Measurement of ϕ to KK from $\sqrt{s} = 200$ GeV Au-Au and pp Collisions

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1 Introduction

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I) Introduction
   A) Overview of this paper
   B) General statement about heavy ions/RHIC
   C) Why the phi is interesting
     1) chiral symmetry restoration - mass, width, BR
     2) strangeness production
   D) Review of phi results from AGS/SPS/RHIC
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The ϕ meson has a number of characteristics which make it a good probe strongly interacting matter under the extreme conditions in Au-Au collisions at RHIC. It is composed entirely of strange quarks which are not present in the initial gold nuclei. Compared to the u and d quarks, the strange quark is relatively heavy 300 MeV. This means that the production of the ϕ and its subsequent behavior is sensitive to the conditions under which particle production proceeds - characteristics such as the temperature, equilibration time and pressure, as well as the state of the matter early in the collision: i.e. whether the early system is best described in a hadronic or a deconfined partonic picture. More specific examples of this will be described later in the discussion of the data.

Our present understanding of QCD postuates that the vacuum consists of a chiral condensate which provides the necessary symmetry breaking that underlies all hadronic mass. The restoration of chiral symmetry at high temperatures is one of the most important phenomena being explored in relativistic heavy ion collisions. It is, together with deconfinement, one of the fundamental phase transitions should be observed. Quark masses should go from their "dressed" or consituent values to their "bare" or "current" masses. Predictions as to the exact characteristics of the hadrons - which are combinations of quarks - as one reaches the chiral phase transition vary since hadronic mass comes both from the chiral mass of the quarks and the potential between the quarks making up the hadron. (Thermal mass????). Nevertheless, it is important to examine the characteristics of hadrons withing the hot collision volume to look for modificatons which would give an indication of the restoration of chiral symmetry, and ultimately, the properties of the QCD vacuum, responsible for most of the mass in our everyday experience.

The lifetime of the ϕ meson is about 40 fm hence a reasonable fraction decay inside the collision volume giving us hope that the invariant mass and width of the decay products can provide information on the properties of the ϕ in the hot fireball, and in turn, evidence for the possible resotration of chiral symmetry. While the di-lepton decay of the ϕ will give a direct measurement of the mass and width of the ϕ itself, the mass and width reconstructed from hadronic decays will be sensitive both to the properties of the ϕ and the daughter products. It has also been suggested **??** that the ratio of the e^+e^- and K^+K^- decay rates would be sensitive to small changes in the kaon of ϕ mass and width because of the small Q value of the $\phi \rightarrow K^+K^-$ decay.

The ϕ has been previously measured in heavy ion collisions at lower energies E859,E917 at the AGS and NA49, NA50,... at the SPS as well as at RHIC in Au-Au collisions $\sqrt{s}$=130 GeV by the STAR collaboration. Relativistic heavy ion collisions at lower energies are characterized by large baryon densities and explores a different region of the phase diagram of nuclear matter in contrast to RHIC, where the baryon density has been shown to be nearly zero **??**. Particularly at AGS energies, there is a strong enhancement of strangeness, primarily exemplified by the high K to pion ratio. In general *phi* production seems to closely mirror kaon production in that a simillar enhancement is seen as a function of centrality, and simillar inverse slopes are observed. (ref). Talk about SPS.

This paper examines the $\phi \rightarrow K^+K^-$ as observed in Au-Au collisions at $\sqrt{s}$ of 200 GeV and observed by the PHENIX detector at RHIC in the second period of data taking (2000-2001?). The data set is composed of ???? million events taken with a minimum bias trigger. The pp sample is composed of ??. Section II gives a brief description of the subsystems of the PHENIX detector used in the analysis. Sections III and IV describe the analysis including corrections and background subtraction techniques. Section V describes the results, including a detailed analysis of the mass and width. Finally section VI makes some comparisons of yield with other particles, as well as a discussion of various effects which come from a variety of production models.

2 The PHENIX Experiment

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II) PHENIX the detector located at the Relativistic Heavy Ion Colluder
   A) The run and run conditions
      Requirements for good data?
   B) Overview of PHENIX detector and configuration (refer NIM)
       centrality detectors
       Tracking detectors
       PID detectors
       Requirements for good data?
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The PHENIX detector (ref-NIM) is composed of two central spectrometer arms covering a psuedo-rapidity range of ± 0.3 and two muon spectrometers at forward and backward rapidities. This analysis will only use the central arms. The central arms are designed to

3 Single Particle Analysis

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III) Analysis I (single particle)
   A) Tracking
   B) Particle Identification
      1) TOF
      2) EMCAL
   C) Centrality
   D) Overview of Simulations
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4 Pair Analysis

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IV) Analysis II (two particle)
   A) invariant mass
   B) background
      1) event mixing techniques
      2) background normalization
         (it might be nice to produce a NIM paper or something here)
   C) Fitting techniques
      mass resolution
      RBW
      dependencies?
        background/multiplicity
   D) Corrections
      1) Global
         a) run by run
         b) other - triggering etc
      2) Acceptance
      3) tracking/PID eff
         a) single particle
         b) embedding (split up)
            i) tracking
            ii) PID (TOF/EMCAL)
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5 Results

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V) Results
   A) Yields, transverse slope etc
        Fix mass and width?
   B) fits to mass and width
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6 Discussion

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VI) Discussion
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1) Yields vs centrality
   phi/pi, phi/K, if we have pp, phi/pp vs pt?
2) Inverse slope vs centrality
3) Discussion
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7 OUTLINE

Very Rough outline of phi paper

This assumes that the paper will be a PRC. If the Charlie's result of the centrality dependence of the width does hold up, I would vote to publish a PRL on that result and a PRC with everything else. For the purposes of this outline I am assuming here that we will find some analysis reason to explain charlie's result.

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