CRT Front-end-board

The Front-End-Board is a custom design developed by Igor Kreslo, University of BERN, for the readout of SiPMs used in the SBND/MicroBooNE CRT Systems. **The board is commercialized and maintained by CAEN**

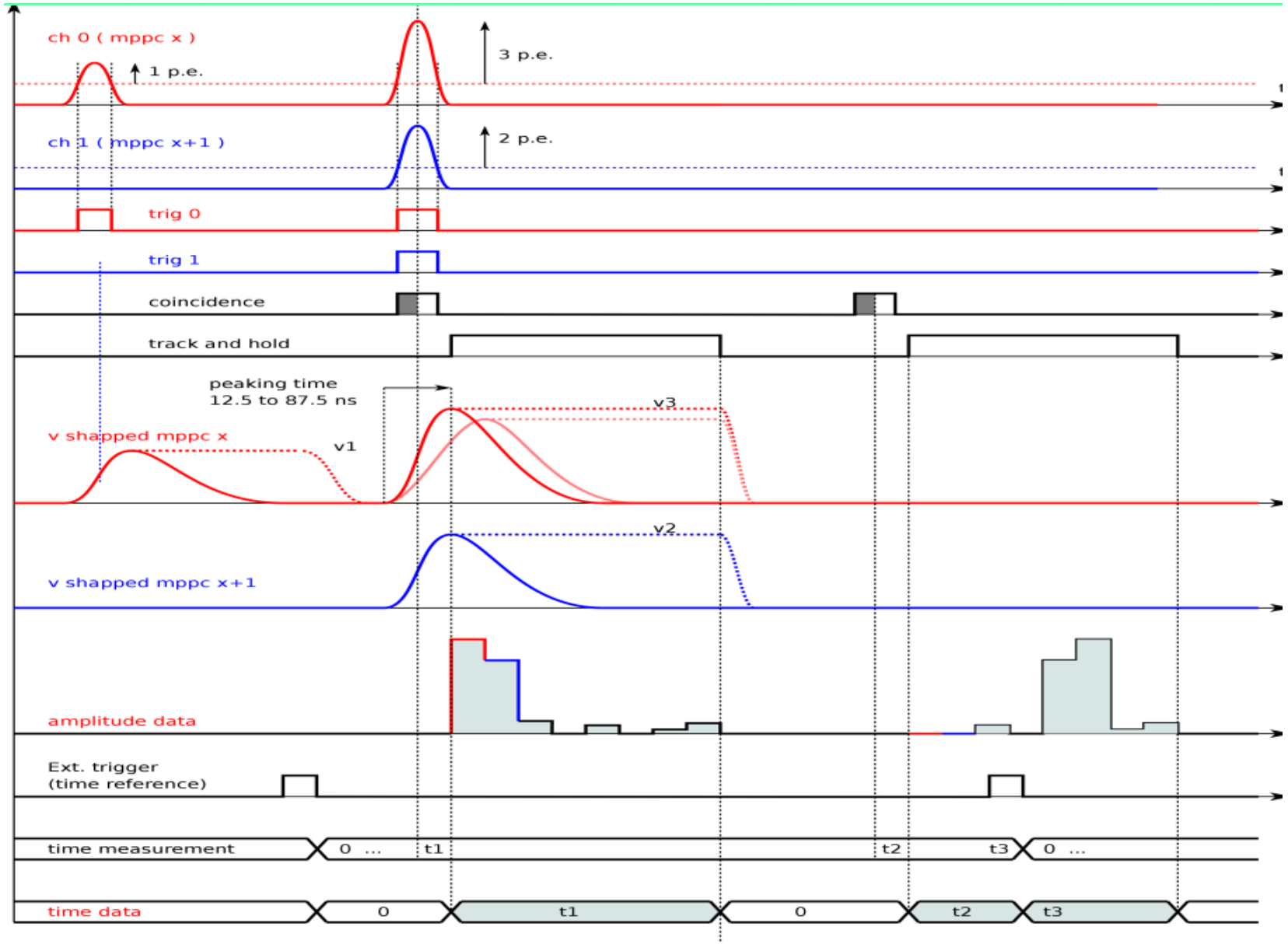
→ **CAEN A1702 "32 Channel Silicon Photomultipliers Readout Front-End Board"**

The same FEB will be used in the Far Detector of Side and Top CRT systems with some changes on the firmware.

The main functionalities of the board are reported below (from CAEN DataSheets):

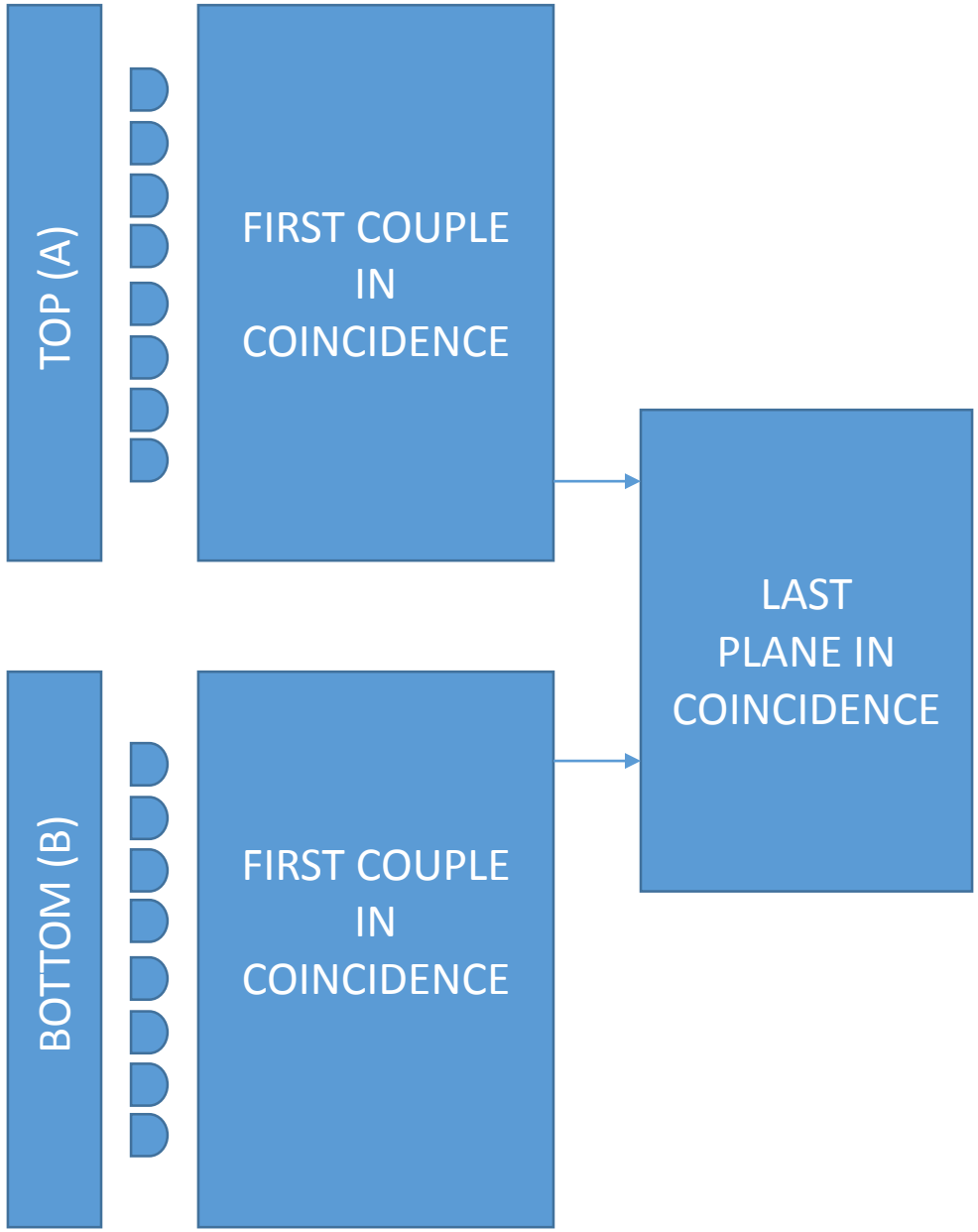
- Provides bias voltage in the range of 20-90 V, individually adjustable for each channel;
- Amplification and shaping of the SiPM output pulse;
- Discrimination of shaped signal at configurable level from 0 to 50 photo-electrons;
- Energy and time measurements;
- Provides basic coincidence of signals from each pair of adjacent even-odd channels;
- Multiple boards event validation using an external signal;
- LEMO I/O for time reference and control signals;
- Data buffering;
- Efficient back-end communication based on Ethernet standard;
- Daisy chain of up to 256 boards into one network interface;

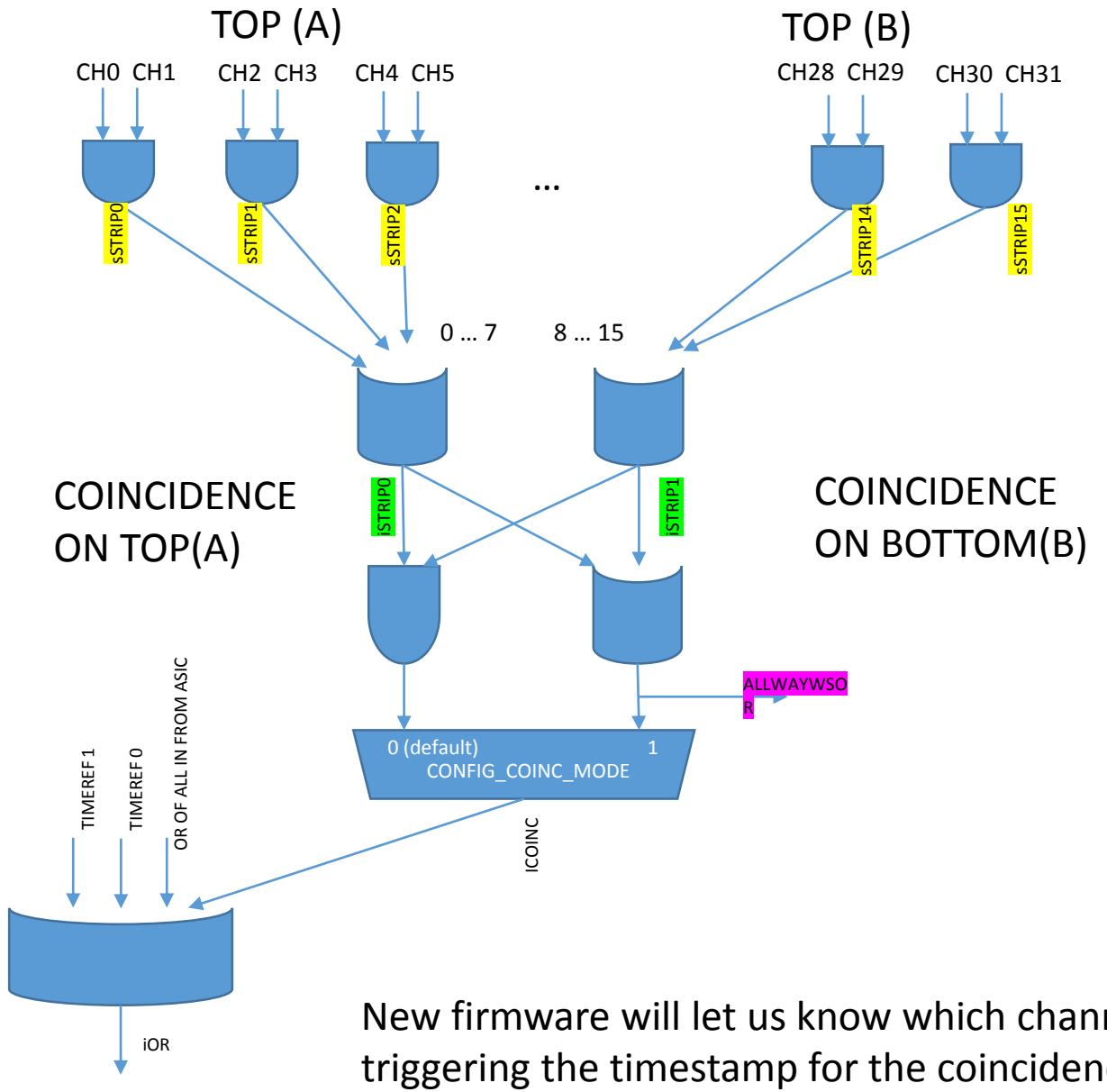
FEB timing diagram



Igor Kreslo, 2015

Specific firmware for Top CRT





New firmware will let us know which channels triggering the timestamp for the coincidence in X-Y layers.

Additional upgrade is ongoing in CAEN to add the remote programming features.

It will allow the firmware upgrade through Ethernet link.

8 FEBs are modified and upgraded to the latest firmware.

Tests of the first sample is ongoing in Bologna.

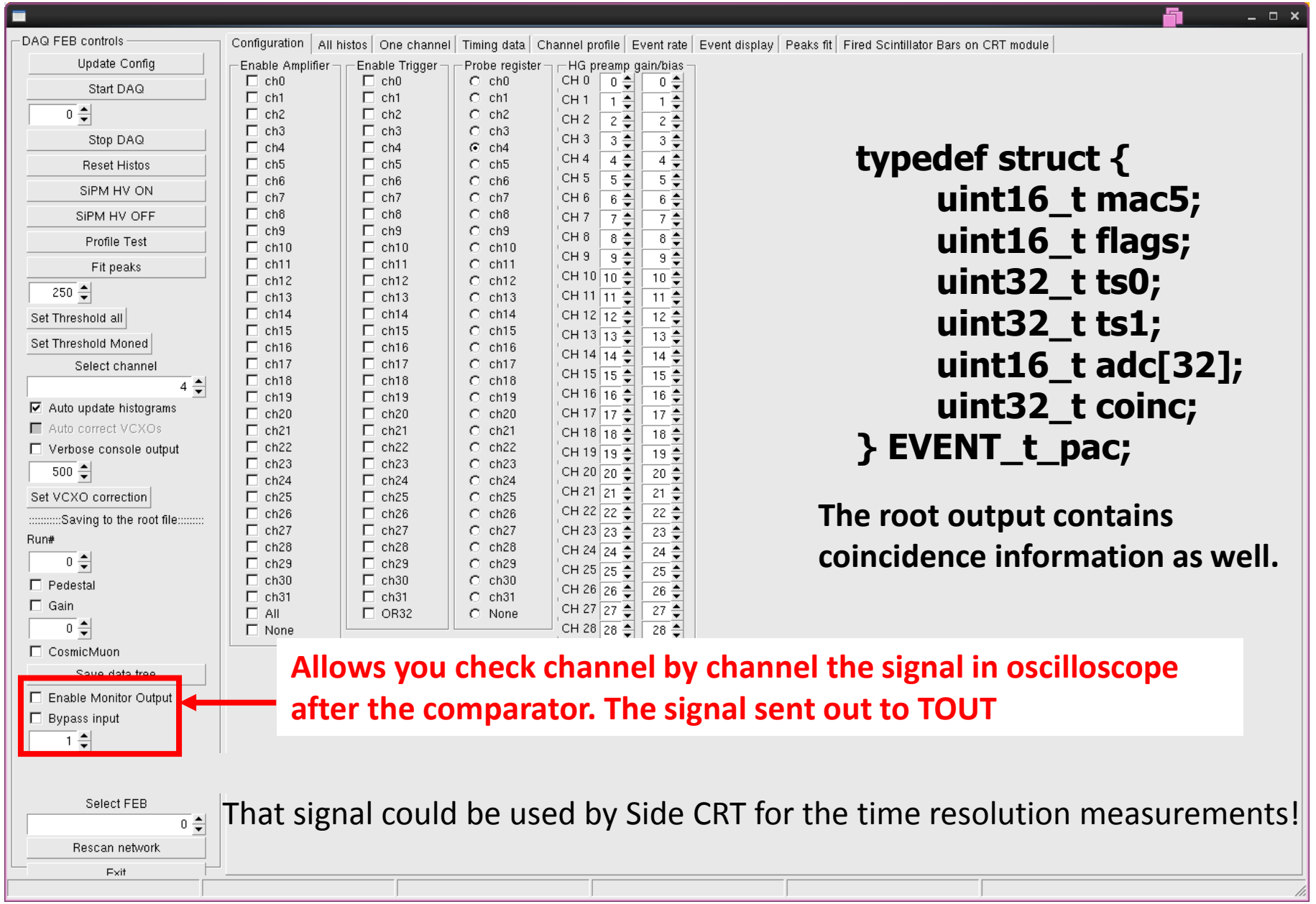
Thanks to Igor for providing us febdrv DAQ software: https://github.com/kreslo/febdrv
In the Top CRT data output, we are going to have also an information of the coincidence on ZMQ data backend structure.

```
typedef struct {
        uint16_t mac5;
        uint16_t flags;
        uint16_t lostcpu;
        uint16_t lostfpga;
        uint32_t ts0;
        uint32_t ts1;
        uint16_t adc[32];
} EVENT_t;
#define EVLEN 80
```

```
typedef struct {
        uint16_t mac5;
        uint16_t flags;
        uint16_t lostcpu;
        uint16_t lostfpga;
        uint32_t ts0;
        uint32_t ts1;
        uint16_t adc[32];
        uint32_t coinc;
} EVENT_t;
#define EVLEN 84
```

Test with multiFEB done!
Binary files converted to root
Format allowing us to use
CRT module monitor display!

Standalone DAQ contains one more features



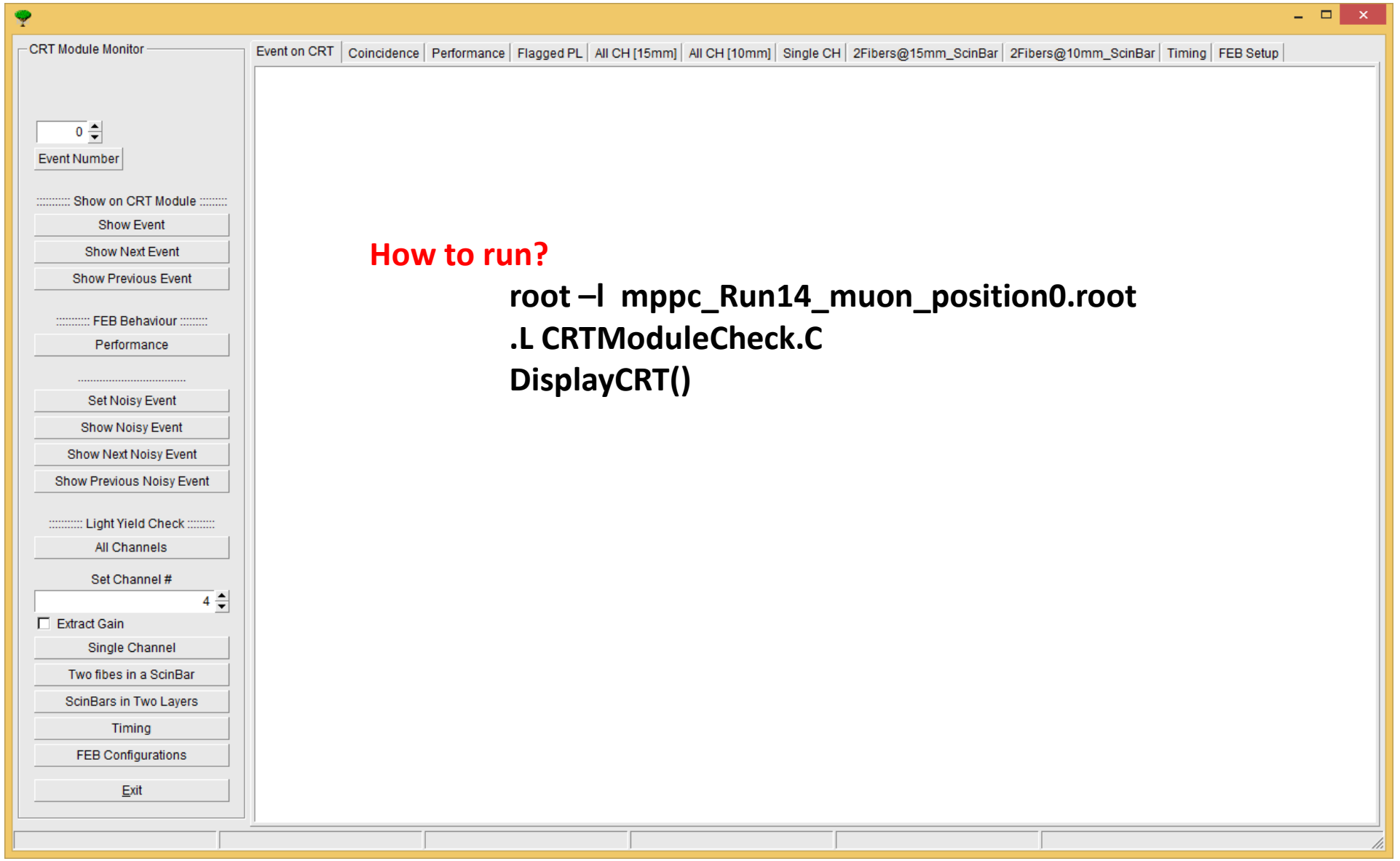

```
typedef struct {
        uint16_t mac5;
        uint16_t flags;
        uint32_t ts0;
        uint32_t ts1;
        uint16_t adc[32];
        uint32_t coinc;
} EVENT_t_pac;
```

The root output contains coincidence information as well.

Allows you check channel by channel the signal in oscilloscope after the comparator. The signal sent out to TOUT

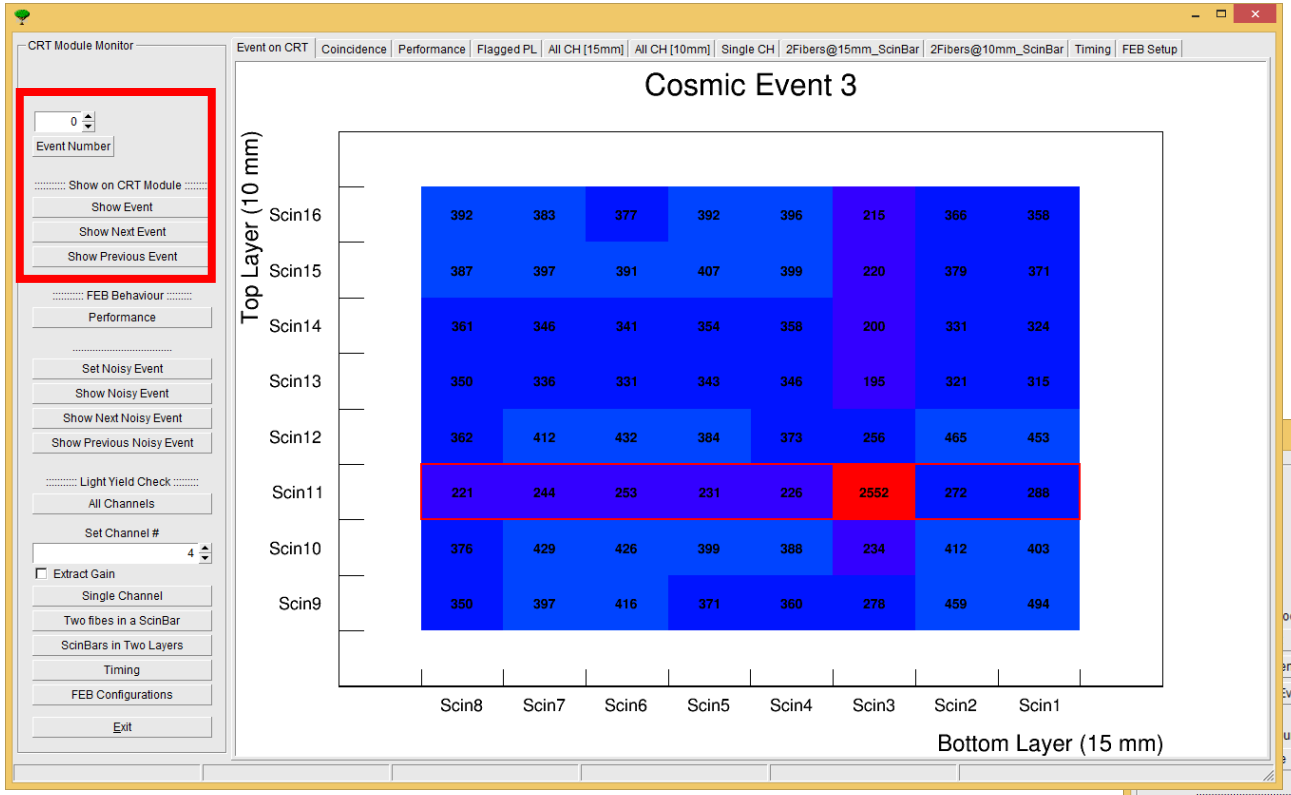
That signal could be used by Side CRT for the time resolution measurements!

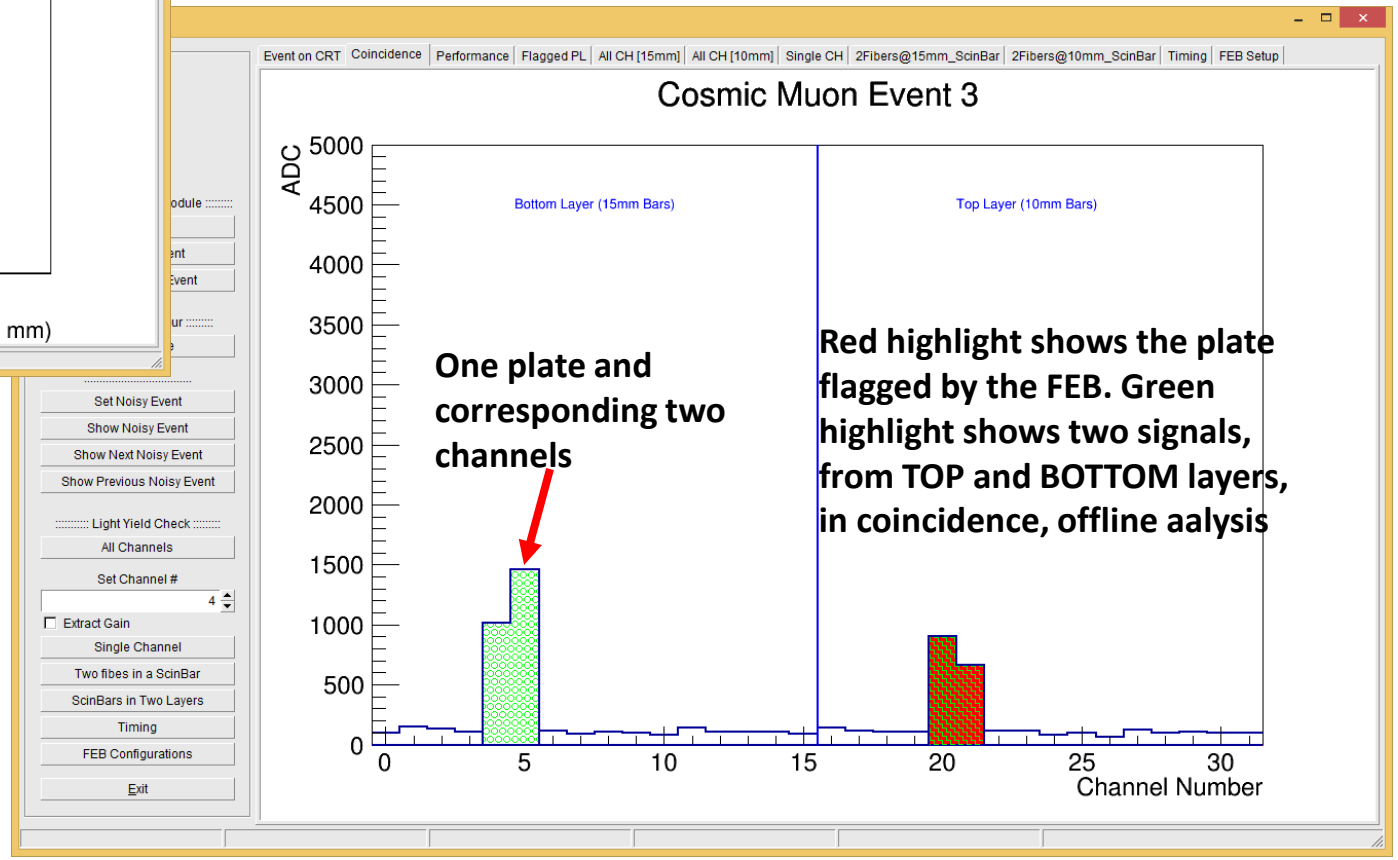
First version of CRT Monitor Display for test stand



How to run?

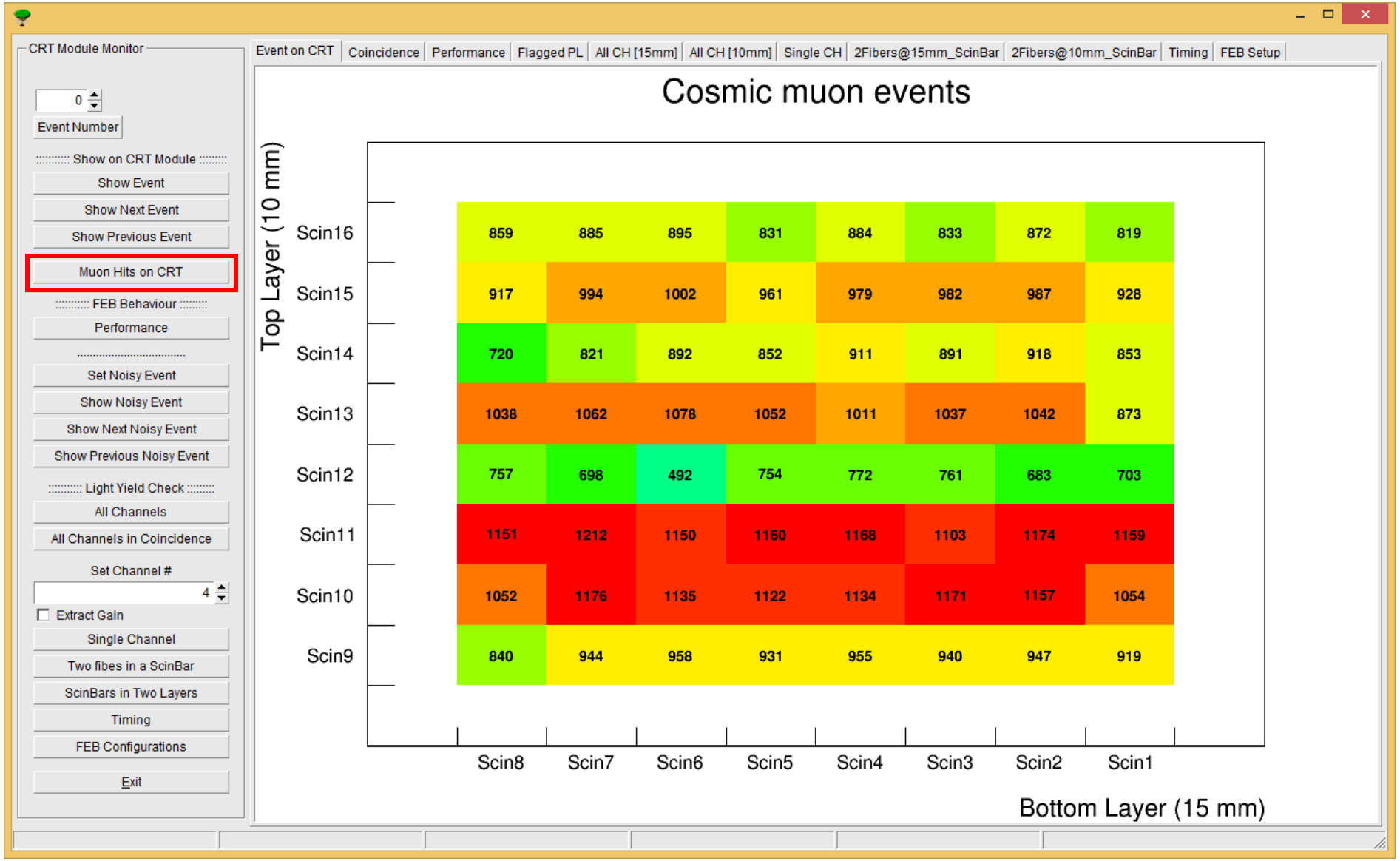
```
root –l  mppc_Run14_muon_position0.root
.L CRTModuleCheck.C
DisplayCRT()
```

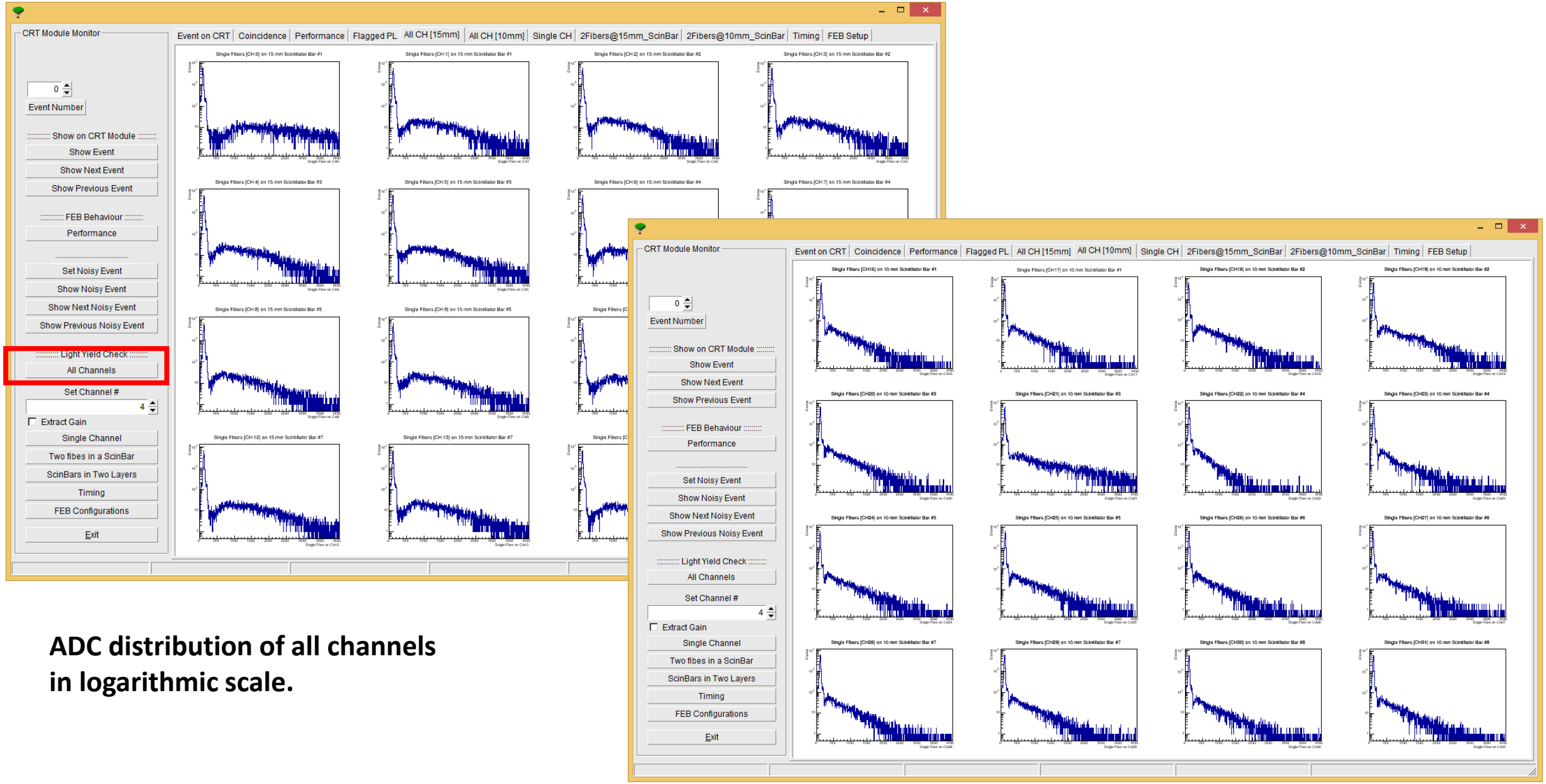




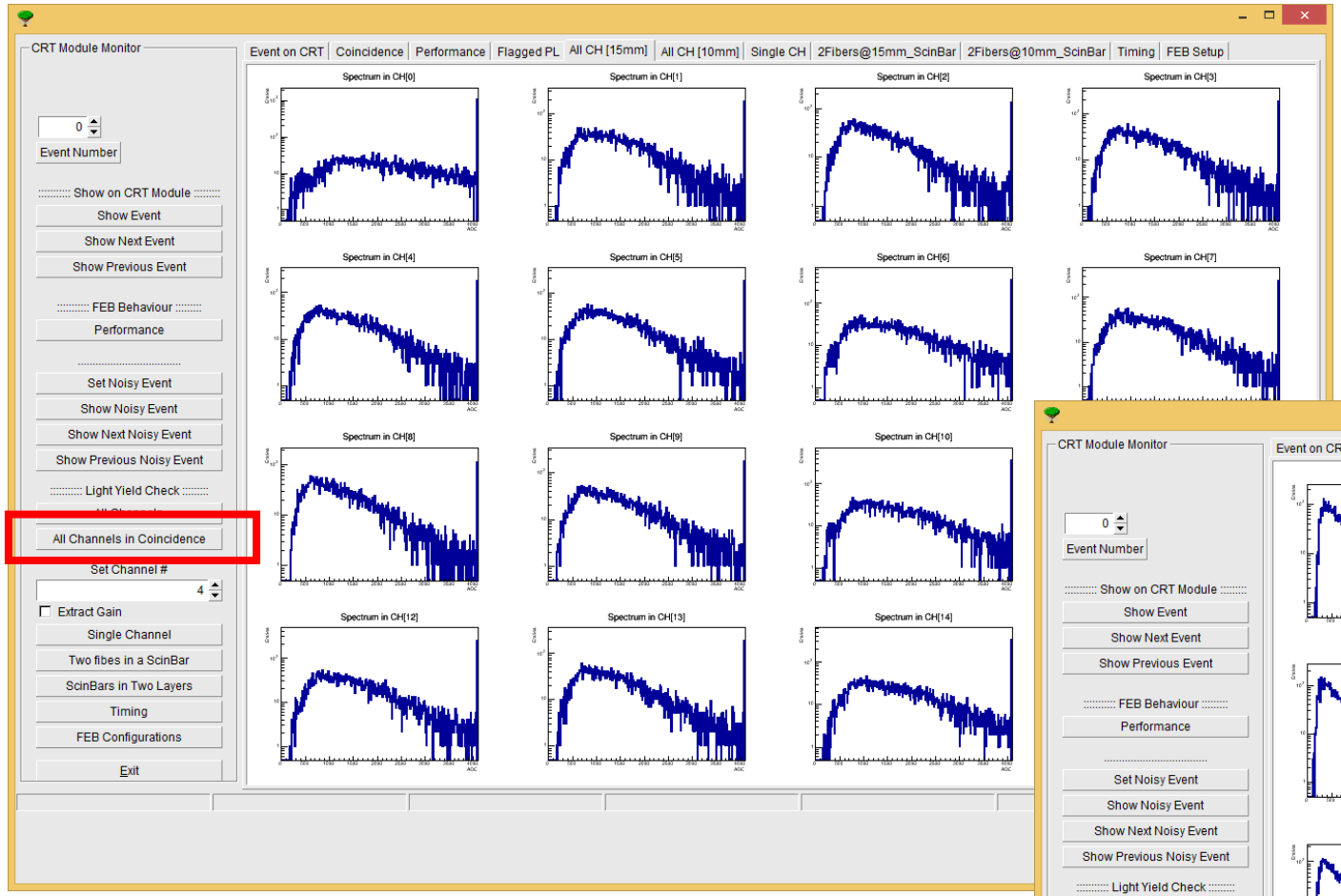
You can jump to any event by giving "Event Number" then click on "Show Event". It will create two plots one on tab "Event on CRT" and other on "Coincidence" tab. You can also go to previous and next event using the buttons of "Show Next Event" and "Show Previous Event" respectively.

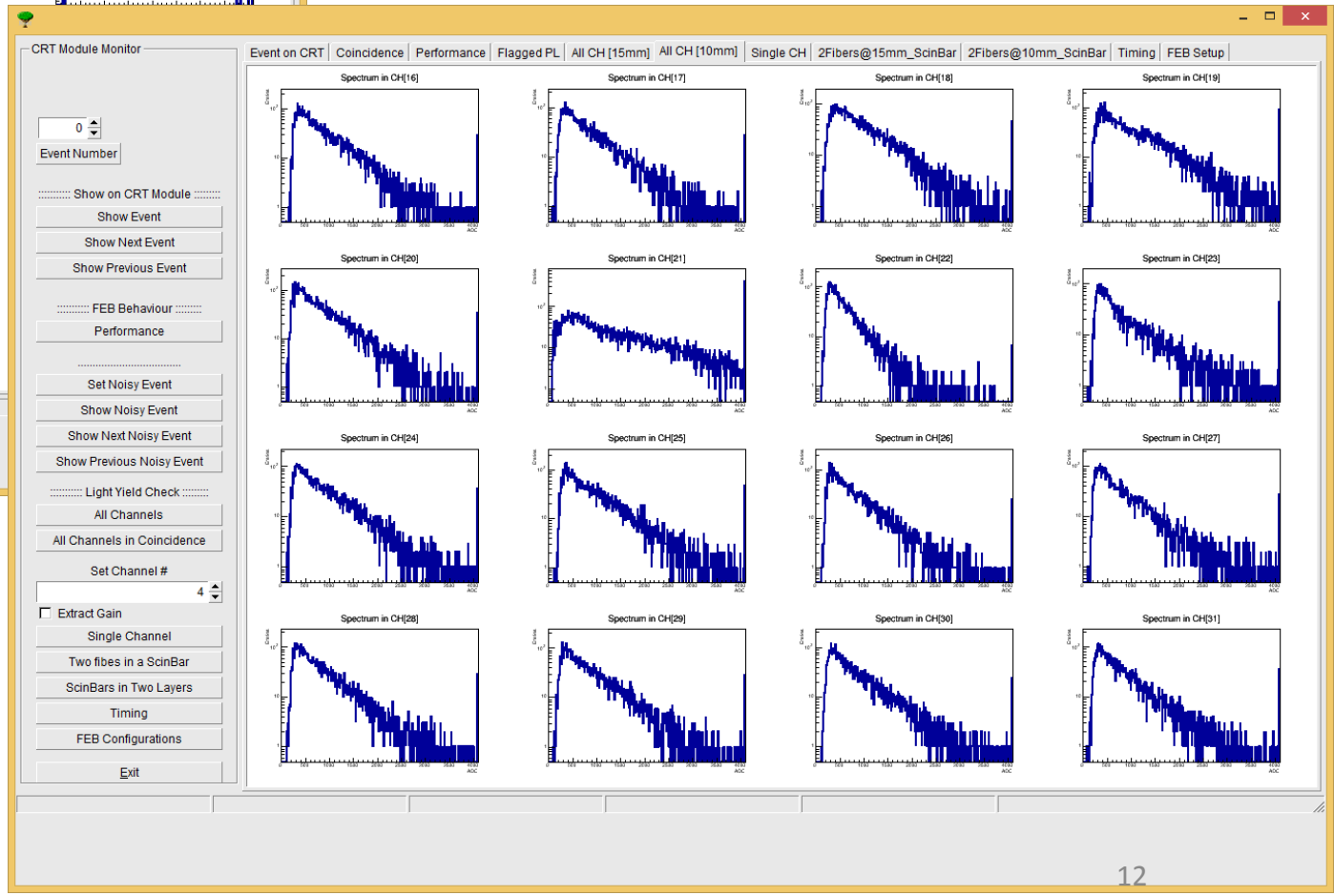
Muon hits on CRT Module





ADC distribution of all channels in logarithmic scale.





ADC distribution of all channels fire the coincidence (in logarithmic scale).

Added following P. Sala request!

CRT Module Monitor

0

Event Number

Show on CRT Module

Show Event

Show Next Event

Show Previous Event

FEB Behaviour

Performance

Set Noisy Event

Show Noisy Event

Show Next Noisy Event

Show Previous Noisy Event

Light Yield Check

All Channels

Set Channel #

8

Extract Gain

Single Channel

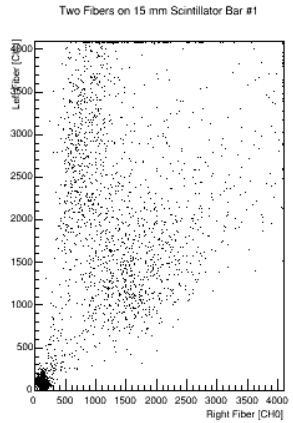
Two fibes in a ScinBar

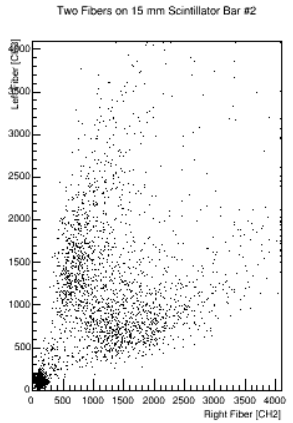
ScinBars in Two Layers

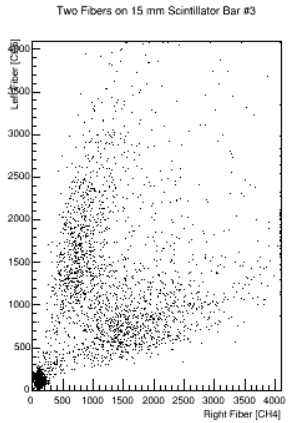
Timing

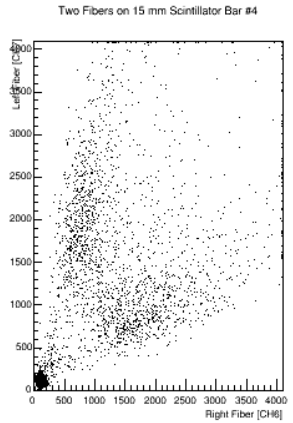
Exit

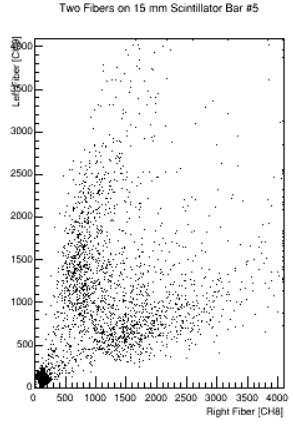
Event on CRT | Coincidence | Performance | Flagged PL | All CH [15mm] | All CH [10mm] | Single CH | 2Fibers@15mm_ScinBar | 2Fibers@10mm_ScinBar | Timing

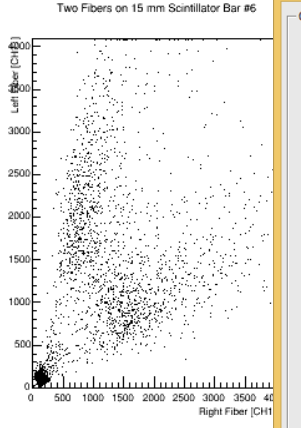












CRT Module Monitor

0

Event Number

Show on CRT Module

Show Event

Show Next Event

Show Previous Event

FEB Behaviour

Performance

Set Noisy Event

Show Noisy Event

Show Next Noisy Event

Show Previous Noisy Event

Light Yield Check

All Channels

Set Channel #

8

Extract Gain

Single Channel

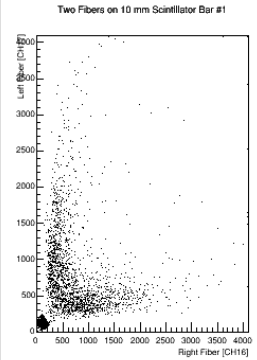
Two fibes in a ScinBar

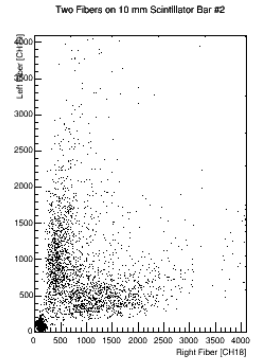
ScinBars in Two Layers

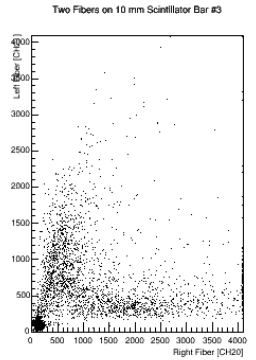
Timing

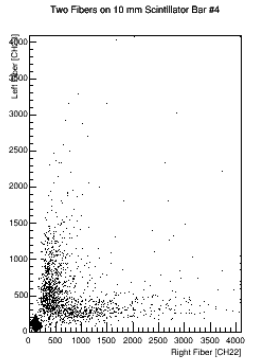
Exit

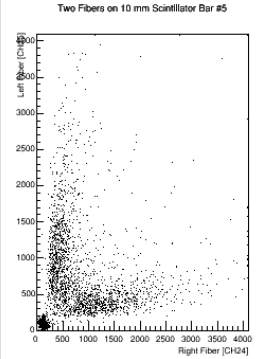
Event on CRT | Coincidence | Performance | Flagged PL | All CH [15mm] | All CH [10mm] | Single CH | 2Fibers@15mm_ScinBar | 2Fibers@10mm_ScinBar | Timing

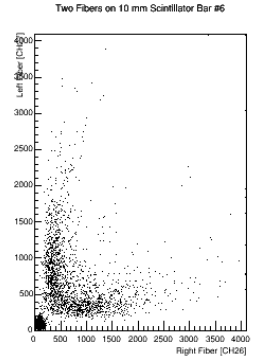


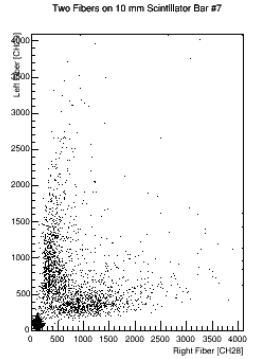


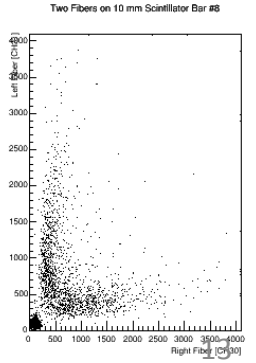


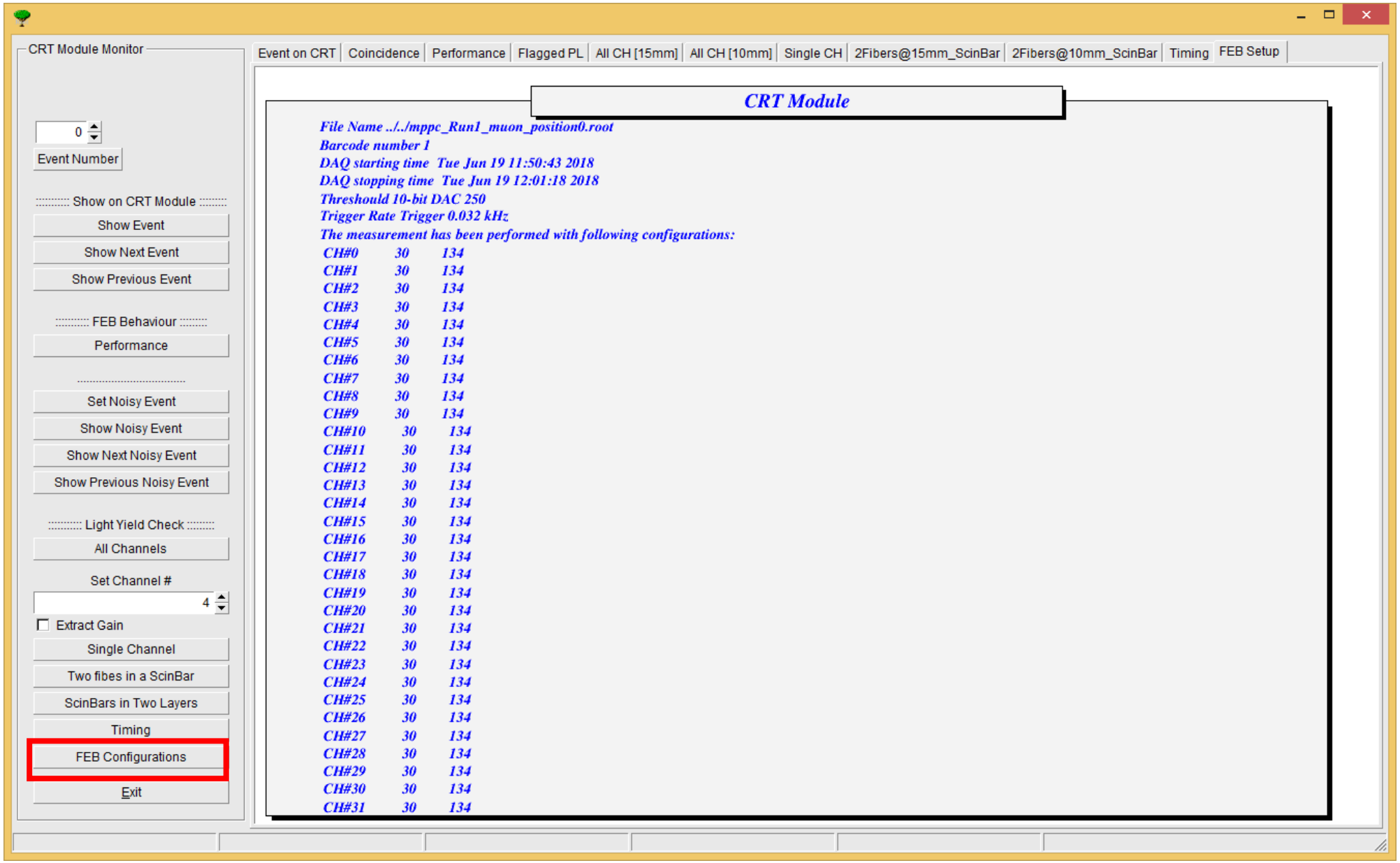











CRT Module Monitor
0
Event Number
Show on CRT Module
Show Event
Show Next Event
Show Previous Event
FEB Behaviour
Performance
Set Noisy Event
Show Noisy Event
Show Next Noisy Event
Show Previous Noisy Event
Light Yield Check
All Channels
Set Channel #
4
Extract Gain
Single Channel
Two fibes in a ScinBar
ScinBars in Two Layers
Timing
FEB Configurations
Exit
Event on CRT
Coincidence
Performance
Flagged PL
All CH [15mm]
All CH [10mm]
Single CH
2Fibers@15mm_ScinBar
2Fibers@10mm_ScinBar
Timing
FEB Setup
CRT Module
File Name ../../mppc_Run1_muon_position0.root
Barcode number 1
DAQ starting time Tue Jun 19 11:50:43 2018
DAQ stopping time Tue Jun 19 12:01:18 2018
Threshould 10-bit DAC 250
Trigger Rate Trigger 0.032 kHz
The measurement has been performed with following configurations:
CH#0 30 134
CH#1 30 134
CH#2 30 134
CH#3 30 134
CH#4 30 134
CH#5 30 134
CH#6 30 134
CH#7 30 134
CH#8 30 134
CH#9 30 134
CH#10 30 134
CH#11 30 134
CH#12 30 134
CH#13 30 134
CH#14 30 134
CH#15 30 134
CH#16 30 134
CH#17 30 134
CH#18 30 134
CH#19 30 134
CH#20 30 134
CH#21 30 134
CH#22 30 134
CH#23 30 134
CH#24 30 134
CH#25 30 134
CH#26 30 134
CH#27 30 134
CH#28 30 134
CH#29 30 134
CH#30 30 134
CH#31 30 134