What assumptions should we use to estimate yields?

VTX meeting, Tony Frawley, August 12, 2003

My charge from Craig Ogilvie was to comment on:

“ ... what assumptions we should uniformly make about rates, luminosity, uptimes, bandwidth, triggers etc. The goal would be for everyone to use the same set of assumptions when we calculate expected counts for different physics observables.”

Since this is a VTX meeting, I will try to look ahead to conditions as we expect them to be when the VTX detector becomes available for physics running.

Warning: Projected RHIC performance is a very murky area! I have chosen to use the optimistic CAD performance projections.

Overview

This is my understanding of the best case scenario for upgrades:

Year	Run	Upgrades available
2004	4	Partial Aerogel
2005	5	Aerogel
2006	6	Aerogel
2007	7	Aerogel,VTX-barrel,HBD,μ
2008	8	Aerogel,VTX,HBD,μ,TPC

Recent guidance from Thomas Roser on CAD projected performance:
http://www.phenix.bnl.gov/phenix/WWW/p/draft/zajc/sp/presentations/RBUP03/2003-08_RHIC_Lum_Projections_TRoser.pdf

Au-Au luminosities and Rates: 2008

The VTX barrel appears in 2007 and the endcaps in 2008 in current planning. **So we start with Roser's latest 2008 luminosity projections.**

L_{peak} = 32 x 10^{26} cm^2 s^{-1} σ_{BBC} = 92% of 6.9 b R_{peak} = 20 kHz
L_{aver} = 8 x 10^{26} cm^2 s^{-1} σ_{BBC} = 92% of 6.9 b R_{aver} = 5 kHz

But this is **delivered** by RHIC - if 70% is lost to our vertex cuts, we get:

R_{peak}	= 14 kHz
$R_{average}$	= 3.5 kHz

Note: With the present DAQ we will be limited to ~ 8 kHz into Lvl2.
This will reduce the luminosity sampled by ~ 20% if R_{peak} is 14 kHz

Au-Au Event size with TPC and VTX

Run 2 AuAu **central event** size was 380 kB (Jamie Nagle, Aug 4 email to phenix-trigger-l).

Add 120 kB for muon north → 500 kB total

Add 200 kB for TPC → 700 kB total

From John Lajoie (see https//p25ext.lanl.gov/~hubert/phenix/silicon/) for central events:

VTX barrel event size (zero suppressed): 160 kB → 860 kB total
VTX endcap event size (zero suppressed): 340 kB → **1200 kB total**

Central event size ~ 1200 kB
Minbias event size ~ 600 kB

Au-Au Bandwidth

Assume disk archiving rate in 2008 will be 250 MB/s but we will have x 2 data compression. **Equivalent to 500 MB/s uncompressed**.

For a minbias event size of 500 MB/s, we could archive only 830 Hz:

6% of the peak rate of	**14 kHz**
24% of the average rate of	**3.5 kHz**

So we will need Lvl2 triggers to capture all of the rare events.

Note that I was unable to get input from Martin about this before the meeting. It may be that the archiving rate will increase by 2008.

p-p luminosities and rates: 200 GeV in 2008

The maximum luminosity for p-p in 2008 in the latest Roser guidelines is:

L_{peak} = 8.9 x 10^{31} cm^{-2} s^{-1} **σ_{BBC} = 21.8 mb** **R_{peak} = 1.9 MHz**

L_{aver} = 7.2 x 10^{31} cm^{-2} s^{-1} **σ_{BBC} = 21.8 mb** **R_{aver} = 1.6 MHz**

This is **delivered** by RHIC - assume 70% is lost to our vertex cuts:

R_{peak}	**= 1.4 MHz**
$R_{average}$	**= 1.1 MHz**

p-p luminosities and rates: 500 GeV in 2008

The latest Roser guidline for maximum p-p luminosity for 500 GeV is 2.5 times the 200 GeV luminosity (~ 8 weeks of machine development):

L_{peak} = 2.2 x 10^{32} cm^{-2} s^{-1} **σ_{BBC} = 21.8 mb** **R_{peak} = 4.9 MHz**

L_{aver} = 1.8 x 10^{32} cm^{-2} s^{-1} **σ_{BBC} = 21.8 mb** **R_{peak} = 3.9 MHz**

This is **delivered** by RHIC - assume 70% is lost to our vertex cuts:

R_{peak}	**= 3.4 MHz**
$R_{average}$	**= 2.7 MHz**

p-p event size with TPC and VTX

I do not have an estimate for this.

Run 3 p-p event size was ~ 90 kB.

For the TPC assume 50% of Au-Au minbias size, ie. 100 kB.

For the VTX assume 50% of Au-Au minbias size, ie. 125 KB

Assume p-p event size = 315 kB

p-p bandwidth

Assume disk archiving rate in 2008 will be 250 MB/s but we will have x 2 data compression. **Equivalent to 500 MB/s uncompressed**.

For a minbias event size of 315 kB, we could archive only 1600 Hz:

0.05% of the peak rate of 3.4 Mhz
0.06% of the average rate of 2.7MHz

Trigger Issues

Au-Au:

- Triggering only at Lvl2 is OK for event rates ~ 10 kHz
- Slight loss (~20%) if we get peak rates of 14 KHz
- We will have to **increase the rejection** of our Lvl2 triggers at these rates - add VTX information?

p-p:

- Trigger at Lvl1 to reduce > 1 MHz to 8 kHz
- Trigger at Lvl2 to reduce 8 kHz to ~ 1.5 kHz
- We probably need **more rejection.**

Estimating yields

Roser's latest integrated luminosity projections for **delivered** luminosity:

5+14 week Au-Au run in 2008:

maximum integrated luminosity = 2410 μb^{-1}

5+14 week 200 GeV p-p run in 2008:

maximum integrated luminosity = 224 pb^{-1}

5+14 week 500 GeV p-p run in 2008:

maximum integrated luminosity = 2.5 x 224 pb^{-1} **= 560 pb^{-1}**

(But allow 8 weeks special development time for 500 GeV pol. p-p)

Bill has made a very nice spreadsheet showing run scenarios for the next 5 years - see:

http://www.phenix.bnl.gov/phenix/WWW/p/draft/zajc/sp/presentations/RBUP03/RBUP03.htm

This is a discussion starter for the PHENIX decadal plan proposal.

Integrated luminosity factors in 2008

If you don't have an **integrated** luminosity estimate you can roughly estimate the average RHIC delivered luminosity by multiplying the **peak luminosity** by:

Average over store	= 0.4	(exponential decay)
Average fraction of time at store	= 0.6	(RHIC uptime)
Luminosity evolution during run	= 0.5	
Total	= **0.12**	

To get the average PHENIX luminosity, multiply the **RHIC delivered luminosity** by:

Z vertex cuts	= 0.7	(**if** storage RF works)
PHENIX uptime	= 0.5	
Total	= **0.35**	

Reconstruction cuts

We also need to consider PID/reconstruction efficiency, trigger efficiency, and losses due to runs that fail quality cuts. (Also, for VTX physics there may be some signal lost to DCA cuts, depending on what is being measured, and how).

So make sure that you use a realistic (Acceptance . $\varepsilon_{\mathbf{reconstruction}}$) and **then** reduce the signal by ~ 50% for trigger efficiency + good run selection:

p-p:

J/ψ Acc . $\varepsilon_{\mathbf{reconstruction}}$	= 0.026 – 0.010 (Run 2)	
Trigger efficiency	~ 0.8	(??)
Fraction passing run QA	~ 0.7	(guess)

Au-Au:

J/ψ Acc . $\varepsilon_{\mathbf{reconstruction}}$	= **0.0042 – 0.0017 (Run 2) !!!!**	
Trigger efficiency	~ 0.9	(??)
Fraction passing run QA	~ 0.7	(guess)

Summary for 2008

Au-Au

Peak luminosity = **32 x 10^{26} cm^2 s^{-1}** avge luminosity = **8 x 10^{26} cm^2 s^{-1}**
Peak rate = **14 kHz** average rate = **3.5 kHz**
Central event size = **1200 kB** minbias event size = **600 kB**
5+14 week run in 2008: max integrated luminosity = **2410 μb^{-1} delivered**
5+14 week run in 2008: max integrated luminosity = **843 μb^{-1} caught**

p-p at 200 GeV

Peak luminosity = **8.9 x 10^{31} cm^{-2} s^{-1}** avge luminosity = **7.2 x 10^{31} cm^{-2} s^{-1}**
Peak rate = **1.4 Mhz** average rate = **1.2 MHz** event size = **315 kB**
5+14 week p-p run in 2008: max integrated luminosity = **224 pb^{-1} delivered**
5+14 week p-p run in 2008: max integrated luminosity = **78 pb-1 caught**

p-p at 500 GeV

Peak luminosity = **2.2 x 10^{32} cm^{-2} s^{-1}** avge luminosity = **1.8 x 10^{32} cm^{-2} s^{-1}**
Peak rate = **3.4 MHz** average rate = **2.7 Mhz** **e**vent size = **315 kB**
5+14 week p-p run in 2008: max integrated luminosity = **560 pb^{-1} delivered**
5+14 week p-p run in 2008: max integrated luminosity **= 196 pb^{-1} caught**

Summary for 2008 (cont.)

General

Max data archiving rate 500 MB/s (**uncompressed equivalent)**
Max rate to EVB ~ **8 kHz**
PHENIX luminosity = RHIC delivered luminosity **x 0.35**
Include **realistic** run-QA, trigger eff., reconstruction eff., in yield estimates

RHIC 11 luminosities and rates

RHIC 11 construction could begin FY 2008 at the earliest. Completion of the project would require about 3 years, so **2011 operation at the earliest**.

But I mention RHIC 11 luminosities here because we do need to keep in mind that we should have triggers and a DAQ that can handle them!

For RHIC 11 details (which may be obsolete by now) see:

http://www.star.bnl.gov/public/NSAC_RHIC11_eRHIC_2-15-03.pdf

Au-Au luminosities and Rates: RHIC 11

The **earliest** operation for RHIC 11 would be 2013.

Average luminosity **increases by ~ 10** for RHIC 11, peak luminosity increases by less:

L_{peak} = 90 x 10^{26} cm^2 s^{-1} σ_{BBC} = 92% of 6.9 b R_{peak} = 57 kHz

L_{aver} = 70 x 10^{26} cm^2 s^{-1} σ_{BBC} = 92% of 6.9 b R_{aver} = 44 kHz

Again, this is **delivered** by RHIC - assume 70% is lost to our vertex cuts:

R_{peak}	= 40 kHz
$R_{average}$	= 31 kHz

p-p luminosities and rates: RHIC 11

Maximum luminosity for p-p for RHIC 11

L_{peak} = 8 x 10^{32} cm^{-2} s^{-1} σ_{BBC} = 21.8 mb **R_{peak} = 17.4 MHz**

L_{aver} = 6 x 10^{32} cm^{-2} s^{-1} σ_{BBC} = 21.8 mb **R_{aver} = 13.0 MHz**

This is **delivered** by RHIC - assume 70% is lost to our vertex cuts:

This puts more pressure on our Lvl1 triggers. But whether we will ever get here is not yet clear.

R_{peak}	= 12.0 MHz
$R_{average}$	= 9.0 MHz