RICH MC & Reconstruction

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MIPP Monte Carlo

- Plugged in realistic RICH Geometry:

  Hamamatsu PMTs, Russian PMTs and holes

- Matched MC geometry coordinates and PMT numbering scheme with GRICHGeo:

  H,V Tube 1 = 61.4568 25.4032
  H,V Tube 32 = 61.4568 -24.5967
  H,V Tube 33 = 60.0601 24.5967
  H,V Tube 64 = 60.0601 -25.4032
  H,V Tube 2817 = -61.4568 25.4032
  H,V Tube 2848 = -61.4568 -24.5967

- MC works in interactive mode, but not in batch mode
- MC does not seem to read from input files

Reconstruction Algorithm

- Given a particle hypothesis *j* & momentum → compute the number of photoelectrons n_i for every PMT *i* in RICH array
- Since probability to observe exactly m photoelectrons

$$P(m) = \frac{e^{-n_i} n_i^m}{m!}$$

  the probability for a PMT to fire is

$$1 - P(0) = 1 - e^{-n_i}$$

- For each PMT *i*, assign a likelihood

$$L_i = \begin{cases} e^{-n_i - n_b} & \text{if PMT did not fire} \\ 1 - e^{-n_i - n_b} & \text{if PMT did fire} \end{cases}$$

  From run11606, 4294 calibration events:

  $n_{b,Russian}$ = 1.19e-3

  $n_{b,Hamamatsu}$ = 3.52e-4

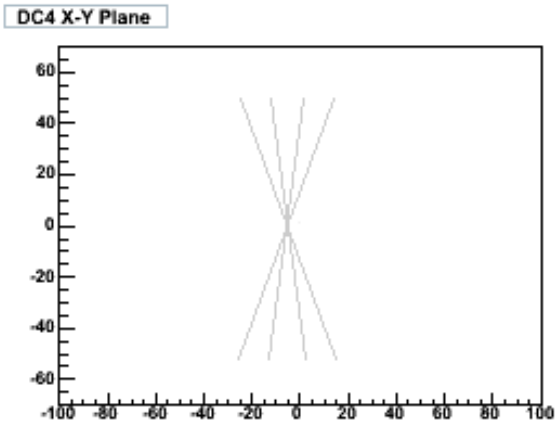
- Total likelihood for hypothesis *j*

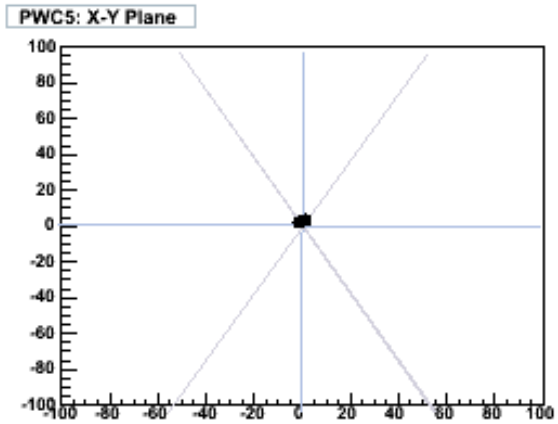
$$L_j = \prod L_i$$

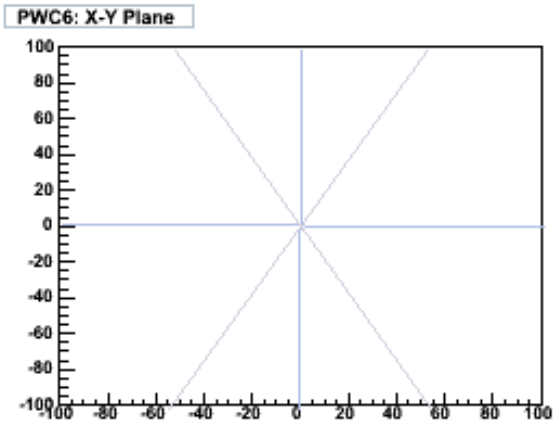
Testing Reconstruction Algorithm on MC

- Using ~2000 MC 40GeV particles (*p, K,* π) at (x,y,z)=(0,0,0) [between DC3 and DC4], compute
  - RICH PID Efficiency
    0. Electron
    1. Muon
    2. Pion
    3. Kaon
    4. Proton
  - Log likelihood
- Study effect of track momentum and ring center on particle identification and log likelihood calculation
  - Assume momentum *p* has a 10% error
  - Assume $x_c = x_c + \Delta x$, where Δx = 1cm, 2cm
  - Assume $y_c = y_c + \Delta y$, where Δy = 1cm, 2cm

MC 40GeV p event







MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 1
SubRun: 0
Event: 2

Mon Jan 23 2006
00:09:06.845671

*** Trigger ***
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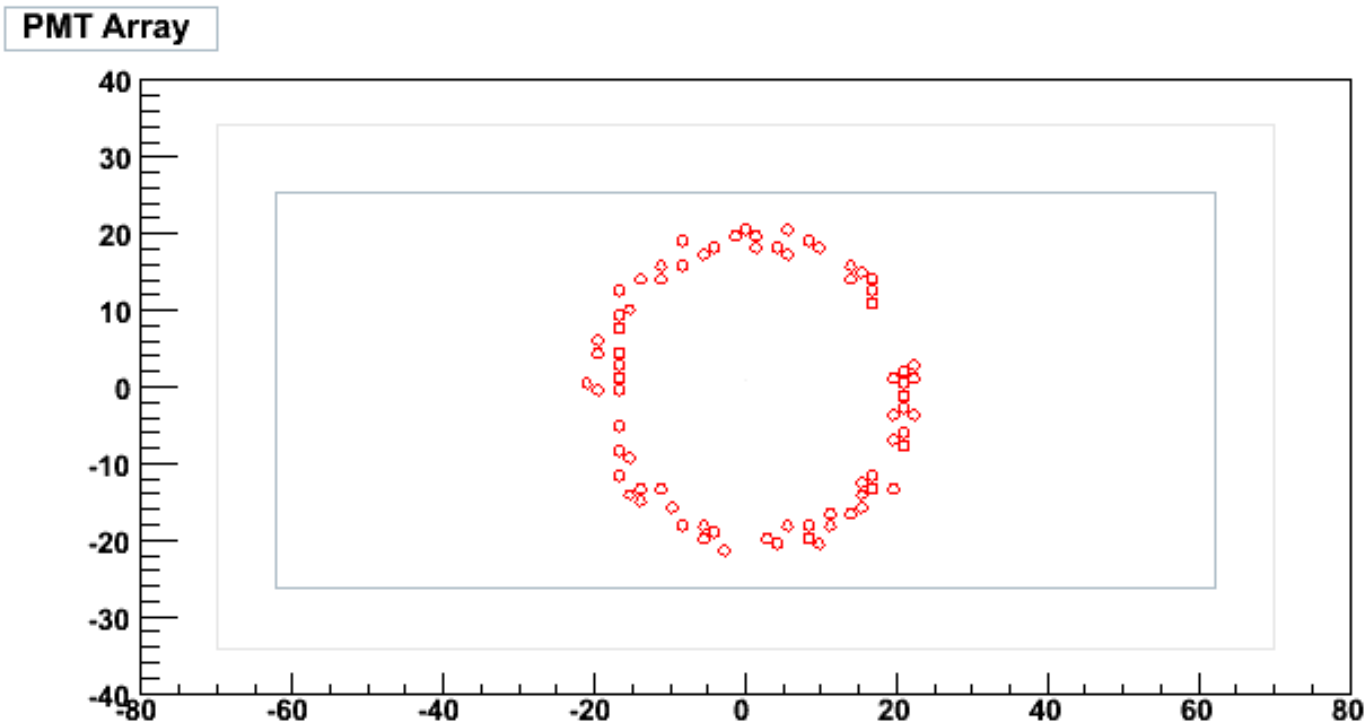
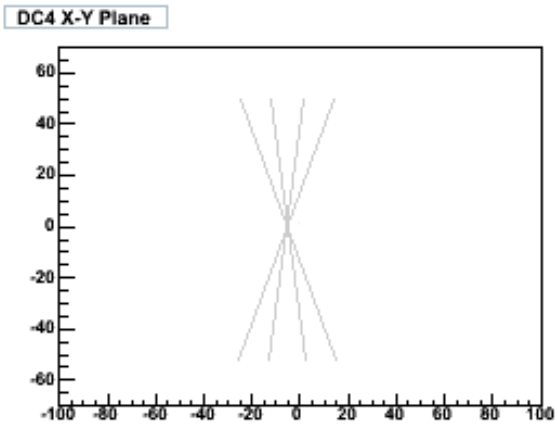
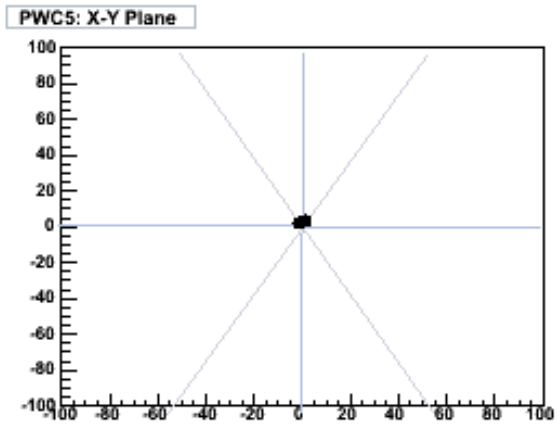
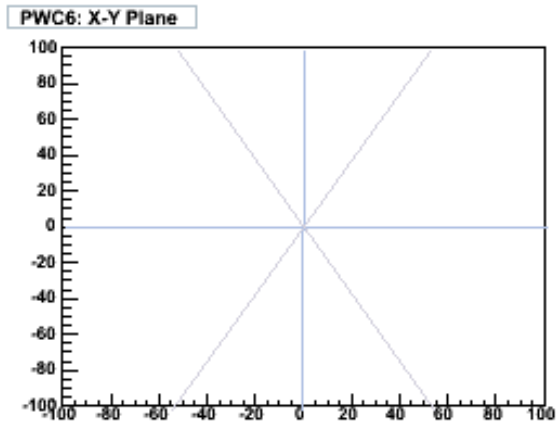
Word: unknown



MC 40GeV K event







MIPP (FNAL E907)

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Run: 1
SubRun: 0
Event: 2

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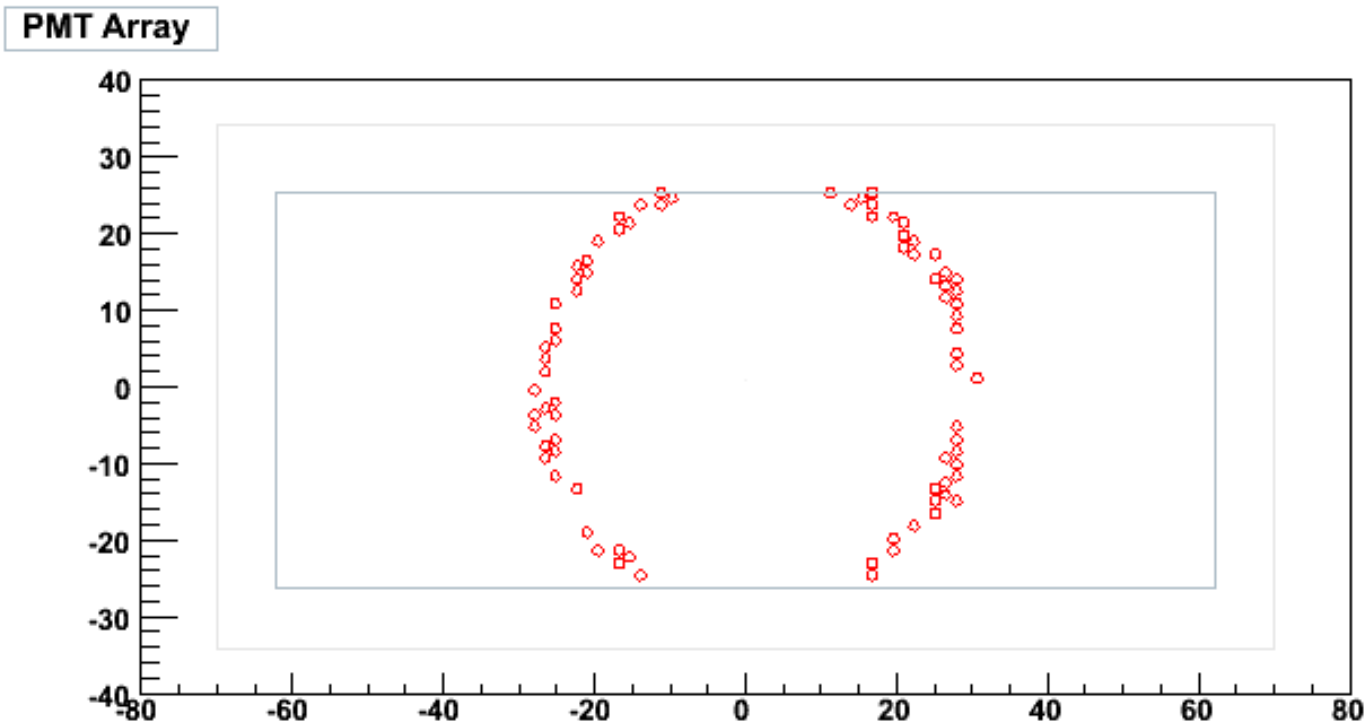
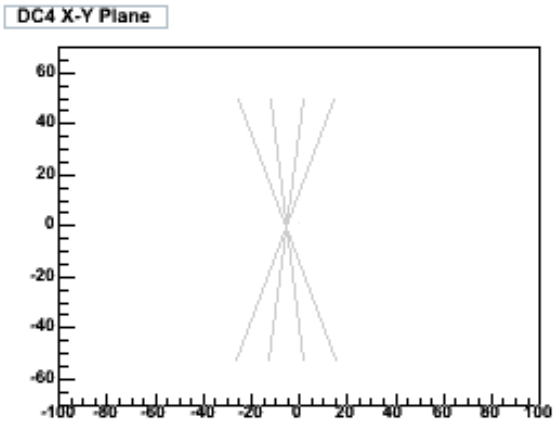
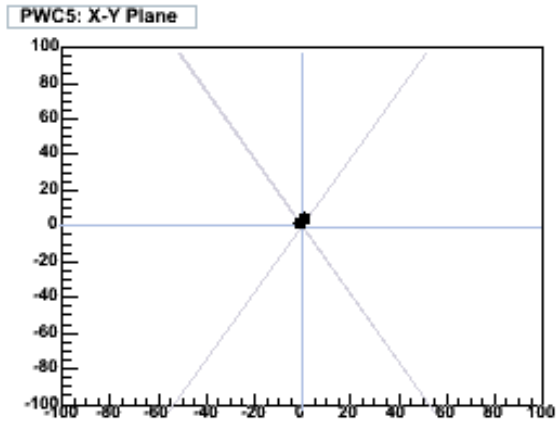
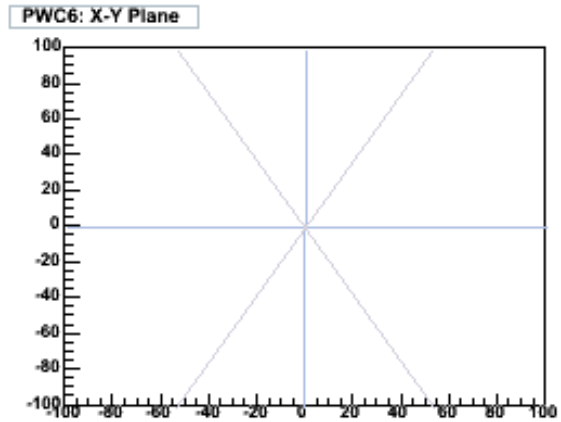


MC 40GeV π event







MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 1
SubRun: 0
Event: 1

Sun Jan 22 2006
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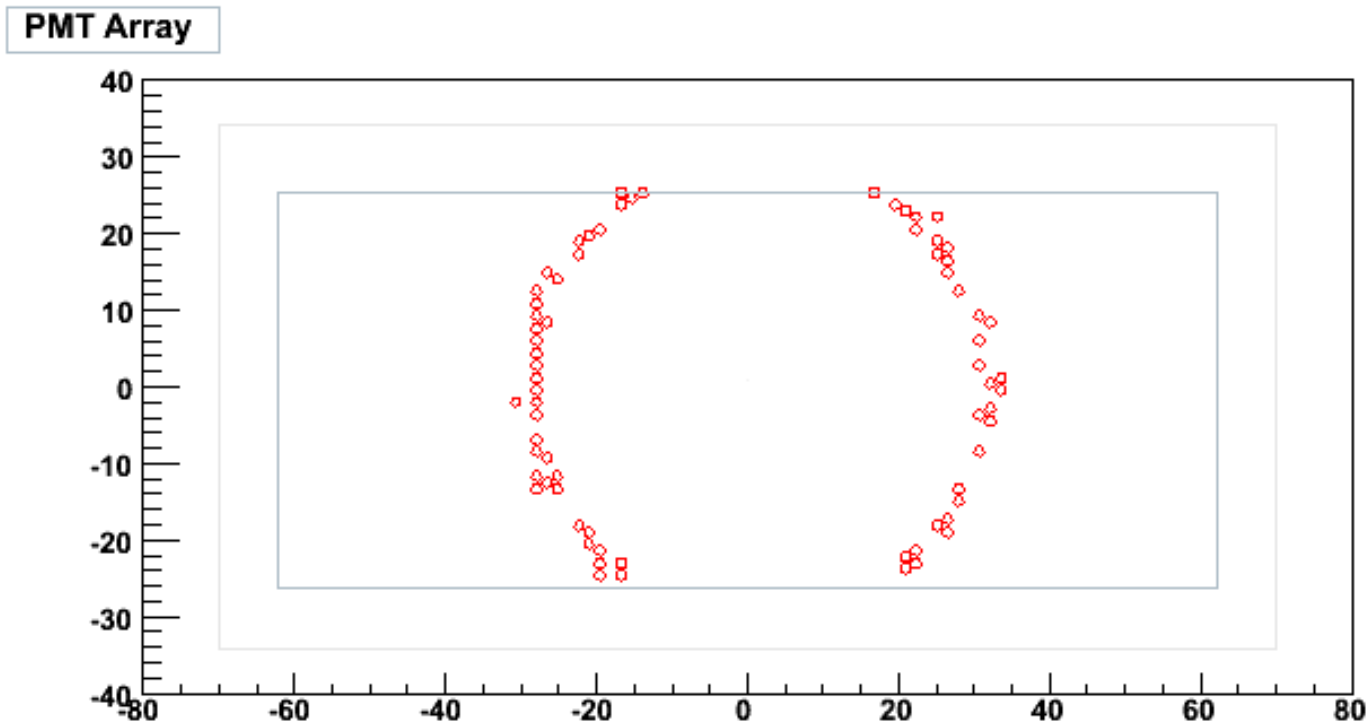
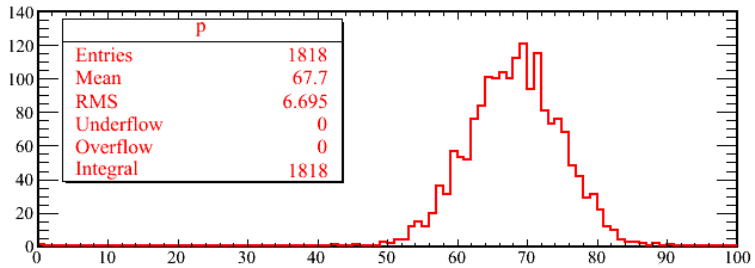
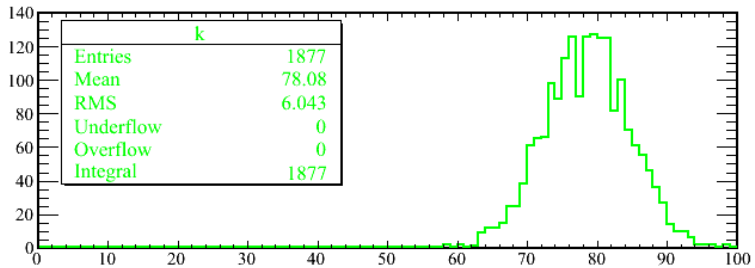


MC RICH Digits Distribution for 40GeV particles

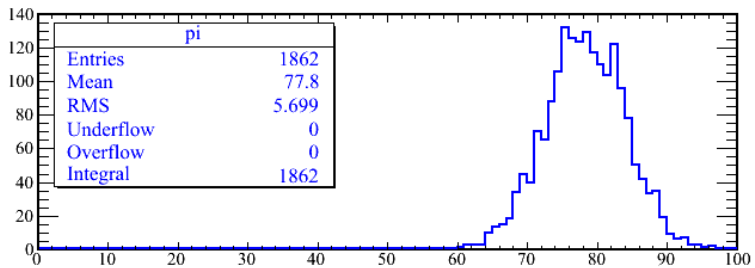
MC (40GeV-p, empty target): RICH Digits Distribution



MC (40GeV-K, empty target): RICH Digits Distribution



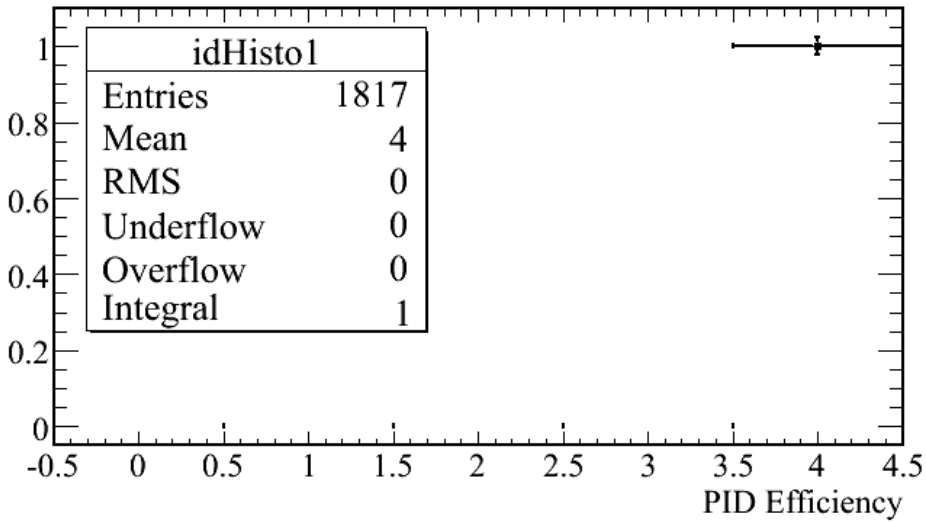
MC (40GeV-π, empty target): RICH Digits Distribution



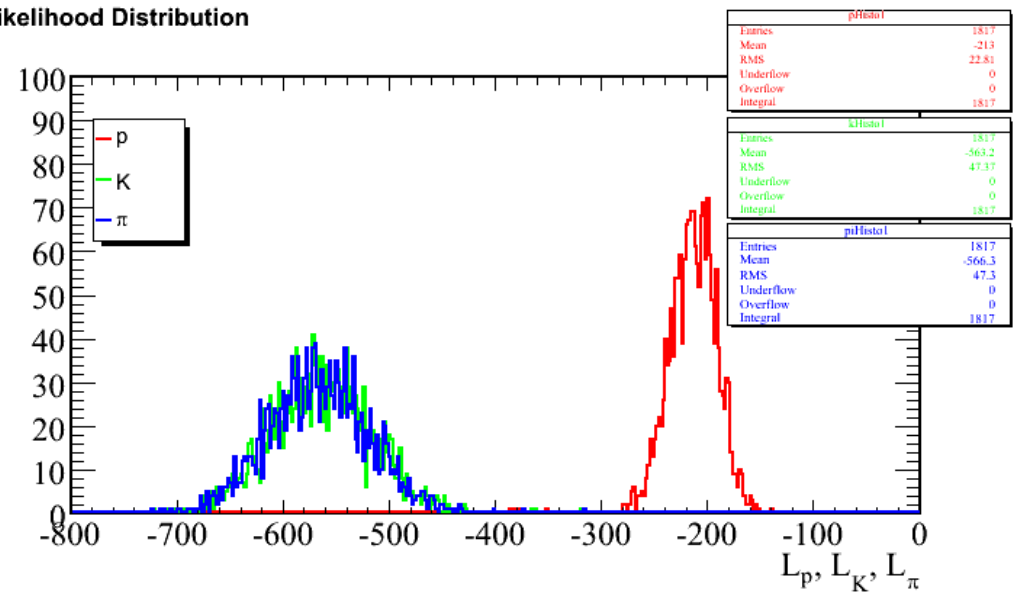
- Fewer digits seen in data
- Maybe the efficiency of PMTs are lower than we expect?

MC 40GeV p: PID Efficiency & Log Likelihood

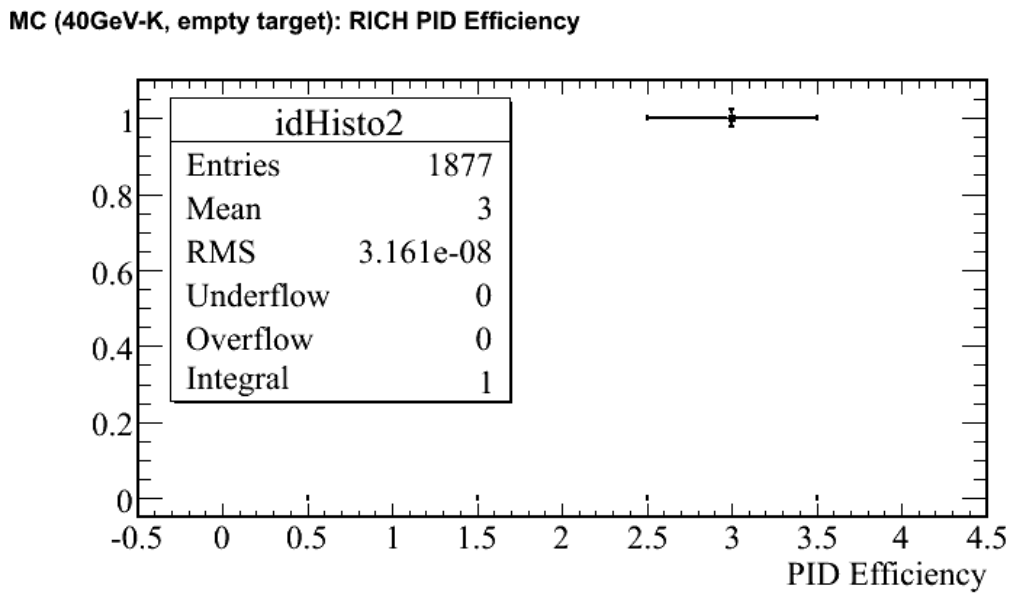
MC (40GeV-p, empty target): RICH PID Efficiency

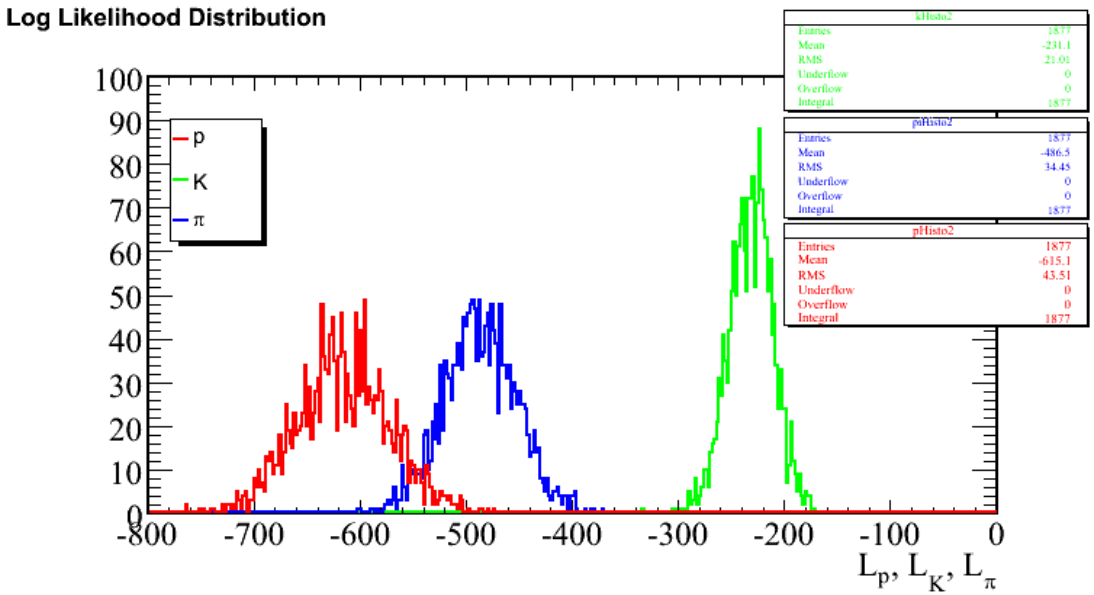


Log Likelihood Distribution

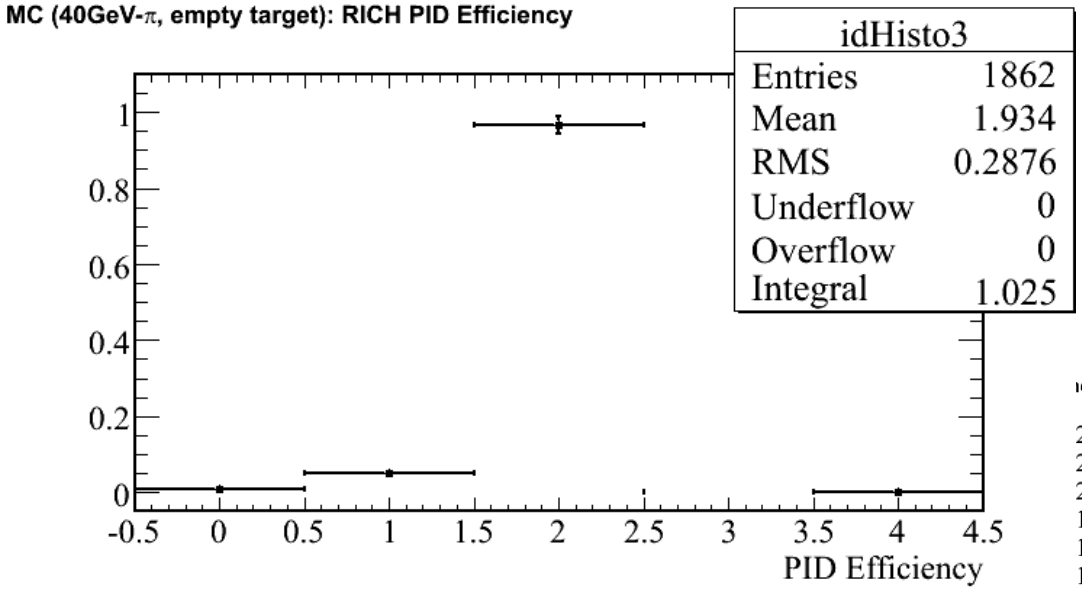


MC 40GeV K: PID Efficiency & Log Likelihood

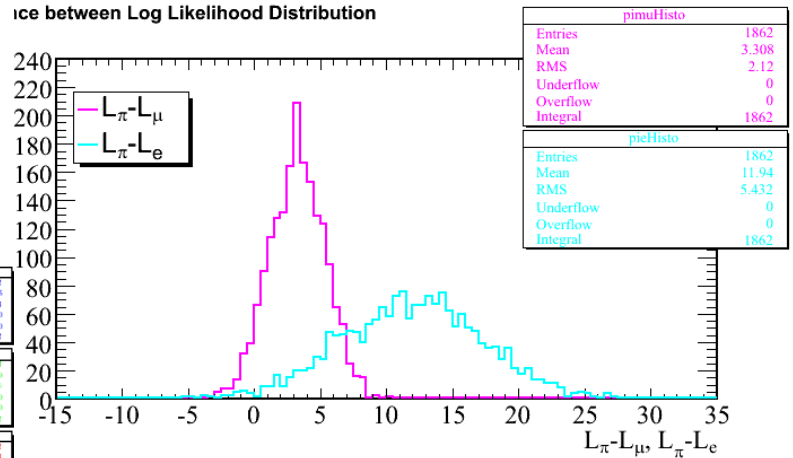


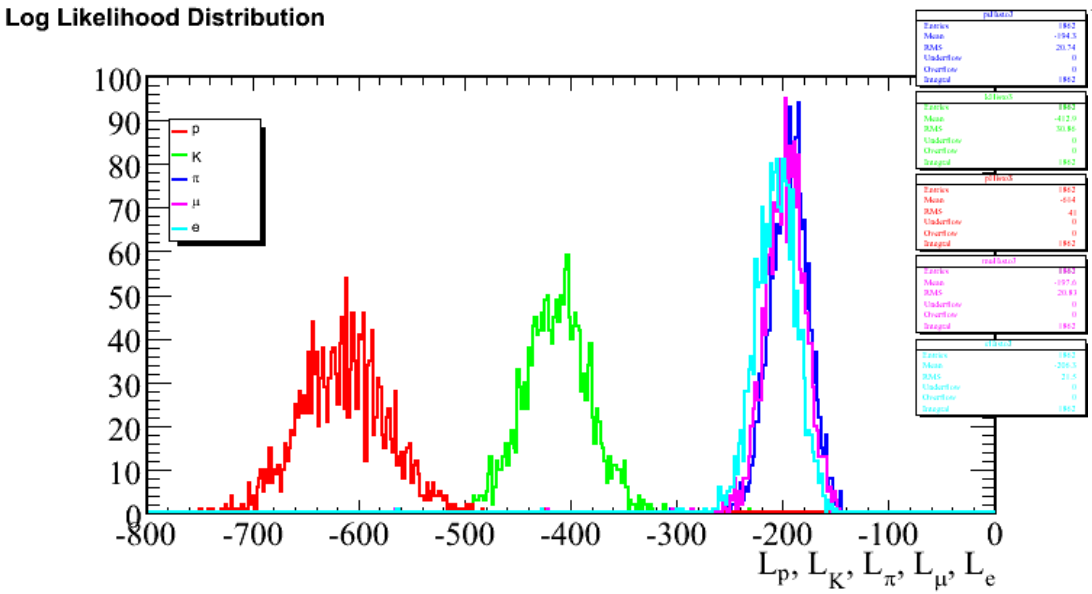


MC 40GeV π: PID Efficiency & Log Likelihood



Difference in Log Likelihood Distribution

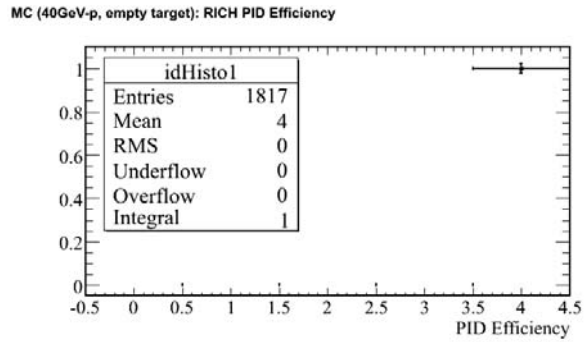


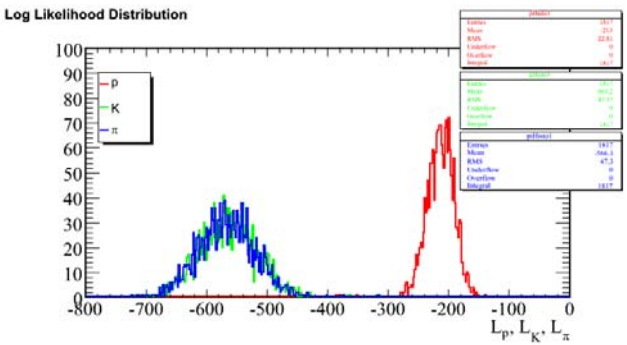


L_e, L_μ, L_π are very similar!!!

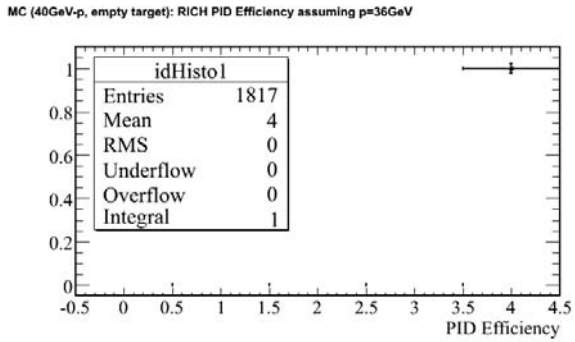
MC 40GeV p: Momentum change by 10%

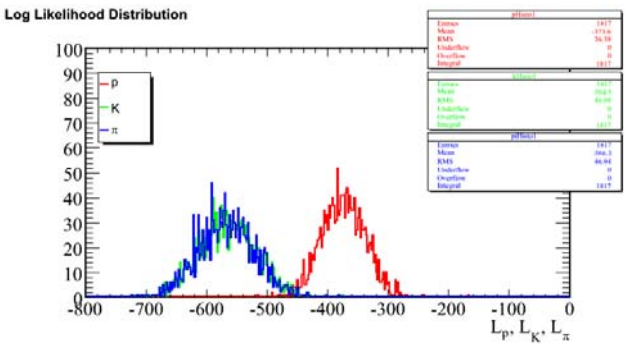
p=40GeV



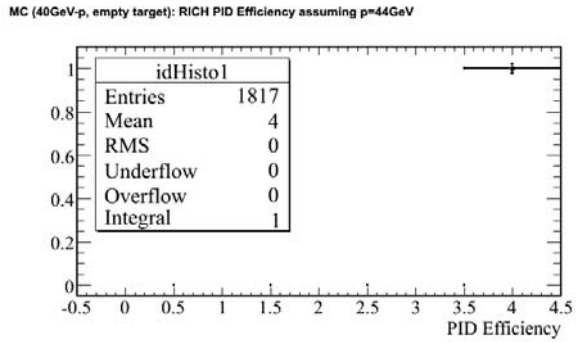


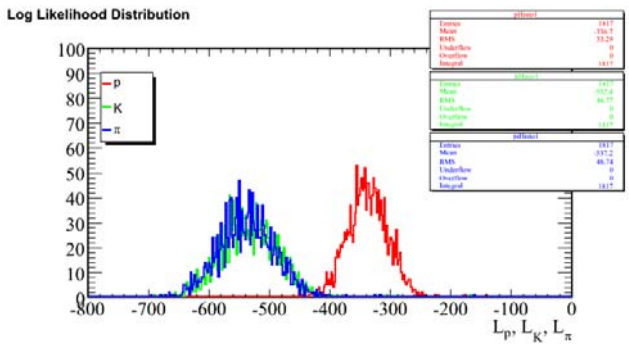
p=36GeV





p=44GeV

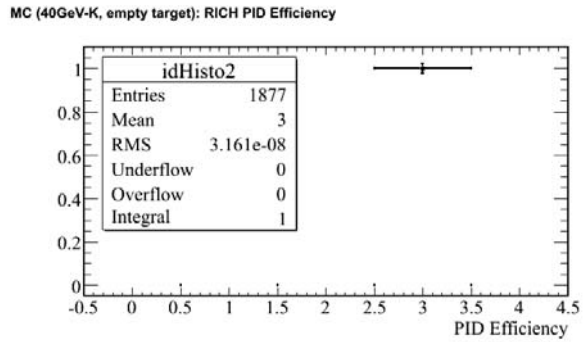


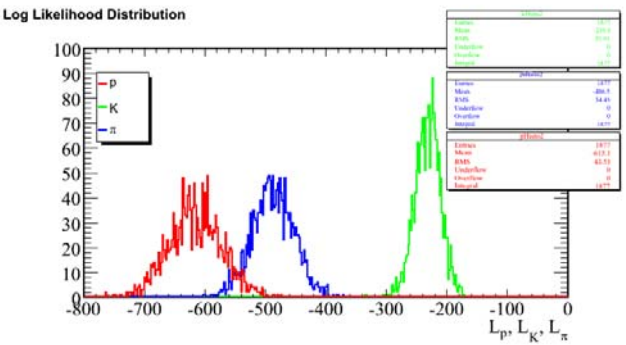


If predicted momentum is off by 10% at 40GeV,
it does not affect Proton PID.

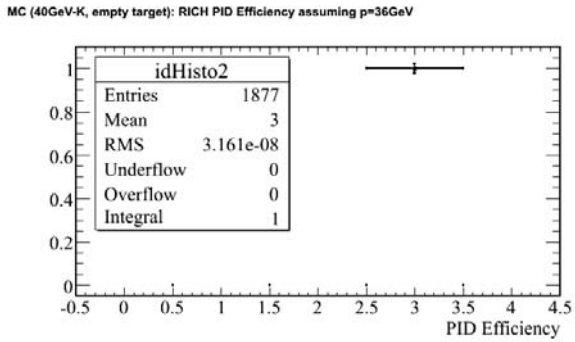
MC 40GeV K: Momentum change by 10%

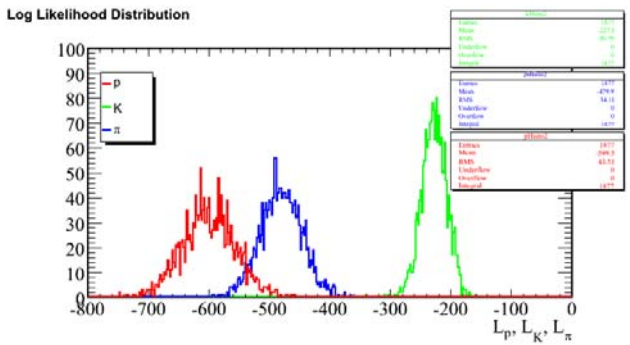
p=40GeV



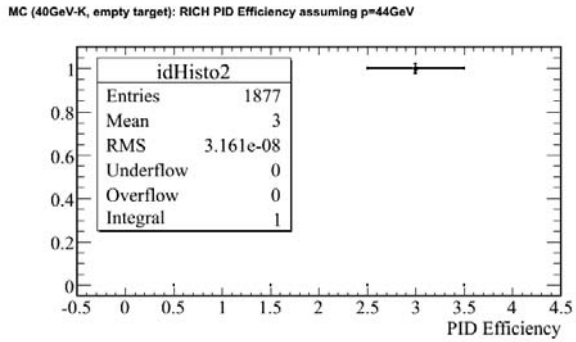


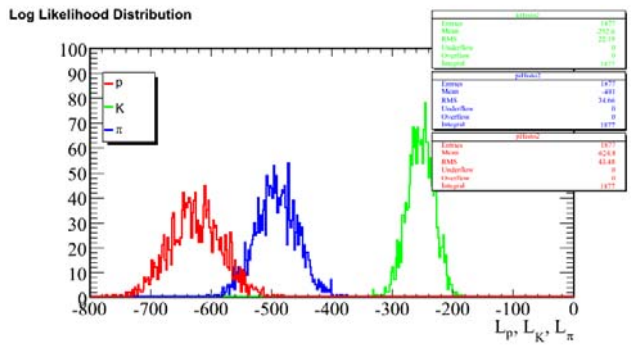
p=36GeV





p=44GeV

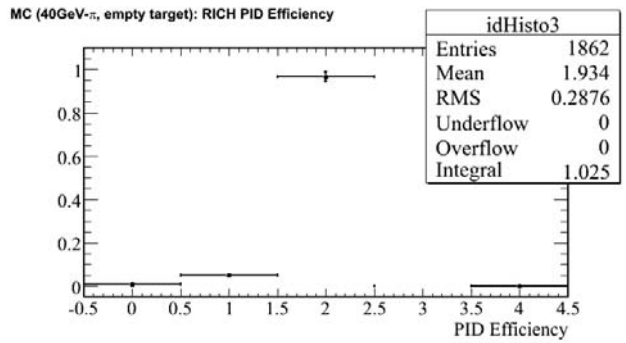


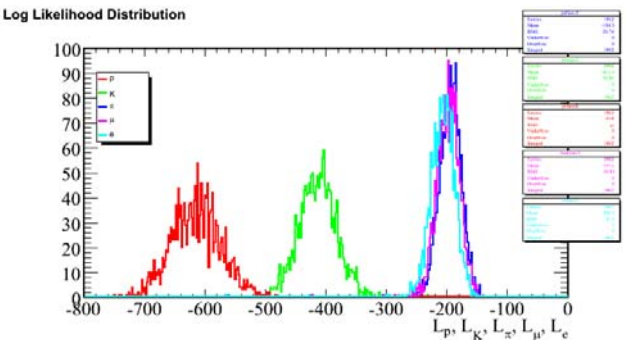


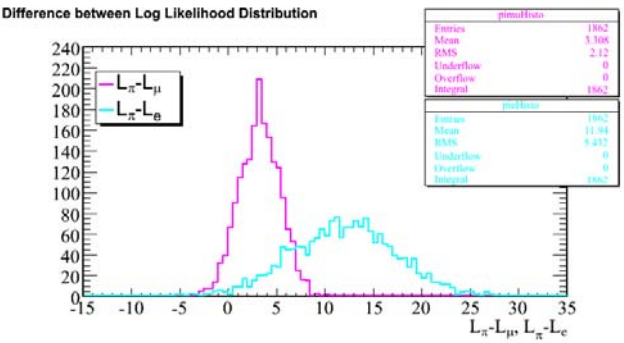
If predicted momentum is off by 10% at 40GeV,
it does not affect Kaon PID.

MC 40GeV π: Momentum change by 10%

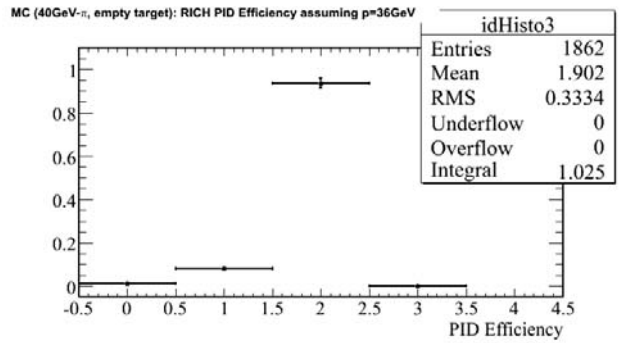
p=40GeV

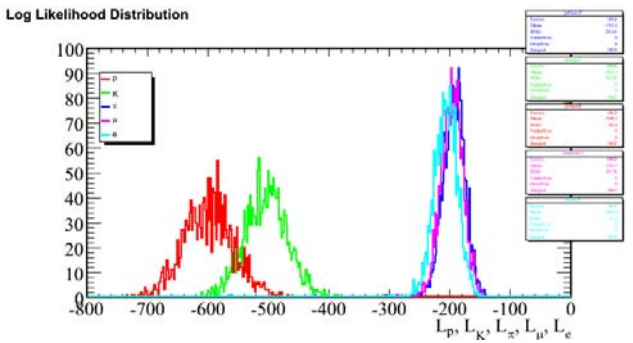


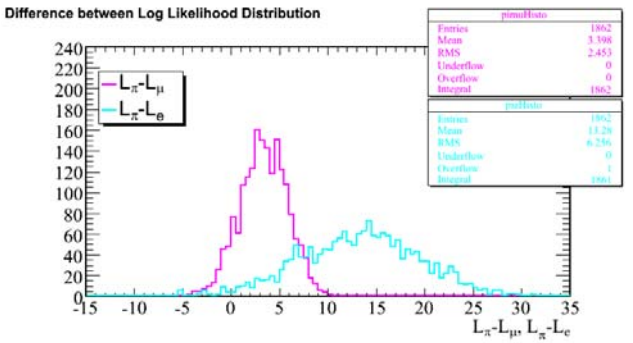




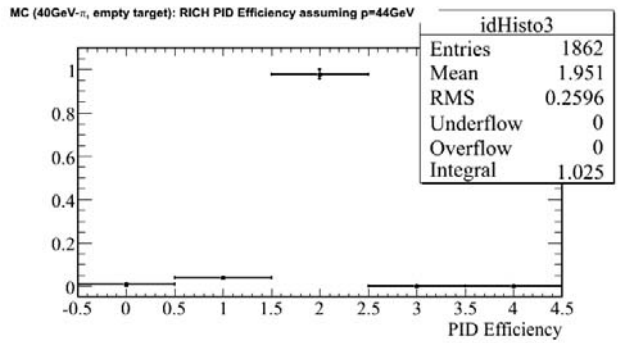
p=36GeV

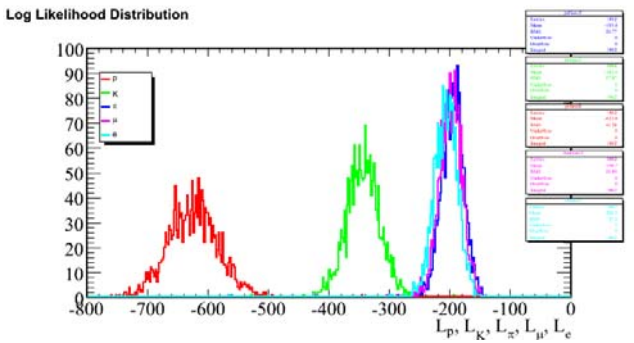


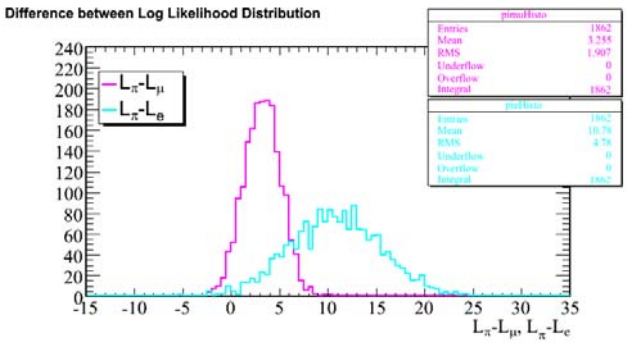




p=44GeV



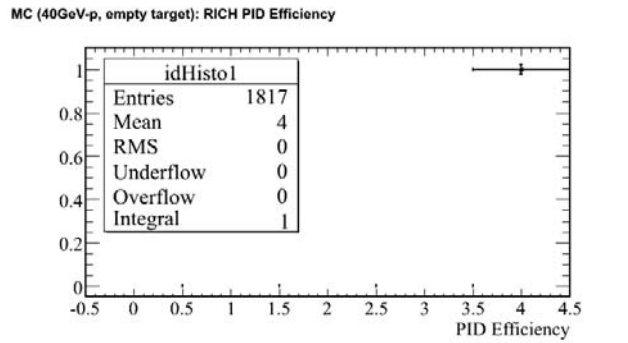


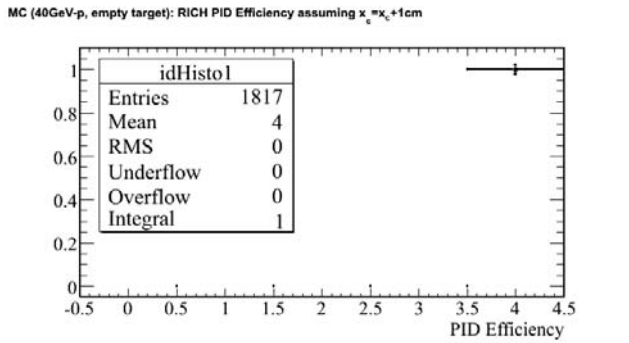


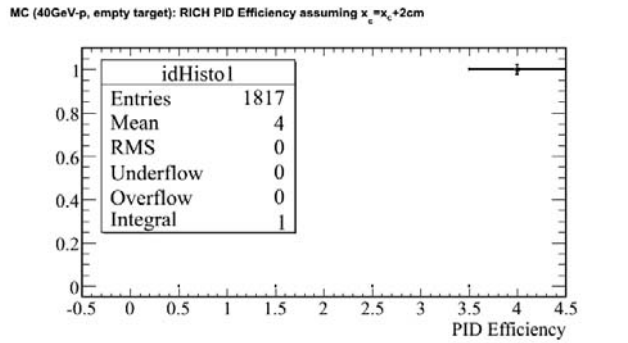
If predicted momentum is off by 10% at 40GeV, it does not affect Pion PID.

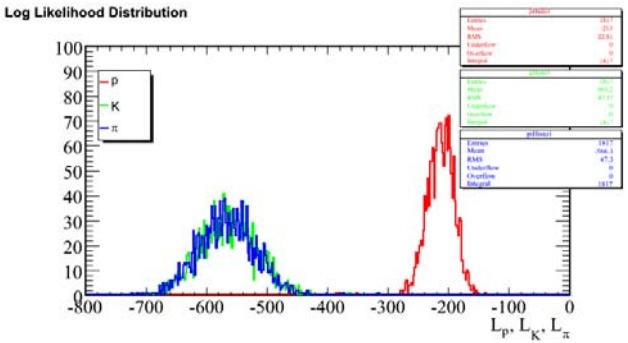
MC 40GeV p: Ring center x_c by 1cm, 2cm

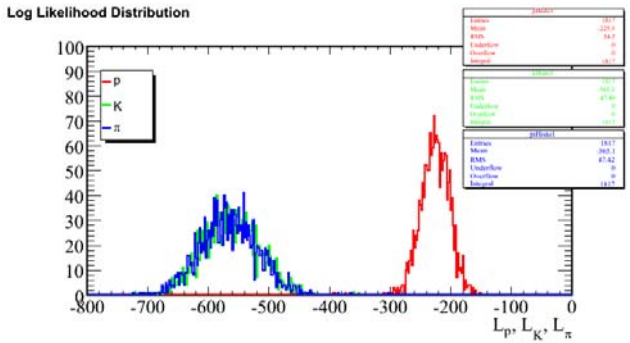
x_c | $x_c = x_c + 1cm$ | $x_c = x_c + 2cm$

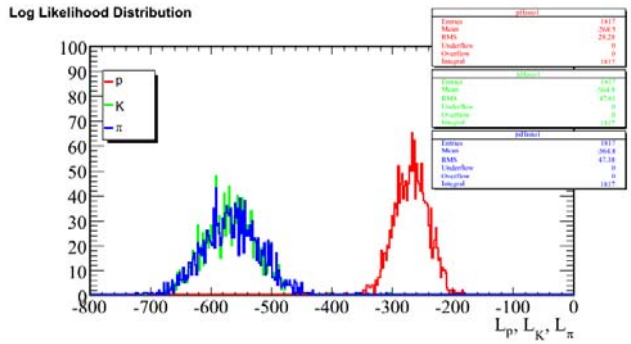








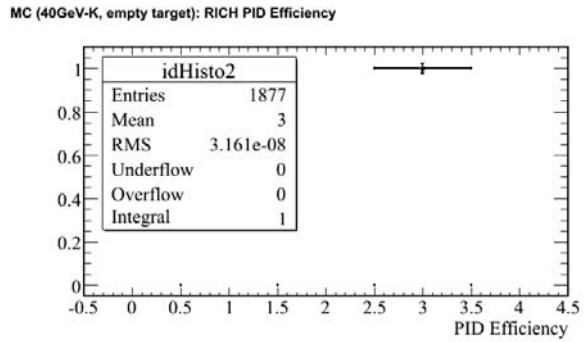


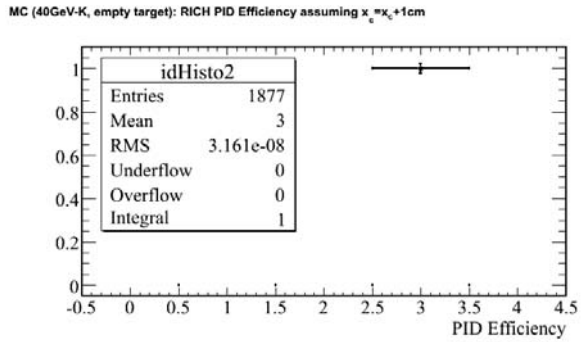


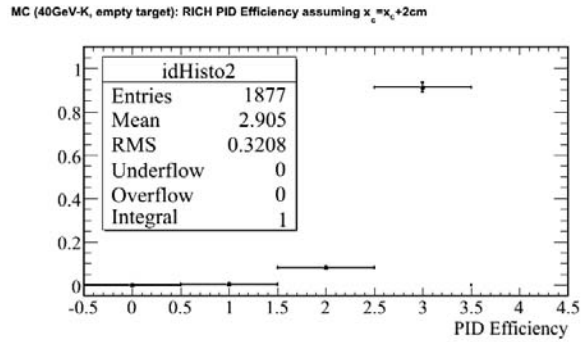
If predicted ring center x_c is changed by 1cm or 2cm, it does not affect Proton PID.

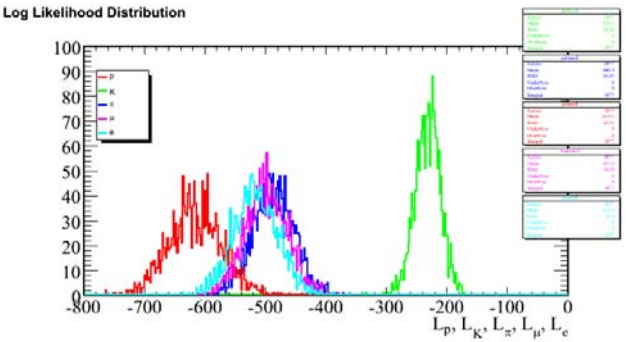
MC 40GeV K: Ring center x_c by 1cm, 2cm

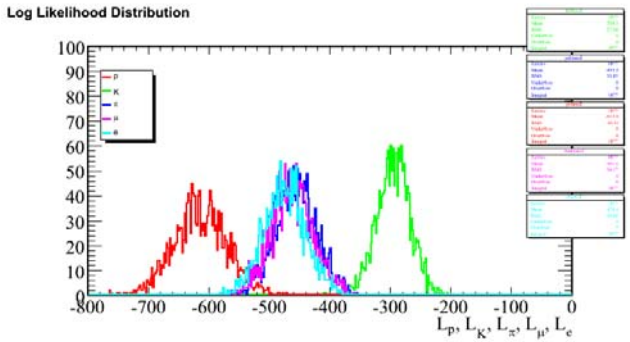
x_c | $x_c = x_c + 1cm$ | $x_c = x_c + 2cm$

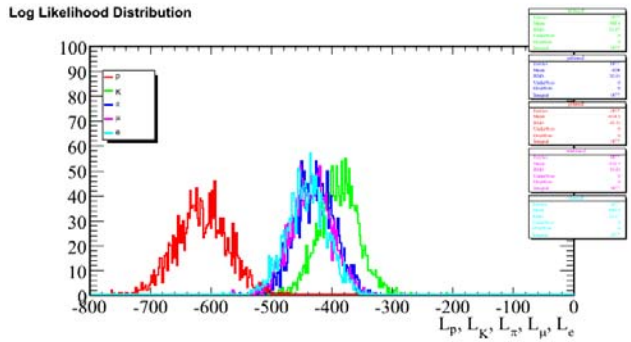








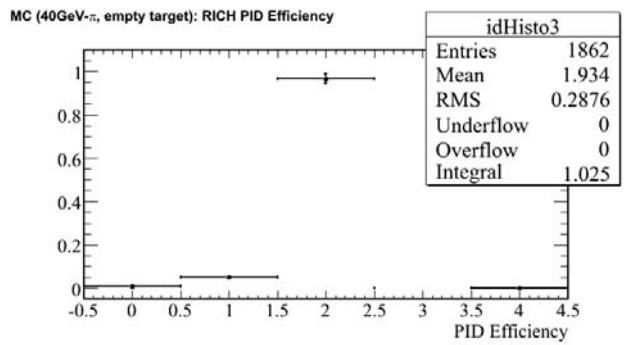


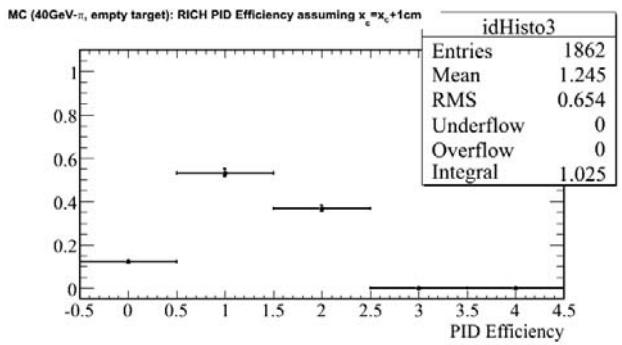


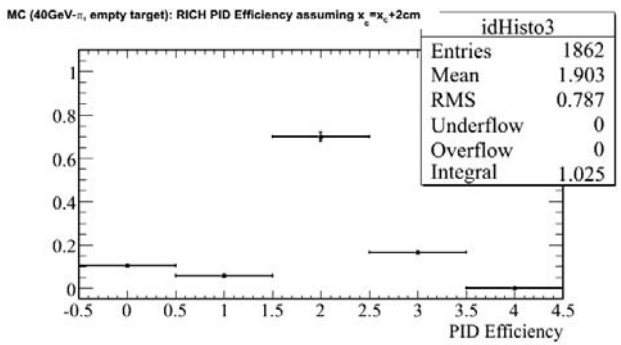
When predicted ring center x_c is changed by ≥2cm, Kaon PID starts to change to Pion, Muon & Electron.

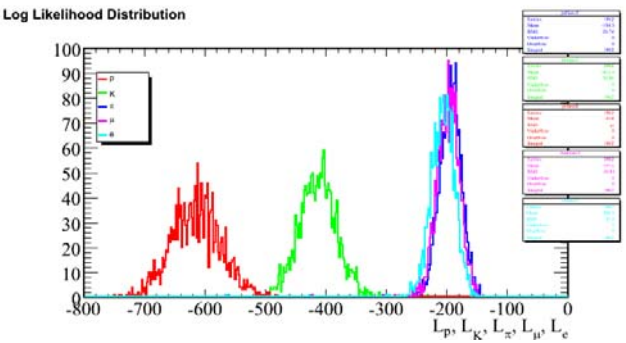
MC 40GeV π: Ring center x_c by 1cm, 2cm

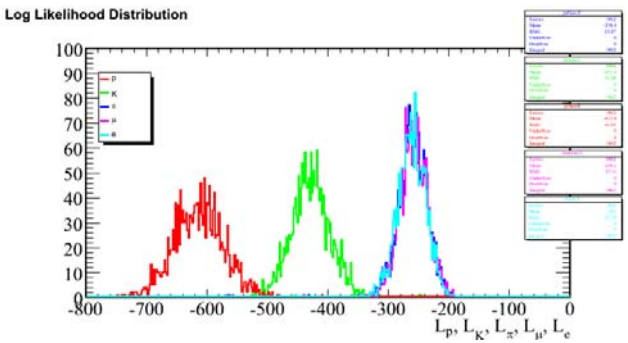
x_c	$x_c = x_c + 1$cm	$x_c = x_c + 2$cm

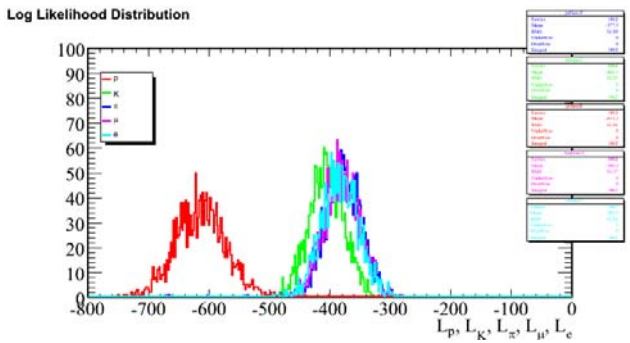


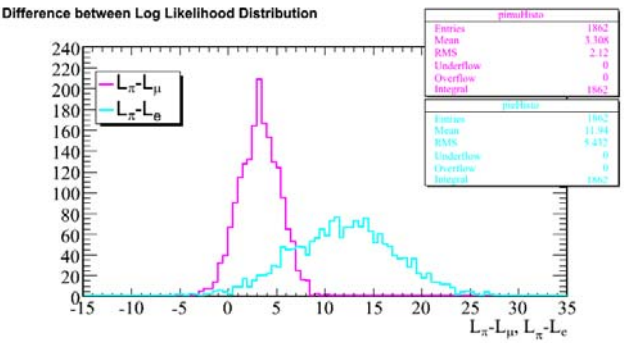


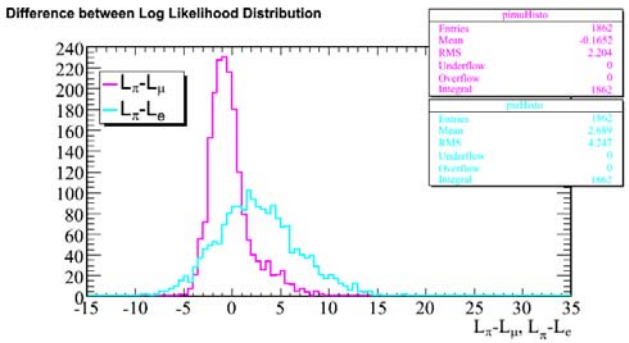


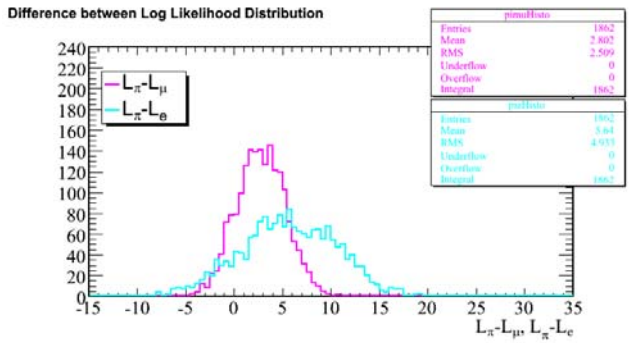








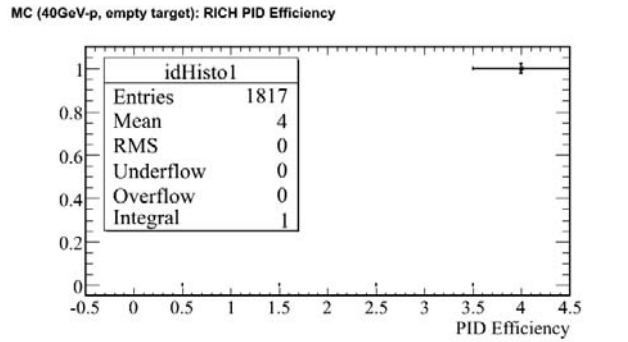


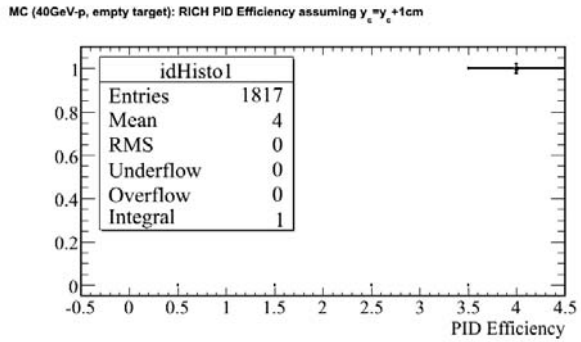


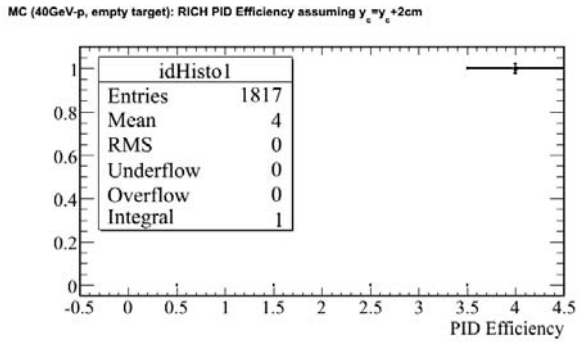
When predicted ring center x_c is changed by ≥1cm,
Pion PID starts to change to Muon, Electron & Kaon!

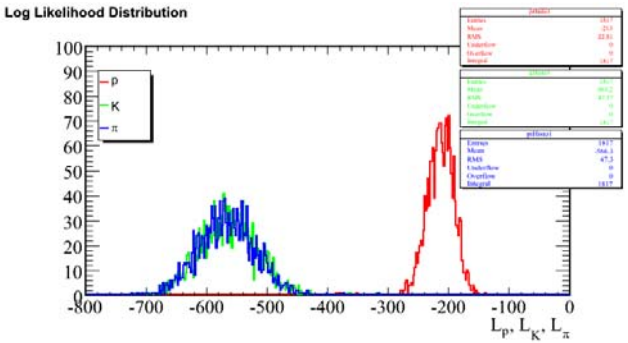
MC 40GeV p: Ring center y_c by 1cm, 2cm

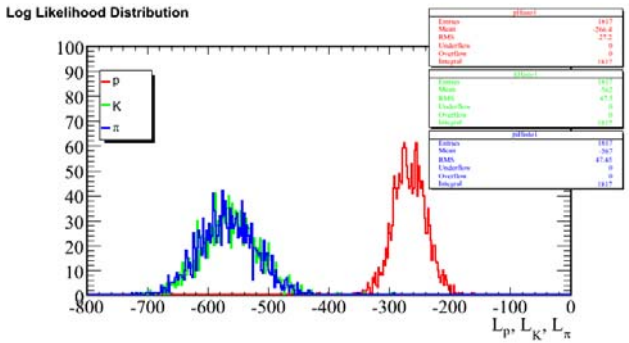
y_c | $y_c = y_c + 1cm$ | $y_c = y_c + 2cm$

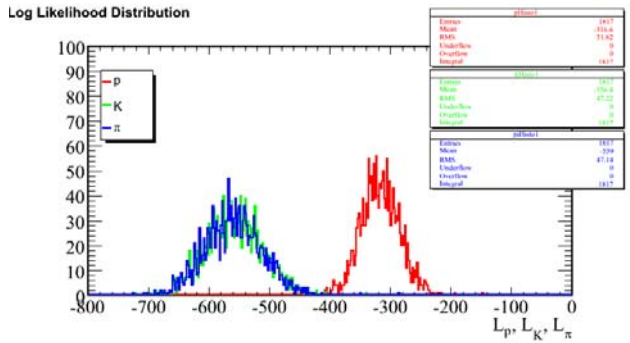








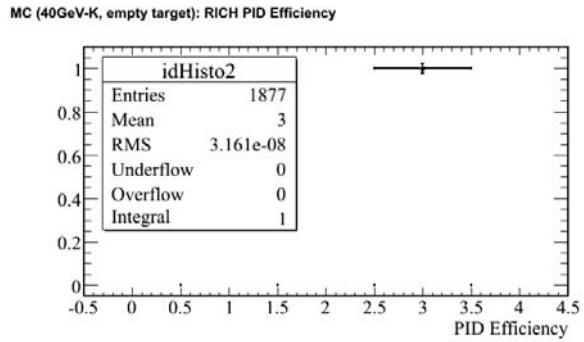


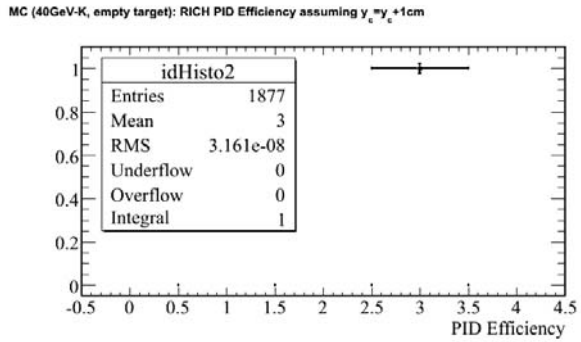


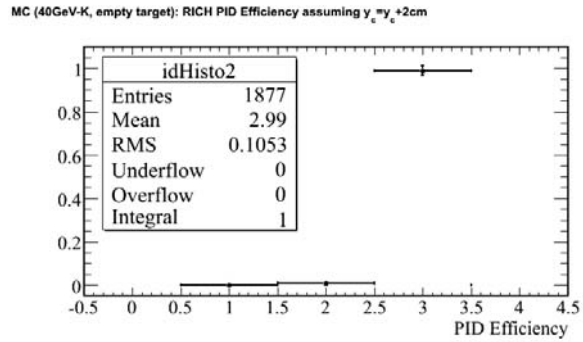
If predicted ring center y_c is changed by 1cm or 2cm, it does not affect Proton PID.

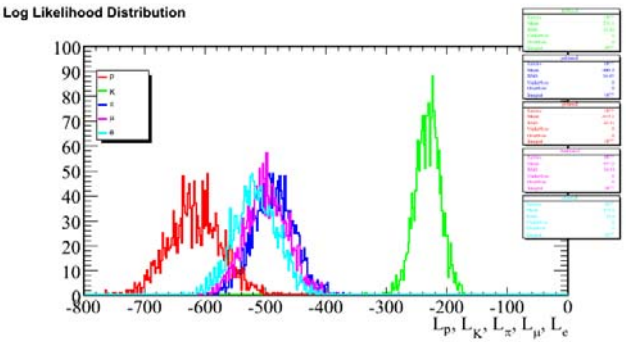
MC 40GeV K: Ring center y_c by 1cm, 2cm

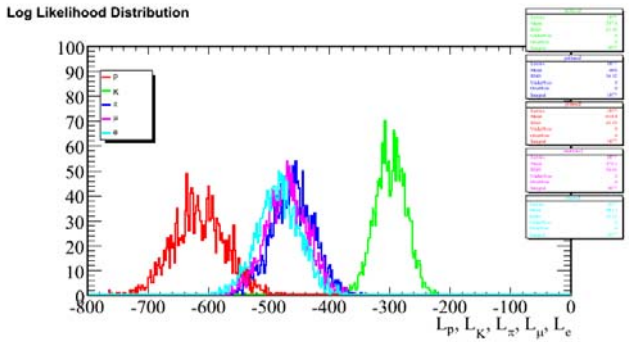
y_c	$y_c = y_c + 1$cm	$y_c = y_c + 2$cm

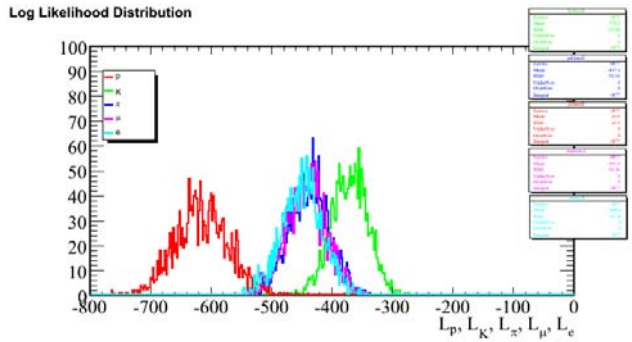








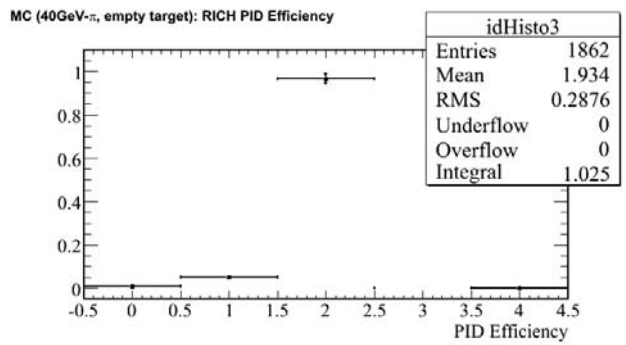


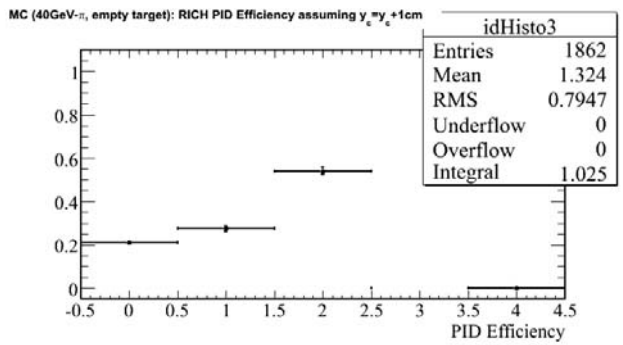


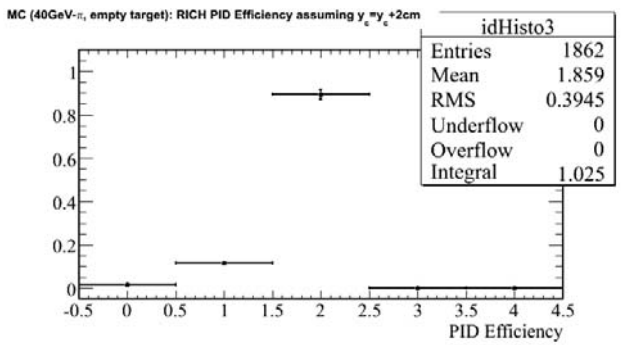
When predicted ring center y_c is changed by ≥2cm, Kaon PID starts to change to Pion, Muon & Electron.

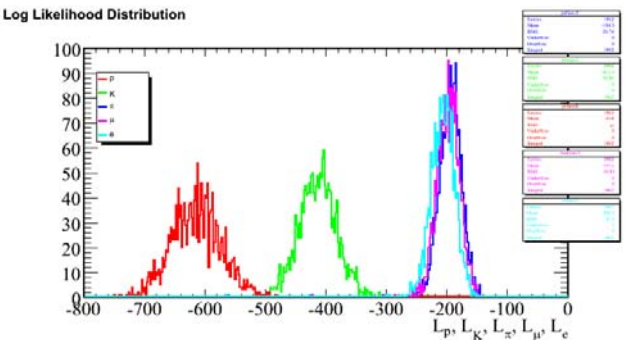
MC 40GeV π: Ring center y_c by 1cm, 2cm

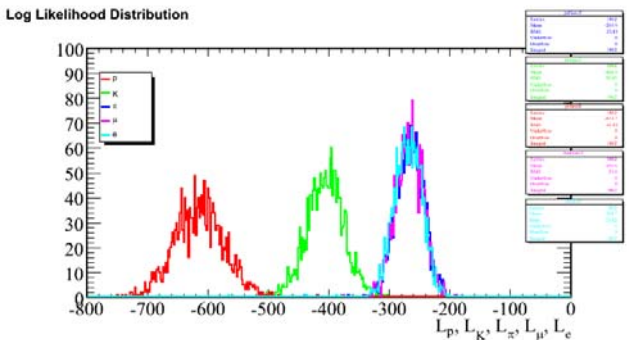
y_c	$y_c = y_c + 1$cm	$y_c = y_c + 2$cm

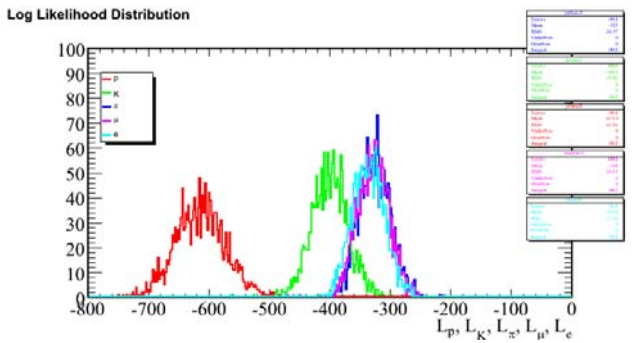


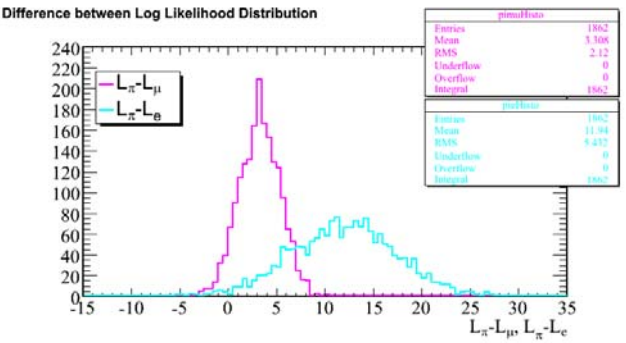


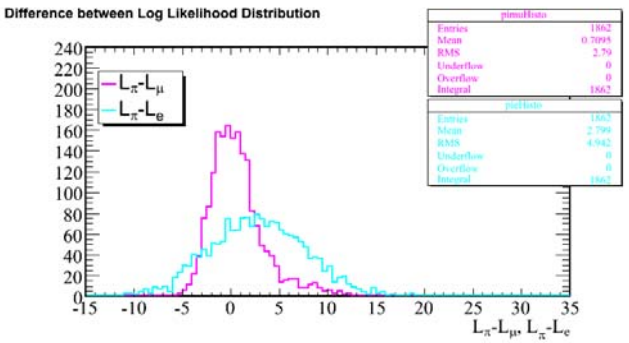


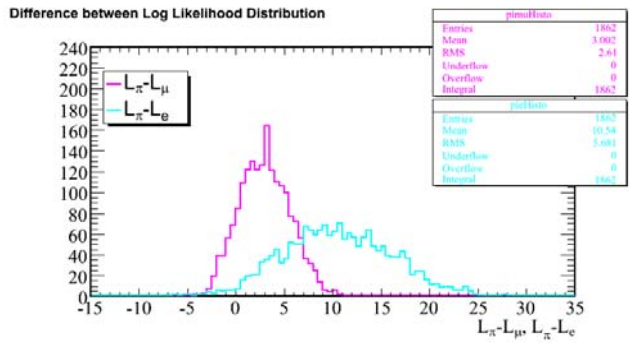












When predicted ring center y_c is changed by ≥1cm,
Pion PID starts to change to Muon & Electron.

Summary

- 10% change in predicted momentum does not seem to have much effect on PID
- However, change of ring center by
  - 2cm – affect K and π PID
  - 1cm – affect π PID
- Therefore, the ring center needs to be predicted within $\pm$1cm to obtain accurate RICH PID