Detector Integration of GLD and GLDc

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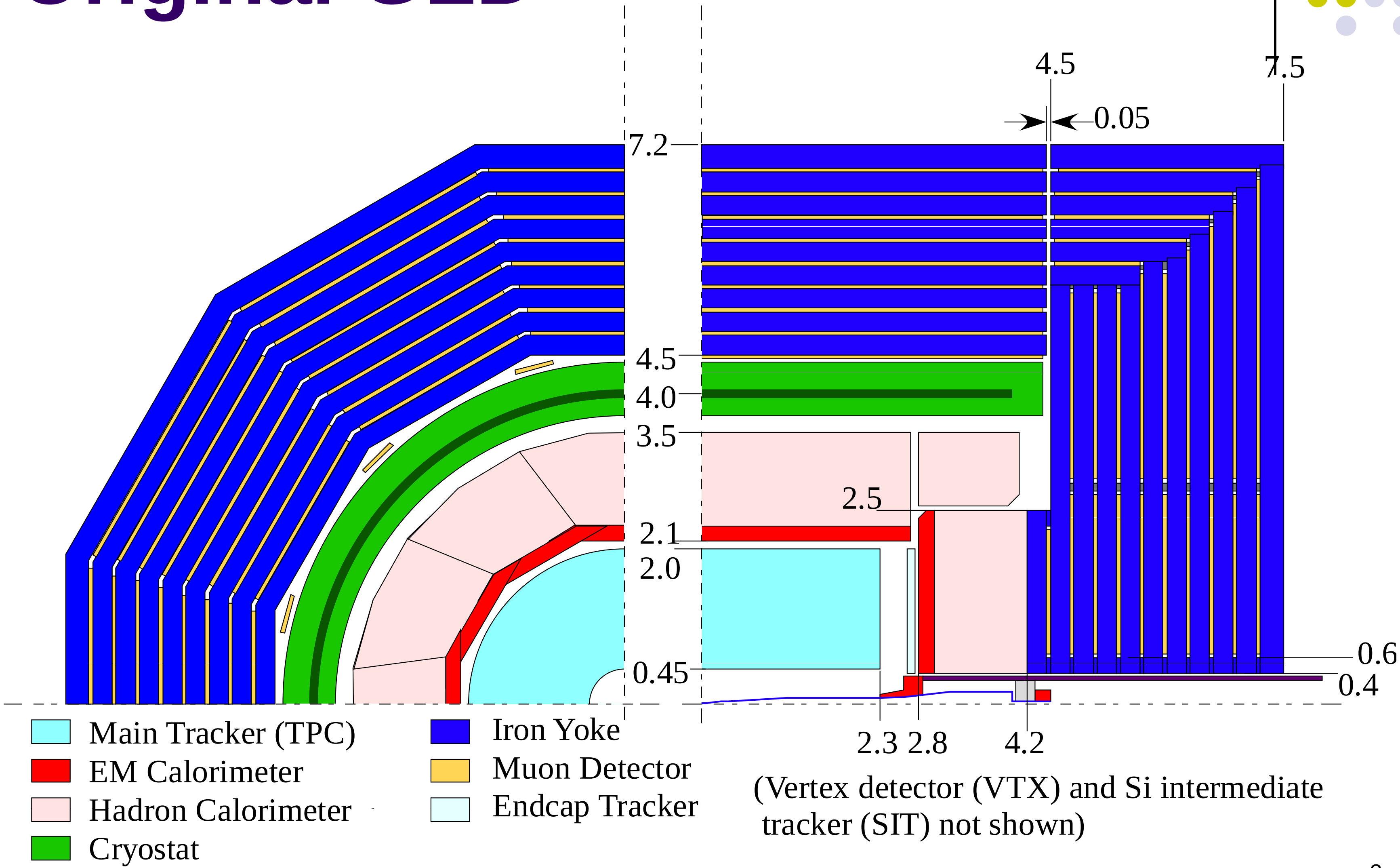
Compact GLD Option

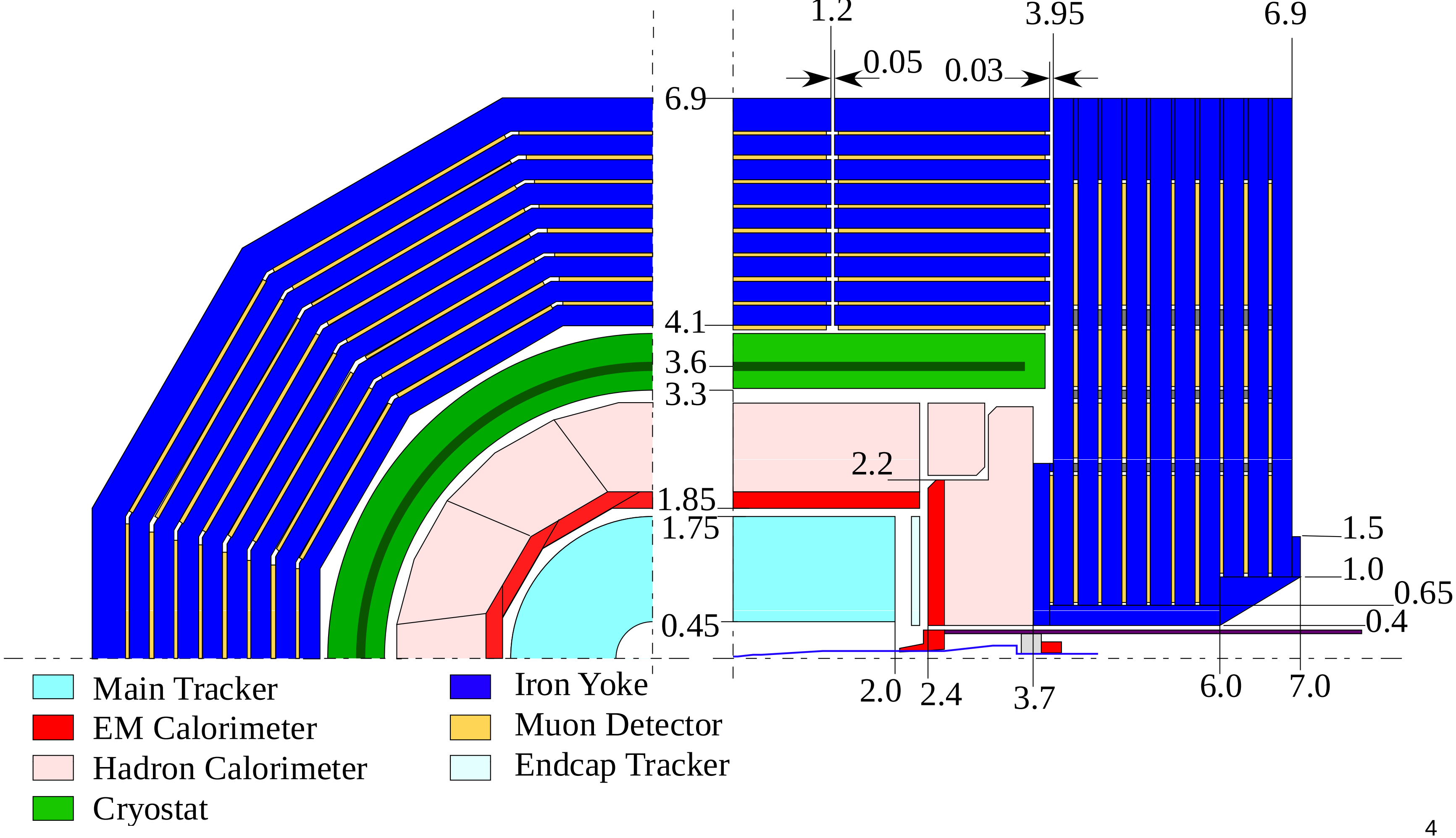
- Motivation
  - GLD and LDC will write a common LoI
  - The detector design should have common parameters
  - Common parameters should be determined based on detailed simulation study, but it will take a time ~0.5y(?)
  - As a working assumption for the moment, a modified design of GLD with the central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

Original GLD



(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 (active region)		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

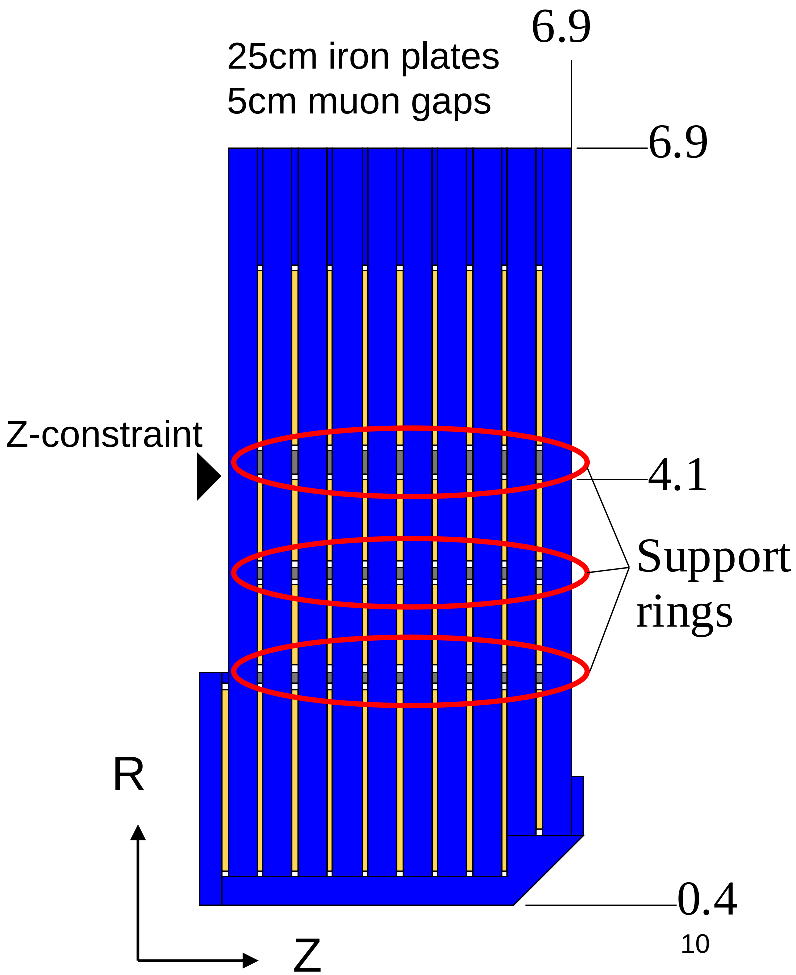
- GLD
  - Barrel part (Yoke+Sol.) > 6000 ton
  - For CMS style assembly (using 2000 ton crane to descend), it should be split into 5 rings and there will be many gaps
    - Large stray field
    - Difficulty in alignment of rings
  - In present design, GLD barrel yoke is split in R- and ϕ-direction into 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

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

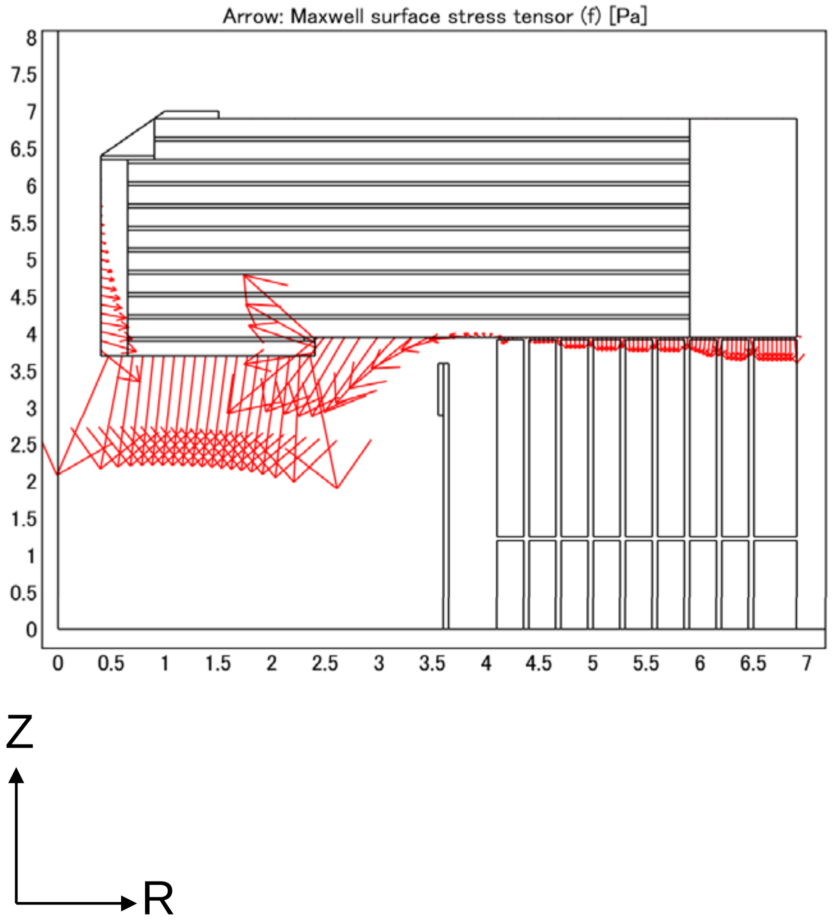
Endcap Deformation

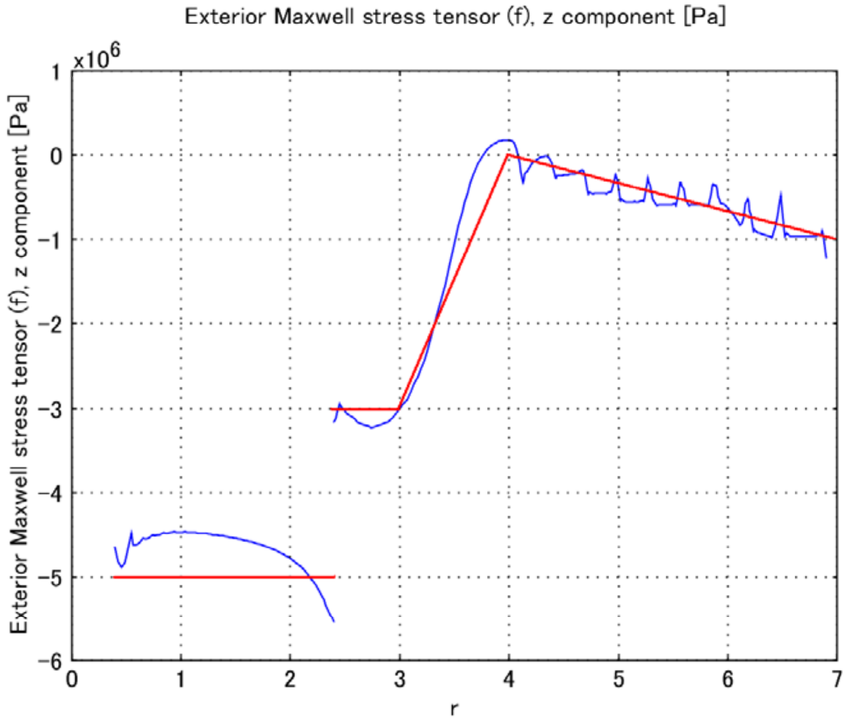
- Calculation by FEA method
  - Endcap is treated as a whole and surface force is calculated
  - The surface force at the front surface of the endcap is obtained as a function of R, and parameterized by a simple function
  - This simple function is used for the calculation of the deformation
  - Z-constraint 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)

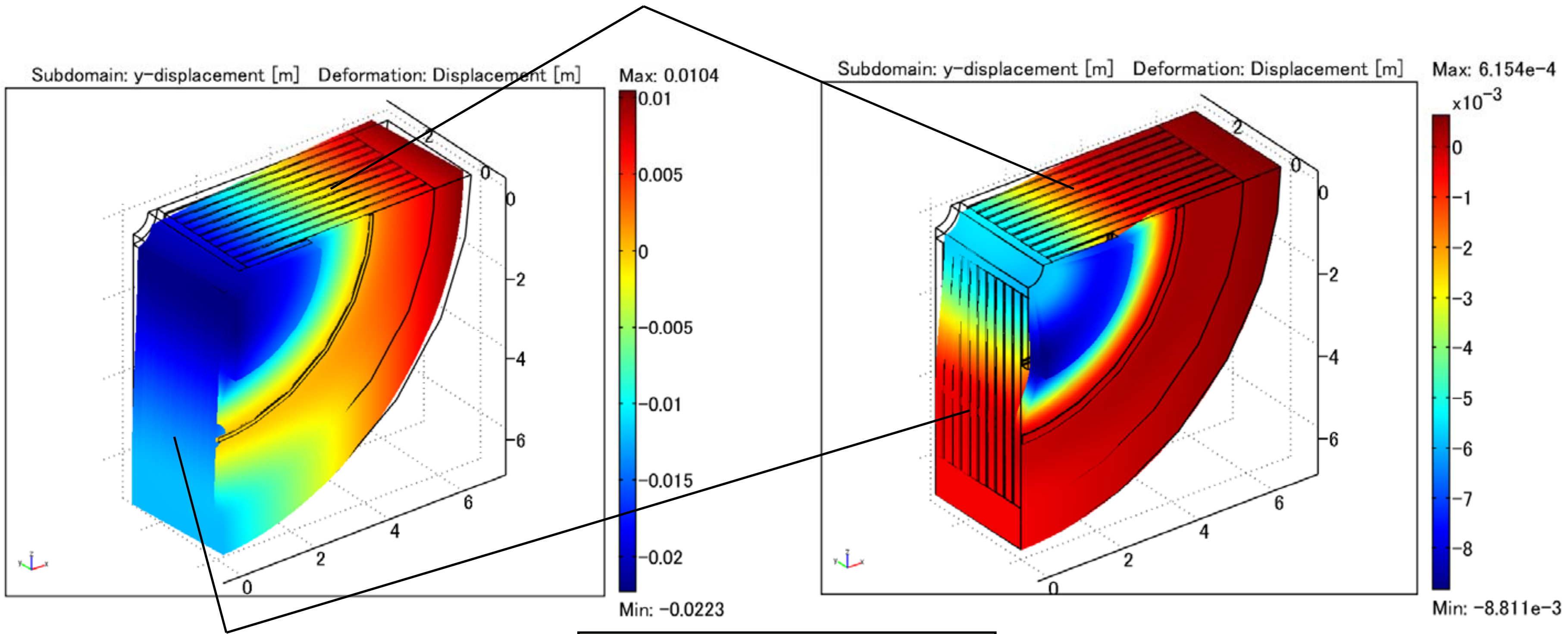
3D: 3-dimensional model
2D: Axial symmetric 2-dimensional model

180: Splitting endcap
360: Non-splitting endcsp

Endcap Deformation

- No support ring
- One support ring/gap

Symmetry plane



Splitting plane

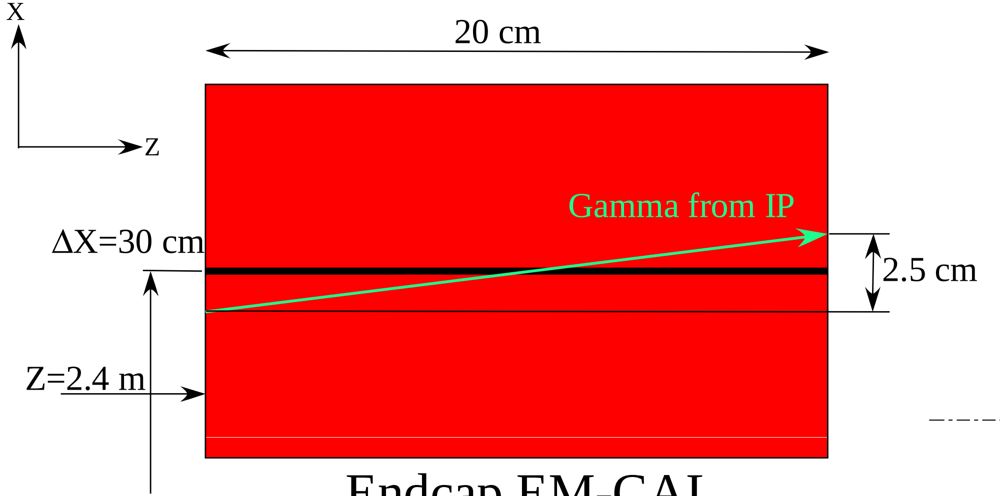
3D-180 degree model

Gap in sub-detectors

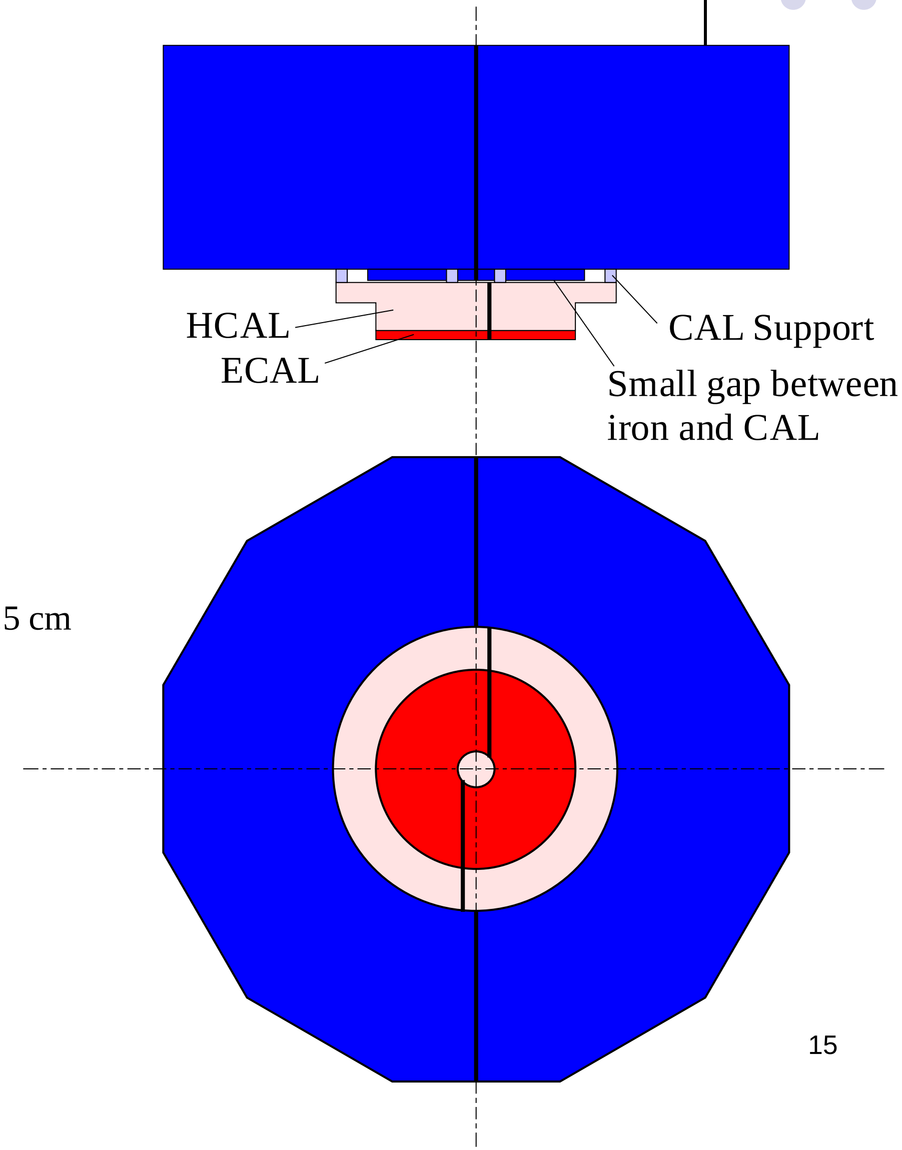
- Endcap calorimeters
  - Split along a plane which does not cross the IP (x=30cm plane, for example)
- Endcap muon detector
  - Split along the x=0 plane (same as iron yoke)
  - Tracks entering the muon-detector gap can be detected by TPC and calorimeters
  - If the particle is a pion, it creates hadronic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

Gap in sub-detectors

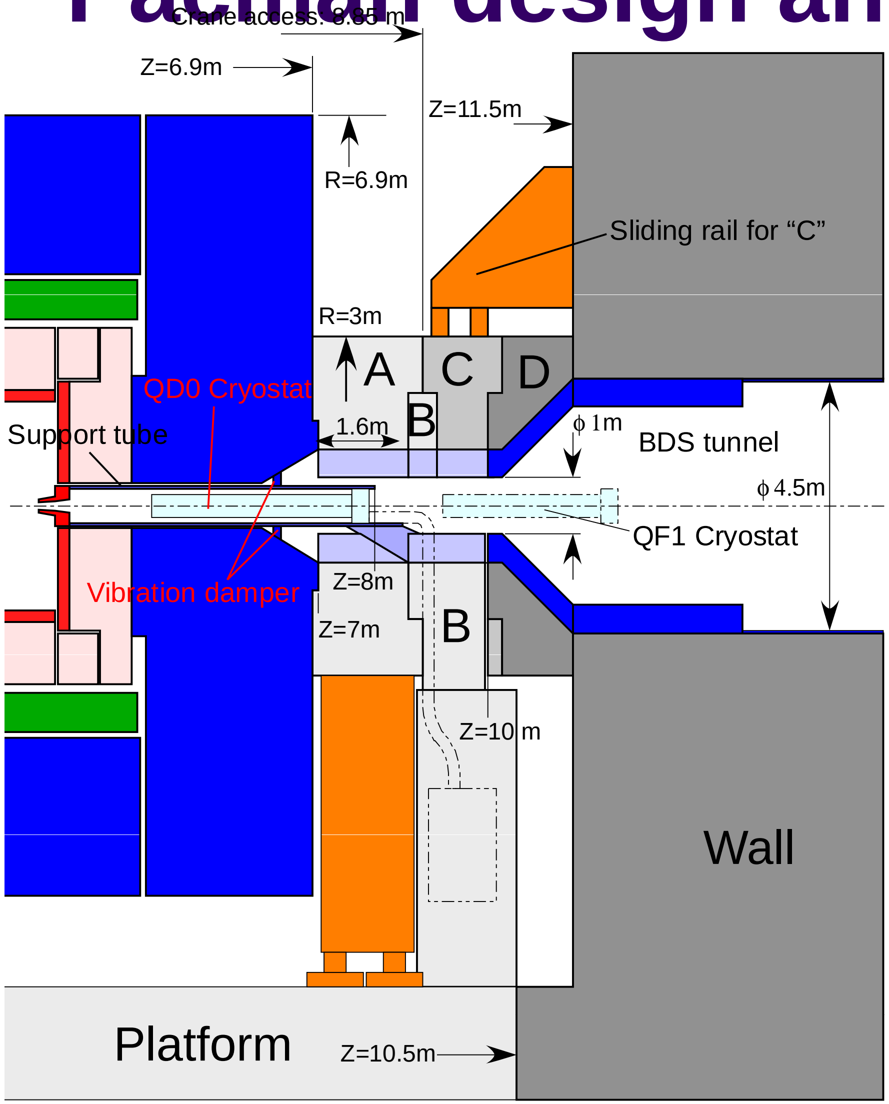
- Endcap CAL



Endcap EM-CAL



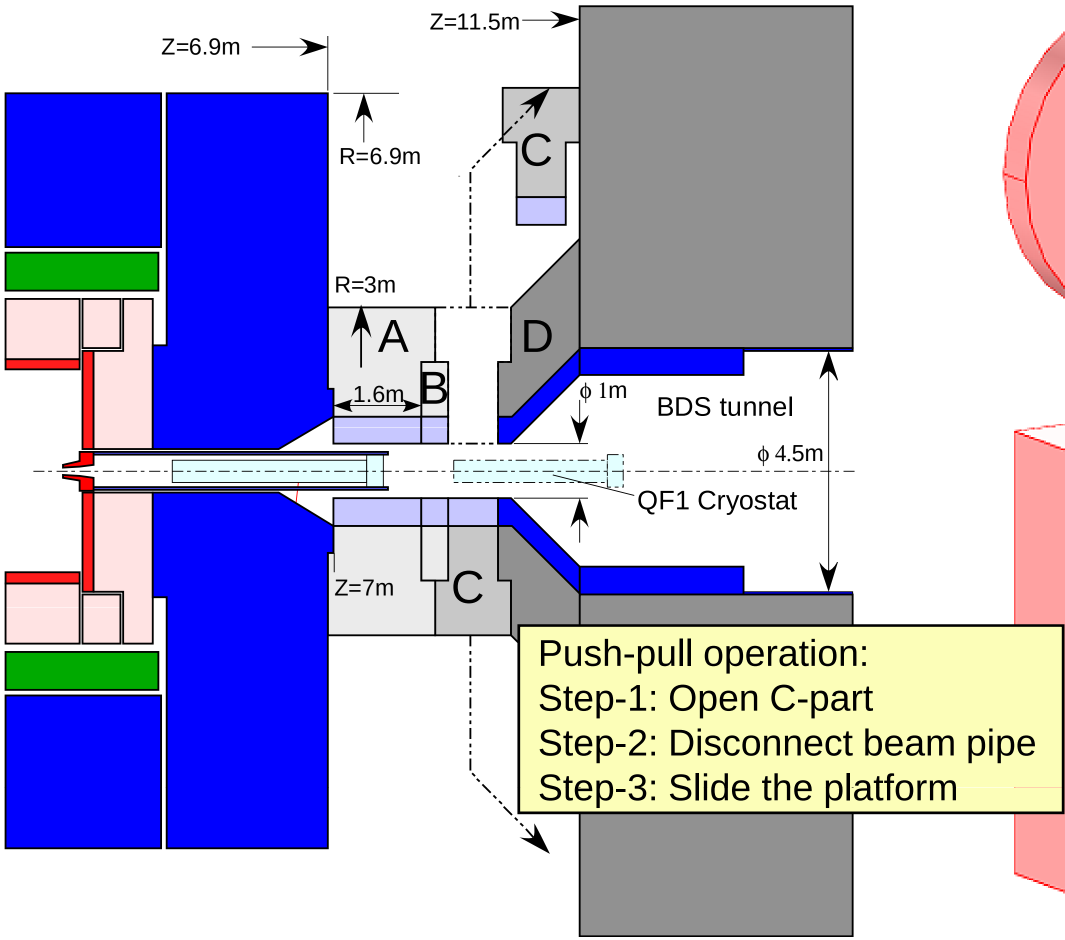
Pacman design and FD support



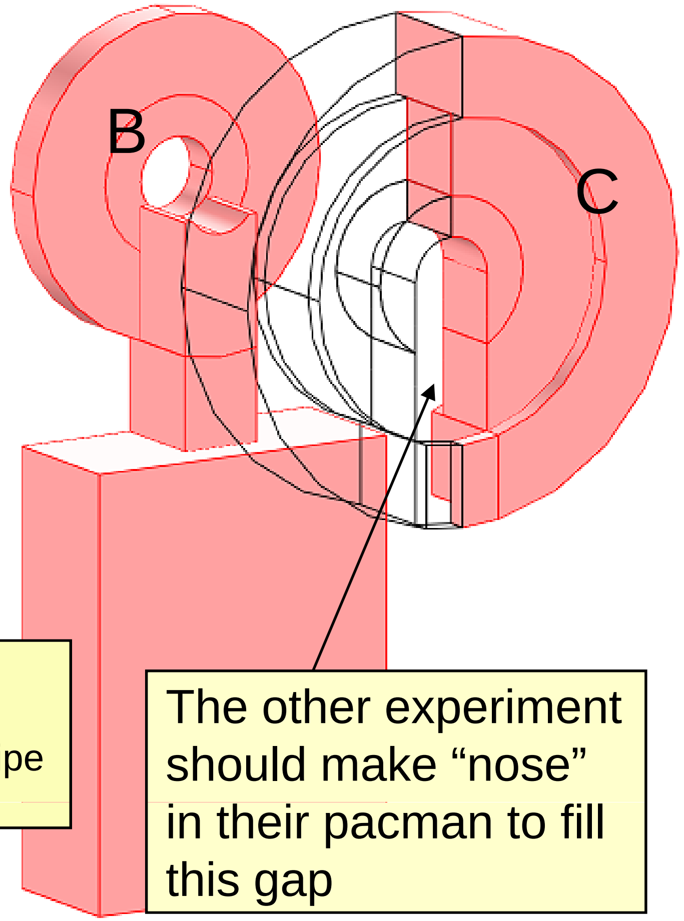
- A: slide sideway using air pad
- B: supported from the floor of platform
- QD0 cryostat is supported by the support tube and the support tube is supported from B
- We can put additional support for the support tube at the entrance of endcap yoke to damp the vibration, if necessary
- Upper part of B (~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

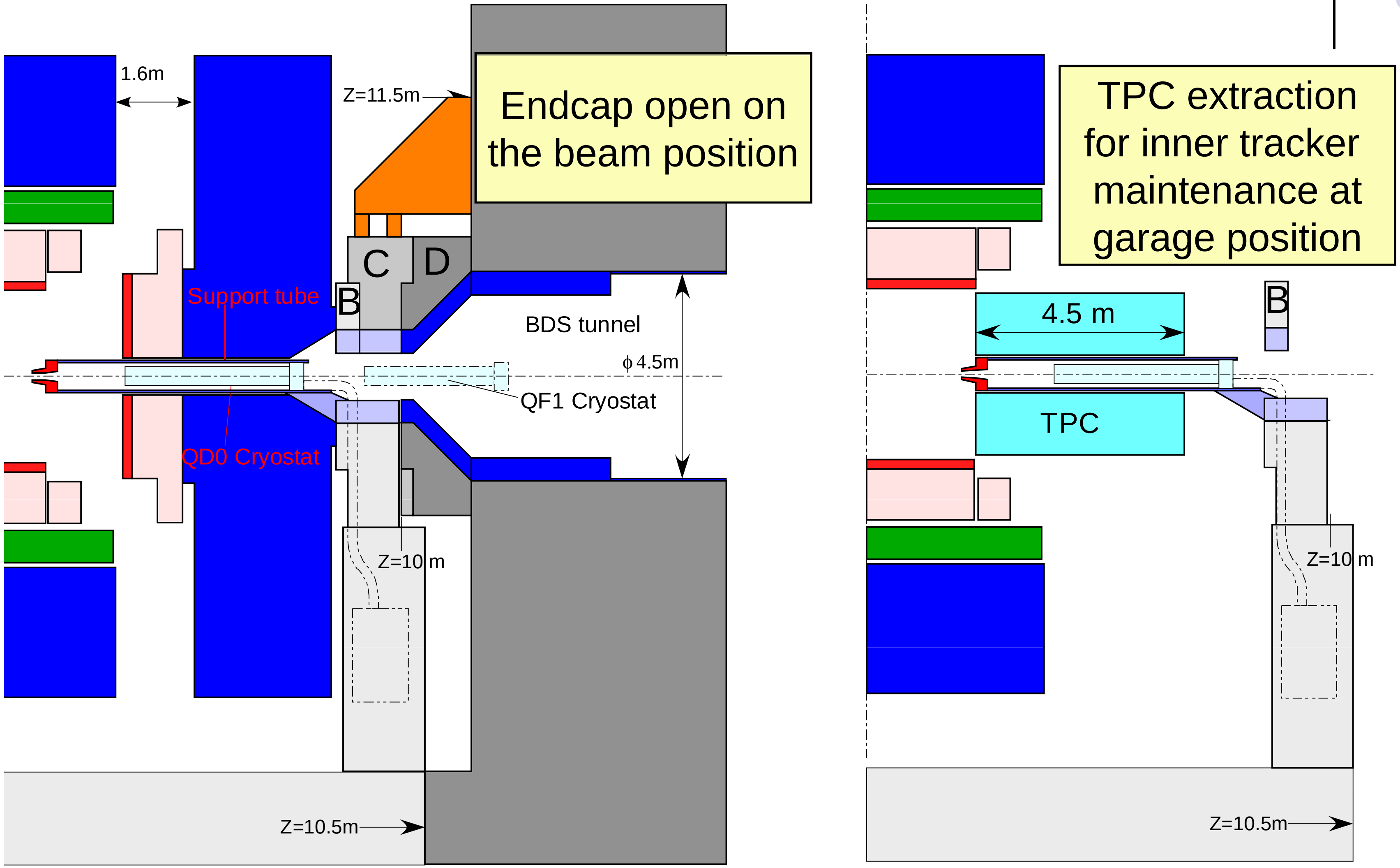
- Plan view



- 3D view

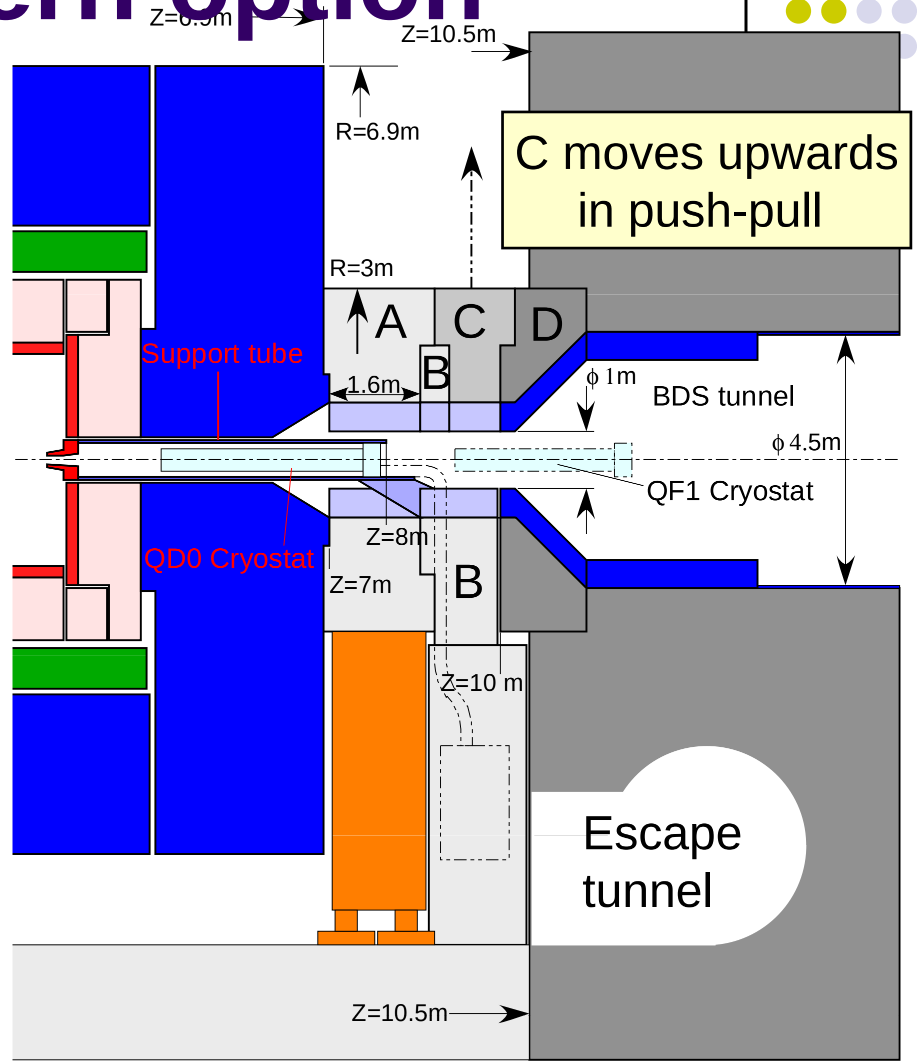


Pacman design and FD support

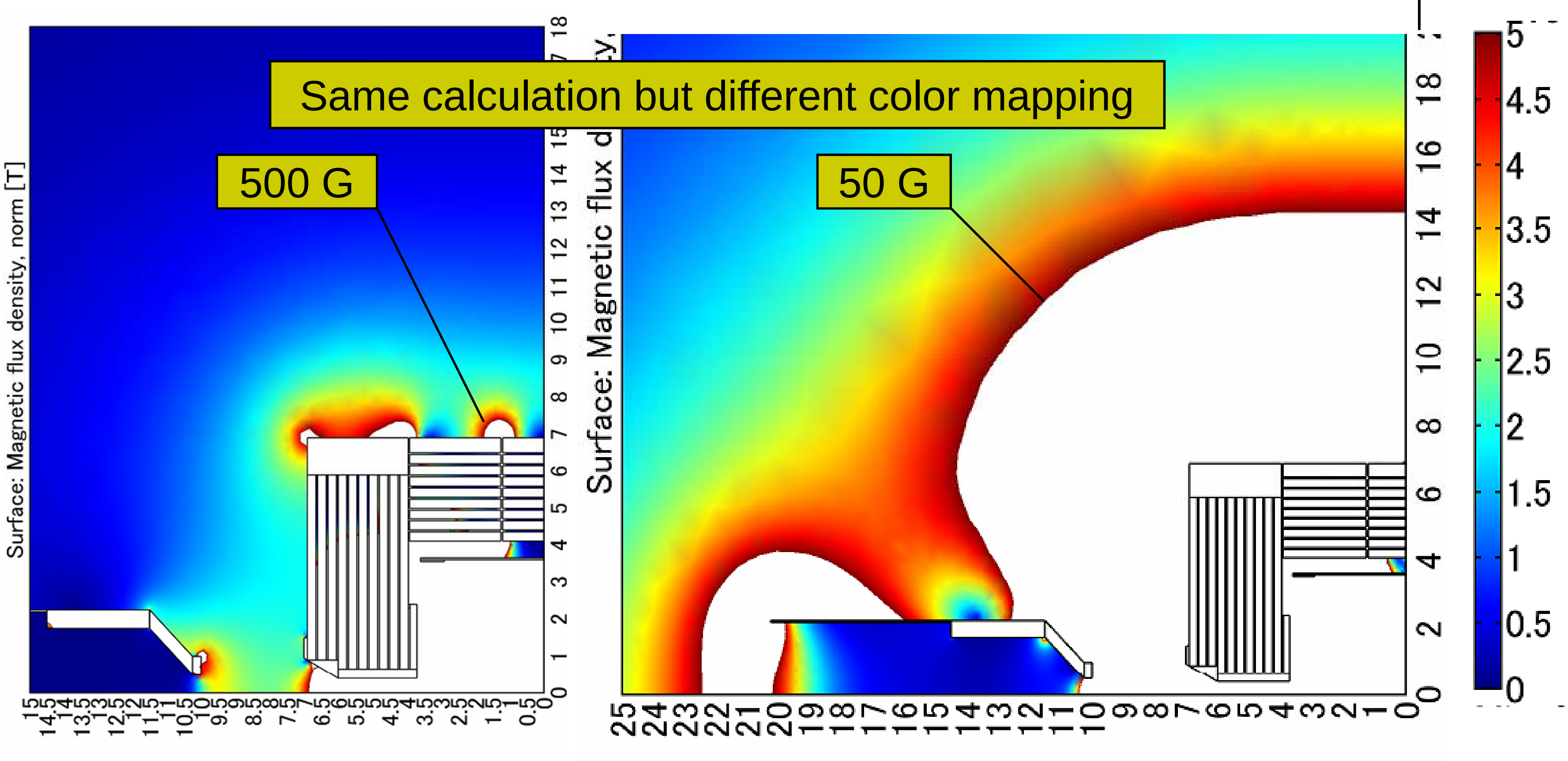


Still smaller cavern option

- 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 ?)



B field of GLDc



B_0=3.5 T

B(10.5m<Z<20m) <50 G

B(R>8m) <500 G

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

Difference between GLD and LDC

- CMS style or not (same for GLDc)
- Thickness of iron return yoke
- Diameter of endcap hole
- Beam pipe shape
- Global shape: octagonal or dodecagonal
- L* → Depends on Z_{endcap}

Thickness of iron return yoke

- 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 iron slabs
  - GLD: 25~30cm / LDC: 10cm
  - Deflection due to magnetic force should be estimated

Diameter of endcap hole

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

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 enough to support the pressure
  - Simulation study for lum. measurement
- Beam pipe near IP
  - Pair background simulation based on new machine parameters in RDR at 500 GeV **and 250 GeV** (We may have to ask GDE)

Global shape

- GLD: Dodecagonal shape in order to reduce unnecessary gaps between TPC and ECAL, between HCAL and solenoid, and between solenoid and iron return yoke
- LDC: Octagonal shape

- For calorimeters, dodecagonal shape is better (see SiD study: M.Breidenbach at ALCPG2007)
- How should we decide for return yoke?

Other Issues

- Issues not studied yet
  - 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
  - …..
  - …..