Abstract

In p+p, d+Au, and Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV with the STAR detector at RHIC, $\Sigma(1385) \rightarrow \Lambda + \pi$ were measured using two techniques; three-particle mixing and a hybrid mixing technique. We present results from both of these methods and compare the invariant mass spectra and the backgrounds.

Keywords: Resonances, Relativistic Heavy Ion Collisions

Introduction

Due to the very short lifetime ($\sim$ few fm/c) of resonances a large fraction of the decays occur inside the reaction zone in the most central relativistic heavy ion collisions. These resonances have a high probability of not being reconstructed as their daughter particles are likely to re-scatter in the medium. Resonances with higher transverse momentum are more likely to be reconstructed because of their longer relative lifetimes. This means they are more likely to decay outside of the medium and hence their daughter particles would interact less with the medium[1]. This may give rise to effects such as changes in the physical properties of the resonances, width broadening and mass shifts, or changes in the transverse momentum $(p_T)$ spectra due to re-scattering of the decay particles. Hence the study of resonances provides an additional tool to determine the hadronic expansion time between chemical and thermal freeze-out. Due to its strange quark content and high mass, $\Sigma(1385)$ may also give additional information about strangeness enhancement, one of the possible signatures of the Quark Gluon Plasma [2].

There are also several models currently available that attempt to describe hadronic matter with resonances. One is based on the thermal model and argues that the direct measurement of resonances can probe both the hadronization temperature and the lifetime of the interacting hadron gas phase [3]. In this model, the ratios of resonances to lighter particles with identical number
of valance quarks are sensitive to the freeze-out temperature because all of the chemical dependence cancels out in the ratio.

1. Analysis and Particle Identification

Charged daughter particles are identified by the momentum and the energy loss per unit length (dE/dx) measured in the Time Projection Chamber of STAR (TPC)\[4\]. For long-lived particles (cτ \sim few cm\) such as the \(K^0\), \(\Lambda\), and \(\Xi\), the decay vertex topology is used for identification. This technique cannot be used for resonances due to their very short lifetimes (cτ\(\Sigma(1385)\) = 5 fm/c). However an alternative method, called the mixing technique, can be used and also applied to identify other short-lived particles such as pentaquarks and dibaryons.

The decay channel that we investigate is \(\Sigma(1385) \rightarrow \Lambda + \pi\). We use two methods to identify \(\Lambda\)’s. In the first method, the three particle mixing technique (TPM), every \(\pi\) is combined with every \(p\) to produce a \(\Lambda\) candidate. Then the \(\Lambda\) candidate is combined with all remaining \(\pi\) to get \(\Sigma(1385)\). In the second method, the hybrid mixing technique (HM), \(\Sigma(1385)\)’s are identified by combining topologically reconstructed \(\Lambda\)’s with \(\pi\)’s. In both techniques the background is described by combining \(\pi\)’s from one event with the \(\Lambda\)’s from another event.

2. Status of Current Studies

\(\Sigma(1385) \rightarrow \Lambda + \pi_{bachelor}\) is identified in p+p, d+Au, and Au+Au collisions with the mixing techniques. Figure 1 is the invariant mass spectra of the \(\Sigma(1385)\) for the various nuclear systems studied. With the TPM technique, in the lower kinematic limit of the invariant mass spectrum a background structure appears (Fig 1-a). This initial structure increases in the d+Au collisions and totally dominates the spectrum in Au+Au collisions, due to an increase in background combinatorial statistics. Monte Carlo studies show that a partial contribution of the background structure comes from the misidentification of the \(\Lambda\)’s with the \(\pi_{bachelor}\) and misidentification of \(K\)’s as \(\pi\)’s. A more detailed study with the simulations is needed to find the ratio of each contribution and the other possible sources. The HM technique can be used to identify \(\Sigma(1385)\) with less efficiency but with a cleaner background (Fig 1-b,c,d). Since \(\Lambda\)’s can be identified more cleanly with the decay topology technique, the initial structure disappears. Antiparticle to particle ratios of \(\Xi\) and \(\Sigma(1385)\) are observed as 0.89 ± 0.04 and 0.90 ± 0.07 respectively in p+p collisions. These values are consistent with a net baryon-free collision environment.

With available events, it is possible to study the \(p_T\) spectra of the \(\Sigma(1385)\) for all systems. In order to correct for STAR’s efficiency and acceptance, a study using Monte Carlo tracks embedded into real events is necessary.
Σ(1385) Resonance Studies with STAR at $\sqrt{s_{NN}} = 200$ GeV

3. Summary

Using the mixing technique Σ(1385) and Ξ are constructed in $\sqrt{s_{NN}} = 200$ GeV p+p, d+Au, and Au+Au data. Raw yields and ratios are presented. Corrections to these values are being investigated and will be resolved in the very near future. Fireball temperature of the collision can be studied using the $p_T$ distributions after the corrections. Studying Au+Au collisions is essential to understand possible rescattering and medium effects on resonances. It is possible to study pentaquarks with STAR and with the upcoming run starting this January 2004 we will continue our investigation of exotic particles by using the STAR Silicon Vertex Tracker (and eventually a new Time of Flight detector system).

References

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