

# RICH Detector

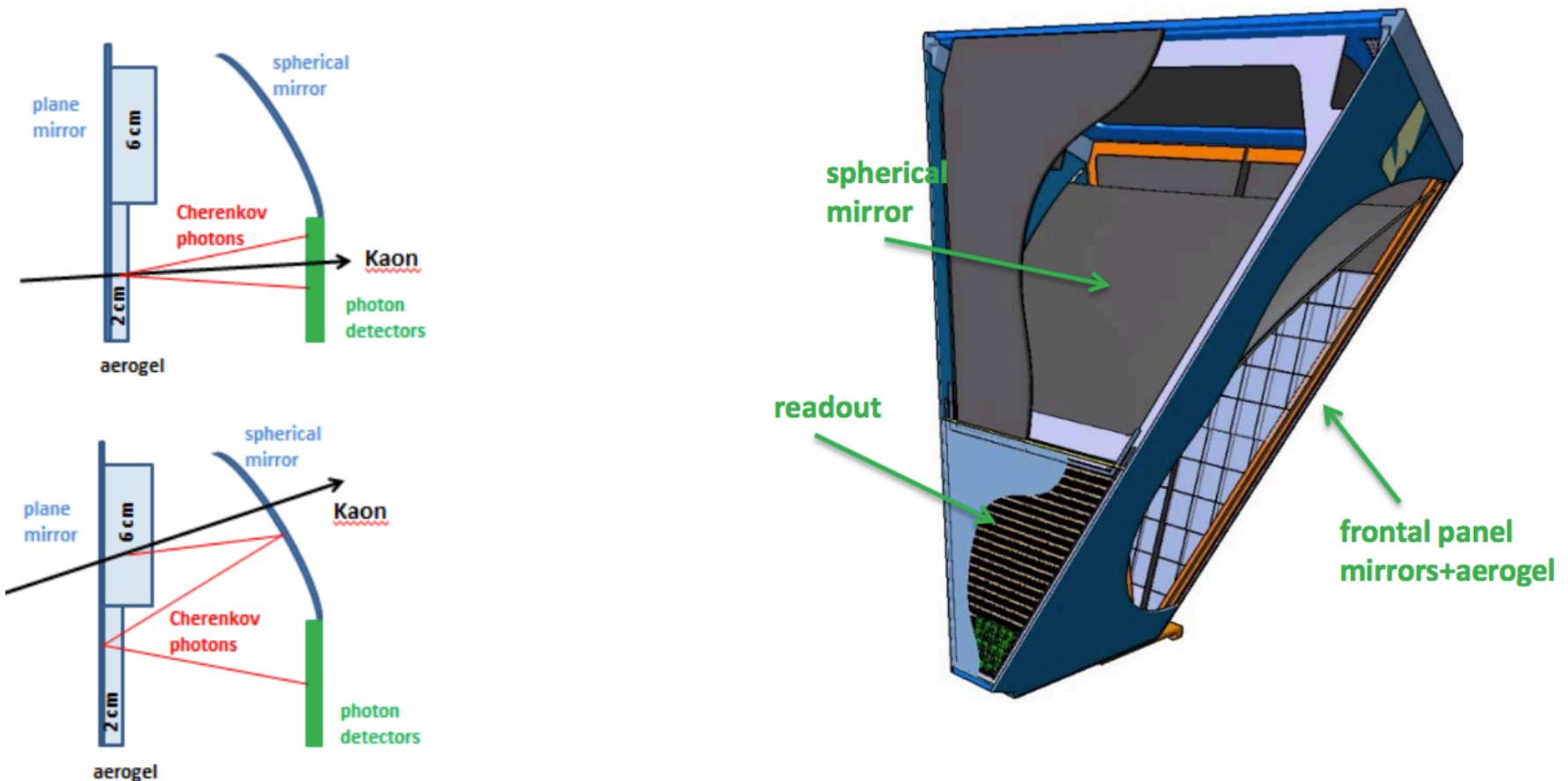
M. Contalbrigo  
INFN Ferrara

CLAS Collaboration Meeting  
13-16 June 2017

# 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



# Mechanic Assembling

- ✓ External RICH vessel assembled in EEL-124
- ✓ Entrance, exit and electronic panels ready

Thanks to DSG group!

Entrance bottom



Entrance top



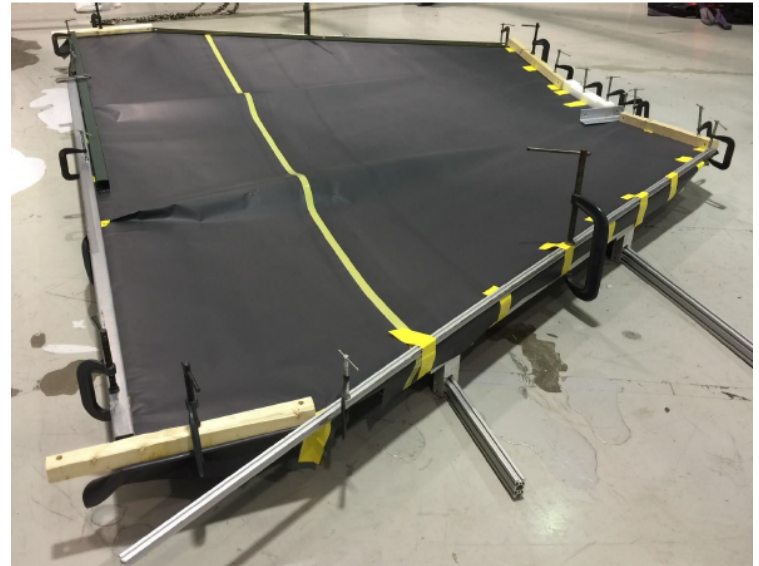
Electronic Panel





# Exit Panel

External Al structure + Tedlar (DSG + Argonne)





# Gas System

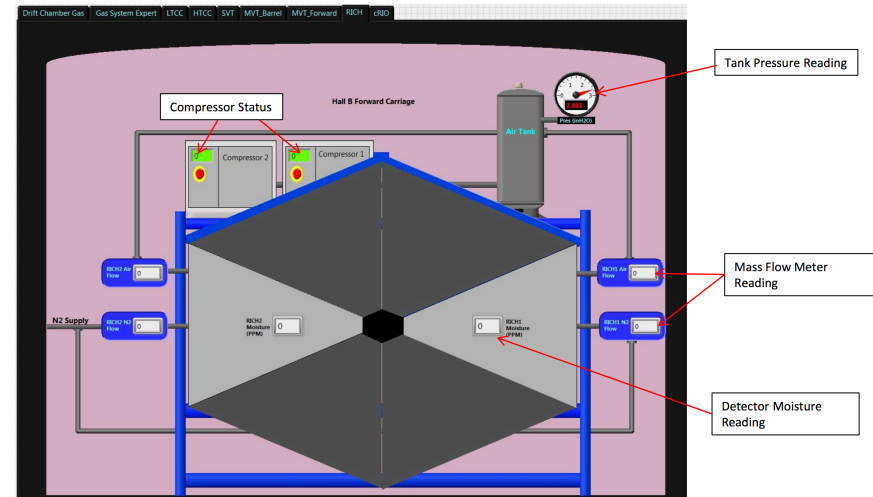
- ✓ Gas system being installed in EEL-124 (DSG)

Operative test foreseen in August 17  
with fully instrumented electronic panel

## Air Tank and Gas Line Controls



## Gas System GUI

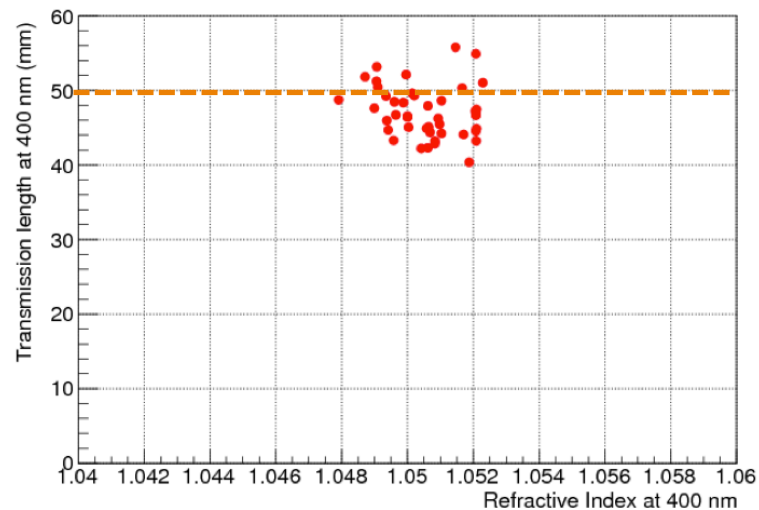
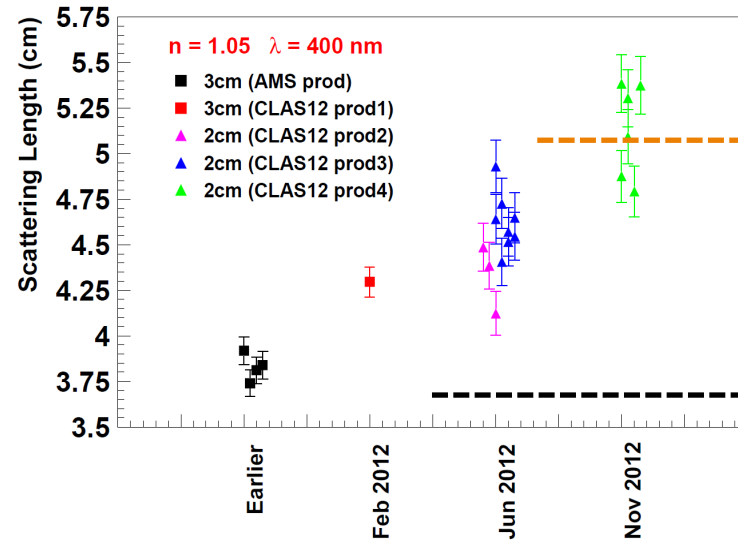
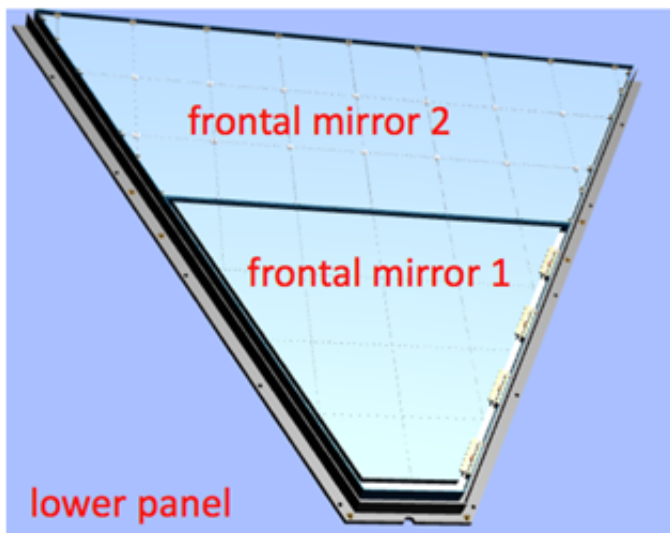
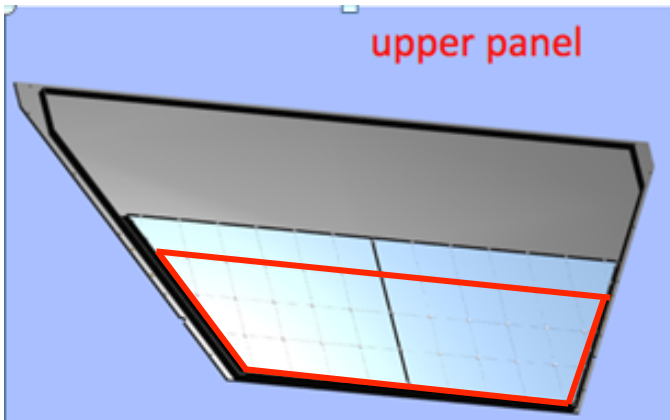


## Clean Air Compressor



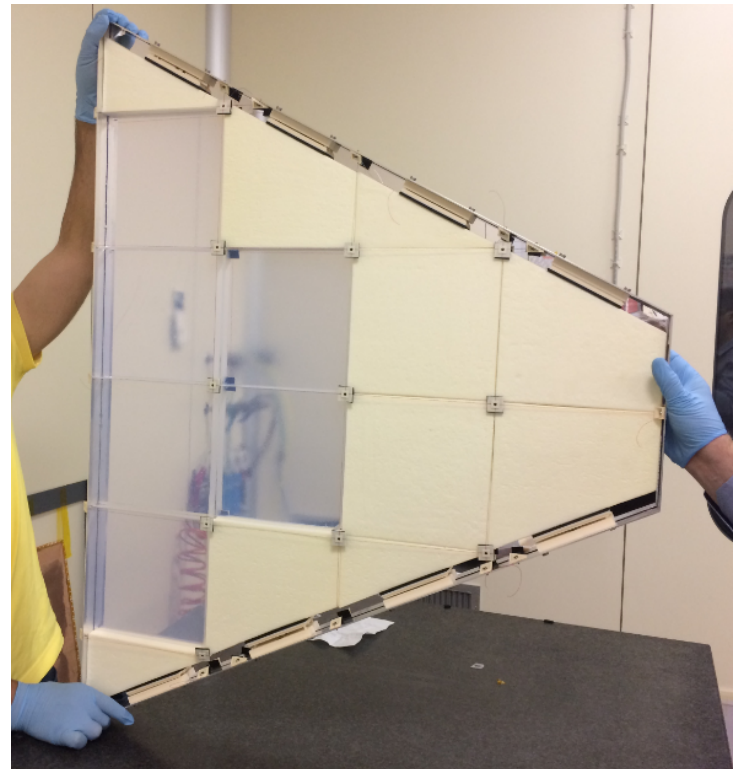
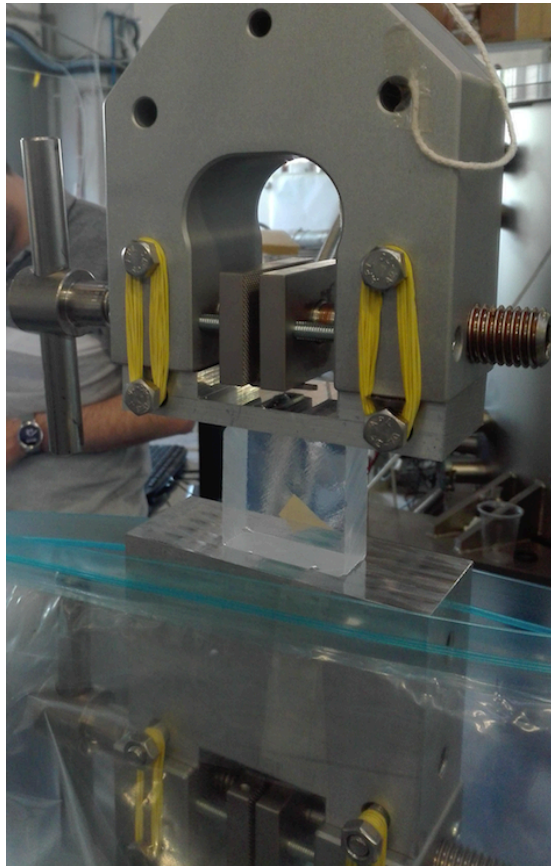
# Aerogel

- ✓ Production of 3 cm: minimal quantity achieved  
All delivered tiles within specifications
- ✓ Production of 2 cm: ongoing  
Completion expected beginning of August



# Aerogel

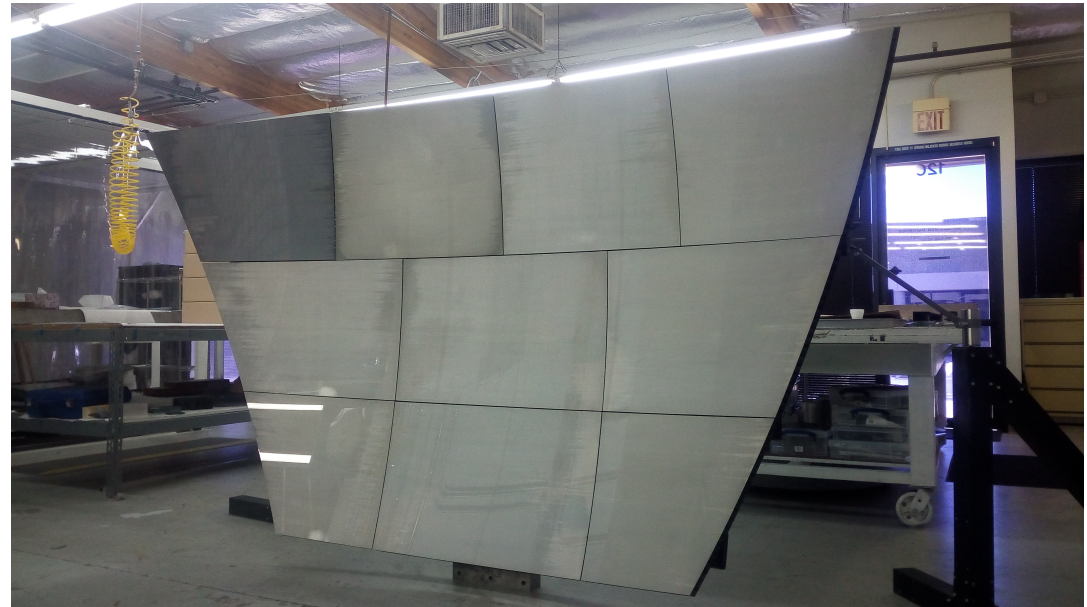
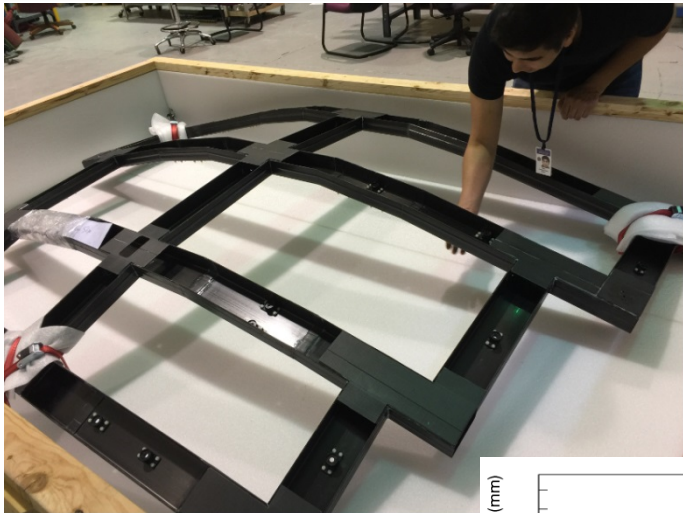
- ✓ Mechanical stress tests  
Can sustain compressions much bigger than planned
- ✓ First assembly test performed  
Safe rotations up to  $10^\circ$  beyond vertical



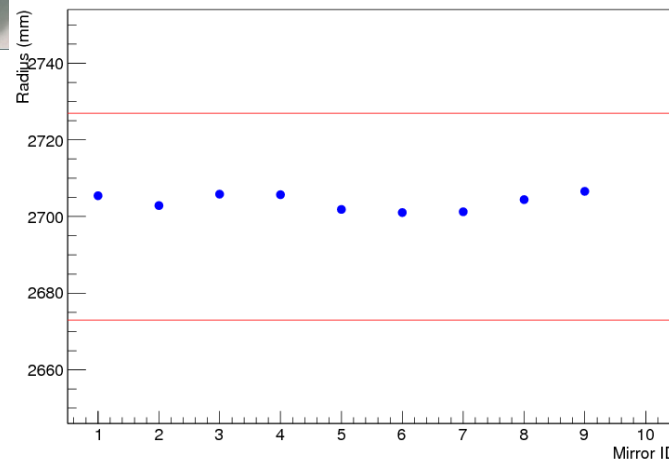


# Spherical Mirrors

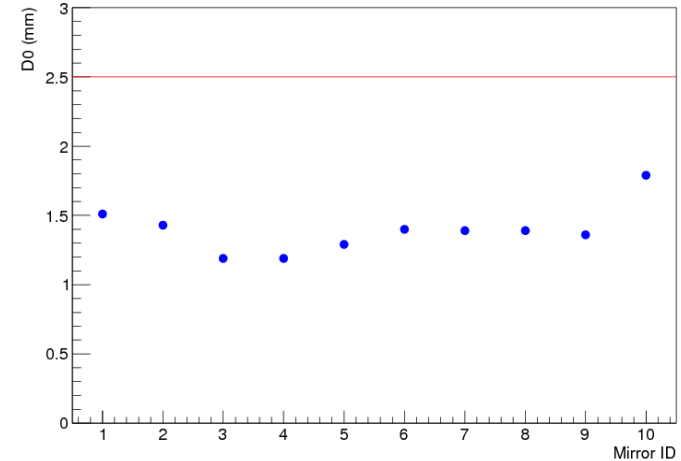
- ✓ All 10 mirror produced  
30% less areal density vs LHCb  
Specifications met
- ✓ Support structure delivered
- ✓ Coating ongoing @ ECI



Radius, specs  $\pm 1\%$



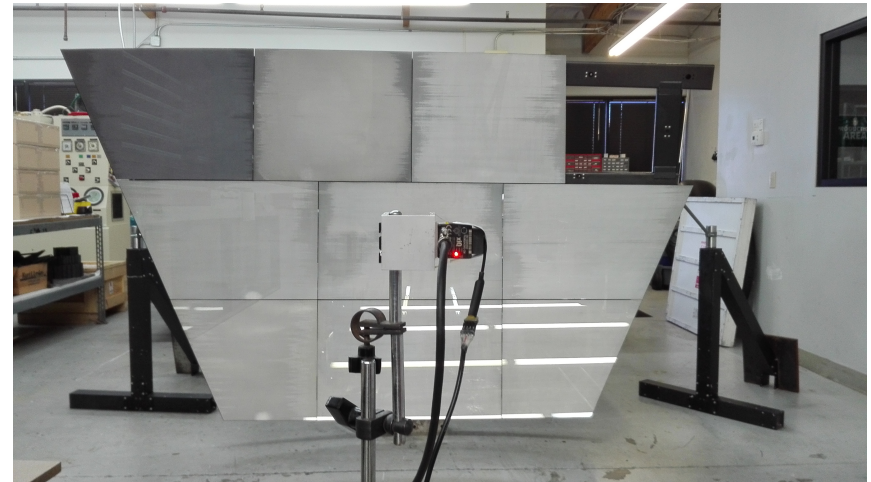
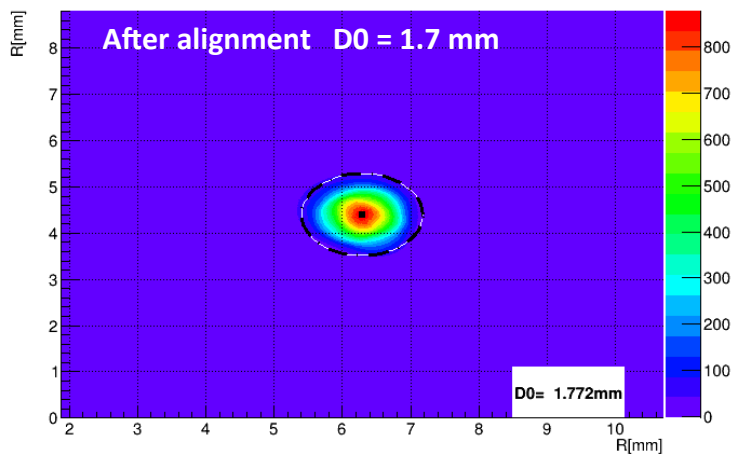
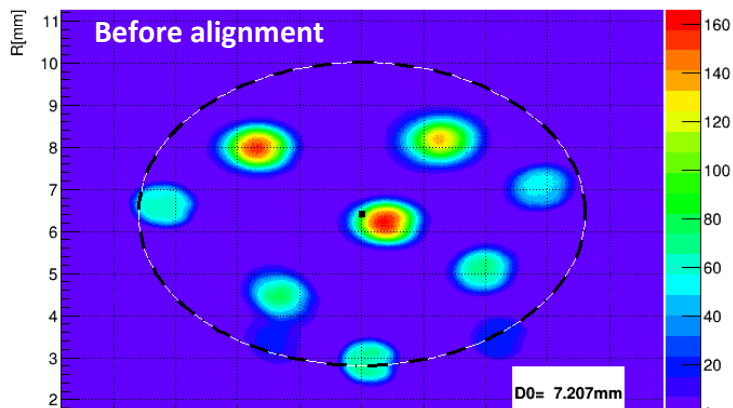
Reflected spot size, specs  $< 2.5$  mm



# Alignment

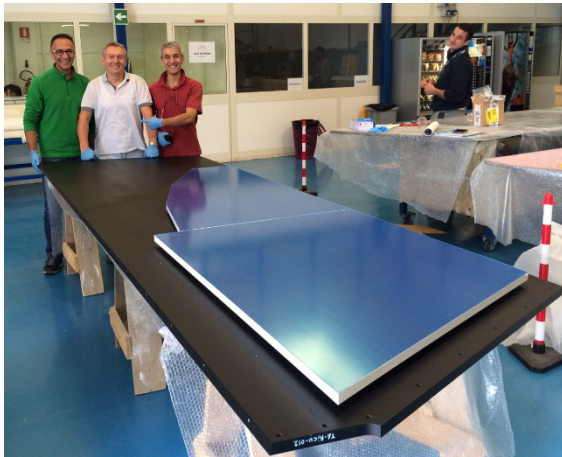
✓ Effective procedure (~ 20 min)

Uncoated 3.5 m<sup>2</sup> composite mirror achieves a point-like image comparable to single mirror  
<< 5 mm specs

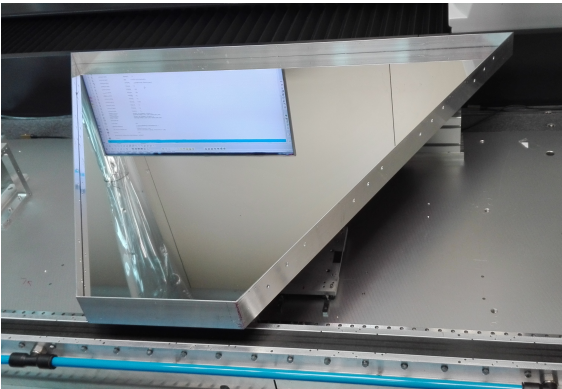


# Planar Mirrors

- ✓ Lateral mirror produced (3/5 accepted + spares)  
Glass skin + Al honeycomb core  
Material budget comparable to CFRP @ 1/10 cost
- ✓ Assembling validated
- ✓ Front mirror production starting  
Demo under mechanical tests  
Process cleaning being improved

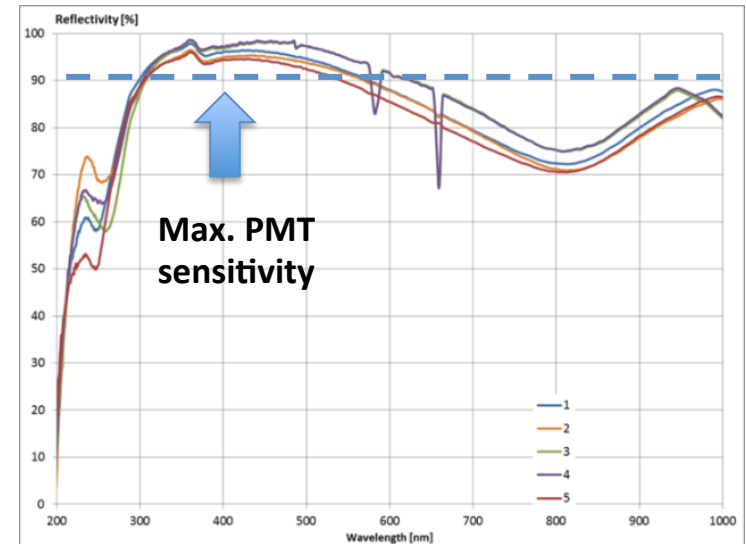


Lateral mirror  
assembling test

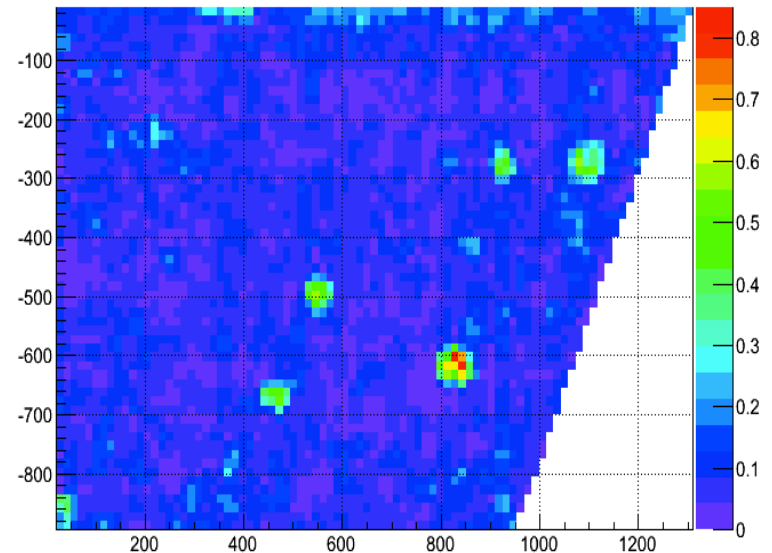


Surface mapping  
with CMM machine

Reflectivity specs: > 90% at 400 nm



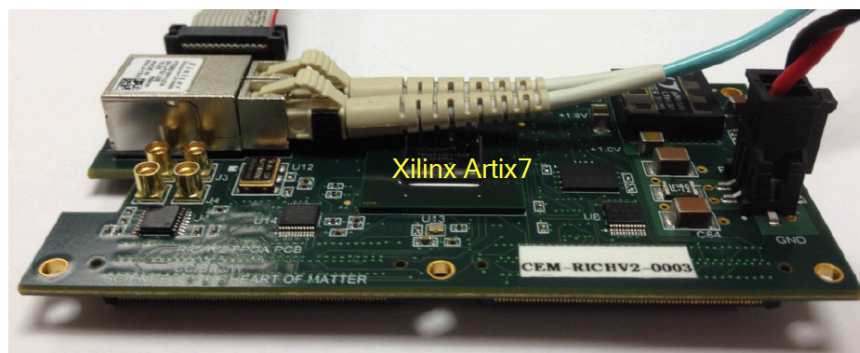
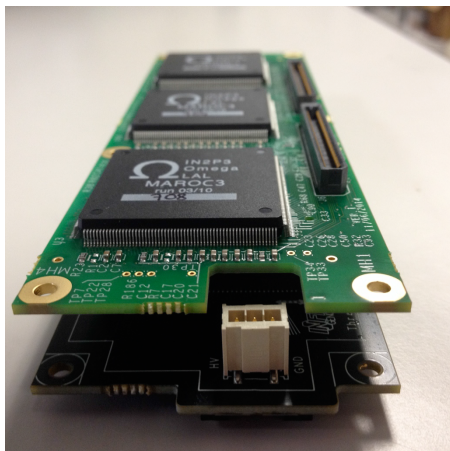
Slope of surface from CMM machine





# RICH Front-End Electronics

In collaboration with FE group



example of MAROC signal processing

Analog: Charge (1 fC)

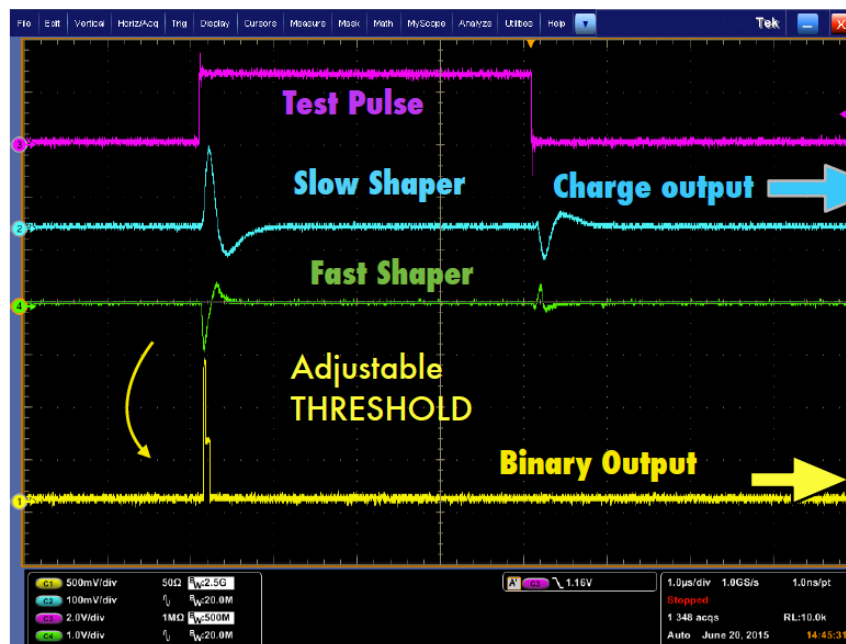
Digital: Time (1 ns)

Trigger latency (8  $\mu$ s)

Optical ethernet (2.5 Gbps)

Trigger: external  
internal  
self

On-board pulser



**ADC  
(MAROC)**  
calibration only  
more on backup slide

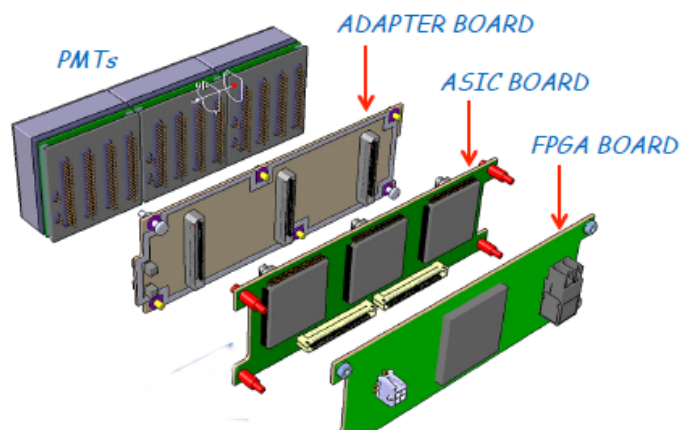
**SCALER/TDC  
(FPGA)**

**TDC used for  
physics runs!**

Single channel response, 1 microsecond/div

# Readout Electronics

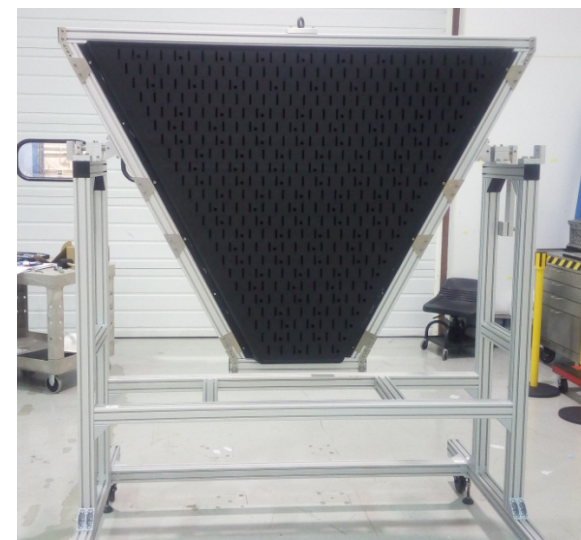
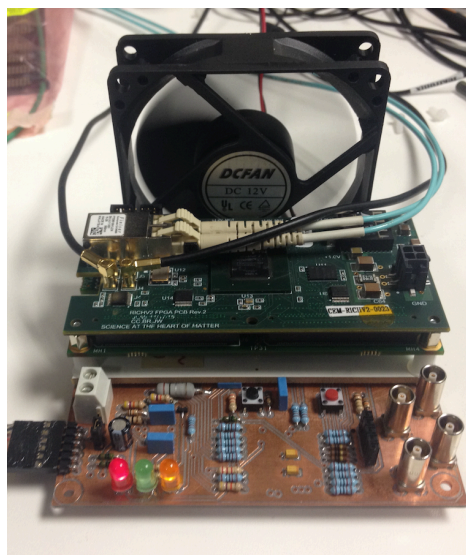
- ✓ Front-end production complete  
Acceptance test performed
- ✓ Electronic Panel ready for assembling
- ✓ Completion of readout services by August  
Power mainframe in use  
SSP readout under test (Cody, Ben, Matteo)



**SY4527 LV & HV Power Supply  
(compatible with EPICS)**

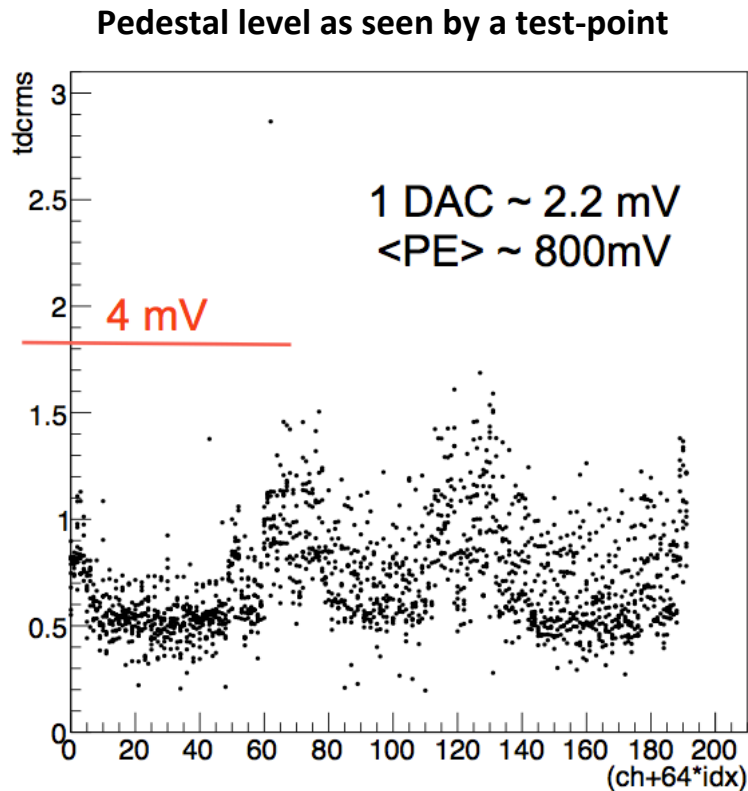


**5 SSP Fiber-Optic DAQ  
(compatible with CLAS12)**

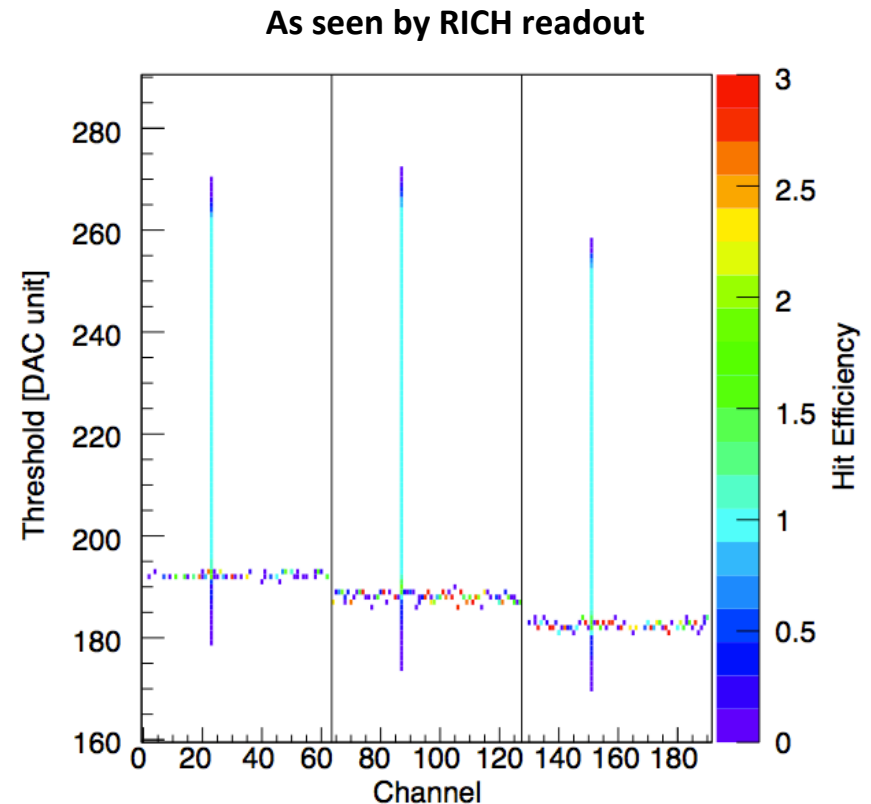


# FE Electronics: Digital Readout

During Acceptance tests



During Internal Pulser Calibration

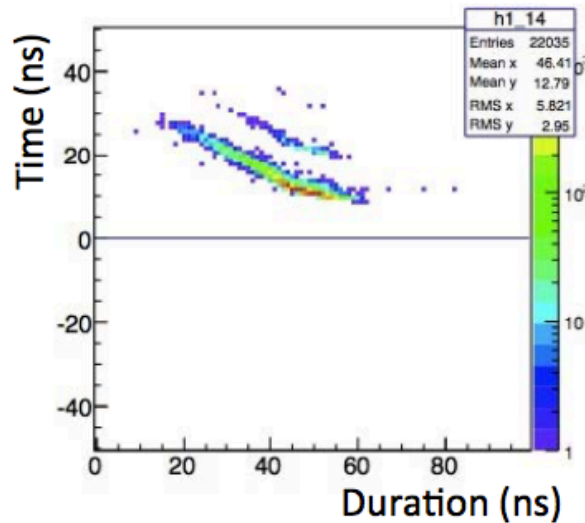


Discrimination down to 20 fC, i.e. few % of SPE, allows sensor characterization

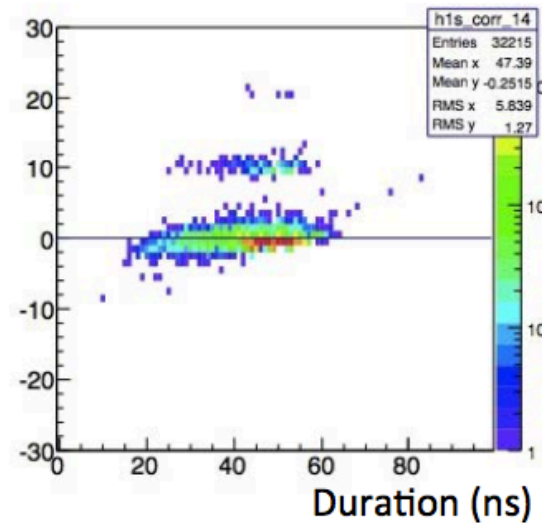


# FE Electronics: Timing

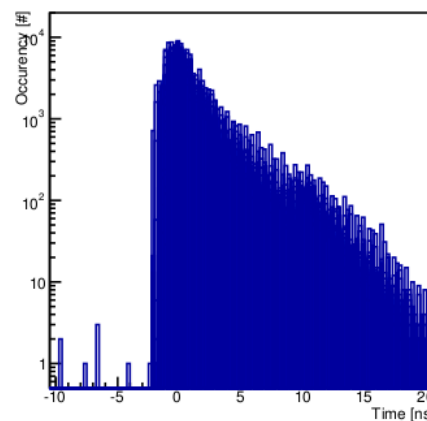
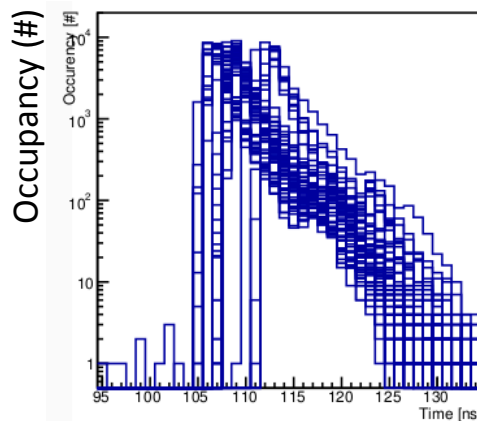
Typical time-walk with charge



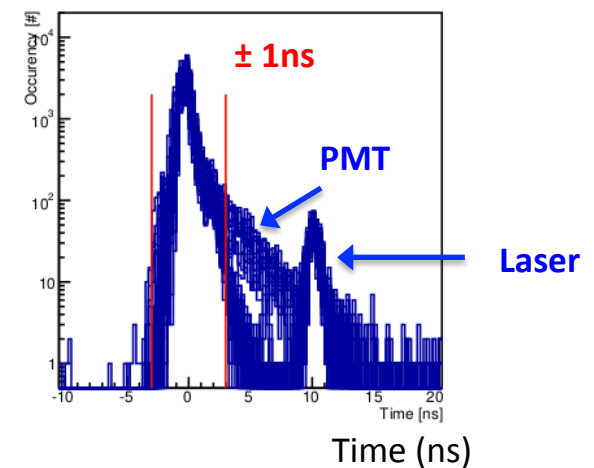
Time offset and walk corrected



Channel by channel time calibration: -offsets



-walk



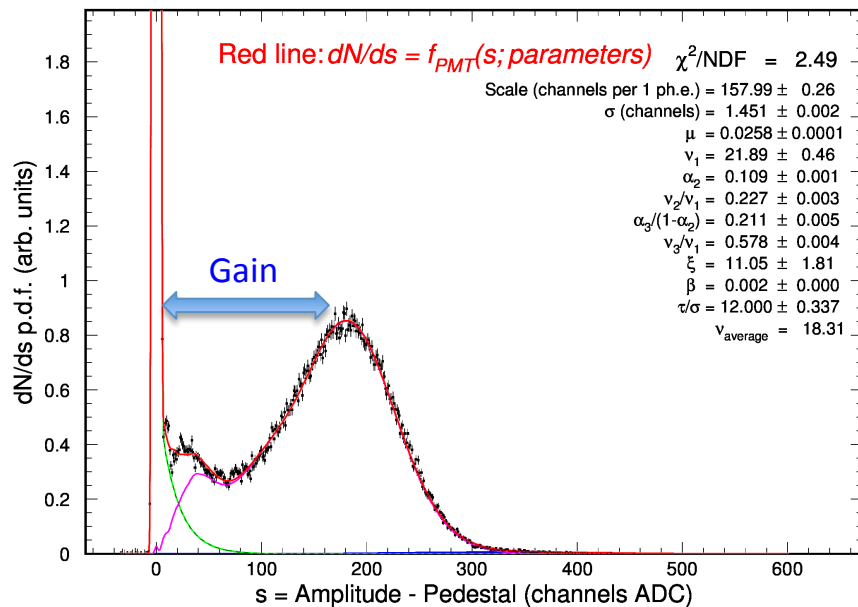
# FE Electronics: Charge

Multiplexed readout up to 100 kHz

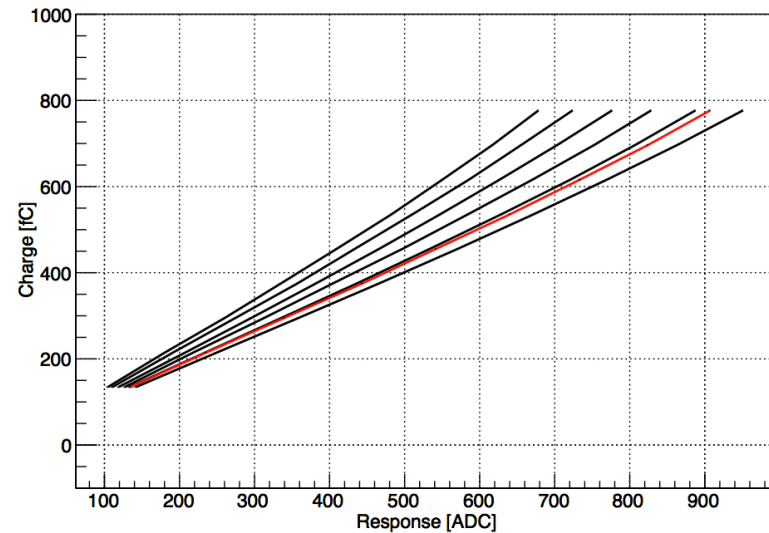
High resolution SPE spectrum

Viable for efficiency and gain monitors

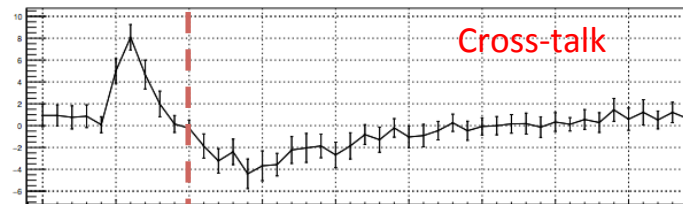
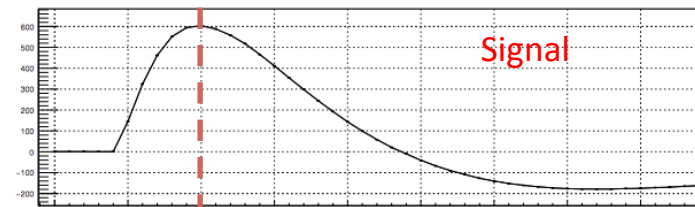
In conjunction with timing, allows the study of PMT discharge and cross-talk



ADC Calibration (Slow Shaper)



Charge = shaper amplitude at the sampling time



Sampling time

# RICH Electronic: Cross-talk

ASIC 1 CHANNEL 27 CHTILE 91

Ch191  
Entries: 1000000  
Mean: -0.1723  
RMS: 2.317

ASIC 1 CHANNEL 25 CHTILE 89

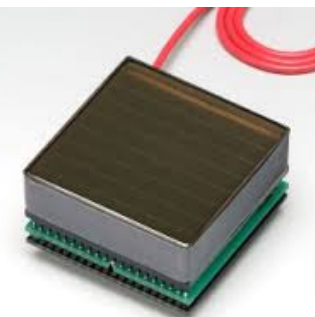
Ch191  
Entries: 1000000  
Mean: -0.009904  
RMS: 4.535

ASIC 1 CHANNEL 26 CHTILE 90

Ch191  
Entries: 1000000  
Mean: -0.08976  
RMS: 1.942

**GA0501**

95	93	94	92	96	98	97	99
91	89	90	88	100	102	101	103
87	85	86	84	104	106	105	107
83	81	82	80	108	110	109	111
79	77	78	76	112	114	113	115
75	73	74	72	116	118	117	119
71	69	70	68	120	122	121	123
67	65	66	64	124	126	125	127



ASIC 1 CHANNEL 23 CHTILE 87

Ch191  
Entries: 1000000  
Mean: -0.7392  
RMS: 2.974

ASIC 1 CHANNEL 21 CHTILE 85

Ch191  
Entries: 1000000  
Mean: 5.046  
RMS: 45.8

~ 20 fC  
~ 1/80 SEP

ASIC 1 CHANNEL 22 CHTILE 86

Ch191  
Entries: 1000000  
Mean: -0.6405  
RMS: 3.543

ASIC 1 CHANNEL 20 CHTILE 84

Ch191  
Entries: 1000000  
Mean: -0.4765  
RMS: 1.608

Electronic

ASIC 1 CHANNEL 19 CHTILE 83

Ch191  
Entries: 1000000  
Mean: -0.4407  
RMS: 1.876

ASIC 1 CHANNEL 17 CHTILE 81

Ch191  
Entries: 1000000  
Mean: -0.7921  
RMS: 2.859

ASIC 1 CHANNEL 18 CHTILE 82

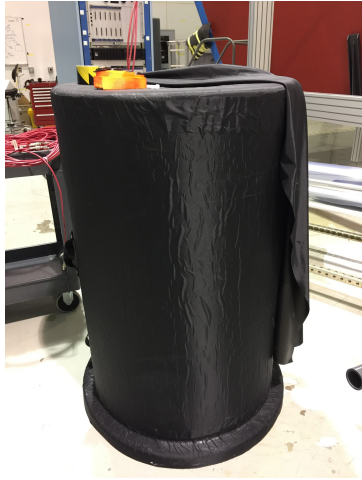
Ch191  
Entries: 1000000  
Mean: -0.2393  
RMS: 1.508

ASIC 1 CHANNEL 16 CHTILE 80

Ch191  
Entries: 1000000  
Mean: -0.7348  
RMS: 1.799



# Cosmic Run



## Phase 1 (June-July):

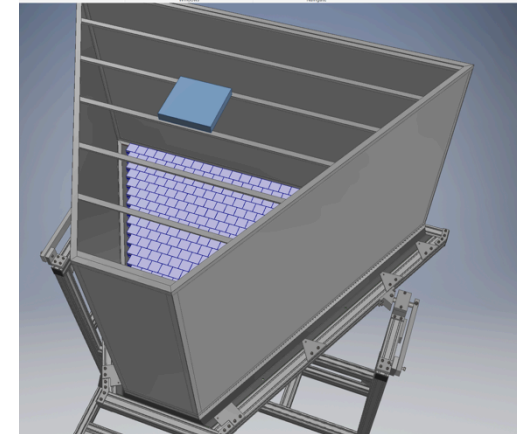
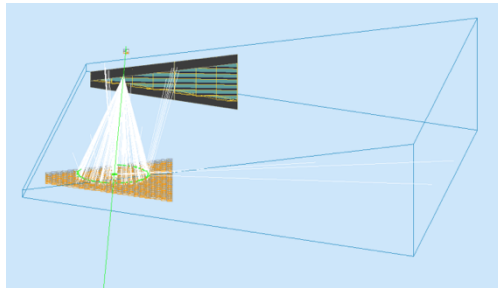
- fixed geometry
- 32 readout tiles (30 on the ring, 2 for tracking)
- SVT black cover

Goal: full readout chain

## Phase 2 (August):

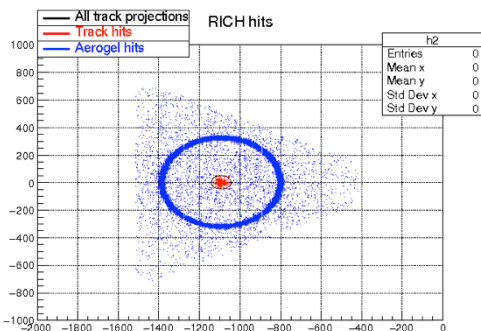
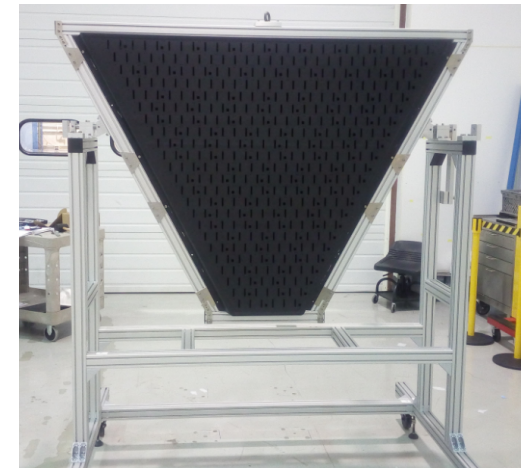
- Full panel instrumented
- Custom light-tight box
- Various track patterns

Goal: RICH readout commissioning

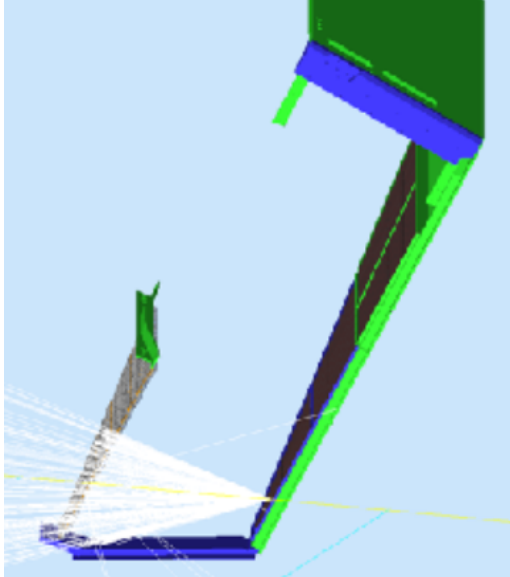


Important to define/commission

space and time alignment  
photon vs track signals  
gemc simulations  
coat-java reconstruction  
monitor suite  
    slow control  
    event display  
calibration suite



# RICH Software



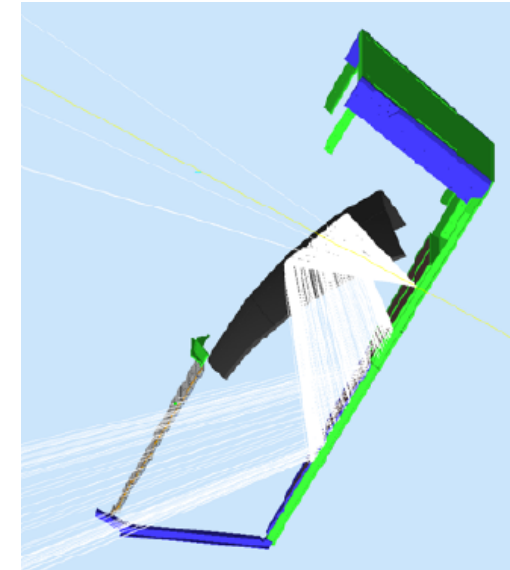
RICH geometry is implemented in the software mostly from CAD through mesh files

- a detailed, consistent and updated description of the detector can be obtained
- simulation and reconstruction shared the same database

Possible conflicts with optical photon tracking not yet solved  
(mother volume, spherical mirror)

Digitization of the MAPMT response:

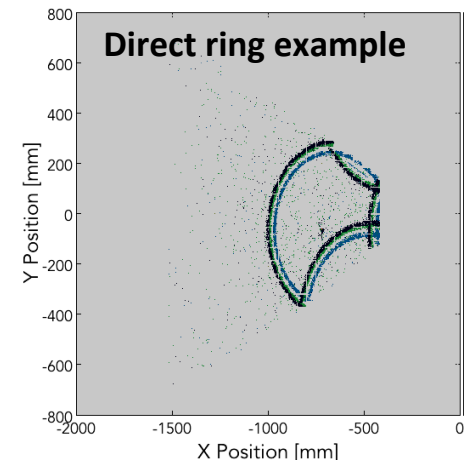
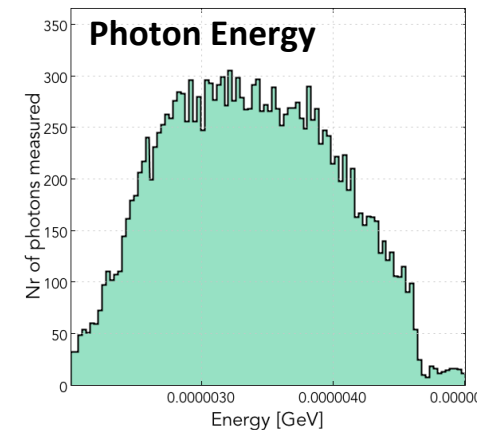
- calculate the pixel ID
- interface to CCDB
- apply efficiency
- simulated ADC and TDC spectra



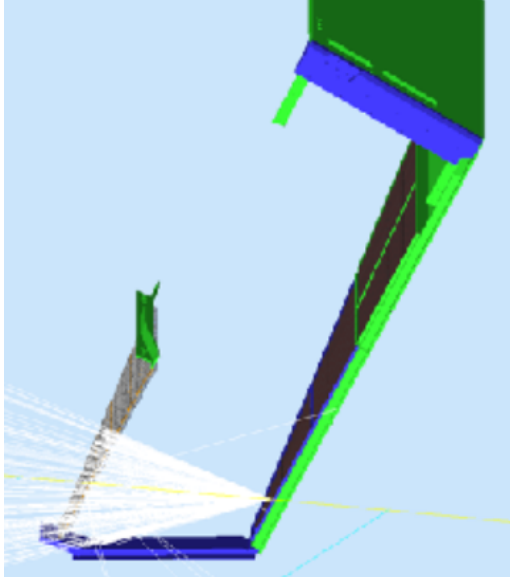
Event reconstruction started

- match with DC information in coat-java
- photon tracing algorithm  
(tested with prototype and cosmic runs)
- event display

Strong crew: Matteo, Ilaria, Marco, Giovanni,  
Justin, Morgen, Elise, Aram, Andrey, ...



# Gemc Digitization



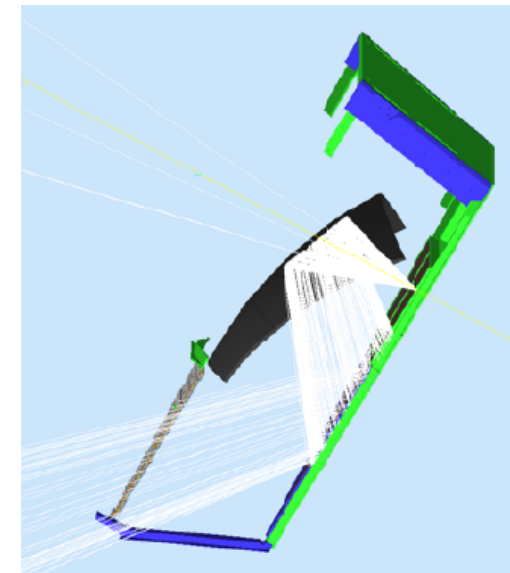
## ADC conversion:

- gaussian smeared conversion of Npe in charge collection
- linear conversion in ADC units

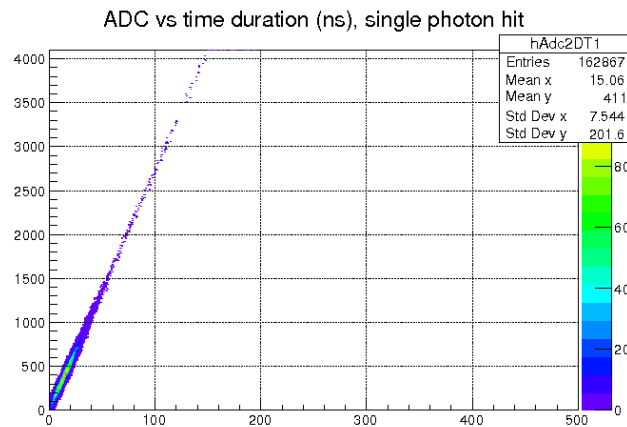
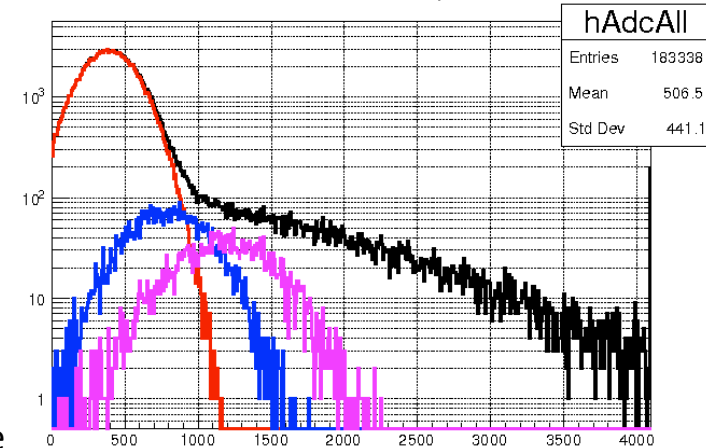
## TDC conversion:

- 1 ns gaussian smearing of the leading time
- time duration proportional to charge

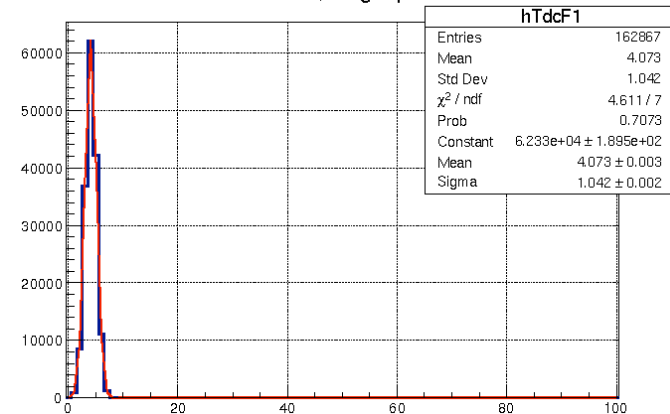
Will be made more realistic following electronics calibration



ADC vs Number of p.e.



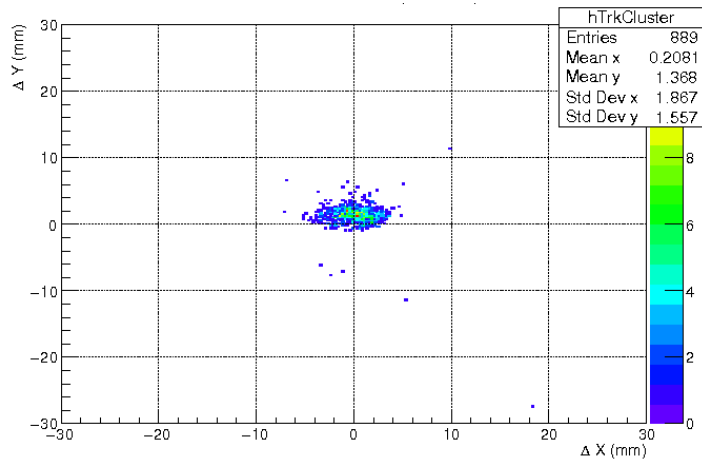
TDC fall time, single photon hit



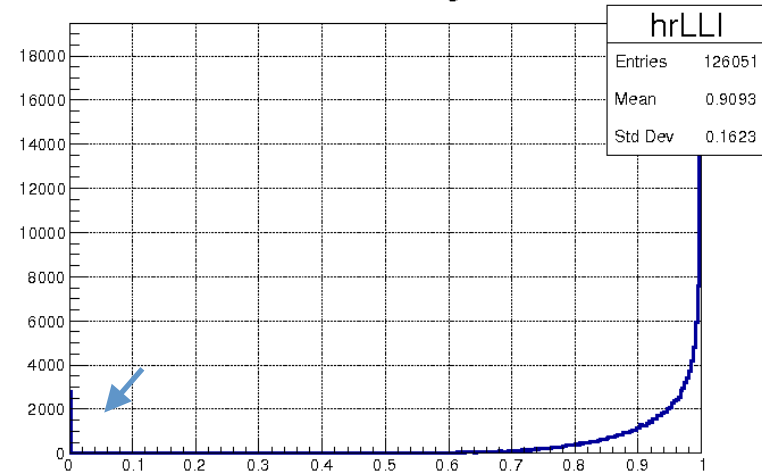


# Cosmic Run Simulations

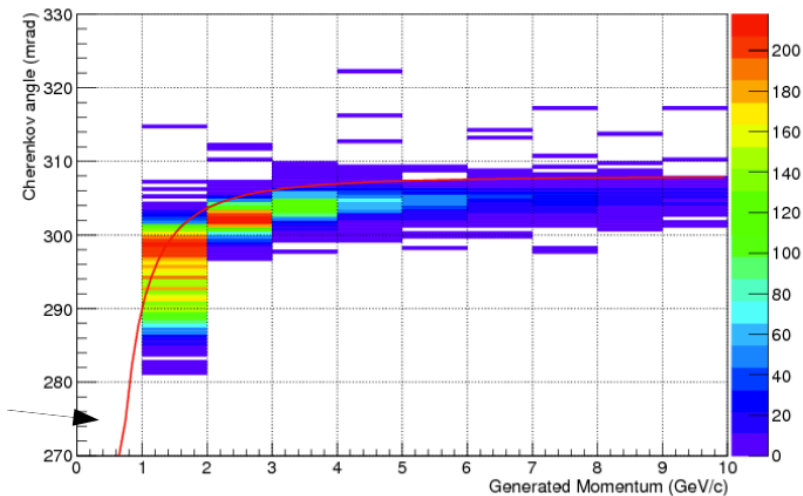
## Tracking on MA-PMT



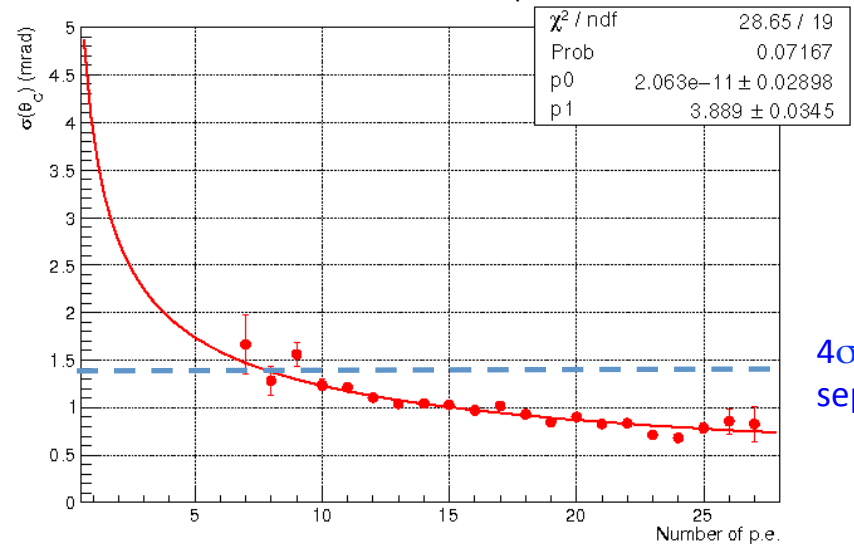
## Rec. Hit Cherenkov Log-Likelihood



## Cherenkov angle



## Resolution vs Npe



4 $\sigma$  K-p  
separation

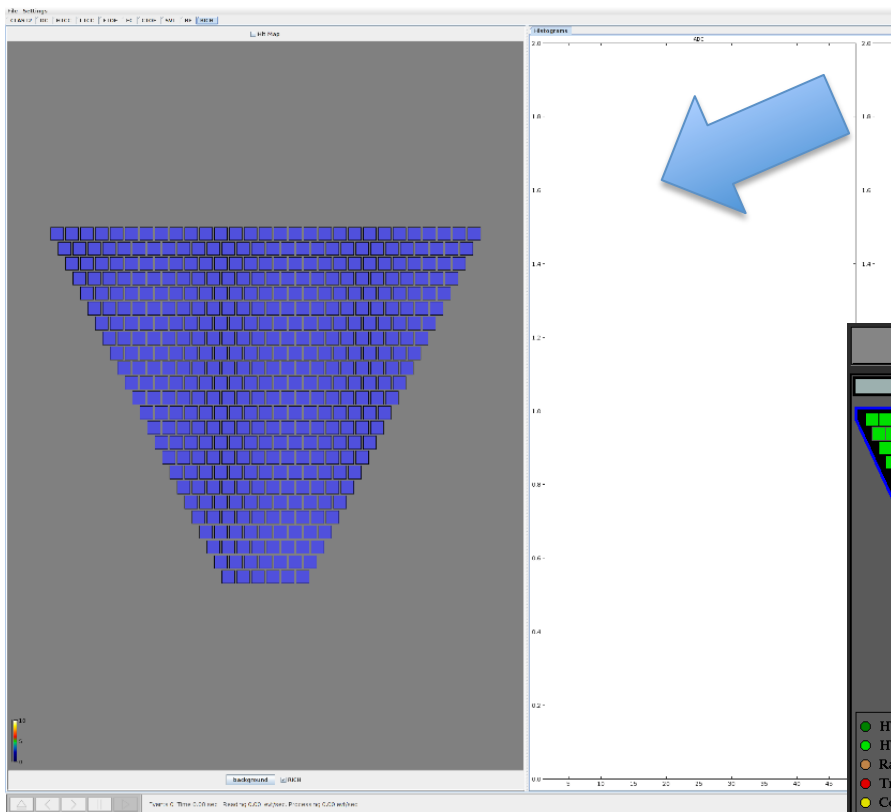
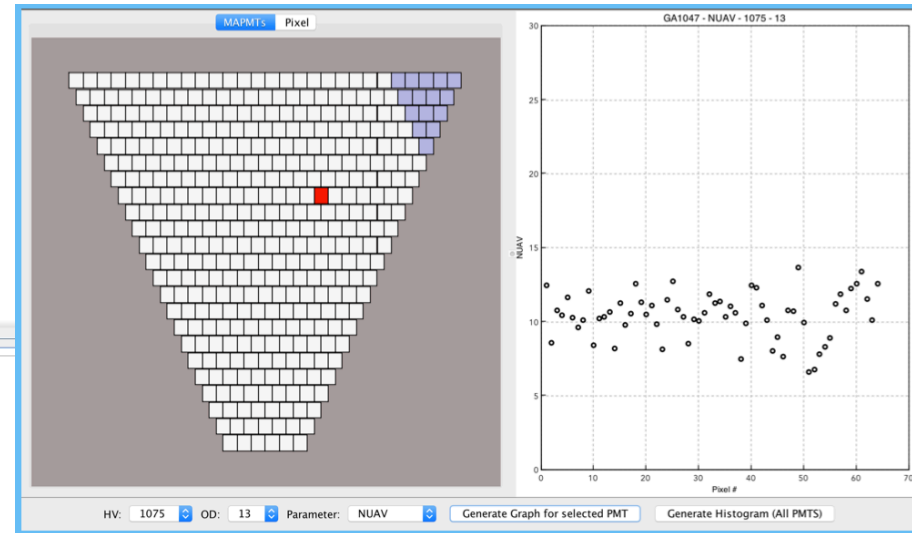
# Monitor & Calibration Suite

Converting the stand alone version developed in Duquesne to the CLAS standard

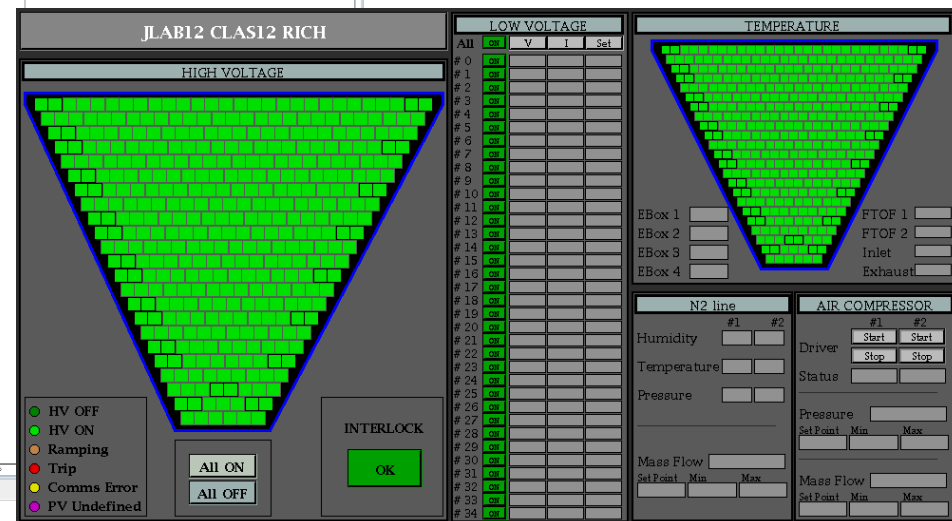
Same java libraries are used, so smooth transition expected

To be checked if the original flexibility can be fully exported

Monitor suite under development



Basic slow control suite ready



# Summary and Timeline

Mechanics:	Key elements assembled Adapting installation tools (cart and strong back)
Services	Gas system approved and being assembled Power lines and DAQ under procurement (already available for ¼ of the panel)
Electronics	Production done Calibration ongoing Staged cosmic run for commissioning
Aerogel	3cm procurement done (minimum quantity) 2cm production completion planned in August
Mirrors Spherical	Mirrors and support structure delivered Coating ongoing
Planar	Lateral 1.6mm skin mirrors produced Improving process (cleaning) for frontal 0.7mm skin mirrors
Software	gemc simulations being refined coatjava reconstruction under development monitor/calibration suites under development working to test (part of) calibration in July challenge

Installation foreseen in September 2017