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CREMLIN PLUS
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FDIRC Simulations

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Detector

- Onion shell: Vertex detector, Drift chamber, RICH/DIRC, Calorimeter, Solenoid
- PID including barrel and endcap part (green)
- Distance to IP: 1,100 mm
- Inner radius: 200 mm
- Outer radius: 800 mm
- Polar angle range: $10^\circ \ldots 40^\circ$
- Momentum range: $0.5 \ldots 1.5\,\mathrm{GeV}/c$
- Separation of $\mu^\pm$ and $\pi^\pm$

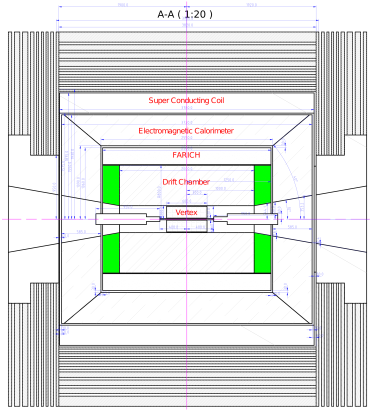


Figure: SCT Detector

Required Resolution

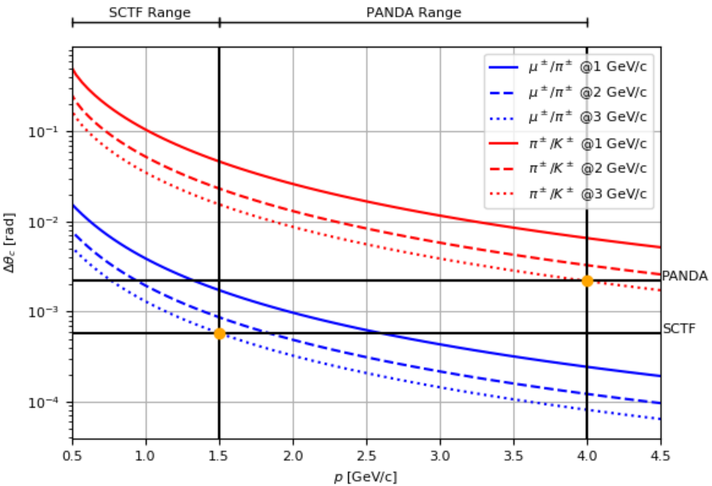


Figure: Required detector resolution

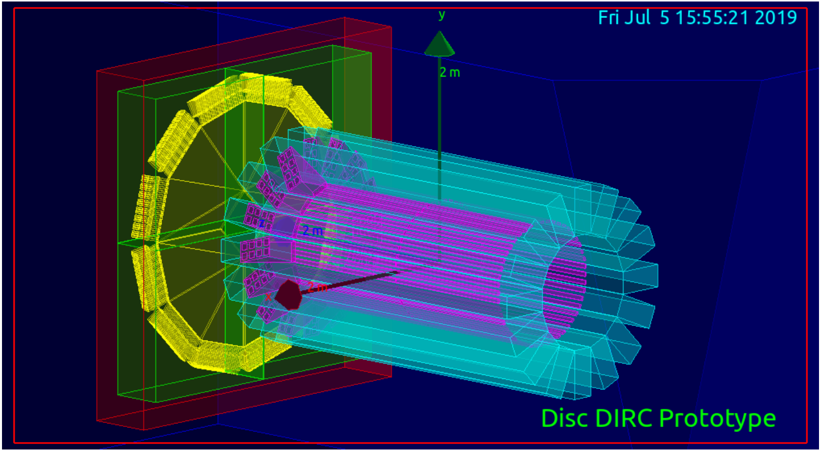


Figure: Original simulations including both FDIRC concepts

Previous Results

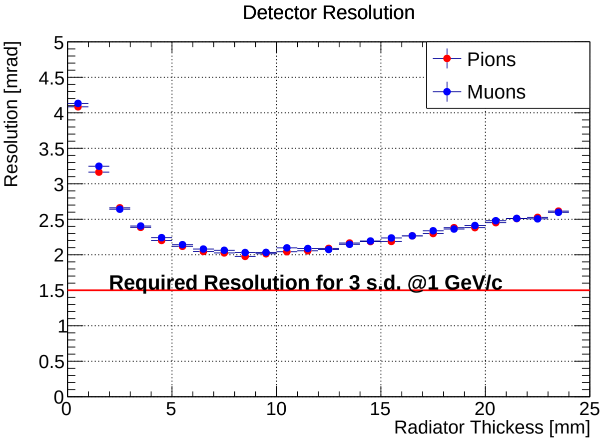


Figure: Results from previous meeting wihtout optimization

$\Rightarrow$ Optimization required!

Resolution Studies

Square sum of all individual errors equals the overall detector resolution:

$$\sigma_{\theta_c}^2 = \frac{\sigma_{\text{geom}}^2 + \sigma_{\text{sens}}^2 + \sigma_{\text{opt}}^2 + \sigma_{\text{disp}}^2}{N} + \sigma_{\text{track}}^2 + \sigma_{\text{strag}}^2 \qquad (1)$$

- σ_{geom}: Error resulting from width of FELs
- σ_{sens}: Error from finite pixel width
- σ_{opt}: Optical errors from mirror
- σ_{disp}: Error from chromatic dispersion
- σ_{track}: Tracking resolution of charged particle
- σ_{strag}: Angle straggling of charged particle in radiator

Time of Propagation

- Distance between intersection and FEL:

$$s_0 = R - d \tan\theta_p \qquad (2)$$

- Optical photon path:

$$s = \frac{s_0}{\cos\varphi} \qquad (3)$$

with $\varphi = \pi/2 - (\theta_p + \theta_c)$

- Required TOP Resolution:

$$t = \frac{1}{n}\left|\frac{s_{\mu,\pi}}{v} - \frac{s_{\pi,K}}{v}\right| \qquad (4)$$

- Not feasible!

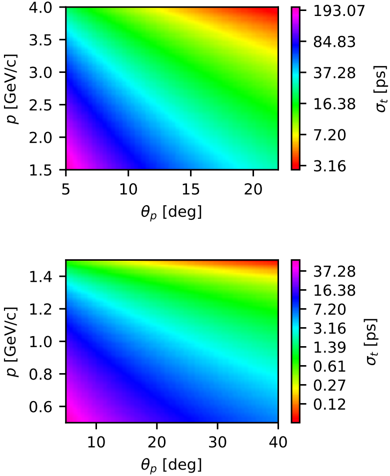
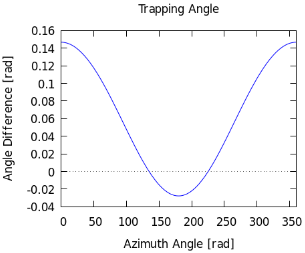
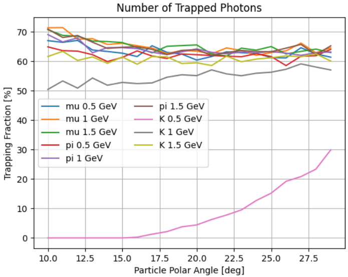


Figure: PANDA and SCTF

Photon trapping as a function of the polar angle, momentum, and particle species:





Analytical calculation possible
Maximum trapping fraction: 70%
Minimum trapping fraction: 60%

Photon Losses

Possibilities of photon losses:

- Trapped photons $\varepsilon_{\text{trap}}$ (ca. 70%)
- Sensor losses ε_{pde} (ca. 90%)
- Optical losses ε_{opt} (ca. 10%)
- Ineffective area between bars $\varepsilon_{\text{geom}}$ (ca. 20%)
- Propagation losses such as diffraction, scattering, and absorption $\varepsilon_{\text{prop}}$ (ca. 5%)

Photon loss studies:

- Created photons: $N_{\text{tot}} \approx 1000$ per event
- Remaining photons:

$$\Rightarrow Ns \approx 20 \ldots 60 \tag{5}$$

Angle Straggling

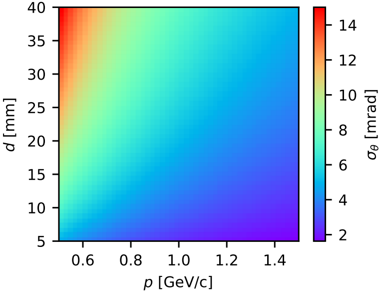


Figure: Angle straggling without and with additional tracking behind detector.

$\Rightarrow$ Additional tracking behind DIRC detectors required!

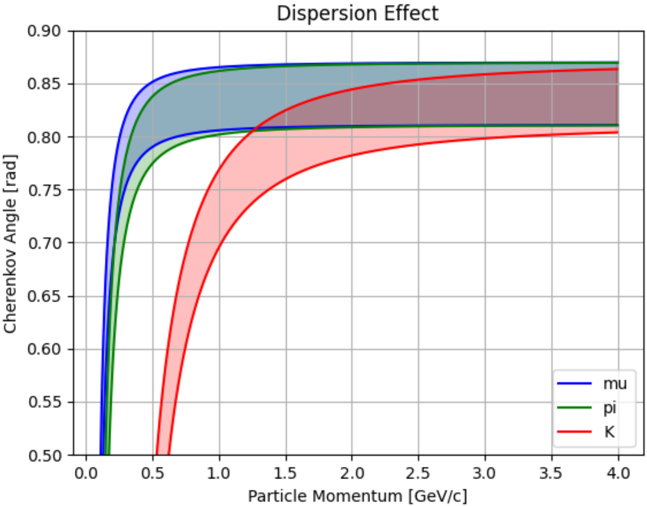


Figure: Cherenkov angle ($200 \leq \lambda \leq 900\,\mathrm{nm}$)

Detector Resolution (Dispersion)

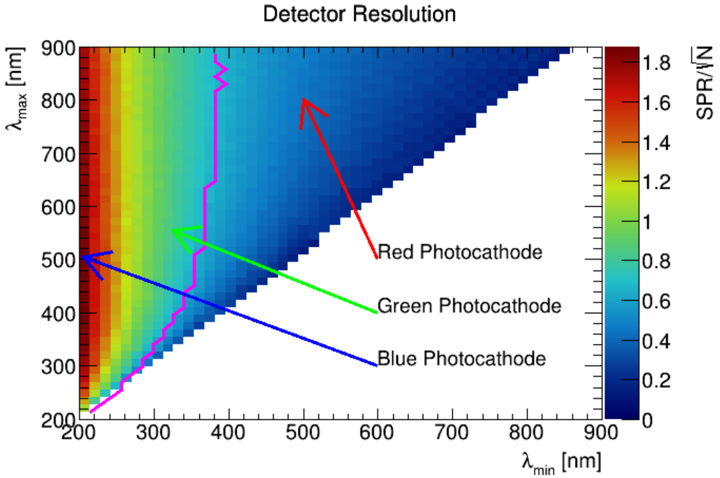


Figure: Detector Resolution for fused silica and pions.

Dispersion Correction

- Tilting upper face of prism for additional refraction
- Possible prototype in talk by Avetik

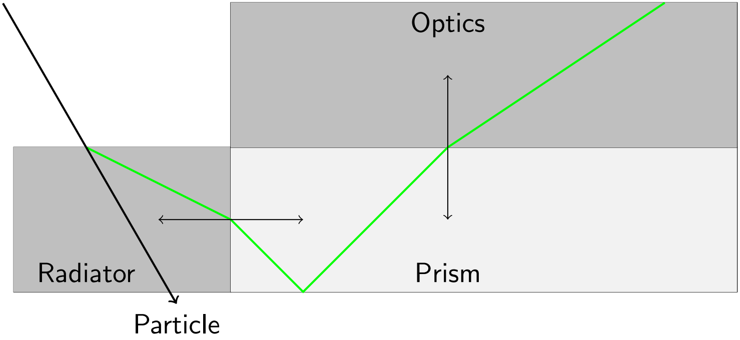


Figure: Prism for dispersion correction

Dispersion Correction

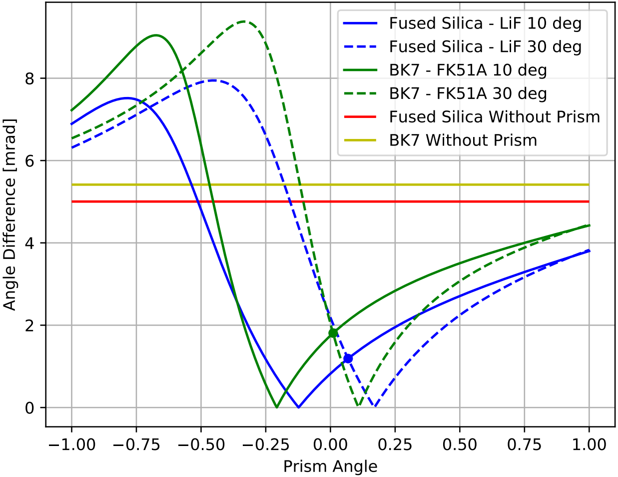


Figure: Photon angles as a function of the prism angle.

Single Photon Resolution (Angle Scan)

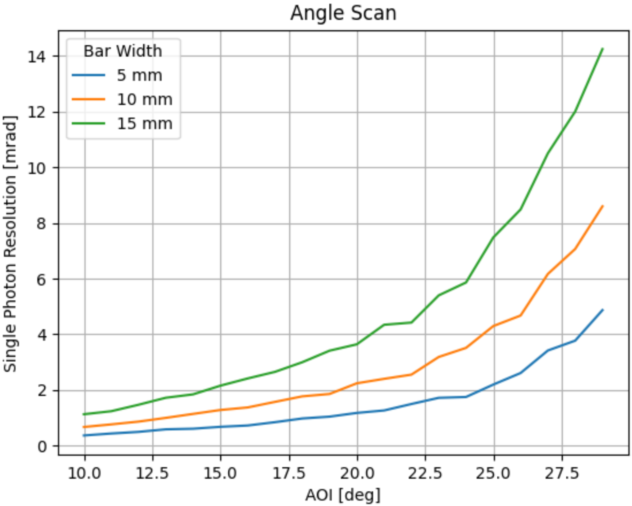


Figure: Single photon resolution as a function of the particle polar angle

Detector Resolution (Bar Width)

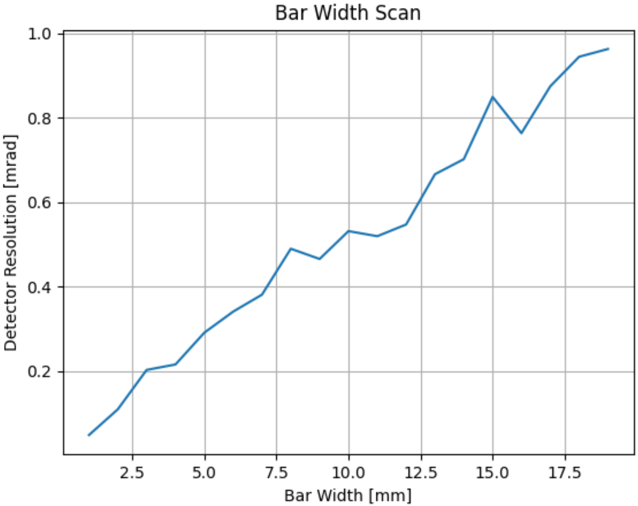


Figure: Detector Resolution resolution as a function of the bar width

Sensor Width

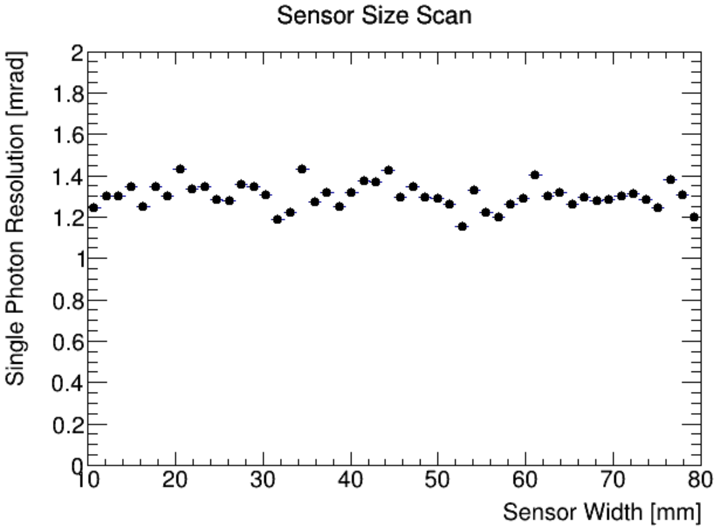


Figure: Sensor width scan with adapting mirror radius

Pixel Scan

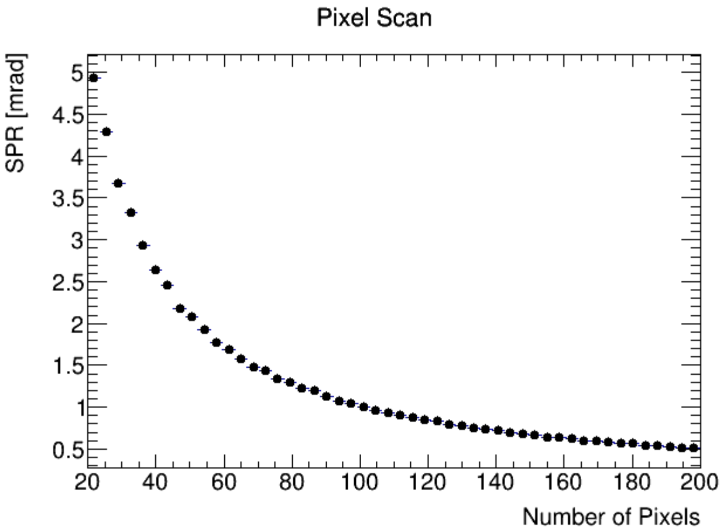


Figure: Pixel scan

Conclusion & Outlook

- Small resolution of $\leq 1\,\mathrm{mrad}$ challenging but not impossible
- Dispersion: major influence on resolution $\Rightarrow$ correction or optimization in sensor required
- Systematic error dominated by angle straggling: additional tracking with high resolution behind DIRC compulsory
- Optical resolutions in right order of magnitude
- Next step: Inserting all results in Geant4 top optimizing parameters simoultanously