The most important result demonstrated so far in the study of relativistic heavy ions at RHIC is the observed suppression of high p_T pions in central collisions as compared to either *pp* collisions or peripheral Au + Au collisions. A second, quite surprising observation is the unusually large proton to pion ratio at high p_T . In particular PHENIX has observed that in central Au + Au collisions the proton to pion ratio is enhanced by a factor of 3 as compared to the ratio in peripheral collisions. In fact the proton and anti-proton production scales with N_{coll} in the region $1.5 < p_T < 4.5$ GeV/c, in sharp contrast to the strong suppression of pion production [24]. Naively, one would expect that high p_T particles are the result of the fragmentation of quarks. Because of the power law nature of the hard scattering spectrum, most of the particles at high p_T are expected to be leading hadrons. The fragmentation functions, at least in the vacuum, are expected to be universal and independent of the colliding system under consideration. In fact their dependence on momentum transfer Q^2 is rather small and can be shown to follow similar relations as the familiar DGLAP equations for the ordinary structure functions. The fragmentation functions have been reasonably well measured at e^+e^- colliders, where the baryons are expected to be less than 20% of the total. This expectation is completely inconsistent with the PHENIX data.

One immediate question is whether it is the mass of the proton, or the fact that the proton is a baryon which gives rise to this peculiar behavior. The ϕ meson which has a mass similar to that of a proton, but like the pion, has 2 valence quarks, should distinguish between these possibilities.In order to examine the behavior of the ϕ we look at the ratio R_{CP} which is the the ratio, as a function of p_T of the yield in central collisions to the yield in peripheral collisions normalized to the number of binary collisions, N_{coll} (see table 1). In the case of pions, the R_{CP} variable illustrates the striking suppression of pions at high p_T. We first convert the measured m_T spectra into p_T spectra (see Figure 18, as well as [23,24]) and then divide by the number of collisions. We immediately see in Figure 18 that above about 1.5 GeV the protons converge to the same line while the ϕ does not. To examine this feature more closely, we plot the ratio between the central and peripheral data, *i.e.* the ratio R_{CP} (Figure ?). The systematic error arising from the determination of N_{coll} is represented by the dotted bar and is about 19% for the ϕ measurement. This systematic error is exactly correlated with similar errors for the protons and pions shown by the solid vertical bar at the right of the Figure. The point to note here is the *comparison* among the R_{CP} values for the pions, the protons and the ϕ, respectively. In this comparison, the systematic errors in determining N_{coll} cancel.

The important systematic errors to consider are those that can move the ϕ points with respect to the proton points. The sources of error for the ϕ are the multiplicity dependent corrections, mass window and as described previously in this paper. For the protons and pions the largest sources of errors come from the multiplicity dependent corrections. Further errors for the protons and pions are detailed in references [23,24]. This relative error was determined to be about 7% and is represented by the extended solid bar just below RCP =1. Clearly the ϕ's behavior is more like that of the pions and not like that of

the protons; hence we conclude that the ϕ shows a similar high p_T suppression as the pions. This observation provides support for models which depend on the number of valence quarks in the particle such as recombination models [26,27,28,29], in contrast to models which depend on the mass of the particle.
[Do we want to say more here about hydro?]

5. Conclusion

A systematic measurement has been made of ϕ production at mid-rapidty in Au + Au collisions with $\sqrt{s_{NN}} = 200$ GeV at RHIC. The general features of the data include the yield which rises from $0.318 \pm 0.028(\text{stat}) \pm 0.051(\text{syst})$ in peripheral collisions to $3.939 \pm 0.604(\text{stat}) \pm 0.620(\text{syst})$ in central collisions. There is seen to be little centrality dependence to the inverse slope which is about 360 MeV. The centroid mass and resonance width are extracted with high enough precision to rule out any large (MeV scale) deviations from the accepted PDG values. At p_T below 1.5 GeV, a blast wave description of the central pion, kaon and proton spectra with a freeze-out temperature of about 100 MeV, and a transverse velocity of 0.76c describes the central ϕ data as well. A similar conclusion holds at the lower centralities. At higher transverse momenta, all particles lie above the blast wave fits, which may be indicative of a different mechanism of particle production. A study of the ratio R_{CP} of the ϕ yields a critical new piece of information in understanding the anomalous proton to pion ratio seen in central heavy ion collisions at RHIC, since the ϕ is a meson with a mass similar to that of a proton. The R_{CP} value for the ϕ above a transverse momentum of 1.5 GeV is about 0.5, similar to that of pions and inconsistent with the proton value of 1, indicating that the ϕ is suppressed at high p_T as one might expect for energy loss considerations. The lower p_T blast wave fits which imply hydrodynamic behavior at the hadronic stage and the inconsistency with simple hydrodynamics at higher p_T is an important factor to consider as one begins to understand the mechanism of particle production in central collisions at RHIC.