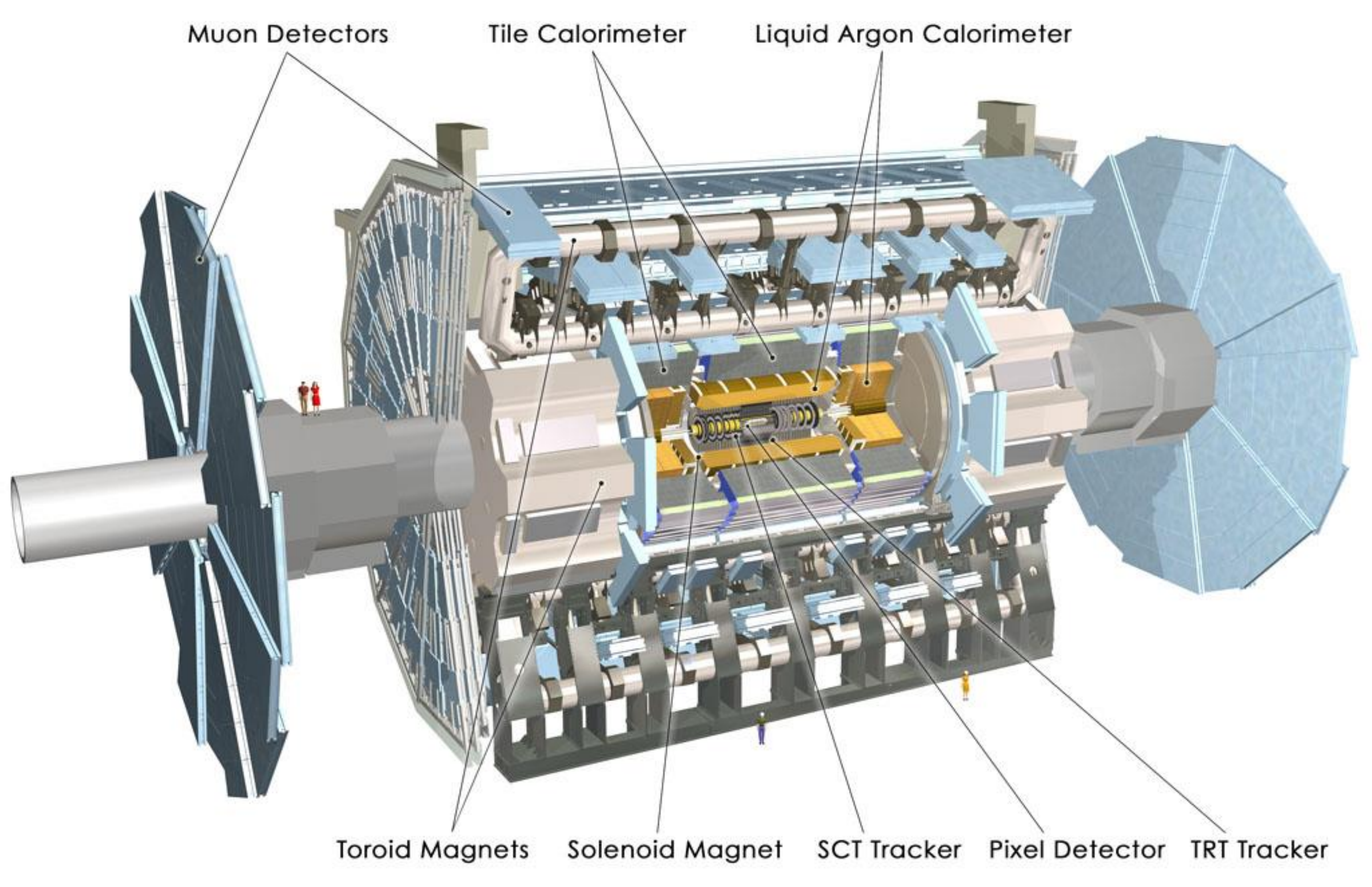
Granularity of ATLAS Tile Calorimeter studied through Geant4 simulations

Anabel Romero
Universidad Simón Bolívar

ATLAS and the Tile Calorimeter



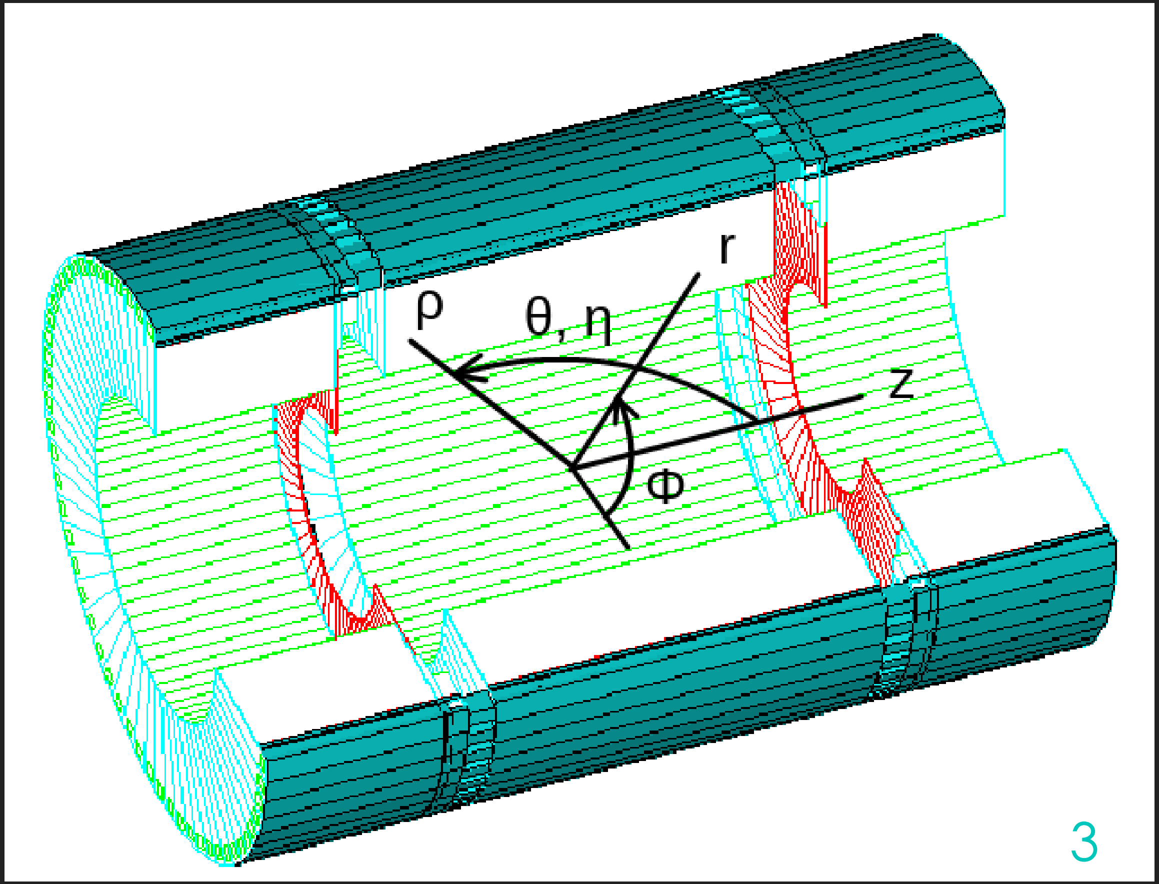
Coordinates

Cylindrical coordinates:
Z, r, Φ

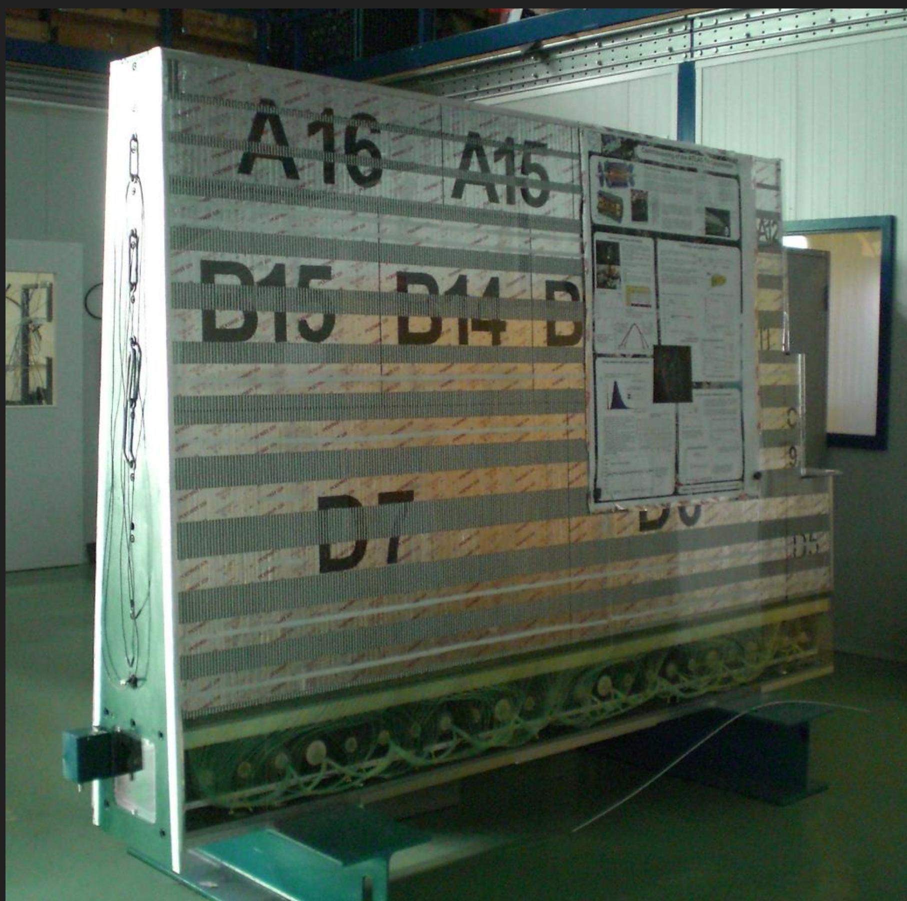
Spherical coordinates:
ρ, Φ, θ

Instead of θ, we use η, which is defined as:

$$\eta = -ln\left(tg\left(\frac{\theta}{2}\right)\right)$$



Module



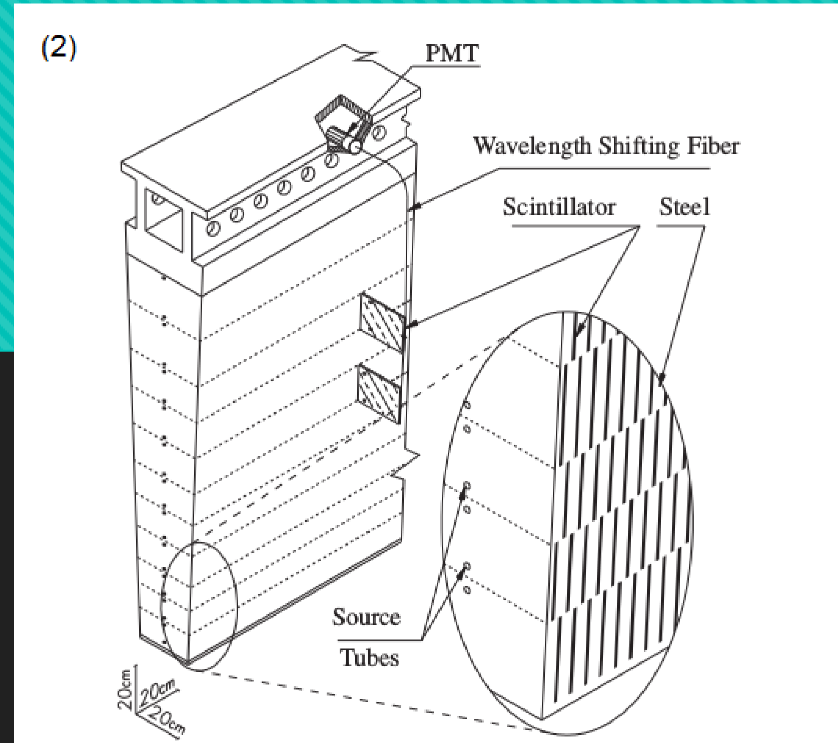
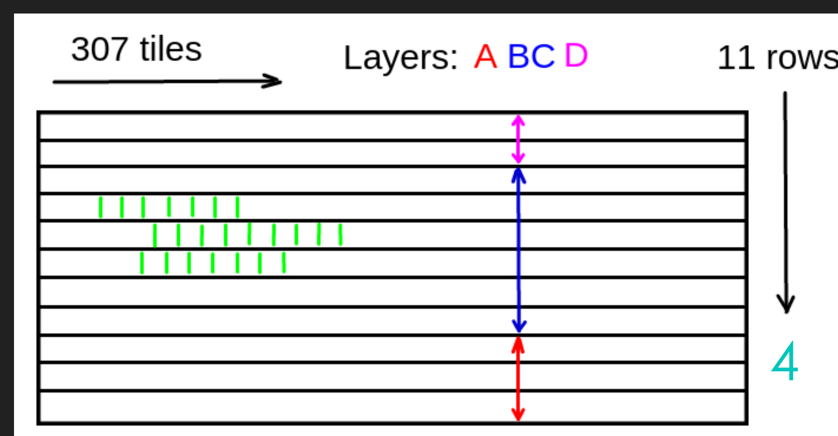


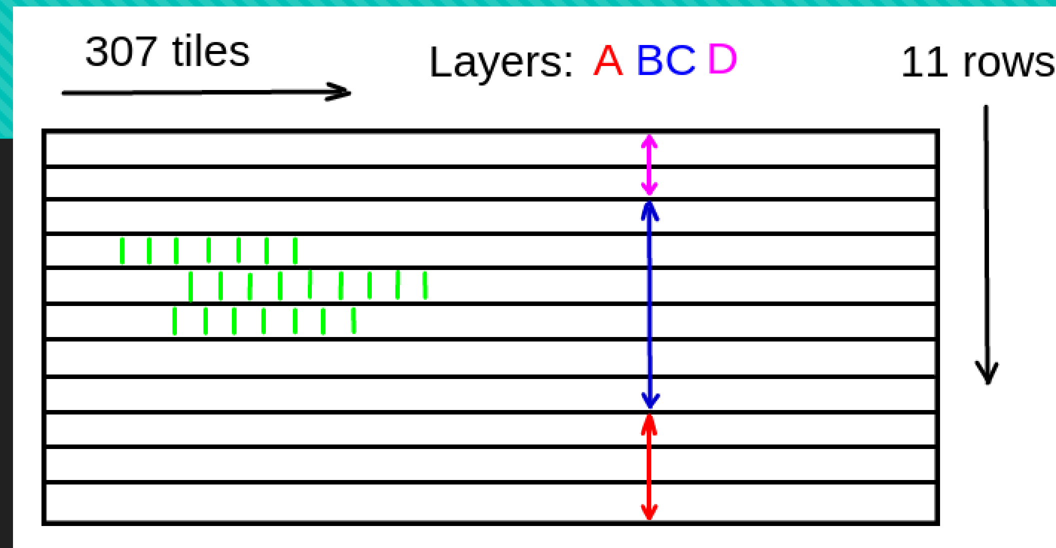
Fig. 2. Mechanical structure of a TileCal module, showing the slots in the iron for scintillating tiles and the method of light collection by WLS fibers to PMTs. The holes for radioactive source tubes that traverse the module parallel to the colliding beams are also shown.

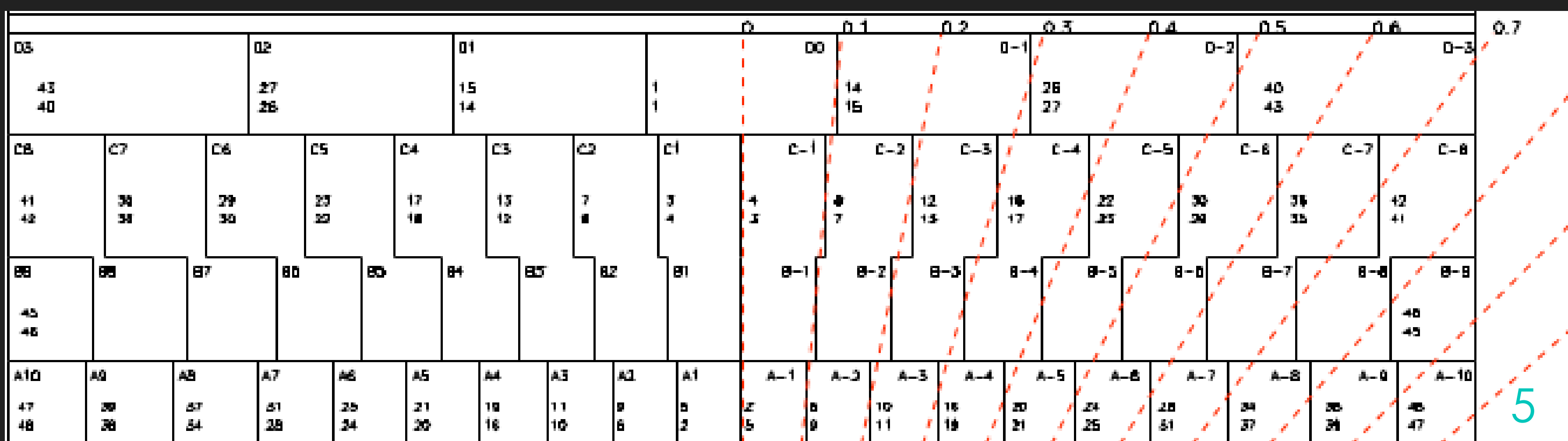


Granularity

64 modules →
$\Delta\Phi = 2\pi/64 = 0.1$ rad

Cells defined so
that $\Delta\eta = 0.1$ rad

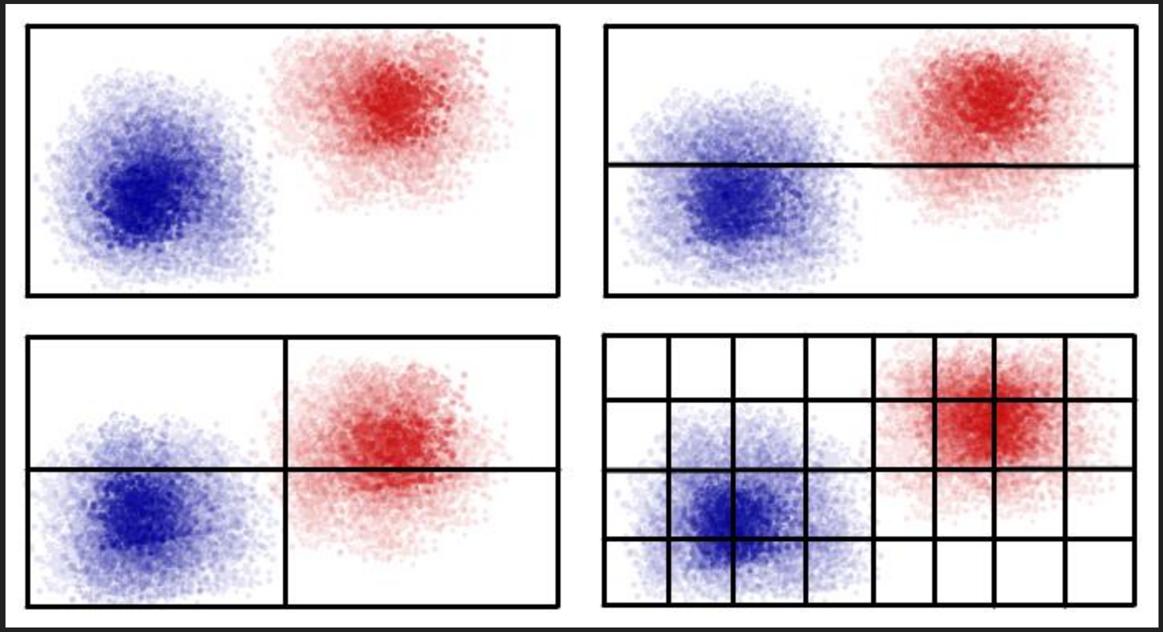




Why is granularity important or interesting?

Example:

- Boxes represent detectors.
- Particle Red and particle Blue hit the detectors and deposit their energies.
- Energy distribution is as shown below.

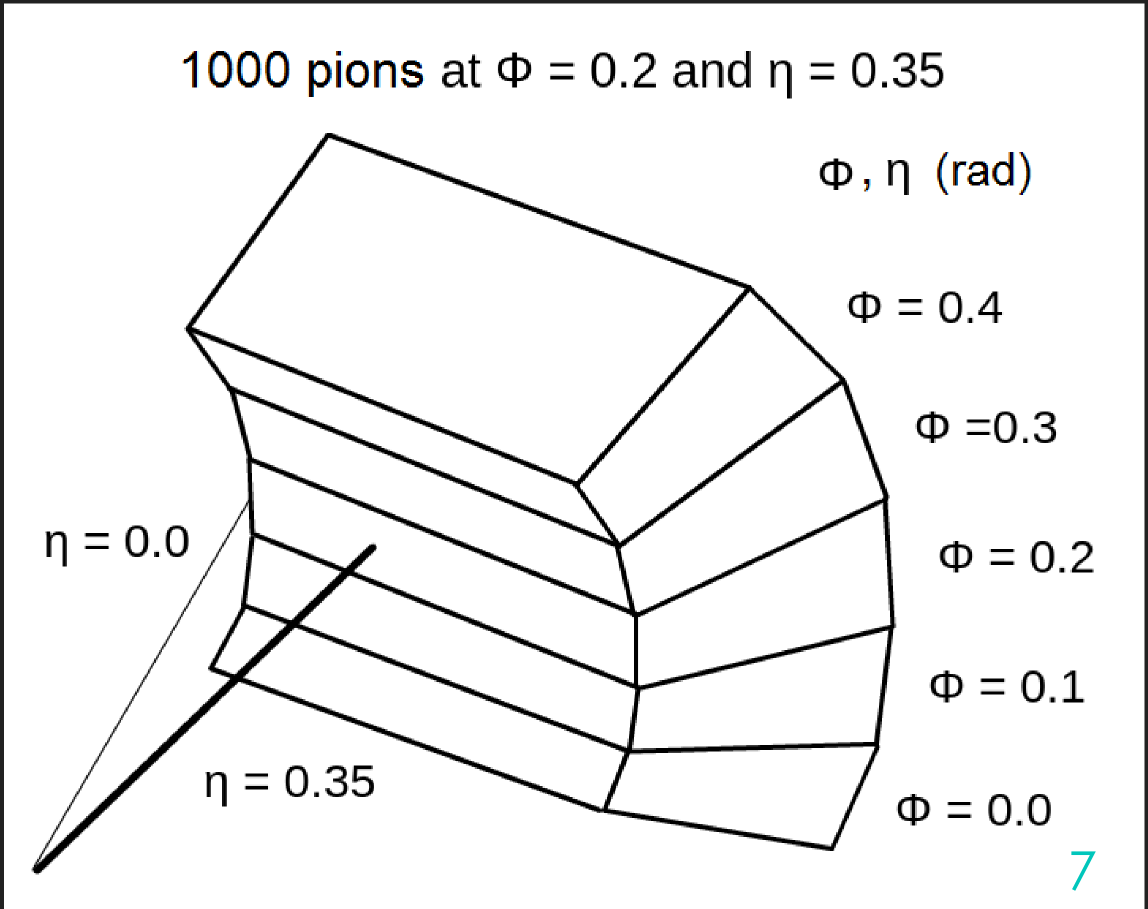


Which configuration of detectors would allow us to know the energy of each particle with least error?

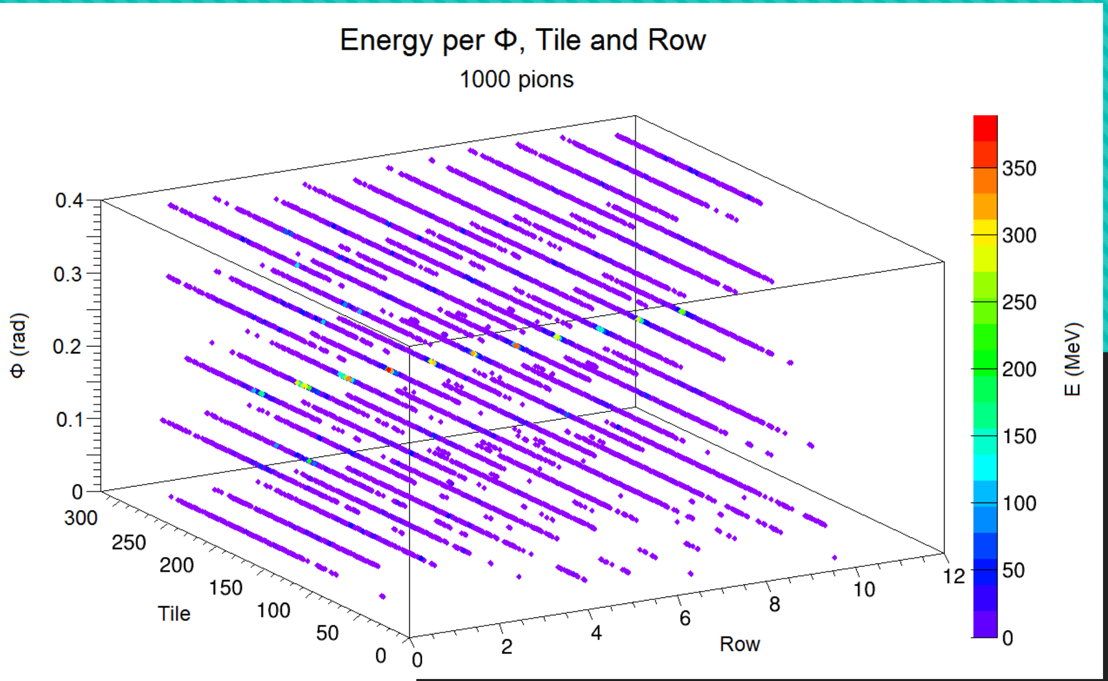
Simulations

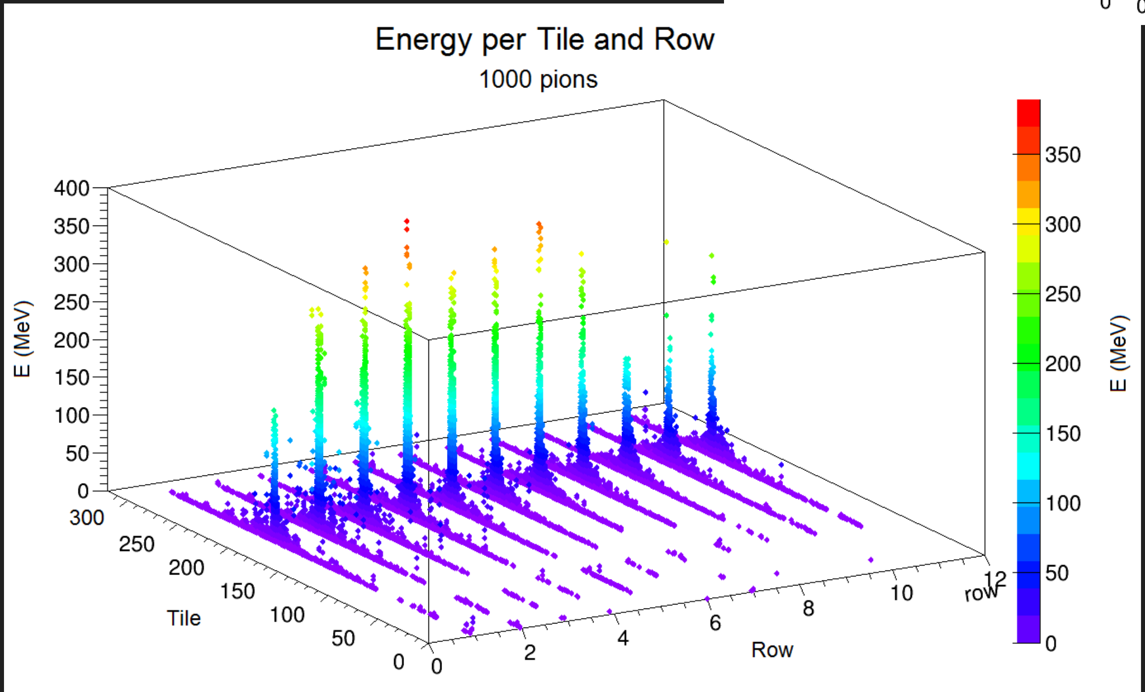
Objectives:

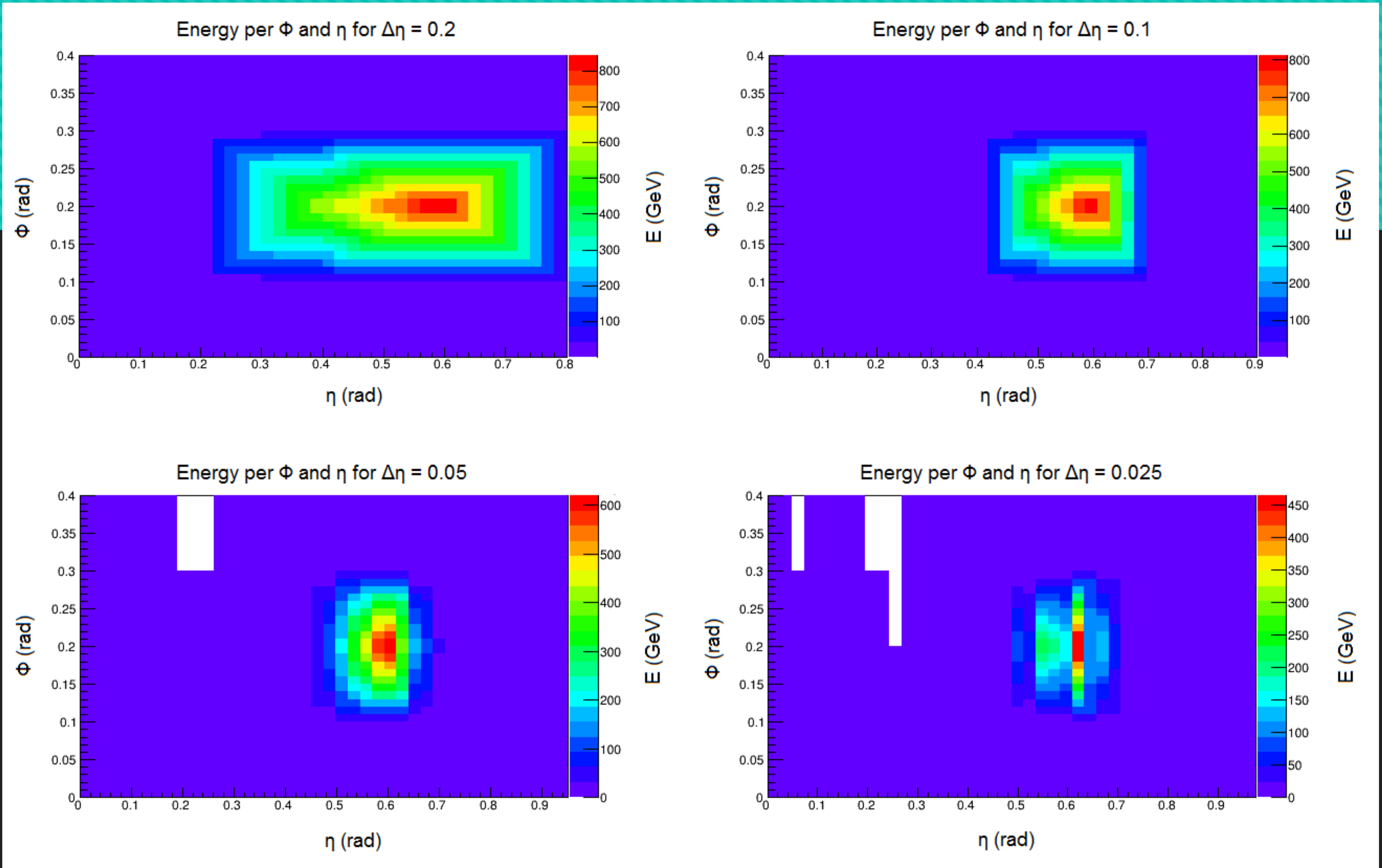
- Simulate different granularities $\Delta\Phi \times \Delta\eta$.
- Obtain partial energy deposited within a radius: $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ for different granularities.



Results


Energy per Φ, Tile and Row
1000 pions
Φ (rad)
0.4
0.3
0.2
0.1
0
300
250
200
150
100
50
0
Tile
0
2
4
6
8
10
12
Row
E (MeV)
350
300
250
200
150
100
50
0

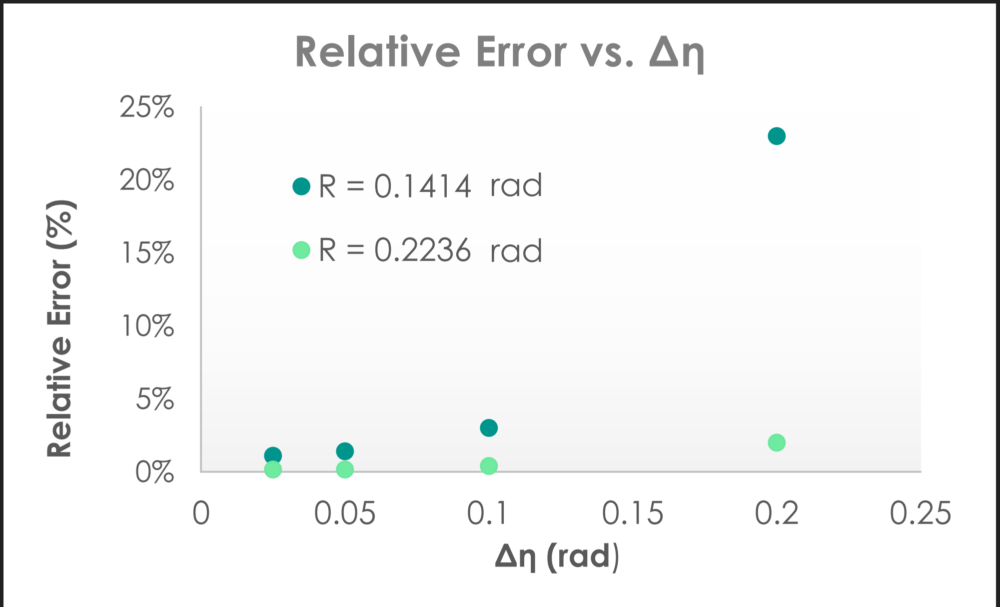

Energy per Tile and Row
1000 pions
E (MeV)
400
350
300
250
200
150
100
50
0
300
250
200
150
100
50
0
Tile
0
2
4
6
8
10
12
Row
row
350
300
250
200
150
100
50
0


Energy per Φ and η for Δη = 0.2
Energy per Φ and η for Δη = 0.1
Energy per Φ and η for Δη = 0.05
Energy per Φ and η for Δη = 0.025
Φ (rad)
η (rad)
E (GeV)

1000 pions

Table 1. Partial energy deposited within a radius $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ for 1000 pions				
	$\Delta\eta$ = 0.2 rad	$\Delta\eta$ = 0.1 rad	$\Delta\eta$ = 0.05 rad	$\Delta\eta$ = 0.025 rad
R = 0.1414 rad	1300 ± 300 GeV	1540 ± 40 GeV	1557 ± 22 GeV	1561 ± 17 GeV
R = 0.2236 rad	1550 ± 30 GeV	1574 ± 6 GeV	1578.2 ± 2.7 GeV	1578.6 ± 2.3 GeV

Table 2. Relative error in energy deposited within a radius $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ for 1000 pions				
	$\Delta\eta$ = 0.2 rad	$\Delta\eta$ = 0.1 rad	$\Delta\eta$ = 0.05 rad	$\Delta\eta$ = 0.025 rad
R = 0.1414 rad	23 %	3%	1.4 %	1.1 %
R = 0.2236 rad	2 %	0.4 %	0.17 %	0.15 %



Conclusions

- Reducing the granularity would reduce the error in partial energy measurements.
- With half the current granularity, the percentage error would decrease by a factor of 2.2.

References:

1. ATLAS Collaboration, *ATLAS Tile Calorimeter Technical Design Report*, CERN/LHCC/96-42, 1996.
2. ATLAS Collaboration, *Testbeam studies of production modules of the ATLAS Tile Calorimeter*, Nuclear Instruments and Methods in Physics Research A 606 (2009) 362–394.