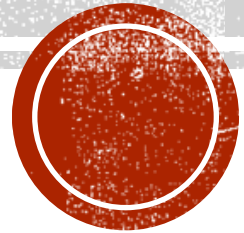
bHCAL Meeting – Acceptance Hole



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University of New Hampshire

10/17/2025

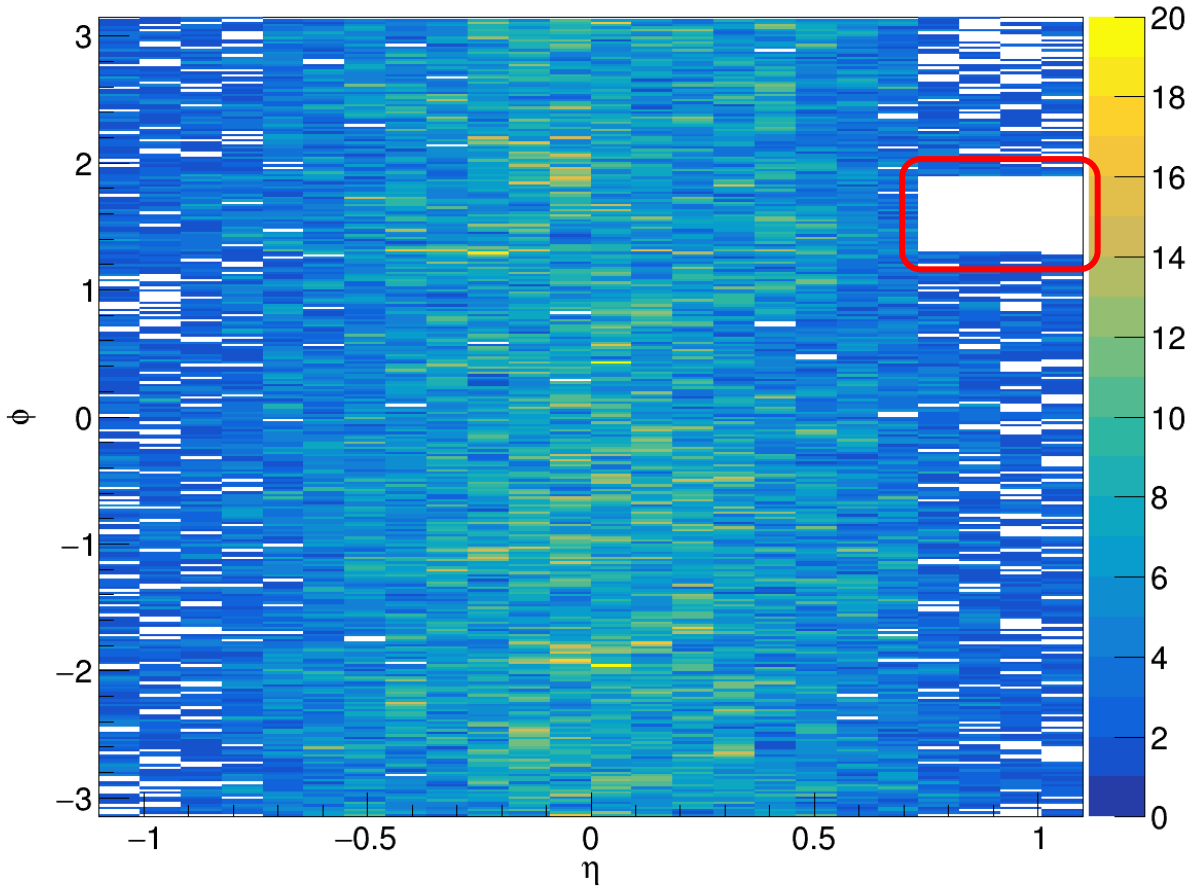
OVERVIEW

- Study to determine origin of hole in bHCAL acceptance in ePIC simulation framework

- Simulation setup:
  1. Simulate single particles using npsim and pass through ePIC
     - Generated 10k π^+ at 2 GeV for each simulation pass
     - Different kinematic distributions in η and ϕ (details in corresponding slides)
  2. Reconstruct using EICRecon
  3. Fill histograms

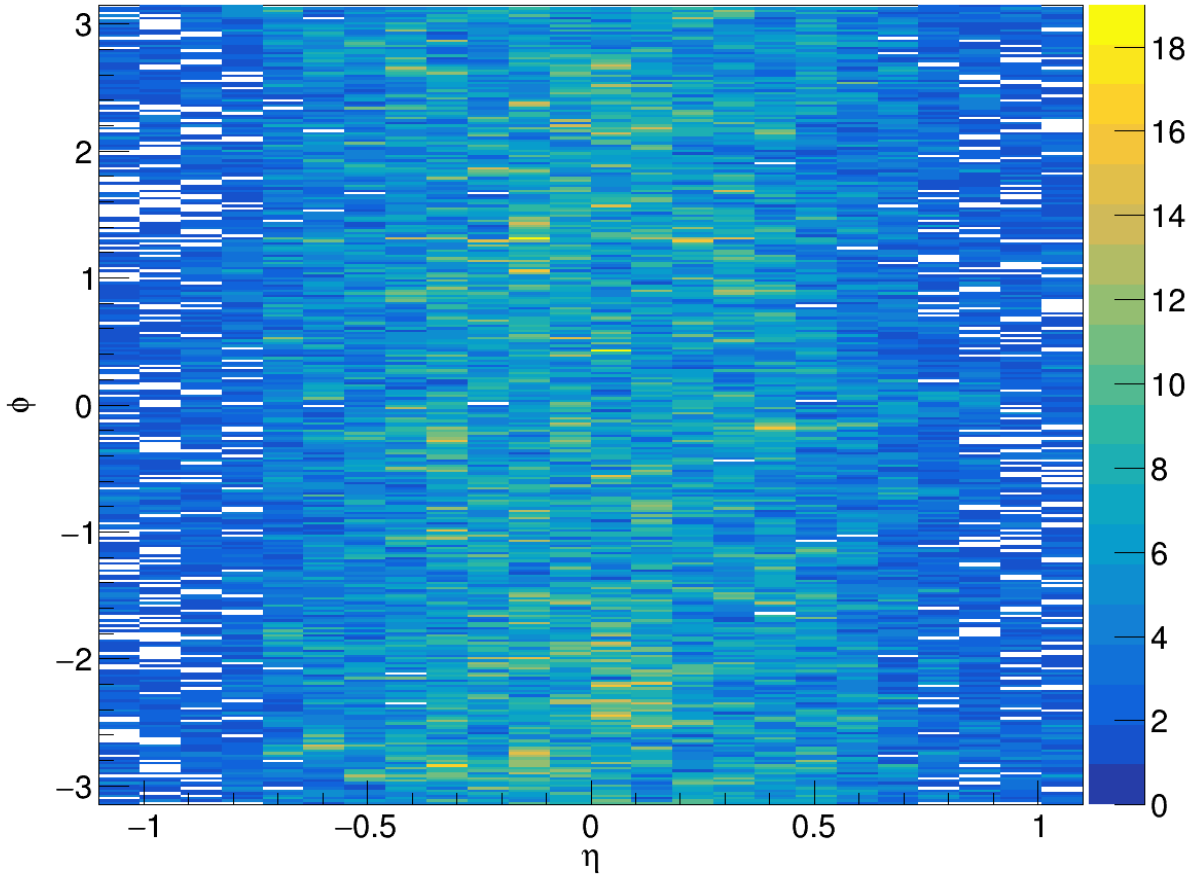
ORIGINAL GEOMETRY

- Old simulation with original geometry
- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - Uniform in ϕ
  - $\theta = (33.5, 146)$ deg, with $\cos\theta$ distribution
- (top) Full ePIC detector
- (bottom) bHCAL only
- With the acceptance hole



NEW GEOMETRY

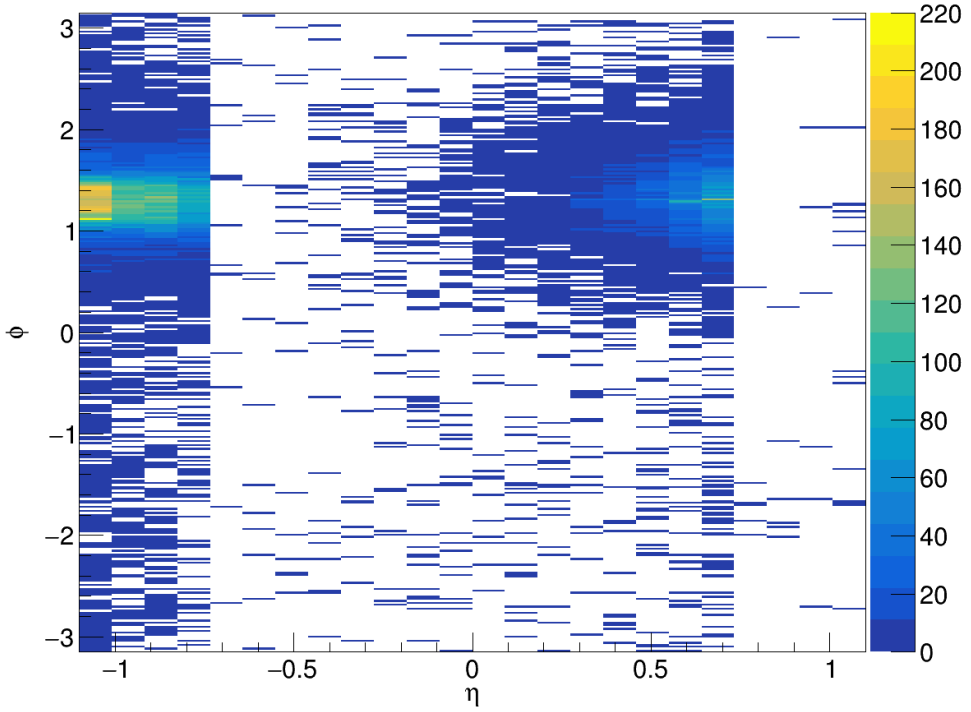
- New simulation with modified geometry
- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - Uniform in ϕ
  - $\theta = (33.5, 146)$ deg, with $\cos\theta$ distribution
- (top) Full ePIC detector
- (bottom) bHCAL only
- **No acceptance hole**



ACCEPTANCE SCAN 1 – OLD

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - $\phi = (1.35, 1.80)$ rad, **uniform**
  - $\eta = (0.8, 1.1)$, **uniform**



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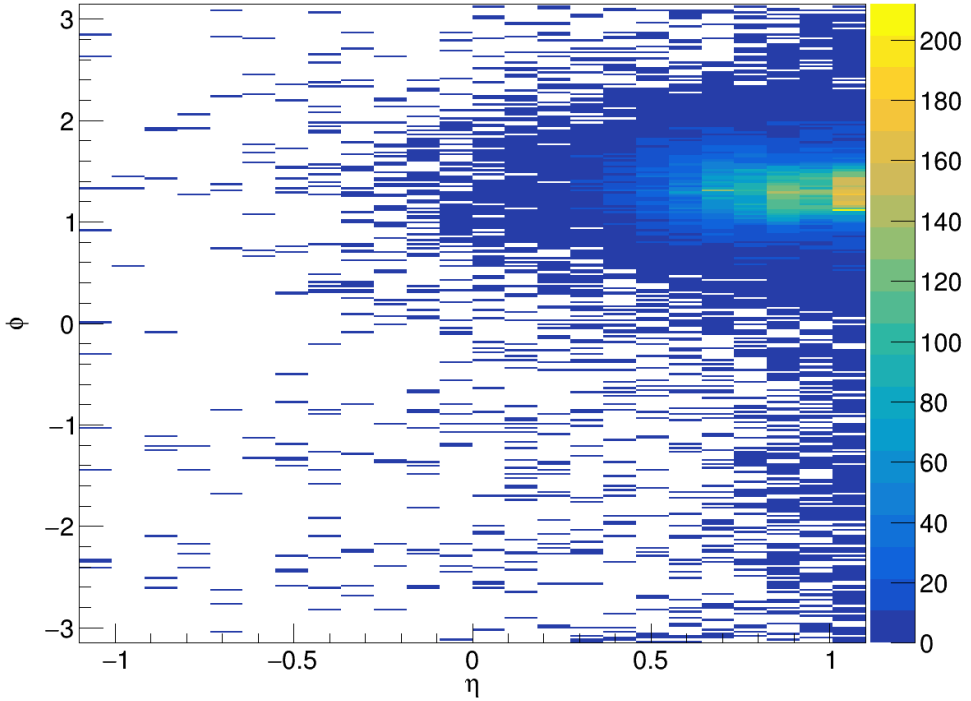
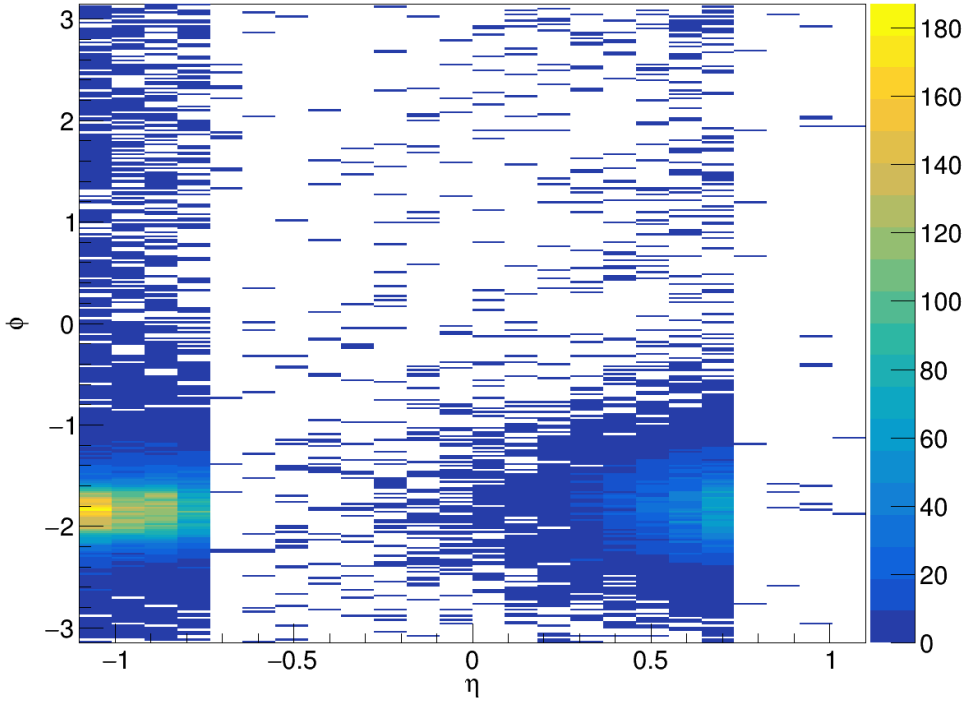


ACCEPTANCE SCAN 2 – OLD

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - $\phi = (-1.80, -1.35)$ rad, **uniform**
  - $\eta = (0.8, 1.1)$, **uniform**



ACCEPTANCE SCAN 2 – NEW

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
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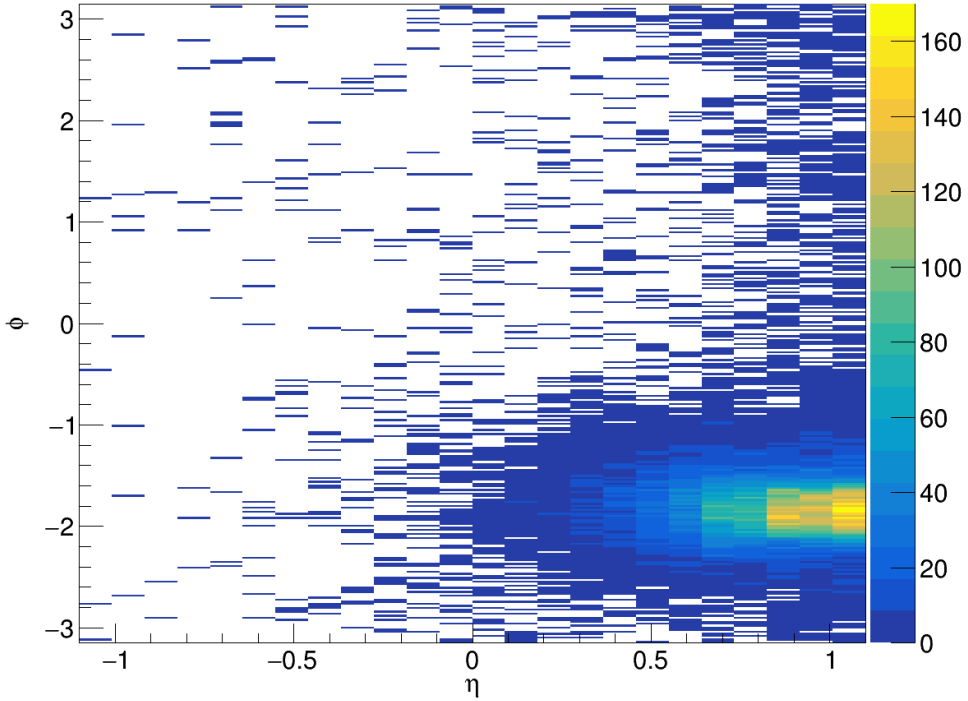
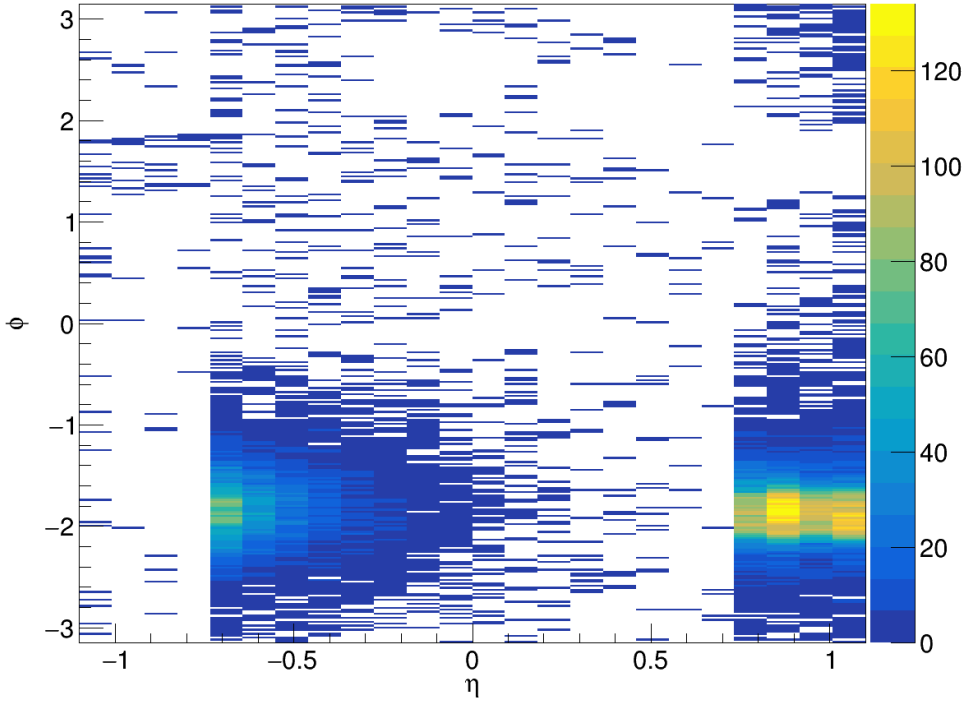


ACCEPTANCE SCAN 3 – OLD

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - $\phi = (-1.80, -1.35)$ rad, **uniform**
  - $\eta = (-1.1, -0.8)$, **uniform**



ACCEPTANCE SCAN 3 – NEW

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
  - π^+ at 2 GeV (10k)
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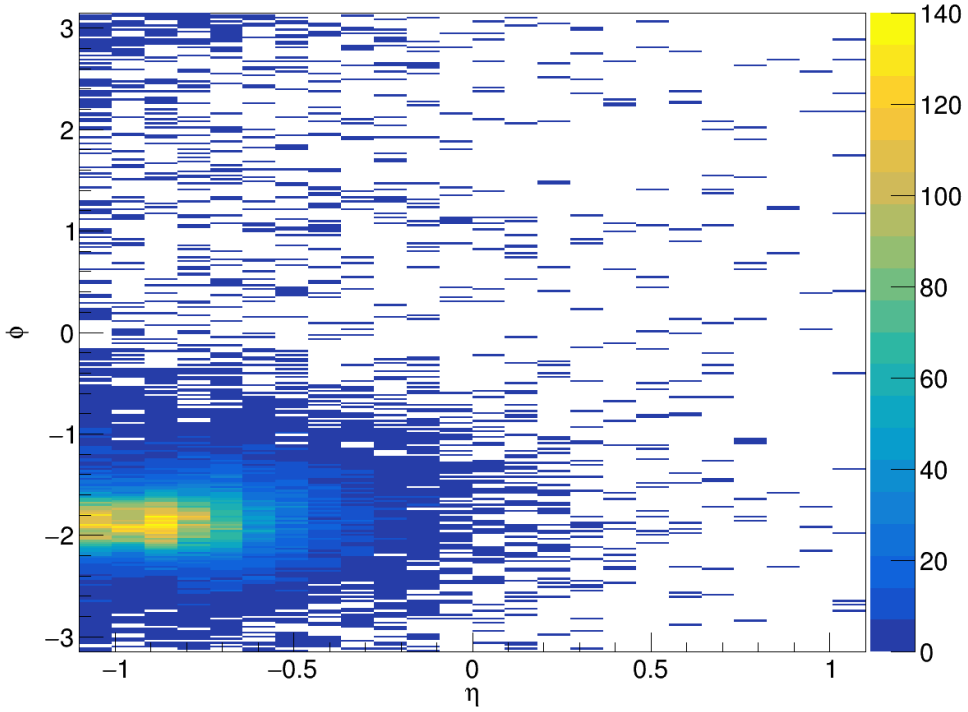

ACCEPTANCE SCAN 4 – OLD

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window

- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - $\phi = (1.35, 1.80)$ rad, **uniform**
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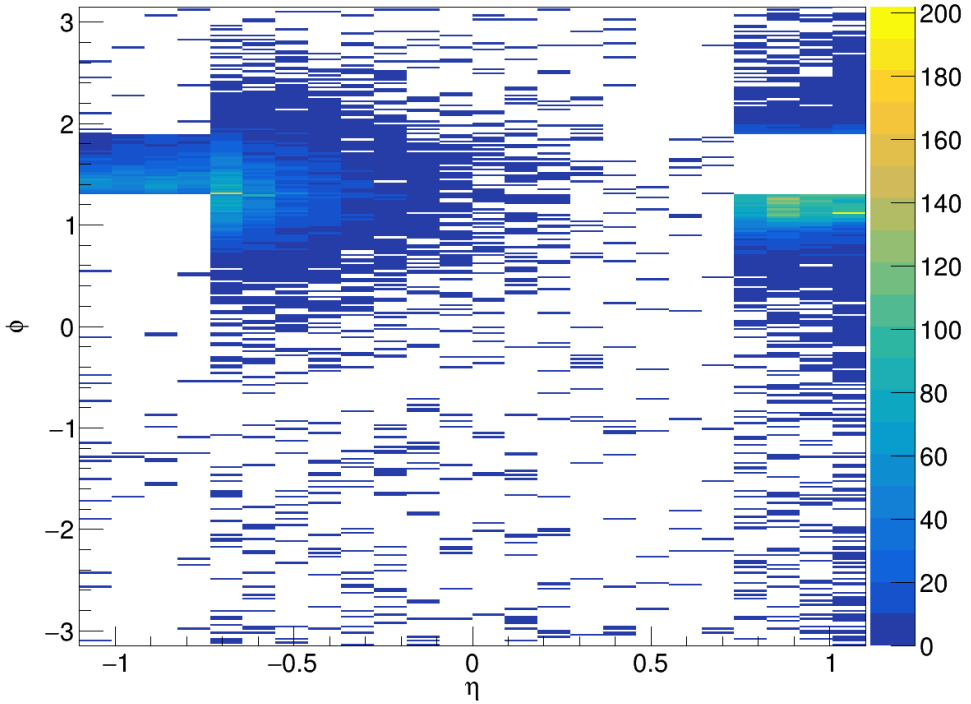

ACCEPTANCE SCAN 4 – NEW

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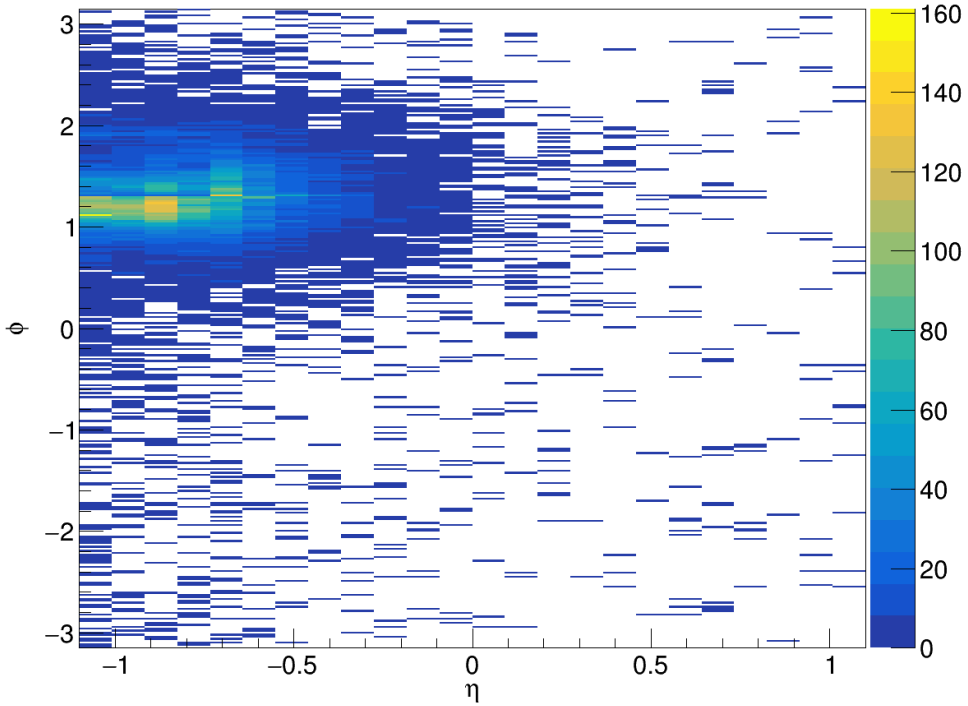
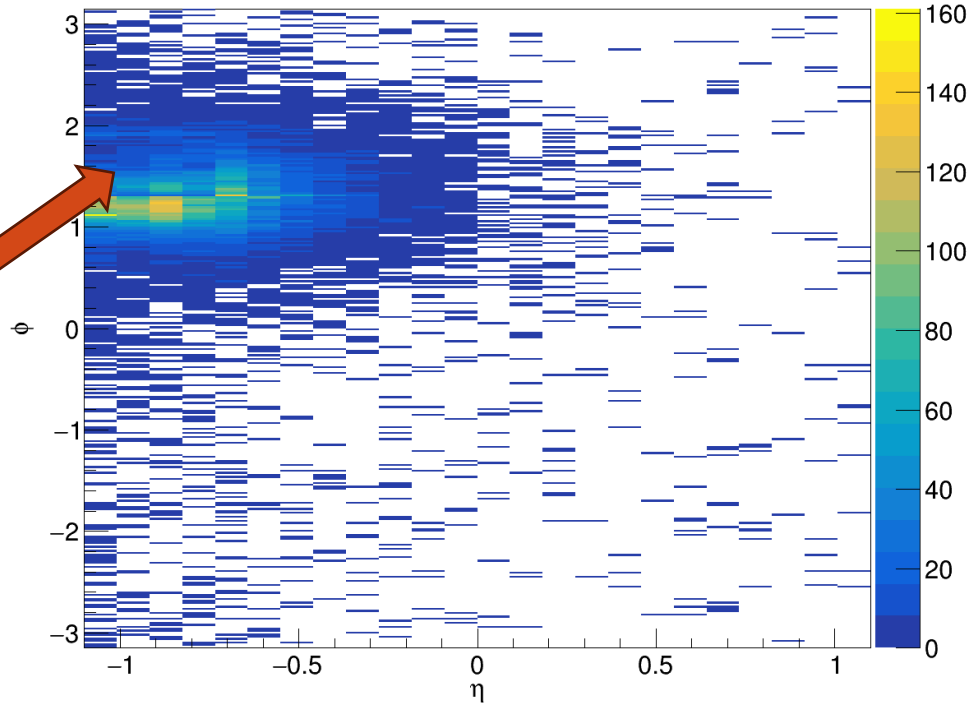


ACCEPTANCE SCAN 4 – NEW

- Test simulation scanning bHCAL acceptance
  - Shooting π^+ to a window about the size of the hole
  - Changing position of the window
- Particle gun setup:
  - π^+ at 2 GeV (10k)
  - $\phi = (1.35, 1.80)$ rad, uniform
  - $\eta = (-1.1, -0.8)$, uniform
- Chimney tiles visible
  - They are physically smaller than regular tiles – smaller reconstructed signal



CHANGES TO GEOMETRY

- The issue with the misplaced η hits was identified to be caused by different default tile position in the gdml files for Tiles 09-12 (4 outer η rings) than for Tiles 01-08 (central η rings) and Chimney Tiles
  - Tiles 01-08 and Chimney Tiles
    - Default position is close to center of the coordinate system
  - Tiles 09-12 (original)
    - Default position is far in negative x

Tile08_reduced.gdml

```
<?xml version='1.0' encoding='us-ascii'?>
<gdml xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://service-spi.web.ce
  <define>
  <position name="Mesh2Tess_0" unit="mm" x="-1668.665+1852.807861328125" y="-426.824+808.344482421875" z="-3.5" />
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```

Tile09_reduced.gdml (original)

```
<?xml version='1.0' encoding='us-ascii'?>
<gdml xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://service-spi.web.cern
  <define>
  <position name="Mesh2Tess_0" unit="mm" x="-1980.199+-2413.33154296875" y="-482.037+808.344482421875" z="-3.5" />
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  <position name="Mesh2Tess_6" unit="mm" x="-1980.199+-1795.8123779296875" y="-482.037+123.9625015258789" z="-3.5" />
  <position name="Mesh2Tess_7" unit="mm" x="-1980.199+-1795.8123779296875" y="-482.037+123.9625015258789" z="3.5" />
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  <position name="Mesh2Tess_13" unit="mm" x="-1980.199+-2149.891845703125" y="-482.037+799.2944946289062" z="3.5" />
  <position name="Mesh2Tess_14" unit="mm" x="-1980.199+-2221.36181640625" y="-482.037+799.2944946289062" z="3.5" />
  <position name="Mesh2Tess_15" unit="mm" x="-1980.199+-2149.891845703125" y="-482.037+808.344482421875" z="-3.5" />
  </define>
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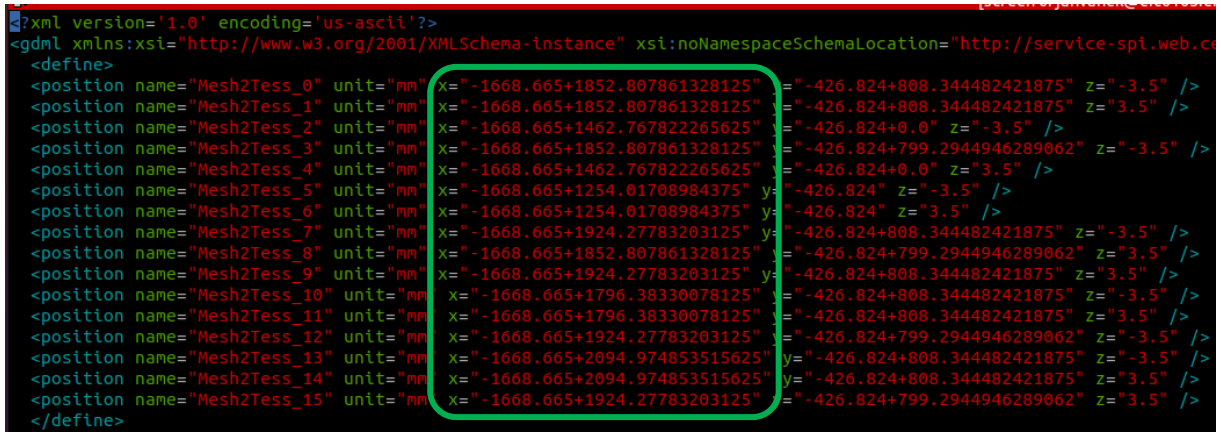
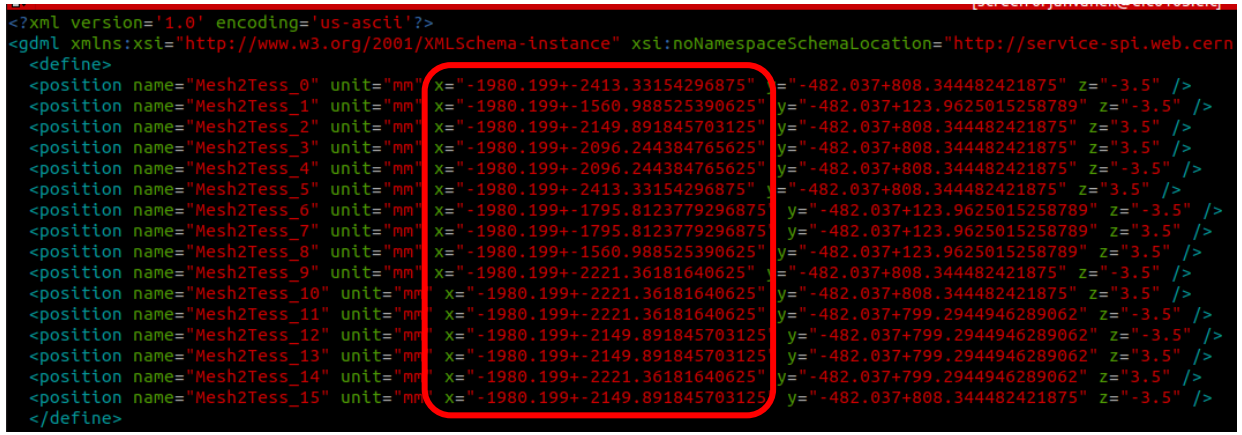


Tile09_reduced.gdml (original)



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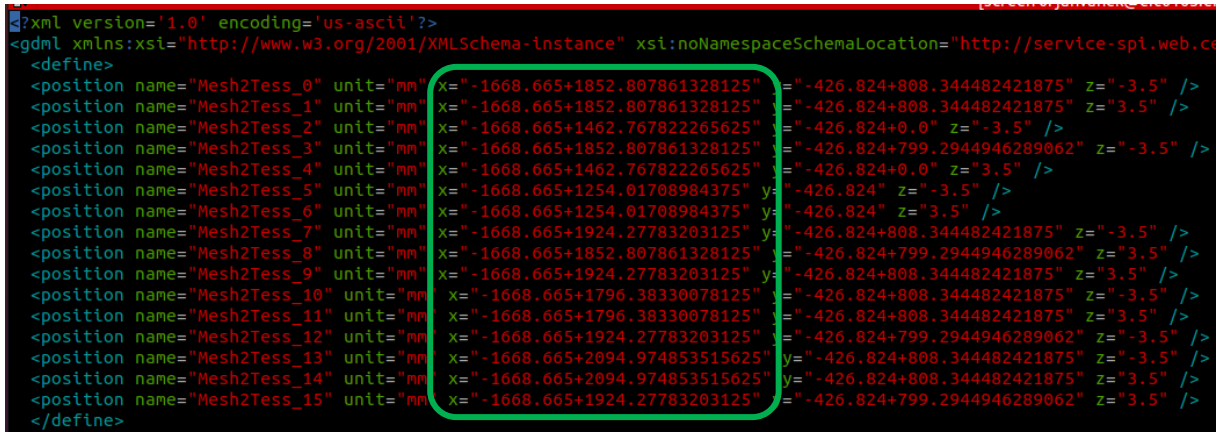
  - Tiles 01-08 and Chimney Tiles
    - Default position is close to center of the coordinate system
  - Tiles 09-12 (original)
    - Default position is far in negative *x*
  - Tiles 09-12 (new)
    - Default position shifted to the center, to be consistent with other tiles
    - Re-calculated offsets so that mesh vertices land in the same place as in the original geometry
    - Modified cpp file that builds the detector to place the new tiles correctly

Tile08_reduced.gdml

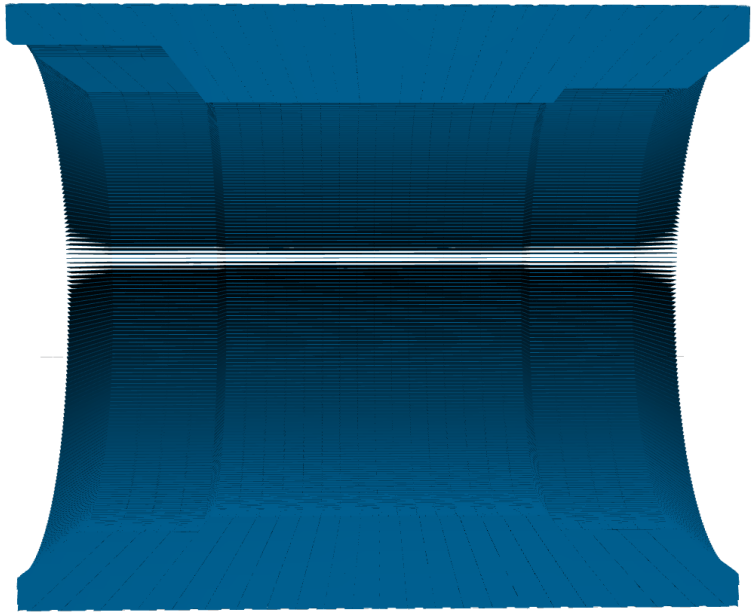


Tile09_reduced.gdml (new)

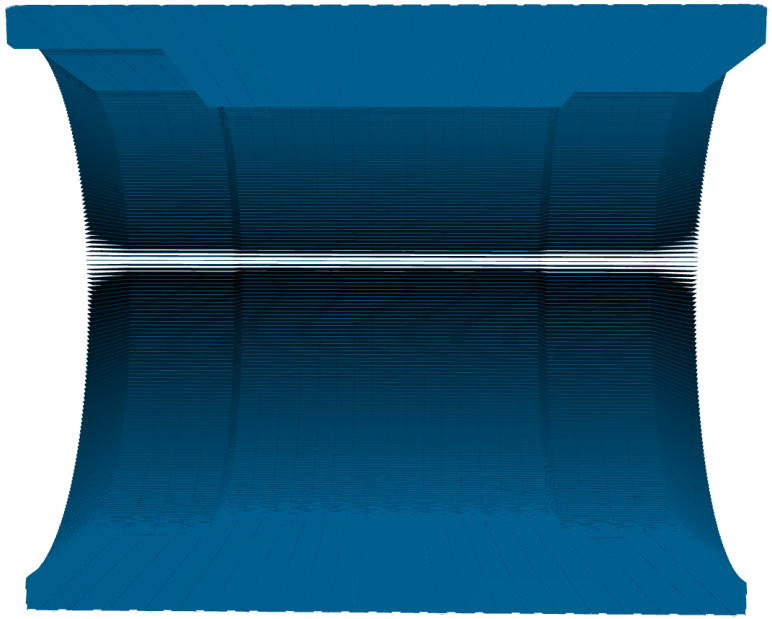
GEOMETRY CHECK

- Visual check that the new geometry is consistent with the original one
  - Direct comparison of the exported geometry
  - No obvious differences
  - New geometry appears consistent with the original

- Other checks
  - With available macros to check overlaps
  - During npsim runtime
    - No error messages



Original



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Original

- Other checks
  - With available macros to check overlaps
  - During npsim runtime
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New

SUMMARY AND OUTLOOK

- Was able to fix the acceptance hole issue
  - Fixed geometry in individual tile geometry gdml files for 4 outer η rings (Tile09-12)
- New geometry tested for overlaps and used in simulation
  - New version seem to pass all tests
- Ran new simulations with updated geometry
  - New results look OK
- **In progress:**
  - Updated gdml files for Tile09-12 to epic-data repo (separate branch)
    - https://github.com/eic/epic-data/tree/bHCAL_hole_patch
  - Submitted a pull request to the main epic repo
    - PR #967

THANK YOU FOR ATTENTION