Tracking with Multiple Mass Hypotheses

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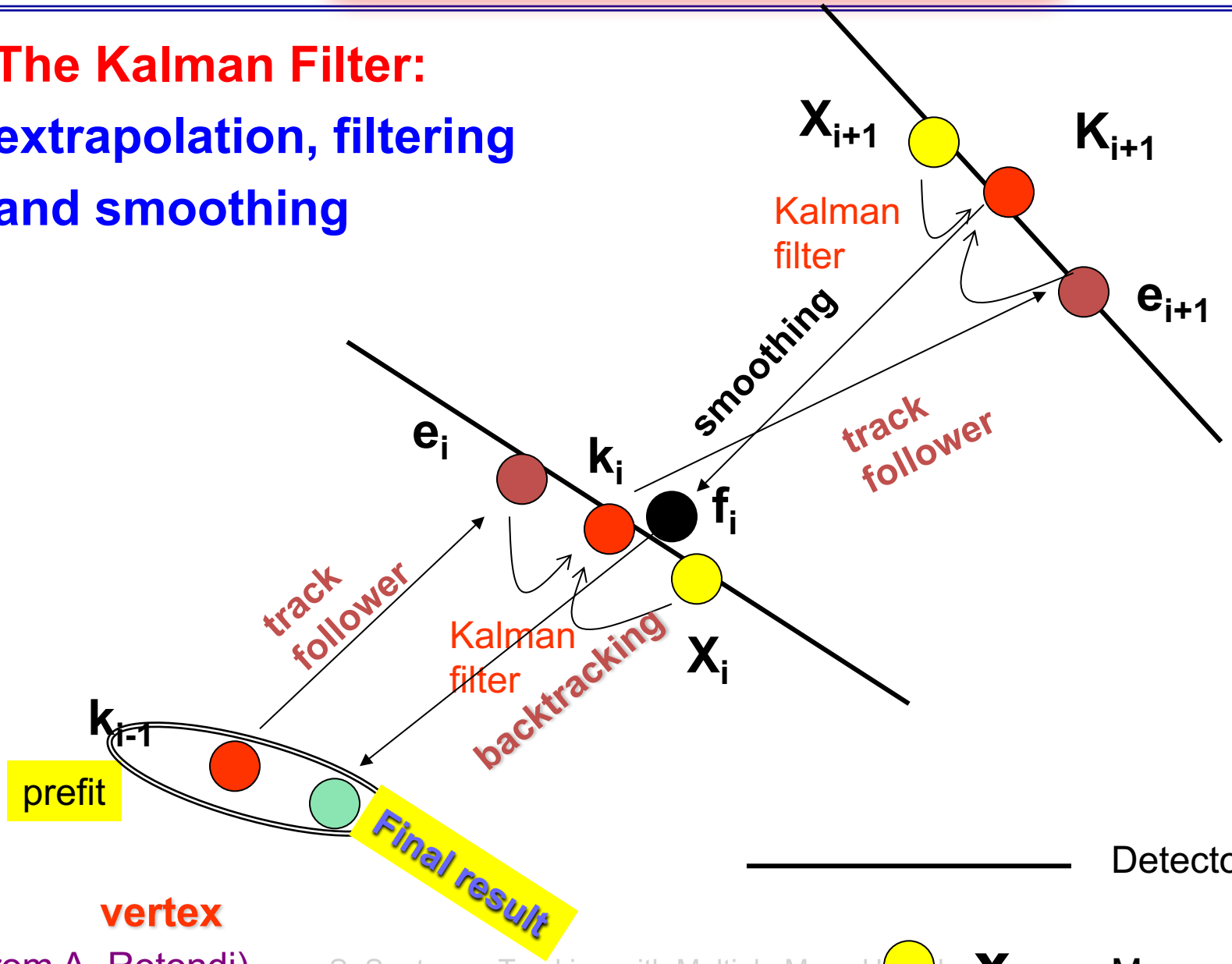
Track Fitting?

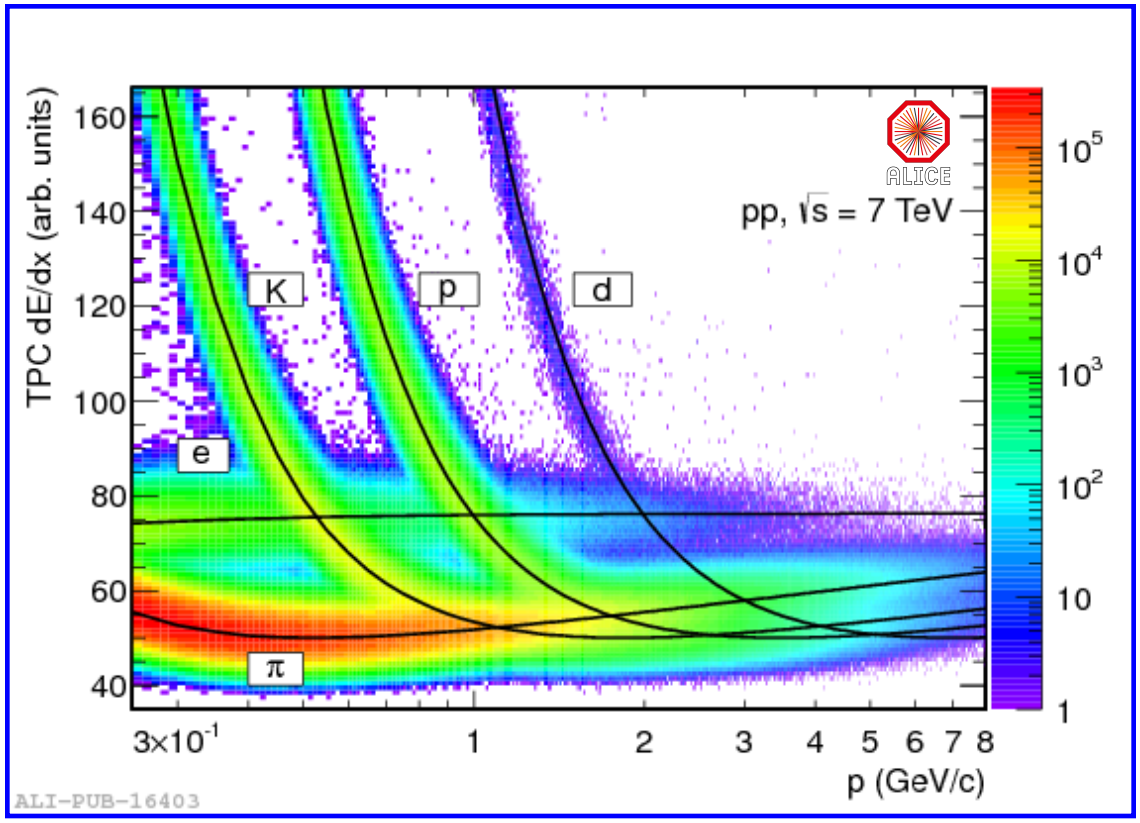
The Kalman Filter:
extrapolation, filtering and smoothing



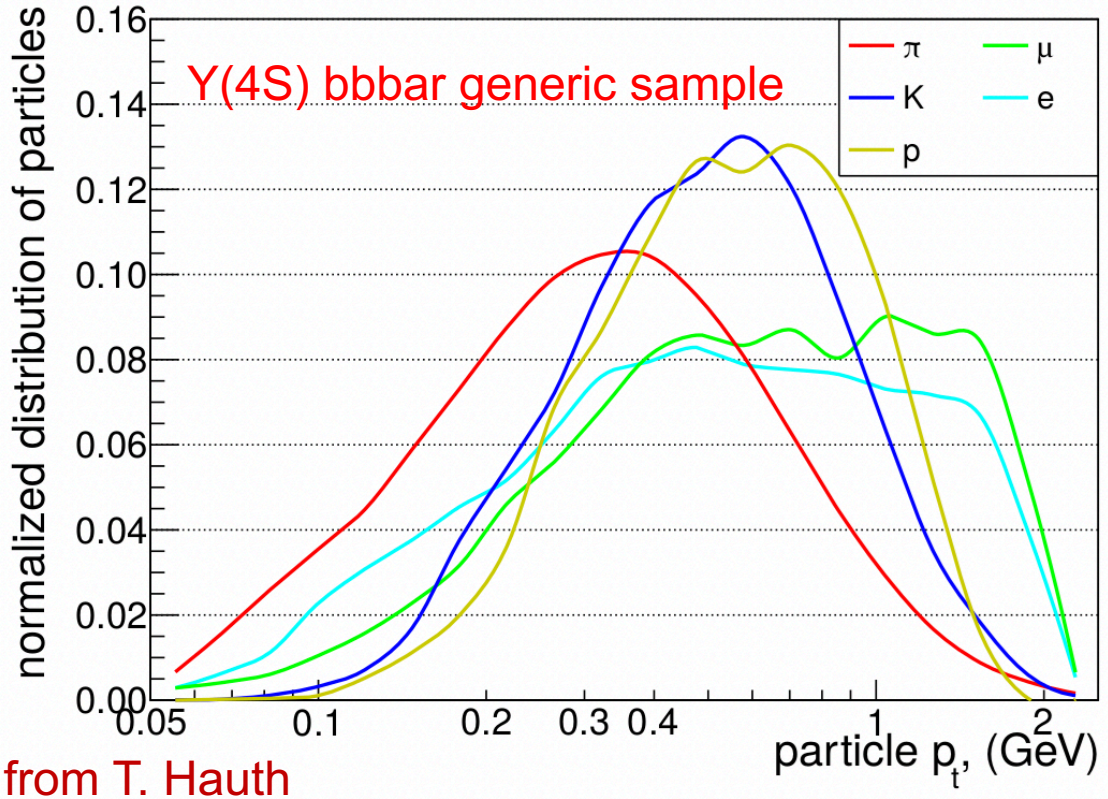
(from A. Rotondi)

Energy Loss Importance

- Different particles, different energy loss
- At high momentum not large differences
- At low momentum, wrong mass hypothesis can lead to wrong results



Our Momentum Range of Interest



from T. Hauth

- ✓ Large fraction of pions
- ✓ Particles below 1 GeV/c (mostly)

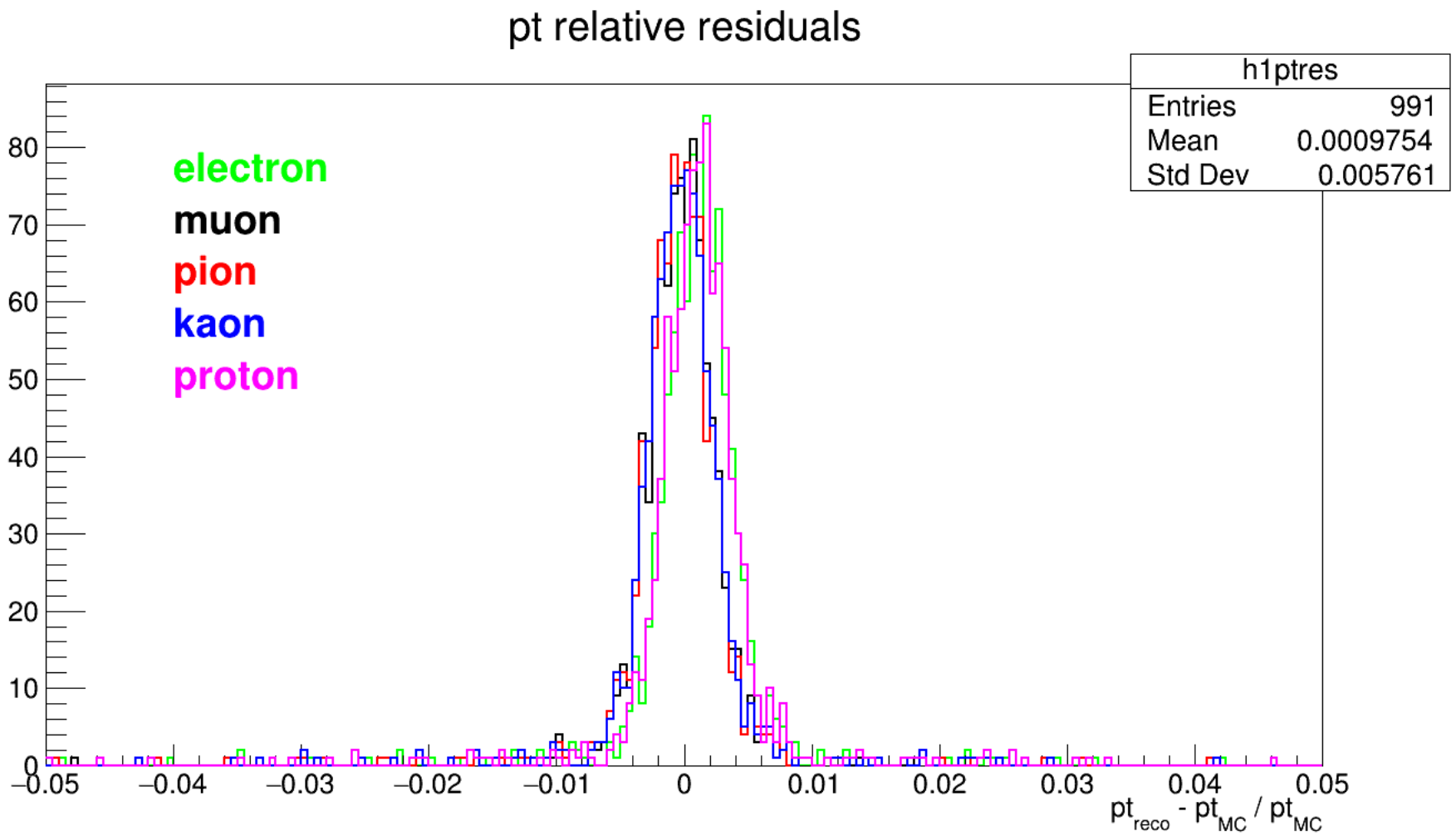
Particle type	Average fraction
$\pi^{\pm}$	72.8%
$K^{\pm}$	14.9%
$e^{\pm}$	5.8%
$\mu^{\pm}$	4.7%
$p^{\pm}$	1.8%

WARNINGS

- ➢ Low multiplicity samples reach larger momentum values
- ➢ Energy loss depends on total momentum (and not on p_t)

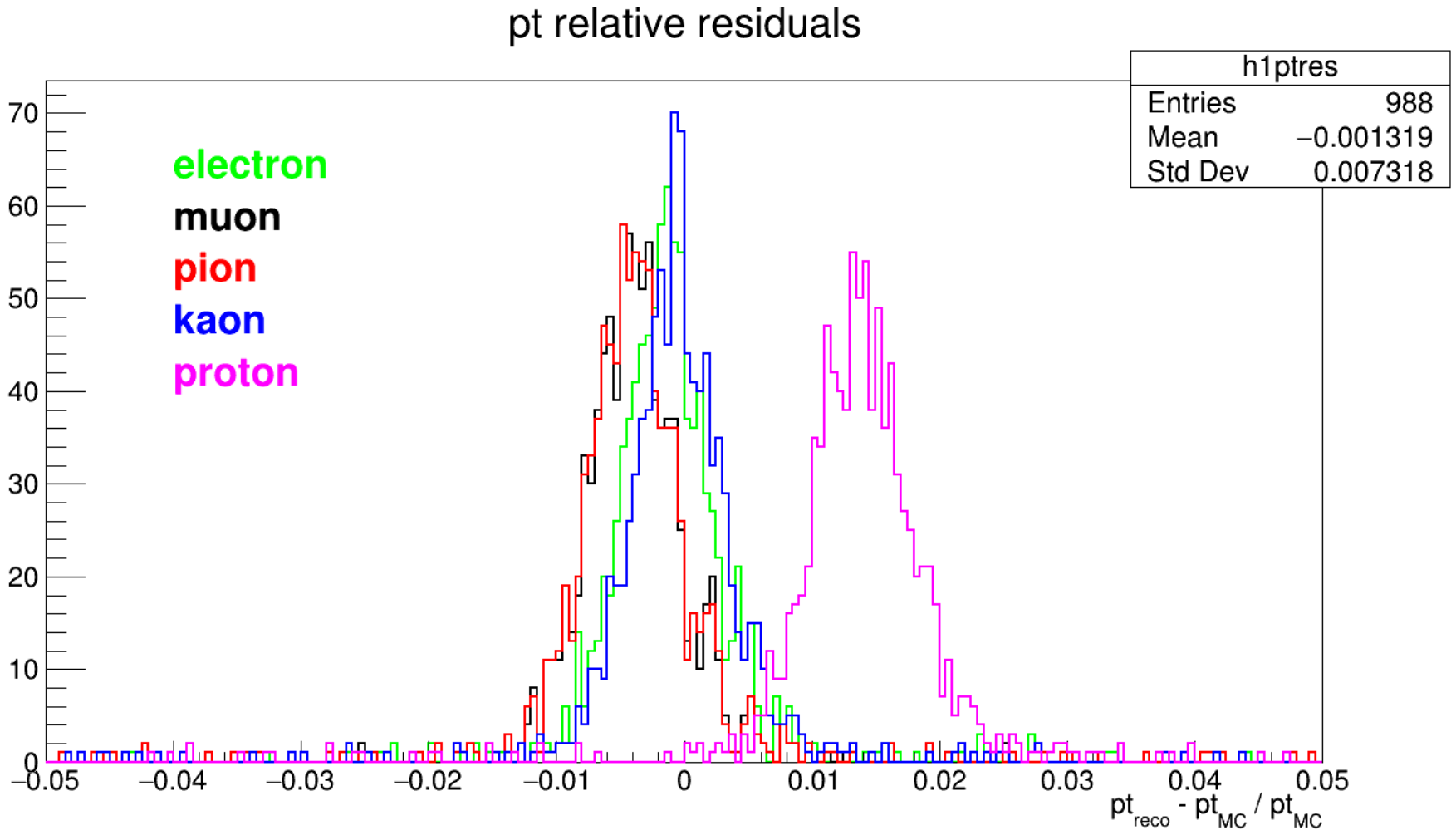
Kaons at p_t 1 GeV/c, 60°

Let's fit the kaon tracks with different particle hypotheses



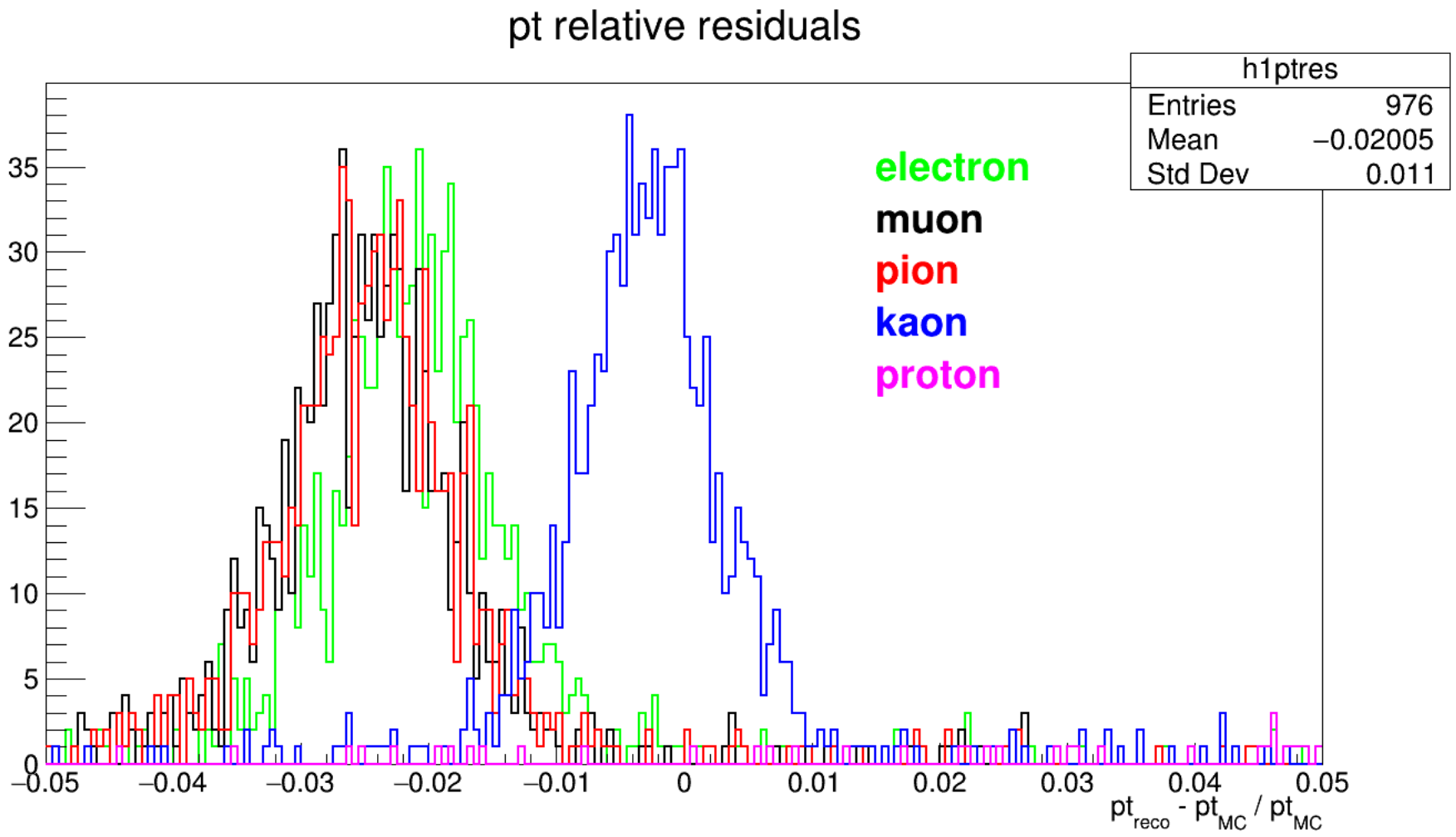
Everything more or less consistent, protons at bit higher momentum

Kaons at p_t 0.5 GeV/c, 60°



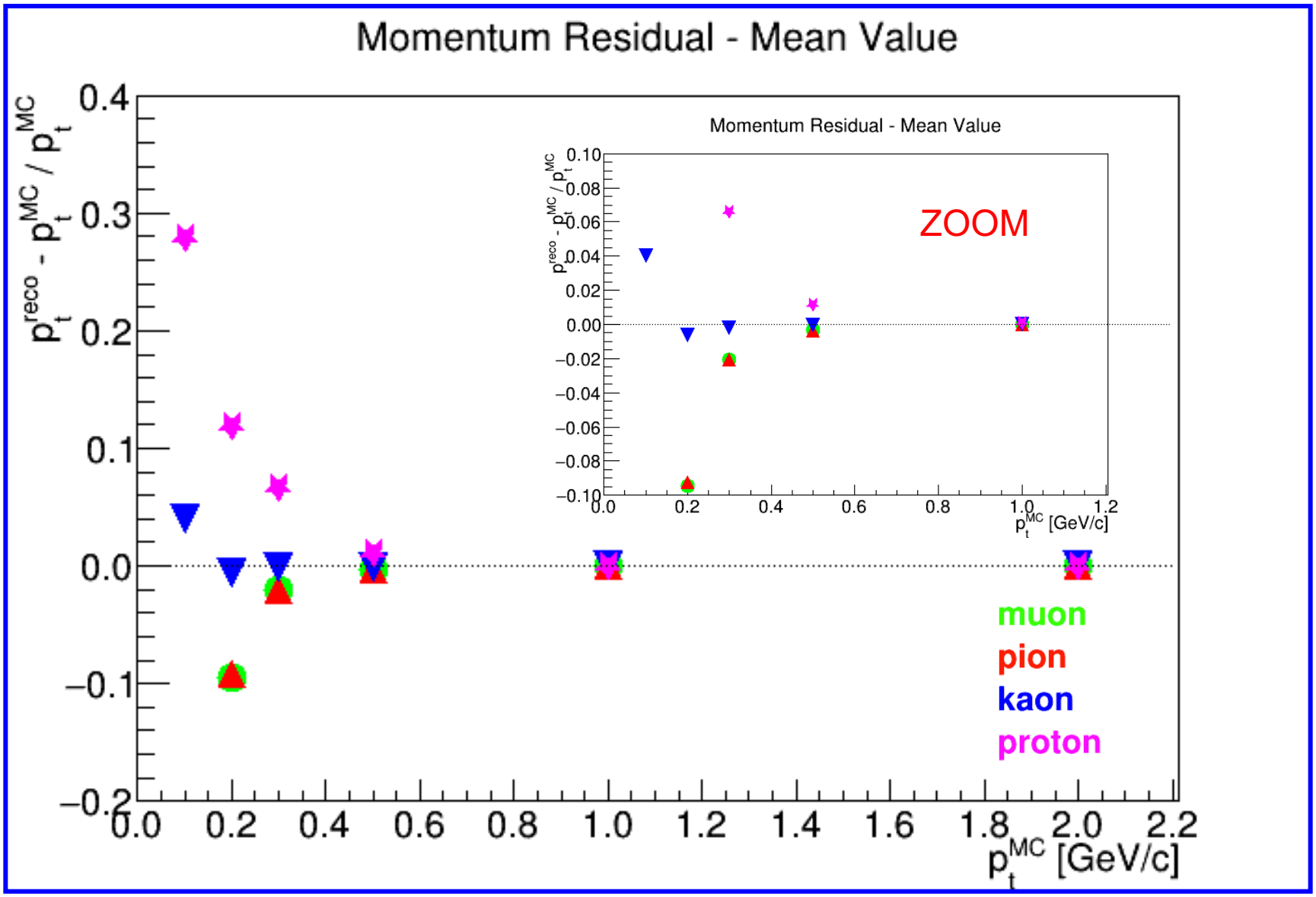
Correct hypothesis good, pions at low momentum, protons at higher momentum

Kaons at p_t 0.3 GeV/c, 60°

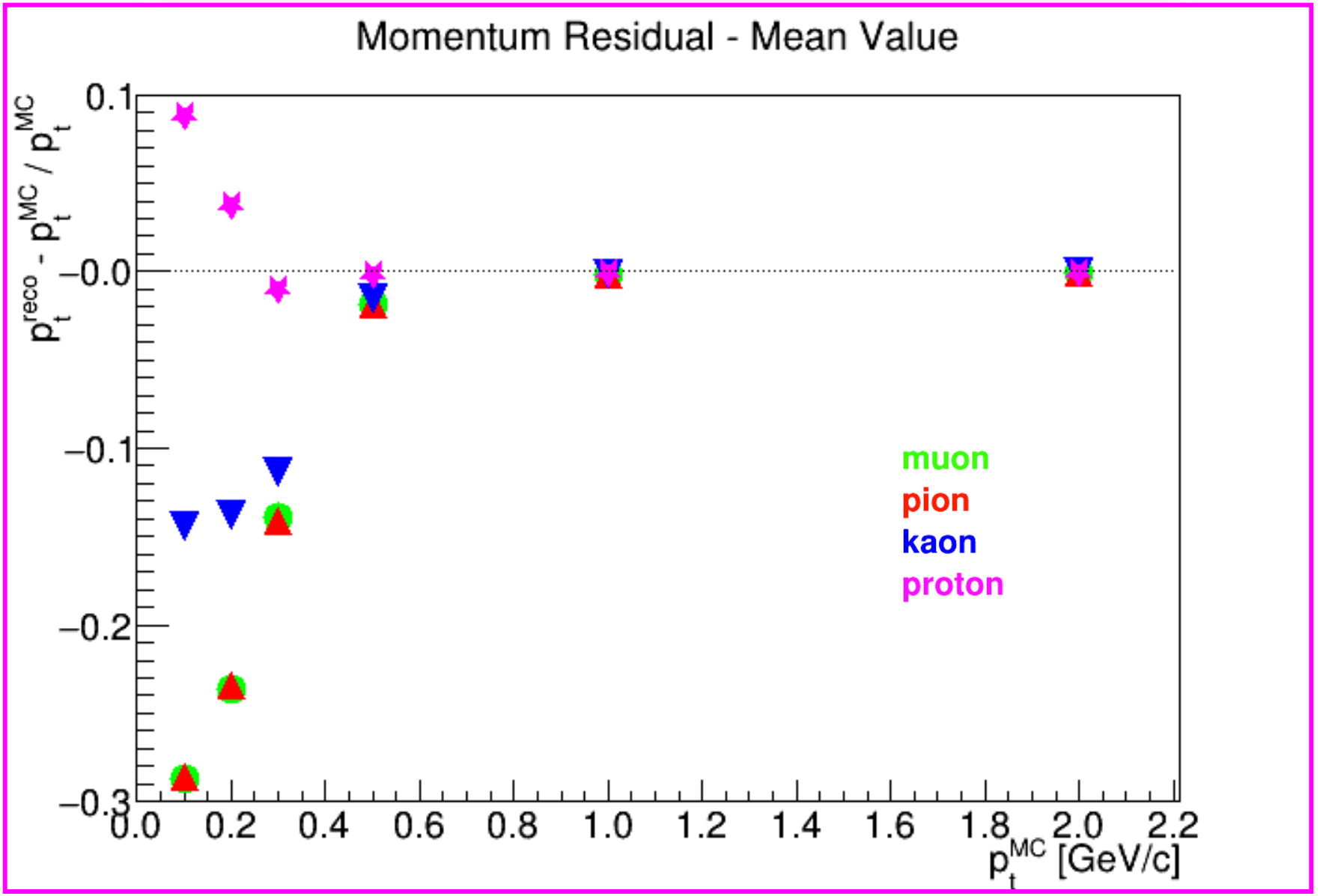


The lower the momentum, the larger the discrepancy when wrong particle is assumed in the fit

Mean Peak Position for kaon tracks



Mean Peak Position for proton tracks



Current Software Status

Before (pre)release-01-00-00(a)

- In the releases: single particle hypothesis (π)
- In the head: 4 particle hypotheses (μ π K p)

Starting from (pre)release-01-00-00(a)

- In both release and head: 3 particle hypotheses (π K p)

Muon hypothesis?

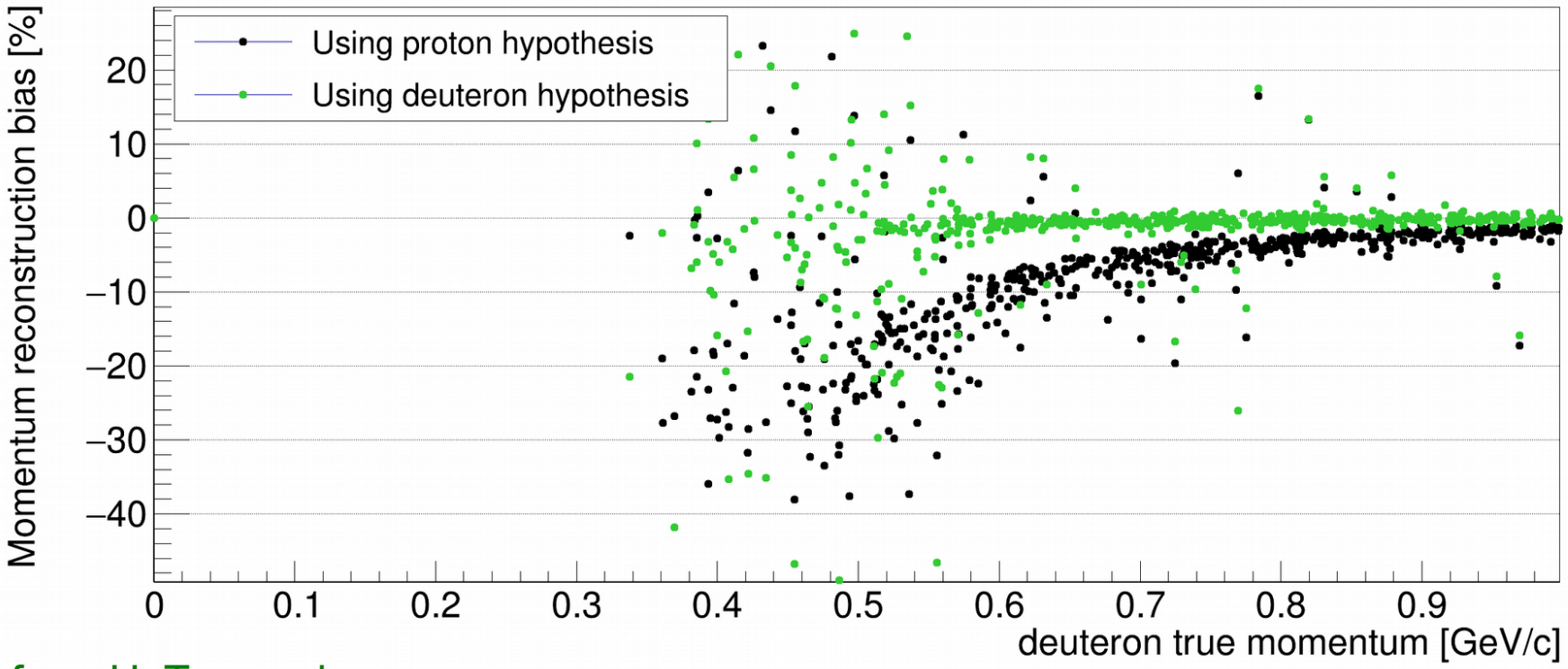
- ✓ Equivalent to pion, not needed

Electron hypothesis?

- ✓ No good treatment for bremsstrahlung so far, better to use pion hypothesis
- ✓ A possible cure: find the ECL bremsstrahlung cluster and merge the energy

Deuterons?

- Some analyses will need deuteron reconstruction
- An additional particle hypothesis costs disk space and CPU time
- At some time we will need also this hypothesis for dedicated studies



from U. Tamponi

Resource Estimation: Disk Space

	Total branch size kB/evt			Size difference kB/evt		Ratio with 1 hyp	
	1 hyp	3 hyp	4 hyp	3-1 hyp	4-3 hyp	3/1 hyp	4/1 hyp
mDST	13.54	15.83	16.59	2.29	0.76	1.17	1.22
Track	0.02	0.03	0.03	0.01	0.01	1.76	2.22
TrackFitResults	1.42	3.69	4.44	2.27	0.75	2.59	3.12
MCParticles	3.31	3.31	3.31	0.00	0.00	1.00	1.00

mDST increases of 17% with 3 fit hypotheses, up to 22% with 4 hypotheses

TrackFitResults increase does not scale exactly with number of fit hypothesis:

- 3 hypotheses -> size x 2.59
- 4 hypotheses -> size x 3.12

Resource Estimation: Computing Time

	Total computing time s/evt			Time difference s/evt		Ratio with 1 hyp	
	1 hyp	3 hyp	4 hyp	3-1 hyp	4-3 hyp	3/1 hyp	4/1 hyp
All	6.40	6.83	7.00	0.43	0.17	1.07	1.09
SumSimulation	4.61	4.61	4.61	0.00	0.00	1.00	1.00
SumTracking	1.19	1.61	1.78	0.42	0.17	1.35	1.49
Track Fitting	0.15	0.45	0.58	0.29	0.13	2.89	3.75
SumTracking - Track Fitting	1.04	1.17	1.20	0.13	0.03	1.12	1.16

The global time time increases of 7% with 3 fit hypotheses,

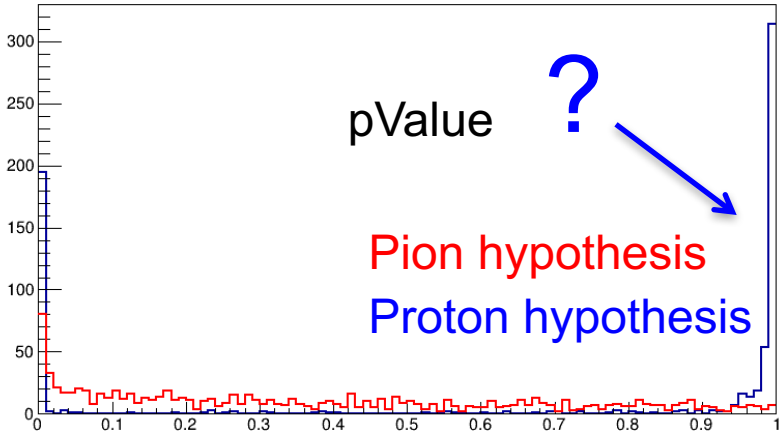
up to 9% with 4 hypotheses

Open Issues

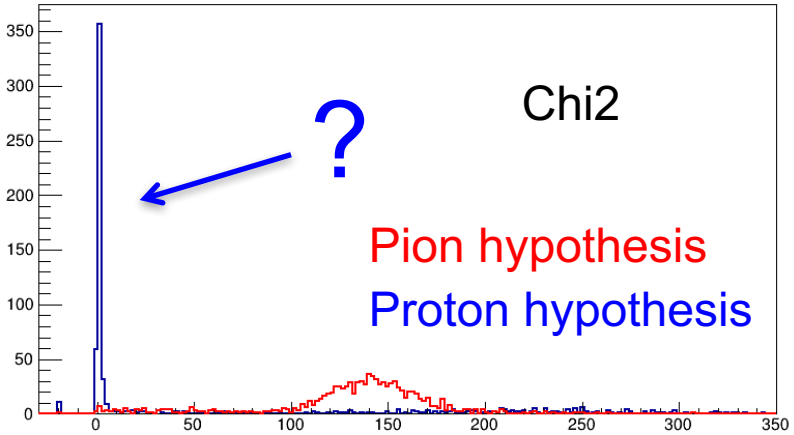
Wrong hypothesis fit

Pions at p_t 0.2 GeV/c, 60° - MC Track Finding

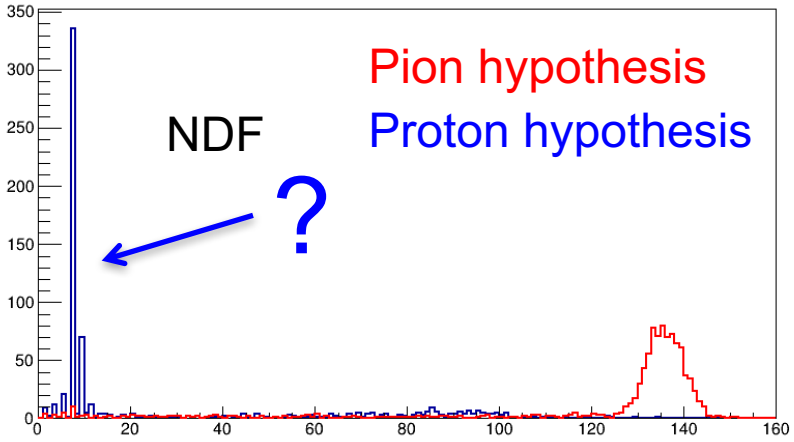
TrackFitResults.m_pValue {TrackFitResults.m_pdg==2212}



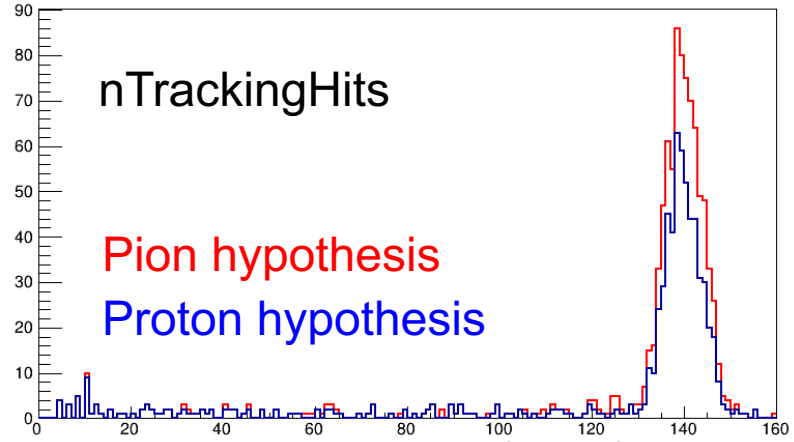
TrackFitResults.m_Chi2 {TrackFitResults.m_pdg==2212}



TrackFitResults.m_Ndf {TrackFitResults.m_pdg==2212}



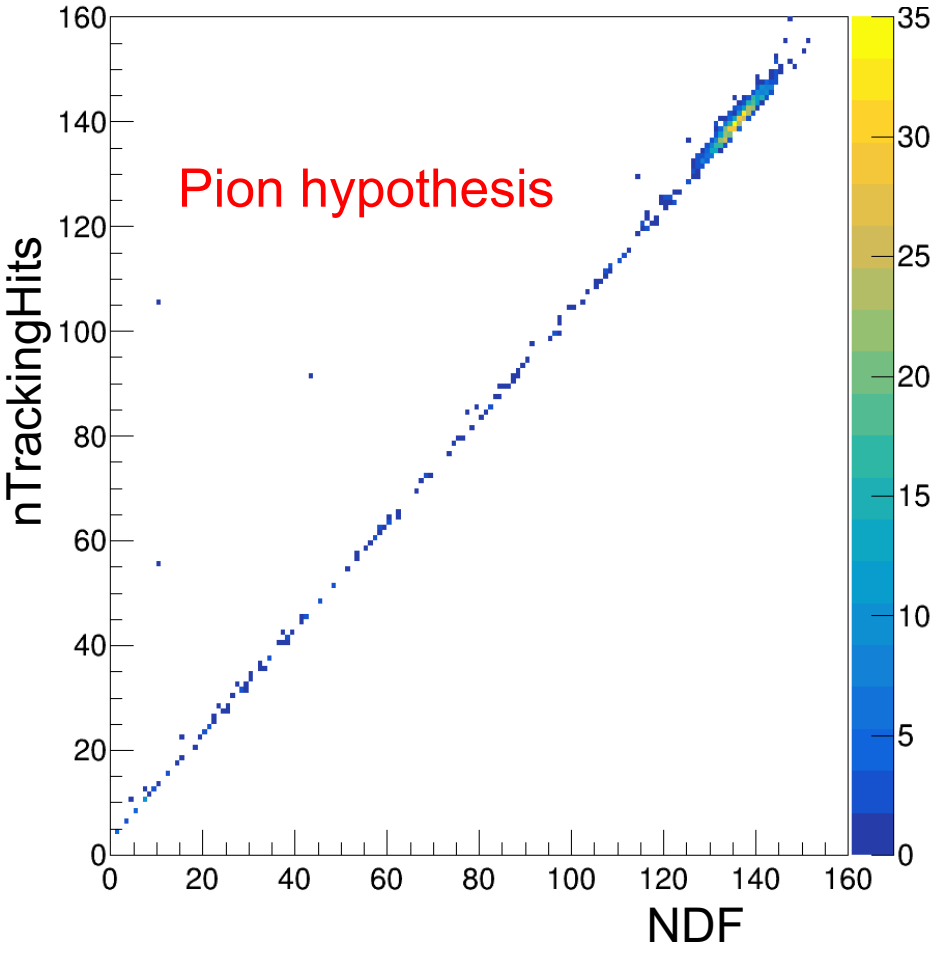
TrackFitResults.m_nTrackingHits {TrackFitResults.m_pdg==211}

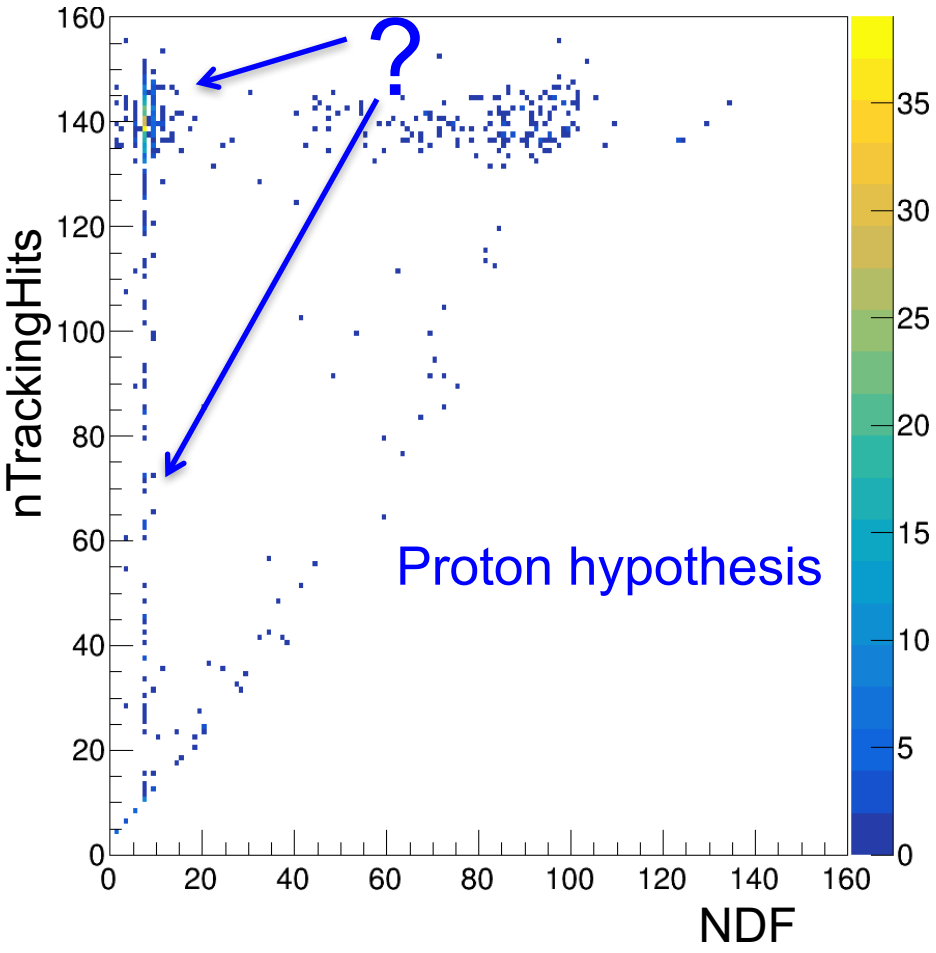


protons are less since fit can fail

Wrong hypothesis fit

Pions at p_t 0.2 GeV/c, 60° - MC Track Finding





If the hypothesis “very wrong”, DAF removes almost all the hits

Efforts needed to remove bad fitted tracks

Trying to summarize

From (pre)release-01-00-00 three mass hypotheses for the track fitting.

This solves systematic deviations in the reconstructed momentum.

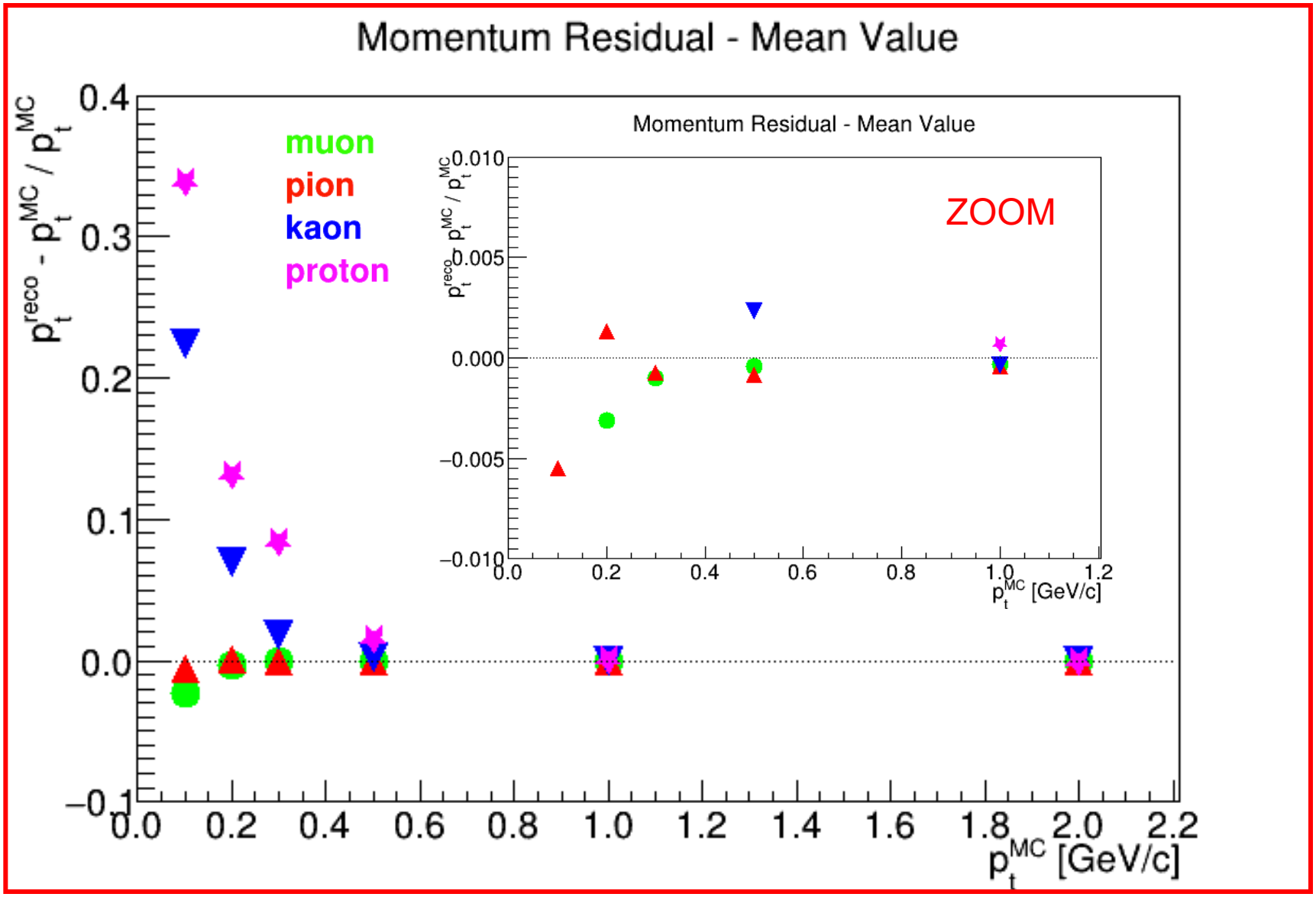
The increase in disk space and in computing time is inside the budget, still room to add additional particle hypotheses

Very bad fits (i.e. low pt with wrong particle hypothesis) sometimes return a very low number of degrees-of-freedom, due to DAF outlier removal. Possibility to check nTrackingHits/NDF to remove badly fitted tracks?

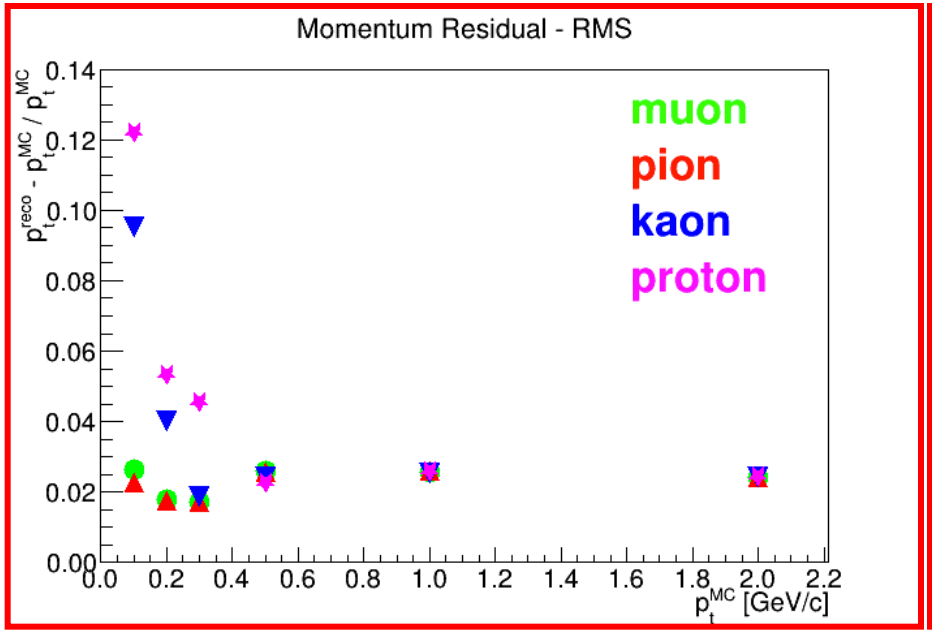
In the long term: tracking fit quality could provide additional help in particle identification, but first we need to understand better what is doing the fitter.

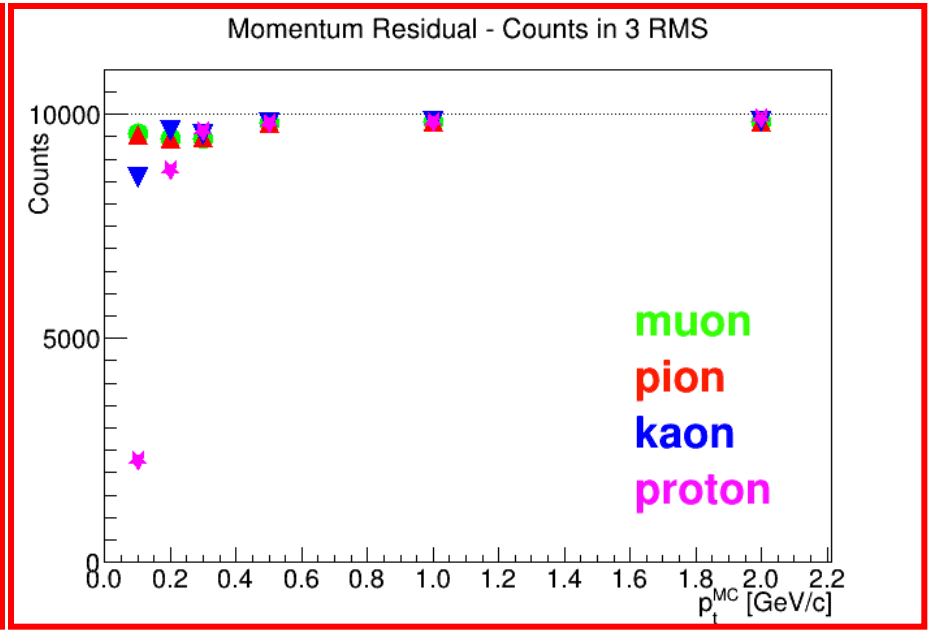
Spares

Pions: Mean Peak Position



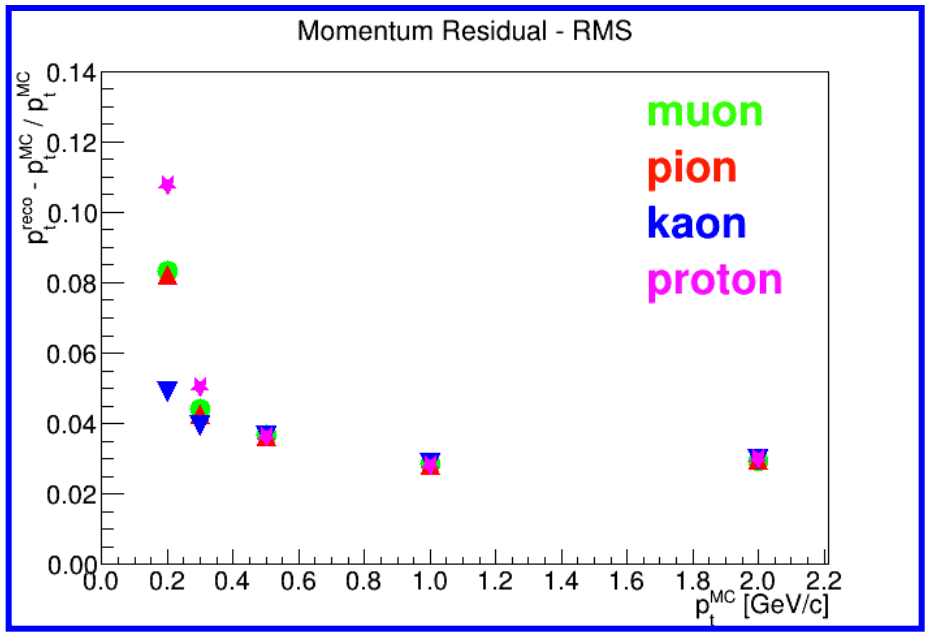
Pions RMS and counts inside 3 RMS

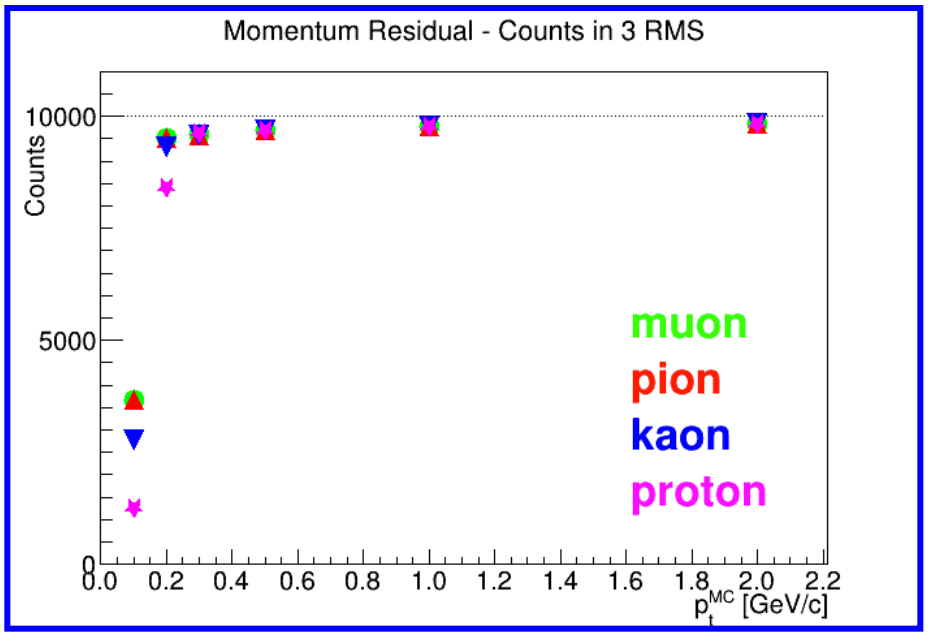




- Since wrong-particle hypotheses have no Gaussian shape, no sigma of fit but RMS of residual histograms between -0.8 and 0.8.
- This RMS depends on histogram edges. It is NOT the momentum resolution, but just a term of comparison.

Kaons: RMS and counts inside 3 RMS





Kaon reconstruction with kaon hypothesis always the better

At 100 MeV/c... Goodbye kaons!

Protons: Mean, RMS, counts in 3 RMS