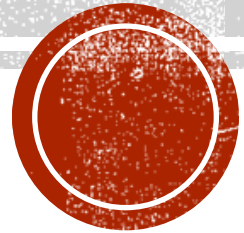
bHCAL Meeting – Neutron Calibration Update



Jan Vanek

University of New Hampshire

04/17/2026

OVERVIEW

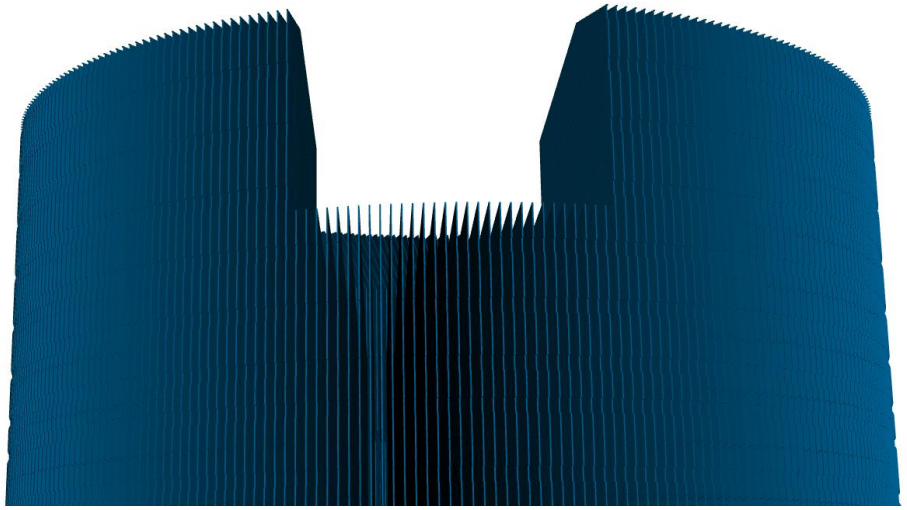
- Check of current bHCAL geometry
  - Checks based on recently observed tile shift in η vs. ϕ hit map

- Background studies status

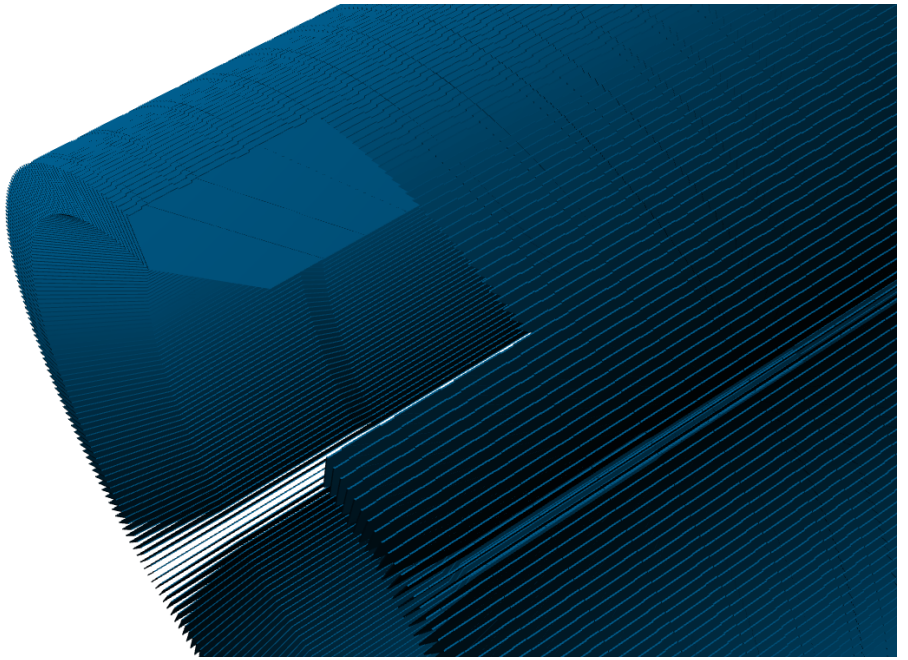
GEOMETRY CHECK

CHIMNEY TILES

- Checked geometry around removed chimney tiles

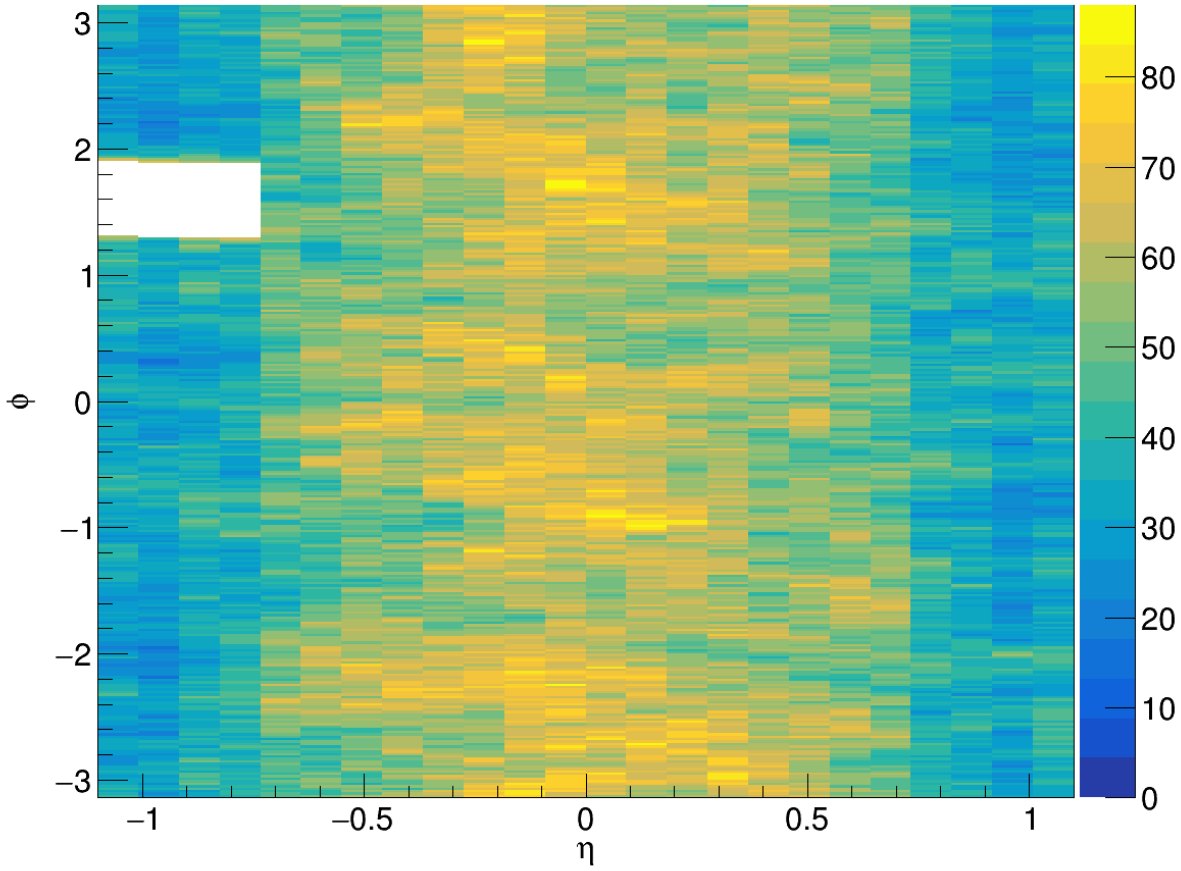


- Tiles at the edge of the chimney region are placed correctly

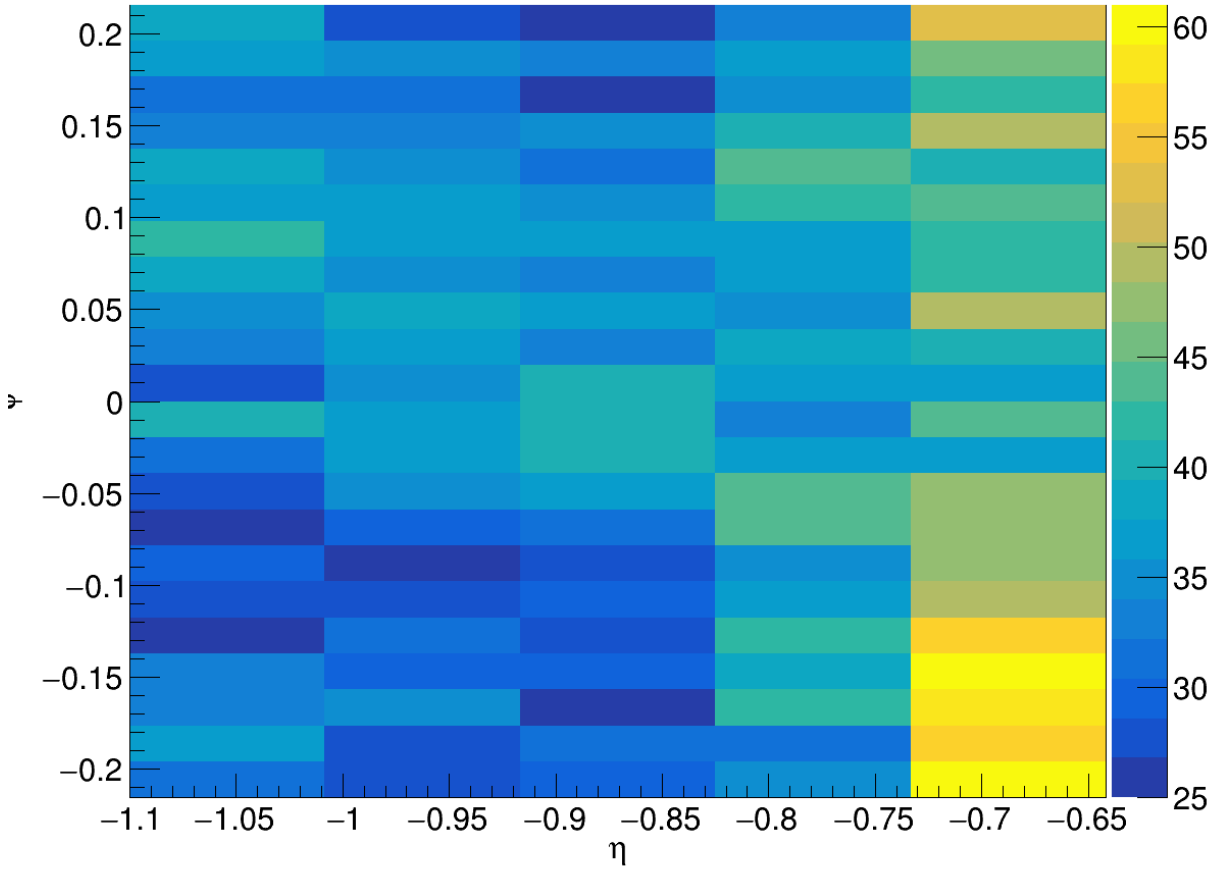


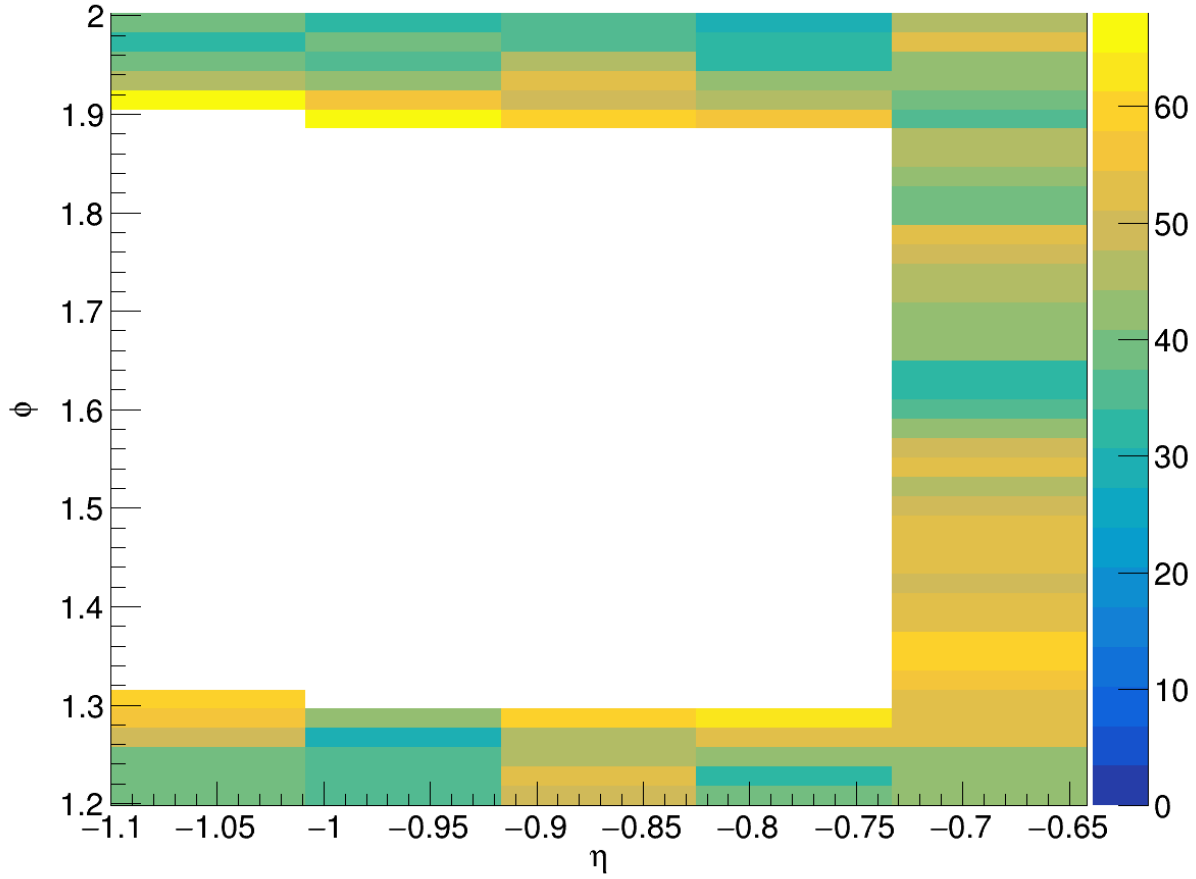
NEW η VS. ϕ MAP – DEFAULT BINS

- η vs. ϕ hit map in bHCAL
- Default binning
  - $-1.1 < \eta < 1.1$, 24 bins
  - $-\pi/2 < \phi < \pi/2$, 320 bins
- Two misplaced tiles near chimney region
- Possible causes:
  - Bins in ϕ are not centered at 0 where we expect a tile
  - Bin widths probably not quite right as we also have a tile exactly at $\phi = \pm\pi/2$



NEW η VS. ϕ MAP – DEFAULT BINS (DETAIL)



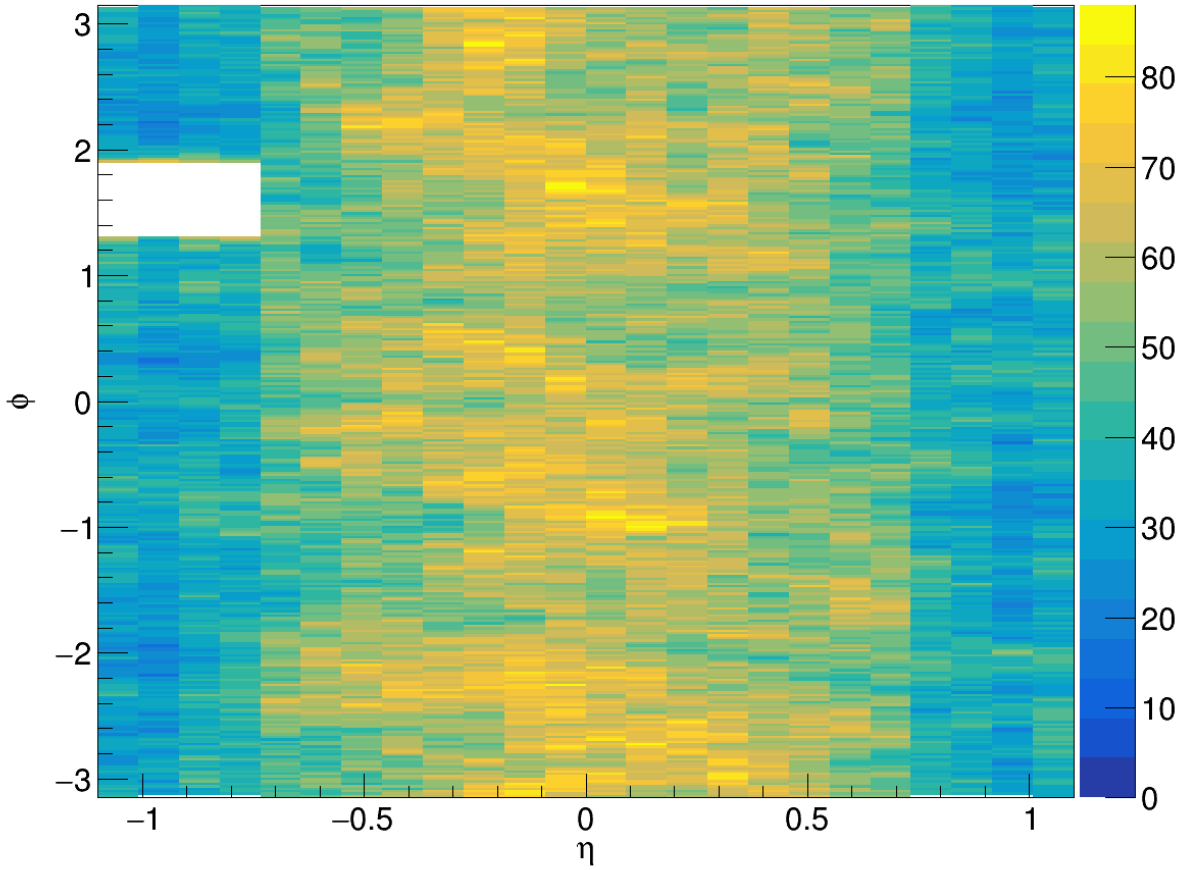


NEW η VS. ϕ MAP – NEW BINS

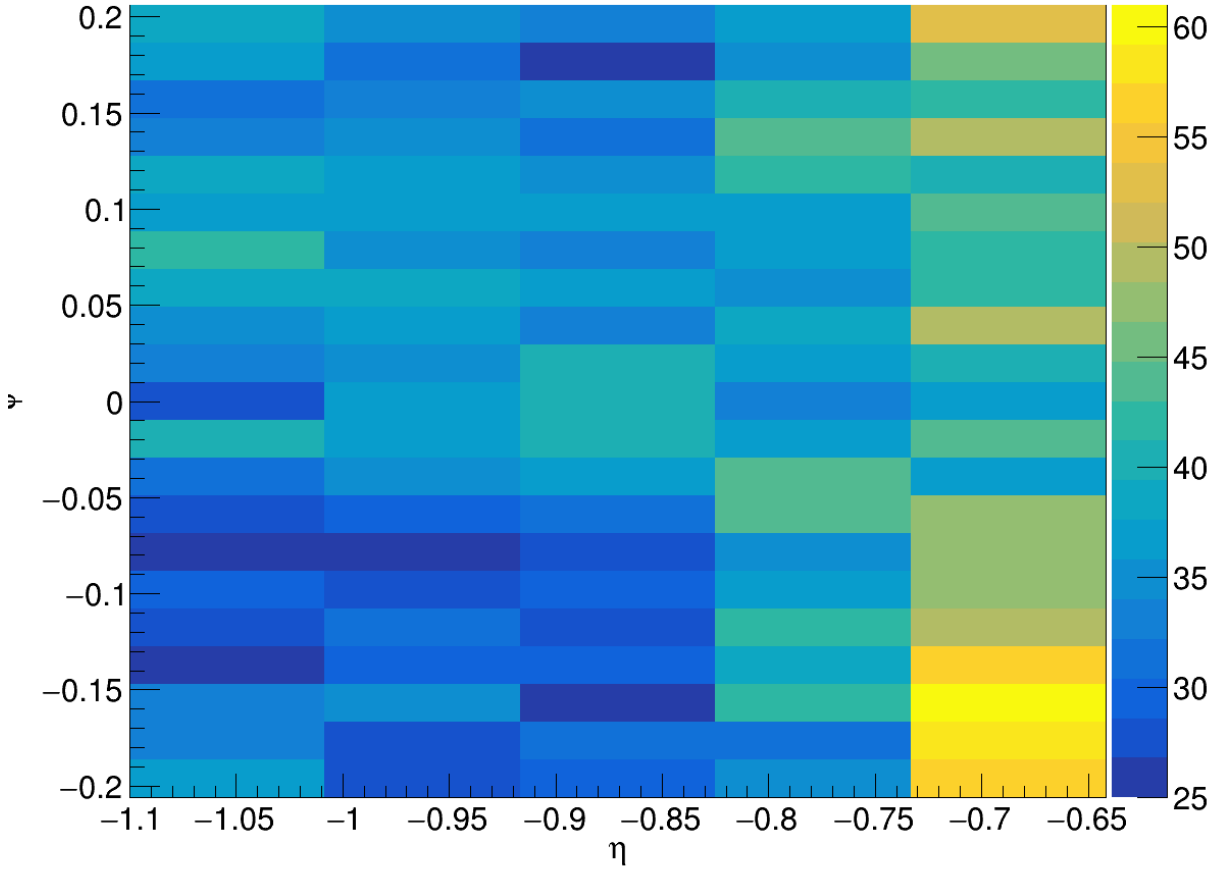
- η vs. ϕ hit map in bHCAL

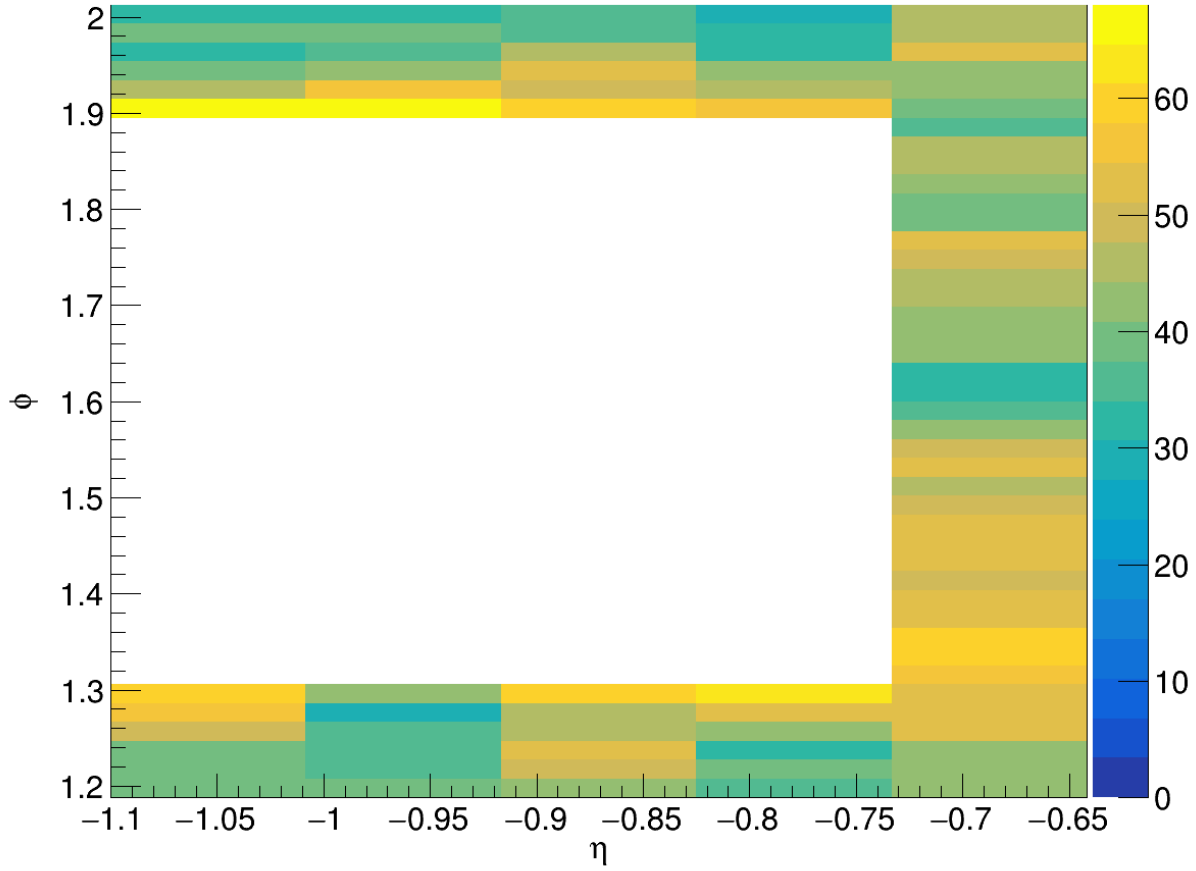
- **New binning**
  - $-1.1 < \eta < 1.1$, 24 bins
  - $-\pi/2 - \pi/320 < \phi < \pi/2 + \pi/320$, **321 bins**

- Features of new bins
  - Bins centered around $\phi = 0$
  - New full bin width bins at $\phi = \pm\pi/2$
    - The additional bin is to account for fluctuations of hit coordinate close to $\phi = \pm\pi/2$



NEW η VS. ϕ MAP – NEW BINS (DETAIL)

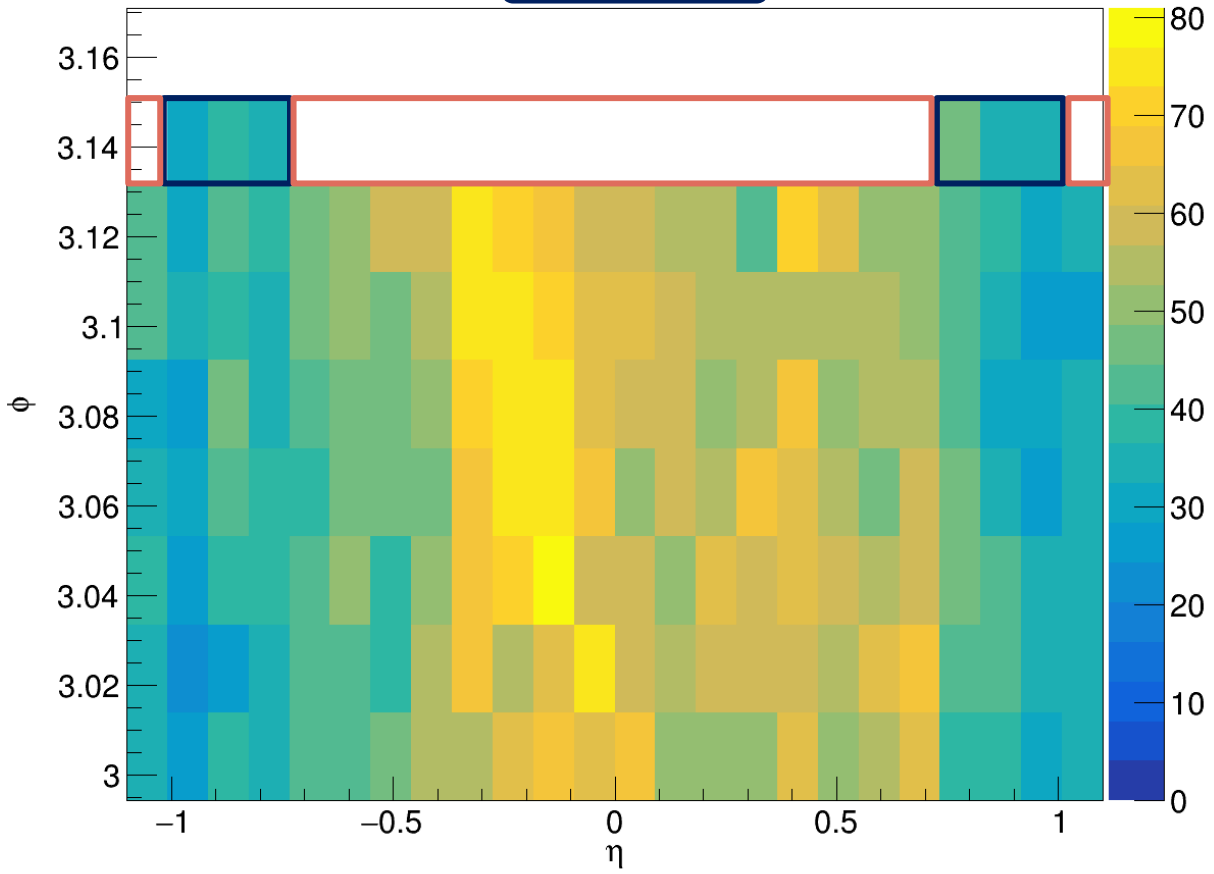




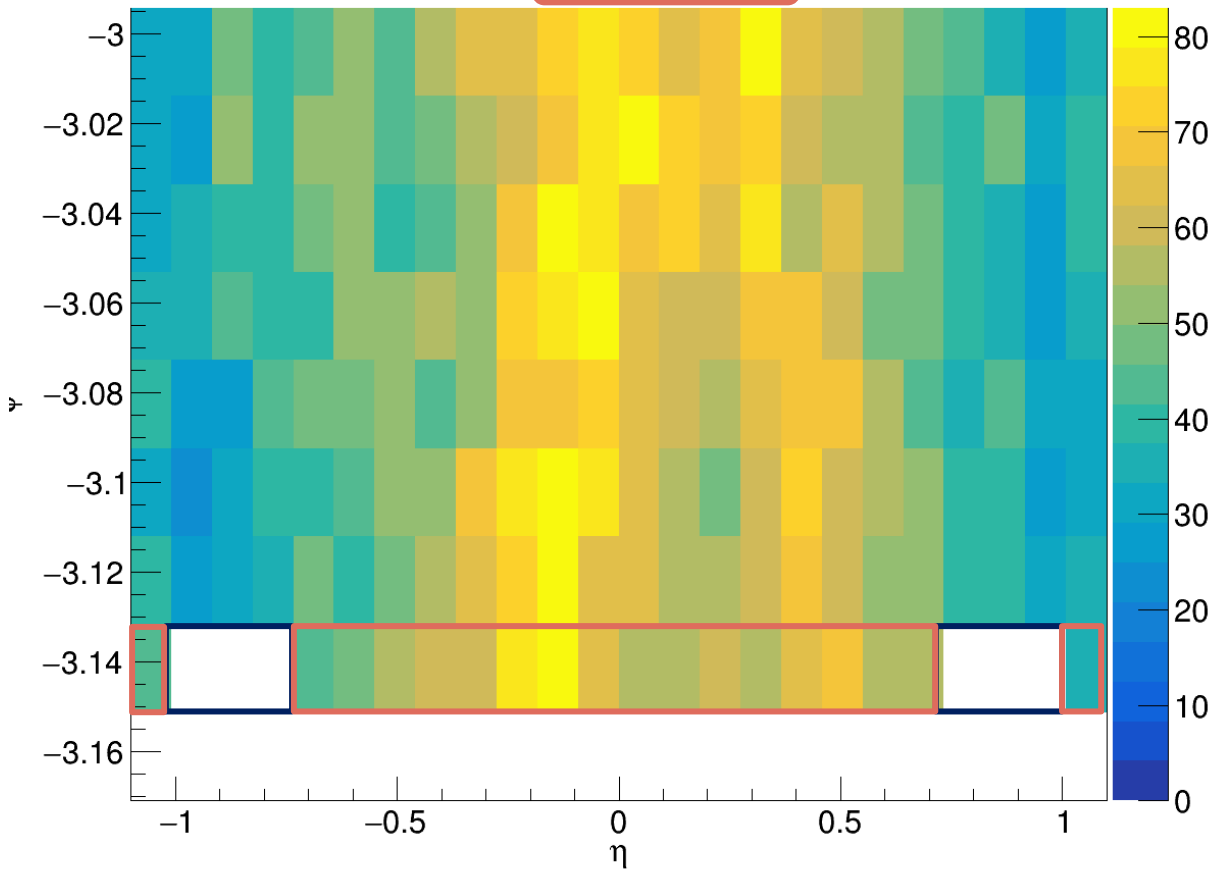
NEW η VS. ϕ MAP – NEW BINS (DETAIL 2)

Reconstructed hit position

$\phi = 3.14141$



$\phi = -3.13863$



GEOMETRY CHECK SUMMARY

- Everything seems to be OK with the current geometry
- Tile misplacement only due to binning which sometimes does not exactly match tile placement
  - Can cause hit migration between bins
- This should not be a major issue for bHCAL in simulations, just something to keep in mind

BACKGROUND STUDY

BACKGROUND OVERVIEW

- Using recommended central DIS production
  - 26.02.0, DIS, NC, $10\text{x}100\ \text{GeV}^2$, with and without background

- Efficiency vs. E (p) and η
  - First version implemented
  - Neutrons, protons, π^+

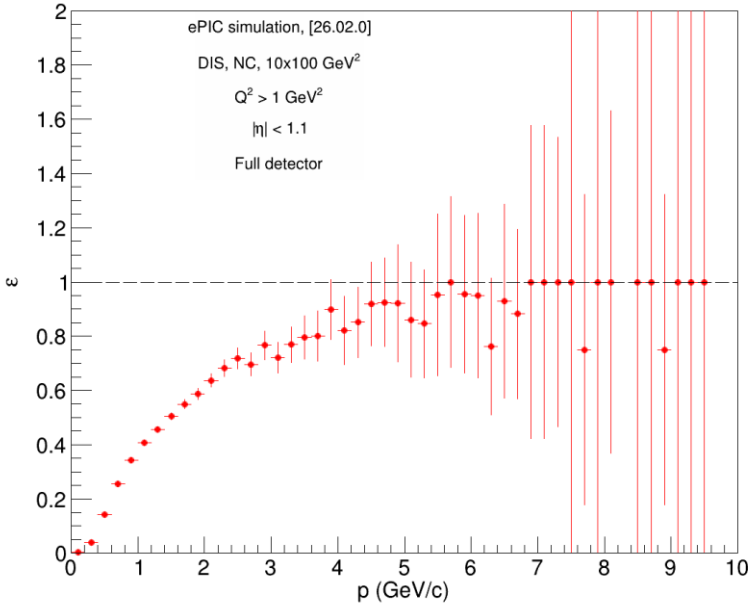
- Spatial resolution
  - First version implemented
  - Neutrons, protons, π^+

- Energy resolution vs. E and η
  - Same procedure as for single particle simulations but in bins of energy/momentum/η
  - To be implemented

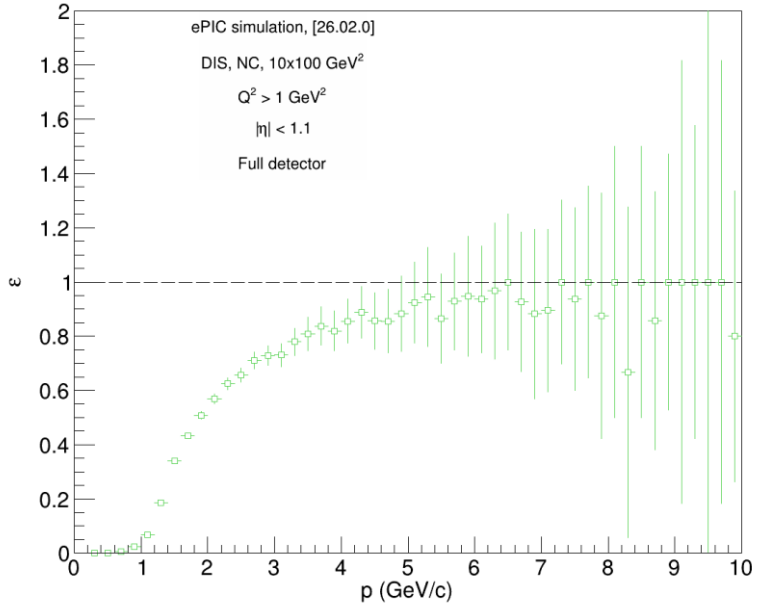
EFFICIENCY VS. p – NO BACKGROUND

- Efficiency vs. E (p) and η
  - Efficiency definition: $\varepsilon = \frac{N_{MC,bHCAL,match}}{N_{MC}}$
  - Particle selection:
    - $|\eta_{MC}| < 1.1$

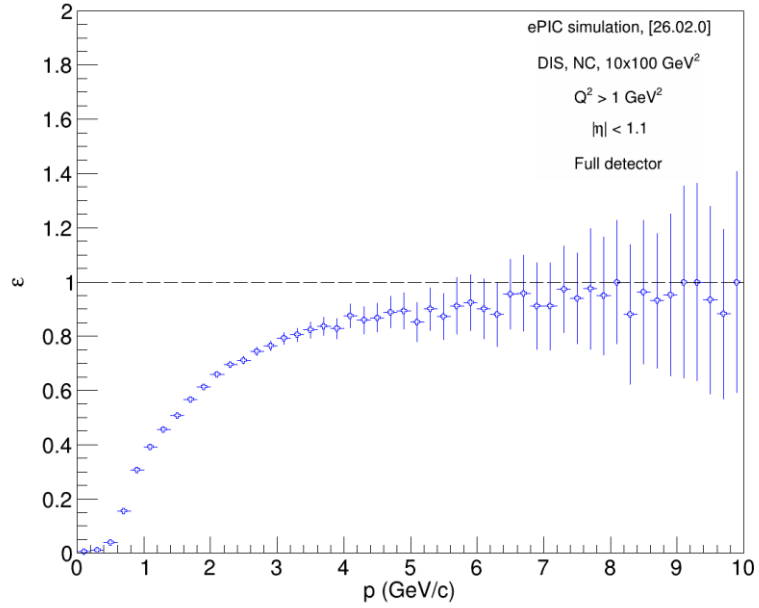
Neutron



Proton



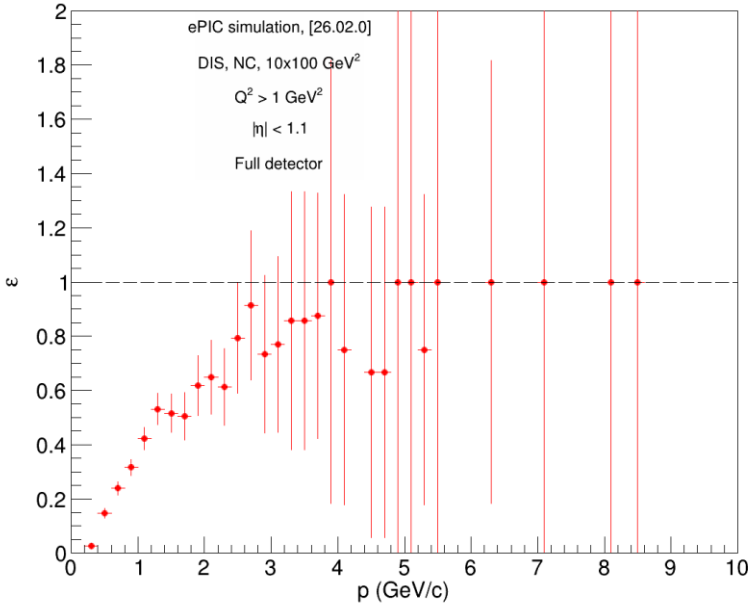
π^+



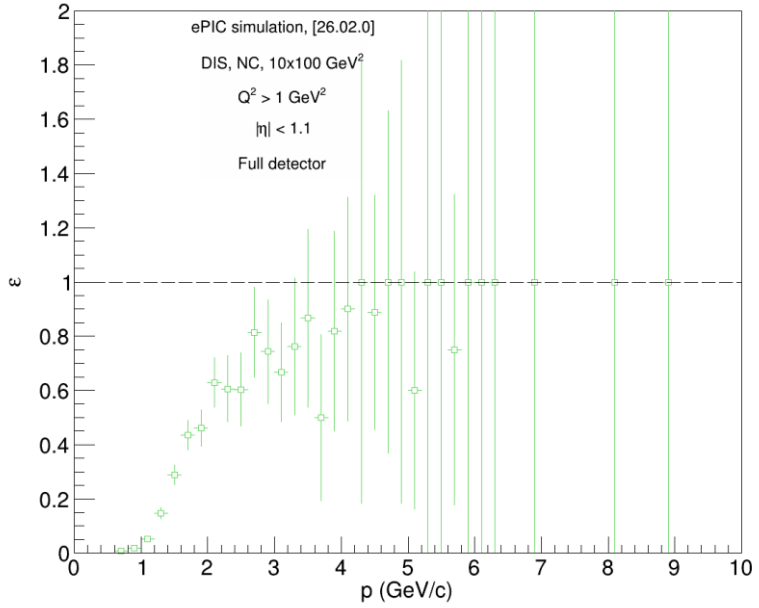
EFFICIENCY VS. p – WITH BACKGROUND

- Efficiency vs. E (p) and η
  - Efficiency definition: $\varepsilon = \frac{N_{MC,bHCAL,match}}{N_{MC}}$
  - Particle selection:
    - $|\eta_{MC}| < 1.1$

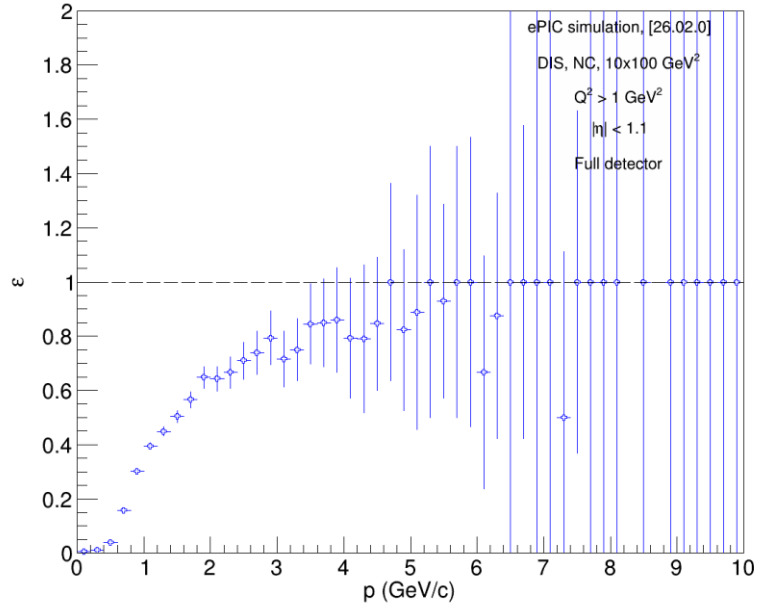
Neutron



Proton



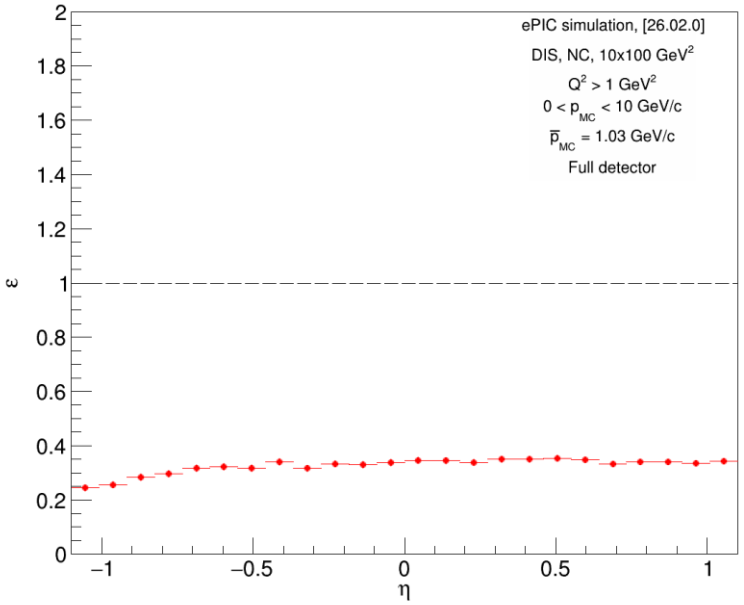
π^+



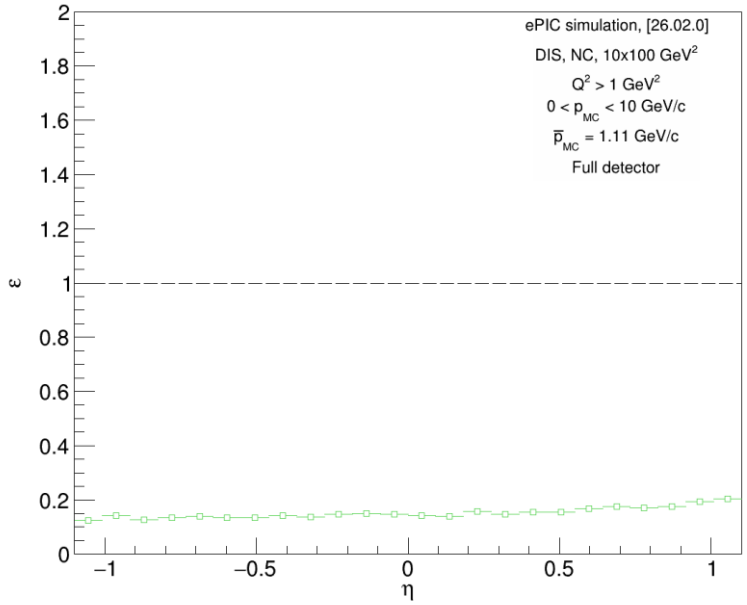
EFFICIENCY VS. η – NO BACKGROUND

- Efficiency vs. E (p) and η
  - Efficiency definition: $\varepsilon = \frac{N_{MC,bHCAL,match}}{N_{MC}}$
  - Particle selection:
    - $|\eta_{MC}| < 1.1$
    - **No cuts on p – This will/can be updated**

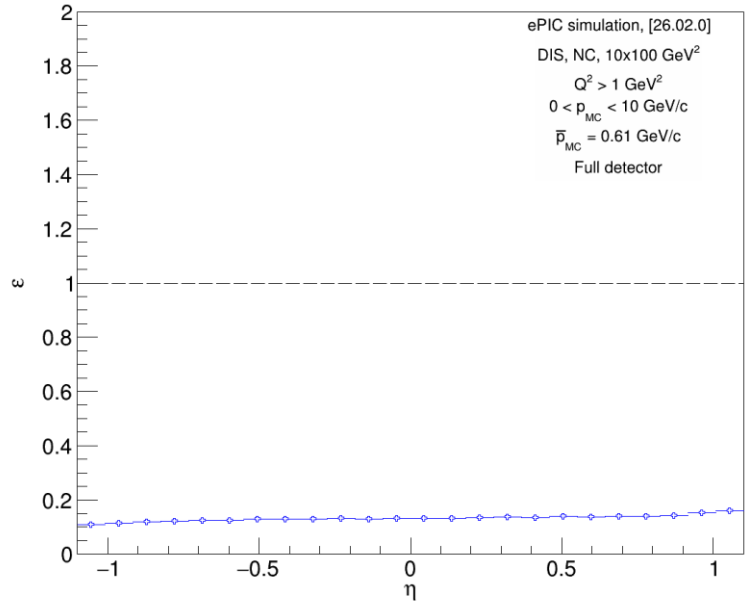
Neutron



Proton



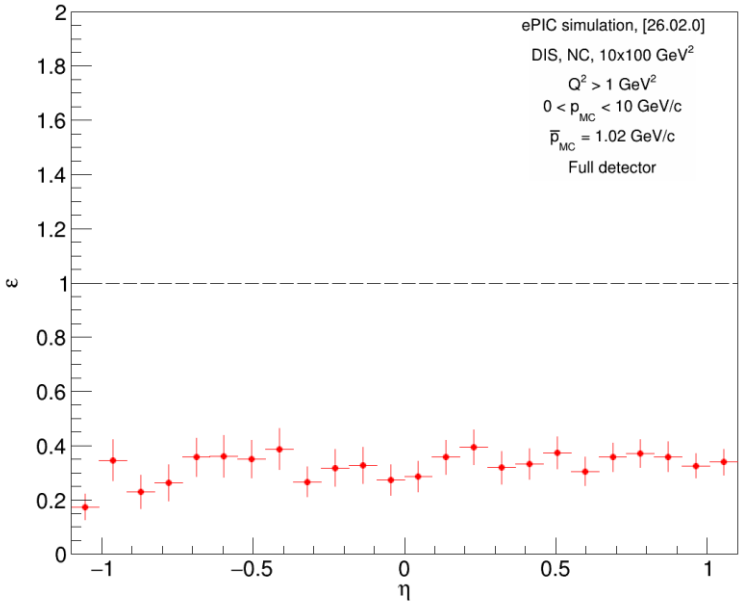
π^+



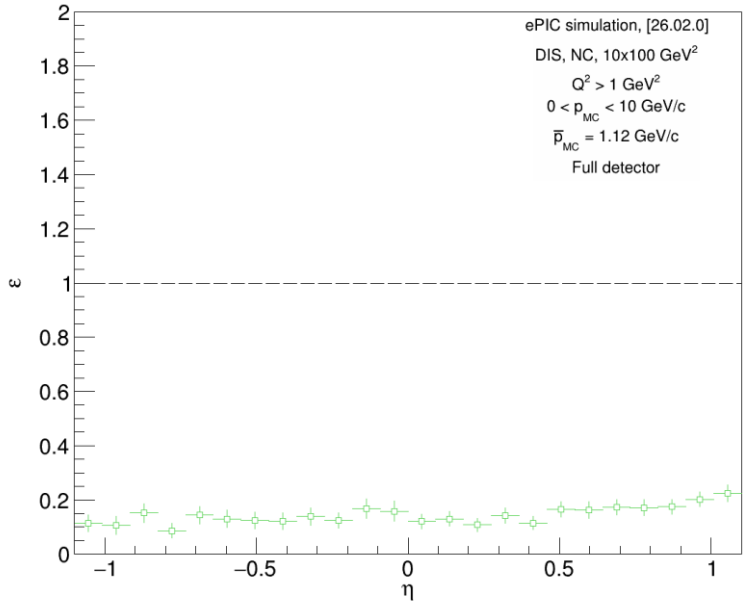
EFFICIENCY VS. η – WITH BACKGROUND

- Efficiency vs. E (p) and η
  - Efficiency definition: $\varepsilon = \frac{N_{MC,bHCAL,match}}{N_{MC}}$
  - Particle selection:
    - $|\eta_{MC}| < 1.1$

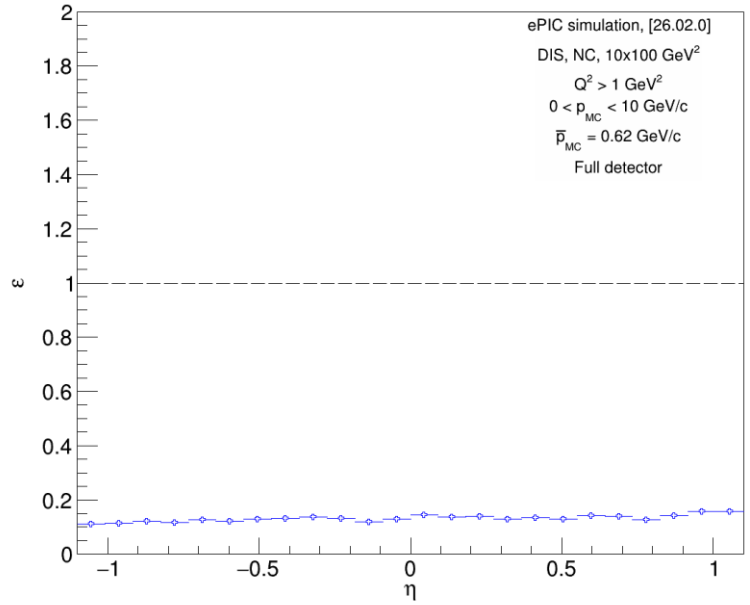
Neutron



Proton



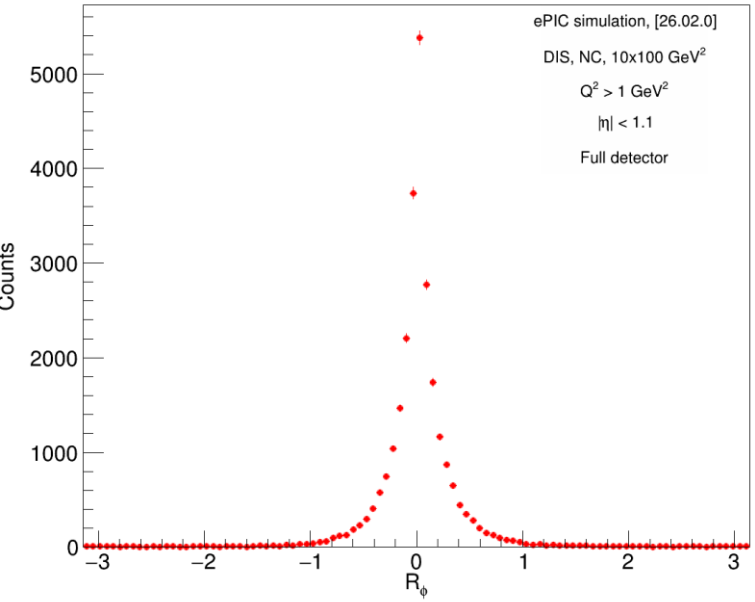
π^+



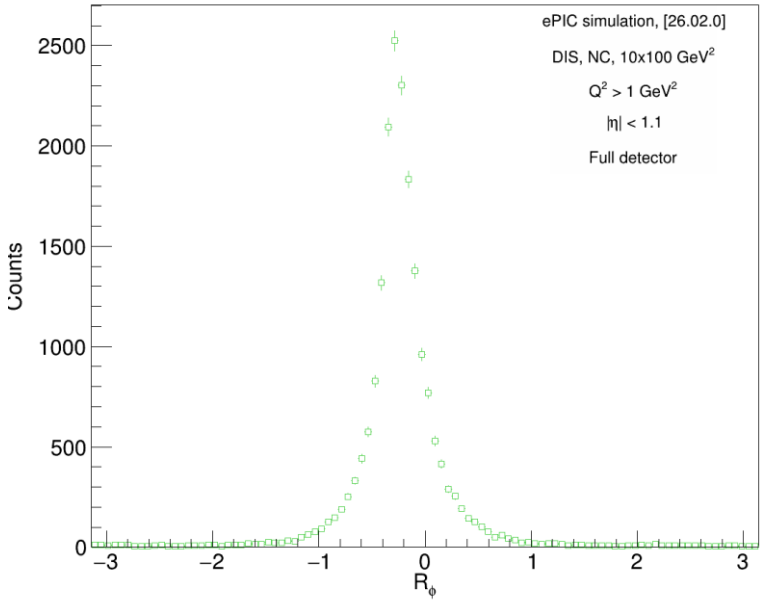
SPATIAL RESOLUTION (ϕ) – NO BACKGROUND

- ϕ resolution
  - First, rotated ϕ_{clust} by $-\phi_{MC}$ and get ϕ'_{clust}
    - Taking ϕ_{MC} as reference direction
  - $R_\phi = -\phi'_{clust}$
- Proton and π^+ mean offset due to charge (p_{MC} is at primary vertex, RC hit is at bHCAL)

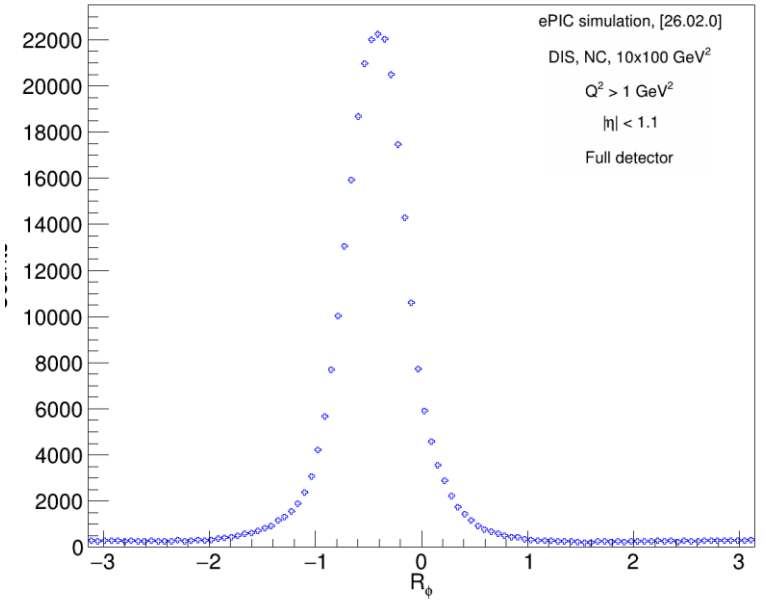
Neutron



Proton



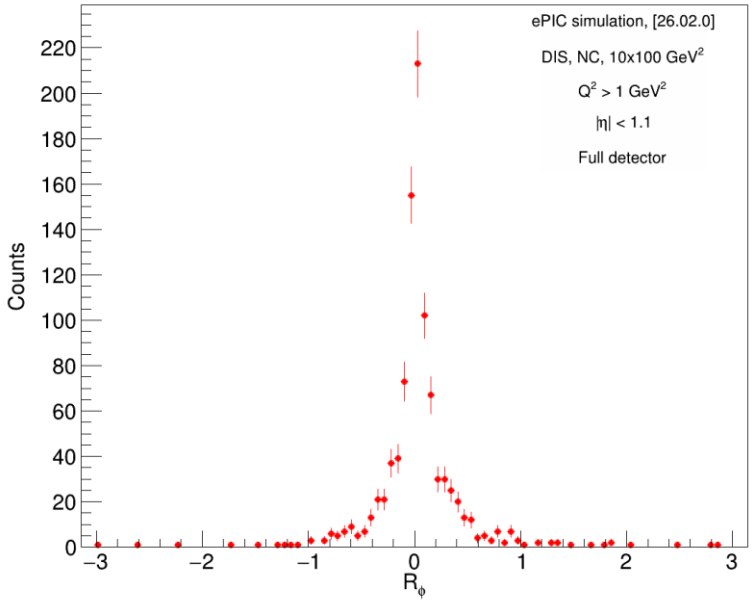
π^+



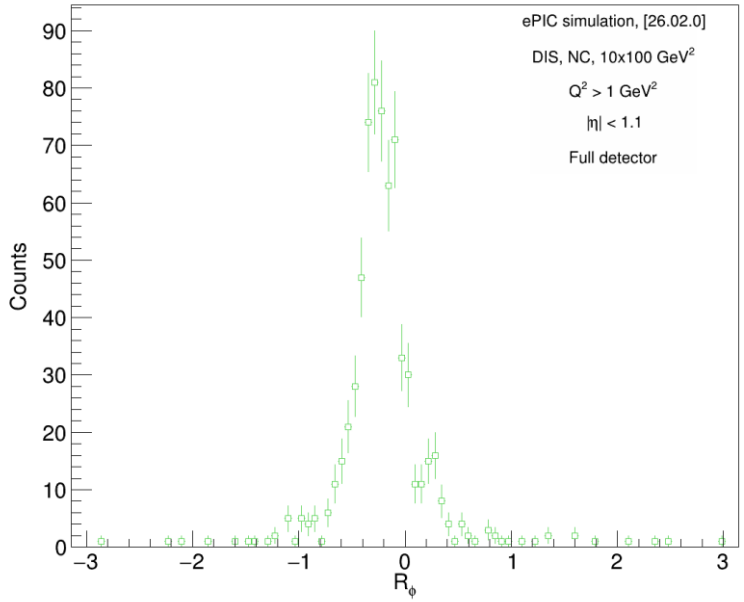
SPATIAL RESOLUTION (ϕ) – WITH BACKGROUND

- ϕ resolution
  - First, rotated ϕ_{clust} by $-\phi_{MC}$ and get ϕ'_{clust}
    - Taking ϕ_{MC} as reference direction
  - $R_\phi = -\phi'_{clust}$
- Proton and π^+ mean offset due to charge (p_{MC} is at primary vertex, RC hit is at bHCAL)

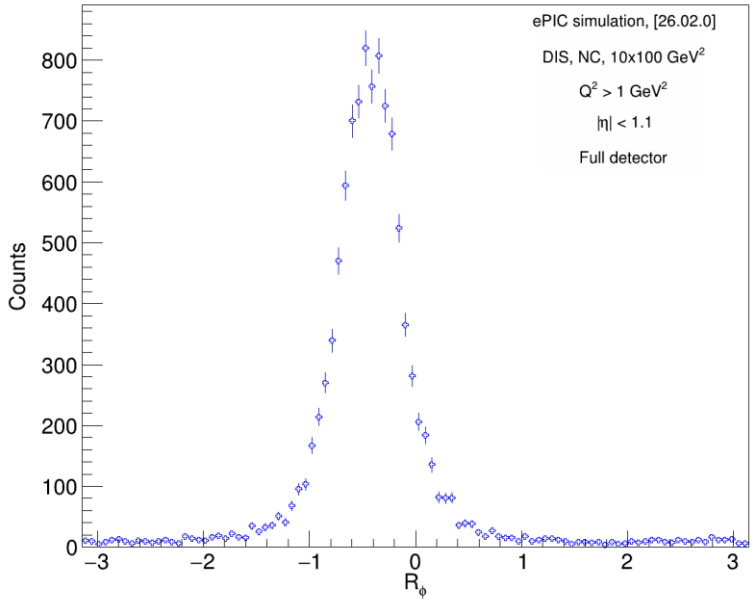
Neutron



Proton



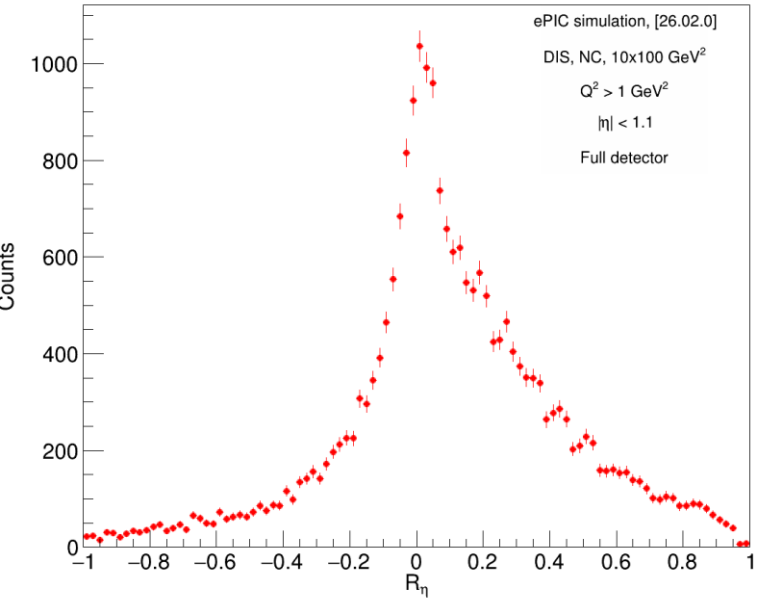
π^+



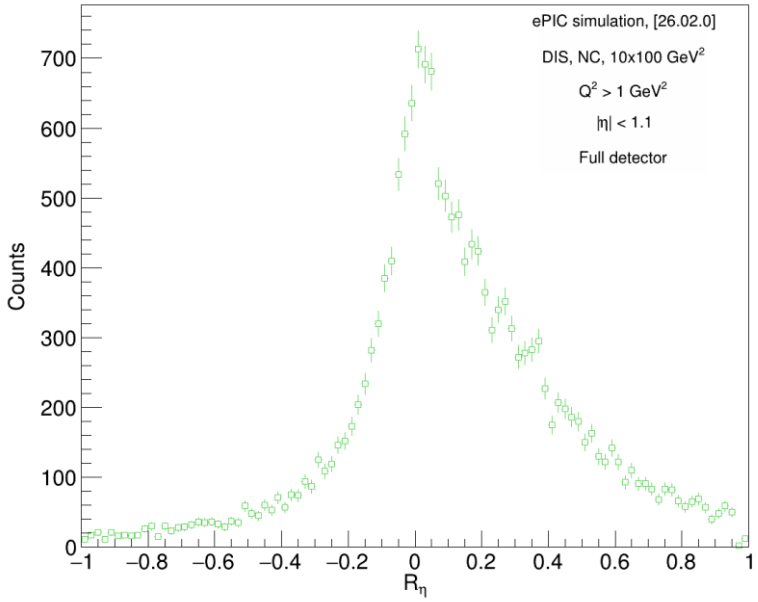
SPATIAL RESOLUTION (η) – NO BACKGROUND

- η resolution
  - $R_\eta = \frac{\eta_{MC} - \eta_{clust}}{\eta_{MC}}$

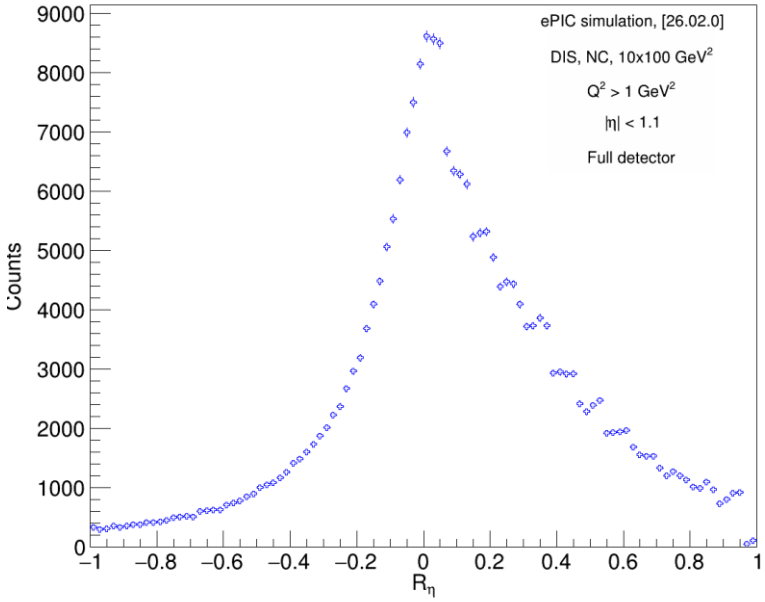
Neutron



Proton



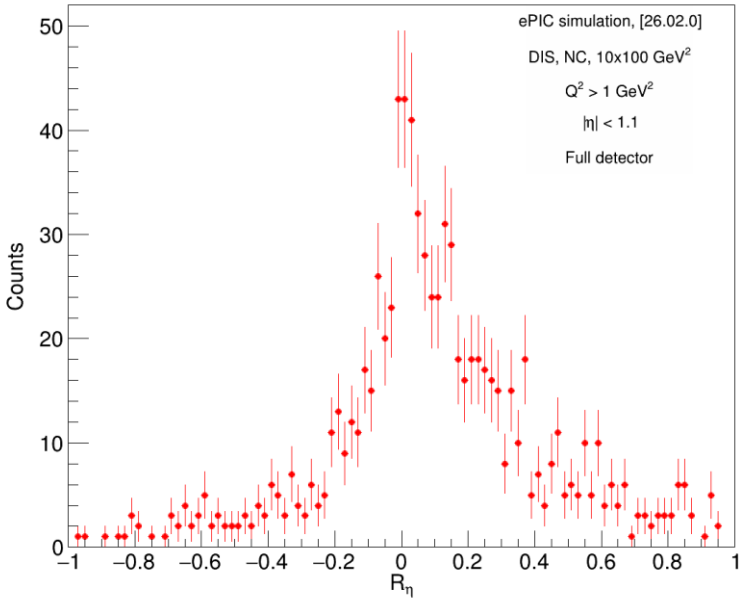
π^+



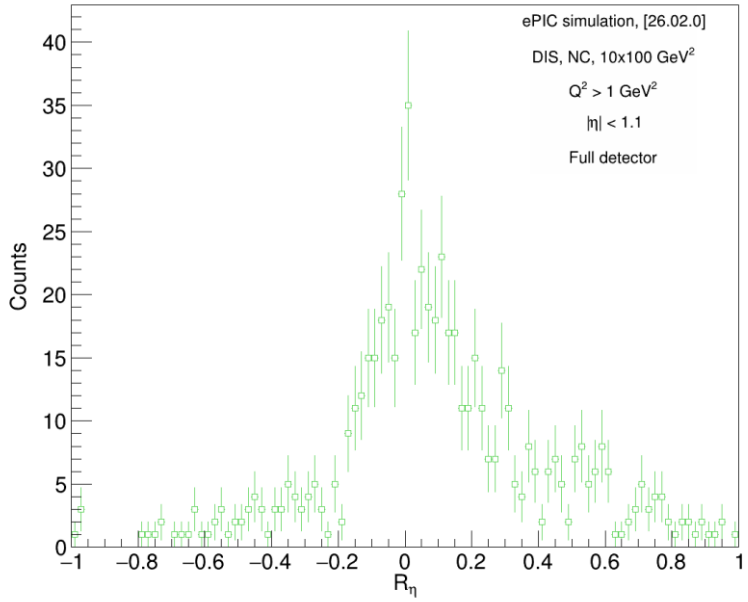
SPATIAL RESOLUTION (η) – WITH BACKGROUND

- η resolution
  - $R_\eta = \frac{\eta_{MC} - \eta_{clust}}{\eta_{MC}}$
- **No major differences within statistical precision for all distributions**
  - Background sample statistically limited

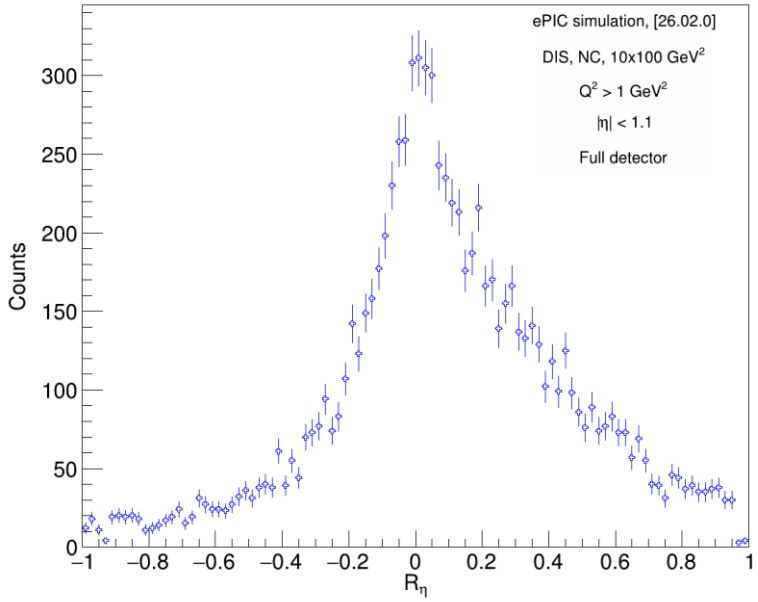
Neutron



Proton



π^+



SUMMARY

- Checked geometry for misplaced tiles
  - No issues found, observed mismatches caused only by ϕ binning of η vs. ϕ hit map
- No major differences between no background and background sample within statistical precision
  - Efficiency and spatial resolution
  - Background sample statistically limited
- Will add energy resolution to background study
  - Possibly more sensitive than efficiency and spatial resolution?

THANK YOU FOR ATTENTION