BERKELEY LAB

Low momentum PID with TOF

Wenqing Fan and Rey Cruz Torres (LBNL)

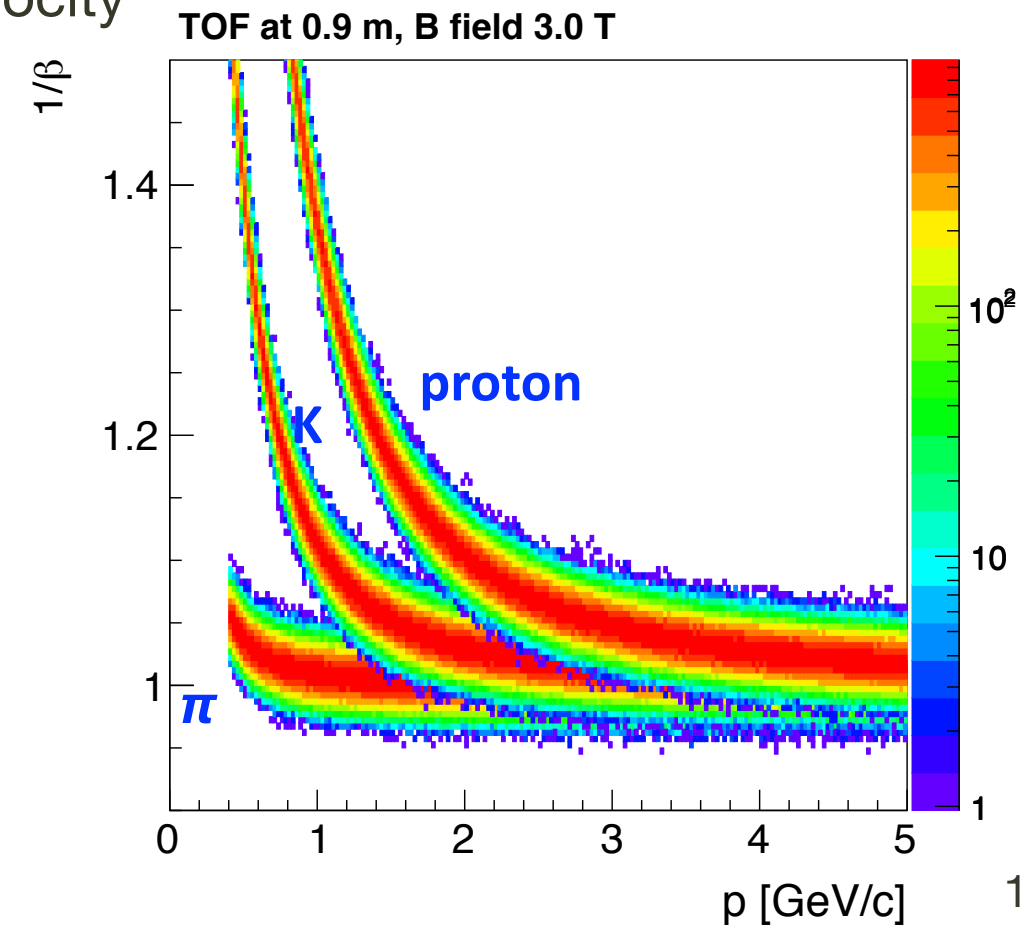
EIC@IP6 PID working group meeting

05/17/2021

with help & inputs from LBNL memebers, Wei Li and Shuai Yang (RICE)

Toy MC simulation

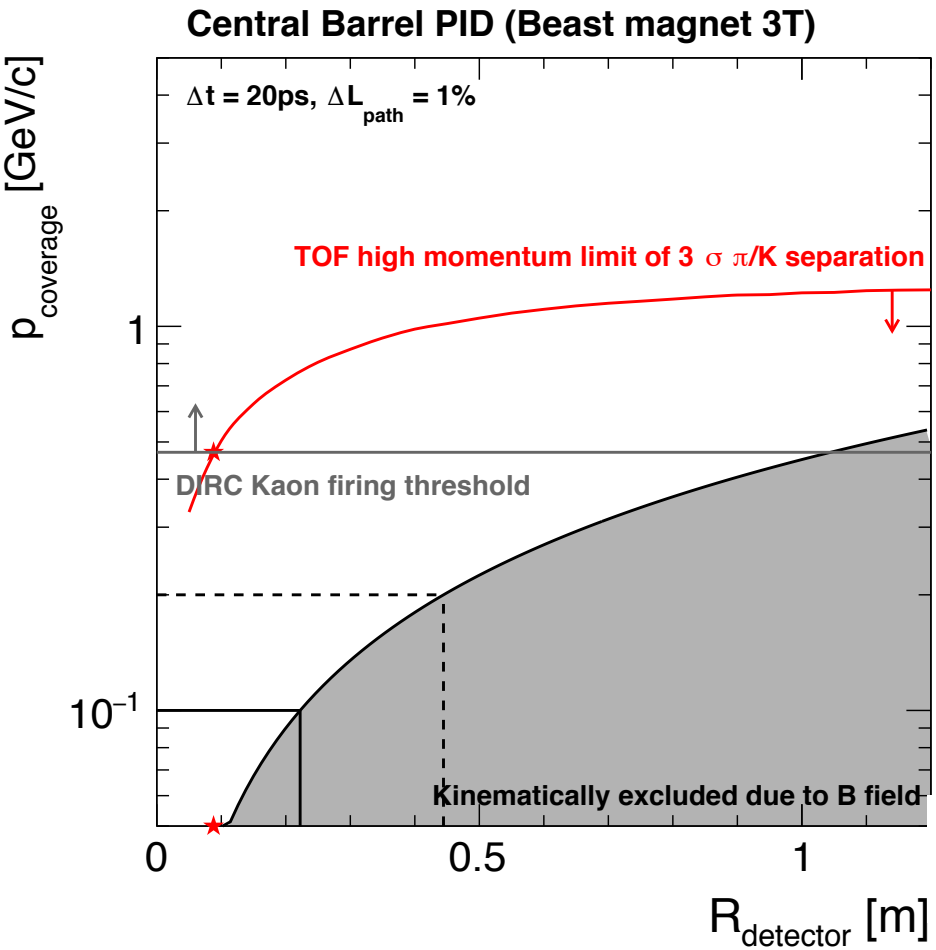
- Estimate high momentum reach of 3σ PID for TOF at different radial location (to complement DIRC performance)
- Throw particles (π, K, proton) of different p at η=0
  - Calculate path length L assuming uniform B field along z
  - Truth: $t_0 = 0$, $t_f = t_0 + t_{flight}$ = L/velocity
  - $\beta = L^{reco} / [(t_f^{reco} - t_0^{reco})\cdot c]$
    - t_f^{reco} : smear t_f by 20 ps
    - t_0^{reco} : smear t_0 by 20 ps
    - L^{reco} : smear L by 1%
- Extract the high p limit of 3σ separation
- Run for different R (5, 10, …120cm) location



Effect of B field and timing resolution

- One needs to be very careful with the low momentum cutoff due to the strong B field (espicially 3T)

$$p_T\,[\mathrm{GeV}/c] \;=\; 0.3 \cdot B\,[\mathrm{T}] \cdot r/2\,[\mathrm{m}]$$



NO PID (DIRC, TOF, dE/dx) detector ~1m can identify particles below 0.4 GeV in the mid-rapidity!

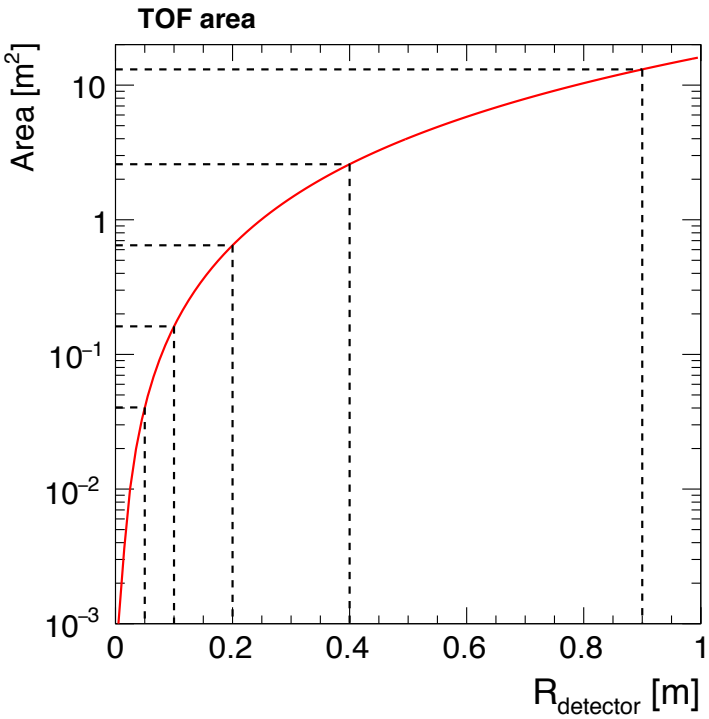
For LGAD TOF have 3σ π/K separation, it needs to be placed >10cm

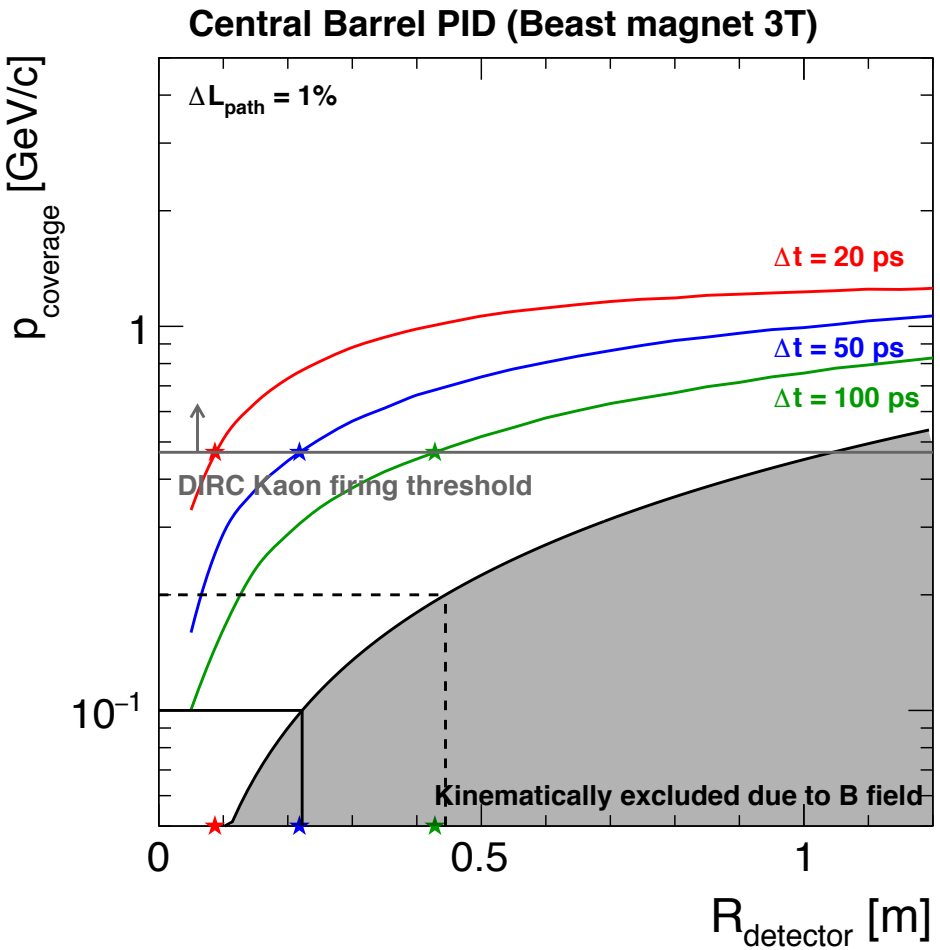
If one want to use dE/dx (cluster counting) or TOF to cover low p, it needs to sits at a smaller R (<25cm if one want PID ~0.1 GeV, <45cm if one want PID ~0.2GeV)

Also related to min p can be reconstructed via tracking, no need to have PID where there is no p measurement

Effect of B field and timing resolution

- TOF with better intrinsic resolution can be put closer to the interaction point → smaller area





20ps: 5-25cm (45cm) to reach down to 0.1GeV (0.2GeV)

50ps: 10-25cm (45cm) to reach down to 0.1GeV (0.2GeV)

100ps: cannot reach down to 0.1GeV, ~45cm reach down to 0.2GeV

Summary

- DIRC cannot identify particles below firing threshold or particles which can not reach it
- Complementry PID detector should be put close enough so low momentum particles can reach it
- TOF: further → higher momentum reach; closer → smaller area
- Close coordination with tracking studies to optimize the subsystem configuration for both PID and tracking
  - EIC Tracking and PID studies beyond the Yellow Report: https://indico.bnl.gov/event/11629/contributions/49503/attachments/34446/55872/210512_EIC%40IP6_tracking_pid.pdf
  - Nest step: put LGAD at different radial locations and study its impact on the momentum and projecting resolution