Status and Future Work

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from EC-based PHENIX working groups

Electron Measurements (DRAFT)

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1 Backgrounds, acceptances...

...calculations should be done with the PHENIX Monte Carlo machinery which has all of the material and all physics processes **including K decays**.

- Recheck the dN/dy to be used in simulations. The existing event generators need to be rerun at JACEE energy to see whether they reproduce the observed dN/dy.
- Redo all of the previous simulations (also those described below) at the same (double Hijet) dN/dy.
- Recheck the radiation budget.
- π/e Rejection and Electron Identification needs to be quantified for each of the three electron identification detectors, using the full simulation of the PHENIX experiment, with ALL MATERIALS INCLUDED. These have been studied, but need to be revisited and the numbers updated.

2 Vector meson measurements

Dilepton decays of the ω, ϕ and J/ψ are accessible with electrons in the PHENIX central arms.

- Update the mass resolution in PHENIX for dielectron decays of ϕ and J/ψ, using the full simulation of the tracking system.
- Show the acceptance, in rapidity and p_t for these.
- What is the efficiency of detection (and reconstruction, of course), as a function of rapidity and p_t.
- Evaluate the effect on the p_t cutoff and mass resolution of low field running.
- Evaluate the effect of dalitz and conversion background on the vector meson measurements. Can we do a good job with minimal effort to remove these backgrounds? How much does the cone cut help (or matter)?

3 Continuum electron pairs

One of the main goals of PHENIX, unique among the RHIC experiments, is to measure the dilepton continuum.

- At relatively low masses—thermal
- $\sim 2 - 3GeV$—Open charm combinatorial background
- higher masses—Drell Yan.

Continuum electron pairs is the most difficult measurement that PHENIX will do, particularly before upgrades to allow Dalitz rejection.

The challenge is to find the small number of electrons among the large number of pions, and separate the electrons of interest from those arising from conversions and Dalitz decays. It is necessary to reevaluate how well we will do on day-1.

- The studies mentioned above to quantify the electron identification efficiency and the background electron rates from Dalitz decays, conversions, and out-of-aperture materials are crucial to determine at which mass and p_t PHENIX has sensitivity to thermal dileptons.
- Obviously we must put resources into trying to eliminate the dalitz and conversion background from the electron signal (and also the decay in flight for the muons).
- Even if we successfully eliminate some background, how will we know what the remaining signal/background is in the final data. This can and should be done by measurement, typically by varying the experimental conditions, similar in spirit to target-out measurements.
- There is a classical and elegant method to estimate the fraction of a given electron signal that is due to a photonic source.
- We must plan on and think about measuring our background in all cases and not rely on calculations (either external Monte Carlo or our own).

4 Open Charm in single and di-leptons

The decays of open charm will populate the di-electron spectrum in the mass region 2-4 GeV/c^2. A substantial number of charm particle pairs produced per central Au+Au collision is predicted.

5 Use conversions and Dalitz for Physics

Another aspect that merits study is whether we can use this massive dalitz and conversion background to measure something useful.

- **Inclusive photons:π^0 and η cross sections** A measurement of the conversion/dalitz pair p_T spectrum for $m_{e^+e^-} \leq 100$ MeV/c^2 for π^0, and $140 \leq m_{e^+e^-} \leq 400$ MeV/c^2 for η. Is it possible in PHENIX, at which p_T does it make sense, where is it competive or better than the more conventional direct method?
- direct photons via internal conversion: *Tserruya-Specht pairs?* Thus there is a region in the mass range $400 \leq m_{e^+e^-} \leq 600$ MeV/c^2 where there is no known source of lepton pairs. Thers is no background from π^0 and η dalitz decay which are restricted to di-leptons with mass less than that of the respective particle. However, internal conversions of direct photons have no such restriction. This method is particularly effective at low p_T where the rate is high and where the γ/π ratio is very small.

6 Electron trigger Working Group

- In spite of the huge background of real electrons per central collision, an electron trigger still makes sense since the inclusive $e^{\pm}$ rate drops by several (perhaps 3) orders of magnitude until the electrons from open charm begin to dominate at $p_T \geq 1.0 - 1.5$ GeV/c. **Thus an electron trigger with this p_T cutoff makes sense,** particularly for charm and J/Ψ production. Another advantage of such a trigger is that it may allow charm and J/Ψ production to be measured inclusively, independently of the centrality trigger. Of course, the RHIC luminosity will hopefully increase; and for lighter beams, a trigger is essential.

- An electron trigger in real time is quite challenging and interesting since it involves almost all the subsystems of PHENIX: BB, MVD/HBD, tracking, RICH, EMcal, online, simulation (both hardware and software). One outline of a trigger strategy has been given in PN85, following up on work of Akiba in the pCDR and earlier.

- **It is imperative that an electron trigger working group become active.** This group should include members of the RHIC, Tracking, EMCal, DAQ/Online subsystems as well as simulations experts.

- [July 1996] Exercise with 200M events.

Discussion items for Electron/muon and trigger groups

- What is the strategy for taking the data? For instance do we just run 100Million, minimum bias events, at 500 Hz=2 10^5 seconds (1 to 2 weeks) or 100Million central events at 140 Hz=7 10^5 seconds (another 4 to 8 weeks) In this running time, how many events of interest in the 2 categories: $\phi \rightarrow K^+K^-$, $\mu^+ mu^-$, e^+e^-. $J/\Psi \rightarrow e^+e^-$, $\mu^+\mu^-$ Are there sufficient events to do physics? Assuming that the detector works perfectly and there is only combinatoric background, what would we plot? And from what we could plot what physics could we learn?—what I mean is that all the channels have different acceptances, perhaps they are totally disjoint? Also, the same questions for charm by inclusive single e, by single μ, intermediate mass e^+e^- pairs, intermediate mass $\mu^+\mu^-$ pairs, $e - \mu$ coincidences.

- Can or How will we get the physics from the 200 million events described above? This means a real strategy of reconstruction, efficiency, background elimination. How will we know that our estimation of the background is correct? What other knowledge will be required to calculate the background: e.g. mixed events, special runs, measurements of dalitz decay, adding or subtracting absorber in the muon nose-cones, etc.
  - This subject also leads to the question of whether the real detector simulation shows that the background is sufficiently low that we can find the electrons, muons and kaons that we are interested in and not just 'albedo' or other garbage? Of course the answer depends on dn/dy assumed, since the bigger dn/dy, the more albedo, the more overlap of random charged tracks with good rings and good photons, etc. If not, what can we fix?
  - Another issue is how much p+A, p-p, d-d or other running would be required for comparison with this data set, assuming that your favorite event-generator is correct. What I mean is that if we make a 'discovery', then lots of extra running will be required. How much running do we need to confirm that RQMD or FRITIOF explains our data?

- If we can't get adequate physics running dead-time limited with either a minimum-bias or central-trigger, what kind of triggers would be useful?

PHYSICS of electrons in PHENIX

Physics Topics

or

my list of tasks for electron working group

Y. Akiba (INS–Tokyo)

January 9, 1996
PHENIX collab. meeting

0. Introduction
1. light hadrons and $e^{\pm}$
2. light vector mesons
(3. heavy quark)
4. J/Ψ measurement
5. Measurement in p+p and p+A

MJT Physics topics using electrons 11/96

Topic	Method	Comment
π^0	external conversions (+Dalitz) $m_{e^+e^-} \leq m_{\pi^0}$	Inclusive γ
η	$140 \leq m_{e^+e^-} \leq 400$ MeV/c^2	Dalitz decay
Direct γ	$400 \leq m_{e^+e^-} \leq 600$ MeV/c^2	Internal Conversion
ρ^0	$600 \leq m_{e^+e^-} \leq 900$ MeV/c^2	Lose money on every sale...
ω^0	$m_{e^+e^-} \simeq 782 \pm 8$ MeV/c^2	Should work (?)
ϕ	$m_{e^+e^-} \simeq 1019 \pm 4$ MeV/c^2	compare K^+K^-
Charm	$e^{\pm}$ inclusive $p_T \geq 1.1$ GeV/c	No combinatoric bkg.
$c - \bar{c}$	$1.6 \leq m_{e^+e^-} \leq 5$ GeV/c^2	Jet Quenching
$c - \bar{c}$	$1.6 \leq m_{e^{\pm}\mu^{\mp}} \leq 5$ GeV/c^2	Jet Quenching Msmt. Charm bkg for D-Yan
Drell-Yan	$4.0 \leq m_{e^+e^-}$ GeV/c^2	QCD Sanity check
J/Ψ	$m_{e^+e^-} \simeq 3097 \pm 0.09$ MeV/c^2	QGP or Bust Inclusive, Central $(AB)^{\alpha}$ p_T dependence
Ψ'	$m_{e^+e^-} \simeq 3686 \pm 0.3$ MeV/c^2	Rate Limit ?
Υ	$9.6 \leq m_{e^+e^-} \leq 10.6$ GeV/c^2	*Rate Limit*

7 Acceptance Questions on for the 10K Simulation

1. *What is p_T and Energy distributions of lower, higher member of the pair?* I ask this question so as to understand what effect a trigger based on an energy cut would make.

2. *What fraction of the total events have the e^+ and e^- in the same arm, as a function of p_T of the parent meson? p_T of the lower energy member of the pair?* I ask this question to be able to understandand whether we need to insist that the level one trigger require 2-particles in the same arm or in opposite arms. It is possible that a single electron trigger with a higher energy threshold than the e-pair trigger will pick up these events, with high efficiency and with no additional dead-time. This should also be checked for ω, ϕ, and J/Ψ.

3. *All the calculations should also be done at 1/2 field.*

4. *Results should be presented separately for "inclusive", "central" and possibly "peripheral" collisions.*

5. *Comment on models: For the di-electrons, any model has very few parameters.*

   (a) $dn/dy|_{y=0}$ for $p-p$

   (b) $< p_T >$ of the meson, or a simple parameterization of the p_T distribution (which may or may not change in the case of a QGP, or AB).

   (c) Nuclear dependence for AB collisions $= (AB)^{\alpha}$ or perhaps slightly more complicated. Thus we should be able to characterize any new model by these 3 parameters and be able to tell how the simulation depends on the parameters. Of course if we are just using Au+Au then a) and c) reduce to one number $dn/dy|_{y=0}$ for Au+Au.

   (d) I am tacitly assuming that the $|y| < 0.35$ acceptance of the central spectrometer is sufficiently small that we can take dn/dy=constant over this interval. It would be good to check that the relevant cross-section for the di-electron acceptance is $2 \times 0.35 \times dn/dy|_{y=0} \simeq \int_{-0.35}^{0.35} dy \times dn/dy$. Many cross section/acceptance/model dependence wars have been fought over acceptances referred to the total cross section of the parent meson (integrated over rapidity) which may differ markedly in regions e.g. $y > 0.35$, or $y > 2.5$ where the detector has no possibility of measurement.

(e) Thus the di-muon region has detection capability over the range from ~ 1.25 to 2.5 in rapidity and so is much more sensitive to the width and exact shape of $dn/dy(y)$ than is the electron arm, so this must be more explicitly taken into account. For instance for phenix-spin, there are precisely zero Z^0 di-muons in the same muon arm, since according to all models, there are no Z^0 produced with $y > 1.0$. This is surely not the case for the "lighter" mesons.