A new method to improve the electron momentum reconstruction with PANDARoot

Binsong MA
Institut de Physique Nucléaire, ORSAY

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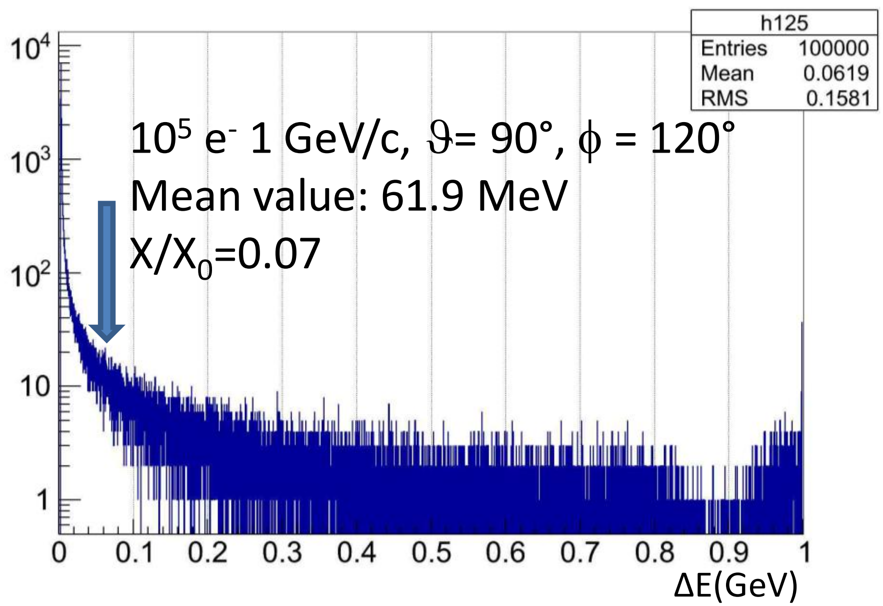
Outline

- Electron reconstruction with Kalman Filter and its problem.
- Our proposal: use the measured Bremsstrahlung photon energy in EMC to improve the electron momentum reconstruction with Kalman Filter.
- The algorithm to select the photon from the tracking system region and the validation for different momenta and polar angles
- The limit of the method.

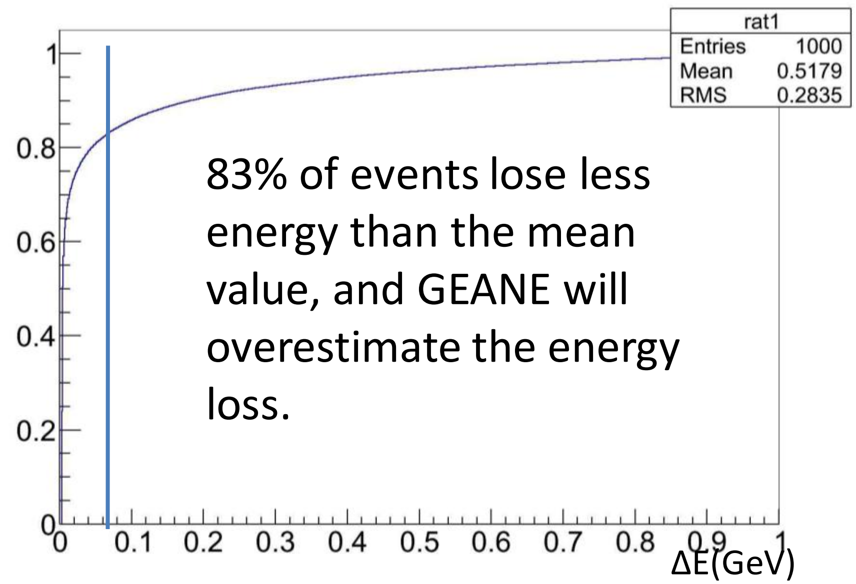
Problem of e^- reconstruction with Kalman Filter

- Track follower of Kalman Filter(KF): GEANE
- GEANE calculates the mean electron energy loss and the rms, but Bremsstrahlung is highly non-gaussian!

Electron energy loss in tracking system



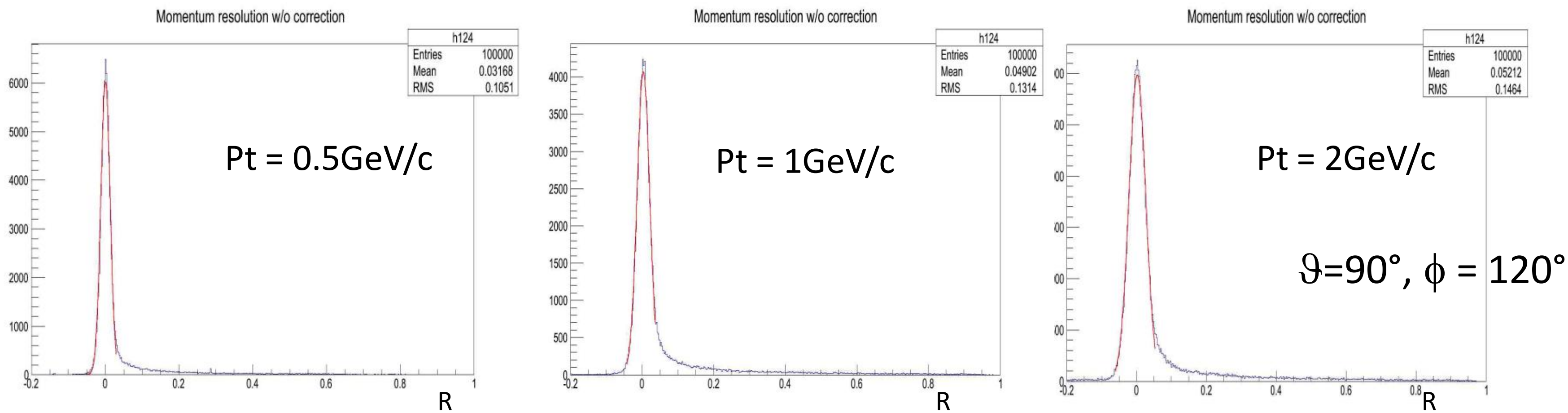
Proportion of events with energy loss below ΔE



So, KF can not handle the problem correctly

Electron resolution at different energies

Reconstruction with μ hypothesis: no Bremsstrahlung in GEANE



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

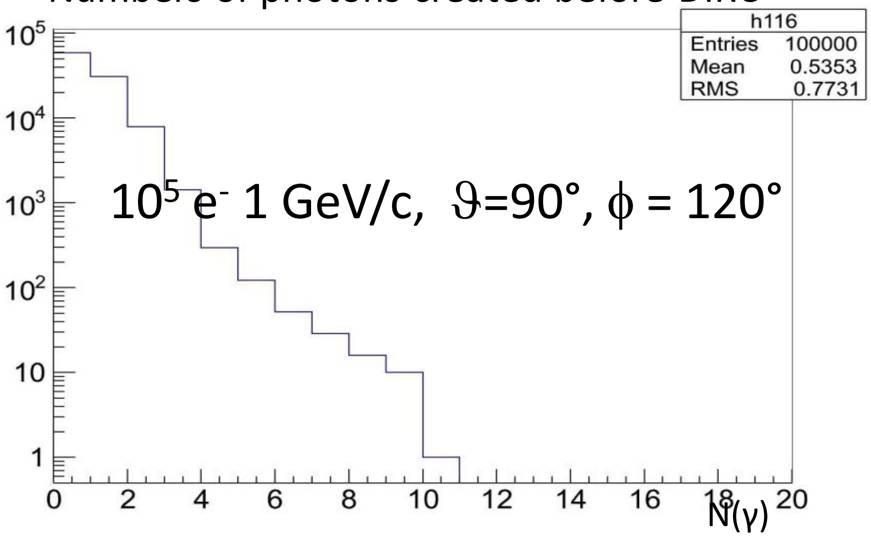
Large tail in electron reconstructed momentum distribution with KF.
But, the angular reconstruction at the target is good.

P(GeV/c)	Sigma(%)	Evts inside 2sigma(%)
0.5	1.26	75.4
1	1.76	71.1
2	2.4	71.5

Which we want to improve

Photon emission before DIRC(MC)

Numbers of photons created before DIRC



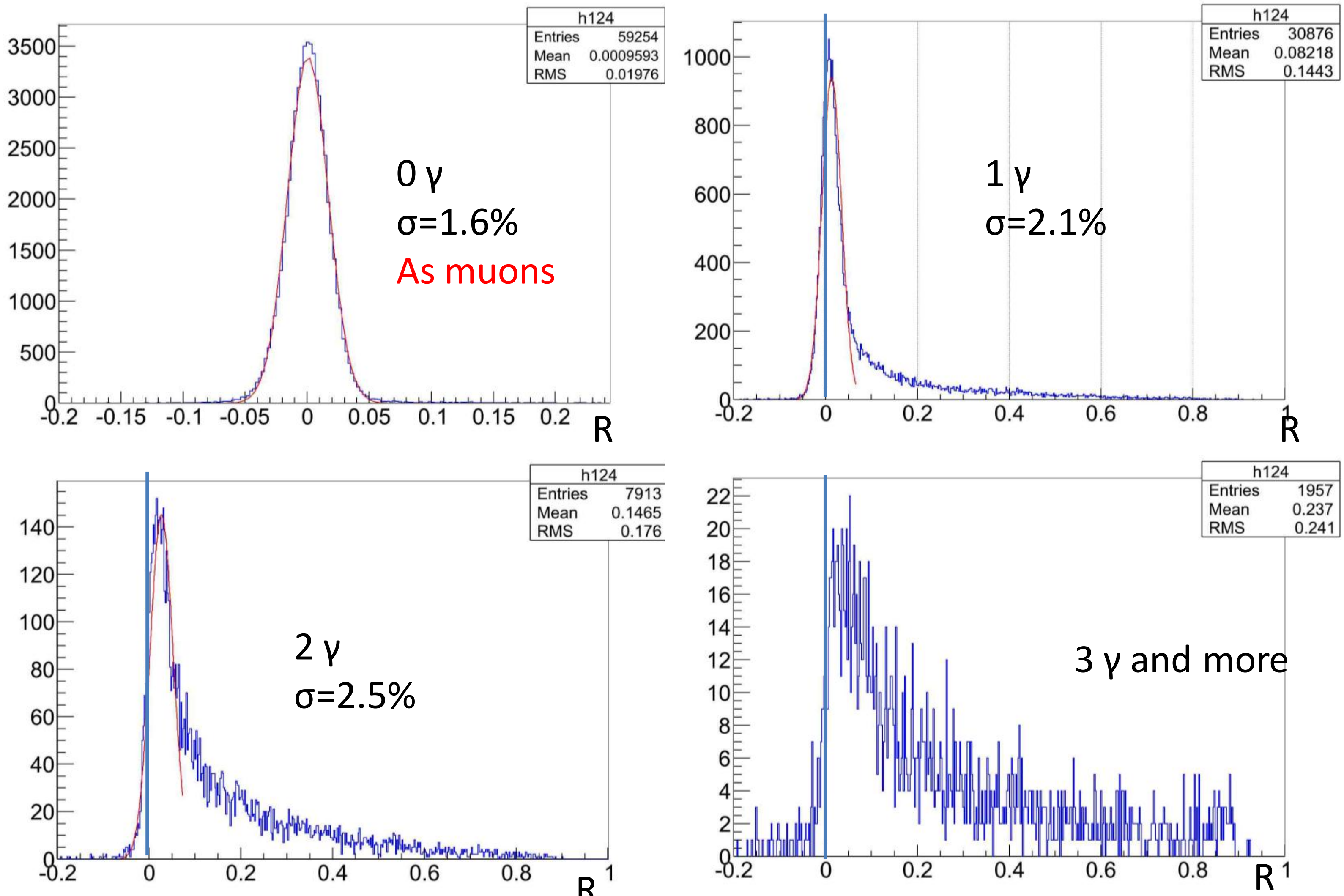
Threshold of photon energy: 1MeV

Numbers of γ	Electron 0.5GeV/c	Electron 1GeV/c	Electron 2GeV/c
0	67.3%	59.1%	51.7%
1	25.8%	30.7%	34.3%
2	5.2%	7.8%	10.9%
3 and more	1.7%	2.4%	3.1%

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

Momentum resolution for different numbers of emitted γ

10^5 e^- 1 GeV/c, ϑ=90°, ϕ = 120°, μ hypothesis, Eγ > 1MeV, reconstruction with KF



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

Our proposal: use the γ energy from EMC

- Handle the problem event by event

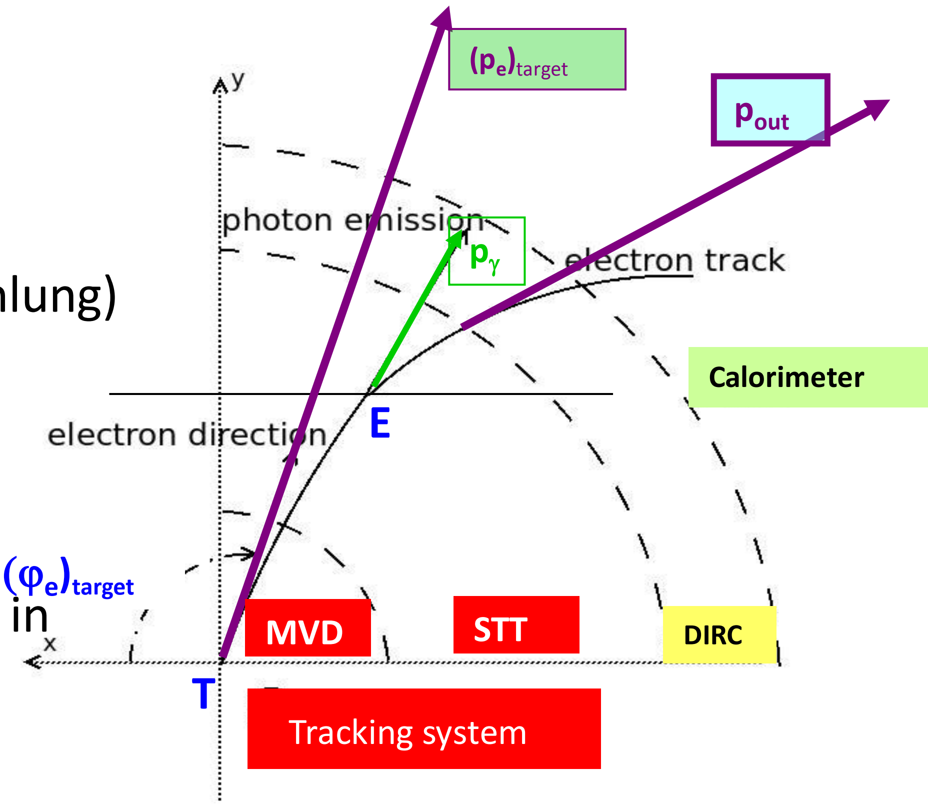
- If a γ is emitted before the DIRC, momentum of the electron at the exit of tracking system: $|P_{out}| \approx |P_{MC}| - |P_{\gamma}|$ (γ is emitted in the same direction as electron)

- the KF with μ hypothesis (i.e. no Bremsstrahlung) gives a recontructed momentum $|P_{KF}|$

- we check that $P_{KF} \approx P_{out}$

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

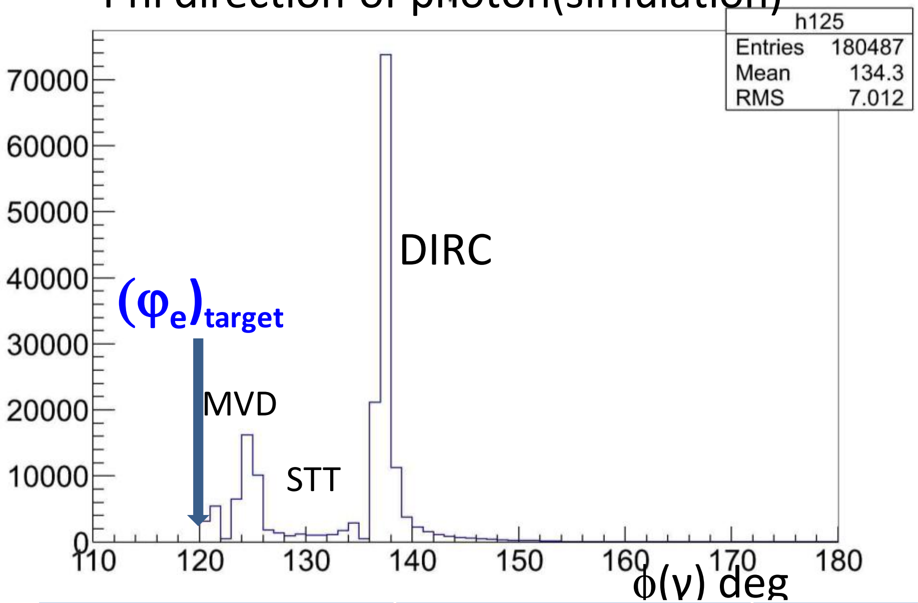
- calculate : $|p_e|_{target} = |p_{KF}| + \Sigma |p_{\gamma(i)}|$

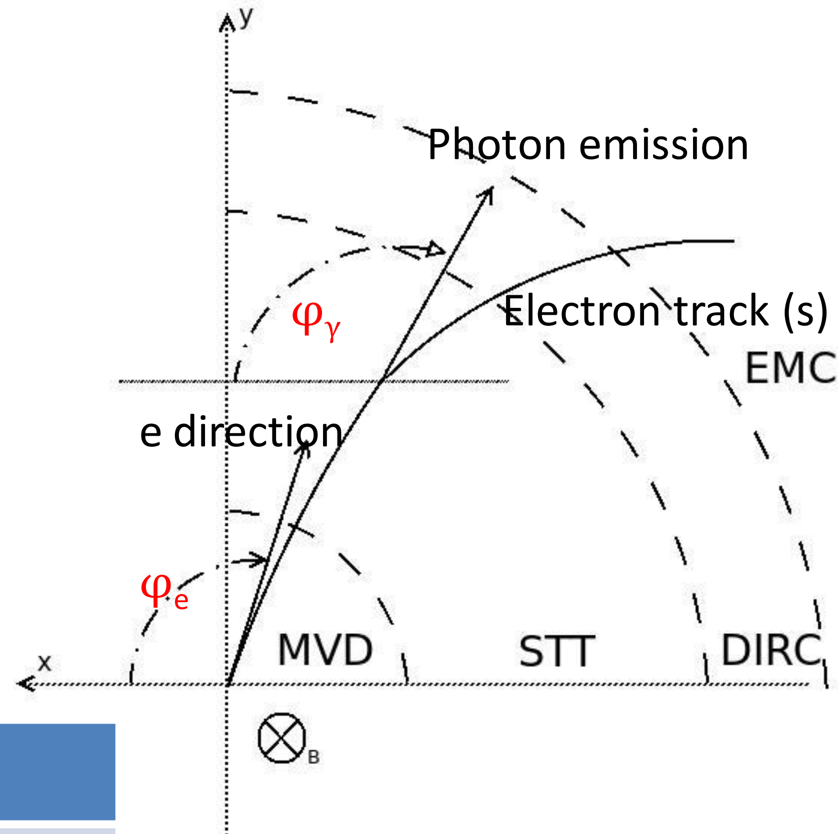


Photon direction from MC

e^- 1GeV/c, ϑ=90°, ϕ = 120°

Phi direction of photon(simulation)



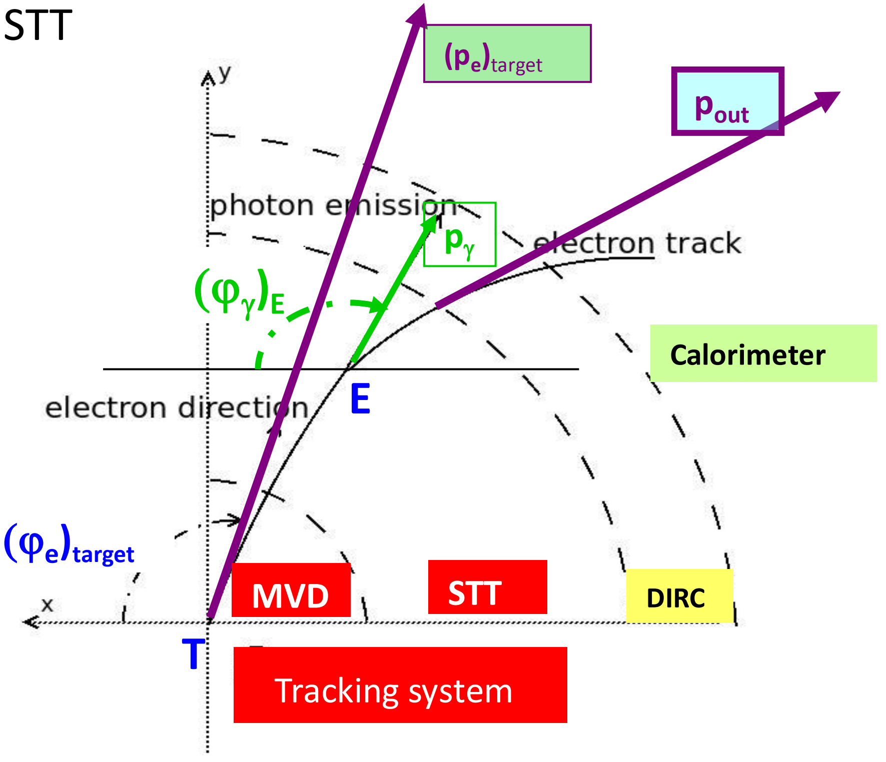


	φ_γ(deg)	φ_e (deg)
MVD(0-16cm)	120 - - 126	120 - - 125.6
STT(16-40cm)	126 - - 135	125.6 - - 134
DIRC(40-50cm)	135 - - 139	134 - -137.2

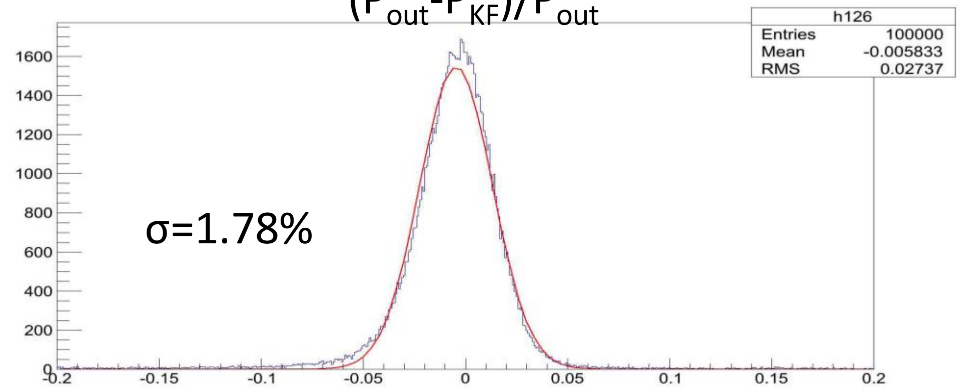
Direction of photon emission $\phi_\gamma(s)$
=Direction of electron $\phi_e(s)$

Compare P_{out} and P_{KF}

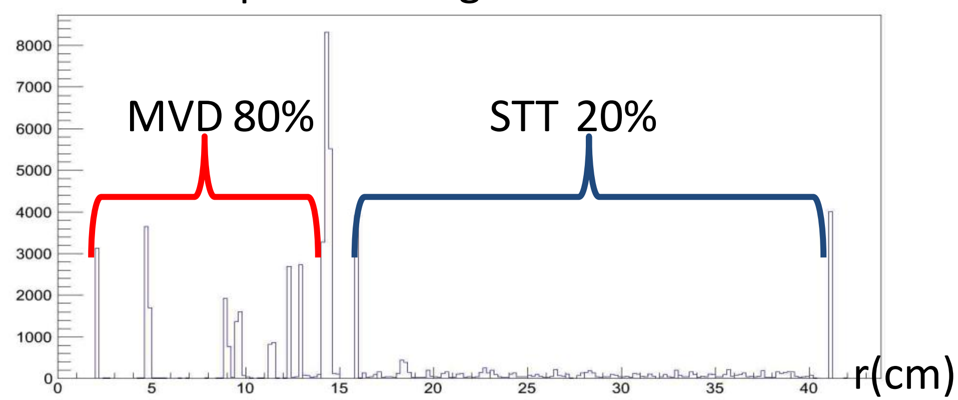
P_{out}: electron momentum at the last point of STT



$(P_{out}-P_{KF})/P_{out}$



The position of gamma emission



The KF reconstructs the momentum after γ emission (after point E, not at the target) with a good resolution. This is due to the fact that most γ emitted close to target(MVD)

→ ***Adding the γ energy should improve the resolution of momentum at the target?***

Bremsstrahlung γ selection algorithm

γ_{in} selection algorithm

→ electron/photon separation:
Using the information from PidCandidate

→ γ_{out} and γ_{in} separation :
Using $\Delta\theta$ and $\Delta\varphi$: the different between photon angle and the electron initial angle.

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

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

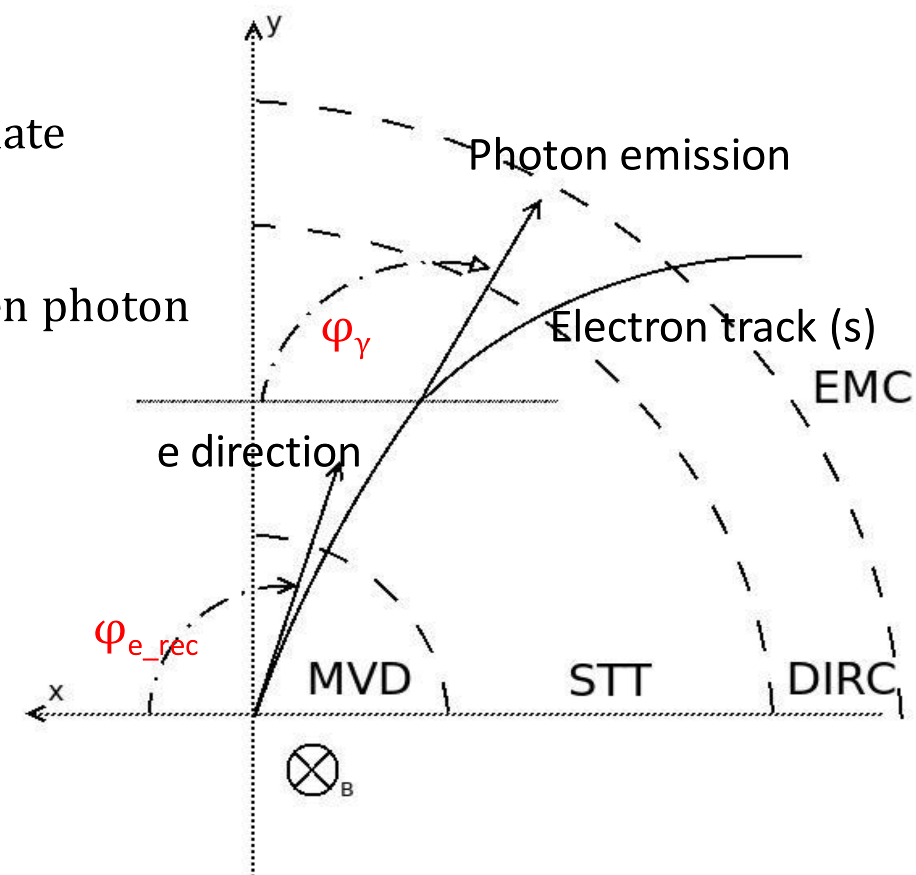
Ex: photon emitted in the target:

$\Delta\theta = \Delta\varphi = 0°$

at the end of the tracking system:

$\Delta\theta = 0°$

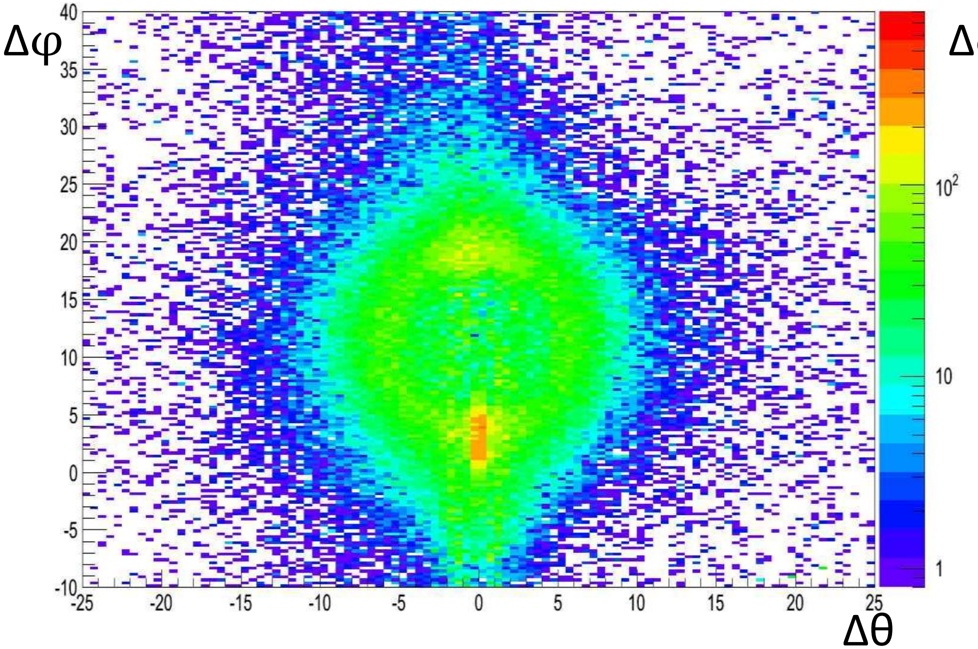
$\Delta\varphi_{max} = 2\arcsin(0.12/Pt)$



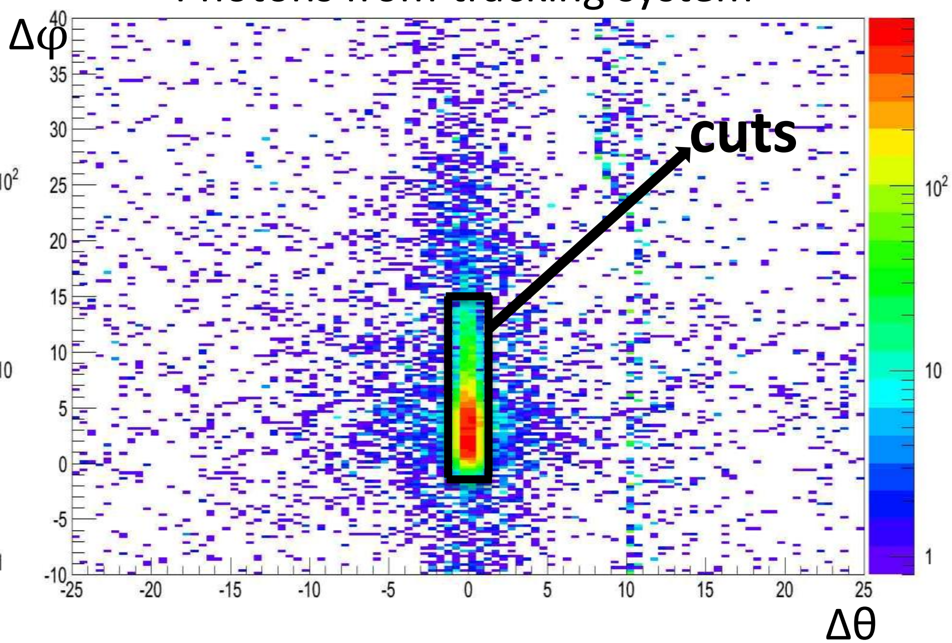
The differents Δθ and Δφ distribution for γ_{out} and γ_{in}

10^5 e^- P_t=1GeV/c, ϑ=[5°,140°], φ=[0°,360°], μ hypothesis

Photons from DIRC and EMC



Photons from tracking system



So, we can put cuts for Δθ and Δφ to select the photons from tracking system.

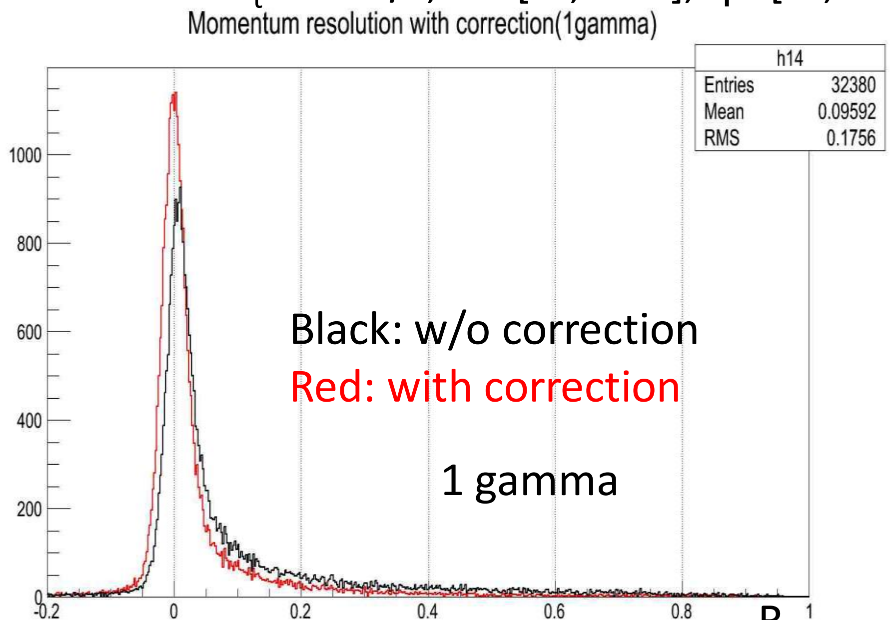
Cuts : $|\Delta\theta| < 2°$

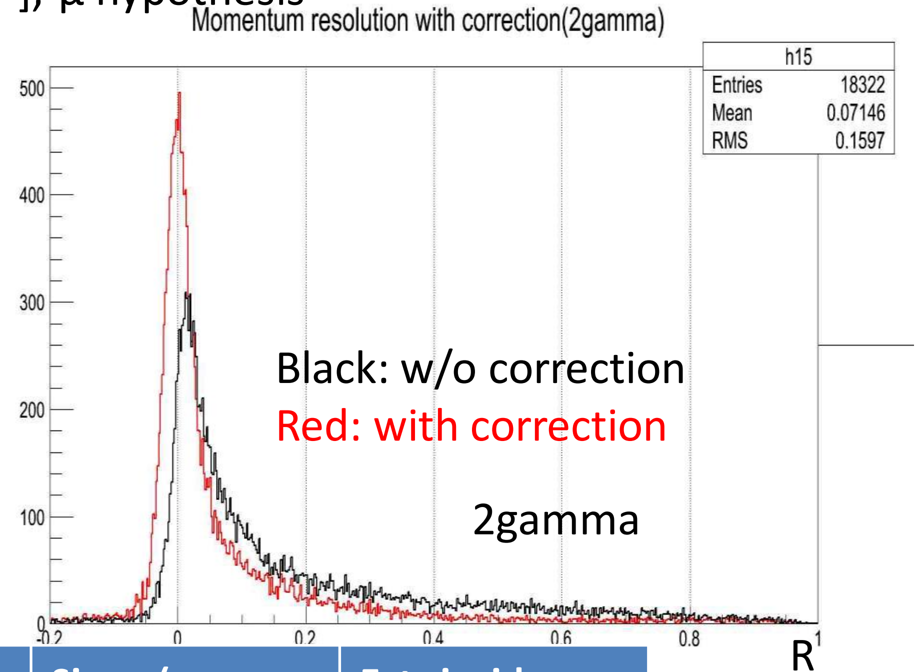
$-1° < \Delta\varphi < 2\arcsin(0.12/Pt)$. (geometry calculation, limit of the end of the tracking system region)

$(14°)$

The effect of this method for the resolution (P_t=1GeV/c)

10^5 e^- P_t=1GeV/c, ϑ=[5°,140°], φ=[0°,360°], μ hypothesis



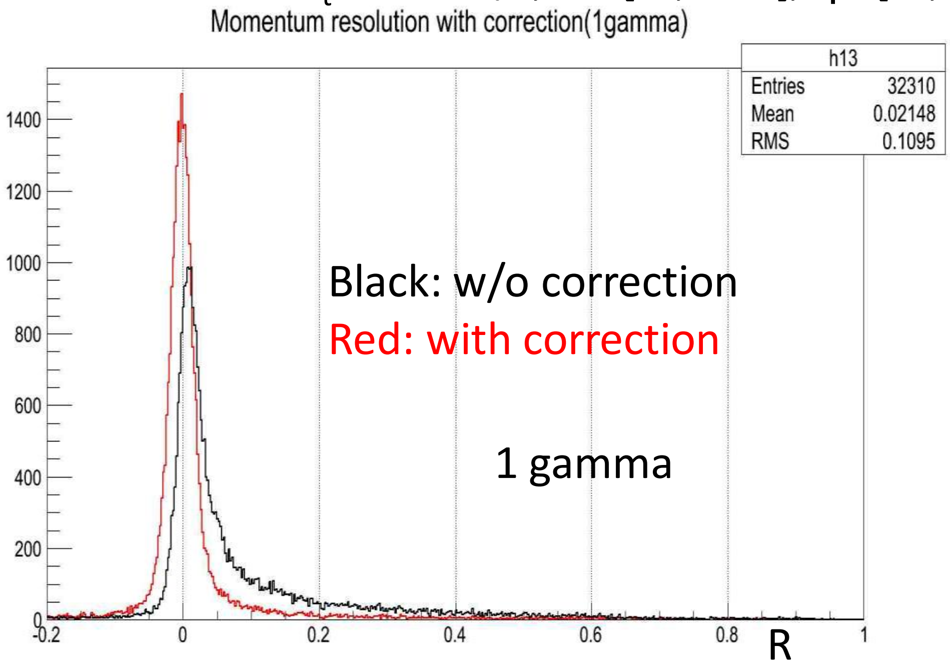


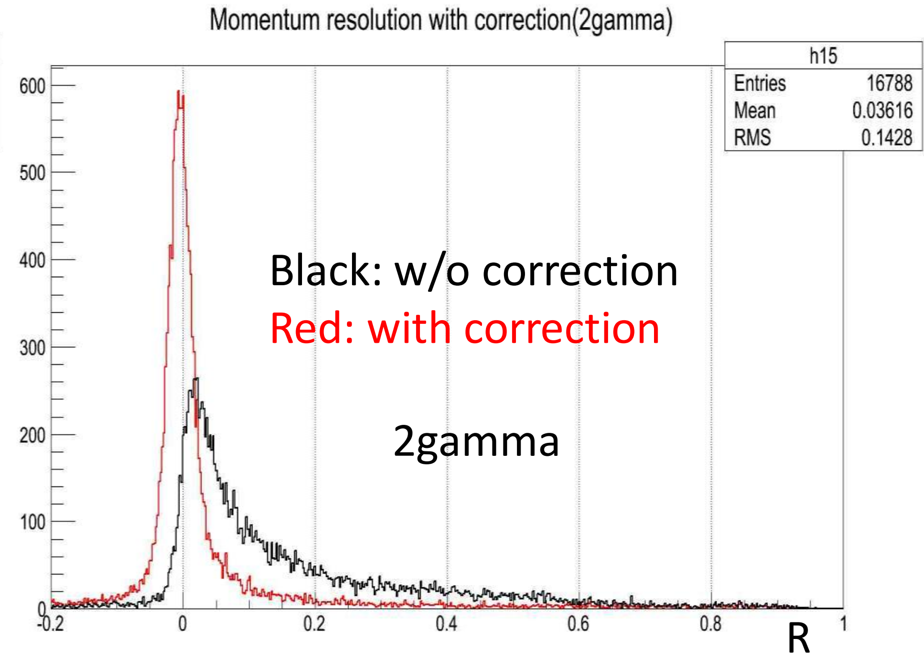
N(γ)		Mean(gauss fit)	Sigma(gauss fit)	Evts inside 2sigma
1 gamma (32.3%)	With E(γ)	<0.01%	2.0%	67.8%
	w/o E(γ)	1.1%	2.18%	54.4%
2 gamma (18.3%)	With E(γ)	<0.1%	2.2%	56.0%
	w/o E(γ)	2.1%	2.5%	37.3%

→ improved

The effect of this method for the resolution (P_t=0.5GeV/c)

10^5 e^- P_t=0.5GeV/c, ϑ=[5°,140°], φ=[0°,360°], μ hypothesis



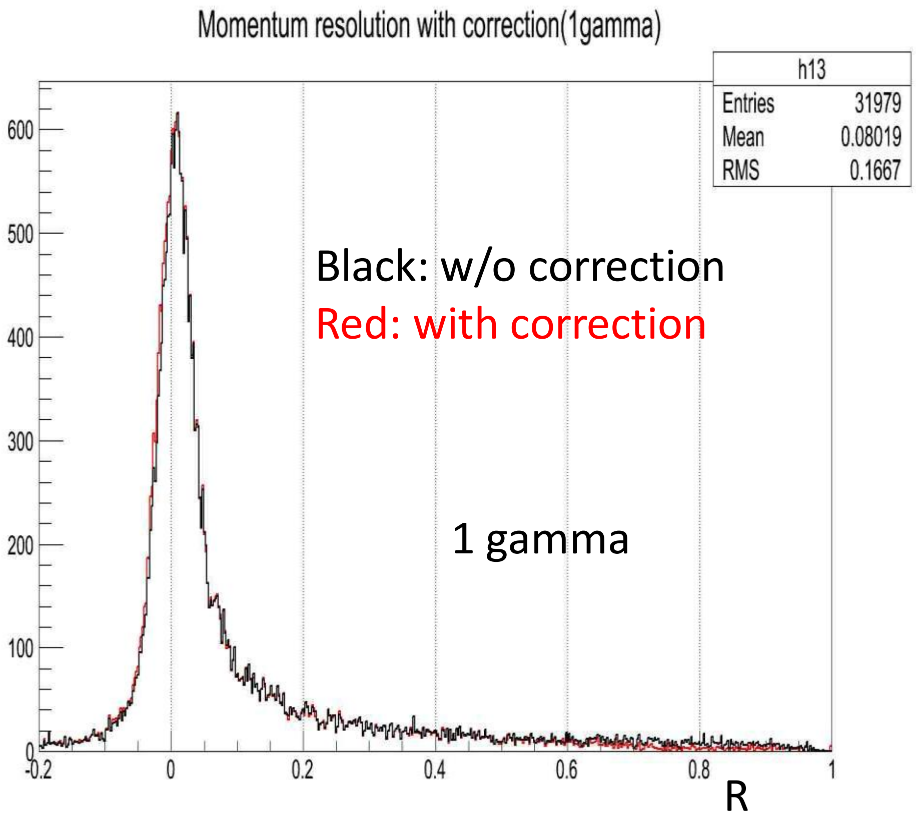


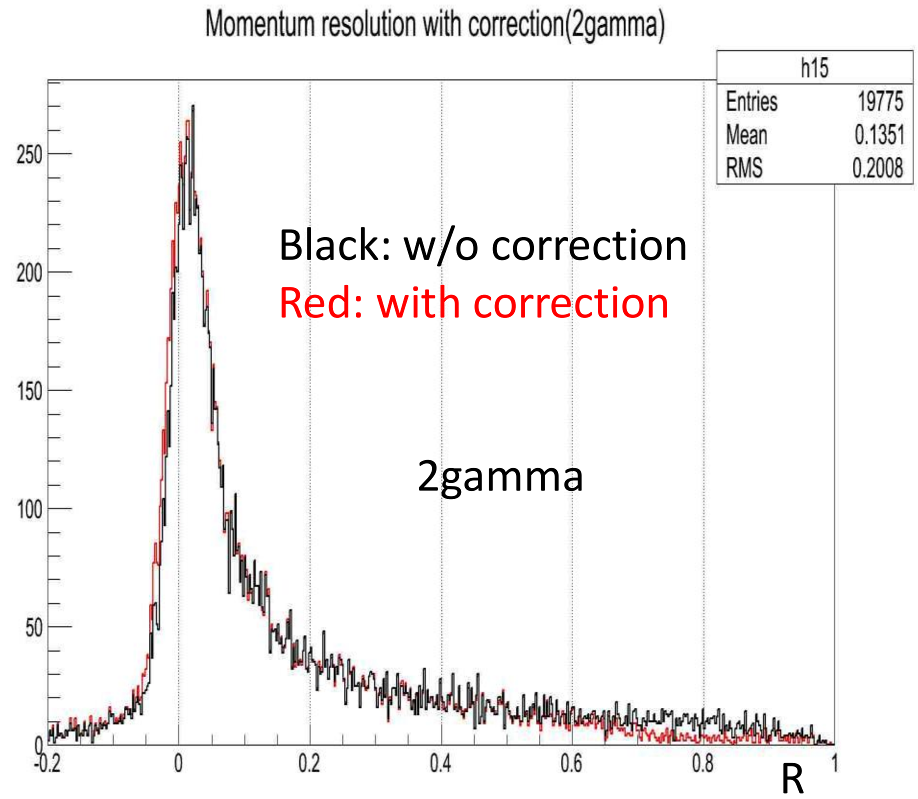
N(γ)		Mean(gauss fit)	Sigma(gauss fit)	Evts inside 2sigma
1 gamma (32.3%)	With E(γ)	<0.1%	1.7%	71.1%
	w/o E(γ)	1.2%	1.9%	51.5%
2 gamma (16.8%)	With E(γ)	<0.1%	2.2%	65.4%
	w/o E(γ)	2.4%	2.4%	33.2%

→ improved

The effect of this method for the resolution (P_t=2GeV/c)

10^5 e^- P_t=2GeV/c, ϑ=[5°,140°], φ=[0°,360°], μ hypothesis

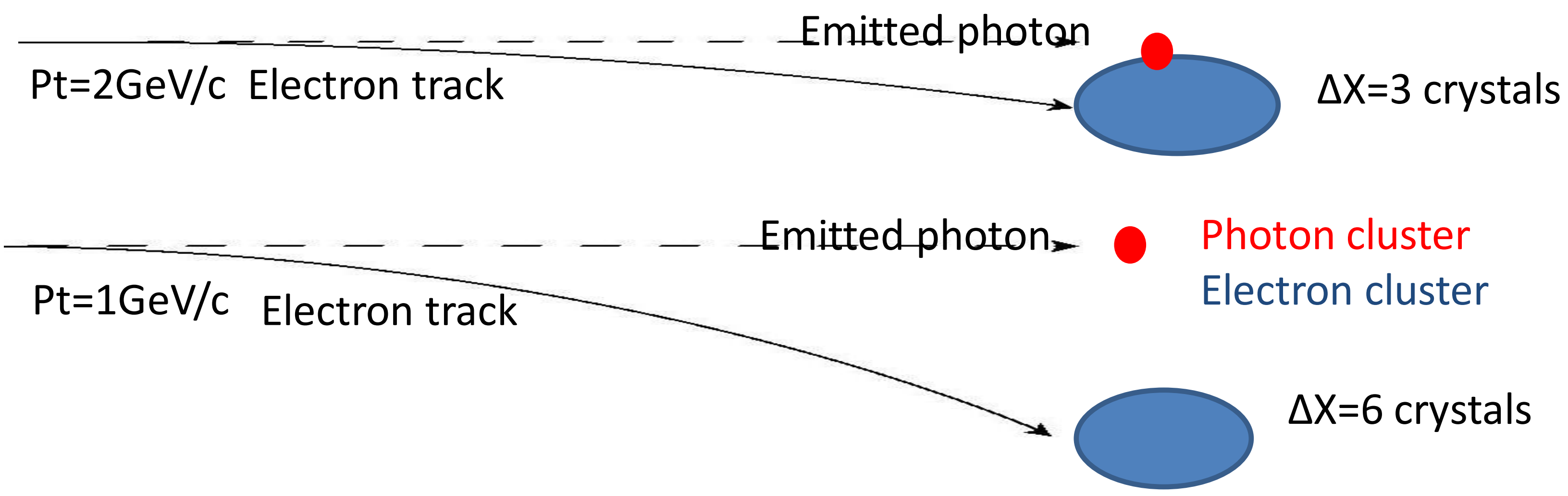




For P_t = 2GeV/c, this method does not work!

The limits of the method

the efficiency of this method will be very low at the high transverse momentum region(above 2GeV/c)



Conclusion

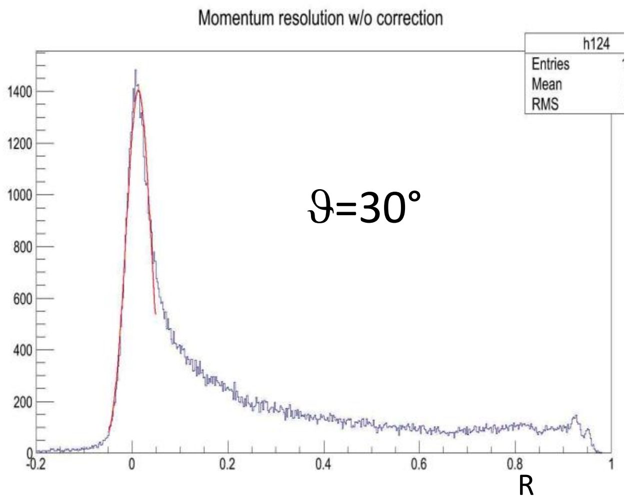
- Adding the photon energy from EMC to the reconstructed energy of electron reduces the tail of resolution peak.
- This method is valid for all range of θ and φ but only in low momentum region.

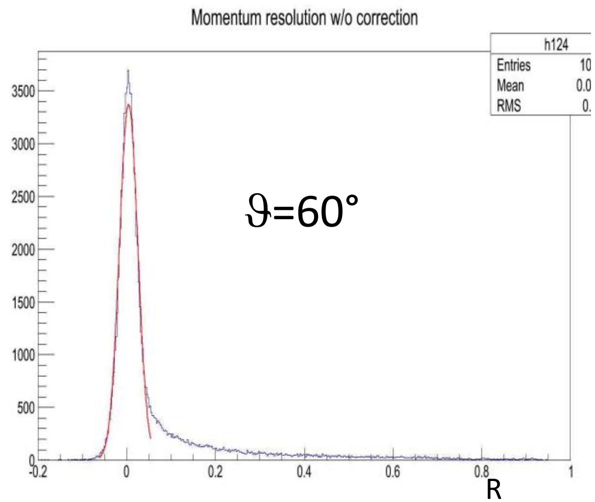
  ($P_t \leq 1GeV/c$))
- On-going work: improve the efficiency of the method

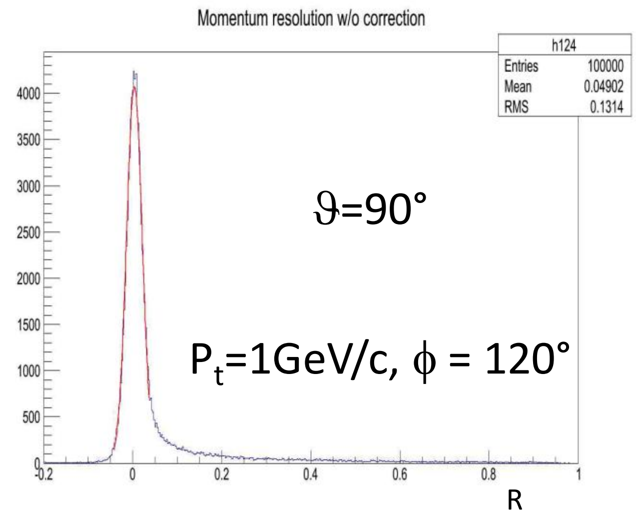
Backup slides

Electron resolution at different angles

Reconstruction with μ hypothesis: no Bremsstrahlung in GEANE







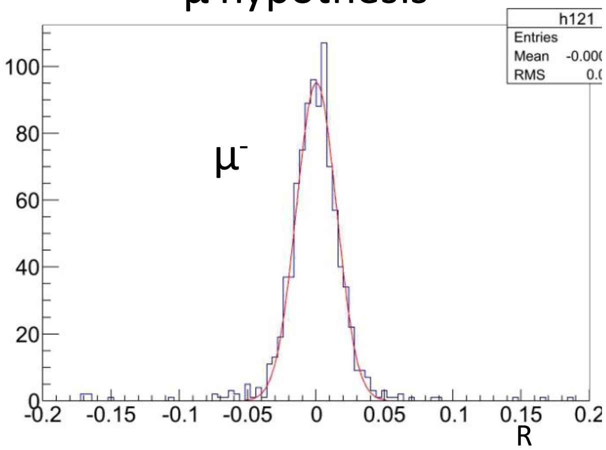
theta(deg)	Sigma(%)	Evts inside 2sigma(%)
30	2.56	35.5
60	2.08	69.3
90	1.76	71.1

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

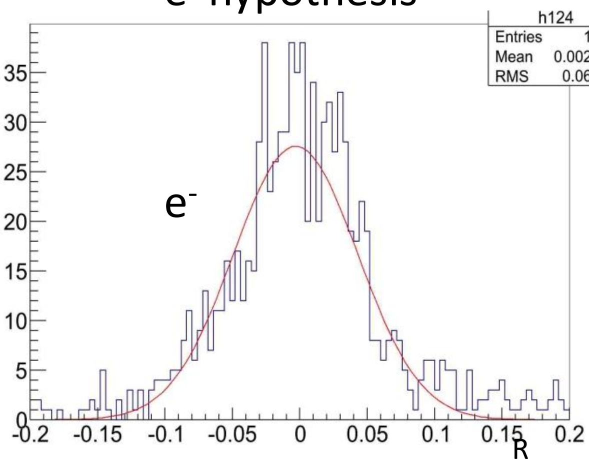
e^-/ μ^- momentum reconstruction with KF

P = 1GeV/c, ϑ= 90°, ϕ = 120°.

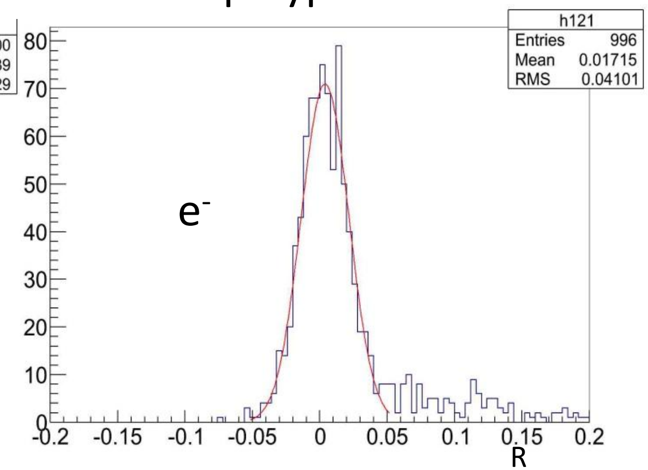
μ hypothesis



e^- hypothesis



μ hypothesis



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

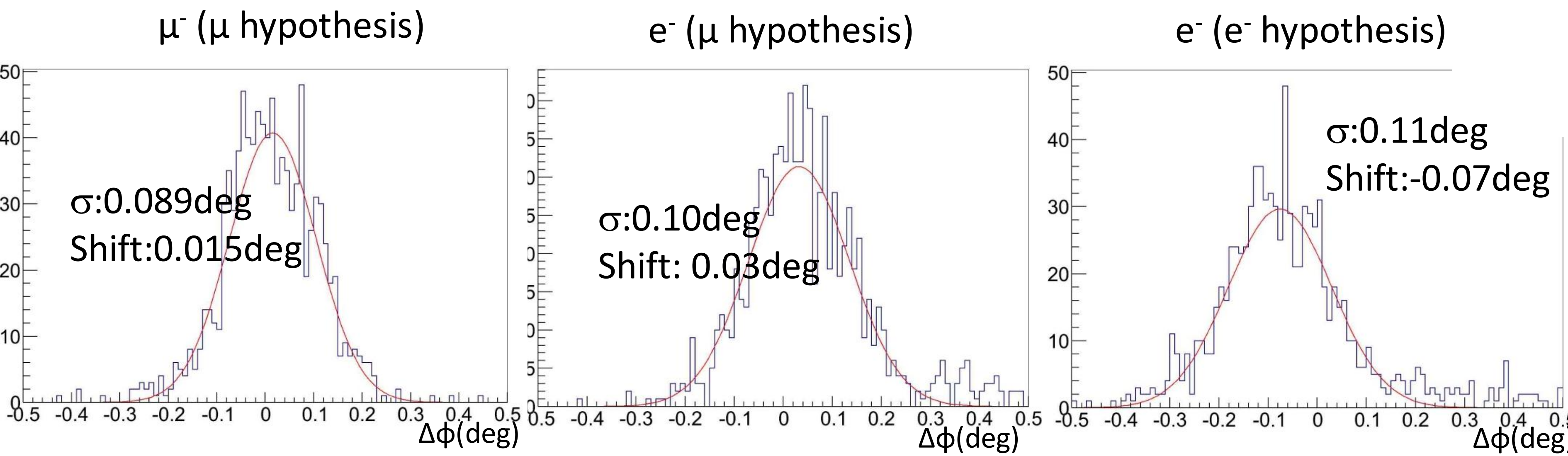
	μ (μ hypo)	e^- (e^- hypo)	e^- (μ hypo)
Mean(gauss)	<0.1%	-0.32%	0.37%
Sigma	1.6%	4.6%	1.8%

e^- hypothesis: Bremsstrahlung taken into account in GEANE.
μ hypothesis: only multi scattering and ionization in GEANE

e^- with e^- hypothesis: momentum resolution very bad (σ=4.6%).
e^- with μ hypothesis: better result but with large tails.

e^- and μ^- angular resolutions

P=1GeV/c, ϑ=90° , ϕ=120°



	$\sigma(\phi)$ (deg)	$\sigma(\vartheta)$ (deg)
μ^- (μ hypothesis)	0.089	0.066
e^- (μ hypothesis)	0.10	0.068
e^- (e^- hypothesis)	0.11	0.068

Good angular resolution for e^- with μ hypothesis.

Tiny worsening of angular resolution for electron.

Small shifts: 0.03 deg. This is due to the fact that photons are emitted in the direction of the electron.