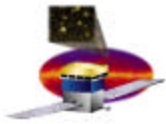


The Event Path

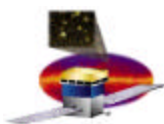
16 August 2001

**Stanford Linear Accelerator Center
Stanford CA**



Overview of the Event Path

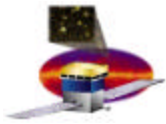
- **Event Path**
 - **Event Size Estimate**
 - **Event Arrival**
 - **Event Composition**
 - **Event Correctness**
 - **Event Filtering**
 - **Monitoring**
 - **On Board Science**
 - **Event Writing**
 - **GBM support**



Event Size Estimates

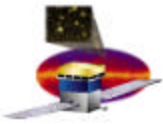
Subsystem	Hits	Noise	Fixed + Bits/Hit	Volume (bits)
CAL	8 logs	16 logs	$16 \cdot 192 + 32 \cdot n$	3840
TKR	24 strips	24 strips	$0 + 64 \cdot n$	3072
ACD	5 Tiles	1 Tiles	$192 + 32 \cdot n$	384
TRG			320	320
Total				7616

- 6 x 32 bit words of overhead/tower
- CAL, 1% noise occupancy
- TKR, 2×10^{-5} noise occupancy
- 80 Mbs @ 10HKz
- Design is done for 160- 320 Mbs



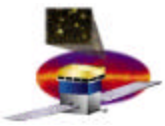
Event Composition

- **The Event Builder delivers complete events to the CPU:**
 - **Data from the 16 towers, includes:**
 - Tower specific trigger data.
 - CAL data.
 - Tracker data.
 - **Global Trigger Data.**
 - **ACD Data.**

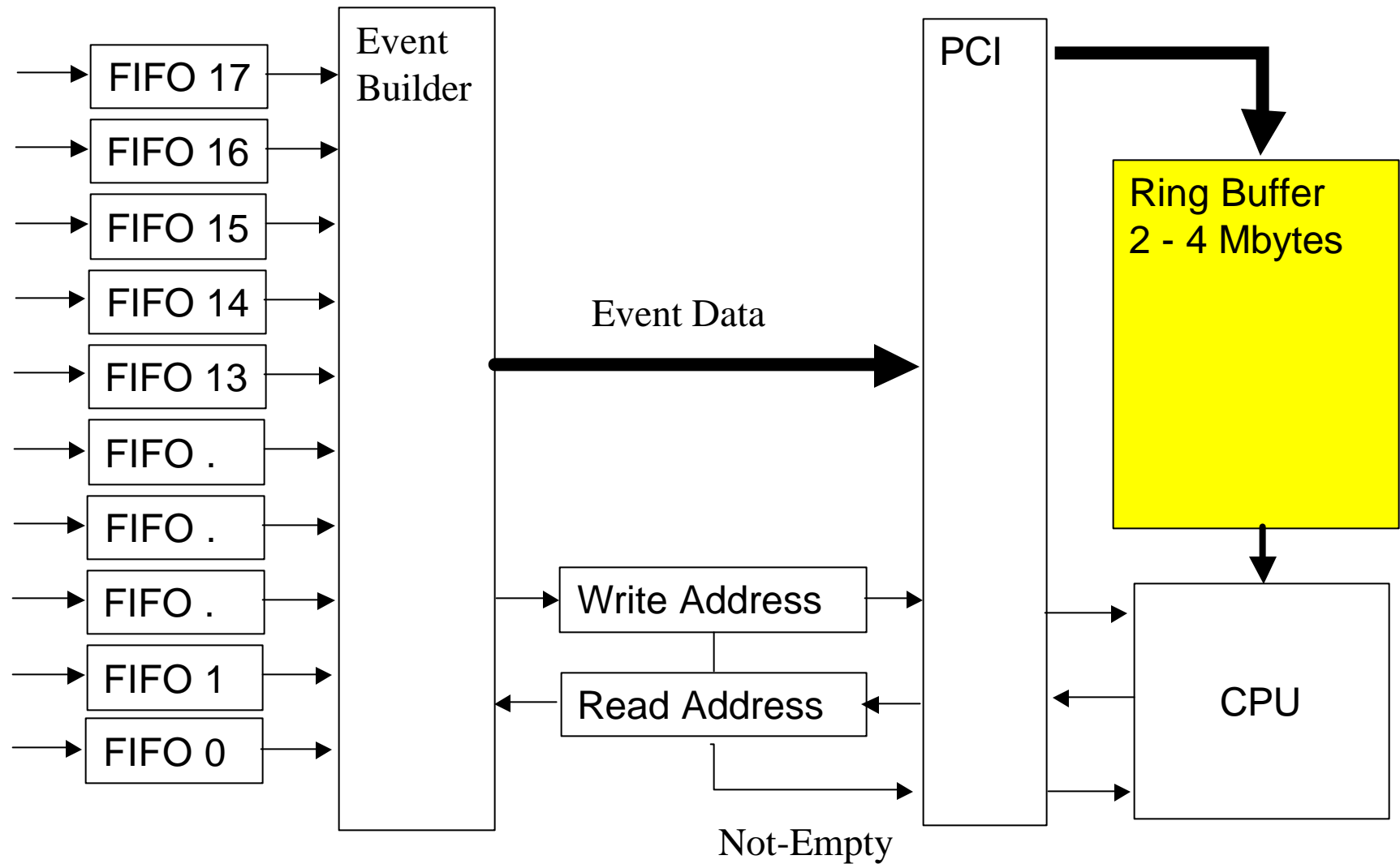


Event Arrival

- **Event Builder DMAs events into processor memory.**
 - **Input memory will be configured as a circular buffer.**
 - **Size will be ~2 - 4Mbytes.**
 - **Holds 1-2K events.**
 - **Smooths out bursty behaviour.**
- **Flow-control between EB & CPU is through two registers.**
 - **A write pointer, the end of the last complete event.**
 - **A read pointer, the beginning of the first event to process.**
 - **Processor is free to read these registers at any time.**
 - **Event builder advances write pointer as events arrive.**
 - **Processor advances read pointer as events are consumed.**
- **Processor is notified on transition of empty -> non-empty.**

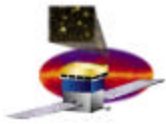


EB – CPU Interface



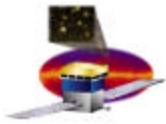
JJRussell

Event Path 6



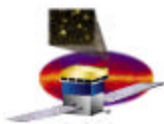
Event Integrity

- Event Integrity is checked, i.e. is the event structurally sound.
 - All components present.
 - Consistent with coming from the same trigger.
 - Event sequence numbers the same.
 - Event time tags match.
- Front-end Integrity Check.
 - Check for parity errors and consistency errors.
- This is *not* a check of data quality.
 - Purely a check on the transport and assembly chain.



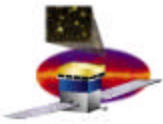
Event Classification/Filtering

- **The problem:**
 - **Input Rate: 5-10KHz input rate of mostly charged tracks.**
 - **Output Rate: 30-60Hz.**
 - **Real constraint is bandwidth, more bandwidth**
 - **Higher output rate**
 - **Less sensitivity, more robust**



Event Filtering - Strategy

- FSW filters event using a hierarchical approach
 - Deal with the easy stuff first
 - Pick algorithms and ordering carefully
 - Figure of merit = $\text{rejection_power} / \text{CPU cycle}$
 - CNO events are set aside for monitoring purposes.
 - Identified by ACD HI trigger primitive. (~50-100Hz)
 - High Energy Events
 - Identified using the CAL HI trigger bits (estimate < 50 Hz).
 - To reduce rate to ~1Hz, CAL group suggests
 - ETOT calculation based on CAL data.
 - Simple CAL based pattern recognition.
 - Very cheap; robustness needs investigating.
- Unfortunately, this does not make much of a dent in 10KHz.

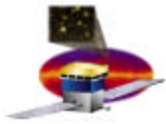


Event Filtering - Continued

- How to reject the charged particle background?
- Issues
 - Is there enough information in the data to do the job?
 - Offline studies indicate yes.
 - Can information be extracted in a timely and robust fashion?
 - Object of active study.
- First line of defense
 - Reject events which point to a lit ACD tile.

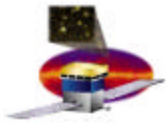
CHIME	All Gamma $T < 26^\circ$	All Gamma $T < 45^\circ$	All Gamma $T < 60^\circ$	All Gamma $T < 73^\circ$
15%	89%	87%	82%	77%

Results of First Level Rejection, courtesy S.Ritz



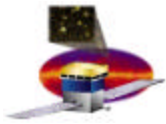
Event Filtering - Implementation

- Two implementation approaches:
 - Use information from TKR at layer level resolution.
 - Essentially a more sophisticated version of the trigger.
 - Catches tracks which cross tower boundaries.
 - Use full resolution of the TKR and ACD.
- Which to use is decided by:
 - Confidence level in the track.
 - More resolution => more precise definition of a track.
 - Pointing accuracy.
 - Layer level resolution provides little pointing information.



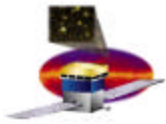
Event Filtering – CPU Implications

- **A signal/noise issue**
 - **Has great implications on CPU usage.**
 - Filtering dominates the needed CPU cycles.
 - But *not* the memory needs.
- **The issue:**
 - **If can work at the resolution of layers,**
 - CPU cycles to do this are reasonable.
 - Technical studies are needed to quantify this.
 - **If noise of the tracker and/or ACD demands track finding,**
 - The number of CPU cycles greatly increases.
 - The magic boundary is crossed when the filtering process must access/unpack the tracker data.
 - Hard to quantify at this time, since input data format is in flux.



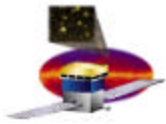
Event Filtering – CPU Implications

- If forced to unpack the TKR data.
 - Current unpacking algorithm consumes only 50% more time than *just reading the data*.
 - Cannot gain from further optimization of code.
 - Only way to gain is to unpack only what is necessary.
 - Working with hardware engineers to achieve this.
- Taking care to ensure that tower data can be randomly accessed.
 - Allows access to tower summary data without having to serially decode the data.
 - Memory access time is the major issue, not CPU cycles.



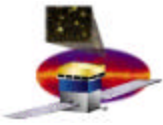
Event Filtering Monitoring

- **FSW software monitors the performance of the filtering process.**
 - **The decision of the event filtering is final.**
 - **Filtering characteristics affects the physics.**
 - **The approximately 300:1 reduction is daunting.**
- **Aimed at those items which only the flight software can do.**
 - **Maintain and ship to the ground critical distributions.**
 - **Accept/reject statistics at various stages will be kept.**
- **FSW monitor two key quantities:**
 - **Purity.**
 - **Efficiency.**



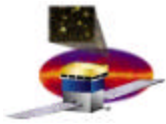
Event Filter Monitoring - Purity

- **Purity is the less critical FSW issue.**
 - **Purity determines the number of events passed by the filter.**
 - **Constraint is that they fit in the output bandwidth.**
 - **Ground software will polish the sample.**
 - **Well, almost, on-board science demands have a say here.**



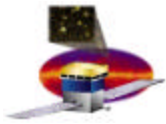
Event Filtering Monitoring - Efficiency

- Flight Software monitors the filter's efficiency.
 - Efficiency is a strong function of energy, direction, etc.
 - Filter's efficiency must be unfolded from these raw distributions to recover the original distributions.
- Checking an completely unbiased sample is impractical.
 - A sample of 1000 unbiased gammas requires 300K events.
 - 300K events corresponds 3 hours @ 30hz.
 - Can be done on a spot basis, but not a continuous basis.
 - Binning by energy, direction requires even more statistics.
- Approach, use biased sample of events.
 - Strategy
 - Change the order that the filter stages are run.
 - Use overlapping, but independent triggers.



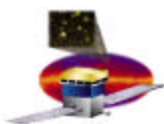
On Board Science

- **FSW does additional processing to support on board science**
 - **Increases the purity of the sample.**
 - Requires the computation of additional and quantities.
 - Requires the refinement of existing parameters.
 - **On board science requirements do not effect the filtering.**
- **Maintains lists of photon candidates to identify transient events**
 - **Data contains relevant physical quantities.**
 - e.g. Energy, direction, time, etc.
 - **Lists are composed on the EPs and gathered by the SIU.**
 - Latencies are less than 1msec.
 - **Lifetime on the list is limited.**
 - **Lists are scanned to make physics distributions.**



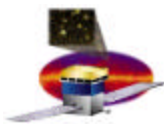
GBM Support

- **FSW services GBM Alert messages**
 - **Delivered as an interrupt signal on a dedicated wire.**
 - **Issued by the GBM within 5 msec of event**
 - **LAT responds by loosening filtering criteria.**
- **FSW services GBM Location Messages**
 - **Delivered as a 1553 message**
 - **Issued within 2 seconds of the event**
- **FSW services GBM repointing requests**
 - **GBM may request the LAT to forward a repointing request to the spacecraft.**
 - **Avoids 2 masters trying to instruct the spacecraft.**



Event Writing

- **FSW applies various loss-less compression techniques.**
 - Preliminary studies indicate a factor of 2 reduction.
 - Hope to increase the compression to a factor of 3-4.
 - Goal is a compressed event size ~500-750 bytes.
- **Output data is packaged in a format suitable for storage on the Spacecraft's Solid State Recorder.**
 - Reed-Soloman encoding and randomizer are applied by the spacecraft, not a FSW responsibility.
- **Data is transmitted to the SSR over a link of at least 32Mbps.**
 - The oversized bandwidth is used to cover burst behavior.
 - Also supports quickly moving test and diagnostic data.



Issues and Concerns

- Data format from the hardware greatly influences
 - Event data size.
 - CPU resources (cycles, not memory).
- Filtering algorithm depends on
 - Signal/Noise in ACD, TKR.
 - Is pile-up a problem?
 - The ‘absence’ of information is very important.
 - A dead ACD tile is very different from an absence signal.
 - ACD robustness
 - Cannot just substitute a layer of TKR for an ACD tile.
 - At 10^{-5} noise, a layer gives a false veto 1% of the time.
 - Efficiency is ~95%, too much leakage .
 - Must do tracking in the region of the missing tile.
- Efficiency monitoring.