RICH Upgrade Status

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(For the rich group)

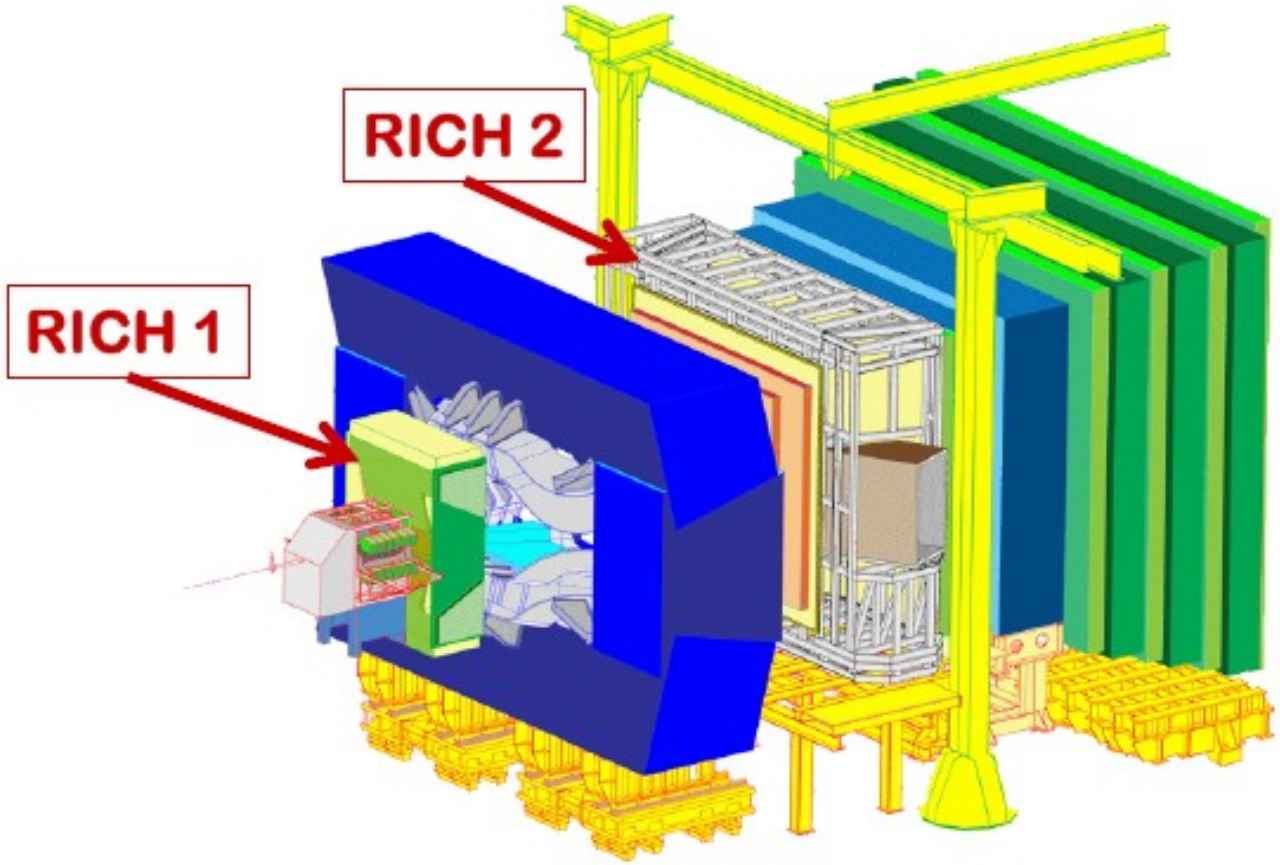
14 October 2015

Outline

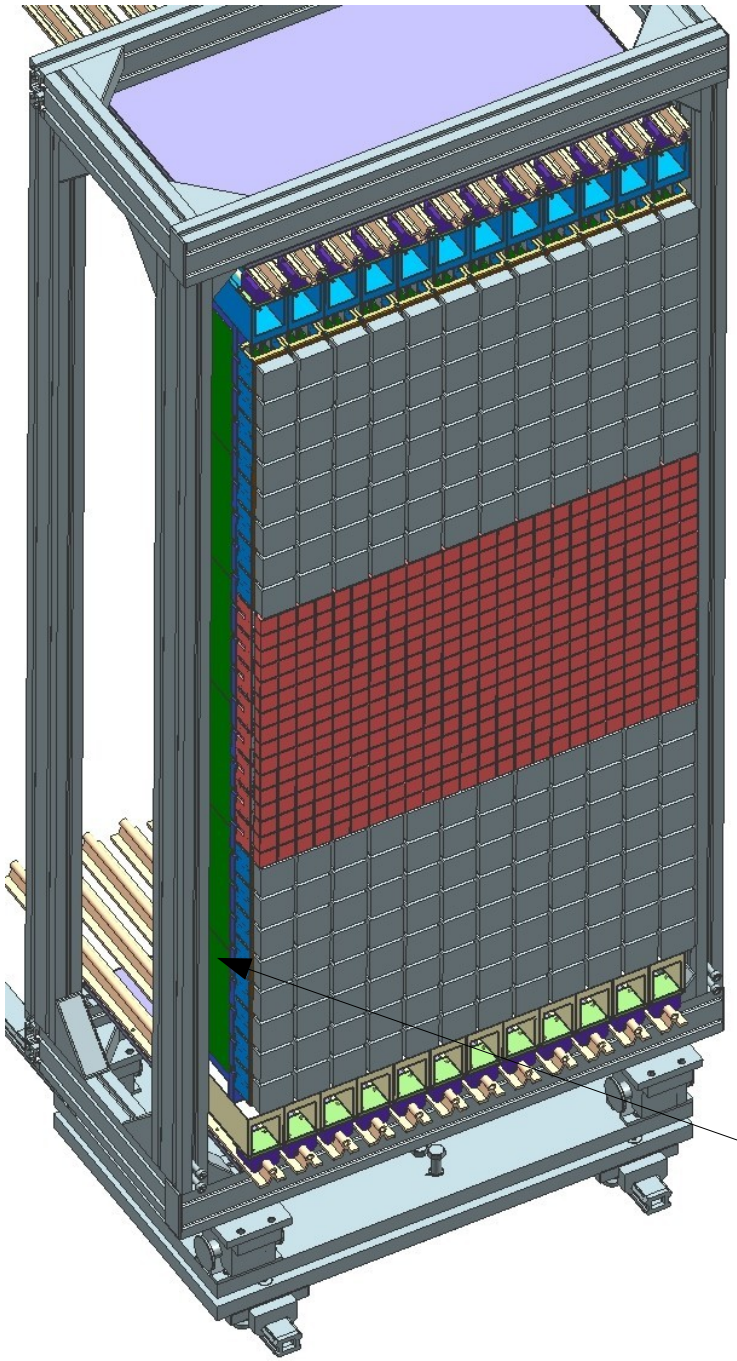
- Thermo-mechanical design: prototypes and simulation
- MaPMT: procurement, magnetic field characterization, QA preparation
- Elementary cell design
- FEE: Claro 8v2 status
- Testbeam
- Irradiation program

The RICH Upgrade

- Replace HPD with MaPMT
- Replace readout electronics and support mechanics
- Modify optics for RICH1



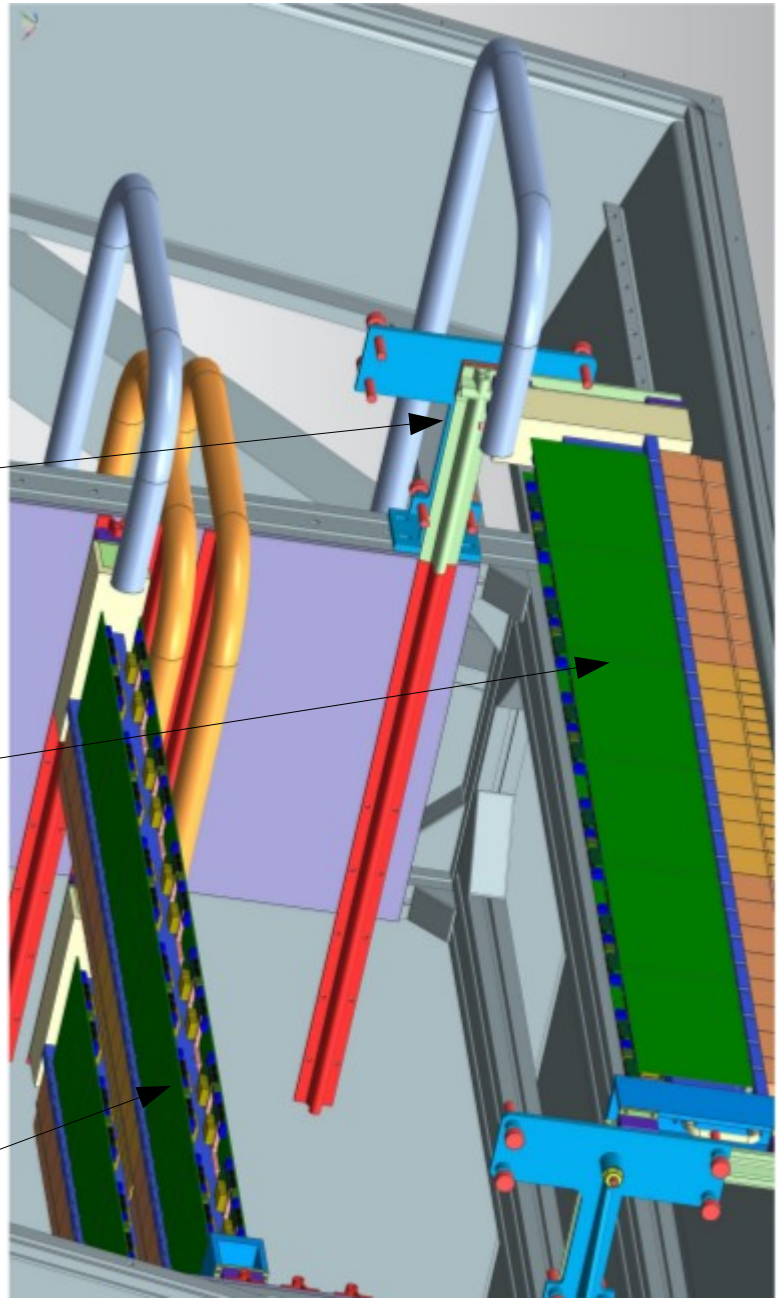
Design of the Column assembly



Rotation Extraction system

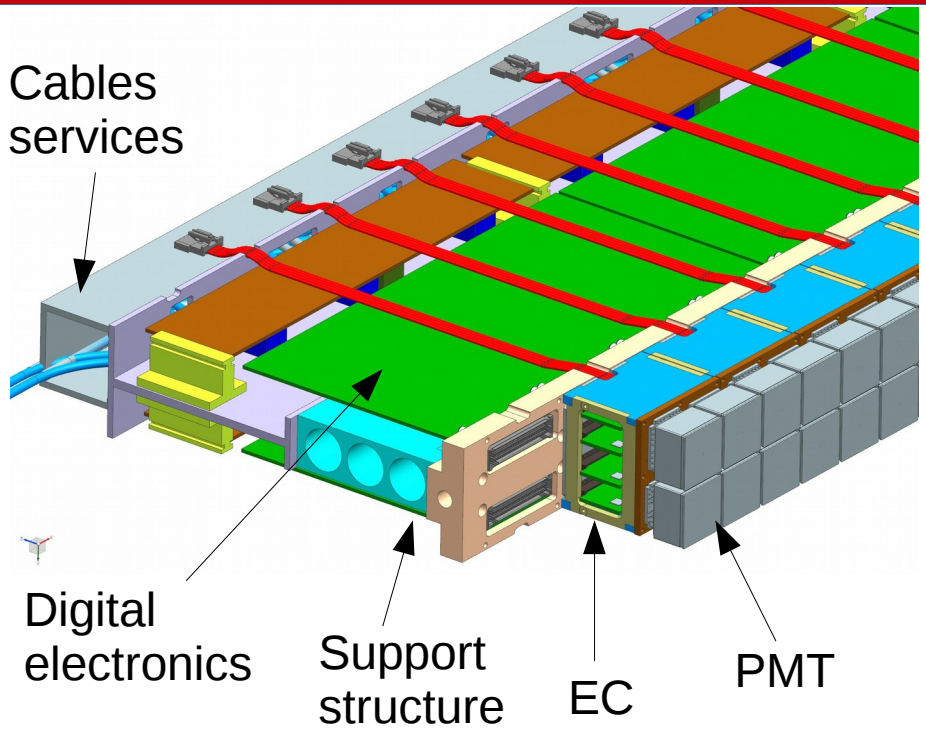
Rotated/ extracted column

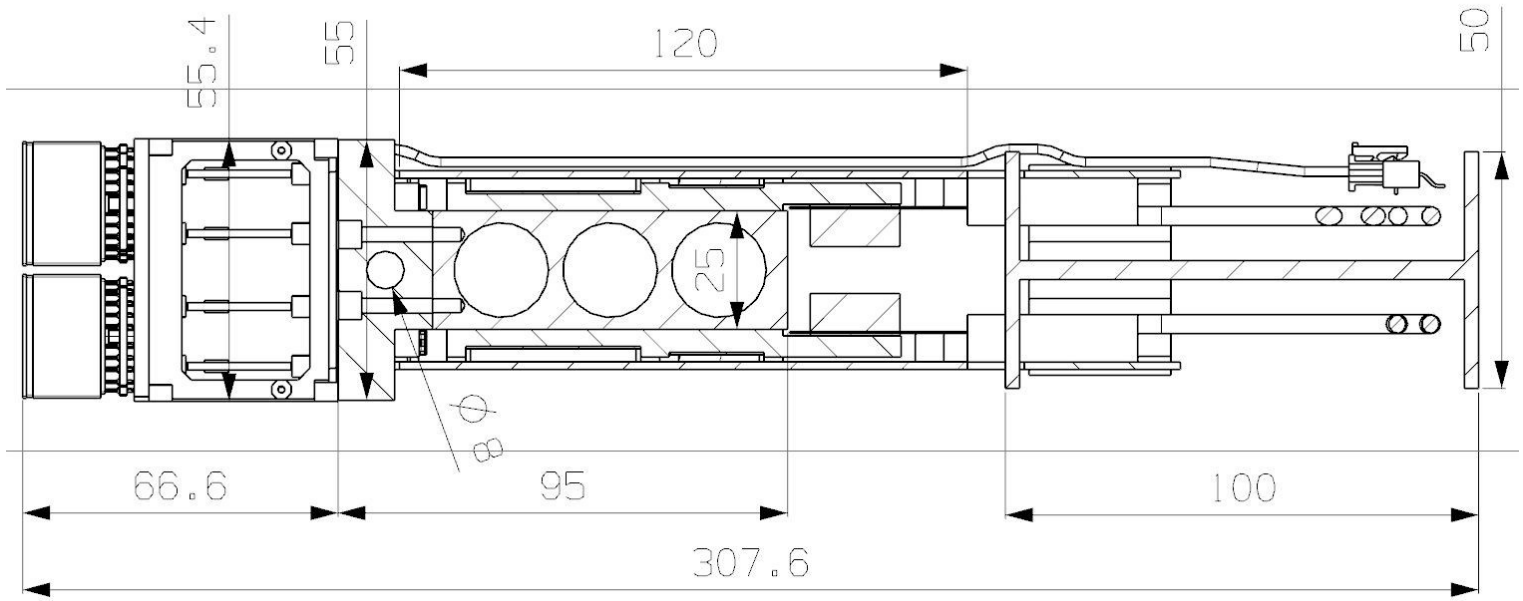
Column



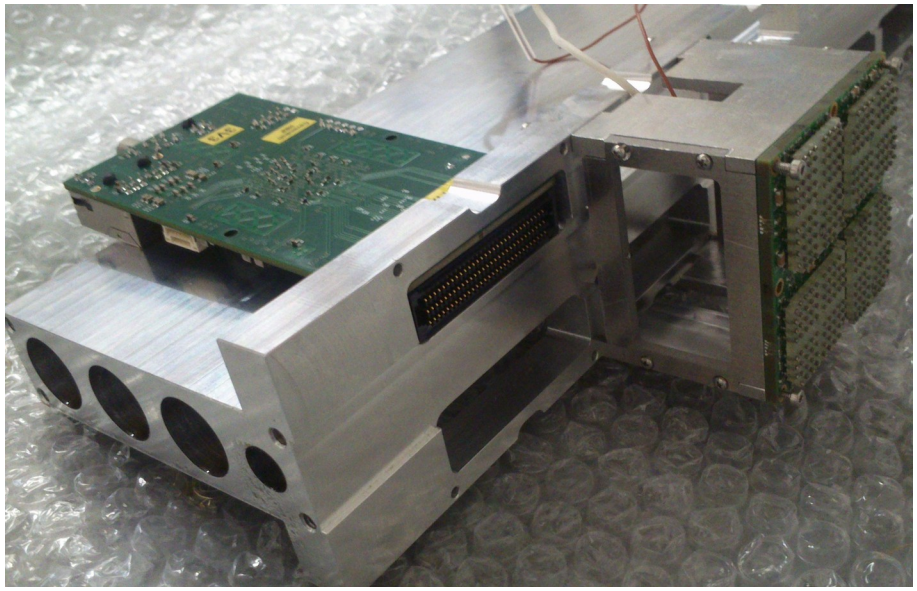
Design of the mechanical support structure

- The mechanical structure supporting the PMT, the electronics and housing the cooling system is in an advanced design state. The main uncertainties are related to the design of the digital electronics boards which has been modified recently
- Compact design → used also in RICH1



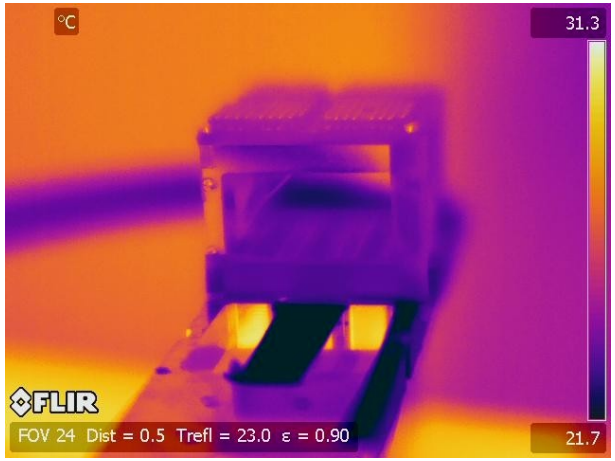


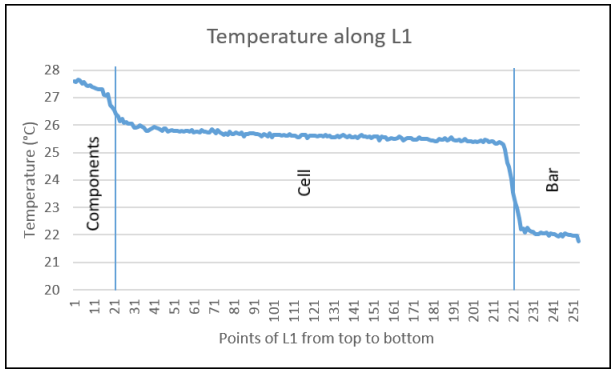
Prototype Column produced and characterized



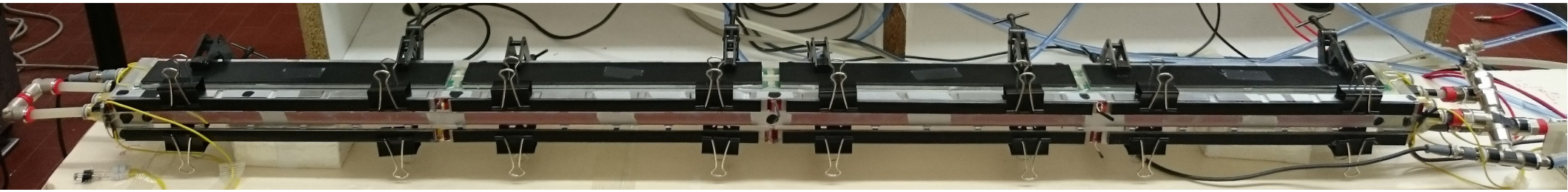
- Produced from a cast plate
- Alternative option: produce from a laminated bar
  - Cheaper and better mechanical properties but has internal tensions

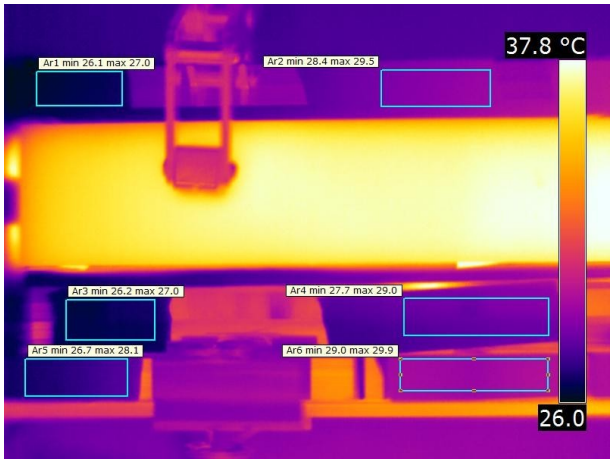
Cooling efficiency has been simulated and measured on a test setup
Results useful to tune simulation and refine design

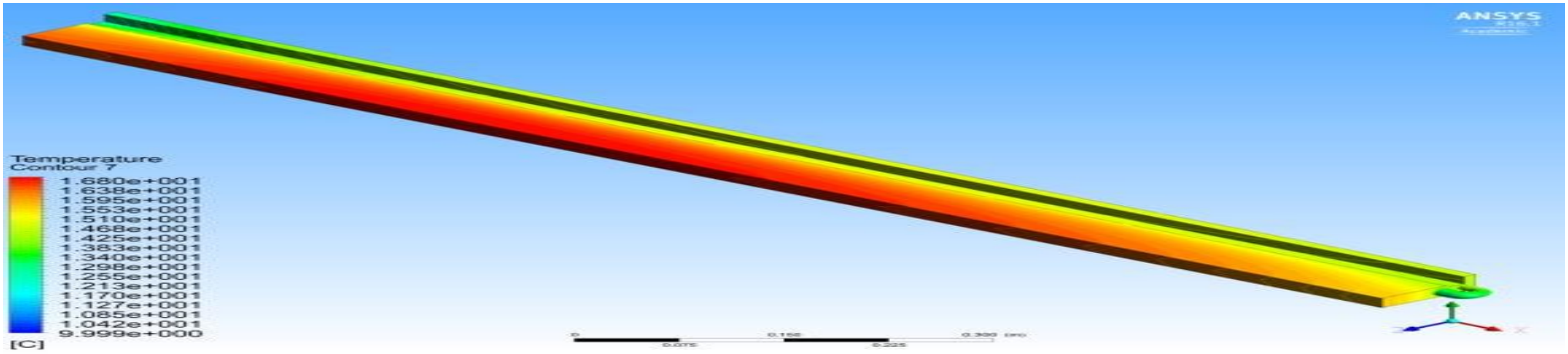




Bar Cooling efficiency test

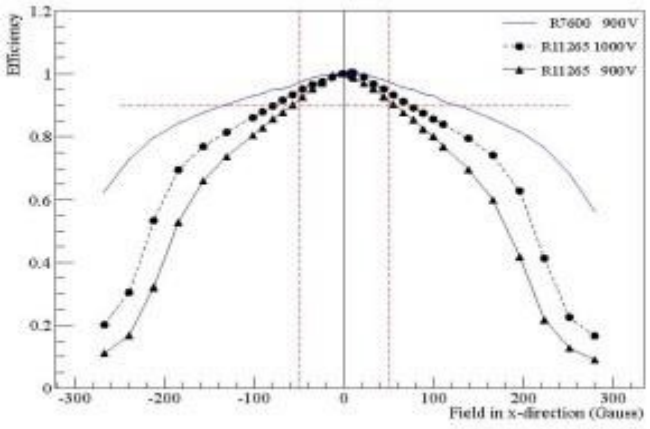


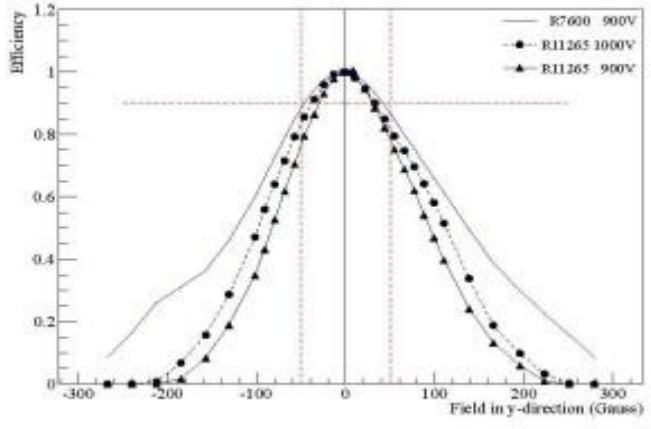


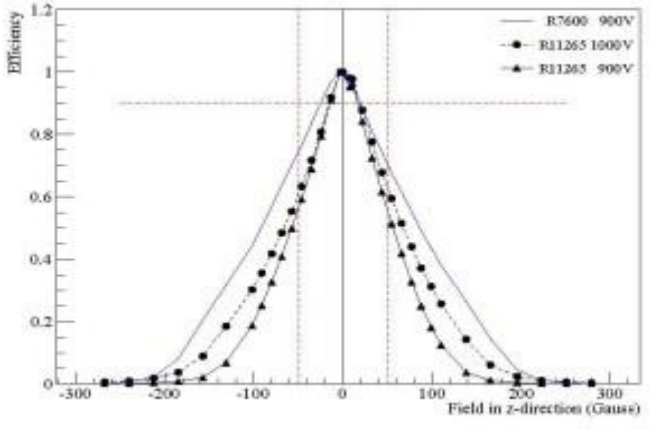


MaPMT

- Contract finalized with Hamamatsu for 3100 small and 450 large MaPMT
- UV window has been chosen based on better radiation tolerance
- Production schedule over 28 months
- Study of Efficiency of MaPMT in B field
  - Efficiency curves (normalized to zero B field) averaged over all pixels of the R11265 and the R7600 as a function of the magnetic field applied in both transverse directions (x and y) and in the longitudinal direction (z, worst case).

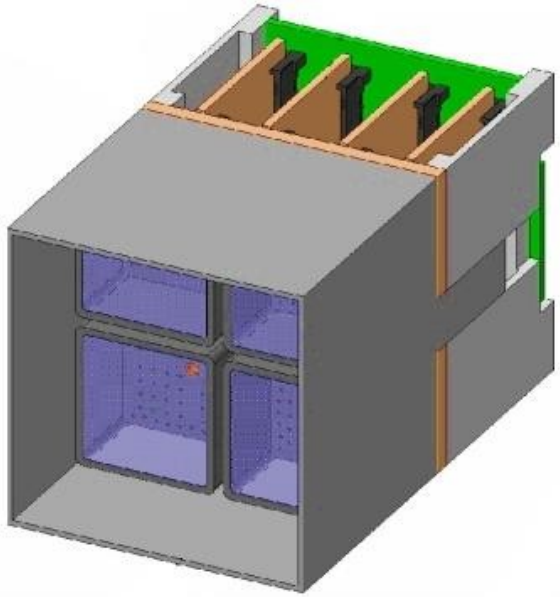


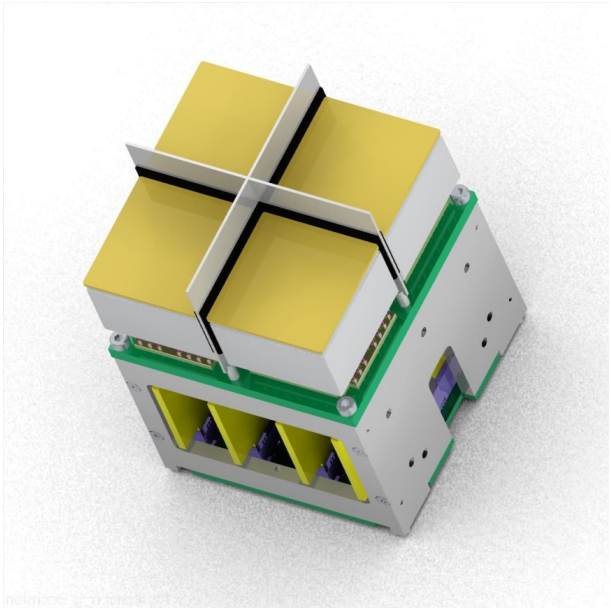


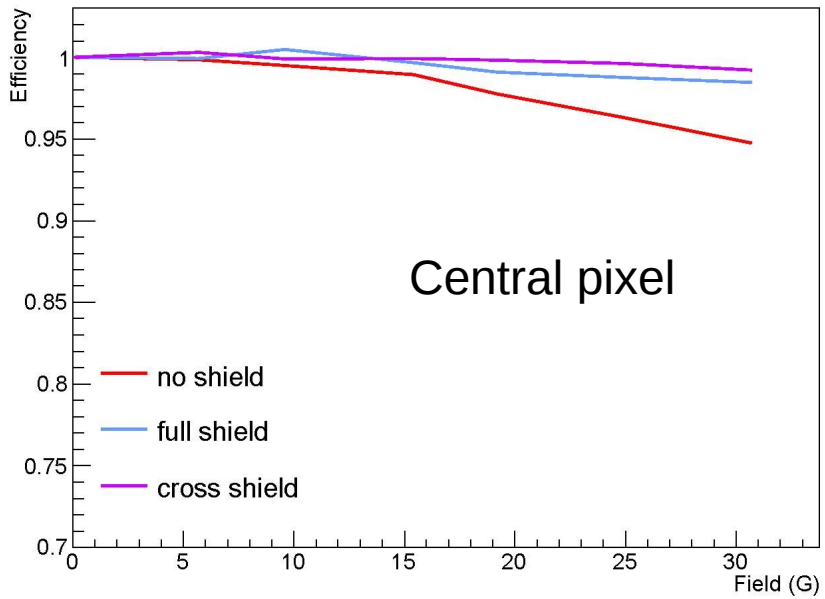


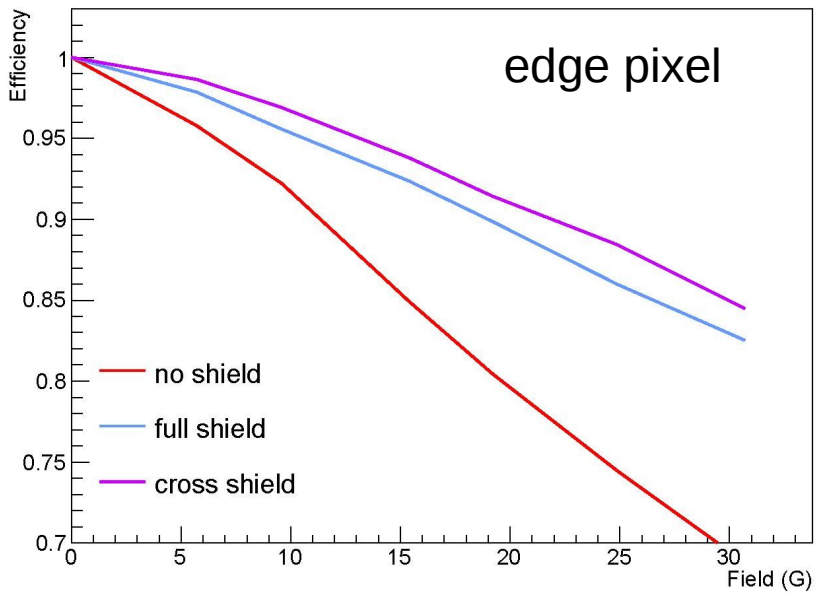
Magnetic Shield Design

- Design being refined



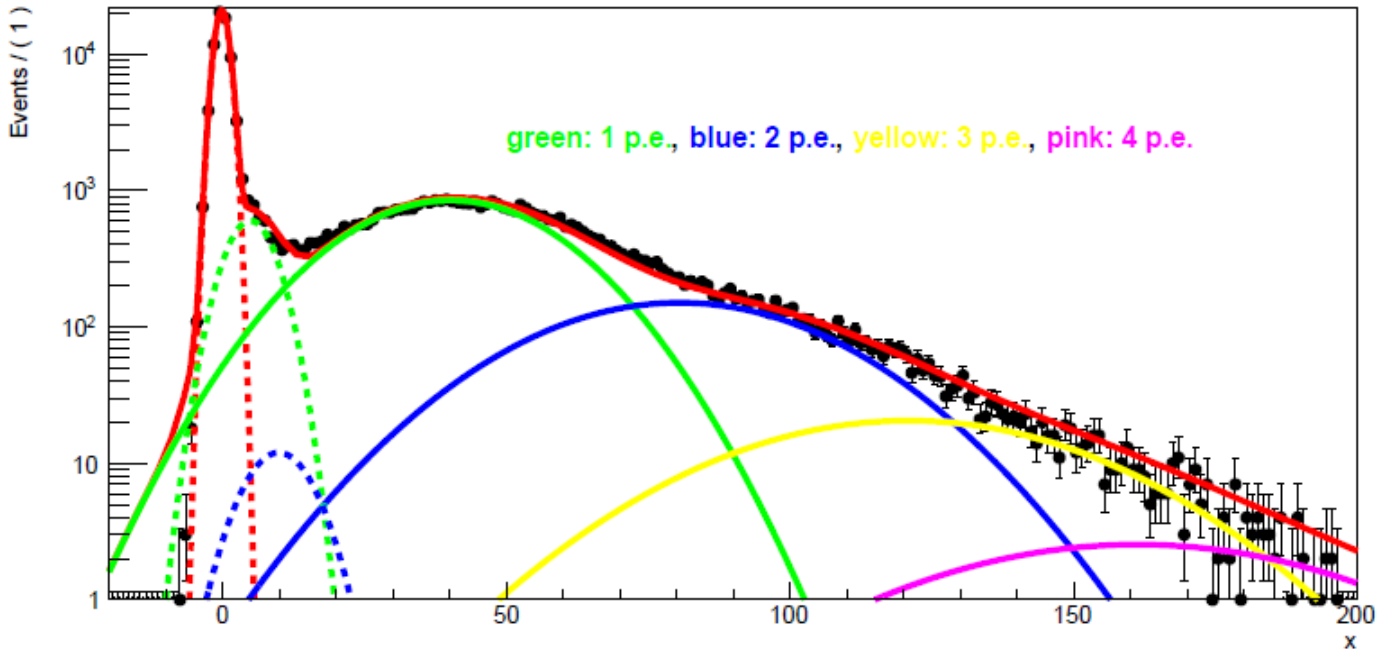






MaPMT QA

- Test setups for characterization of PMT in progress, ready be the end of the year
- Example of extraction of PMT parameters from pulse height distribution: gain, HV dependence



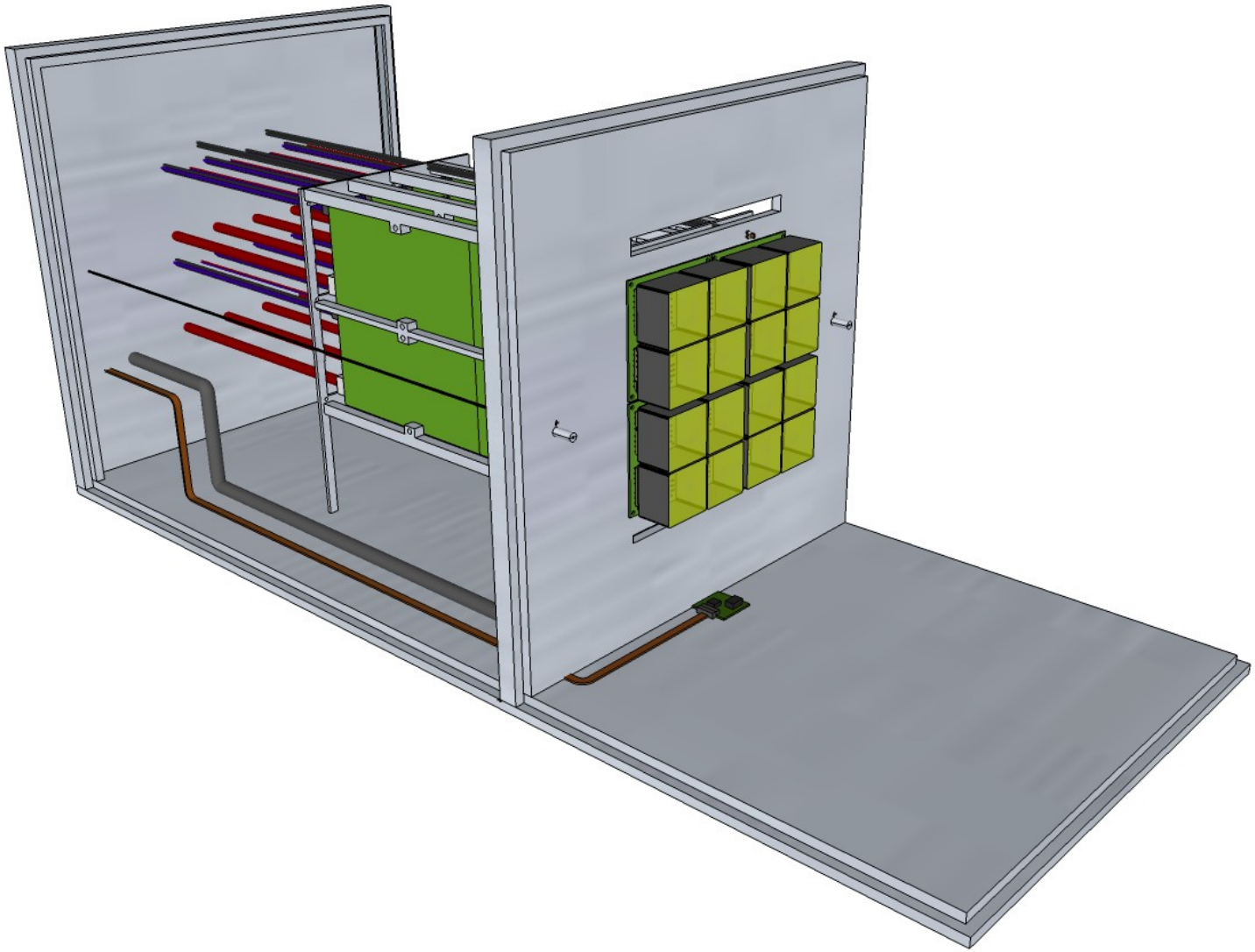
green, blue, yellow, pink continuous: photo-cathode conversions

green, blue, yellow, pink dotted: first dynode conversions

red dotted: noise

red continuous: sum

MaPMT test setups

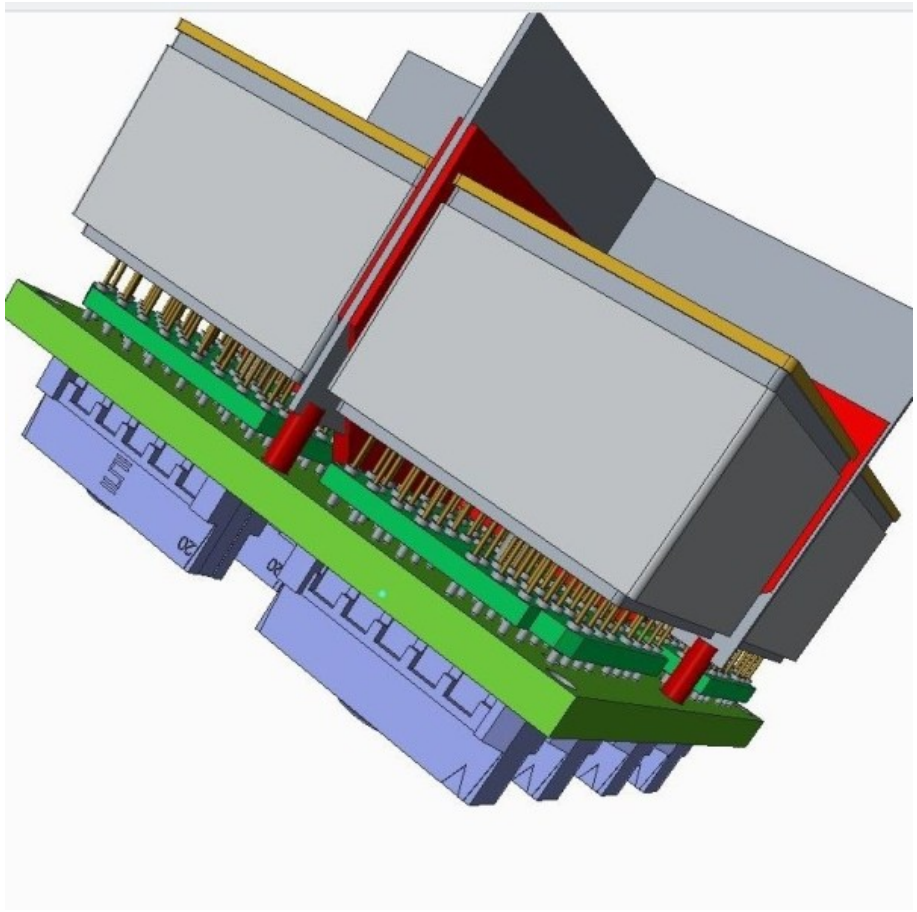


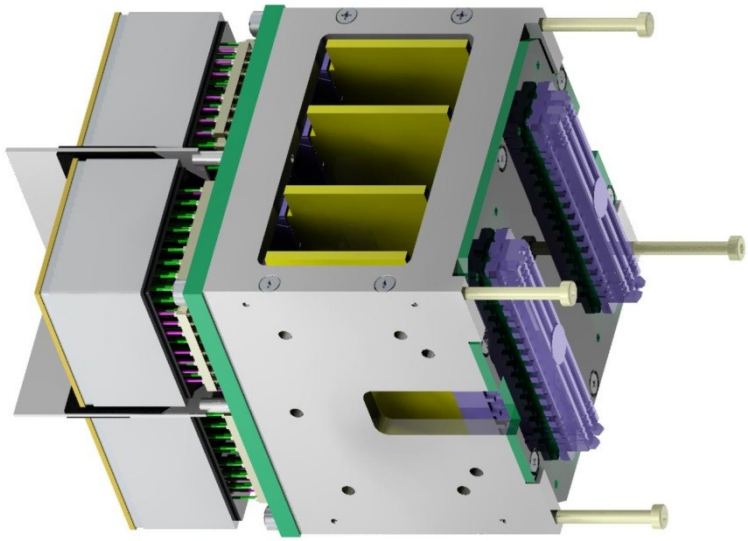
QA for the PMT, electronics, EC

- April and September workshops for planning and agreeing on the QA test procedure
- MAPMT: full characterization: tube & pixel gain (HV) (at low and high illumination rate), dark counts, peak-to-valley ratio, signal loss, cross-talk, relative light yield (for some tubes: QE).
- CLARO: currents, configure, readback, test pulse, charge injection.
- FEB: s-curves for test pulse and charge injection (yielding thresholds and offsets).
- EC: threshold scans with constant pulsed illumination at nominal HV (yielding optimum attenuation/threshold for each pixel).
- Column functionality tests: communication and configuration fully functional, dark counts, signal from illumination at nominal HV.
- Commissioning:
  - initial configuration from QA results, HV scans with dark counts and illumination, threshold/attenuation scans with target HV;
  - refinement of configuration.

Elementary cell design for small PMT

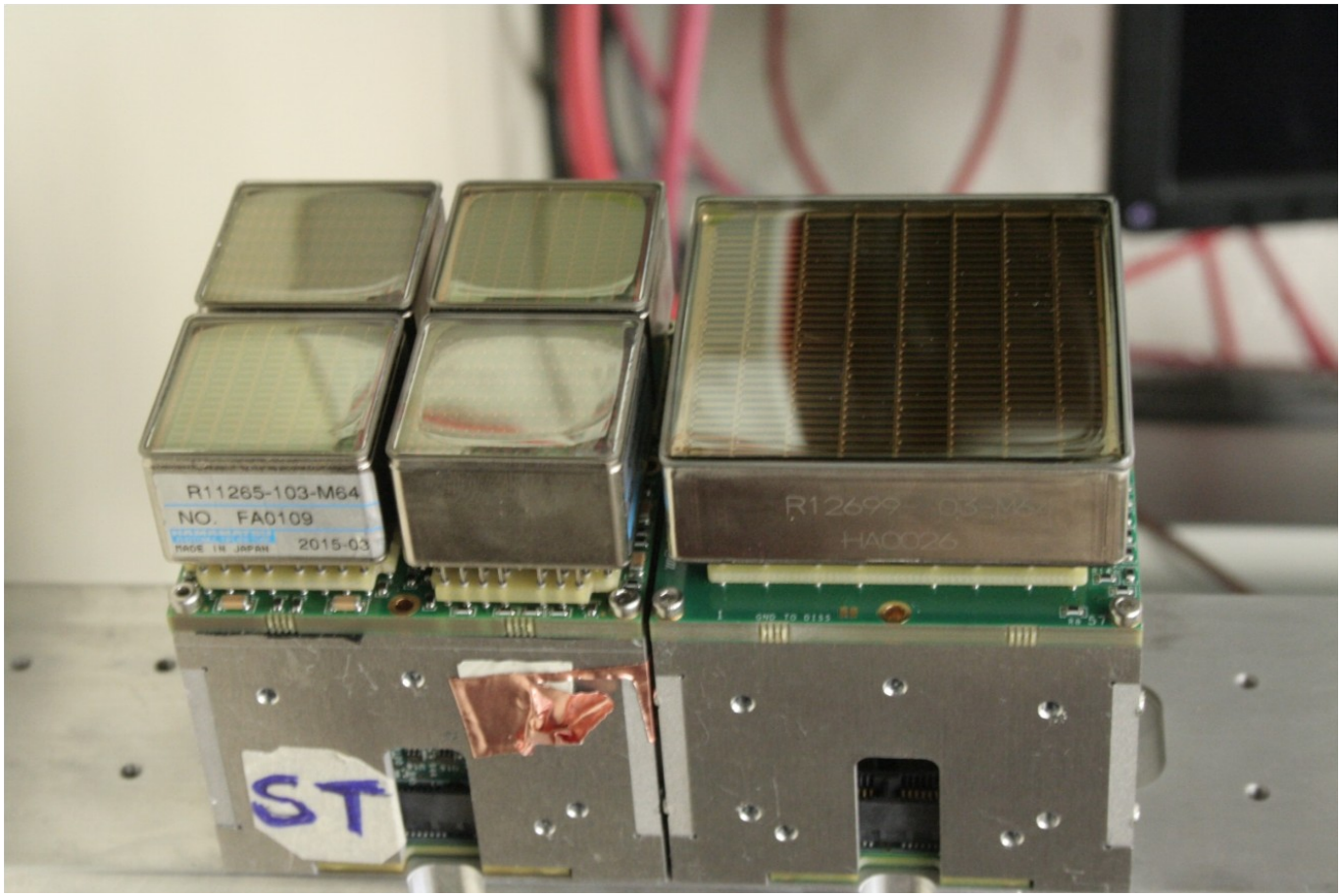
- The design has been finalized (pending the PRR)





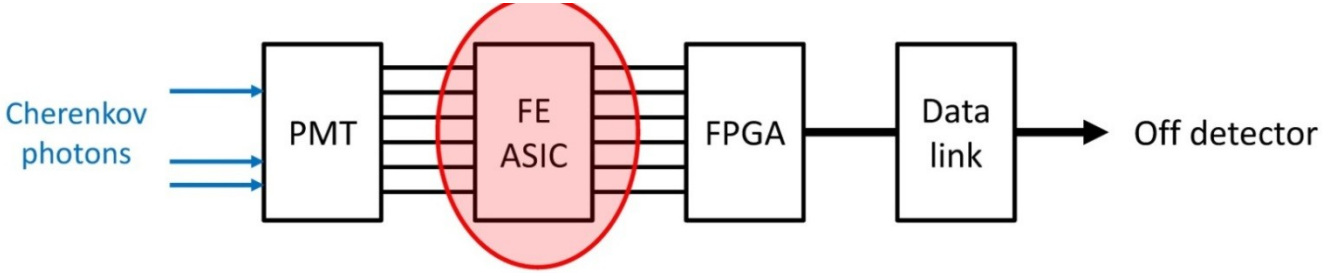
Elementary cell for large PMT

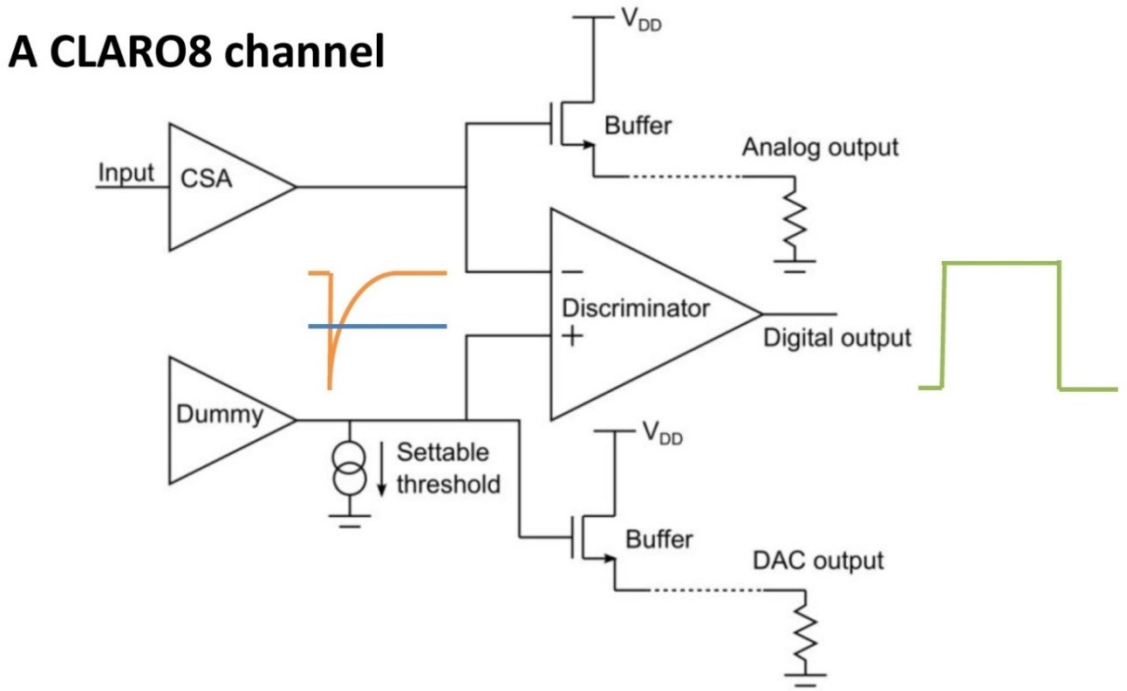
- Used in the external parts of RICH2 to reduce costs and channels
- Design in progress



CLARO

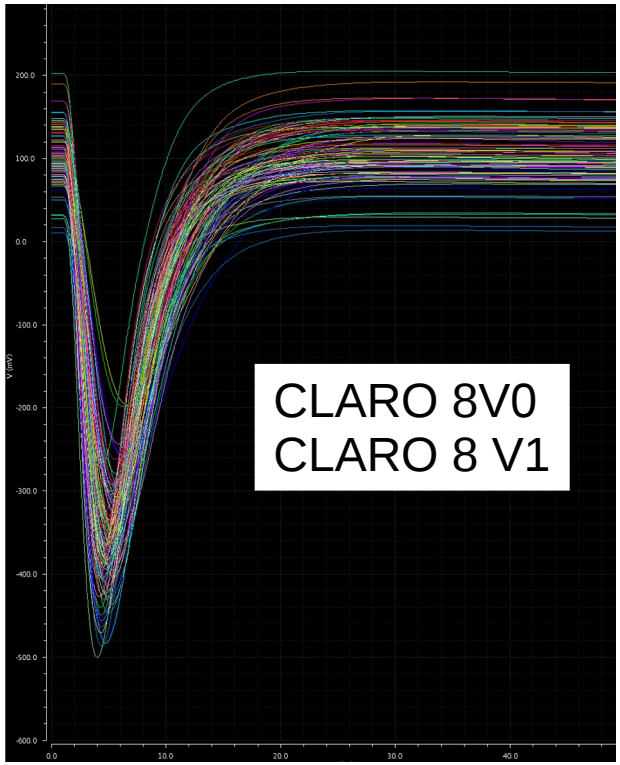
- Fast single photon counting with MaPMT

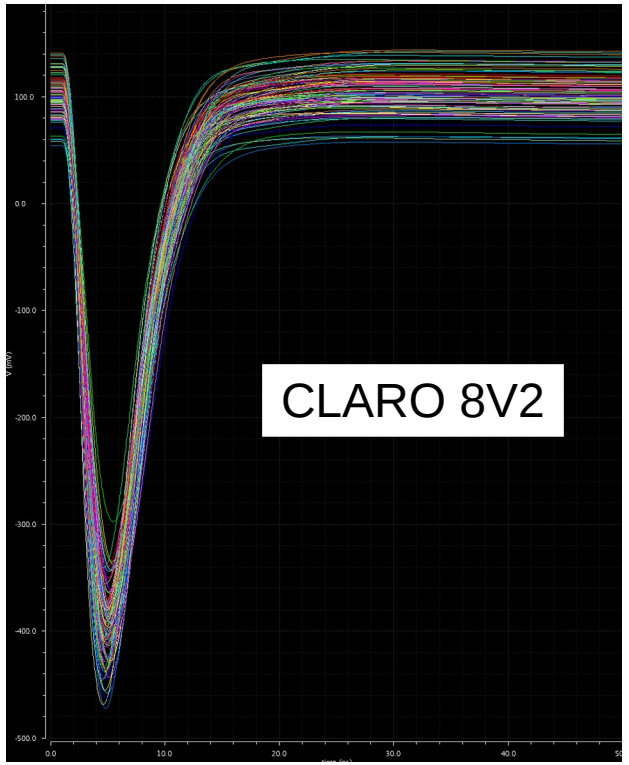




CLARO 8 Status

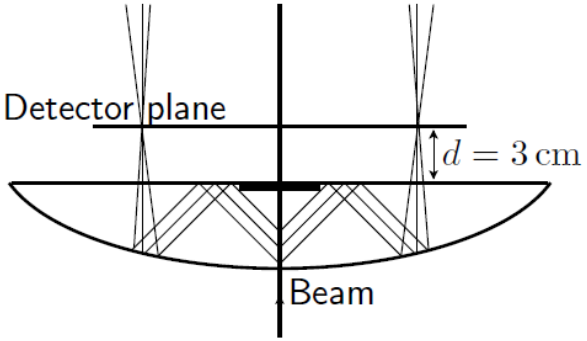
- CLARO 8V2 is the candidate for production
- Has been submitted in April and ~250 chips has been received (if green light from irradiations, beam tests, PRR)
- Various improvements over previous version
  - Example : improved threshold and gain dispersion

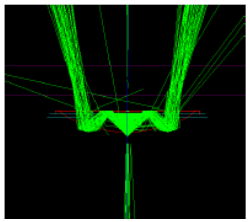


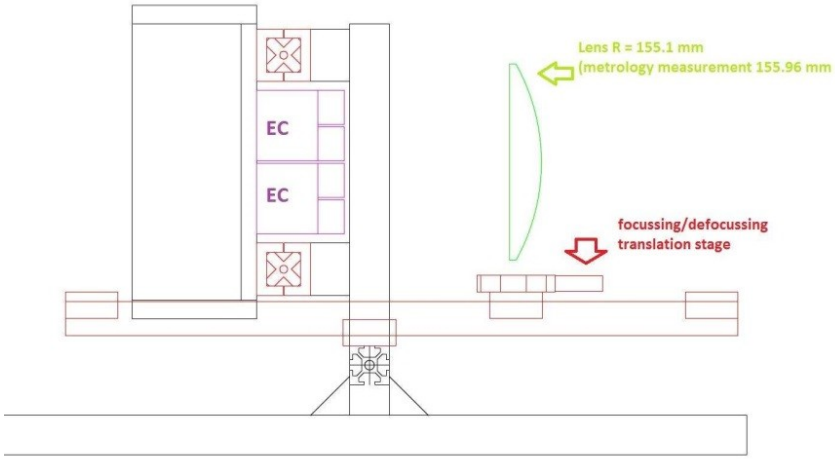


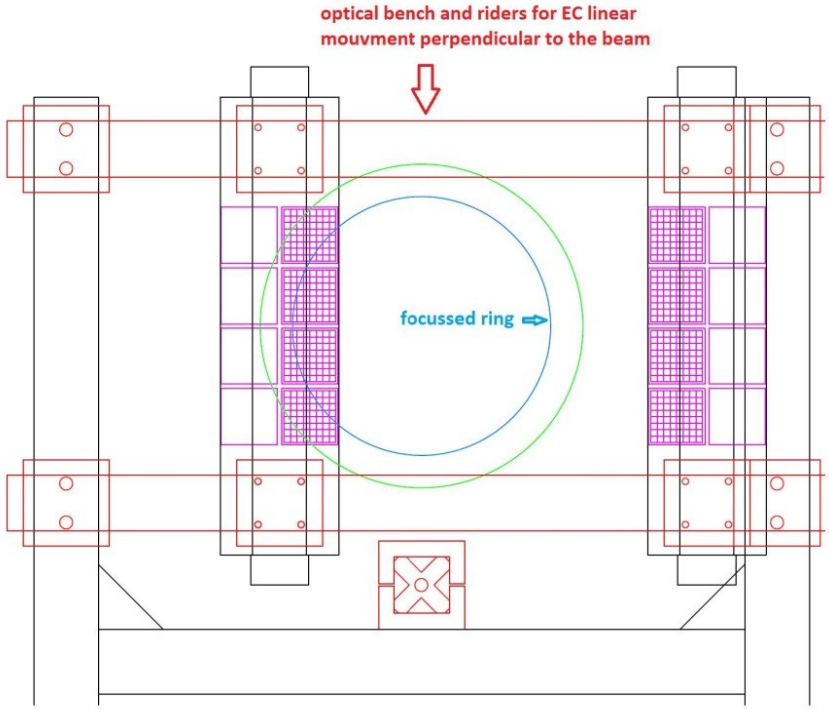
Test beam in July and September 2015

- An easy and robust concept was developed in TB 2014.
- At first the light is totally internally reflected.
- A reflective layer was deposited on the spherical surface.
- An absorber layer on the flat surface allows to choose the track path length to accept photons from.
- Improved setup developed in 2015

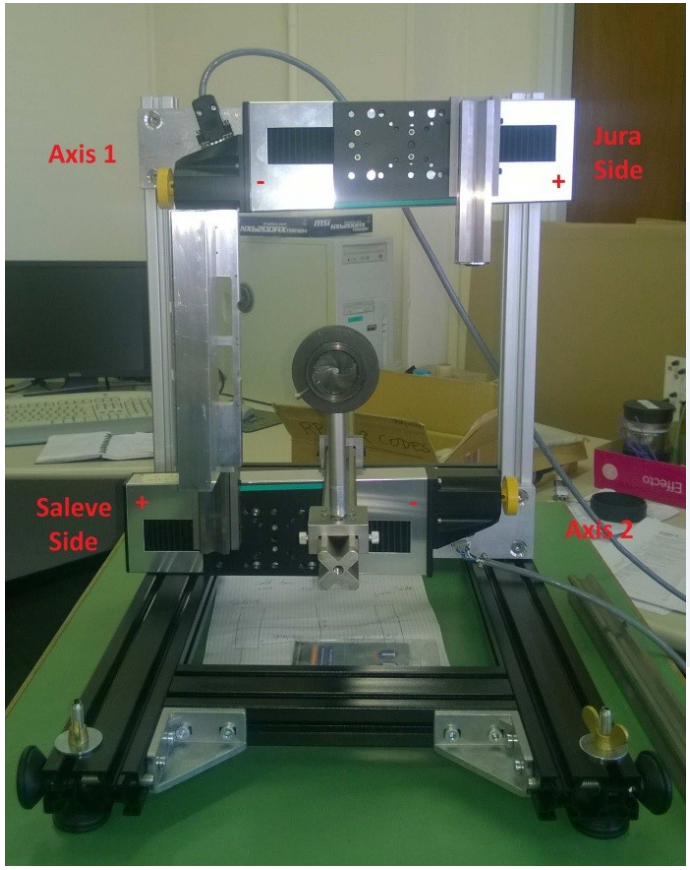


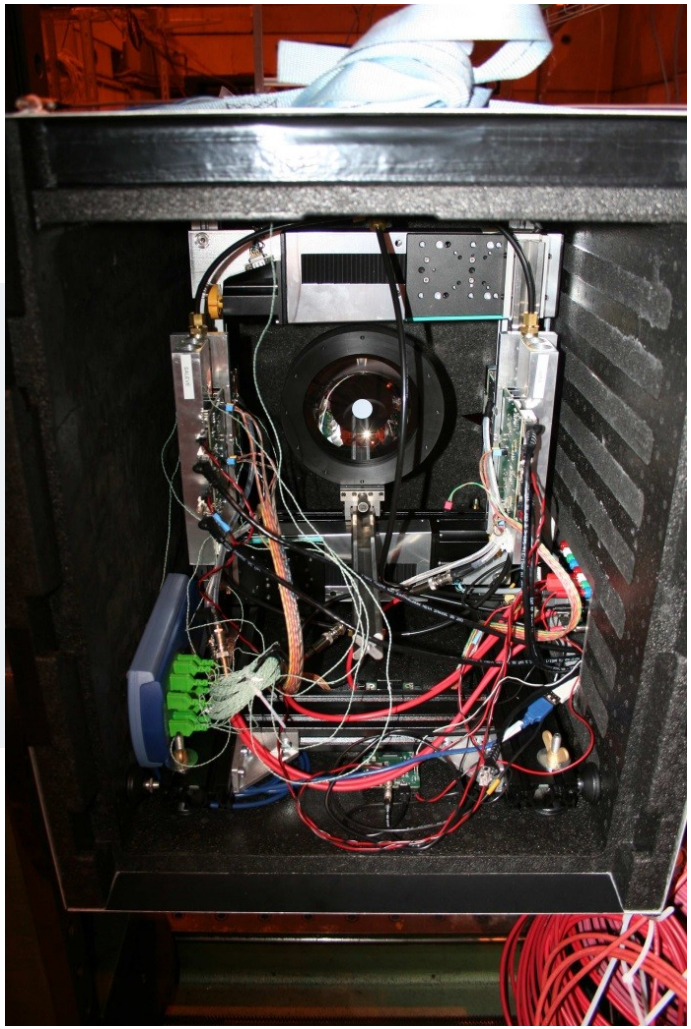






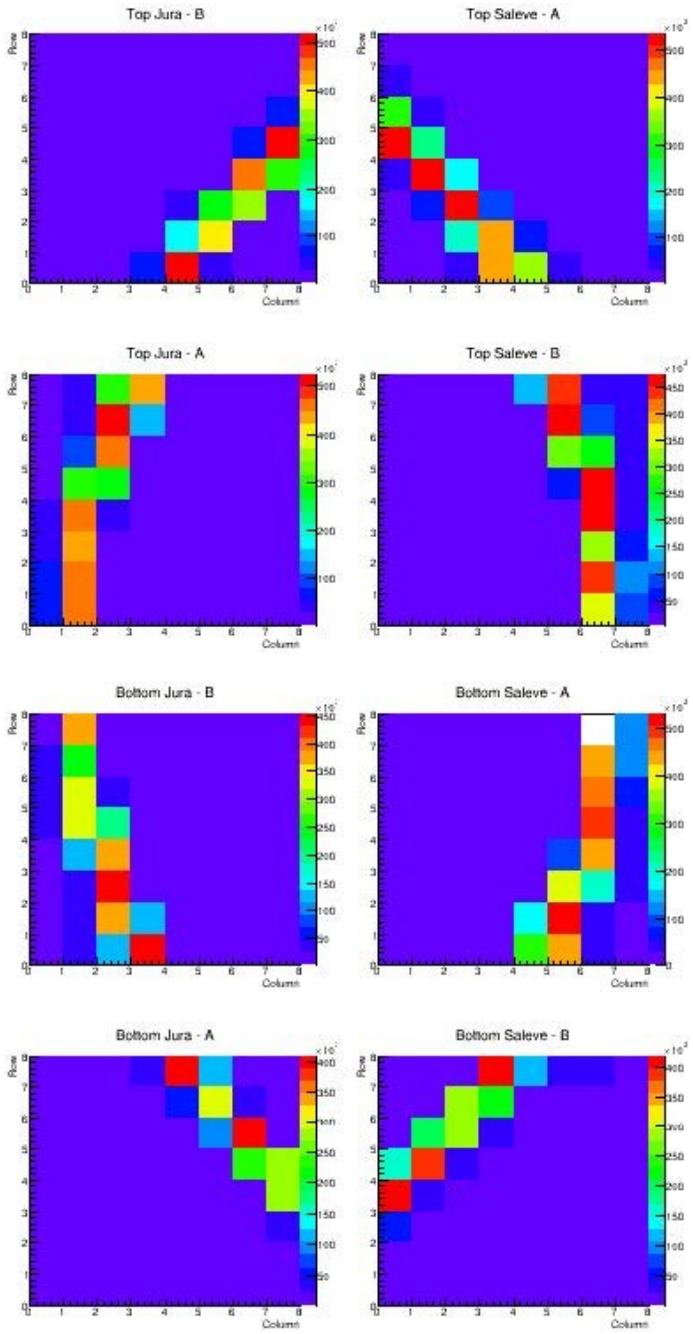
Experimental testbeam setup





One arm of the photodetector

Two arcs of the Cherenkov rings



Threshold setting procedure

- Single photoelectron detection efficiency

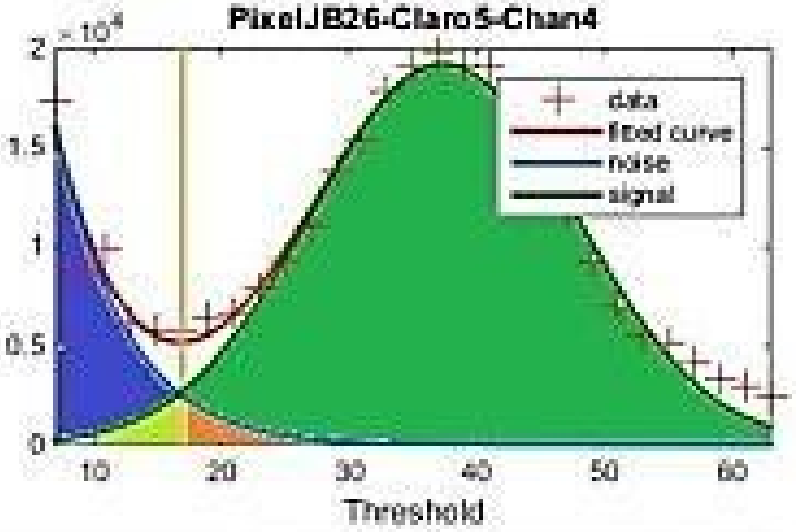
  It's the ratio of the single photoelectron peak area above the threshold (dark green + orange) and the total area (dark green + light green + orange)

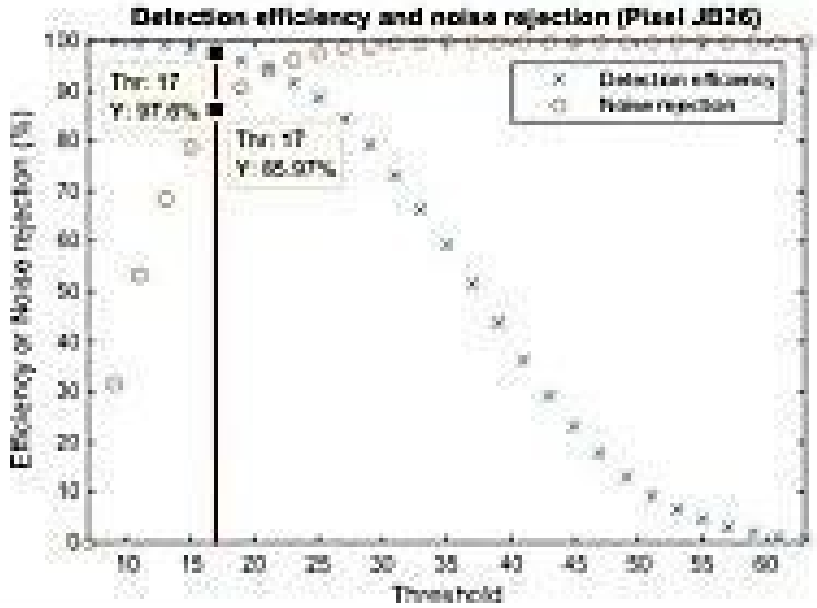
  This quantifies how much single photoelectron events are cut by setting the threshold at that value

- Pedestal events rejection

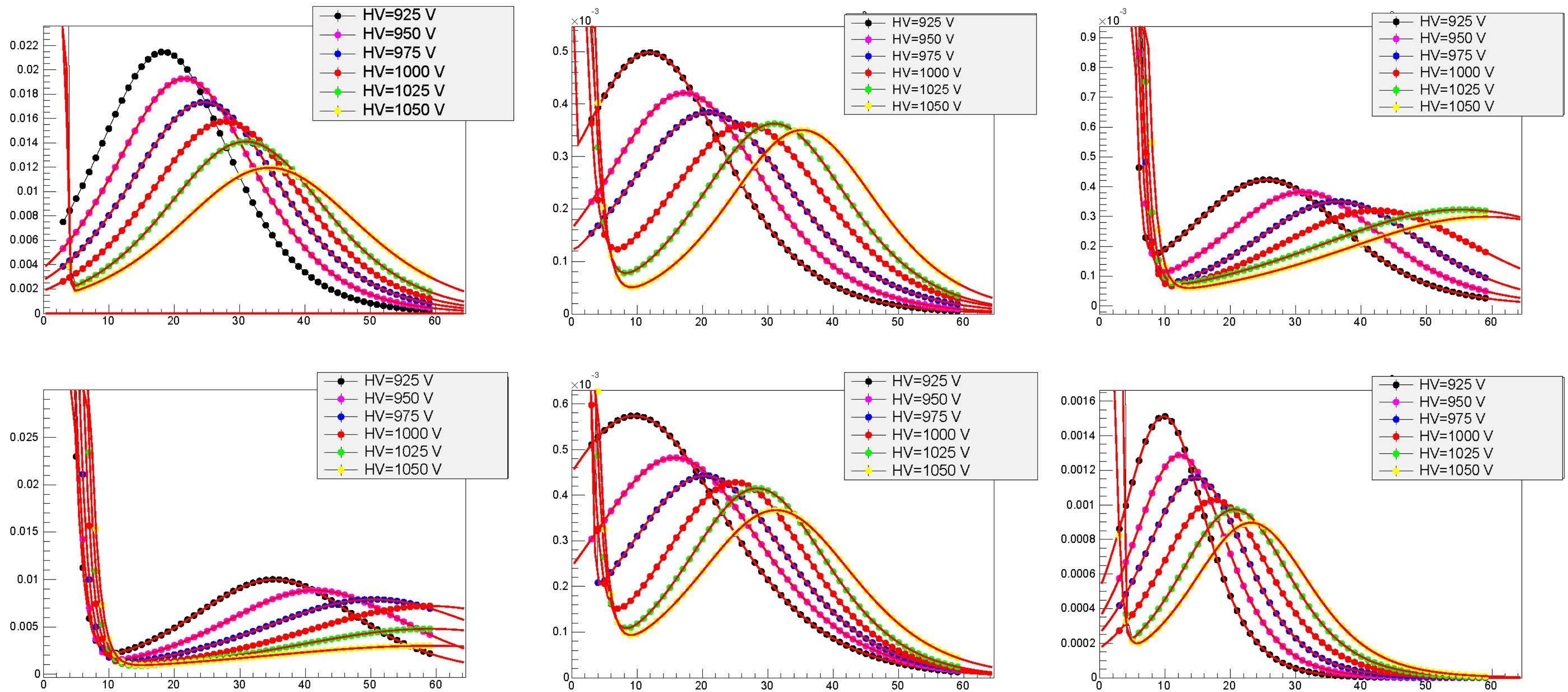
  Pedestal events rejection is the ratio between the pedestal area below threshold (blue + light green) and the total pedestal area (blue + light green + orange)

  This quantifies how much false counts (due to noise pedestal) can be eliminated by increasing the threshold

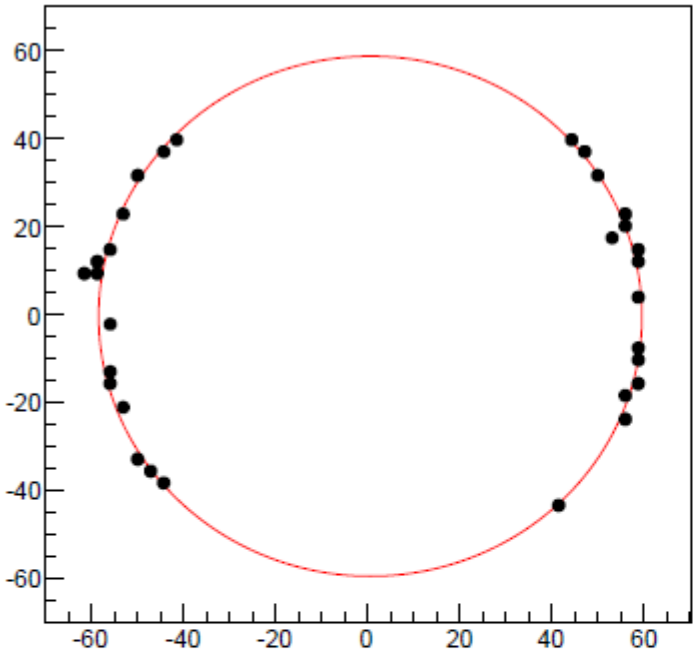




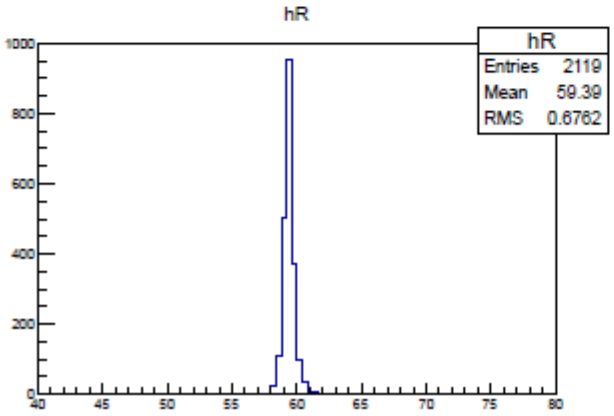
Detector characterization and HV scans

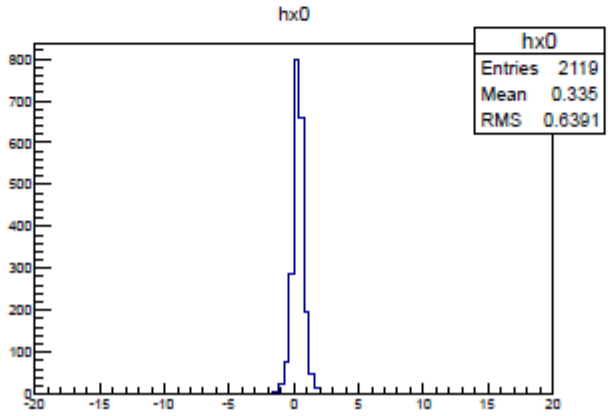


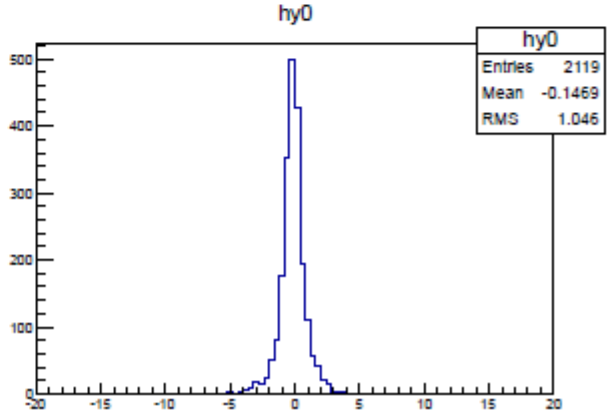
Fit of the ring



- $R_{ring} = 59.4\,mm$
- $\sigma = 0.67\,mm$
- Compatible with simulations



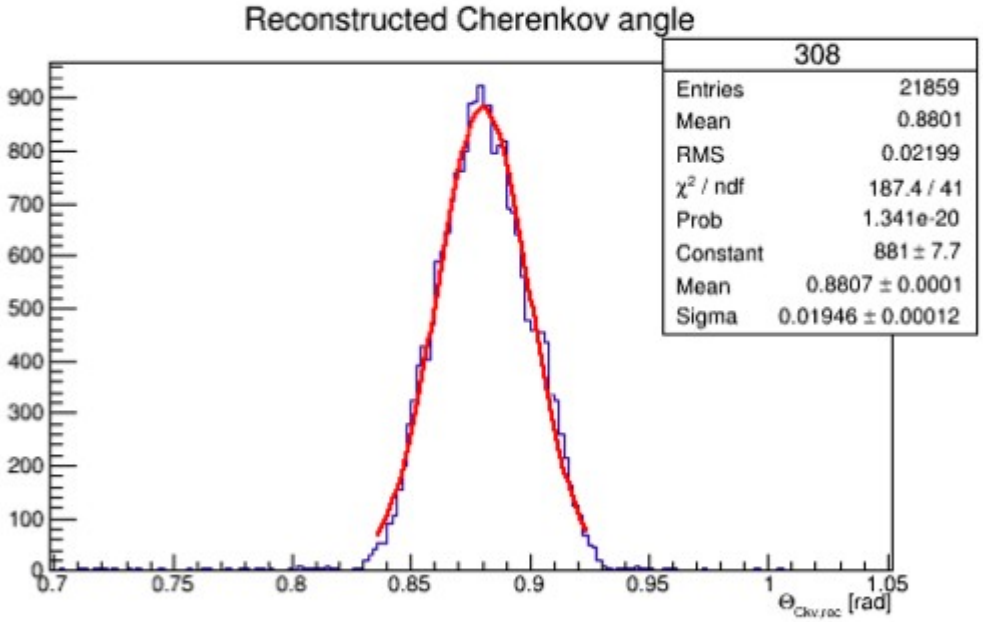




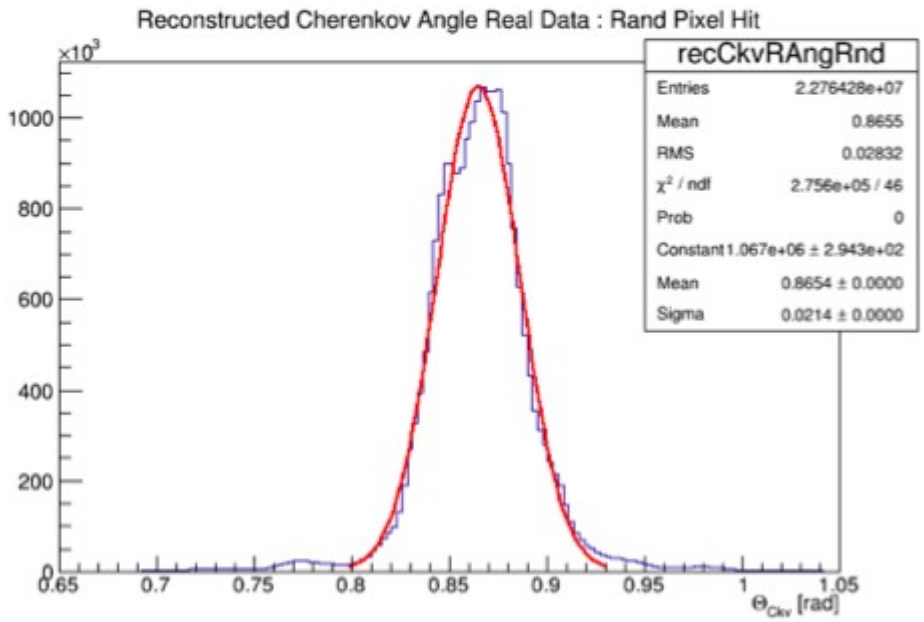
Cherenkov angle reconstruction

- A reconstruction of the Cherenkov angle has been performed
- Good agreement between MC and real data

Reconstructed MC Ckv Angle



Real Data Ckv Angle



$\theta_{Ckv,MC} = 880.7 \pm 19.4$ mrad

$\theta_{Ckv,real} = 865 \pm 21$ mrad

Irradiations: present status

- Components/devices irradiated so far:
  - CLARO4 prototypes (protons, neutrons, X-rays)
  - Hamamatsu PMT glass windows (protons)
  - CLARO8v0 (only cumulative effects with protons on 2 chips)
  - Base board and HV cables
  - CLARO8v1 (with ions in Louvain and Legnaro)
  - CLARO8v1 (with protons in Legnaro)
- Components/devices to be irradiated:
  - CLARO8v2 (ALDO?)
  - FPGA and digital board
  - PMTs + other Elementary Cell single components
  - Complete EC from PMT to digital board

3

Updated Milestones (Draft)

7	RICH	CLARO + Front-End Board	EDR, 7th of Oct	Oct-14	Oct-14
8	RICH	CLARO + Front-End Board	PRR	Jan-15	Jan-16
9	RICH	Elementary Cell	EDR, 16th of Oct, Baseboard+FEB+Backboard, mechs + therma	Oct-14	Oct-14
10	RICH	Elementary Cell	PRR	Jan-15	Feb-16
11	RICH	Photon Detector Module	EDR, Optoelectronic chain module + assembly	Mar-15	May-16
12	RICH	MaPMT	Place MaPMT order and start production	Mar-15	Oct-15
13	RICH	Digital board	EDR, DB hardware with basic firmware + ECS	Jan-15	Feb-16
14	RICH	Digital board	PRR	Aug-15	Sep-16
15	RICH	RICH1 Mechanics	EDR, incl Gas encl., Phot boxes, Phot funnel, Interfaces	May-15	Feb-16
16	RICH	RICH1 Mechanics	PRR	Oct-15	Sep-16
17	RICH	RICH2 mechanics	EDR	Nov-15	Feb-16
18	RICH	RICH2 mechanics	PRR	Jun-16	Sep-16
19	RICH	Installation	ready for installation	Aug-18	Apr-19

Conclusions

- Open issues in october 2014 mostly addressed
  - MaPMT QA program, magnetic shield design, claro v2 performance, thermomechanical design and prototypes, thermal simulation, EC-H design, [HV PS choice]
- Design of the thremomechanical interface is well advanced
- Design of the elementary cell is finalized
- MaPMT QA program has been defined and contract for procurement is ready to be signed
- Magnetic shield design has been improved
- Improvements in CLARO8 V2 has been successfully verified=> candidate for production
- Testbeam program alloed to study grounding, noise, threshold setting procedures and ring reconstruction