Inclusive Z-boson production and underlying event.
LHC ATLAS Experiment, 13 TeV

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The motivation

Our Bose-Einstein (BEC) correlation studies leads us to several observation:

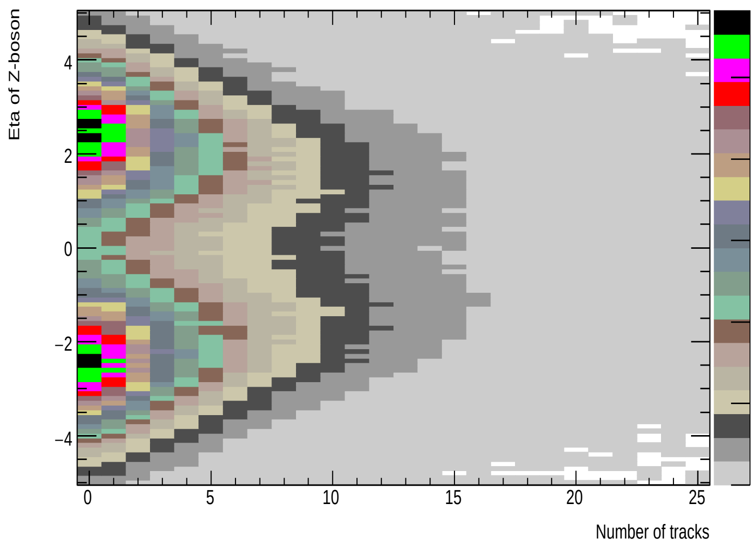
- The Multi-particle final state in proton collisions are caused by Multiple Interaction (MI) and only rather limited number of secondaries are being produced in a single one.
- By other words there are many small size particle sources distributed in much larger area of a radiation zone.
- It looks that such small sources are a product of QCD vacuum excitation.

Z-boson are produced in the hard interaction of proton components, in quark-antiquarks collisions. It can be that MI does not ”know” of such process and produces many particles in the same event as an addition to final states of the hard interaction,called as underlying event.

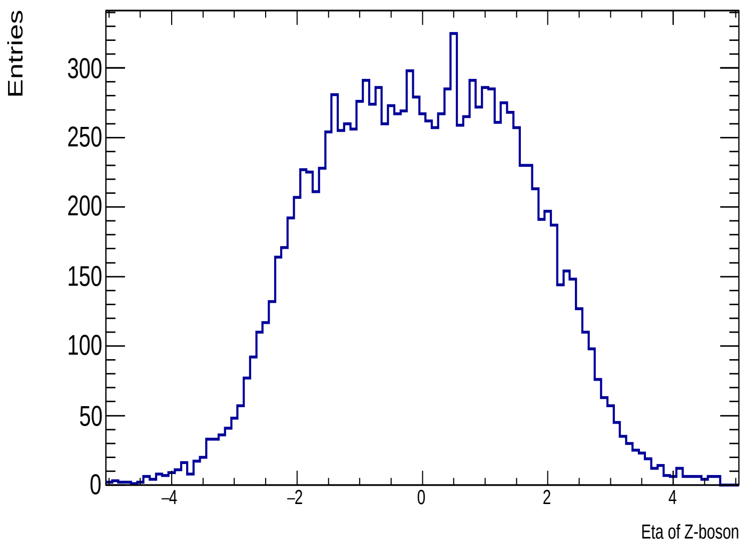
Particles produced with Z-boson in quark-antiquarks collision have a kinematical correlation with Z-boson. Underlying event products have NO any correlation with Z-boson, however might have correlations (BEC as an example) with particles accompanied Z-boson.

Z-boson observables.

Fig 1 shows the η distributions of Z-boson.



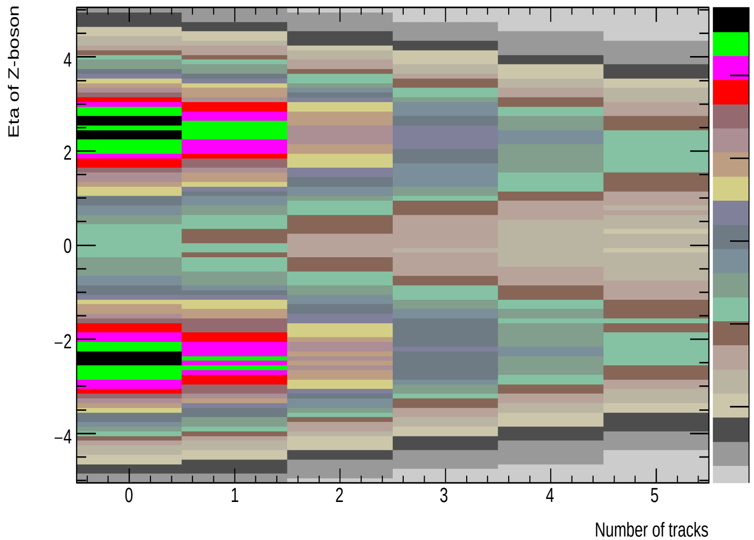
(a) η of Z boson as NTRK



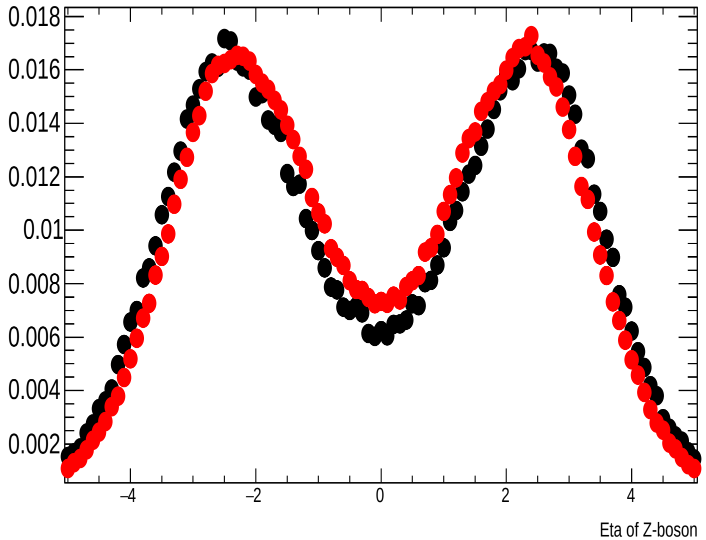
(b) η of Z boson with NTRK.Gt.25

Figure 1: Psevdorapidity η distribution of Z-boson.

One can see that η distribution qualitatively different for small number of tracks and large one. For the first time we can estimate the contribution of Born production (no companion track) $\sim 17\%$ and production with initial state radiation (number of tracks is less than ~ 5) $\sim 53\%$. The rest $\sim 30\%$ is the production in Compton process. η distribution for the first two cases are similar.



(a) Psevdorapidity η distribution of Z-boson without NTRK.lt.5



(b) η distribution of Z-boson without tracks(black) and with NTRK.lt.5(blue)

Figure 2: Psevdorapidity η distribution of Z-boson without tracks(black) and with NTRK.lt.5(blue).

The value of Z-boson transverse momentum increases with number of tracks - the natural recoil influence.

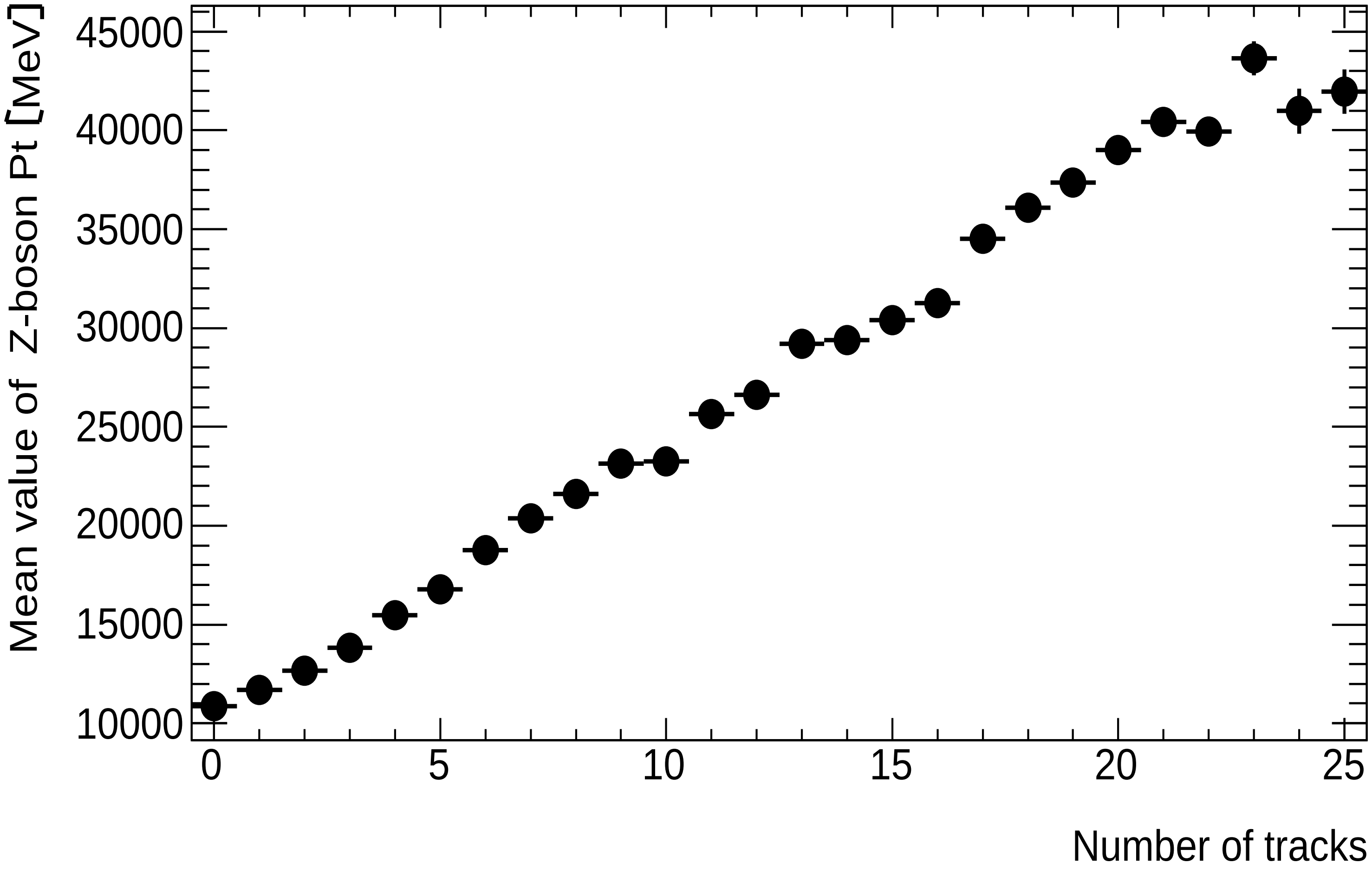


Figure 3: The distribution of Z-boson momentum transfer as a function of number of tracks.

Angular correlations of Z-boson momentum angle with the same angle for a particle

Recoil effects are clearly seen in angular correlations. Fig shows $\Delta\phi$ correlation. As we already know, events with small multiplicity corresponds a selection Drell-Yan process with an initial state radiation.

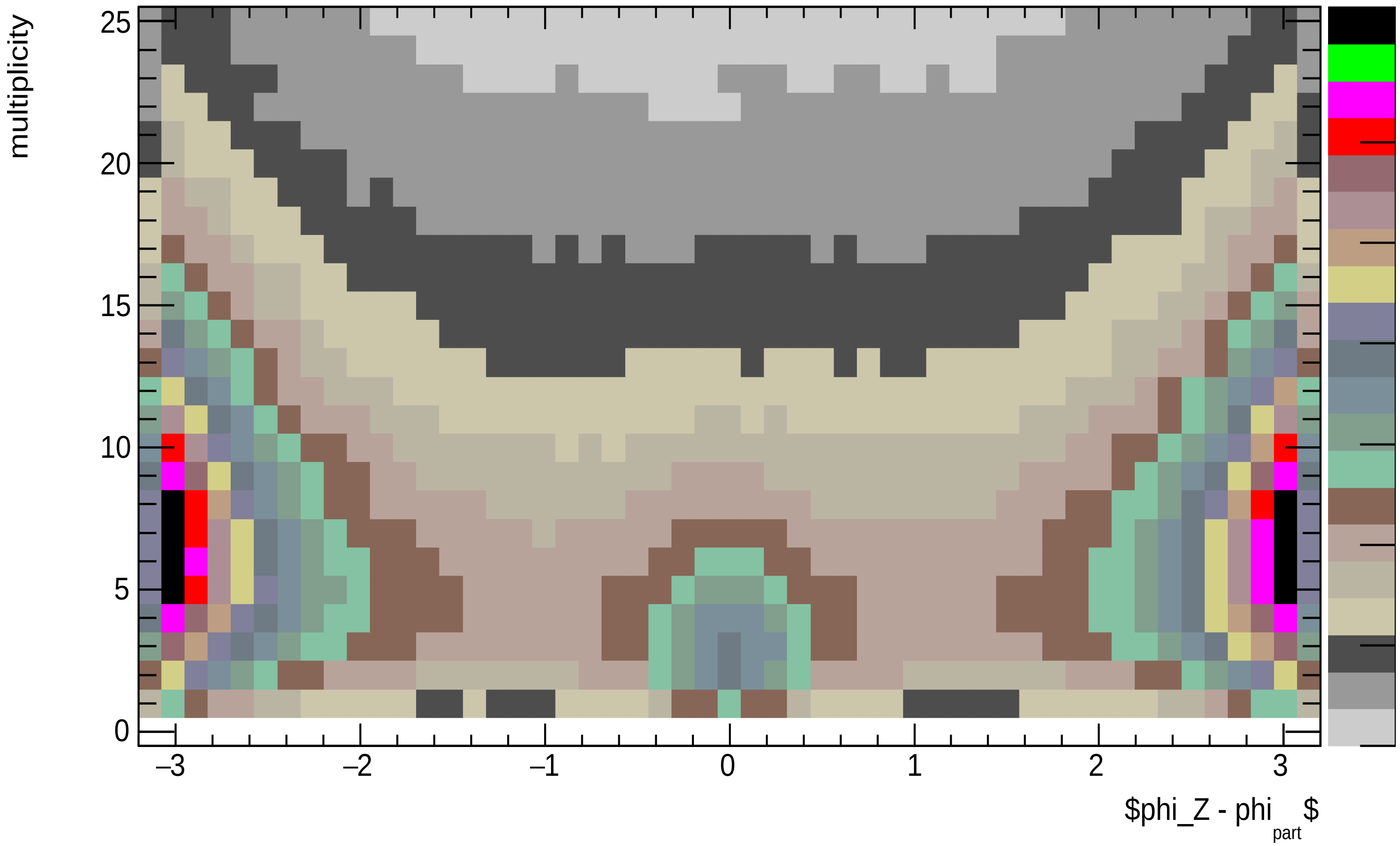


Figure 4: The $\Delta\phi$ correlation as a function of number of tracks.

Let us consider $\Delta\phi$ correlation with $N_{ch} > 20$. One can easy select a sample of tracks which not correlate with Z. The percentage of underlying tracks is $\sim 67\%$. This value has rather weak dependence on low multiplicity cut (a percent level under change this cut from 15 till 25).

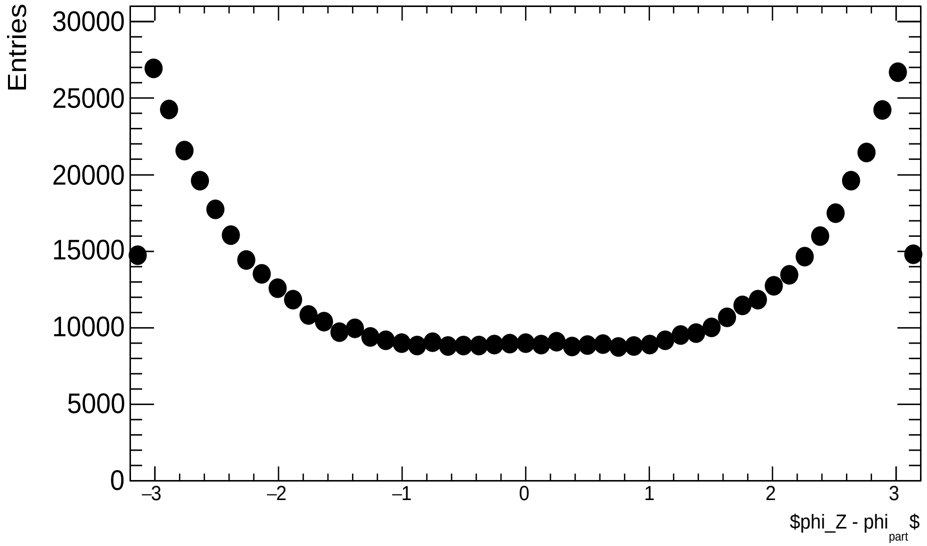


Figure 5: The $\Delta\phi_Z$ correlation with number of tracks larger 20.

During investigation of Bose-Einstein correlation $\Delta\phi$ of the same sign particles has been considered. Fig shows such correlation with the selection tracks with transverse momentum higher than 500 MeV. The current analysis of inclusive Z-boson production includes particles with the same cut. In Fig we do see very much different pictures for this two cases. Interpretation of such observation is still not clear.

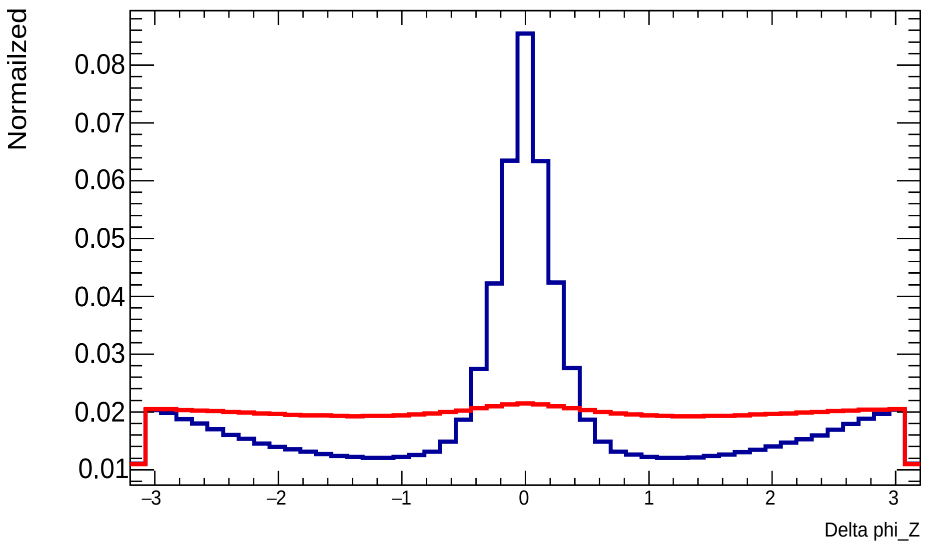


Figure 6: The comparison of $\Delta\phi$ particle correlation in inclusive Z-boson production (blue) with the similar one for the MinBias case(red).

Conclusions

- For the first time an estimate has been done for contributions of different mechanism of the inclusive Z-Boson production.
- The underlying event has been identified and its probability is estimated.

The numbers can be dependent on the value of the minimal particle momentum transfer. To perform quantitative Bose-Einsten analysis the ”recalibration” run has to be done with the minimum particle momentum of 100 MeV (at least, for a meaningful statistics of 5M events).