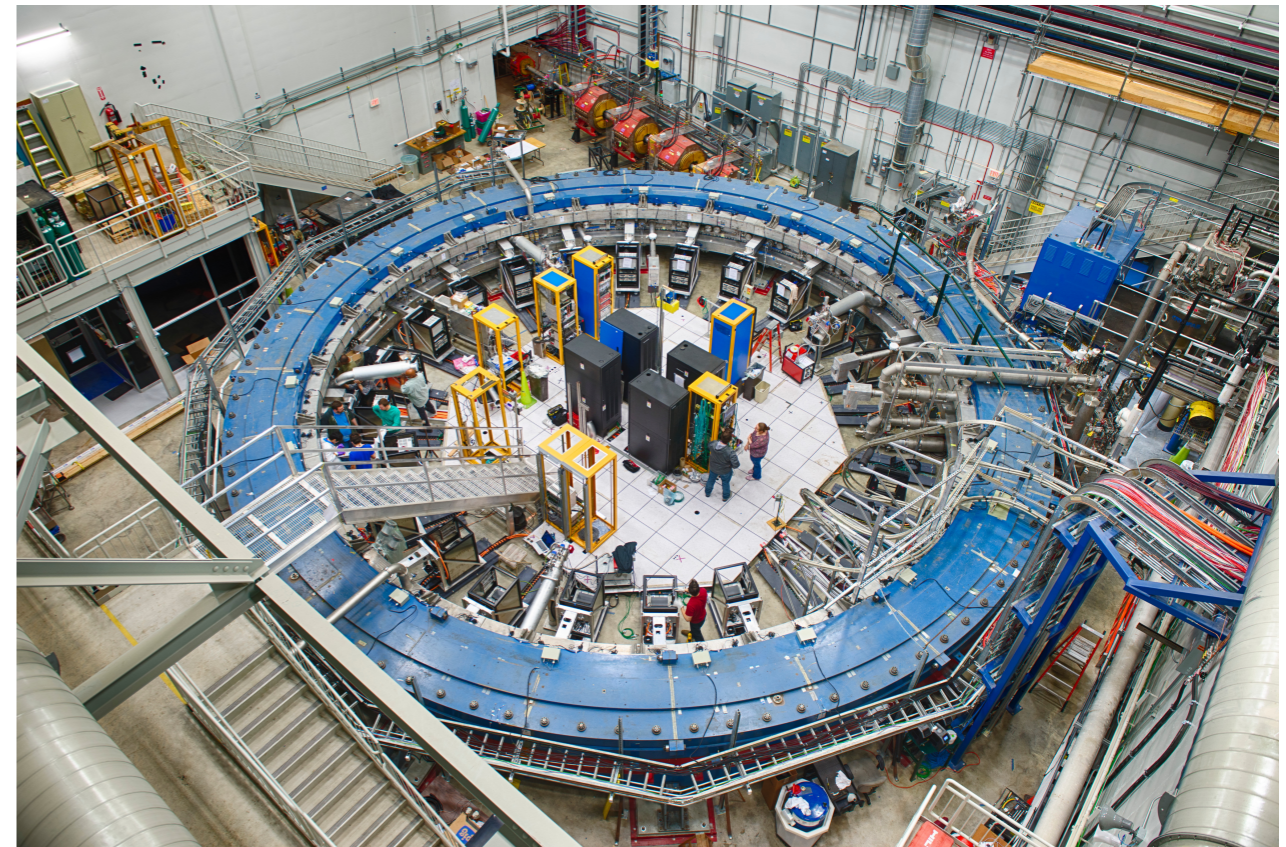


Использование программного пакета MIDAS в эксперименте «Мион g-2»

Н.В. Хомутов

Muon g-2 Experiment Overview

- Goal is to measure the anomalous magnetic moment of the muon to 140 ppb, which is a factor of 4 better than has been previously measured.
- Muon fills are injected into the ring at a rate of 12 Hz.
- The precession frequency of the muons is measured by detecting decay positrons in 24 segmented calorimeters inside the ring.



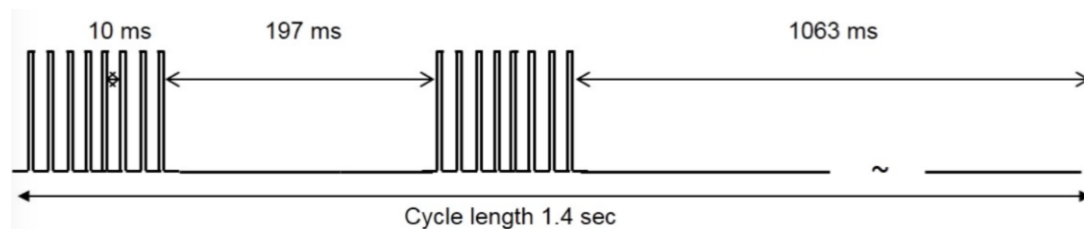
DAQ Input Sources

- 24 Calorimeters
 - 1 uTCA crate for each calorimeter
 - 54 channels * 24 calos = 1296 channels of digitized data.
 - Data processed by 12 Cornell WFD5s @800 MHz and sent from AMC13.
- 4 Fiber Harps
 - 7 channels * 4 harps = 28 channels
 - Data processed by Cornell WFD5s
- Quads and Kickers
 - 4 quad channels and 15 kicker channels
 - Data processed by Cornell WFD5s
- 3 Trackers
 - Data from Multihit TDCs sent from FC7s in a uTCA crate
- IBMS (inflector beam monitoring system)
 - Running on CAEN digitizer



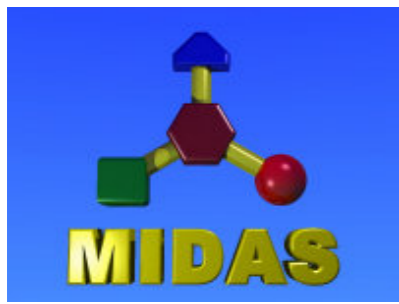
Rate requirements

- Accommodate 12 Hz average rate of muon fills that consist of sequences of eight successive $700 \mu\text{s}$ fills with 10 ms fill-separations.



- Time-averaged rate of raw ADC samples is 20 GB/s, which must be reduced by a factor of 100.
- Data is processed in GPUs to accomplish this task.
- Total data on tape after 2 years of running will be 10 PB.

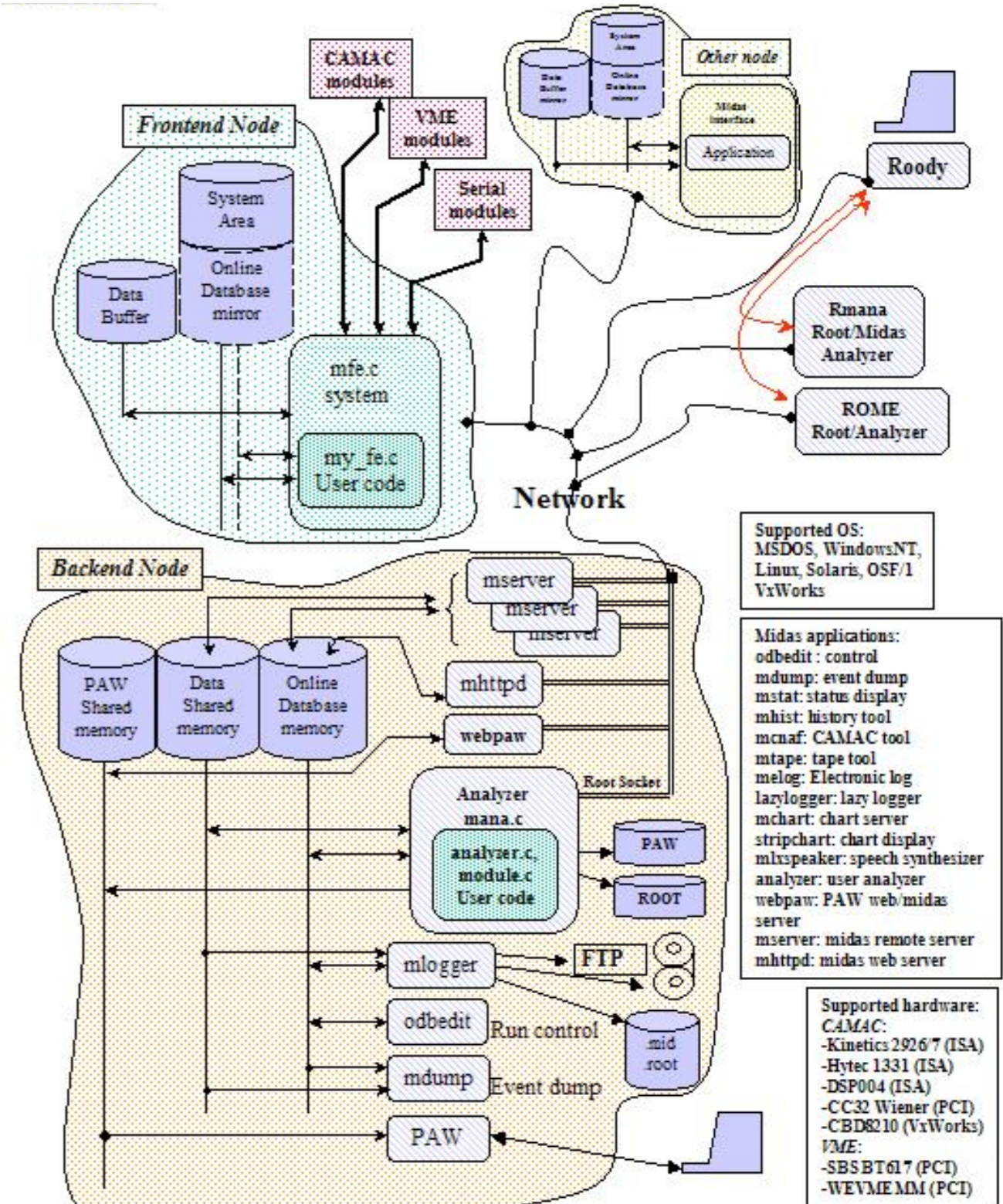
Source	MB Per Fill	MB Per Second
Raw data	1,600	19,400
T-Method	9.4	112.5
Q-Method	4.0	48.5
Prescaled Raw	1.6	19.4
Tracker	0.75	9
Laser Monitor	0.08	1
Auxiliary	0.33	4
Event Builder:	16.2	194.4



Maximum Integrated Data Acquisition System

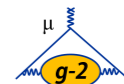
<https://midas.triumf.ca>

<https://bitbucket.org/tmidas/midas.git>



What is MIDAS?

- Maximum Integrated Data Acquisition System
- Maintained by TRIUMF and PSI
- Reference at midas.triumf.ca
- An Online Database (ODB) stores the real-time experiment configuration.
- Experiment is controlled via a web interface that interfaces with the ODB.
- Users write frontend programs that read data from the electronics and write it in MIDAS banks.

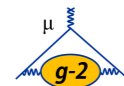


MIDAS Processes

- mlogger: writes midas data files, writes select ODB parameters to MySQL database.
- mhttpd: MIDAS web interface.
- mserver: Central server that handles communication between all MIDAS processes.
- EventBuilder: Combines data fragments from multiple frontends into single event.

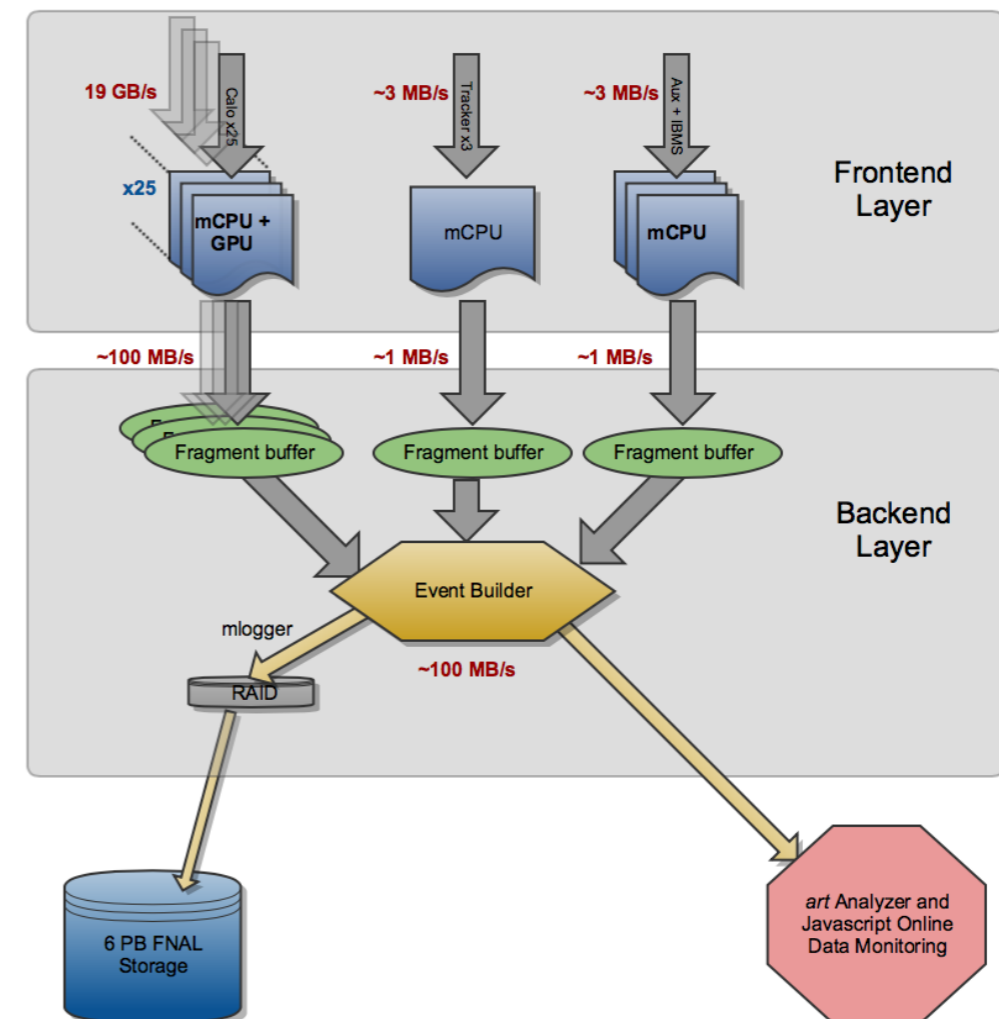
Muon g-2 experiment specific code:

- MasterGM2: Interfaces with CCC, trigger, and GPS. Communicates with frontends using RPC calls.
- Fast frontends: Write data at beam rate (i.e. 12 Hz)
- Slow frontends: Write data periodically (i.e. 1 Hz)



DAQ Design

- Layered array of commodity, networked processors
- Frontend layer for readout of detectors.
- Backend layer for assembly of event fragments.
- Slow control layer.
- Online analysis layer using *art*+JS.
- Field DAQ operates independently, but with a similar design.



Field DAQ

- Field DAQ runs in independent MIDAS experiment.
- Contains seven asynchronous frontends reading data from fixed magnetic field probes and from a trolley that periodically transverses the ring to perform precision measurements of magnetic field.
- Data is correlated with the fast DAQ offline using GPS timestamps.

The screenshot displays the Muon g-2 DQM interface. At the top, there are navigation tabs: Status, ODB, Messages, Alarms, Programs, History, MSCB, and Help. Below these are control buttons: Restart Front-Ends, Restart Logger, Restart Server, Restart DQMs, Trolley Control, and Plunging Probe Control. The main content is divided into three sections:

- Run Status:** Shows Run 395 is Running. Start time is Thu Jun 1 08:52:27 2017. Running time is 0h26m35s. Alarms are On, and Restart is No. Experiment Name is g2-field. Trolley Status is n. A log entry shows: 09:19:00 [Fixed Probes,DEBUG] issued trigger.
- Equipment:** A table showing the status of various equipment components.
- Logging Channels:** A table showing the status of logging channels.

Equipment	Status	Events	Events[/s]	Data[MB/s]
Fixed Probes	Fixed Probes@g2field-fe2-priv	398	0.3	0.995
TrolleyInterface	Frontend stopped	0	0.0	0.000
GallFermi	Frontend stopped	0	0.0	0.000
Surface Coils	Frontend stopped	0	0.0	0.000
Monitor	Frontend stopped	0	0.0	0.000
Fluxgate	Frontend stopped	0	0.0	0.000
PS Feedback	Frontend stopped	0	0.0	0.000

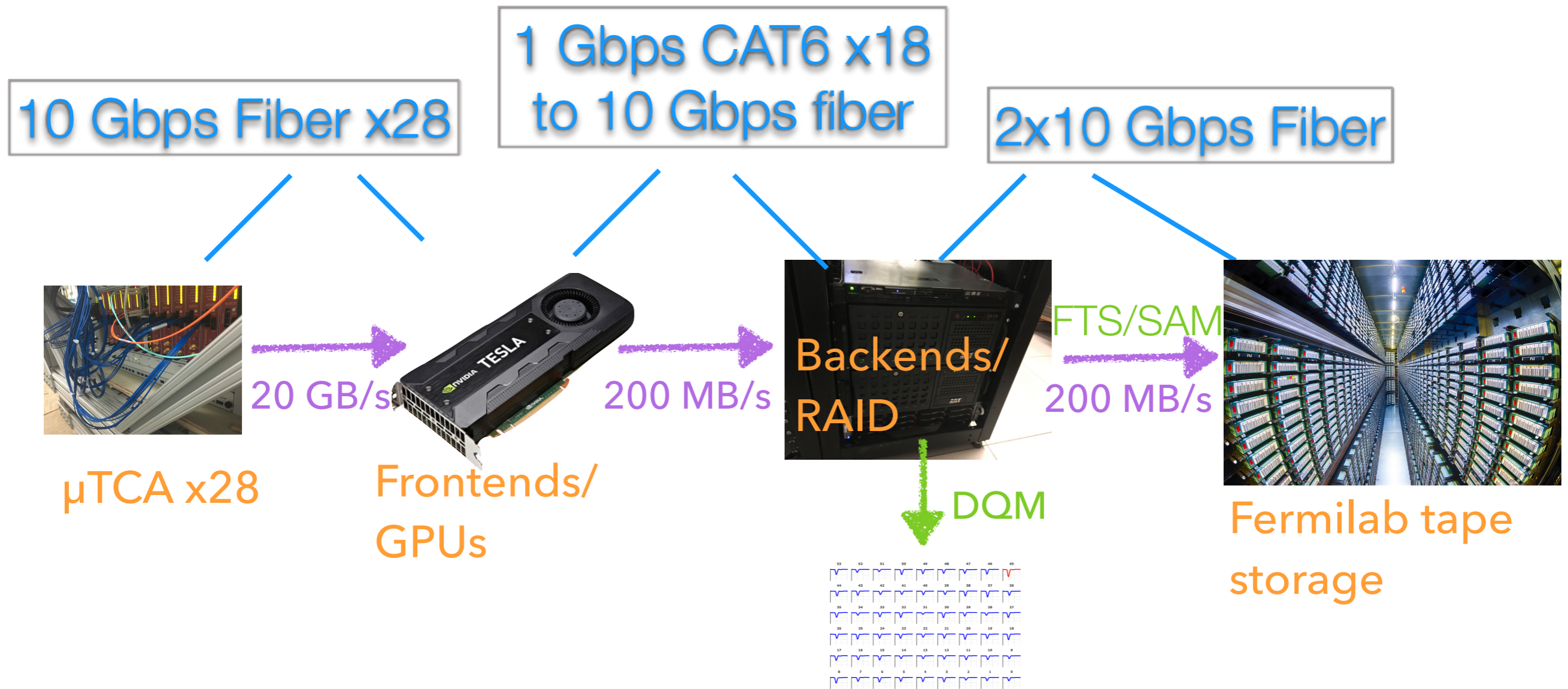
Channel	Events	MiB written	Compr.	Disk level
#0: run00395_00.mid.gz	399	949.078	N/A	7.1 %

Muon g-2 DQM

Run395 Event5

Subsystems

DAQ Architecture



MIDAS configuration

- 32 fast frontends (data at beam fill rate).
- 35 slow control frontends.
- Midas alarm system.
- Midas sequencer used for calibration runs.
- ODB dumped to JSON file and saved to Postgres database at each end of run.

The screenshot displays the MIDAS control interface. At the top, there are navigation buttons: Status, ODB, Messages, Alarms, Programs, Sequencer, Config, Help. Below these are buttons for Test, Restart Fast Frontends, ChanMap, Straw Tracker Power, Straw Tracker Settings, and VFDS.

The main section is titled "Run Status" and shows:

- Run 1618: Running (with a Stop button)
- Start: Wed Jun 28 05:38:50 2017
- Running time: 0h29m03s
- Data dir: /data2/gm2
- Experiment Name: GM2
- git hash:
- CCC Run State: Run In Progress

Below the run status is a table of equipment with columns: Equipment, Status, Events, Events[/s], and Data[MB/s].

Equipment	Status	Events	Events[/s]	Data[MB/s]
MasterGM2	MasterGM2@g2be1.fnal.gov	1222	0.7	0.000
EB	Ebuilder@g2be1.fnal.gov	1221	0.0	0.000
AMC1300	AMC1300@g2aux-priv	1223	1.0	0.001
AMC1301	AMC1301@g2calo0102-data	1223	1.0	2.016
AMC1302	AMC1302@g2calo0102-data	1222	0.7	1.949
AMC1303	AMC1303@g2calo0304-data	1221	0.7	0.096
AMC1304	AMC1304@g2calo0304-data	1221	0.7	0.095
AMC1305	AMC1305@g2calo0506-data	1222	0.9	1.780
AMC1306	AMC1306@g2calo0506-data	1223	1.0	1.886
AMC1307	AMC1307@g2calo-spare-priv	1222	0.7	1.939
AMC1308	AMC1308@g2calo-spare-priv	1221	0.7	0.093
AMC1309	AMC1309@g2calo0910-data	1221	0.7	0.094
AMC1310	AMC1310@g2calo0910-data	1222	0.7	1.968
AMC1311	AMC1311@g2calo1112-data	1222	0.7	1.940
AMC1312	AMC1312@g2calo1112-data	1223	1.0	1.944
AMC1313	AMC1313@g2calo1314-data	1223	1.0	1.972
AMC1314	AMC1314@g2calo1314-data	1222	0.7	1.963
AMC1315	AMC1315@g2calo1516-data	1221	0.7	0.095
AMC1316	AMC1316@g2calo1516-data	1223	0.7	1.911
AMC1317	AMC1317@g2calo1718-data	1222	0.7	1.954
AMC1318	AMC1318@g2calo1718-data	1223	1.0	1.928
AMC1319	AMC1319@g2calo1920-data	1222	0.7	1.892
AMC1320	AMC1320@g2calo1920-data	1221	0.7	0.092
AMC1321	AMC1321@g2calo2122-data	1221	0.7	0.093
AMC1322	AMC1322@g2calo2122-data	1221	0.7	0.125
AMC1323	AMC1323@g2calo2324-data	1222	0.7	1.858
AMC1324	AMC1324@g2calo2324-data	1223	1.0	1.977
AMC1325	AMC1325@g2laserdaq-data	1221	0.7	0.069
AMC1326	AMC1326@g2aux-priv	1221	0.7	5.735
StrawTrackerLVandSC03	StrawTrackerLVandSC03@g2tracker1.fnal.gov	0	0.0	0.000
StrawTrackerDAQ	StrawTrackerDAQ@g2tracker0.fnal.gov	1221	0.7	0.006
StrawTrackerHV03	StrawTrackerHV03@g2tracker1.fnal.gov	0	0.0	0.000
IBMS Detector	IBMS Detector@g2ibms-priv	1223	0.7	0.121
CaloSC01	CaloSC01@g2sc-priv	0	0.0	0.000
CaloSC02	CaloSC02@g2sc-priv	0	0.0	0.000
CaloSC03	CaloSC03@g2sc-priv	0	0.0	0.000
CaloSC04	CaloSC04@g2sc-priv	0	0.0	0.000
CaloSC05	CaloSC05@g2sc-priv	0	0.0	0.000
CaloSC06	CaloSC06@g2sc-priv	0	0.0	0.000
CaloSC07	CaloSC07@g2sc-priv	0	0.0	0.000
CaloSC08	CaloSC08@g2sc-priv	0	0.0	0.000
CaloSC09	CaloSC09@g2sc-priv	0	0.0	0.000
CaloSC10	CaloSC10@g2sc-priv	0	0.0	0.000
CaloSC11	CaloSC11@g2sc-priv	0	0.0	0.000
CaloSC12	CaloSC12@g2sc-priv	0	0.0	0.000
CaloSC13	CaloSC13@g2sc-priv	0	0.0	0.000
CaloSC14	CaloSC14@g2sc-priv	0	0.0	0.000
CaloSC15	CaloSC15@g2sc-priv	0	0.0	0.000
CaloSC16	CaloSC16@g2sc-priv	0	0.0	0.000
CaloSC17	CaloSC17@g2sc-priv	0	0.0	0.000
CaloSC18	CaloSC18@g2sc-priv	0	0.0	0.000
CaloSC19	CaloSC19@g2sc-priv	0	0.0	0.000
CaloSC20	CaloSC20@g2sc-priv	0	0.0	0.000
CaloSC21	CaloSC21@g2sc-priv	0	0.0	0.000
CaloSC22	CaloSC22@g2sc-priv	0	0.0	0.000
CaloSC23	CaloSC23@g2sc-priv	0	0.0	0.000
CaloSC24	CaloSC24@g2sc-priv	0	0.0	0.000
ESQ_slow	ESQ_slow@g2quad-01	1729	1.0	0.000
ESQ	ESQ@g2quad-02	1223	0.7	0.000
IFIX	Ol	173	0.0	0.000
mscb110	Ol	29	0.0	0.000
mscb13e	Ol	2871	0.0	0.000
mscb319	Ol	29	0.0	0.000
mscb323	Ol	29	0.0	0.000
KickerSC_mscb282	Ol	29	0.0	0.000
mscb174	Ol	29	0.0	0.000
Beam	Beam@g2sc-priv	346	0.3	0.000

At the bottom, there is a "Logging Channels" section with a table:

Channel	Events	MIB written	Compr.	Disk level
gm2_run01618_48.mid	4992	48906.884	N/A	61.1%

Below the logging channels is a "Clients" section with a table:

Client	Events	MIB written	Compr.	Disk level
midas [g2be1.fnal.gov]				
mercur [g2be1.fnal.gov]				
StrawTrackerHV03 [g2tracker1.fnal.gov]				

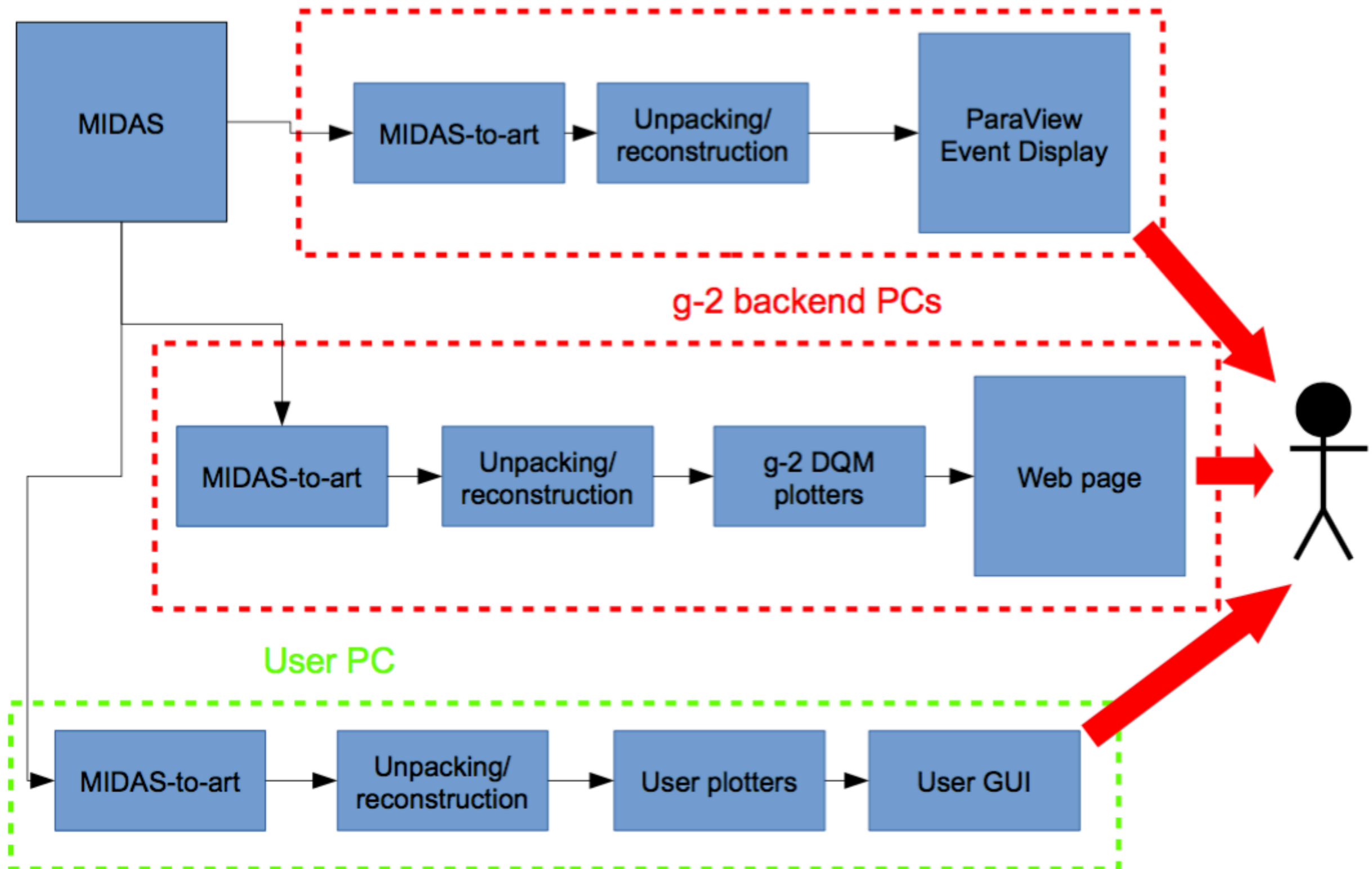
Fermilab *art* framework and *midas-to-art*

art is an event-processing framework developed/maintained by Fermilab SCD

- used by (g-2), mu2e, NOvA, and others
- (g-2) unpacking/recon/analysis done in *art* modules
- *art* has its own file/data format
- *midas-to-art* plugin: reads MIDAS files into *art* jobs, translates MIDAS banks into *art* event data
- strong preference in collaboration to develop *art*-based DQM so we can reuse offline modules
- online *art* can be used as backend for number of different frontend DQM pages/event-displays, etc.

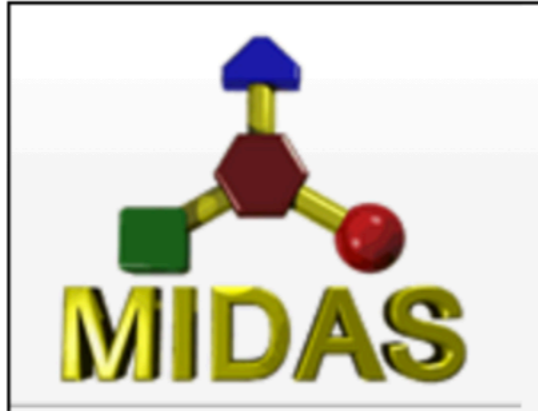


Data flow with MIDAS-to-art



General Architecture

bidirectional
communication



midas experiment/mserver



midas-to-art
unpackers
producers
analyzers

any module we've written can
run online
(limited only by speed)

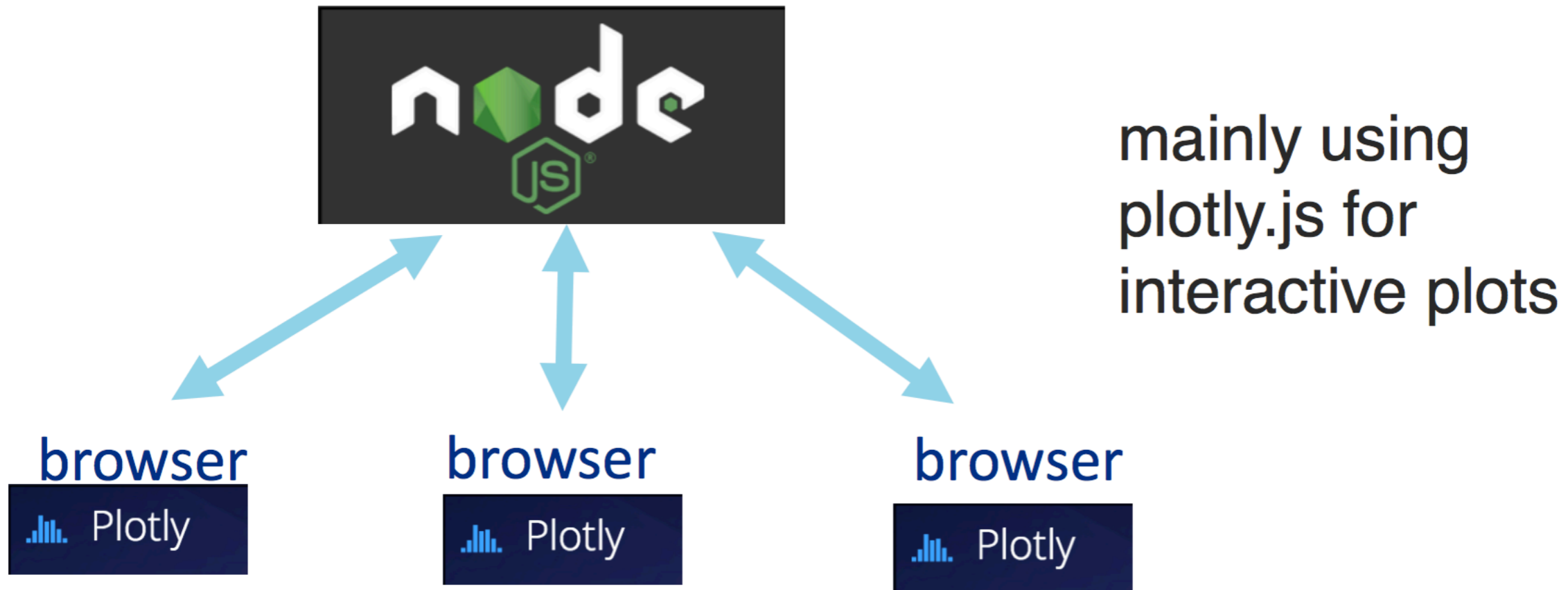


node.js webservers
data aggregation
client communication



connections to multiple clients

plot rendering is outsourced to clients



- server sends data through WebSockets on client request
- clients are insulated from both *art* job and MIDAS
- we use some additional js visualization tools (D3.js)

positron pulse in a calorimeter

calo 8 traces

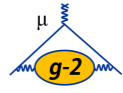
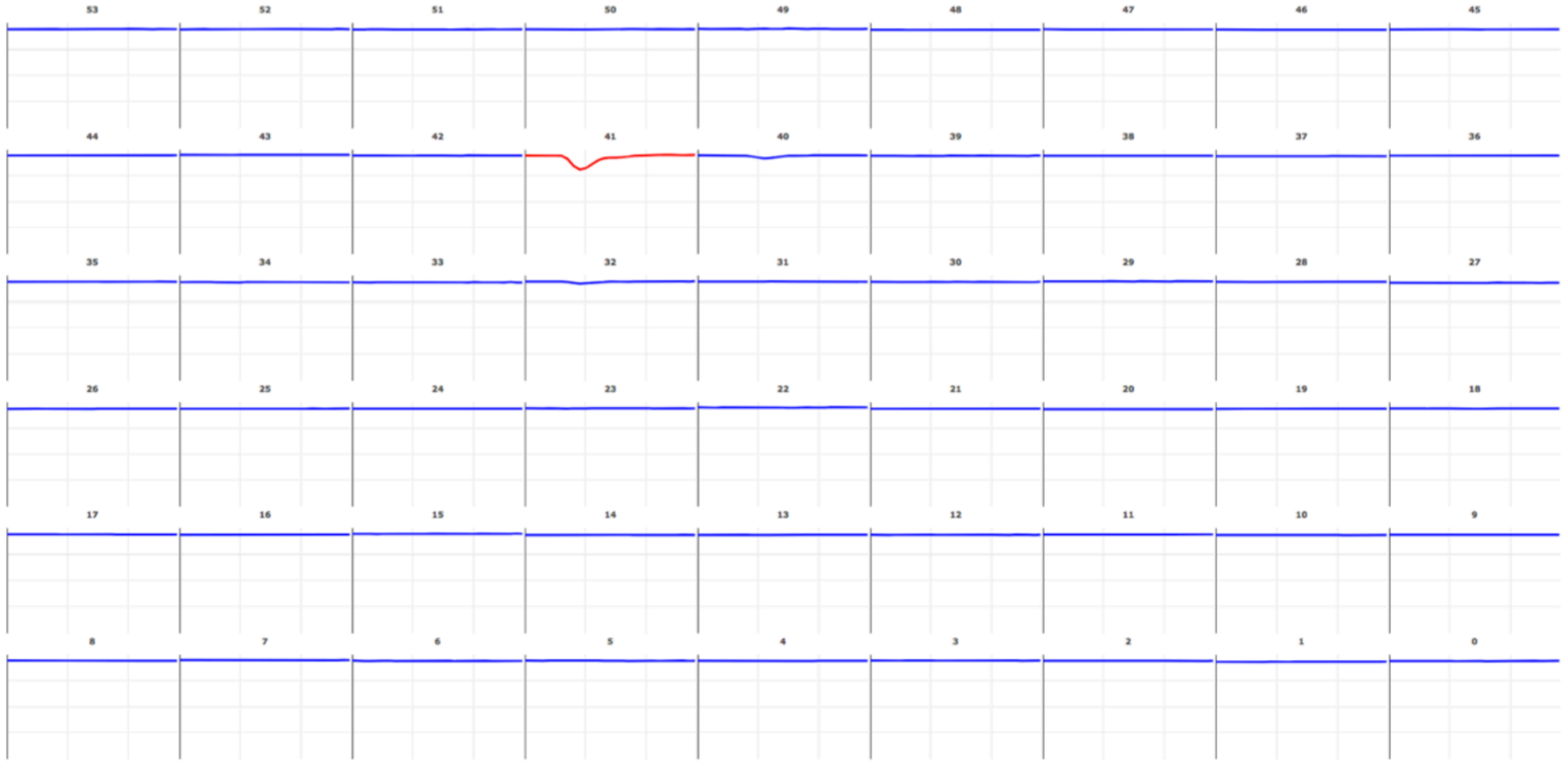
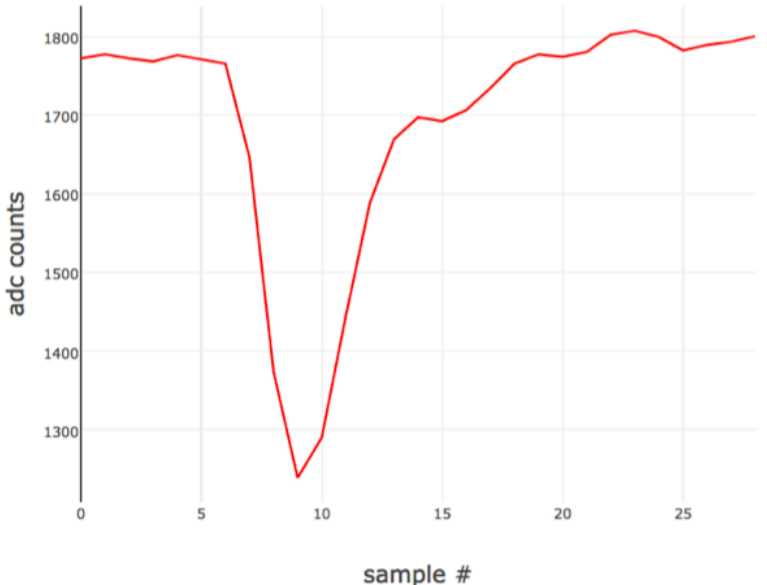
RUN 1911 EVENT 347 ISLAND 12

summary traces Q S recon laser headers

auto update: ON pause update late

late island: first sample number 124428

xtal 41



straw tracker TDC hits

Muon g-2 DQM Run 1912 Event 5 Subsystem -

Straw Tracker Overview Station 2- Physics Plots -

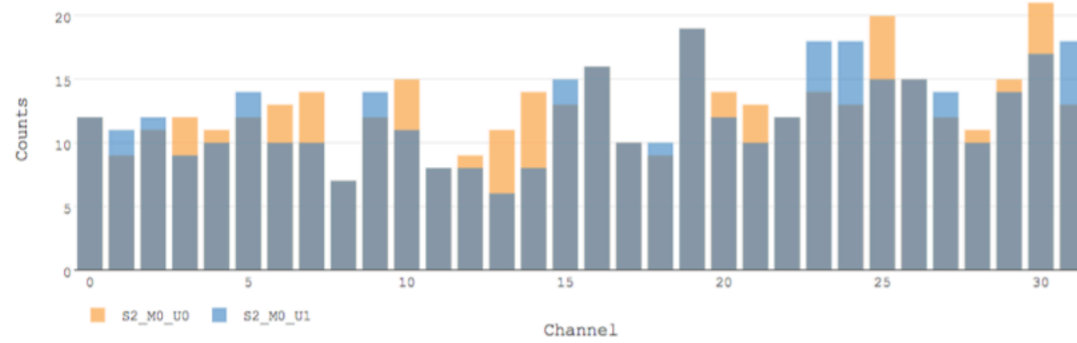
Connected Clear Histos

Module 0 Straw Tracker Module 9 Fitted 127/128 Straws Present VB12 Not Present	Module 1 Straw Tracker Module 2 Fitted 127/128 Straws Present VB24 Not Present	Module 2 Straw Tracker Module 0 Fitted X/128 Straws Present	Module 3 Straw Tracker Module 1 Fitted 127/128 Straws VB14 Not Present
Module 4 Straw Tracker Module 6 Fitted 128/128	Module 5 Straw Tracker Module 5 Fitted 126/128 Straws UA8, UA17 Not Present	Module 6 Straw Tracker Module 00 Fitted 127/128 Straws (Straw 31)	Module 7 Straw Tracker Module 4 Fitted 127/128

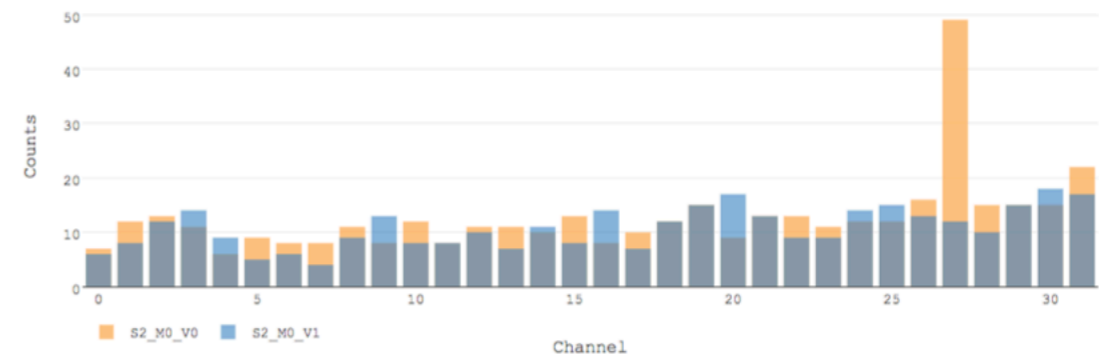
Channels

Tracker 2 INFO M0 M1 M2 M3 M4 M5 M6 M7

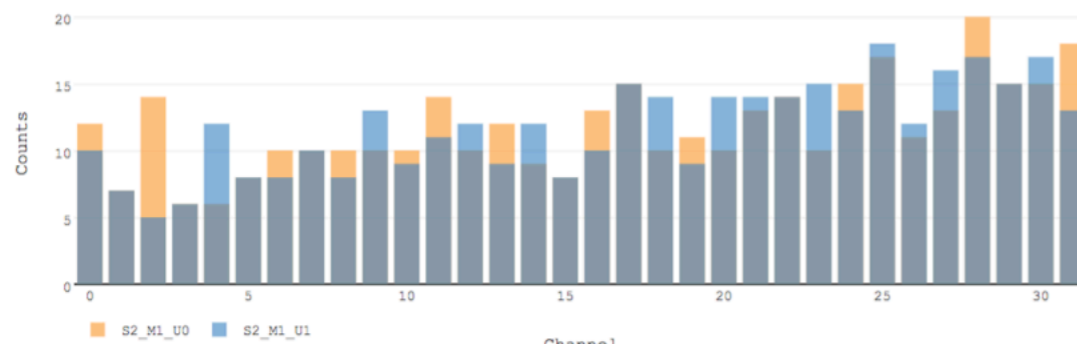
S2_M0_U



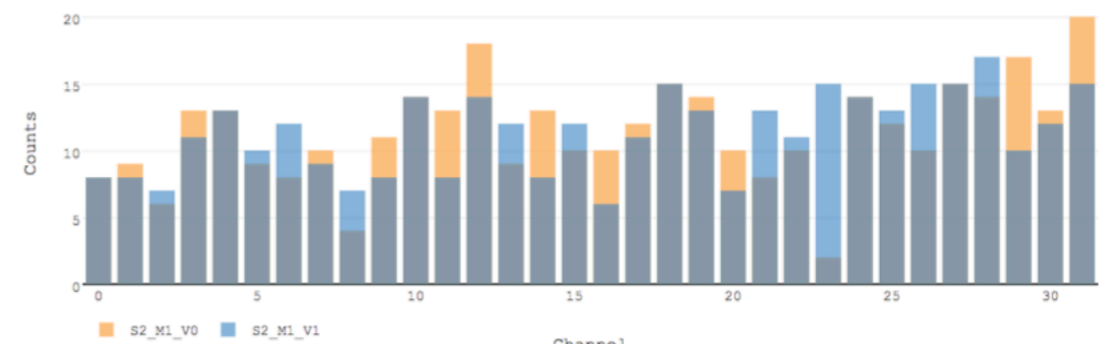
S2_M0_V



S2_M1_U



S2_M1_V

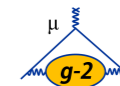


S2_M2_U

S2_M2_V

0

1



MIDAS Alarms

- The MIDAS alarm system was used as the primary alarm system.
- Alarms were set on temperatures and voltages from MSCB devices.
- Other slow frontends set alarms automatically when encountering an error.

The screenshot displays the MIDAS control interface. At the top, there is a navigation bar with buttons for Status, ODB, Messages, Alarms, Programs, Sequencer, Config, and Help. Below this, there are buttons for Test, Restart Fast Frontends, ChanMap, Straw Tracker Power, Straw Tracker Settings, and WFD5. The main content area shows two alarm messages: a yellow warning bar for 'Warning: Computer room temperature high' and a red alarm bar for 'Alarm: Computer room temperature too high', both with 'Reset' buttons. Below the alarms is a 'Run Status' section. It features a red box on the left with 'Run 2075 Stopped' and a 'Start' button. To the right, it shows 'Start: Fri Jul 14 23:39:34 2017' and 'Stop: Fri Jul 14 23:34:51 2017'. There are two green status indicators: 'Alarms: On' and 'Restart: Yes'. Below these, it lists 'Experiment Name: GM2', 'git hash:', and 'CCC Run State: Idle'. At the bottom, a green bar shows the timestamp '20:28:42 mhttpd:Alarm: Computer room temperature too high'.

MIDAS web alarm page

Alarms - Mozilla Firefox
Mjsonrpc - MidasWiki x Alarms x +

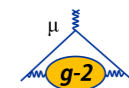
localhost:8082/?cmd=Alarms

Status ODB Messages **Alarms** Programs Sequencer Config Help

Reset all alarms Disable the alarm system Speak

Evaluated alarms						
Alarm	State	First triggered	Class	Condition	Current value	
Demo ODB	Disabled	-	Alarm	/Runinfo/Run number > 100	6667	Reset
EB	OK	-	Warning	/Equipment/EB/Statistics/kBytes per sec. > 2000000	0	Reset
RateL	OK	-	Alarm Low	/Equipment/EB/Statistics/kBytes per sec. > 3000000	0	Reset
RateH	OK	-	Alarm High	/Equipment/EB/Statistics/kBytes per sec. > 5000000	0	Reset
Test Alarm	OK	-	Test	/Runinfo/Run number = 0	6667	Reset
Magnet_sectorB_temp	OK	-	Warning	/Equipment/mscb13e/Variables/Input[8-9] > 30	24.89489	Reset
Magnet_sectorB_temp2	OK	-	Alarm	/Equipment/mscb13e/Variables/Input[8-9] > 30	24.89489	Reset
Magnet_sectorB_bottom_temp	Disabled	-	Warning	/Equipment/mscb13e/Variables/Input[10] > 27	25.36532	Reset
Magnet_sectorB_bottom_temp2	Disabled	-	Alarm	/Equipment/mscb13e/Variables/Input[10] > 30	25.36532	Reset
mscb110-8_temp	OK	-	Warning	/Equipment/mscb110/Variables/Input[8] > 27	21.21	Reset
mscb110-8_temp2	OK	-	Alarm	/Equipment/mscb110/Variables/Input[8] > 30	21.21	Reset
Kicker_OilLevel_1	Disabled	-	Kicker Alarm	/Equipment/KickerSC_mscb282/Variables/Input[35] < 1	1	Reset
Kicker_OilLevel_2	Disabled	-	Kicker Alarm	/Equipment/KickerSC_mscb282/Variables/Input[36] < 1	1	Reset
Kicker_OilLevel_3	Disabled	-	Kicker Alarm	/Equipment/KickerSC_mscb282/Variables/Input[37] < 1	1	Reset
Straw Tracker HV	OK	-	Tracker Data Alarm	/Equipment/StrawTrackerHV03/Variables/Channel tripped > 0	0	Reset
IBMS rate	OK	-	Warning	/Equipment/IBMS Detector/Statistics/Events per sec. > 50	0.3332222592469177	Reset
FiberHarp180Y	OK	-	Warning	/Equipment/FiberHarpControl/Variables/Input[7] == 0	1	Reset
FiberHarp180X	OK	-	Warning	/Equipment/FiberHarpControl/Variables/Input[3] == 0	1	Reset
FiberHarp270Y	OK	-	Warning	/Equipment/FiberHarpControl/Variables/Input[16] == 0	1	Reset
FiberHarp270X	OK	-	Warning	/Equipment/FiberHarpControl/Variables/Input[12] == 0	1	Reset

Program alarms



MIDAS Alarm system capabilities

- Alarm setting on any ODB variable against a threshold parameter
- Alarm triggered by evaluated condition
- Selection of Alarm check frequency
- Selection of Alarm trigger frequency
- Customization alarm scheme: multiple choices of alarm type
- Selection of alarm message destination (to system message log or to elog)
- Email or SMS alerts can be sent
- Alarm triggered when a Program is not running

A MIDAS experiment uses the ODB (fast online database) for storing various equipment parameters such as electronics settings and slow control variables.

Only some basic tools are available for viewing and editing the ODB data out of the box: a command-line **odbedit** application and a web based odb editor provided by the standard MIDAS **mhttpd** web server. These tools are good enough only for a relatively small odb with simple data organisation.

A custom solution is necessary for larger experiments (like “Muon g-2”@Fermilab or MEG-II @PSI), where many thousands of settings and channels should be controlled. Such settings could be also more naturally structured not as 1-D arrays, but as n-tuples or trees or multidimensional tables.

In the following slides custom MIDAS pages developed for controlling DAQ electronics for the “Muon g-2” experiment are presented.

Some features implemented in custom MIDAS pages

- Different types of data (boolean, integer, string etc.) could be edited.
- The same value (or a structured set of values) could be written to a subset of an array defined by a range selector.
Example: **1,3,5-9,22**.
- Any values before writing to the ODB could be checked for validity.

Setting Mixed Type Parameters in 3-D table (top)

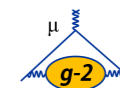
WFD5 Channels

Configure 1 crate: Crate #
 Configure multiple crates: Crate #

DATA LAST WRITTEN on

/Equipment/AMC1301/Settings/RiderXX/Board/

Key name	Rider 01	Rider 02	Rider 03	Rider 04	Rider 05	Rider 06	Rider 07	Rider 08	Rider 09	Rider 10	Rider 11	Rider 12	WFD5 ##	Value	SET
Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1	1	S
Frontend Configuration Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	1	S
FPGA Firmware Version Required	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	<input type="text" value="2.5.1"/>	1	2.5.1	S
Digitization Frequency (MHz)	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	<input type="text" value="800"/>	1	800	S
Front Panel Clock Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	1	S
Front Panel Clock Frequency	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	<input type="text" value="ttc"/>	1	ttc	S
ADC Data Endianness	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	<input type="text" value="little"/>	1	little	S
Trigger Delay (ns)	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	1	0	S
Async Mode: Enabled	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	0	S
Async Mode: Waveform Length	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	<input type="text" value="80"/>	1	80	S
Async Mode:	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	<input type="text" value="4"/>	1	4	S



Setting Mixed Type Parameters in 3-D table (bottom)

WFD5

localhost:8082/CS/wfd5

90%

Search

Presamples

Trigger Type 1: Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	1	S
Trigger Type 1: Waveform Count	1	1	1	1	1	1	1	1	1	1	1	1	1	1	S
Trigger Type 1: Waveform Length	560000	560000	560000	560000	560000	560000	560000	560000	560000	560000	560000	560000	1	560000	S
Trigger Type 1: Waveform Gap	16	16	16	16	16	16	16	16	16	16	16	16	1	16	S
Trigger Type 2: Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	1	S
Trigger Type 2: Waveform Count	4	4	4	4	4	4	4	4	4	4	4	4	1	4	S
Trigger Type 2: Waveform Length	800	800	800	800	800	800	800	800	800	800	800	800	1	800	S
Trigger Type 2: Waveform Gap	159200	159200	159200	159200	159200	159200	159200	159200	159200	159200	159200	159200	1	159200	S
Trigger Type 3: Enabled	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	1	S
Trigger Type 3: Waveform Count	1	1	1	1	1	1	1	1	1	1	1	1	1	1	S
Trigger Type 3: Waveform Length	800	800	800	800	800	800	800	800	800	800	800	800	1	800	S
Trigger Type 3: Waveform Gap	16	16	16	16	16	16	16	16	16	16	16	16	1	16	S
Error Threshold: Corrupt Data	10	10	10	10	10	10	10	10	10	10	10	10	1	10	S
Error Threshold: Unknown TTC	10	10	10	10	10	10	10	10	10	10	10	10	1	10	S
Error Threshold: DDR3 Overflow	7549747	7549747	7549747	7549747	7549747	7549747	7549747	7549747	7549747	7549747	7549747	7549747	1	7549747	S

Setting Boolean Parameters in 3-D table

WFD5 Channels

localhost:8082/CS/wfd5c

Status ODB Messages Alarms Programs Sequencer Config Help

WFD5 Riders

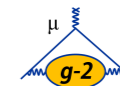
Configure 1 crate: Crate #
 Configure multiple crates: Crate #

DATA LAST WRITTEN on

Channel Setting:

/Equipment/AMC1301/Settings/RiderXX/ChannelXX/Enabled															
Ch #	Rider 01	Rider 02	Rider 03	Rider 04	Rider 05	Rider 06	Rider 07	Rider 08	Rider 09	Rider 10	Rider 11	Rider 12	WFD5 ##	Value	SET
00	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="button" value="S"/>
01	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="button" value="S"/>
02	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="button" value="S"/>
03	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="button" value="S"/>
04	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="button" value="S"/>

Setting Integer Parameters in 3-D table



Setting String Parameters in 3-D table

WFD5 Channels

localhost:8082/CS/wfd5c

Status ODB Messages Alarms Programs Sequencer Config Help

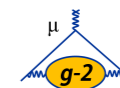
WFD5 Riders

Configure 1 crate: Crate #
 Configure multiple crates: Crate #

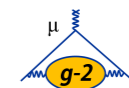
DATA LAST WRITTEN on

Channel Setting:

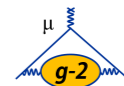
/Equipment/AMC1301/Settings/RiderXX/ChannelXX/FPGA Firmware Version Required															
Ch #	Rider 01	Rider 02	Rider 03	Rider 04	Rider 05	Rider 06	Rider 07	Rider 08	Rider 09	Rider 10	Rider 11	Rider 12	WFD5 ##	Value	SET
00	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	1	2.3.2	S
01	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	1	2.3.2	S
02	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	2.3.2	1	2.3.2	S



Two table layout with common selectors



BACKUP



MasterGM2 frontend

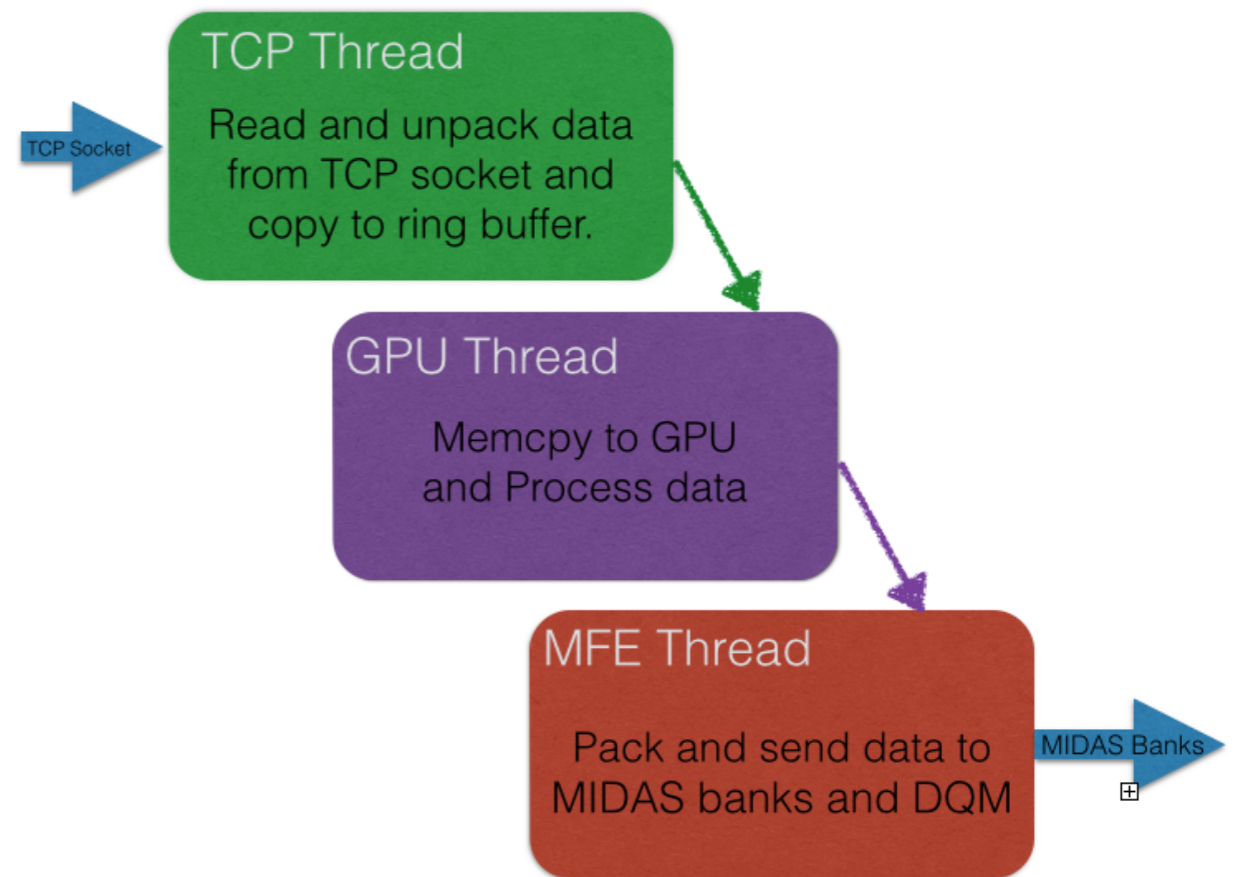
- Communicates with other frontends using RPC calls.
- Provides begin of run and end of run RPCs to all frontends.
- Provides end of fill trigger to synchronous frontends.
- Configures clock and control system.
- Reads trigger times from Meinberg GPS unit and writes them to a MIDAS bank.



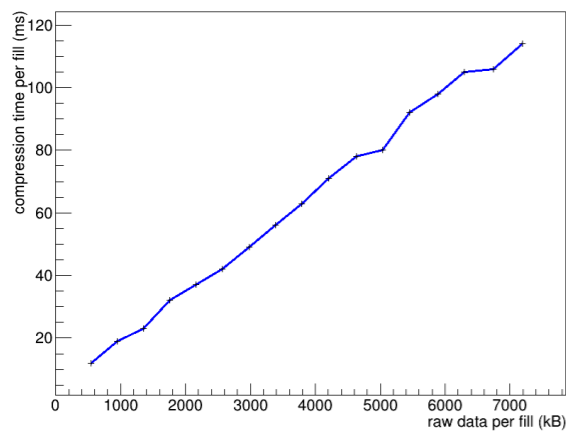
```
Bank:GPS0 Length: 20(I*1)/5(I*4)/5(Type) Type:Unsigned Integer*4  
1-> 0x000018c2 0x580838bc 0x5dcabfb0 0x580838bc 0x5dd48308
```

AMC13 Frontend

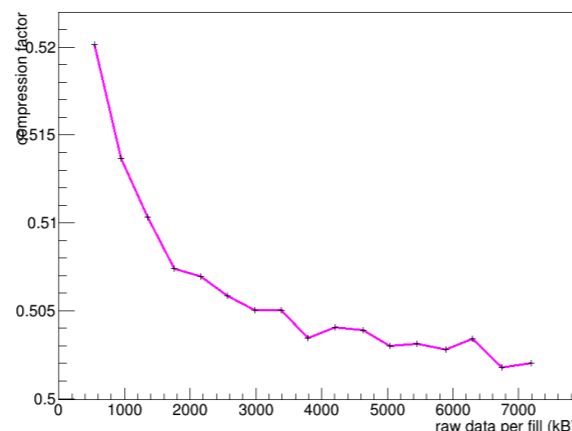
- Each frontend process reads data from one uTCA crate over 10 Gb ethernet with TCPIP.
- Data is processed in Nvidia Tesla K40 GPUs using CUDA code that is integrated into the frontend.
- Midas banks are losslessly compressed using zlib.



compression time versus raw data

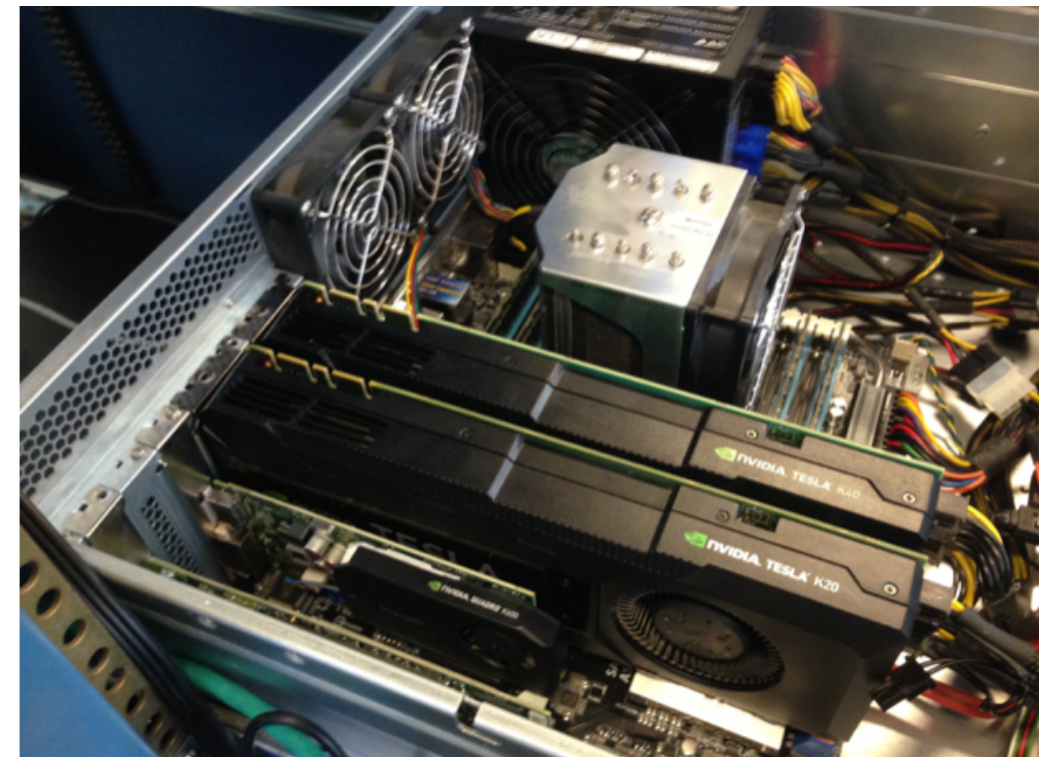


compression factor versus raw data



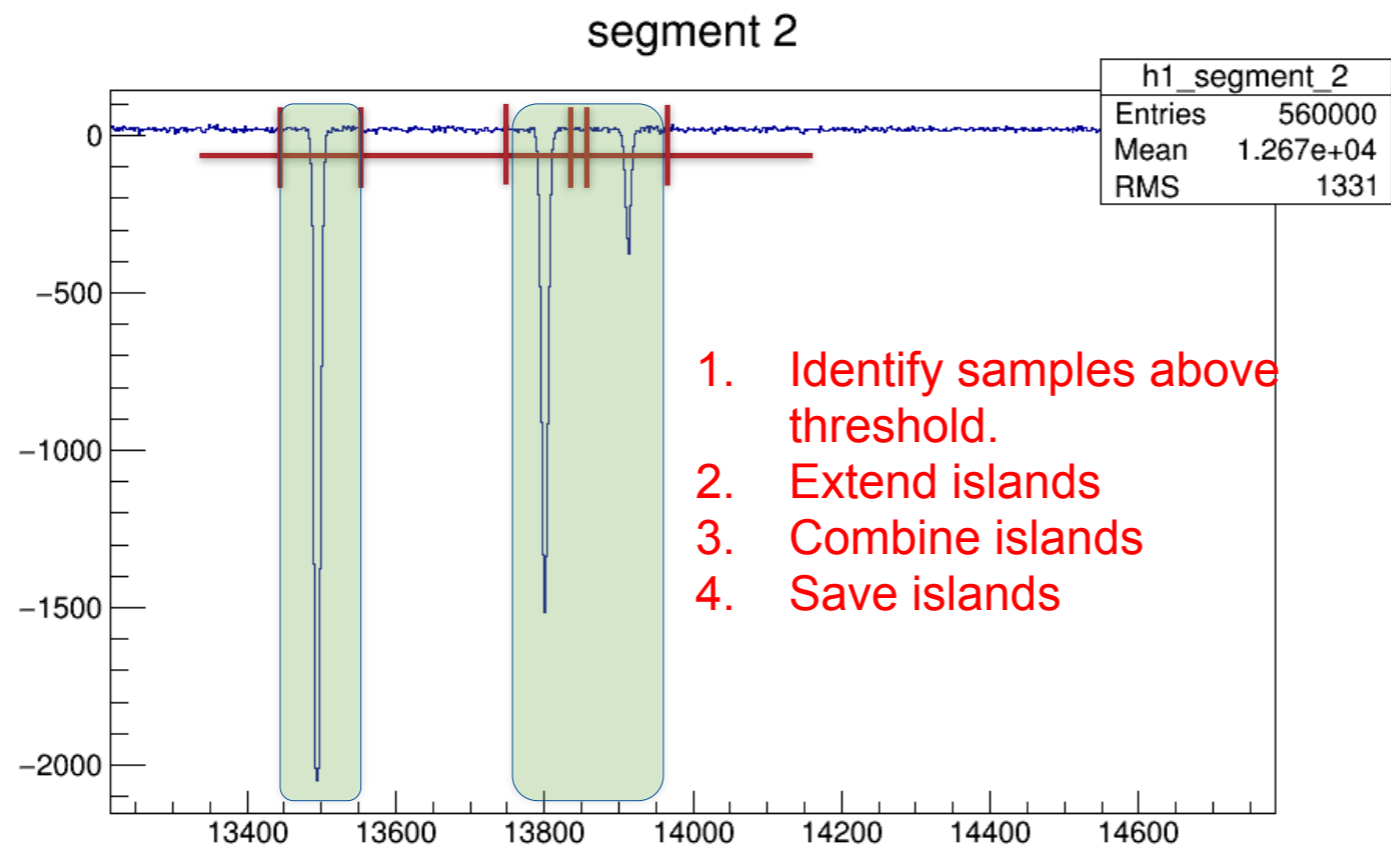
GPU Processing

- The frontend includes CUDA routines for data processing.
- Each GPU processes data from one calorimeter.
- Raw fill is copied to GPU memory, where it is reduced using T-method (island chopping), Q-method (histogramming), pedestal calculation, and template fitting.
- The output of each process is written in one MIDAS bank.



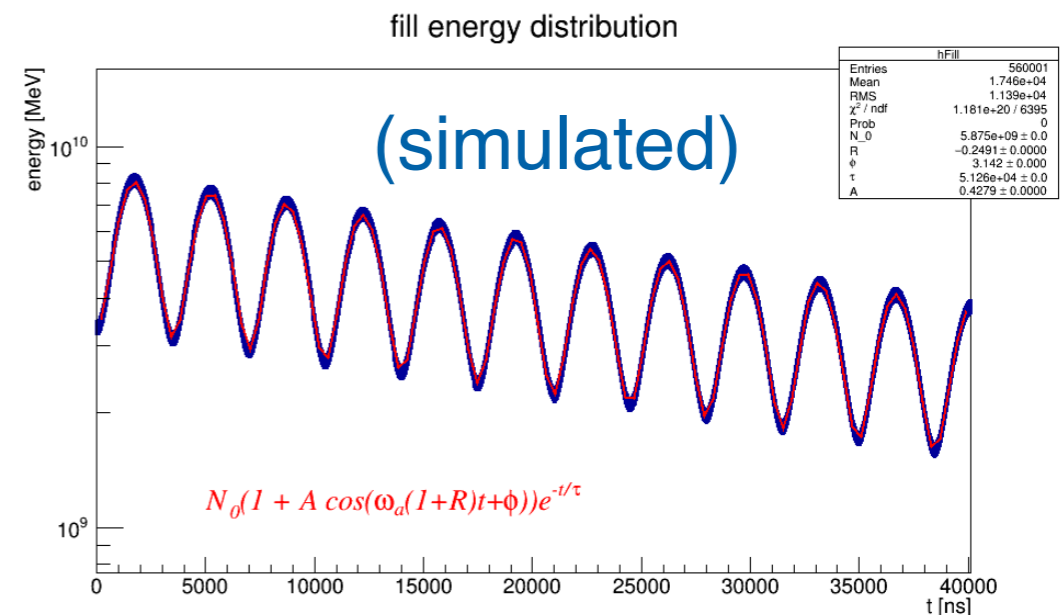
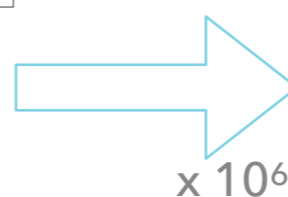
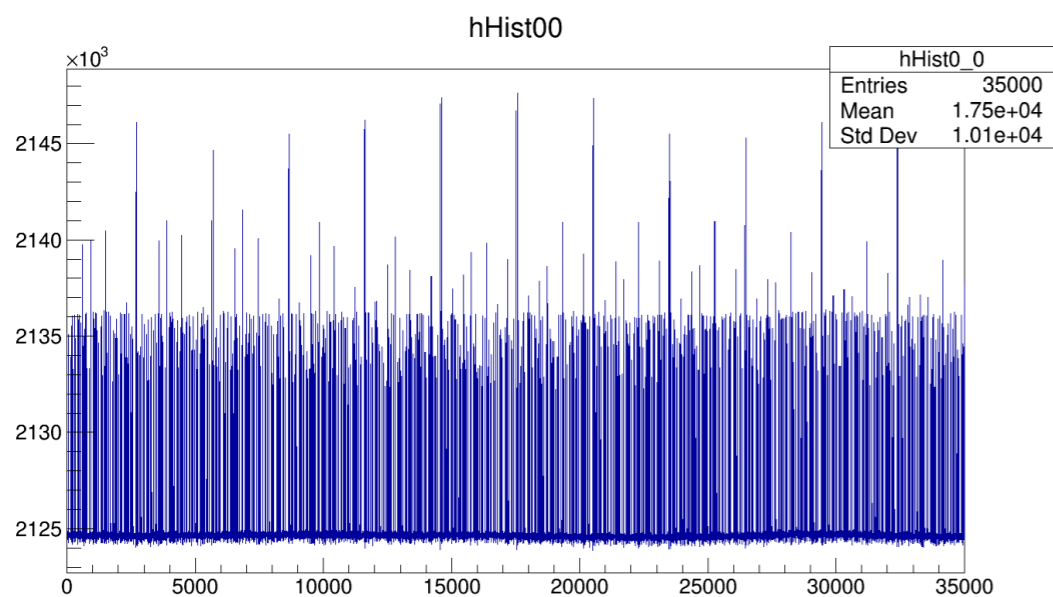
T-Method

- Identify and save regions of the waveform containing positron hits.
- A typical waveform will have ~ 180 islands.



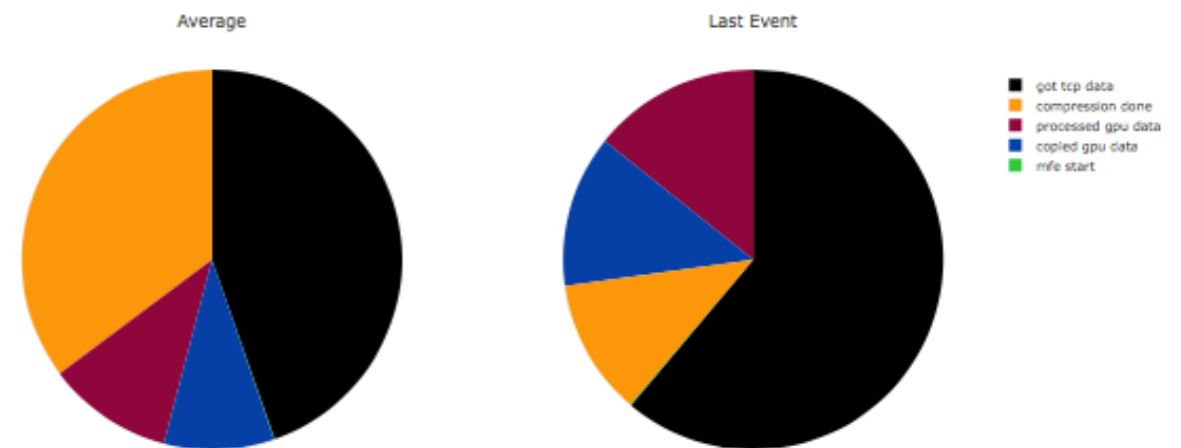
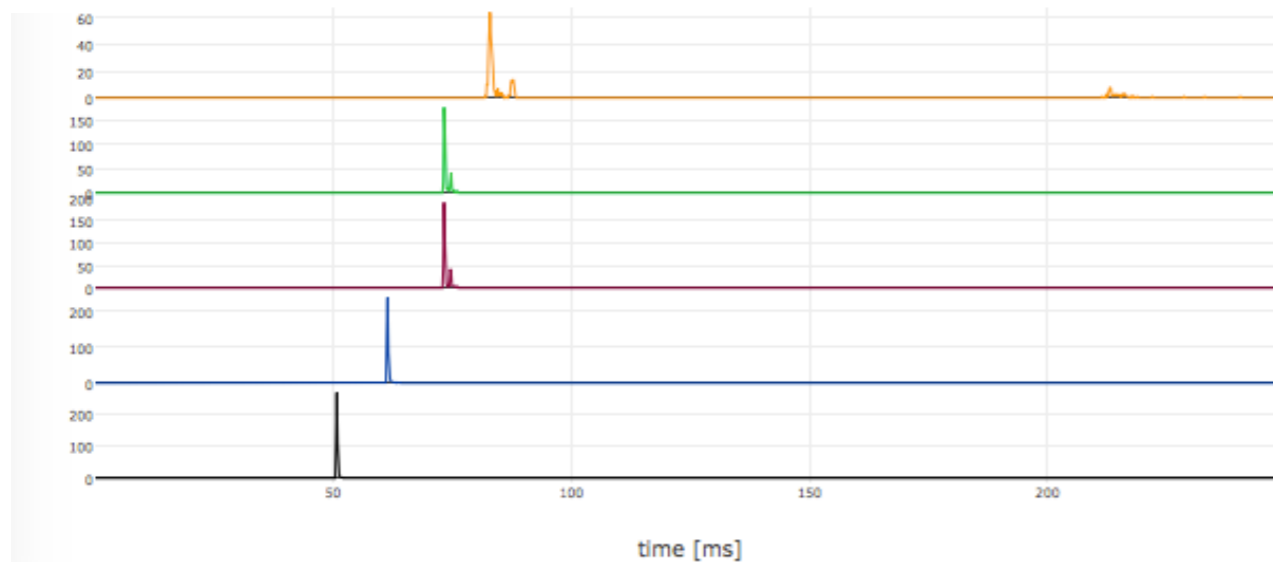
Q-method

- Full waveforms are decimated in time and summed over many fills to create a histogram that is saved in the data file.
 - i.e. If we decimate in time by 10 and flush every 100 fills, we reduce the data rate by a factor of 1000, so from 20 GB/s to 20 MB/s.
- Use smaller bins at lower times and wider bins at later times to insure that we can extract the pedestal.



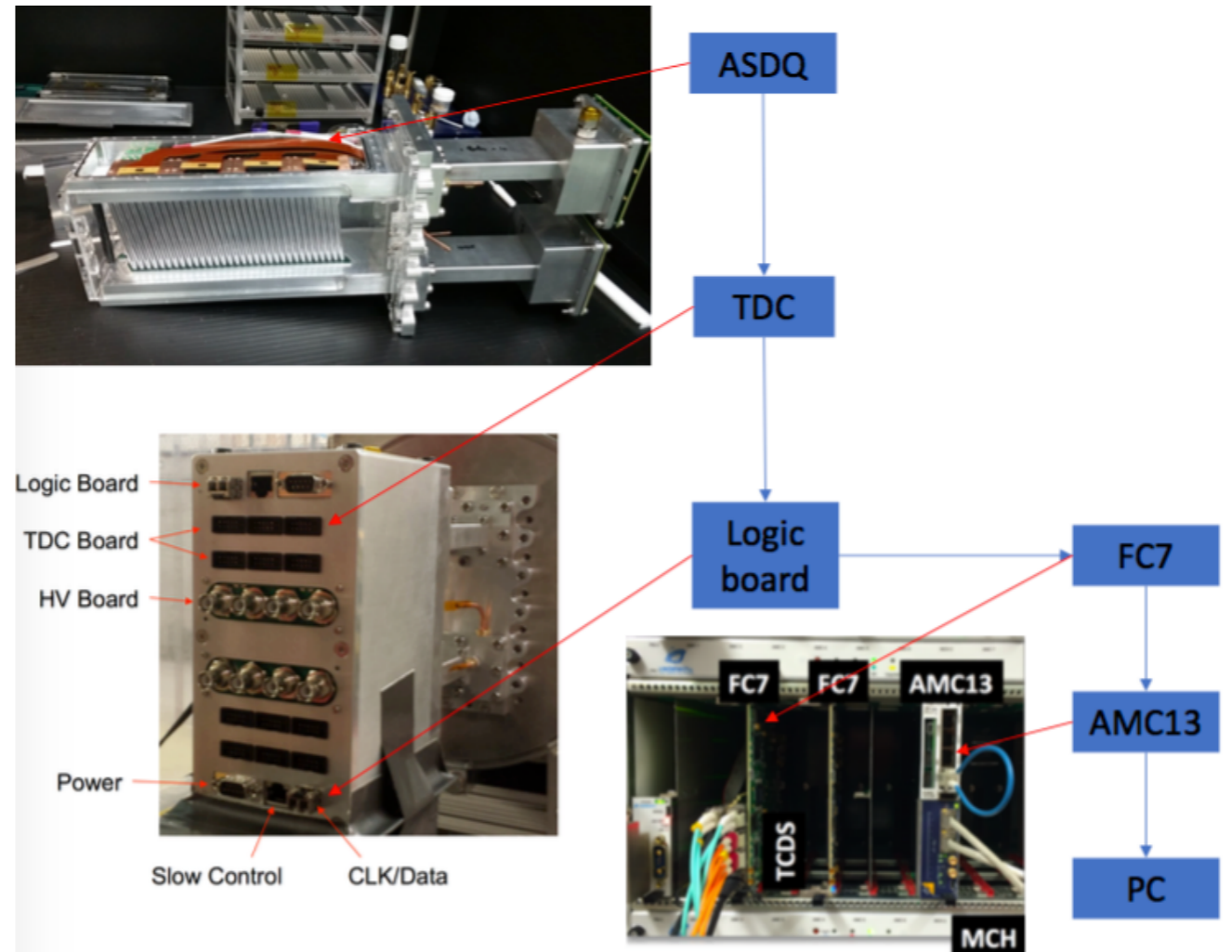
Processing time

- Must process each event in 83 ms to keep up with average beam rate of 12 Hz.
- Most time is spent reading data from TCP socket and copying it to the GPU.
- Processing time in the GPU is very small.



Tracker Frontend

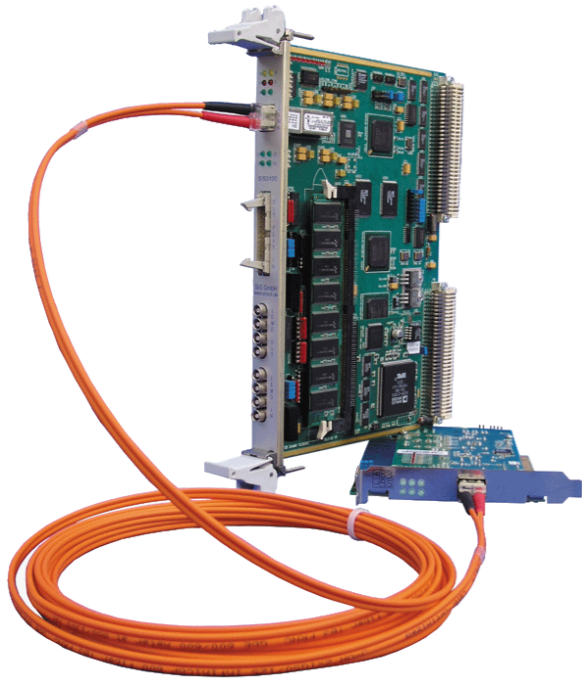
- Three tracker stations will be read via one uTCA crate.
- Reads data from AMC13.
- Instead of digitizers, data comes from multihit TDCs that are read via FC7 cards.



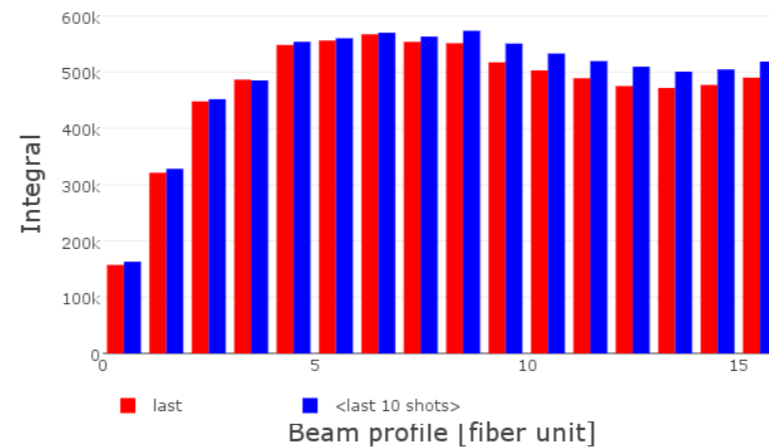
(Thanks R. Chislett for the diagram)

IBMS Frontend

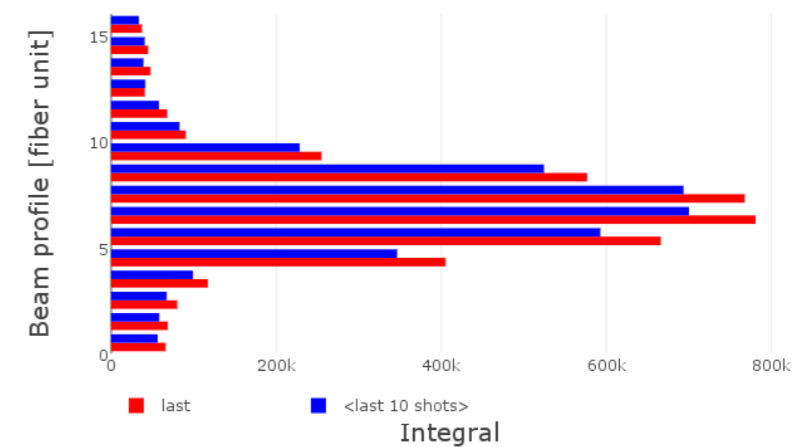
- Data from the inflector beam monitoring system (IBMS) is read out via a CAEN digitizer.
- A custom MIDAS frontend was written to integrate this detector into the DAQ.



IBMS 1 X Profile



IBMS 1 Y Profile



Slow Controls

- DAQ includes six SCS3000 mscb devices.
- 24 beaglebones reading slow control data from calorimeters.
- HV and LV frontends for tracker system.
- Slow frontend reading magnet properties from IFIX via an OPC client.
- Beamline frontend periodically reading output of beam components from database.
- Slow control data is stored in a Postgres database and displayed using a custom Django web display.

