BOSE-EINSTEIN EFFECTS IN MULTIPLICITY AND NET-CHARGE CORRELATIONS IN PP COLLISIONS USING PYTHIA8 SIMULATIONS

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Abstract

Correlations between various observables, e.g. multiplicities of particles produced in pp collisions at the LHC energies within intervals separated in pseudorapidity and azimuth angle, could be a sensitive tool to analyze hadron collisions dynamics and test hadron production models.

In this report we present results of studies of multiplicity correlation coefficient topology for like- and unlike-sign pairs of charged particles using PYTHIA8 event generator [1]. Correlation coefficients were extracted using long-range forward-backward correlation method [2].

Peculiar behavior of correlation coefficient topology of net-charge is obtained in short-range region. Analysis shows that effects of Bose-Einstein statistics [3] have strong influence in this region of such correlations.

The results indicate the necessity of experimental studies of net-charge correlation topology that could bring new constraints to PYTHIA8 tunes.

Bose-Einstein effects in Pythia 8

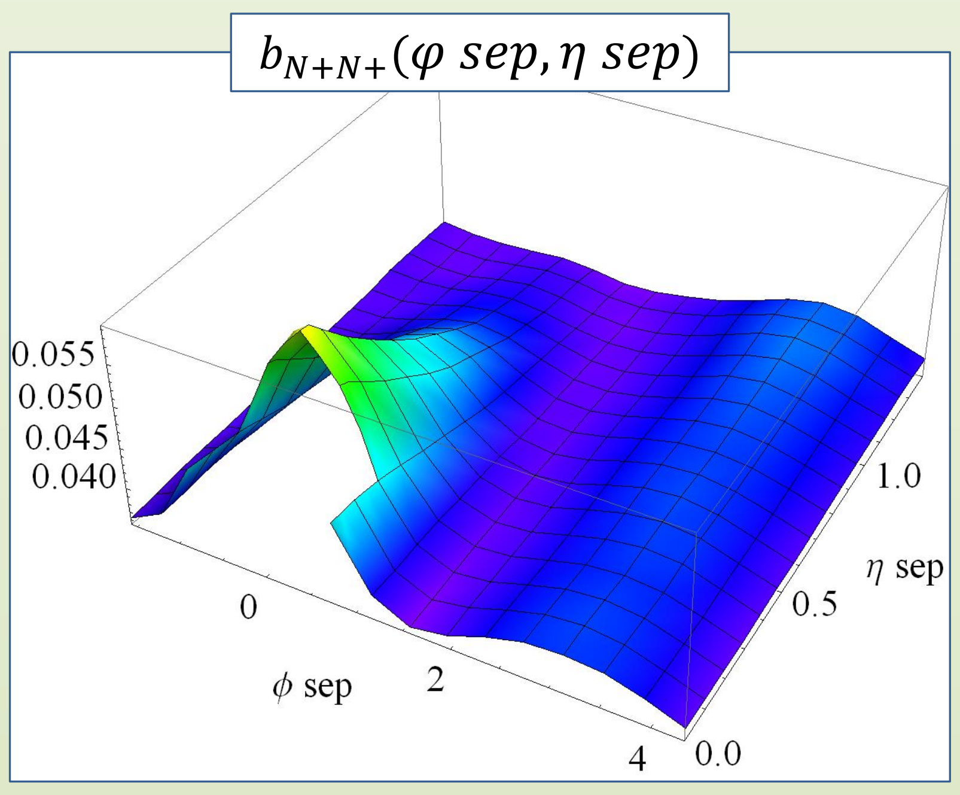
Because it is impossible to symmetrize matrix elements within Pythia a crude but robust estimate is used [3], shifting identical particles' momenta and aiming to enhance two-particle correlation by

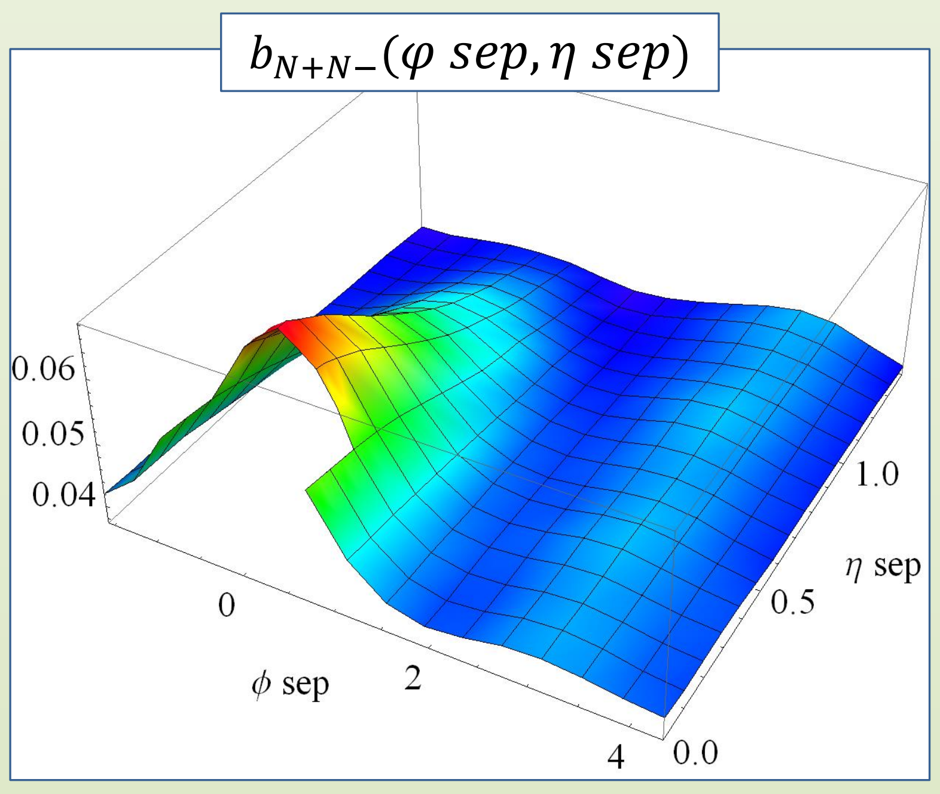
$$f_2(Q) = \underbrace{(1+\lambda\exp(-Q^2R^2))}_{\text{Pulls identical particles' momenta closer}}\underbrace{(1+\alpha\lambda\exp(-\frac{Q^2R^2}{9}))}_{\text{Pushes all particles' momenta away to restore energy conservation}}\underbrace{(1-\lambda\exp(-\frac{Q^2R^2}{4}))}_{\text{Needed for normalization}}$$

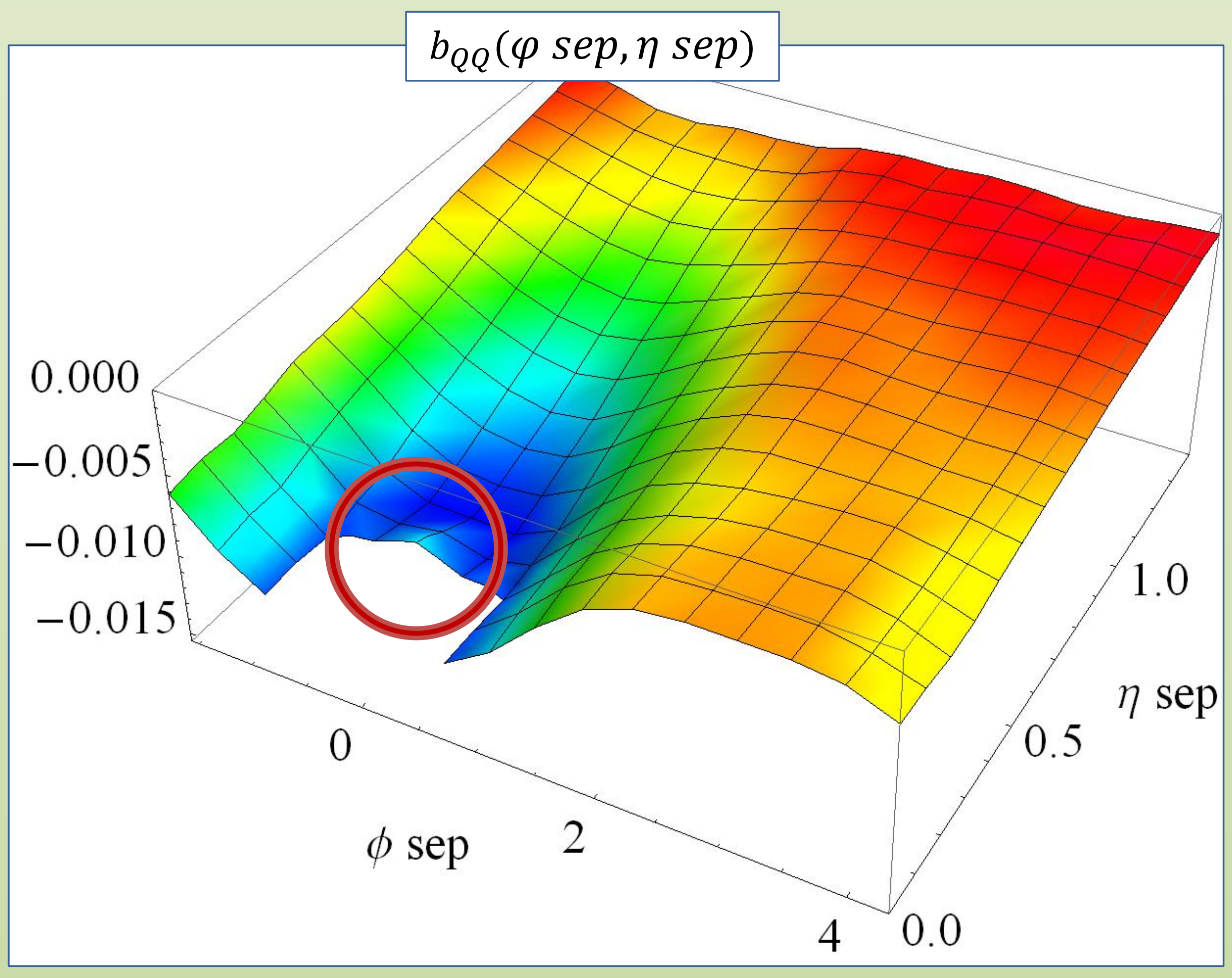
$$Q^2 = (p_1+p_2)^2 - (m_1+m_2)^2$$

λ parameter defines the strengh of correlation
R defines reference range in Q where the effect takes place

Bose-Einstein effects: on







Since b_{QQ} can be expressed as

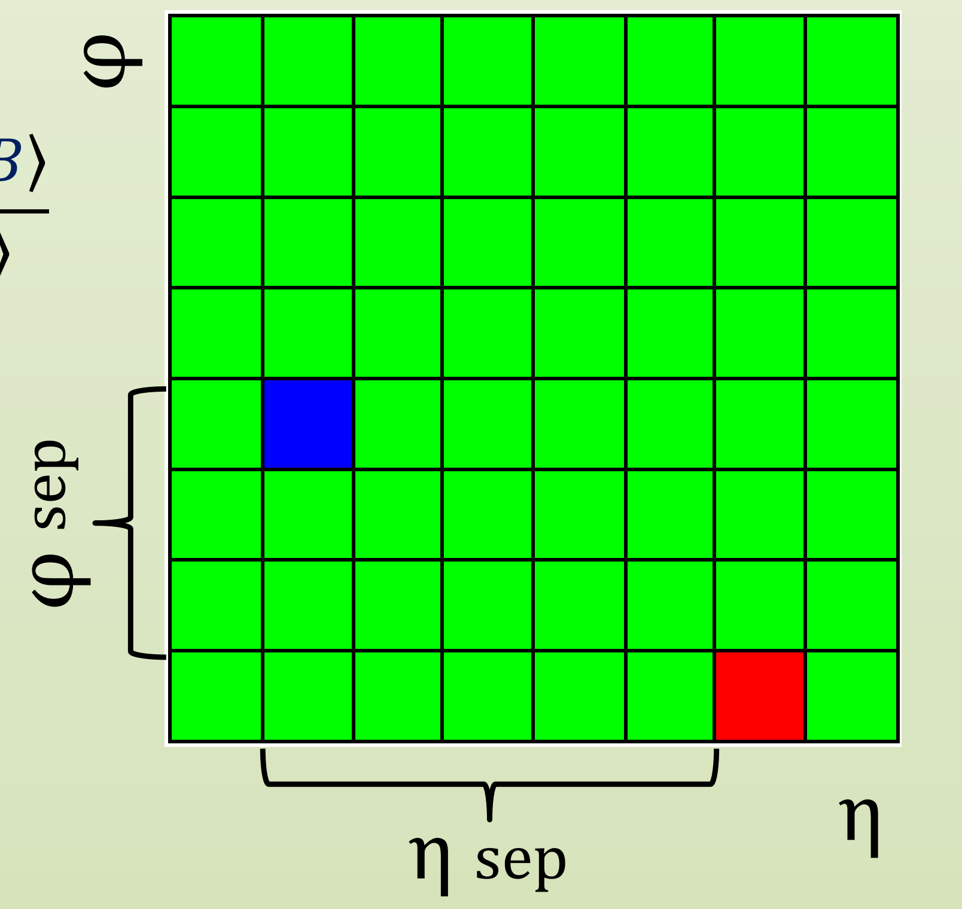
$$b_{QQ} = (b_{N+N+} - b_{N+N-})\frac{1}{1-b_{N+N-}{}^{F-F}}$$

And $b_{N+N-}{}^{F-F} \approx 0{,}05$

The bump appear because of the different behavior of b_{N+N+} and b_{N+N-} near the top point with former having a more steep rise.

Method

Forward and Backward windows are picked in pseudo-rapidity and azimuth angle phase space. For each configuration one can get correlation coefficient in two ways:



Correlation formula:

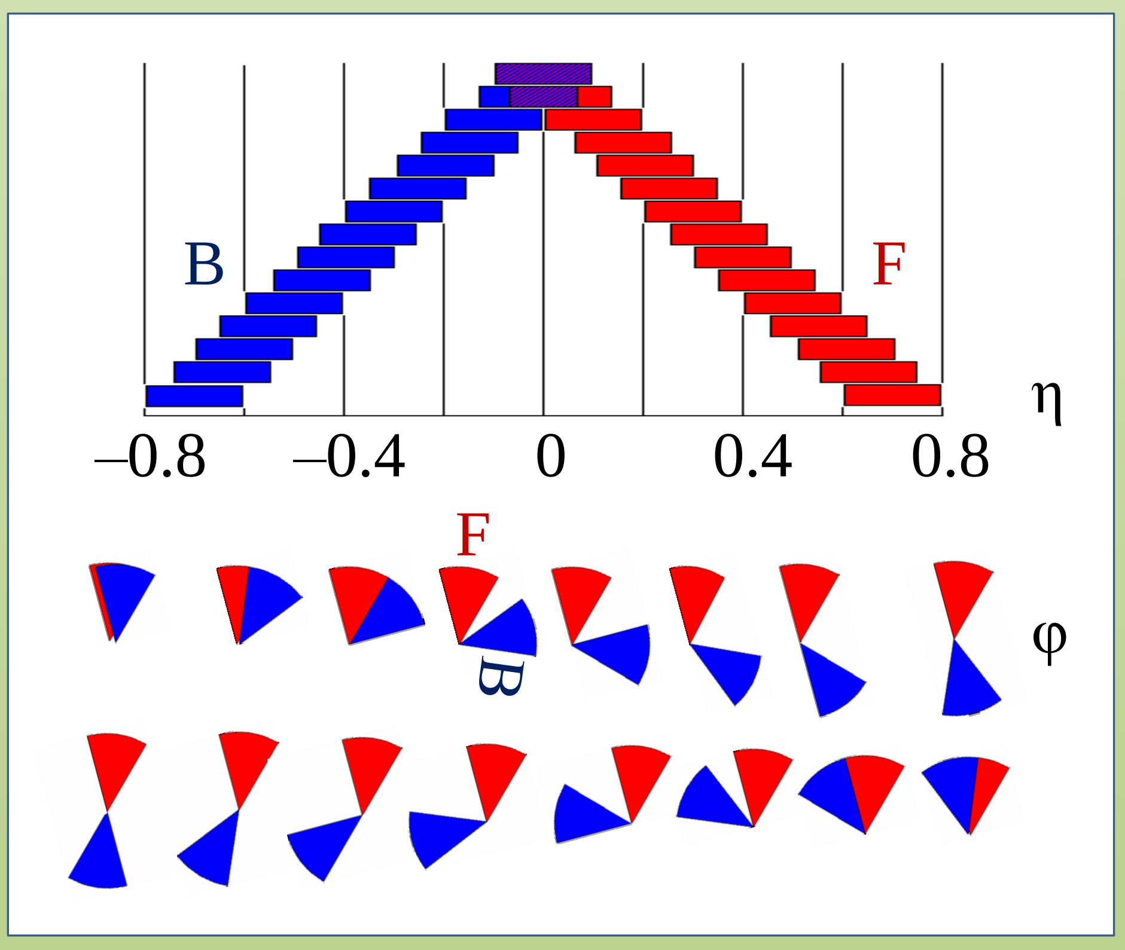
$$b_{FB}(\varphi\ sep, \eta\ sep) = \frac{\langle FB\rangle - \langle F\rangle\langle B\rangle}{\langle F\rangle^2 - \langle F^2\rangle}$$

Linear fit:

$$\langle B\rangle_F = a + F\ b_{FB}(\varphi\ sep, \eta\ sep)$$

F and B are:
Number of positive particles N+
Number of negative particles N-
Net-charge Q=N+ - N-
Or any other observable

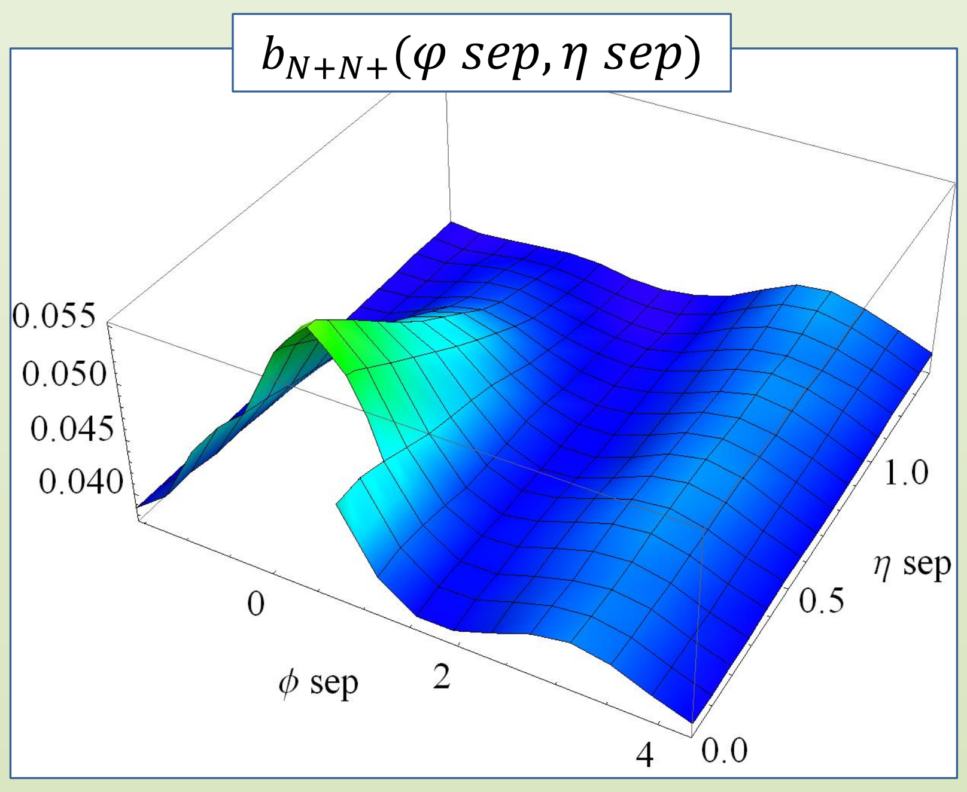
Windows configurations:

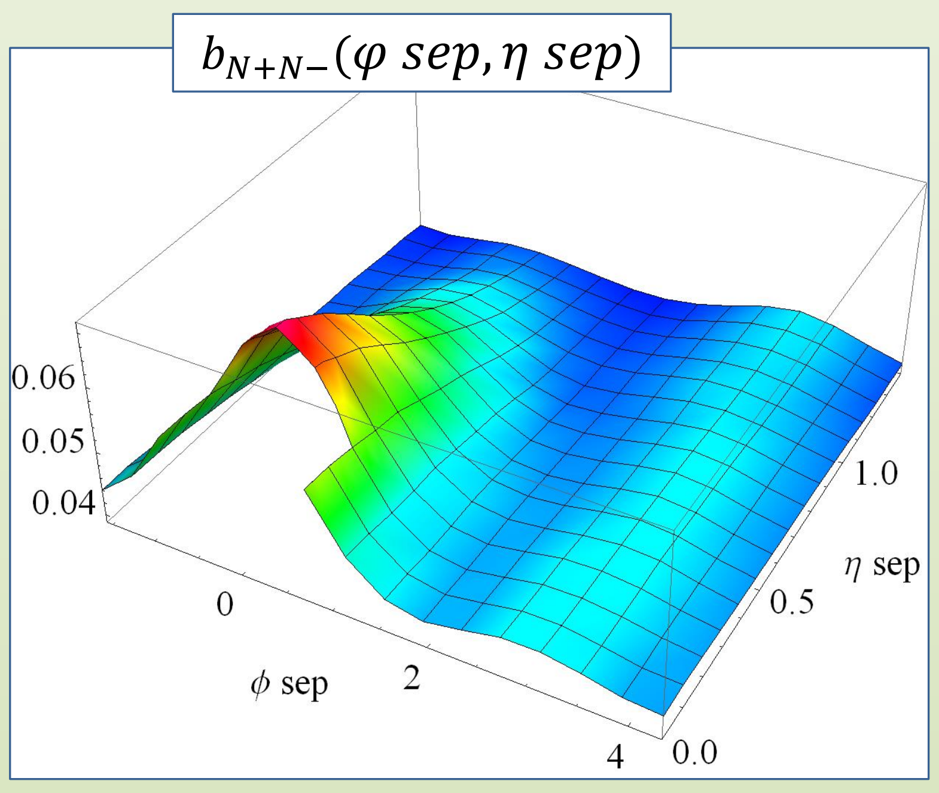


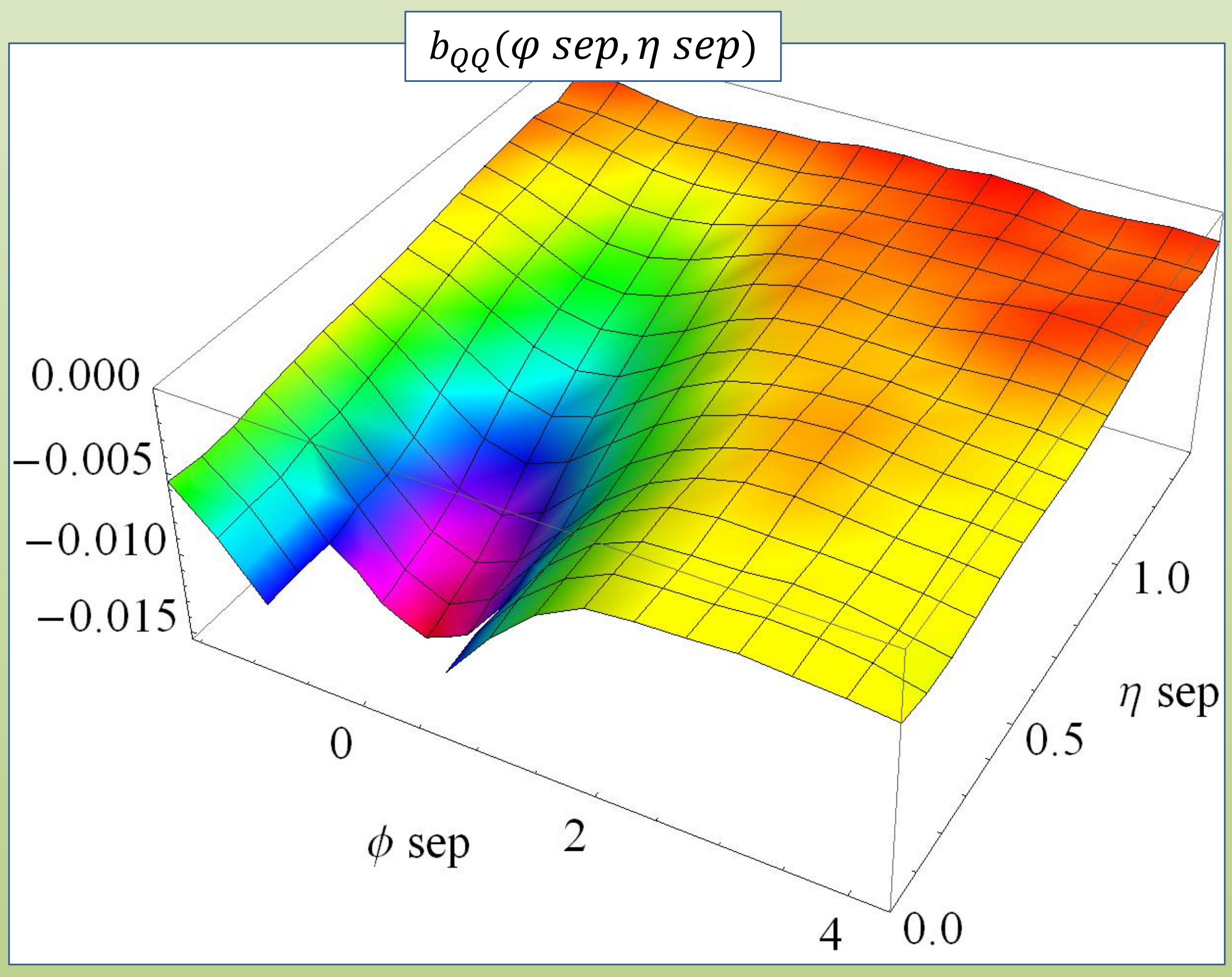
Acceptance:
Pseudo-rapidity range (-0.8, 0.8)
pT > 0.3 GeV/c

Windows width:
0.2 in pseudorapidity
π/4 in angle

Bose-Einstein effects: off







References

[1] http://home.thep.lu.se/~torbjorn/Pythia.html
[2] ALICE collaboration, ALICE PPR, vol. 2, part 2, 452-455 (2005)
[3] L. Lonnblad, T. Sjostrand, Eur.Phys.J., C2, 165-180, (1998) //arXiv:hep-ph/9711460