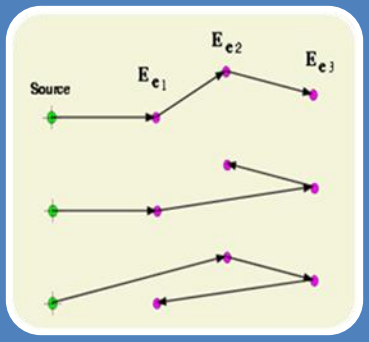
Gretina DAQ

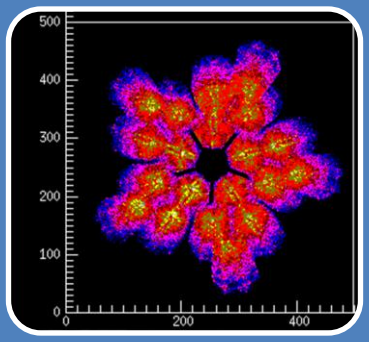
Chris Campbell

LBL



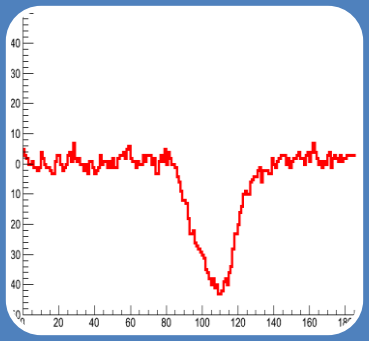
Mode 1

- Tracked data
- Interactions grouped and ordered
- Includes Mode 2 data



Mode 2

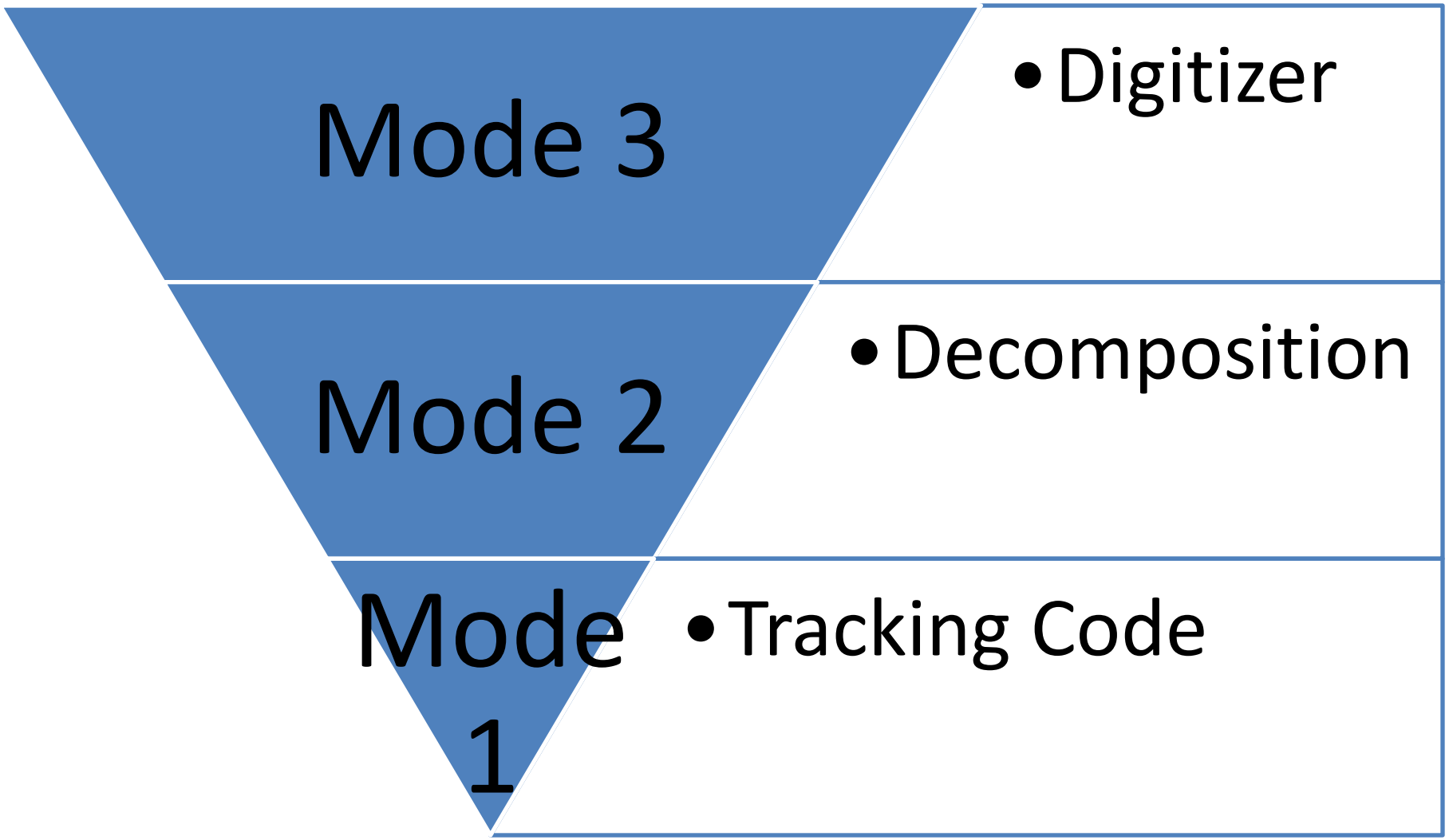
- Interaction points by crystal
- Crystal: Energy, position, time
- Interactions: Energy split and position in crystal



Mode 3

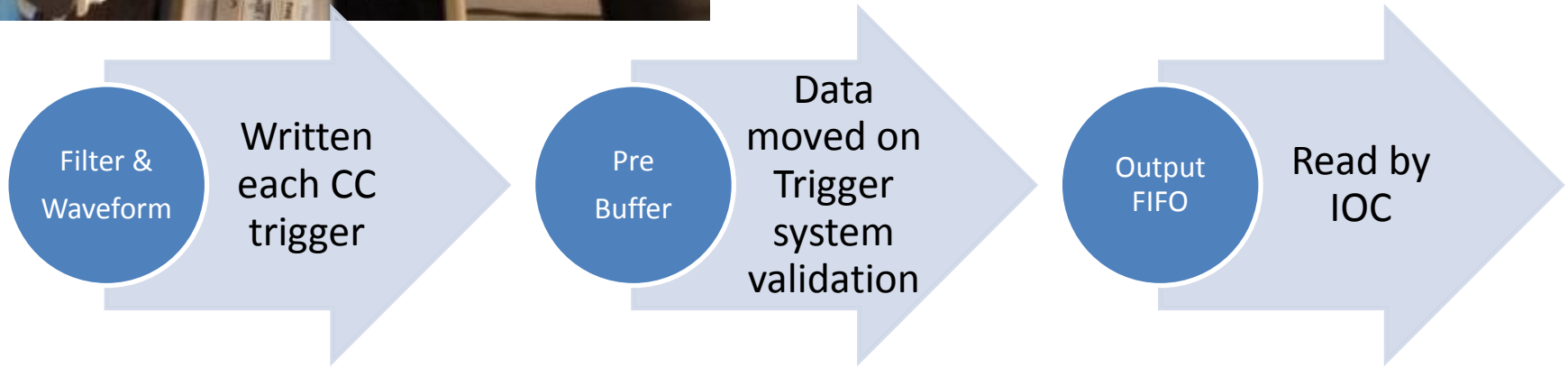
- Data organized by digitizer channels
- Header + waveform
- Header holds channel ID, filter data, time stamps

Data Flow in Gretina



Gretina Digitizer (LBL)

- Flash ADC
  - 100 MHz
  - 14 bit
  - 200 MB/sec of waveforms/channel
- Seven Gretina modules
  - 28 crystals
  - 40 channels/crystal
  - 1120 channels
- Full system waveform rate
  - 224 GB/sec
  - GRETA ~ 1 TB/sec
- So, we select the data!



Gretina DAQ (I)

Each of the 28 crystals has:

- Separate VME backplane and IOC
  - Slow control in EPICS
  - Reads & timesorts digitizer data
  - Passes data to compute cluster
- 4 LBNL Digitizer Modules
  - 10 channels (9 segments + core)
  - 1 Flash ADC / ch, 14bit 100MHz
  - On-board FPGA filters
    - Energy (trapezoid)
    - **Leading Edge** **(not CFD)** (trigger primitive)
    - Pole-zero correction
    - Baseline Restoration
- Event data includes:
  - Timestamp
  - Filter data
  - Waveform subset

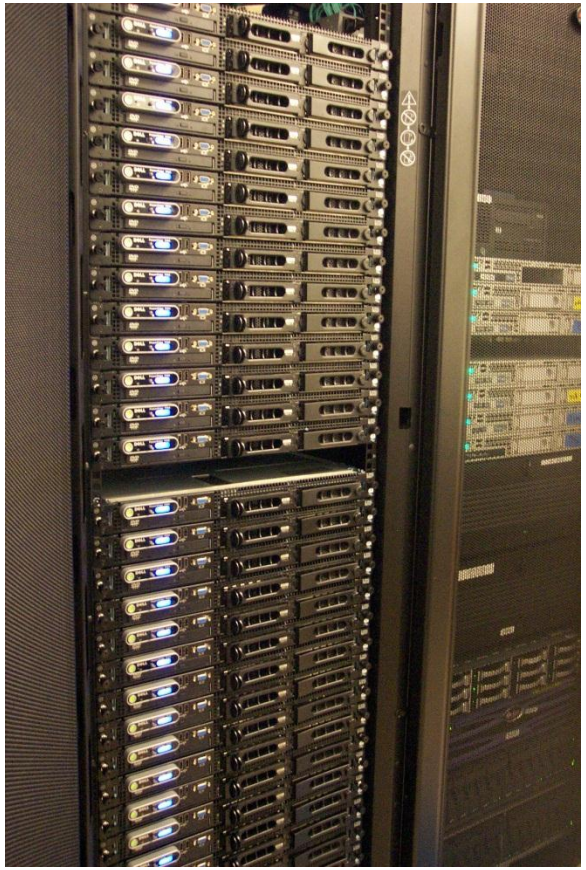
Gretina DAQ (I)

Trigger system:

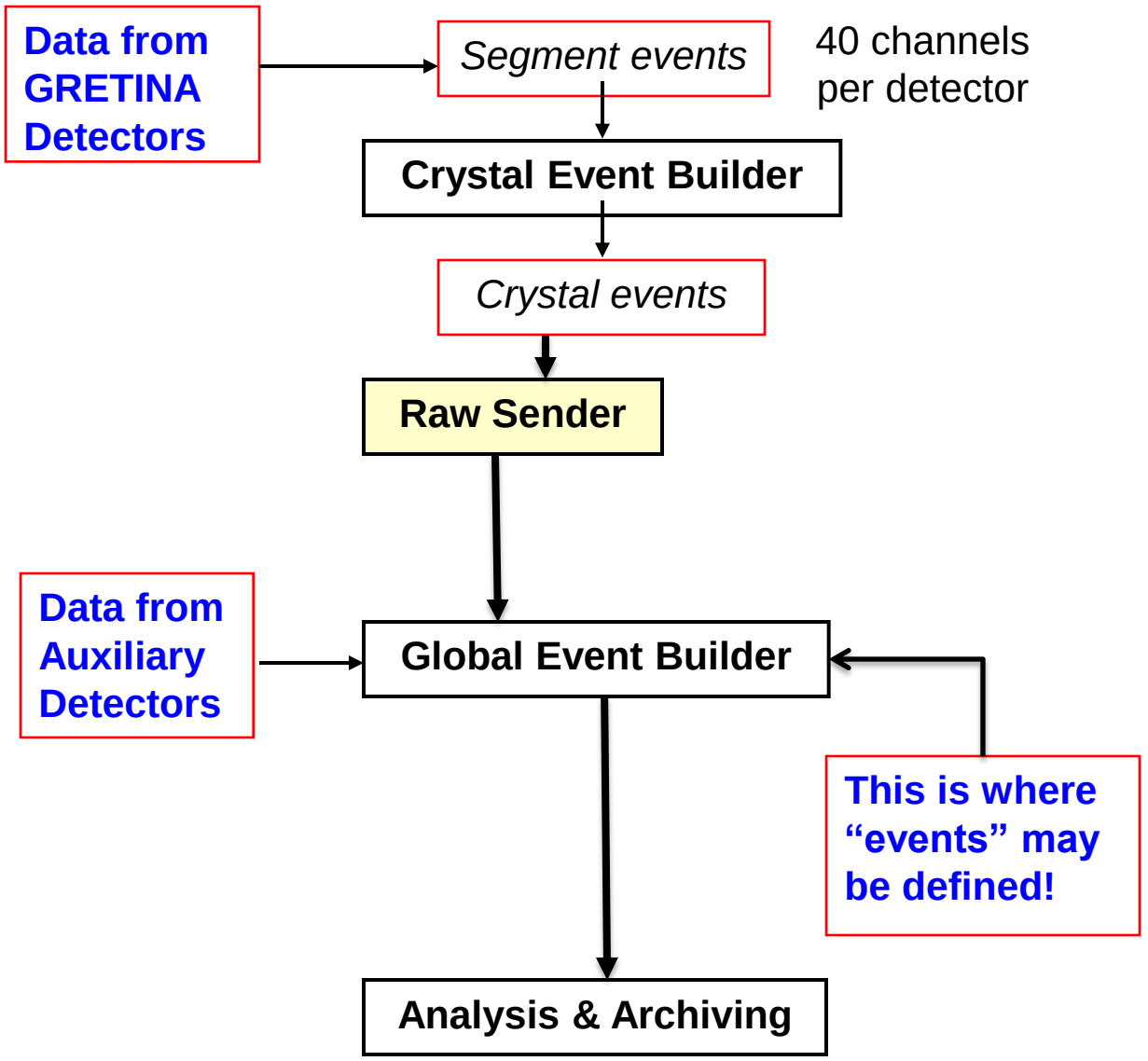
- 5 ANL Trigger modules
  - 1 Master + 4 Routers
- Master clock distribution
- Multiple trigger types
  - Multiplicity
  - External (coincidence)
  - Isomer
  - Sum Energy
- Event validation by timestamp broadcast

- NIM in/out interface with auxiliary DAQ available

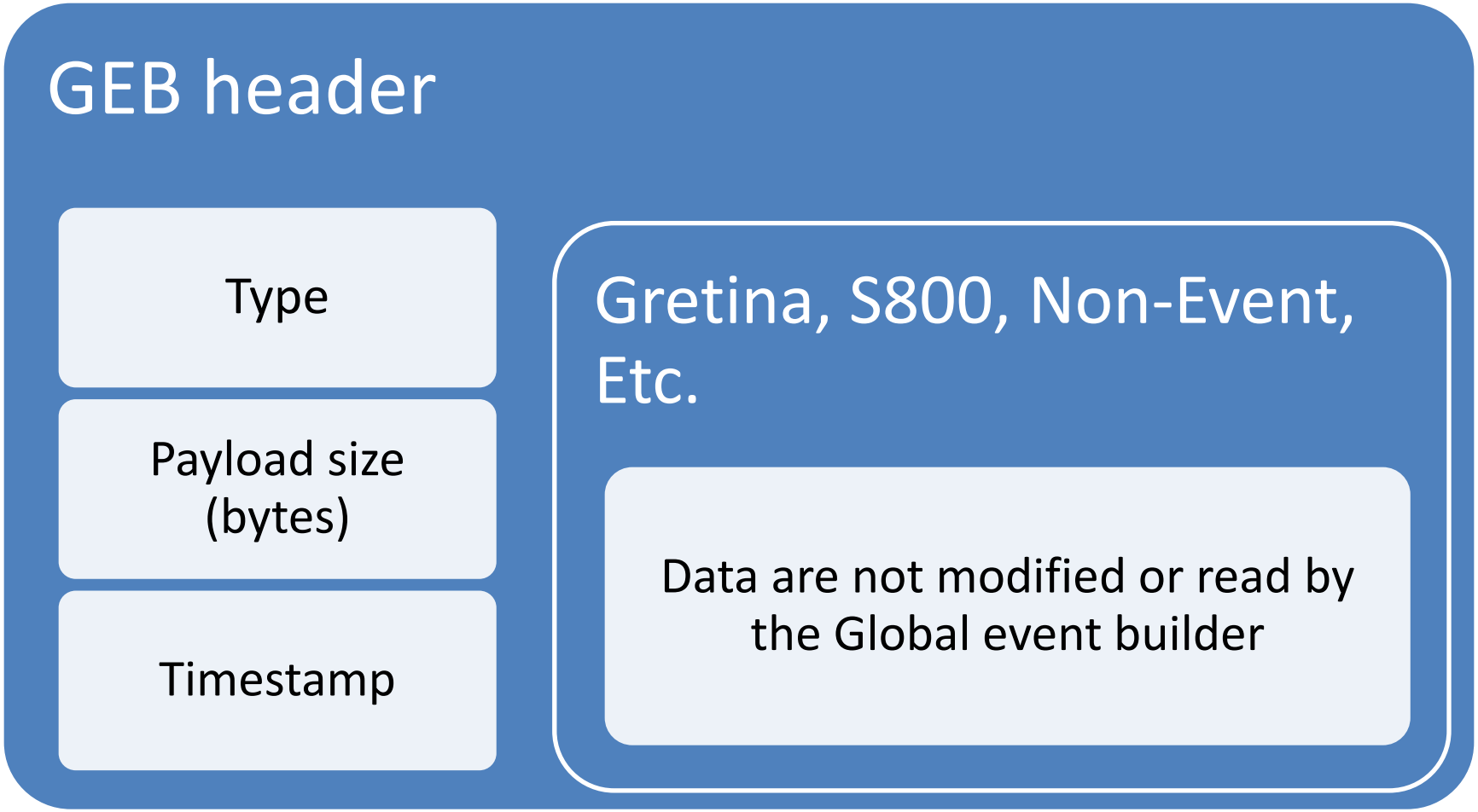
Computing: Mode 3



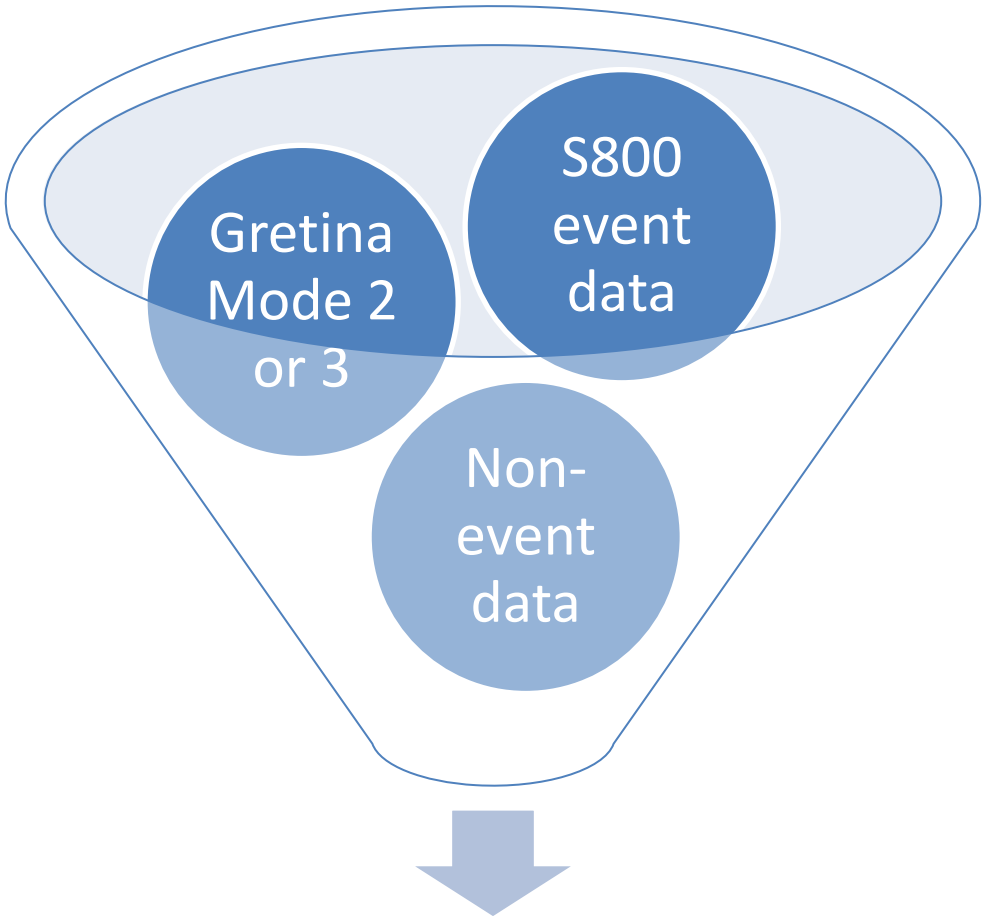
70 nodes
2 cpu / node
4 core / cpu



GEB (Global Event Builder) packets



Global event builder



- Data are sorted according to GEB header timestamp
- Sorted data is held until it is older than the newest data by a number of seconds.
- This correlation time is set by the user.
- GEB is a data bottleneck.

Mode 3 data collection sub-types

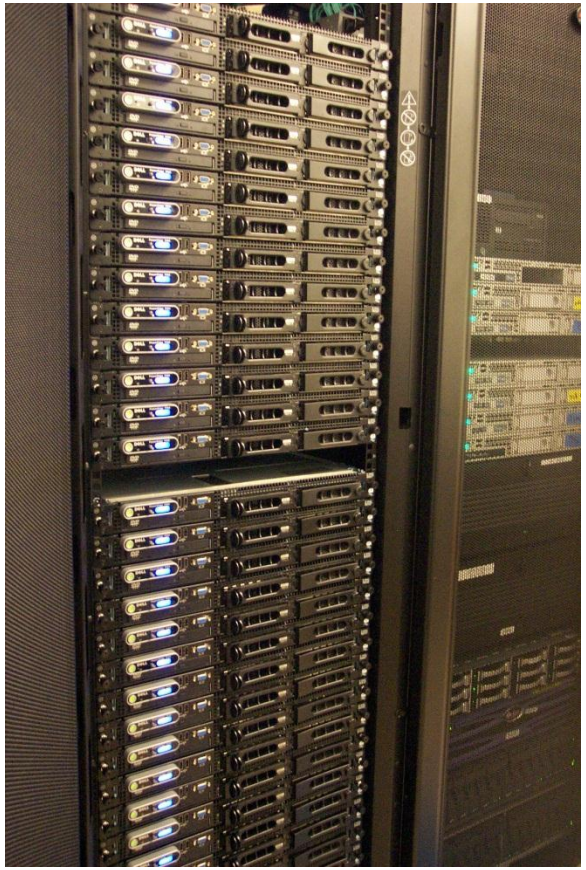
- To eventually get Mode 2 (interaction positions)
  - Take data for all 40 channels for a triggered crystal
    - TTCS Mode
  - Collect ~ 2μs (200 samples) of waveform data centered on charge collection
  - Thus, 16kB/triggered crystal hit

- For energy calibration,
  - Read only hit (net charge) channels
    - Internal Mode
  - Collect minimal waveform, typically 6 samples for baseline
  - Typically, 200 – 300 B/triggered crystal hit

Mode 3 to disk

- Limitations:
  - 1 MB output FIFO per Digitizer board
  - 20MB/sec total VME readout by IOC
  - 60MB/sec maximum sustained Gretina DAQ to disk
- Estimates:
  - Room Background
    - ~100Hz/crystal => 1.6MB/sec/crystal
    - 28 crystals => 45MB/sec
  - 1 μCi source
    - ~600Hz/crystal => 10MB/sec/crystal
    - 28 crystals => 280MB/sec
- TTCS Mode 3 Calibrations are hard!
  - Imposed dead time system implemented by toggling trigger
  - OR, downscale the Gamma_OR trigger

Computing: Mode 2



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4 core / cpu

Data from GRETINA Detectors

Segment events

40 channels per detector

Crystal Event Builder

Crystal events

Parallelism:
4 Decomp instances per crystal

Signal Decomposition

Interaction points

1-28 crystals

Data from Auxiliary Detectors

Global Event Builder

This is where "events" may be defined!

Analysis & Archiving

Goal:

Processing 20,000 Gamma rays /sec

Mode 2 Data Flow for 1kHz/crystal

IOC

- 16 MB / sec / bank from VME, to 4 Decomps
- System: 450 MB / sec to Cluster, ok 10Gb link~1.2GB/sec

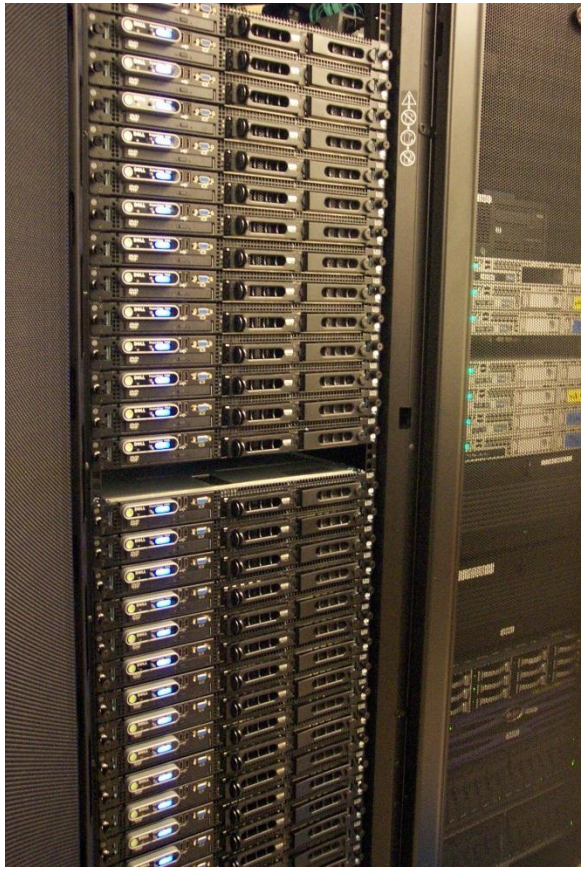
Decomp

- 8 MB / sec into each node (2 Decomps) from IOC's
- Each 16kB crystal event => ~450B Mode2
- 250 kB / sec / node sent to GEB

GEB

- 15 MB / sec Total received from 56 nodes
- Disk Limitation of 60 MB / sec not a problem
- When is time-sorting a limiting factor?

Computing: Mode 1



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Data from GRETINA Detectors

Segment events

40 channels per detector

Crystal Event Builder

Crystal events

Signal Decomposition

Interaction points

1-28 crystals

Data from Auxiliary Detectors

Global Event Builder

Global Events

Tracking

Analysis & Archiving

This is where "events" may be defined!

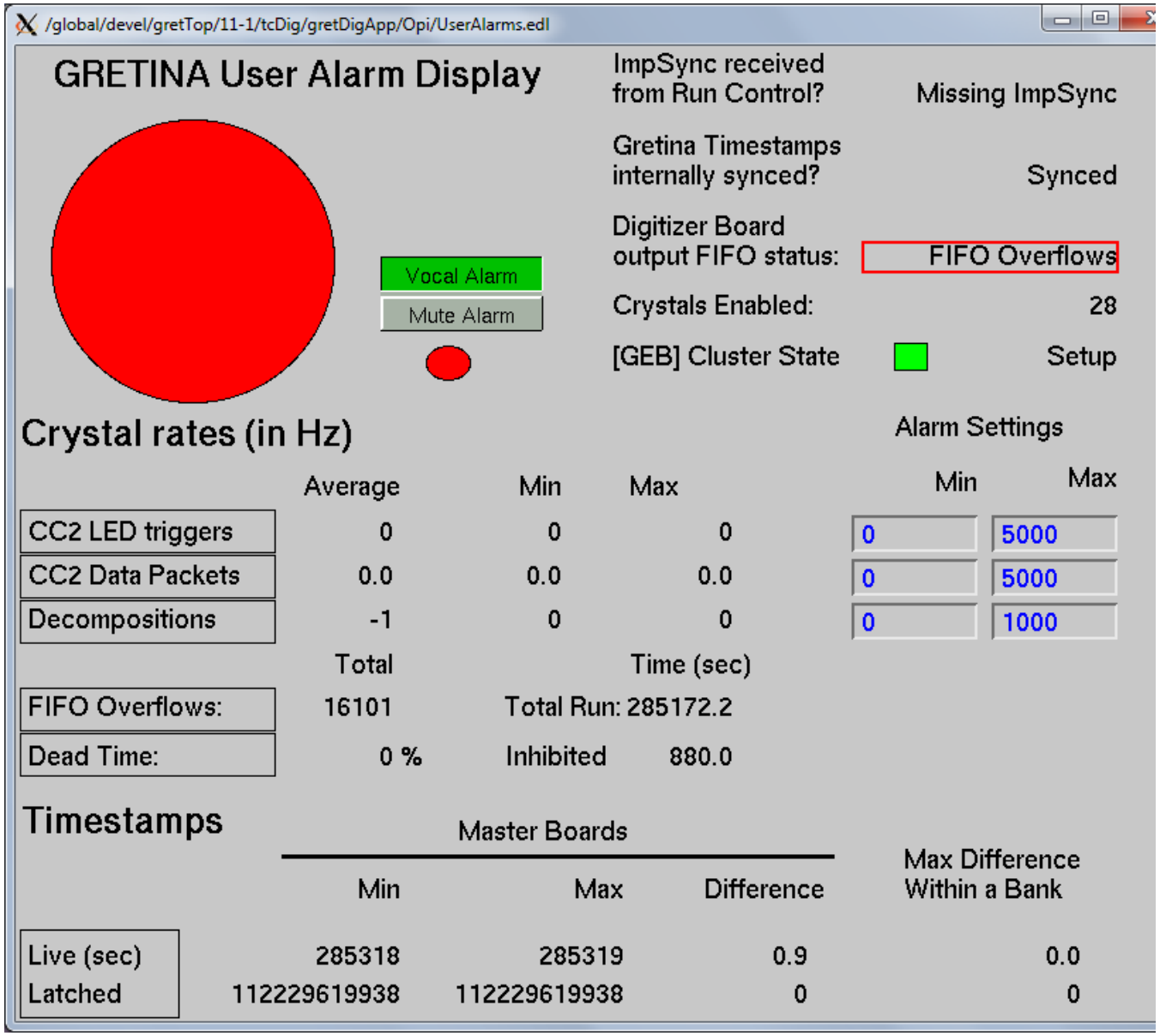
Goal:

Processing 20,000 Gamma rays /sec

Auxiliary detectors

- Minimum requirement: synchronize + trigger
  - Timestamp
    - Added to Auxiliary DAQ, e.g. using a scaler
    - Gretina provides 50MHz clock and IMP SYNC (clock reset)
  - Trigger
    - Made in GRETINA trigger system and sent out
    - OR, Made externally and sent to GRETINA trigger system
- Merge data streams:
  - Auxiliary DAQ can output to the Global Event Builder directly
  - OR, File merge
    - DAQs write independent data files
    - Post-processing merges according to timestamps
- Can digitize Auxiliary detector triggers and timing signal(s) on Bank 29

ONLINE DAQ MONITORING - GRETINA



Key information has been distilled into one meaningful alarm page.

Digitizer timestamp synchronization tested every 10 seconds.

Scripts/Buttons allow users to recover from problems

Problems:

- Digitizer stability
  - Firmware failures requiring FPGA reset
    - Run stop, Reset settings, Run start
  - Rate dependent failure above a few kHz per crystal with current firmware @NSCL
    - Higher rates ran stably under a previous version
    - Some compile dependence
  - Firmware is NOT software: clock jitter
    - Fixes will involve programming and hardware changes
  - Full DAQ (112 digitizer system) needed to test “system” failure rate
- IOC network failure
  - Failure one IOC (of 28 in system) per 1-2 days
    - Run stop, Reset settings, Run start
  - Under investigation
- High rates and segment summing
  - Both need digitizer firmware changes to run without losses

Digitizer FPGA features implemented – to be tested

- Fixed-time energy pick-off
  - Instead of peak-find energy, might improve resolution
- Baseline restorer (BLR) changes
  - Vary time constant to minimize noise contribution
  - Inhibit window based on CC_LED, not local LED, to lower the effective segment energy threshold
  - Inhibit window re-triggering (for high rates)
- Longer noise window
  - Inhibit spurious triggers

FPGA improvements

- High rate dead time
  - Due to singular pre-buffer, only one event can be constructed and held for trigger validation at a time
  - Led to external trigger workaround at BGS
  - Better solution possible IF max trigger latency allows
- Serdes improvement
  - Digitizer to Trigger communication of “slow data”
  - Necessary for more advanced trigger conditions
    - Sum Energy – Will this be used during ATLAS campaign?
- Shifted validate window to select trigger validations with a known time delay
- Digitizer timing MUX replacement to reduce clock jitter and improve code stability
- Add data to output format? (baseline, Trigger TS)

Questions for users?

- What trigger conditions will you need?
  - Is sum energy needed?
- What trigger rate and latency can we expect from your auxiliary detector?
- What auxiliary detector data size and rate will be sent to GEB? At what latency?
- What crystal rate and readout rate are expected?