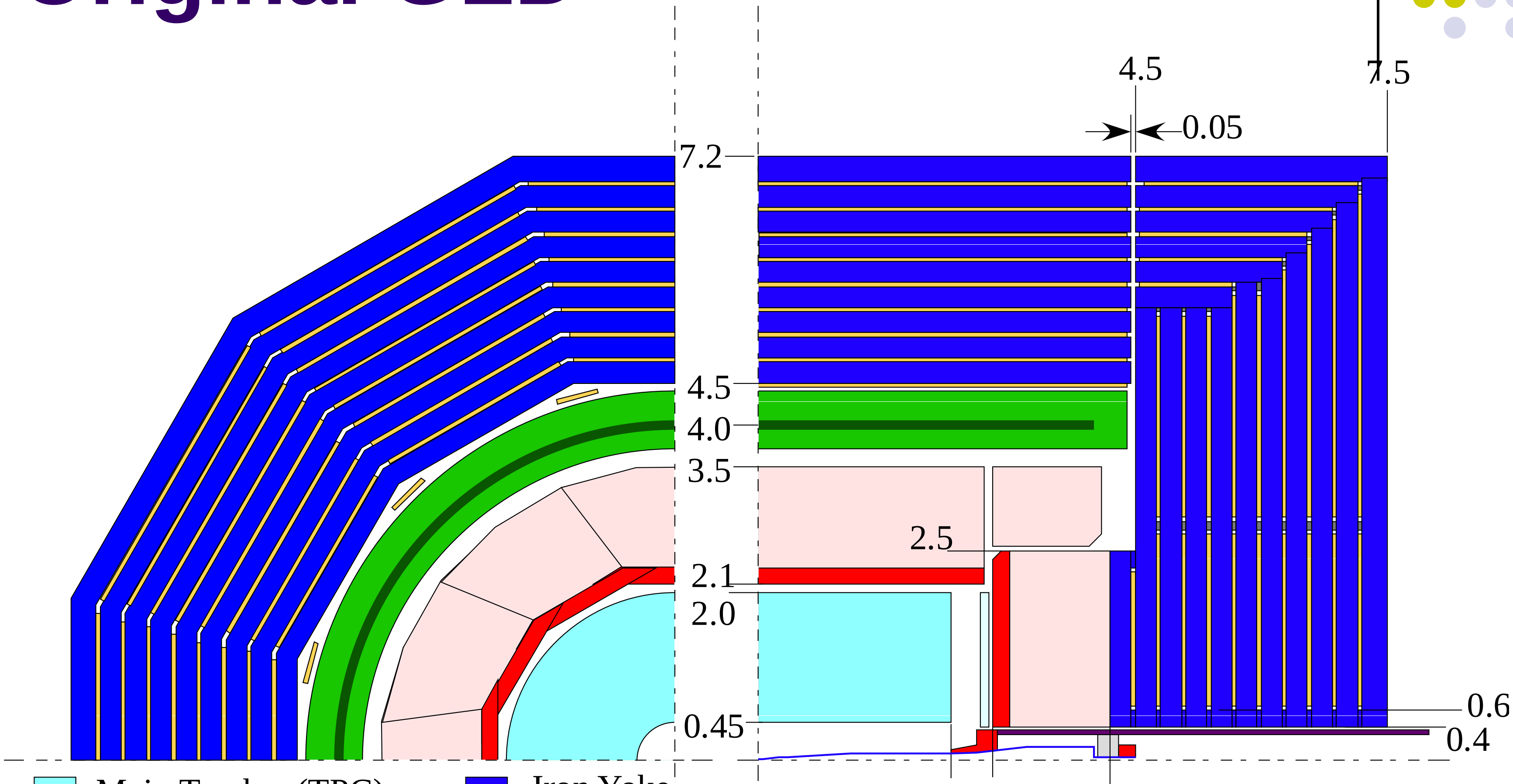
	GLD	LDC	SiD
B (T)	3	4	5
R_{CAL} (m)	2.1	1.6	1.27
p_t^{min} in CAL (GeV/c)	0.95	0.96	0.95
$B R^2_{CAL}$ (Tm^2)	13.2	10.2	8.1
t_{HCAL} (λ)	5.7	4.6	4
E_{store} (GJ)	1.6	1.7	1.4
R_{Fe} (m)	7.2	6.0	6.45

Part-II. GLDc

Compact GLD Option – GLDc

- Motivation
  - GLD and LDC will write a common LoI
  - The detector design should have common parameters
  - Common parameters should be determined based on detailed simulation study, but it will take a time ~0.5y(?)
  - As a working assumption for the moment, a modified design of GLD with the central values for B and R_{CAL} between original GLD and LDC is made for the study on engineering issues (IRENG07 @SLAC)
    - B=(3+4)/2=3.5 T
    - R_{CAL}=(2.1+1.6)/2=1.85 m

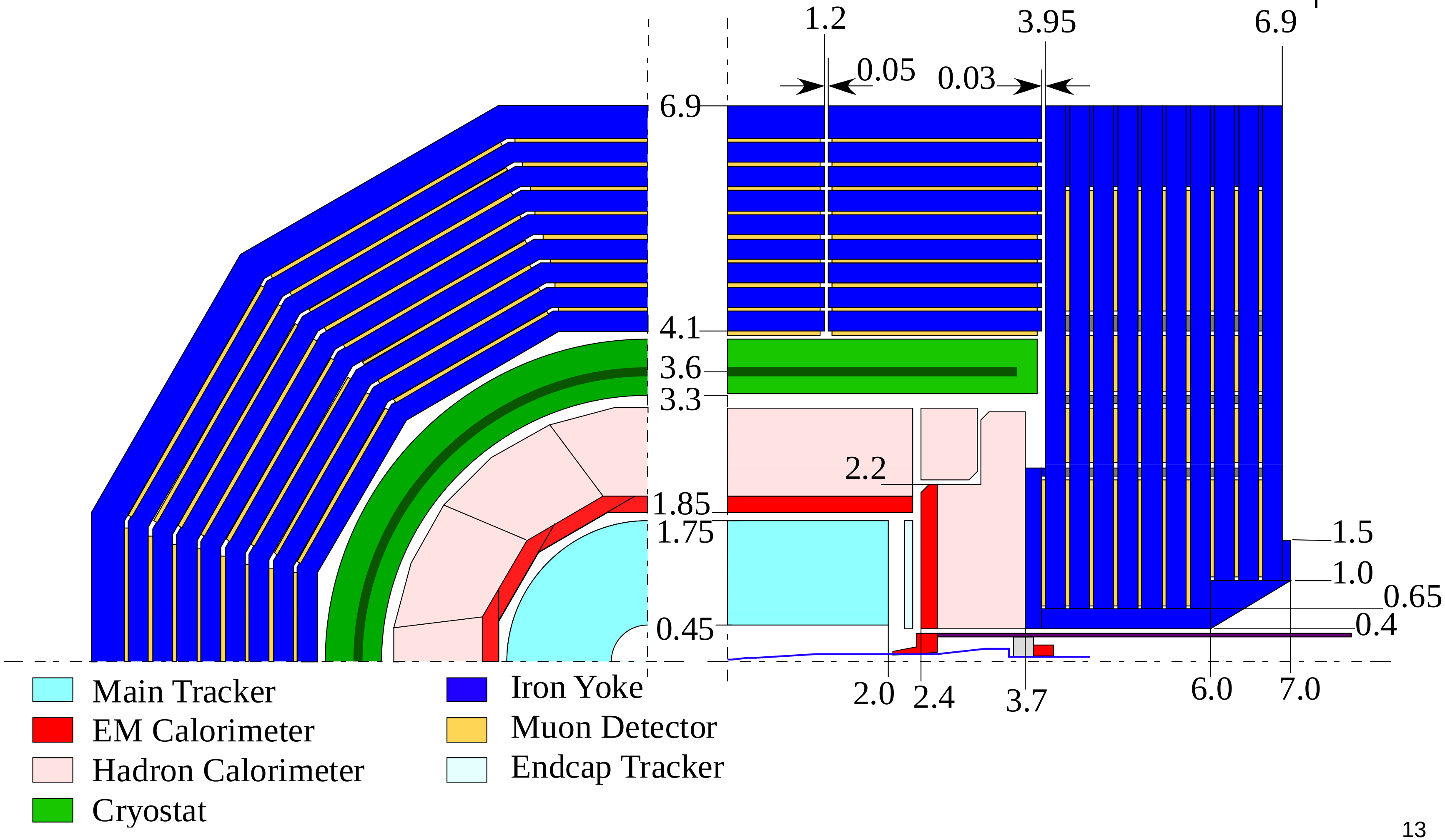
Original GLD



Main Tracker (TPC)
EM Calorimeter
Hadron Calorimeter
Cryostat
Iron Yoke
Muon Detector
Endcap Tracker

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

Compact GLD - GLDc



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	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

$BRin^2$=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**

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

L* for GLDc

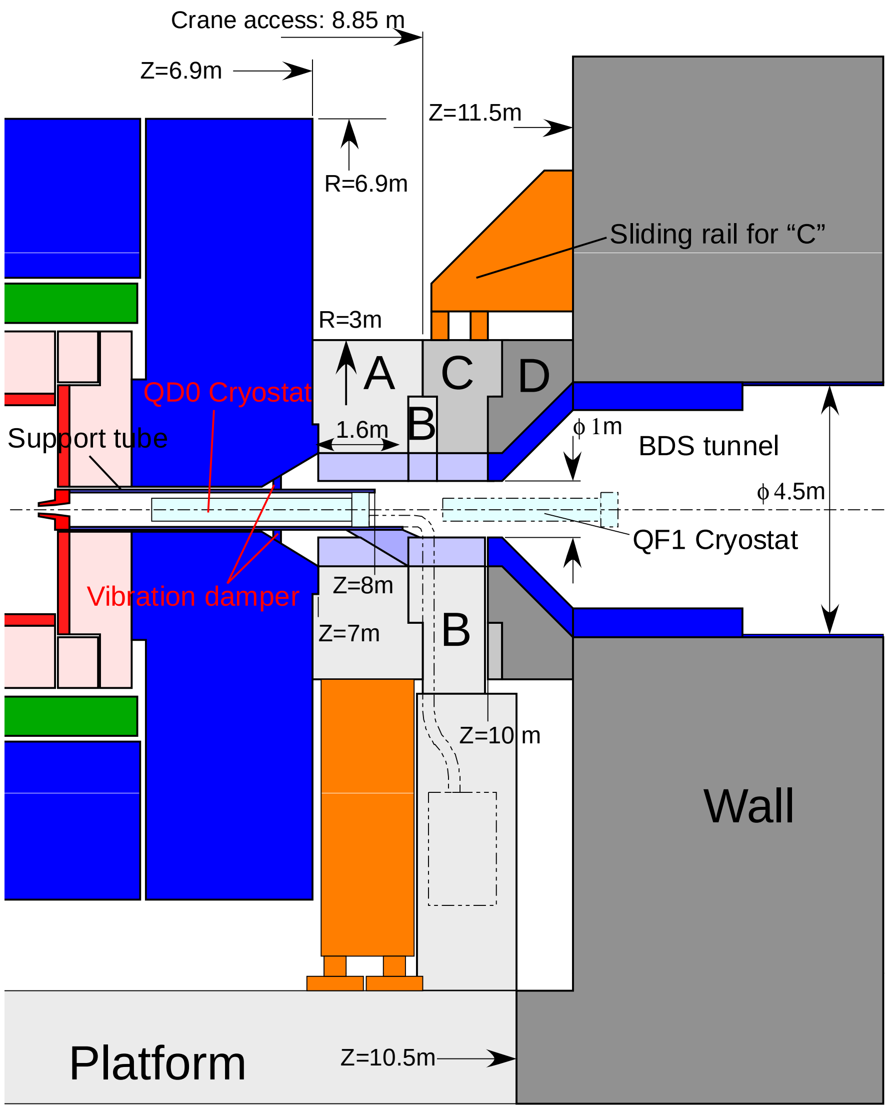
Component	Start	Length
End cap yoke	3.7 m	
BCAL	3.8 m (note-1)	0.2 m
BPM	4.0 m	0.2 m
QD0 cryostat	4.2 m	0.264 m
QD0 coil (L*)	4.464 m	

L* of ~4.5 m seems adequate

note-1:

By putting BCAL at $Z>Z_{endcap}$, 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

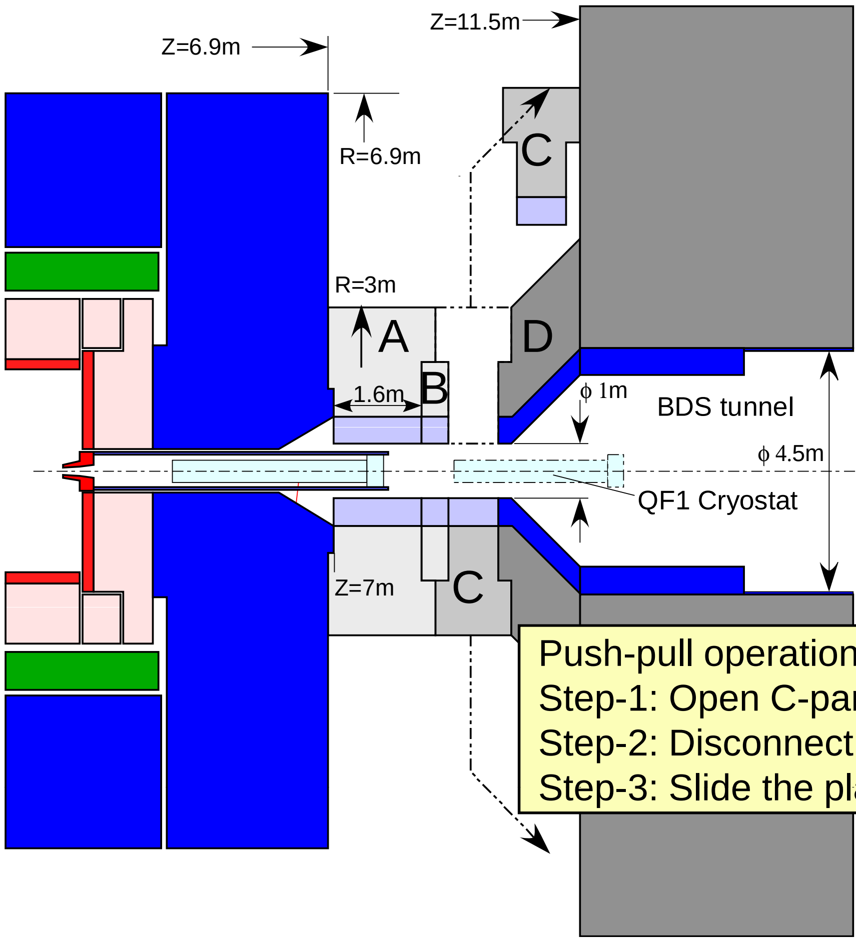
Pacman design and FD support



- 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

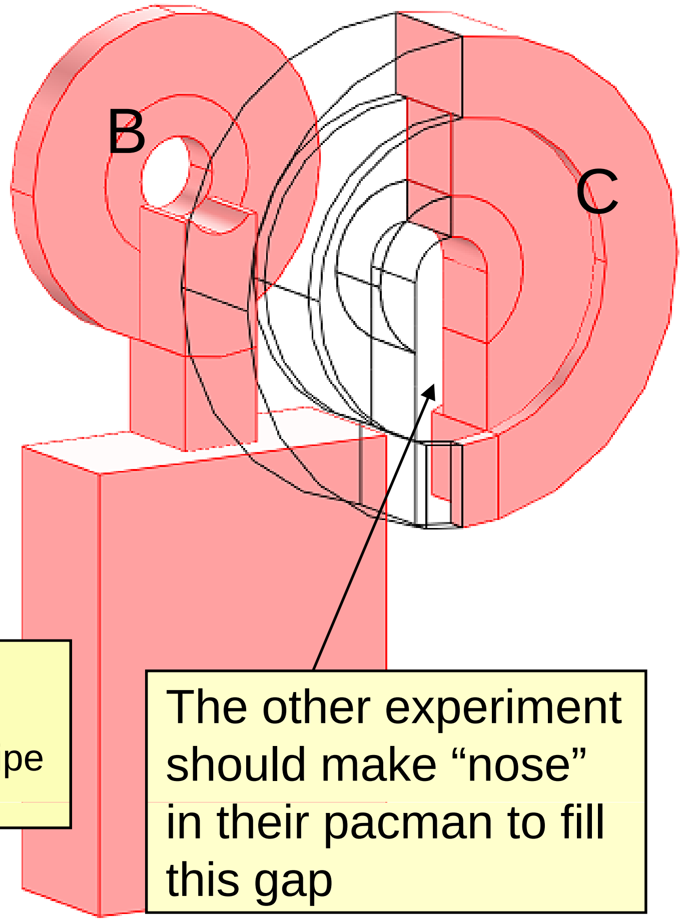
Pacman design and FD support

- Plan view



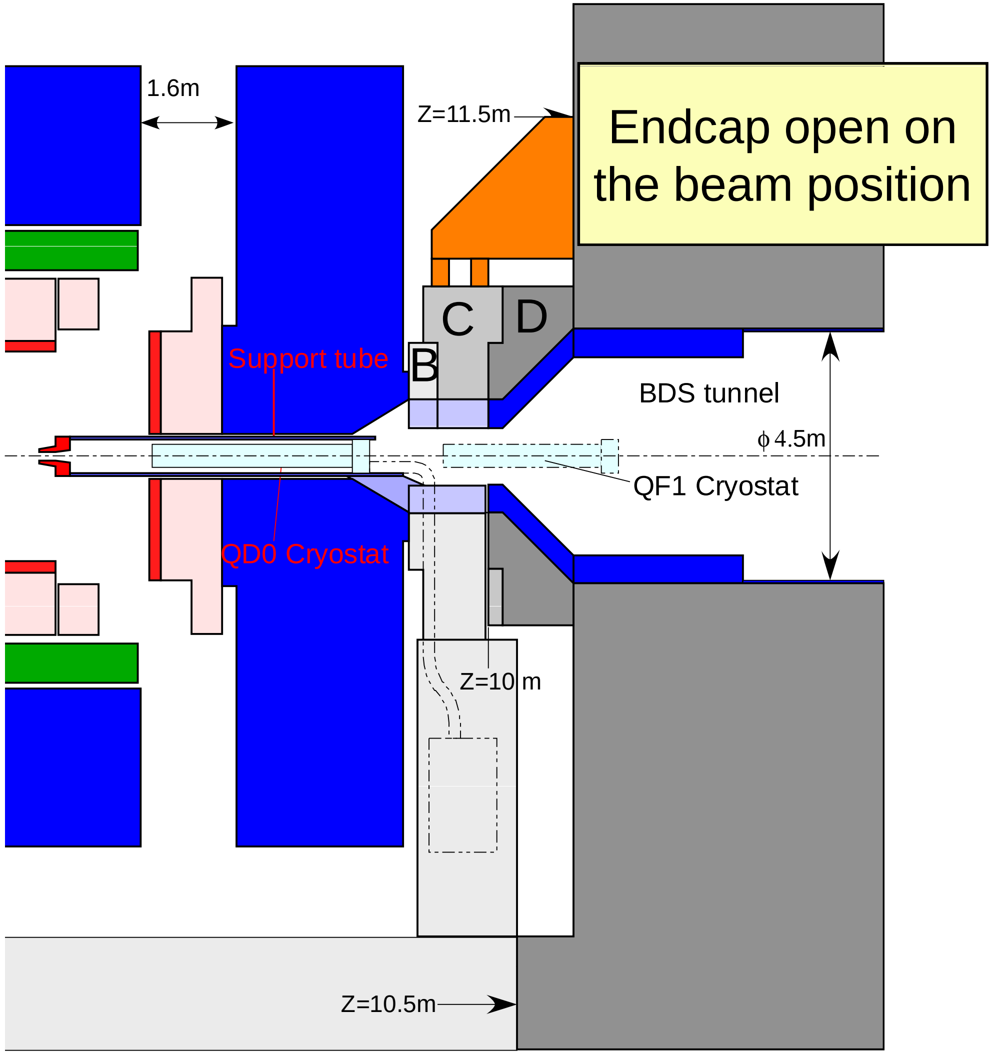
Push-pull operation:
Step-1: Open C-part
Step-2: Disconnect beam pipe
Step-3: Slide the platform

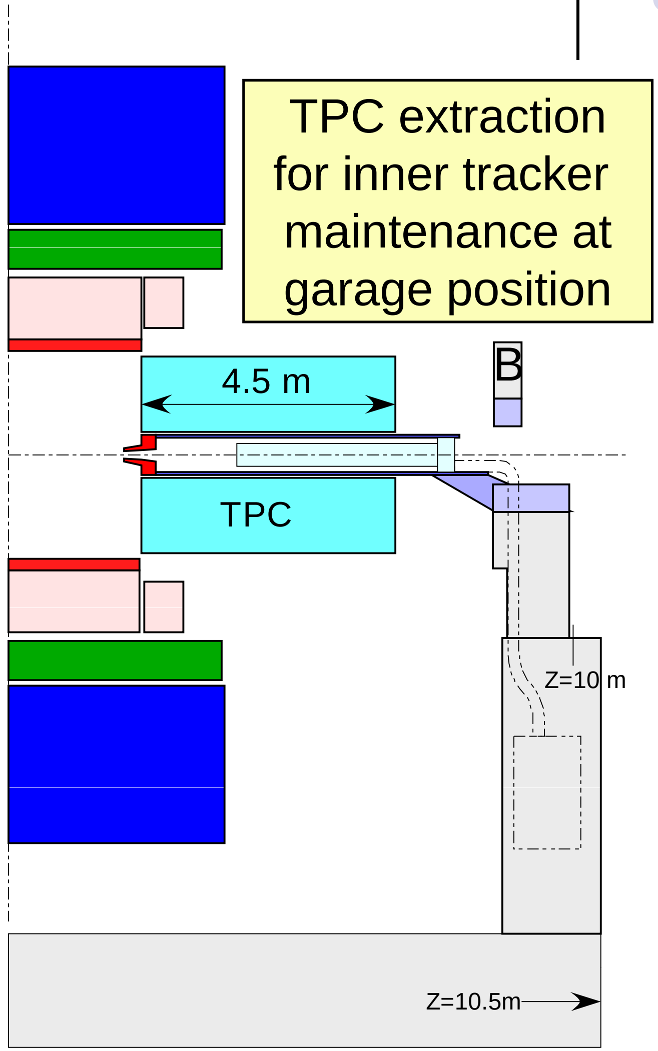
- 3D view



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

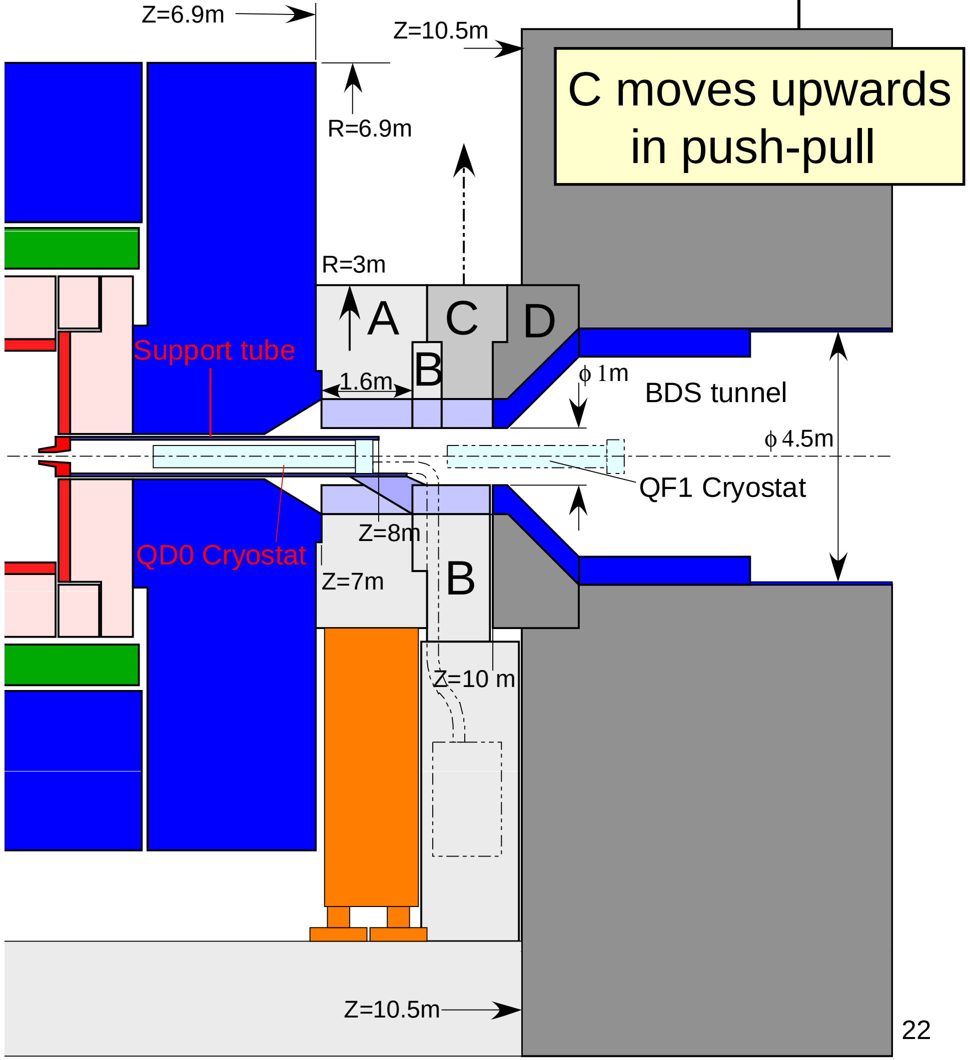
Pacman design and FD support





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 ?)



Other Engineering Issues

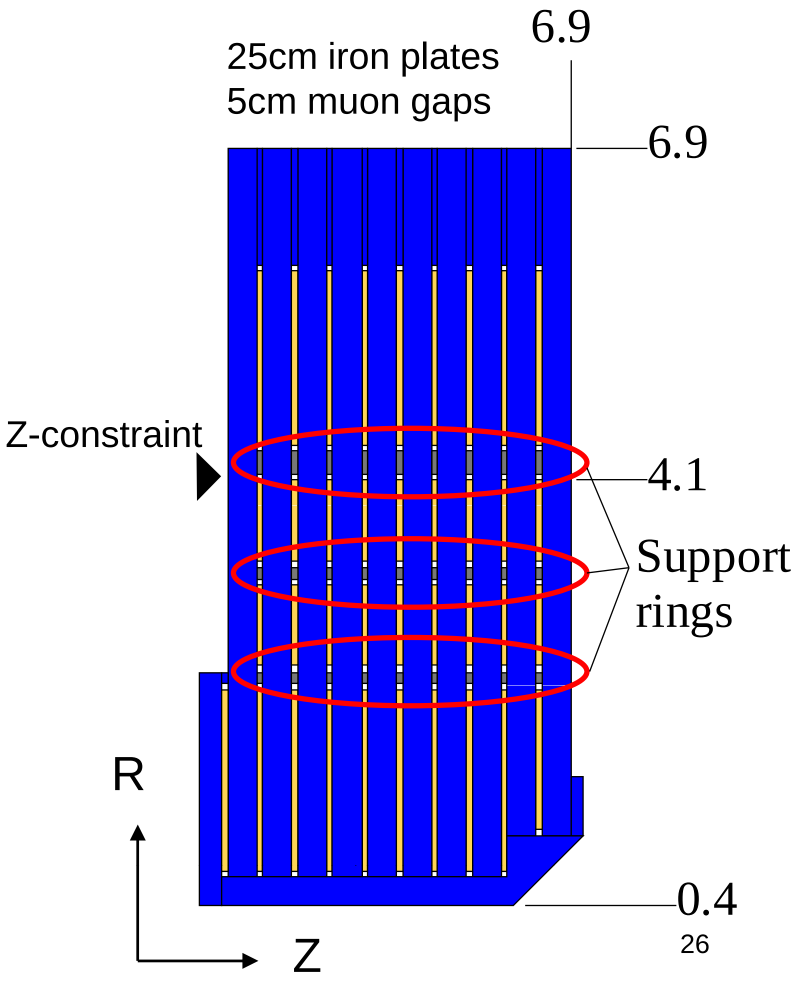
- Issues not studied yet
  - Detector cooling
  - Detector alignment
  - Luminosity (run period) needed for track-based alignment
  - Support scheme of beam pipe
  - Vibration analysis
  - Seismic issues
  - Services for detector solenoid including push-pull operation
  - Tolerable stray field from the viewpoint of safety and interference with near-by electric apparatus (E-hut)
  - Fire safety
- How to proceed these studies?
  - These issues will be covered by “MDI/Integration Working Group” of ILD

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
- 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

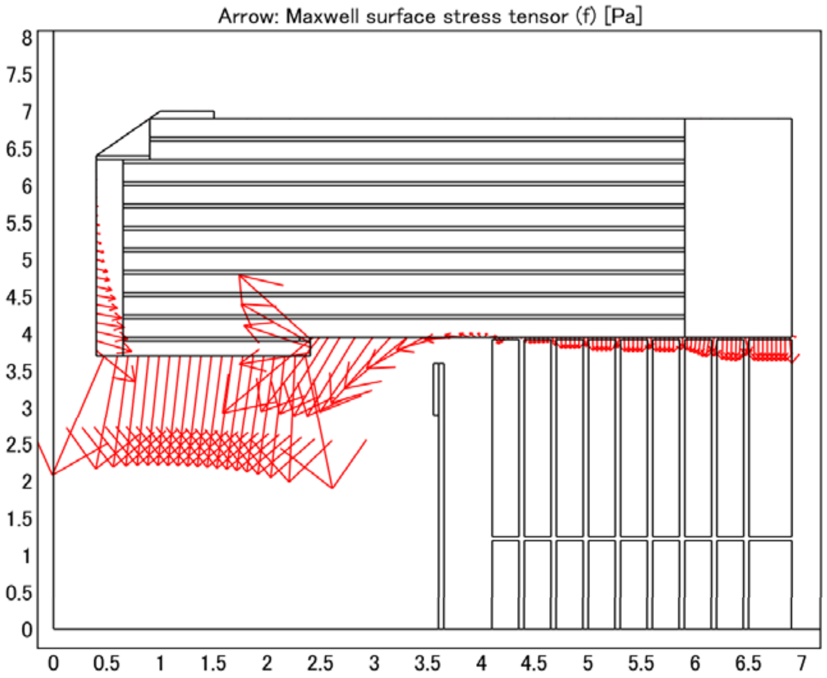
Endcap Deformation

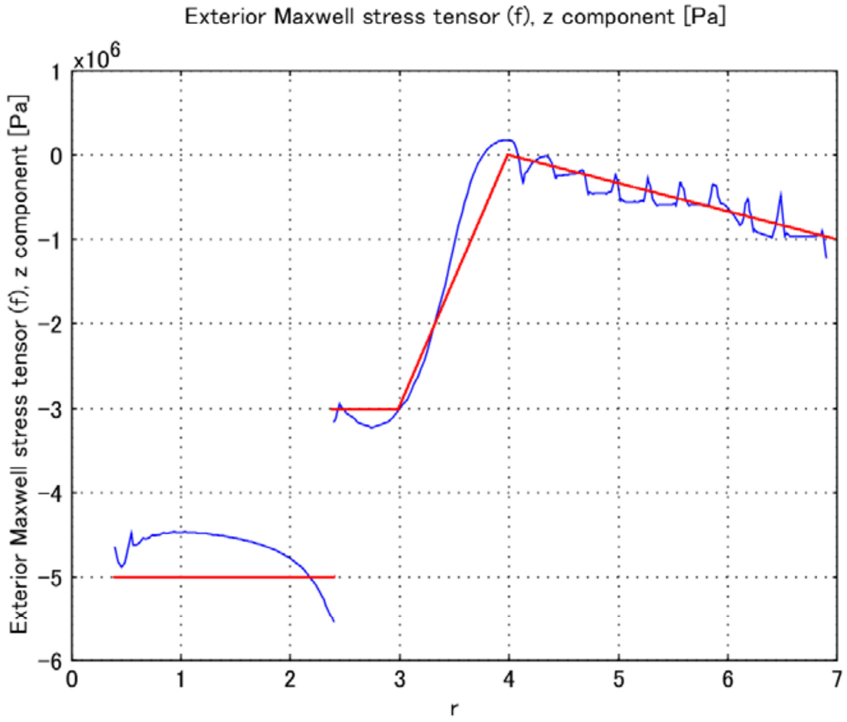
- Calculation by FEA method
  - Endcap is treated as a whole and surface force is calculated
  - The surface force at the front surface of the endcap is obtained as a function of R, and parameterized by a simple function
  - This simple function is used for the calculation of the deformation
  - Z-constraint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

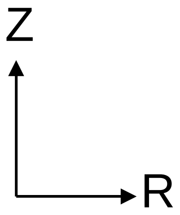


Endcap Deformation

- 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)

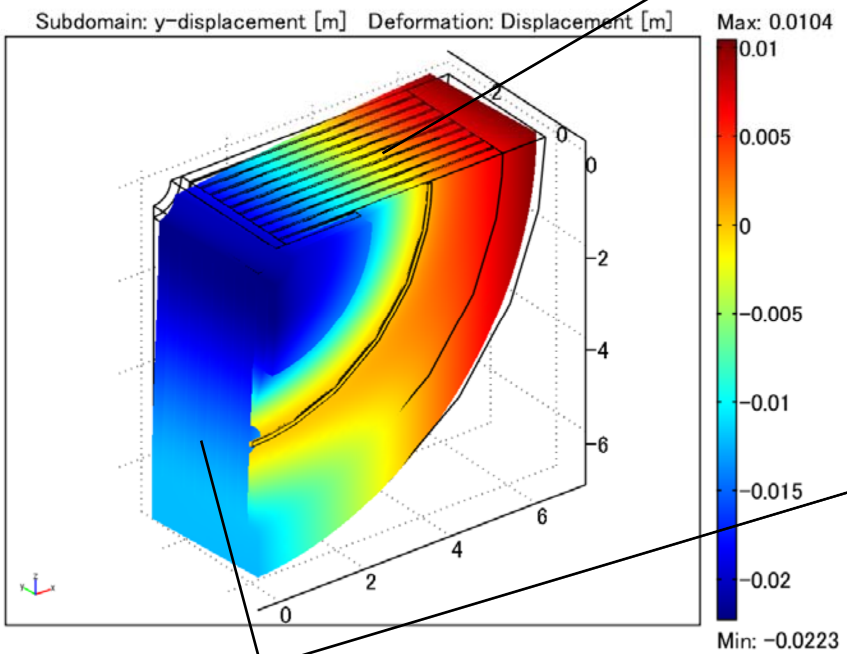
3D: 3-dimensional model
2D: Axial symmetric 2-dimensional model

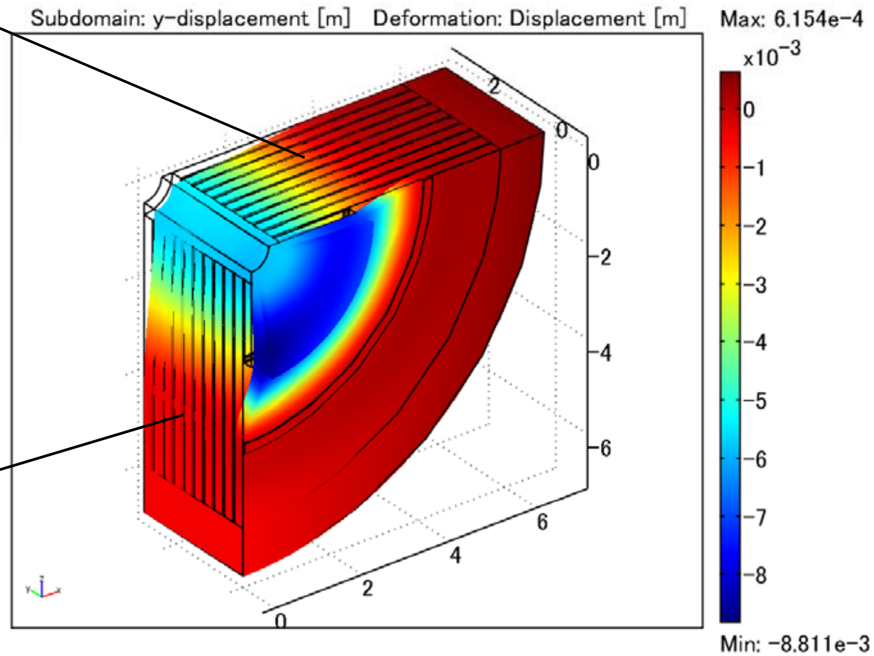
180: Splitting endcap
360: Non-splitting endcsp

Endcap Deformation

- No support ring
- One support ring/gap

Symmetry plane





Splitting plane

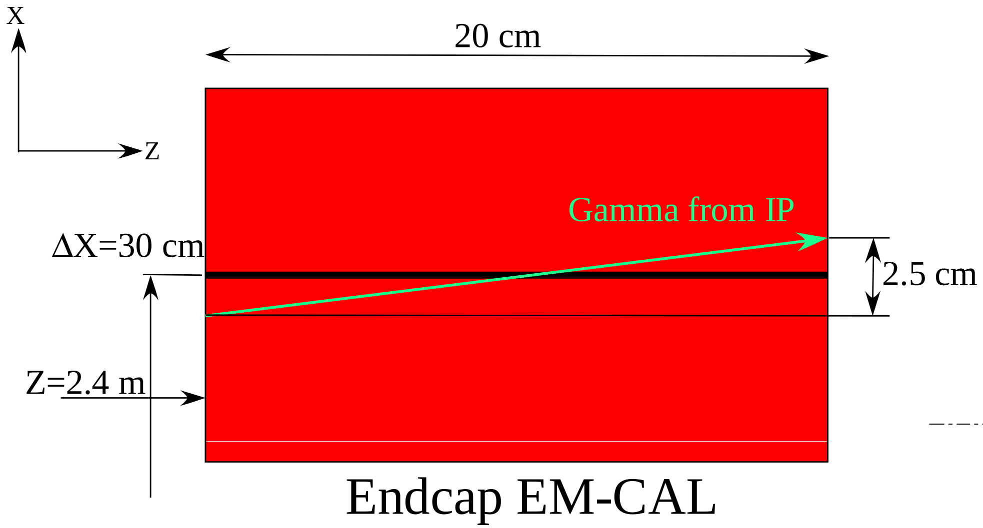
3D-180 degree model

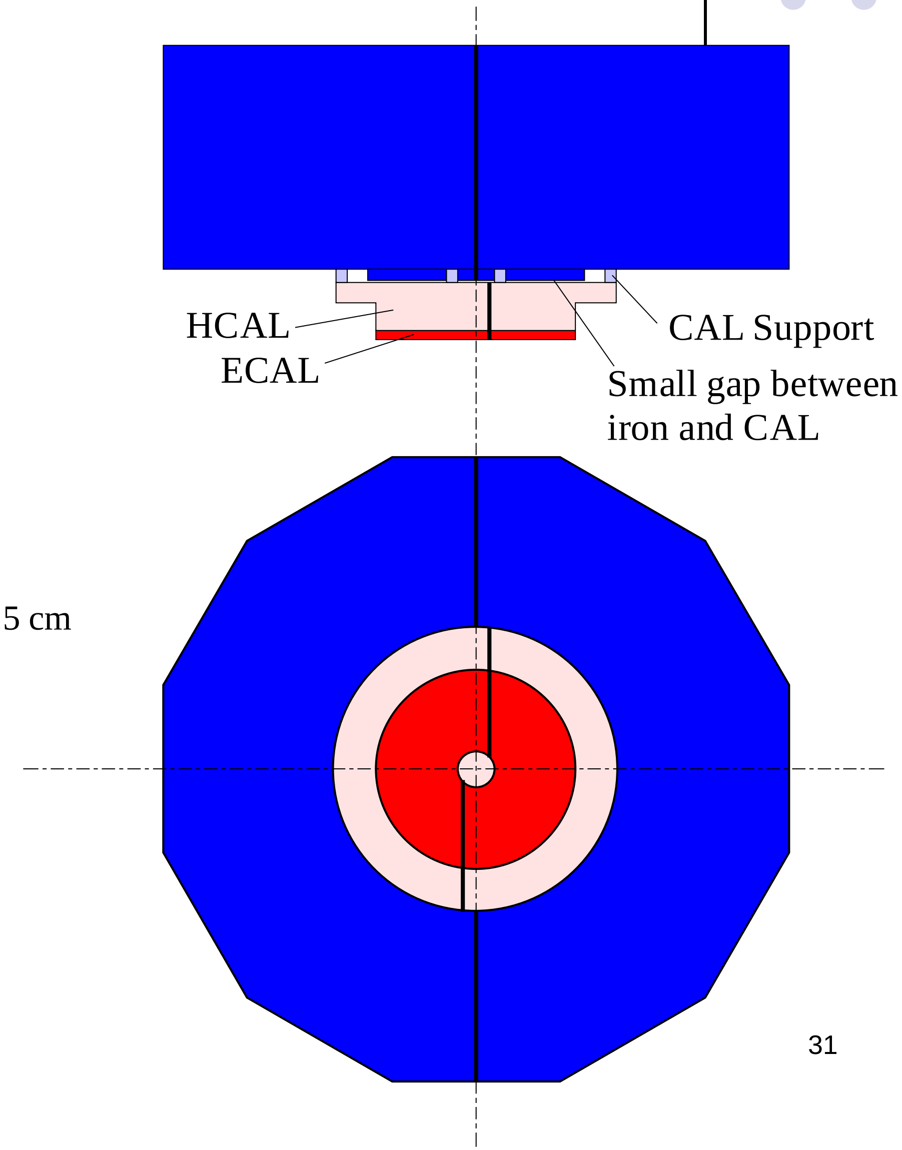
Gap in sub-detectors

- Endcap calorimeters
  - Split along a plane which does not cross the IP (x=30cm plane, for example)
- Endcap muon detector
  - Split along the x=0 plane (same as iron yoke)
  - Tracks entering the muon-detector gap can be detected by TPC and calorimeters
  - If the particle is a pion, it creates hadronic shower in iron yoke, and would be detected by muon detector even if there is small gap

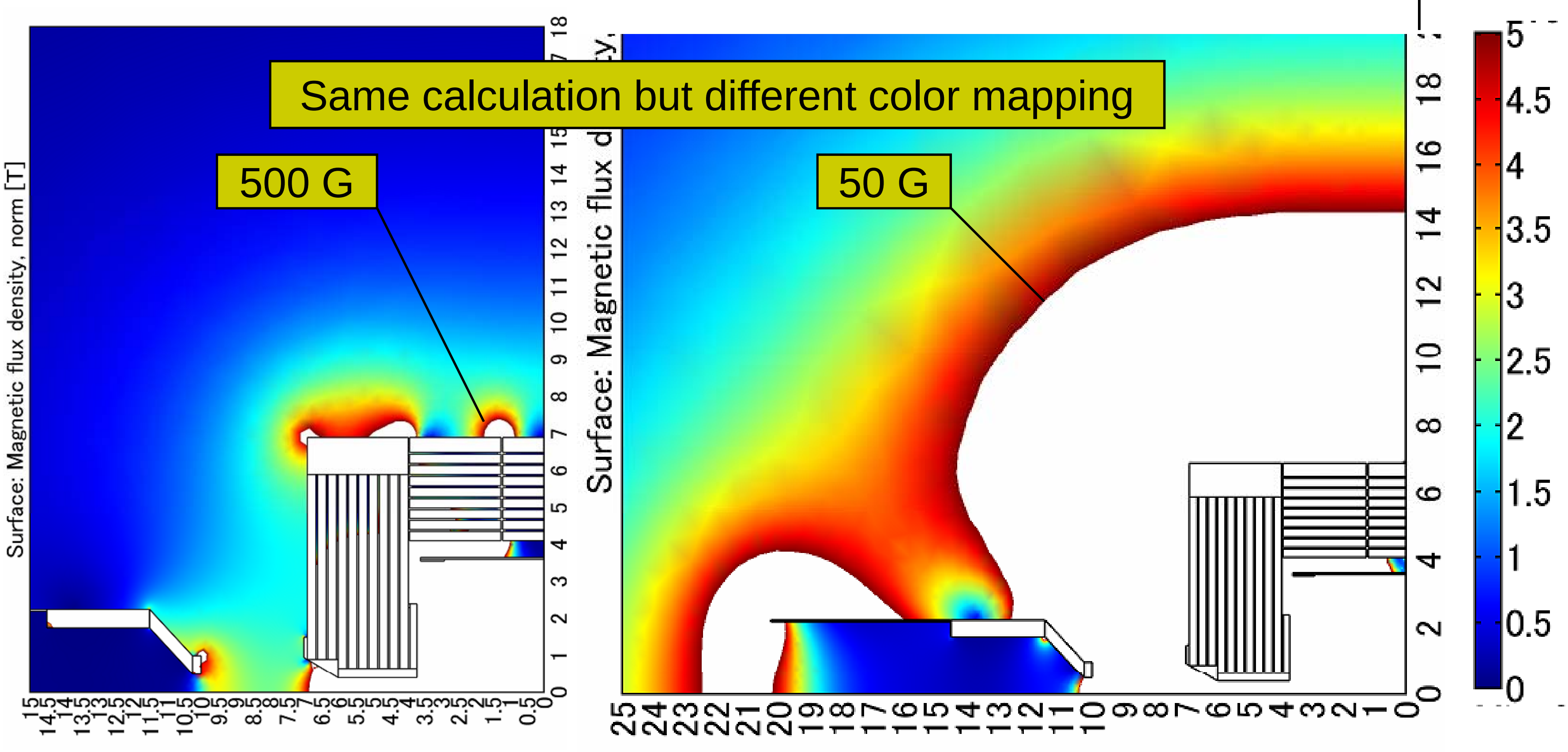
Gap in sub-detectors

- Endcap CAL





B field of GLDc



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

GLDc requirements for CFS

- Surface assembly hall
  - Same as CMS (?)
- Main shaft
  - 16 m in diameter or larger
- Underground cavern
  - 21 m floor (platform) width
  - Crane access to Z~9m
  - Cavern size is site-dependent
- Power consumption
  - Detector: xx kW
  - E-hut, sol. power supply, etc.: yy kW
  - Final doublet: ➔ Ask WG-B
  - Platform movement: ??
  - Light, air-conditioning: ➔ Ask WG-C

Guess of power consumption of detector		
	Detector	E-hut, etc.
VTX	300 W	3 kW
SIT		
TPC		
CAL	9 kW	70 kW
Solenoid	-	200kW/20kW
Total		