Gretina data flow and formats

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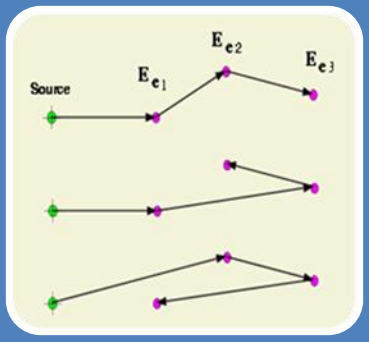
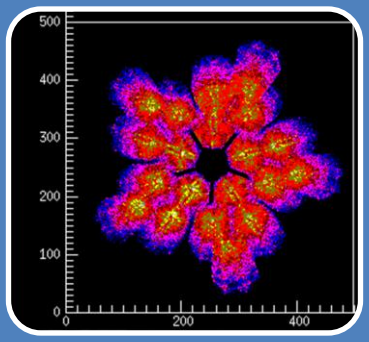
LBL



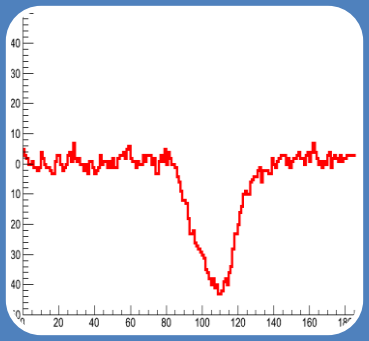
Mode 1

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



Mode 2

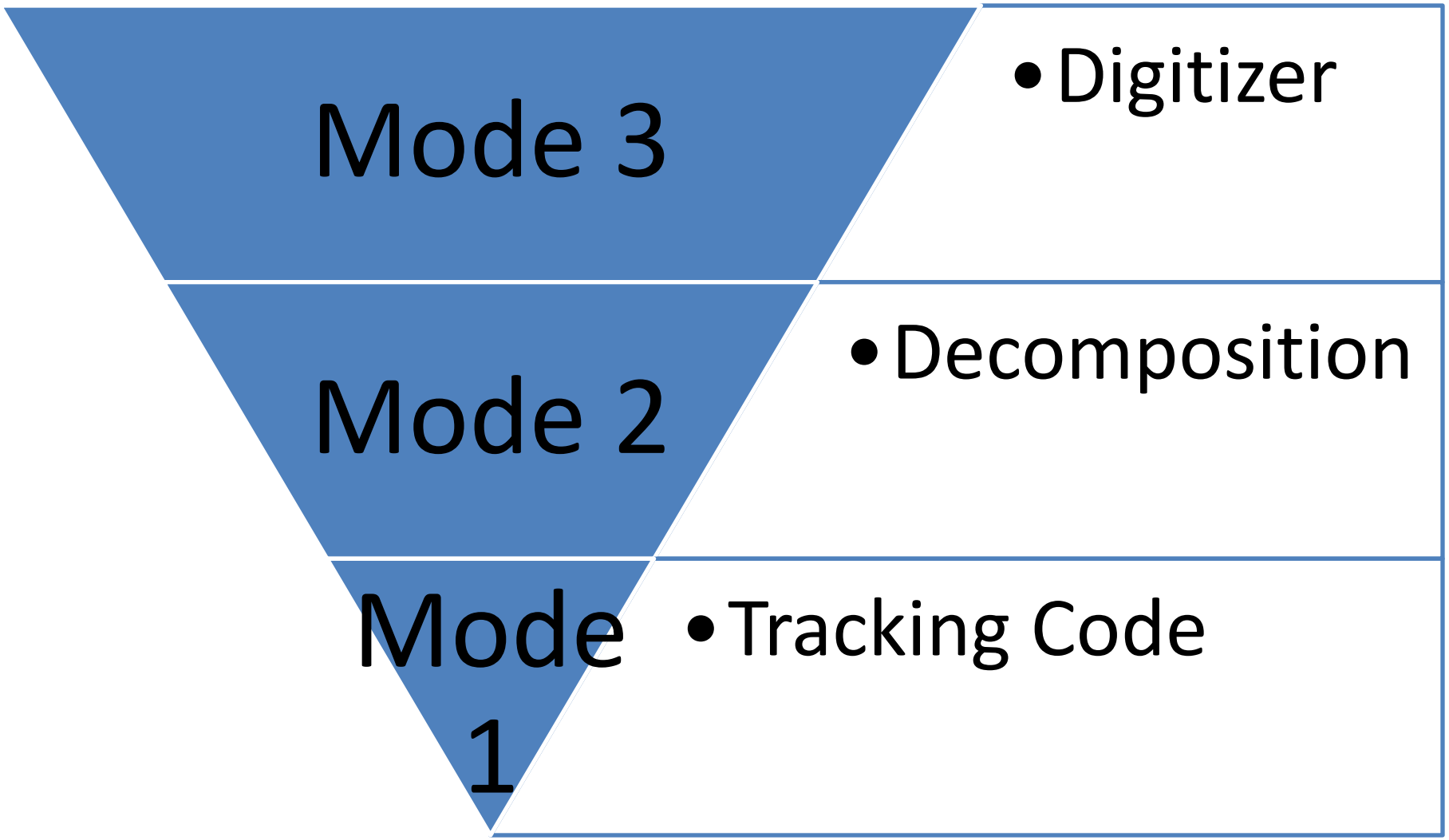
- Interaction points by crystal
- Crystal: Energy, position, time
- Interactions: Energy split and position in crystal



Mode 3

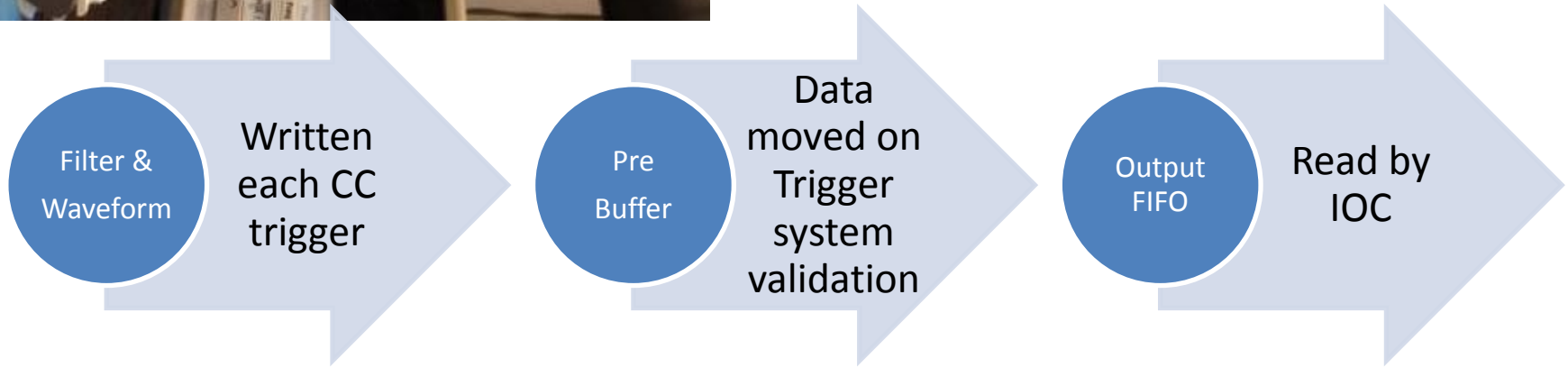
- Data organized by digitizer channels
- Header + waveform
- Header holds channel ID, filter data, time stamps

Data Flow & order of talk



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:

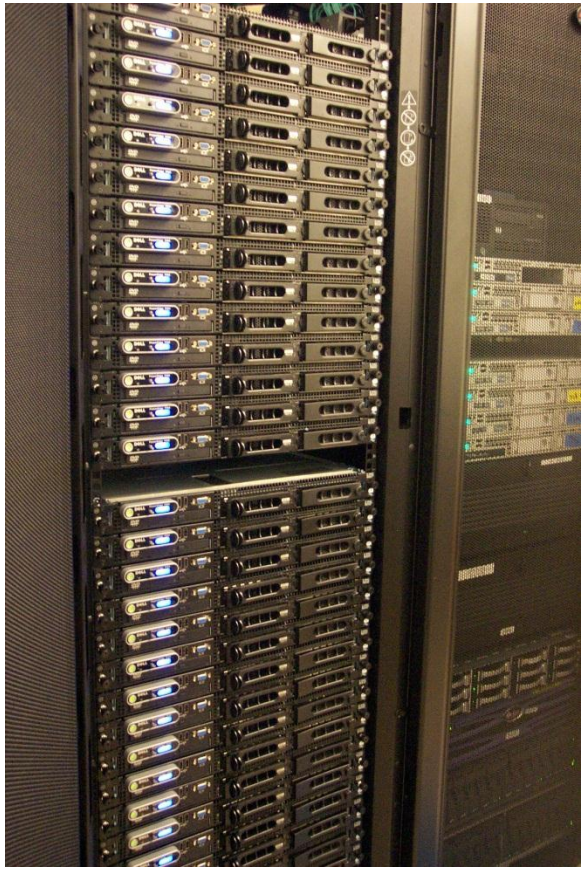
- Separate VME backplane and IOC
  - Slow control in EPICS
  - Reads & timesorts digitizer data
  - Passes data to compute cluster
- 4 LBNL Digitizer Modules
  - 10 channels (9 segments + core)
  - 1 Flash ADC / ch, 14bit 100MHz
  - On-board FPGA filters
    - Energy (trapezoid)
    - Leading Edge (trigger primitive)
    - Pole-zero correction
    - Baseline Restoration
- Event data includes:
  - Timestamp
  - Filter data
  - Waveform subset

Gretina DAQ (I)

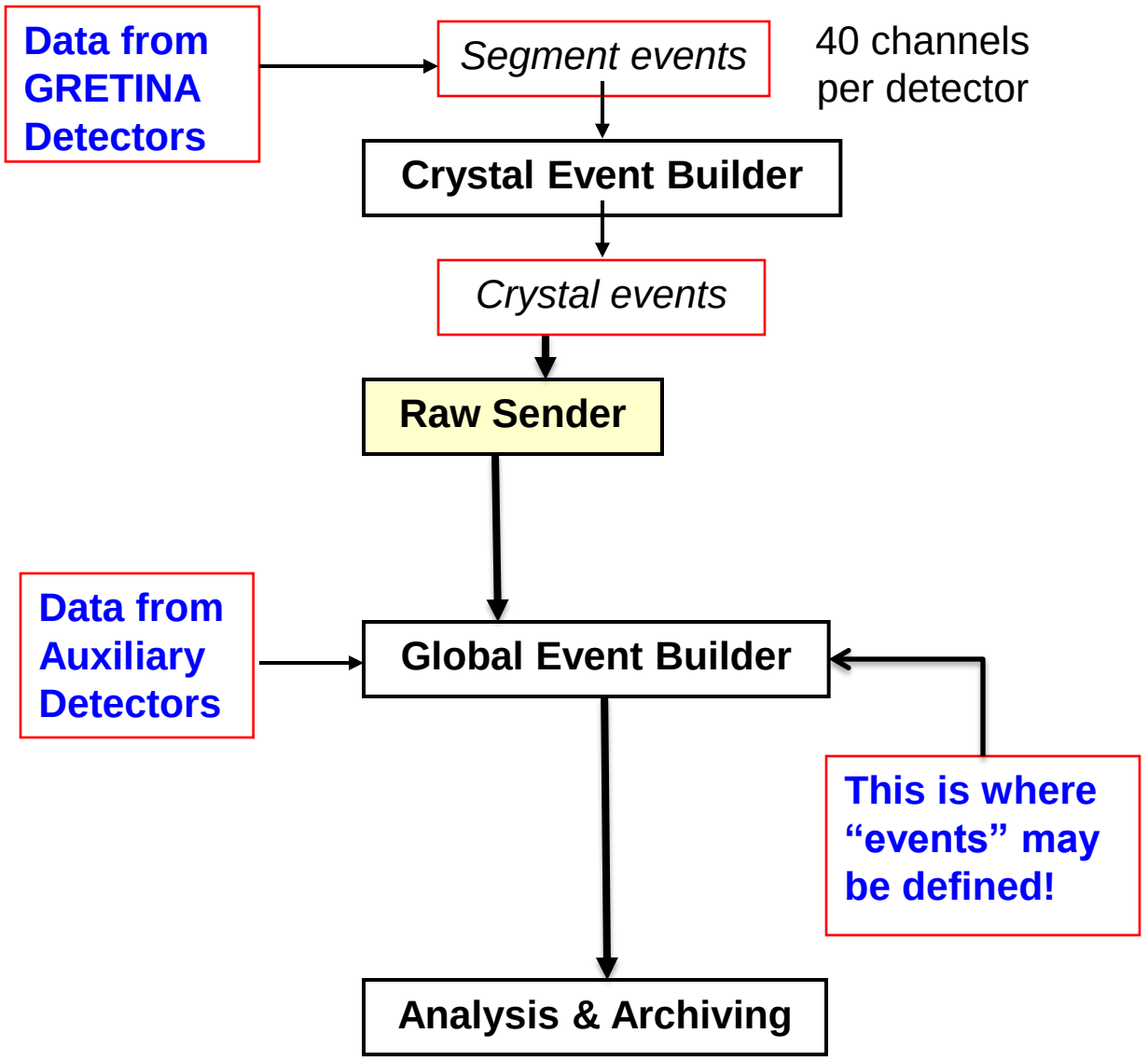
Trigger system:

- 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

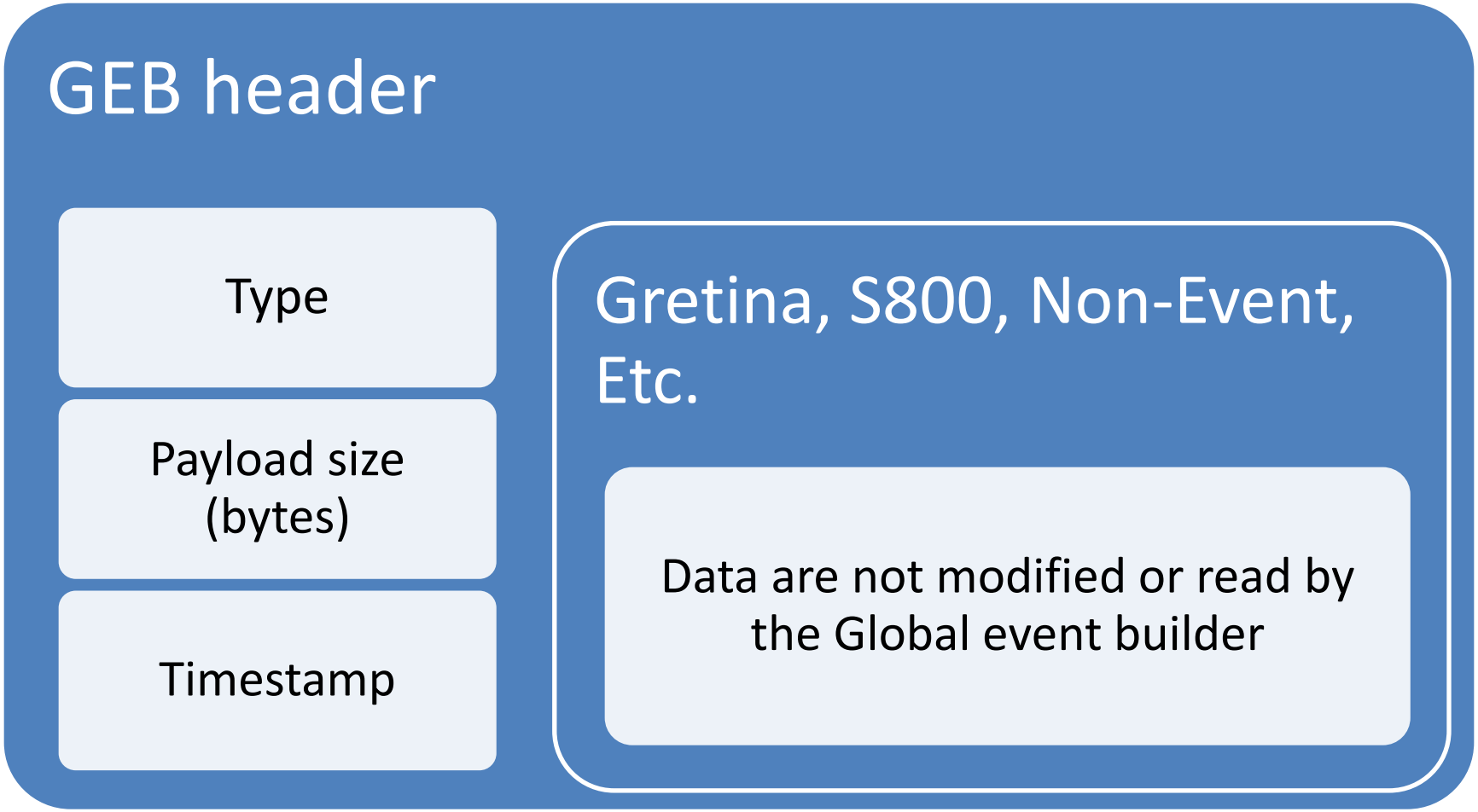
Computing: Mode 3



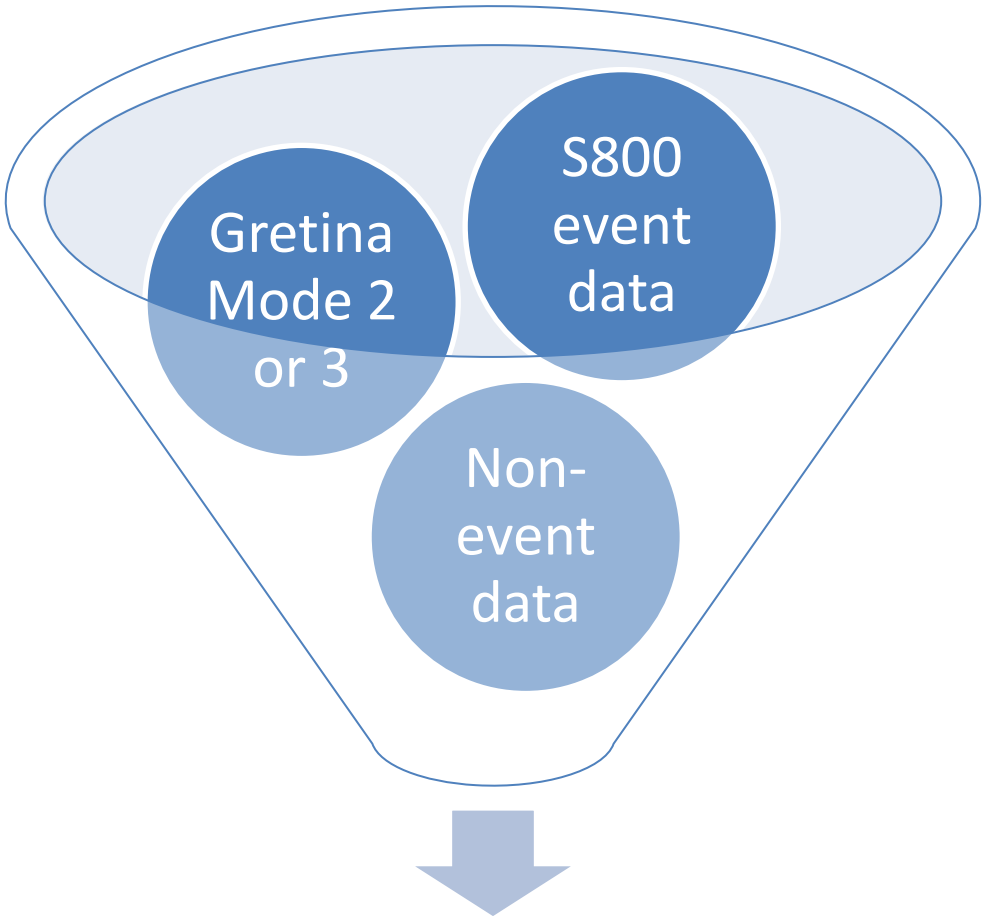
70 nodes
2 cpu / node
4 core / cpu



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 format, 1 channel

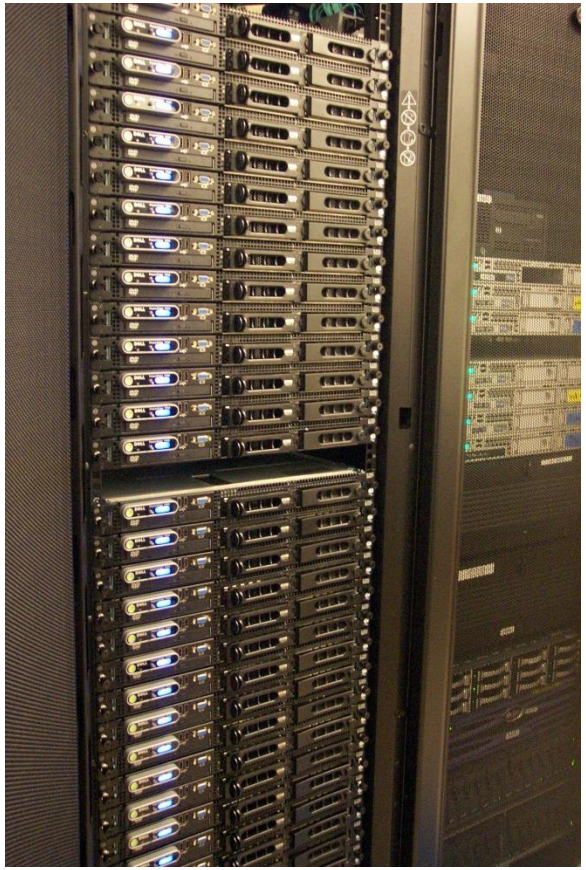
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23 24 25 26	27 28 29 30 31
Board ID[1]	Packet length (header included)	GA
LED / external timestamp bits 0 - 15*	LED / external timestamp bits 16 – 31*	
LED / external timestamp bits 32 - 48*	Energy bits 0 – 15	
Energy bit 16 – 24 | x | x | T | S | E | C | P	CFD Timestamp bits 0 – 15	
CFD Timestamp bits 16 - 31	CFD Timestamp bits 32 – 47	
CFD point 1 bits 0 - 15	CFD point 1 bits 16 – 31	
CFD point 2 bits 0 - 15	CFD point 2 bits 16 – 31	
Raw data point 0 (Sign extended)	Raw data point 1 (Sign extended)	
Raw data point 2 (Sign extended)	Raw data point 3 (Sign extended)	

- 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
  - 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
- Mode 3 Calibrations are hard!
  - Imposed dead time system implemented by toggling trigger
  - System fails at >~2kHz / crystal
  - Limits calibration sources!!!

Computing: Mode 2



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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

Decomposition – Mode 2 format

```
struct crys_intpts {
  int type;           /* defined as abcd5678 */
  int crystal_id;
  int num;            /* # of int pts from decomp, or # of nets on decomp error */
  float tot_e;        /* dnl corrected */
  int core_e[4];      /* 4 raw core energies from FPGA filter (no shift) */
  long long int timestamp;
  long long trig_time;    /* not yet impl */
  float t0;
  float cfd;
  float chisq;
  float norm_chisq;
  float baseline;
  float prestep;    /* avg trace value before step */
  float poststep;   /* avg trace value following step */
  int pad;          /* non-0 on decomp error, value gives error type */
  struct {
    float x, y, z, e;       /* here e refers to the fraction */
    int seg;                /* segment hit */
    float seg_ener;         /* energy of hit segment */
  } intpts[MAX_INTPTS];
};
```

Pros

- Smaller data, ~450bytes
- Directly useful for physics

Cons

- Waveform data is lost

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

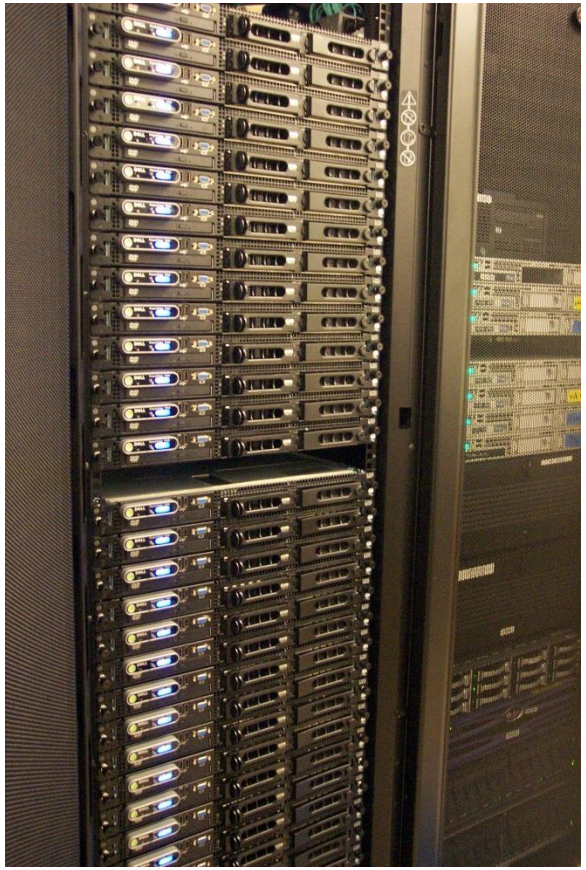
Decomp

- 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

Mode 1 format

- No loss of information going from Mode2 to Mode1
- Tracking is tacked onto the corresponding Mode2 data.
- Events must be defined to track!

```
typedef struct CL_INTPTS {
float xx, yy, zz;
float edet;
int order; /* 0 == first interaction point */
long long int timestamp;
int shellHitPos; /* internal use only */
int detno; /* not sure it is used or meaningful
*/
} CL_INTPTS;

typedef struct CLUSTER_INTPTS {
int valid; /* alway 1 in output, may be zero
internally */
int ndet; /* # interaction points */
int tracked; /* ==1 if we managed to track */
float fom; /* fom value for the tracking */
float esum; /* gamma ray energy */
int trackno;
int bestPermutation;
int processsed; /* not used now */
CL_INTPTS intpts[MAX_NDET];
} CLUSTER_INTPTS;
```

Modes/Formats change history

- 9/2011
  - GEB headers added
- 3/2012
  - Mode2&3 parallel file recording
- 7/2012
  - Mode 2 upgraded
  - DNL correction added to Mode2
- 9/2012
  - Scaler/diagnostic data to be added

GEB headers list

```
#define GEB_TYPE_DECOMP 1
#define GEB_TYPE_RAW 2
#define GEB_TYPE_TRACK 3
#define GEB_TYPE_BGS 4
#define GEB_TYPE_S800_RAW 5
#define GEB_TYPE_NSCLnonevent 6
#define GEB_TYPE_GT_SCALER 7
#define GEB_TYPE_GT_MOD29 8
#define GEB_TYPE_S800PHYSDATA 9
```