dRICH: August 2023 test beam highlights

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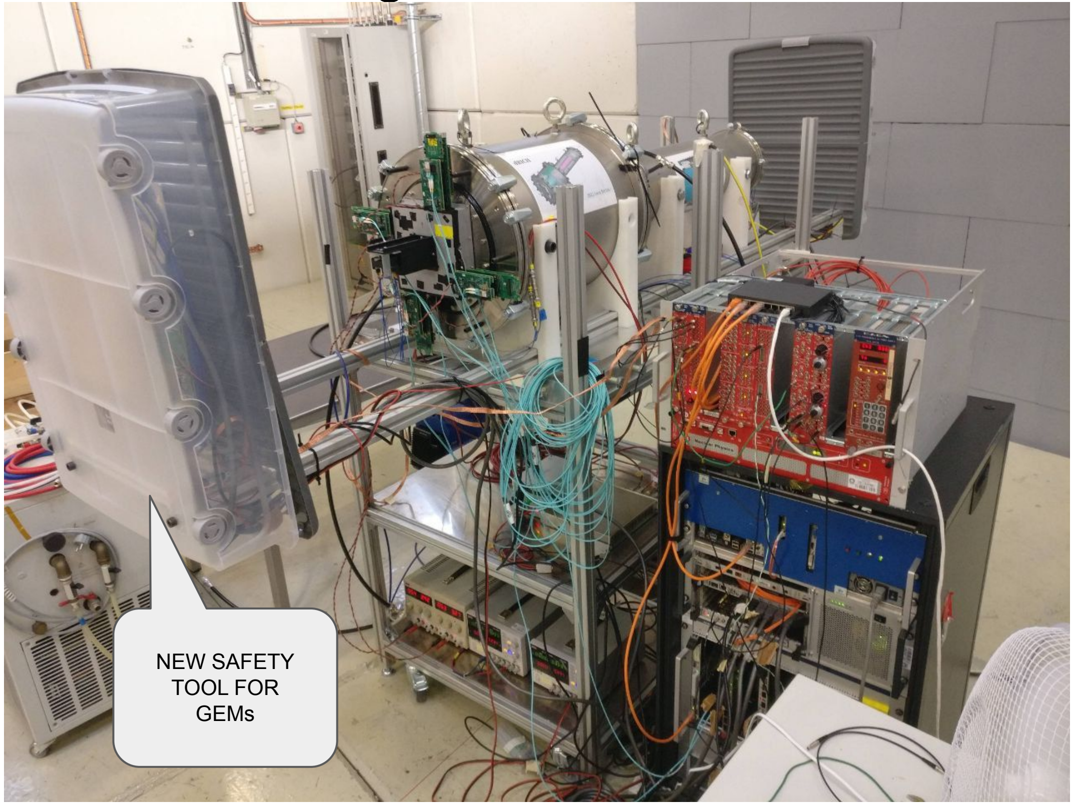
Thanks to Marco, Luca, Nicola, Simon, Daniel, Francesco M, and Francesco N.
who carried out the test beam

Test beam august 2023



CERN T10, beam of positive or negative mixed hadron with momentum between 4 and 11.5 GeV/c.

Goals:

- Study the resolution for the aerogel ring using various refractive index
- Study the uniformity of different tiles with the same refractive index
- Evaluate the capability to distinguish low momentum electron and pion.
- Study the separation of pion and kaon

Improvements:

- New aerogel box allowing to test different tiles
- More and better characterized tiles of aerogel
- More effective beam time
- Better calibration of the two beam Cherenkov detector

Aerogel studies

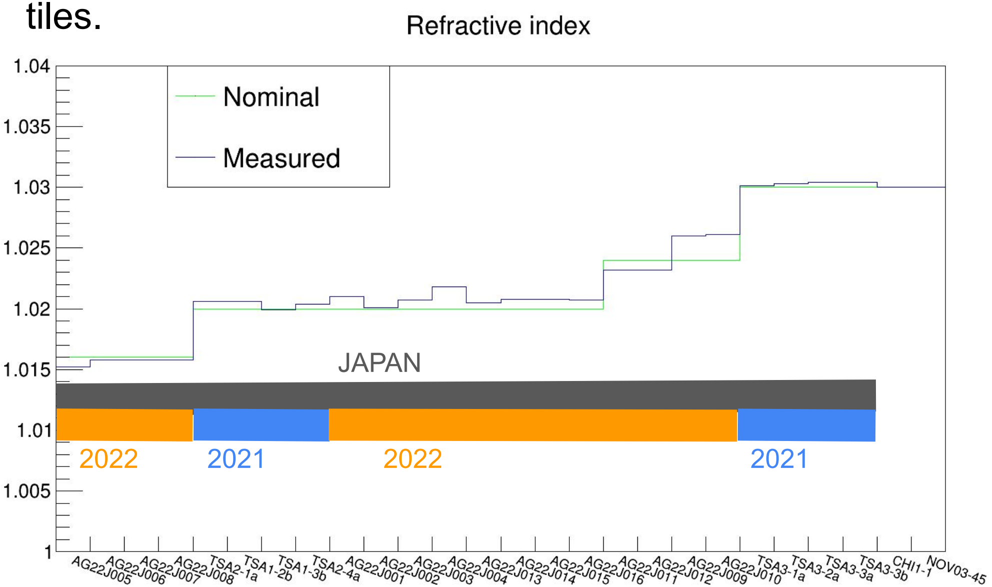
Aerogel characterization in Ferrara

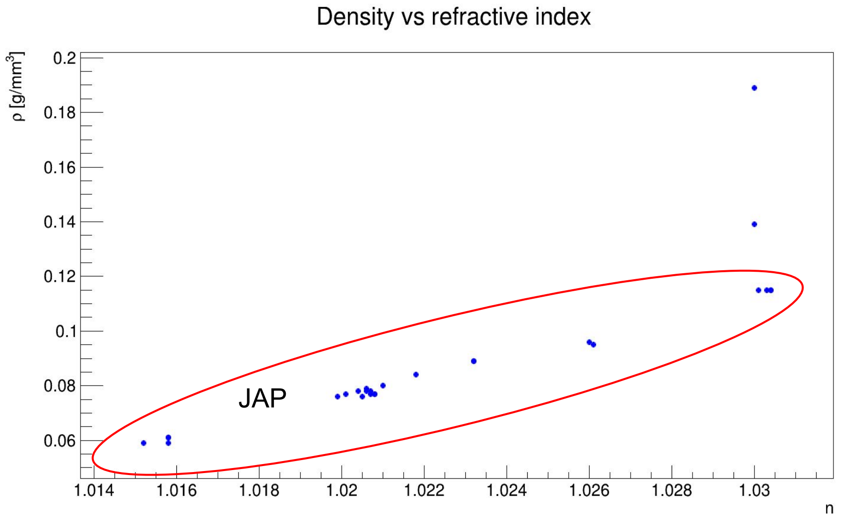
ID	Producer	Year
TSA*-**	Japan	2021
AG22J***	Japan	2022
NOV03-45	Russia	2015
CHI01-1	China	2023

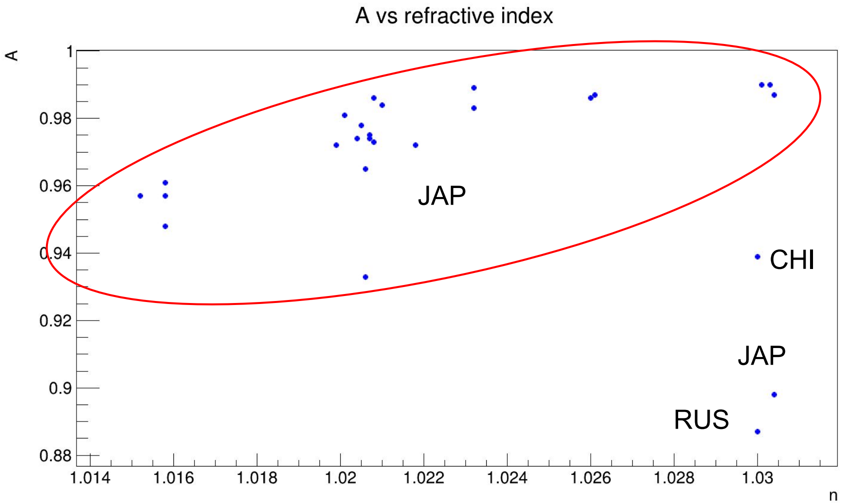
Transmittance measurement fitted with Hunt extended formula [see A.R Altamura talk REF]

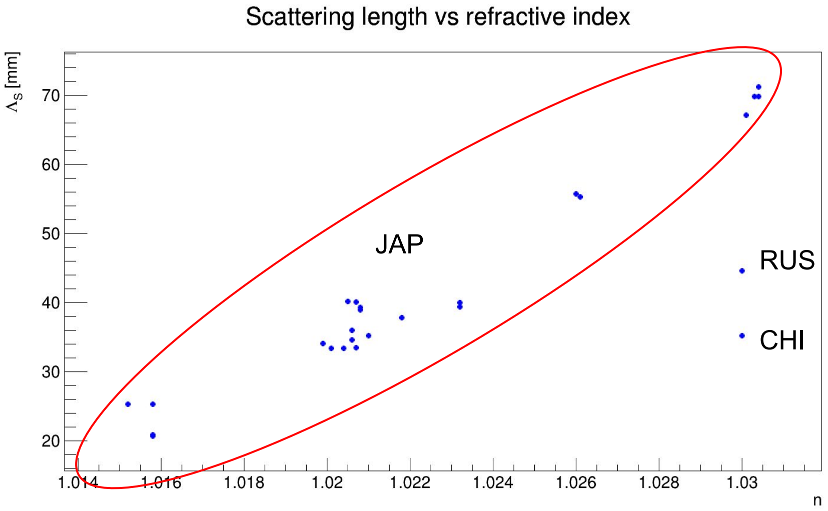
$$T(\lambda) = e^{-\frac{t}{\Lambda_{trasm}}} = e^{-t\left(\frac{1}{\Lambda_A}+\frac{1}{\Lambda_S}\right)} = A \cdot e^{-\frac{B\,t}{\lambda^8}} \cdot e^{-\frac{C\,t}{\lambda^4}}$$

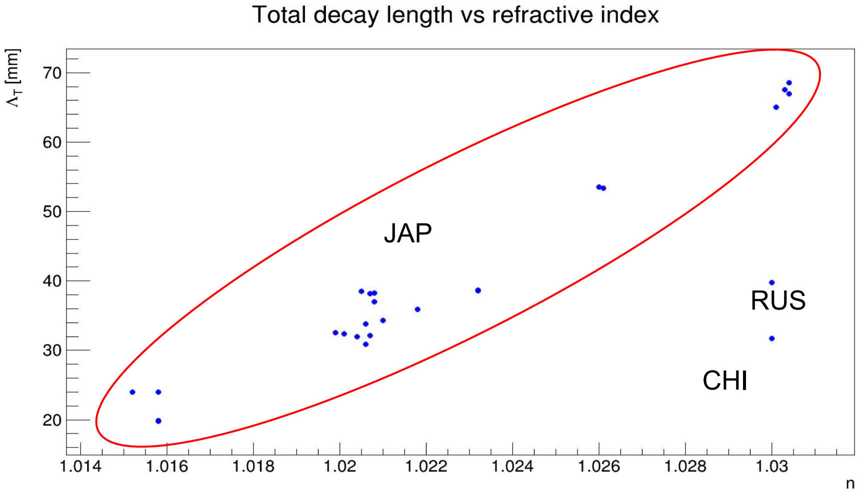
Comparing several tiles with different refractive index to evaluate the quality of the aerogel and the uniformity of the tiles.




Density vs refractive index
ρ [g/mm³]
n
JAP


A vs refractive index
A
n
JAP
CHI
JAP
RUS


Scattering length vs refractive index
Λ_S [mm]
n
JAP
RUS
CHI

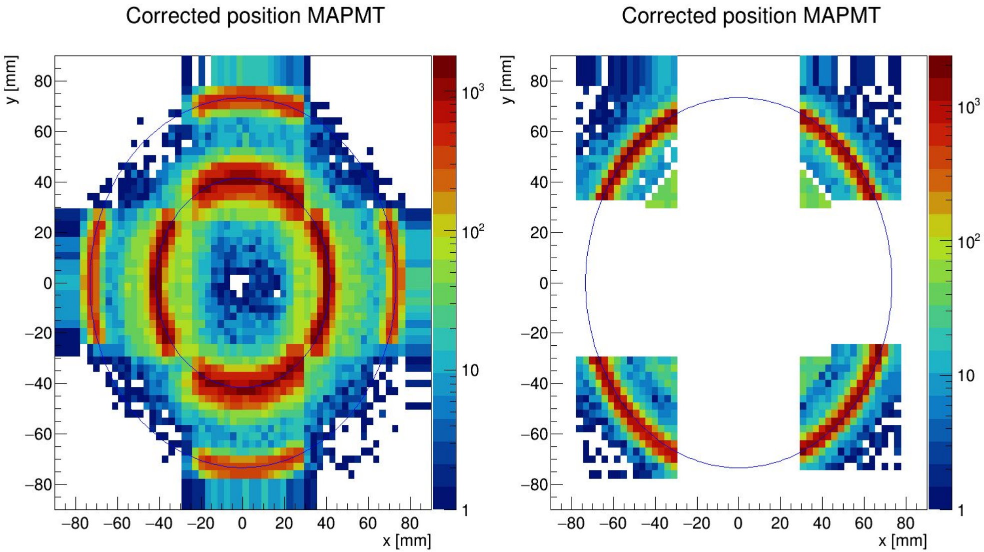

Total decay length vs refractive index
Λ_T [mm]
n
JAP
RUS
CHI

Aerogel studies with the prototype

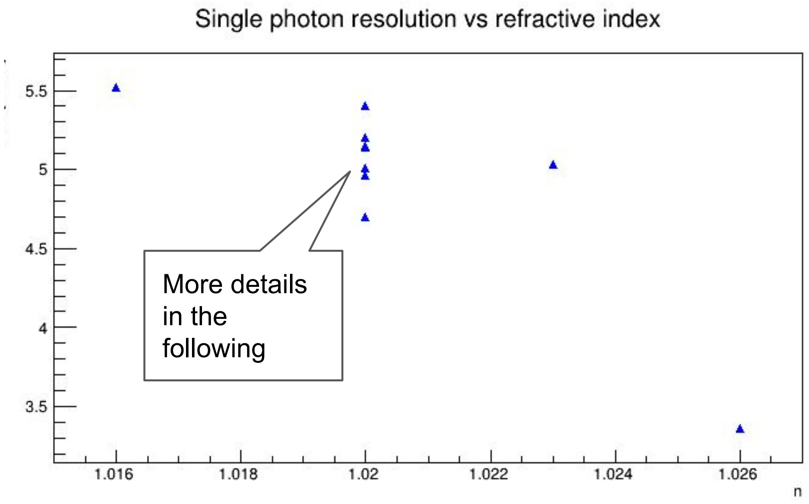
Data acquisition performed using two different configurations of the MAPMTs in the detector box:

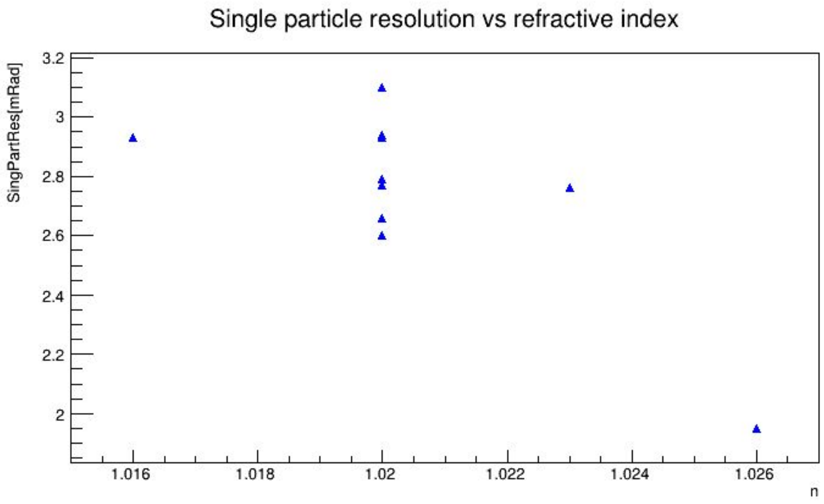
- CORNER, which covers a large part of the aerogel ring and allows to study tiles with different refractive index
- CROSS, needed for the gas study, allows to use aerogel up to n = 1.02 before the ring exits from the photodetector area.

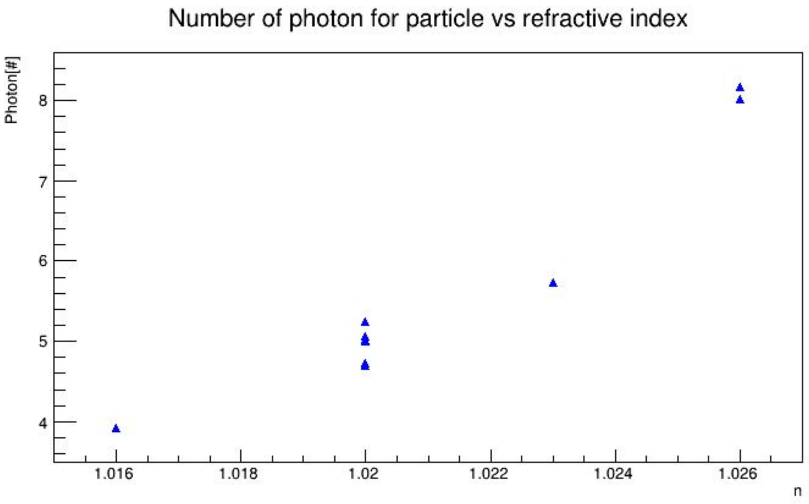
Tiles selection for test beam based on refractive index uniformity (EIC configuration 2 + 2 cm of aerogel). The n = 1.03 were tested but the cherenkov photons fall out of mirror acceptance.

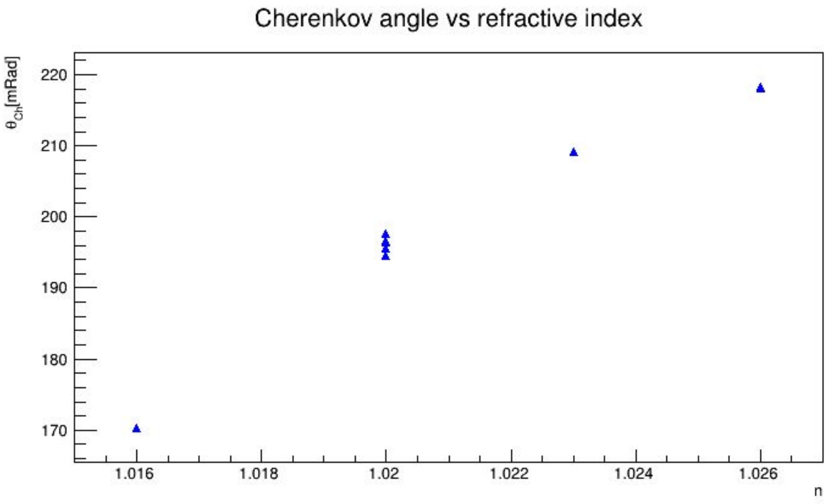


Tiles	TSA1 2b-3b	AG22J 7-8	AG22J 1-3	AG22J 9-10	AG22J 11-12	AG22J 15-16
n index	1.020	1.016	1.020	1.026	1.023	1.020
Prod/year	Jap/2021	Jap/2022	Jap/2022	Jap/2022	Jap/2022	Jap/2022

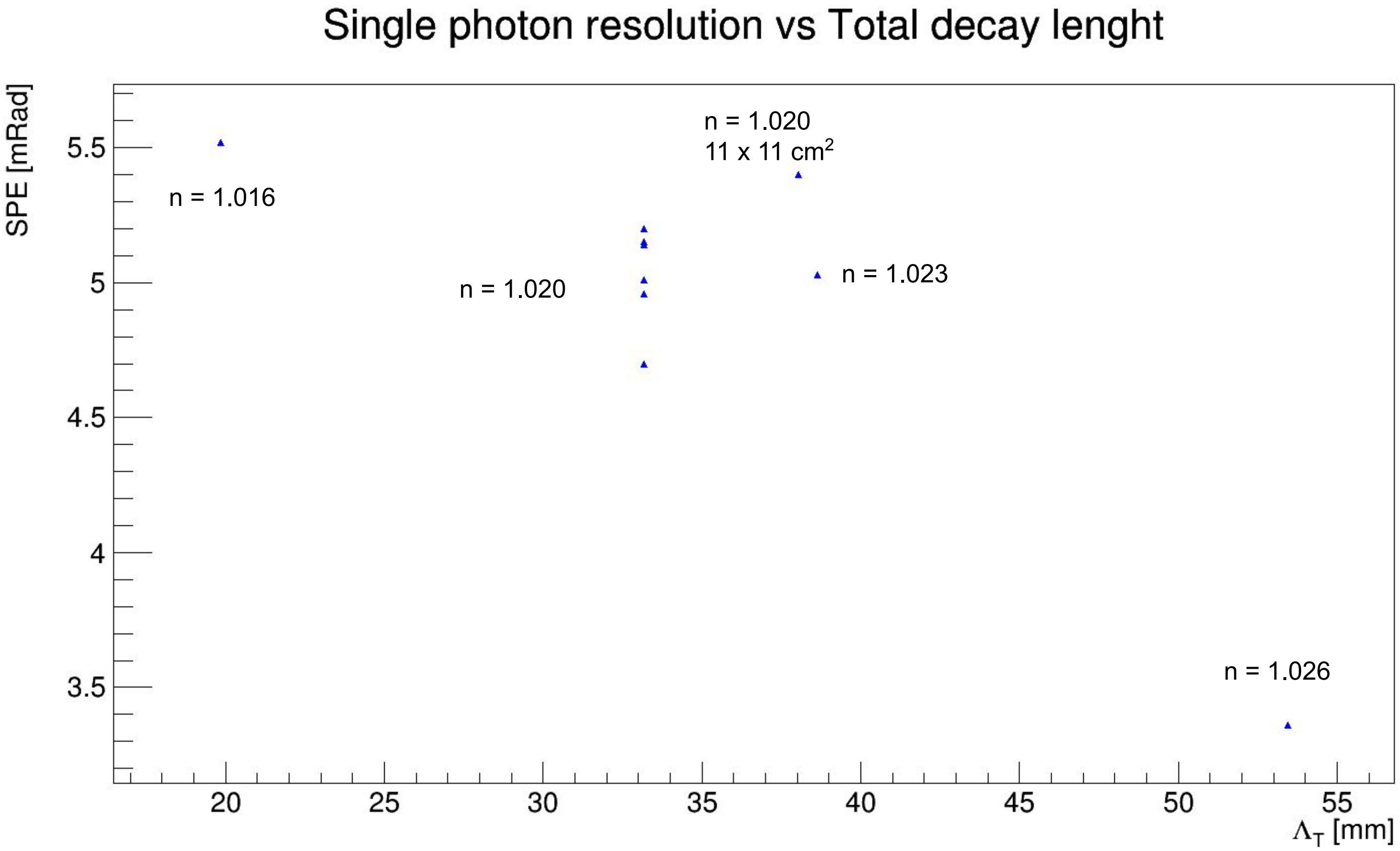

Single photon resolution vs refractive index
5.5
5
4.5
4
3.5
1.016
1.018
1.02
1.022
1.024
1.026
n
More details in the following

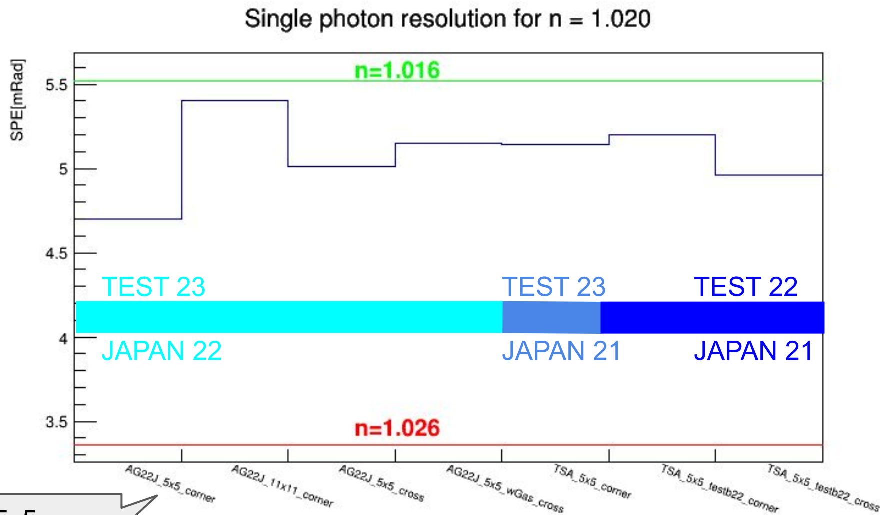

Single particle resolution vs refractive index
SingPartRes[mRad]
3.2
3
2.8
2.6
2.4
2.2
2
1.016
1.018
1.02
1.022
1.024
1.026
n

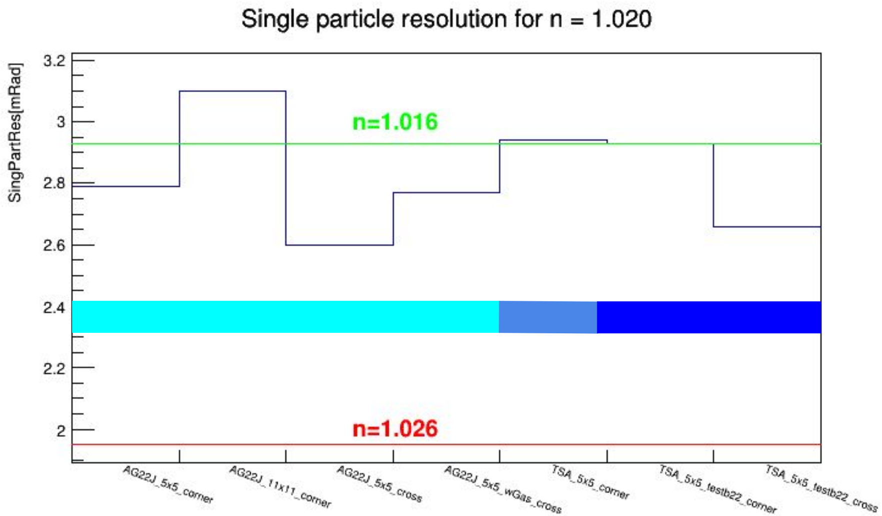

Number of photon for particle vs refractive index
Photon[#]
8
7
6
5
4
1.016
1.018
1.02
1.022
1.024
1.026
n


Cherenkov angle vs refractive index
θCh[mRad]
220
210
200
190
180
170
1.016
1.018
1.02
1.022
1.024
1.026
n

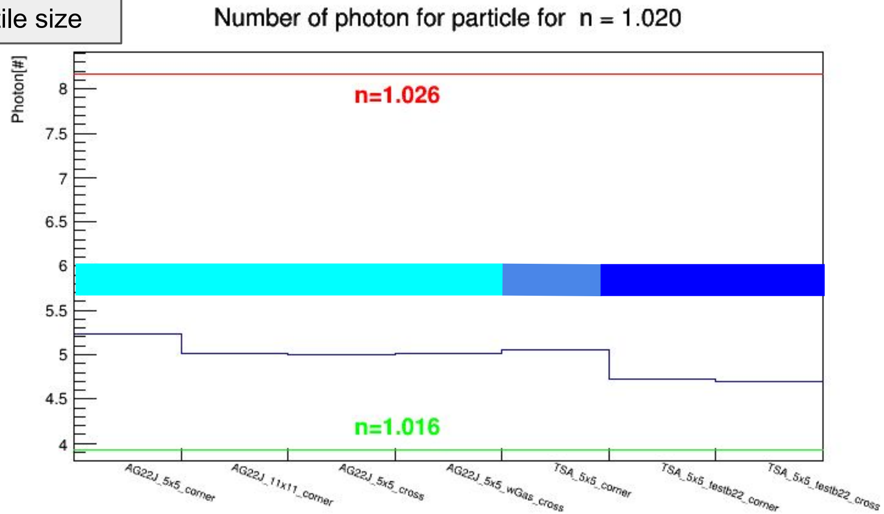
Comparing test beam results with lab measurements

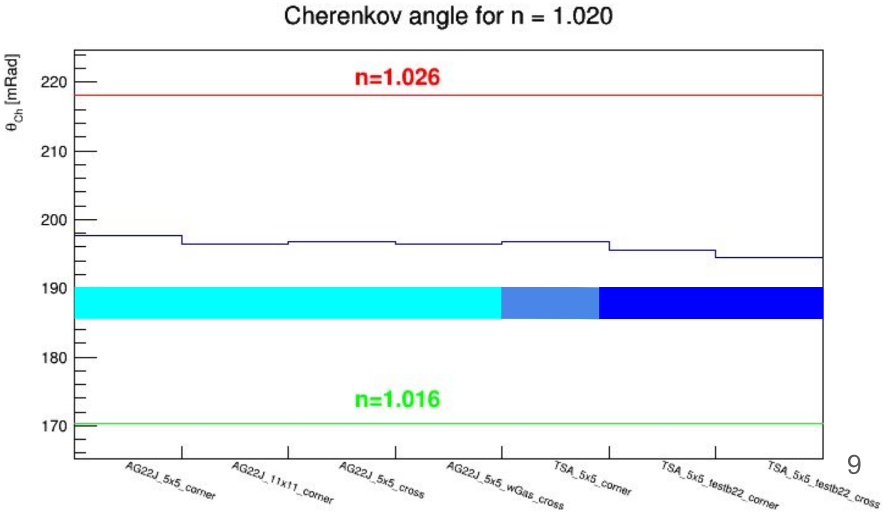






5x5 cm
tile size

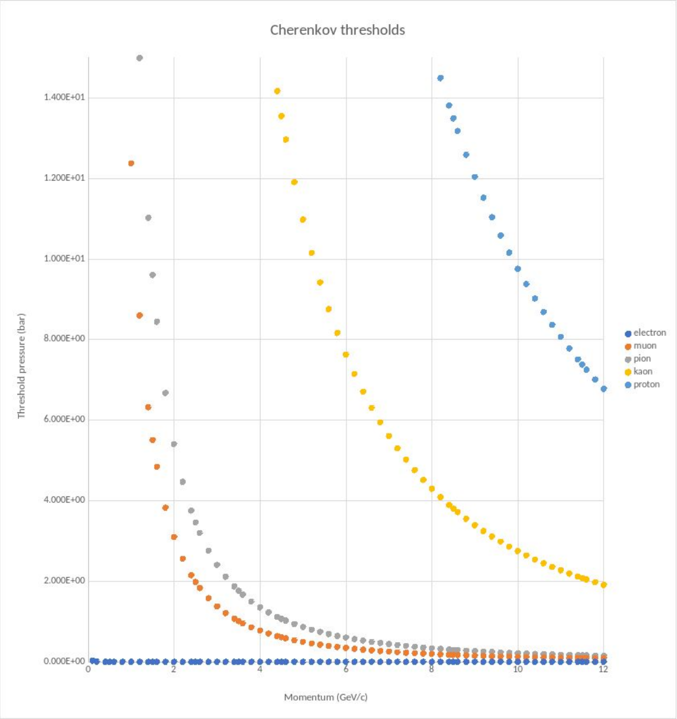




Study on particle separation

Beamline Cherenkov detector

- 2 Cherenkov threshold detector
- 1 at high pressure (up to 16 bar), 1 at low pressure (up to 4.2 bar)
- possibility to adjust the pressure of the gas, fixing different thresholds
- possibility to change the gas increasing the range of threshold values
- We used both in tagging and anti-tagging mode, generally fixing the pressure 0.3-0.5 bar under the threshold.
- We used Carbon Dioxide to study hadrons
  - both the detectors fire for pion, only 1 fires for kaon and non for proton.
  - aerogel ring
- We swap one detector to Helium to study the electron-pion separation
  - both the detectors fires for electrons, only 1 fires for pion
  - gas ring

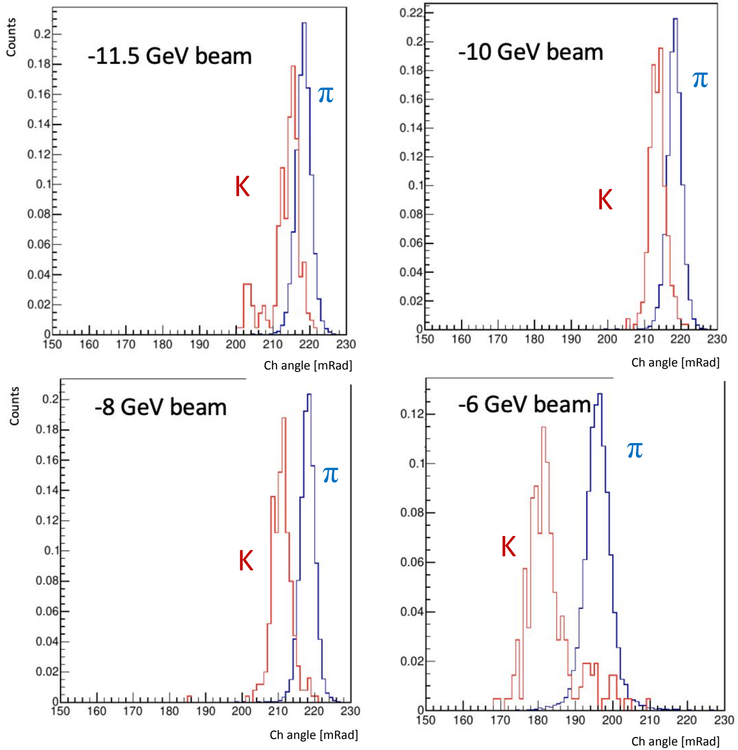


Relation between gas pressure and the particle momentum at threshold. Courtesy of Maarten Van Dijk

Online analysis

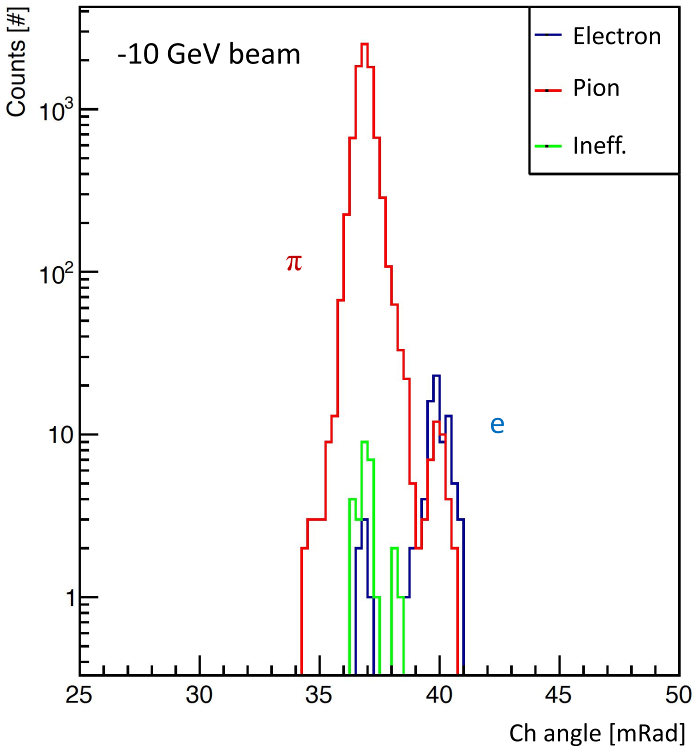
Kaon-Pion separation

Aerogel ring n=1.026 with beam Cherenkov tagging



Electron-Pion separation

Gas ring with beam Cherenkov tagging



Conclusions

- The aerogel characterization in the laboratory shows that tiles with larger refractive index have better optical properties (in particular larger Λ_T).
- The results obtained are comparable with those of the 2022 test beam (aerogel for n = 1.020).
- Measurement using several tiles with different refractive index have been acquired.
- Confirming the characterization, the best results have been obtained from the aerogel with larger refractive index.
- Using the aerogel with n = 1.026, the single photon resolution of 3.3 mRad have been achieved. This is closer to the value provided by simulation of ~3 mRad than any previous results we obtained.
- The improvement on the beam Cherenkov detector allowed us to produces the first plots showing a well defined separation of pion and kaon.
- This will allow to study the performance of the prototype in term of particle separation.
- The study on electrons and pions shows that it is possible to distinguish them using the prototype.