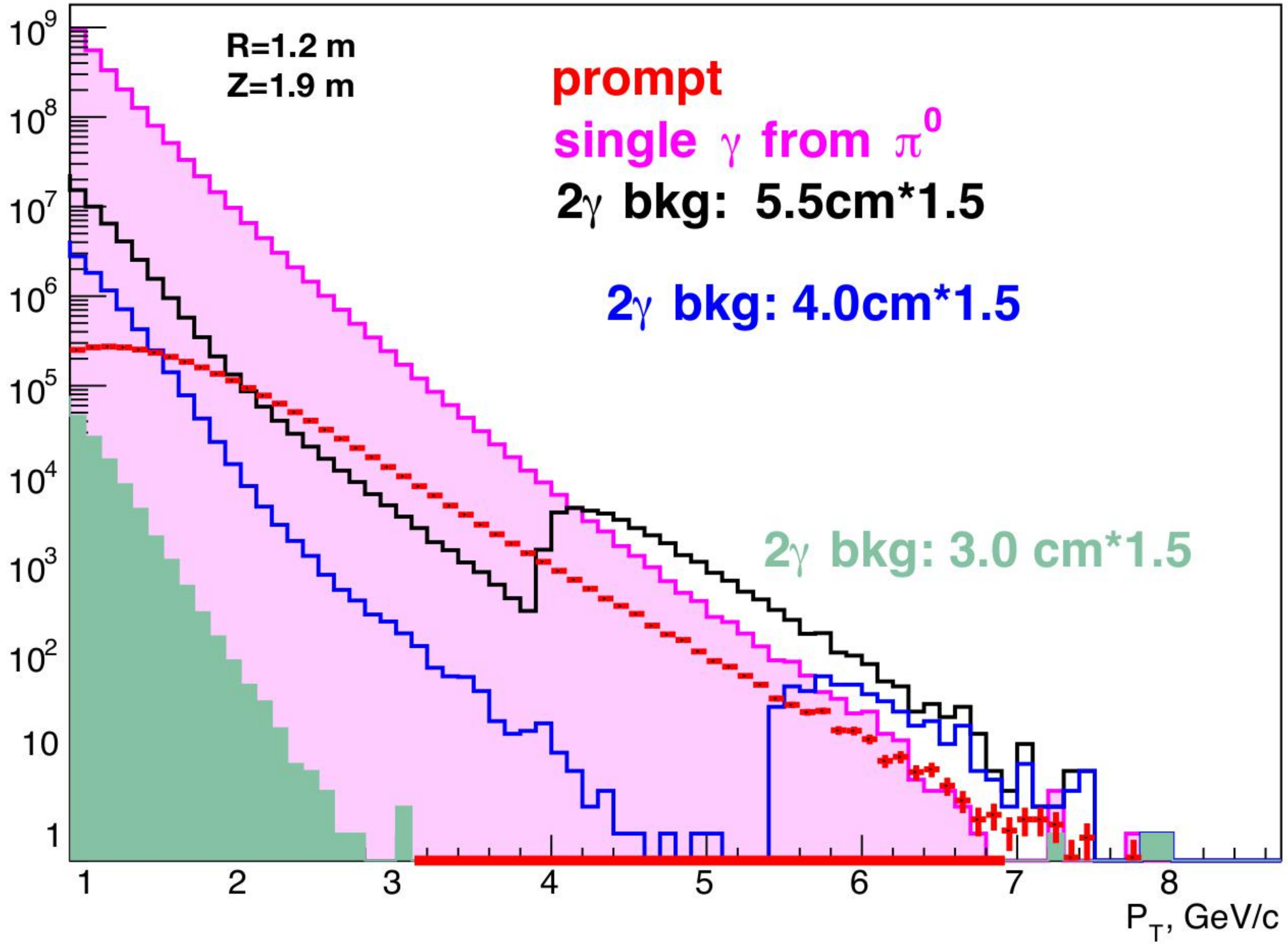
# Separation of $\gamma/\pi^0$ clusters in SPD ECAL

SPD Physics & MC meeting

07.10.2020

# Motivation

**Figure by Alexey Guskov**



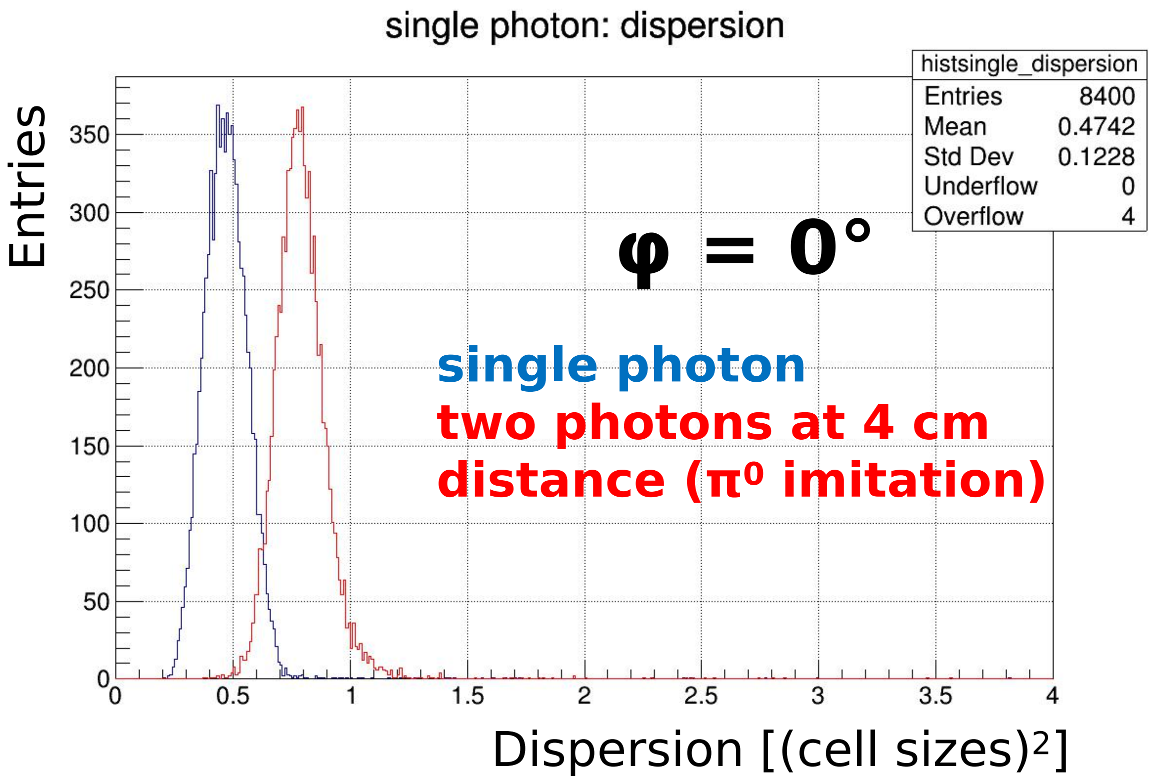

Physics goal:
measurements with prompt photons at $p_T$ >~ 4 GeV

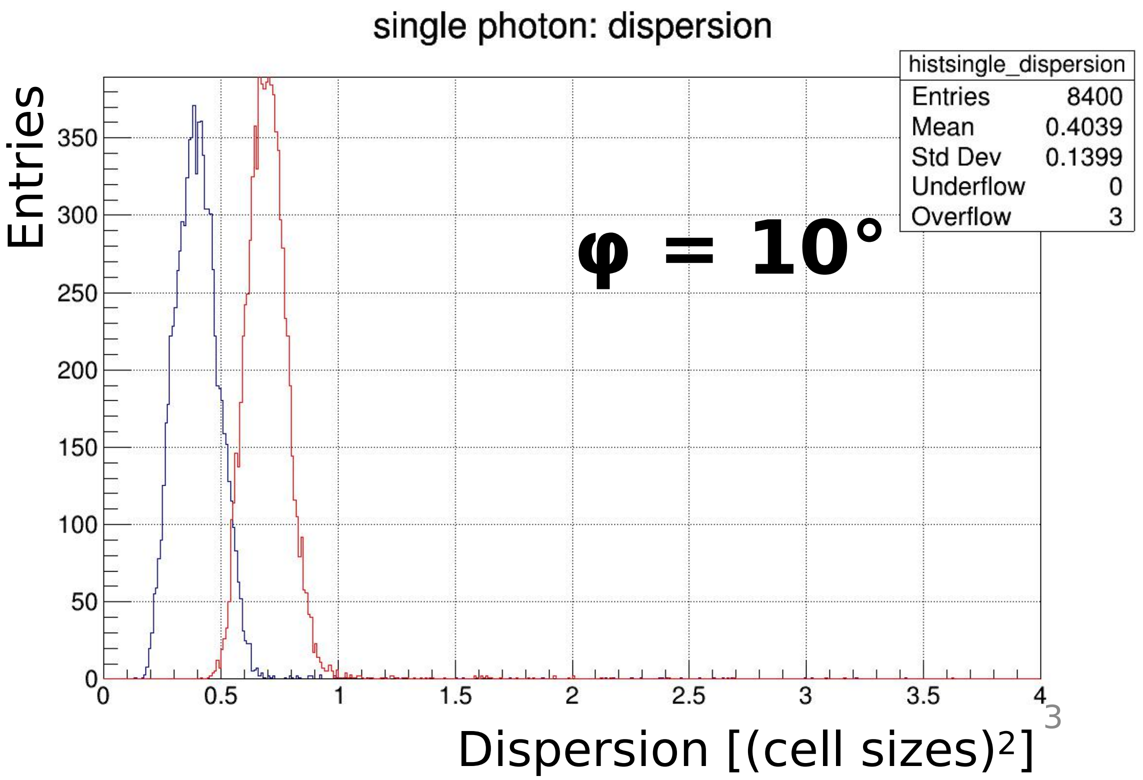
Recently, size of ECAL was decreased
→ smaller distance between photons from $\pi^0 \rightarrow \gamma\gamma$ decay
→ more $\pi^0$ are misidentified as γ in ECAL

# Cluster shape analysis

"DIspersion": $r2 = \langle r^2 \rangle = S_{XX} + S_{YY} = \frac{\sum_{i=1}^{N} e_i((x_i - x_c)^2 + (y_i - y_c)^2)}{\sum_{i=1}^{N} e_i}$ $x_c$, $y_c$: cluster center of gravity

(4x4 cm non-projective cell) **one can separate π0/γ clusters using "dispersion"**



# Cluster shape analysis

https://cds.cern.ch/record/2042173/files/LHCb-PUB-2015-016.pdf

Other variables can be used:

- The first one is related to the size of the cluster, referred to as $r2$ or shower shape. It is simply the second order momenta:

$$r2 = < r^2 > = S_{XX} + S_{YY} = \frac{\sum_{i=1}^{N} e_i((x_i - x_c)^2 + (y_i - y_c)^2)}{\sum_{i=1}^{N} e_i} \quad (3)$$

- The second variable informs about the importance of the tails, here referred to as $r2r4$:

$$r2r4 = 1 - \frac{< r^2 >^2}{< r^4 >} \quad (4)$$

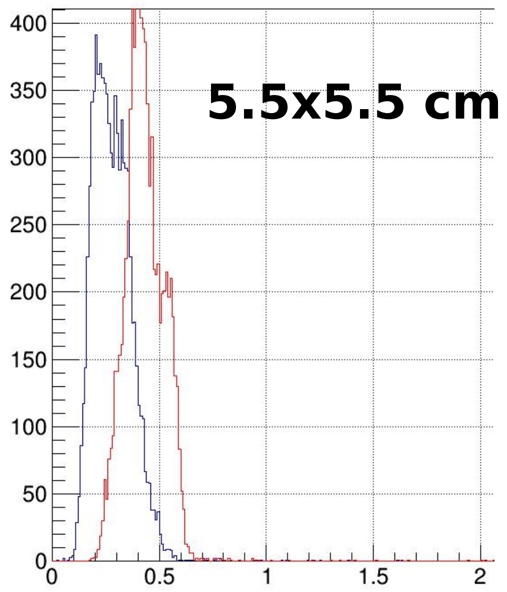
- The following is known as $\kappa$ and is related to the ratio of the eigenvalues of the matrix $S$, which is $(1+\kappa)/(1-\kappa)$. Thus, it relates to the major and minor semiaxes of an ellipse.

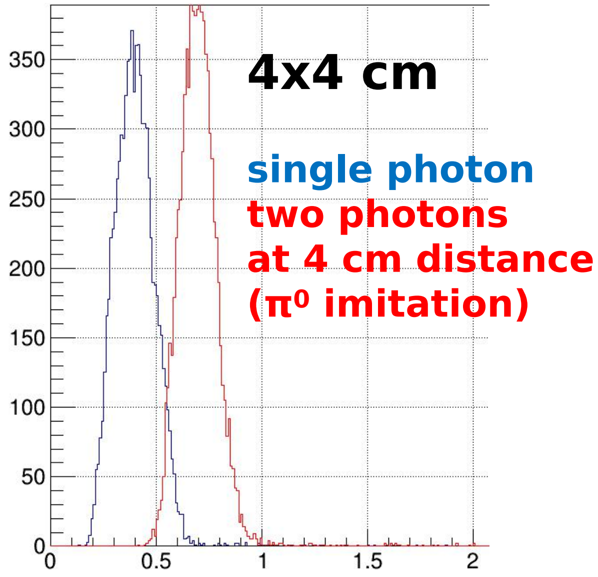
$$\kappa = \sqrt{1 - 4\frac{S_{XX}S_{YY} - S_{XY}^2}{(S_{XX} + S_{YY})^2}} = \sqrt{1 - 4\frac{\det S}{\mathrm{Tr}^2 S}} \quad (5)$$

- The last one, referred to as *asym*, provides information about the orientation of the ellipse or correlation between X and Y coordinates.

$$\mathrm{asym} = \frac{S_{XY}}{\sqrt{S_{XX}S_{YY}}} \quad (6)$$

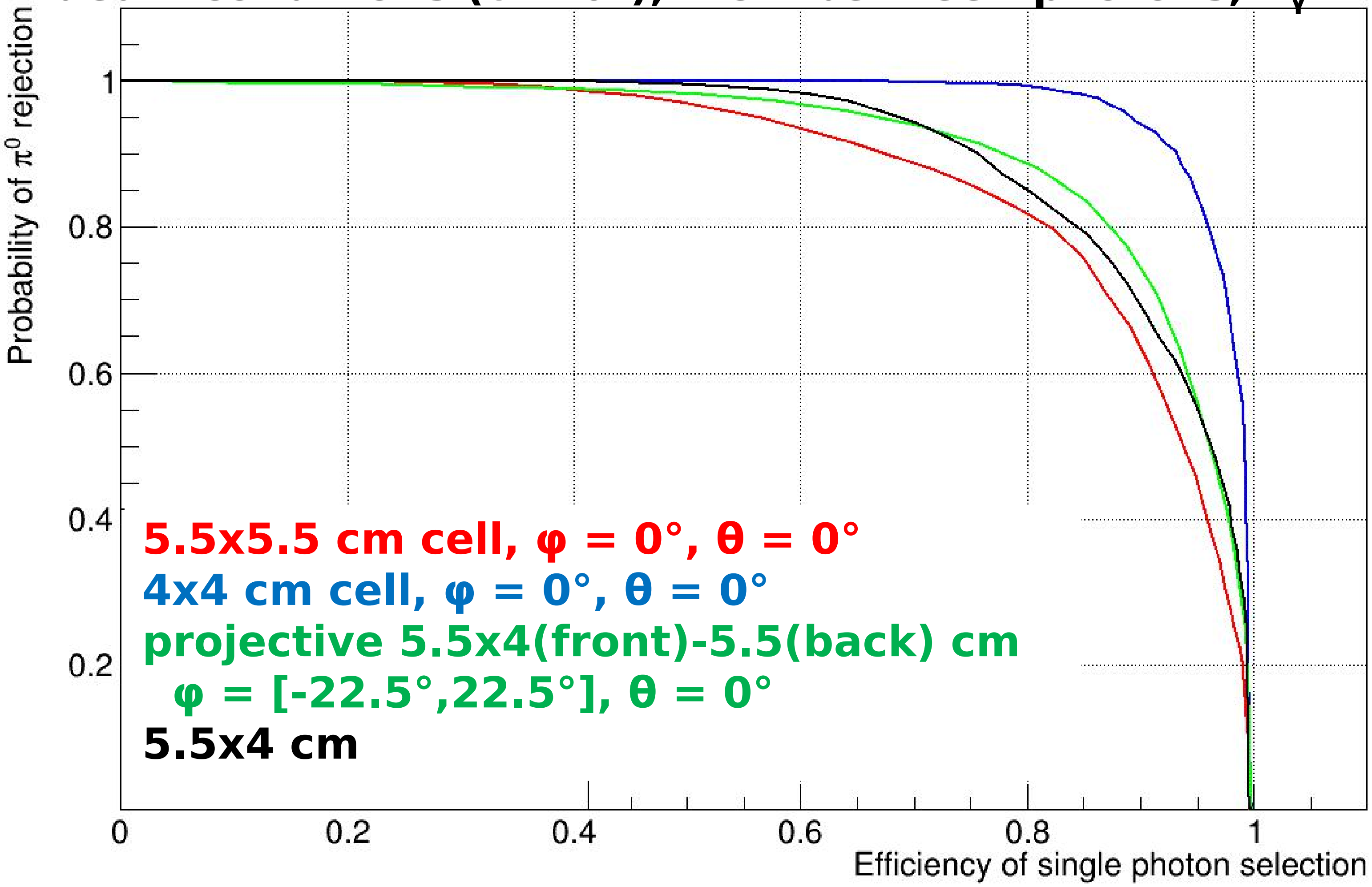
# Comparison of different cell sizes




Each possible **"dispersion" cut** → **point on** "efficiency/purity" **graph**

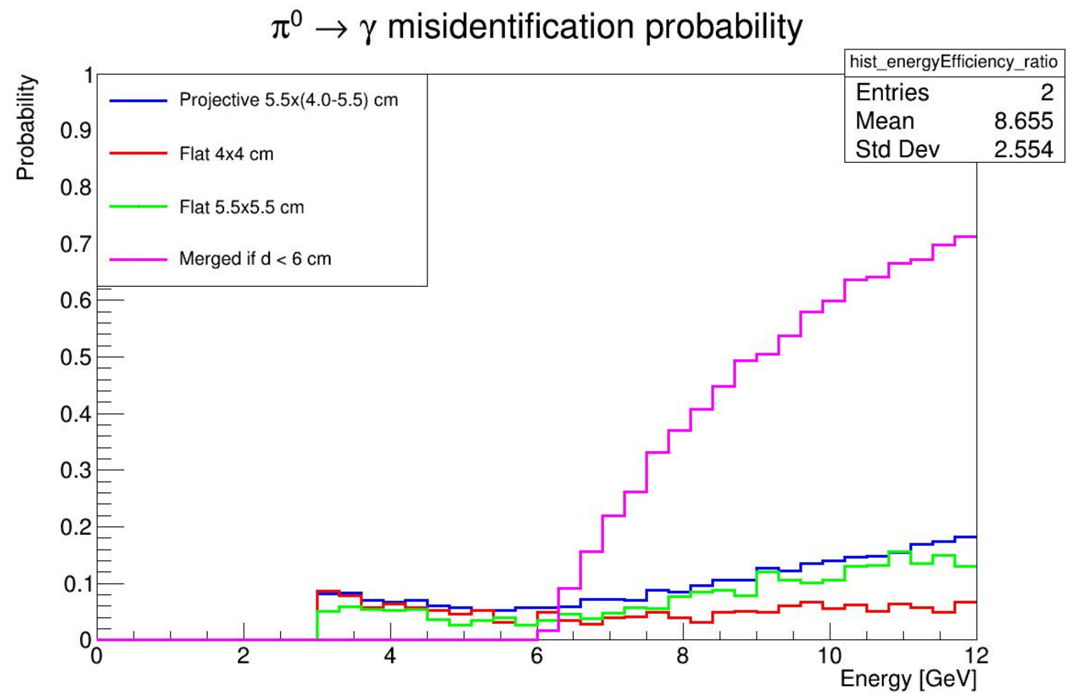
**"ideal" conditions ($\theta = 0°$), 4 cm between photons, $E_\gamma = 3$ GeV**



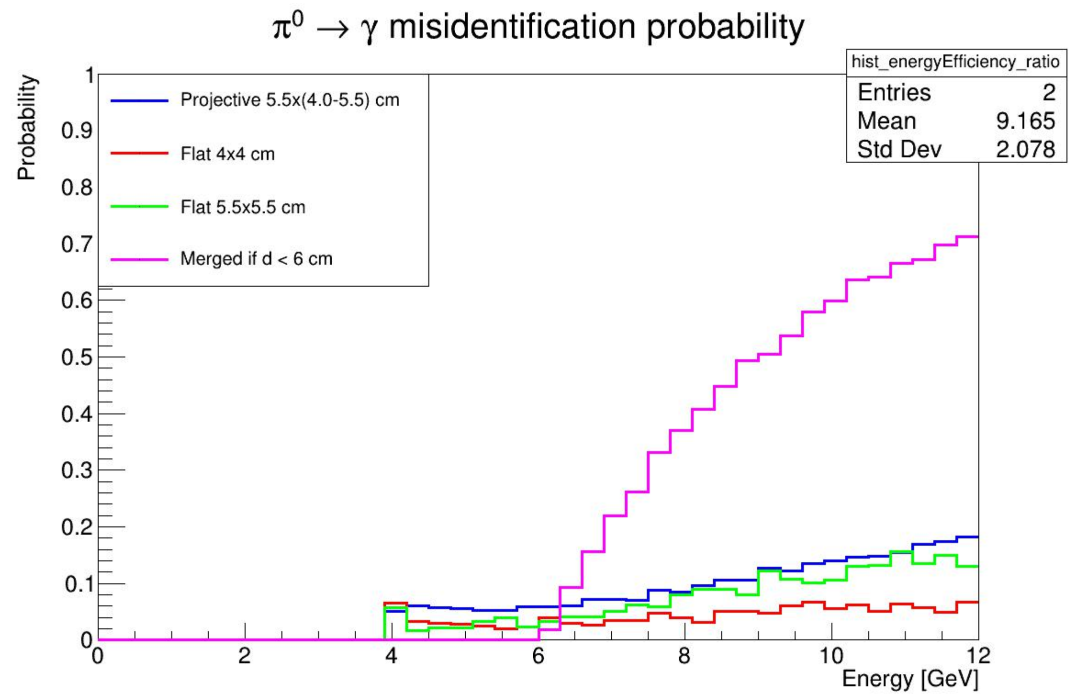
# Comparison of different cell sizes

$\pi^0$ decays generated,
$|\cos(\theta)| < 0.8$ (barrel),
3 GeV $< E_{\pi 0} <$ 12 GeV,
$\varphi = 0°$ for non-projective geometries
**Dispersion cut as a function of θ is selected so that 80% of photons are accepted**

**no $p_T$ cut**



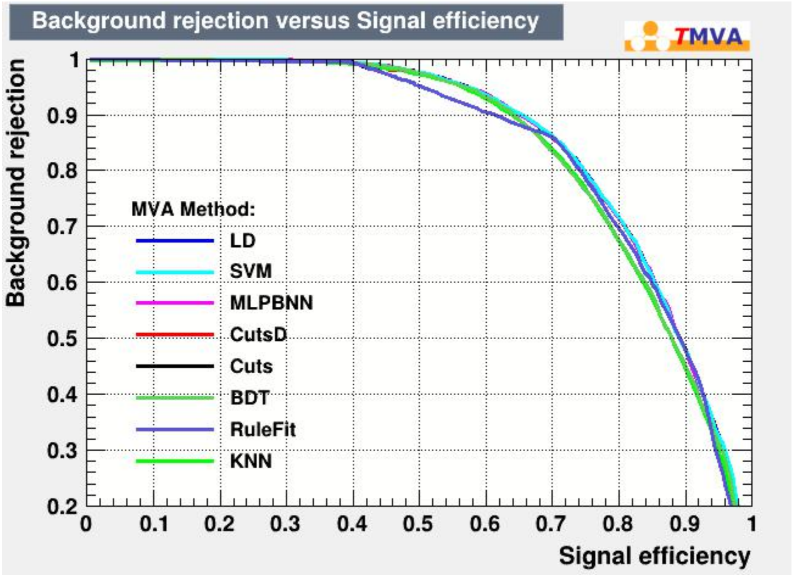

**$p_T$ cut: $p_T >$ 4 GeV/c**



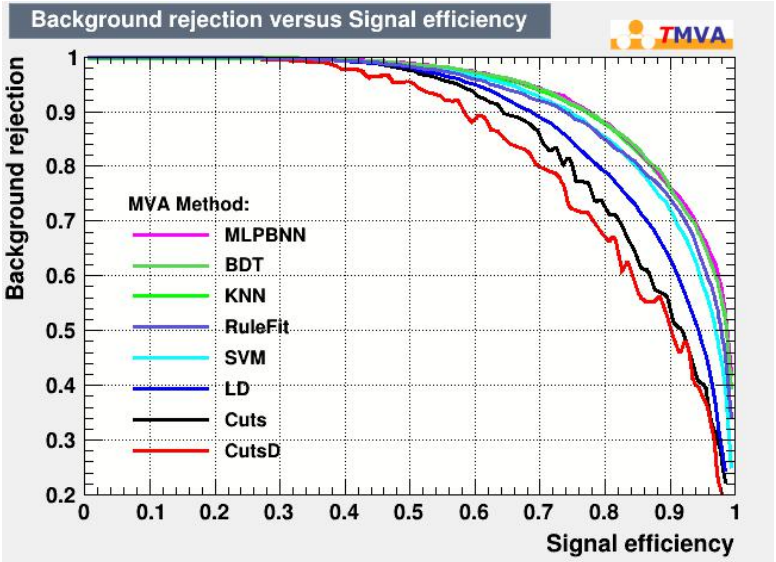
# Other points

- The separation algorithm can be improved using other variables besides “dispersion”: background suppression 2-2.5 times
- In real data, more systematics may arise from calibrations etc.

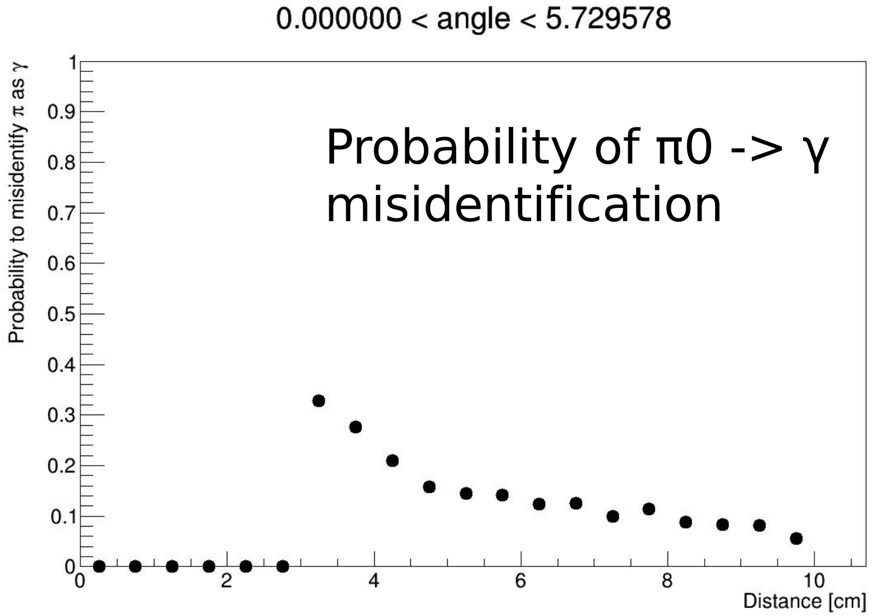
**φ = [-22.5°,22.5°], θ = 0,**
**Two parameters:** dispersion + φ



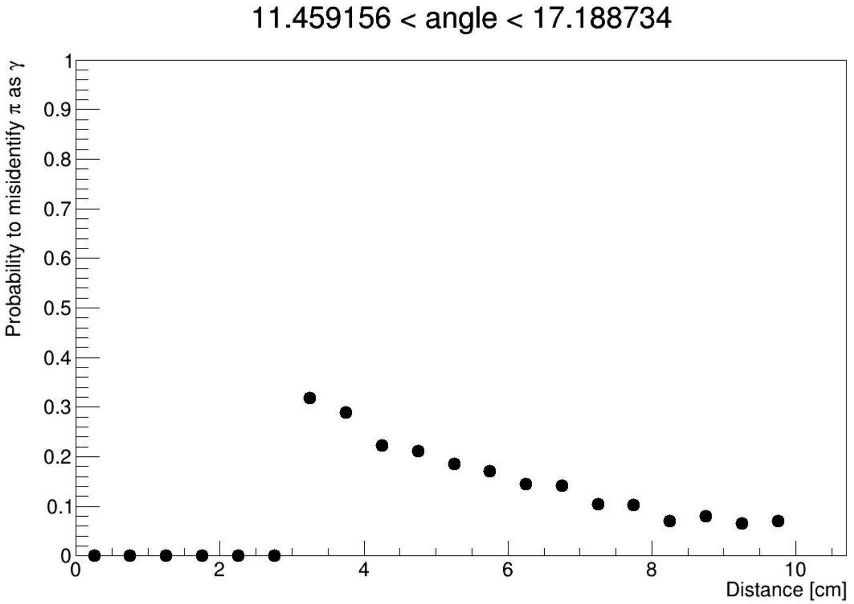

**φ = [-22.5°,22.5°], θ = 0,**
**Four parameters:** dispersion, r2r4, κ, asym

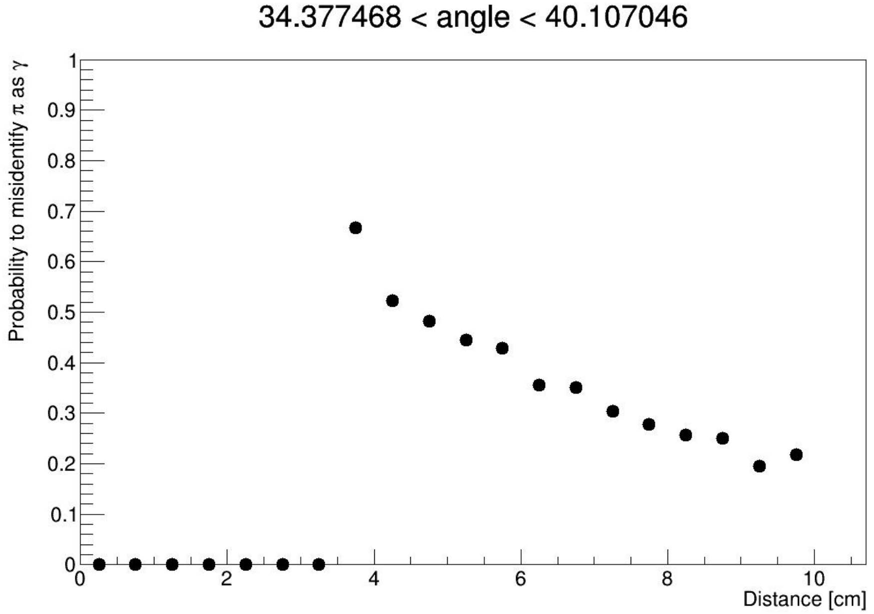


# Fast reconstruction: merging probability



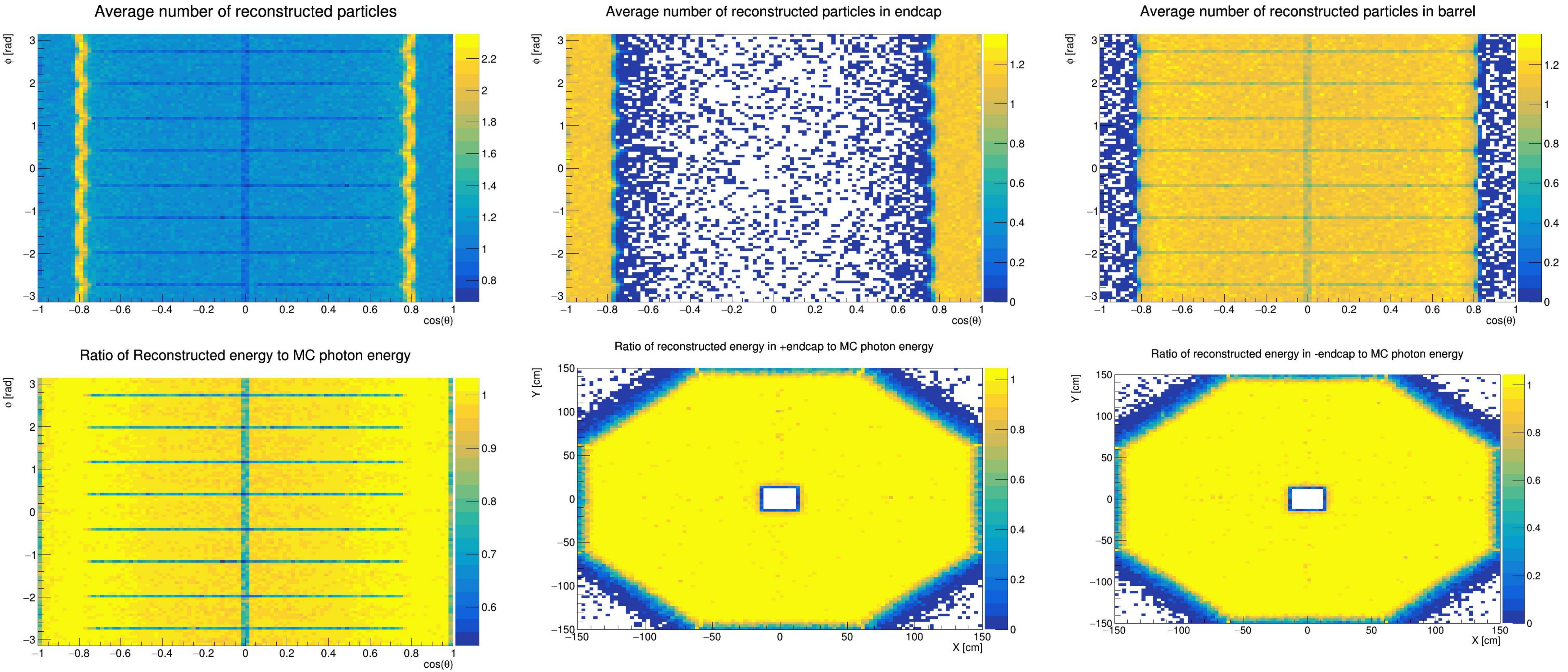

Probability of π0 -> γ
misidentification



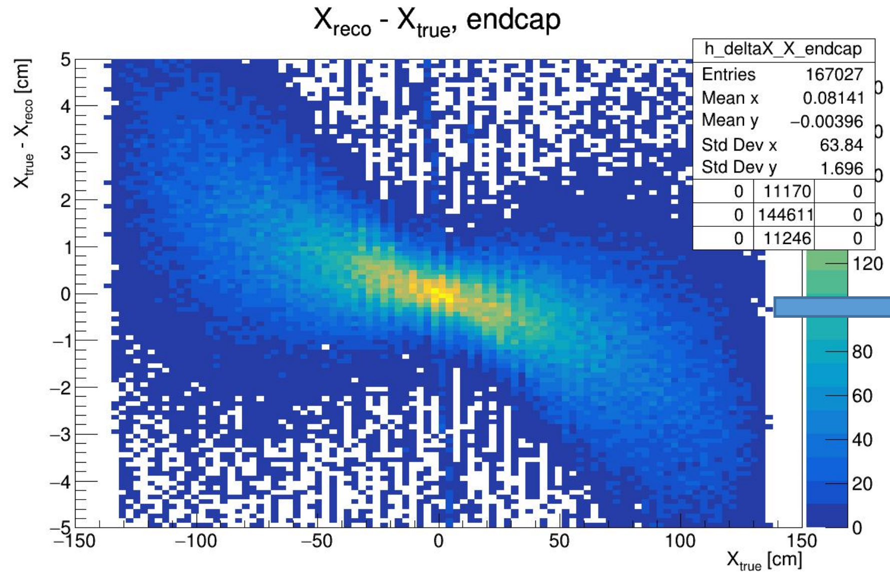

5.5 cm cell (!)
Selecting 80% photons

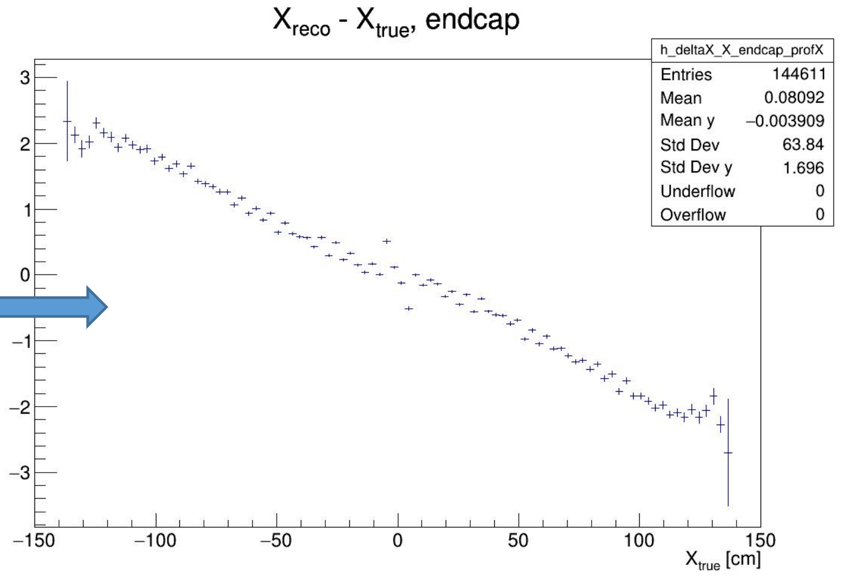
# Full reconstruction: ECAL integrity



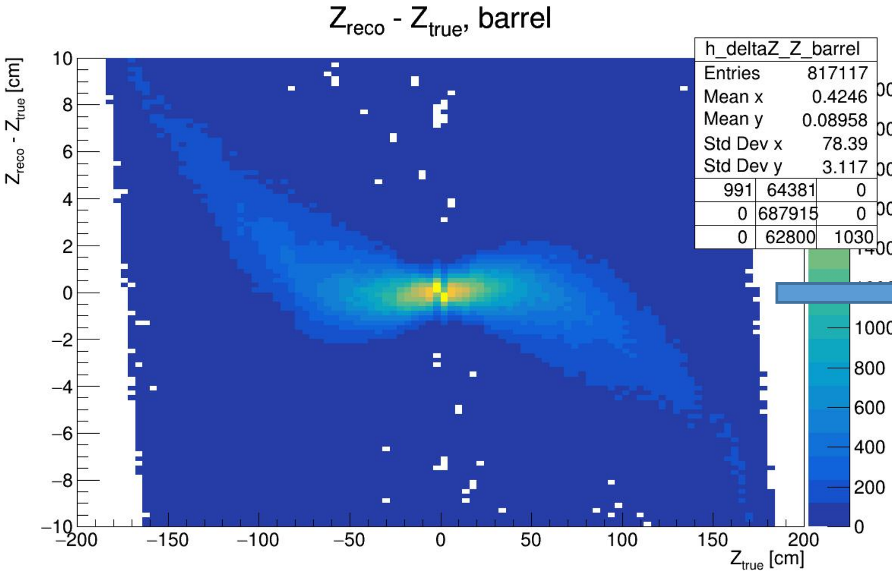

Medium is simulated properly, need combined Endcap+Barrel clustering
Need particle energy threshold

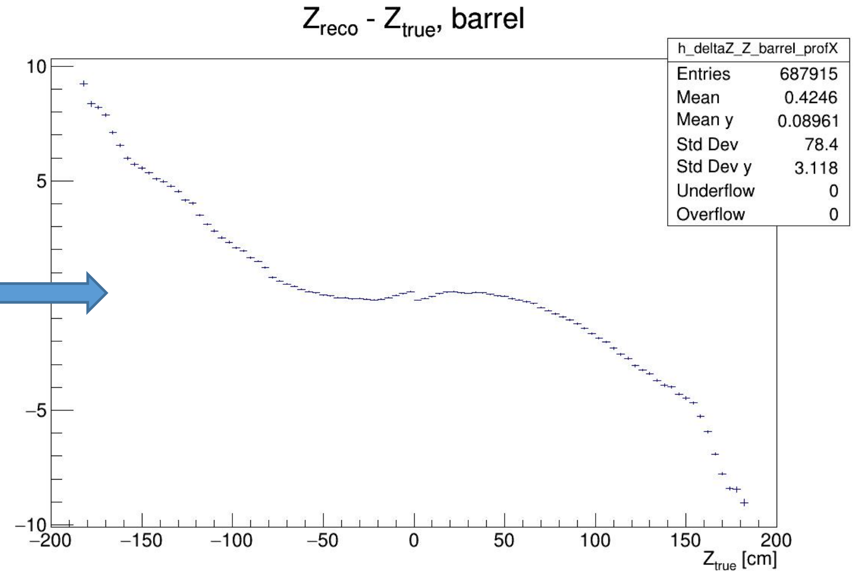
# Full reconstruction: position resolution




$X_{corr} = f_{pol1}(X)$



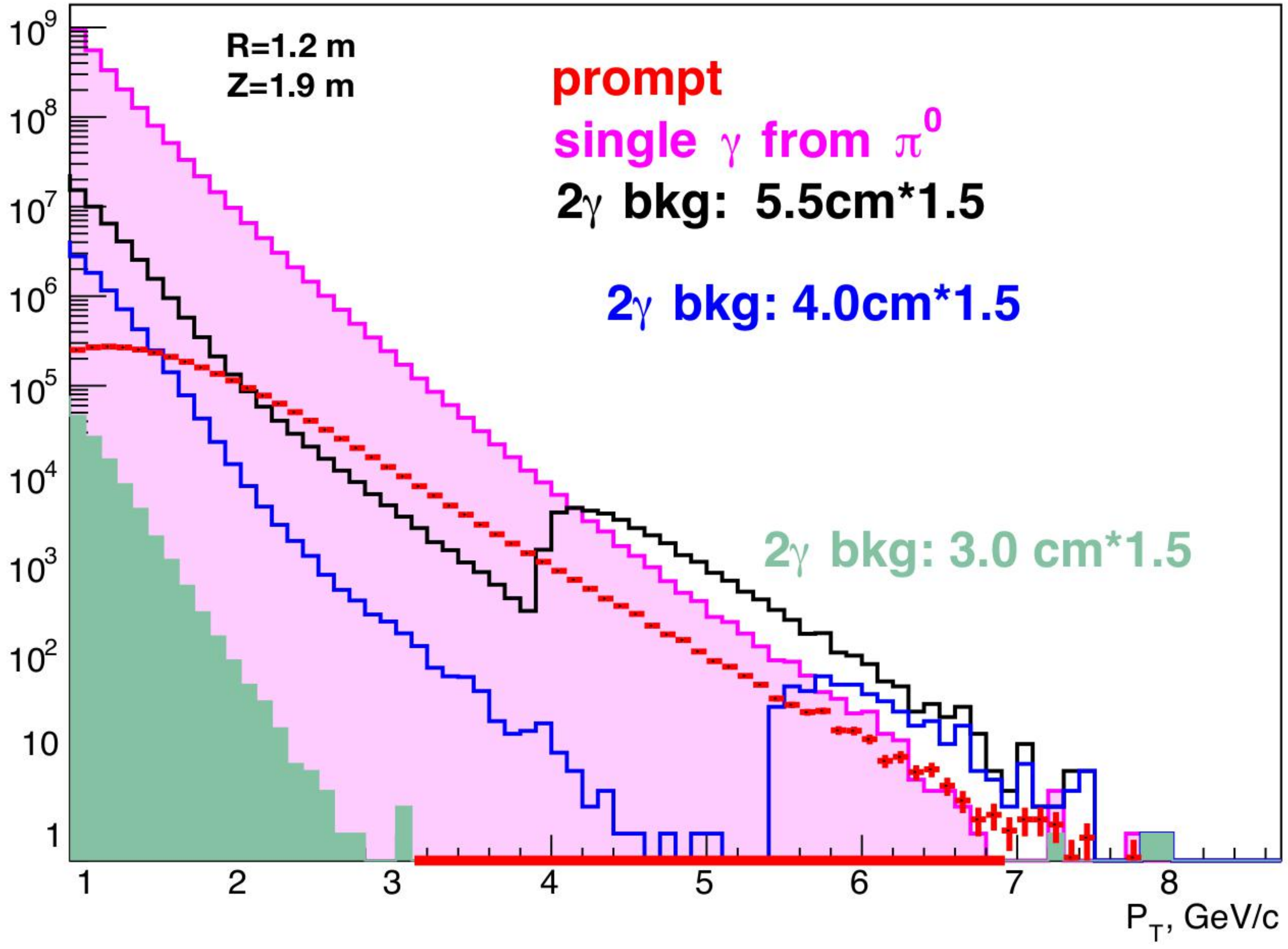

$Z_{corr} = f_{pol3}(Z)$

# Conclusions

- From naive calculation, 4x4 cm cell: while selecting 80% $\gamma$ clusters, 95% of $\pi^0$ clusters will be rejected (only barrel).
- This rough estimate can be improved by using more cluster shape variables and worsened due to systematics, specific to real data.
- First version of **fast** reconstruction: Friday 09.10
- First version of **full** reconstruction: Monday-Tuesday next week

# Conclusions

**Figure by Alexey Guskov**




**The blue curve** -> improved by ~1 order of magnitude