Proton–Lambda Correlations in Au–Au Collisions at \( \sqrt{s_{NN}} = 200 \) GeV from the STAR Experiment

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Received 8 July 2004

Abstract. The space-time evolution of the source of particles formed in the collision of nuclei can be studied through particle correlations. The STAR experiment is dedicated to study ultra-relativistic heavy ions collisions and allows to measure non-identical strange particle correlations. The source size can be extracted by studying \( p-\Lambda, \bar{p}-\bar{\Lambda}, p-\bar{\Lambda} \) and \( p-\bar{\Lambda} \) correlation functions. Strong interaction potential has been studied for these systems using an analytical model. Final State Interaction (FSI) parameters have been determined and has shown a significant annihilation process present in \( p-\bar{\Lambda} \) and \( p-\bar{\bar{\Lambda}} \) systems not present in \( p-\Lambda \) and \( p-\bar{\Lambda} \).

Keywords: interferometry, non-identical particles, Final State Interaction
PACS: 25.75.Gz

1. Introduction

Non-identical particles are correlated due to final state Coulomb and nuclear interactions [1]. Contrary to \( p-\Lambda \) [2–4], the nuclear Final State Interaction (FSI) of \( \bar{p}-\bar{\Lambda} \), \( p-\bar{\bar{\Lambda}} \) and \( p-\bar{\bar{\bar{\Lambda}}} \), is still unknown. In this paper, data from the STAR experiment are shown and the Lednický & Lyuboshitz model [5] is used to analyse experimental correlation functions [6]. The STAR detector (a Solenoid Tracker At RHIC), installed at RHIC (Relativistic Heavy Ion Collider), allows the reconstruction of the particles produced during the Au+Au collisions at 200 GeV per nucleon pair in the center of mass.
2. Experimental Correlation Functions

The particles are measured in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV using the Time Projection Chamber (TPC). Central events accounting for 10% of the total cross section are selected.

The relevant variable is the momentum of one of the particles in the pair rest frame called here $\vec{k}^*$. The non-correlated background is constructed by mixing events with primary vertex separated from each other by less than 10 cm. The correlation function has been extracted by constructing the ratio of two distributions. The numerator is the $|\vec{k}^*|$ distribution of pairs from the same event. The denominator is the $|\vec{k}^*|$ distribution of pairs from mixed events.

Protons and anti-protons are selected using their specific energy loss ($dE/dx$). Protons and anti-protons are selected using their specific energy loss. In addition some geometrical cuts are applied, giving a lambda/anti-lambda purity sample of 86%, the remaining 14% representing the combinatoric background. Only lambdas/anti-lambdas in the rapidity range $|Y| < 1.5$ are selected. Due to the acceptance of the detector, the transverse momentum range is 0.3–2.0 GeV/c.

The contamination and the feed-down have been studied in order to estimate the purity (Eq. (1)) of $p$, $\bar{p}$, $\Lambda$ and $\bar{\Lambda}$ as a function of the transverse momentum ($p_t$). The purity is defined as the product of the probability of identification (Pid) multiplied by the fraction of primary particles (Fp).

$$\text{Purity}(p_t) = \text{Pid}(p_t) \times \text{Fp}(p_t).$$

The probability of identification has been estimated as a function of $\vec{k}^*$ for charged particles. Identified protons (anti-protons) from the selected sample account for 76.5 ± 2% (74 ± 2%). For lambda/anti-lambdas the probability of identification correspond to the signal over noise value, it is independent of $|\vec{k}^*|$: 86.54 ± 0.04% (86.13 ± 0.04%).

The feed-down estimation has been done for $p$, $\bar{p}$, $\Lambda$ and $\bar{\Lambda}$ as a function of the transverse momentum ($p_t$) in order to take into account the $|\vec{k}^*|$ dependence of the purity. Combined results from STAR [11–16] and predictions from the thermal model [10] have been used. The approximations done by estimating the purity, raise the problem of considerable uncertainties on extracted values for FSI parameters and radii.

The calculated feed-down leads to an estimated purity of 54% for primary protons ($\langle p_t \rangle = 0.70$ GeV/c). Most of the secondary protons come from lambda decay and represent 35% of the protons used to construct the correlation function. Other sources of contamination of protons are provided by decay products of $\Sigma^+$ and pions interacting with matter, which represent respectively 10% and 1% of the sample.