ePIC: Position measurements in endcap EMCals

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ePIC Calorimetry Meeting

Input

dd4hep simulation with default (latest?) configuration

Single photons

RawHit (deposited energy in a tower) used

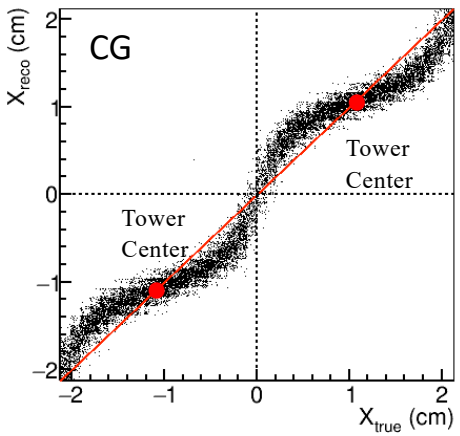
Smearing applied independently for all towers

Allows to play with resolution, noise, thresholds, etc.

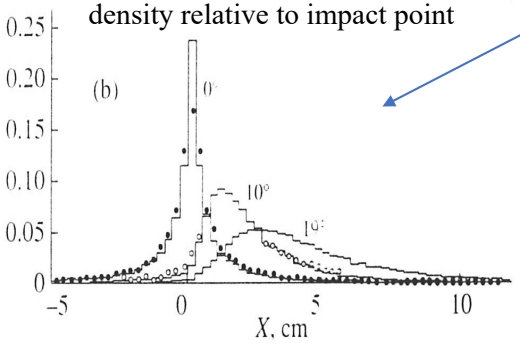
	eEMCal	fEMCal
Energy resolution	$\sigma_E/E = \frac{2.7\%}{\sqrt{E[GeV]}} \oplus 1.1\%$	$\sigma_E/E = \frac{10\%}{\sqrt{E[GeV]}} \oplus 2\%$
Energy threshold per tower	5 MeV	15 MeV
Noise per tower	1.7 MeV	5 MeV

Center of Gravity, corrected

eEMCal: 4 GeV γ



PHENIX PbSc: 1dim shower density relative to impact point



$$X_{CG} = \frac{\sum X_i w_i}{w_i}, \quad w_i = E_i$$ Biased!

From exponential transverse shower shape:

$$X_{CG} = \frac{1}{2}\frac{\sinh(x/b)}{\sinh(1/2b)}$$ b ~ const

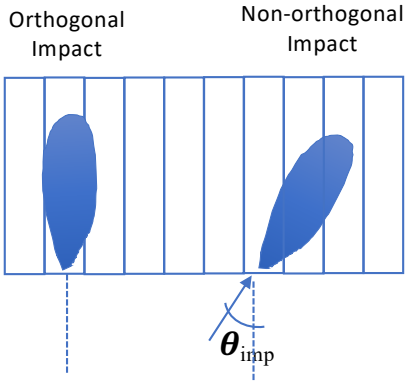
For non-orthogonal impact:

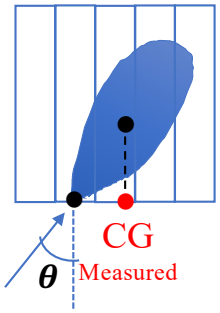
$$X_{CG} = \frac{1}{2}\frac{\sinh((x-\delta)/b)}{\sinh(1/2b)} + \delta$$ $b=b(E,\boldsymbol{\theta})$, $\delta=\delta(E,\boldsymbol{\theta})$

b describes shower width

δ reflects shower skewness

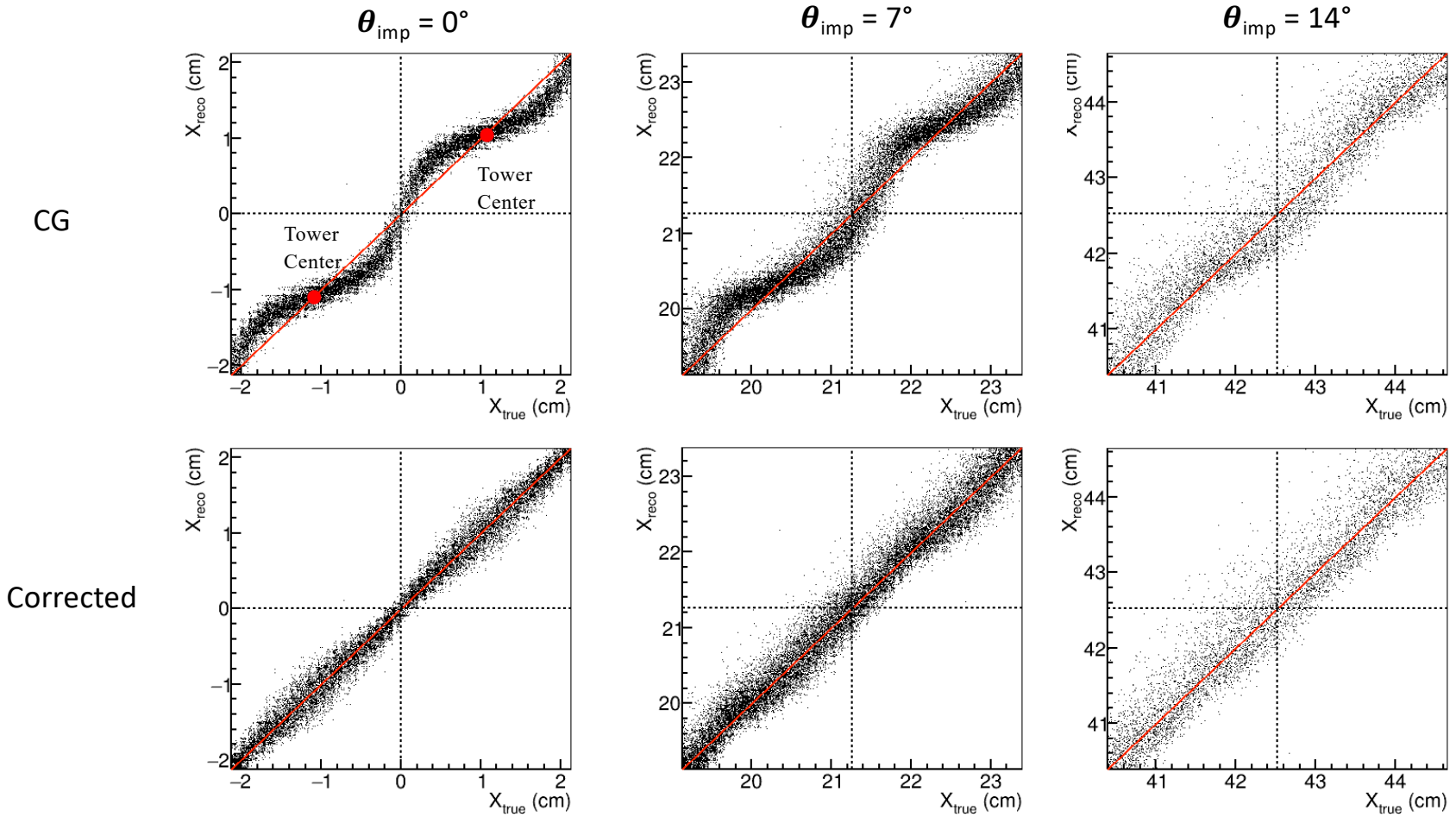
Also corrected for shower depth
either in horizontal (PHENIX) or vertical direction (sPHENIX)





Center of Gravity, corrected

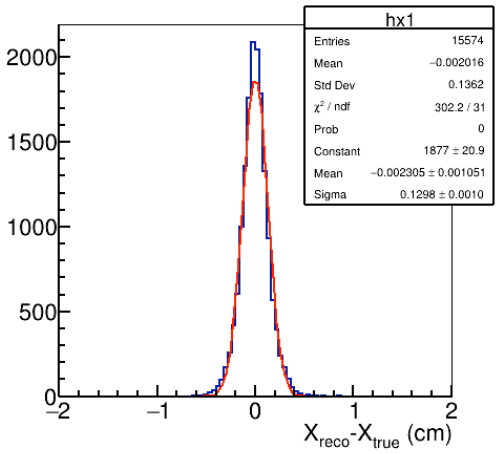
After shower depth correction



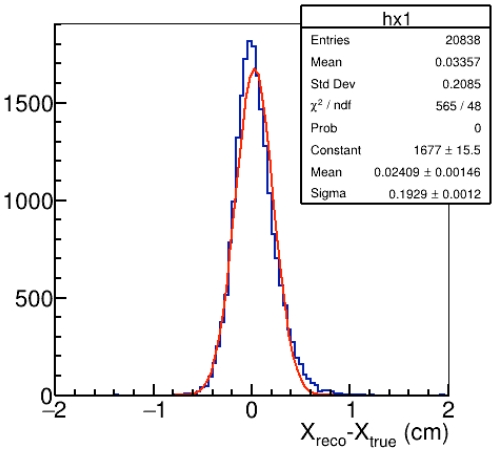
Position Resolution

eEMCal: 4 GeV γ

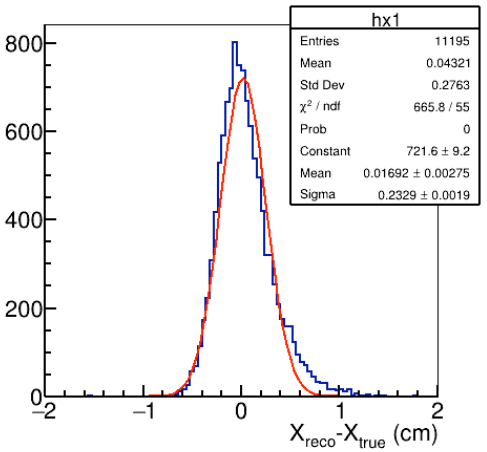
θ_{imp} = 0°



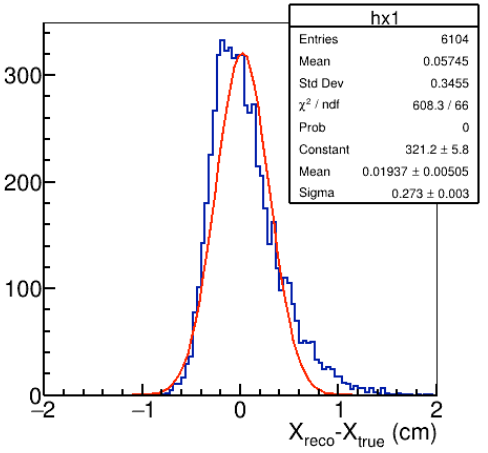
θ_{imp} = 7°



θ_{imp} = 11°

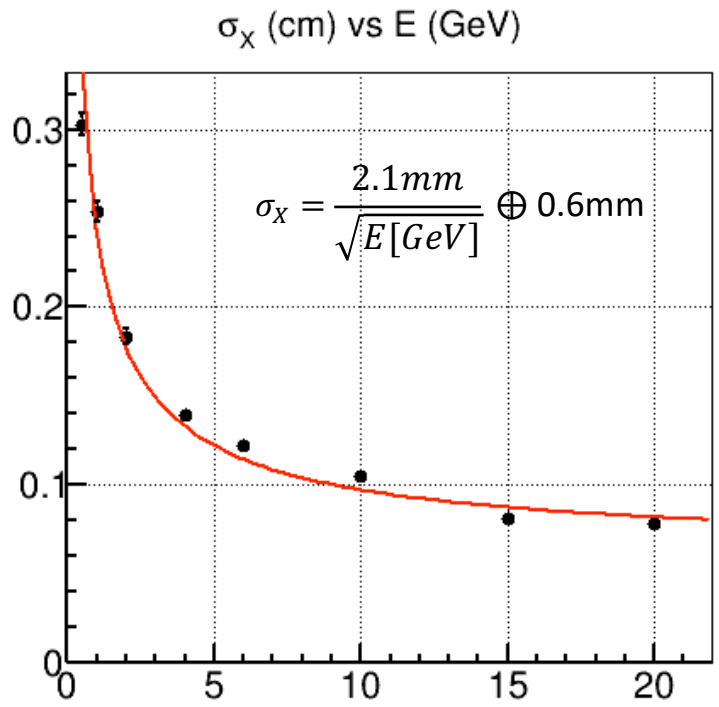


θ_{imp} = 14°



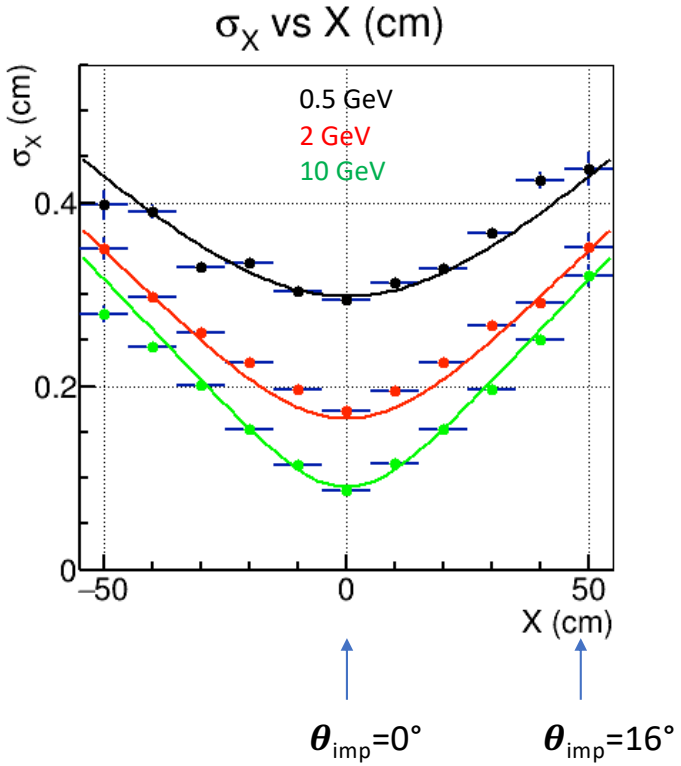
Position Resolution: Orthogonal Impact

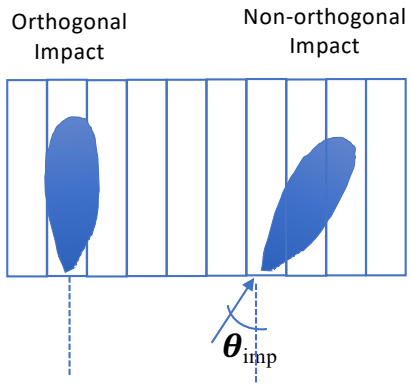
eEMCal



Position Resolution: Non-Orthogonal Impact

eEMCal





For neutral tracks in endcap geometry $\boldsymbol{\theta}_{\text{imp}}=\boldsymbol{\theta}$

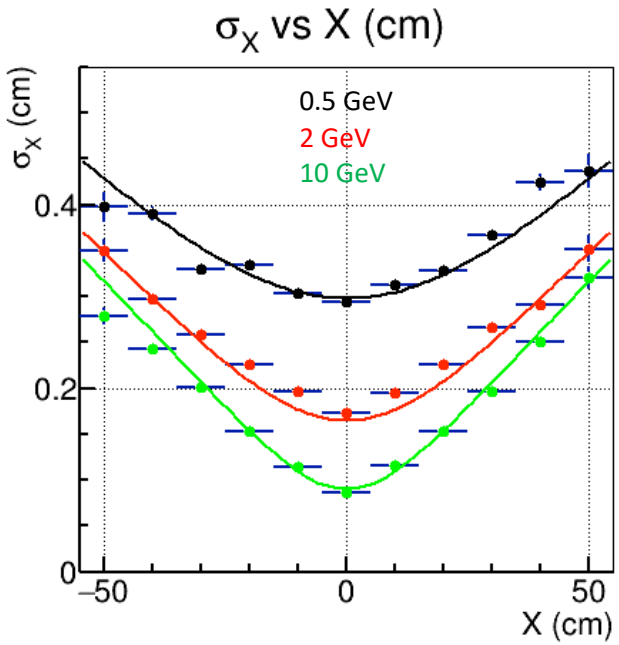
$$\sigma_X = \left(\frac{2.1mm}{\sqrt{E[GeV]}} \oplus 0.6\text{mm}\right) \oplus \left(11mm \cdot \sin\theta_{imp}\right)$$

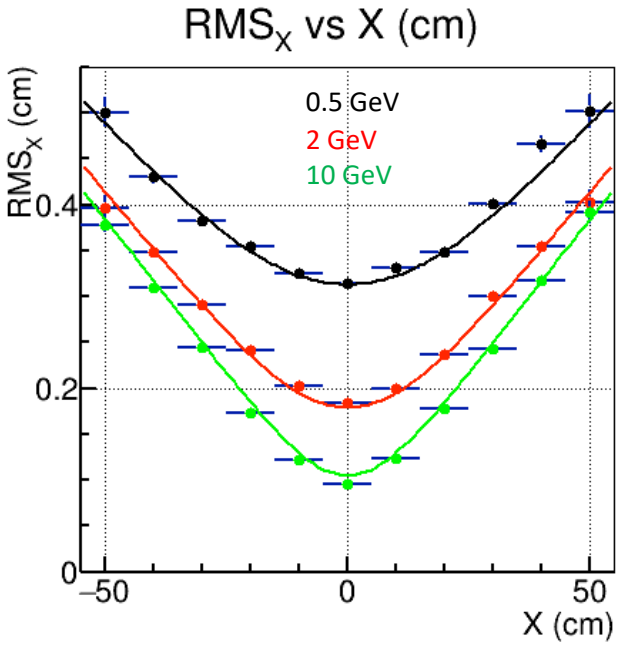
Non-projectivity term
(due to long. shower fluct.)

Maximal "Non-projectivity" term in EEEMCal is 3.5mm ($\boldsymbol{\theta}$=19°)

Position Resolution: Sigma vs RMS

eEMCal





$$\sigma_X = \left(\frac{2.1mm}{\sqrt{E[GeV]}} \oplus 0.6\text{mm}\right) \oplus \left(11mm \cdot \sin\theta_{imp}\right)$$

Maximal "Non-projectivity" term in EEEMCal is 3.5mm ($\boldsymbol{\theta}$=19°)

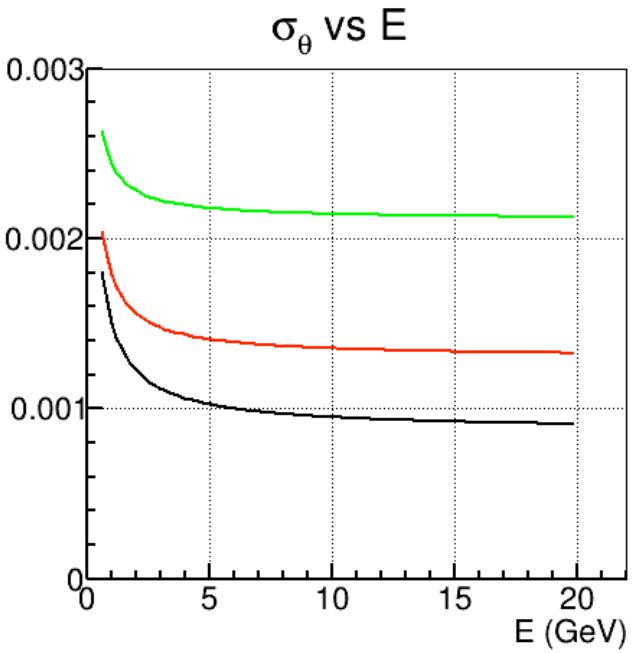
$$\sigma_X = \left(\frac{2.2mm}{\sqrt{E[GeV]}} \oplus 0.7\text{mm}\right) \oplus \left(14mm \cdot \sin\theta_{imp}\right)$$

Maximal "Non-projectivity" term in EEEMCal is 4.5mm ($\boldsymbol{\theta}$=19°)

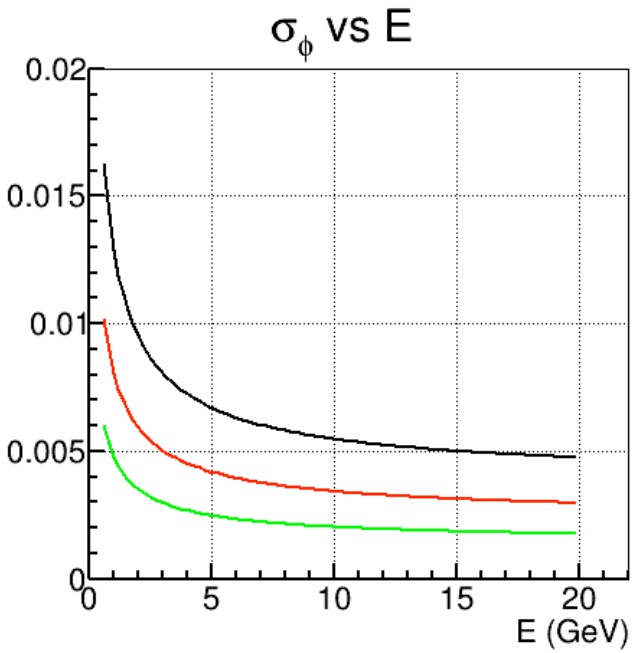
$\boldsymbol{\theta}$, φ Resolutions

eEMCal

From RMS parameterization
(on the previous slide)



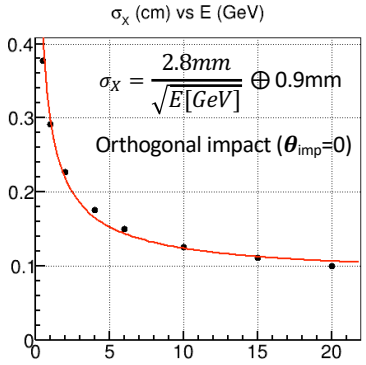
η = -2
η = -2.5
η = -3



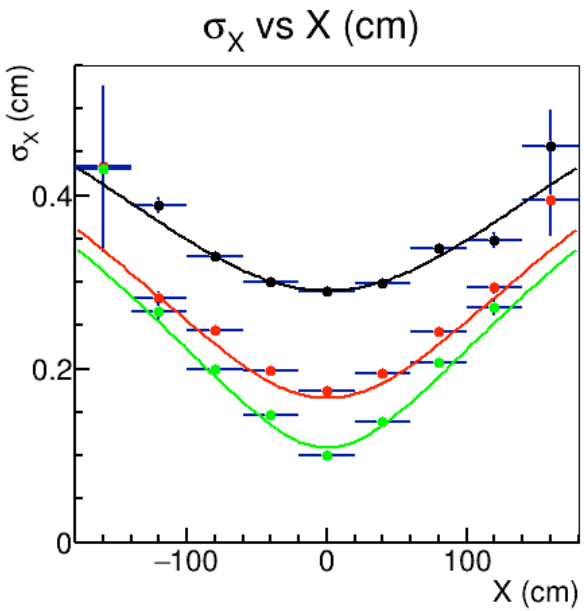
BTW: No effect of non-projectivity term on σ_{φ}

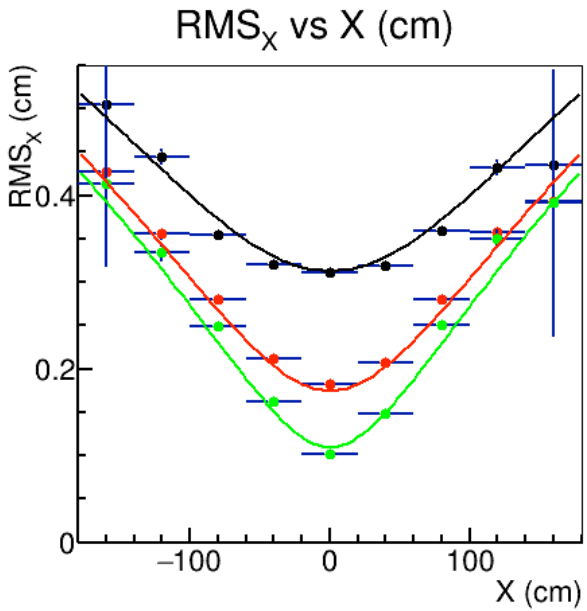
Now for fECal: Pos. Resolution

fECal



1 GeV
4 GeV
20 GeV





$$\sigma_X = \left(\frac{2.8mm}{\sqrt{E[GeV]}} \oplus 0.9\text{mm}\right) \oplus \left(7mm \cdot \sin\theta_{imp}\right)$$

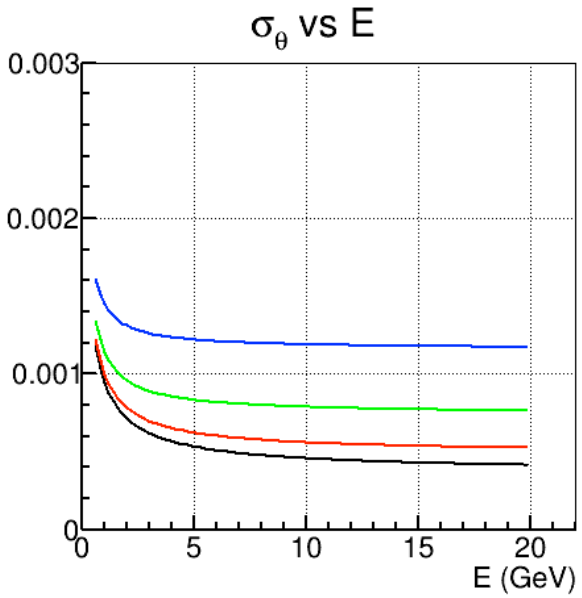
$$\sigma_X = \left(\frac{3.0mm}{\sqrt{E[GeV]}} \oplus 0.9\text{mm}\right) \oplus \left(9mm \cdot \sin\theta_{imp}\right)$$

Maximal "Non-projectivity" term in fEMCal is 3.3mm (θ=28°)

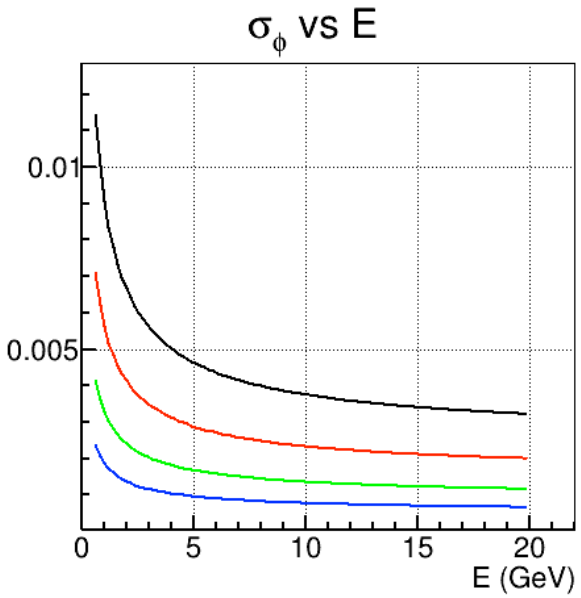
Maximal "Non-projectivity" term in fEMCal is 4.2mm (θ=28°)

Now for fECal: $\boldsymbol{\theta}$, φ Resolutions

fECal



η = 1.5
η = 2
η = 2.5
η = 3



Pos. Resolution: electrons, hadrons

Those were for **Photons** (straight track from the vertex)

Electrons

Shallower than photon

=> bias in $\boldsymbol{\theta}$ (or r) by ~$X_0 \sin(\boldsymbol{\theta})$ (~3mm or ~1-2 mrad maximum)

Bent in the magnetic field (mainly φ direction)

=> bias in φ (~10mrad/p[GeV/c])

=> another term in σ_φ (~2mrad/p[GeV/c])

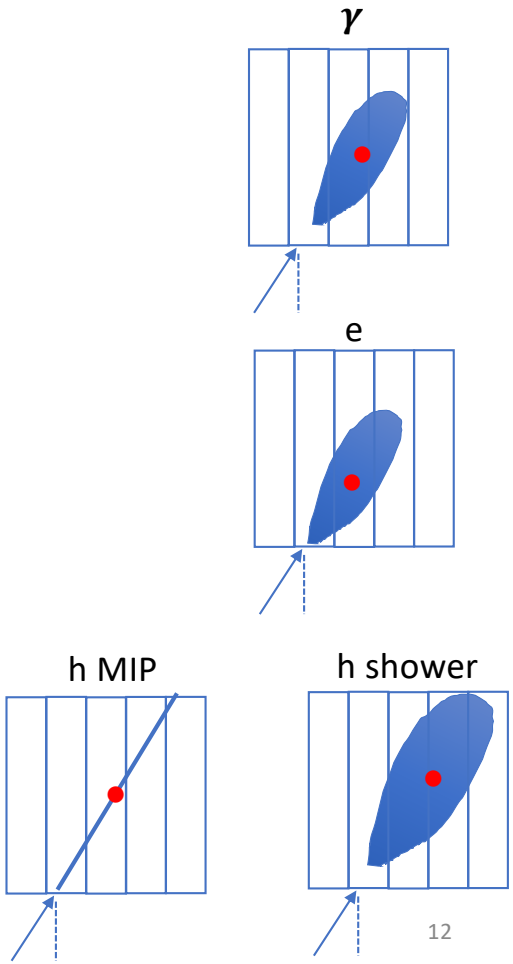
Reconstruction may be spoiled by accompanied radiated photons

Charged hadrons

MIPs vs Shower

Bias in $\boldsymbol{\theta}$ and φ (up to 1-2 cm shift in r or 5-10 mrad in $\boldsymbol{\theta}$)

Worse resolution (from PHENIX scaling: $\sigma_X \sim 1cm \oplus 4\,cm \cdot \sin(\theta)$)



Backup

Center of Gravity Corrected vs Log