

Status of simulation studies for the nHCal

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ePIC nHCal DSC meeting

- Muons and electrons as products from VM decay.
 - a) Check how well muons / electrons can be discriminated from other particles
 - i) without
 - ii) with the nHCal.
 - b) What is the reconstruction efficiency?
 - c) What is the nHCal's impact of the VM's performance? How does the acceptance change?

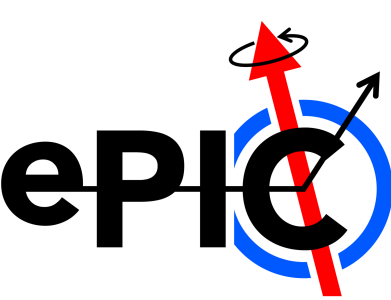
`/work/eic2/EPIC/RECO/23.12.0/epic_craterlake/DIS/NC/10x100/minQ2=10`
Base Address TYPE and Version Detector Config Physics Beam Properties

- Example file:
 - `pythia8NCDIS_5x41_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_5.0503.eicrecon.tree.edm4eic.root`
 - Located in `S3/eictest/EPIC/RECO/24.07.0/epic_craterlake/DIS/NC/5x41/minQ2=1`
- Not counting other particle species & only counting stable or decay particles:

```
Number of generated events: 1981
Number of generated electrons±: 2062
Number of generated protons±: 1457
Number of generated muons±: 6
Number of generated pions±: 7175
Number of generated kaons±: 650
Number of generated rho0: 552
Number of generated jpsi: 0
```

- Default run file, unless indicated otherwise

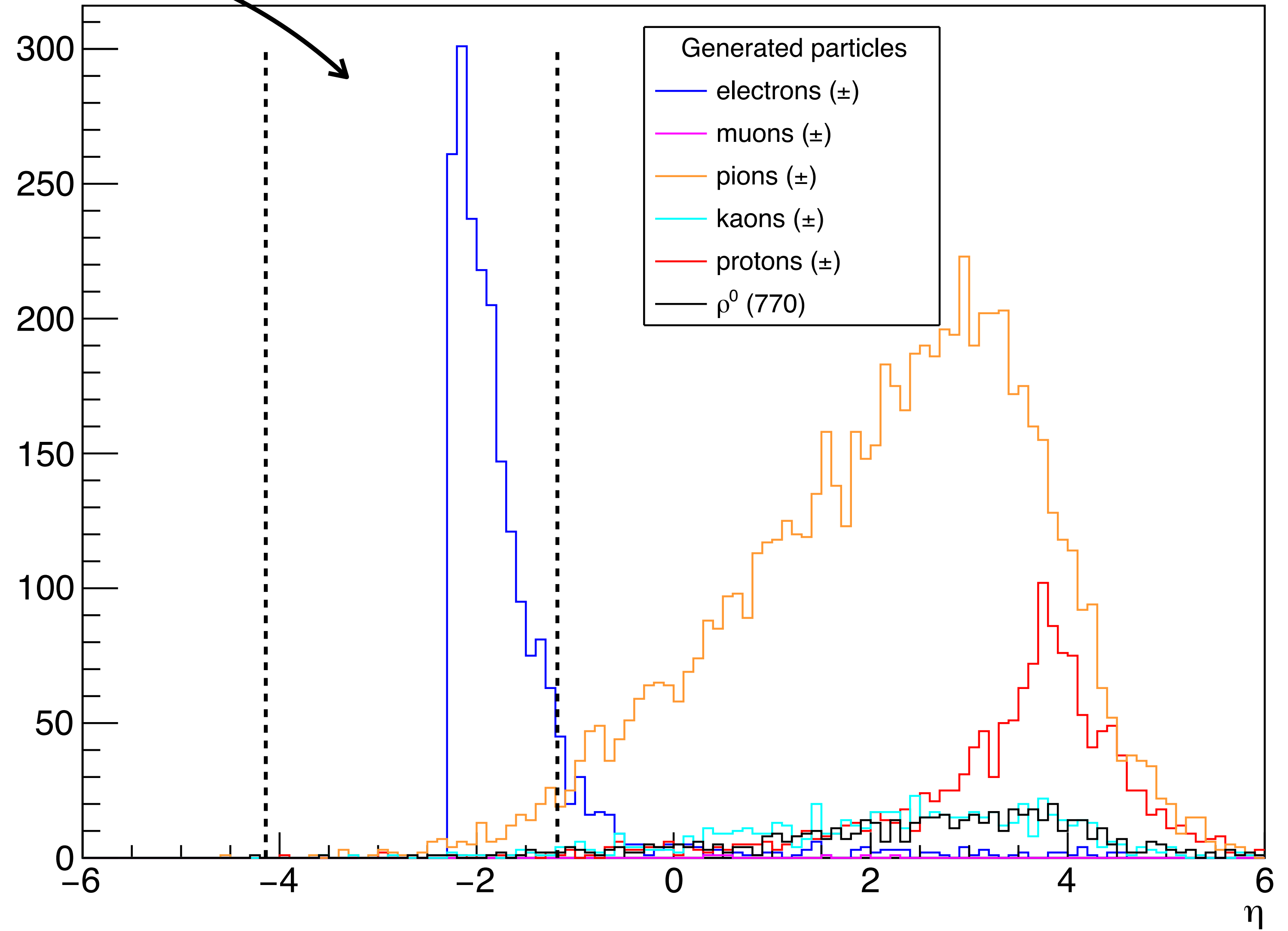
Generated eta distribution - pythia, $Q_{2min} = 1 \text{ GeV}^2$, 5x41



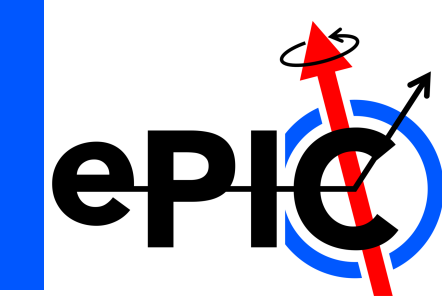
pythia8NCDIS_5x41_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_5.0503.eicrecon.tree.edm4eic

nHCal acceptance

- Front geometry limit: $-4.03 < \eta < -1.18$
- Back geometry limit: $-4.14 < \eta < -1.27$
- Clusters: $-3.95 < \eta < -1.25$

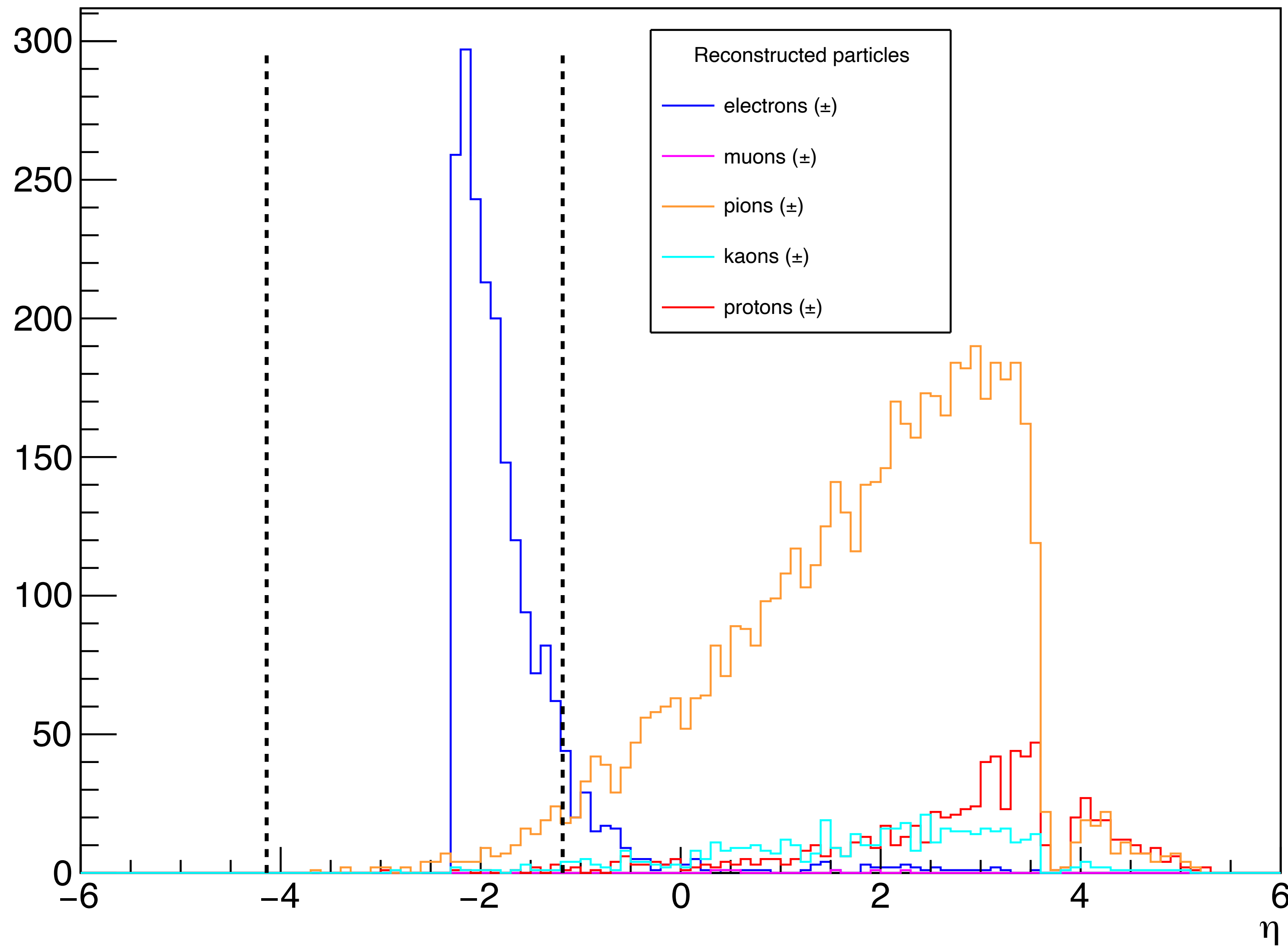


Reconstructed eta distribution - pythia, $Q_{2min} = 1 \text{ GeV}^2$, 5x41

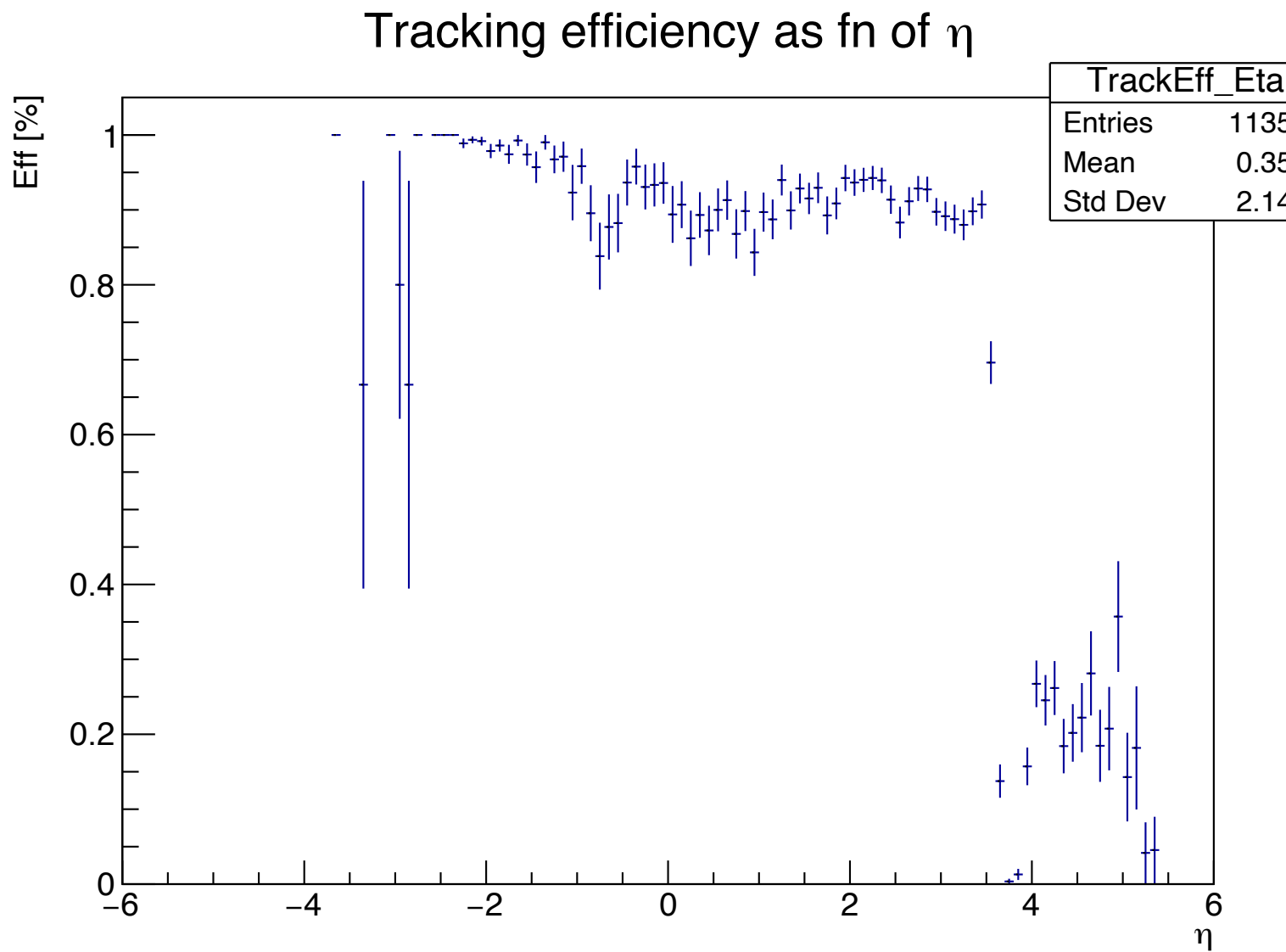
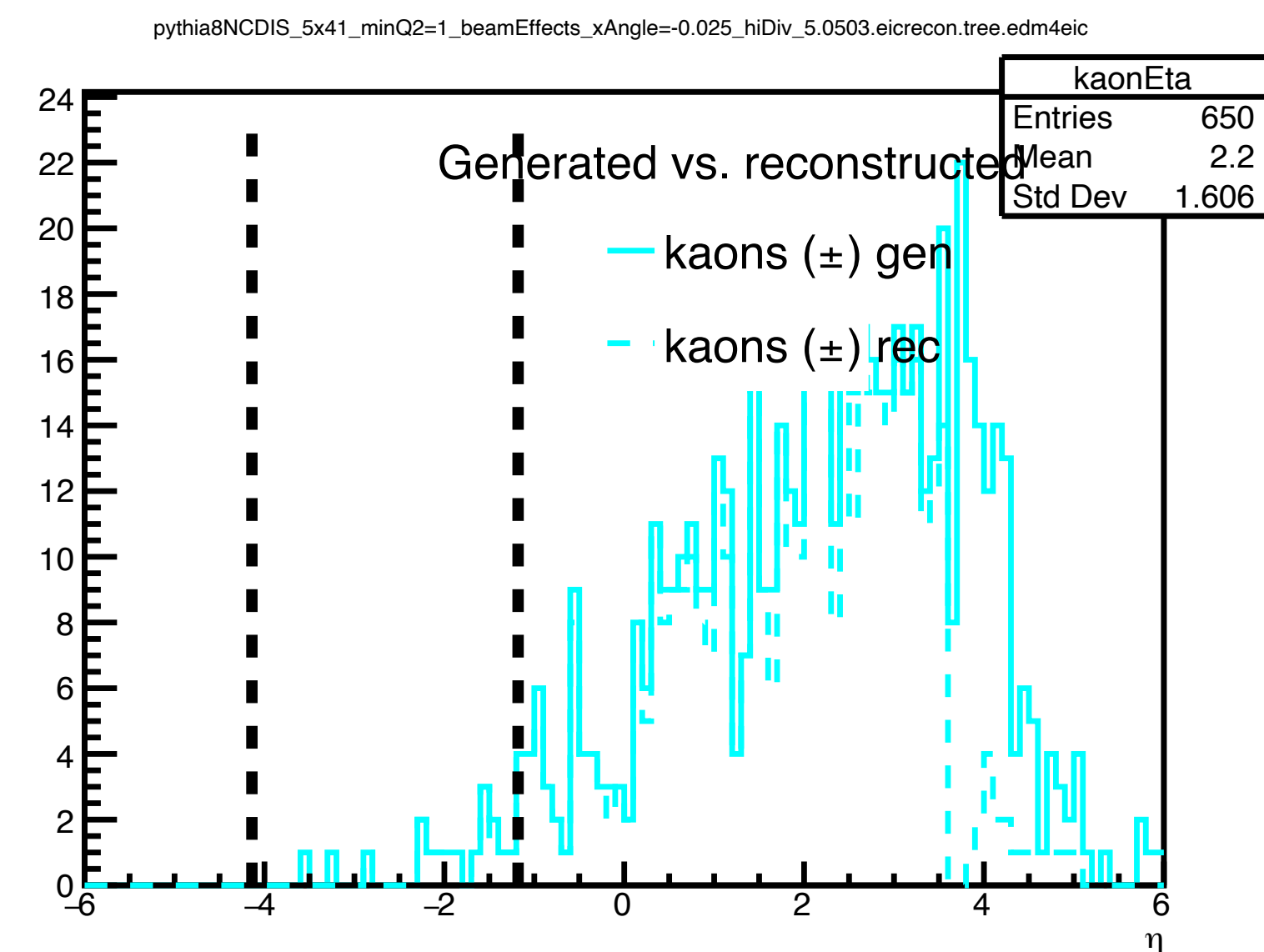
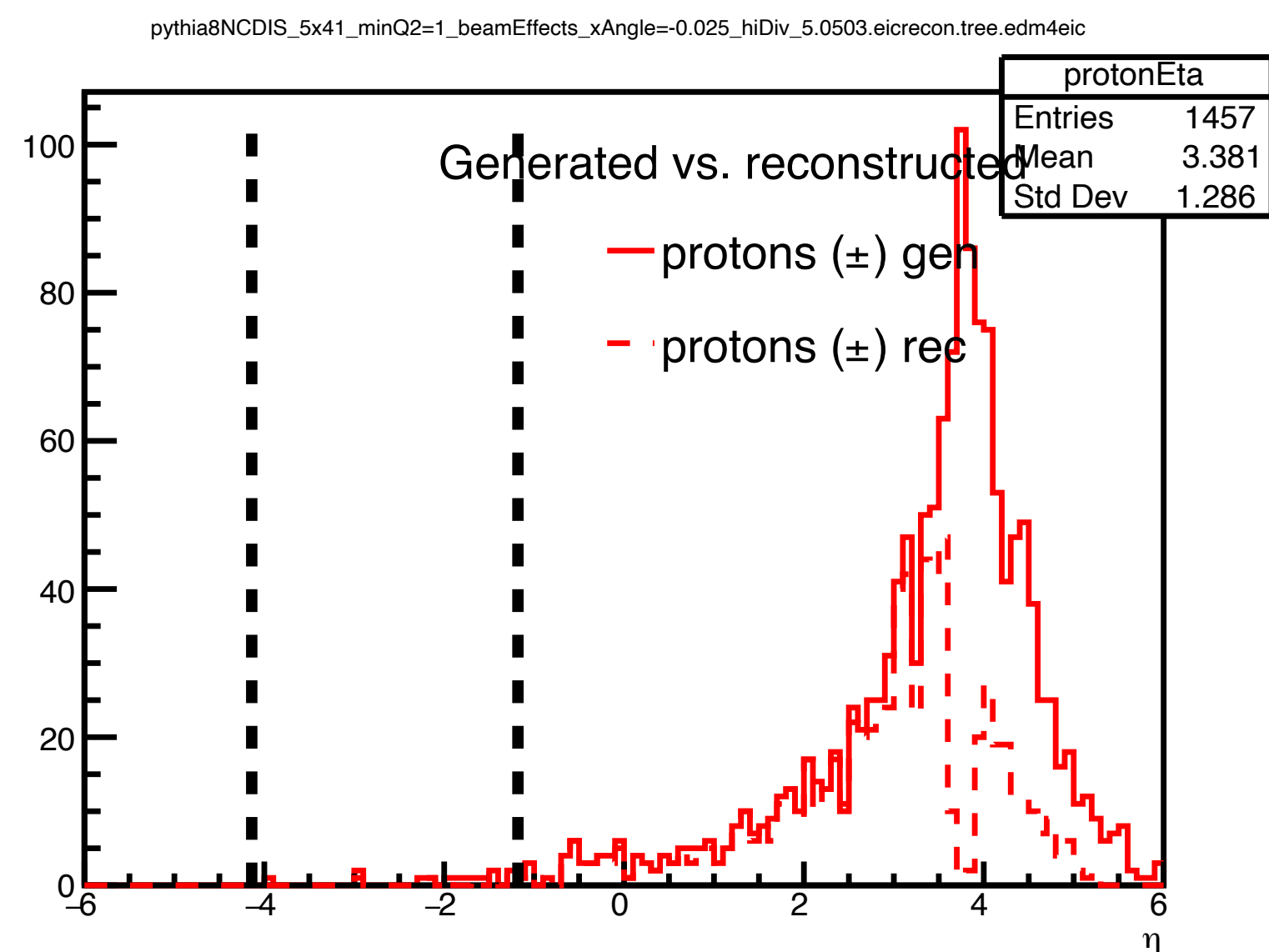
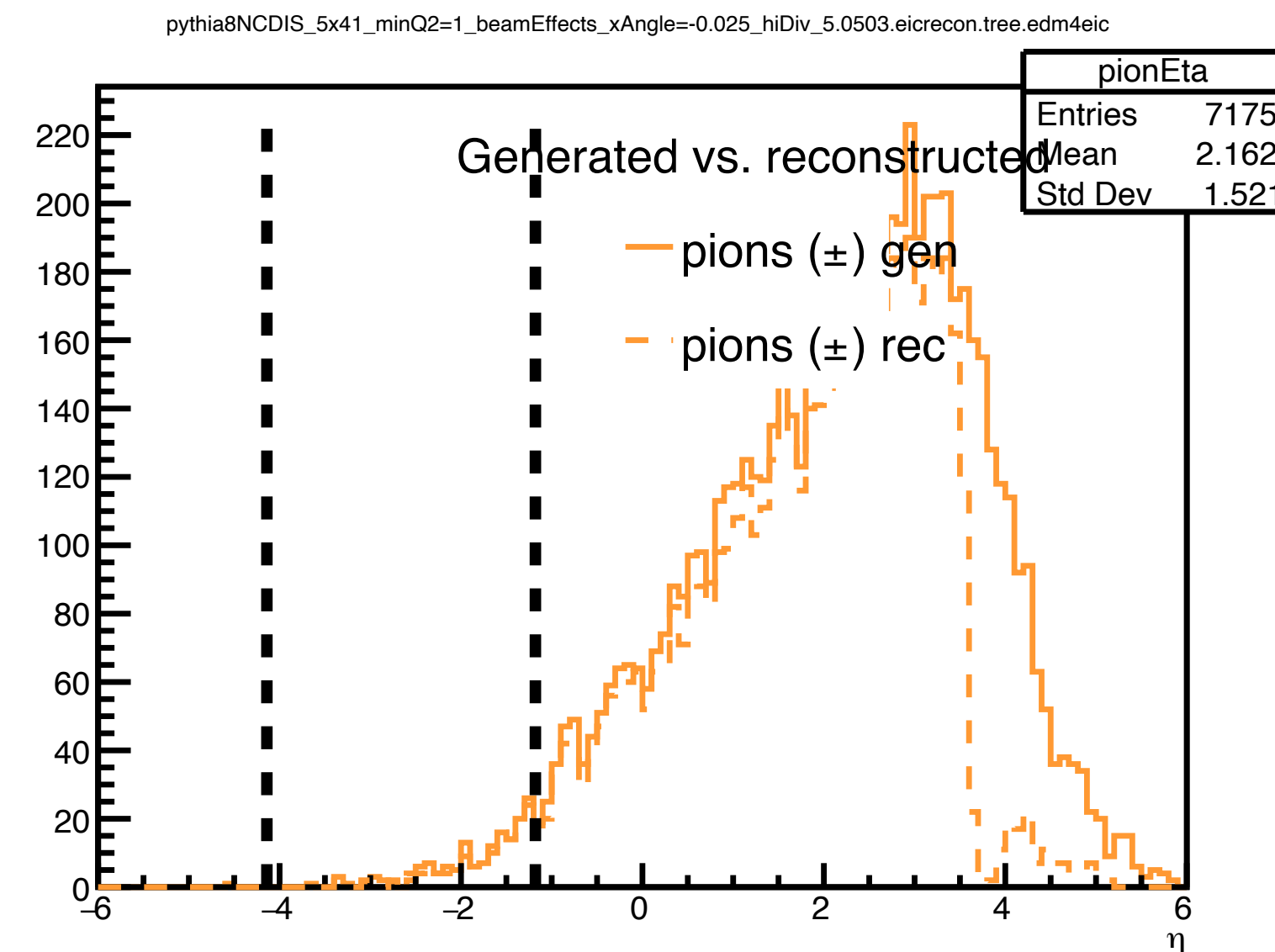
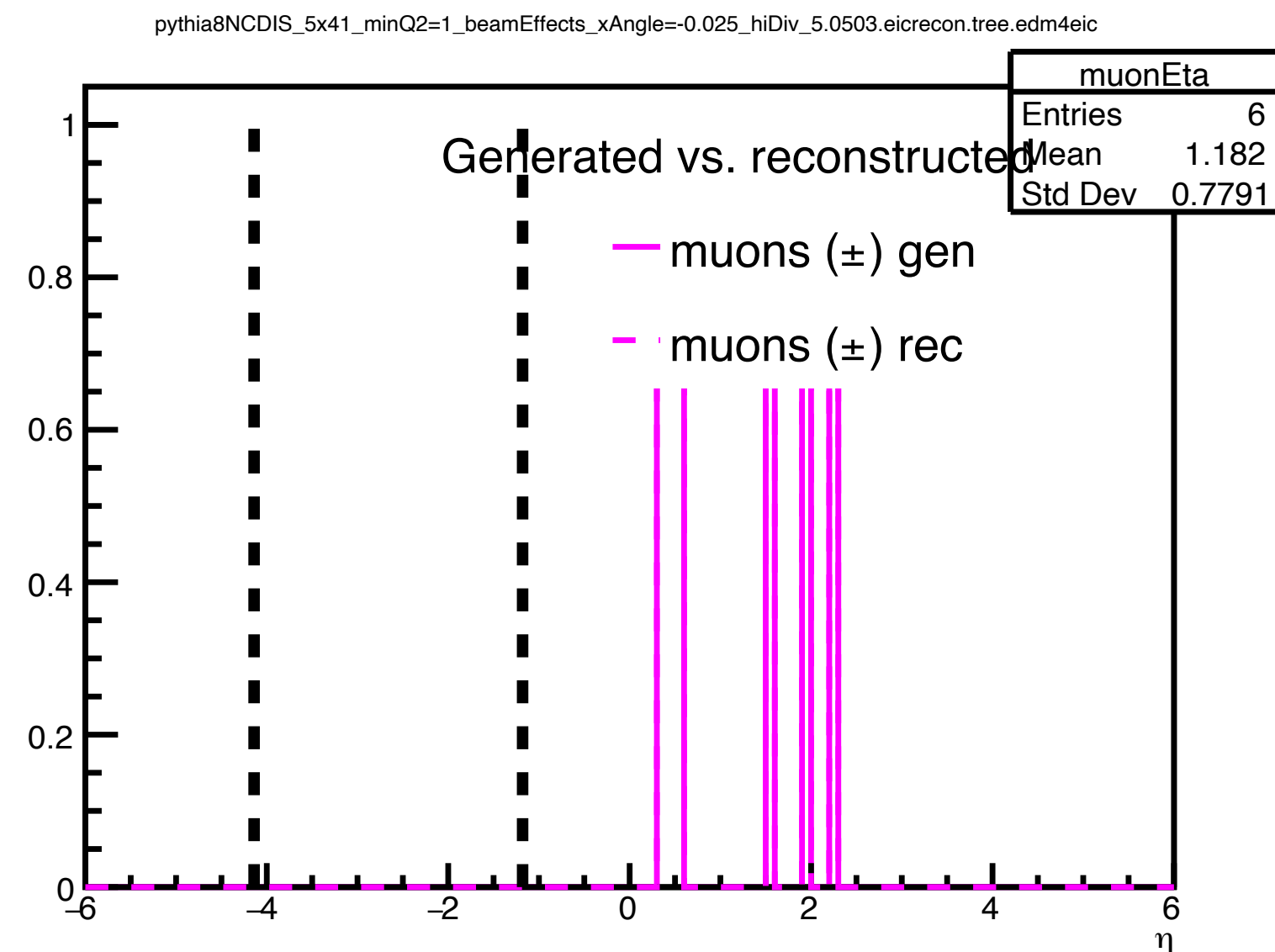
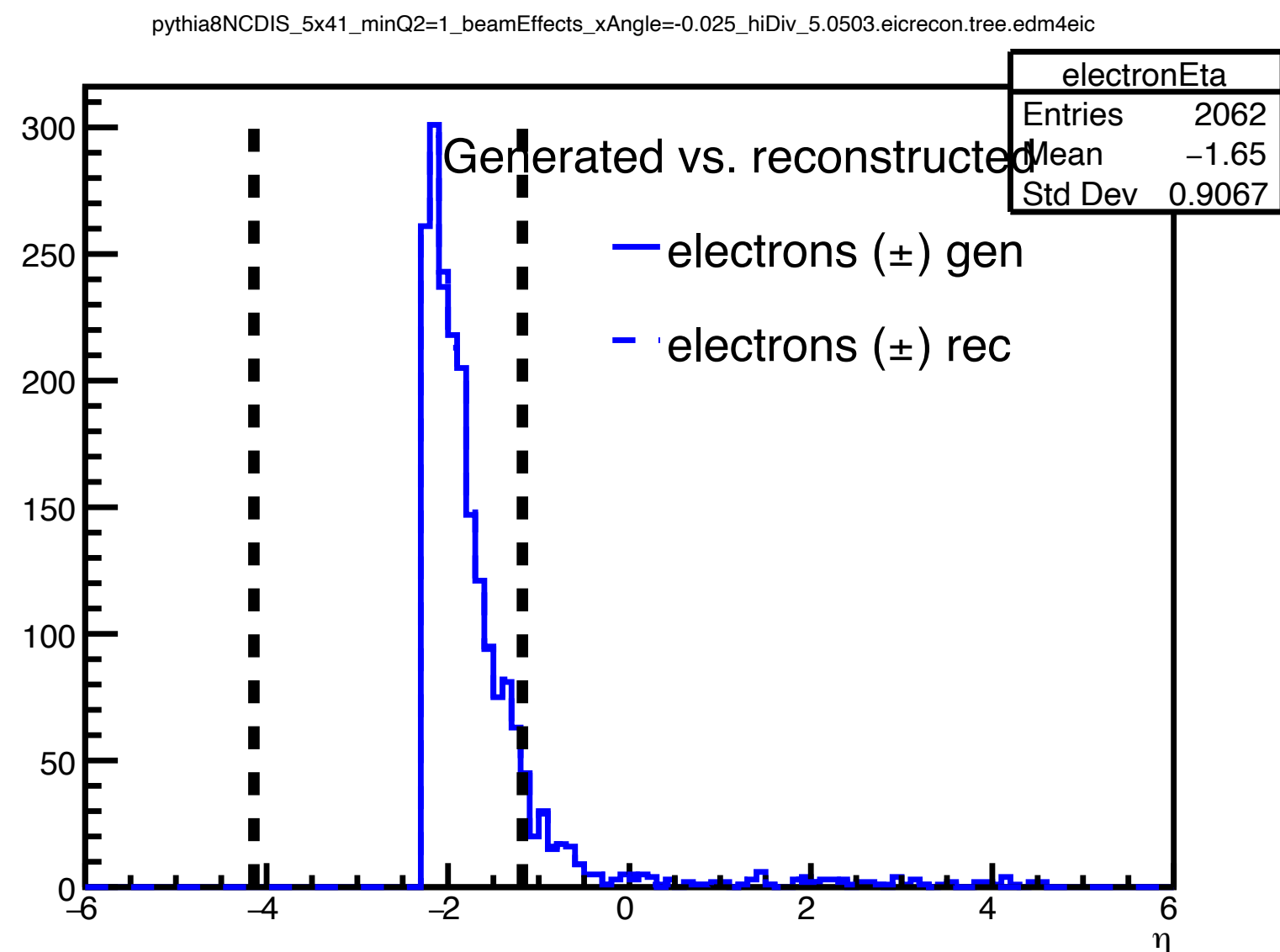


pythia8NCDIS_5x41_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_5.0503.eicrecon.tree.edm4eic

only reconstructed
particles matched to
generated



eta distributions - gen vs. rec - pythia, $Q_{2min} = 1 \text{ GeV}^2, 5 \times 41$



► higher $E_e \times E_p \rightarrow$ particles are boosted to higher eta

5x41

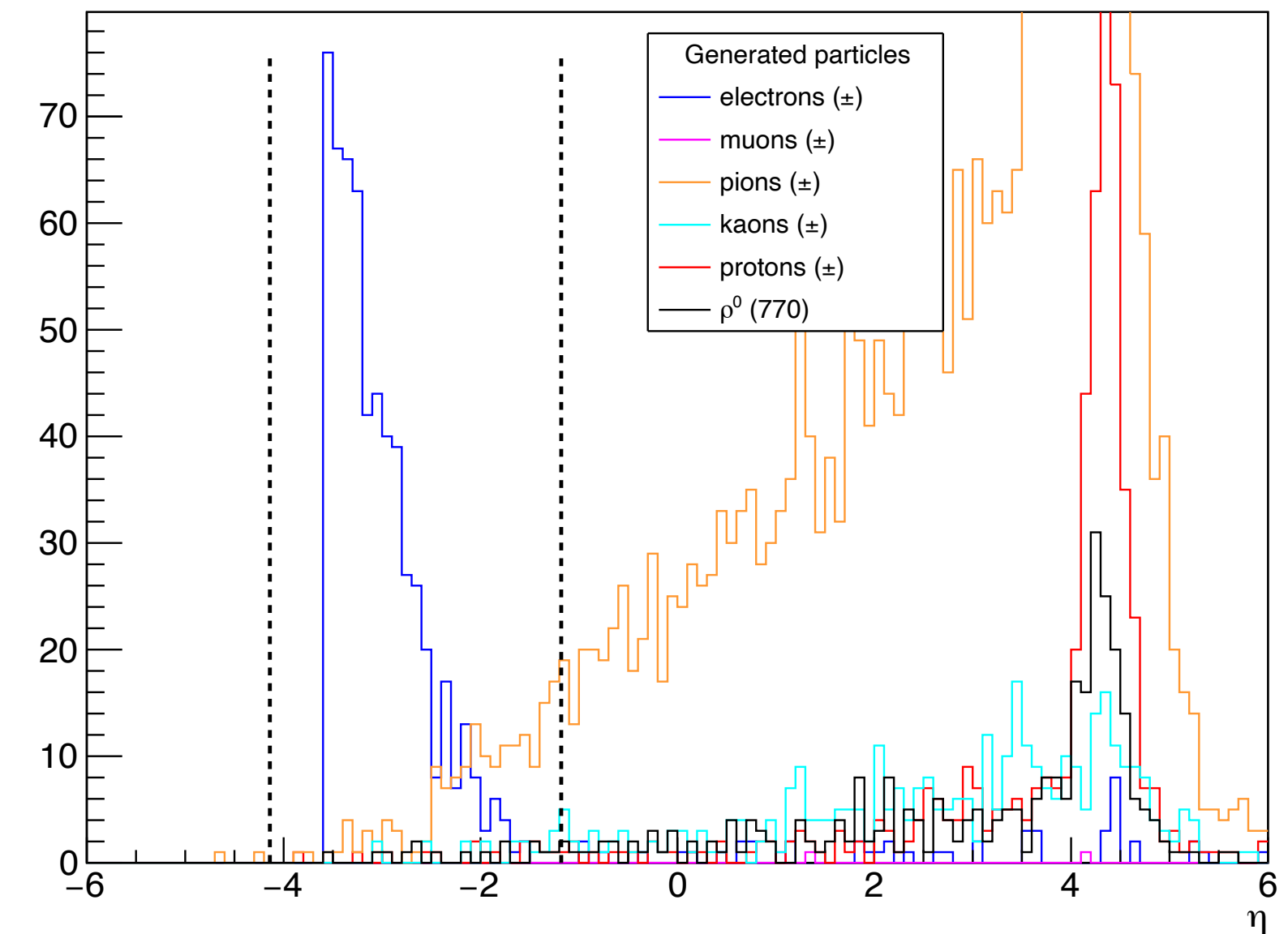
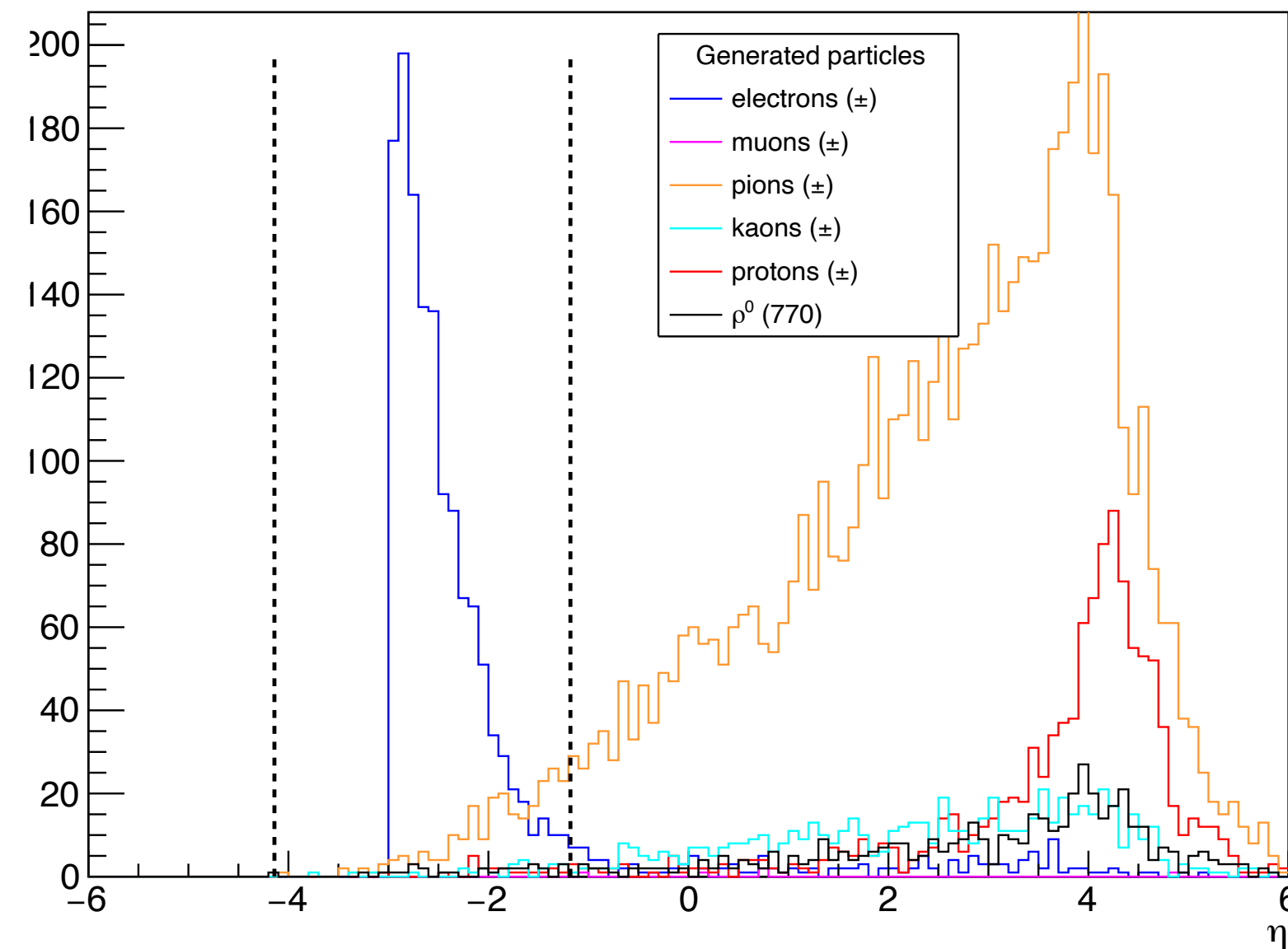
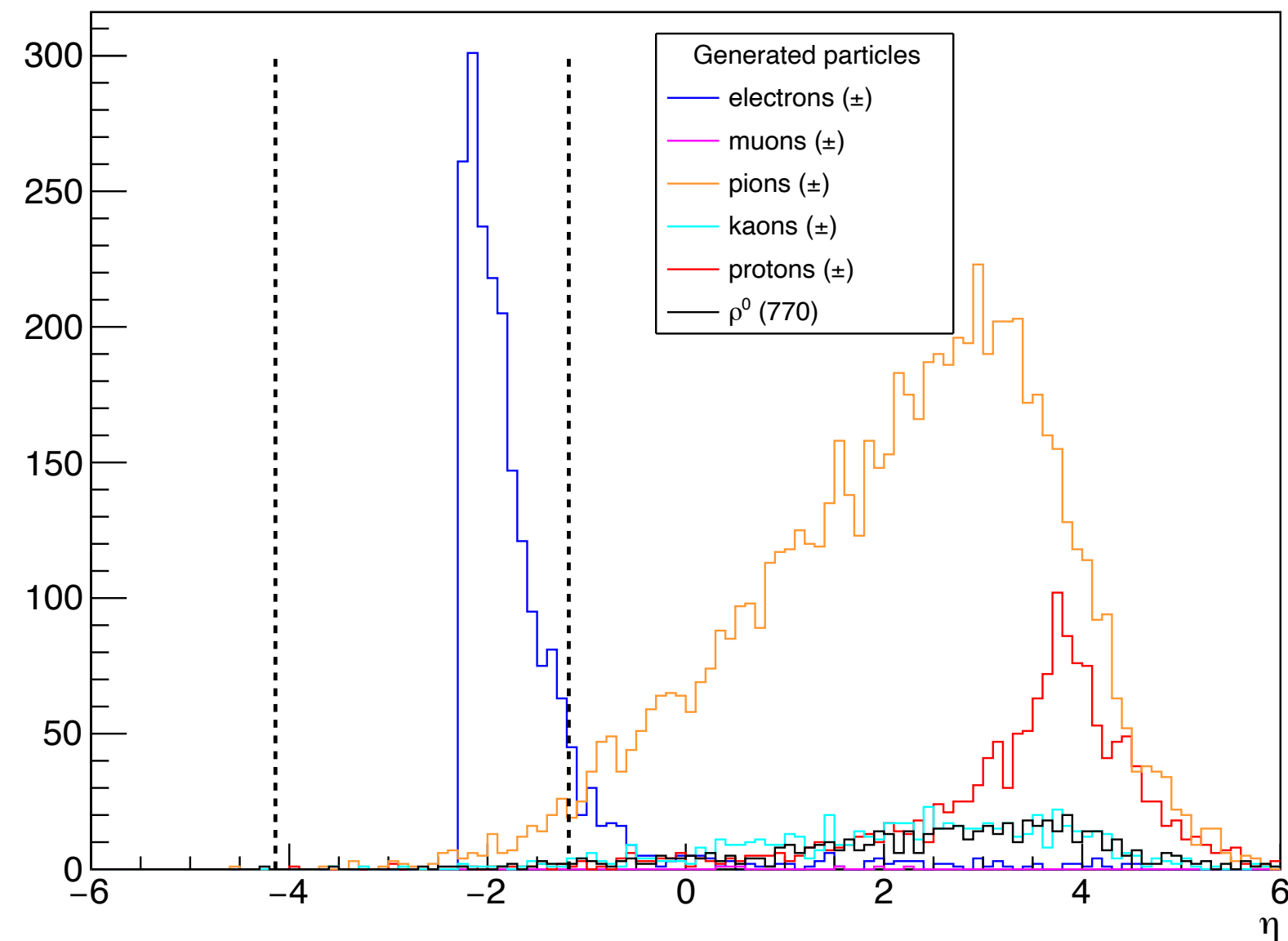
10x100

18x275

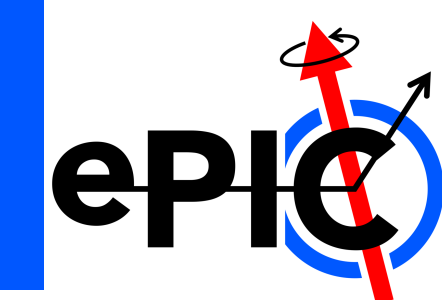
pythia8NCDIS_5x41_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_5.0503.eicrecon.tree.edm4eic

pythia8NCDIS_10x100_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_2.0256.eicrecon.tree.edm4eic

pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0998.eicrecon.tree.edm4eic

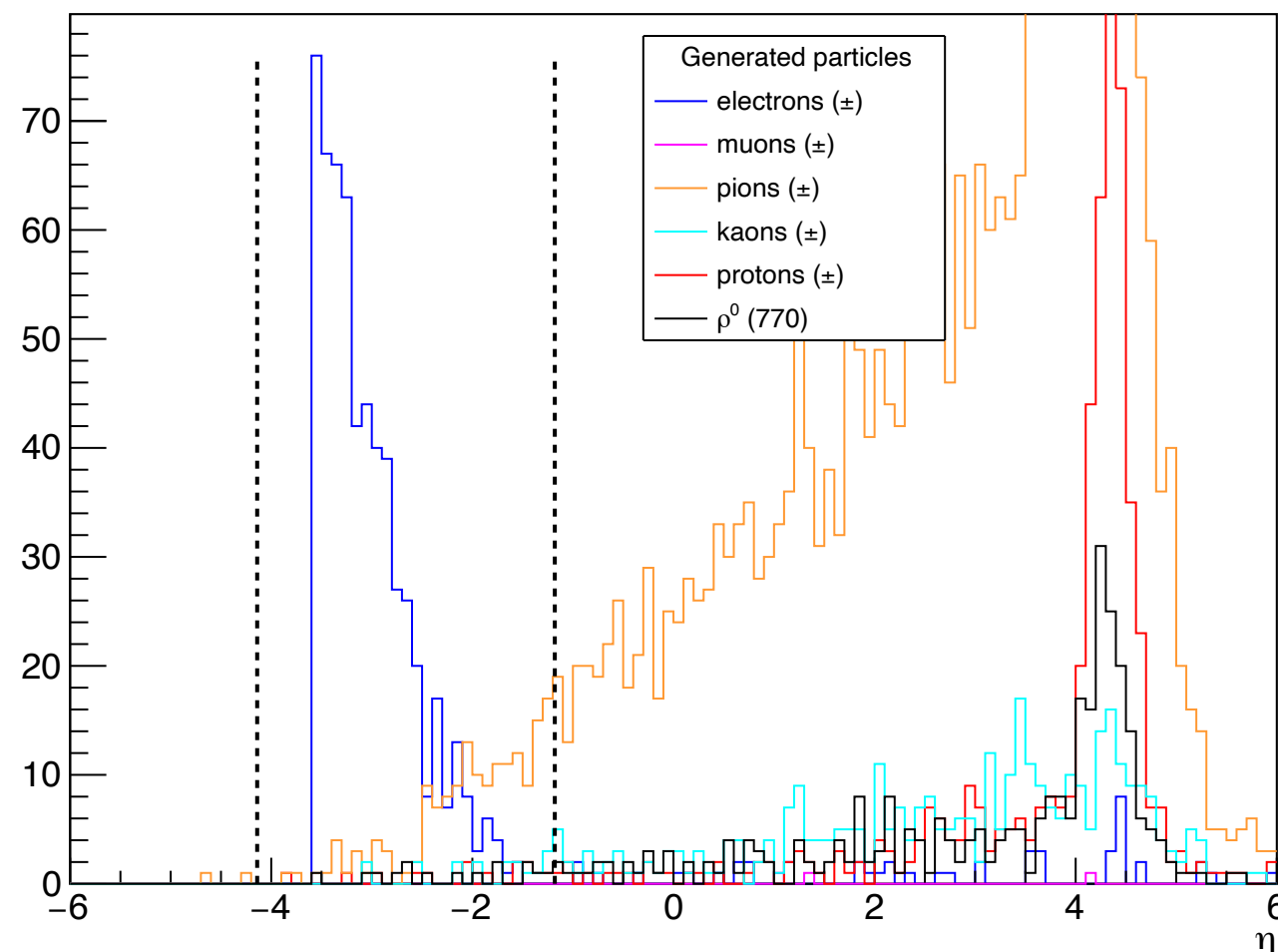


Generated eta distribution - pythia, 18x275, vary Q^2_{\min}



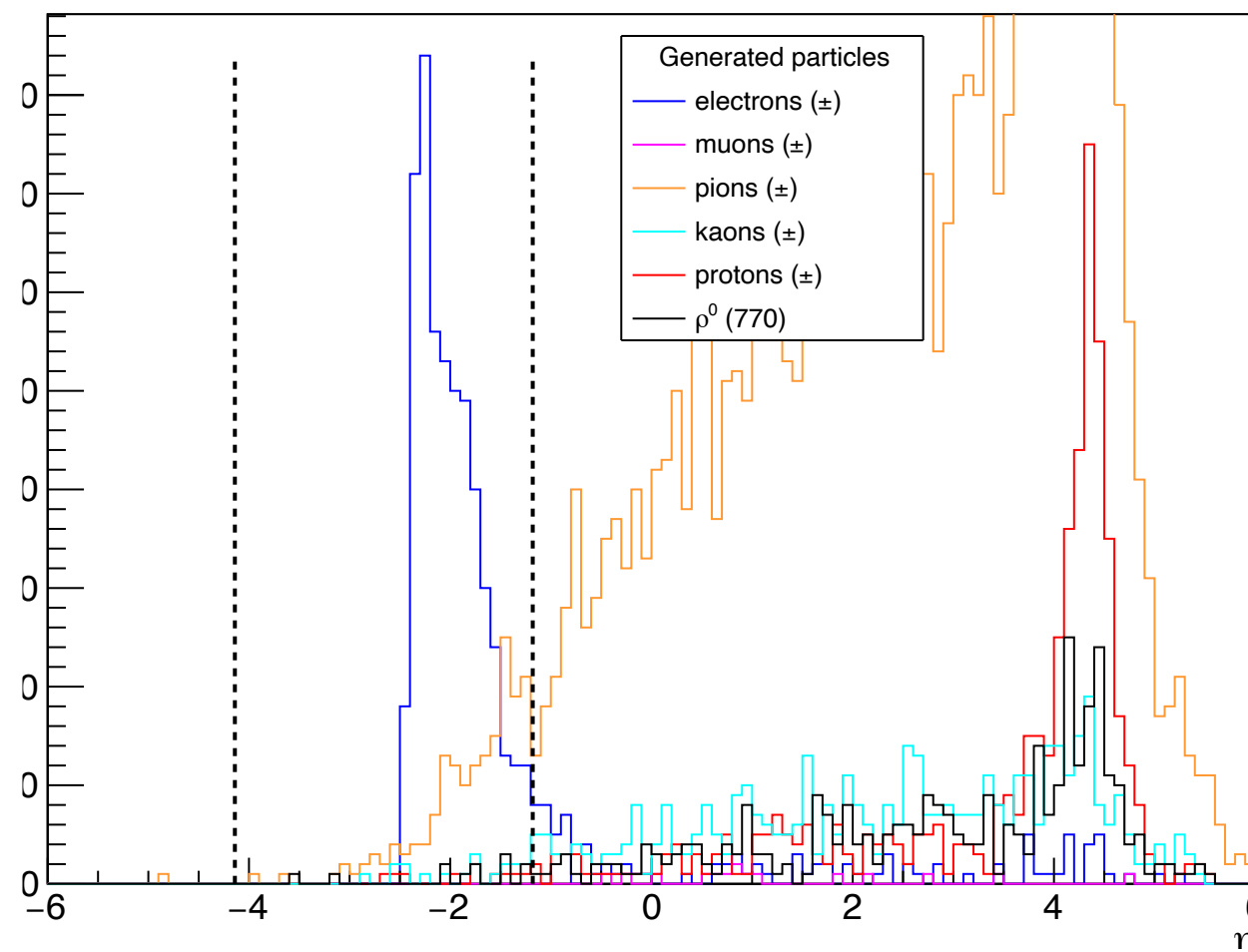
Q2min=1

pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0998.eicrecon.tree.edm4eic



Q2min=10

pythia8NCDIS_18x275_minQ2=10_beamEffects_xAngle=-0.025_hiDiv_3.0294.eicrecon.tree.edm4eic



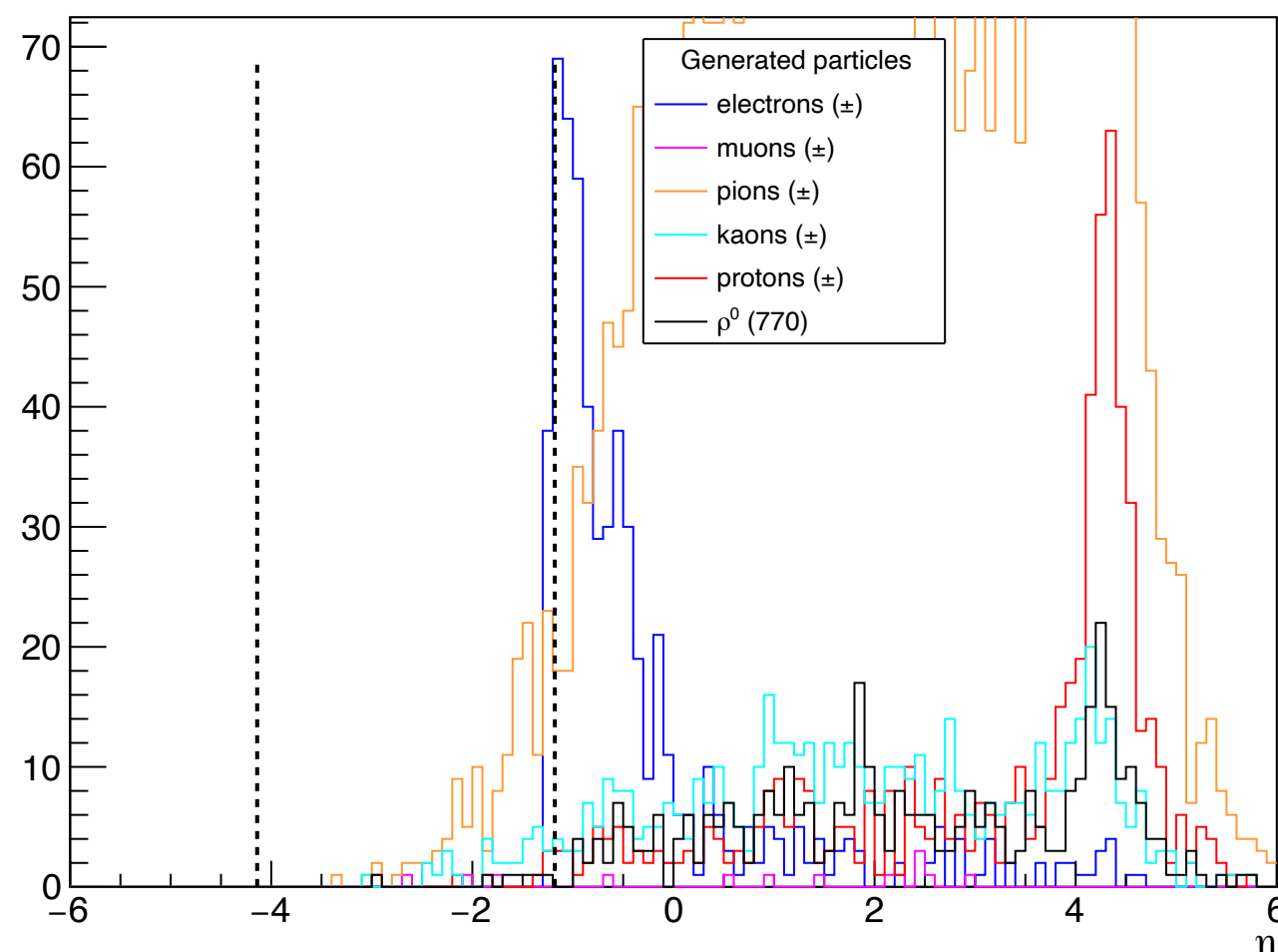
- ▶ Higher and highest Q^2 squeeze the particles towards the barrel
- ▶ Photoproduction (very low Q^2) pushes some particles into nHCal acceptance

Q2=0.000000001-1
(photoproduction)

pythia_ep_noradcor_10x100_q2_0.000000001_1.0_run39.ab.0606.eicrecon.tree.edm4eic

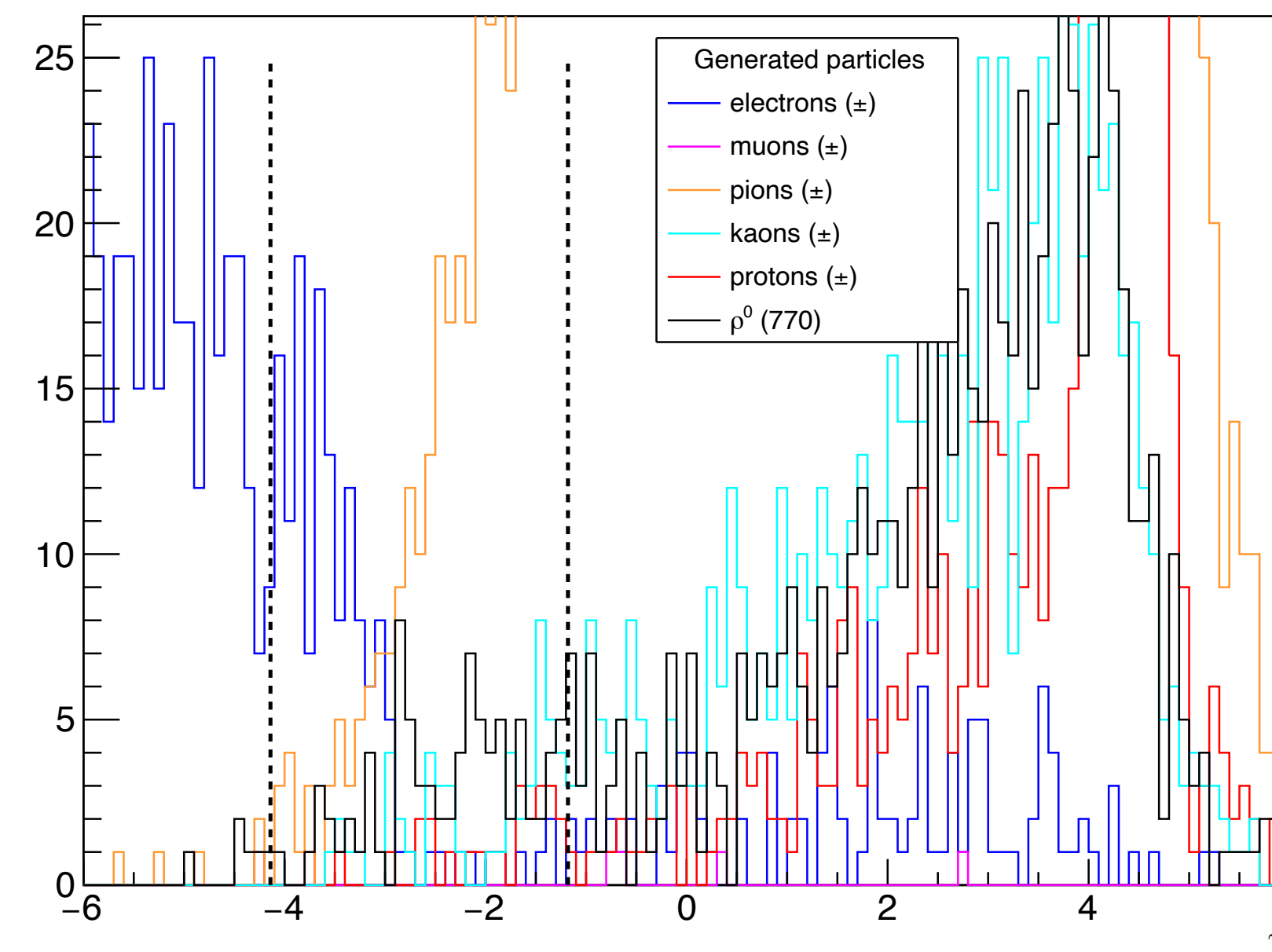
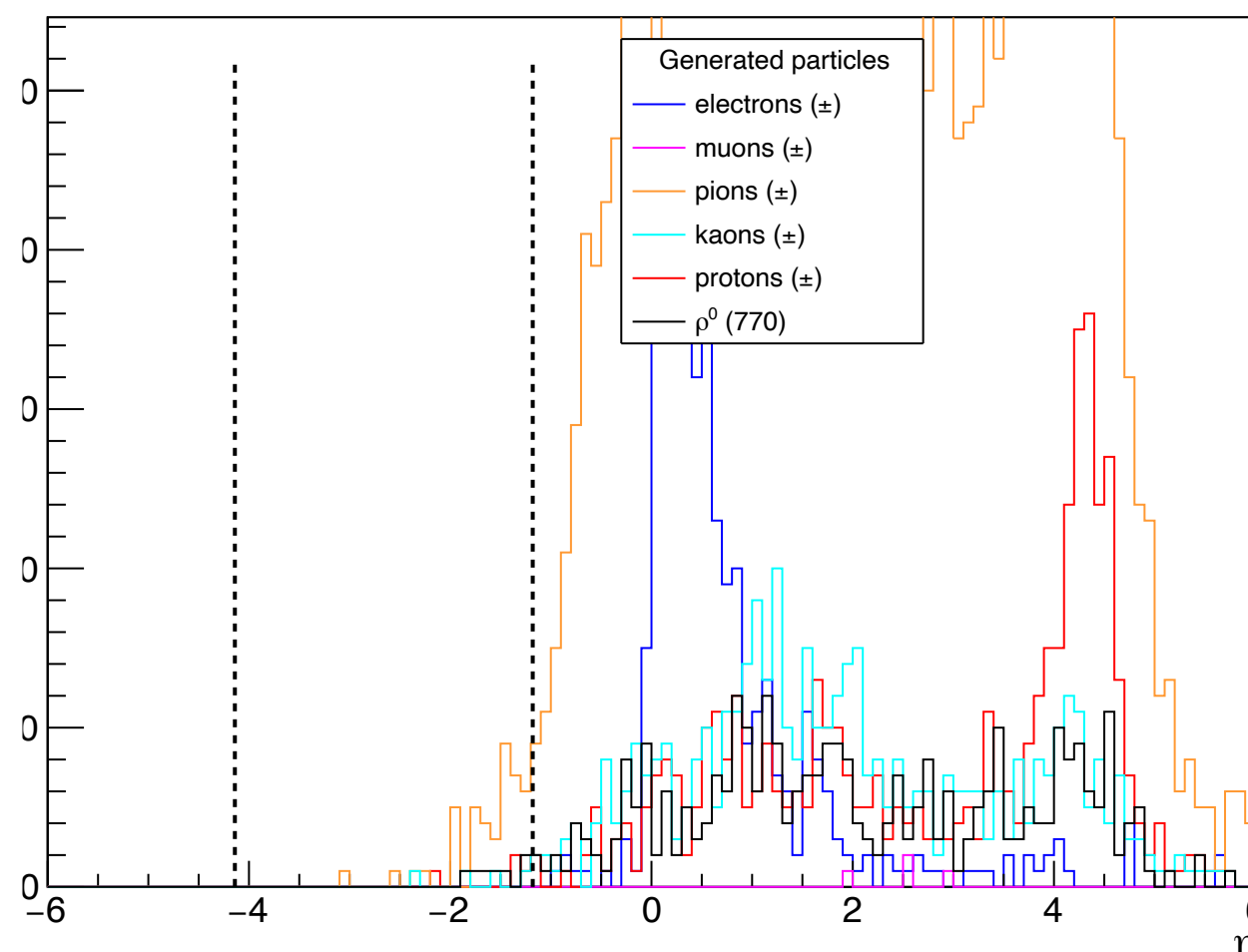
Q2min=100

pythia8NCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1.0015.eicrecon.tree.edm4eic



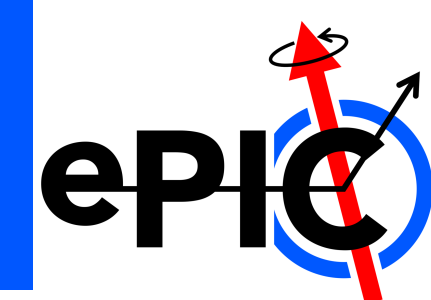
Q2min=1000

pythia8NCDIS_18x275_minQ2=1000_beamEffects_xAngle=-0.025_hiDiv_1.0019.eicrecon.tree.edm4eic



- `TTreeReaderArray<int> daughters_index(tree_reader, "_MCParticles_daughters.index");`
- `TTreeReaderArray<unsigned int> daughters_begin(tree_reader, "MCParticles.daughters_begin");`
- `TTreeReaderArray<unsigned int> daughters_end(tree_reader, "MCParticles.daughters_end");`
- from a search on Mattermost: `MCParticles.daughters_begin` and `MCParticles.daughters_end` is a set of indices to the `_MCParticles_daughters` collection. That then contains the MCParticle indices of the daughters.

MCParticles parents and daughters - all particles



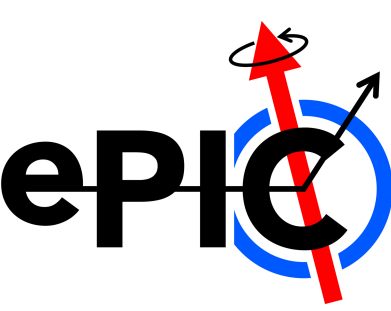
Ev#: 581, P-index: 0, PDG: 2212, GenStatus:4, i_parents: 0, i_daughters: 2, pb: 0, pe: 0, db: 1, de: 2
Ev#: 581, P-index: 1, PDG: 2, GenStatus:61, i_parents: 1, i_daughters: 1, pb: 0, pe: 0, db: 5, de: 5
Ev#: 581, P-index: 2, PDG: 2101, GenStatus:63, i_parents: 1, i_daughters: 5, pb: 0, pe: 3, db: 8, de: 12
Ev#: 581, P-index: 3, PDG: 11, GenStatus:4, i_parents: 0, i_daughters: 1, pb: 3, pe: 3, db: 4, de: 4
Ev#: 581, P-index: 4, PDG: 11, GenStatus:21, i_parents: 1, i_daughters: 2, pb: 3, pe: 1, db: 6, de: 13
Ev#: 581, P-index: 5, PDG: 2, GenStatus:21, i_parents: 1, i_daughters: 2, pb: 1, pe: 4, db: 6, de: 13
Ev#: 581, P-index: 6, PDG: 2, GenStatus:23, i_parents: 2, i_daughters: 1, pb: 4, pe: 6, db: 7, de: 7
Ev#: 581, P-index: 7, PDG: 2, GenStatus:62, i_parents: 1, i_daughters: 5, pb: 6, pe: 2, db: 8, de: 12
Ev#: 581, P-index: 8, PDG: 221, GenStatus:2, i_parents: 2, i_daughters: 3, pb: 2, pe: 2, db: 14, de: 16
Ev#: 581, P-index: 9, PDG: 111, GenStatus:2, i_parents: 2, i_daughters: 2, pb: 2, pe: 2, db: 17, de: 18
Ev#: 581, P-index: 10, PDG: 213, GenStatus:2, i_parents: 2, i_daughters: 2, pb: 2, pe: 2, db: 19, de: 20
Ev#: 581, P-index: 11, PDG: 2112, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 2, pe: 2, db: 21, de: 20
Ev#: 581, P-index: 12, PDG: 111, GenStatus:2, i_parents: 2, i_daughters: 2, pb: 2, pe: 4, db: 21, de: 22
Ev#: 581, P-index: 13, PDG: 11, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 4, pe: 8, db: 23, de: 22
Ev#: 581, P-index: 14, PDG: 211, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 8, pe: 8, db: 23, de: 22
Ev#: 581, P-index: 15, PDG: 211, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 8, pe: 8, db: 23, de: 22
Ev#: 581, P-index: 16, PDG: 111, GenStatus:2, i_parents: 1, i_daughters: 2, pb: 8, pe: 9, db: 23, de: 24
Ev#: 581, P-index: 17, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 9, pe: 9, db: 25, de: 24
Ev#: 581, P-index: 18, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 9, pe: 10, db: 25, de: 24
Ev#: 581, P-index: 19, PDG: 211, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 10, pe: 10, db: 25, de: 24
Ev#: 581, P-index: 20, PDG: 111, GenStatus:2, i_parents: 1, i_daughters: 2, pb: 10, pe: 12, db: 25, de: 26
Ev#: 581, P-index: 21, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 12, pe: 12, db: 24, de: 26
Ev#: 581, P-index: 22, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 12, pe: 16, db: 24, de: 26
Ev#: 581, P-index: 23, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 16, pe: 16, db: 24, de: 26
Ev#: 581, P-index: 24, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 16, pe: 20, db: 24, de: 26
Ev#: 581, P-index: 25, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 20, pe: 20, db: 24, de: 26
Ev#: 581, P-index: 26, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 20, pe: 16, db: 24, de: 26

decay (GenStatus = 2): $\eta \rightarrow \pi^+ \pi^- \pi^0$

stable particle (GenStatus = 1): π^\pm , photon; no daughters

beam particle (GenStatus = 4): proton, electron; no parents

Decay particles - wrong daughters



EPIC/REC0/24.07.0/epic_craterlake/DIS/NC/5x41/minQ2=1

pythia8NCDIS_5x41_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_5.0503.eicrecon.tree.edm4eic

Number of generated events: 1981

Number of **generated pi0**: 4147, of which **decay** into
2 gamma: 1358,
gamma + positively charged: 1193,
gamma + negatively charged: 454

Number of **generated rho0**: 552, of which **decay** into
pi+ pi-: 10,
eff. positive charge: 433,
eff. negative charge: 2,
into mu+ mu-: 0,
into e+ e-: 0

Should I ignore the unphysical decay channels?
Do I have a bug?
Is this a bug in the production?

- To do immediately:

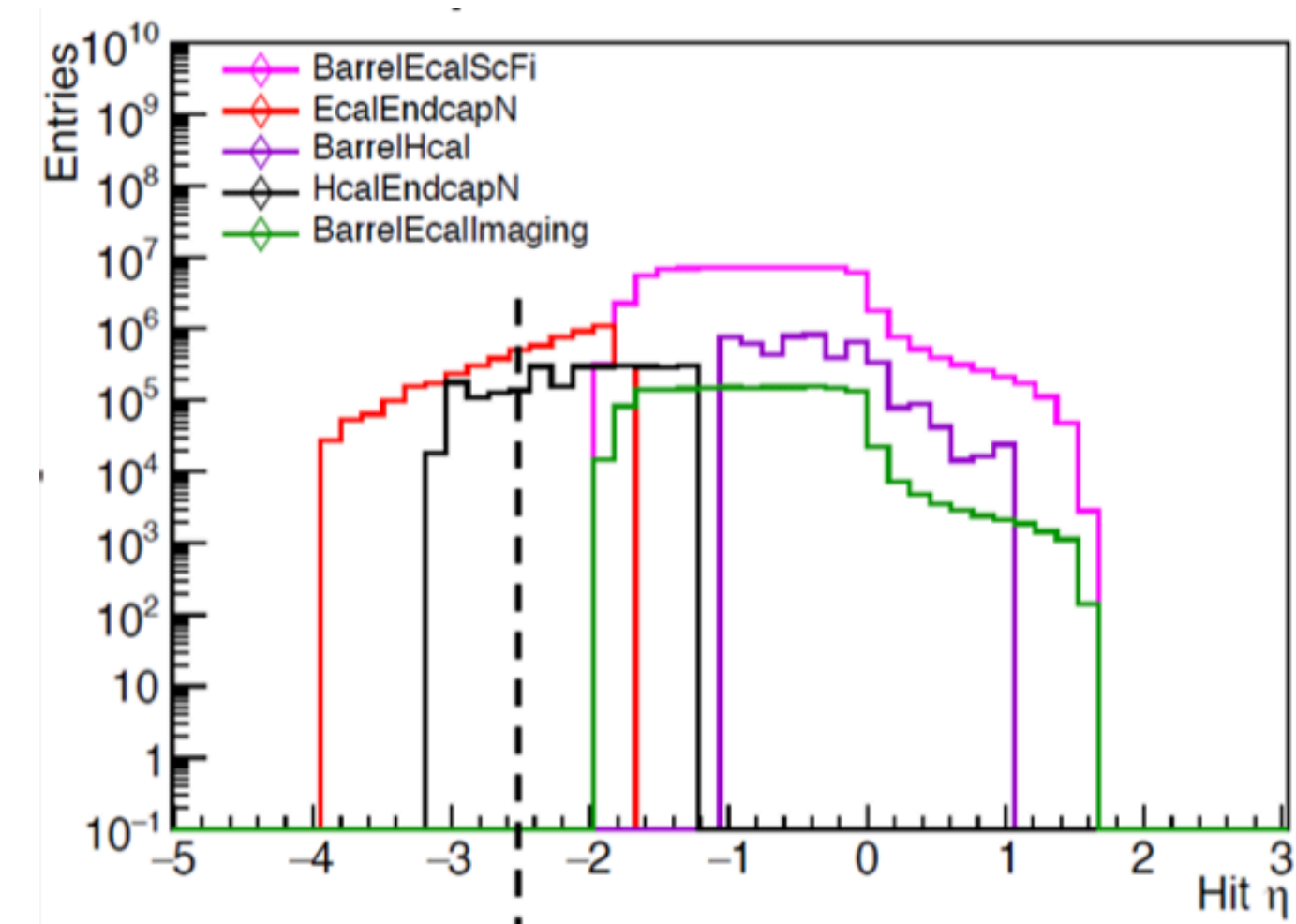
- ▶ Identify μ , e , π , K coming from the decay of ρ^0 and other VMs (ϕ , J/Ψ , $Upsilon$, ...) \rightarrow will need more stat for this \rightarrow Run over more than 1 MC file at a time
- ▶ Reproduce hit distribution to update outdated hit plot

- Questions:

- ▶ Where are the settings that are used to generate the central simulation campaigns?
- ▶ Where on github (?) is the code to produce the central simulation campaigns?

- Next:

- ▶ Understand what is in other various event generators (exclusive, etc.), contact WG conveners / other experts
- ▶ Simulations with and without nHCal included in the ePIC geometry... with latest settings
- ▶ ...?



Subhadip Pal, CTU

- rho_10x100_uChannel_Q2of0to10_hiDiv.0047.eicrecon.tree.edm4eic
- pi0_18x275_uChannel_Q2of0to10_hiDiv.0113.eicrecon.tree.edm4eic
- EpIC1.0.0-1.1_DVMP_10x100_hiAcc_ab_1.0071.eicrecon.tree.edm4eic.root
- sDEMPgen-1.1.0_5x41_pi+_9.0018.eicrecon.tree.edm4eic.root
- DVCS.3.ab_hiDiv.18x275.0786.eicrecon.tree.edm4eic.root
- TCS_gen_ab_hiDiv_18x275p_s959_novtx.0038.eicrecon.tree.edm4eic.root
- pythia_ep_noradcor_10x100_q2_0.000000001_1.0_run39.ab.0606.eicrecon.tree.edm4eic.root
- pythia_ep_noradcor_5x41_q2_0.000000001_1.0_run39.ab.0102.eicrecon.tree.edm4eic.root

The nHCal in the ePIC simulation

- The file `$(DETECTOR_PATH)/$(DETECTOR_CONFIG).xml` includes the nHCal geometry:
`$(DETECTOR_PATH)/compact/hcal/backward.xml`
- => The nHCal is included in the default ePIC geometry:

```
<layer repeat="HcalEndcapNLayer_NRepeat"
vis="HcalEndcapLayerVis" >
  <slice material="StainlessSteel"
thickness="HcalEndcapNSteelThickness" vis="HcalAbsorberVis"/>
  <slice material="Air" thickness="HcalEndcapNLayerGap/2"
vis="InvisibleNoDaughters"/>
  <slice material="Polystyrene"
thickness="HcalEndcapNPolystyreneThickness" vis="HcalSensorVis"
sensitive="yes" limits="cal_limits"/>
  <slice material="Air" thickness="HcalEndcapNLayerGap/2"
vis="InvisibleNoDaughters"/>
</layer>
```

- Is this the most up-to-date (best) description?

```
<!-- SPDX-License-Identifier: LGPL-3.0-or-later -->
<!-- Copyright (C) 2022 Wouter Deconinck, Leszek Kosarzewski, Ryan Milton -->

<lccdd>
<define>
  <documentation>
    ### Material Thickness
  </documentation>
  <constant name="HcalEndcapNSteelThickness" value="4.0 * cm"/>
  <constant name="HcalEndcapNPolystyreneThickness" value="0.4 * cm"/>
  <constant name="HcalEndcapNLayerGap" value="0.1 * cm"/> <!-- 2*thicker than LFHCal -->

  <constant name="HcalEndcapN_polyhedron_rmax" value="251.444*cm"/>
  <constant name="HcalEndcapN_segments_rmin" value="19.9431*cm"/>
  <constant name="HcalEndcapN_segments_rmax" value="HcalEndcapN_rmax/(cos(180*deg/HcalEndcapN_CaloSides))"/>

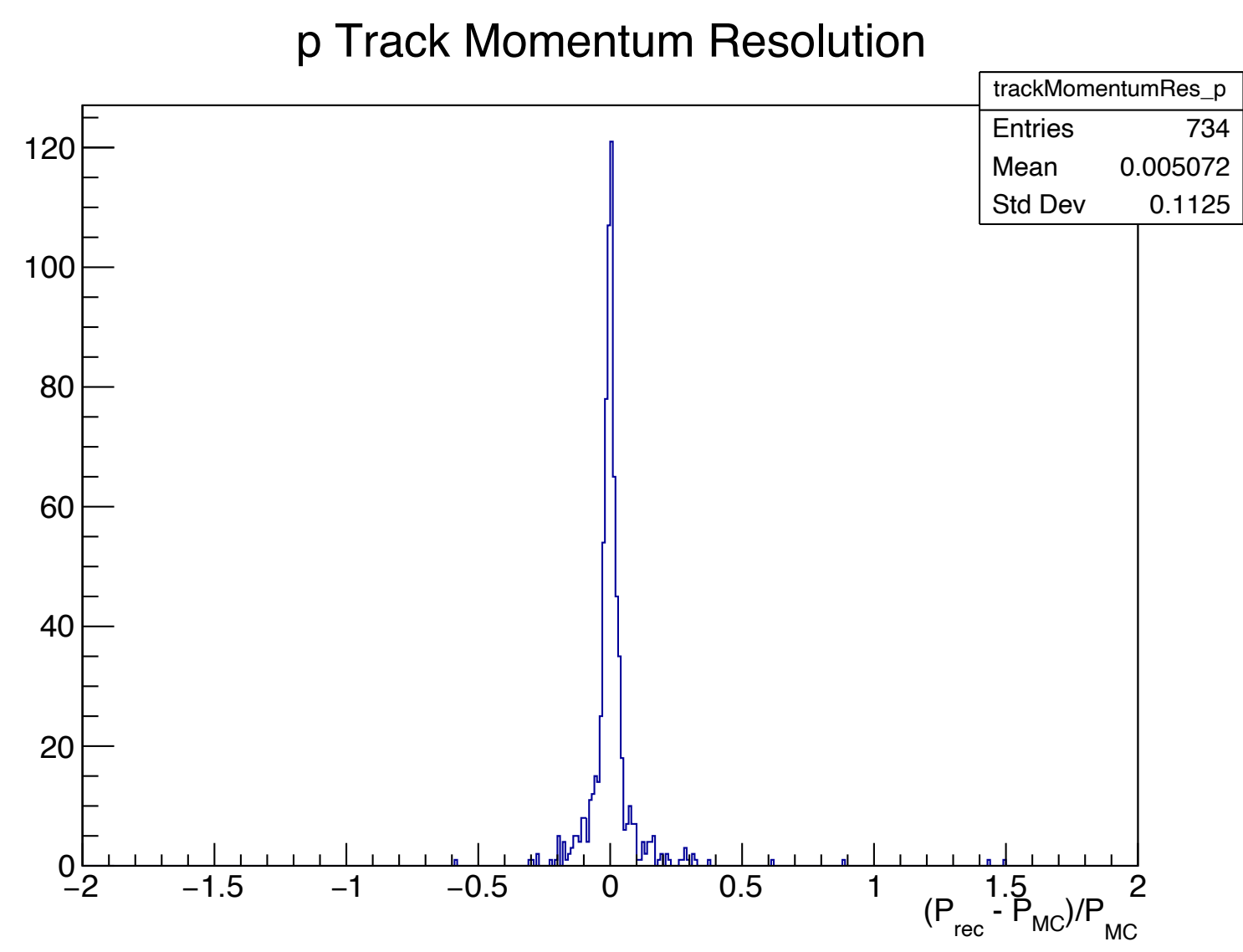
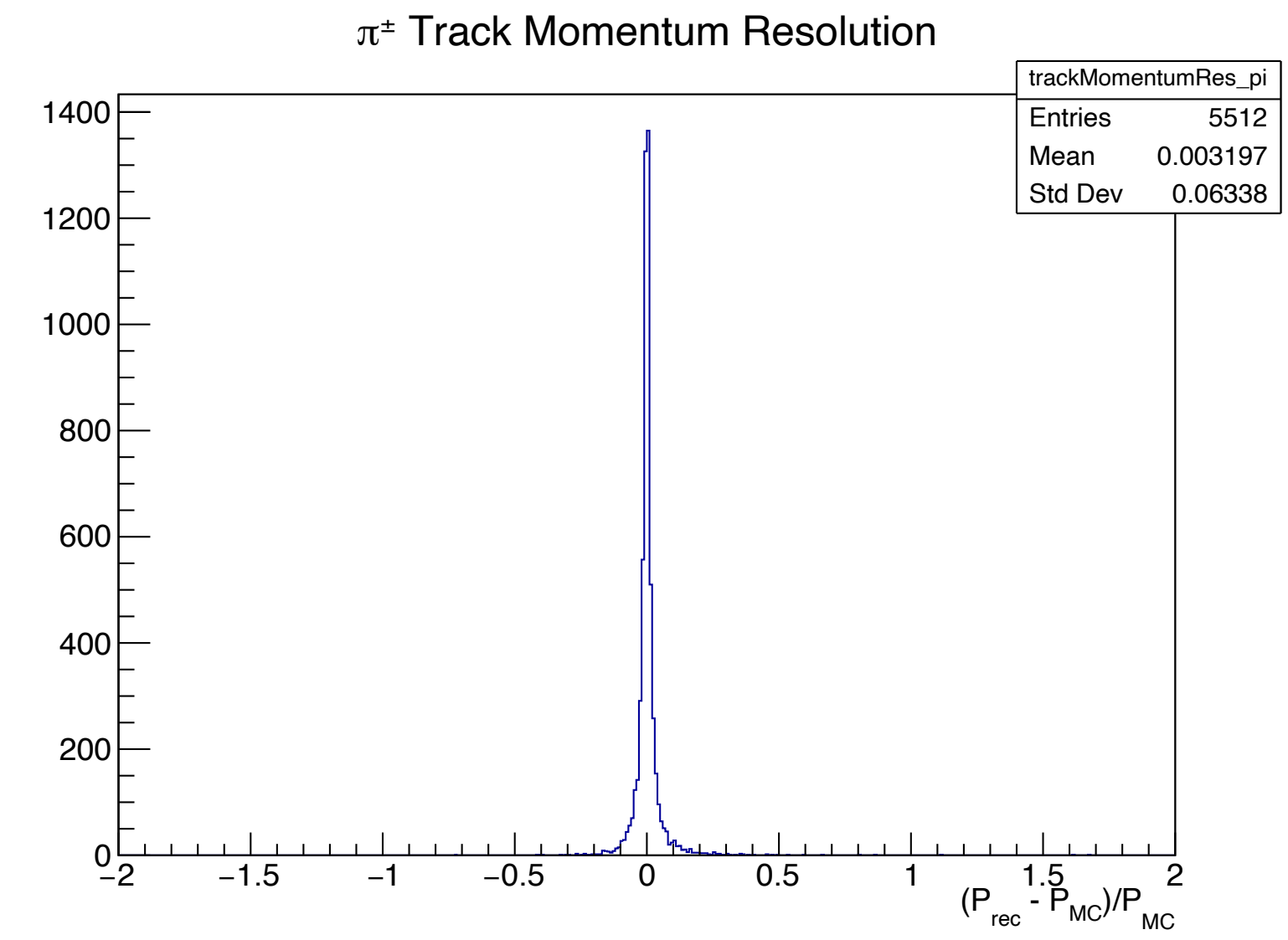
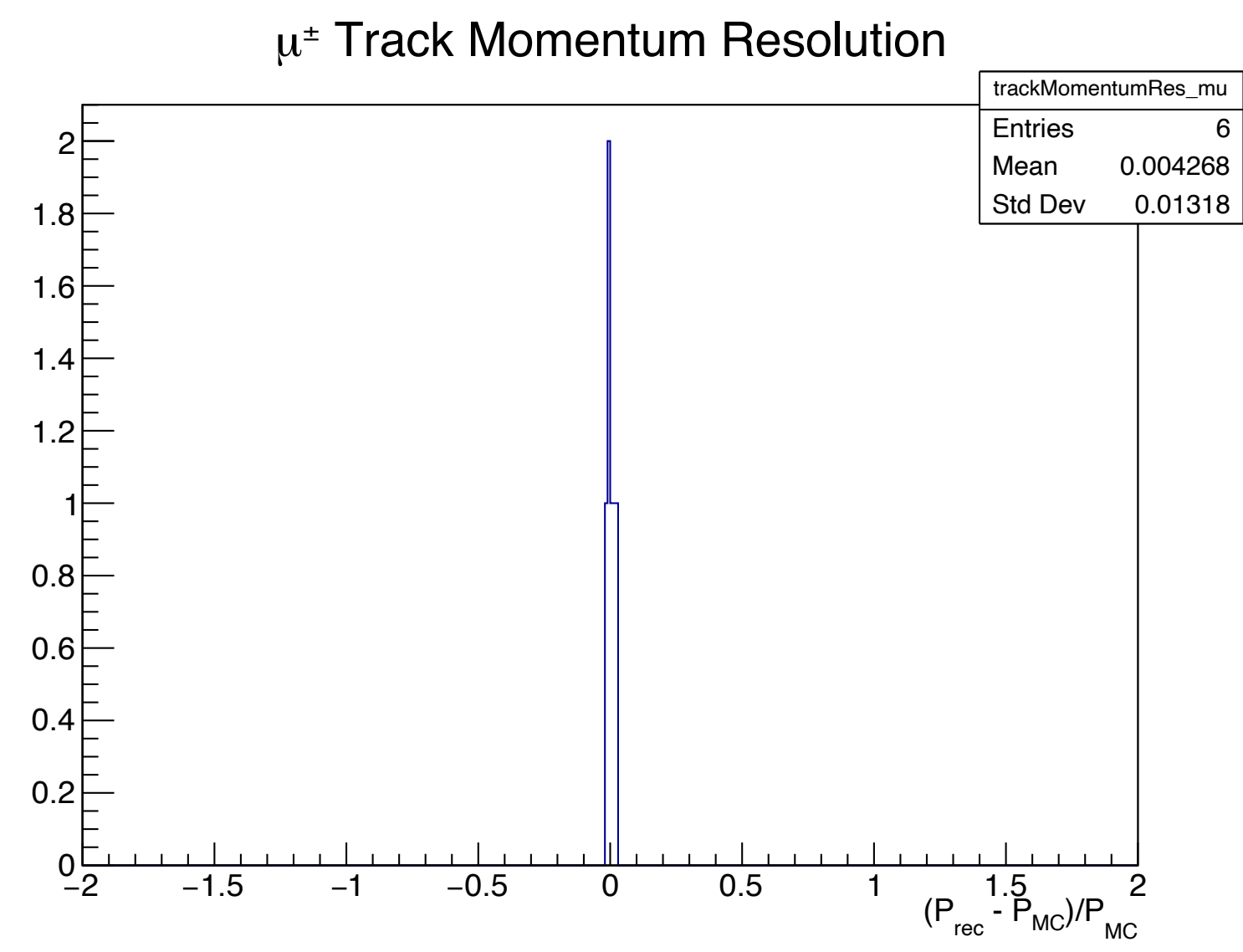
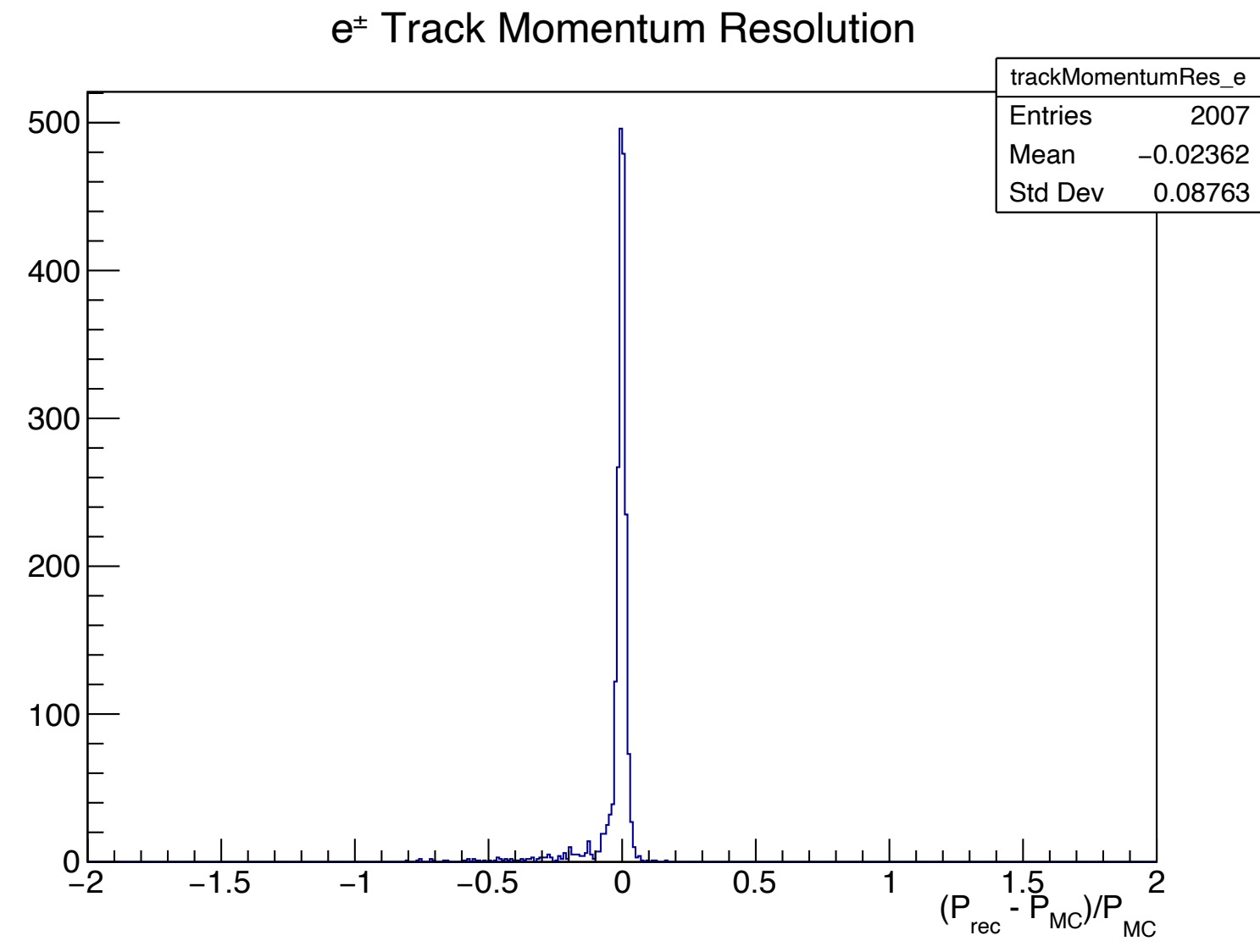
  <documentation>
    - Hcal Endcap N Layers and computed Thickness
  </documentation>

  <constant name="HcalEndcapNSingleLayerThickness"
    value="HcalEndcapNSteelThickness + HcalEndcapNPolystyreneThickness + HcalEndcapNLayerGap"/>
  <constant name="HcalEndcapNLayer_NRepeat" value="floor(HcalEndcapN_length / HcalEndcapNSingleLayerThickness)"/>
  <constant name="HcalEndcapN_thickness" value="HcalEndcapNLayer_NRepeat * HcalEndcapNSingleLayerThickness"/>
</define>

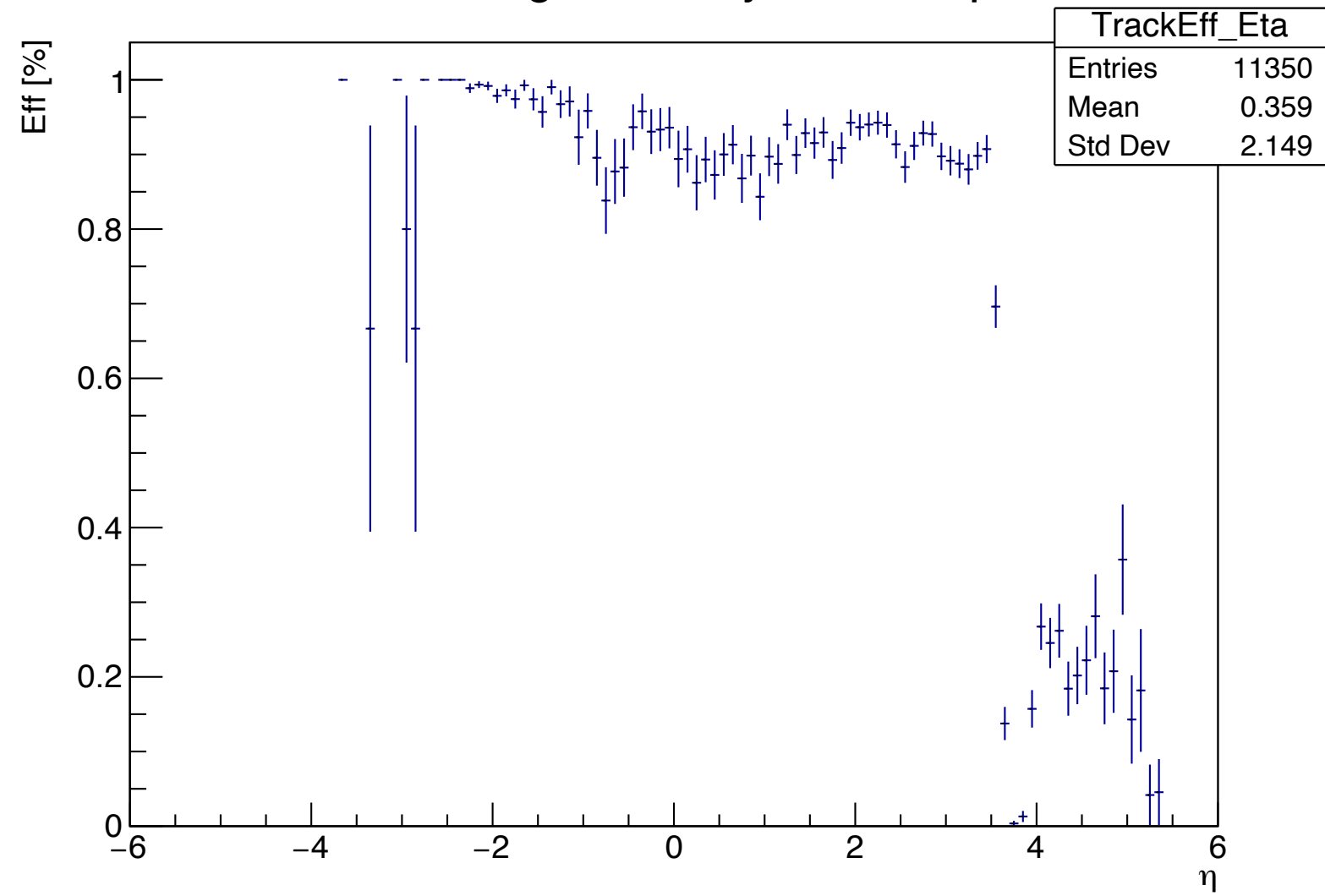
<!-- Define detector -->
<detectors>
<documentation>
  ### Backwards (Negative Z) Endcap Hadronic Calorimeter
</documentation>
<detector
id="HcalEndcapN_ID"
name="HcalEndcapN"
type="epic_PolyhedraEndcapCalorimeter2"
readout="HcalEndcapNHits"
vis="HcalEndcapVis"
calorimeterType="HAD_ENDCAP" reflect="true">
  <position x="0" y="0" z="0"/>
  <dimensions
    numsides="HcalEndcapN_CaloSides"
    zmin="HcalEndcapN_zmin"
    rmin="HcalEndcapN_rmin"
    rmax="HcalEndcapN_rmax"/>
  <layer repeat="HcalEndcapNLayer_NRepeat" vis="HcalEndcapLayerVis" >
    <slice material="StainlessSteel" thickness="HcalEndcapNSteelThickness" vis="HcalAbsorberVis"/>
    <slice material="Air" thickness="HcalEndcapNLayerGap/2" vis="InvisibleNoDaughters"/>
    <slice material="Polystyrene" thickness="HcalEndcapNPolystyreneThickness" vis="HcalSensorVis" sensitive="yes" limits="cal_limits"/>
    <slice material="Air" thickness="HcalEndcapNLayerGap/2" vis="InvisibleNoDaughters"/>
  </layer>
</detector>
</detectors>

<!-- Definition of the readout segmentation/definition -->
<readouts>
  <readout name="HcalEndcapNHits">
    <segmentation type="CartesianGridXY" grid_size_x="100 * mm" grid_size_y="100 * mm"/>
    <id>system:8,barrel:3,module:4,layer:8,slice:5,x:32:-16,y:-16</id>
  </readout>
</readouts>

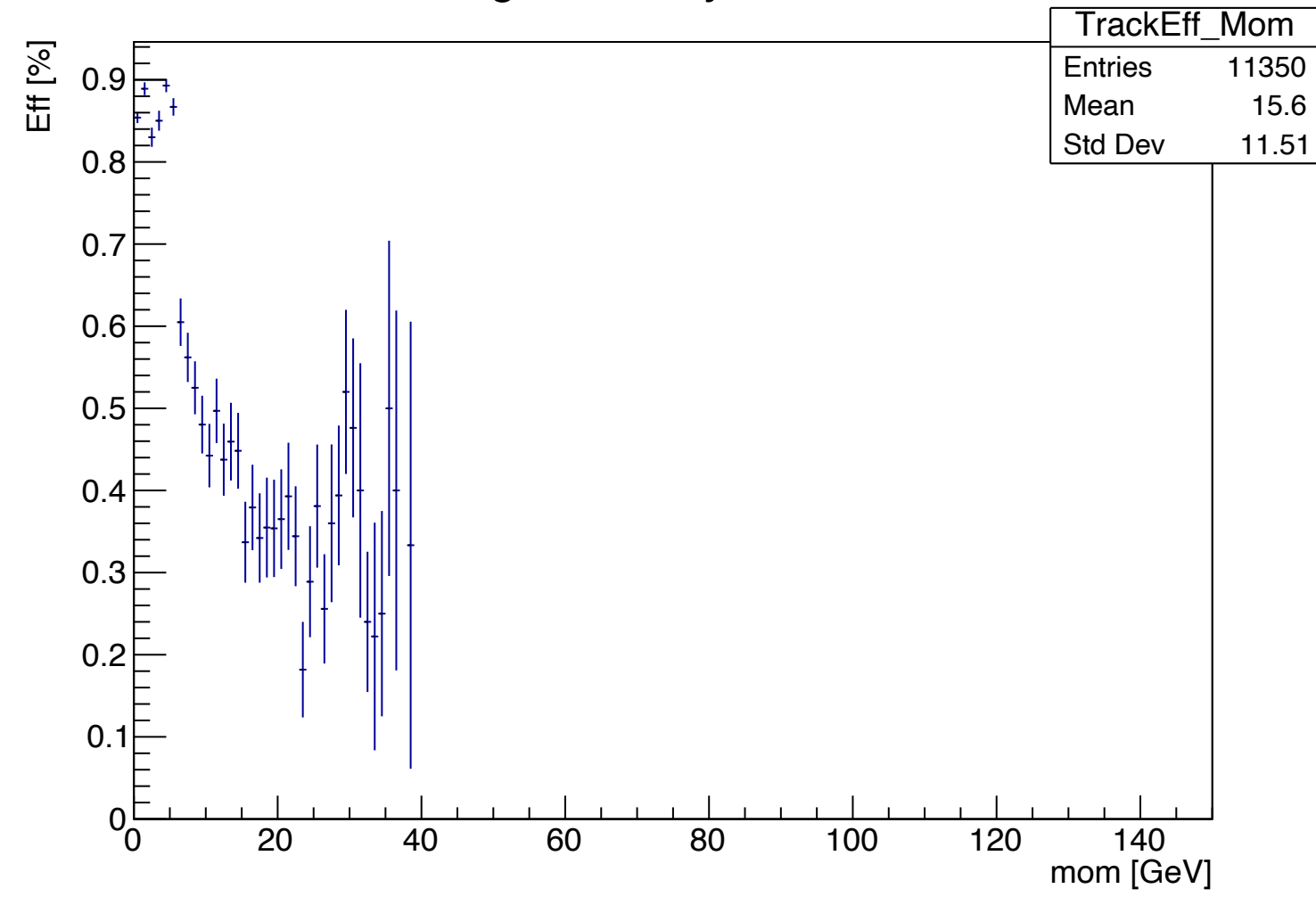
</lccdd>
```



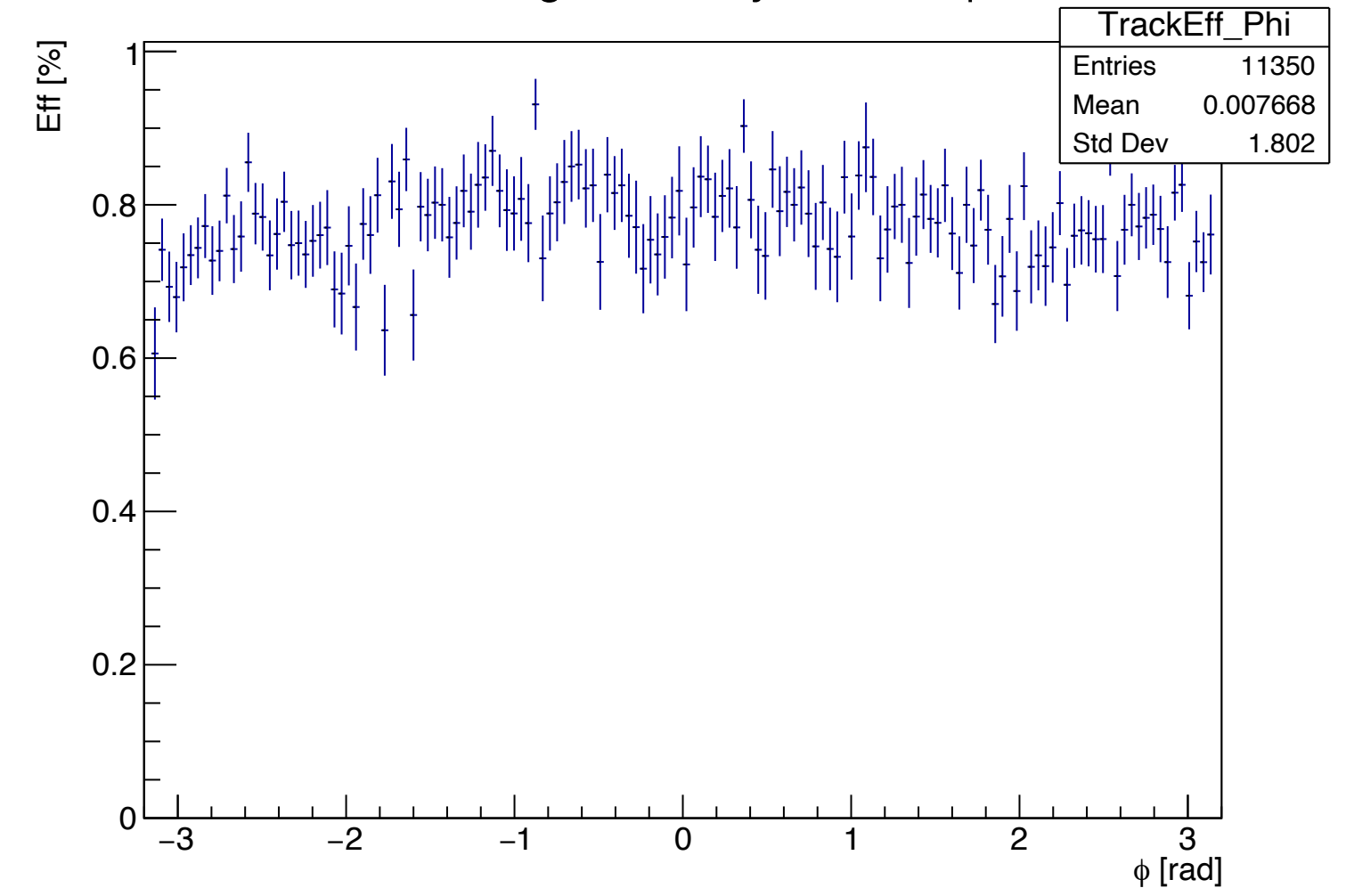
Tracking efficiency as fn of η



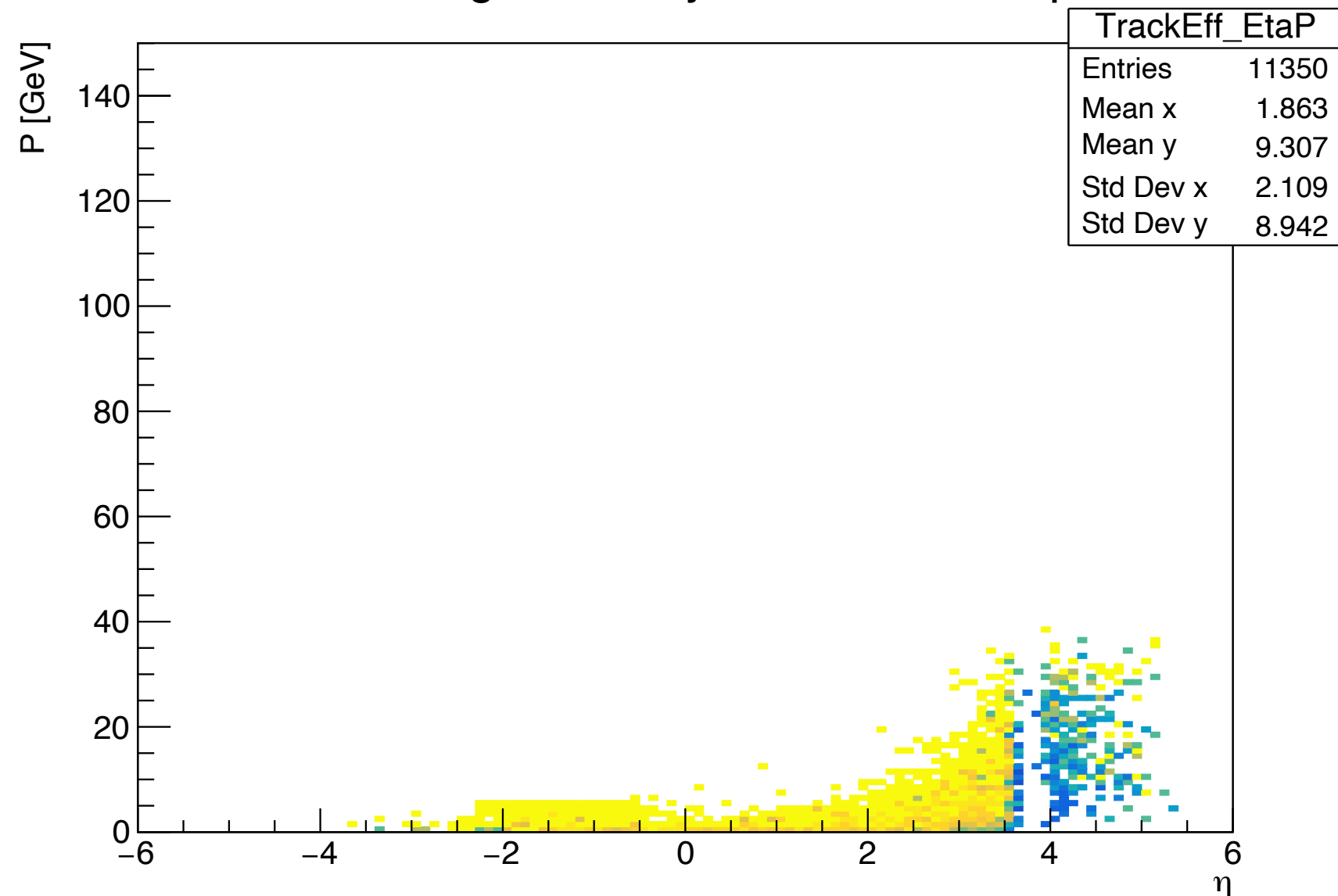
Tracking efficiency as fn of mom



Tracking efficiency as fn of ϕ



Tracking efficiency as fn of P and η



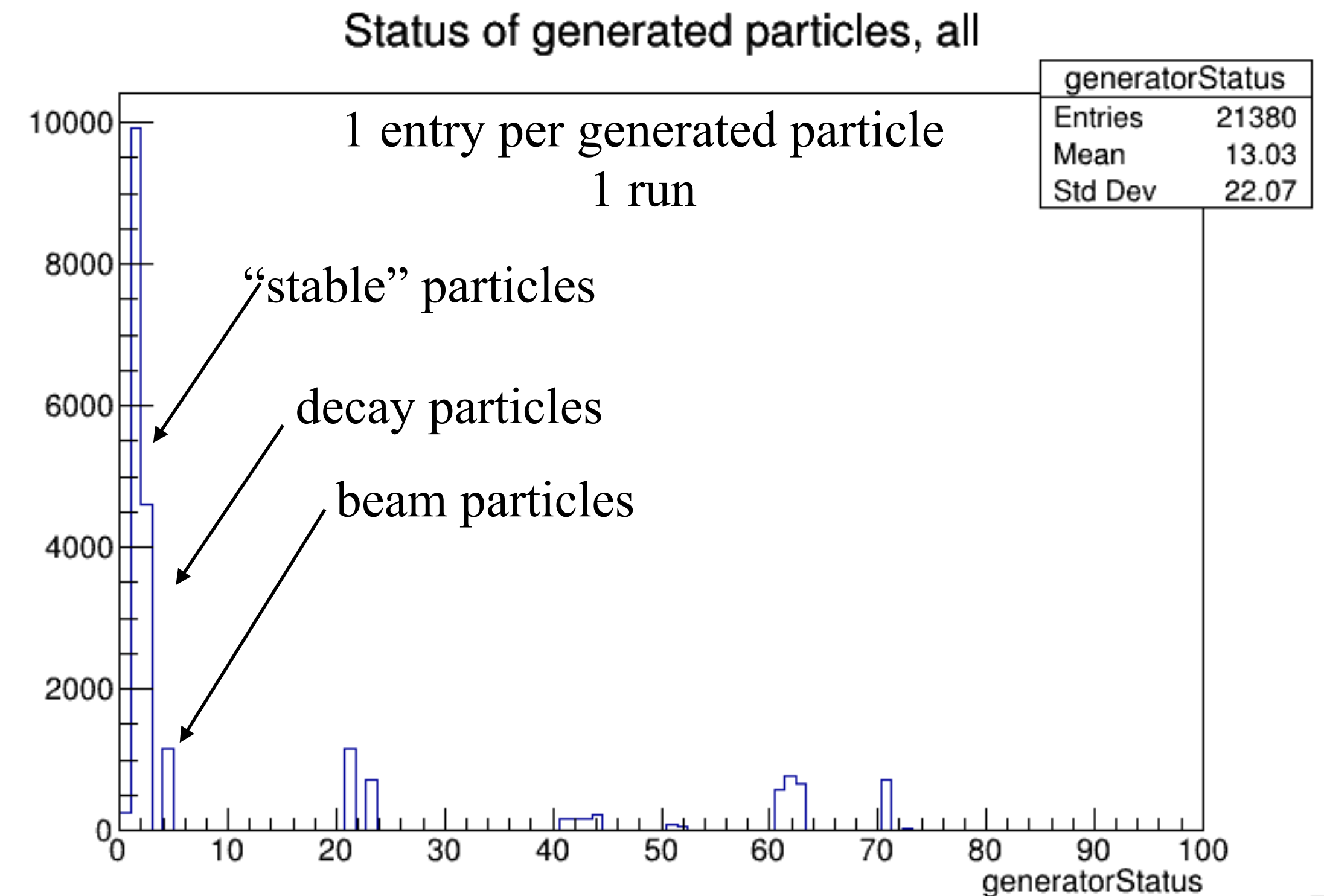
- S3/eicctest/EPIC/RECO/24.07.0/epic_craterlake/DIS/NC/18x275/minQ2=1
- MCParticles.generatorStatus: 1: stable; 2: decay; 4: beam particle; 21, 23, 61, 62, 63, 71, ... are [di]quark-related
Set in DD4Hep -> Geant4InputAction::setGeneratorStatus. It is possible that it stays in its initial value= 0

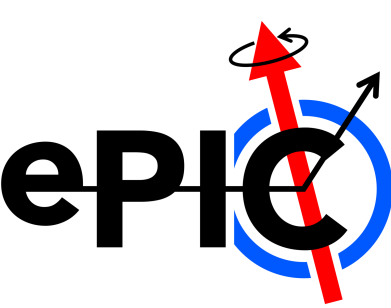
- Selecting only **stable (1) or decay (2)** particles:

Number of generated events: 581
Number of generated electrons: 1207
Number of generated protons: 1107
Number of generated muons: 3
Number of generated pions: 3670
Number of generated kaons: 365
Number of generated rho0: 313
Number of generated jpsi: 0

Number of reconstructed electrons: 599
Number of reconstructed protons: 164
Number of reconstructed muons: 2
Number of reconstructed pions: 2287
Number of reconstructed kaons: 252

(lost 1 muon because it has status 0...)





What is included in `MCParticles.daughters_begin` and `MCParticles.daughters_end` is a set of indices to the `_MCParticles_daughters` collection. That then contains the MCParticle indices of the daughters.

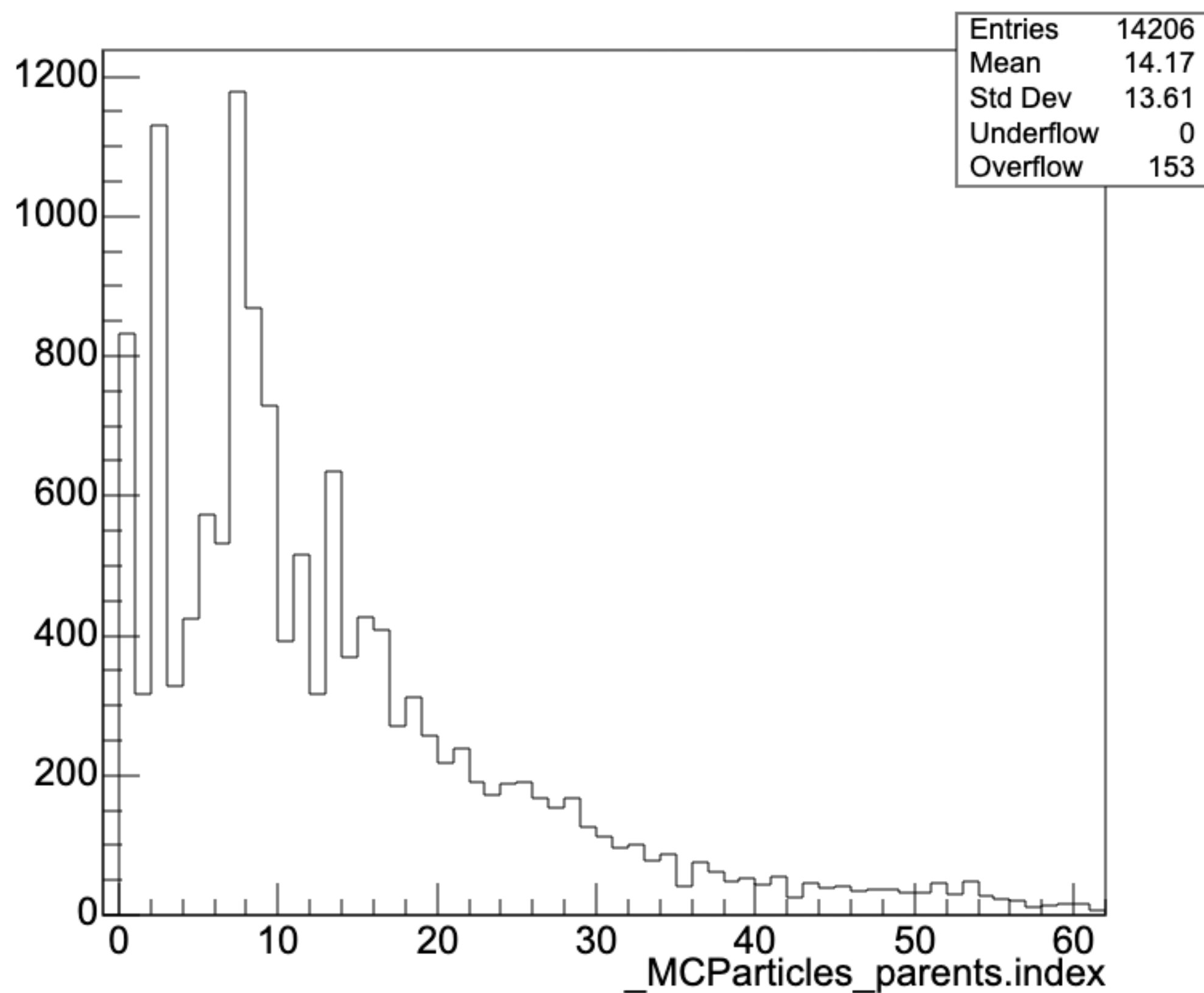
For example, on that event, you can see `MCParticles.daughters_begin:MCParticles.daughters_end:_MCParticles_daughters[MCParticles.daughters_begin].index:_MCParticles_daughters[MCParticles.daughters_begin+1].index` below in the columns with bolded headers. This event has the 2214 at index 10, with `daughters_begin` at 17 and `daughters_end` at 19 (exclusive), so the daughters have indices in `_MCParticles_daughters` at index 17 and 18. Those indices are the underline 14 and 15, which is what you expect.

Table 1

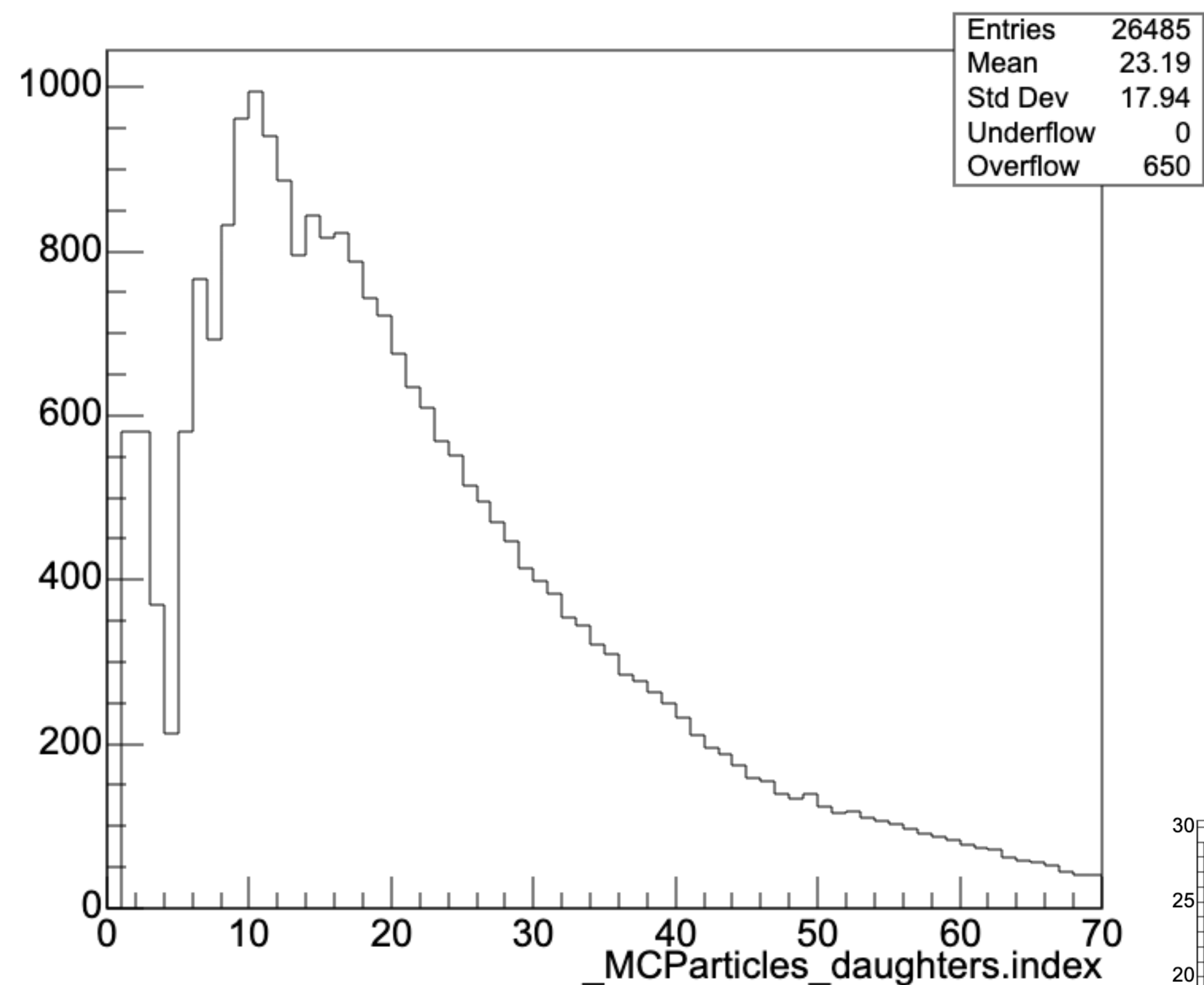
root	[18]	begin:MCParticles.daughters_end:_MCParticles_daughters[MCParticles.d	"Entry\$==481")
****	*****	*****	*****
*	Row	cl * MCParticl	* _MCPartic * MCParticl * MCParticl * _MCPartic * _MCPartic * MCParticl * MCPartic
****	*****	*****	*****
*	481	* 0 *	0 * 0 * 0 * 2 * 1 * 2 * -6.836757 * 0.0269992 * 274.70120 *
*	481	0 *	1 * 0 * 2 * 3 * 5 * 8 * -1.913090 * 0.1341571 * 47.586360 *
*	481	* 1 *	2 * 0 * 3 * 6 * 8 * 9 * -5.230277 * -0.189162 * 228.13504 *
*	481	* 2 *	2 * 3 * 6 * 7 * 4 * 6 * -0.000790 * -0.001247 * -17.99352 *
*	481	* 2 *	3 * 3 * 7 * 9 * 6 * 11 * -0.000790 * -0.001247 * -17.99360 *
*	481	3 *	4 * 1 * 9 * 11 * 6 * 11 * -0.660673 * 0.0026090 * 26.545969 *
*	481	4 *	6 * 4 * 11 * 12 * 7 * 8 * -1.895213 * -0.380629 * 26.490619 *
*	481	6 *	7 * 6 * 12 * 15 * 8 * 9 * -2.841020 * -0.167077 * 46.511547 *
*	481	7 *	9 * 2 * 15 * 17 * 12 * 13 * -1.852332 * -0.093008 * 39.270828 *
*	481	9 *	11 * 2 * 17 * 17 * 14 * 15 * -1.217609 * -0.078034 * 21.093732 *
*	481	11 *	13 * 2 * 17 * 19 * 14 * 15 * -5.001356 * -0.185196 * 214.28201 *
*	481	13 *	15 * 4 * 19 * 19 * 16 * 17 * 1.2337501 * 0.3819910 * -17.93897 *
*	481	15 *	16 * 8 * 19 * 19 * 16 * 17 * -1.420148 * -0.174157 * 34.093940 *
*	481	16 *	17 * 8 * 19 * 21 * 16 * 17 * -0.432184 * 0.0811491 * 5.1768918 *
*	481	* 17 *	18 * 10 * 21 * 21 * * * -3.535949 * -0.449146 * 144.04588 *
*	481	18 *	19 * 10 * 21 * 21 * * * -1.465407 * 0.2639502 * 70.236137 *
*	481	19 *	20 * 13 * 21 * 21 * * * -0.092389 * 0.0760597 * 1.4554925 *
*	481	20 *	21 * 13 * 21 * 21 * * * -0.339794 * 0.0050893 * 3.7213962 *
****	*****	*****	*****
==>	18 sel		ected entries

`_MCParticles_parents[MCParticles.parents_begin].index`
`MCParticles.daughters_begin`
`MCParticles.daughters_end`
`_MCParticles_daughters[MCParticles.daughters_begin].index`
`_MCParticles_daughters[MCParticles.daughters_begin+1].index`

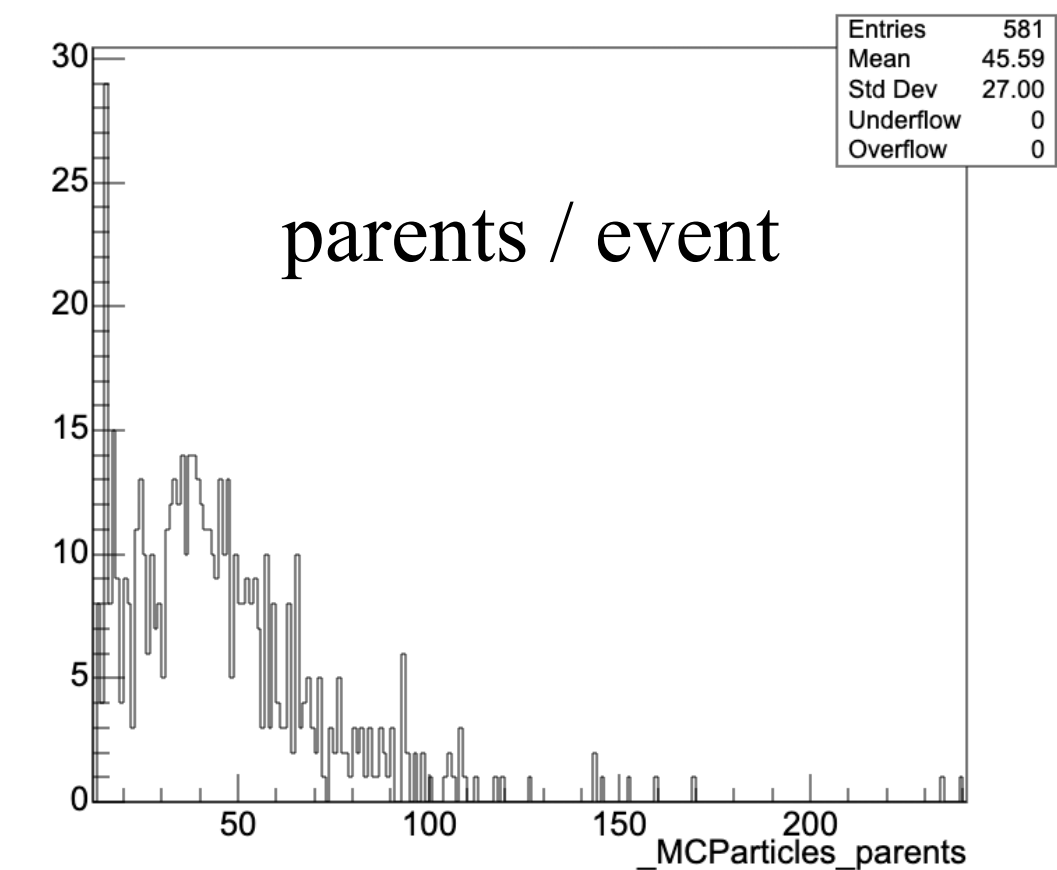
drawing branch '_MCParticles_parents.index' from events



drawing branch '_MCParticles_daughters.index' from events



drawing branch '_MCParticles_parents' from events



MCParticles parents and daughters - all particles, wrong



```
Event #: 581, 27 gen particles, 32 parent particles, 32 daughter particles
Ev#: 581, P-index: 0, PDG: 2212, GenStatus:4, i_parents: 1, i_daughters: 3, pb: 0, pe: 0, db: 1, de: 5
Ev#: 581, P-index: 1, PDG: 2, GenStatus:61, i_parents: 2, i_daughters: 2, pb: 0, pe: 0, db: 5, de: 8
Ev#: 581, P-index: 2, PDG: 2101, GenStatus:63, i_parents: 2, i_daughters: 6, pb: 0, pe: 3, db: 8, de: 4
Ev#: 581, P-index: 3, PDG: 11, GenStatus:4, i_parents: 1, i_daughters: 2, pb: 3, pe: 3, db: 4, de: 6
Ev#: 581, P-index: 4, PDG: 11, GenStatus:21, i_parents: 2, i_daughters: 3, pb: 3, pe: 1, db: 6, de: 6
Ev#: 581, P-index: 5, PDG: 2, GenStatus:21, i_parents: 2, i_daughters: 3, pb: 1, pe: 4, db: 6, de: 7
Ev#: 581, P-index: 6, PDG: 2, GenStatus:23, i_parents: 3, i_daughters: 2, pb: 4, pe: 6, db: 7, de: 8
Ev#: 581, P-index: 7, PDG: 2, GenStatus:62, i_parents: 2, i_daughters: 6, pb: 6, pe: 2, db: 8, de: 14
Ev#: 581, P-index: 8, PDG: 221, GenStatus:2, i_parents: 3, i_daughters: 4, pb: 2, pe: 2, db: 14, de: 17
Ev#: 581, P-index: 9, PDG: 111, GenStatus:2, i_parents: 3, i_daughters: 3, pb: 2, pe: 2, db: 17, de: 19
Ev#: 581, P-index: 10, PDG: 213, GenStatus:2, i_parents: 3, i_daughters: 3, pb: 2, pe: 2, db: 19, de: 21
Ev#: 581, P-index: 11, PDG: 2112, GenStatus:1, i_parents: 3, i_daughters: 1, pb: 2, pe: 2, db: 21, de: 21
Ev#: 581, P-index: 12, PDG: 111, GenStatus:2, i_parents: 3, i_daughters: 3, pb: 2, pe: 4, db: 21, de: 23
Ev#: 581, P-index: 13, PDG: 11, GenStatus:1, i_parents: 3, i_daughters: 1, pb: 4, pe: 8, db: 23, de: 23
Ev#: 581, P-index: 14, PDG: 211, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 8, pe: 8, db: 23, de: 23
Ev#: 581, P-index: 15, PDG: 211, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 8, pe: 8, db: 23, de: 23
Ev#: 581, P-index: 16, PDG: 111, GenStatus:2, i_parents: 2, i_daughters: 3, pb: 8, pe: 9, db: 23, de: 25
Ev#: 581, P-index: 17, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 9, pe: 9, db: 25, de: 25
Ev#: 581, P-index: 18, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 9, pe: 10, db: 25, de: 25
Ev#: 581, P-index: 19, PDG: 211, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 10, pe: 10, db: 25, de: 25
Ev#: 581, P-index: 20, PDG: 111, GenStatus:2, i_parents: 2, i_daughters: 3, pb: 10, pe: 12, db: 25, de: 24
Ev#: 581, P-index: 21, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 12, pe: 12, db: 24, de: 24
Ev#: 581, P-index: 22, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 12, pe: 16, db: 24, de: 24
Ev#: 581, P-index: 23, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 16, pe: 16, db: 24, de: 24
Ev#: 581, P-index: 24, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 16, pe: 20, db: 24, de: 24
Ev#: 581, P-index: 25, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 20, pe: 20, db: 24, de: 24
Ev#: 581, P-index: 26, PDG: 22, GenStatus:1, i_parents: 2, i_daughters: 1, pb: 20, pe: 16, db: 24, de: 24
```

MCParticles parents and daughters - all particles, wrong



	Event #:	581,	particle index:	0,	PDG:	2212,	stable (1=yes):	4,	i_parent:	0,	i_daughter:	1
	Event #:	581,	particle index:	1,	PDG:	2,	stable (1=yes):	61,	i_parent:	0,	i_daughter:	2
	Event #:	581,	particle index:	2,	PDG:	2101,	stable (1=yes):	63,	i_parent:	3,	i_daughter:	5
	Event #:	581,	particle index:	3,	PDG:	11,	stable (1=yes):	4,	i_parent:	1,	i_daughter:	8
	Event #:	581,	particle index:	4,	PDG:	11,	stable (1=yes):	21,	i_parent:	4,	i_daughter:	9
	Event #:	581,	particle index:	5,	PDG:	2,	stable (1=yes):	21,	i_parent:	5,	i_daughter:	10
	Event #:	581,	particle index:	6,	PDG:	2,	stable (1=yes):	23,	i_parent:	6,	i_daughter:	11
	Event #:	581,	particle index:	7,	PDG:	2,	stable (1=yes):	62,	i_parent:	2,	i_daughter:	12
	Event #:	581,	particle index:	8,	PDG:	221,	stable (1=yes):	2,	i_parent:	7,	i_daughter:	4
	Event #:	581,	particle index:	9,	PDG:	111,	stable (1=yes):	2,	i_parent:	2,	i_daughter:	6
	Event #:	581,	particle index:	10,	PDG:	213,	stable (1=yes):	2,	i_parent:	7,	i_daughter:	13
	Event #:	581,	particle index:	11,	PDG:	2112,	stable (1=yes):	1,	i_parent:	2,	i_daughter:	6
	Event #:	581,	particle index:	12,	PDG:	111,	stable (1=yes):	2,	i_parent:	7,	i_daughter:	13
?	Event #:	581,	particle index:	13,	PDG:	11,	stable (1=yes):	1,	i_parent:	2,	i_daughter:	7
	Event #:	581,	particle index:	14,	PDG:	211,	stable (1=yes):	1,	i_parent:	7,	i_daughter:	8
	Event #:	581,	particle index:	15,	PDG:	211,	stable (1=yes):	1,	i_parent:	2,	i_daughter:	9
	Event #:	581,	particle index:	16,	PDG:	111,	stable (1=yes):	2,	i_parent:	7,	i_daughter:	10
	Event #:	581,	particle index:	17,	PDG:	22,	stable (1=yes):	1,	i_parent:	4,	i_daughter:	11
	Event #:	581,	particle index:	18,	PDG:	22,	stable (1=yes):	1,	i_parent:	5,	i_daughter:	12
	Event #:	581,	particle index:	19,	PDG:	211,	stable (1=yes):	1,	i_parent:	8,	i_daughter:	14
	Event #:	581,	particle index:	20,	PDG:	111,	stable (1=yes):	2,	i_parent:	8,	i_daughter:	15
	Event #:	581,	particle index:	21,	PDG:	22,	stable (1=yes):	1,	i_parent:	8,	i_daughter:	16
	Event #:	581,	particle index:	22,	PDG:	22,	stable (1=yes):	1,	i_parent:	9,	i_daughter:	17
	Event #:	581,	particle index:	23,	PDG:	22,	stable (1=yes):	1,	i_parent:	9,	i_daughter:	18
	Event #:	581,	particle index:	24,	PDG:	22,	stable (1=yes):	1,	i_parent:	10,	i_daughter:	19
	Event #:	581,	particle index:	25,	PDG:	22,	stable (1=yes):	1,	i_parent:	10,	i_daughter:	20
	Event #:	581,	particle index:	26,	PDG:	22,	stable (1=yes):	1,	i_parent:	12,	i_daughter:	21



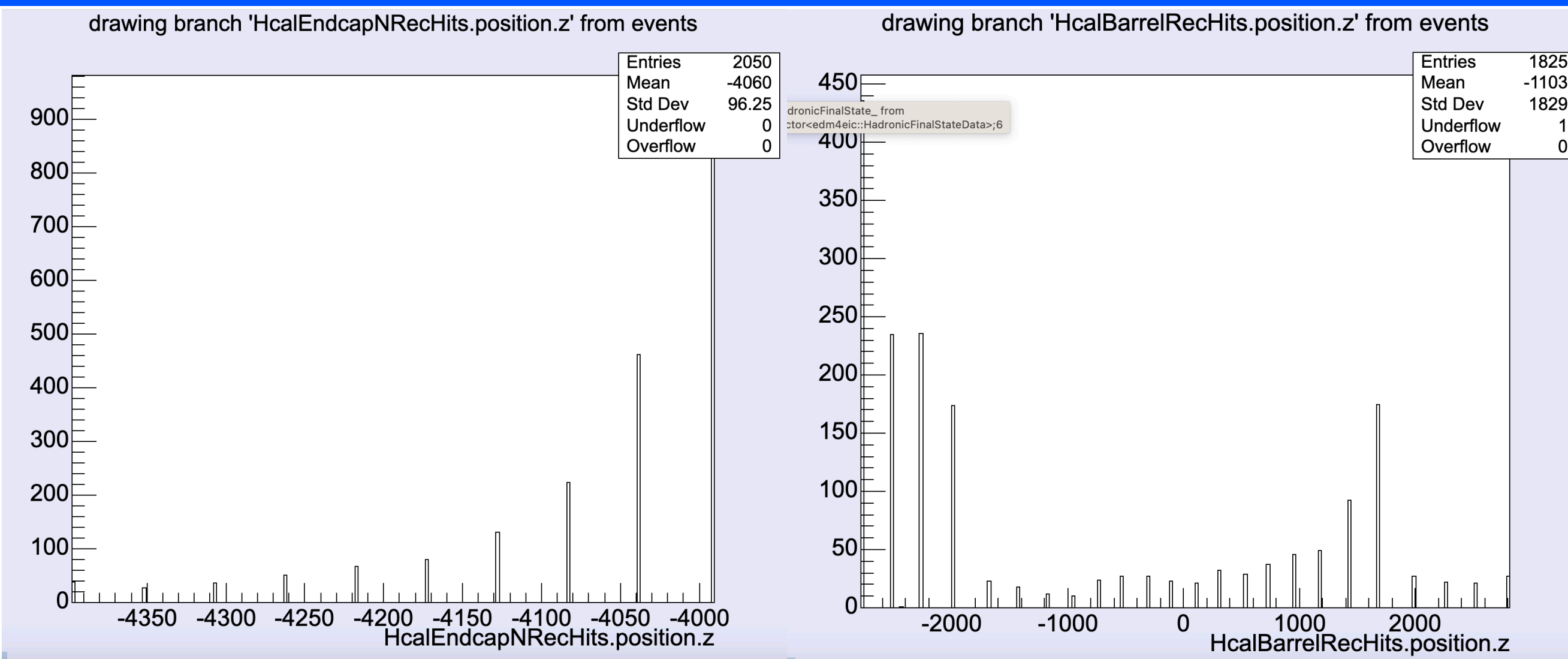
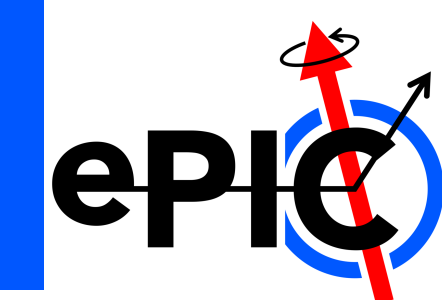
??
eta0 ->
pi+/- pi0
gamma
??

rho+ (213)-
>gamma
gamma...??

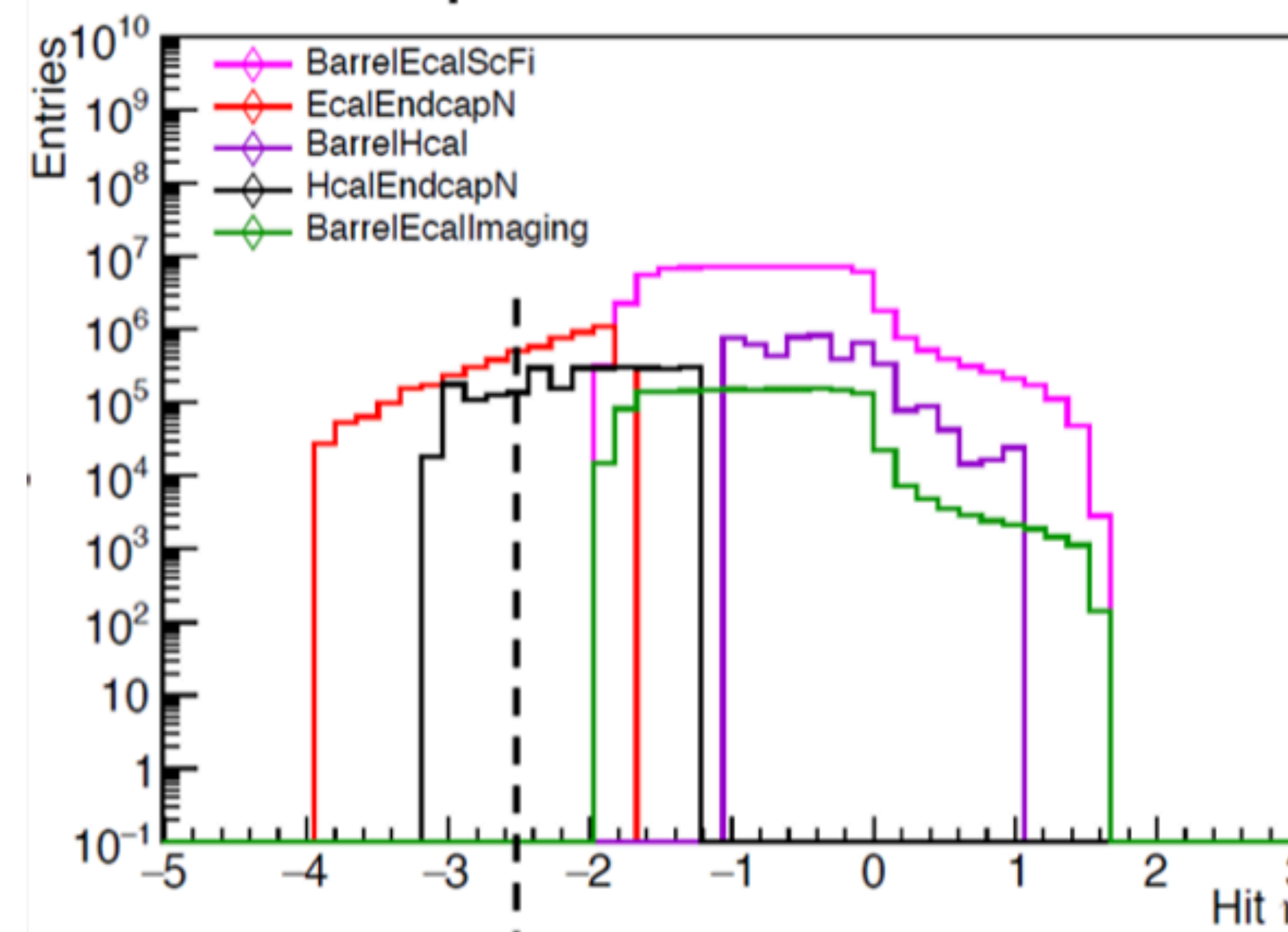
OK, pi0
decay

```
Event #: 581, particle index: 0, PDG: 2212, stable (1=yes):4, i_parent: 0, i_daughter: 1
Event #: 581, particle index: 3, PDG: 11, stable (1=yes):4, i_parent: 1, i_daughter: 8
Event #: 581, particle index: 8, PDG: 221, stable (1=yes):2, i_parent: 7, i_daughter: 4
Event #: 581, particle index: 9, PDG: 111, stable (1=yes):2, i_parent: 2, i_daughter: 6
Event #: 581, particle index: 10, PDG: 213, stable (1=yes):2, i_parent: 7, i_daughter: 13
Event #: 581, particle index: 11, PDG: 2112, stable (1=yes):1, i_parent: 2, i_daughter: 6
Event #: 581, particle index: 12, PDG: 111, stable (1=yes):2, i_parent: 7, i_daughter: 13
Event #: 581, particle index: 13, PDG: 11, stable (1=yes):1, i_parent: 2, i_daughter: 7
Event #: 581, particle index: 14, PDG: 211, stable (1=yes):1, i_parent: 7, i_daughter: 8
Event #: 581, particle index: 15, PDG: 211, stable (1=yes):1, i_parent: 2, i_daughter: 9
Event #: 581, particle index: 16, PDG: 111, stable (1=yes):2, i_parent: 7, i_daughter: 10
Event #: 581, particle index: 17, PDG: 22, stable (1=yes):1, i_parent: 4, i_daughter: 11
Event #: 581, particle index: 18, PDG: 22, stable (1=yes):1, i_parent: 5, i_daughter: 12
Event #: 581, particle index: 19, PDG: 211, stable (1=yes):1, i_parent: 8, i_daughter: 14
Event #: 581, particle index: 20, PDG: 111, stable (1=yes):2, i_parent: 8, i_daughter: 15
Event #: 581, particle index: 21, PDG: 22, stable (1=yes):1, i_parent: 8, i_daughter: 16
Event #: 581, particle index: 22, PDG: 22, stable (1=yes):1, i_parent: 9, i_daughter: 17
Event #: 581, particle index: 23, PDG: 22, stable (1=yes):1, i_parent: 9, i_daughter: 18
Event #: 581, particle index: 24, PDG: 22, stable (1=yes):1, i_parent: 10, i_daughter: 19
Event #: 581, particle index: 25, PDG: 22, stable (1=yes):1, i_parent: 10, i_daughter: 20
Event #: 581, particle index: 26, PDG: 22, stable (1=yes):1, i_parent: 12, i_daughter: 21
```

Hits in nHCal (“HcalEndcapN”)

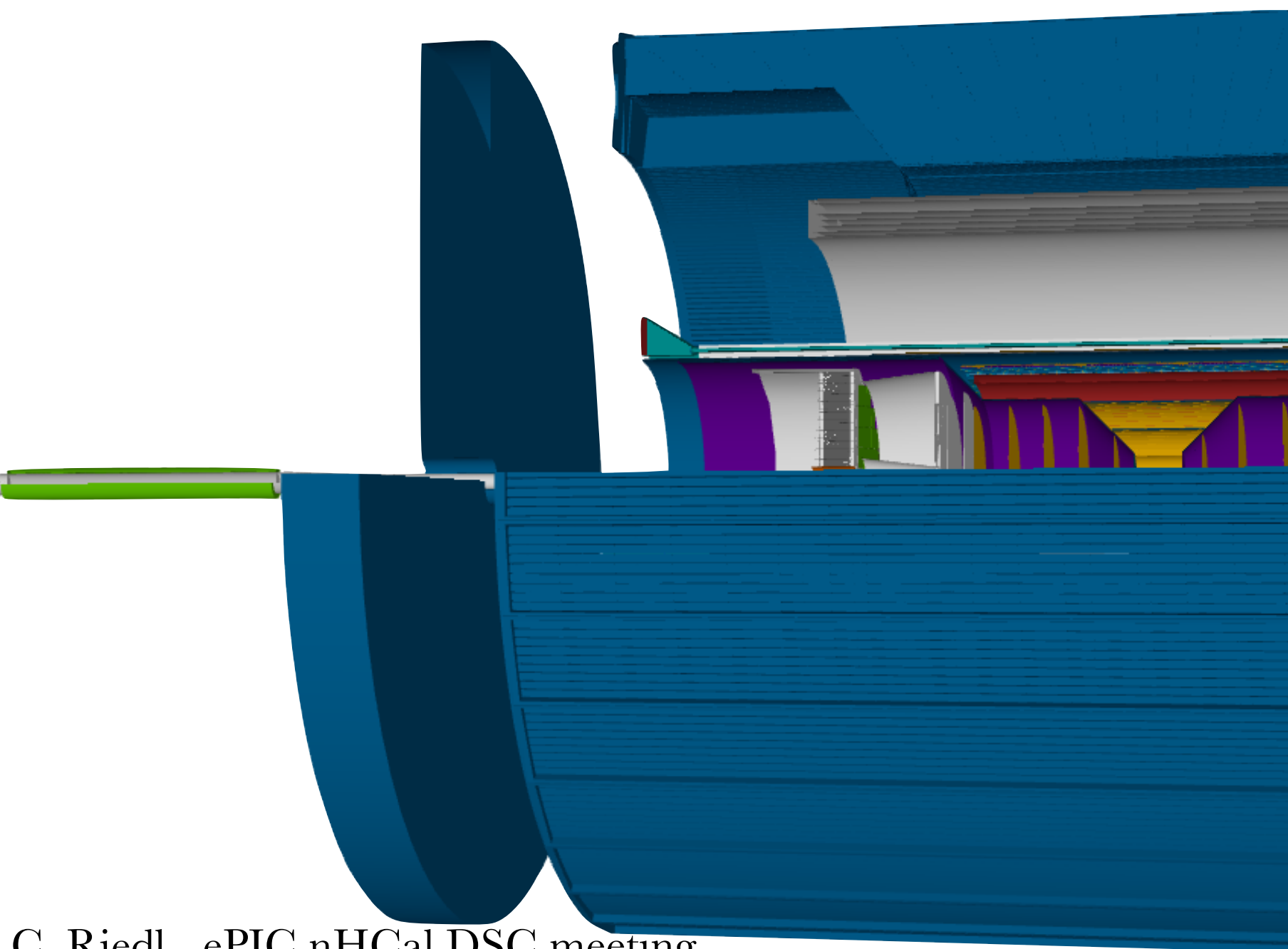
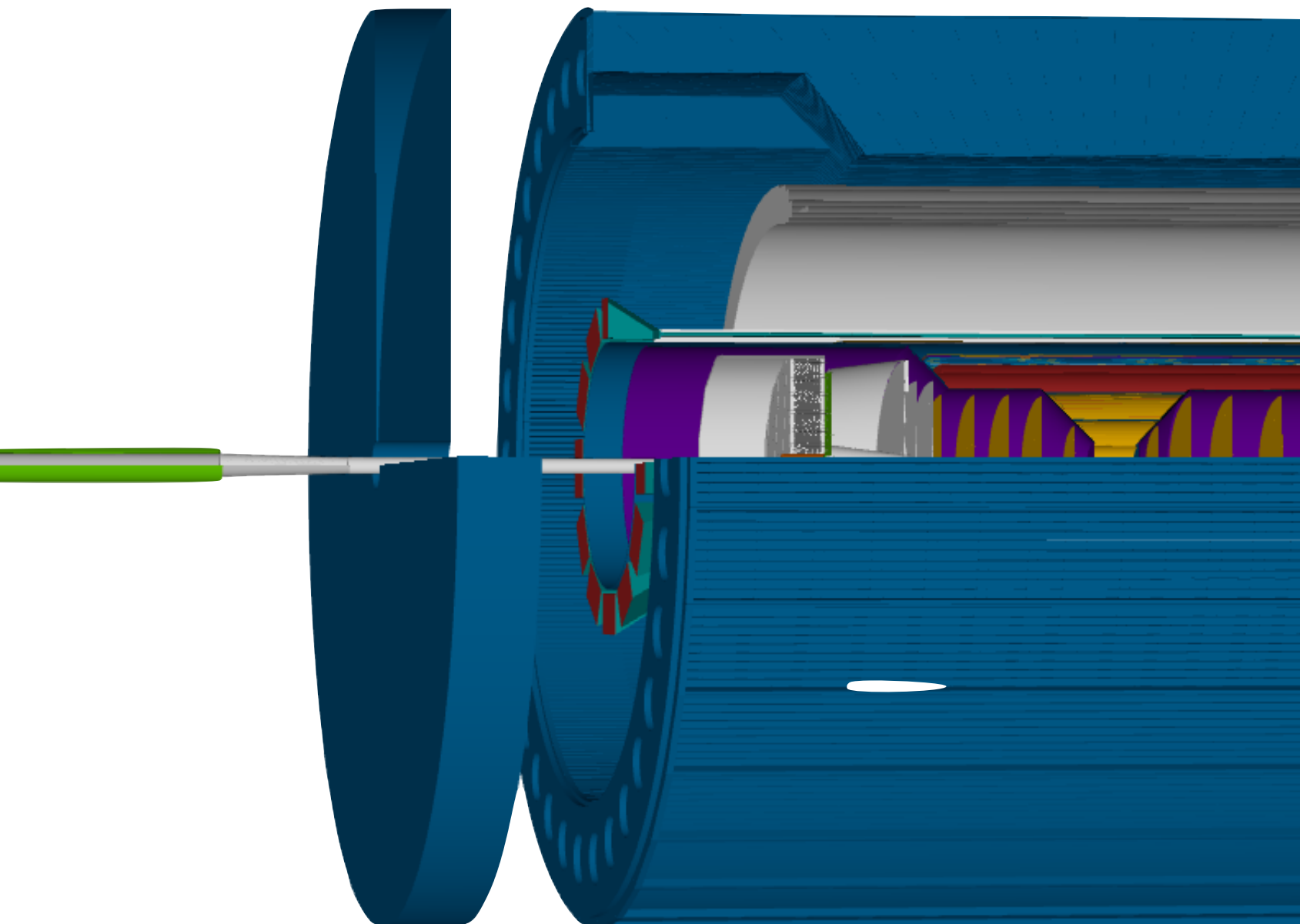
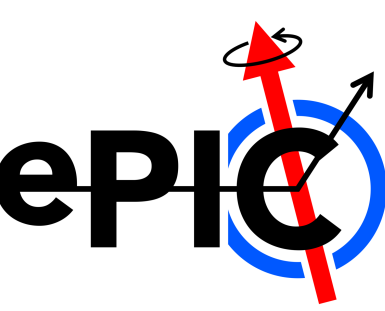


Hits overlap



- Construct 3-vector of the hits , like $nHCalhits(x,y,z)$ and then call $nHCalhits.PseudoRapidity()$...

Subhadip Pal, CTU



flux return removed

