ZEUS secondary vertexing c & b analyses: rejection of background from strange decays

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Ganna Dolinska

Kiev National Taras Shevchenko University

Supervisor: Philipp Roloff

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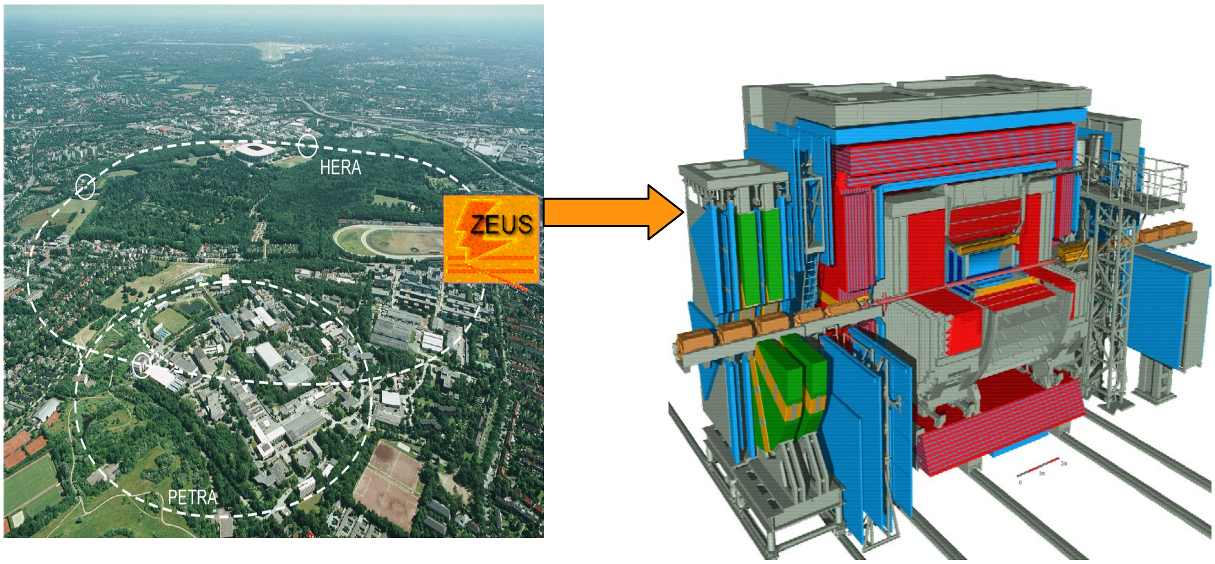
Abstract

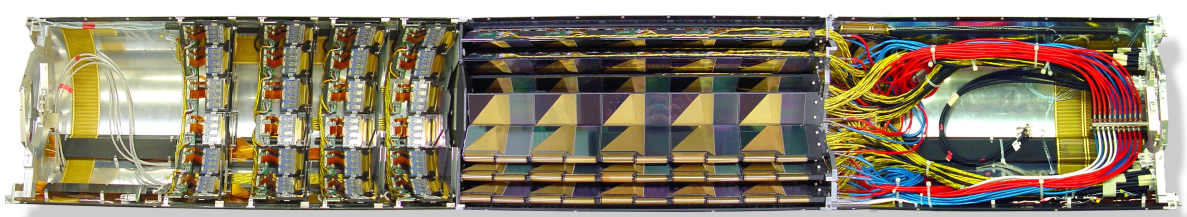
This report will describe the study of the influence of K^0_s mesons in inclusive secondary vertices in ZEUS, HERA II, DESY.

The ZEUS detector, HERA



HERA – was a collider, where the e^{+-} p collisions took place. The energy of center of mass system was 318 GeV.

ZEUS was a collider experiment at HERA. ZEUS was a multipurpose detector with almost 4π geometry. The most important parts for the study presented here are the CTD (central tracking detector, in solenoidal magnetic field 1.43 T) and the MVD (micro vertex detector, which was actually an update for HERA II).



BOTTOM MICRO VERTEX DETECTOR

Physical overview

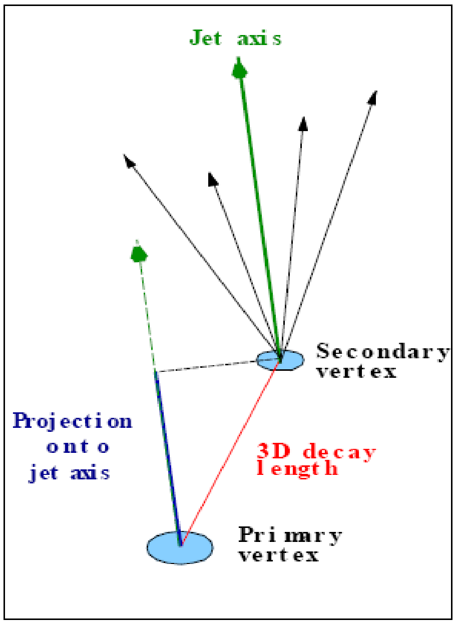


Fig.1

We reconstruct vertices from charm and beauty decays, since charm and beauty are long living particles ($c\tau$ typically a few hundred μm). We are doing it to define charm and beauty cross section.

Jets appear on some distance of primary vertex. This distance is a 3D decay length (Fig.1).

We are looking for K^0_s mesons in the jets.

The main aim of this study is investigation of K^0_s decays background.

DIS selection

In the presented study we select DIS events. For this selection we apply such cuts:

- $44GeV < (E - pz) < 65GeV$
- $y_{jb} > 0.02$
- $y_{el} < 0.7$
- $5 < Q^2_{da} < 1000$
- $|Z_{vertex}| < 50$ cm

K^0_s mesons

K^0_s is a short-lived neutral meson, which weekly decays primarily into two pions. The decay mode, which is relevant, is $K^0_s \rightarrow \pi^+ \pi^-$(the branching ration is about 69%). The proper decay length of it is 2.68 cm.

To study the influence of K^0_s on the background level we used Monte Carlo (MC) samples. They are inclusive ARIADNE, $Q^2 > 4$.

To obtain the K^0_s signal we applied such cuts:

K0s CUTS:

- $p_t(\pi) > 0.15$ GeV
- $|\eta(\pi)| < 1.75$
- Removal of photon conversions: $M(e+e-) > 0.05$ GeV
- Λ removal: $M(p\pi^-) > 1.12$ GeV
- $|\eta(\pi)| < 1.6$
- $0.482 < M(\pi^+\pi^-) < 0.512$ GeV
- Outer super layer of π tracks ≥ 3

And after these cuts were applied the signal looks like this:

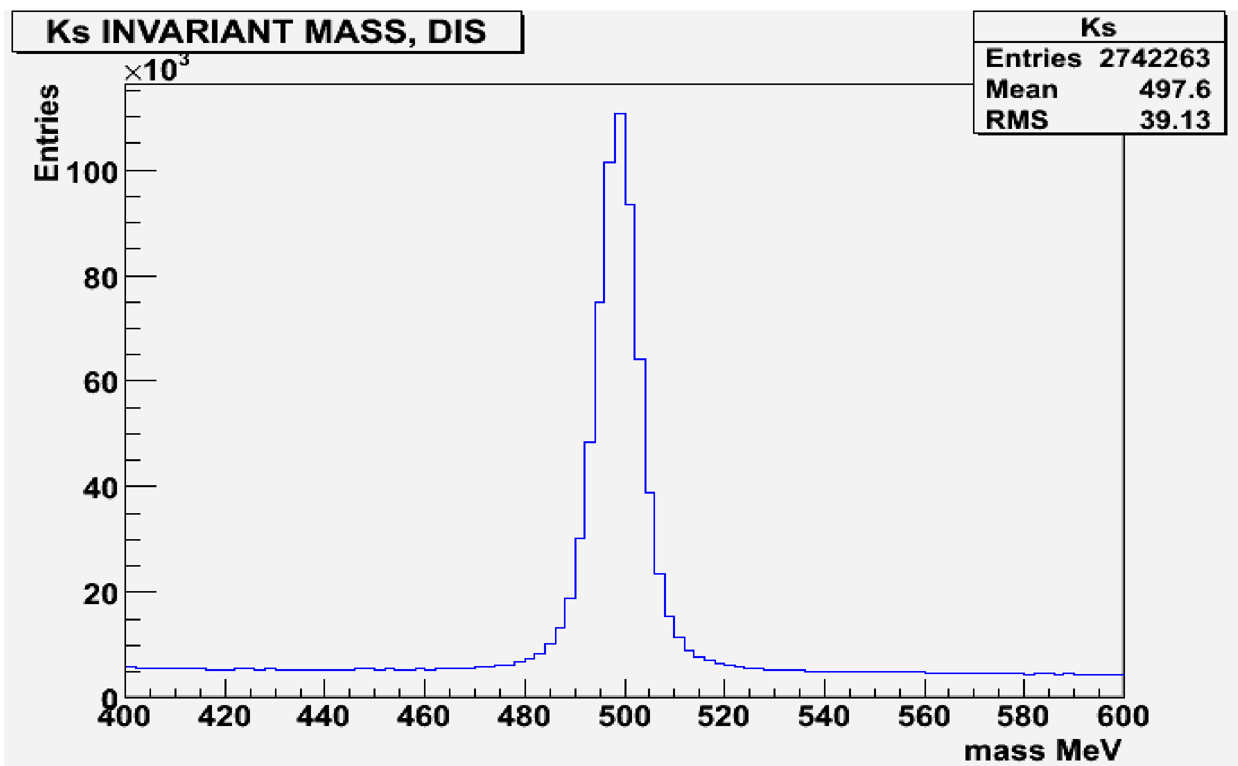


Fig2. K0s invariant mass

Jet selection

A jet is a narrow cone of hadrons or other particles.
As it was told above, we are looking for K_S^0 mesons in the jets.

To select the jets we use these cuts:

- Et(jet) > 5 GeV
- $|\eta(\text{jet})| < 1.5$

Here are some distributions for jets after the cuts:

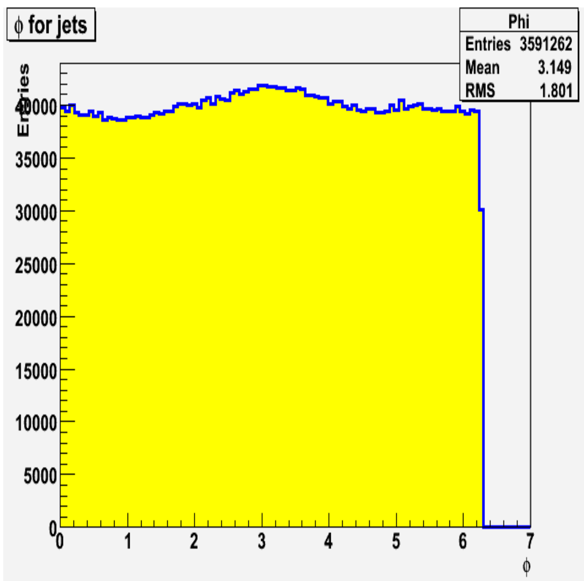


Fig3. Jet φ

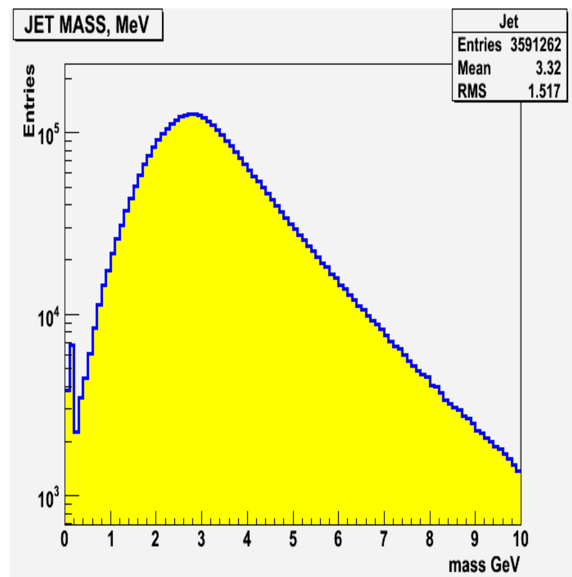


Fig.4 Jet invariant mass

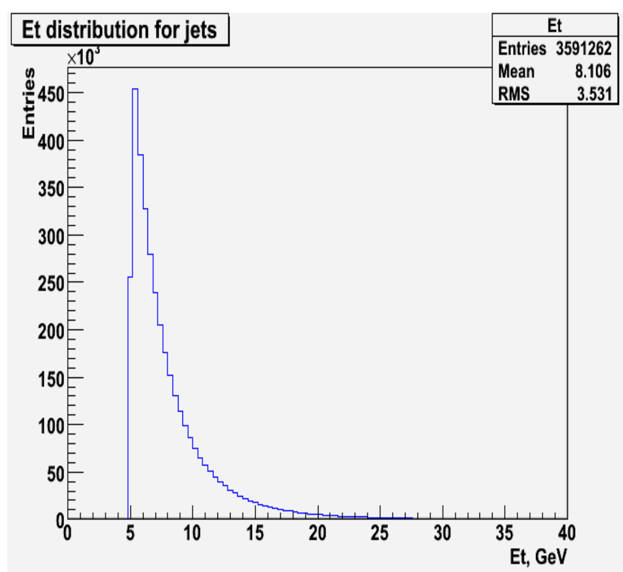


Fig.5 Jet Et

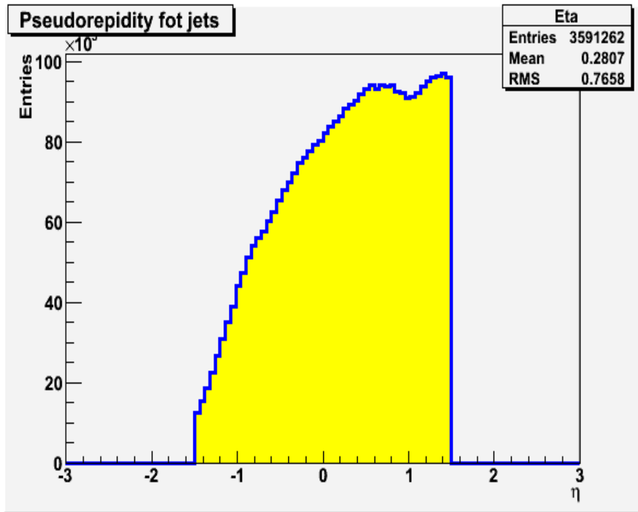


Fig.6 Phseudorepidity for jets

Secondary vertex selection

Secondary vertices are fitted from good tracks (p_T > 500 MeV) associated with jets. To associate tracks with jets we study R, which is defined like this:

$$R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$$

If R<1, then we mark the track as the associated to jets ones.

The cuts for the vertex selection are:

- $|Z_{secvtx}| < 30$
- χ^2 / NDOF < 6

And after applying these cuts we have such distributions:

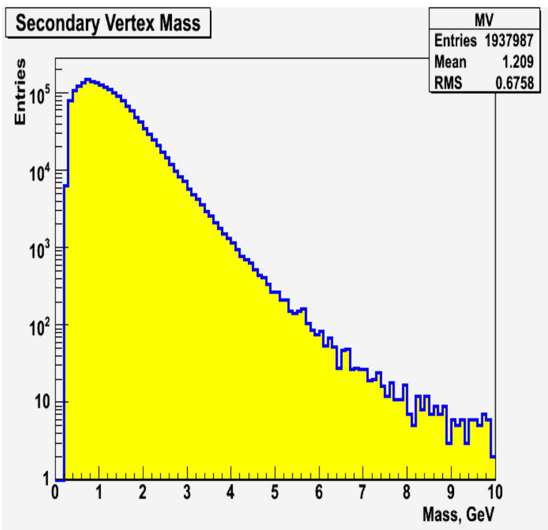


Fig. 7 Secondary vertex mass

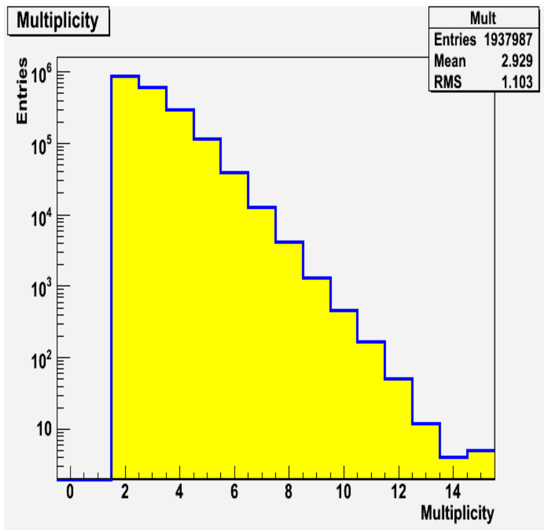
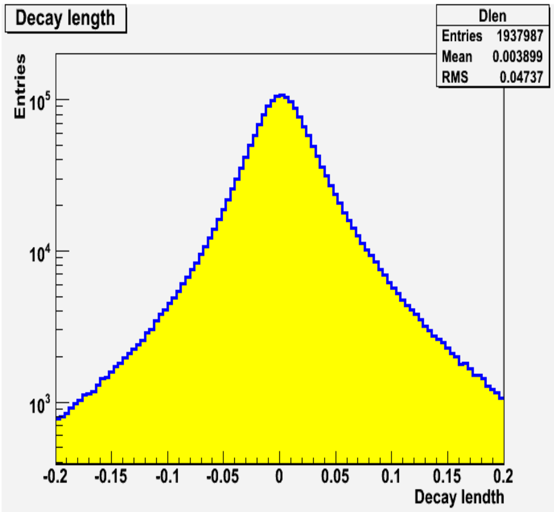


Fig.8 Multiplicity



Without χ^2 cut

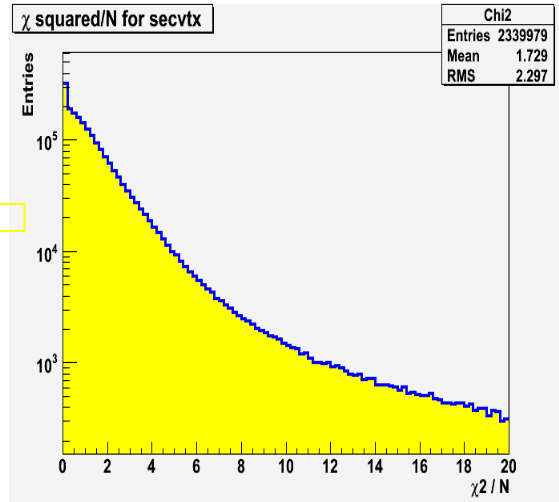


Fig.9 Decay length

Fig 10. Normalized χ^2

As we can see from Fig.8, there is and asymmetry in the distribution for the decay length. It is mainly caused by heavy flavour. So we decided to remove charm and beauty quarks and to look at the mirrored significance.

Mirrored significance

The significance is the ratio of 2D decay length to it's error.

The explanation of what is actually the 2D decay length can be found on Fig.1. It is the distance between primary and secondary vertex projected on the jet axis. On Fig.1 it is the Projection onto jet axis.

To explain the meaning of “mirrored significance”, we will use the Fig.11

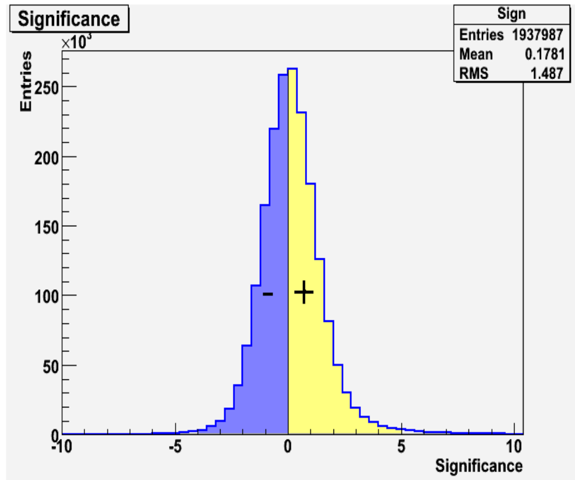


Fig.11 Significance

To get mirrored significance, we have to mirror “-” region to the positive site of X axis and then to subtract it from “+”.

From the definition of the mirrored significance, we see, that we can study the asymmetry from it.

So here is the mirrored significance for the inclusive (Fig.12) and light flavor (Fig. 13) case:

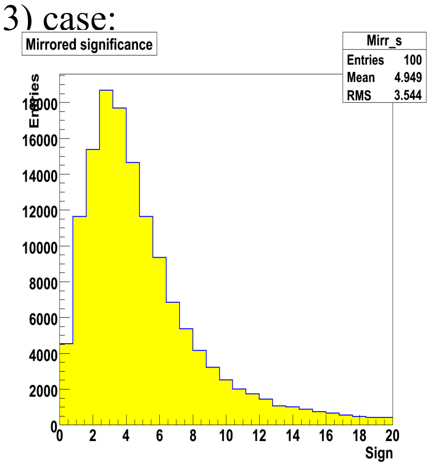


Fig. 12

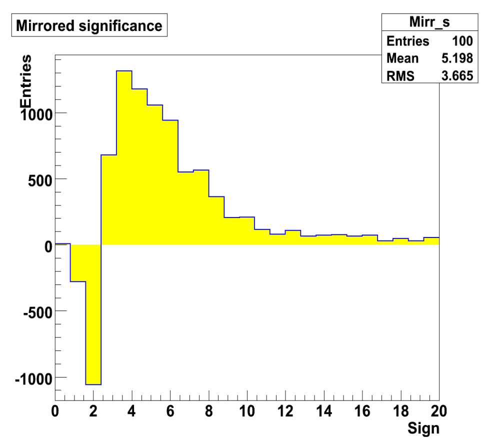


Fig.13

As we see, even in the light flavor case, where we have removed charm and beauty quarks, the asymmetry remained. What is the reason for it? We decided to look, what is the contribution of K_S^0 to this asymmetry.

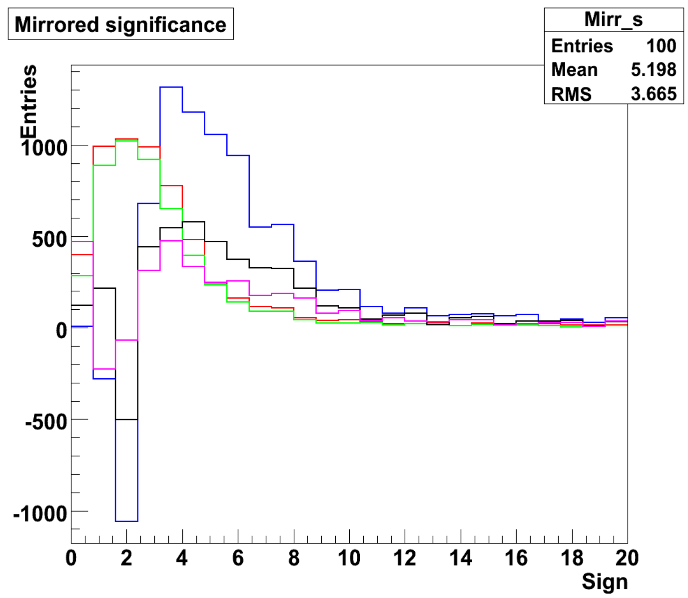


Fig.14 Mirrored significance for light flavors

BLUE line is the one for the inclusive case

BLACK line is for the case when one generated pions match to the tracks after the reconstruction

PINK line is for the case, when two generated pions are matched to the reconstructed tracks

RED line is for the case, when one track of the pions from K_S^0 is matched to the secondary vertex

GREEN line is for the case, when two tracks of pions of the K_S^0 are matched to the secondary vertex

It was also interesting to look at the distributions of the mirrored significance in bins of secondary vertex mass. It means, we select some region of secondary vertex mass and plot the mirrored significance only for this region. Usually, there are three bins of mass, which are necessary for light flavor studies, for charm studies and for beauty studies. Here are these plots:

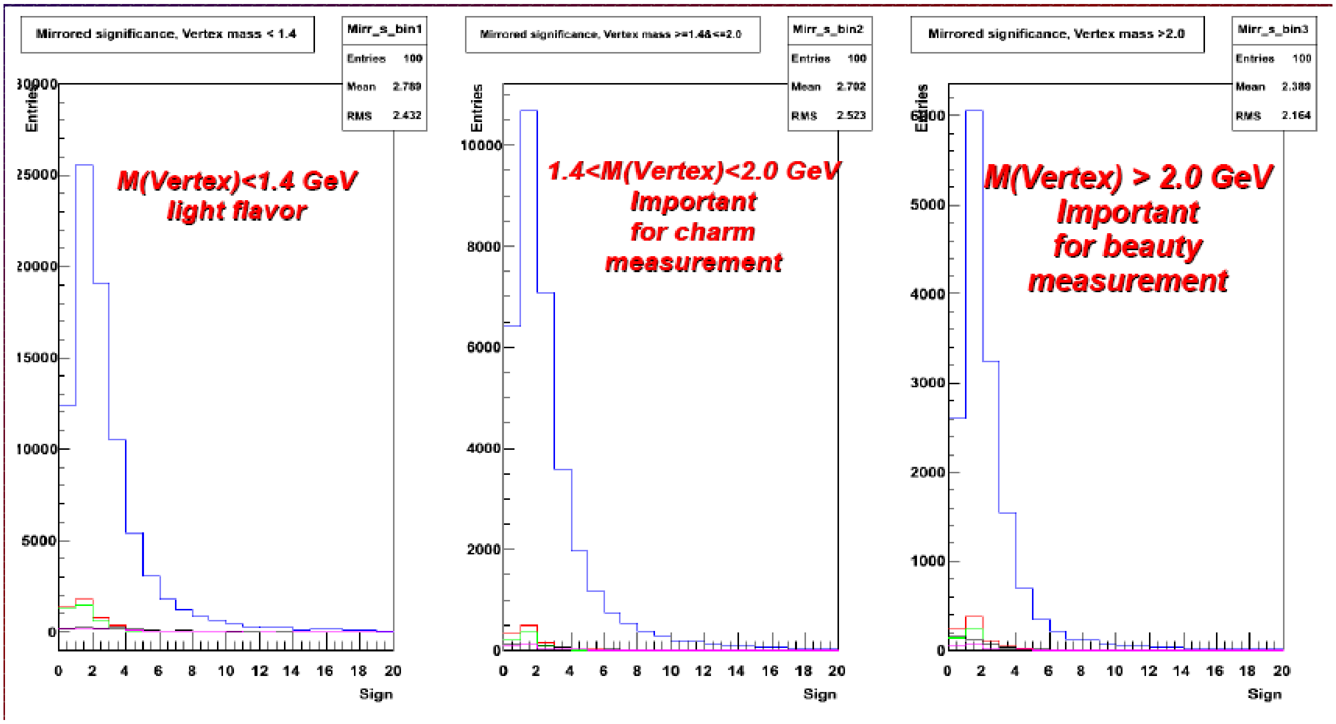


Fig.15 Mirrored significance in bins of mass

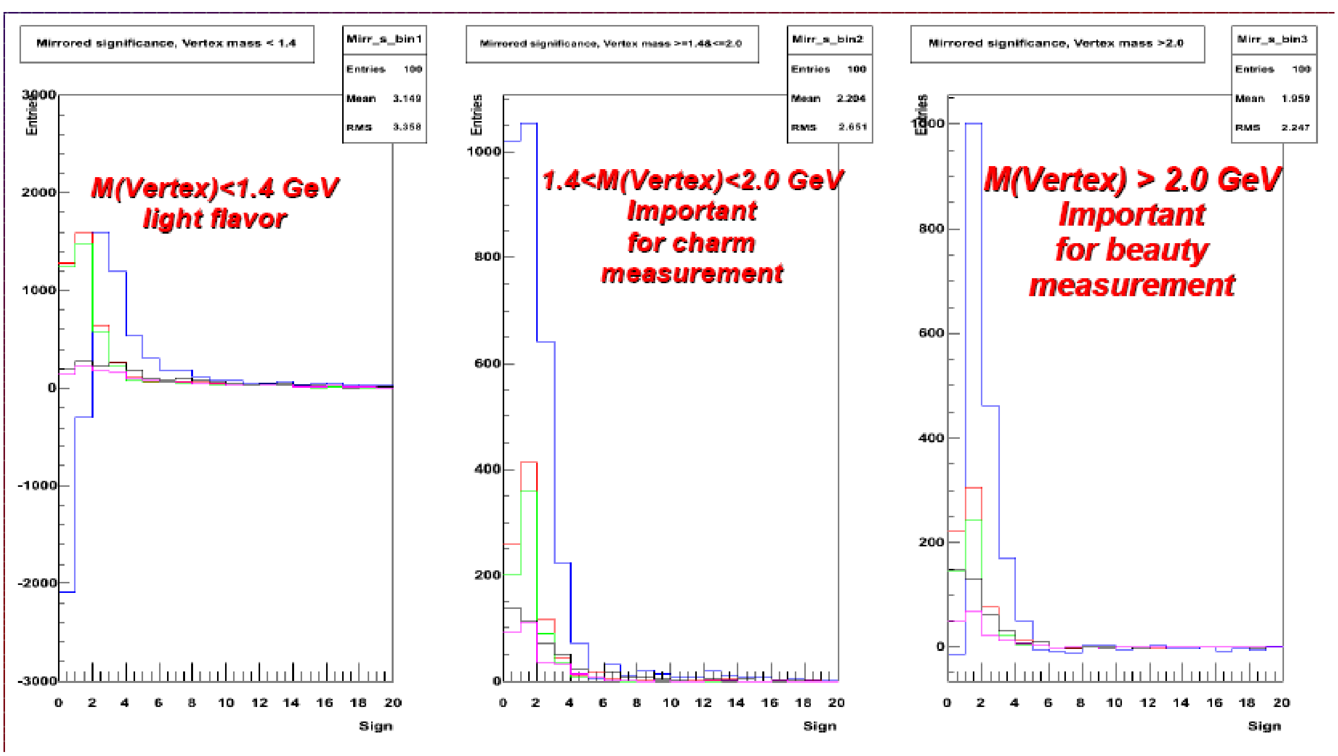


Fig.16 Mirrored significance in bins of mass for light flavors (without charm and beauty quarks)

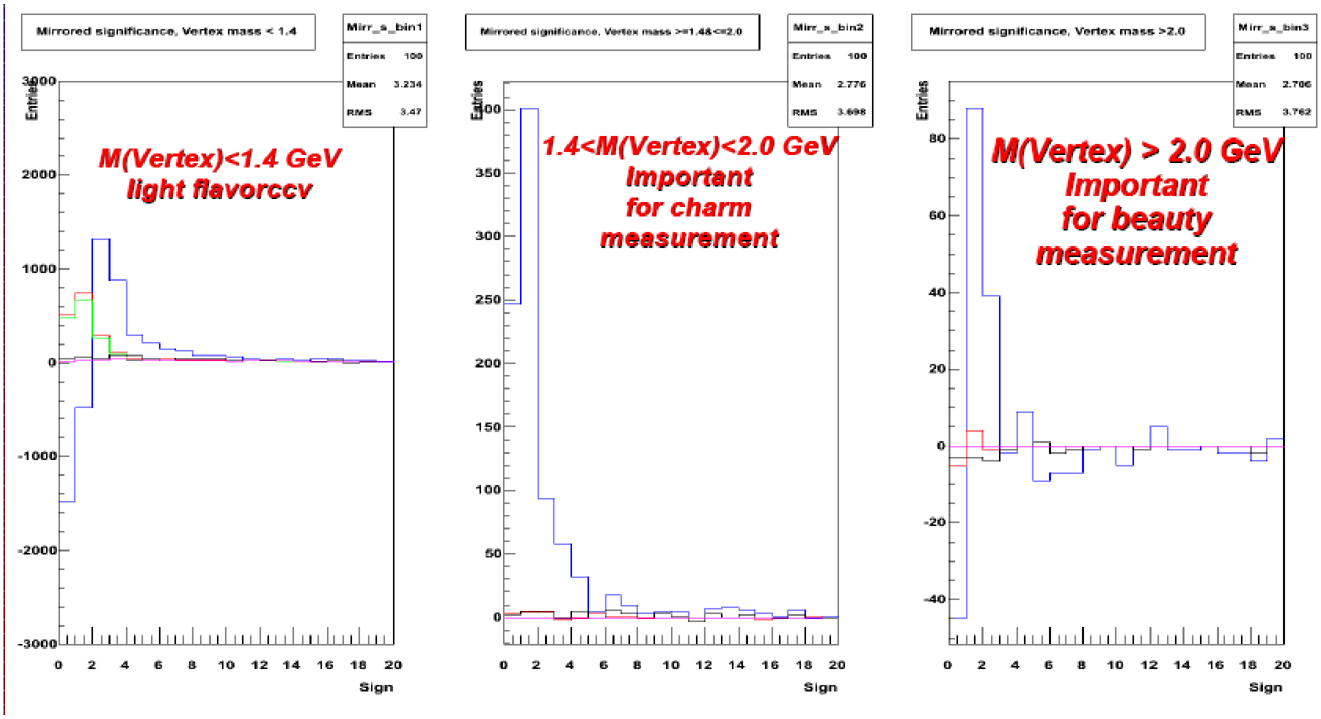


Fig.16 Mirrored significance in bins of mass for light flavors (without charm and beauty quarks) and with multiplicity equals 2

As we can see from these plots, the true K_S^0 , reconstructed from the generator level (these are the black and the pink ones), cause only about 10% of asymmetry. So, as we see, K_S^0 are not the main reason of asymmetry. These may be the Λ particles. But the number of them is factor 40 less then the number of K_S^0 . These also may be the secondary interaction. The another study is needed for this case.

Another interesting thing is that the reconstructed K_S^0 – red and green once – seem to cause about 50% of all asymmetry. It is not natural. It means that somehow the finder of K_S^0 which was used in this case (V0lite block in Common NTuples) uses less strict cuts.

Conclusions:

K_S^0 cause about 10% of the asymmetry in the light flavor. And there is some disagreement in V0lite finder block and the true reconstructed data.

In future the study of secondary interactions is needed.