

HGCROC Event Reconstruction

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Oct 16, 2024



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

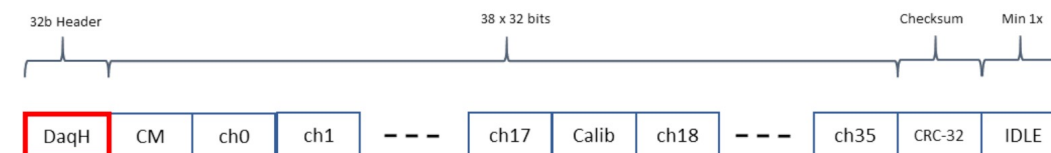
Data Format

```

--- packet header: 05 A0 00 03 00 00 00 00 00 55 FF
A0 00 24 00 01 52 71 24 5A B4 15 85 00 00 80 00 05 F0 00 00 07 40 00 00
A0 00 24 01 01 52 71 24 06 F0 00 00 09 00 00 00 07 B0 00 00 09 70 00 00
A0 00 24 02 01 52 71 24 06 B0 00 00 07 50 00 00 06 60 00 00 06 90 00 00
A0 00 24 03 01 52 71 24 08 90 00 00 07 B0 00 00 07 B0 00 00 07 A0 00 00
A0 00 24 04 01 52 71 24 06 90 00 00 05 F0 00 00 09 00 00 00 07 30 00 00
A1 00 25 00 01 52 71 24 53 17 13 85 00 00 00 00 07 70 00 00 07 A0 00 00
A1 00 25 01 01 52 71 24 02 50 00 00 09 00 00 00 05 F0 00 00 08 20 00 00
A1 00 25 02 01 52 71 24 07 D0 00 00 02 F0 00 00 07 50 00 00 08 20 00 00
A1 00 25 03 01 52 71 24 04 A0 00 00 04 30 00 00 02 D0 00 00 03 50 00 00
A1 00 25 04 01 52 71 24 05 A0 00 00 09 40 00 00 05 00 00 00 06 F0 00 00
A0 00 25 00 01 52 71 24 5A B4 15 85 00 00 00 00 00 20 00 00 18 80 00 00
A0 00 25 01 01 52 71 24 00 00 00 00 3F 90 00 00 1A D0 00 00 14 C0 00 00
A0 00 25 02 01 52 71 24 15 00 00 00 02 00 00 00 0E 90 00 00 0C 90 00 00
A0 00 25 03 01 52 71 24 0B 10 00 00 15 00 00 00 16 90 00 00 00 00 00 00
A0 00 25 04 01 52 71 24 05 00 00 00 11 10 00 00 28 00 00 0A E0 00 00
            
```

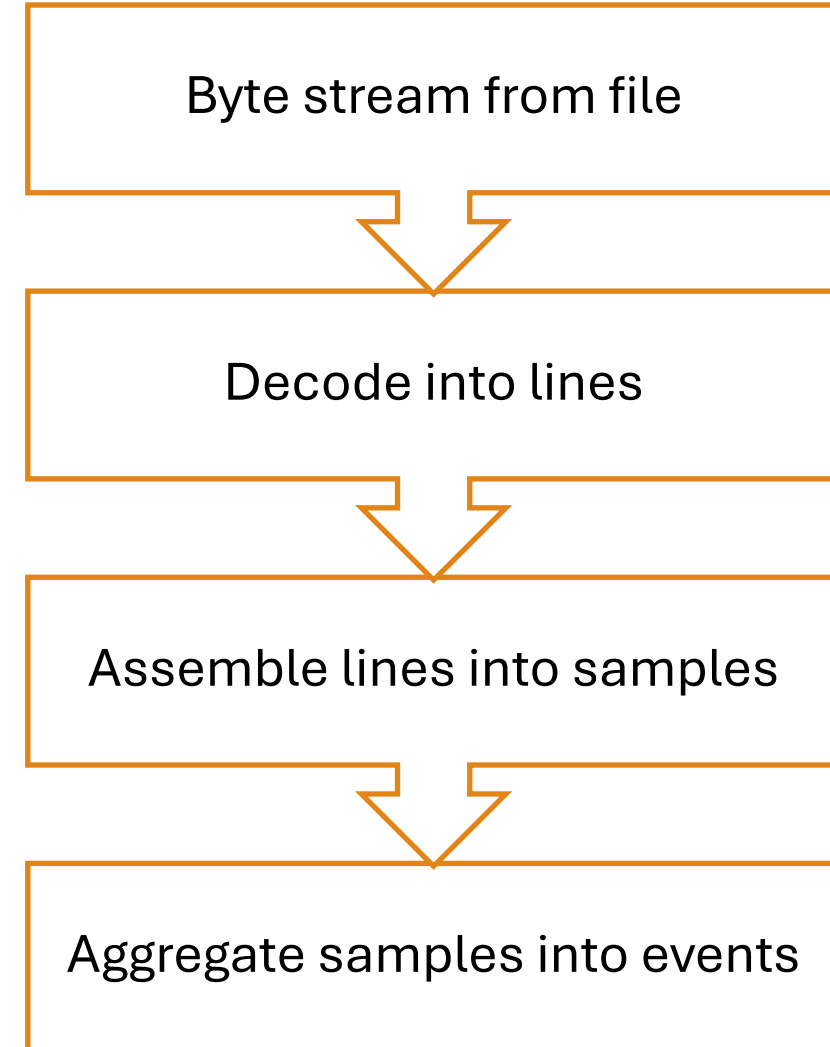
- Data is written in binary – in text will slow down the speed dramatically
- 4-byte IDs, 4-byte timestamp, and 32-byte data payload
- 5 lines for one half of an ASIC – 400 bytes for one H2GCROC

H2GCROC Encoding



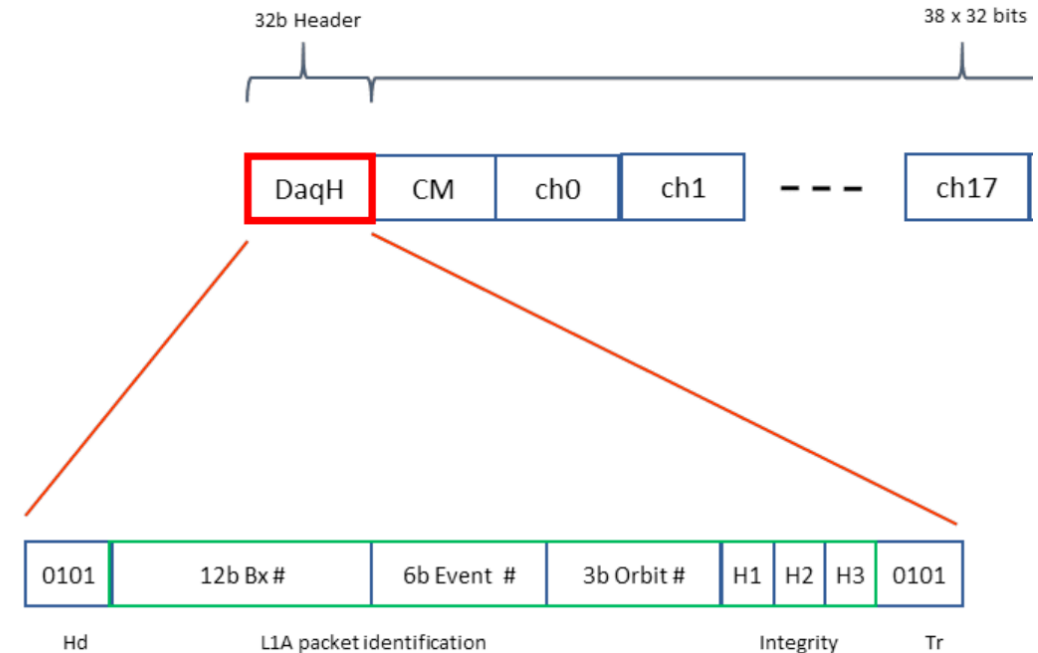
Reconstruction pipeline – Individual KCU

- ❖ 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
 - ❖ $2 \text{ ASICS} * 2 \text{ halves} * n \text{ samples}$



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

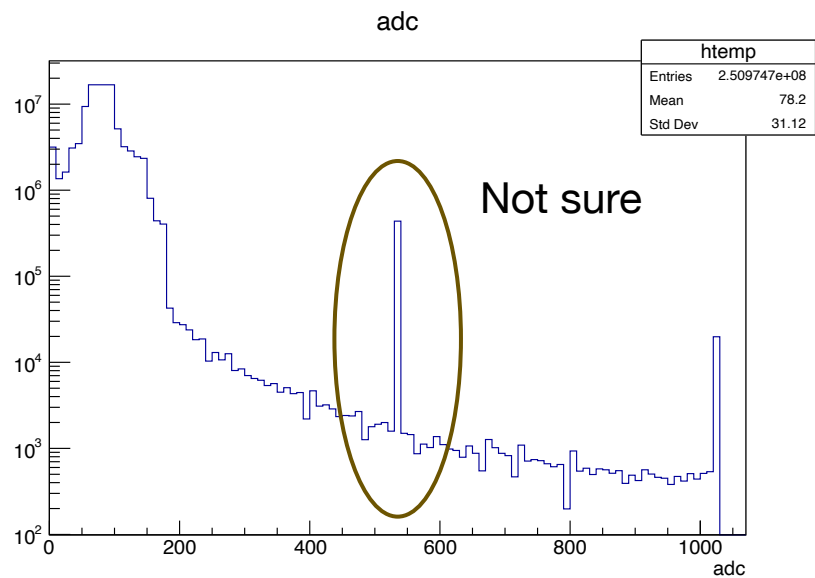
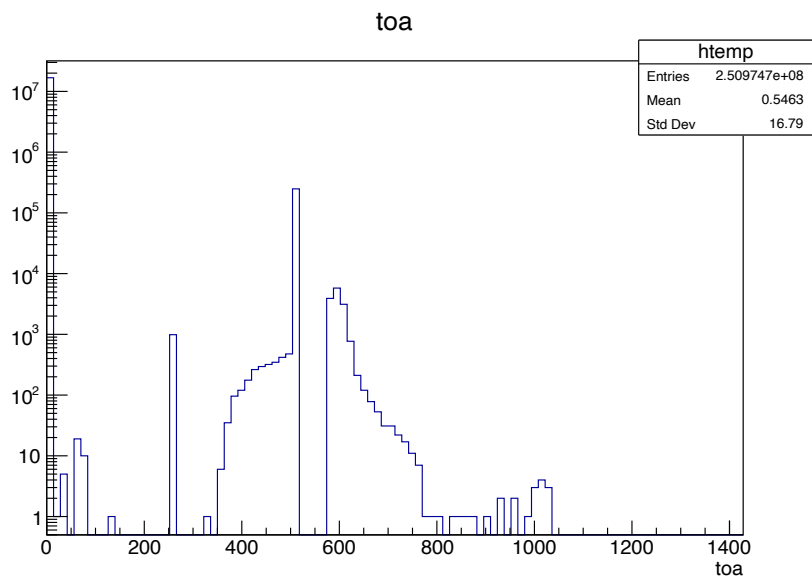
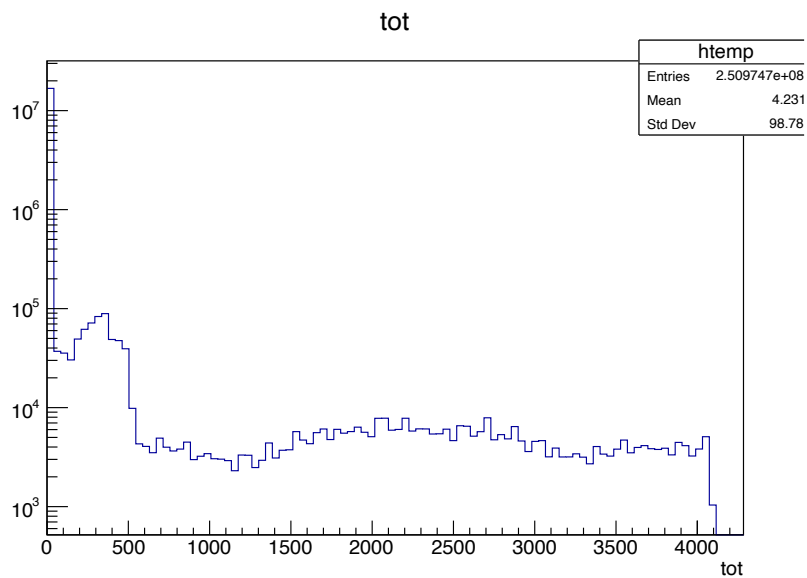


First look - performance

- ❖ 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



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