Two–particle Bose–Einstein Correlations in $pp$–collisions at $\sqrt{s} = 0.9$ and 7 TeV measured with the ATLAS detector

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Introduction

The Bose–Einstein correlations (BEC) lead to an enhancement of the production of identical bosons that are close together in phase space. The measurement of the two–particle BEC allows to study characteristics of the boson source and hadronization features.

Analysis

The two–particle correlation function:

$$C_{\ell}(p_1,p_2) = \frac{M_{\ell}(p_1,p_2)}{N_{\ell}(p_1)N_{\ell}(p_2)}$$

The double $R(Q)$ correction function:

$$R_{\ell}(Q) = \frac{C_{\ell}(Q)}{C_{\ell}(0)}$$

The MBTS trigger

Minimum Bias Trigger Scintillators (MBTS) [1]:

- 32 independent wedge–shaped plastic scintillators (16 per side of the ID)
- read out by PRTMs
- 2.00 $\langle |q| \rangle = 3.84$
- for triggering on min bias events, $> 99\%$ efficiency

The MBTS are used for triggering in 0.9 TeV and 7 TeV analyses.

Data and MC samples

Study based on the $pp$–collision datasets at the centre–of–mass energies $\sqrt{s} = 0.9$ and 7 TeV [2,3] and MC samples: MC09 PYTHIA6 (main) [4]. Perugi0 PYTHIA, PHoJet and EPOS.

The integrated luminosities are $\sim 7\,\mu b^{-1}$, $\sim 190\,nb^{-1}$, $\sim 12.4\,nb^{-1}$ for 0.9 TeV, 7 TeV Minimum Bias and 7 TeV High Multiplicity, respectively.

Main track and event selection criteria:

- $p_T \geq 100\,MeV$, $|\eta| < 2.5$
- At 0.9 TeV, 7 TeV MB:
  - Min Bias (MB) trigger relies on the MBTS
  - one primary vertex with 2 tracks
  - At 7 TeV HMT:
  - High Multiplicity (HM) trigger ($\geq 124$ tracks with $p_T > 0.3\,MeV$ on a single vertex at the trigger level) – one primary vertex with 108 tracks

The data are corrected for detector effects, such as the resolution and efficiencies, etc.

Summary

The multiplicity dependence of the BEC parameters characterizing the correlation strength $\lambda$ and the correlation source size $R$ is investigated at charged–particle multiplicities of up to 240. As $n_c$ increases $\lambda$ decreases and $R$ increases. The saturation effect in the $R_{n_c}(Q)$ dependence is observed using the high–multiplicity 7 TeV data sample.

The dependence of the BEC parameters on the average transverse momentum of the particle pair $k_t$ is also investigated. As $k_t$ increases $\lambda$ and $R$ decrease. The same behaviour for the $n_c$ and $k_t$ dependences is observed, and $R$ becomes larger for increasing charge multiplicity, consistently with the results of the $R_{n_c}(Q)$ dependence.

$n_c$ dependence of the BEC parameters

The average transverse momentum $k_t$ of the pair of particles:

$$k_t = \frac{|p_{t1} + p_{t2}|}{2}$$

Figure 3. The dependence of $R(Q)$ on $k_t$ for $n_c \leq 30$

Figure 4. $n_c$ and $k_t$ dependencies of 7 TeV MB

Main results:

- As $n_c$ increases $\lambda$ decreases and $R$ increases
- Within the uncertainties $\lambda$ and $R$ are energy–independent
- $R$ exhibits a saturation at high–multiplicities and for $n_c \geq 55$ is independent of the multiplicity

A bit of theory

The saturation of $R$ at high $n_c$ predicted by the Pomeron–based model [7], due to highly overlapping of colliding protons, i.e. at $n_c > 70$, remarkably close to the one obtained in our studies (see the Constant fit result for $n_c \geq 55$). However, the model predicts $R$ decreases with $k_t$ for $n_c \geq 70$ in contradiction with our analysis.

Figure 5. Comparison of the $R_{n_c}(Q)$ fits

The total errors are presented. The statistical errors for $p_T > 15\,MeV$.

References


Figure 6. $n_c$ and $k_t$ dependencies of 7 TeV MB

Main results:

- The behaviour is similar to the $k_t$ dependence of $\lambda$ and $R$
- $R$ values increase with $n_c$ in agreement with the feature observed in Figure 2

Reference:

arXiv:1502.07947