Trigger Outline for Au-Au Option in Run-4

Planning for TN (Trigger Nirvana) in Run-04.

1. Expectations for Run-04 Au-Au Luminosities

2. Trigger Planning for Run-04

3. Lessons Learned from Run-02 and Run-03

4. Specific Call for Input

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Run-4 Au-Au Projections

Wide parameter space:

L(peak) = 4 x 10^26 → 2500 Hz AuAu
L(peak) = 8 x 10^26 → 5000 Hz AuAu
L(peak) = 14 x 10^26 → 8750 Hz AuAu → maximum from Roser Plan

Z-Vertex Loss → 30% (often seen in previous runs)
→ 50% (sometimes seen in previous runs)
→ 75% (high level expectation)

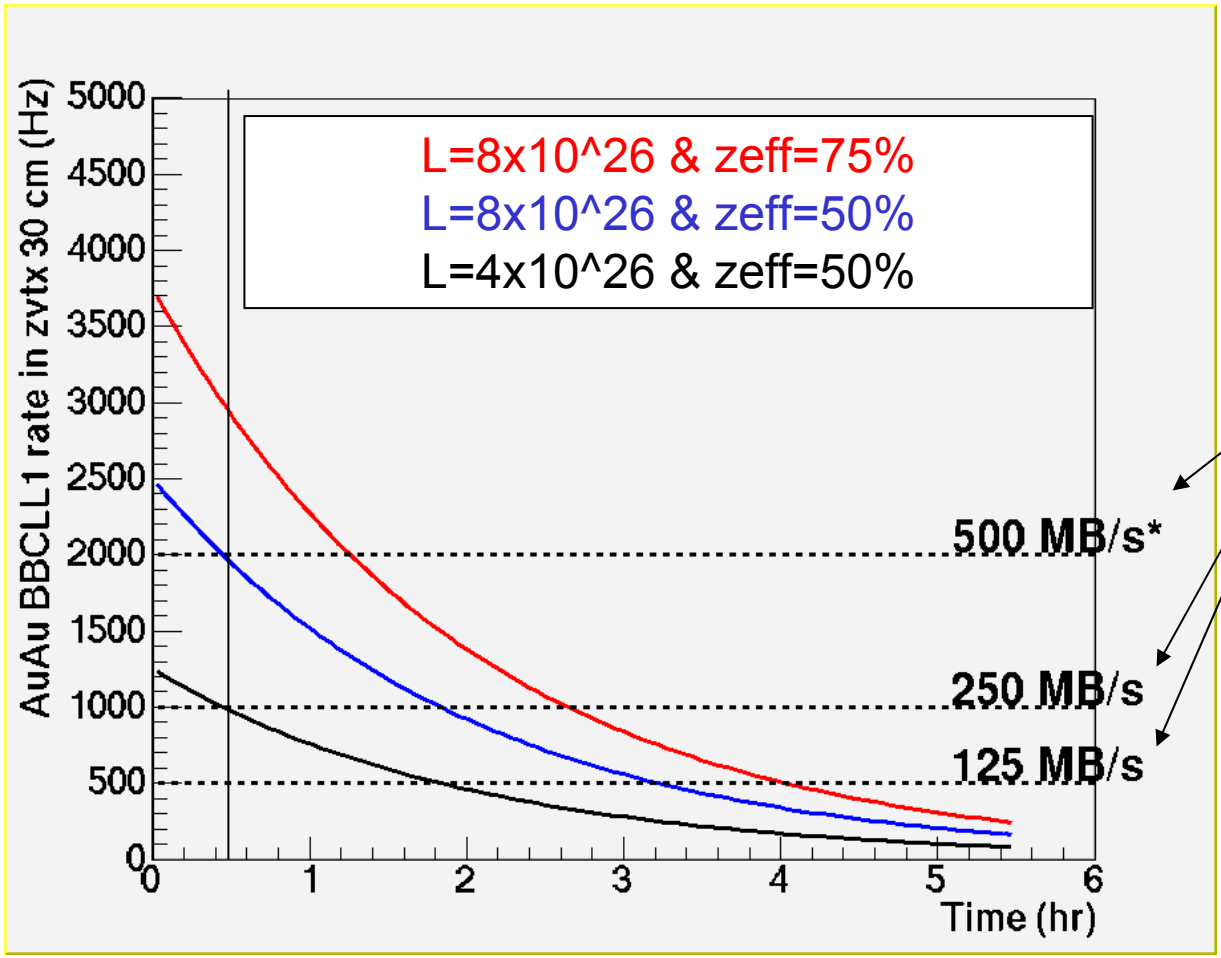
Beam store fill for 5 hours, with 2 hour lifetime.

Peak BBCLL1 rates within |zvtx| < 30 cm

→ **1250 Hz** → (L=4x10^26) & (zeff=50%)
→ **2500 Hz** → (L=8x10^26) & (zeff=50%)
→ **3750 Hz** → (L=8x10^26) & (zeff=75%)
→ **4375 Hz** → (L=14x10^26) & (zeff=50%)
→ **6560 Hz** → (L=14x10^26) & (zeff=75%)

If we achieve the middle luminosity scenario below and can archive* (with compression) the equivalent of 500 MB/s, we can record all data with BBCLL1 “Minimum Bias” triggers. This assumes all bandwidth for “Minimum Bias” data and 0.25 MB per event size.

In this case, Level-2 is still critical for monitoring and filtering, but not triggering.



* 24% loss of integrated luminosity from 30 minute start up time of HV/DAQ/etc.

Au-Au Challenge Ahead

I believe the most challenging case scenario will be archiving 250 MB/s (known technology) and the highest luminosity = 3000 Hz. Of course it could be more challenging.

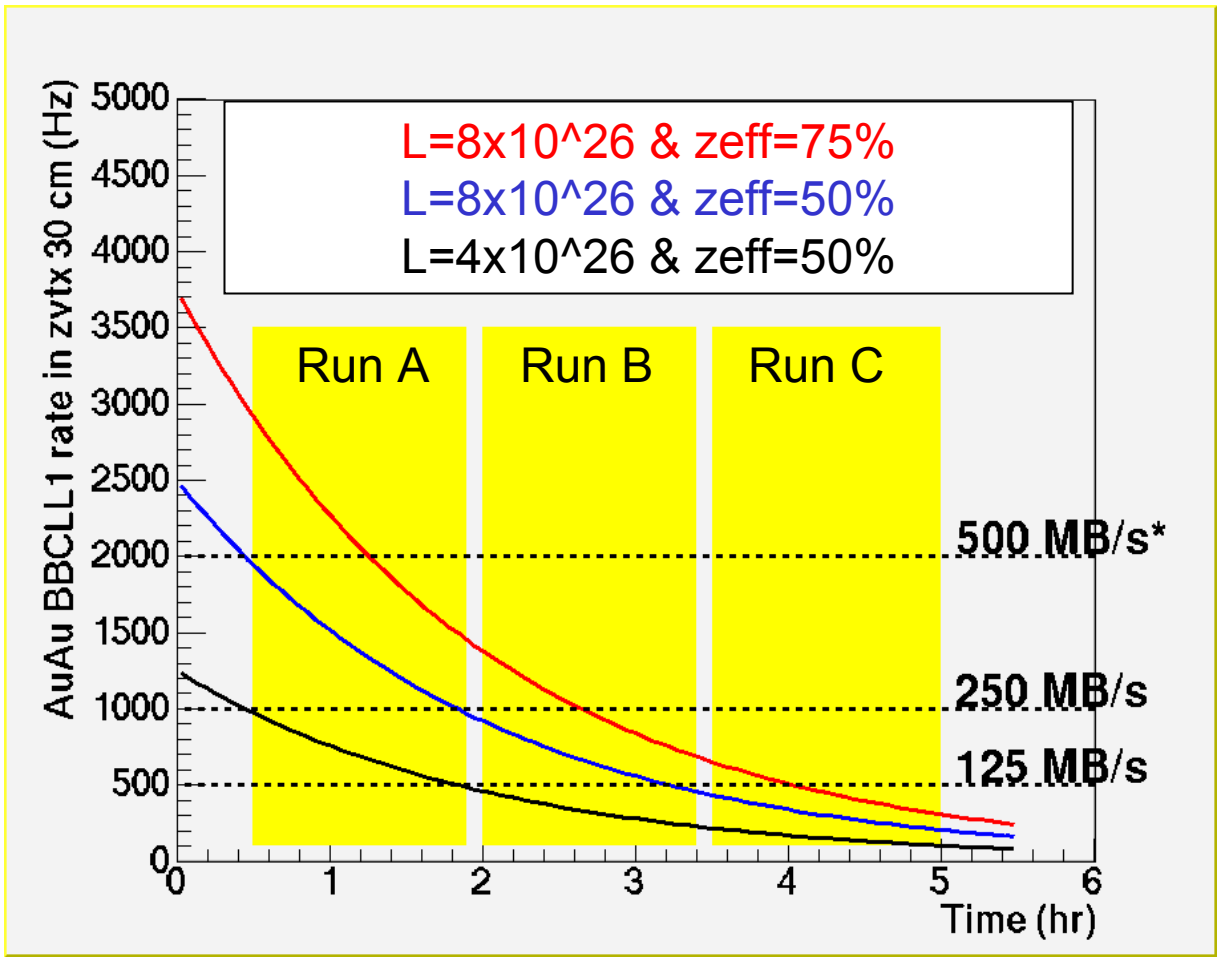
Key Example Values:

Assume Red Case
MB Event Size = 0.25 MB
LVL2 Event Size = 0.4 MB

70% BW for MB
→ 700 Hz archv.

30% BW for LVL2
→ 190 Hz archv.

Implies LVL2 rejection factor = (3000-700)/190
= **12**



Possible Projected Run Totals

Model of dividing each store into three runs.

Run A – MB Forced Accept Value = 4	LVL2 Rejection = 12
Run B – MB Forced Accept Value = 2	LVL2 Rejection = 4
Run C – MB Forced Accept Value = 1	LVL2 Rejection = none

In a 20 week run, with 15 weeks of Au-Au production

Two 5-hour stores per day = 40% RHIC eff.
Additional 50% PHENIX eff.

RUN A – MB = 2.7E8	LVL2SAMP = 1.1E9
RUN B – MB = 3.0E8	LVL2SAMP = 6.0E8
RUN C – MB = 2.7E8	LVL2SAMP = 2.7E8
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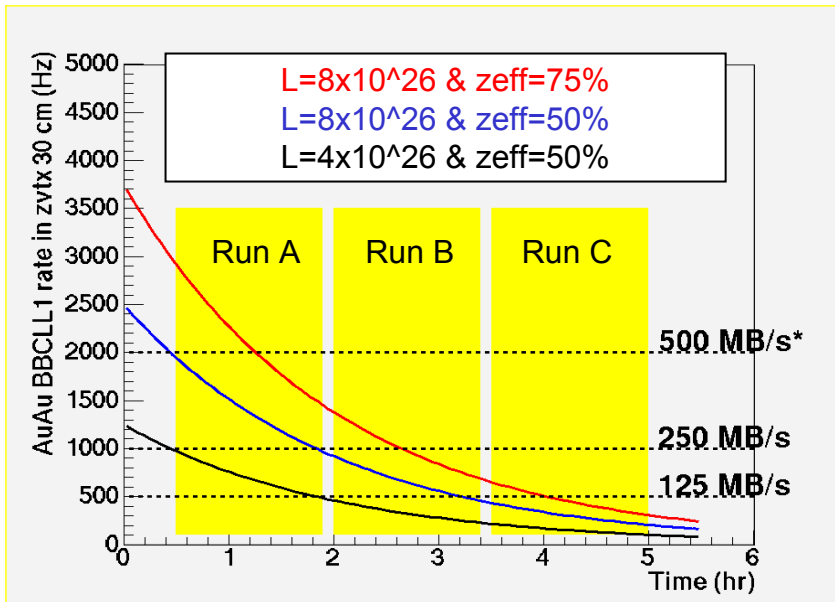
Total	**MB = 0.8E9**	**LVL2SAMP = 2.0E9**
	= 116 μb^{-1}	**= 315 μb^{-1}**

Only a factor of 3 difference !



Infinite Room for Arguments

The point is to have some estimate for what we expect in Run-4, specifically for the purpose of planning trigger work.

It is a waste of time to have an extended argument about reading the crystal ball.

Roser's maximum for a 19 week Au-Au run is 840 μb-1 and minimum is 290 μb-1. These are just RHIC collision totals.

Tony's correction for 50% PHENIX uptime and 50% vertex selection gives 210 μb-1 and 73 μb-1.

Maximum instantaneous BBCLL1 rate (within vertex cuts) may be as large as 5 kHz.
Lots of DAQ work to achieve this rate.

A Simple Plan

In Run-2 we used 20-30% of the bandwidth for Minimum Bias triggers, and had a wide array of Level-2 algorithms to enhance various physics topics.

Lessons learned:

Many of these algorithm results have not been used 1 ½ years later.
Various efficiencies degrade these triggered events relative to minimum bias.
We have a limited time budget and manpower effort for Level-2 triggers.

Proposal (see emails from Tony and Akiba and others):

For Run-4 Au-Au use 70% of the bandwidth for Minimum Bias triggers.
Select a few key physics topics that meet the following criteria:

1. Physics significantly benefits from additional factor of 3 in statistics
2. High efficiency Level-2 trigger algorithm can be developed
3. People are interested and willing to put in the work up front

Each Level-2 trigger would need to have **> 75-100** rejection factor.

Any additional triggers would have to have **> 500** rejection factors and be fast.

Short List

1. J/ψ → $\mu\mu$ and higher mass muon pairs
2. J/ψ → ee and higher mass electron pairs
3. High p_T photons (for example > 3.5 GeV – see work by Justin Frantz)

4. muons at high p_T Single
5. ϕ → $\mu\mu$ (i.e. two short MUID roads)
6. Single electron at high p_T
7. Electron-muon coincidence
8. Aerogel trigger for high p_T protons/antiprotons
9. High p_T hadrons for correlation analyses
10. You get the idea……

A Simple Plan goes bad…..

Run-2 Level-2 Trigger Mix

DAQ Bandwidth (MB/s) =	30						BBCLL1 Rate				BBCLL1 Rate			
Minimum Bias Event Size (kB) =	199						600				1350			
Level 2 Trigger Name	E/Pt/Minv	Effic.	Cent	BBCLL1	EVT Size		ON/OFF	Prescale	Percentage	Corrected	ON/OFF	Prescale	Percentage	Corrected
	Cut		Cut	Reject.	(kB)				BANDWIDTH	Overlap			BANDWIDTH	Overlap
Minimum Bias (BBCLL1)	none	100	100	1	199		1	12	33.2	33.2	1	45	19.9	19.9
L2EmcHighPtTileTrigger	3.50		100	148	337		1	1	4.6	4.1	1	4	2.6	2.3
L2EmcHighPtTileRecutTrigger	2.50		100	18	329		0	10	0.0	0.0	0	10	0.0	0.0
L2EmcHighPtTilePeriphTrigger	1.50		40	16	160		1	2	4.0	4.0	1	2	9.0	9.0
L2ChargedHighPtTriggerWest	5.00		100	151	338		1	2	2.2	2.2	1	10	1.0	1.0
L2ChargedHighPtTriggerWestRecut	7.00		100	250	338		1	1	2.7	1.4	1	2	3.0	2.7
L2ChargedHighPtTriggerEastNoTEC	5.00		100	58	338		1	5	2.3	2.3	1	20	1.3	1.3
L2ChargedHighPtTriggerEastRecutNoTEC	7.00		100	80	338		1	2	4.2	3.4	1	4	4.8	4.5
L2SingleElectronTrigger	2.50		100	412	313		1	1	1.5	1.5	1	1	3.4	3.4
L2SingleElectronTriggerRecut	3.20		100	2475	380		1	1	0.3	0.0	1	1	0.7	0.0
L2SingleElectronTriggerCentcut	1.50		40	728	153		1	1	0.2	0.2	1	1	0.4	0.4
L2JPsiElectronTrigger	2.20		100	33	390		1	1	23.6	21.3	1	2	26.6	25.3
L2JPsiElectronTriggerRecut	2.00		100	20	399		1	10	4.0	4.0	1	20	4.5	4.5
L2JPsiElectronTriggerCentCut	2.20		40	12378	180		1	1	0.0	0.0	1	1	0.0	0.0
L2PHIElectronTriggerCent	0.70		40	73	183		1	1	2.0	2.0	1	1	4.5	4.5
L2MuDiMuonTrigger	2 deep	75*70	100	58	312		1	1	10.8	10.8	1	2	12.1	12.1
L2MuDiMuonPeriphTrigger			40	1650	168		1	1	0.1	0.1	1	1	0.2	0.2
L2MuSingleMuonTrigger			100	7	293		1	99999	0.0	0.0	1	99999	0.0	0.0
L2MuSingleMuonPeriphTrigger	1 deep		40	100	170		1	1	1.4	1.4	1	1	3.1	3.1
L2EMuTrigger			100	255	378		1	1	3.0	3.0	1	1	6.7	6.7
L2EMuTriggerRecut			100	63	370		1	5	2.3	2.3	1	10	2.6	2.6
L2CoherentPeriphTrigger	ZDC only		0	1	130		1	1	0.0	0.0	1	1	0.0	0.0
									102	97.0			106	103.5

Too many Level-2 algorithms.

Leads to CPU competition, monitoring complexity, and slicing the pie too many ways.

Level-2 Time Budget

DAQ Report:

Plan is for 128 node event builder in Run-4 with absolute minimum bandwidth of 3 kHz.

This allows for ~ 90 Assembly and Trigger Processor nodes, each with dual-CPU.

Thus, at 3 kHz, with 180 CPU, there is 60 milliseconds per event.

If we really only run 3 algorithms, that allows for 20 milliseconds per event. This is probably optimistic since ATP's have other calls on their CPU, in particular if we employ compression.

Brian, who is in charge of Level-2, should comment/correct any of these numbers.

Specific Call for Input

Case A: **See earlier slide: MB = 0.8E9 LVL2SAMP = 2.0E9**
= 116 μb-1 = 315 μb-1

Case B: **If we can only archive ~ 125 MB/s, the Level-2 sample remains the same, but the MB sample will be only 0.4E9 = 58 μb-1.**

Physics Working Group members need to think about whether the proposed common "Minimum Bias" sample is reasonable for their physics analyses.

If people have other Level-2 triggers they feel are necessary, at the July core week meeting I would like to hear the following:

a. The physics rate argument for needing these statistics
b. The core idea for a Level-2 algorithm and some estimate for rejection
c. The names of people who might work towards this effort

We need to start the real work and I would like to have the general plan settled at this meeting.

Data Archiving and Processing

"Archiving 50 MB/s [at RCF] should be no problem. We have seen long periods near 100 MB/s and few hour long burst of almost 200 MB/s. The different between those numbers is the difference between 2xGb connections and 7 x 24 MB/s tape drives. Those same tape drives would reach back the raw data for reconstruction, so you have to be sure you don't double count them. I think we could sustain 70-80 MB/s arching and do reconstruction at the same time."

Dave Morrison

• 70 MB/s at RCF → 40% RHIC x 50% PHENIX → 250 MB/s in 1008

"[A total of] 500 TB of data. Again, no problem in principle. Tape costs about $350/TB, so you're looking at about $175,000 of PHENIX operating money to buy the tape."

Dave Morrison

"The most recent reconstruction performance is a bit better than 10 seconds per event on a 1.4 GHz PIII." If we arching 250 MB/second for the 19 week run, this would take 1.5 years (solid) to reconstruct given present performance.

Filtering

Many good suggestions (see Tom Hemmick and Tony Frawley's emails) about data filtering.

Filtering only works for a few streams (few probably being less than 5) and each must have sufficient rejection relative to minimum bias.

Level-2 algorithms whether for triggering or filtering must adhere to very high standards of testing, robustness, speed and documentation. Attendance at well announced Level-2 meetings is of order a few.

Nirvana !