Status Report of Disc DIRC Software

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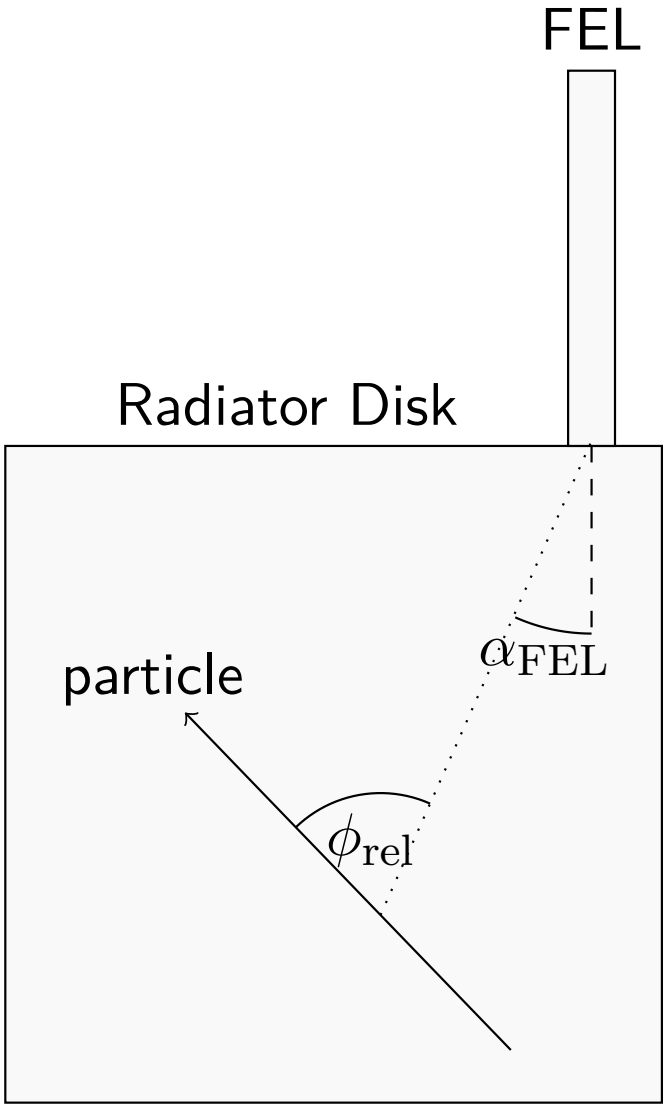
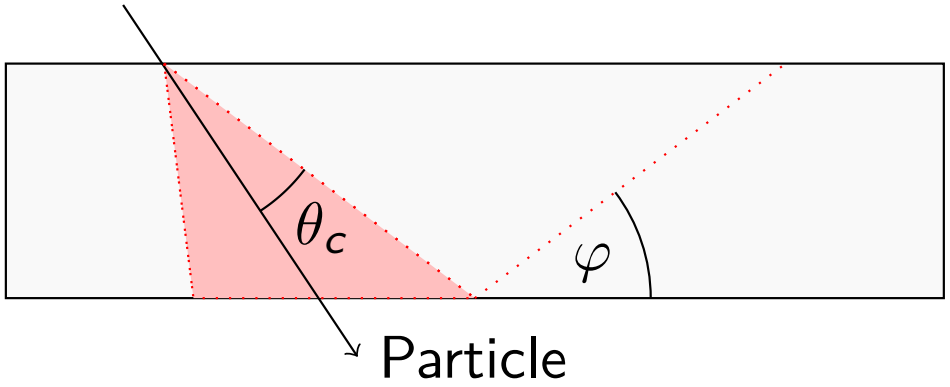
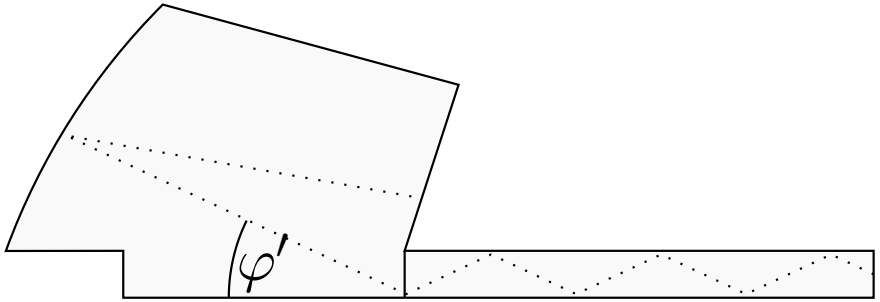
Theoretical Model

Angle Definitions:





$$\tan\varphi' = \frac{\tan\varphi}{\tan\alpha_{FEL}}$$



Theoretical Model

Calculation of the Cherenkov angle:

$$\theta_c = \arccos(\sin\theta_p \cos\phi_{rel} \cos\varphi + \cos\theta_p \sin\varphi) \tag{1}$$

- θ_p: θ angle of particle
- ϕ_{rel}: angular difference between ϕ angle of particle and photon
- φ: Angle between total reflected photon and radiator disk surface

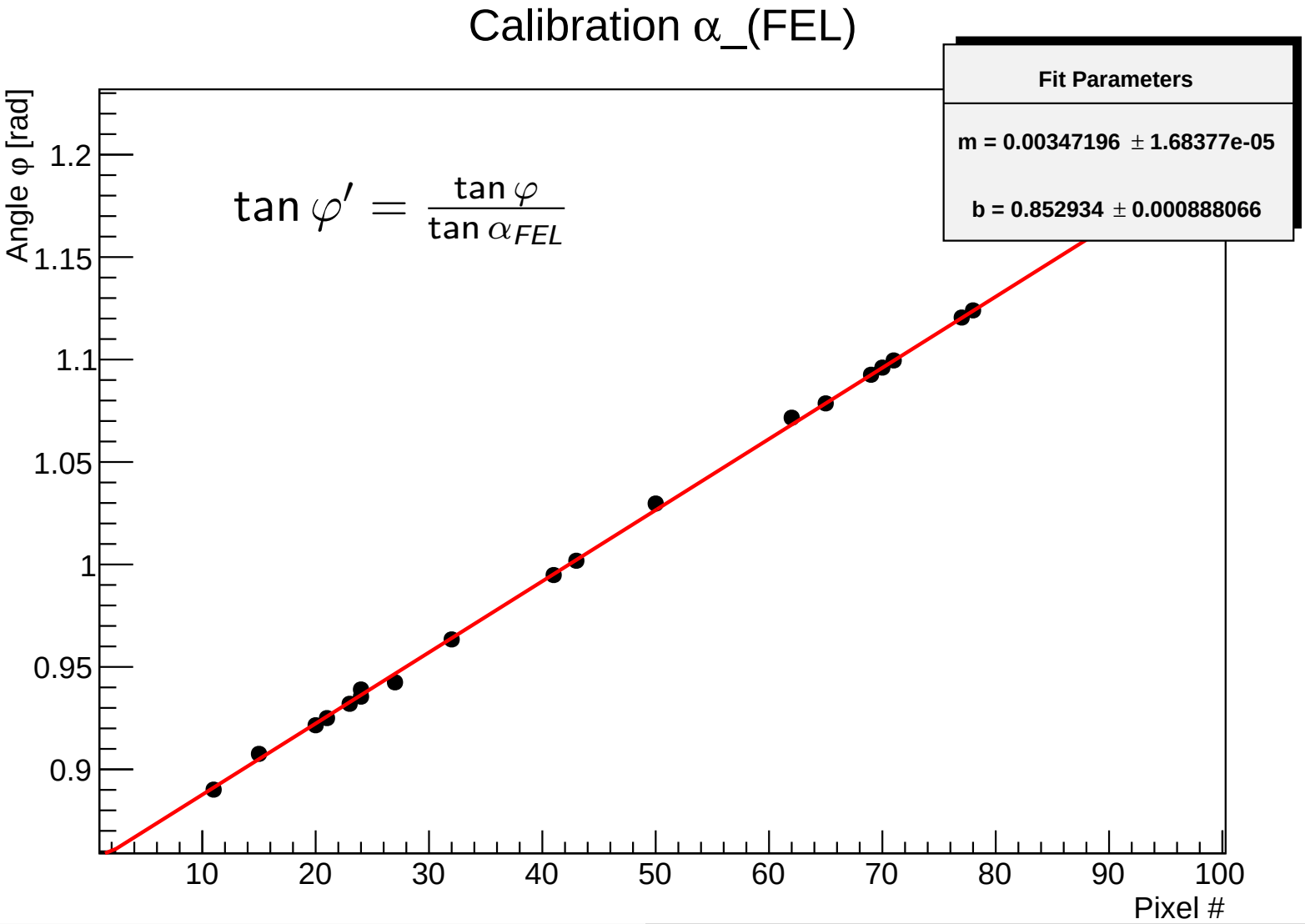
Calculation of φ if θ_c is known:

$$\cos\varphi = \frac{A\cos\theta_c}{B} \pm \sqrt{\frac{\cos^2\theta_p - \cos^2\theta_c}{B} + \left(\frac{A\cos\theta_c}{B}\right)} \tag{2}$$

with $A = \sin\theta_p \cos\phi_{\mathrm{rel}}$ and $B = A^2 + \cos^2\theta_p$

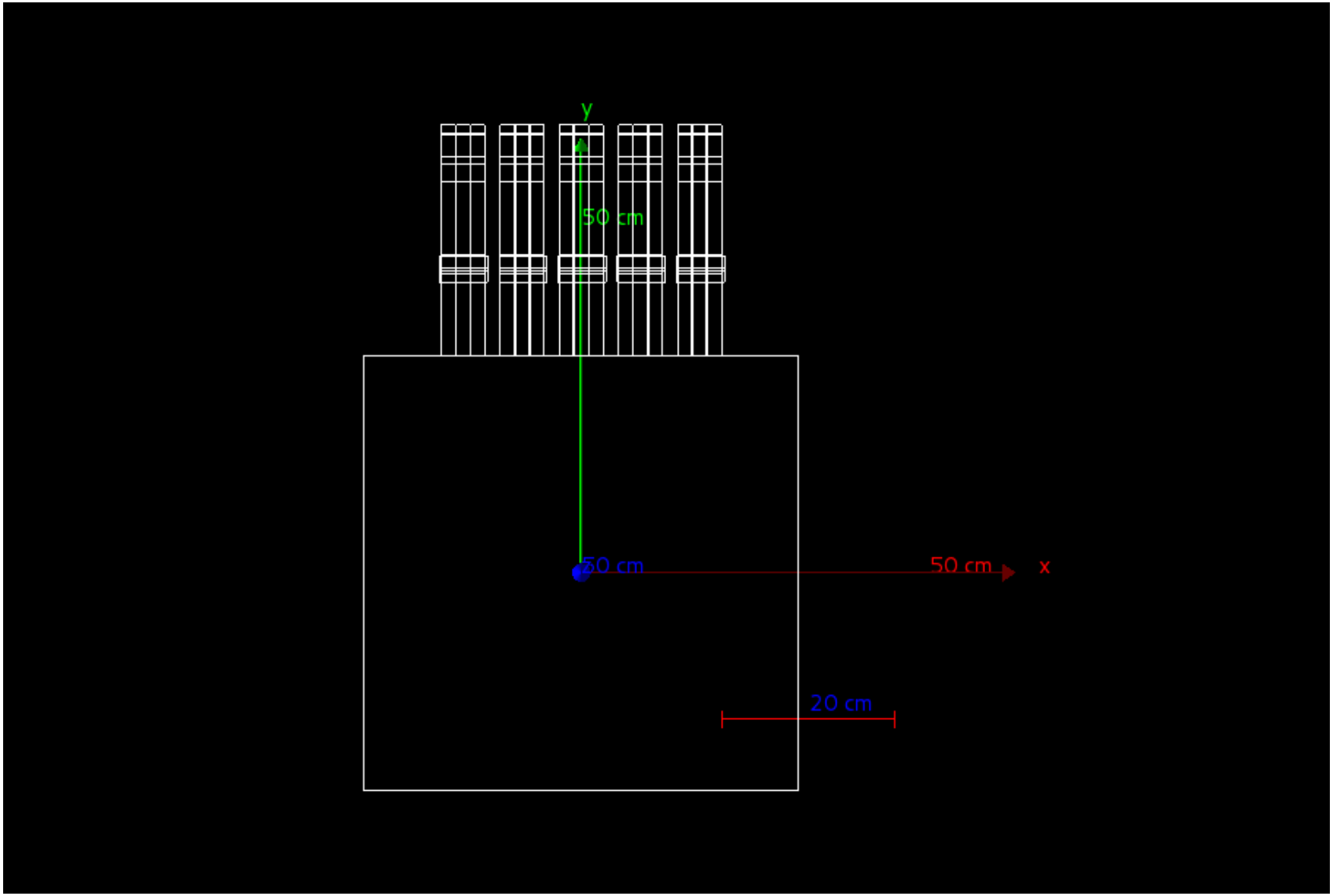
Calibration

Correlation between pixel number and angle φ:



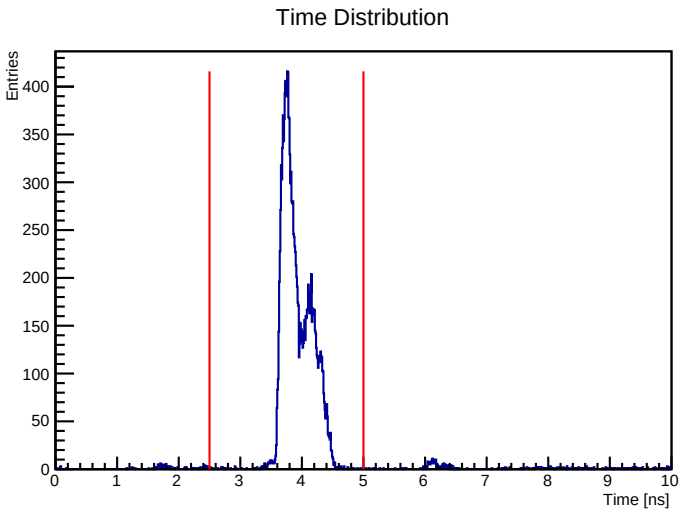
Disc DIRC Prototype

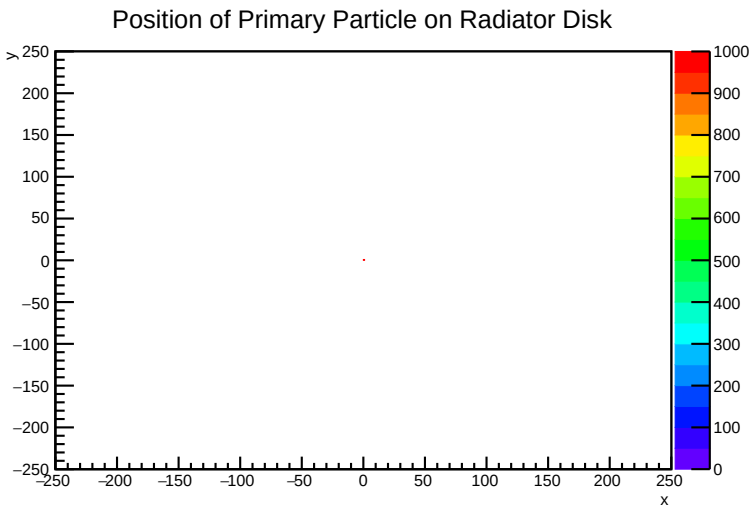
Tested with geometry of Disc DIRC prototype with 15 FELs

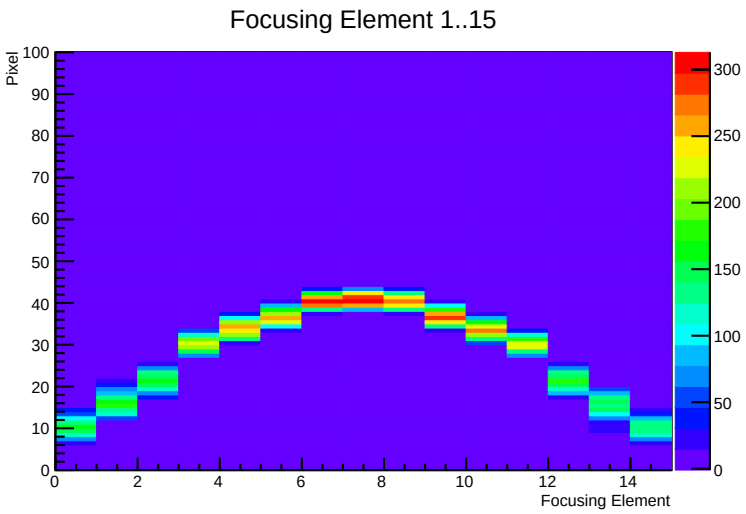


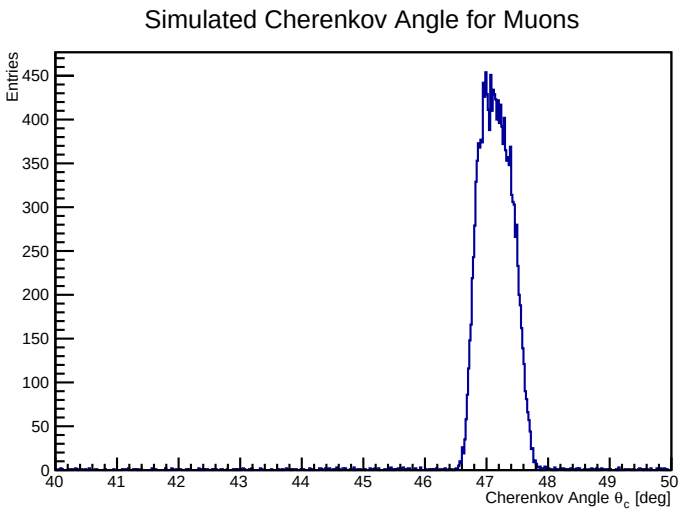
Simulation Results for Prototype

Beam momentum: $p = 4\,\mathrm{GeV/c}$, particles: π^+
$x = y = 0\,\mathrm{mm}$, $\theta = 10°$, $\phi = 0°$, $n = 1000$ events









Simulations with Testbeam Parameters

- Composition of particle beam at 2 GeV:
  - 55 % pions
  - 40 % protons
  - 5 % kaons
- Beam diameter: approx. 2 cm (nearly gaussian distributed with flat plateau)
- Different positions and angles possible

Reconstruction Algorithm

Input parameters:

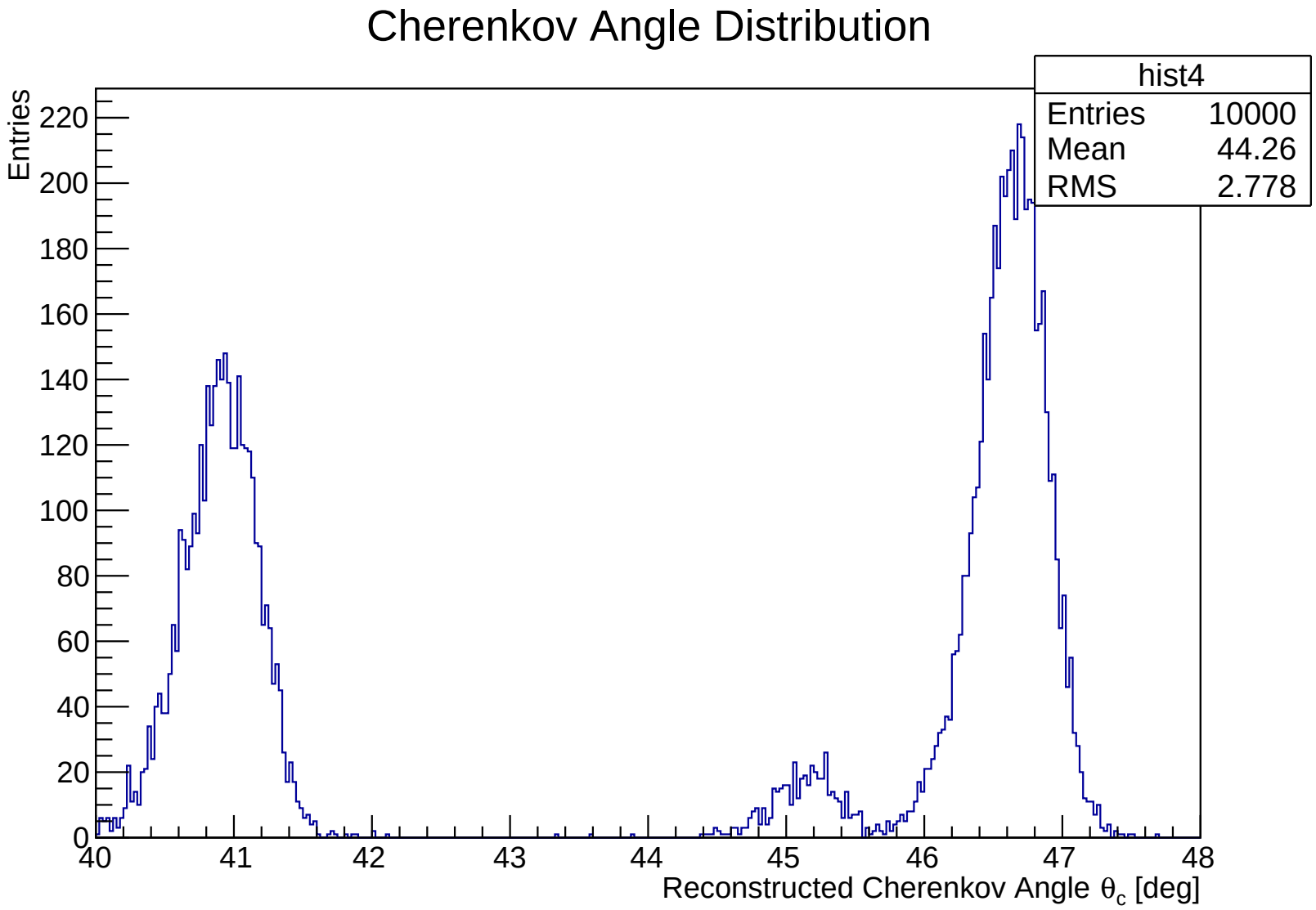
- Particle position on radiator disk: (x_0, y_0)
- Angles of particle trajectory (θ, ϕ)

Reconstruction steps:

1. Only accepting photons inside specific shutterwindow $t_1 < t < t_2$
2. (Wavelength cut for bandpass filter optional)
3. Calculation of α_{FEL}, ϕ_{rel} and t from the particle position (x_0, y_0)
4. Calculation of φ' from the pixel position z_p
5. Calculation of φ with α_{FEL}
6. Calculation of the cherenkov angle θ_c
7. Only accepting events with hits in at least 5 FELs

Reconstruction of Cherenkov Angles

Beam momentum: $p = 2\,\mathrm{GeV}/c$



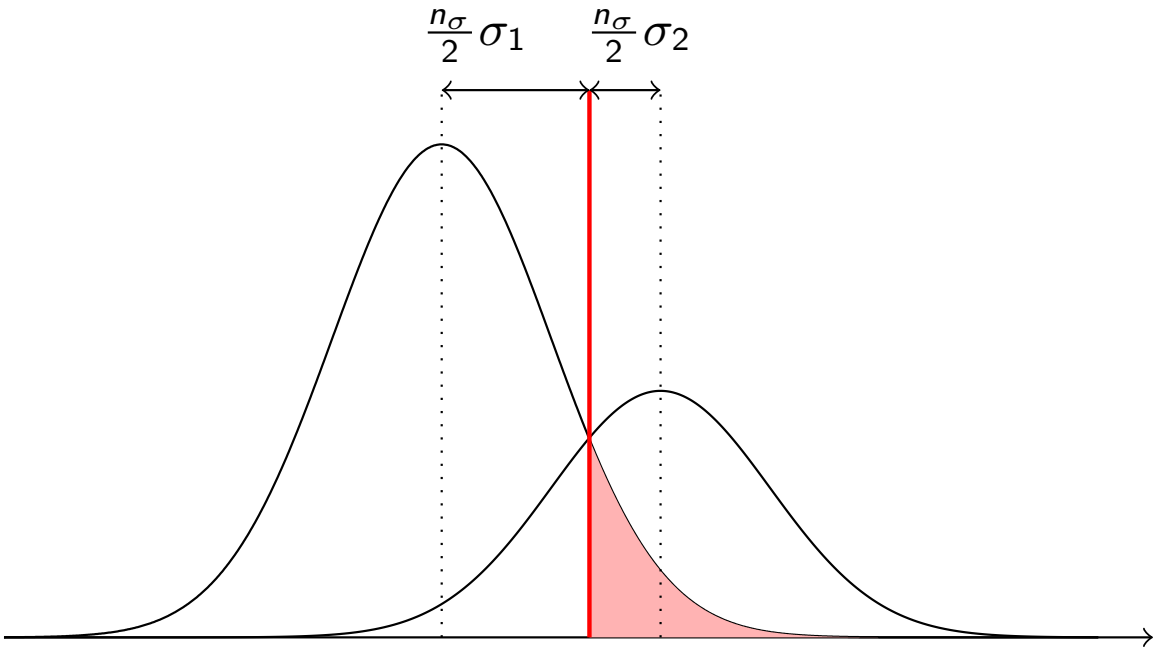
Seperation Power

Calculation of seperation power for $p = 3\,\mathrm{GeV/c}$:

$$n_\sigma = \frac{\bar{\theta}_{c,\pi} - \bar{\theta}_{c,k}}{\frac{1}{2}(\sigma_{\bar{\theta}_{c,\pi}} + \sigma_{\bar{\theta}_{c,k}})} = 2.9$$

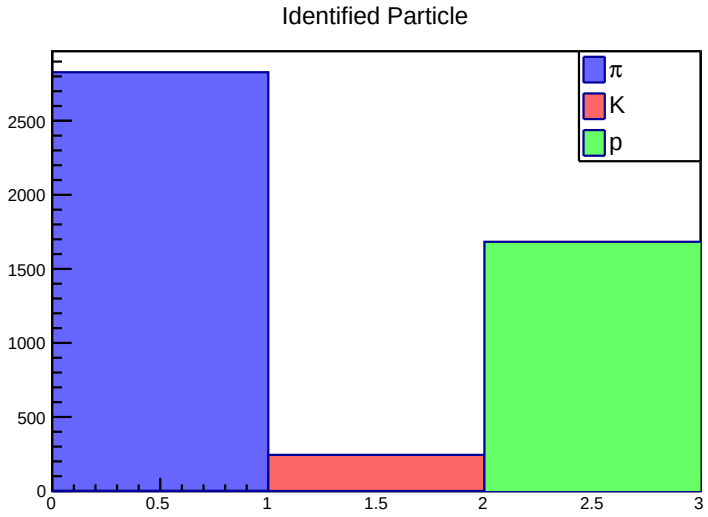
Probability for misidentification:

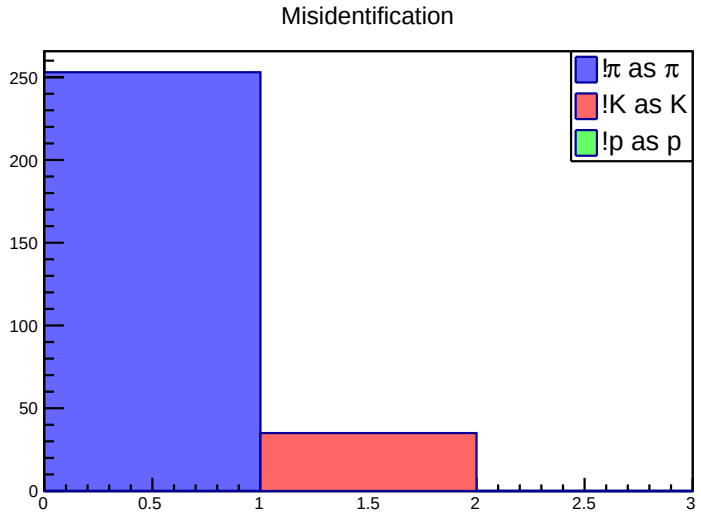
$$P_{\mathrm{misid}}(n_\sigma) = \frac{1}{2}\left[1 - \mathrm{erf}\left(\frac{n_\sigma}{2 \cdot \sqrt{2}}\right)\right] = 7.1\,\%$$

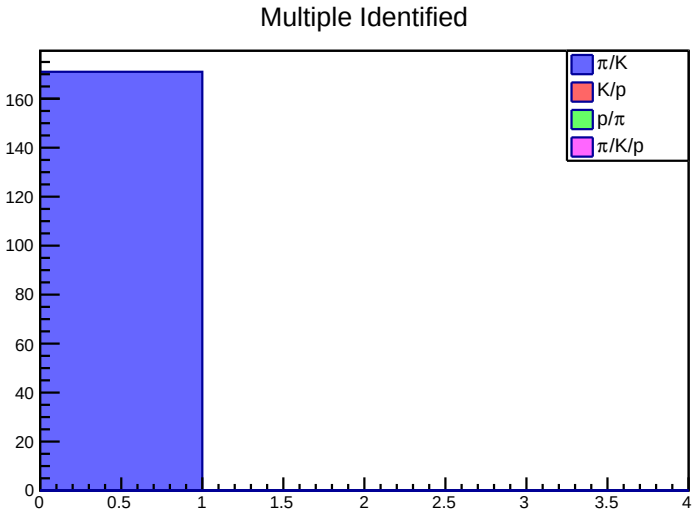


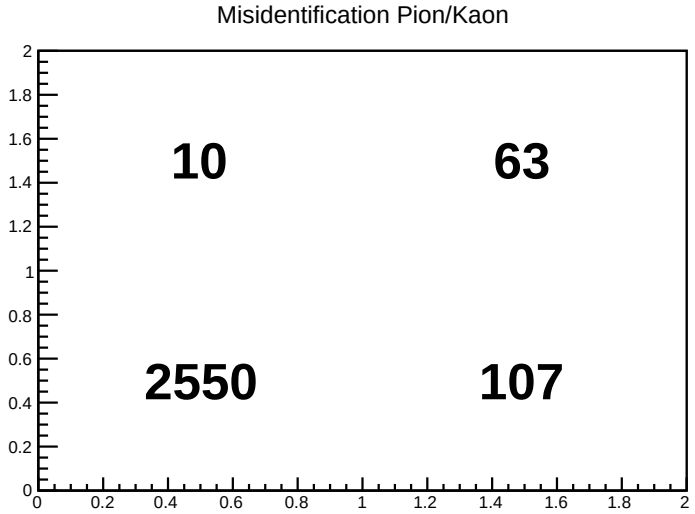
Particle Identification

Beam momentum: $p = 3\,\mathrm{GeV/c}$









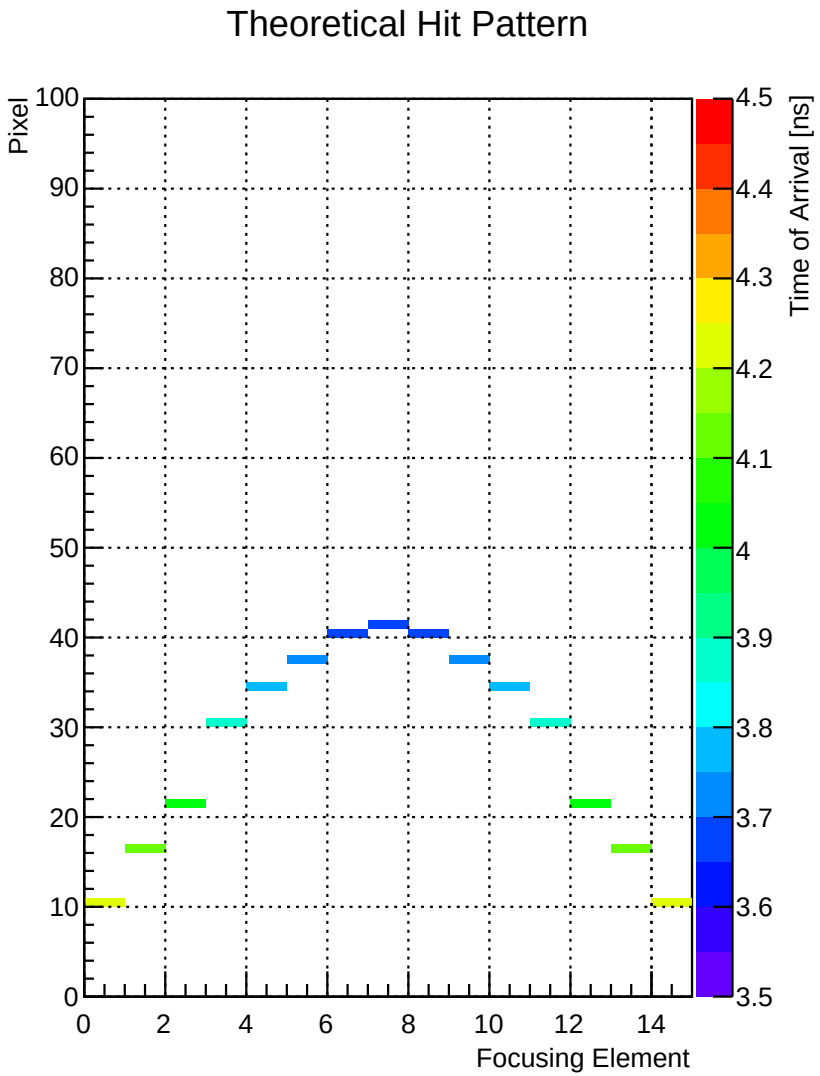
Improved PID

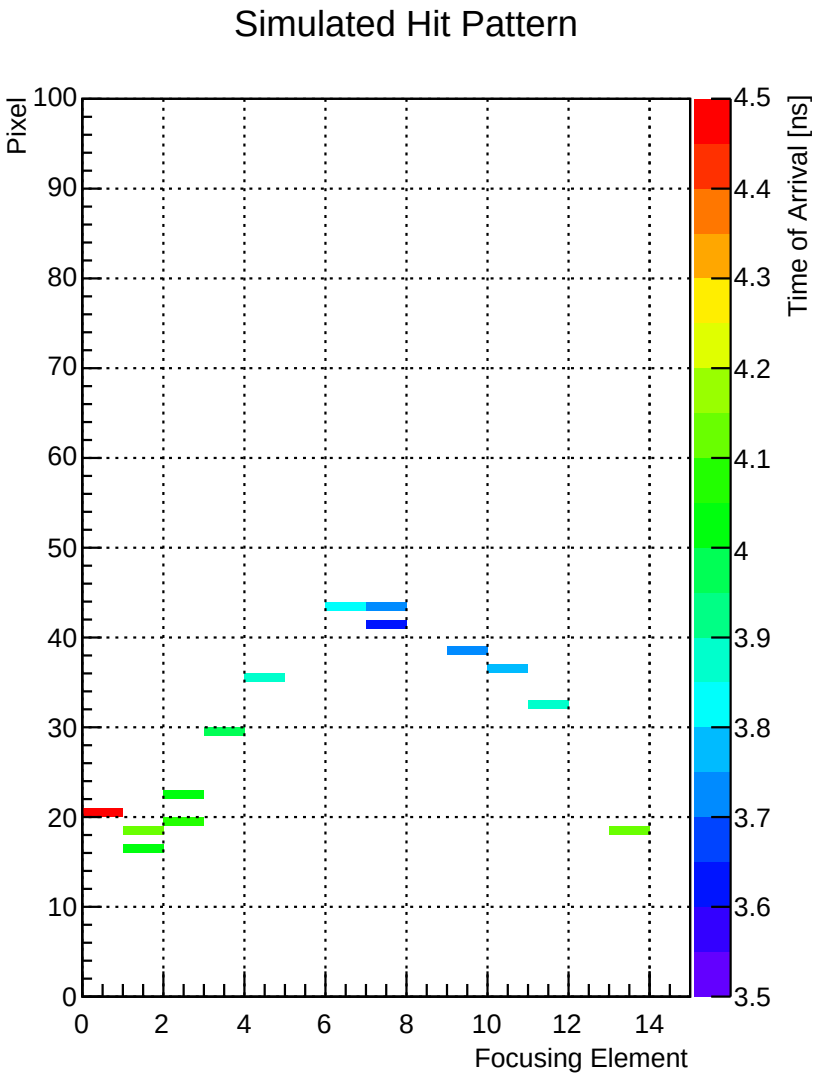
Pseudo Likelihood Function:

- Creating hypothesis for particle mass m_h for π, p and K
- Predicting average photon wavelength
- Calculation of predicted hit pattern for given hypothesis
- Computing reference time for getting rid of outliners
- Matching the hit patterns
- Quantifiying pattern matching with combined likelihood function

Hit Pattern Prediction

Particle: π^+, beam momentum: $p = 4\,\text{GeV}$





Summary & Outlook

- Reconstruction and PID working with “old“ PandaRoot version
- Algorithms tested with planed prototype
- Next step: inserting code into trunk version and uploading into PandaRoot repository