G-2 DAQ system

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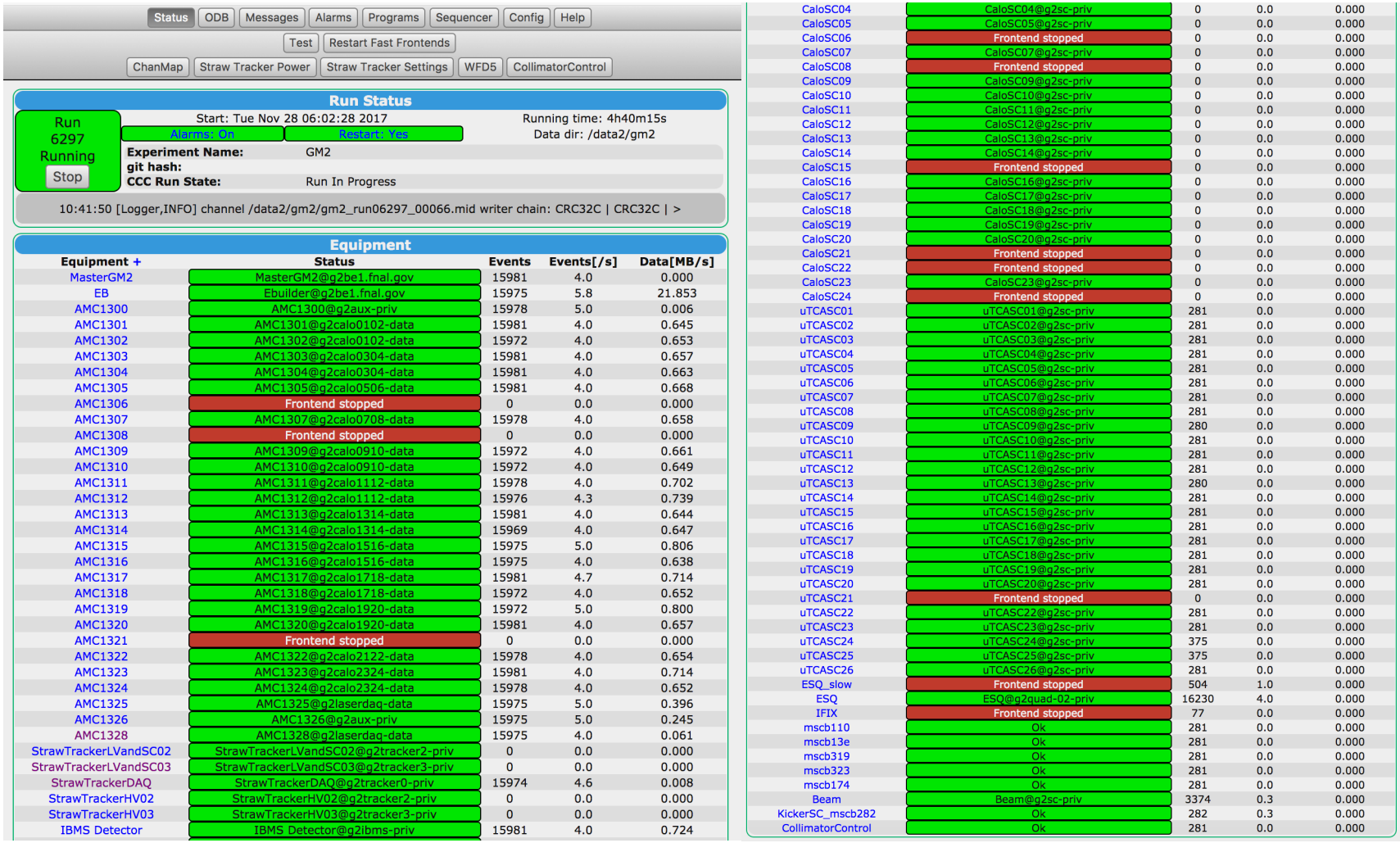
EDM workshop
Liverpool
2nd October 2018

Introduction

The g-2 DAQ system uses the MIDAS framework



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

Test | Restart Fast Frontends

ChanMap | Straw Tracker Power | Straw Tracker Settings | WFD5 | CollimatorControl

Run Status

Run 6297 Running — Stop

Start: Tue Nov 28 06:02:28 2017 — Running time: 4h40m15s

Alarms: On | Restart: Yes — Data dir: /data2/gm2

Experiment Name: GM2

git hash:

CCC Run State: Run In Progress

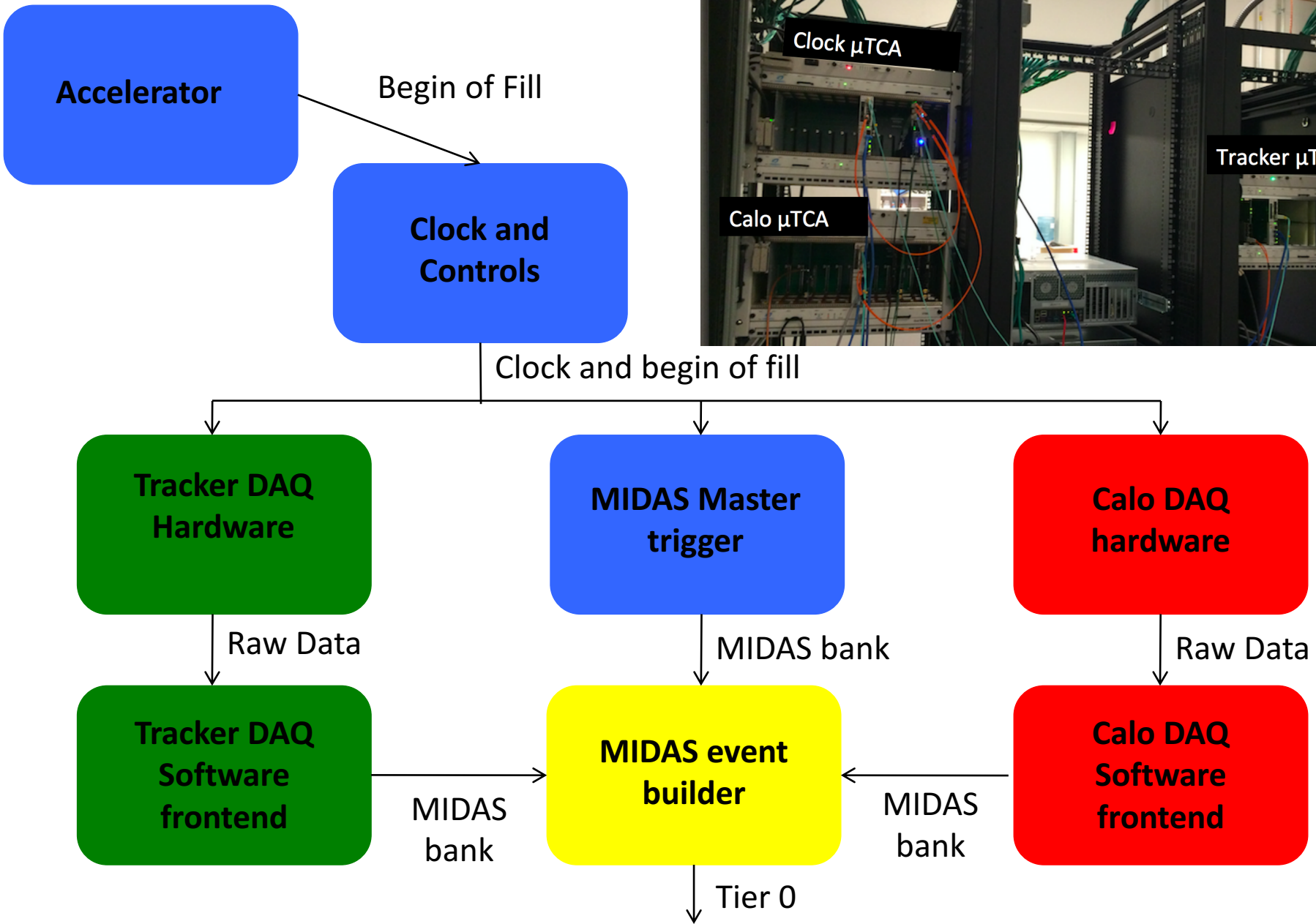
10:41:50 [Logger,INFO] channel /data2/gm2/gm2_run06297_00066.mid writer chain: CRC32C | CRC32C | >

Equipment

Equipment +	Status	Events	Events[/s]	Data[MB/s]
MasterGM2	MasterGM2@g2be1.fnal.gov	15981	4.0	0.000
EB	Ebuilder@g2be1.fnal.gov	15975	5.8	21.853
AMC1300	AMC1300@g2aux-priv	15978	5.0	0.006
AMC1301	AMC1301@g2calo0102-data	15981	4.0	0.645
AMC1302	AMC1302@g2calo0102-data	15972	4.0	0.653
AMC1303	AMC1303@g2calo0304-data	15981	4.0	0.657
AMC1304	AMC1304@g2calo0304-data	15981	4.0	0.663
AMC1305	AMC1305@g2calo0506-data	15981	4.0	0.668
AMC1306	Frontend stopped	0	0.0	0.000
AMC1307	AMC1307@g2calo0708-data	15978	4.0	0.658
AMC1308	Frontend stopped	0	0.0	0.000
AMC1309	AMC1309@g2calo0910-data	15972	4.0	0.661
AMC1310	AMC1310@g2calo0910-data	15972	4.0	0.649
AMC1311	AMC1311@g2calo1112-data	15978	4.0	0.702
AMC1312	AMC1312@g2calo1112-data	15976	4.3	0.739
AMC1313	AMC1313@g2calo1314-data	15981	4.0	0.644
AMC1314	AMC1314@g2calo1314-data	15969	4.0	0.647
AMC1315	AMC1315@g2calo1516-data	15975	5.0	0.806
AMC1316	AMC1316@g2calo1516-data	15975	4.0	0.638
AMC1317	AMC1317@g2calo1718-data	15981	4.7	0.714
AMC1318	AMC1318@g2calo1718-data	15972	4.0	0.652
AMC1319	AMC1319@g2calo1920-data	15972	5.0	0.800
AMC1320	AMC1320@g2calo1920-data	15981	4.0	0.657
AMC1321	Frontend stopped	0	0.0	0.000
AMC1322	AMC1322@g2calo2122-data	15978	4.0	0.654
AMC1323	AMC1323@g2calo2324-data	15981	4.0	0.714
AMC1324	AMC1324@g2calo2324-data	15978	4.0	0.652
AMC1325	AMC1325@g2laserdaq-data	15975	5.0	0.396
AMC1326	AMC1326@g2aux-priv	15975	5.0	0.245
AMC1328	AMC1328@g2laserdaq-data	15975	4.0	0.061
StrawTrackerLVandSC02	StrawTrackerLVandSC02@g2tracker2-priv	0	0.0	0.000
StrawTrackerLVandSC03	StrawTrackerLVandSC03@g2tracker3-priv	0	0.0	0.000
StrawTrackerDAQ	StrawTrackerDAQ@g2tracker0-priv	15974	4.6	0.008
StrawTrackerHV02	StrawTrackerHV02@g2tracker2-priv	0	0.0	0.000
StrawTrackerHV03	StrawTrackerHV03@g2tracker3-priv	0	0.0	0.000
IBMS Detector	IBMS Detector@g2ibms-priv	15981	4.0	0.724
CaloSC04	CaloSC04@g2sc-priv	0	0.0	0.000
CaloSC05	CaloSC05@g2sc-priv	0	0.0	0.000
CaloSC06	Frontend stopped	0	0.0	0.000
CaloSC07	CaloSC07@g2sc-priv	0	0.0	0.000
CaloSC08	Frontend stopped	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	Frontend stopped	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	Frontend stopped	0	0.0	0.000
CaloSC22	Frontend stopped	0	0.0	0.000
CaloSC23	CaloSC23@g2sc-priv	0	0.0	0.000
CaloSC24	Frontend stopped	0	0.0	0.000
uTCASC01	uTCASC01@g2sc-priv	281	0.0	0.000
uTCASC02	uTCASC02@g2sc-priv	281	0.0	0.000
uTCASC03	uTCASC03@g2sc-priv	281	0.0	0.000
uTCASC04	uTCASC04@g2sc-priv	281	0.0	0.000
uTCASC05	uTCASC05@g2sc-priv	281	0.0	0.000
uTCASC06	uTCASC06@g2sc-priv	281	0.0	0.000
uTCASC07	uTCASC07@g2sc-priv	281	0.0	0.000
uTCASC08	uTCASC08@g2sc-priv	281	0.0	0.000
uTCASC09	uTCASC09@g2sc-priv	280	0.0	0.000
uTCASC10	uTCASC10@g2sc-priv	281	0.0	0.000
uTCASC11	uTCASC11@g2sc-priv	281	0.0	0.000
uTCASC12	uTCASC12@g2sc-priv	281	0.0	0.000
uTCASC13	uTCASC13@g2sc-priv	280	0.0	0.000
uTCASC14	uTCASC14@g2sc-priv	281	0.0	0.000
uTCASC15	uTCASC15@g2sc-priv	281	0.0	0.000
uTCASC16	uTCASC16@g2sc-priv	281	0.0	0.000
uTCASC17	uTCASC17@g2sc-priv	281	0.0	0.000
uTCASC18	uTCASC18@g2sc-priv	281	0.0	0.000
uTCASC19	uTCASC19@g2sc-priv	281	0.0	0.000
uTCASC20	uTCASC20@g2sc-priv	281	0.0	0.000
uTCASC21	Frontend stopped	0	0.0	0.000
uTCASC22	uTCASC22@g2sc-priv	281	0.0	0.000
uTCASC23	uTCASC23@g2sc-priv	281	0.0	0.000
uTCASC24	uTCASC24@g2sc-priv	375	0.0	0.000
uTCASC25	uTCASC25@g2sc-priv	375	0.0	0.000
uTCASC26	uTCASC26@g2sc-priv	281	0.0	0.000
ESQ_slow	Frontend stopped	504	1.0	0.000
ESQ	ESQ@g2quad-02-priv	16230	4.0	0.000
IFIX	Frontend stopped	77	0.0	0.000
mscb110	Ok	281	0.0	0.000
mscb13e	Ok	281	0.0	0.000
mscb319	Ok	281	0.0	0.000
mscb323	Ok	281	0.0	0.000
mscb174	Ok	281	0.0	0.000
Beam	Beam@g2sc-priv	3374	0.3	0.000
KickerSC_mscb282	Ok	282	0.3	0.000
CollimatorControl	Ok	281	0.0	0.000

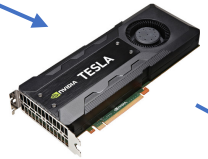
It consists of fast frontends (read out data on every trigger) and periodic slow control frontends

Introduction

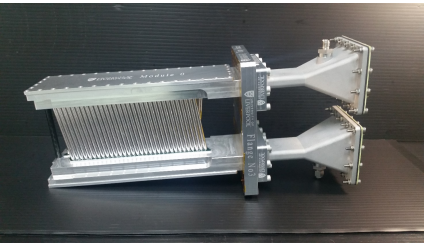


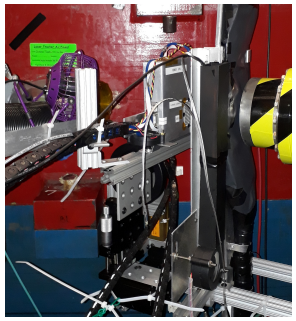
Introduction

20 GB/s



200 MB/s





DQM

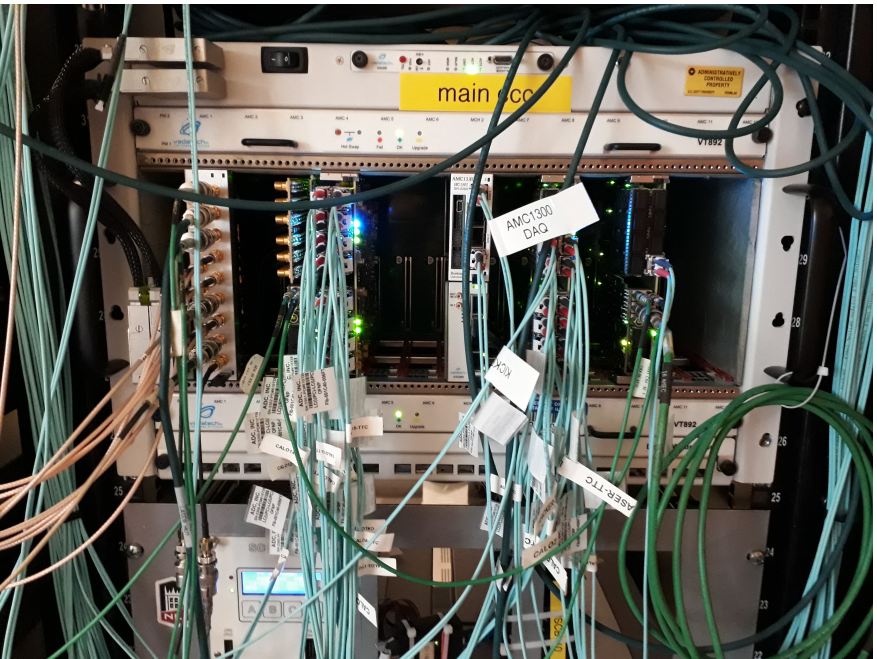
FTS/tape

Nearline

Clock and Controls System

The CCC provides the 40 MHz clock and the trigger to the uTCA crates over fibre

- 40 MHz clock continuously going to all uTCA crates (into the AMC13)
- Takes the accelerator trigger and sends the programmed trigger sequence to all fast frontends
- Every frontend must send back an event



TTC Trigger Sequencer Last Updated: 20/03/18 14:50:54

INDEX	PRE-TRIGGER GAP	TRIGGER TYPE
Sequence 1		
1	5350 ns	1 Muon
2	2996225 ns	2 Laser
Sequence 2		
1	4950 ns	1 Muon
2	2996625 ns	2 Laser
Sequence 3		
1	4550 ns	1 Muon
2	2997025 ns	2 Laser
Sequence 4		
1	4150 ns	1 Muon
2	2997425 ns	2 Laser
Sequence 5		
1	2925 ns	1 Muon
2	2998650 ns	2 Laser
Sequence 6		
1	2525 ns	1 Muon
2	2999050 ns	2 Laser
Sequence 7		
1	2125 ns	1 Muon
2	2999450 ns	2 Laser
Sequence 8		
1	1725 ns	1 Muon
2	2999850 ns	2 Laser
3	10000000 ns	4 Async

- Different trigger types can be responded to differently
- Feedback system means triggers can be throttled if one frontend is not keeping up

Clock and Controls System

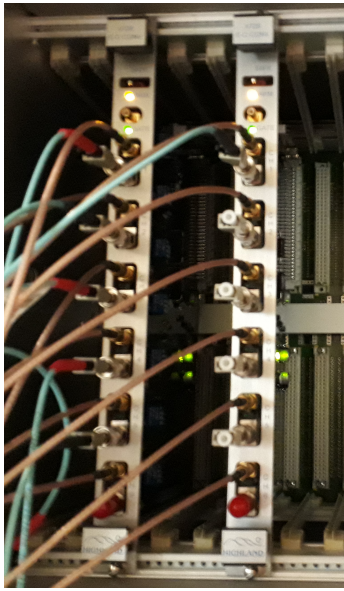
UCL

The system can also provide analog triggers which do not require a response

Analog Trigger 15 - Laser Hut Last Updated: 27/02/18 20:09:53

INDEX	TRIGGER DELAY	TRIGGER WIDTH
Sequence 1		
1	4984.44444 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 2		
1	4584.44444 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 3		
1	4184.44444 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 4		
1	2960.00000 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 5		
1	2560.00000 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 6		
1	2160.00000 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 7		
1	1760.00000 ns	68.88889 ns
2	2669000.00000 ns	168.88889 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns
Sequence 8		
1	5384.44444 ns	68.88889 ns
2	2669000.00000 ns	115.55556 ns
3	0.00000 ns	0.00000 ns
4	0.00000 ns	0.00000 ns

Triggers are used for the kickers, quads and laser systems



- Timings taken from accelerator signal with programmable width and delay
- Runs off a 450MHz clock for better timing accuracy

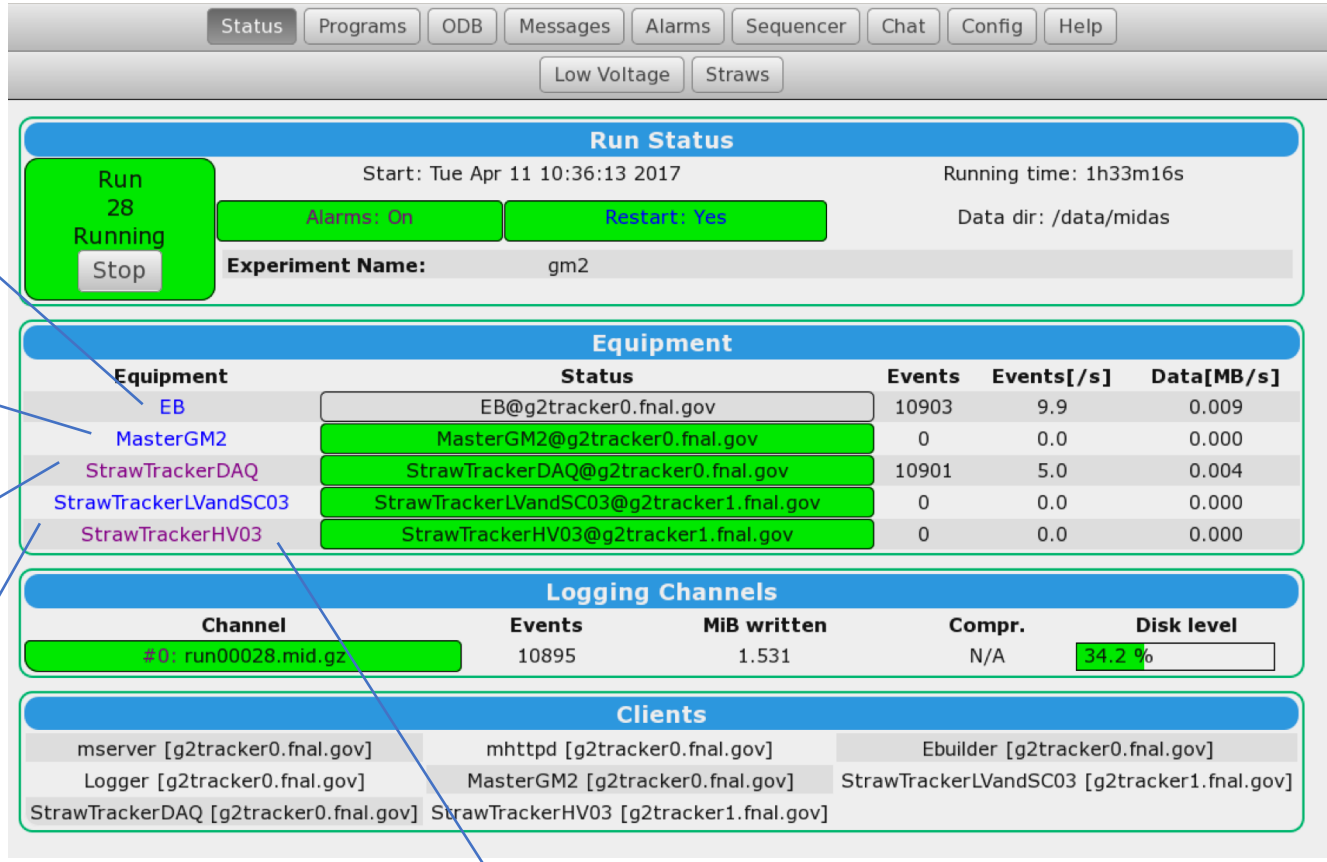
Straw Tracker DAQ system

Event builder, combines the events from the different frontends

Master GM2 stores the trigger information (begin of fill)

Straws frontend collects the straws data into a MIDAS bank

Slow Controls frontend records monitoring data (currents, temperatures etc.)



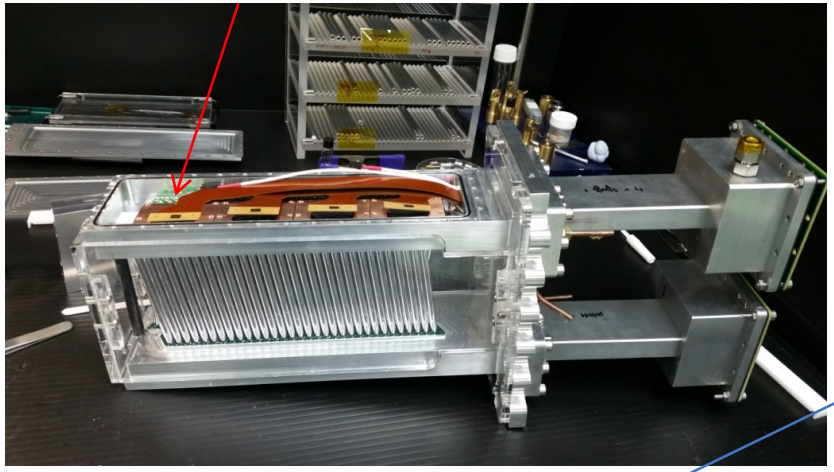
High Voltage frontend
Monitors the high voltage supply and issues an alarm if the HV trips

Straw Tracker Readout Chain

The straw tracker DAQ has a hierarchical structure through the various layers of electronics

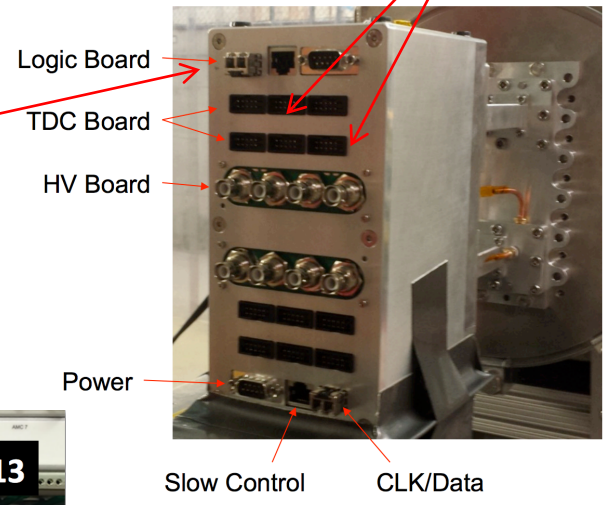
The straws are readout by **ASDQs** :

- 1 ASDQ board for 16 straws
- 8 ASDQ boards per tracker module



The data is passed to the **TDCs** :

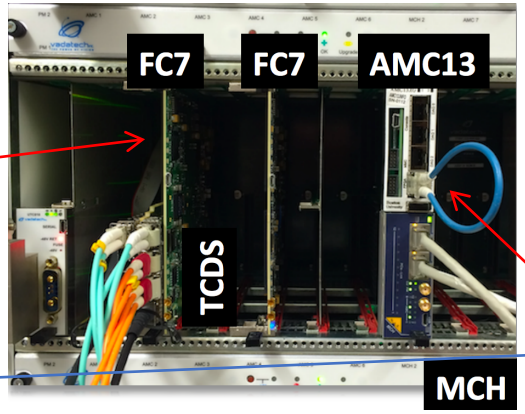
- 2 TDCs per TDC board
- 1 TDC per ASDQ



The **logic board** collates the data from 4 TDCs (2 LBs per tracker module)

The data from the logic board is passed to the **FC7** :

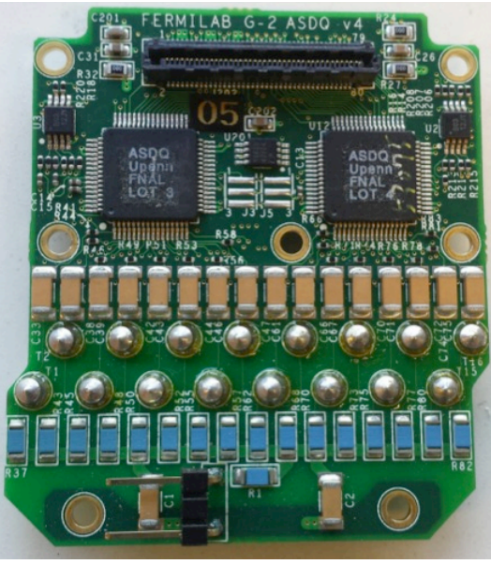
- Reads data from 16 logic boards
- 1 FC7 per tracker station



The data from all FC7s is passed to the **AMC13** and read into the **PC**

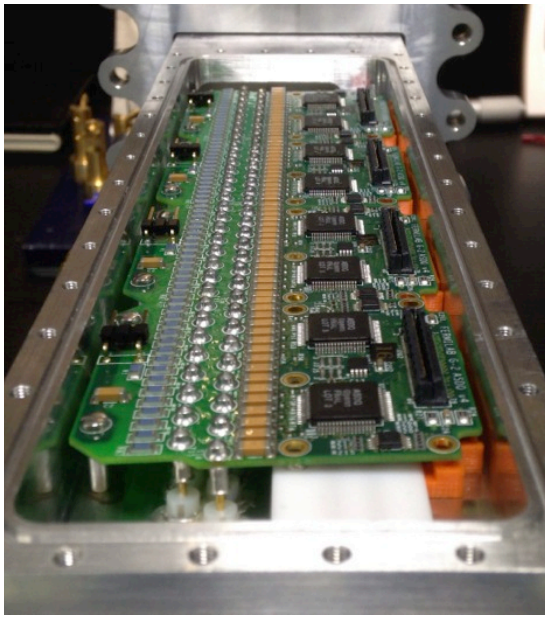
Tracker Frontend Readout

The tracker readout hardware consists of ASDQs, TDCs, Logic boards, FC7s and an AMC13



Straw Ends

Non-readout pin cover

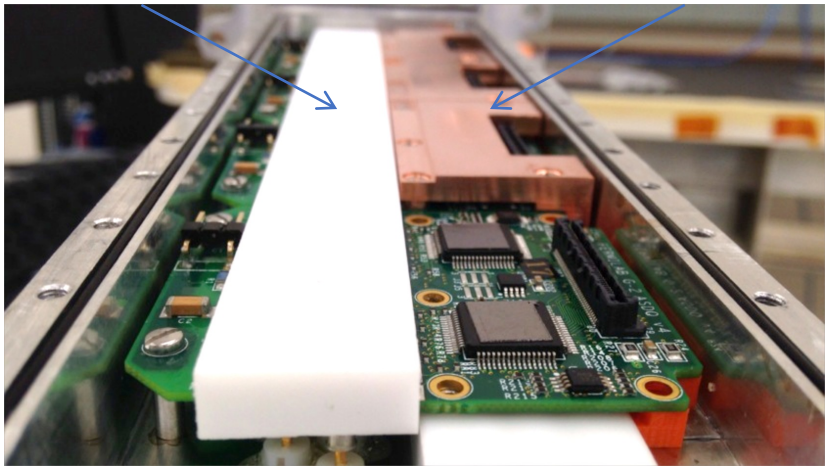


Socket cover

Cooling bar

The ASDQs plug onto the end of the straws :

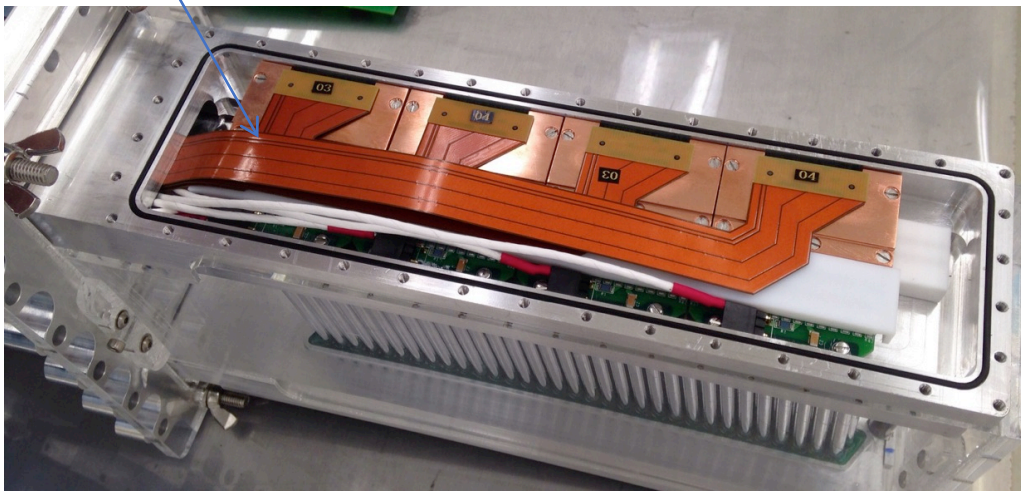
- 8 ASDQs per manifold (4 boards)
- Take care of pulse shaping, baseline restoration and discrimination
- Produce a digital output

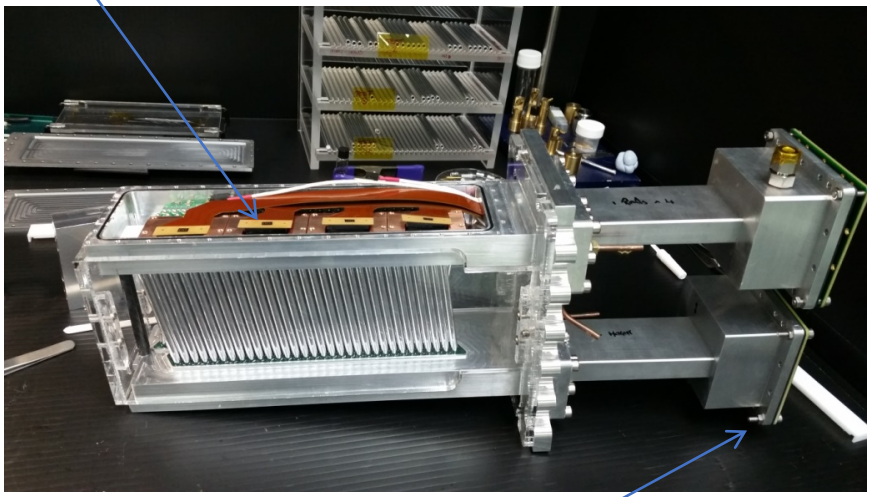


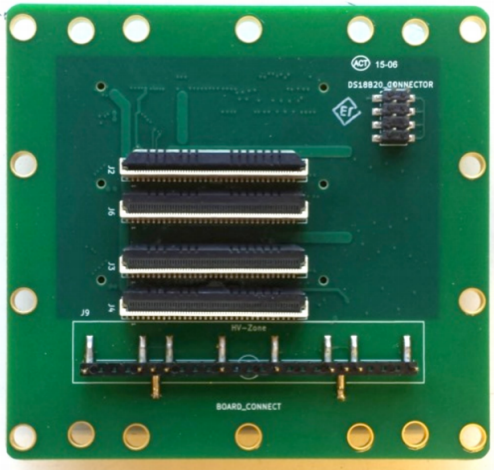
Tracker Frontend Readout

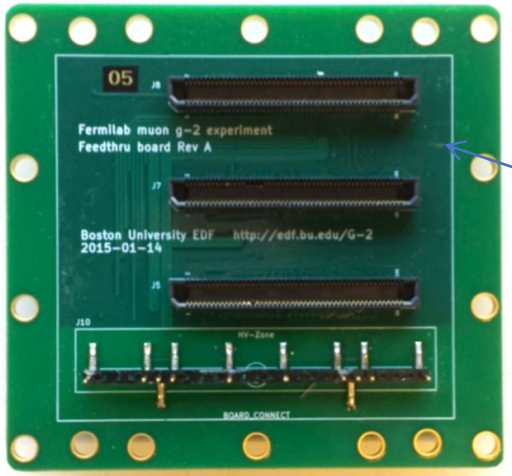
The flexi cables plug onto the ASDQs :

- Provide power and reference voltages
- Carry the signal from the ASDQs









The flexi cables connect to the feedthrough board :

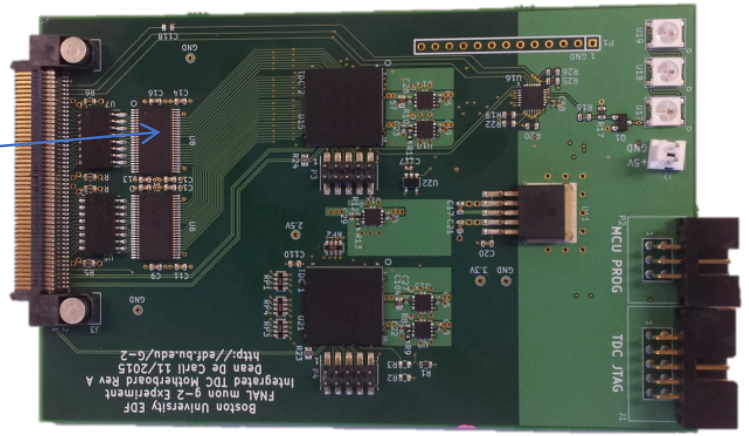
- Forms the gas seal
- Acts as a backplane for the boards

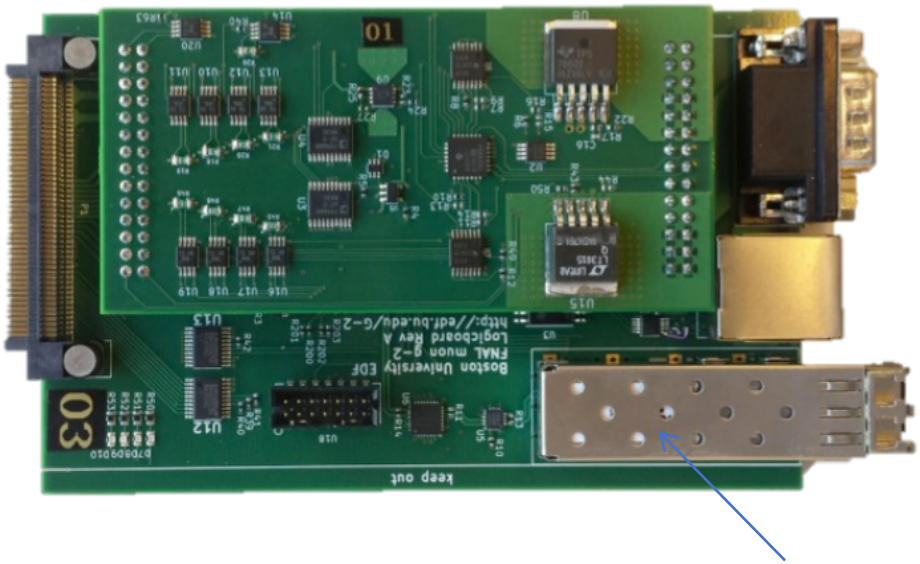
Tracker Frontend Readout

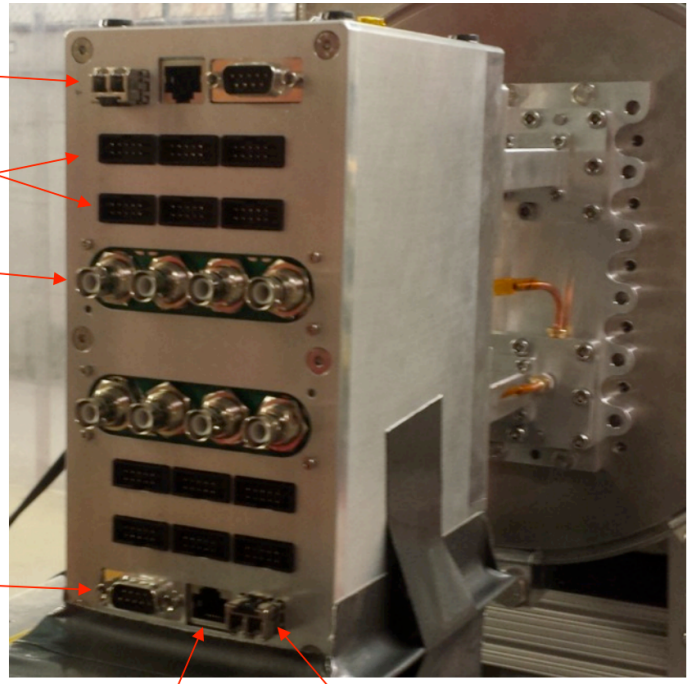
UCL

The data is passed to the TDCs :

- 2 TDC boards per manifold each with 2, 16 channel FPGAs
- Convert the digital signals from the ASDQs







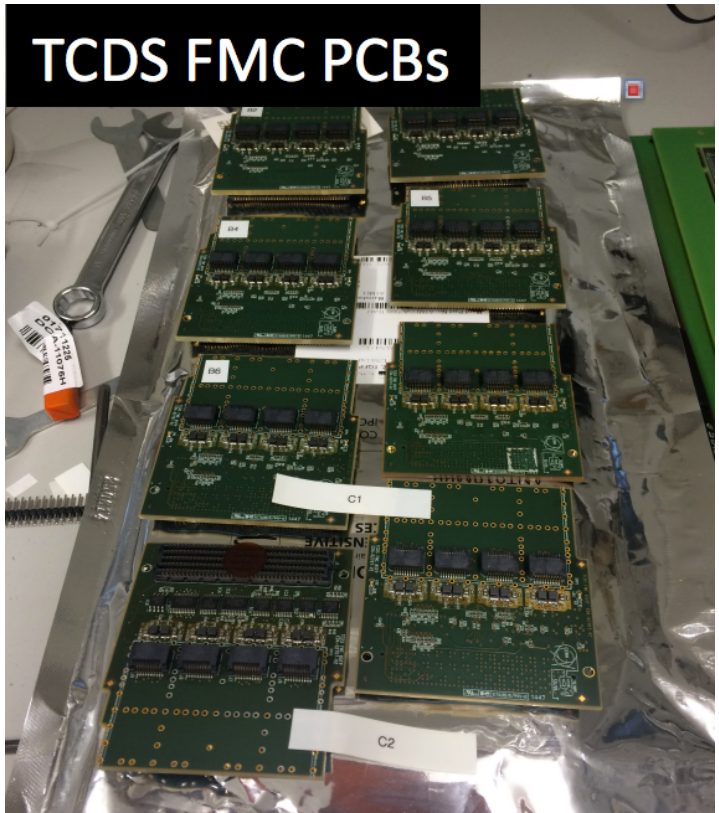
The TDCs pass the data onto the logic boards :

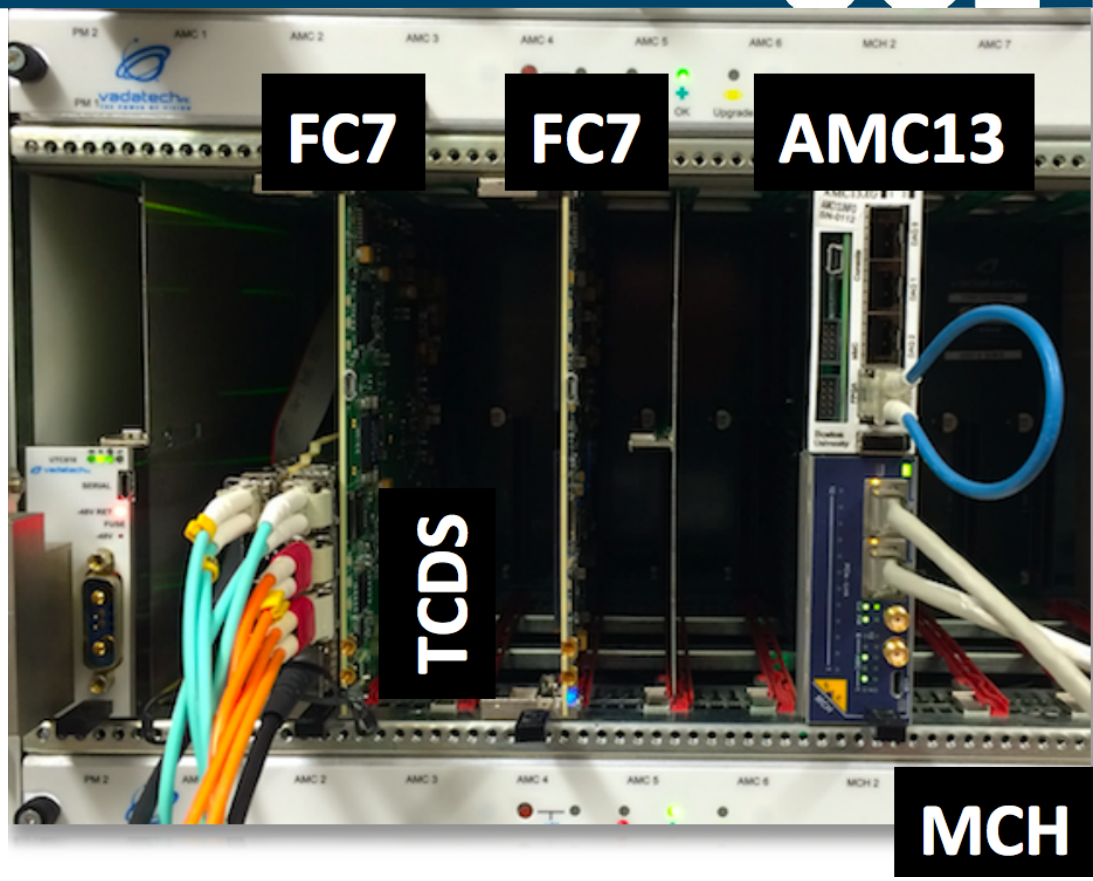
- Buffers and sends out the data from the TDCs
- Slow Control connection for programming settings and loading firmware
- Regulates voltages from ±5V Low voltage input

Tracker Backend Readout

The data from the logic board is sent over fibre to the FC7 :

- Takes 16 fibre inputs (1 whole tracker station per FC7)
- Collects the data from all 16 Logic boards and sends it out
- Provides the clock to the logic board



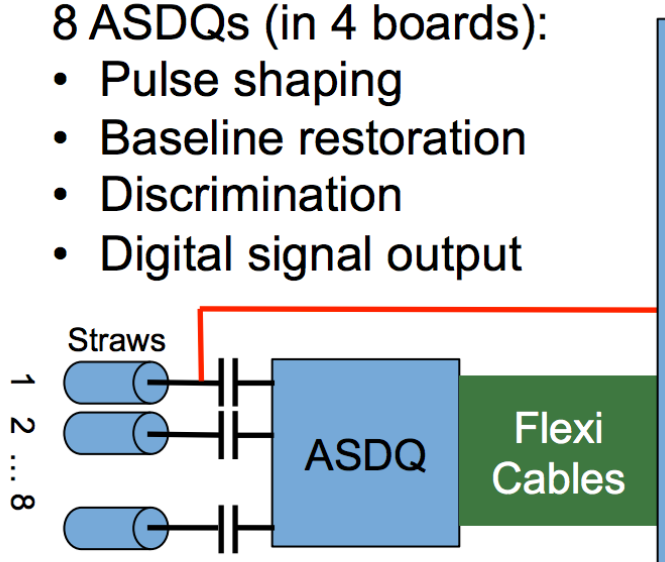


The FC7 sends the data on to the AMC13 :

- Forms the connection to the PC via 10Gb ethernet
- Data send out over fibre to a PCIe card in the PC

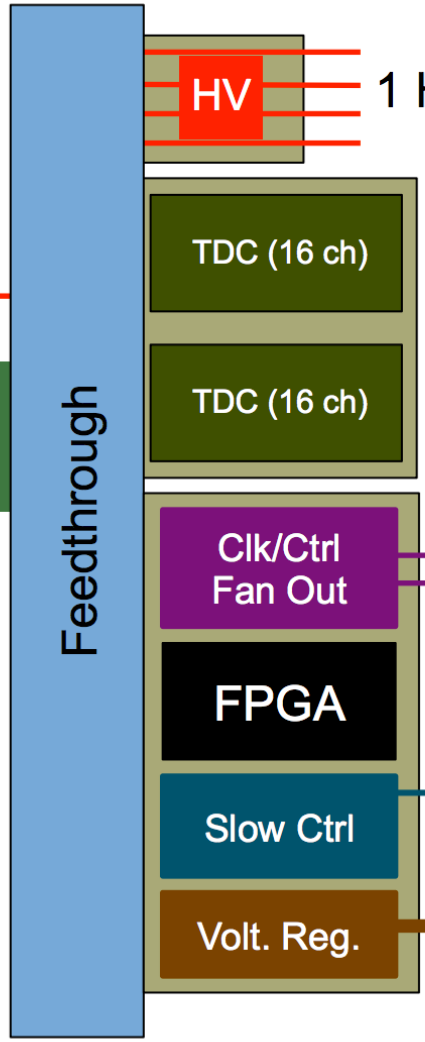
Straw Tracker Electronics

8 ASDQs (in 4 boards):
- Pulse shaping
- Baseline restoration
- Discrimination
- Digital signal output



4 Flexicables:
- Power, ref. volts and signals to and from ASDQ boards

1 Feedthrough board:
- Makes gas seal
- Acts as a backplane to connect all boards



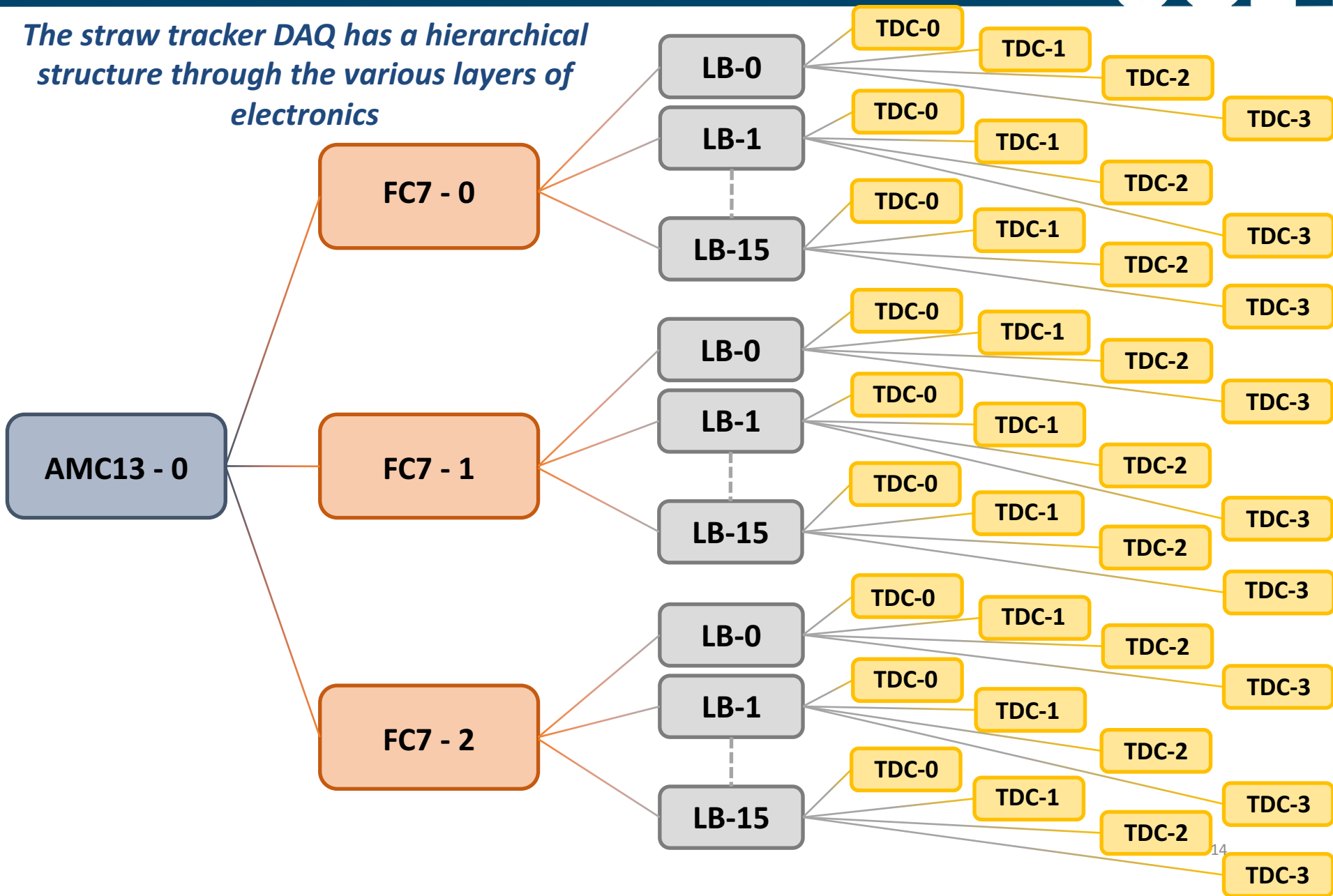
1 HV Board (1 ch. per ASDQ board)

2 TDC Boards:
- 2 FPGA 16 ch. TDCs per board
- Digital signals from ASDQs converted (625 ps LSB)

1 Logic board:
- Interface to outside world
- Takes clk/ctrl, power & slow control
- Buffers & sends data from TDCs
- Regulates voltages
- Links to slow control for settings & loading firmware

Straw Tracker DAQ Frontend

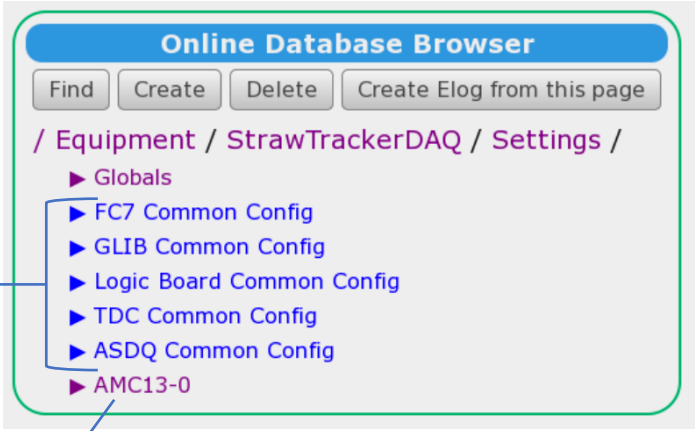
The straw tracker DAQ has a hierarchical structure through the various layers of electronics



The ODB

The Online database controls the adjustable parameters for the trackers

Global settings for each level (applied to every board of that type)

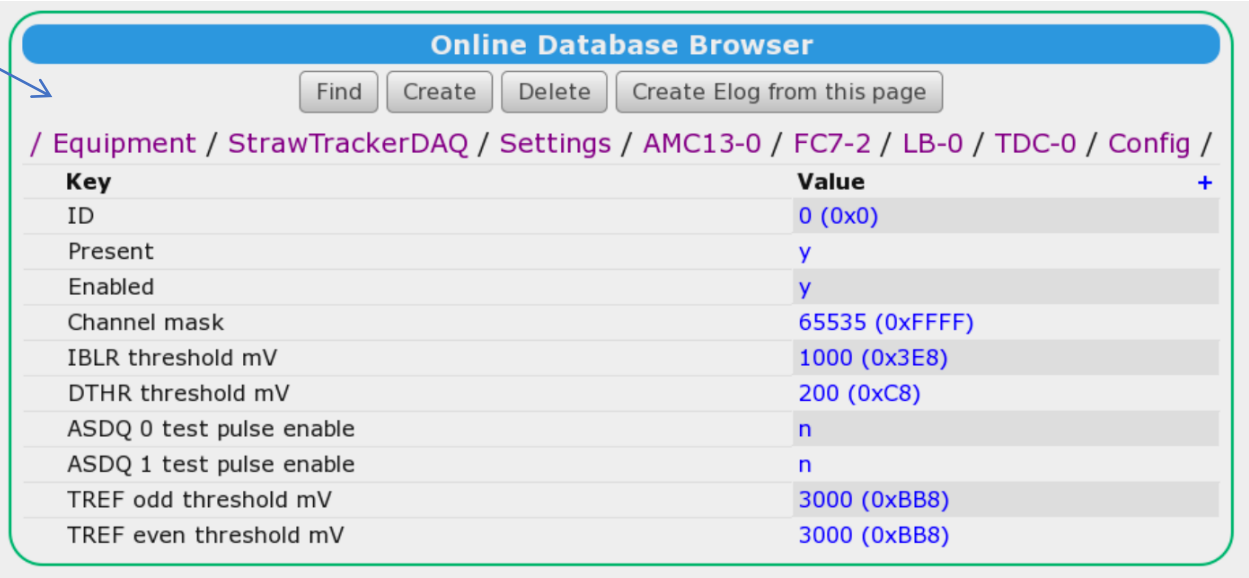


The parameters are programmed to the boards when the frontend is started

Includes any programmable parameter in the FPGAs

Start of the hierarchical structure through each board

The ODB is saved at the end of each run for reference



Key	Value
ID	0 (0x0)
Present	y
Enabled	y
Channel mask	65535 (0xFFFF)
IBLR threshold mV	1000 (0x3E8)
DTHR threshold mV	200 (0xC8)
ASDQ 0 test pulse enable	n
ASDQ 1 test pulse enable	n
TREF odd threshold mV	3000 (0xBB8)
TREF even threshold mV	3000 (0xBB8)

The ODB

Custom pages can also be created to allow easier access to ODB variables

Tracker-2 Settings

FC7-2 Settings

ID	Enabled	Present	Number Of LBs
4	y	y	16

change TDC thresholds

LB-0 Settings		LB-1 Settings		LB-2 Settings		LB-3 Settings	
ID	0	ID	1	ID	2	ID	3
Present	y	Present	y	Present	y	Present	y
Enabled	y	Enabled	y	Enabled	y	Enabled	y
Number of TDCs	4	Number of TDCs	4	Number of TDCs	4	Number of TDCs	4
LV channel	2	LV channel	2	LV channel	3	LV channel	3
LV output	0	LV output	1	LV output	0	LV output	1

TDC-0		TDC-1		TDC-2		TDC-3	
ID	0	ID	1	ID	2	ID	3
Present	y	Present	y	Present	y	Present	y
Enabled	y	Enabled	y	Enabled	y	Enabled	y
DTHR theshold	200	DTHR theshold	200	DTHR theshold	200	DTHR theshold	200
Channel mask	65535	Channel mask	65535	Channel mask	65535	Channel mask	65535

The straw settings page gives easy access to the most commonly used variables

The power page has buttons to turn the power on and off and contains useful numbers for monitoring

Low Voltage Status

Tracker	Logic Board	On	+5V current	-5V current	Temperature		
2	0	1	0.49	0.11	21.44	on	off
2	1	1	0.46	0.1	21.34	on	off
2	2	1	0.51	0.12	24.14	on	off
2	3	1	0.45	0.12	24.24	on	off
2	4	1	0.55	0.11	NAN	on	off
2	5	1	0.47	0.11	NAN	on	off
2	6	1	0.5	0.11	22.83	on	off
2	7	1	0.47	0.11	22.93	on	off

All tracker power

Tracker uTCA On | Tracker uTCA Off | All HV On | All HV Off

Tracker Power On

Tracker 2 LV On | Tracker 2 HV On

Tracker Power Off

Tracker 2 LV Off | Tracker 2 HV Off

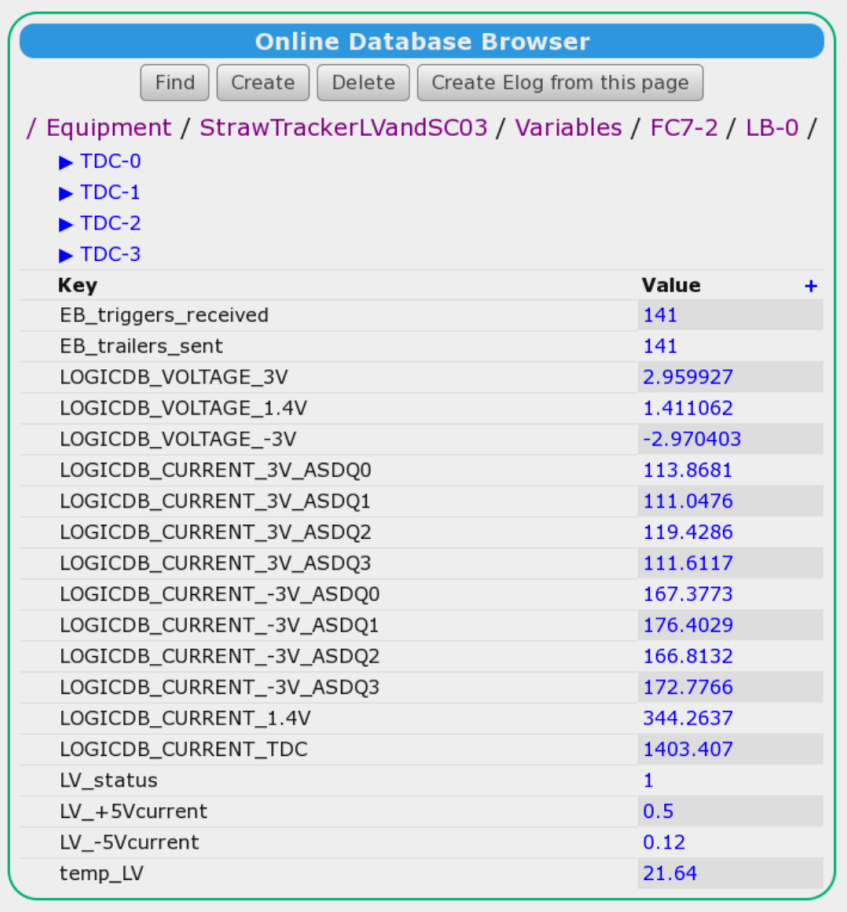
Recent Relevant Messages

```
1492182229 10:03:49.338 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 started
1492182127 10:02:07.597 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 stopped
1492182118 10:01:58.868 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 started
1492181877 09:57:57.918 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 stopped
1492181868 09:57:48.185 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 started
1492181627 09:53:47.658 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 stopped
1492181626 09:53:46.564 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 started
1492181602 09:53:22.613 2017/04/14 [LVpower,INFO] Program LVpower on host g2tracker1 started
```

Straw Tracker LV and SC

The Low Voltage and Slow Controls frontend controls the USB connection to the tracker and records monitoring information – temperatures, voltages…

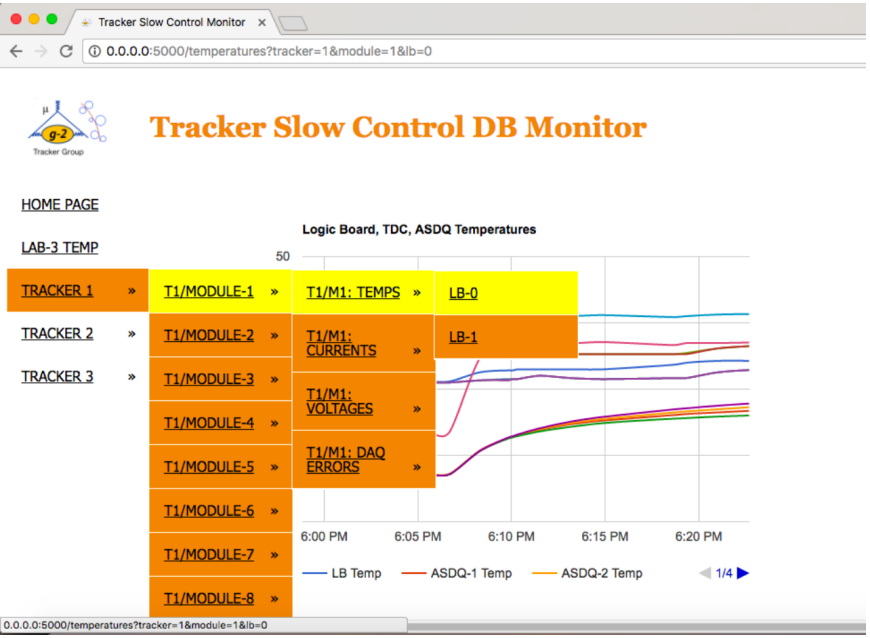
- **The monitoring variables** are read about once a minute (adjustable from the ODB)
  - Temperatures
  - Currents
  - Voltages
  - DAQ errors
- The values are recorded in both the **ODB** and in the **postgres database**
- The frontend is independent of the event builder
- There is a Slow Control Monitoring page to observe the variables
- Alarms in MIDAS are thrown based on these variables



Key	Value
EB_triggers_received	141
EB_trailers_sent	141
LOGICDB_VOLTAGE_3V	2.959927
LOGICDB_VOLTAGE_1.4V	1.411062
LOGICDB_VOLTAGE_-3V	-2.970403
LOGICDB_CURRENT_3V_ASDQ0	113.8681
LOGICDB_CURRENT_3V_ASDQ1	111.0476
LOGICDB_CURRENT_3V_ASDQ2	119.4286
LOGICDB_CURRENT_3V_ASDQ3	111.6117
LOGICDB_CURRENT_-3V_ASDQ0	167.3773
LOGICDB_CURRENT_-3V_ASDQ1	176.4029
LOGICDB_CURRENT_-3V_ASDQ2	166.8132
LOGICDB_CURRENT_-3V_ASDQ3	172.7766
LOGICDB_CURRENT_1.4V	344.2637
LOGICDB_CURRENT_TDC	1403.407
LV_status	1
LV_+5Vcurrent	0.5
LV_-5Vcurrent	0.12
temp_LV	21.64

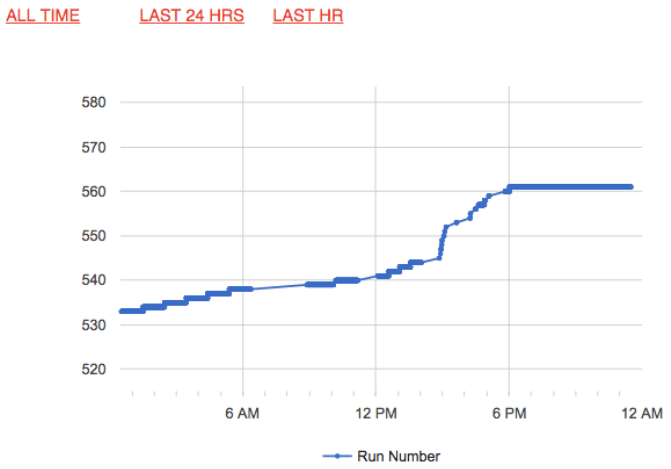
Slow Controls Monitoring Page

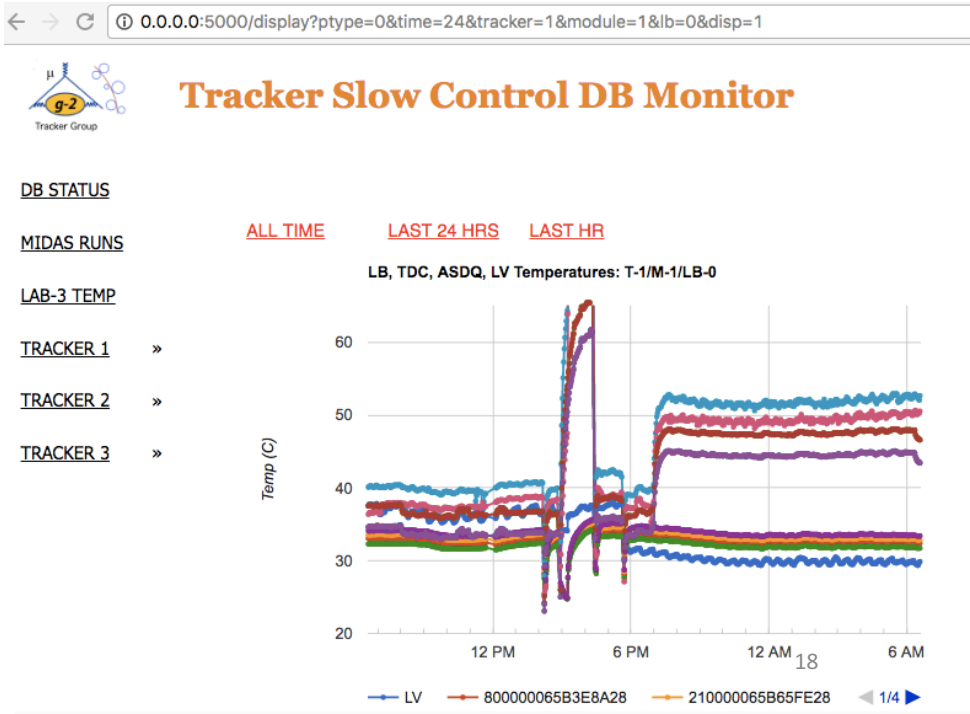
Plots of the slow control variables read from the postgres database are displayed on a webpage : g2tracker0.fnal.gov:5000



The navigation bar on the left allows you to look at the different tracker modules

There are displays for temperatures, currents, voltages and DAQ errors

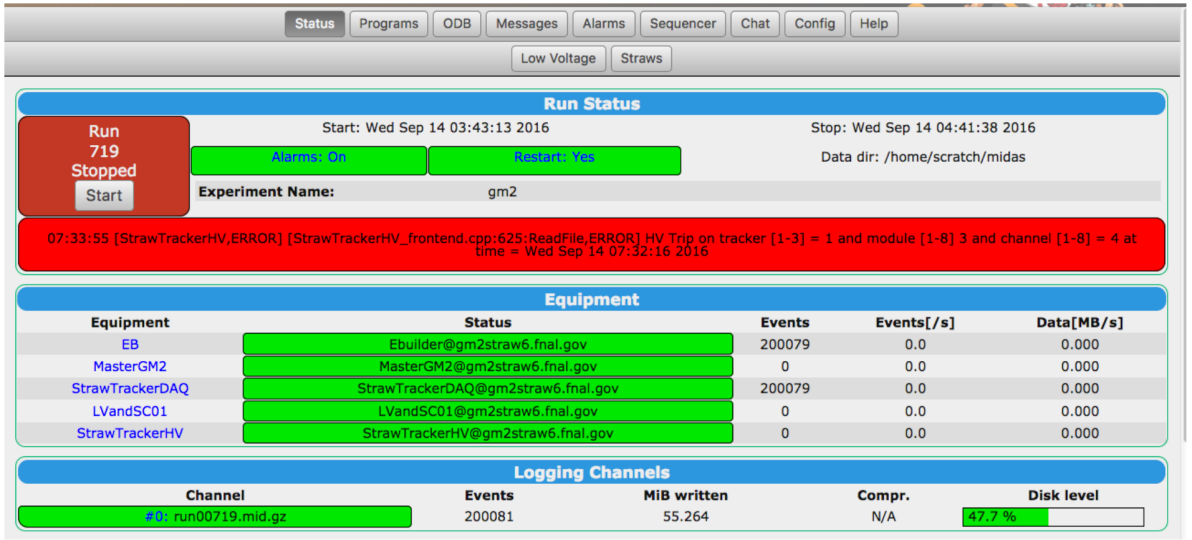




High Voltage monitoring

The HV monitor displays the status of the high voltage supply to the tracker modules. The HV frontend throws an alarm in the case of trips

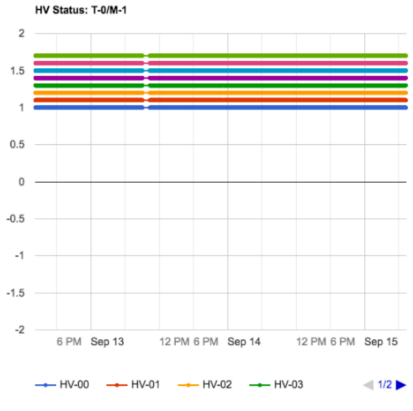
The HV frontend also throws alarms if the HV monitor stops running

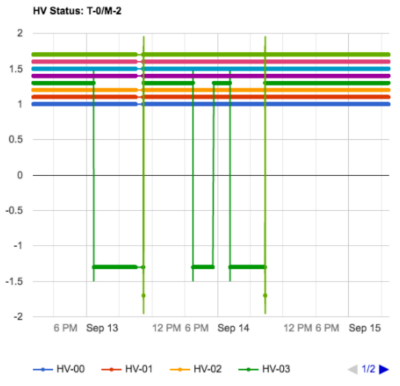


Straw Tracker-2 HV Status

22/11/2017 10:00:36 | 0 TRIPS FOUND | 64 CHs FOUND OFF | 0 CHs FOUND ON

MODULE INPUT	VOLTAGE	CURRENT	V SET	I SET	RAMP UP	RAMP DOWN	TRIP TIME	STATUS
T2M0U0	0	0.0	0	0.0	100	100	0	OFF
T2M0U1	0	0.0	0	0.0	100	100	0	OFF
T2M0U2	0	0.0	0	0.0	100	100	0	OFF
T2M0U3	0	0.0	0	0.0	100	100	0	OFF
T2M0V0	0	0.0	0	0.0	100	100	0	OFF
T2M0V1	0	0.0	0	0.0	100	100	0	OFF
T2M0V2	0	0.0	0	0.0	100	100	0	OFF
T2M0V3	0	0.0	0	0.0	100	100	0	OFF
T2M1U0	0	0.0	0	0.0	100	100	0	OFF
T2M1U1	0	0.0	0	0.0	100	100	0	OFF
T2M1U2	0	0.0	0	0.0	100	100	0	OFF
T2M1U3	0	0.0	0	0.0	100	100	0	OFF
T2M1V0	0	0.0	0	0.0	100	100	0	OFF
T2M1V1	0	0.0	0	0.0	100	100	0	OFF





Data format

The data format includes headers for each board in the hierarchy containing useful information

AMC13 HEADER

31			23	15	7	0
x"00"			Event number			
Muon trigger data write to DDR time (43 .32)			Word count			
"00"	ZC	Trigger type	x"00"	Muon trigger data write to DDR time (31 .. 16)		
Muon trigger data write to DDR time (15 .. 0)			Board ID			

FC7 HEADER``

31			23	15	7	0
x"FC"			Spill number (Muon trigger count)			
Channels present			Channels enabled			
Date						
Board ID			AMC13 Events sent counter			
b"00000"		Last written DDR address (in a page)			"000"	DDR page number
LB in event reg			"0000"	C5 Muon trigger send time (43 .. 32)		
C5 Muon trigger send time (31 .. 0)						
"00"	ZC	Trigger Type	AMC 13 busy count			

This is what is put in the MIDAS data bank which is subsequently passed to the DQM / to the offline and unpacked

Data format

This is the format for the Logic boards and TDCs

With some padding for header words the data is essentially one 32 bit word per hit in the detector

-	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0x3C = K28.1								0																							
1	0																size															
2	0								Spill # [23..0]																							
3	Time MSB [43..12																															
4	0								type		FE	Er	OOS				TDC_{EN}						Time LSB [11..0]									
5	TDC0: 31:enabled, 30:OOS, 29: size error																0	size														
6	TDC1: 31:enabled, 30:OOS, 29: size error																0	size														
7	TDC2: 31:enabled, 30:OOS, 29: size error																0	size														
8	TDC3: 31:enabled, 30:OOS, 29: size error																0	size														
9	0 (TDC: 1)																														0x3C	
-	0																														0x67 = 'g'	
-	0																														0x2D = '-'	
-	0																														0x32 = '2'	
-	⋮																															
-	0 (TDC: 2)																														0x3C	
-	0																														0x67 = 'g'	
-	0																														0x2D = '-'	
-	0																														0x32 = '2'	
-	⋮																															
-	0 (TDC: 3)																														0x3C	
-	0																														0x67 = 'g'	
-	0																														0x2D = '-'	
-	0																														0x32 = '2'	
-	⋮																															
-	0 (TDC: 4)																														0x3C	
-	0																														0x67 = 'g'	
-	0																														0x2D = '-'	
-	0																														0x32 = '2'	
-	⋮																															
size - 3	size																															
size - 2	CRC																															
size - 1	0																														0x5C = K28.2	

addr	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0																													0x3C = K28.1		
1	0																													0x67 = 'g'		
2	0																													0x2D = '-'		
3	0																													0x32 = '2'		
4	0																													0x54 = 'T'		
5	0																													0x44 = 'D'		
6	0																													0x43 = 'C'		
7	Version date: 0x201YMMDD																															
8	size																						Channel Mask									
9	0																Spill # [23..0]															
10	Time MSB [43..12]																															
11	0																								Time LSB [11..0]							
12	Start time (160ns LSB)																						End time (160ns LSB)									
13	SelB time (160ns LSB)																						Readout time (160ns LSB)									
14	0																													SW-addr	HW-addr	
15	1-scalars; 0-both edges;others: 0																															
16	Scalar Count 15																															
17	Scalar Count 14																															
18	⋮																															
19	Scalar Count 1																															
20	Scalar Count 0																															
21	0	0	1	edge	Ch: 0-15												Coarse time: LSB 5ns, range 0 - 10.485775 ms														Fine	
-	⋮																															
size-1	0	0	1	edge	Ch: 0-15												Coarse time: LSB 5ns, range 0 - 10.485775 ms														Fine	

The hits are stored as a channel number and a time the rest is reconstructed offline

Data rates

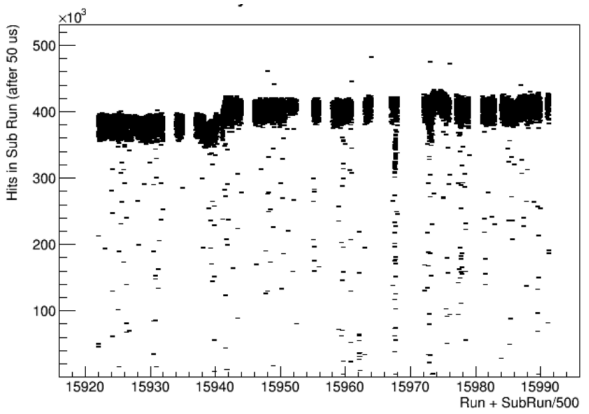
The trackers take up a tiny proportion of the total data rate from the experiment currently

Bank	Data size per event (Mb)	Data rate (Mb/s)
Q-method	6.00	69
Laser out of fill	2.50	29
Laser crate	0.32	3.7
Kicker crate	0.53 -> 0.50	6 -> 5.75
Calo sum	1.54 -> 0.40	17.7 -> 5
T0	0.18	2
IBMS	0.39	4.4
Calo headers	0.22	2.5
GPU fits	1.00	11.5
YS	0.36 -> 0.00	4 -> 0
Straws	0.075	0.85
Total	11.585	133.7

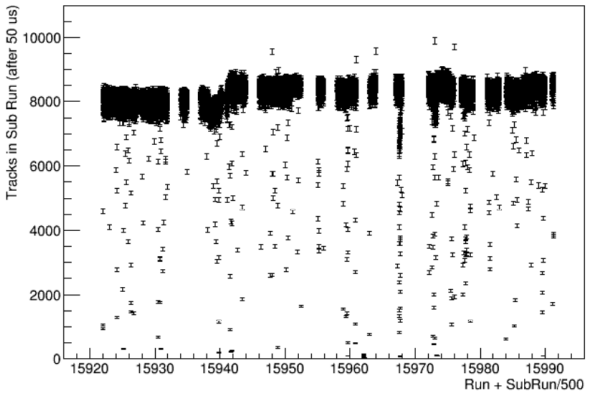
The trackers write out 0.04% of the data we are writing currently

Currently in each fill there are on average:

- ~5000 hits
- ~100 reconstructed tracks



Quality 'Y' && Quads/Kickers

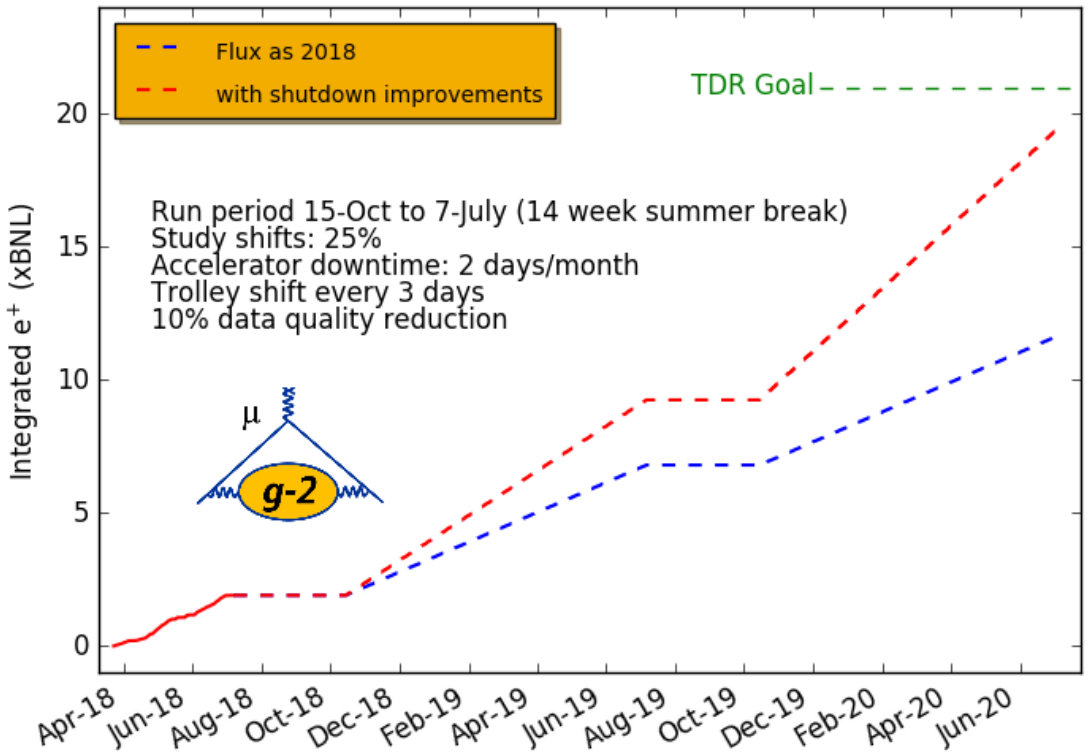


Data rates

Over the next two years the muon storage is expected to increase by a factor of ~2

Gain	Cause
1.20	Installation of momentum-collimating wedges (cooling) in beamline
1.1-1.2	Higher kicker voltages
1.1	More reliable operation of electrostatic quads at higher voltage
1.05	Installation of 2 faster-switching PS in upstream beamline
1.5	**TOTAL Product 2019**
1.4	New infector
2.1	**TOTAL Product 2020**

A linear increase with rate would give a total for two tracking stations of about 2 Mb/s



Summary

- The current DAQ uses the MIDAS framework
- The frontends use uTCA crates with an AMC13 for the readout
- The tracker readout goes through ASDQs, TDCs, Logic boards and FC7s to the AMC13 and then on to the PC
- The current CCC system provides a 40 MHz clock with programmable triggers (based off the accelerator signal)
- The overall data rate is very low