HPS
Trigger Status
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Trigger Module Status

FADC Status

- **Firmware:** complete (until a bug is found or a new feature is requested!)
- **Hardware:** all installed, plenty of spares available

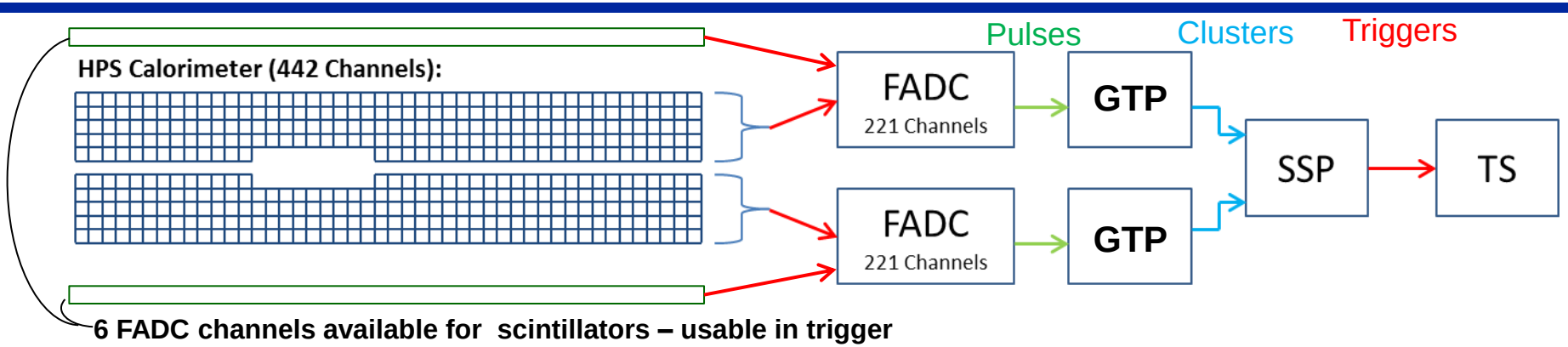
GTP Status

- **Firmware:** complete (until a bug is found or a new feature is requested!)
- **Hardware:** installed, recently received 1 spare unit (needs checkout)

SSP Status

- **Firmware:** mostly complete
  - trigger logic is complete
  - additional trigger logic requests are expected
  - need to add event builder
- **Hardware:** all installed, plenty of spares available

ECAL Trigger Overview



FADC (Flash Analog-to-Digital Converter)

- 250Msps, 12bit pulse digitizer for: Readout & Trigger (energy, timing)

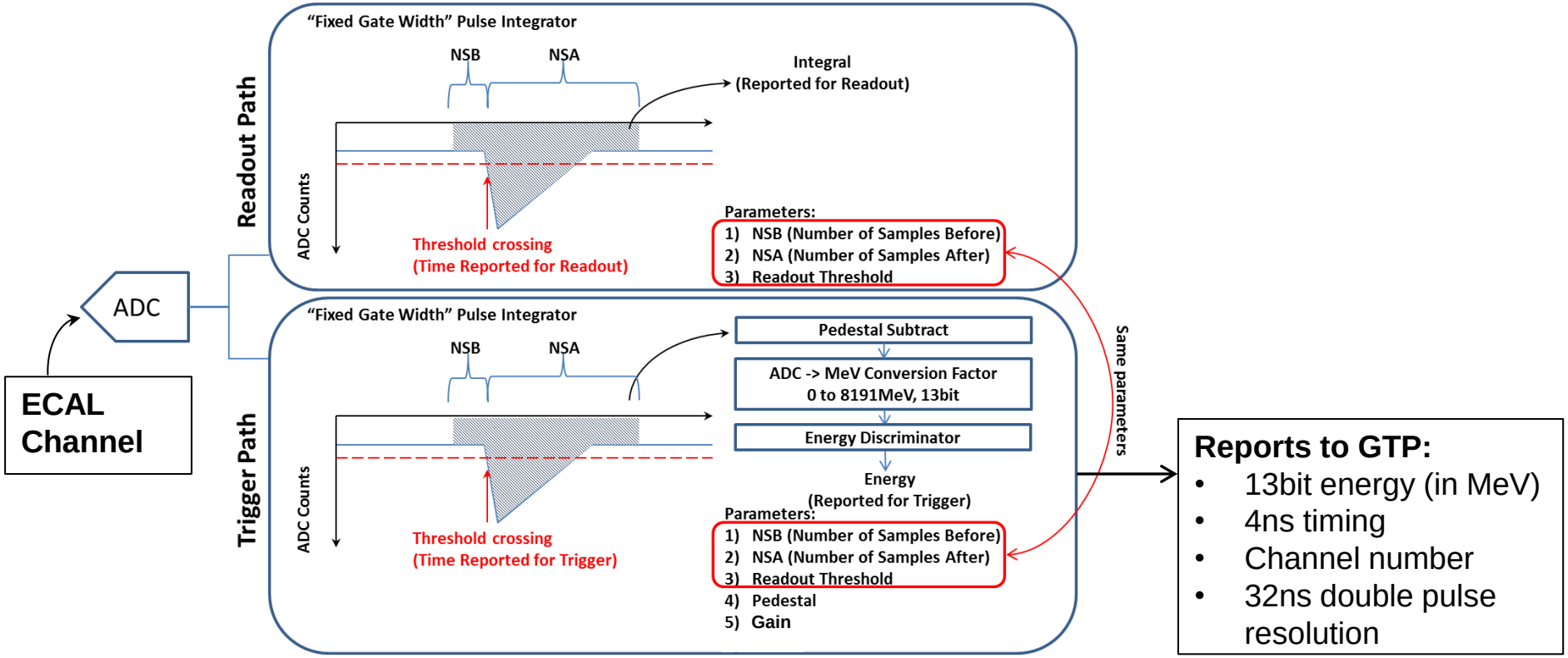
GTP (Global Trigger Processor)

- Collects pulse data from all FADC channels in crate
- Searches for clusters on half (top or bottom) of the ECAL
- Sends cluster energy, time, position, hit count to SSP for trigger processing

SSP (Sub-System Processor)

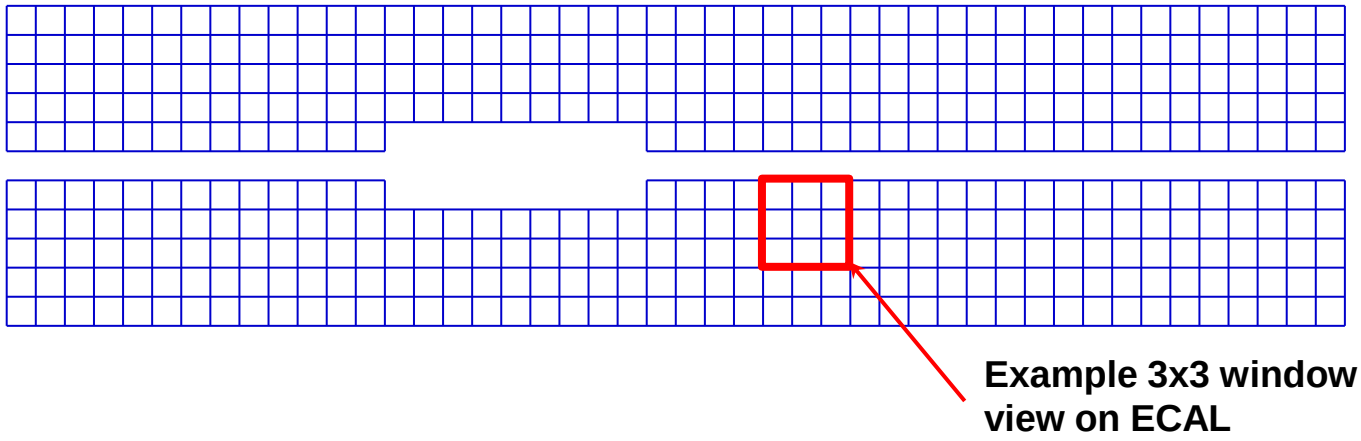
- Collects clusters from top & bottom halves of ECAL from GTP
- Performs cuts on individual clusters: energy, hit count
- Performs cuts on paired clusters: energy sum/difference, coplanar, distance-energy
- Delivers trigger signals to TS (Trigger Supervisor) for readout

FADC – Pulse Processing



- Trigger pedestal is the same parameter that would be calculated for the readout data.
- Trigger gain parameter sets energy units in MeV so GTP and SSP trigger parameters work in these units as well.
- Both pedestal and gain require calibration to determine parameters.

GTP – Cluster Processing



1. **Search for ECAL hits ≥thr that is a local maximum (in 3x3 window and in cluster coincidence time Δt)**
2. **Sum 3x3 window of hits within Δt of hit from step 1**
3. **Identify 3x3 window hit pattern**
4. **Report cluster to SSP defined as:**
   - **cluster center (defined by step 1)**
   - **3x3 window energy sum (defined by step 2)**
   - **3x3 hit pattern (defined by step 3)**
   - **4ns resolution timestamp**

SSP Event Information

Structure Element	Size (bytes)	Element Information
Block Header	4	Block Number: 11bits VME Slot: 5bits EventsPerBlock: 11bits
Event Header	4	Event number: 27bits
Trigger Timestamp	8	Timestamp: 48bits (~13 day rollover)
ECal Cluster	8	Cluster Center X: 6bits Cluster Center Y: 4bits Cluster Energy: 13bits Cluster Nhits: 4bits Cluster Time: 9bits Trigger pattern: up to 18bits
…		
ECal Cluster	8	
…		
Event Header	4	
Trigger Timestamp	8	
ECal Cluster	8	
Block Trailer	4	Block Word Count: 22bits VME Slot: 5bits

SSP will create event data containing all found clusters.

Programmable time window:

- **"trigger look-back"**
- **"window width"**

Clusters are tagged with trigger decision results (pass/fail):

- **HPS physics cuts**
- **Cosmic**
- **Random**
- **etc…**

Scalers/Histograms

FADC

- Pulse threshold crossing per channel (Scaler)
- Pulse energy distribution per channel (Histogram)

SSP

- ECal top,botton cluster energy (Histogram)
- ECal cluster rates per crystal (Histogram)
- Cluster trigger singles rates (in and accepted) (Scaler)
- Cluster trigger pair rates (in and accepted per cut) (Scaler)
- Cluster trigger pair cuts
  - Pair - energy difference accepted/rejected (Histogram)
  - Pair - energy sum accepted/rejected (Histogram)
  - Pair - energy * slope accepted/rejected (Histogram)
  - Pair - coplanarity accepted/rejected (Histogram)

TS (TI Master) Trigger Inputs

6 Front panel inputs are available:

1. SSP – HPS “singles” (ClusterTop || ClusterBottom)
2. SSP – HPS “pairs” (HPS physics trigger)
3. SSP – Secondary HPS “pairs” (Calibration trigger)
4. SSP – Secondary HPS “singles” (Calibration trigger)
5. SSP – Cosmic (Ecal scintillator coincidence)
6. LED Pulser (?)

1 Internal random source (inside TS):

- programmable from ~10Hz to ~500kHz

Prescalers (inside TS) for each trigger input:

- programmable from 2 to 32,768 (in powers of 2)

“Singles” Trigger

Trigger equation:

$$((E_{min} <= E_{Top} <= E_{max}) \text{ and } (NHits_{Top} >= NHits_{min}) \text{ and } ClusterPositionValid(X_{Top}, Y_{Top}))$$

or

$$((E_{min} <= E_{Bot} <= E_{max}) \text{ and } (NHits_{Bot} >= NHits_{min}) \text{ and } ClusterPositionValid(X_{Bot}, Y_{Bot}))$$

Note:

- ClusterPositionValid is a VME programmable table that defines cluster positions to accept or reject
- Currently planning to implement 2 of these trigger bits (they will operate simultaneously with independent parameters)

Color legend:

- Trigger data from detector
- VME programmable parameter
- Hardcoded parameter/logic

“Pair” Trigger

Trigger equation:

$$(|T_{Top} - T_{Bot}| <= \Delta t_{max}) \text{ and}$$
$$(|E_{Top} - E_{Bot}| <= \Delta E_{max}) \text{ and}$$
$$(E_{Top} + E_{Bot} <= E_{max}) \text{ and}$$
$$(E_{min} <= E_{Bot} <= E_{max}) \text{ and}$$
$$(E_{min} <= E_{Bop} <= E_{max}) \text{ and}$$
$$(Nhits <= HitThreshold) \text{ and}$$
$$(\text{Min}(E_{Top}, E_{Bot}) + R \times F <= Threshold_{Slope}) \text{ and}$$
$$(|\tan^{-1}(X_{top}/Y_{top}) - \tan^{-1}(X_{bot}/Y_{bot})| <= Coplanarity_{Angle}) \text{ and}$$
$$ClusterPairPositionValid(X_{Top}, Y_{top}, X_{Bot}, Y_{Bot})$$

Note:

- ClusterPairPositionValid is a VME programmable table that defines cluster pair positions to accept or reject
- Currently planning to implement 2 of these trigger bits (they will operate simultaneously with independent parameters)
- Planning to have pairs work on all combinations of cluster pairs (i.e. 2 clusters on same side can for a pair), but has not yet been implemented (will do soon!)

Color legend:

- Trigger data from detector
- VME programmable parameter
- Hardcoded parameter/logic

Cosmic Trigger

Trigger equation:

$$(|ScintillatorHitTime_{Top} - ScintillatorHitTime_{Bot}| <= \Delta t_{max})$$

Note:

- Discrimination threshold for each scintillator is set on the respective FADC channel

Color legend:

- Trigger data from detector
- VME programmable parameter
- Hardcoded parameter/logic

GTP – Cluster Processing cont…

- Previous clustering algorithm worked much simpler, which resulted in many duplicate cluster reporting (redundant data)

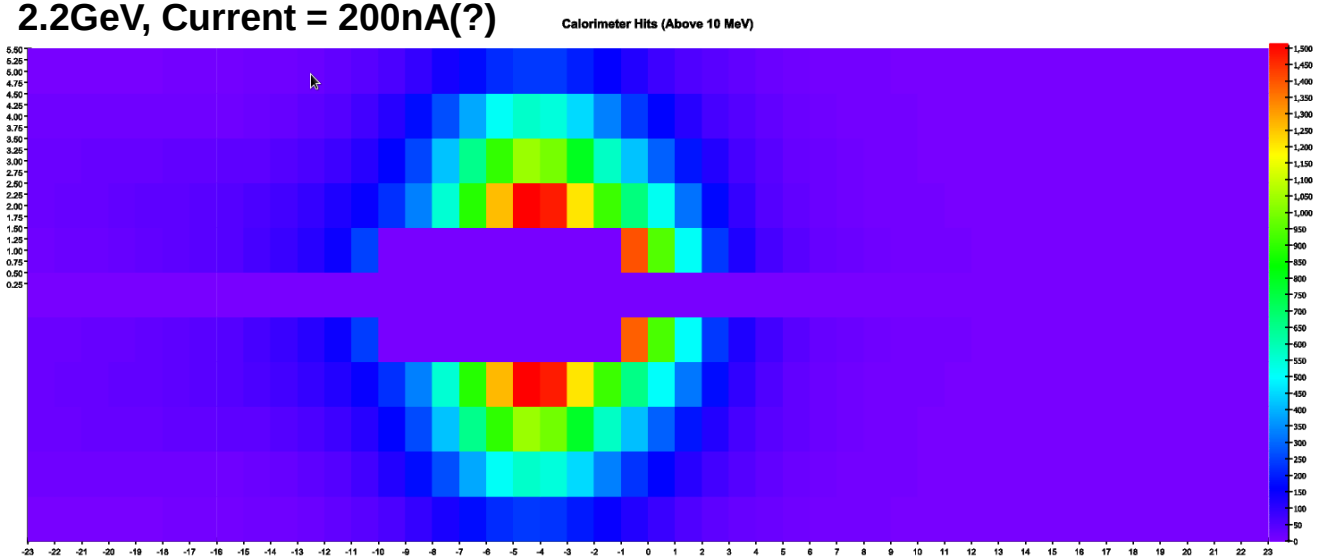
- This is the main reason pairs were restricted to a cluster on the ECal top and ECal bottom (otherwise duplicates would be seen as pairs at the higher level trigger), but the new implementation shouldn't have this problem.

- So I'm planning to enable the pairs to process all cluster combinations for calibration trigger requests

- Each GTP can send 250M-Clusters/sec to SSP…So cluster rates need to be well under this to prevent buffer overflows (which will create dead-time). Does appear to be any issue here though

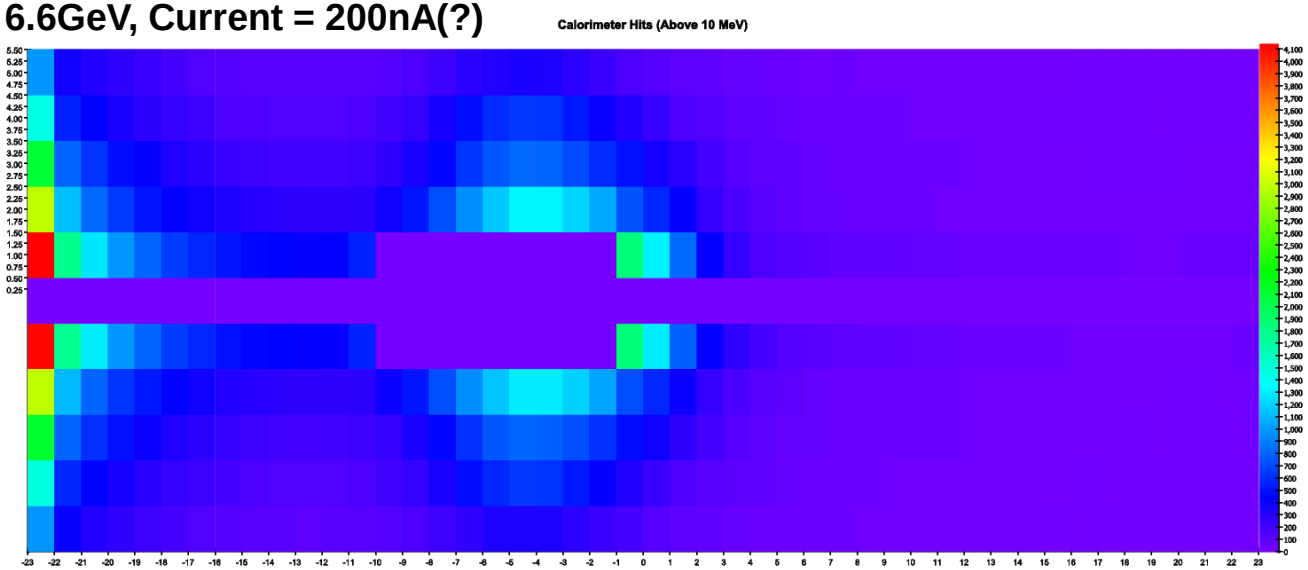
>10MeV hit rates

2.2GeV, Current = 200nA(?)



← 1500kHz

6.6GeV, Current = 200nA(?)



← 4100kHz

Current Status

Trigger system has been used and running for several weeks now

In general there are not show stoppers, just annoyances:

- **Sometimes need to try a few times to start a run to get it going (TI & GTP initialization issues, should be fixed soon)**
- **Once running, it continues to run with no noticeable problems**

We have been testing with the new TI muti-ROC support using the GTP as a second ROC

- **This testing may help work out issues in TI that will help SLAC SVT integration**
- **GTP can now report events on clustering trigger if we have the need/desire**

What's next?

Starting with highest priority:

1) Wrap up Multi-ROC testing (looks like we're there)

2) Compile 'final' SSP firmware with the latest trigger feature requests

3) Fix outstanding bugs/annoying issues

4) Add more hardware diagnostics (histograms mainly)

We should be ready to test with ECal & Cosmics very shortly.