DAQ Introduction

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- DAQ Overview
- Procedure to Run the DAQ
- Something's gone wrong. What do I do?

Introduction

- High Rates at RHIC
- Physics interests
  - Rare processes
    - J/ψ (μ and e channels), High P_t Spectra, others.
- Design Requirements
  - Triggering
    - To select rare events
  - Buffering
    - Alleviate dead time
  - High Bandwidth
  - Fast Processing
    - Level2 trigger processing

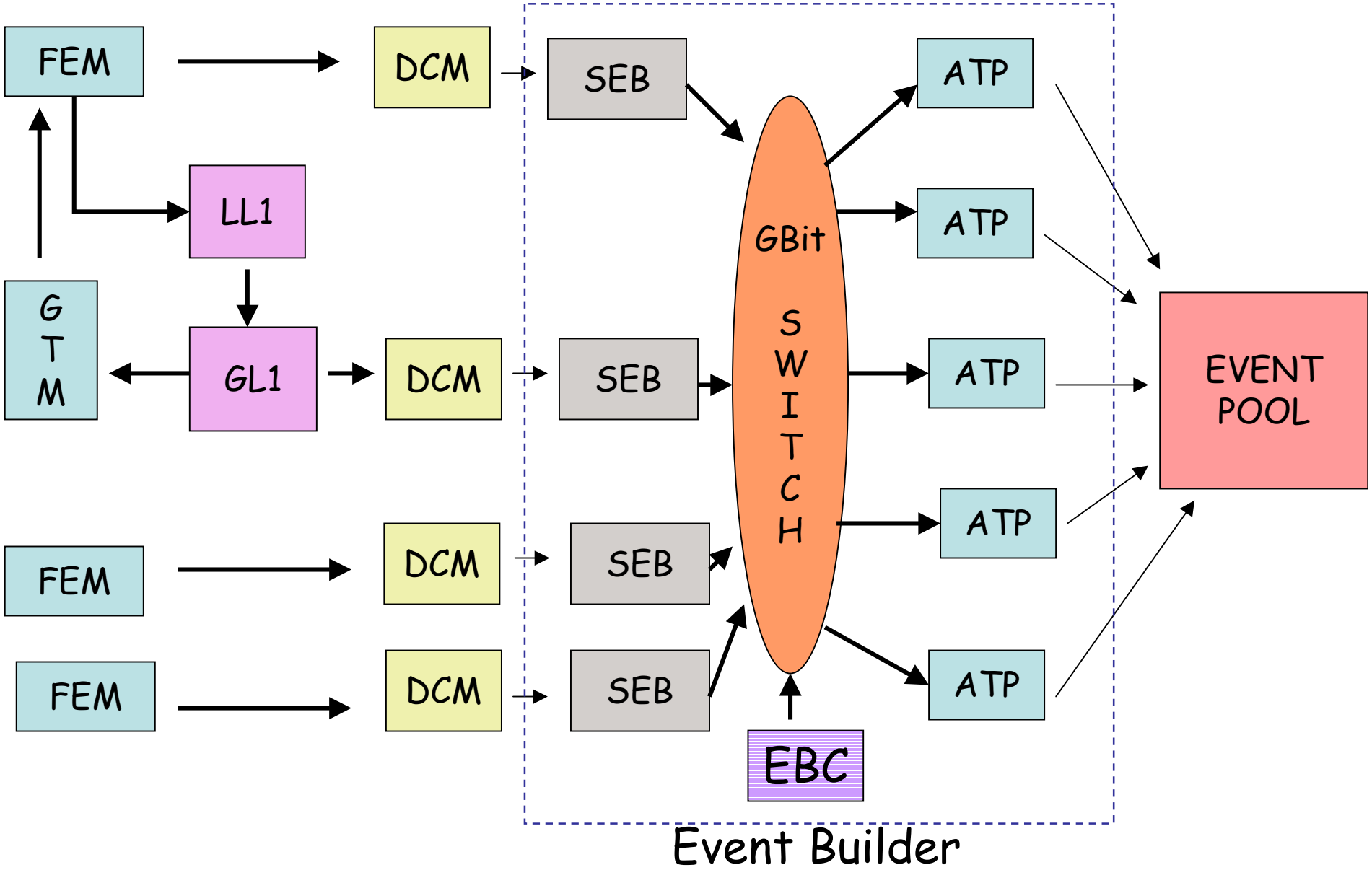
Glossary

- FEE – Front End Electronics
- FEM – Front End Module
- DCM – Data Collection Module
- JSEB – Jack's Sub-Event Buffer
- EvB – Event Builder
  - SEB – Sub-Event Builder
  - ATP – Assembly-Trigger Processor
  - EBC – Event Builder Controller
- GBit – Gigabit Ethernet
- ET Pool – Event Pool

DAQ DESIGN

- Timing
  - Synchronization system between the RHIC and the Detector
- Front End Electronics
  - Hardware which digitizes the signals from the RHIC detector components.
- Trigger
  - System which determines when a "good" collision occurs.
- DCM
  - Modules which collect the data from the FEMs
- EVB
  - SEB
    - Input Stage to the Event Builder
  - ATP
    - Event Assembler and Level2 data processing
  - EBC
    - Regulating the data flow between the SEB's and the ATP's
- Buffer Box
  - Final storage of the data (Before sending to HPSS)

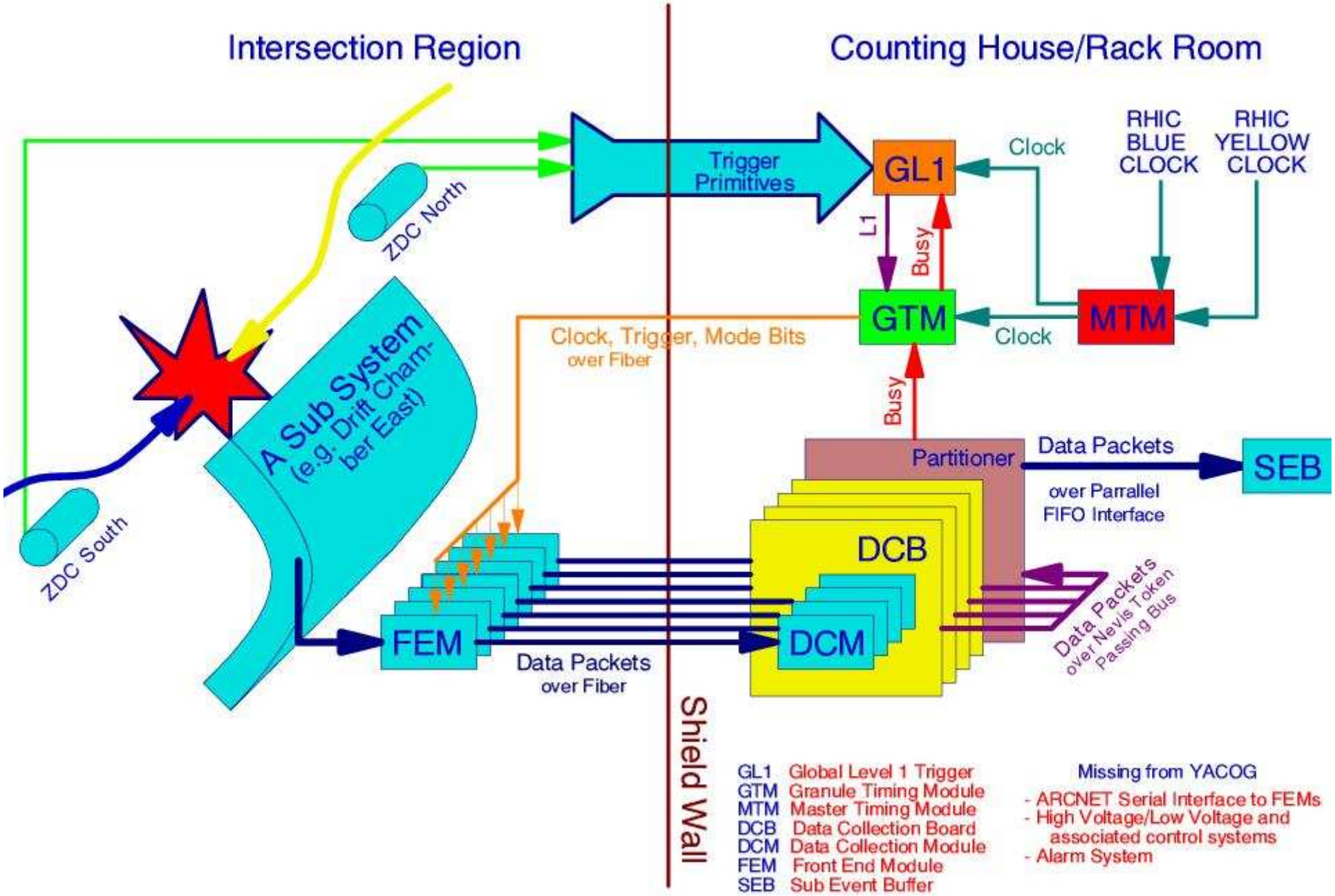
DAQ at a Glance



Granules and Partitions

- One of the desired features of the DAQ its ability to run each sub system independently.
  - This affects the design of the Trigger, Since each subsystem needs to have its own independent set of triggers.
- DAQ -> into small subunits of data taking called **"Granules".**
  - Example, DC.E, DC.W, EMC.E.B, etc.
- Also it's important to run a set of granules together as a DAQ unit (**Partition**).
  - The Trigger then is configured to send triggers to sets of granules that make up a Partition.
  - The granules of the Partition get the same trigger.
  - Triggers are vetoed by common Partition Busy
    - Up to 32 partitions

The Hardware Components of A Granule



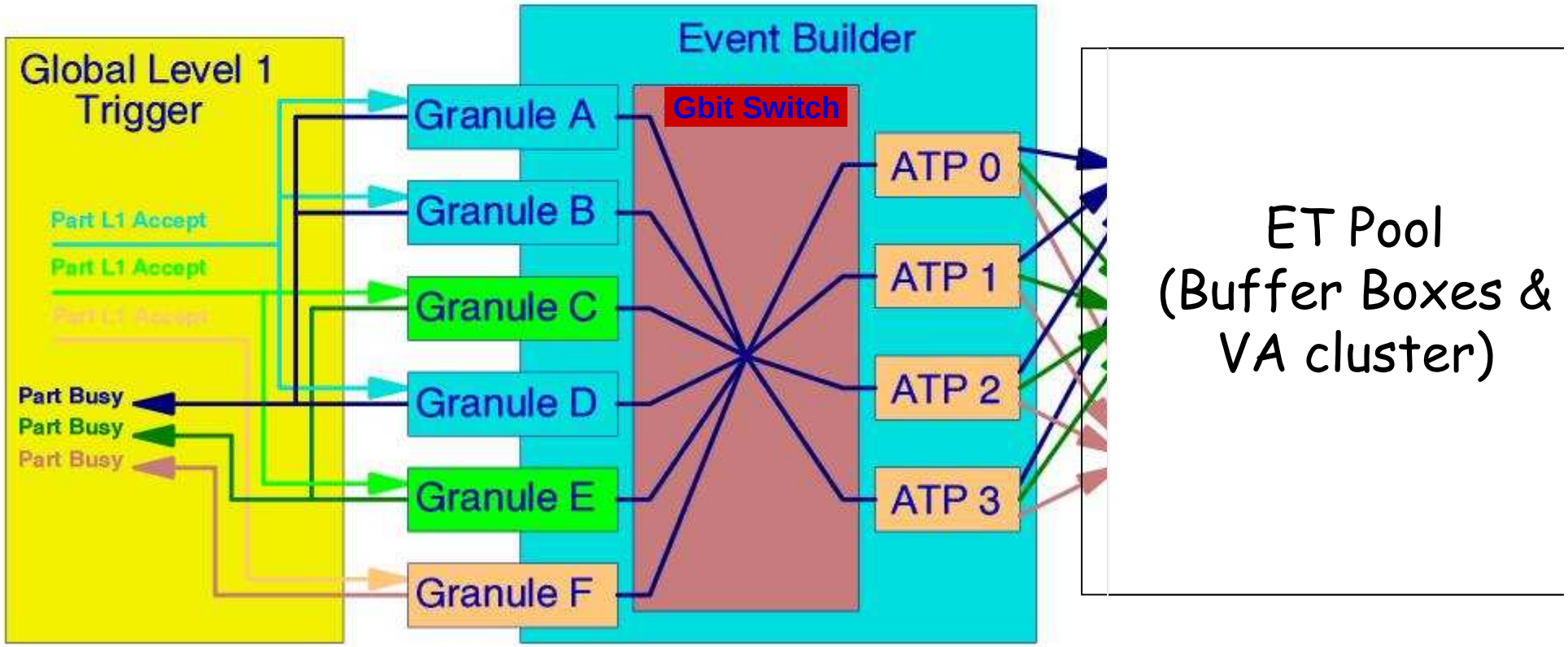
Granules and Partitions

A 3 Partition Example Configuration

Blue Partition
Granule A
Granule B
Granule D

Green Partition
Granule C
Granule E

Tan Partition
Granule F



Timing…

- The PHENIX detector FEMs need to run at the same frequency (exactly) as the RHIC accelerator.
- RHIC provides a master clock signal to all the experiments.
  - The copy at PHENIX is sent into the Master Timing Module (MTM).
  - The MTM fans out the this clock to all the Granule Timing Modules (GTMs)
  - The GTMs then fan out a copy of this same clock to all the FEMs (through Gigabit fiber optic technology)
    - GTM can generate clock signal itself (standalone mode)

GTM is used for other functions which will be described later

Trigger

- One cannot collect data at every crossing, because
  - Too many empty crossing
    - Collisions occur at about 10KHz, while the beam crossing rate occurs at 9.6MHz.
  - It would take years to collect the data needed to do any interesting physics
- Trigger system is designed to tell the PHENIX detector to record data when a collision occurred
  - Or when an "interesting" collision occurs
    - One which has muon tracks, high energy or momentum charged or neutral particles.
- Signals which are used to make a trigger decision are taken from the FEMs and fed into the Local Level 1
  - Example: BBCLL1 - Beam Beam paddle multiplicities and hit times

Trigger continued – GL1

GL1 (Global Level-1 Trigger) : generating trigger from LL1 reduced bit data, coordinating busies and managing partition

- LL1 systems process the data from the FEMs and send an "Accept" signal to the GL1
  - The accept signal means that a set of conditions are met
- Once the GL1 gets an "accept" from all LL1 systems, it sends out a Level-1 accept to the FEMs of all the granules that make up the running partition
  - This is done through the GTMs
- Once the FEMs receive a Level-1 accept, they send their stored data to the DCMs.
  - There is a complicated multi event buffering designed into the FEMs which will be discussed later.

  - Note: 4 us for a Level 1 to make a decision

Scalers

- Raw Triggers
  - Level-1 signals generated in the GL1 irrespective of the busy vetoing.
- Live Triggers
  - Level 1 triggers which are not vetoed by the busy signal
- Scaled Trigger
  - One out of every N triggers which sent to the GTMs
    - Most of the time N is set to 1(Scale Down =0)
    - For High Rate Triggers Like ZDC, N is set to 100.
    - Scaled Trigger Rate = Live Trigger Rate/(Scale Down + 1)
- Live Time
  - Live Triggers/Raw Triggers

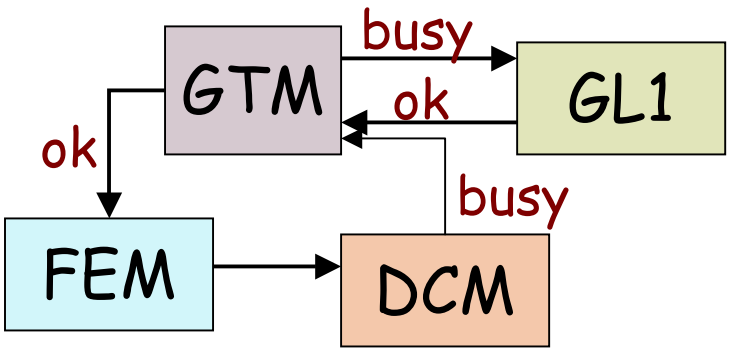
FEMs

- The FEMs are the main digitizing component of the PHENIX detector.
  - Digitizes/ stores all the analog signals.
  - Buffers 40 beam cross worth of digitized or analog data (no dead time) – this is the time it takes LL1 to make a decision
- Upon the receipt a Level-1 accept, the data is sent to the DCMs through Gigabit optic fibers
- Ability of 5 Level 1 Accept event buffering (not quite accomplished)

- Note: time it take to transfer data to DCM 194us

GTM

- Main System which controls the operation of a granule.
  - It feeds the LL1 accepts to the granules



  - Takes care of passing busy signals to the GL1
    - Several busy sources
      - Internal GTM count N busy (to prevent triggers arriving faster than the FEM's can convert and transmit data)
      - DCM busy
  - Sends the "mode bits" to the FEM
    - Mode bits are control signals which set the FEM's into different data taking states.
      - Reset, Start Data collection etc.

DCM/DCB

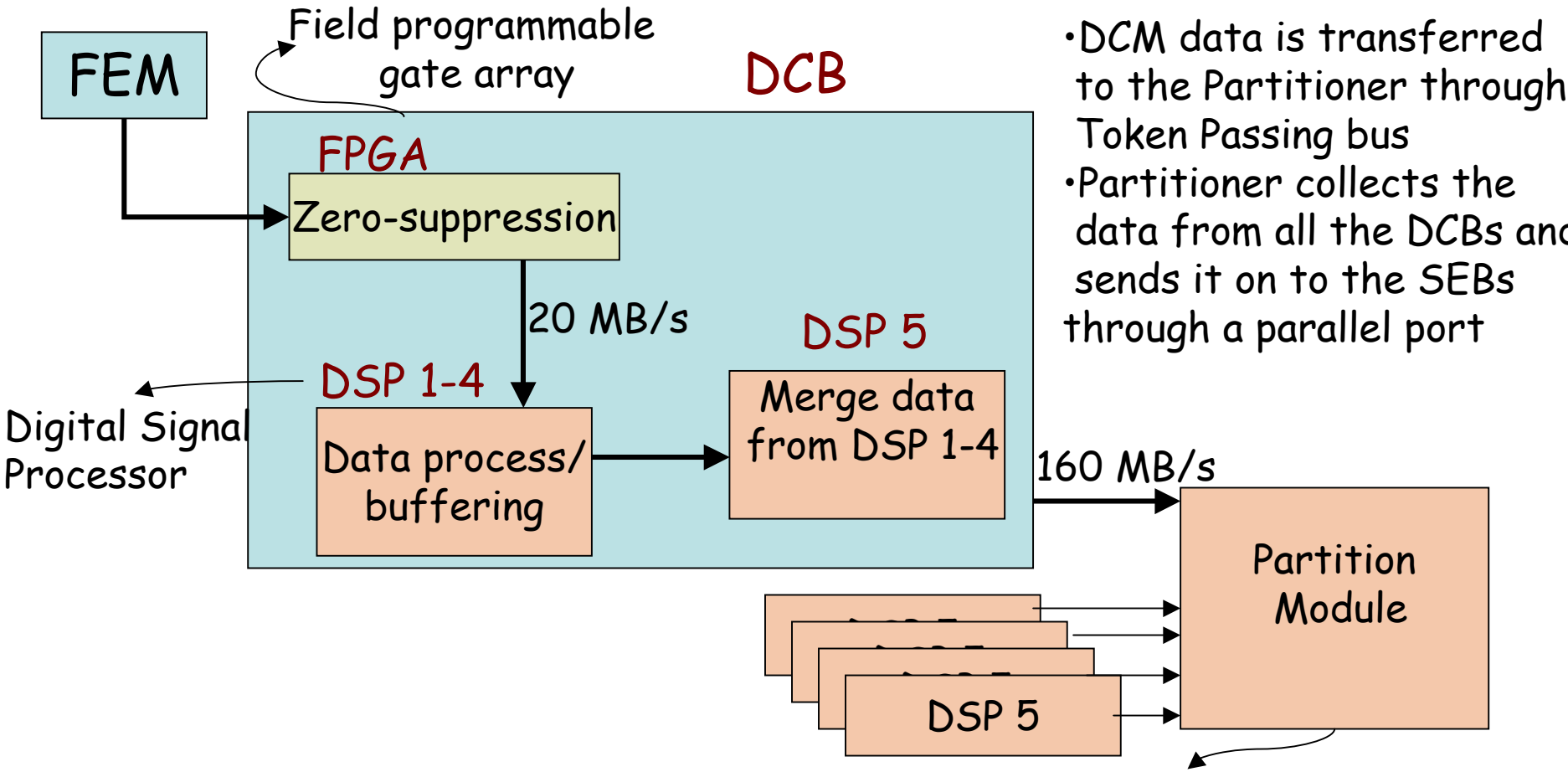
- DCM's collect the data from the FEM's through Gigabit optical fibers
- 2 FEMs are multiplexed to one DCM input

DCM Functionality:

- Zero suppression (compare pedestal subtracted data with pre-set threshold values)
- Data formatting $\rightarrow$ Event Builder
- Checksum (error checking)

- DCM groups
  - Many DCM's groups used to readout one granule
  - One DCM group per one SEB

DCM/DCB



- DCM data is transferred to the Partitioner through a Token Passing bus
- Partitioner collects the data from all the DCBs and sends it on to the SEBs through a parallel port

combines the DCM busy signals
and sends it to GTM

Event Builder

Perform the final stage of event assembly in the PHENIX data acquisition system, assembles fragments from
each data stream into complete events and to provide and environment in which Level-2 trigger processing is performed

- Data from the Partition Module is sent to the Sub-Event Buffer (SEB)
  - event fragments + clock signals received and buffered in a PCI interface card (JSEB)
  - Over 32 bit parallel cables (allows JSEB to raise hold against PM)
  - JSEB has two 1MB buffers
  - PCI bus driver delivers data to the SEBs buffer from one of the JSEB buffers while the other receives data

Event Builder

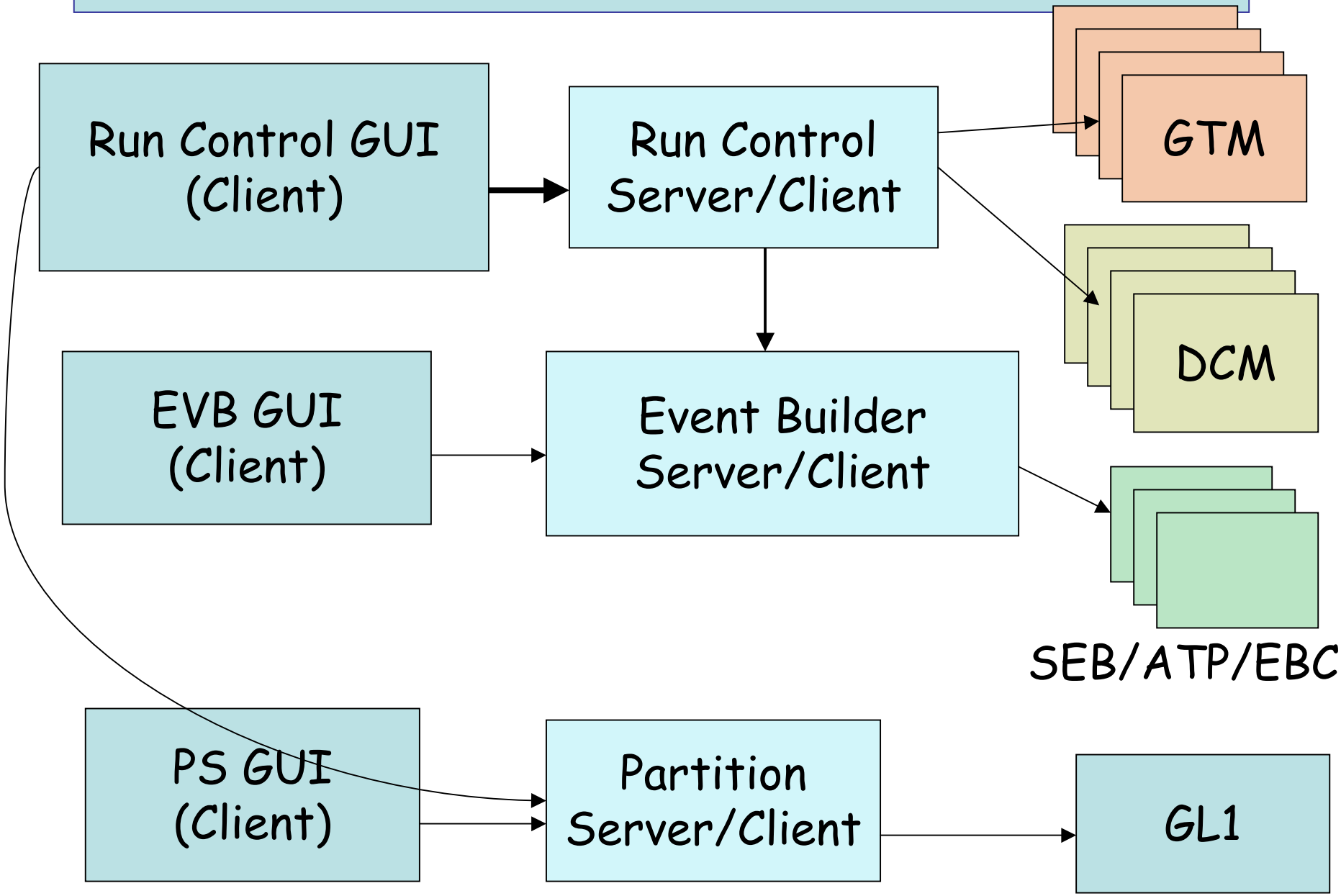
- Event Builder Controller (EBC) receives notification that data has arrived from the GL1 SEB.
  - Tells the ATPs to go fetch the data out of the SEBs
  - An ATP requests data from all the SEBs that belong to a Partition
- ATP (Assembly Trigger Processor)
  - Upon getting the data from the SEBs directly, they concatenate the event fragments and then execute the level 2 algorithm (if enabled.)
  - Built events are then sent to the Buffer Boxes for data storage via Ethernet connections.
- Transport of data and control messages from SEB to ATP is through a 96-port Gigabit switch. Transfer rates up to 120 MB/sec are theoretically possible.
- EBC keeps track of the completion of the various assignments for a given crossing and sends "flush" messages to the SEBs when assembly has been completed for all partitions

"Pull Architecture"

Run Control

- Run Control is the main overall software which controls the data taking for the experiment.
  - Controls the state of all the various DAQ components
    - GTMs
    - DCMs
    - Event Builder
      - SEB,ATP,EBC
    - Buffer Boxes
  - Provides the user interface for the DAQ operator to control PHENIX data taking
- The design of Run Control is based on a client/server model
  - Servers control the state of the hardware
  - Clients provide the user interface by which the operator controls the servers, and thus the DAQ hardware.

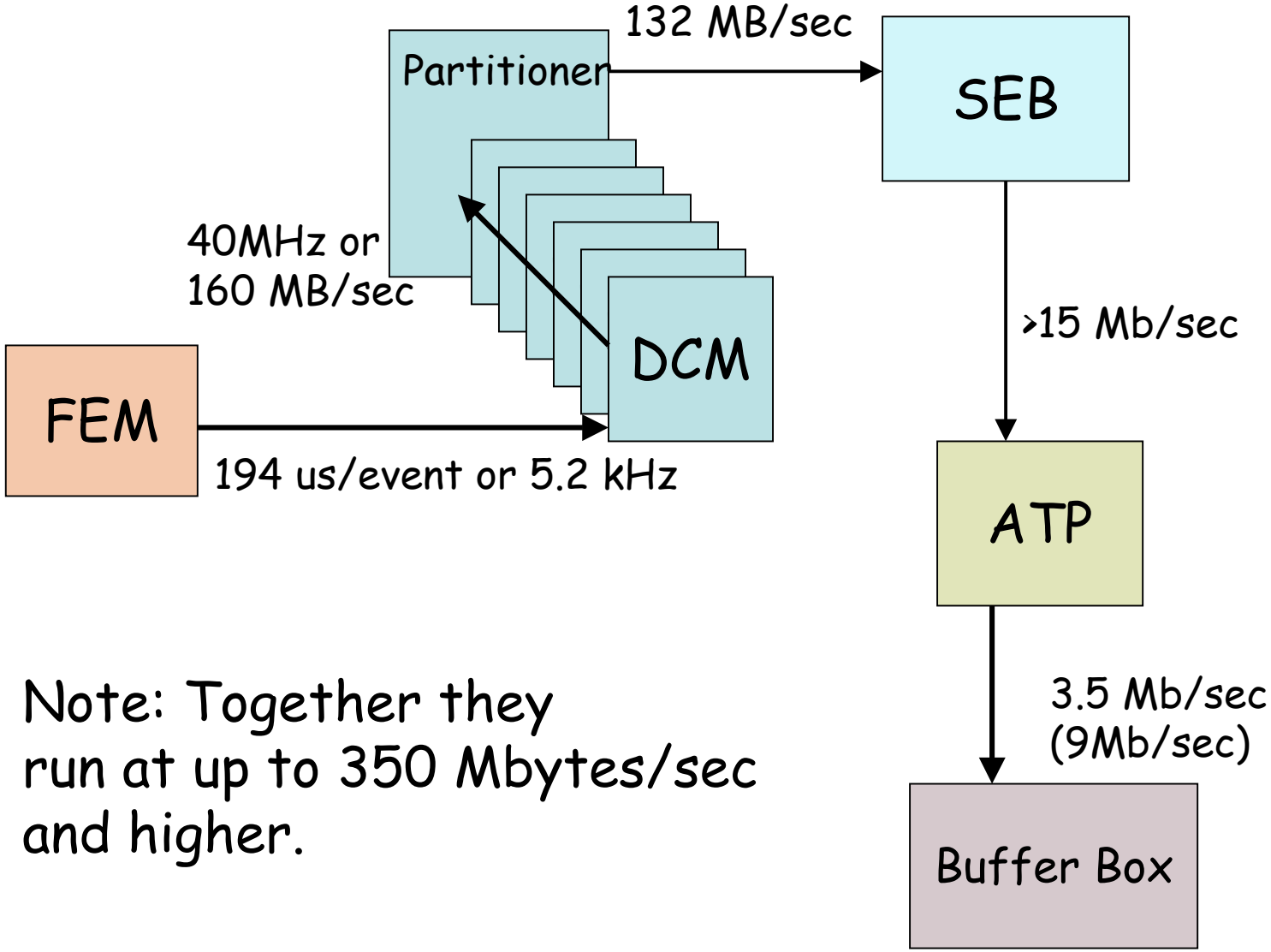
Run Control


Run Control GUI
(Client)
Run Control
Server/Client
GTM
DCM
EVB GUI
(Client)
Event Builder
Server/Client
SEB/ATP/EBC
PS GUI
(Client)
Partition
Server/Client
GL1

CORBA

- The networking protocol by which the run control software components talk to each other.
  - Based on a client/server architecture through a heterogeneous computing environment.
    - VxWorks, Linux, Windows NT
  - Servers implement "CORBA Objects" and execute the functionality described in the member functions of the object.
  - Clients get a reference to the Servers "CORBA Object" and execute their member function. This causes the server to execute the code of the member function.

Data Throughput



Note: Together they run at up to 350 Mbytes/sec and higher.

Procedure to Run

Some resources

- DAQ mini-howto on Run4 Page:
  - http://www.phenix.bnl.gov/phenix/WWW/run/04/daq/step_by_step.html
- Run Control Tutorial (old – to be updated)
  - http://www.phenix.bnl.gov/phenix/WWW/run/04/subsys_tutorials/daq/RunningTheDaq.pdf

Procedure to Run
overview

- Initialization of FEEs
- Selection of clock + clock fix (Master Clock & Feed -> "Parallel Clock Fix")
- Startup of GL1 trigger configuration (Level-1 GUI)
- Startup of servers (Partition and EVBServer)
- GL1 Run Control Startup
- Big Partition Run Control Startup
- Specific Details (DAQ Mini-howto): http://www.phenix.bnl.gov/phenix/WWW/run/04/daq/step_by_step.html

ONCS Tools Menu

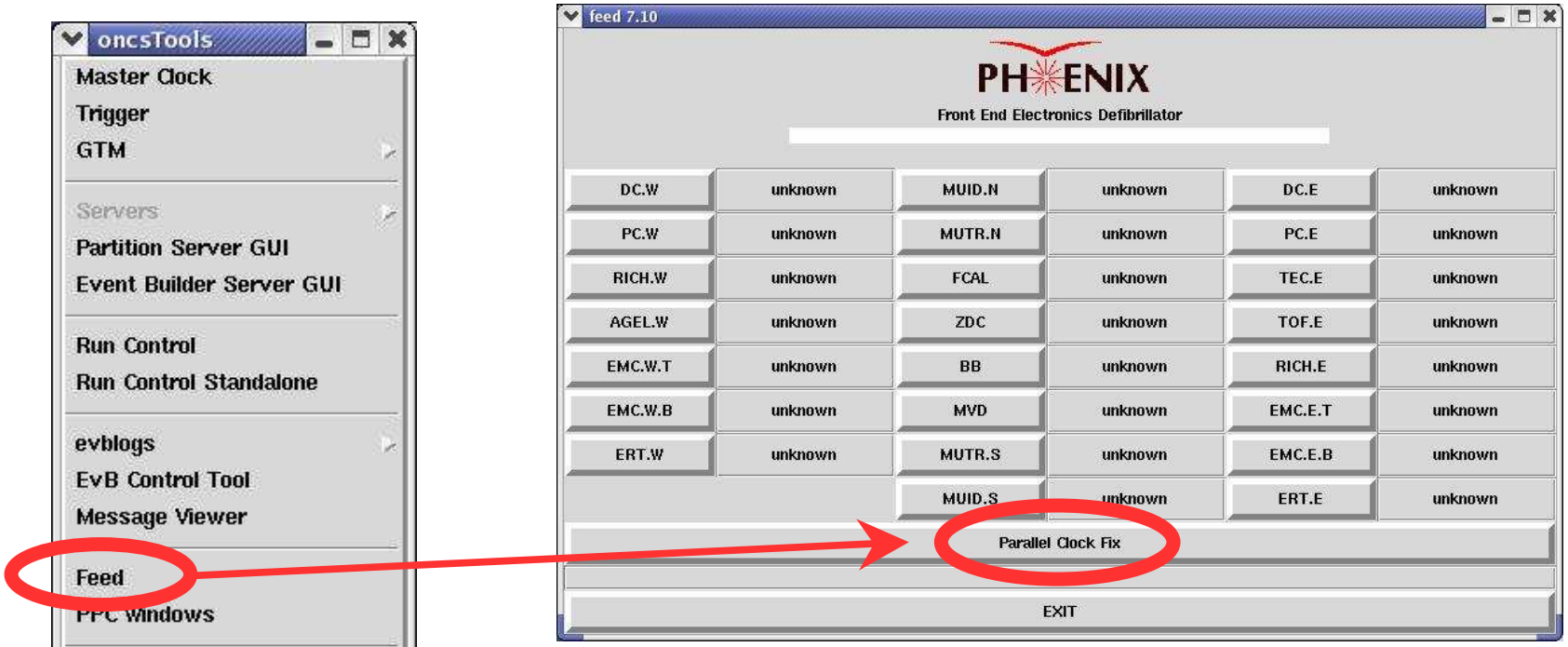
Run Control runs on phoncsb, the dual screen workstation

- Make sure oncsTools.tcl is running; if not, start with the command **oncsTools.tcl**. Do this on phoncsc also.
- You should see a window like this…
- From oncsTools.tcl on phoncsc, start the iocondev monitoring windows by selecting PPC Windows.

Master Clock

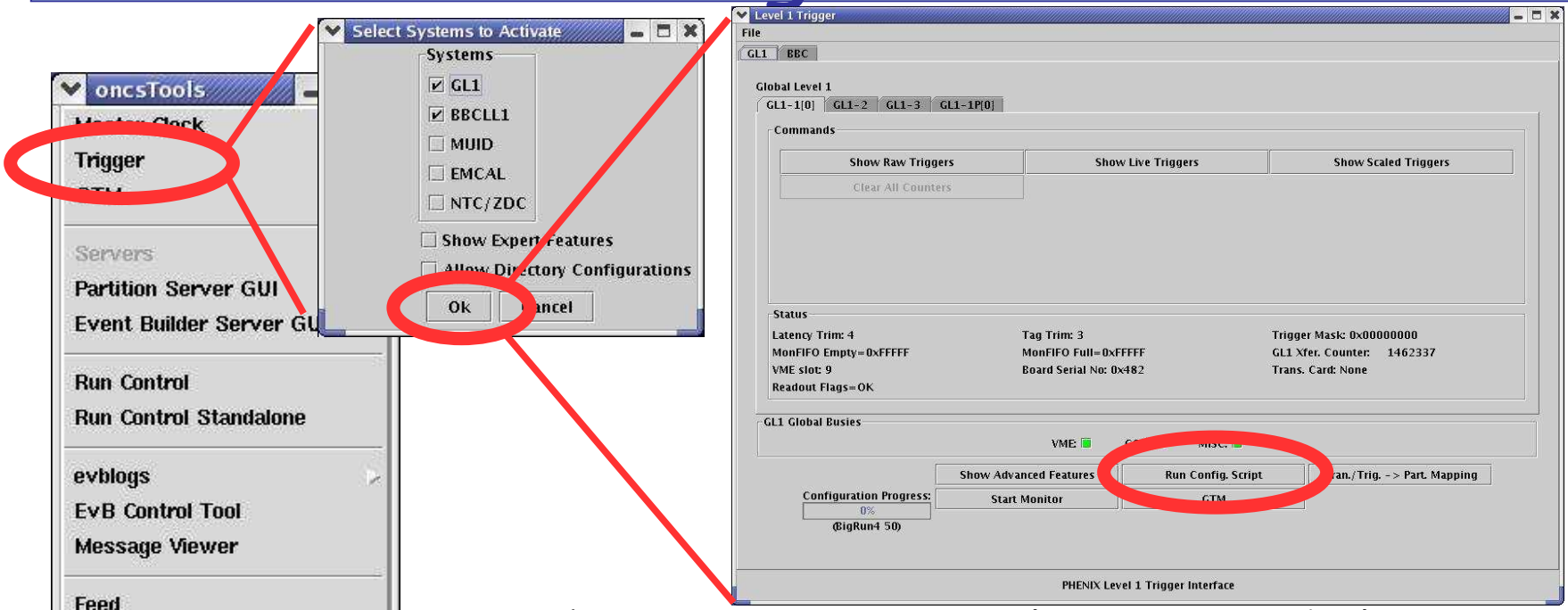
- Select the Master Clock menu item
- Select the type of clock depending on the current state of the machine, and what the SL tells you to do:
    - Beam is cogged: Select Blue Clock
    - Beam is off or about to be dumped: Select Internal Clock
- The Clock will change in a few sec to reflect your choice.

Parallel Clock Fix



- Used to initialize FEMs so PLLs are in phase in the Glinks
- When the clock changes, select Parallel Clock Fix
- If a subsystem fails, check with SL. It may be necessary to initialize its FEMs using the buttons on the Feed GUI.

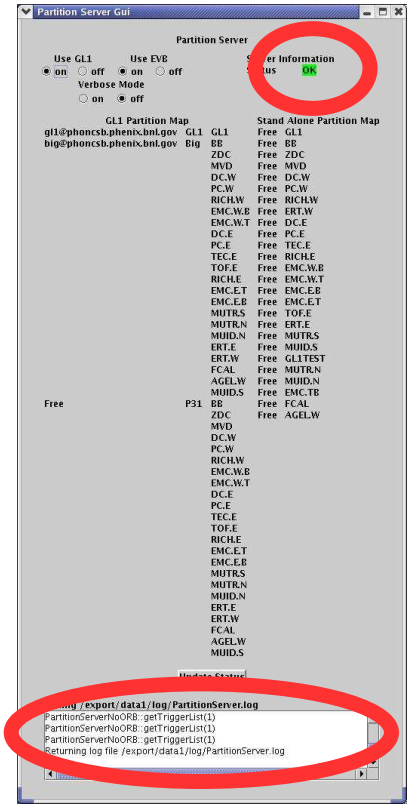
Global Level 1 (GL1) Trigger Configuration

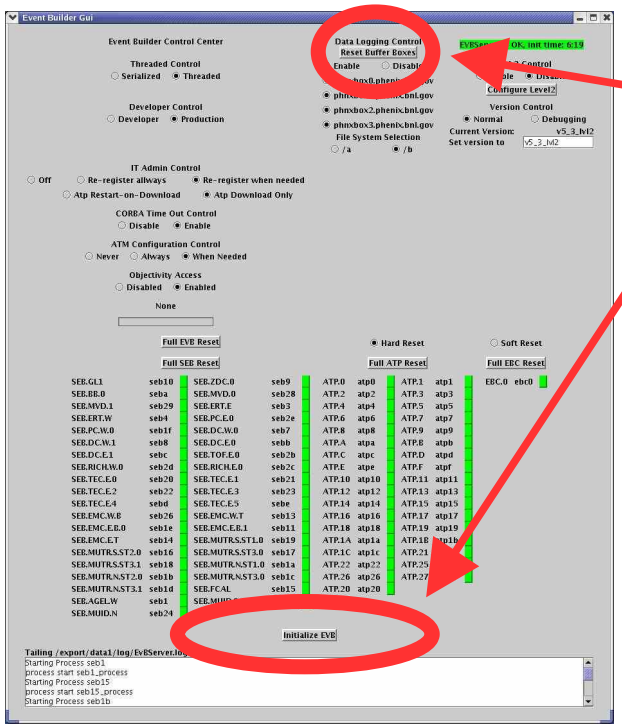


1. Run the trigger GUI. Select OK in dialog box. Select GL1 Tab. Select Run Config Script
2. In the popup, selection depends on SL's orders:
    1. Blue Clock: BigRun4 (version determined by SL)
    2. Internal Clock: Config determined by SL
3. Click BBC Tab. Run Config Script. Select "PP" (always)

Starting the Servers

- Start the servers with the command **oncsStartServers.csh**
- This will start the PartitionServer, the EVBServer, and GUIs for each of them(Prefered)
- The GUIs by themselves can also be started from the oncsTools menu



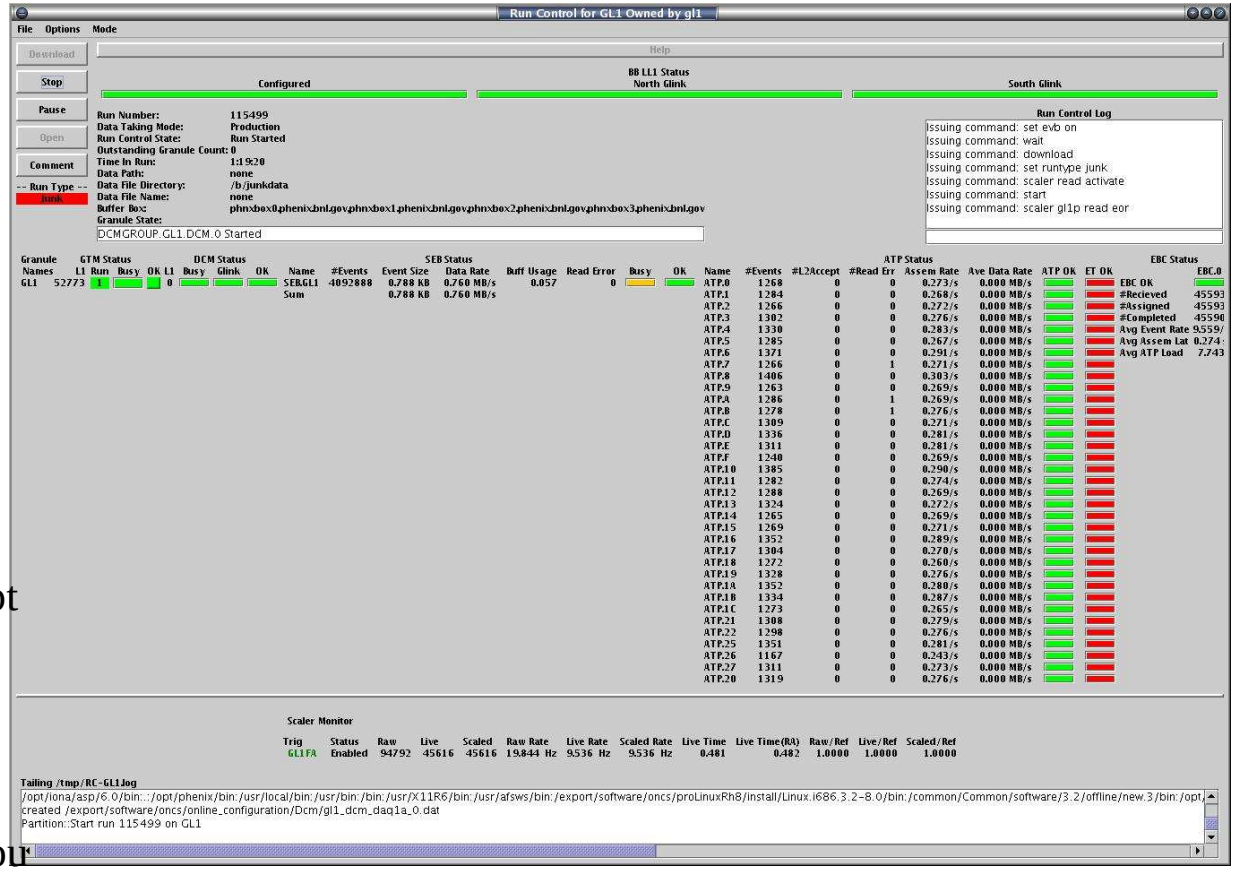


PartitionServer: Make sure EvB is selected. If errors occur, status light will be red and error messages will be in the log box.

Event Builder:
- Enable BBoxes
- Select all 4
- Choose /a or /b
- Press Initialize EvB

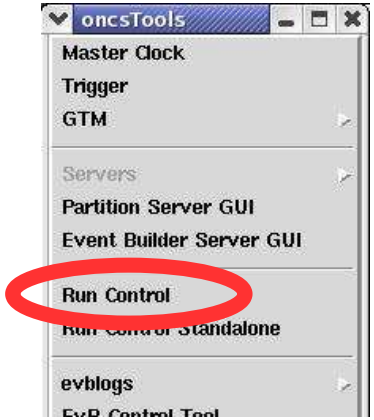
Any errors in the EvB? The SEB/ATP/EBC buttons may turn red if an error occurs. After the run has ended, you can try to reinitialize individual components by clicking on the red button next to the name. If that doesn't work, call the DAQ expert.

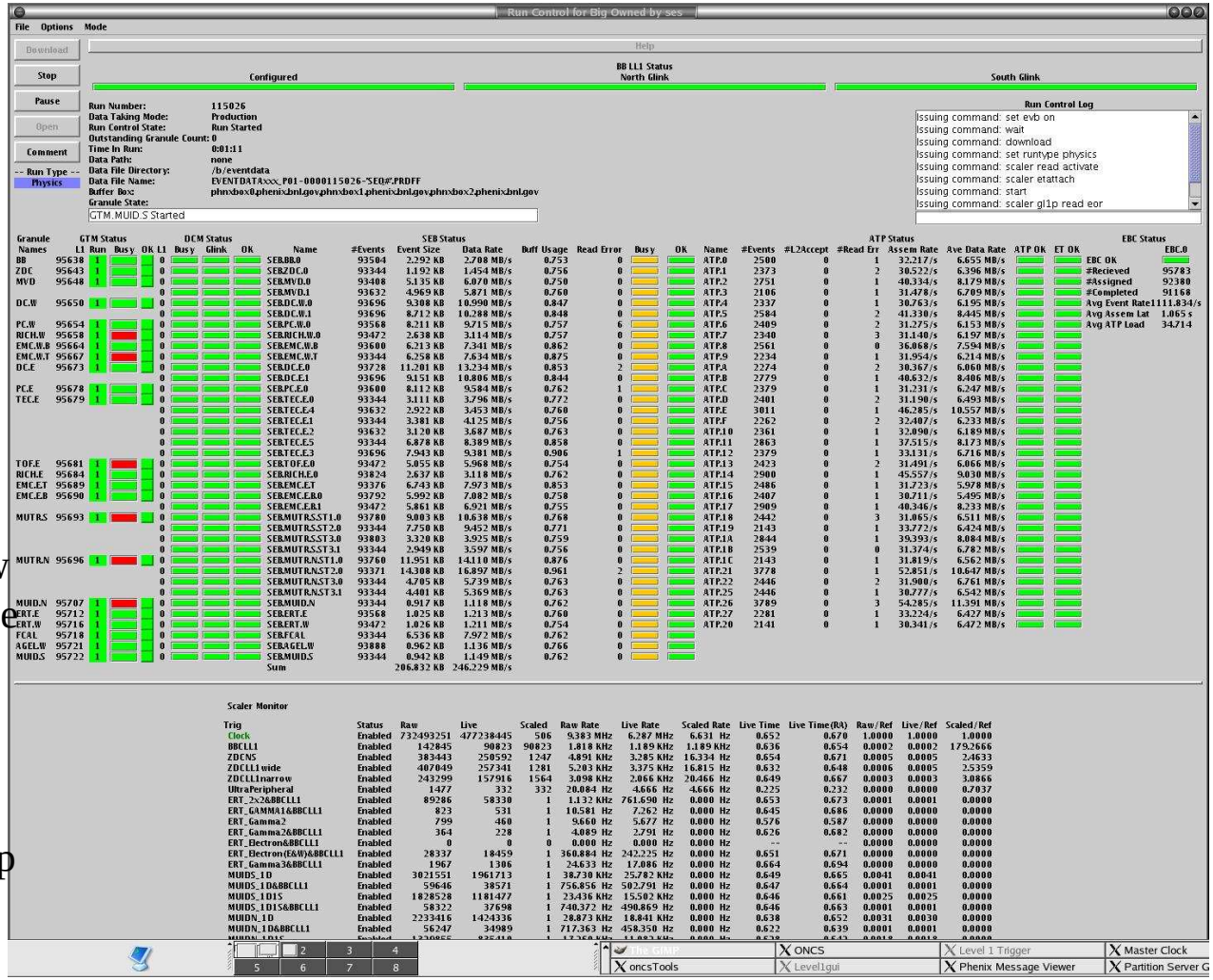
GL1 Run Control



- Select Run Control from menu
- Select GL1 from the popup list
- Type your name at the popup prompt
- In RC, select menu Mode->EvB Enable
- Press Download button
- Press Start
- If everything is running properly, you will see event counters increasing for the SEB, ATP, & EBC

Big Run Control





- Select Run Control from oncs menu
- Select Big from popup menu
- Type in your name in popup window
- From Mode menu, select EvB Enable
- ~~From Options menu, select Load Trigger Config (this is done once)~~
- Press Download
- Press Start
- Select “Physics” data from the popup

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summary

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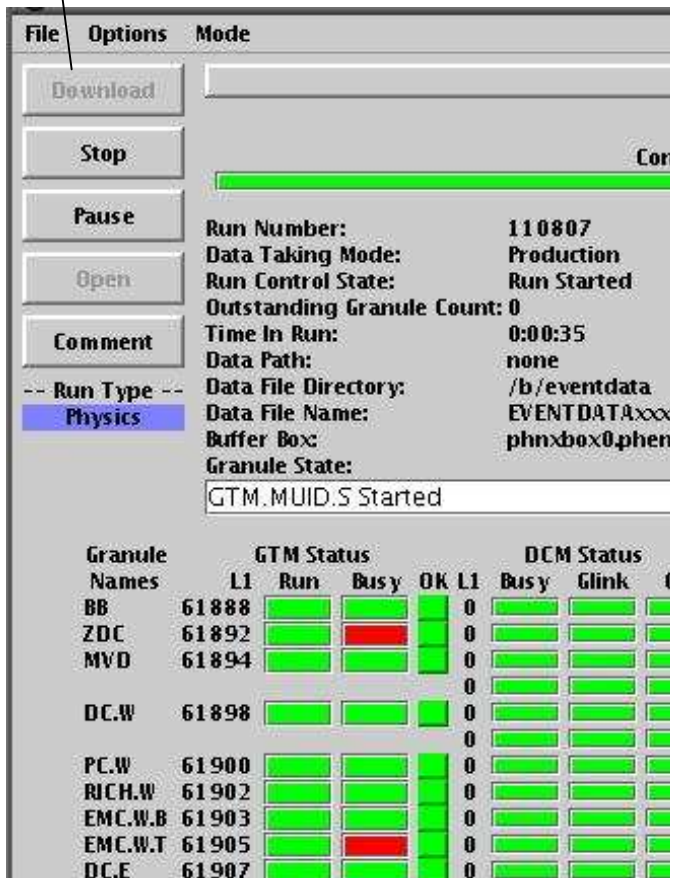
Running The Run Control GUI

Download

1. Resets error codes on all components
2. Set granule status to busy
3. EvB Components
    1. All: refresh CORBA references
    2. EBC: Boots,Configs,Inits,Runs (0)
    3. SEB: Same, independent of part
    4. ATP: Same, also L2 Init
4. *GTM, DCM configurations*
5. *ARCNET processing*
6. *DCM Thresholds*



More on what happens

Start

- Get run number
- Update BB names
- Get Lvl2 status
- Reset Objects' Error codes
- Configure Lvl2 for ATPs
- EvB: start() methods on all of ATP, SEB, EBC

Understanding RC Status LEDs

- RC displays LEDs to monitor status of various components
- EvB
  - SEB: Idle, Active, Busy, Unknown status
  - ATP: Run Started, Run Not Started, Exception Caught, Undefined Partition, Unknown status
  - ET: Run Started, BB links opened, BB Links closed, Unknown
  - EBC: Run Started, Run Not Started, Undefined Partition, Exception Caught, Unknown status
- DCMs, GTMs

Common Problems

- SEB GLINK button red(feed,maybe recycle LV,contact subsystem expert)
- DCM busy, rate drop to <200 Hz
  - but SEB looks ok.(test RC in SA mode, contact DCM and/or subsystem expert).
  - SEB buffer usage is full and busy light on (stop and start both GL1 and Big RC).
- Big Partition hangs while running – GL1 show read errors.
  - GL1 DCM problem.(stop both RC, hard reset GL1 DCM)
  - GL1 trigger board problem.(reset in following order iocondev 14,15,16)
- BBox connections failed, mainly caused by unsuccessful stop RC. (stop Big RC, press reset button on Event Builder Gui repeatly, until no further orange warnings. Contact DAQ expert)
- ATP LEDs go black(ATP in bad state, can ignore)
- Run Control starts and is running fine – But there is no stop button!(RC failure, most likely this run won't registed in DB, kill RC, reset BB, and restart a new big RC, contact RC expert).
- Lvl2-enabled – Multithreaded GL1 Download crashes EVB Server(skip for now)

Additional Resources

- Run page -> DAQ operator section
  - http://www.phenix.bnl.gov/phenix/WWW/run/04/
- Sergey's recent posting to run-l
  - https://www.phenix.bnl.gov/phenix/WWW/p/lists/phenix-run-l/msg09727.html

- DAQ docs to be evolving WIP