Quintuple-GEM Based RICH Detector for EIC

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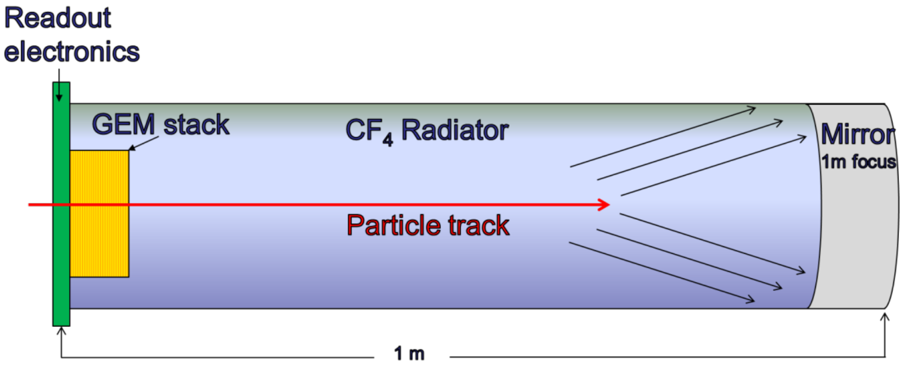
Brief Introduction:

Tested a Ring-Imaging Cherenkov detector prototype with:

- CsI Photocathode on top GEM
- Mirror in deep UV -> MgF_2 coating
- Single Photon Capability ->quintuple GEM stack with APV25-SRS
- Radiator choice: CF_4

- **The windowless technology + wave-length-tuned mirror:** Minimize the loss of photons
- **Small Ref. Index:** Particle identification (PID) reaching out to high momenta



Ref: IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 62, NO. 6, DECEMBER 2015

Flow for the next slides:

Determine different weight factors for RICH performance (Inspired by test beam results)

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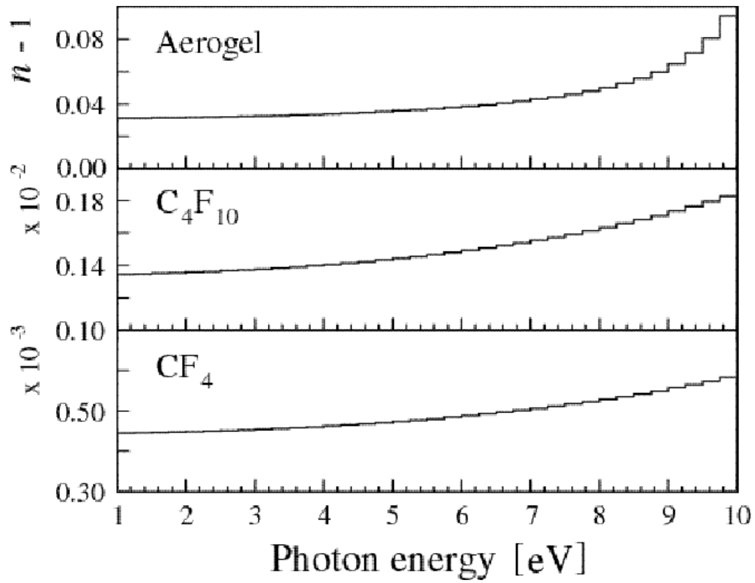
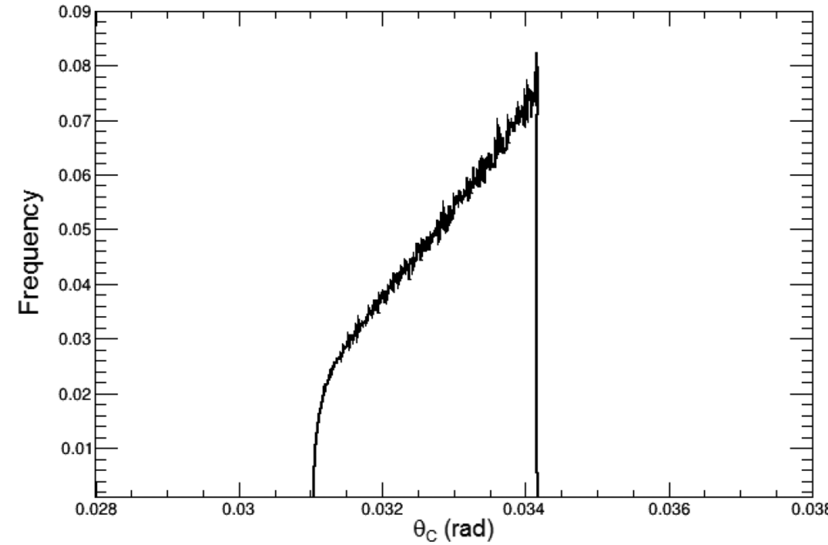
Extrapolate the performance for EIC requirements

Angular Dispersion of Cherenkov Angle



Chromatic dispersion for the Cerenkov angle

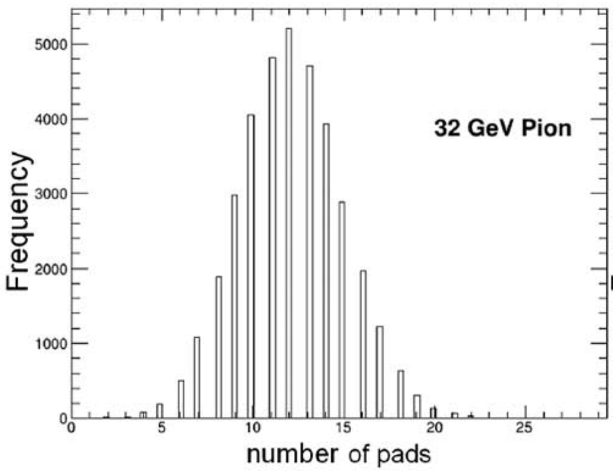


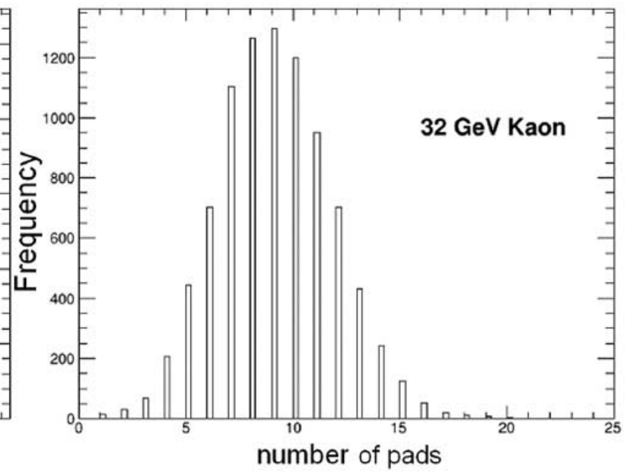
- n is not a constant but varies with λ
- n(λ) -> R(λ)
- Weighted with:
  $1/\lambda^2$ for Cherenkov Intensity also with QE(λ) of CsI

Radius Probability (per photon):

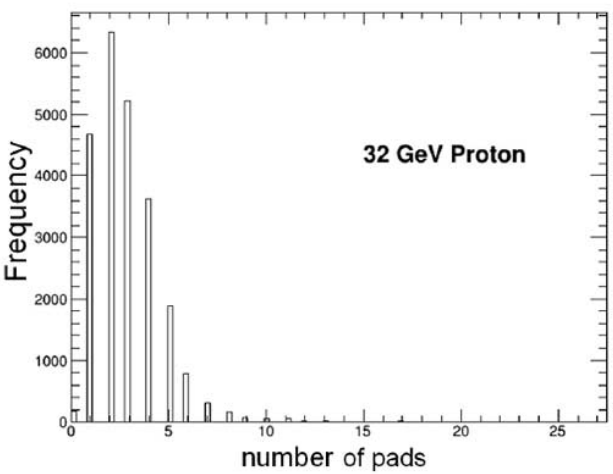
$\sigma_R/R \sim 2.5\%$

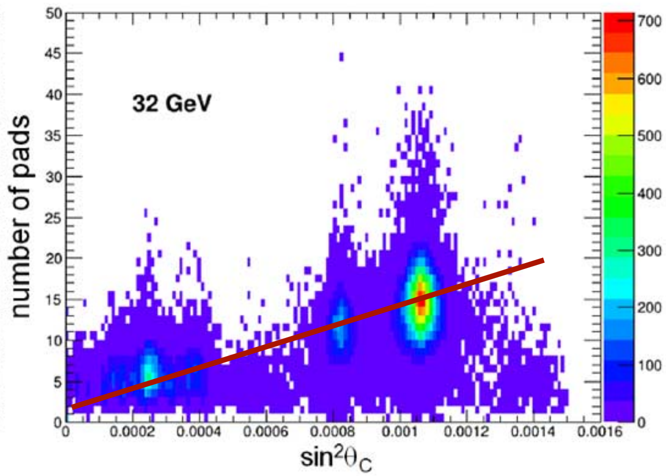
Number of Pads Included





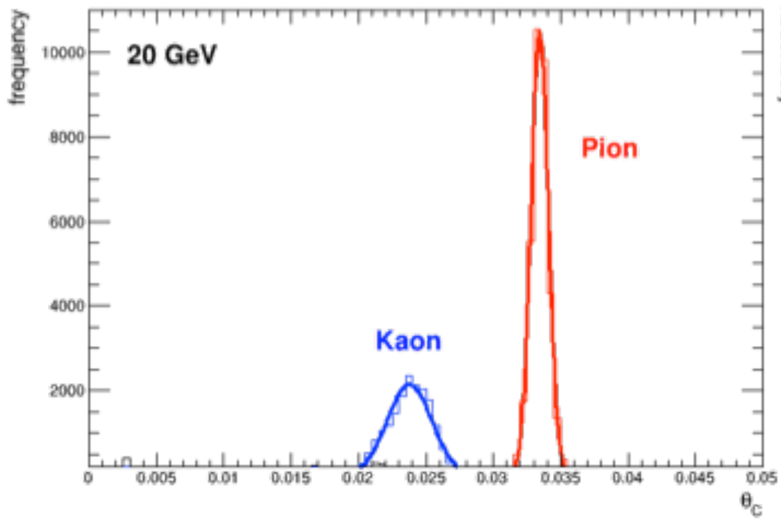
$$\frac{dN_\gamma}{dL} \propto sin^2\theta_c \propto R^2$$

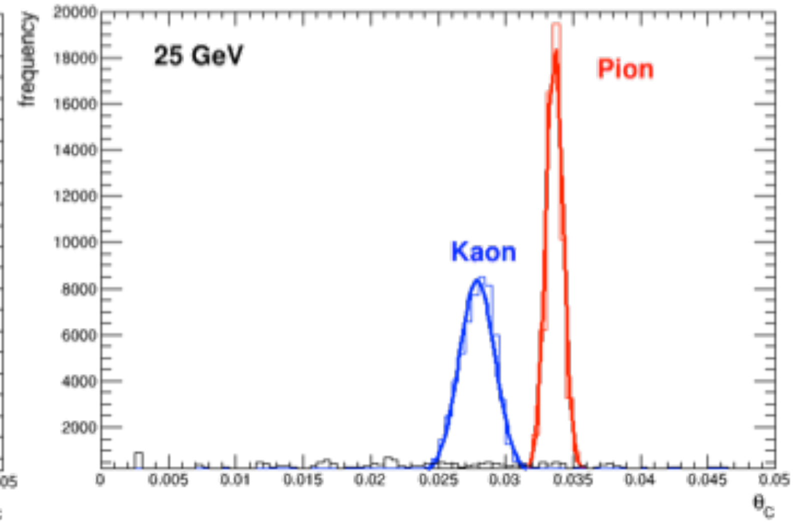




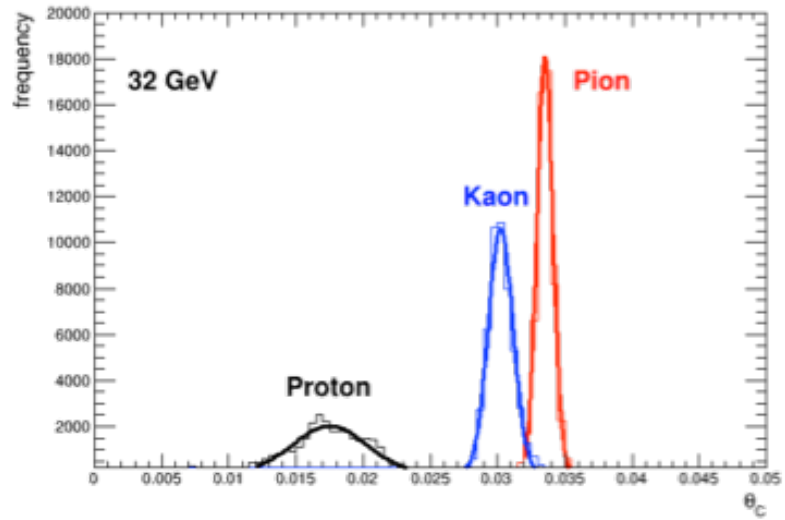
A yield of 12 photons per ring for the pion sample can be concluded from these data.

Complete Set of Radii Results:



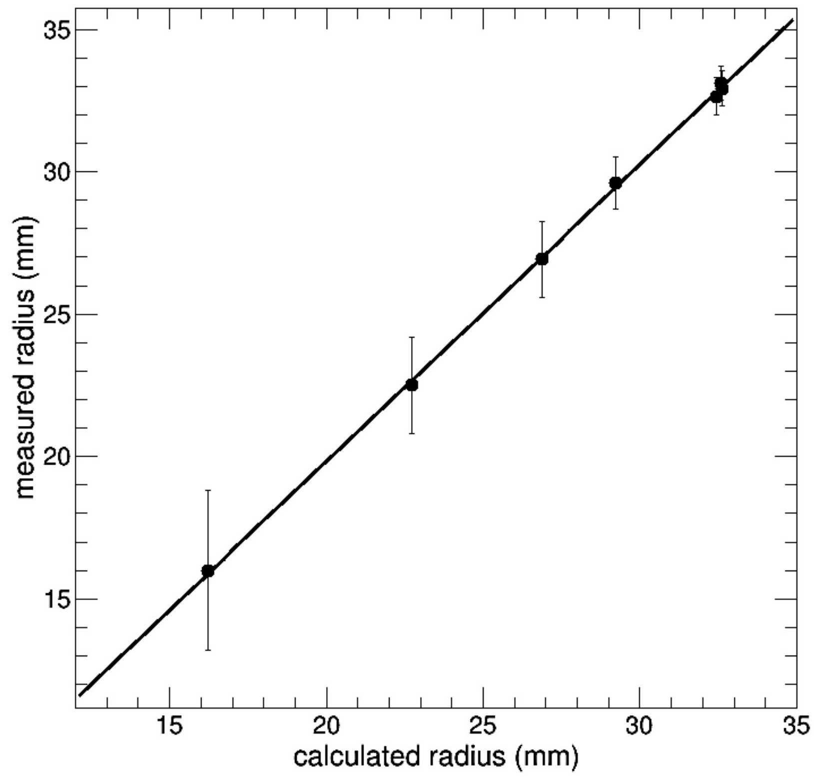


- Reasonable results at all measured energies.
- NOTE: 32 GeV is the highest available energy for Kaons at FTBF.

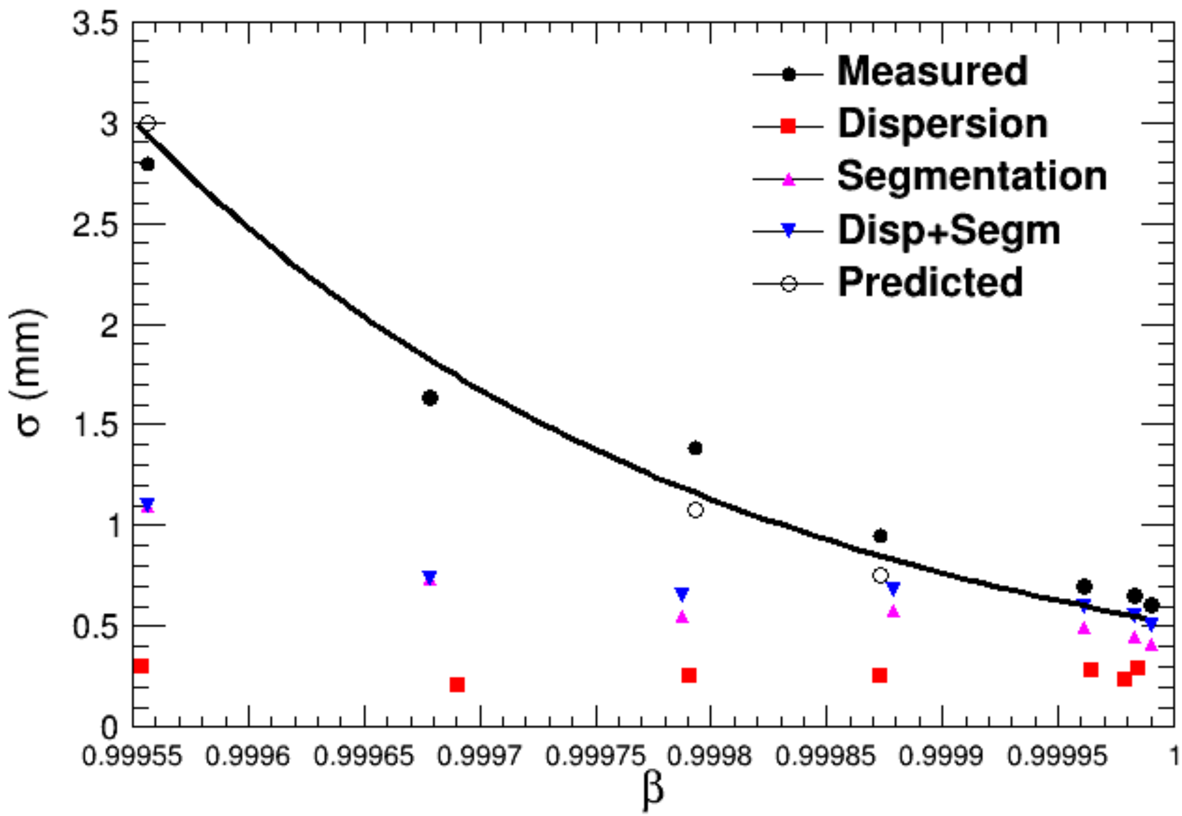


Scaling of Radius with expectation

- All data is used with equal weights.
- Index of Refraction is free parameter.
- Fitted result: n = 1.000558 (as expected!).



Understanding the ring widths:

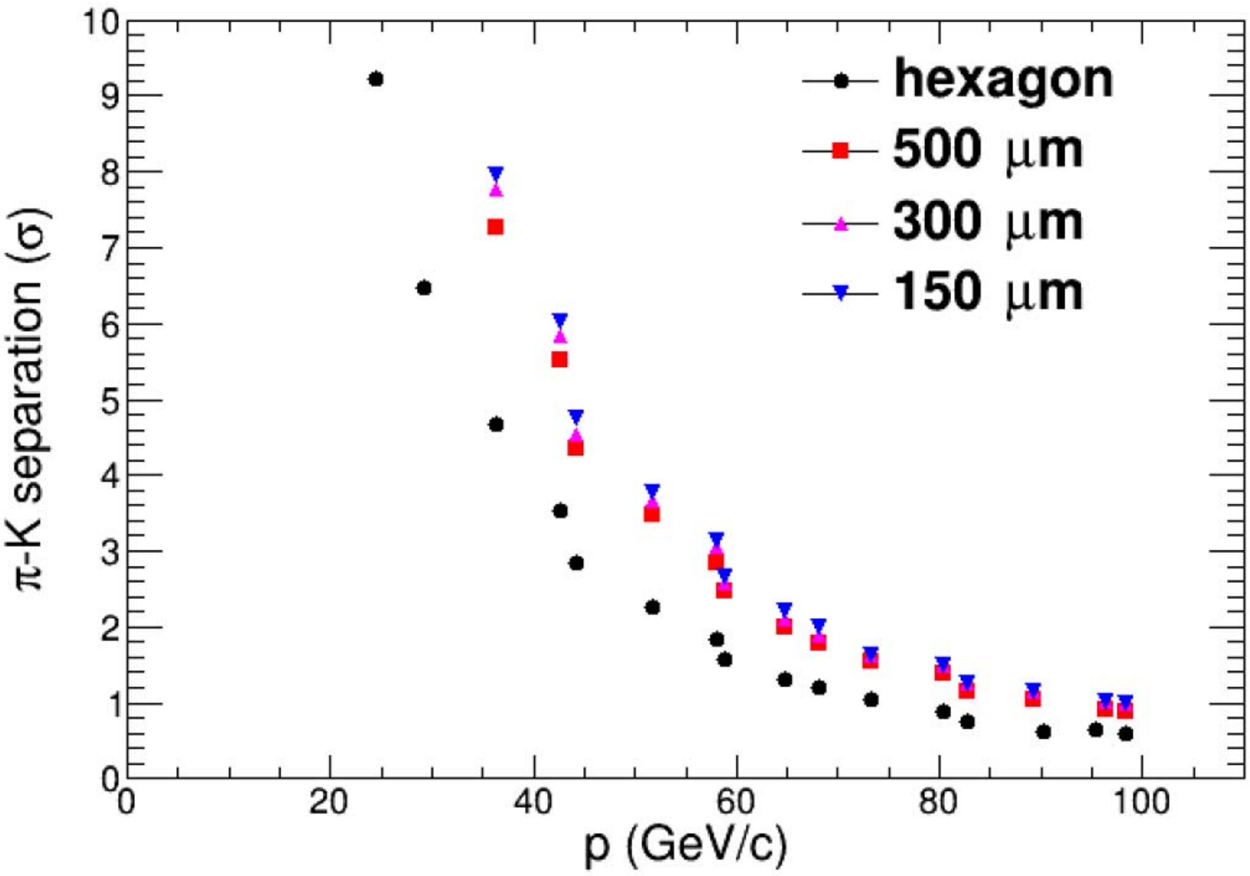


For:

Δp/p = 5.1%

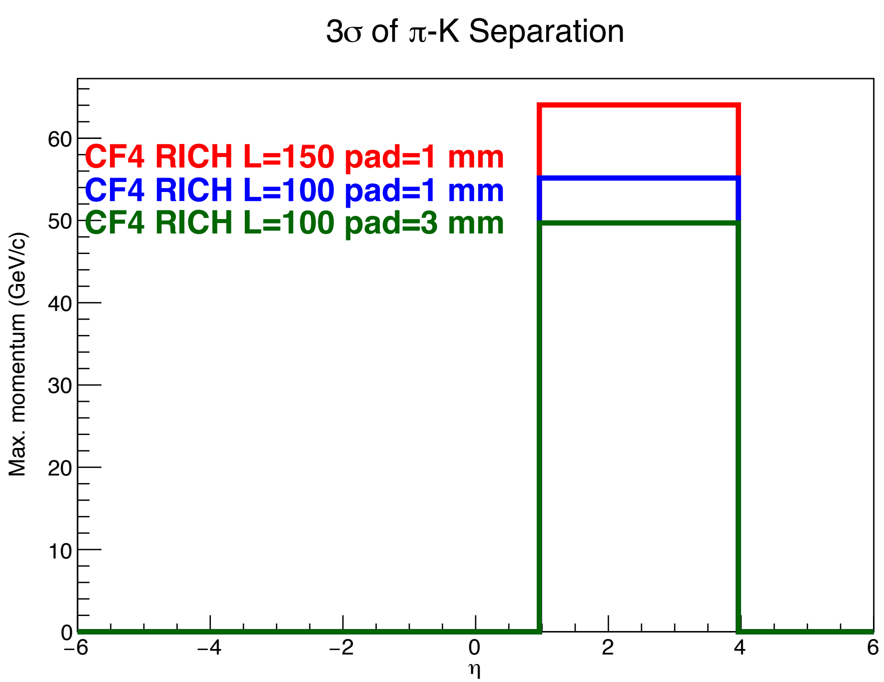
Constant = 244 microns

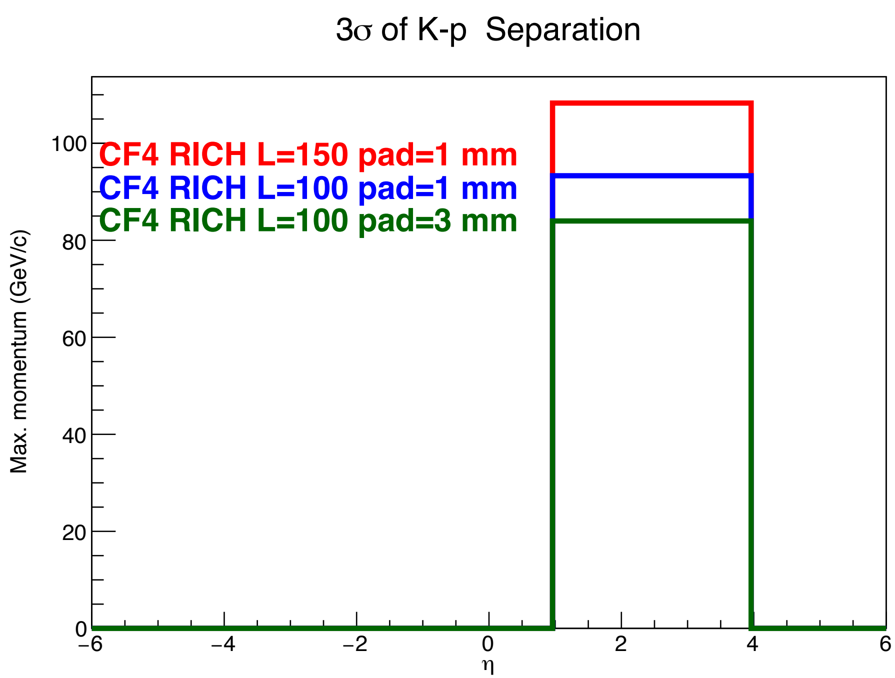
Separation Power



The separation power is increasing when going from hexagons used in this setup to pads with increasing position resolution.

Performance with 1% momentum resolution



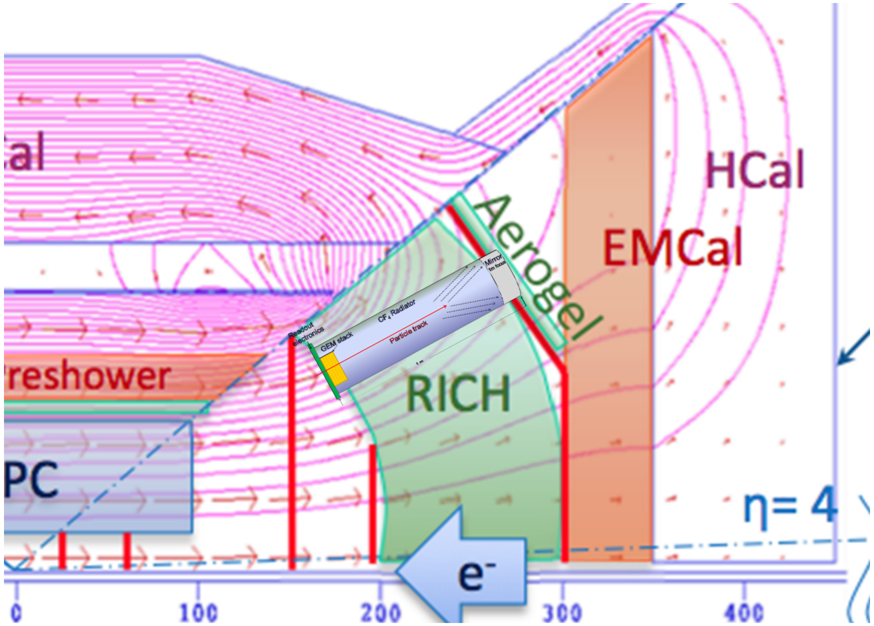


Minimum momentum for 3σ Separation:

We assume that if the lower mass particle radiates, we can distinguish. To define "radiates" we choose about 1/3rd of the maximum yield (95% probability of seeing one or more and 5% for fewer than one)

Pion/Kaon: ~5 GeV/c
Kaon/Proton: ~17 GeV/c

Note: RICH in Magnetic Field:



- Magnetic Field in RICH!
- Field shape to “point at collision Vertex”
- **v×B** ≈0
- Although not true near beam-pipe.

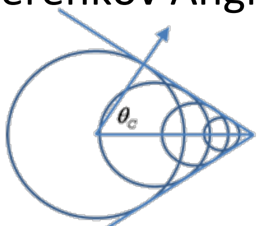
Summary:

- Technology used: **CF4 based Ring Imaging Cherenkov**
- Momentum range covered: **Shown**
- Robustness of the design (e.g. sensitivity to magnetic field) and has a prototype been built? **No sensitivity to magnetic Field, prototype has been built.**
- Are the electronics considerations clear (channel count, data size, rate, background) **Can be optimized according to the needs**
- Time needed to complete the R&D and available workforce: **TBD**
- Status of Simulation and Reconstruction: **TBD**

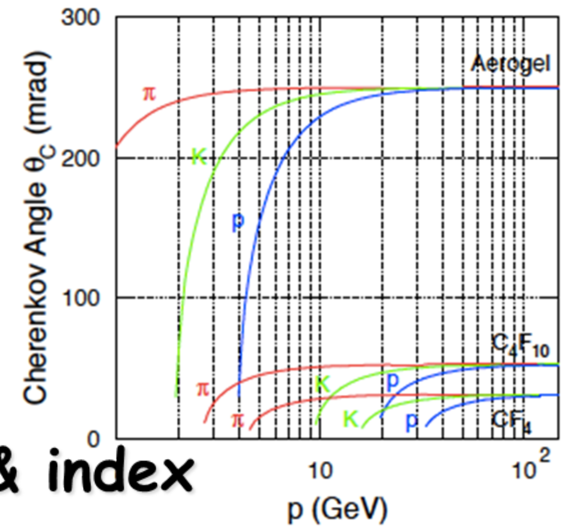
Specs have been implemented in the performance code as asked by PID co-conveners

Backup:

Cherenkov Angle determines β



$$\theta_C = \cos^{-1}\left(\frac{1}{\beta n}\right)$$



- **Cherenkov Light – "Optical Boom"**
- **Cherenkov angle depends upon velocity & index**
  - **Low n distinguishes particles to high momentum.**
  - **Low n yields less light!**
- **Go where the light is:**
  - $$\frac{dN}{dL} = 2\pi\alpha_{EM}\sin^2\theta_C \int_{\lambda_{MIN}}^{\infty} \varepsilon(\lambda) QE(\lambda) \frac{1}{\lambda^2} d\lambda$$
  - **Deep UV Cherenkov yield is highest…how to get there?**