Appendix A

Event Rates

In this section we estimate the event rates of selected physics processes corresponding to some of the major goals of the NCC detector. All rates are for a single NCC. We start with expected luminosities for RHIC II from the BNL Collider Accelerator Division (CAD). We then assume a 50% duty factor for the RHIC machine, and a 60% up time for the PHENIX detector during a 12 week run to obtain an integrated luminosity (see table A.1). Rates are calculated for RHIC II luminosities, however rates for RHIC I are also given for particular cases.

There are several typical losses in efficiency from our experience in the first 5 years of data taking. These are listed in table A.3. The first arises from a vertex cut, which we take to be ± 10 cm from the nominal collision point. We assume 55% efficiency from losses due to the spread of the beam. For RHIC I this will be a 35% efficency since the spread of the beam is larger. Secondly, the minimum bias trigger uses the Beam-Beam Counters (BBC) located up and downstream of the collision point. In the high multiplicity environment of heavy ion collisions - this trigger is almost 100% efficient. However in low multiplicity p+p and p+A collisions, the efficiency drops since in some cases, no particles actually trigger the

Table A.1: Luminosity guidance from CAD for RHIC II. We assume a 50% duty cycle for RHIC to give a weekly integrated luminosity. We then assume a 12 week run and a 60% uptime for PHENIX to give an total integrated luminosity. The max rate is the interaction rate at peak luminosity.

Species CM Energy	p+p 200 GeV	p+p 500 GeV	pAu 200 GeV	dAu 200 GeV	CuCu 200 GeV	Au+Au 200 GeV
lum ($s^{-1}cm^{-2}$)	1×10^{32}	5×10^{32}	2.5×10^{29}	1.9×10^{29}	8×10^{28}	7×10^{27}
interaction rate	4200	21000	320	585	248	47 kHz
lum/wk ($pb^{-1}wk^{-1}$)	33	166	0.083	0.062	0.025	0.0025
Int Lum (pb^{-1})	238	1195	0.6	0.45	0.18	0.018

Table A.2: Luminosity assumptions for RHIC I. We assume a 50% duty cycle for RHIC to give a weekly integrated luminosity. We then assume a 12 week run and a 60% uptime for PHENIX to give an total integrated luminosity.

Species CM Energy	p+p 200 GeV	p+p 500 GeV	pAu 200 GeV	dAu 200 GeV	CuCu 200 GeV	Au+Au 200 GeV
lum ($s^{-1}cm^{-2}$)	3×10^{31}	–	–	0.09×10^{29}		0.92×10^{27}
lum/wk ($pb^{-1}wk^{-1}$)	9.9	–	–	0.0028	–	0.000327
interaction rate	4200	21000	320	585	248	47 kHz
Int Lum (pb^{-1})	71.3	–	–	0.02	–	0.0024

Table A.3: Efficiency factors added into the rate calculations. In the analysis we typically require that the vertex be within 10 cm of the nominal collision point (a requirement set by the barrel VTX detector), which results in a loss of 0.55 for RHIC II. For RHIC I, the beam spread is larger and results in a loss of 0.31. For A+A collisions the minimum bias trigger formed by the Beam-Beam counters are essentially 100% efficient, however in p+p and p+A collisions there is some loss.

Species	p+p 200 GeV	p+p 500 GeV	pAu	dAu	CuCu	Au+Au
vertex cut RHIC II	0.55	0.55	0.55	0.55	0.55	0.55
vertex cut RHIC I	0.31	0.31	0.31	0.31	0.31	0.31
min bias trigger eff	0.75	0.75	0.90	0.90	1.0	1.0
reconstruction eff	0.80	0.80	0.80	0.80	0.80	0.80
total eff factor RHIC II	0.33	0.33	0.40	0.40	0.44	0.44
total eff factor RHIC I	0.19	0.19	0.23	0.23	0.25	0.25

BBC. Finally we have taken 80% for the reconstruction efficiency, a reasonable number from our experience in the last several years.

Pythia was used to obtain p+p cross sections for direct photons, π^0's, W's, and the χ_c. To obtain heavy ion yields we assumed a point-like cross section - that is the cross sections were scaled by the product of the atomic weights of the incoming nuclei. For π^0's and the χ_c a suppression factor was assumed consistent with the data from Runs 1-5 or about a factor of 2 for minimum bias collisions. Tables A.4 and A.5 give the yields for a 12 week run for pp, pA, Cu+Cu and Au+Au collisions for a single NCC.

We are studying the effect of triggering as described in section 3.9.1. A simple 8x8 tile trigger should be sufficient for p+p and p+A collisions given a DAQ bandwidth of 8kHz. However, at present a simple 8x8 trigger will be ineffective in heavy ion collisions giving rejections of less than 2. Using a minimum bias trigger for heavy ion collisions results in substantial loss of a e.g. a factor of 6 in Au+Au collisions and 30 in Cu+Cu collisions.

This does not affect the χ_c since this depends on a dimuon trigger and will not come from triggering using the NCC. The work on the trigger is in its very early stages and more sophisticated trigger schemes will be explored. In addition improvements are envisioned to the DAQ to increase its rate by a factor of 2 or more.

Table A.7 gives a summary of the physics program addressed by the Nosecone Calorimeter. Rates for direct photons and π^0's are typically about 5 times that which will be available in the central EMC in A+A collisions. Without the NCC the χ_c would be impossible in heavy ion collisions. The rate into the central EMC is simply too small. The NCC, by contrast utilizes the large acceptance of the muon arms to detect the J/ψ, and is itself a large acceptance detector. For both p+p and p+A collisions, the crucial aspect of the NCC is the forward rapidity coverage which allows one to reach low x 10^{-3}.

Table A.4: Yields in p+p collisions of various processes into the acceptance of a single NCC for a 12 week RHIC II run with efficiency factors listed in Table A.3

Species	process		Yield
pp 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	62M
		$p_T(\pi^0) > 10$ GeV	260K
		$p_T(\pi^0) > 15$ GeV	8K
		$p_T(\pi^0) > 20$ GeV	450
pp 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	1M
		$p_T(\gamma) > 10$ GeV	33K
		$p_T(\gamma) > 15$ GeV	2.6K
		$p_T(\gamma) > 20$ GeV	280
pp 200 GeV	W$\rightarrow e + \nu_e$	$p_T(e) > 5$ GeV	16
		$p_T(e) > 10$ GeV	11
		$p_T(e) > 20$ GeV	5
pp 200 GeV	$\chi_{c1} \rightarrow \gamma J/\psi \rightarrow \gamma\mu\mu$		26K
	$\chi_{c2} \rightarrow \gamma J/\psi \rightarrow \gamma\mu\mu$		42K
pp 500 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	1300M
		$p_T(\pi^0) > 10$ GeV	17M
		$p_T(\pi^0) > 15$ GeV	1.3M
		$p_T(\pi^0) > 20$ GeV	190K
pp 500 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	24M
		$p_T(\gamma) > 10$ GeV	1.7M
		$p_T(\gamma) > 15$ GeV	270K
		$p_T(\gamma) > 20$ GeV	65K
pp 500 GeV	W$\rightarrow e + \nu_e$	$p_T(e) > 5$ GeV	4.9K
		$p_T(e) > 10$ GeV	4.4K
		$p_T(e) > 20$ GeV	2.8K
pp 500 GeV	$\chi_{c1} \rightarrow \gamma J/\psi \rightarrow \gamma\mu\mu$		790K
	$\chi_{c2} \rightarrow \gamma J/\psi \rightarrow \gamma\mu\mu$		1.1M

Table A.5: Yields in pAu, Cu+Cu and Au+Au collisions of various processes into the acceptance of a single NCC for a 12 week RHIC II run with efficiency factors listed in Table A.3.

Species	process		Yield
pAu 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	37M
		$p_T(\pi^0) > 10$ GeV	150K
		$p_T(\pi^0) > 15$ GeV	4.7K
		$p_T(\pi^0) > 20$ GeV	270
pAu 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	610K
		$p_T(\gamma) > 10$ GeV	20K
		$p_T(\gamma) > 15$ GeV	1.5K
		$p_T(\gamma) > 20$ GeV	170
pAu 200 GeV	$\chi_{c1} \to \gamma J/\psi \to \gamma\mu\mu$		10K
	$\chi_{c2} \to \gamma J/\psi \to \gamma\mu\mu$		16K
CuCu 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	130M
suppressed		$p_T(\pi^0) > 10$ GeV	545K
		$p_T(\pi^0) > 15$ GeV	16K
		$p_T(\pi^0) > 20$ GeV	942
CuCu 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	4.1M
		$p_T(\gamma) > 10$ GeV	130K
		$p_T(\gamma) > 15$ GeV	10K
		$p_T(\gamma) > 20$ GeV	1.1K
CuCu 200 GeV	$\chi_{c1} \to \gamma J/\psi \to \gamma\mu\mu$		40K
suppressed	$\chi_{c2} \to \gamma J/\psi \to \gamma\mu\mu$		65K
AuAu 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	100M
suppressed		$p_T(\pi^0) > 10$ GeV	440K
		$p_T(\pi^0) > 15$ GeV	13K
		$p_T(\pi^0) > 20$ GeV	1.1K
AuAu 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	4M
		$p_T(\gamma) > 10$ GeV	130K
		$p_T(\gamma) > 15$ GeV	10K
		$p_T(\gamma) > 20$ GeV	1.1K
AuAu 200 GeV	$\chi_{c1} \to \gamma J/\psi \to \gamma\mu\mu$		43K
suppressed	$\chi_{c2} \to \gamma J/\psi \to \gamma\mu\mu$		70K

Table A.6: Yields of various processes into the acceptance of a single NCC for a 12 week RHIC I run with efficiency factors listed in Table A.3

Species	process		Yield
pp 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	10M
		$p_T(\pi^0) > 10$ GeV	43K
		$p_T(\pi^0) > 15$ GeV	1.3K
		$p_T(\pi^0) > 20$ GeV	75
pp 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	167K
		$p_T(\gamma) > 10$ GeV	5.5K
		$p_T(\gamma) > 15$ GeV	433
		$p_T(\gamma) > 20$ GeV	50
pp 200 GeV	$\chi_{c1} \to \gamma J/\psi \to \gamma\mu\mu$		4K
	$\chi_{c2} \to \gamma J/\psi \to \gamma\mu\mu$		7K
AuAu 200 GeV	π^0 production	$p_T(\pi^0) > 5$ GeV	7.7M
suppressed		$p_T(\pi^0) > 10$ GeV	32K
		$p_T(\pi^0) > 15$ GeV	980
		$p_T(\pi^0) > 20$ GeV	58
AuAu 200 GeV	direct photon production	$p_T(\gamma) > 5$ GeV	290K
		$p_T(\gamma) > 10$ GeV	9.6K
		$p_T(\gamma) > 15$ GeV	750
		$p_T(\gamma) > 20$ GeV	81
AuAu 200 GeV	$\chi_{c1} \to \gamma J/\psi \to \gamma\mu\mu$		3.1K
suppressed	$\chi_{c2} \to \gamma J/\psi \to \gamma\mu\mu$		5K

Table A.7: The coverage by the NCC of some of relevant kinematical variables given the rates mentioned previously.

Process	Species	Physics Goal	
π^0 production	pAu 200 GeV	saturation	$1< y <3$; $p_T \sim 15$ GeV
	p+p 200 GeV	"CGC"	$1< y <3$; $p_T \sim 15$ GeV
direct photon production	pAu 200 GeV	saturation	$1< y <3$; $p_T \sim 15$ GeV
	p+p 200 GeV	"CGC"	$1< y <3$; $p_T \sim 15$ GeV
π^0 production	Au+Au 200 GeV	parton energy loss	$1< y <3$; $p_T \sim 15$ GeV
Heavy Ions	Cu+Cu 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
	pAu 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
	p+p 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
direct photon production	Au+Au 200 GeV	jet tomography	$1< y <3$; $p_T \sim 15$ GeV
"photon-jet"	Cu+Cu 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
Heavy Ions	pAu 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
	p+p 200 GeV		$1< y <3$; $p_T \sim 15$ GeV
$\chi_{c1} \rightarrow \gamma J/\psi \rightarrow \gamma\mu\mu$	Au+Au 200 GeV	confinement	$1< y <2$
Heavy Ions	Cu+Cu 200 GeV		$1< y <2.5$
	pAu 200 GeV		$1< y <3$
	p+p 500 GeV		$1< y <3$
π^0 production	p+p 200 GeV	$A_{LL}(p_T)$	
Spin	p+p 500 GeV		
direct photon production	p+p 200 GeV	$\Delta G(x)$at low x	$x \sim 3 \times 10^{-3}$
Spin	p+p 500 GeV		$x \sim 1 \times 10^{-3}$
W$\rightarrow e + \nu_e$ *Spin*	p+p 500 GeV	$\Delta\overline{q}$	
Spin			