DArT data acquisition

DART Meeting , LSC 04/2022

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Dart DAQ overview

DAQ overview:

- 1 CAEN V1730SB digitizer that reads up to 16 channels (SiPM + VETO PMTs)
- DAQ trigger generated by V1730SB (threshold trigger, programable logic & coincidence window)
- TimeStamp generated by V1730SB [31-bit counter, **16 ns resolution** → 17 s range] extended by software
- Readout using MIDAS framework

HARDWARE

- Crate VME CAEN: on long-term loan from LSC
- V2718 CAEN VME controller: on long-term loan from LSC
- 1 CAEN V1730SB digitizer
- CAEN A3818 PCI Express CONET2 controller (**data transfer up to 80 MB/s**)
- DAQ PC (HPE ML350 Gen10) 16 cores - Intel(R) Xeon(R) Silver 4208 CPU @ 2.10GHz, 2 GB RAM, Hard drive: 4 TB

CAEN V1730SB Digitizer

ANALOG INPUTS

- **16 channels** single ended (MCX connectors)
- **14 bits resolution. Full scale: 0.5 or 2 Vpp** (software selectable)

SAMPLING RATE:

- **500 MS/s** Simultaneously on each channel

BUFFER DIMENSION:

- **5.12 MS/ch divisible into 1 – 1024 buffers**
- Programmable event size and pre/post-trigger

TRIGGER

- **Self-trigger: channel over/under threshold**
- External-trigger: Common by TRG-IN connector

DAQ software overview

DAQ implemented using the MIDAS software (https://daq00.triumf.ca/MidasWiki)

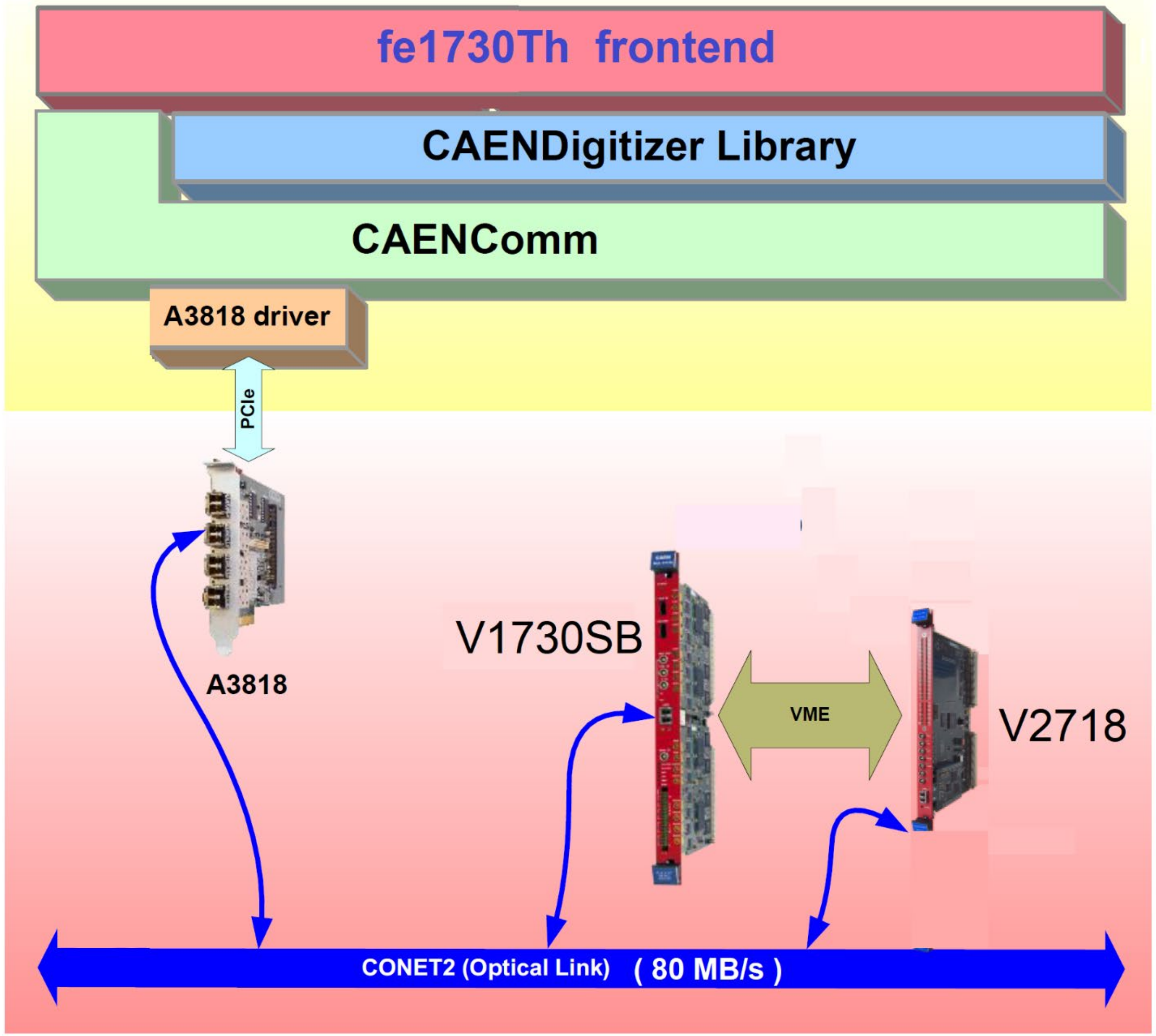
https://github.com/MariaCAPA/dartdaq

- fe1730Th:
  - fronted (communication with V1730SB)

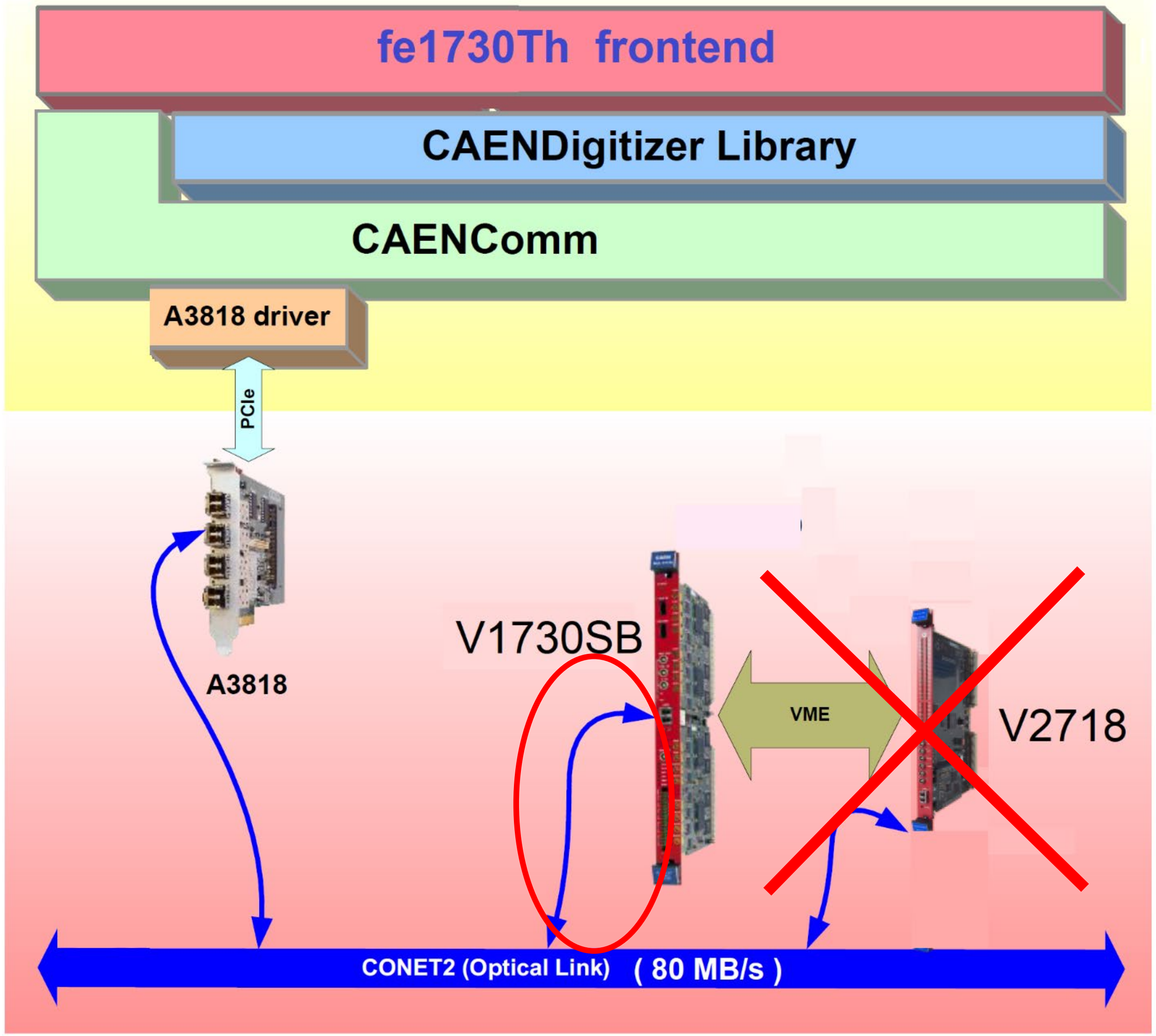
    → libCAENComm.so.1.5.0

    → libCAENDigitizer.so.2.17.0
- wfViewer:
  - Online waveform visualization
  - Online histogram generation
- midas2root:
  - Rootfile generation for pre-analysis
- TDartReadRun:
  - Offline waveform selection & visualization

Comm links, drivers & libraries

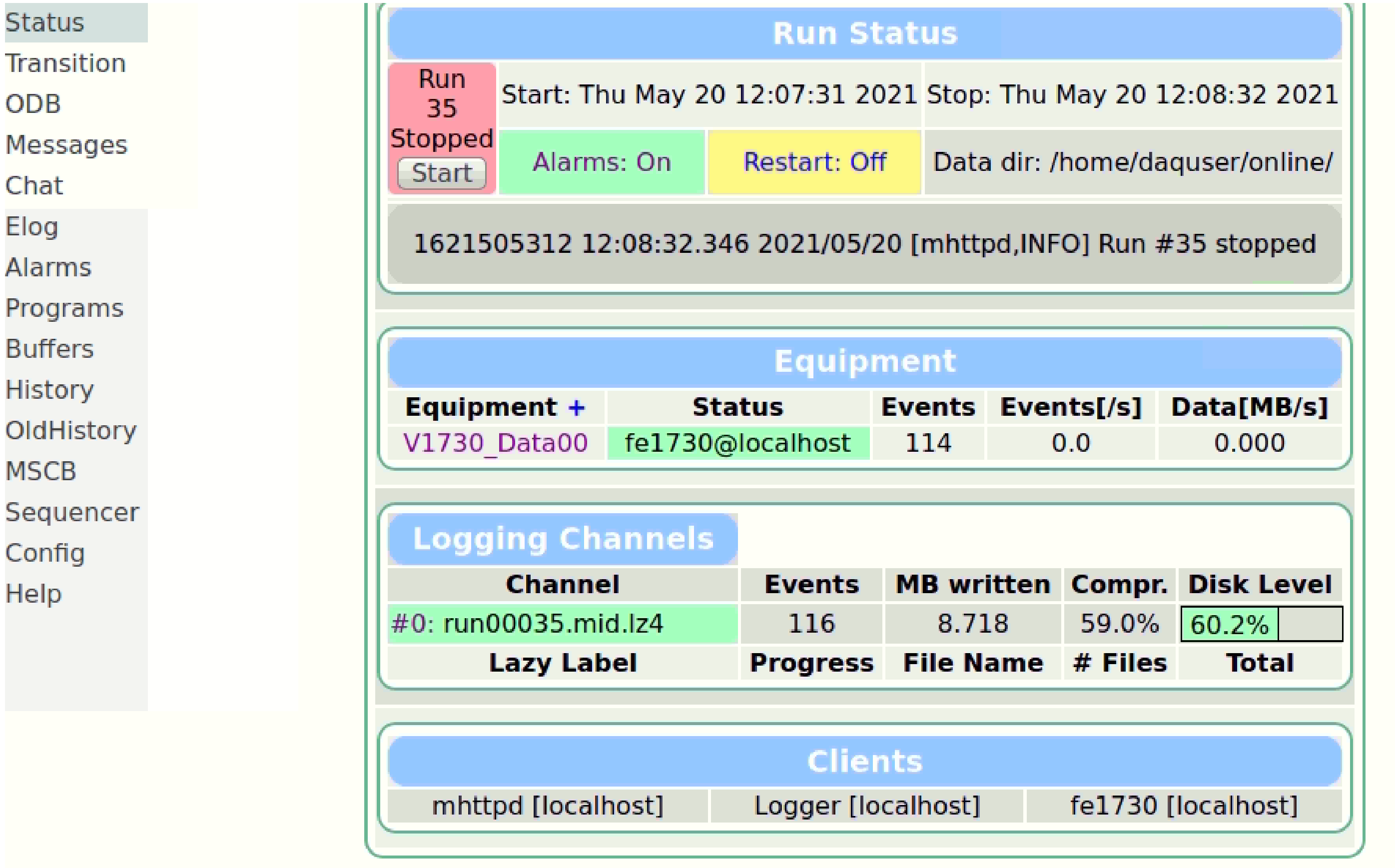


Comm links, drivers & libraries



DAQ operation

- MIDAS DAQ controlled through a webserver
- Script to start / stop DAQ system (start_Daq.sh , stop_Daq.sh)
- Midas & V1730SB configuration parameters stored in a database (ODB) accessible from the webserver or by command line (odbedit)



Run Status

Run 35 Stopped

Start: Thu May 20 12:07:31 2021 Stop: Thu May 20 12:08:32 2021

Alarms: On Restart: Off Data dir: /home/daquser/online/

```
1621505312 12:08:32.346 2021/05/20 [mhttpd,INFO] Run #35 stopped
```

Equipment

Equipment +	Status	Events	Events[/s]	Data[MB/s]
V1730_Data00	fe1730@localhost	114	0.0	0.000

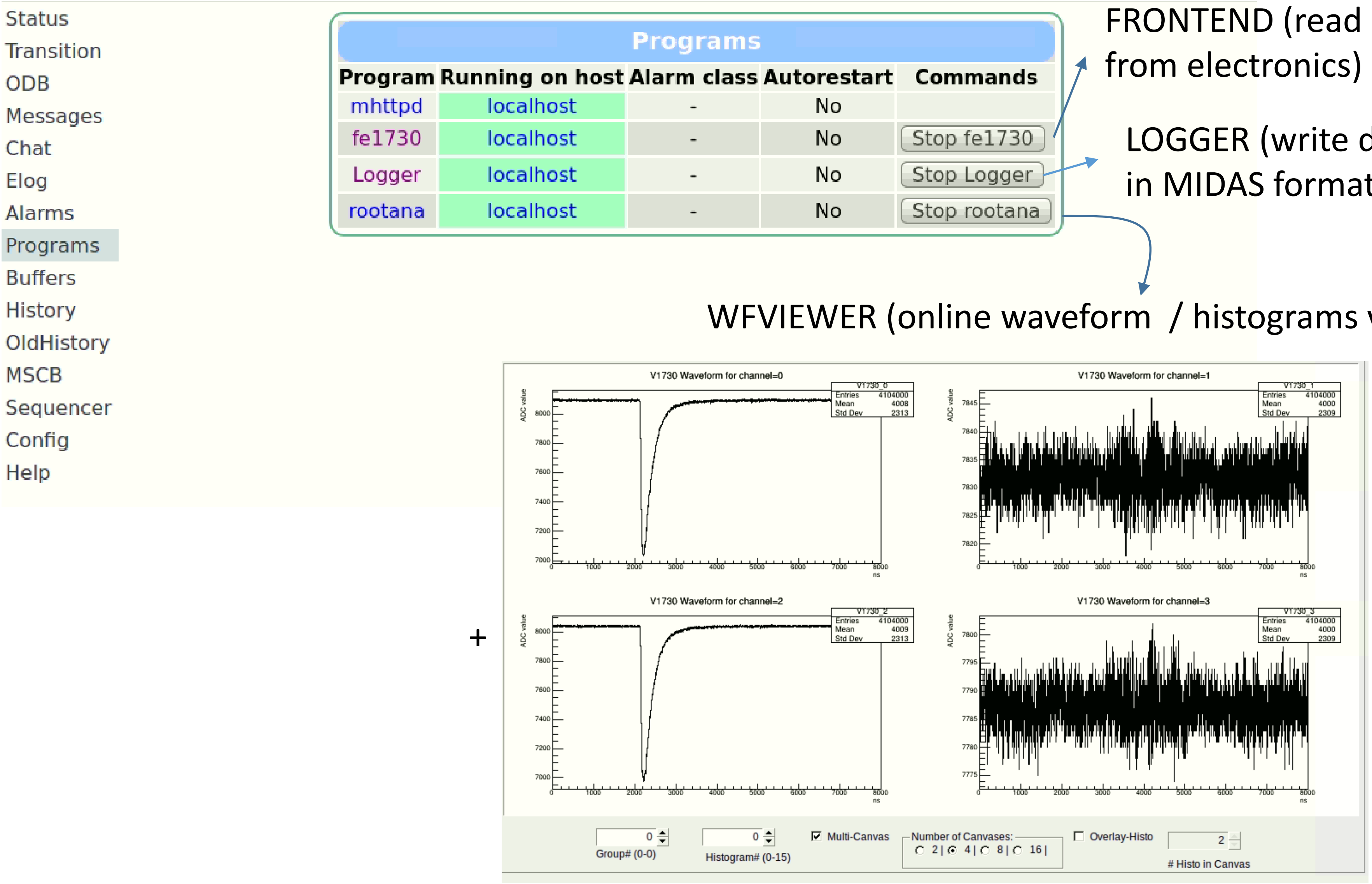
Logging Channels

Channel	Events	MB written	Compr.	Disk Level
#0: run00035.mid.lz4	116	8.718	59.0%	60.2%
Lazy Label	Progress	File Name	# Files	Total

Clients

mhttpd [localhost]	Logger [localhost]	fe1730 [localhost]

DAQ programs



Status
Transition
ODB
Messages
Chat
Elog
Alarms
Programs
Buffers
History
OldHistory
MSCB
Sequencer
Config
Help

Programs

Program	Running on host	Alarm class	Autorestart	Commands
mhttpd	localhost	-	No	
fe1730	localhost	-	No	Stop fe1730
Logger	localhost	-	No	Stop Logger
rootana	localhost	-	No	Stop rootana

FRONTEND (read data from electronics)

LOGGER (write data in MIDAS format)

WFVIEWER (online waveform / histograms visualization)

+

V1730 Waveform for channel=0 — V1730_0: Entries 4104000, Mean 4008, Std Dev 2313

V1730 Waveform for channel=1 — V1730_1: Entries 4104000, Mean 4000, Std Dev 2309

V1730 Waveform for channel=2 — V1730_2: Entries 4104000, Mean 4009, Std Dev 2313

V1730 Waveform for channel=3 — V1730_3: Entries 4104000, Mean 4000, Std Dev 2309

Group# (0-0): 0
Histogram# (0-15): 0
☑ Multi-Canvas
Number of Canvases: ○ 2 | ● 4 | ○ 8 | ○ 16 |
☐ Overlay-Histo
Histo in Canvas: 2

DAQ Configuration

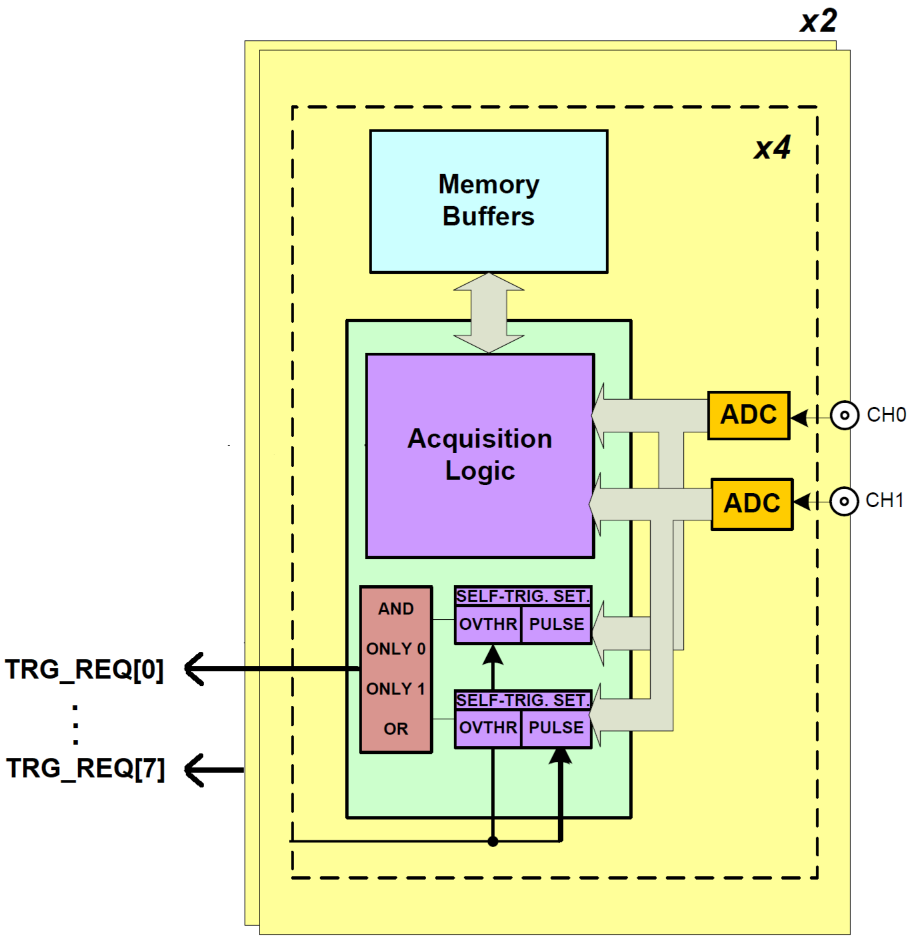
ODB: /Equipment/V1730_Data00/Settings

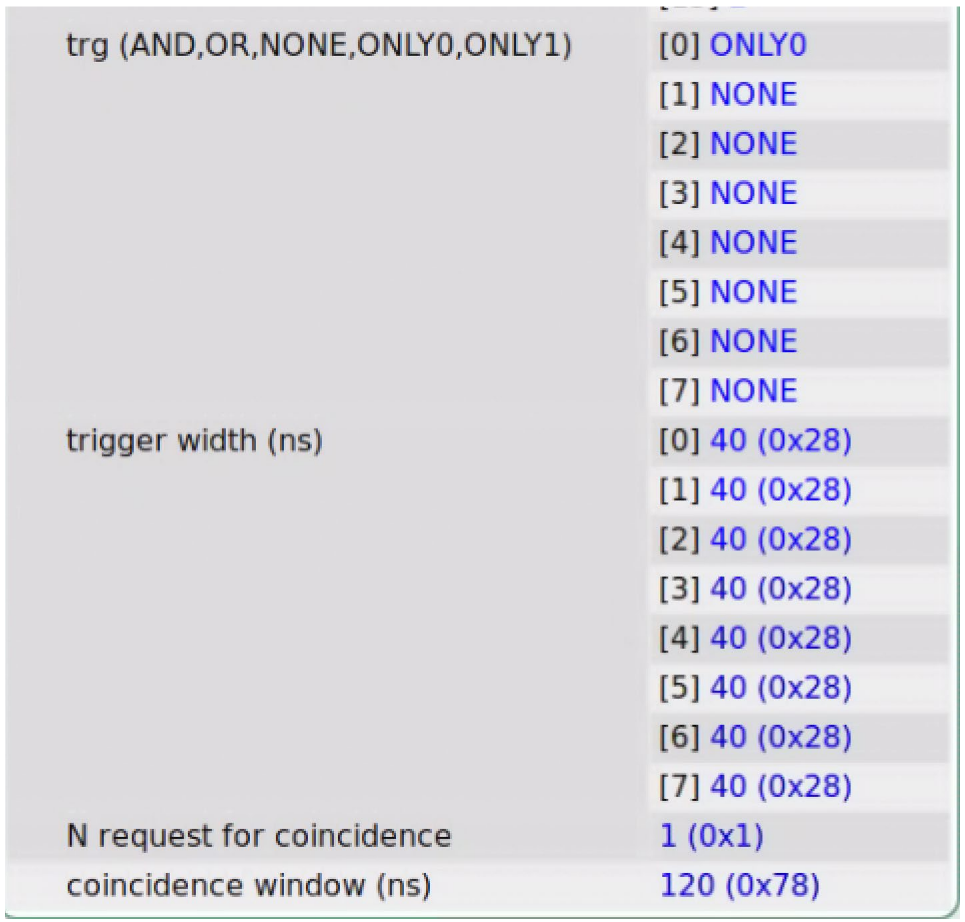
Configurable parameters:

- pulse polarity (+,-)
- external trigger (y,n)
- nrecord length (points)
- post-trigger (%)
- enable channel [0-15]
- baseline position (%)   [0-15]
- threshold (ADC counts) (*)   [0-15]
- dynamic range (V) (0.5,2) [0-15]
- Trigger logic x2 ch (AND,OR,NONE,ONLY0,ONLY1) [0-7]
- trigger width (ns)   [0-7]
- N request for coincidence
- coincidence window (ns)

(*) when run starts, the baseline is calculated with first 200 events and the threshold is set relative to the baseline

Trigger logics





trg (AND,OR,NONE,ONLY0,ONLY1)	[0] ONLY0
	[1] NONE
	[2] NONE
	[3] NONE
	[4] NONE
	[5] NONE
	[6] NONE
	[7] NONE
trigger width (ns)	[0] 40 (0x28)
	[1] 40 (0x28)
	[2] 40 (0x28)
	[3] 40 (0x28)
	[4] 40 (0x28)
	[5] 40 (0x28)
	[6] 40 (0x28)
	[7] 40 (0x28)
N request for coincidence	1 (0x1)
coincidence window (ns)	120 (0x78)

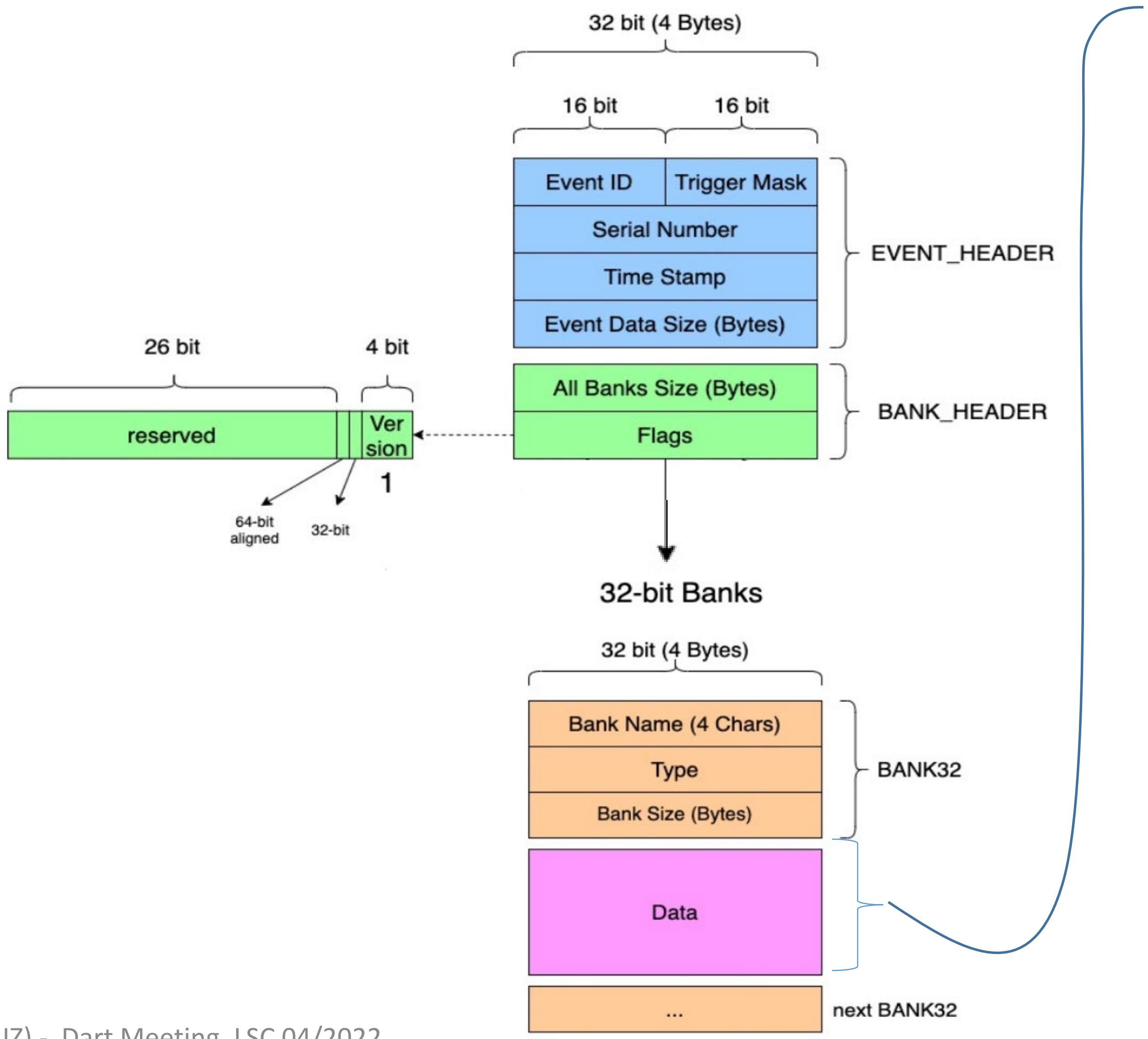
V1730SB memory organization

During the acquisition, data stream is continuously written in a circular memory buffer.
When the trigger occurs, the digitizer writes further samples for the post trigger and freezes the buffer that can be read by one of the provided readout links. The acquisition can continue without any dead time in a new buffer, up to a maximum rate given by the maximum data transfer capability of the optical link (80 MB/s)
For higher rates, the buffer is overwritten and some of the events are lost

# buffers	memory / ch	samples / ch	Max rate 2 ch (Hz)	Max rate 16 ch (Hz)
1	10.24 MB – 20 B	5.12 MS – 10 S	3.9	0.5
2	5.12 MB – 20 B	2.56 MS – 10 S	7.8	1.0
4	2.56 MB -20 B	1.28 MS – 10 S	15.6	2.0
8	1.28 MB – 20 B	0.64 MS – 10 S	31.3	3.9
16	0.64 MB – 20 B	0.32 MS – 10 S	62.5	7.8
32	0.32 MB – 20 B	0.16 MS – 10 S	125.0	15.6
64	0.16 MB – 20 B	0.08 MS – 10 S	250.0	31.3
128	0.08 MB – 20 B	0.04 MS – 10 S	500.0	62.5
256	0.04 MB – 20 B	0.02 MS – 10 S	1000.0	125.0
512	0.02 MB – 20 B	0.01 MS – 10 S	2000.0	250.0
1024	0.01 MB – 20 B	5.12 kS – 10 S	4000.0	500.0
512	12000 B	6000 S	3495.3	436.9

Custom sizes are allowed
(number of buffers not optimal)

DATA format (Midas)



16 bits

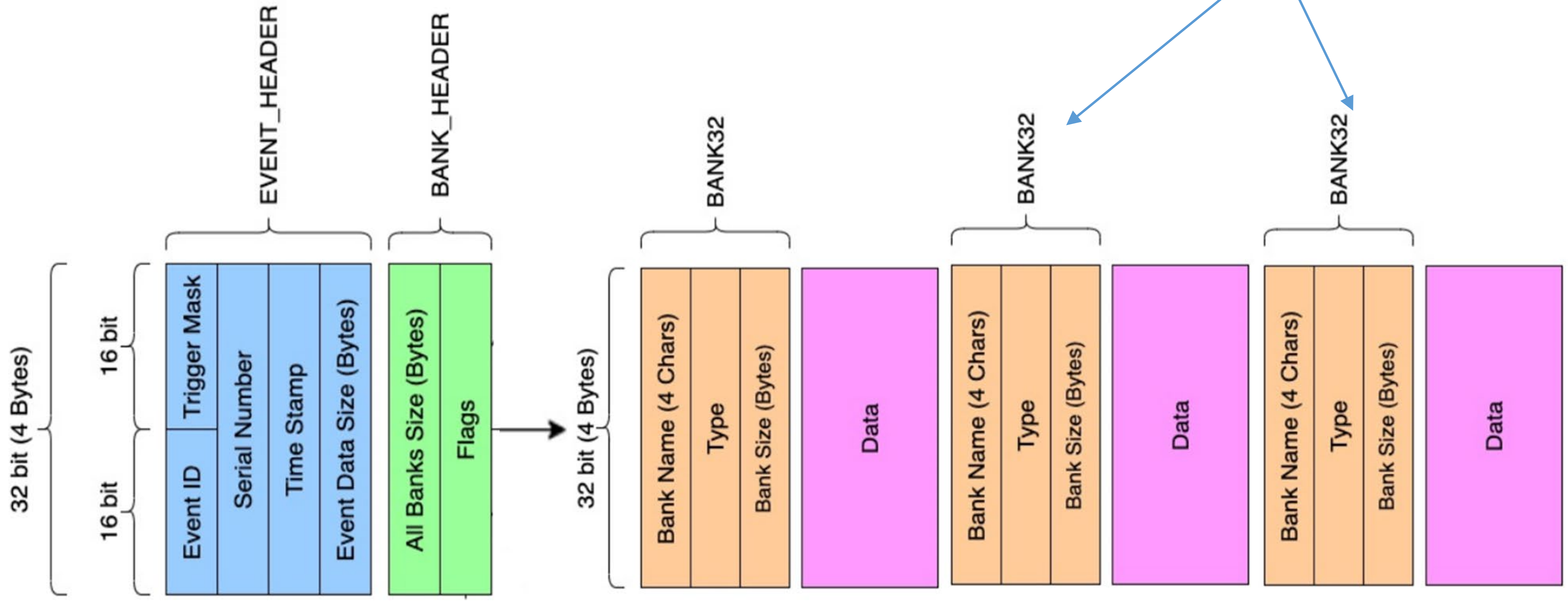
Channel_mask
Flags [1-> reading error]
Nsamples
timestamp [ns] from v1730
Data ch[0]
….
Data ch[1]
….
Data ch[n]
….

Frontend: first version (fe1730)

Frontend poll the v1730SB board, collect events (all buffers available) and send them to the buffer manager as different data banks of the same MIDAS event

Example: 3 of the V7130SB buffers filled @ polling:

Those events were not correctly handled by the subsequent analysis

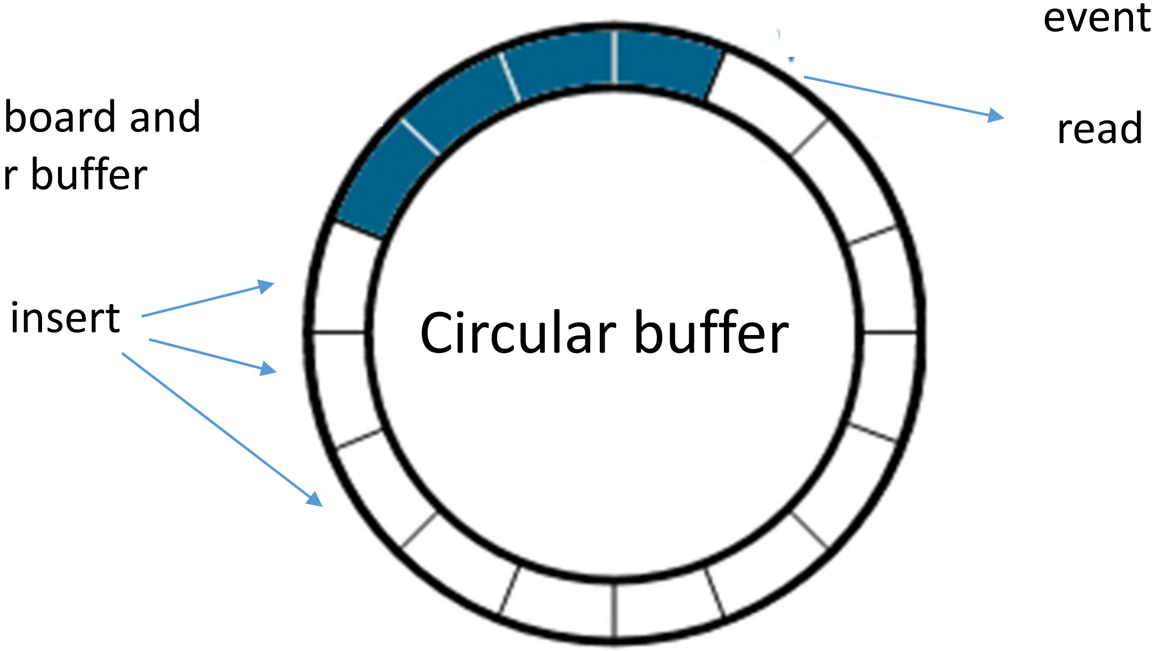


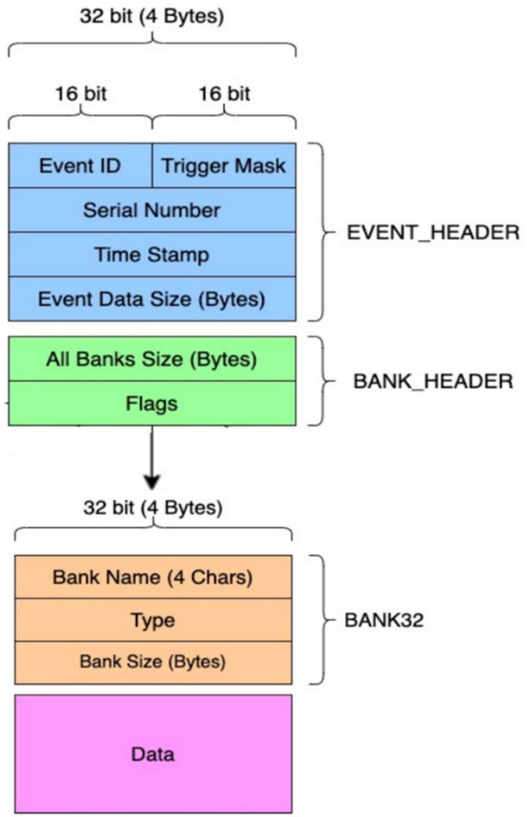
Frontend: current versión (fe1730Th)

The frontend launch two different threads:

Main Thread: continuosly read the circular buffer and créate the MIDAS events one by one

readThread: poll the v1730SB board and store events in internal circular buffer (rb midas object)



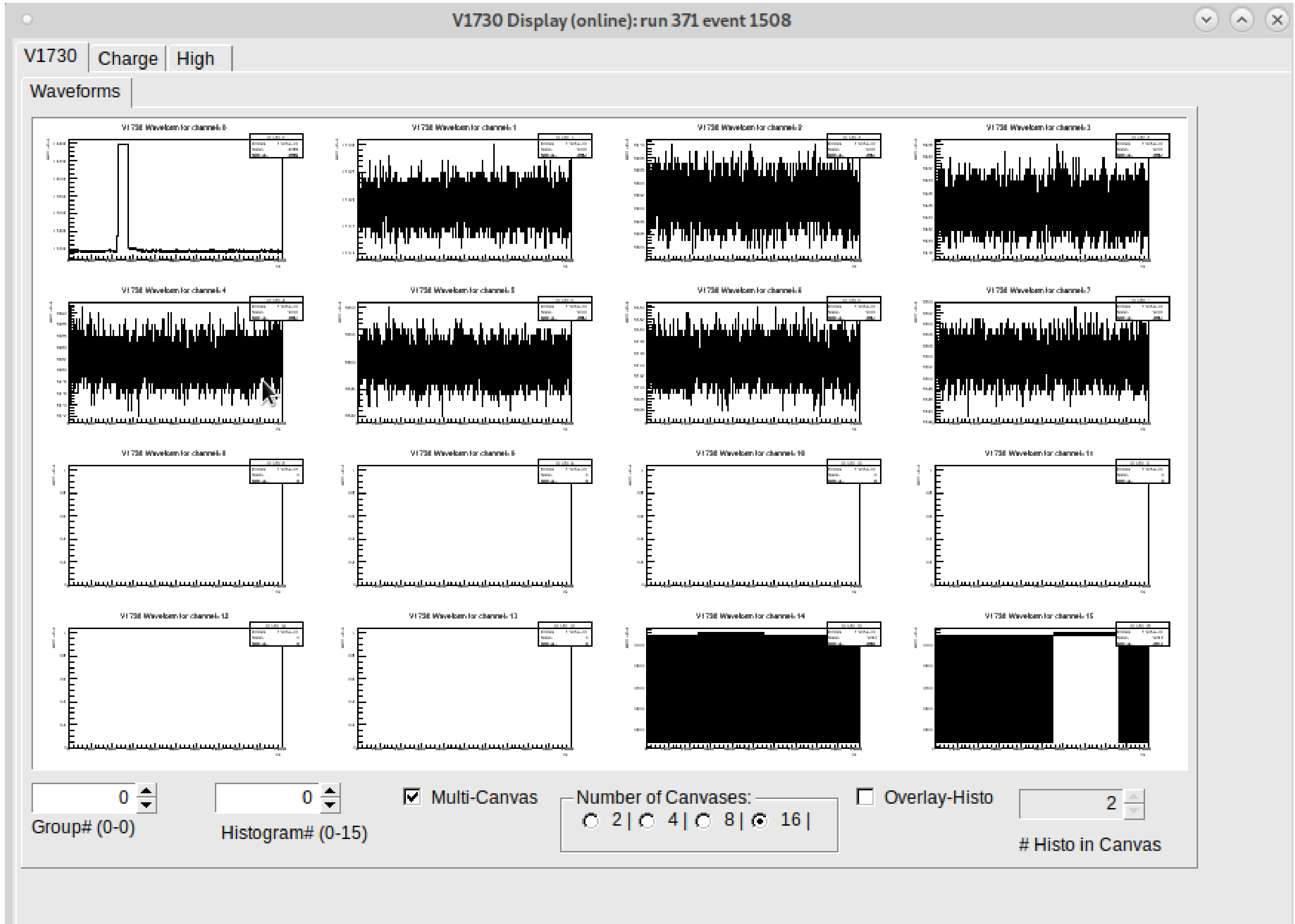


Event ID	Trigger Mask
Serial Number	
Time Stamp	
Event Data Size (Bytes)	
All Banks Size (Bytes)	
Flags	

Bank Name (4 Chars)
Type
Bank Size (Bytes)
Data

Problem with channels 8-15

Channels 8 – 15 not correctly digitized



V1730 Display (online): run 371 event 1508

V1730
Charge
High
Waveforms
V1730 Waveform for channel-0
V1730 Waveform for channel-1
V1730 Waveform for channel-2
V1730 Waveform for channel-3
V1730 Waveform for channel-4
V1730 Waveform for channel-5
V1730 Waveform for channel-6
V1730 Waveform for channel-7
V1730 Waveform for channel-8
V1730 Waveform for channel-9
V1730 Waveform for channel-10
V1730 Waveform for channel-11
V1730 Waveform for channel-12
V1730 Waveform for channel-13
V1730 Waveform for channel-14
V1730 Waveform for channel-15

0 Group# (0-0)

0 Histogram# (0-15)

☑ Multi-Canvas

Number of Canvases: ○ 2 | ○ 4 | ○ 8 | ● 16 |

☐ Overlay-Histo

2 # Histo in Canvas

- Same issue with wavedump CAEN software → no MIDAS-related
- I'm in contact with CAEN support. Testing new firmware

Status

- Crash and deadtime problems solved with fe1730Th frontend
- PC frezzout problems seemed to be related to VME controller (??). Solved with direct link A3818 – V1730SB
  TODO: check with new firmware
- Channels 8 – 15 not correctly digitized (not midas-related. Same issue with wavedump CAEN software)
- With 16 channels x 6000 S/ch acquisition csn go up to ∼400 Hz wighout any dead time. For larger rates we don’t have a control of the live time