RICH software in DD4Hep

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The overview of the workchain

Simulation

Inputs:
a. Geometry (.xml, .cpp files)
b. Particle information (.hepmc file/s)

Outputs (.root format):
a. Geometry information
b. Simulation (hit) information

NPSIM

Reconstruction

Inputs:
a. Simulation .root files
b. IRT instructions via .py file

Output:
a. Final Outfile.

Juggler

Analysis Code → Final Outfile = RICH analysis

Requirement of IRT in DD4Hep

The option file (.py) is passed individually for pfRICH (dRICH) containing the options for the reconstruction of the said detector in dd4hep.

Elements the .py file contains:

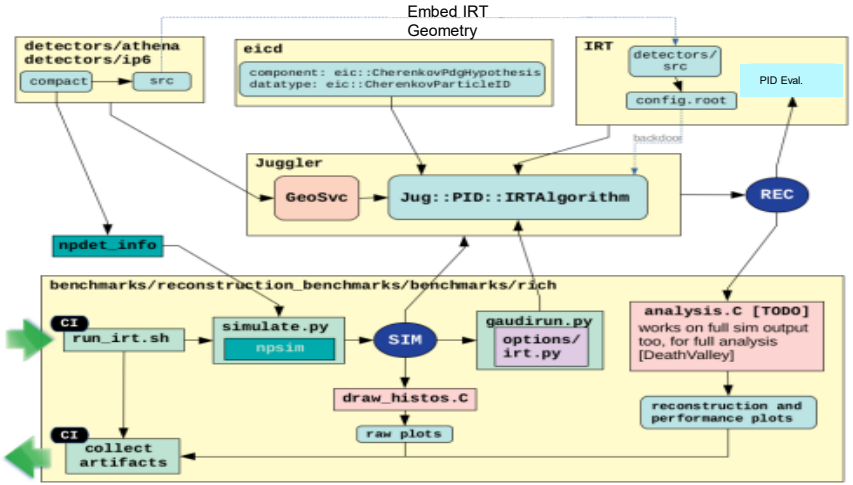
a. The geometric and simulation root files.
b. The QE values as a function of photon wavelength.
   → Internally the bins are made smoothen. The number of QE bins are passed here (QEbins = 100).
c. The parameters for the radiators. E.g. Number of z bins, the gaussian smearing, working refractive index and the attenuation length if required.
d. Variable to treat the type of particles. Right now we deal mcparticles.
e. Safety factor.

Technical note: The two inputs are associated to the EIC data services and Geometric services.

Tasks served by IRT:

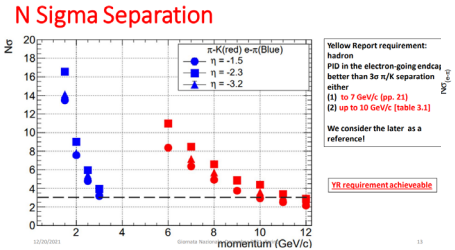
- Reconstruction of single photon Cherenkov angle.
- Assignment of weights to photons → used in PID, computation of track theta (Not by ring recognition) …

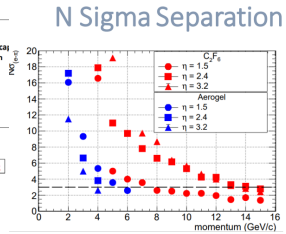
Software scheme

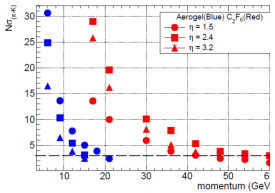


- ATHENA software is modular.
- Yellow boxes are the individual modules
- Arrows indicate the connections and information exchange.
- The ‘new’ IRT module is connected to the juggler.
- The reconstructed info are usable for PID evaluation in the sandbox or can be passed to the benchmark plots (hit info)

Results with the described software:





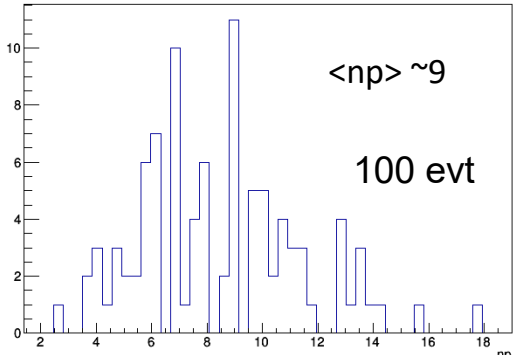


1. Characterization of pfRICH and dRICH with single particle in vertex, true mc particle information.
2. No noise had been included.
3. No physics performance had been studied.

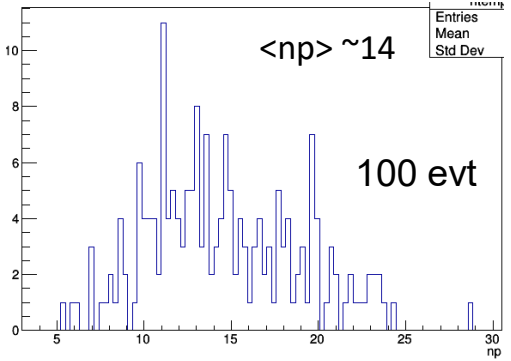
Situations with the multiparticle studies

Sthe similar performance plots with multiparticles in the vertex.

First to study with pfRICH (simple geometry and less impact of B Field) 12 GeV pi-K in a vertex. Expected <npe> ~9; From Frank-Tamm formula.



Single particles at vertex



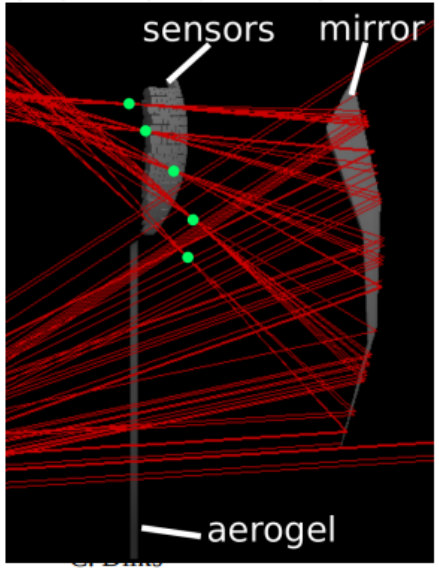
Two particles at vertex

- Unphysical associated number of photons (larger than expected number of photons at saturation) is observed. Double counting?
- The current algorithm does not use a pattern recognition. Uses the photons in an event and assign a weight to the photons for mass hypothesis.
- Inclusion of ring recognition → Similar to Alexander's standalone G4 studies?

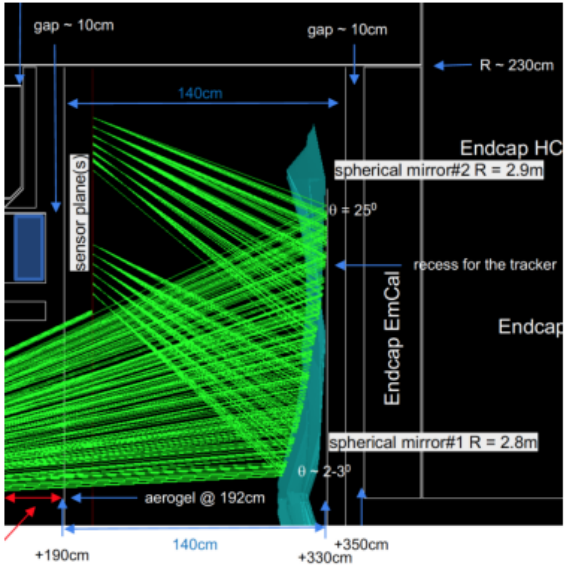
Single particle studies are not affected by this cause.

dRICH Dual Mirrors

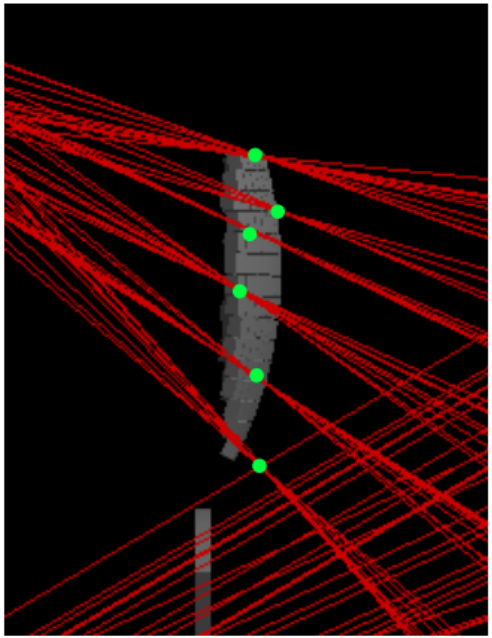
single-mirror config, 5 collimated photon beams; this is what we ran with for the proposal (canyonlands)



Alexander's dual mirror configuration, in standalone Geant4 sandbox



current status of dual mirror configuration in DD4hep:



still plenty of room for improvement!!

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Work to be done on the software sides

dRICH Reconstruction

- Connect IRT code to the full ATHENA software framework https://eicweb.phy.anl.gov/EIC/irt
  - cmake packaging and CI added to IRT repository
  - IRT code controlled by a Juggler algorithm, IRTAlgorithm
  - raw hit plots added to reconstruction_benchmarks
  - Entry point: move (or copy) performance plot production to benchmarks
- Several draft MRs – to be organized, rebased, and requested for review soon

Current situation and work to be done

- Materials presented w/ single mirror (canyonland) config. For single particles w/o noise hits.
- The true mcparticles are used and ACTS related modifications are foreseen to use reconstructed tracks.
- Inclusion of noise information and ring recognition related modification of the IRT codes are to be done.
- Optimization and studies related to the dual mirror configuration.
- Possibility to implement reflective side mirrors → improvement of the acceptance.