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Multi-Channel Measurements of Light Vector Mesons at PHENIX

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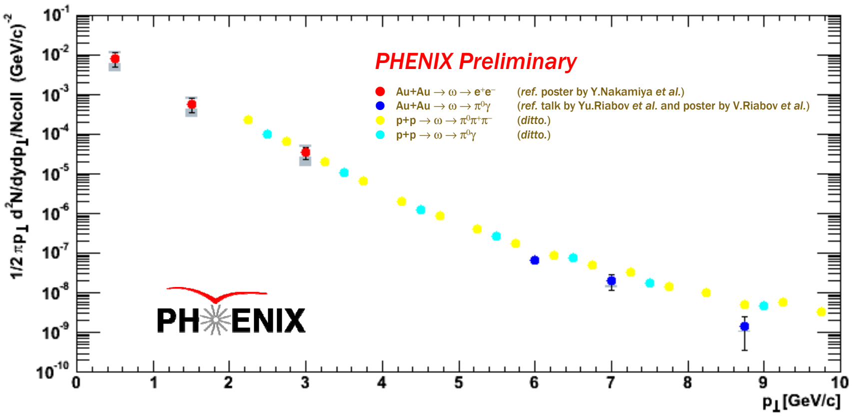
Note: If you are familiar with this physics topic, read down from the top.
If you are not, read up from the bottom !

A Recent Experimental Highlight

ω meson production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV has been measured in PHENIX both in e^+e^- and $\pi^0\gamma$ decay channels, as well as in $\pi^0\pi^+\pi^-$ and $\pi^0\gamma$ channels in p+p and d+Au collisions. See also: talk by Yu.Riabov *et al.* (Nov.19, parallel 3.1) and posters by Y.Nakamiya *et al.* and V.Riabov *et al.*.

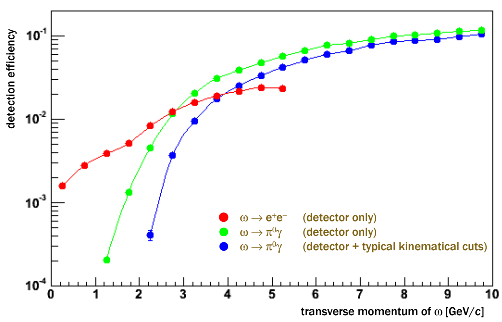
Invariant Yield of ω per Nucleon-Nucleon Collision in Au+Au and p+p Collisions at $\sqrt{s_{NN}}$ = 200 GeV



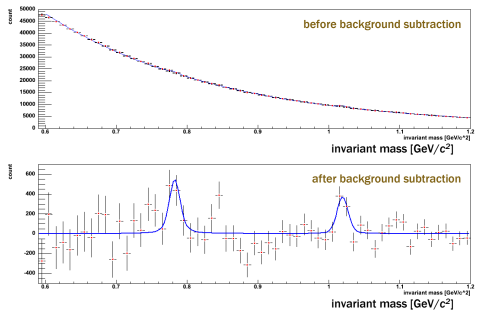
Multiple Species of Vector Mesons via Multiple Decay Channels

PHENIX is capable of measurements of multiple species of light vector mesons, in multiple decay channels into leptons, photons and hadrons. ω mesons in Au+Au collisions, for instance, have been measured in hadronic and photonic decay channels in the high transverse momentum (p_t) region as well as in the historically popular di-electron channel in the low p_t. Despite the possible difference between the probes in degree of penetration in the final hadronic states, the consequent wide kinematical coverage provides an additional axis in systematics: decay probability in the matter.

Detection Efficiency of PHENIX for ω Decaying into e^+e^- and $\pi^0\gamma$



Invariant Mass Distribution of e^+e^- in ω and φ Mass Region in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV

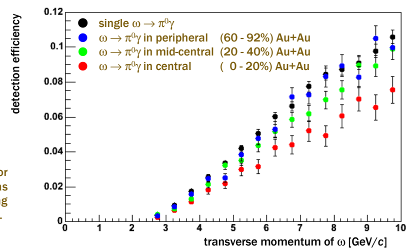


Background subtraction is often the largest source of systematic error, especially when the shape of the background is not well known. Event mixing method is used to evaluate the combinatorial background as far as applicable. Uncertainty of the remaining background is accounted in systematic error evaluation.

Challenges and Progresses in Au+Au Analysis

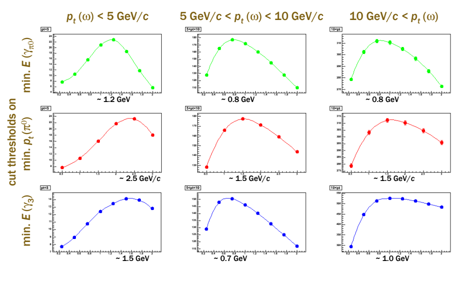
The largest challenge in measurements of light vector mesons in heavy ion collisions is their small signal to background (S/B) ratios due to huge combinatorial backgrounds in multi body decays. A number of key techniques are developed in evaluation and subtraction of background to extract the signal. Various kinematical cuts have been optimized based on simulation studies to maximize the S/B ratio which is a limiting factor of statistical significance of the signal.

Multiplicity Dependence of Detection Efficiency of PHENIX for ω Decaying into $\pi^0\gamma$



Multiplicity dependent factor of detection efficiency has been studied by embedding test particles into real events.

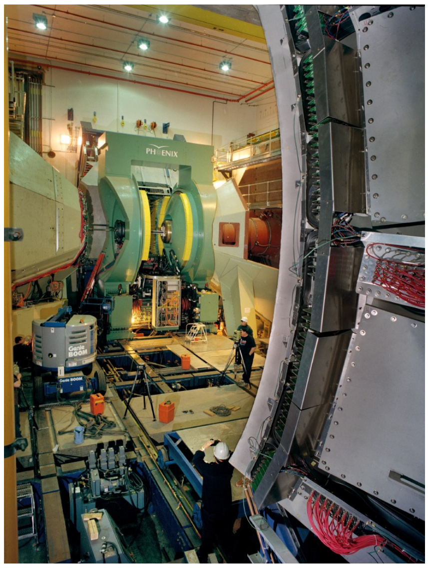
Signal to Background Ratio (in Arbitrary Unit) for ω Decaying into $\pi^0\gamma$



Signal to background (S/B) ratio limits statistical significance of cross section measurement. Kinematical cuts are optimized to maximize the S/B ratio based on simulation studies.

PHENIX at RHIC: The Right Tool

The high capabilities of the PHENIX experiment to measure leptons and photons as well as hadrons, along with the high integrated luminosities achieved by the RHIC accelerator, make the experiment uniquely suitable for systematic studies on properties of mesons at high energy densities, hopefully including above the QCD phase transition. Another important feature of RHIC is its versatility. Comparison among collision systems from p+p to Au+Au provides a vital systematics, with baseline measurements in p+p and d+Au collisions with the same apparatus as in Au+Au. More channels including ω decaying into e^+e^- in the light collision systems are under study.



Light Vector Mesons as Probes of (Partial) Chiral Symmetry Restoration

Mass states of light vector mesons are considered to be sensitive probes of partial chiral symmetry restoration theoretically expected in high energy and/or baryon densities. Some of the experimental results at CERN SPS (*e.g.* CERES Collaboration, PRL 91, 042301, 2003) and KEK PS (E325 Collaboration, PRL 96, 092301, 2006) are explained as onsets of the phenomenon. In high energy heavy ion collisions, their modifications have been looked for also as a signature of deconfined partonic state of matter. Systematic comparison among results from different regions in the QCD phase diagram and via different channels will provide critical information for the study of partial chiral symmetry restoration.

What are "Mesons in Non-Hadronic Phase" ?

A frequently asked question on measurement of possible mass modification of light vector mesons in "deconfined partonic matter" is: what do we really see by looking at hadrons in non-hadronic phase ? Even above the phase boundary between confinement and deconfinement, quarks may form bound states which should be interpreted as precursors of hadrons. The recent discovery in lattice QCD that J/Ψ remains as a prominent peak up to about 1.6 times the critical temperature (M.Asakawa and T.Hatsuda, J.Phys.G30, S1337, 2004) is a numerical support of the picture. Their mass states may however be modified from those in vacuum and of special interest to understand the properties and origins of mass of hadrons.

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