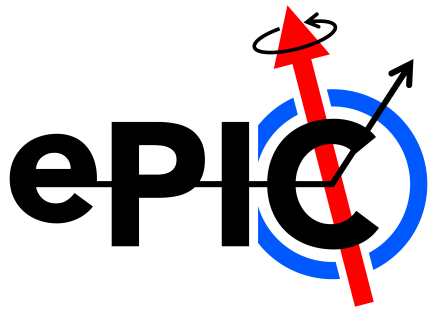
ePIC dRICH Simulation status update

Chandradoy Chatterjee
On behalf of ePIC dRICH simulation team

INFN Trieste

29^{th} November 2023



Outline

1. Introduction

2. Recent studies and updates
   - Realistic PDU description
   - Optimization of Aerogel
   - Injection of Noise
   - Realistic component designs
   - Impinging angle of Photons
   - Outcome of simulation campaign

3. Conclusions

1. Introduction

2. Recent studies and updates
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   - Realistic component designs
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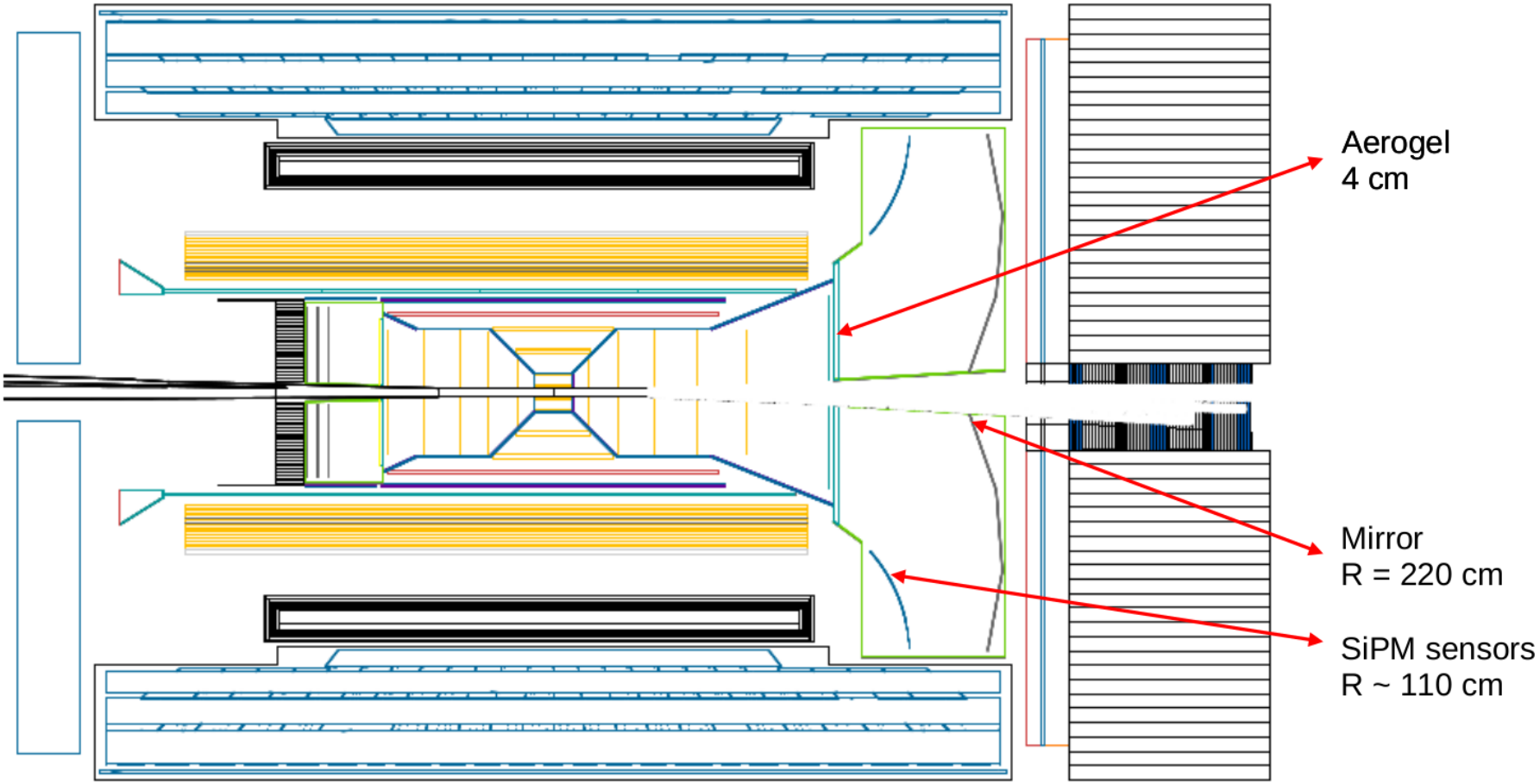
3. Conclusions

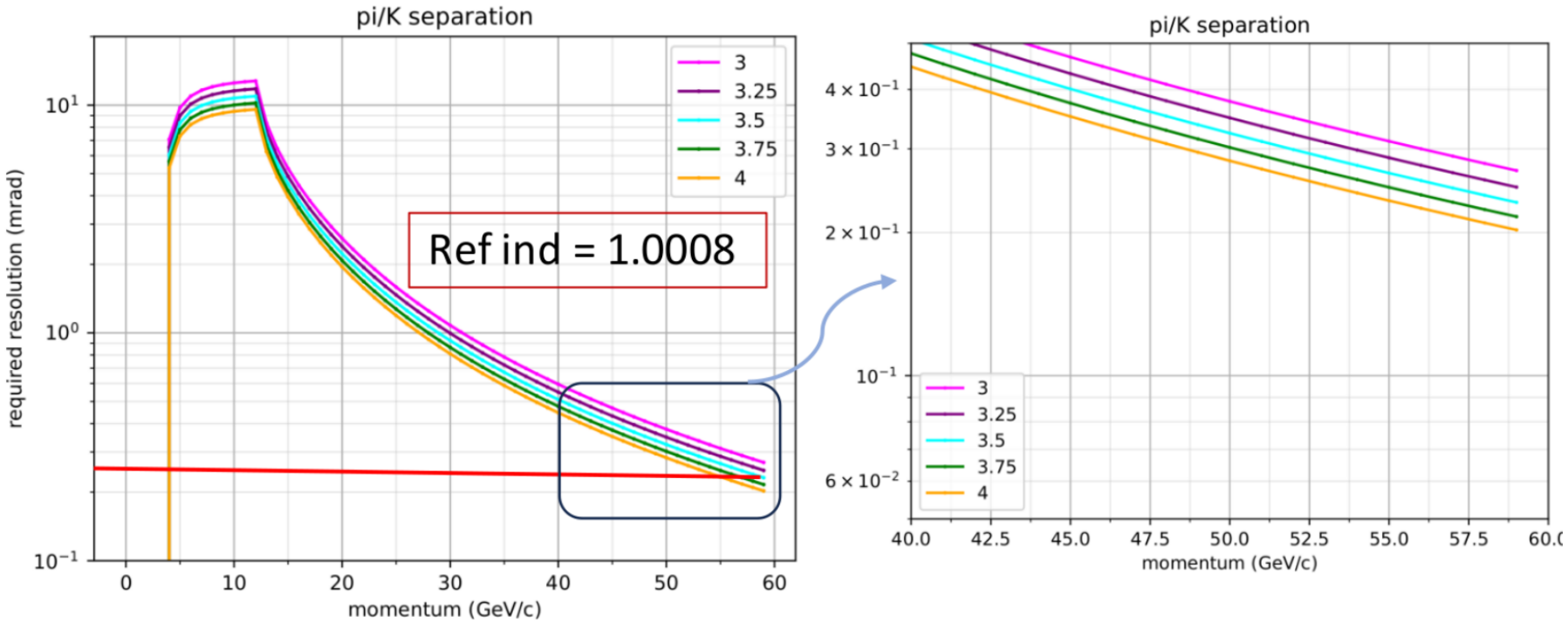
Throw back

- A dual radiator RICH (dRICH) is designed to perform high momentum particle identification in the forward region of ePIC detector.
- 3-sigma separation for pi/K up to 50GeV in the high pseudo-rapidity and substantial overlap between gas and aerogel radiators.
- Baseline design: total 120 cm of vessel length. A 4 cm thick aerogel of refractive index 1.019 and followed by C_2F_6 gas of nominal (n-1) 800 ppm.
- SiPM based sensors are placed in spherical tiles are placed in six sectors to detect focalized photons from 6 spherical mirrors.
- The dRICH sits 195 cm upstream of the IP and extended up to 315cm.
- Before July review an extensive effort was made to parameterize all optical properties extended up to same wavelength range and tuning of the optics.

dRICH schematic



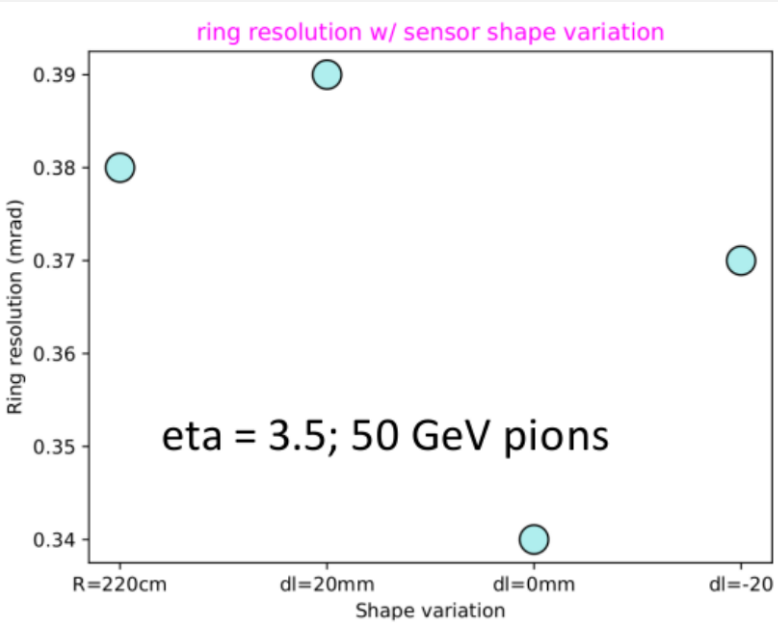
Requirements

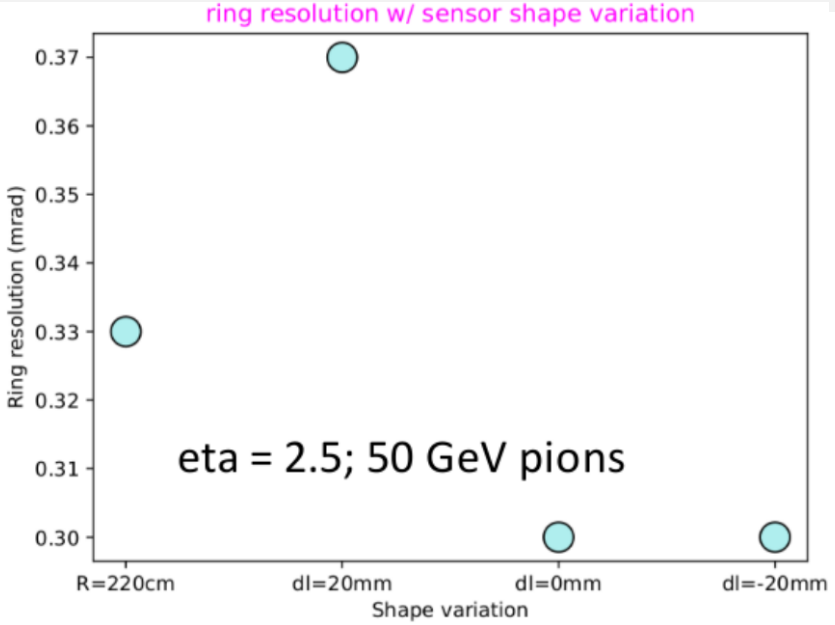


- In order to achieve at least a 3σ pion/Kaon separation above 50 GeV/c we need a ring resolution[1] around 0.3 mrad.
- An optical tuning has been performed for the most demanding pseudo-rapidity region ($2.5 \leq \eta \leq 3.5$).

[1] $\sigma_{PE}/\sqrt{N_{PE}}$ (No noise hits)

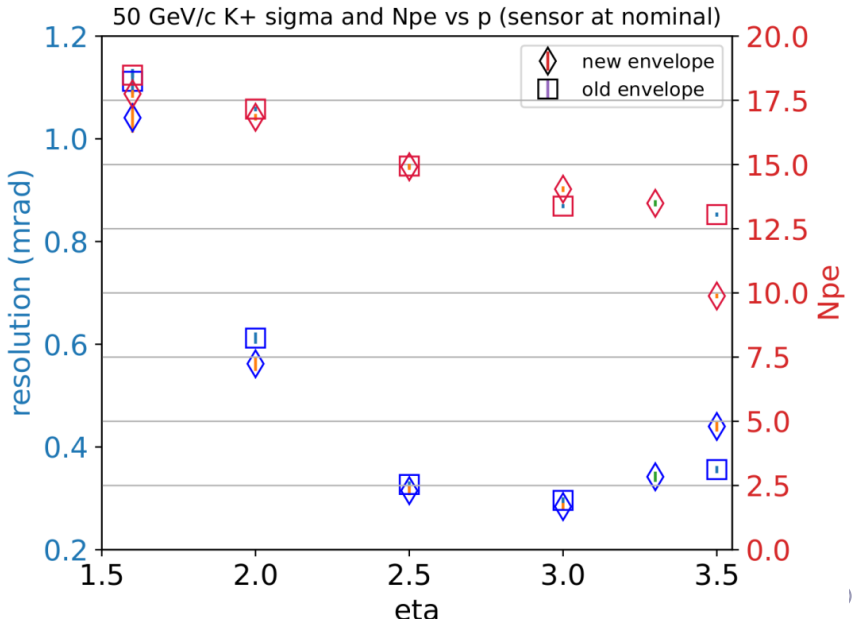
Sensor Shaping and vessel positioning



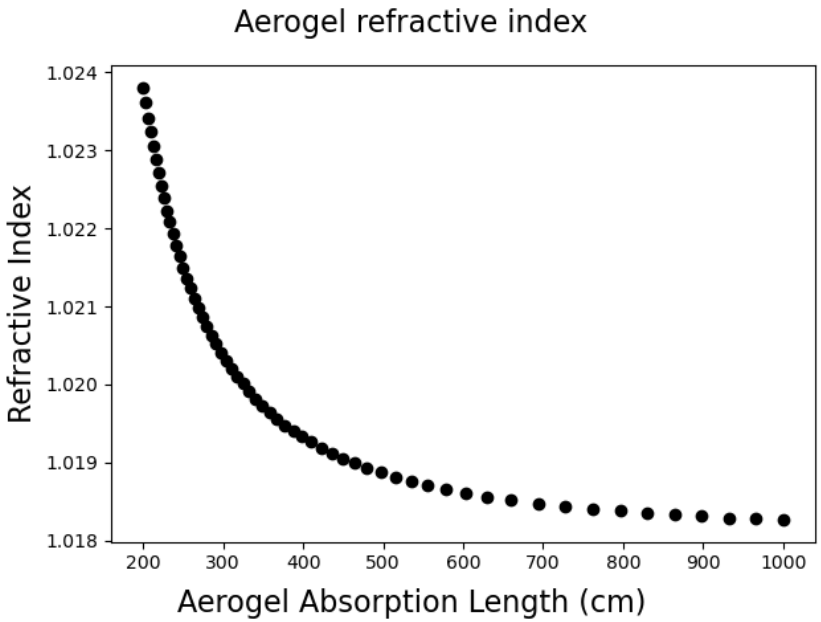


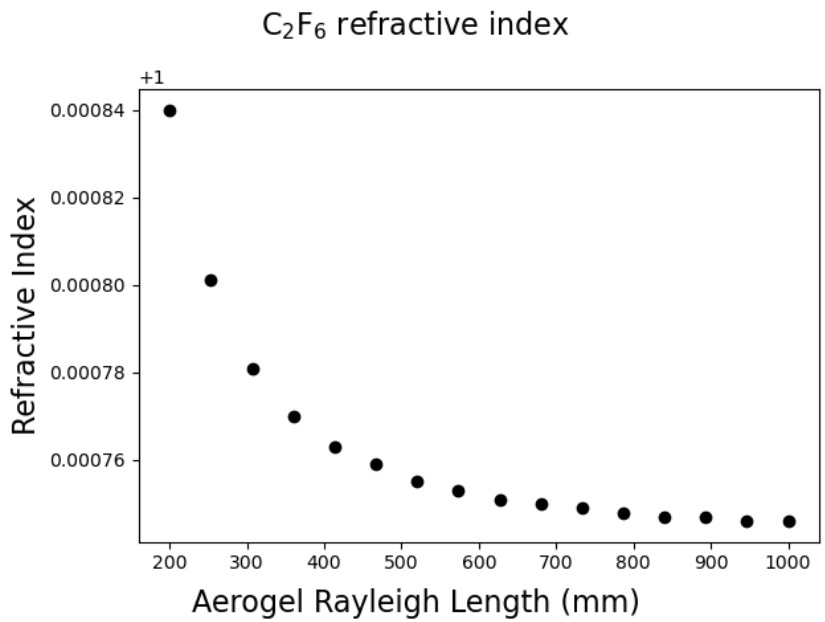
Optimize shape and location has been chosen. It has been demonstrated a global shift[a] of the dRICH by 5 cm has no effect in resolution and number of photons in different pseudo-rapidity.

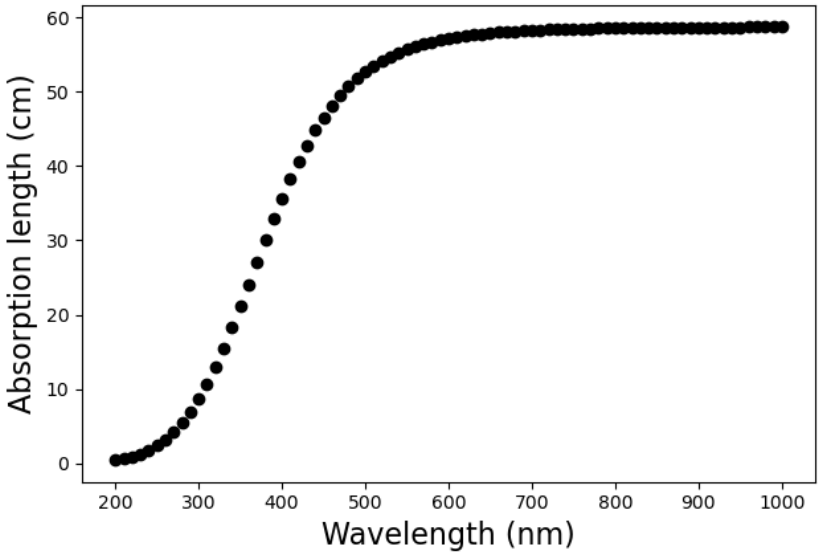
[a] Old: nominal, New: 5 cm shift

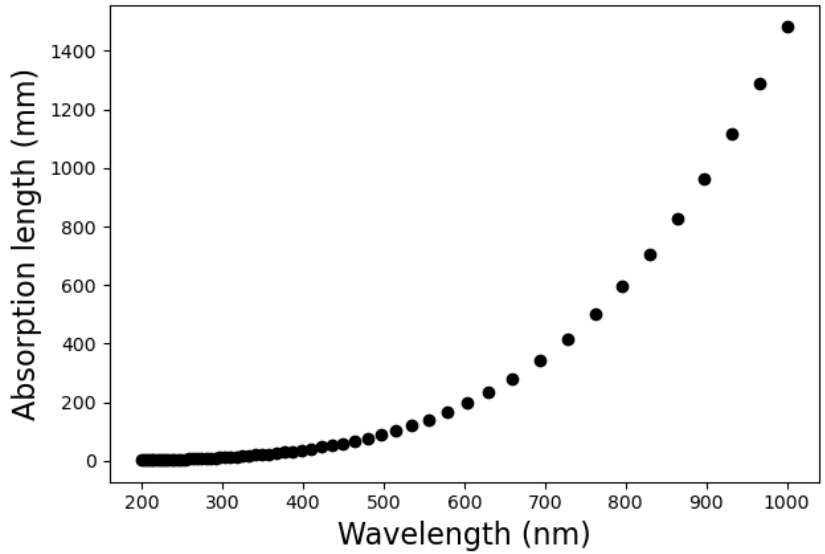


Parametrization of radiators

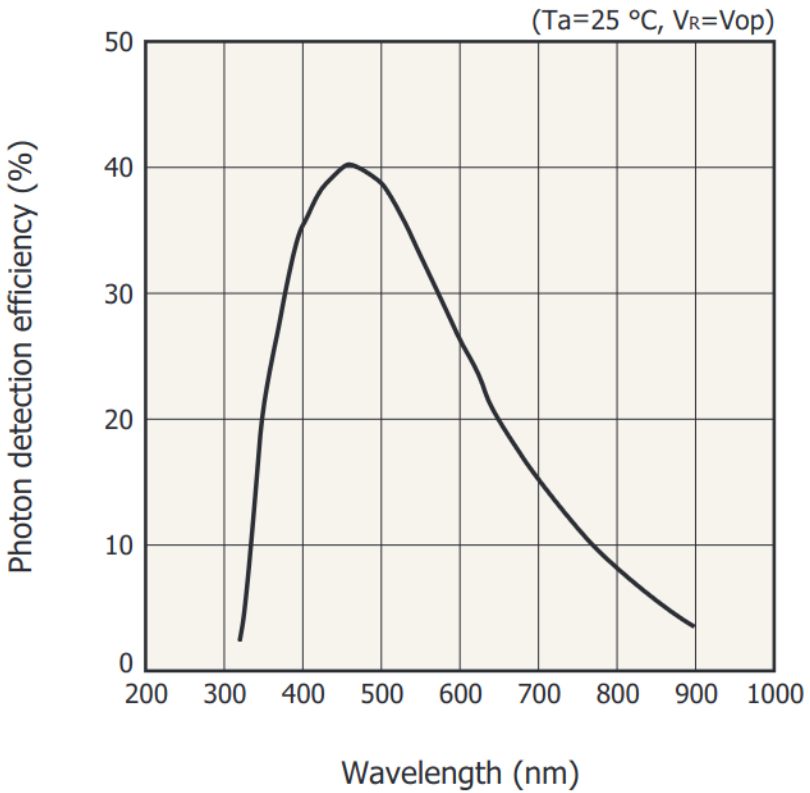


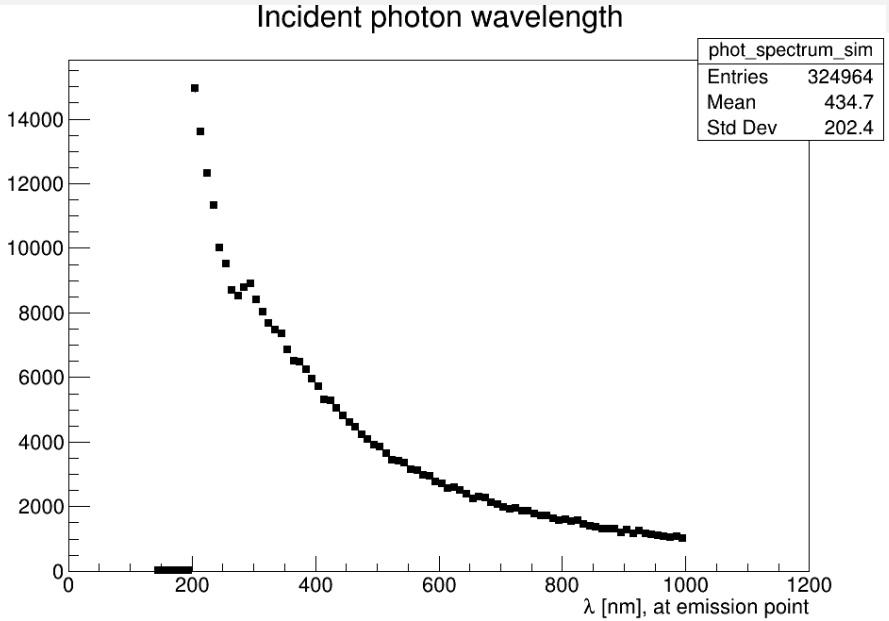


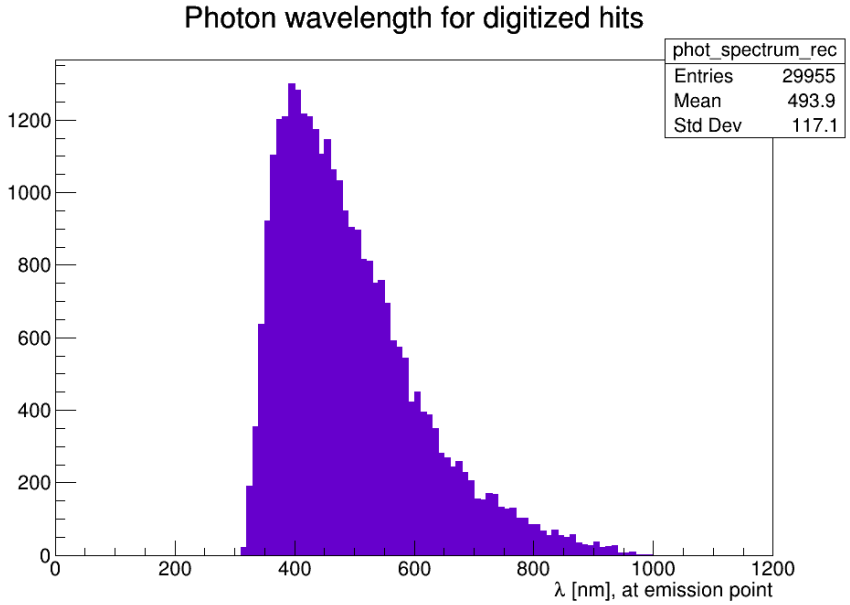




dRICH Photon sensors

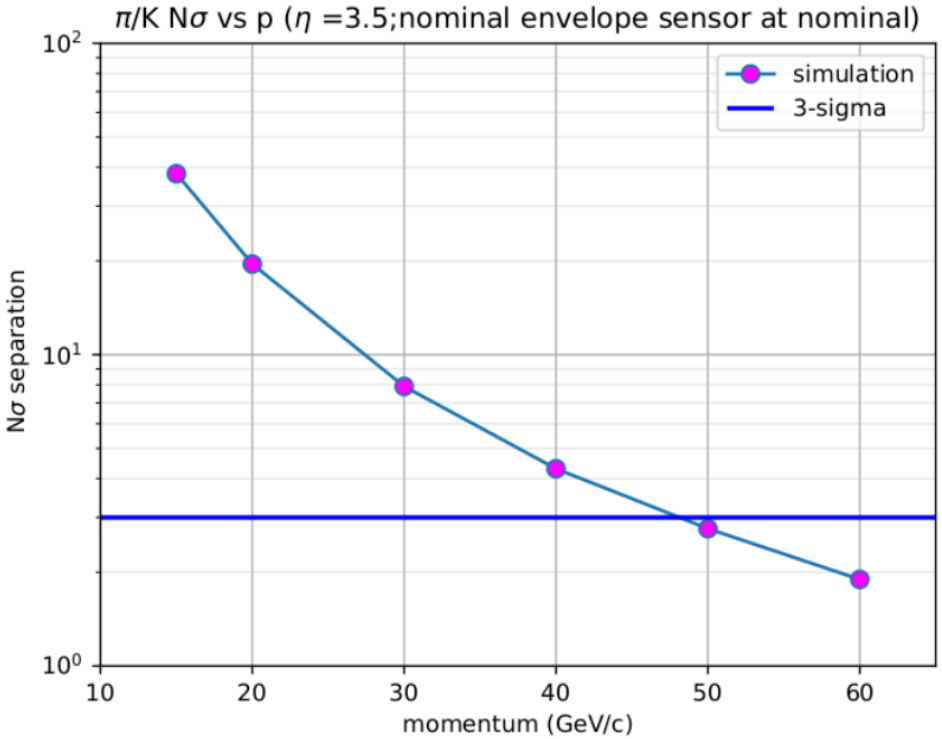


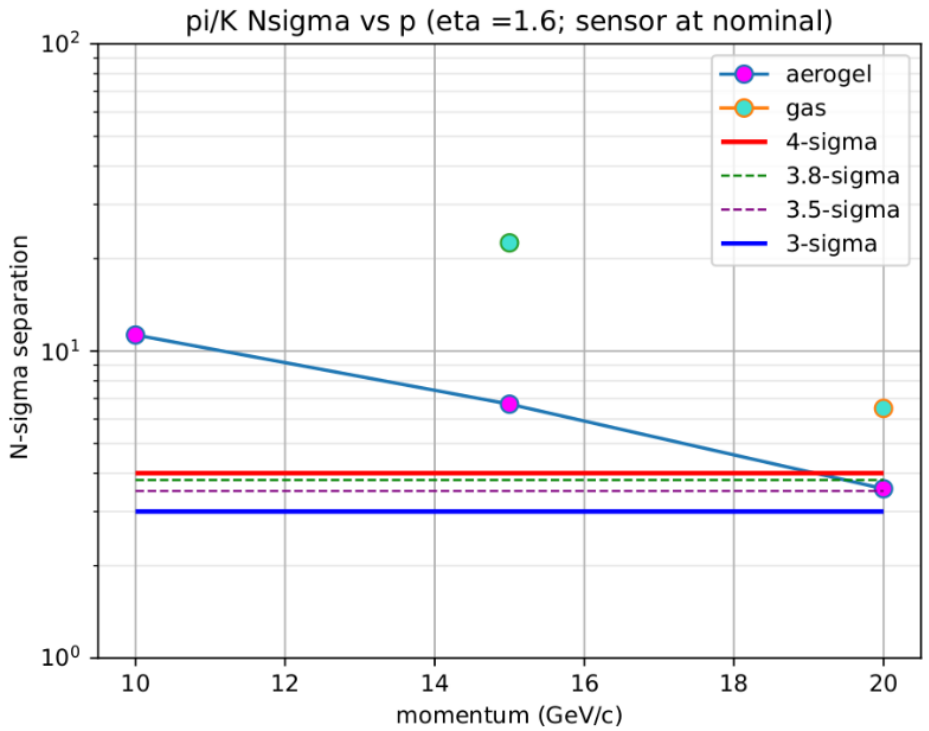




- SiPMs have similar qualifications of ATHENA.
- The Aerogel is followed by an acrylic filter.

Performance: July





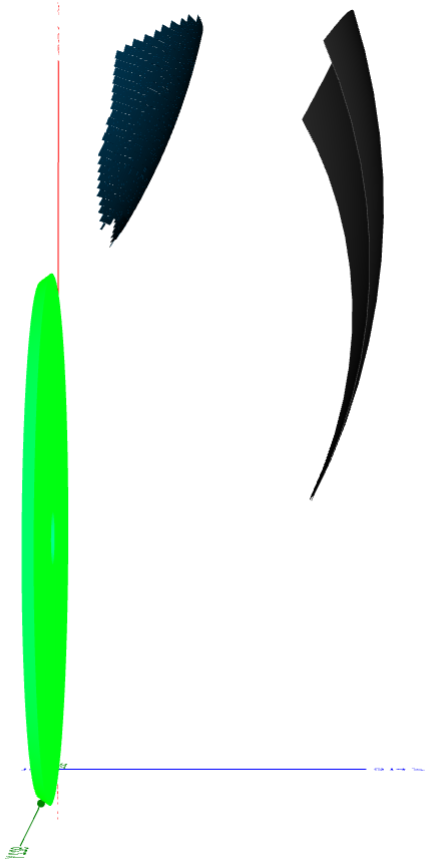
3 sigma limit

3.5 => 50 GeV/c

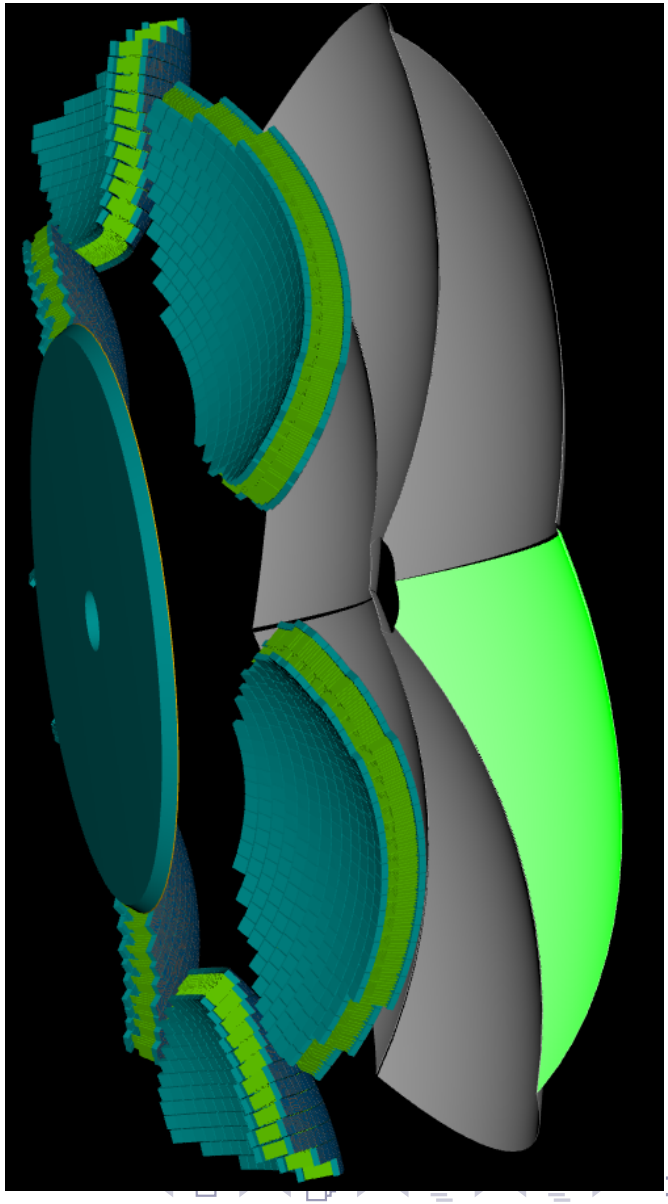
1.6 ~ 30 GeV/c

It has been found that dRICH in the very forward region is capable of delivering the required performance, it was substantial overlap with its gas and aerogel radiators.

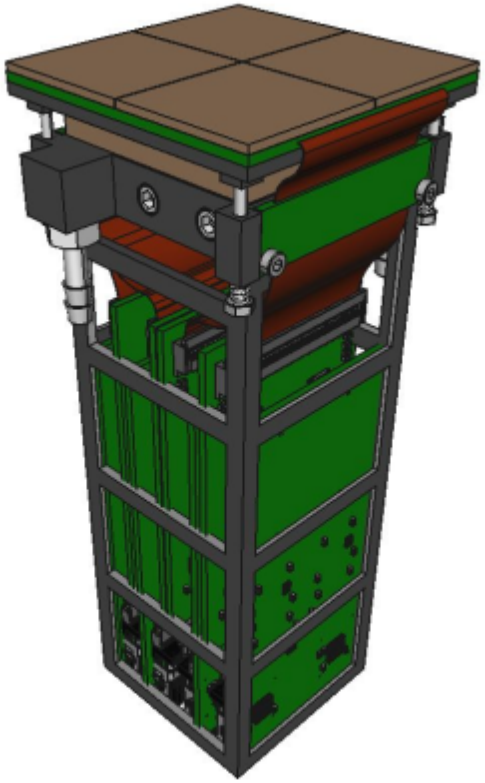
Updating PDU description



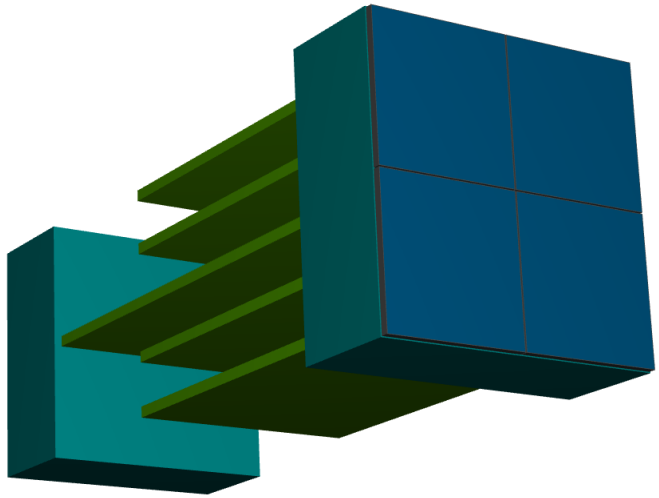
First realistic implementation of Photon Detection Units.



Updating PDU description

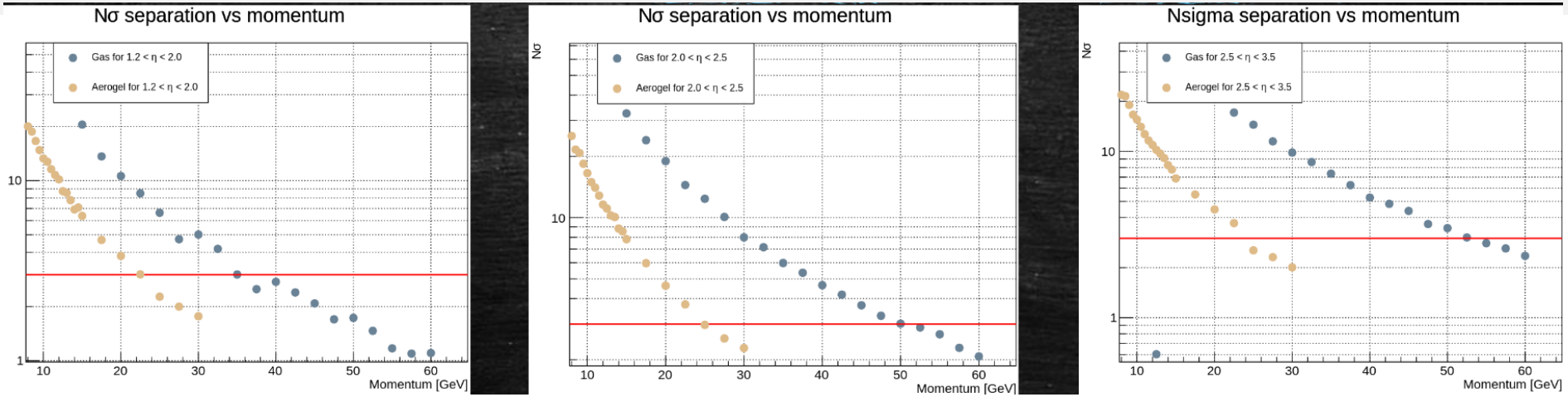


new EIC-driven readout unit

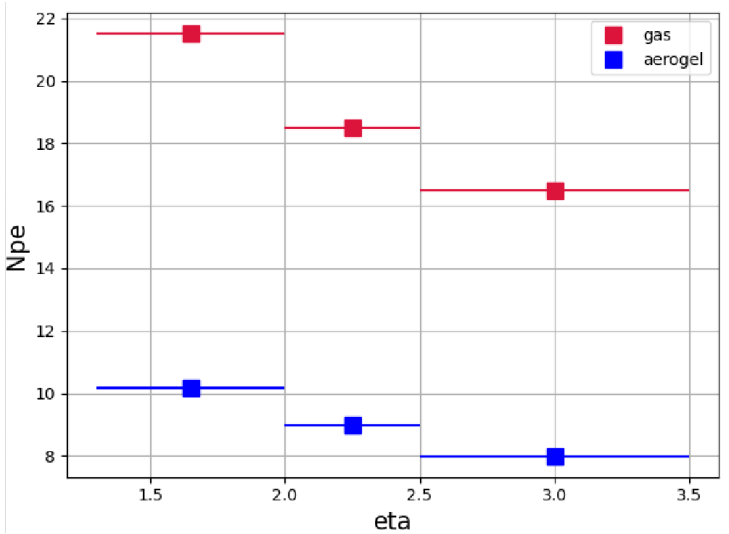


Detailed performance study has been made by Luisa with new PDU surfaces and has been cross-checked.

Performance of dRICH: updated PDU description

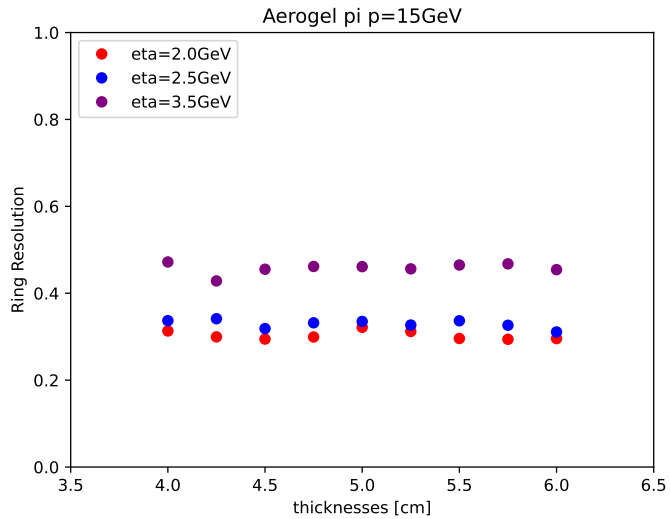


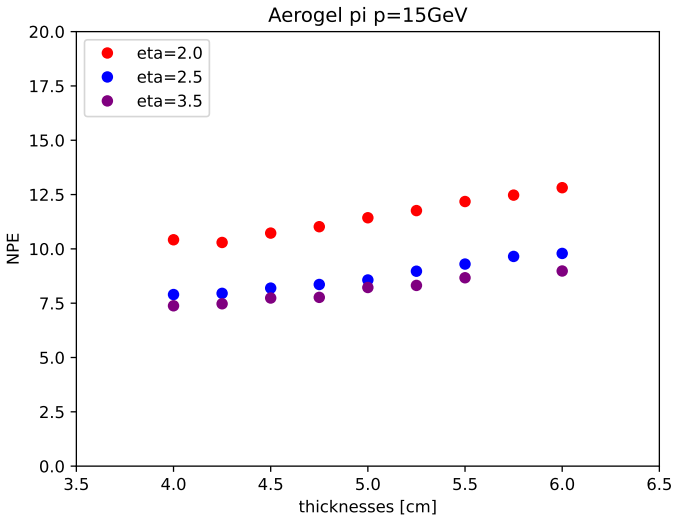
- Number of photons consistent with july simulation studies.
- Below η 2.0; PID is limited by spherical aberration. Can be reached up to 35 GeV/c.
- In higher pseudo-rapidity regions Aerogel/Gas overlap can be achieved up to 25 GeV/c and 3σ limit slightly higher than 50 GeV/c.

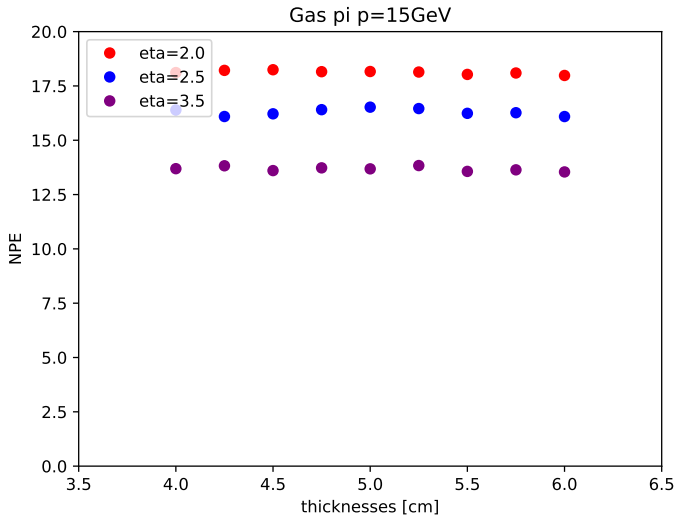


Thickness optimization (W.I.P)

- Studies so far with 4 cm thickness and 1.019 nominal index. Increase Npe by increasing thickness and/or refractive index.
- Tiziano demonstrated that with increasing thickness no apparent drop in ring resolution. New aerogel parameters will be used to perform similar studies.







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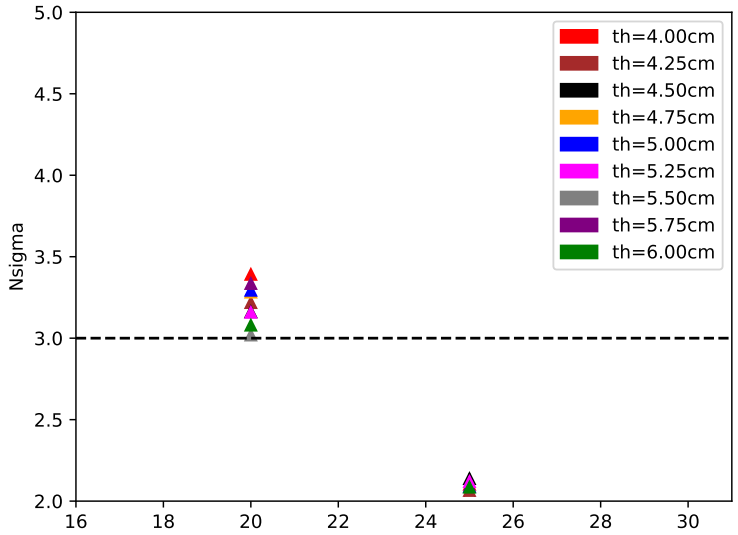
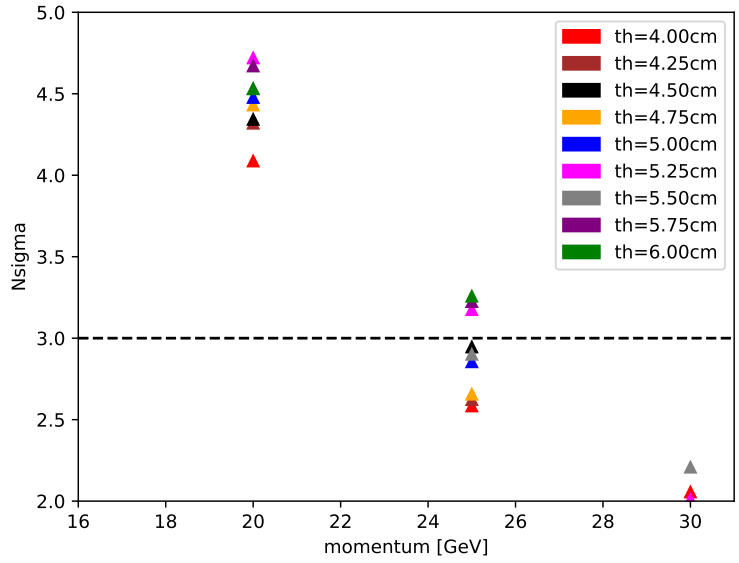
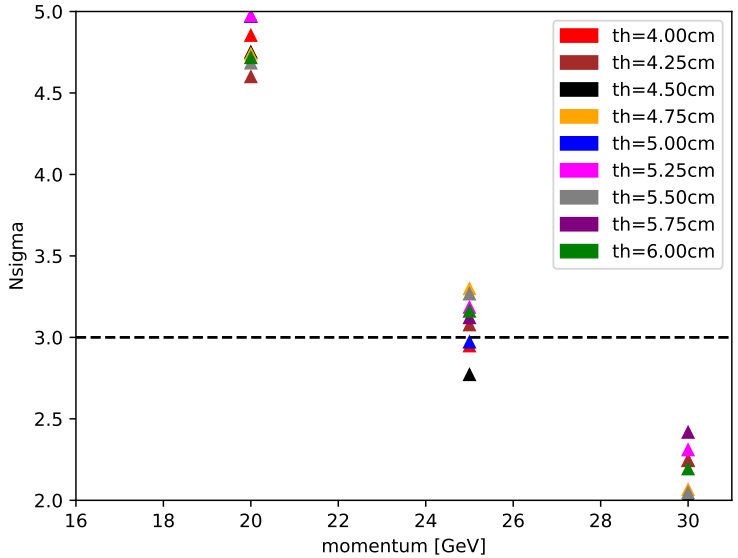


3.5



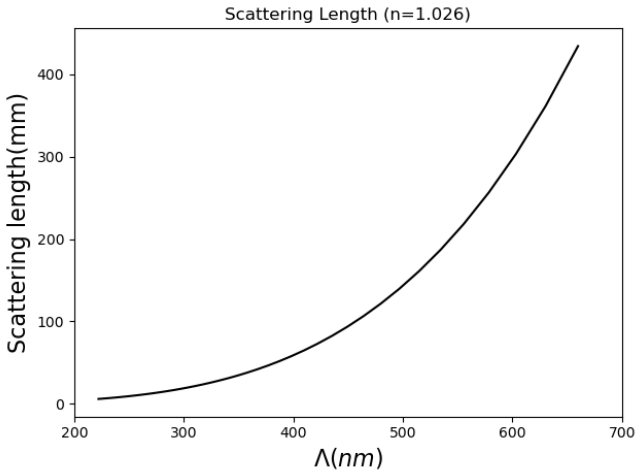
2.5

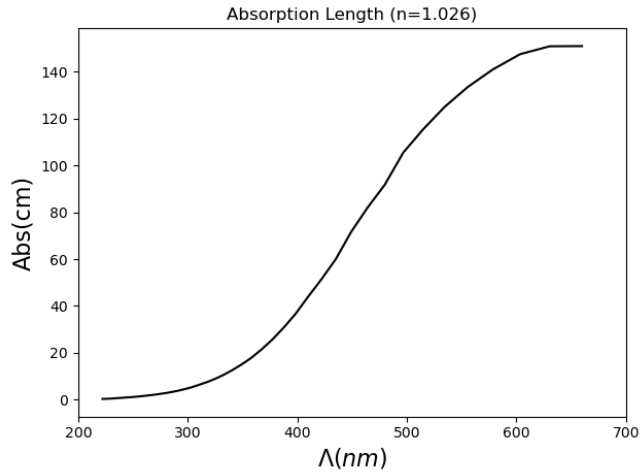


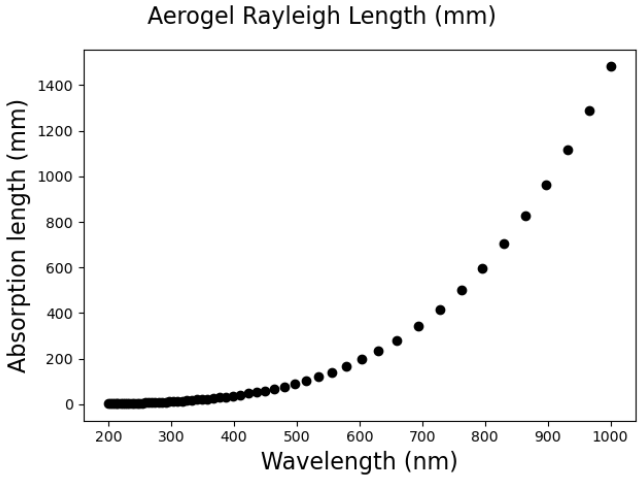
2.0

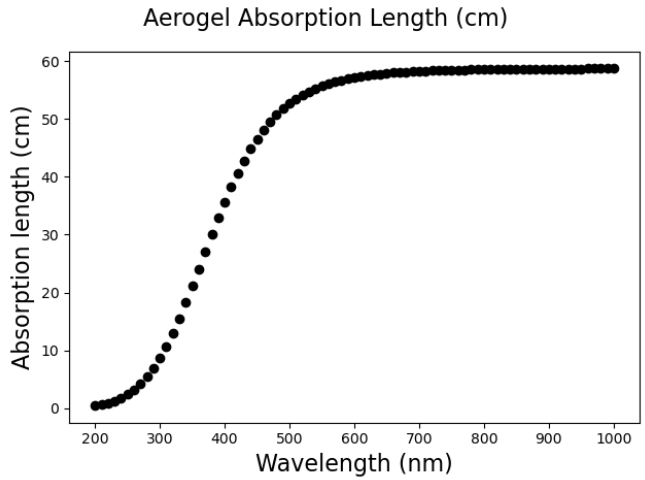
- At all pseudo-rapidities we see thicker aerogel indicates better separation.
- Separation depends on aerogel parameters. Studies will be done with new aerogel parameters.

New Aerogel parameters







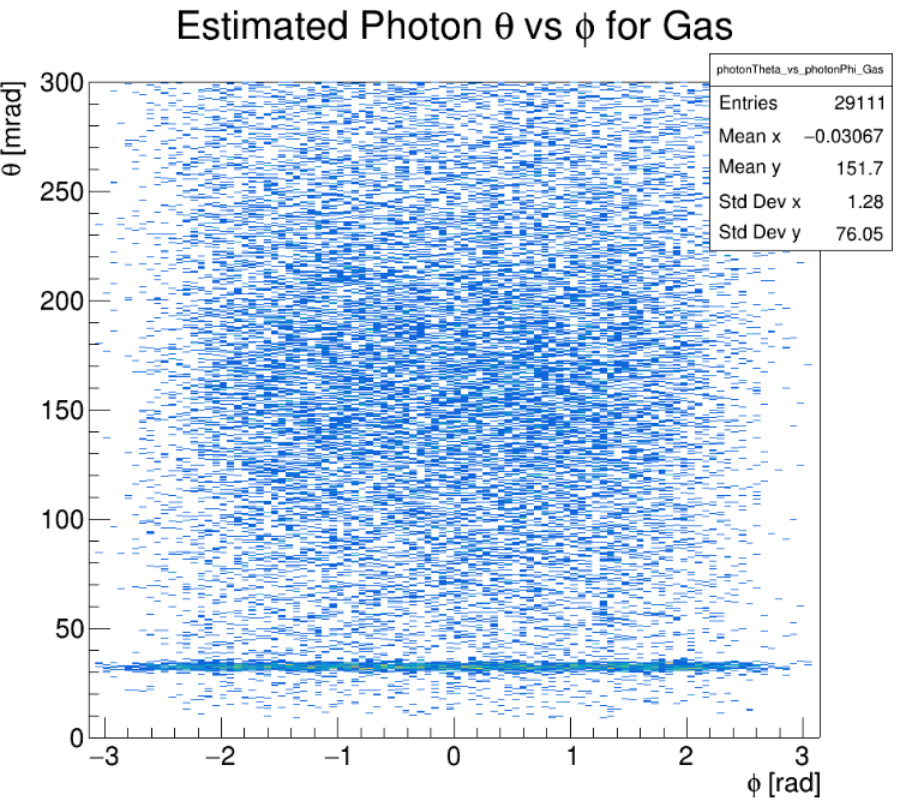


typo

(absorption→Scattering)

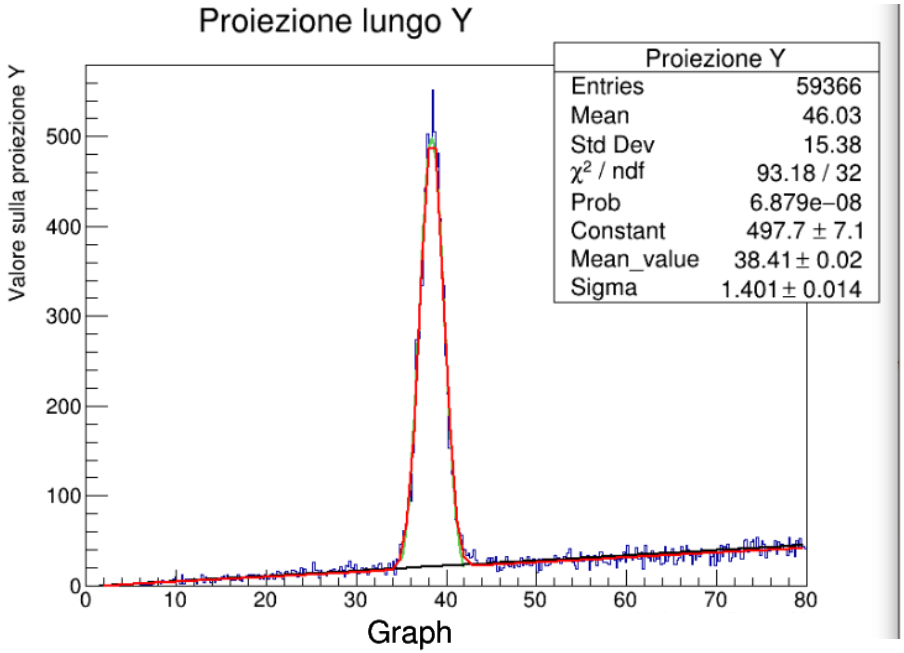
New Aerogel properties will be implemented and studied, properties will be extrapolated up to 1000 nm. Also pfRICH aerogels can be implemented (current saturation angle $\sim$ 270 mrad) for tests .

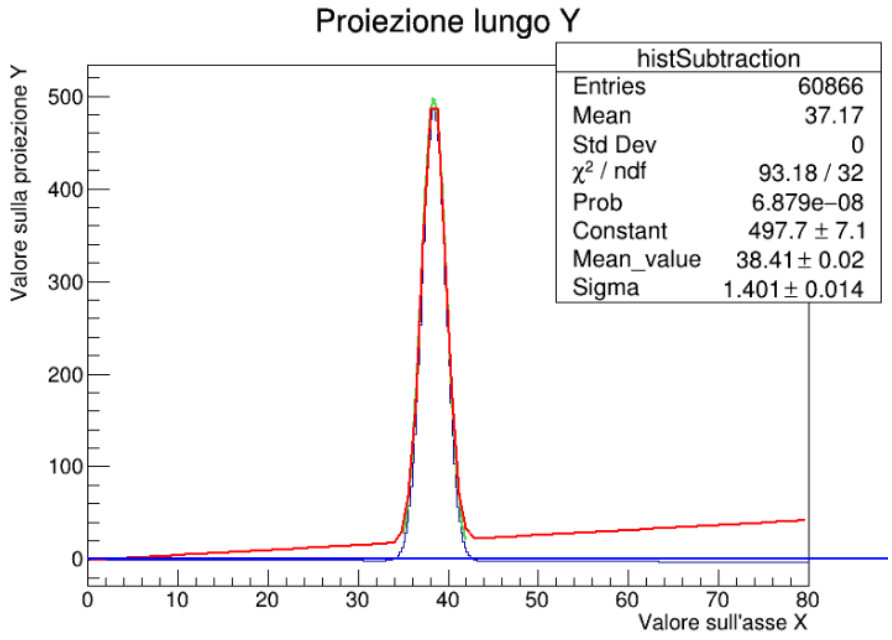
Injection of Noise

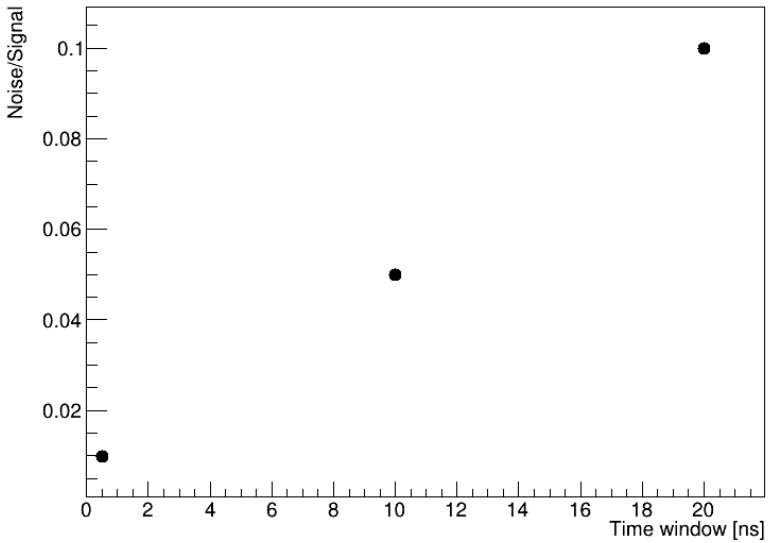


- The noise has been implemented at the reconstruction level by Luigi.
- Takes into account Poisson distribution. Randomly a cell ID is assigned for each expected noise hit.
- The rates and time window are configurable in a '.yml' file.

Injection of Noise: X-checks and evaluation





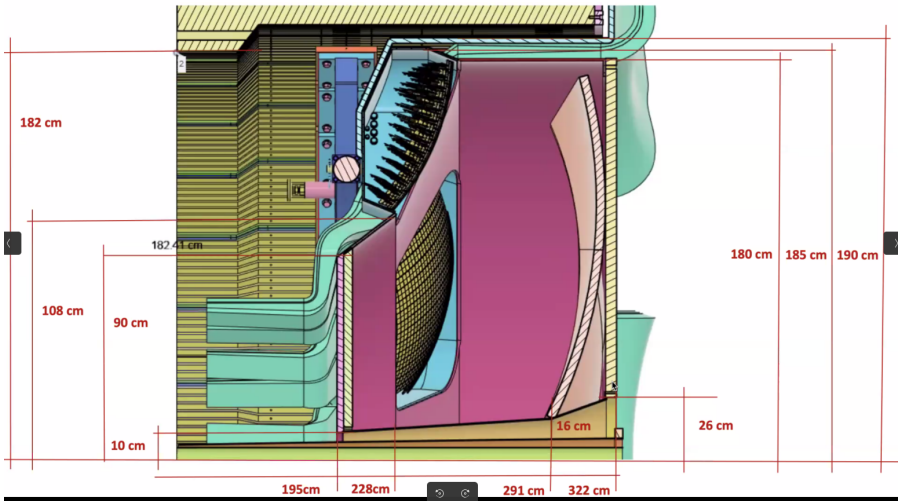


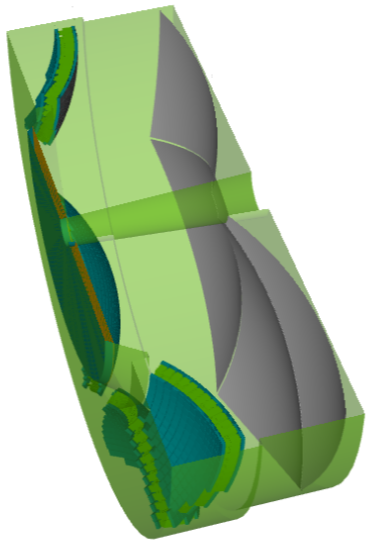
- For a fixed rate the noise over signal as a function of time window has been studied by Luisa. For a fixed time window with different rates, SPE resolution, Noise over background will be studied by Tiziano. Noise hits can also be injected in official simulation.

Realistic Sensor box (W.I.P)

The dRICH sensor-box shaping has been initiated a first version is merged in the main detector description.

- Vessel radius is reduced to 180 cm.
- The sensor box still extended radially up to 185 cm.
- No quartz window placed so far. The quartz window will play a role in the impinging angle of the photons.

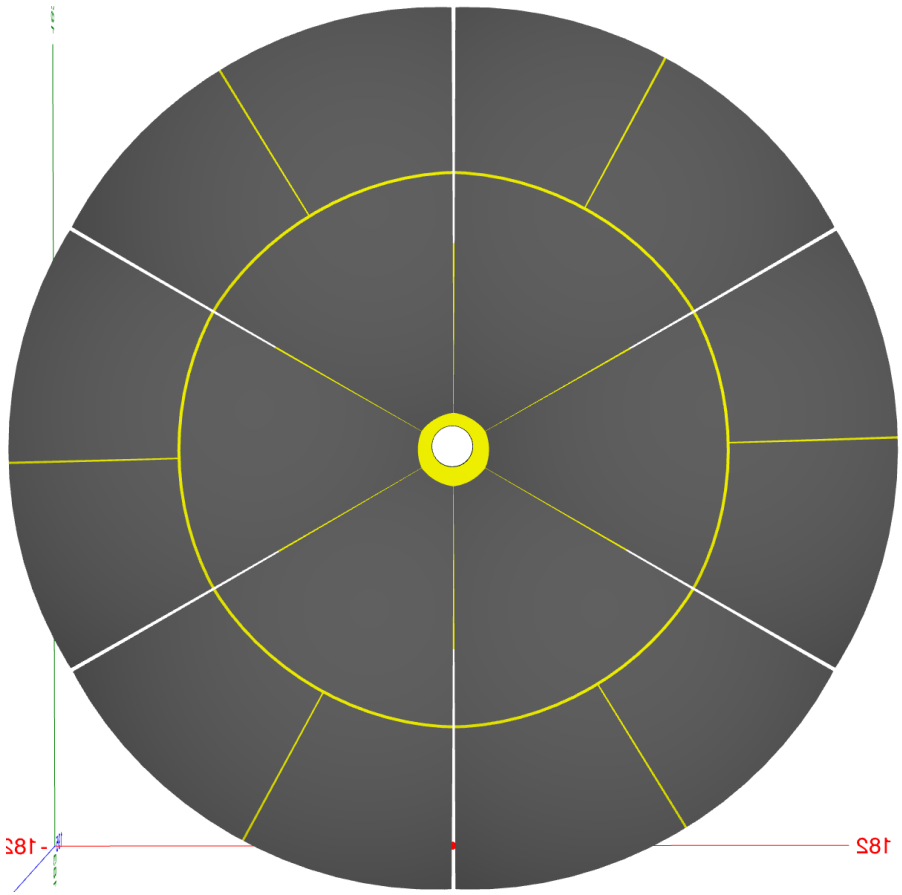




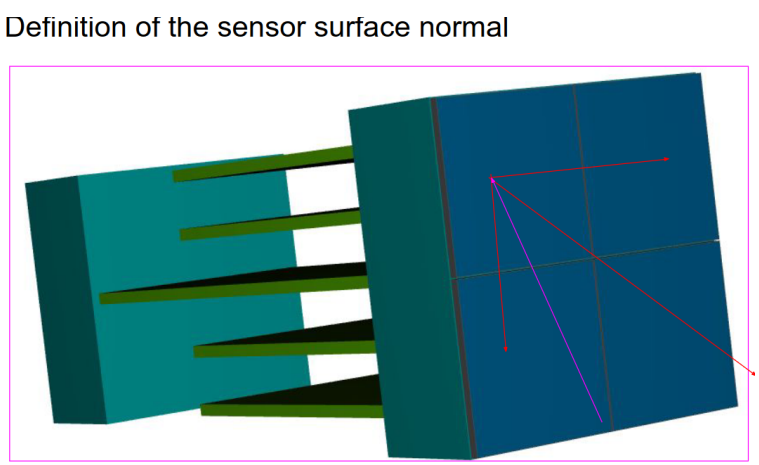
Realistic Mirror and Aerogel tiling (W.I.P)

The Aerogel is currently a unique disk and each petals of our mirror is unique (unrealistic).

- Titling of the mirror is ongoing (Draft PR).
- Aerogel tiling for the time being can be done like pfRICH (example strategy).
- Estimation of the dead-area will be studied afterwards.



Photon impinging angle



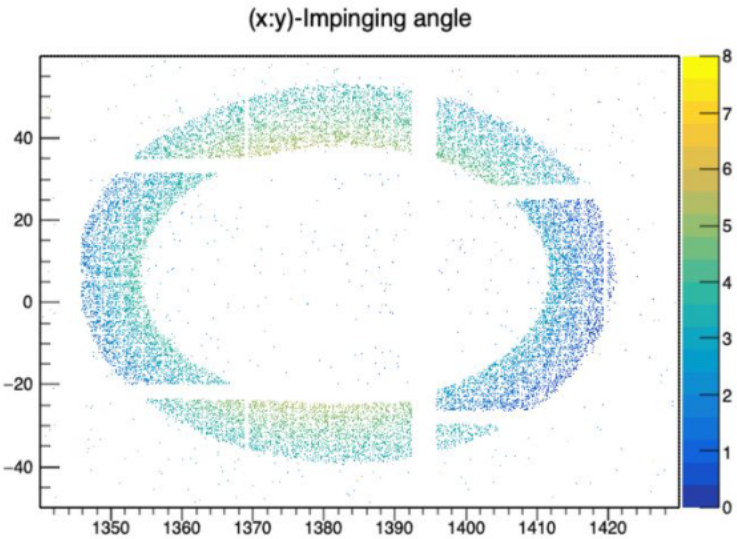


Figure: Gas ring $\eta = 1.8$

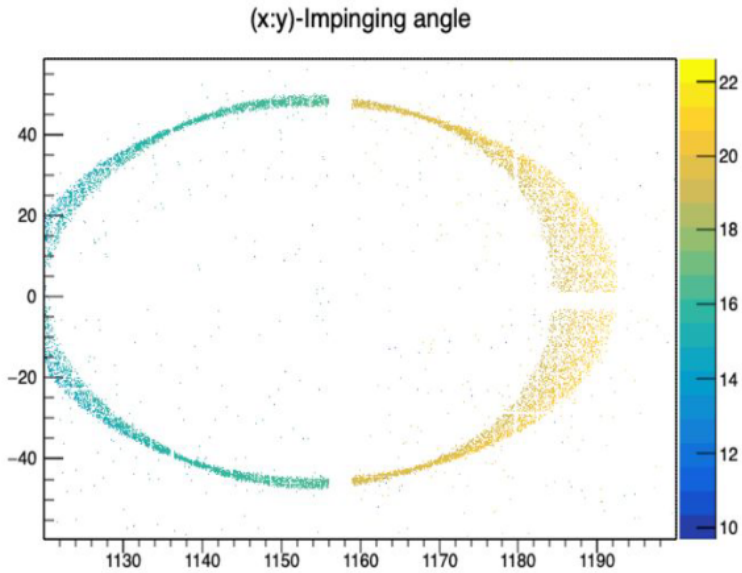
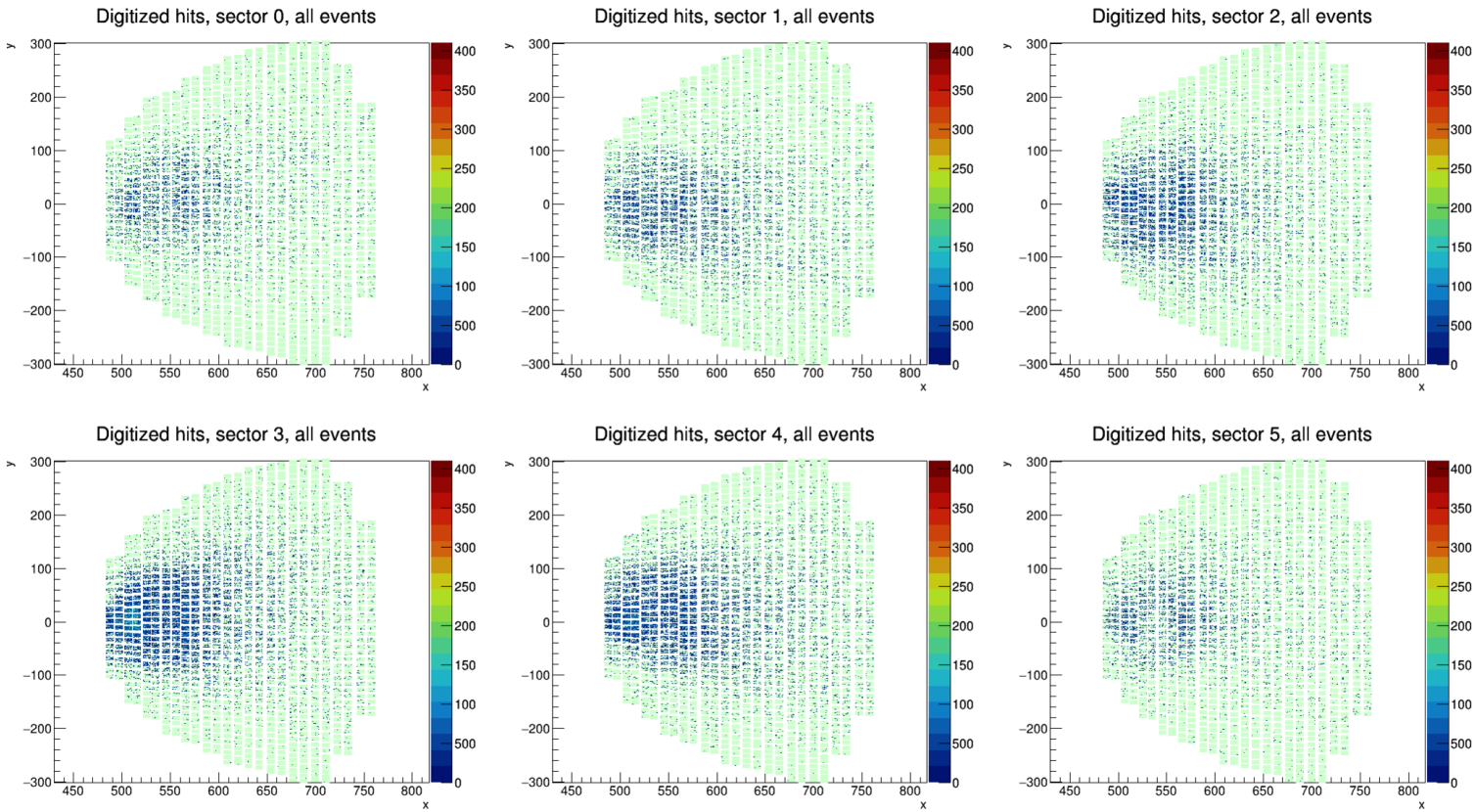


Figure: Gas ring $\eta = 3.5$

- Tiziano demonstrated interplay between focalization and impinging angles.
- The impinging angle also depends on azimuthal angle of Cherenkov photons.
- The feature is independent of Cherenkov angles.
- At higher rapidity Aerogel photons reflected from split mirrors make large angles (close to 40^o).
- Impact of quartz window will be studied in future.

dRICH in ePIC simulation campaign



- The official simulation campaigns of ePIC has dRICH included.
- The first look of the hit maps indicates that hits cover largely the region expected.
- An analysis chain, including robust PID is required to analyze the outcome.

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3. Conclusions

Conclusions

- Several updates have been made after July review; preserving dRICH performance.
  1. dRICH is capable of 3σ pi/K separation slightly above than 50 GeV/c in the forward region.
  2. Emission point uncertainty enhances due to spherical aberration in the lower rapidity, PID limited to 35 GeV/c.
  3. electron/pion separation can be achieved up to 4 GeV/c with Gas. The lower limit will be studied with new aerogel parameters.
  4. Substantial overlap between aerogel and gas PID in all pseudo-rapidities.
- We are slowly but constantly implementing more realistic descriptions and optimizing existing components.
- Updates to the main detector description is ongoing with dRICH updates. Simulation campaign data will be studied and robust PID algorithm is needed to be implemented. Joint adventure with pfRICH can be foreseen.