

Retina fitter implementation at CMS

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Big picture

- Track fitting downstream the pattern recognition via AM.
- Assume $d_0 = 0$ and fit for curvature, ϕ , η , and z_0 ;
- Aim at:
 - ▶ very high efficiency/low fake rate;
 - ▶ track parameters resolutions:
 - $\frac{\sigma_{p_T}}{p_T} \approx \text{few } \%$ at 20 GeV/c;
 - $\sigma_\phi \approx 1 \text{ mrad}$;
 - $\sigma_\eta \approx 0.005$;
 - $\sigma_{z_0} \approx 1 \text{ mm}$.

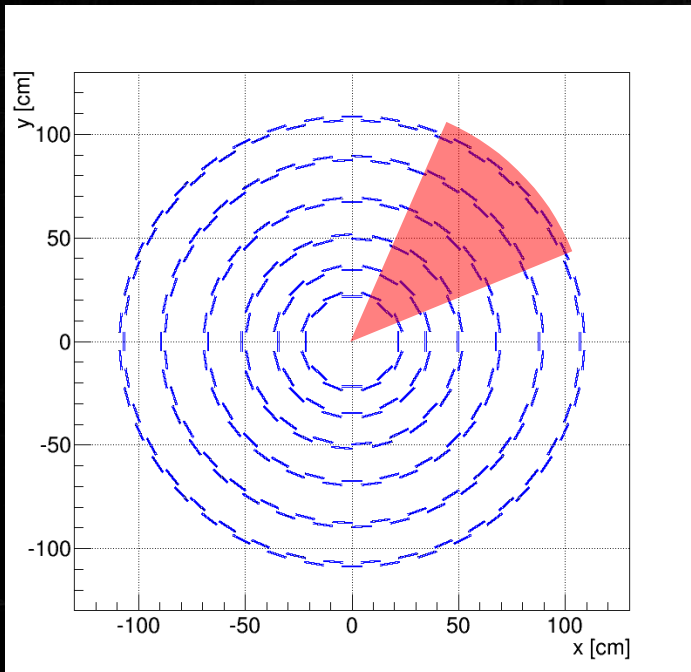


Trigger towers geometry

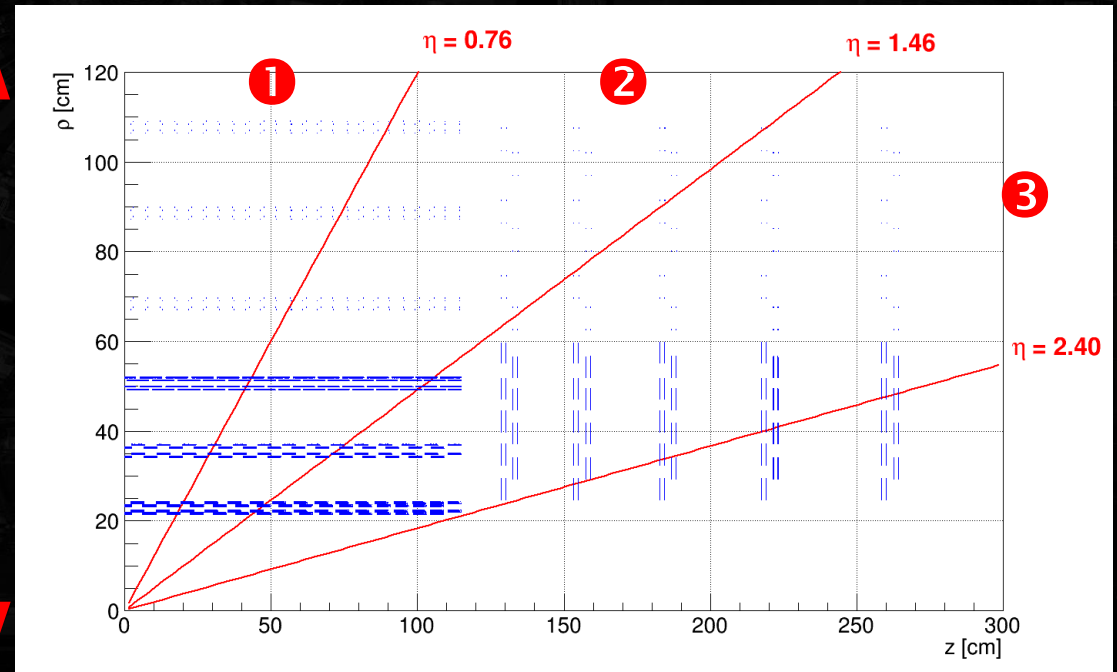
- Exploit ϕ - η detector symmetries:
 - ▶ rotate trigger towers to $\pi/8 < \phi < 3/8 \pi$;
 - ▶ flip $-z \rightarrow +z$.

- Three trigger tower typologies:

- ❶ central: $0 < |\eta| < 0.76$;
- ❷ intermediate: $0.76 < |\eta| < 1.46$;
- ❸ forward: $1.46 < |\eta| < 2.40$.



strip-strip sensors
pixel-strip sensors





Fitting strategy

- Two independent fits in x - y and ρ - z views:

- ▶ x - y fit \rightarrow curvature and ϕ :

- conformal mapping: circles through origin \rightarrow straightlines

$$x' = \frac{x}{x^2 + y^2} \qquad y' = \frac{y}{x^2 + y^2}$$

- x_{\pm} transformation:

$$p, q \rightarrow x_{\pm} = \frac{x_1 \pm x_2}{2}$$

- ▶ associate stubs to x - y maximum;

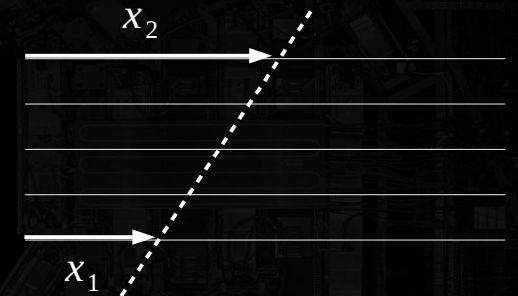
- ▶ ρ - z fit \rightarrow η and z_0 :

- x_{\pm} transformation.

- Two step fit with different retina granularities.

- Two fitting modes:

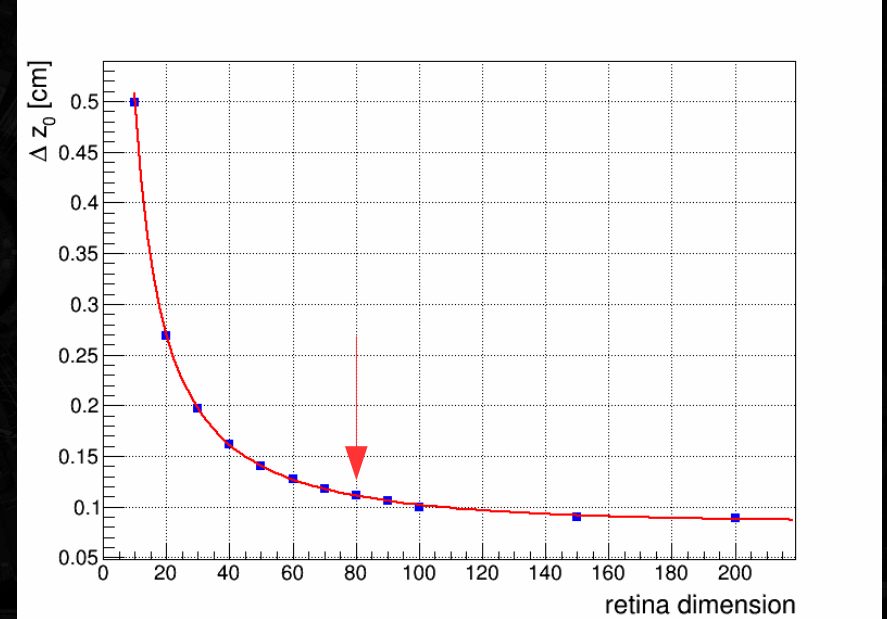
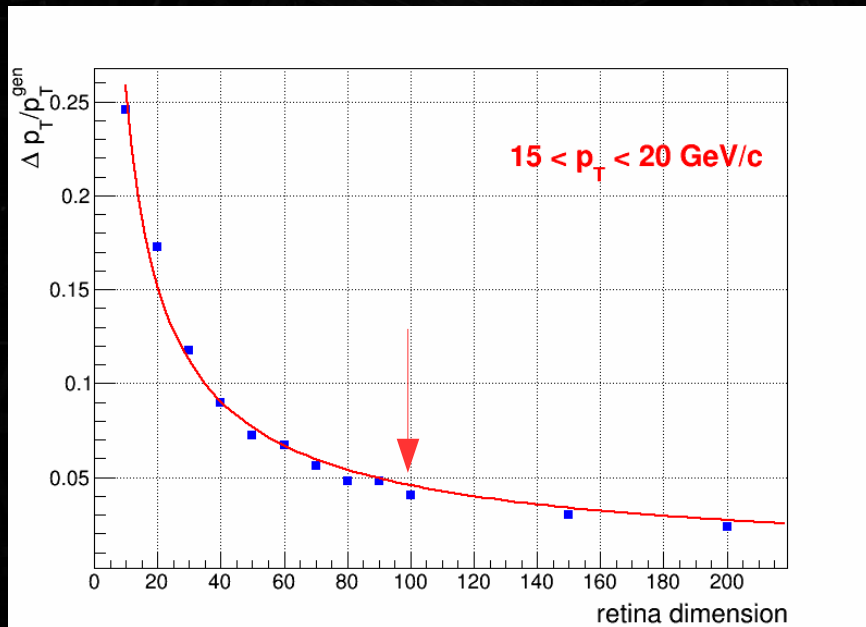
- fitting per road,
- fitting per trigger tower.





Retina granularity scan

- Step 1 granularity is fixed at 40×40 bins for x - y and 20×20 bins for ρ - z :





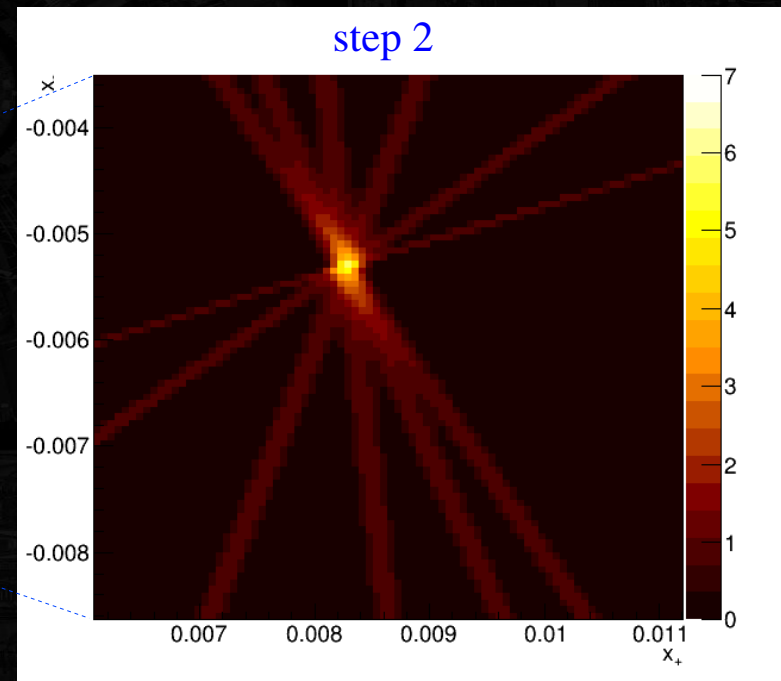
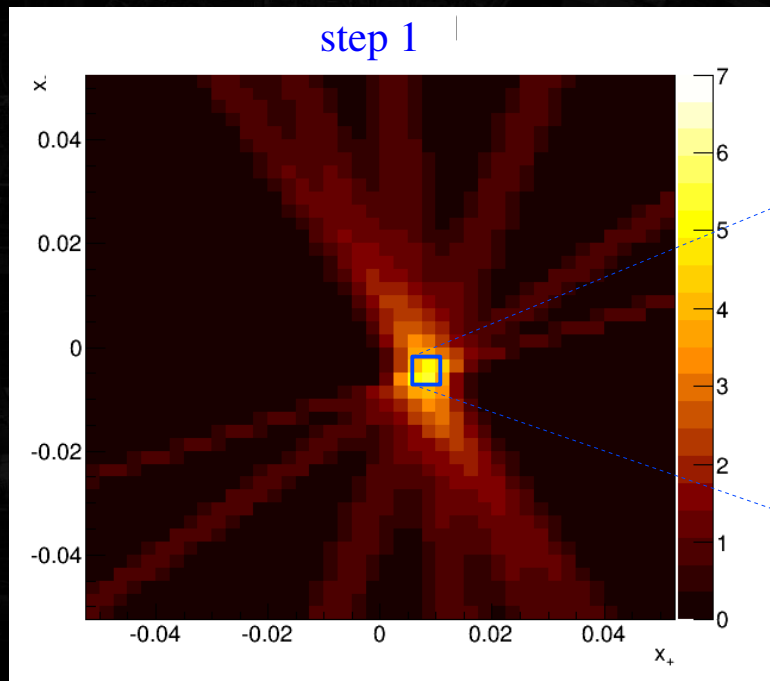
$x-y$ fit

Step 1 configuration:

- ▶ 40×40 -bin grid;
- ▶ $\sigma_{step1} = \sqrt{\Delta x_+^2 + \Delta x_-^2}$;
- ▶ $threshold_{max} = 4.5$.

Step 2 configuration:

- ▶ open a 100×100 -bin grid around $\max_{step1} \pm \Delta x_{step1}$;
- ▶ $\sigma_{step2} = \sqrt{\Delta x_+^2 + \Delta x_-^2}$;
- ▶ $threshold_{max} = 4.5$.





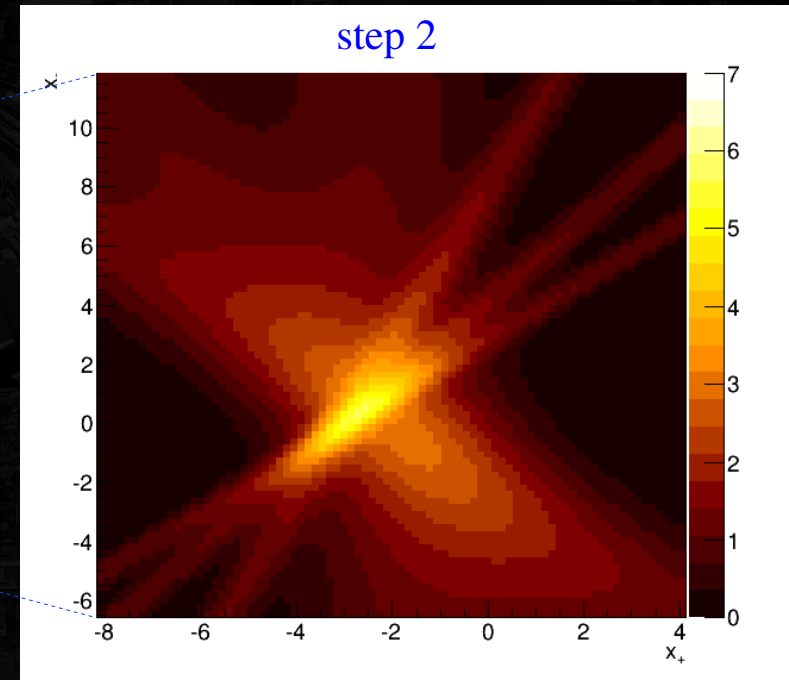
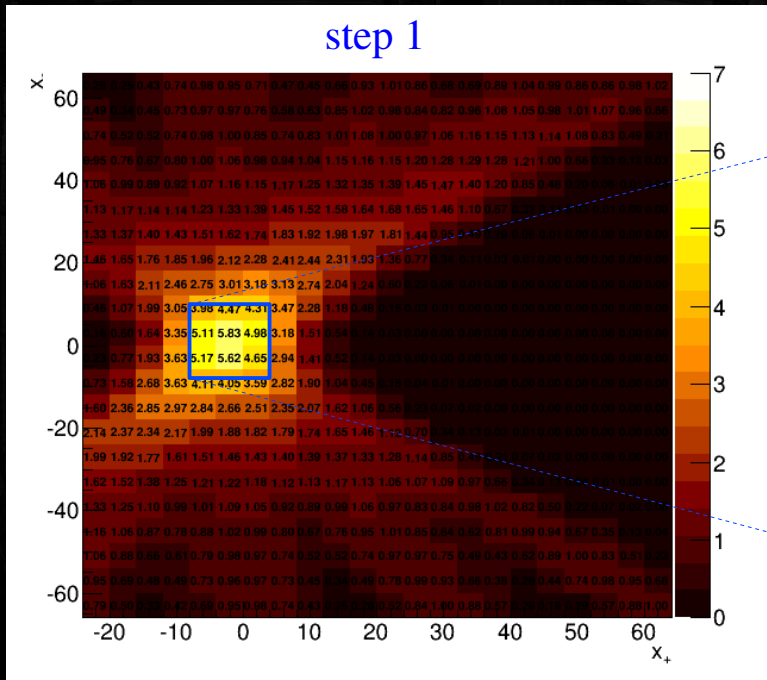
ρ -z fit

Step 1 configuration:

- ▶ 20×20 -bin grid;
- ▶ $\sigma_{step1} = \sqrt{\Delta x_+^2 + \Delta x_-^2}$;
- ▶ $threshold_{max} = 4$.

Step 2 configuration:

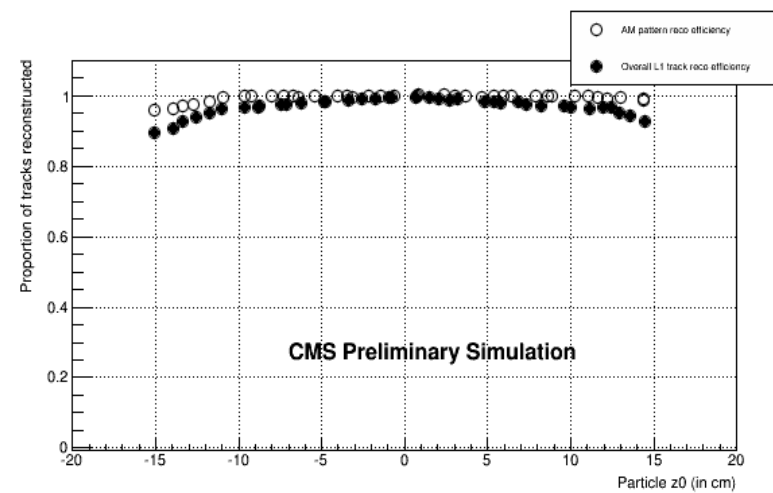
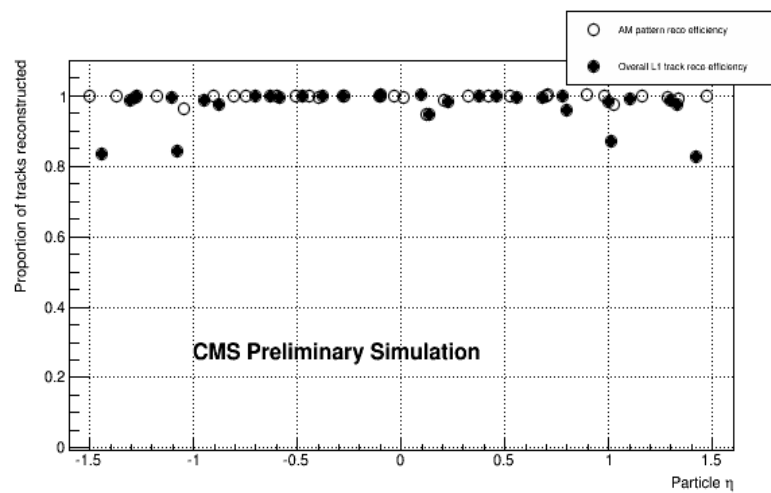
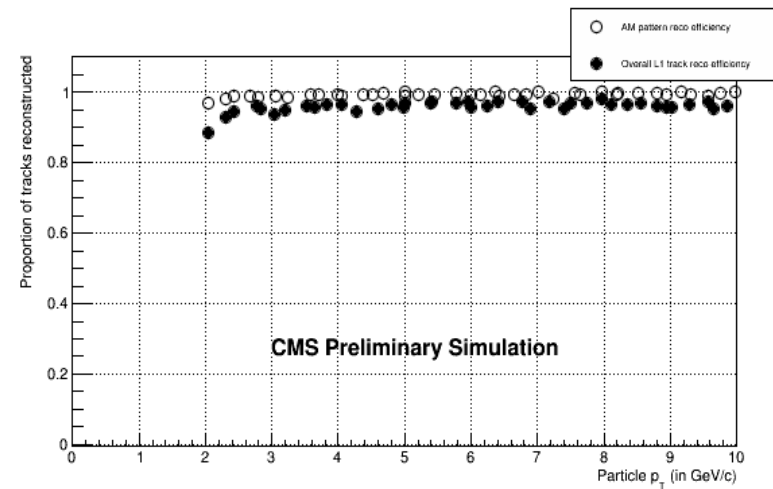
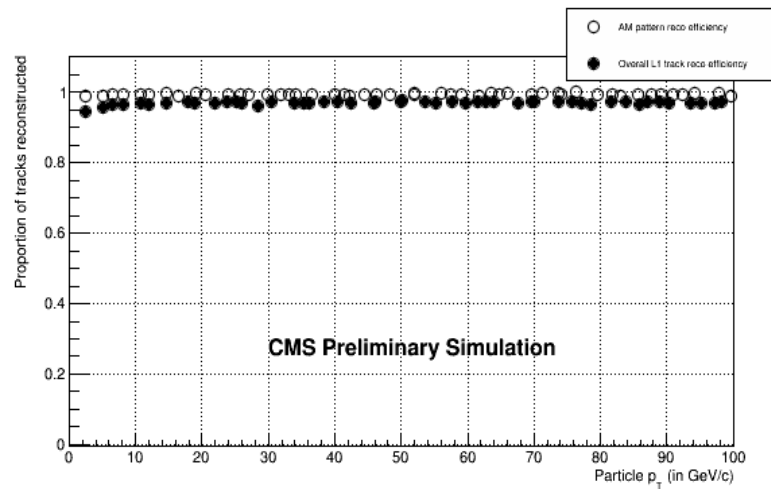
- ▶ open a 80×80 -bin grid around
- ▶ $max_{step1} \pm 1.5 \Delta x_{step1}$;
- ▶ $\sigma_{step2} = \begin{cases} \sqrt{\Delta x_+^2 + \Delta x_-^2} & \text{(PS mod.)}, \\ 8 \sqrt{\Delta x_+^2 + \Delta x_-^2} & \text{(2S mod.)}; \end{cases}$
- ▶ $threshold_{max} = 4$.





μ^\pm w/o PU: PR and trk efficiency

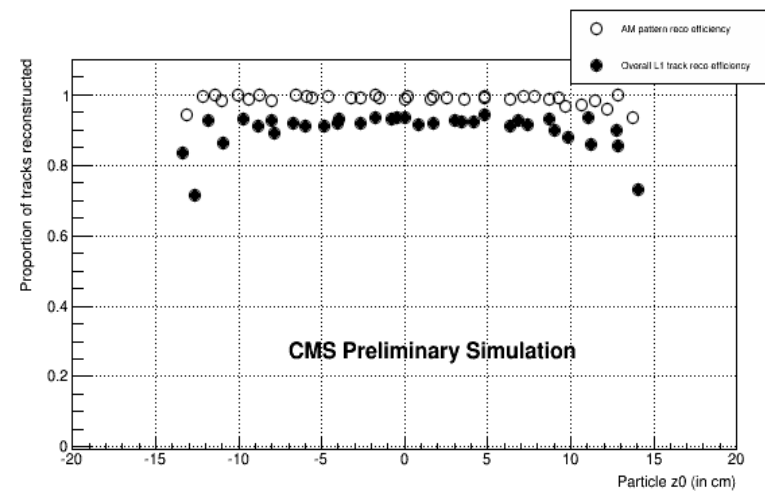
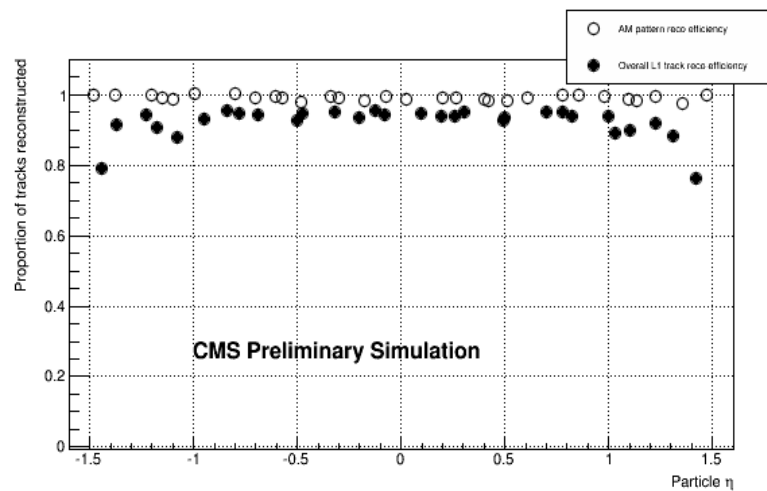
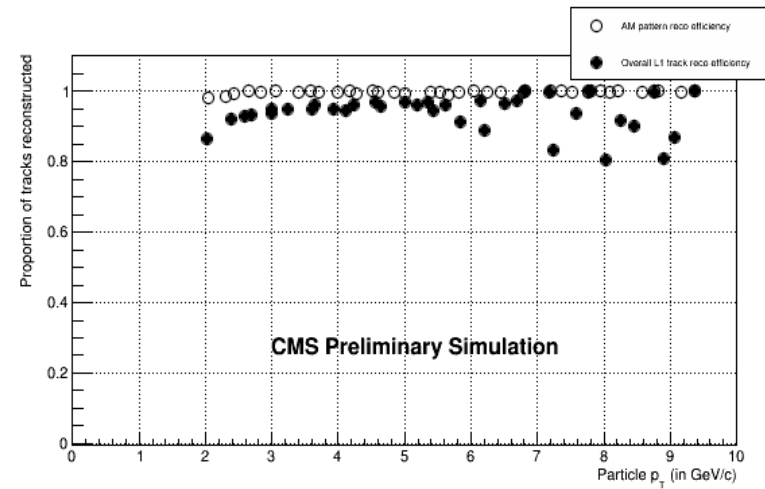
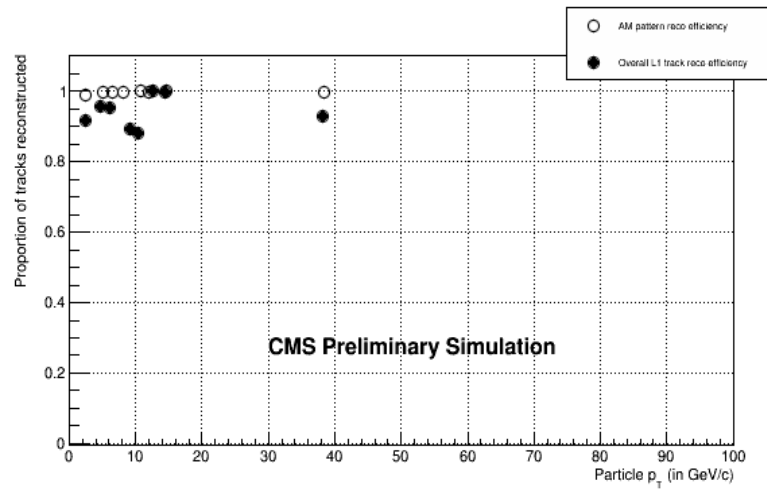
● Muons with $p_T > 2 \text{ GeV}/c$, $N_{\text{hits}} \geq 5$.





μ PU140: PR and trk efficiency

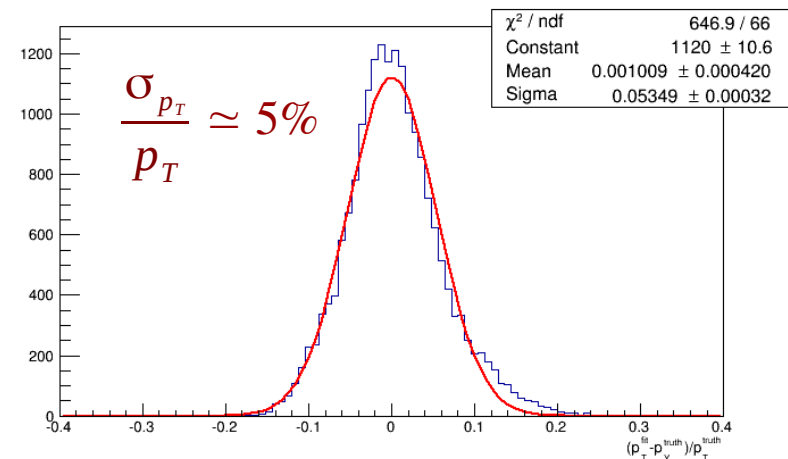
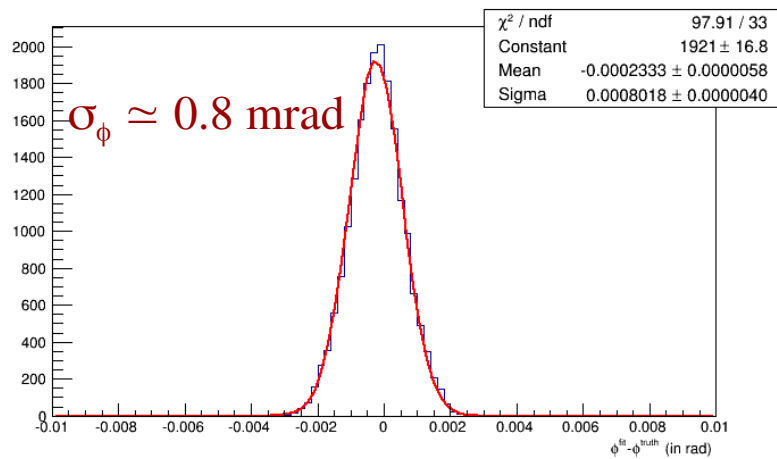
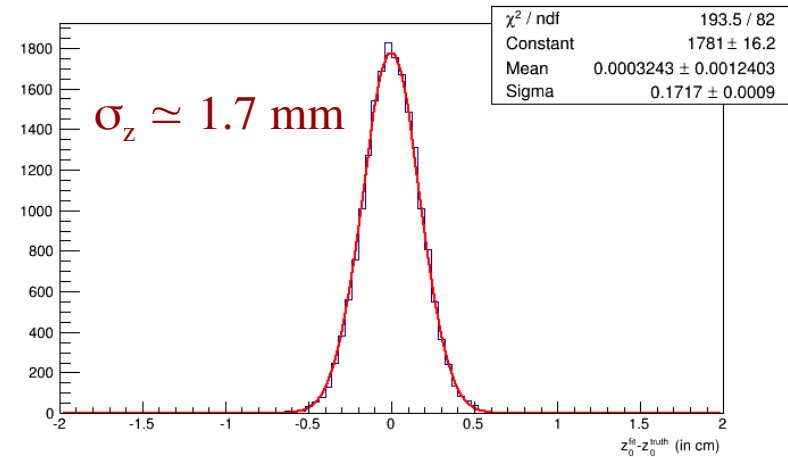
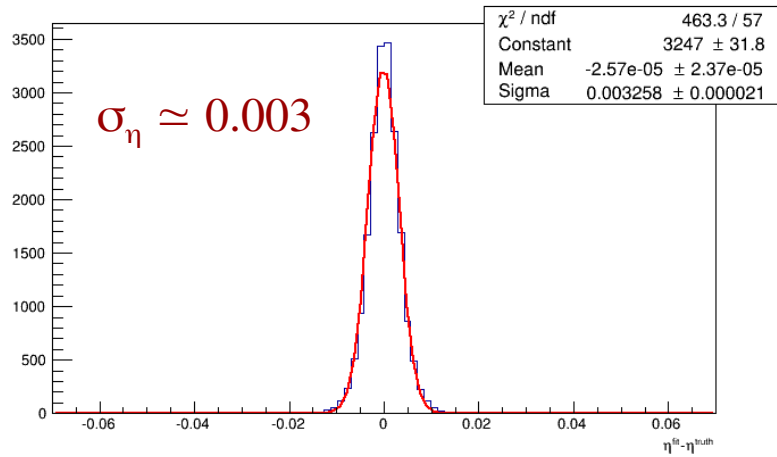
All particles with $p_T > 2 \text{ GeV}/c$, $N_{\text{hits}} \geq 5$.





μ^\pm w/o PU: full detector resolutions

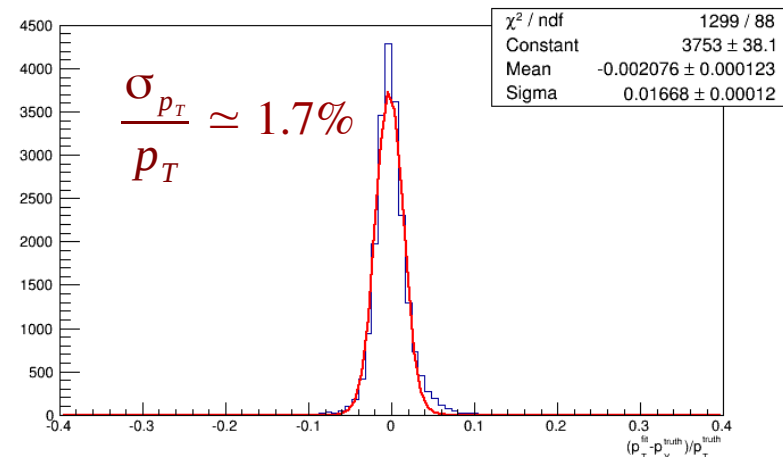
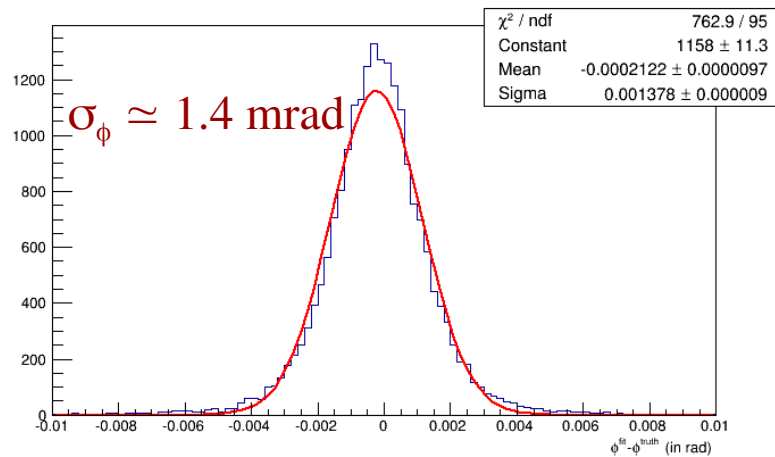
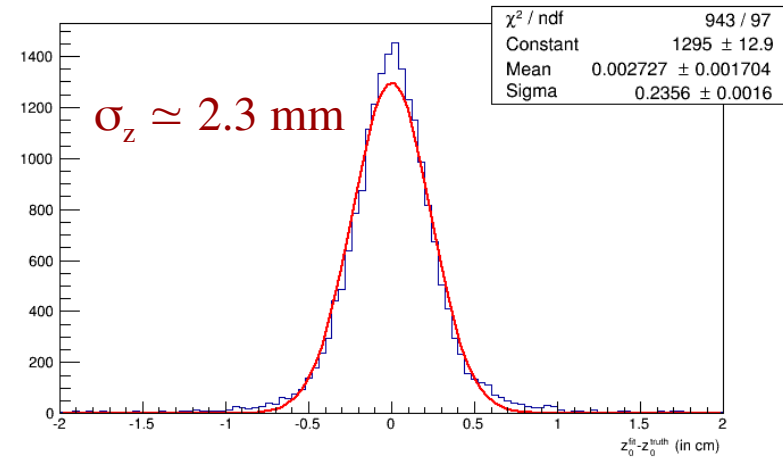
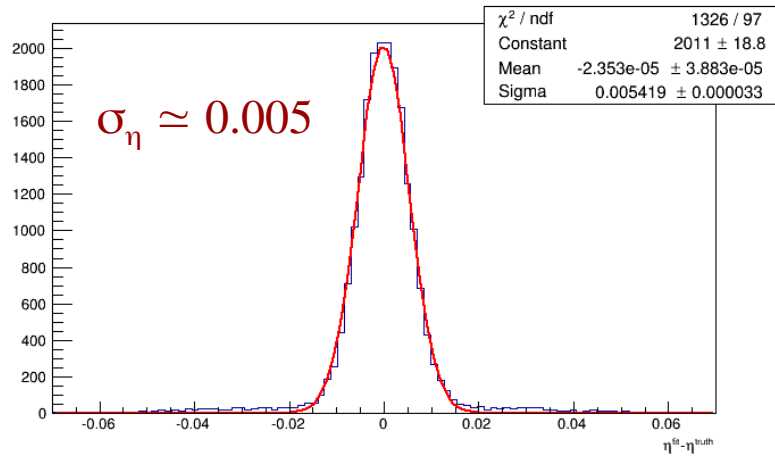
- Muons with $15 < p_T < 20$ GeV/c, $N_{\text{hits}} \geq 5$.





μ PU140: full detector resolutions

- All particles with $p_T > 2 \text{ GeV}/c$, $N_{\text{hits}} \geq 5$.





μ^\pm w/o PU: resolutions vs p_T

Muons with $p_T > 2 \text{ GeV}/c$, $N_{\text{hits}} \geq 5$.

