ECAL End-Caps - structure and assembly

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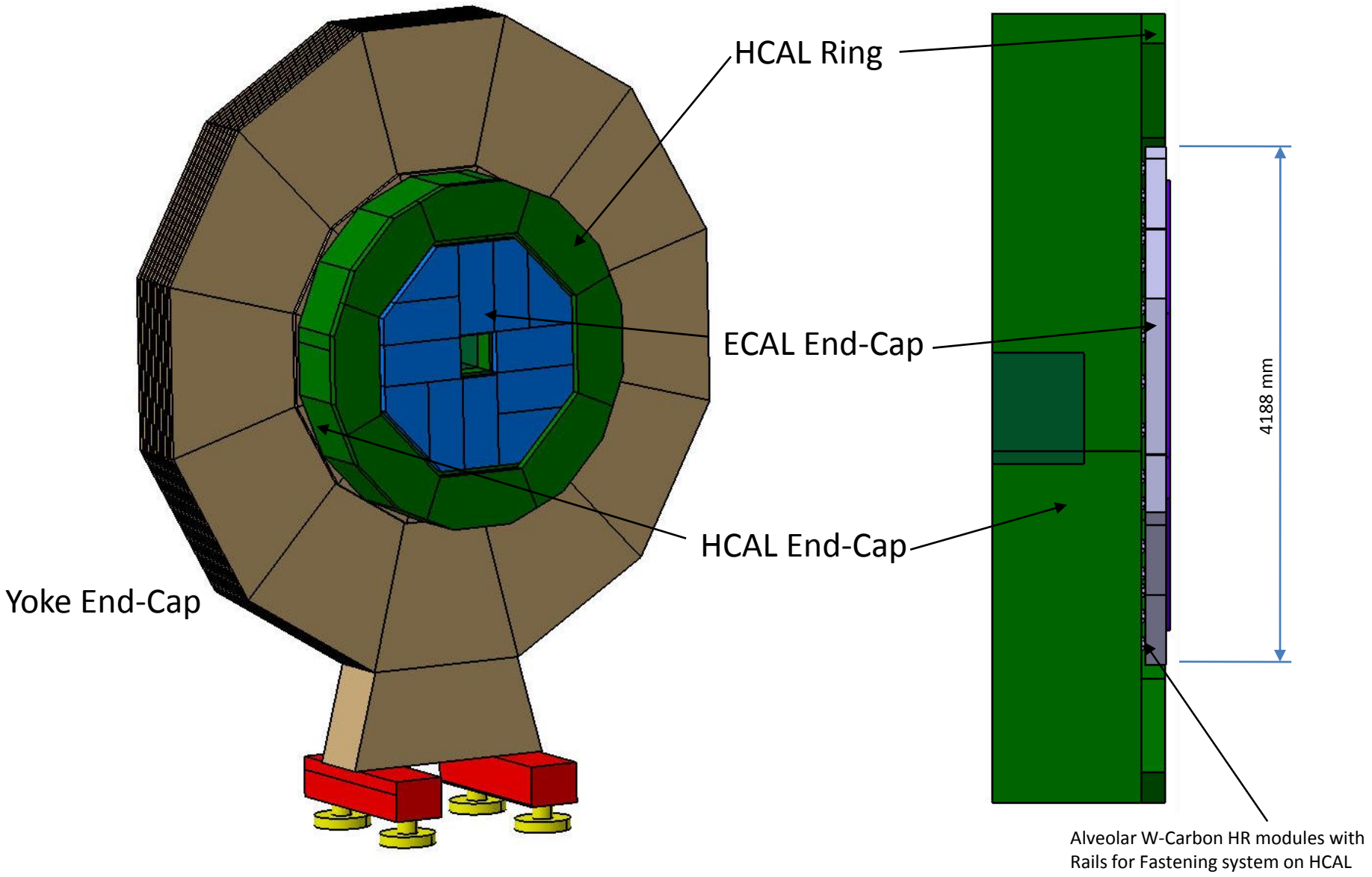
13.04.2012
ILD Regional Integration meeting @ LAL

PRELIMINARY

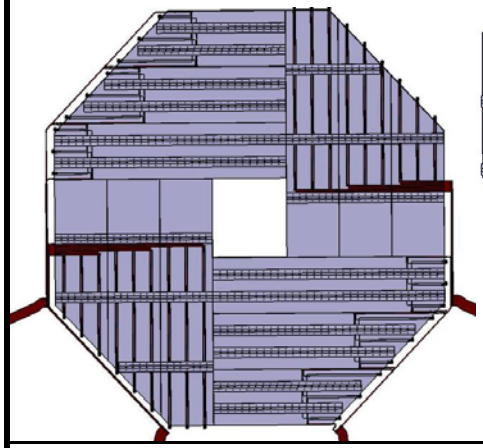
Preliminary reminders

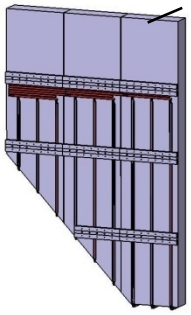


ECAL Fully equipped End-cap weight : ~ 25.5 T

Current structure of End-Caps

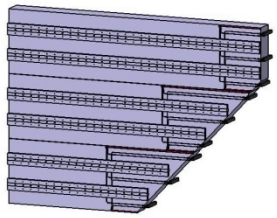
Modular structure	2 End-Caps Total of 24 modules - 4 x 3 modules each



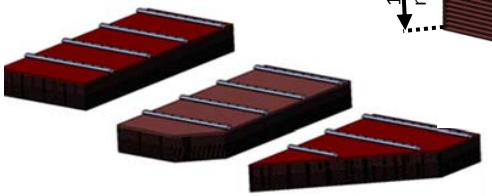


Max. Length. 2.5 m

2 quarters

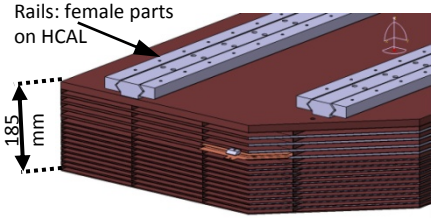


3 modules in each quarter



(2 orientations of rails)

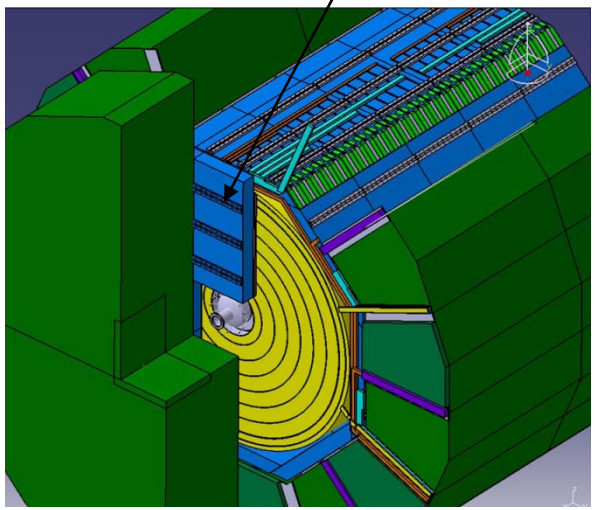
Rails: female parts on HCAL



1 of the 3 « standard » modules of each quarter

Alveolar W-Carbon HR structure with Fastening (rails) and Cooling system

Up to now, ECAL End-Cap is fastened on HCAL End-Cap inner face with rails

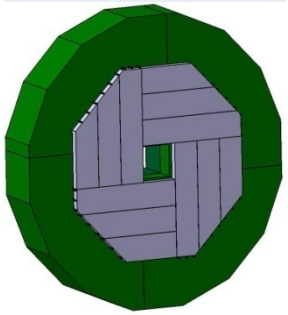


- Both Ecal End-Caps are to be fastened onto HCAL End-caps, hanging from it by rails
- Each End-Cap will be divided in 4 quarters composed of 3 modules each (12 modules in total).
- This subdivision is due to the fact that physics cracks are prevented with this geometry. Relative ease of implementation.
- Cooling system to be install on rear face prior to insertion.
- Symmetry of onboard services, dissymmetry of outboard ones.
- The insertion tooling will have to allow the handling and positioning of ~6,5 t quarters in the alcoves of the cavern (Spaces for detector assembly/services).

4 solutions to move End-Caps down into the cavern

Assembly on surface

Full End-Cap on HCAL



Mechanical
- Interconnection done
- Alignment done
- Services connected(local)

- Modules fully equipped ?
- Sub detectors (slabs) are fully commissioned ?
- Once below they can be connected to the outboard services

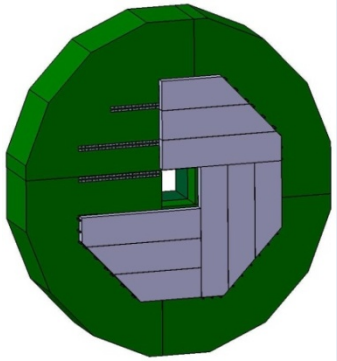
Full End-Cap only

wrong option/ final insertion

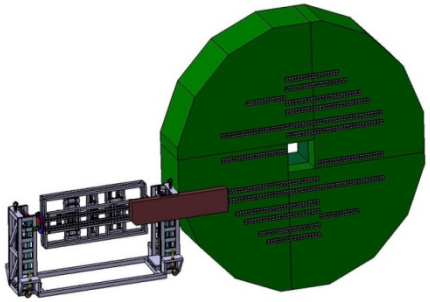
Ex.: Lowering of one ATLAS muon small wheel into the cavern.

Assembly in the pit (favorite)

2x4 Quarters



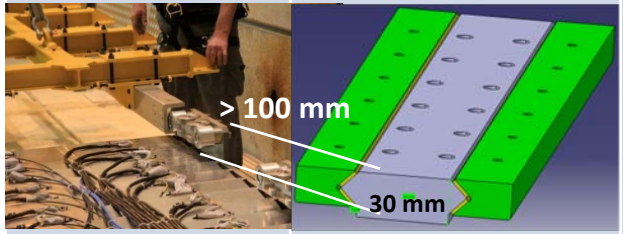
2x12 Modules



pre-assembly of modules on surface

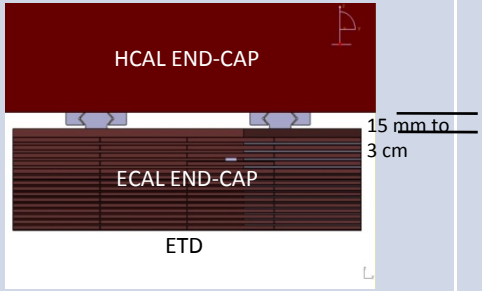
Conception of specific handling and positioning tools

Rails and fastening system – Ex. Lifting beam of ALICE → Sliding with rollers **pushed on glide strips**

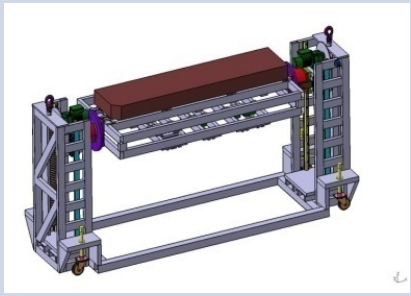


Impact of alignment constraints on mounting
Rails profile and position still to be validated !!!

Platform supporting insertion tooling
Positioning of ECAL quarters in front of HCAL End-Cap
→ **lateral space** needed for sliding



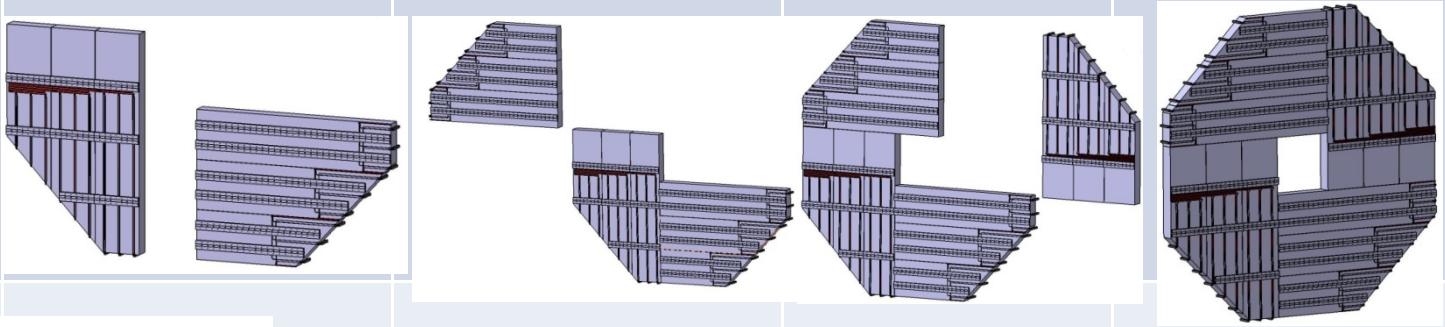
insertion tooling with orientation tuning, alignment and fastening systems
Insertion of modules and/or quarters



Synoptic for integration

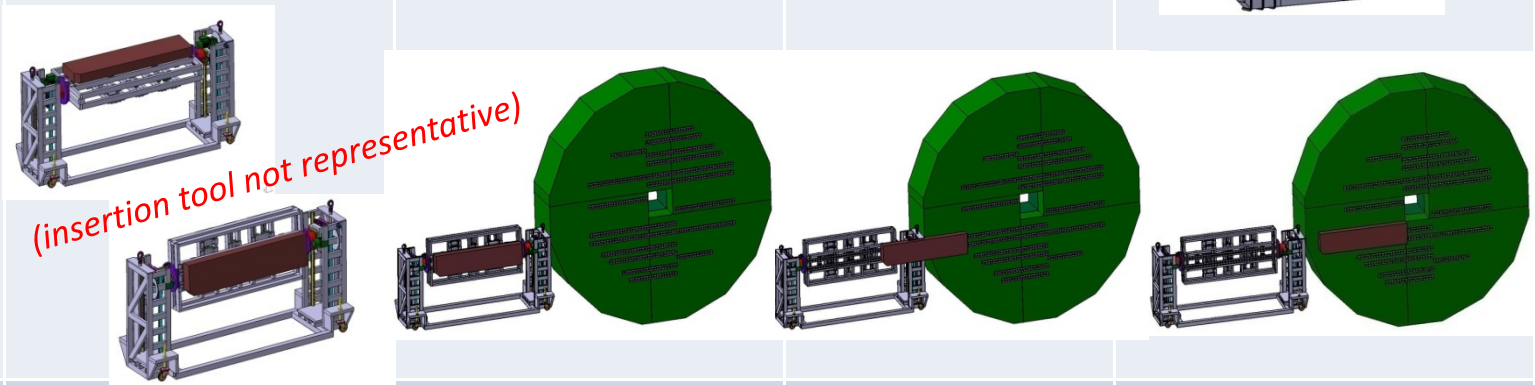
3 major options for integration

Assembly
on surface
12 Modules
by quarters



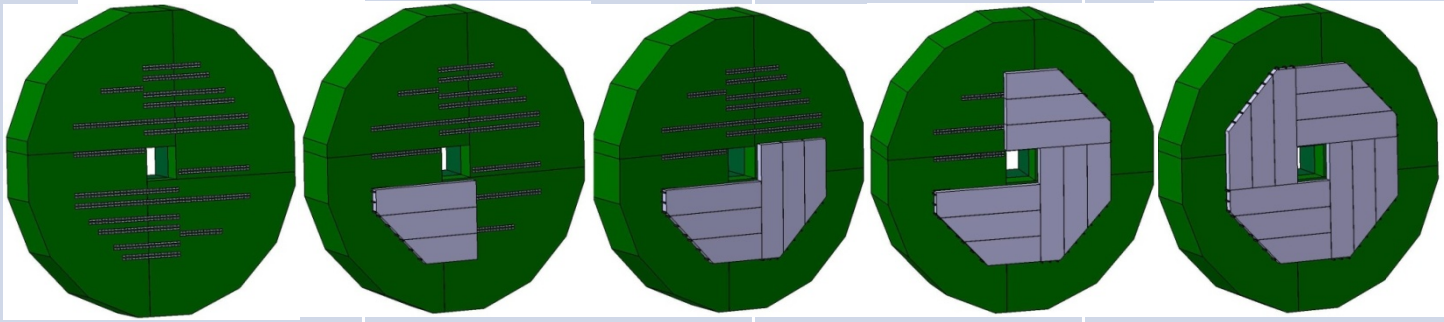
Assembly
On HCAL

12 Modules



Assembly
On HCAL
End-Cap

4 Quarters



ECAL End-Caps: weight and volume

Total Weight 1 EC
25426 kg

Fully equipped with slabs

ECAL End-cap D=4188		Dimensions								Rails	Services
		Nb of modules	Volume / quarter			Volume / modules			Weight	Orientation	Weight	Weight
			L (mm) / Y	l (mm) / X	H (mm) / Z	L (mm) / Y	l (mm) / X	H (mm) / Z	(kg)		(kg)	(kg)
ECAL End-Cap (1)		12	4188	4188	185				25208		162	56
1.1	Quarter 1	3	2492	1695	185				6302	Horizontal / left	57	13
	Module 1.1					1828.85 (-563.4)	563.4	185	1585	Horizontal / left	8	4.5
	Module 1.2					2394.25 (-563.4)	563.4	185	2164	Horizontal / left	22	4.5
	Module 1.3					2492.2	563.4	185	2553	Horizontal / left	27	4
1.2	Quarter 2	3	1695	2492	185				6302	Vertical / down	24	15
	Module 2.1					1828.85 (-563.4)	563.4	185	1585	Vertical / down	6	5
	Module 2.2					2394.25 (-563.5)	563.4	185	2164	Vertical / down	9	5
	Module 2.3					2492.2	563.4	185	2553	Vertical / down	9	5
1.3	Quarter 3	3	2492	1695	185				6302	Horizontal / right	57	13
	Module 3.1					1828.85 (-563.4)	563.4	185	1585	Horizontal / right	8	4.5
	Module 3.2					2394.25 (-563.5)	563.4	185	2164	Horizontal / right	22	4.5
	Module 3.3					2492.2	563.4	185	2553	Horizontal / right	27	4
1.4	Quarter 4	3	1695	2492	185				6302	Vertical / up	24	15
	Module 4.1					1828.85 (-563.4)	563.4	185	1585	Vertical / up	6	5
	Module 4.2					2394.25 (-563.5)	563.4	185	2164	Vertical / up	9	5
	Module 4.3					2492.2	563.4	185	2553	Vertical / up	9	5

M_{module} = L (mm) x $l_{ext\ alveolus}$ (mm) x Nb colonne x $1.8184 \times 10^{e-3}$ + M_{rails} + $M_{services}$

M_{rails} ~ 0.005 kg/mm

$M_{services}$ = cooling exchanger CU + piping Stainless Steel without cabling !

$M_{external\ services}$ = 160 kg around EC / trough detectors (Stainless Steel)

Assembly phase (1)

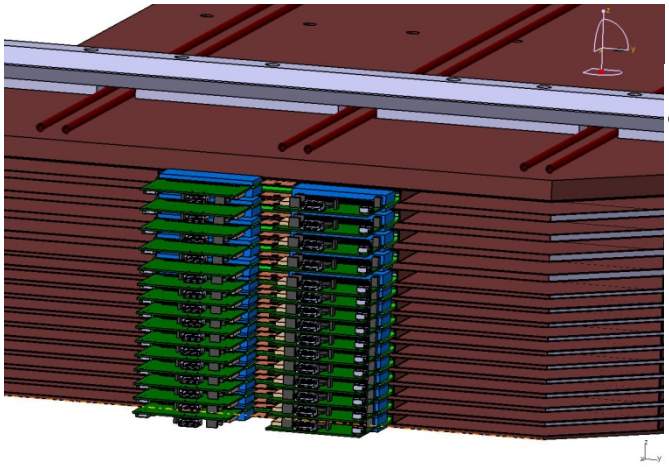
Assembly of modules and quarters in the assembly hall

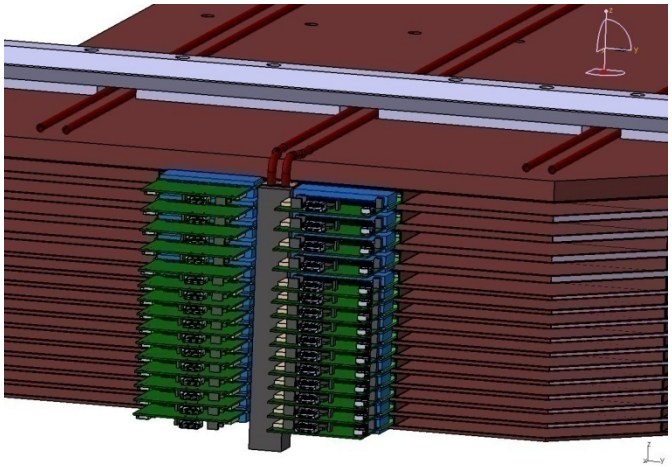
1. Modules equipment and test

to be refined

Task	Description / constraint	tooling	FTE	Time	Assembly area	Comment
1	Handling of 1 (over 24) module.	Crane, table	2 T	1 week	20m²	
2	Insertion of 45 slabs per modules. 1 Slab =10 to 25 kg alignment within alveoli = 500 µm over 2.5 m		2 T			
3	Electrical connections up to LDA boards		2 T			
4	Cooling blocs (3) up to Module edge, over LDA up to main distribution line position		2 T			
5	Tests (electronic and signal)		2 T	1 week		To be done in parallel
Weight per module: ~1.6 t to 2.6 t						

Same processes repeated 4 times per group of 3 modules (equipment of 1 End-cap)





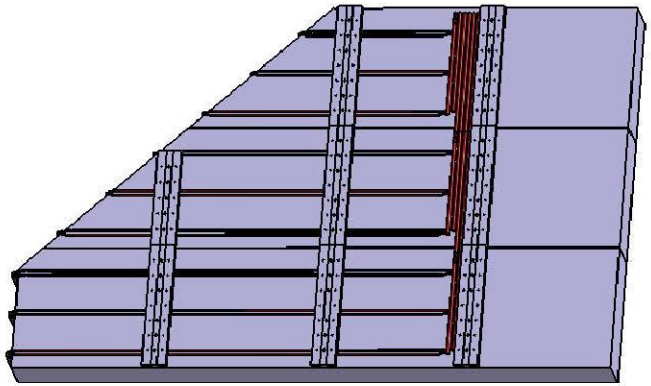
Assembly phase (2)

Assembly of modules and quarters in the assembly hall

2. Quarters assembly on mounting support frame

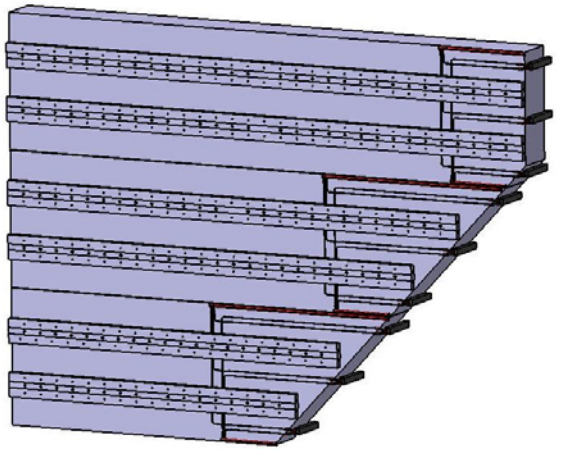
to be refined

Task	Description / constraint	tooling	FTE	Time	Assembly area	Comment
1	Handling of 3 modules. 1.6 t to 2.6 t on quarter support frame	crane, mounting jig and quarter support frame	2 T	1 week	25m²	
2	Mechanical interconnection of the modules to complete one quarter					
3	Cooling pipes connections over the 3 modules.	Mounting jig for cooling pipes				
4	Electrical connections up to quarter edge	Mounting jig for wiring				
5	alignment of rails with template	Mounting jig for rails				To be done in parallel
Total weight : ~ 6,5 t / quarter						



The assembly in quarter (2 ≠ configurations) will depend of:

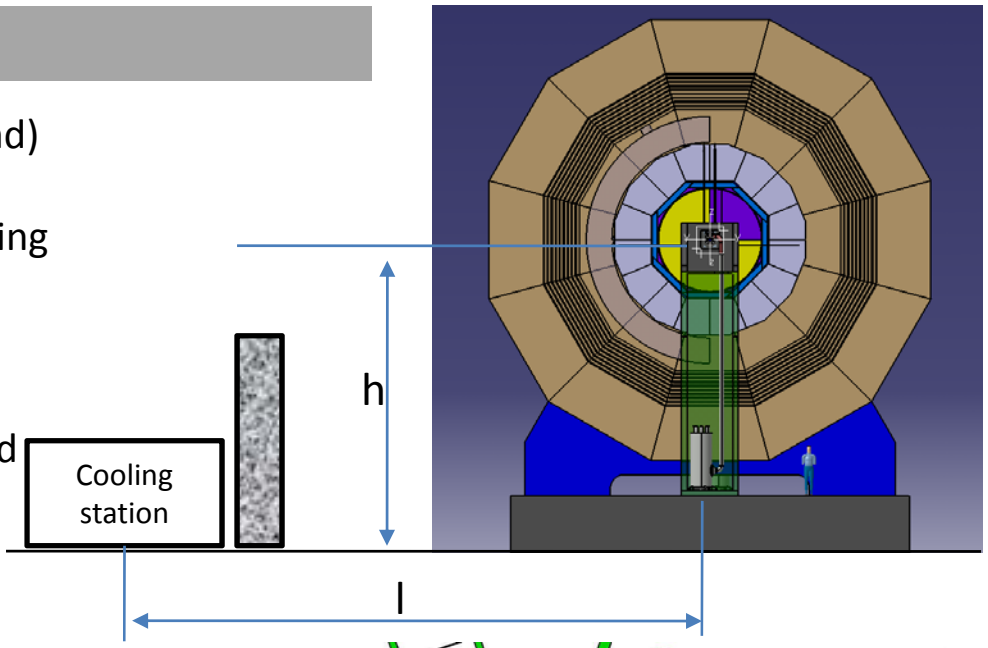
- Integration process
- Maintenance scenario



ECAL General Cooling Integration

Specific need due to Leakless system

- Minimal height between cooling station (ground) and beam axis (h): 11 m
- Maximal distance between beam axis and cooling station (l) : 30 m
- Congestion of tubing + measurement between cooling station and detector : 0.5m²
-Separation wall between the cooling station and the pit (protection / magnetic field and radiation).



- Dimensions of the cooling station: length=> 3 m, width=> 2 m, height 2 m.

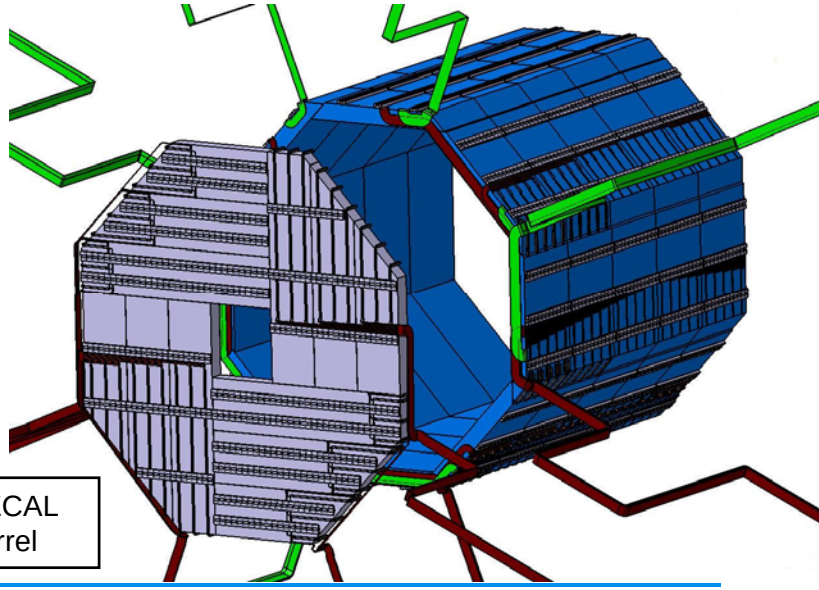
Overall thermalization foreseen

- Fluids Circulation + cabling

=> passages for pipes outwardly of the detector

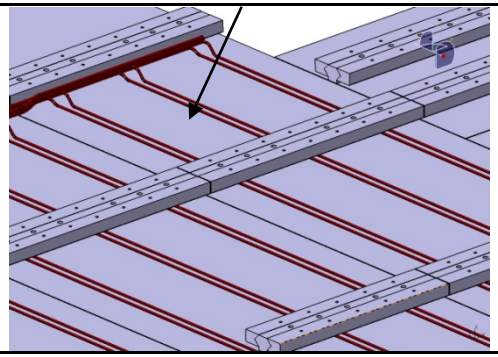
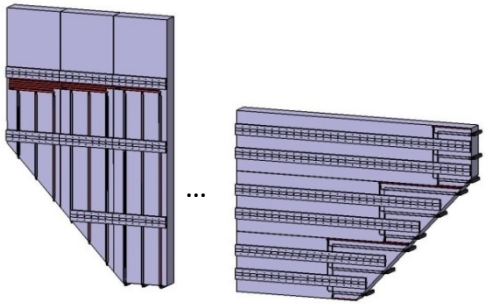
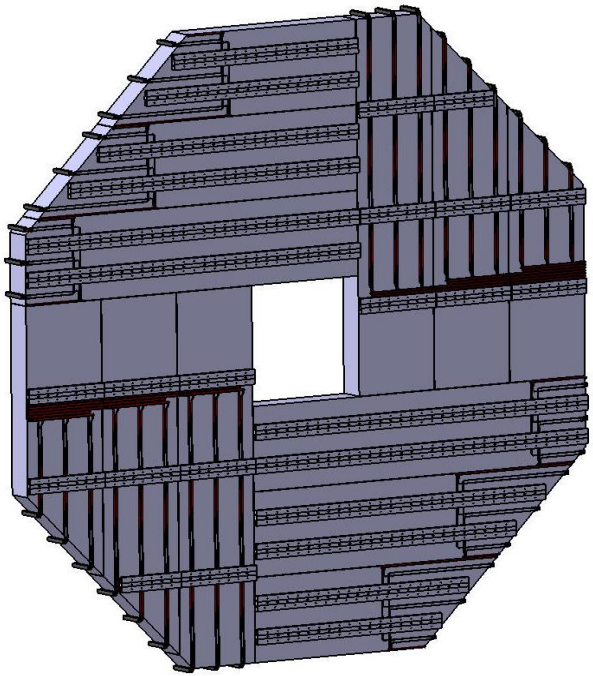
=> Free space for connections

- Step1: onboard pipes & cables connection
- Step2: pipes & cables connection trough detectors



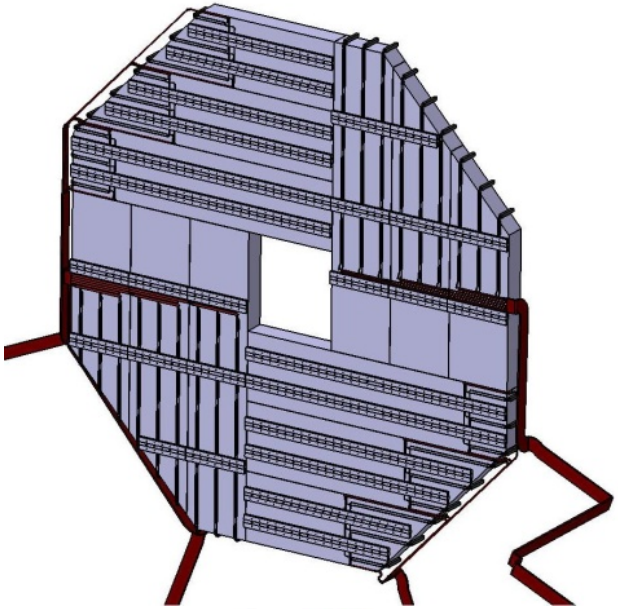
Cooling lines for ECAL End-cap and Barrel

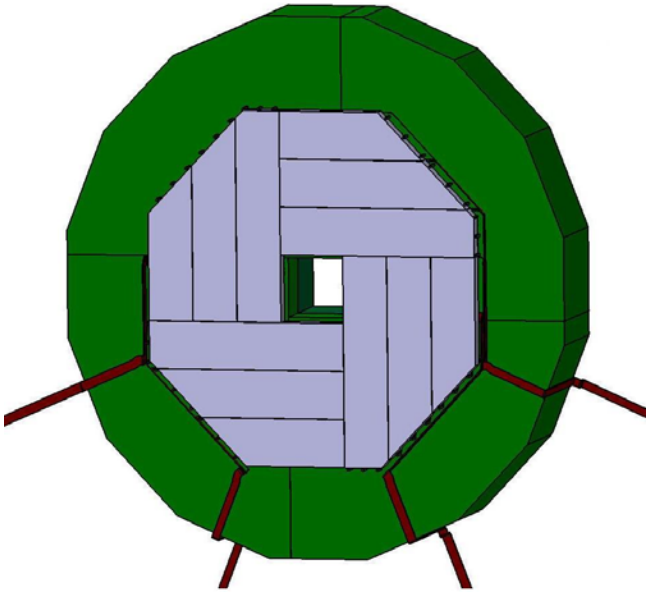
ECAL End-Cap Local Cooling Integration

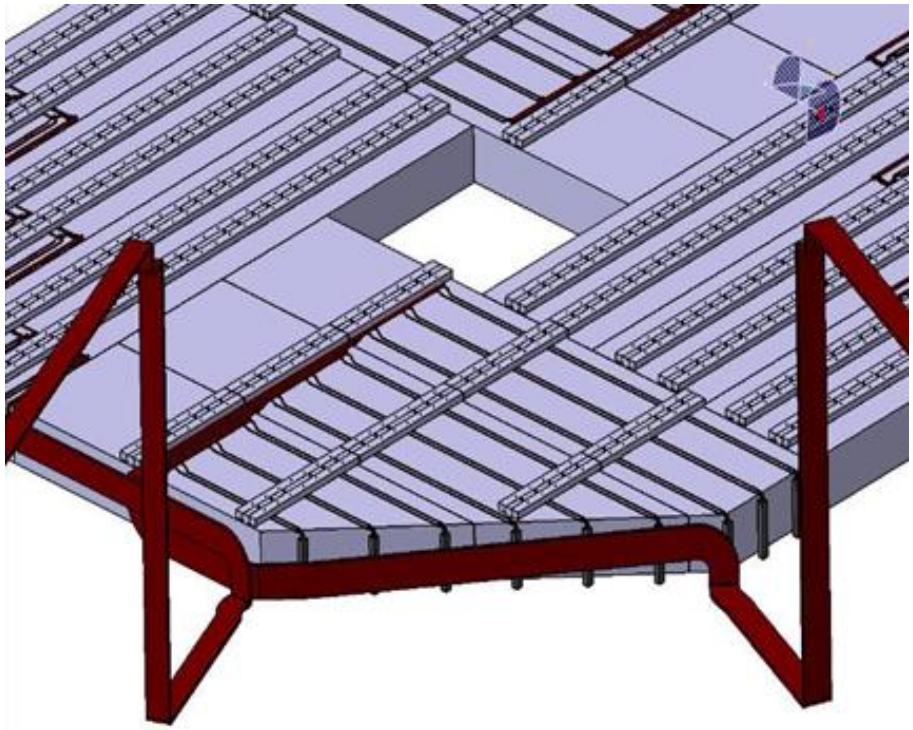
Operation		Time /Unit	ETP	Installation of cooling pipes on modules/quarters – under rails	Time /EC	ETP
Integration on each of the 12 modules …for cooling and services	 Time Included in Assembly phase 1	1 day	2		6 days (surface)	2 + 2 //
Quarter cooling integration	 Time Included in Assembly phase 2	1 day	2		2 days (cavern)	2 + 2 //
						

General cooling connection time to add …

ECAL End-Cap General Cooling Integration

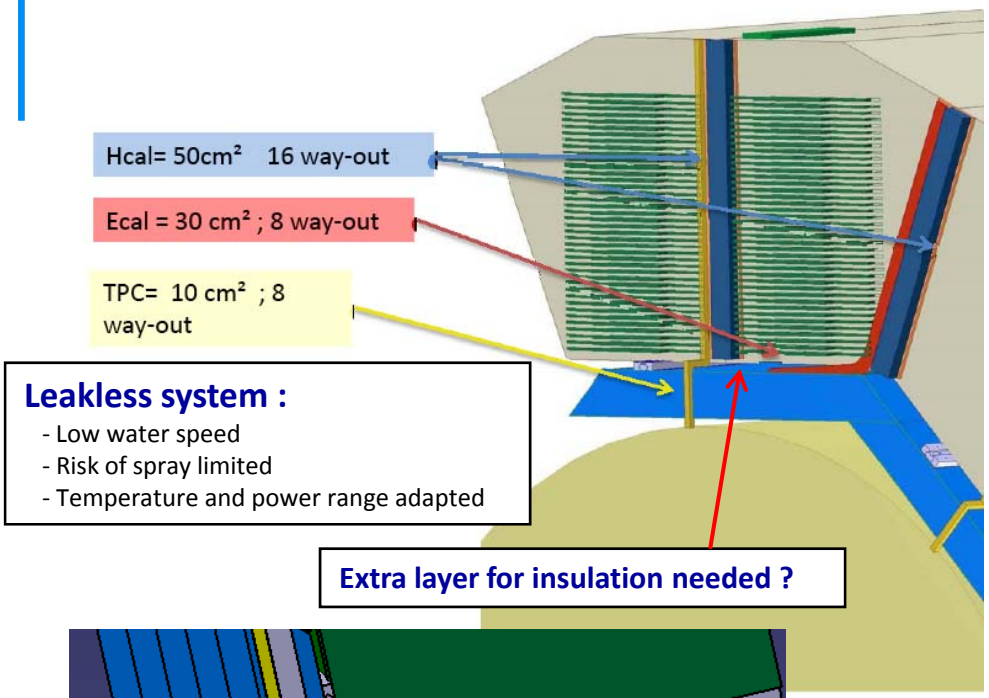






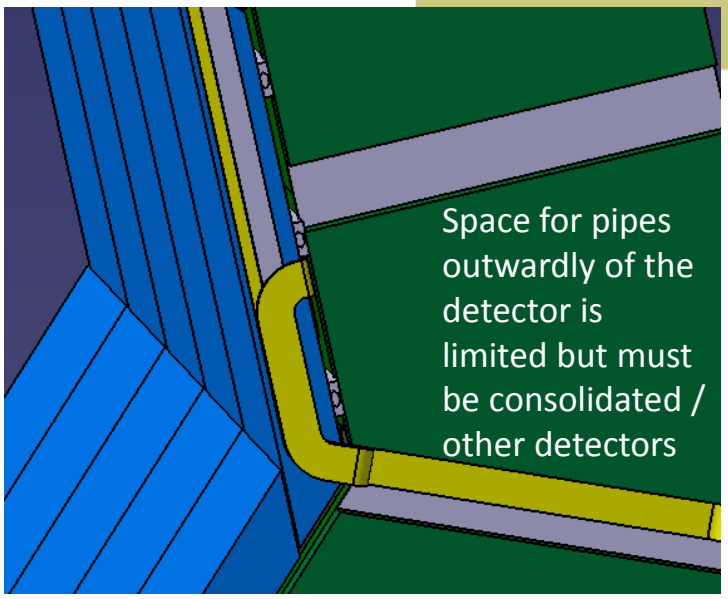
Task Description	FTE	TIME
Connection of leakless system to modules /quarters (pipes incoming by lower side of End-cap)	4	2 weeks
Full connection of 1 End-Cap: general EC integration + *piping trough detectors to cooling station*	4	1 month

ECAL Cooling Integration – Impact / HCAL



Leakless system :
- Low water speed
- Risk of spray limited
- Temperature and power range adapted

Extra layer for insulation needed ?



Thermal flux inside a column of 1 module

Power on PCB = 0,205 W (barrel) / 0,356 W (End-cap)
Boundary condition T = 23 °C

Results

Barrel : (1.5m)

Max T < 25,5 °C
ΔT = 2,2°C

End Cap : (2.5m)

Max T = 29 °C
ΔT = 6°C

Power : 30*0,356 = 10,68 W

Status: the detectors must be independents (thermal aspect).
Reality => low power (3Kw) spread over large surfaces associated with a small space between the detectors (3 cm) => influence of air via important conduction => flux between detectors certain
=> Real T° of detector impossible to predict without global modelling; so no possibility to know if our detector will cool or heat detectors around

Conclusion

Cooling front –end to remove the power of ECAL
Low temperature gradient -> cooling system suitable for HCAL ?
→ extra thermal insulation / HCAL ? (no flux exchange with other detectors)

ECAL End-Caps: integration area

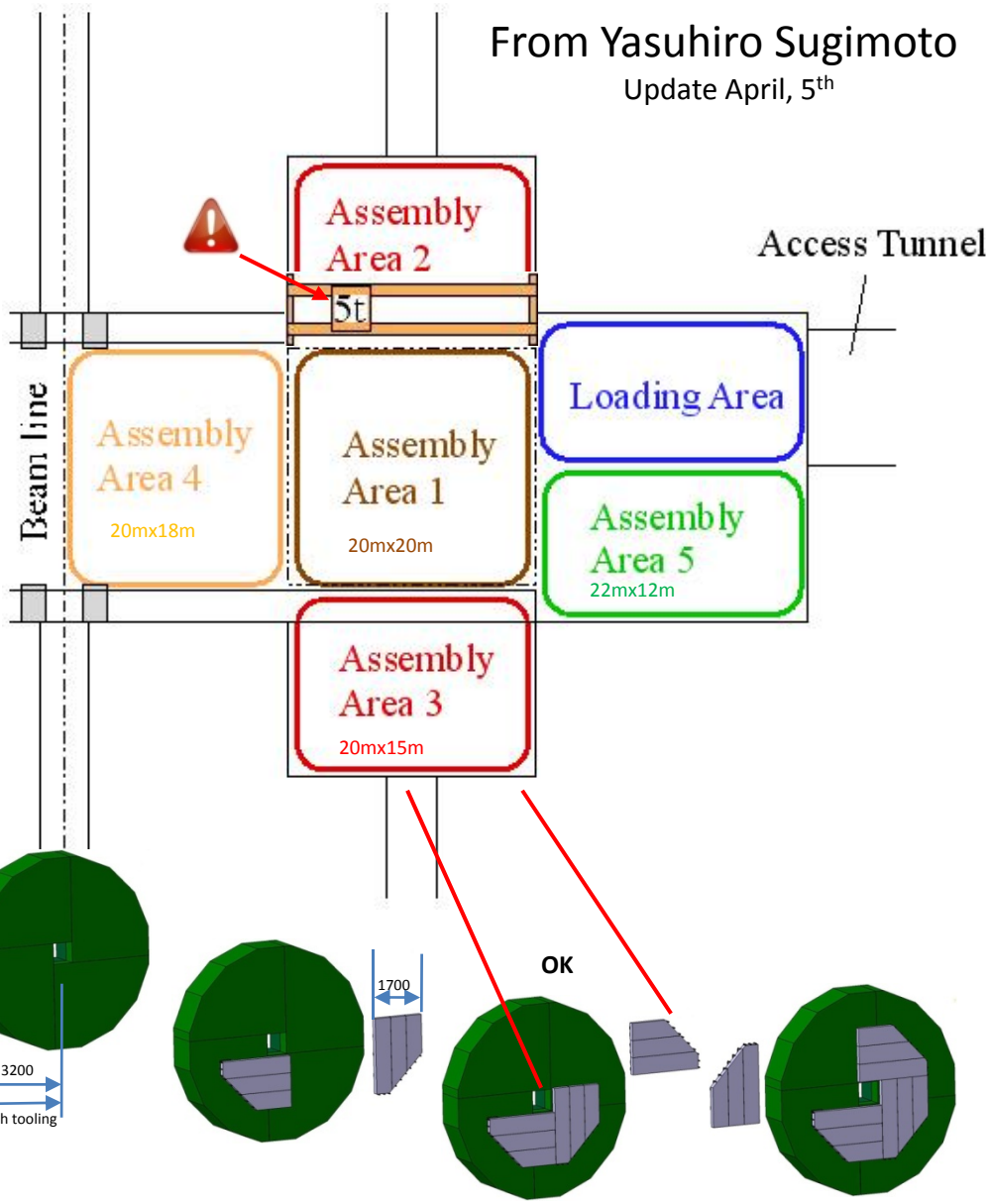
Construction sites dedicated to end caps (installation & cabling): alcoves n° 2 & 3

From Yasuhiro Sugimoto
Update April, 5th

- Assembly spaces in the alcoves: ok

- The crane capacity in the alcoves (5t) is too small.
  The ECAL endcap quarters have a mass of **6,5t** and we need to be able to move them with a crane in the alcoves for insertion on HCAL End-Cap. 10t crane needed (EC+tooling)

- Alternative: cradle, but it has to be aligned (*raised*) to the proper height…



Needed space near detector for Integration & maintenance

Minimum width = 7 m/beam line for integration
Storage area : 1 quarter=> 10 m² / 12 modules=> 50 m²
Assembly area: 25 m² / quarter - 20 m² / module
Insertion on HCAL End-Cap on each side: per full quarters

PRELIMINARY

ECAL End-Caps: integration overview

< 5 months / EC

N°	Major Tasks Description for 1 End-Cap (*Preliminary studies of the Ecal End-Cap assembly*)	FTE	TIME	Ressource name
1	ECAL End-Cap Base Moving Unit / Base Moving Frame / Quarter Mounting Frame Insertion tool, transport , installation, alignment	4	**~ 1 month**	crane 1 , crane 2
2 //	Rails: fixing (female parts) on the rear face of the HCAL End-Caps: Positioning / Alignment / Checking	3	~ 1 month	Specific tooling TBD
3	Quarter 1 (3 modules) assembly in the assembly hall, fully equipped, tested and aligned	6 //	**4 weeks**	quarter support frame 1, crane 1
	3 Modules Equipment and test (assembly of 1 of the 3modules in the assembly hall)	2	1 week x 3	
	Tests (electronic and signal) of the 3 constitutive modules	2 //	1 week x 3	
	Quarter assembly on mounting support frame	2	1 week	
	Transportation of quarter in mountain site (or modules only / space available for tooling approach on both sides of detector in cavern)	4	2 days	
4 //	Quarter 2 (3 modules) assembly in the assembly hall, fully equipped, tested and aligned …	6 //	4 weeks	quarter support frame 2, crane 1
5	Quarter 3 (3 modules) assembly in the assembly hall, fully equipped, tested and aligned …	6 //	**4 weeks**	quarter support frame 1, crane 1
6 //	Quarter 4 (3 modules) assembly in the assembly hall, fully equipped, tested and aligned …	6 //	4 weeks	quarter support frame 2, crane 1
7	Integration of 1 Ecal End-Cap on HCAL End-Cap	4	**1 month**	crane 1 , crane 2 quarter support & MF
	Insertion of 4 Ecal End-Cap quarters on HCAL End-Cap (quarter on its support frame) Positioning of the quarter on specific sliding tool / Pre-alignment operations / Insertion	4	2 days x 4	crane 1 , crane 2 quarter support & MF
8	1 ECAL End-Cap general cooling integration	4	2 weeks	
9	Remove ECAL End-Cap Mounting Frame / Base Moving Frame / Quarter Mounting Frame…	4	1 week	crane 1 , crane 2

Main issue /mechanical quarter behavior during insertion on HCAL: Quarter Mounting Frame (To Be Studied)

In case of cavern : this is done in assembly hall Mountain site (in the cavern)