

RICH Reconstruction working progress

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- Reconstruction Algorithm
- Event Display
- RICH Reconstruction Performance
 - MC p-C run: 10,000 events
- Summary & Next Step

Reconstruction Algorithm

- Exact calculation of number of photoelectrons

$$N_e(r) = L \int \frac{2\pi\alpha}{\lambda^2} \left(1 - \frac{1}{\beta^2 n^2}\right) \cdot \varepsilon_c(\lambda) \cdot d\lambda$$

where $\varepsilon_c(\lambda)$ = efficiency for collecting photons of wavelength λ

$$N_e(r) = 2\pi\alpha \cdot L \int \frac{1}{\lambda^2} \left(1 - \frac{1}{\beta^2 n(\lambda)^2}\right) \cdot \varepsilon_c(\lambda) \cdot d\lambda$$

$$N_e(\text{PMT } i) = 2\pi\alpha \cdot L \int \frac{1}{\lambda(r)^2} \left(1 - \frac{1}{\beta^2 n(\lambda(r))^2}\right) \cdot \varepsilon_c(\lambda(r)) \frac{dr}{d\lambda} \cdot \frac{\text{Arc length of PMT}}{2\pi} dr$$

- Likelihood calculation

– For each PMT i , assign a likelihood

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

– Total likelihood for hypothesis j

$$L_j = \prod L_i$$

Reconstruction Algorithm

- Get Track Info
 - momentum & ring center
- Analysis
 - Given a momentum, define signal region: smallest r_p to largest r_e
 - For each particle hypothesis j , compute the expected number of photoelectrons n_i for every PMT i in the signal region and calculate likelihood L_j
- In this study, use MCCRICHHit2 to find track information

Event Display 7851

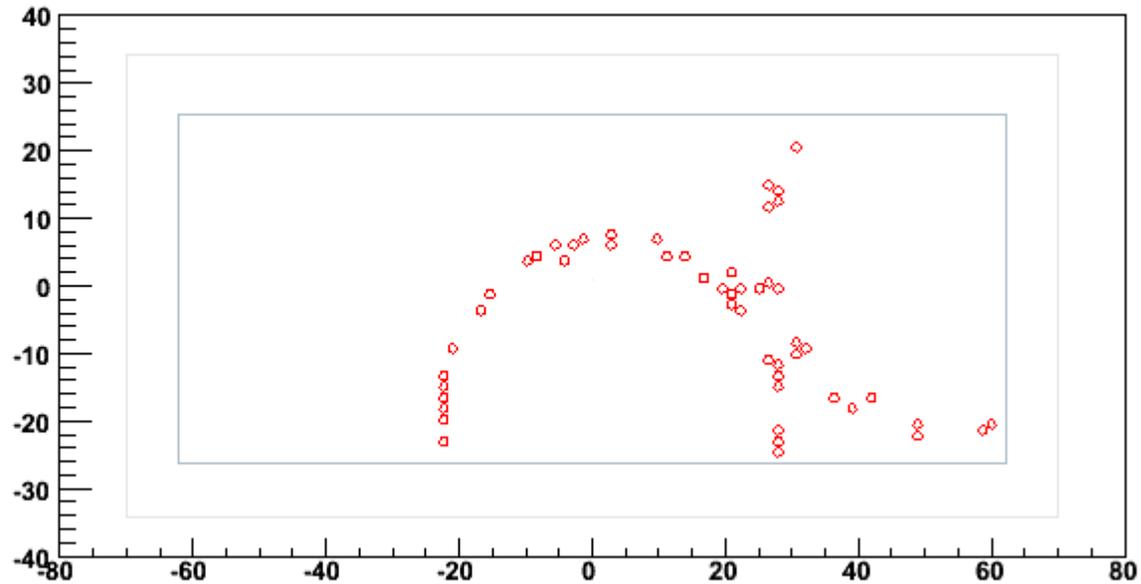
MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 7851

Wed Jun 21 2006
16:43:11.648986

*** Trigger ***
Undefined
Word: unknown

PMT Array



Event Display 7851

MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 7851

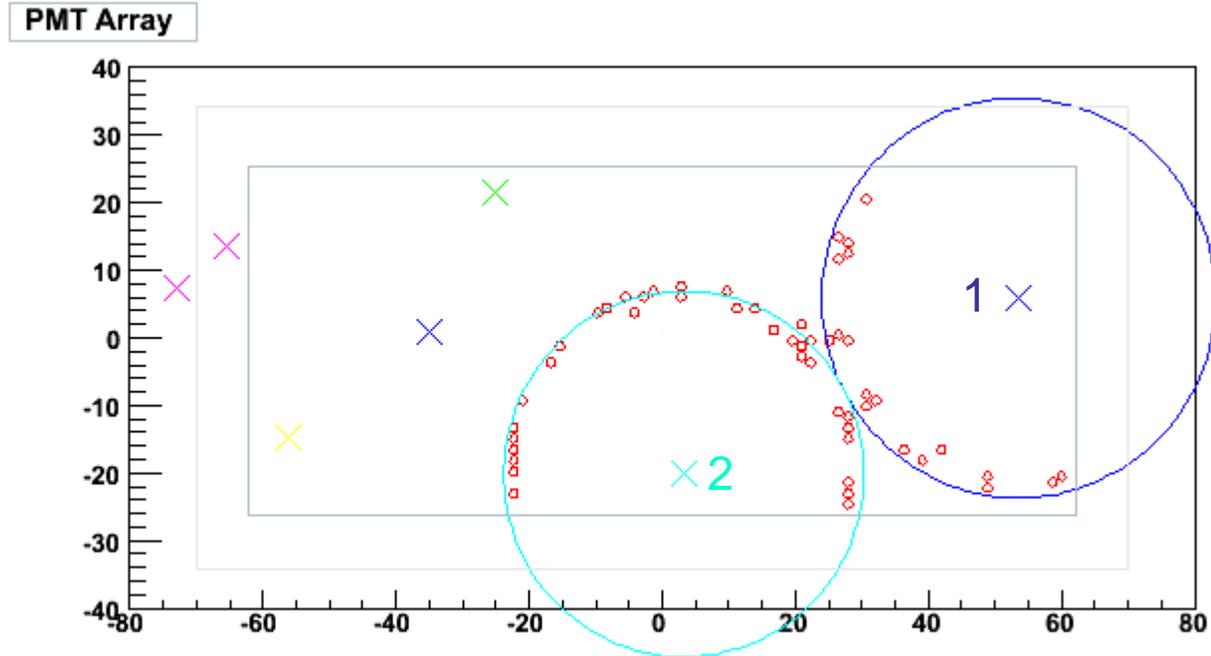
Wed Jun 21 2006
16:43:11.648986

*** Trigger ***
Undefined
Word: unknown

X Predicted
ring center

1. 10.7GeV π

2. 57.7GeV p



Particles are correctly identified!!!

Event Display 534

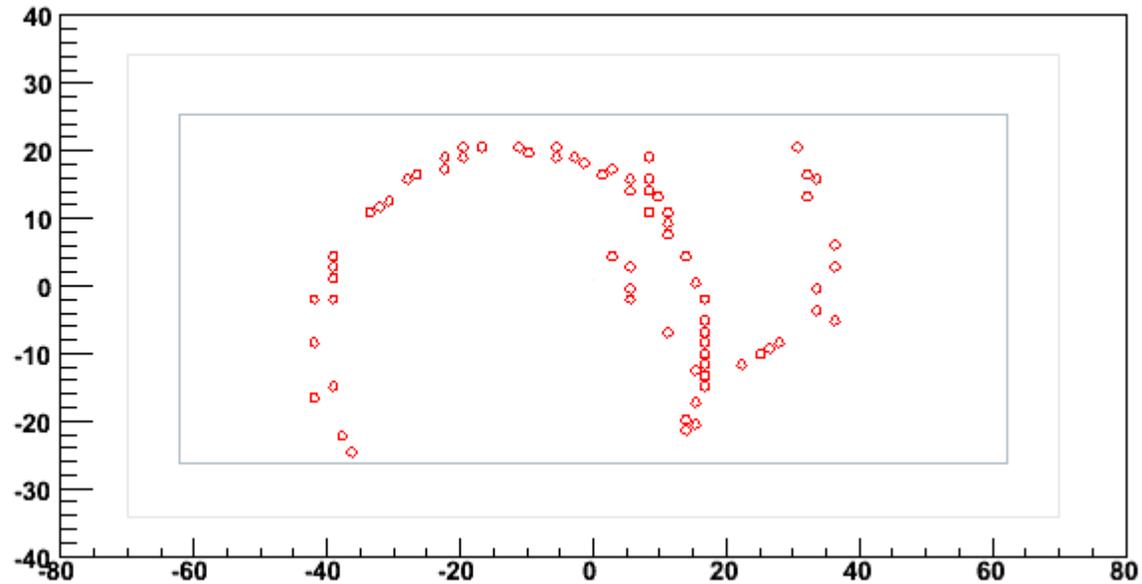
MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 534

Wed Jun 21 2006
11:25:30.880013

*** Trigger ***
Undefined
Word: unknown

PMT Array



Event Display 534

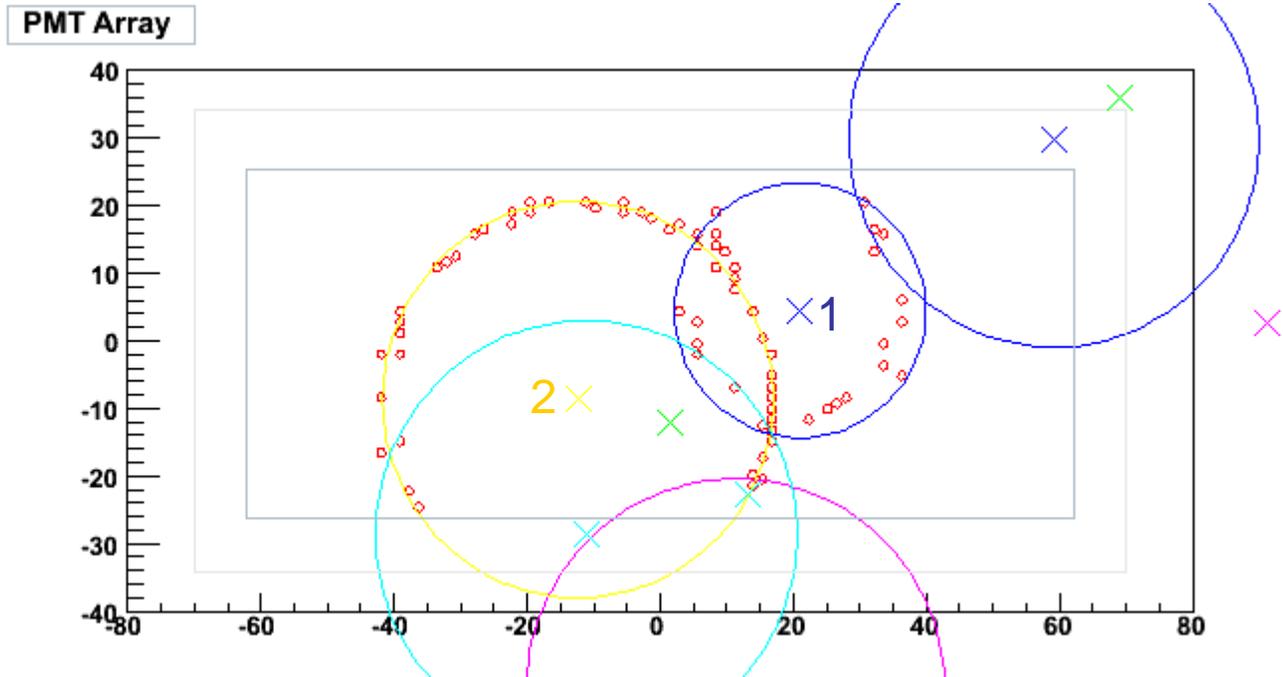
MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 534

Wed Jun 21 2006
11:25:30.880013

*** Trigger ***
Undefined
Word: unknown

- X Predicted ring center
- 1. 18.6GeV π
- 2. 14.7GeV e



Particles are correctly identified.

*However, tracks without RICH rings are misidentified!
Set a cut on the minimum # digits associated with track?*

Event Display 7543

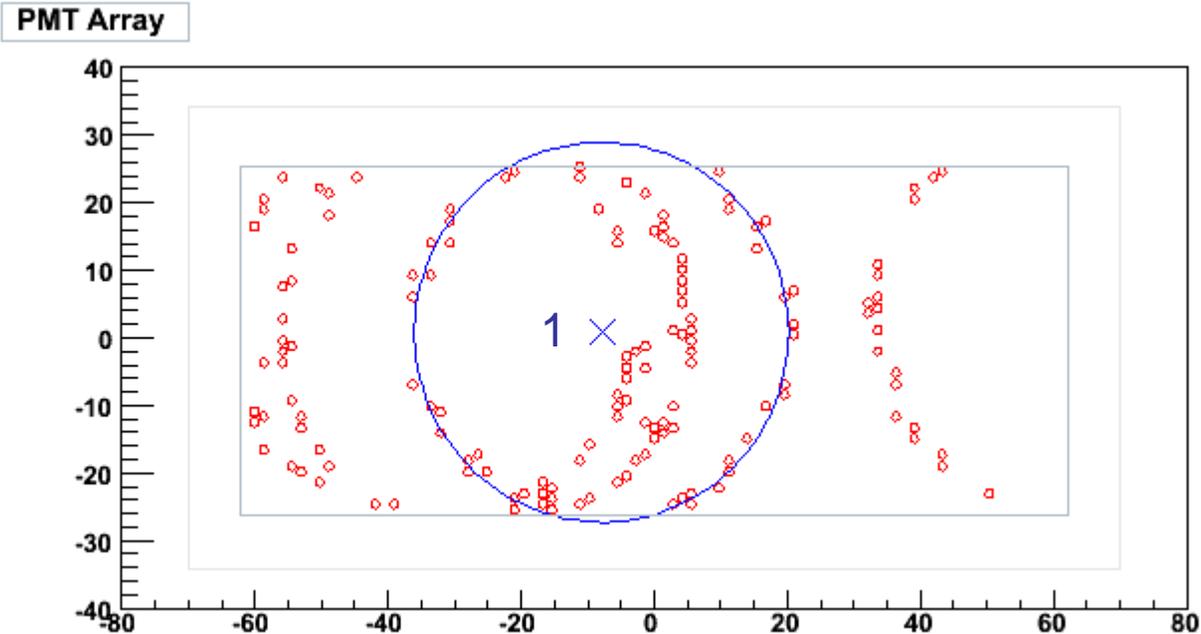
MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 7543

Wed Jun 21 2006
15:30:06.983977

*** Trigger ***
Undefined
Word: unknown

- X Predicted ring center
- 1. 72.8GeV p



One particle is correctly identified.

However, there are RICH rings without associated tracks!

Event Display 3438

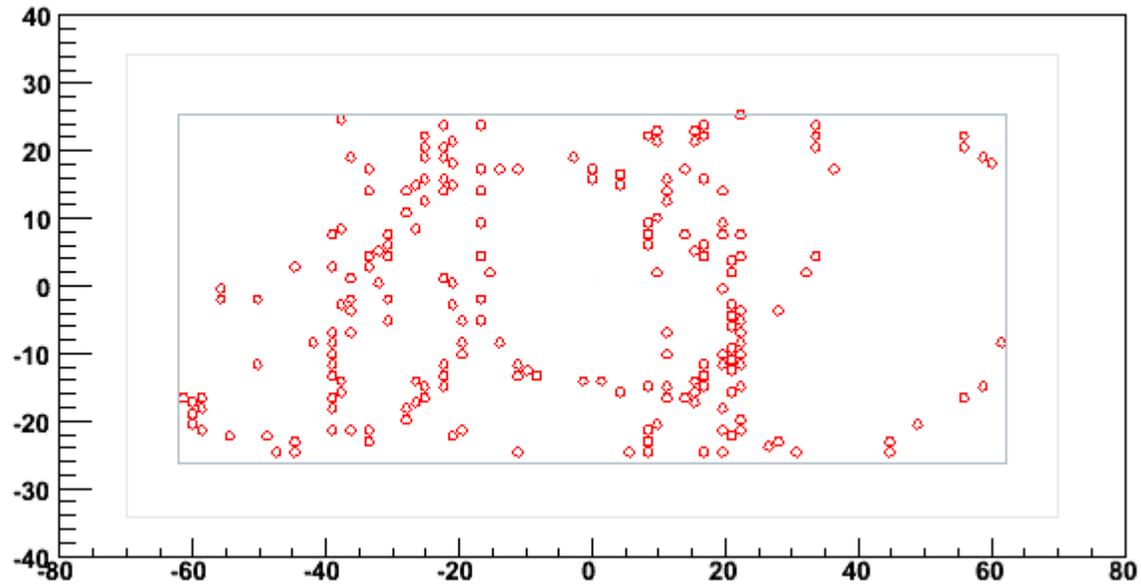
MIPP (FNAL E907)

Mom.: 0 GeV/c
Target:
Run: 30000000
SubRun: 0
Event: 3438

Wed Jun 21 2006
13:07:12.726469

*** Trigger ***
Undefined
Word: unknown

PMT Array



Event Display 3438

MIPP (FNAL E907)

Mom.: 0 GeV/c
Target: 30000000
Run: 0
SubRun: 0
Event: 3438

Wed Jun 21 2006
13:07:12.726469

*** Trigger ***
Undefined
Word: unknown

X Predicted
ring center

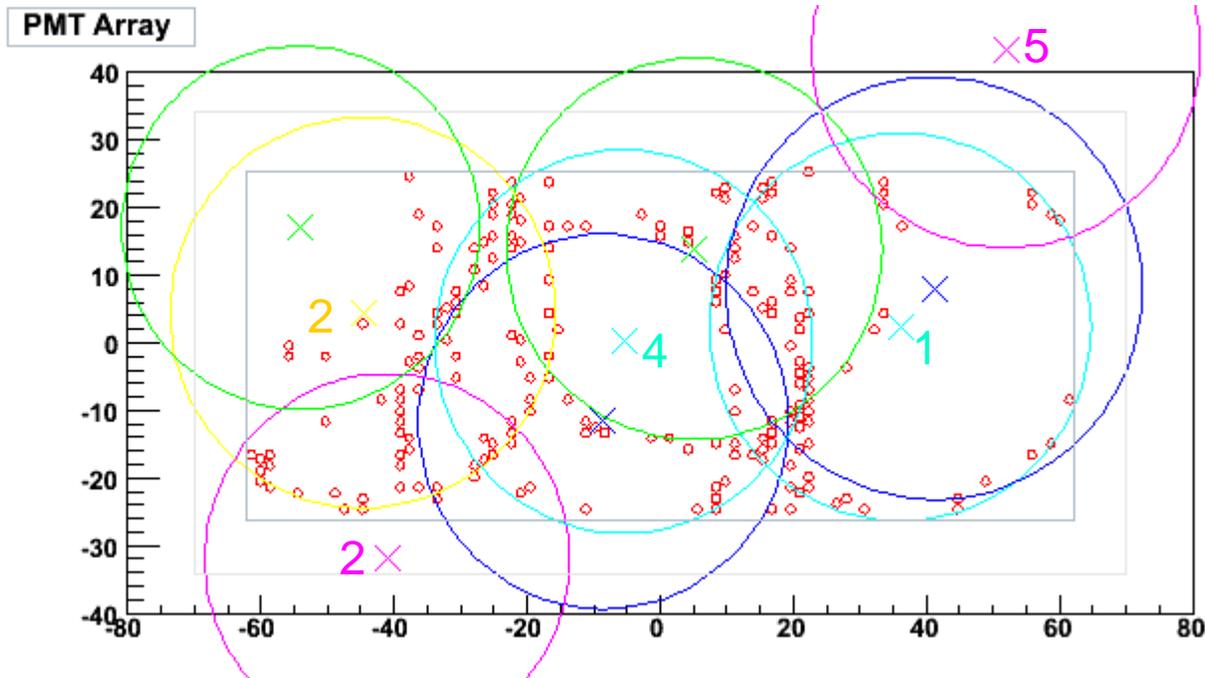
1. 10.3GeV π

2. 7.1GeV π

3. 11.1GeV π

4. 9.2GeV π

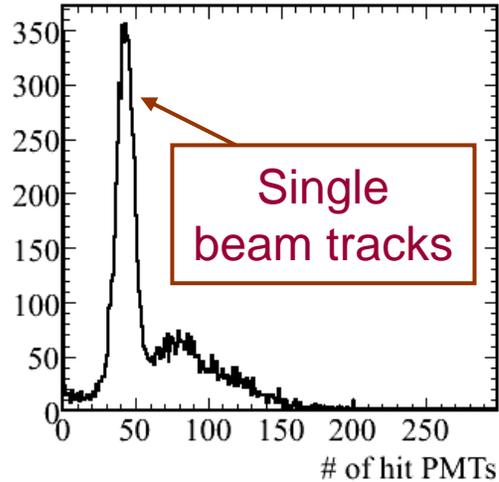
5. 12.9GeV π



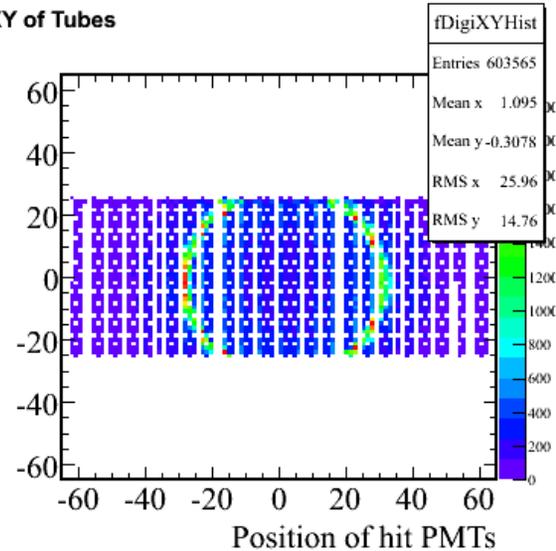
Complicated event!!!

General RICH Histograms

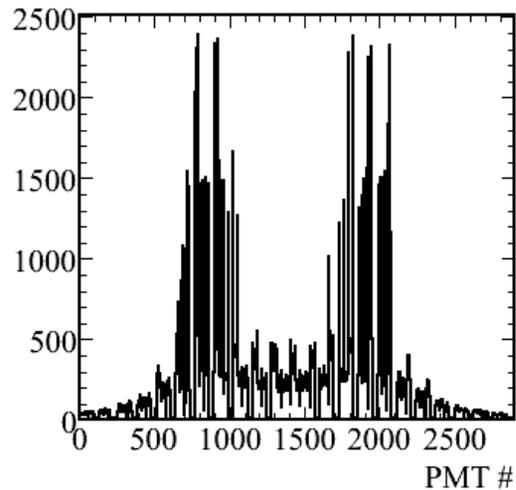
Number of Hit Tubes



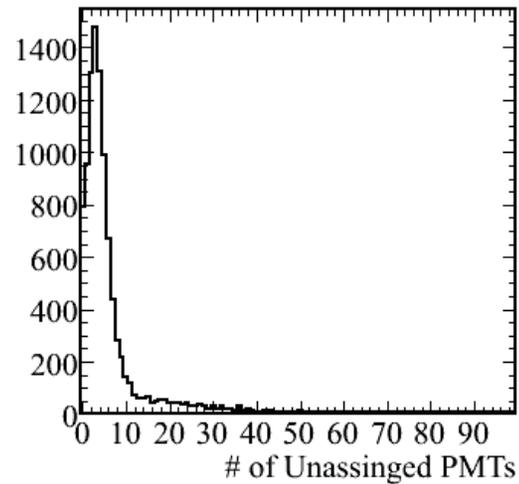
XY of Tubes



Which Tubes

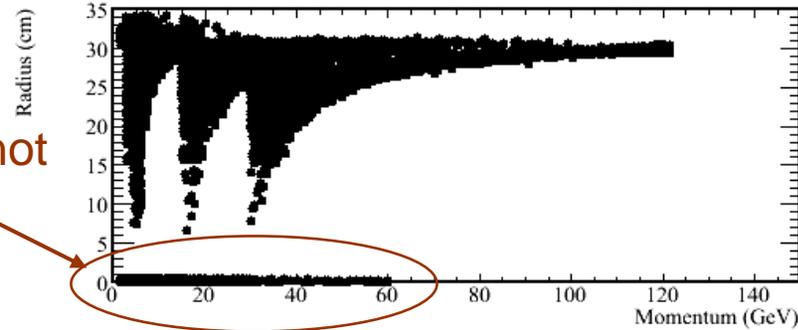


Number of Unassigned Tubes



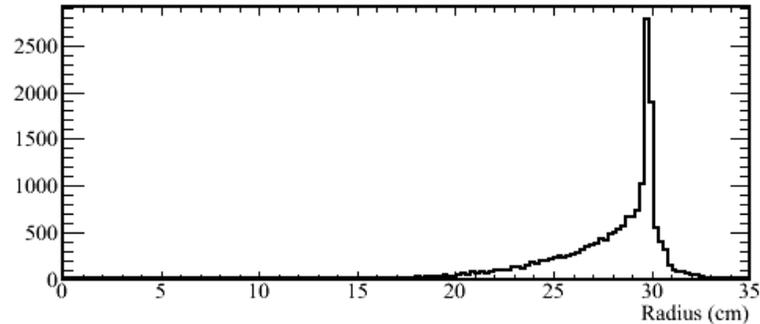
More RICH Histograms

Momentum vs Ring Radius - Positive Tracks

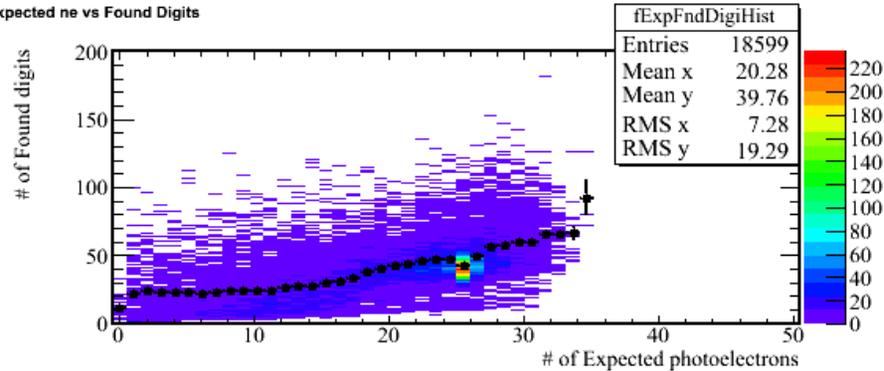


No fitted radius: does not match any hypothesis

Ring Radius Pos Tracks



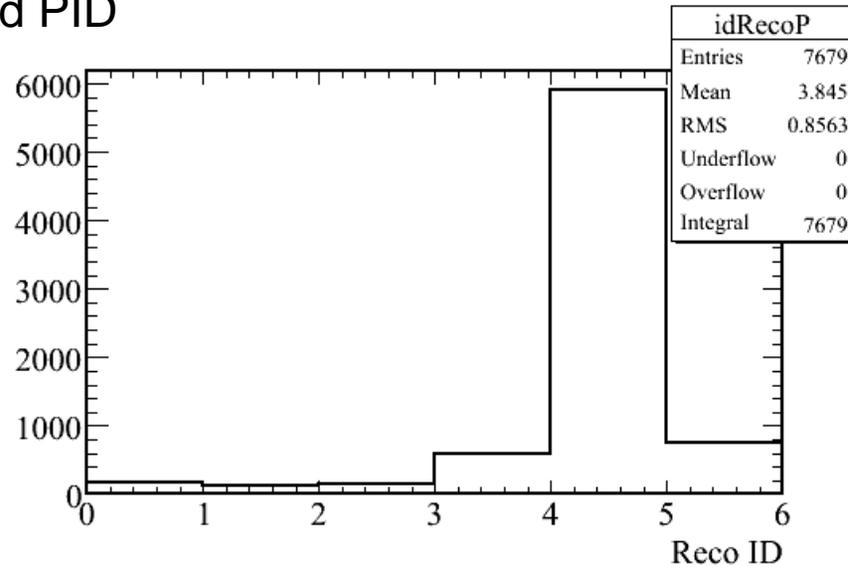
Expected ne vs Found Digits



of Found digits
 \propto Expected ne

True p Identification

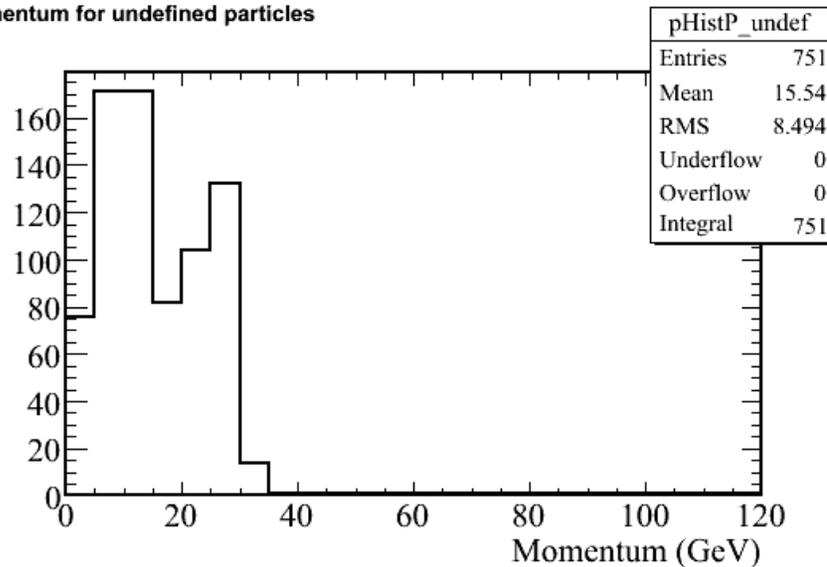
Reconstructed PID



RICH PID

- 0 *Electron*
- 1 *Muon*
- 2 *Pion*
- 3 *Kaon*
- 4 *Proton*
- 5 *Undefined*

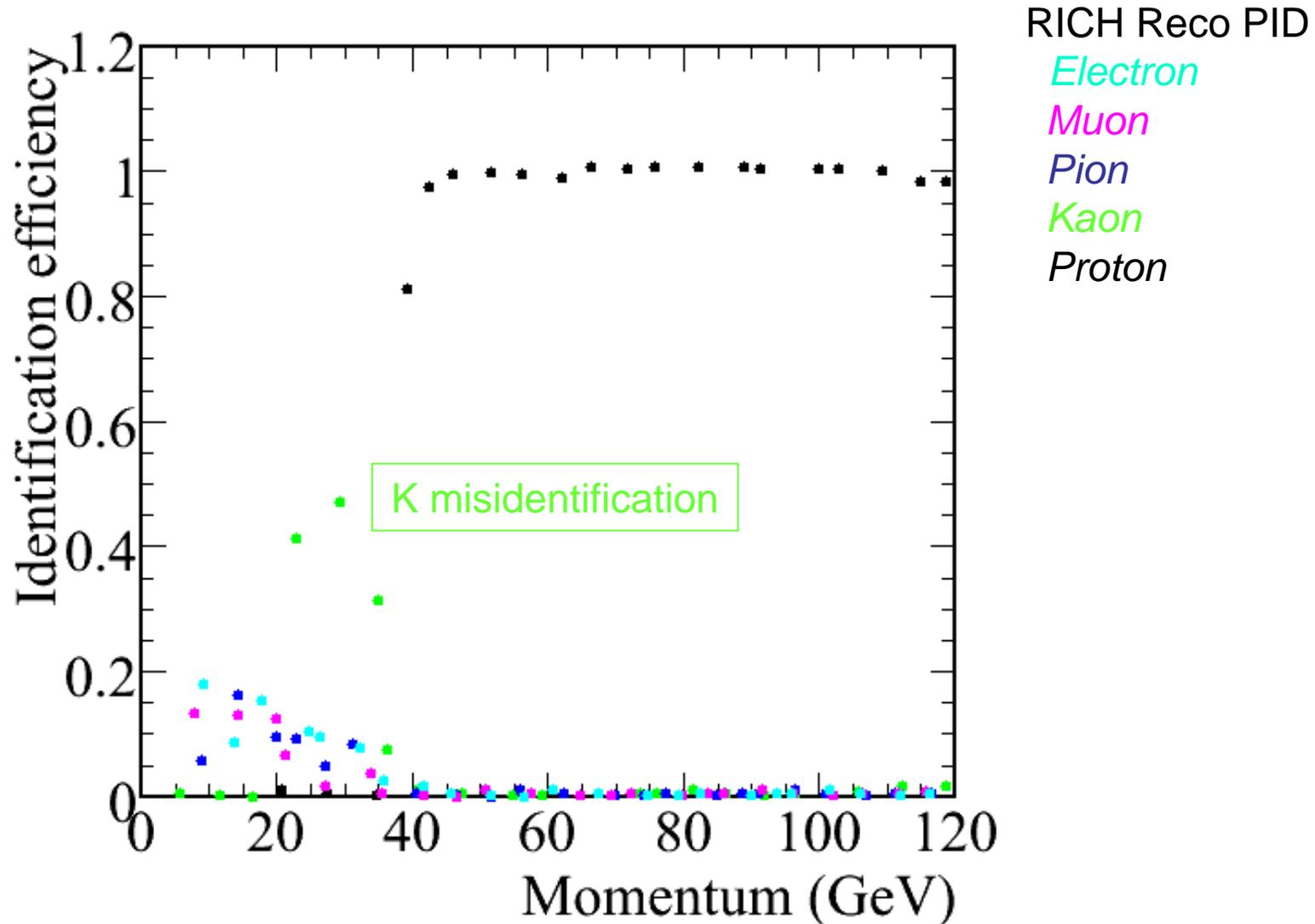
Momentum for undefined particles



Almost all undefined particles are below p threshold ~33GeV

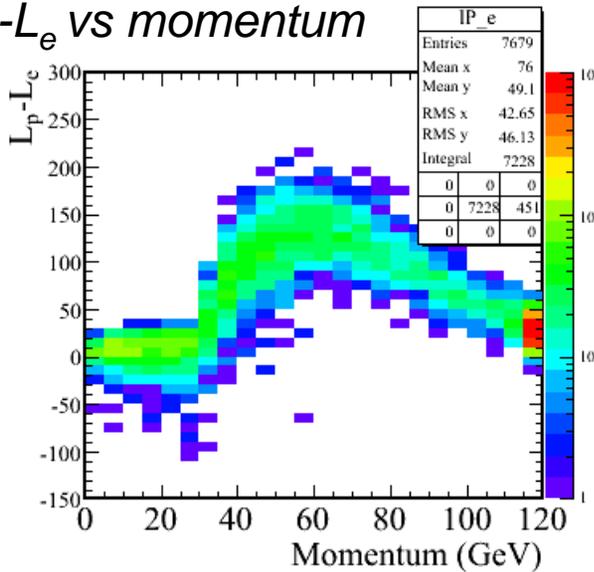
True p Identification

Efficiency of p identification vs momentum

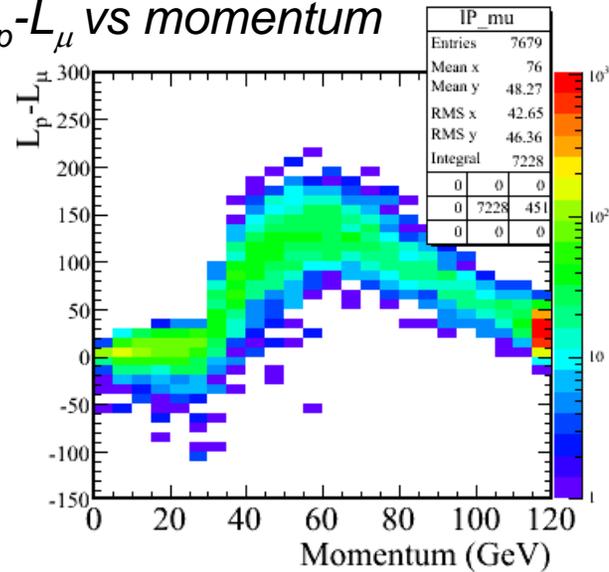


True p Identification

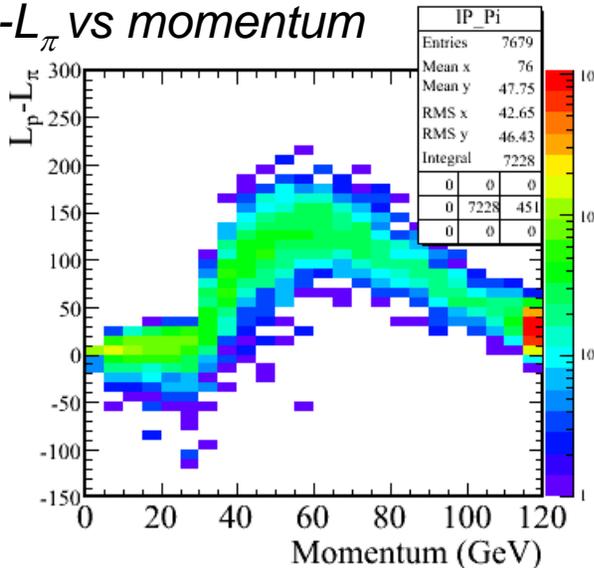
$L_p - L_e$ vs momentum



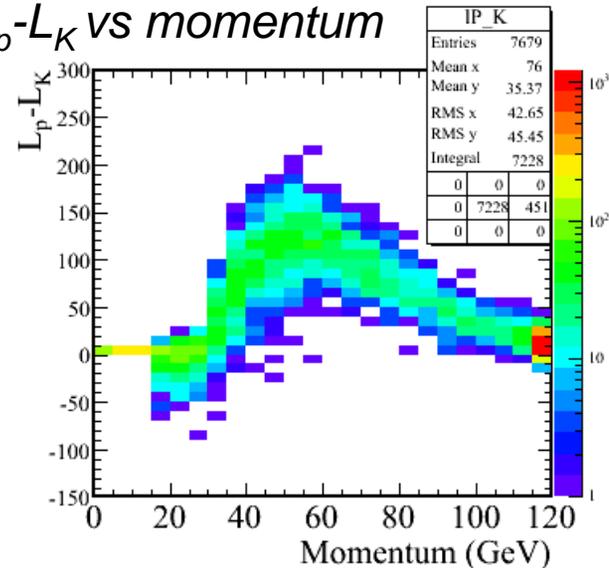
$L_p - L_\mu$ vs momentum



$L_p - L_\pi$ vs momentum

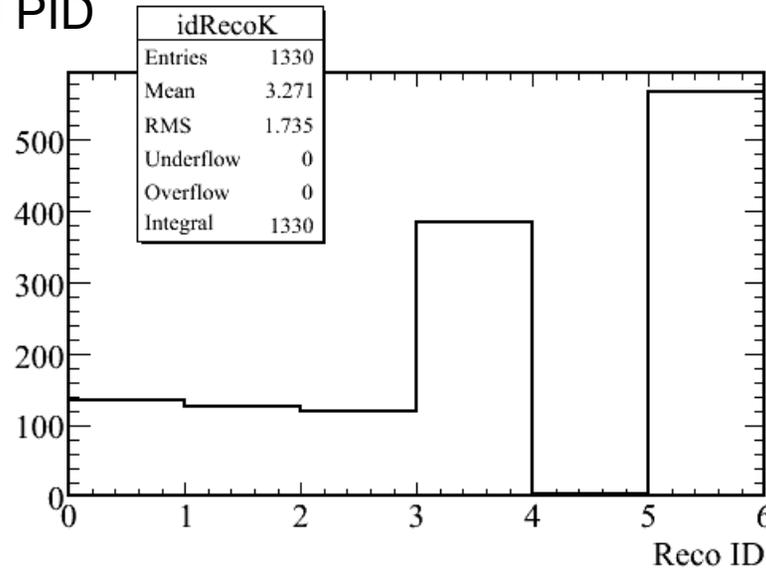


$L_p - L_K$ vs momentum



True K Identification

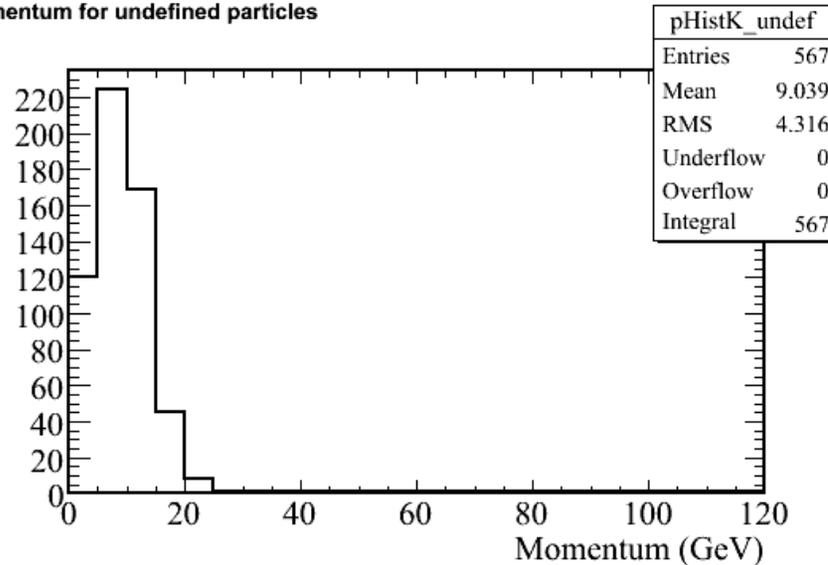
Reconstructed PID



RICH PID

- 0 *Electron*
- 1 *Muon*
- 2 *Pion*
- 3 *Kaon*
- 4 *Proton*
- 5 *Undefined*

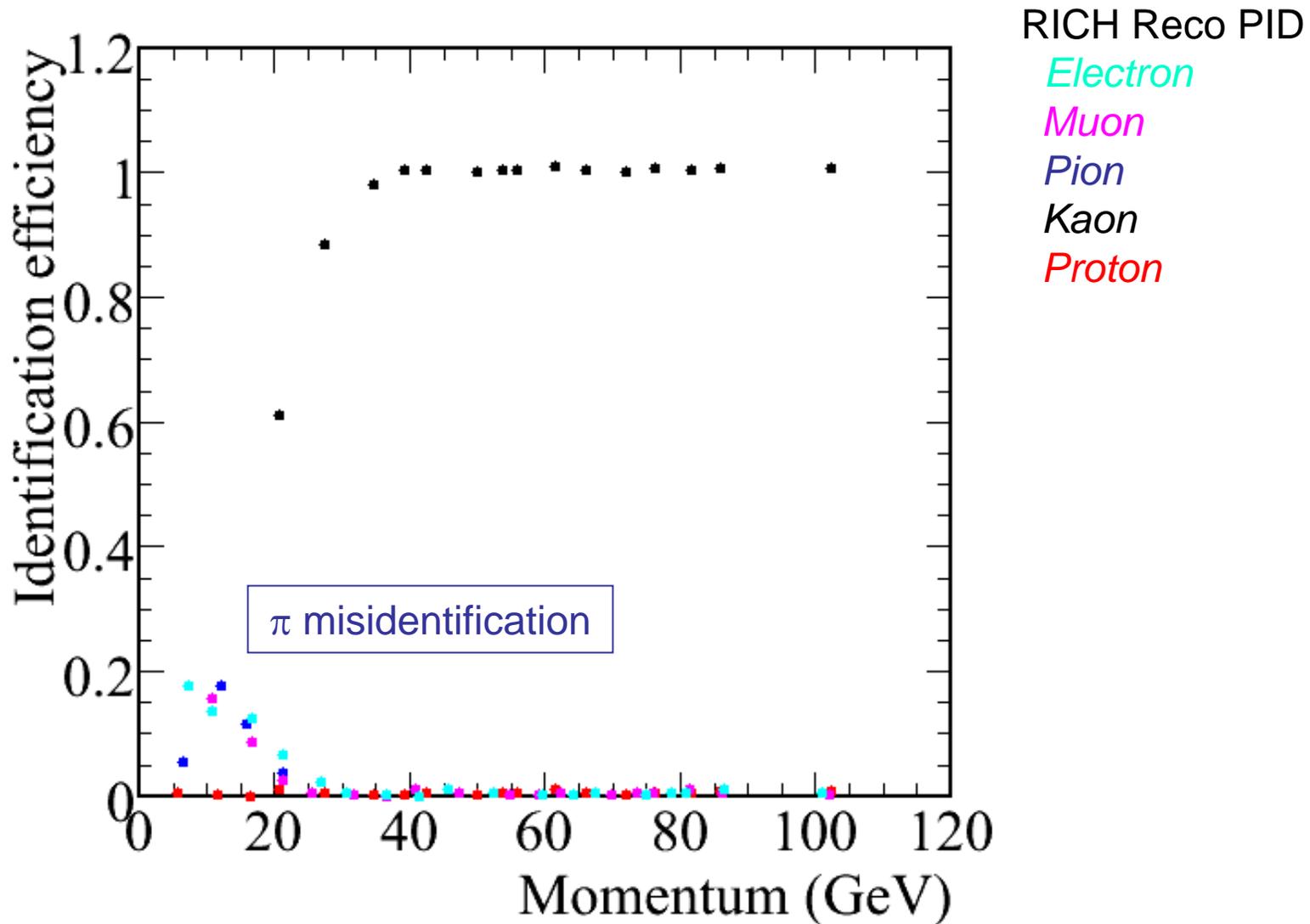
Momentum for undefined particles



Most undefined particles
are below K threshold
~17GeV

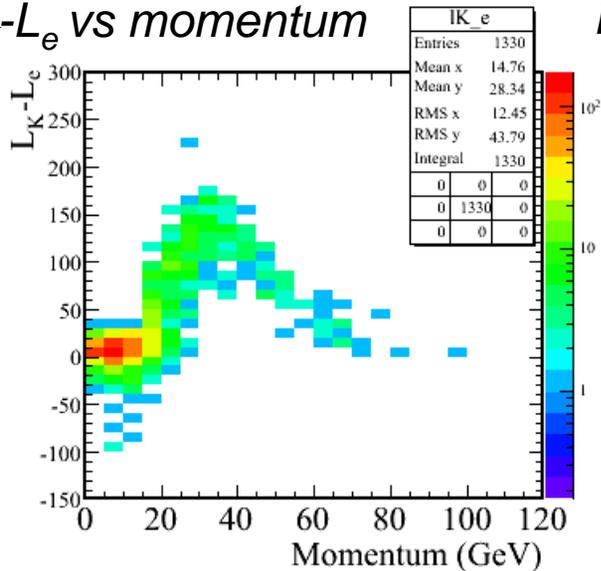
True K Identification

Efficiency of K identification vs momentum

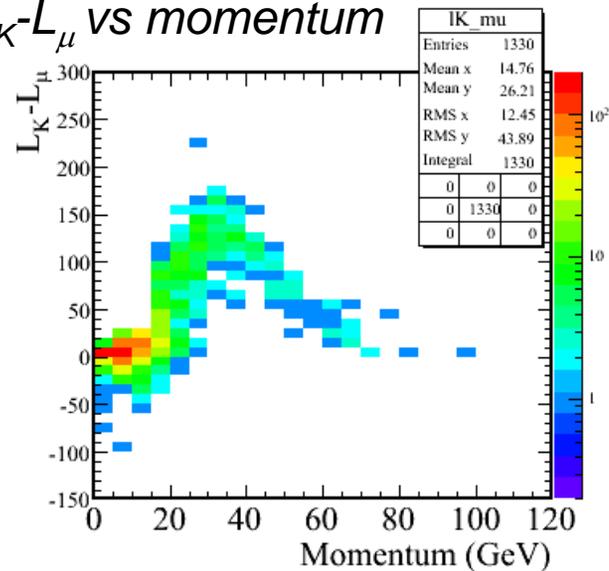


True K Identification

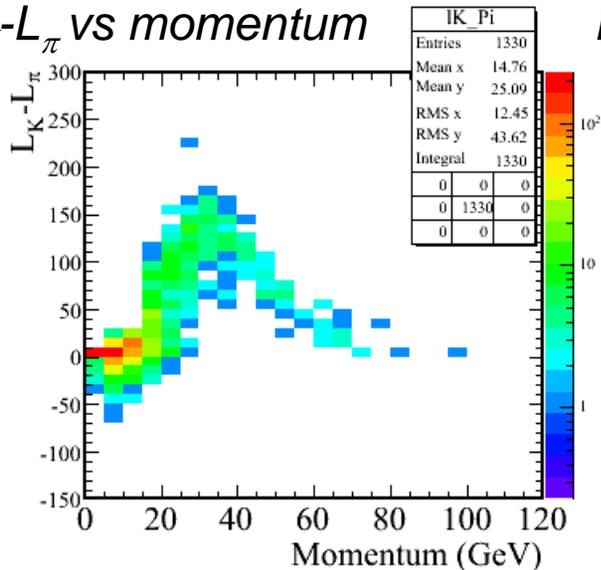
$L_K - L_e$ vs momentum



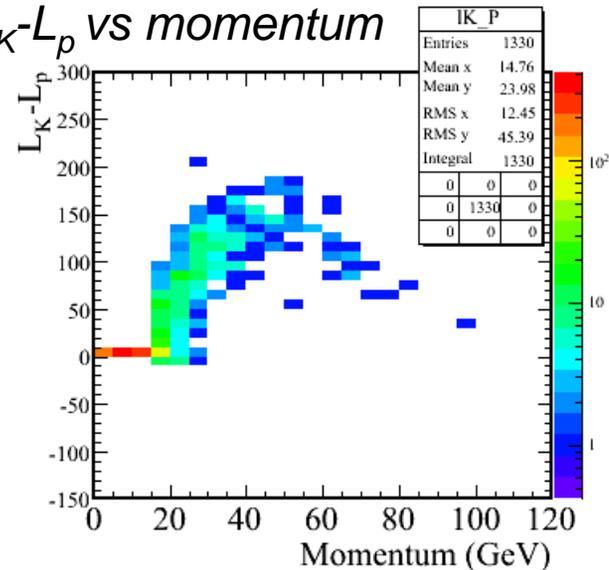
$L_K - L_\mu$ vs momentum



$L_K - L_\pi$ vs momentum

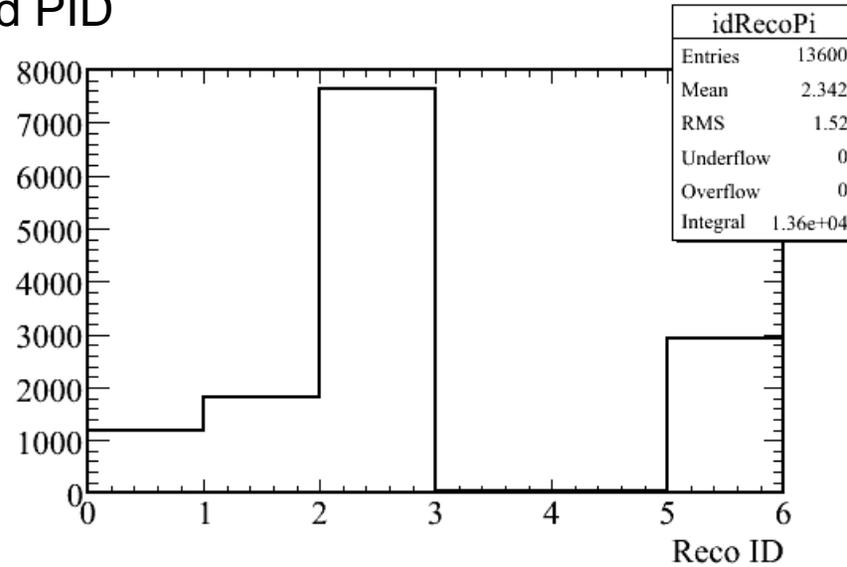


$L_K - L_p$ vs momentum



True π Identification

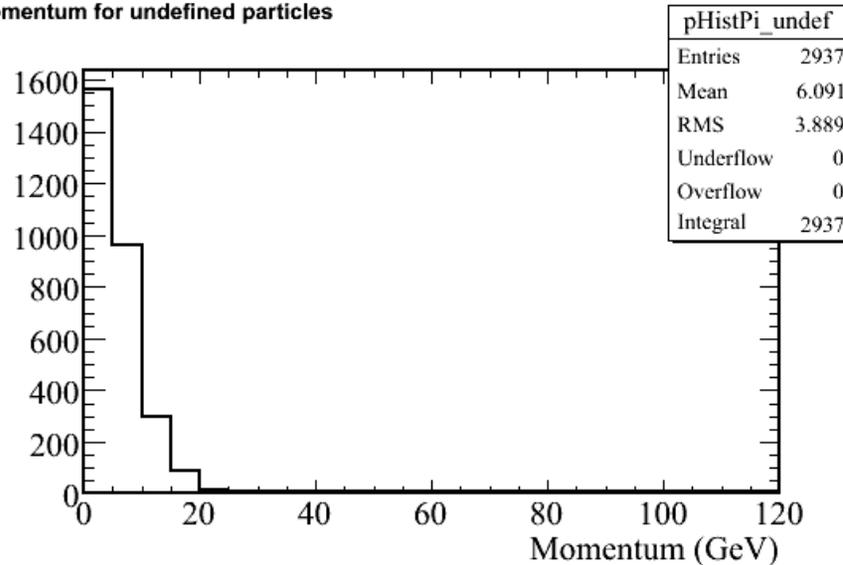
Reconstructed PID



RICH PID

- 0 *Electron*
- 1 *Muon*
- 2 *Pion*
- 3 *Kaon*
- 4 *Proton*
- 5 *Undefined*

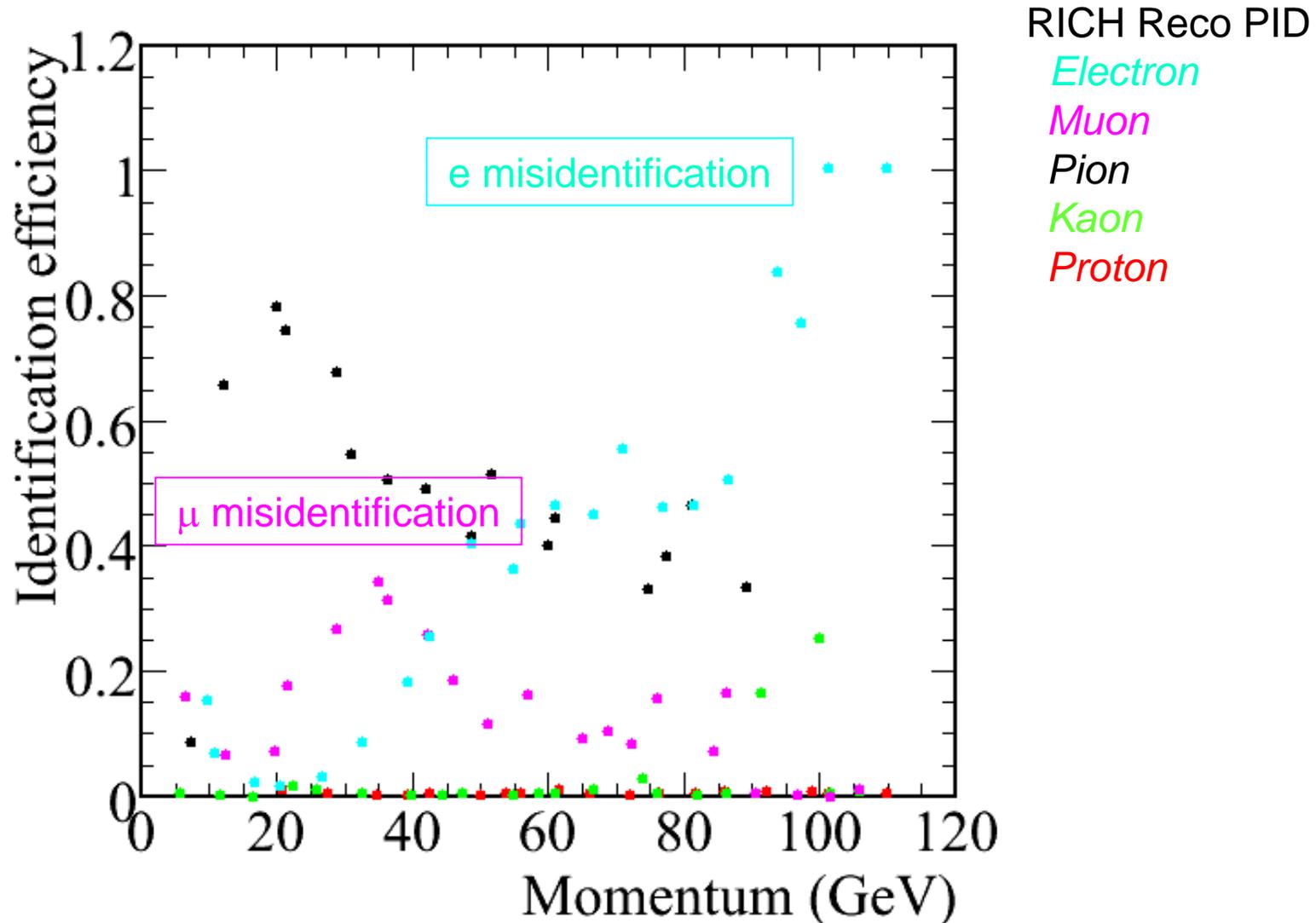
Momentum for undefined particles



Half of the undefined particles are below π threshold $\sim 5\text{GeV}$

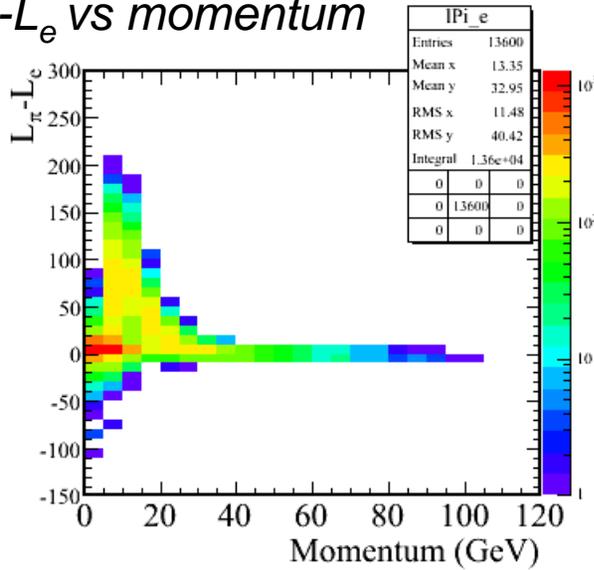
True π Identification

Efficiency of π identification vs momentum

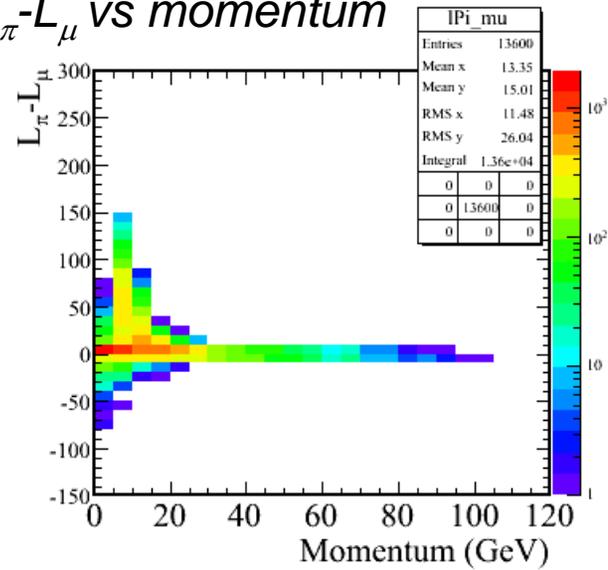


True π Identification

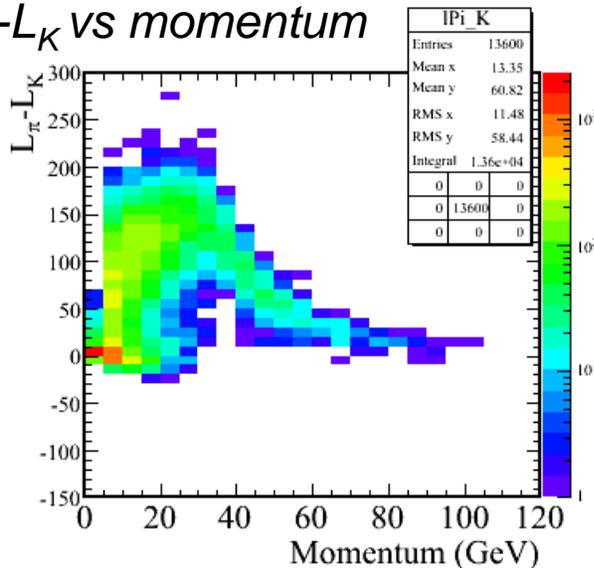
$L_\pi - L_e$ vs momentum



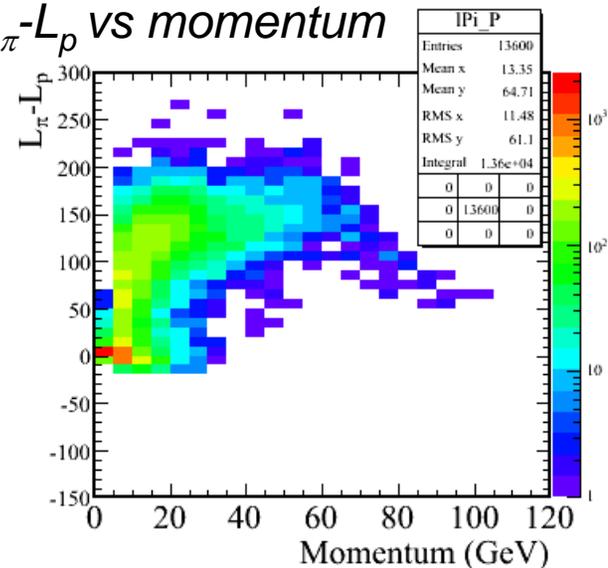
$L_\pi - L_\mu$ vs momentum



$L_\pi - L_K$ vs momentum



$L_\pi - L_p$ vs momentum



Summary & Next Step

- Timing: 10,000 events took ~36 mins [exact cal.]
(Compared to Nick's FastPhotoElectrons: ~30 mins)
- Problems with reconstruction
 - Misidentify tracks have no rings
Set a cut on minimum digits associated with a track?
 - Rings with no track?
- Next step
 - More careful study on misidentification events
 - Associate digits with tracks in MC
Rewrite RICH digitization in C++
 - Change integration accuracy in photoelectrons calculation to check if it affects PID
 - Background density from calibration runs: Nick Graf
 - Etc.....