ILD: Global Integration Concept

Report from ILD Integration Taskforce Meeting

Karsten Buesser

ILD Meeting
KEK, 27.02.2019

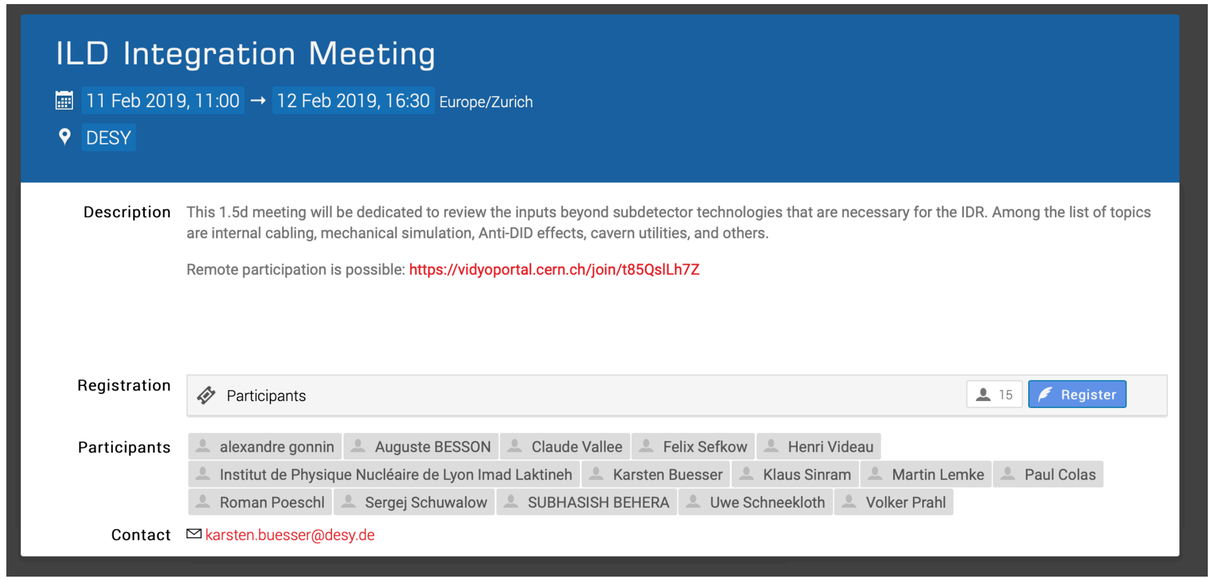
ILD Integration Task Force

- Charge: Define integration of ILD sub detectors as a coherent detector within the experimental hall
- Members:
  - Central: C. Bourgeois, D. Breton, K. Buesser, A. Gonnin, R. Poeschl, Y. Sugimoto
  - Vertex & FTD: A. Besson, D. Moya, I. Vila, M.-A. Villarejo, M. Vos
  - TPC: P. Colas, V. Prahl
  - Calorimeters: M. Anduze, J.-C. Ianigro, I. Laktineh, F. Sefkow, H. Videau
  - VFS: S. Schuwalow
  - Coil/Yoke: U. Schneekloth, R. Stromhagen
  - DAQ: M. Wing

ILD Integration Meeting

- February 11/12 at DESY
- 14 participants at LAL, more remotely connected
- (Almost) all subdetectors represented

- Reports of integration status from all sub-detectors
- Magnets incl. Anti-DID impacts
- Services, Cables, Patch panels
- Costing
- IDR



https://agenda.linearcollider.org/event/8126/timetable/

Vertex Detector

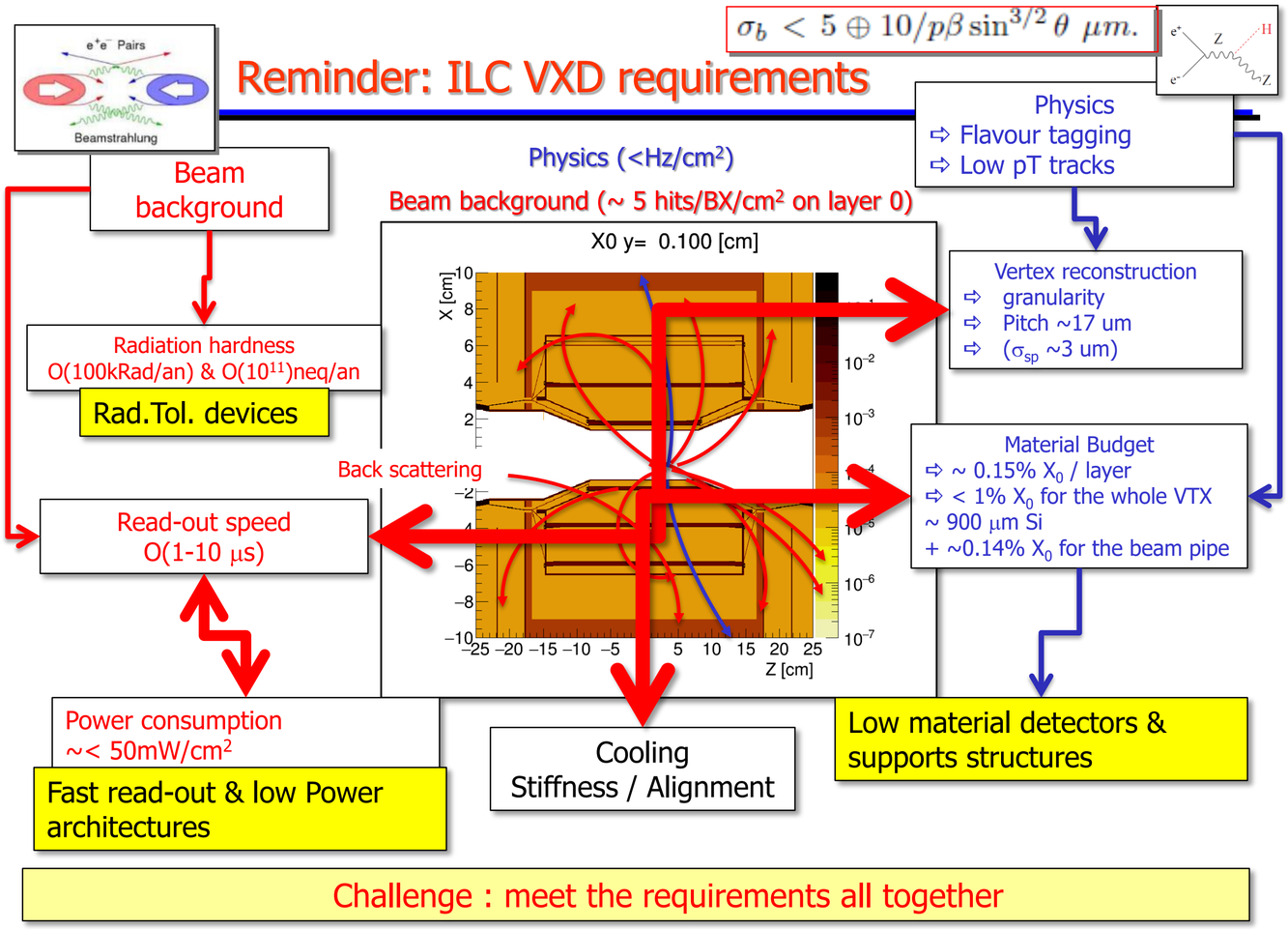
- Steady progress in the understanding of the system properties
- Updates on power and cost available

Beam background rate	Read-out speed	<Power (NO P.P.)	<Power> (P.P.)	
	(μs)	(W)	Conservative	Ambitious
DBD	4 μs	102 W	~31 W	~12 W
DBD	2 μs	122 W		
DBD x 2	4 μs	107 W		
DBD x 2	2 μs	127 W		

PSIRA

[c] High unit costs due to small production 9

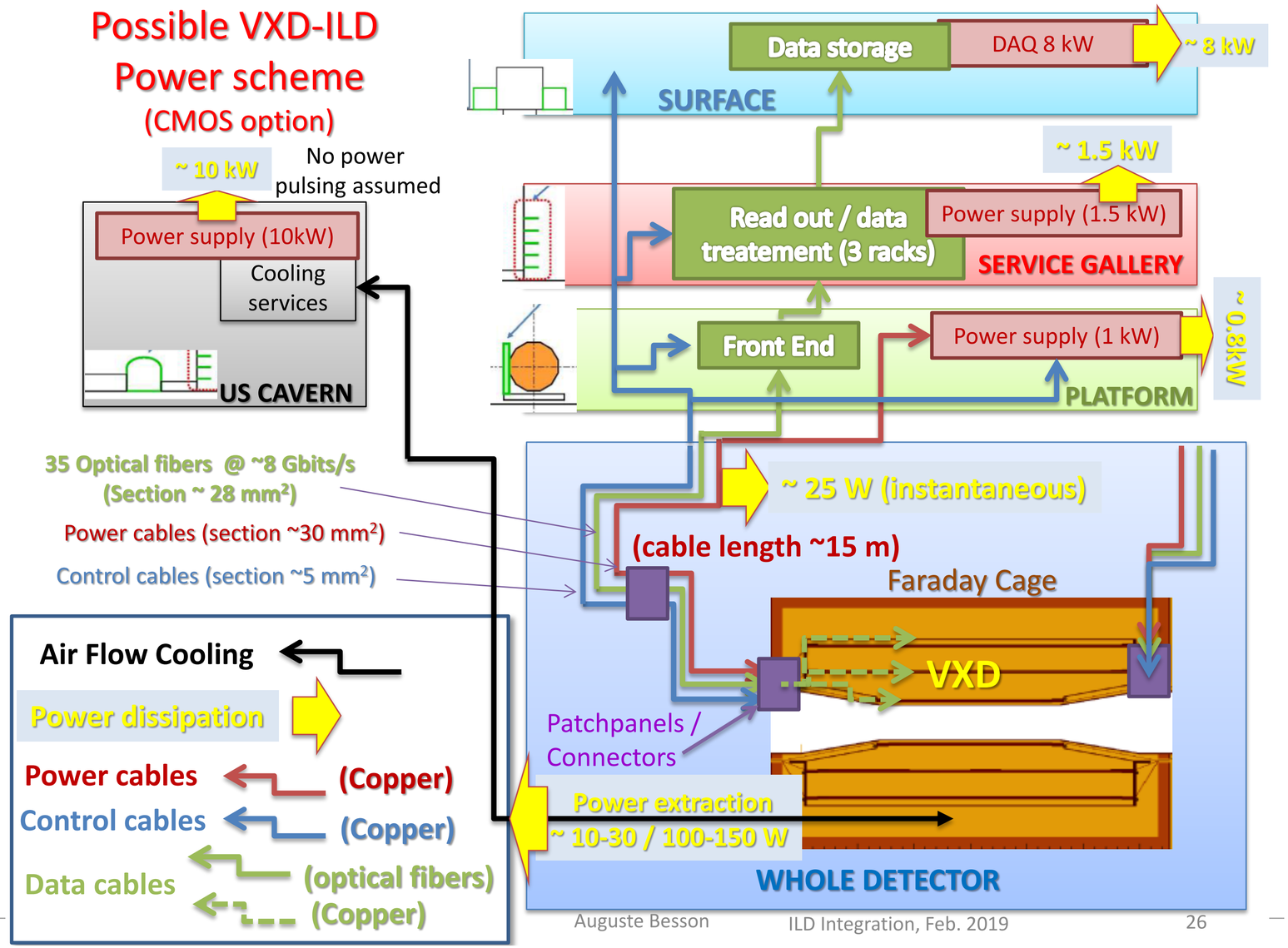
Detector	Cost	Sensors	Mechanics	Eletronics	Services	Installation	Total
VXD	Material	1152	452	486	770	100	2960
	Manpower	100	500	400	250	200	1450
	TOTAL (kEUR)	1252	952	886	1020	300	4410



Vertex Detector Services

- Rather detailed plan for power, readout, control cables
- Cooling scheme still undecided
- Input for detector environment planning

- Open questions
  - Cooling the beam pipe ?
  - Shielding cables to be evaluated
  - Faraday cage
  - Patch panels ⇨ detector opening ?
  - Data cable ⇨ Connectors to optical fibers



Intermediate Si Tracking

- Detector integration studies for FTD
- Costing available for SIT

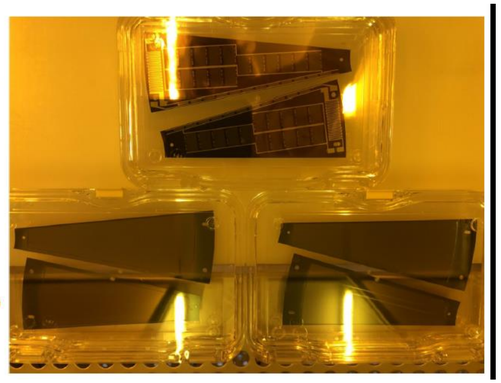
SIT	Material	3820	760	1275	1580	110	7545
	Manpower	200	500	800	300	200	2000
	TOTAL (kEUR)	4020	1260	2075	1880	310	9545

News from Forward disks

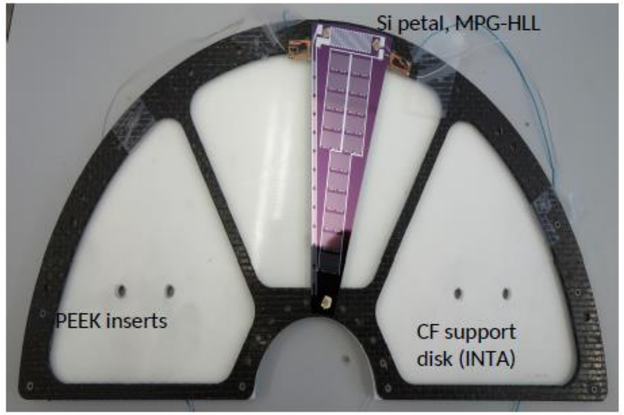
- A new mock up is being built (FTD1 & 2)
  - Thermo-mechanical properties
  - Planarity

New production at silicon lab of the Max Planck society in Munich

Petals arrived at IFIC in September 2018 and are currently being mounted on mock-up structure



Mock-up for FTD1 and 2 is being assembled at IFIC



AIDA 2020

First measurements look promising:
- kinematic mount absorb thermal expansion as expected
- deformations under power load and air-flow are O(5 μm)
- mechanical stability in stable conditions is much better

TPC Support

- Support from cryostat or from HCAL?
- an old topic…
- but needs to be resolved!

Gravitational loads
- Self-weight of structure : 895 kg
- Weight of the modules : 1176 kg (84 modules / endplate and 7 kg / modules)

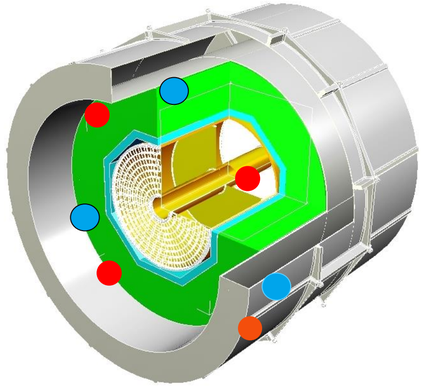
→ Total weight of 2 000 kg

Overpressure of 3 mbar
- Pressure applied on the cages
- Forces applied on each endplate by taking into account the pressure on modules

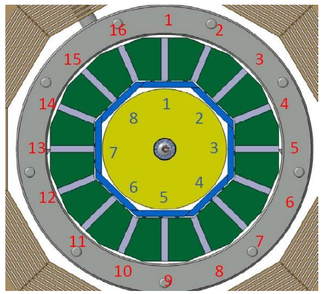
	AHCAL	Cryostat
3x120°	- Accuracy + Shorter support structure - HCAL deformation -Stability under seismic conditions of the AHCAL	+ Accuracy - Longer support structure + Cryostat deformation +/- Seismic stability
4x90°	See above - More space required	See above - More space required

TPC Support Structure

Requirements of the TPC support structure, AHCAL around !



Main dimensions of the TPC (outside)
Ø Od = 3616, r=1808
Ø Id = 658, r=329
Length = 4700 incl. endplate and cabling

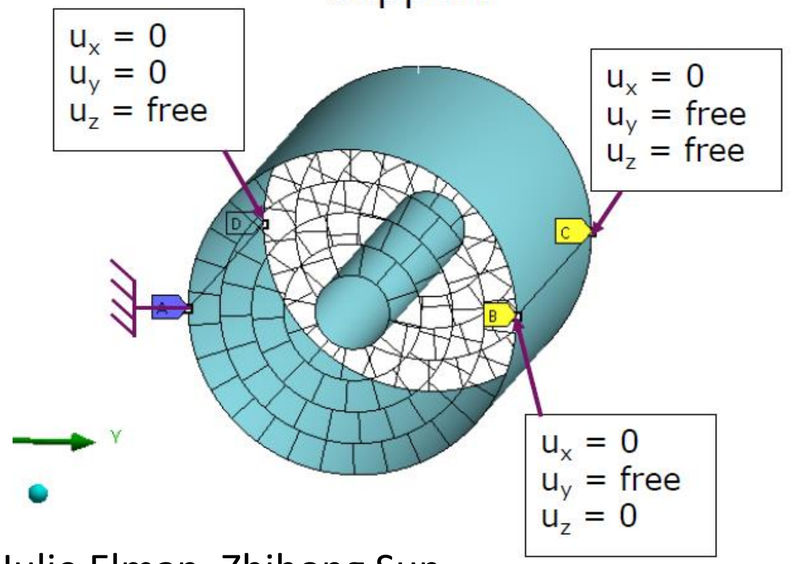


3 Point 3x120°, preferred gaps: 1,12, 6

4 Point 4x90°, preferred gaps: 3, 15, 11, 7 but this gaps filled 100%

Only the cryostat is foreseen to support the TPC

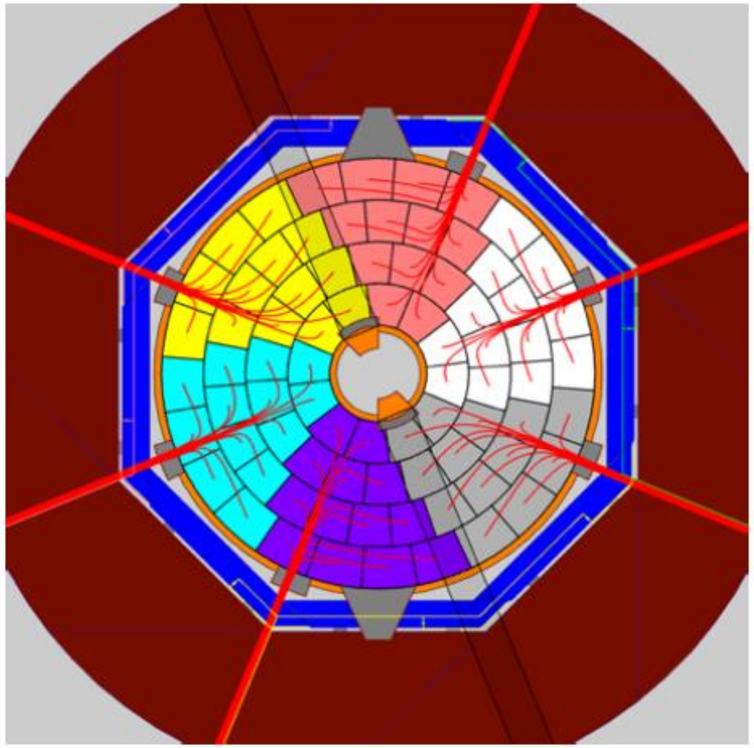
Isostatic median support

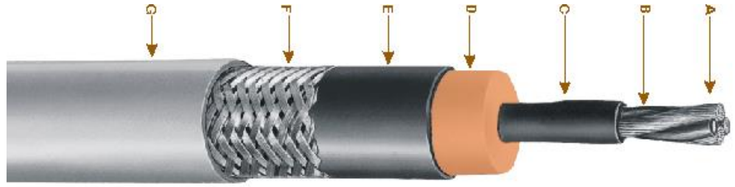


Julie Elman, Zhihong Sun

TPC Interfaces

INTERFACES





Very High Voltage for the central cathode : Very big cable (insulation), curvature radii 70mm to 280mm. Or make it onsite (needs space also)

Low-voltage power: bundles of 10 copper cables
6 mm² section (32 A).
6 sectors per end-plate : 120 cables, 12kW(100 W per cable).
With 20 m cables (R=O.06 Ω) 60 W loss.
Can we accept this such a loss (60% of the useful power?)
Need cable cooling? DC-DC converters?

Detector HV and fibres for readout less demanding

Patch panels on each sector to allow disconnecting the TPC

Do we need a jacket against heat from the ECAL?

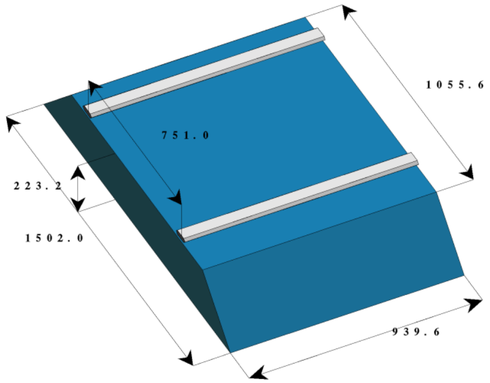
SiECAL

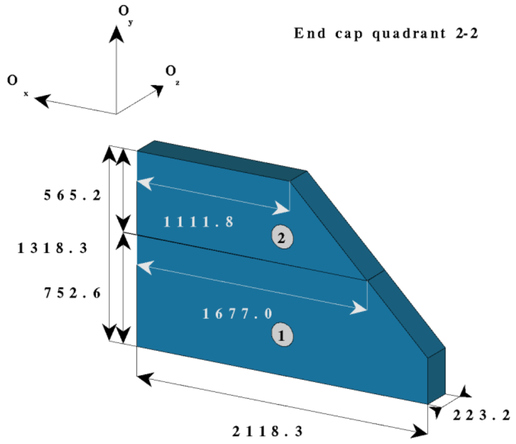
- Also SiECAL is revising the sample structure of the calorimeter
  - experience from CMS HGCAL
  - realism

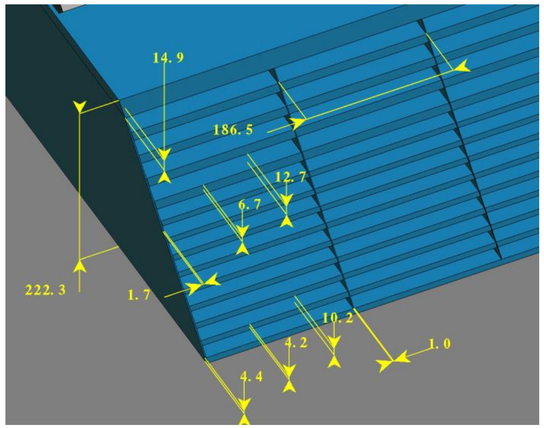
The development of the CMS HGCAL has impacted the ILD SiW-Ecal on three aspects:
- The price of 1 cm² of silicon for CMS is close to ½ the TDR price
- HGCAL will use 200mm wafers
- The question of timing.

The 200mm diameter ingots are sliced in wafers 725µm thick as a standard.
Using such a thickness improves the resolution and the signal over noise ratio.
(if we were to go to “scintillator thicknesses” (2 to 3 mm), the stochastic resolution would be 12 to 11%)

But we need slightly more space,
as the resolution improved we can slightly relax on the sampling.
The choice has been to go for 26 layers 18 thin and 8 thick,
on top of the space needed for the silicon matrices it provides also easier clearances.



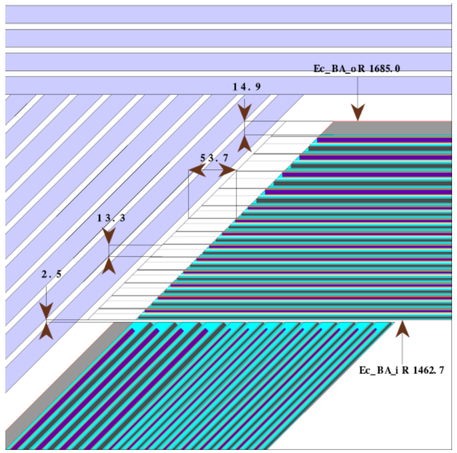




SiECAL - Revised Design

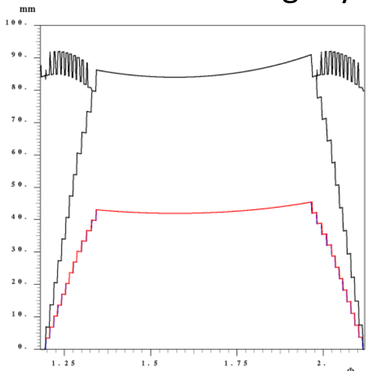
The sensitive layer depth structure and the slabs

Going to 26 layers while keeping 24 X0's (?) means slightly thicker tungsten plates: 2.471 and 4.942mm. The chip and PCB thicknesses are slightly relaxed.

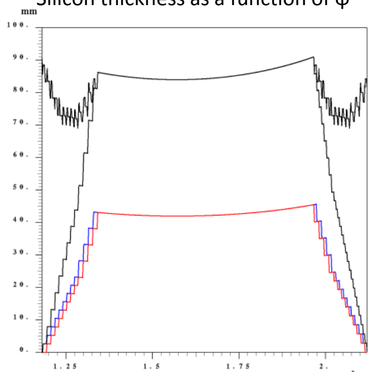


The electronics end of a stave

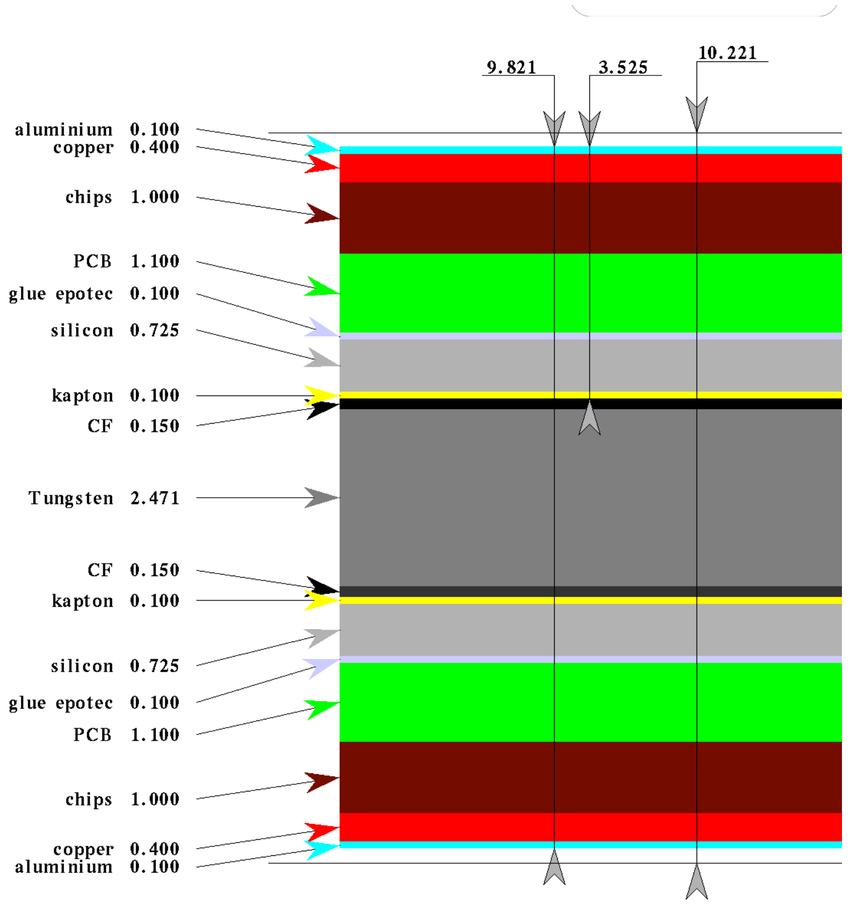
Problems in ϕ



Silicon thickness as a function of ϕ

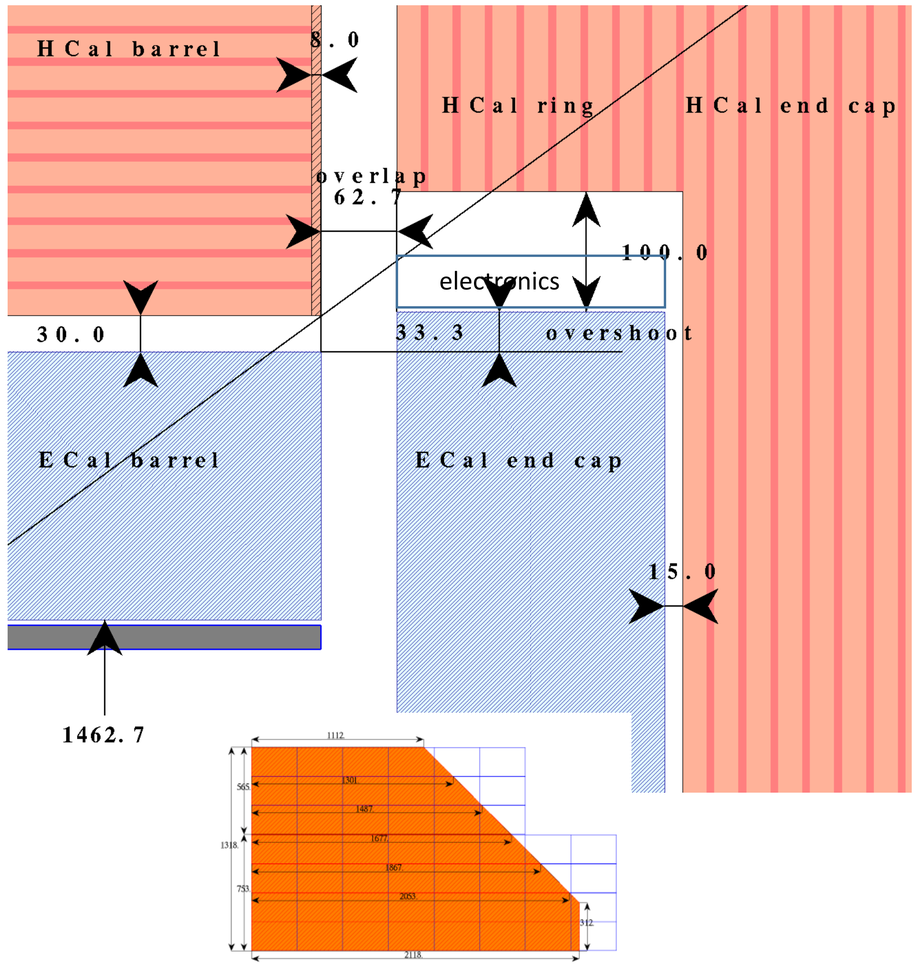


W thickness as a function of ϕ



Thin slab structure

SiECAL - Revised Design Implications



Problems in θ

Notice that the end cap electronics detailed design is lacking

To cope with the increasing ECal thickness
while not moving the HCal
the TPC has been somewhat reduced in radius
(not the sensitive part though)
and the distance between barrel and end cap reduced from 100mm to 63. This improves the ECal connection. Around the Ecal end cap the 100mm are not empty but partly (in ϕ) full of electronics.

The questions linked to the services going out and the Ecal Hca interface will be covered by Roman.

Another question arises from the space between ECal and HCal in the end caps. The fastening of the ECal end cap and the insertion of the cooling needs 30mm rather than 15.

AHCAL - New Model

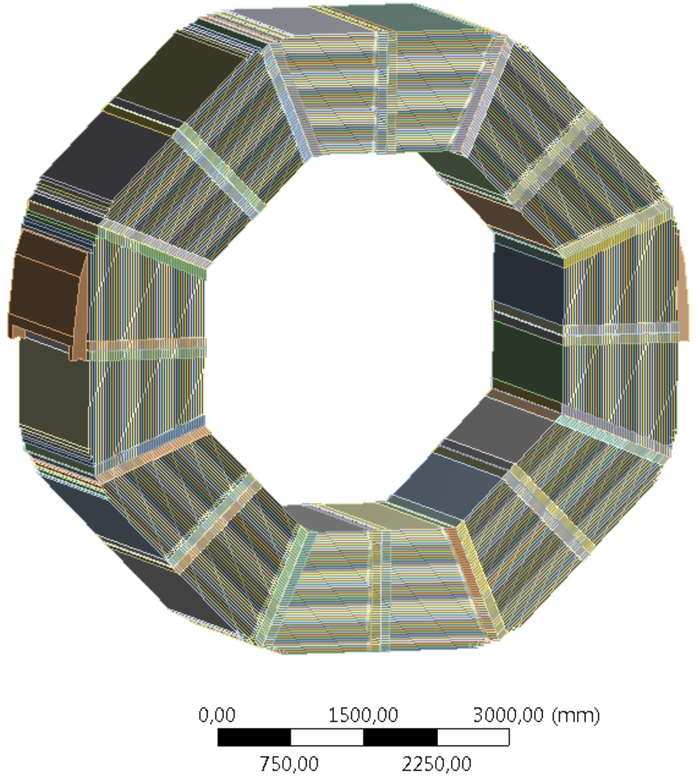
- Re-design of LDC-based model to ILD done
- Optimisation for mechanical stability
  - keeping the realism

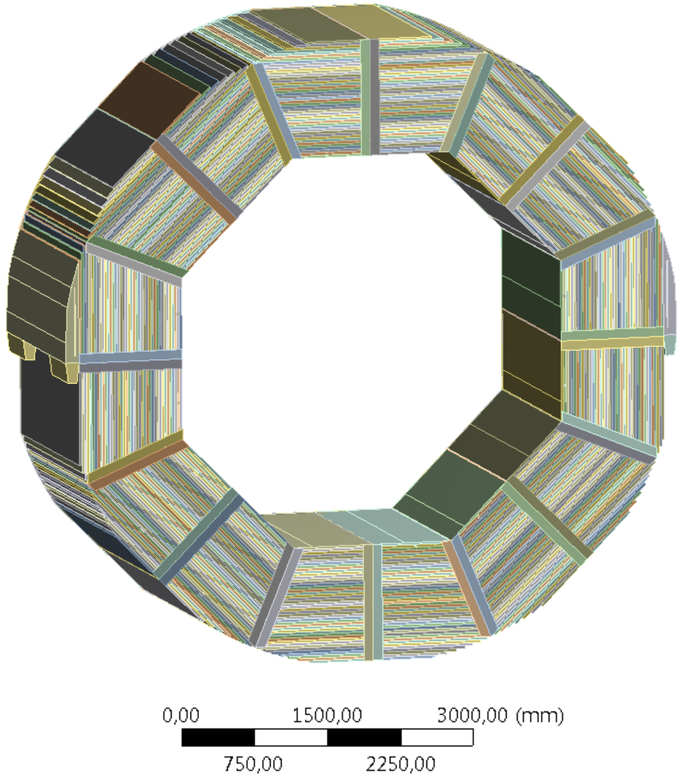
	Old	New
Plate Thickness	16mm	19mm
Number of Plates	**49 Layers** with: => 46 "full" layers => 3 "reduced" layers	**44 Layers** with: => 37 "full" layers => 7 "reduced" layers
Periodicity/Pitch	Every **26,5mm**	Every **28,0mm**
AHCAL Mass (total)*	262.108kg	291.953kg
AHCAL Length	**2.160mm**	**2.350mm**
AHCAL Outer Radius	3.392,5mm	3.349mm
AHCAL Inner Radius	1.947,5mm	2.058mm
Connection of AHCAL Segments	Coverplates: - 200mm (width) - 15mm (thickness)	Coverplates: - 200mm (width) - 15mm (thickness) Backplates: - 10mm (thickness)

1.445mm

1.291mm

* Detector mass about 16,82kg/m² (corresponds to thin cassettes) included and ECAL mass not included



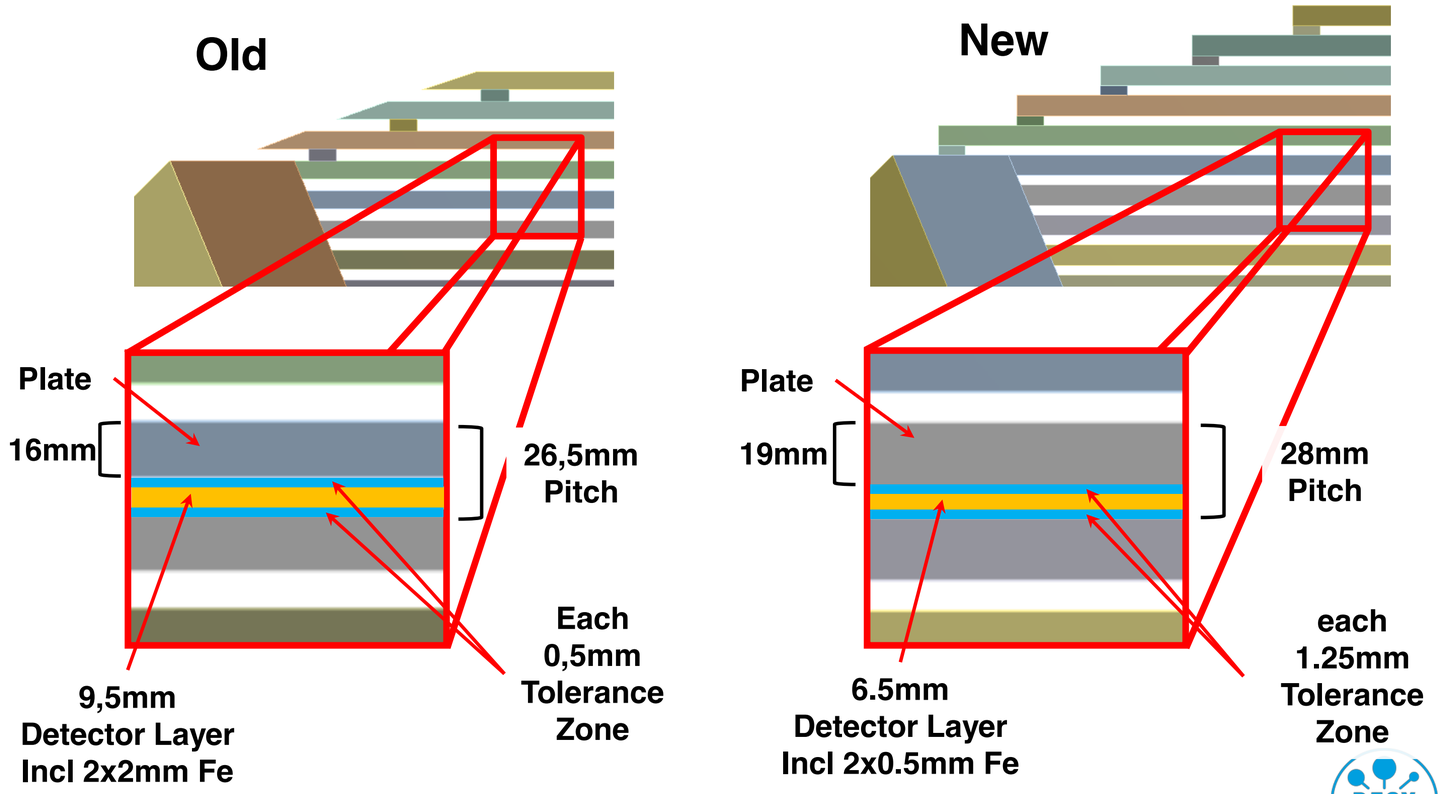


AHCAL - New Model

- Updated sampling structure
- Thinner cassettes
- Realistic tolerances

> Definition Periodicity / Pitch in Detail

+ 3mm in absorber
-- 3 mm i cassette
+ 1.5 mm tolerance

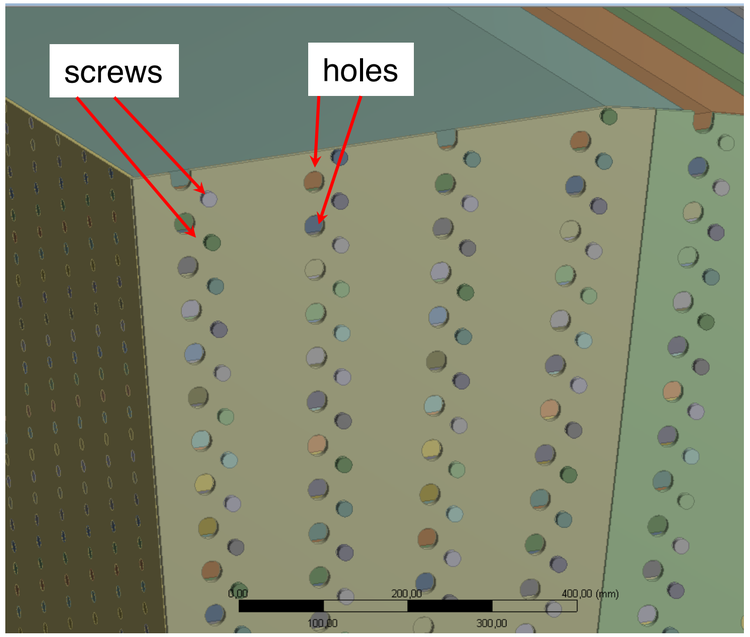


AHCAL - New Model

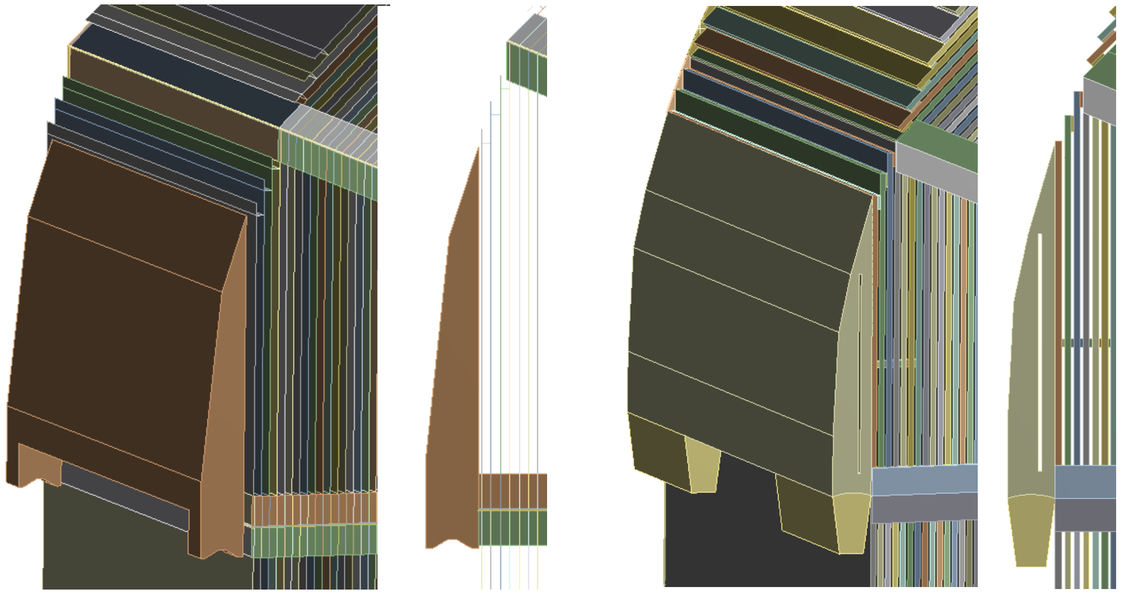
- Backplates on module rings
- Improved support structure

> „Special Design“ of the backplates:

- Two AHCAL-Rings should be mounted next to each other as near as possible
- The screw heads of both AHCAL-Rings have gaps/recesses in the opposite backplate
- Therefore screws of the backplates have an offset in their arrangement



> Change Support geometry to enable the mounting of detector units within the support structure, the height in the additional layer is about 720mm



before **after**

AHCAL - New Model

- Reinforcements in critical areas

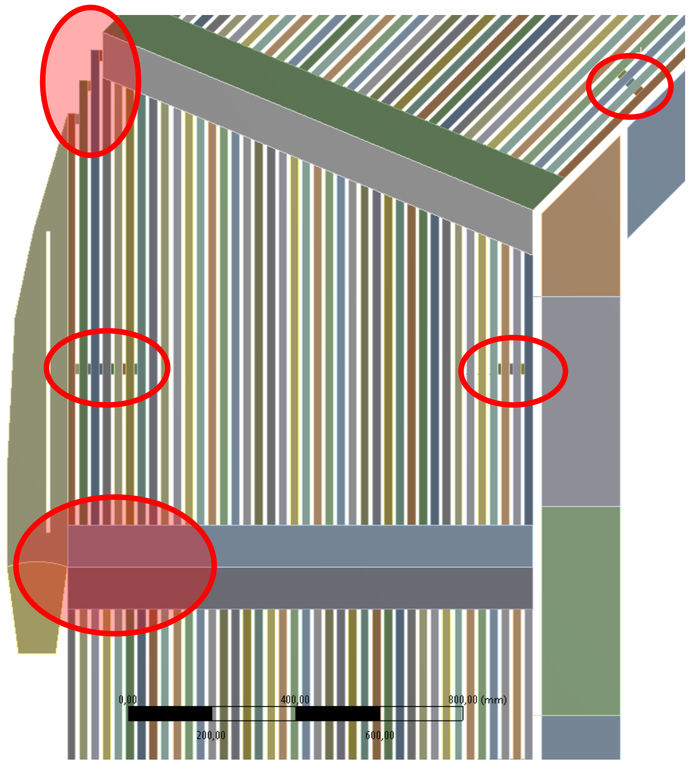
> High forces and moments in the near of the supports

> Connection between support and first plate

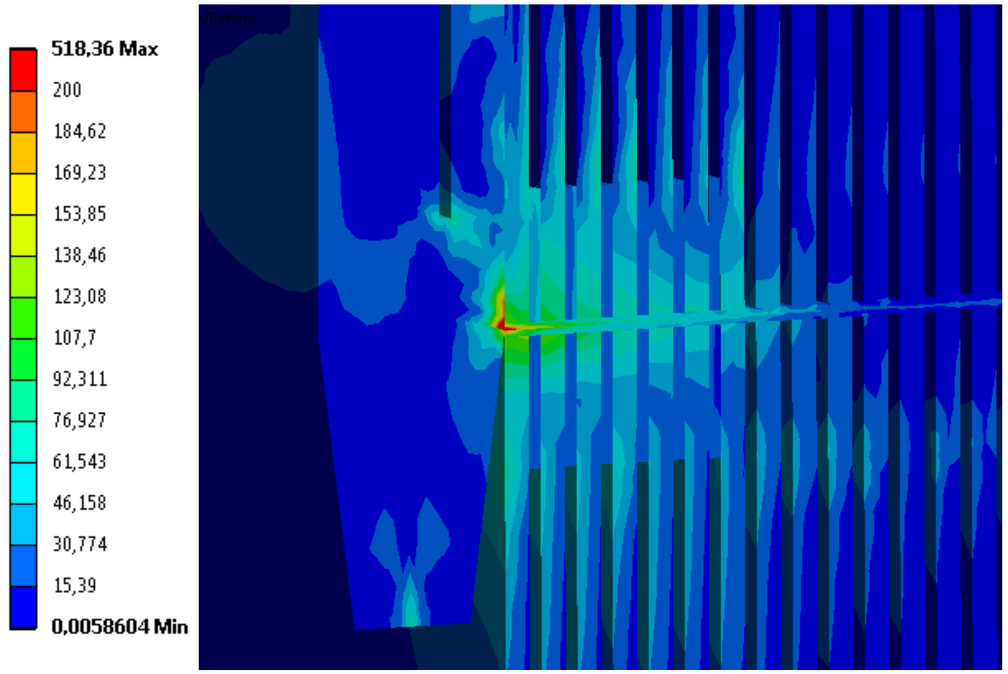
> In the last study additional spacer introduced

> Critical areas near the support and on top plates (ledges) needs more reinforcements

> Load through gravitational effects (vertical, 1g)



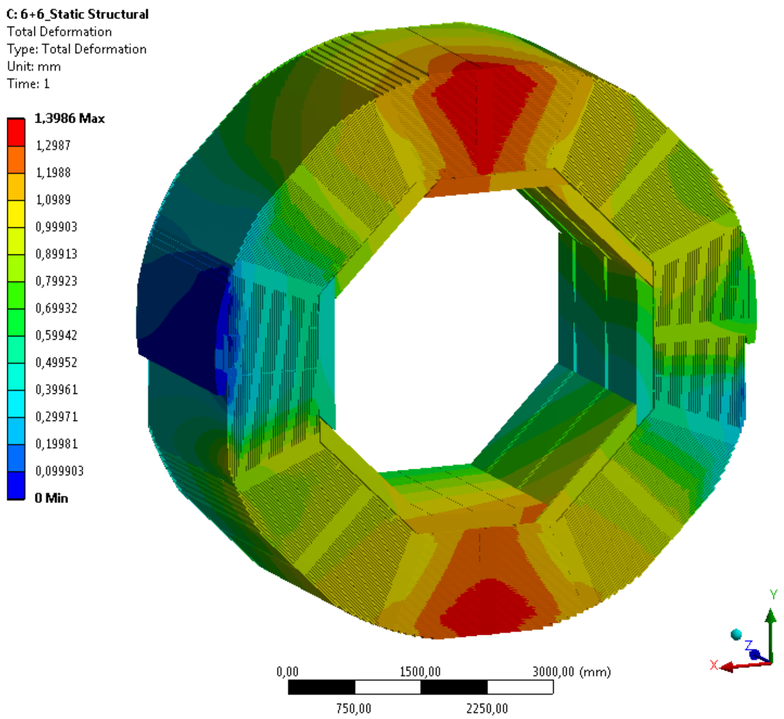
> Reduction of max. Mises-Stresses with more Blocks: **6 + 6 Blocks**



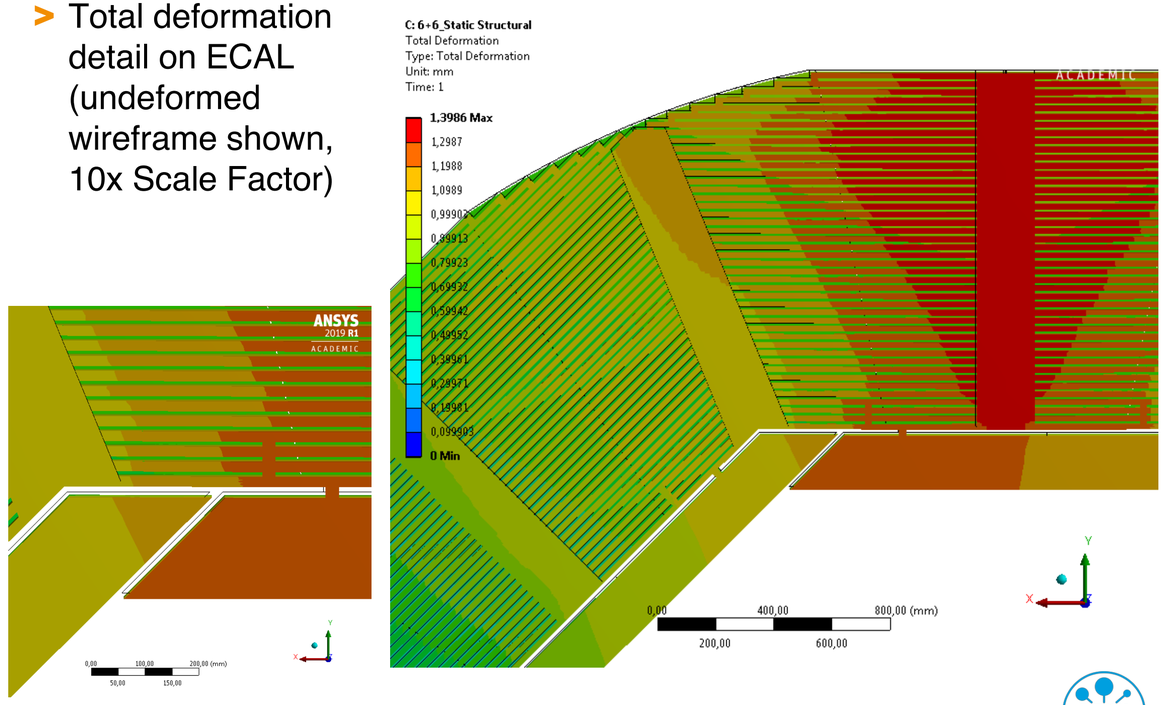
* Near support, reliable values without singularities

AHCAL Statical Load Simulations

- Total deformation of the 6 + 6 case (1,40mm)



- Total deformation detail on ECAL (undeformed wireframe shown, 10x Scale Factor)



AHCAL - Towards Seismic Studies

- Additional 1g force applied perpendicular to detector axis
- Deformations still under control, no collisions!

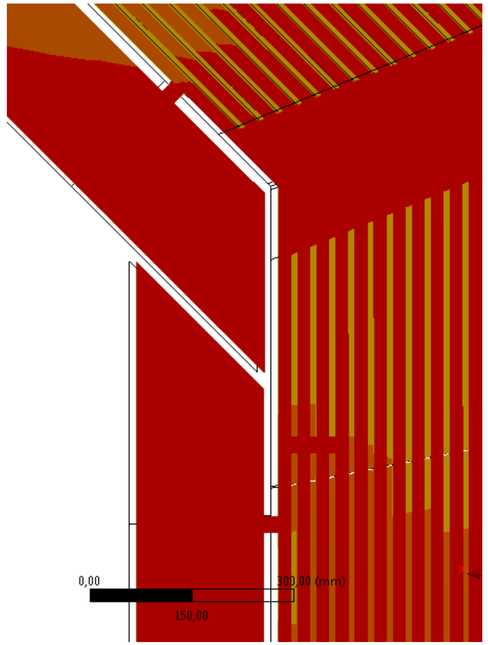
- Next step: dynamic simulations with excitation spectra

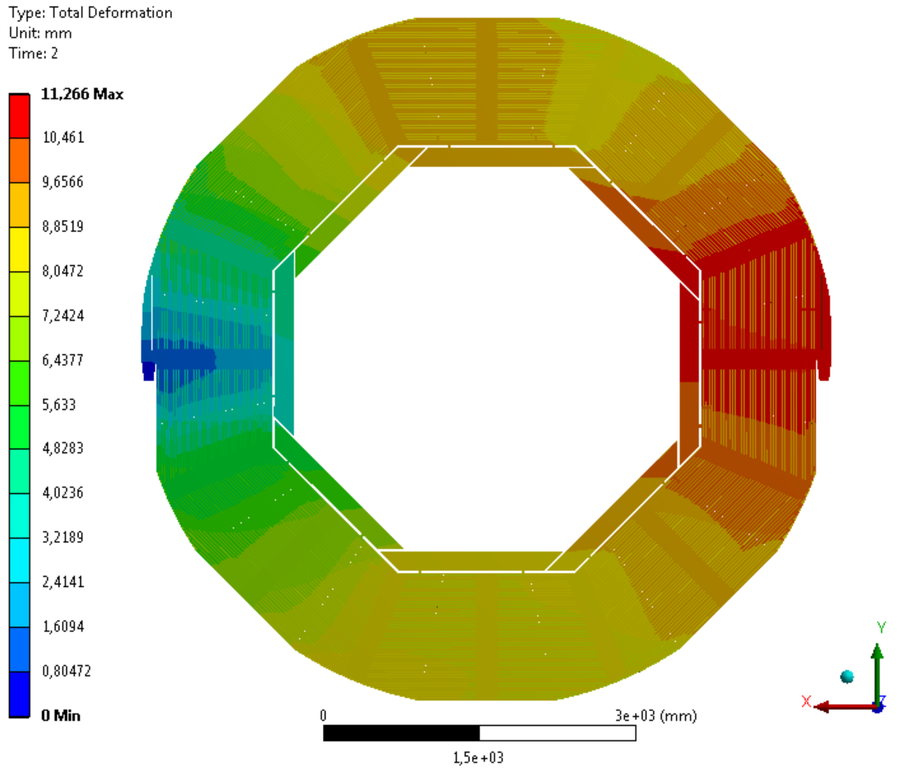
- AHCAL model is now ready for calculation cross-checks
  - step file available

> Total deformation from 2. load case (1g vertical, 1g pos. x-direction)

> 11,27mm (scale value 1x)

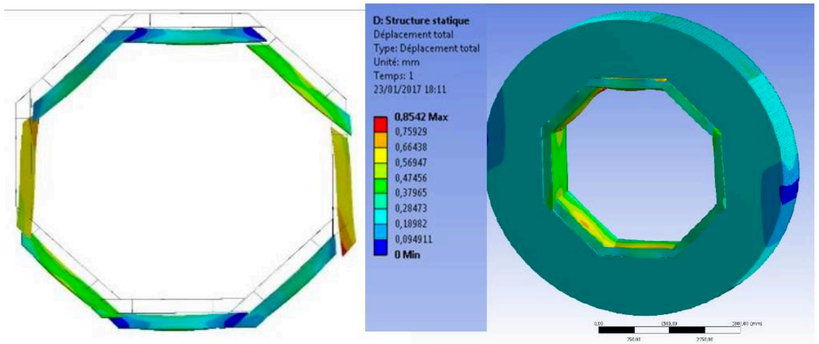
> No collision detected!





SDHCAL

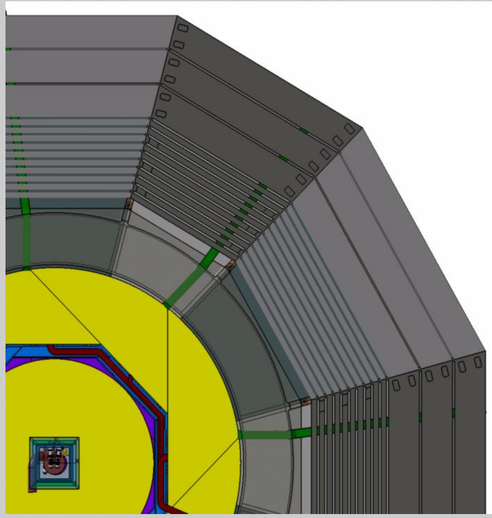
- SDHCAL integrated in Videau absorber structure
- Conceptual plans for routing of cables and services exists
- Mechanical model ready for cross-checks with TESLA-Structure

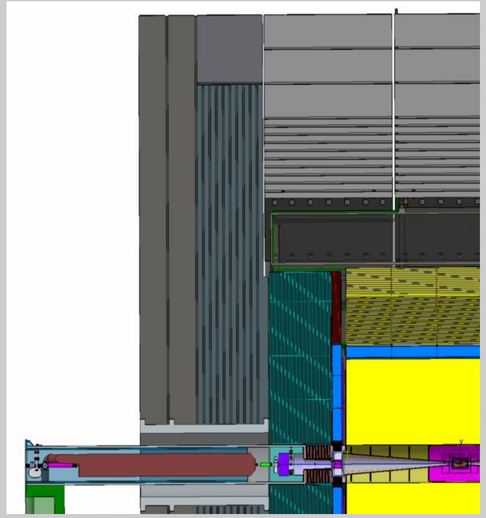


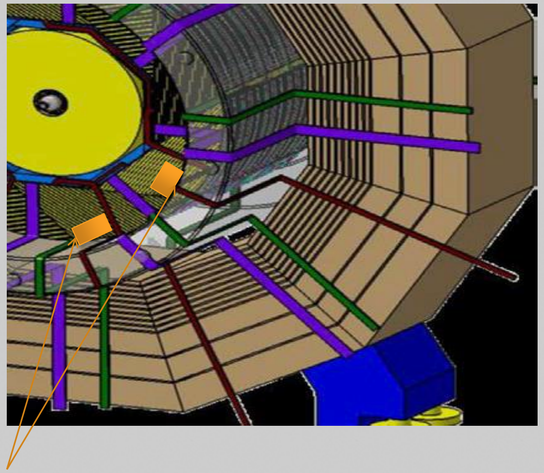
VIDEAU model :

Total displacement 0,9 mm
Smallest gap between ECAL modules in phi : 2,31mm

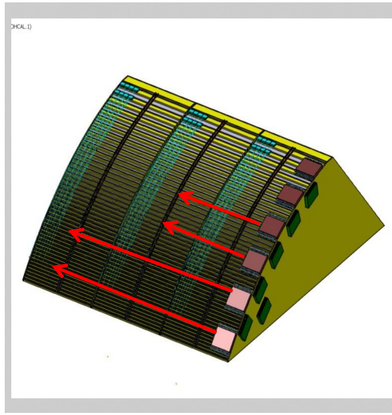
M. Anduze, Th. Pierre Emile





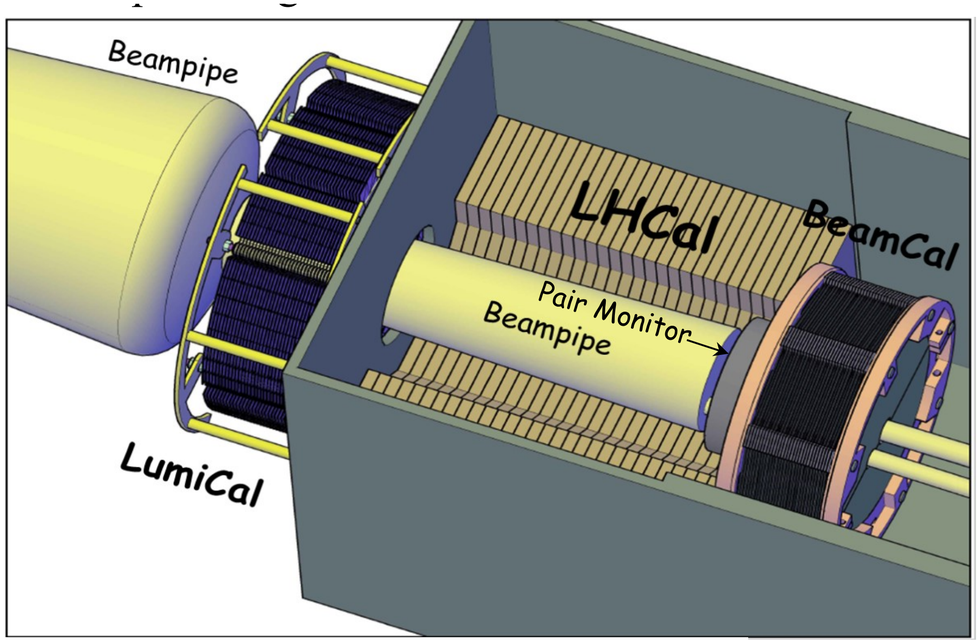


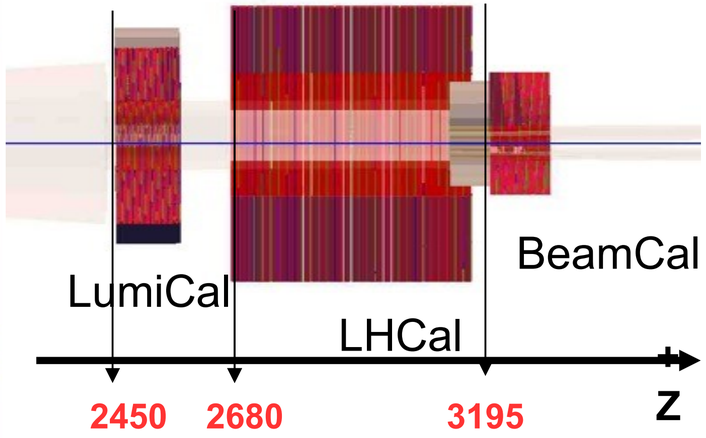
Patch panels will be fixed on the lateral face of the SDHCAL barrel

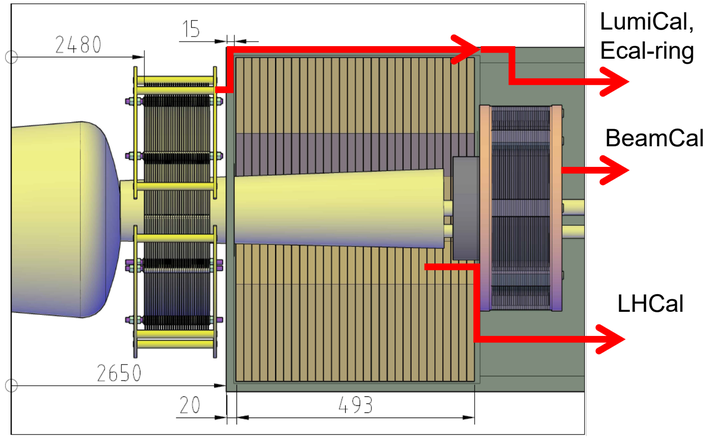


FCAL

- Revised layout with reduced L*
  - needs to be included in global ILD CAD model
- Conceptual design of services and cable paths
- Interface description and utility survey done



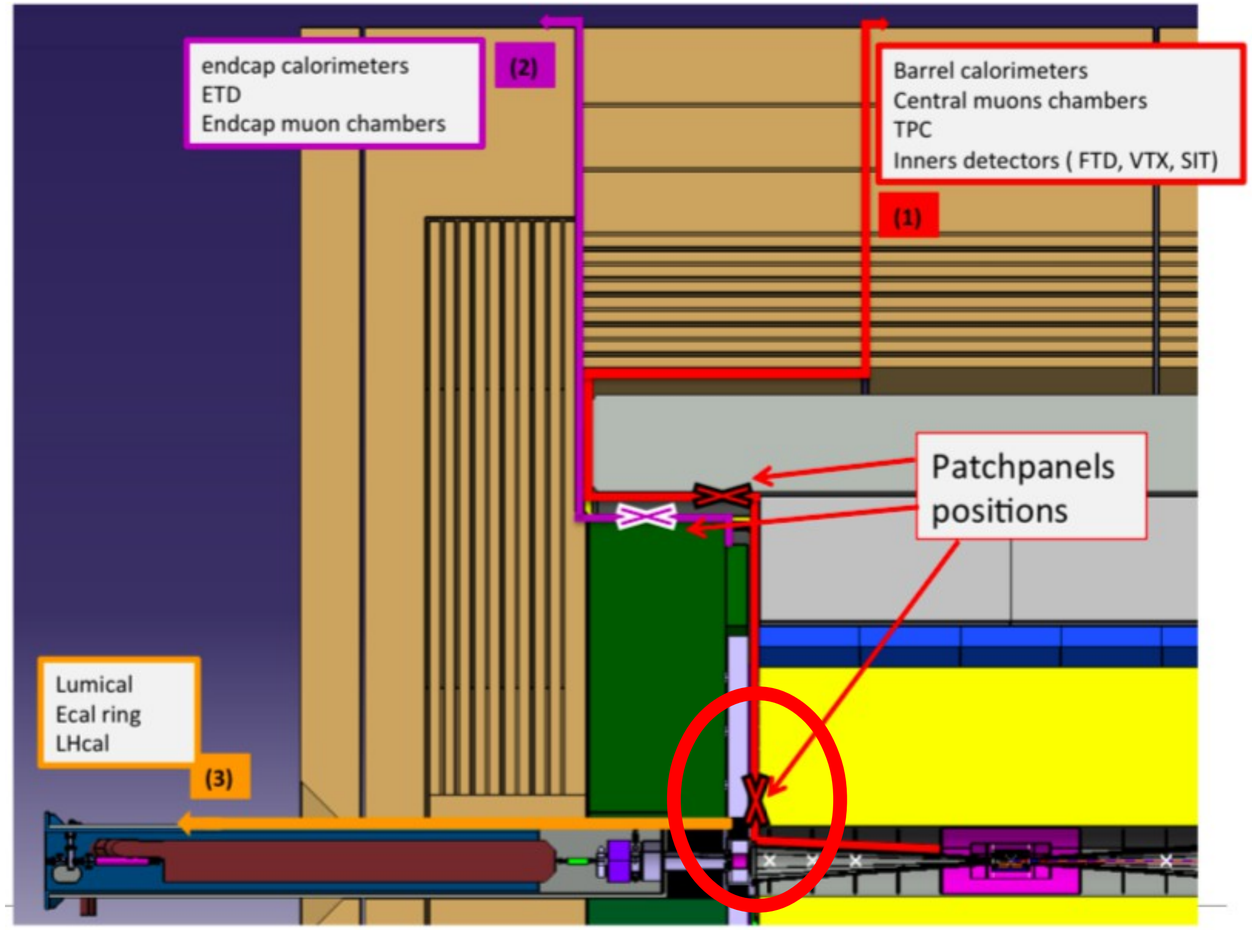




ILD Cabling Scheme

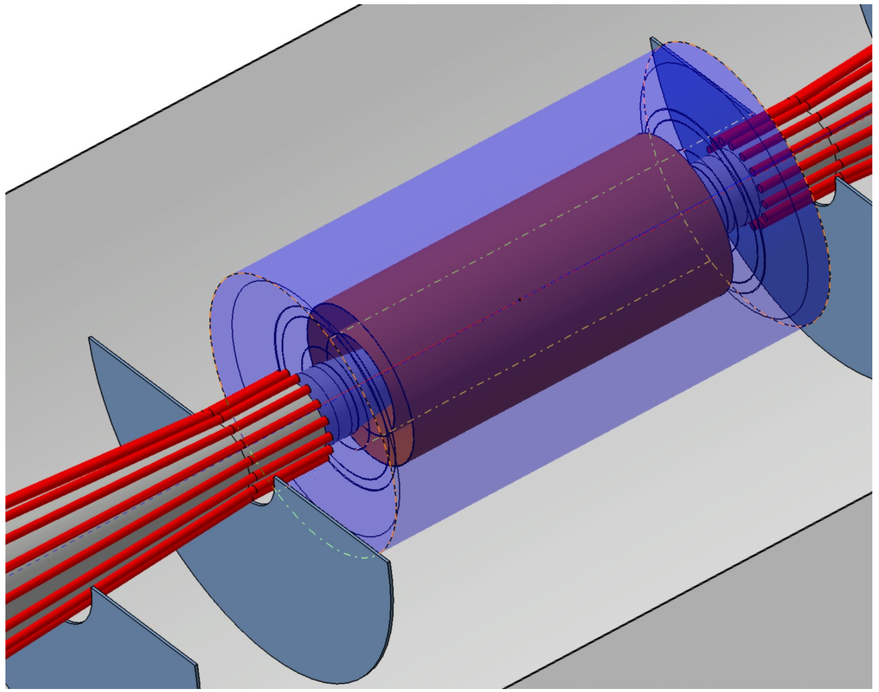
- General exits:
  - Barrel detector: gap between barrel yoke rings
  - Endcap detector: gap between endcap and barrel yoke
  - FCAL: along QD0
- The occupation of the available cable paths needs to be reviewed
- The location and size of the patch panels is critical

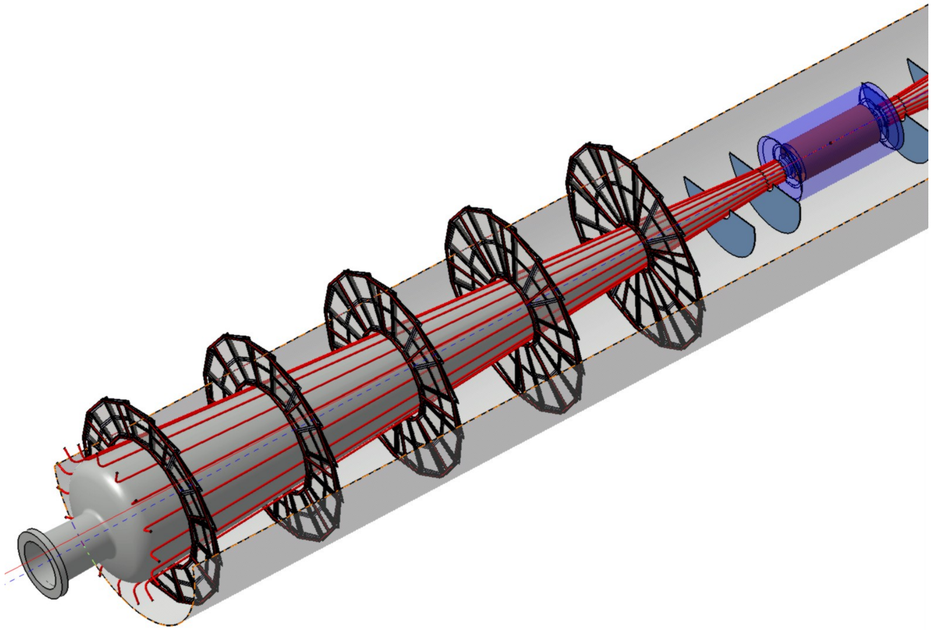
Cabling scheme à la DBD (Clerc/Cornat/Videau)



Inner Detector Cables

- Recent review by Roman, Henri, Auguste, Alexandre

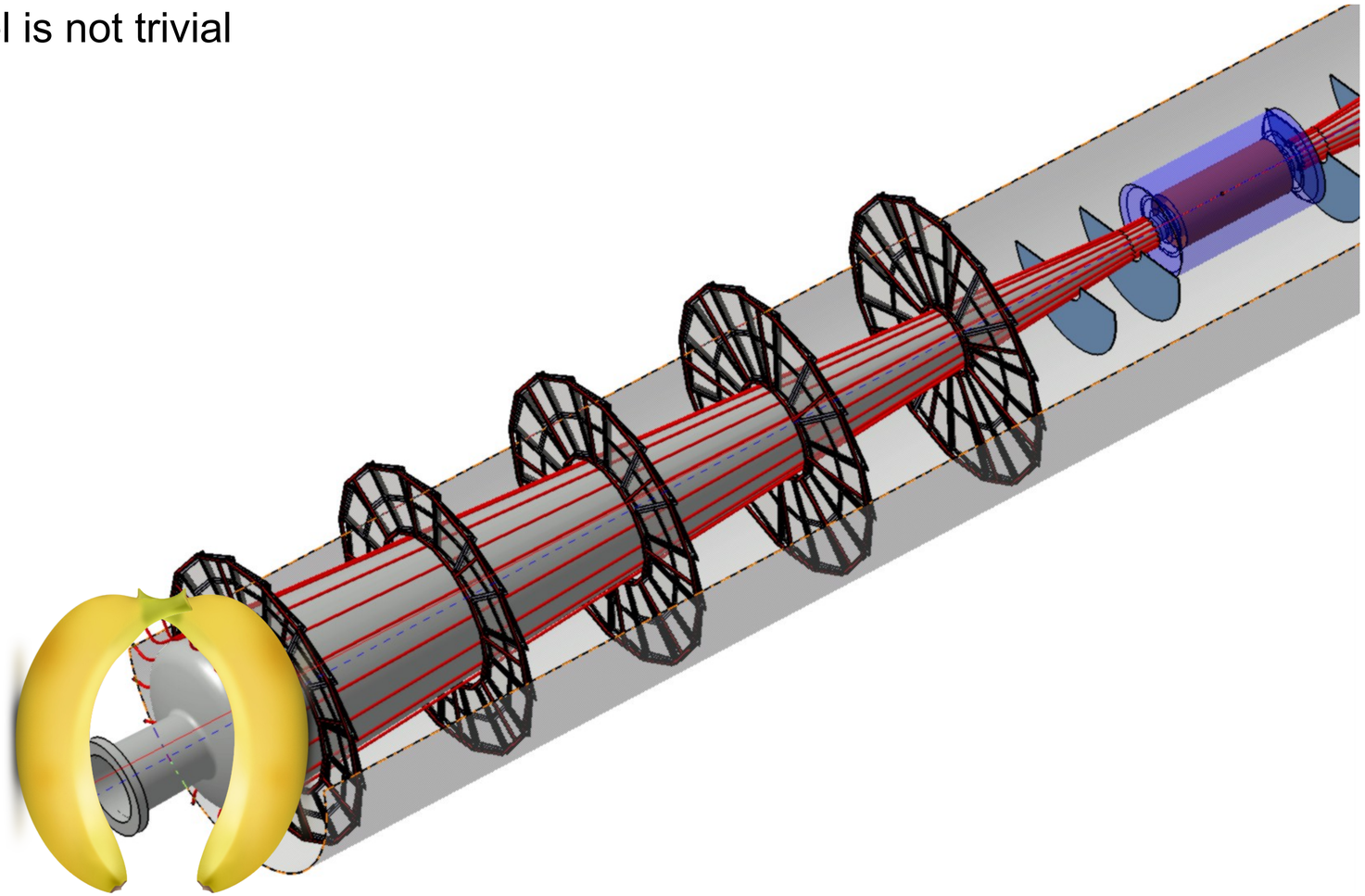




A. Gonnin

Inner Detector Cables

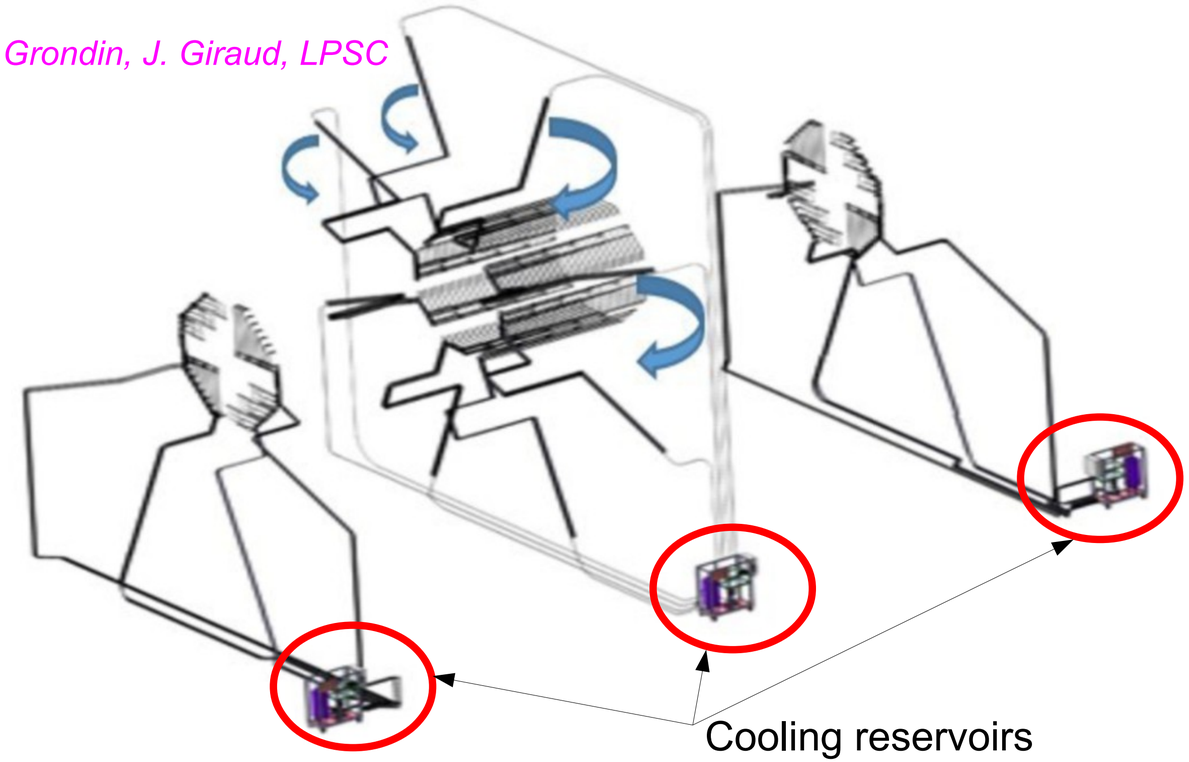
- Recent review by Roman, Henri, Auguste, Alexandre
  - The inner detector patch panel is not trivial

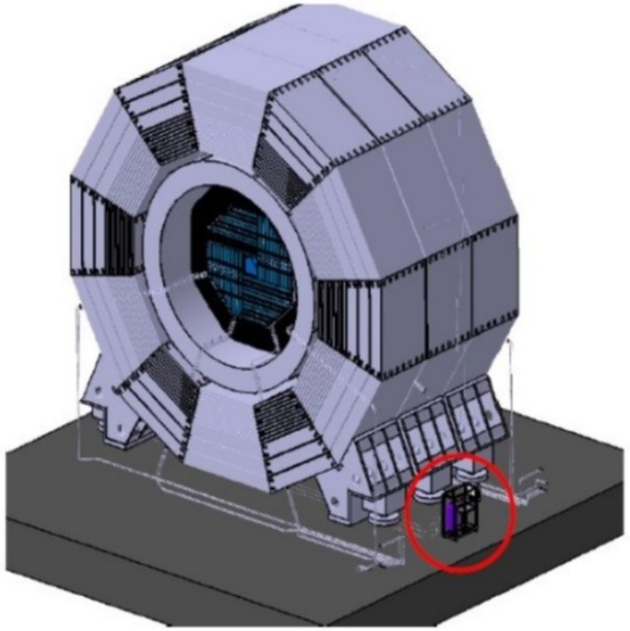


Don’t forget the cooling…

- SiECAL studies on leak-less cooling system

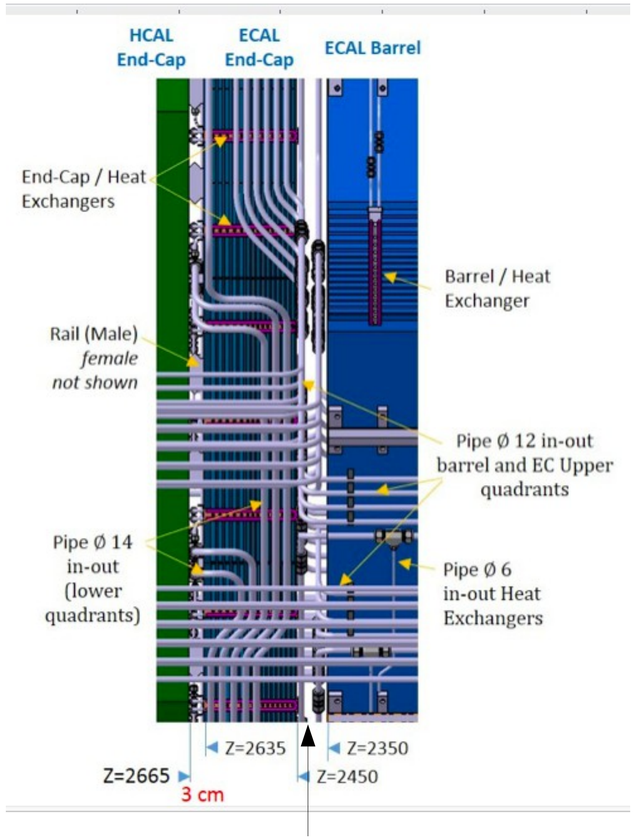
D. Grondin, J. Giraud, LPSC



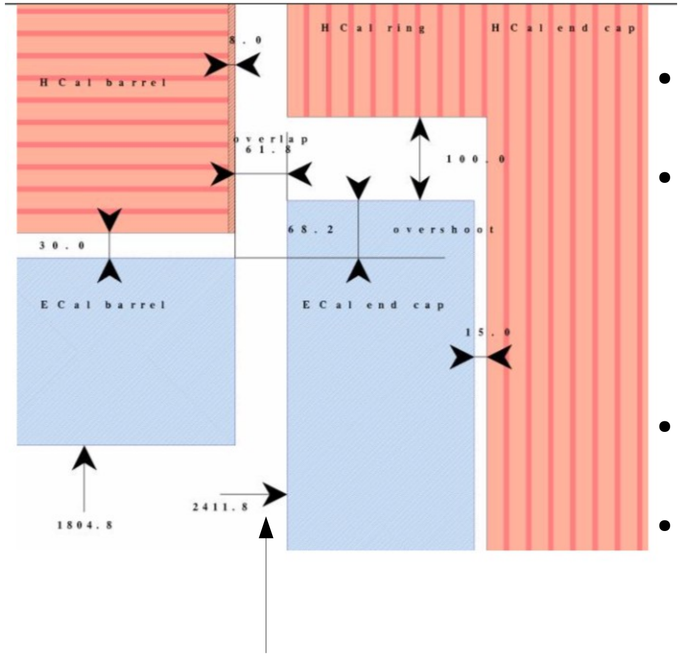


- Cooling reservoir has to be placed at a given height according to leakless design
- Preferable position is on platform, if not at corresponding place in service gallery
  - However, cooling pipes should also remain as short as possible to avoid friction losses
  - Current R&D (see above) supposes placement on platform

Realism in Cooling System Design



100mm



62.8mm

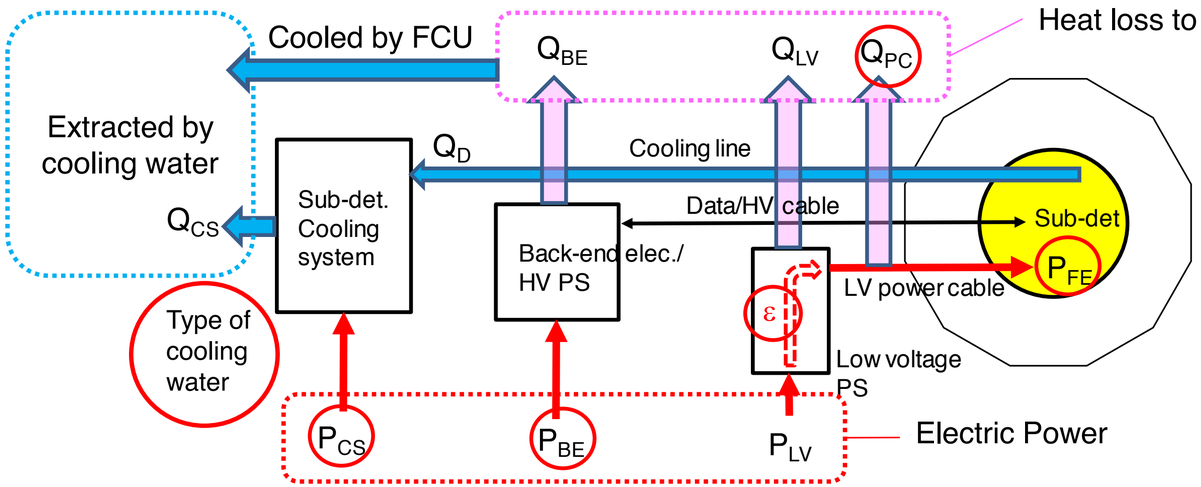
- So far cooling system has been designed for 100mm between barrel and end cap (i.e. DBD design)
- IDR (large model) foresees only 62.8mm
- Dedicated discussion on 4/2/19 lead to the conclusion that cooling pipes could be accommodated within 62.8mm
- However, circuit-points are rather bulky
- Would prefer to maintain 100mm between Hcal barrel and Hcal ring
- At the expense to remove one layer from Hcal ring
- In general endcaps require many further careful looks

Detector Utilities Survey

- Input required for planning of detector environments
  - Electric power, cooling water, space
- Received answers from
  - VTX, TPC, ECAL, SDHCAL, AHCAL
  - numbers for other detectors will be estimated
- Magnet is main driver for power consumption
- Subdetectors compete for space close to the detector
  - everyone wants to be on the platform
    - won't work

Utility Survey

- 6 items for electricity/cooling water



- P_{FE} : Power consumption of sub-detector Front-end Electronics
- Q_D : Heat loss in sub-det. (= P_{FE})
- Q_{PC} : Heat loss in power cables
- P_{LV} : AC power input to LV PS
- ε : Efficiency of LV PS (P_{LV}*ε= P_{FE} +Q_{PC})
- Q_{LV} : Heat loss in the LV PS (=(1-ε)*P_{LV})
- P_{BE} : AC power input to back-end elec./HV power supply
- Q_{BE} : Heat loss in the BE/HV PS (=P_{BE})
- P_{CS} : Electric power to drive the cooling system
- Q_{CS} : Heat to be extracted from cooling system (= Q_D +P_{CS})

Detector Utilities Survey

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Utility Survey

- 6 items for electricity/cooling water

	CMS	CLIC	SiD	ILD
Detector Solenoid	900	900	294	800
QD0/QF1/CC	NA	NA	NA	600
FEE	600	<10	12	75
BEE	650	<10	70	47
PC farm	800	1000	NA	1000
DH utility	NA	NA	105	246
Cooling	850	750	NA	65
HVAC	600	600	NA	600
Sum	4400	3250	481	3432

- Q_D : Heat loss in sub-det. (= P_{FE})
- Q_{PC} : Heat loss in power cables
- P_{LV} : AC power input to LV PS
- ε : Efficiency of LV PS ($P_{LV}*\varepsilon = P_{FE} + Q_{PC}$)
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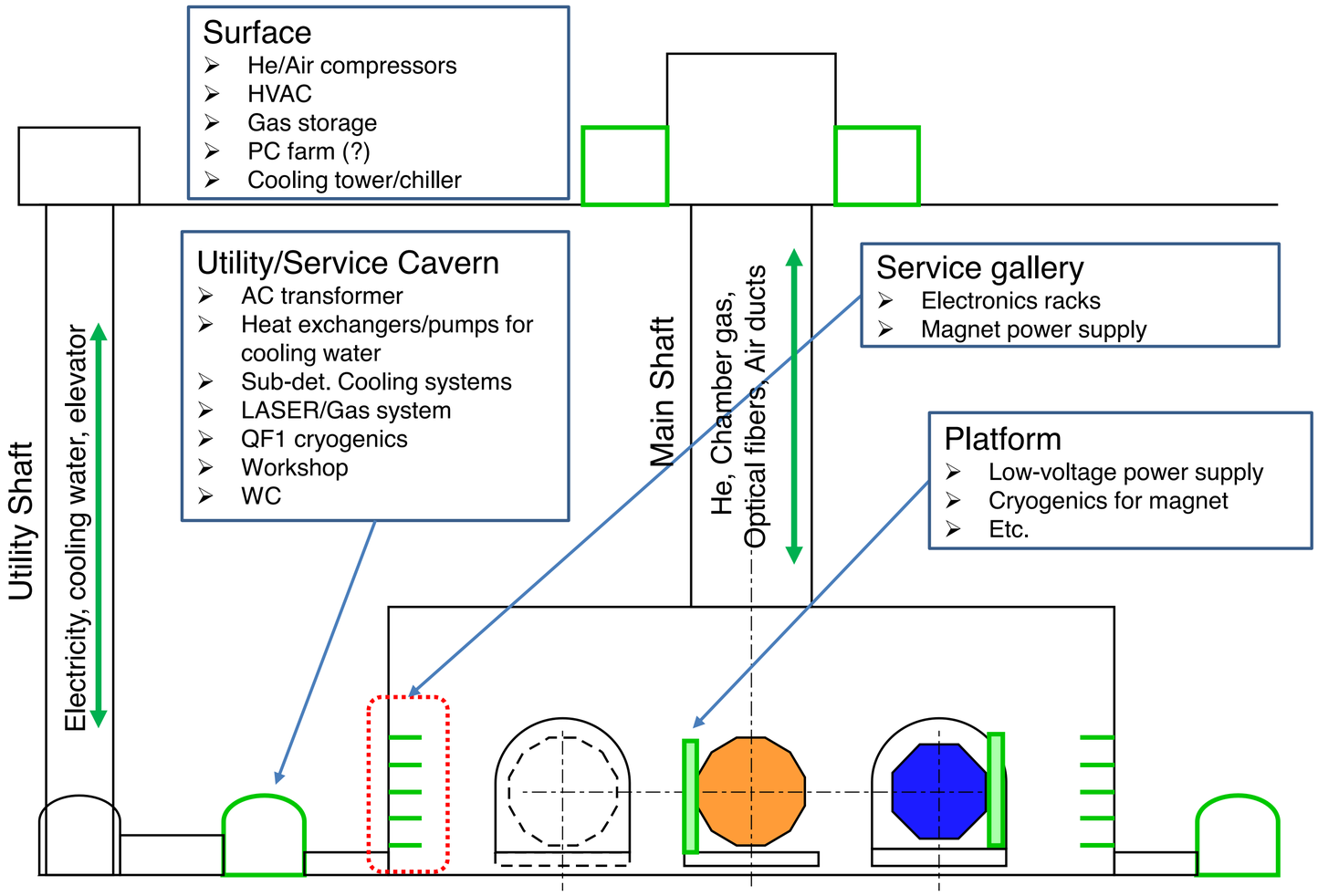
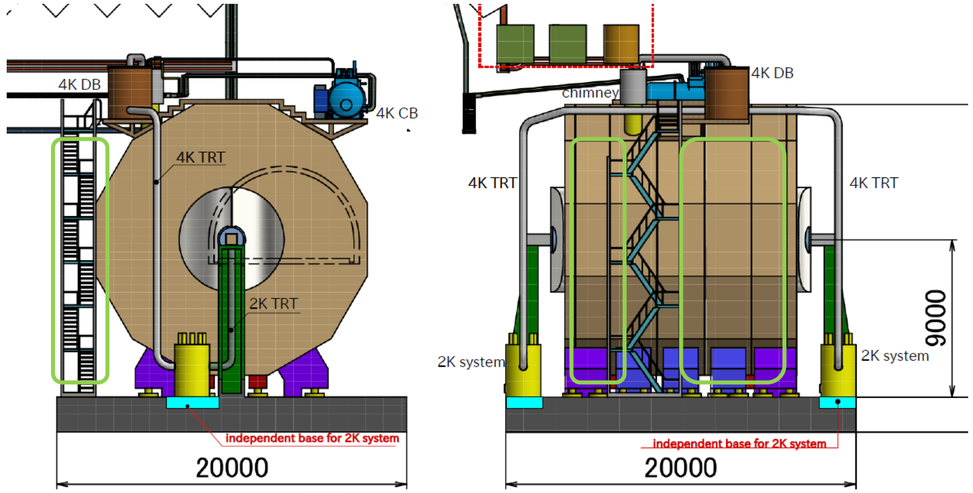
Location of Utilities and Services



- People tends to like electronics rack space on the platform, where
  - few 100 G leakage field could exists
  - access may not be allowed during experiment
- Because space on the platform is limited, there could be severe competition between sub-detectors

Sub-detector name			VTX	SIT	FTD	TPC	SET	ECAL	SD HCAL	A HCAL	MUON	Lumi CAL	BeamCAL	LH CAL
Number of 19-inch electronics racks	Platform		2 (?)	0	0	0	0	3	6	12	0	0	0	0
	Service gallery		3	0	0	0	0	0	2	1	0	0	0	0
	Utility/Service Cavern (USC)		0	0	0	4	0	0	0	0	0	0	0	0
Sub-detector cooling system	Floor in USC		Don't mind	Don't mind	Don't mind	Don't mind	Don't mind	1st floor	1st floor	0	Don't mind	Don't mind	Don't mind	Don't mind
	WxDxH	m^3	6x1x2	0	0	12x(0.8x0.7	0	4x3x2	4x4x2	0	0	0	0	0
Gas system	Space on surface (WxD)	m^2	0	0	0	8x4	0	0	8x4	0	0	0	0	0
	Space in USC (WxD)	m^2	0	0	0	0	0	0	4x4	0	0	0	0	0
	Space on service gallery (WxD)	m^2	0	0	0	0	0	0	1x1	0	0	0	0	0
	Space on platform (WxD)	m^2	0	0	0	2x2	0	0	2x1	0	0	0	0	0
Laser system	Space in USC (WxD)	m^2	0	0	0	1x0.6	0	0	0	0	0	0	0	0



Conclusion

- There is steady progress in the understanding of the subdetector and ILD global integration
  - The devil is always in the detail
- Need to review (after March 8th….)
  - cable paths and capacities
  - TPC support
  - integration of ILD in the experimental environment: utilities, services, space
  - integrated cooling strategy

- We have actually started to write the respective IDR chapters…