Physics Goals of Si Vertex Detector

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- Physics priorities latter part of this decade
 - spin carried by gluons: $\Delta G vs x$
 - modification of gluon structure function in nuclei
 - properties of earliest, densest stage of Au+Au
- Observables
 - open charm, open beauty in pp, pA, AA
 - over a broad range of y, pt



Strawman





 ΔG Before vs After Si Vertex



- a) jet-axis for photon+jet-axis => constraint on x
- b) c=>e, μ displaced vertex low-x S/B, D=>K π high-x
- c) b=>displaced J/ ψ low/high-x, b=>e, displaced vertex high -x

Si vertex extends x-range with overlap => integral ΔG

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Example, $B=>J/\psi=>\mu\mu$



B => J/ψ, utilizing large acceptance muon arms requires end-disks of vertex detector

pA Charm, Beauty Production

- Heavy-flavor production via $gg => q + \overline{q}$
- Extracting gluon structure function nuclei, shadowing
 - vertex detector provides broader range in x
 - » into predicted shadowing region
 - check consistency of several observables



AA Charm, Beauty Production

- Possible charm enhancement in earliest stage of reaction
- High-pt heavy-quarks may lose less energy in the plasma
 Kharzeev et al. predict reduced gluon Bremsstrahlung
- Charm is critical baseline for J/ψ suppression
- Charm provides key info for di-lepton continuum
- Goals require broad-range in pt and y coverage
 - spectra and yields of open charm, beauty
 - » pp, pA and AA
- Strategy
 - different decay channels => complementary pt, y ranges



Decay Channels => Different y, pt Ranges

Charm

- low-pt, D=>e, μ +X, displaced electrons, muons
- high-pt, D=>K π
- Beauty
 - B=>J/ ψ => $\mu^+\mu$ or e⁺e⁻, displaced J/ ψ
 - high-pt B=> e+X, displaced electrons



Landscape: Mid-Rapidity Sources of Electrons



pt of e⁻ pp 250 GeV/c Pythia

Suggests a strategy:

Remove Dalitz via vertex cut charm pt(e) < 3 GeV/c beauty pt(e) > 3 GeV/c

details next...

pt(e) (GeV/c)



Robust Low-pt Charm D=>eX



- 1) remove Dalitz e, DCA cut
- 2) or fit DCA distribution folded with resolution
- \Rightarrow charm yield low pt_D
- ⇒ reduce systematic error of existing charm result PRL 88:192303,2002



Open Charm Forward Rapidity, Si Endcaps



- Inclusive D=>μ+X dominated by π, K decays
 - insist muon comes from within 1cm of collision
 - removes many muons
 from π, K decay

high-statistics, robust charm

same y, pt range as J/ψ => critical normalization



High-pt: Flavor Dependence Energy-loss

- @ higher pt, e and μ decay channels dominated by beauty
 - hadronic decay for high-pt charm spectra
 - » multiple-scattering, small acceptance less problematic



Au+Au 4 blue-book luminosity, 50 full days/year, yield Au+Au= AA*(yield p+p)

Mid-Rapidity Open Beauty



Measure DCA distribution for pt (e) > 3 GeV/c

e.g. with dca >120 μ m

p+p #electrons 320K/year Au+Au #electrons 125K/year



Open Beauty in Endcaps



Large acceptance in muon arms => high rate

e.g. with z vertex > 0.1cm

p+p #J/ψ 20K/year Au+Au #J/ψ 7K/year





a) ~1% X/X₀ per layer

R&D in thinning/bump-bonding, monolithic

- b) 1st layer as close to beam-pipe as possible
- c) rely on PHENIX central + muon arms for PID, momentum
- d) 4 layers => accurate, redundant DCA







Vital Statistics

	Channels	Occupancy (central Au+Au)
barrel 1 st : pixels	1.3 M	<1%
barrel 2 nd : strips	92 K	12%
barrel 3 rd strips	123 K	7%
barrel 4 th strips	154 K	5%
endcaps; pixels	2.8 M	<3%



Electrons: Resolution Distance Closest Approach



 $50\mu m x 425\mu m$ pixels, full multiple scattering dca resolution (electrons) < $50 \mu m$ at moderate pt less than $c\tau$, D⁰: 125 μm D[±]: 317 μm



Matching to Muon Arms

- Match tracklets in Si to muon spectrometer
 - cut on same charge
 - cut on momentum match before/after muon shielding
 - matches hit, efficiency > 90%



Other Physics

- Strange baryons, Λ , Ξ , Ω
 - confirm by-then-existing STAR results
- Better angle measurement for μ+μ- pairs
 - improved mass resolution for all vector mesons
 - » J/ ψ , ψ ', Upsilon
- Improved signal/background for J/ψ
 - J/ ψ flow ?

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Summary

- Physics case for vertex upgrade
 - gluon spin structure function broad range in x
 - gluon shadowing in nuclei
 - charm enhancement early-stage of heavy-ion collision
 - charm baseline for J/ψ suppression
 - energy-loss of high-pt heavy quarks
- Charm, beauty in pp, pA, AA collisions
 - broad pt, y range
 - » use different decay channels to reach different parts of phase space
- Required R&D
 - described in next talk



backups



PHENIX QM02





Electron pt Spectra from D





x2 from B=>J/ ψ



