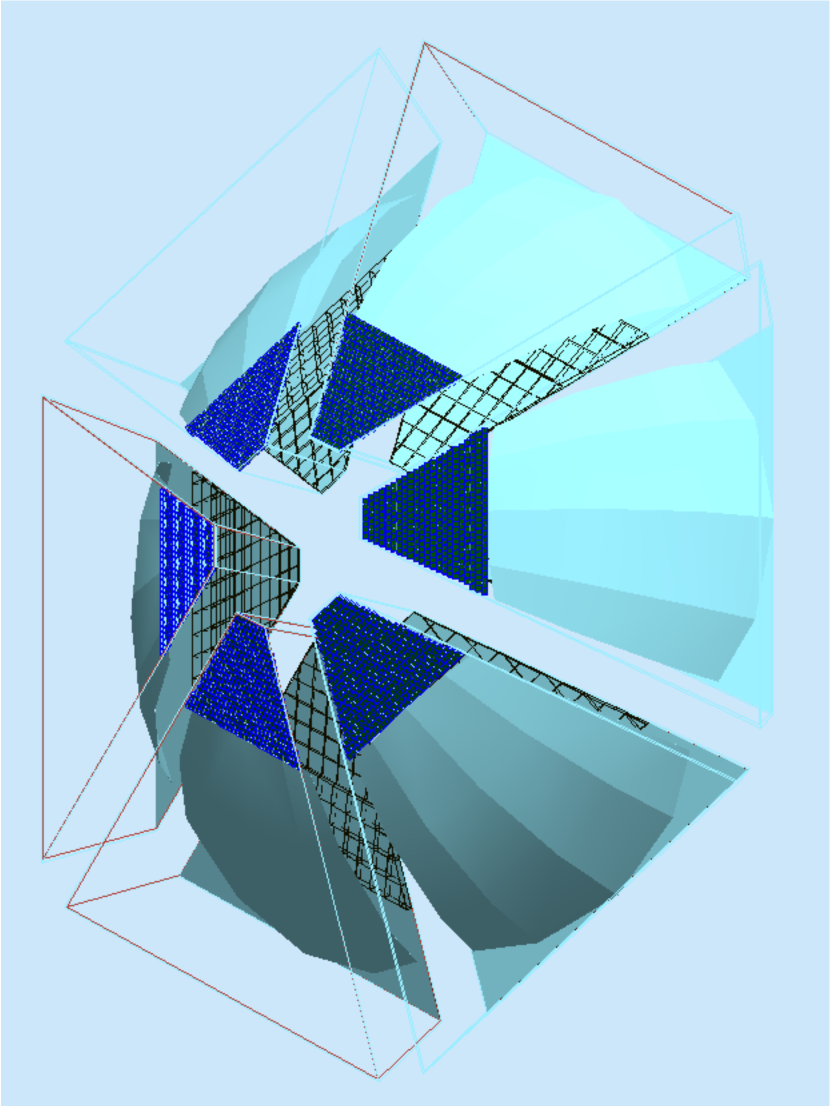
RICH Software & calibration



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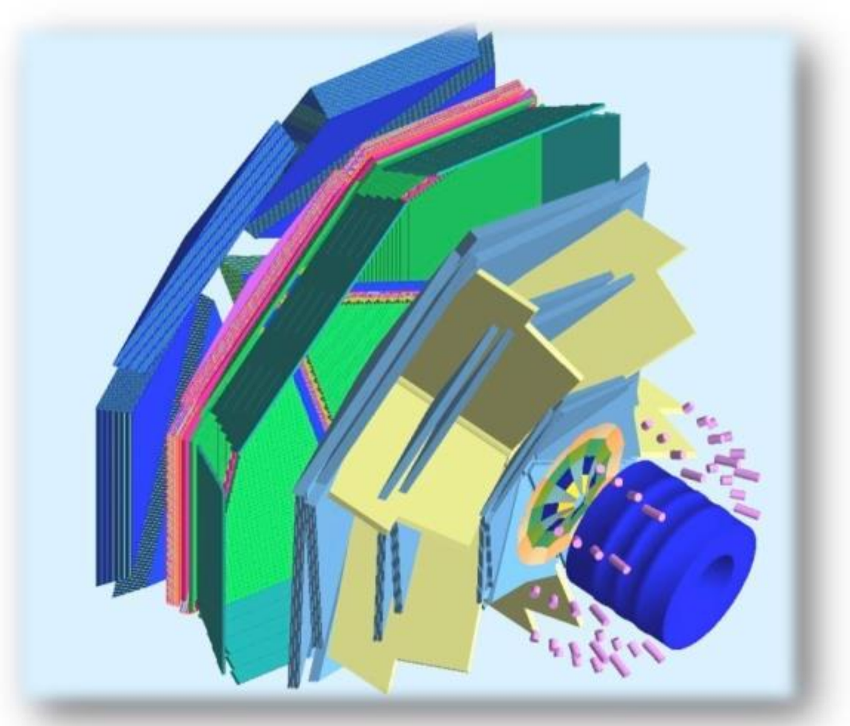
CLAS12 RICH review – October 13rd, 2015.

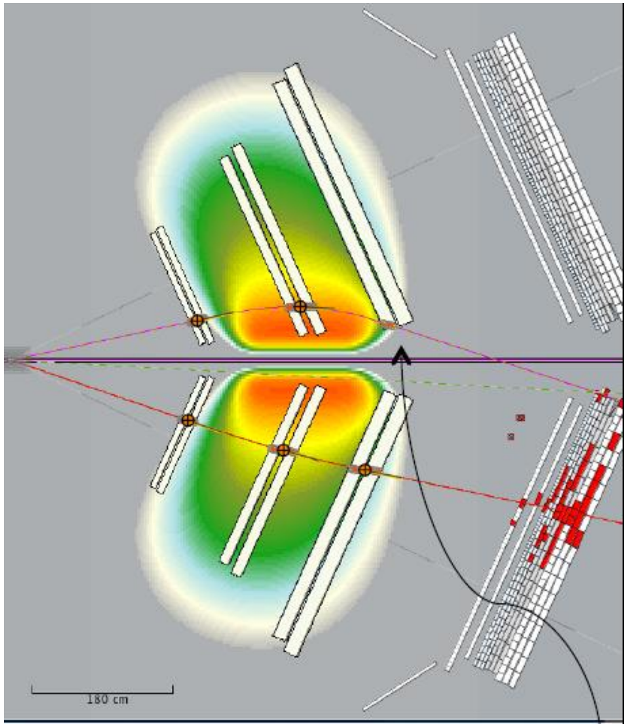
Simulation & reconstruction framework

The RICH in the CLAS12 software framework

Two software enviroments are being developed for CLAS12, one **devoted to simulations** and one **devoted to reconstruction**. Eventually, they will share a **common database** containing all related subdetector information are **geometrical parameters, materials and optical properties**.



GEMC (GEant4 Monte-Carlo) is an application based on Geant4 libraries. Simulation parameters (geometry, fields, etc) are defined in databases



ClaRA (CLAS12 Reconstruction & Analysis framework) is a multi-threaded analysis framework based on a Service Oriented Architecture

RICH simulations in the Geant4 CLAS12 environment

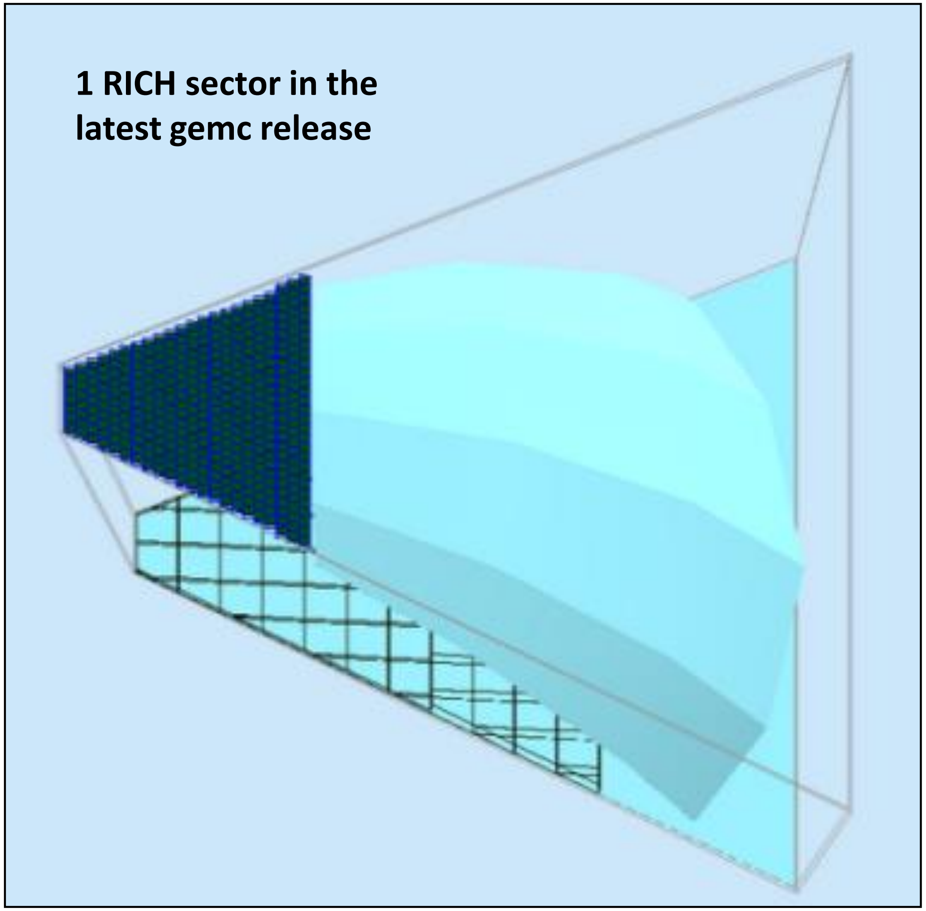
RICH is now almost fully implemented in the latest gemc release:

- detector geometry has been developed (at the level of detail significant for simulations)
- geometry parameters&materiales are kept updated with the latest mechanical developments
- optical properties are being introduced, following the mirror and aerogel tests

First set of simulations has been performed

1. fluence analysis (neutron and photon) in the RICH region (for estimating possible radiation damage effects)
2. impact of RICH material budget on downstream detectors

Results confirming the TDR



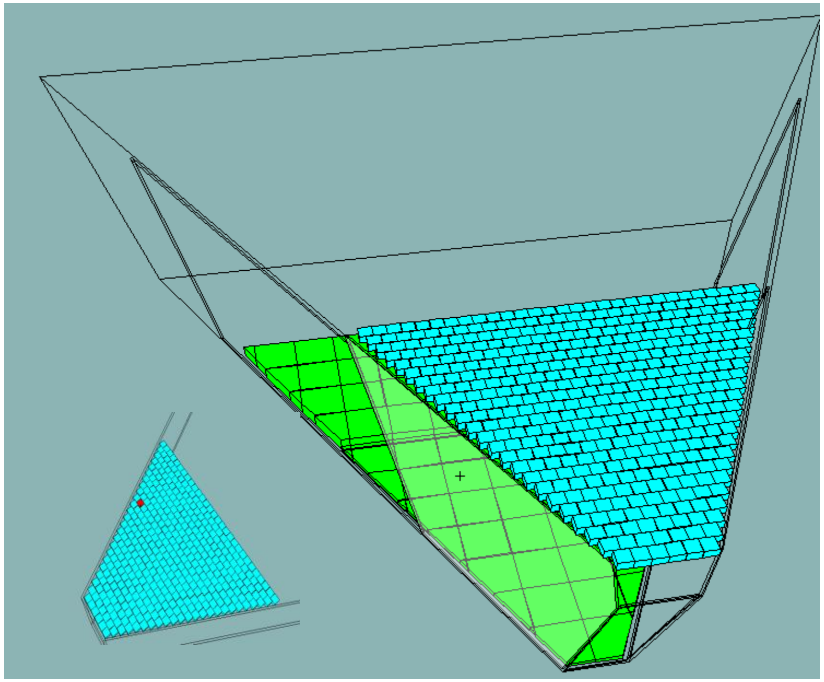
CLAS12 general software not ready for full PID studies

RICH in the CLAS12 JAVA reconstruction framework

- clas-geometry
  - Source Packages
    - org.jlab.geom
    - org.jlab.geom.abs
    - org.jlab.geom.base
    - org.jlab.geom.component
    - org.jlab.geom.detector.bst
    - org.jlab.geom.detector.cnd
    - org.jlab.geom.detector.dc
    - org.jlab.geom.detector.ec
    - org.jlab.geom.detector.ft
    - org.jlab.geom.detector.ftof
    - org.jlab.geom.detector.rich
    - org.jlab.geom.gui
    - org.jlab.geom.prim

- org.jlab.geom.detector.rich
  - RICHDetector.java
  - RICHFactory.java
  - RICHLayer.java
  - RICHMapmts.java
  - RICHRMirror.java
  - RICHRadiator1.java
  - RICHRadiator2.java
  - RICHSector.java
  - RICHSphericalMirror.java
  - RICHSuperlayer.java
  - RICHTrapezoid.java
  - RichGeometryApp.java

- MAPMTs
- Aerogel tiles
- planar and spherical mirrors
- Electronic panel



The same structure of other detectors has been followed.

The CLAS12 Calibration Constant Database

A database design was created for the GlueX experiment in Hall D (called \CCDB") and a version was implemented for CLAS12. This database is intended to store all constants for geometry and calibration, and possibly the magnetic field maps as well.

In the RICH case, common parameters for database are:

1. geometry parameters to build RICH components
2. component materials
3. MAPTM parameters: quantum efficiencies, gains
4. Mirror optical properties (reflectivity)
5. Aerogel (refraction index, transmission lenghts)

- geometry parameters (1) are already organized in an external file ready for DB
- materials are keeping updated in the simulations following mechanical developements, and are being implemented in JAVA

CLAS12 **Wiki** Page for CCDB: https://clasweb.jlab.org/wiki/index.php/CLAS12_Constants_Database

CLAS12-Specific Scripts and Library Extensions: https://github.com/JeffersonLab/clas12-ccdb

Reconstruction algorithm

Direct ray tracing

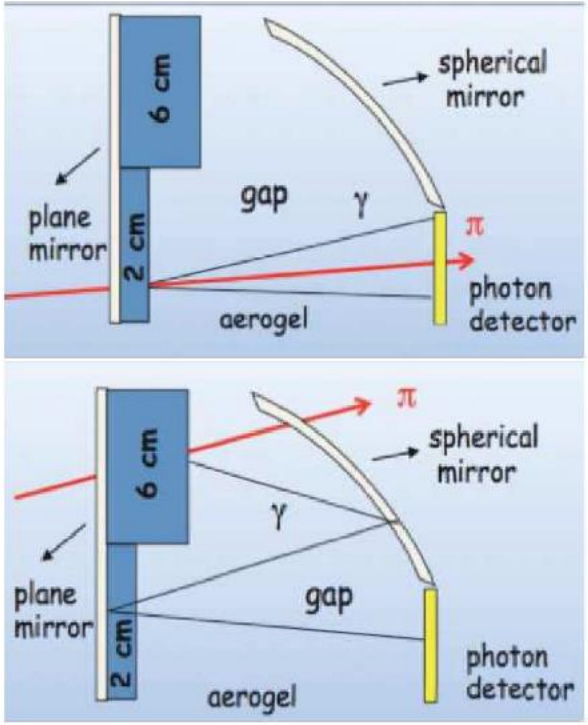
Because of the complicated geometry of the CLAS12 RICH, the expected Cherenkov photon hit pattern will never be a full ring → complicated mixing between photons detected directly and photons detected after reflections.

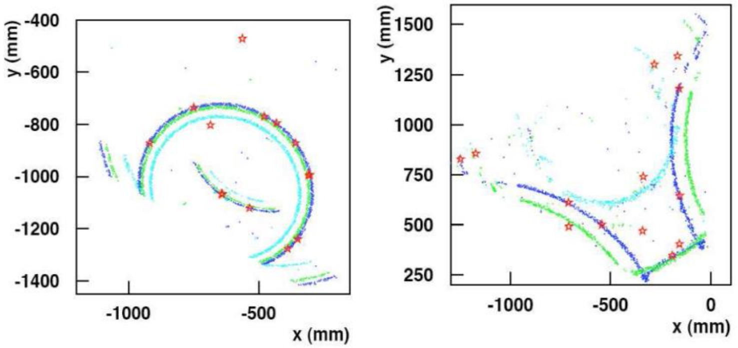
DIRECT RAY TRACING: impact point of the photon is calculated based on the Cherenkov emission angle for a given particle hypothesis

→ likelihood fit on simulated data produced by generating real photons

PID realized by calculating the likelihood for a measured pattern for a specific particle hypothesis, and selecting the one corresponding to the highest probability

Method has been tested and applied on the first set of simulations. However, it is too intensive from a computational point of view.

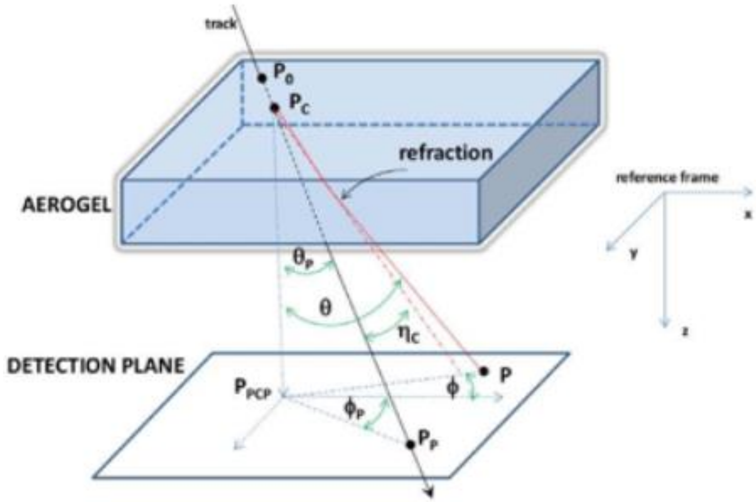




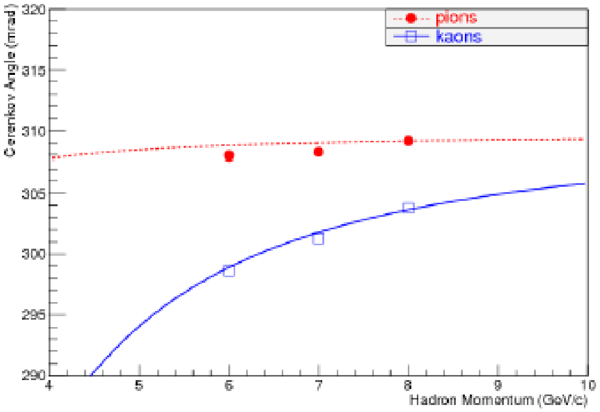
Indirect ray tracing

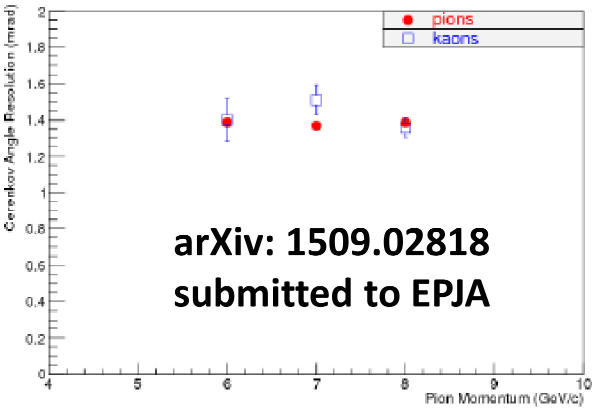
Given a track and a hit in the photon detection plane, use geometry set-up to estimate the Cherenkov emission angle analytically.
Possible alternative to avoid direct ray tracing simulation step in reconstruction.

- **successfully adopted on CERN data taken through the prototype in the proximity imaging case**
- Using Snell equation, photon hit position is written analytically, and minimised to find ϑ



- Knowing ϑ, Cherenkov angle of hit before refraction can be reconstructed
- **Feasibility in the reflected-light case under investigation (approximations needed)**



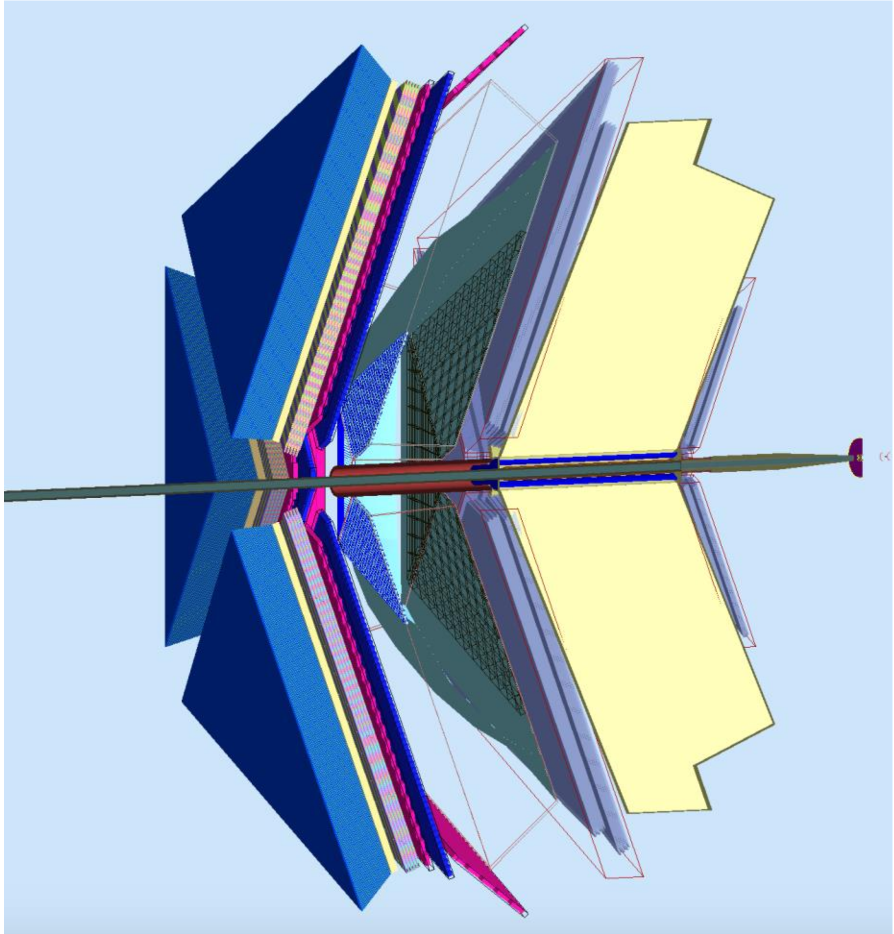


arXiv: 1509.02818 submitted to EPJA

Reconstruction in the CLAS12 environment

Due to the complexity of the indirect ray tracing problem in the final RICH environment (multiple reflections etc) an analytical solution is not feasible.

- Indirect ray tracing can be combined with a fit to estimate, for each detected photon, the angle of emission
- TDC information can be exploited to estimate the number of reflections occurred before the photon hit the PMT
- Particle Identification performances will be tested and optimized during the «commissioning with beam» phase, where very selective PID requests from other subsystem (TOF, EC, DC) can be exploited
- Specific processes will be exploited to test different hadrons: $ep \rightarrow ep$; ${K_0}^S \rightarrow \pi^+\pi^-$; $\Lambda \rightarrow \pi^- p$; $\varphi \rightarrow K^+K^-$



RICH commissioning&calibration

Software for the RICH calibration and monitoring

CALIBRATION
25000 electronic channels will be calibrated using dark counts and charge injectors

- software is being developed, following electronic R&D
- common threshold for 64 channels, individual gains
- working point settings for all the PMT

Calibration results will be stored in the general CLAS12 database

MONITORING
periodic checks to test their stability, variations can be corrected for through adjusting MAROC gains

- digital line: rate spectra vs. threshold
- analog line: ADC single-photon spectrum parameters

Outlook and conclusions

- RICH implementation in the *simulation* framework almost completed (geometry, materials, optical properties). Organized following gemc architecture.

- Implementation of the RICH in the *reconstruction* framework: geometry description is in progress (volumes), structure similar to the one of the other CLAS12 subsystems.

- A *common set of parameters* (geometry dimensions), *materials* and *optical properties* is being mantained to keep consistency among the simulation and reconstruction frameworks

- Reconstruction: a working algorithm (indirect ray tracing) has been identified. It has to be optimized to maximize its efficiency and to minimize the computational time.

- Software to run the calibration and monitoring of the RICH is under development