RICH Particle Identification: performance improvements

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Event selection: $K_{2\pi}, K_{\mu 2}, K_{e3}$

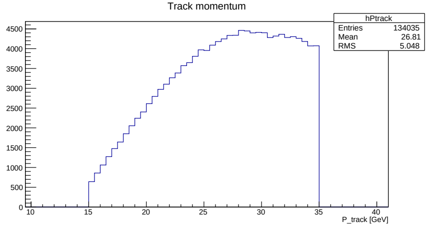
Standard selections and:

- One downstream track
- Momentum range: 15 - 35 GeV/c
- Stricter E/p cuts:
  - muon: $E/p < 0.05$
  - pion: $0.2 < E/p < 0.7$
  - positron: $0.95 < E/p < 1.05$
- CONTROL Trigger
- RICH Ring reconstruction: TRecoRICHEvent::GetRingCandidate()
- 1 RICH Ring in time (3 ns) and space (20 mm) coincidence

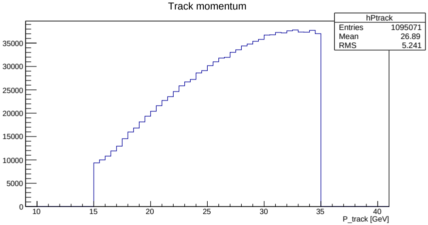
Runs 6501, 6582, 6632, 6656 - r1666

Momentum distributions after the event selections

$K_{2\pi}$



$K_{\mu 2}$



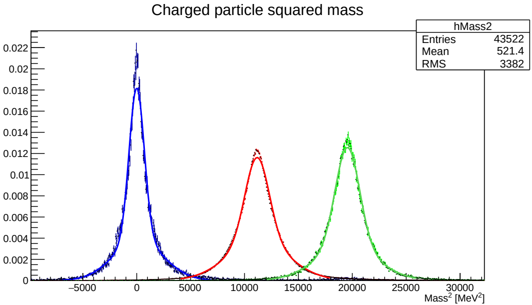
The higher momenta region is more populated than the lower one: the RICH performances are probably underestimated.

RICH PID: squared mass

$$m^2 = m^2(p, R) = p^2 \cdot \left(\frac{F^2 \cdot n^2}{F^2 + R^2} - 1 \right)$$

$$n = 1.000062\ ,\ F = 17020\ mm$$

Fits: *double-Gaussian* functions



χ^2/ndf value:

- positron: 790.229 / 274
- muon: 2938.47 / 274
- pion: 615.108 / 274

RICH PID: probability density functions

- Fits: *double-Gaussian* functions
- Analitical functions for the m^2 are known a priori
- Three Probability Density Functions for the m^2, one for each particle:

$$f_e(x),\ f_\mu(x),\ f_\pi(x)$$

- IDentification Probability for a certain value **x** of the m^2:

$$P_i(x) = \frac{f_i(x)}{\sum f_i(x)}\ ;\ i = e, \mu, \pi$$

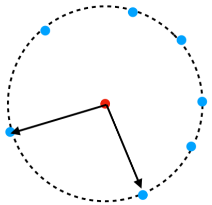
- The particle can be identified as the one with highest Probability value

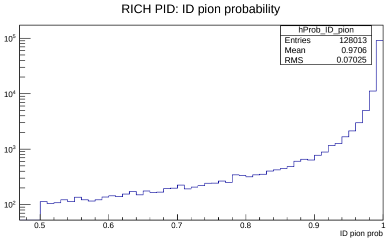
RICH PID: ideas

Adding more information (and cuts) depending on the PID-probability vaule:

- $\Delta\Phi_{max}$
- ring fit χ^2
- number of ring hits
- ring center from the STRAW
- ...

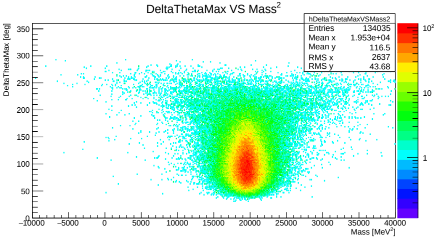
Introducing less bias, and only if necessary to improve the PID performances.



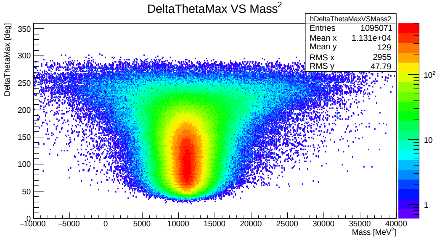


RICH PID and $\Delta\Phi_{max}$

$K_{2\pi}$



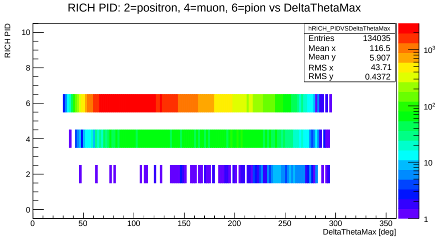
$K_{\mu 2}$



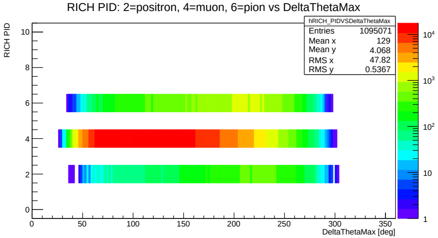
Misidentification probability increases together with $\Delta\Phi_{max}$

RICH PID and $\Delta\Phi_{max}$

$K_{2\pi}$



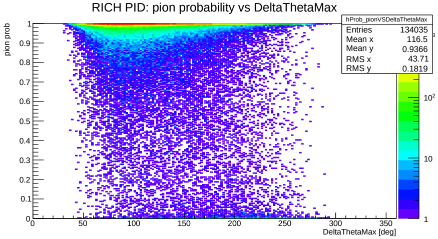
$K_{\mu 2}$



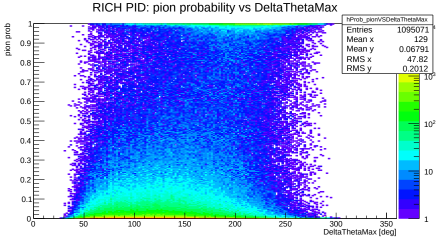
Misidentification probability increases together with $\Delta\Phi_{max}$

RICH PID: $\Delta\Phi_{max}$ and *probability*

$K_{2\pi}$



$K_{\mu2}$

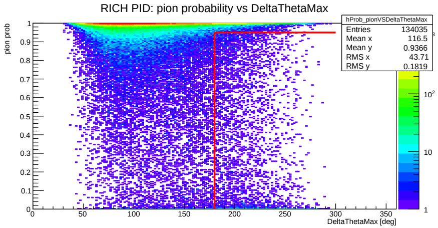


Misidentification probability increases together with $\Delta\Phi_{max}$

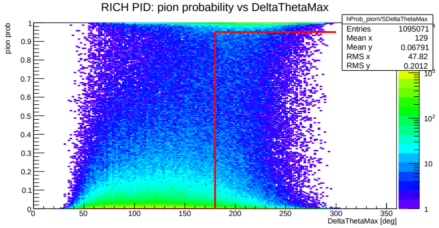
RICH PID: $\Delta\Phi_{max}$ and *probability*

$$\Delta\Phi_{max} < 180^\circ \text{ or } Prob(\pi) > 0.95$$

$K_{2\pi}$



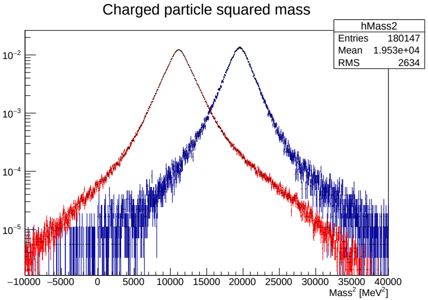
$K_{\mu 2}$



Misidentification probability increases together with $\Delta\Phi_{max}$

Measurement of the $\pi - \mu$ separation

- 1^{st} method: counting the number of events that pass all the cuts with respect to all the events in the selected samples
  - sensible to the background in the selected sample
- 2^{nd} method: calculating the integral of the analitical functions fittend on the m^2 distributions
  - errors introduced by the fit algorithm and the estrapolation



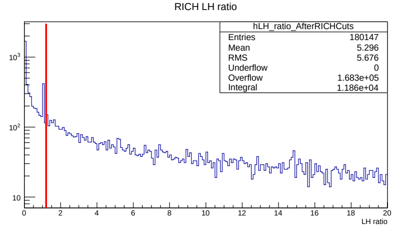
The results of the two methods do not agree

Comparison with the likelihood method

Muon contamination
for 90% of pion efficiency

SEPARATION CUTS	$\epsilon(\mu)$
M^2	0.0317 ± 0.0001
M^2 $LH_{ratio} > 1.2$	0.00394 ± 0.00005
M^2 $\Delta\Phi_{max} < 180^\circ$ *or* $Prob(\pi) > 0.95$	0.0286 ± 0.0001
M^2 $LH_{ratio} > 1.2$ $\Delta\Phi_{max} < 180^\circ$ *or* $Prob(\pi) > 0.95$	0.00398 ± 0.00005

$K_{2\pi}$



$$LH_{ratio} = \frac{LH(\pi)}{max[LH(\mu), LH(e)]}$$

Conclusion and Outlook

- Improvements on RICH PID performances could be performed, adding the two quantities:
  - PID probability,
  - $\Delta\Phi_{max}$.

- *To do* list:
  - Studing the bias introduced by the event selections and the residual background
  - Studing the differences between the several kinds of way to use the RICH information
  - Understanding how to well measure the $\pi - \mu$ separation
  - Understanding the correlation with other methods (e.g. Likelihood)
  - Moving to the 2017 data and the last reprocessing version (waiting for the *CONTROL trigger* filter).