UPDATE ON CALORIMETRY

M. Aleksa, J. Faltova, C. Helsens, A. Henriques,
C. Neubüser, N. Topiline, A. Zaborowska

5 April 2017
FCC hadron detector meeting

Estimated # channels for FCC calorimeters

	Calo partition	Technology	η coverage	# long. layers	$\Delta\eta$ x $\Delta\varphi$	# channels
ECAL	**EM B**	LAr / Pb	< 1.7	8	0.01 x 0.012	1,294 x 10^3
	EM EB		1.5 – 2.5	6	0.01 x 0.012	562 x 10^3
	EFCAL		2.5 – 6.0	6	0.025 x 0.025	457 x 10^3
HCAL	**HEC**	LAr / Cu	1.7 – 2.5	6	0.025 x 0.025	104 x 10^3
	HFCal		2.3 – 6.0	6	0.05 x 0.05	113 x 10^3
	Tile B	Tiles / Stain. Steel	< 1.3	10	0.025 x 0.025	222 x 10^3
	Tile EB		1.0 – 1.8	8	0.025 x 0.025	65 x 10^3
Total	**ECAL (LAr / Pb)**					**2,313 x 10^3**
	HCAL (LAr / Cu)					**217 x 10^3**
	HCAL (Tiles / S. Steel)					**288 x 10^3**
	ALL					**2,818 x 10^3**

Delphes:

$(\Delta\eta \times \Delta\varphi)$

EM B: $\mathbf{0.05 \times 0.012}$

Tile B: $\mathbf{0.05 \times 0.05}$

no longitudinal layers

Proposed ECAL + HCAL granularity

- Technologies allow to increase or reduce the number of channels

Electromagnetic calorimeter: design

Cylinders with absorber

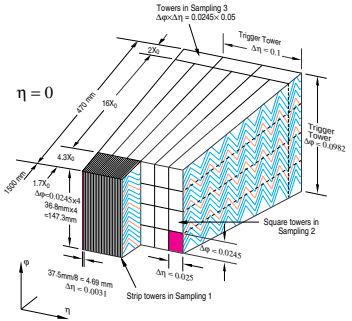
- idealistic,
- simple to implement,
- used up to now.

Electromagnetic calorimeter: design

Cylinders with absorber

- idealistic,
- simple to implement,
- used up to now.

ATLAS accordion calorimeter



- complex,
- difficult to build.

Electromagnetic calorimeter: design

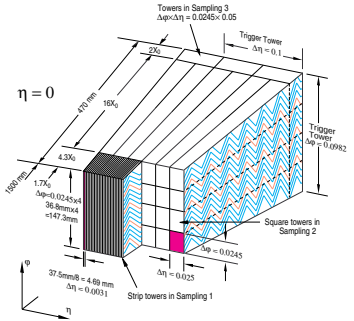
Cylinders with absorber

- idealistic,
- simple to implement,
- used up to now.

Inclined absorber planes

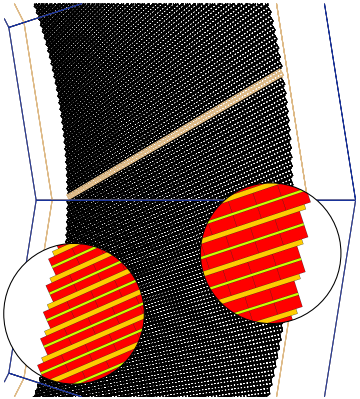
- simple,
- increasing lAr gap (change of sampling fraction with calo depth).

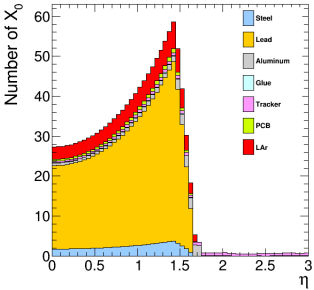
ATLAS accordion calorimeter



- complex,
- difficult to build.

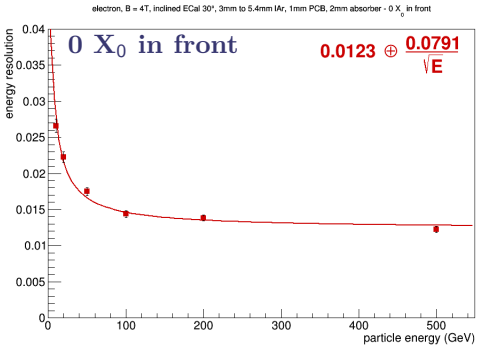
Inclined ECal: design

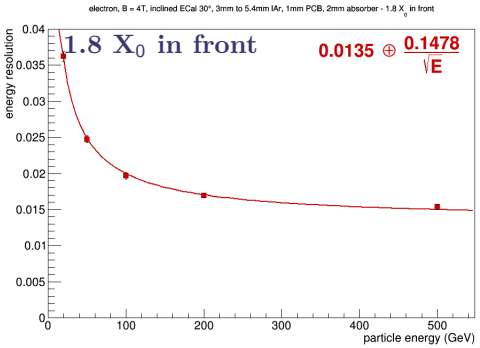




- 2 mm absorber plate:
  - lead in middle
  - steel on the outside
  - glued together
- 1 mm readout (printed circuit board) in between absorbers
- 3 mm to 5.4 mm (80% increase) liquid argon gap
- 30° inclination angle

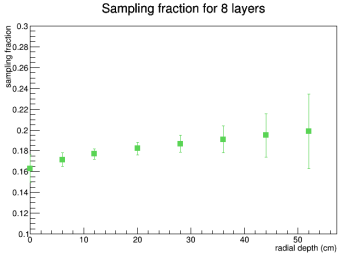
Inclined ECal: Energy resolution - first check





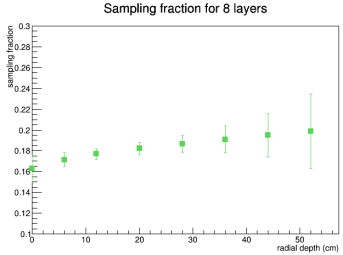
- calculation done with **one value of sampling fraction** (for each energy)
- 1.8 X_0 realistic amount of material in front, important to minimise the cryostat material (further study will be done for 1.5 X_0 that seems to be feasible)
- liquid argon / absorber ratio differs with calorimeter depth
- shower fluctuations lead to large constant terms

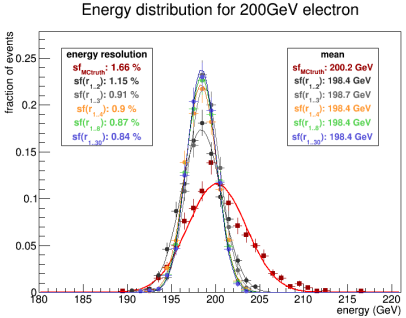
Inclined ECal: Sampling fraction



- SF = energy deposited in active material out of total deposited energy (within one longitudinal layer)

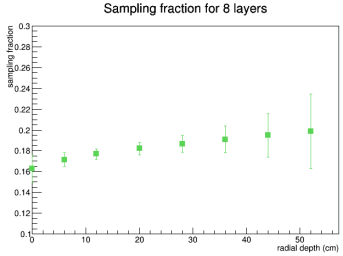
Inclined ECal: Sampling fraction



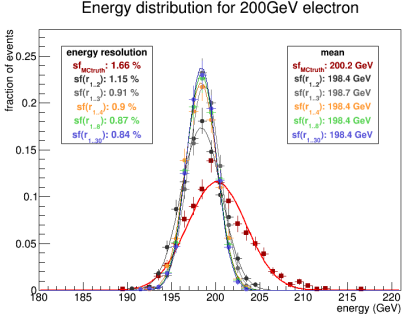


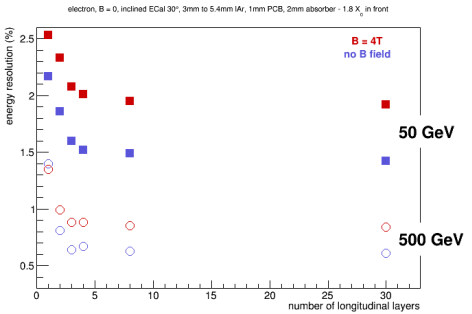
- SF = energy deposited in active material out of total deposited energy (within one longitudinal layer)
- 4 layers are the minimum needed to correct for the EM scale

Inclined ECal: Sampling fraction

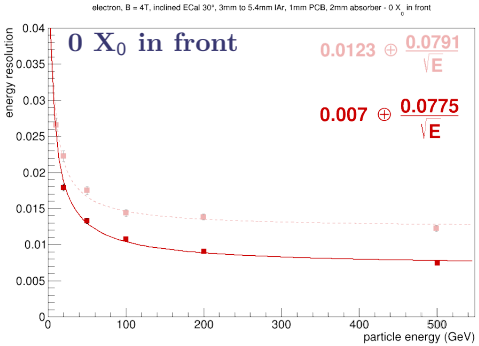


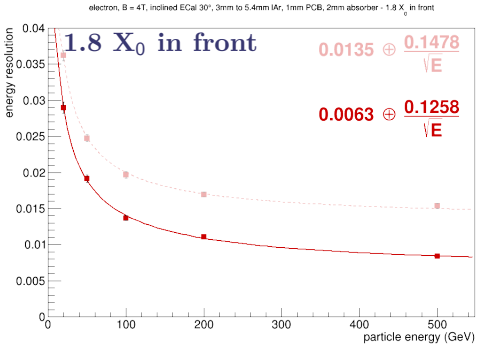
- SF = energy deposited in active material out of total deposited energy (within one longitudinal layer)
- 4 layers are the minimum needed to correct for the EM scale
- Energy resolution improves quickly with number of layers used for SF calculation





Inclined ECal: Energy resolution - improved





- calculating **sampling fraction in (8) longitudinal layers**
- correction to cell energy, no prior knowledge of the particle energy
- decrease of the constant term
- improvement of the sampling term

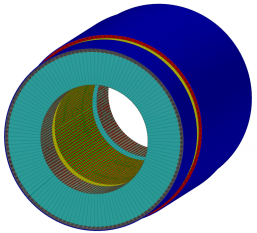
Inclined ECal: Plans

- Optimisation of the inclination angle and liquid argon gap size
- Validation using tracker in front of calorimeter and realistic cryostat (total of 1.5 X_0 for η=0)
- Sliding window reconstruction

Tile hadronic calorimeter: mechanic assembly

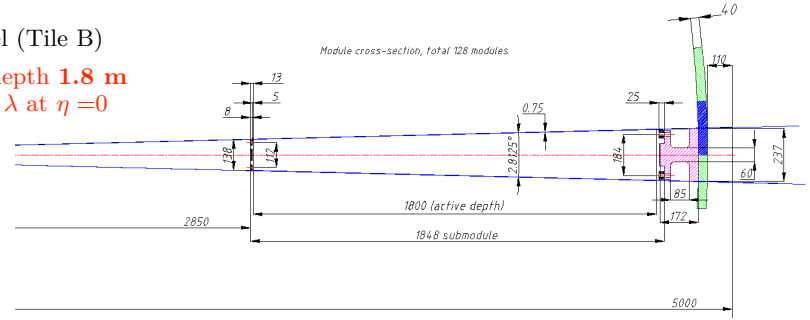
Study done by Nikolai Topiline from JINR

- stainless steel
- scintillating tiles
- WLS fibres (ratio 4.7:1)
- SiPMTS as readout



Barrel (Tile B)

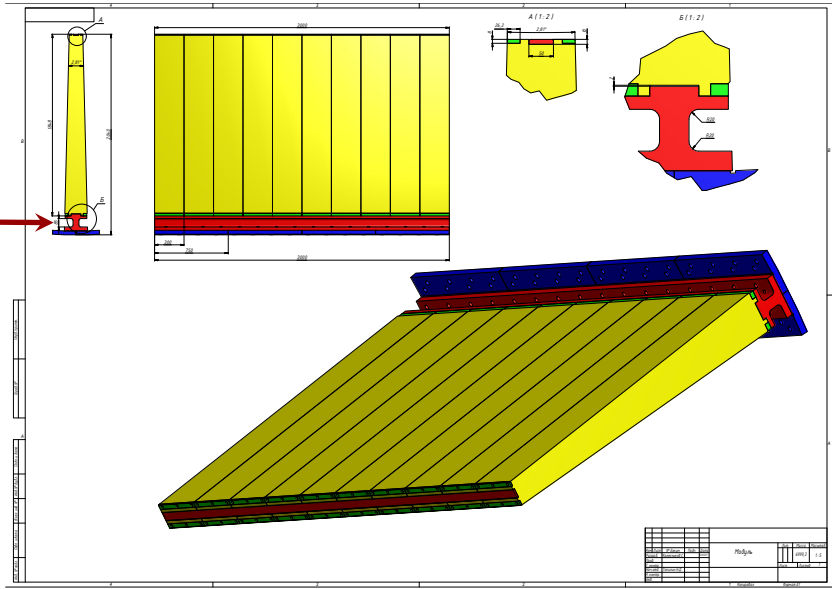
active depth **1.8 m** = 8.7 λ at η =0



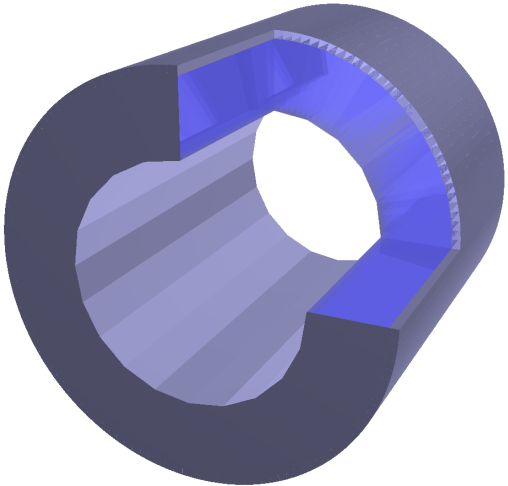
barrel weight: 2 687 t

Tile hadronic calorimeter: mechanic assembly

$85\times85\text{mm}^2$ per module for siPMT+electronics over several meters in Z

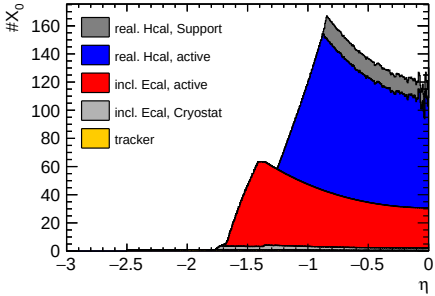


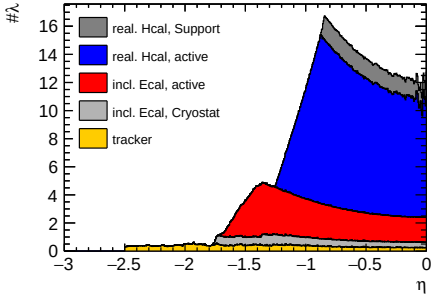
Implementation of realistic TileCal design in FCCSW

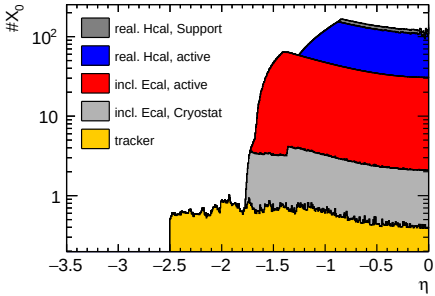


10 layers: $2 \times 10\,\text{cm}$ $(0.5\#\lambda)$
$+ \; 4 \times 15\,\text{cm}$ $(0.75\#\lambda)$
$+ \; 4 \times 25\,\text{cm}$ $(1.3\#\lambda)$
instead of 18 layers of 10 cm each
+ girder and crossbar (steel support)

New material scans



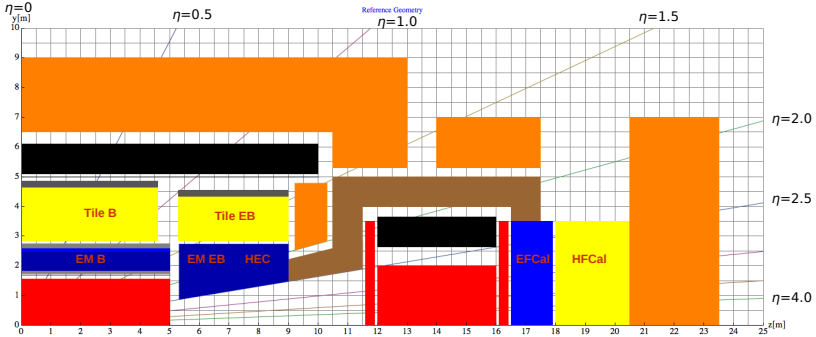




- tracker
- inclined ECal
- realistic TileCal design

BACKUP SLIDES

FCC calorimeter system



Electromagnetic (EM) calorimeters

- Barrel (EM B)
- Extended Barrel (EM EB)
- Forward calorimeter (EFCal)

Hadronic calorimeters

- Barrel (Tile B)
- Extended Barrel (Tile EB)
- Hadronic endcap (HEC)
- Forward calorimeter (HFCal)

- **Note: Technology has not been chosen yet**
  - Current baseline: Fe + Scintillators (Tile B, Tile EB), Pb + LAr (all the rest)