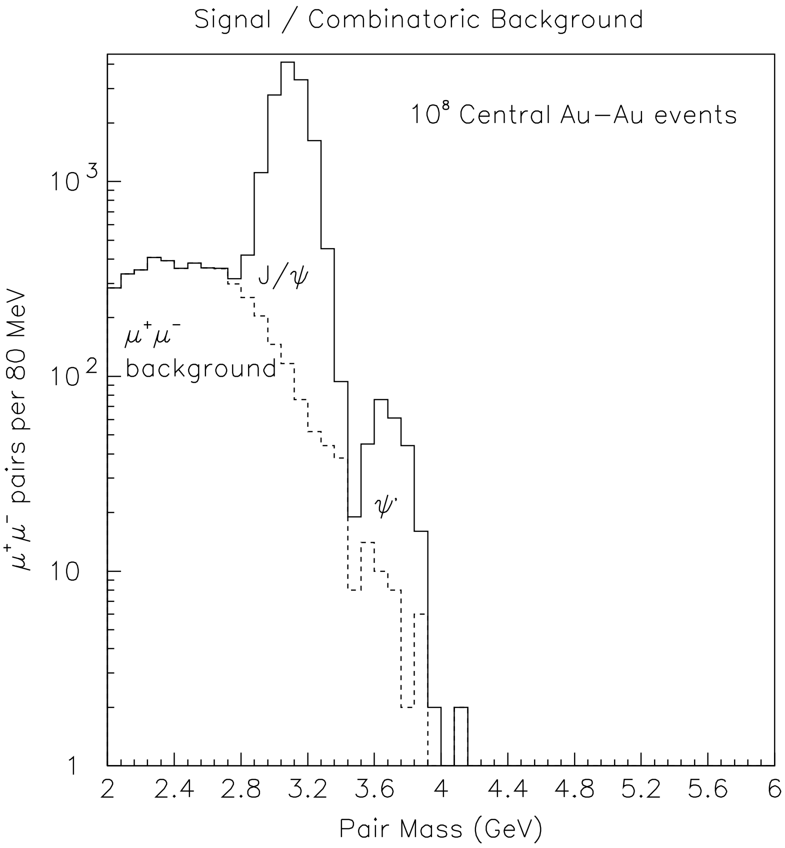

Figure 10.32: Dimuon invariant mass spectrum based on PISA calculations for the J/ψ and ψ' region with kinematic cuts on the accepted muons.

nances can be obtained by introducing carefully tuned kinematic cuts on the accepted muons. An example of such a calculation is shown in Fig. 10.32, which depicts the invariant mass spectrum in the J/ψ region. Introduction of two dimensional cuts in θ and momentum, tuned for each resonance, can increase the S/N by a factor of several.

To illustrate the sensitivity of the S/N to the stiffness of the pion p_T spectrum, we show in Fig. 10.33 how S/N varies as function of the inverse p_T slope. The p_T spectrum is taken proportional to $p_T \exp(-p_T/\lambda)$, where λ is the inverse slope. Note, how the S/N for J/ψ decreases by a factor of 200 when λ is increased from 150 MeV/c to 250 MeV/c. This extreme sensitivity of S/N to the stiffness of the p_T spectrum represents the major uncertainty in the S/N calculations, since the exact shape of the p_T spectrum for heavy ion collisions at RHIC is unknown. Unknown effects of mini-jets and rescattering make it very difficult to extrapolate from p + p data at similar energies.

The background below the Υ will not be combinatorial, but instead will originate from Drell-Yan production. Figure 3.6 demonstrates that for the statistics expected for a RHIC year of beam time at nominal luminosity ($\approx 2 \times 10^9$ central Au + Au events) the Υ and

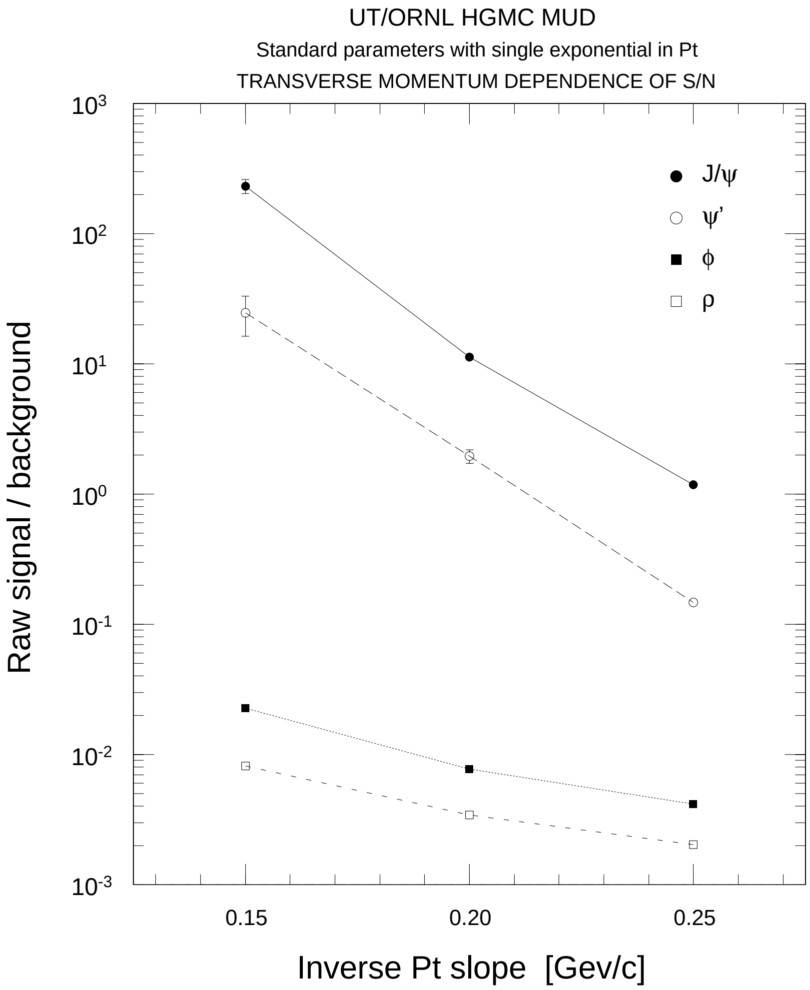

Figure 10.33: S/N for four vector mesons as function of the inverse p_T slope of the pion in the primary event.

the Υ' can be separated and distinguished above the DY background. Whereas it seems questionable if a further subdivision of the Υ yield into p_T bins would be fruitful with the current statistics, it is feasible to make simple comparisons between the yields of Υ and J/ψ for central versus peripheral collisions, which is a important test of the vector meson suppression mechanisms.

At first glance, the S/N for ρ and ϕ seems to be so small that any further work with these resonances is impossible. Careful subtraction of the combinatorial background, however, does makes it possible to extract large yields as was already shown in Table 3.3. The relative error on the ρ yield is even lower than for the electron detector, at least for $p_T > 1$ GeV/c. This will make the muon detector PHENIX's primary tool for investigating the ρ. Careful comparisons to the electron detector measurements are, however, necessary in order to unravel the effects of the unresolved ω resonance.

The subtraction of the combinatorial background of unlike-sign muon pairs can be done in two ways: (1) by subtracting the like-sign background obtained under exactly the same trigger conditions, or (2) by creating an unlike-sign background spectrum from event mixing of all positive muons from even events and negative muons from odd events. Method (1) has the advantage of a correct normalization, but might not be accurate, if, for example, the K^+ and K^- yields deviate substantially, which is possible based on AGS and SPS results. Method (2) has the advantage of correctly creating the uncorrelated unlike-sign distributions without assumptions about K^+/K^- ratios, but the normalization is complicated.

In order to optimize the design of the muon spectrometer, the dependence of the S/N ratio on a variety of parameters has been investigated. In the following section, the most important of these studies is discussed.

The most significant component of the S/N is the average vertex to absorber distance, since the great majority of background muons originate from decay of pions before they are absorbed in the absorber. The dramatic increase in S/N with decreasing vertex-absorber distance is illustrated in Fig. 10.34, where the raw S/N for ρ, ϕ, J/ψ and ψ' is shown as function of this distance. The S/N decreases exponentially with the absorber distance. The 32 cm chosen as the nosecone to vertex distance represents an acceptable compromise between S/N in the muon arm and vertex acceptance. The variation of the vertex z position with a $\sigma_z = 22$ cm does not change the S/N significantly; detailed simulations have shown that the decrease in S/N for large negative z events is more than compensated by the increased S/N for the accepted positive z events. Given the large acceptance of the muon arm one may include only events with vertex to nosecone distance less than approximately 30 cm in the offline analysis. This would significantly enhance the S/N and only cut the overall yield by a factor of two.

Figure 10.35 illustrates the muon pair p_T dependence of several quantities in HGMC. Figure 10.35a shows how the S/N improves significantly for all resonances for increasing p_T. This is important since it will allow us to study the crucial p_T-dependence of the vector meson yields out to large p_T. As can be seen from Fig. 10.35d the relative yield has a broad minimum between 1–2 GeV/c and measurements are possible up to p_T values above 3 GeV/c, where the yield vanishes.

Figure 10.36 shows contour plots of the yield of accepted muons from decay of the J/ψ and the background below the resonance, respectively. The background muons tend to have a more asymmetric distribution with maxima for both small and large values of θ. This asymmetry allows a kinematic cut on the single muons to be introduced to improve the S/N ratio. An additional possibility is to introduce cuts on the energy asymmetry $\alpha = (E_1 - E_2)/E_1 + E_2)$. As can be seen from Fig. 10.37 the background tends to have larger energy asymmetries and a cut for $\alpha < 0.5$ will again increase S/N for the J/ψ at the expense of a fairly small yield reduction.

The last study of S/N enhancement is shown in Fig. 10.38, where the effect on S/N of changing the spectrometer location in polar angle is illustrated. The S/N for the vector mesons is plotted as a function of the rapidity acceptance, assuming that the absorber

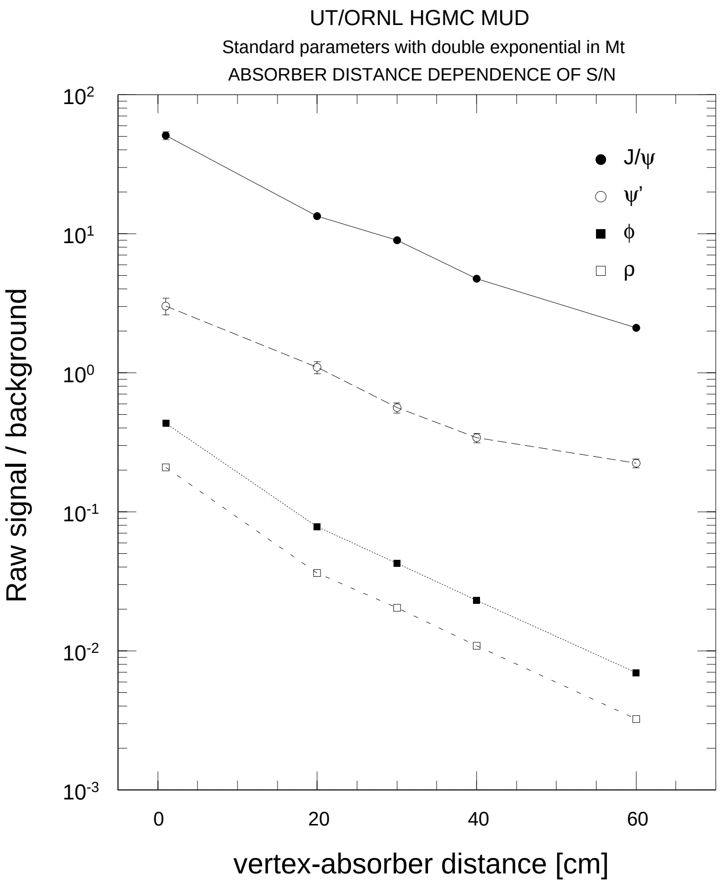

Figure 10.34: Variation of S/N as a function of the distance between the front face of the absorber and the average vertex position.

thickness is independent of the acceptance. The horizontal error bars indicate the acceptance interval of the muons. A more forward position of the detector increases the S/N significantly. The relative yield uncertainty is reduced for light resonances ρ and ϕ as shown in Fig. 10.39, but the heavier resonances like J/ψ and ψ' show little rapidity dependence. It can therefore be concluded, that any reduction in the forward coverage of the muon detector will detoriate its performance.

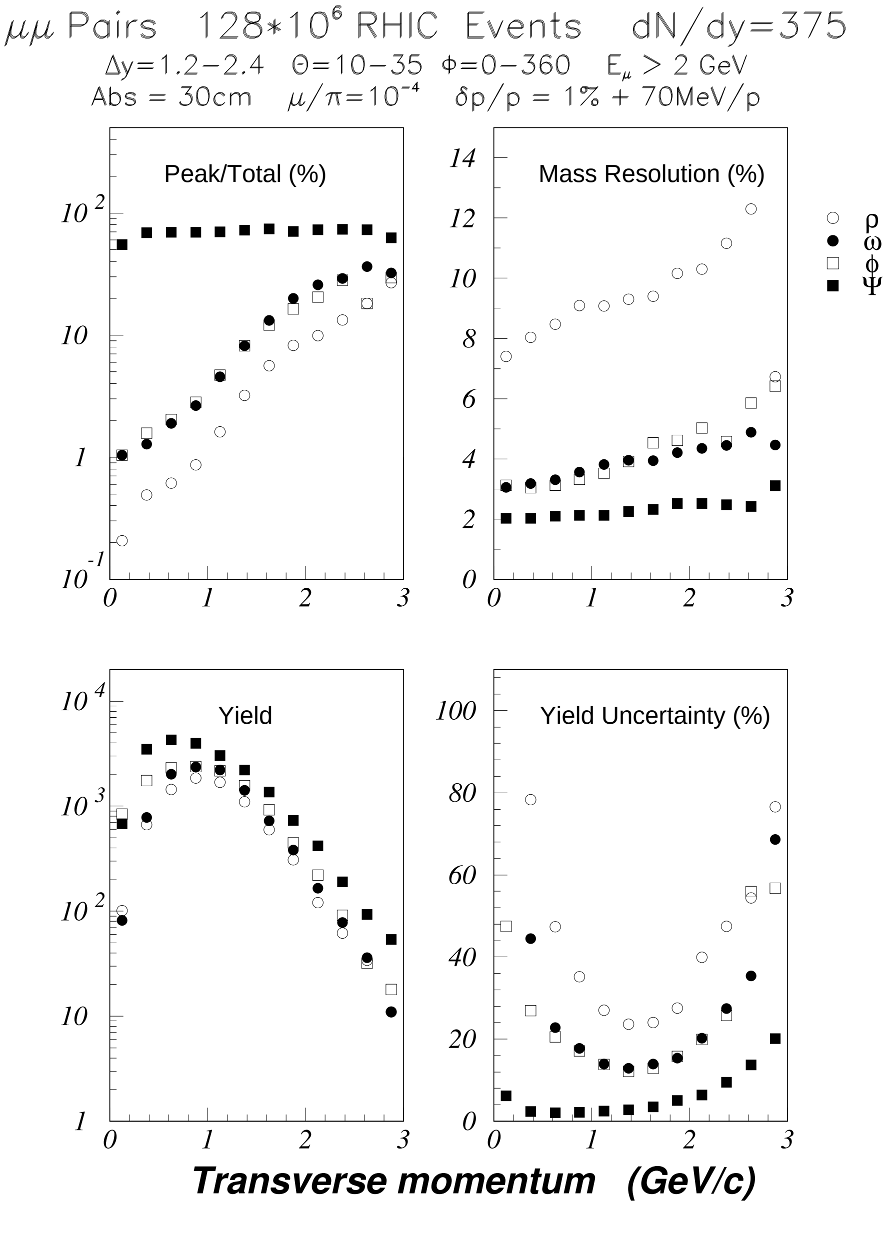

Figure 10.35: The p_T dependence of the following quantities: (top left) Peak yield over total yield, (top right) Invariant mass resolution, (lower left) Yield, and (lower right) Relative yield uncertainty. The abscissa is the total p_T of muon pairs originating from decay of ρ, ω, ϕ and J/ψ.