Dual-radiator RICH: update
EIC PID consortium meeting

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Outline

- Why a dual-radiator RICH (dRICH) in the h-endcup
- The simulation:
  - established baseline
  - recent results and developments
- The prototype
  - a first simulation
  - photon detectors table of comparison
- Future developments

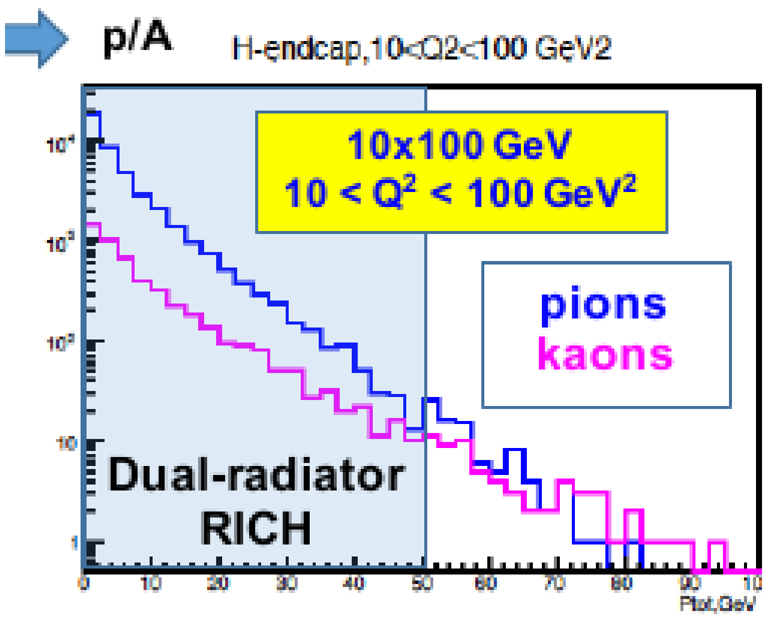
Proposed activities FY17

- Study of the background and performances with an acrylic shield separating the aerogel from the gas
- Geant4 digitalization of the photo-detector: optimal ladder-like shape fitting the real focal surface around the spherical first order approximation (current activity)
- Formulation of requirements on the EIC detector for optimal RICH performance
- Identification of candidates for the photo-detector (SiPM, MCP-PMT), it has to be insensitive to magnetic field
- Study and definition of a small scale prototype
- Optimization of the reconstruction algorithms: with the aim of reducing some single p.e. error source by software (i.e. with a kind of likelihood approach)
- Simulation of the feasibility of a compact version of the dRICH to better fit the BNL versions of the EIC detector, and evaluate the performance using the current BNL parameters for the magnetic field (*a collaboration is going oin in this direction*)

Why a dRICH in the hadron side

We want to study several processes where the capability of PID is extremely important.

- Common configuration Jlab/BNL (***e* 10 GeV x *p* 100 GeV**)



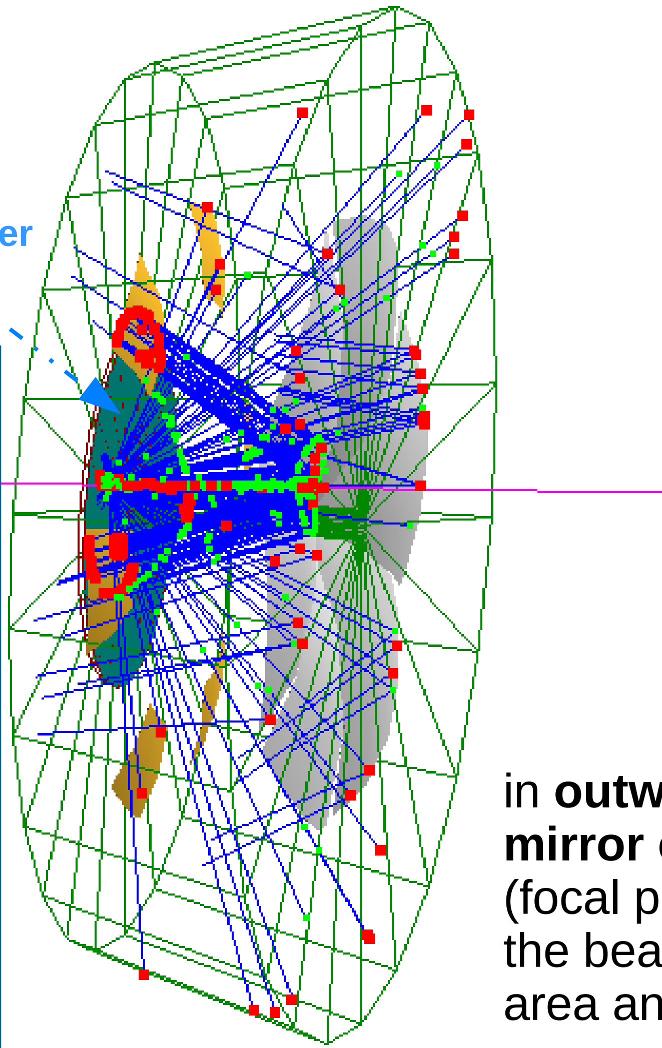
- The high momentum region contains important physics (i.e. SIDIS)
- We want to have hadron-PID capability in the range [~3,50]

dRICH baseline

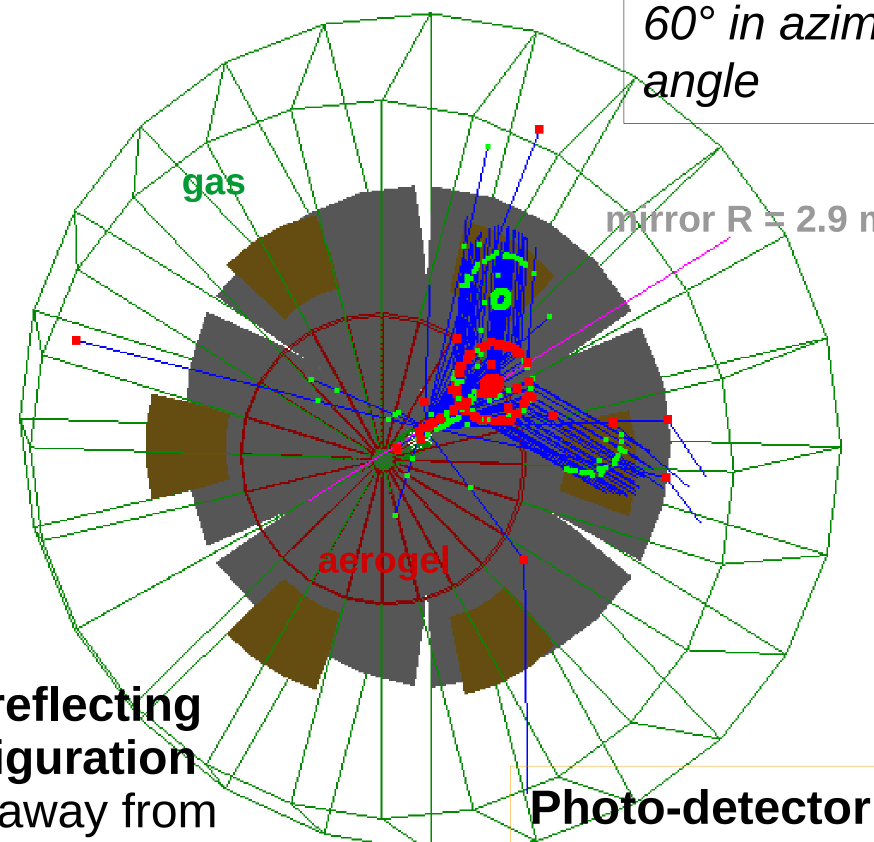
Aerogel (4 cm) & C_2F_6 gas (160 cm)

Simulation in GEMC (GEANT based framework)

<u>Polar coverage</u>
[5°,25°]
<u>6 sectors</u> of 60° in azimuthal angle



A 3mm thick acrylic filter has been applied, in front of the aerogel, to minimize Rayleigh scattering effects



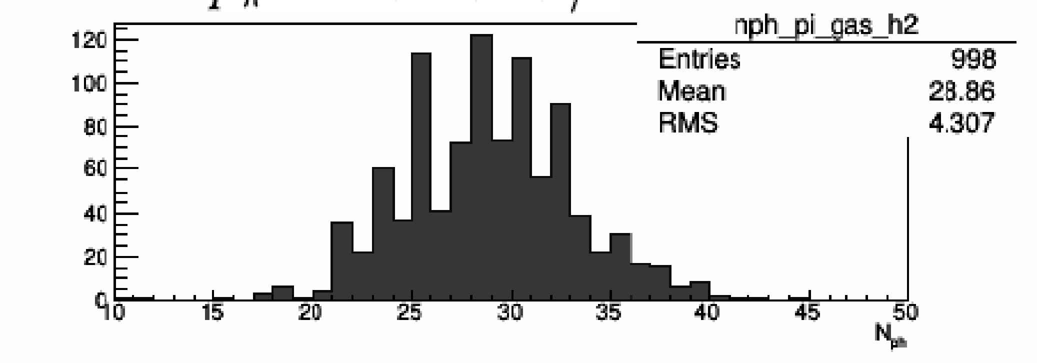
in **outward reflecting mirror configuration** (focal plane away from the beam, reduced area and background)

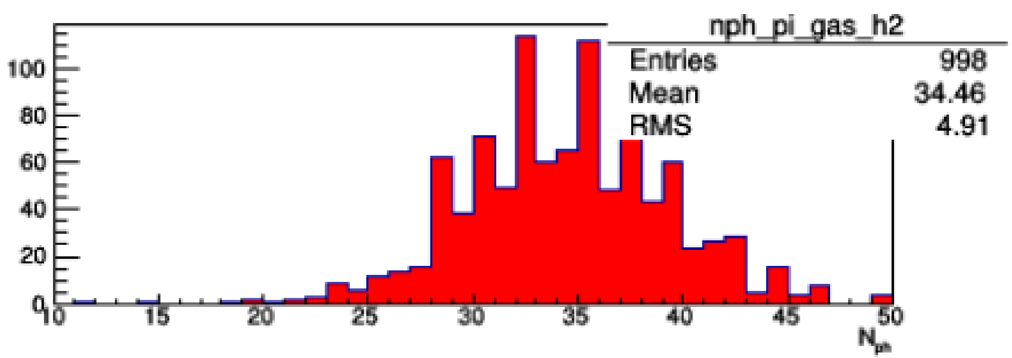
<u>dRICH is in magnetic field</u> (3T central field in the simulation)

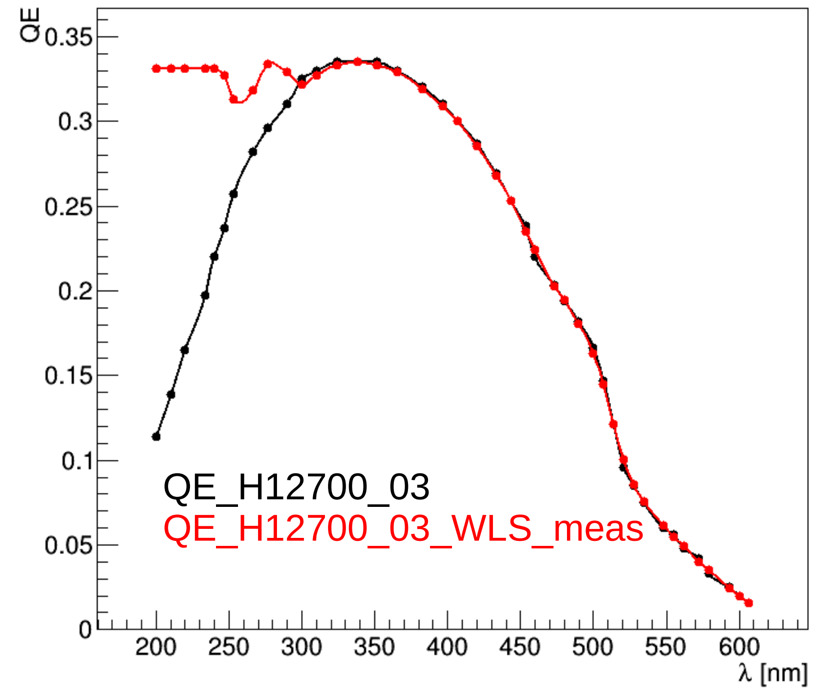
Photo-detector:
spherical shape
8500 cm² (per sector)
pixel size 3 mm

Number of p.e. for the gas – C_2F_6 (n = 1.00086)

$p_\pi = 31\ GeV/c$



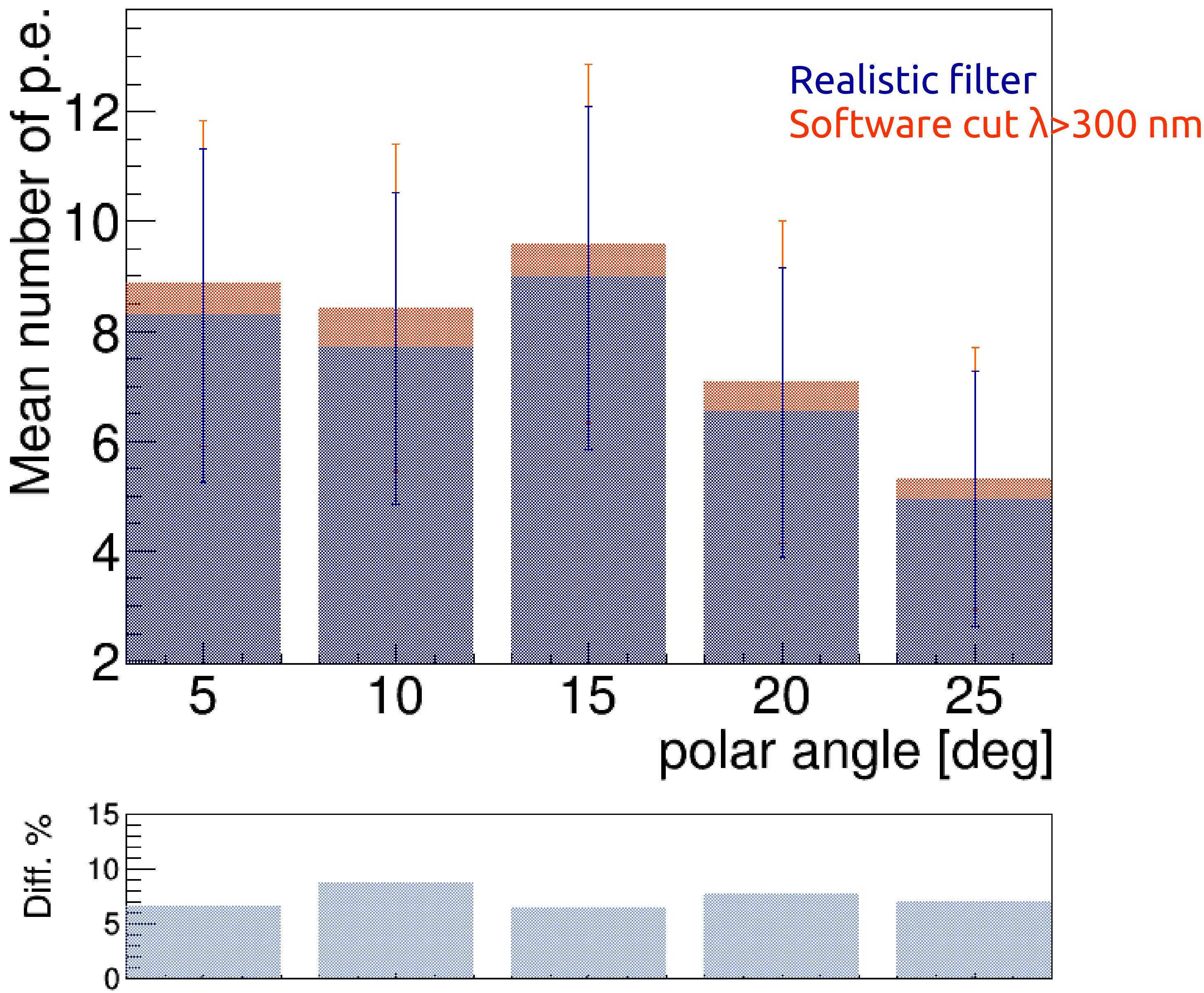




$$\lim_{\beta \to 1} N_{ph} = C \cdot L \cdot \epsilon(\lambda) \cdot \frac{n^2 - 1}{n^2} \propto \frac{n^2 - 1}{n^2}$$

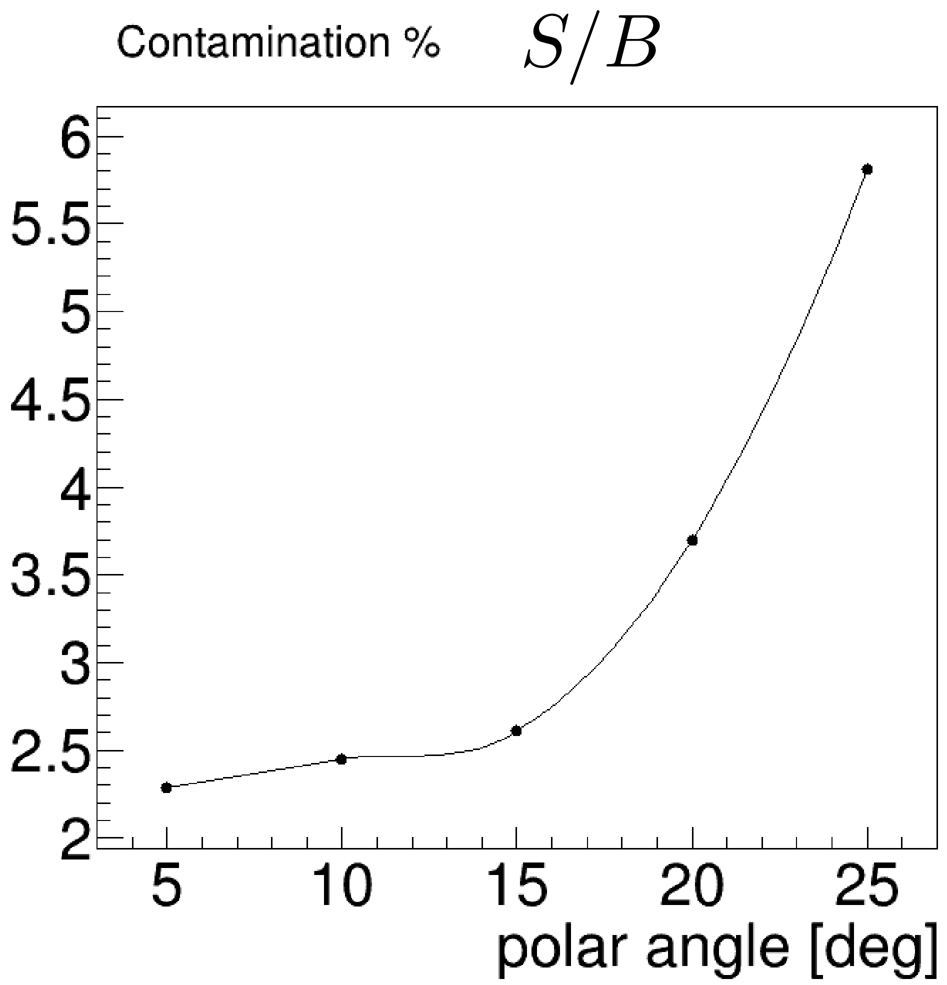
- The above distributions are resized by 0.7*Npe, assuming the same normalization of CF_4. To be validated with a prototype.

Aerogel (4 cm) N_{pe} vs polar angle



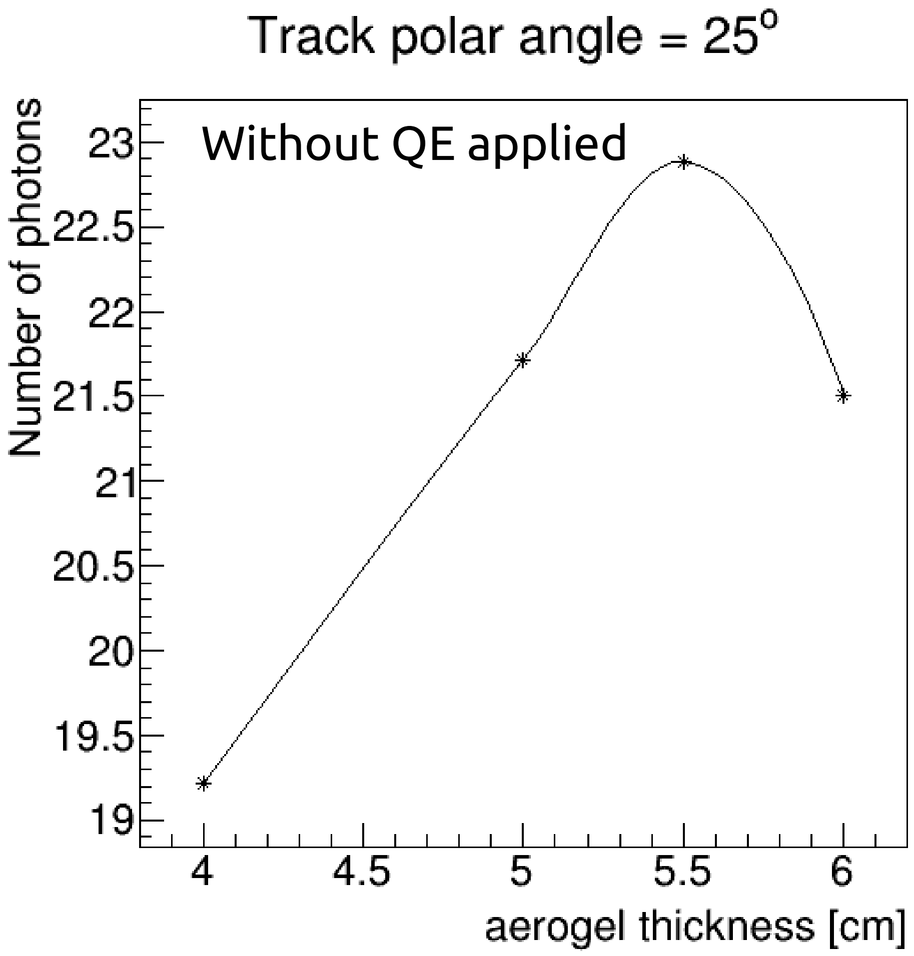
On the background with the shield

Occupancy
1 per event



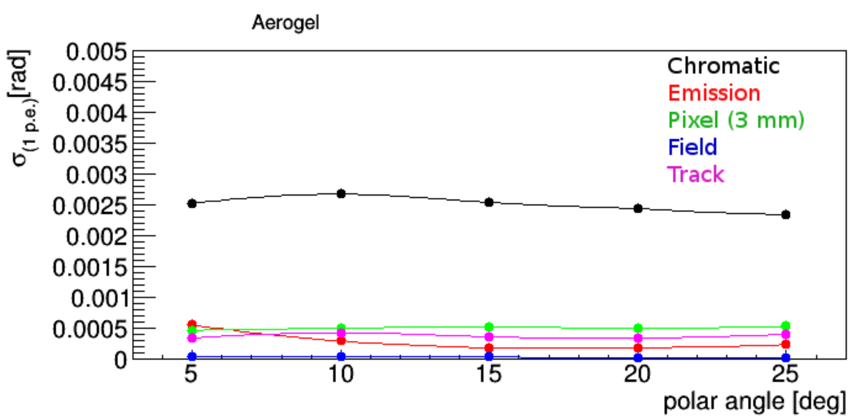
Aerogel – thickness vs number of photons

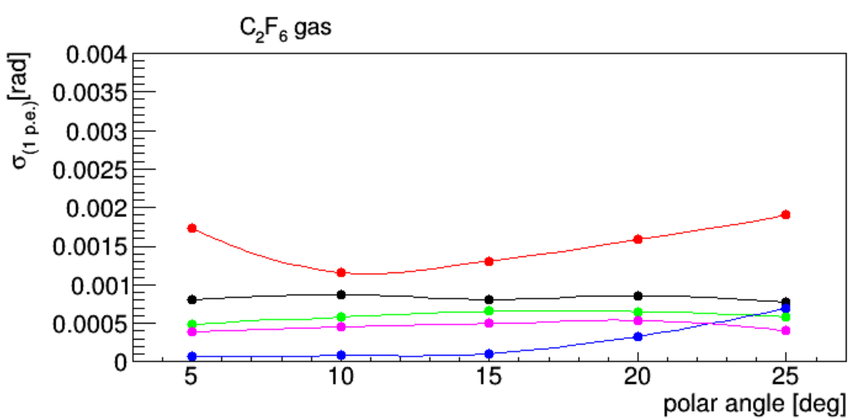
- Our baseline is 4 cm
- Aerogel can be extended to 5 cm thickness to gain some photon at high angles
- Aerogel blocks are usually provided in blocks 2 or 3 cm thick



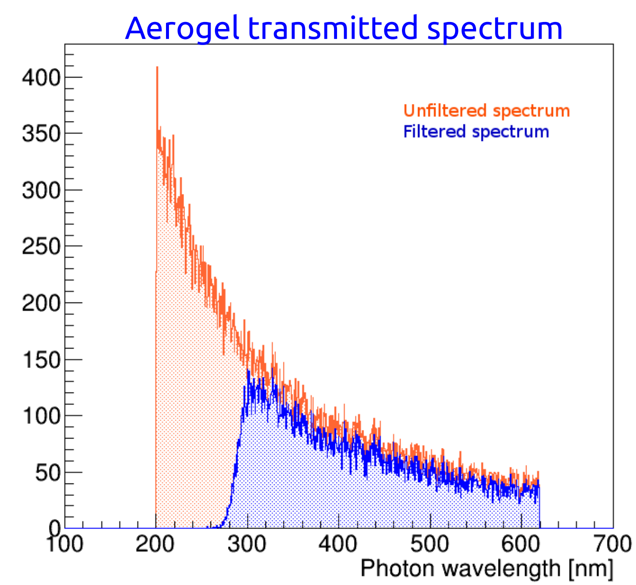
dRICH characterization

- Detailed optical properties of the aerogel (inferred from the detailed prototyping study of the CLAS RICH collaboration) included in the simulation (i.e. Rayleigh scattering, n(λ), absorption length, ...)
- All the main contribution to the Cherenkov angle resolution have been evaluated

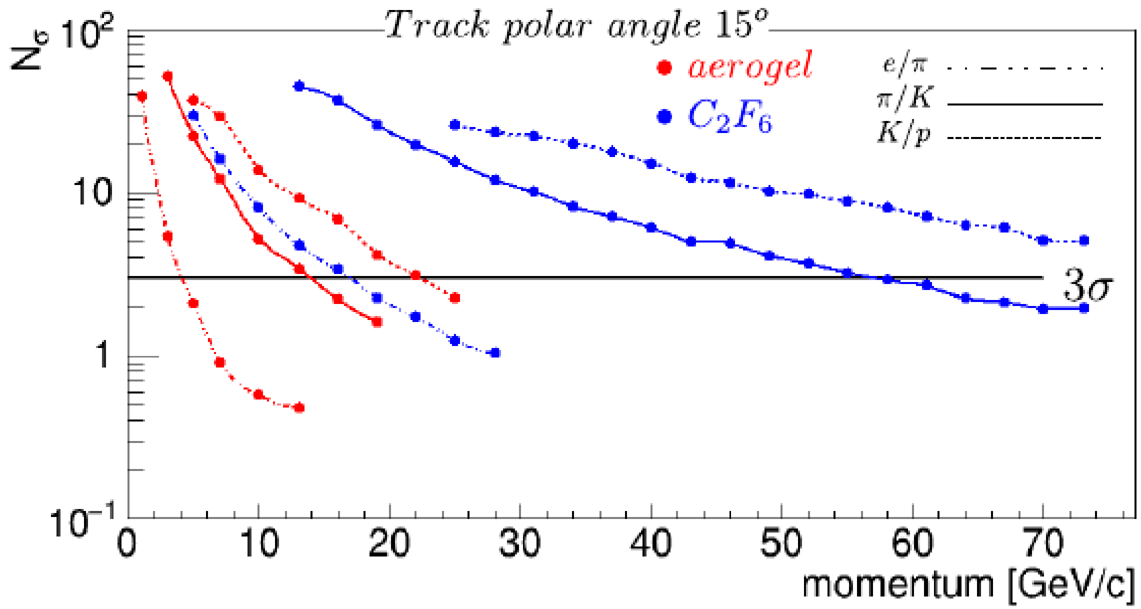




The emission error is the dominant Contribution to the 1 p.e. error for the gas.



PID capability



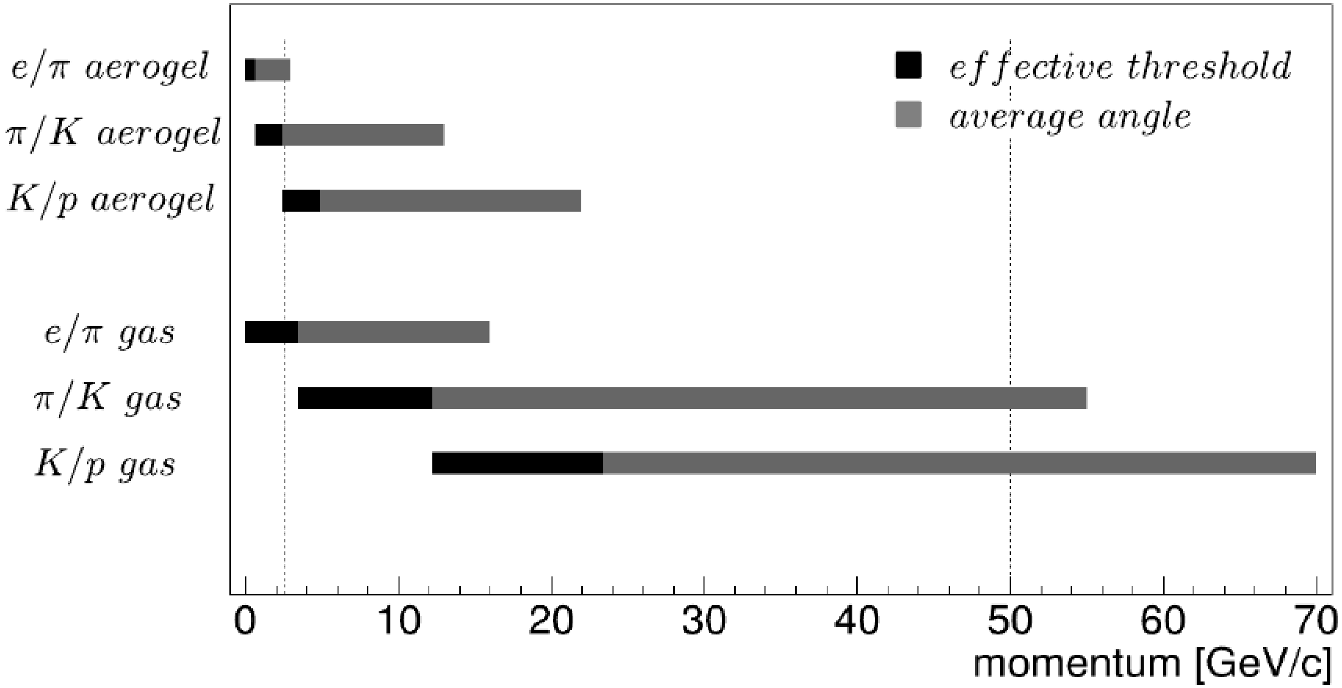
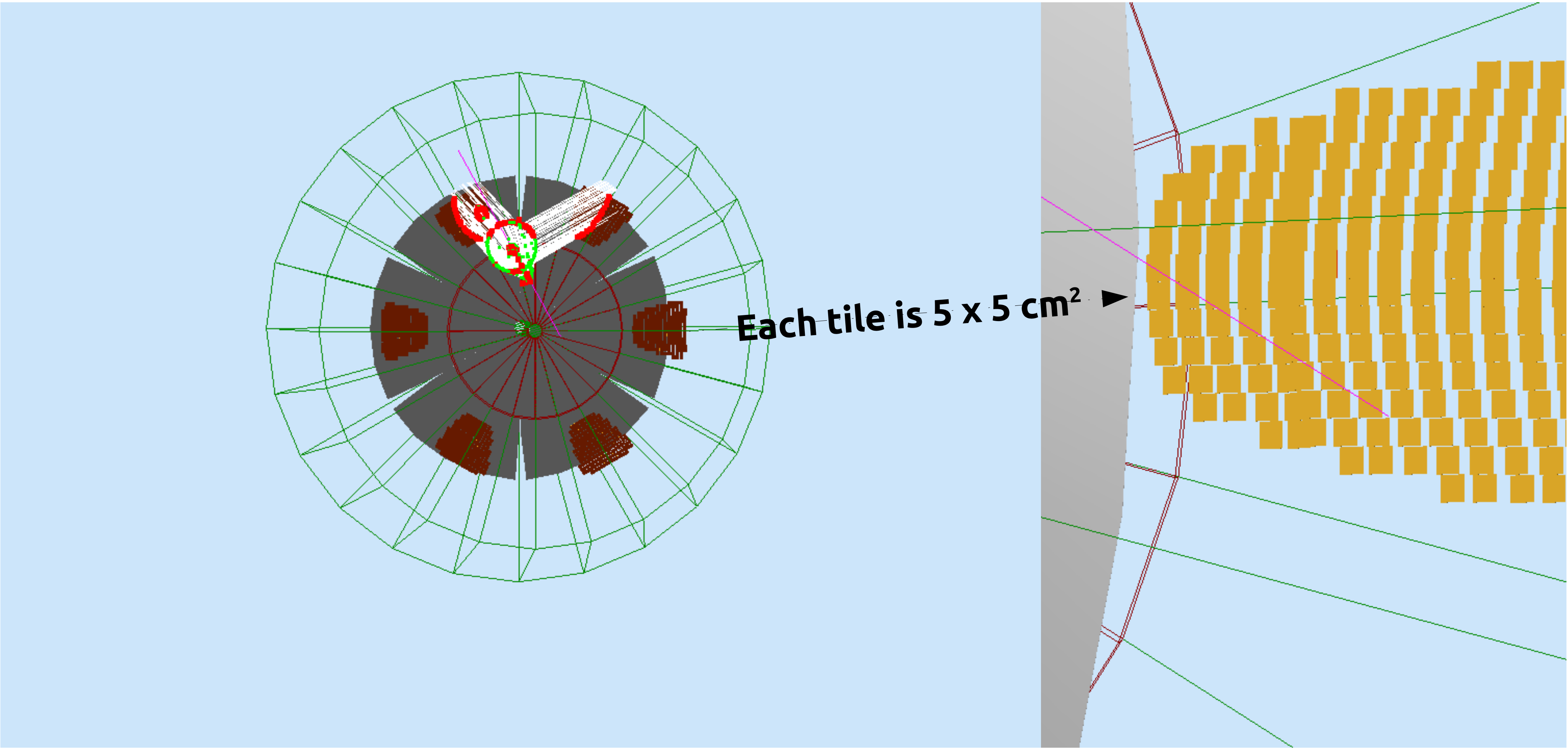


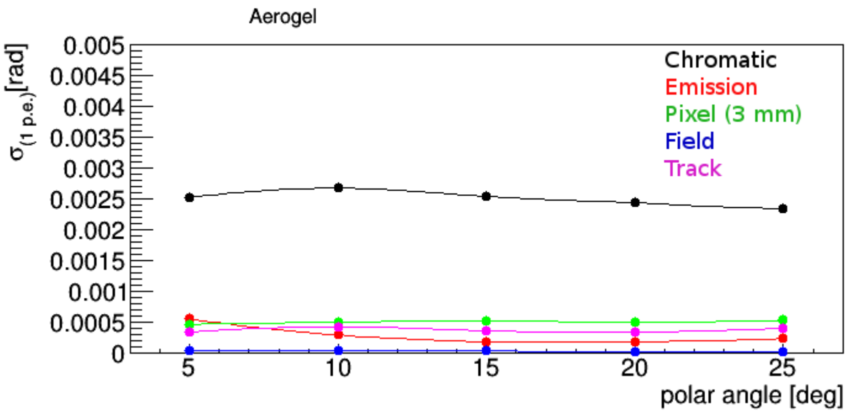
Photo-detector plane tessellation

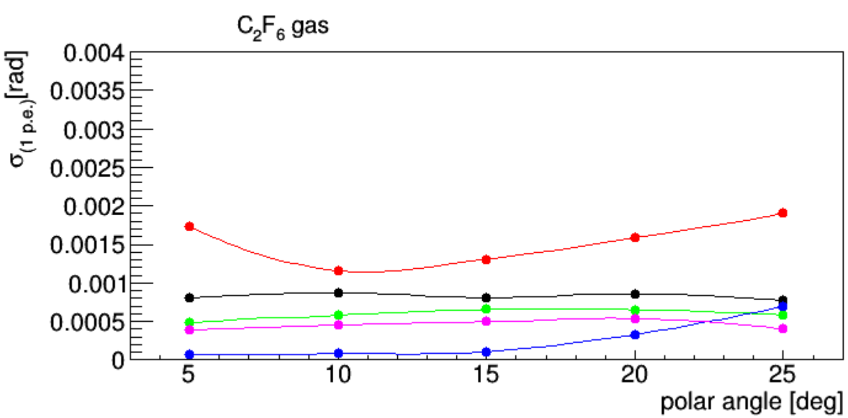
Adaptive surface



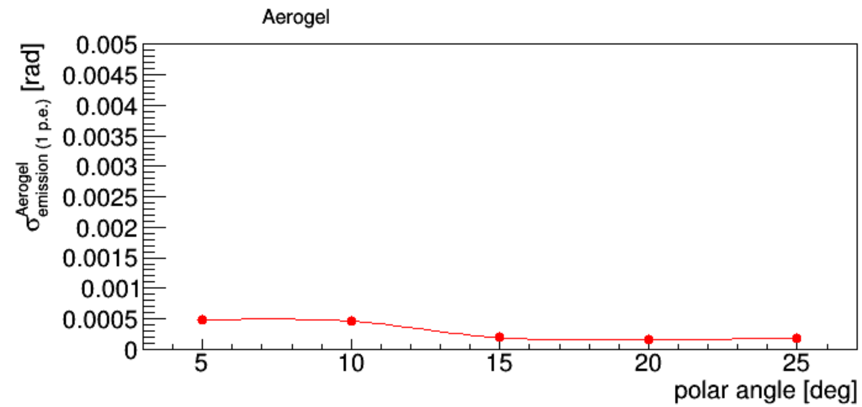
Emission error

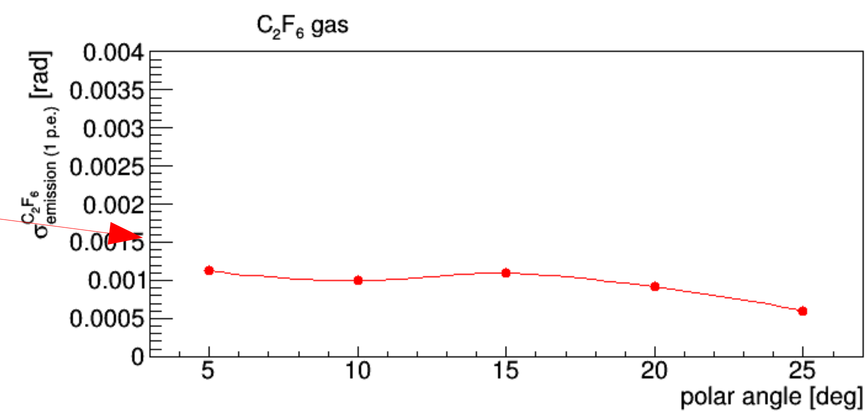
Naive spherical detector





Adaptive detector

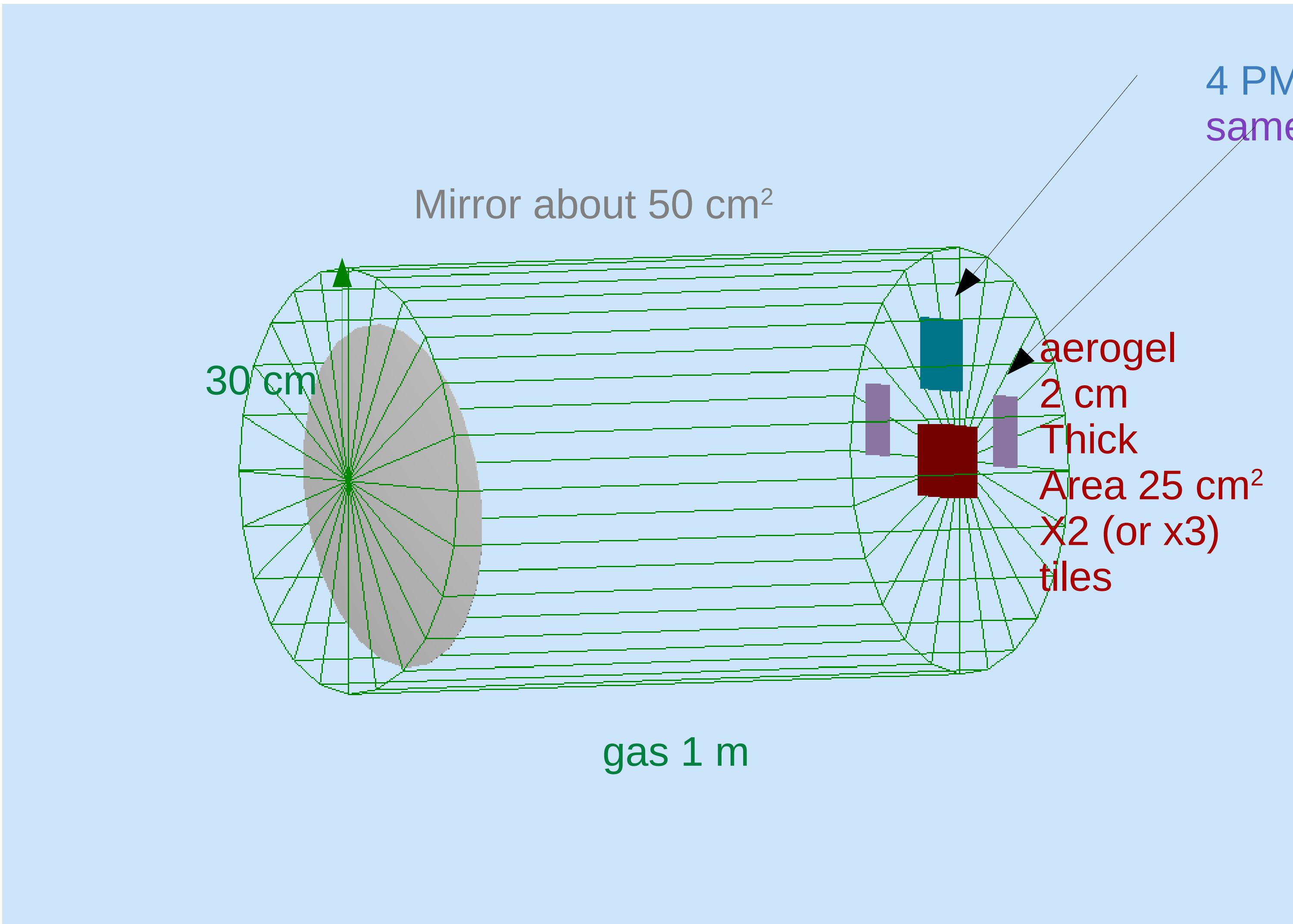




Still under optimization!

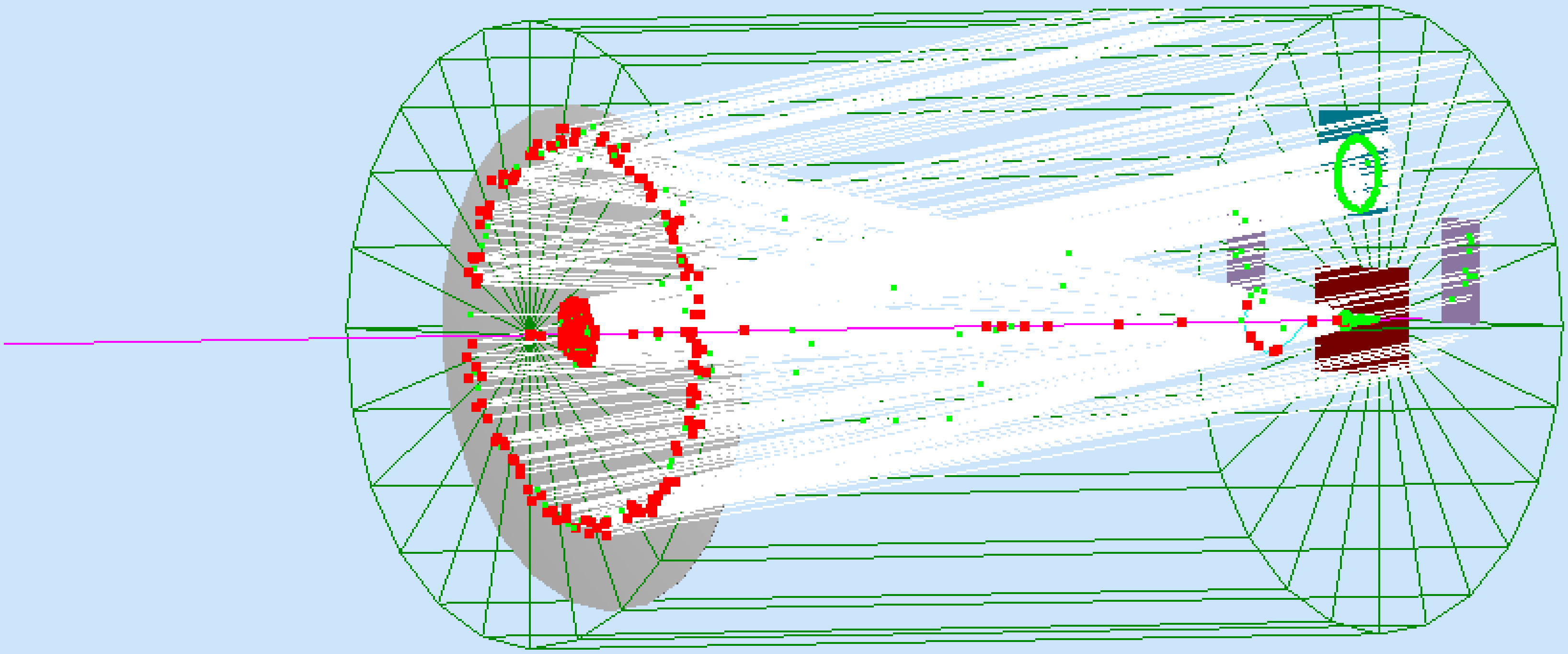
Prototype

Prototype – minamial version

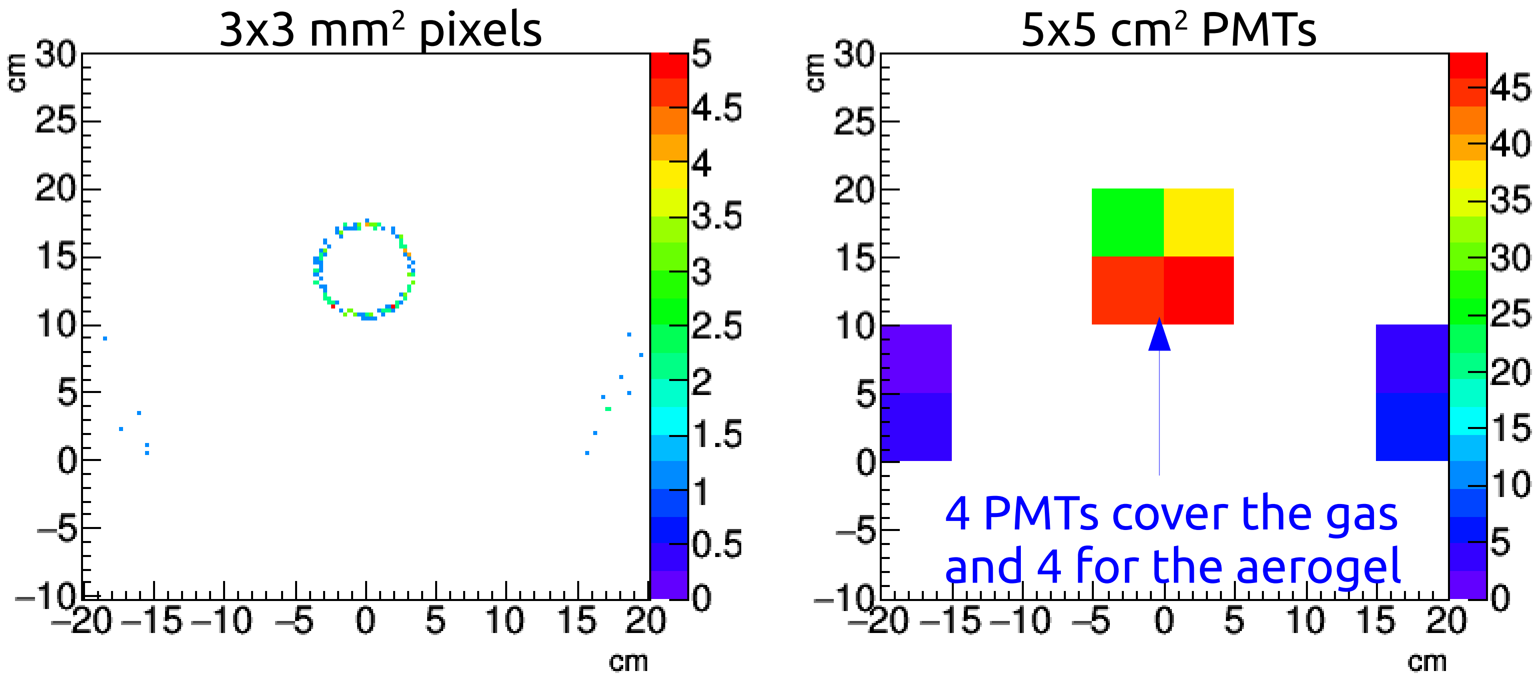


Prototype – minimal version

4 PMTs for the gas
same 4 for the aerogel

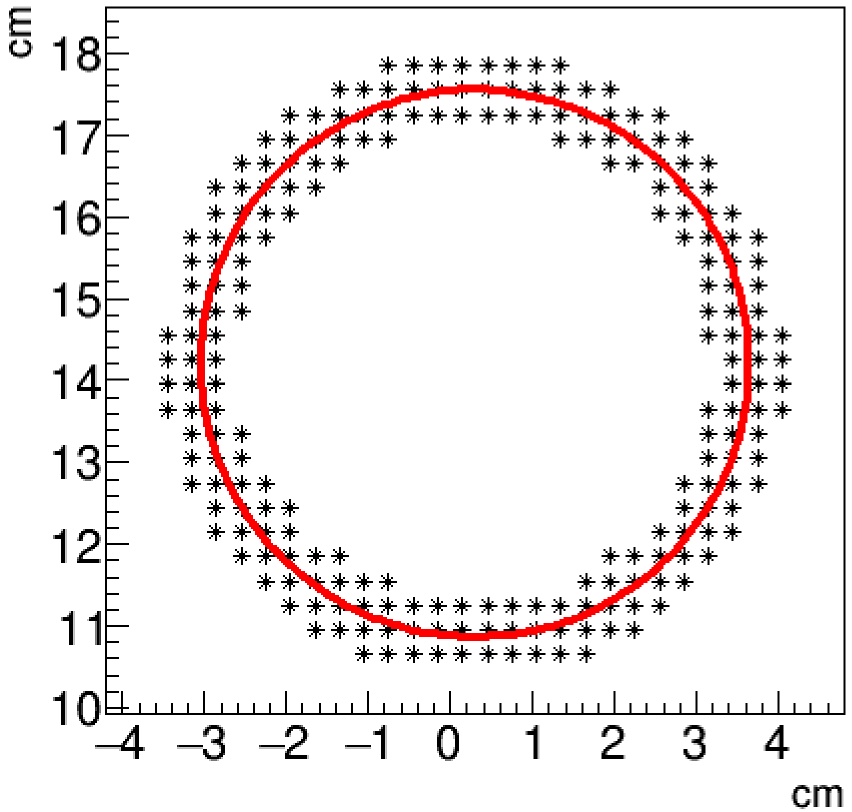


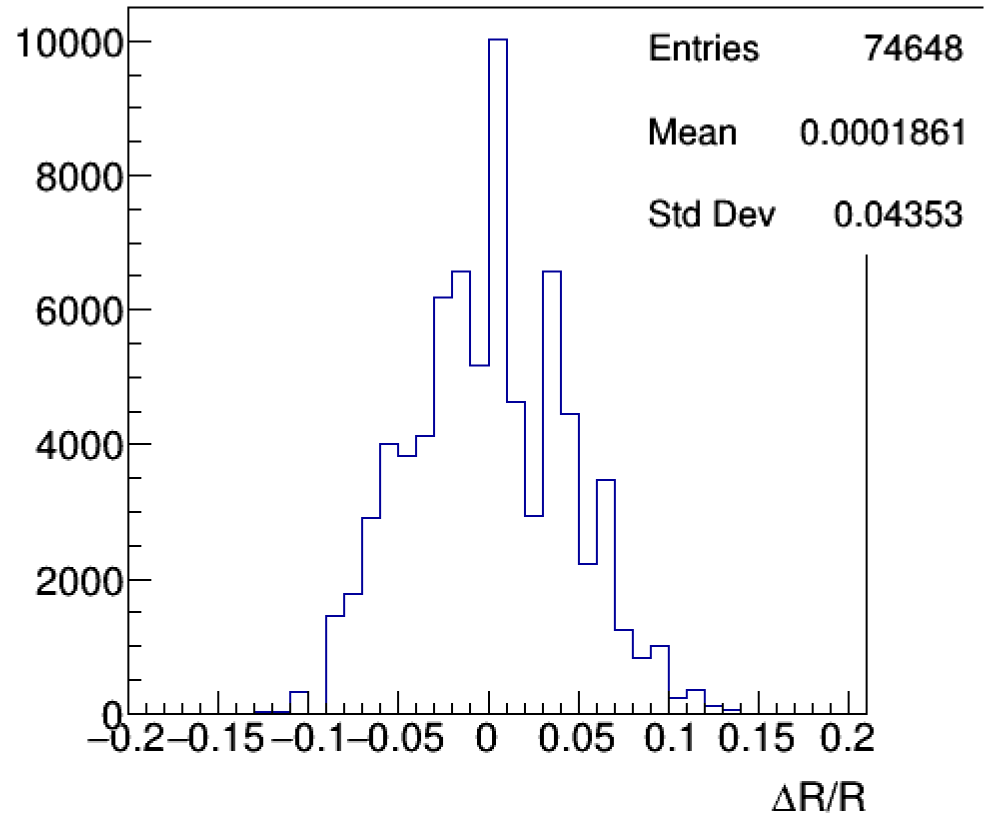
Prototype – coverage with 4 PMTs



Note: for the aeroegl maybe 6 PMTs better,
necessary to have at least 2-3 p.e. per event

Prototype – gas coverage with 4 PMTs





500 cumulated tracks, pions at 6 GeV/c

Note: the reconstruction of the aerogel ring is less accurate with only 4 PMTs.

Table of comparison

* combined with a good electronics

Parameters	PMT	MCP-PMT	SiPM	LAPPD
Gain	10^6	10^6	10^6	10^6
Timing Resolution*	Ok TTS ~ 300 ps	Fast TTS < 50 ps	Ok* < 200 ps	Fast
Dark noise	(KHz)	(KHz)	(MHz)	(KHz)
Radiation Hardness	ok	ok	Rate and temperature dependent	ok
Single photon	ok	ok	ok	ok
Magetic field tolerance	Less tolerant	ok ~1T	Insensitive	ok
Detection efficiency	>20%	>20%	>20%	>20%
Cost	2K	10K	2K	?

To do next

- **We are on track with the commitments for FY17**

Possible future plans: FY18

- Find synergies (with mRICH, etc ...) for a first prototype
- Try dRICH in a realistic (EIC related) fisical evironment
- Detailed study of an adaptive detector surface: if realized it will request detailed simulations and dedicated methods to put and maintain the tiles in place with high accuracy
- It adopted, the adaptive surface may requests stringent features of the photon detector, i.e. compactness and small size. SiPMs would be of some advantage in this sense.
- ...
- ...