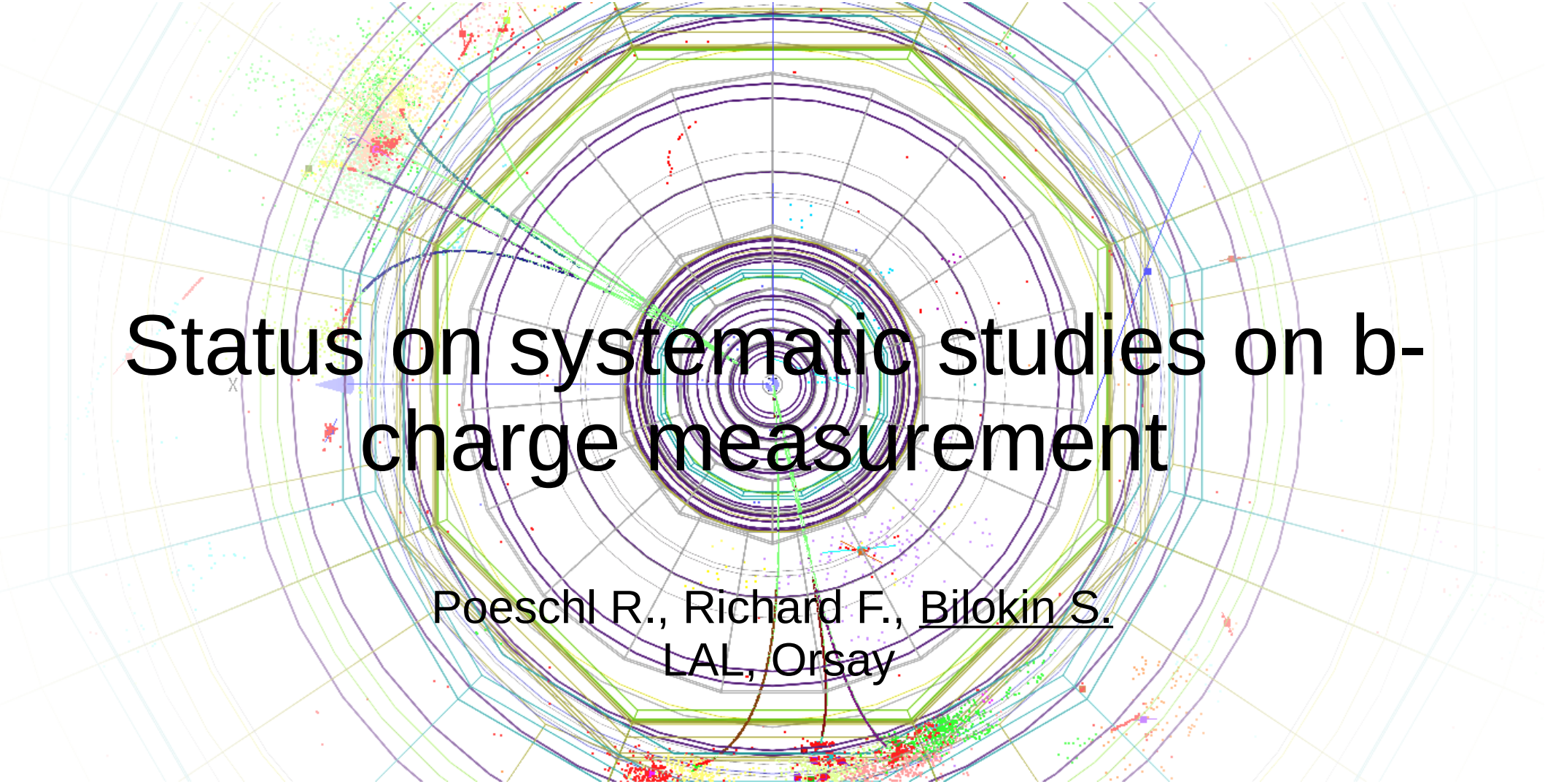


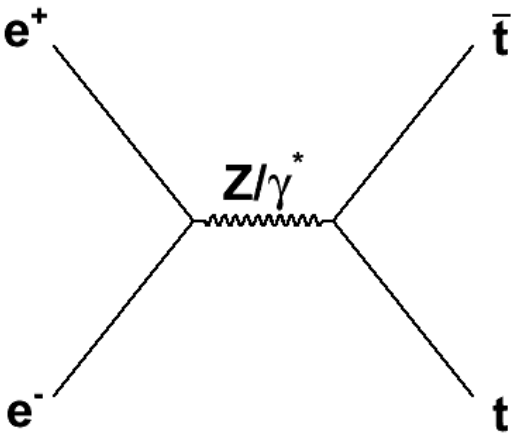
Status on systematic studies on b-charge measurement

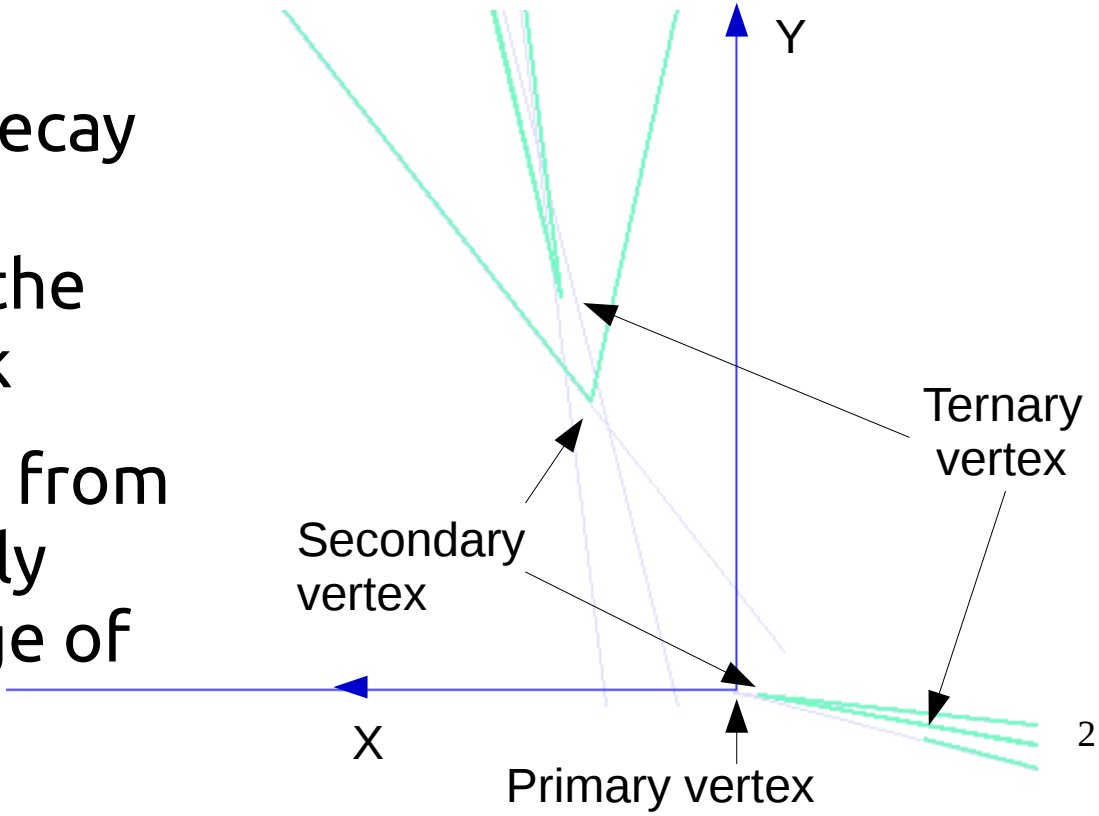
Poeschl R., Richard F., Bilokin S.
LAL, Orsay

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Research method

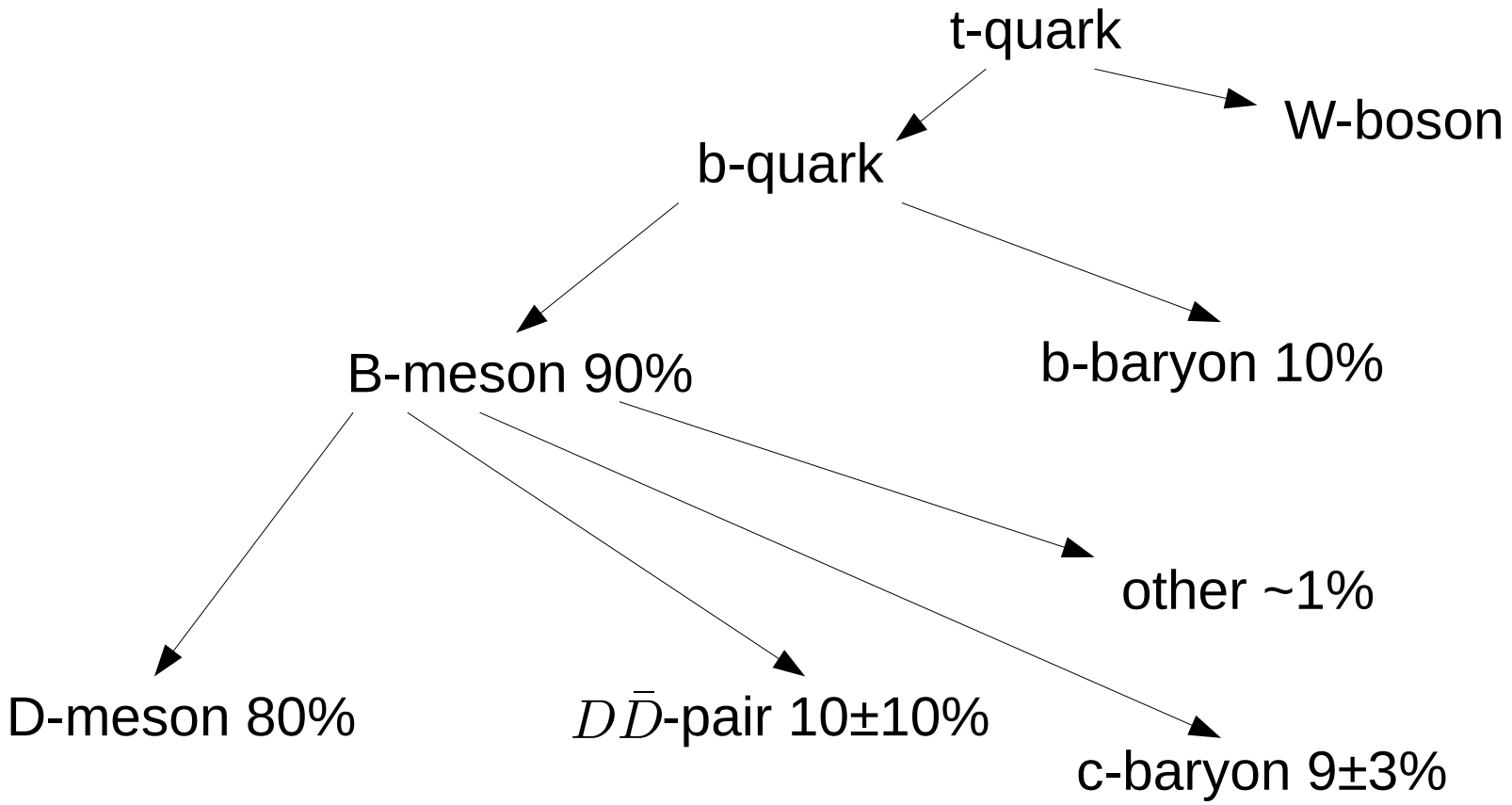
- Main purpose of this work is to detect the charge of top and antitop quarks. This is crucial for calculation of forward-backward asymmetry A_{fb} in $t\bar{t}$ process at ILC
- We use properties of decay products from the B-hadrons to determine the charge of initial t-quark
- The charge of K-meson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





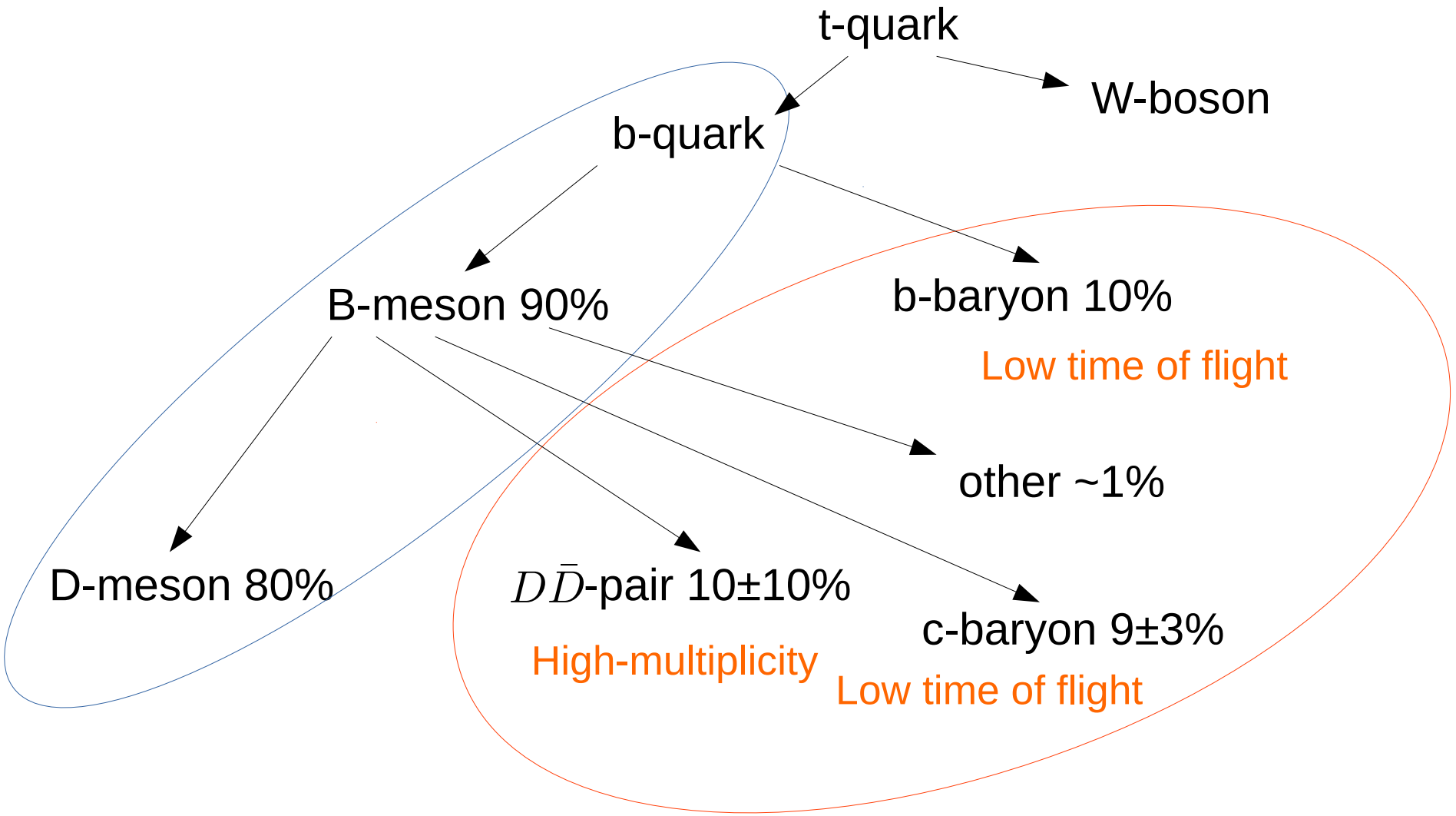
Process overview

- Hadronization and decay modes of b-quark:



Process overview

- Hadronization and decay modes of b-quark:



Research setup

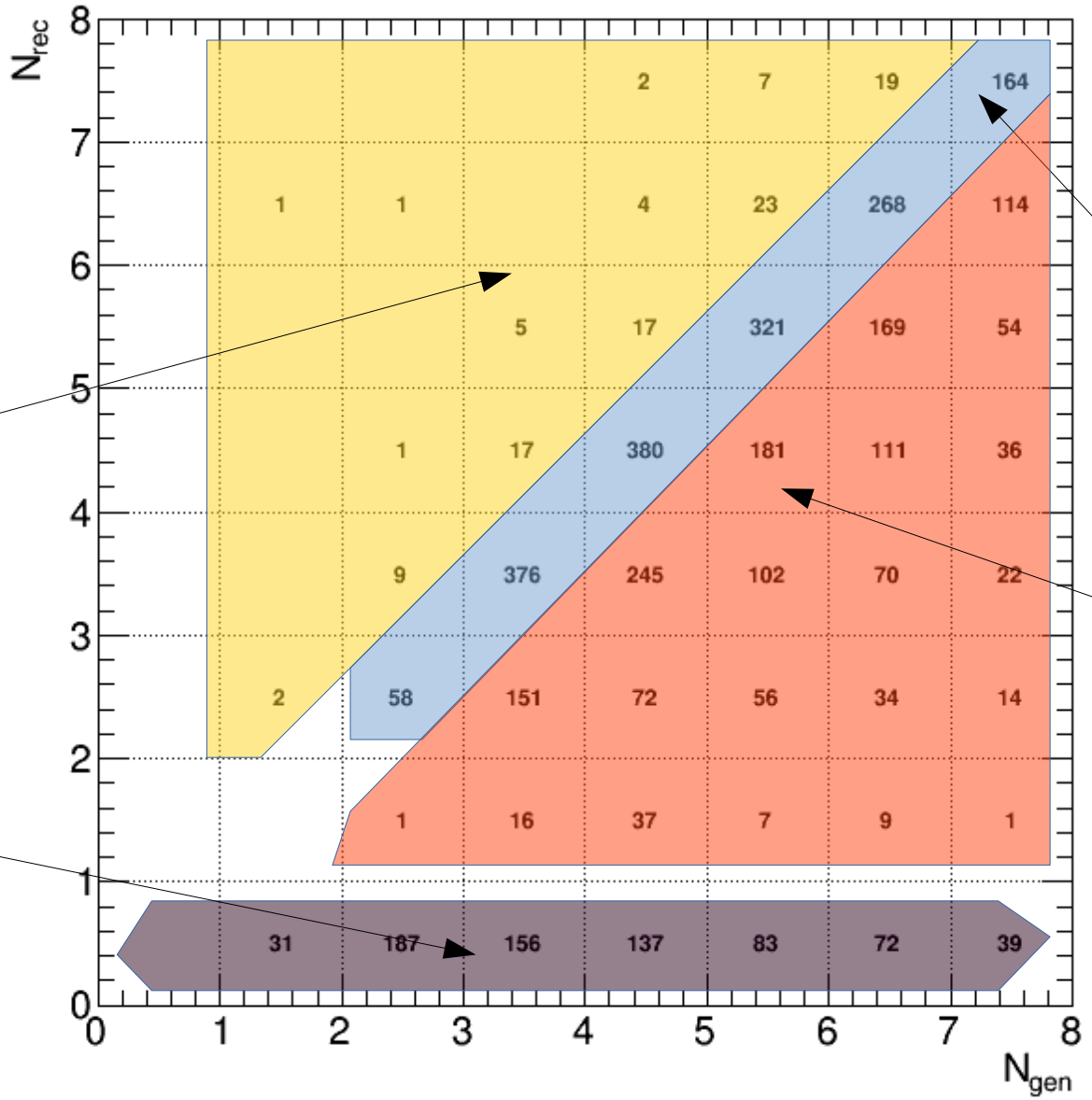
- There was developed a code that can extract vertices from generator collections by particle type or PDG
- This code creates a collection of generated vertices that are tagged by a charge of initial b-quark
- For each generated vertex we select prongs – particles, that leave tracks in detector
- We use JetVertexRefiner collection from LCFI+ algoritm in recontructed slcio files to get the reconstructed vertices
- Tag the reconstructed one by properties of generated vertex if a difference in direction < some angle cut
- Dataset: $e_L^+ e_R^- \to t\bar{t} \to \nu l^{\pm} b\bar{b} q\bar{q}\ (\mathrm{no}\ \gamma\gamma\ \mathrm{bkg})$

  4000 events test sample

Number of tracks comparison

SOT-Vertices = Secondary Or Ternary Vertices

SOT-Tracks = Tracks emerging from SOT-Vertices



Above diagonal, 1 or more added tracks, incorrect charge

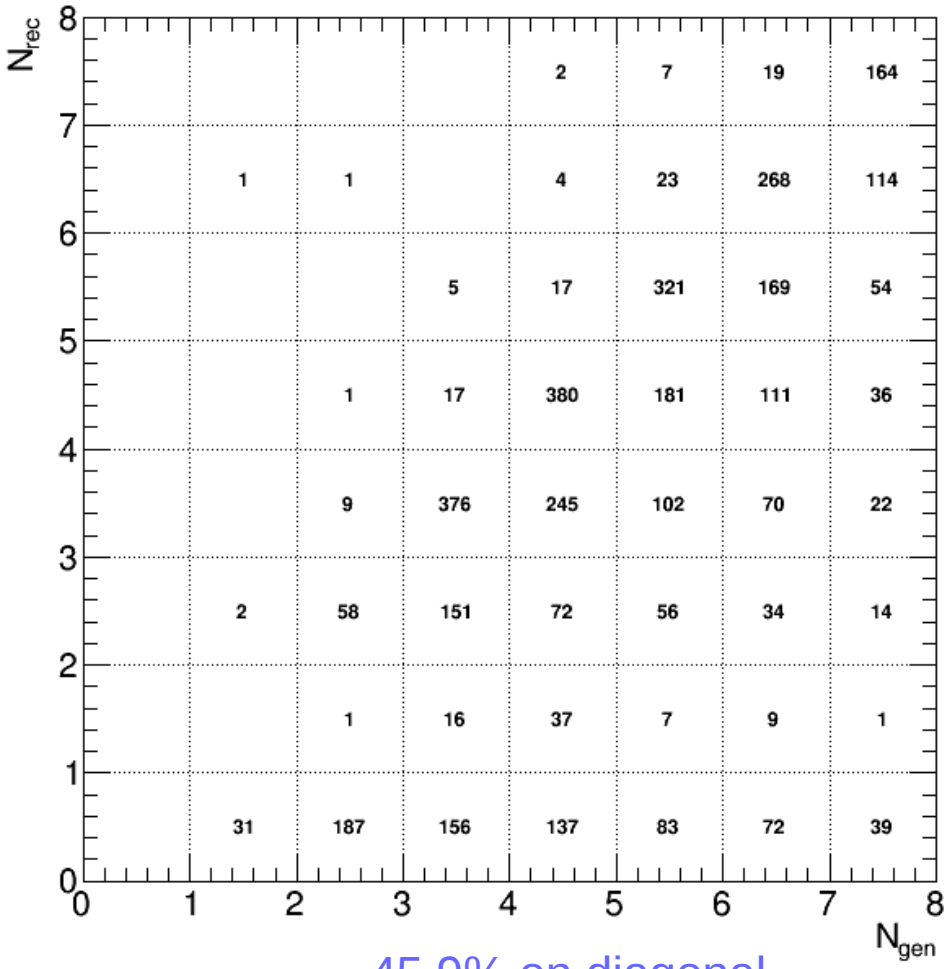
Diagonal, Correct charge

Below diagonal, 1 or more missed tracks, incorrect charge

No reconstructed vertices

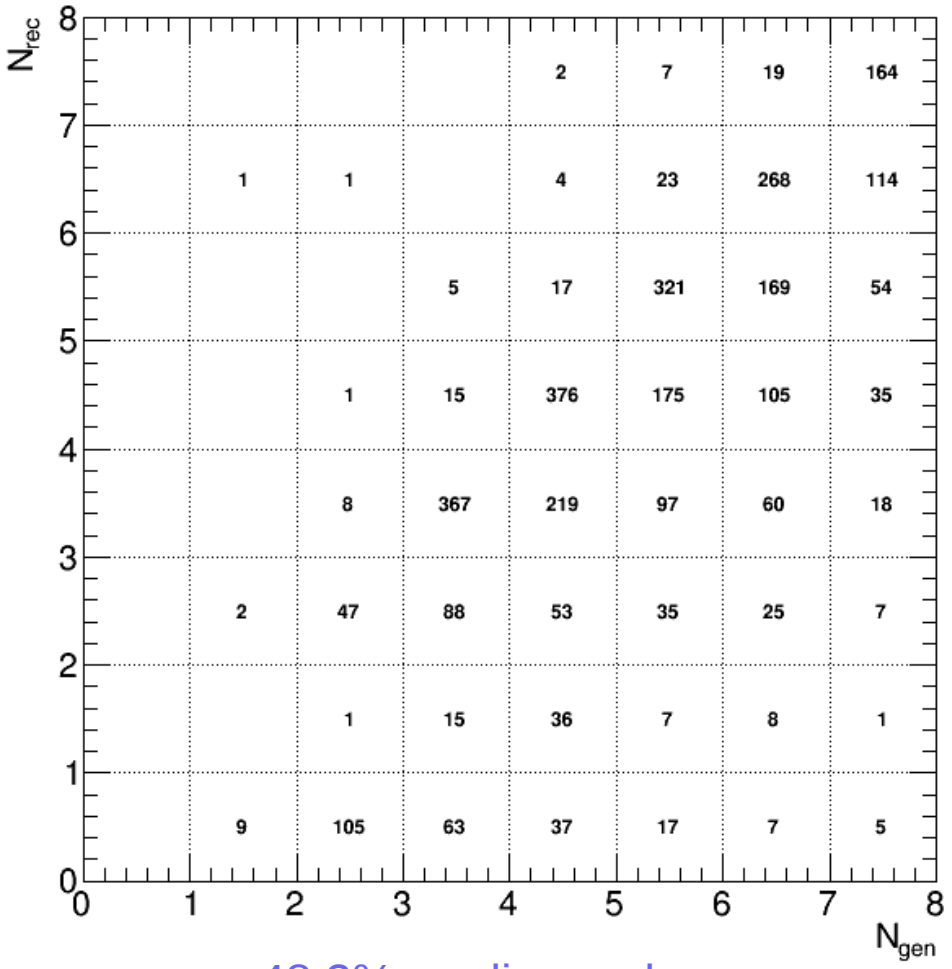
Number of tracks comparison

Raw comparison



45.9% on diagonal

Comparison after b-tag > 0.3 cut for each b-jet.

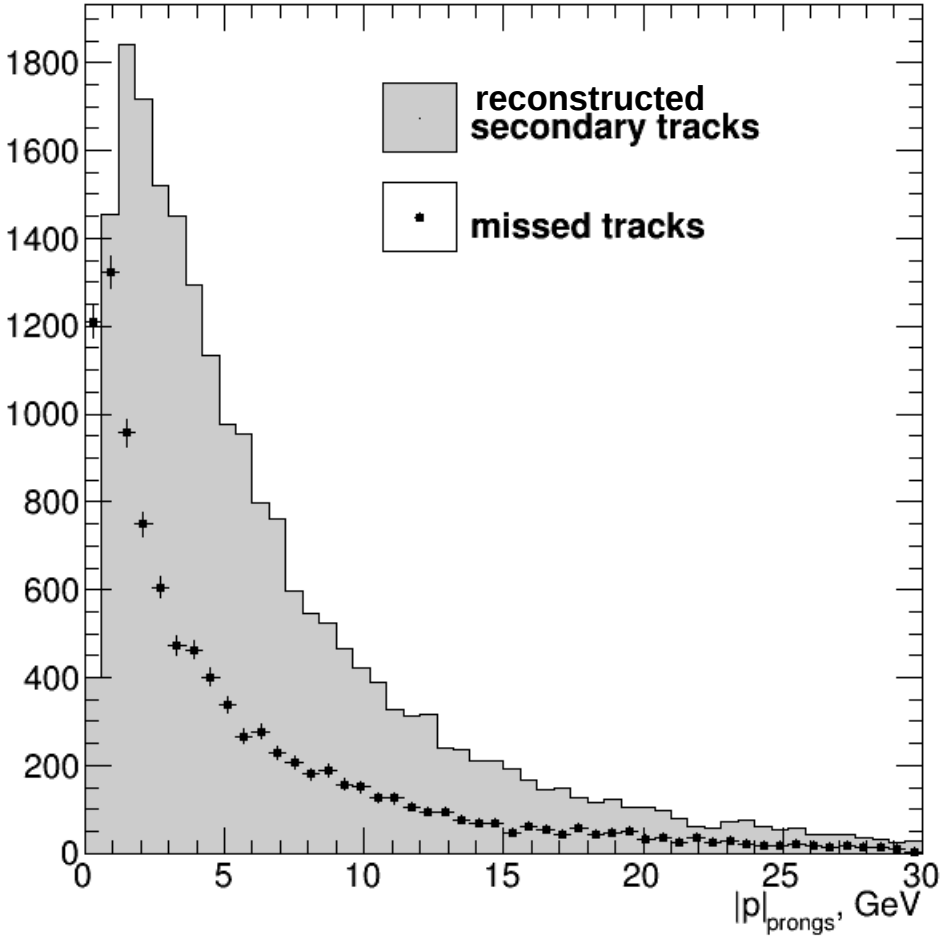


48.3% on diagonal

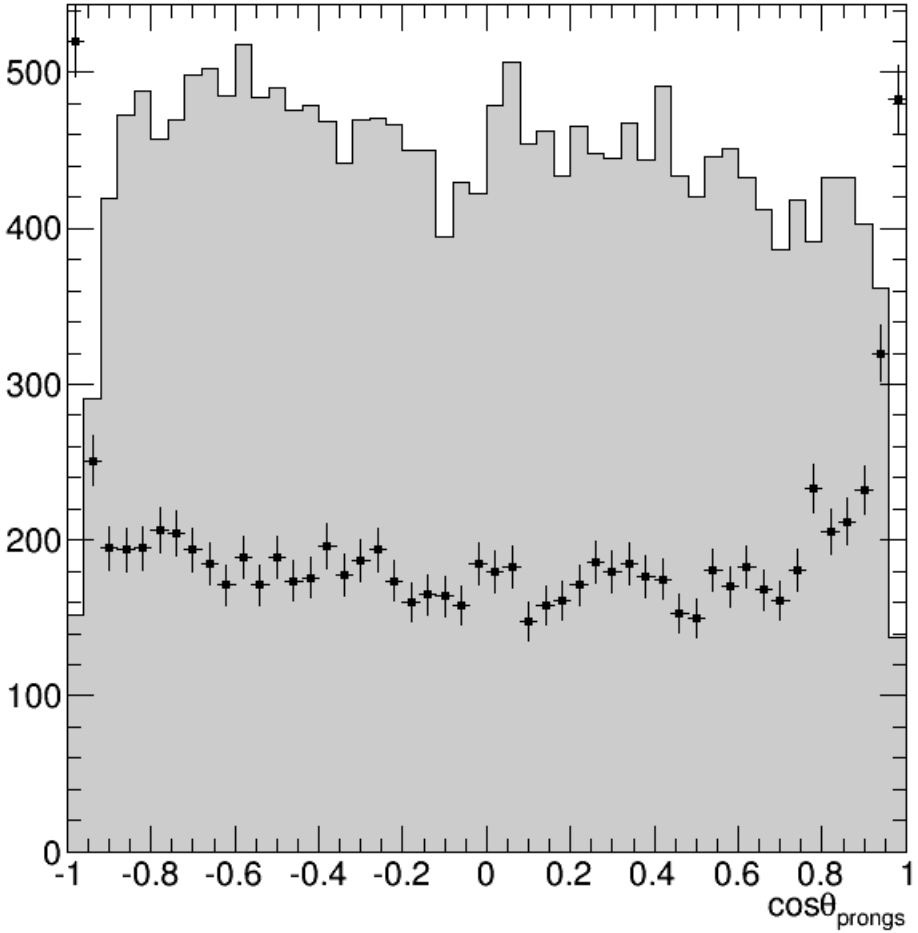
- B-tagging reduces fraction of events without vertex and events with low multiplicity of SOT-Vertices.

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

Investigation of SOT-Tracks

- Lost SOT-Tracks (LSOT-Tracks) can be divided into 2 categories:

LSOT-VTX Tracks	LSOT-NOVTX Tracks
Generated SOT Tracks that are not assigned to a correctly reconstructed SOT-Vertices	Tracks associated with an undetected SOT-Vertex

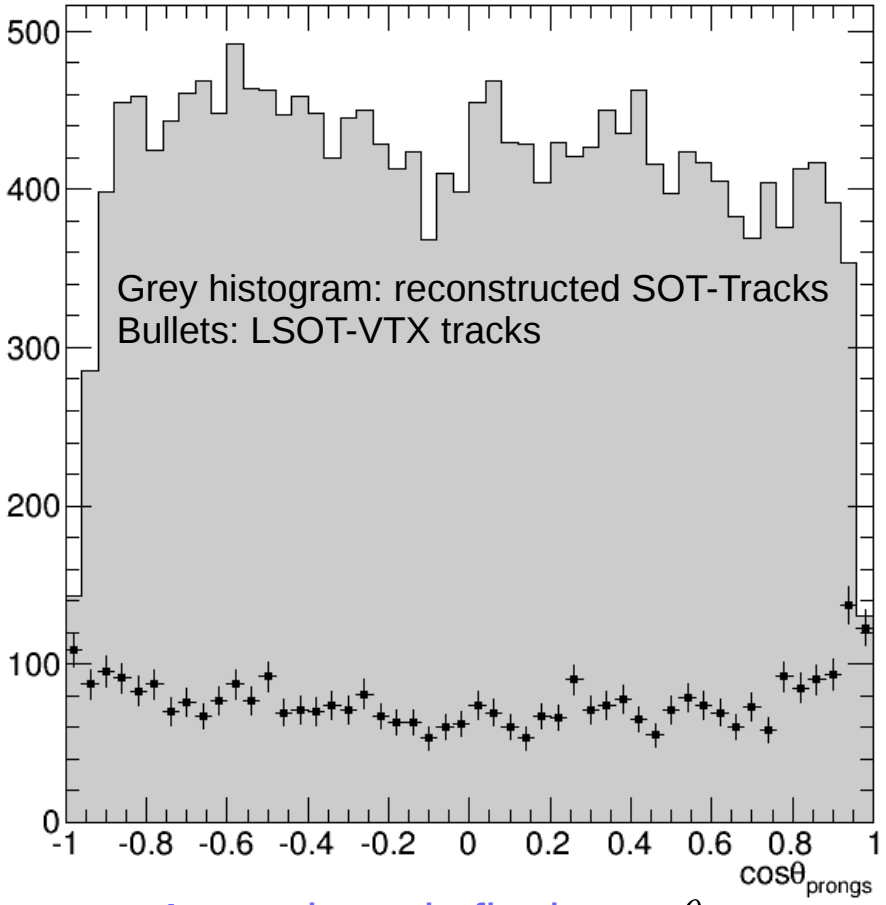
Possible reasons to lose a SOT track:

- χ^2 cuts in vertex reconstruction
- Small offset to primary vertex
- Decay of particles
- Soft particles

- Forward region
- Soft B-mesons
- Short Time of Flight
- Low multiplicity
- χ^2 cuts in vertex reconstruction

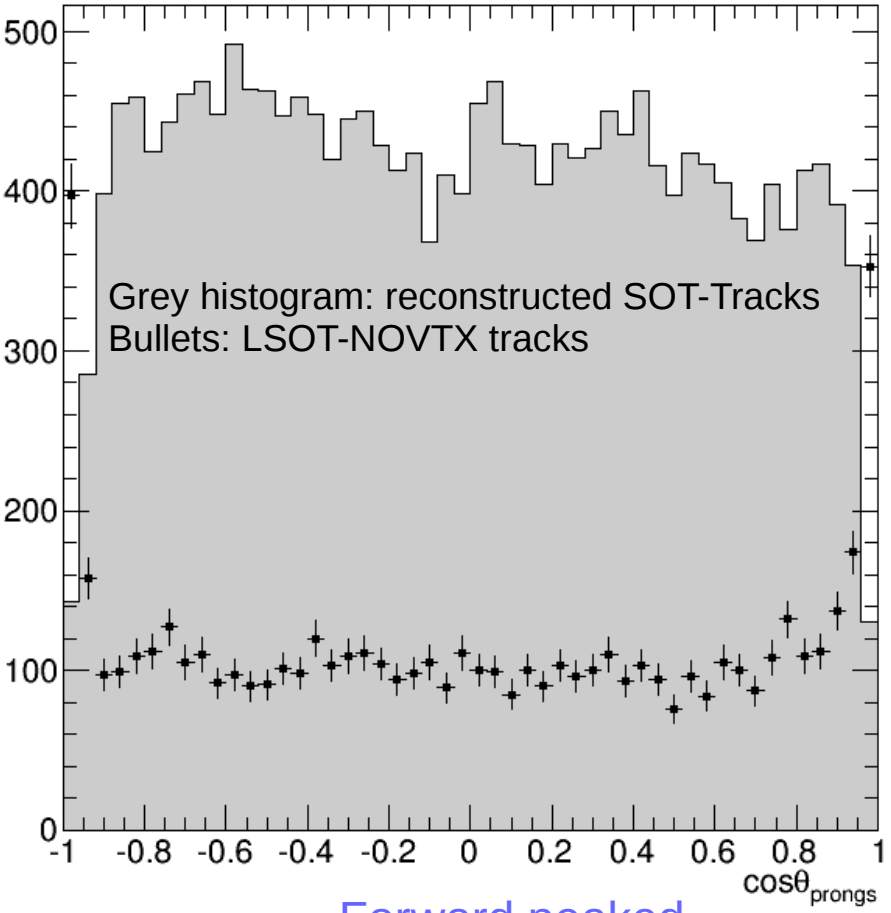
Analysis of LSOT-Tracks

LSOT-VTX tracks



Approximately flat in $cos\theta$

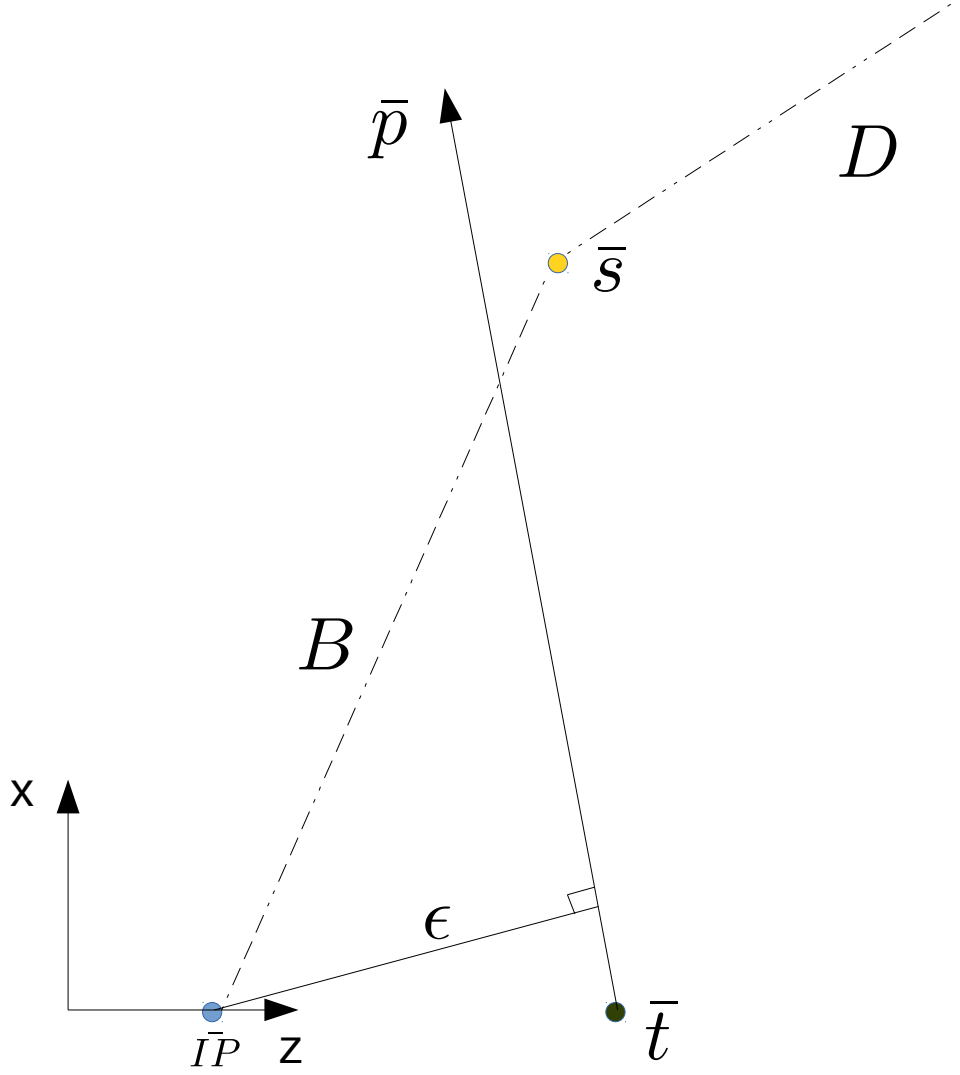
LSOT-NOVTX tracks



Forward peaked

- No cosθ dependency to loose a track in case of presence of a reconstructed SOT-Vertex
- Enhanced risk to miss SOT-Vertices in forward region

Definition of Estimators



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

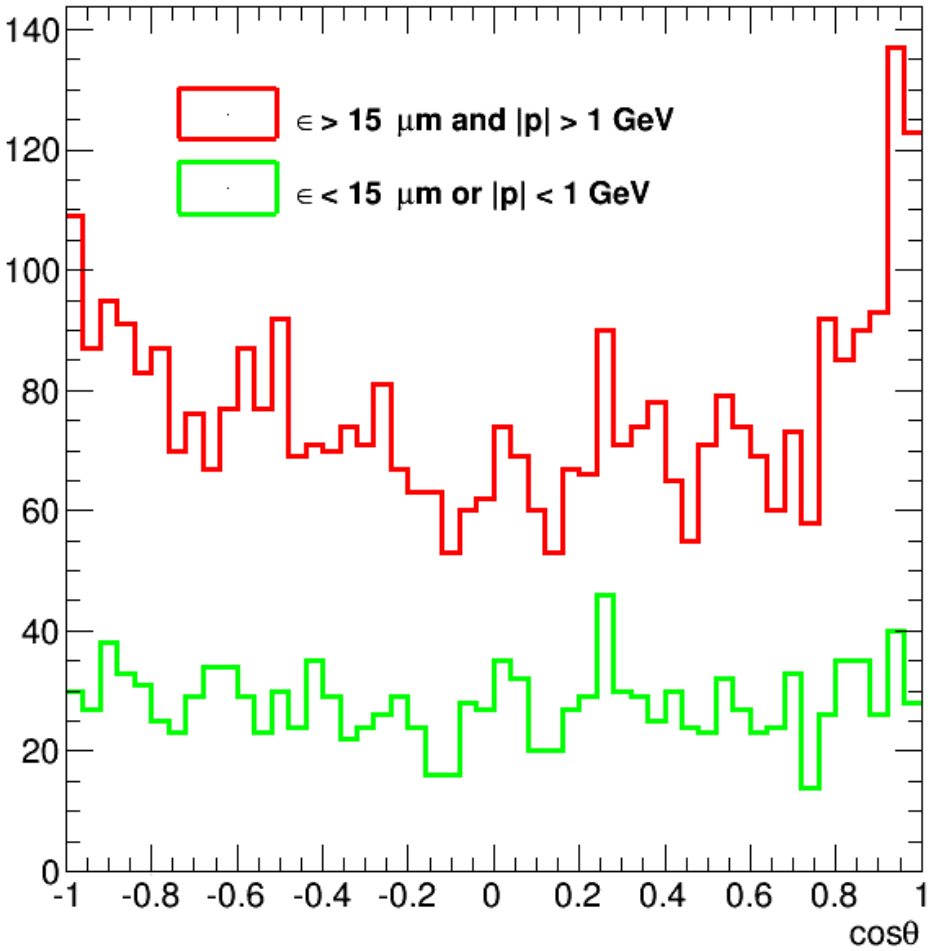
$$\sigma = a \oplus \frac{b}{|p| sin^{2/3}\theta}$$

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

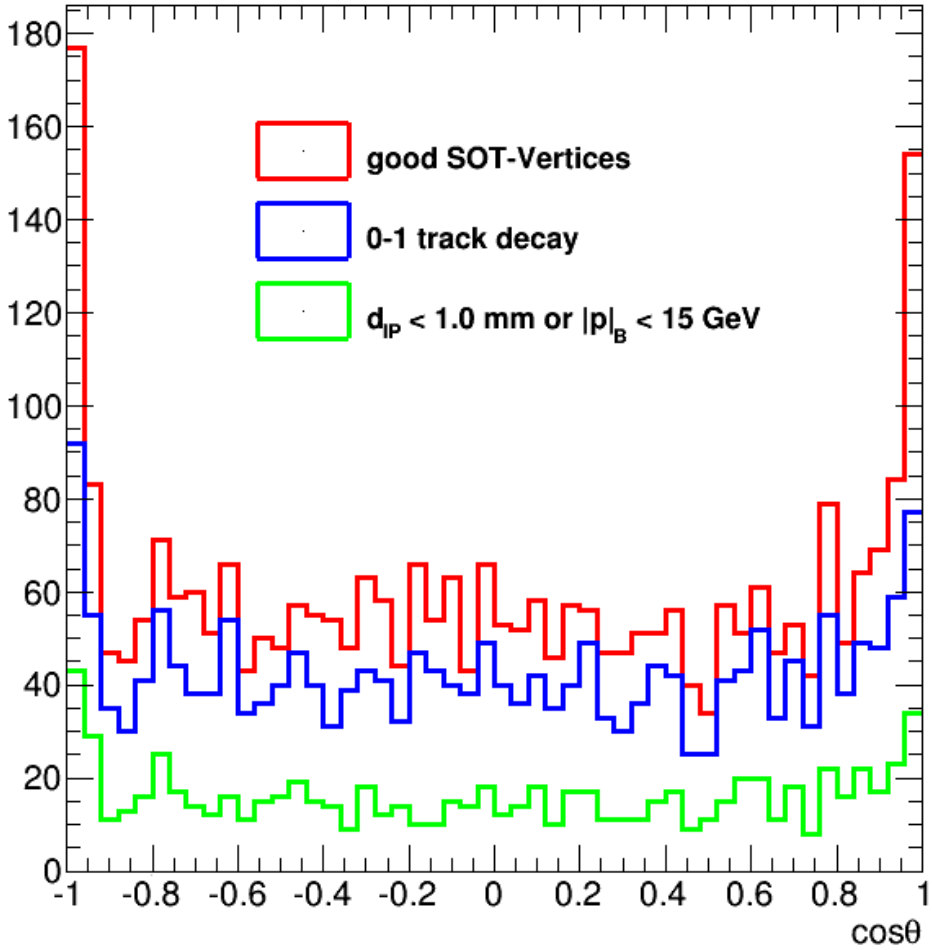
- **IP** – interaction point (primary vertex) , **s** – secondary vertex, **t** – point of closest approach of a track, **p** – reconstructed momentum, ϵ - offset of a track from primary vertex

Lost tracks analysis

LSOT-VTX Tracks

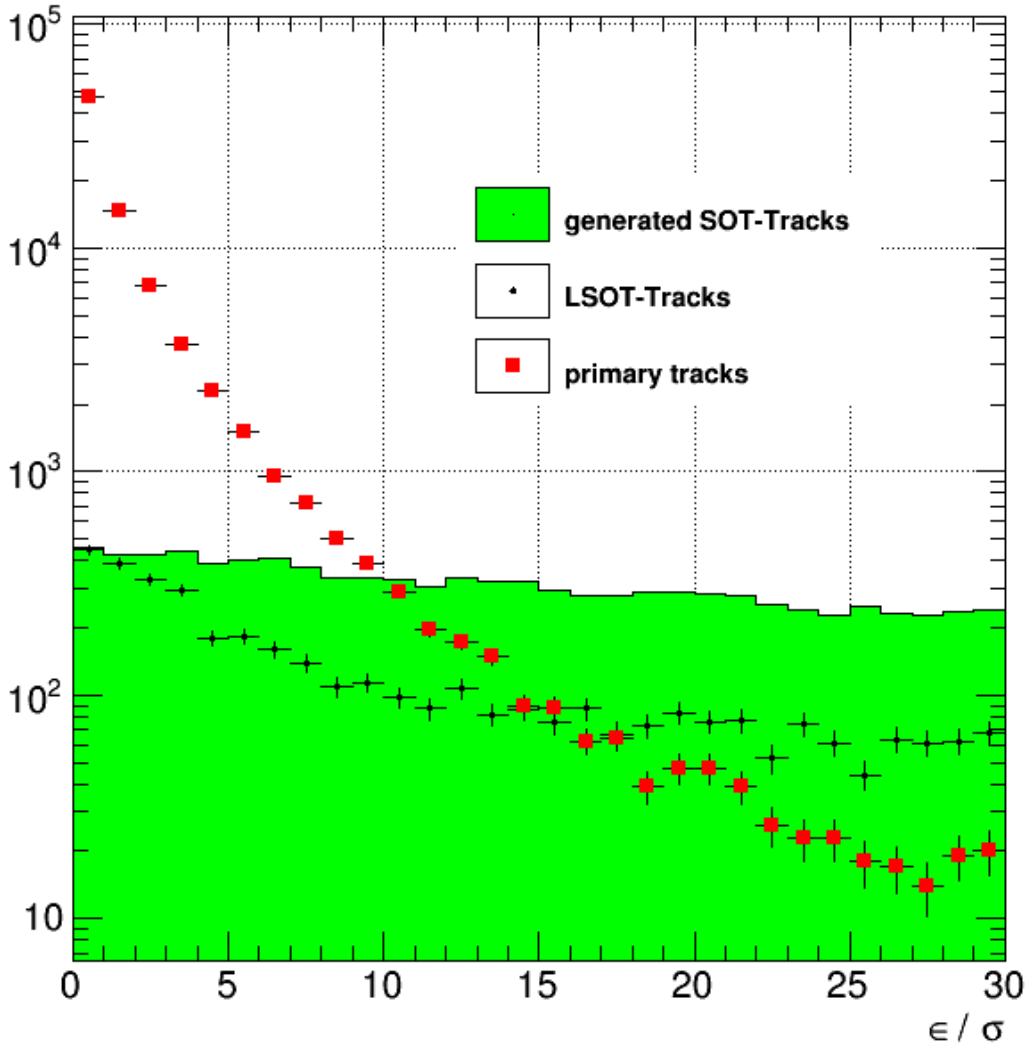


LSOT-NOVTX Vertices



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

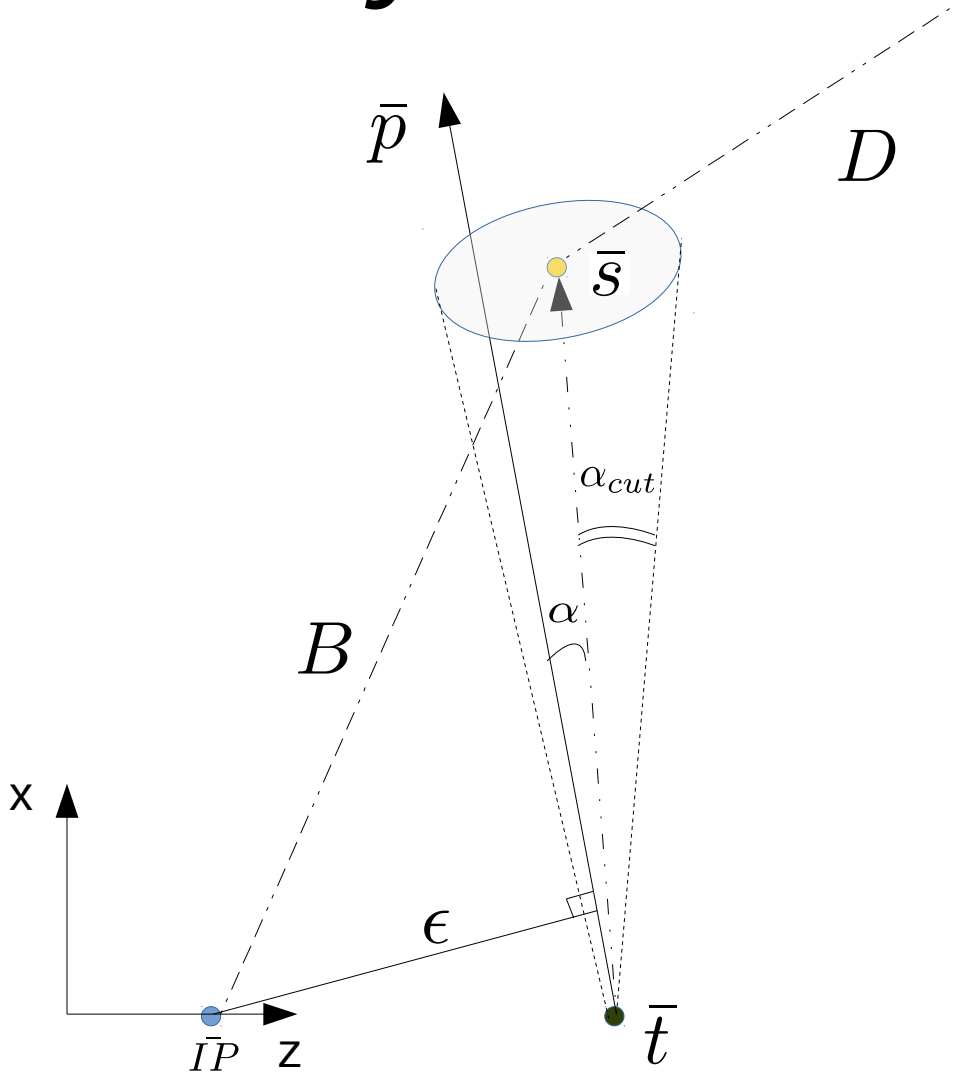
Comparison of offset significance



- The secondary and missed tracks are generated tracks from B-mesons.
- The errors on the offset of generated SOT- and LSOT-Tracks is calculated by formula in DBD.
- The errors for primary tracks are computed using the covariance matrices of momentum and reference point of a primary track

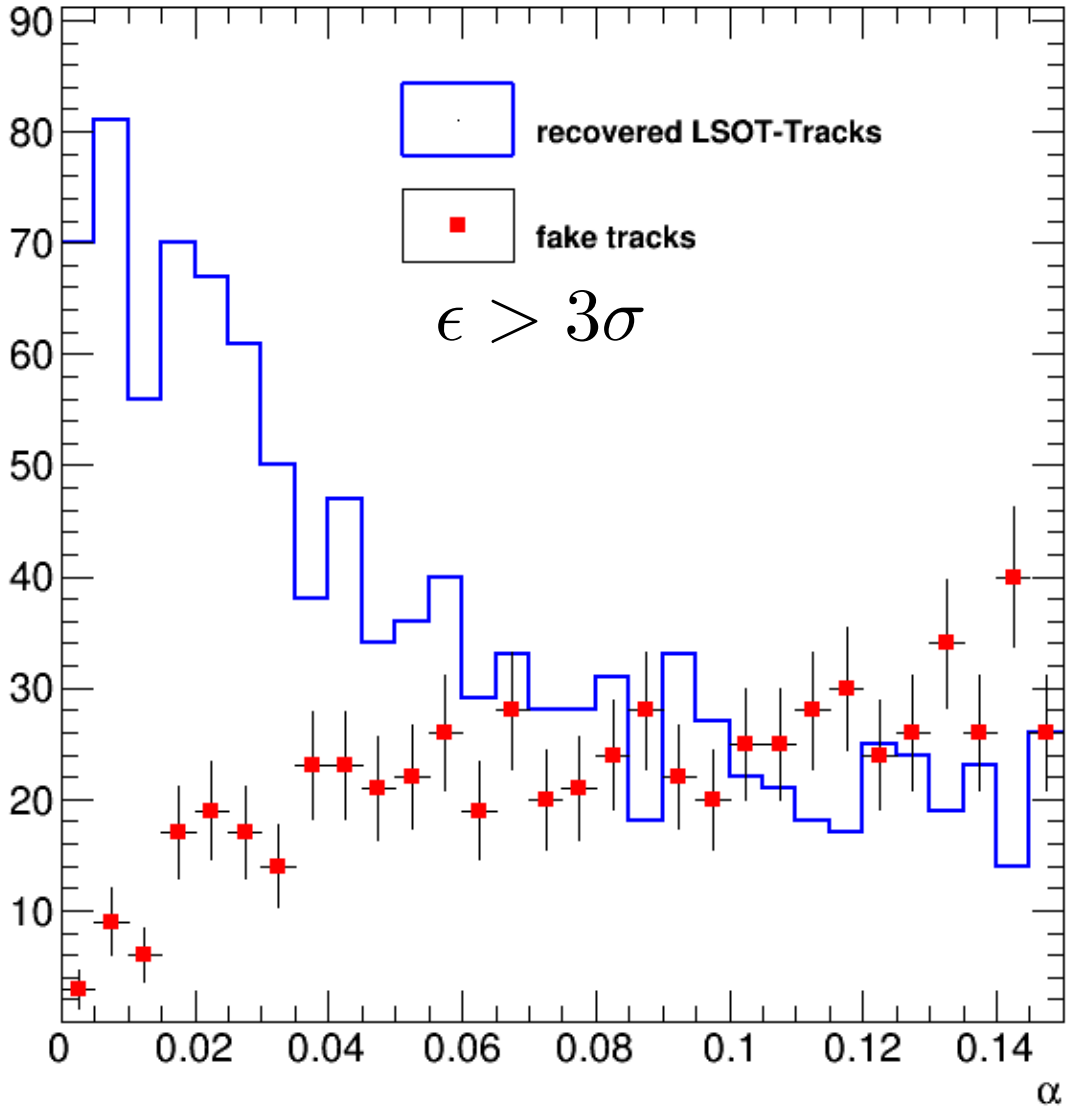
- Non stacked histogram of track offset divided by uncertainty for different types of tracks. Secondary tracks with less than 3 sigma deviation are tend to be missed.

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

Results of recovery



- Histogram comparison of α angles for recovered LSOT tracks and fake tracks taken by algorithm.
- Possible reasons for low efficiency of this method are:
  - Interaction or decay of particles in TPC
  - Vertex position is not precise along the B-meson flight direction

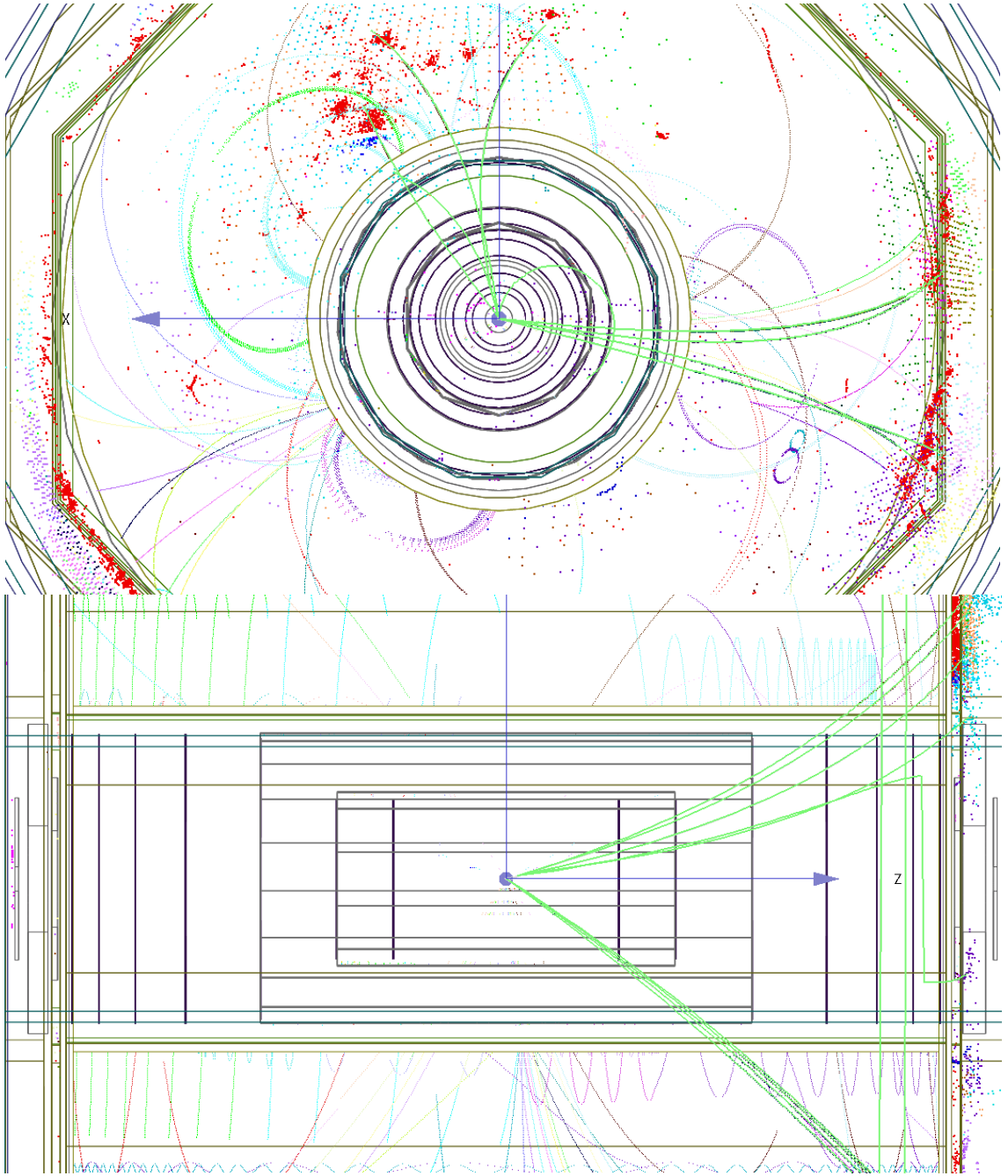
- This method gives only 17 % of LSOT-VTX Tracks with 75 % of purity depending on angle cut

Summary

- There was developed a code that can extract generated vertices from event generator collections by particle PDG
- The generated vertices were compared to reconstructed ones
- The different cases of incorrect charge measurement require different methods to improve the situation.
- The developed method of recovering of missed tracks provides 17% of LSOT-VTX with 75% of purity.
- Further work:
  - Increase the efficiency of recovering
  - Explore 1 reconstructed vertex decay of a B-meson with bad chi-square and try to separate it into two vertices
  - Use particle id for kaon identification
  - Use information from ternary vertex

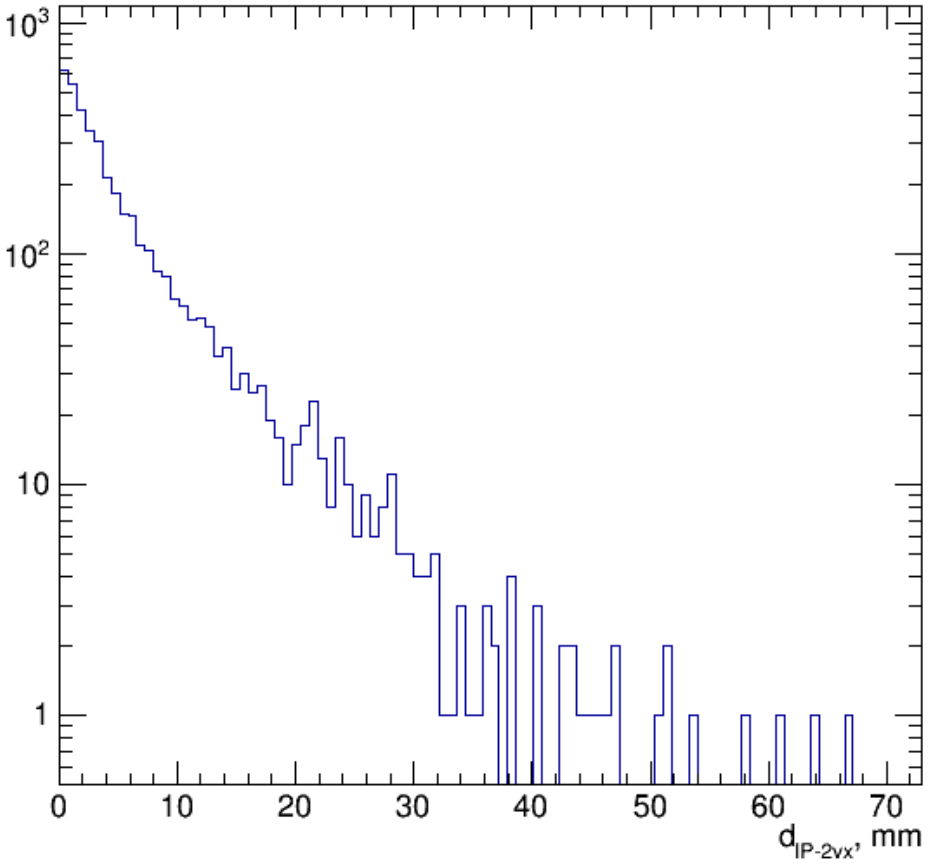
Thank you!

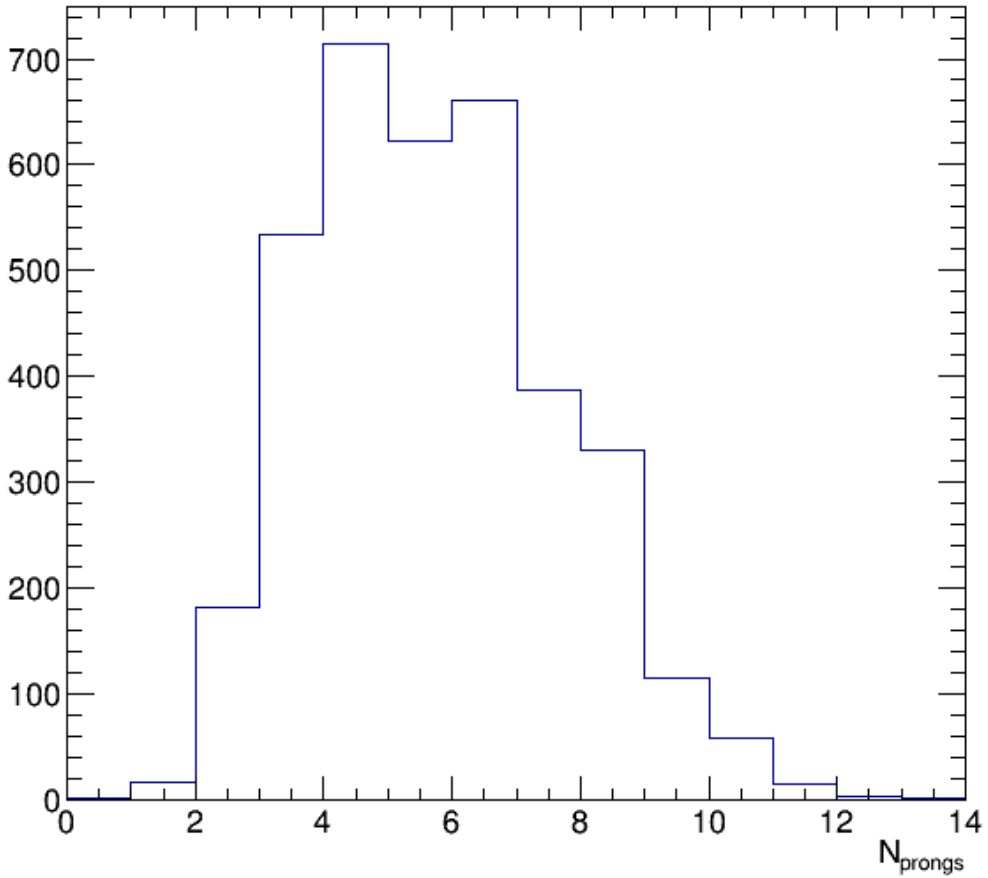
C Event Display



- 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

Generated vertices

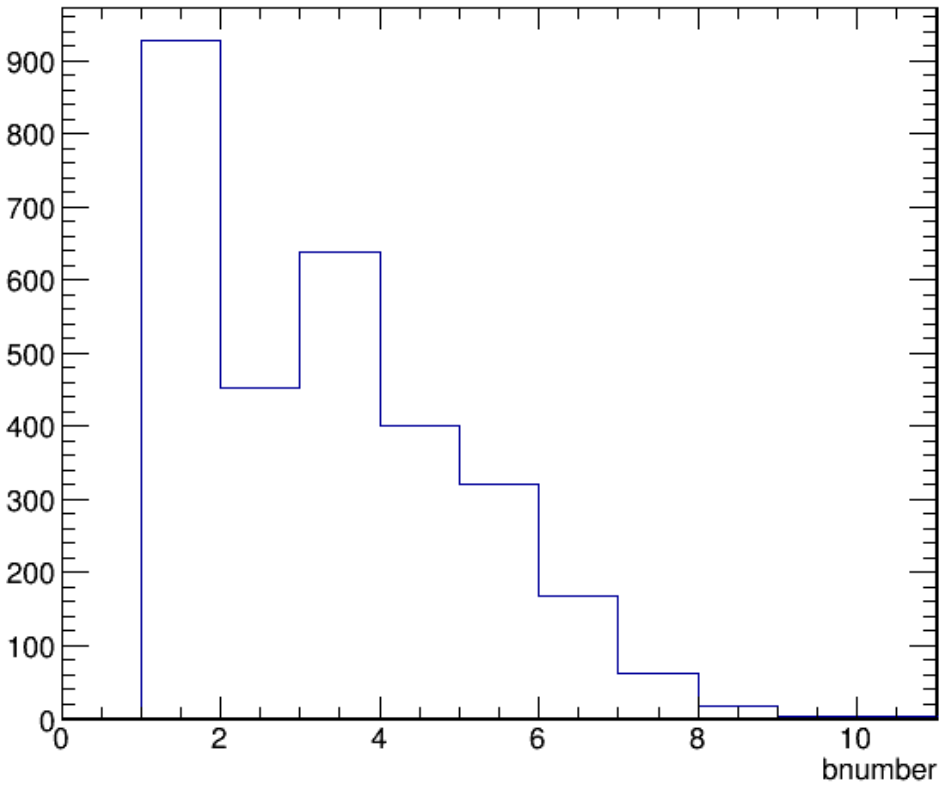




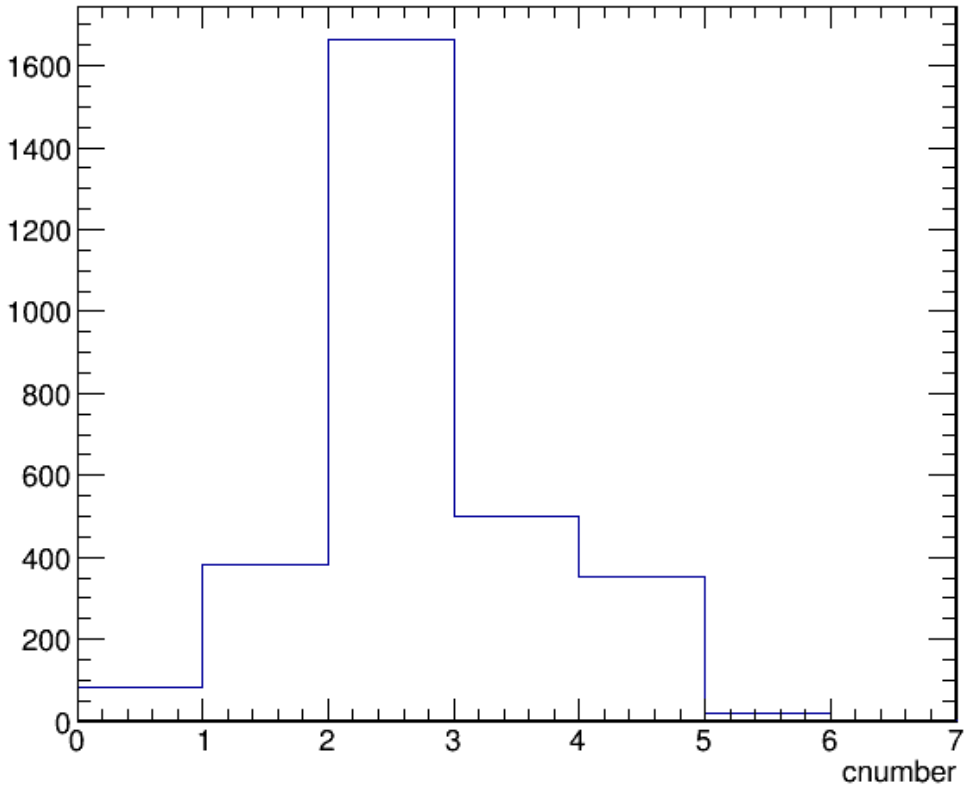
- Distance from IP to B-meson decay vertex (left), prongs of initial B-meson (right)

Multiplicity of b-c vertices

b-vertex



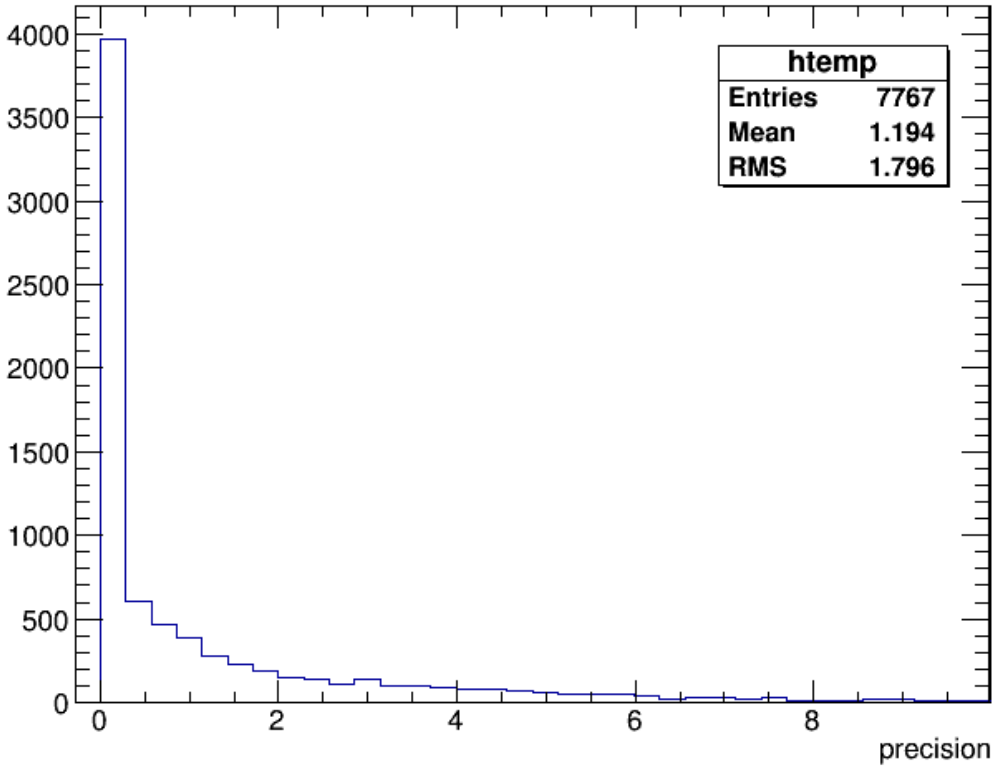
c-vertex



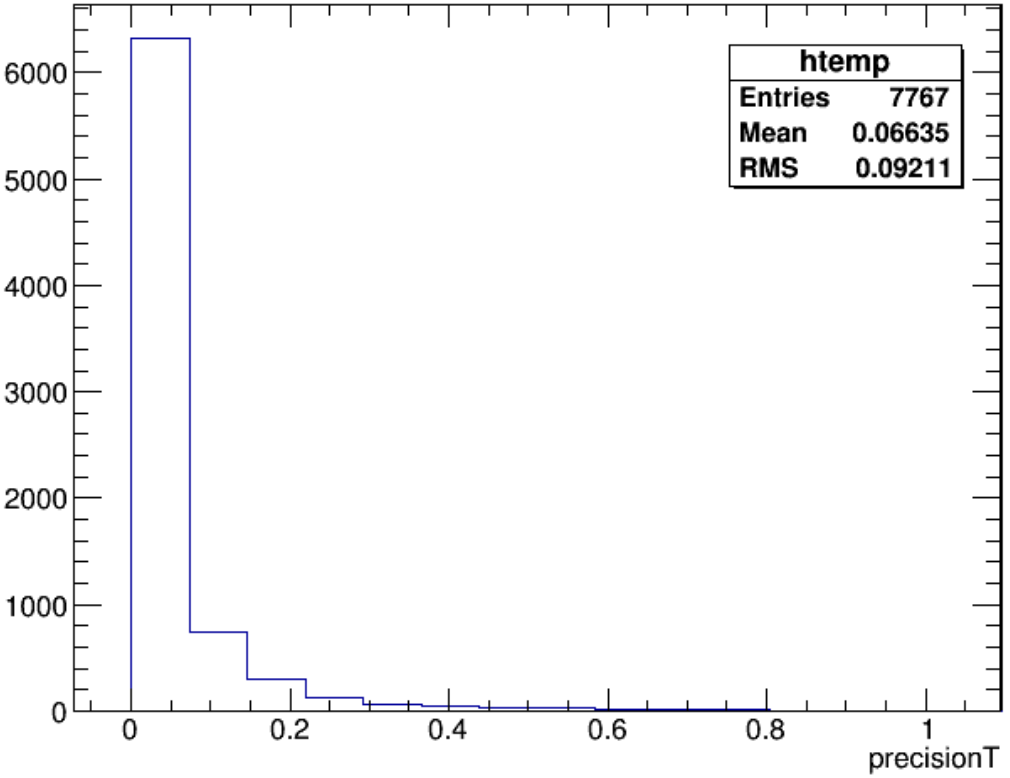
- Number of tracks for b and c vertices. For charge measurement the 1-prong decay is dangerous and it is present in both vertices

Precision of vertex position

Distance

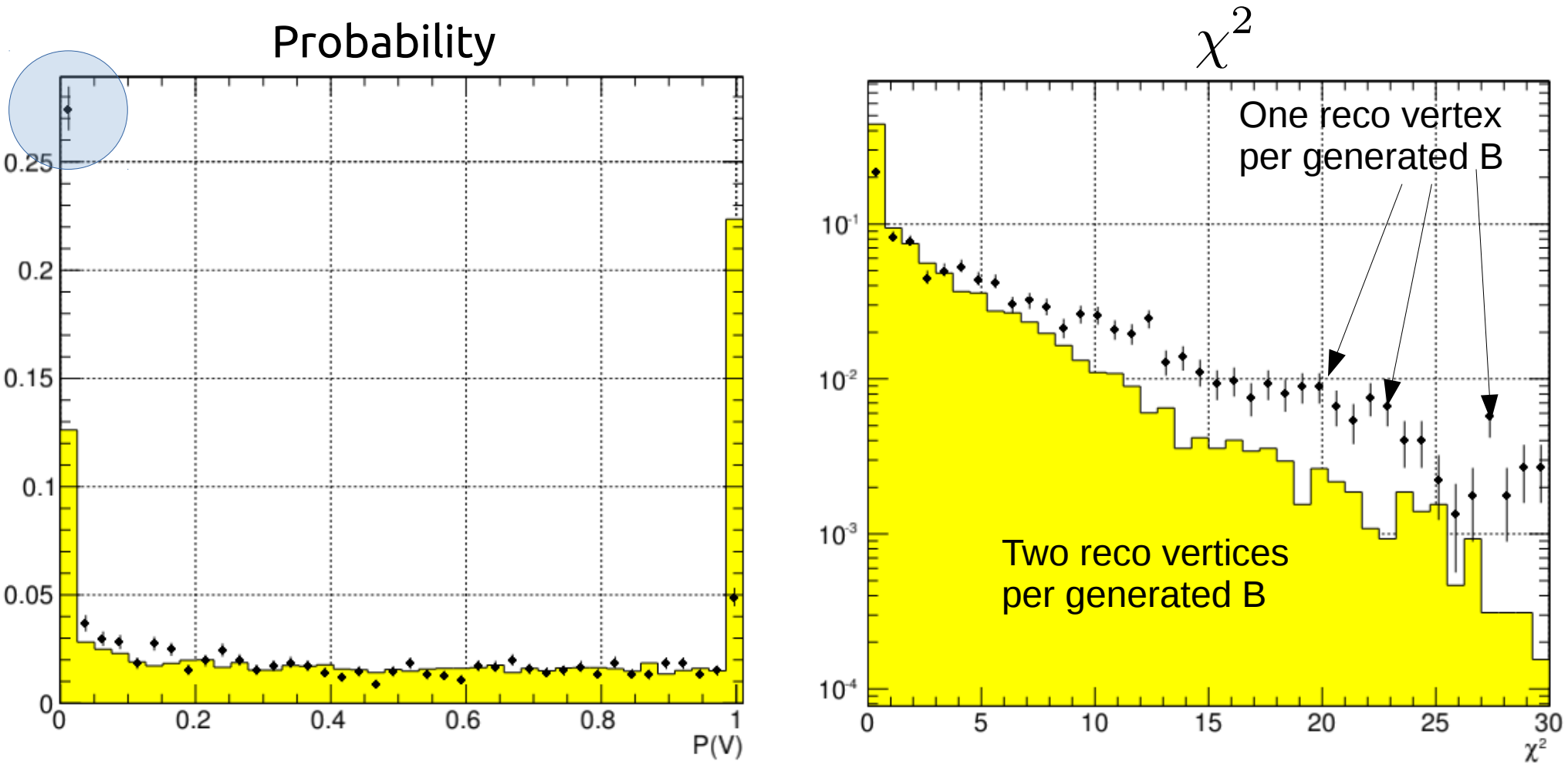


Transverse distance



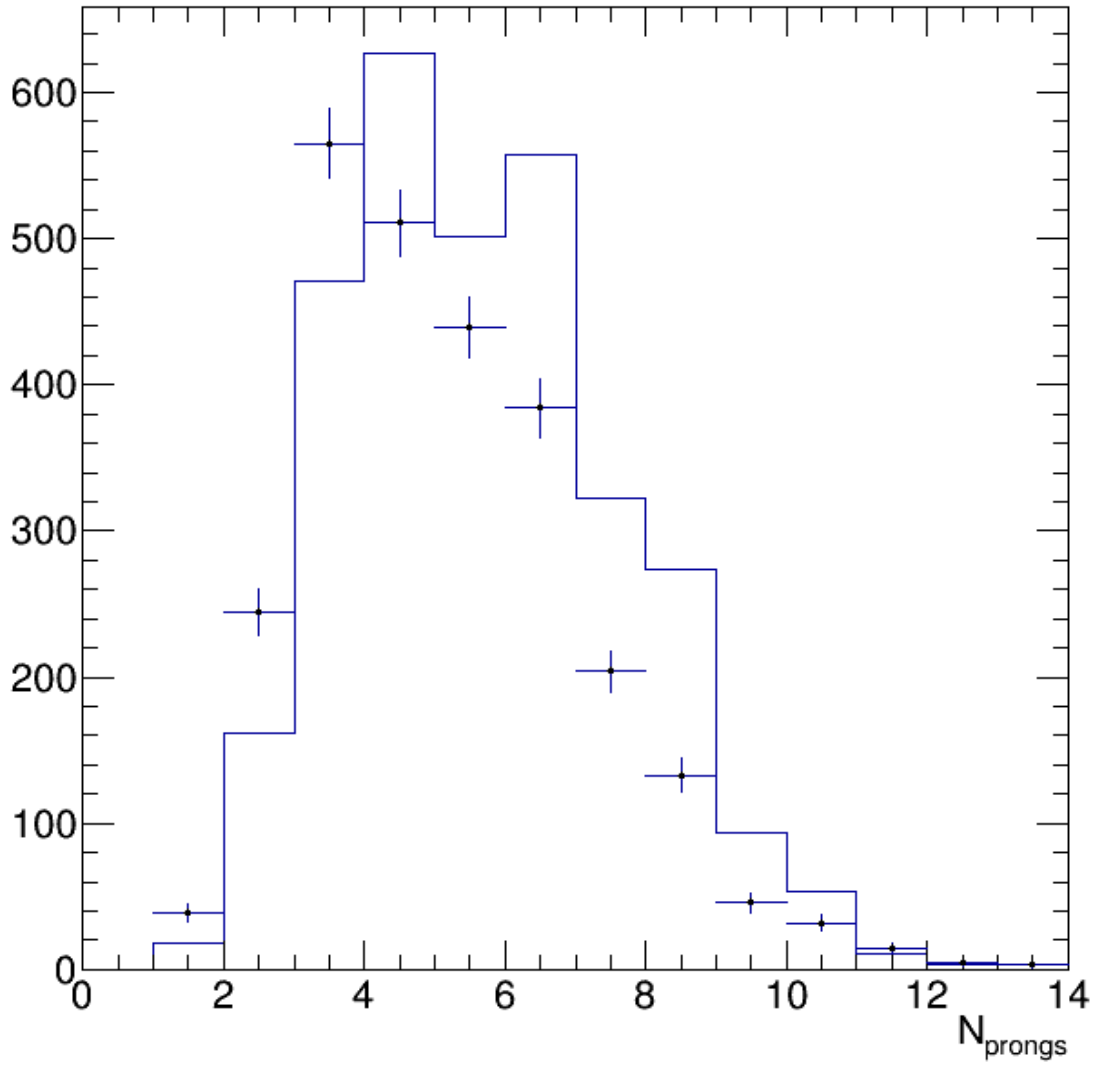
- Distance between reconstructed and generated vertices. The direction of b-hadron known precisely.

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