The recent preliminary results from central Au+Au collisions at √(sNN) = 130 GeV from the STAR experiment at RHIC are presented and discussed along with the results on the Λ(1520) production in central Pb+Pb and p+p collisions at √s = 17 GeV from the NA49 experiment at the SPS. The Λ(1520) is measured with the invariant mass reconstruction of the decay products in the hadronic channel (K−, p). The mean Λ(1520) multiplicity scaled by the number of participants decreases from p+p to Pb+Pb collisions at the same energy of √s = 17 GeV. An upper limit estimate of the multiplicity from the first measurement at √(sNN) = 130 GeV shows the same trend. Comparisons with model predictions provides an indication of possible medium effects on the resonance and their decay daughters.

1. Introduction

The Λ(1520) is a baryon resonance with a mass of m = 1519.5 MeV/c² and a width in vacuum of Γ = 15.6 MeV. This corresponds to a lifetime of τ = 13 fm/c which is of the same order as the fireball source. The measurement of Λ(1520) in heavy ion collisions may provide information about the early state of the expanding source in terms of the influence of the medium on the resonance and decay particles. Comparisons between p+p and A+A interactions may show directly the influence of the medium. However from these results it is not easy to distinguish between a medium effect on the resonance or their decay products. Additional multiplicity measurements from other short lifetime resonances allow us to make an estimate of the chemical freeze out temperature and lifetime of the fireball if only rescattering of the decay products in the medium is considered. The possible change of the width of the resonance signal, associated with a change in lifetime, can provide an additional effect on the multiplicity of the resonance measured with the invariant mass reconstruction method.

2. Analysis

The STAR [1] and the NA49 [2] experimental setup consists of large volume Time Projection Chambers (TPC) which measure the momenta of charged particles and their energy loss, dE/dx. A central trigger selects the 14% (STAR) and 5% (NA49) most central inelastic interactions. The decay daughter candidates for K− and p are selected via their momenta and dE/dx. The Λ(1520) signal is obtained by the invariant mass reconstruction of each pair combination and the subtraction of a mixed event background estimated by combining candidates from different events. The

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largest uncertainty of this analysis is calculating the correction factor for a total \((4\pi)\) multiplicity in \(A+A\) collisions, where the phase space distribution is not measured. The inverse slope parameters \(T\) are taken from the measured \(\Lambda_s, T = 350\) MeV (STAR \cite{11}) and \(T = 300\) MeV (NA49 \cite{15}). The assumption for the rapidity distribution is a gaussian with a width \(\sigma = 1.5 \pm 0.5\) and \(\sigma = 1.0 \pm 0.5\) for STAR and NA49 respectively. The total mean acceptances in the TPCs are \(0.51 \pm 0.08\) (STAR) and \(0.82 \pm 0.5\) (NA49). Figure 1 shows the acceptance distributions from a simulation in phase space coordinates \(y\) and \(p_T\) for the STAR and NA49 TPCs.

\[\text{Figure 1. Acceptance of the } \Lambda(1520) \text{ in STAR (left) and NA49 (right) TPCs in rapidity and transverse momentum.}\]

\(p+p\) at \(\sqrt{s} = 17\) GeV

The invariant mass distribution from 400,000 \(p+p\) collisions is shown in Figure 2 (left) \cite{9, 14}. The Breit-Wigner fit parameters mass \(m = 1517.1 \pm 1.5\) MeV/c\(^2\) and width \(\Gamma = 15.4 \pm 3.8\) MeV/c\(^2\) are consistent within errors with the values from the Particle Data Group \cite{16}. The mean multiplicity is \(\langle \Lambda(1520) \rangle = 0.0121 \pm 0.003\). A comparison with measurements at different energies in Figure 2 (right) shows good agreement with the energy dependence of the particle production.

\[\text{Figure 2. Left: } \Lambda(1520) \text{ mass plot after mixed event background subtraction with a Breit-Wigner function. Insert plot: Mass plot before mixed event background subtraction. Right: } \Lambda(1520) \text{ multiplicity in elementary } p+p \text{ collisions for various energies} \text{.}\]
Pb+Pb at $\sqrt{s}=17$ GeV

Figure 3 shows the invariant mass distribution with 400,000 events from Pb+Pb collisions [9, 14]. The Breit-Wigner fit parameters for the mass $m=1518.1\pm2.0$ MeV/c$^2$ and width $\Gamma=22.7\pm6.5$ MeV/c$^2$. The $\Gamma$ seems a little broad but is consistent within errors with the values from the Particle Data Group [16]. This leads to a mean multiplicity $\langle \Lambda(1520) \rangle = 1.45 \pm 0.29 \pm 0.28$ with statistical and systematical errors.

3. Discussion of $\Lambda(1520)$ production at $\sqrt{s}=17$ GeV

If we scale the $\Lambda(1520)$ multiplicity from p+p collisions with the number of participants for central Pb+Pb collisions $(360/2)$ we get a prediction of $\langle \Lambda(1520) \rangle = 2.2$. If we then scale with the known $\Lambda$ strangeness enhancement factor ($\sim 2-2.5$) [10] the yield becomes $\langle \Lambda(1520) \rangle \approx 5$. This number is close to the predictions from thermal model calculations with $\langle \Lambda(1520) \rangle = 3.5 \ (\gamma_s = 0.7)$ [14] and $\langle \Lambda(1520) \rangle = 5.2 \ (\gamma_s = 1)$ [7]. The measured yield in central Pb+Pb collisions is $\langle \Lambda(1520) \rangle = 1.45 \pm 0.40$ which is a factor of 2-3 lower than the expected value. This trend of signal suppression is also visible in the $\langle \Lambda(1520) \rangle/\Lambda$ and $\langle \Lambda(1520) \rangle/\pi$ particle ratios.

The particle ratios $\langle \Lambda(1520) \rangle/\langle \pi \rangle$ in Figure 4 (left) and $\langle \Lambda(1520) \rangle/\langle \Lambda \rangle$ in Figure 4 (right) decrease from p+p to Pb+Pb collisions. If we assume that the $\langle \Lambda(1520) \rangle/\langle \Lambda \rangle$ ratio were produced thermally the chemical freeze out temperature would be smaller than 100 MeV from the model predictions. This is in contradiction to the freeze out temperature calculated from other particles [5]. F. Becattini pointed out in his talk at this conference that the $\Lambda(1520)$ multiplicity at SPS energies cannot be described by his thermal model. The question is what can cause this signal loss during the expansion of the fireball source. There are several ideas of possible medium effects which can cause a reduction of the measured $\Lambda(1520)$ resonance. One possible medium...
effect on the decay products is their rescattering, which changes their momentum and energy. The UrQMD model calculation gives a signal loss of 50% for the $\Lambda(1520)$ as a result of rescattering of the $K^-$ and the protons. If only the rescattering effect is present, it should also be seen for the $K^*(892)$, whose lifetime is 3 times shorter. However from NA49 the $K^*(892)/\pi$ measurement shows no visible suppression within errors (see Figure 5).

Model calculations shown in Figure 6 including the lifetime of the fireball source and the chemical freeze out temperature by comparing two particle ratios namely $\Lambda(1520)/\Lambda$ and $K^*(892)/K$ shows that there is only agreement between the two ratios if the temperature is lower than 100 MeV and the time between the chemical and thermal freeze out is close to zero. The low temperature is in contradiction with the thermal freeze out temperature, which is around 170 MeV. A conclusion from this model is that the rescattering of the decay particles in medium may not be the only effect.
Another possibility which would result in a reduction of the measured Λ(1520) signal can be a medium effect on the resonance itself. A broader width of the resonance in medium corresponds to a shorter lifetime and this in terms causes a larger signal loss due to rescattering of the decay products. A prediction based on relativistic chiral SU(3) dynamic calculations [12, 13] gives a 100 MeV broadening of the Λ(1520) resonance and a mass shift of about 100 MeV to lower masses in medium at a density of ρ = 0.17 fm$^{-3}$. The fact that the Λ(1520) signal from Pb+Pb reactions from NA49 shows no width broadening within the errors, indicates that only the decay daughters which come from a Λ(1520) resonance with normal width survive and decay at the end of the fireball evolution. In this conference a talk from E.E. Kolomeitsev shows that this medium effect is not only able to describe the signal loss it may also describe a possible change in the slopes of the p$_T$ distribution. This was shown for the φ particle in the hadronic and the leptonic channel. The calculations are only done for the φ particle. The Λ(1520) and the K*(892) are in progress. To gain some confidence in the signal suppression of the Λ(1520) resonance due to in-medium effects it is necessary to measure additional resonances (e.g. Σ(1385)) and take additional measurements at different energies.

4. Au+Au at $\sqrt{s_{NN}} = 130$ GeV

The RHIC data from 2000 are used to look for the Λ(1520) at higher energy. The analysis is done with 370,000 central Au+Au events. Figure 7 (left) shows the invariant mass distribution of the selected decay particles (insert plot) and the mixed event background subtracted histogram. There is no clear Λ(1520) signal visible, also the background from the mixed event method is imperfect. The counts in the invariant mass region where we expect the signal multiplied by the correction factor give a number which is consistent with zero within statistical and systematical errors. The preliminary total mean multiplicity is $\langle \Lambda(1520) \rangle = 0.92 \pm 0.81 \pm 0.83$. From the statistical errors we can estimate how sensitive we are to Λ(1520) production and exclude a multiplicity using the upper limit method. Here $\langle \Lambda(1520) \rangle < 4.2$ at the 95% confidence level. The expected multiplicity from extrapolated elementary p+p reactions including an addition factor of 2 for strangeness enhancement is $\sim 7.7$. The
upper limit estimate suggests that at RHIC energies we see the same trend of signal loss as at SPS energies. The simulation in Figure 7 (right) shows the predicted invariant mass signal from a statistical analysis if the \( \langle \Lambda(1520) \rangle \) yield were 7.7.

**Figure 7.** Left: Invariant mass plot for \( K^- \) and p pairs after mixed event background subtraction. Insert plot: Mass plot before mixed event background subtraction. Right: Simulation for \( \langle \Lambda(1520) \rangle = 7.7 \).

### 5. Conclusions

The \( \Lambda(1520) \) multiplicity measured from the NA49 experiment at the SPS in p+p collisions at \( \sqrt{s} = 17 \text{ GeV} \) is in good agreement with the data from the literature. The measured multiplicity in Pb+Pb at \( \sqrt{s} = 17 \text{ GeV} \) is \( \langle \Lambda(1520) \rangle = 1.45 \pm 0.40 \) which cannot be described by a thermal model only. A suppression factor of 2 is needed to reproduce the measured multiplicity. A comparison with the \( K^*(892) \) resonance gives indications of medium effects on the \( \Lambda(1520) \) resonance itself. The first measurement from the STAR experiment at RHIC energies \( \sqrt{s_{NN}} = 130 \text{ GeV} \) gives an upper limit of \( \langle \Lambda(1520) \rangle < 4.2 \), which follows the same suppression trend as the SPS results. The question why the \( \Lambda(1520) \) multiplicity is lower than expected is unanswered yet, but many interesting theoretical ideas have been proposed. We hope to extract a signal from STAR with the data from the year 2001 where are about 3.5 million central Au+Au events at \( \sqrt{s_{NN}} = 200 \text{ GeV} \) have been recorded.

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