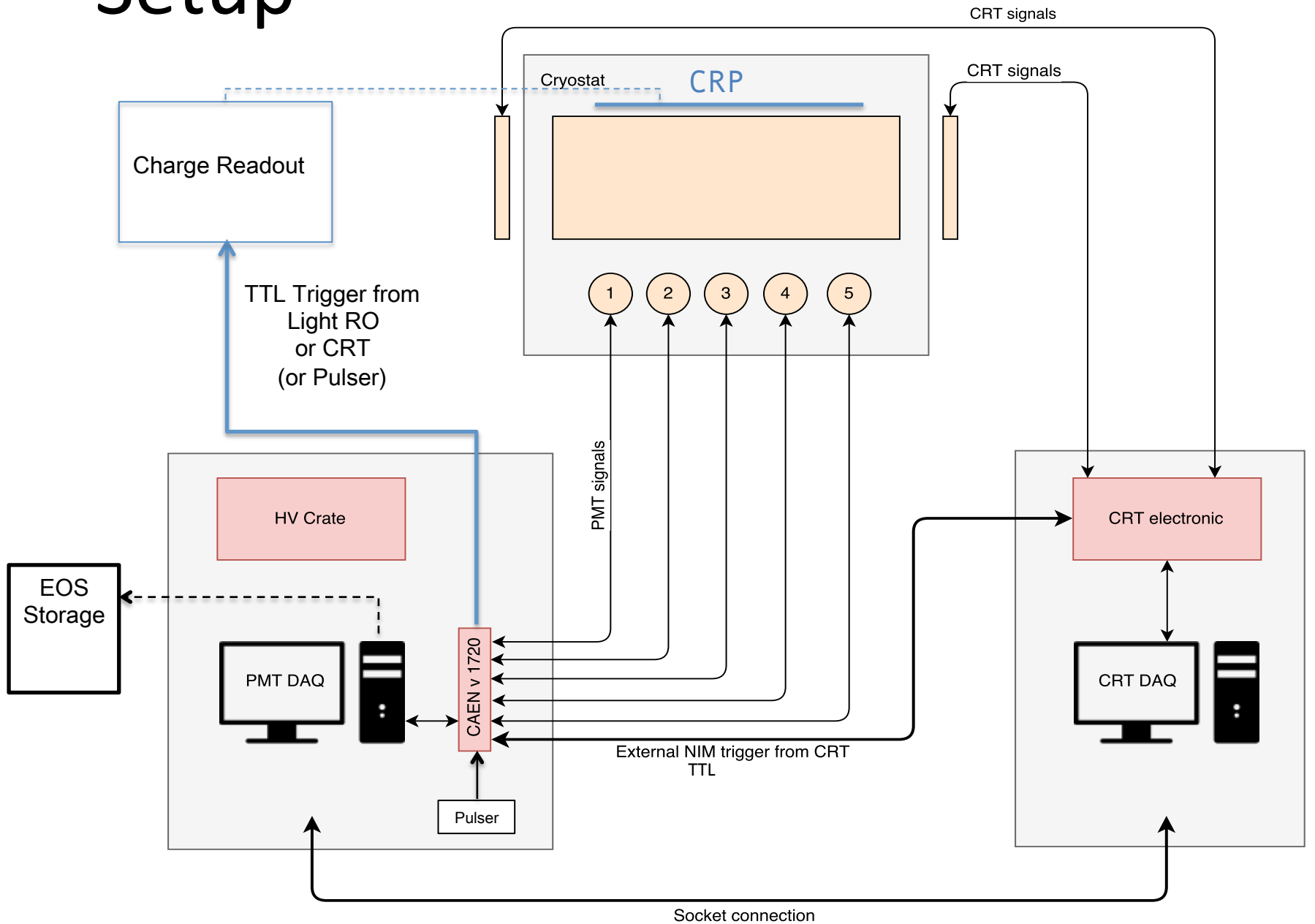


Review of 3x1x1 PMT System

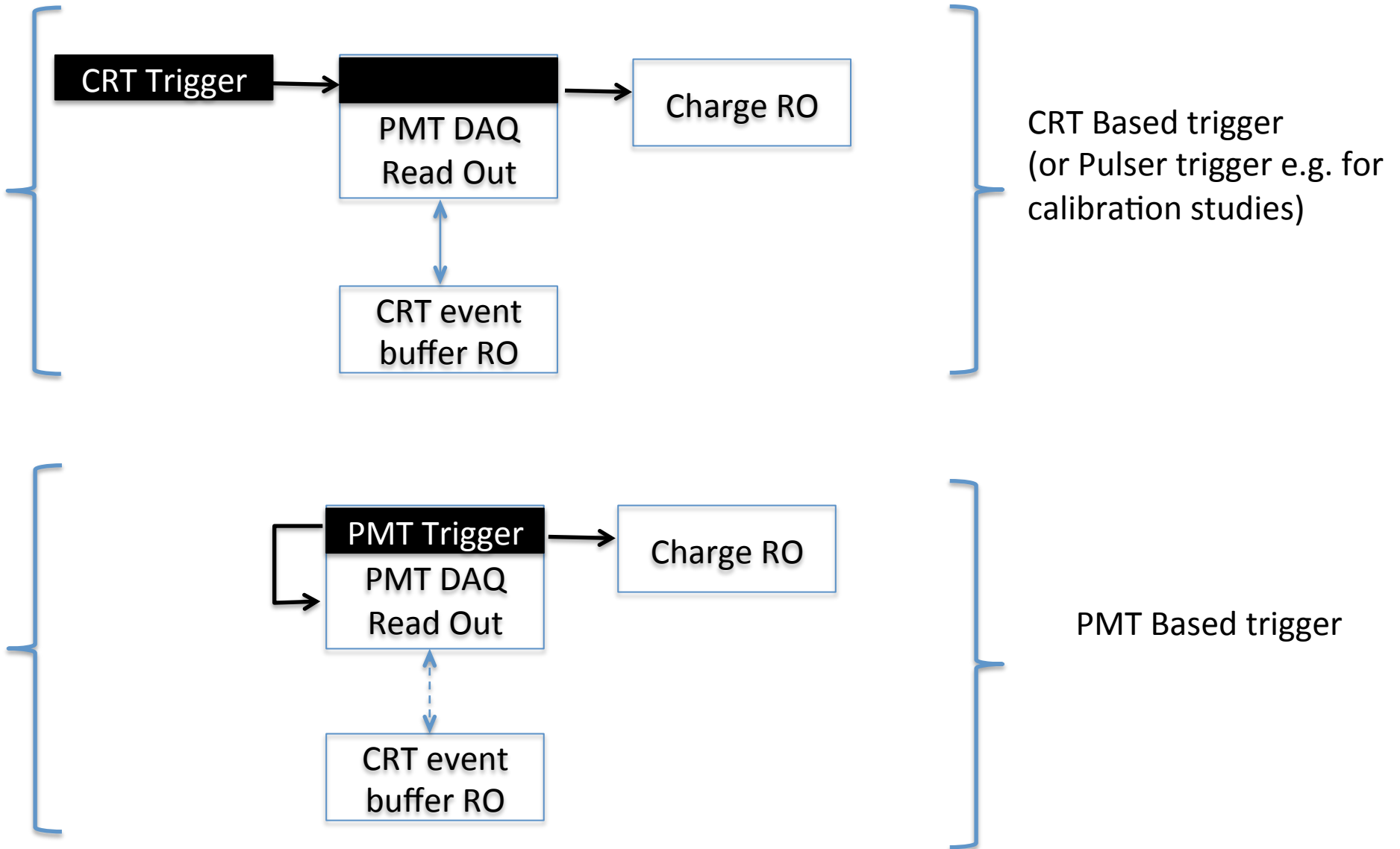
Silvestro, Alberto
CIEMAT and IFAE groups

Science Board Meeting 26/07/2017

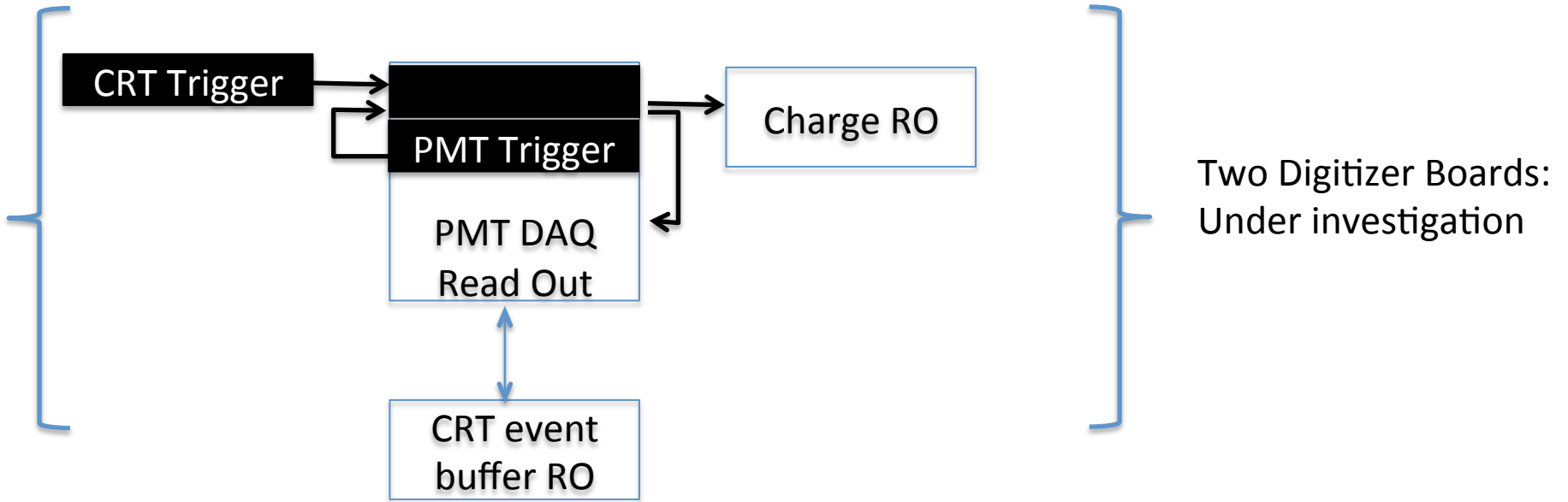
Setup



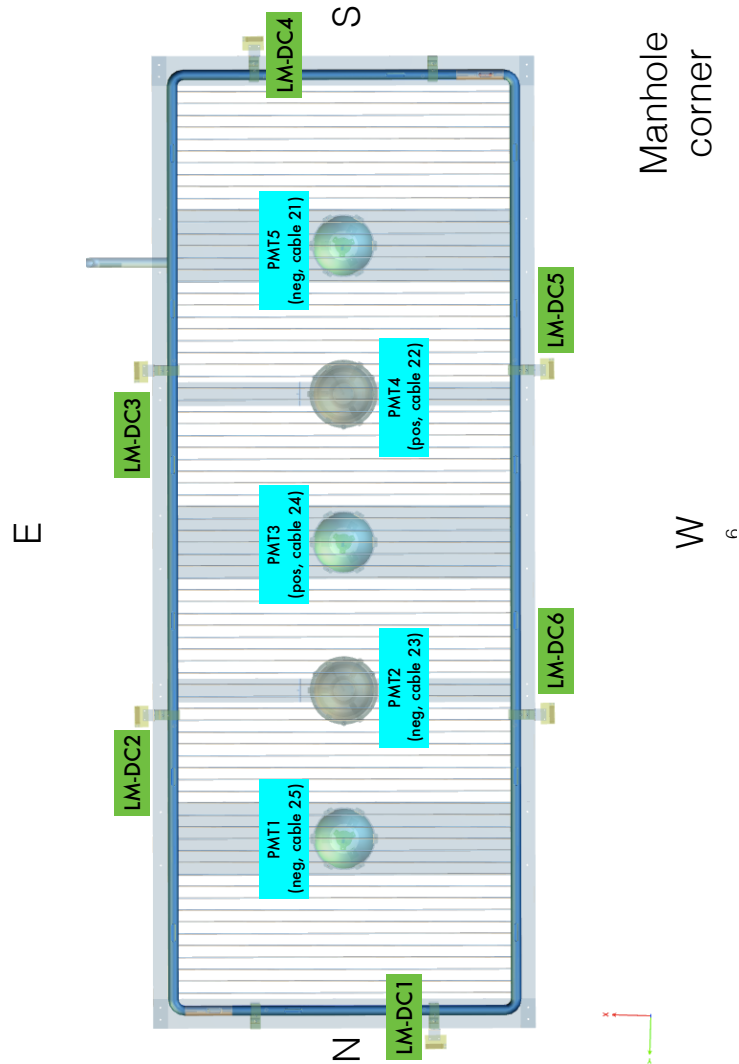
Trigger/DAQ Flow Schemes



Trigger/DAQ Flow Schemes



PMTs Setup



Name	PMT1	PMT2	PMT3	PMT4	PMT5
Pos/Neg	— (2 wires)	— (2 wires)	+ (1 wires)	+ (1 wires)	— (2 wires)
PMT #	FA0093	FA0092	FA0090	FA0094	FA0091
operating HV	1200 V	1200 V	1150 V	1150 V	1200 V
HV cable #	25	23	24	22	21
Signal cable #	3 (?)	2 (?)	none	none	1 (?)
TPB	direct coating	plate	direct coating	plate	direct coating
Base	KEK	KEK	CIEMAT	CIEMAT	KEK

PMT Waveform Digitization

- The readout Board: CAEN V1720
 - 8 channels, 12 bit ADC, 250 MS/s, 2 V input range
 - Buffer memory 1.25 MS/ch (5 ms time window)
 - External NIM trigger
 - Software configurable self-trigger logic
- The DAQ Software:
 - MIDAS: linux based DAQ developed by PSI & TRIUMF
 - Easy setup + web based interface for data taking
- Storage: 2TB local USB disk + 1TB storage on EOS



PMT Digitizer Configuration & Trigger Configuration

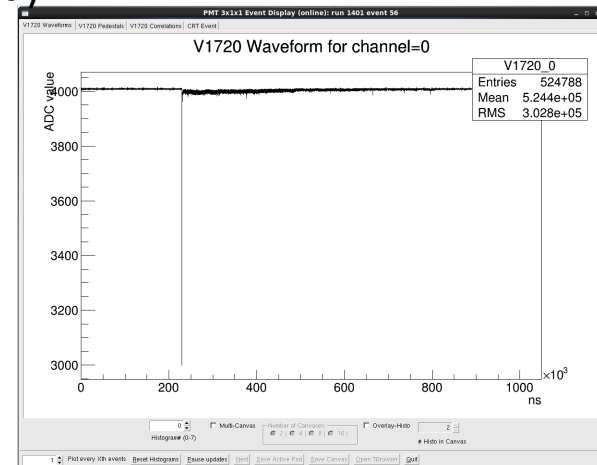
Online Database Browser

Find Create Delete Create Elog from this page

/ Equipment / FEv1720I / Settings / Board0 /

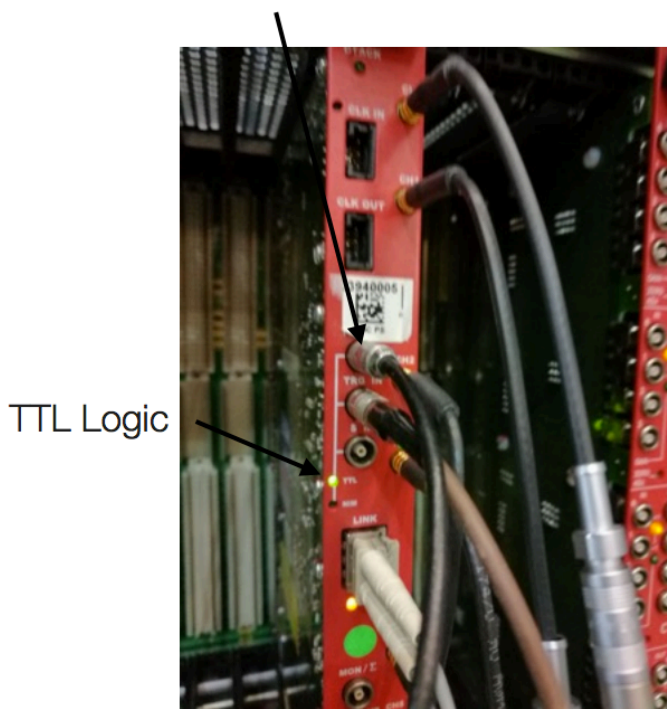
Key	Value	
setup	0 (0x0)	
Acq mode	0 (0x0)	
Channel Configuration	82 (0x52)	
Buffer organization	2 (0x2)	
Custom size	0 (0x0)	
Channel Mask	63 (0x3F)	
Trigger Source	1073741824 (0x40000000)	
Trigger Output	1073741824 (0x40000000)	
Post Trigger	51200 (0xC800)	
almost_full	100 (0x64)	
Threshold	[0] 0 (0x0)	
	[1] 0 (0x0)	
	[2] 0 (0x0)	
	[3] 0 (0x0)	
	[4] 0 (0x0)	
	[5] 0 (0x0)	
	[6] 0 (0x0)	
	[7] 0 (0x0)	
NbOUTThreshold	[0] 0 (0x0)	
	[1] 0 (0x0)	
	[2] 0 (0x0)	
	[3] 0 (0x0)	
	[4] 0 (0x0)	
	[5] 0 (0x0)	
	[6] 0 (0x0)	
	[7] 0 (0x0)	
ZS_Threshold	[0] 0 (0x0)	
	[1] 0 (0x0)	
	[2] 0 (0x0)	
	[3] 0 (0x0)	
	[4] 0 (0x0)	
	[5] 0 (0x0)	
	[6] 0 (0x0)	
	[7] 0 (0x0)	
DAC	[3] 1 (0x1)	
	[4] 1 (0x1)	
	[5] 1 (0x1)	
	[6] 1 (0x1)	
	[7] 1 (0x1)	
	[0] 7413 (0x1CF5)	
	[1] 7171 (0x1C03)	
	[2] 7409 (0x1CF1)	
[3] 6812 (0x1A9C)		
[4] 7701 (0x1E15)		
[5] 7000 (0x1B58)		
[6] 7000 (0x1B58)		
[7] 7000 (0x1B58)		

- ✓ Scripts ready to setup different configurations
 - Trigger Source
 - External/Internal
 - Trigger Output
 - Buffer Organization
 - Digitization Time Window (S1 to S2)
 - Thresholds
 - PMT Majority based Trigger Logic
 - Offsets
 - Pedestals (automated)
 - CRT event retrieval
 - ...



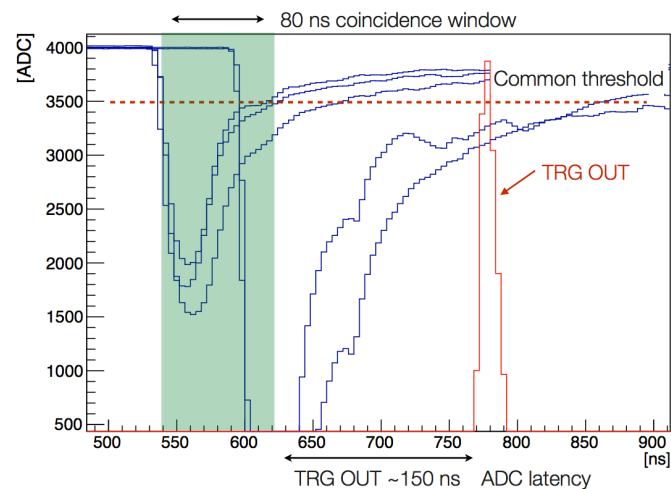
PMT – Digitizer - Trigger Formation

- TTL Trigger distributed to Charge Readout Computer
 - ✓ CRT Trigger
 - ✓ PMT Based Trigger
 - 5 PMTs over thr coincidence within given time window (80 ns).
 - Rate adjusted at @3 Hz (as requested form CRO)

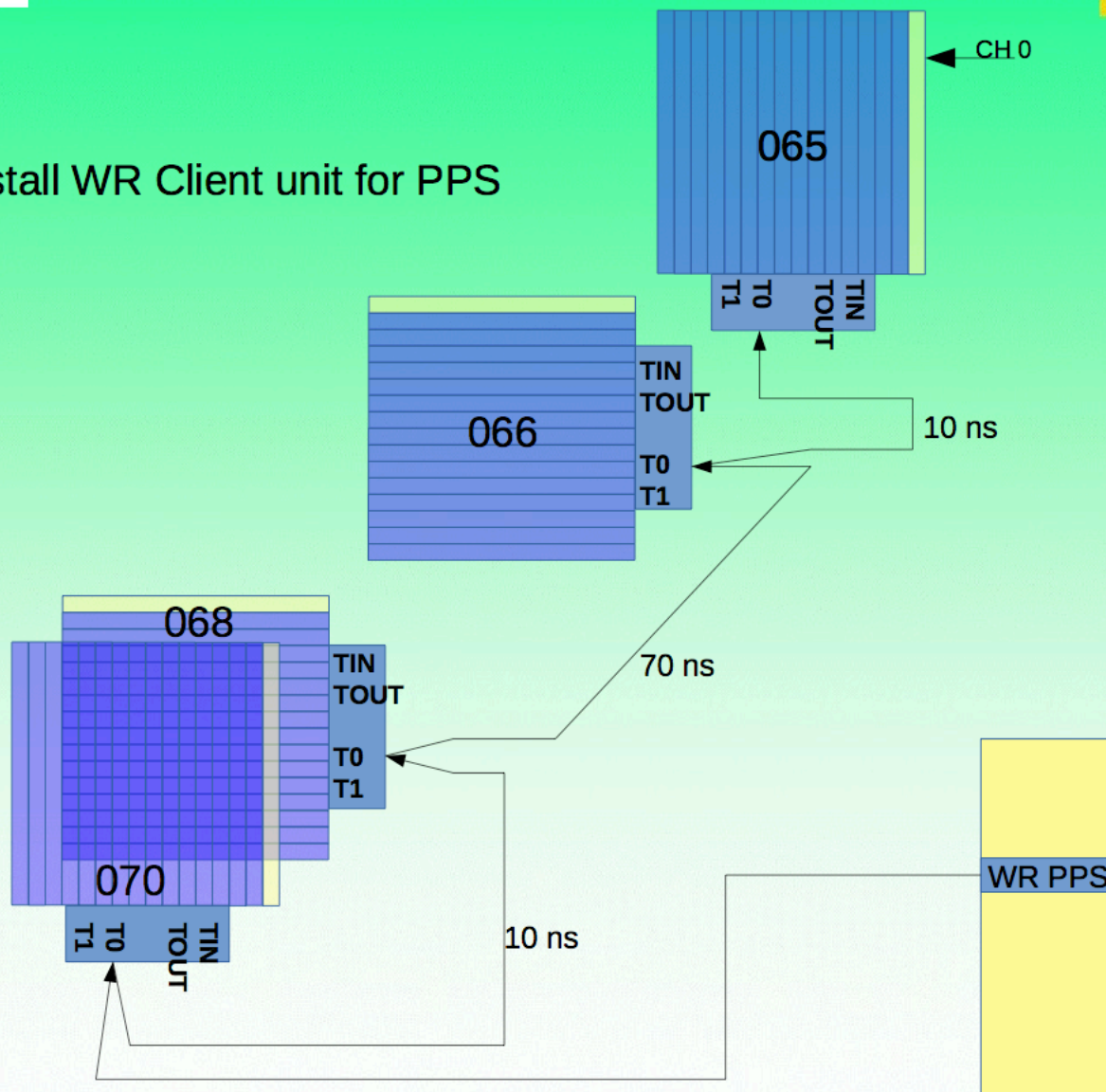


TTL Logic

PMT ADC Board

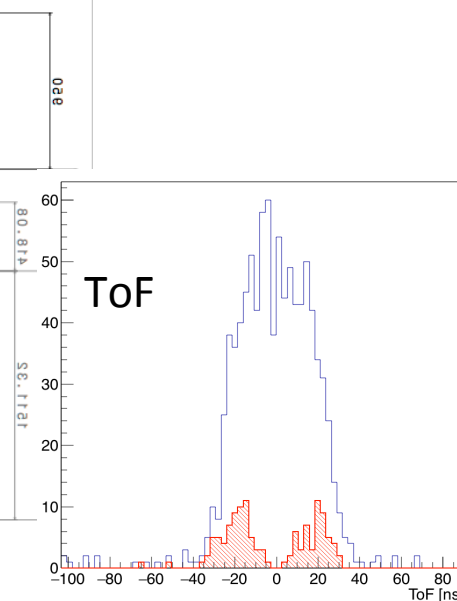
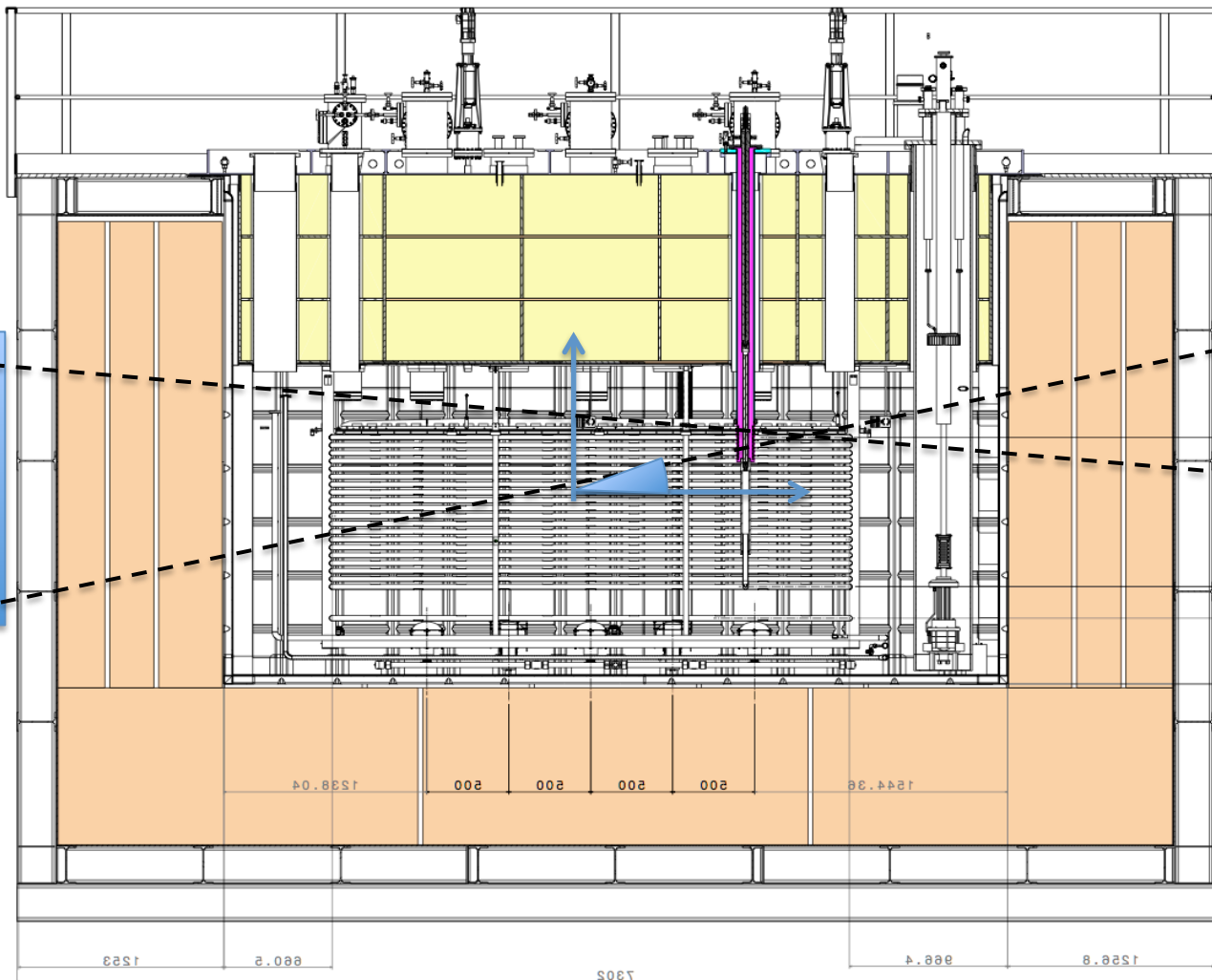


TODO: install WR Client unit for PPS



CRT Detector

- CRT event reconstruction from raw data applied offline -> stored to root files
 - Hits selection
 - Timing corrections (as from the CRT group) → ToF
 - Fired strips → Hit space position → track slope and intercept

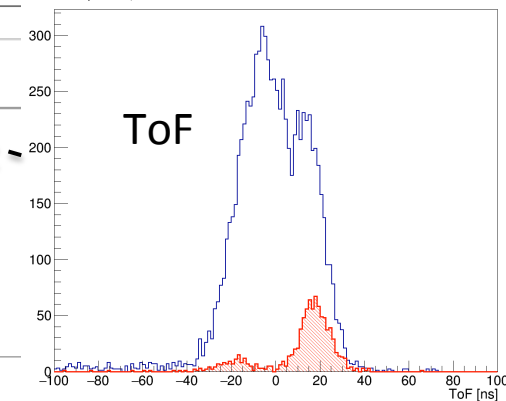
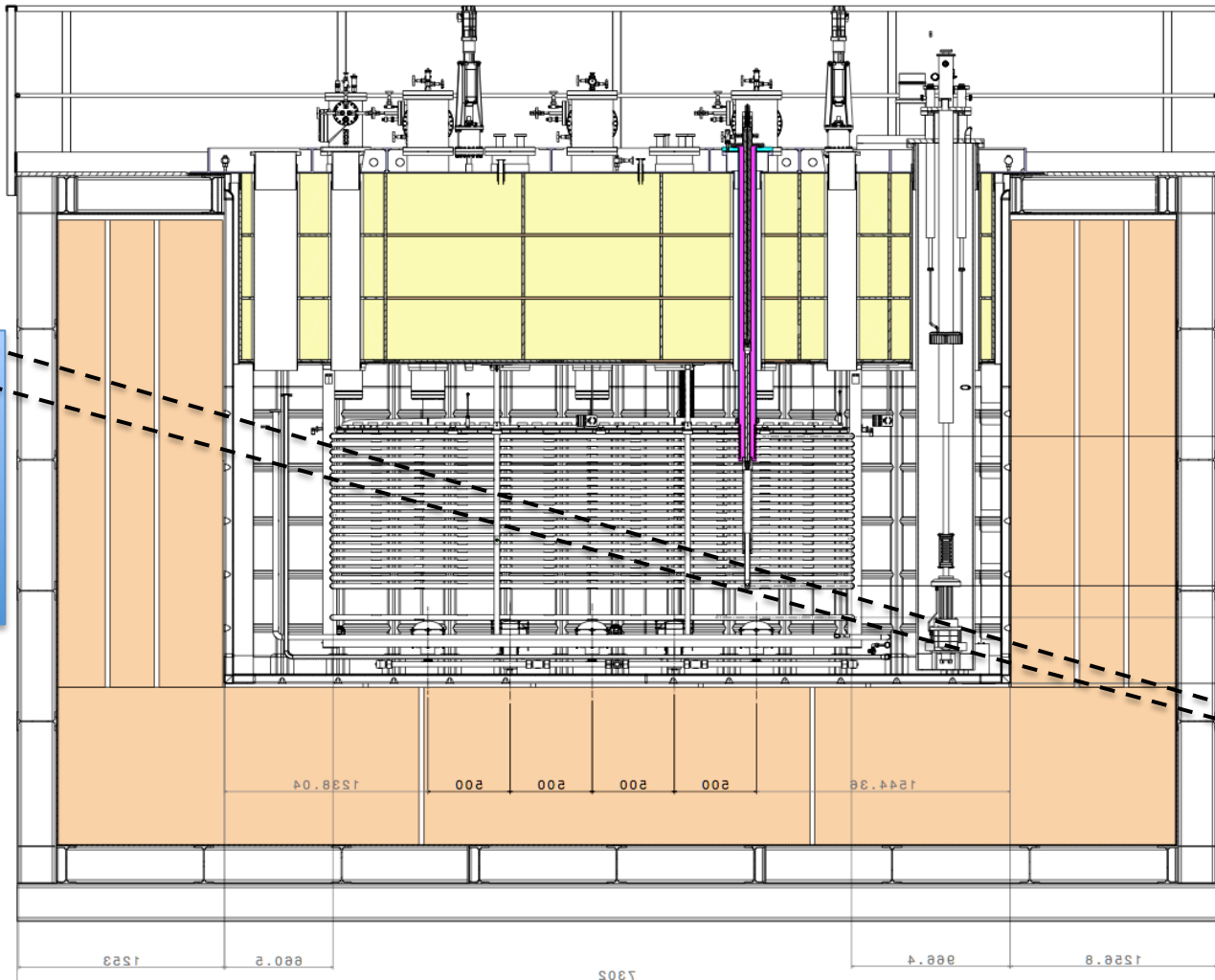


CRT Detector

- Geometry changed in order to:
 - Understand main source of trigger events (shower vs traversing muon)
 - Increase trigger purity
 - Get more uniform “Illumination” for calibration studies
 - Ideally panel “asimmetry” should be larger (work in progress)



CERN+BERN groups



CRT/PMT event matching

- CRT emits a trigger. Then the event is published on the server in max 1s
 - Hardware trigger is received
 - Wait 1s before polling CRT server
in this case you are sure event is published.
Require 10 events each time (the whole buffer)
 - Poll immediately the CRT server. Do matching offline.
This is a solution for high trigger rates
 - ms pc time tag added now to the DAQ event header. Should improve matching efficiency
 - Polling strategy can be configured via Frontend
-
- The diagram consists of two blue curly braces on the right side of the list. The top brace groups the items 'Hardware trigger is received', 'Wait 1s before polling CRT server', and 'Require 10 events each time (the whole buffer)'. To the right of this brace is the text 'On server (delayed) Polling'. The bottom brace groups the items 'Poll immediately the CRT server. Do matching offline.' and 'This is a solution for high trigger rates'. To the right of this brace is the text 'On Trigger Polling'.


```

=> poll_event n: 13 source: 0 count: 469 test: 0 ; Ncount: 469 Nloop: 0 ; Wed, 29 Mar 2017 14:49:05 +0000 (GMT) + 60798000 nsec 1490798945
real time 0:01:16.093, CP time 0.770
Buffer Not Empty 1 count 7 sCAEN 0 469
IIDAS event header: actual_time 1490798945, serial_number 12
-> read_trigger_event Wed, 29 Mar 2017 14:49:05 +0000 (GMT) + 68311000 nsec 1490798945
size 2504 (0x814c) stored 1 (0x812c) sCAEN 0
AM = 0x1
Module:00 Hndle:0 S/N:00000012 Nloop:7/469 ( 1.49) sCAEN:0 Event Stored:0x1 Event Size:0x9c8
read event into bank
:504
febevtRequest
wait on : Wed, 29 Mar 2017 14:49:05 +0000 (GMT) + 68584000 nsec
wait end: Wed, 29 Mar 2017 14:49:06 +0000 (GMT) + 68648000 nsec
call zmq 10
getting 0 67438242 1490798944 996
getting 1 0 0 0
getting 2 0 0 0
getting 3 0 0 0
getting 4 0 0 0
getting 5 0 0 0
getting 6 0 0 0
getting 7 0 0 0
getting 8 0 0 0
getting 9 0 0 0

```

DAQ side

```

=> poll_event n: 14 source: 0 count: 469 test: 0 ; Ncount: 469 Nloop: 7 ; Wed, 29 Mar 2017 14:49:16 +0000 (GMT) + 59673000 nsec 1490798956
real time 0:01:27.558, CP time 0.890
Buffer Not Empty 1 count 445 sCAEN 0 469
IIDAS event header: actual_time 1490798956, serial_number 13
-> read_trigger_event Wed, 29 Mar 2017 14:49:16 +0000 (GMT) +53364000 nsec 1490798956
size 2504 (0x814c) stored 1 (0x812c) sCAEN 0
AM = 0x1
Module:00 Hndle:0 S/N:00000013 Nloop:445/469 (94.88) sCAEN:0 Event Stored:0x1 Event Size:0x9c8
read event into bank
:504
febevtRequest
wait on : Wed, 29 Mar 2017 14:49:16 +0000 (GMT) +533944000 nsec
wait end: Wed, 29 Mar 2017 14:49:17 +0000 (GMT) +534018000 nsec
call zmq 10
getting 0 0 0 0
getting 1 0 0 0
getting 2 0 0 0
getting 3 0 0 0
getting 4 0 0 0
getting 5 0 0 0
getting 6 0 0 0
getting 7 0 0 0
getting 8 0 0 0
getting 9 0 0 0

```

```

.....
pmtsender: received 5-hit event from detector at 1490798944 sec 996 msec, first ts0= 67438001
|#_____ | pmtsender:local unix time: 1490798946 s, good events in buffer: 1
Wed Mar 29 14:49:06 2017 pmtsender: Received request for 10 events. Will send 10 events.
|_____ | Cleared 10 events. Good events in buffer: 0
.....Wed Mar 29 14:49:17 2017 pmtsender: Received request for 10 events. Will send 10 event
|_____ | Cleared 10 events. Good events in buffer: 0
.....
pmtsender: received 5-hit event from detector at 1490798958 sec 509 msec, first ts0= 612606374
|#_____ | pmtsender:local unix time: 1490798960 s, good events in buffer: 1
Wed Mar 29 14:49:20 2017 pmtsender: Received request for 10 events. Will send 10 events.
|_____ | Cleared 10 events. Good events in buffer: 0

```

This is a polling without a published CRT event SPURIOUS TRIGGER ?? but Buffer is empty -> discard event (check for same-second Triggers first)

CRT side

```

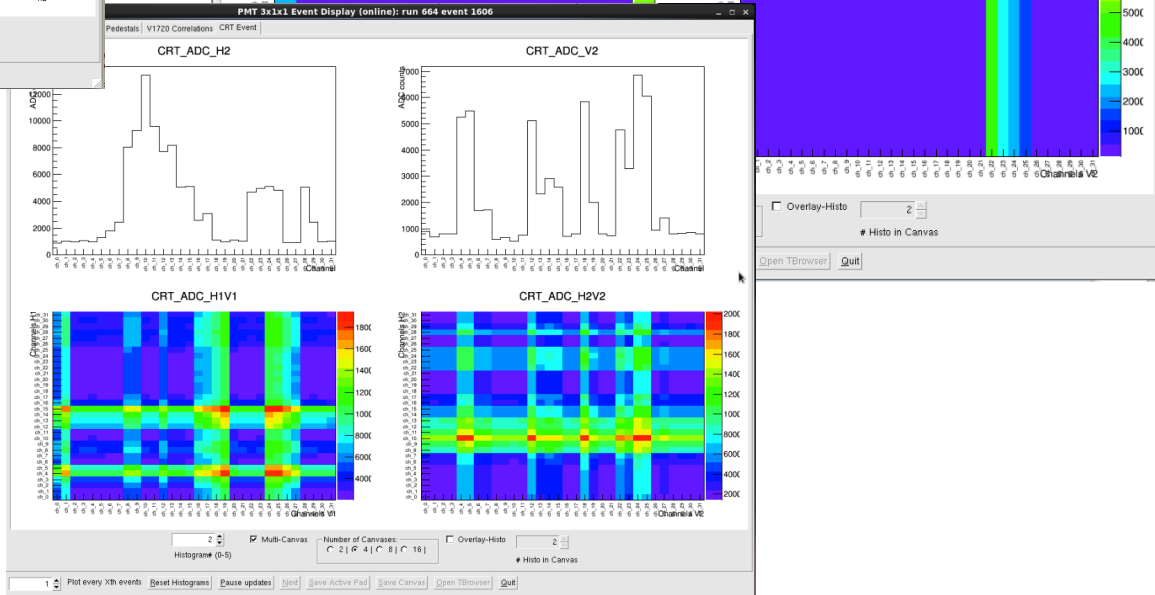
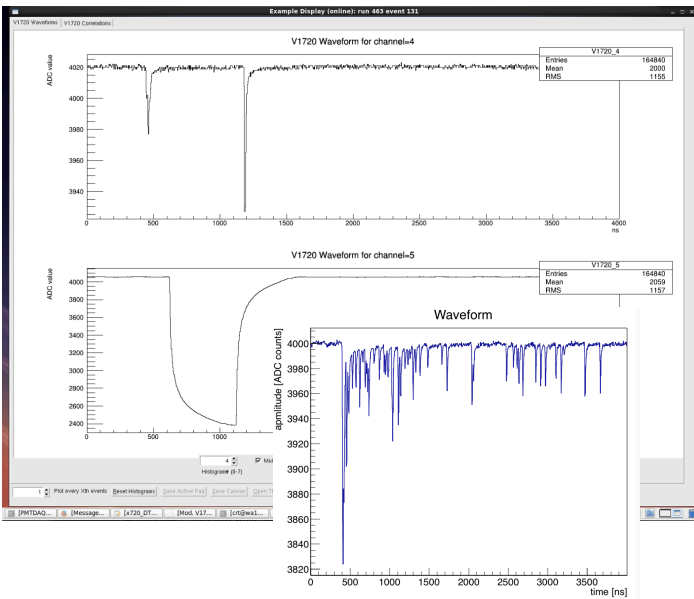
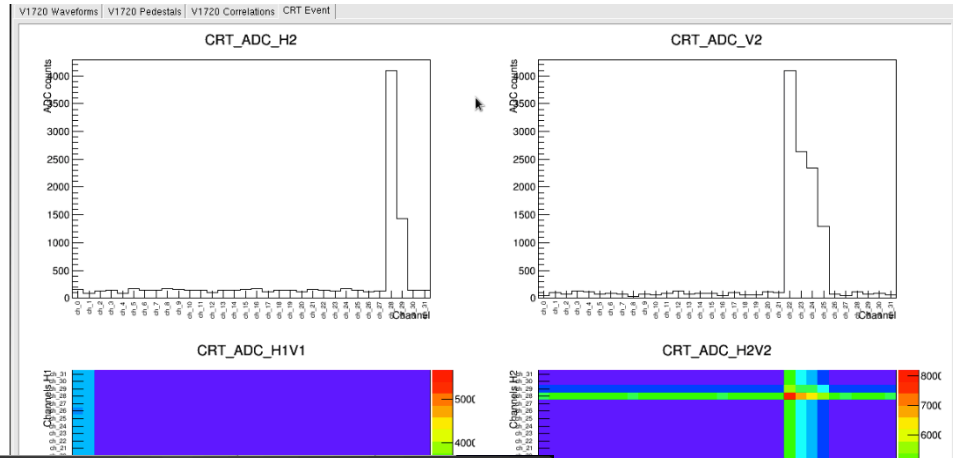
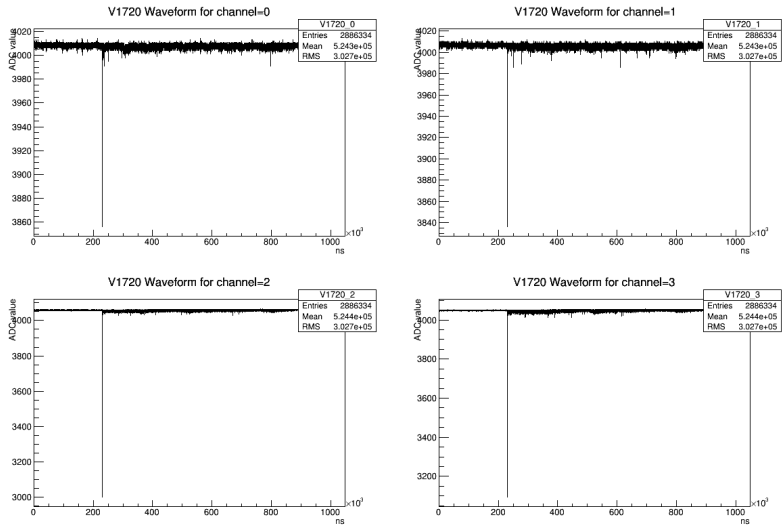
=> poll_event n: 15 source: 0 count: 469 test: 0 ; Ncount: 469 Nloop: 445 ; Wed, 29 Mar 2017 14:49:19 +0000 (GMT) +532387000 nsec 1490798959
real time 0:01:30.638, CP time 0.920
Buffer Not Empty 1 count 76 sCAEN 0 469
IIDAS event header: actual_time 1490798959, serial_number 14
-> read_trigger_event Wed, 29 Mar 2017 14:49:19 +0000 (GMT) +613365000 nsec 1490798959
size 2504 (0x814c) stored 1 (0x812c) sCAEN 0
AM = 0x1
Module:00 Hndle:0 S/N:00000014 Nloop:76/469 (16.20) sCAEN:0 Event Stored:0x1 Event Size:0x9c8
read event into bank
:504
febevtRequest
wait on : Wed, 29 Mar 2017 14:49:19 +0000 (GMT) +613646000 nsec
wait end: Wed, 29 Mar 2017 14:49:20 +0000 (GMT) +613712000 nsec
call zmq 10
getting 0 612606514 1490798958 509
getting 1 0 0 0
getting 2 0 0 0
getting 3 0 0 0
getting 4 0 0 0
getting 5 0 0 0

```

On the next trigger right match is preserved

Online Monitoring

Accessible from webserver for the shifter



Raw Data Processing / Event Data Structure

Raw data file (.mid) contains information on both PMT and CRT events

Raw data processed to produce .root files with both raw and reconstructed event infos.

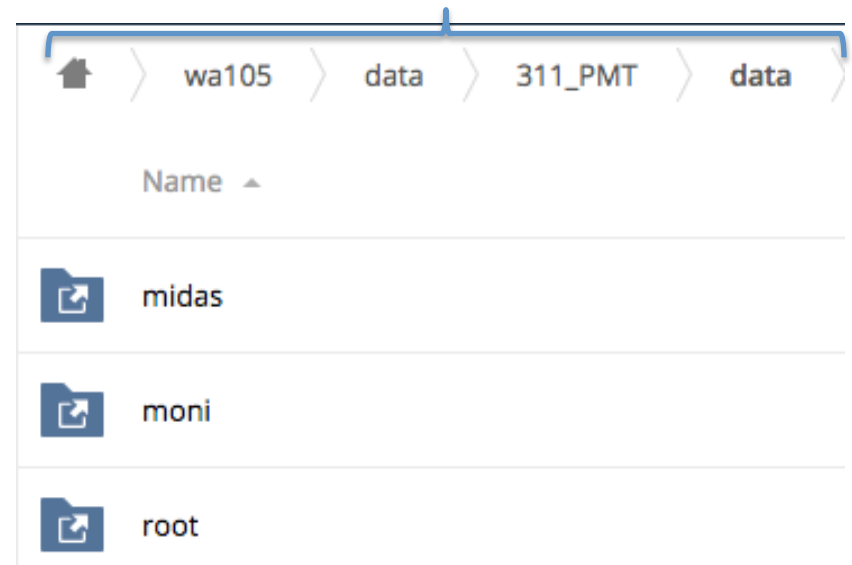
- DAQ (TTree::midas_data)
 - Waveform per channel [ADCs]
 - Time sample [ns], Number of samples
 - Timestamp [ms]
 - CRT track reconstruction params (if present), ToF
- CRT (TTree::crt_data)
 - Channels ADC. Trigger Times
(for all the retrieved events)
- RUN (TTree::run_info)
 - Some digitizer configuration: offsets

```
=====> EVENT:4
TimeStamp      = 1500653590
TriggerTimeTag = -2147483648
event          = 5
nchannels      = 6
nsamples       = 1000
TimeSample     = 4
crt_adc        = 188,
                214, 186, 164, 210, 193, 196, 221, 200, 188, 179,
                159, 195, 176, 186, 215, 187, 172, 207, 160
crt_plane_times_raw = 814848594,
                    319142445, 814848598, 505077564, 814848644, 568938856, 814848660, 652672721
crt_SE_time    = 1500653590,
                798
crt_TS_time    = 814848874,
                590181656
crt_daq_match  = 1
crt_reco       = 1
crt_track_param = 221.029,
                0.0332319
crt_track_times = 814848594,
                814848644
crt_track_pos0 = 265.653,
                3753.26, 345.971
crt_track_pos1 = 156.317,
                -3765.37, 96.0865
crt_ToF_H1V1   = -8.11561
crt_ToF_H2V2   = -5.87564
crt_ToF        = 27.4892
adc_value_0    = 4022,
                4022, 4022, 4023, 4023, 4022, 4022, 4021, 4021, 4023, 4022,
                4022, 4023, 4022, 4023, 4023, 4023, 4021, 4022, 4022
adc_value_1    = 4023,
                4023, 4023, 4022, 4022, 4022, 4024, 4023, 4024, 4023, 4024,
                4023, 4022, 4022, 4023, 4023, 4023, 4023, 4022, 4022
adc_value_2    = 4001,
                4000, 4001, 4000, 4001, 4000, 4000, 4000, 4000, 4000, 4000,
                4001, 4001, 4001, 4000, 4000, 3999, 4000, 4000, 3999, 4001
adc_value_3    = 4002,
                4001, 4001, 4001, 4001, 4002, 4001, 4000, 4001, 4001, 4002,
                4001, 4001, 4002, 4001, 4002, 4002, 4002, 4000, 4002
adc_value_4    = 3999,
                4000, 3999, 4000, 4001, 4001, 3999, 4000, 4000, 3999, 4001,
                4000, 4000, 3999, 4001, 4000, 4001, 3999, 4000, 4001
adc_value_5    = 4095,
                4095, 4095, 4095, 4095, 4095, 4095, 4095, 4095, 4095, 4095,
                4095, 4095, 4095, 4095, 4095, 4095, 4095, 4095, 4095
```

Data Repository

- ✓ Data transferred to EOS once per day
 - Raw Data (midas)
 - Processed ROOT Files
 - Monitoring Files
- ✓ Files metadata derived from elog
 - List of good runs in preparation

EOS Path from /eos/experiment/



Summary

- ✓ DAQ chain extended robust operation achieved from 4 μ s (1k samples) to 1 ms (250k samples) and for acquisition rate up to a few kHz
- ✓ Several Data Taking configurations available to optimize data taking for:
 - calibration
 - S1/S2 studies
 - Charge/Light correlation