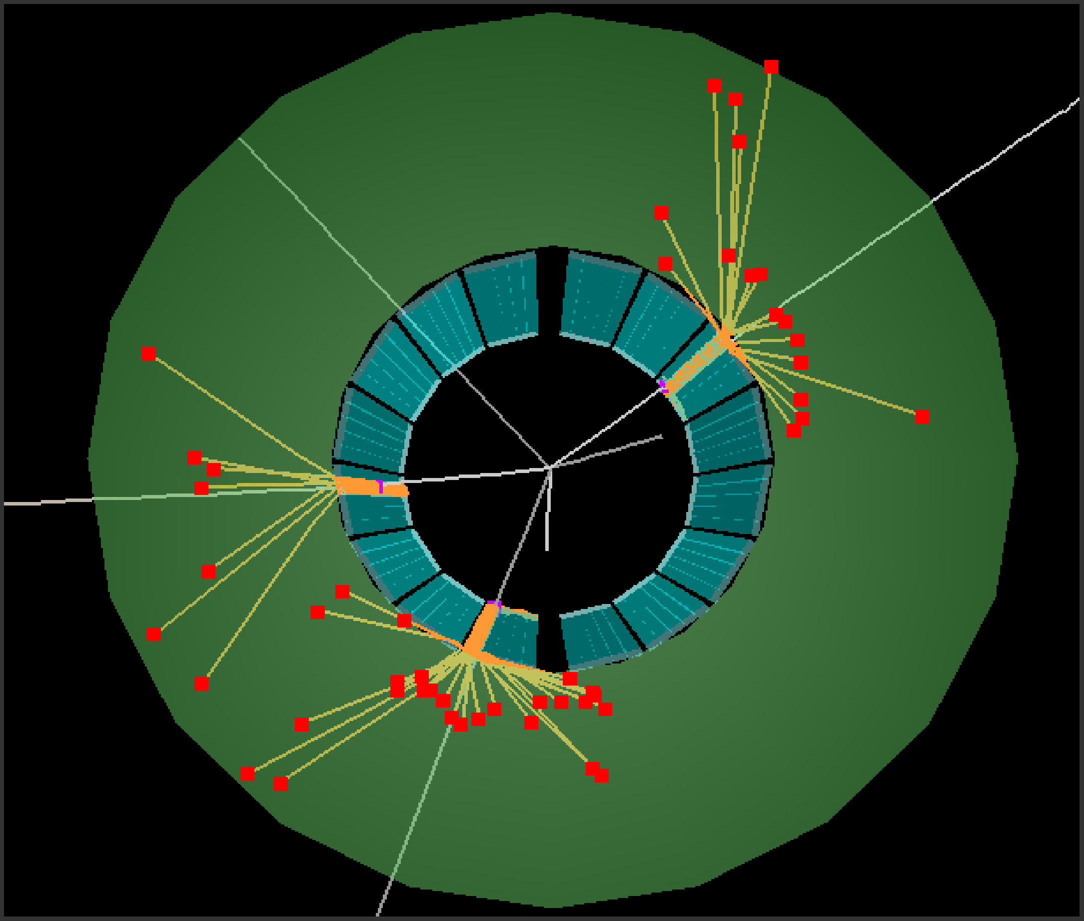
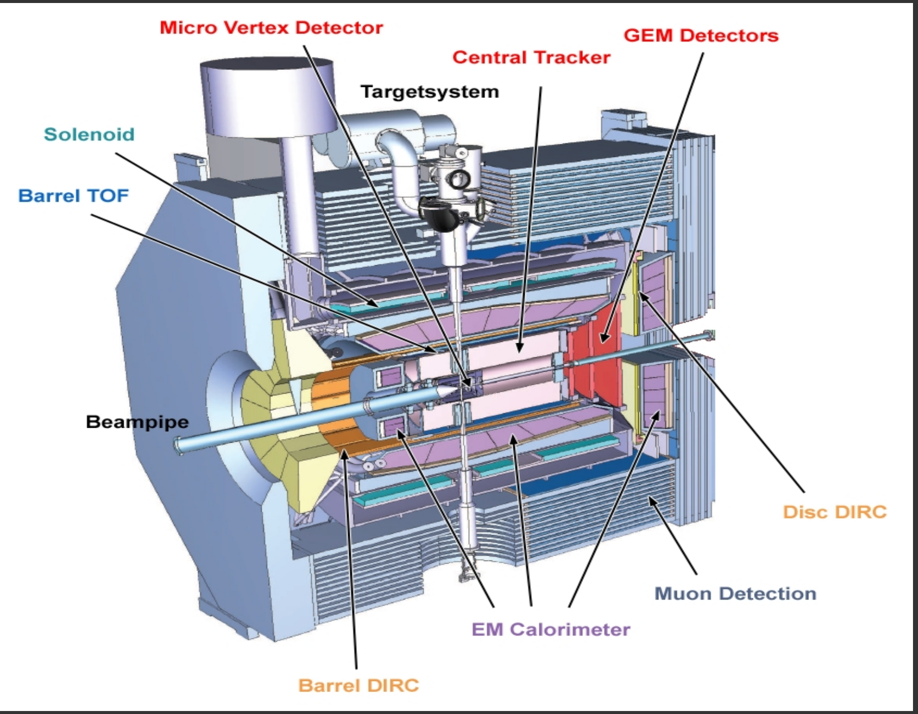


Simulation and Reconstruction of the PANDA Barrel DIRC

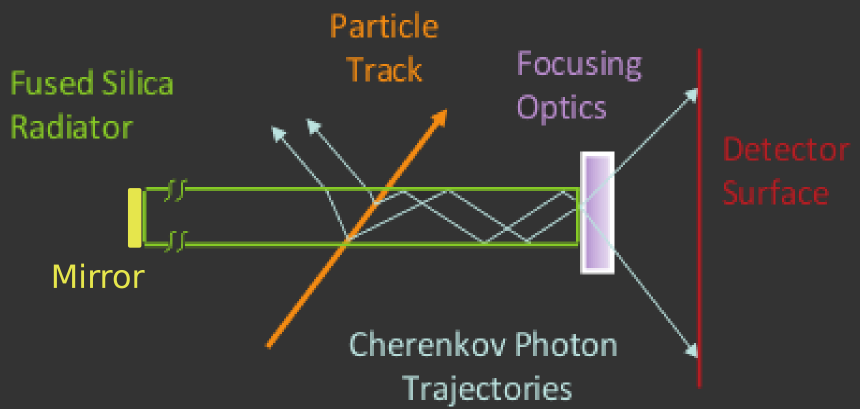
Maria Patsyuk

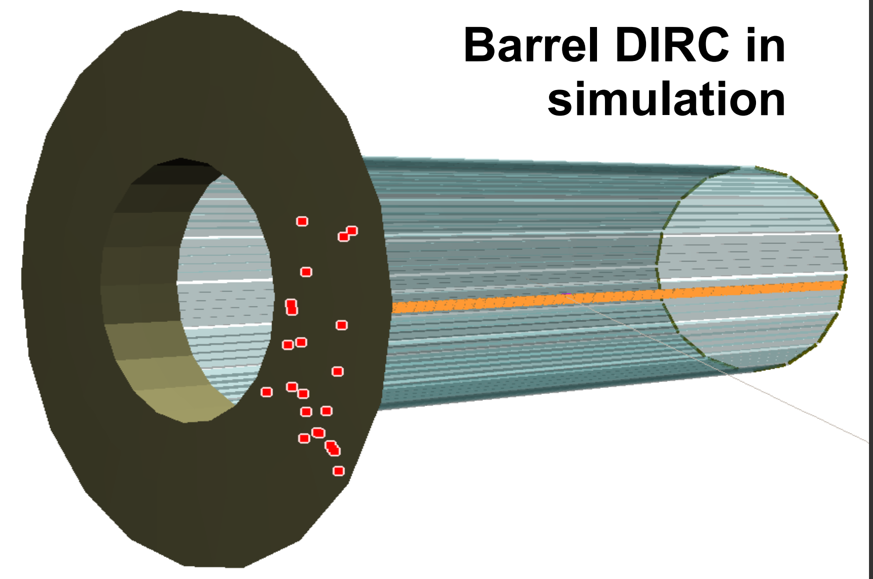
PANDA Barrel DIRC



- PANDA DIRC is a PID detector

- Cherenkov light coming from the charged particle is trapped in the radiators and guided to the photo detector plane. Depending on the particle velocity the hit patterns are different:





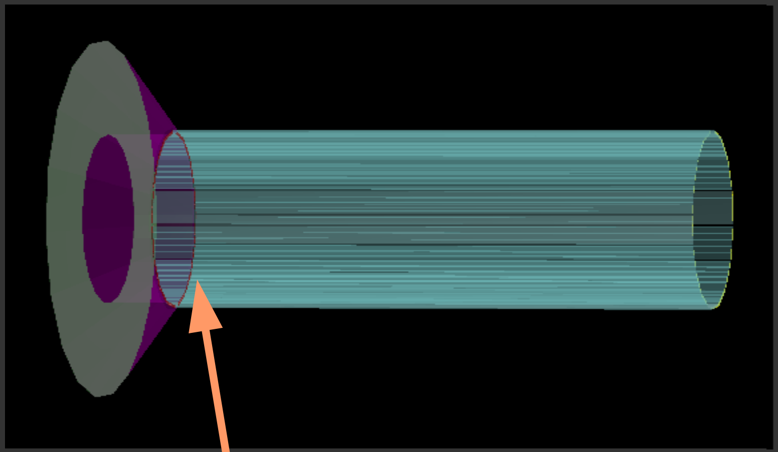
- PANDA PID requirement: π/K separation in the range of [0.5; 3.5] Gev/c

- Design goal: 3 mrad Cherenkov angle resolution, which means ~8-9 mrad single photon Cherenkov angle resolution and > 20 photons per track detected

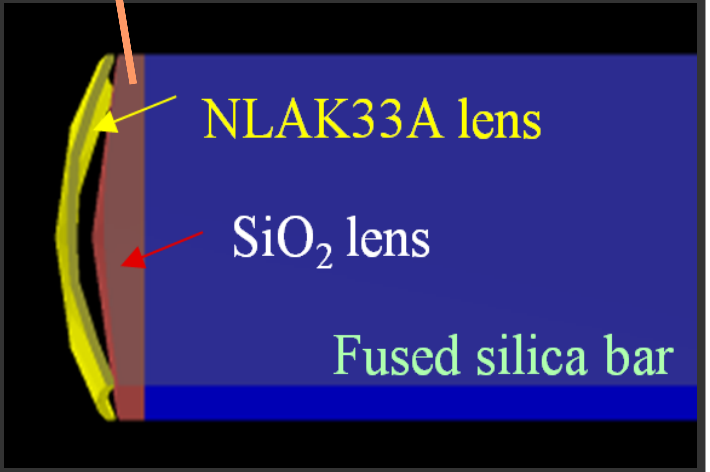
- Baseline design is based on the BABAR-DIRC, but many parameters should be optimized

Geometry: design options

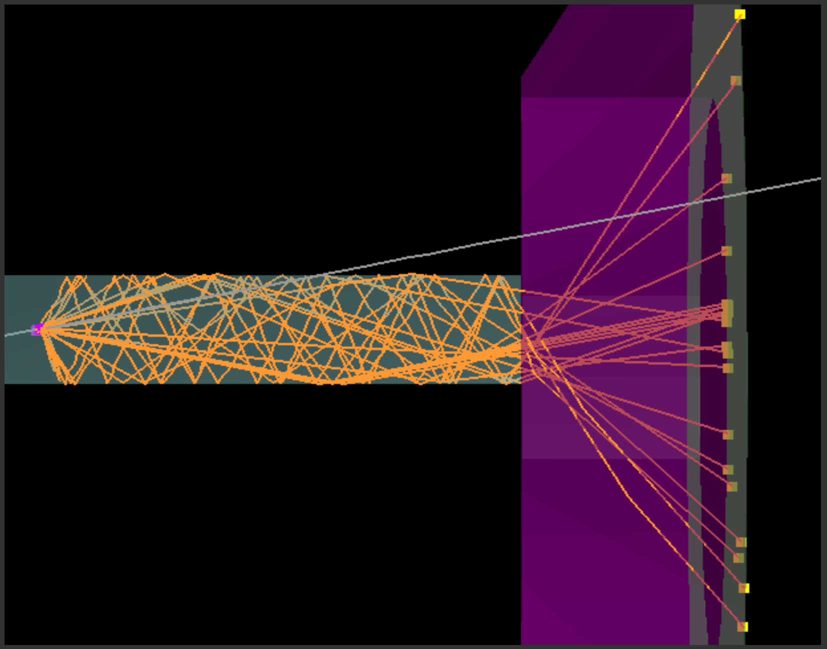
Radiator bars (5 bars per bar box)



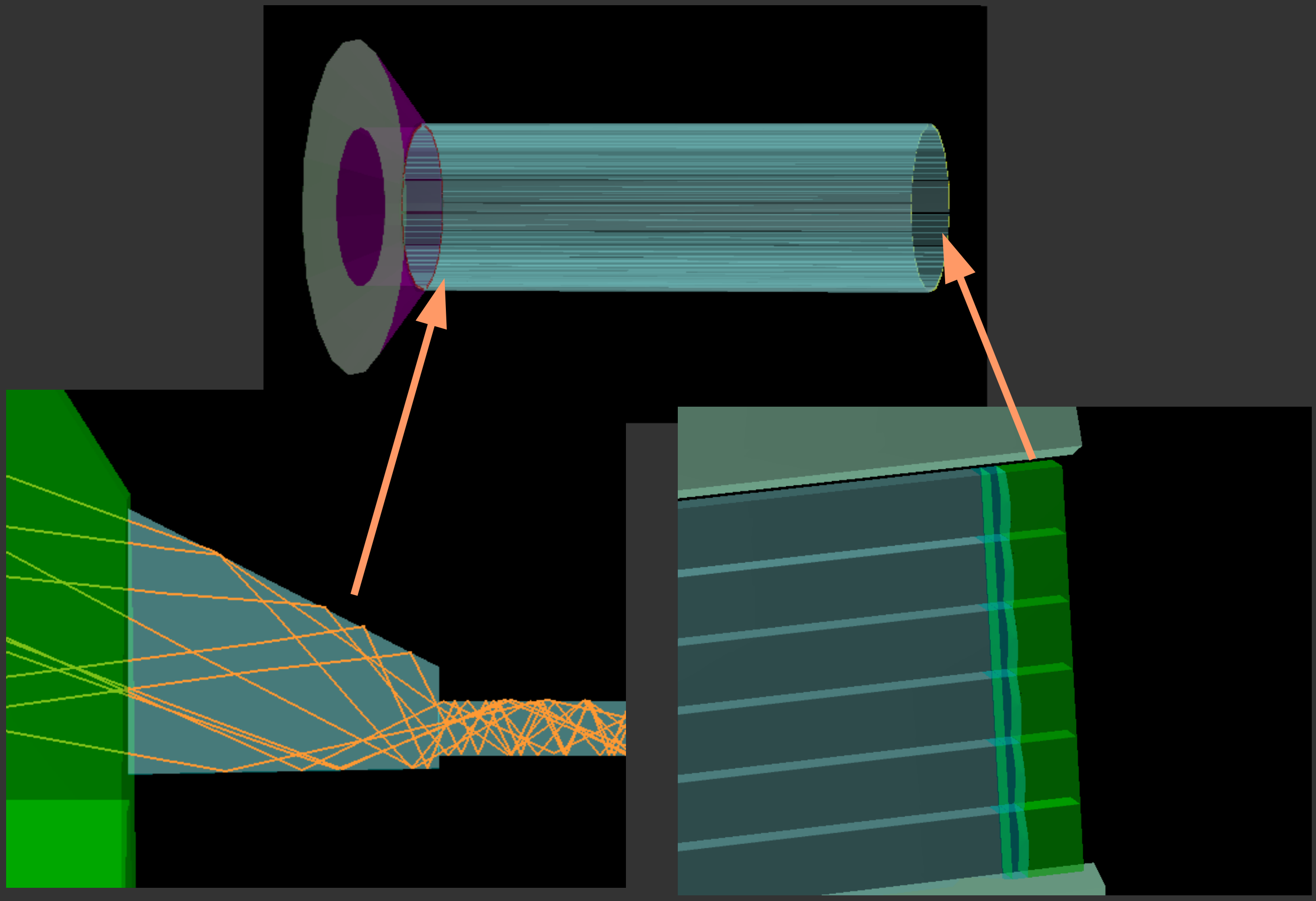
Baseline design, focusing system - coated doublet lens



Radiator plate

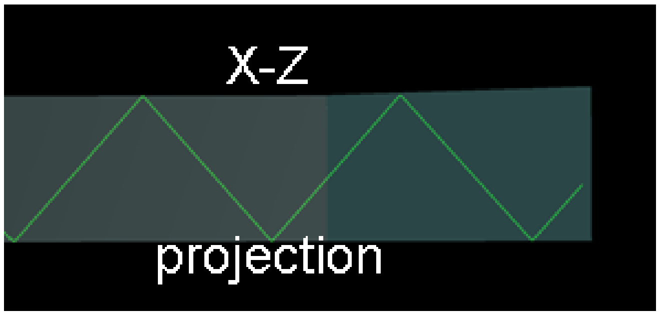


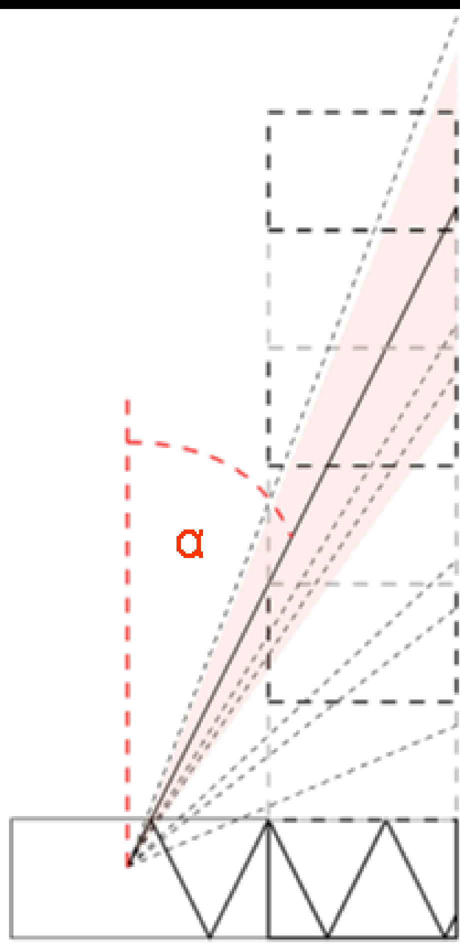
Geometry: design options

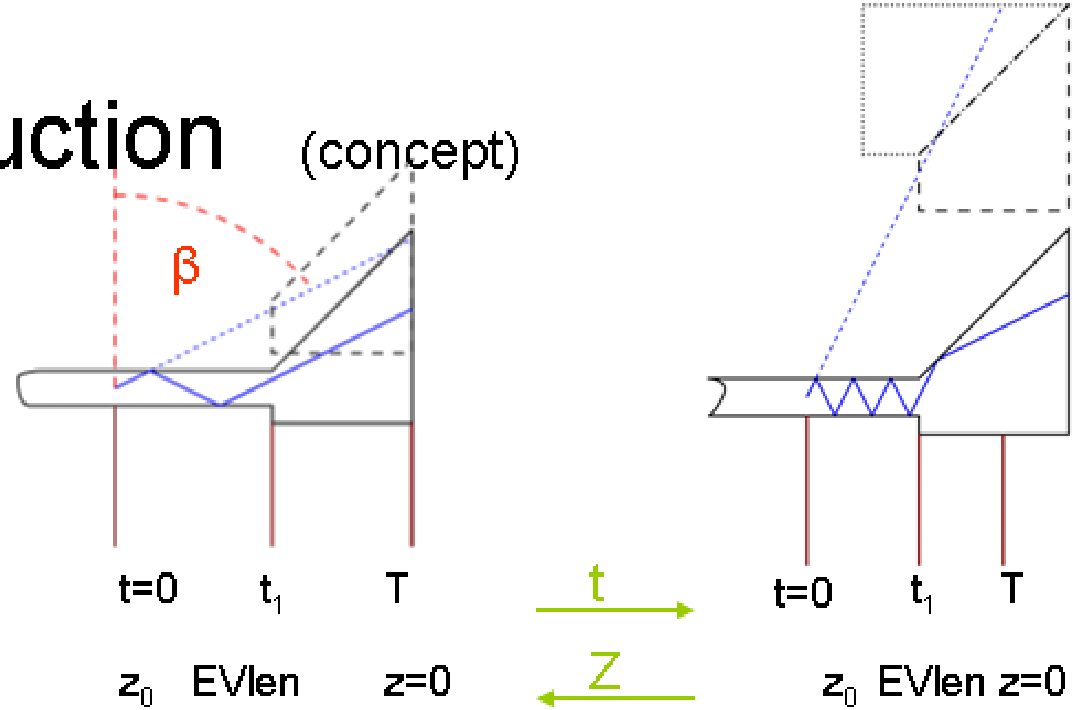


- Prism compresses the phase space in radial direction and reduces the number of required pixels
- Forward mirror focuses forward-going photons
- Separated expansion volumes (one for each bar box) reduce weight, simplifiy detector design. They can be used with prisms

Plate Reconstruction (concept)







Direct photon

RU photon

$$t_1 = T \cdot \frac{z_0 - EVlen}{z_0}$$

$$\frac{z_0 - EVlen}{t_1 \sin\beta} = c_n' \qquad c_n' = c_n \cdot \sin\alpha$$

$$\Rightarrow \alpha = \arcsin\left(\frac{z_0}{T \cdot c_n \cdot \sin\beta}\right)$$

Still in development

Has not been tested

Marko Zühlsdorf

Sim & Reco approach

3 usual stages of detector simulation & reconstruction:

- Simulation	Particles are tracked, hits on the photo detector plane are produced (using pixelisation algorithm instead of real small detection pixels). Timing information is not taken into account
- Digitization	No such stage yet, hit positions on the photo detector are taken as raw data for reconstruction.
- Reconstruction	Is under development, depends on features of the particular design

Reconstruction approach

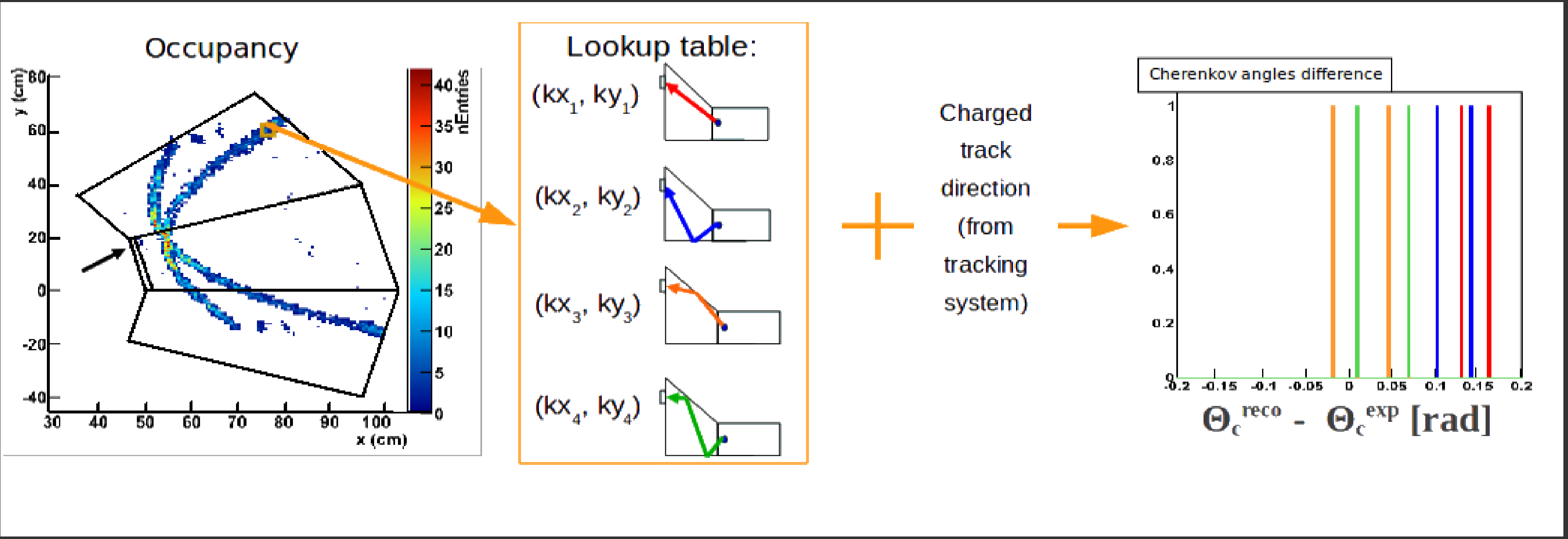
Photo detector plane is covered with PMT-MCPs, hit pixels are used as the detector raw data. Time information is planned to be used as well.

Procedure:

1. Before reconstruct track patterns create look-up tables where initial photon direction for each pixel is saved (taking into account 4 possible photon paths to the photo detector)

2. Get charged particle direction from tracking system (or from MC data)

3. For each pixel of the hit pattern combine information about the photon and the charged particle direction to reconstruct the Cherenkov angle and plot it (subtracting the expected Cherenkov angle)

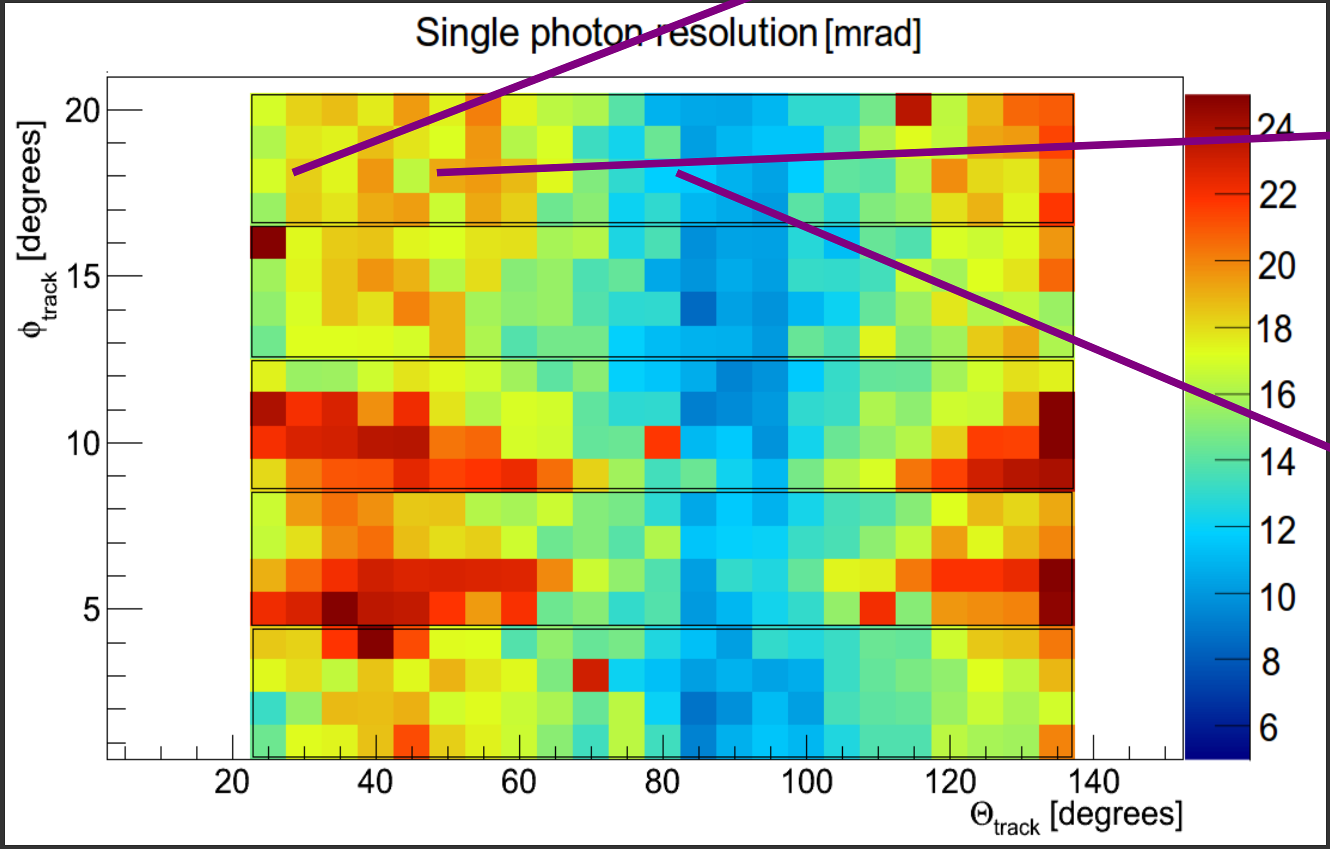


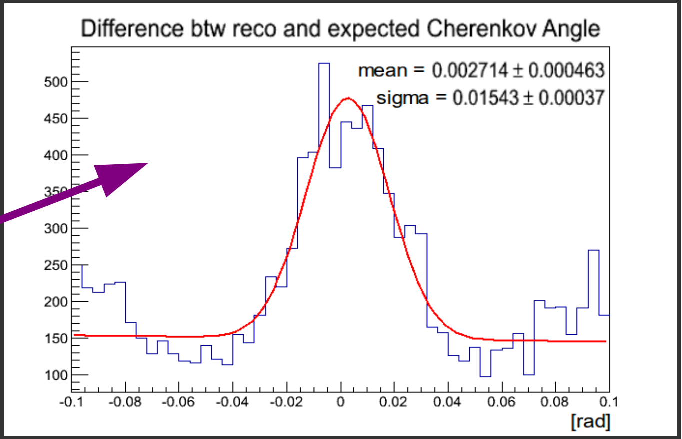
Performance of the simplest DIRC design

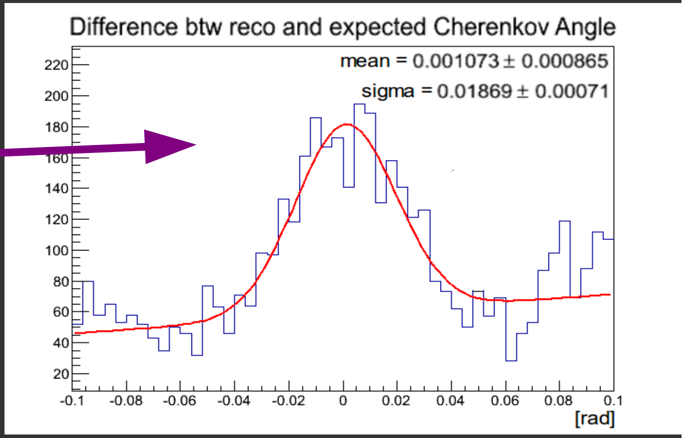
No focusing, fused silica bars are directly attached to the expansion volume (EV)

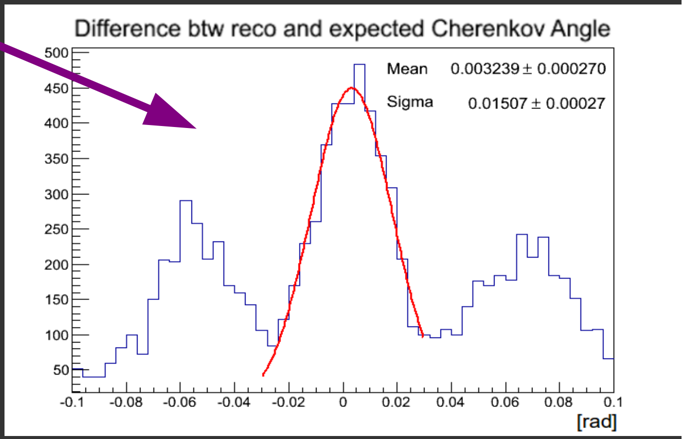
Simple estimation of Single photon Cherenkov angle resolution - 18-19 mrad

map of θ_c^{photon} for one bar box, 3 GeV muons

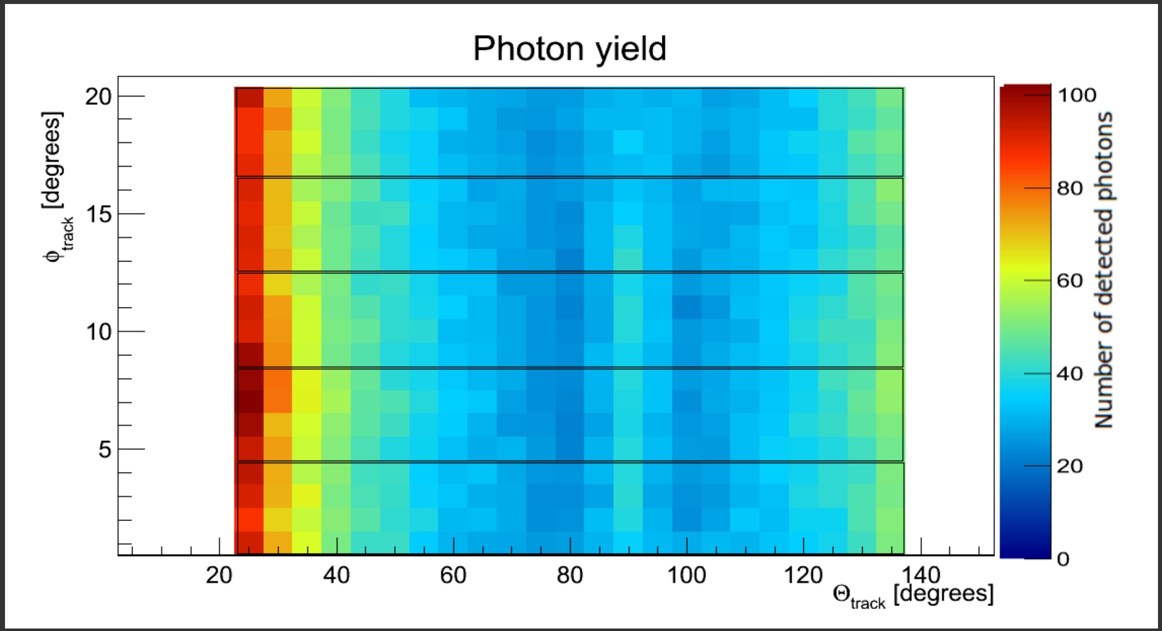




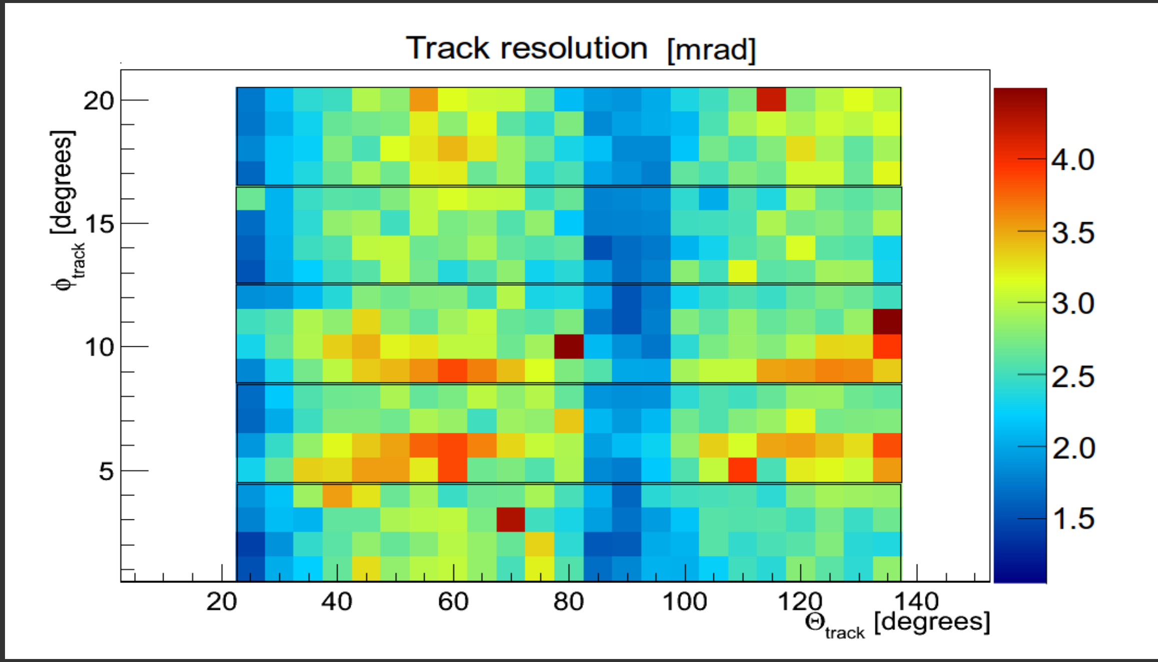




Performance of the simplest DIRC design



A map of number of detected photons per charged track



A map of Cherenkov angle resolution per track assuming ideal tracking and perfect bar shape

$$\sigma_{\theta_C^{track}} = \sigma_{\theta_C^{photon}} / \sqrt{N_{photons}}$$

Summary of Sim&Reco status

1. The final DIRC design has not been decided yet

2. The reconstruction procedure is dependent on the particular design features and is under development

3. Time information is not yet properly taken into account

→ the geometry file on the svn is not the final one, but main parameters are fixed

→ no Digitization stage in the reconstruction yet: positions of hit pixels are taken as raw data

→ no time-based event mixing

→ DIRC is not yet available in the full PandaRoot reconstruction (but there is a parametrization approach of the DIRC reconstruction available)

Some technical questions

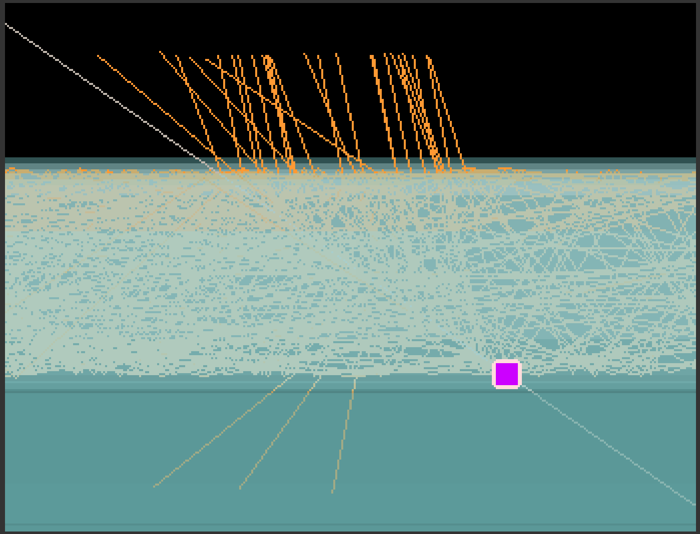
1. DIRC geometry as a .root file → special settings in the g4Config.C

TG4RunConfiguration* runConfiguration

//   = new TG4RunConfiguration("geomRoot", "QGSP_BERT_EMV", "stepLimiter+specialCuts+specialControls"); *// how it was*

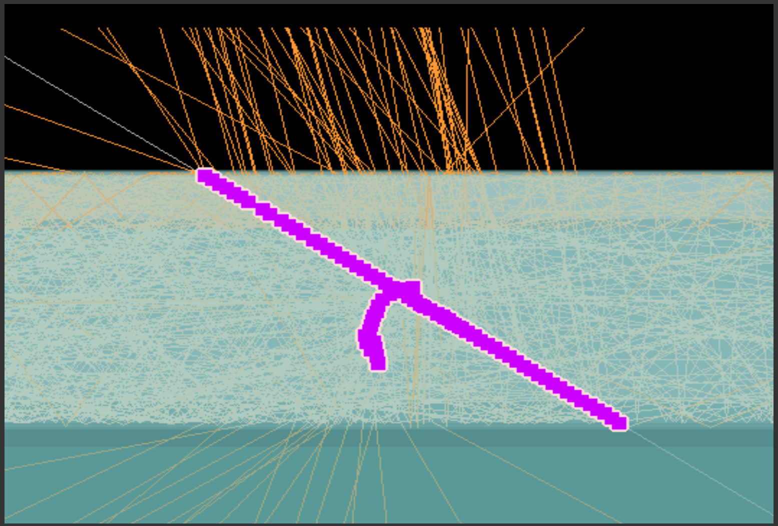
= new TG4RunConfiguration("geomRootToGeant4", "QGSP_BERT_EMV+optical", "stepLimiter+specialCuts+specialControls"); *// how we need it*

2. Jan2012 external packages → too many PndDrcBarPoints:



Mai2011 packages – DrcBarPoint only at the entrance of the charged track into the DIRC bar

We can't use Jan2012 packages!

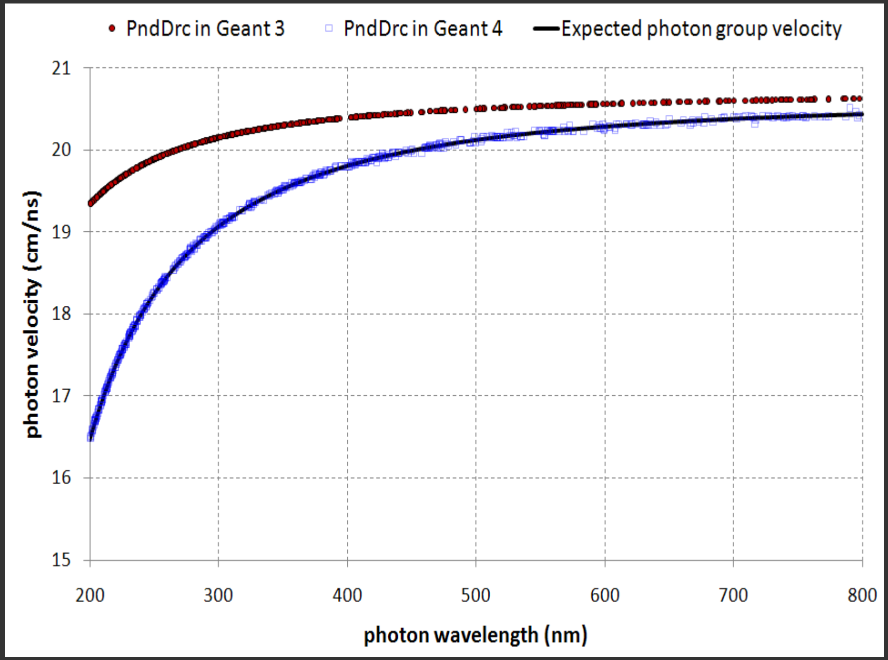


Jan2012 packages – DrcBarPoints along the track

Some technical questions

3. **Geant3 vs Geant4**

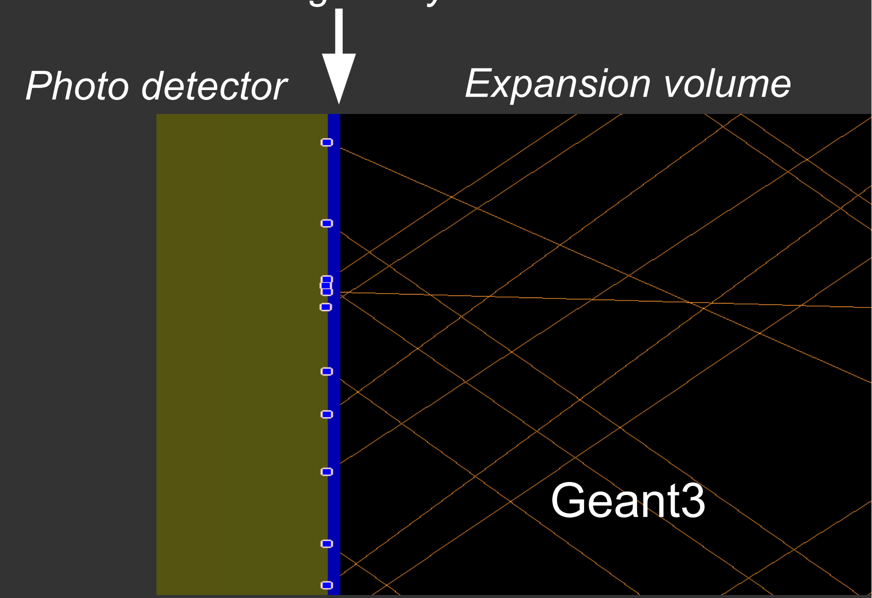
- group velocity in Geant4 is right, in Geant3 is not!

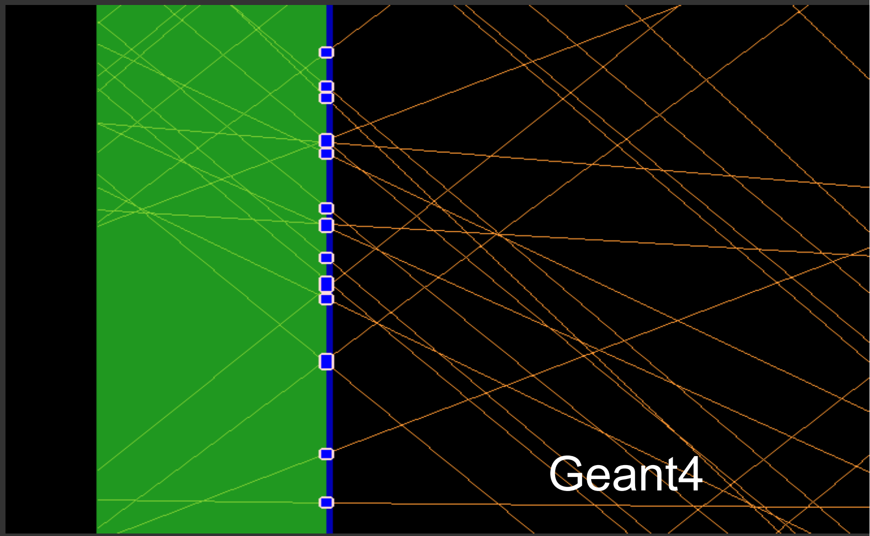


- accuracy problem in Geant3, which does not occur in Geant4 →

Photons are stopped at the border between volumes (geometry has no overlaps). This effect is wavelength dependent.

Volumes are put side by side:





Fast 'reconstruction'

1. To separate π / K / p the Cherenkov angle of the charged particle and the number of detected photons are measured in the Barrel DIRC

2. How is the fast parametrization procedure done now:

Is it the right place for the smearing to stay in the reconstruction mainstream?

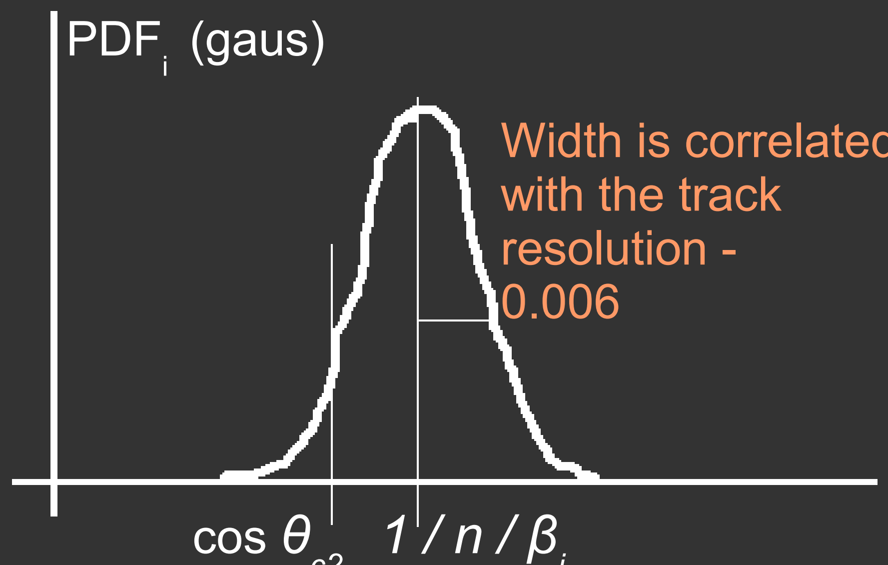
Track resolution value is wrong, it should be ~0.003 !

- PndDrc → $\theta_{c1} = acos\ (E\ /\ 1.47\ /\ p);$

- PndDrcHitProducerReal → $\theta_{c2} = gRandom \rightarrow Gaus(\theta_{c1},\ 0.008);$

- PndPidAssociatorTask → evaluate $PDF(1\ /\ n\ /\ \beta_i)$ at θ_{c2} to get the probability for this track to be a particle i.

$1\ /\ n\ /\ \beta_i$ is calculated using particle mass and momenta



Fast 'reconstruction'

3. How the fast parametrization procedure could be improved:

Tracking, bar imperfections ...

Single photon resolution is a function of the track polar angle

track resolution $$\sigma_{\theta_C}^{track} = \sigma^{corr} \oplus \frac{\sigma_{\theta_C}^{\gamma}}{\sqrt{N}}$$

Track resolution could be smeared with the right sigma

Number of detected photons could be estimated and smeared as well

a). Simple improvement:

The sigma value for the track resolution is corrected.

Only track resolution is smeared.

The width of the PDFs is changed.

b). More complicated improvement:

Single photon resolution is introduced as a function of the track polar angle.

Number of detected photons is estimated and smeared (Poisson for signal and background).

PDFs are changed to correlate with the new way of track resolution estimation.