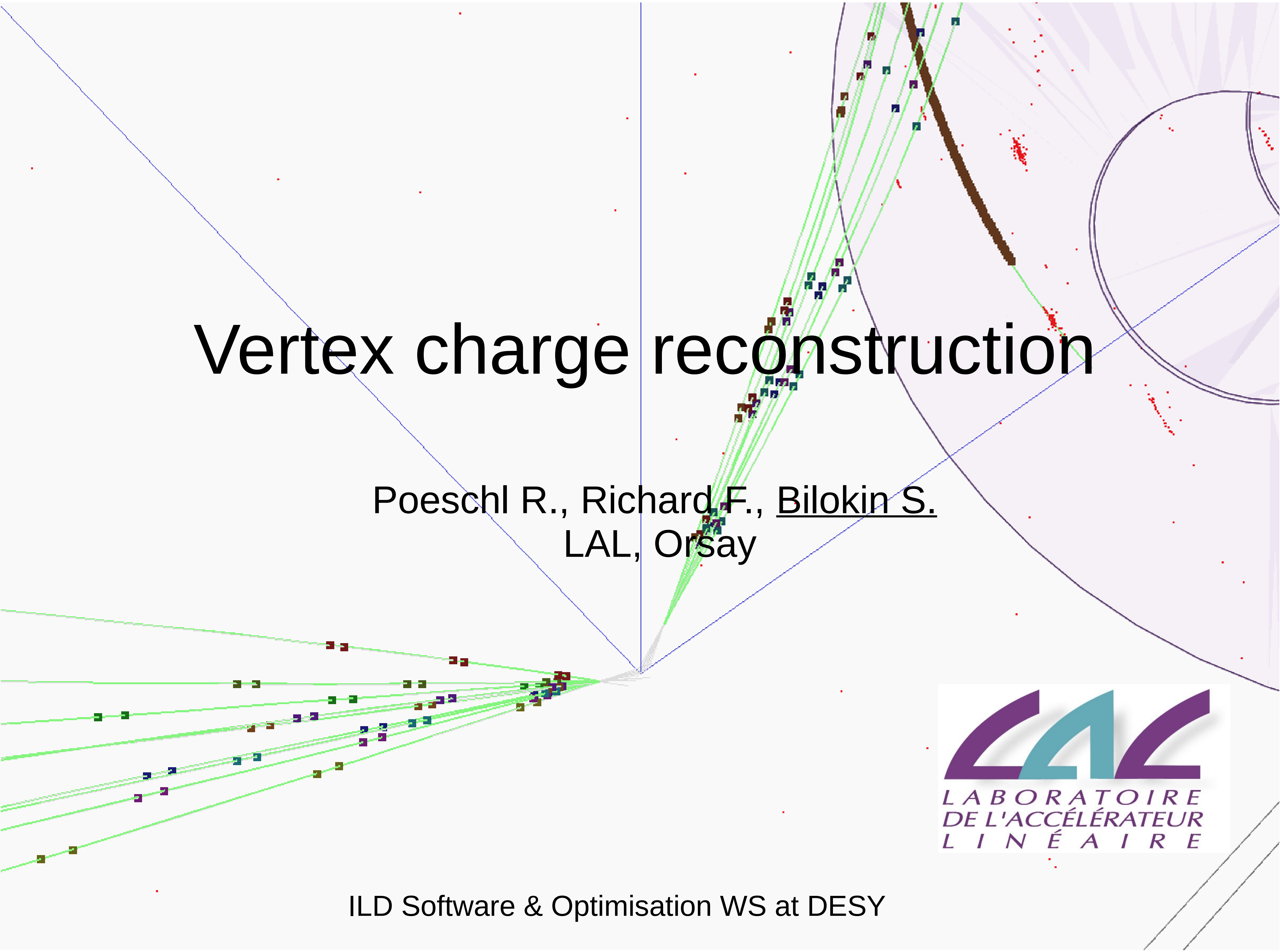


Vertex charge reconstruction

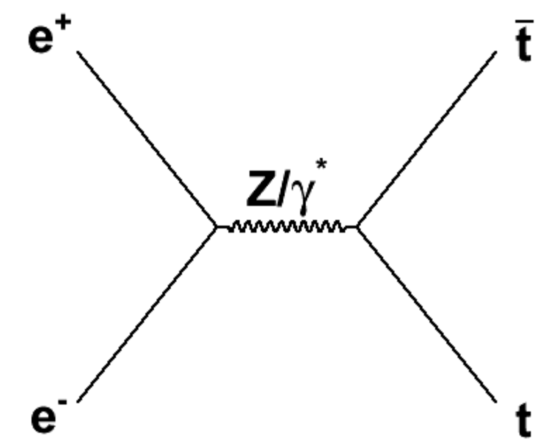
Poeschl R., Richard F., Bilokin S.
LAL, Orsay

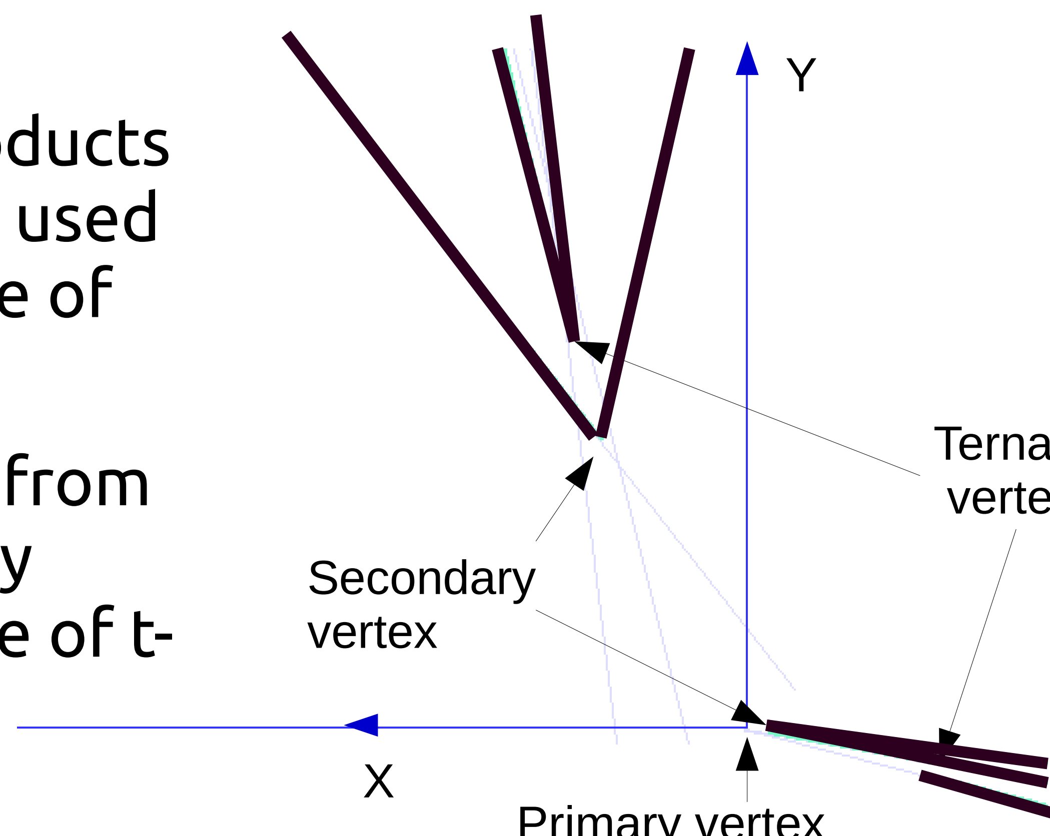
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

ILD Software & Optimisation WS at DESY

Objective

- Main purpose of this work is to detect the charge of top and antitop quarks. This is crucial for calculation of forward-backward asymmetry A_{fb} in $t\bar{t}$ process at ILC
- Properties of decay products from the B-hadrons are used to determine the charge of initial t-quark
- The charge of K-meson from ternary vertex is directly connected to the charge of t-quark



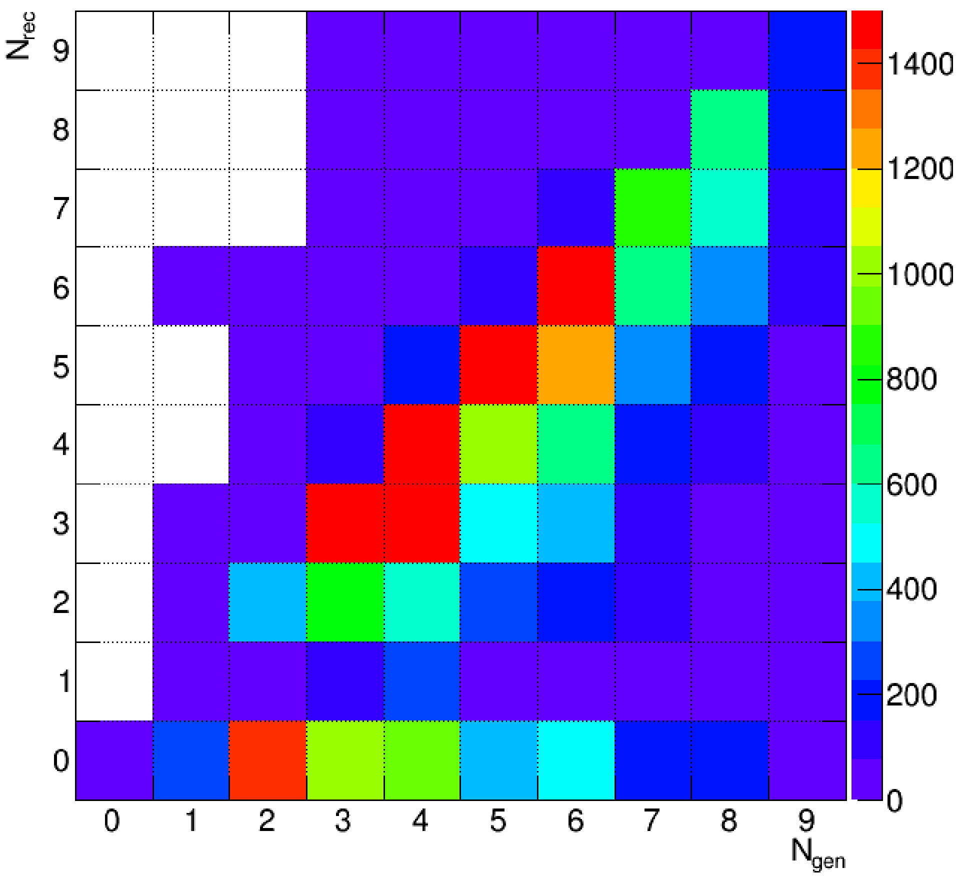


Research methods

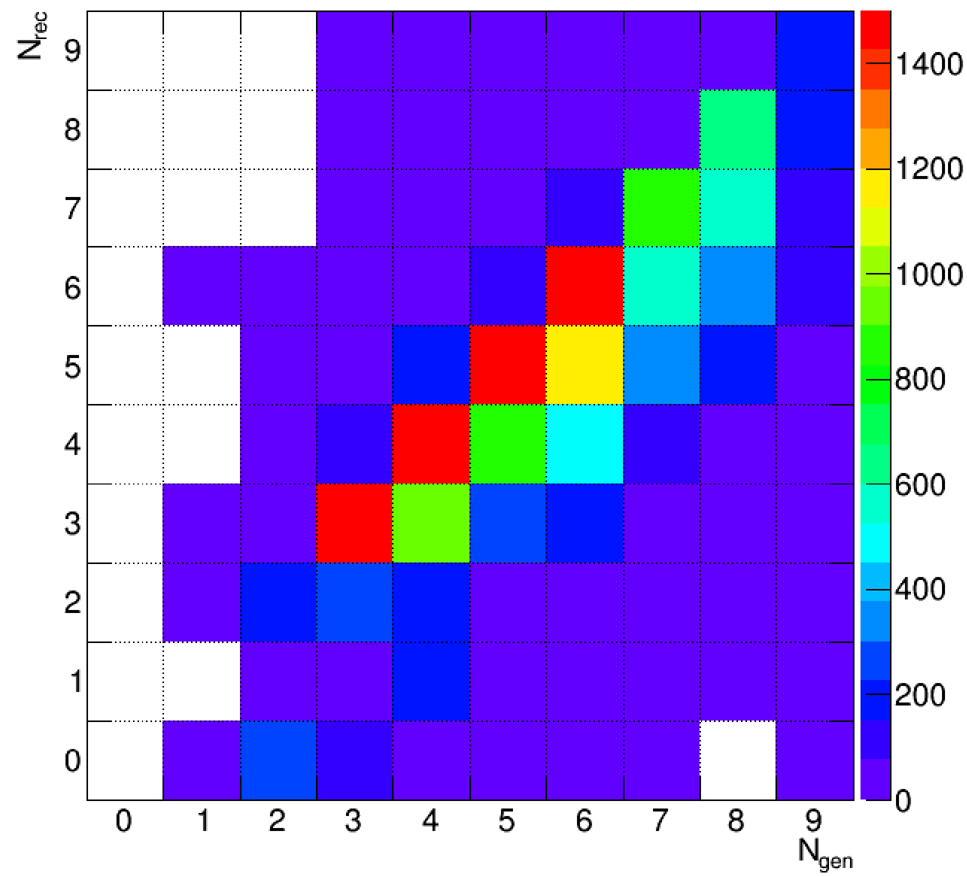
- We are using 500 GeV semileptonic ttbar sample with pair background v01-16-05 (DBD)
- Same sample using CellsAutomatonMV as tracking algorithm v01-17-08 (Minivector)
- TruthVertexFinder from MarlinReco/Analysis to get generated vertices
- Modified VertexChargeRecovery from MarlinReco/Analysis

Number of tracks comparison DBD

Raw result



Btag > 0.8 & Pb > 15 GeV



45.7% on the diagonal

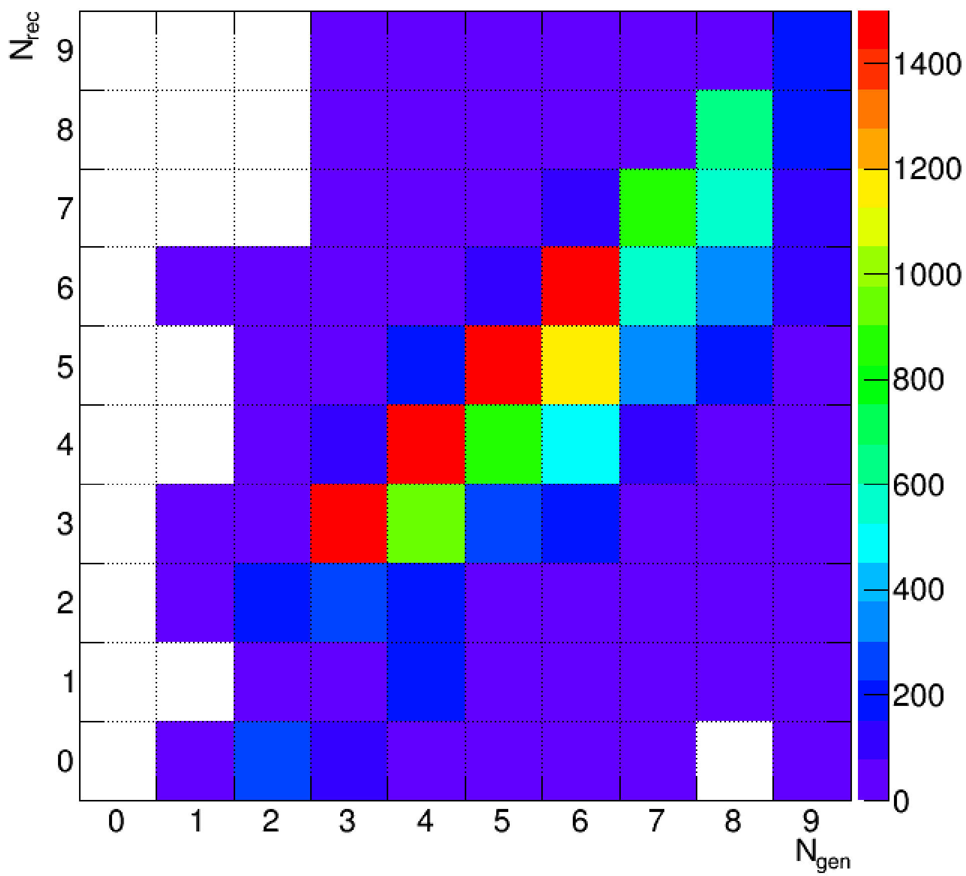
52.0% on the diagonal

- Btag cuts reduce fraction events with low multiplicity of B-Vertices. TruthVertexFinder is used to get N_{gen}

Number of tracks comparison DBD

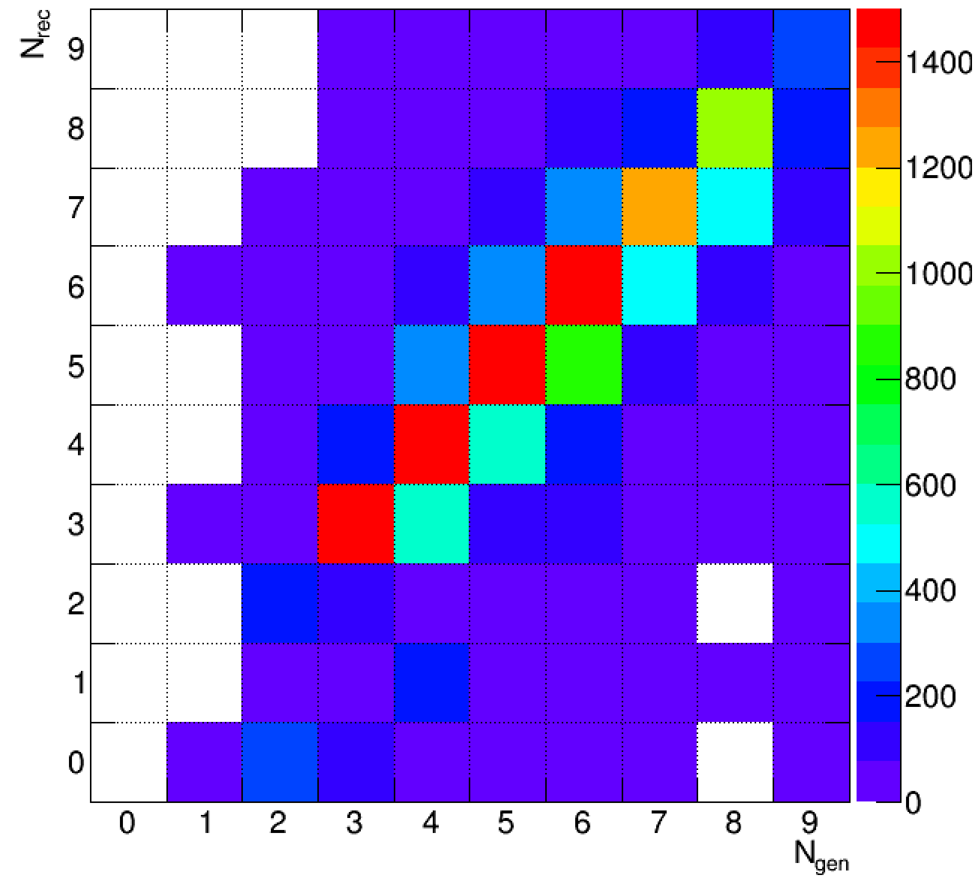
Btag > 0.8 & Pb > 15 GeV

Original



52.0% on the diagonal

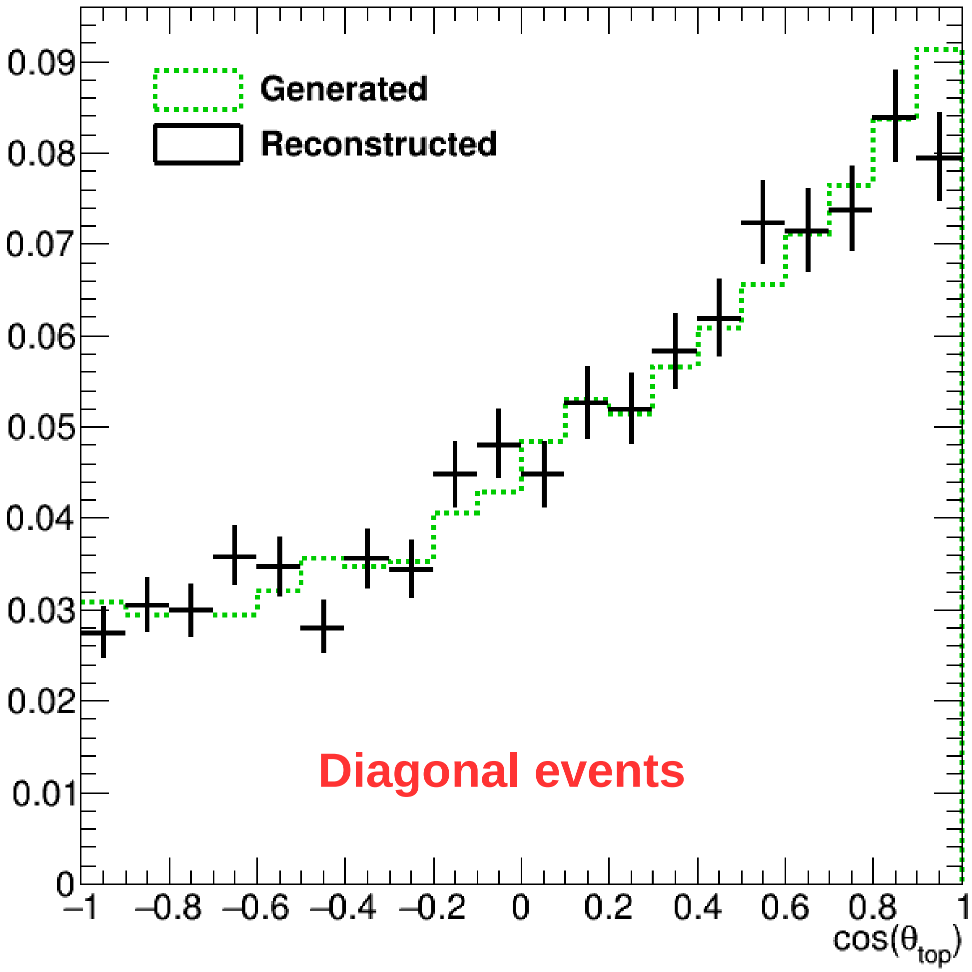
Recovery



62.3% on the diagonal

The recovery is done by VertexChargeRecovery processor modified to use tracks rejected by PandoraPFA

Top asymmetry: diagonal events

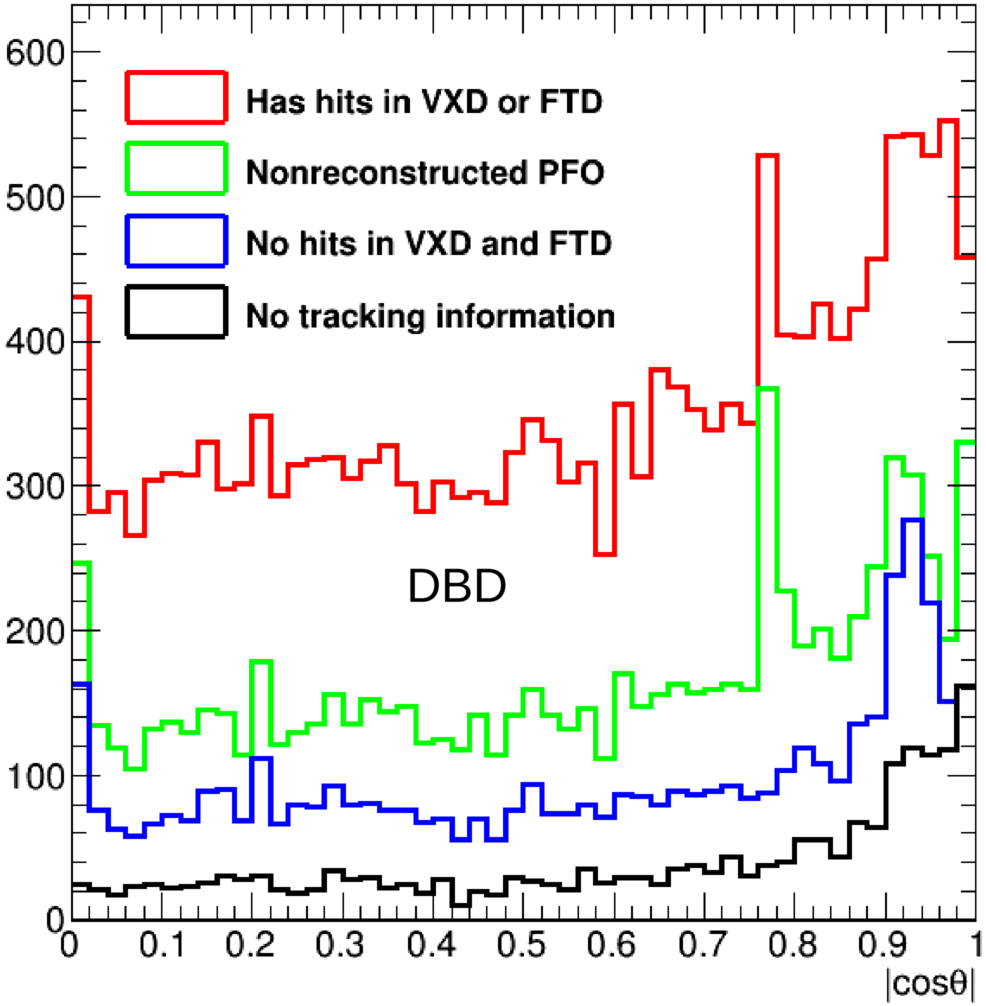


95.5% precision

- TruthVertexFinder works correctly!
- To reach this quality we should maximize the vertex reconstruction quality:
  - Recover corrupted vertices
  - Reject corrupted vertices
  - Apply different tracking algorithms
  - Use alternative vertexing algorithm

- The result of top asymmetry reconstruction with correctly reconstructed b vertices.

Missed tracks DBD

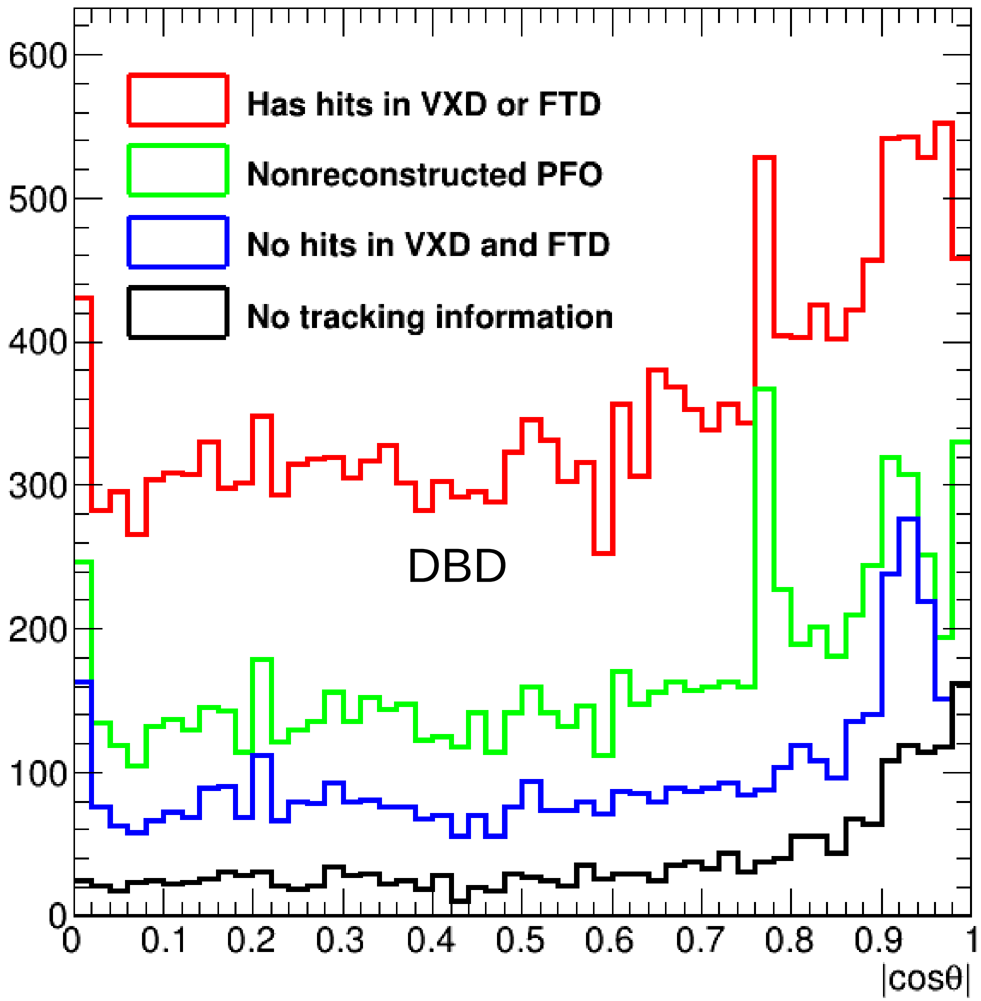


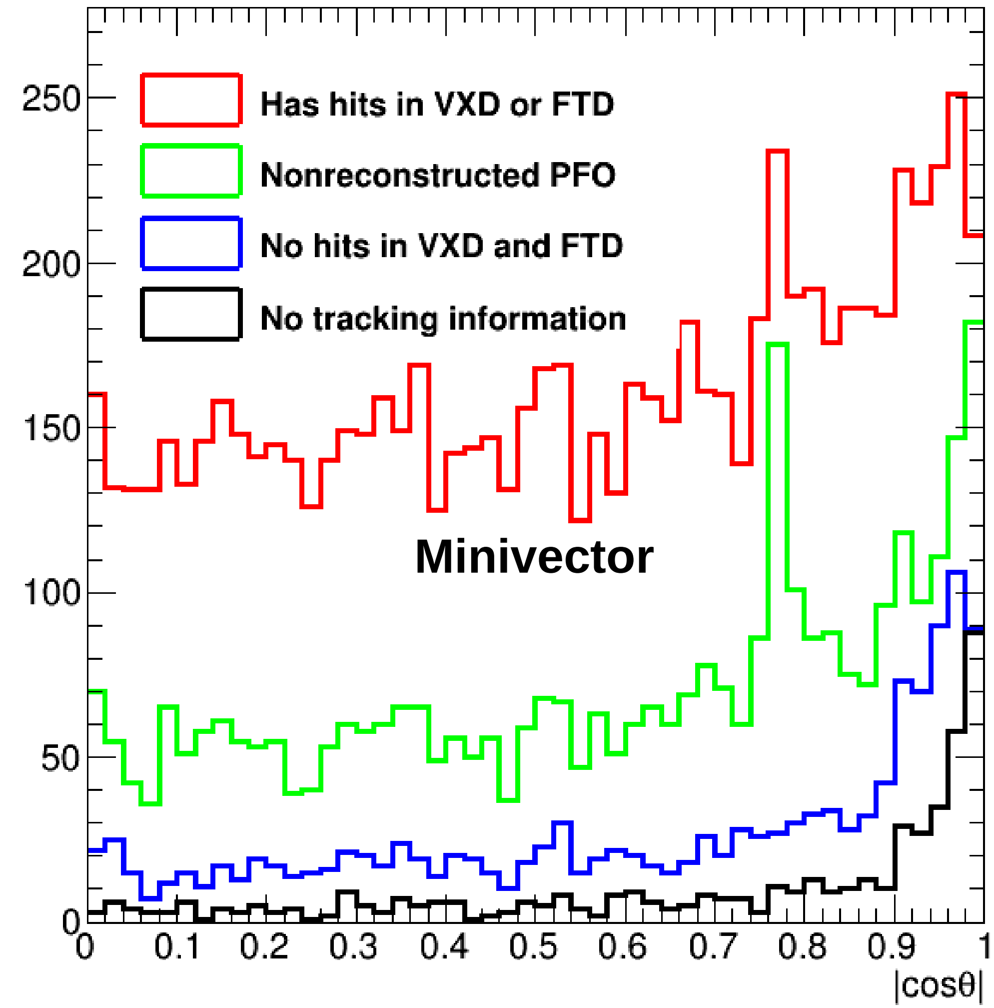
12% of generated

- Statistics:
  - All missed tracks ~ 12%
    - No PFO – 3.8%
    - No VXD, no FTD – 2.4%
    - No track – 1.3%
    - Others – 4.5%

- Angular distribution of the missed tracks from reconstructed vertices. DBD tracking.

Missed tracks DBD vs Minivector



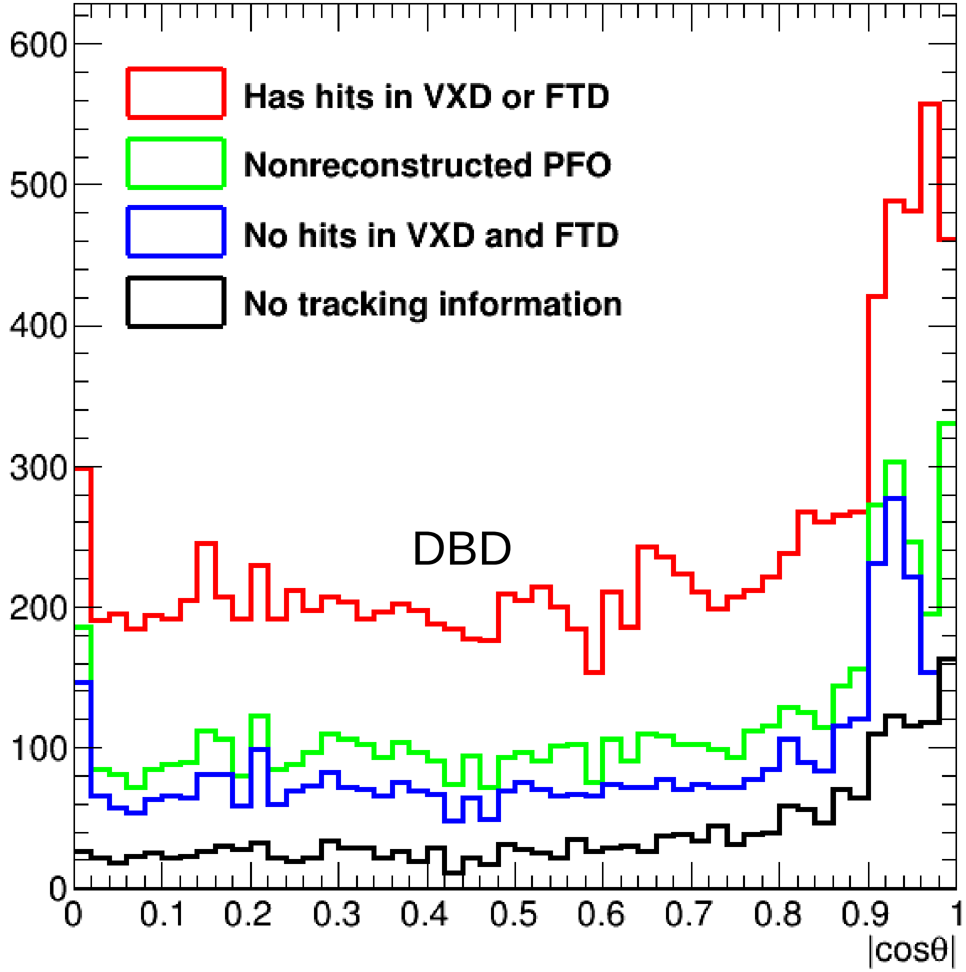


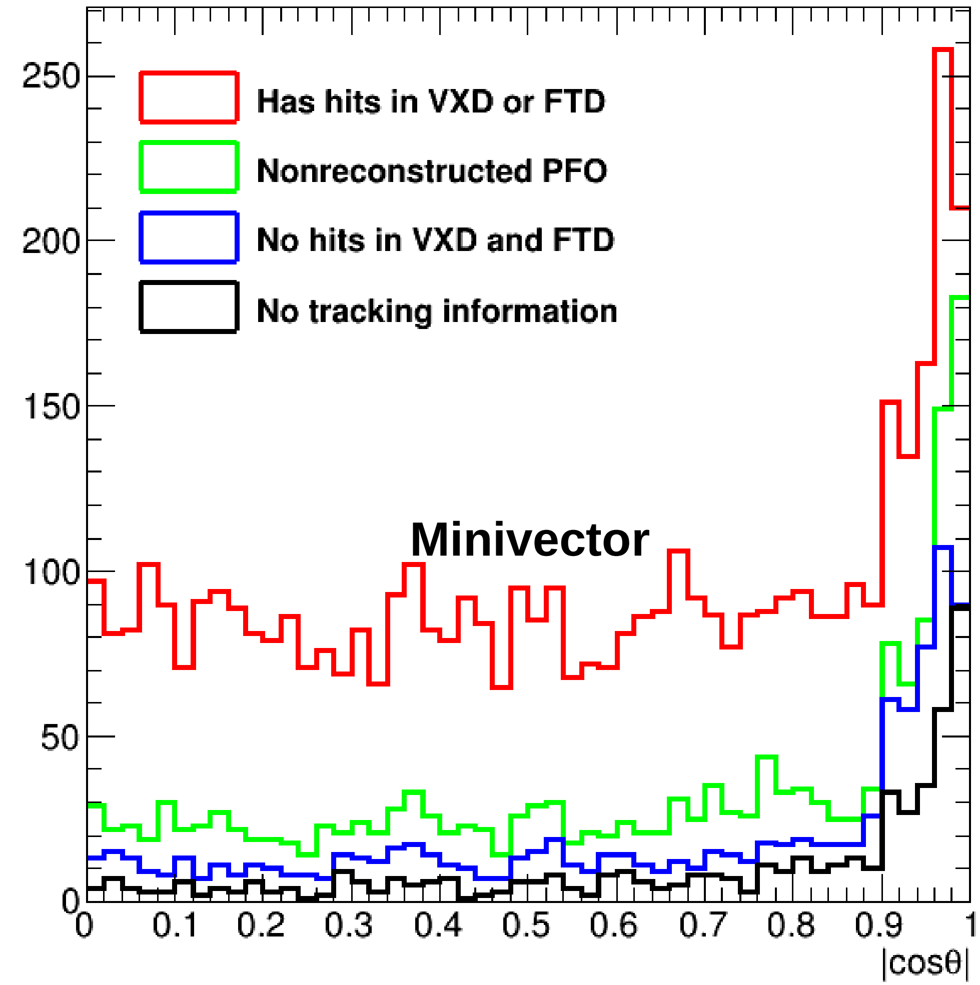
12.2% of generated

12.3% of generated

- Angular distribution of the missed tracks from reconstructed vertices. DBD tracking.

Missed tracks DBD vs Minivector+recovery



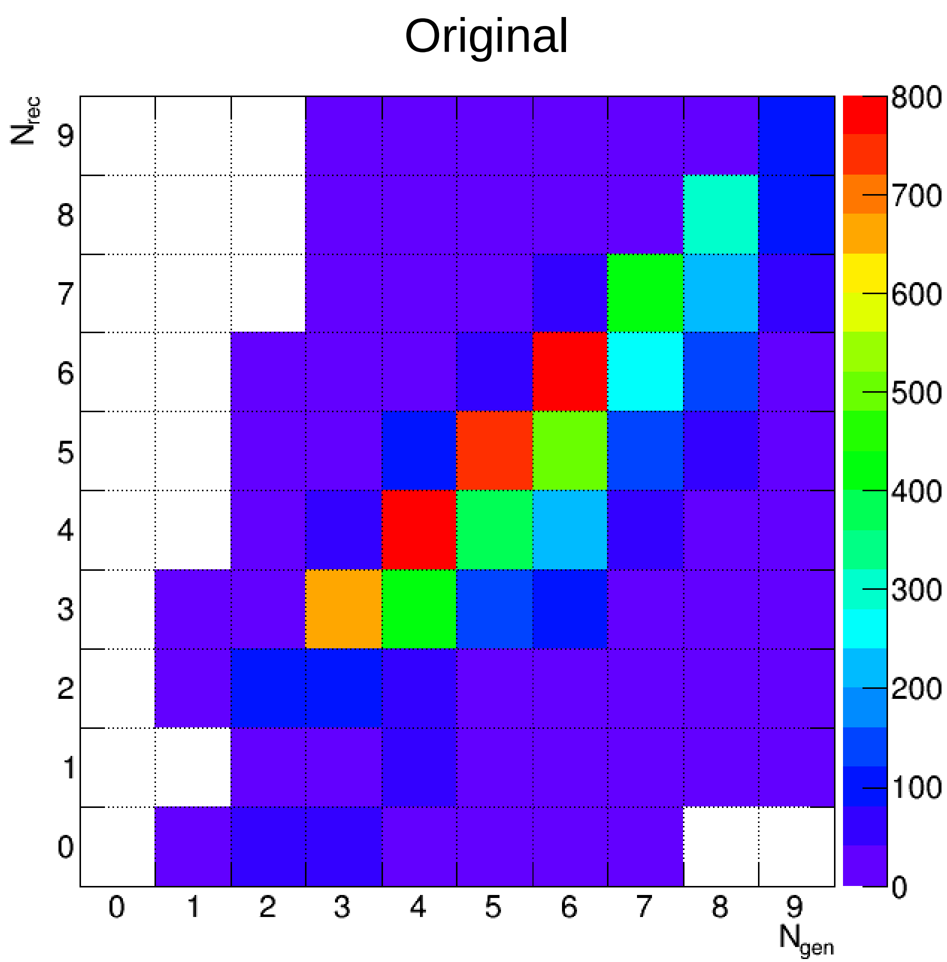


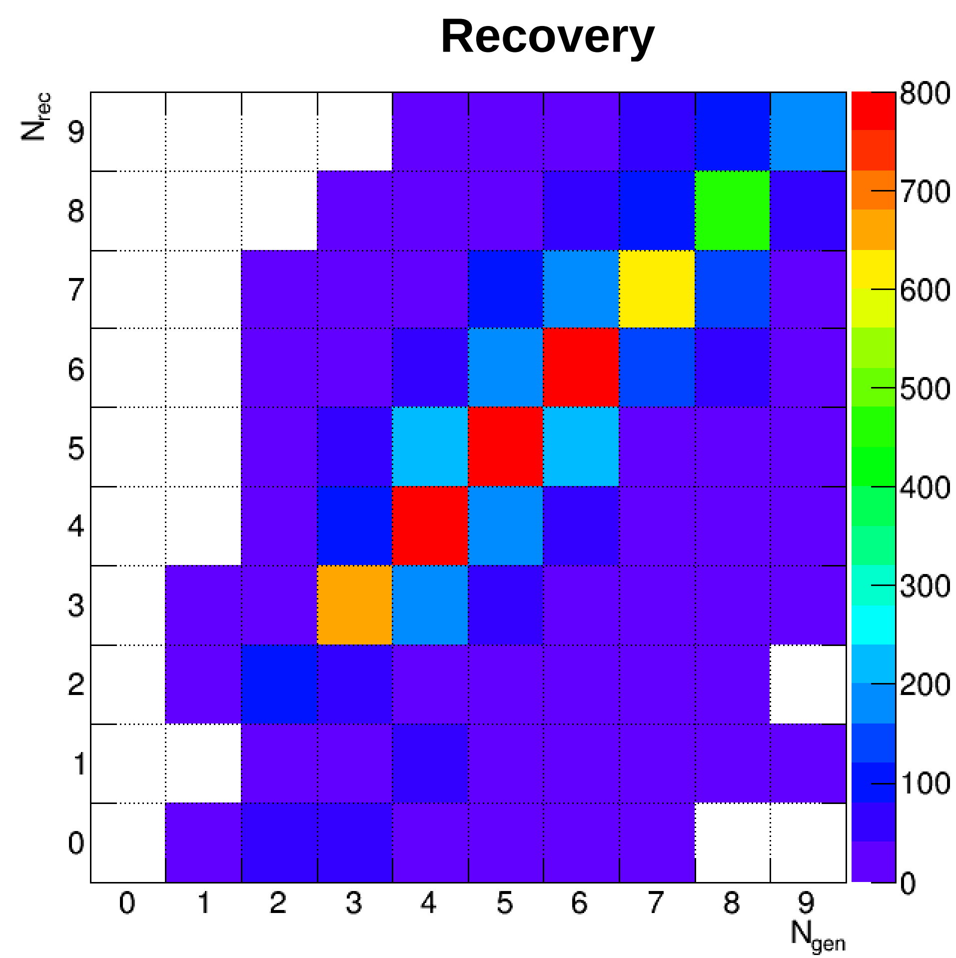
8.1% of generated

7.4% of generated

- Angular distribution of the missed tracks from reconstructed vertices. VertexChargeRecovery is used

Number of tracks comparison Minivector



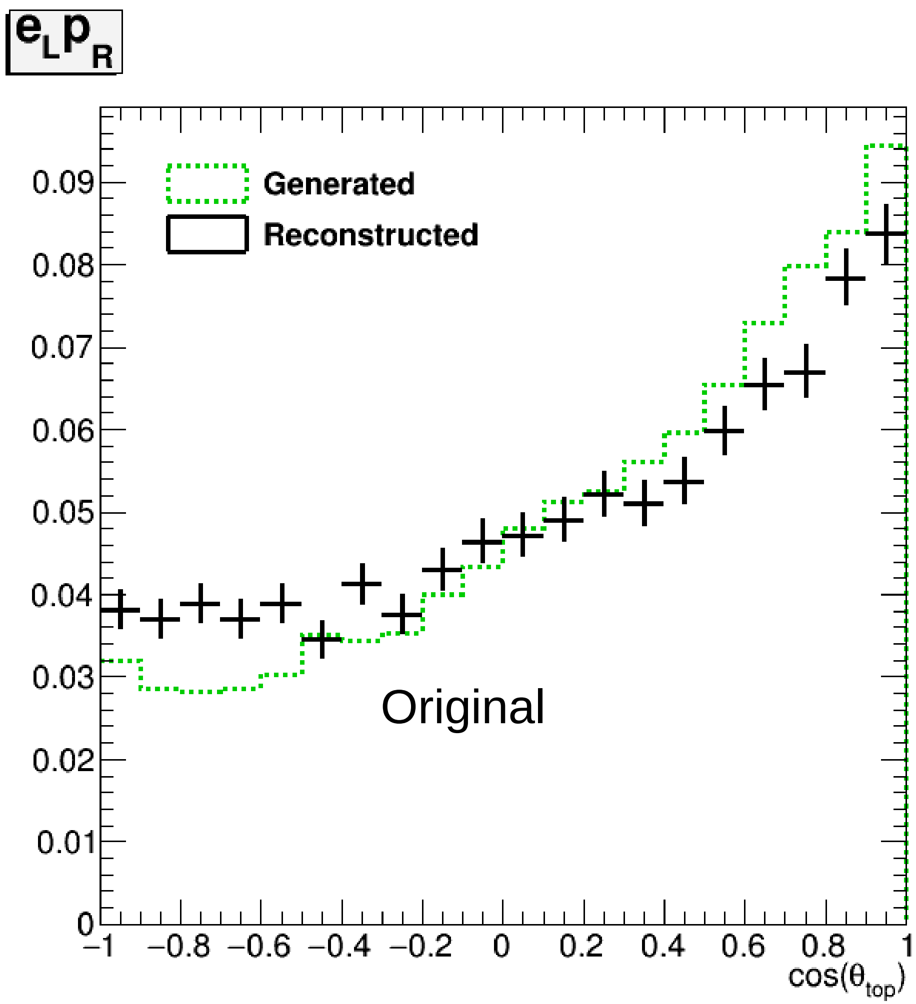


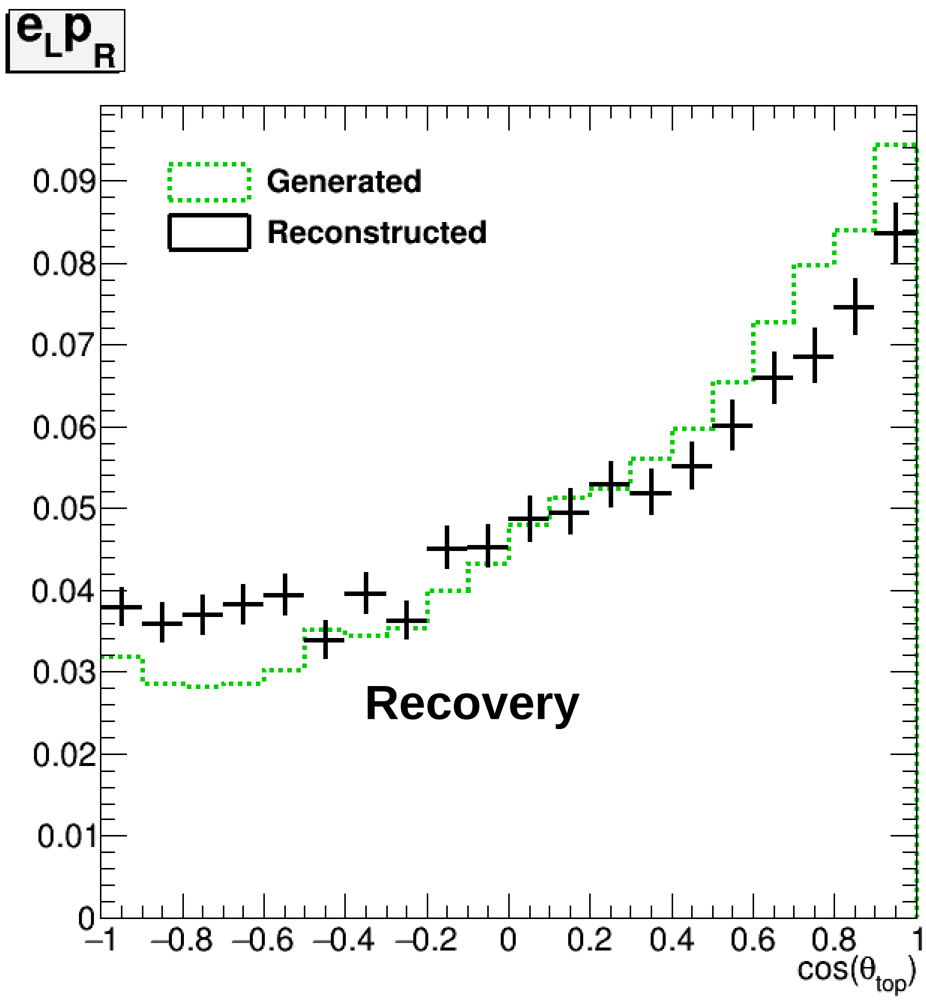
51.0% on diagonal

63.3% on diagonal

Btag > 0.8 & Pb > 15 GeV

Top asymmetry - DBD reconstruction



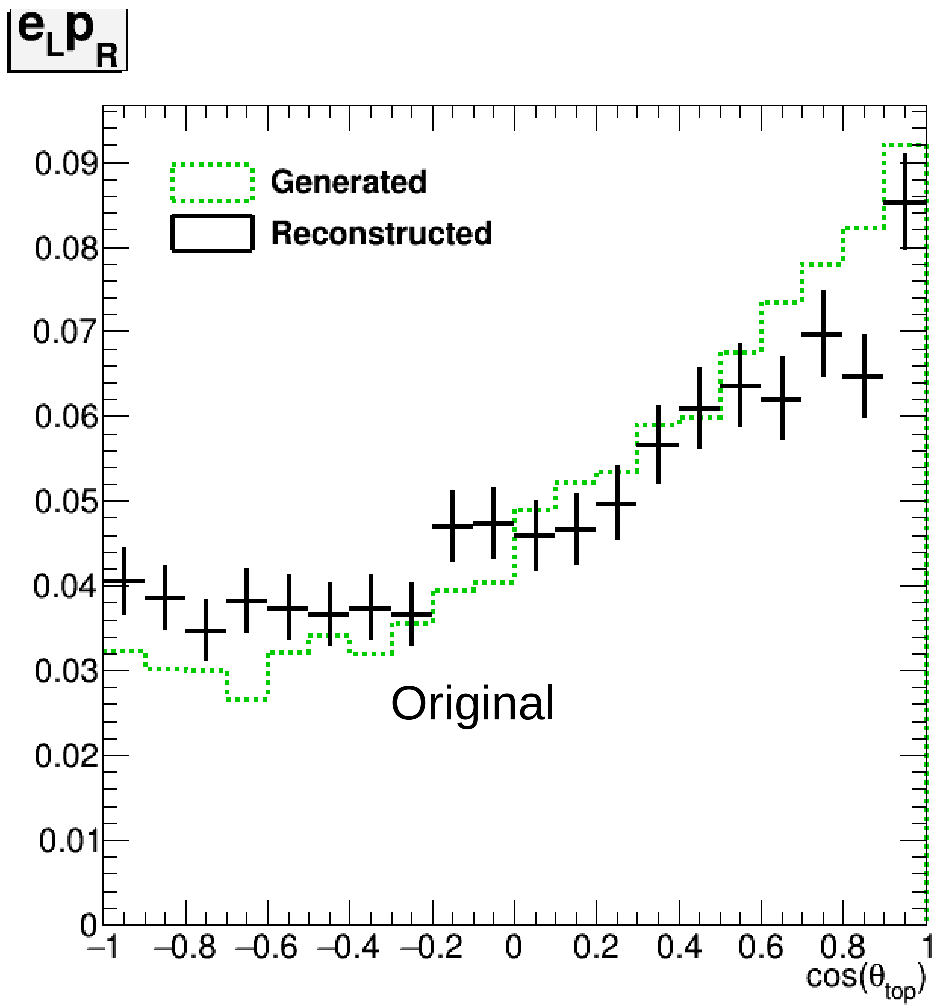


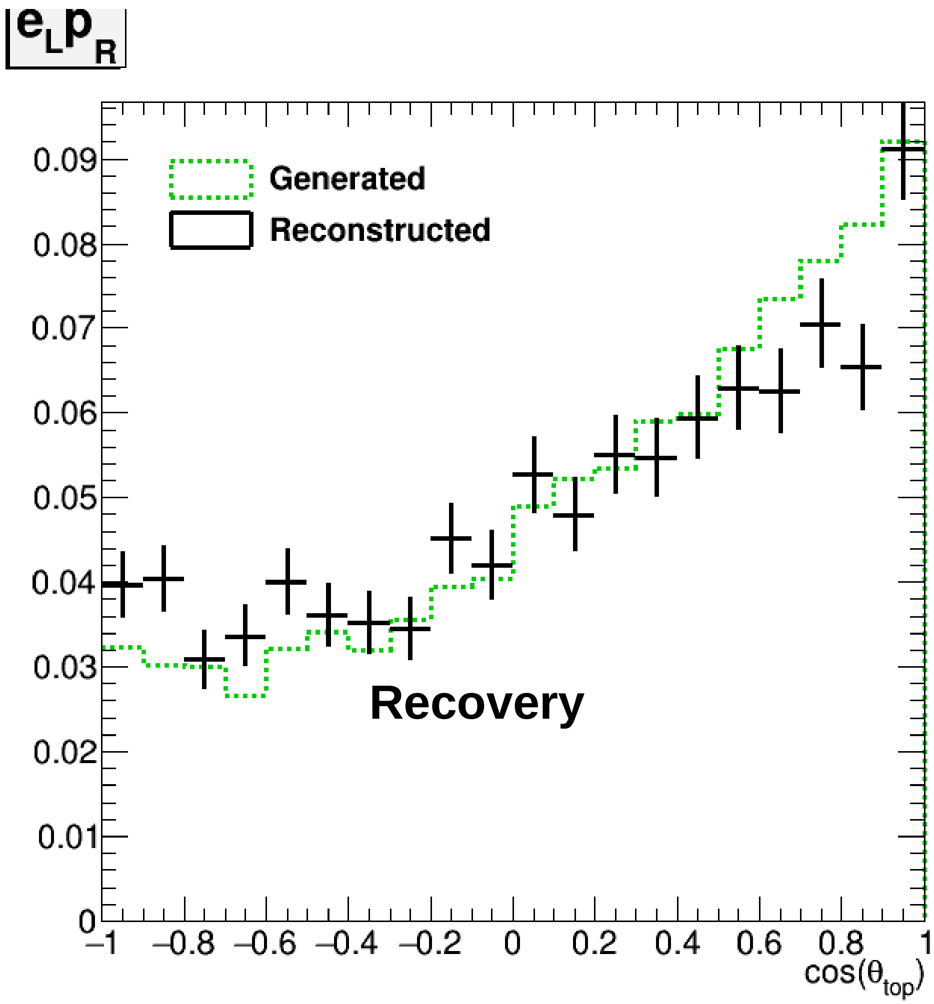
65.5% precision

67.7% precision

- The result of top asymmetry reconstruction with real b charge measurement. DBD tracking, recovery

Top asymmetry – Minivector reconstruction





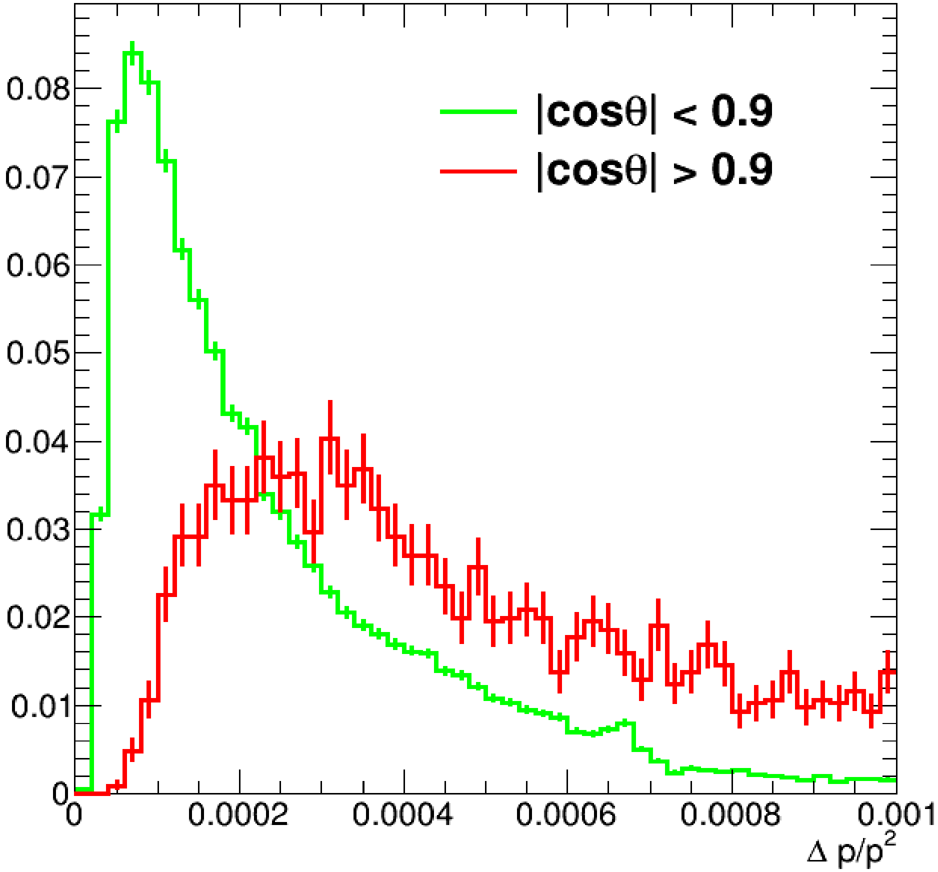
63.2% precision

73.4% precision

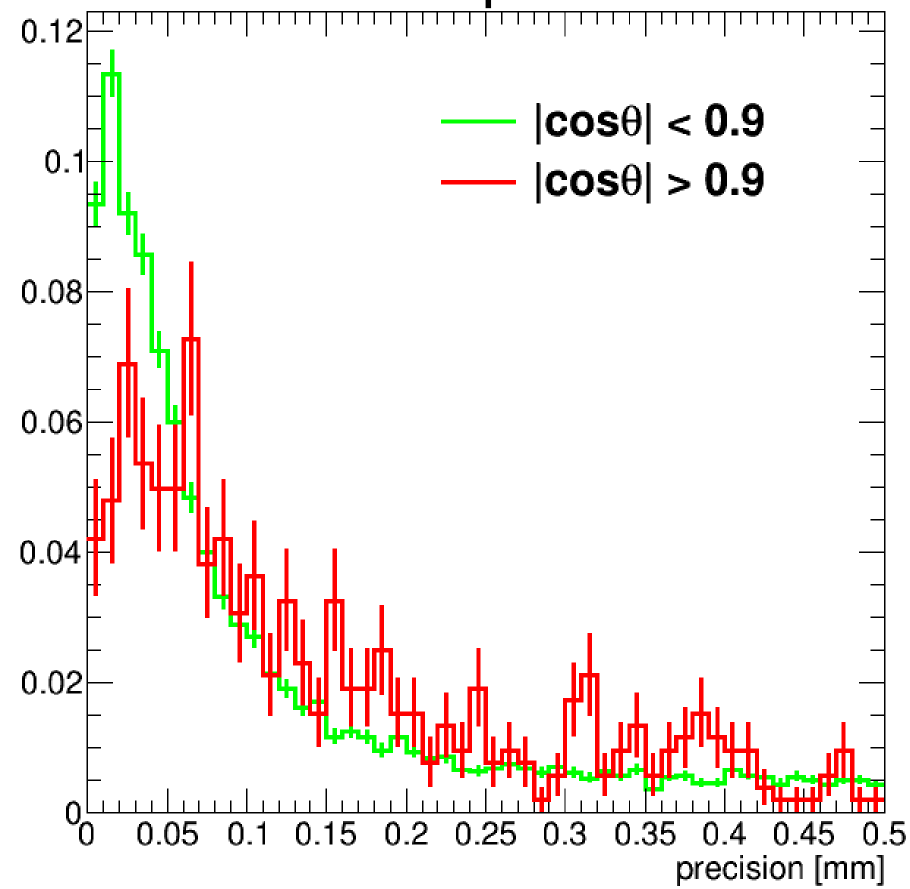
- The result of top asymmetry reconstruction with real b charge measurement. Minivector tracking, recovery

Reconstruction quality in Minivector

Reason?



Consequence?



- Momentum uncertainty of reconstructed tracks (left) and distance between generated and reconstructed vertices (right) in the barrel and in the forward region.

Summary

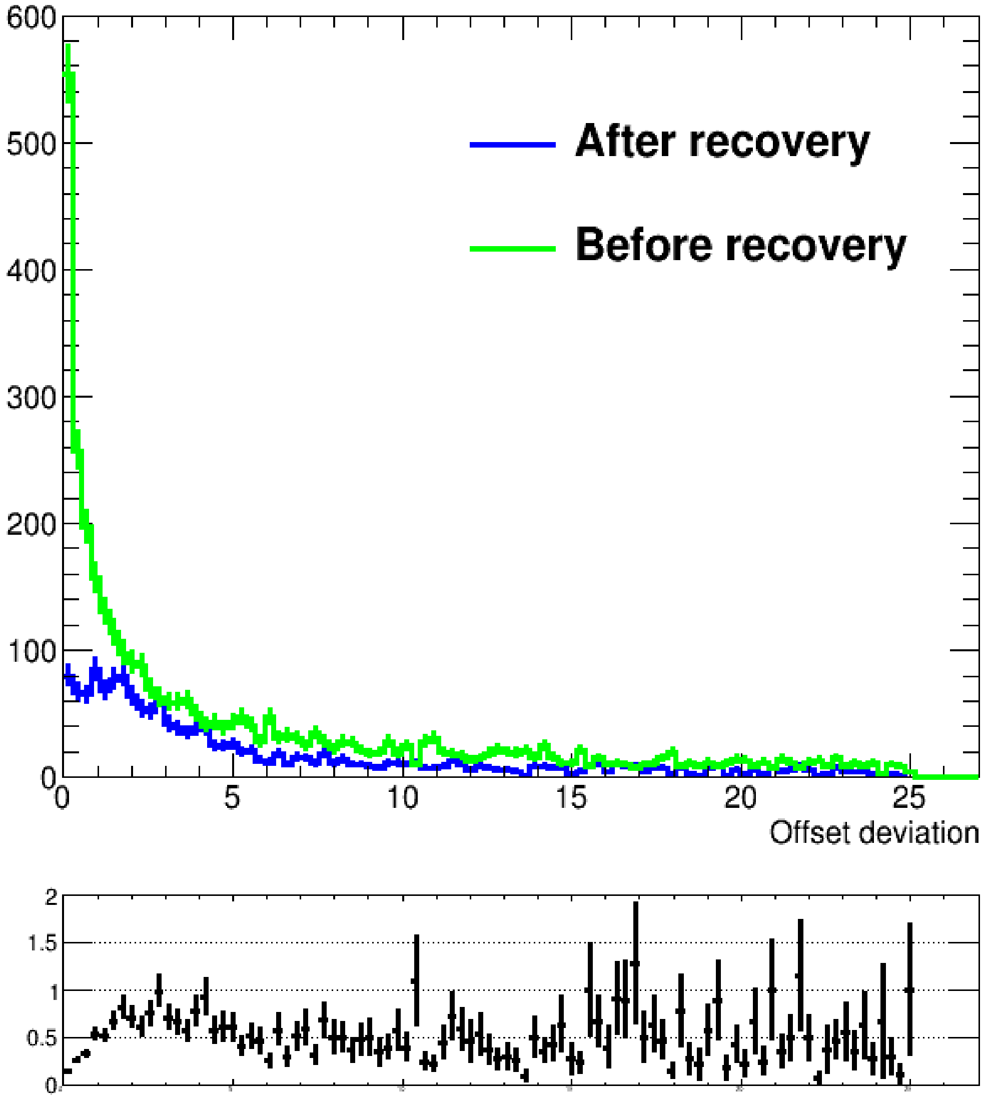
- Vertex reconstruction efficiency can be tested on physics observable – top quark asymmetry
- B-tracks rejected by PandoraPFA are successfully added by VertexChargeRecovery
- Vertex and track reconstruction precision is lower in the forward region
- Minivector tracking give a slightly better results than DBD tracking and it has better behavior in the forward region
- Still a number of handles to improve

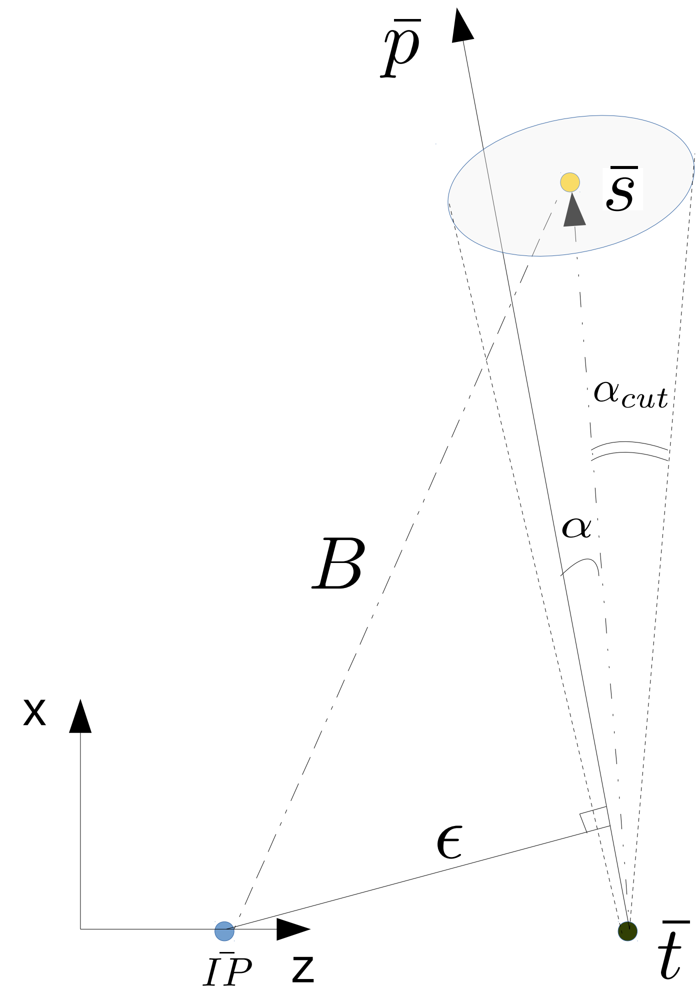
Further work

- Use new version of minivector, which is supposed to solve some problems observed in the current analysis (this week)
- Investigate the problems in the forward region
- Use Adaptive Vertex Fitting algorithm
- Use ternary vertex kaon charge (just started)

Thank you!

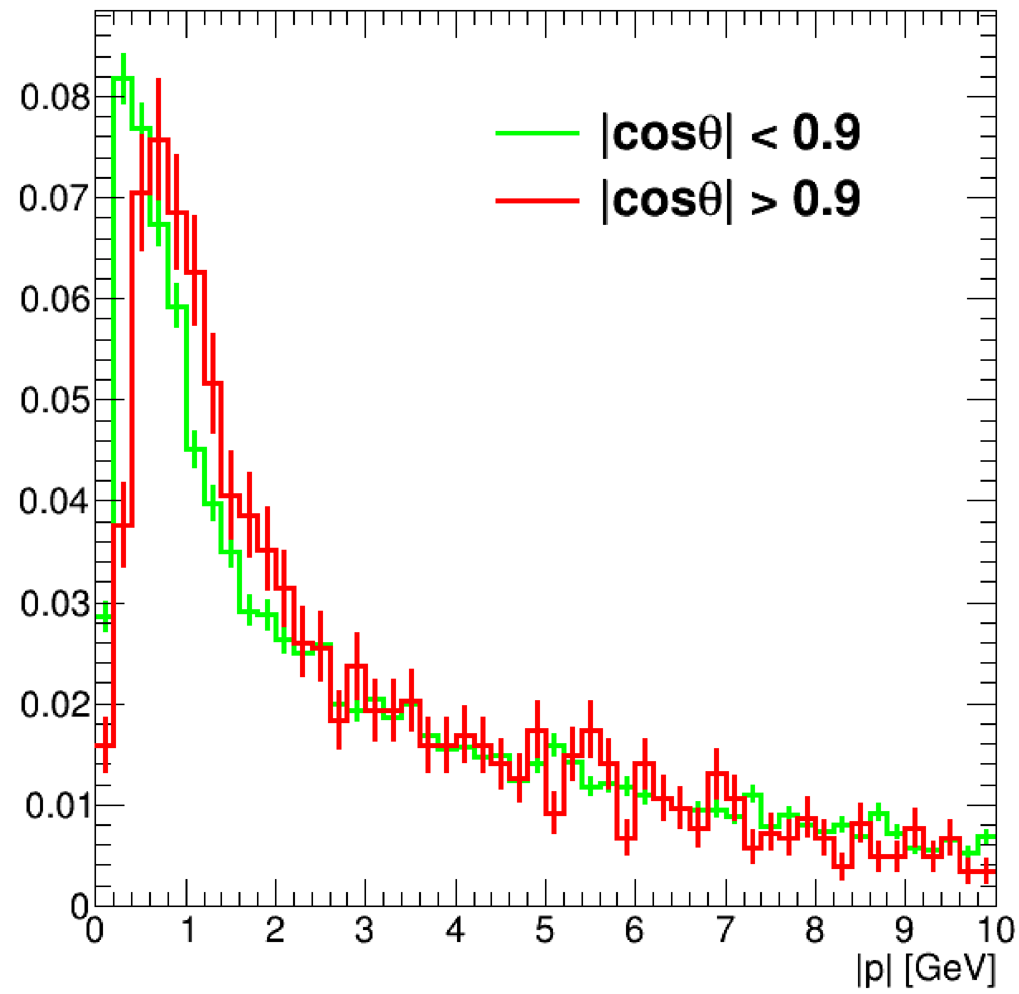
Offset deviation - Minivector reconstruction





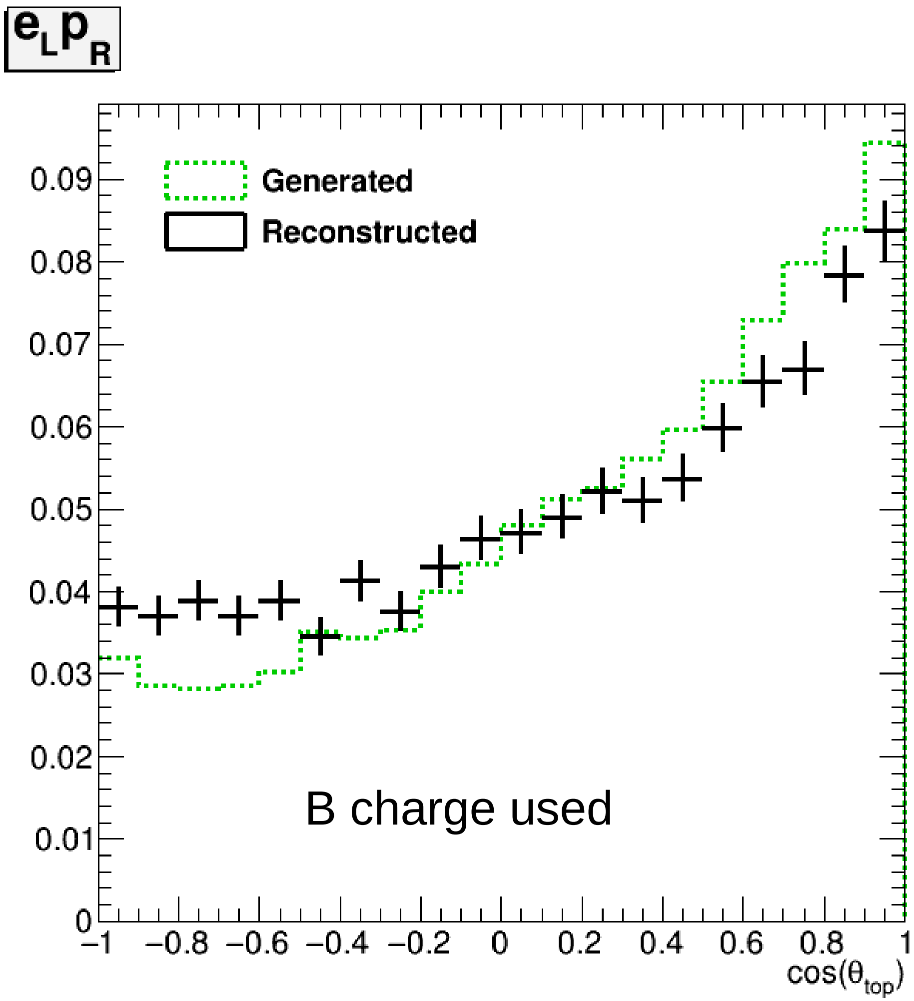
- Majority of missed tracks have low offsets. These tracks can be recoverable if their angle w.r.t. secondary vertex is small

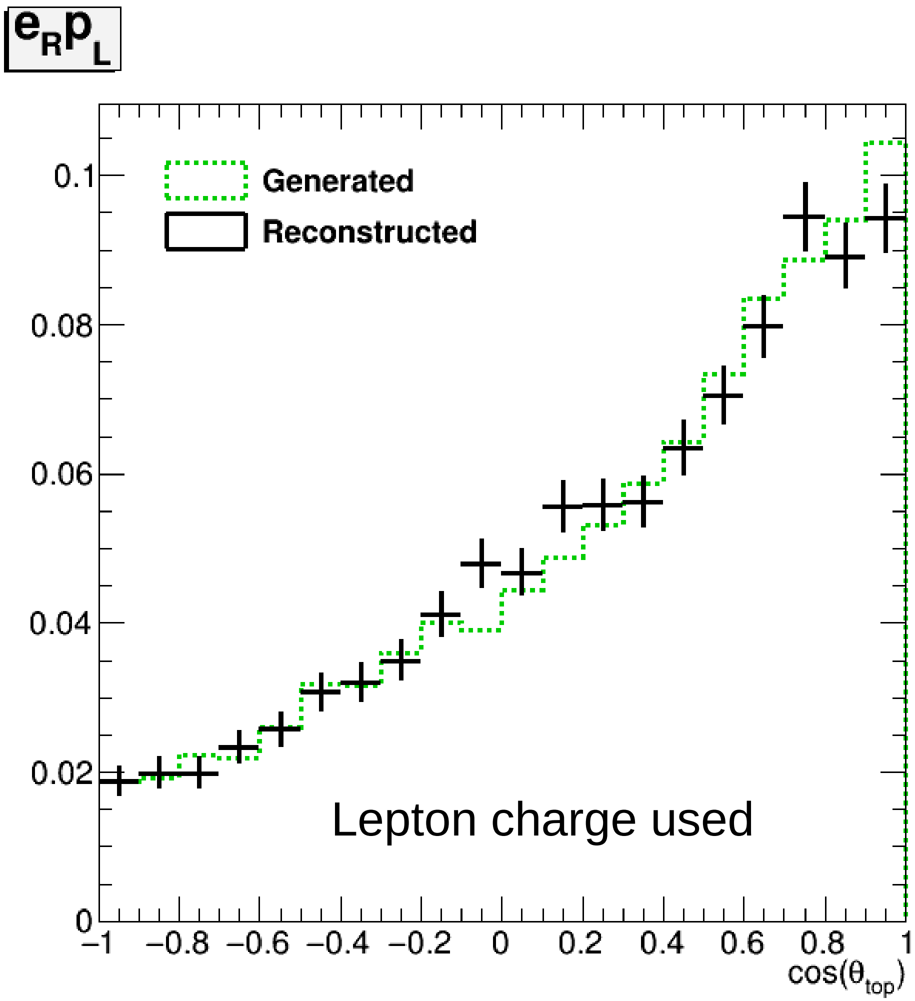
Momentum - DBD reconstruction



- Momentum of the missed tracks for the barrel and the forward region

Top asymmetry DBD



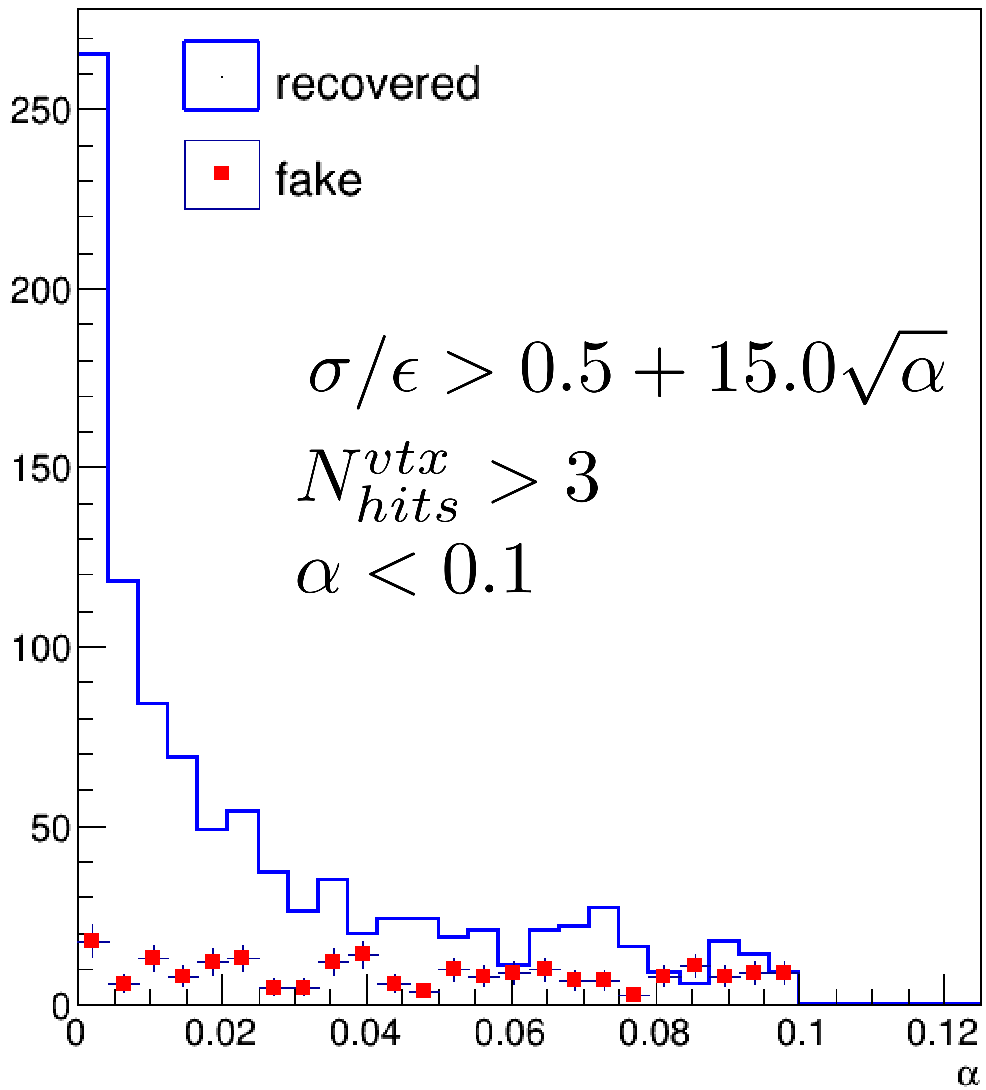


65.5% precision

96.3 % precision

- The result of top asymmetry reconstruction with real b charge measurement. DBD tracking, no recovery

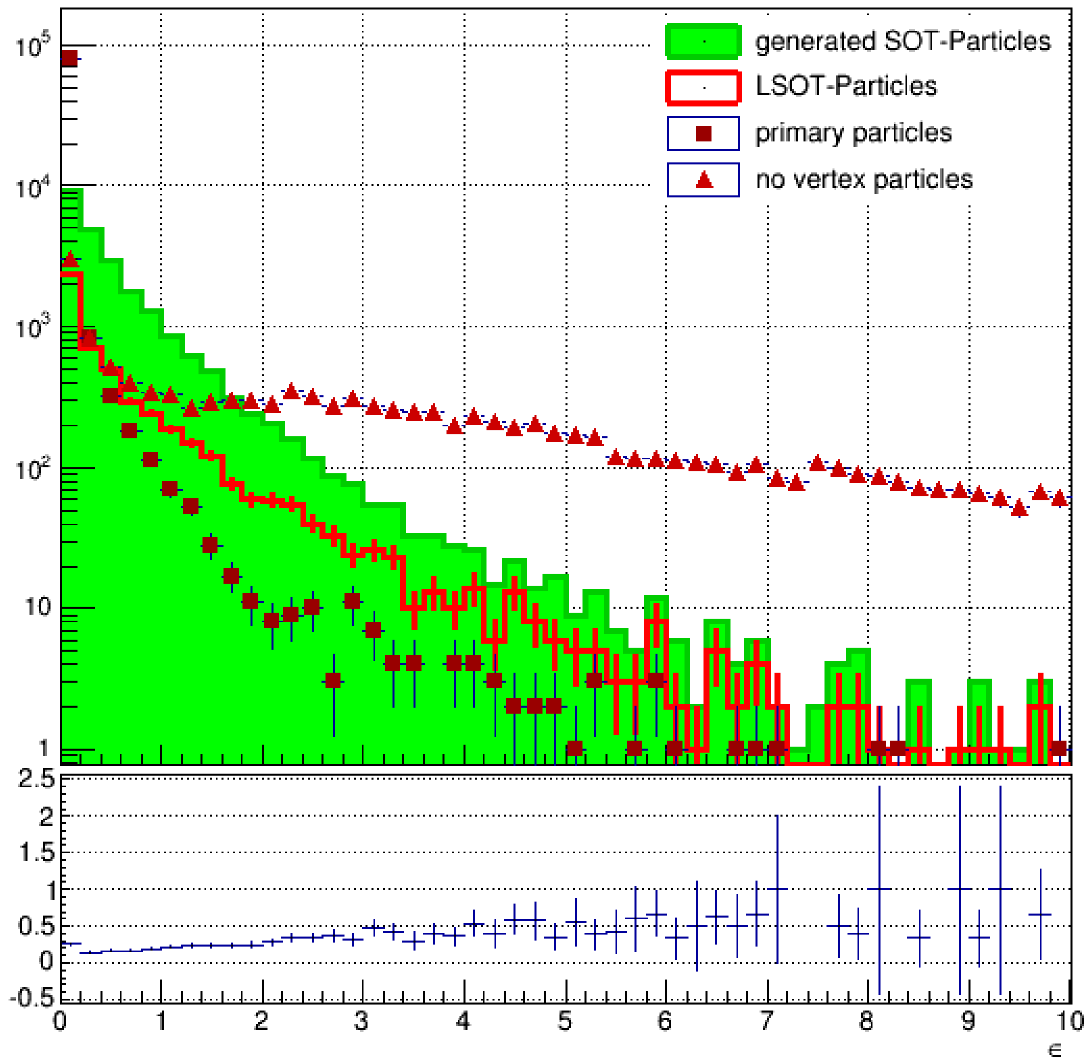
Preliminary results of recovery



- Histogram of α angles for recovered LSOT particles and fake particles taken by algorithm
- Up to 67% of target particles can be recovered with 82 % of purity
- The recovery procedure should be optimized by charge reconstruction quality
- Technical issues will be discussed at HLRecoW

- The number of recovered particles can be increased by injecting tracks that were not used by PFA in the recovery

Comparison of offsets

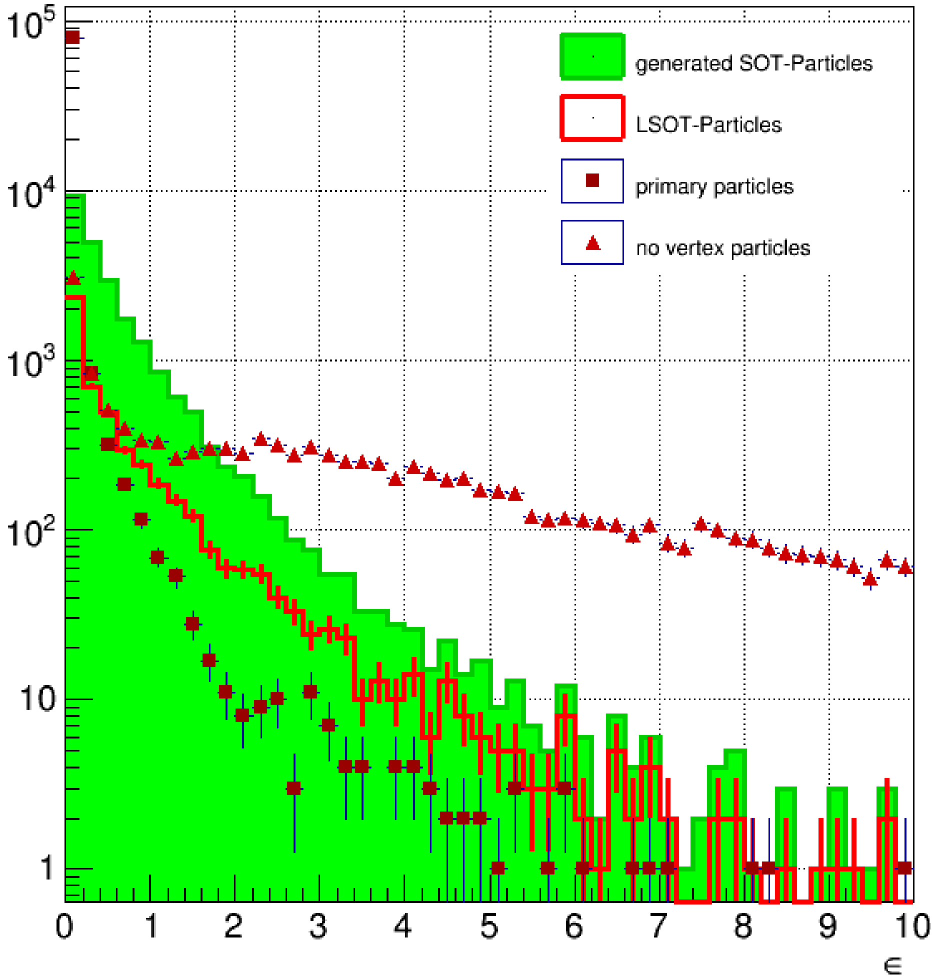


- The secondary and missed particles are generated particles from B-mesons.
- The “no vertex” particles are tracks that had not been attached to neither primary nor secondary vertex.
- “No vertex” particles and primary vertex tracks are reconstructed tracks.

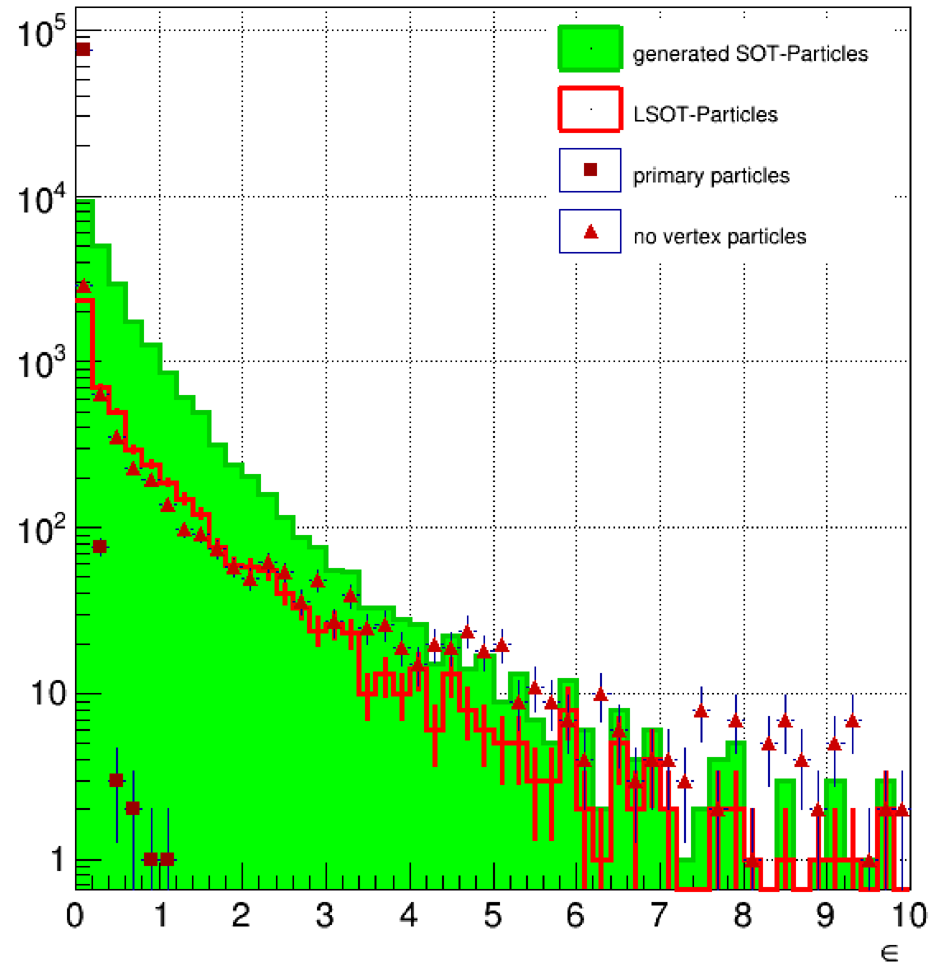
- True secondary particles are excluded from primary and “no vertex” particles histograms

Comparison of offsets

All primary and “no vertex” particles



Particles with >3 hits in VXD

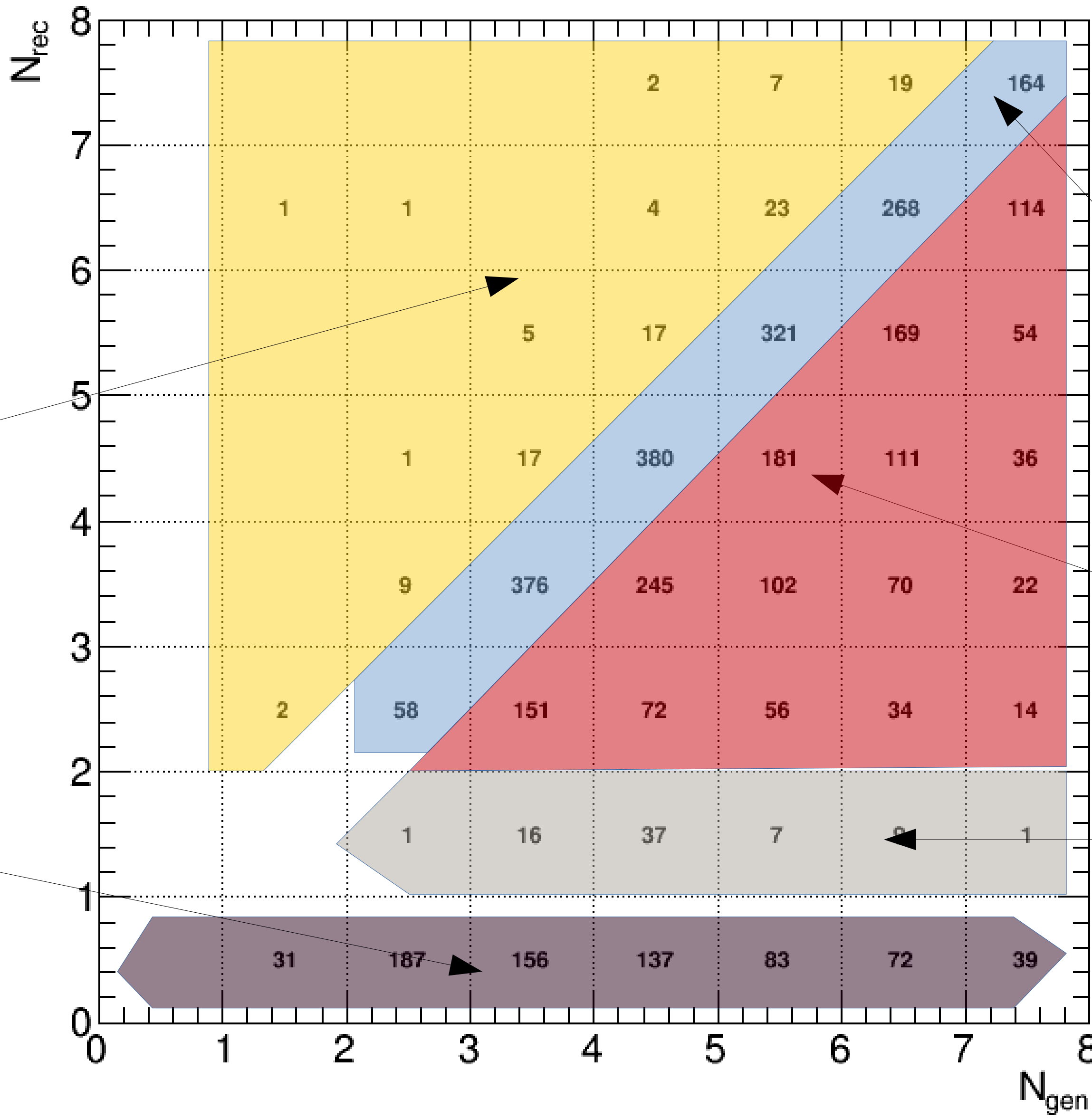


- After VXD hits cuts the main background is “no vertex” particles. Primary particles have low offsets after cuts.

Number of particles comparison

SOT-Vertices = Secondary Or Ternary Vertices

SOT-Tracks = Tracks emerging from SOT-Vertices



Above diagonal, 1 or more added tracks, incorrect charge

Diagonal, Correct charge

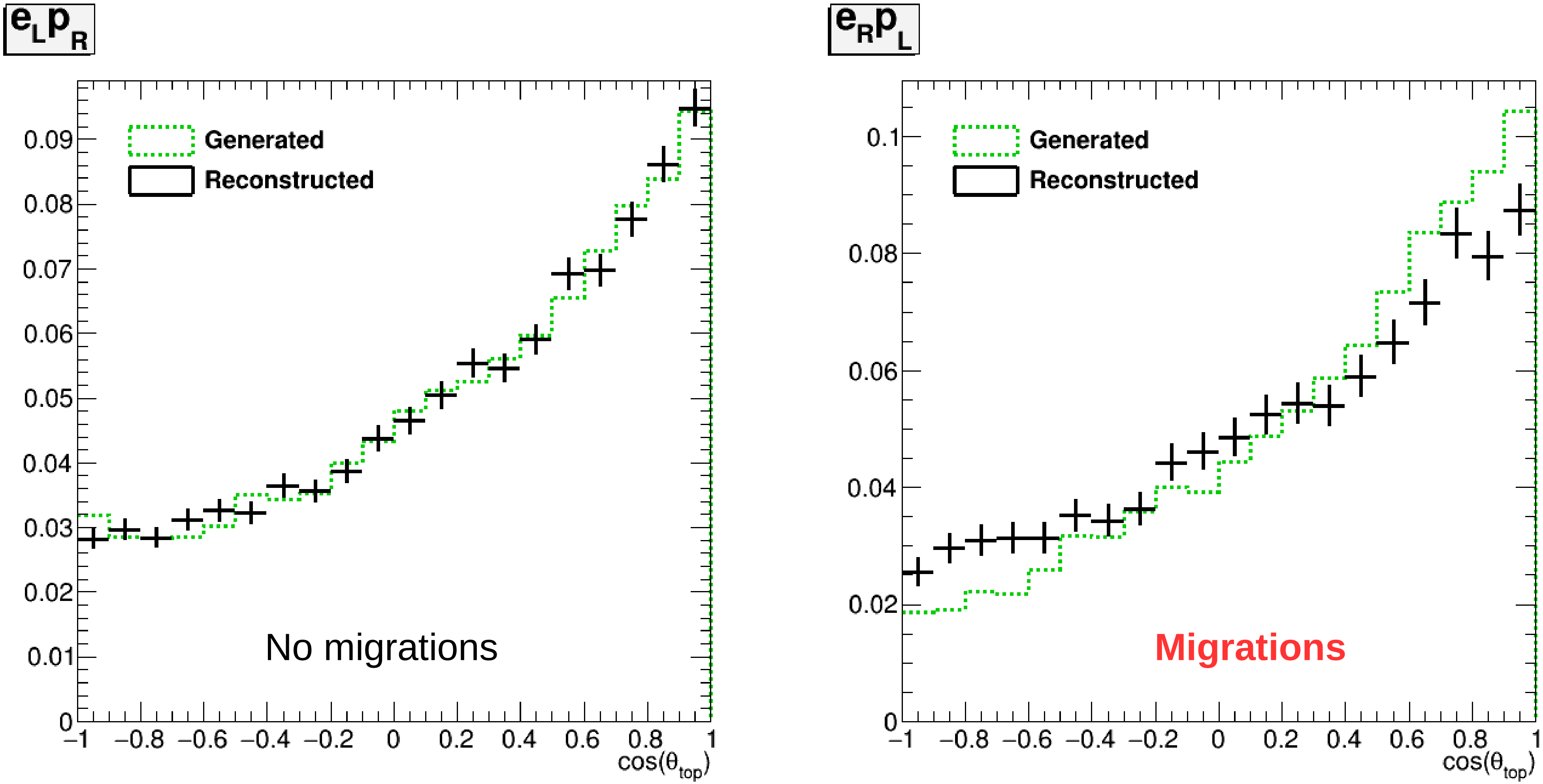
Below diagonal, 1 or more missed tracks, incorrect charge

No reconstructed vertices

Populated by leptons, b charge can be calculated

One should diagonalize this table as much as possible to get a correct charge measurement

Top asymmetry: Using generated b charge

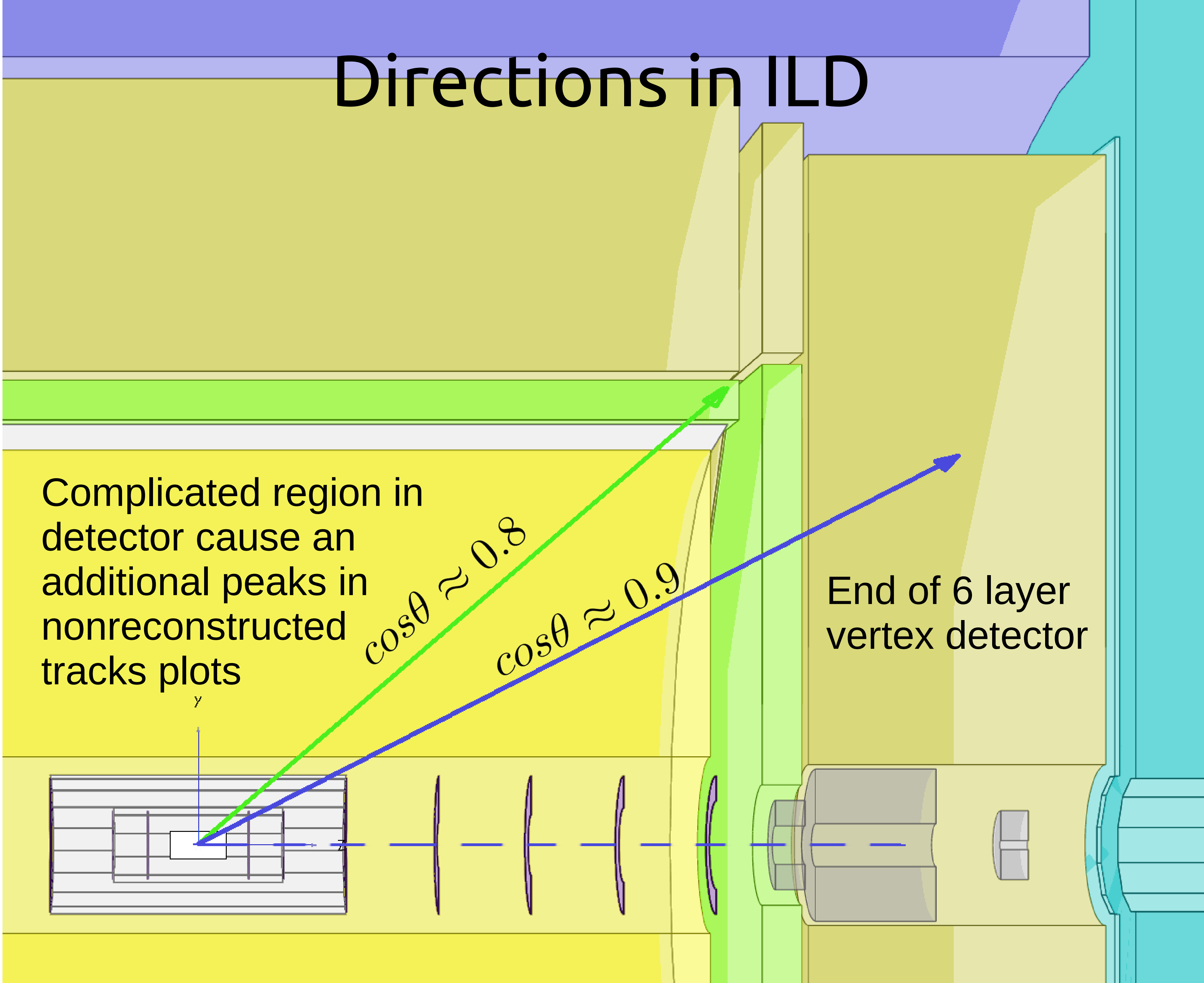


99.4% precision

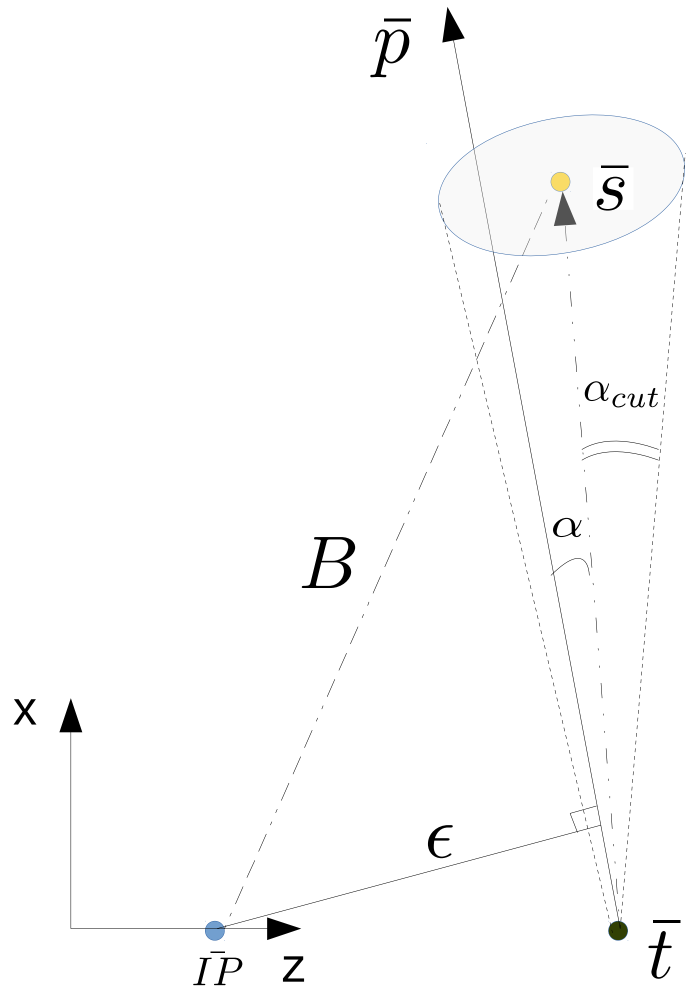
72.5% precision

- The result of top asymmetry reconstruction with 100% purity and efficiency of b charge.

Directions in ILD



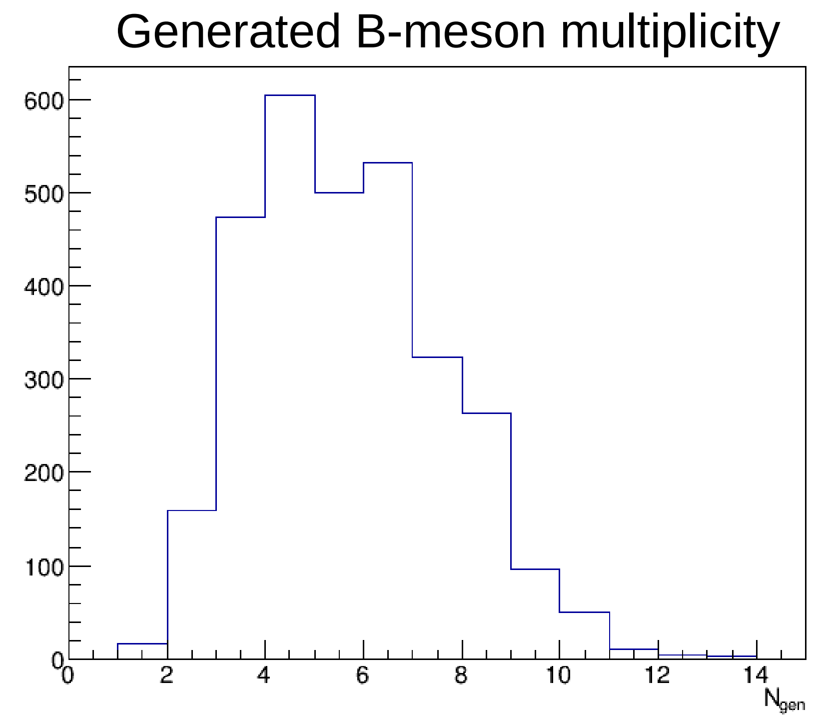
Recovery of vertices



- **IP** – interaction point (primary vertex) , **s** – secondary vertex, **t** – point of closest approach of a track, **p** – reconstructed momentum, ϵ - offset of a track from primary vertex

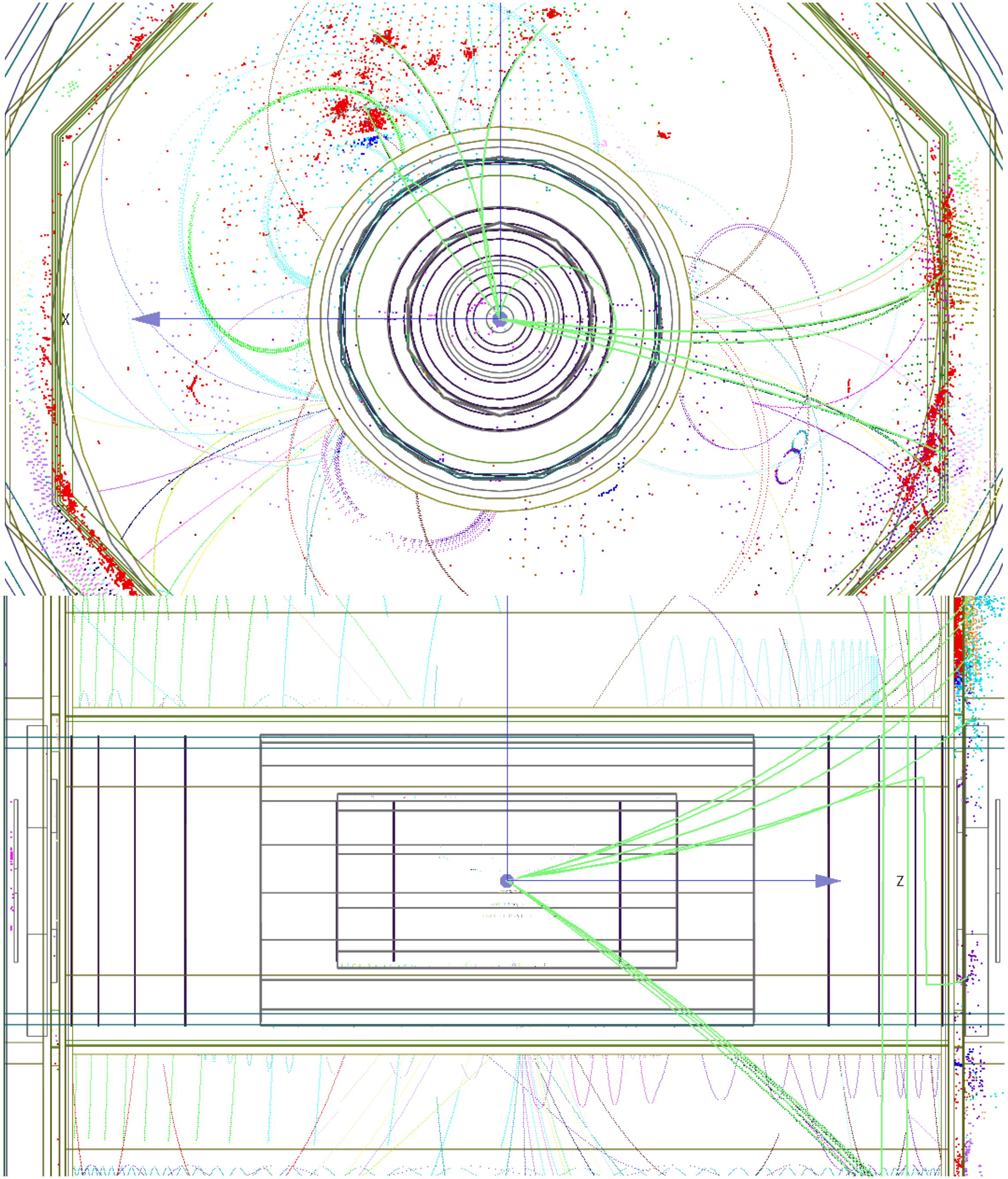
Probability to lose a particle

- The calculated chance to lose a particle from reconstructed SOT vertex is ~14%:
- It subdivides into:
  - Not reconstructed as PFO ~ 5%
    - No tracking information ~ 1.5%
    - Has reconstructed track ~ 3.5%
  - No hits in VXD ~ 3%
  - Recoverable particles from 6% to 9%



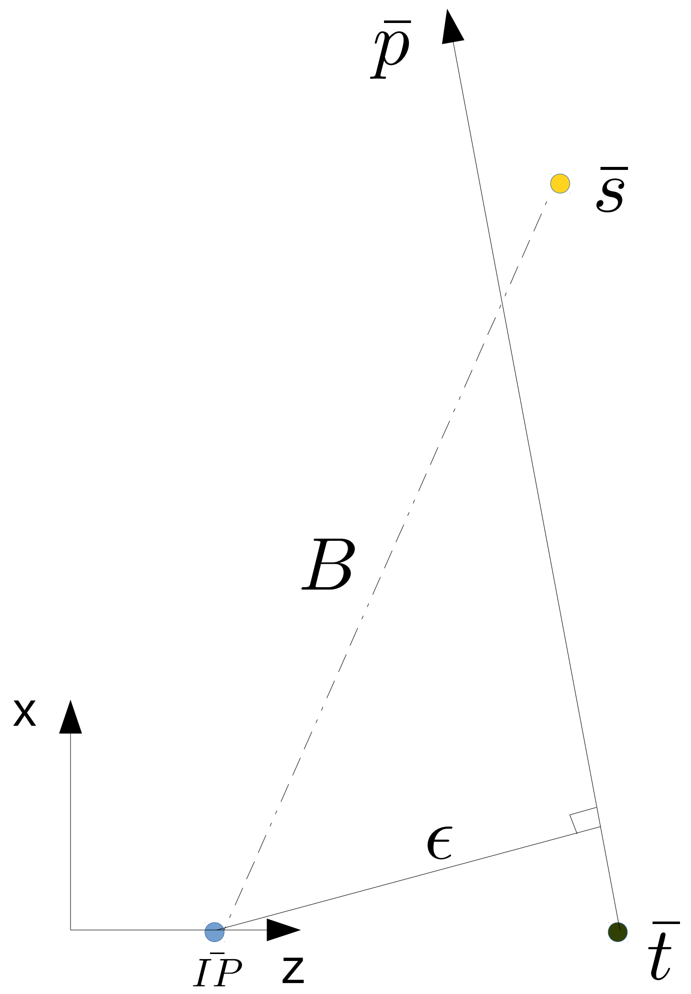
- Average B meson multiplicity is 5, and for each track we have such probability to not to reconstruct it as SOT-Vertex particle

C Event Display



- Front and side projection of ILD event in CED.
- It was configured to show only prongs from b-hadrons
- View can be switched between generated particles to reconstructed ones

Definition of Estimators



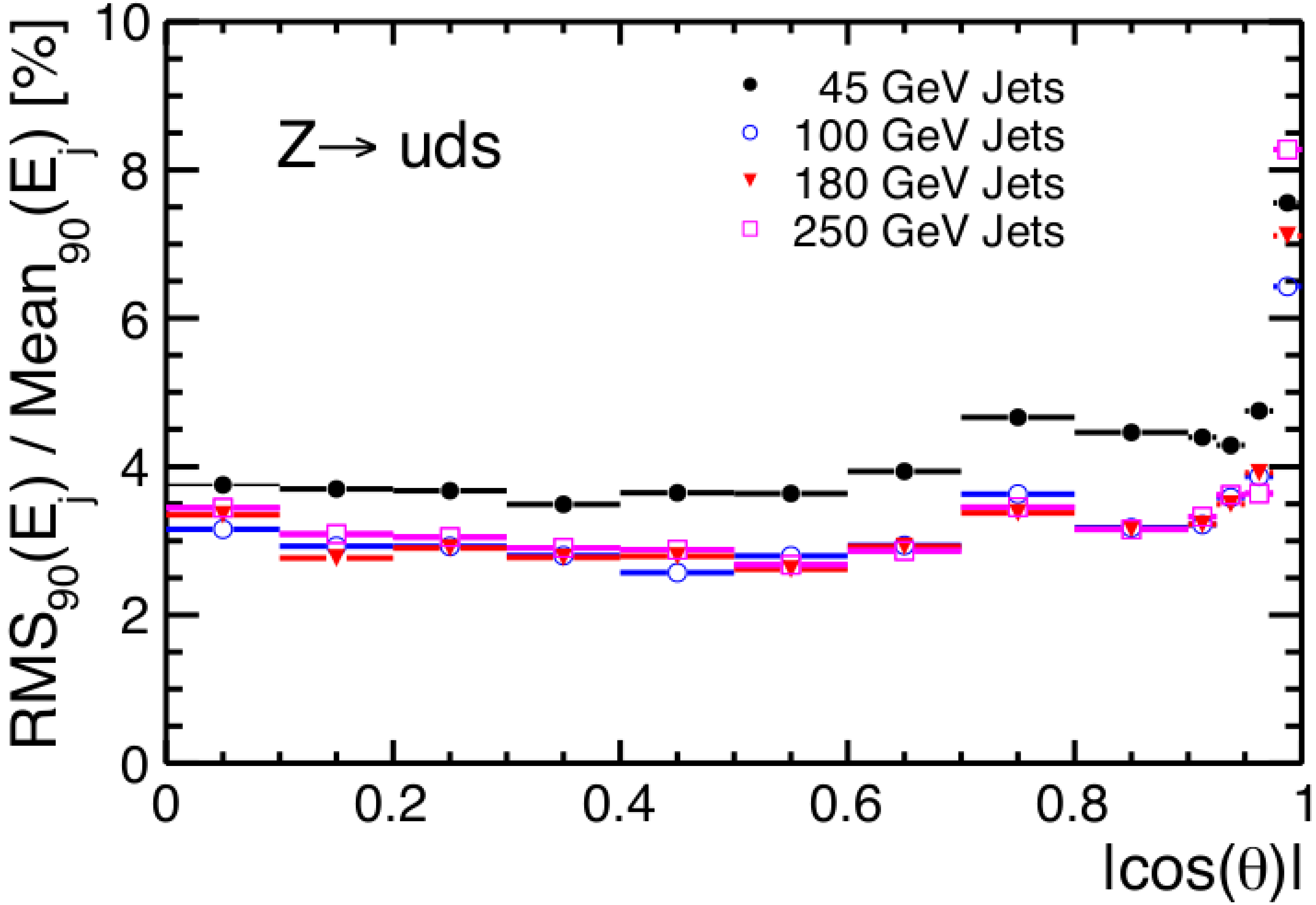
- To compute the offset we are using the linear approximation of tracks
- The resolution on the offset can be approximated by a formula from DBD:

$$\sigma = a \oplus \frac{b}{|p| sin^{2/3} \theta}$$

$$a = 5 \mu m; b = 10 \mu m \cdot GeV$$

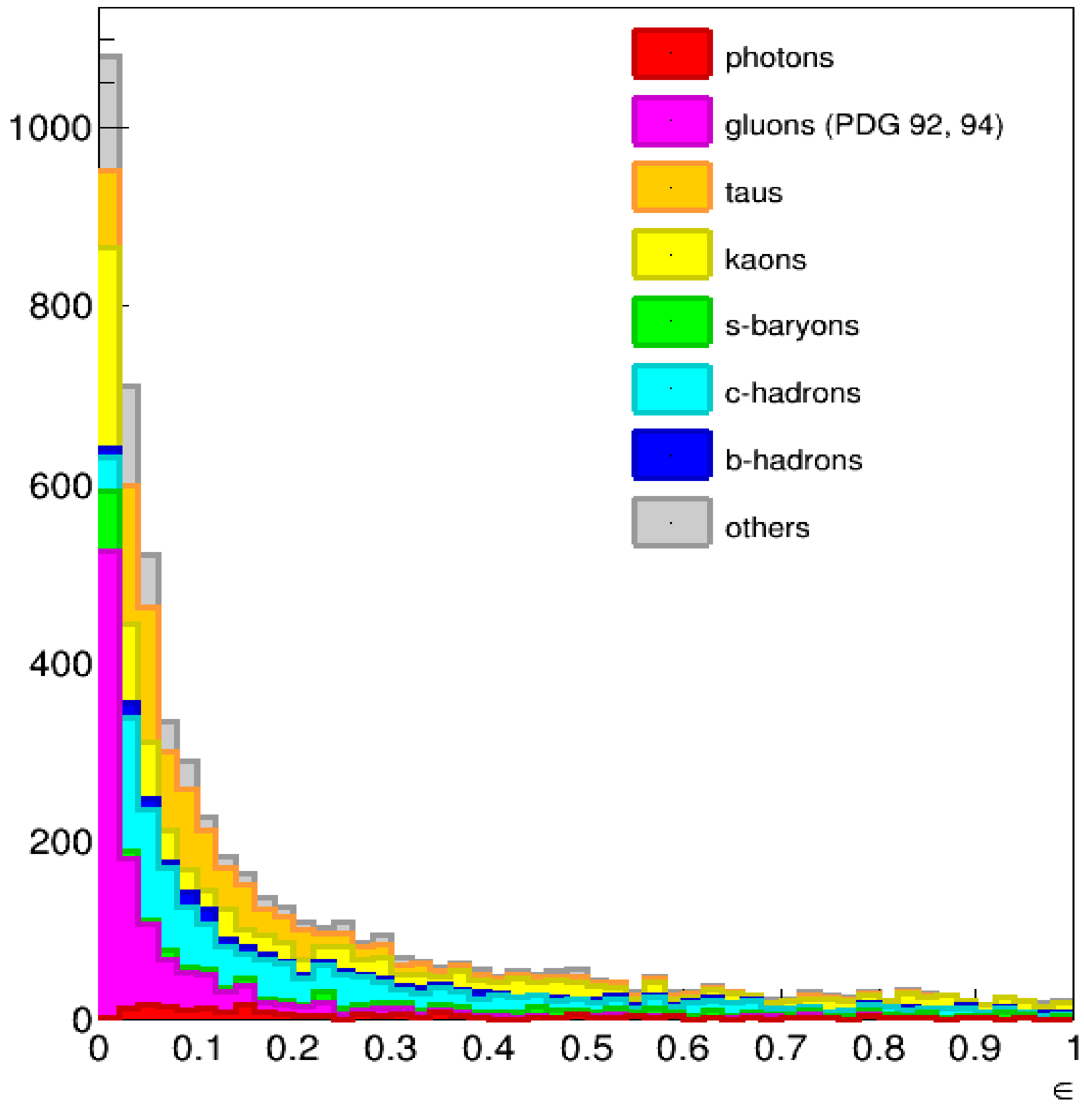
- **IP** – interaction point (primary vertex) , **s** – secondary vertex, **t** – point of closest approach of a track, **p** – reconstructed momentum, ϵ - offset of a track from primary vertex

JER in ILD TDR



Complicated region in detector cause an additional bump in jet energy resolution plots

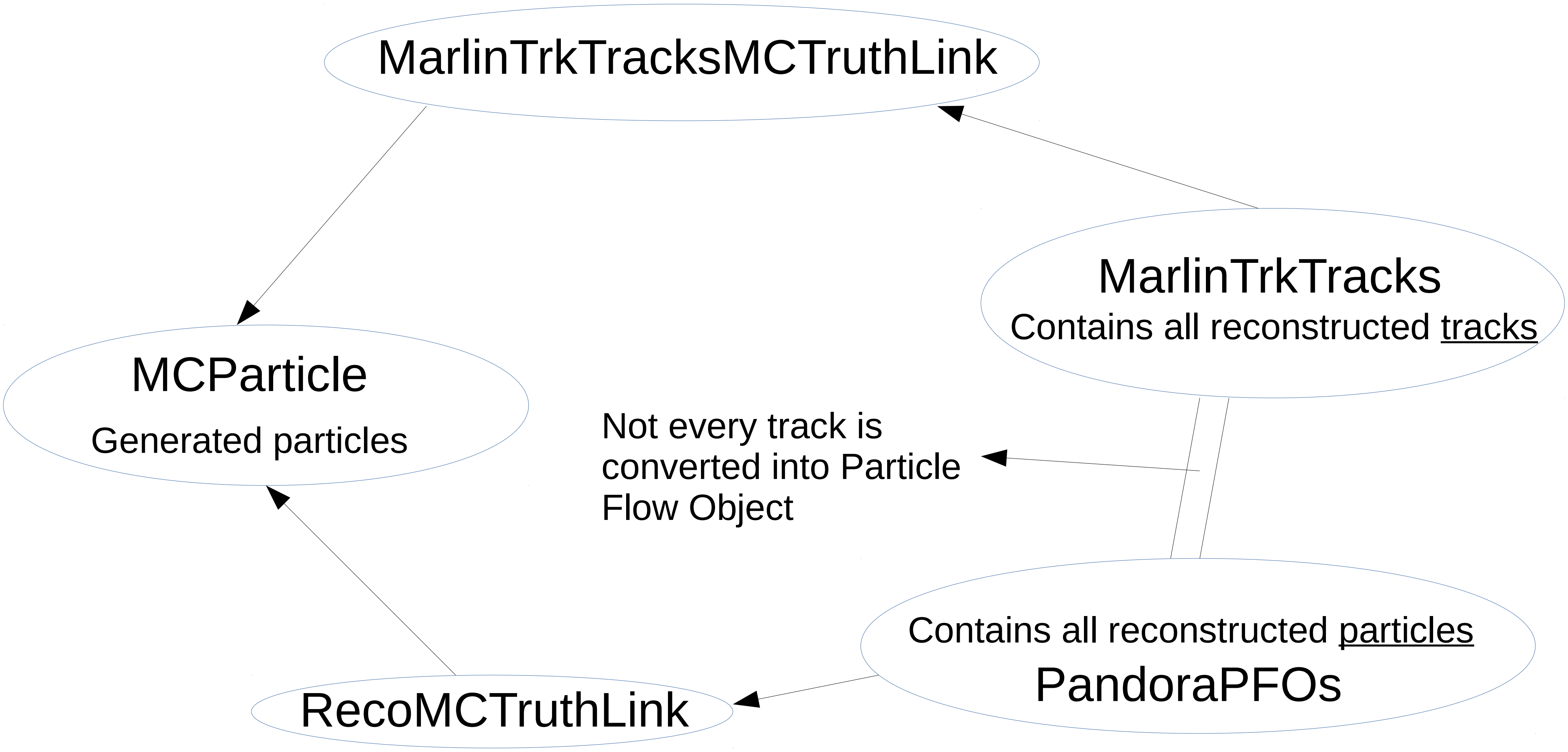
Origin of no vertex tracks



- This is offset histogram of “no vertex” tracks subdivided by different origin of a track using generator truth after VXD hits > 3 cut.
- Main contributions are coming from c- and s-hadrons, taus and “gluons”

- Majority of c-hadrons and tau-leptons should come from W-jets, and these tracks have to be separated from b-jets by large angle

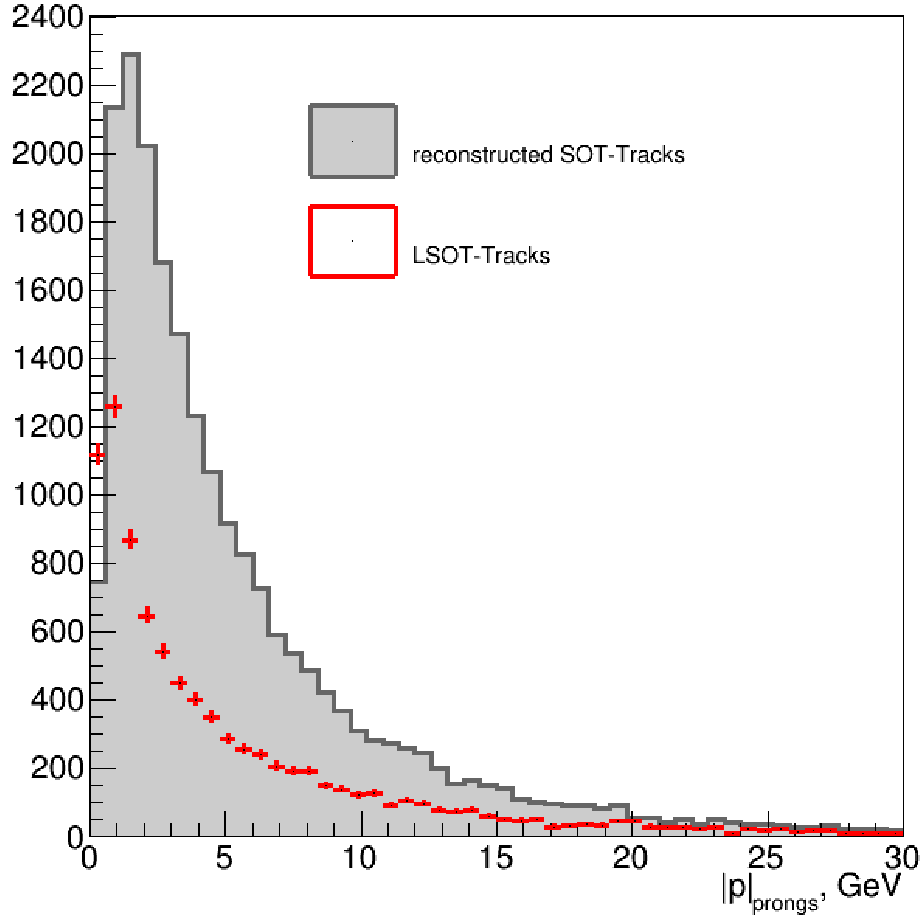
Truthlinks used



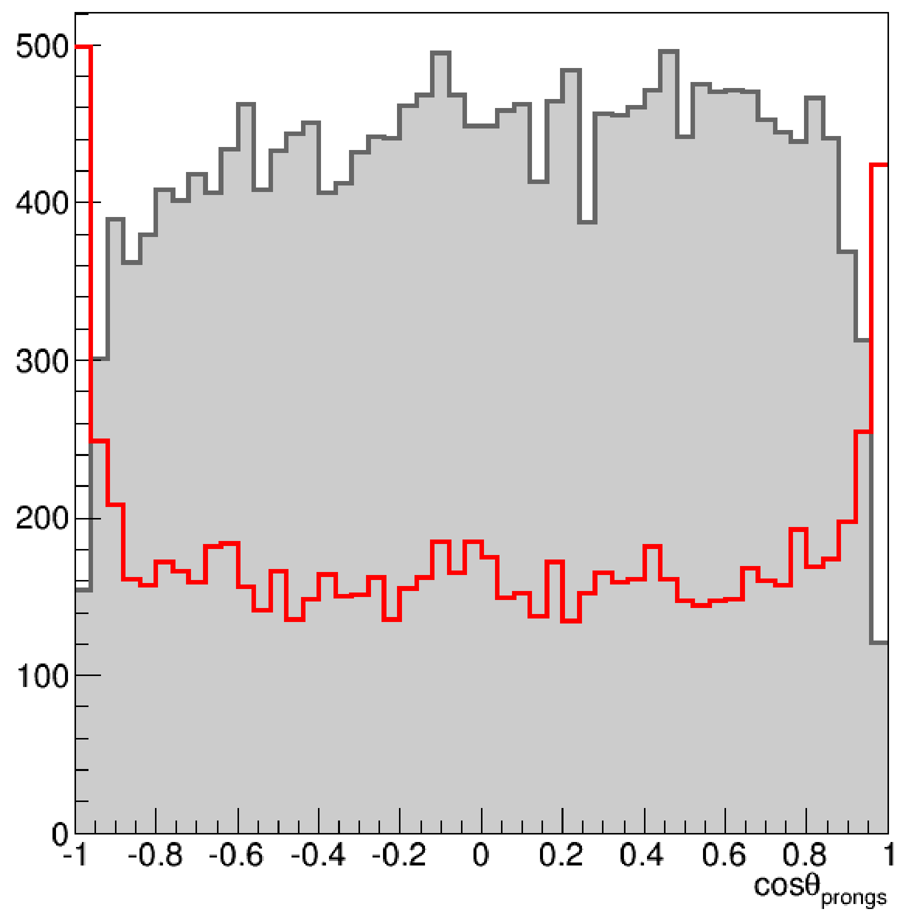
There is ~3% uncertainty between these truthlinks

Lost SOT-Tracks analysis

Momentum comparison

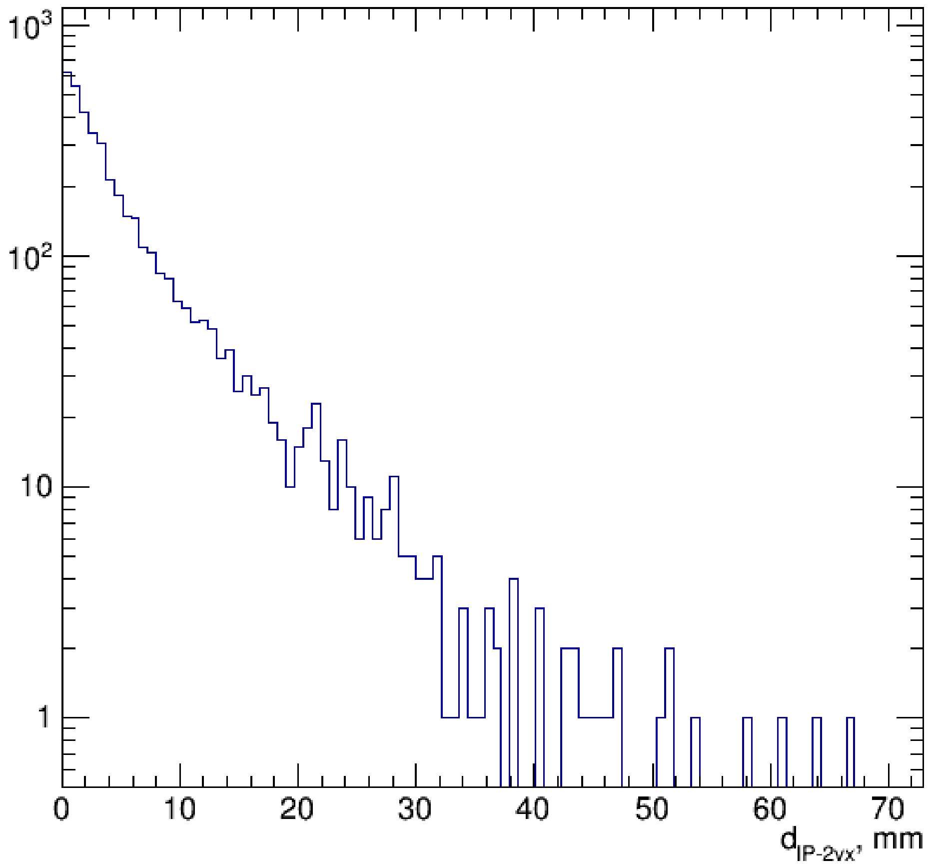


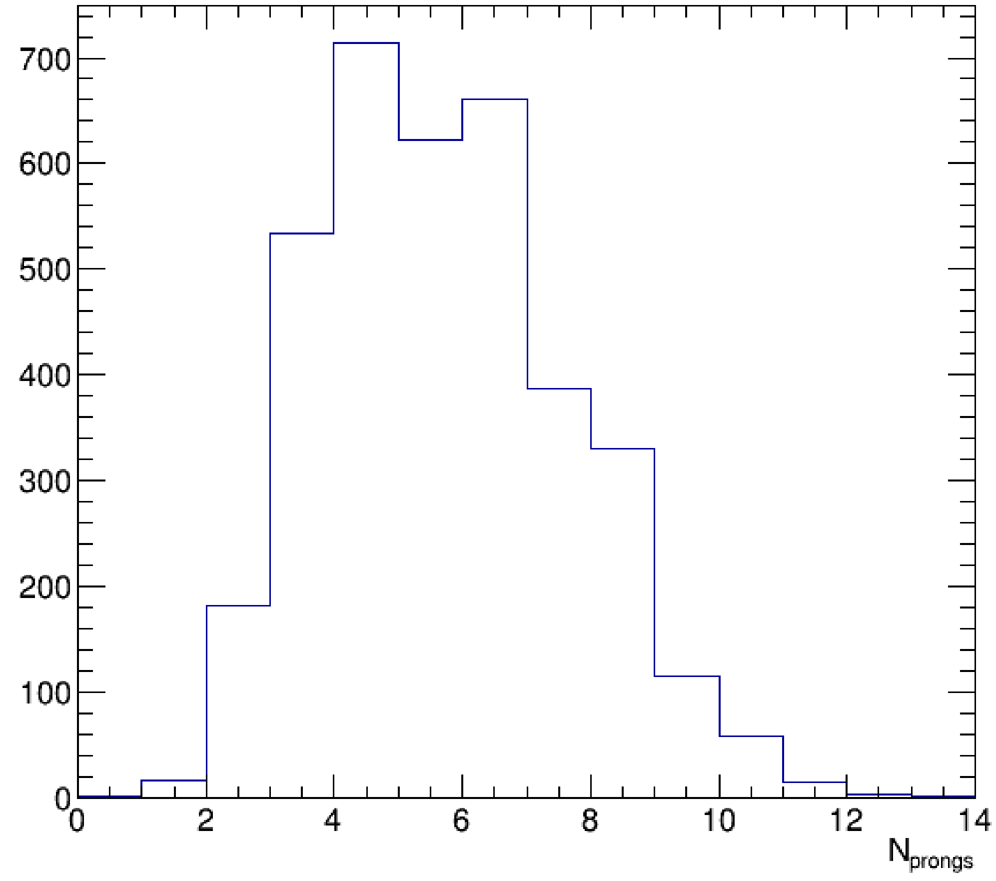
Angular comparison



- There is a tendency to lose a track with low momentum or in forward region. We should investigate all the reasons to lose a track

Generated vertices

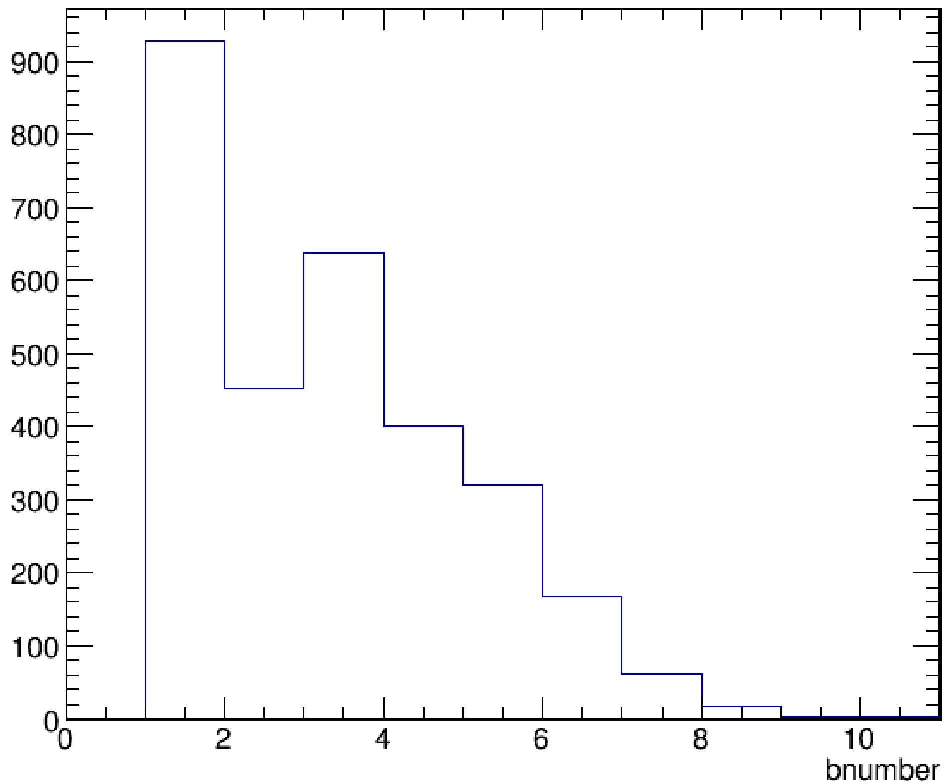




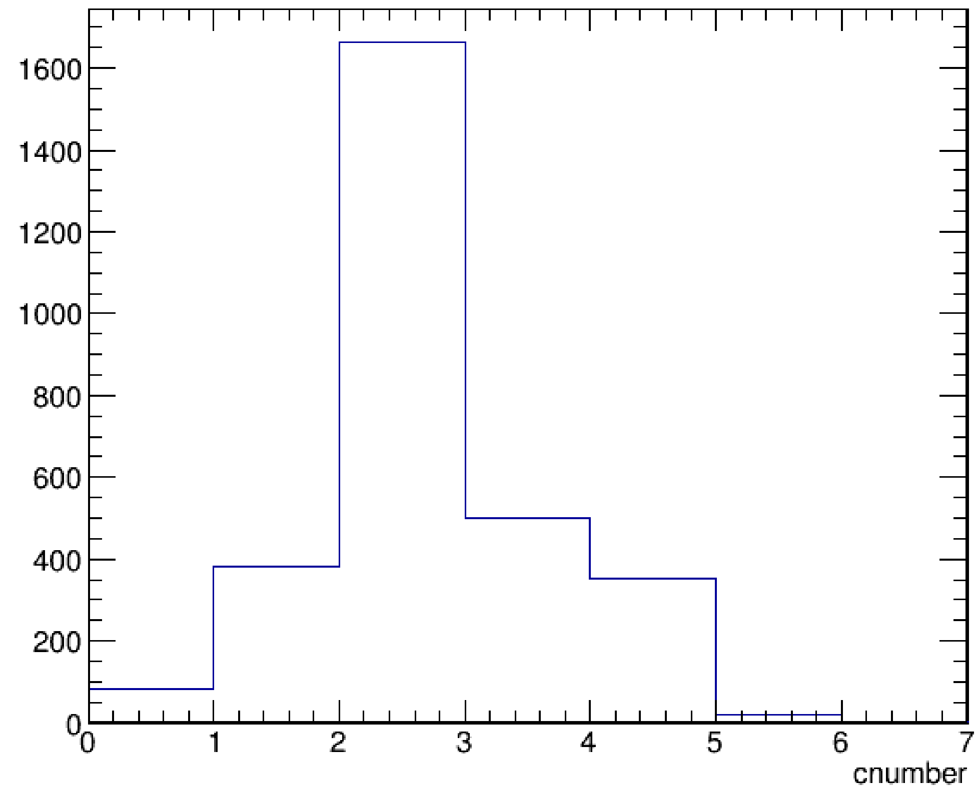
- Distance from IP to B-meson decay vertex (left), prongs of initial B-meson (right)

Multiplicity of b-c vertices

b-vertex



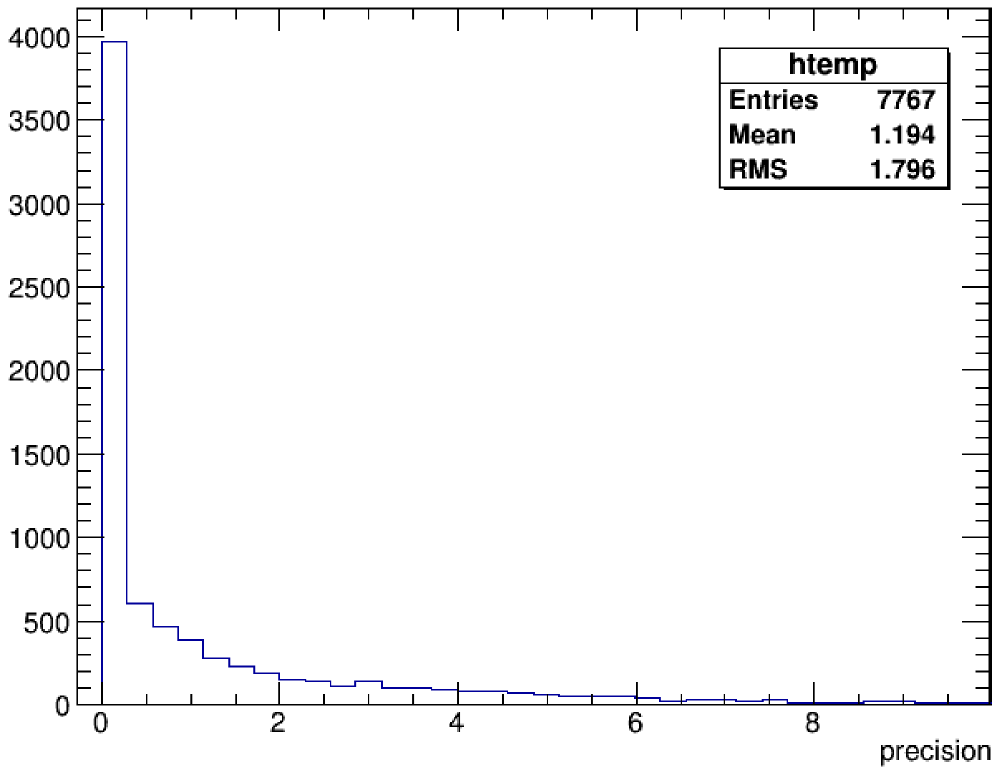
c-vertex



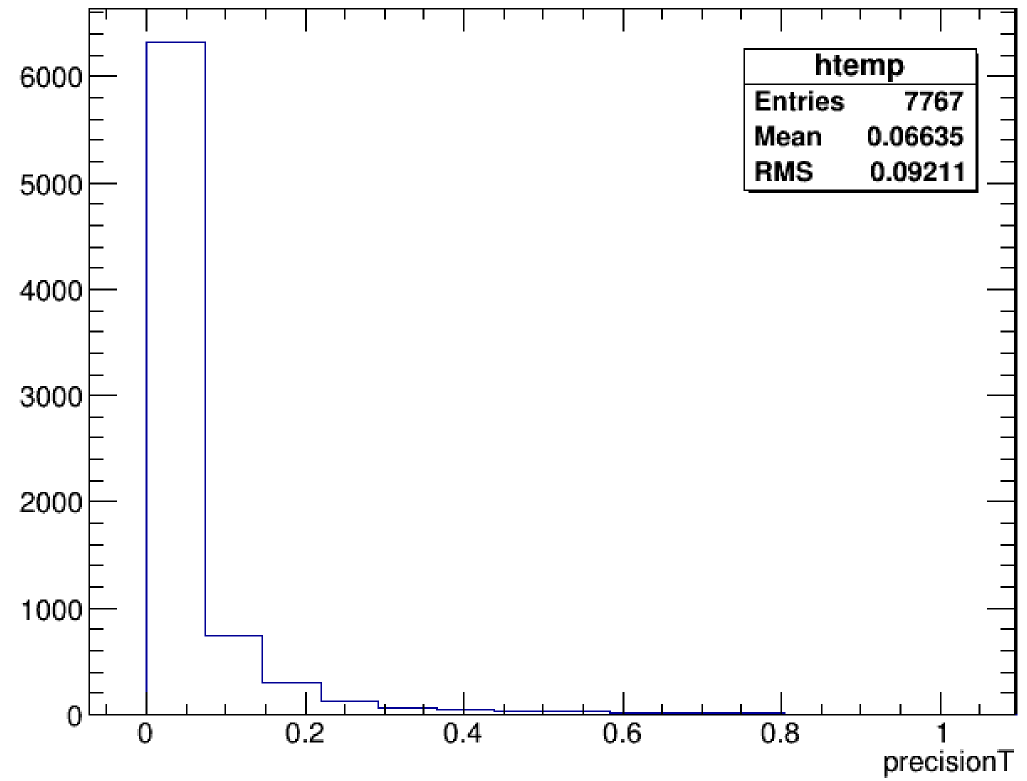
- Number of tracks for b and c vertices. For charge measurement the 1-prong decay is dangerous and it is present in both vertices

Precision of vertex position

Distance

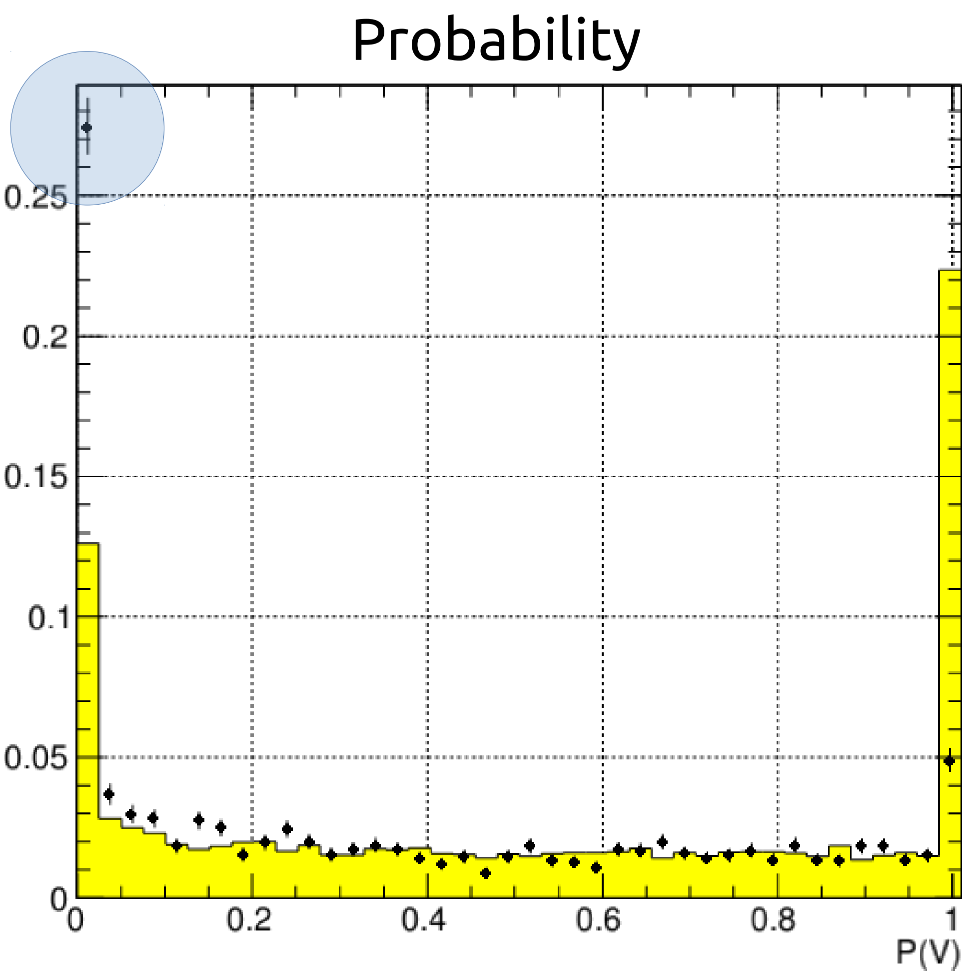


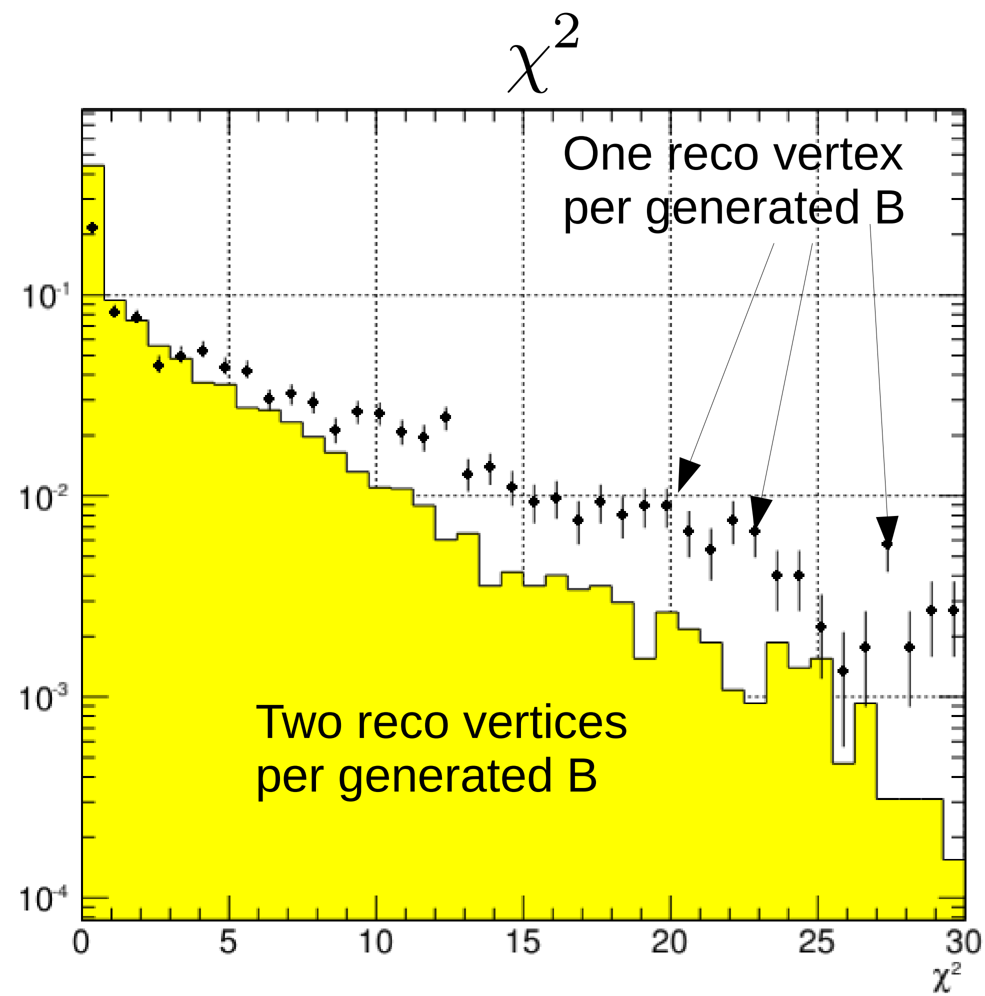
Transverse distance



- Distance between reconstructed and generated vertices. The direction of b-hadron known precisely.

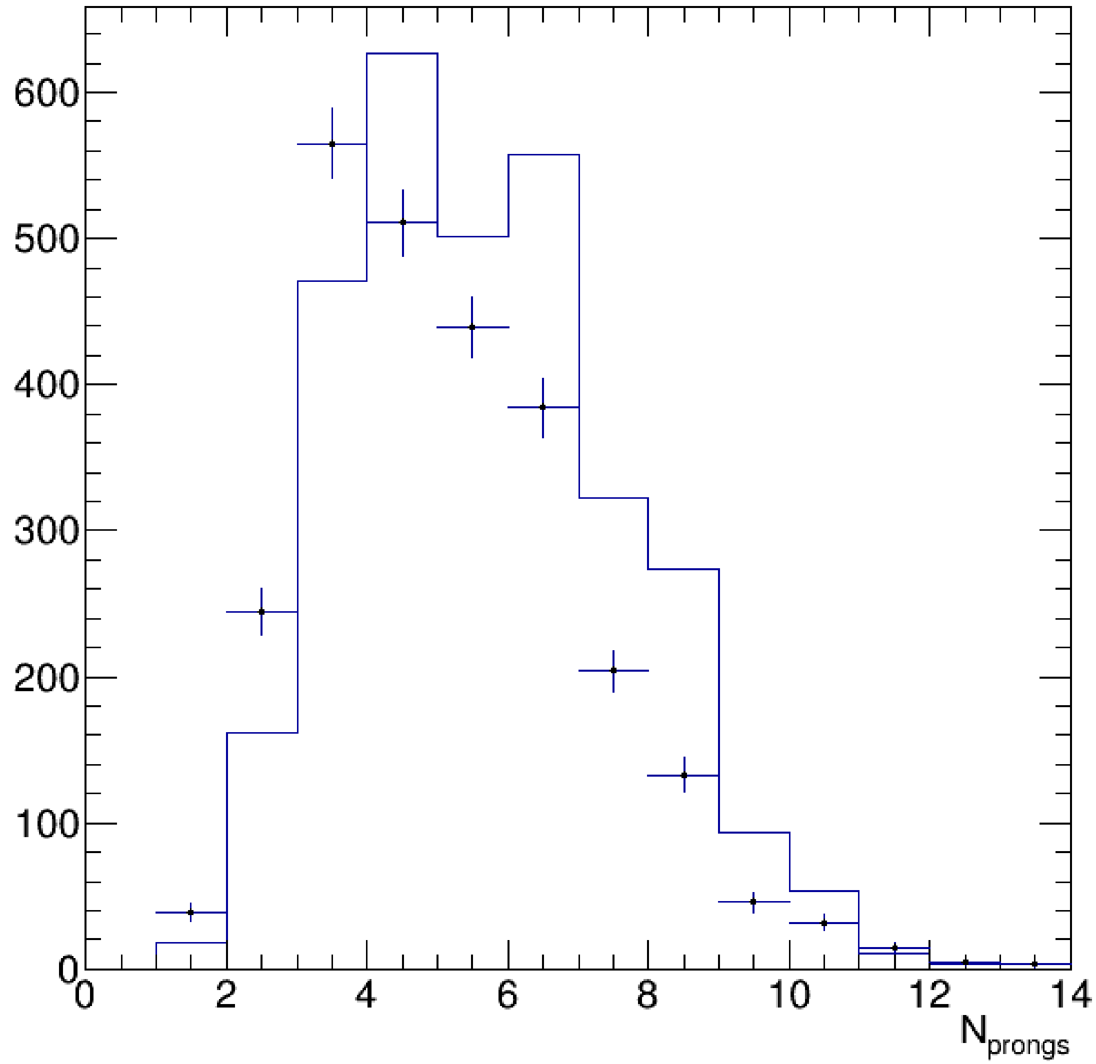
Reconstructed vertices





- Probability (left) and chi-square from LCFI+ (right) comparison for 1 vertex per b-jet (dots) and 2 vertices per b-jet (yellow). The presence of ternary vertex increase chi-square value of vertex fitting.

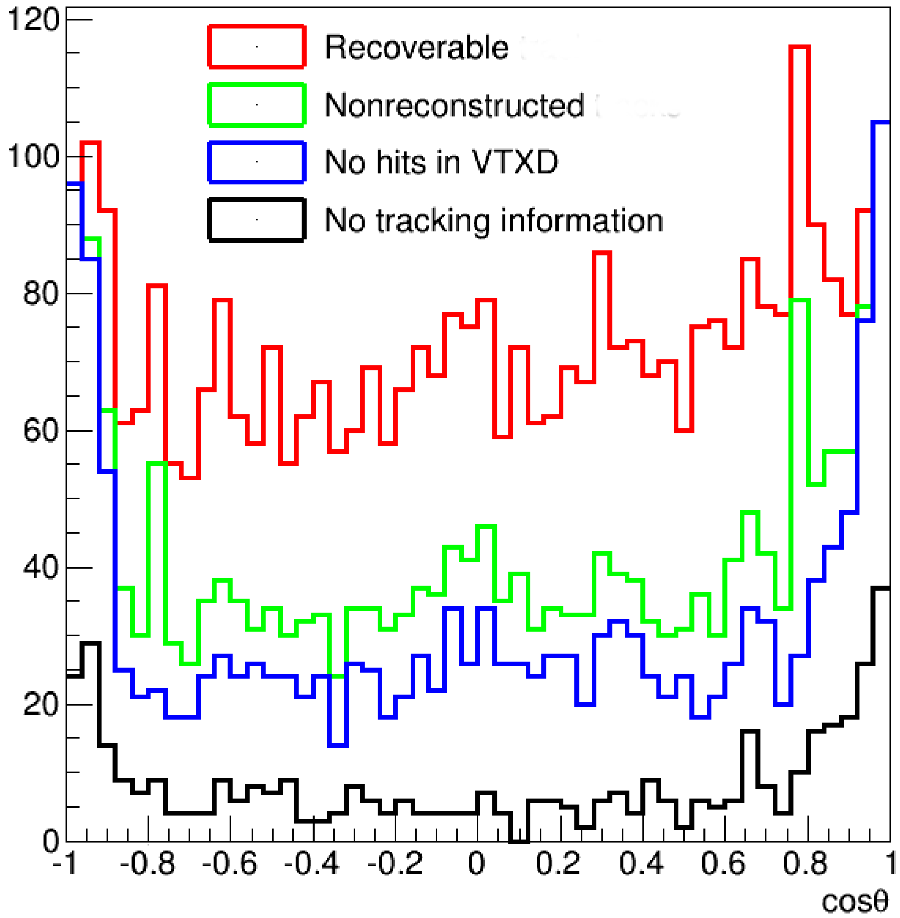
Reconstructed vertices



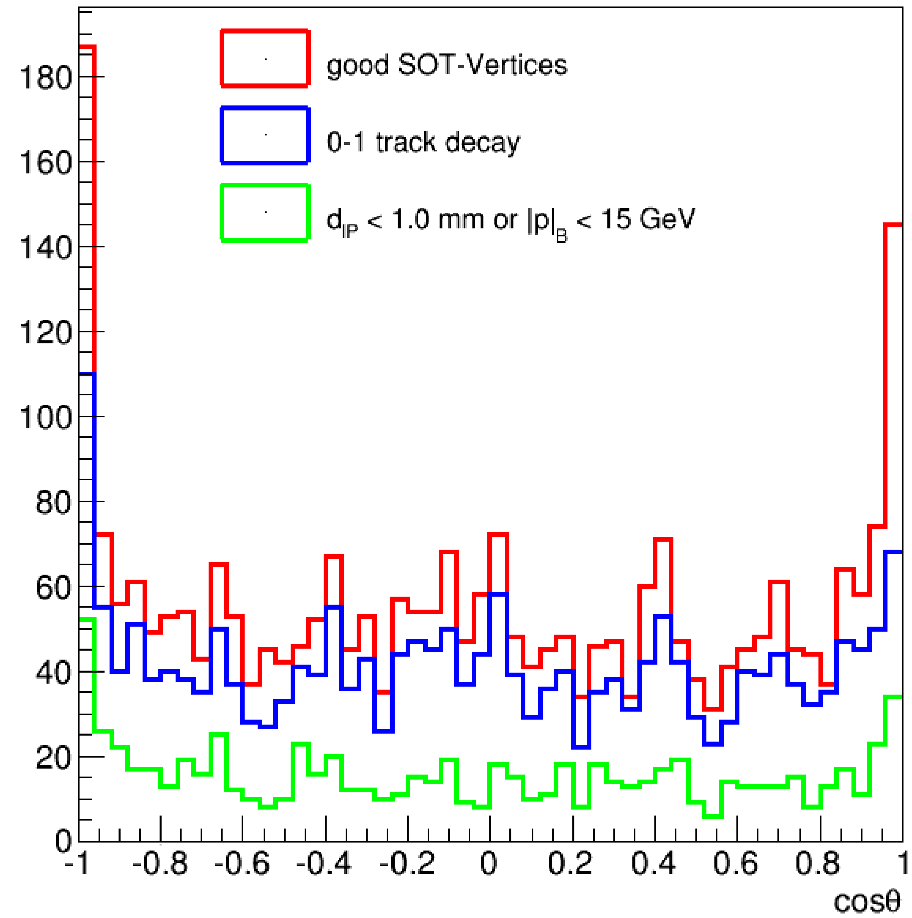
- Number of tracks from generated vertices (yellow) and reconstructed (crosses). Distributions do not coincide

Lost particles analysis

LSOT-VTX Particles



LSOT-NOVTX Vertices



- There is an enhanced risk to lose a 1-track decay vertex and high chances to miss any SOT vertex in forward region