Quick update from dRICH prototype

EIC_NET general meeting

05/12/2022

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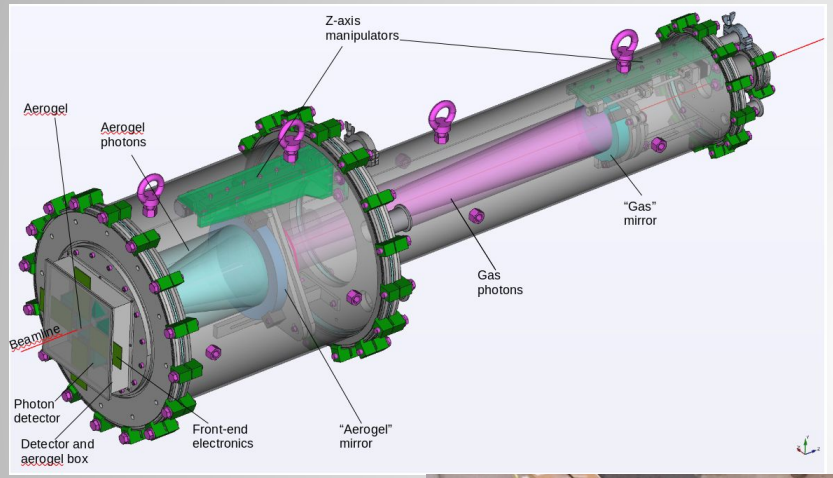
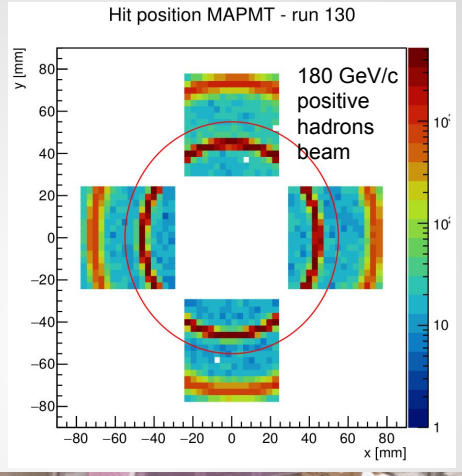
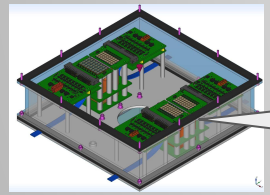
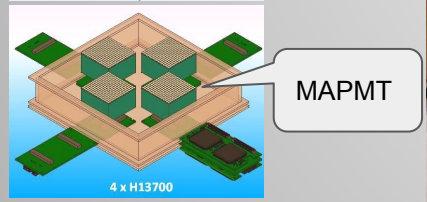
On the behalf of the dRICH prototype group

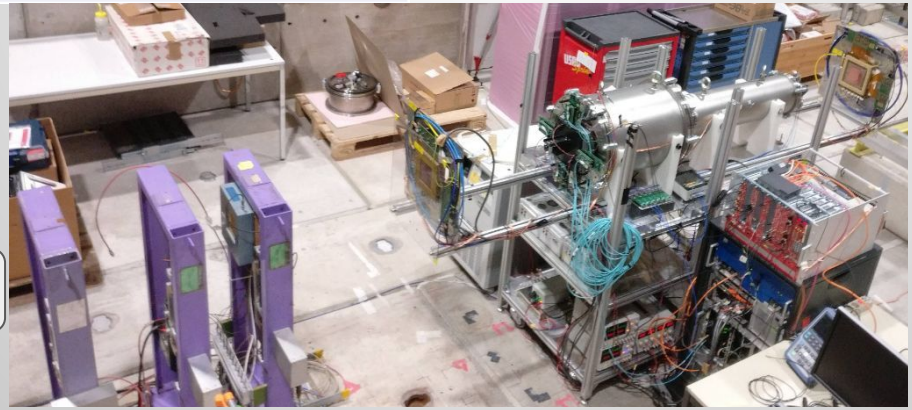
The dRICH prototype











It exploits the Cherenkov photons produced by two radiators

- aerogel, n ≃ 1.02
- C_2F_6, n ≃ 1.00085

and reflected to the same matrices of photosensor to distinguish hadrons in the full momentum range 3-50 GeV/c.

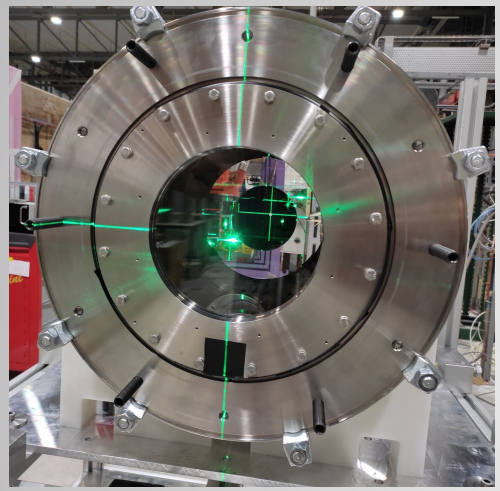
On going activities:

- 2022 test beam data analysis
- Improvement of simulation
- Development for the 2023 test beam: large-area photodetection plan EIC-driven with SiPM/ALCOR

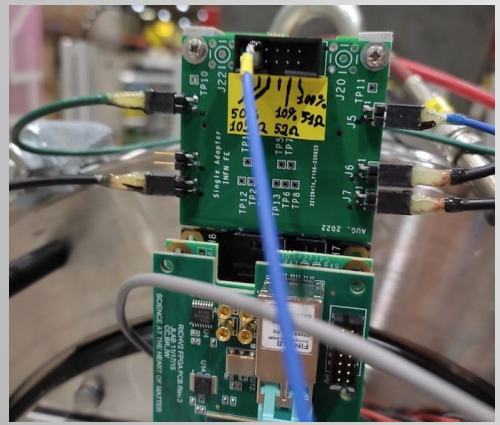
The 2022 test beam campaign

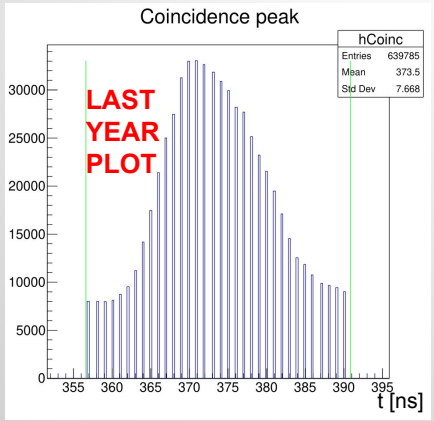
- 7-21 september at SPS, positive and negative beam of mixed hadrons between 15 and 180 GeV.
  Higher momentum beam to perform systematic studies on components and characterize the prototype. Sensor used: MAPMT.
  3 days to prepare the setup and set the beam, 4 days of machine development and 2 days of beam down → ~ 4 days with the detector running.
- 5-19 october at PS, positive and negative beam of mixed hadrons between 4 and 12 GeV.
  Lower momentum beam to perform study on the prototype performance and the SiPM/ALCOR DAQ chain. Sensor used: MAPMT and SiPM
  3 days to prepare the setup and set the beam, 2 days of beam down → ~ 9 days with detector running.

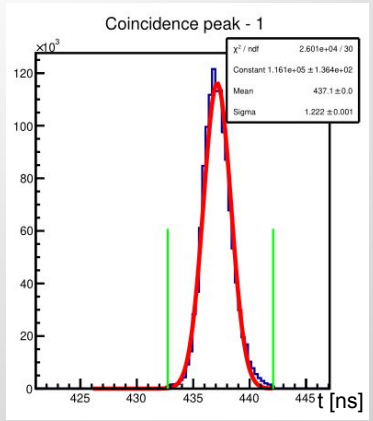
Test beam report - MAPMT

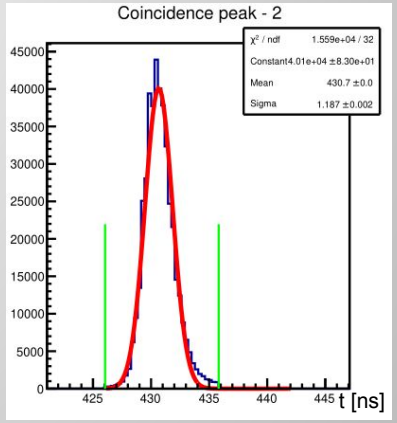


- A new alignment tool
- Introduction of the hit reconstruction in the analysis software
- Cherenkov taggers of the beam were used during the measurement
- A new readout system for the trigger signals to reduce the time jitter

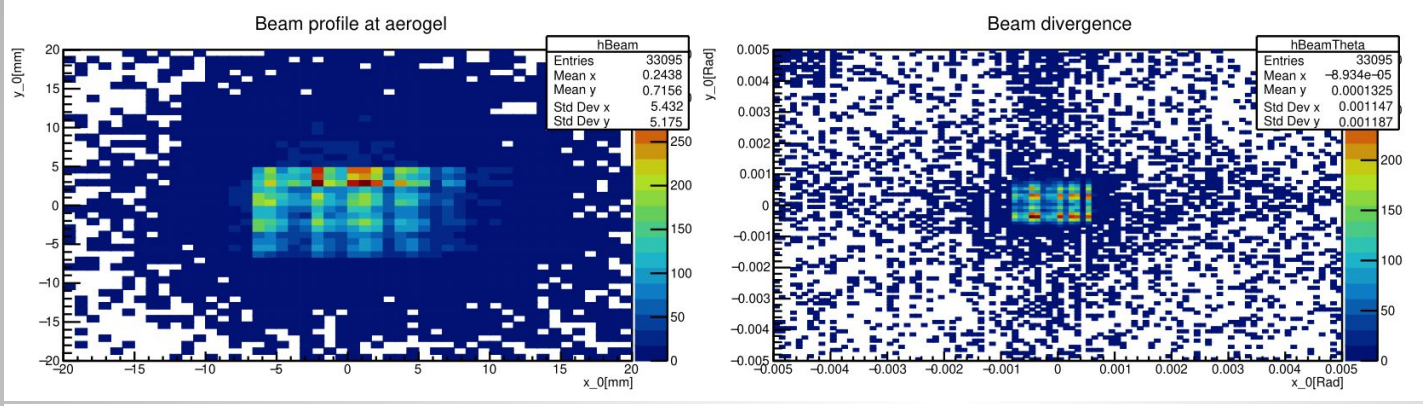


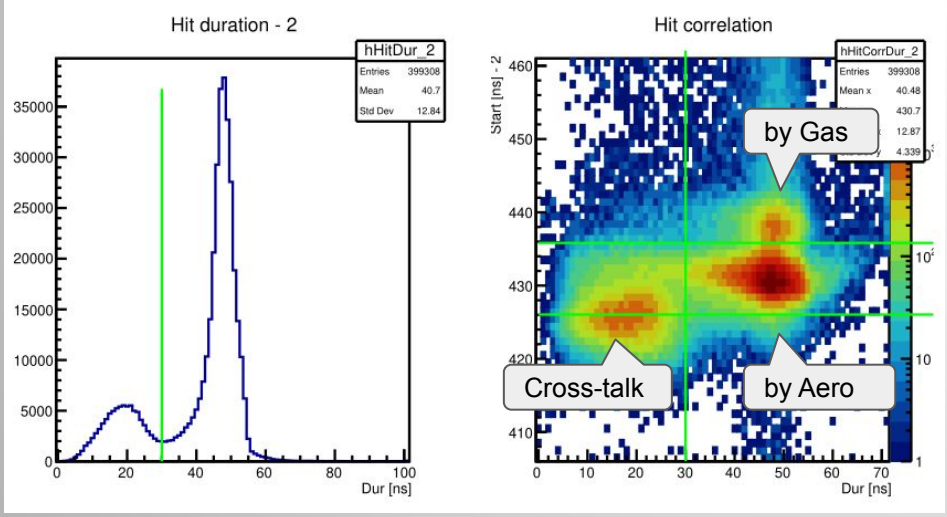


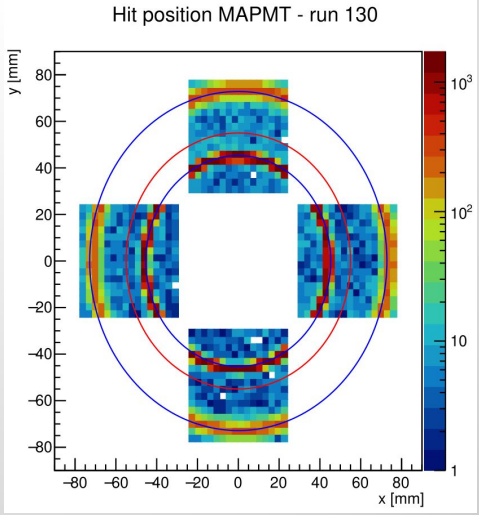




Test beam report - MAPMT







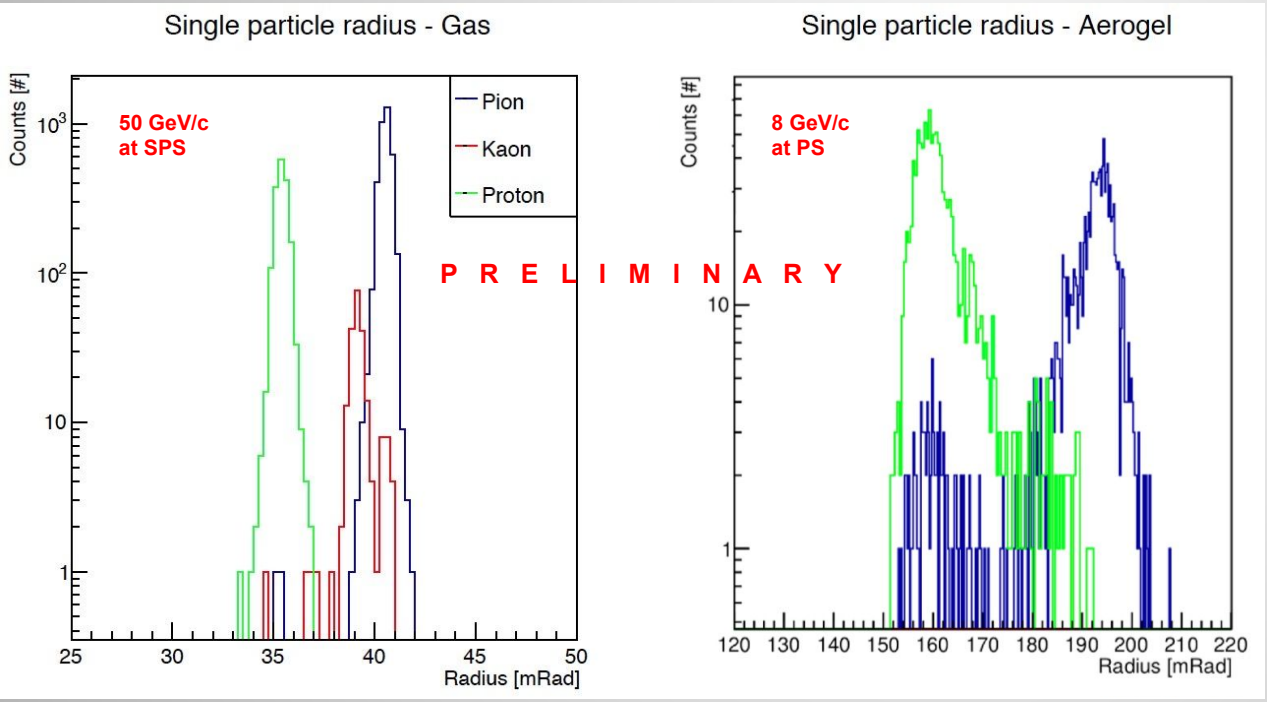
Top: beam profile and divergence

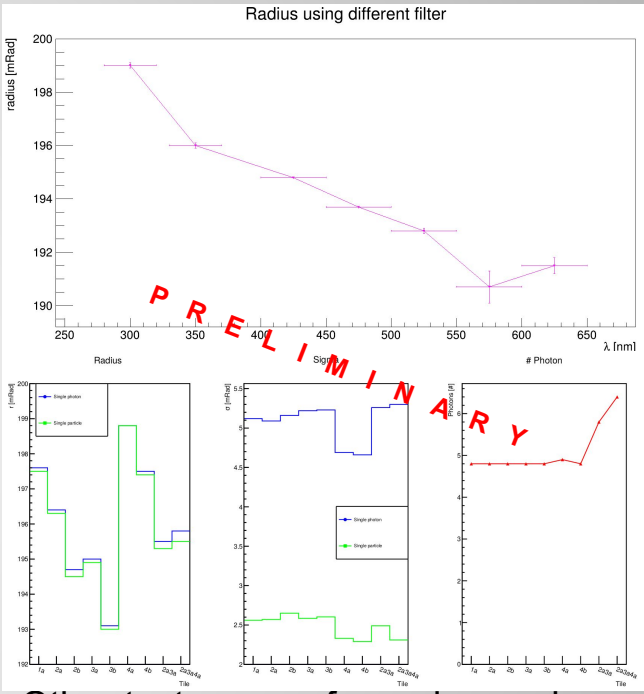
Bottom left: Time-Over-Threshold
Bottom center: Hit selection conditions
Bottom right: hit distribution on the detectors

- Red line: geometrical separation between aerogel and gas rings
- Blue lines: obtained ring for gas (in) and aerogel (out)

Test beam report - MAPMT

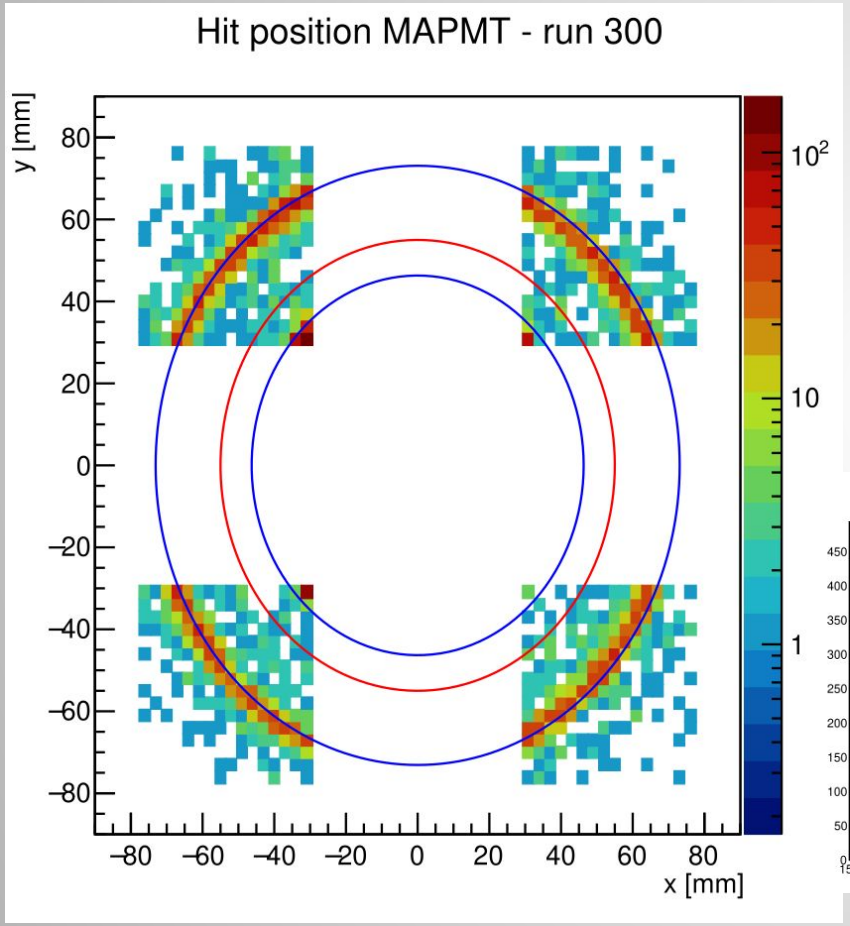
The cherenkov trackers provides the PID of the beam components. These two plots show the separation of proton using gas (left) and aerogel (right)





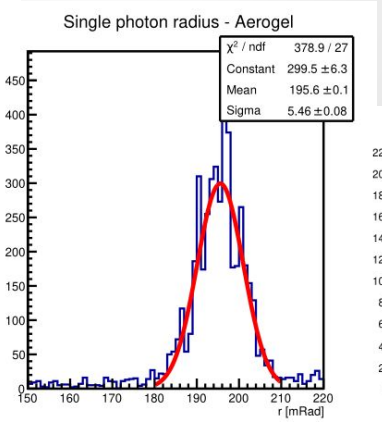
Other tests we performed regards the mirror position, the chromatic dispersion of aerogel using optical filters and differences between aerogel configurations

MAPMTs in the corners

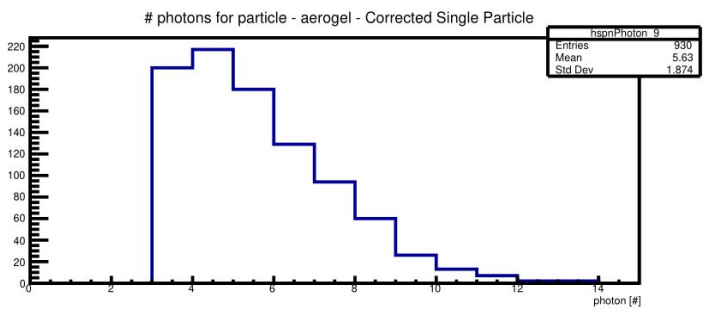


We placed the MAPMTs in the corners to cover the complementary portion of the aerogel ring, which is significant for aerogel, with a different occupancy of the photon detectors.

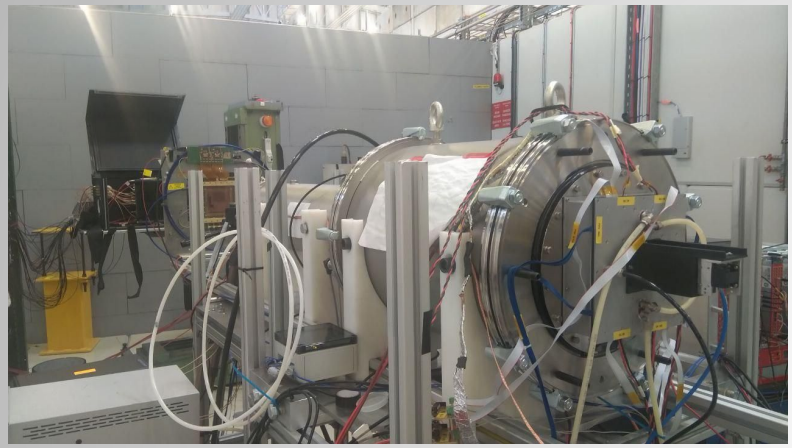
In the future we will try to merge data using the tracking information to obtain a complete ring with a larger number of photons.

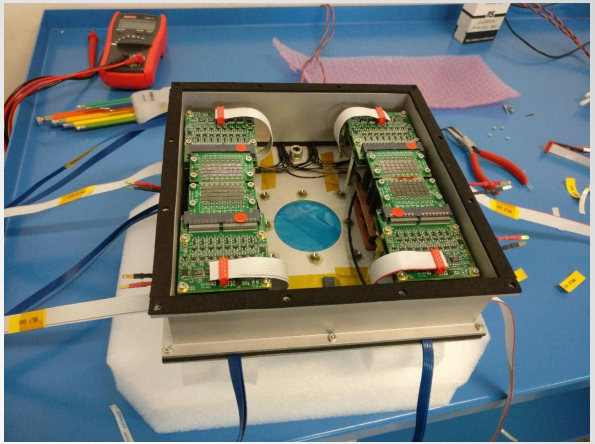


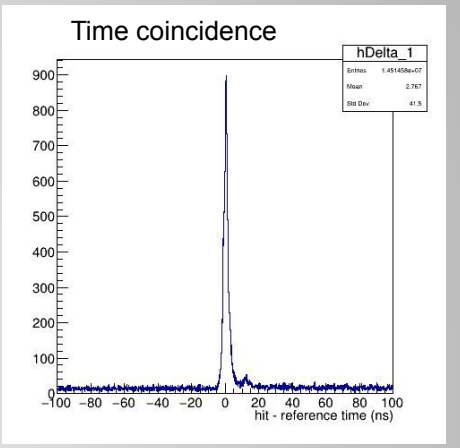
10 GeV/c negative beam



Test beam report - SiPM

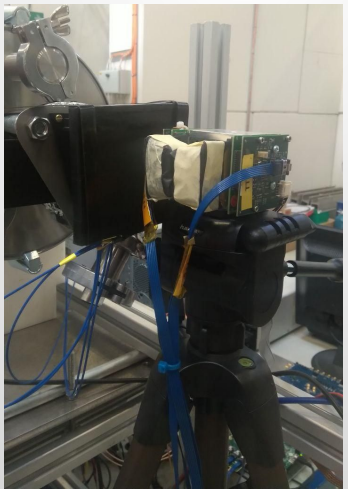






Successful operation of irradiated (up to 10^{10}) and annealed SiPM using a complete prototype readout chain based on ALCOR-v1

Timing system based on scintillators downstream the detector instrumented with SiPM and full ALCOR readout to provide reference time



Thanks to R. Preghenella

Test beam report - SiPM

8 GeV (positive beam)

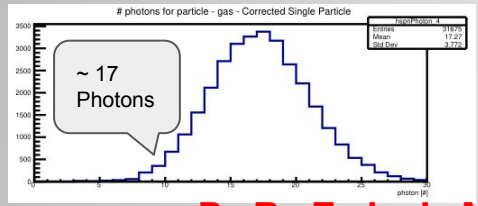
8 GeV (negative beam)

Thanks to R. Preghenella

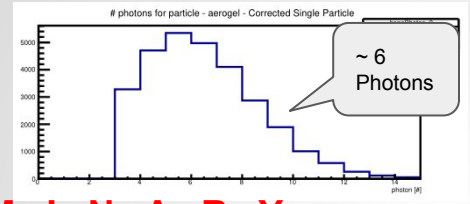
Test beam results

Results using the 180 Gev/c beam at sps

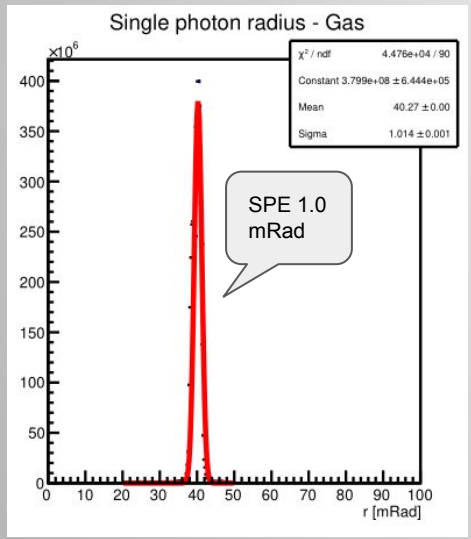
GAS

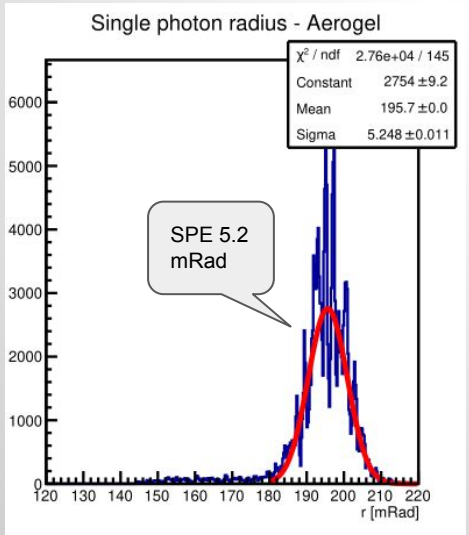


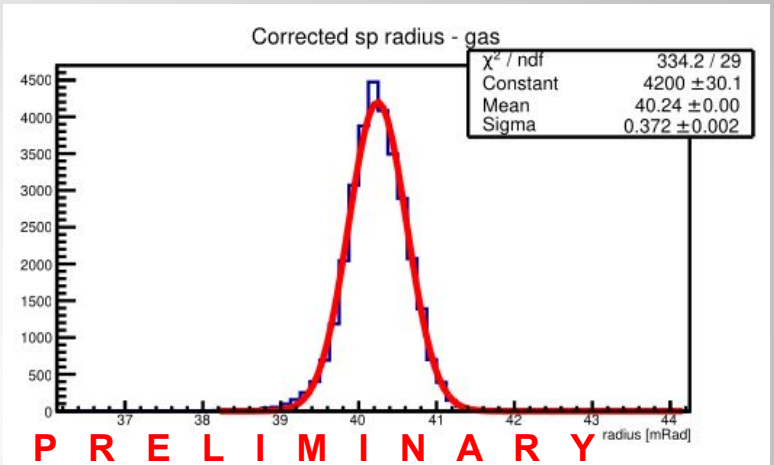
AEROGEL



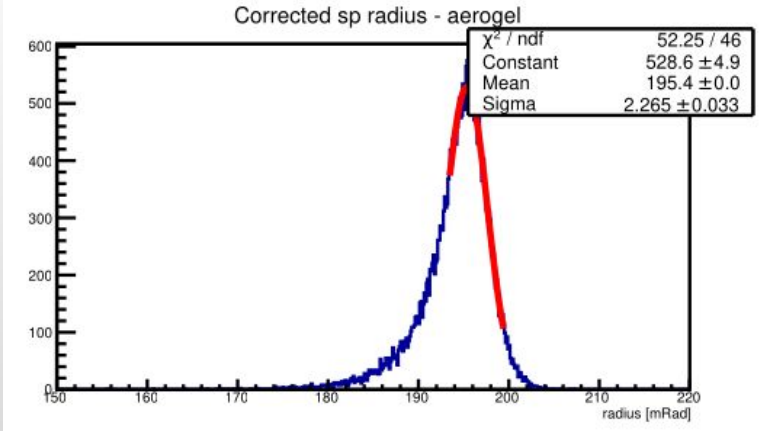
P R E L I M I N A R Y



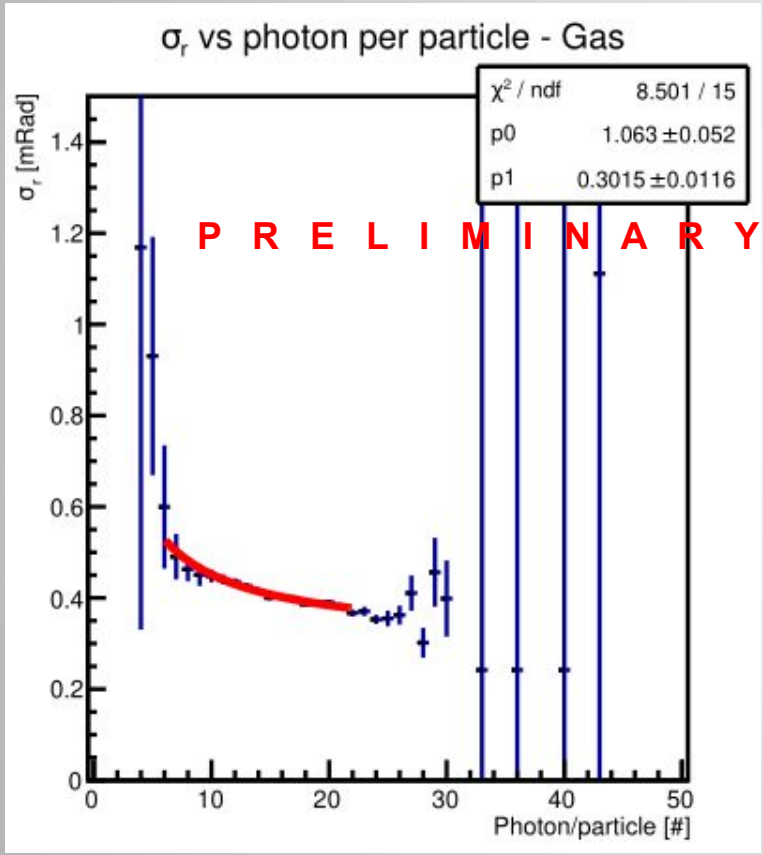


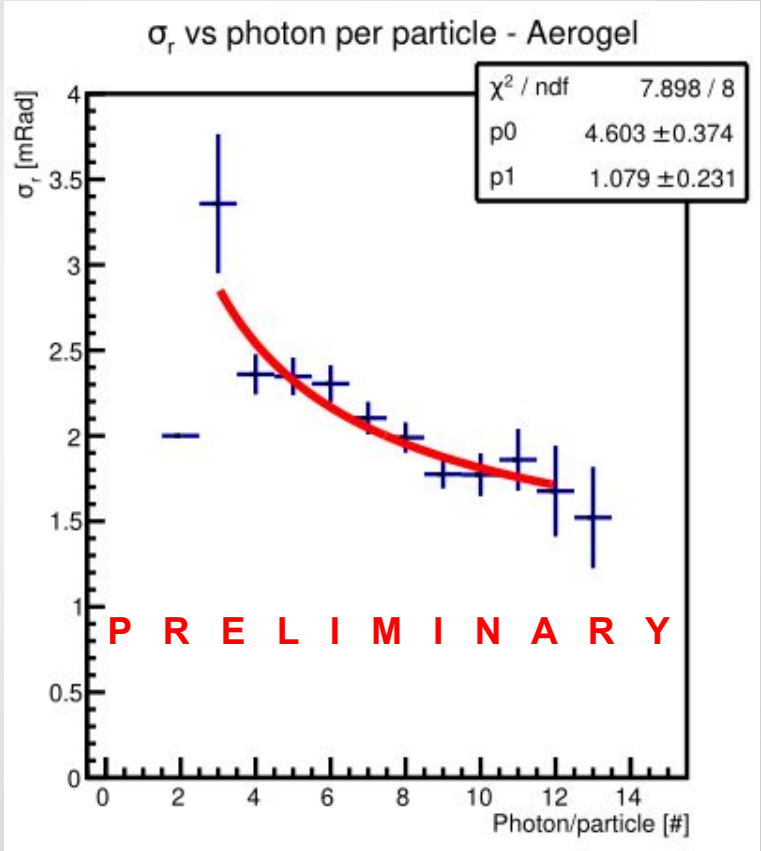


P R E L I M I N A R Y



Test beam results





Fitted with

$$\sqrt{\frac{p_0^2}{x} + p_1^2}$$

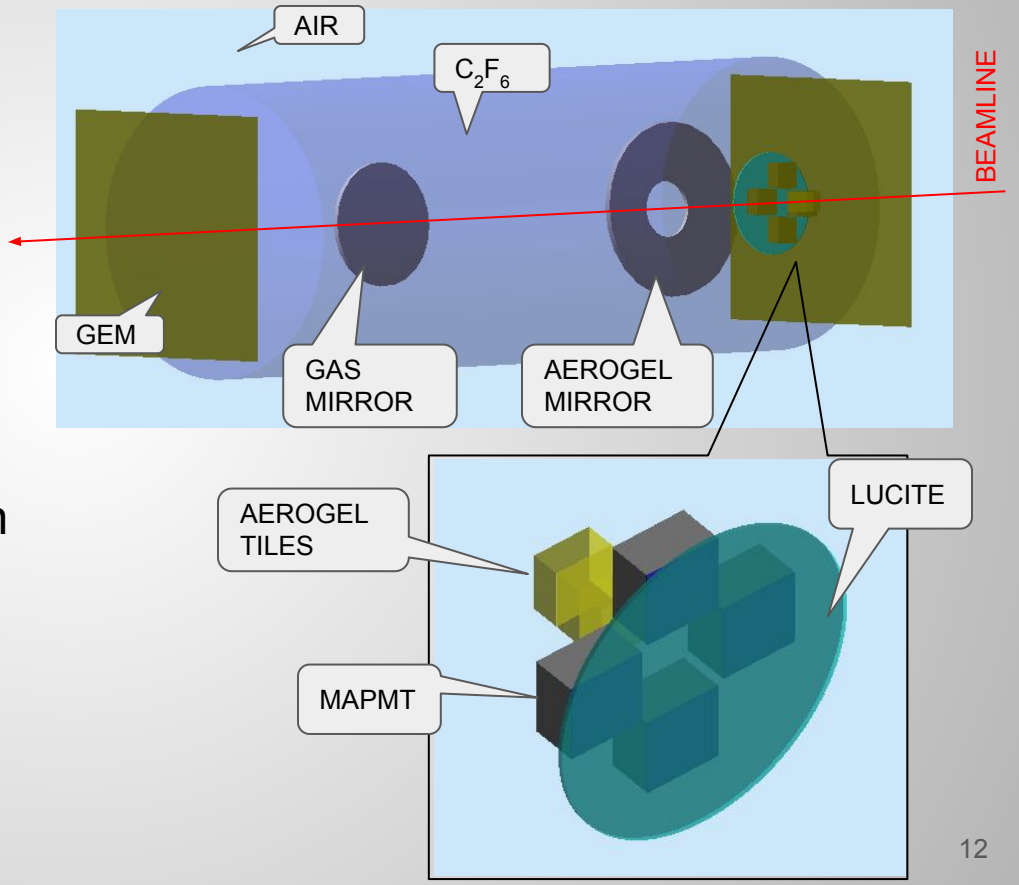
p_0 = Single photon resolution
p_1 = Constant term

There is still the systematic non zero constant term. We will use the new simulation to reproduce and understand the resolution and constant term.

Simulation status

New layout, more similar to the prototype

- More elements in the beamline (lucite, GEMs, air)
- New geometry (real mirror and MAPMTs position, aerogel divided in tiles)
- New materials from characterization (SUVT and UVT lucite, aerogel)



Components characterization

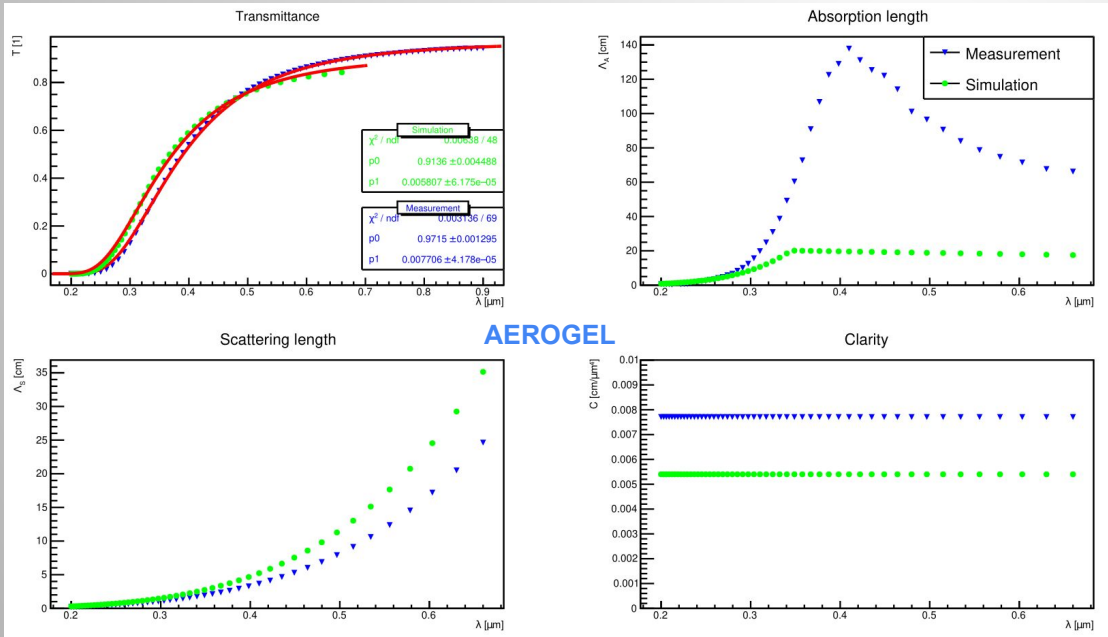
1. Transmittance measurement with the spectrophotometer
2. Fit with Hunt formula
3. Extraction of parameter C, the clarity
4. Correction of the parameter A as function of the wavelength
5. Computation of absorption and scattering length

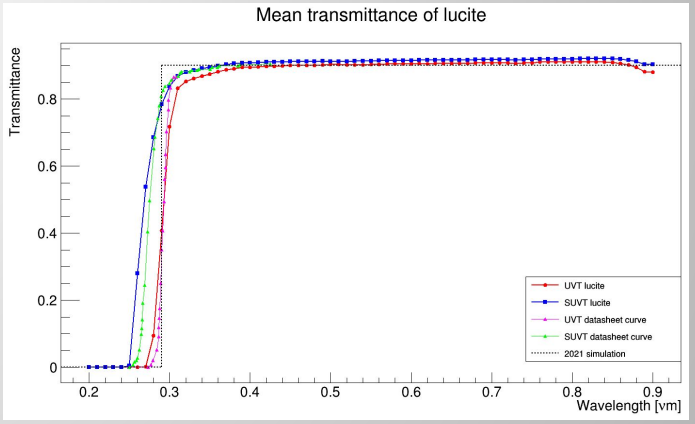
TRANSMITTANCE — THICKNESS — HUNT FORMULA

$$T = e^{-\frac{t}{\Lambda_{tot}}} = e^{-t\left(\frac{1}{\Lambda_A}+\frac{1}{\Lambda_S}\right)} = Ae^{-\frac{Ct}{\lambda^4}}$$

$$\Lambda_A = \frac{-t}{lnA}$$ **Absorption length**

$$\Lambda_S = \frac{\lambda^4}{Ct}t$$ **Scattering length**





Conclusion and outlook

- We performed the two test beam collecting a quite satisfying amount of data
- We achieved some preliminary encouraging results, but not yet in agreement with the 2021 simulation, which probably was too simple and could result optimistic.
- We are developing a more realistic simulation, in next weeks we will produce a set of data, to obtain new estimation of the expected performance of the prototype.
- We are developing the new boards for a large-area photodetection plane based on the SiPM and the ALCOR readout, it will be close to the final design for the real detector at EIC, including the cooling and maybe the online annealing systems.

The end

Thanks to anyone who contributed to the dRICH prototype project!