PID performance studies with ePIC dRICH detector

dRICH Simulation Meeting

21 November 2024

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Previous presentations

- **29 August 2024**
  - ✦ Learning dRICH software for simulating particles (pions)
  - ✦ Estimation of mean Cherenkov angle (θ_c) and Cherenkov angle residual ($\Delta\theta_c$)
- **12 September 2024**
  - ✦ $N\sigma$ values calculated corresponding to $\pi - K$ and $p - K$ separation in two η-regions [1.5-2.5] and [2.5-3.5] using polar scan & plotted as a function of particle momentum
  - ✦ data overwriting (?) while simulation using polar scan
- **25 September 2024**
  - ✦ Simulation one-by-one for each value of p & η and then merging the files according to two η regions: [1.5 to 2.5] and [2.5 to 3.5] for each p-value **[using gas as radiator]**
  - ✦ Fully working machinery for producing N_σ vs p plots for $\pi - K$ and $p - K$ separation
- **10 October 2024**
  - ✦ Use of GPU facility@CUK for simulation with finer kinematic bins (with HEPMC files)
  - ✦ N_σ vs p plots for $\pi - K$ and $p - K$ separation for gas and two aerogels (n=1.019 & 1.026)
  - ✦ Improvement in separation power with new aerogel (n = 1.026)
  - ✦ Outliers in $\theta_c - vs - p$ plots for gas radiator in particular pseudorapidity bins (3.0 & 3.1)

Today's presentation

- Resolving the outliers in $\theta_c - vs - p$ plots for gas radiator
- Estimation of separation power corresponding to $e - \pi$ separation
- Charge independence of the Cherenkov production
- Photon count study for: (i) two aerogels (ii) for different particles (protons and pions)

Analysis Details

- Two sets (old code and revised code) of simulations using hepmc files as input
  - The switching from "old code" to "revised code" is based on revision in aerogel parameters (n = 1.019 to n = 1.026)
  - No change in algorithm/structure during this switching

- Each HEPMC file (with fine kinematic bins) contains 2000 events but the simulation, due to time/storage constraints, was done with the first 1000 events.
  - PIDs: [2212, 321, 211, 11]
  - Momentum (74 bins): [0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20.0, 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5, 30.0, 30.5, 31.0, 32.0, 34.0, 36.0, 38.0, 40.0, 42.0, 44.0, 46.0, 48.0, 50.0, 55.0, 60.0]
  - Pseudorapidity: [1.5-3.5] in 0.1 steps
    - Example 1.5 $\Rightarrow$ bin of 1.499 to 1.501

- Bin details in Google Sheet and analysis root files at link
- Negative pions simulated for charge independence study for fewer kinematic values

GPU Facility @CUK

GPU Specifications

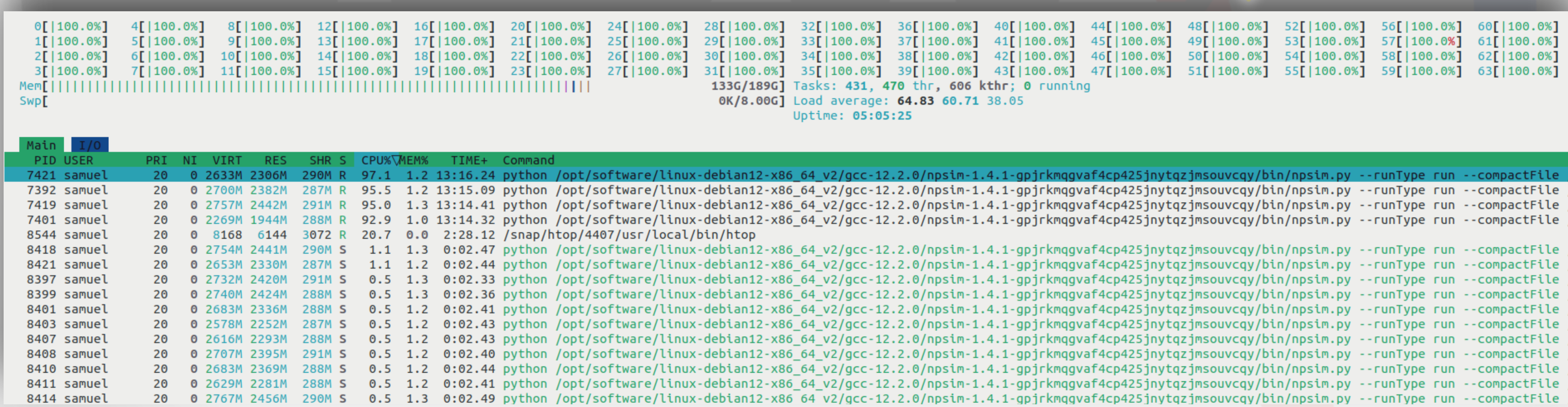
CPU	Intel(R) Xeon(R) Gold 6130 CPU @ 2.10GHz
CPU Max	3.7 GHz
CPUs	64
Phys. Mem	188 GB
Storage	1.8 TB x 2
GPU	Tesla V100 with 32 GB memory

Availability

12h per day

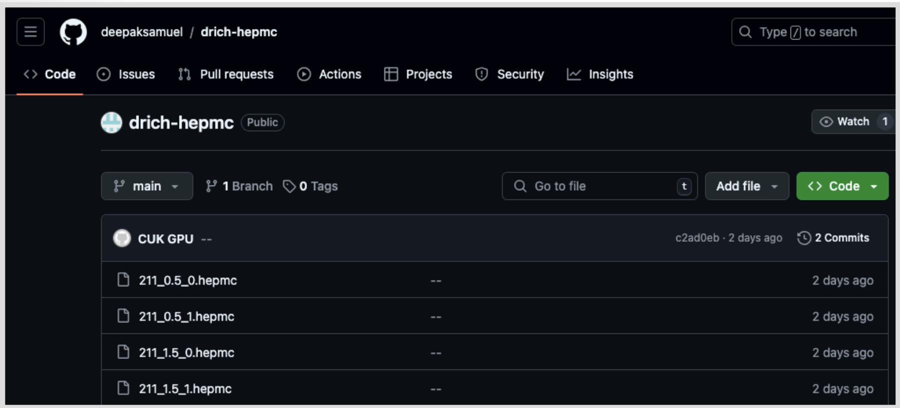
for ePIC activities

Parallel processing of DRICH simulations

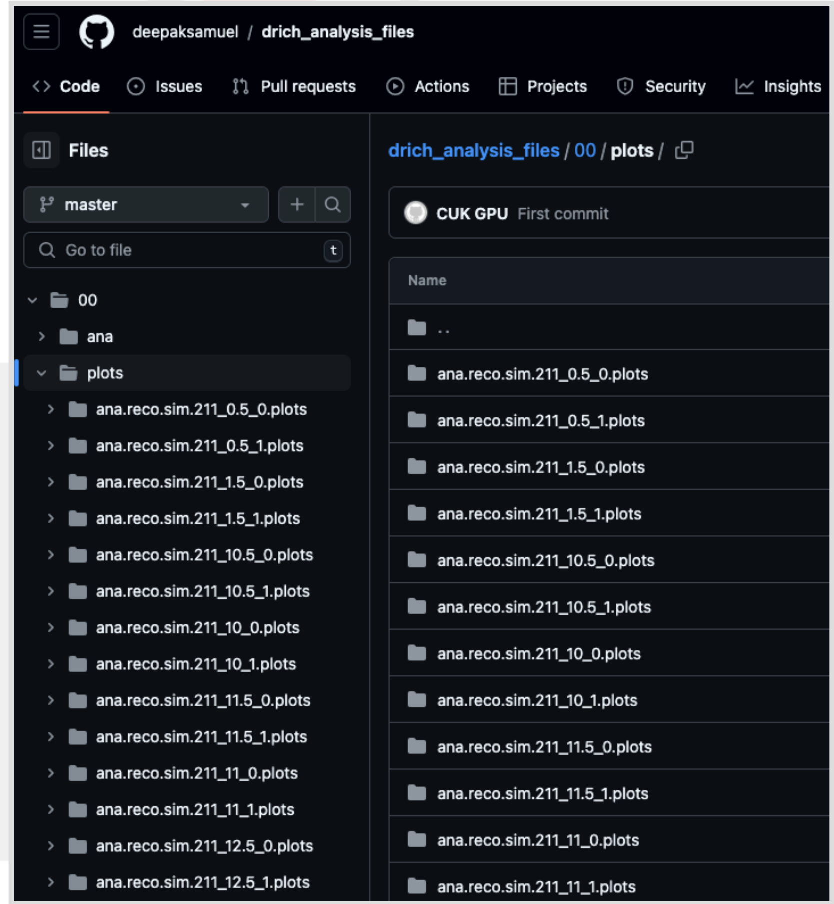


Use of GPU for Simulation

https://github.com/deepaksamuel/drich-hepmc



https://github.com/deepaksamuel/drich_analysis_files

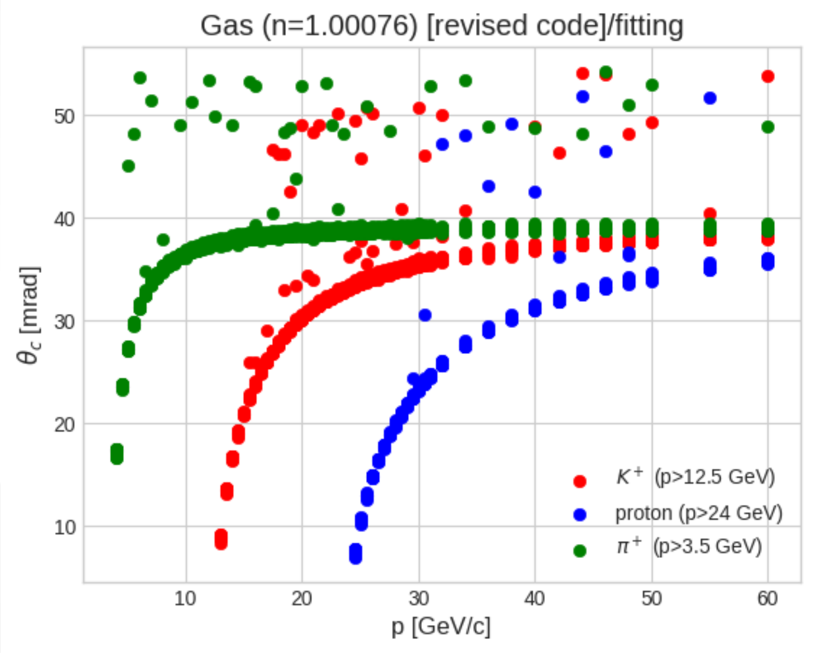


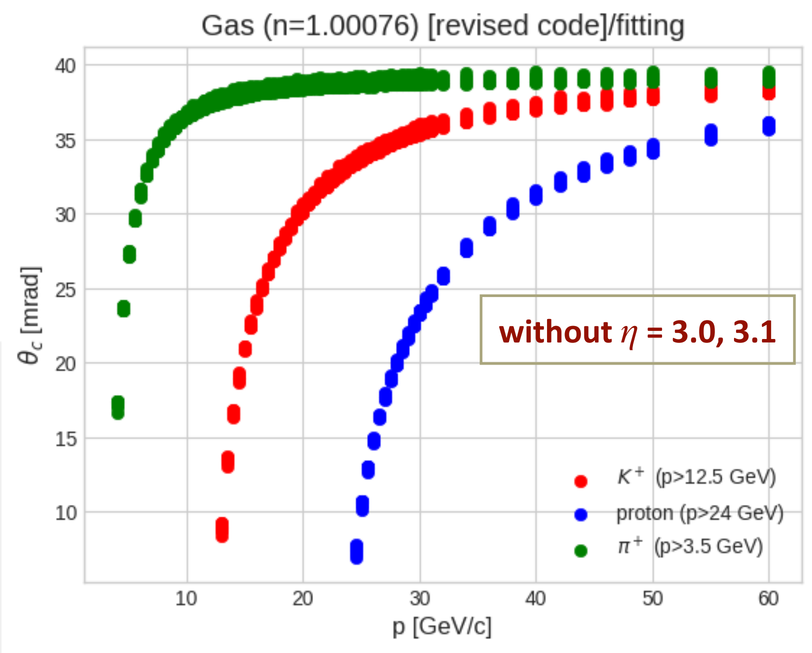
- Use of GPU for event simulation
- Production of HEPMC files
- Thanks to basis script & guidance from Chandra & significant efforts from Deepak
- *Event generation is being done (for pions, kaons, protons and electrons)*

- The HEPMC files are also accessible to other members of the group for their use

Outliers in θ_c -*vs*-p plots for gas radiator

Credits: Girdish, Adithyan



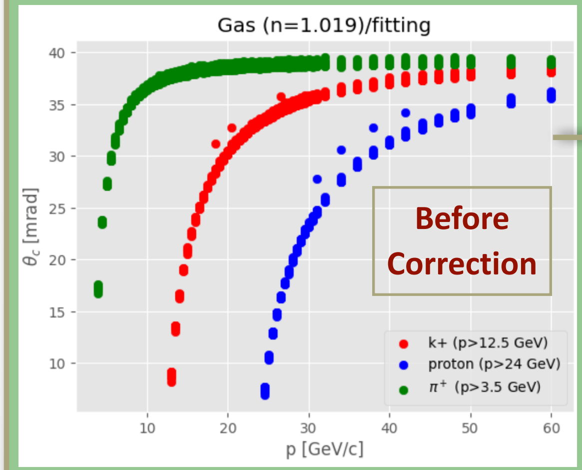


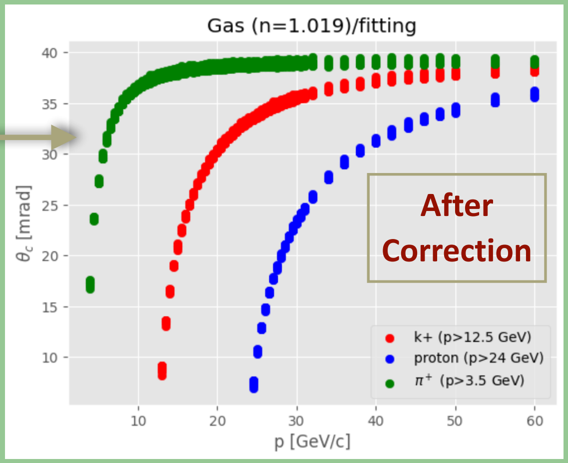
- Few outlier in $\theta_c - vs - p$ plots for gas radiator in pseudorapidity bins (3.0 & 3.1)
- Issue in case of pseudorapidity bin of 3.0 is found to be caused by error in the fitting and has been resolved now
- Issue in case of pseudorapidity bin of 3.1 is still not understood and the corresponding data points has been removed while plotting

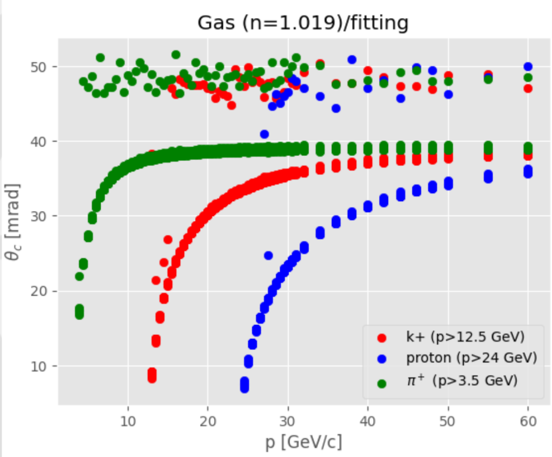
Outliers in θ_c -*vs*-p plots for gas radiator

Credits: Girdish, Adithyan

particle	eta	p (GeV)	Old θ_c (mrad)	New θ_c (mrad)
kaon	3.0	18.5	31.17	28.3
kaon	3.0	20.5	32.78	30.54
kaon	3.0	26.5	35.8	34.25
proton	3.0	31.0	27.8	24.59
proton	3.0	34.0	30.6	27.56
proton	3.0	38.0	32.8	30.09
proton	3.0	42.0	34.2	31.83







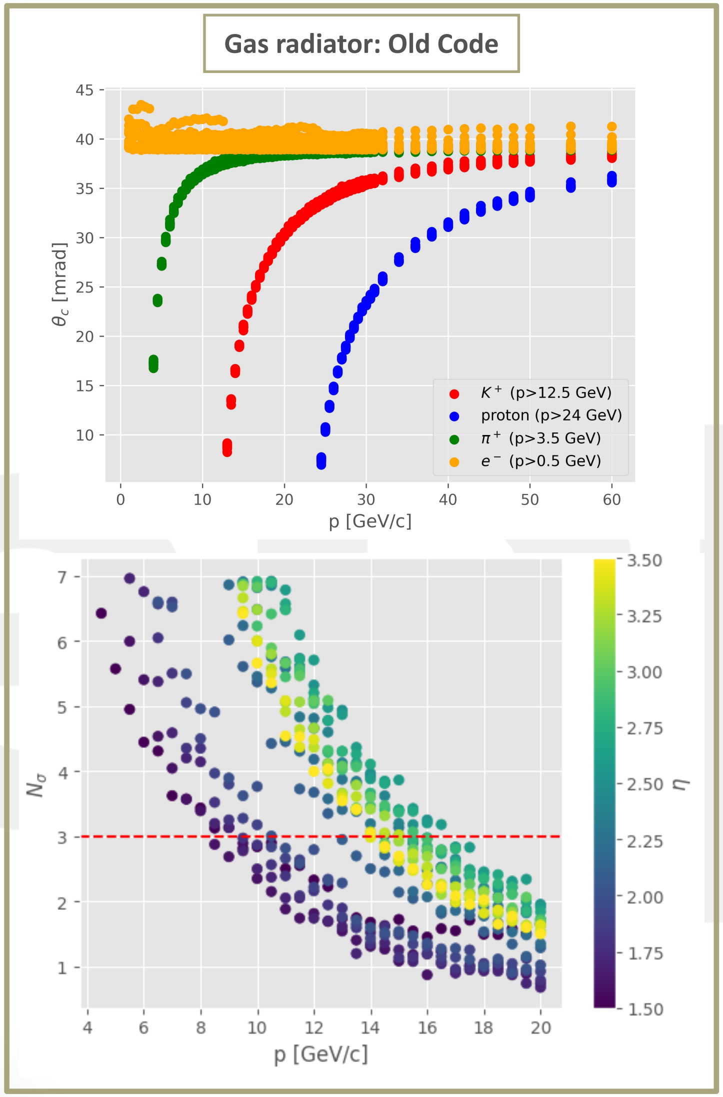
without η = 3.1 & with η = 3.0

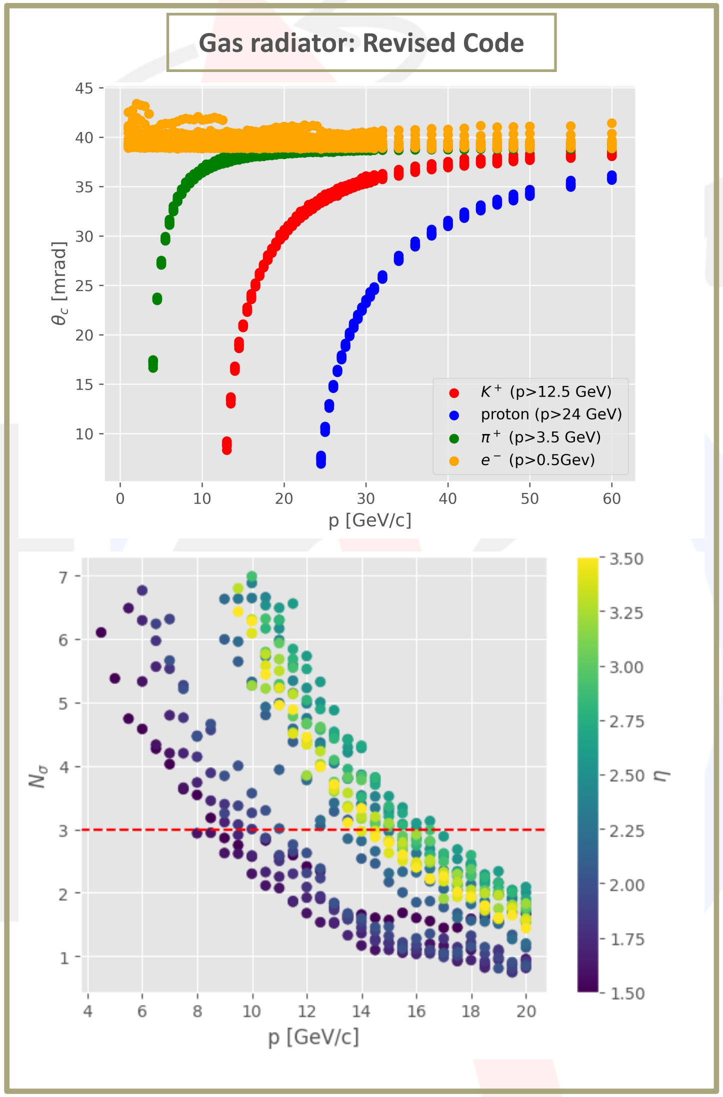
Outliers corresponding to η = 3.0 has been resolved by correcting the range for Gaussian fitting

All Data

Outliers corresponding to without η = 3.1 are still there

Inclusion of $e - \pi$ separation

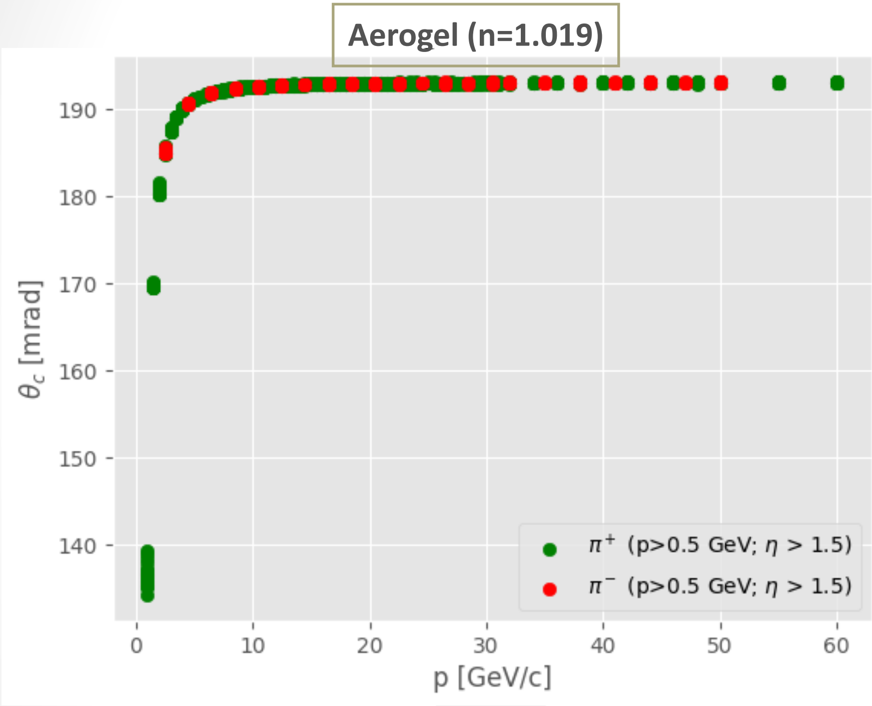


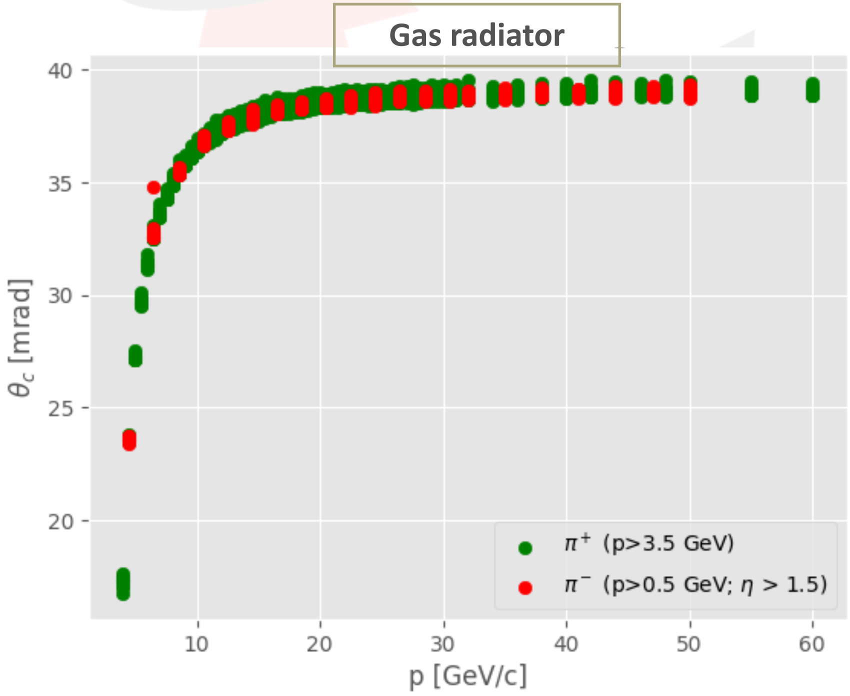


- Data corresponding to η = 3.1 is not considered

Credits: Rohit, Tanya

Charge independence study for pions

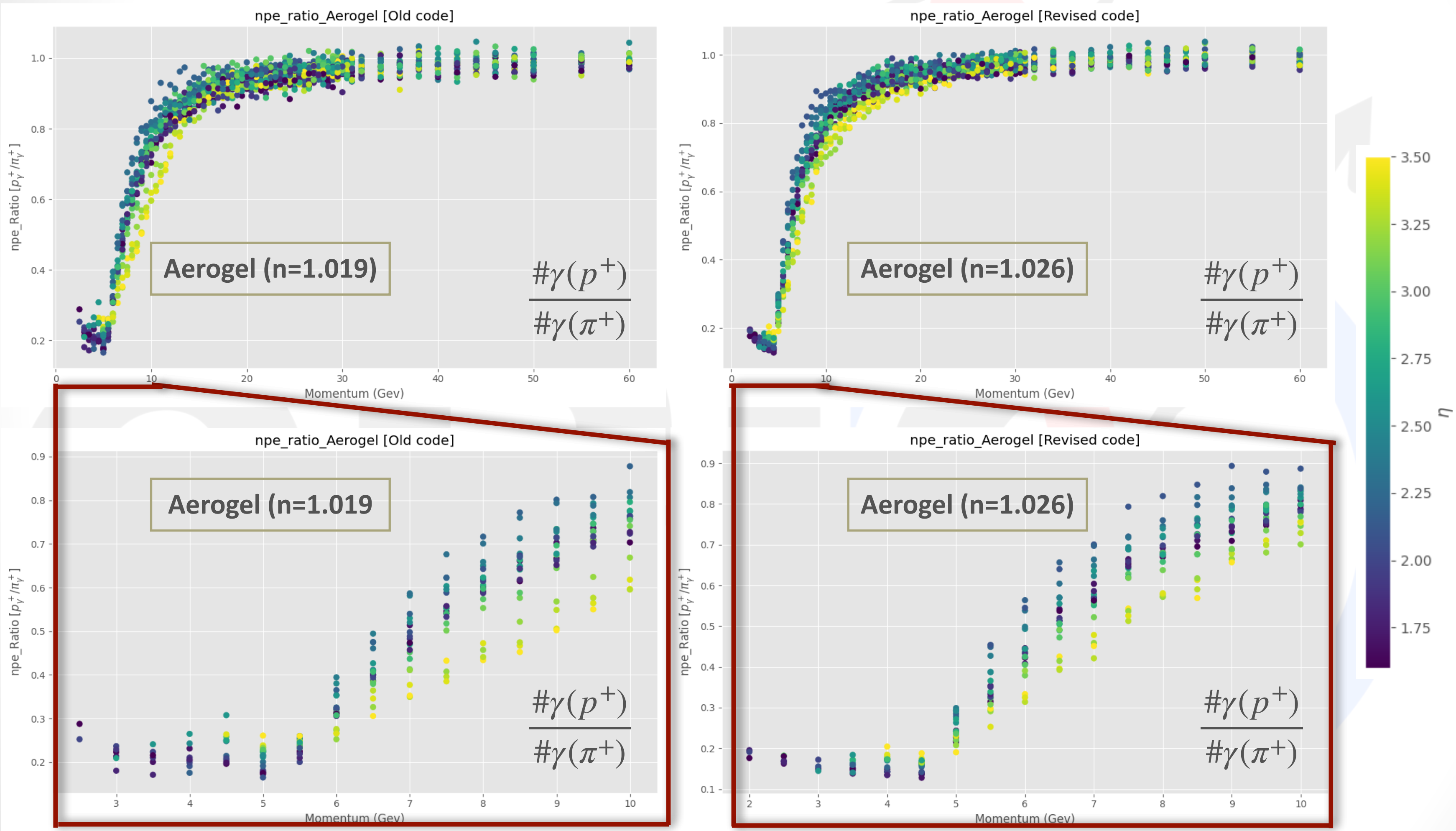




- No significant effect is observed in θ_C distribution for positive pions or negative pions, that establishes the charge independence of the Cherenkov production

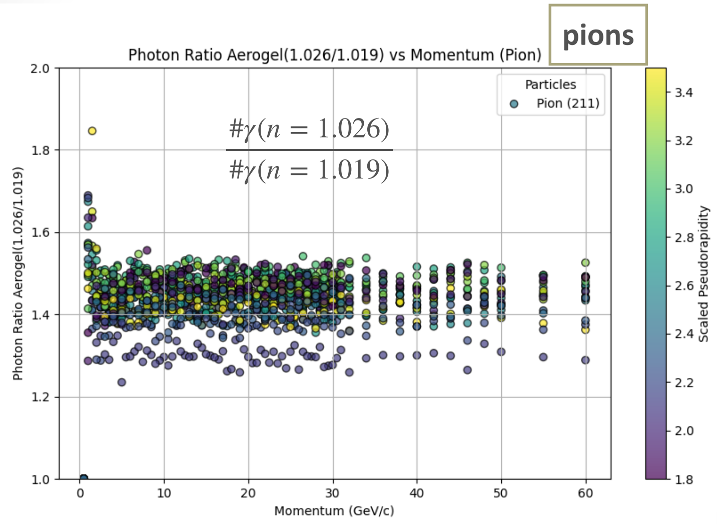
Photon count study for two aerogels

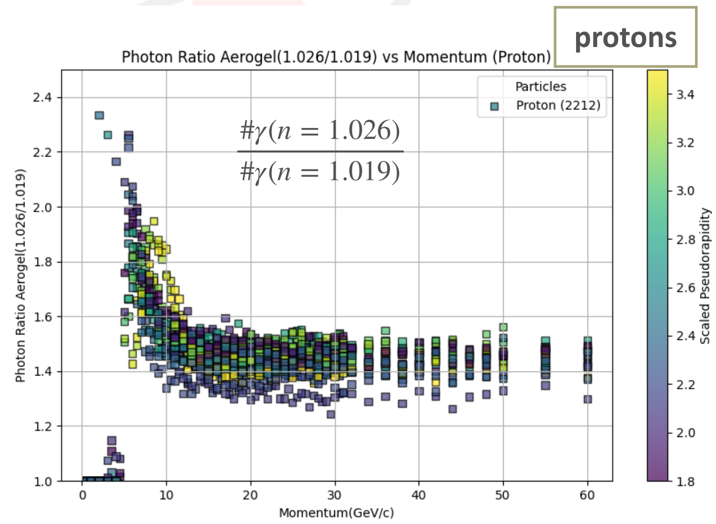
Credits: Nebin, Rohit

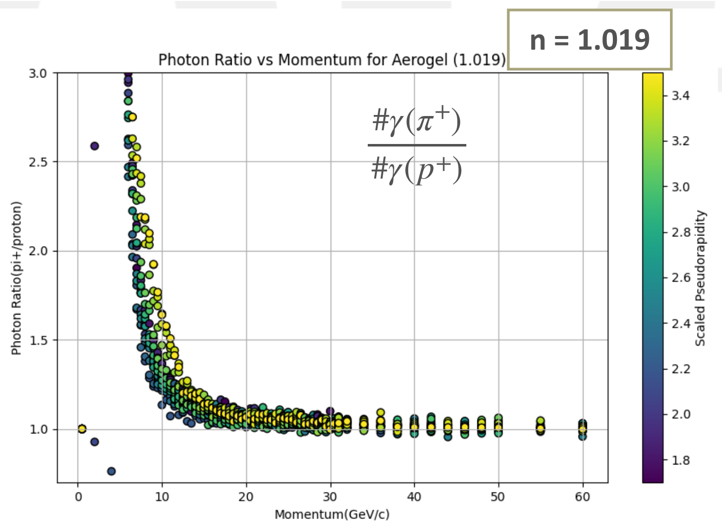


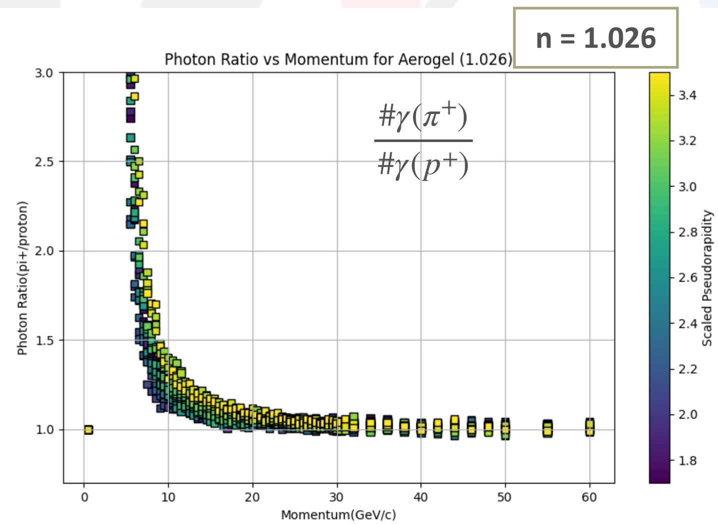
Photon count study for two aerogels

Credits: Nebin, Rohit



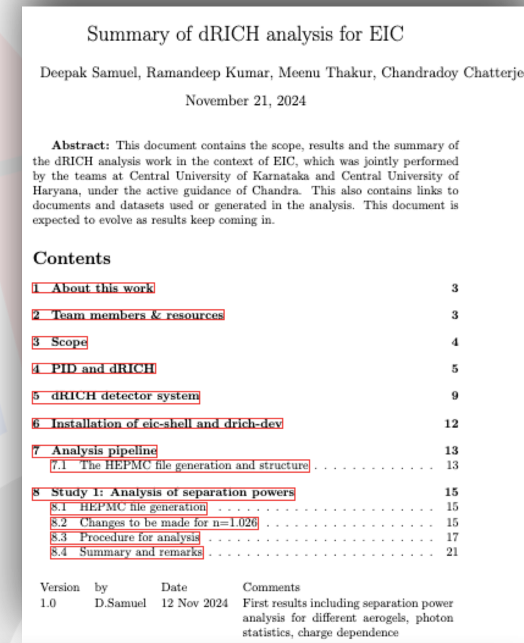






Summary

- We aim to perform PID performance studies for dRICH at ePIC
  - N_σ vs p plots for both radiators [with old/revised codes]
- Outliers corresponding to $\eta = 3.0$ has been resolved
- Considering the importance of electron detection, PID performance study is included for $e - \pi$ separation
- New aerogel (n=1.026) is found to be more sensitive as compared to old aerogel (n=1.019)
- Cherenkov production is observed to be unbiased towards the charge of particle
- Photon count study for two radiators and different particles
- Documentation (under process)
- Abstract submitted to DAE Symposium: ***Accepted for oral presentation***
- Future task: involvement in IRT coding for event reconstruction



Summary of dRICH analysis for EIC

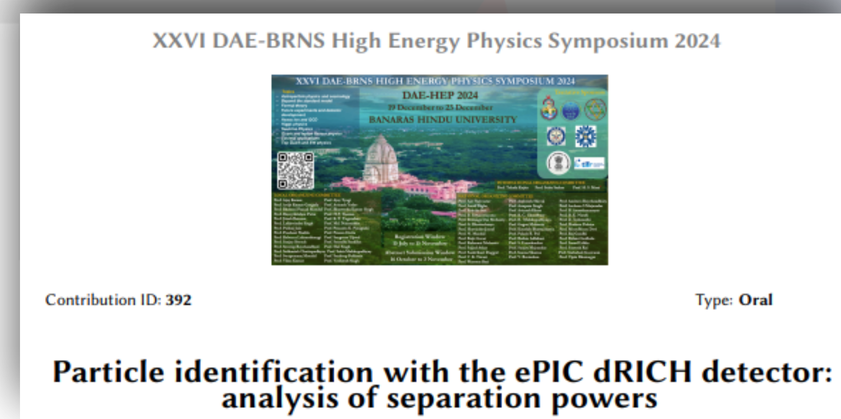
Deepak Samuel, Ramandeep Kumar, Meenu Thakur, Chandradoy Chatterjee

November 21, 2024

Abstract: This document contains the scope, results and the summary of the dRICH analysis work in the context of EIC, which was jointly performed by the teams at Central University of Karnataka and Central University of Haryana, under the active guidance of Chandra. This also contains links to documents and datasets used or generated in the analysis. This document is expected to evolve as results keep coming in.

Contents

Version	by	Date	Comments
1.0	D.Samuel	12 Nov 2024	First results including separation power analysis for different aerogels, photon statistics, charge dependence



XXVI DAE-BRNS High Energy Physics Symposium 2024

Contribution ID: 392 Type: **Oral**

Particle identification with the ePIC dRICH detector: analysis of separation powers

Thank you

We look forward to your comments and suggestions…