A new method to improve the electron momentum reconstruction with PANDARoot

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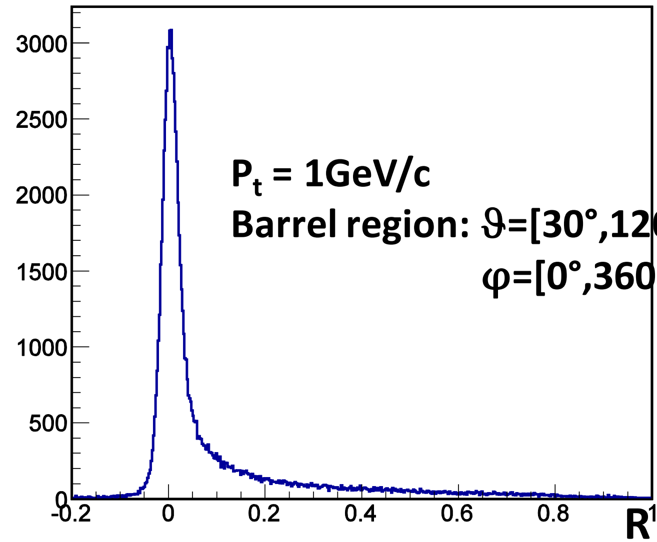
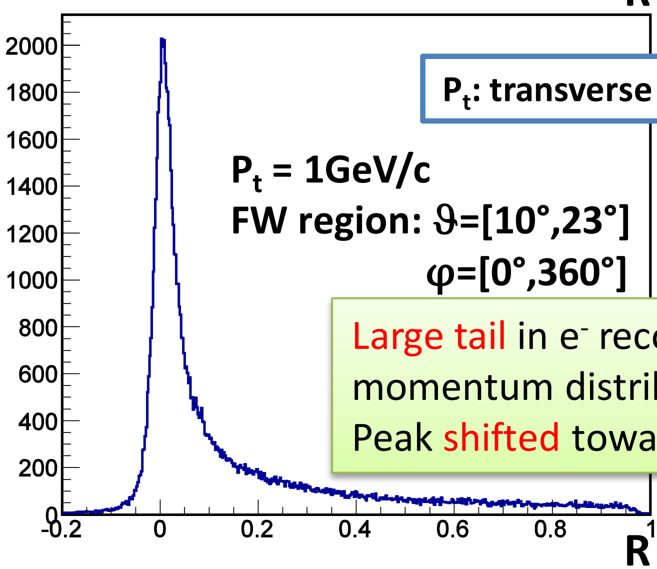
Outline

- The existing problems of electron reconstruction.
- My proposal: use the measured Bremsstrahlung γ energy in the EMC(Electromagnetic Calorimeter).
- Two cases for this method:
  - case 1: separated e^-/γ bumps
  - case 2: merged e^-/γ bumps. (New)
- Preliminary results.
  - Barrel
  - Forward endcap. (New)
- Outlook

Electron momentum resolution

$R = (P_{MC}-P_{KF})/P_{MC}$





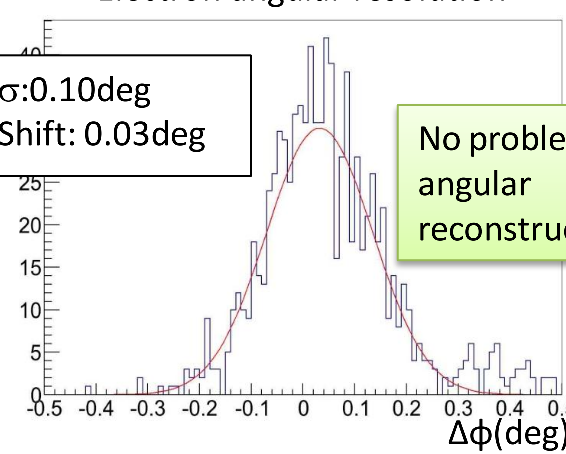
P_t: transverse momentum

Large tail in e^- reconstructed momentum distribution,
Peak shifted towards positive values.

P_t(GeV/c)	σ(%) from Gaussian fit	Evts inside 2σ(%)
0.5 Barrel	1.5	55.6
1 Barrel	1.8	58.9
2 Barrel	2.4	61.0
0.5 FW	1.9	46.6
1 FW	2.1	46.3
2 FW	2.4	45.6

Needs to be improved

Electron angular resolution



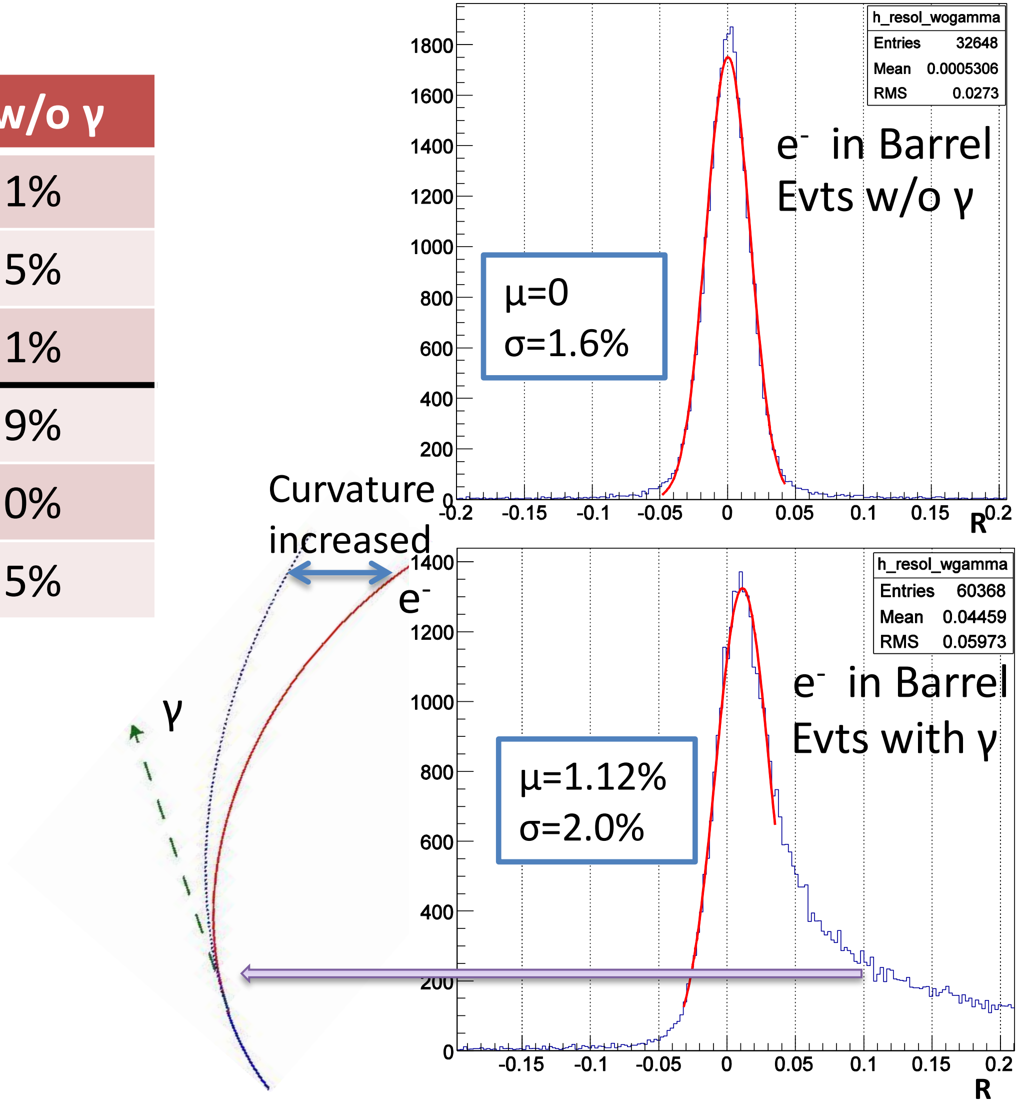
No problem for angular reconstruction

e^- resolution and γ emission

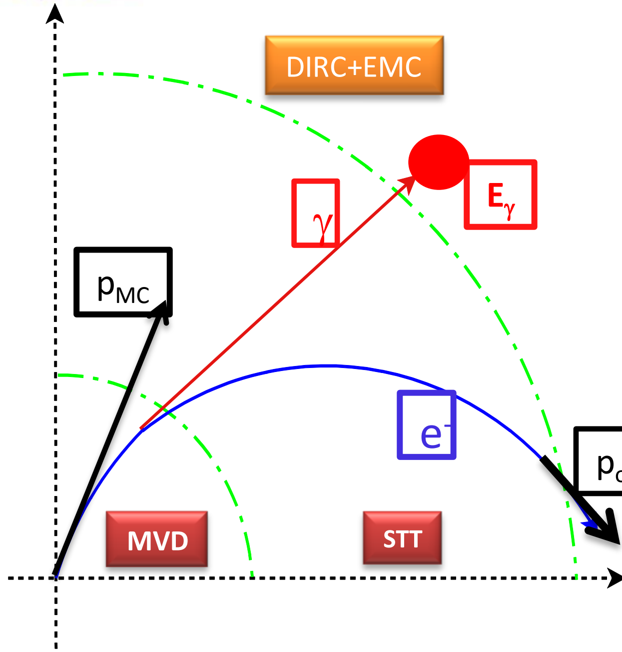
P_t of e^-	Evts with γ	Evts w/o γ
0.5GeV/c Barrel	61.9%	38.1%
1GeV/c Barrel	65.5%	34.5%
2GeV/c Barrel	68.9%	31.1%
0.5GeV/c FW	81.1%	18.9%
1GeV/c FW	84.0%	16.0%
2GeV/c FW	86.5%	13.5%

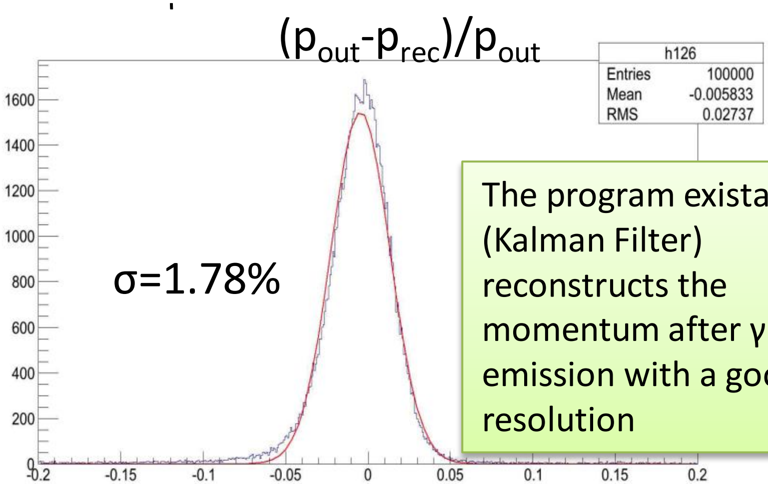
$E_\gamma > 1$MeV

The problem of momentum resolution is due to the emission of photon.



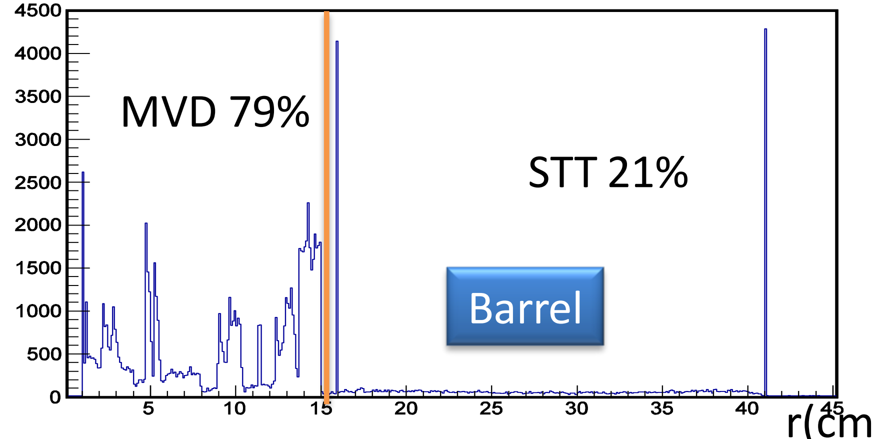
e^- momentum reconstruction with γ emission

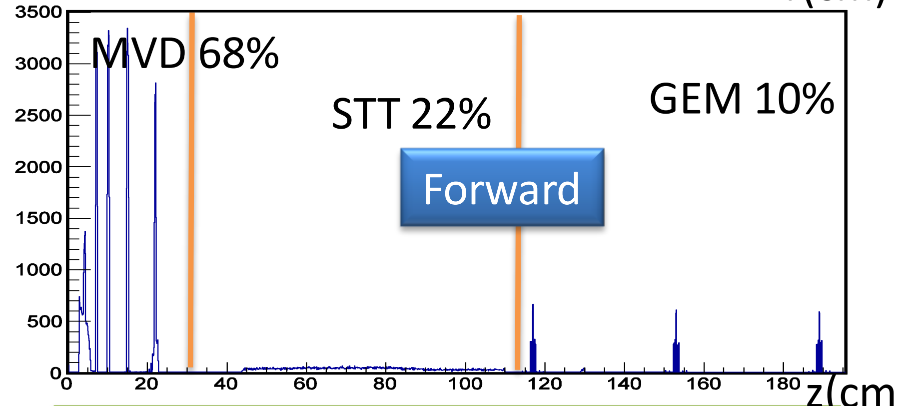




The program existant (Kalman Filter) reconstructs the momentum after γ emission with a good resolution

The position of gamma emission





- Most γ emitted close to target(MVD)
- The track is mostly defined by STT hits (MVD 4 to 6 points, STT 24 to 26 points)
- $P_{rec} \approx P_{out}$

My proposal: use the γ energy from EMC

- Handle the problem event by event

- The reconstructed momentum

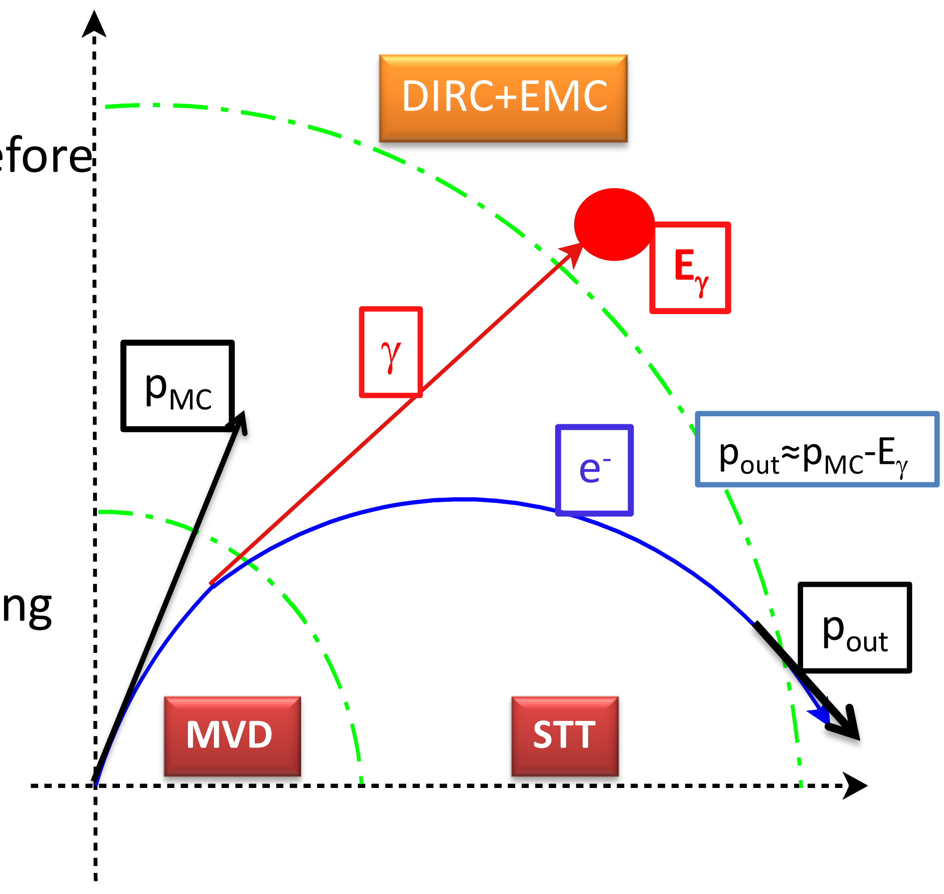
$p_{rec} \approx p_{out}$ (momentum of the electron before the DIRC)

- If a γ is emitted before the DIRC:

$p_{out} \approx p_{MC} - E_{\gamma}$ (γ is emitted in the same direction as e^{-})

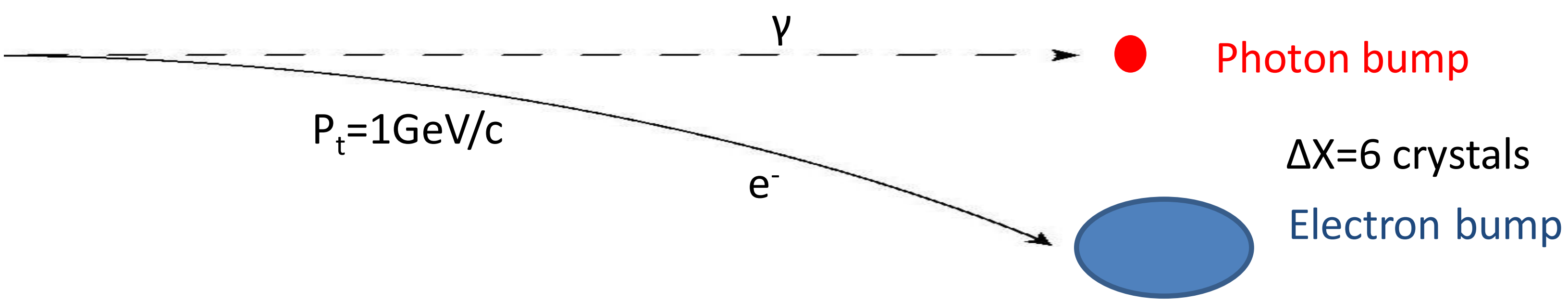
- Searching the associated Bremsstrahlung γs in the EMC.(ΣE_{γ})

- Calculate: $\mathbf{p_{corr} = p_{rec} + \Sigma E_{\gamma(i)}}$

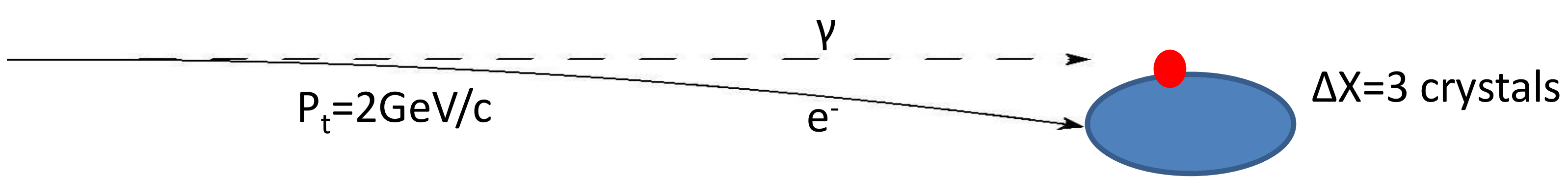


Looking for the Bremsstrahlung γ in EMC

- Case one: the clusters or bumps of e^- and γ can be well distinguished.



- Case two: γ and e^- bumps are merged.



- For an electron event both cases are considered in parallel.

Bremsstrahlung γ selection algorithm for separated e^-/γ bumps

→ Look for a photon bump in EMC:
(a neutral candidate)

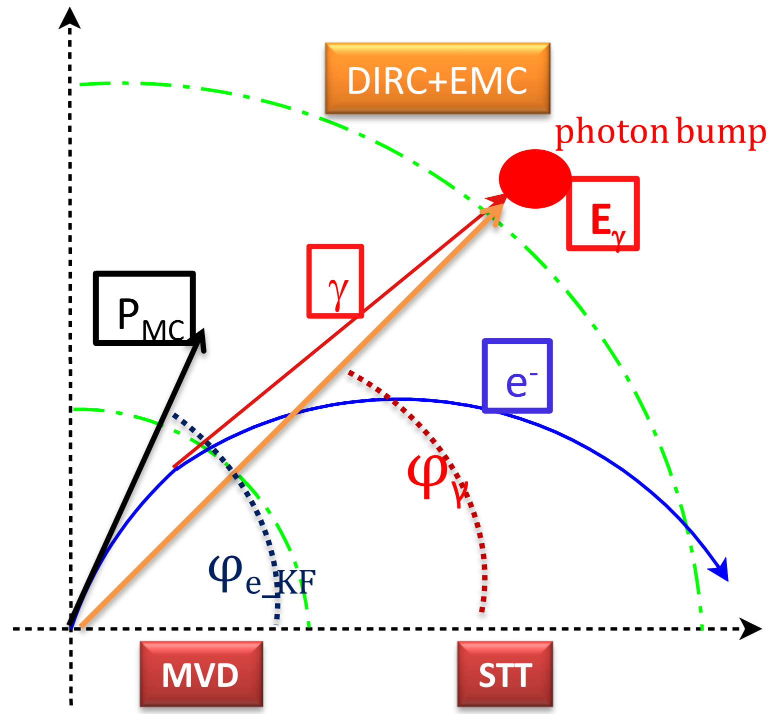
→ Selection of photons emitted before DIRC :
Using Δθ and Δφ:

$$\Delta\theta = \theta_\gamma - \theta_{e\_rec}$$
$$\Delta\varphi = \varphi_\gamma - \varphi_{e\_rec}$$

γ bump (for θ_γ, φ_γ) — tracking (for θ_{e_rec}, φ_{e_rec})

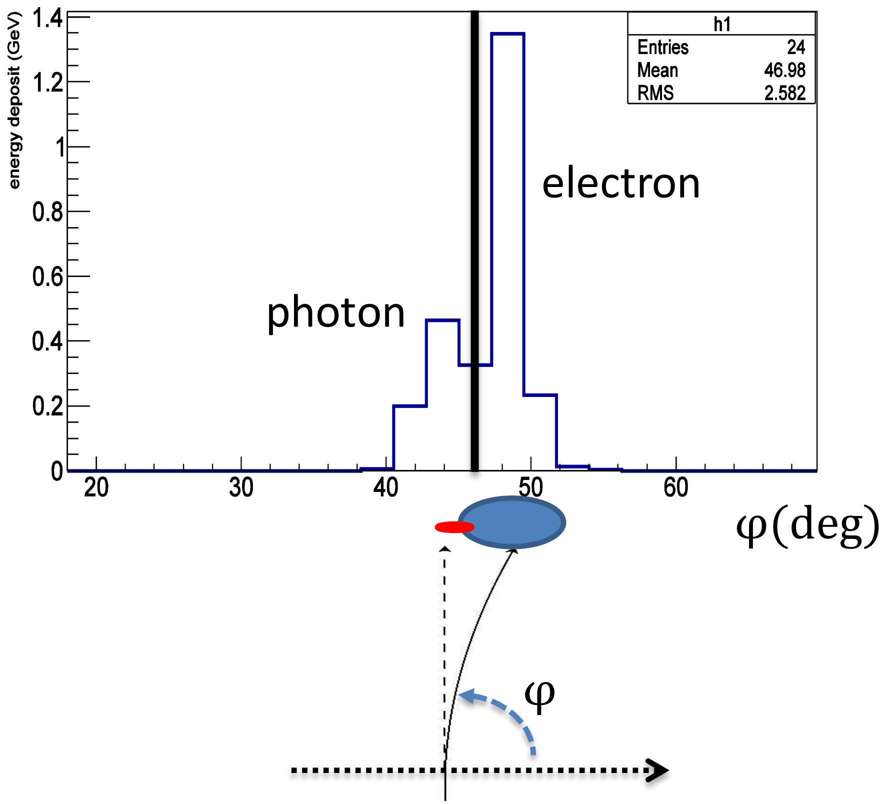
Cuts : $|\Delta\theta| < 2°$
$-1° < \Delta\varphi < 2\arcsin(0.12/P_t)$. barrel
$-1° < \Delta\varphi < (1.2/P_t)\tan\theta$. forward

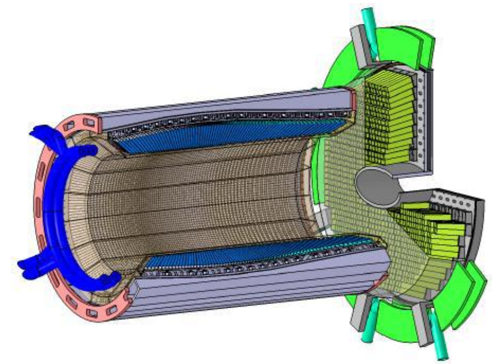
Maximum e^- deviation angle

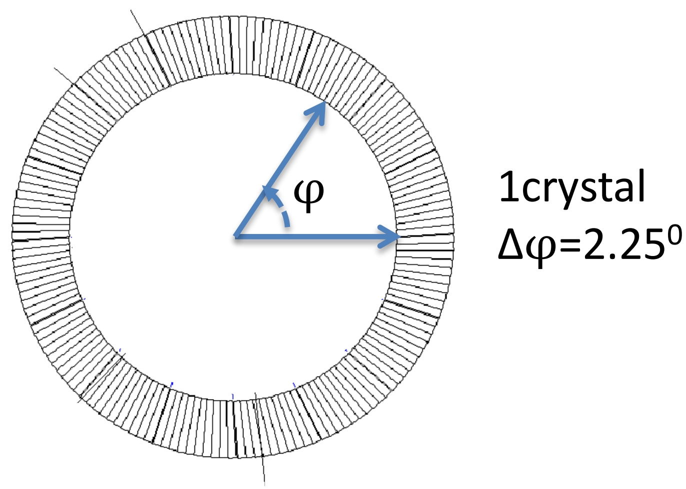


γ selection algorithm for merged e^-/γ bumps

- Sum of energy deposits in crystals at a given φ.





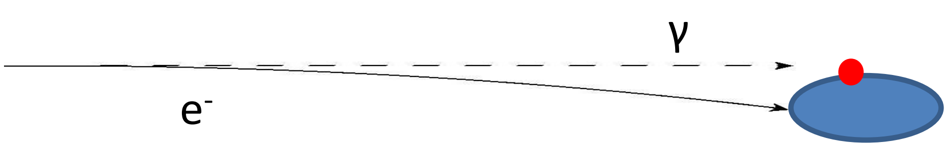


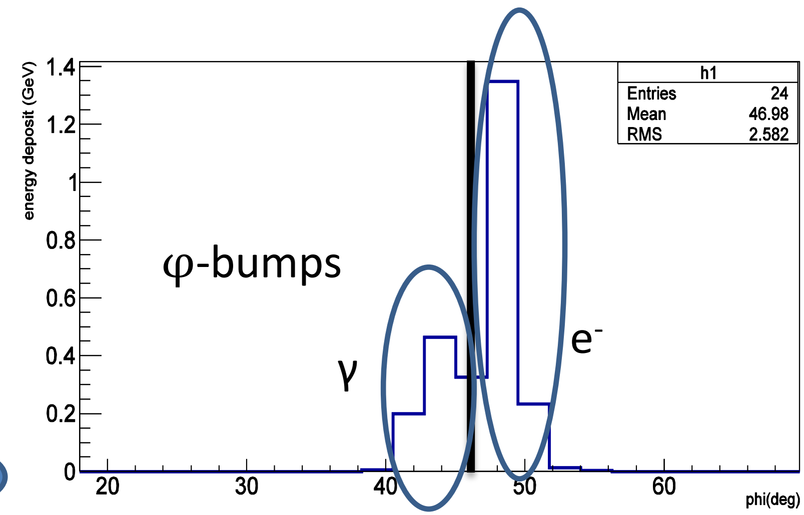
γ selection algorithm for merged e^-/γ bumps

Looking for a φ-bump:

- Scan the bins of the energy deposit spectrum three by three, each bin i receives a code depending on N_{i-1}, N_i, N_{i+1}.
- φ-bumps are defined between two valleys (code =-2).
- The φ-bump at the right edge is considered as e^-. The other φ-bumps are considered as photons.
- The split electron φ-bumps are also considered.
- $p_{corr} = p_{rec} + \Sigma E_{\gamma(i)}$

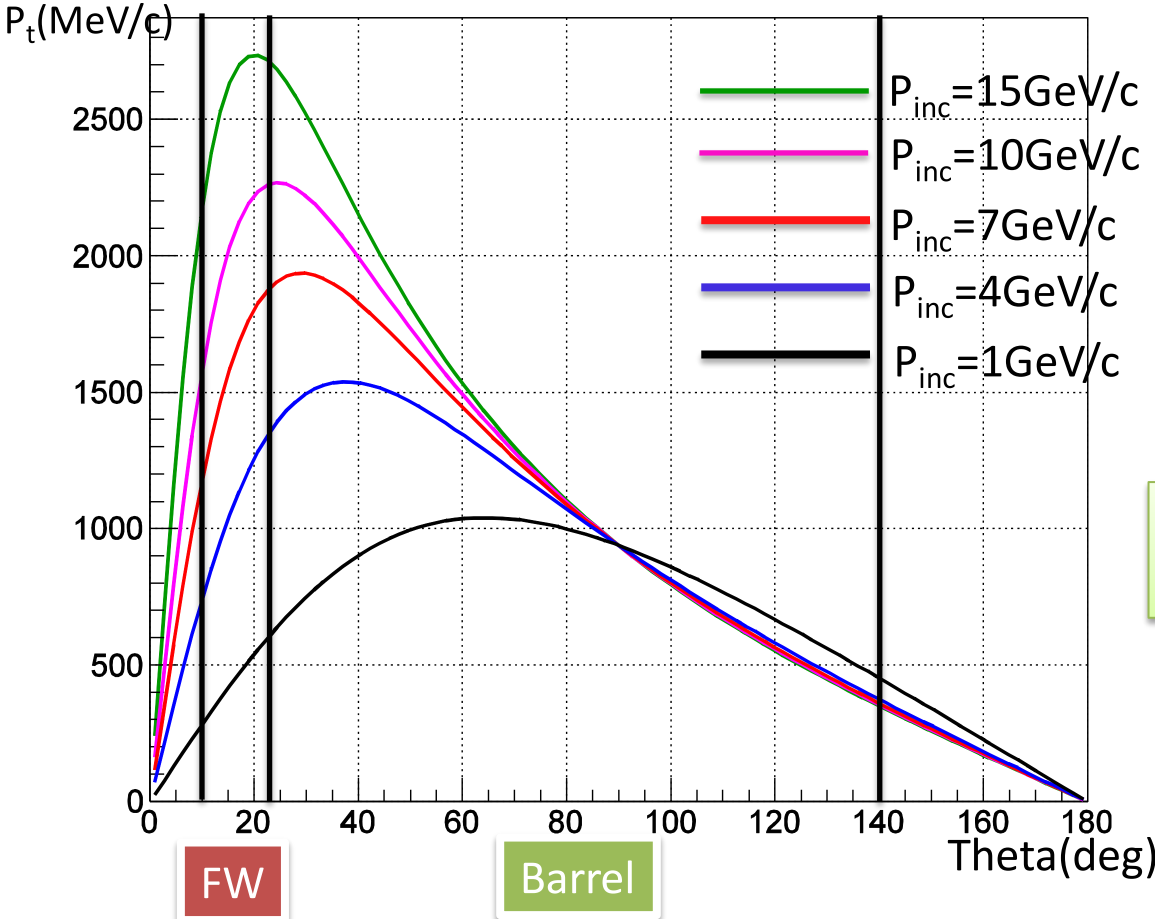
code	cases
1	Rise
-1	Drop
0	Peak
-2	Valley





Kinematical considerations

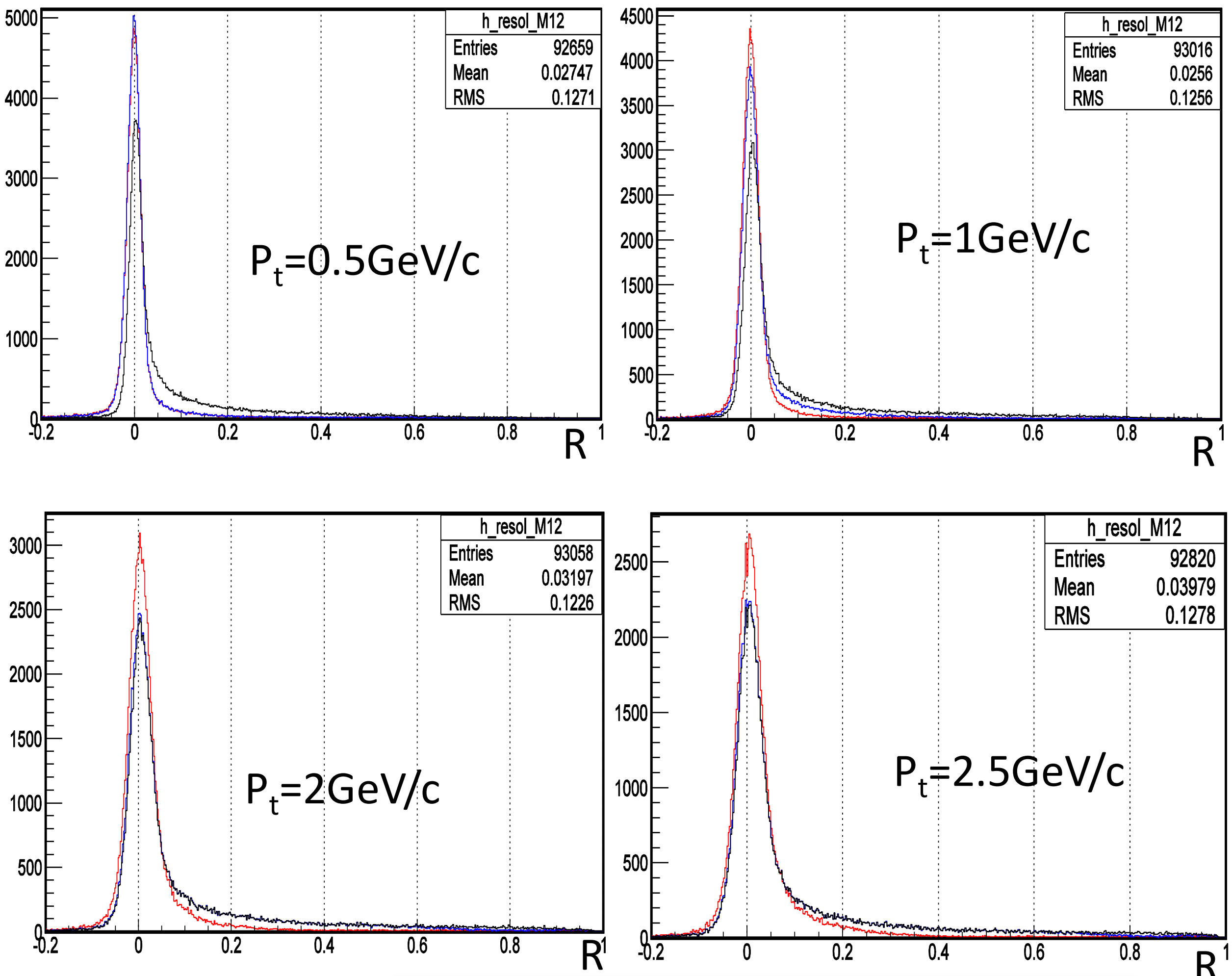
P_t for the $\bar{p}p \rightarrow e^+e^-$ reaction



Barrel: P_t <2.8GeV/c
Forward: P_t <2.8GeV/c

Simulations for 10^5 e^-
P_t = 0.5, 1, 1.5, 2, 2.5 GeV/c

Preliminary result for the electrons in the Barrel EMC region



ϑ=[30°,120°],
φ=[0°,360°]

w/o correction
correction with only separated e-/γ bumps
correction with both separated and merged e-/γ bumps

- The peak is better centered
- The proportion of the tail is reduced.

Performance of the method for the momentum resolution (Barrel region)

Electron Pt	case	Gaussian fit σ	μ	Proportion of evts inside 2σ
	w/o	1.5%	0.41%	55.6%
Pt=0.5GeV/c	First	1.6%	-0.14%	80.1%
	First+Second	1.6%	-0.12%	78.9%
	w/o	1.8%	0.48%	58.9%
Pt=1GeV/c	First	1.8%	-0.05%	72.3%
	First+Second	1.8%	-0.09%	79.5%
	w/o	2.2%	0.53%	59.1%
Pt=1.5GeV/c	First	2.2%	0.32%	63.7%
	First+Second	2.2%	0.09%	79.9%
	w/o	2.4%	0.60%	61.0%
Pt=2GeV/c	First	2.4%	0.50%	63.4%
	First+Second	2.5%	0.35%	77.5%
	w/o	2.7%	0.70%	61.0%
Pt=2.5GeV/c	First	2.6%	0.57%	62.7%
	First+Second	2.6%	0.53%	73.6%

First case:
only separated e-/γ bumps
First+second case:
separated and merged e-/γ bumps

Reduction of the shift.
Increase of number of events inside two sigma: 60% → 79% (about 85% for muons)
Efficiency of e^+e^- selection (both in Barrel) increases by a factor ~ 1.75.

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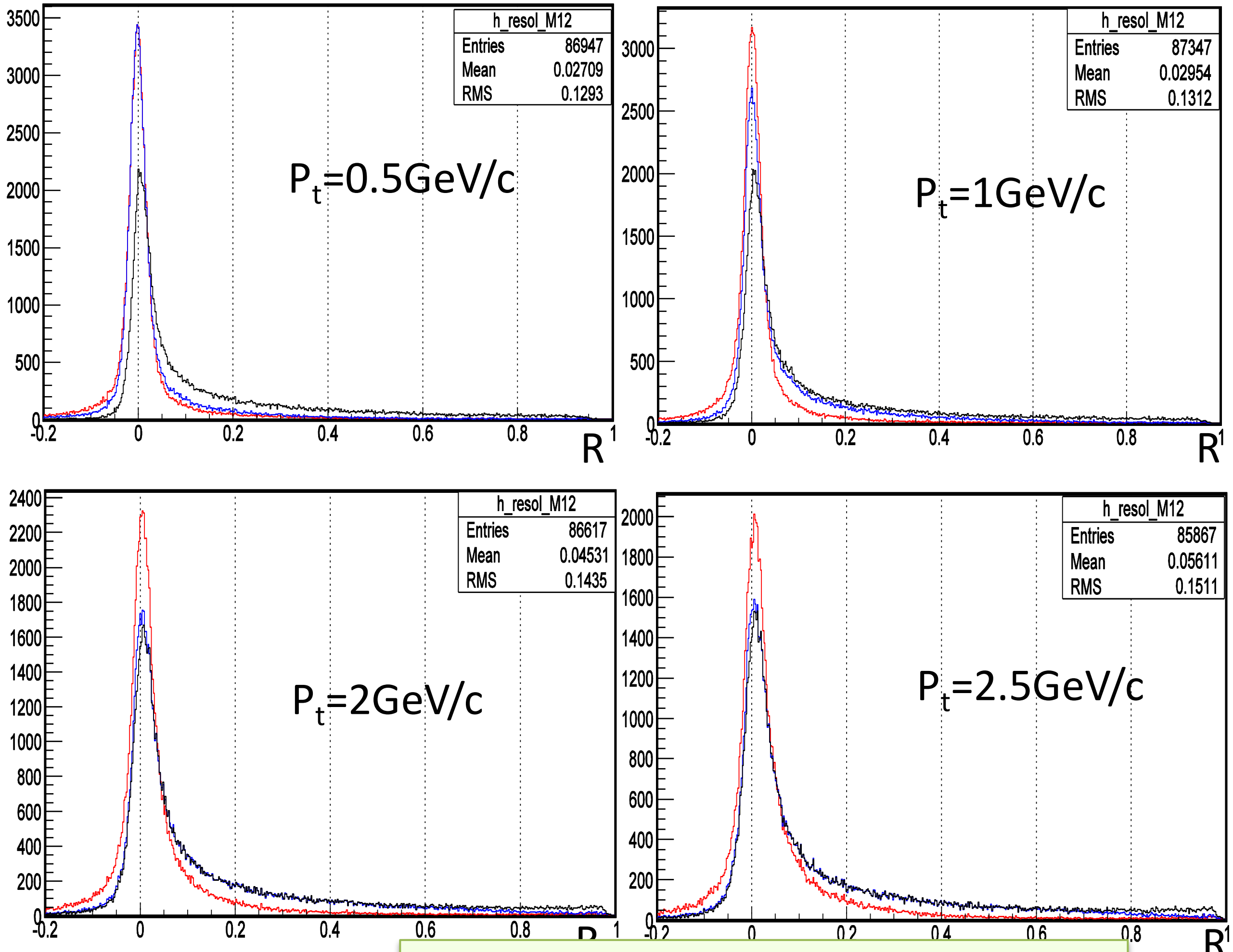
Preliminary result for the electrons in the forward EMC Endcap region



ϑ=[10°,23°],
φ=[0°,360°]

w/o correction
correction with only separated e-/γ bumps
correction with both separated and merged e-/γ bumps

- The peak is better centered
- The proportion of the tail is reduced.
- left tail to be investigated

Performance of the method for the momentum resolution (Forward Endcap region)

Electron Pt	case	Gaussian fit σ	μ	Proportion of evts inside 2σ
	w/o	1.9%	0.83%	46.6%
Pt=0.5GeV/c	First	1.8%	-0.10%	67.5%
	First+Second	1.9%	-0.12%	69.5%
	w/o	2.1%	0.84%	46.3%
Pt=1GeV/c	First	1.8%	0.18%	54.8%
	First+Second	2.0%	0.17%	67.4%
	w/o	2.2%	0.93%	45.3%
Pt=1.5GeV/c	First	2.3%	0.62%	50.4%
	First+Second	2.1%	0.40%	62.5%
	w/o	2.4%	1.03%	45.6%
Pt=2GeV/c	First	2.4%	0.87%	48.1%
	First+Second	2.3%	0.59%	62.9%
	w/o	2.2%	0.93%	46.2%
Pt=2.5GeV/c	First	2.3%	0.62%	48.2%
	First+Second	2.1%	0.40%	58.2%

First case:
only separated e-/γ bumps
First+second case:
separated and merged e-/γ bumps

Reduction of the shift.
Increase of number of events inside two sigma: 46% → 65% (about 80% for muons)
Efficiency of e^+e^- selection (one in Barrel, one in FW) increases by a factor ~ 1.9.

Conclusions and outlook

- New method based on the photon detection in the EMC to correct electron Bremsstrahlung.
- Reduction of the tail of resolution peak. (33% --45% more events inside two sigma)
- Method valid for both Barrel and Forward Endcap regions and for P_t from 0.5 to 2.5 GeV/c.
- Outlook:
  - Check the problem of left tail in the FW case.
  - Check the performance for positrons.
  - Check the gain in efficiency for $\bar{p}p \to e^+e^-$ signal selection.
  - Impact on radiative corrections ($\bar{p}p \to e^+e^-\gamma$).
  - Implement this method in PandaRoot.