LCFIPlus
+
Mono-photon benchmark

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1. LCFIPlus

Performance of vertex reconstruction

- **Test implementation to match vertex and MCParticle corresponding to semistable B-hadrons and C-hadrons.**
  Basic idea :
  - Find semistable B-hadrons and C-hadrons to be found in each event.
  - Looping tracks associated to each vertex and find corresponding MCParticles to these tracks.
  - Using these MC information, identify the ("nearest" in terms of generation) origins of the tracks (IP, B-hadron, C-hadron, Beam bkg., Others)
  - Compute the fraction of the track-origins for each vertex, and take
  - the highest origin as its truth.

Output example (Primary vertex part)

```
#####################  Evt = 34 ########################
####  Looking for primary vertex …
    ####  New vertex …
      Reconstructed vertex has 42 tracks.
      Candidate origin 0) 0 (0x7ffe1bc45ae0) ntrcks assigned = 40
      Candidate origin 1) -421 (0x69a11e0) ntrcks assigned = 1
      Candidate origin 2) 511 (0x6971810) ntrcks assigned = 1
      Best estimation : 0 (0x7ffe1bc45ae0), w = 0.952381
.
.
.
.
.
```

0 : primary vertex

Output example (secondary vertex part)

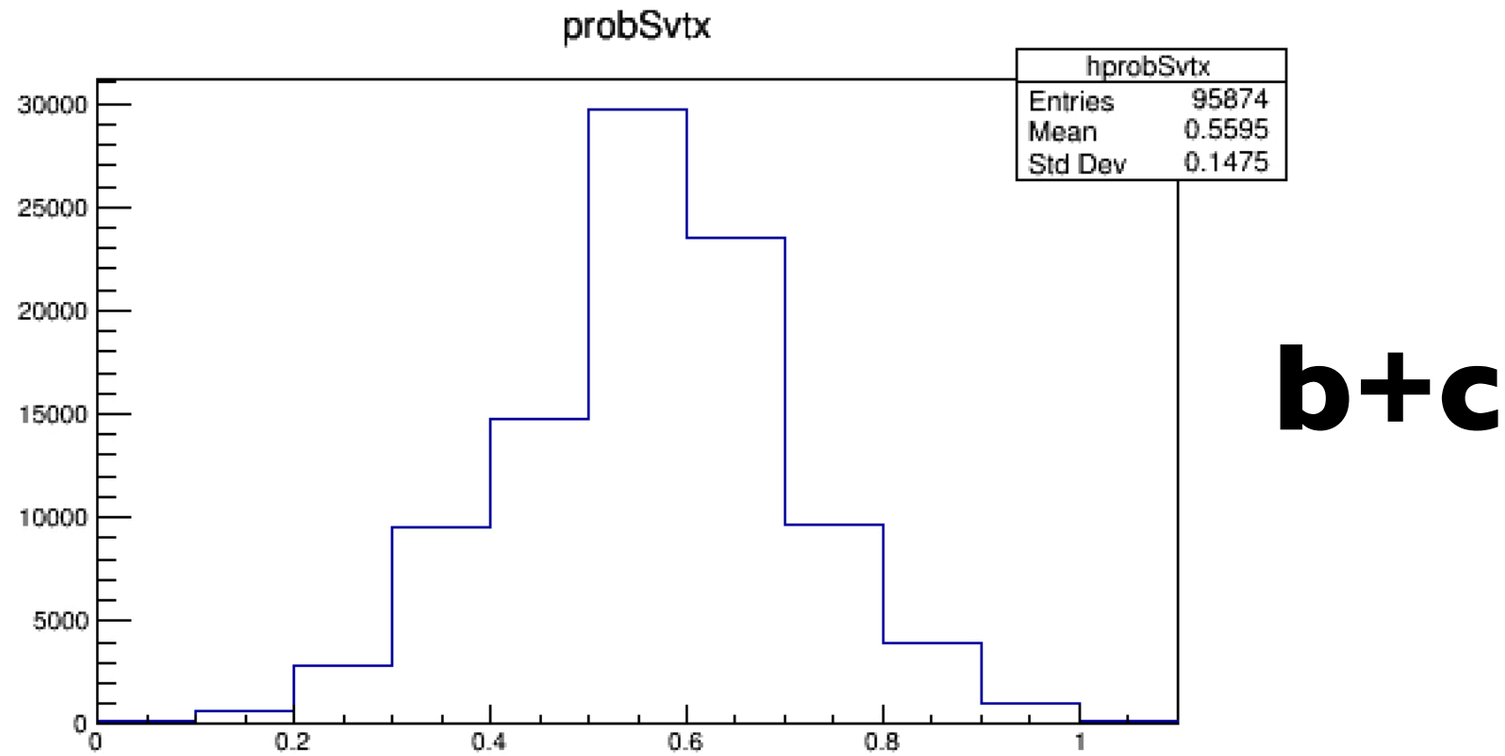
```
####  Looking for secondary vertices …
    ####  New vertex …
      Reconstructed vertex has 2 tracks.
      Candidate origin 0) -511 (0x27f5160) ntrcks assigned = 2
      Best estimation : -511 (0x27f5160), w = 1
    ####  New vertex …
      Reconstructed vertex has 2 tracks.
      Candidate origin 0) 421 (0x65101f0) ntrcks assigned = 2
      Best estimation : 421 (0x65101f0), w = 1
    ####  New vertex …
      Reconstructed vertex has 7 tracks.
      Candidate origin 0) 511 (0x6971810) ntrcks assigned = 7
      Best estimation : 511 (0x6971810), w = 1
    ####  New vertex …
      Reconstructed vertex has 3 tracks.
      Candidate origin 0) -421 (0x69a11e0) ntrcks assigned = 1
      Candidate origin 1) 511 (0x6971810) ntrcks assigned = 1
      Candidate origin 2) -521 (0x31868b0) ntrcks assigned = 1
      Best estimation : -421 (0x69a11e0), w = 0.333333
    ####  New vertex …
      Reconstructed vertex has 3 tracks.
      Candidate origin 0) -521 (0x31868b0) ntrcks assigned = 3
      Best estimation : -521 (0x31868b0), w = 1
    ####  New vertex …
.
.
.
```

Output example (Summary part)

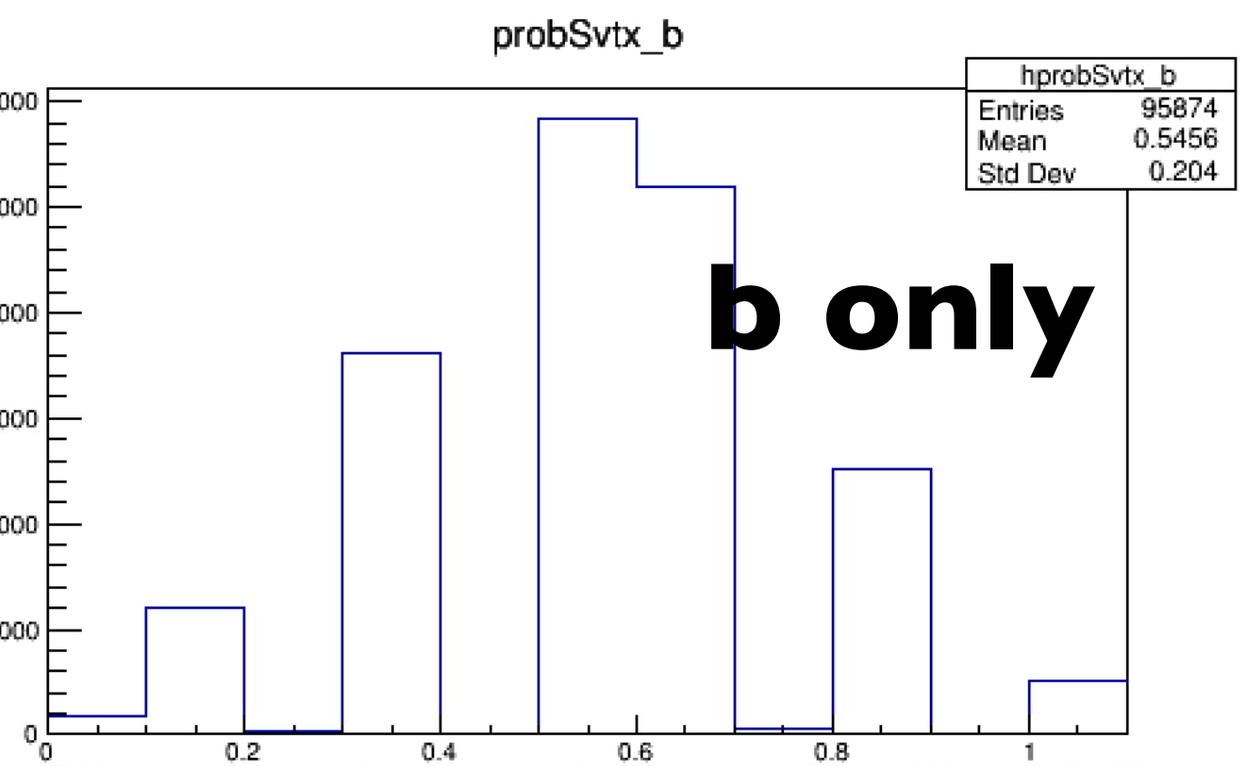
```
#### Summary (Secondary vertices) ####
# of vertices to be found = 11
     1)  -521 (0x2e889c0)  Found.
     2)   511 (0x65bfc50)  Found.
     3)   511 (0x65ce660)  Found.
     4)  -511 (0x65b6010)  Found.
     5)   521 (0x65b3c00)  Found.
     6)  -521 (0x2da10a0)  Not found. (3 pfo tracks for this vertex exist but were not
associated.)
     7)  -411 (0x2e76dd0)  Found.
     8)  -421 (0x2dd76c0)  Found.
     9)   421 (0x2dceff0)  Not found. (2 pfo tracks for this vertex exist but were not
associated.)
    10)   421 (0x2de2440)  Found.
    11)   421 (0x2d6a7b0)  Found.
Vertex reconstruction efficiency = 0.818182 (9/11)
Vertex reconstruction efficiency (b) = 0.833333
Vertex reconstruction efficiency (c) = 0.8
```

Fraction distribution

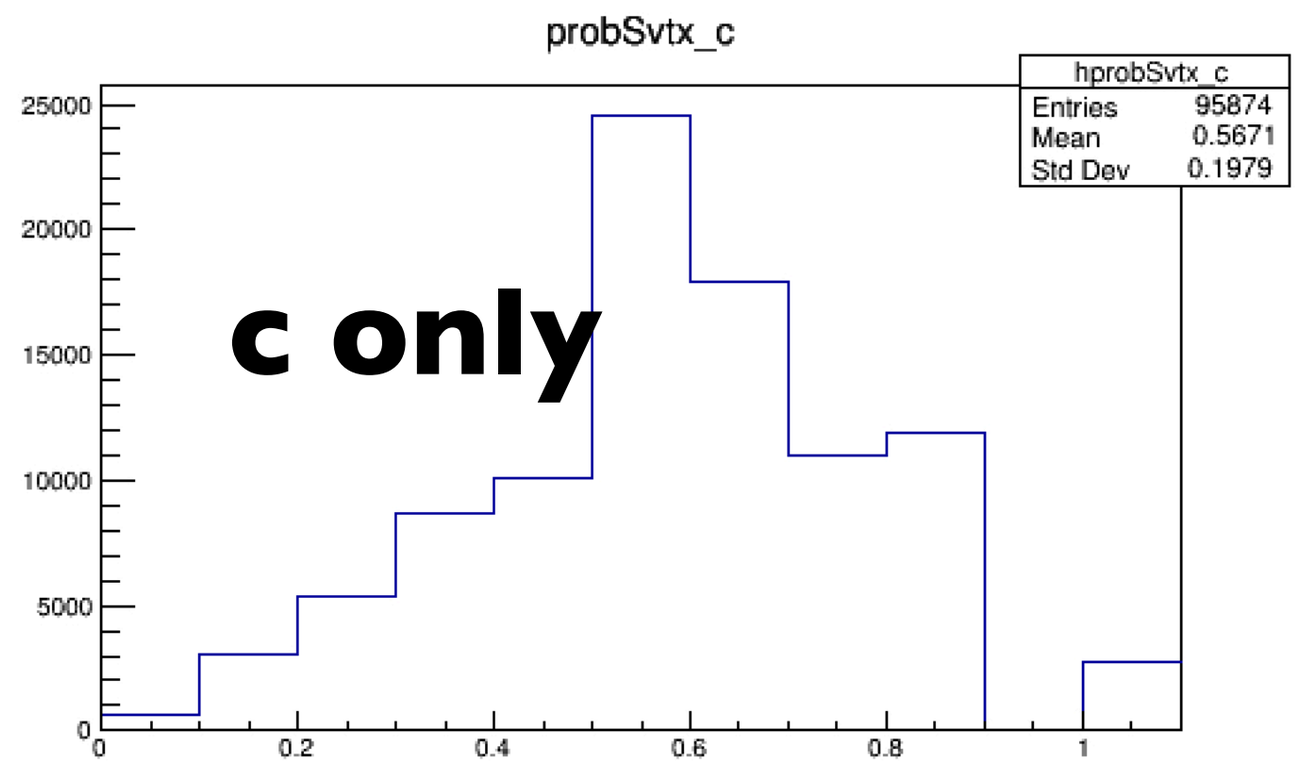
Vertex rec. efficinecy for 6b samples



b+c



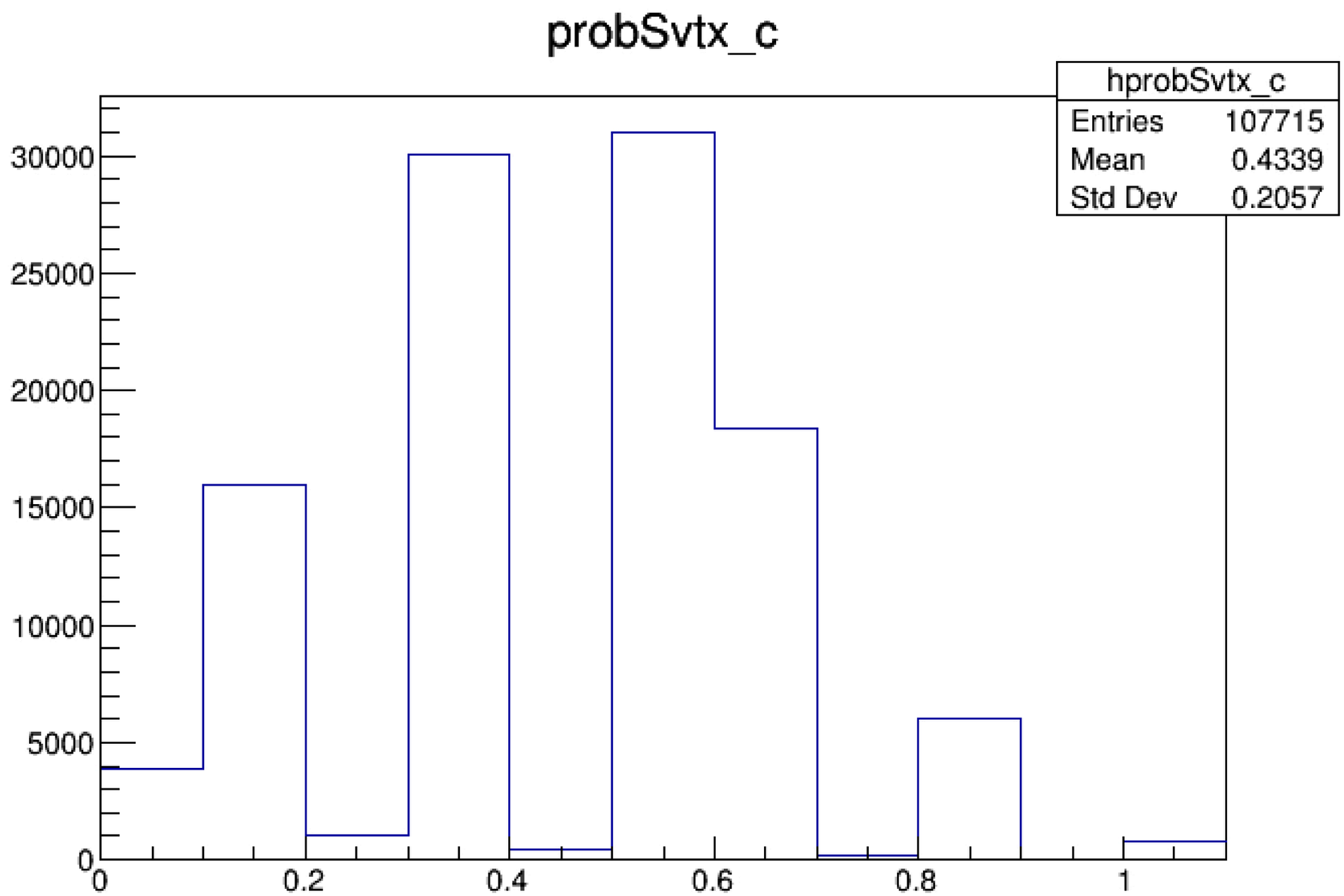
b only



c only

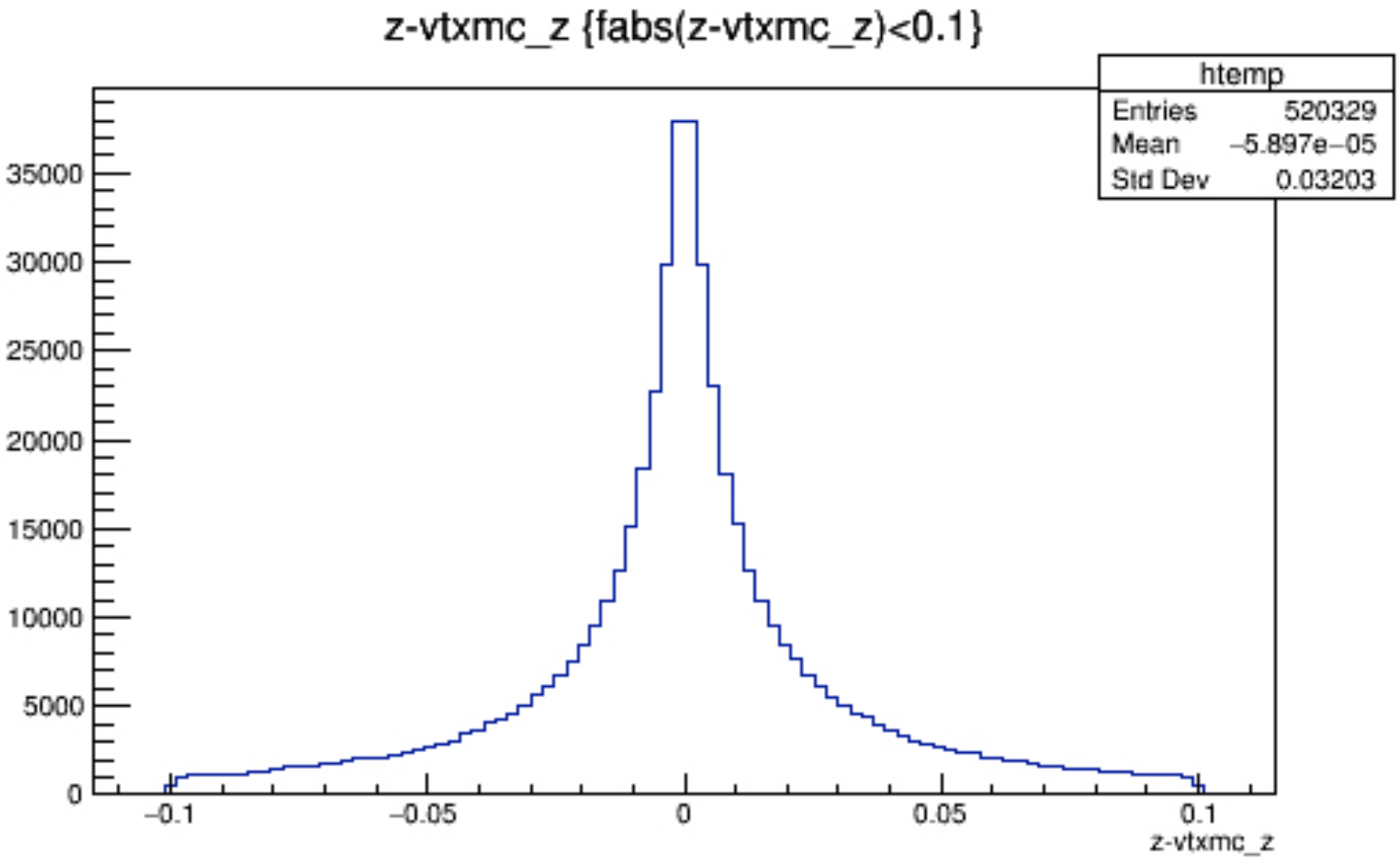
Note that Denominators for "b only" and "c only" are different from b+c case.
This is why sum of "b only" + "c only" does not match to "b+c" histogram.

Vertex rec. efficinecy for 6c samples



Residual w.r.t matched origin

secondary vertex (b+c) z position



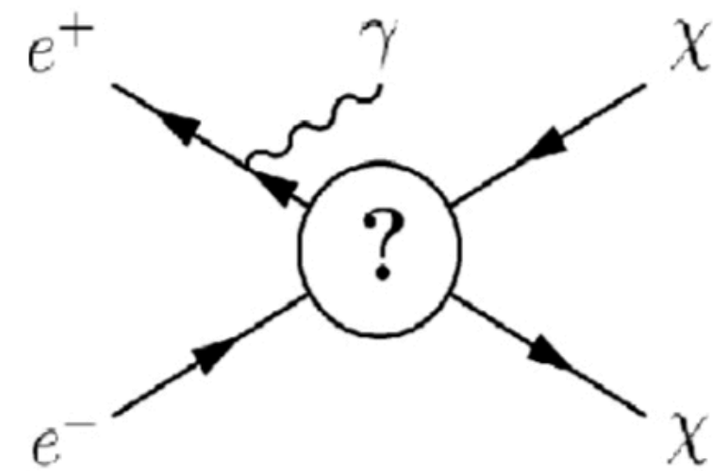
[mm]

2. Mono-photon benchmark

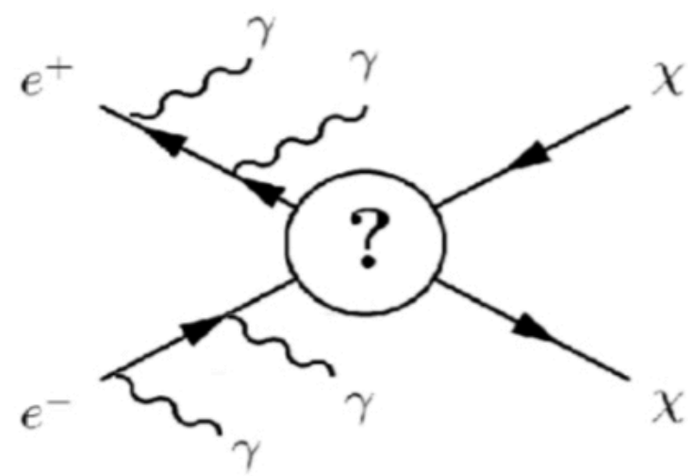
WIMP Detection at ILC

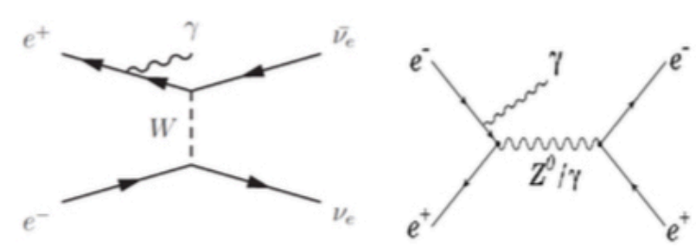
Moritz, LCWS17

- **Signal**
  - **WIMP pair production with a photon from initial state radiation** $e^+e^- \to \chi\chi\gamma$
  - quasi model-independent
  - single photon in an "empty" detector $\to$ missing four-momentum
  - observables: E_γ, θ_γ



- **Main Background Processes**
  - **Neutrino pairs** $e^+e^- \to \nu\bar{\nu}\gamma$
    - irreducible
    - polarisation: enhance or suppress
  - **Bhabha scattering** $e^+e^- \to e^+e^-\gamma$
    - huge cross section
    - cross section rises for low polar angles
    - mimics signal if leptons in forward region are undetected





Detector benchmark with Mono-photon process

- **One of inputs for IDR**
  - Energy resolution, angular resolution, detection efficiency etc.
  - BeamCal veto for Bhabha suppression
- **Sample**
  - e+e- —> nu nu nγ (both as signal and background)
  - e+e- —> e+ e- nγ (possible background if e+e- are undetected.)
  - Produced with l5 and s5 ILD models.
  - Produced with beam background (so called seeable pair).
- **With helps from Moritz**
  - analysis macros
  - advices/suggestions

Cut efficiency (Moritz's macro)
νν + Nγ sample used

for I5 sample (only1 file used for now)

```
final cut flow:
   initial number of events:                37000
   number of photons that fulfill signal definition: 22503 => 60.8189%
   number of events that fulfill pt cut: 19806 => (53.5297%) => 88.0149%
   number of events that fulfill Evis cut: 18131 => (49.0027%) => 80.5715%
   number of events that fulfill BCal cut: 11496 => (31.0703%) => 51.0865%
```

for DBD sample (Moritz's sample) (only1 file used for now)

```
final cut flow:
   initial number of events:    59913
   number of photons that fulfill signal definition:37015 => 61.7812%
   number of events that fulfill pt cut:32471 => (54.1969%) => 87.7239%
   number of events that fulfill Evis cut:29235 => (48.7958%) => 78.9815%
   number of events that fulfill BCal cut:28689 => (47.8844%) => 77.5064%
```

Moritz confirmed that both samples were generated from same generator files, but used different overlay processes.

Cut efficiency (Moritz's macro)

bhabha + Nγ sample used

for l5 sample (only1 file used for now)

```
final cut flow:
   initial number of events:            353342
   number of photons that fulfill signal definition: 117458 => 33.242%
   number of events that fulfill pt cut: 24915 => (7.05124%) => 21.2118%
   number of events that fulfill Evis cut: 11920 => (3.3735%) => 10.1483%
   number of events that fulfill BCal cut: 89 => (0.0251881%) => 0.0757718%
```

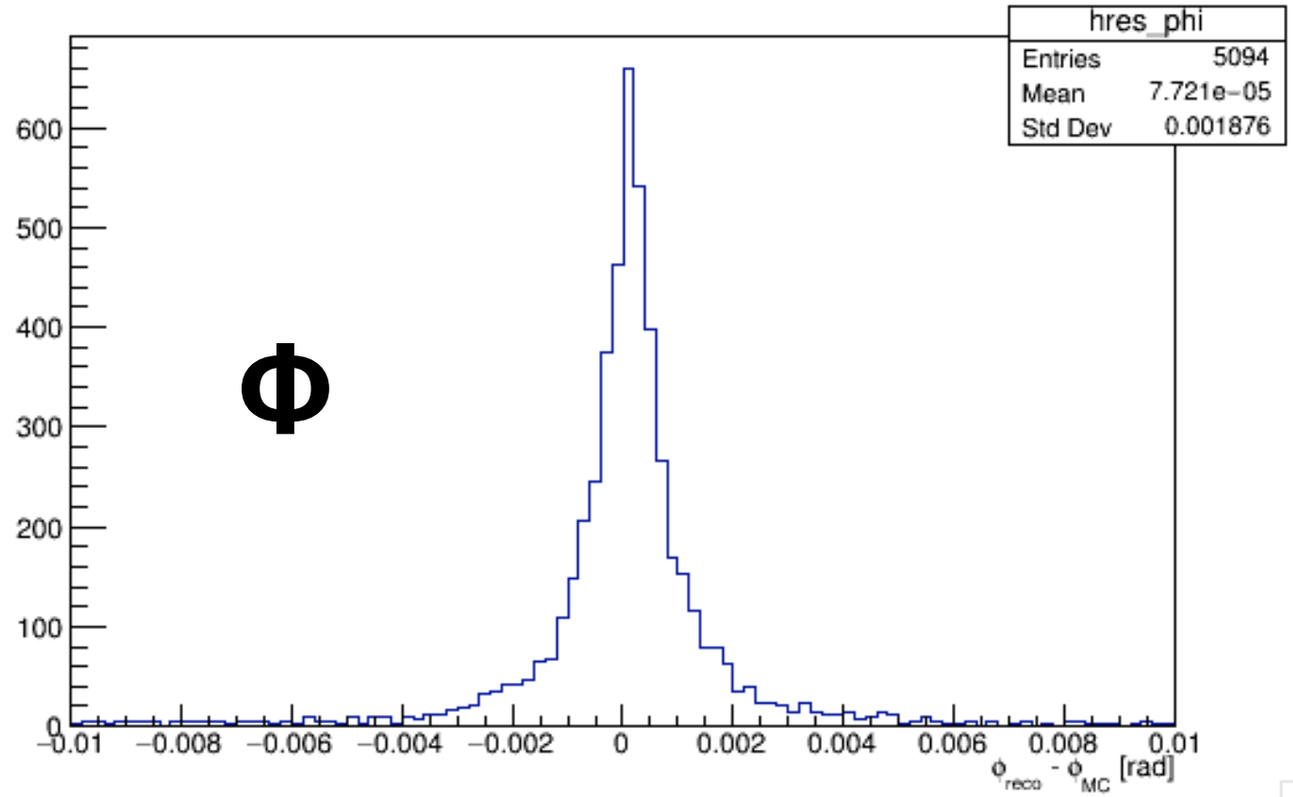
for DBD sample (Moritz's sample) (only1 file used for now)

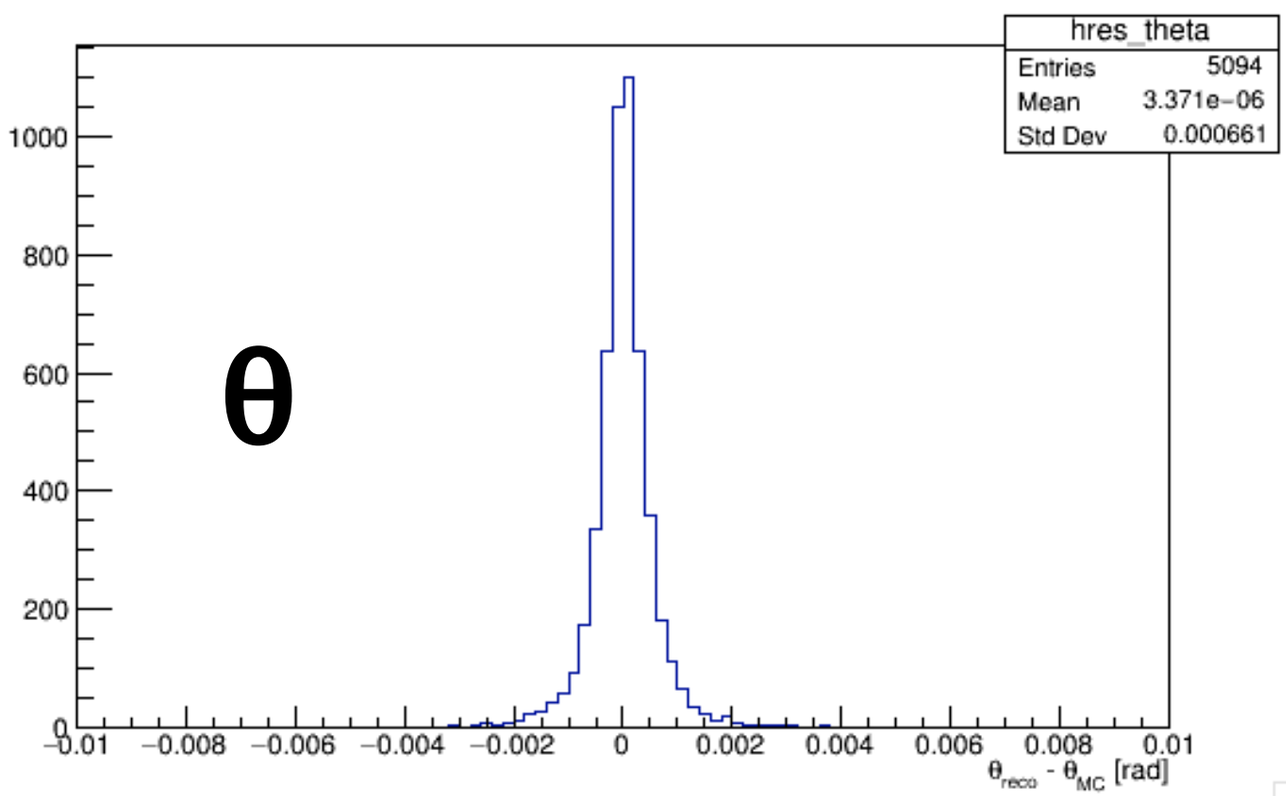
```
final cut flow:
   initial number of events:    42415
   number of photons that fulfill signal definition:16956 => 39.9764%
   number of events that fulfill pt cut:6452 => (15.2116%) => 38.0514%
   number of events that fulfill Evis cut:1363 => (3.21349%) => 8.03845%
   number of events that fulfill BCal cut:33 => (0.0778027%) => 0.194621%
```

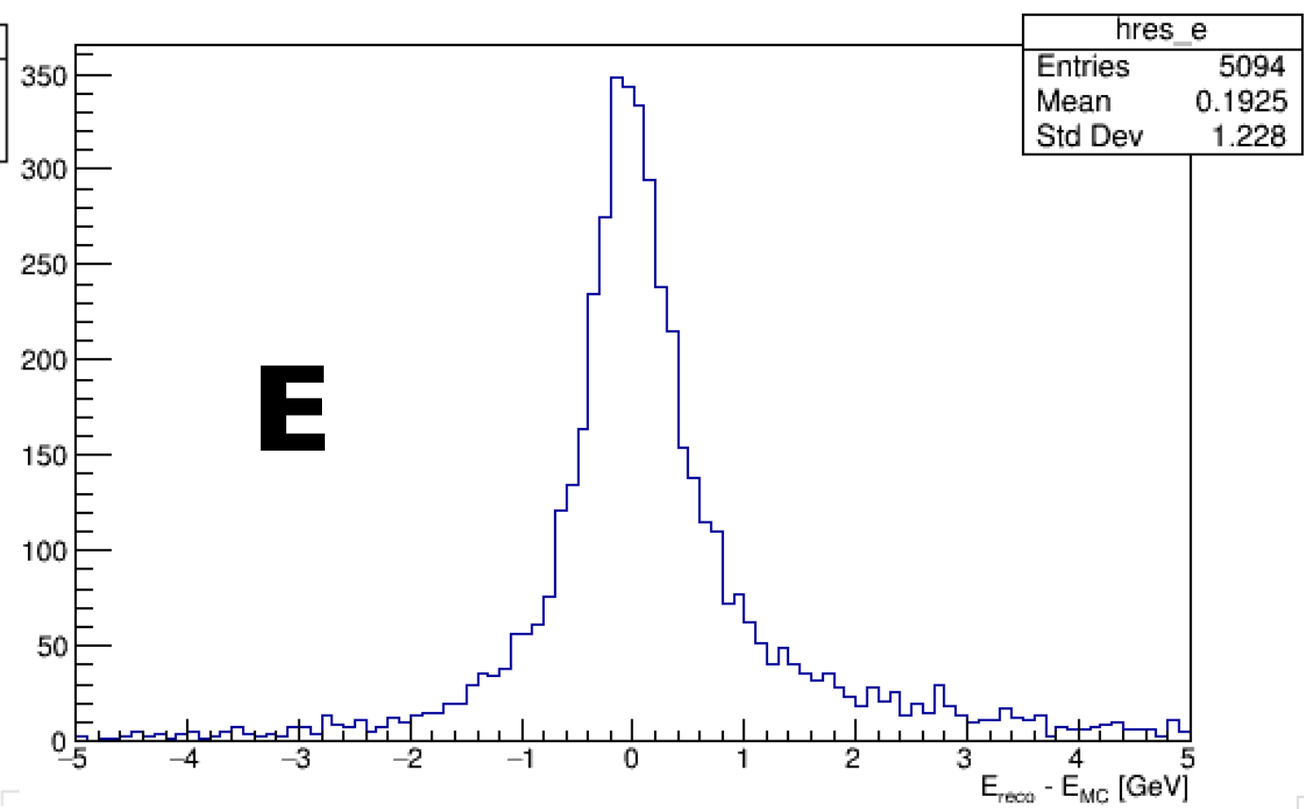
Residual

I5, νν + Nγ sample used

(based on RecoMCTruthLink)

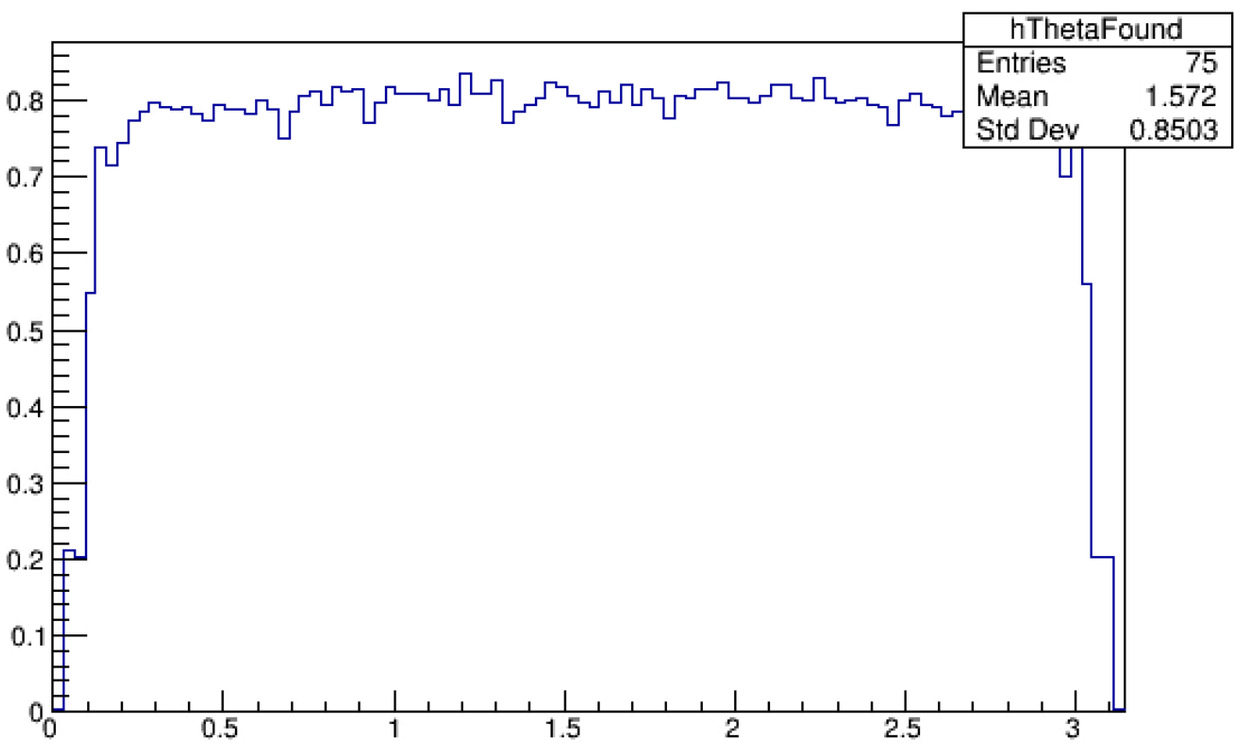






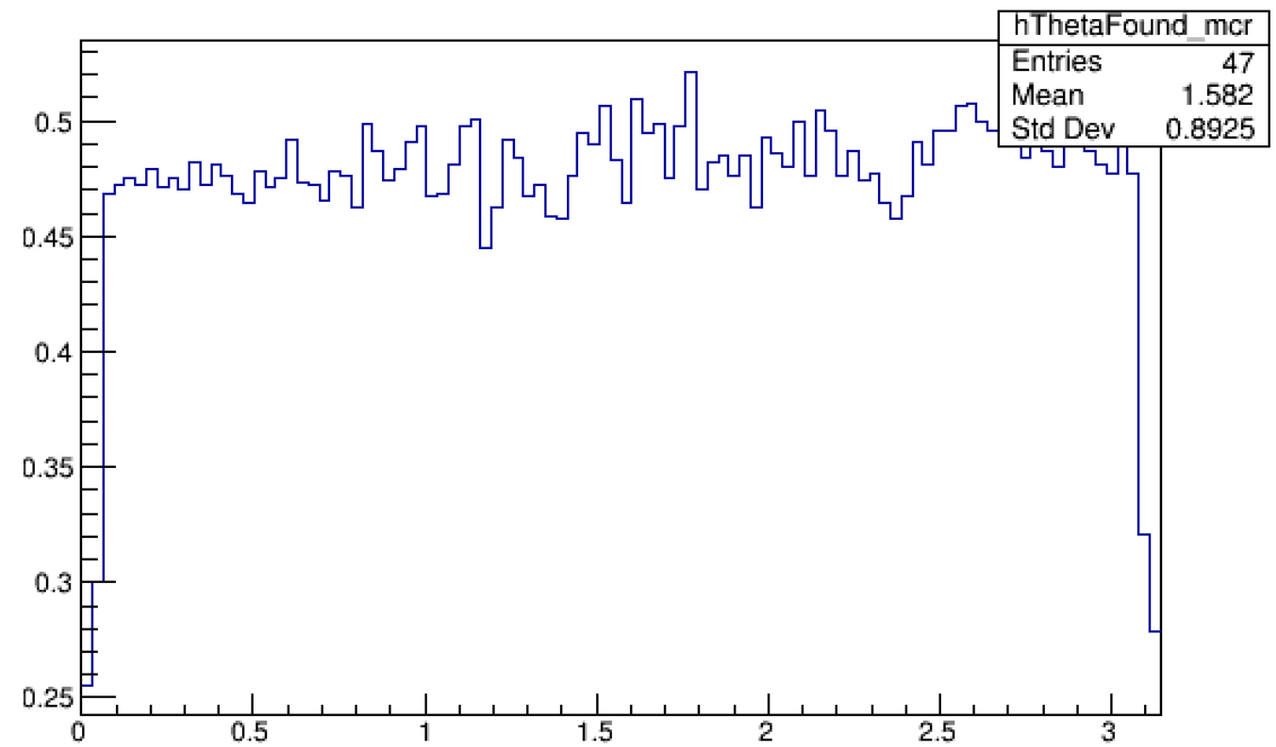
Issue (I) : RecoMCTruthLink

PFO MCParticle matching by comparing angles and energy



purity may be low.

PFO MCParticle matching based on RecoMCTruthLink



Why is the efficiency so low even for barrel region?? Still do I have something wrong with RecoMCTruthLink?

BCal MC info matching

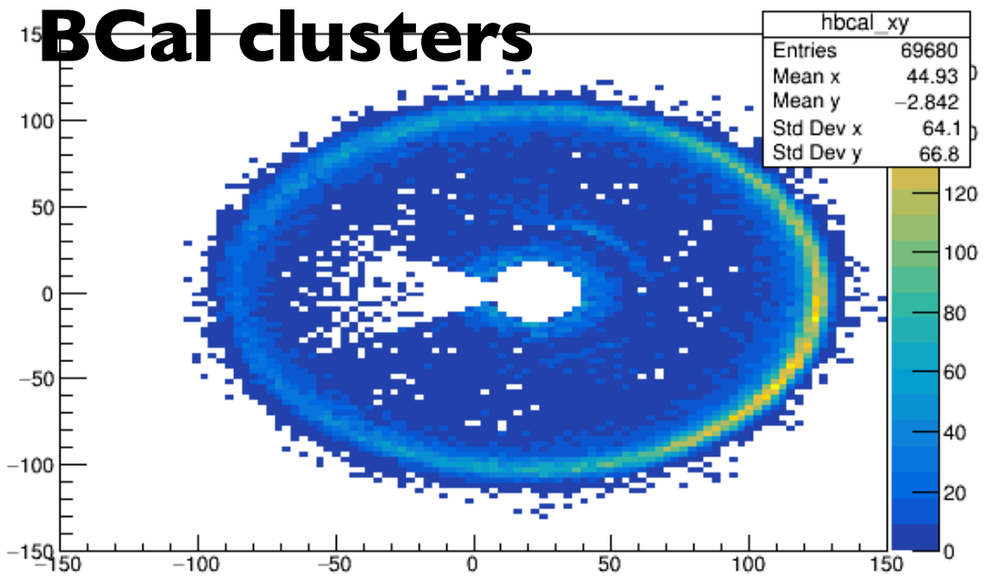
- **To investigate in detail, MC info correspoinding to BCal is useful.**

- **No LCRelation for these**
  - In early study, they match BCal cluster and MCParticle by using angles and energy.

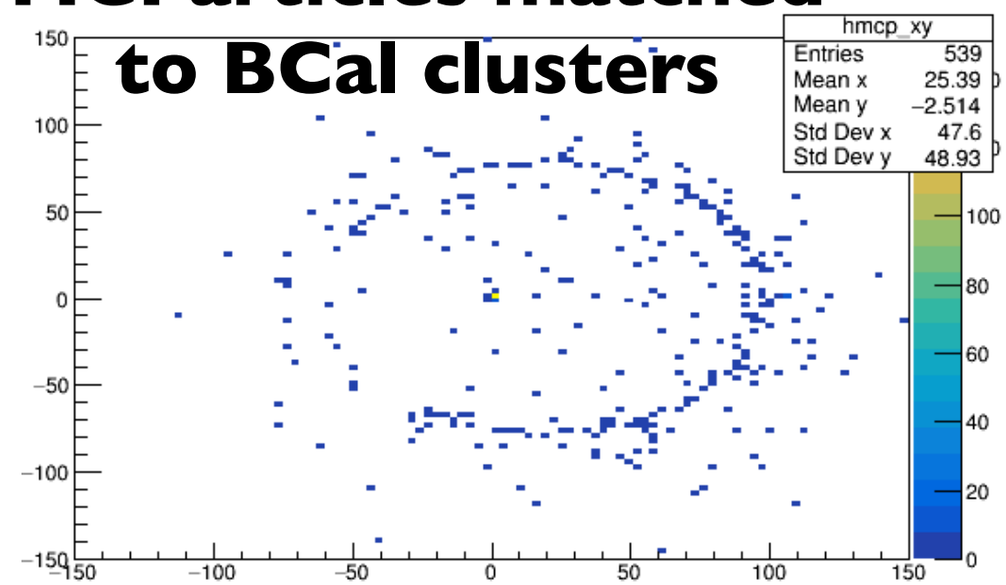
- **Goal**
  - Re-tune bcal veto parameters or reconstruction parameters to achieve same level of background rejection performance as before by looking MC information.

Issue (2) : BCal MC info matching

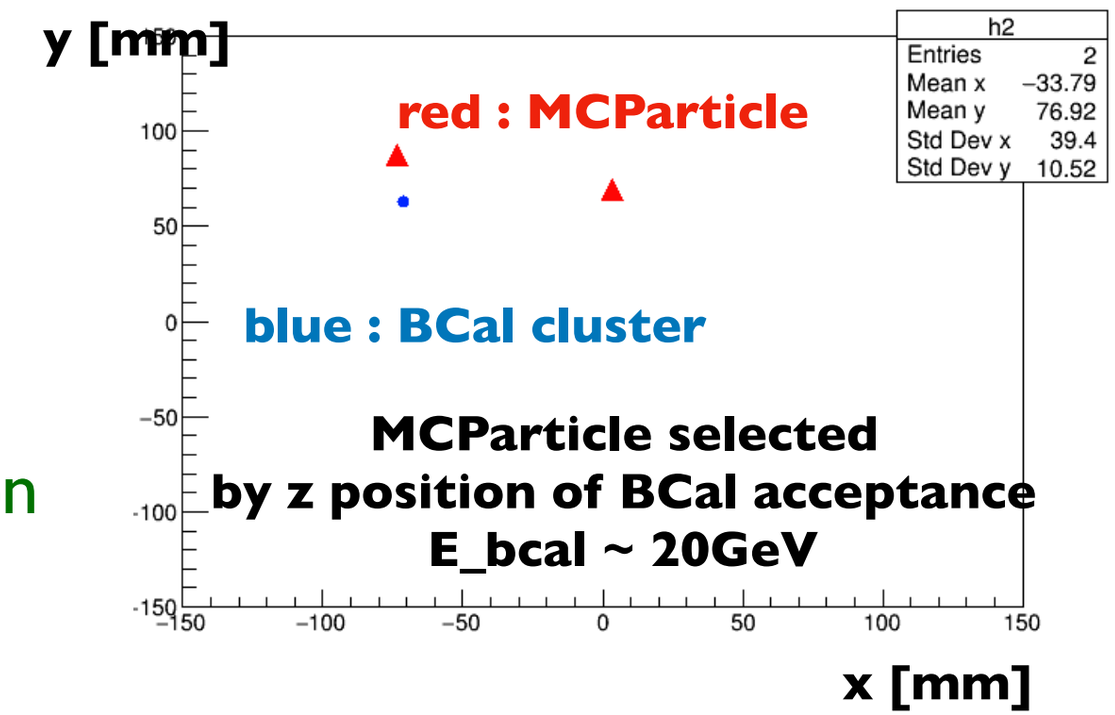
BCal clusters



MCParticles matched to BCal clusters



- **Matching is not easy task…**
  - Background hits introduced in BCal
  - The low efficiency for low energy particles
  - No energy calibration, no optimaization for reconstruction parameters for the new geometry (become closer to IP)



Summery & Plan

- **LCFIPlus**
  - Test implementation to see how well vertices are reconstructed.
  - Preparing inputs for IDR.
- **Mono phton**
  - Seems to need re-tuning background rejection parameters/ reconstruction parameters. —> MC-BCal cluster matching would be useful.
  - Issues : RecoMCTrtuthLink, BCal-MCTruth matching.
  - Preparing inputs for IDR.