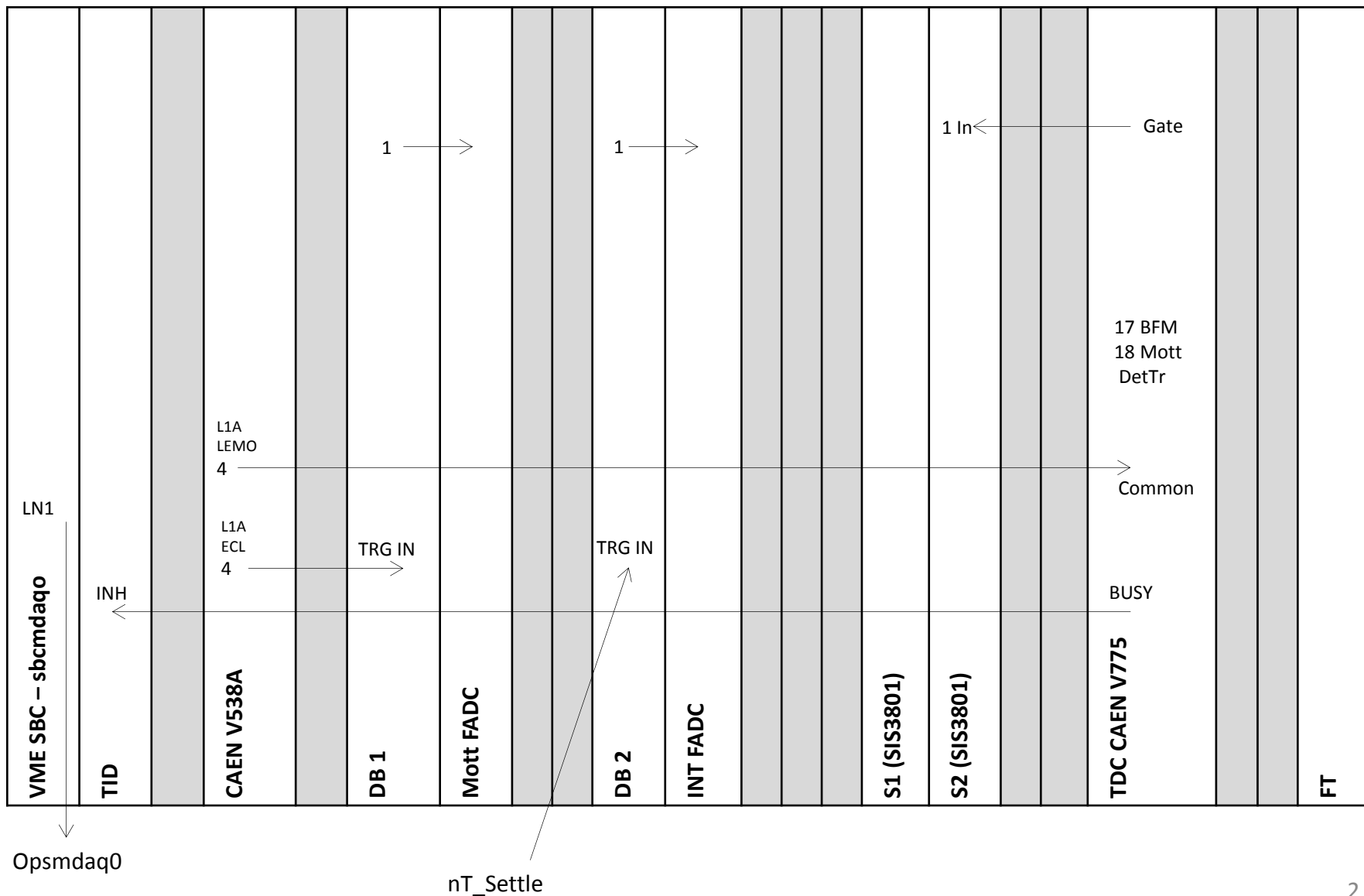


Mott DAQ Speed

February 16, 2015

VME CRATE (VME8200 9U 21Slot - VME64x backplane with no P0 connector)



Data Taking Configurations

Name	Readout	Trigger
Scalers	Scaler S1 (helicity gated), S2 (un-gated)	Delayed nT_Settle
Mott_Sample	Mott FADC (Mode=1), S1, S2, TDC	Mott Detector
Mott_SemiInt	Mott FADC (Mode=7), S1, S2, TDC	Mott Detector
PEPPo_Int	INT FADC, S1, S2	nT_Settle
SemiIntFast	Mott FADC (Mode=7), BlockLevel=1	Mott Detector
SemiIntBlock	Mott FADC (Mode=7), BlockLevel=50	Mott Detector

Use Faster DAQ Mode

- For DAQ to be faster:
 - No Readout of CAEN V775 TDC or SIS3801 Scalers; only FADC readout
 - Use block readout
- FADC has a mode with smaller data size and time readout: Pulse Integral and High Resolution Time Mode
- What about scalers?
- We took data with this mode ... results are shown next ...

Comparison of:

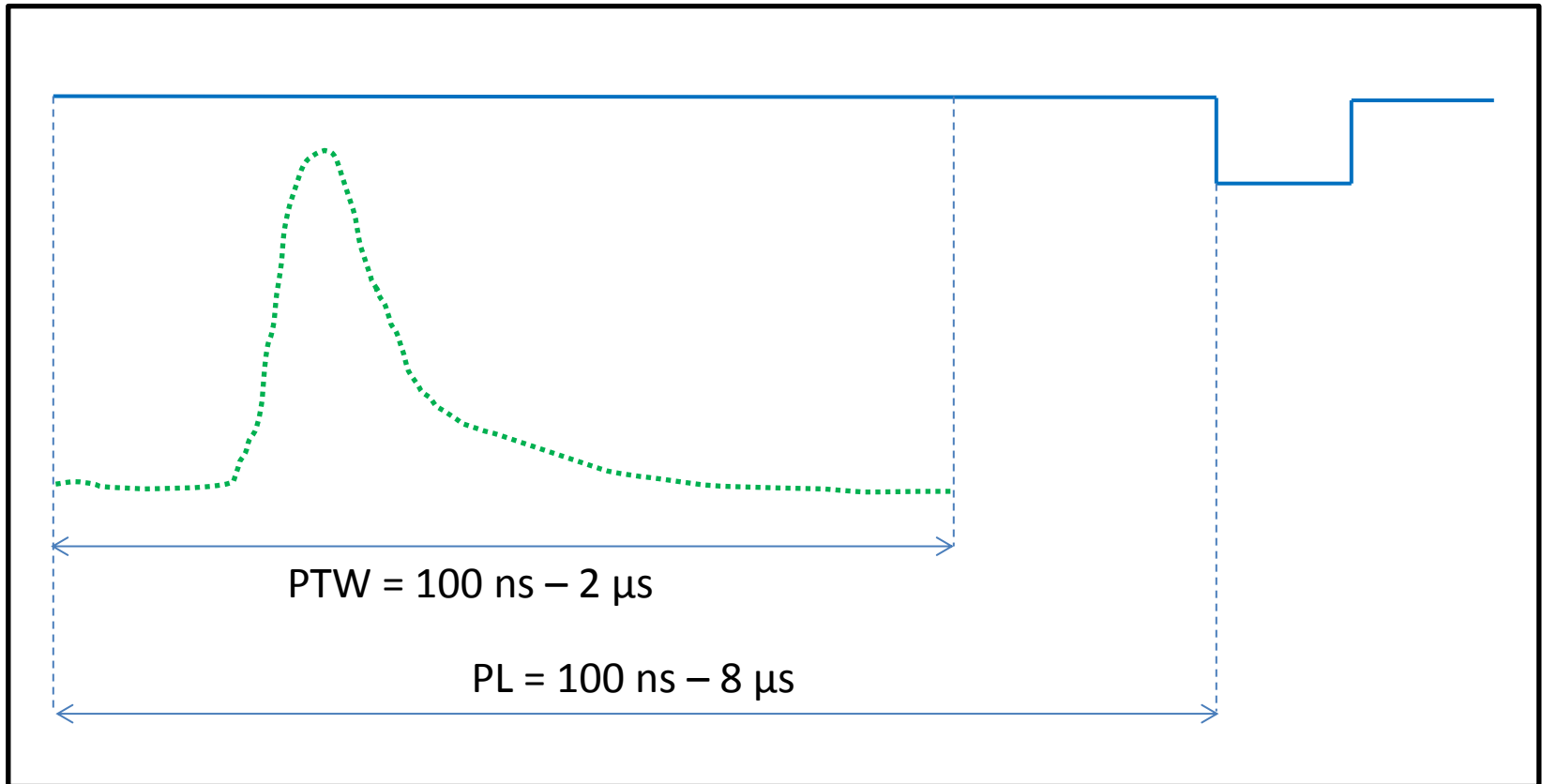
Raw ADC Data Samples Mode

vs.

Pulse Integral and High Resolution Time
Mode

RAW ADC DATA SAMPLES – RUN 7673

Raw ADC Data Samples



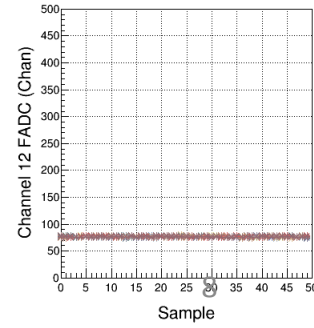
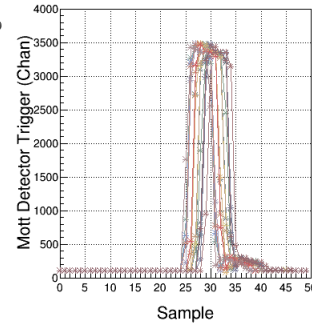
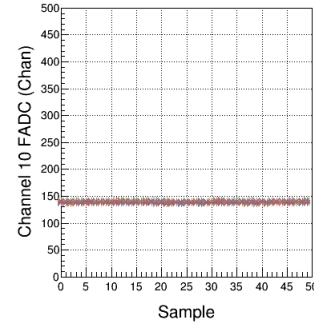
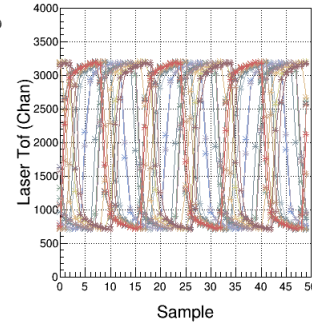
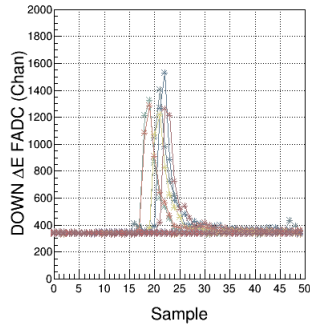
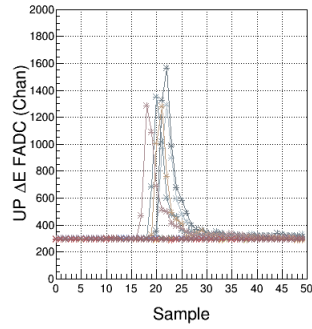
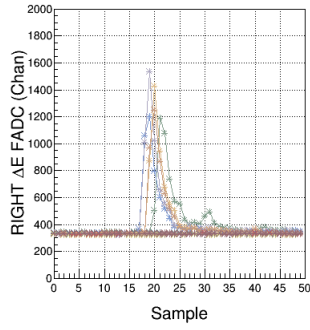
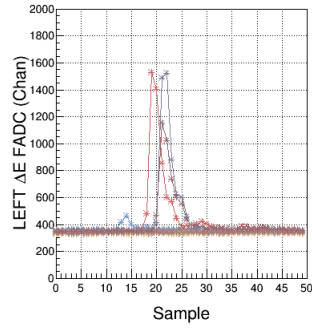
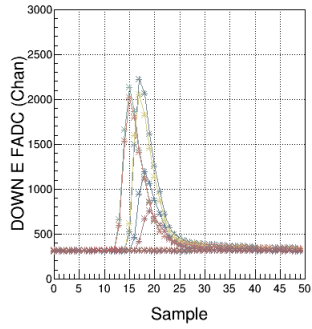
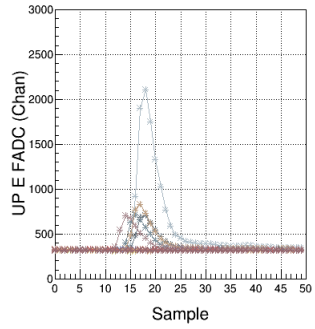
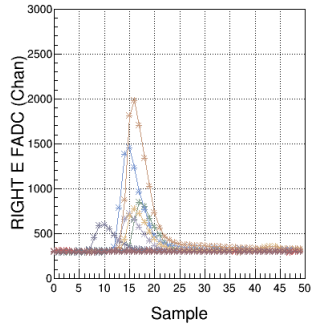
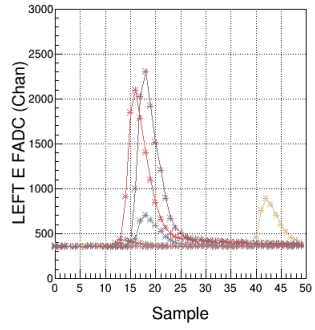
Mott Settings:

- I. Programmable Latency (PL) = 60 samples
- II. Programmable Trigger Window (PTW) = 50 samples
- III. Threshold = 0
- IV. Each Sample = 4 ns (250 MHz), 0 – 4096 (2^{12})

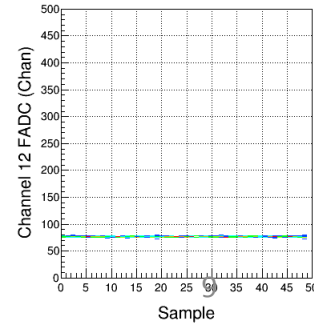
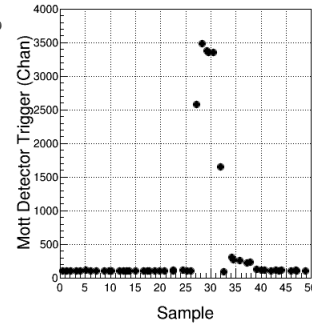
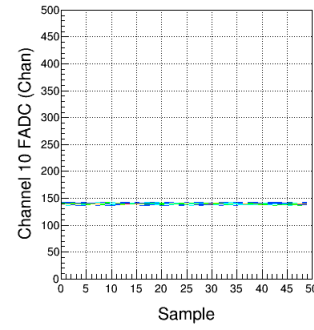
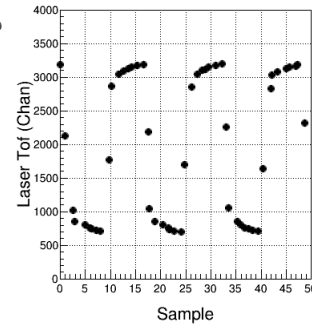
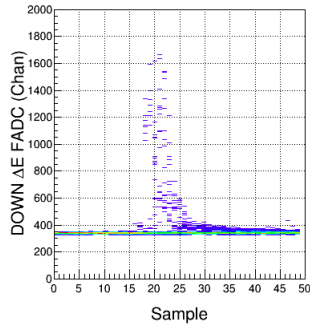
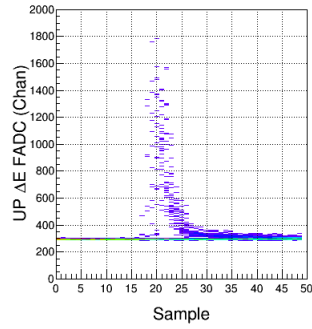
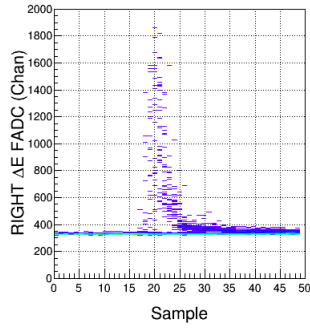
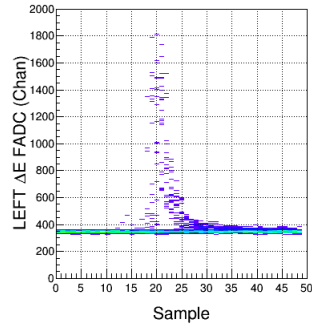
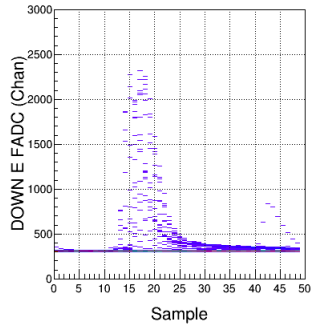
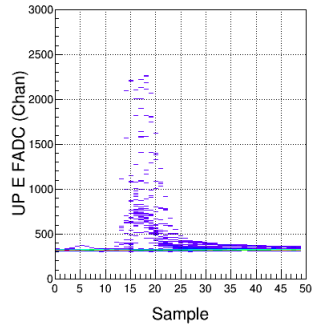
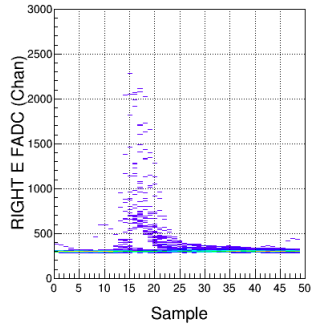
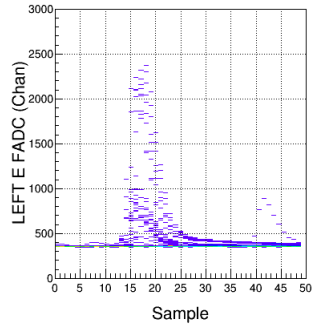
Mott Readout:

- I. 50 samples

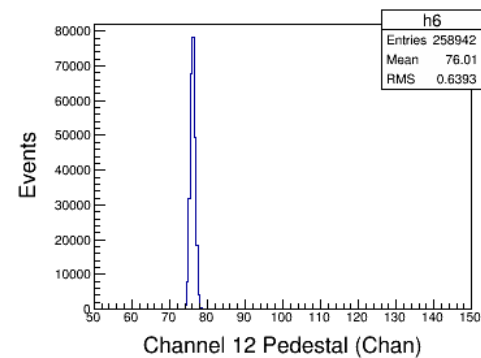
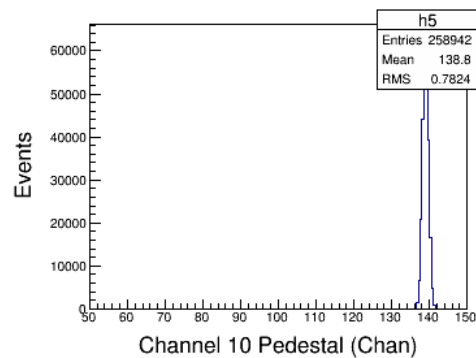
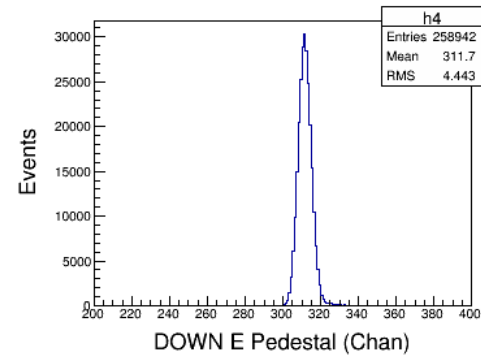
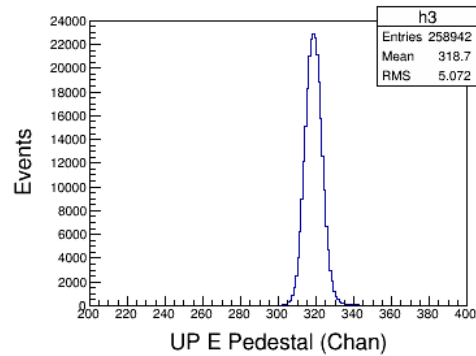
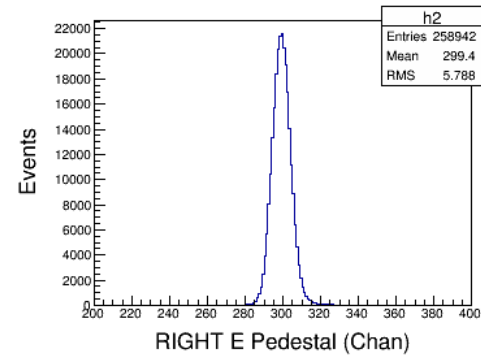
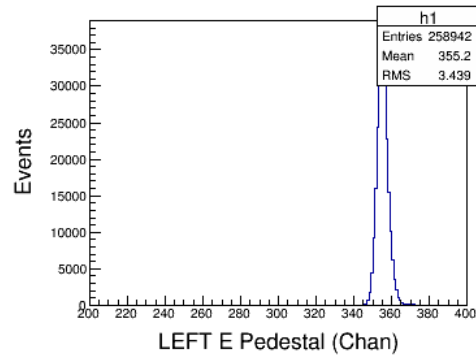
Samples



Samples

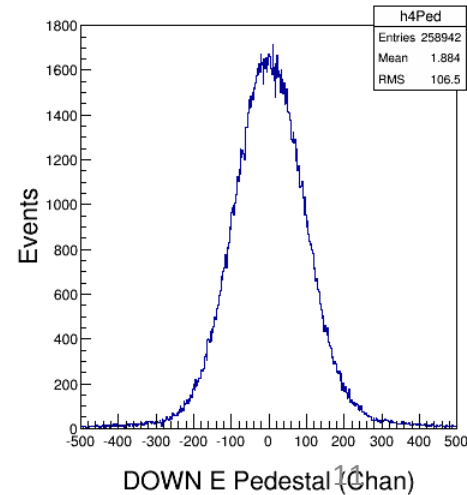
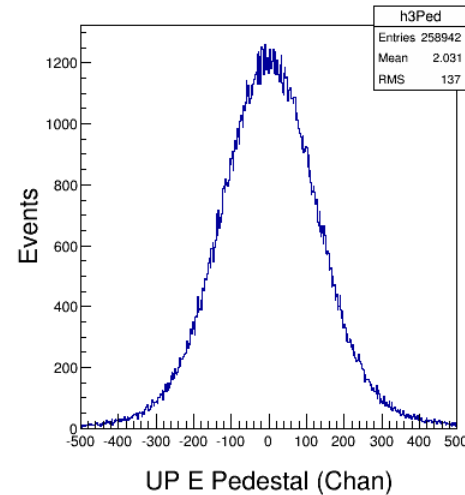
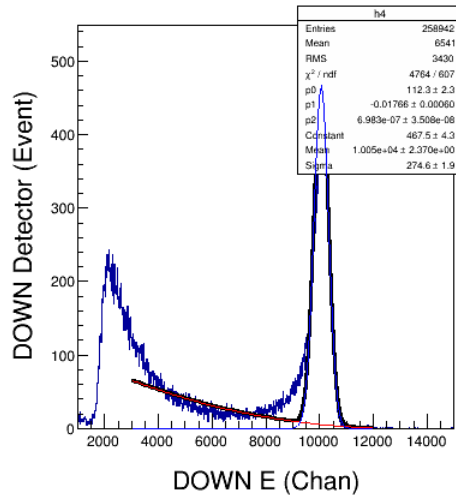
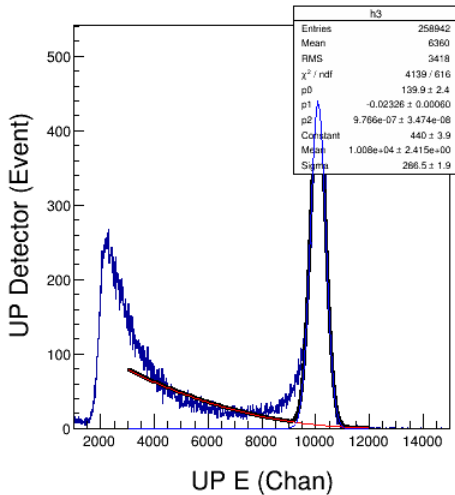
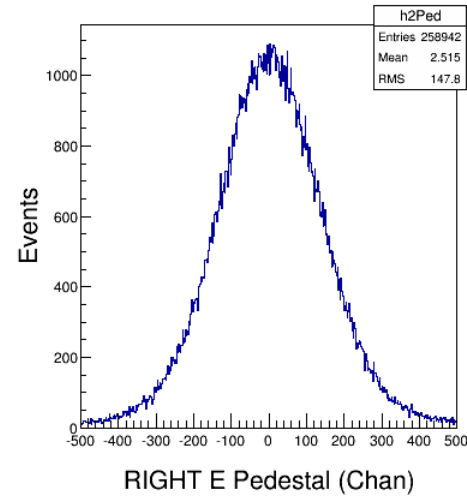
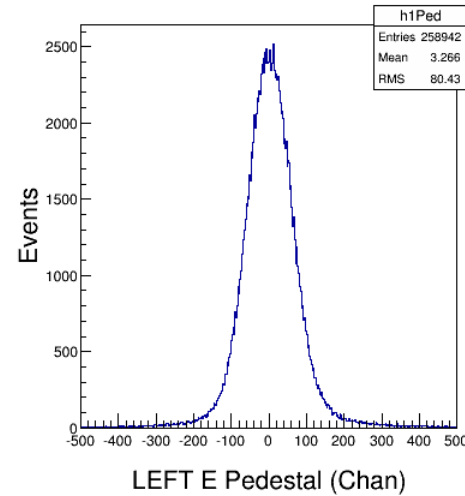
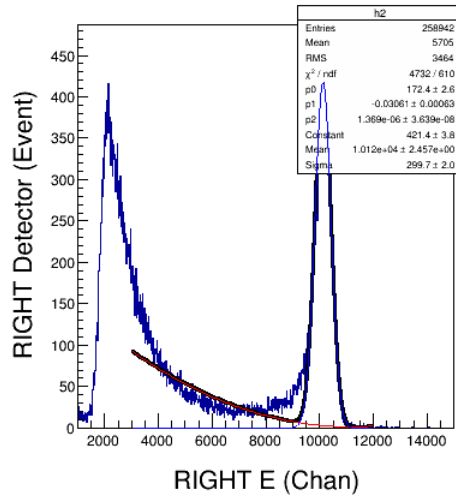
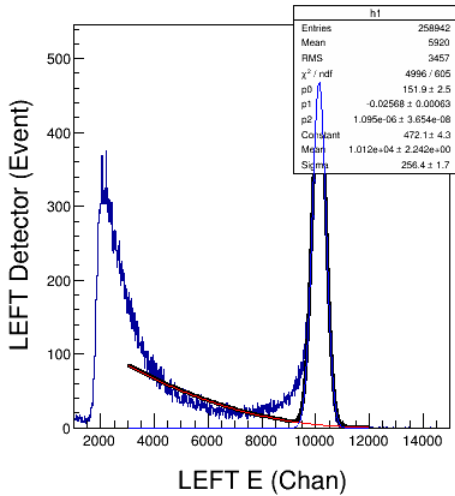


Analysis: Pedestals

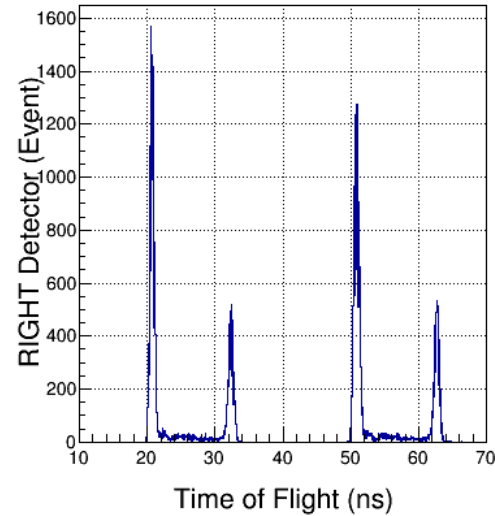
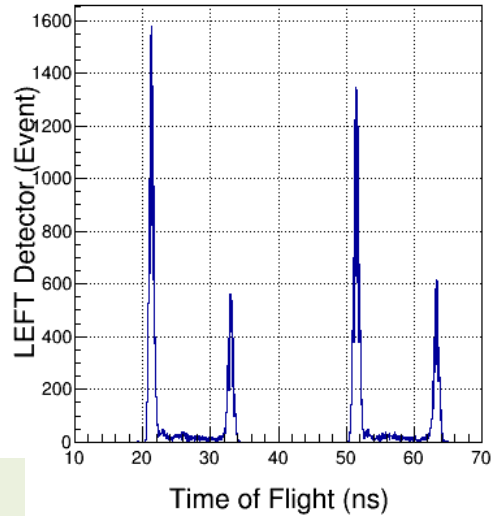


Analysis: Energy

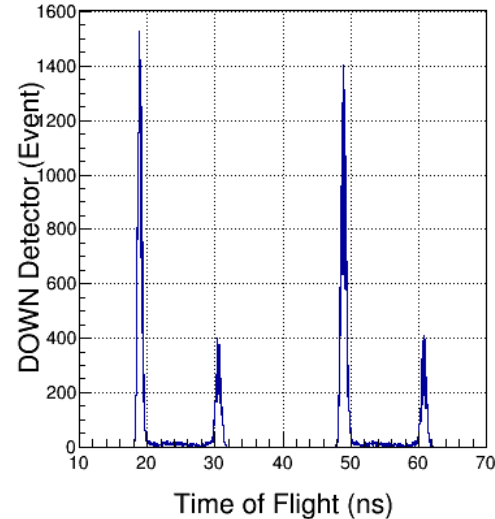
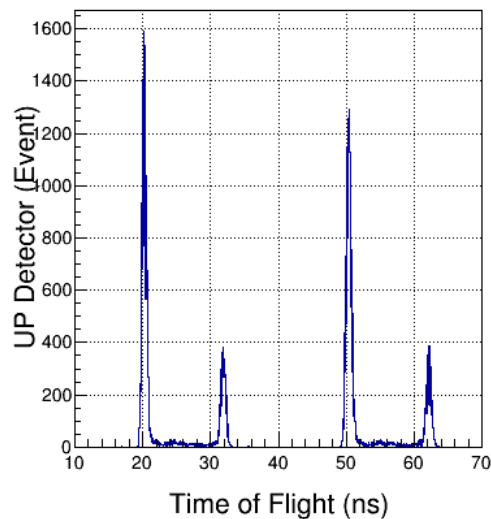
$$\sigma_E \sim 2.7\%$$



Analysis: Time-of-flight

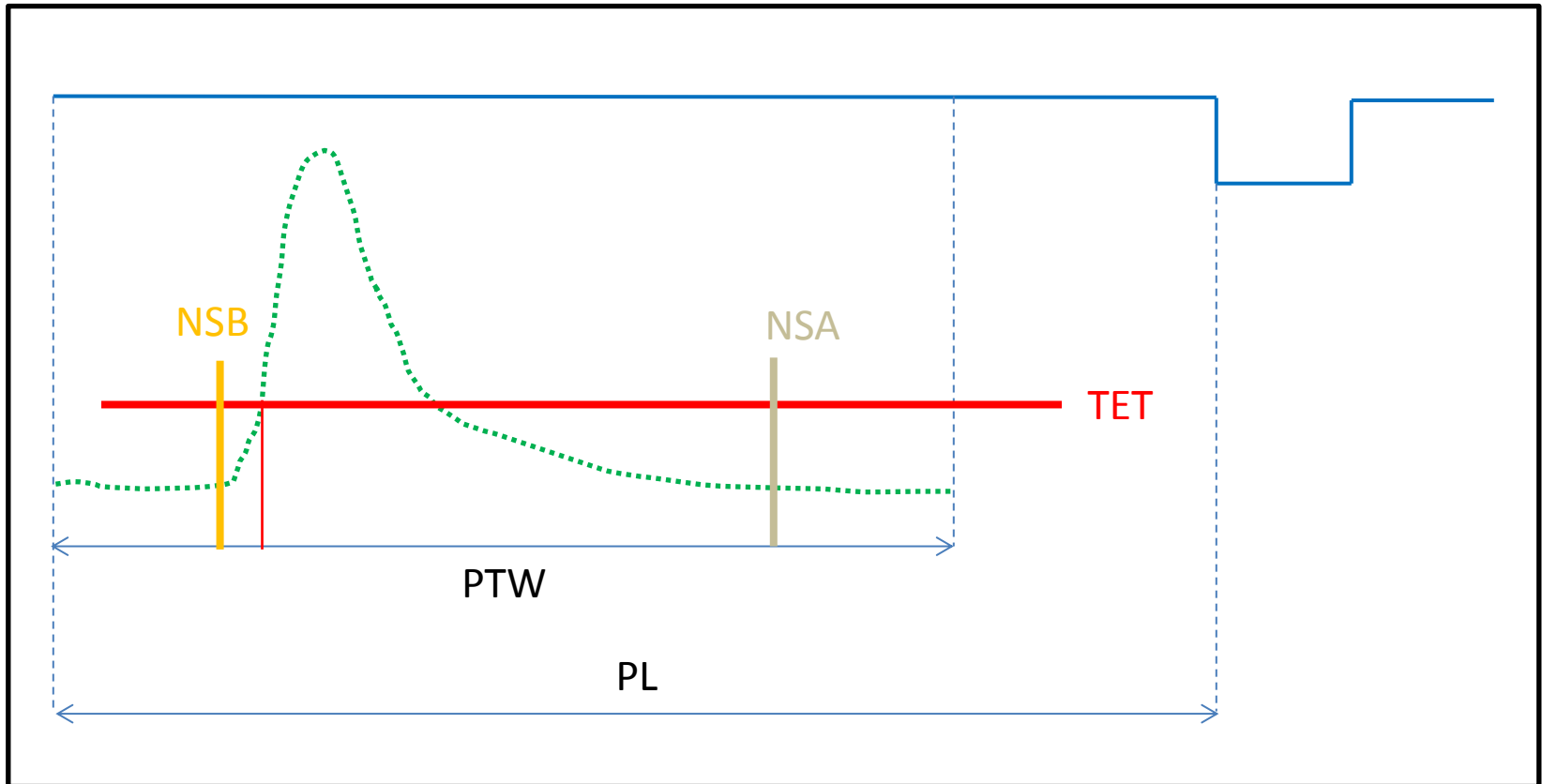


$$\sigma_t \sim 0.2 \text{ ns}$$



PULSE INTEGRAL AND HIGH RESOLUTION TIME – RUN 7672

Pulse Integral & High Resolution Time



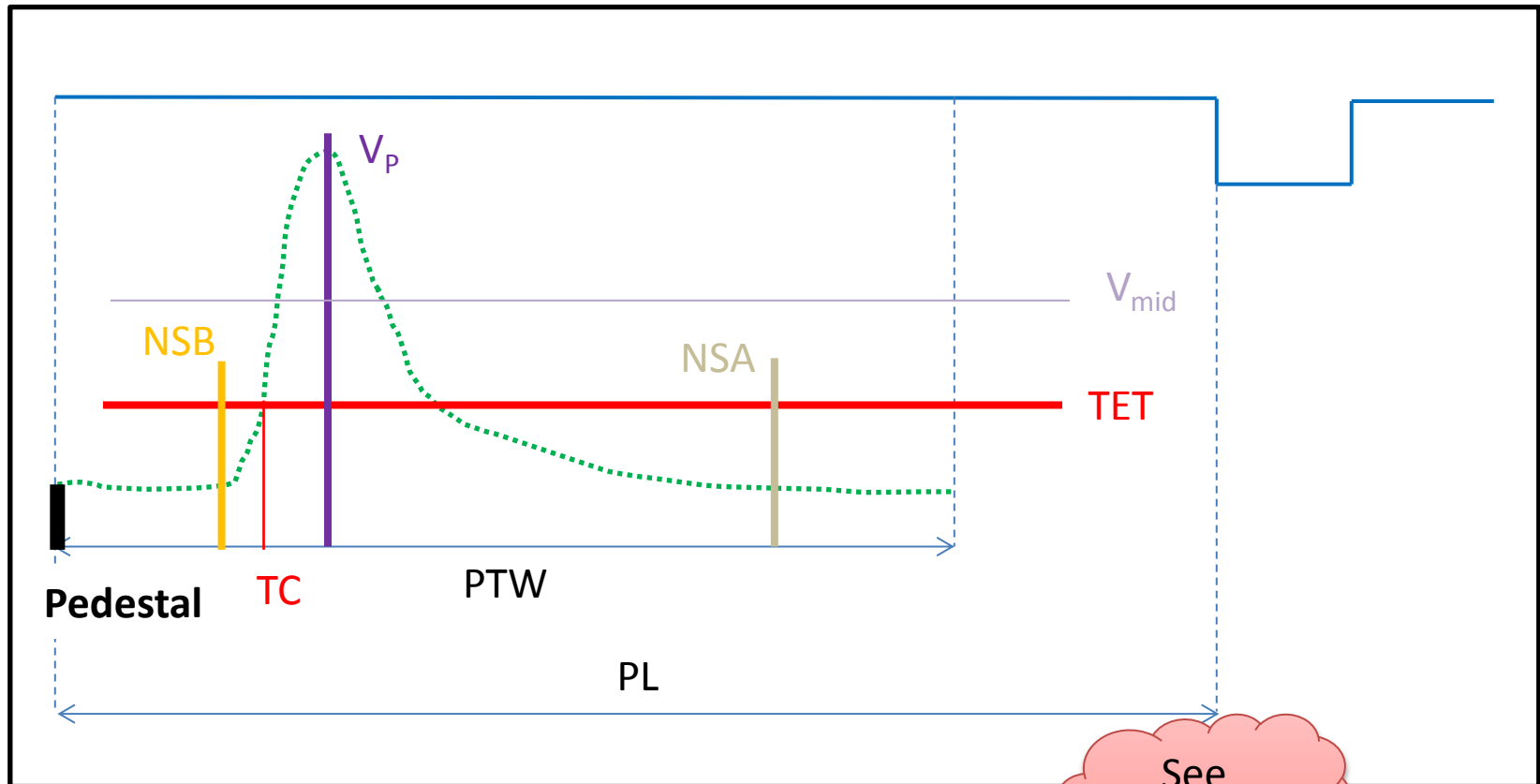
Mott Settings:

- I. $PL = 60$ samples, $PTW = 50$ samples, $NW = NSB + NSA$
- II. Programmable Trigger Energy Threshold (TET)
- III. Number of pulses (NP) in $PTW = 1$ (up to 3 pulses)
- IV. Number of Samples Before threshold crossing (NSB) = 5
- V. Number of Samples After threshold crossing (NSA) = 28

TET

```
fadc_threshold[0] = 600; // CH1 - E LEFT
fadc_threshold[1] = 600; // CH2 - E RIGHT
fadc_threshold[2] = 600; // CH3 - E UP
fadc_threshold[3] = 600; // CH4 - E DOWN
fadc_threshold[4] = 600; // CH5 - dE LEFT
fadc_threshold[5] = 600; // CH6 - dE RIGHT
fadc_threshold[6] = 600; // CH7 - dE UP
fadc_threshold[7] = 600; // CH8 - dE DOWN
fadc_threshold[8] = 1750; // CH9 - BFM
fadc_threshold[9] = 100; // CH10 - Free
fadc_threshold[10]= 1000; // CH11 - Mott Trigger
fadc_threshold[11]= 100; // CH12 - Free
fadc_threshold[12]= 10; // CH13 - Delayed Helicity
fadc_threshold[13]= 10; // CH14 - T_Settle
fadc_threshold[14]= 10; // CH15 - Pat Sync
fadc_threshold[15]= 10; // CH16 - Pair Sync
```

Pulse Integral & High Resolution Time



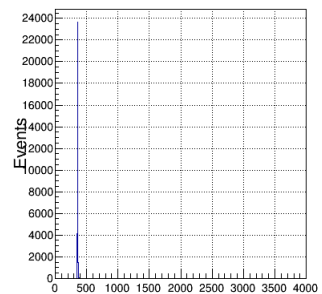
Mott Readout:

- I. Pedestal = Average of first 4 samples of window
- II. Peak Value (V_p)
- III. Pulse Integral = Sum of raw samples $\text{MIN}(\text{NSB}+\text{NSA}, \text{PTW})$
- IV. Pulse Coarse Time = Sample number N_1 such that $V(N_1) \leq (V_p - \text{Ped})/2 < V(N_2)$
- V. Pulse Fine Time = $64 (V_{\text{mid}} - V(N_1)) / (V(N_2) - V(N_1))$. From 0 to 63 in steps of 62.5 ps

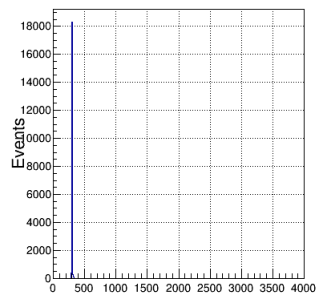
See
Note 1

See
Note 2

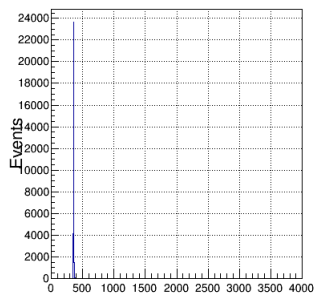
Pulse Pedestal



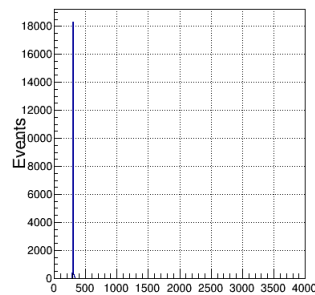
Pedestal - LEFT E (Chan)



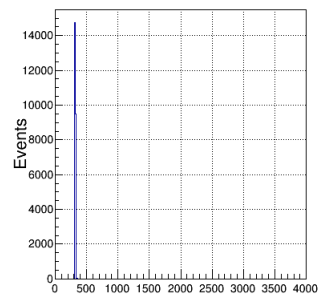
Pedestal - RIGHT E (Chan)



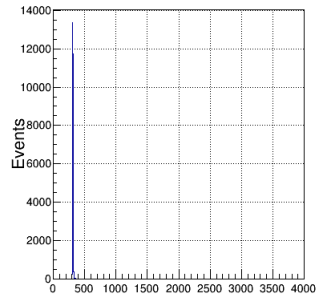
Pedestal - LEFT E (Chan)



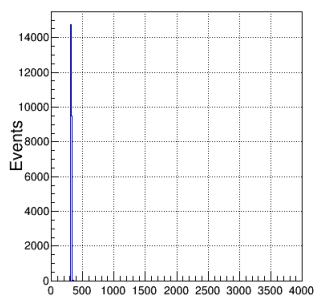
Pedestal - RIGHT E (Chan)



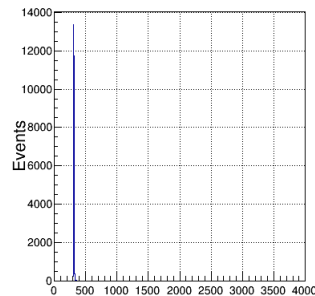
Pedestal - UP E (Chan)



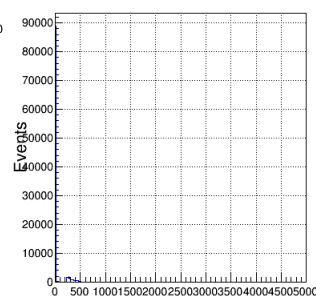
Pedestal - DOWN E (Chan)



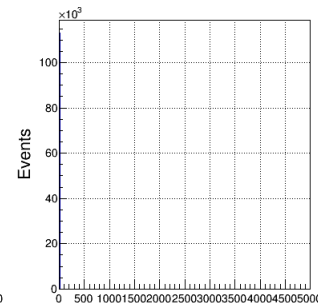
Pedestal - UP E (Chan)



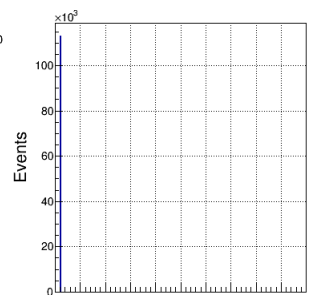
Pedestal - DOWN E (Chan)



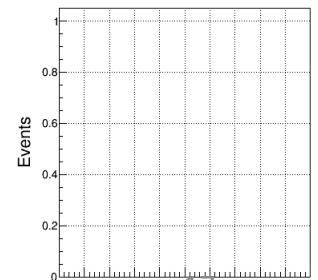
Pedestal - Laser ToF (Chan)



Pedestal - Channel 10 (Chan)

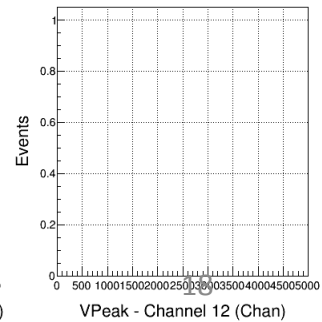
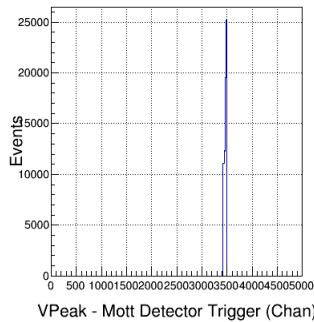
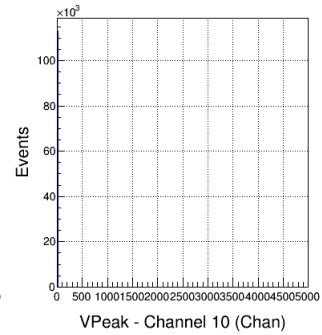
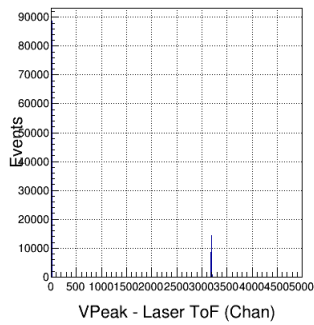
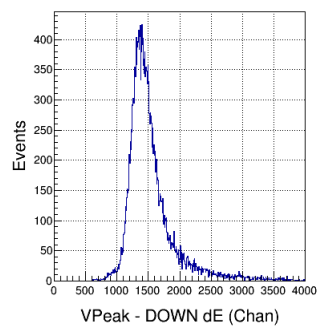
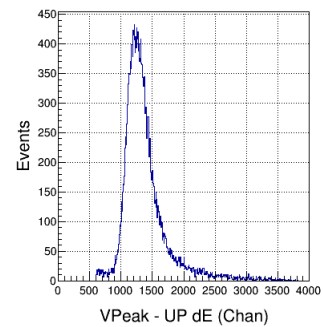
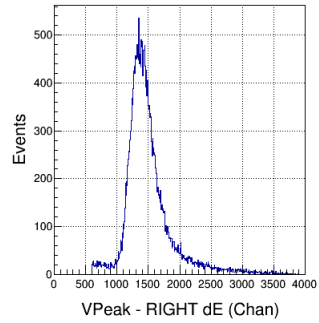
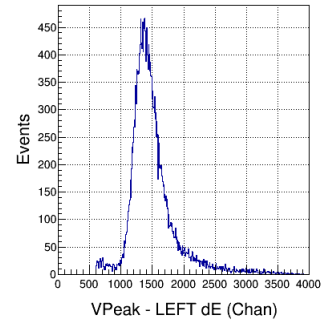
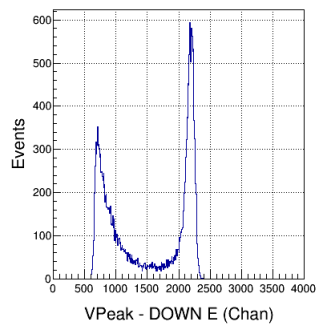
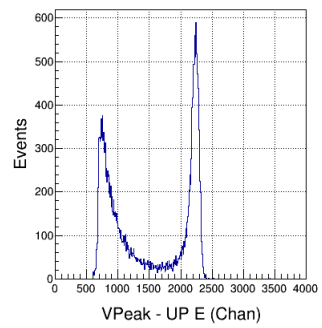
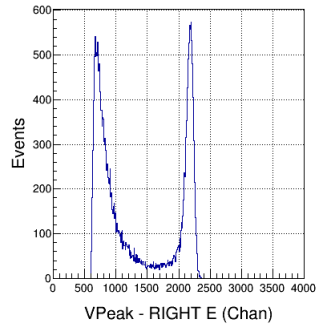
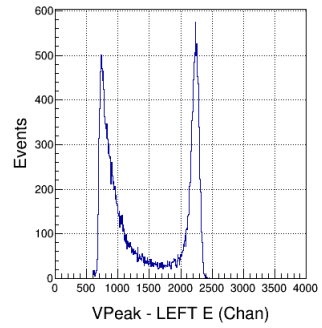


Pedestal - Mott Detector Trigger (Chan)

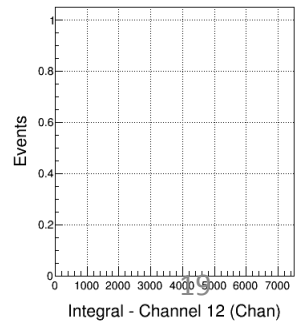
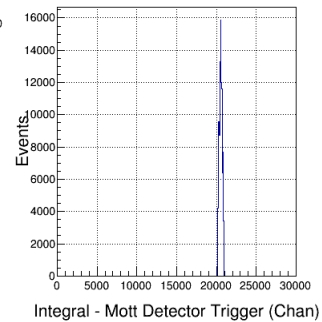
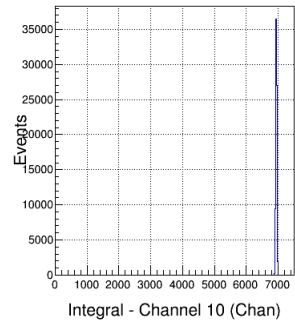
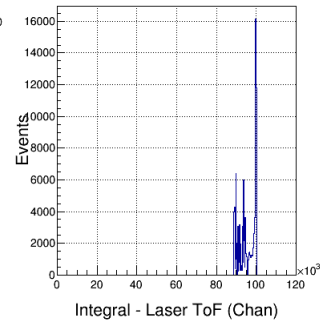
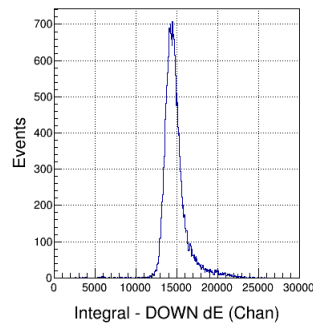
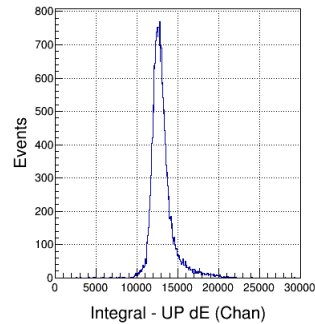
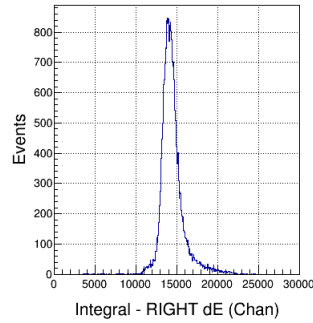
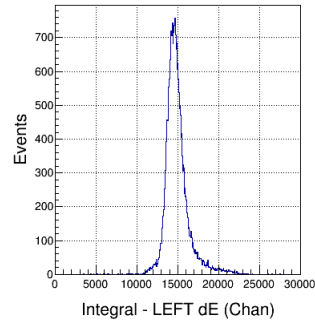
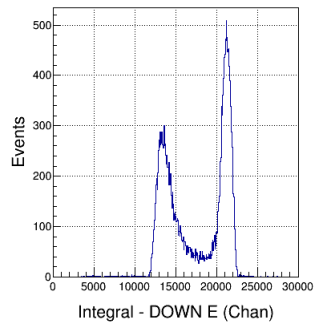
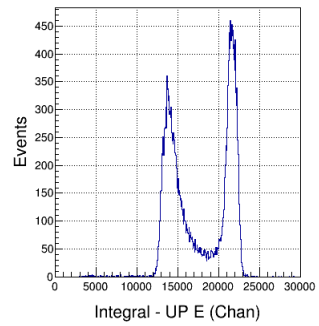
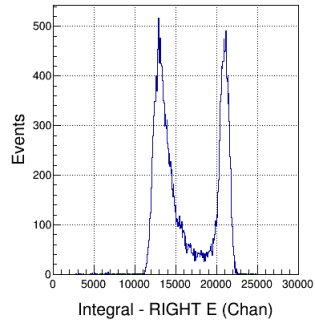
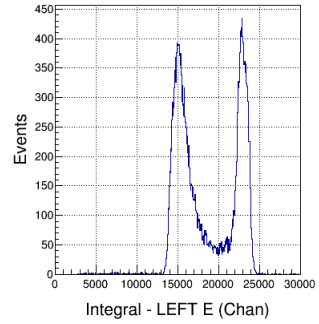


Pedestal - Channel 12 (Chan)

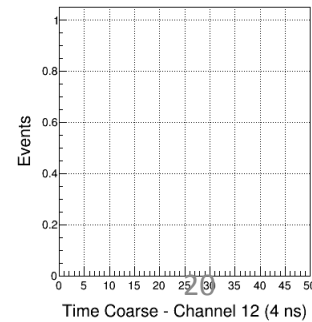
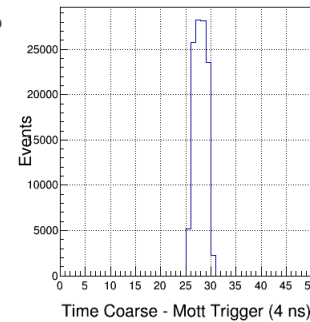
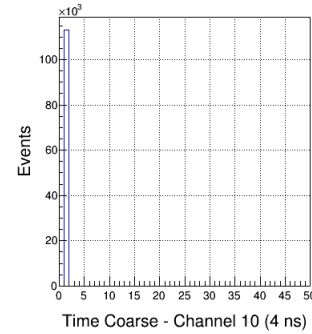
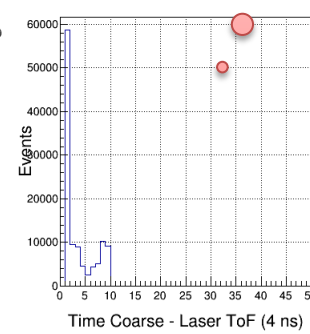
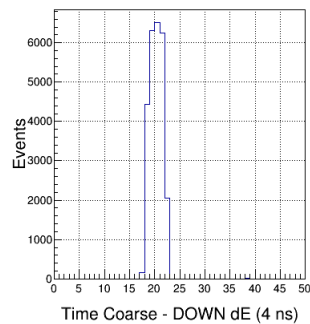
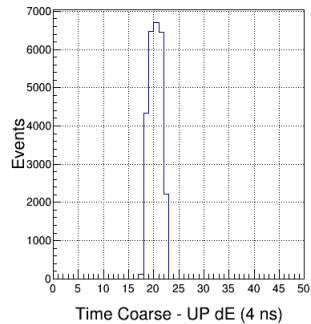
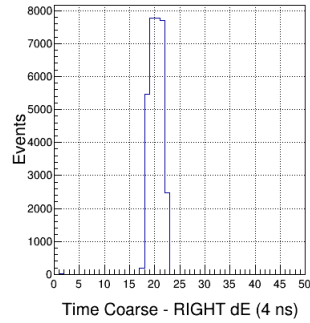
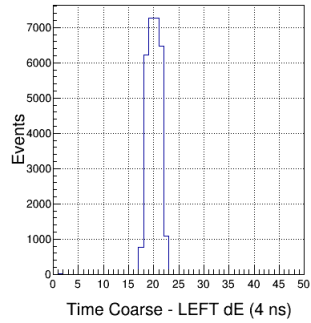
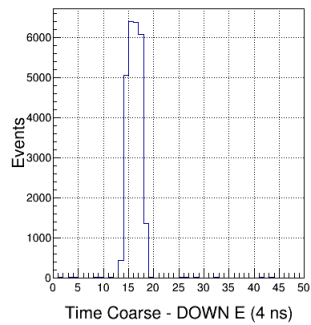
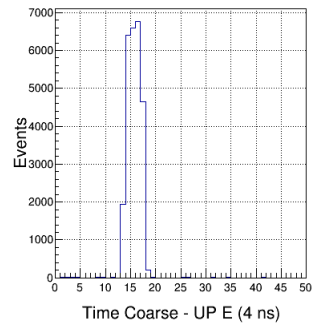
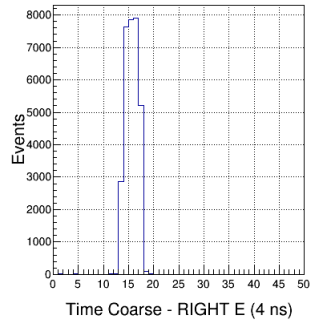
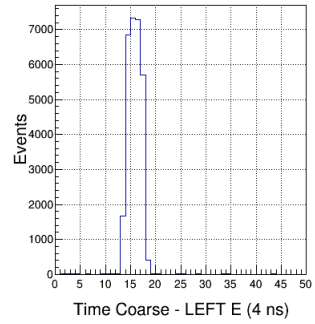
Pulse Peak Value (VP)



Pulse Integral

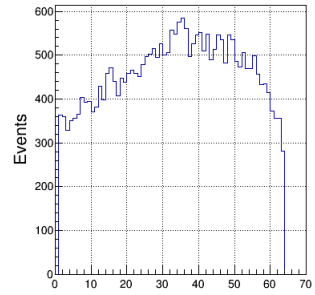


Pulse Coarse Time

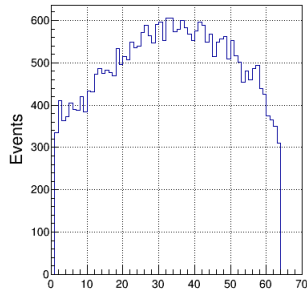


See Note 3

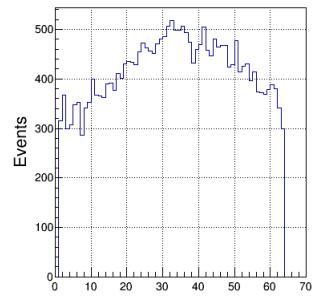
Pulse Fine Time



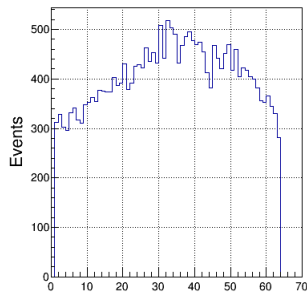
Time Fine - LEFT E (62.5 ps)



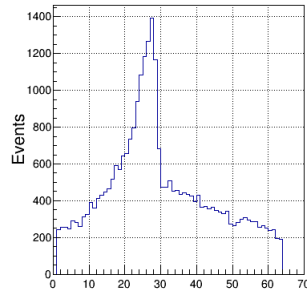
Time Fine - RIGHT E (62.5 ps)



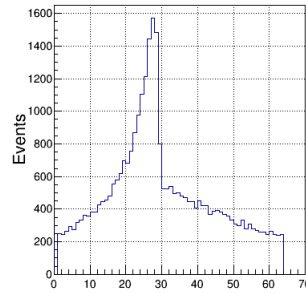
Time Fine - UP E (62.5 ps)



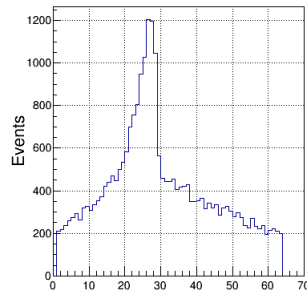
Time Fine - DOWN E (62.5 ps)



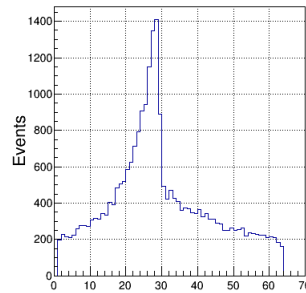
Time Fine - LEFT dE (62.5 ps)



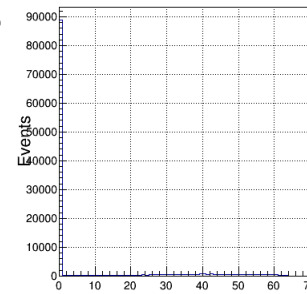
Time Fine - RIGHT dE (62.5 ps)



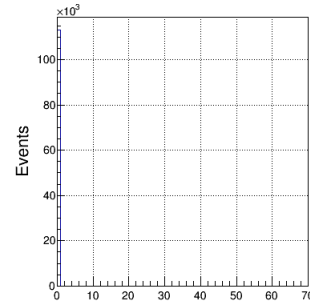
Time Fine - UP dE (62.5 ps)



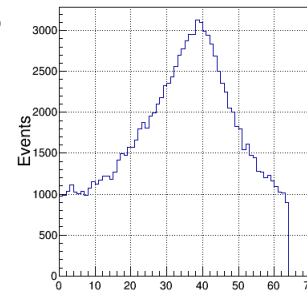
Time Fine - DOWN dE (62.5 ps)



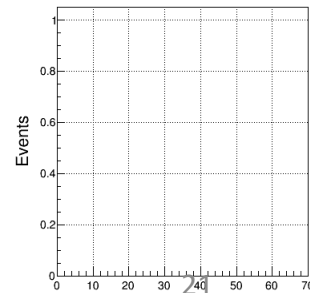
Time Fine - Laser ToF (62.5 ps)



Time Fine - Channel 10 (62.5 ps)

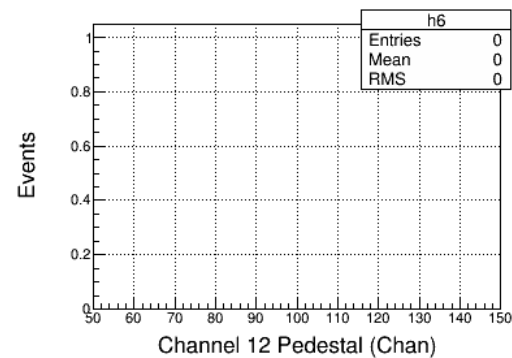
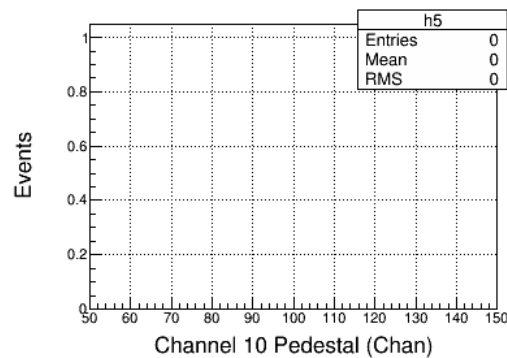
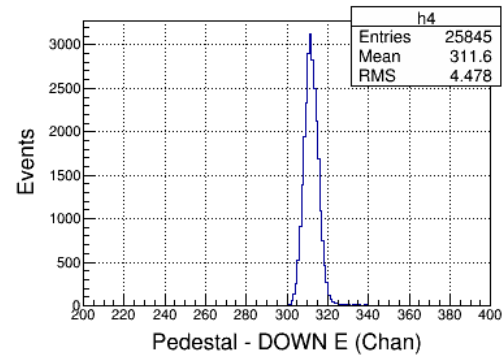
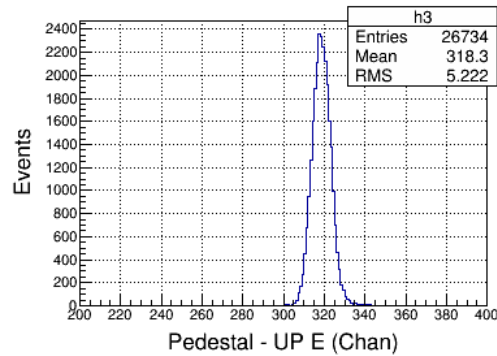
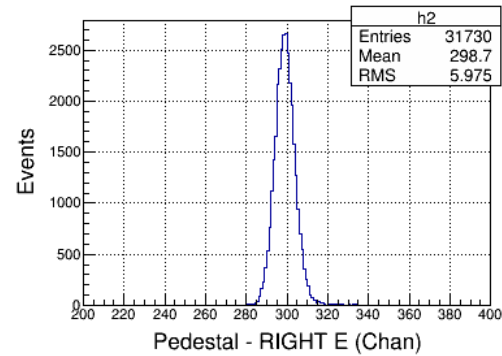
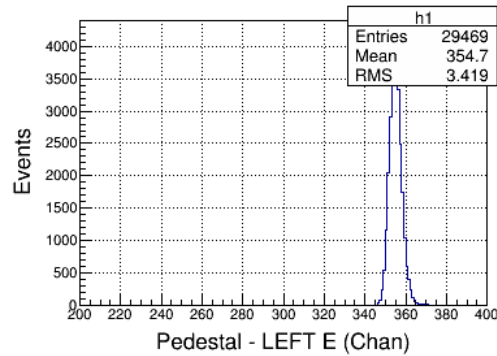


Time Fine - Mott Trigger (62.5 ps)

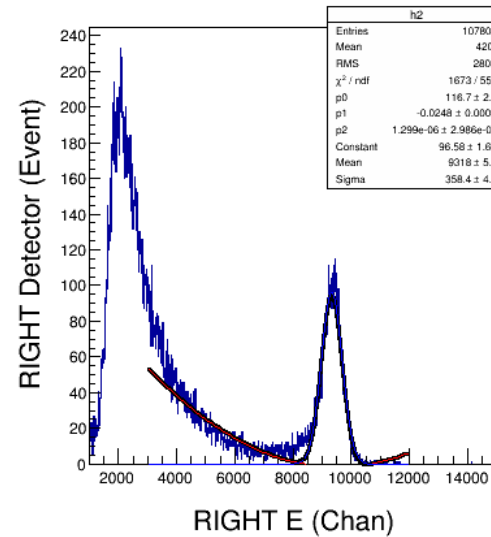
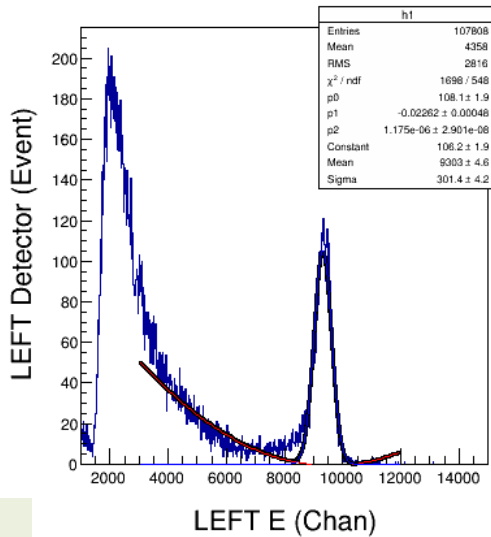


Time Fine - Channel 12 (62.5 ps)

Analysis: Pedestals



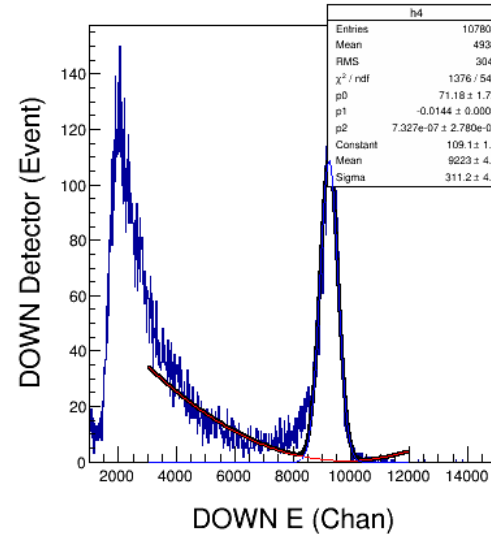
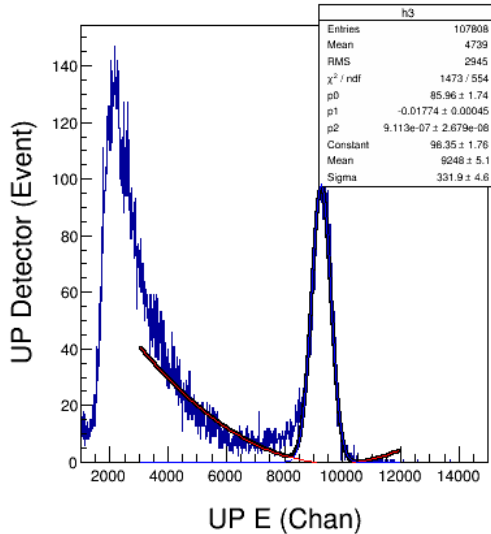
Analysis: Energy



- Energy from run 7642
- Pedestal from run 7672

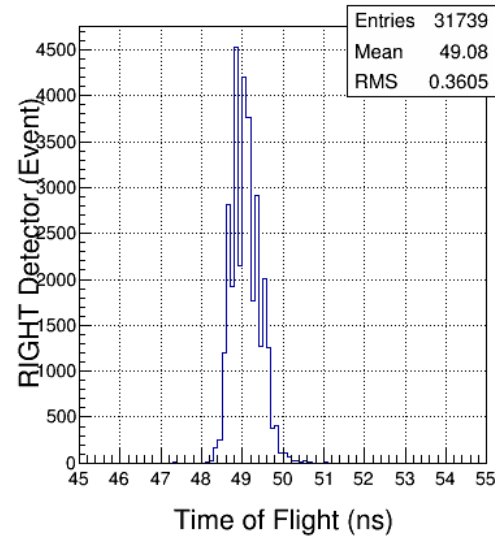
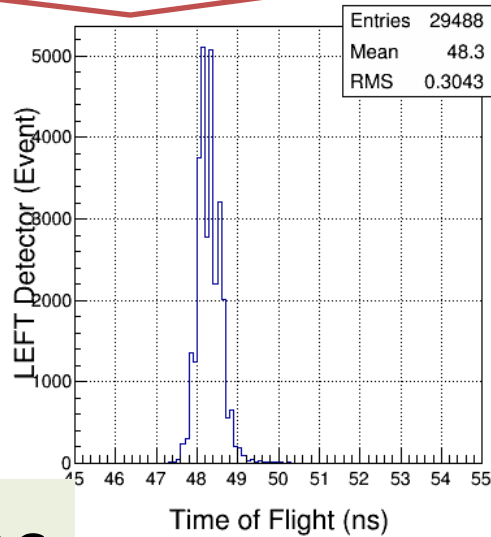
$\sigma_E \sim 3.2\%$

The increase partially due to average pedestals being subtracted. New data will have this fixed

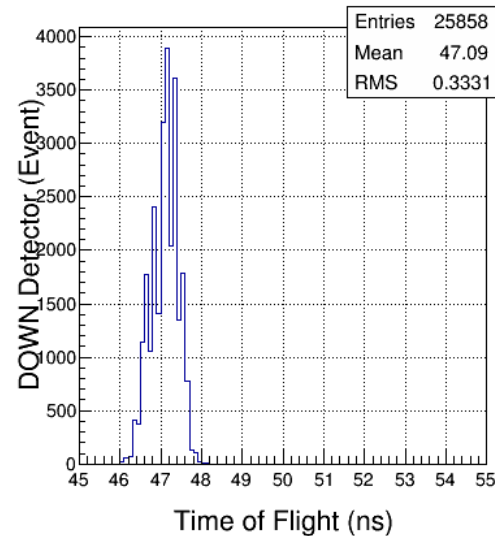
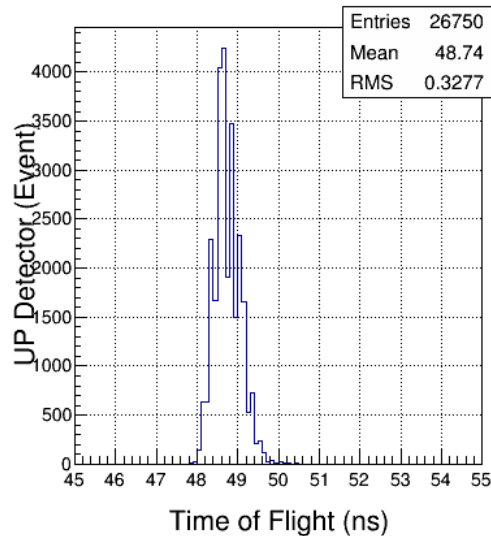


Analysis: Self Timing Peak

```
T->Draw("(TimeCoarse11*4.0 + TimeFine11*0.0625) - (TimeCoarse1*4.0 + TimeFine1*0.0625) >> h1", "TimeCoarse1>1.0 &&TimeCoarse11 >1.0")
```

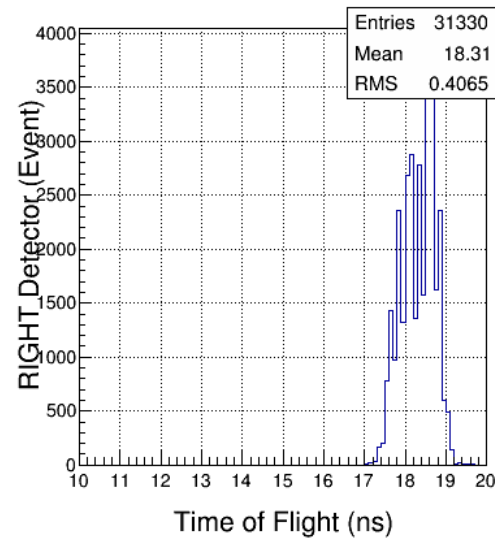
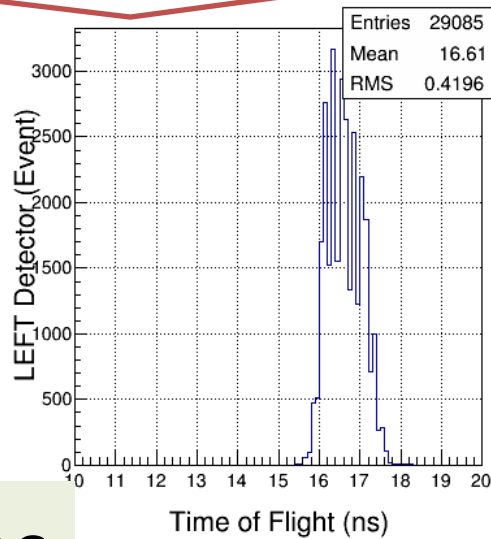


$$\sigma_t \sim 0.33 \text{ ns}$$

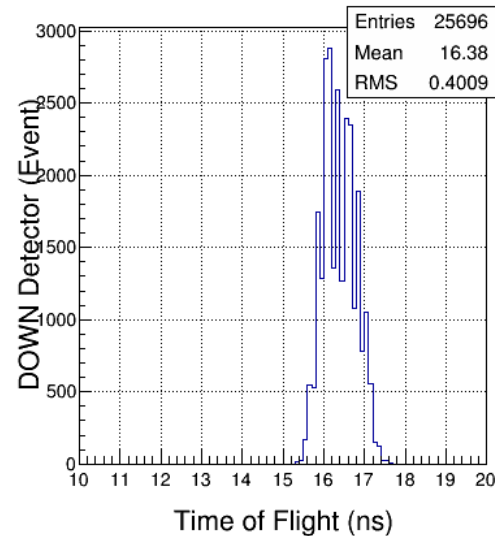
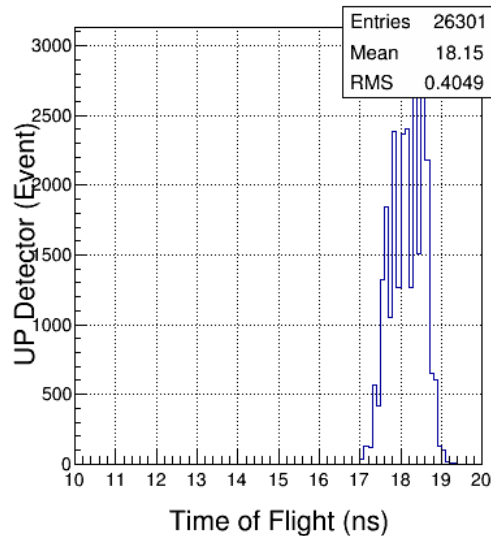


Analysis: E-dE Timing Peak

```
T->Draw("(TimeCoarse5*4.0 + TimeFine5*0.0625) - (TimeCoarse1*4.0 + TimeFine1*0.0625) >> h1", "TimeCoarse1>1.0 &&TimeCoarse5 >1.0")
```

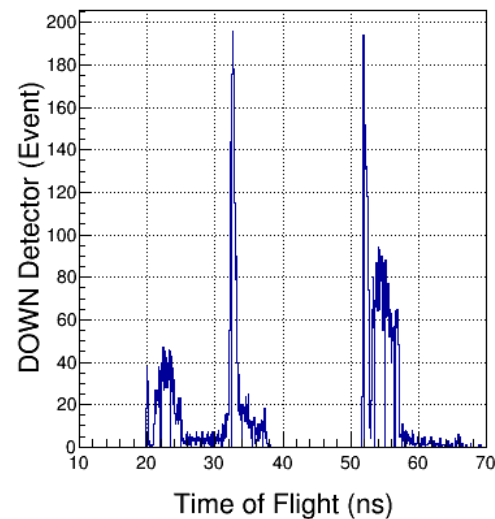
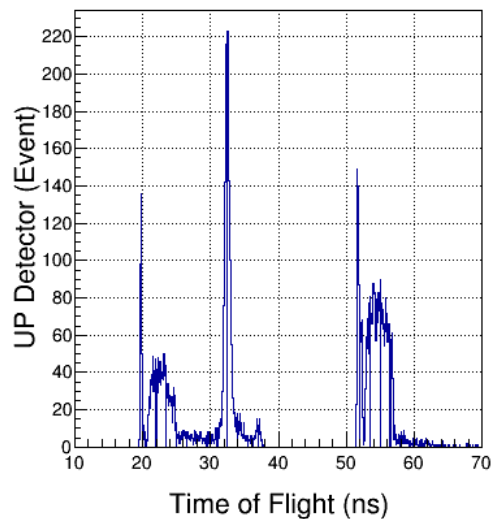
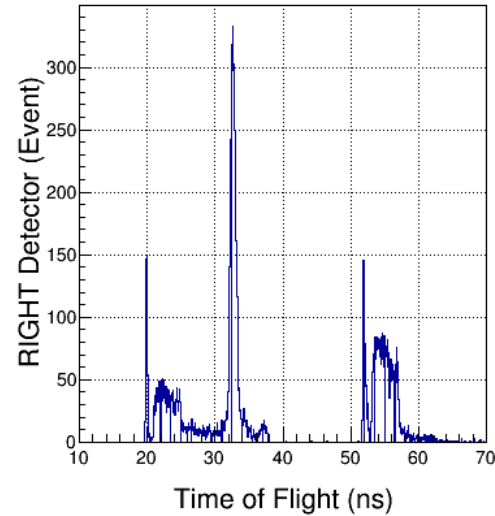
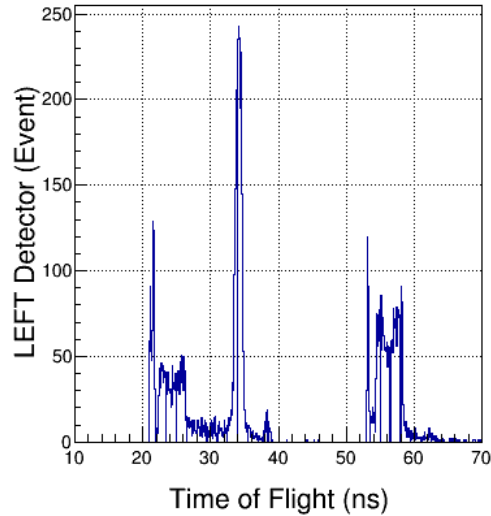


$$\sigma_t \sim 0.40 \text{ ns}$$



Analysis: Time-of-flight

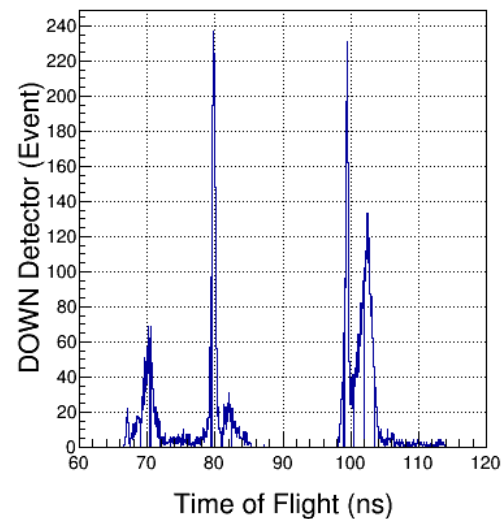
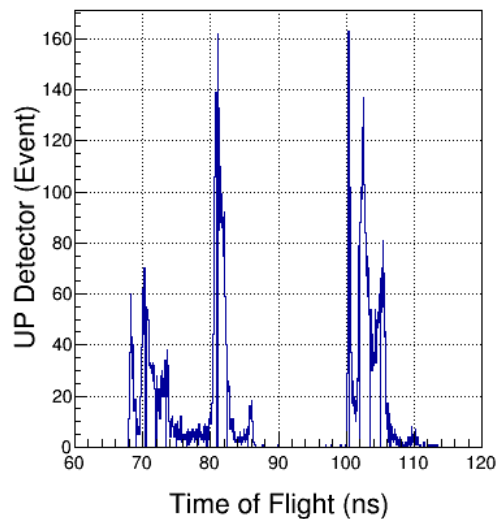
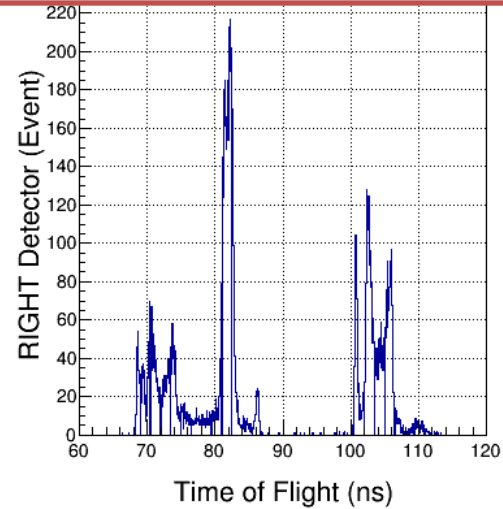
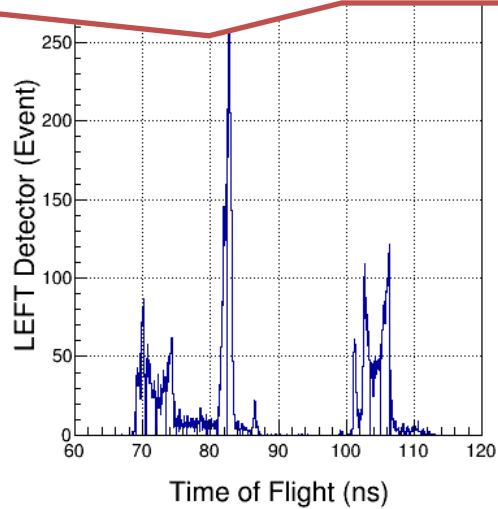
```
T->Draw("(TimeCoarse1*4.0 + TimeFine1*0.0625) - (TimeCoarse9*4.0 + TimeFine9*0.0625) >> h1", "TimeCoarse1>1.0 &&TimeCoarse9 >1.0")
```



Use CH1-CH4

Analysis: Time-of-flight

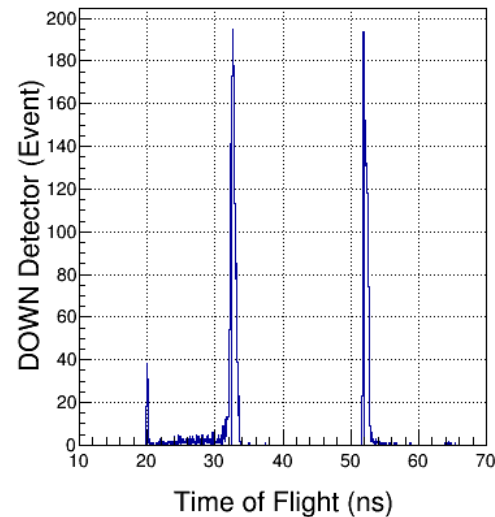
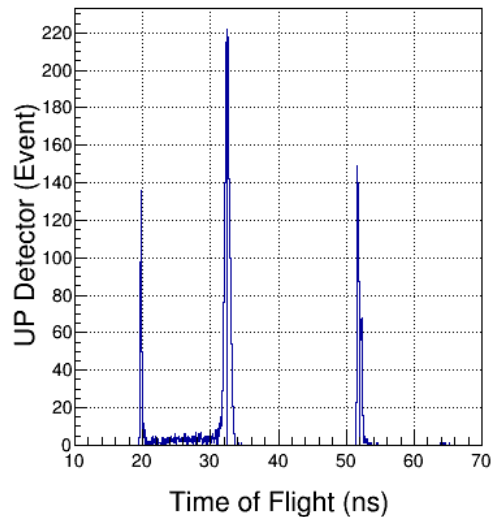
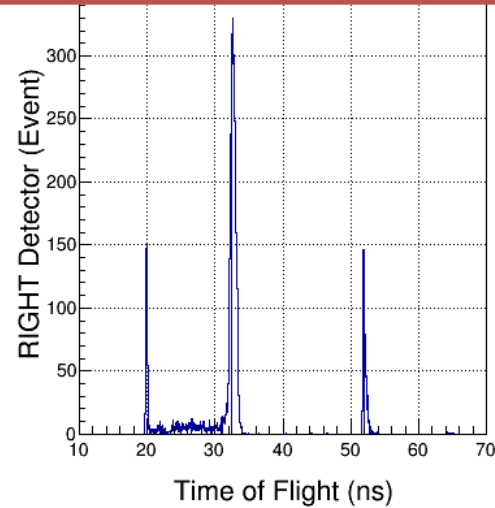
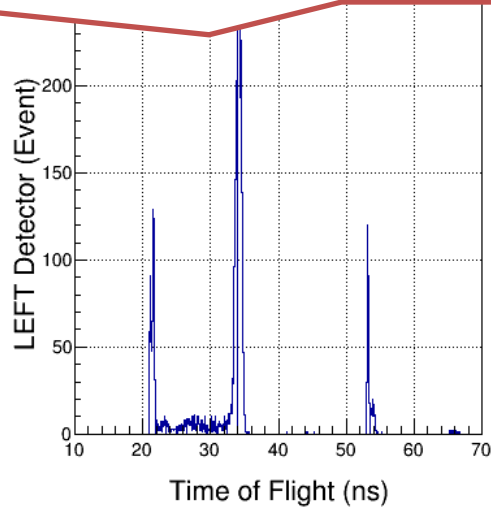
```
T->Draw("(TimeCoarse11*4.0 + TimeFine11*0.0625) - (TimeCoarse9*4.0 + TimeFine9*0.0625) >> h1", "TimeCoarse1>1.0 &&TimeCoarse9 >1.0 ")
```



Use CH11

Analysis: Time-of-flight

```
T->Draw("(TimeCoarse11*4.0 + TimeFine11*0.0625) - (TimeCoarse9*4.0 + TimeFine9*0.0625) >> h1", "TimeCoarse1>1.0 &&TimeCoarse9 >1.0 &&VPeak9>0.0")
```



Use CH11

Notes

Note 1

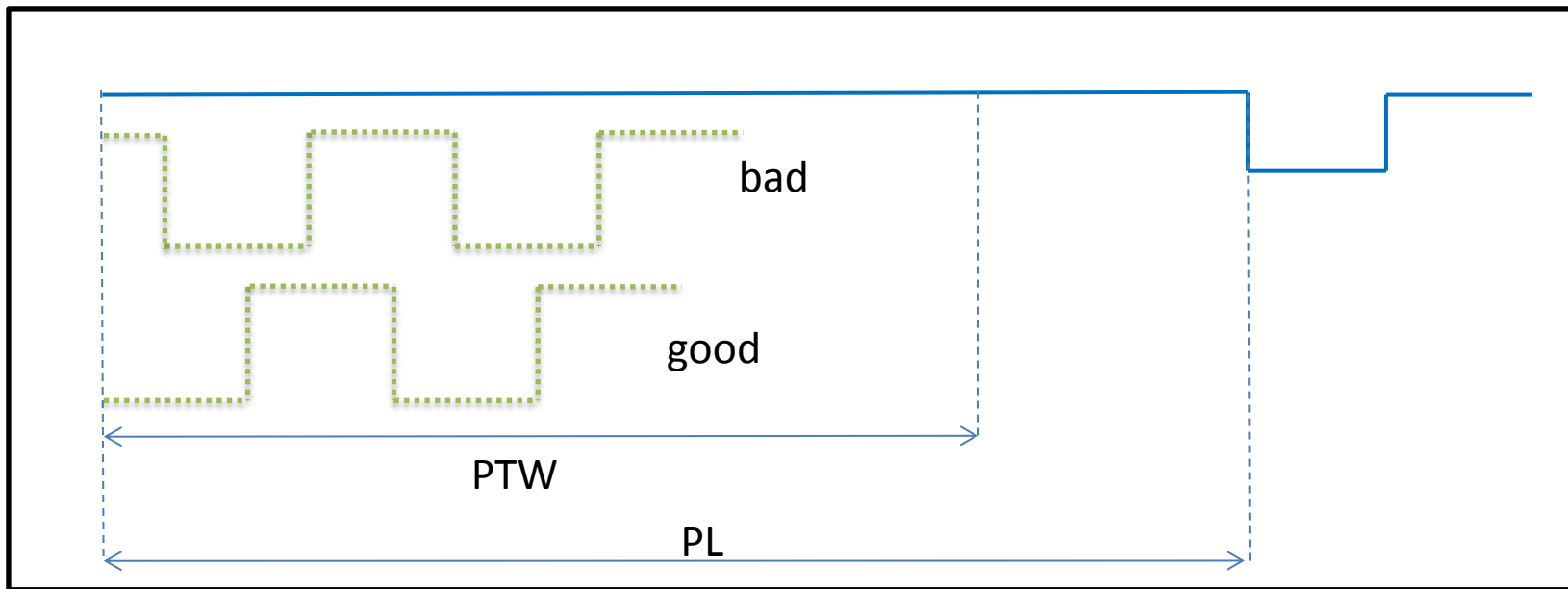
- If first sample above threshold then:
course time = 1, fine time = 0, ped = 0, and VPeak = 0

Note 2

- $\text{MIN}(\text{NSB} + \text{NSA}, \text{PTW})$: Make sure $\text{NSB} + \text{NSA}$ is less than PTW . Otherwise from CODA readout, cannot tell how many samples were summed; this is needed for pedestal subtraction.

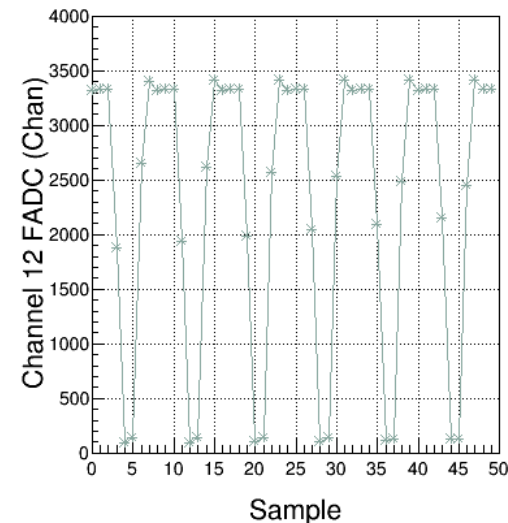
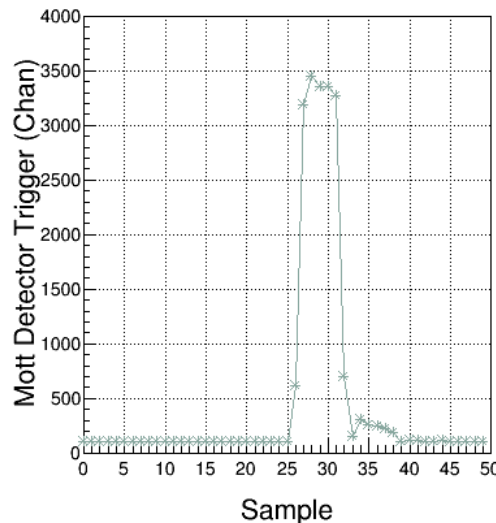
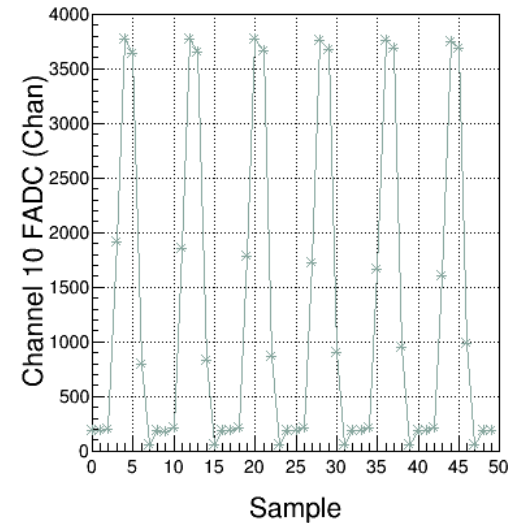
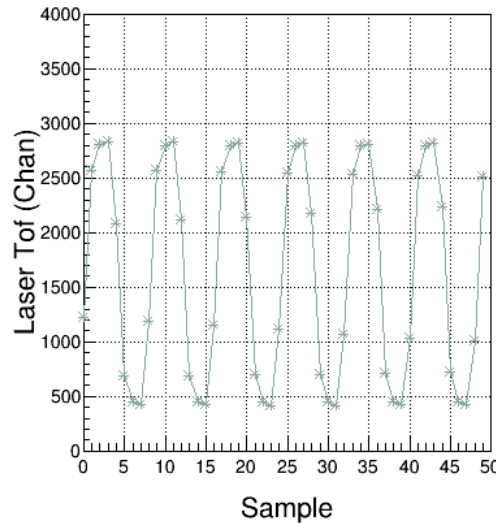
Note 3

- How FADC deal with a periodic square wave. Possible Solutions:
 - Add same signal to another channel delayed by $\frac{1}{2}$ period
 - Use signal and signal_bar



Two more Laser Timing Signals

- Added two more laser timing signals to FADC.
- From Disc 708, OUT signal was connected to FADC Ch10 and OUT_bar was connected to Ch12.
- Original laser timing signal is still connected to Ch9.

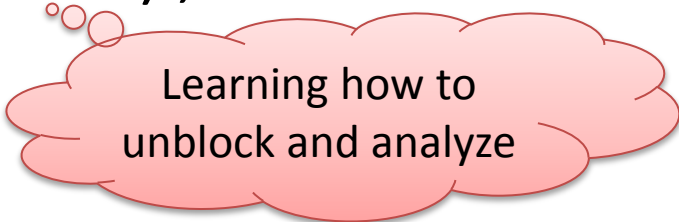


Conclusions – so far ...

- Pulse Integral and High Resolution Time Mode has good energy and time resolutions. Must have:
 - Correct FADC parameters: Threshold, NSB, NSA
 - How to deal with a periodic signal?
- Again, what about scalers?
- A new CODA Configuration was created with this mode (no CAEN v775 TDC and no SIS3801 Scalers) with block readout. Next ...

Conclusions – so far ...

- Measure deadtime with 2.2 μA on 1 μm gold foil:
 - I. Run 8225: Mott_Semilnt configuration (FADC+TDC+Scalers), Deadtime = 28% at 5.1 kHz.
 - II. Run 8227: SemilntFast configuration (only readout of FADC, Blocklevel = 1) , Deadtime = 17% at 5.1 kHz.
 - III. Run 8228: SemilntBlock configuration (only readout of FADC, Blocklevel = 50) , Deadtime = 1% at 5.1 kHz.



Learning how to
unblock and analyze