Identified charged hadron spectra and ratios in Au+Au and d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

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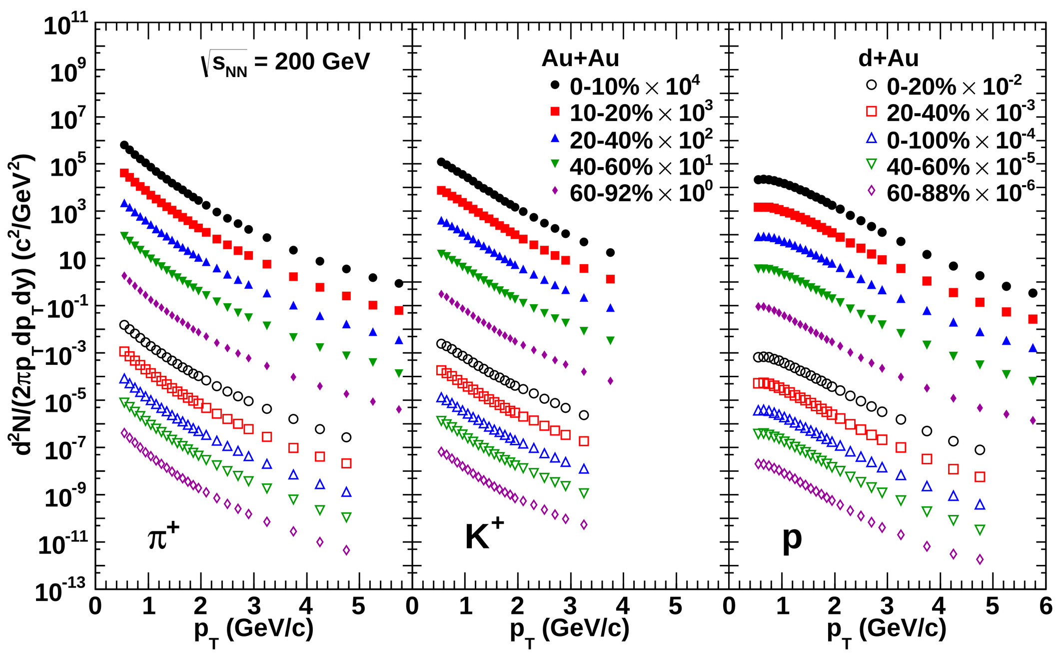
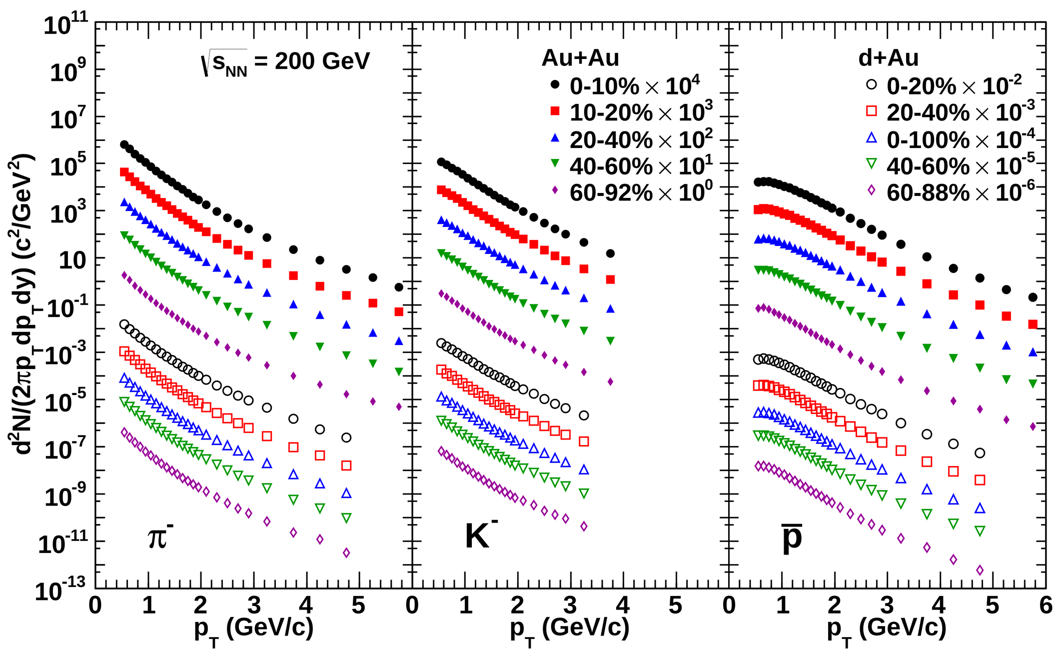
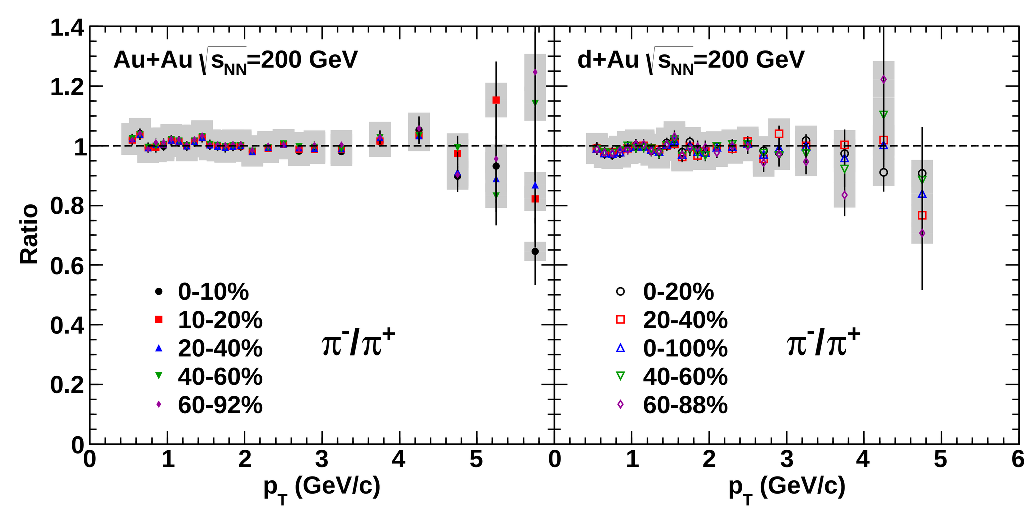
Spectra

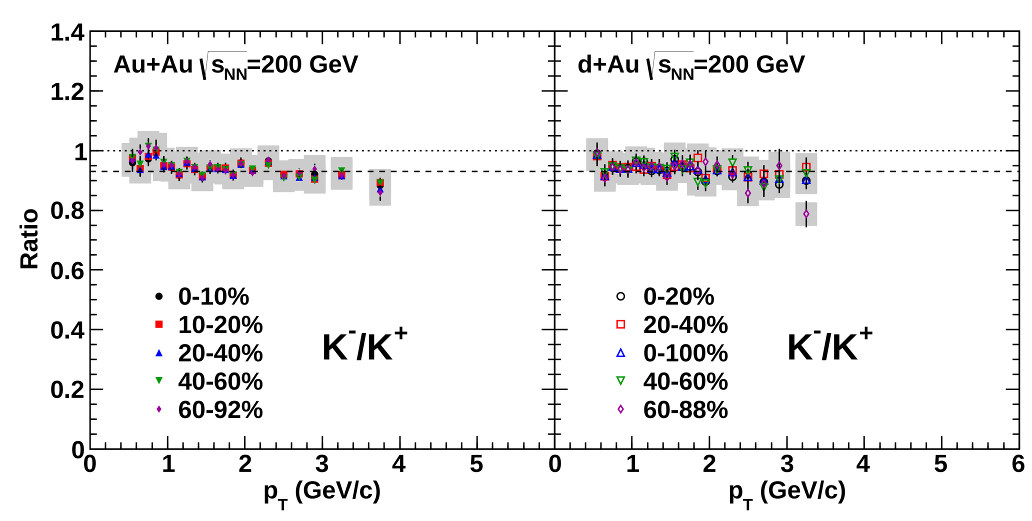


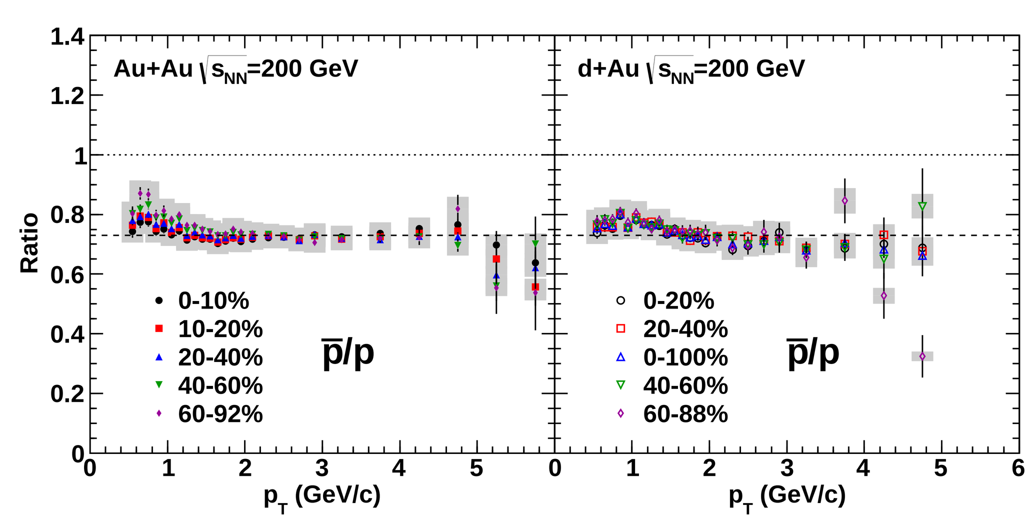


PHENIX has recently reported [1] measurements of identified charged hadron spectra and ratios in Au+Au and d+Au collisions at $\sqrt{s_{NN}} =$ 200 GeV. In this analysis, the spectra and ratios previously reported by PHENIX in Au+Au [2] and d+Au collisions [3] are revisited, extending the p_T reach of previous measurements and significantly improving the statistical precision. In principle all the information reported in [1] and in this poster is encoded in the spectra. Particle ratios, however, often help illustrate differences between particle species, centrality classes, collision systems, etc. There has been tremendous interest in the field recently regarding the possibility of flow in small systems like d+Au and p+Pb, which is best evinced in the spectra themselves. The author anticipates and encourages theoretical studies of these spectra in addition to the many other observables presented at this conference and elsewhere.

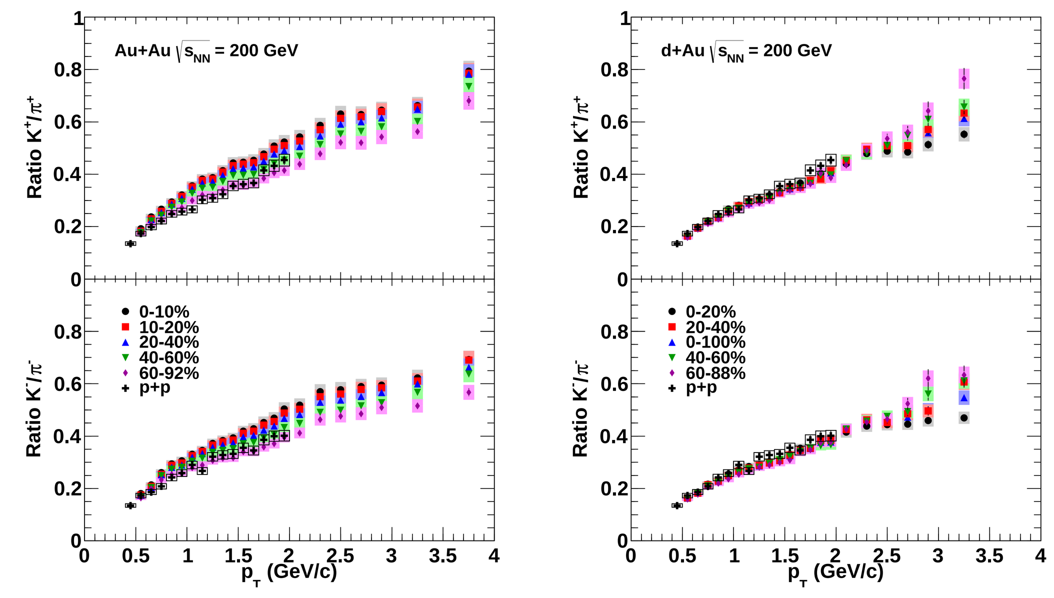
Ratios



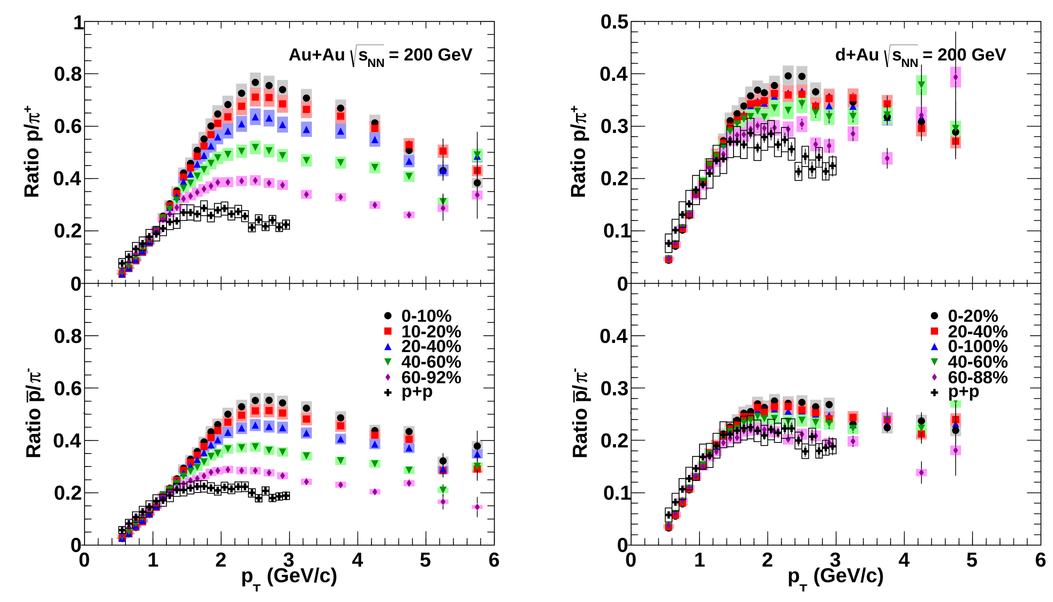




In a sense, the antiparticle to particle ratios are the most uninteresting result imaginable, as they are independent of p_T, centrality, and even collision species. But in fact this result is actually rather surprising. Simple considerations of isospin suggest that each of these ratios should decrease considerably with p_T, as is indeed observed in p+p collisions. But that is not observed in the Au+Au and d+Au measurements.

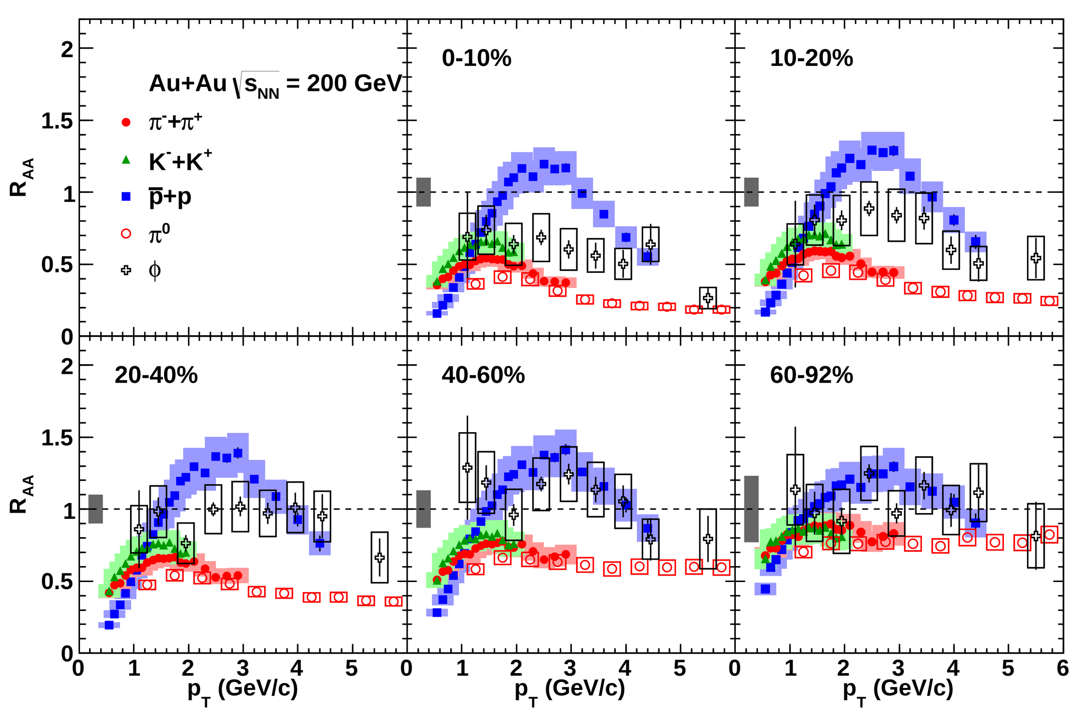


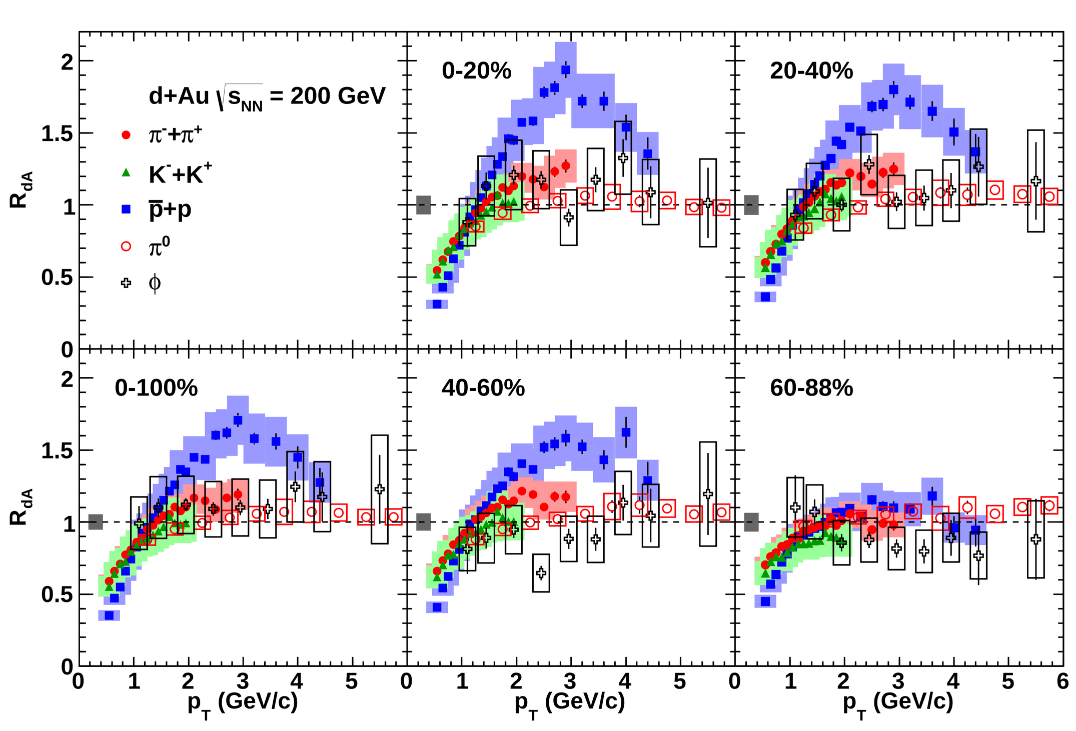
The K/π ratios may help shed light on the strangeness production mechanism(s). In d+Au collisions, the K/π ratios are independent of centrality and are consistent with the results in p+p, indicating that there is no strangeness enhancement in d+Au. In Au+Au collisions, there is a centrality dependent enhancement, with the K/π ratio increasing with increasing N_{part}. Moreover, the ratio increases with p_T more quickly for more central collisions than it does in more peripheral collisions. These results indicate strangeness enhancement in Au+Au collisions, qualitatively consistent with other measurements of strange particles.



The p/π ratios help elucidate the baryon production mechanism(s). The baryon enhancement was one of the most important discoveries in the early days of the RHIC program. Parton recombination was developed to explain both the elliptic flow data as well as the anomalously high p/π ratios. Here we show this ratio in Au+Au collisions for each centrality bin, indicating a clear monotonic increase of the ratio with increasing N_{part}. This detailed measurement can help explore the interplay of parton recombination and radial flow effects. We find a similar increase in the ratio with increasing N_{part} in d+Au collisions. Although the difference appears small, one has to consider the small range of N_{part} accessible in d+Au collisions and in fact the change is quite significant. This suggests a degree of commonality that may be a result of the hadronization mechanism, or the collective expansion, or an interplay of both.

Nuclear Modification Factors





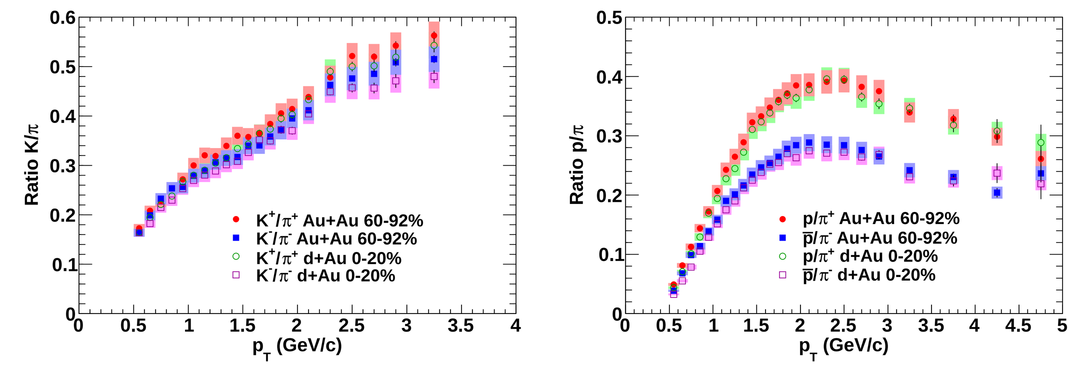
The R_{AA} of identified particles shows a monotonic increase of the suppression pattern with increasing N_{part} for mesons, indicating the expected effects of increasing opacity and density of the medium. Conversely, the baryons (protons) have nearly the same pattern for all centralities. This observation is complementary to the p/π ratio, indicating the competing effects of attenuation through parton energy loss and enhancement through the hadronization mechanism.

The R_{dA} of identified particles is quite remarkable. All mesons, including even the heavy ϕ meson, are only slightly modified and consistent with unity within the experimental uncertainties for all centralities. On the other hand, the baryons (protons) show a very large enhancement that is strongly dependent on N_{part}. This dependence is all the more remarkable considering the small range of N_{part} accessible in d+Au collisions. That the ϕ meson and the proton behave so differently despite their similar masses is a strong suggestion that the enhancement is due to particle type and not particle mass. This suggests that the hadronization mechanism plays a major role in the observed physics effects.

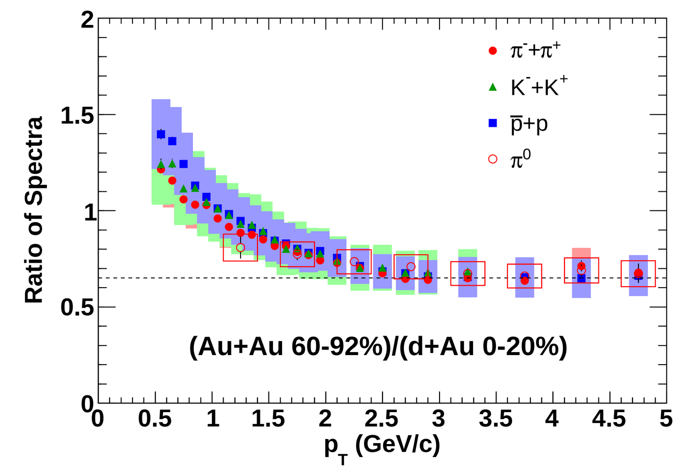
Comparison of peripheral Au+Au and central d+Au

Centrality	$\langle N_{coll} \rangle$	$\langle N_{part} \rangle$
Au+Au		
60-92%	**14.8 ± 3.0**	**14.7 ± 2.9**
d+Au		
0-20%	**15.1 ± 1.0**	**15.3 ± 0.8**

Given the similarities between Au+Au and d+Au already observed it is natural to compare the two directly. Moreover, there is a very nice coincidence that for the peripheral bin of Au+Au and the central bin of d+Au both the N_{coll} and N_{part} are consistent within errors across the two systems. This makes quantitative comparisons between the two justifiable.



One sees that both the K/π and p/π ratios are identical in the two systems. This strongly suggests that the particle production mechanism is the same for each system. For the K/π it's noteworthy that both peripheral Au+Au and all centralities in d+Au are consistent with the p+p measurement, suggesting no strangeness enhancement for this range of N_{part}. For the p/π on the other hand, there is an appreciable enhancement over p+p in both systems, indicating a common mechanism for baryon enhancement in both systems.



Finally, given the quantitative similarities between peripheral Au+Au and central d+Au, we take the ratio of the two spectra directly. It is very important to note that no scaling is applied, and moreover that a scaling by the respective N_{coll} or N_{part} values would change the ratio imperceptibly. One observes a seemingly universal curve for all particle species. There is a possibility of a mass splitting at low p_T, which would be expected from collective expansion effects, however the particles are consistent with each other within the experimental uncertainties. Additionally, all particles trend towards a common value of 0.65 for $p_T > 2.5$ GeV/c. This is again strongly suggestive of a common particle production mechanism. It also may lead to insights into the differences between symmetric and asymmetric collision systems that have the same N_{part} and/or N_{coll}. Further measurements of asymmetric collision systems like Cu+Au, Si+Au, ^{3}He+Au, and p+Au are sure to yield very interesting results.

References

[1] A. Adare et al., Phys. Rev. C88, 024906 (2013)

[2] S.S. Adler et al., Phys. Rev. C69, 034909 (2004)

[3] S.S. Adler et al., Phys. Rev. C74, 024904 (2006)