Low p PID using TOF in ATHENA software

ATHENA PID meeting (09/27/2021)

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Low p threshold for RICH detectors

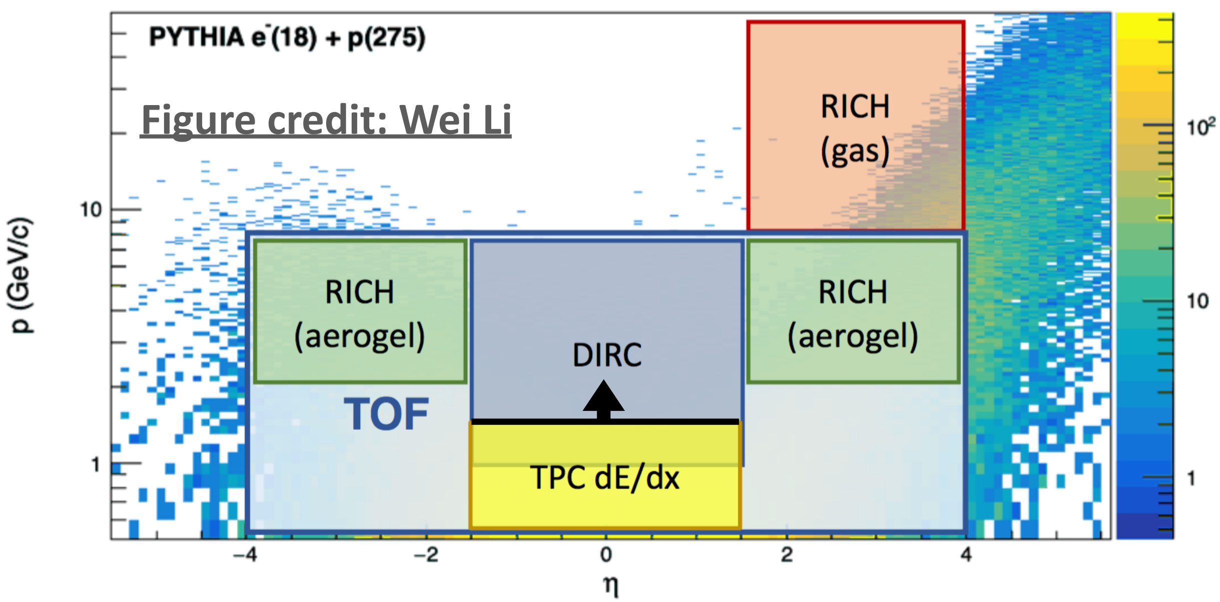
EICUG YR

Physics requirements:

Rapidity	π/K/p and π0/γ	e/h	Min pT (E)
-3.5 – -1.0	7 GeV/c	18 GeV/c	100 MeV/c
-1.0 – 1.0	8-10 GeV/c	8 GeV/c	100 MeV/c
1.0 – 3.5	50 GeV/c	20 GeV/c	100 MeV/c

radiator	index	Threshold (GeV/c) e	π	K	p
quartz (DIRC)	1.473	0.00048	0.13	0.47	0.88
aerogel (mRICH)	1.03	0.00207	0.57	2.00	3.80
aerogel (dRICH)	1.02	0.00245	0.69	2.46	4.67
C_2F_6 (dRICH)	1.0008	0.01277	3.49	12.34	23.45
CF_4 (gRICH)	1.00056	0.01527	4.17	14.75	28.03

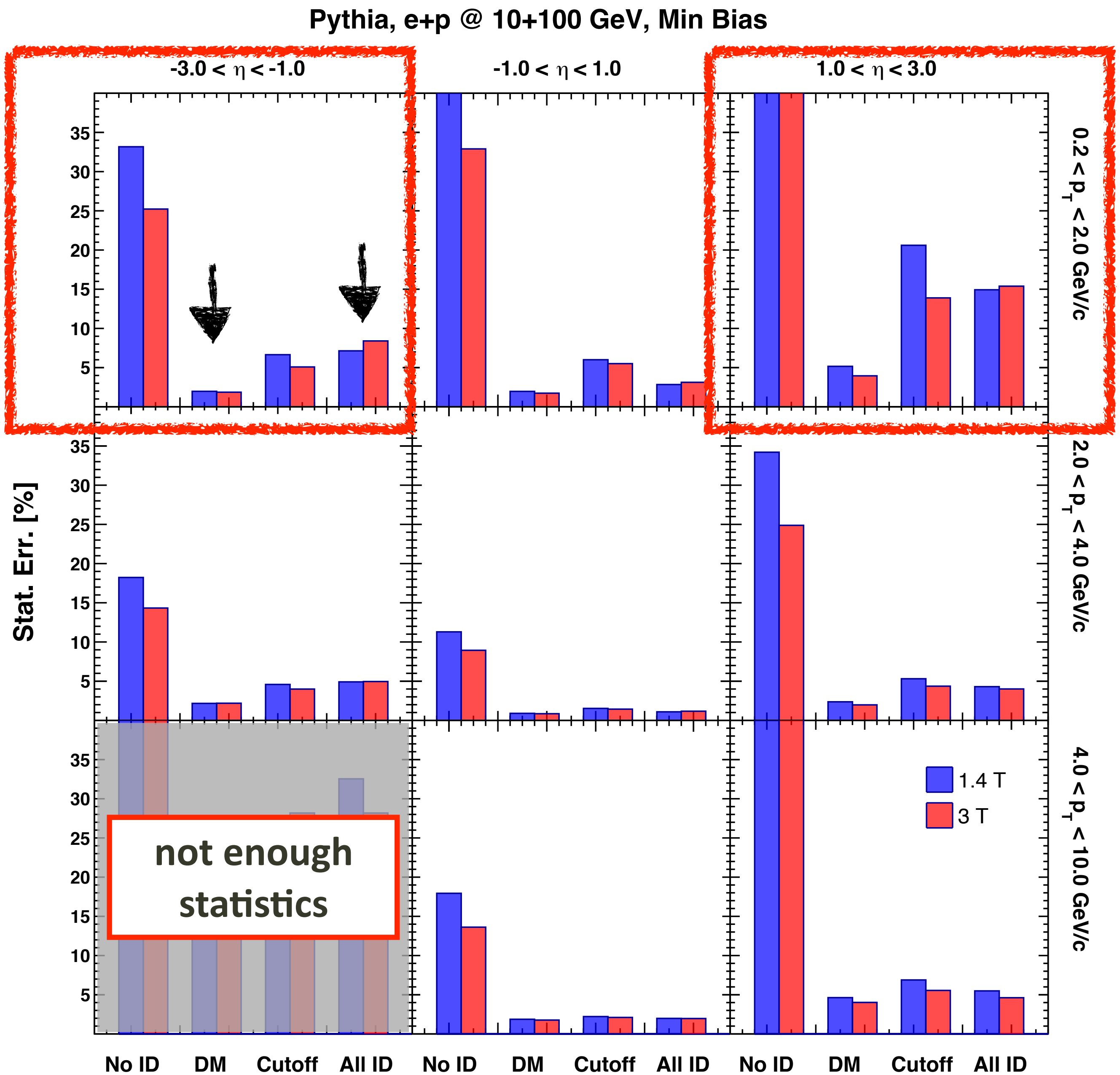
Table 11.23: Table of Cherenkov thresholds for various media.



Magnetic field can affect the low p_T range

Impact on forward Λ_c reconstruction

https://indico.bnl.gov/event/11762/contributions/49533/attachments/34597/56145/EIC_ECCE_wenqing_051821.pdf



Low p cutoff using DIRC+dRICH as PID affect Λ_c significantly

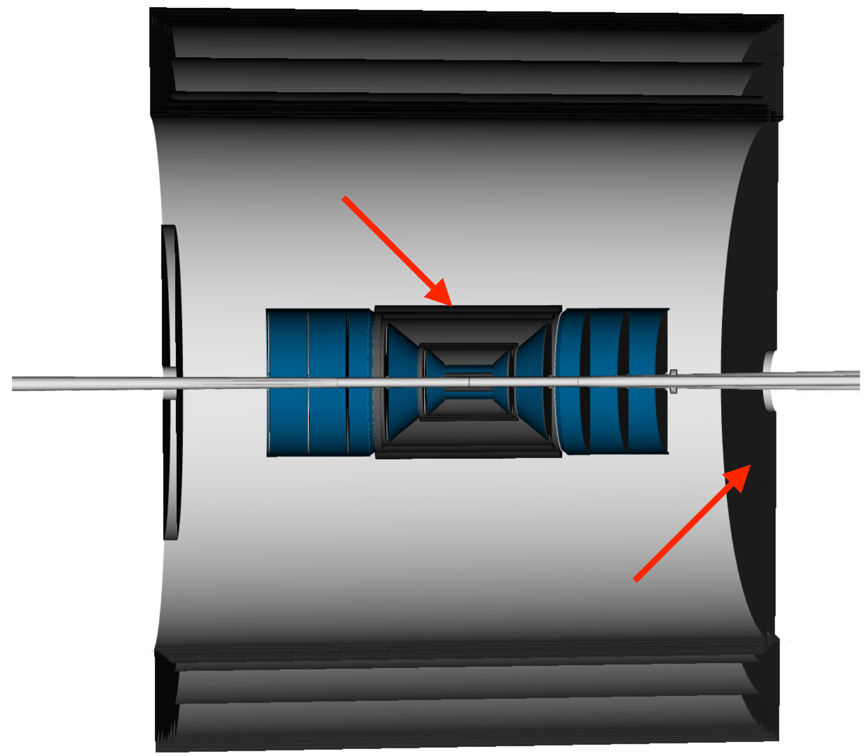
Larger effect at |η|>1

larger effect at low p_T

3T has slightly better precision comparing to 1.4T

Information from DD4HEP

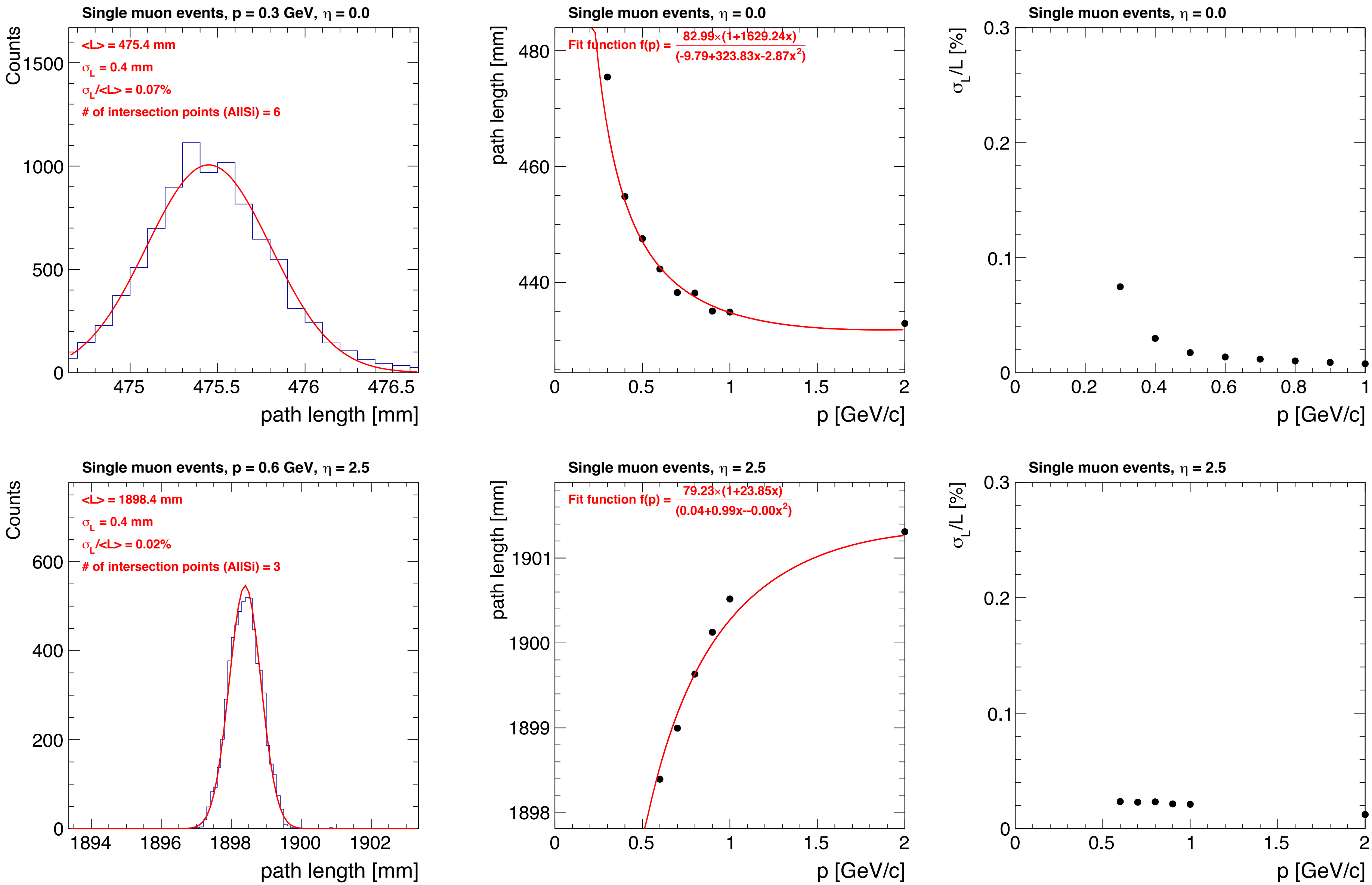
- Test in Athena software framework
  - Simplistic setup containing only the tracking detectors without support cones or shells
  - Using the outter-most barrel layer and forward GEM as reference surface for path length calculation



- Single muon events with fixed momentum and eta (1000 events)
  - Currently focusing on low mometum: 0.1, 0.2, …, 1.0, 2.0 GeV
  - η: 0, 0.5, 1, 1.5, 2, 2.5, 3
  - Output: reconstructed momentum, path length, # of intersection points with All-Si layers

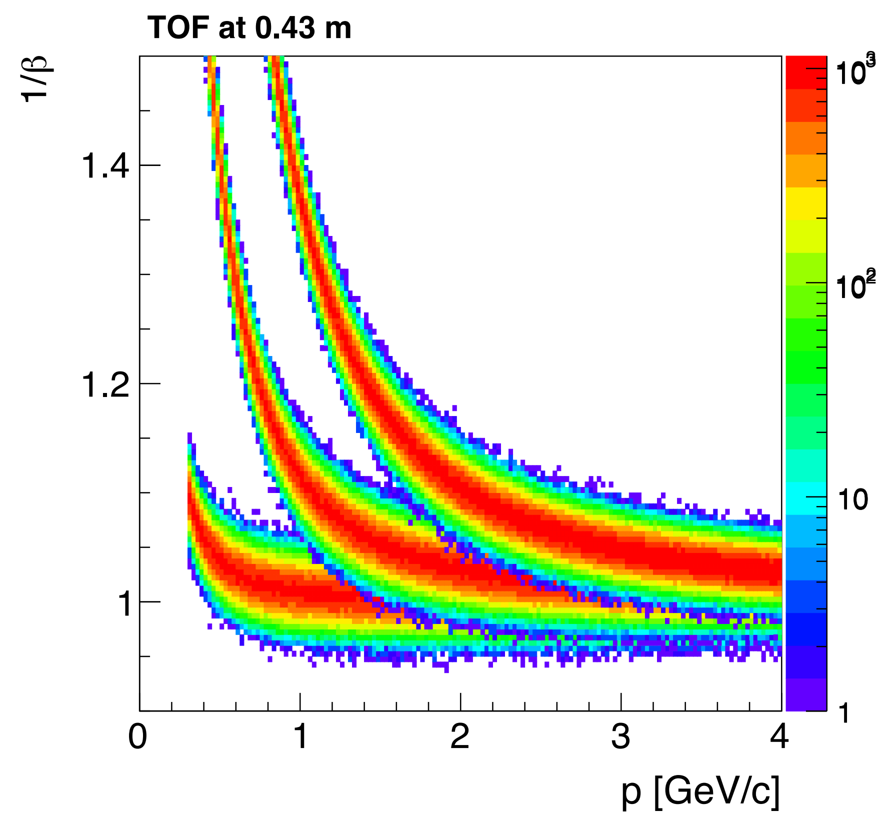
Toy MC to extract the π/K/p separation power

- Extrapolate pathlength and uncertainty as function of p and η
  - Barrel @ 43cm, forward @ 185cm



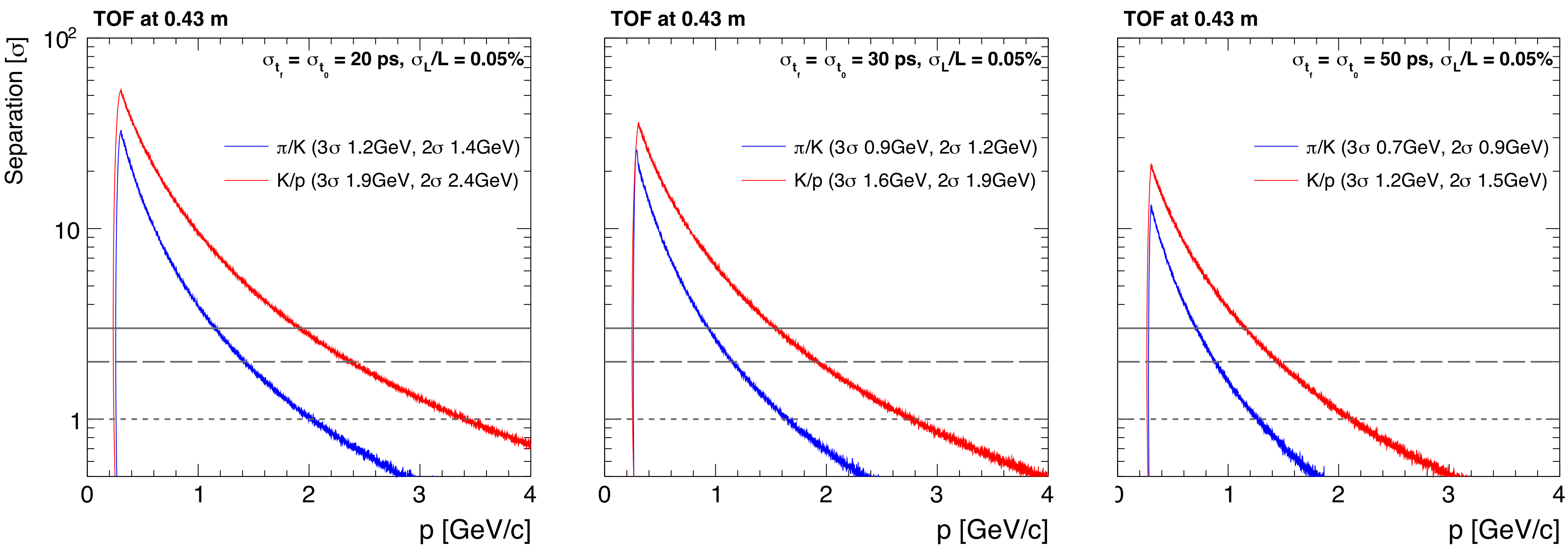
Toy MC to extract the π/K/p separation power

- Extrapolate pathlength and uncertainty as function of p and η
  - Barrel @ 43cm, forward @ 185cm
- Throw particles (π, K, proton) of different p and η
  - Calculate time of flight t_{flight} = L/velocity
  - Truth: $t_0 = 0$, $t_f = t_0 + t_{flight}$ = L/velocity
  - $\beta = L^{reco} / [(t_f^{reco} - t_0^{reco})\cdot c]$ where L^{reco} smear by full sim result
    - t_f^{reco} : smear t_f by 20, 30, 50 ps
    - t_0^{reco} : smear t_0 by 20, 30, 50 ps
    - L^{reco} : smear L by the uncertainties extracted from full simulation
- Extract the high p limit of 3σ separation



Barrel TOF

- DIRC firing threshold: 0.47 (K), 0.88 (p)
- Reference radius: 43cm



Summary

- One TOF layer at ~43cm can compensate the DIRC momentum coverage
- Check also for foward TOF
- Have TOF in the full simulation setup at planned position
- Work with software group to write the path length out
- Caveat:
  - Currently tracking using truth seeding, the low p threshold, resolution for tracking itsself might be an optimistic case now