φ resolution study by MC

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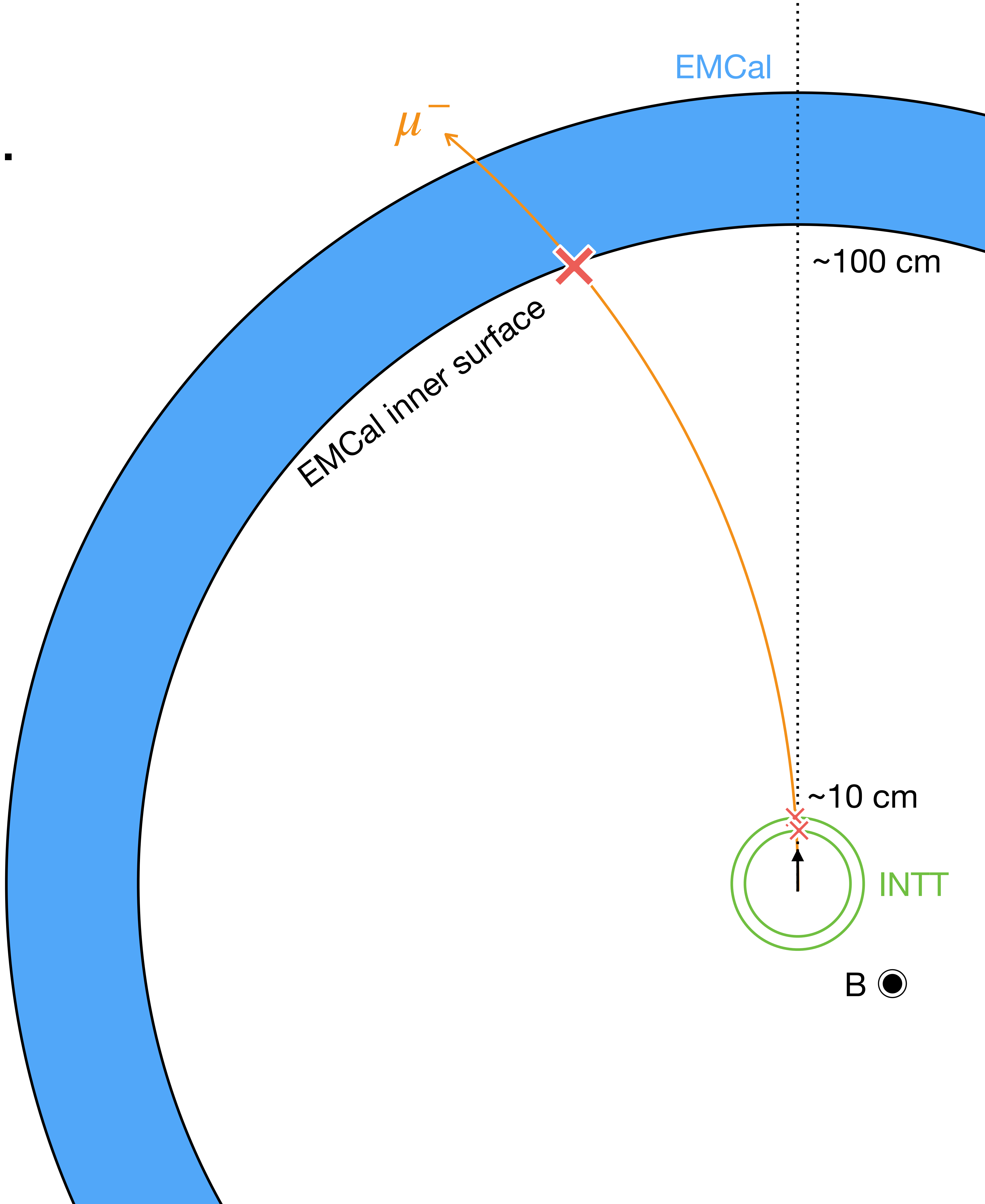
Single μ⁻ MC for angle resolution evaluation

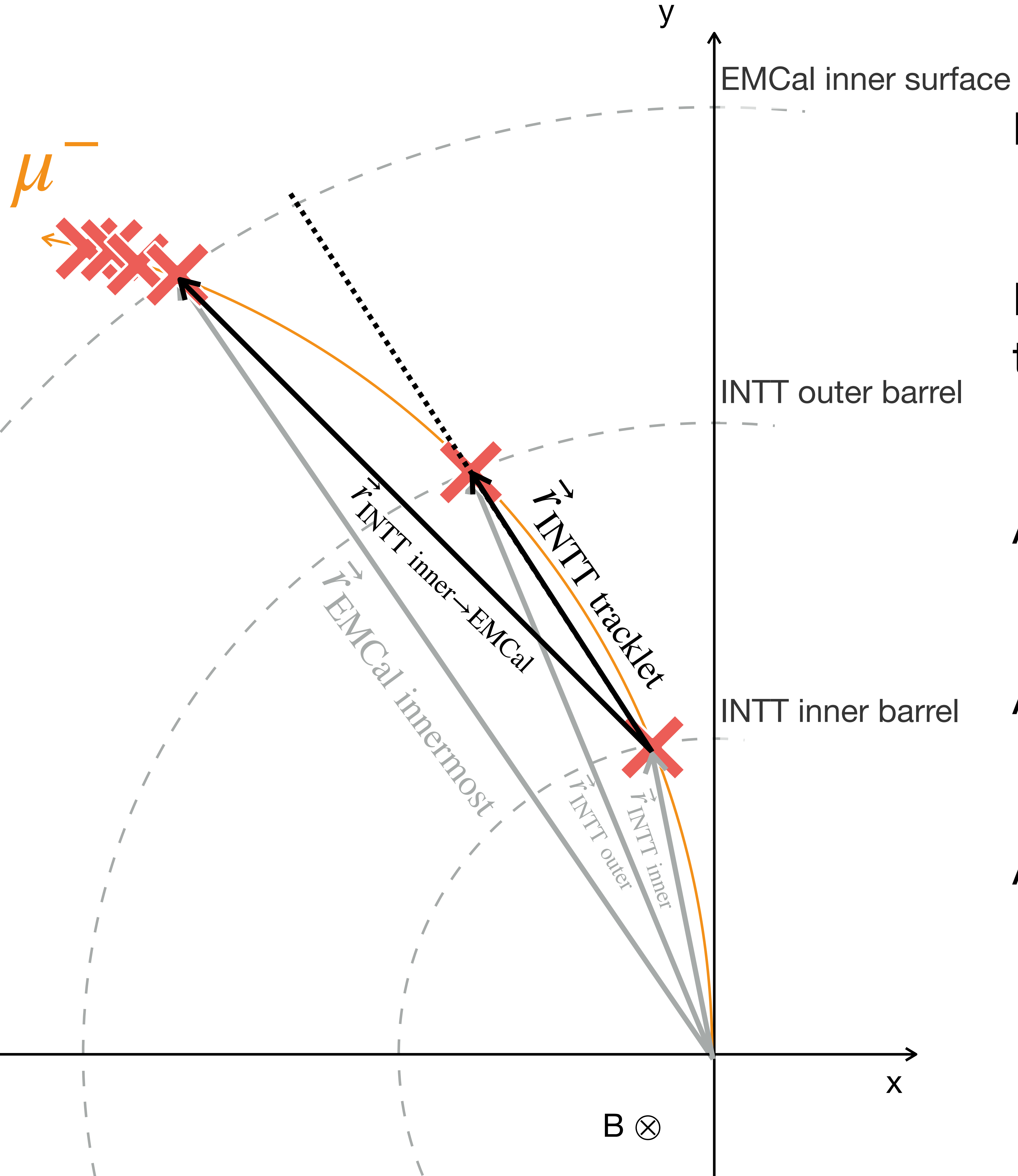
- It must be useful if we can estimate hit position on the inner surface of EMcal using INTT hit information.
- We can make such rough estimation table from single μ MC.
- The uncertainty of the estimation is a hint of tracking resolution.



Basic idea of angular resolution evaluation

Note: Currently,

$$\vec{r} = \vec{r}_{\text{mes.}} - \vec{r}_{\text{vertex}}\Big|_{\vec{r}_{\text{vertex}}=(0,0,0)} = \vec{r}_{\text{mes.}}$$



EMCal hit: the innermost (smallest ρ) G4Hit on EMCal

$$\vec{r}_{\text{EMCal innermost}}$$

INTT tracklet vector: a line from G4Hit on the inner barrel to that on the outer

$$\vec{r}_{\text{INTT tracklet}} = \vec{r}_{\text{INTT outer}} - \vec{r}_{\text{INTT inner}}$$

A vector from INTT inner barrel to EMcal hit:

$$\vec{r}_{\text{inner}\to\text{EMCal}} = \vec{r}_{\text{EMCal}} - \vec{r}_{\text{inner}}$$

Angle resolution evaluator:

$$\Delta\phi = \phi_{\text{inner}\to\text{EMcal}} - \phi_{\text{INTT tracklet}}$$

Angle resolution:

$$\frac{\sigma_{\Delta\phi}}{\left|\mu_{\Delta\phi}\right|},$$

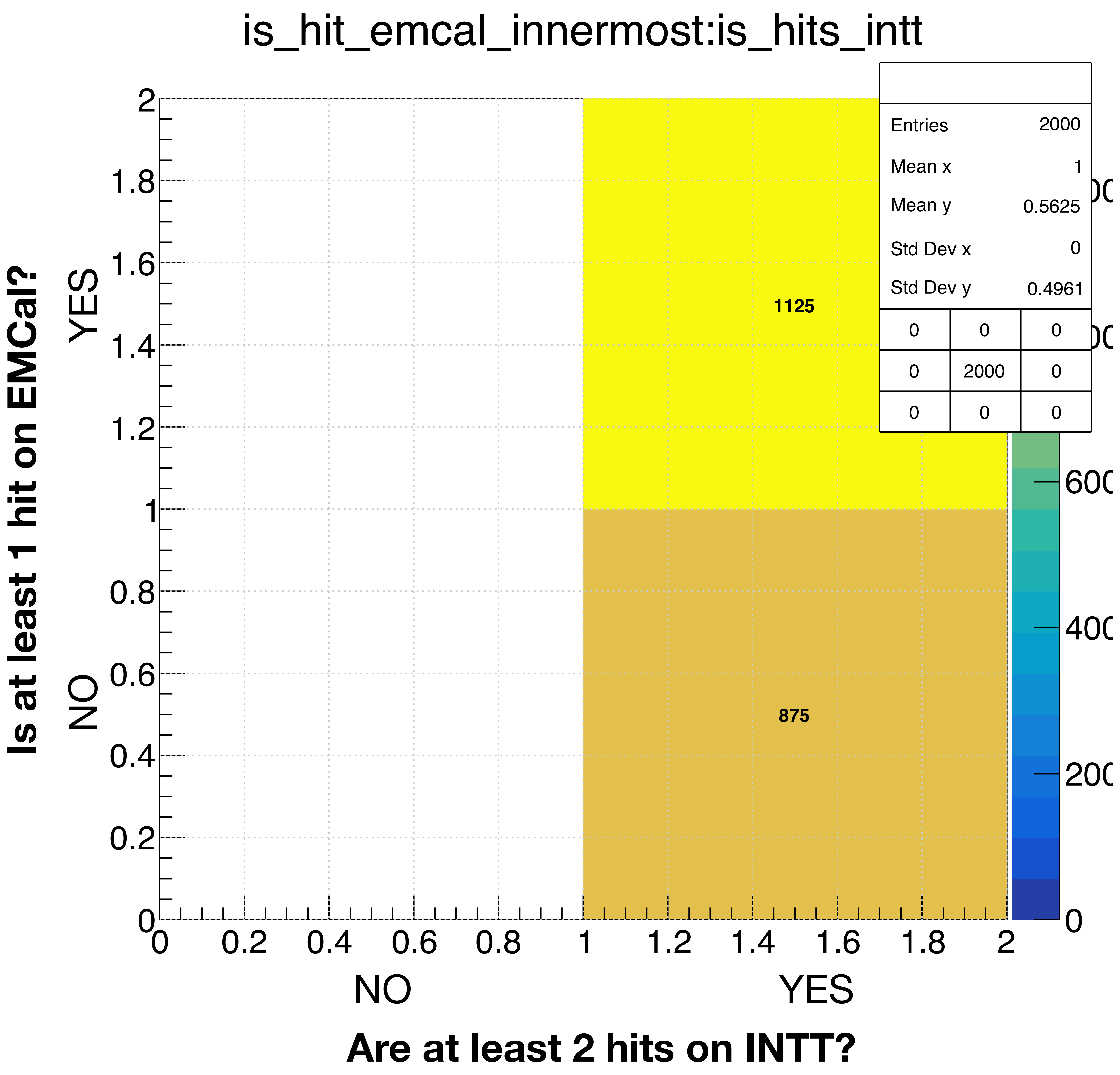
where μ and σ are determined by gaussian fit to $\Delta\phi$ distribution

Pilot run: Condition

Setup:

- Single μ^- MC with $\vec{p} = (0,\ 1,\ 0)\ \mathrm{GeV/c}$
  - i.e. no angular distribution
- $\vec{r}_{\mathrm{vertex}} = (0,0,0)\ \mathrm{cm}$
- Beam pipe, MVTX, INTT, TPC, TPOT, and EMCal are in the simulation.
- 2000 events
  - It took long time. Is 80 min / 100k OK?

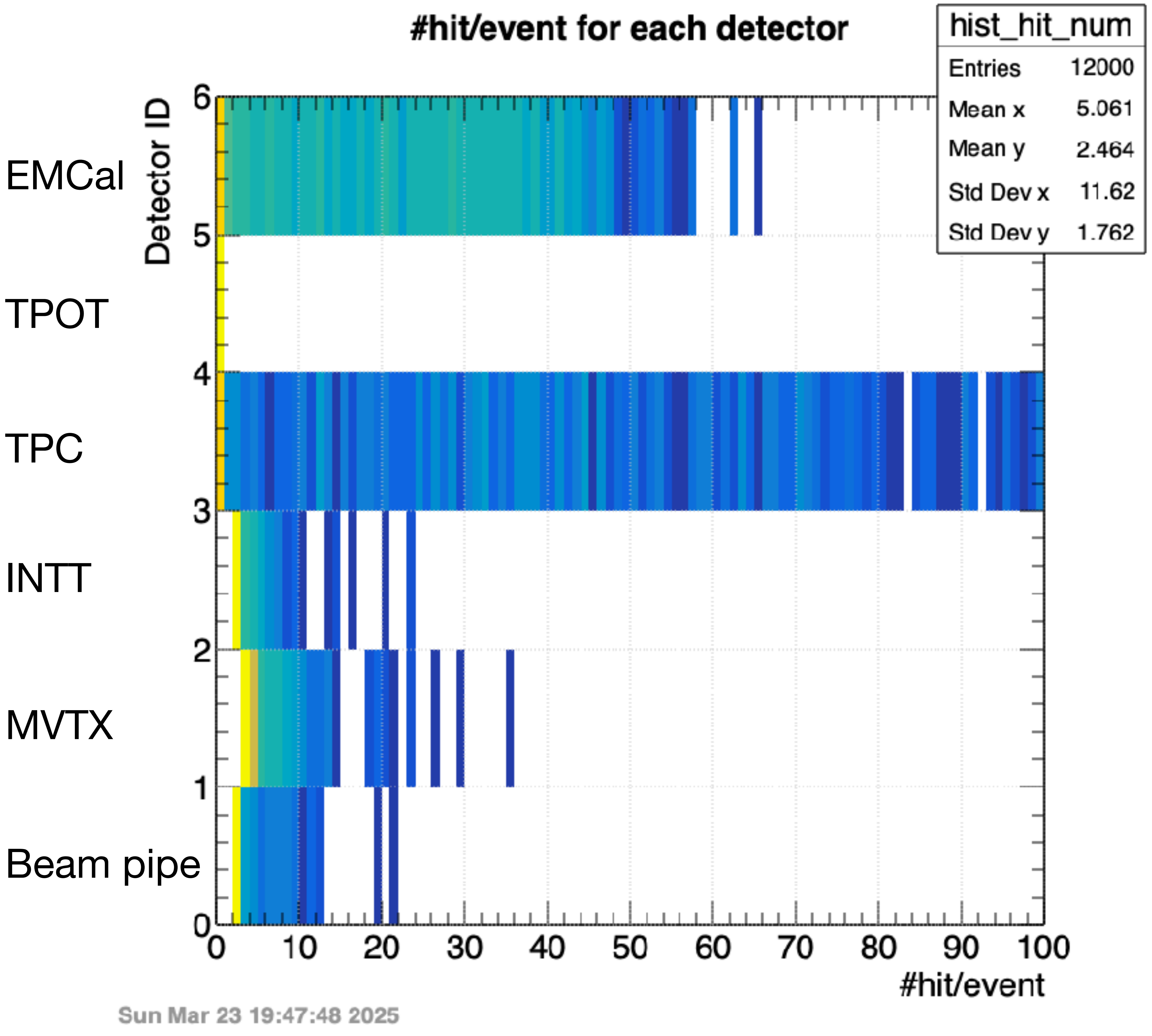
Pilot run: is a hit on INTT/EMCal?



← Events in this row: no G4hit on EMcal

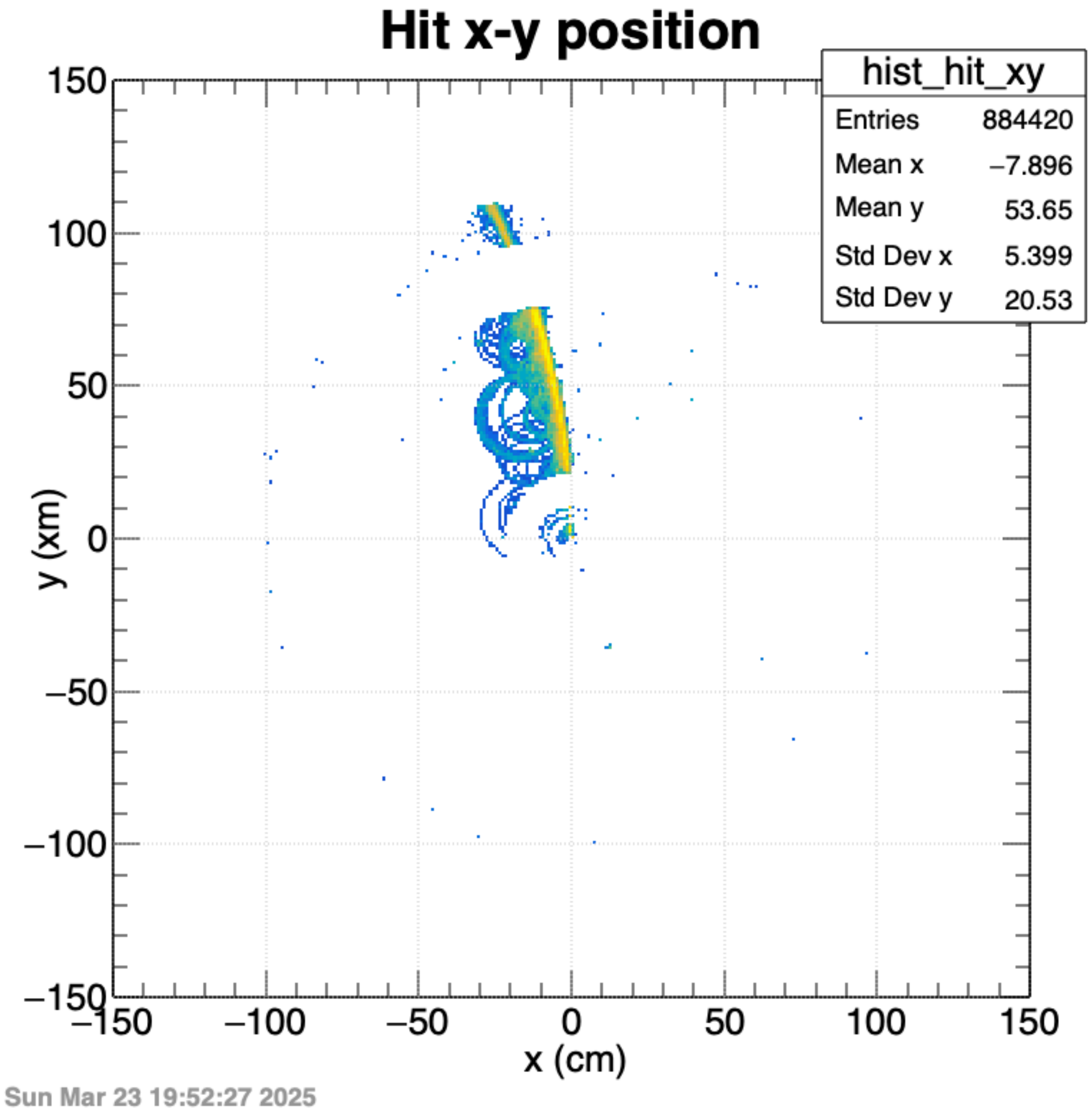
Why was no hit made on EMCal for large fraction of events?

Pilot run: #G4hit for each detector



TPC also has no hit for 40% of events.

Pilot run: #G4hit position



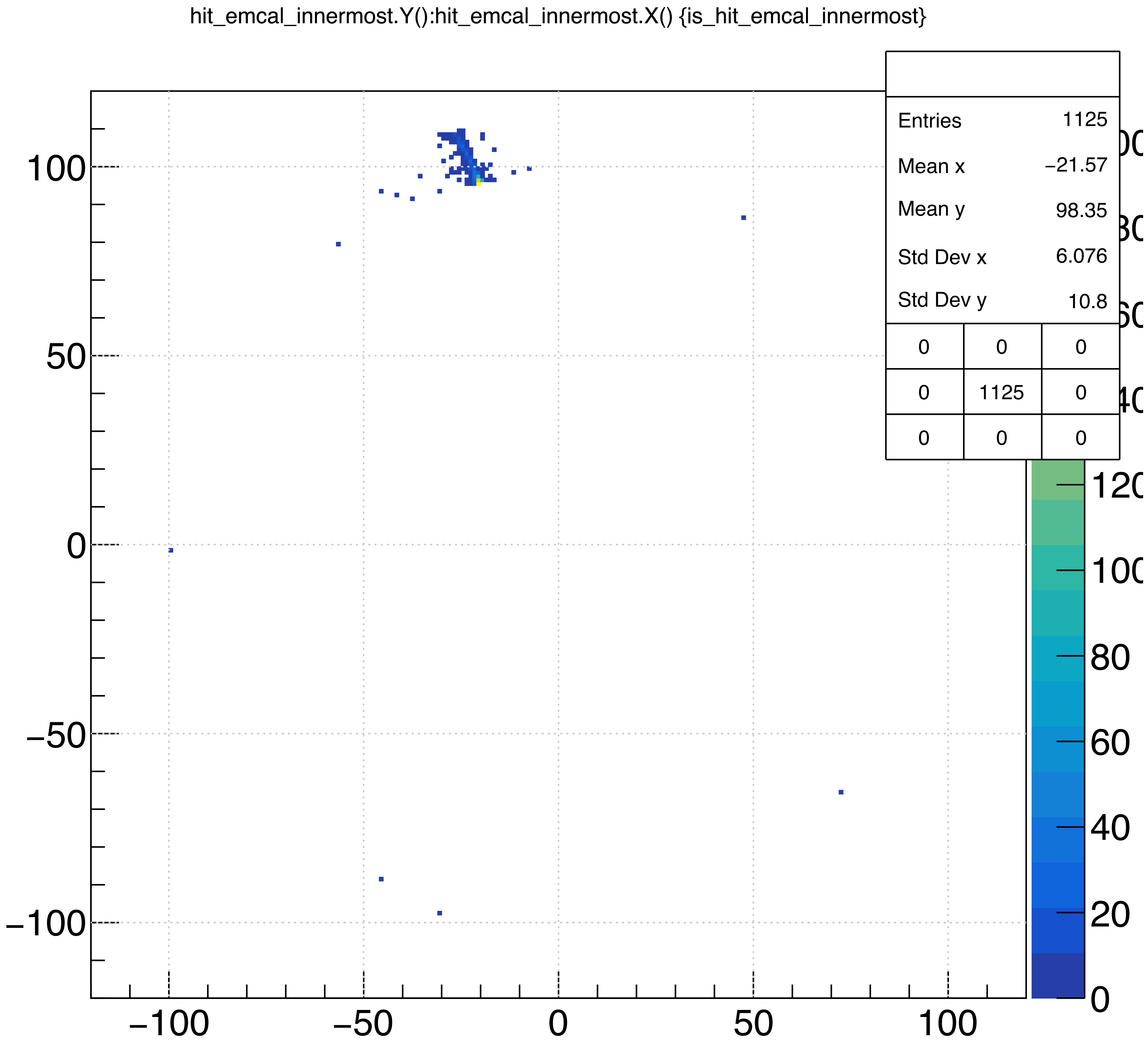
x vs y position of G4hit. No event/hit selections were applied.

2000 events are accumulated.

Trajectory of muons are clearly seen.

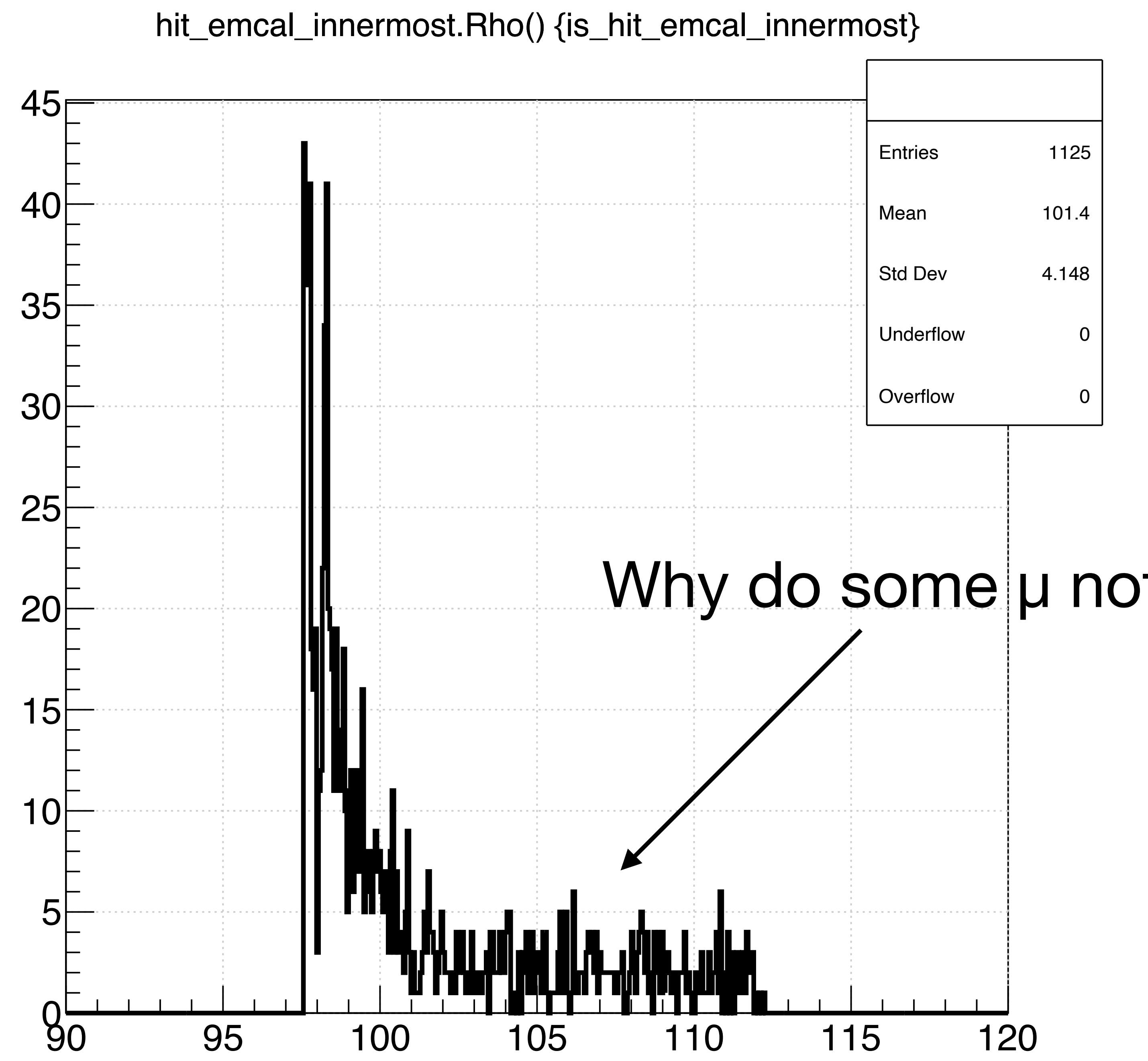
Some hits were generated in totally different directions from the beam.

Pilot run: Parameter distributions



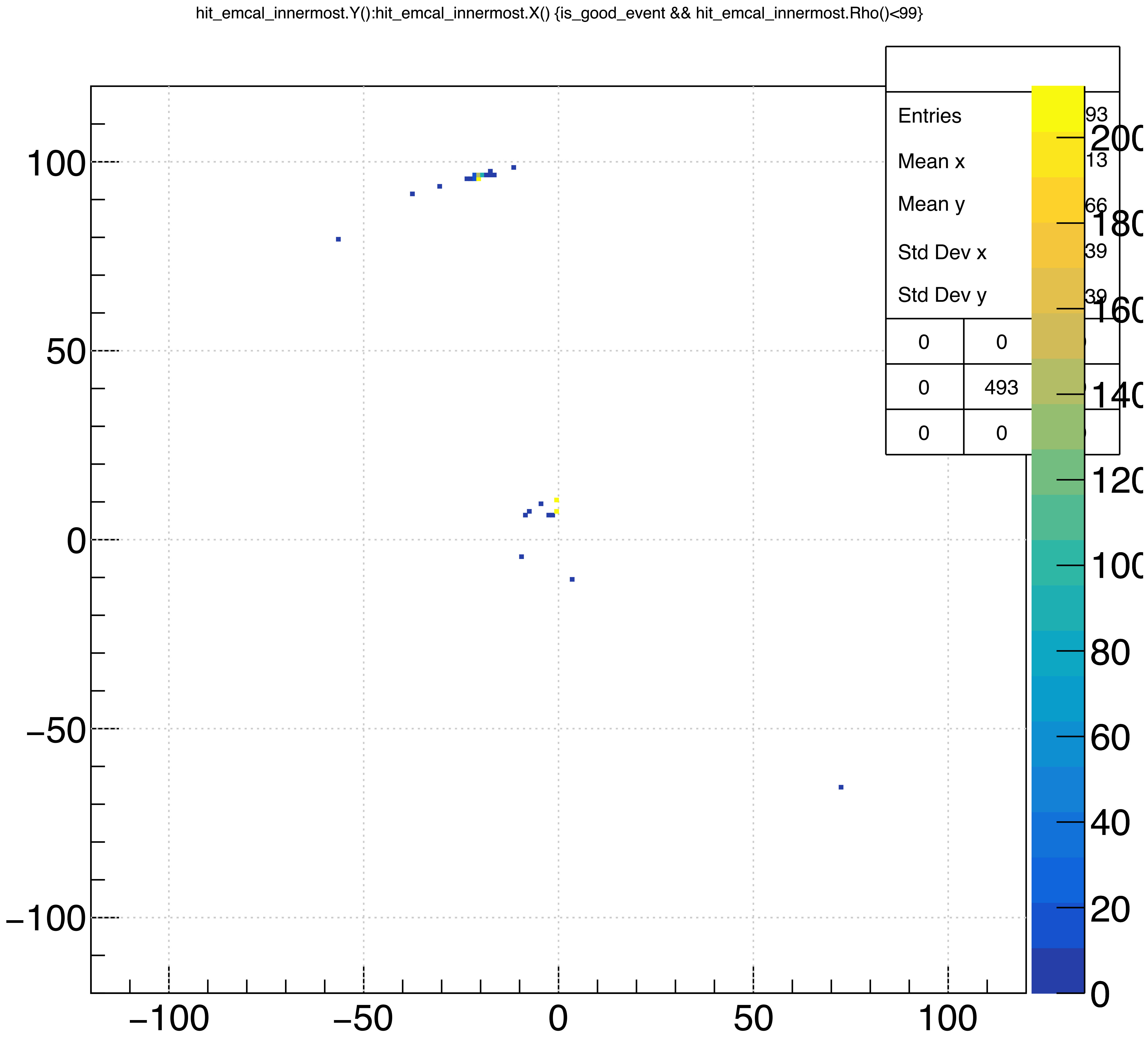
- (Left) x_{EMcal} vs y_{EMCal} distribution
- The distribution is uniform in azimuth

- (Below) $\rho_{\mathrm{EMCal}} = \sqrt{x_{\mathrm{EMCal}}^2 + y_{\mathrm{EMCal}}^2}$ distribution

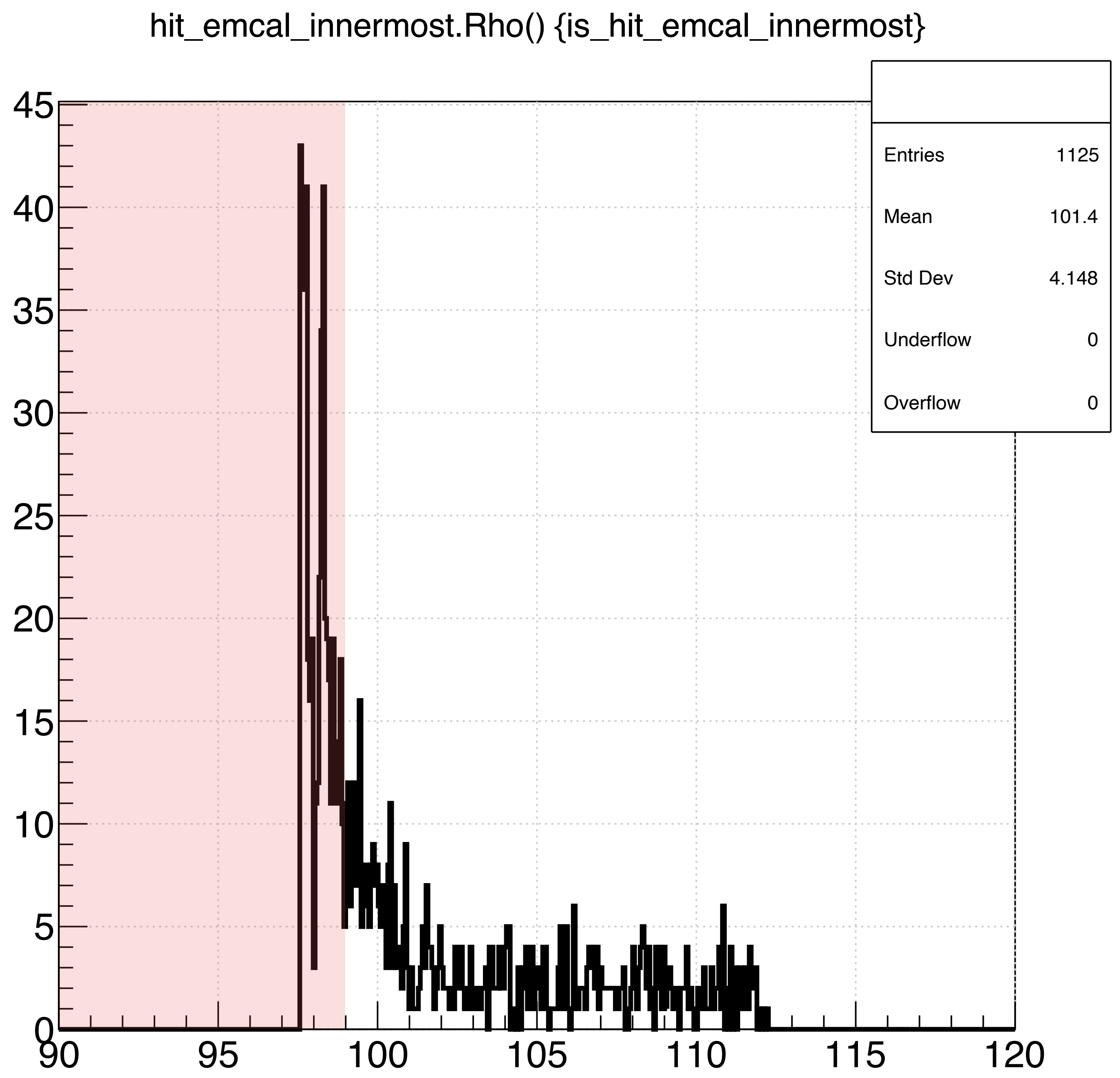


Why do some μ not interact with surface of EMCal?

Pilot run: Parameter distributions



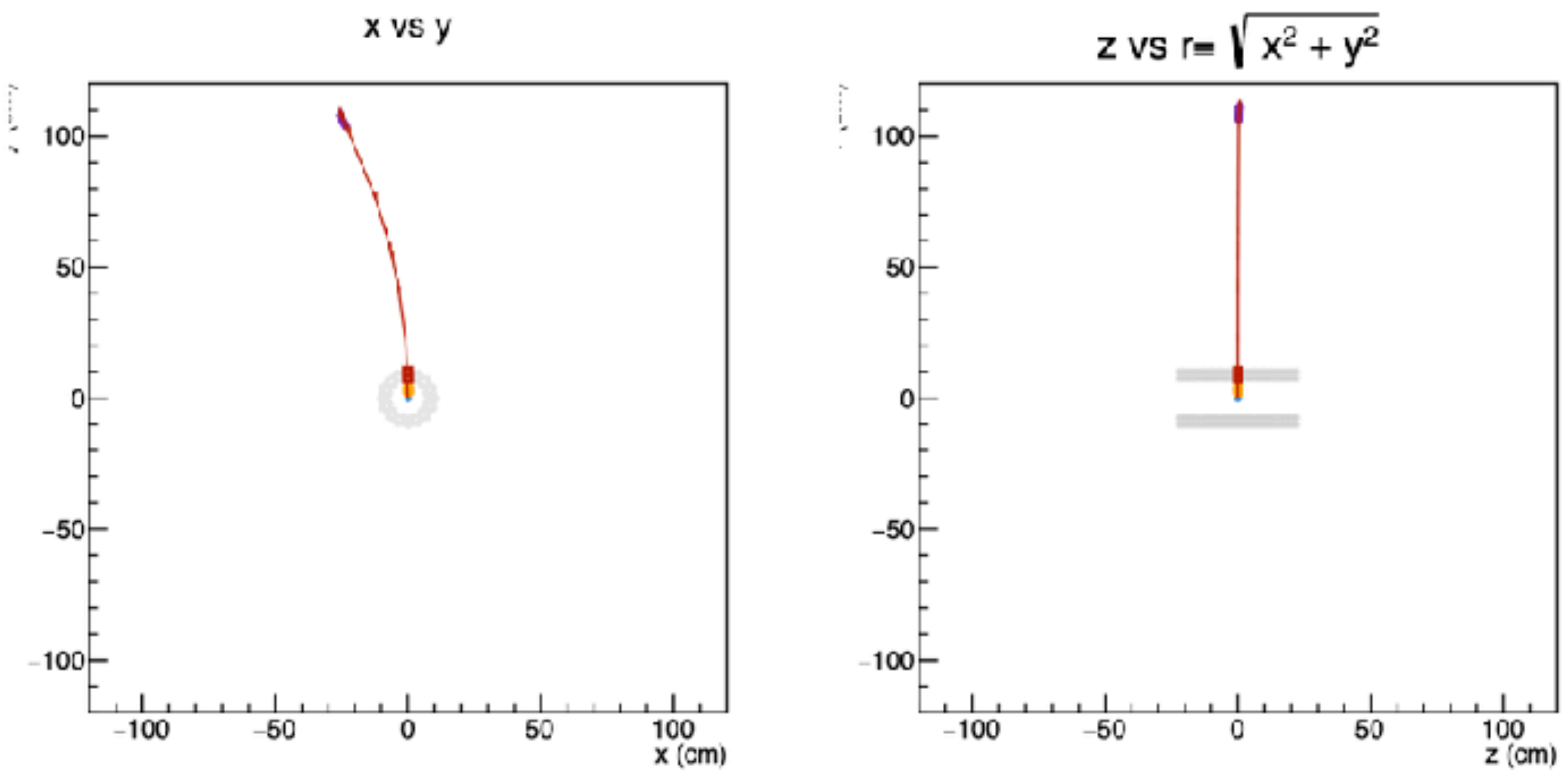
- (Left) x_{EMcal} vs y_{EMCal} distribution with a cut of $\rho_{\mathrm{EMCal}} < 99$ cm

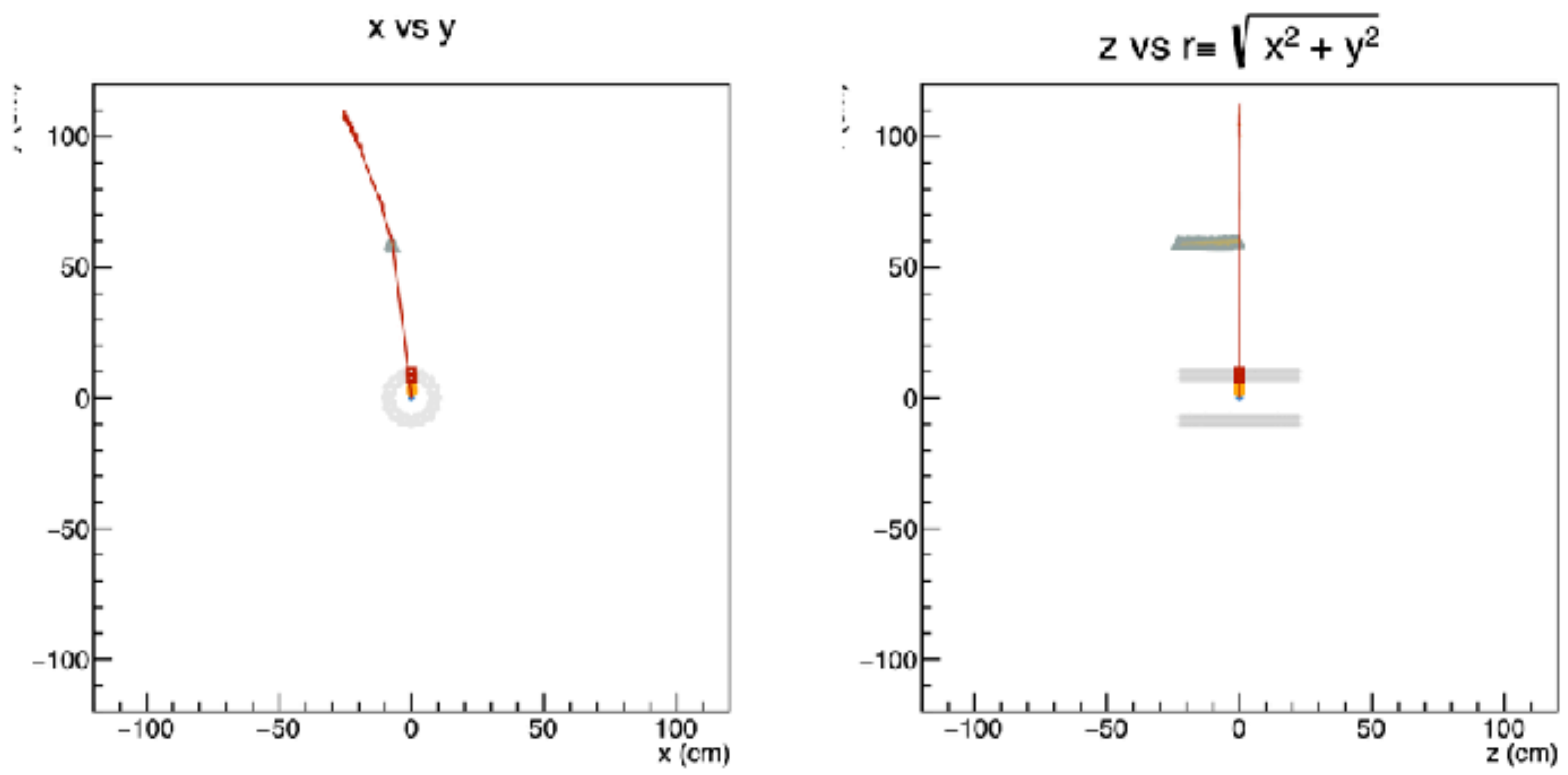


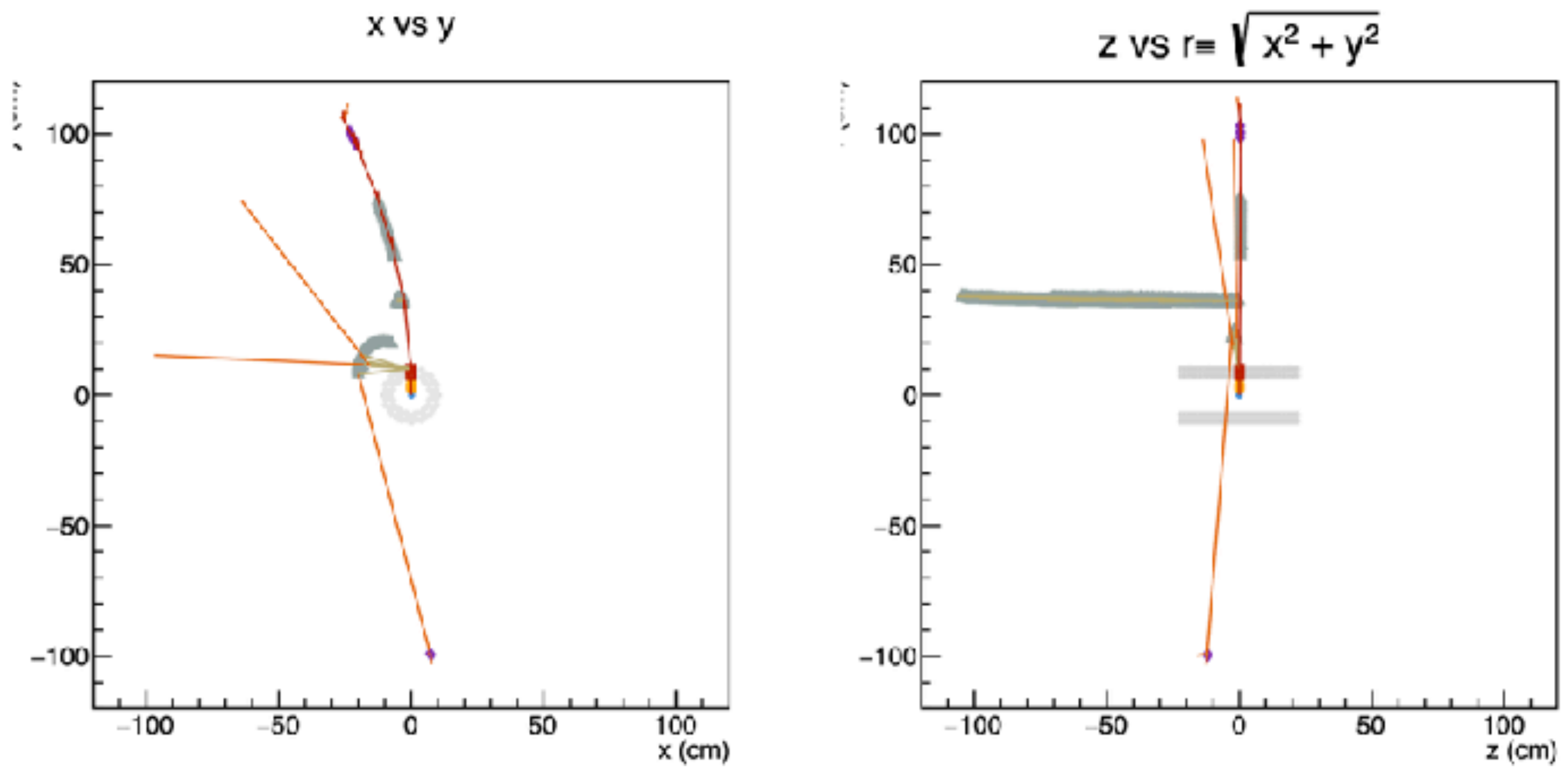
Pilot run: Event displays

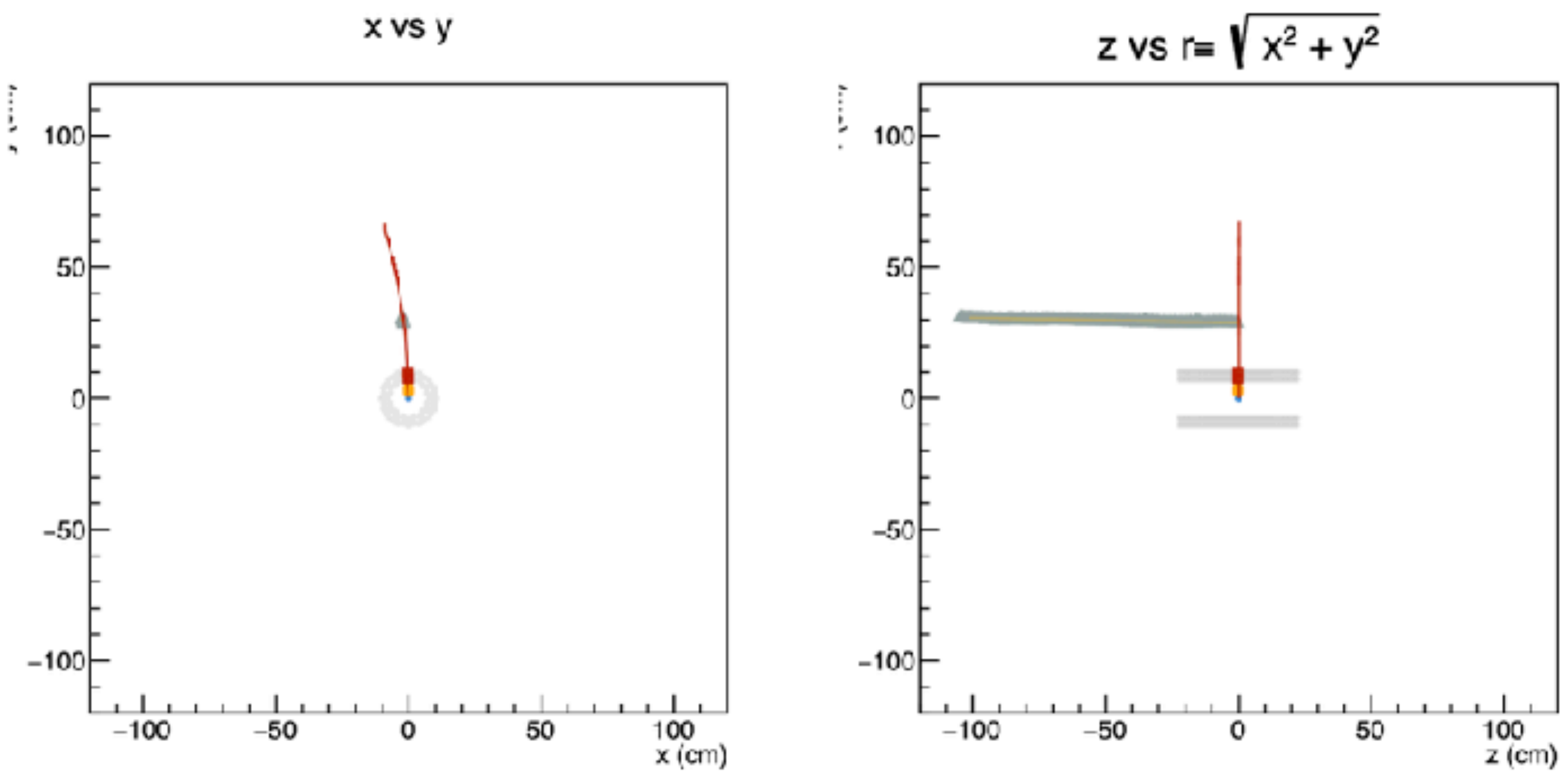
Cuts

- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\text{EMCal}} < 99\ \text{cm}$

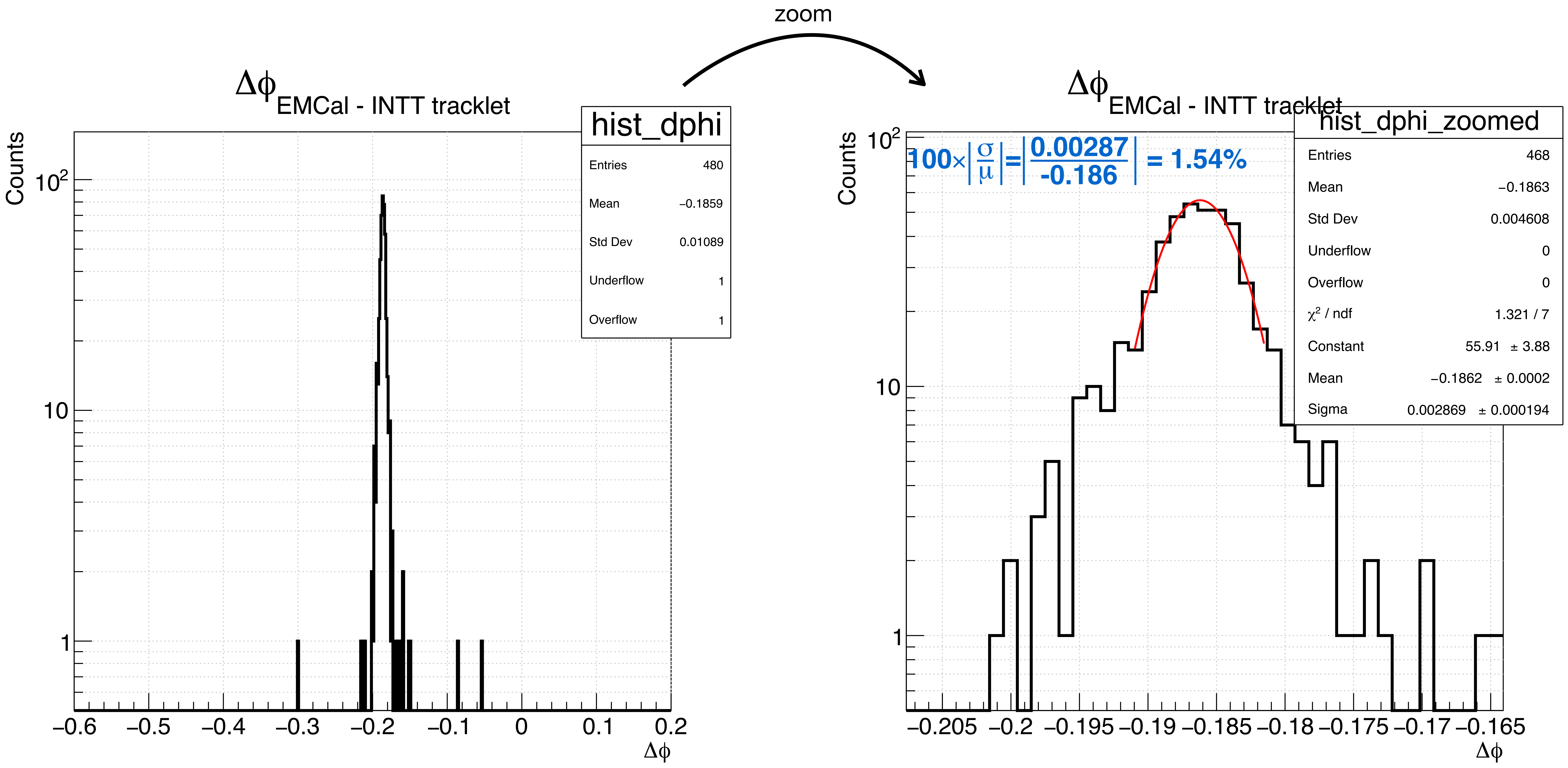








Pilot run: ϕ angle resolution



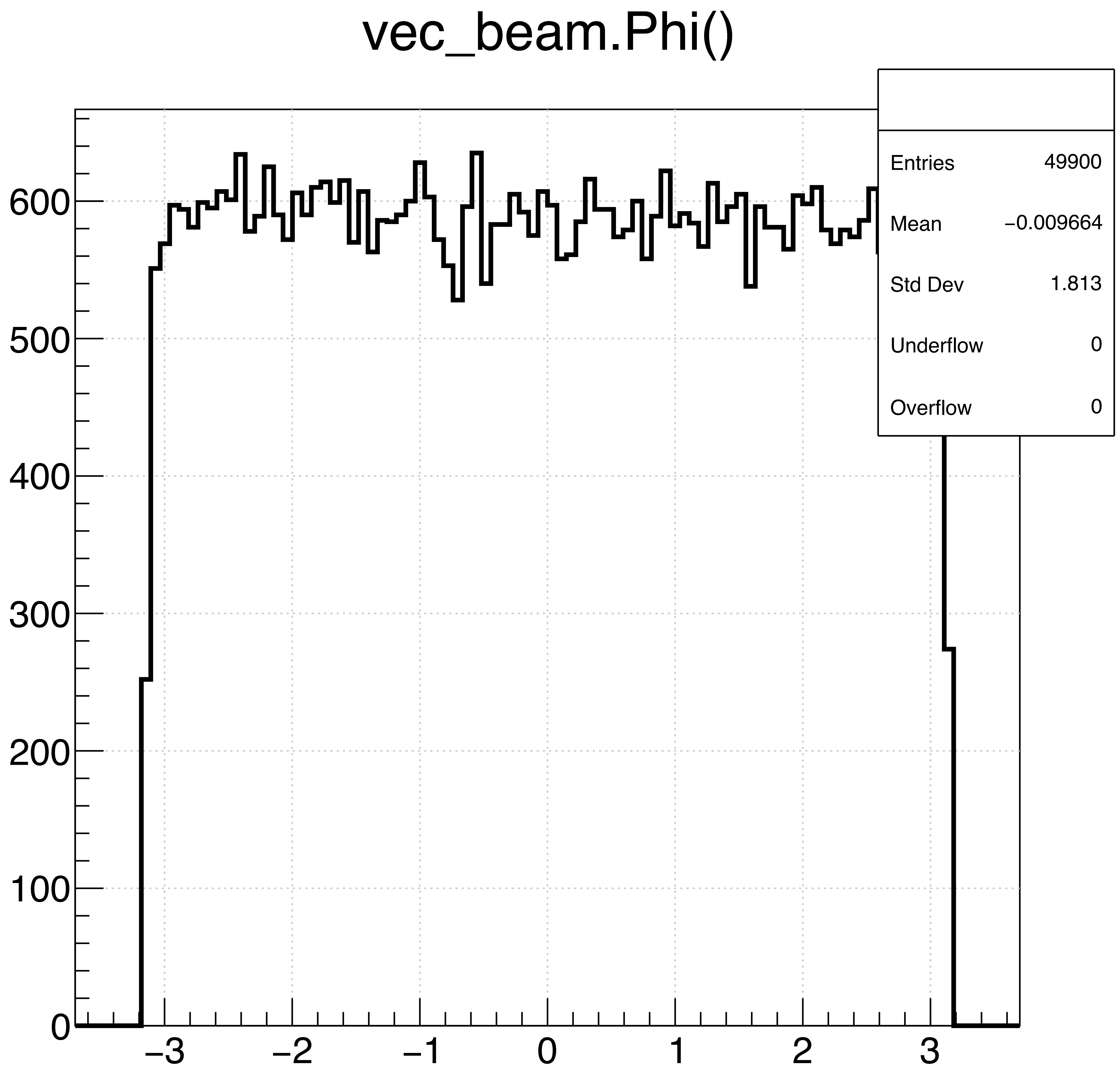
run 1: Condition

Setup:

- Single μ^- MC with $p_T = 1\ \mathrm{GeV/c}$
- $\phi = [-\pi, \pi]$
- $\eta = 0$
- $\vec{r}_{\mathrm{vertex}} = (0{,}0{,}0)\ \mathrm{cm}$
- Beam pipe, MVTX, INTT, TPC, TPOT, and EMCal are in the simulation.
- ~50k events

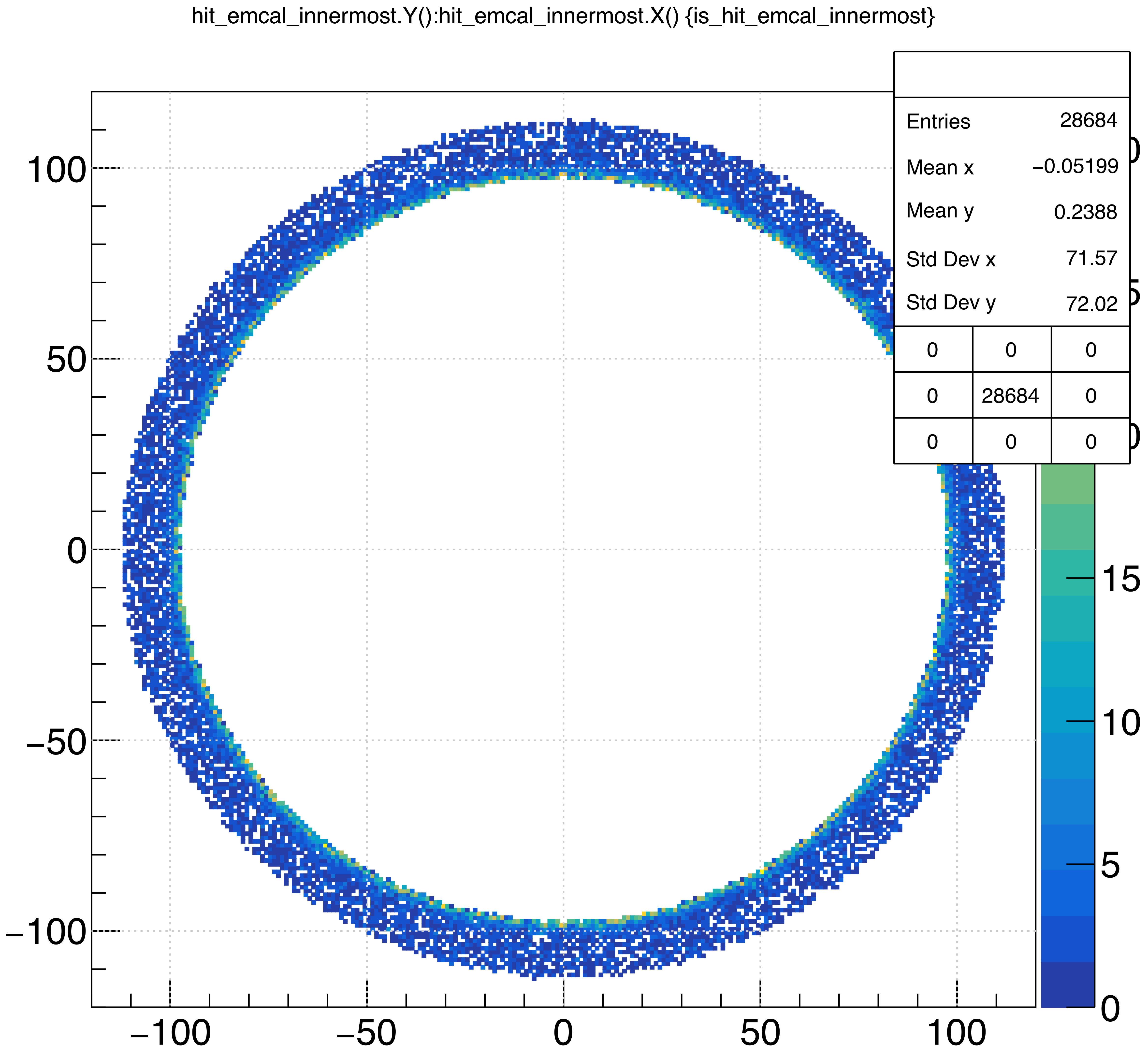
Run	#event	Beam	Momentum (GeV/c)	ϕ dist (rad)	η dist	vertex (cm)	Δϕ mean (mrad)	Δϕ std. dev. (mrad)	Δϕ resolution (%)
Pilot	2k	μ^-	(p_x, p_y, p_z)= (0, 1, 0)	fixed at π/2	fixed at 0	fixed at (0, 0, 0)	186	2.87	1.54
1	50k	μ^-	p_T = 1 GeV	[-π, π]	fixed at 0	fixed at (0, 0, 0)			

Run 1: Parameter distributions

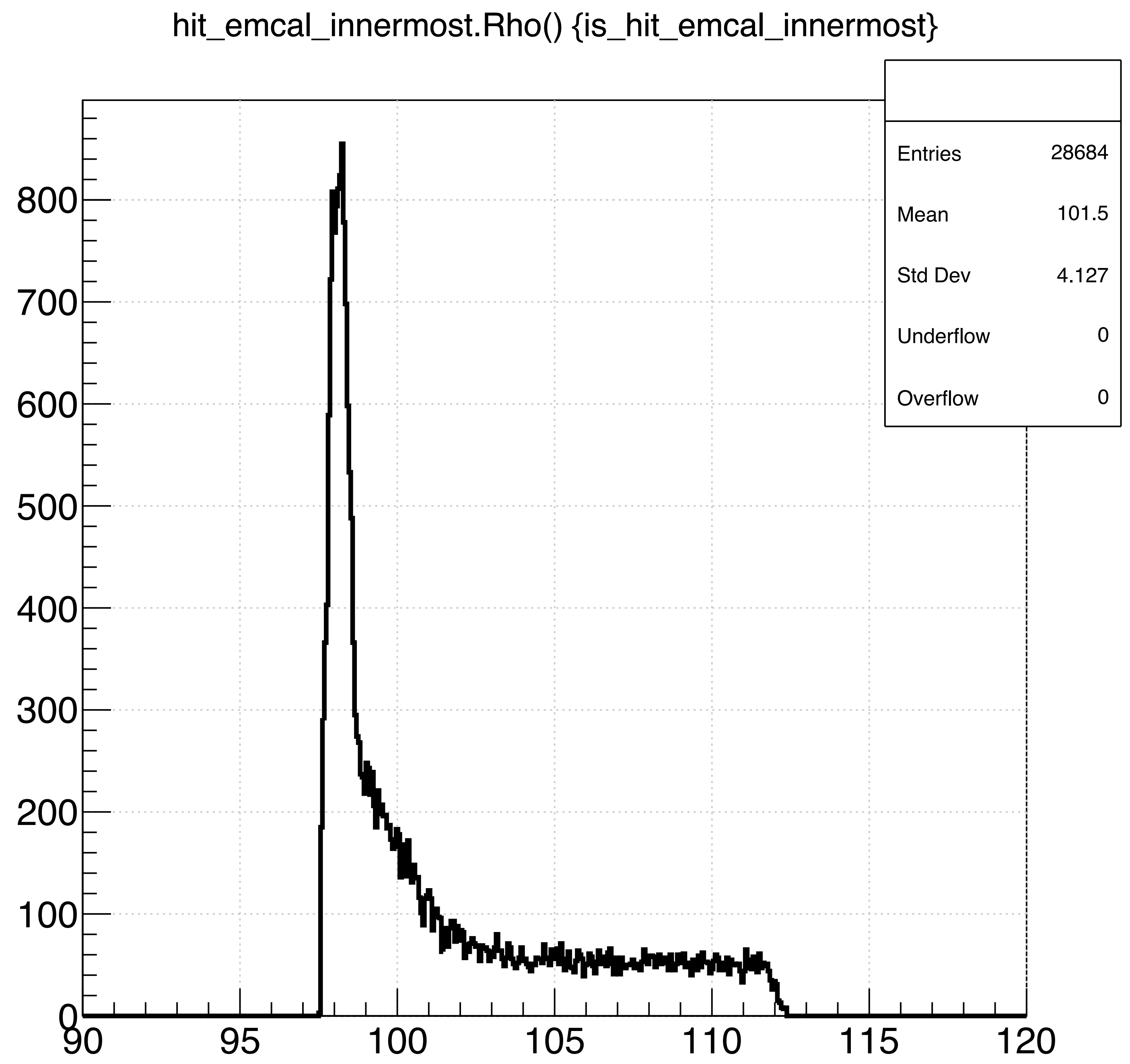


- ϕ_{beam} distribution
- Beam was generated uniformly in azimuth

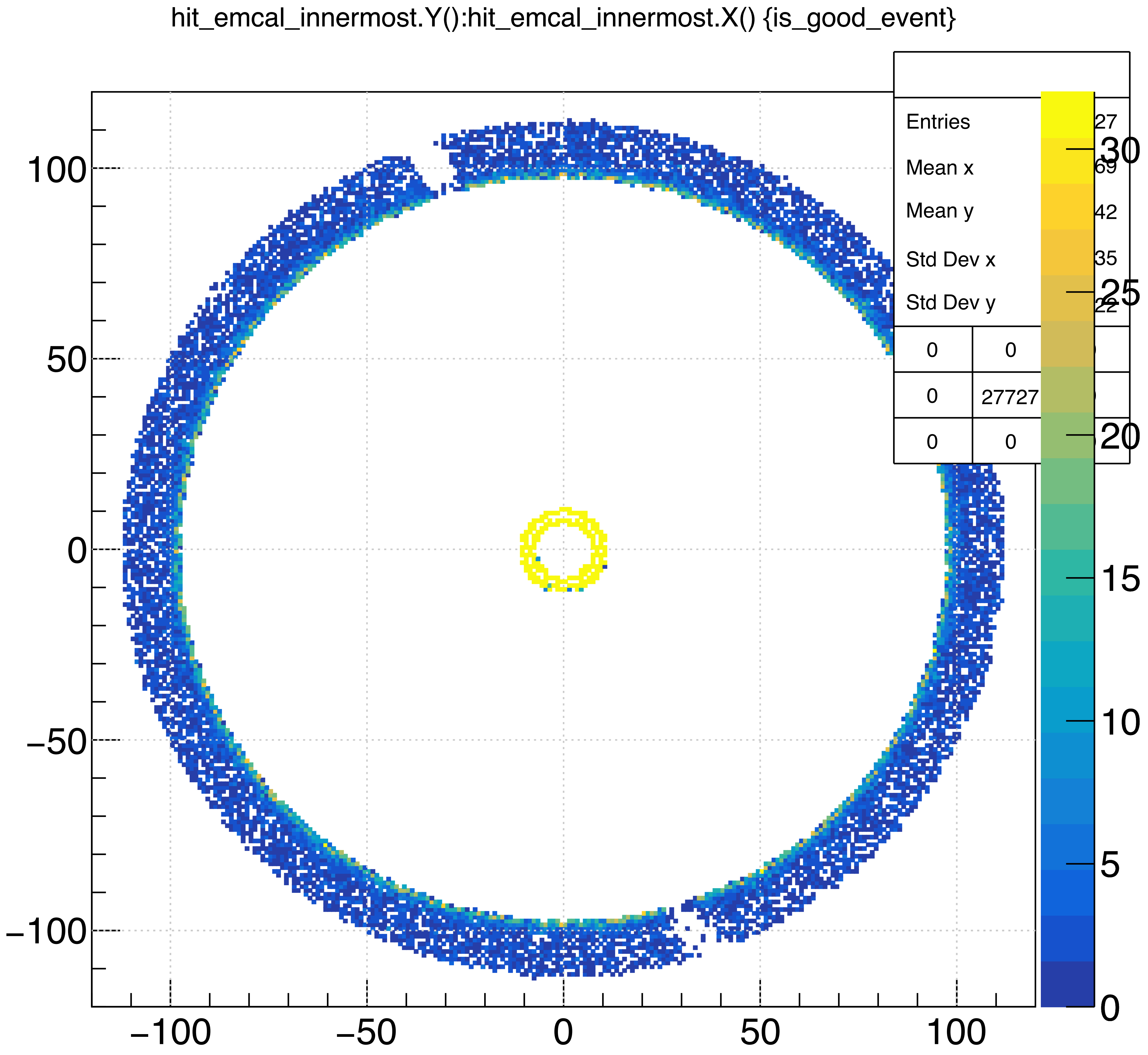
Run1: Parameter distributions



- (Left) x_{EMcal} vs y_{EMCal} distribution
- The distribution is uniform in azimuth
- (Below) $\rho_{\mathrm{EMCal}} = \sqrt{x_{\mathrm{EMCal}}^2 + y_{\mathrm{EMCal}}^2}$ distribution

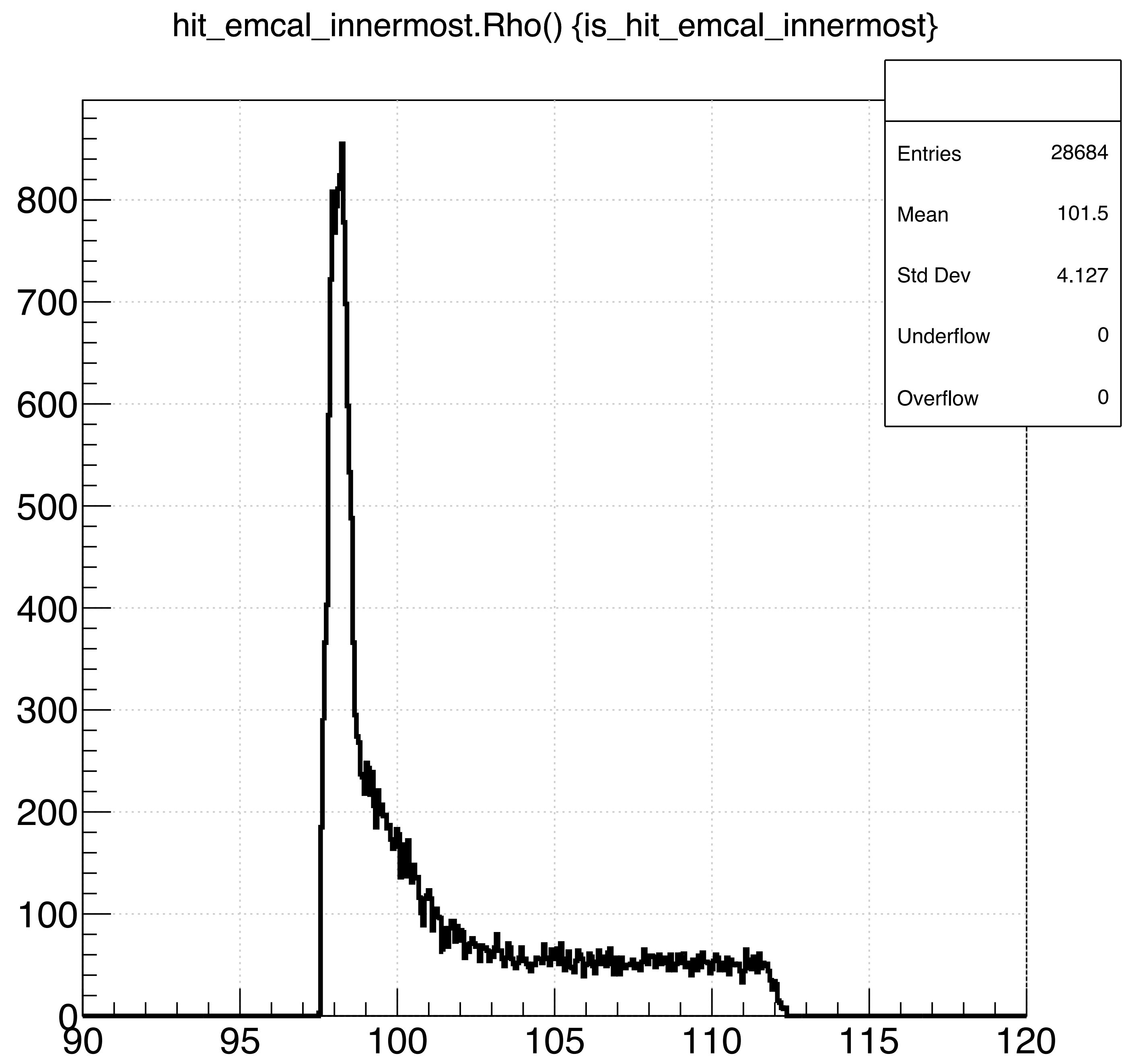


Run1: Parameter distributions

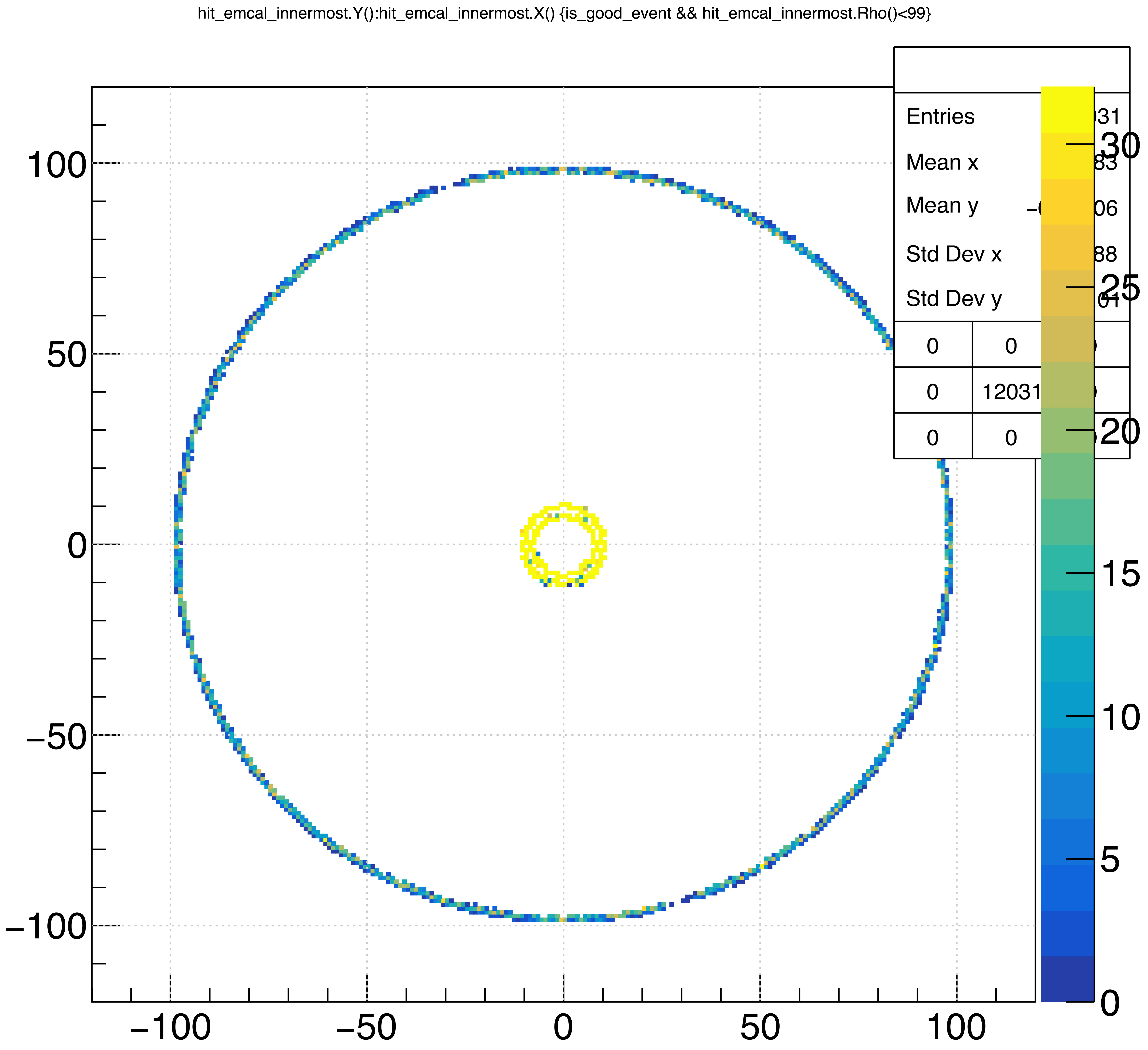


- (Left) x_{EMcal} vs y_{EMCal} distribution with cuts:
  - at least 1 EMCal hit
  - at least 2 INTT hits

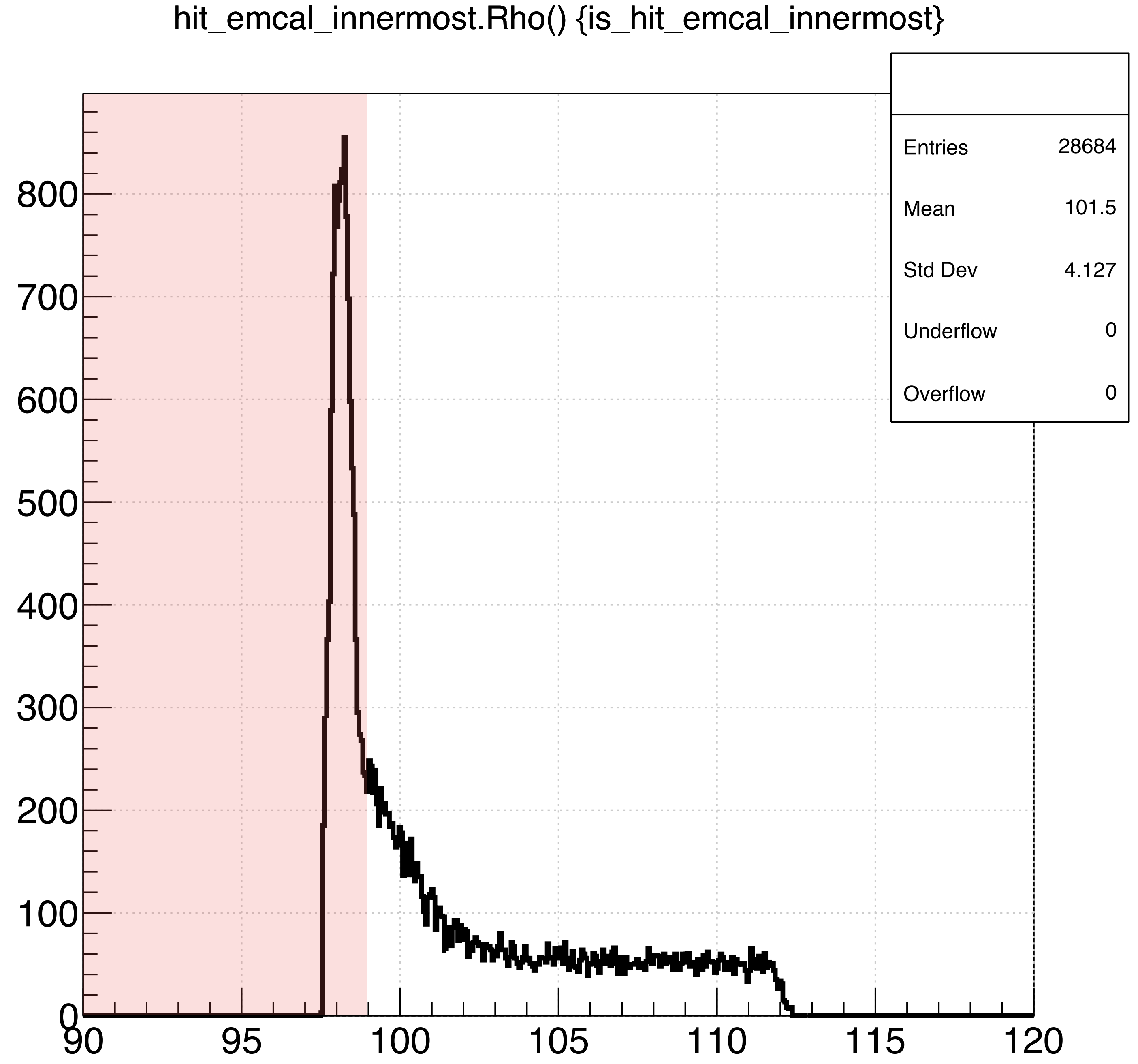
- (Below) $\rho_{\text{EMCal}} = \sqrt{x_{\text{EMCal}}^2 + y_{\text{EMCal}}^2}$ distribution



Run1: Parameter distributions



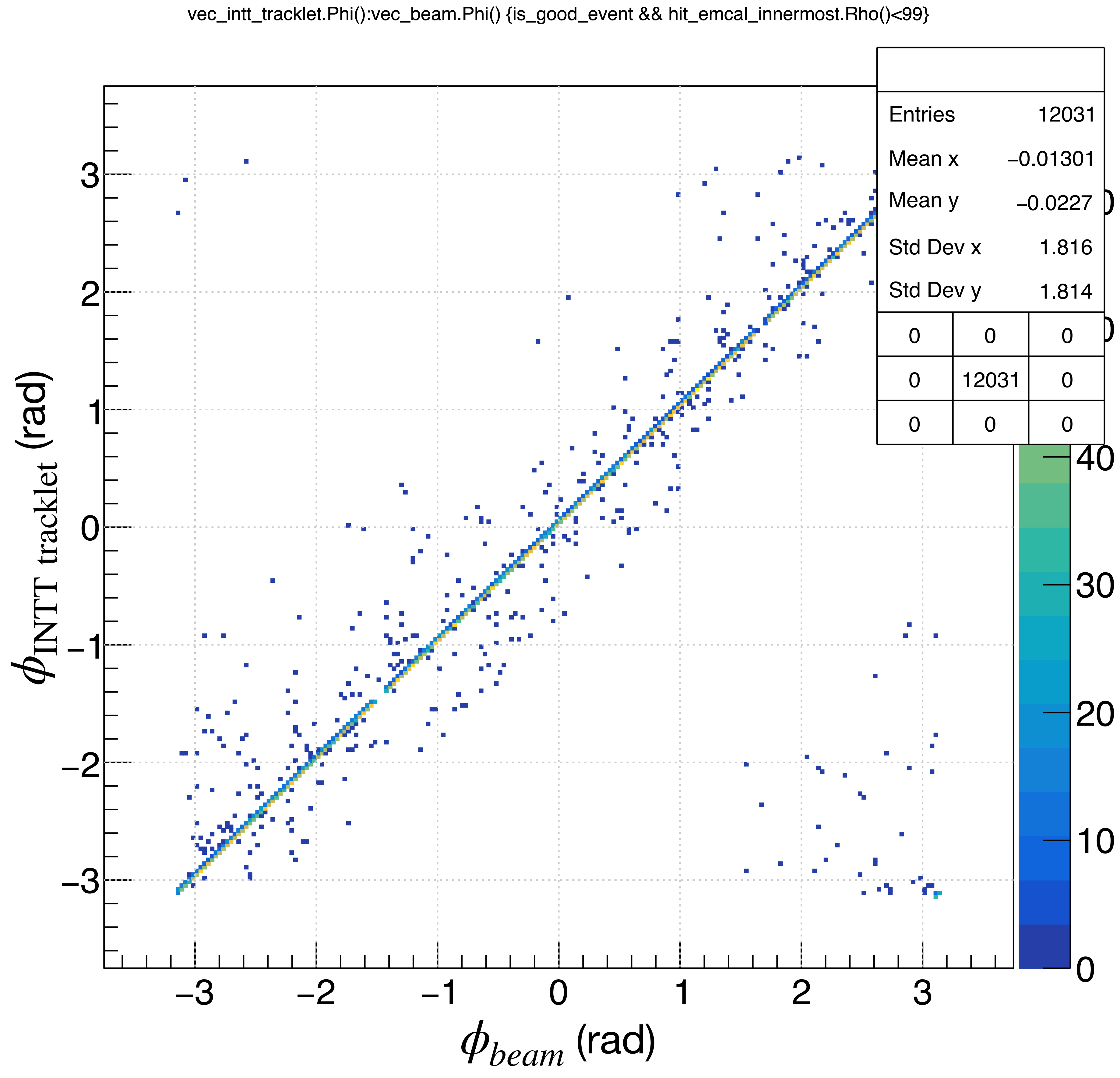
- (Left) x_{EMcal} vs y_{EMCal} distribution with cuts:
  - at least 1 EMCal hit
  - at least 2 INTT hits
  - $\rho_{\mathrm{EMCal}} < 99$ cm
- (Below) $\rho_{\mathrm{EMCal}} = \sqrt{x_{\mathrm{EMCal}}^2 + y_{\mathrm{EMCal}}^2}$ distribution

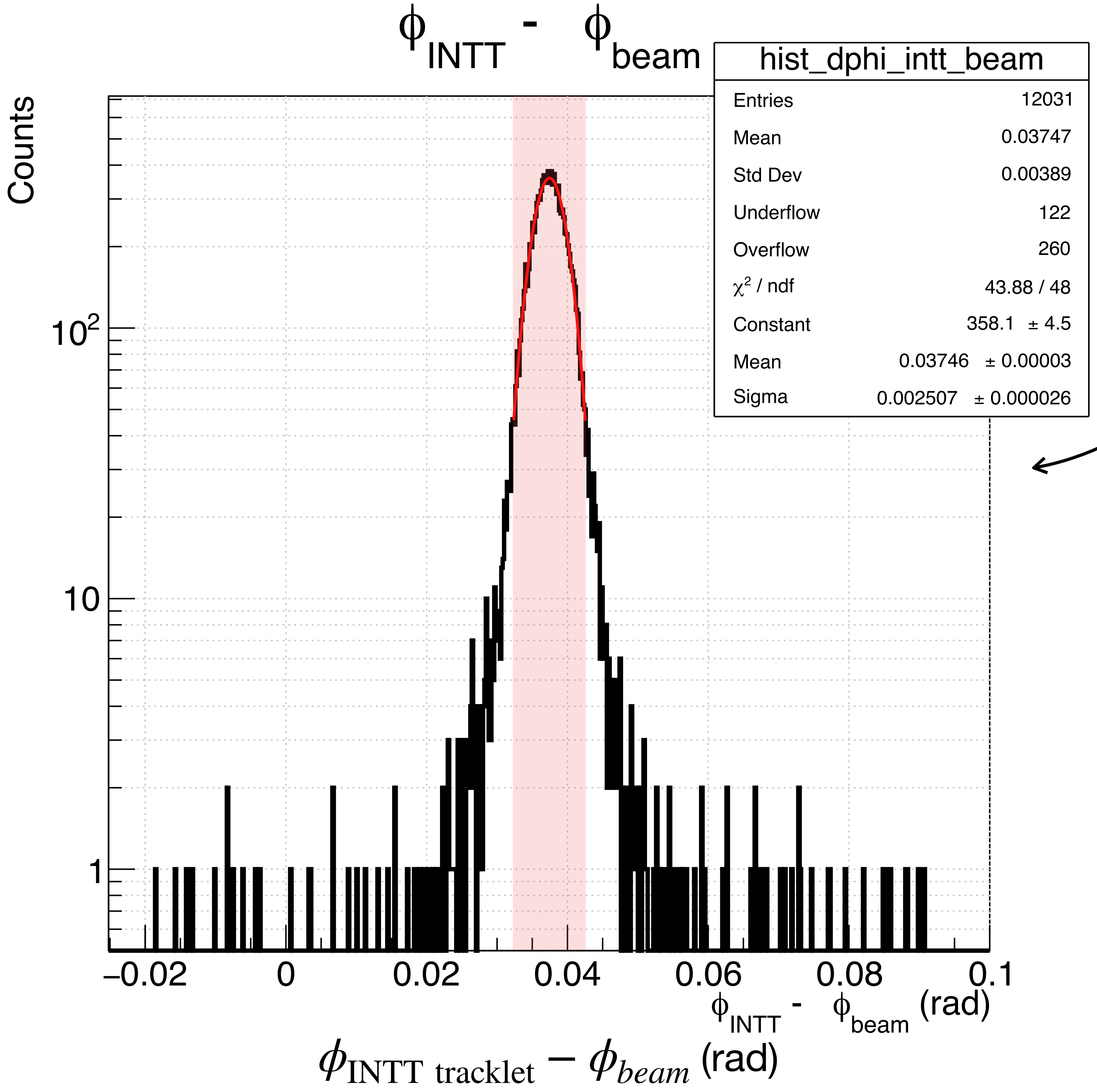


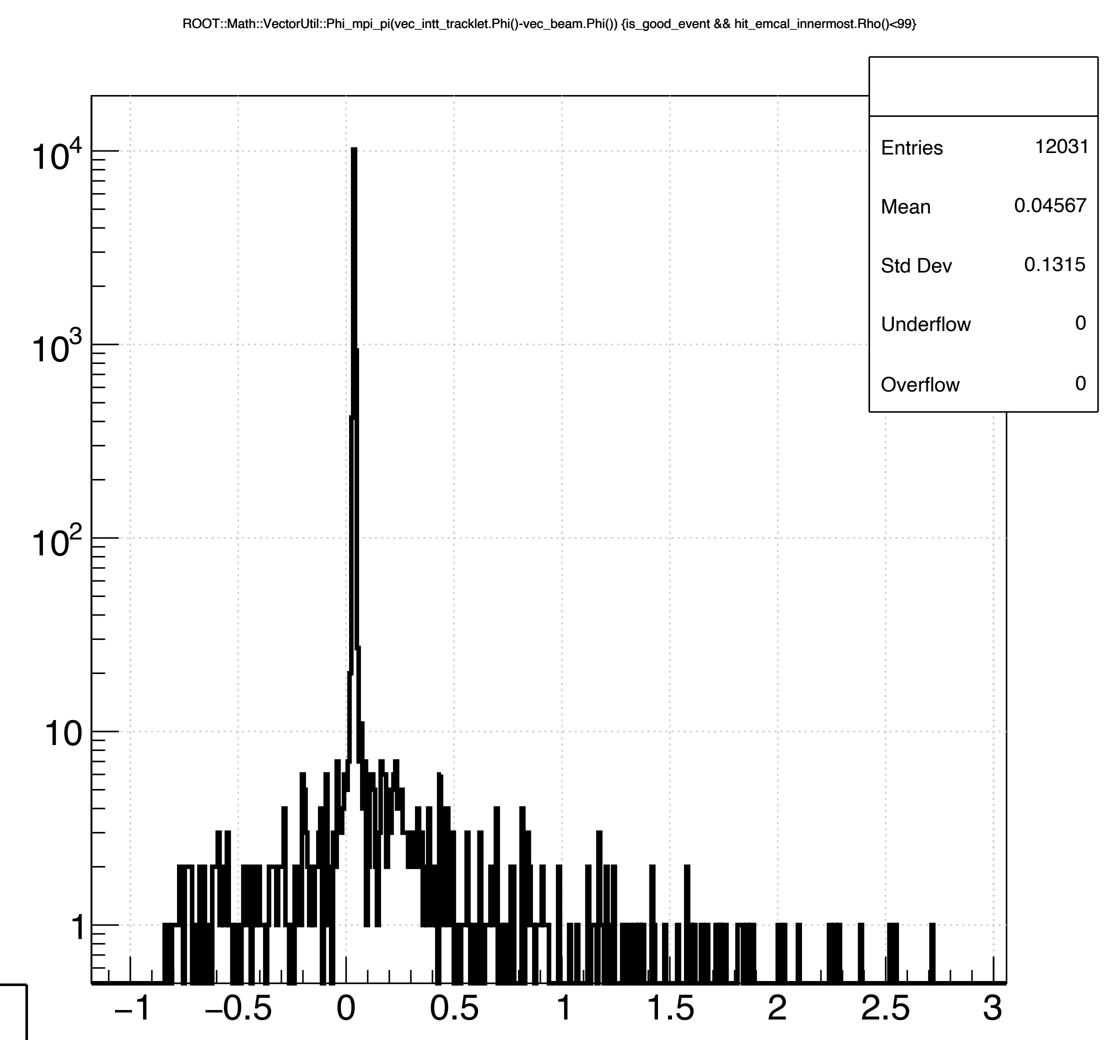
Run1: ϕ of beam and INTT tracklet

Cuts

- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\mathrm{EMCal}} < 99$ cm

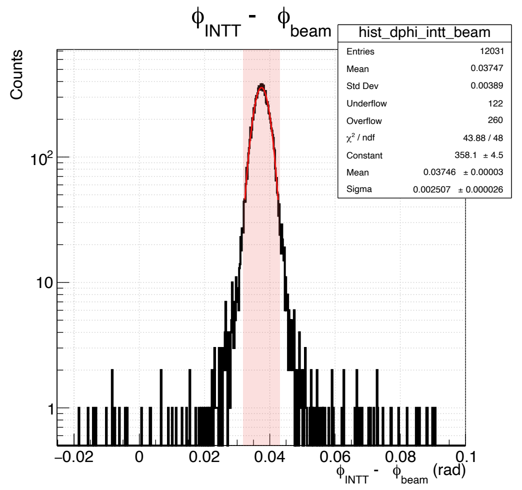






zoom

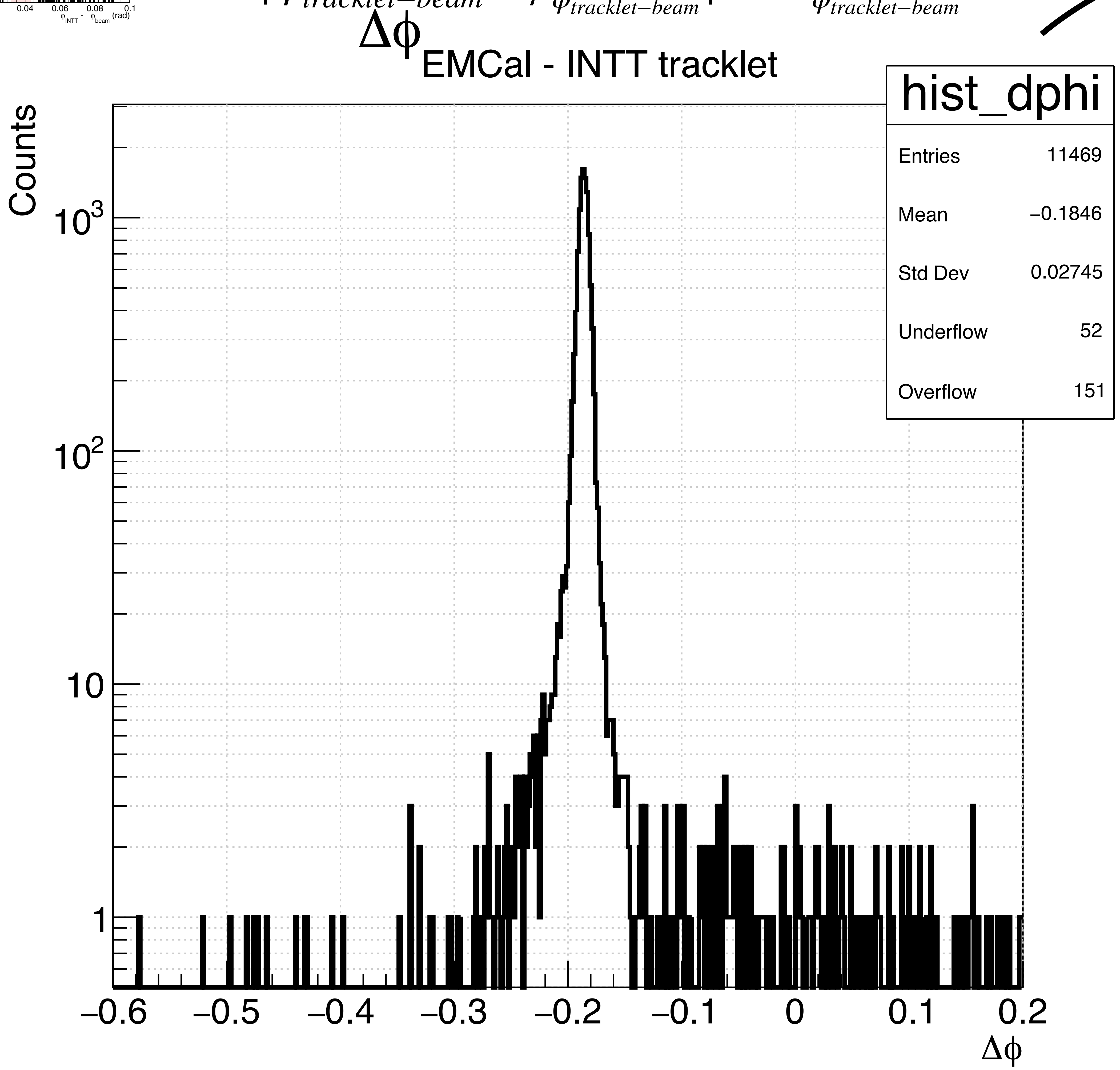
Run1 : ϕ angle resolution

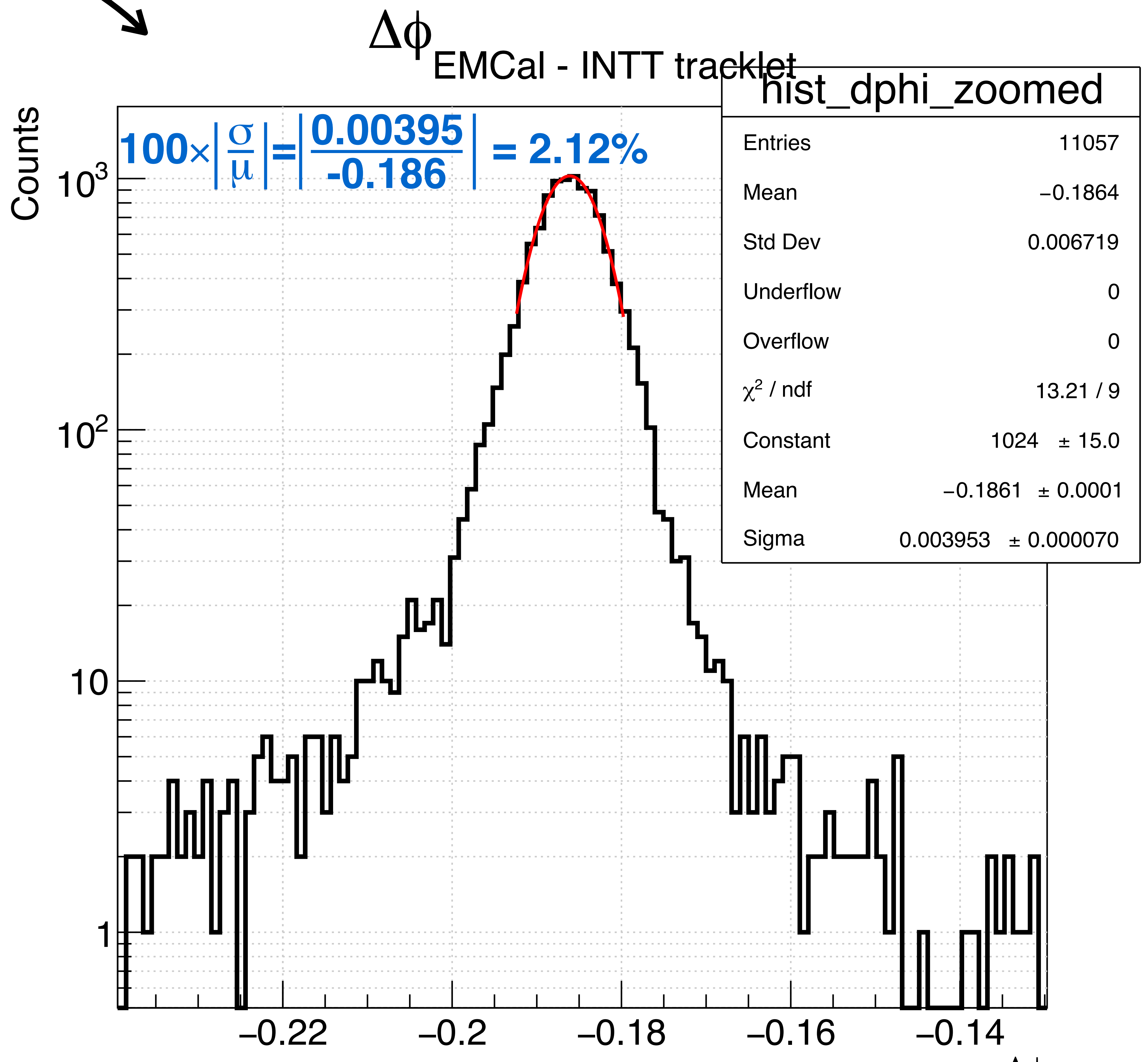


Cuts

- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\text{EMCal}} < 99$ cm
- $|\phi_{tracklet-beam} - \mu_{\phi_{tracklet-beam}}| < 2\sigma_{\phi_{tracklet-beam}}$

zoom



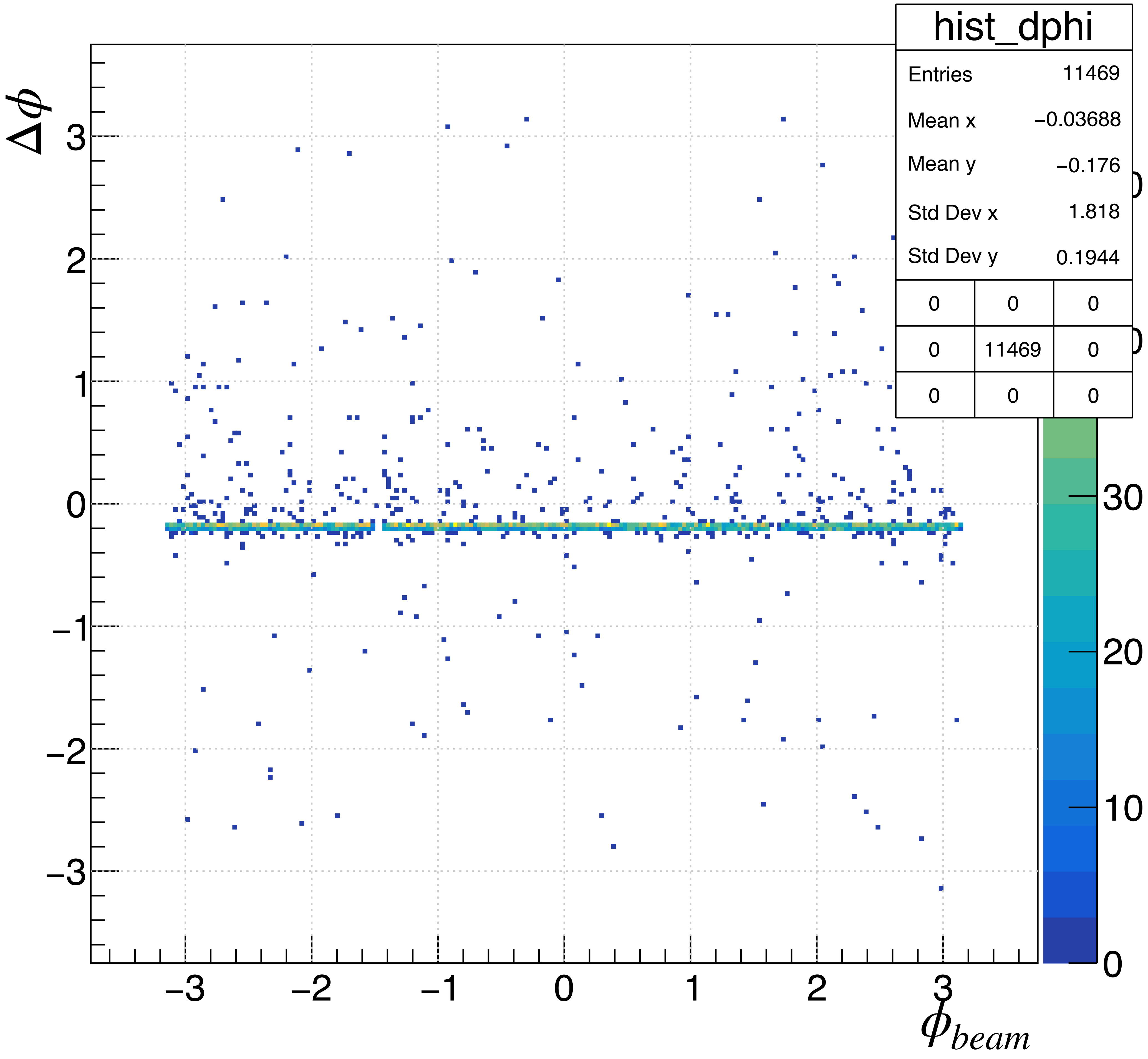


Fittings were performed 10 times iteratively.

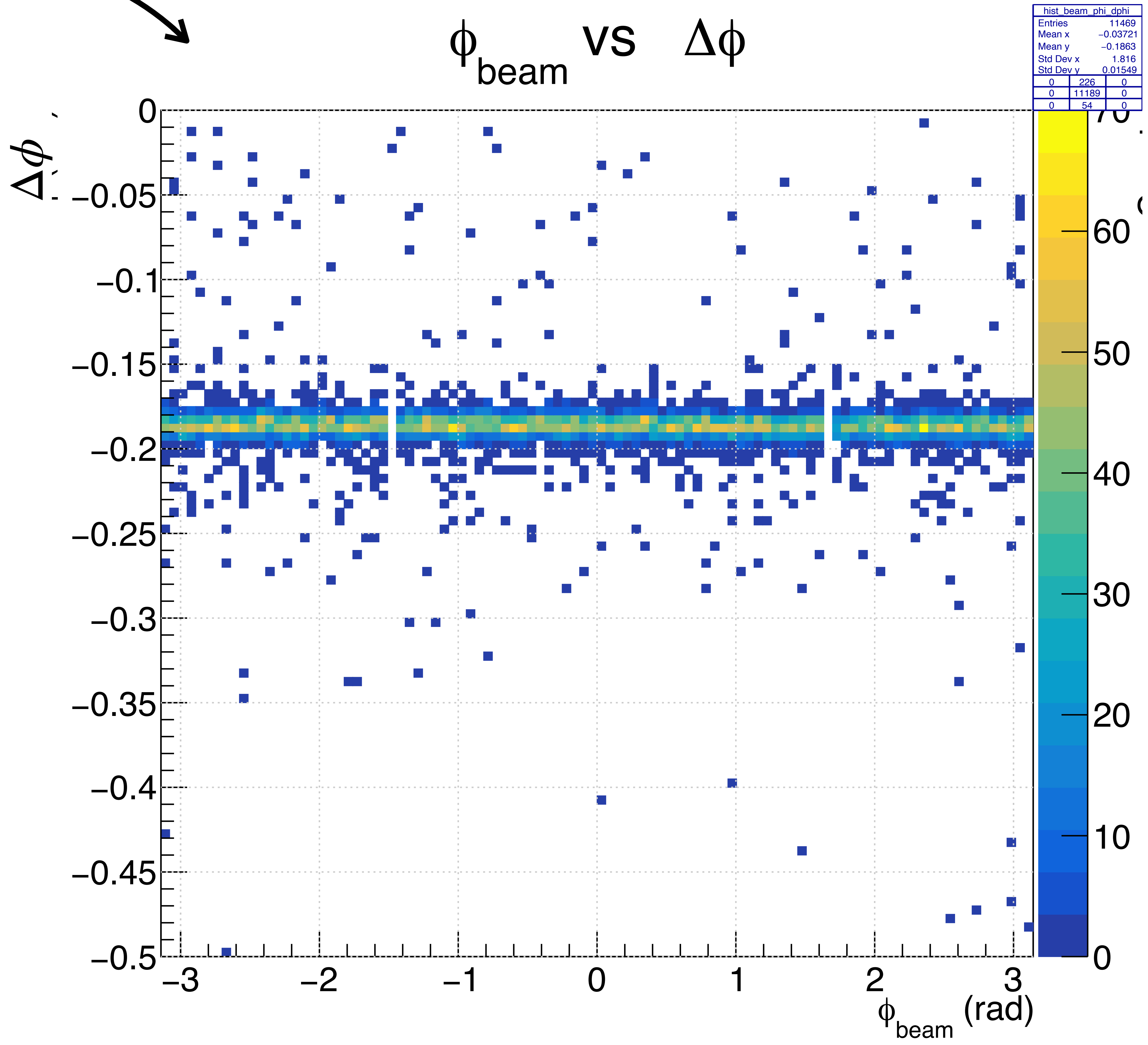
Run1 : ϕ angle resolution as a function of ϕ_{beam}

Cuts

- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\text{EMCal}} < 99$ cm
- $|\phi_{tracklet-beam} - \mu_{\phi_{tracklet-beam}}| < 2\sigma_{\phi_{tracklet-beam}}$



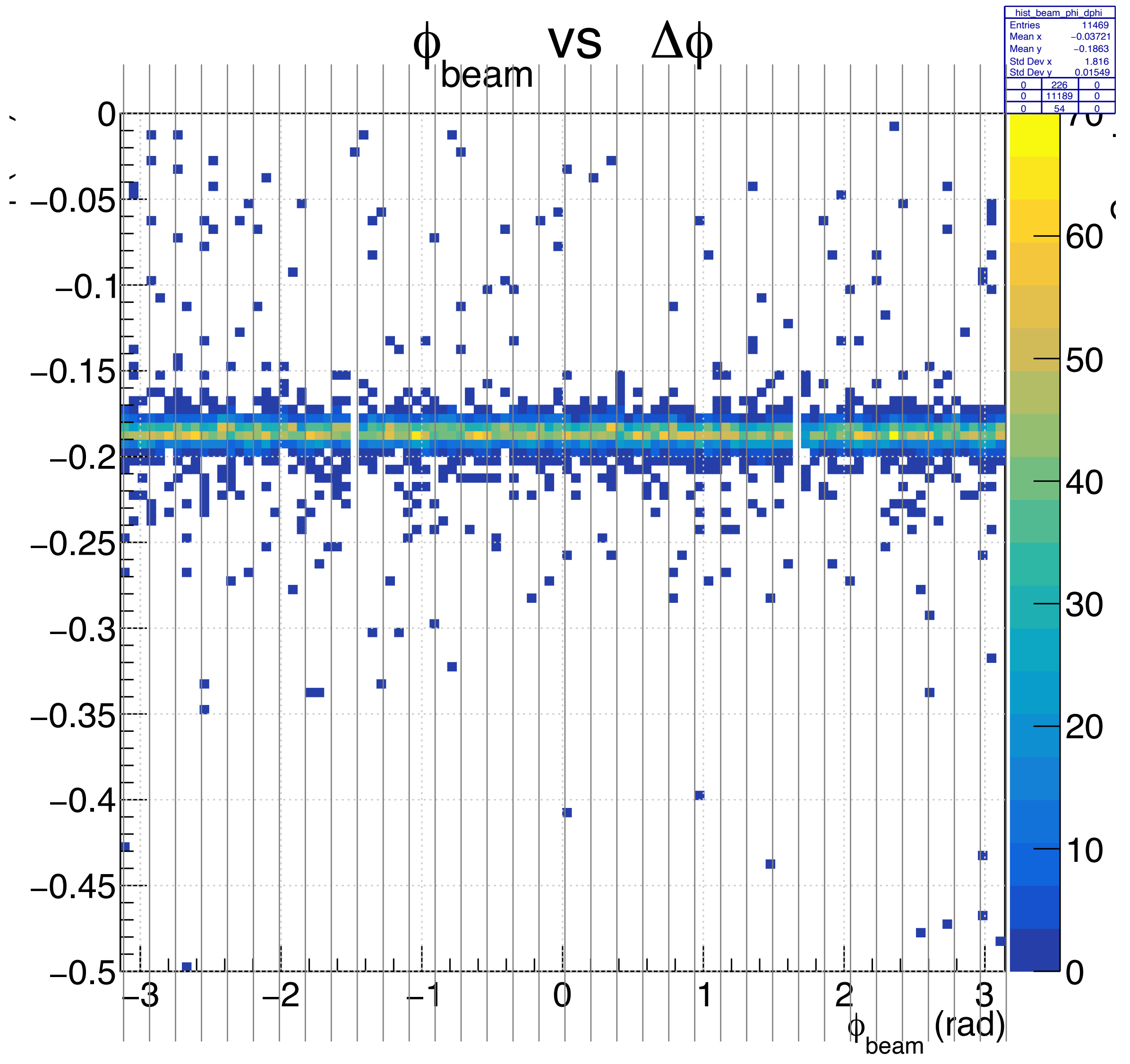
zoom



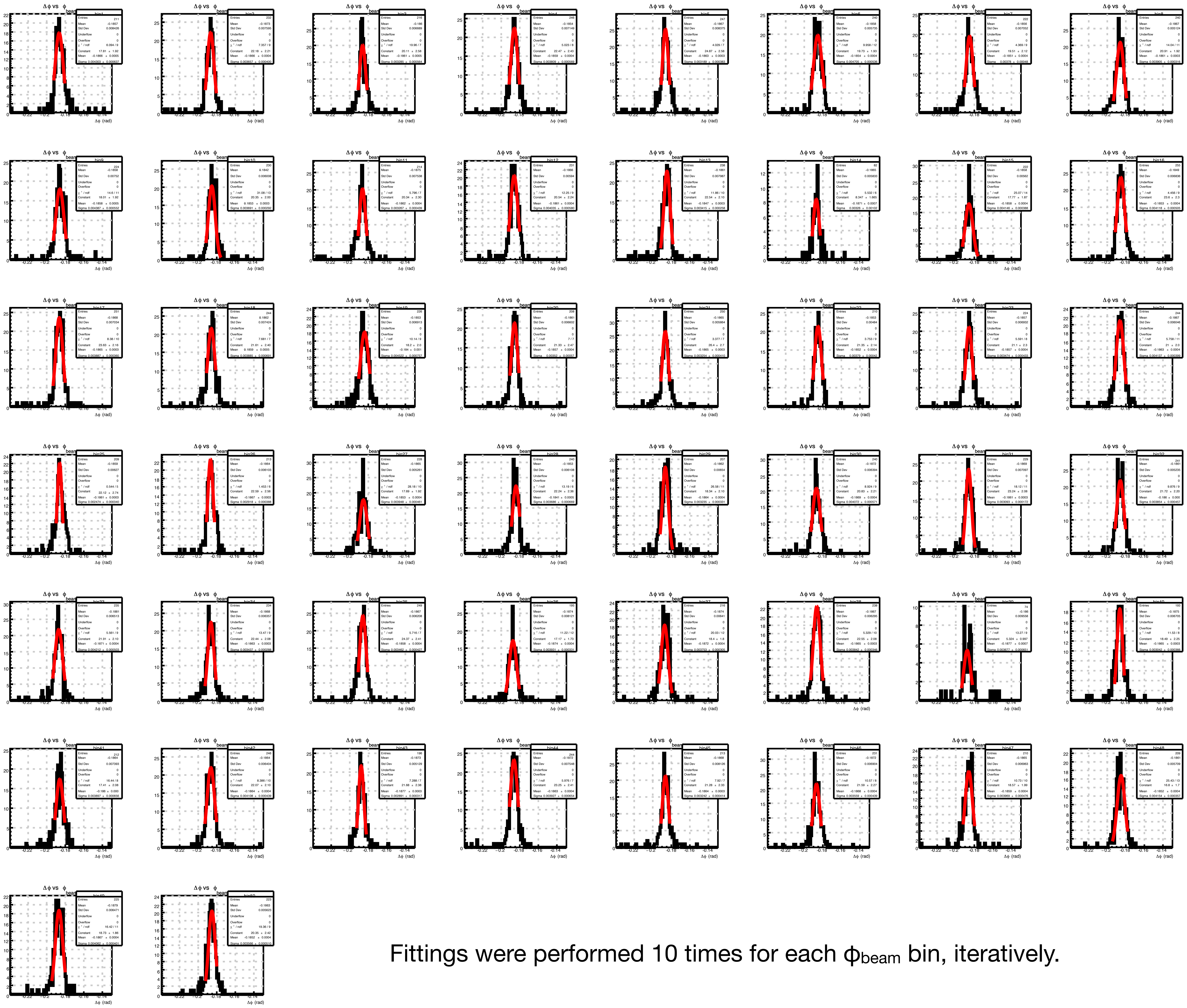
Run1 : ϕ angle

Cuts

- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\mathrm{EMCal}} < 99$ cm
- $|\phi_{tracklet-beam} - \mu_{\phi_{tracklet-beam}}| < 2\sigma_{\phi_{tracklet-beam}}$

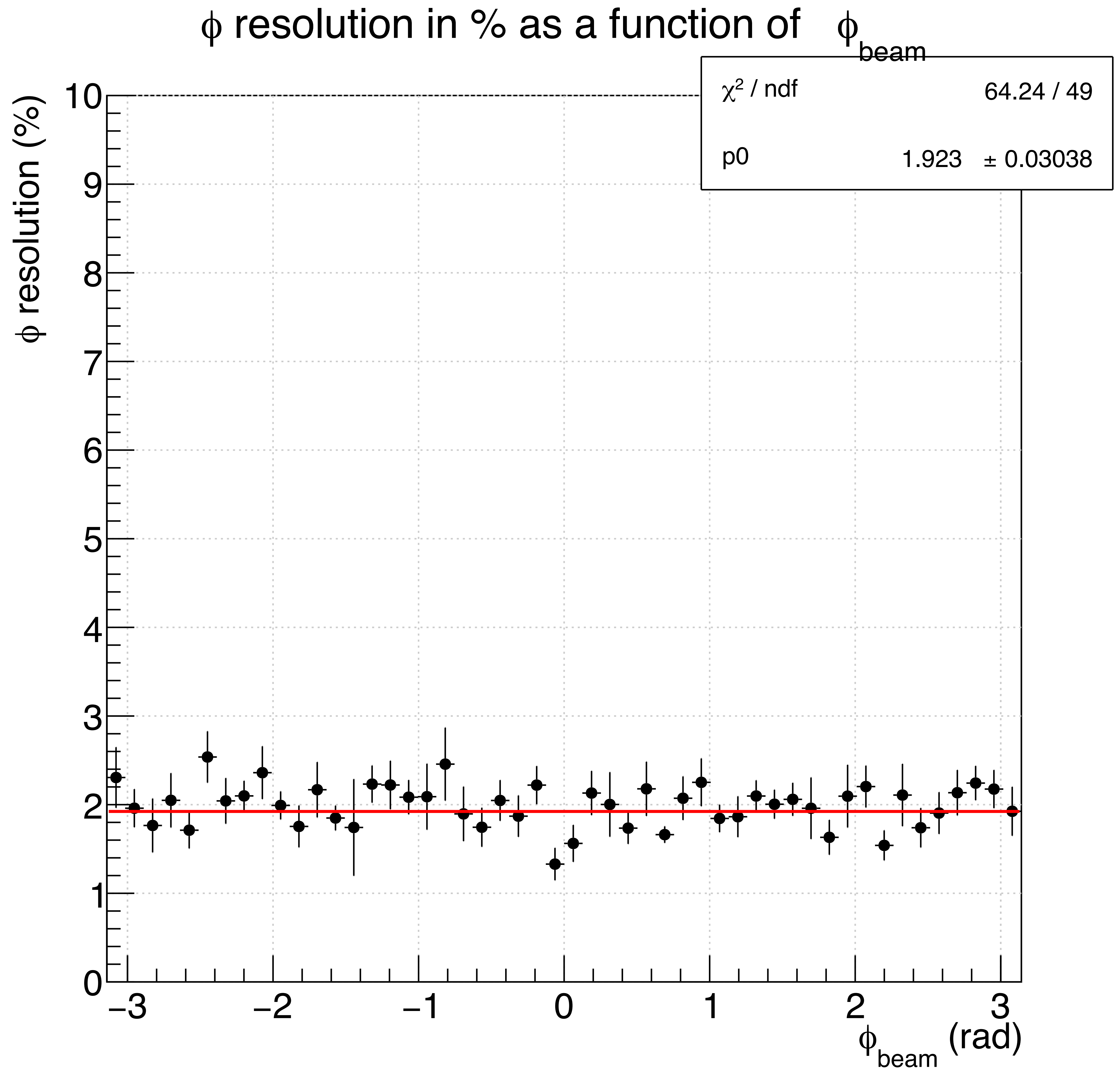


Mean and std. dev. are evaluated for each ϕ_{beam} bin.
The bin width is currently 2π/50.



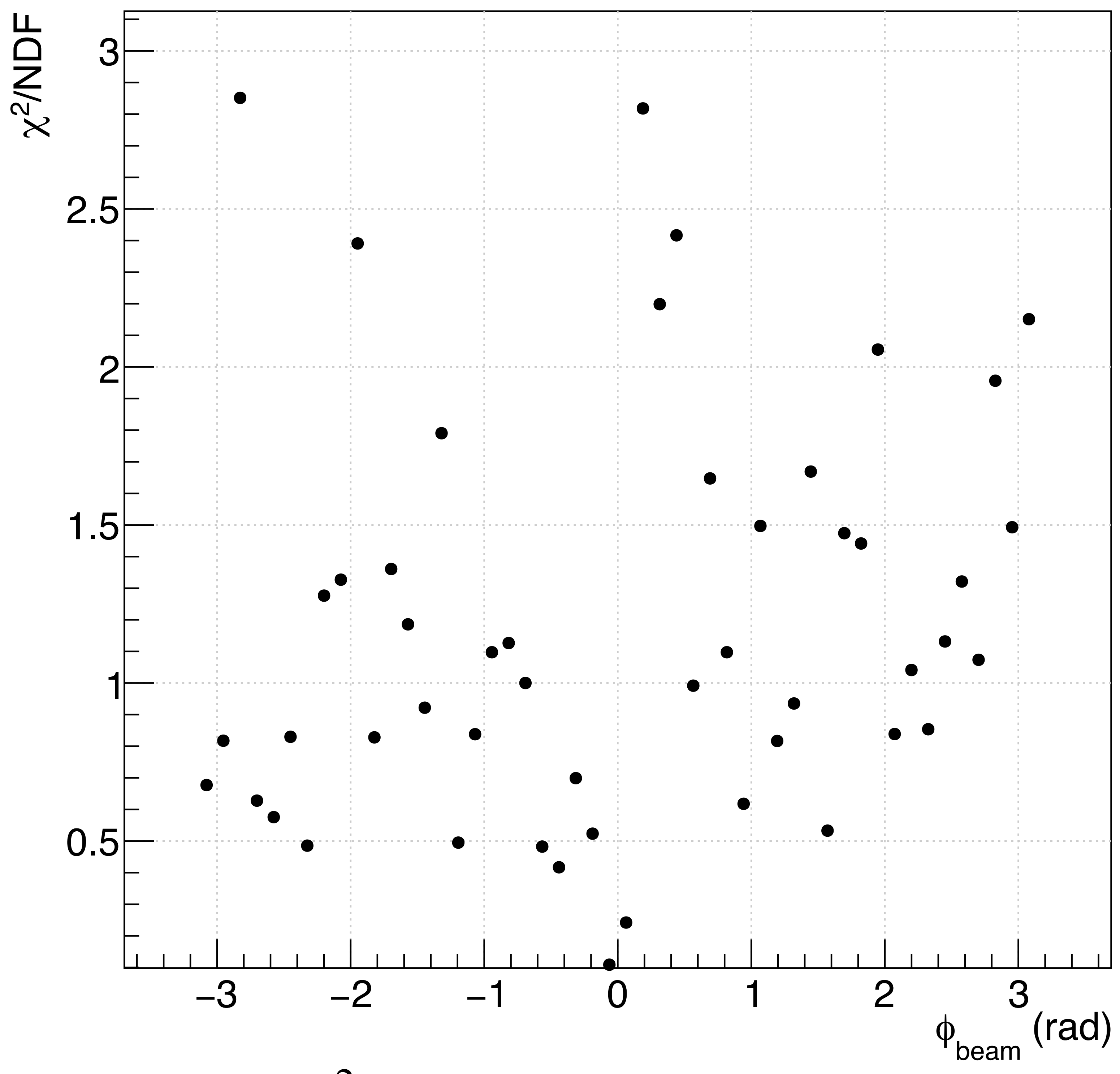
Fittings were performed 10 times for each ϕ_{beam} bin, iteratively.

Run1 : ϕ angle resolution as a function of ϕ_{beam}



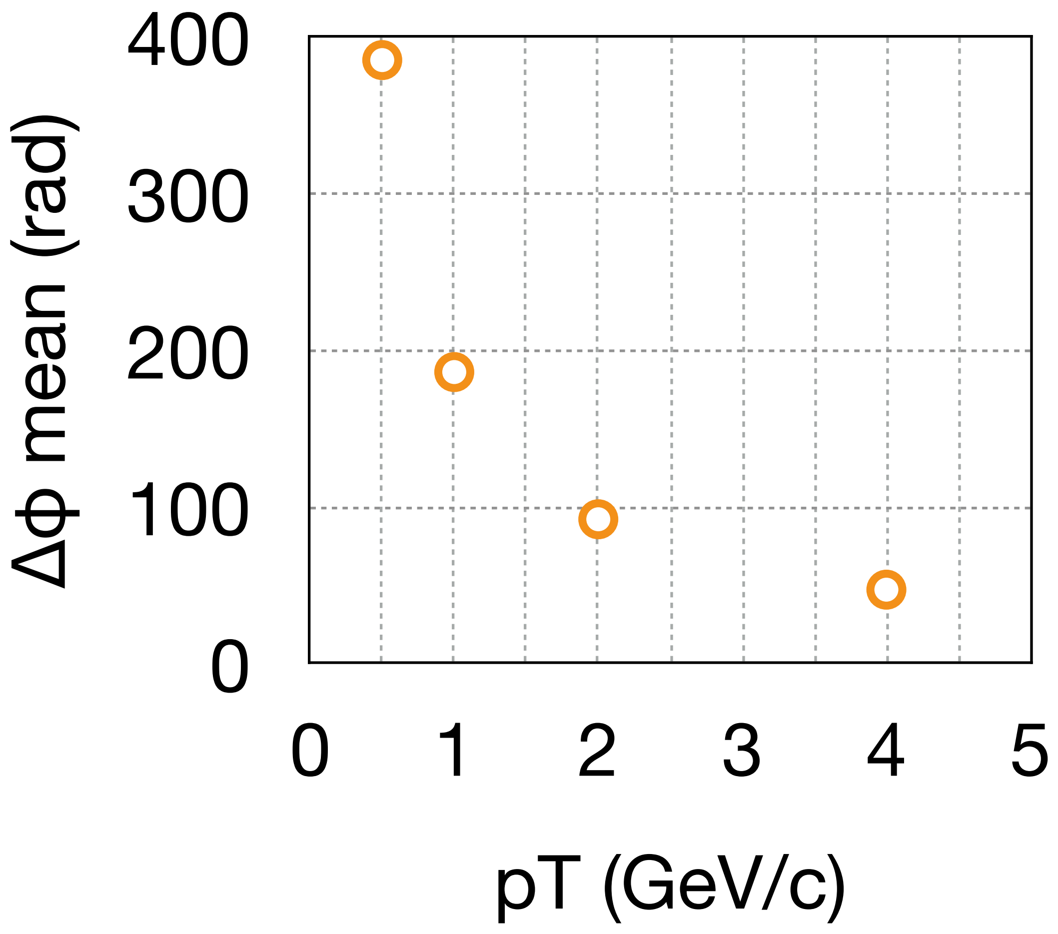
Cuts

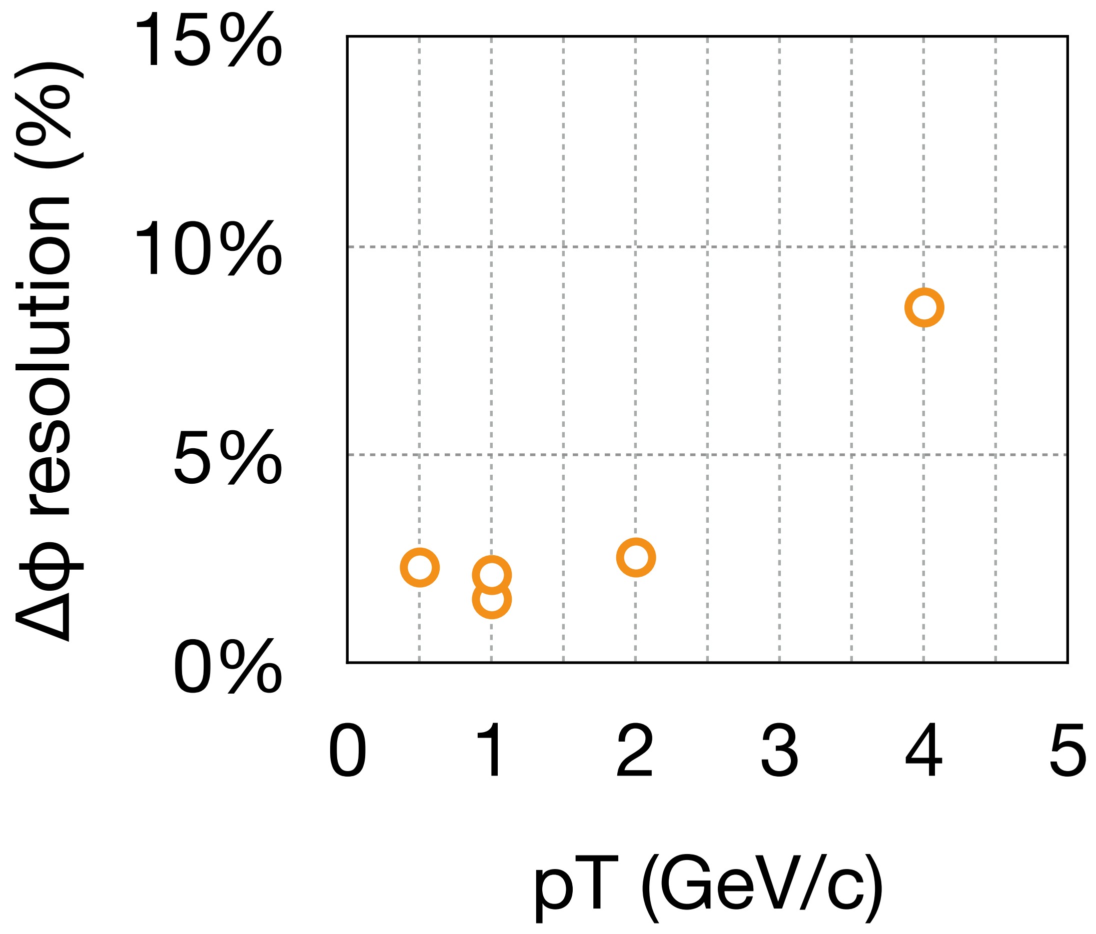
- At least 1 EMCal hit
- At least 2 INTT hits
- $\rho_{\text{EMCal}} < 99$ cm
- $|\phi_{tracklet-beam} - \mu_{\phi_{tracklet-beam}}| < 2\sigma_{\phi_{tracklet-beam}}$

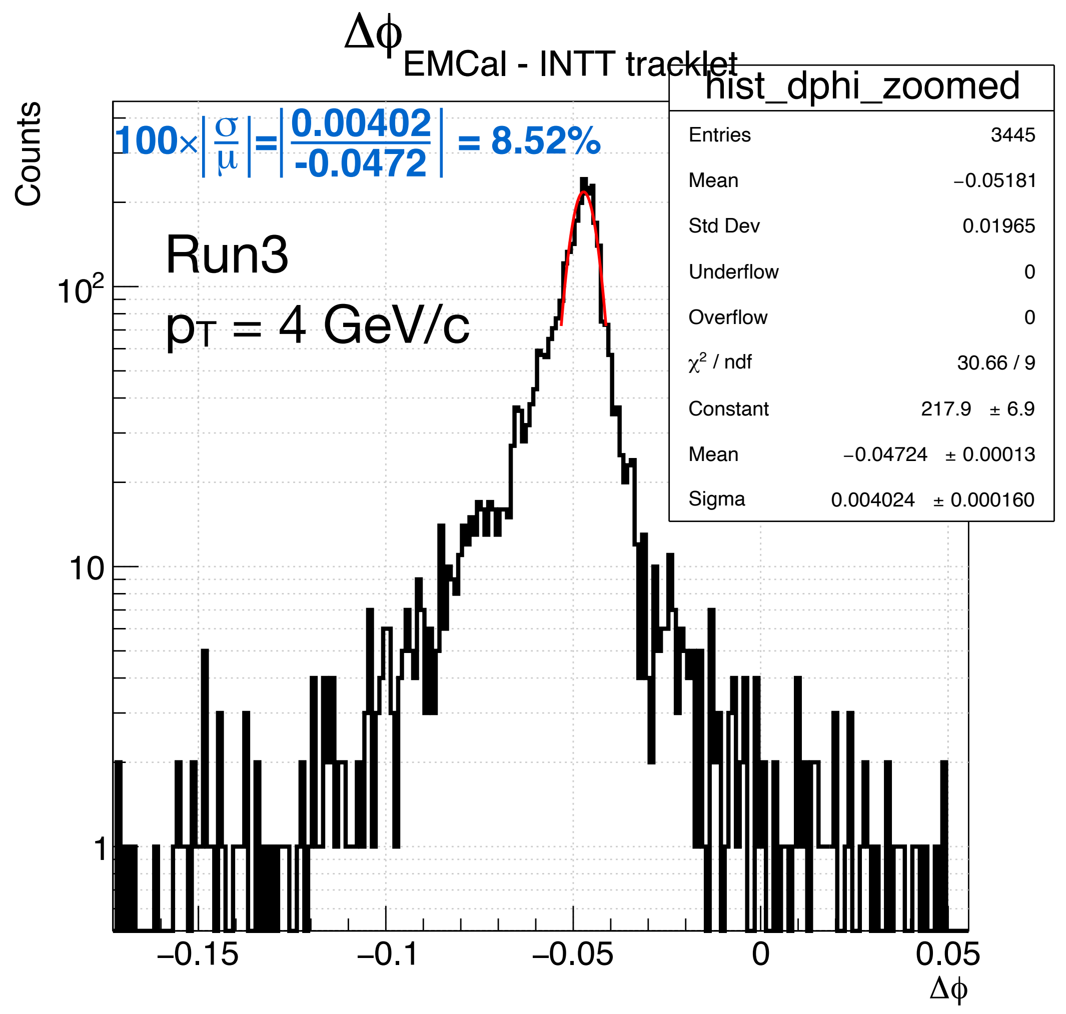


χ^2/NDF of gaussian fittings.

Beam Energy Scan







Run	#event	Beam	Momentum (GeV/c)	ϕ dist (rad)	η dist	vertex (cm)	Δϕ mean (mrad)	Δϕ std. dev. (mrad)	Δϕ resolution (%)
Pilot	2k	μ^-	1	fixed at π/2	fixed at 0	fixed at (0, 0, 0)	186	2.87	1.54%
1	50k	μ^-	1	[-π, π]	fixed at 0	fixed at (0, 0, 0)	186	3.95	2.12%
2	50k	μ^-	2	[-π, π]	fixed at 0	fixed at (0, 0, 0)	92.1	2.34	2.54%
3	50k	μ^-	4	[-π, π]	fixed at 0	fixed at (0, 0, 0)	47.2	4.02	8.52%
4	50k	μ^-	0.5	[-π, π]	fixed at 0	fixed at (0, 0, 0)	385	8.85	2.30%

←!?