

# Simulation studies update dRICH

Chandradoy Chattejee  
on behalf of dRICH simulation team

<https://indico.bnl.gov/event/25662/>

# dRICH performance: input

- ✦ 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 Specifications

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

R. Kumar

dRICH Simulation Meeting

21 November 2024

```

0[|100.0%] 4[|100.0%] 8[|100.0%] 12[|100.0%] 16[|100.0%] 20[|100.0%] 24[|100.0%] 28[|100.0%] 32[|100.0%] 36[|100.0%] 40[|100.0%] 44[|100.0%] 48[|100.0%] 52[|100.0%] 56[|100.0%] 60[|100.0%]
1[|100.0%] 5[|100.0%] 9[|100.0%] 13[|100.0%] 17[|100.0%] 21[|100.0%] 25[|100.0%] 29[|100.0%] 33[|100.0%] 37[|100.0%] 41[|100.0%] 45[|100.0%] 49[|100.0%] 53[|100.0%] 57[|100.0%] 61[|100.0%]
2[|100.0%] 6[|100.0%] 10[|100.0%] 14[|100.0%] 18[|100.0%] 22[|100.0%] 26[|100.0%] 30[|100.0%] 34[|100.0%] 38[|100.0%] 42[|100.0%] 46[|100.0%] 50[|100.0%] 54[|100.0%] 58[|100.0%] 62[|100.0%]
3[|100.0%] 7[|100.0%] 11[|100.0%] 15[|100.0%] 19[|100.0%] 23[|100.0%] 27[|100.0%] 31[|100.0%] 35[|100.0%] 39[|100.0%] 43[|100.0%] 47[|100.0%] 51[|100.0%] 55[|100.0%] 59[|100.0%] 63[|100.0%]
Mem[|||||]
Swp[|]
133G/189G Tasks: 431, 470 thr, 606 kthr, 0 running
Load average: 64.83 60.71 38.05
Uptime: 05:05:25

Main | I/O
PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
7421 samuel 20 0 2633M 2366M 290M R 97.1 1.2 13:16.24 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
7392 samuel 20 0 2700M 2382M 287M R 95.5 1.2 13:15.09 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
7419 samuel 20 0 2757M 2442M 291M R 95.0 1.3 13:14.41 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
7401 samuel 20 0 2269M 1944M 288M R 92.9 1.0 13:14.32 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
8544 samuel 20 0 8168 6144 3072 R 20.7 0.0 2:28.12 /snap/htop/4407/usr/local/bin/htop
8418 samuel 20 0 2754M 2441M 290M S 1.1 1.3 0:02.47 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
8421 samuel 20 0 2653M 2330M 287M S 1.1 1.2 0:02.44 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
8397 samuel 20 0 2732M 2420M 291M S 0.5 1.3 0:02.33 python /opt/software/linux-debian12-x86_64_v2/gcc-12.2.0/npsim-1.4.1-gpjrknqgvaf4cp425jnytzqjmsouvqy/bin/npsim.py --runType run --compactFile /
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```

12 hours/day available for EIC and ePIC related activities. All 64 cores are in use.

All analysis files are stored (some simulation and reconstruction files are also saved).

# dRICH performance: input

## 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.

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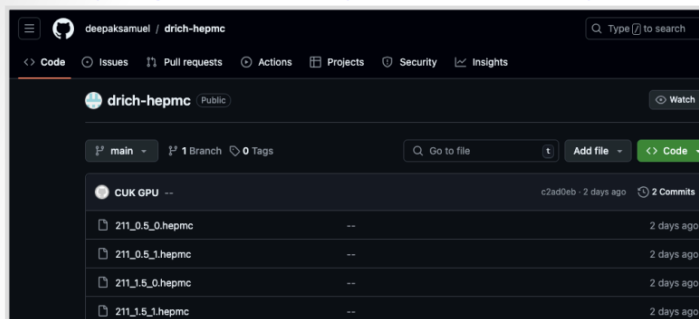
Version	by	Date	Comments
1.0	D.Samuel	12 Nov 2024	First results including separation power analysis for different aerogels, photon statistics, charge dependence



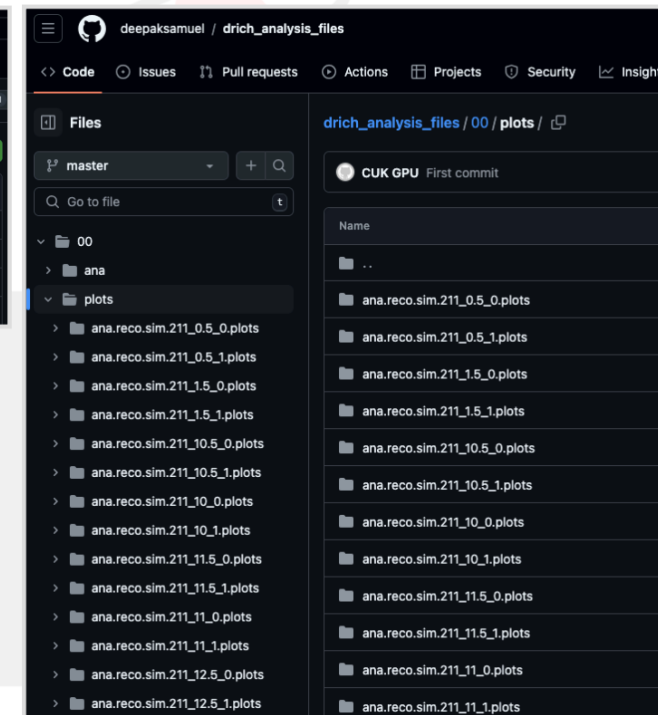
## Use of GPU for Simulation



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

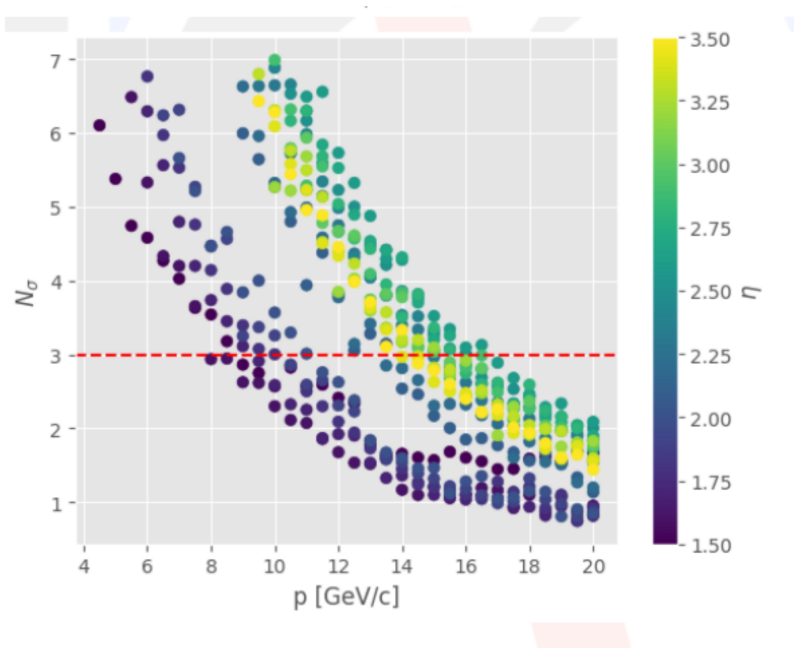


[https://github.com/deepaksamuel/drich\\_analysis\\_files](https://github.com/deepaksamuel/drich_analysis_files)



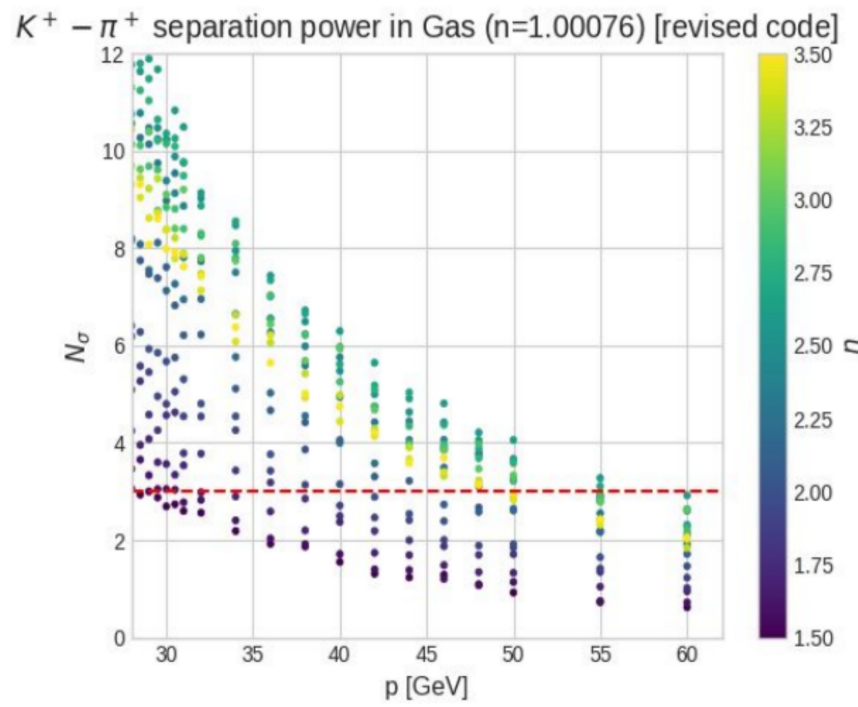
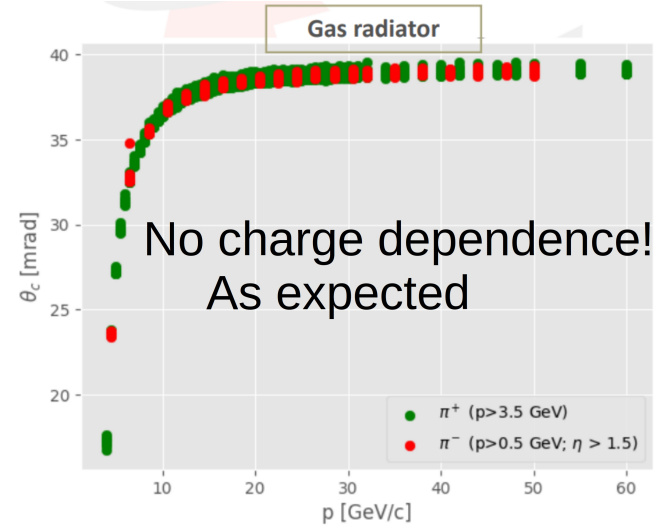
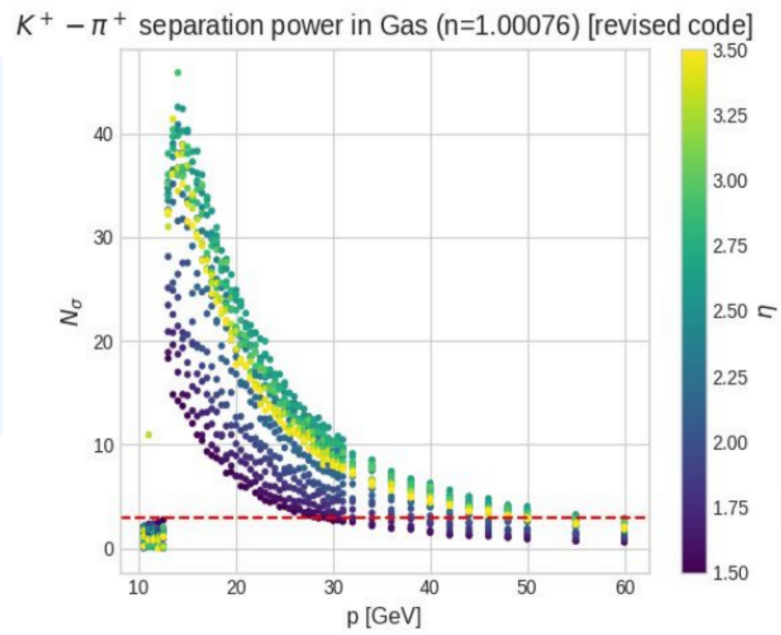
- Use of GPU for event simulation
- Production of HEPMC files
- Thanks to basis script & guidance from Chandra & significant efforts from Deepak
- *Event generation is being done (for pions, kaons, protons and electrons)*
- The HEPMC files are also accessible to other members of the group for their use

# dRICH separation power : gas



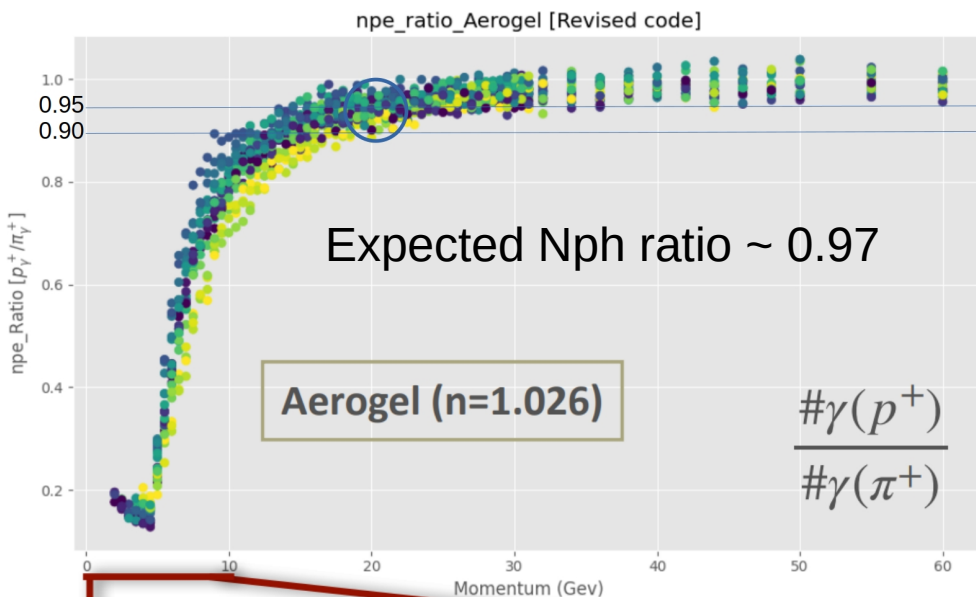
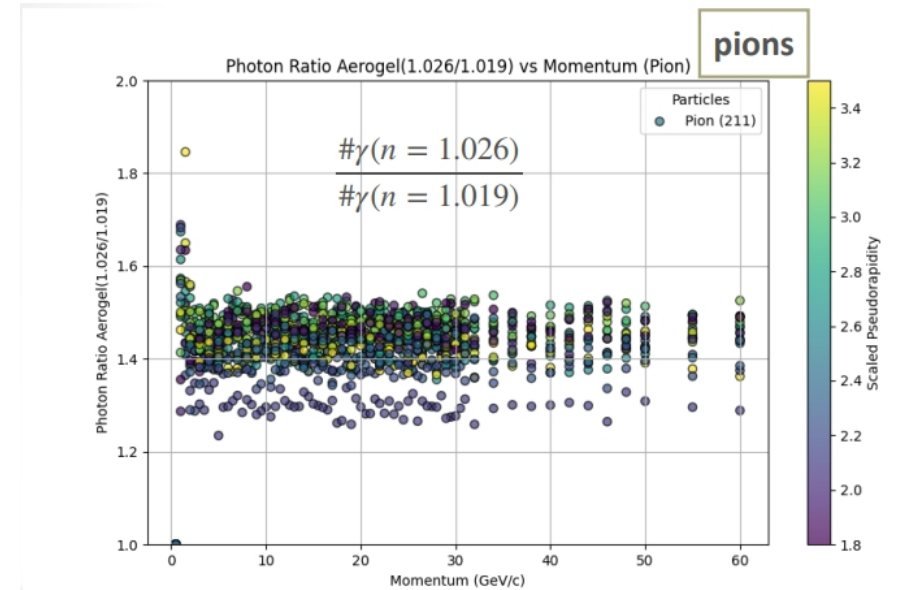
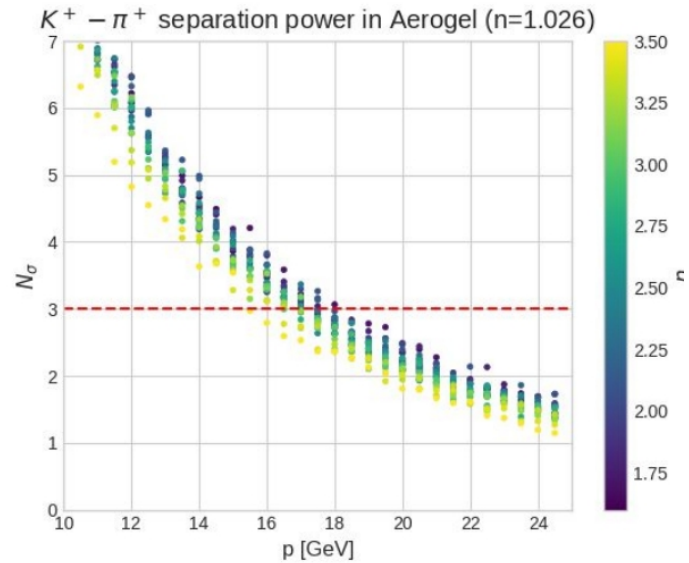
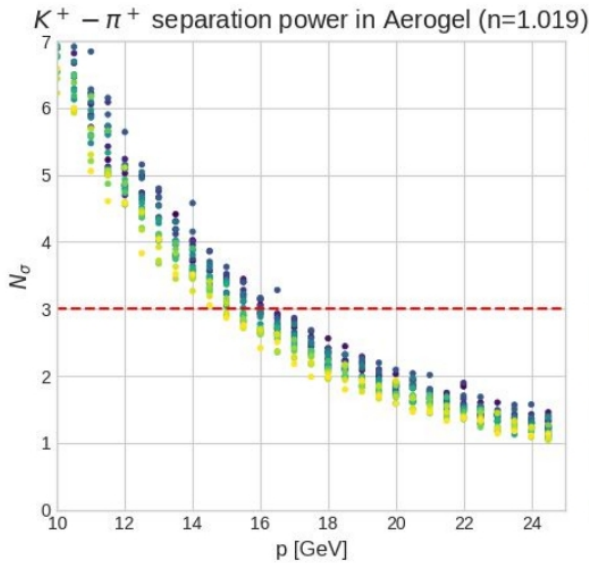
electron/pion separation

Credits: Rohit, Tanya



1. No charge dependence.
2. Newest geometry, mag. Field; pi/K upto 50 GeV 3-sigma for most of highest eta values.
3. LUT and contours are under preparation.
4. <14-16GeV> for e/pi separation in gas

# dRICH separation power : Aerogel



1. T.Boasso suggested aerogel 1.026 performs better than 1.019. Large data set studies validated such observations.
2. Almost 2 GeV improvement. No noise added so far (will be checked).
3. Aerogel 1.026 has at higher photon count,  $\sim 50\%$
4. Photon ratio of pions and protons follows F&T law, way to cross-check the simulation and beam test results.

# Single photon resolution: Chromatic error

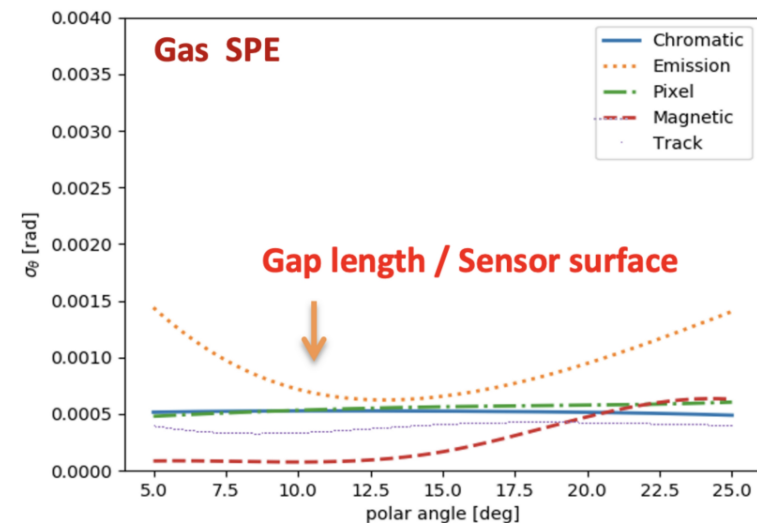
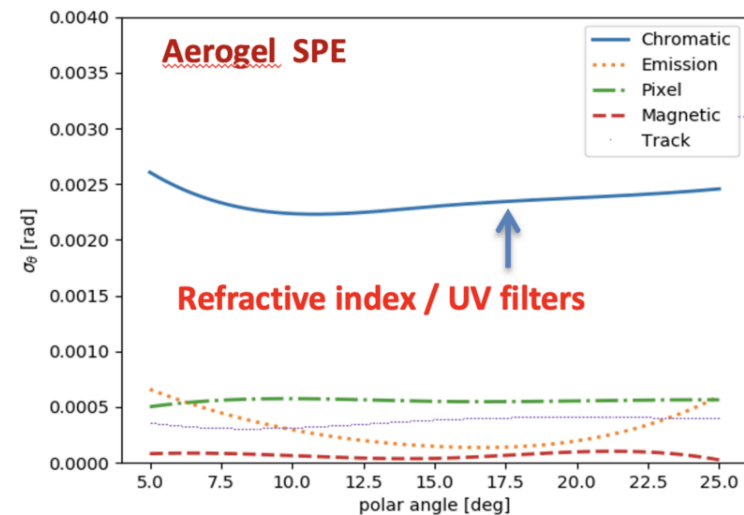
## Analysis details

- To calculate the contribution of chromatic aberration I ran simulations both with the refractive index fixed and with the lambda dependency.
- 1000 events.
- PID: 211
- Momentum fixed:
  - For gas @ 50 GeV/c.
  - For aerogel @ 15 GeV/c.
- Different bins of  $\eta$ .

```

4.89411eV 1.001406
6.19921eV 1.001489
"/>
<matrix name="ABSLLENGTH_C4F10_PFRICH" coldin="2" values="
1.23984eV 6.0*n
6.19921eV 6.0*n
"/>
<!-- DRICH aerogel, for density=0.11 g/cm3 -->
<matrix name="RINDEX_Aerogel_DRICH" coldin="2" values="
1.23984eV 1.01826
1.28348eV 1.01828
1.33030eV 1.01829
1.38067eV 1.01831
1.43500eV 1.01833
1.49379eV 1.01835
1.55759eV 1.01838
1.62709eV 1.01840
1.70308eV 1.01844
1.78652eV 1.01847
1.87855eV 1.01852
1.96673eV 1.01856
2.05490eV 1.01861
2.14308eV 1.01866
2.23126eV 1.01871
2.31943eV 1.01876
2.40761eV 1.01881
2.49579eV 1.01887
2.58396eV 1.01893
2.67214eV 1.01899
2.76032eV 1.01905
2.84849eV 1.01912
2.93667eV 1.01919
3.02485eV 1.01926
3.11302eV 1.01933
3.20120eV 1.01941
3.28938eV 1.01948
3.37755eV 1.01956
3.46573eV 1.01965
3.55391eV 1.01973
3.64208eV 1.01982
3.73026eV 1.01991
3.81844eV 1.02001
3.90661eV 1.02010
3.99479eV 1.02020
4.08297eV 1.02030
4.17114eV 1.02041
4.25932eV 1.02052
    
```

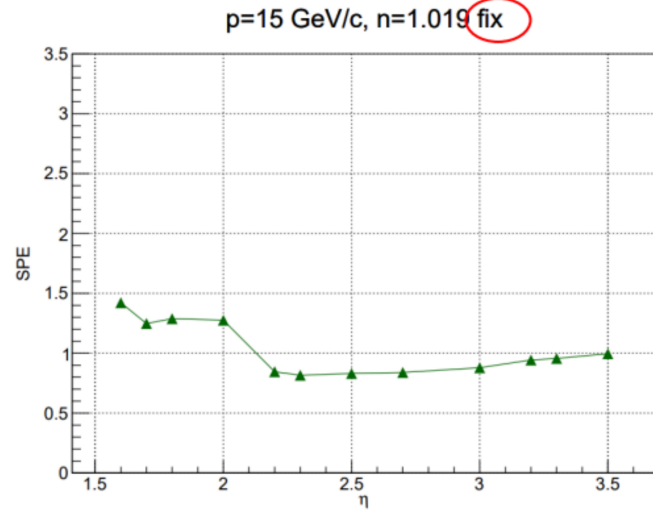
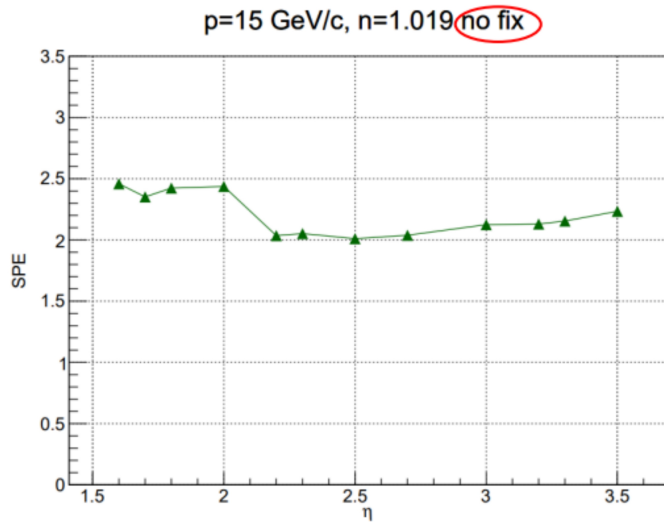
epic/compact/optical\_materials.xml



Studies by Luisa

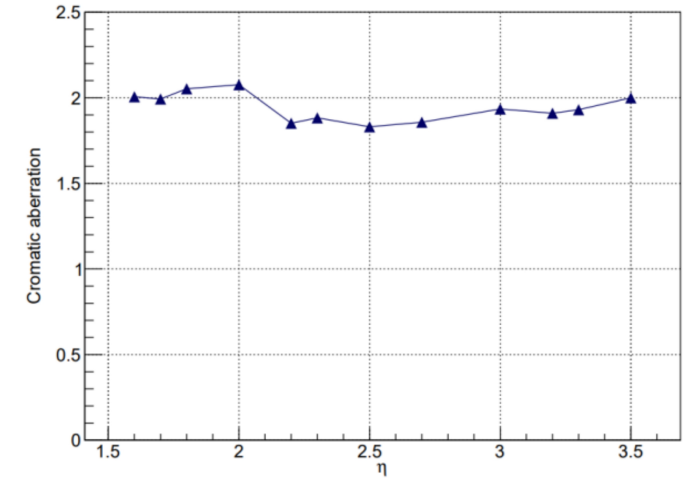
# Single photon resolution: Chromatic error

Aerogel 1.019

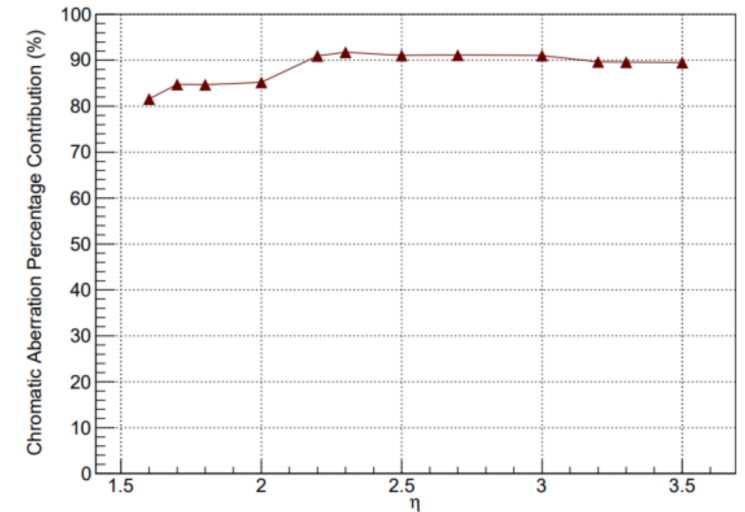


Studies by Luisa

Chromatic aberration vs  $\eta$ , p=15 GeV/c, n=1.019



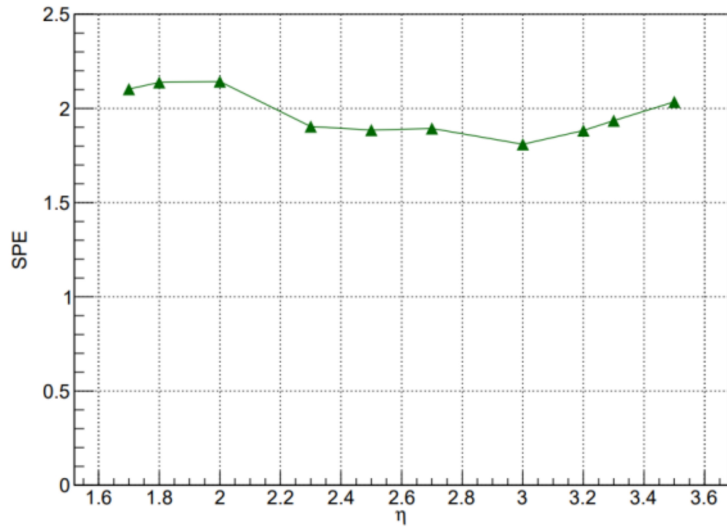
Chromatic Aberration Percentage Contribution vs  $\eta$ , p=15 GeV/c, n=1.019



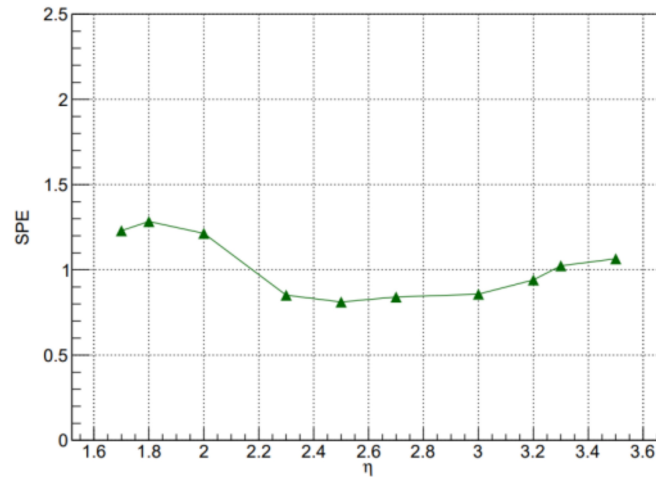
# Single photon resolution: Chromatic error

Aerogel 1.026

p=15 GeV/c, n=1.026 **no fix**



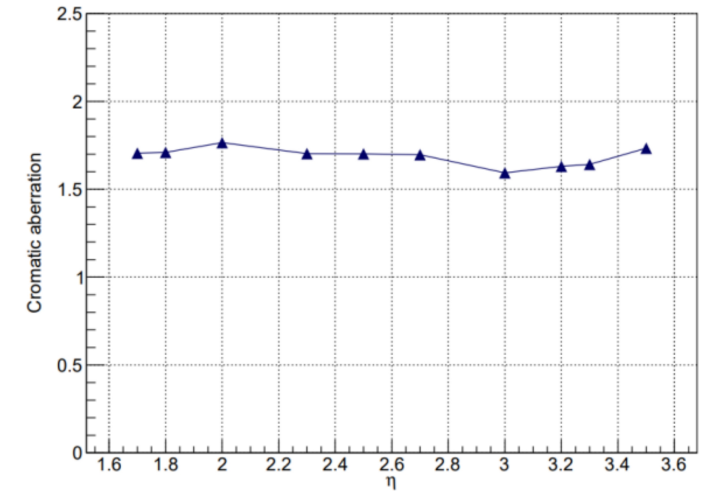
p=15 GeV/c, n=1.026 **fix**



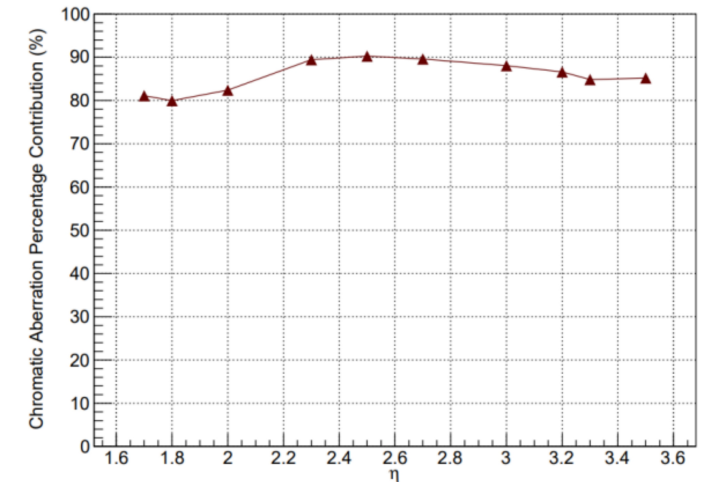
Studies by Luisa

Effect of acrylic filter will be studied.

Chromatic aberration vs  $\eta$ , p=15 GeV/c, n=1.026



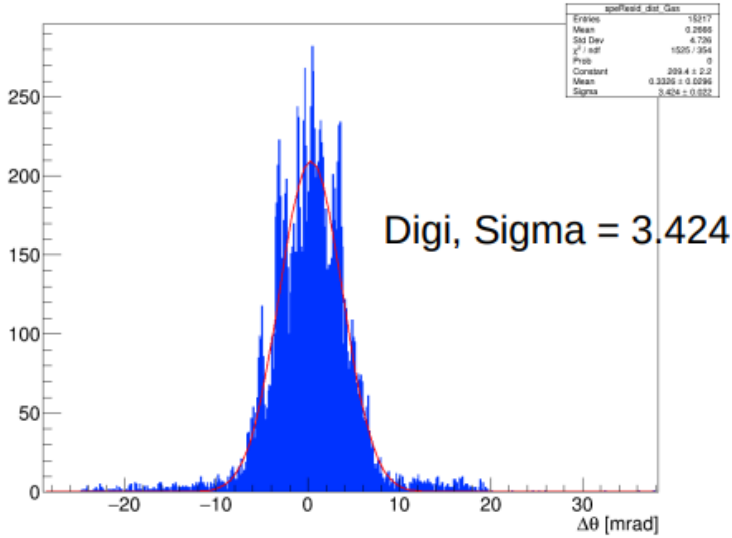
Chromatic Aberration Percentage Contribution vs  $\eta$ , p=15 GeV/c, n=1.026



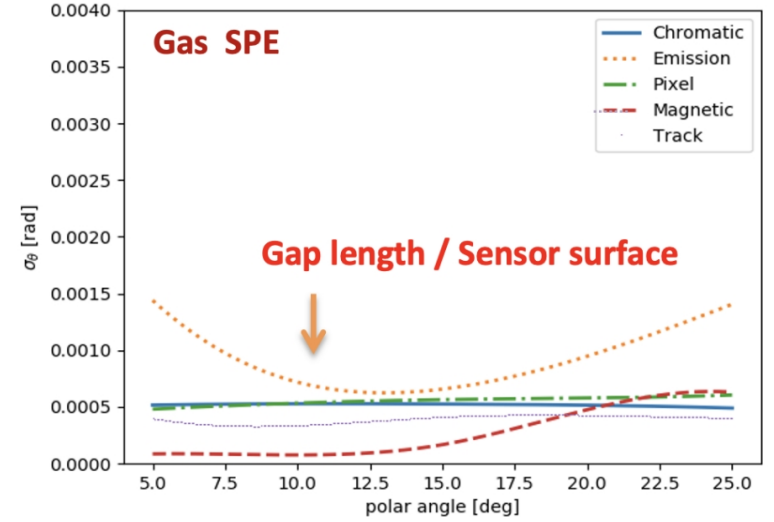
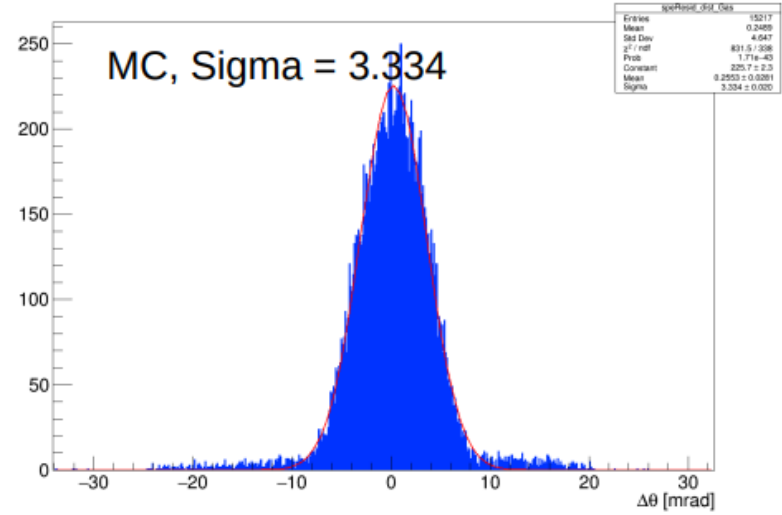


# Single photon resolution: Pixelization

Reconstructed SPE Cherenkov Angle Residual for Gas



Reconstructed SPE Cherenkov Angle Residual for Gas

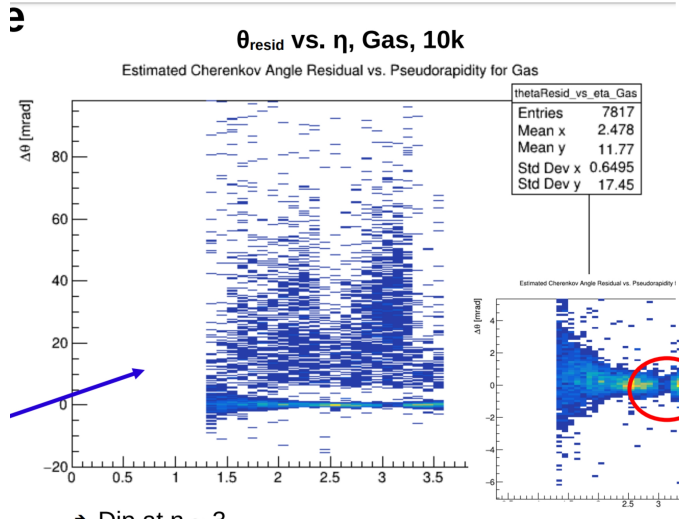


Pixel contribution: 0.78 mrad  $\sim$  0.00078 rad

Further studies will be made.

Seems compatible!

# Resolution



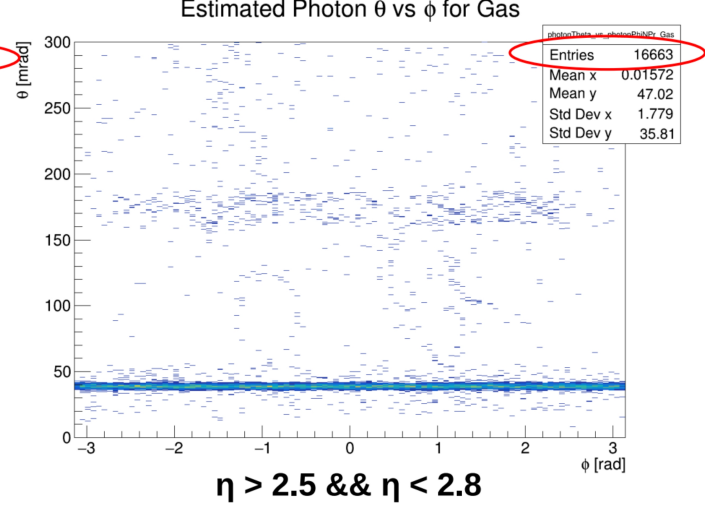
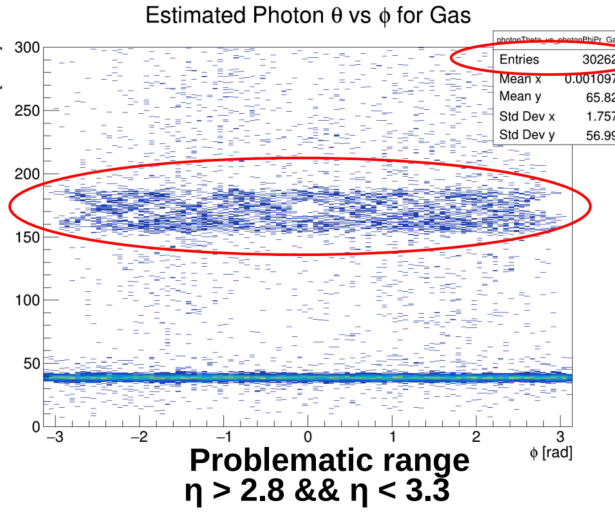
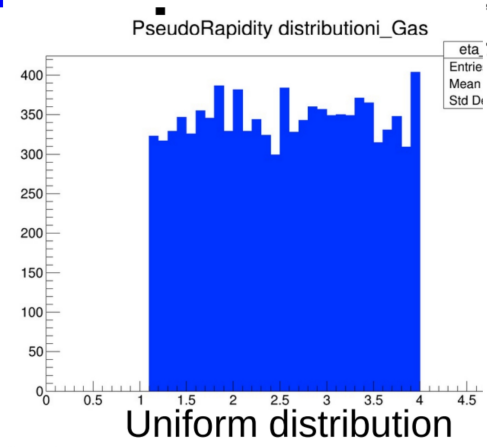
- Dip at  $\eta \sim 3$
- Events scattered at  $+\Delta\theta$  upto 100 mrad

## Before

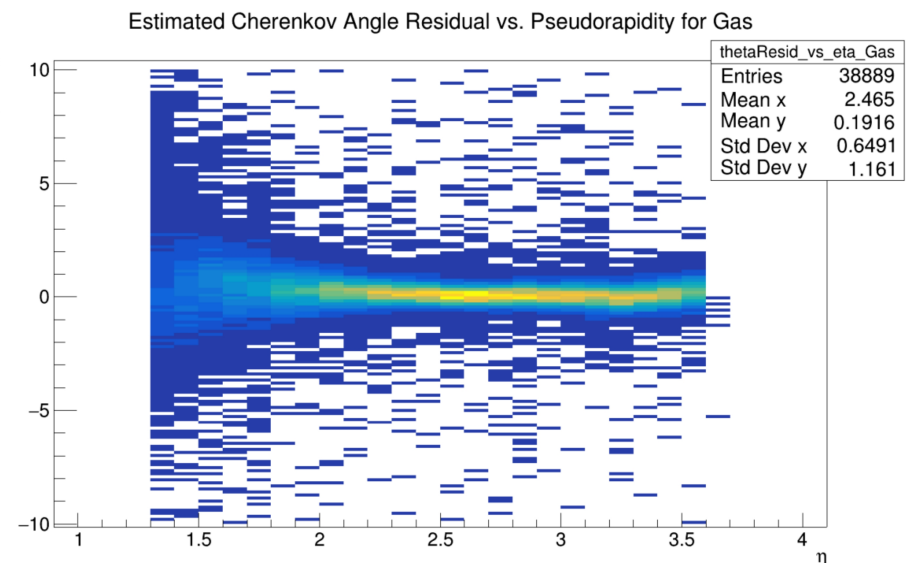
```
for(const auto& [theta,phi] : cherenkov_pid.getThetaPhiPhotons()){//UNCOMM
    theta_rec += theta;
}
theta_rec /= cherenkov_pid.getNpe(); -----> θRing
```

## After

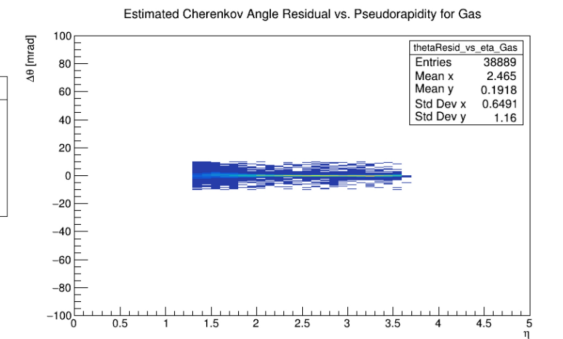
```
for(const auto& [theta,phi] : cherenkov_pid.getThetaPhiPhotons()){
    if(TMATH::Abs(theta-theta_exp)<0.010){ //modified, in rad
        theta_rec += theta;
        Npe++;
    }
    else theta_rec+=0;
}
theta_rec /= Npe; -----> θRing
```



## Studies by Jinky



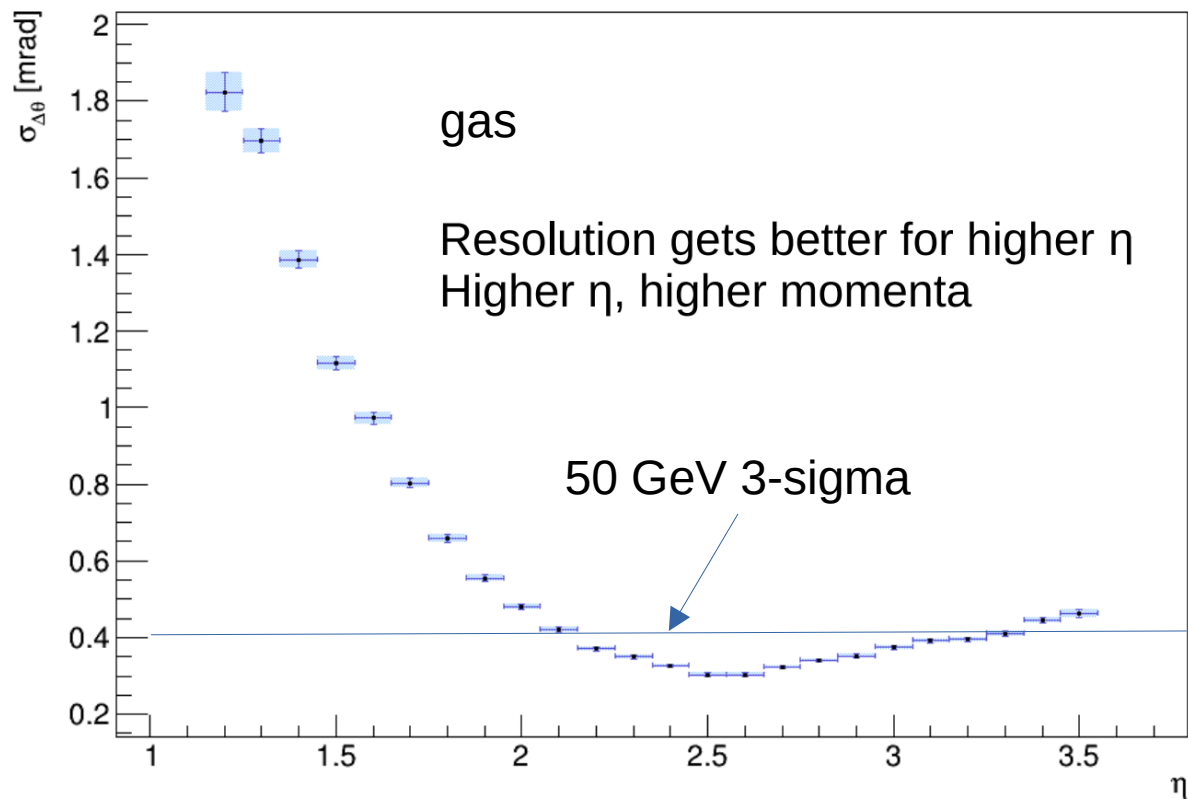
## Gas, 50k



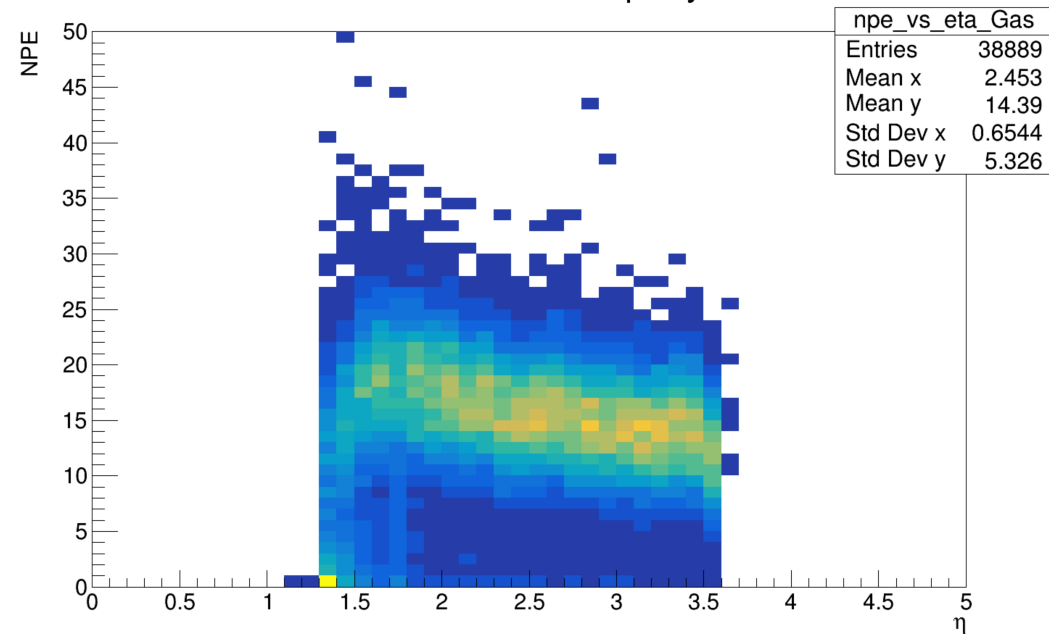
- Scatter plot of Cherenkov angle residual,  $\Delta\theta$  and  $\eta$
- $\Delta\theta = \theta_{resid} = (\theta_{Ring} - \theta_{exp})$
- $\Delta\theta$  broad for  $\eta < 1.8$

# Resolution

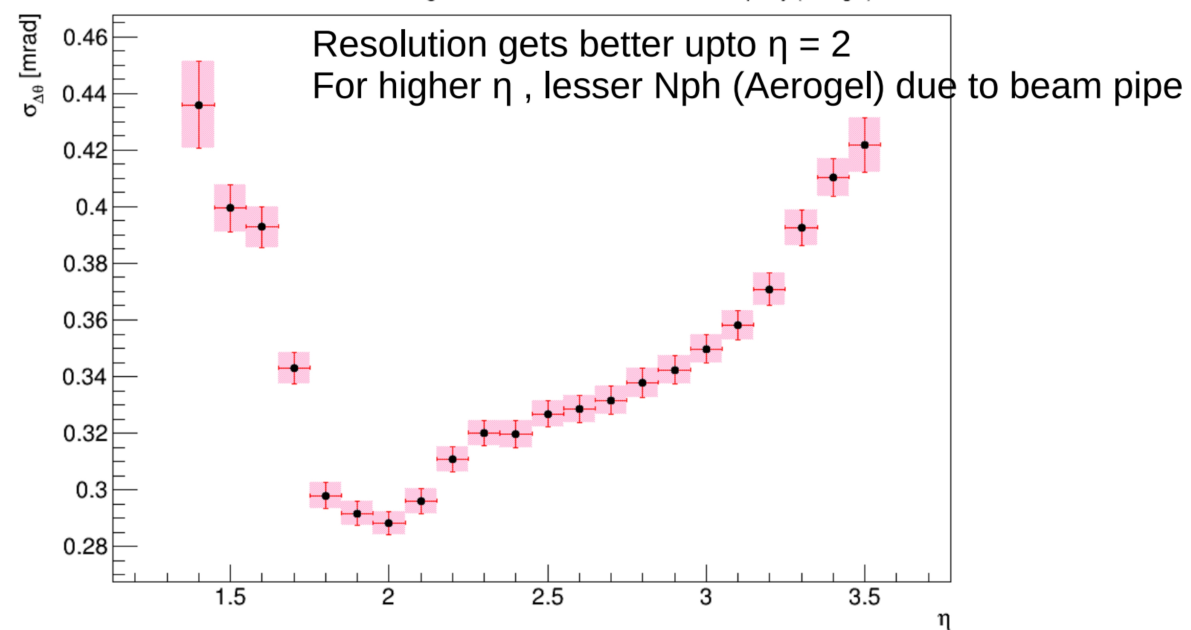
Studies by Jinky



Overall NPE vs. Pseudorapidity for Gas



Resolution of Cherenkov Angle Residual as a Funtion of Pseudorapidity (Aerogel)



# Summary

- 1) We are progressing with the simulation studies.
- 2) For the TDR we will update the plots soon.
- 3) We will soon start the IRT reconstruction updates.