RESONANCE MEASUREMENTS

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Many resonances were observed at RHIC: $\rho(770)^0$, $f_0(980)$, $K^*(892)^{0\pm}$, $\phi(1020)$, $\Delta(1232)^{++}$, $f_2(1270)$, $\Sigma(1385)$, and $\Lambda(1520)$.

The measurement of resonance yields showed that for short-lived resonances, there are significant rescattering of the resonance daughters that can regenerate the resonances or prevent them to be reconstructed. In the case of the K^{*0} ($c\tau =$ 4 fm), using the K^{*0}/K ratio measured in Au+Au and pp collisions we estimated that the lifetime between chemical and kinetic freeze-outs is ~ 3 fm if the daughters rescattering preventing the K^{*0} to be reconstructed is the dominant process. If $K\pi \to K$ is relevant, then the lifetime should be greater than ~ 3 fm. In the case of the ϕ ($c\tau = 44$ fm), the rescattering of the resonance daughters should be negligible, since the ϕ decays outside the medium. Indeed, the ϕ/K ratio is independent of centrality, also indicating that the ϕ is not produced via KK coalescence.

It was inconclusive whether the nuclear modification factor difference between the K^0_S and Λ was due to a baryon-meson effect or simply a mass effect. The K^{*0} nuclear modification factor was measured at intermediate p_T and it was shown that it is closer to the K^0_S nuclear modification factor than the Λ, favoring the baryon-meson effect in the particle production in the intermediate p_T region.

In the intermediate p_T range, identified hadron v_2 measurements have shown that the hadron v_2 follows a simple scaling of the number of constituent quarks in the hadrons. Therefore, the v_2 for the K^* produced at hadronization should follow the scaling law with $n = 2$, where n is the number of constituent quarks. However, for the K^* regenerated through $K\pi \to K^*$ in the hadronic stage, v_2 should follow the scaling law with $n = 4$. Significant K^* v_2 was measured; however, due to the large statistics uncertainties, it was not possible to identify the K^* production fractions from direct quark combinations or hadron combinations.

$\rho(770)^0$ mass shifts of about -40 MeV/c^2 and -70 MeV/c^2 were measured in pp and peripheral Au+Au collisions at RHIC, respectively. In addition, a $K(892)^*$ mass shift of about -10 MeV/c^2 at low p_T was observed in pp collisions. The possible explanations for a mass shift are phase space, medium modification, Bose-Einstein correlations, and interference. The phase space does not account for the $\rho(770)^0$ mass shift measured at RHIC, CERN, and LEP. Bose-Einstein correlations and interference does not account for the mass shift observed in high multiplicity pp and peripheral Au+Au collisions at RHIC, suggesting the medium modification of the ρ^0 meson.

In order to have a complete picture, we should measure the spectra, the masses, the widths, the v_2, and the nuclear modification factors for all resonances as a function of centrality in Au+Au collisions, and also in lighter systems for comparison. We should measure the leptonic decay channels of resonances such as the $\rho(770)^0$, $\omega(782)$, and $\phi(1020)$. The comparison with the hadronic decay channel of the $\rho(770)^0$ and $\phi(1020)$ is very important, since it will give insight of the collision dynamics and information on a possible chiral symmetry restoration. We should also look at different resonances, e.g. $a_1 \to \gamma\pi$.

In order to accomplish all these measurements we need more statistics, detector upgrades, and better understanding of the combinatorial background. In the case of detector upgrades, the TOF (Time Of Flight) full coverage will considerably improve the resonance measurements. The TOF will provide clean particle identification of π, k, and p up to $\sim$ 5 GeV/c, which will not only decrease the signal to background ratio, but also allow the measurement of resonances at higher p_T. In addition, the TOF will provide a clean electron identification at lot p_T. Even though the TOF will provide clean particle identification of π, the bulk of particles produced in heavy-ion collisions are π's. As a consequence, the TOF will not improve significantly the $\pi^+\pi^-$ combinatorial background, which means that this will still need further understanding. We will also need to be able to deal with the background, and for that we can use the TPC (Time Projection Chamber), TOF, SVT (Silicon Vertex Tracker), and HFT (Heavy Flavor Tracker). The number of events needed to measure the $\phi \to e^+e^-$ and $\omega \to e^+e^-$ with a 3σ signal in central Au+Au collisions is estimated to be 2M and 8M, respectively for a TPC+TOF detector combination. In the case of TPC+TOF+SVT+HFT combination, 100K and 200K events are needed to measure the ϕ and ω, respectively. This shows that the SVT+HFT can significantly reduce the photon conversion background. For more details see K. Schweda talk and write-up.

According to R. Rapp, all previous calculations of photons from a_1 decays so far have concentrated on the corresponding inclusive photon yield, and therefore it is very difficult to isolate the a_1 contribution; in addition, it gives little information about the spectral shape of the a_1 (axialvector-isovector) channel. This is the main point about trying to measure the associated (charged) pion. If chiral symmetry is (approximately) restored, the a_1 spectral distribution is expected to undergo major modifications, becoming (approximately) identical to the one of the ρ meson (vector-isovector channel). Together with the dilepton measurements of the ρ meson we might be able to make the most convincing case on chiral symmetry restoration.

We studied the $a_1 \to \gamma\pi$ channel using transport model calculations. Here we used minimum bias Au+Au UrQMD events at $\sqrt{s_{NN}}$ = 200 GeV. In UrQMD, $a_1 \to \gamma\pi$ with B.R. = 0.1, $a_1 \to \rho\pi$ with B.R. = 0.9, $Mass_{a_1}$ = 1230 MeV/c^2, and Γ_{a_1} = 400 MeV/c^2. Only 5% of the a_1 produced are not absorbed in the medium, and from the a_1 not absorbed 80% are a_1 from the $\gamma\pi$ channel and 20% are a_1 from the $\rho\pi$ channel. The spectral shape of the $a_1 \to \gamma\pi$ that are not absorbed is significantly different from the spectral shape of the a_1 produced, where the position of the a_1 is shifted by about -200 MeV/c^2 .

The number of events to measure the $a_1 \to \gamma\pi$ in minimum bias Au+Au collisions with a 3σ signal is estimated to be 54M, where we used an efficiency of 5% to measure γ through its conversion ($e^+e^- \to \gamma$). The background was estimated using minimum bias Au+Au Hijing events at $\sqrt{s_{NN}}$ = 200 GeV and a detailed description of the STAR detector without the HFT and the full coverage TOF. In Hijing, there is no a_1 produced, but $\pi^0 \to \gamma\gamma$ and $\gamma \to e^+e^-$.