HGCROC Event Reconstruction

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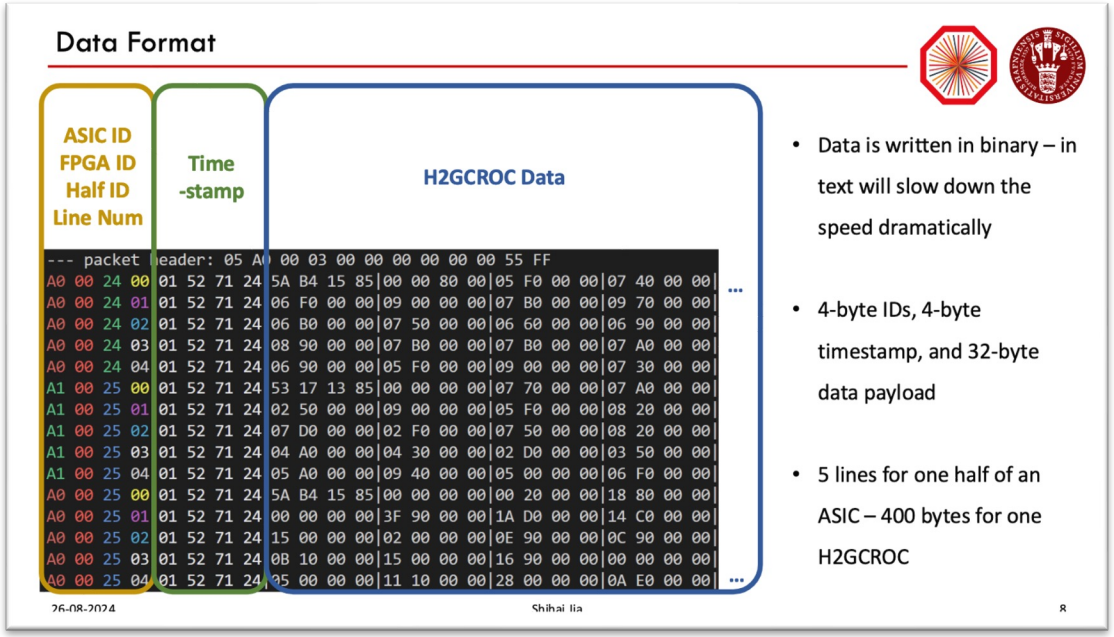
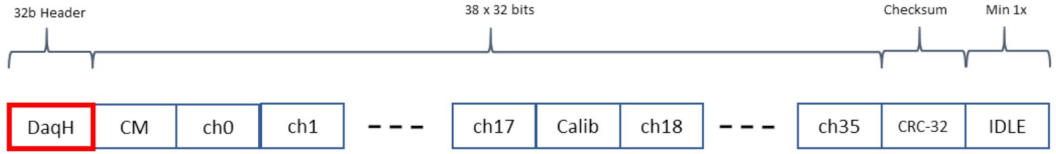
Data format

- Data sent from 4 FPGAs to DAQ computer over UDP
- Sent in 1452 byte packets
  - 12 byte packet header
  - 60 “lines”
- 5 lines encode a sample for one half
  - 40 bytes divided into 36 channels, common mode and calibration channels, a header, and a CRC check

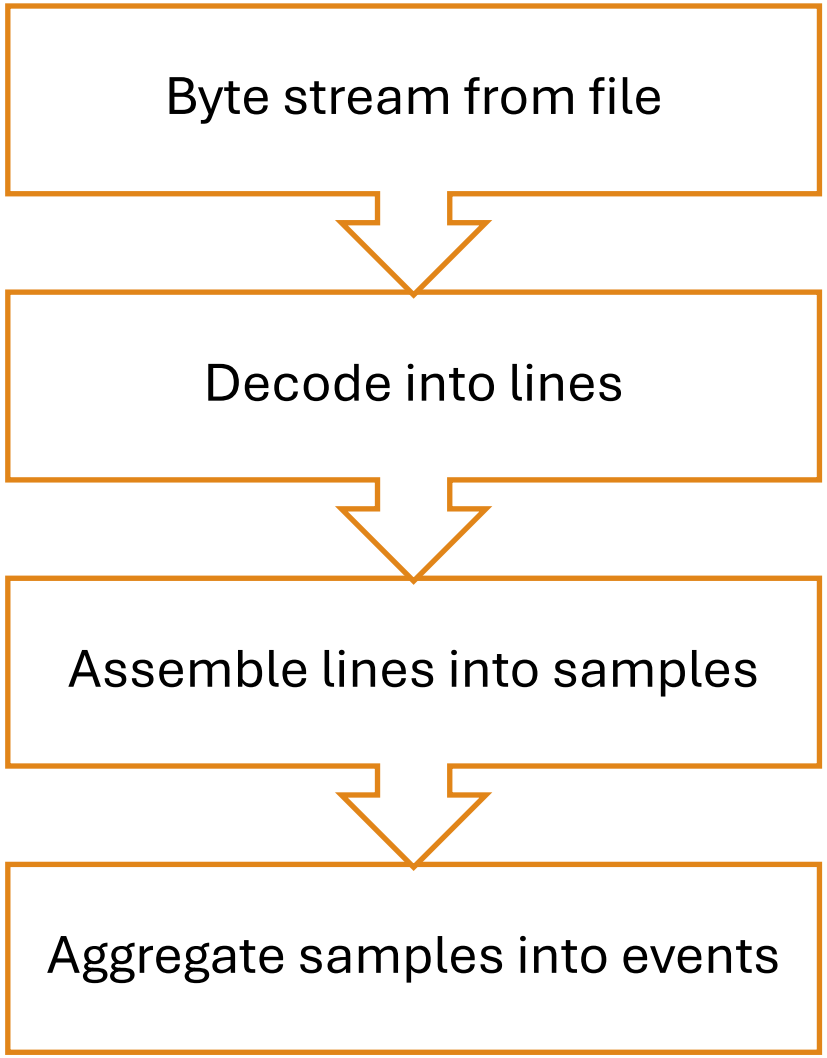


H2GCROC Encoding



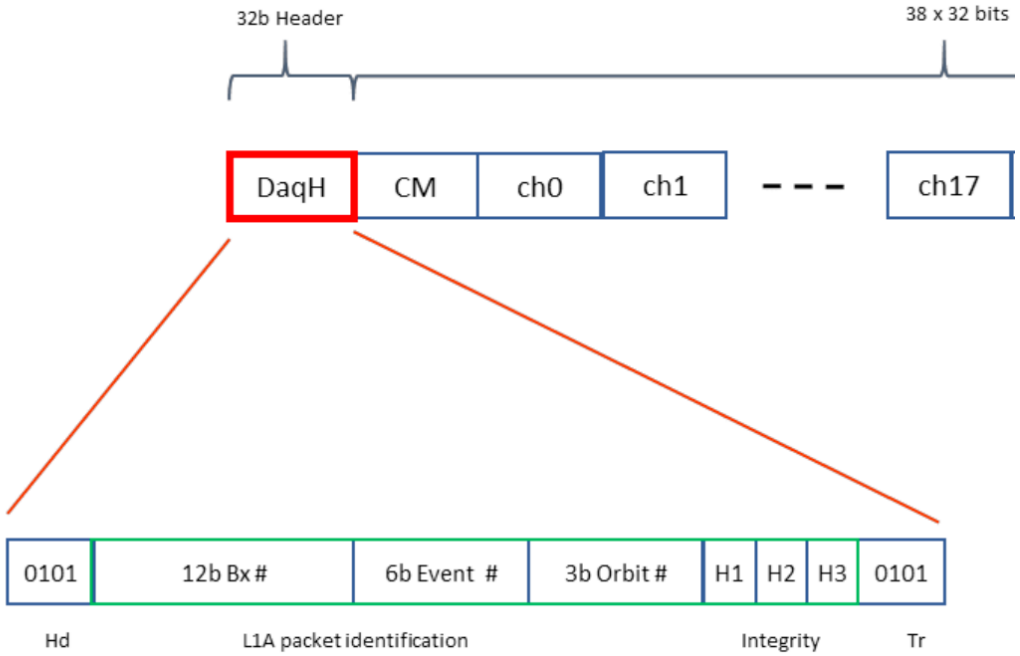
Reconstruction pipeline – Individual KCU

- Each KCU is initially processed individually
- File streamed in, limit how much needs to be kept in memory
  - As a line is completed, it is passed on to waveform building
- Does not require lines to arrive in order, grouped based on timestamp
- Waveform building relies on knowing timestamp spacing between samples (41 counts)
  - Does not require first sample to arrive first, can shuffle around
- Events consist of $4n$ samples
  - 2 ASICS * 2 halves * n samples



Reconstruction pipeline – Event alignment

- Data across all KCUs must be aligned to fully reconstruct each event
- Each sample is tagged with 6 bit event number, increments once per trigger
  - Including retriggering from running in sampled mode
- Before alignment, event number is “unwrapped” per KCU
  - 61, 62, 63, 0, 1, … -> 61, 62, 63, 64, 65, …
- Alignment based on delta between current event number and next event number
- If it is not equal for all KCUs, events are skipped until delta is the same

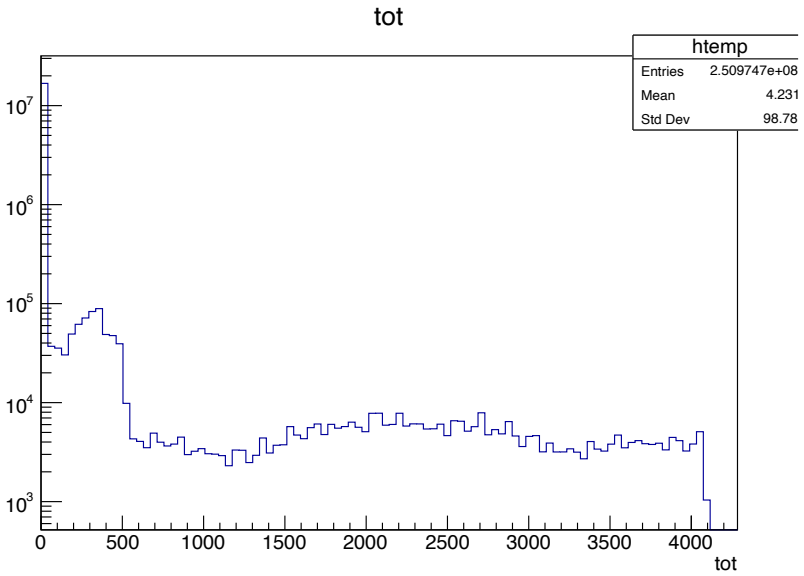


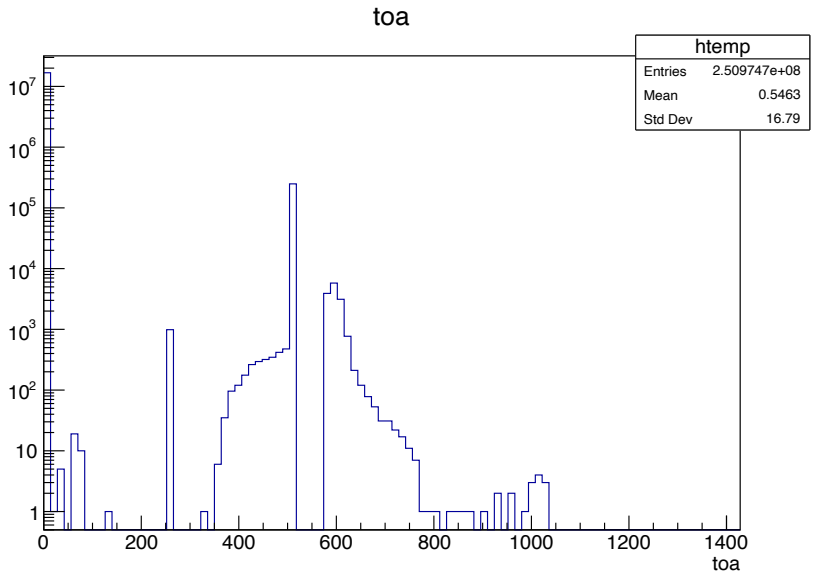
First look - performance

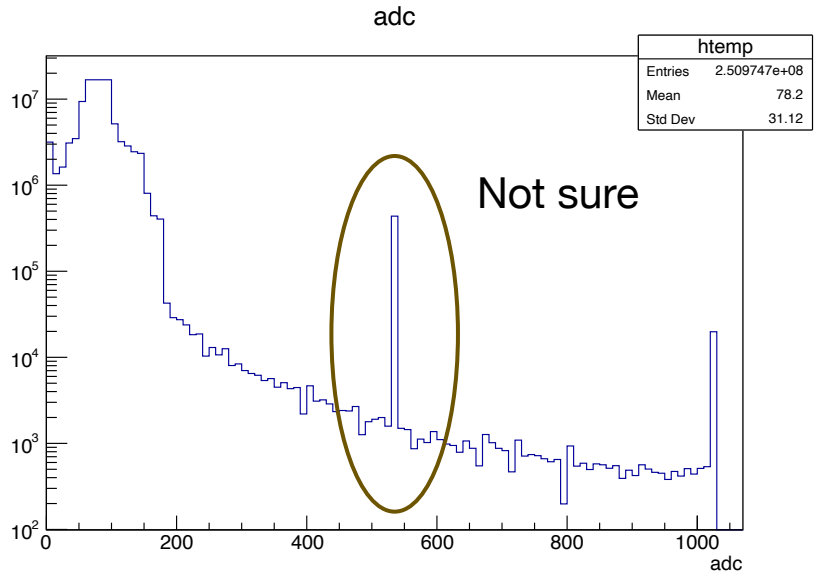
- Starting with muon runs
  - Run 302 through 321
- About 2000 triggers per run from the scalar
- More than 1950 events reconstructed per run
- ADC, TOA, TOT, event number saved
  - Working on position and other metadata

```
root [1] events->Print()
******************************************************************************
*Tree    :events    : Events                                                  *
*Entries :    43572 : Total =      3527832253 bytes  File  Size =  327102180 *
*        :          : Tree compression factor =  10.81                       *
******************************************************************************
*Br    0 :event_number : event_number/i                                       *
*Entries :    43572 : Total  Size=     176843 bytes  File Size  =      63537 *
*Baskets :       22 : Basket Size=      32000 bytes  Compression=   2.77     *
*.............................................................................*
*Br    1 :timestamps : timestamps[4]/i                                        *
*Entries :    43572 : Total  Size=     699760 bytes  File Size  =     193416 *
*Baskets :       23 : Basket Size=      32000 bytes  Compression=   3.61     *
*.............................................................................*
*Br    2 :adc       : adc[576][10]/i                                          *
*Entries :    43572 : Total  Size= 1007810391 bytes  File Size  =  240163853 *
*Baskets :    42513 : Basket Size=      32000 bytes  Compression=   4.19     *
*.............................................................................*
*Br    3 :toa       : toa[576][10]/i                                          *
*Entries :    43572 : Total  Size= 1007810391 bytes  File Size  =    9961864 *
*Baskets :    42513 : Basket Size=      32000 bytes  Compression= 101.08     *
*.............................................................................*
*Br    4 :tot       : tot[576][10]/i                                          *
*Entries :    43572 : Total  Size= 1007810391 bytes  File Size  =   14723531 *
*Baskets :    42513 : Basket Size=      32000 bytes  Compression=  68.39     *
*.............................................................................*
*Br    5 :hit_x     : hit_x[576]/i                                            *
*Entries :    43572 : Total  Size=  100698899 bytes  File Size  =     787146 *
*Baskets :     3284 : Basket Size=      32000 bytes  Compression= 127.85     *
*.............................................................................*
*Br    6 :hit_y     : hit_y[576]/i                                            *
*Entries :    43572 : Total  Size=  100698899 bytes  File Size  =     787146 *
*Baskets :     3284 : Basket Size=      32000 bytes  Compression= 127.85     *
*.............................................................................*
*Br    7 :hit_z     : hit_z[576]/i                                            *
*Entries :    43572 : Total  Size=  100698899 bytes  File Size  =     787146 *
*Baskets :     3284 : Basket Size=      32000 bytes  Compression= 127.85     *
*.............................................................................*
*Br    8 :hit_max   : hit_max[576]/i                                          *
*Entries :    43572 : Total  Size=  100705475 bytes  File Size  =   29318085 *
*Baskets :     3284 : Basket Size=      32000 bytes  Compression=   3.43     *
*.............................................................................*
*Br    9 :hit_pedestal : hit_pedestal[576]/i                                  *
*Entries :    43572 : Total  Size=  100721915 bytes  File Size  =   29320811 *
*Baskets :     3284 : Basket Size=      32000 bytes  Compression=   3.43     *
*.............................................................................*
```

Spectra


tot
htemp
Entries 2.509747e+08
Mean 4.231
Std Dev 98.78
tot


toa
htemp
Entries 2.509747e+08
Mean 0.5463
Std Dev 16.79
toa


adc
htemp
Entries 2.509747e+08
Mean 78.2
Std Dev 31.12
Not sure
adc

Next steps

- Validate alignment
  - Check against clock delta
  - Use position data, do we see straight lines in muon events?
  - Incorporate heartbeat packet
- Understand lost events
  - Is there an issue in reconstruction, or did we just drop packets?
- FPGA 0, ASIC 0, Half 0 event counter
  - Cause of much frustration, seems to have a bug
  - Other counters seem fine, everything worked as soon as I align to the half 1 counter