The CLAS12 RICH
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The RICH design

The goal of the detector is to separate kaons from pions and protons in the momentum range 3-8 GeV/c with rejection power > 500

- Aerogel radiator to match the momentum range
- Hybrid optics: proximity and mirror focusing
- Multi-Anode PMTs

![Diagram of the RICH design](image-url)
RICH project status

Main recent milestones
1) The assembly of the RICH mechanics is started at JLab
   • Thanks to the DSG for their support
2) Electronic production done, characterization tests in progress

Parallel activities
1. Aerogel: got >75% of the 3cm minimum quantity required. Production of the 2cm layer started.
2. Planar Mirrors: 3/5 lateral mirror accepted. 2 front mirror in production.
3. Spherical mirrors: all 10 mirrors accepted. Back to vendor to build support and alignment structure.
4. MA-PMTs: 80 H8500 and 350 H12700 PMTs delivered by Hamamatsu and tested at JLab. All MA-PMTs match the specifications.
5. Software: geometry implementation in the CLAS12 environment mostly done, preliminary reconstruction studies
6. Slow control: design ongoing
Assembly structure completed

March 6
RICH box assembled

March 9:
RICH rotation test

March 10:
RICH in vertical position

March 15
Frontal panels assembly

March 17
Electronic panel installation test

March 21
RICH assembly completed

March 24

The frontal panels have been dismounted and the RICH is back in horizontal position

Ready for the assembly of the Argonne exit panel
MAPMTs

- All H8500/H12700 MAPMTs delivered and tested in the SPE regime with a laser (25000 channels). Parameters stored in CCDB

P. Degtiarenko, arXiv:1608.07525
The RICH readout is based on the 64 channel MAROC front end chip
- single channel adjustable preamp
- highly configurable signal shaping
- binary output after fast shaping with adjustable threshold
- charge measurement available

Readout system organized in tiles serving 2 or 3 MAPMTs

Production completed
- 155 Adapter boards produced (17 spares)
  - basic tests starting
- 155 MAROC boards produced (17 spares)
  - basic tests performed before shipping to JLab (422 chips, 27008 channels)
  - 5/155 boards need further check
  - characterization tests starting
- 152 FPGA produced (14 spares) and tested

PMTs

Adapter Board

ASIC Board

FPGA Board
Digital readout

Fast binary readout for data taking
• TDC information
• time-over-threshold -> charge

Raw measurement

After time walk correction
RMS < 1ns
Analog readout

Slow analog readout available for calibration and monitoring

Single photon spectrum measured with the laser test stand

- excellent charge resolution
- pedestal width at few % of SPE mean
- linear response for few p.e. signals
The aerogel radiator

Large 20x20 cm² tiles assembled in two sectors
- large angle sector: 2 layers of 3 cm thickness, mounted on the carbon fiber panel
- small angles: 1 layer of 2 cm thickness, mounted on the frontal mirrors

- Delivered 75% of the 3cm minimum quantity required.
- Production of the 2cm layer started.
Aerogel characterization

Few samples of the 3 cm production shipped to Fe for full characterization
Optical properties measured at CUA (Washington) on the full production

- All the delivered tiles within the mechanical and optical specifications
- Results of our measurements in agreement with vendor passport data
- Test results stored in the CCDB

Transparency coefficient $A_0$

Difference between our measurement $A_0$ and passport values

$\text{mean} \approx 4 \times 10^{-3}$
The mirror system

Serves to contain all the Cherenkov photons inside the RICH and to reduce the readout area

- Ten spherical mirror
  - total surface $\sim 3.6 \text{ m}^2$
  - two carbon fiber skins
  - production completed
  - send to CMA for the production of the support

- Four lateral and one bottom planar mirrors
  - total surface $\sim 3.7 \text{ m}^2$
  - two glass skins
  - 3 mirrors accepted, last 2 under characterization

- Two frontal planar mirror
  - total surface $\sim 3 \text{ m}^2$
  - two glass skins
  - in production
Spherical mirrors: spot size measurement

All the 10 mirrors well within the specifications
Lateral planar Mirrors

- Sandwich of two thin layers of glass with Al honeycomb core: technology used in telescopes
  - 2x1.6 mm lateral and bottom: standard
  - 2x0.7 mm frontal: specifically developed for CLAS12
- Radiation length comparable with carbon fiber (~1%X₀)
- Much lower costs
RICH software development

RICH geometry implementation from CAD files

The geometry is generated in the java environment, then imported in gemc

- Five sets of volumes have been identified, according to the material:
  - aerogel tiles
  - aerogel wrapping
  - glass mirrors
  - carbon fiber elements
  - aluminum elements

- Stand-alone implementation of MAPMT
- Material properties defined

Hit digitization on the MAPMT photocathode

- calculate the pixel ID
- apply efficiency
- simulate ADC spectrum

Next step
- verify the implementation
- run simulation

To be done:
- spherical mirror implementation
Slow control

Main GUIs to control the RICH Front End electronics

Main GUIs for the gas systems
Summary and timeline

- The RICH mechanics has been assembled, no problems found so far
- The production of the electronics has been completed, characterization tests just started (main activity in the next months)
- Production of the inner components is progressing, completion expected by summer

Installation in CLAS12 is foreseen in September
Backup slides
Single photon spectrum measured with a H12700 on the laser test stand

- Excellent charge resolution
- Pedestal width at few % of SPE mean
- Linear response for few p.e. signals

Fit of the spectrum with a new model of the PMT response

Spherical mirrors: dimensional verification

Sandwich of carbon fiber skins with honeycomb core
- 30% improvement in the material budget with respect to LHCb

Technical specification:
+/- 0.25 mm from CAD model

Results are within less than 1 mm

Can be easily compensated during the assembly phase
Gas systems

RICH Cooling Circuit Diagram with Interlock
(G. Jacobs)

RICH \( \text{N}_2 \) Pure Gas System Diagram
(G. Jacobs)
RICH reconstruction

Preliminary studies with simulations and test beam data to define the best PID algorithm

Reconstruction scheme
Stage 1: translate raw data in spatial and time information for each RICH hits
Stage 2: perform particle ID

- Input data:
  - list of charged tracks entering the RICH
  - list of know particles from other detectors (electrons, low energy hadrons)
  - geometry of the RICH

- Output
  - event likelihood for a given set of mass hypothesis