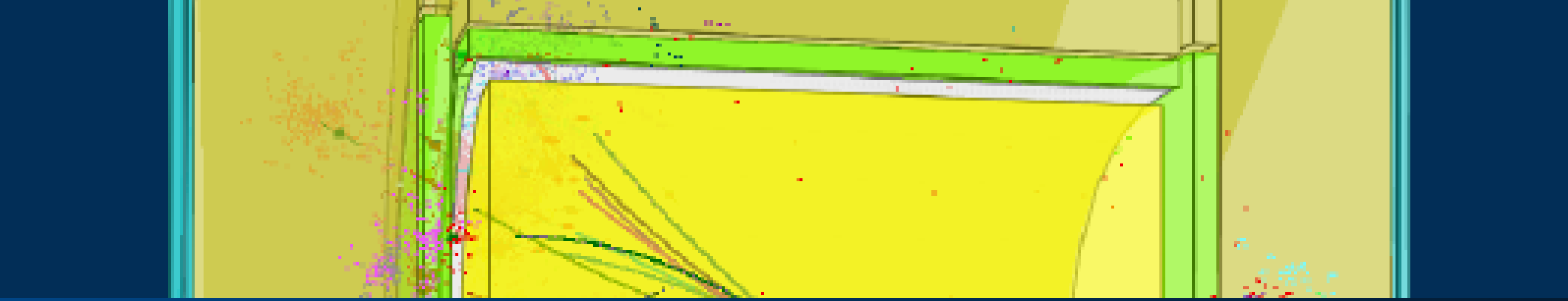


B-quark asymmetry measurements in e-e+→ $b\bar{b}$ at ILC

26/09/2018, ILD Analysis & Software Meeting

Simulation of a $b\bar{b}$ event at ILD (S. Bilokin)

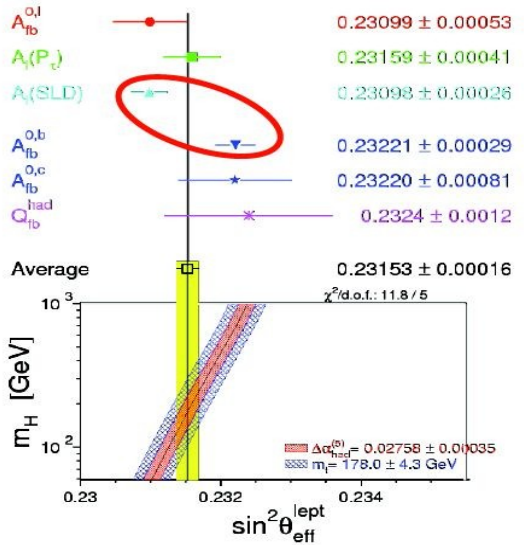
S. Bilokin, **A. Irles**, R. Poeschl, F. Richard

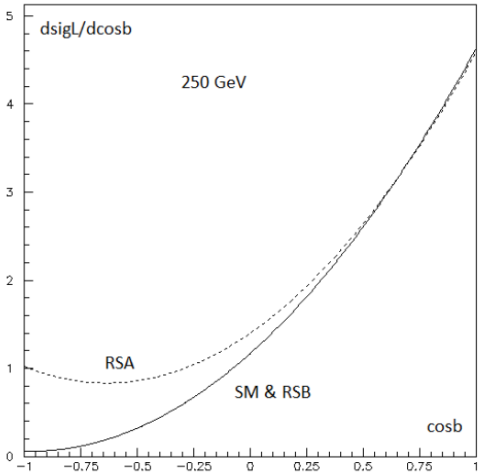
Motivation

- This analysis is the direct follow-up of S. Bilokin thesis studies on b-quark asymmetry measurements in the ILC.
- The goal is to measure the bb asymmetry in $e^+e^- \rightarrow b\bar{b}$, basically by measuring the direction of the two final state jets and their charge. **Why?**

Motivation

- This analysis is the direct follow-up of S. Bilokin thesis studies on b-quark asymmetry measurements in the ILC.
- The goal is to measure the bb asymmetry in $e^+e^- \rightarrow b\bar{b}$ basically by measuring the direction of the two final state jets and their charge. **Why?**





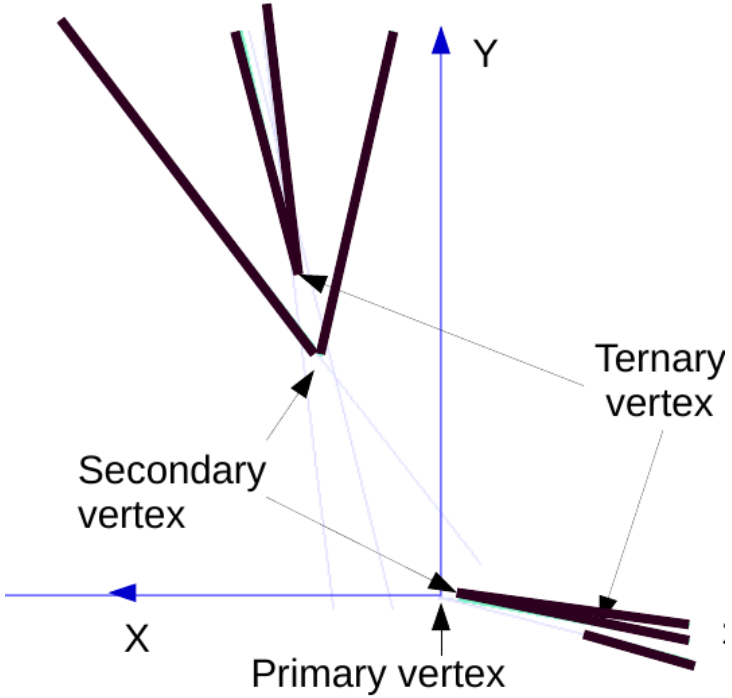
Current LEP & SLC measurements show tension with the SM in the Afb measurement

AMany composite models predict deviations in the fermion electroweak couplings (specially in the heavy flavors)

→ can be observed in the cross sections and Afb measurements if measured at the % level

Motivation

- This analysis is the direct follow-up of S. Bilokin thesis studies on b-quark asymmetry measurements in the ILC.
- The goal is to measure the bb asymmetry in $e^+e^- \rightarrow b\bar{b}$, basically by measuring the direction of the two final state jets and their charge. Why?
- **How?**



- We have two methods to identify b-jet charge:
  - With the charge of the b-quark, calculated as a sum of the charges of secondary and tertiary vertex

    → we call this method the Bc method
  - With the charge of K-mesons, from B-decays, in secondary and tertiary vertexes

    → we call this method the Kc method

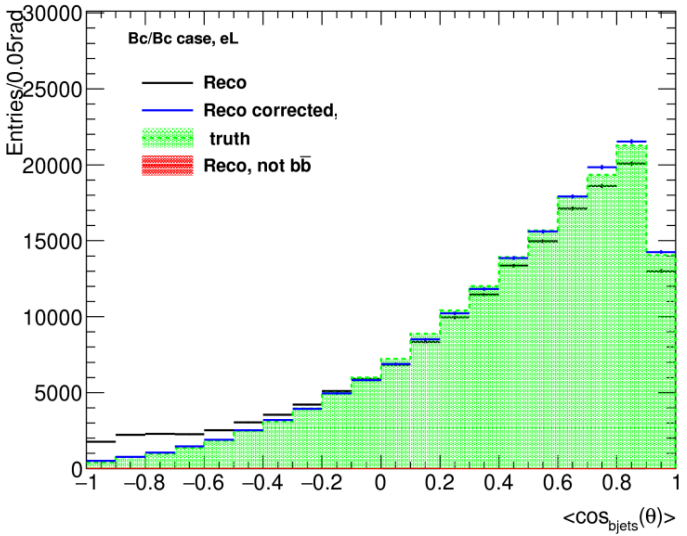
Motivation

- This analysis is the direct follow-up of S. Bilokin thesis studies on b-quark asymmetry measurements in the ILC.
- The goal is to measure the bb asymmetry in $e^+e^- \rightarrow b\bar{b}$, basically by measuring the direction of the two final state jets and their charge. Why?
- **How?**
- The observable is the differential cross section $\dfrac{d\sigma^I}{d\cos\theta}$

Motivation

- This analysis is the direct follow-up of S. Bilokin thesis studies on b-quark asymmetry measurements in the ILC.
- The goal is to measure the bb asymmetry in $e^+e^- \rightarrow b\bar{b}$, basically by measuring the direction of the two final state jets and their charge. Why?
- **How?**
- The observable is the differential cross section $\frac{d\sigma^I}{d\cos\theta}$
- All results shown here are for the bb asymmetry measurement (cosθ) using $e^+e^- \rightarrow b\bar{b}$, 250 GeV, ~266 fb-1 with left (and right) polarization simulated samples
  - /ilc/prod/ilc/mc-dbd/ild/dst-merged/250-TDR_ws/2f-highM_Z_hadronic + ILCsoft v01-17-06
- On purpose, I will not detail the cuts for preselection and background rejection: I follow the same recipe than in S.B.'s thesis.
  - All this will be revisited again for the new samples & software study

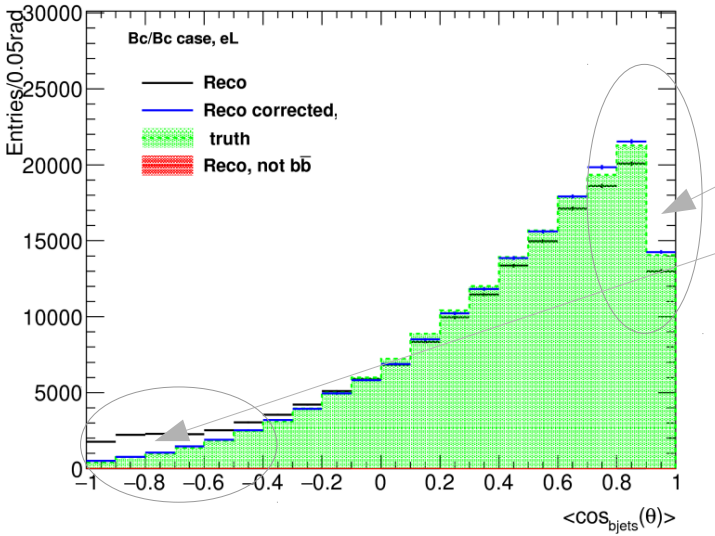
Motivation + some refreshement



- I "repeated" S. Bilokin analysis of the $b\bar{b}$ asymmetry measurement ($\cos\theta$) using $e^+e^- \rightarrow b\bar{b}$ 250 GeV, ~266 fb-1 with left.
- The known "issues" associated (and identified by S.B et al) for this topology are:
  - The acceptance drop in the forward regions.
  - The migration effects: the events with the charge wrongly measured move from positive angles (in the plot) to their negative.
  - Low efficiency: only 13% of the generated events were used.

Nice agreement with what S. Bilokin has in the thesis.

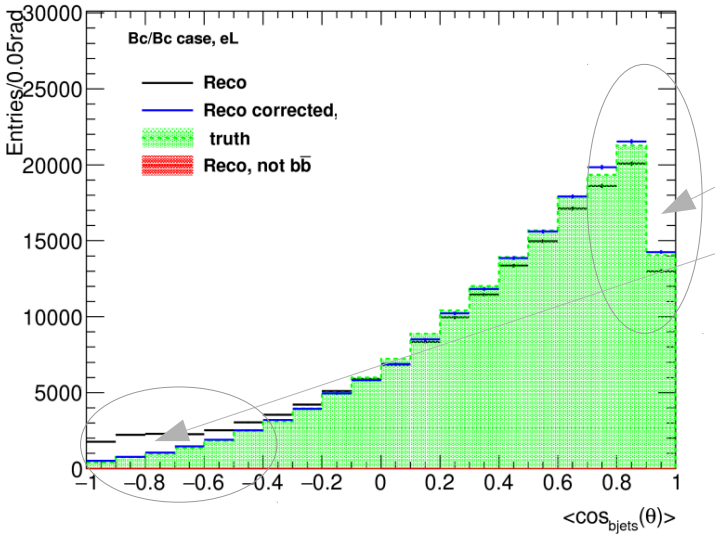
Motivation + some refreshement



- I "repeated" S. Bilokin analysis of the $b\bar{b}$ asymmetry measurement ($\cos\theta$) using $e^+e^- \rightarrow b\bar{b}$ 250 GeV, ~266 fb-1 with left.
- The known "issues" associated (and identified by S.B et al) for this topology are:
  - The acceptance drop in the forward regions.
  - The migration effects: the events with the charge wrongly measured move from positive angles (in the plot) to their negative.
  - Low efficiency: only 13% of the generated events were used.

Nice agreement with what S. Bilokin has in the thesis.

Motivation + some refreshement



Nice agreement with what S. Bilokin has in the thesis.

- I “repeated” S. Bilokin analysis of the $b\bar{b}$ asymmetry measurement ($\cos\theta$) using $e^+e^- \rightarrow b\bar{b}$ 250 GeV, ~266 fb-1 with left.
- The known “issues” associated (and identified by S.B et al) for this topology are:
  - The acceptance drop for in the forward regions due to bad quality of tracking in the microvertexes.
  - The migration effects: the events with the charge wrongly measured move from positive angles (in the plot) to their negative.
  - Low efficiency: only 13% of the generated events were used.
- The first goal of this study is to revisit it to enhance the efficiency.
- The low efficiency and the migration correction procedure are very linked. Why ? → next slide.

Motivation + some refreshment

- For the measurement, information of the charge on the two different jets is used to cross check its value. Only events with the jets with opposite charge are considered. Even more, only events with opposite charge calculated with the same method were accepted.
- Why? Because the correction is done using the rejected events (events with the same charge in both jets)
  - Assume that "p" is the probability of measuring the right charge on the jet

$$N_a = N_a^+ + N_a^- = p^2 N + q^2 N \qquad N_r = 2pqN$$

$$\begin{cases} N_a^+ = p^2 N_{true}^+ + q^2 N_{true}^- \\ N_a^- = p^2 N_{true}^- + q^2 N_{true}^+ \end{cases}$$

Migration terms

# of refused events

$$N = N_a + N_r$$

# of accepted events

- So far, the 13% efficiency quoted by S.B was due to the fact of using only events with both jets measured with the Bc method (BcBc category) or the two jets measured with the kaons (KcKc category).
- For lack of time, all the other possible combinations were not considered.

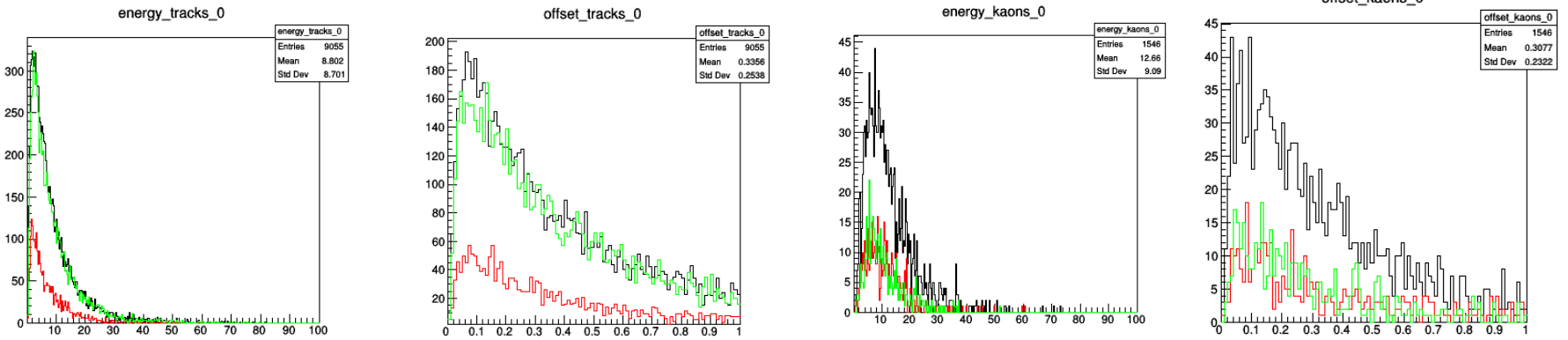
- **The purity of the calculation of the charge is ~ 0.8**

Ideas for the improvement of the efficiency

- The preselection already cuts 45% of the events → it might be improvable, although we cannot expect large variations.
- Improve the vertex charge measurements ? → to be done for the new software + samples (strong synergies with ttbar asymmetry studies)
- Improve the charge calculation using the information from the reconstructed secondary / tertiary vertexes and/or kaons?

Ideas for the improvement of the efficiency

- The preselection already cuts 45% of the events → it might be improvable, although we cannot expect large variations.
- Improve the vertex charge measurements ? → to be revisited for the new software + samples (strong synergies with ttbar asymmetry studies)
- Improve the charge calculation using the information from the reconstructed secondary / tertiary vertexes and/or kaons?
  - i.e. weighting the charge calculation with the offset / energy of the tracks considered? First studies show no obvious room for improvement



Tracks (kaon) information for Jets with right, wrong, zero charge measurement

Ideas for the improvement of the efficiency

- The preselection already cuts 45% of the events → it might be improvable, although we cannot expect large variations.
- Improve the vertex charge measurements ? → to be revisited for the new software + samples (strong synergies with ttbar asymmetry studies)
- Improve the charge calculation using the information from the reconstructed secondary / tertiary vertexes and/or kaons?
  - i.e. weighting the charge calculation with the offset / energy of the tracks considered? First studies show no obvious room for improvement
- Adding the cases were the charge is calculated in the same jet with two different methods.
  - Not considered yet because of the possible correlations introduced.

Ideas for the improvement of the efficiency

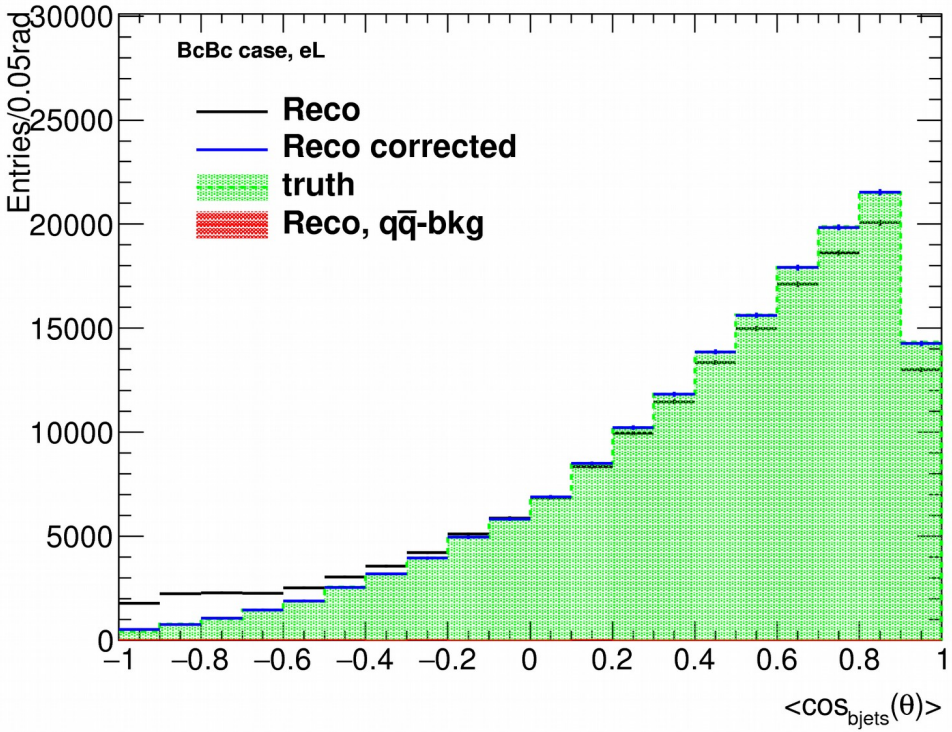
- So far, to accept an event, we needed at least an agreement of the charge measurement in both jets, but we only cared about the BcBc and KcKc.
- What is the potential of improvement looking to different charge calculation methods combinations **in different jets**?

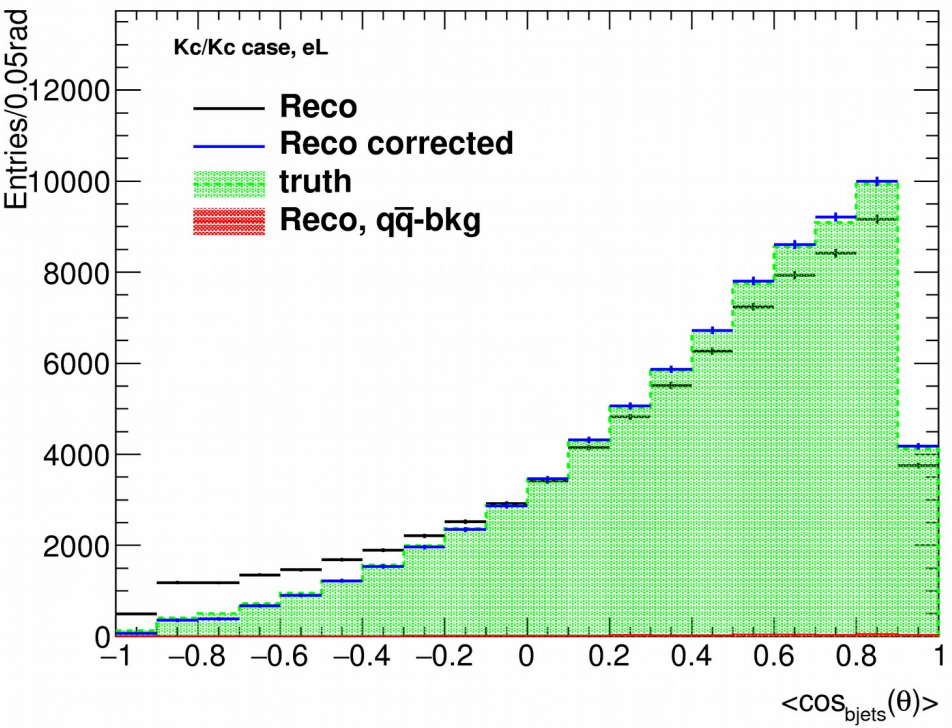
		disagreements				
		0	1	2	3	4
agreements	0	**24,7%**	**4,1%**	**2,6%**	0,0%	**0,2%**
	1	**7,3%**	**2,3%**	0,0%	0,0%	0,0%
	2	**6,6%**	**0,0%**	**1,0%**	0,0%	0,0%
	3	0,0%	0,0%	0,0%	0,0%	0,0%
	4	**1,4%**	0,0%	0,0%	0,0%	0,0%
total		40,0%				

Calculated for a single file.

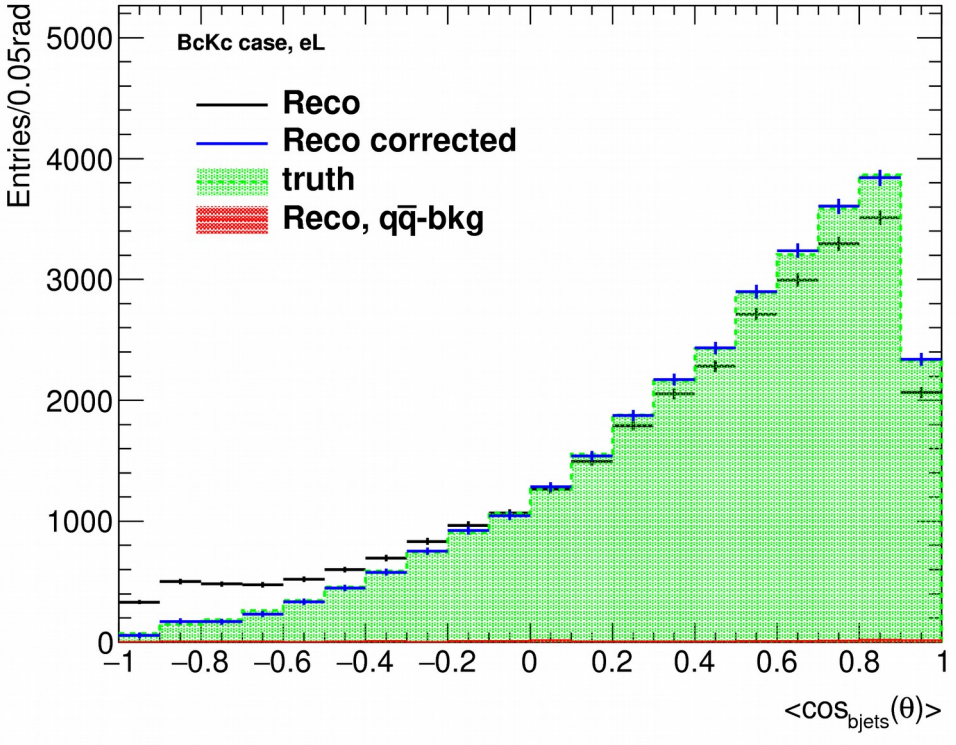
- The efficiency booster is the case in which we only have one measurement (nothing to crosscheck) **+25%**
  - Purity of 0.8 will introduce large migration effects → large correction !
- The maximum efficiency with 0 disagreements and 1 or more agreement is: **~15%**
- Assuming some disagreements, this will go up to ~**18%**

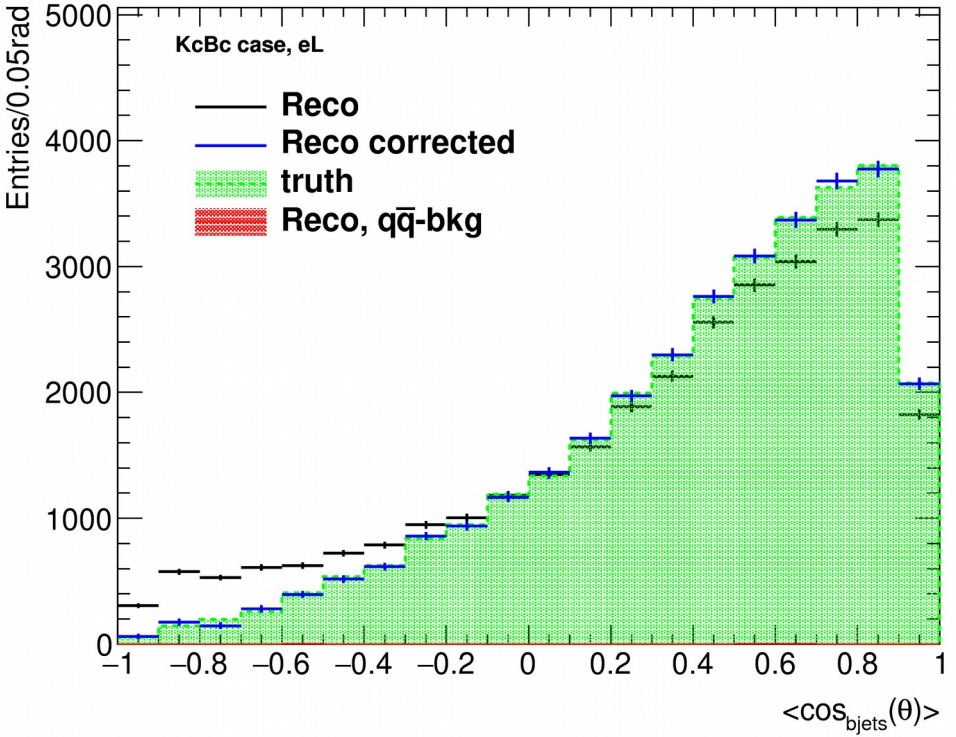
BcBc & KcKc cases



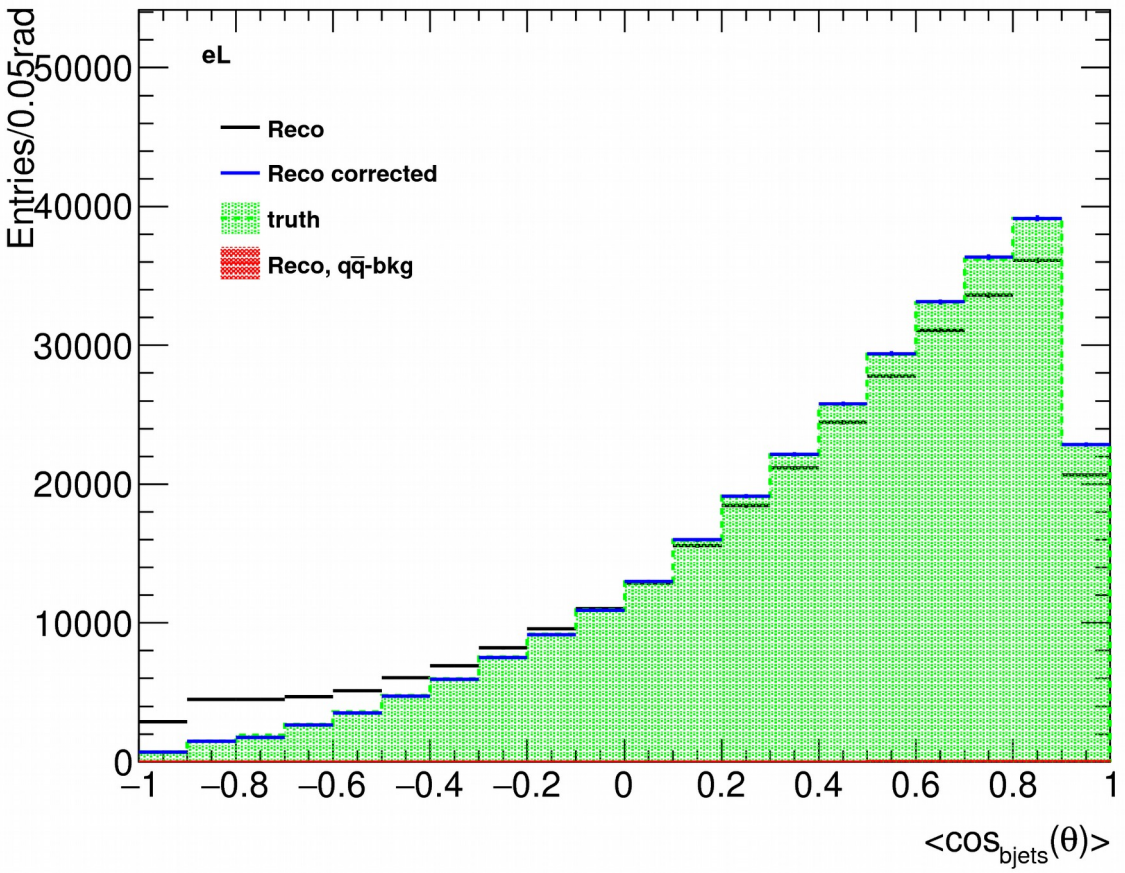


BcKc & KcBc cases





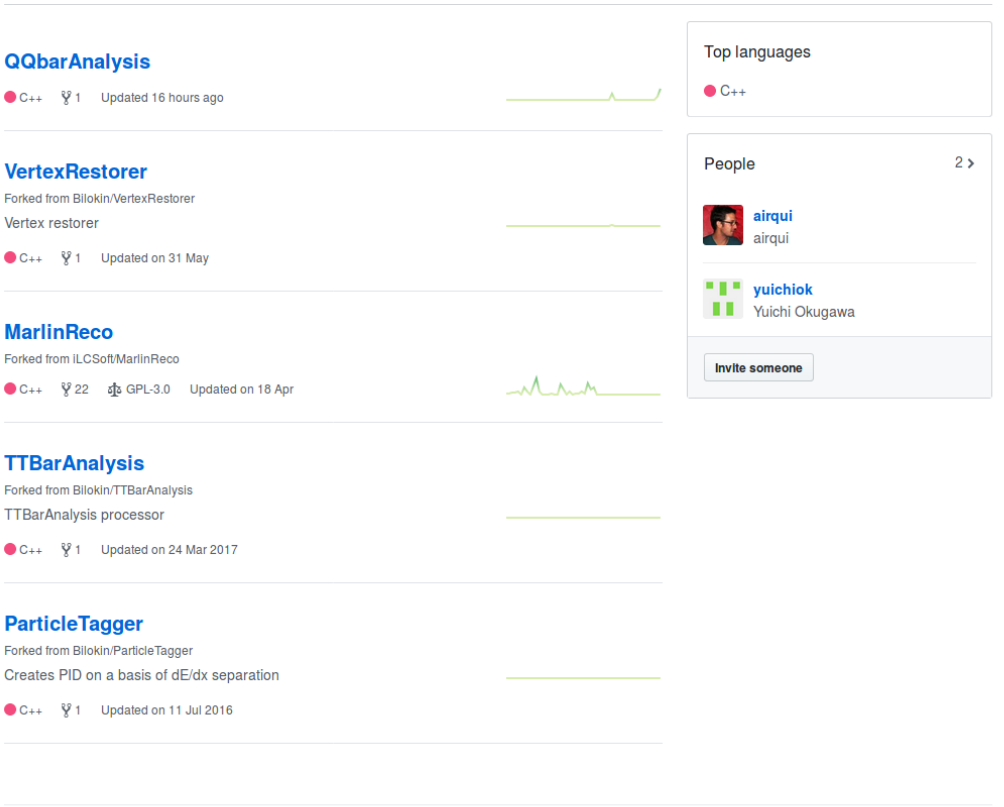
Result for BcBc, KcKc, BcKc and KcBc



- **Total efficiency: 18%**

TTBarAnalysis → QQbarAnalysis

- Code cleaning and restructuration : https://github.com/QQbarAnalysis
  - VertexRestorer → updated
  - QQbarAnalysis (bbbar is at 80% done, ttbar, semileptonic almost at 100% - Y. Okugawa)
  - MarlinReco → forked only as reference (the VertexRestorer in it is outdated?)
  - TTBarAnalysis → old code being exported to the QQbarAnalysis
  - ParticleTagger (non tested)→ dE/dX for Kaon identification
- Soon we will converge in a common processor and it will be forked to **ILDBench_QQbar**



Summary and prospects

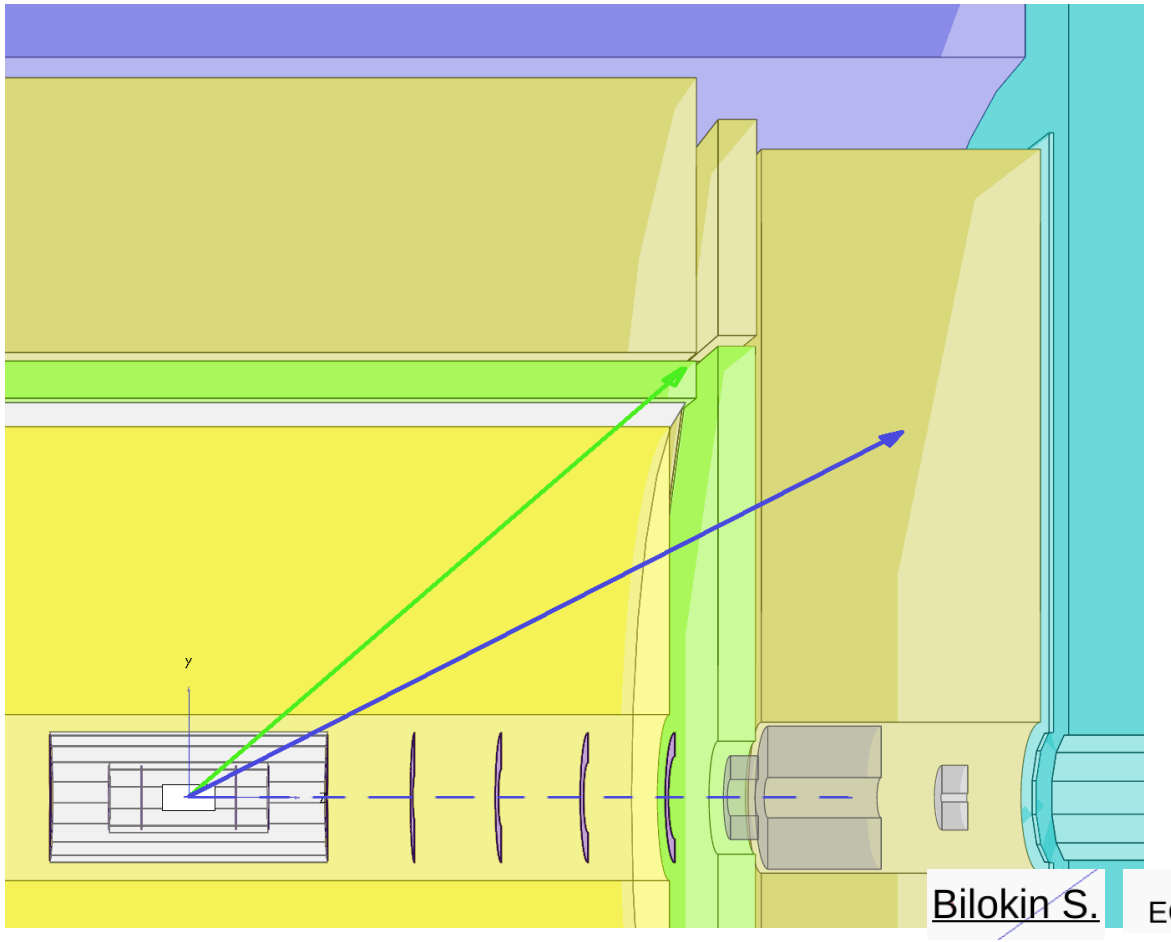
- The efficiency can be improved by using different combinations of the charge calculation.
  - The largest improvement would come from using events with only a charge measurement. This introduces very large corrections due to the “low” purity of the methods.
  - A substantial improvement is possible by considering different combinations of the charge calculation.
  - The charge correction unavoidable and not negligible

- We need to revisit the issue and evaluate how much better our detector can do the charge measurement:
  - For that we will use the new samples (@500GeV) and software.

    As intermediate step, we will check the result for 500GeV for the old software.
  - A full analysis (control plots, optimization of cuts, etc) will then performed and discussed.
- Strong synergies with ttbar analysis.

Back-up slides

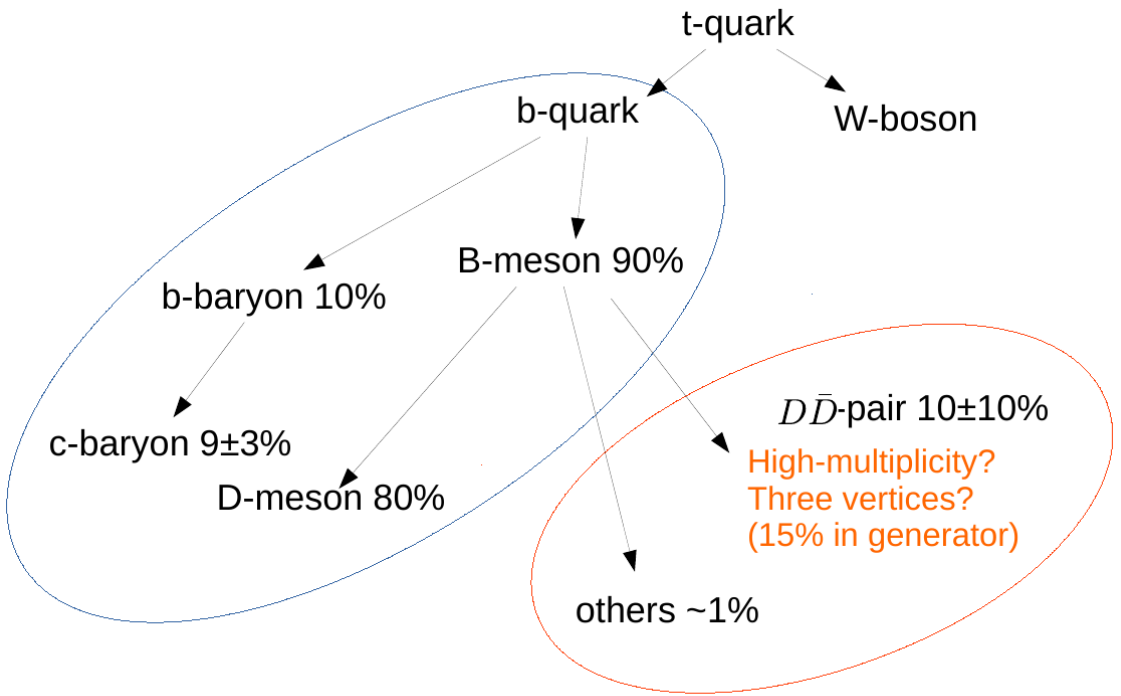
ILD geometry



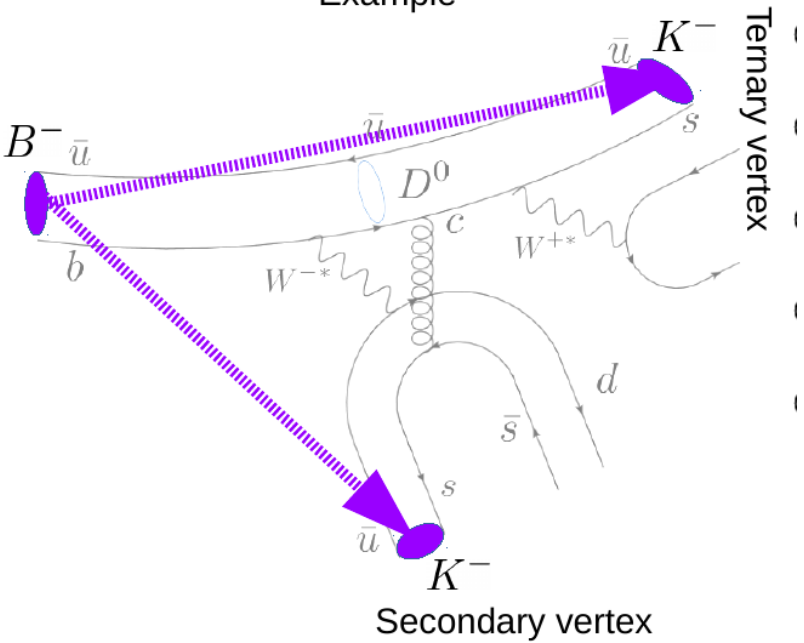
Bilokin S. ECFA LC Workshop 04/06/16

Process overview

- Hadronization and decay modes of b-quark:



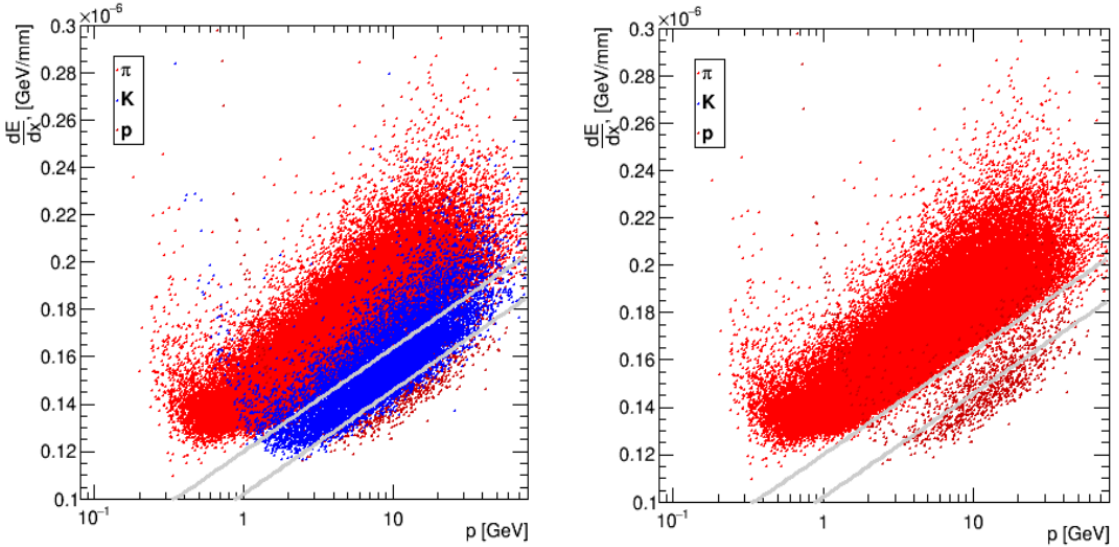
Example



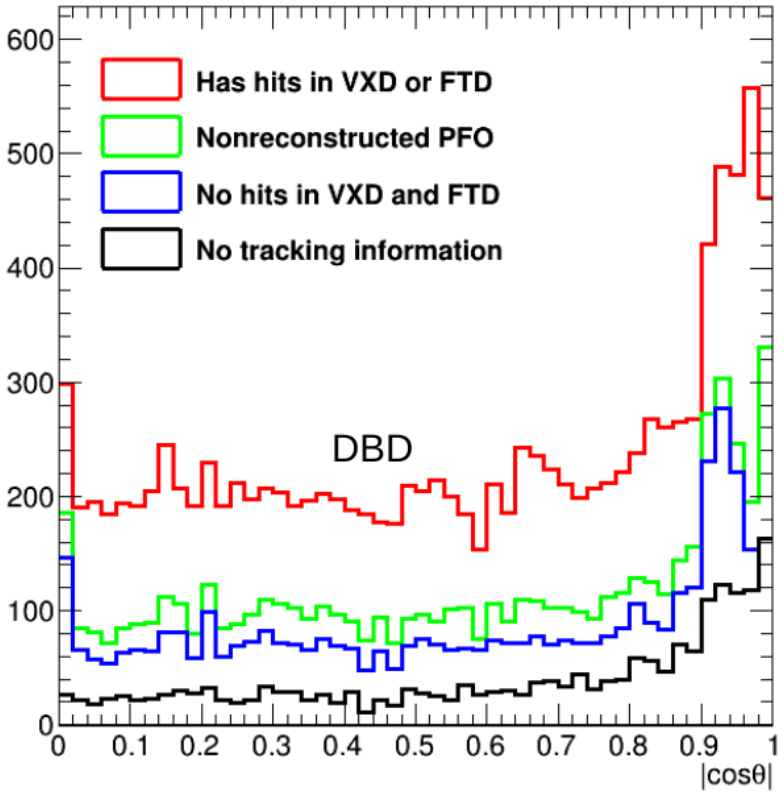
Bilokin S. ECFA LC Workshop 04/06/16

Kaon identification

dE/dx as function of a track momentum for different types of particles from secondary and ternary vertices

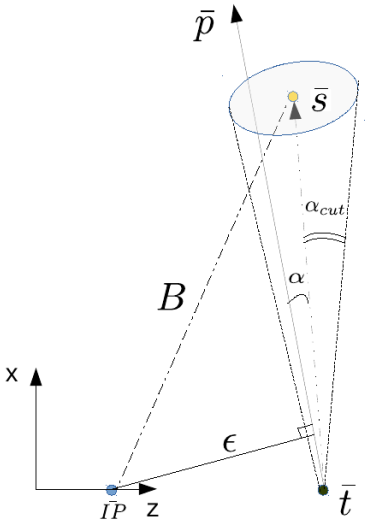


- It is possible to identify kaons with high purity
- In current analysis kaons are selected using generator information for ternary tracks with TPC hits > 60 and $|cos\theta| < 0.95$



8.1% of generated

Recovery of vertices

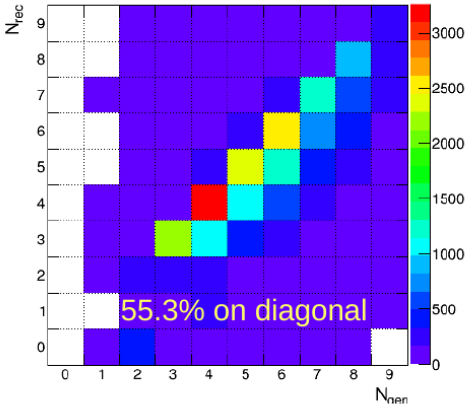


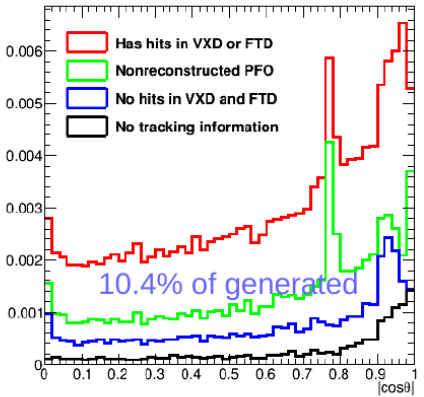
- **IP** – interaction point (primary vertex) , **s** – secondary vertex, **t** – point of closest approach of a track, **p** – reconstructed momentum, ϵ - offset of a track from primary vertex

Bilokin S. ECFA LC Workshop 04/06/16

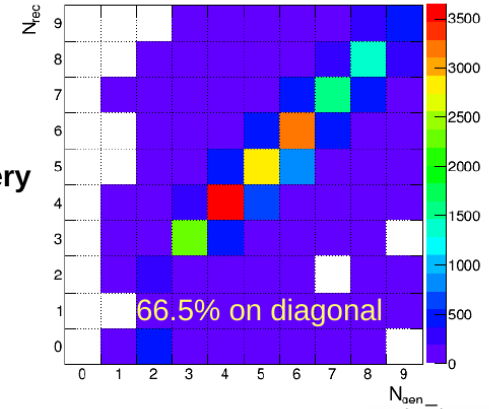
Reconstruction quality DBD vs Recovery

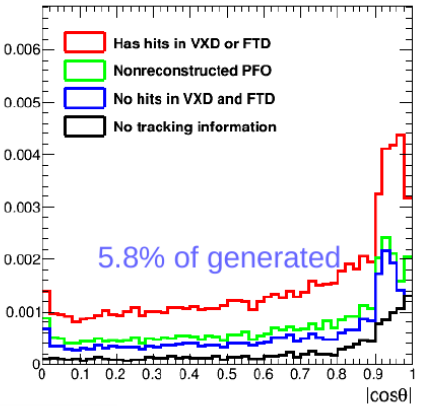
DBD





Recovery





$m(b\bar{b}) > 200\,GeV$

ECFA LC Workshop 04/06/16