Slow Controls and Monitoring

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Computing Readiness Review

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Outline

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- Monitoring system
  - Overview
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  - Current Status
  - Schedule and Milestones

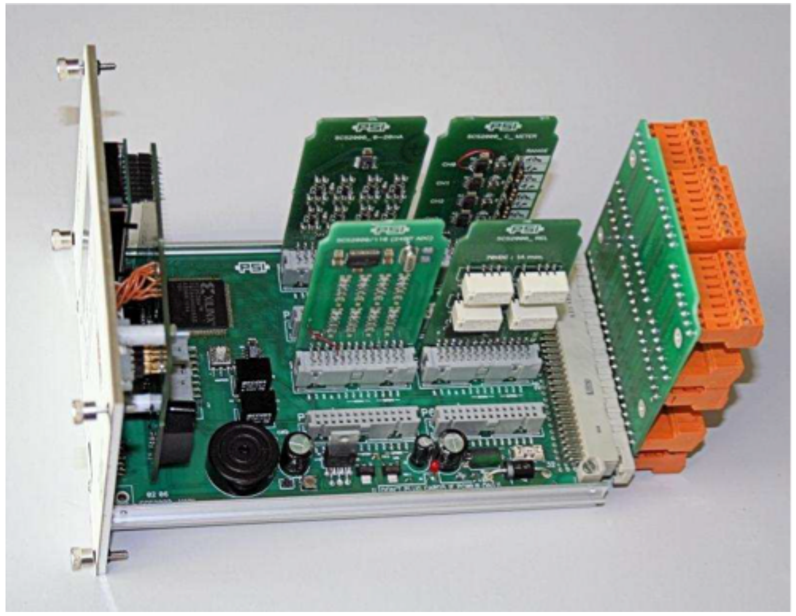
Slow Controls System

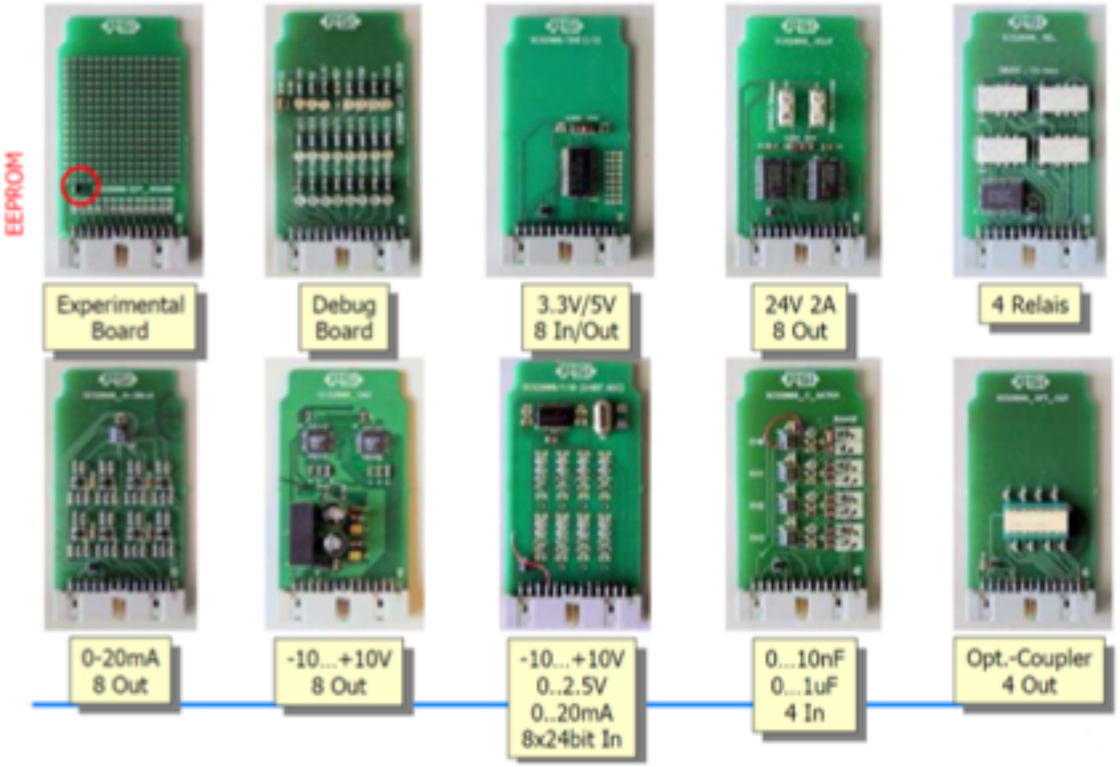
Overview of the Slow Controls System

- The experiment's *slow controls* system is responsible for monitoring and control of parameters that are asynchronous with the muon beam fills
  - Temperatures, pressures, gas flows, voltages, currents, etc…
  - Vital for the stability and successful operation of the detector over the two year data-taking run
- All slow controls infrastructure will interface with the MIDAS DAQ system for controls and data storage
- Many subsystems will utilize the Midas Slow Control Bus (MSCB) hardware from Paul Scherrer Institut
  - Some subsystems will rely on custom hardware which will interface with the MIDAS DAQ system
- Main mechanism for data storage will be a slow controls database
  - It is expected that some critical information will be stored in the main data stream
- Interlocks and alarms (for components with safety implications) will be handled through the main experiment Programmable Logic Controller (PLC)

Midas Slow Control Bus (MSCB)

- MSCB hardware from PSI is a low-cost, flexible solution for slow control monitoring
- Includes SCS-2000/SCS-3000 “master” units
  - Communication is over ethernet
  - Each unit can have up to 8 daughter cards
  - Cards include temperature, ADC, DAC, digital input/output, etc…
- Easy integration into MIDAS DAQ system
- Used for environmental monitoring
- Final system contains 4 SCS-2000/3000 units
  - All are in hand

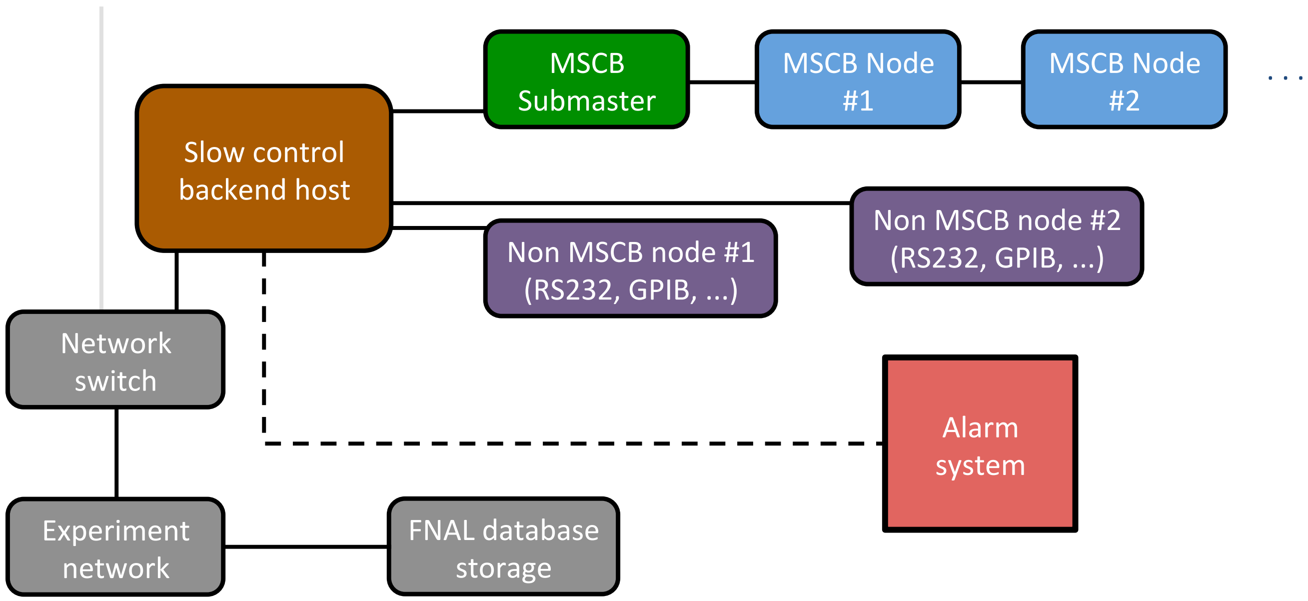




Other Slow Controls Hardware

- While some slow controls monitoring will be based on MSCB hardware, some sub detectors will use custom solutions
- Calorimeter
  - Each calorimeter sled has a Beaglebone that is used for controls and monitoring (including SiPM temperature). Midas front end on the DAQ front end computer communicates with Beaglebone
  - Scheme successfully tested in test beam
- Fiber harps
  - Pneumatic motor control and fiber harp monitoring performed with Arduino. Arduino uses RS-485 (which MSCB is based on) shield to communicate with DAQ.
  - Has been successfully tested
- Tracker
  - Custom hardware solution to monitor LV power supplies and temperature of electronics in tracker modules.
  - Has been successfully tested in test beam, and in cosmic ray test stand
- µTCA crates
  - Adapting software from CMS for crate communication and monitoring

System Communication



- MSCB and custom hardware communicates with slow control backend PC
  - Slow controls back end purchased and is running in MC-1 computer room
- MIDAS front ends have been successfully tested with all MSCB and custom slow controls hardware
- Still need to test with all slow controls front ends in the final network configuration
- Database storage not yet implemented

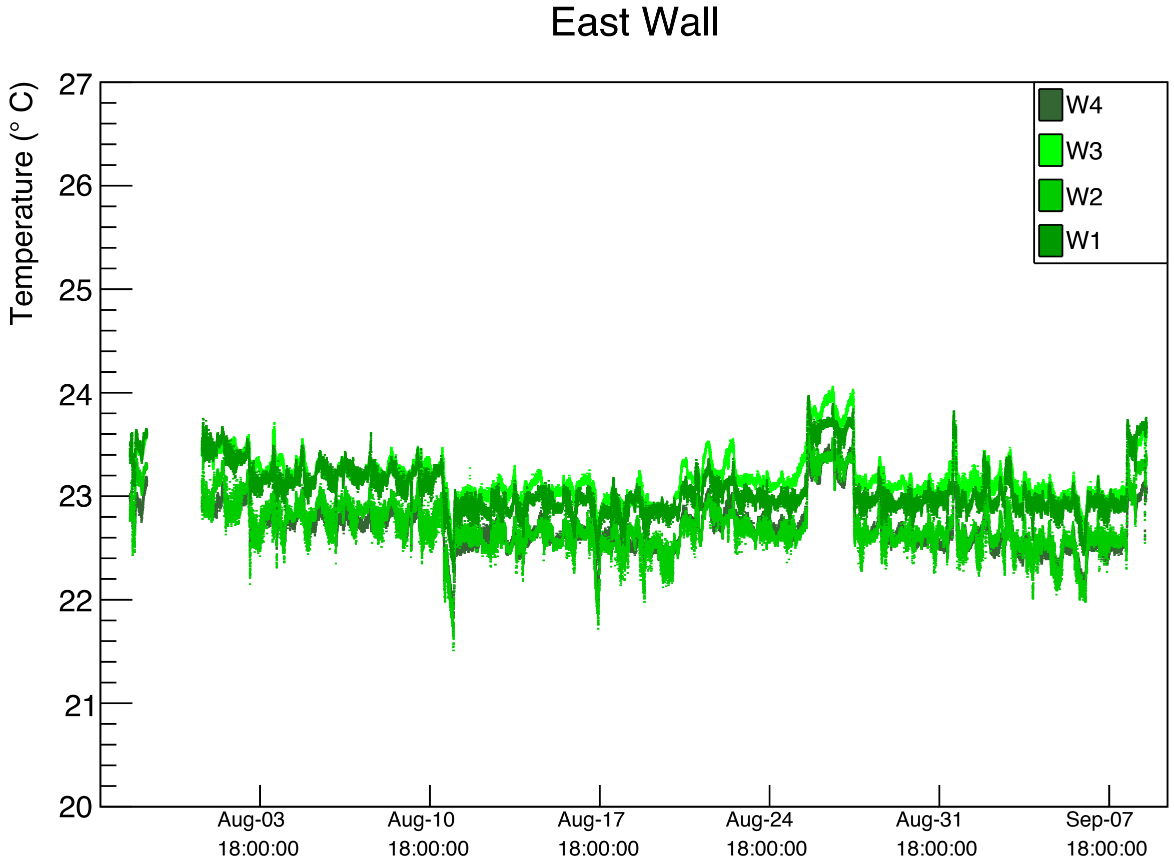
Slow Controls Requirements

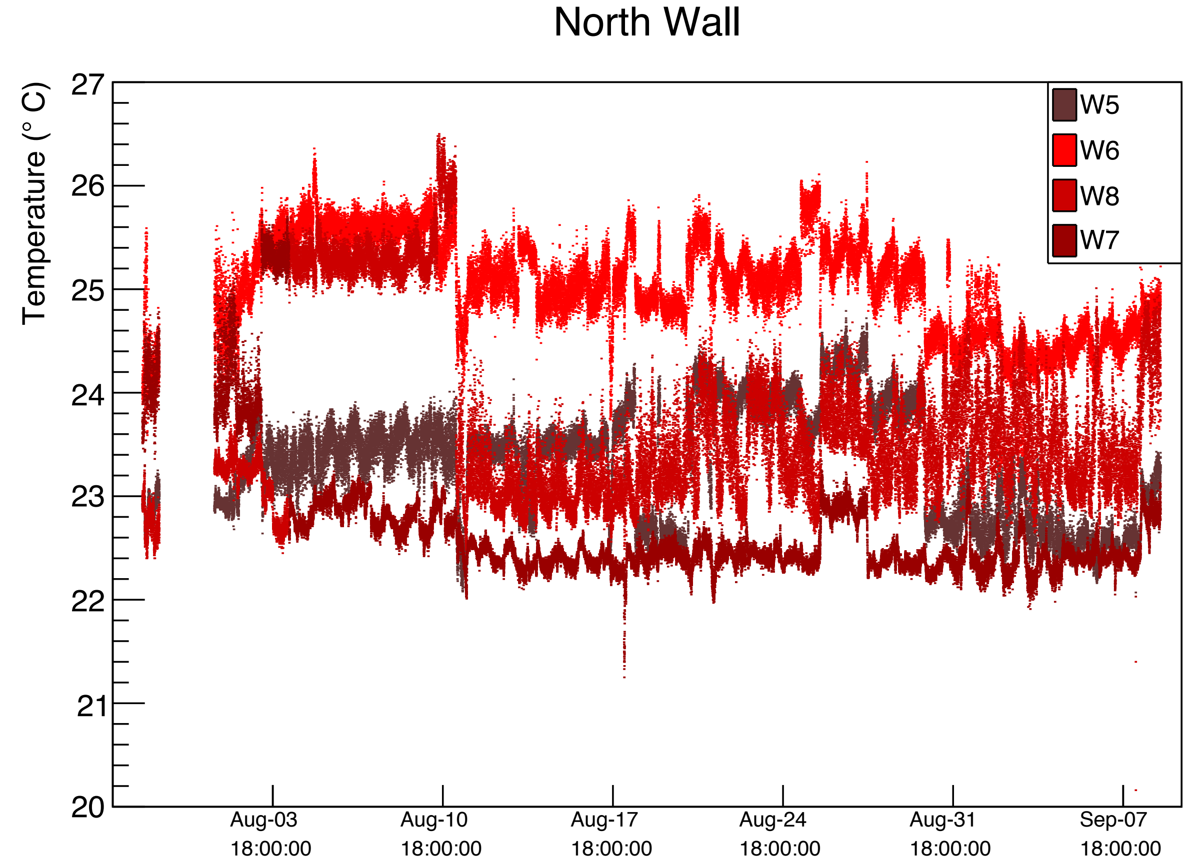
- The slow controls system must monitor and record any data parameters at a rate sufficient to ensure that the systematic uncertainty goals of the experiment are met.
- Specific monitoring requirements for individual sub detectors are determined by that sub detector group
  - For example, the Calorimeter group determines the requirements for monitoring the SiPM temperature
- The slow controls project is responsible for environmental monitoring in the experimental hall
  - Need to verify that the magnet steel temperature remains constant to within 1°C. Requires ~50 temperature sensors (both for air and magnet steel) able to detect temperature changes of ~0.1°C, read out at ~1Hz.
  - Monitor other hall environmental parameters (air pressure and humidity)
- *Note:* Originally, a separate (PLC-based) alarm system was originally part of the slow controls project. This has changed so that any safety-related interlocks will go through the main experimental PLC.

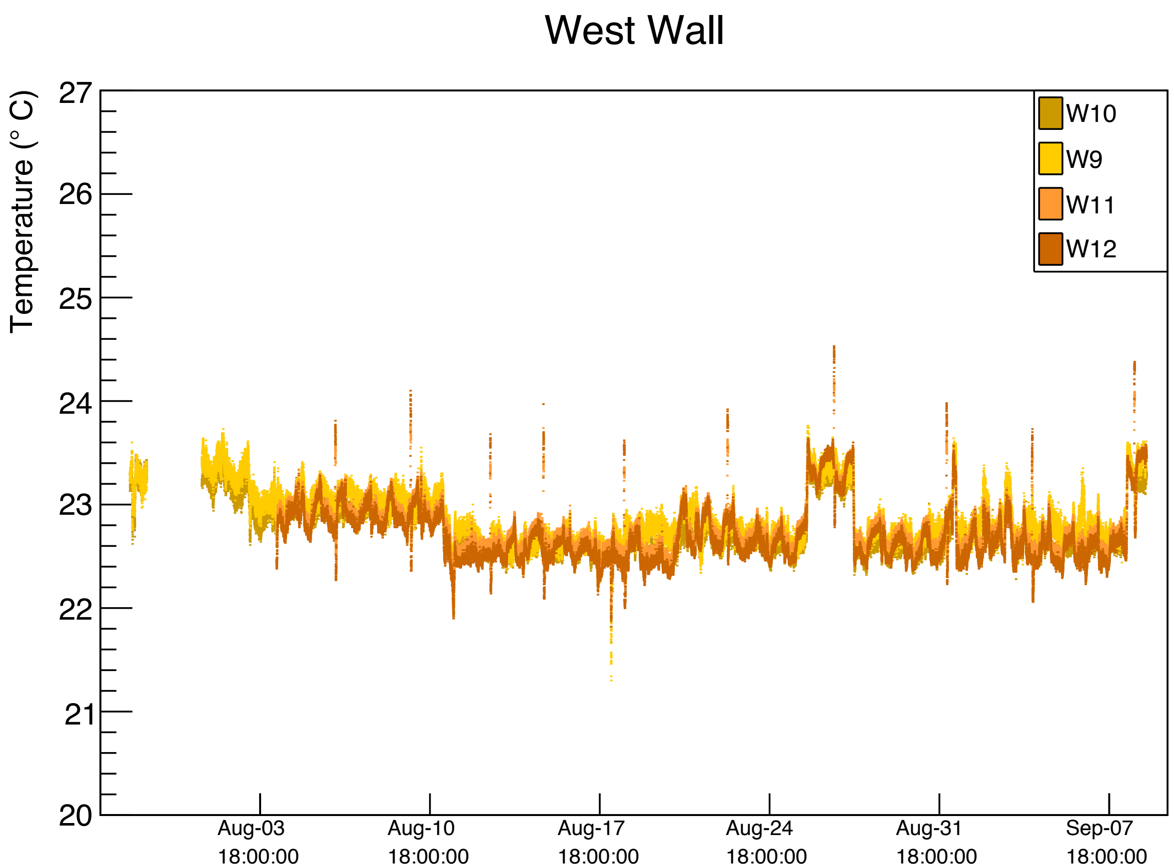
Slow Controls Current Status

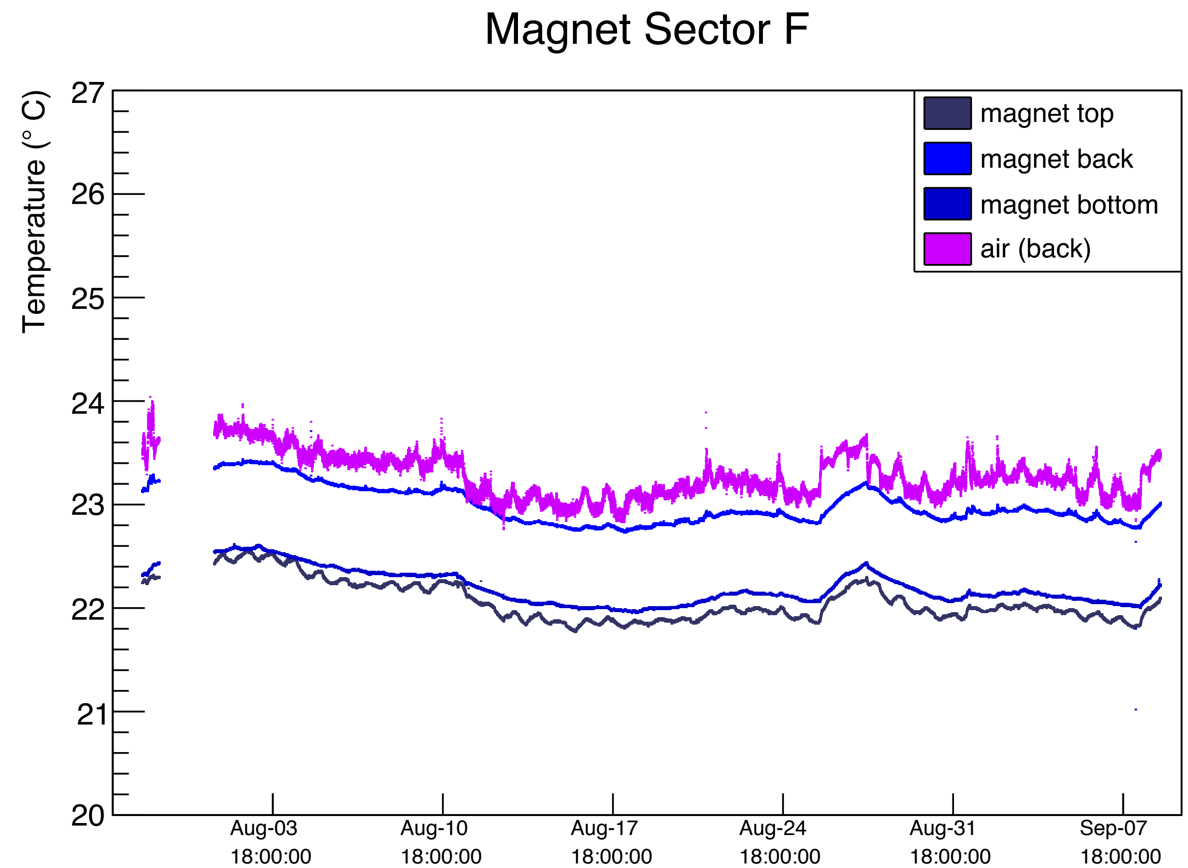
- Environmental sensors in the experimental hall are ~75% installed.
  - Waiting on network installation to install final SCS-2000/3000 units
- 16 temperature sensors currently being read out (on a stand-alone pc in the experimental hall)
- Slow control back end PC purchased and installed in the MC-1 computer room
- Most subsystems (calorimeter, trackers, fiber harps) have tested their slow controls solution in a test beam

MC-1 Experimental Hall Temperatures









Cryo Slow Controls

- The controls system for the magnet cryogenics has been implemented (and is running)
  - Based on the main experiment Siemens PLC
- There are no plans (currently) to merge this controls system into the slow controls system
- If there are useful variables to store, we could certainly store these in the slow controls database

Slow Controls Schedule and Milestones

- Finish installation of hall environmental sensors
  - Nov 2016
- Install/commission other sensors to be read out through MSCB system
  - Example: request from laser calibration team for a few temperature sensors
  - Nov/Dec 2016, or as requests arrive
- Install final readout SCS-2000/3000 units in the hall
  - Dec 2016? Contingent on network and rack installation.
- Commission Midas front-ends on slow controls back-end
  - Dec 2016 for environmental sensors
  - Other subsystems contingent on installation schedules
- Implement slow controls database, and commission data storage
  - Jan 2017
- Verify slow controls data taking and storage systems for other subsystems (kicker, quads, etc…)
  - Dependent on installation schedules

Monitoring System

Overview of the Monitoring System

- Once the slow controls (and other) data is collected, a useful interface to monitor the data is still required
- Adapting a web-based solution already in use for the CMD-3 experiment in Novosibirsk
- Will collect data from many data sources
  - MIDAS slow control DAQ, fast DAQ, online data, near-line data analysis, MIDAS ODB (configuration)
- Existing solution from CMD-3 uses Linux+Apache+MySQL+PostgreSQL +Python, with ROOT for plot generation
- Updating the infrastructure to use modern web technologies (Django)

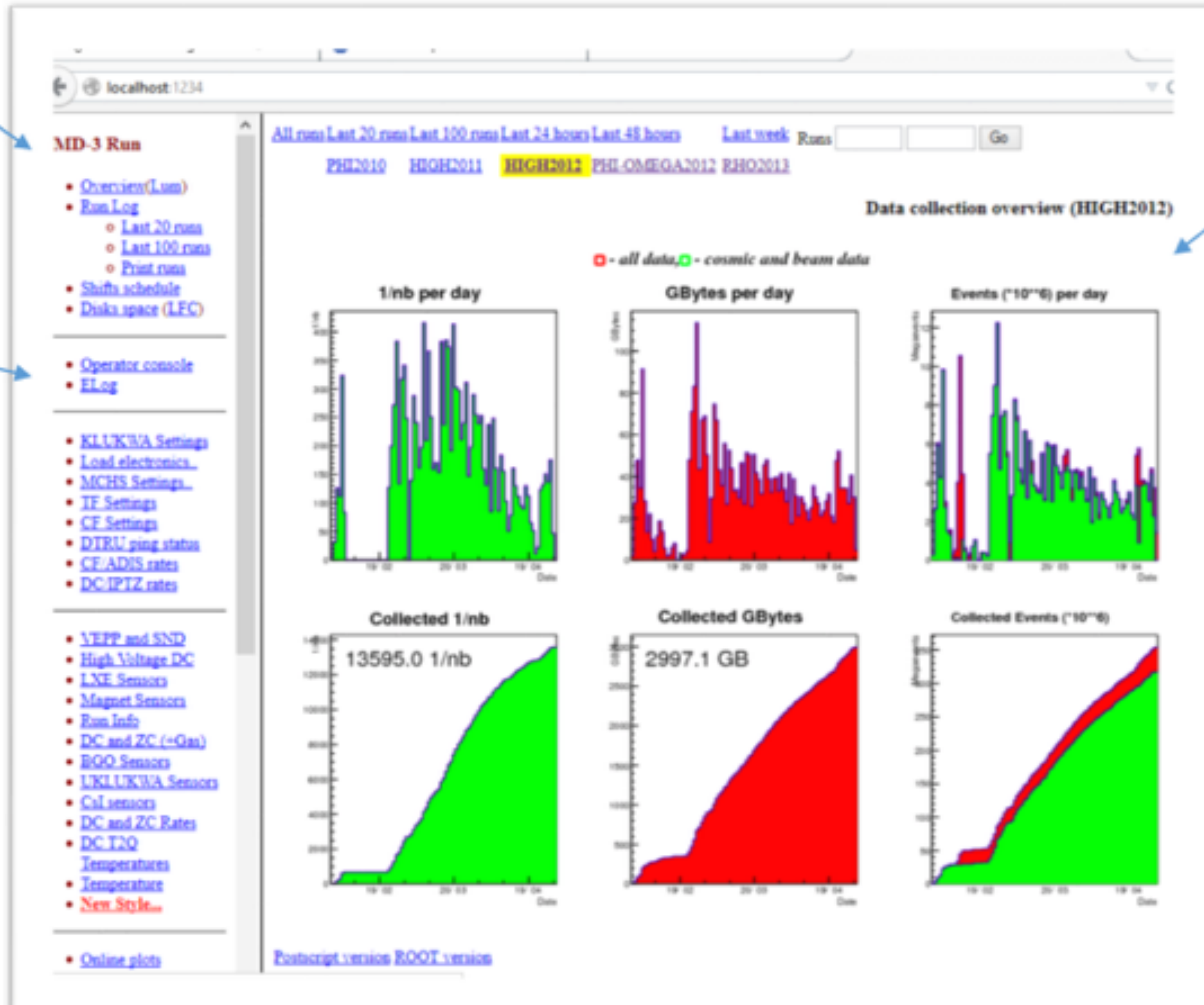
CMD-3 Monitoring Webpage Example (1)

Main page

Links panel

Your favorite Midas and elog

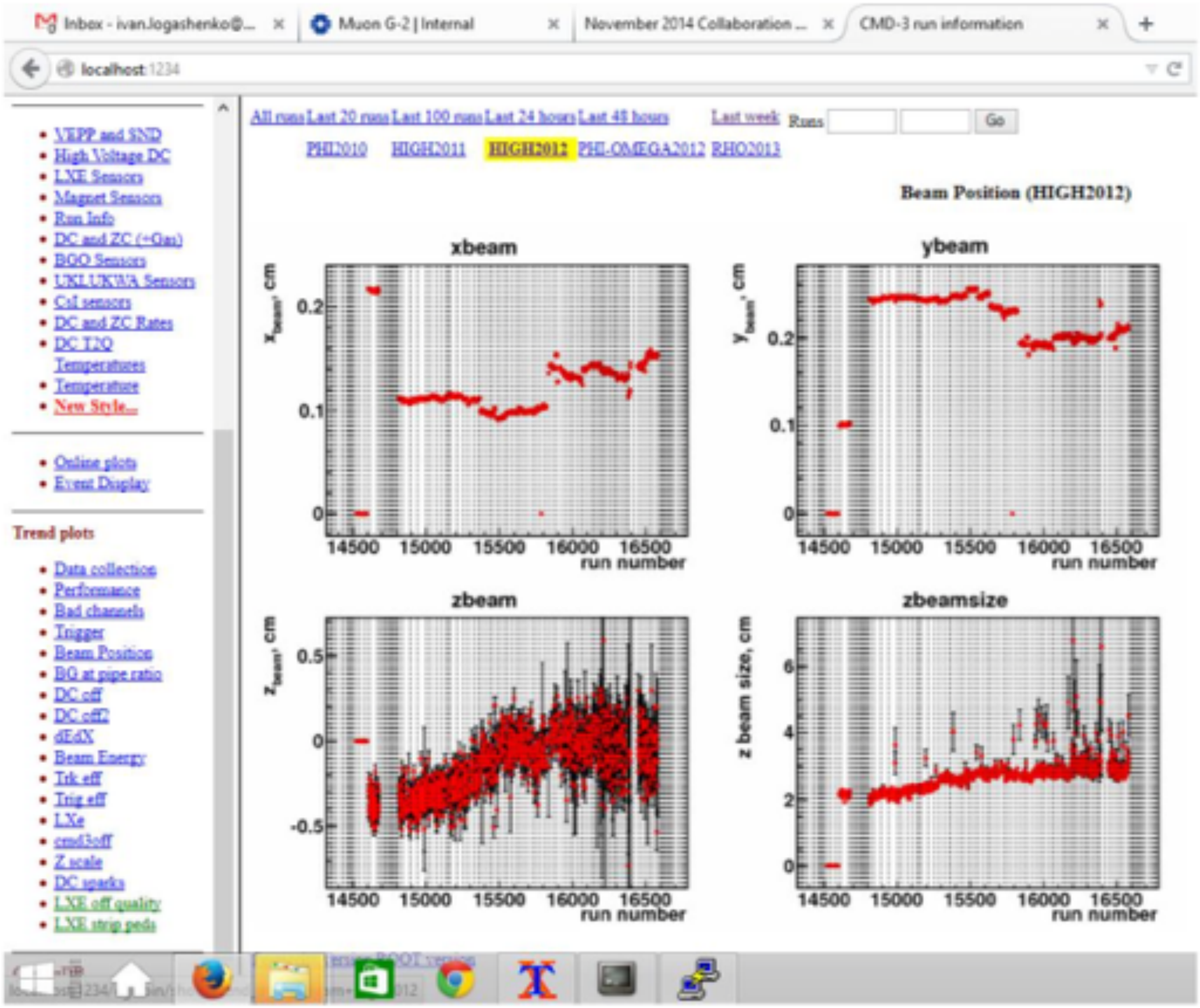
It points to all useful data: run log, midas page, monitoring pages, control pages, trend plots,…



Information panel

CMD-3 Monitoring Webpage Example (2)

Trend plots – run-by-run trending



Monitoring System Requirements

- The monitoring system needs to be able to collect and display both configuration information and data collected from a variety of sources
  - MIDAS ODB, MIDAS raw data, slow controls database, etc…
- Plots should be interactive/adjustable
- Available information must be “comprehensive”, but must also be easily navigable
- Must be usable by both non-expert “shifters” and subsystem experts

Monitoring System Current Status

- Lots of infrastructure code from CMD-3 monitoring system can be re-used
- Remote collaborators have access to computers in DAQ cluster which will host the code. Working on installing needed software.
  - Current plan is to have monitoring web pages only accessible from local DAQ network at MC-1
  - May explore more broad access in the future, but there are security concerns. Modern web technologies do offer options for authentication and access control.

Monitoring System Schedule and Milestones

- Install and commission software infrastructure
  - Collaborators will be at Fermilab for a month starting end of November
  - Goal is to have functional prototype of monitoring website by end of Dec 2016
- Implement and commission individual data sources (Midas, database, etc…)
  - Some of these already in progress and will be implemented by end of Dec 2016. Others (like slow controls database) will come later (lJan 2017).
  - Subsystem specific implementations tied to installation and commissioning schedule

Backup Slides

Parameters (from TDR)

Parameter	Read-back precision	Channel count	Responsibility
Calorimeter			
SiPM bias voltage	~mV	1300	UVa, JMU
SiPM amplifier gain		1300	UW
SiPM temperature	0.1° C	1300	UW
Laser calibration			
Laser temperature	< 0.5 °C	< 10	INFN, ANL
Vibration monitor		~ 10	INFN
Output signals (enable)		< 48	INFN
Input signals		< 48	INFN
Serial laser interface	–	< 10	INFN
Tracker			
HV voltage	~ 1 V	54	FNAL
HV current	0.1 μA	54	FNAL
HV status	–	54	FNAL
LV voltage	~ 0.1 V	54	UCL
LV current	~10 μA	54	UCL
Electronics temperature	~0.5 C°	348	FNAL, BU
Cooling temperature	~1 C°	54	FNAL, NIU
Amb. pressure	few mbar	3	ANL
Amb. temperature	< 0.5 °C	3	ANL

Parameters (from TDR, cont.)

Table 22.1 – *Continued from previous page*

Parameter	**Read-back precision**	**Channel count**	**Responsibility**
Amb. humidity	few %	3	ANL
Gas flow		54	FNAL
Active position sensor		3	FNAL, Liverpool
Electric quadrupole			
Voltage (0-10 V)	0.1 V	5	ANL
Current (0-10 V)	0.1 V	5	ANL
HV disable / enable	–	5	ANL
Aux. detector: Fiber harps			
SiPM bias voltage	few mV	2	Regis
SiPM temperature	0.1° C	4	ANL
Motor control	-	4	Regis
Aux. detector: Entrance counter			
SiPM bias voltage	few mV	2	Regis
Field			
Main magnet current		1	FNAL
Surface coil current		200	FNAL
Yoke temperature	$< 0.5\,°C$	~ 60	ANL
Hall temperature	$< 0.5\,°C$	~ 5	ANL