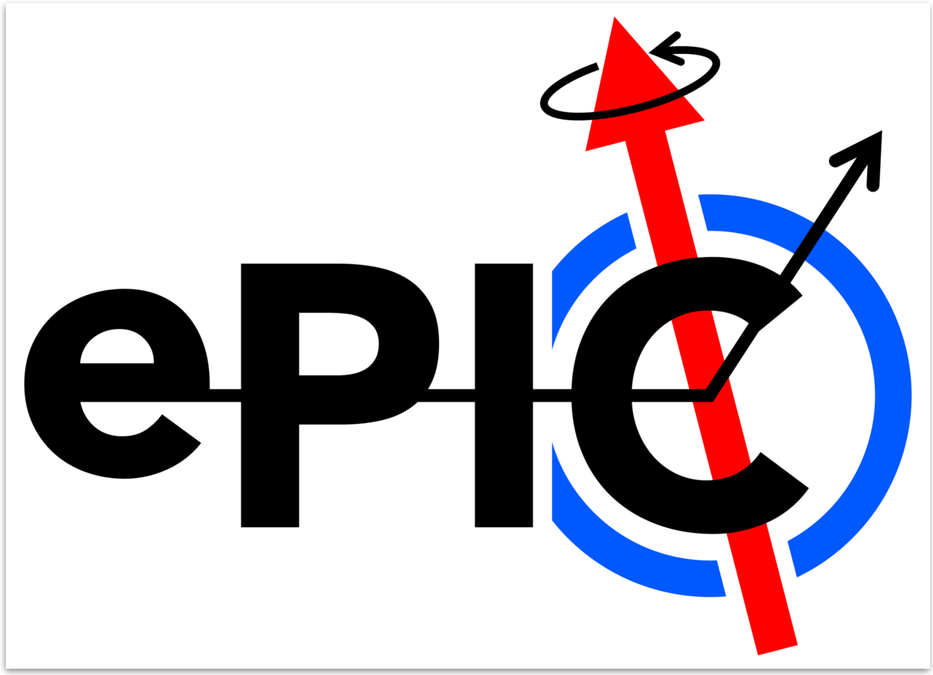


Status of simulation studies for the nHCal

Caroline Riedl (UIUC)
September 2024

Deliverables

- Muon & electron ID to improve VM reconstruction
- Muons and electrons (and mesons) 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?

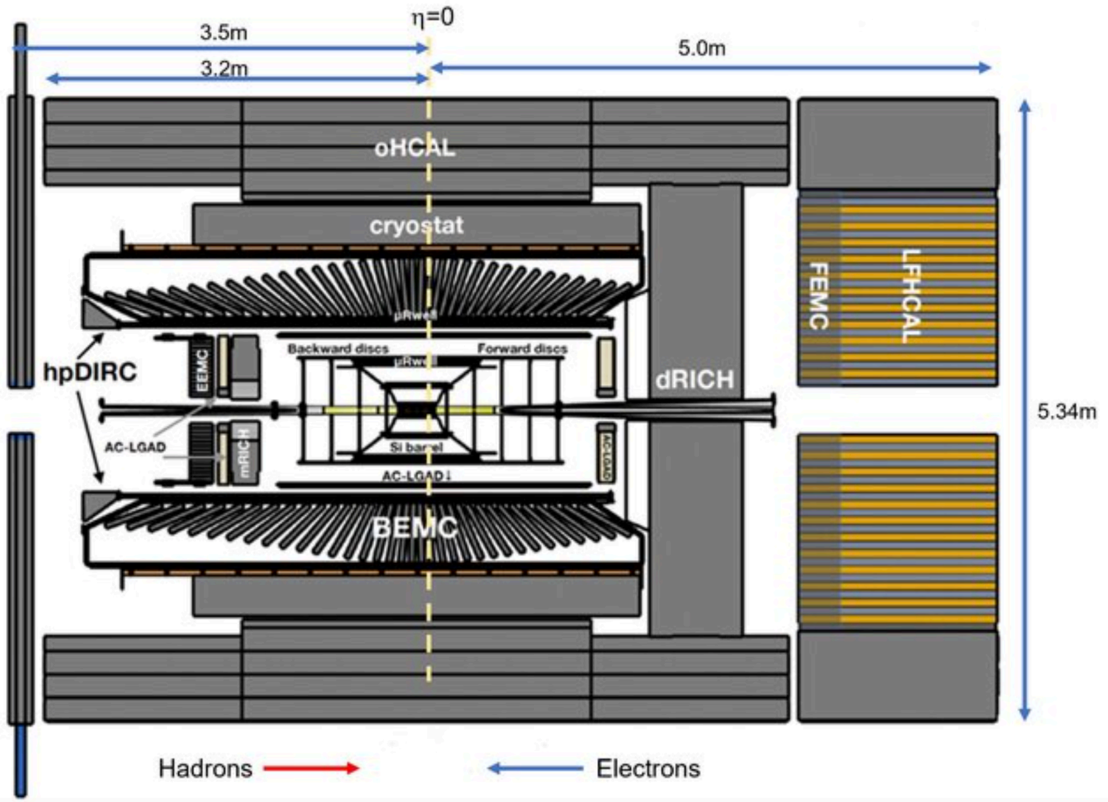
c) What is the nHCal's impact of the VM's performance? How does the acceptance change?

Studied decays and event generators (centrally produced MC)

percentage of **any reco decay particles** in nHCal acceptance	pythia8NCDIS_18x275_minQ2_1or10	pythia8NCDIS_18x275_minQ2_100	pythia8CCDIS_18x275_minQ2_100	pythia_ep_18x275_q2_0.000000001	rho_10x100_uChannel_Q2of0to10_hiDiv	sartre_bnonsat_Au_phi_ab_eAu_q2_15_1	sartre rho?	sartre_bnonsat_Au_jpsi_ab_eAu
	DIS NC minQ2 1 or 10	DIS NC minQ2 100	DIS CC minQ2 100	Photoproduction (low Q2)	rho u-channel	excl phi	excl rho?	excl J/Psi (reco by CKR with npsim)
$\rho \to \pi^+\pi^-$	4%	2%	2%	8%	No rho generated. Only see decay pions. not in nHCal	-	only EVGEN. reconstruct yourself	-
$\rho \to \mu^+\mu^-$	BR ~0.00005				^^	-		-
$\rho \to e^+e^-$					^^	-		-
$\phi \to K^+K^-$	6%	3%	2%	9%	-	42%	-	-
$\phi \to K^+K^- \to \mu^+\mu^-$	kaons are treated as stable particles (GenStatus==1) and are not decayed				-	kaons are not decayed	-	-
$J/\psi \to e^+e^-$	very few J/Psi generated && very low BR				-	-	-	54.5%
$J/\psi \to \mu^+\mu^-$					-	-	-	only decays to ee

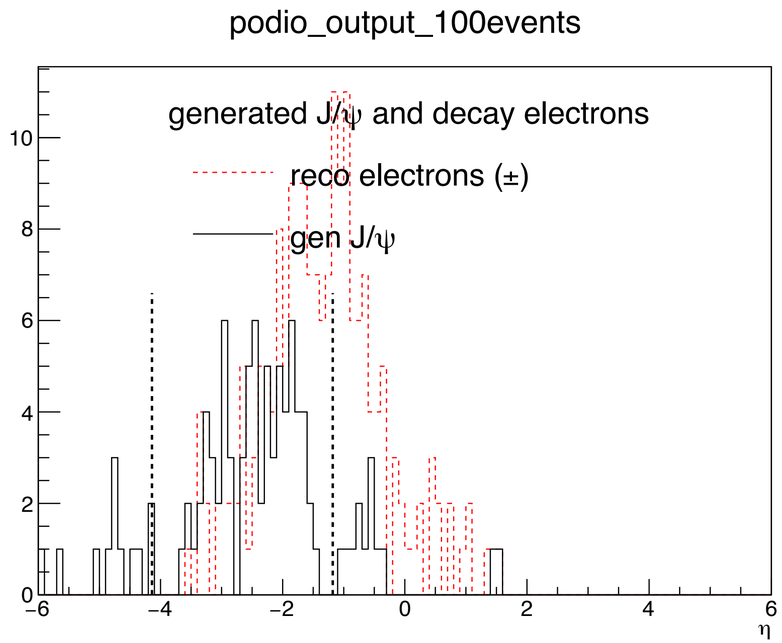
Kaon decays…

- Is it correct / realistic that the kaons are not decayed?
- $\phi \rightarrow K^+K^-$ via strong interaction
  (life time ~ 10^{-22} sec) ~ instant
- $K^{\pm} \rightarrow \mu^{\pm}\nu$ via weak interaction
  (mean life time 1.238*10^{-8} s) 3.7m.
- Many kaons will have decayed before reaching the nHCal



Conclusions from centrally produced samples

- Fractions of mesons from VM decay in nHCal acceptance (includes with full simulation of the ePIC detector and tracks reconstructed)
- DISNC, Pythia8 centrally generated - ~4-6% (2-3%) for Q2min=1…10 (100); studied decays: $\rho^0(770) \rightarrow \pi^+\pi^-$, $\phi(1020) \rightarrow K^+K^-$
  - Di-lepton decay channels have very low branching ratios and are expensive to study.
- Dedicated exclusive generator - Sartre:
  - $\phi(1020) \rightarrow K^+K^-$ 42% (kaons not decayed)
  - $J/\psi \rightarrow e^+e^-$ 55% (no decay to muons)



new

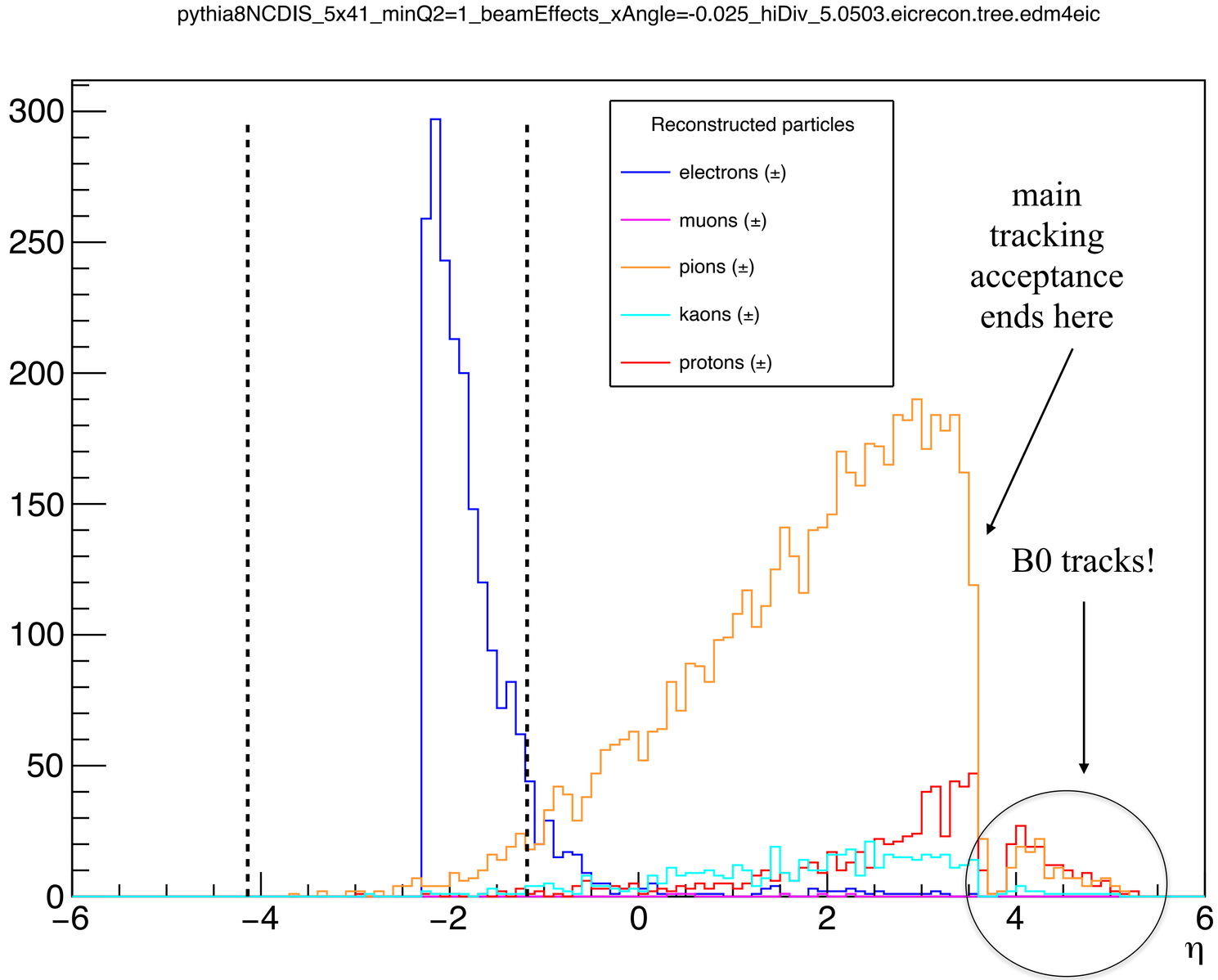
To do

- Study other event generators & VM decays (J/Psi, Upsilon, …) & KLong & CCDIS (low y is important for nHCal acc.)
  - Sartre, studied exclusive phi and J/psi (no rho exists?) -> high meson (and electron) fraction in nHCal
    - does rho production exist? Upsilon?
    - Need more stat for J/Psi = submit jobs to condor. Do the same for excl. rho Sartre; exists only was generated flavor (see diffractive_gen.txt)
    - u-channel VM - find high fraction of electrons in nHCal; but where are the generated VM?
- Study the particle populations on a deeper level:
  - Plot vs. x-Bjorken. Reco / coverage in other calorimeters (→ what Vincent did). To that end, need correct eta ranges (discussion Sep 12)
  - Hits; track-cluster matching. Start and stop vertex of reco'ed particles.
  - Reproduce outdated plots with latest geometry: hit distribution; interaction & radiation length (→ Vincent)
  - Simulations with and without nHCal included in the ePIC geometry… with latest settings
  - Understand calo clustering algorithm, look at event display
- Started working with 2 UIUC undergrad students on ePIC simulations

Collections of all plots

Reconstructed eta distribution - pythia, Q2min = 1 GeV2, 5x41

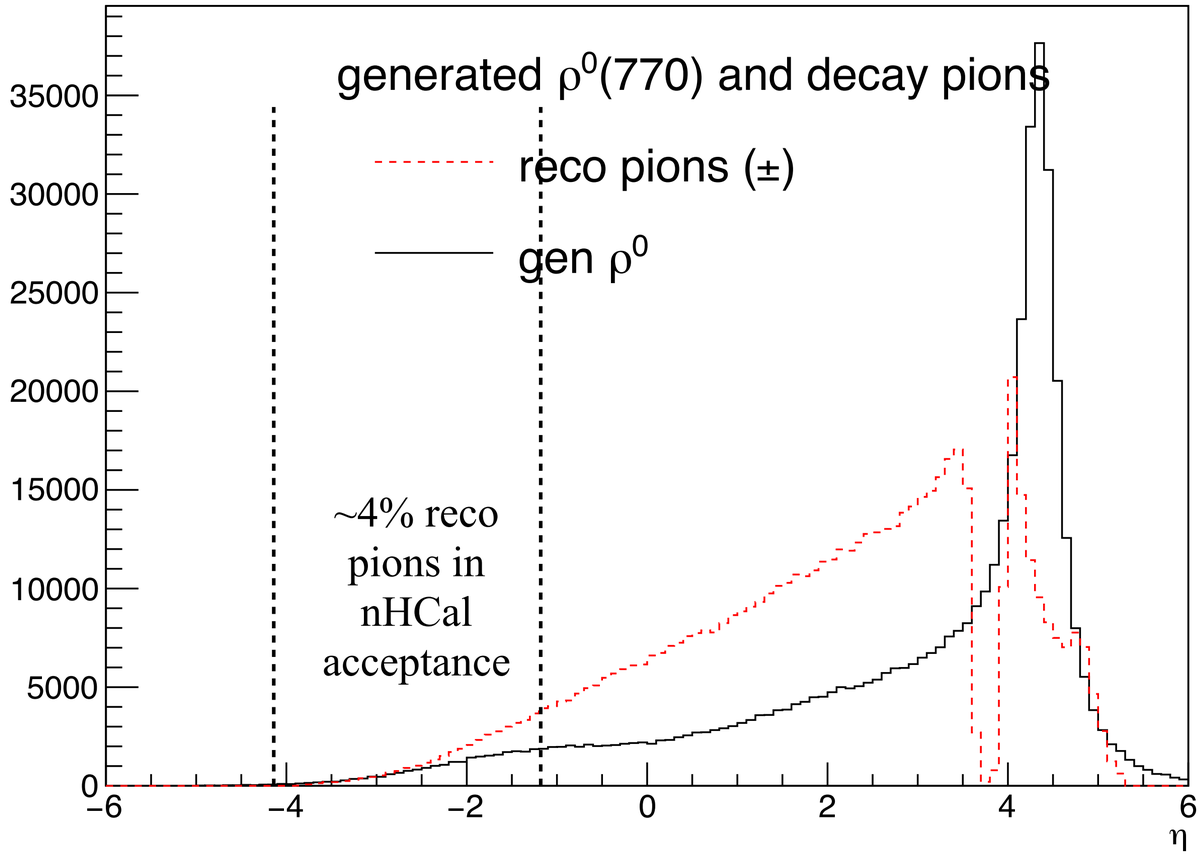
only reconstructed particles matched to generated

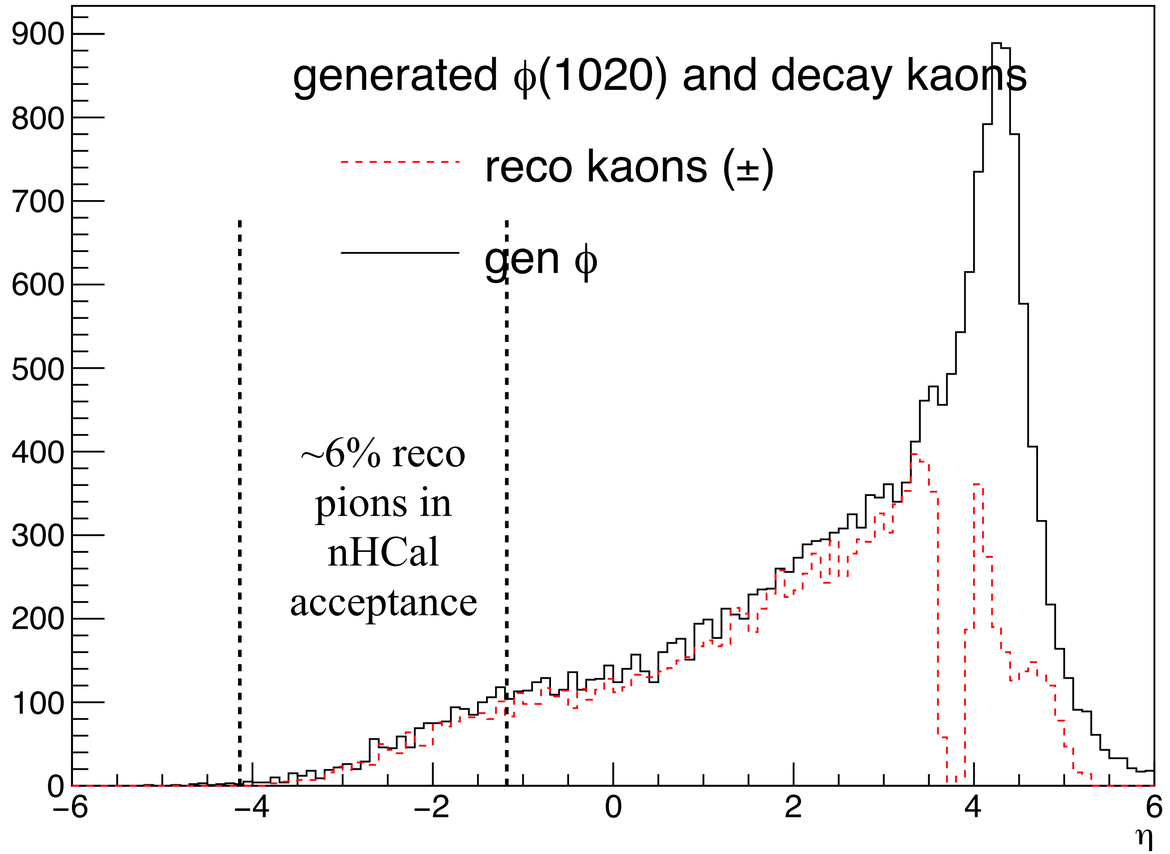


pythia8NCDIS_18x275_minQ2=1 large sample

reconstructed mesons from the decay of vector mesons

Eta of thrown ρ^0 | $\rho \rightarrow \pi^+\pi^-$ $\phi \rightarrow K^+K^-$ | Eta of thrown $\phi(1020)$



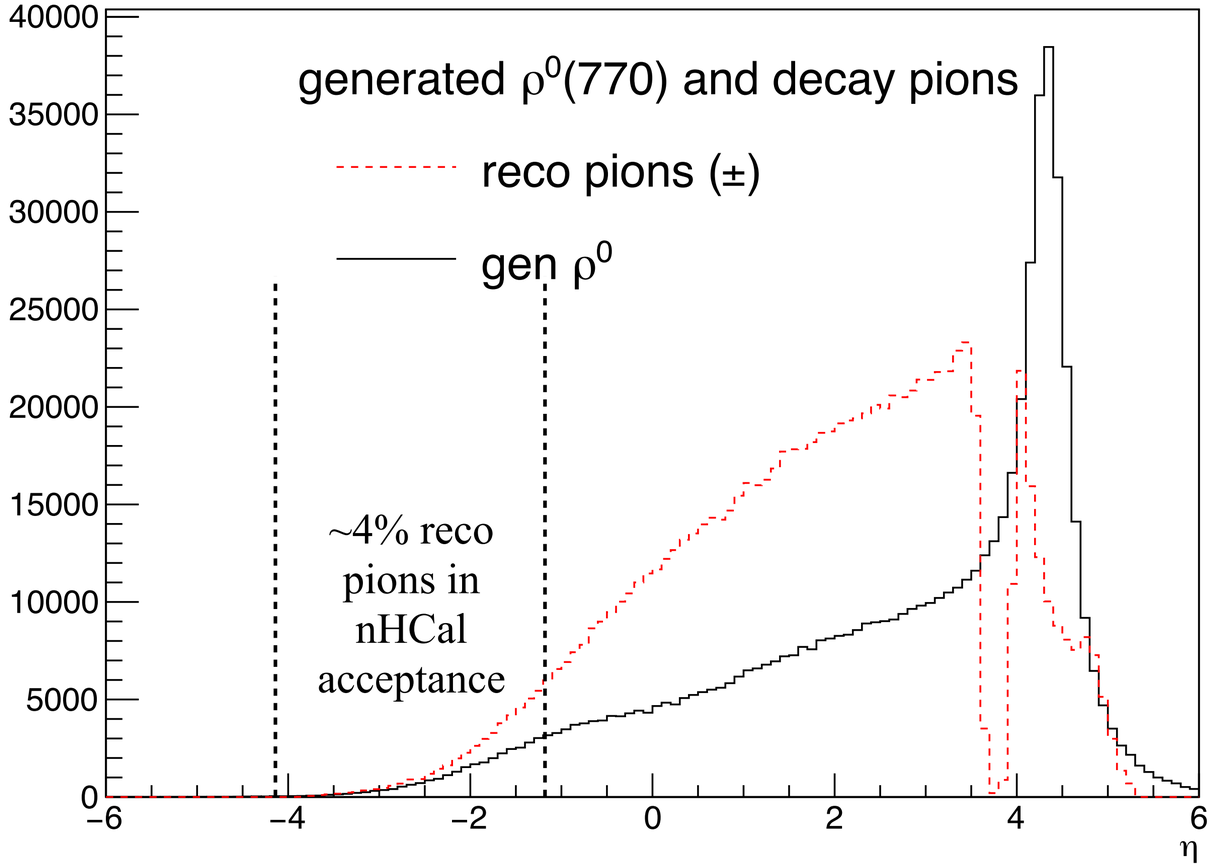


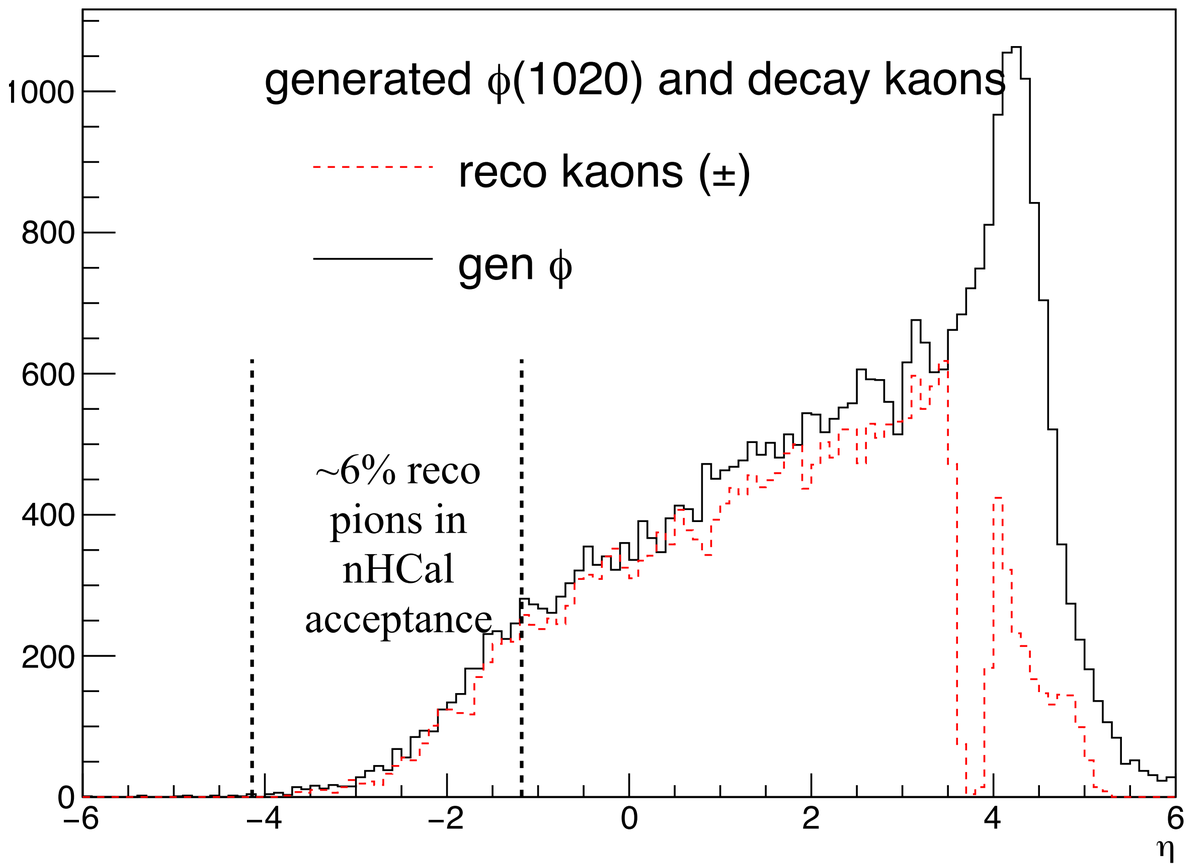
all available files of flavor “pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1”

pythia8NCDIS_18x275_minQ2=10 large sample

reconstructed mesons from the decay of vector mesons

Eta of thrown ρ^0 | $\rho \rightarrow \pi^+\pi^-$ $\phi \rightarrow K^+K^-$ | Eta of thrown $\phi(1020)$





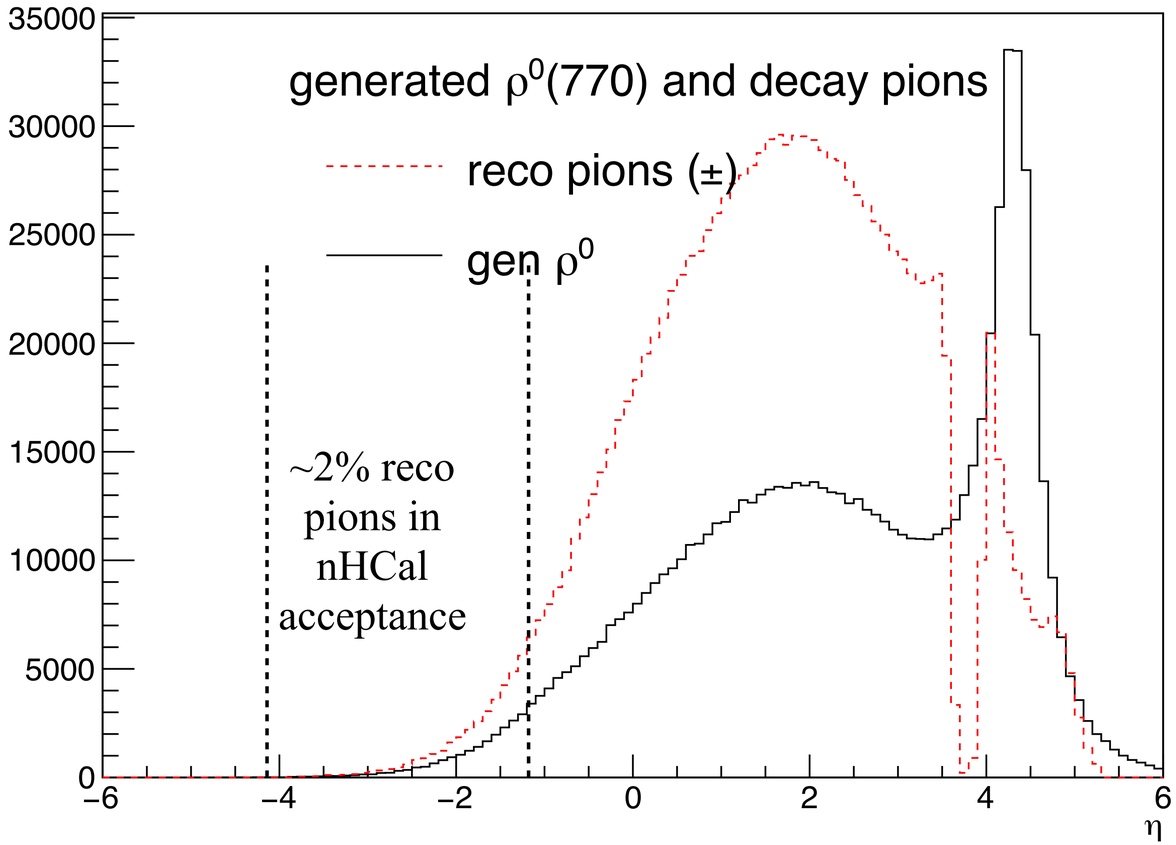
all available files of flavor “pythia8NCDIS_18x275_minQ2=10_beamEffects_xAngle=-0.025_hiDiv_1”

pythia8NCDIS_18x275_minQ2=100 large sample

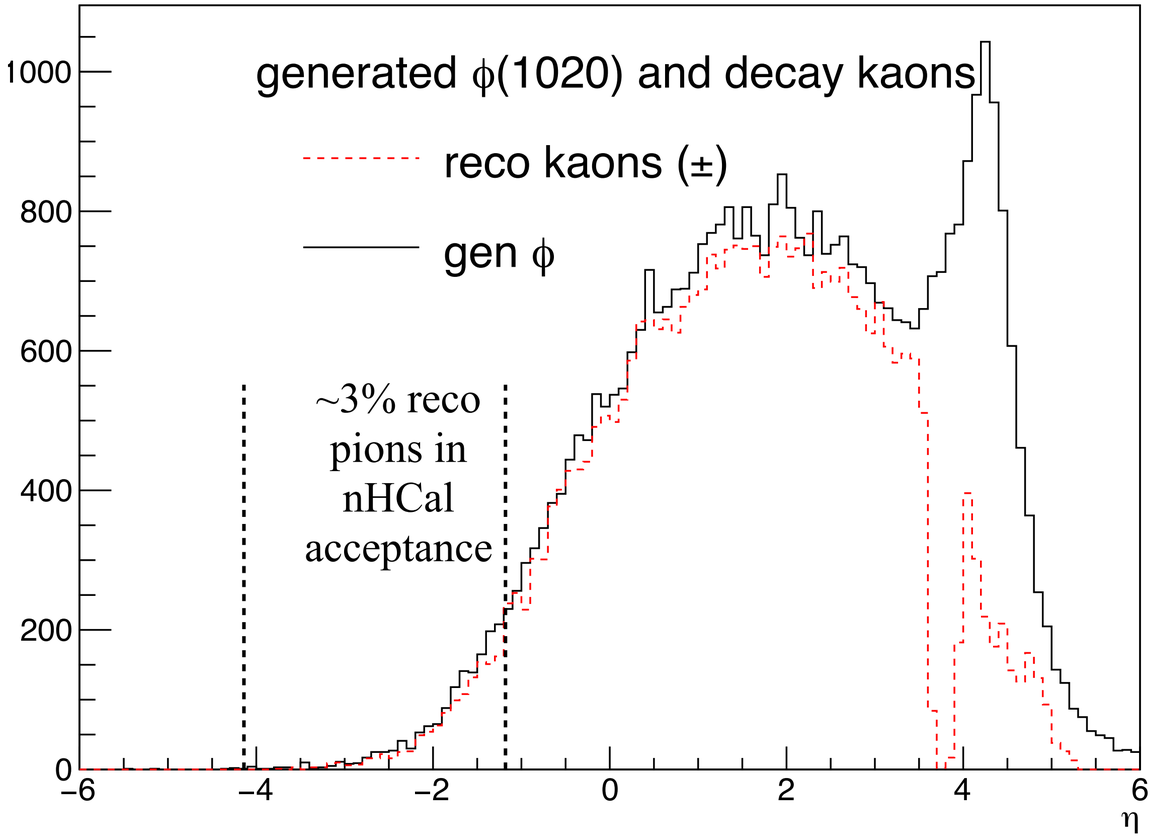
reconstructed mesons from the decay of vector mesons

$\rho \rightarrow \pi^+\pi^-$ $\phi \rightarrow K^+K^-$

Eta of thrown ρ^0



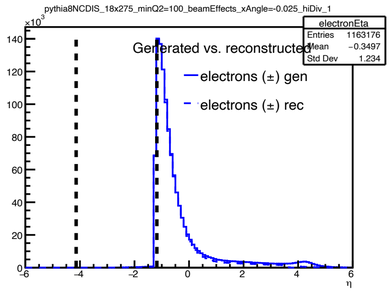
Eta of thrown $\phi(1020)$

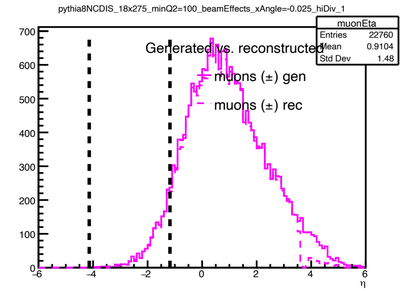


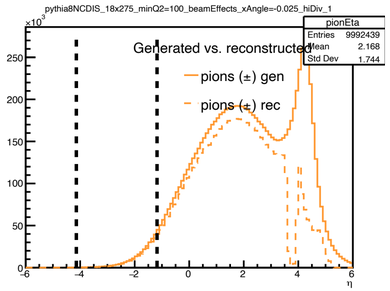
all available files of flavor “pythia8NCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1”

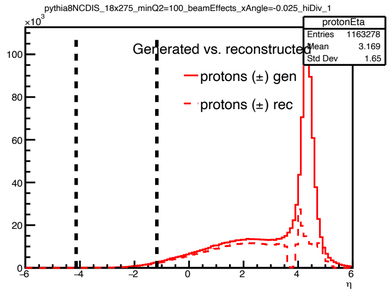
pythia8XXDIS_18x275_minQ2=100

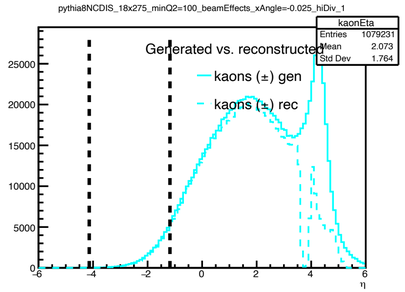
pythia8**NC**DIS_18x275_minQ2=100



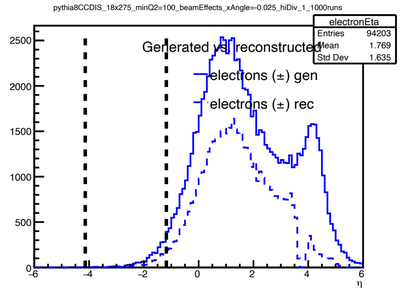


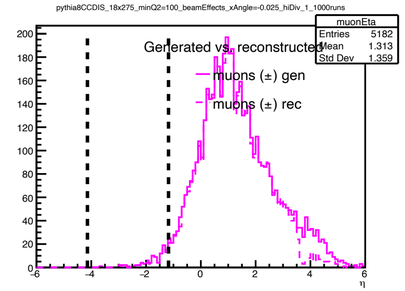


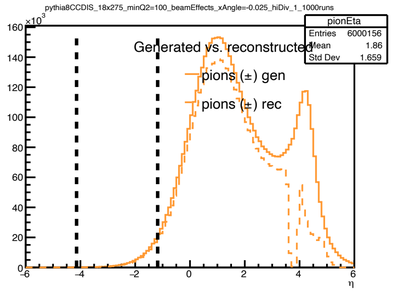


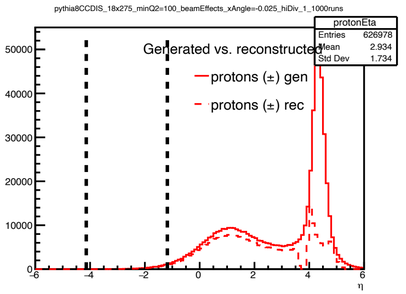


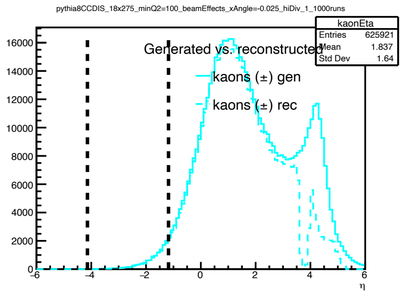
pythia8**CC**DIS_18x275_minQ2=100











all available files of flavor “pythia8NCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1”

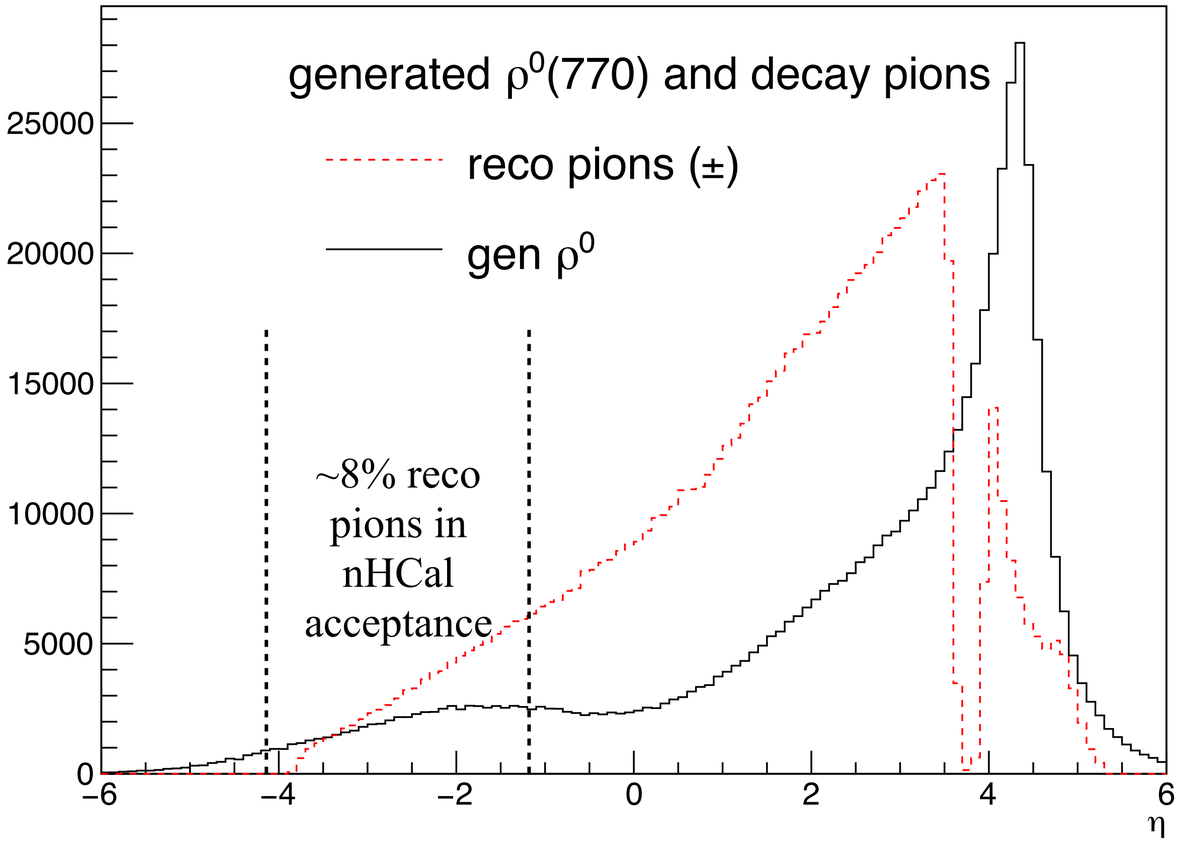
all available files of flavor “pythia8CCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1”

pythia_ep_noradcor_18x275_q2_0.000000001_1.0 large sample

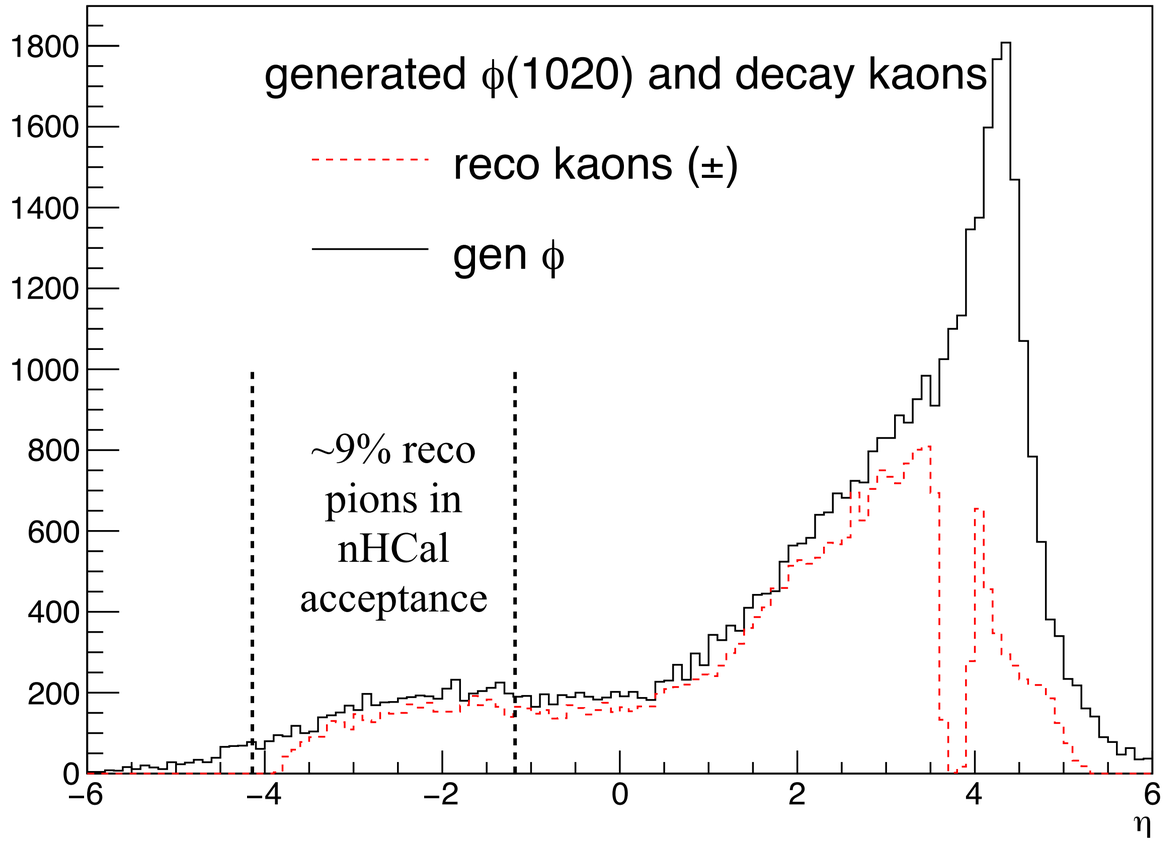
reconstructed mesons from the decay of vector mesons

$\rho \rightarrow \pi^+\pi^-$ $\phi \rightarrow K^+K^-$

Eta of thrown ρ^0

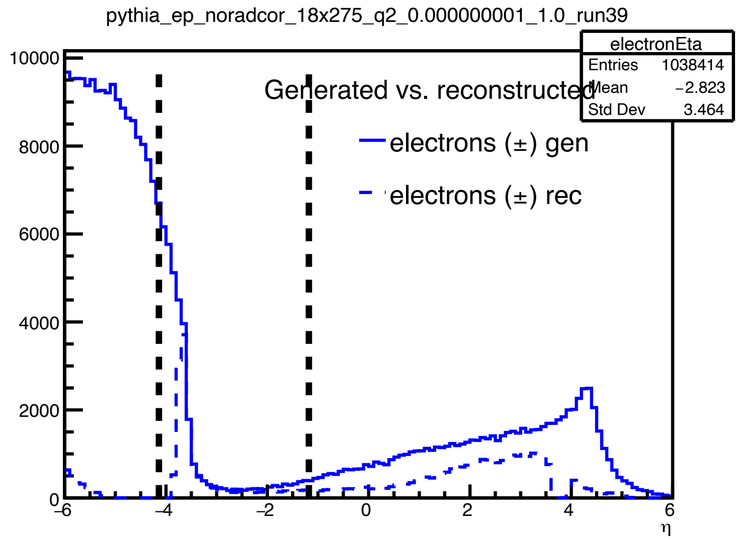


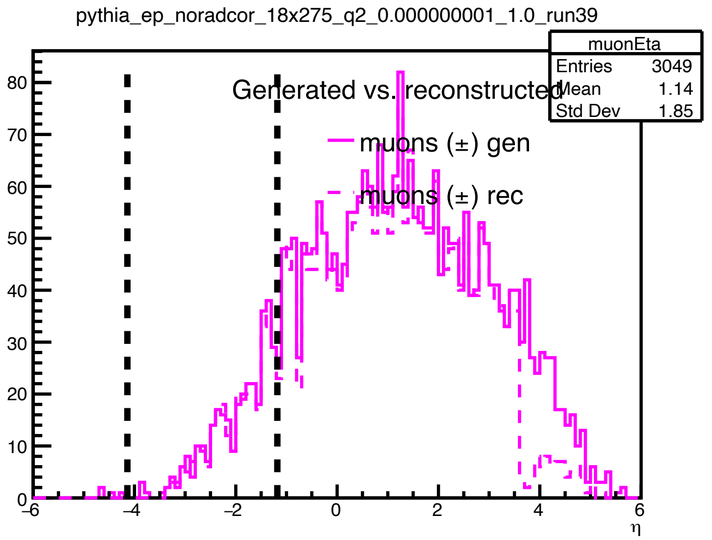
Eta of thrown $\phi(1020)$

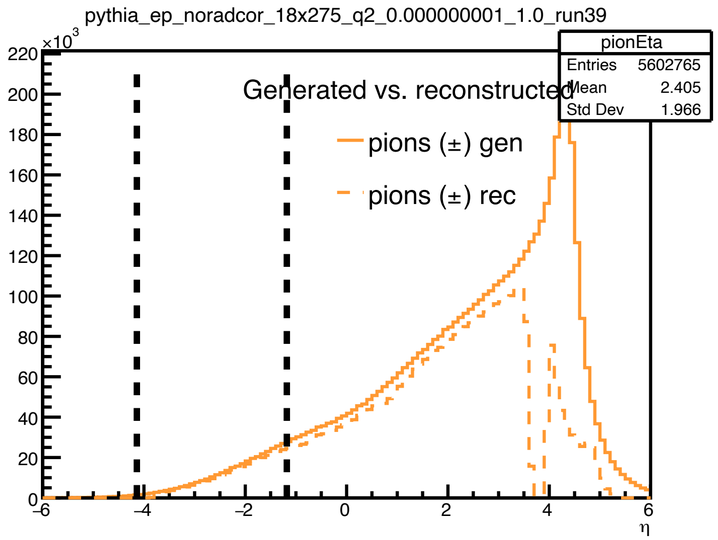


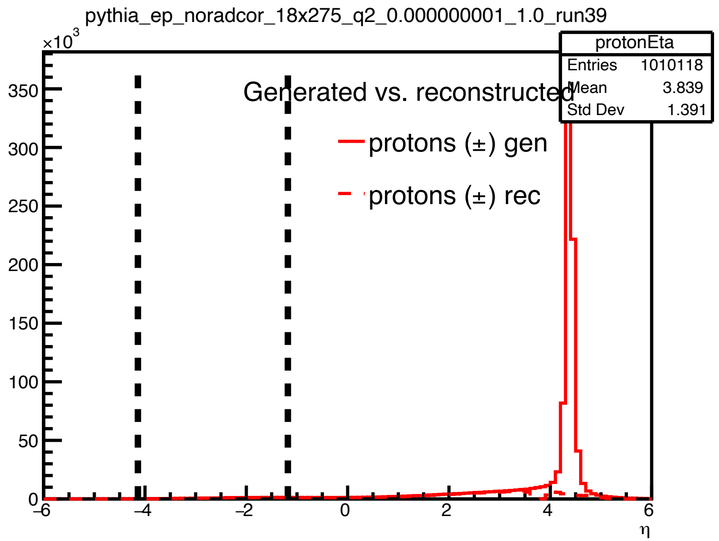
pythia_ep_noradcor_18x275_q2_0.000000001_1.0

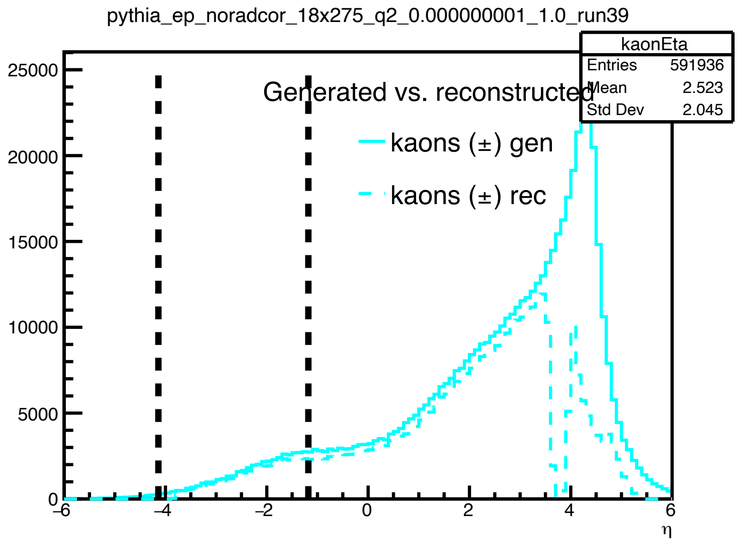
pythpythia_ep_noradcor_18x275_q2_0.000000001_1.0 large sample



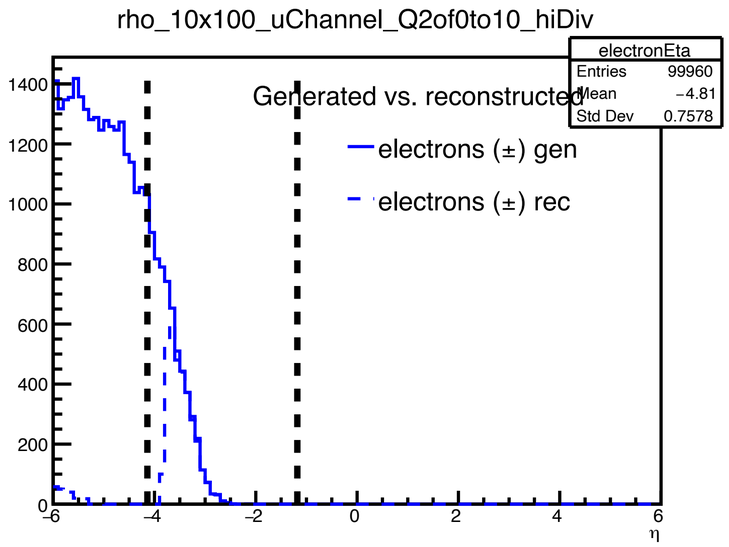


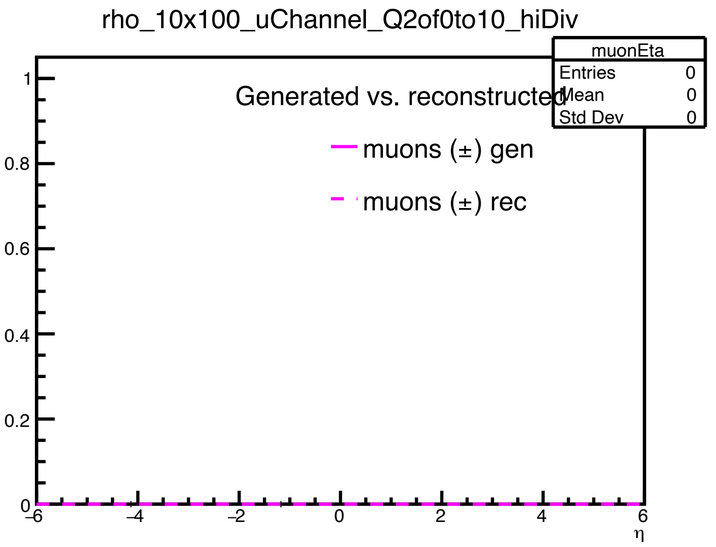


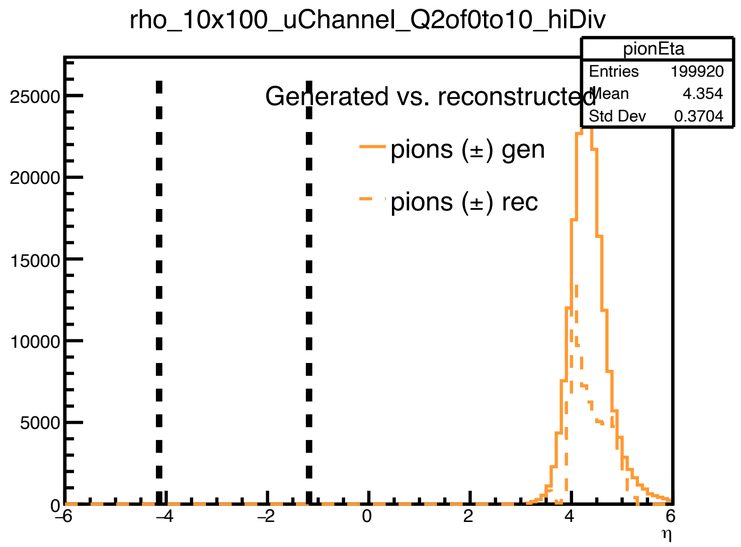


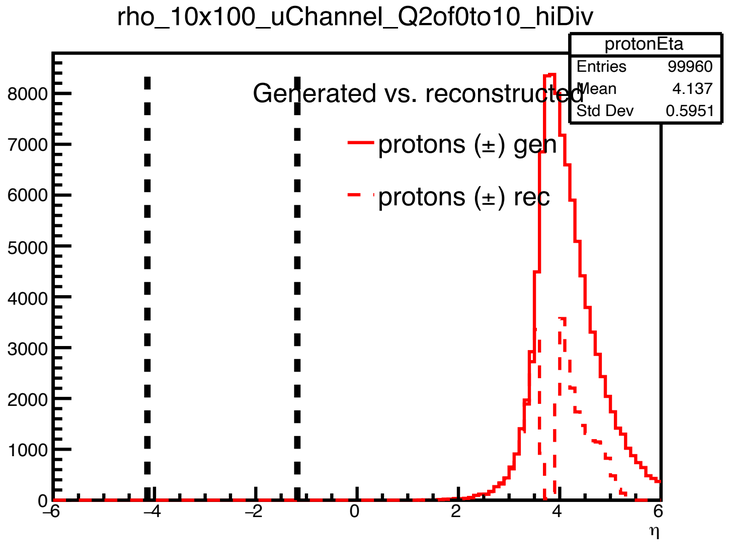


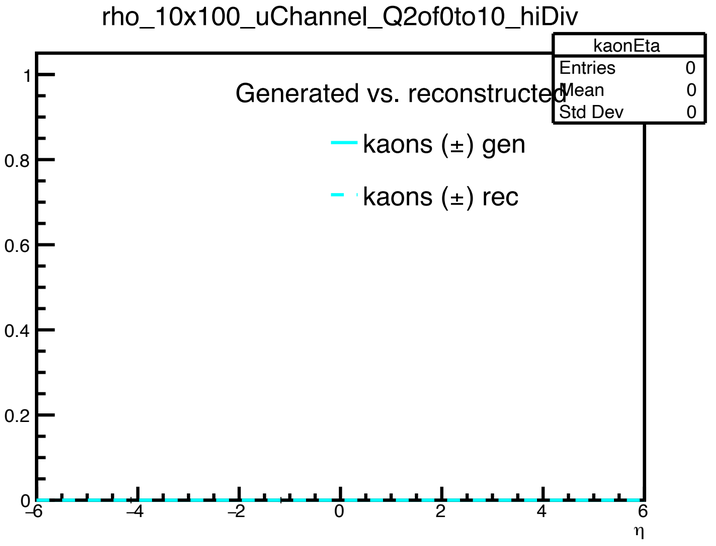
rho_10x100_uChannel_Q2of0to10_hiDiv









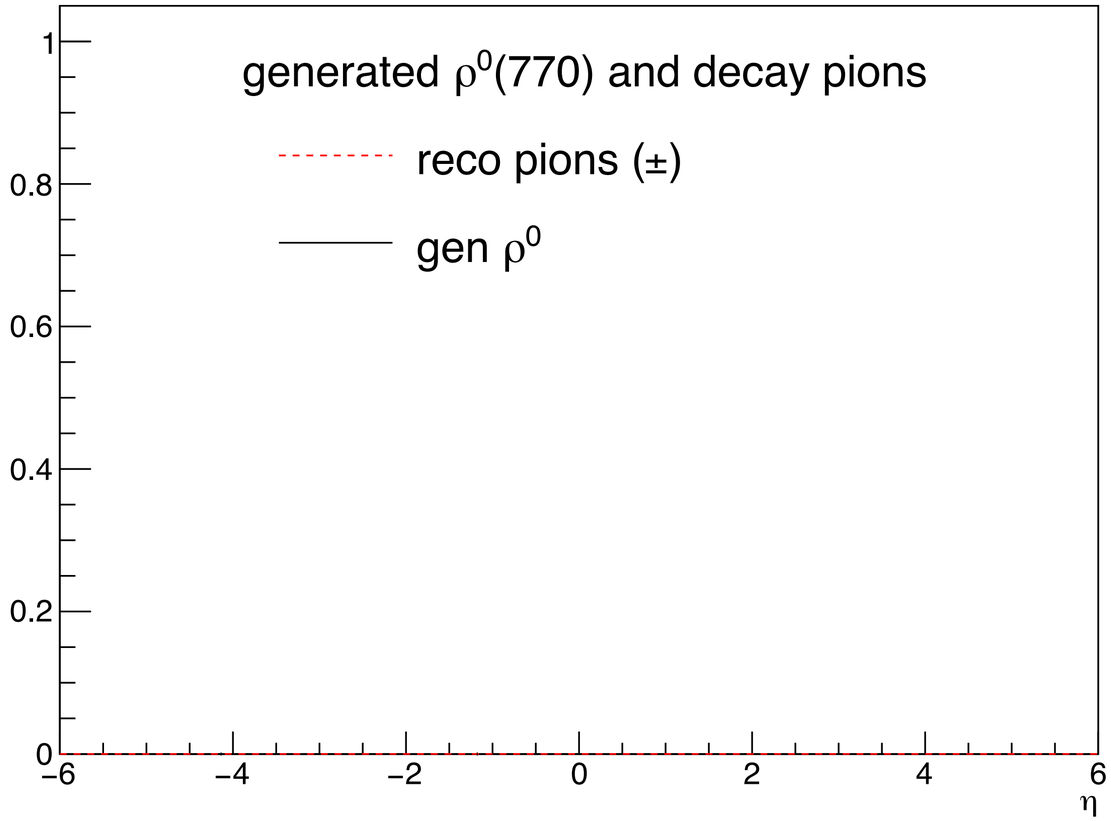


sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_1000runs

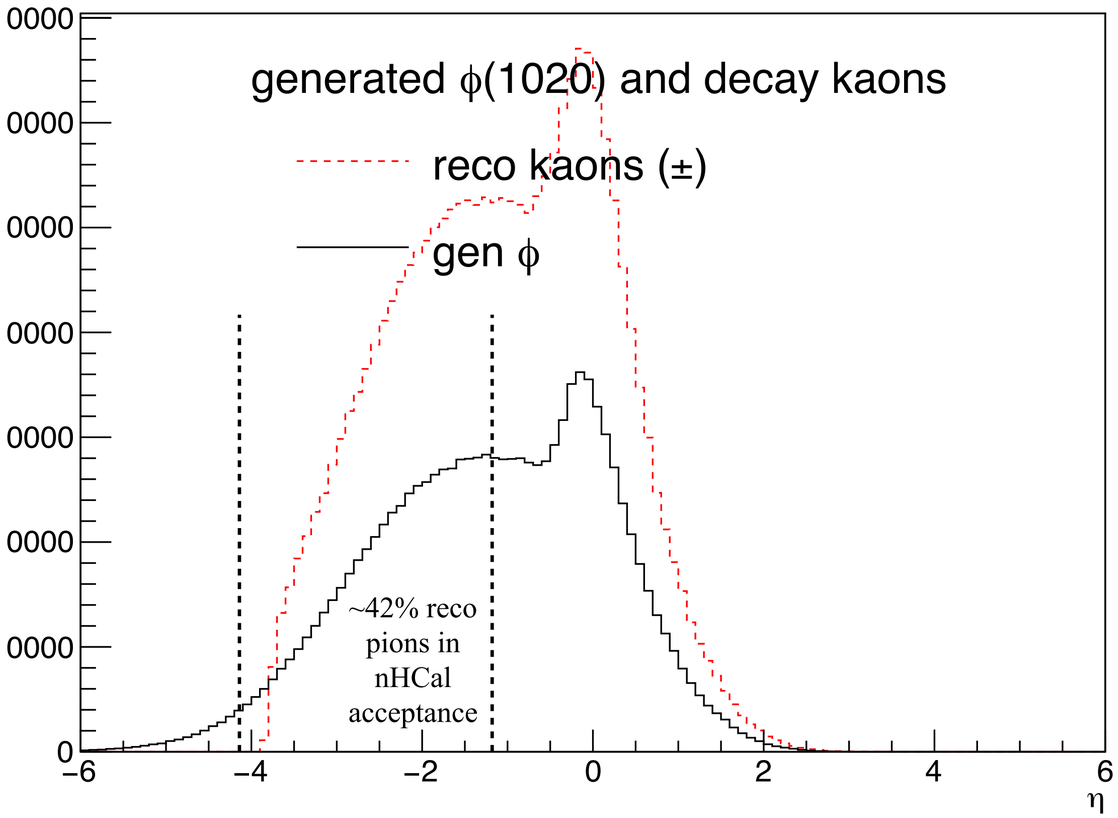
reconstructed mesons from the decay of vector mesons

$$\rho \rightarrow \pi^+\pi^- \qquad \phi \rightarrow K^+K^-$$

Eta of thrown ρ^0

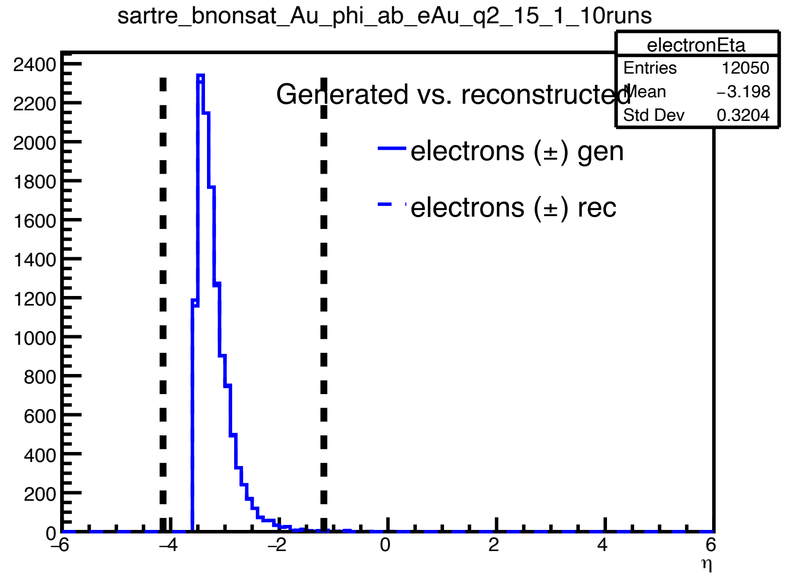


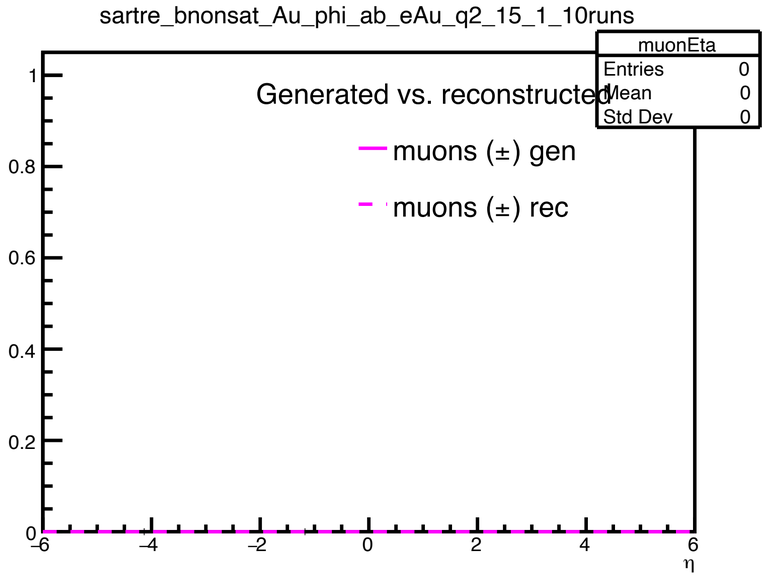
sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_1000runs

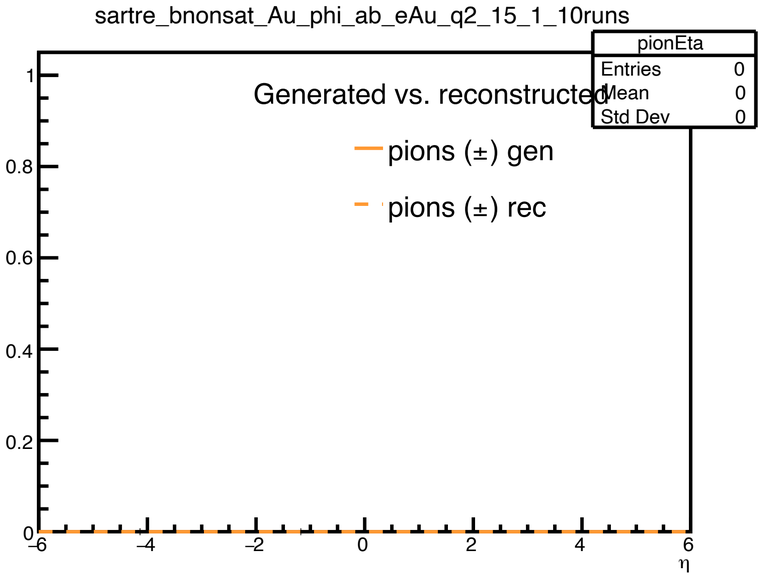


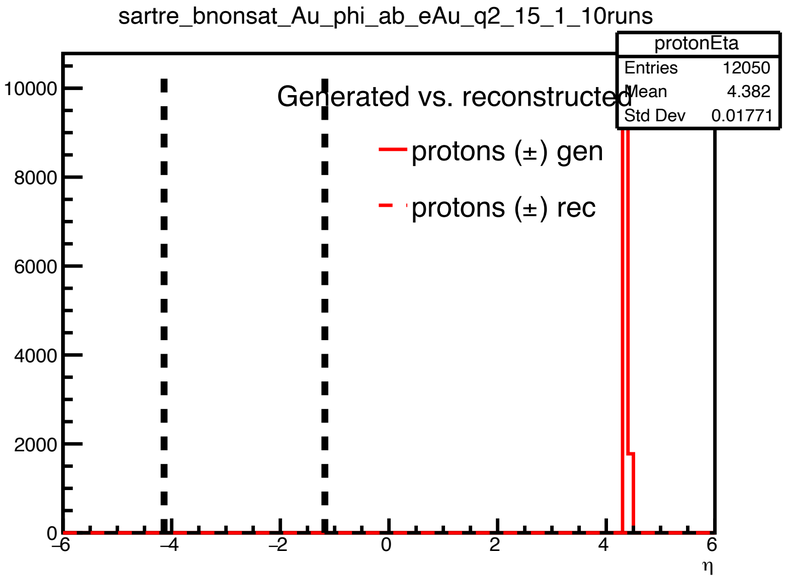
sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_1000runs

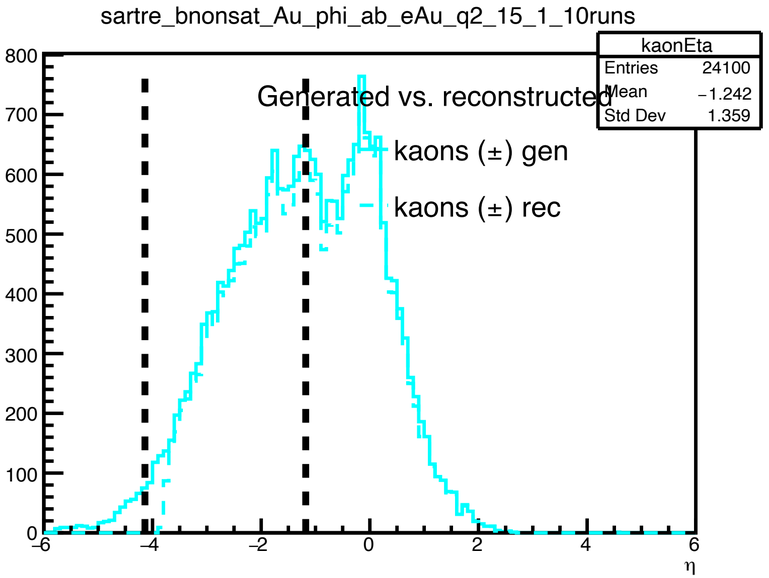
sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_10runs







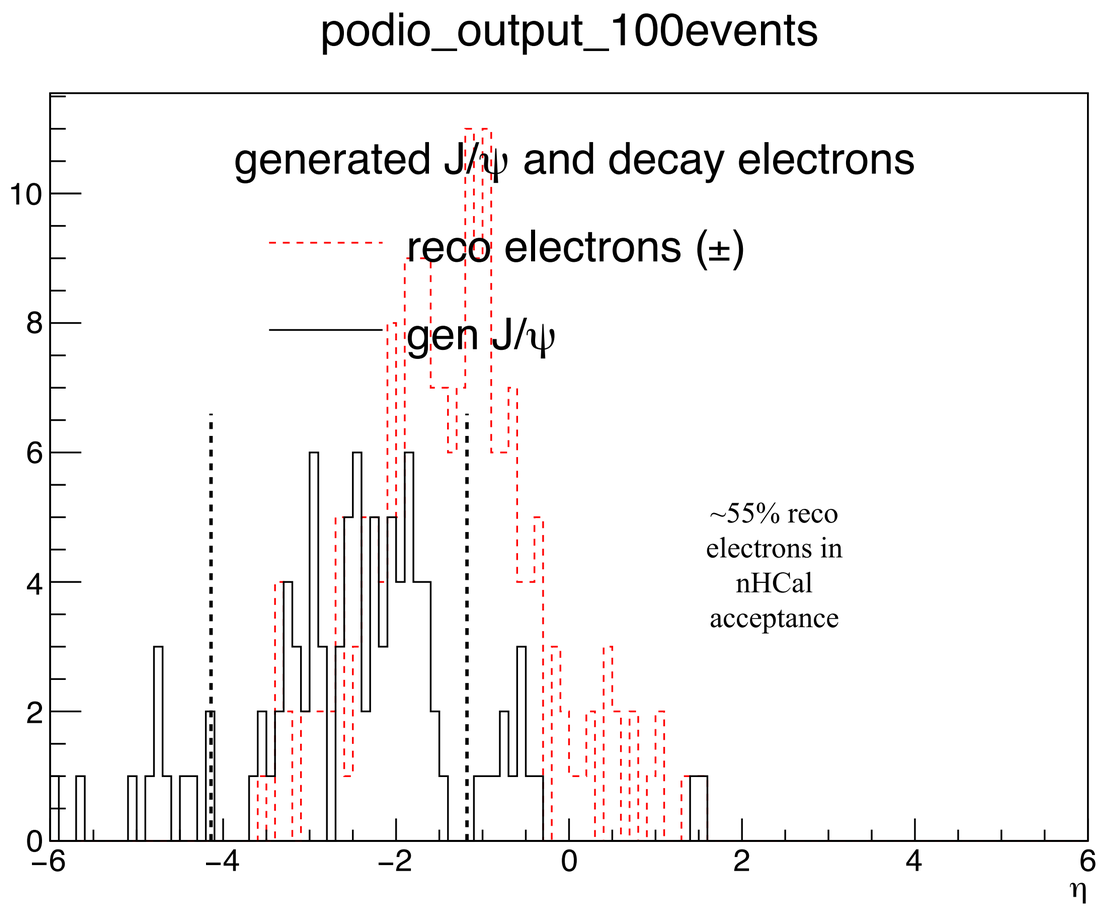




sartre_bnonsat_Au_jpsi_ab_eAu (“podio_output_100events”)

reconstructed mesons from the decay of vector mesons

$$J/\psi \rightarrow e^+e^-$$



MC printouts

pythia8NCDIS_18x275_minQ2=1

all available files of flavor “pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1”

```
Number of generated events: 994215

Number of generated electrons +-: 1089740
Number of generated protons +-: 916730
Number of generated muons +-: 7680
Number of generated pions +-: 5926114
Number of generated pi0: 3396126, of which decay into 2 gamma: 3355591
Number of generated kaons +-: 590676
Number of generated rho0: 462029, of which decay into pi+ pi-: 461467, into mu+ mu-: 17, into e+ e-: 32
        37161 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.040264
Number of generated rho+: 843677
Number of generated phi: 20540, of which decay into K+ K-: 10113
        1137 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0562148
Number of generated omega: 457260
Number of generated J/Psi: 6
Number of generated Upsilon: 0
Number of generated D0: 40778
Number of generated B0: 112

Number of reconstructed electrons +-: 1021339
Number of reconstructed protons +-: 315971
Number of reconstructed muons +-: 6794
Number of reconstructed pions +-: 3646247
Number of reconstructed kaons +-: 378955
```

pythia8NCDIS_18x275_minQ2=10

all available files of flavor “pythia8NCDIS_18x275_minQ2=10_beamEffects_xAngle=-0.025_hiDiv_1”

```
Number of generated events: 992306

Number of generated electrons +-: 1141040
Number of generated protons +-: 1052473
Number of generated muons +-: 24299
Number of generated pions +-: 8321334
Number of generated pi0: 4760645, of which decay into 2 gamma: 4703475
Number of generated kaons +-: 902704
Number of generated rho0: 638480, of which decay into pi+ pi-: 637711, into mu+ mu-: 41, into e+ e-: 31
        46796 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.0366906
Number of generated rho+: 1185727
Number of generated phi: 35175, of which decay into K+ K-: 17200
        2045 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0594477
Number of generated omega: 628419
Number of generated J/Psi: 29
Number of generated Upsilon: 0
Number of generated D0: 134879
Number of generated B0: 1125

Number of reconstructed electrons +-: 1059637
Number of reconstructed protons +-: 452868
Number of reconstructed muons +-: 22216
Number of reconstructed pions +-: 5596826
Number of reconstructed kaons +-: 644385
```

pythia8NCDIS_18x275_minQ2=100

all available files of flavor “pythia8NCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1”

```
Number of generated events: 990491

Number of generated electrons +-: 1163176
Number of generated protons +-: 1163278
Number of generated muons +-: 22760
Number of generated pions +-: 9992439
Number of generated pi0: 5697581, of which decay into 2 gamma: 5628814
Number of generated kaons +-: 1079231
Number of generated rho0: 775561, of which decay into pi+ pi-: 774642, into mu+ mu-: 31, into e+ e-: 34
        37651 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.0243022
Number of generated rho+: 1456419
Number of generated phi: 42075, of which decay into K+ K-: 20717
        1259 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0303857
Number of generated omega: 762390
Number of generated J/Psi: 194
Number of generated Upsilon: 0
Number of generated D0: 116498
Number of generated B0: 6278

Number of reconstructed electrons +-: 1076582
Number of reconstructed protons +-: 569091
Number of reconstructed muons +-: 21232
Number of reconstructed pions +-: 7258330
Number of reconstructed kaons +-: 836176
```

pythia8CCDIS_18x275_minQ2=100 large sample

all available files of flavor “pythia8CCDIS_18x275_minQ2=100_beamEffects_xAngle=-0.025_hiDiv_1_1000runs”

```
Number of generated events: 524809

Number of generated electrons +-: 94203
Number of generated protons +-: 626978
Number of generated muons +-: 5182
Number of generated pions +-: 6000156
Number of generated pi0: 3406427, of which decay into 2 gamma: 3365522
Number of generated kaons +-: 625921
Number of generated rho0: 476427, of which decay into pi+ pi-: 475834, into mu+ mu-: 29, into e+ e-: 28
        16931 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.0177909
Number of generated rho+: 887940
Number of generated phi: 25398, of which decay into K+ K-: 12412
        425 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0171205
Number of generated omega: 467512
Number of generated J/Psi: 15
Number of generated Upsilon: 0
Number of generated D0: 26257
Number of generated B0: 453

Number of reconstructed electrons +-: 49098
Number of reconstructed protons +-: 325906
Number of reconstructed muons +-: 4768
Number of reconstructed pions +-: 4601151
Number of reconstructed kaons +-: 511927
```

pythpythia_ep_noradcor_18x275_q2_0.000000001_1.0_run39

pythia_ep_noradcor_18x275_q2_0.000000001_1.0_run39

```
Number of generated events: 958104

Number of generated electrons +-: 1038414
Number of generated protons +-: 1010118
Number of generated muons +-: 3049
Number of generated pions +-: 5602765
Number of generated pi0: 3046430, of which decay into 2 gamma: 3009819
Number of generated kaons +-: 591936
Number of generated rho0: 566289, of which decay into pi+ pi-: 565535, into mu+ mu-: 34, into e+ e-: 17
        87228 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.0771199
Number of generated rho+: 926672
Number of generated phi: 43384, of which decay into K+ K-: 21210
        3602 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0849128
Number of generated omega: 468862
Number of generated J/Psi: 434
Number of generated Upsilon: 0
Number of generated D0: 17336
Number of generated B0: 39

Number of reconstructed electrons +-: 79814
Number of reconstructed protons +-: 206717
Number of reconstructed muons +-: 2687
Number of reconstructed pions +-: 3677944
Number of reconstructed kaons +-: 375435
```

rho_10x100_uChannel_Q2of0to10_hiDiv

rho_10x100_uChannel_Q2of0to10_hiDiv

```
Number of generated events: 99960

Number of generated electrons +-: 99960
Number of generated protons +-: 99960
Number of generated muons +-: 0
Number of generated pions +-: 199920
Number of generated pi0: 0, of which decay into 2 gamma: 0
Number of generated kaons +-: 0
Number of generated rho0: 0, of which decay into pi+ pi-: 0, into mu+ mu-: 0, into e+ e-: 0
        0 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated rho+: 0
Number of generated phi: 0, of which decay into K+ K-: 0
        0 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated omega: 0
Number of generated J/Psi: 0
Number of generated Upsilon: 0
Number of generated D0: 0
Number of generated B0: 0

Number of reconstructed electrons +-: 3878
Number of reconstructed protons +-: 33810
Number of reconstructed muons +-: 0
Number of reconstructed pions +-: 77792
Number of reconstructed kaons +-: 0
```

```
All events look like this - can I assume that the charged pions all come from rho0 decay? I guess so
+ Entering event #: 2040
Ev#: 2040, P-index: 0, PDG: 11, GenStatus:4, i_parents: 0, i_daughters: 2, pb: 0, pe: 0, db: 1, de: 2
Ev#: 2040, P-index: 1, PDG: 22, GenStatus:13, i_parents: 1, i_daughters: 3, pb: 0, pe: 0, db: 4, de: 6
Ev#: 2040, P-index: 2, PDG: 11, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 0, pe: 1, db: 4, de: 6
Ev#: 2040, P-index: 3, PDG: 2212, GenStatus:4, i_parents: 0, i_daughters: 3, pb: 1, pe: 1, db: 4, de: 6
Ev#: 2040, P-index: 4, PDG: 211, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 1, pe: 1, db: 7, de: 6
Ev#: 2040, P-index: 5, PDG: -211, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 1, pe: 1, db: 7, de: 6
Ev#: 2040, P-index: 6, PDG: 2212, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 1, pe: 4, db: 7, de: 6
```

sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_1000runs

```
Number of generated events: 1155268

Number of generated electrons +-: 1155187
Number of generated protons +-: 1155187
Number of generated muons +-: 0
Number of generated pions +-: 0
Number of generated pi0: 0, of which decay into 2 gamma: 0
Number of generated kaons +-: 2310374
Number of generated rho0: 0, of which decay into pi+ pi-: 0, into mu+ mu-: 0, into e+ e-: 0
        0 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated rho+: 0
Number of generated phi: 1155187, of which decay into K+ K-: 1155187
        968691 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.419279
Number of generated omega: 0
Number of generated J/Psi: 0
Number of generated Upsilon: 0
Number of generated D0: 0
Number of generated B0: 0

Number of reconstructed electrons +-: 1139643
Number of reconstructed protons +-: 0
Number of reconstructed muons +-: 0
Number of reconstructed pions +-: 0
Number of reconstructed kaons +-: 2111110
```

Phi to KK to mumu?

there are no good decay muons…: sartre_bnonsat_Au_phi_ab_eAu_q2_15_1_1run

```
+ Entering event #: 1205
Ev#: 1205, P-index: 3, PDG: 11, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 0, pe: 1, db: 7, de: 5
Ev#: 1205, P-index: 5, PDG: 2212, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 2, pe: 1, db: 7, de: 5
Ev#: 1205, P-index: 6, PDG: 333, GenStatus:2, i_parents: 1, i_daughters: 2, pb: 1, pe: 6, db: 7, de: 8
Event 1205 with gen phi(1020): 333, daughter 1:321, daughter 2:-321, i_daughters:2
-> Event 1205 found phi(1020) decayed into K+ K-: 321 and -321
Ev#: 1205, P-index: 7, PDG: 321, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 6, pe: 6, db: 9, de: 8
Ev#: 1205, P-index: 8, PDG: -321, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 6, pe: 8, db: 9, de: 8
```

only sometimes this: ==> the kaons are not properly decayed…

```
+ Entering event #: 505
Ev#: 505, P-index: 0, PDG: 11, GenStatus:4, i_parents: 0, i_daughters: 2, pb: 0, pe: 0, db: 1, de: 3
Ev#: 505, P-index: 1, PDG: 22, GenStatus:21, i_parents: 1, i_daughters: 2, pb: 0, pe: 0, db: 4, de: 6
Ev#: 505, P-index: 2, PDG: 2212, GenStatus:4, i_parents: 0, i_daughters: 1, pb: 0, pe: 0, db: 5, de: 5
Ev#: 505, P-index: 3, PDG: 11, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 0, pe: 1, db: 7, de: 5
Ev#: 505, P-index: 4, PDG: 990, GenStatus:21, i_parents: 1, i_daughters: 0, pb: 1, pe: 2, db: 7, de: 5
Ev#: 505, P-index: 5, PDG: 2212, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 2, pe: 1, db: 7, de: 5
Ev#: 505, P-index: 6, PDG: 333, GenStatus:2, i_parents: 1, i_daughters: 2, pb: 1, pe: 6, db: 7, de: 8
Event 505 with gen phi(1020): 333, daughter 1:321, daughter 2:-321, i_daughters:2
-> Event 505 found phi(1020) decayed into K+ K-: 321 and -321
Ev#: 505, P-index: 7, PDG: 321, GenStatus:1, i_parents: 1, i_daughters: 1, pb: 6, pe: 6, db: 9, de: 9
Ev#: 505, P-index: 8, PDG: -321, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 6, pe: 7, db: 10, de: 9
Ev#: 505, P-index: 9, PDG: -13, GenStatus:0, i_parents: 1, i_daughters: 0, pb: 7, pe: 8, db: 10, de: 9
**************          MUON!!
```

sartre_bnonsat_Au_jpsi_ab_eAu (“podio_output_100events”)

```
Number of generated events: 100

Number of generated electrons +-: 300
Number of generated protons +-: 100
Number of generated muons +-: 0
Number of generated pions +-: 0
Number of generated pi0: 0, of which decay into 2 gamma: 0
Number of generated kaons +-: 0
Number of generated rho0: 0, of which decay into pi+ pi-: 0, into mu+ mu-: 0, into e+ e-: 0
        0 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated rho+: 0
Number of generated phi: 0, of which decay into K+ K-: 0
        0 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated omega: 0
Number of generated J/Psi: 100 , of which decay into e+ e-: 100, into mu+ mu-: 0
        109 e+ e- make it into the nHCal acceptance, with corresponds to a fraction 0.545
Number of generated Upsilon: 0
Number of generated D0: 0
Number of generated B0: 0

Number of reconstructed electrons +-: 290
Number of reconstructed protons +-: 0
Number of reconstructed muons +-: 0
Number of reconstructed pions +-: 0
Number of reconstructed kaons +-: 0
```

EpIC1.0.0-1.1_DVMP_10x100_hiAcc_ab

```
+ Entering event #: 99981
Ev#: 99981, P-index: 1, PDG: 11, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 0, pe: 0, db: 4, de: 2
Ev#: 99981, P-index: 4, PDG: 111, GenStatus:2, i_parents: 2, i_daughters: 2, pb: 2, pe: 2, db: 6, de: 7
Ev#: 99981, P-index: 5, PDG: 2212, GenStatus:1, i_parents: 2, i_daughters: 0, pb: 2, pe: 4, db: 8, de: 7
Ev#: 99981, P-index: 6, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 4, pe: 4, db: 8, de: 7
Ev#: 99981, P-index: 7, PDG: 22, GenStatus:1, i_parents: 1, i_daughters: 0, pb: 4, pe: 6, db: 8, de: 7
Number of generated events: 99981

Number of generated electrons +-: 99981
Number of generated protons +-: 99981
Number of generated muons +-: 0
Number of generated pions +-: 0
Number of generated pi0: 99981, of which decay into 2 gamma: 99981
Number of generated kaons +-: 0
Number of generated rho0: 0, of which decay into pi+ pi-: 0, into mu+ mu-: 0, into e+ e-: 0
        0 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated rho+: 0
Number of generated phi: 0, of which decay into K+ K-: 0
        0 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated omega: 0
Number of generated J/Psi: 0 , of which decay into e+ e-: 0, into mu+ mu-: 0
        0 e+ e- make it into the nHCal acceptance, with corresponds to a fraction 0
Number of generated Upsilon: 0
Number of generated D0: 0
Number of generated B0: 0

Number of reconstructed electrons +-: 99269
Number of reconstructed protons +-: 22792
Number of reconstructed muons +-: 0
Number of reconstructed pions +-: 0
Number of reconstructed kaons +-: 0
```

It’s exclusive pi0

Older plots from “getting started”

ePIC MC productions

/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
```

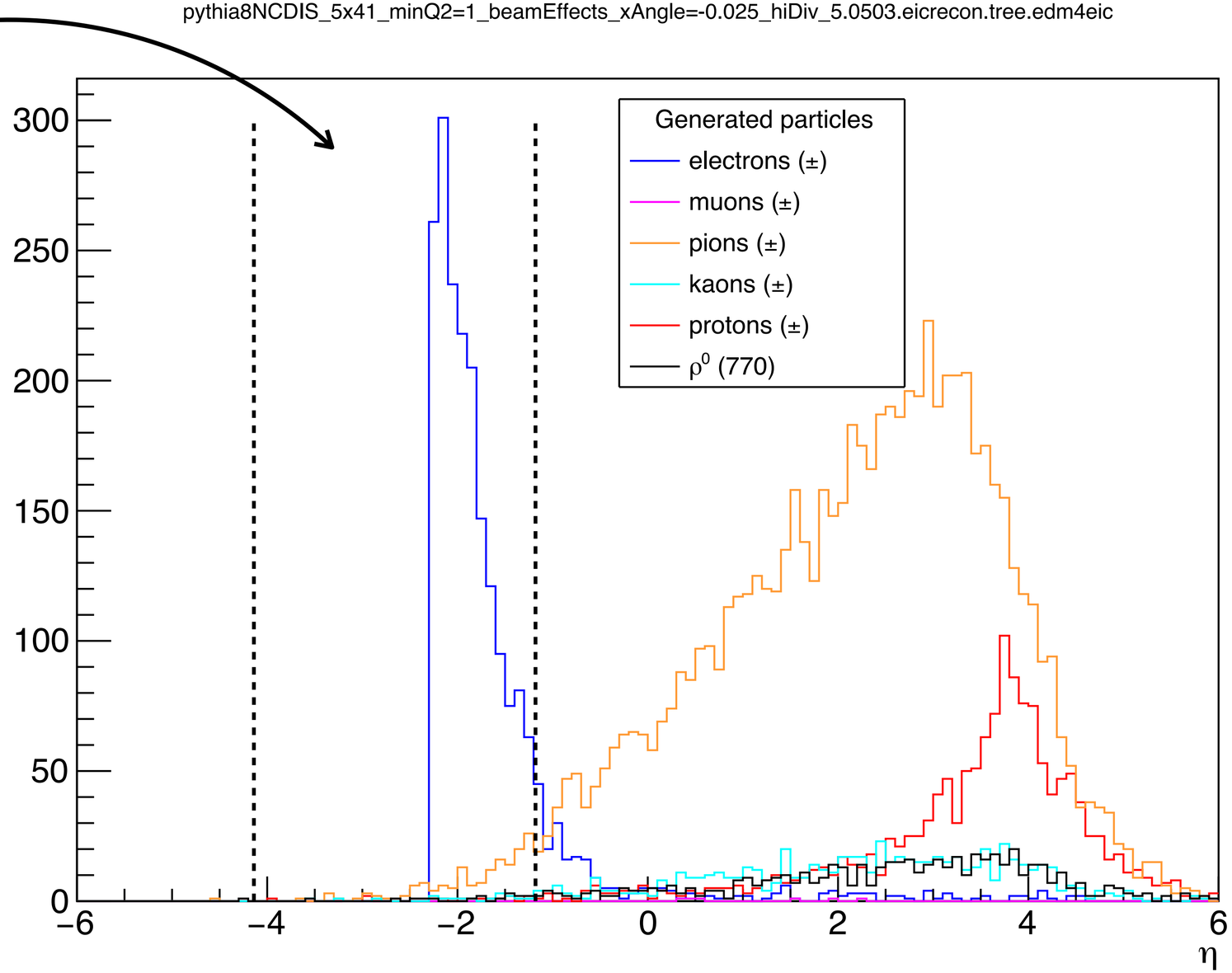
- Default run file, unless indicated otherwise

Generated eta distribution - pythia, Q2min = 1 GeV2, 5x41

nHCal acceptance

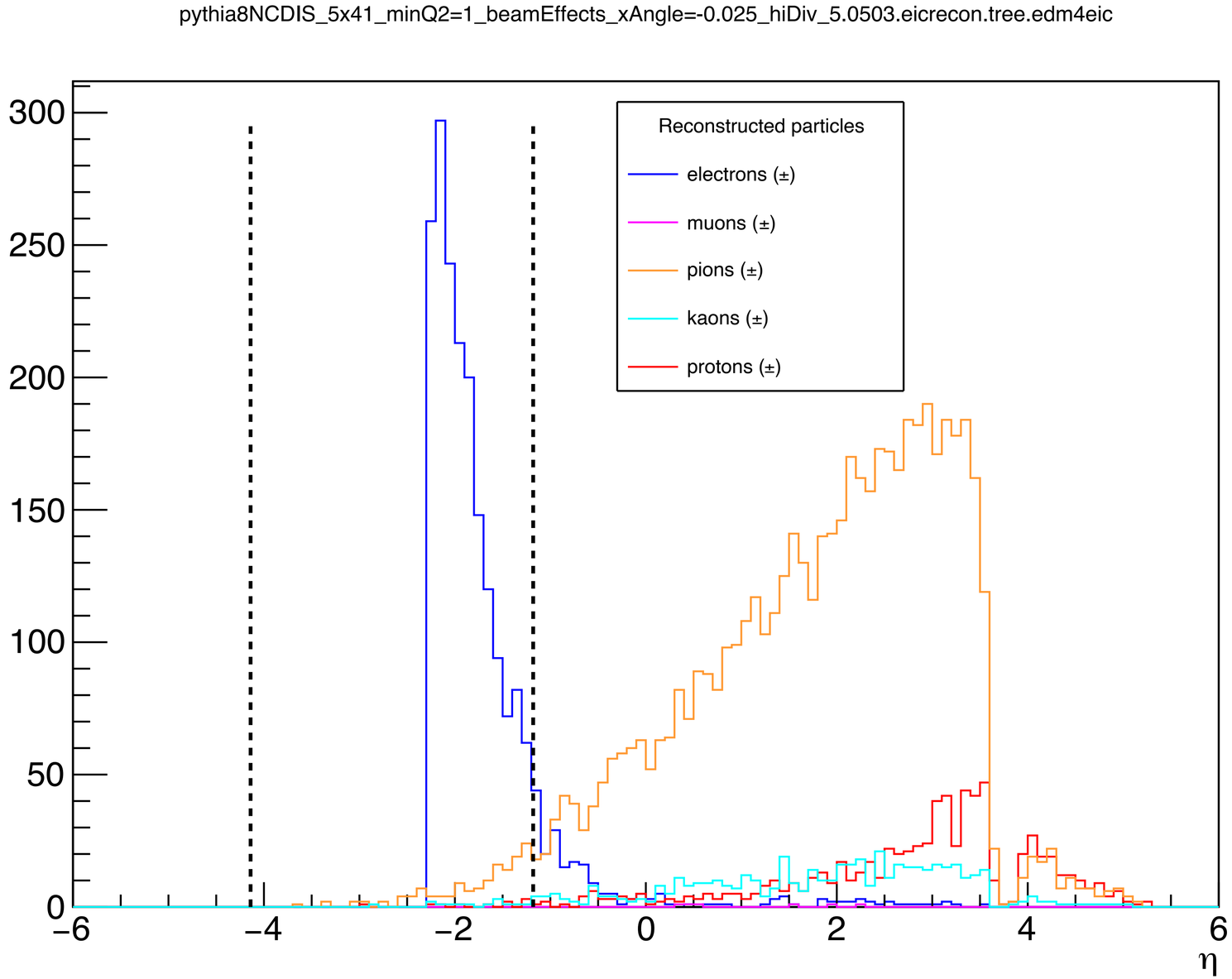
- Front geometry limit: $-4.03 < \eta < -1.18$
- Back geometry limit: $-4.14 < \eta < -1.27$
- Clusters: $-3.95 < \eta < -1.25$

15.5.2024 L. Kosarzewski OSU

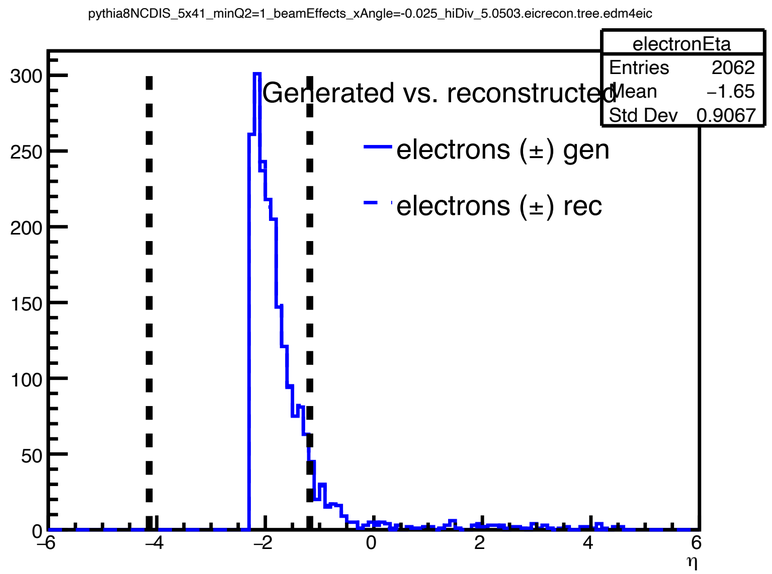


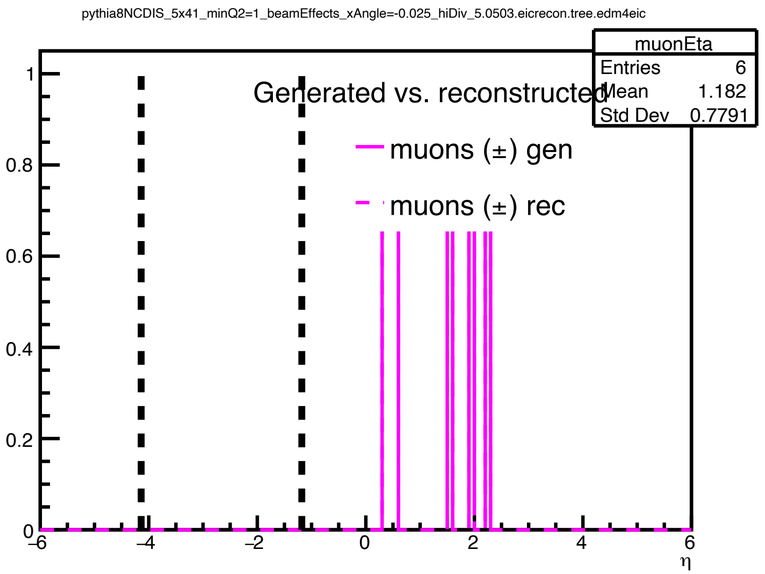
Reconstructed eta distribution - pythia, Q2min = 1 GeV2, 5x41

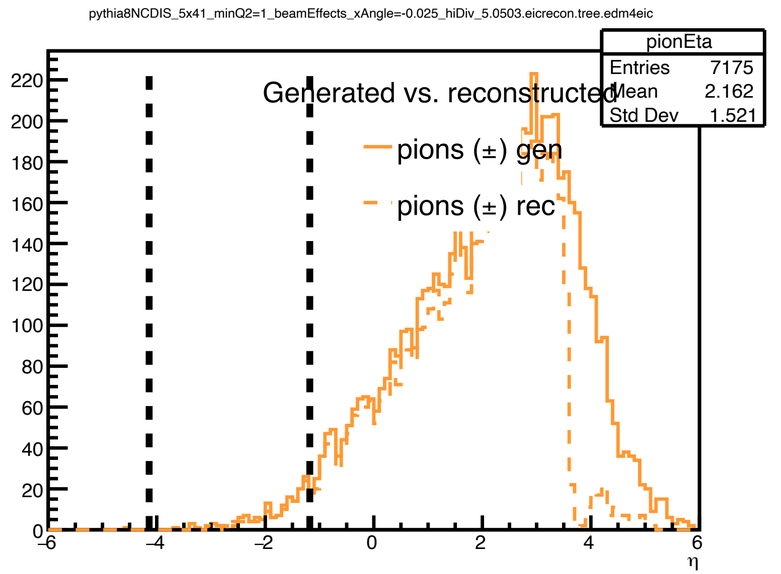
only reconstructed particles matched to generated

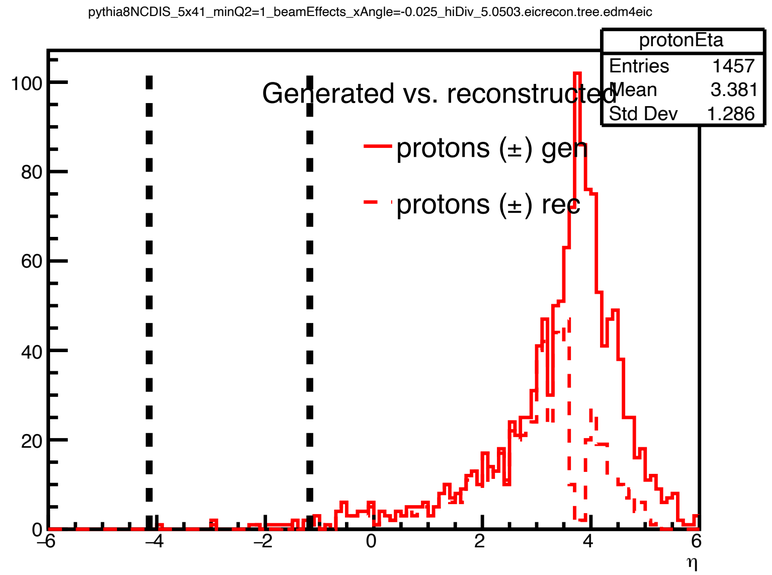


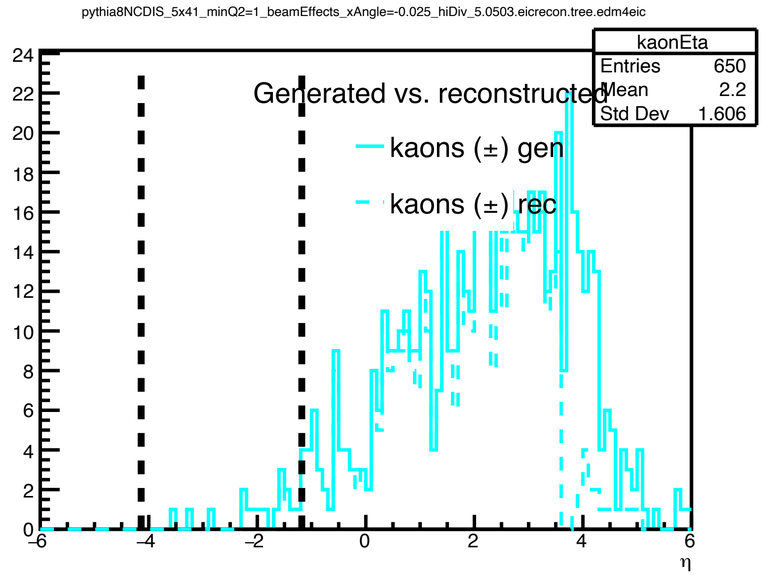
eta distributions - gen vs. rec - pythia, Q2min = 1 GeV2, 5x41

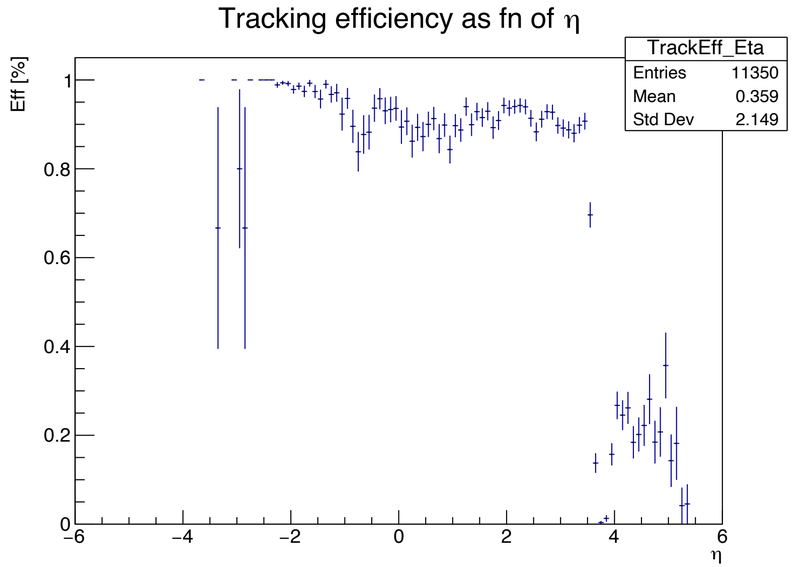








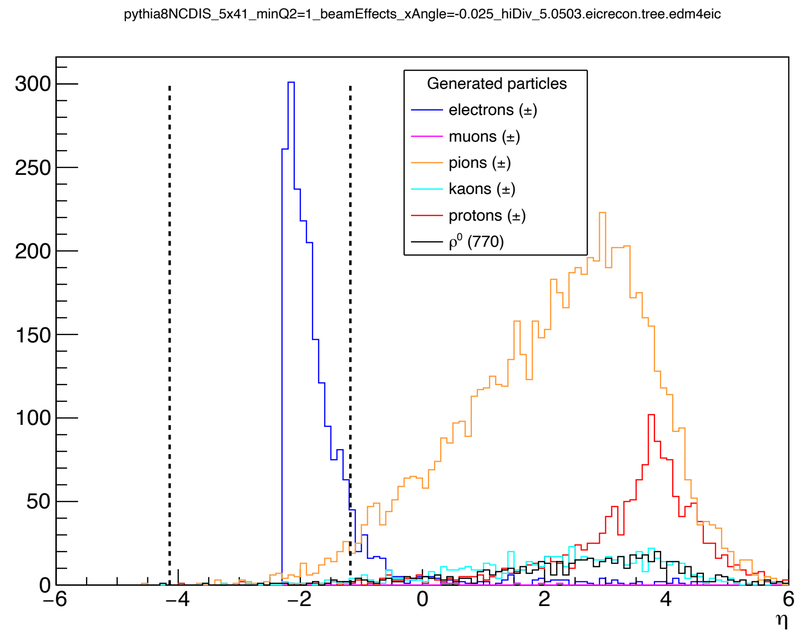




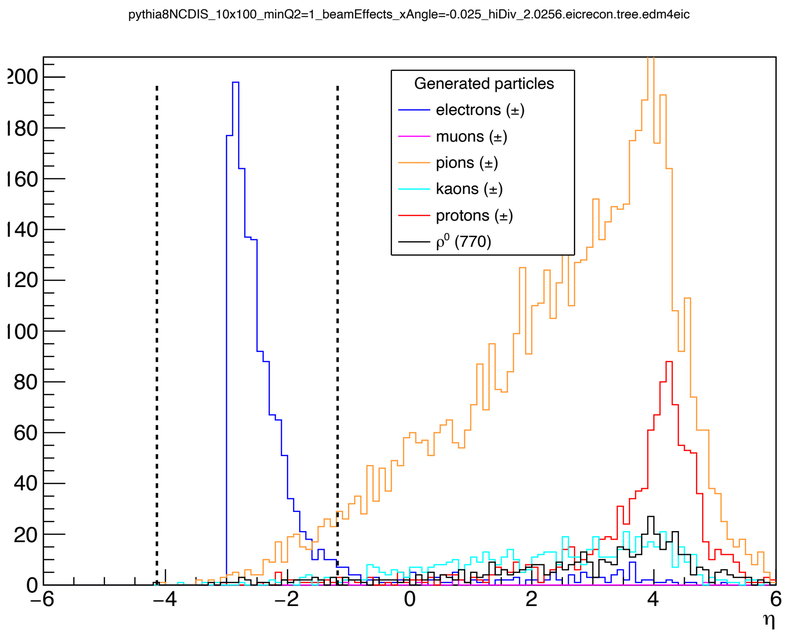
Generated eta distribution - pythia, Q^2_{min} = 1 GeV2, vary $E_e x E_p$

- higher $E_e x E_p$ → particles are boosted to higher eta

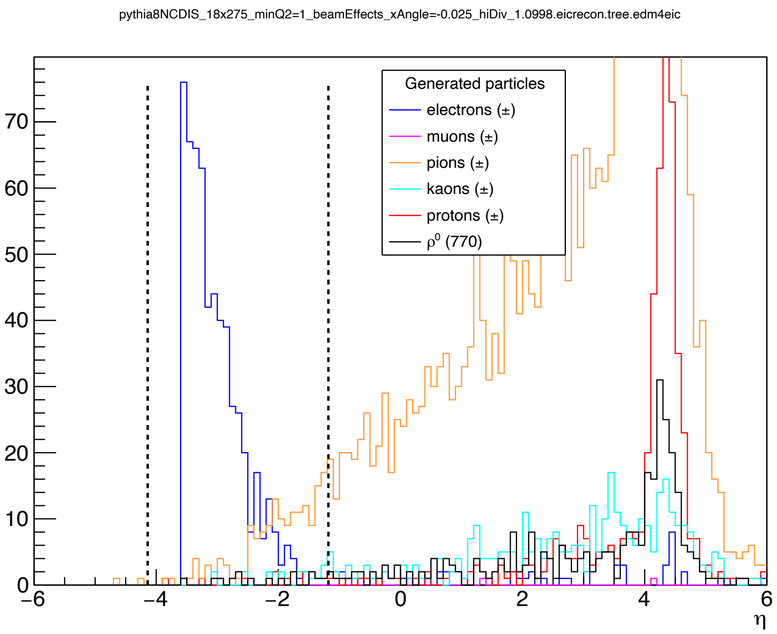
5x41



10x100

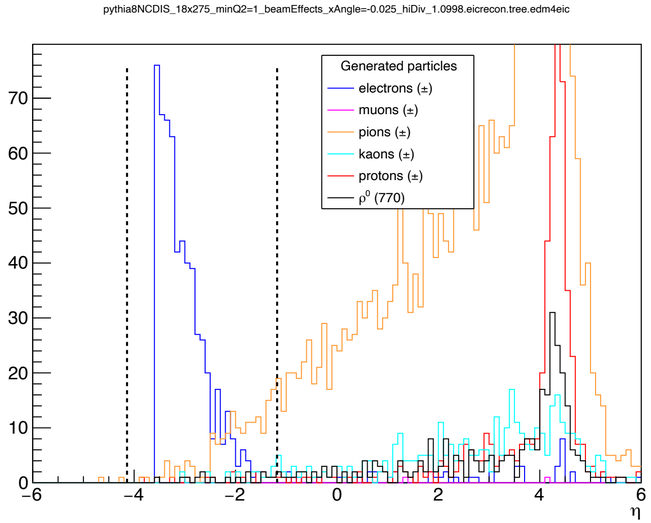


18x275

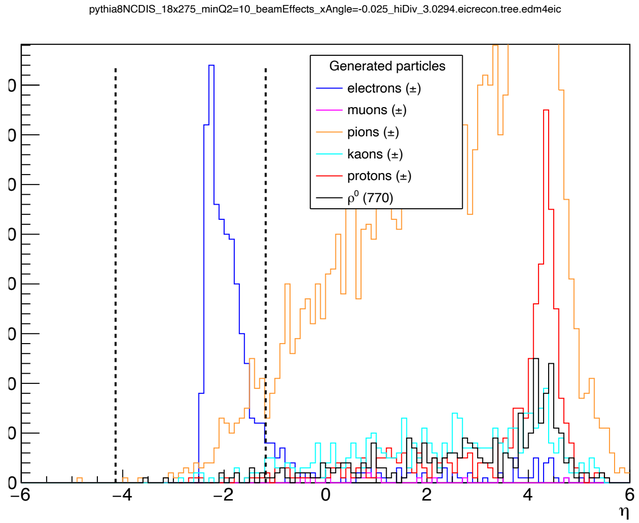


Generated eta distribution - pythia, 18x275, vary Q^2_{min}

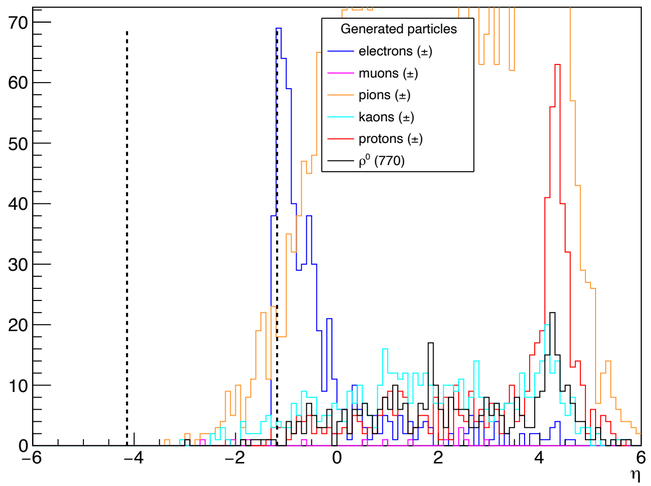
Q2min=1



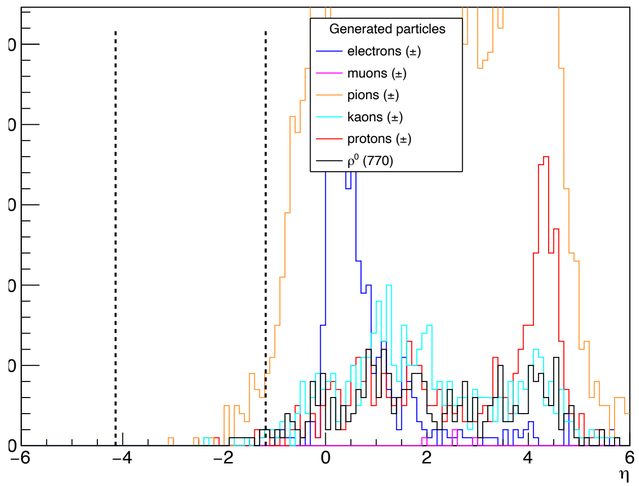
Q2min=10



Q2min=100

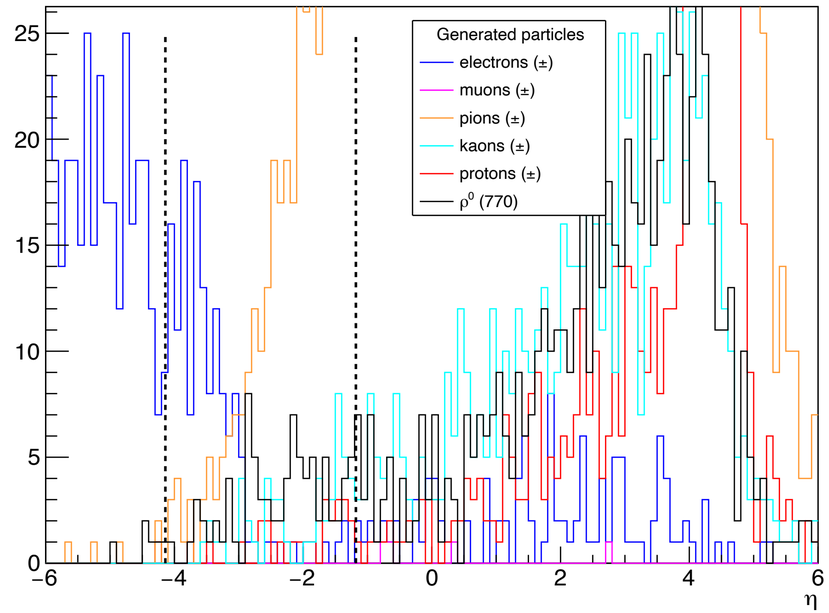


Q2min=1000

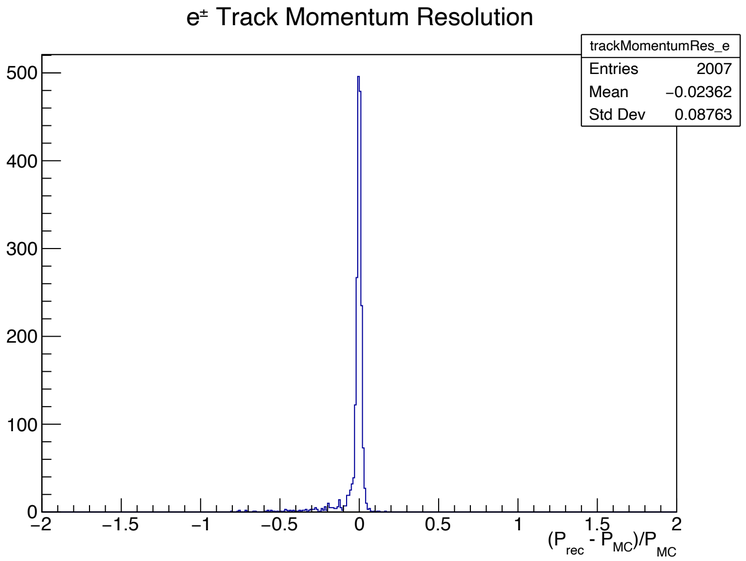


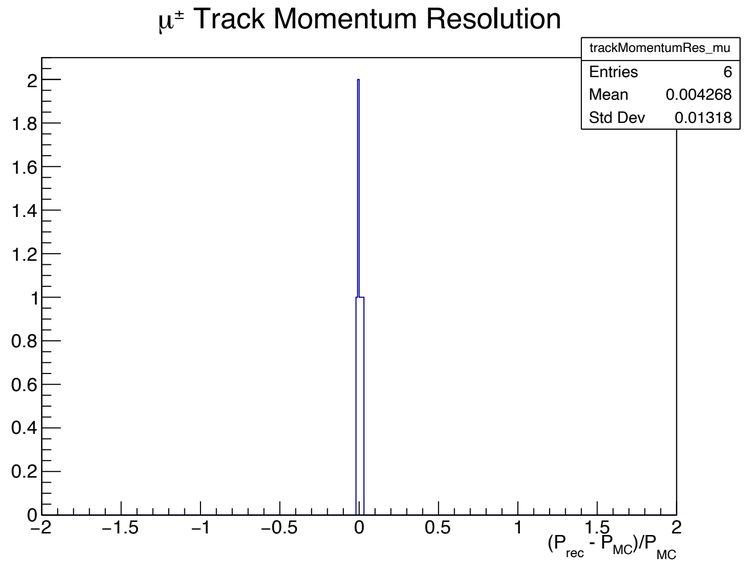
- Higher and highest Q2 squeeze the particles towards the barrel
- Photoproduction (very low Q2) pushes some particles into nHCal acceptance

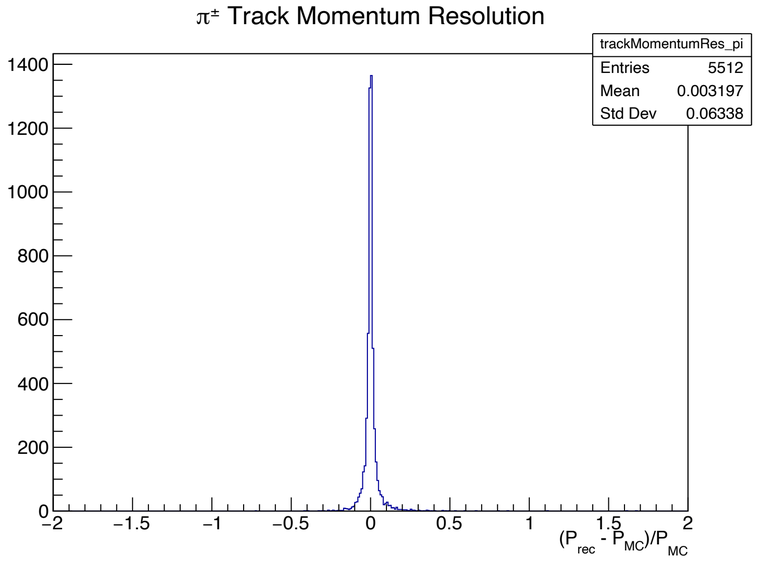
Q2=0.000000001-1 (photoproduction)

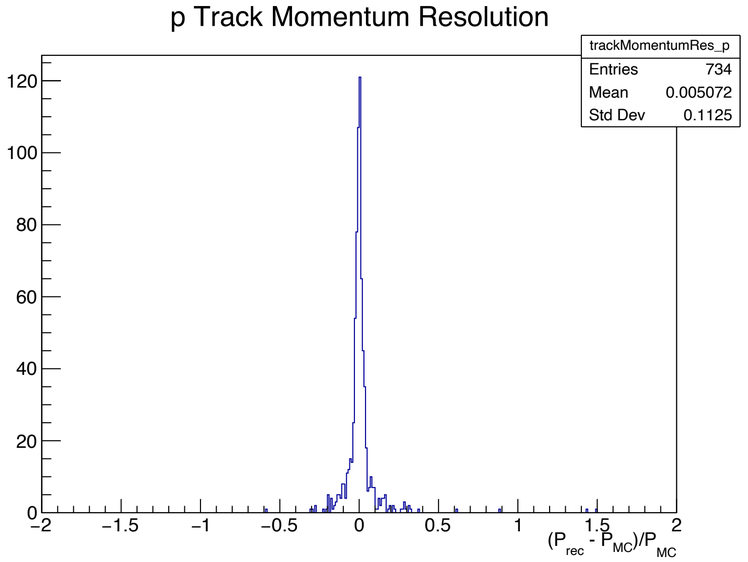


Track momentum resolutions

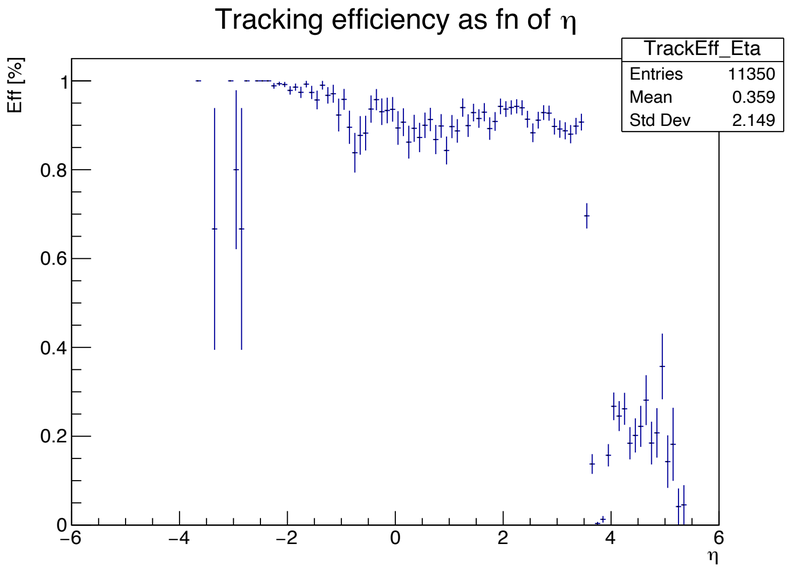


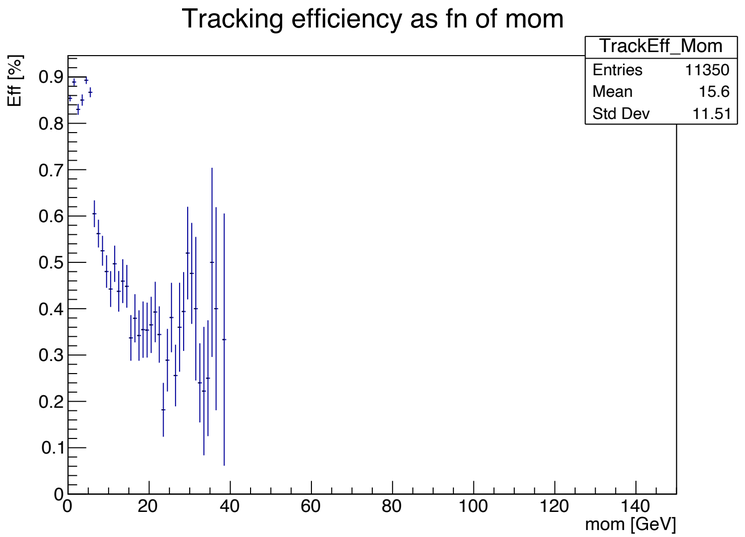


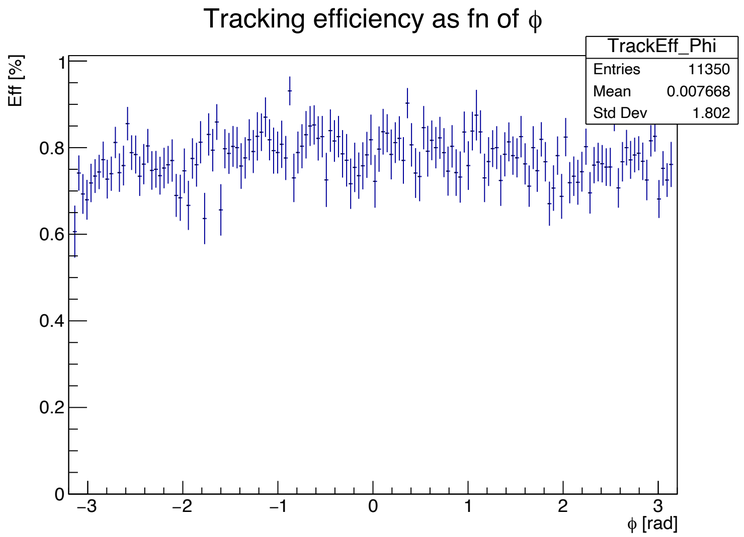


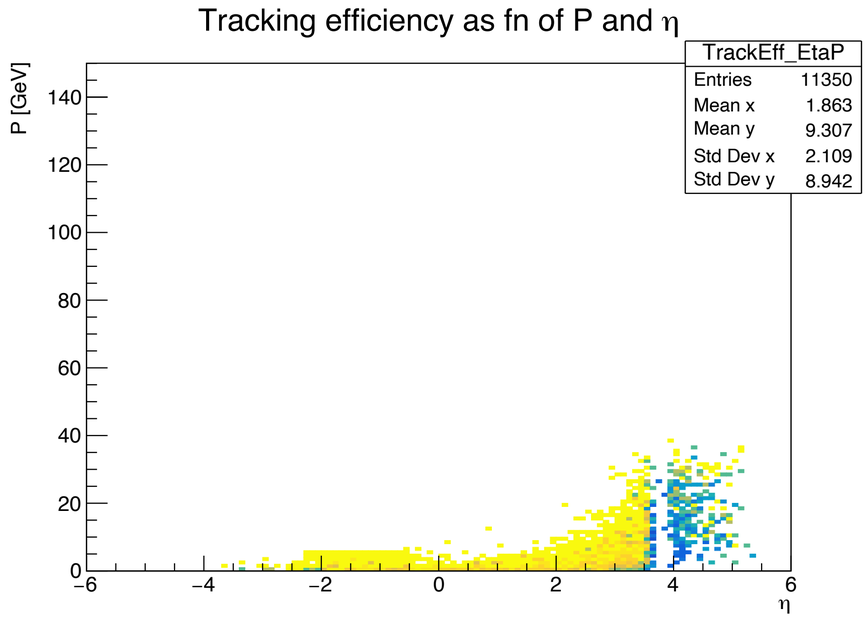


Tracking efficiency









Validations in my code and more information

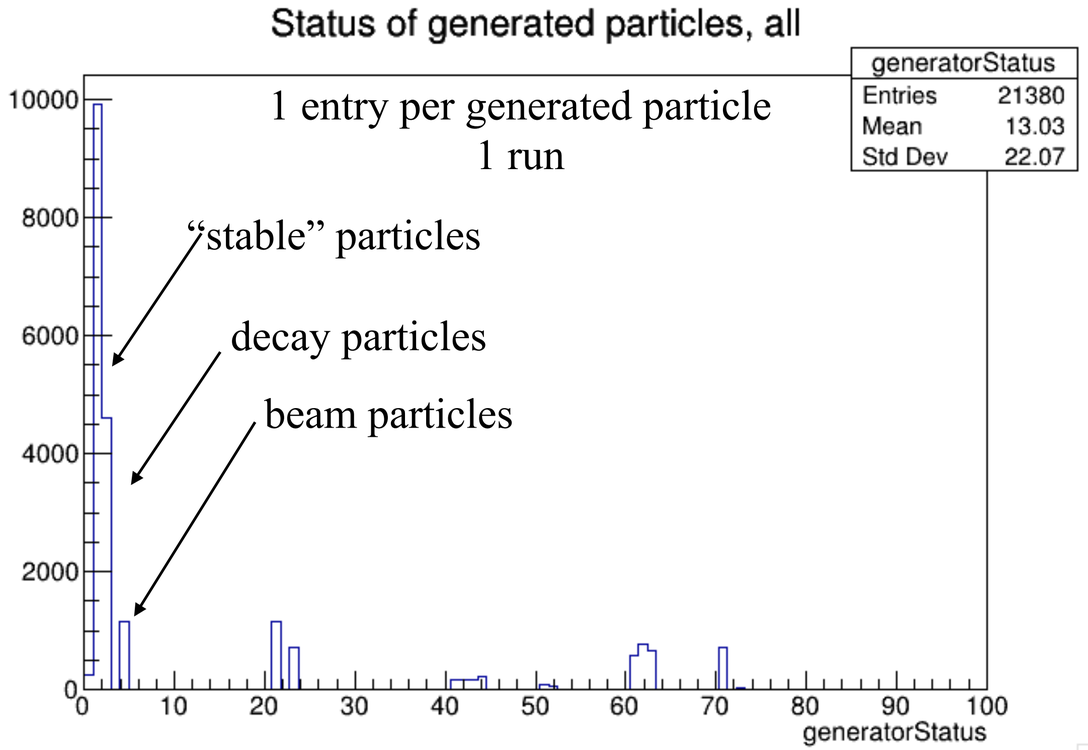
Status of generated particles

- S3/eictest/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…)
```



Parent and daughter indices - Wouter @ Mattermost

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	

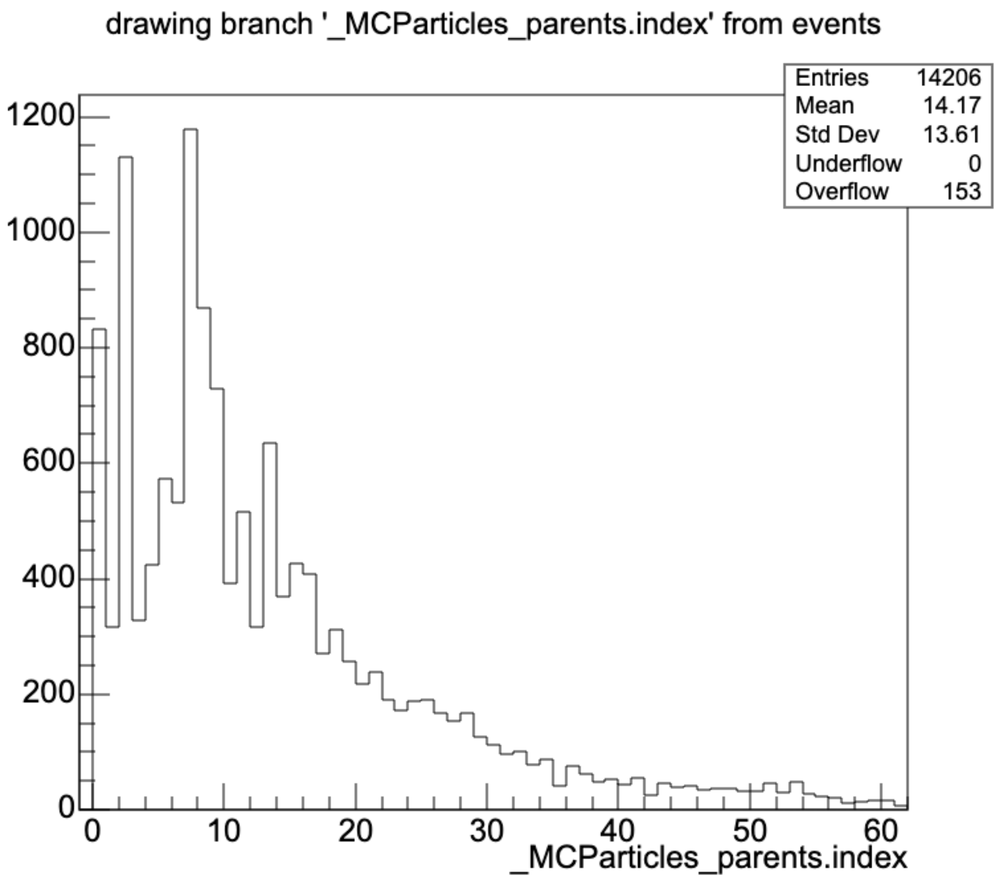
_MCParticles_parents[MCParticles.parents_begin].index
MCParticles.daughters_begin
MCParticles.daughters_end
_MCParticles_daughters[MCParticles.daughters_begin].index
_MCParticles_daughters[MCParticles.daughters_begin+1].index

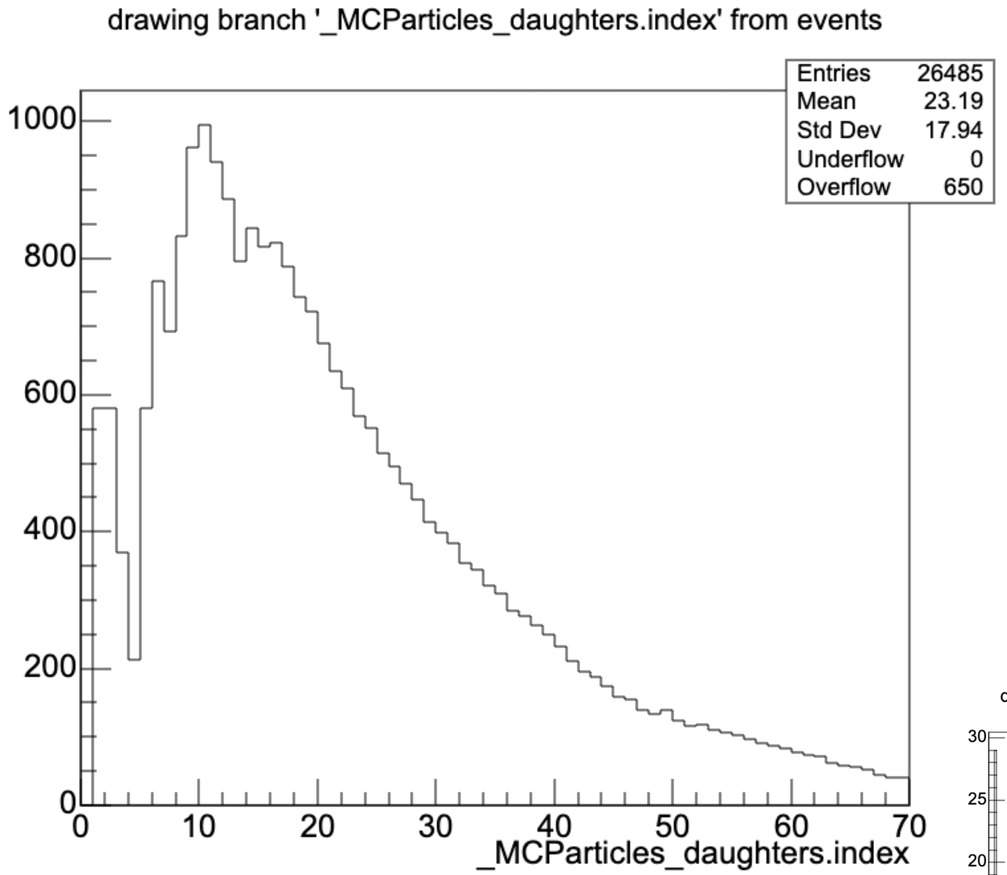
Particle decays - navigating from parent to daughter

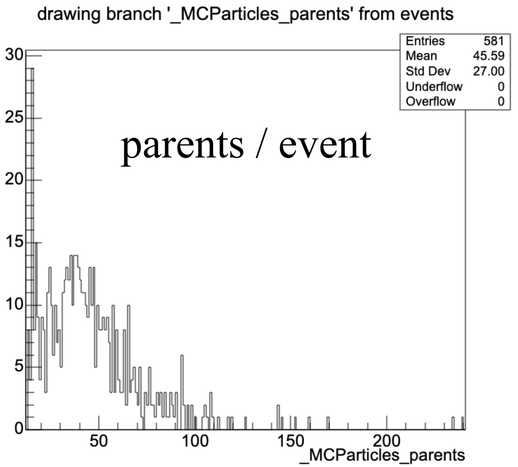
- TTreeReaderArray<int> daughters_index(tree_reader, "_MCParticles_daughters.index");
- TTreeReaderArray<unsigned int> daughters_begin(tree_reader, "MCParticles.daughters_begin");
- TTreeReaderArray<unsigned int> daughters_end(tree_reader, "MCParticles.daughters_end");
- from a search on Mattermost:
  `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.

Parent and daughter indices







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): $\pi^{\pm}$, photon; no daughters

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

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

Validating the code that handles decay navigation

```
EPIC/RECO/24.07.0/epic_craterlake/DIS/NC/18x275/minQ2=1

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

Number of generated events: 581

Number of generated electrons +-: 626
Number of generated protons +-: 526
Number of generated muons +-: 3
Number of generated pions +-: 3670
Number of generated pi0: 1973, of which decay into 2 gamma: 1956
Number of generated kaons +-: 365
Number of generated rho0: 313, of which decay into pi+ pi-: 313, into mu+ mu-: 0, into e+ e-: 0
Number of generated jpsi: 0
```

1956 / 1973 = 99.1% (~OK - expected BR is 98.8%)

expected BR is 99.9%

- Checked pi0 and rho0 decays and within margins, branching ratios are as expected
- No rho0 decays to lepton pairs found in single run (found 1 to ee in a different run)
- Kinematics of decayed pions - sum of 3-momentum vector is rho0 3-momentum vector (another conformation that decay is navigated correctly)

```
rho0 decay: generated rho0 eta: 4.3733, pi1: 4.49585, pi2: 3.0102
            trueMomrho0 X: -0.665527, trueMomrho0 Y: 0.0961247, trueMomrho0 Z: 26.6594
            trueMompi12 X: -0.665527, trueMompi12 Y: 0.0961247, trueMompi12 Z: 26.6594
rho0 decay: generated rho0 eta: 4.33104, pi1: 4.21049, pi2: 4.40309
            trueMomrho0 X: -6.32427, trueMomrho0 Y: -0.0424749, trueMomrho0 Z: 240.359
            trueMompi12 X: -6.32427, trueMompi12 Y: -0.0424749, trueMompi12 Z: 240.359
rho0 decay: generated rho0 eta: 4.21155, pi1: 4.21488, pi2: 2.55612
            trueMomrho0 X: 0.167669, trueMomrho0 Y: -0.355584, trueMomrho0 Z: 13.2576
            trueMompi12 X: 0.167669, trueMompi12 Y: -0.355584, trueMompi12 Z: 13.2576
rho0 decay: generated rho0 eta: 3.66908, pi1: 3.13424, pi2: 3.17975
            trueMomrho0 X: -0.381757, trueMomrho0 Y: -0.394062, trueMomrho0 Z: 10.751
            trueMompi12 X: -0.381757, trueMompi12 Y: -0.394062, trueMompi12 Z: 10.751
rho0 decay: generated rho0 eta: 4.19509, pi1: 3.23494, pi2: 2.97688
            trueMomrho0 X: -0.136425, trueMomrho0 Y: -0.188853, trueMomrho0 Z: 7.72835
            trueMompi12 X: -0.136425, trueMompi12 Y: -0.188853, trueMompi12 Z: 7.72835
rho0 decay: generated rho0 eta: 6.18561, pi1: 5.15977, pi2: 3.94052
            trueMomrho0 X: -0.041526, trueMomrho0 Y: -0.0519121, trueMomrho0 Z: 16.1443
            trueMompi12 X: -0.041526, trueMompi12 Y: -0.0519121, trueMompi12 Z: 16.1443
```

Reconstructed pi^{+-} from rho0 decay

```
Event 555 with gen rho0 #: 113, daughter 1:211, daughter 2:-211, i_daughters:2
-> Event 555 found rho0 decayed into pi+ pi-: 211 and -211
--> Event 555 rho0 decay to 2pi: generated rho0 eta: 4.22999, pi1: 4.16573, pi2: 4.23263
            trueMomrho0 X: -5.4062, trueMomrho0 Y: -0.426629, trueMomrho0 Z: 186.285
            trueMompi12 X: -5.4062, trueMompi12 Y: -0.426629, trueMompi12 Z: 186.285

Event 556 with gen rho0 #: 113, daughter 1:211, daughter 2:-211, i_daughters:2
-> Event 556 found rho0 decayed into pi+ pi-: 211 and -211
--> Event 556 rho0 decay to 2pi: generated rho0 eta: 3.93364, pi1: 4.00417, pi2: 3.21636
            trueMomrho0 X: -1.09625, trueMomrho0 Y: -0.465579, trueMomrho0 Z: 30.4145
            trueMompi12 X: -1.09625, trueMompi12 Y: -0.465579, trueMompi12 Z: 30.4145
          reco daughter-2 eta: 3.19882, reco index daughter-2: 16

Event 559 with gen rho0 #: 113, daughter 1:211, daughter 2:-211, i_daughters:2
-> Event 559 found rho0 decayed into pi+ pi-: 211 and -211
--> Event 559 rho0 decay to 2pi: generated rho0 eta: 2.73289, pi1: 2.33113, pi2: 2.32695
            trueMomrho0 X: -0.273944, trueMomrho0 Y: -0.493102, trueMomrho0 Z: 4.3187
            trueMompi12 X: -0.273944, trueMompi12 Y: -0.493102, trueMompi12 Z: 4.3187
---> Event 559 rho0 decay, reco index rho0: 4
          reco daughter-1 eta: 2.33119, reco index daughter-1: 40
          reco daughter-2 eta: 2.32658, reco index daughter-2: 41

Event 559 with gen rho0 #: 113, daughter 1:211, daughter 2:-211, i_daughters:2
-> Event 559 found rho0 decayed into pi+ pi-: 211 and -211
--> Event 559 rho0 decay to 2pi: generated rho0 eta: 4.42089, pi1: 4.40682, pi2: 4.27424
            trueMomrho0 X: -0.713155, trueMomrho0 Y: -0.158048, trueMomrho0 Z: 30.3718
            trueMompi12 X: -0.713155, trueMompi12 Y: -0.158048, trueMompi12 Z: 30.3718

Event 560 with gen rho0 #: 113, daughter 1:211, daughter 2:-211, i_daughters:2
-> Event 560 found rho0 decayed into pi+ pi-: 211 and -211
--> Event 560 rho0 decay to 2pi: generated rho0 eta: 4.3733, pi1: 4.49585, pi2: 3.0102
            trueMomrho0 X: -0.665527, trueMomrho0 Y: 0.0961247, trueMomrho0 Z: 26.6594
            trueMompi12 X: -0.665527, trueMompi12 Y: 0.0961247, trueMompi12 Z: 26.6594
          reco daughter-2 eta: 3.00956, reco index daughter-2: 25
```

no daughter reco

daughter 1 not reco

both daughters reco

no daughter reco

daughter 1 not reco

Fraction of decay particles in nHCal

"pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1_100files"

$\rho \rightarrow \pi^+\pi^-$

$\phi \rightarrow K^+K^-$

```
Number of generated events: 57723

Number of generated electrons +-: 63255
Number of generated protons +-: 53062
Number of generated muons +-: 456
Number of generated pions +-: 342238
Number of generated pi0: 196594, of which decay into 2 gamma: 194251
Number of generated kaons +-: 34137
Number of generated rho0: 26779, of which decay into pi+ pi-: 26750, into mu+ mu-: 1, into e+ e-: 3
        2134 pi+ pi- make it into the nHCal acceptance, with corresponds to a fraction 0.0398879
Number of generated rho+: 48841
Number of generated phi: 1165, of which decay into K+ K-: 579
        57 K+ K- make it into the nHCal acceptance, with corresponds to a fraction 0.0492228
Number of generated omega: 26341
Number of generated J/Psi: 0
Number of generated Upsilon: 0
Number of generated D0: 2362
Number of generated B0: 9

Number of reconstructed electrons +-: 59261
Number of reconstructed protons +-: 18568
Number of reconstructed muons +-: 390
Number of reconstructed pions +-: 210930
Number of reconstructed kaons +-: 21775
```

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>
```

MC steering files

From Brian July 22, 2024: You can see an example here: https://github.com/eic/eicSimuBeamEffects/blob/master/Pythia8/steerFiles/dis_eicBeam_hiDiv_18x275

Lines 21 - 33 are associated with how we add beam effects into the simulation and can be removed when running stand-alone. As I mentioned, I still need to get this information into the production database, but these steering files were used to create the hepmc files which underpin the NC DIS simulations.

From mailto:rahmans@myumanitoba.ca on Mattermost:
https://chat.epic-eic.org/main/pl/ss5mm514a3fjzyqa3c3ijqcxkh

1) pythia6-eic https://gitlab.com/eic/mceg/PYTHIA-RAD-CORR/-/tags/1.0.0
   Used in SIDIS datasets

2) EpIC https://pawelsznajder.github.io/epic/

Used in DVMP dataset https://github.com/eic/DVMPdataset/releases/tag/EpIC1.0.0-1.1

3) DEMPgen https://github.com/JeffersonLab/DEMPgen/releases/tag/v1.1.0

Used in DEMP dataset

4) GETaLM https://github.com/adamjaro/GETaLM/releases/tag/1.0.0

Used in Electron Beam Gas https://github.com/eic/ElectronBeamGas/releases/tag/GETaLM1.0.0-1.0

5) Pythia8.306

Used in Lambda https://github.com/eic/LambdaGen/releases/tag/pythia8.306-1.0

Used in D0 https://github.com/eic/D0Gen/releases/tag/pythia8.306-1.0

Used in proton beam gas https://github.com/eic/ProtonBeamGas/releases/tag/pythia8.306-1.0

6) Sartre

Used for diffractive jPsi and phi

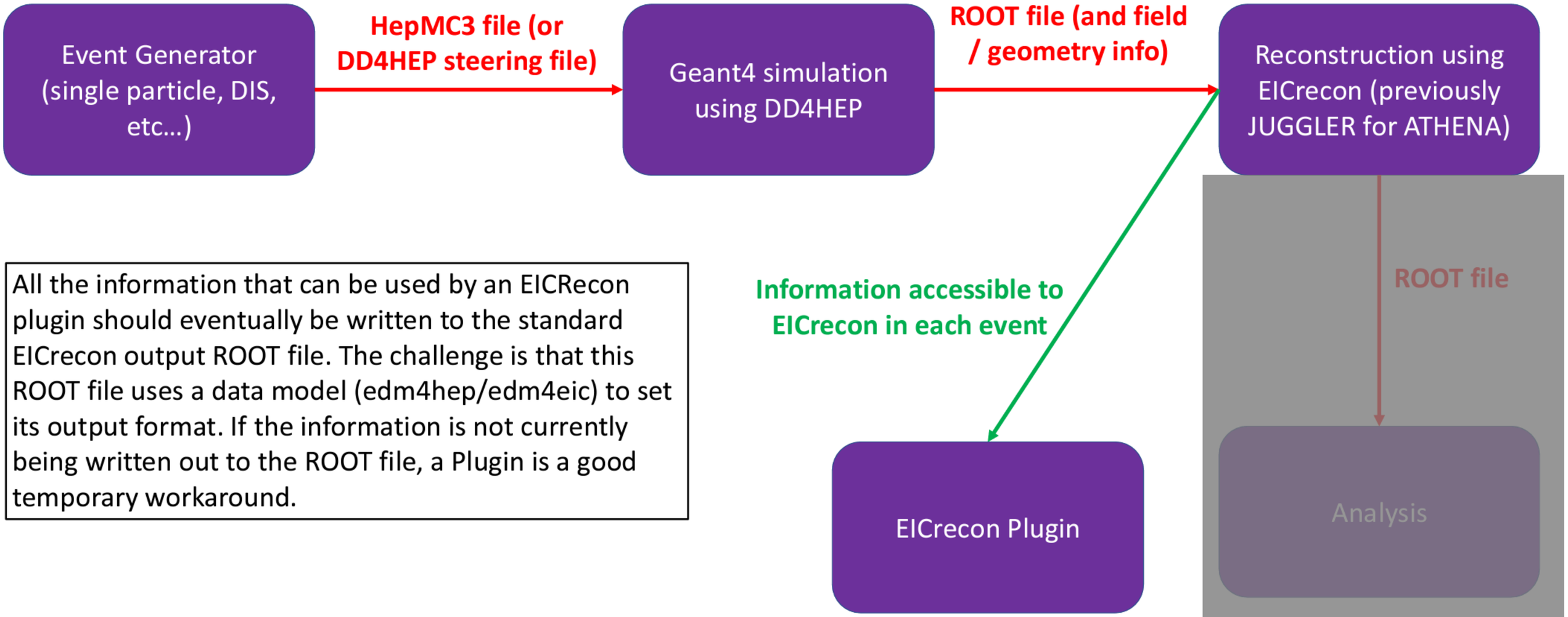
https://github.com/eic/SARTREdataset/releases/tag/sartre-1.39-1.0

7) And although not a generator but the HEPMC_merger

https://github.com/eic/HEPMC_Merger/releases/tag/v1.0.2

Useful sketches

ePIC simulation workflow



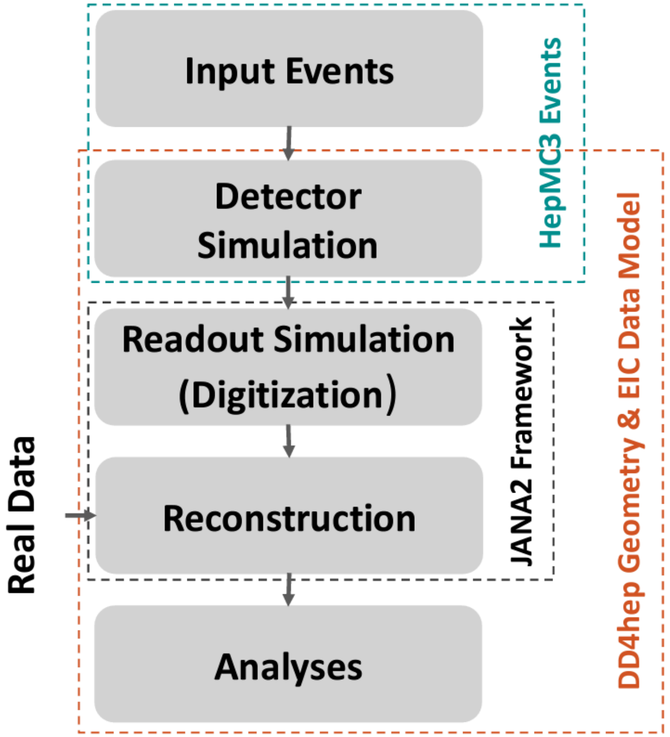
All the information that can be used by an EICRecon plugin should eventually be written to the standard EICrecon output ROOT file. The challenge is that this ROOT file uses a data model (edm4hep/edm4eic) to set its output format. If the information is not currently being written out to the ROOT file, a Plugin is a good temporary workaround.

https://indico.bnl.gov/event/18373/contributions/73838/attachments/46446/78595/eicrecon_anaysis_tutorial.pdf

ePIC MC productions

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

courtesy Markus Diefenthaler



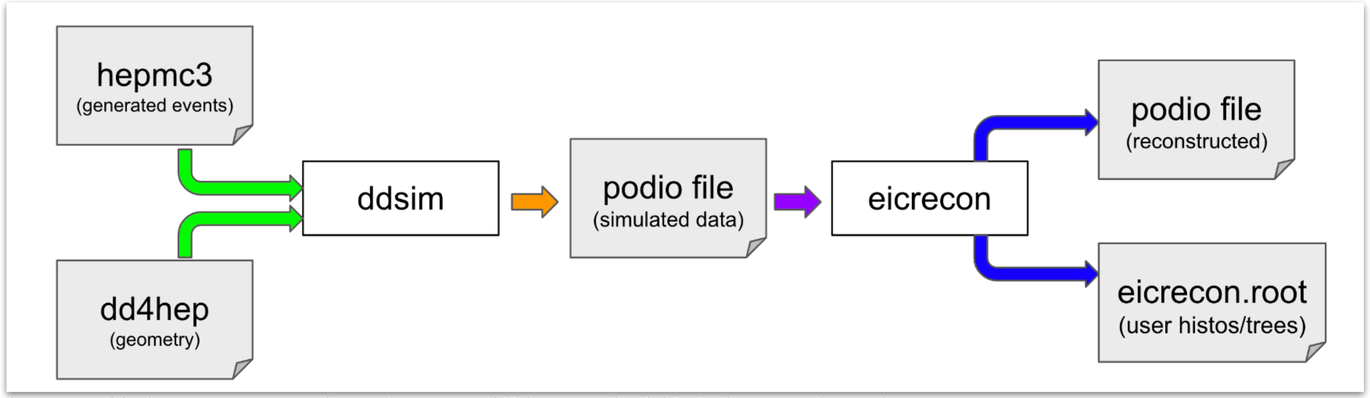
Input events from **MC event generators** or particle guns, with optional background merging.

Geant4 simulations with **DD4hep** for geometry description and exchange, output data in the **EIC Data Model** (EDM4hep + EDM4eic, described in Podio).

Algorithms to transform the GEANT4 hits to mimic real detector readout, including background stacking, “pileup”, DAQ frames.

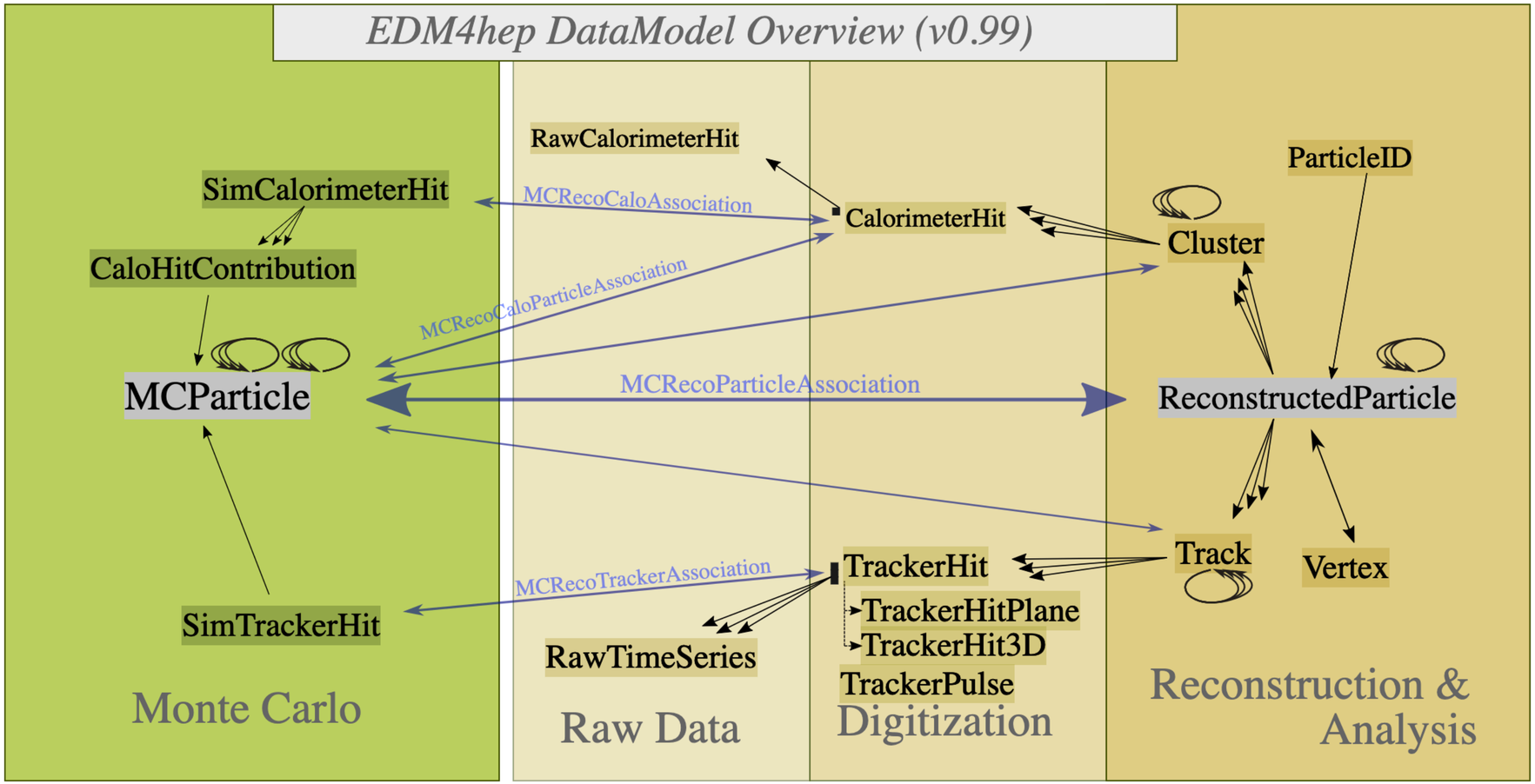
Realistic reconstruction algorithms starting from raw detector output (from digitization or real data).

User analyses in plain C++/ROOT or Python/uproot, facilitated by using a flat data model.



https://eicrecon.epic-eic.org/#/tutorial/01-introduction

EDM4EIC



EDM4eic - EIC data model.

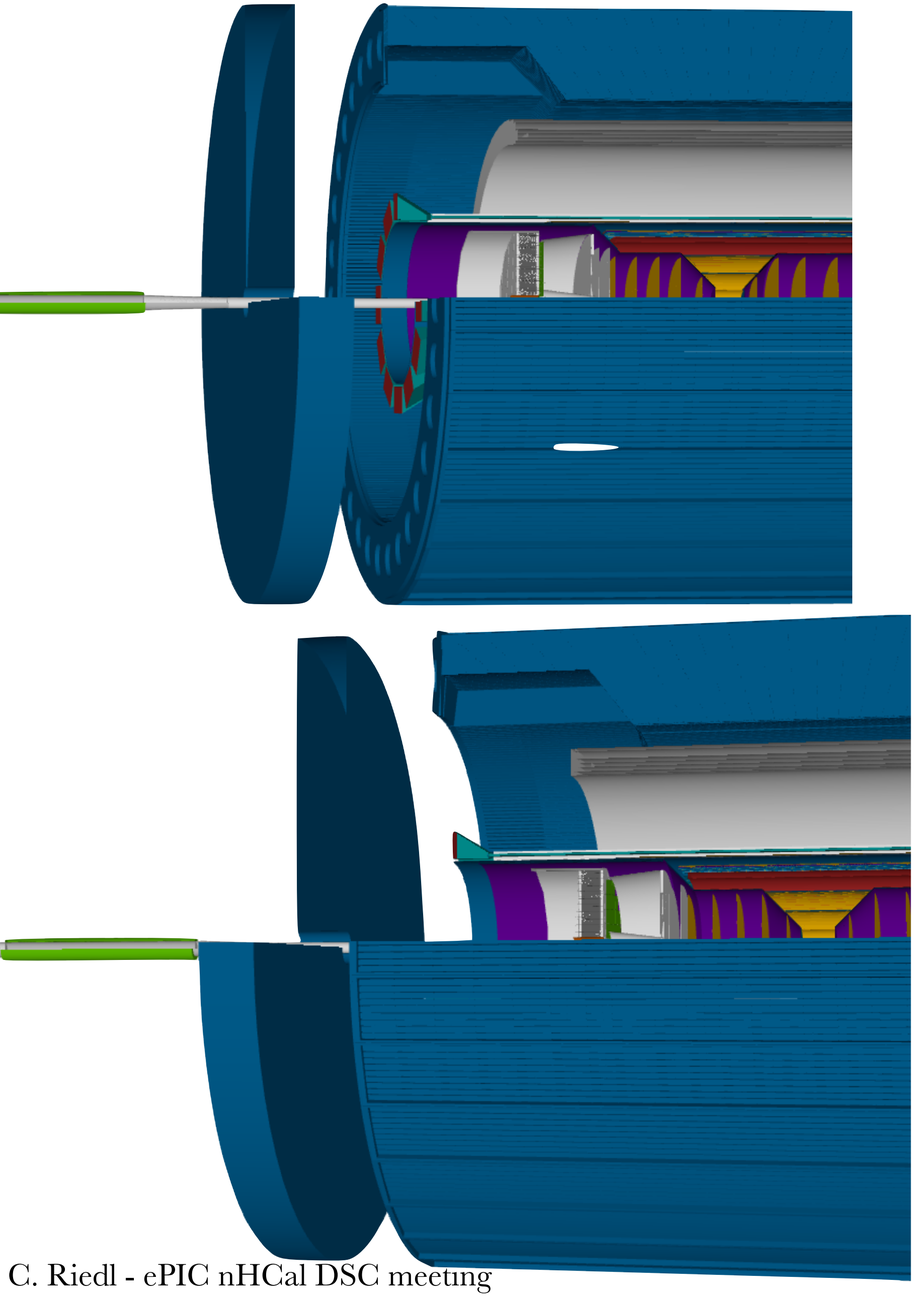
A data model for EIC defined with podio and based on EDM4hep.

PODIO, or plain-old-data I/O, is a C++ library to support the creation and handling of data models in particle physics

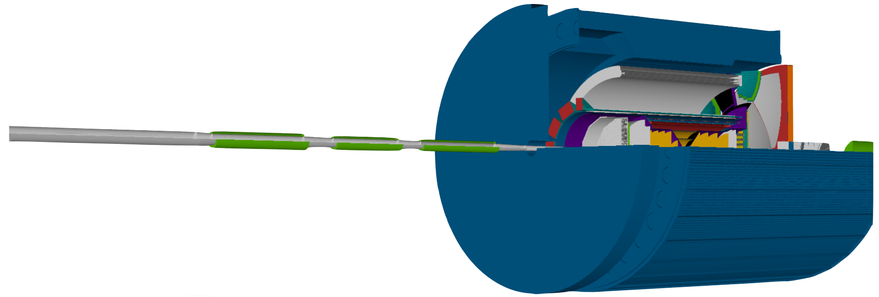
EDM = event data model

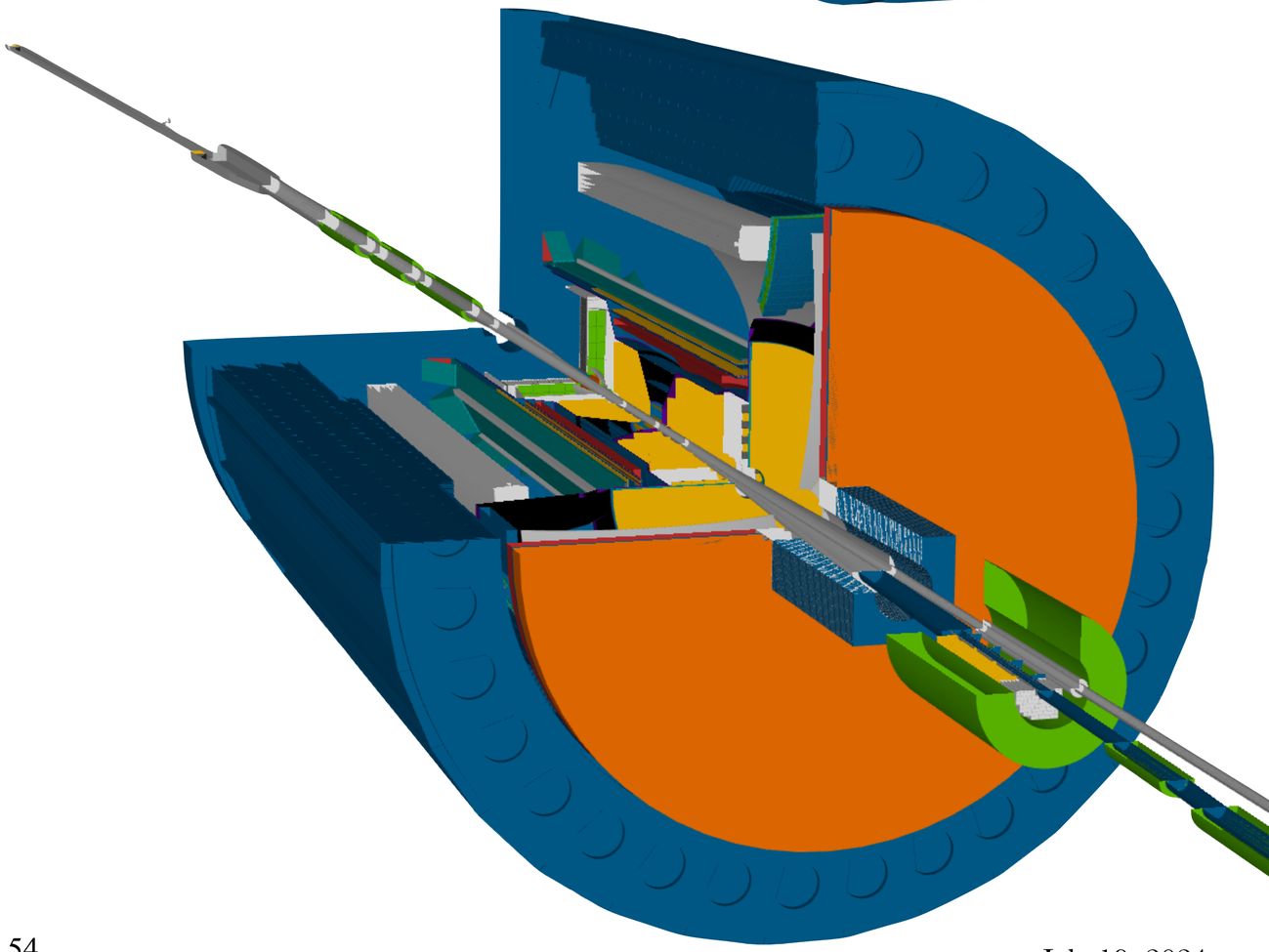
https://edm4hep.web.cern.ch/

ePIC geometry - dd_web_display --export $DETECTOR_PATH/$DETECTOR_CONFIG.xml

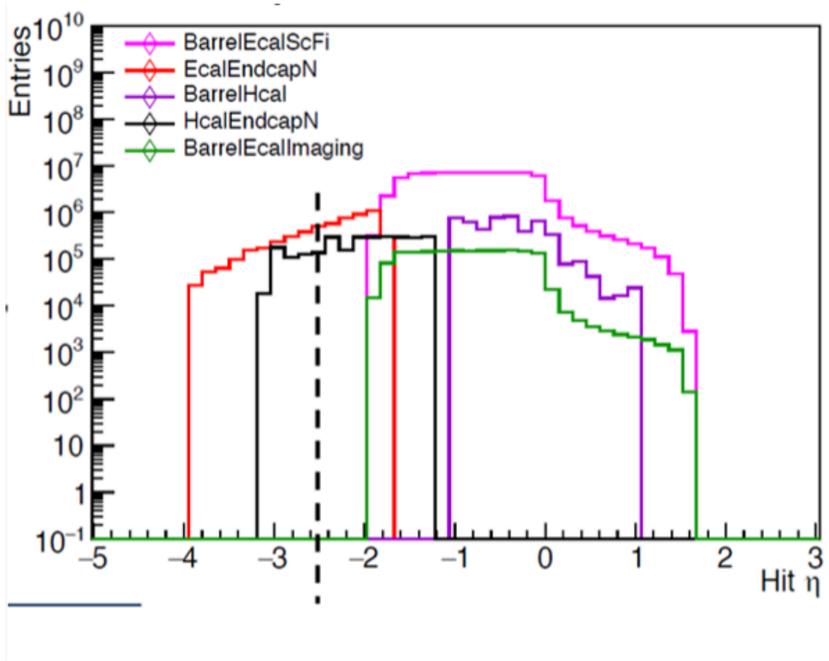


flux return removed





Outdated & to be re-done



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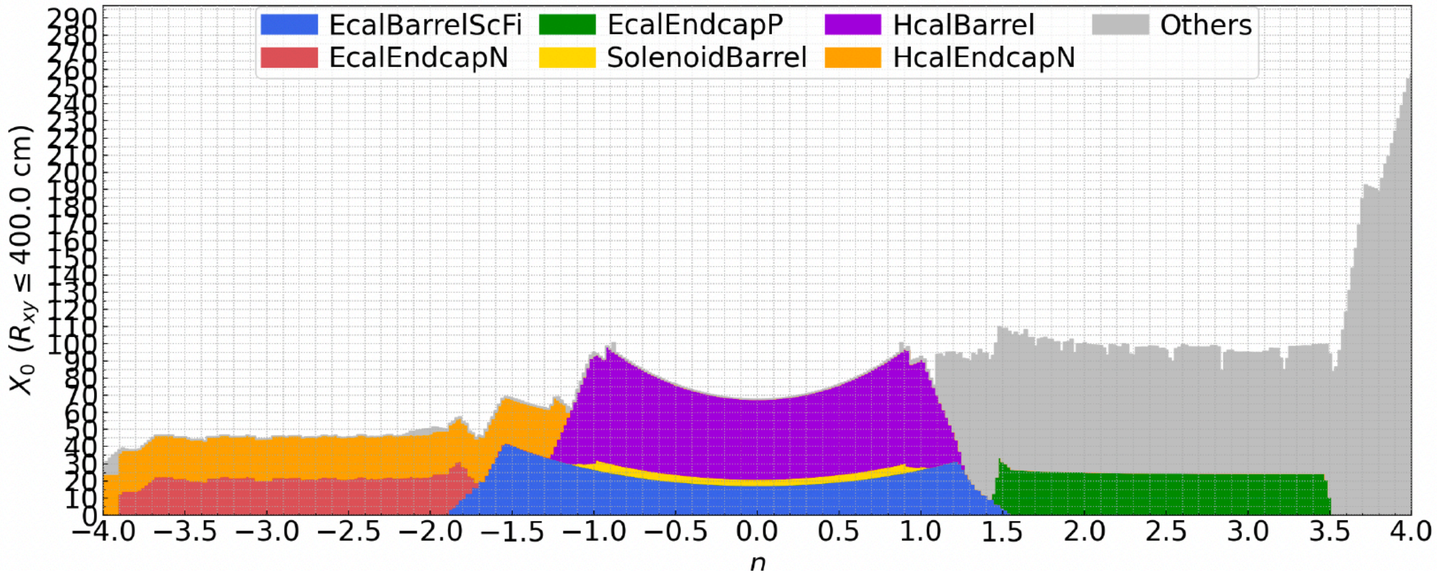

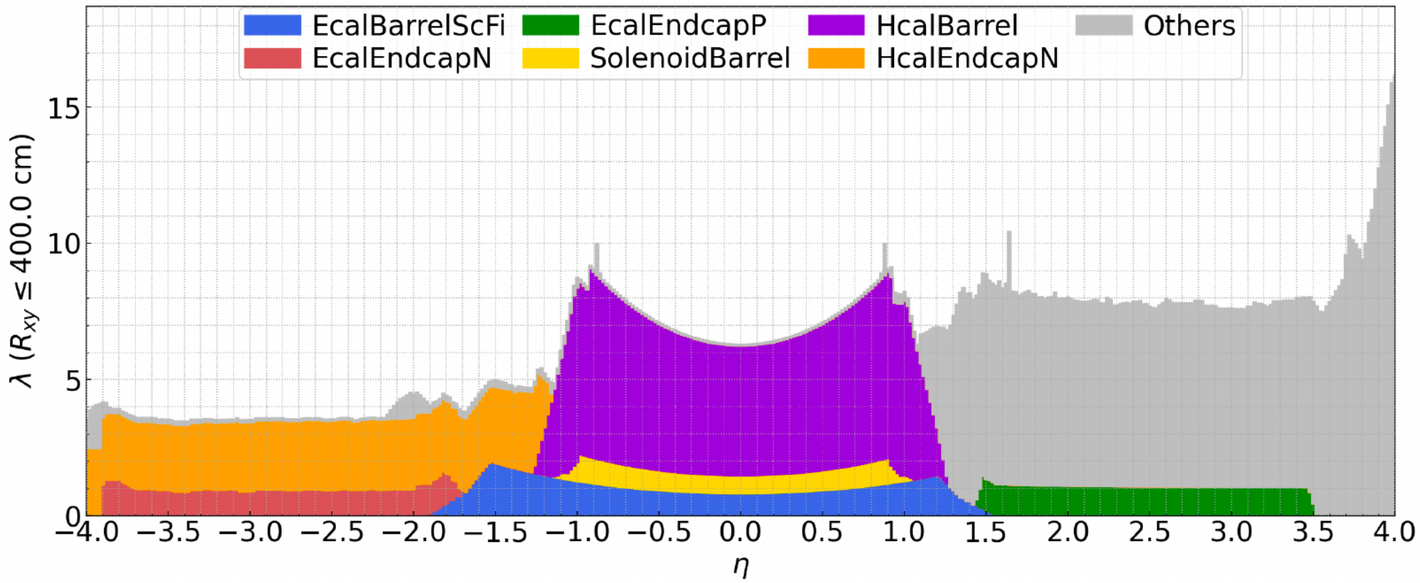

nHCal - use as tagger?

- look into Oleg's slides Friday afternoon
- nHCal as background veto (as done at HERA)