Search for new hadronic states decaying into ΛK+ and ΛK0s with STAR at RHIC

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One of the most spectacular results of RHIC, is that hadrons in heavy ion collisions, appear to be produced mainly through quark coalescence. Exotic multiquark states, allowed by QCD, can therefore form through quark coalescence, and be enhanced as compared to elementary collisions, in which coalescence does not prevail as production mechanism. A preliminary peak, candidate for a new N0 or Ξ0 state has been measured near 1730 MeV in STAR and two other experiments in the ΛK0s and the Σ-K+ invariant masses. The latter if confirmed, excludes the Ξ0 hypothesis.. If this peak is a true N0 state, the isospin partner N+ should exist at same mass. We present preliminary results on a possible candidate peak for the expected isospin partner, namely the N+ → ΛK+ at nearby mass. Furthermore we present new studies for the ΛK0s peak which have been requested by STAR.

One of the most spectacular results of RHIC is the elliptic flow versus transverse momentum scaling with the number of constituent quarks observed in heavy ion collisions at RHIC, suggesting that the majority of midrapidity hadrons in Au+Au collisions at RHIC are formed through quark coalecence out of a partonic source, possibly representing an sQGP. Exotic multiquark states can therefore form through quark coalescence, and be enhanced in heavy ion collisions as compared to elementary particle collisions, in which coalescence does not prevail as production mechanism. Heavy ion collisions at RHIC and LHC may therefore be a unique source of QCD exotics.

Exotics are allowed by QCD, however lattice QCD and different QCD models lead to contradictory predictions, as of their existence and characteristics, reflecting the difficulties in such calculations, touching on non perturbative QCD aspects.

The STAR experiment is the only RHIC experiment able to measure many strange hadrons in a large acceptance. STAR accumulated by now a very high statistics of events over 8 years of long dedicated runs of 6 months each. Therefore, STAR offers at the moment a unique advantage for searches for exotica with high strangeness content, formed at midrapidity, through parton coalescence.

A preliminary narrow peak, candidate for the states udsdsbar (N0) or udssdbar (Ξ0) has been measured near 1730 MeV (Fig. 1) in STAR, in the ΛK0s inv. Mass, in Au+Au collisions at 200 GeV, with S/√B of 5-6 (hep-ex/0406032), as well as in two other experiments, in the ΛK0s and Σ-K+ decay channels. The latter if confirmed, would exclude the Ξ0 hypothesis.. If this peak is a true N0 or Ξ0 state, the isospin partner, N+ for N0, or Ξ- for the Ξ0 should exist at same mass.

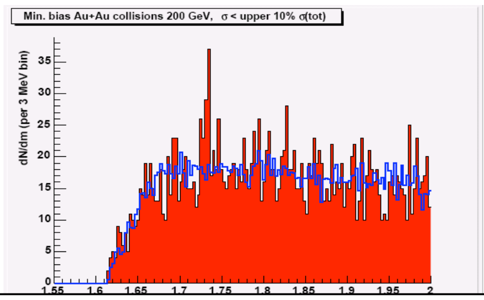

Fig. 1 Invariant Mass ΛK0s in Au+Au coll. at 200 GeV. Blue line : rot. background.

Here we present preliminary results on a candidate peak for the expected isospin partner of the N0, namely the N+ → ΛK+ at nearby mass (master thesis, H. Ricaud). The data analysed are part of Au+Au collisions at 200 GeV taken with a minimum bias trigger in run 2004. The key new feature of the method used for both ΛK+ and ΛK0s analysis as compared to other analysis done within STAR, is the unprecedently hard identification cuts,

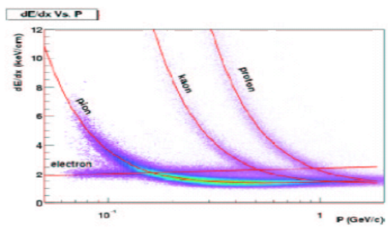

Fig 2 : Energy loss of particles versus momentum.

leading to excellent K+, K0s and Λ identification. In other analysis of STAR such high purity of Λ, K+ and K0s is not required.

The K+ are identified through their De/dx (Fig. 2). We select the K+ in the low momentum range below 0.45 GeV and De/dx>-2 (fig. 2 and fig. 3 left). Taking larger momenta of K+, the pion contamination from the left is increasing (Fig. 3 middle and right).

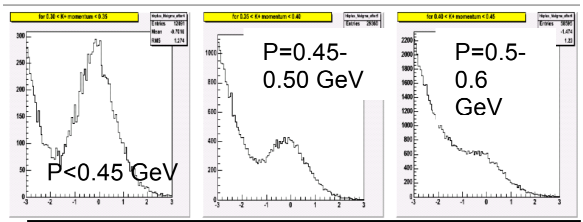

Fig 3 : De/dx in σ away from Kaon mean dE/dx, for different momenta (p) of the K+.

The Λ are identified through topological cuts and Armenteros cuts. Only unambigouos Λ candidates are taken in the analysis. Good candidates which can be also K0s are excluded. The invariant mass of ΛK+ after the selection cuts is shown in fig.4 left. In fig. 4 right, a rotated background estimate is shown before normalization, to demonstrate that the background estimate describes approximately the form of the left plot, and that no peak appears in the background near 1700 MeV.

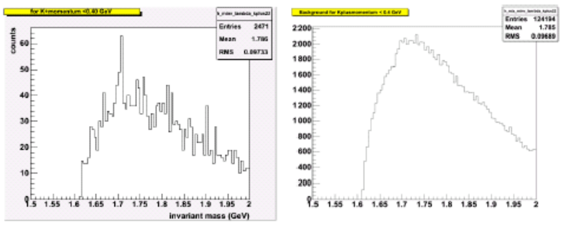

Fig 4 : Invariant mass m(ΛK+) in Au+Au collisions at 200 GeV. Left : signal+background, right : rotational background

A possible peak near 1700 MeV mass is perceived in the left plot, while background normalization and subtraction is needed for this to be claimed as a statement, and for the significance to be qualitatively assesed.

Fig. 5 demonstrates how this possible peak in the invariant mass ΛK+ diminished progressively when the pion contamination in the K+ candidates is enhancing (from upper left, towards down right). This is testing if the possible peak, is behaving as expected for a real signal and so it does. Many more systematic studies are needed.

Following requests of the STAR convenors, we searched if the ΛK0s possible peak is seen also in 2004 data (master thesis, A. Ghoulam). The peak is seen also in the 2004 data in the low and medium luminosity sample, The overall new significance (2001+2004 data together) remain to be assesed.

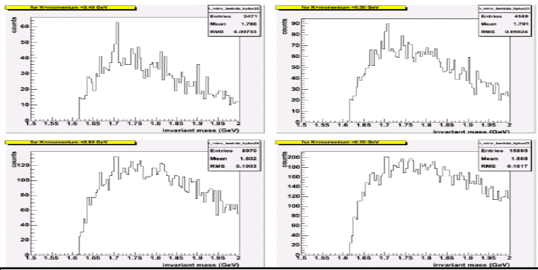

Fig. 5 Invariant mass m(ΛK+). From upper left to down right, the pion contamination in the K+ sample is increasing.

If these candidates are confirmed, they do not need to be pentaquark states. New such multiquark states, can be in several new multiplets, e.g. new 27-plet by J Ellis et al, etc.

The STAR collaboration and the Strangeness Group convenors, requested from us, to finalize the analysis, firstly, using the full available STAR statistics, in order to enhance the significance, and secondly, by doing certain proposed systematic studies. The required work, needs human resources (a PhD) in order to be completed towards a publication.

QCD exotics, if produced through quark coalescence, can show dramatic enhancement in HI collisions at RHIC and LHC. A preliminary peak in ΛK0s inv. Mass, candidate for the states N0 or Ξ0, has been measured near 1730 MeV in Au+Au coll. at 200 GeV in STAR in 2001 data and two other experiments in ΛK0s and Σ-K+ decay channels. The latter if confirmed, supports the N0 hypothesis. If this peak is a true state, the isospin partner N+ should exist at same mass. We present preliminary results on a candidate peak for the expected isospin partner namely the N+ → ΛK+ at nearby mass. The peak is seen for the highest purity Λ and K+ samples. It diminishes progressively with enhanced π contaminatio,n as expected for a real state. The ΛK0s peak has been found also in 2004 Au+Au data. The overall significance 2001+2004 remain to be assesed. These peaks if confirmed, are new states, but do not need to be pentaquarks. The STAR collaboration requests further analysis with more data and systematic studies.