The CLAS12 RICH
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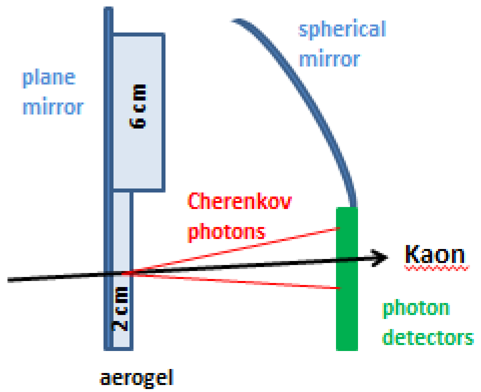
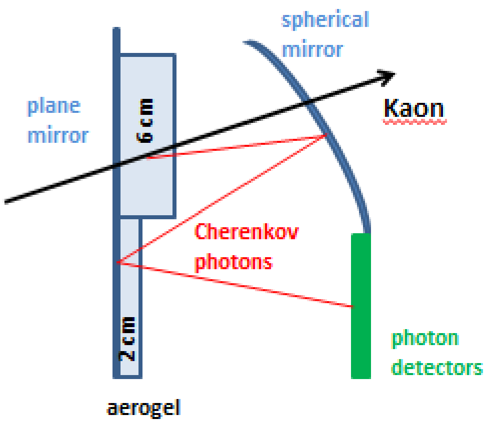
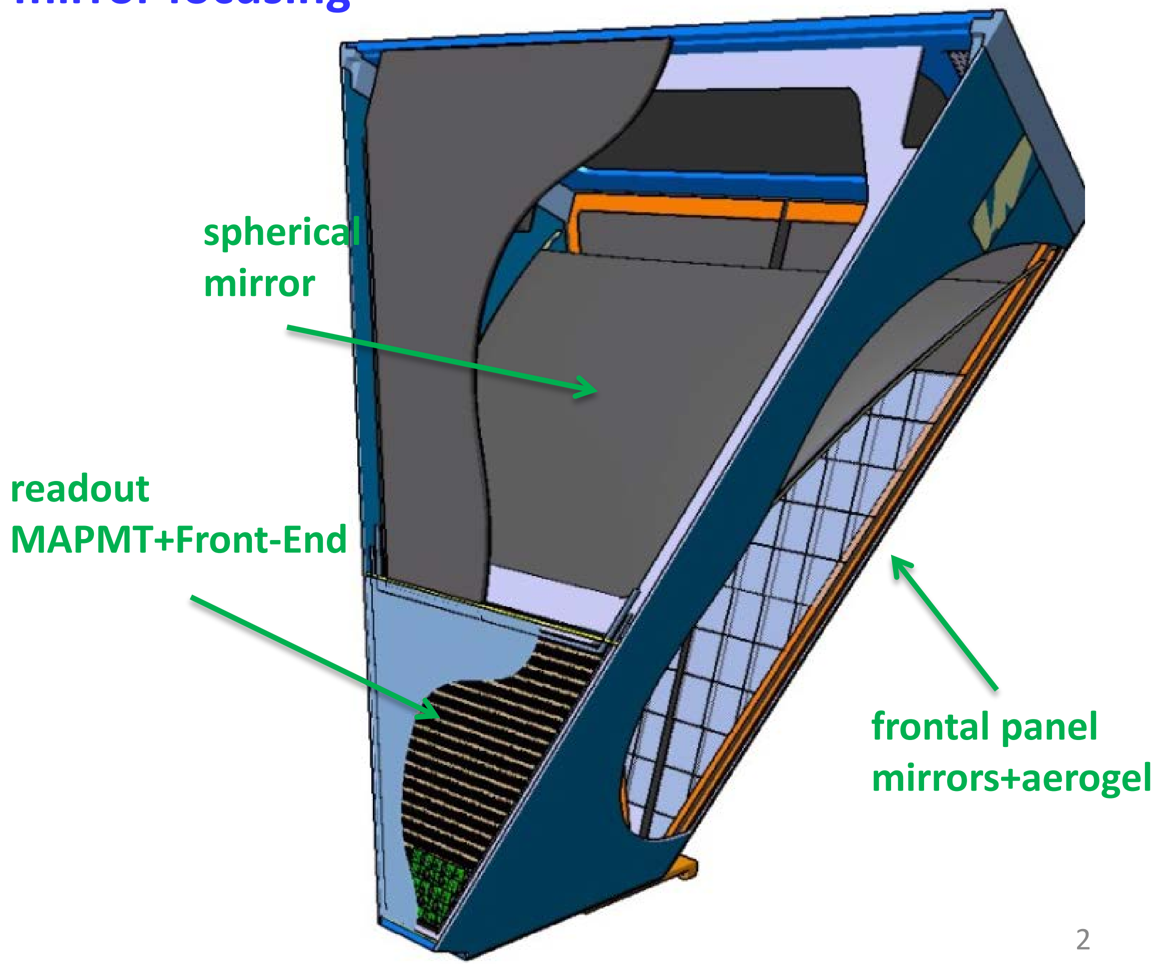
The RICH design

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







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

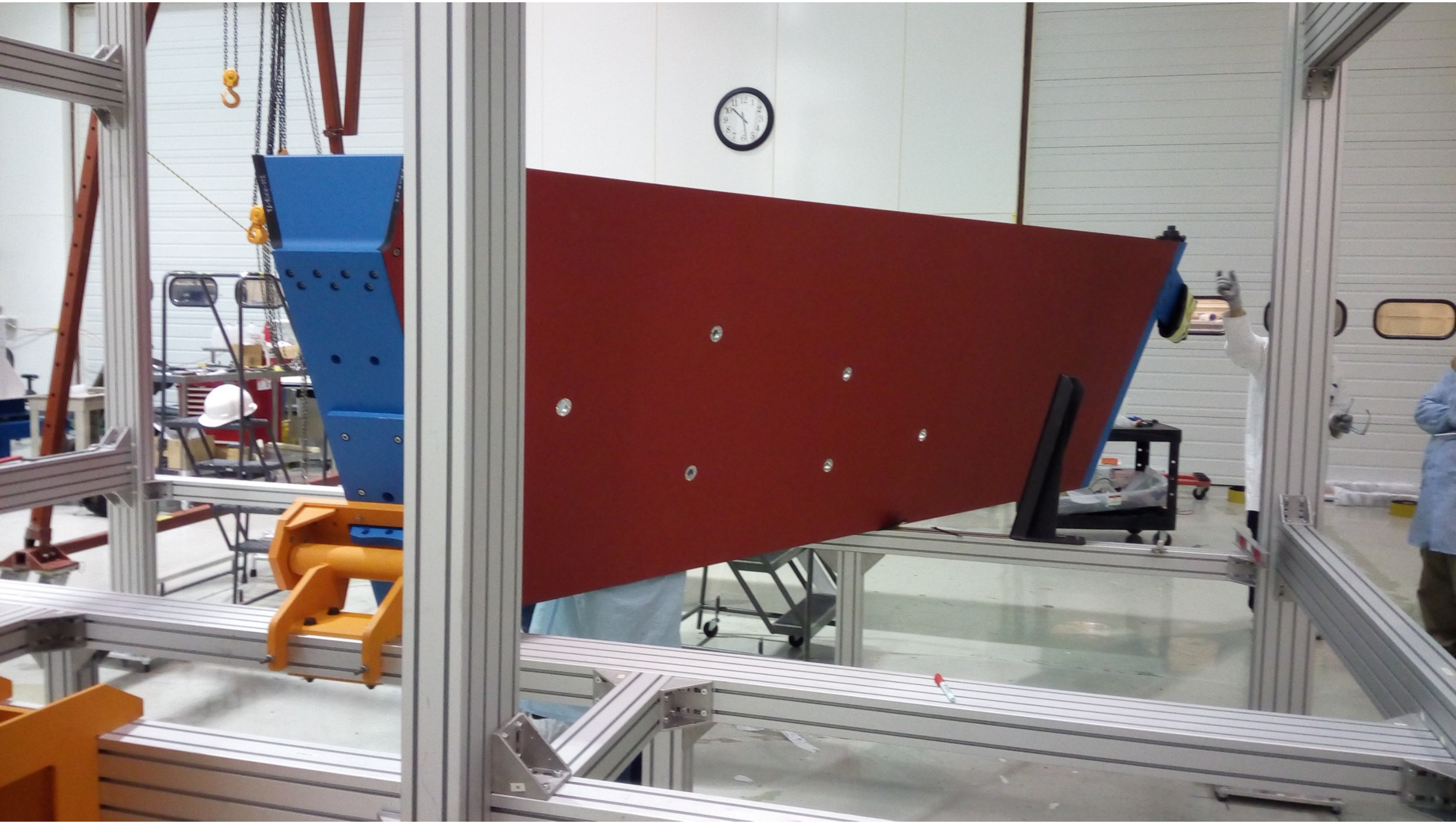
1. ***Aerogel*: got >75 % of the 3cm minimum quantity required. Production of the 2cm layer started.**
2. ***Planar Mirrors*: 3/5 lateral mirror accepted. 2 front mirror in production.**
3. ***Spherical mirrors*: all 10 mirrors accepted. Back to vendor to build support and alignment structure.**
4. ***MA-PMTs*: 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

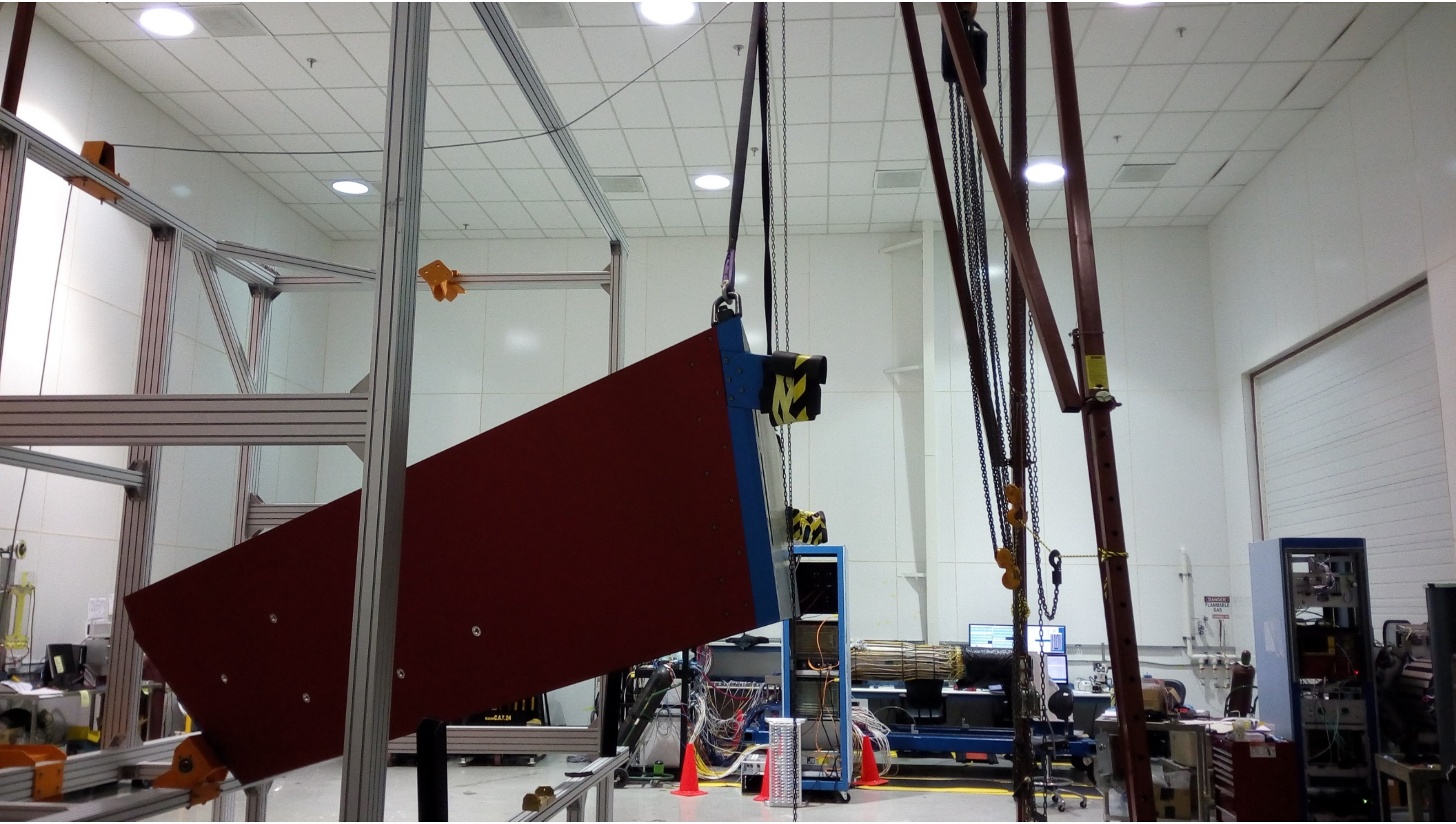
RICH box assembled

March 9:



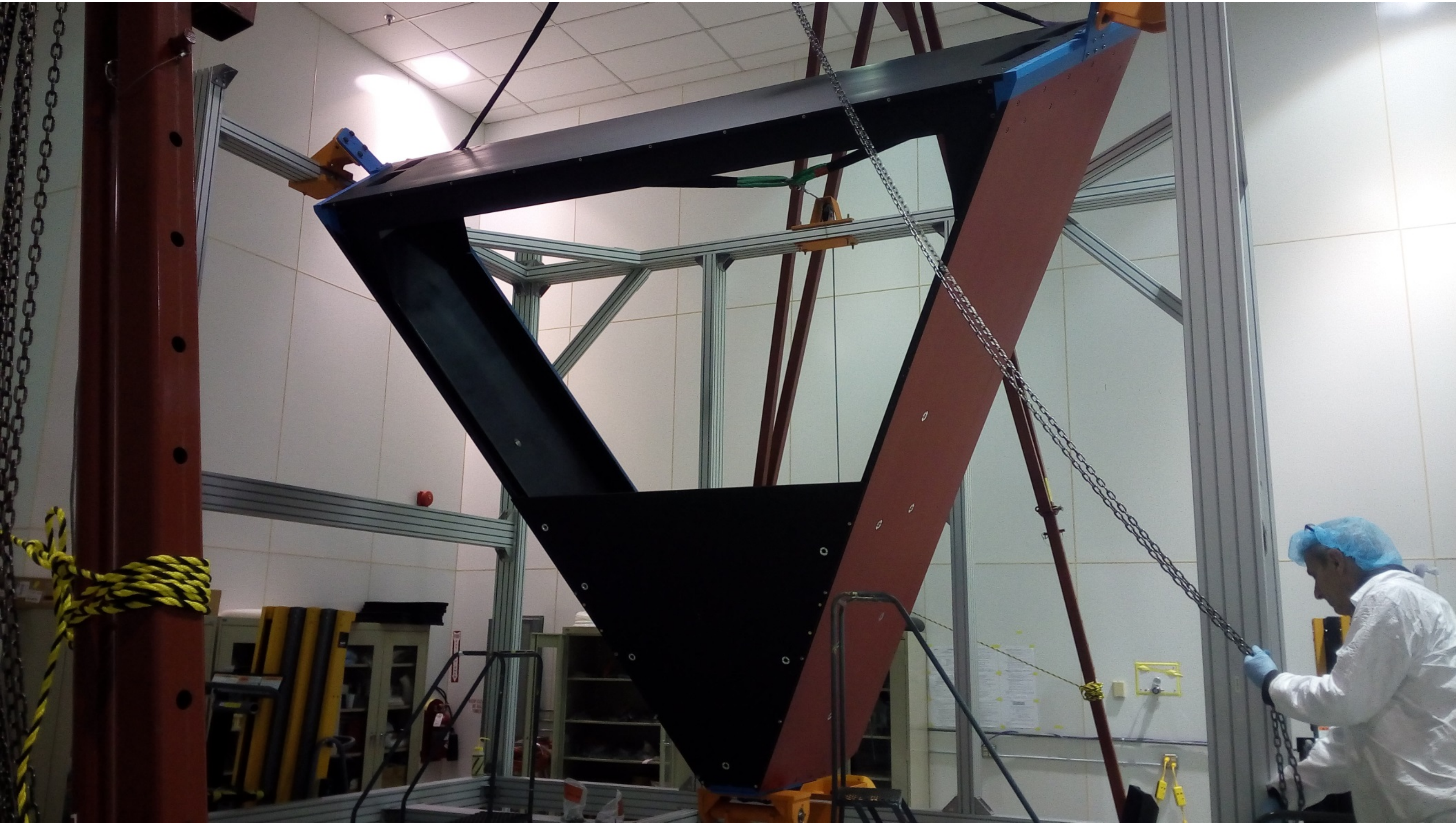
RICH rotation test

March 10:



RICH in vertical position

March 15

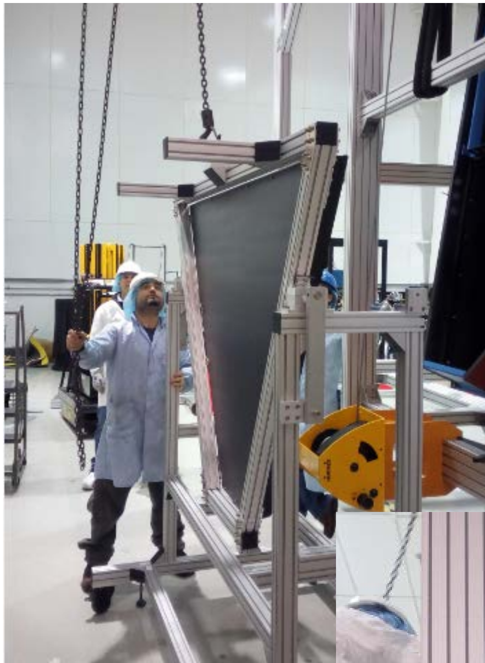


Frontal panels assembly

March 17

Electronic panel installation test

March 21



RICH assembly completed

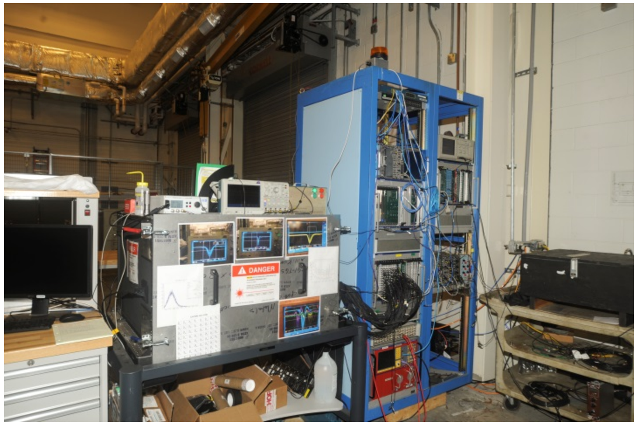
March 24

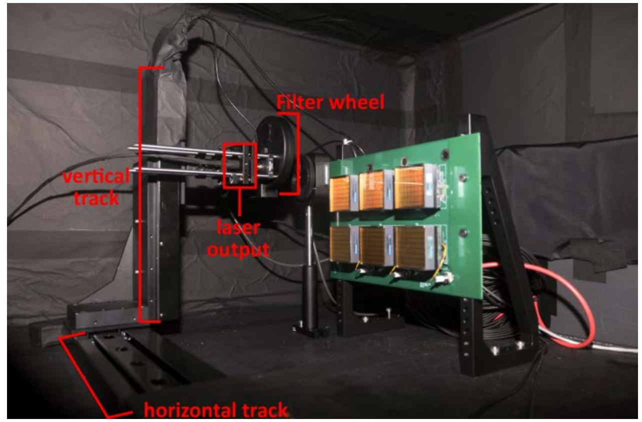
The frontal panels have been dismounted and the RICH is back in horizontal position

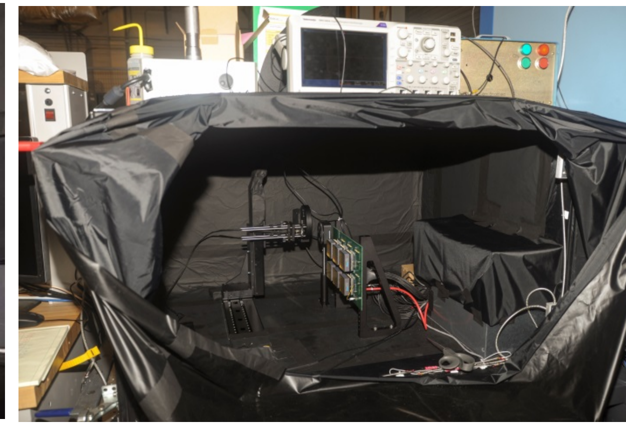
Ready for the assembly of the Argonne exit panel

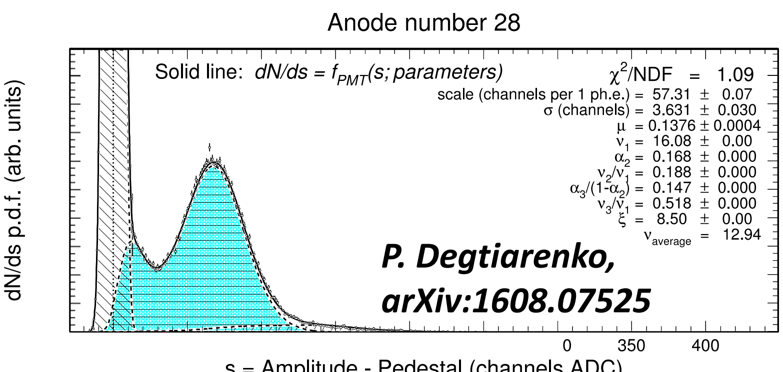
MAPMTs

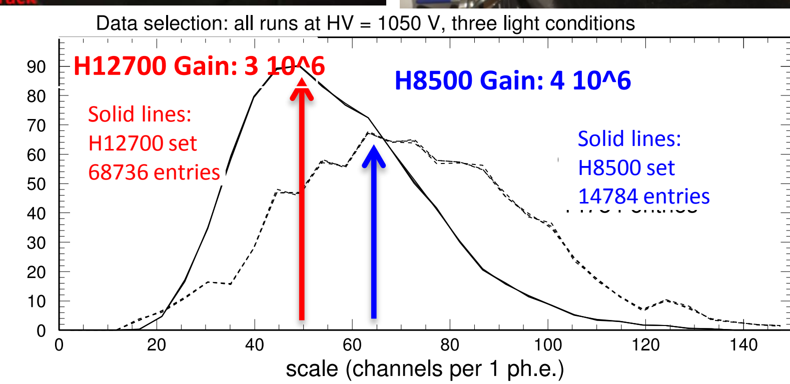
- **All H8500/H12700 MAPMTs delivered and tested in the SPE regime with a laser (25000 channels). Parameters stored in CCDB**

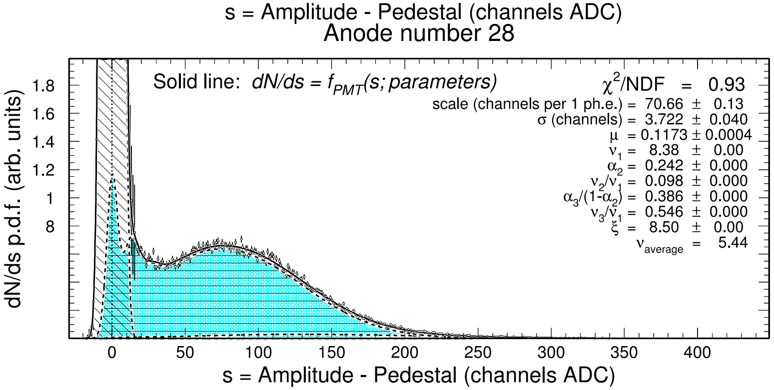


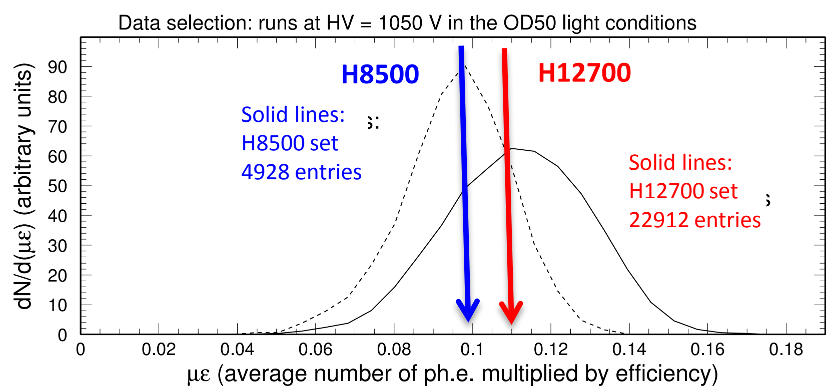












Readout electronics

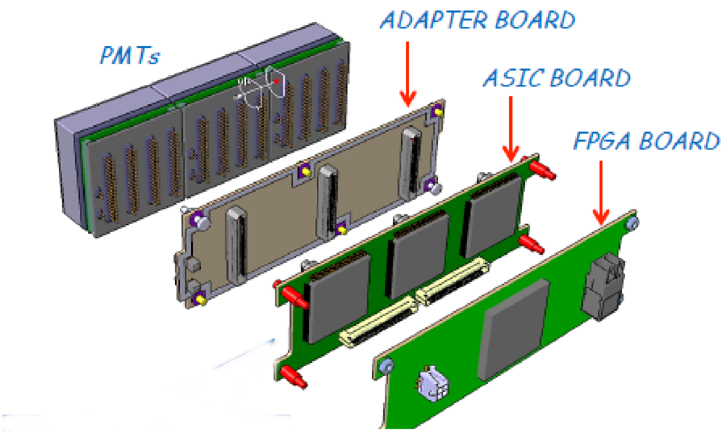
The RICH readout is based on the 64 channel MAROC front end chip

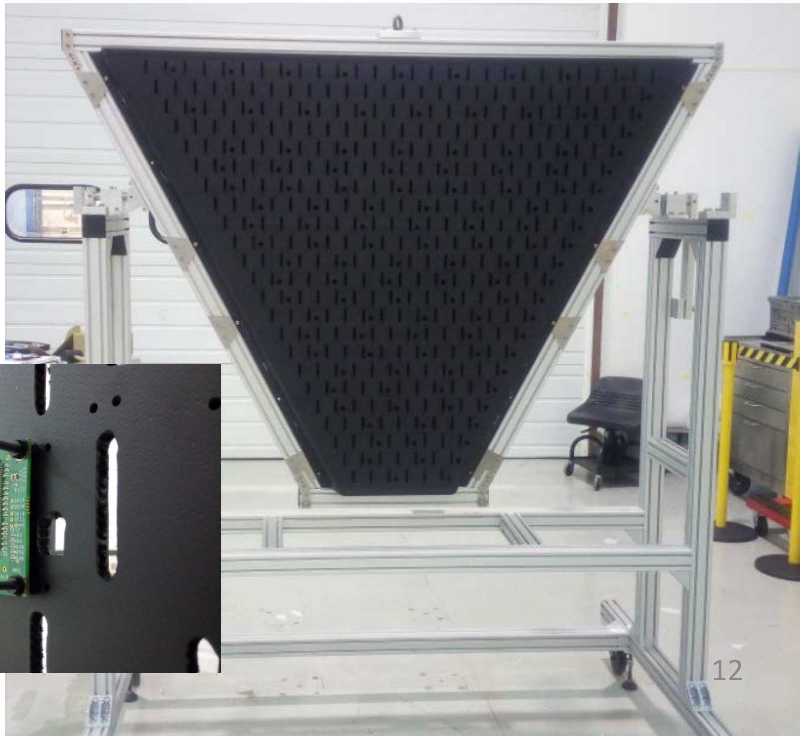
- single channel adjustable preamp
- highly configurable signal shaping
- binary output after fast shaping with adjustable threshold
- charge measurement available

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



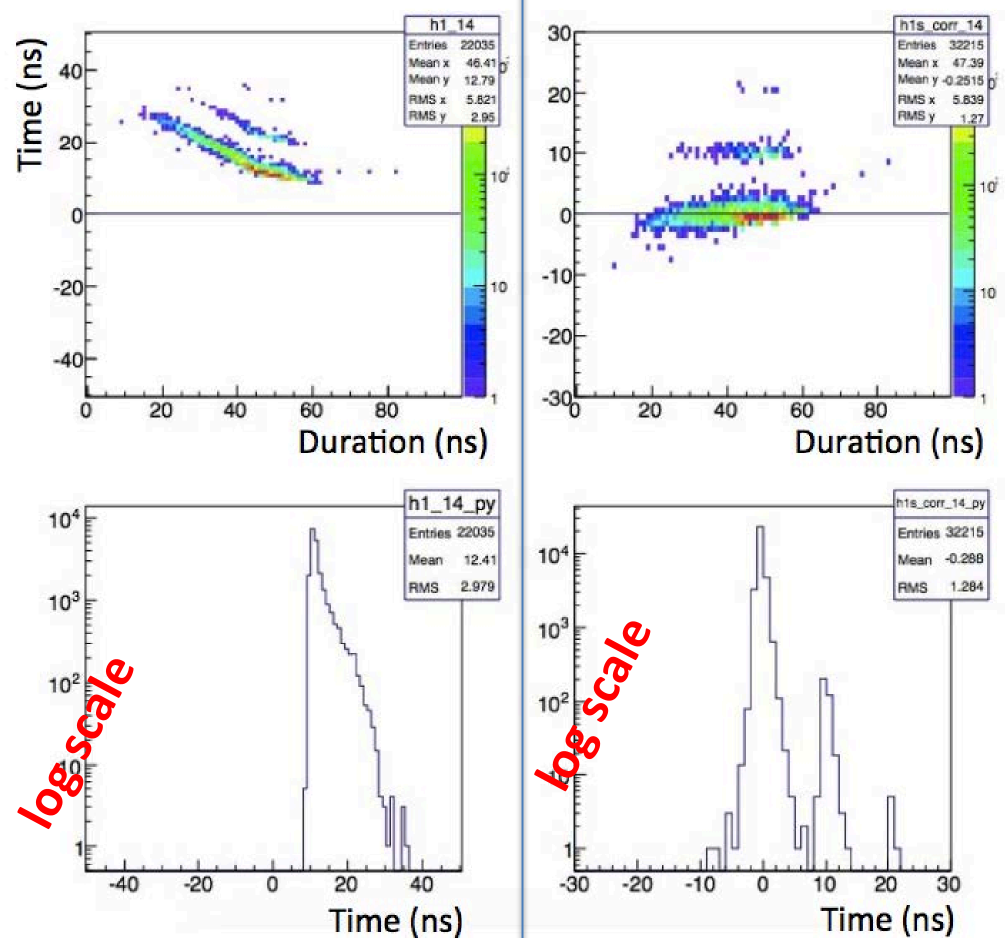


Digital readout

Fast binary readout for data taking

- **TDC information**
- **time-over-threshold -> charge**

Raw measurement

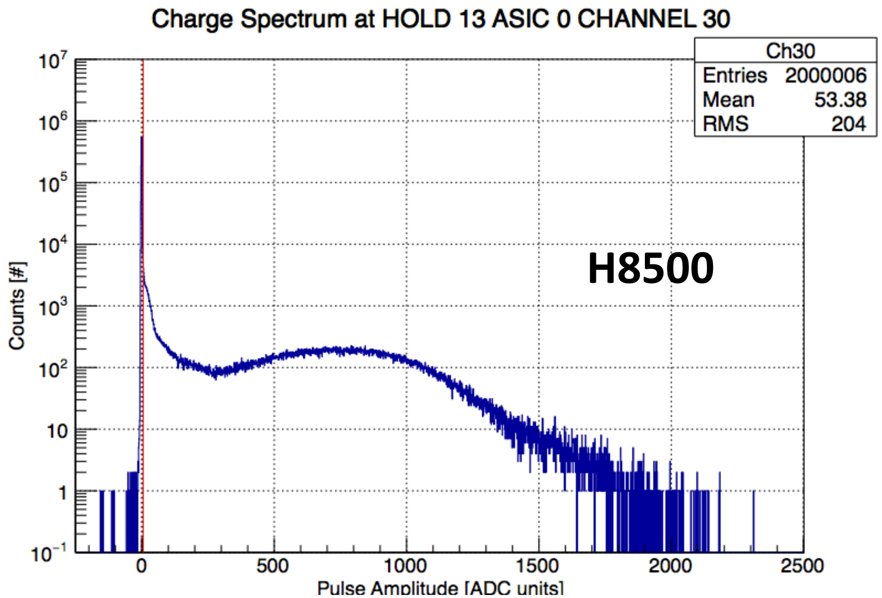


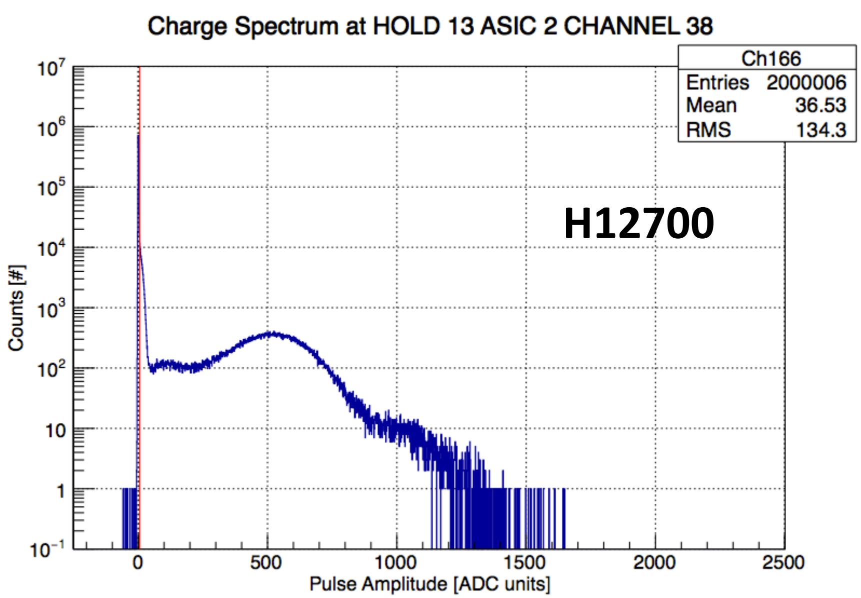
After time walk correction

RMS < 1ns

Analog readout

Slow analog readout available for calibration and monitoring





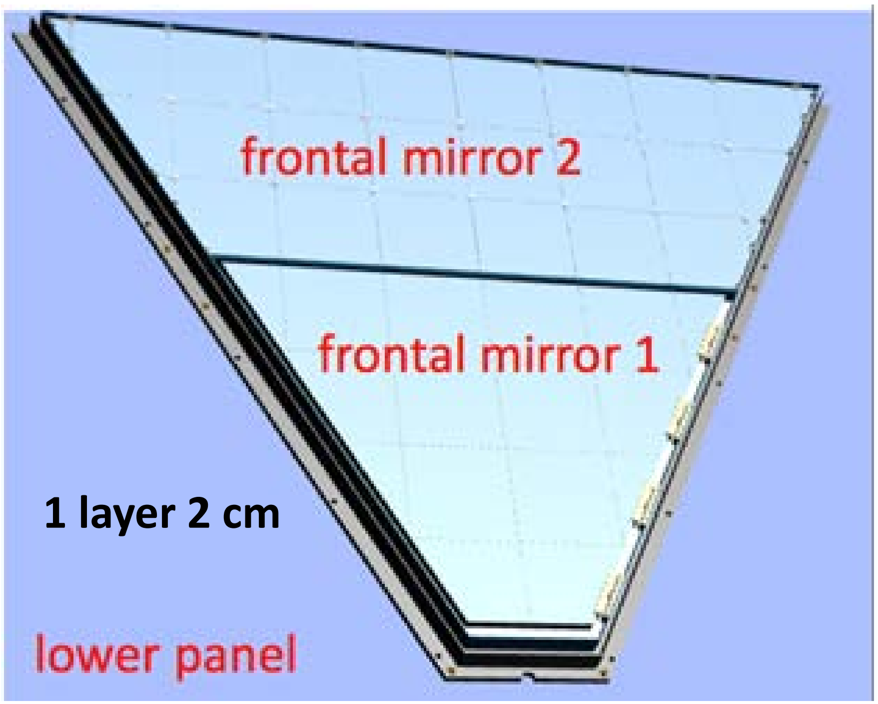
Single photon spectrum measured with the laser test stand

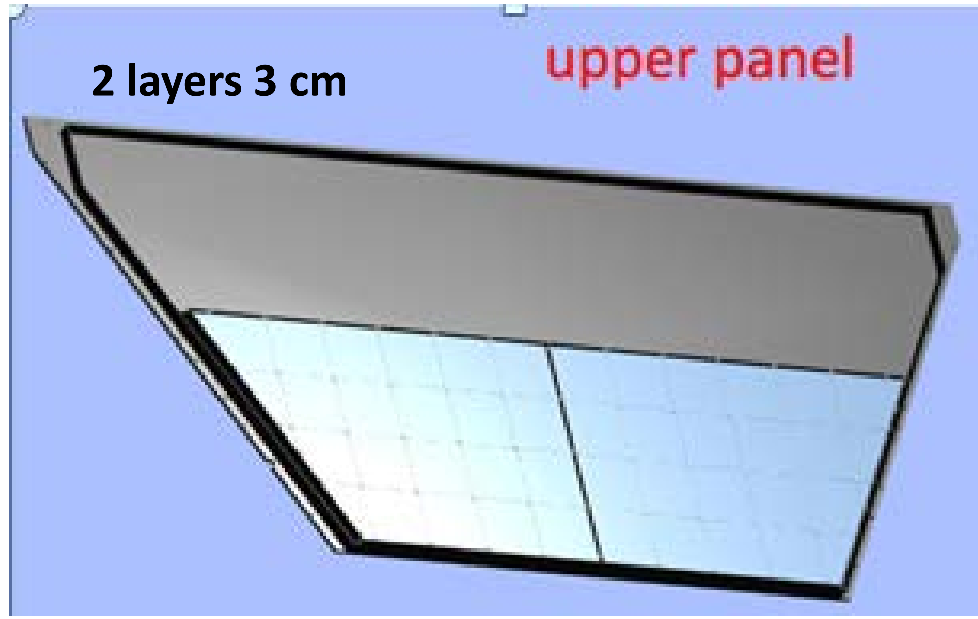
- excellent charge resolution
- pedestal width at few % of SPE mean
- linear response for few p.e. signals

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



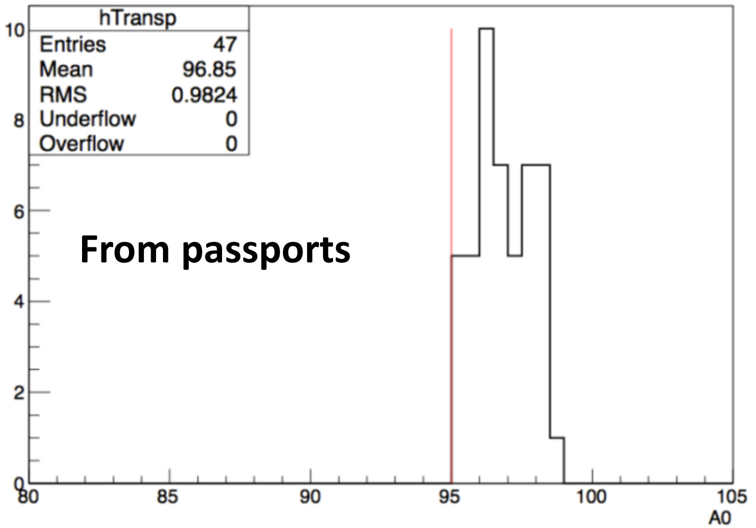


- Delivered 75% of the 3cm minimum quantity required.
- Production of the 2cm layer started.

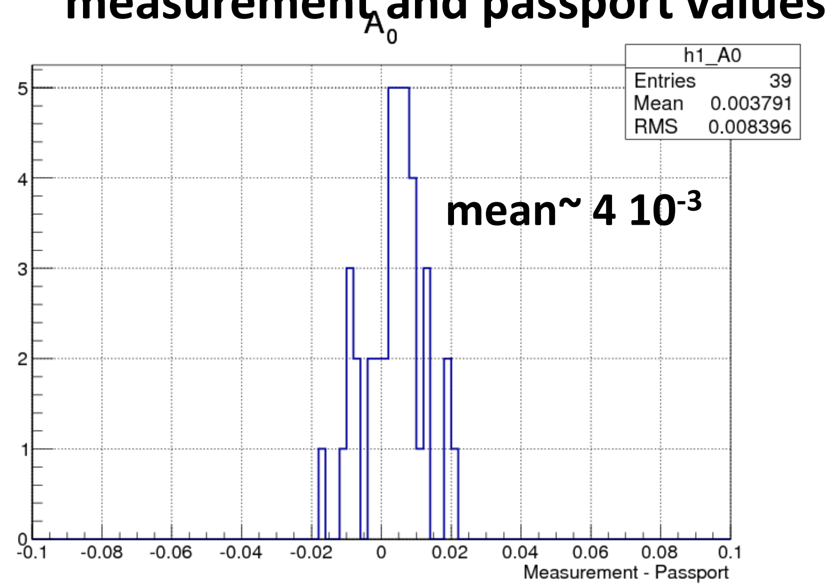
Aerogel characterization

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

Transparency coefficient A0



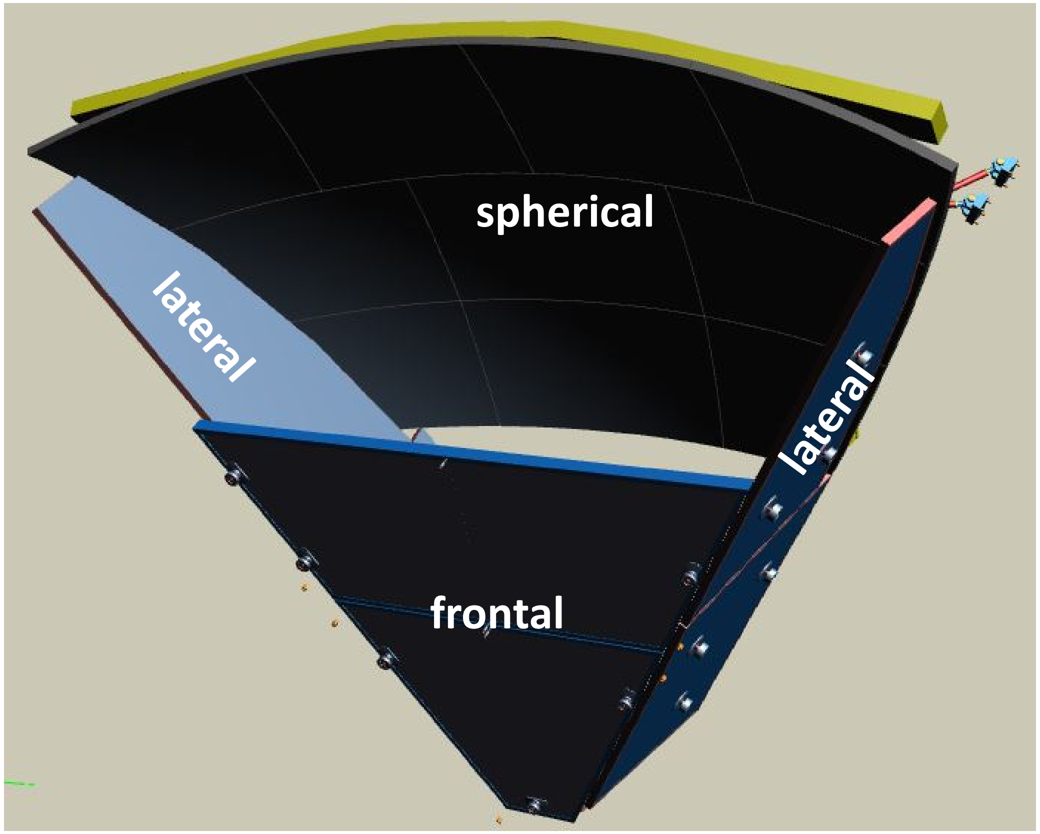
Difference between our measurement and passport values



- ➢ 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

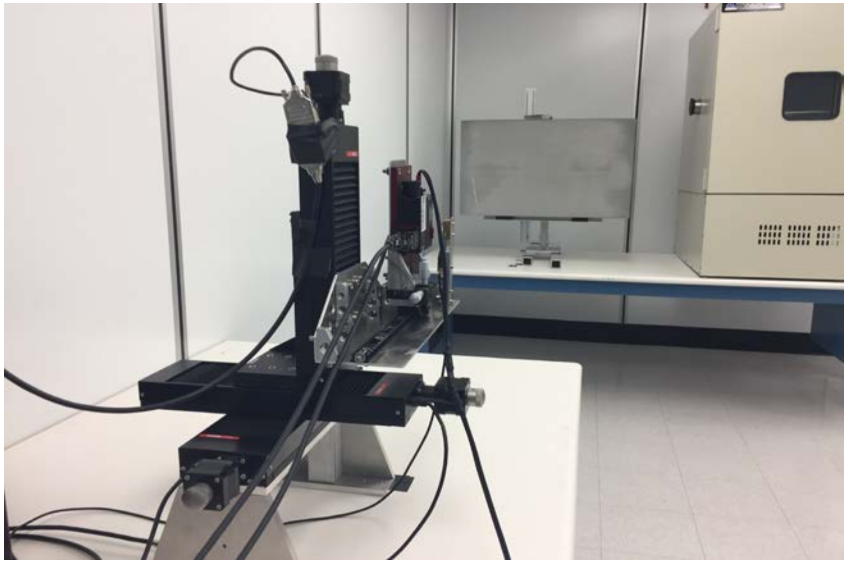
The mirror system

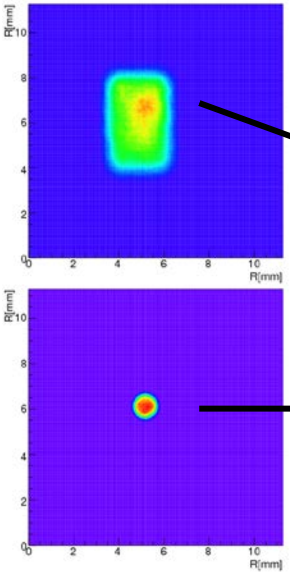
Serves to contains all the Cherenkov photons inside the RICH and to reduce the readout area



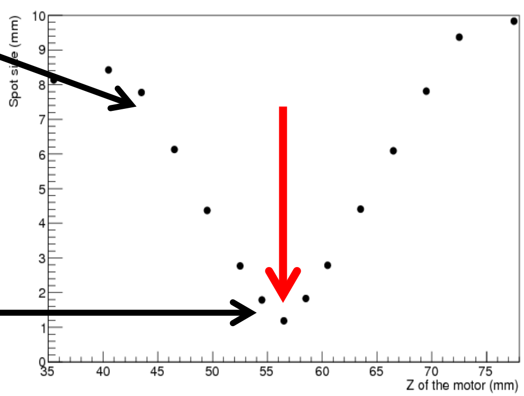
- **Ten spherical mirror**
  - **total surface ~3.6 m^2**
  - **two carbon fiber skins**
  - **production completed**
  - **send to CMA for the production of the support**
- **Four lateral and one bottom planar mirrors**
  - **total surface ~3.7 m^2**
  - **two glass skins**
  - **3 mirrors accepted, last 2 under characterization**
- **Two frontal planar mirror**
  - **total surface ~3 m^2**
  - **two glass skins**
  - **in production**

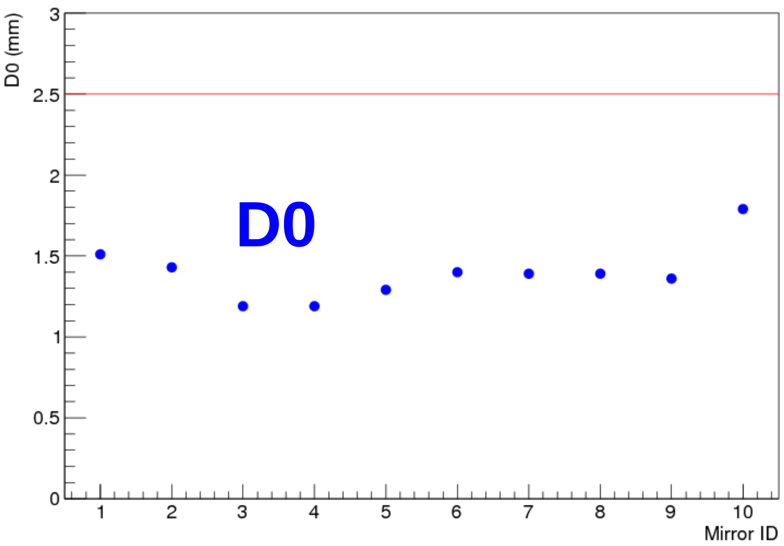
Spherical mirrors: spot size measurement

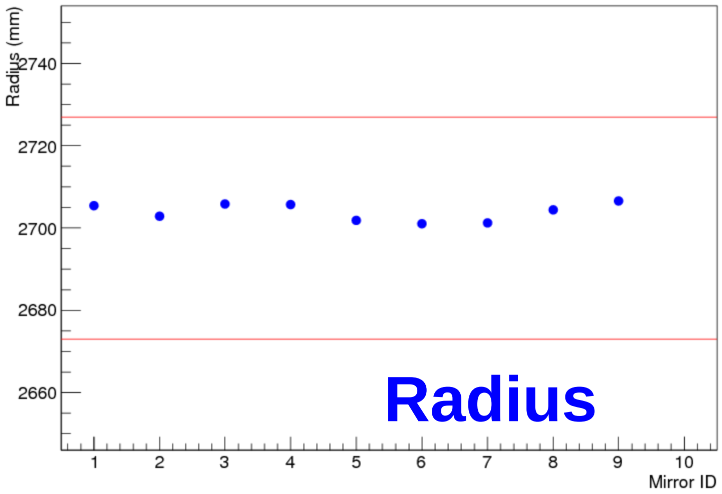




spot size vs z



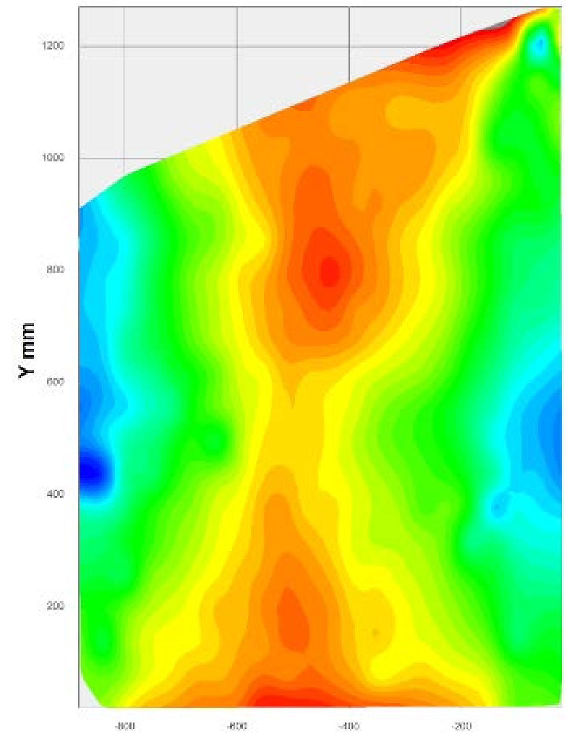


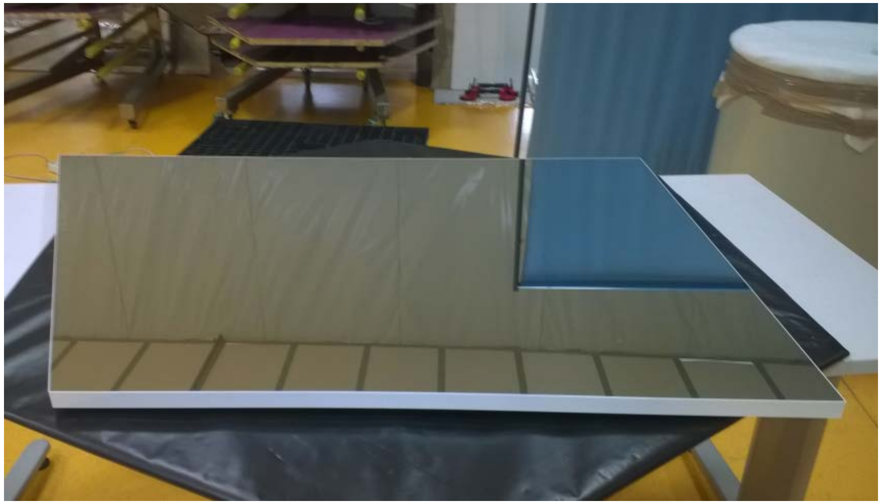


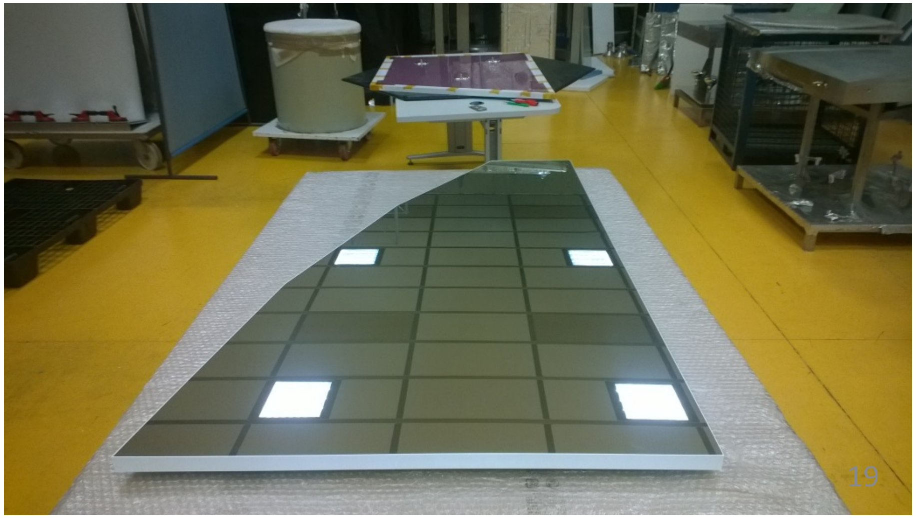
All the 10 mirrors well within the specifications

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: <u>specifically developed for CLAS12</u>**
- ➢ **Radiation length comparable with carbon fiber ($\sim 1\% X_0$)**
- ➢ **Much lower costs**





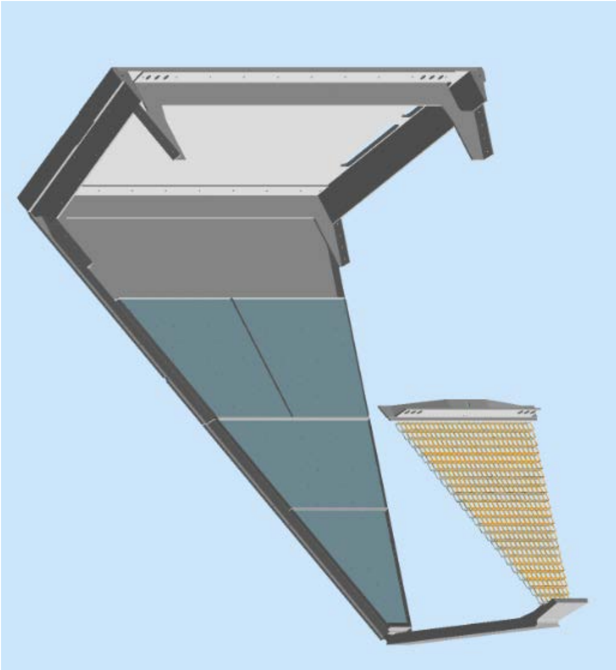


RICH software development

RICH geometry implementation from CAD files

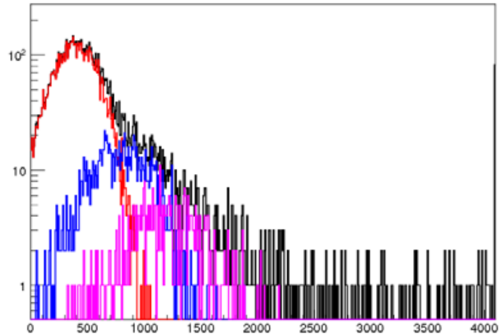
The geometry is generated in the java environment, then imported in gemc

- 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

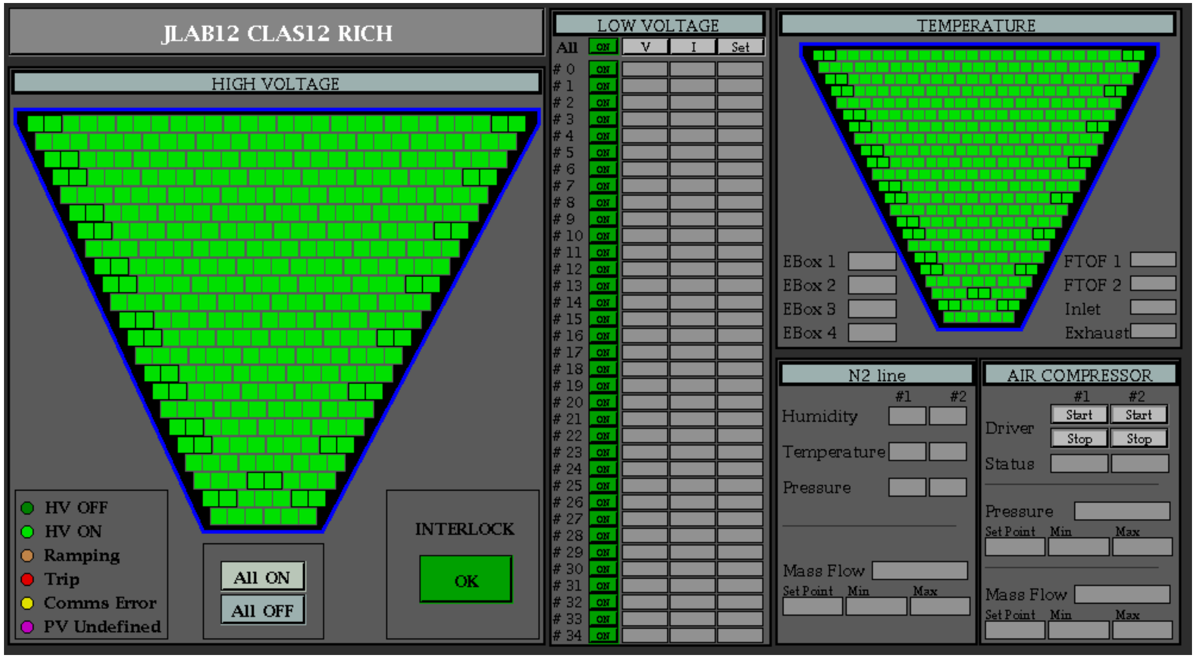
- calculate the pixel ID
- apply efficiency
- simulate ADC spectrum



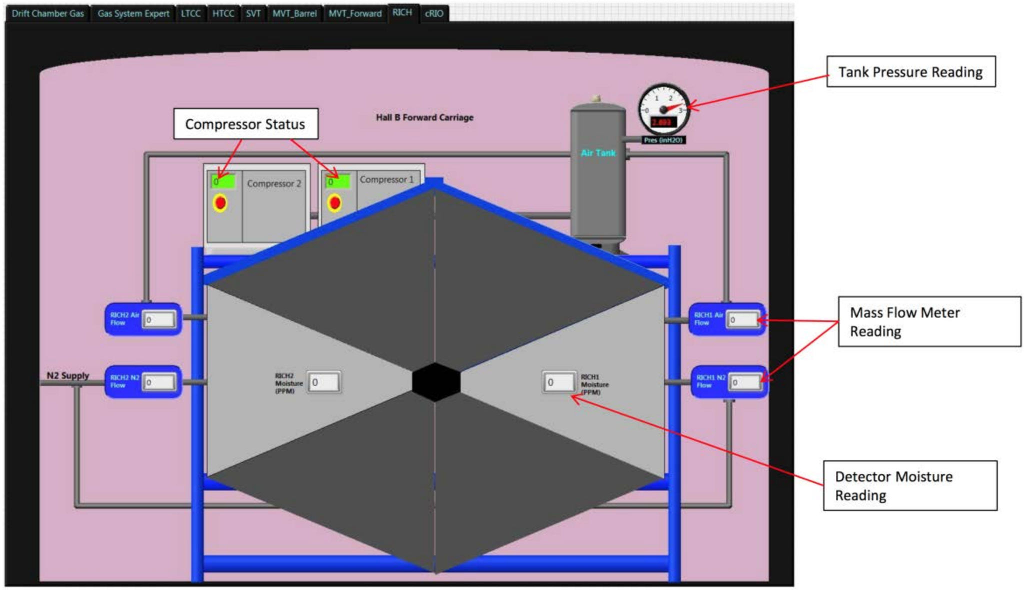
Next step
- verify the implementation
- run simulation

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

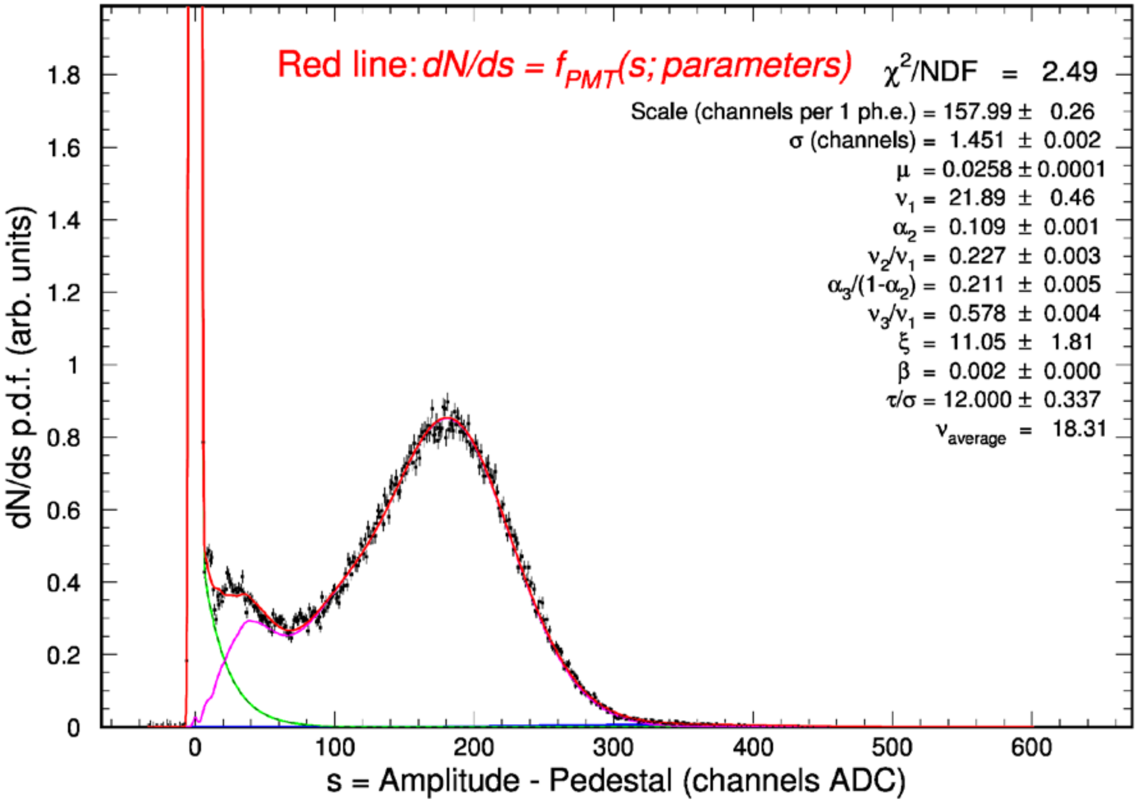
- **The RICH mechanics has been assembled, no problems found so far**
- **The production of the electronics has been completed, characterization tests just started (main activity in the next months)**
- **Production of the inner components is progressing, completion expected by summer**

Installation in CLAS12 is foreseen in September

Backup slides

MAPMT

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

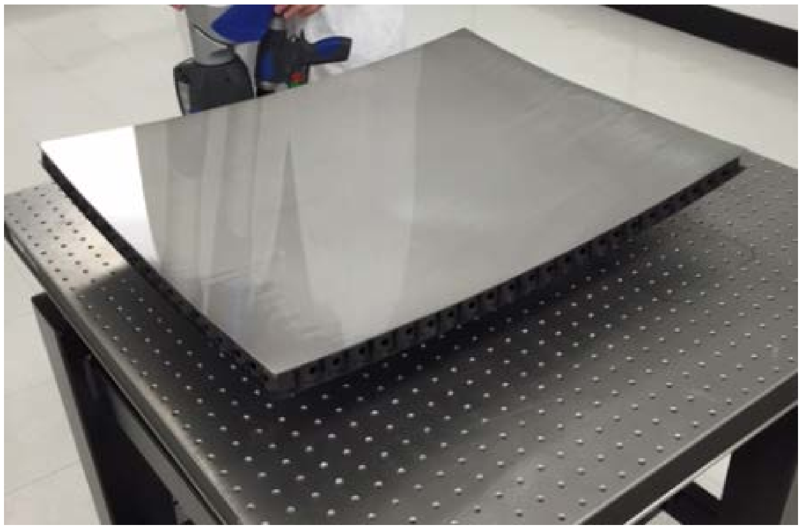
Fit of the spectrum with a new model of the PMT response

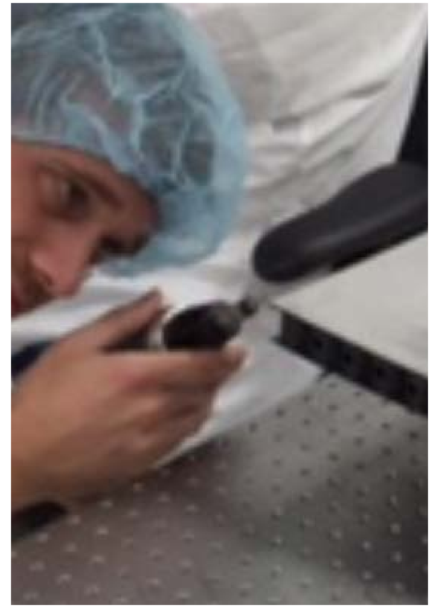
P. Degtiarenko, arXiv:1608.07525, submitted to NIM

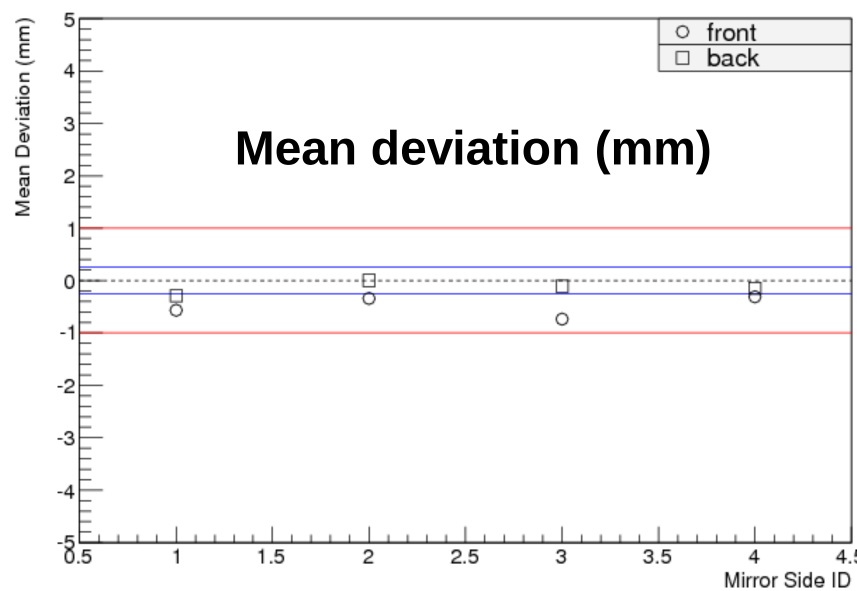
Spherical mirrors: dimensional verification

Sandwich of carbon fiber skins with honeycomb core

- 30% improvement in the material budget with respect to LHCb





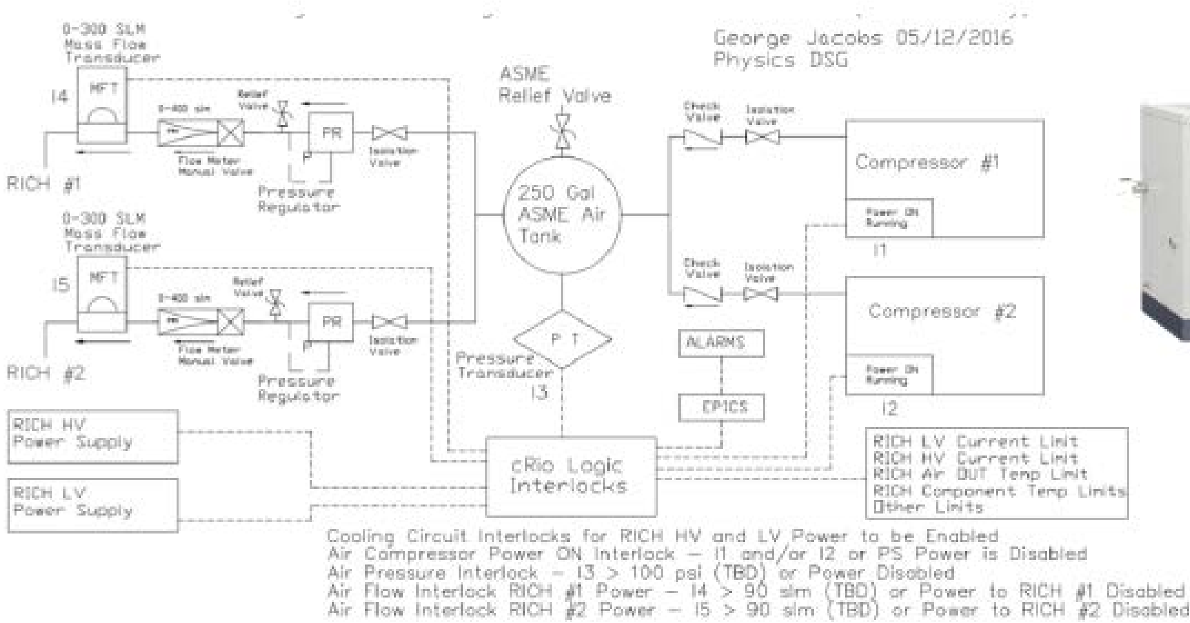


Technical specification:
+/- 0.25 mm from CAD model

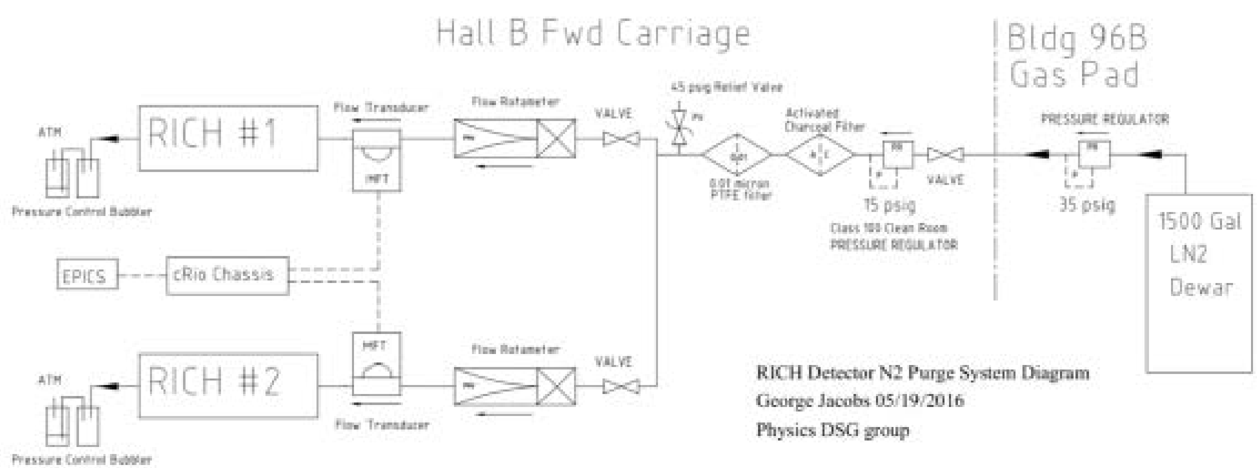
Results are within less than 1 mm

Can be easily compensated during the assembly phase

Gas systems



RICH Cooling Circuit Diagram with Interlock (G. Jacobs)



RICH 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**