Update on angular resolution measurement

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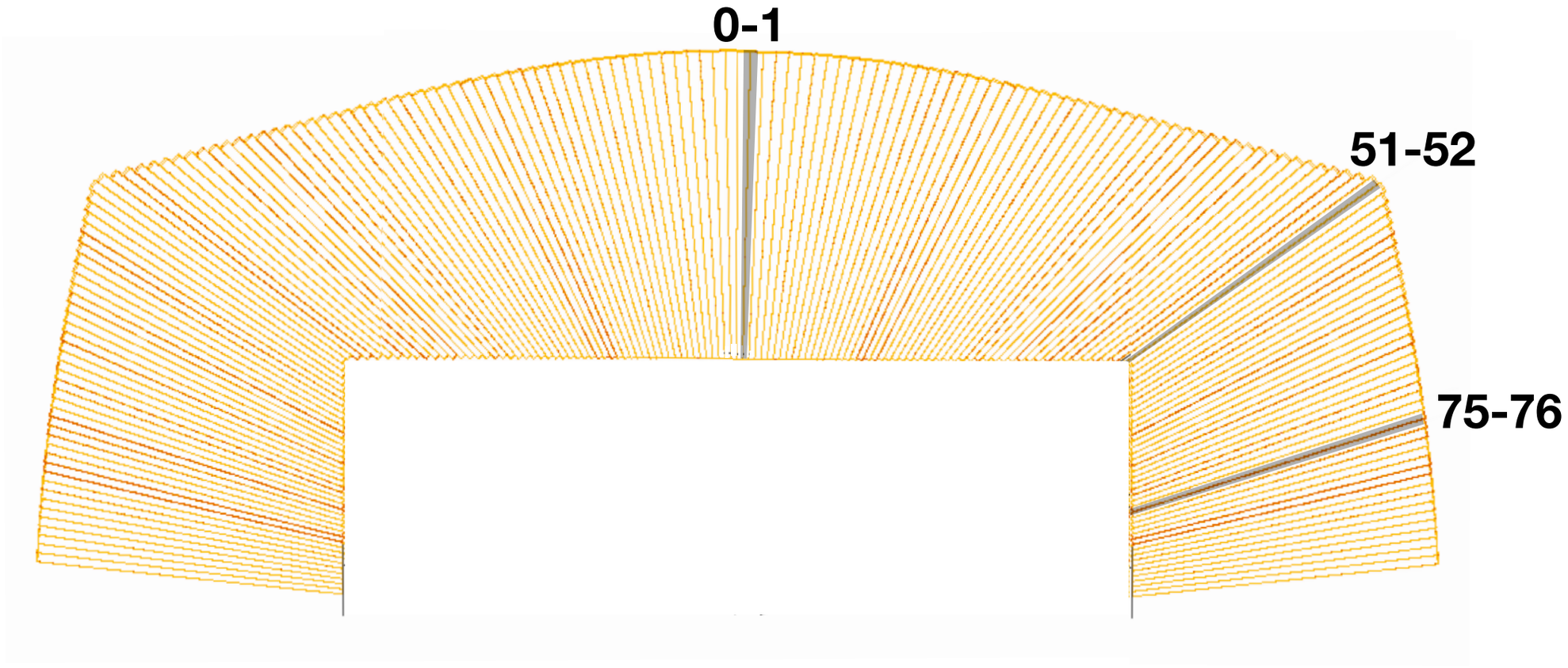
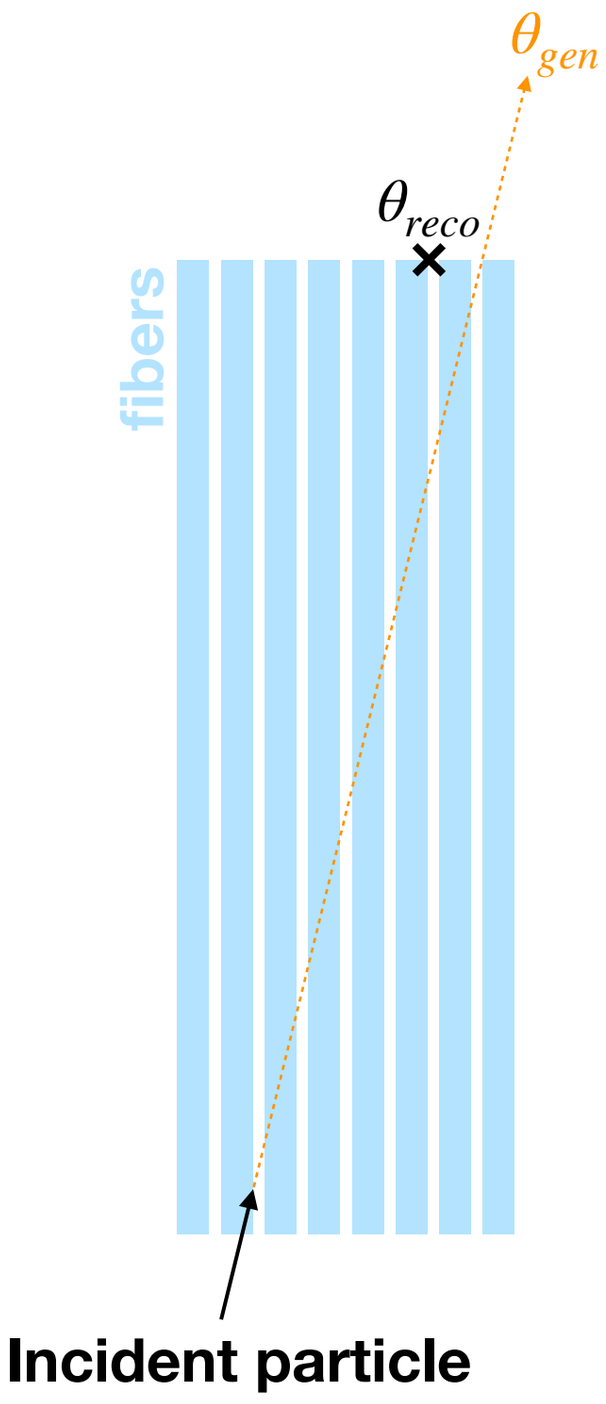
Dual-Readout Meeting 2021.02.24

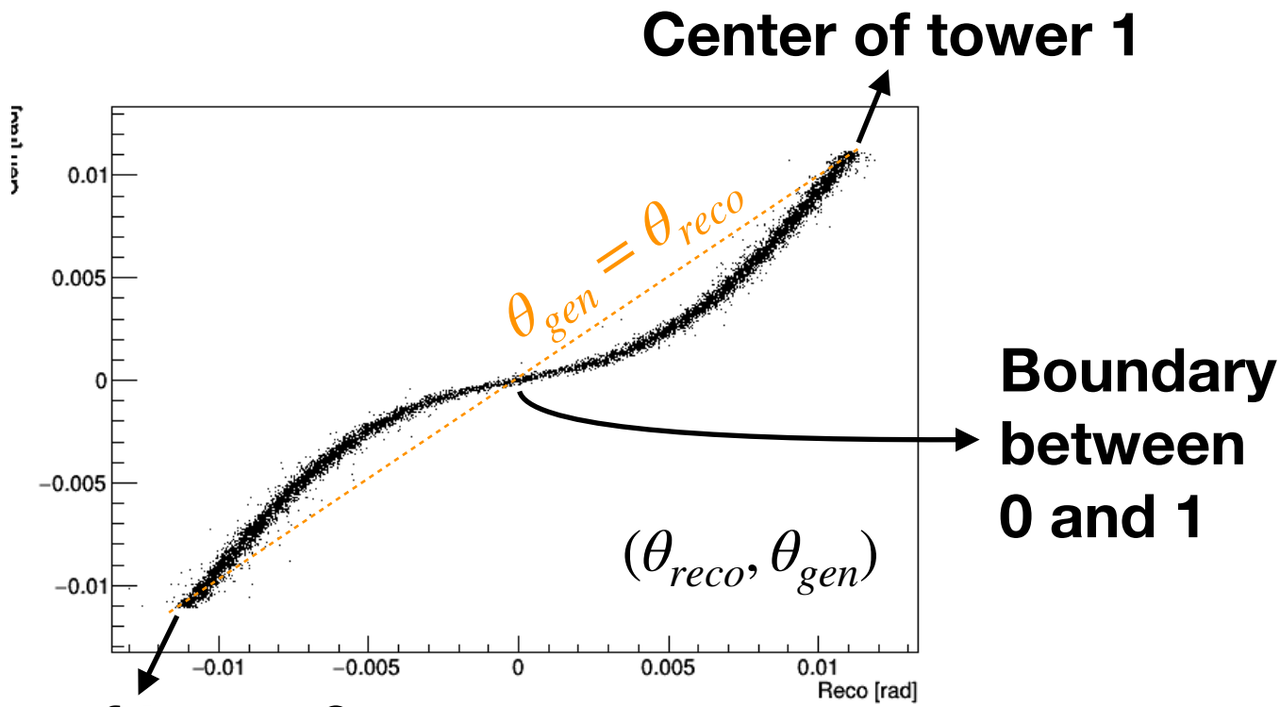
Setup



- Measurement for three different cases
  - Between the center axes of tower0 and tower1
  - Between the center axes of tower51 and tower52
  - Between the center axes of tower75 and tower76
  - Each case is performed 6 times with different energies
    - 10, 20, 40, 60, 80 and 100 GeV electron

Deviation of *reco* from *gen*

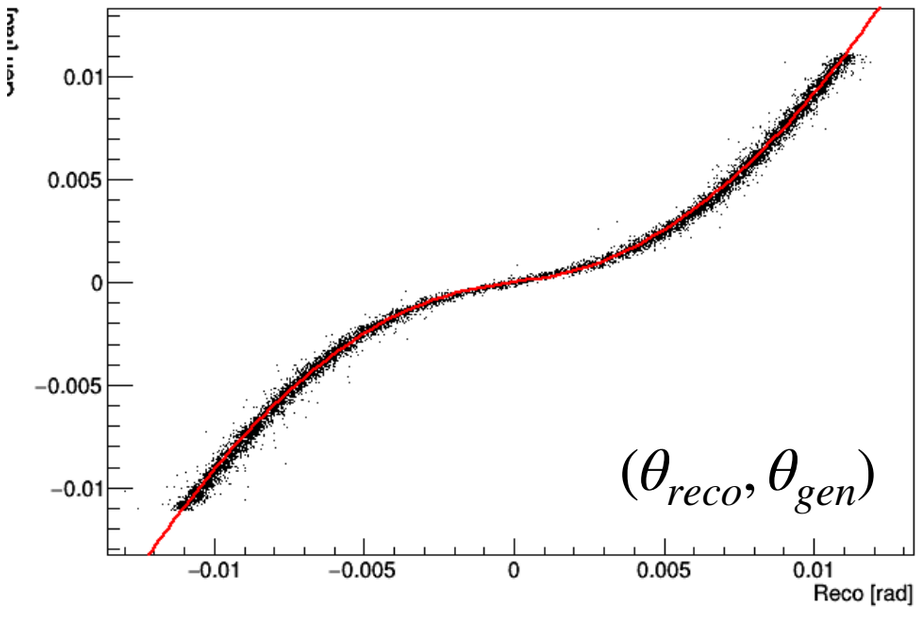


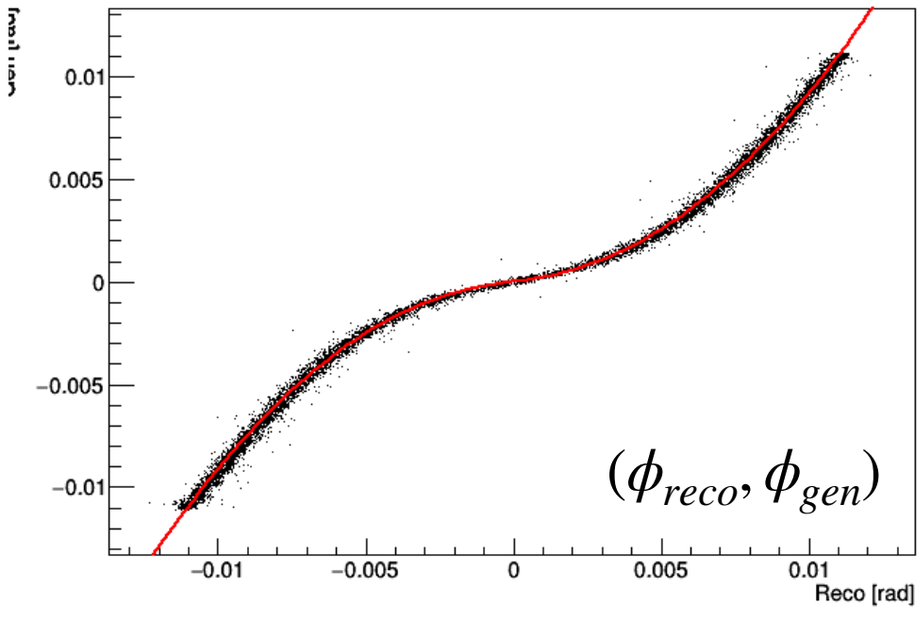


- Horizontal axis: reconstructed angle, *reco*
- Vertical axis: direction of incident momentum, *gen*

- Depending on the angle between an incident particle and fiber alignment, θ_{reco} can locate above/below $\theta_{gen} = \theta_{reco}$ line

Correction





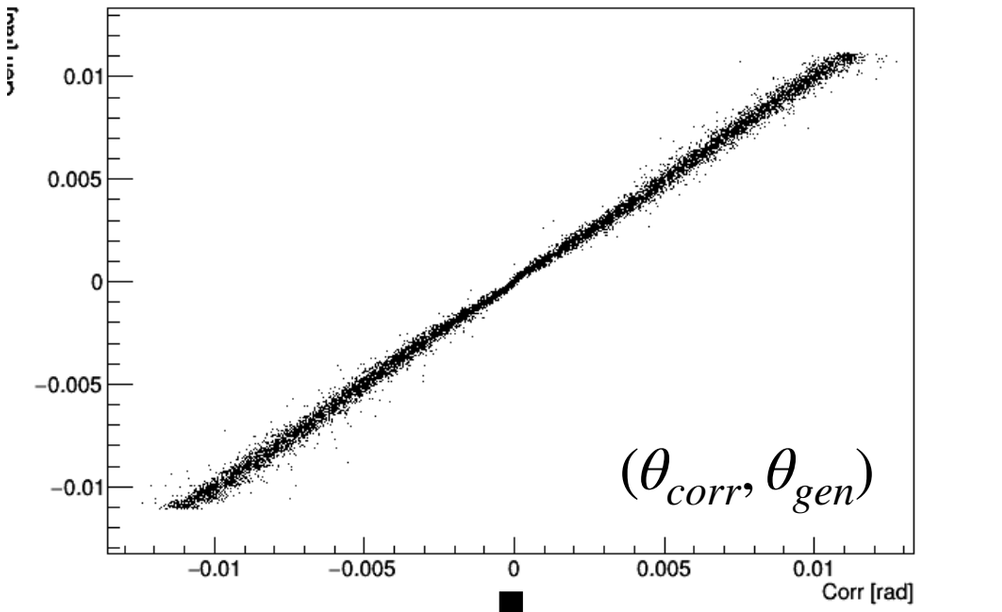
- Since the width of the band represents the resolution, it would be much easier if the band is straight

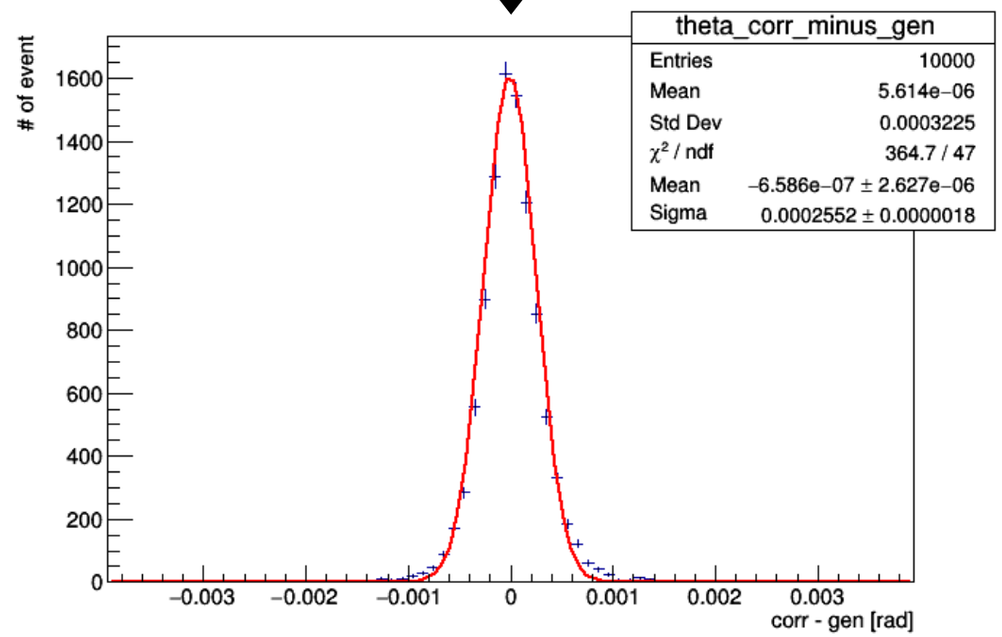
- We can obtain p_0, p_1 and p_2 that fit in (red line)

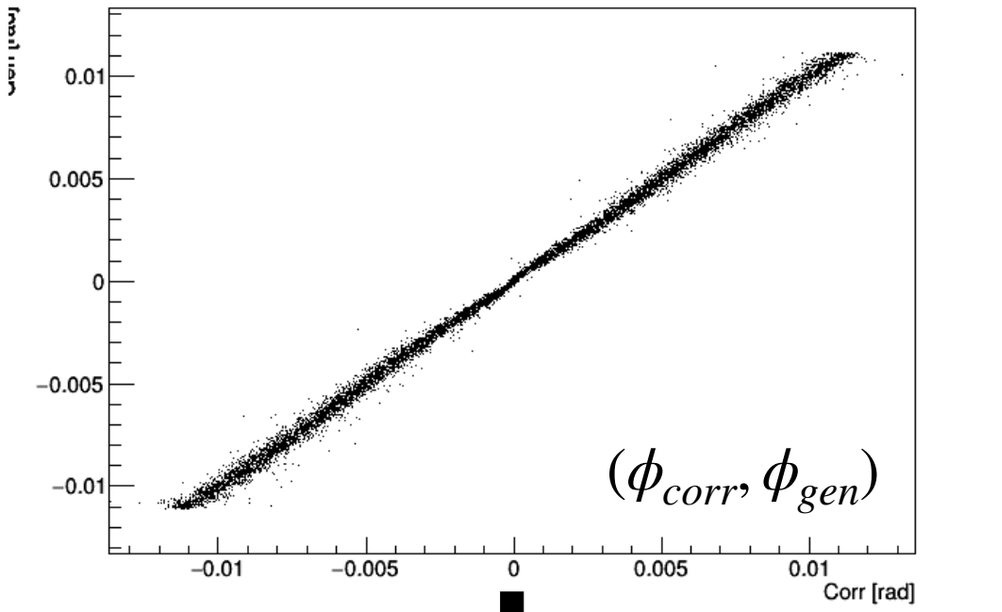
$$x_{gen} = p_0 x_{reco} + p_1 x_{reco}^2 \tan^{-1} p_2 x_{reco}$$

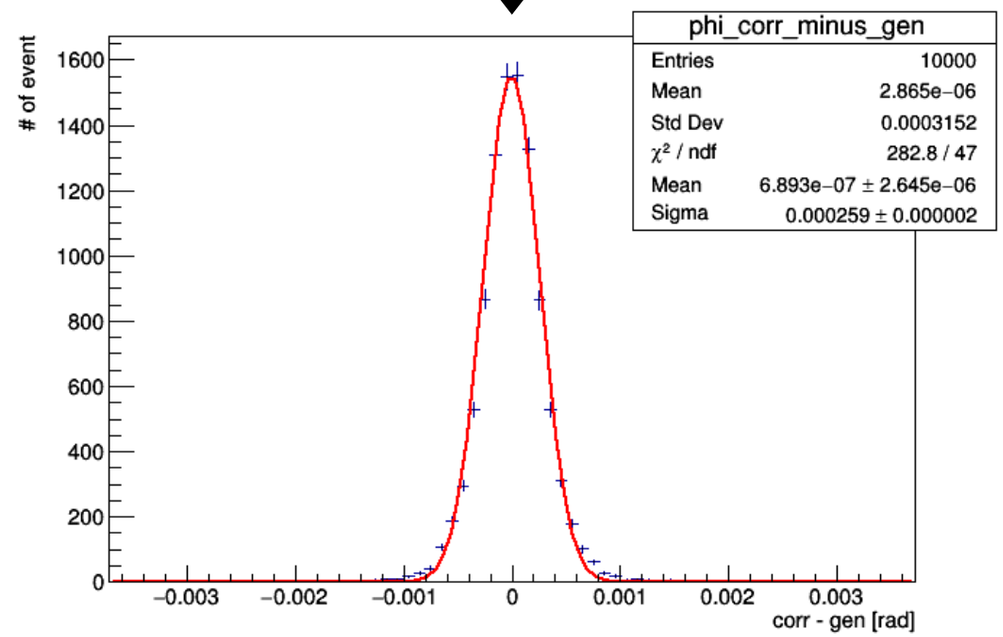
- With obtained parameters, by applying above function, the band becomes straight

Resolution



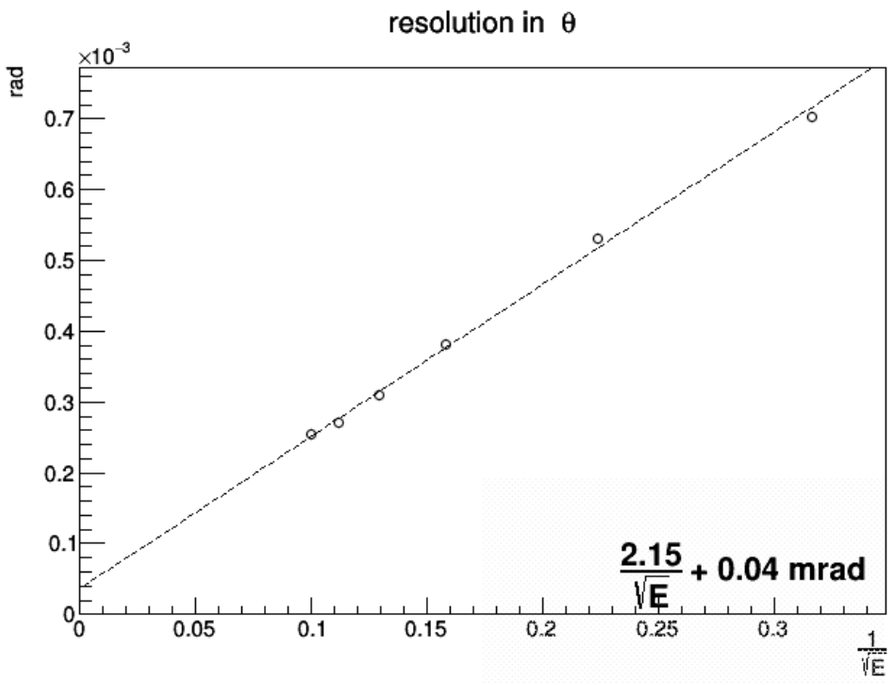


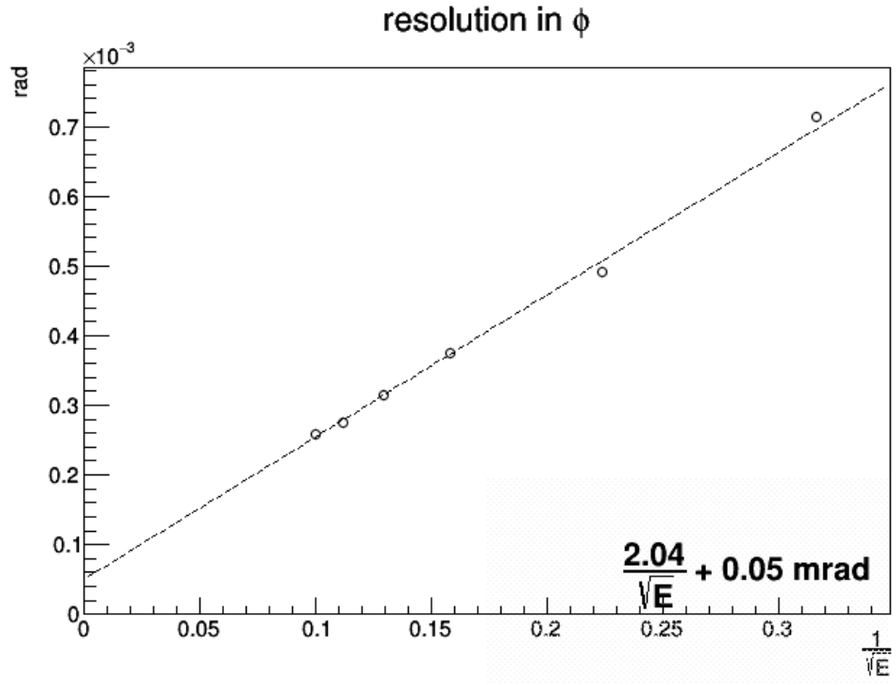




- With straightened bands, by subtracting *gen* value from *corr*, lower plots are obtained
- Lower plots represent the distribution how far *corr* is located from *gen*, i.e. resolution
- After repeating previous procedure for multiple energies, we can represent resolution in a function of energy

Resolution as a function of energy

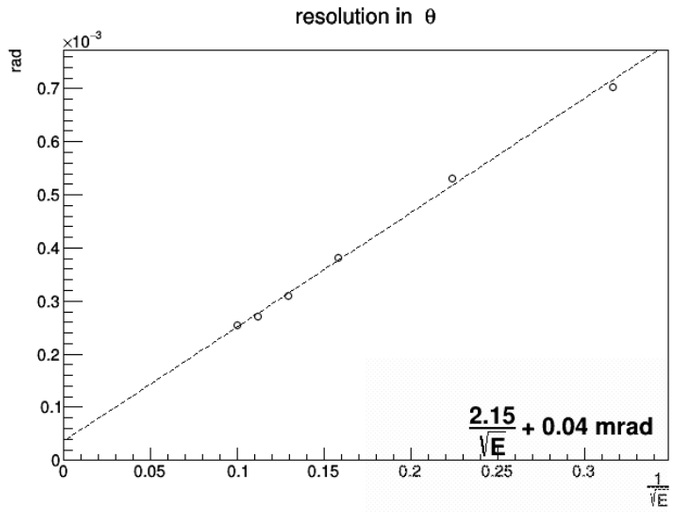


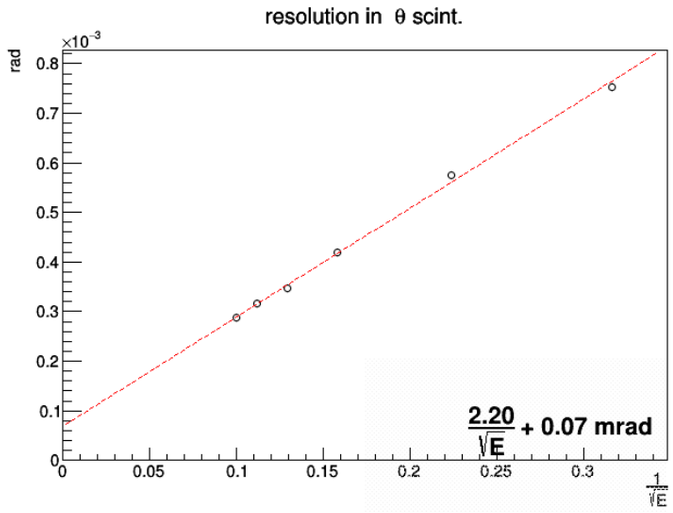


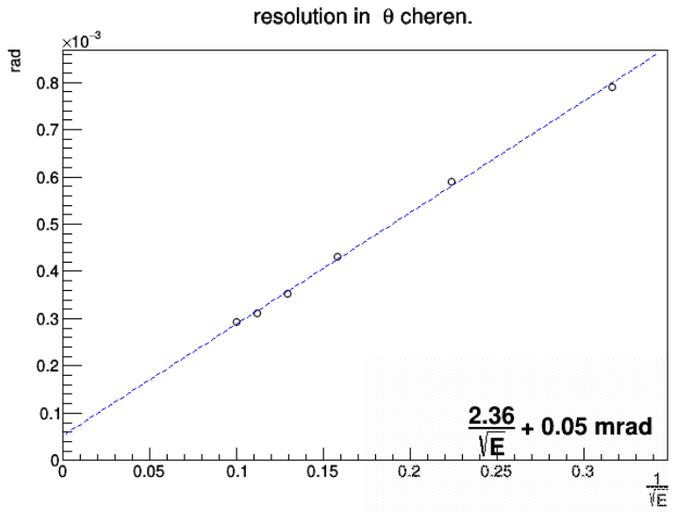
- Fitting a straight line after plotting $\left(1/\sqrt{E}, resolution\right)$ gives the function that represents resolution in energy
- We could check that θ_{res} and ϕ_{res} gives similar values and this makes sense since the tower(module) near center of the calorimeter has similar structure in both direction
- Both shows ~0.25 mrad resolution for 100 GeV electron

θ_{res} at two points

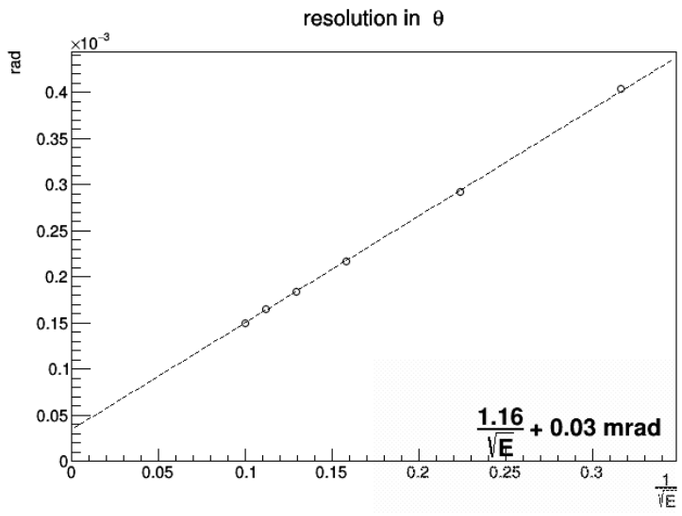
0-1

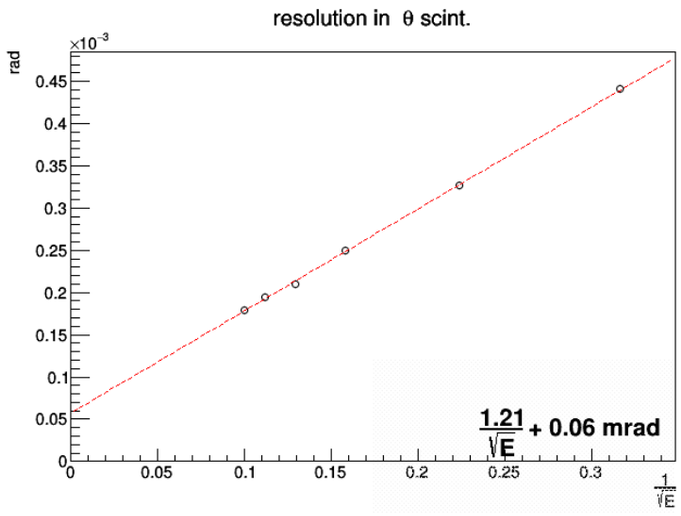


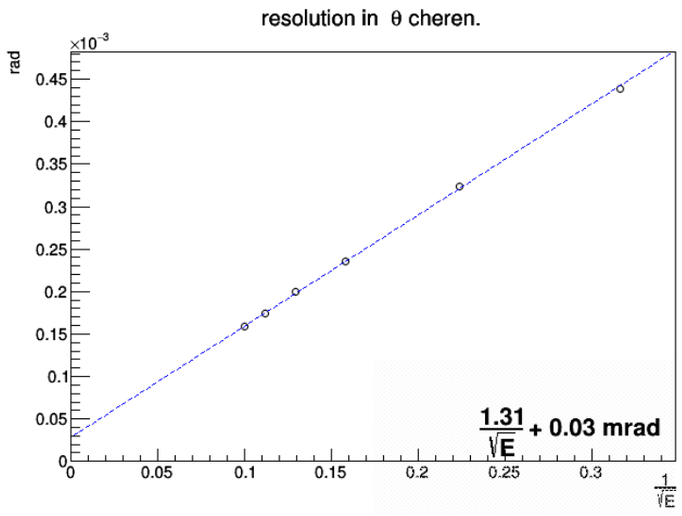




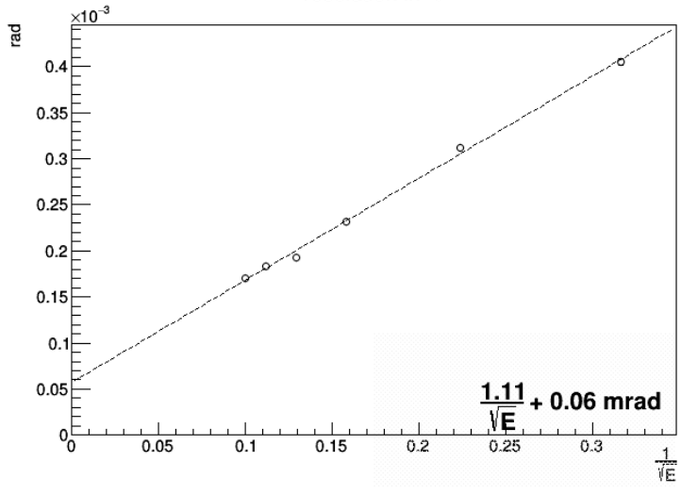
51-52

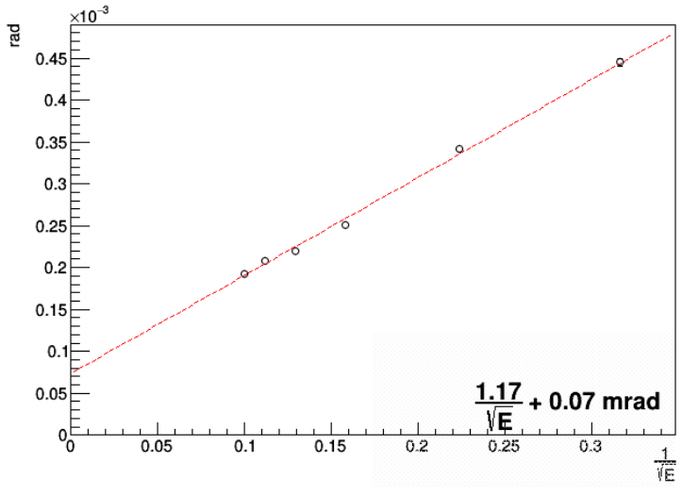


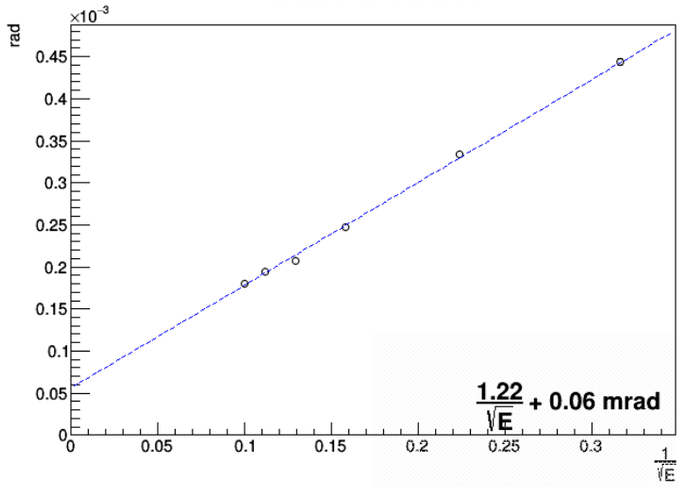




75-76

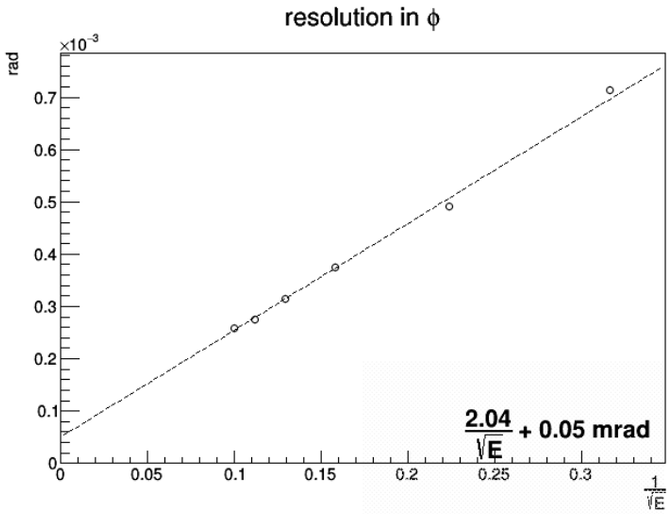


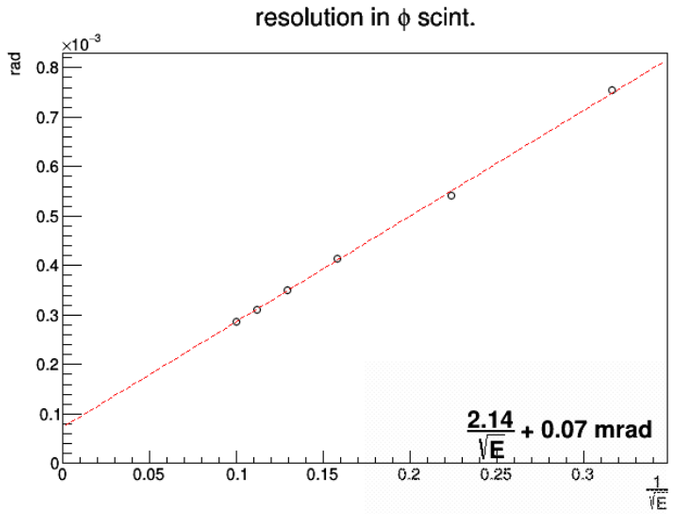


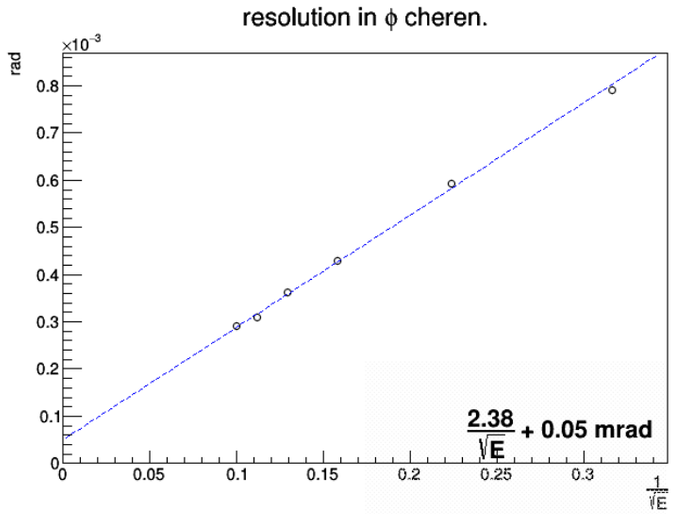


ϕ_{res} at two points

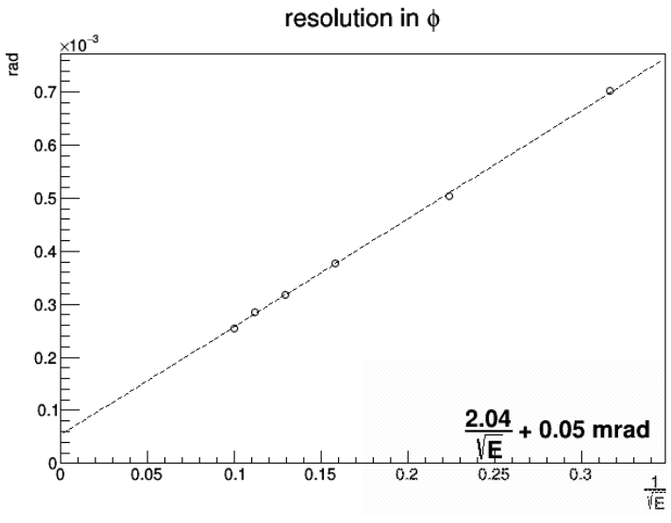
0-1

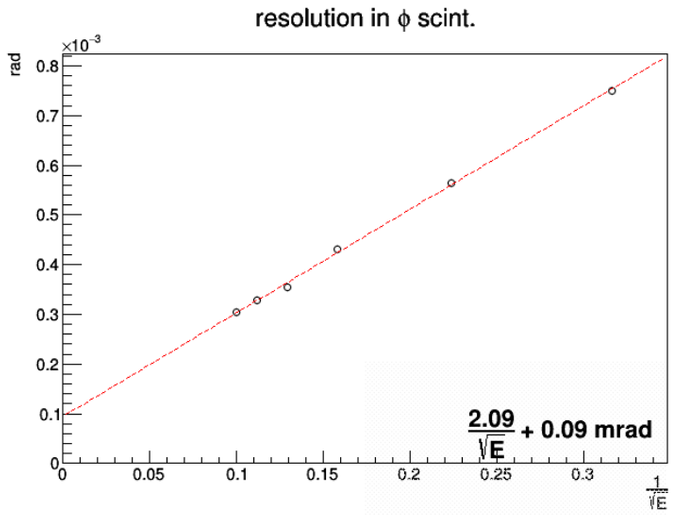


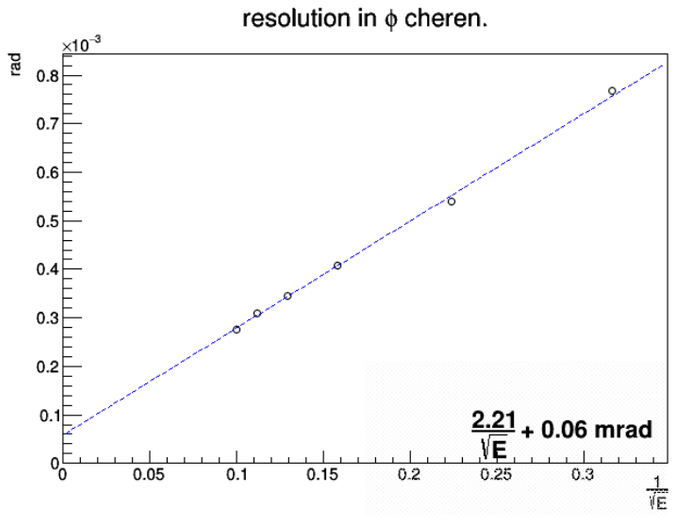




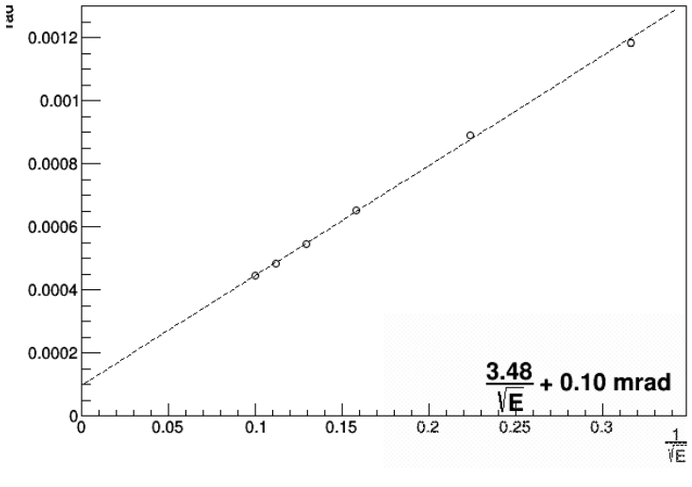
51-52

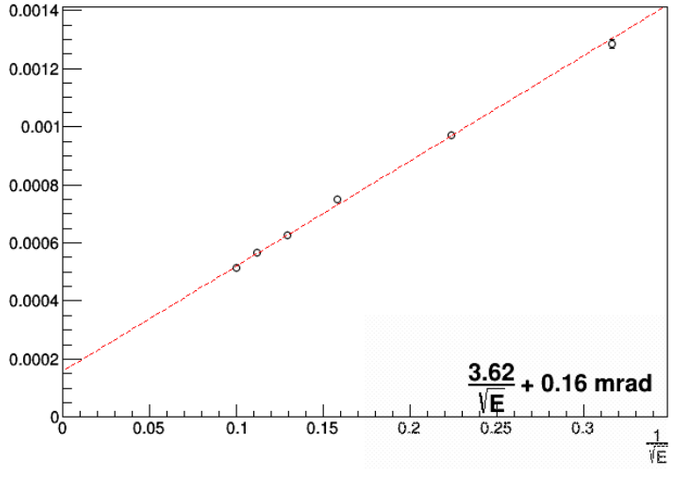


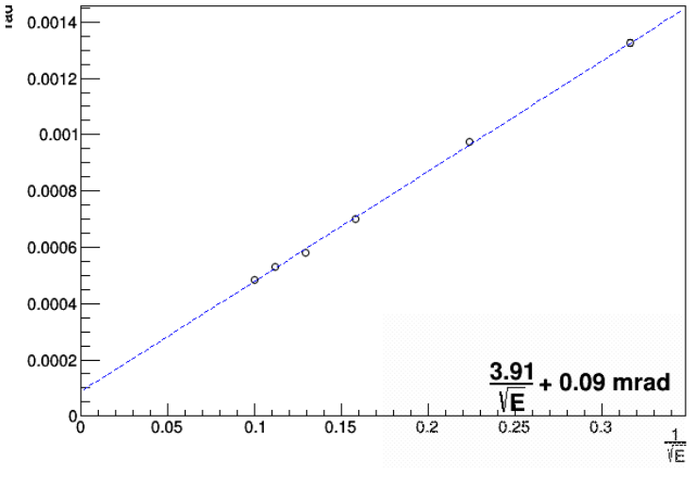




75-76







Aim for further study

- Several parameters might be related to the resolution

tower#	Width in theta (mm)	Delta theta (rad)	angle/fiber in theta (rad)	theta res (mrad)	Width in phi (mm)	Delta phi (rad)	cos(theta) X Delta phi (rad)	angle/fiber in phi (rad)	phi res (mrad)
0	40	0.02222	0.00035	$2.51/\sqrt{E} + 0.04$	40	0.0222	0.0222007	0.00035	$2.04/\sqrt{E} + 0.05$
1	40	0.0222	0.00035		40	0.0222	0.0221897	0.00035	
51	40	0.0128	0.00027	$1.16/\sqrt{E} + 0.03$	40	0.0222	0.0129007	0.00027	$2.04/\sqrt{E} + 0.05$
52	40	0.0128	0.00027		40	0.0222	0.0126641	0.00027	
75	40	0.0128	0.00027	$1.11/\sqrt{E} + 0.06$	40	0.0222	0.00671595	0.00027	$3.48/\sqrt{E} + 0.10$
76	40	0.0128	0.00027		40	0.0222	0.00643965	0.00027	

- Seems complex relation exists
  - It might be width, an angle that a fiber occupies, distance from the vertex, etc.

- Further study is needed to know which affects the resolution

Summary

- In any case, for 100 GeV electrons, < 0.5 mrad resolution is measured

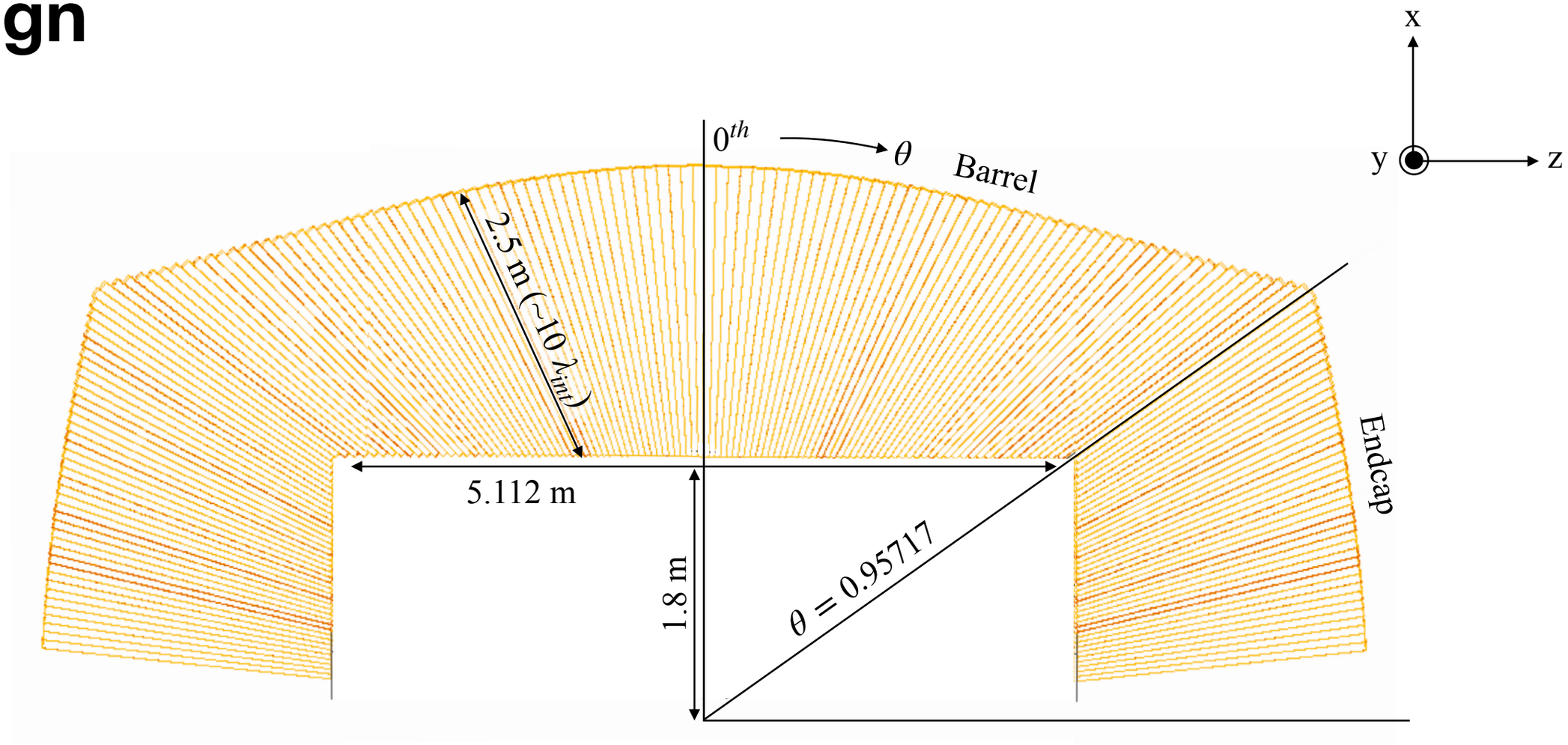
- θ_{res} gets better as it goes from barrel → endcap
- ϕ_{res} on the other hand, exhibits opposite characteristic
  - Several factors that might affect resolution exist; width, distance, etc.

- Further study aims to investigate about the relation between the geometry and the resolution

Backup

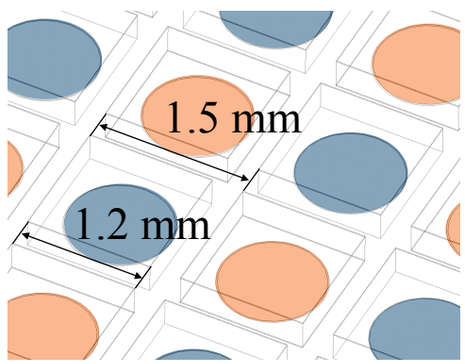
Dual-readout calorimeter

Design



- Copper-fiber dual-readout calorimeter
- Made of 92 different sized towers
- Order of 10^8 fibers in total
  - 63×63 array for 0^{th} tower, 8×48 for 91^{st} tower
  - Exploits *full granularity*
    - SiPM attached to every single fiber

Rear-end of the towers



Fiber arrangement inside the towers