Reconstruction of merged π^0 in the Barrel EMC

PANDA Collaboration Meeting 2/19

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June 25, 2019

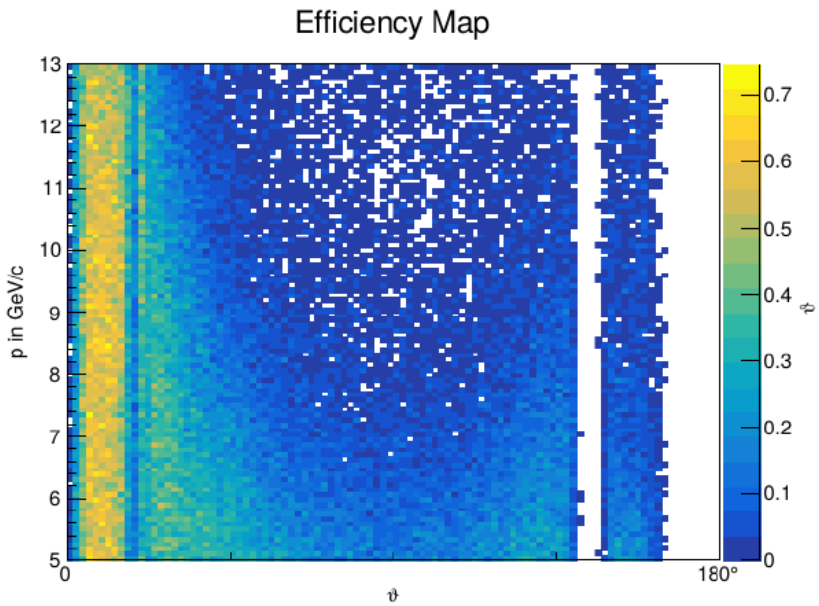
What I'm supposed to do

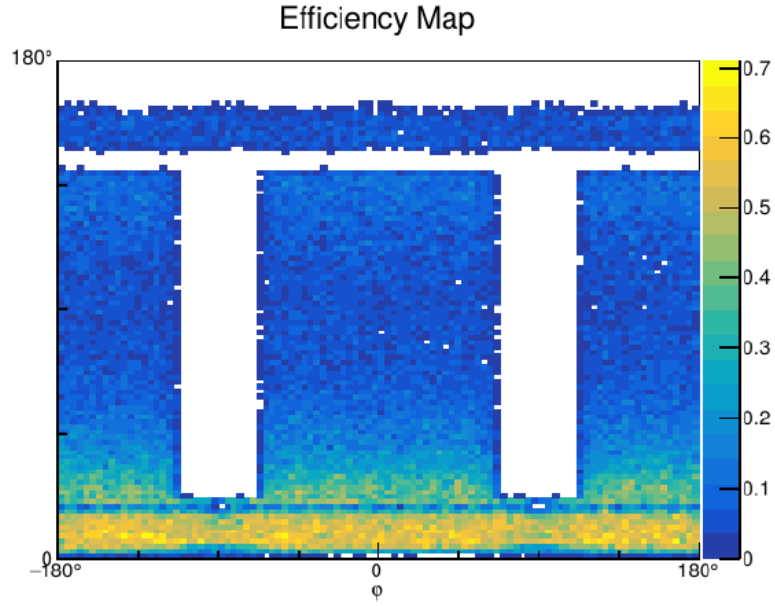
- Efficiency and acceptance studies for PANDA Day-1 setup
- Channel: p p $\rightarrow$ p p π^0
- Beam momentum (1.5-15) GeV/c

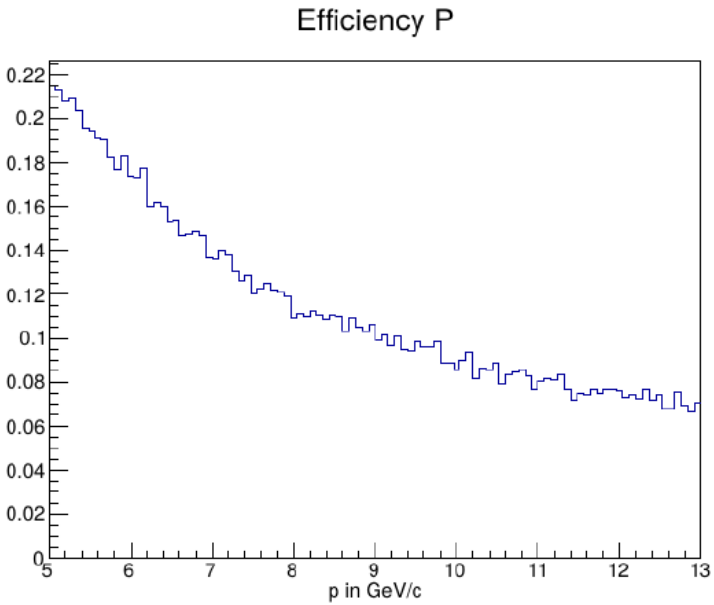
- Test sample
  - BOX generator π^0s @ 5-15 GeV/c
  - Isotropic in ϑ and φ
  - PandaRoot full simulation
  - Day-1 setup
  - π^0 decay performed by GEANT 3
  - Reconstruction of $\pi^0 \rightarrow \gamma\gamma$

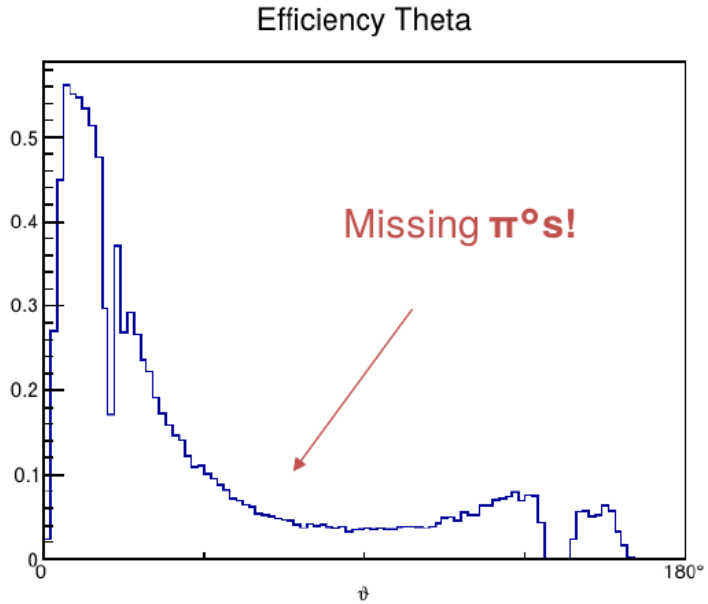
Motivation

π^0 reconstruction efficiency









π^0 Decay

- π^0 decay in rest frame
  - γs are emitted back to back

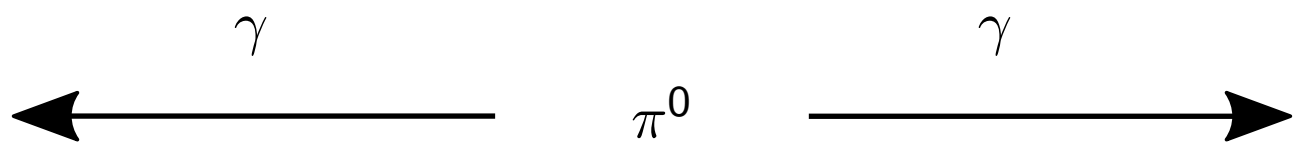
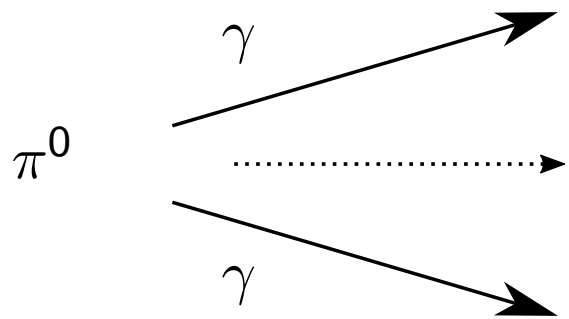
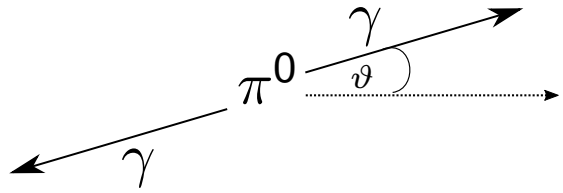


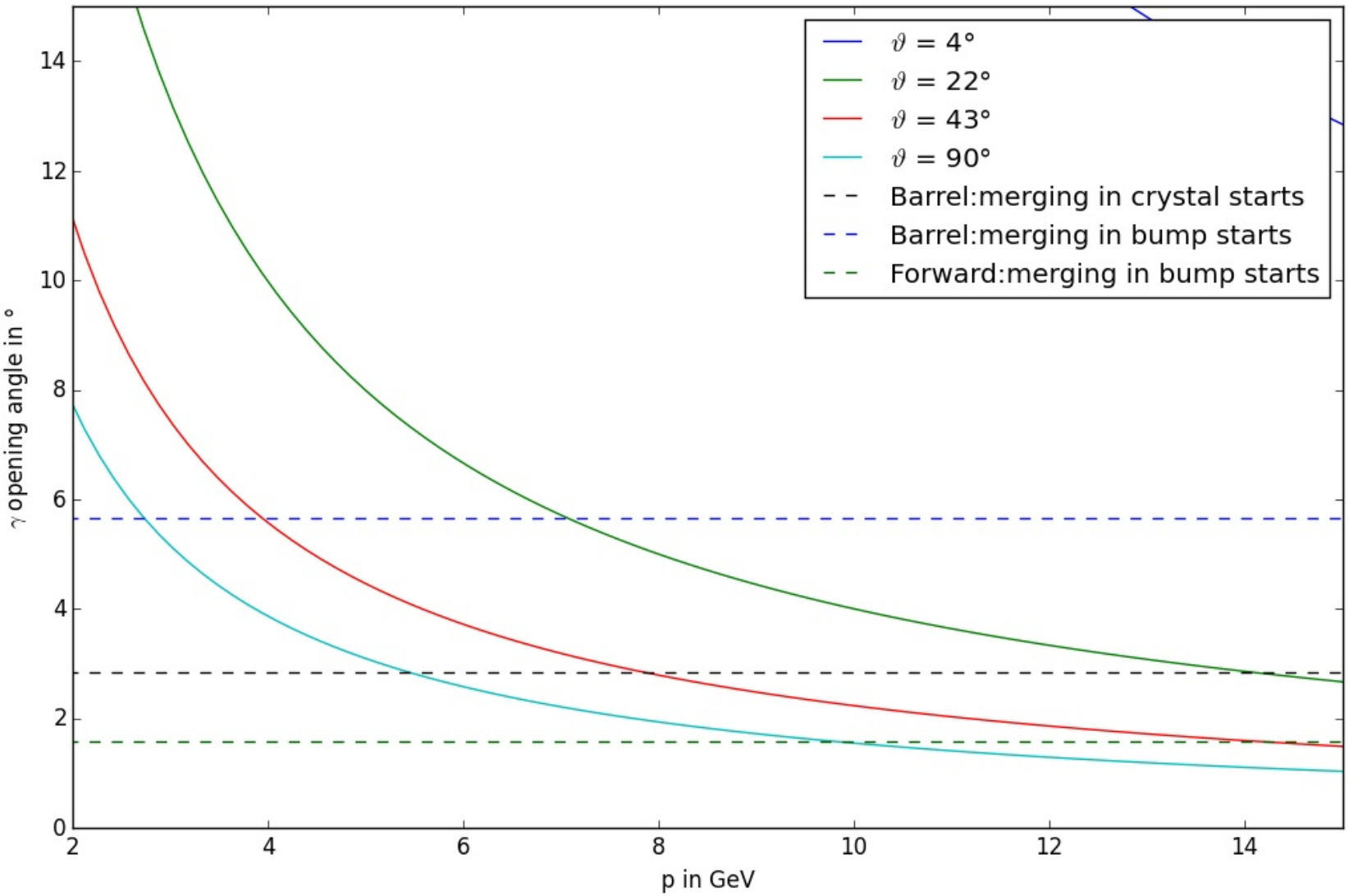
Figure: π^0 decay in its rest frame.

- π^0 decay in lab frame
  - γs are boosted forward
  - Hit neighboring/same EMC crystal
  - Not resolvable with bump splitting algorithm
- Merged π^0



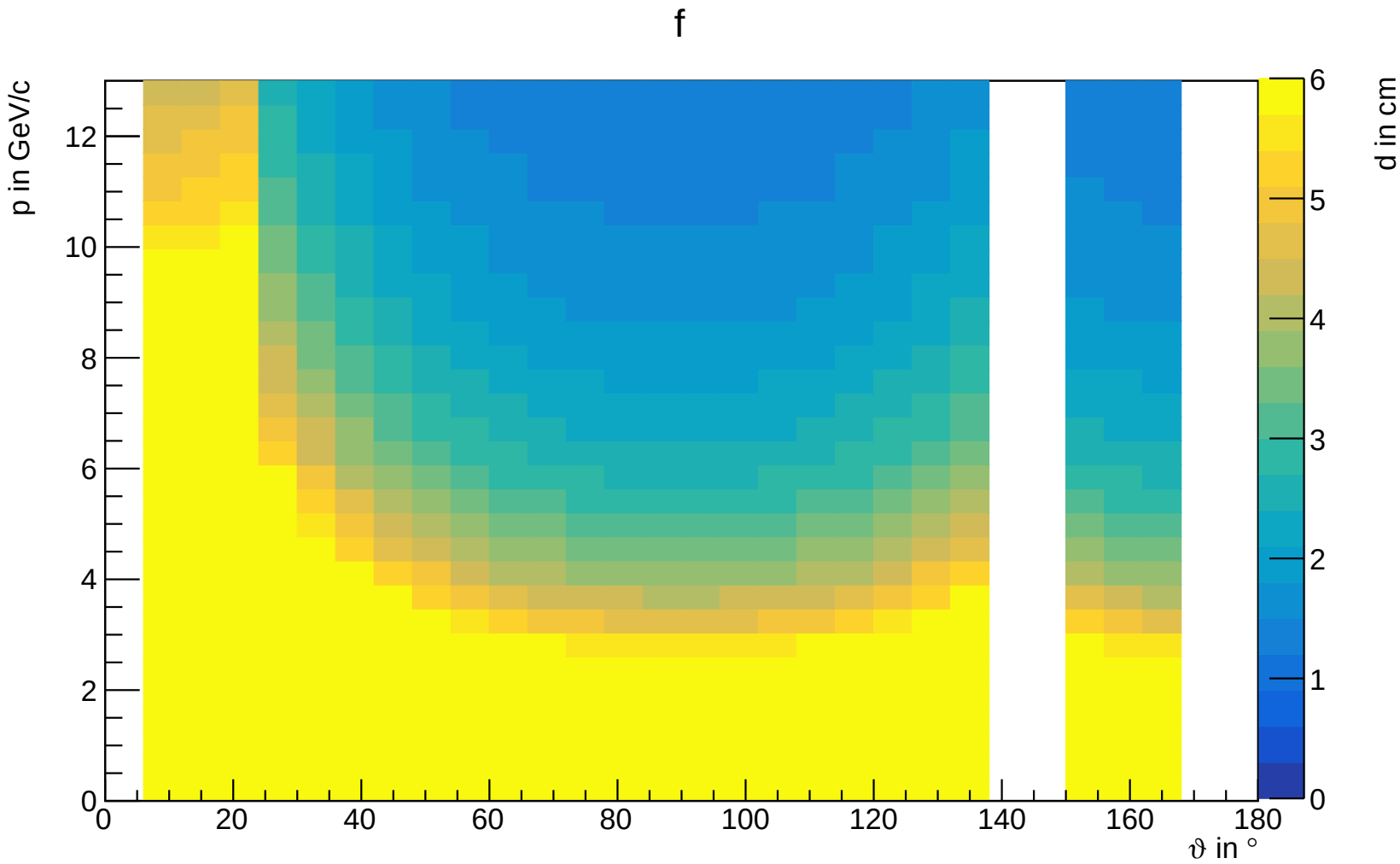
When does merging occur?





Where does merging occur?

- γ impact separation in cm
  - $\geq 5.7\,\text{cm}$ (yellow region): No merging



Analytical reconstruction of merged π^0

Moment analysis of clusters

- Based on moment analysis of clusters
- n^{th} moment defined as:

$$\langle x^n \rangle = \frac{\sum E_i x_i^n}{\sum E_i} \tag{1}$$

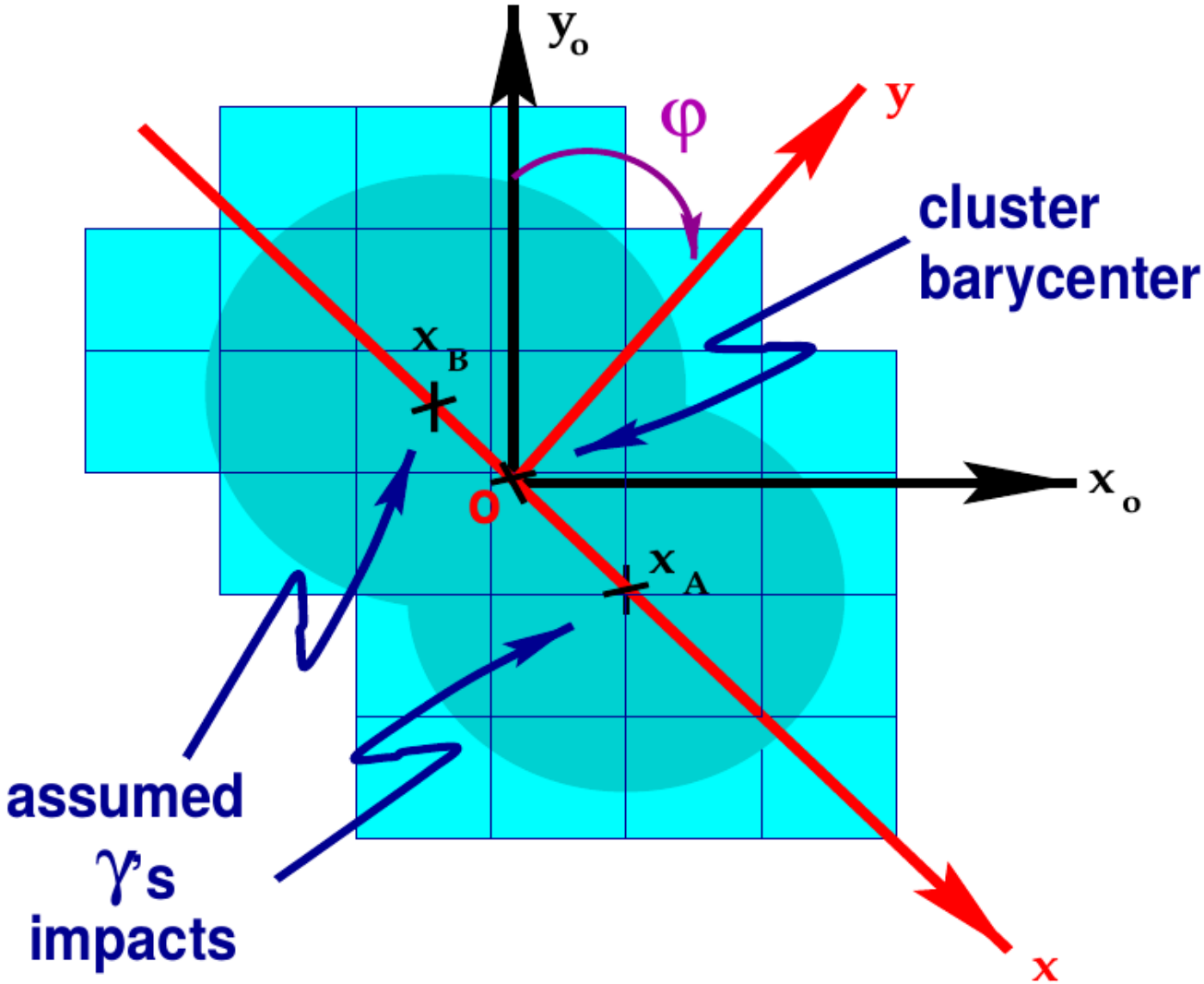
E_i: Digi energy, x_i: Digi position

- Sum over digies contributing to cluster
- Simplify calculation: Rotation in $\langle x_0 y_0 \rangle$ co-moment eigenframe

Method adapted from: "Photon and Neutral Pion reconstruction", O. Deschamps et. al., LHCb Collaboration, 2003

Analytical reconstruction of merged π^0

Rotation in $\langle x_0 y_0 \rangle$ co-moment eigenframe



Picture adapted from: "Photon and Neutral Pion reconstruction", O. Deschamps et. al., LHCb Collaboration, 2003

Analytical reconstruction of merged π^0

Moment analysis of clusters

- Relations in the $\langle x_0 y_0 \rangle$ co-moment eigenframe:

$$E = E_A + E_B \tag{2}$$

$$\left\langle x^1 \right\rangle = \frac{x_A E_A + x_B E_B}{E} = 0 \tag{3}$$

$$\left\langle x^2 \right\rangle = \frac{x_A^2 E_A + x_B^2 E_B}{E} + \sigma_x^2 \tag{4}$$

$$\left\langle x^3 \right\rangle = \frac{x_A^3 E_A + x_B^3 E_B}{E} \tag{5}$$

- Leading to the invariant mass of the cluster

$$M_{AB}^2 = \frac{E^2}{r^2}\left(\left\langle x^2 \right\rangle - \left\langle y^2 \right\rangle\right) \tag{6}$$

- Rotated back in the original frame

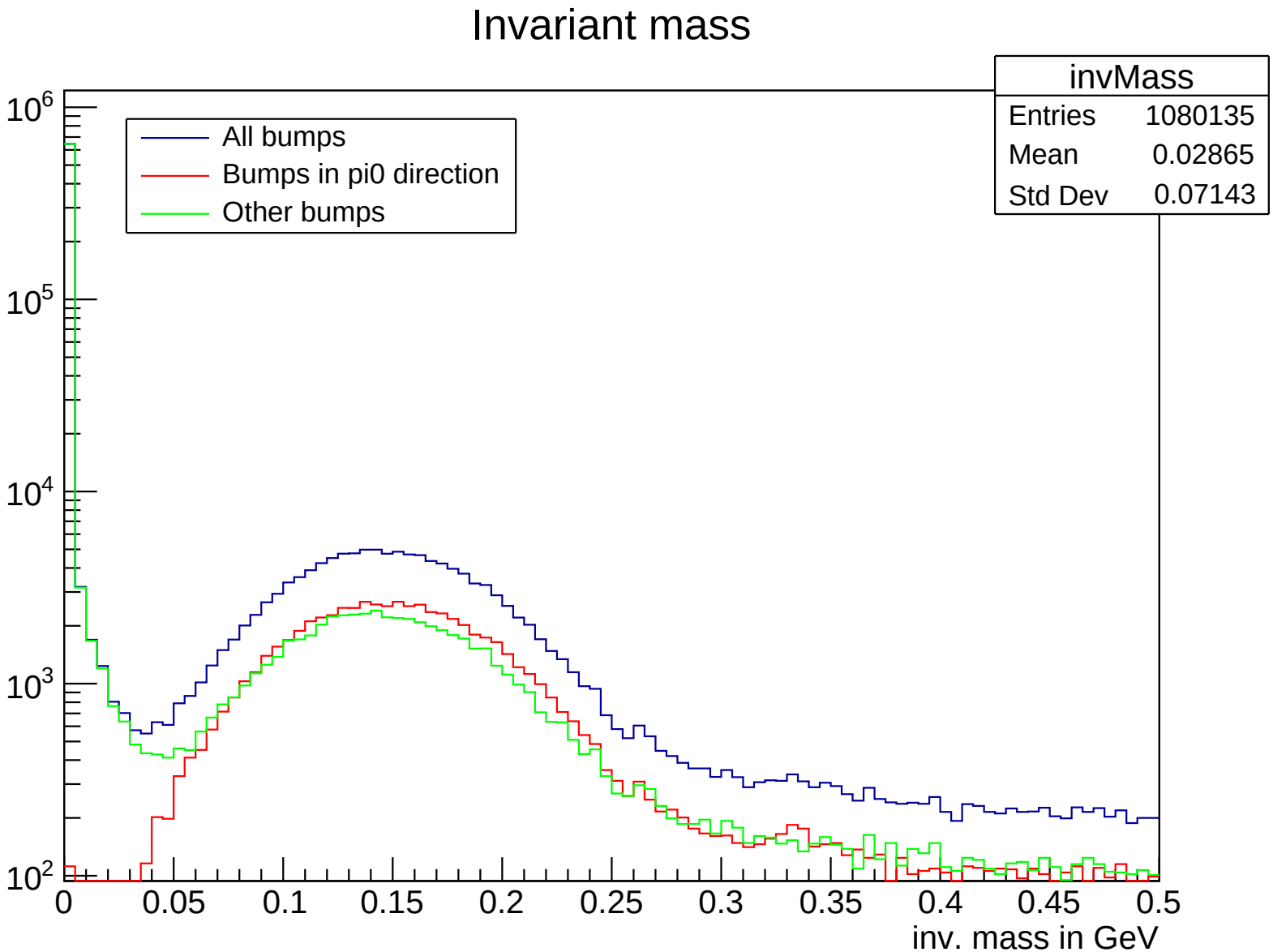
$$M_{AB}^2 = \frac{E^2}{r^2}\frac{\langle x_0^2 \rangle - \langle y_0^2 \rangle}{\cos(2\varphi_0)} \tag{7}$$

π^0 Test Sample

- 100000 BOX generator events
- Single π^0 @ 15 GeV/c
- Only in barrel EMC
- Set option "nomcclean" for pid

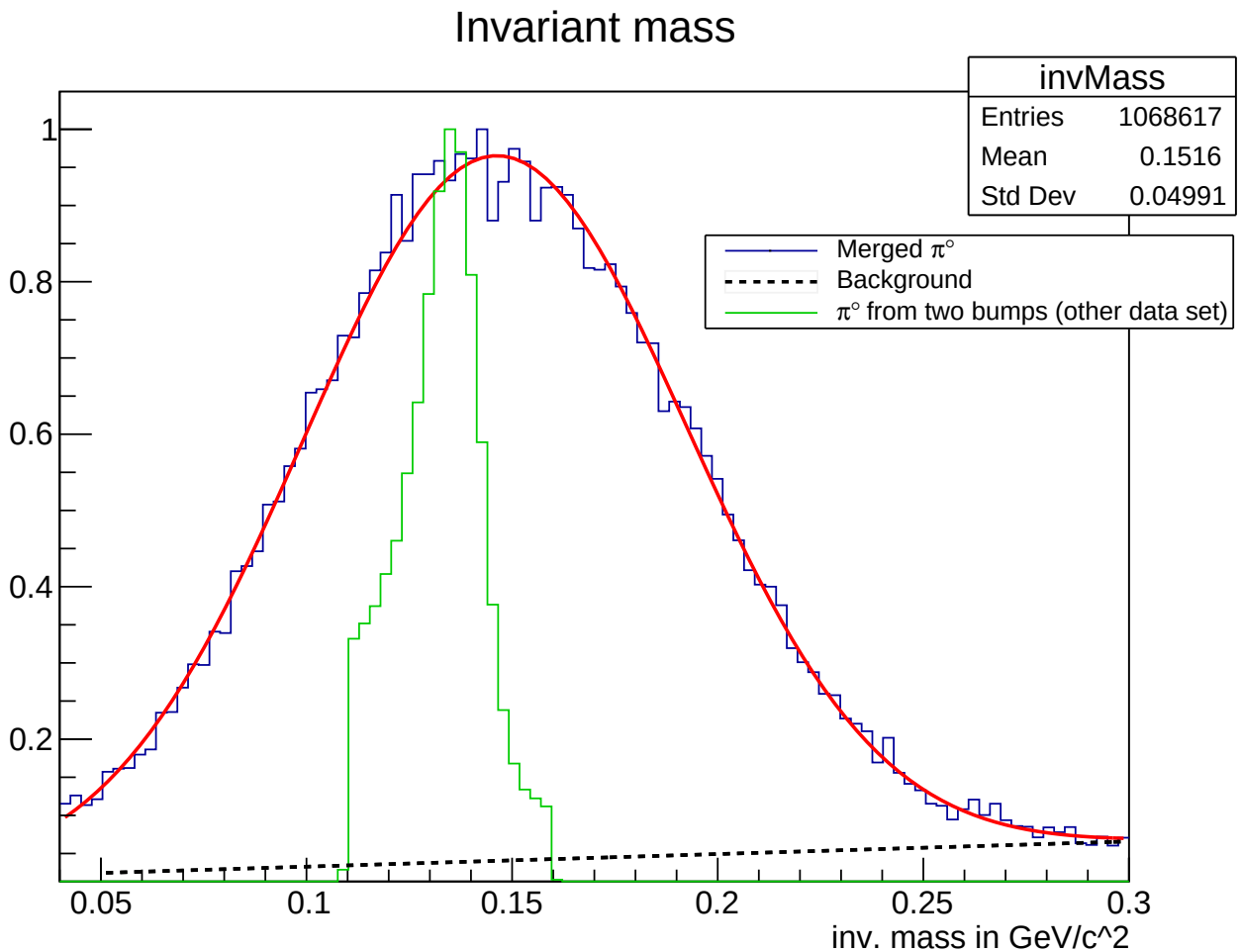
- Do pseudo MC-match if π^0 momentum vector points approx. to cluster centroid

Invariant Mass Spectrum



Invariant Mass of π^0

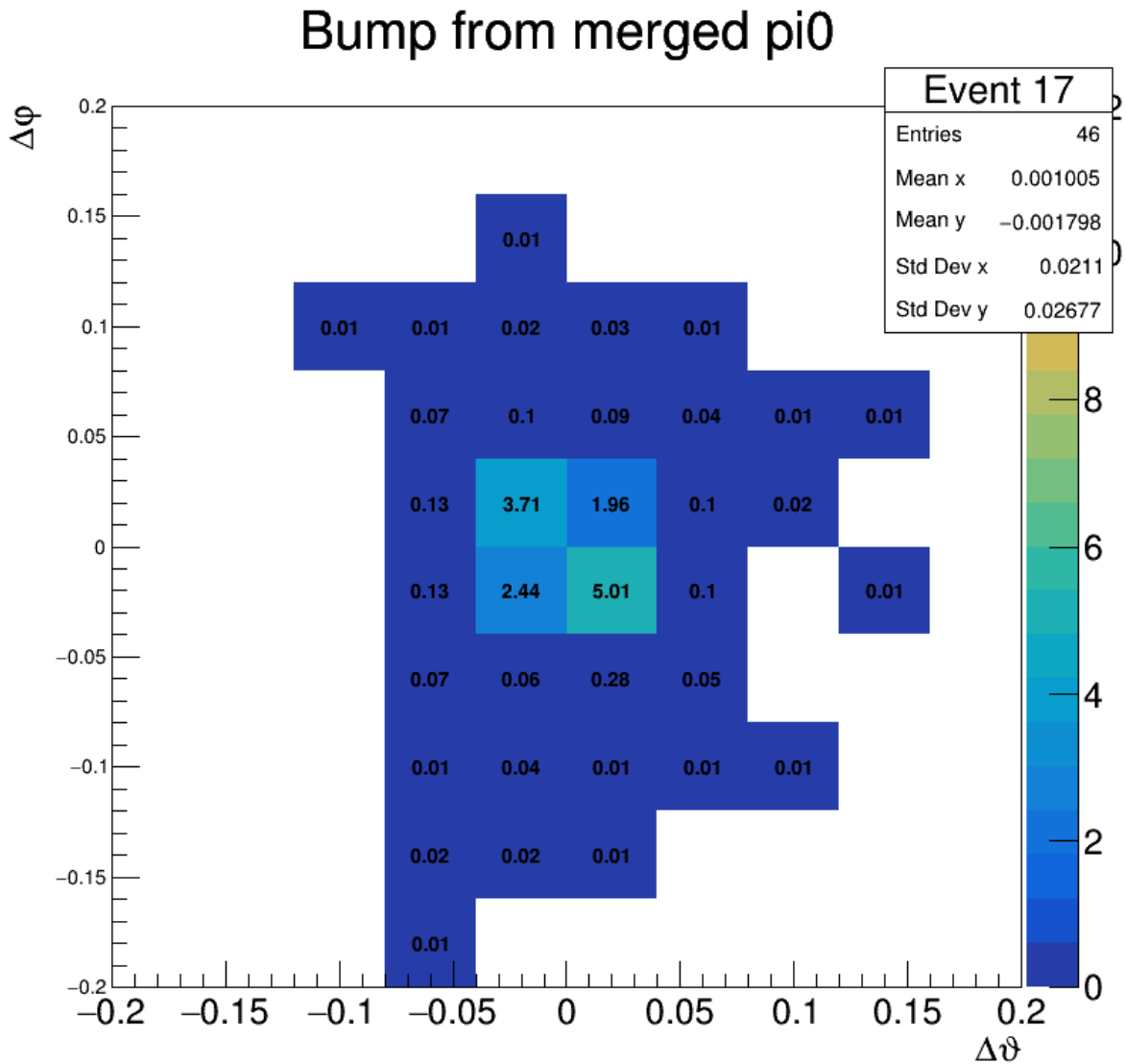
- Fit gaussian + straight line



- $\mu = 146\,\text{MeV}$, $\sigma = 46\,\text{MeV}$
- Reconstruction of 109078 π^0s

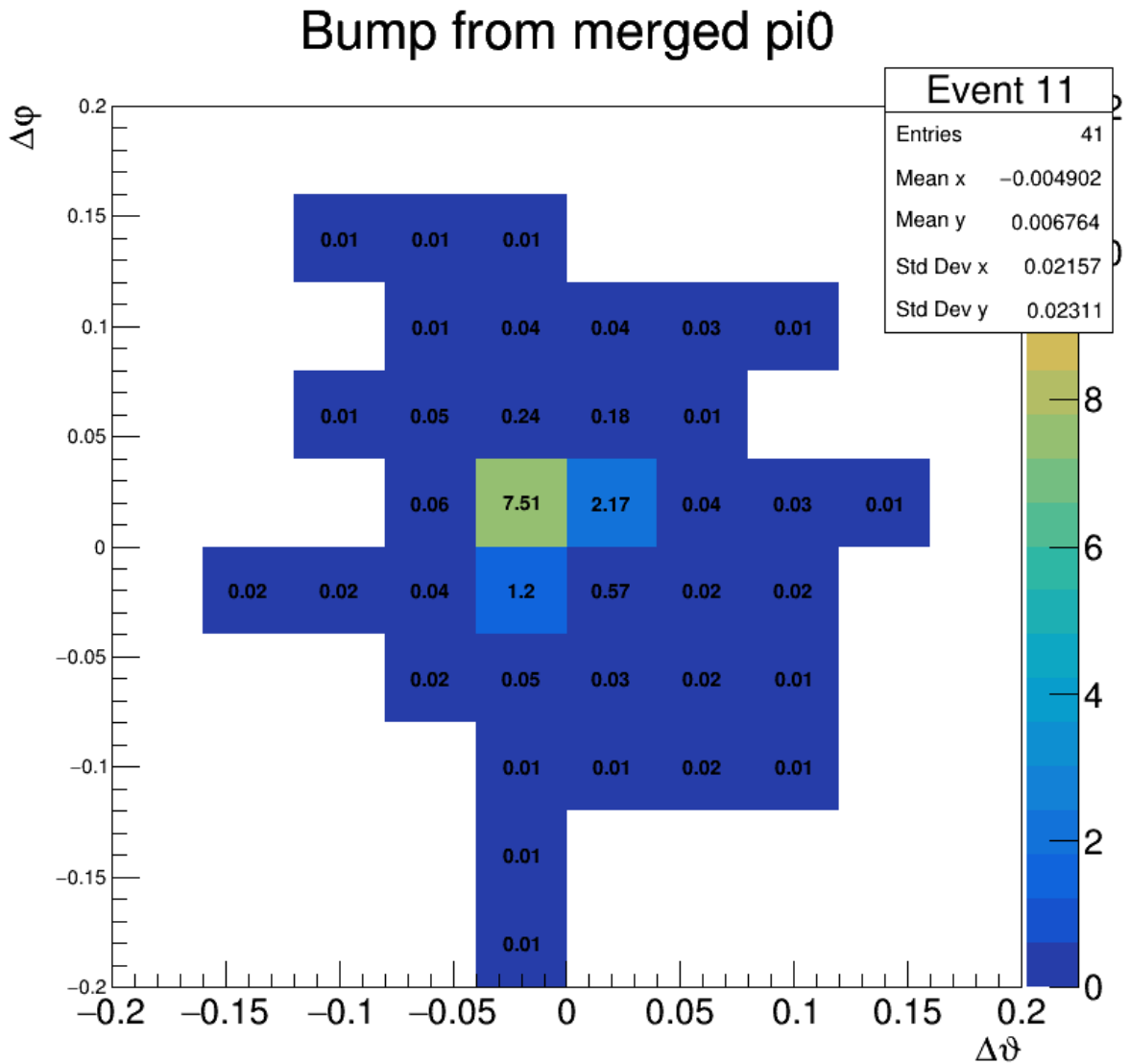
Bump Examples

- Bump from merged π^0 without match, m=0.155 GeV



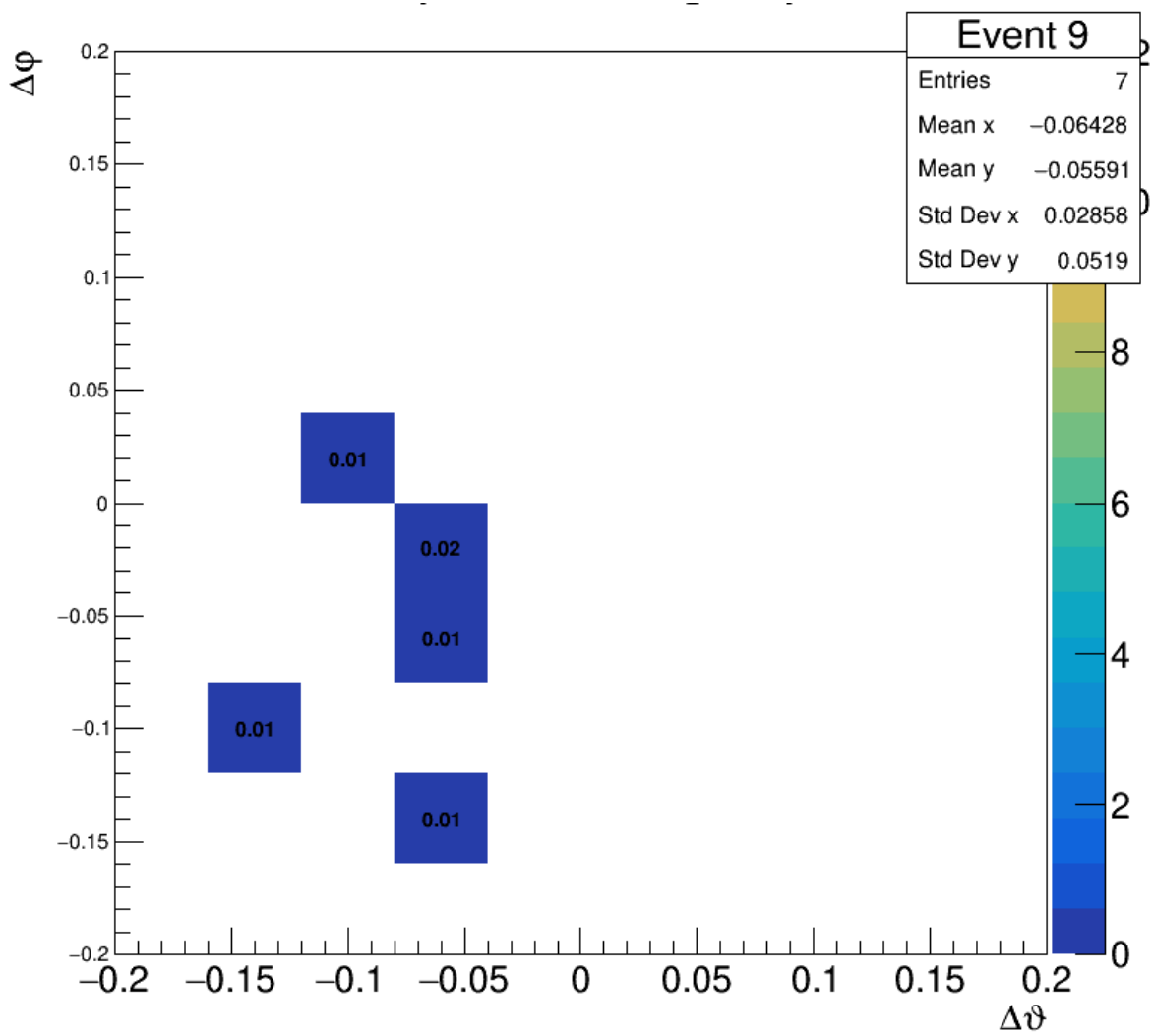
Bump Examples

- Bump from merged π^0 with MC match, m = 0.155 GeV



Bump Examples

- Bump from photon, m = 0.053 GeV



Outlook

- Include Forward + Backward Spectrometer
- Include as task in PandaRoot
- Calibration for π^0 mass
- Looking for systematics