Homework response to the PAC from the RHIC II heavy flavor conveners

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November 4, 2005

PAC requests and comments

- There are typographical errors in the yield table on slide 22. There was a RHIC I Y yield that was wrong.
  - **Fixed in the posted version.**
- We were asked to make clear what heavy flavor measurements require **and can make use of** RHIC II luminosity (ie. use triggers).
  - **Summarized in two later slides.**
- We were asked for estimates of the p_T reach for open heavy flavor available with RHIC II luminosity.
  - **Provided in a later slide.**
- We were asked for yield estimates for R2D (the proposed new detector).

  Provided in a later slide.
- Miklos wanted a better justification for open heavy flavor requiring RHIC II. Aside from $B \rightarrow J/\psi$, we know that we have not made this case very well yet. We are working on it. See some comments in the last slide.

Quarkonium measurements requiring RHIC II luminosity
(The Υ yields include the 1S, 2S and 3S states)

Signal	RHIC Exp.	RHIC I	RHIC II	Measurement
J/ψ → ee	PHENIX	3300	45000	v2 & R_AA vs pT and y
J/ψ → μμ	PHENIX	29000	395000	v2 & R_AA vs pT and y
J/ψ → ee	STAR	16200	220000	v2 & R_AA vs pT and y
ψ' → ee	PHENIX	60	800	R_AA vs pT and y
ψ' → μμ	PHENIX	520	7100	R_AA vs pT and y
ψ' → ee	STAR	300	4000	R_AA vs pT and y
Υ → ee	PHENIX	30	400	R_AA vs pT and y
Υ → μμ	PHENIX	80	1040	R_AA vs pT and y
Υ → ee	STAR	830	11200	R_AA vs pT and y
χc → eeγ	PHENIX	220	2900	R_AA vs pT and y
χc → μμγ	PHENIX	8600	117000	R_AA vs pT and y

PHENIX dielectrons in $|\eta| < 0.35$, dimuons in $1.2 < |\eta| < 2.4$

STAR dielectrons in $|\eta| < 1.0$, J/ψ trigger 10% efficient

Open heavy flavor measurements requiring RHIC II luminosity

Signal	RHIC Exp.	RHIC I	RHIC II	Measurement
$B \rightarrow J/\psi \rightarrow ee$	PHENIX	40	570	bottom R_AA vs pT and y
$B \rightarrow J/\psi \rightarrow \mu\mu$	PHENIX	420	5700	bottom R_AA vs pT and y
$B \rightarrow J/\psi \rightarrow ee$	STAR	190	2500	bottom R_AA vs pT and y

PHENIX dielectrons in $|\eta| < 0.35$, dimuons in $1.2 < |\eta| < 2.4$

STAR dielectrons in $|\eta| < 1.0$, J/ψ trigger 10% efficient

Open heavy flavor p_T reach with RHIC II luminosity

(Needs more work) Both STAR and PHENIX have heavy flavor semileptonic decay spectra from Run 4 Au+Au data. The STAR data appear to extend to ~ 7.5 GeV/c with good statistics. PHENIX has J/ψ spectra that extend beyond 5 GeV/c with good statistics.

RHIC II will produce about 2 orders of magnitude (x 75) more integrated luminosity.

- According to FONLL calculations of p_T distributions for **D → e and B → e** by Ramona Vogt, this will extend the p_T reach by **~ 5 GeV/c**.
- The same calculations indicate that the p_T distributions for **D → Kπ** will be extended by **~ 5 GeV/c**. **No trigger exists yet! No guarantee.**
- A simple extrapolation of the existing Run 4 PHENIX **J/ψ data** suggests that the p_T reach will increase by **~ 3 GeV/c.**

The increase in integrated luminosity per run from RHIC I (> 2008) to RHIC II will be smaller, effectively about x 14.

Yield estimates for R2D

Signal	Experiment	RHIC I	RHIC II	Measurement
$J/\psi \rightarrow ee$	R2D	56000	4300000	v2 & R_AA vs pT and y
$J/\psi \rightarrow \mu\mu$	R2D	56000	4300000	v2 & R_AA vs pT and y
$\psi' \rightarrow ee$	R2D	10000	77000	R_AA vs pT and y
$\psi' \rightarrow \mu\mu$	R2D	10000	77000	R_AA vs pT and y
$\Upsilon \rightarrow ee$	R2D	5100	39000	R_AA vs pT and y
$\Upsilon \rightarrow \mu\mu$	R2D	5100	39000	R_AA vs pT and y
$\chi_c \rightarrow ee$	R2D	86000	670000	R_AA vs pT and y
$\chi_c \rightarrow \mu\mu$	R2D	86000	670000	R_AA vs pT and y
$B \rightarrow J/\psi \rightarrow ee$	R2D	8700	67000	bottom R_AA vs pT and y
$B \rightarrow J/\psi \rightarrow \mu\mu$	R2D	8700	67000	bottom R_AA vs pT and y

Dielectron and dimuon measurements are both in $|\eta| < 3$

Comments on work to be done

We have estimates of quarkonium rates that we think make a good case for RHIC II luminosity. There is still work to do on signal/background estimates but, **except for the χ_c**, we do not expect a large loss of significance due to backgrounds.

For open heavy flavor, **$B \rightarrow J/\psi$ measurements** are very clean measurements of bottom production, and they are not feasible without RHIC II luminosity (except in R2D, which would cost more than the luminosity upgrade).

But we still have some work to do on **other** open heavy flavor measurements that require RHIC II luminosity. We still need quantitative estimates for:

- **Measurements that separate open charm and open bottom and give us independent R_{AA} and v_2 measurements for them.**
- **Rates for jets tagged with heavy flavor.**

And we need to understand if there are electron ID issues at high p_T.