JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Updates in Tracking Algorithm and Glueball Analysis

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PANDA Collaboration Meeting LX.
Computing Session

HIC for FAIR
Helmholtz International Center

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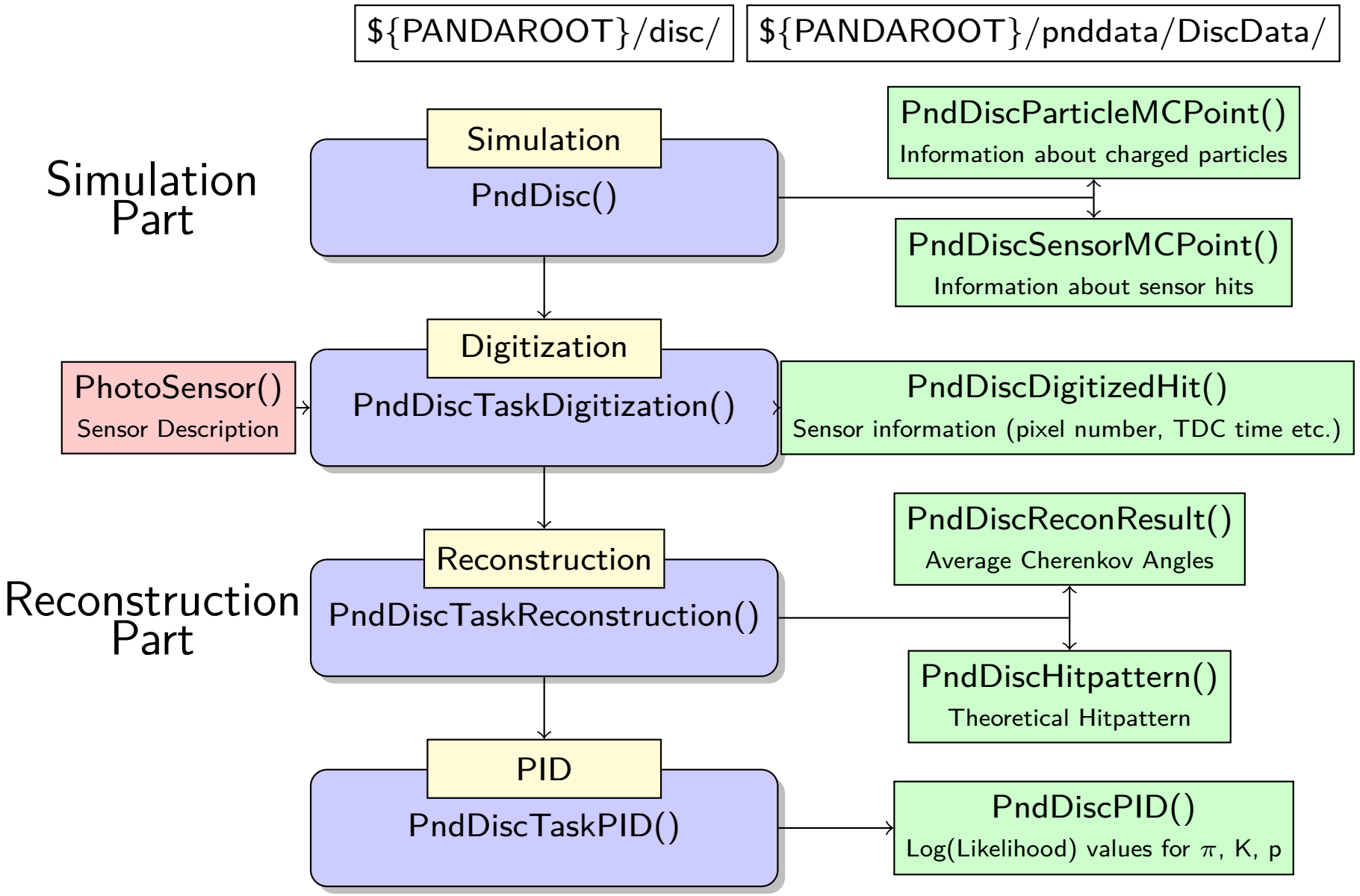
Helmholtz Graduate School for Hadron and Ion Research

Event Based Simulations



Changes in Track Reconstruction

- Possibility to use Monte-Carlo tracks or reconstructed tracks with GenFit:

  PndDiscTaskReconstruction :: *UseTrueTracks*(*kTRUE*/*kFALSE*)

- Getting **position** and **momentum** information with:

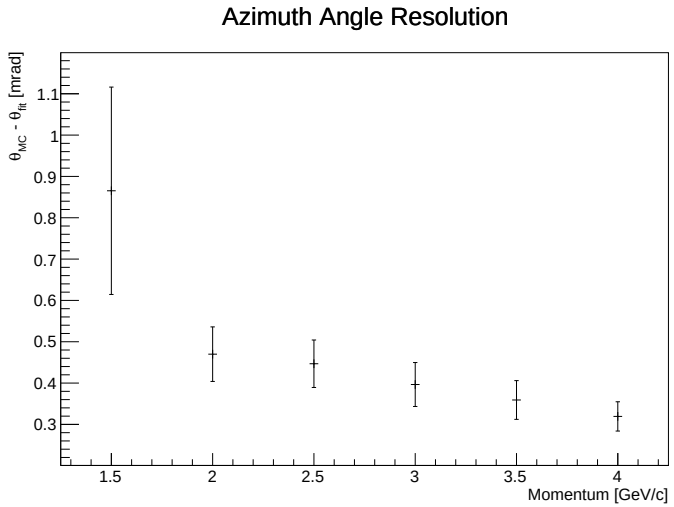
```
TClonesArray *tclarr_track (TClonesArray*)
    io_manager->GetObject("SttMvdGemGenTrack");
PndTrack *track = (PndTrack*)tclarr_track->At(i);
FairTrackParP par = track->GetParamLast();
```

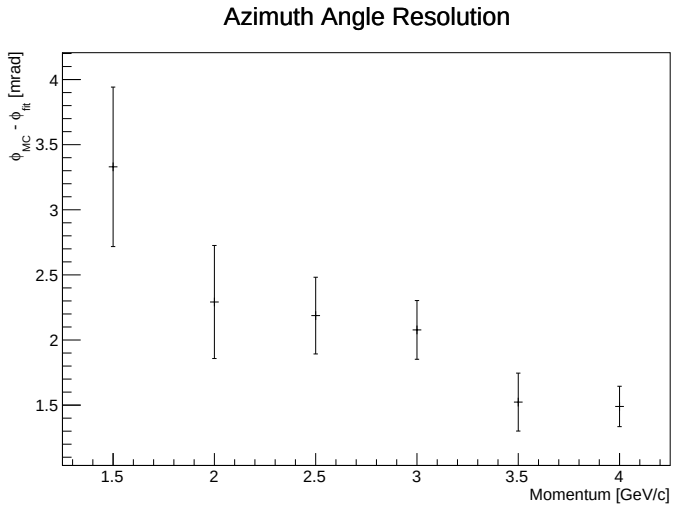
- Calculating position on radiator disk assuming straight line:

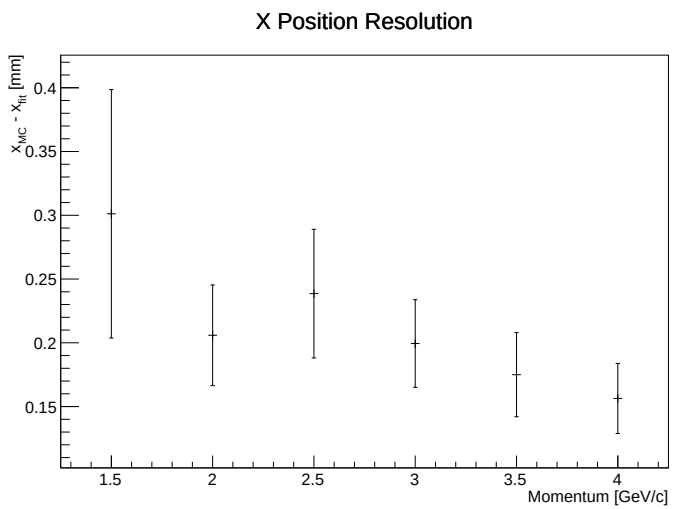
$$\begin{pmatrix} x_{Disc} \\ y_{Disc} \end{pmatrix} = \begin{pmatrix} x_{Last} \\ y_{Last} \end{pmatrix} + \frac{z_{MC} - z_{Last}}{p_z} \cdot \begin{pmatrix} p_x \\ p_y \end{pmatrix}$$

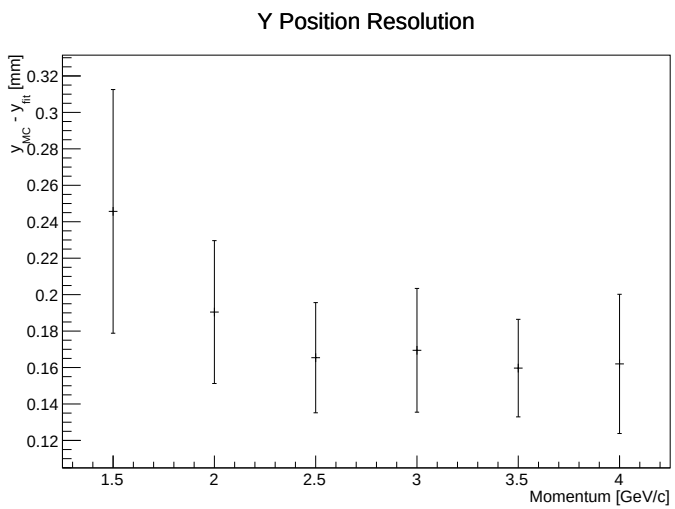
Resolution Studies

Spatial and momentum resolution of Pions as function of momentum p and $\theta = 15°$





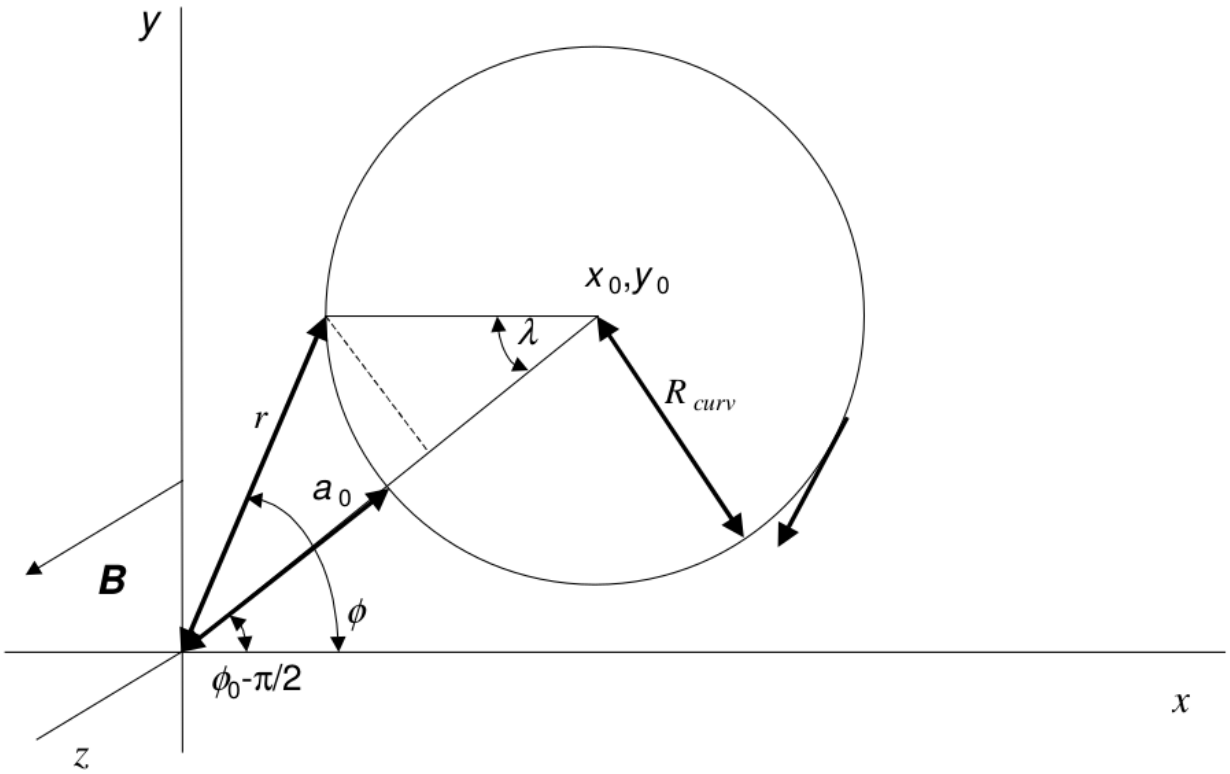




Helix Propagator

Important Helix Parameters:

- Helix center: x_0, y_0, z_0
- Helix radius: $\rho = R_{curv}$
- Impact parameter: a_0
- Helix phase: λ or ϕ



Position Reconstruction

Transverse momentum:

$$p_T = \sqrt{p_x^2 + p_y^2}$$

Calculation of curvature from magnetic field:

$$\rho[m] = \frac{p_T[\mathrm{GeV}]}{0.3B[\mathrm{T}]}$$

Center of helix:

$$x_0 = x + Q\rho\cos(\alpha - \tfrac{1}{2}Q\pi) = x + Q\rho\sin\alpha$$
$$y_0 = y + Q\rho\sin(\alpha - \tfrac{1}{2}Q\pi) = y - Q\rho\cos\alpha$$
$$z_0 = z - 2\rho\cot\theta\arcsin\left(\sqrt{\frac{x^2+y^2-a_0^2}{4\rho^2+4Qa_0\rho}}\right)$$

with

$$\cos\alpha = \frac{p_x}{p_T} \quad \text{and} \quad \sin\alpha = \frac{p_y}{p_T}$$

Position Reconstruction

Transverse impact parameter:

$$a_0 = Q\left(\sqrt{x_0^2 + x_0^2} - \rho\right)$$

Initial phase:

$$\phi_0 = \arctan\left(\frac{y_0}{x_0}\right) + \frac{1}{2}Q\pi$$

Calculation of phase λ:

$$z(\lambda) = z_0 + \rho\lambda\cot\theta \Rightarrow \lambda = \frac{z(\lambda) - z_0}{\rho\lambda\cot\theta}$$

Propagating helix with equations of motion:

$$x'(\lambda) = x_0 + Q\rho\cos(Q\lambda - \phi_0)$$
$$y'(\lambda) = y_0 + Q\rho\sin(Q\lambda - \phi_0)$$

PndHelixPropagator

Cross-check results from internal PandaRoot helix propagator
Implementing class

```
PndHelixPropagator(Double_t fieldStrength,
    TVector3 origin, TVector3 momentum, Double_t charge)
```

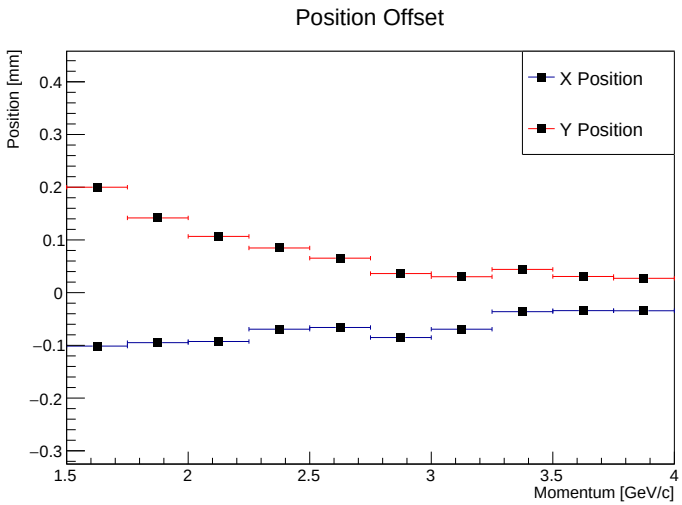
with following parameters

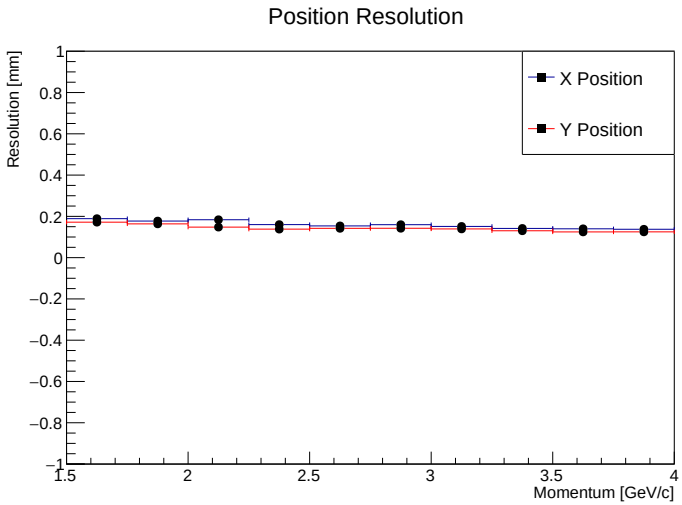
```
TVector3 pos(x, y, z);
TVector3 mom(px, py, pz);

PndHelixPropagator *helix =
   new PndHelixPropagator(B, pos, mom, +1);

FairTrackPar result;

result = helix->PropagateToZ(194.);

result.GetX();
result.GetY();
```

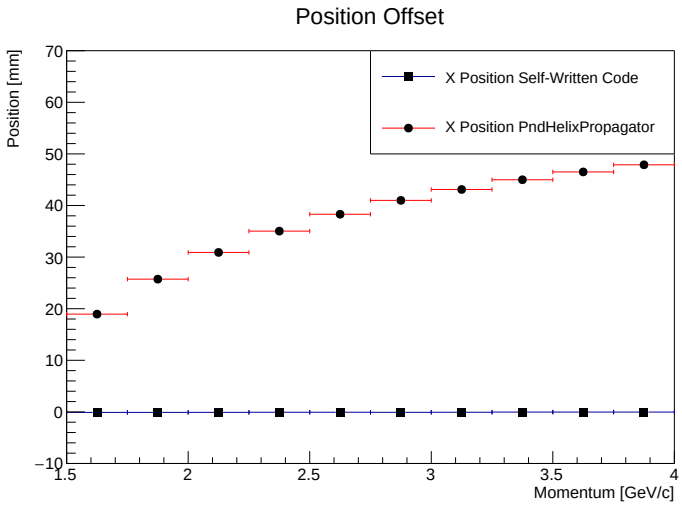
Position and momentum same as for self-written algorithm

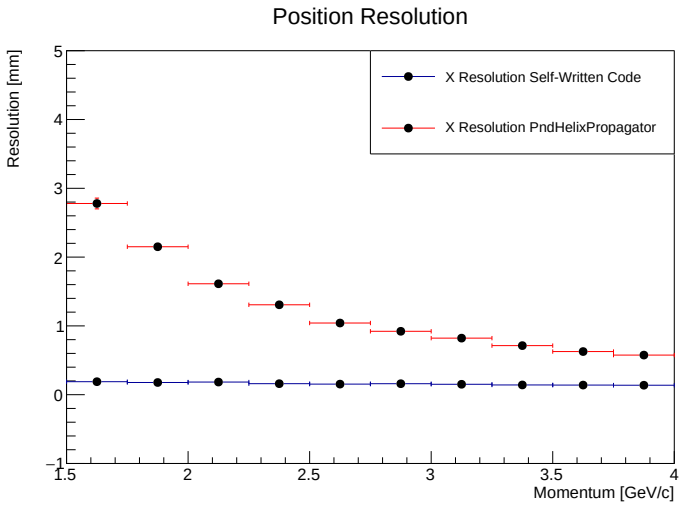
Tracking Resolution

Comparison between self-written code and implemented propagator









EvtGen DEC2010

Decay of $f_0(1500)$ in EvtGen decay file:

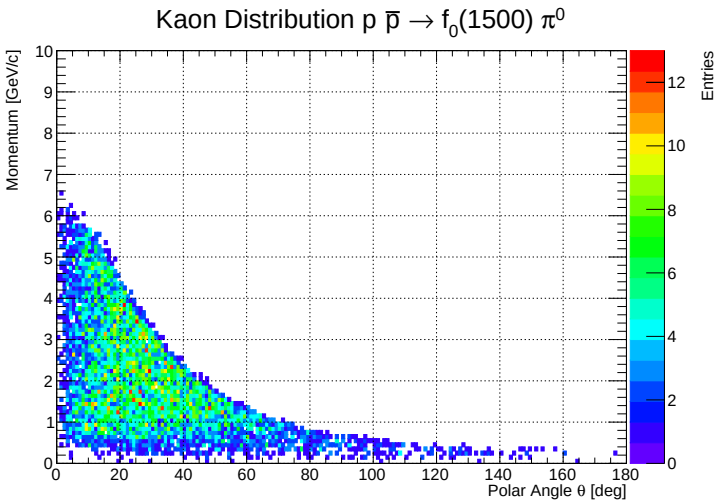
```
Decay f_0(1500)
0.019000000 eta      eta'
0.051000000 eta      eta
0.1410    pi0   pi0   pi0   pi0                    PHSP;
0.3540    pi+   pi-   pi+   pi-                    PHSP;
0.2330    pi+   pi-                               PHSP;
0.1160    pi0   pi0                               PHSP;
0.0430    K+    K-                                PHSP;
0.0215    K_S0  K_S0                              PHSP;
0.0215    K_L0  K_L0                              PHSP;
Enddecay
```

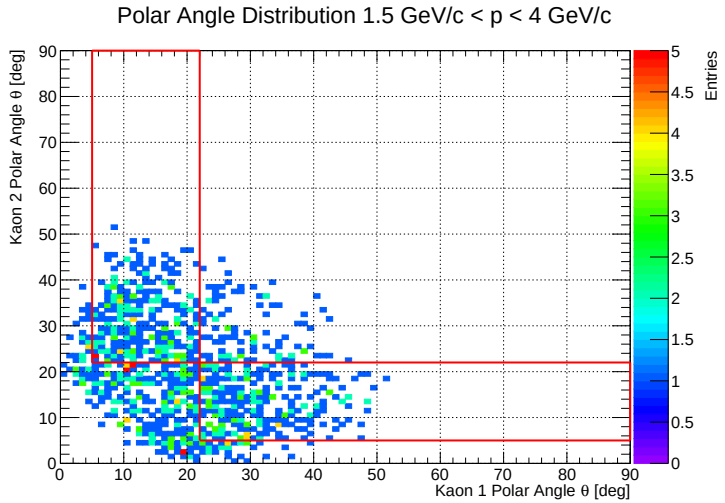
Benchmark Channel: $p\bar{p} \rightarrow f_0\pi^0 \rightarrow \pi^0 K^+ K_-$

Physics Channel Analysis

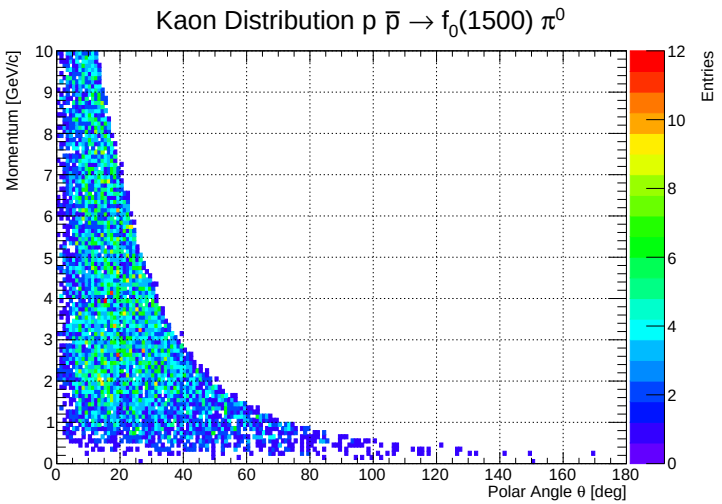
Glueball candidate $f_0(1500)$ decay into K^+K^-:

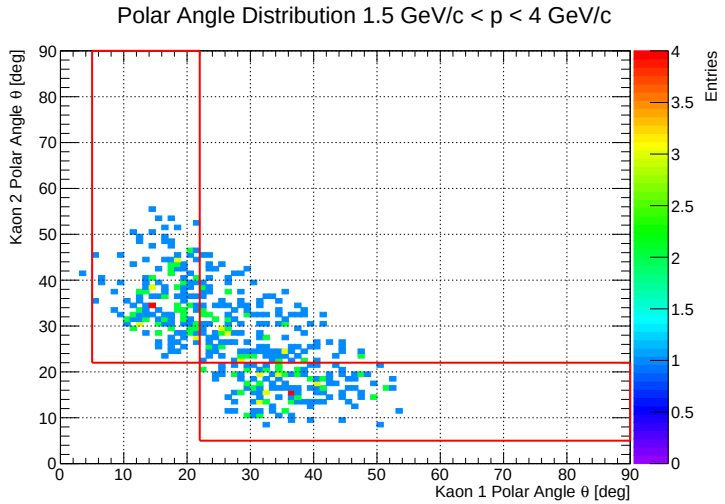
Beam Momentum: 6.5 GeV/c:





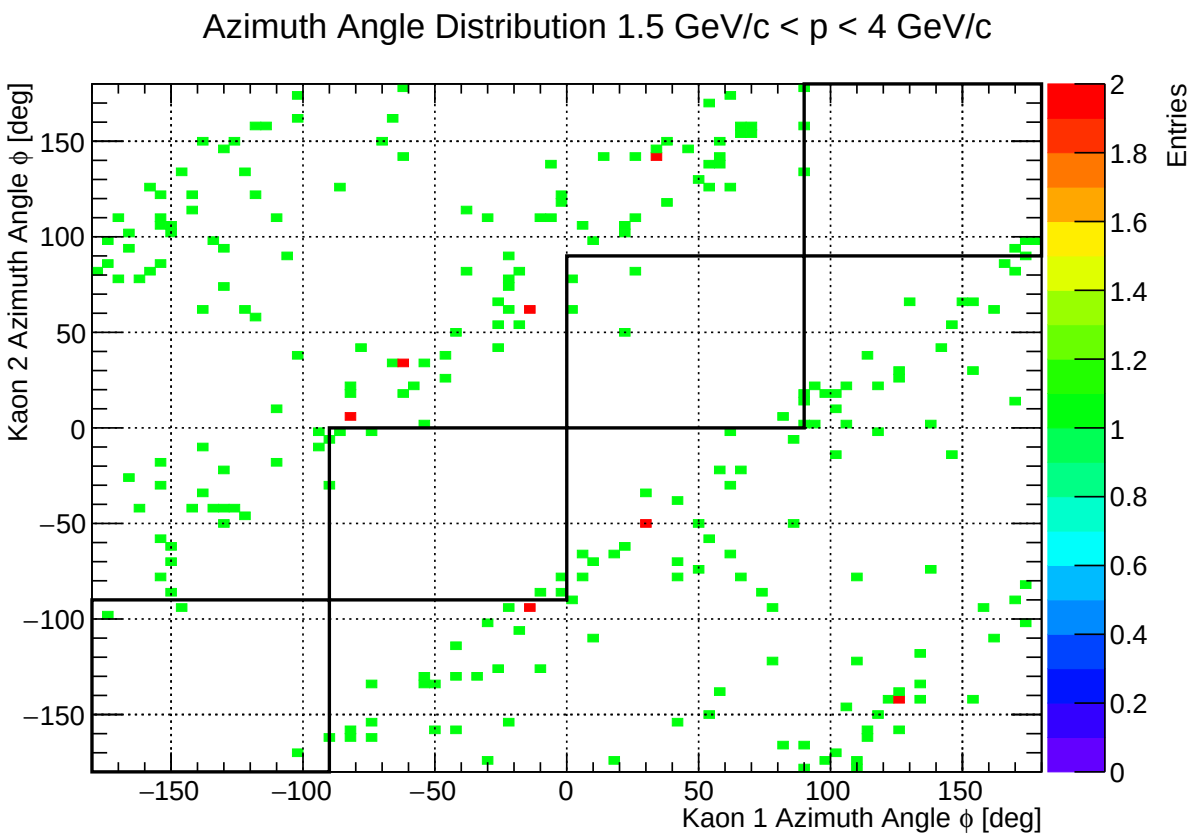
Beam Momentum: 15 GeV/c:





Azimuth Angle Distribution

Beam Momentum: 6.5 GeV/c

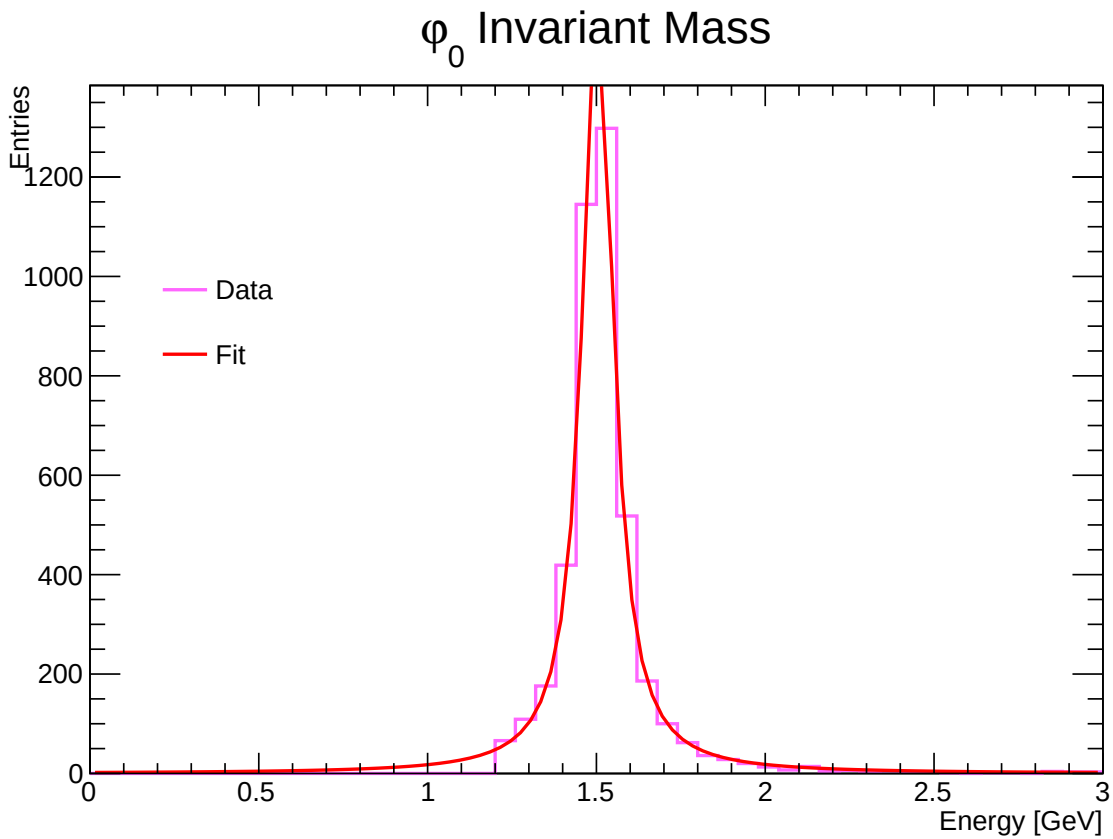


Many events with K^+/K^- traversing through two different radiator quadrants $\rightarrow$ less pile-up

Monte-Carlo Simulations

Invariant mass from kinematics of K^+/K^- decay channel:

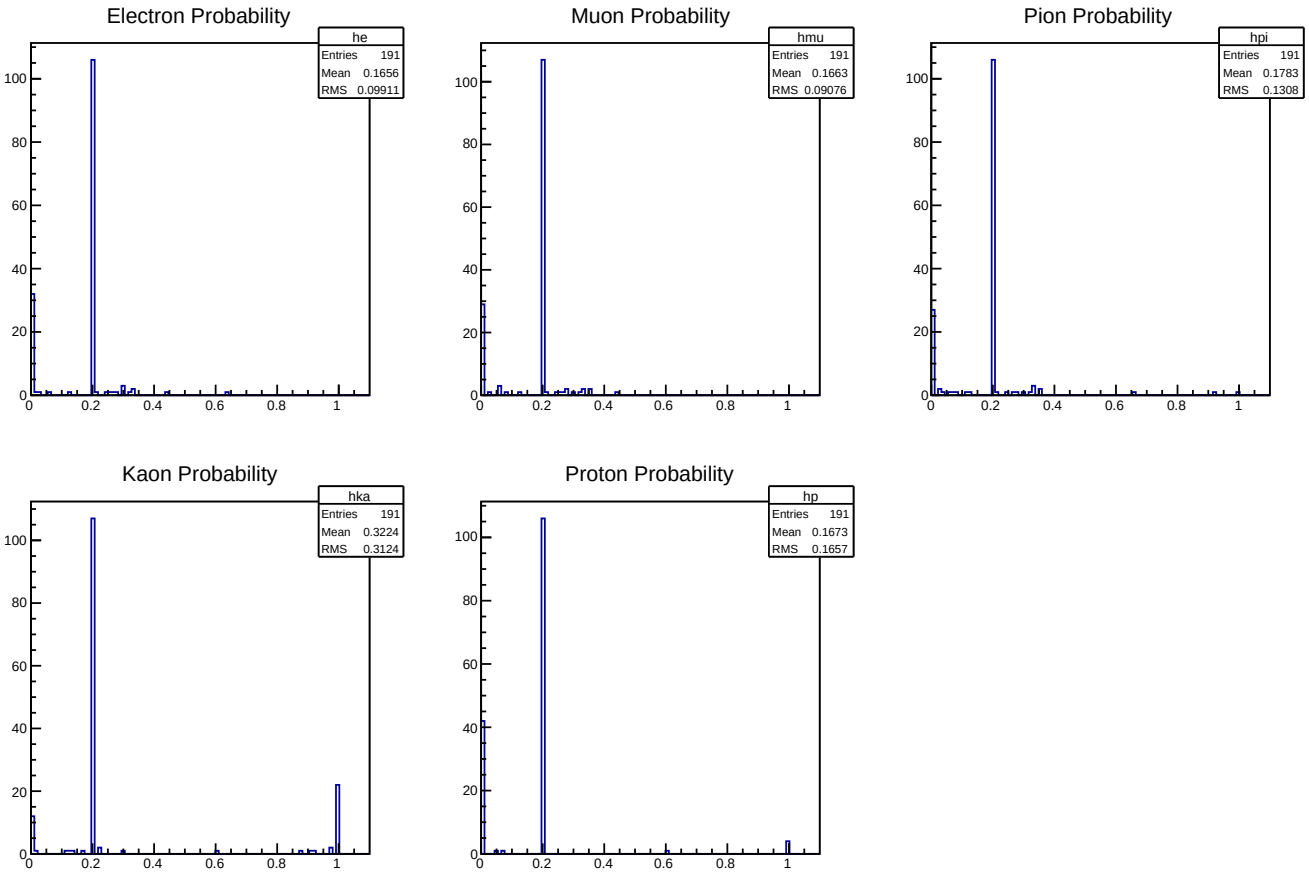
$$m_{f_0} = \sqrt{(E_{K^+} + E_{K^-})^2 + (\vec{p}_{K^+} + \vec{p}_{K^-})^2}$$



PndPidProbability Output

Implementing

```
PndPidProbability* pid_prob = new PndPidProbability();

pid_prob->SetXXXPdf(likelihood);
```

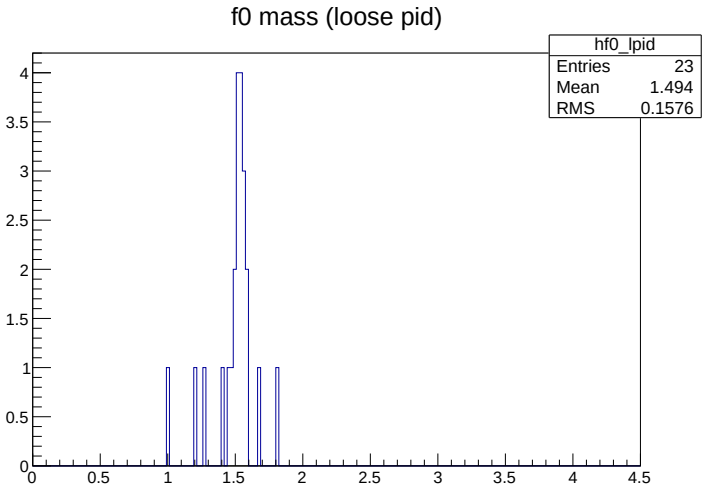


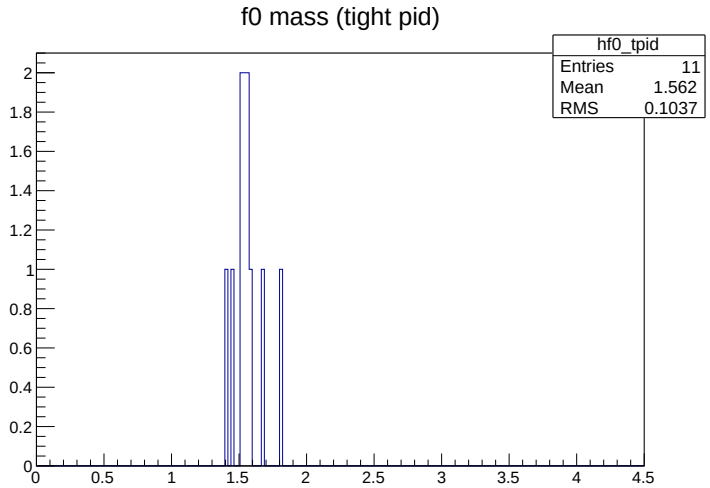
Analysis Script

```
RhoCandList chrg, f0, kplus, kminus;
double m0_f0 = 0.15;

RhoMassParticleSelector *f0MassSel=new
    RhoMassParticleSelector("f0(1500)",m0_f0,1.0);

PndAnalysis* theAnalysis = new PndAnalysis();
if (nevts==0) nevts= theAnalysis->GetEntries();

while (theAnalysis->GetEvent() && i++<nevts)
{
    theAnalysis->FillList(chrg,    "Charged");
    theAnalysis->FillList(kplus, "KaonAllPlus");
    theAnalysis->FillList(kminus,  "KaonAllMinus");

    theAnalysis->FillList(kplus,  "KaonLoosePlus",
         "PidAlgoMvd;PidAlgoStt;PidAlgoDrc;PidAlgoMdtHardCuts;PndAlgoDisc");
    theAnalysis->FillList(kminus, "KaonLooseMinus",
        "PidAlgoMvd;PidAlgoStt;PidAlgoDrc;PidAlgoMdtHardCuts;PndAlgoDisc");

    f0.Combine(kplus, kminus);
    for (j=0;j<f0.GetLength();++j) hf0_lpid->Fill( f0[j]->M() );
    f0.Select(f0MassSel);
}
```

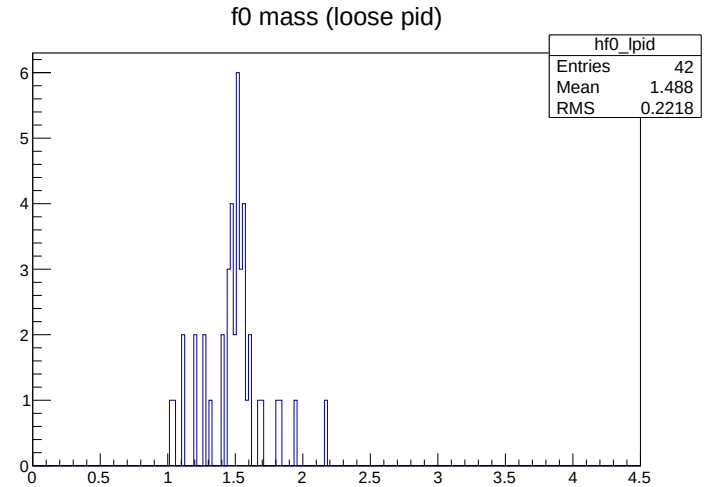
Reconstruction Efficiency

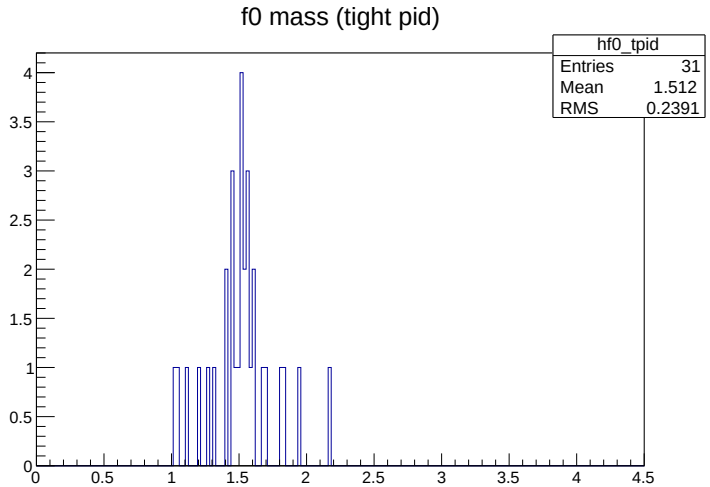
Loose and Tight PID Excluding Disc DIRC:





Loose and Tight PID Including Disc DIRC:





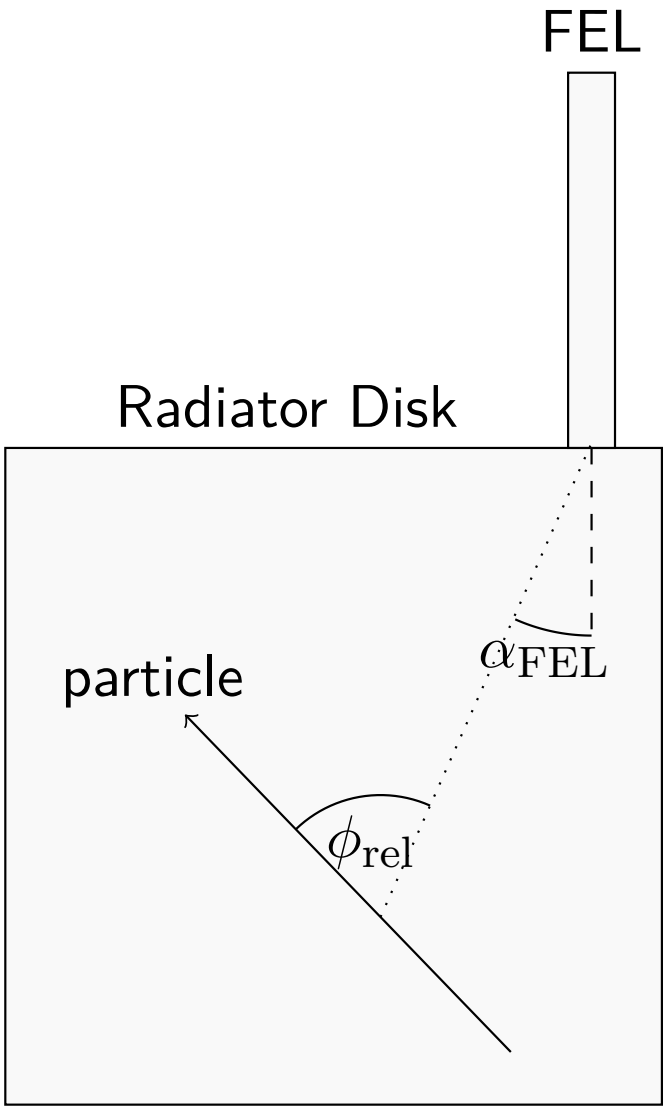
Conclusion & Outlook

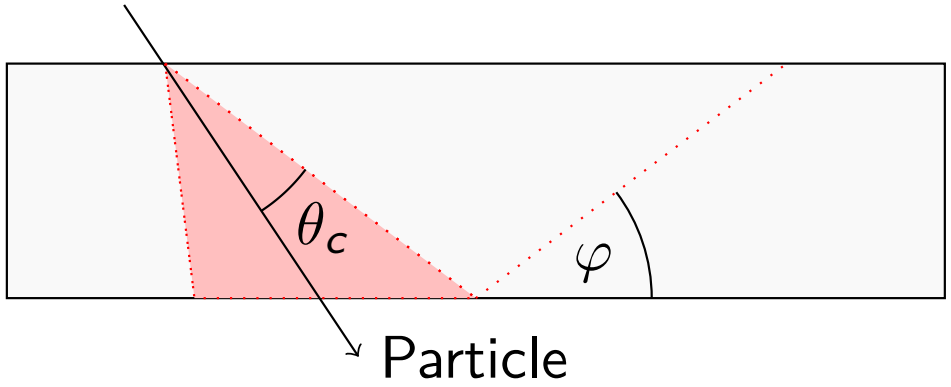
- Investigating discrepency between both helix propagators
- Merging code structures
- Pileup studies for Kaon multiplicity
- Deeper analysis for benchmark channel
- Study of background channels

Backup Slides

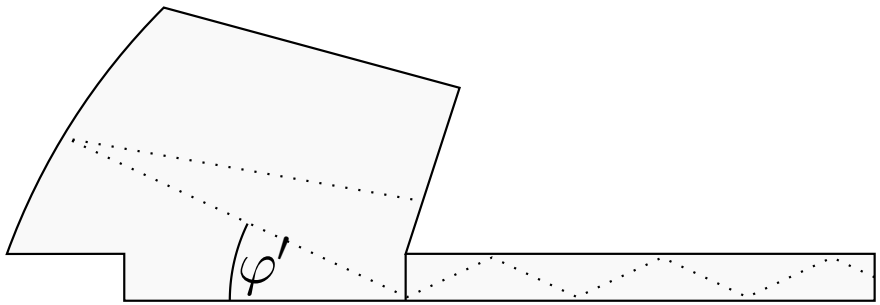
Theoretical Model

Angle Definitions:





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



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 $B = A^2 + \cos^2\theta_p$