Online Monitoring and online calibration/reconstruction for the PHENIX experiment

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Abstract

The PHENIX experiment consists of many different detectors and detector types, each one with its own needs concerning the monitoring of the data quality and the calibration. To ease the task for the shift crew to monitor the performance and status of each subsystem in PHENIX we developed a general client server based framework which delivers events at a rate in excess of 100 Hz.

This model was chosen to minimize the possibility of accidental interference with the monitoring tasks themselves. The user only interacts with the client which can be restarted any time without loss or alteration of information on the server side. It also enables multiple users to check simultaneously the same detector – if need be even from remote locations. The information is transferred in form of histograms which are processed by the client. These histograms are saved for each run and some html output is generated which is used later on to remove problematic runs from the offline analysis. An additional interface to a data base is provided to enable the display of long term trends.

This framework was augmented to perform an immediate calibration pass and a quick reconstruction of rare signals in the counting house. This is achieved by filtering out interesting triggers and processing them on a local Linux cluster. That enabled PHENIX to e.g. keep track of the number of J/Psi's which could be expected while still taking data.

INTRODUCTION

The PHENIX experiment [1] at the Relativistic Heavy Ion Collider (RHIC) consists of 4 large spectrometer arms, two central arms and two forward Muon arms containing 12 different detector subsystems (Fig. 1). Each of these detector systems has different needs in terms of monitoring its performance and producing calibrations for the data production. In the first run of PHENIX it became apparent that a common approach to the online monitoring had to be designed which had to preserve the necessary flexibility to accommodate current and future detectors or additional monitoring tasks (e.g. tracking of RHIC parameters). This new framework was successfully implemented for Run 3. Because the online monitoring receives random event samples and its results are therefore not strictly reproducible we decided not to include any calibration tasks into it. The online calibration effort was started during Run 3 utilizing and adapting the online monitoring framework.

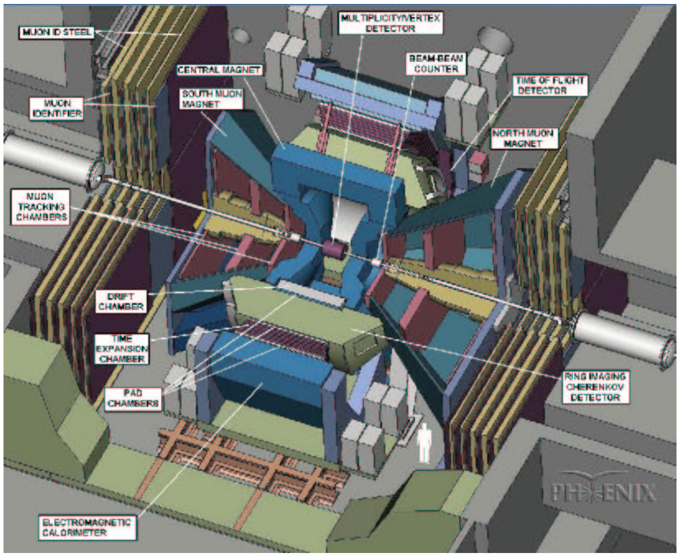


Figure 1: Overview of the PHENIX experiment.

Its goal is to calibrate the detectors while the data is being taken, enabling a fast start of the data production. As an additional benefit this provides the calibrations for a fast analysis on selected data using the computing resources in the counting house. During Run 3 we undertook a first successful attempt of an "online" analysis (π^0 p_t spectra and number of J/Psis) of recent data in the counting house. Essential for this online analysis are effective filters which reduce the amount of data which has to be reconstructed and analyzed to a manageable level. During Run 3 (d+Au) our level 1 triggers provided the necessary rejection and the filtering was performed using these triggers. During Run 4 (Au+Au) we relied on a level 2 trigger to select events with J/Psi candidates which were subsequently reconstructed and analyzed.

ONLINE MONITORING

Fig. 2 shows a sketch of the online monitoring in use by PHENIX. The Events are distributed by an *ET system* [2] with a typical rate in excess of 100 Hz. The source of these events is the most recent data file which was already written by the DAQ. This leads to a time delay between the data taking and the monitoring of these data, but since it takes less than 2 minutes to write a data file this is seen as not critical.

The framework consists of a server which runs the monitoring task(s) continuously and a client with which the user

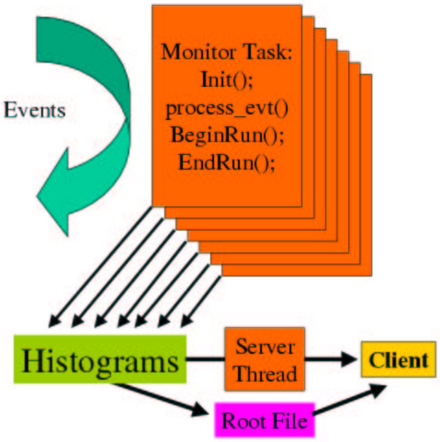


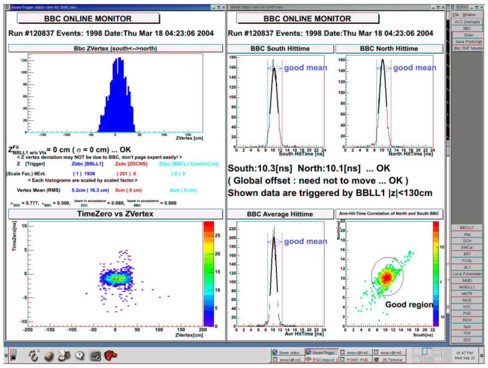
Figure 2: PHENIX Online Monitoring Framework. Multiple monitoring tasks can run within a single process. All relevant information is stored in histograms which are send on request to a client which is started and controlled by a user.

interacts. This approach enables multiple users to look simultaneously at the status of any monitoring task and prevents them from interfering with the monitoring itself. It also enables a client to display information from more then one monitoring task. All relevant information is stored in ROOT histograms which – on request – are passed by a server thread to a client. The client provides mainly the graphical display of the status of a given detector system as seen in Fig. 3. At the end of each run the server saves and resets all histograms. These histograms are subsequently used to create a summary for each run for later reference (Fig. 4). To enable the monitoring of long term trends we implemented a generic data base interface which can be used to display variations of a given variable over time.

The framework is oblivious to the specifics of the monitoring tasks. It is up to the monitoring tasks to create and fill their specific histograms and provide a root based graphical display for the client using standardized interfaces. Multiple monitoring tasks can be run within each server to make optimum use of the available CPUs. With the help of various code checking tools (valgrind [3], insure++ [4]) the servers now run continuously for days while processing millions of events with only occasional problems. As of today PHENIX runs 22 independent monitoring tasks, some more are scheduled to come online for the upcoming Run 5.

ONLINE CALIBRATION AND RECONSTRUCTION

The goal of the online calibration is to provide calibrations which are "good" enough to start the data reconstruction immediately. "Good" enough meaning that applying these calibrations result – at minimum – in reasonable hit positions suitable for the tracking which is the major CPU time consumer during the reconstruction. All other calibrations – some of which need reconstructed tracks to be extracted – can be applied later to the reconstructed output without jeopardizing the quality of the data.



Run #120837 Events: 1998 Date:Thu Mar 18 04:23:06 2004

$Z^{Fit}_{BBLL1\ w/o\ Vtx}$ = 0 cm (σ = 0 cm) ... OK
< Z vertex deviation may NOT be due to BBC, don't page expert easily! >

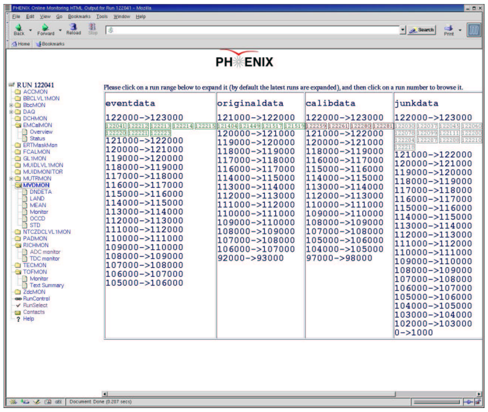
Z [Trigger]	Zbbc [BBLL1]	Zzdc [ZDCNS]	Zbbc [BBCLL1(noVtxCut)]
(Scale Fac.) #Evt.	(1) 1936	(201) 0	(0) 0
Vertex Mean (RMS)	5.2cm (16.3 cm)	0cm (0 cm)	0cm (0 cm)

< Each histograms are scaled by scaled factor.>

σ_{ZDC} = 0.777, ϵ_{BBC} = 0.500, $\frac{\text{beam in acceptance}}{\text{ZDC}}$ = 0.080, $\frac{\text{beam in acceptance}}{\text{BBC}}$ = 0.000

South:10.3[ns] North:10.1[ns] ... OK
(Global offset : need not to move ... OK)
Shown data are triggered by BBLL1 |z|<130cm

Figure 3: Online monitoring client. The shift crew normally only interacts with this root based easing the task of monitoring PHENIX during a run.



Please click on a run range below to expand it (by default the latest runs are expanded), and then click on a run number to browse it.

eventdata
122000->123000
122041 122212 122213 122214 122215 122220 122221 122223
121000->122000
120000->121000
119000->120000
118000->119000
117000->118000
116000->117000
115000->116000
114000->115000
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111000->112000
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108000->109000
107000->108000
106000->107000
105000->106000

originaldata
121000->122000
121404 121449 121517 121519
120000->121000
119000->120000
118000->119000
117000->118000
116000->117000
114000->115000
113000->114000
112000->113000
111000->112000
110000->111000
109000->110000
108000->109000
107000->108000
106000->107000
92000->93000

calibdata
122000->123000
122259 122261 122280 122281
121000->122000
120000->121000
118000->119000
116000->117000
115000->116000
114000->115000
113000->114000
112000->113000
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109000->110000
108000->109000
107000->108000
105000->106000
104000->105000
97000->98000

junkdata
122000->123000
122030 122037 122045 122060 122078 122099 122111 122200 122204 122207 122208 122210 122218
121000->122000
120000->121000
119000->120000
118000->119000
117000->118000
116000->117000
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102000->103000
0->1000

Figure 4: Online Monitoring html output. After a run is ended all histograms are saved automatically. They are used to create a snapshot of the monitoring which is saved for later reference.

The main advantage of performing the calibrations in the counting house is the easy accessibility of the raw data. As an added benefit these calibrations can be used during a fast reconstruction of a subset of the data in the counting house. PHENIX poses a challenge here with its many different detector systems each of which requires a different calibration. This is a problem very similar to the online monitoring and its framework served therefore as the nucleus for the online calibration effort which started during Run 3. In the meantime we almost achieved the goal of having an overall calibration procedure which is used by the shift crew without consulting the group which maintains the detector. For Run 5 we hope to finally succeed with this project.

The PHENIX experiment is designed to measure rare signals. To be able to keep track of the status of a run in terms of achievable physics results one has to reconstruct and analyze a substantial fraction of the events online in the counting house or on the offline computing farm where one has to deal with the overhead induced by retrieving the data again from tape. The later approach is less favorable because it involves the retrieval of enormous amounts of data especially if only events of rare triggers are to be analyzed. In the counting house we have fast filter processes which are capable of processing all data while they are being transferred to our HPSS based storage system. These processes duplicate these rare events in separate raw data files, thus bringing the data volume down to a level where it can be stored and processed on a local Linux farm which currently consists of 44 high end dual processor machines. This online processing was done successful in Run 3 resulting in raw π^0 spectra and raw J/Psi multiplicities as well as raw J/Psi multiplicities in Run 4.

CONCLUSION

During the first runs of PHENIX the emphasis was on the online monitoring to ensure the data quality. We designed and implemented a multi threaded client/server framework which accommodates current and future detectors. Nowadays the shift crews deals with a uniform interface to the online monitoring which enables them to fully concentrate on continuously monitoring the detector status. While the online monitoring is still being continuously improved as new detectors come online, the focus has now shifted towards implementing online calibration schemes for all detectors. These are geared towards enabling an immediate reconstruction pass and are performed by the shift crew while the data is being taken. We have sufficient CPU resources in the counting house to perform an online analysis on a subset of data. A fast filtering process duplicates events from triggers of interest which can then be stored and analyzed locally to provide an online overview of the physics achievable during the ongoing run.

REFERENCES

[1] K. Adcox et al., *PHENIX detector overview*, Nucl. Instr. Meth A 499, 2003, pp 469-479.

[2] C. Timmer, *Event Transfer or "ET" System*, ftp://ftp.jlab.org/pub/coda/docs/manual/ETmanual.ps

[3] http://valgrind.kde.org

[4] http://www.parasoft.com