Trigger Scheduler, Engines, and Rates

A proposal for flight configuration

J. Eric Grove
Purpose

- Intent: Want to run LAT at SLAC with trigger config as much like flight as possible
  - What is flight trigger config?
  - What rate is acceptable?

- See Confluence page for DC2 source and bkg rates
  - [http://confluence.slac.stanford.edu/display/SCIGRPS/Resulting+Trigger+and+Filter+Rates](http://confluence.slac.stanford.edu/display/SCIGRPS/Resulting+Trigger+and+Filter+Rates)
  - Steve presented rates for 3 possible trigger configs
    - Example, configuration 2: `(TKR && (!ROI || CALLO)) || CALHI`
      - Mean rate ~ 2.6 kHz

- See C&A presentation from November
  - Engine configuration here is revised
    - DC2 background simulation to understand trigger rates
      - Analysis by David Smith and me

- Acceptable rate?
  - From 26.5 us deadtime per evt, deadtime fraction at 10 kHz is >26%
  - Onboard filter processing time, from JJ
    - 140 us for HE gamma, less for others
  - Let’s keep peak rate < 7 kHz
    - Want mean rate much lower than that
First, need to understand capabilities of Trigger
- Defining document: LAT-TD-01545
  - The GLT Electronics Module, Programming ICD Specification

Specified in “Trigger Engines” from combinations of “Trigger Conditions”
- 8 Trigger Conditions are defined
  - $2^8 = 256$ possible combinations of these Conditions
  - Each can be allowed (or disallowed) to open a trigger window (i.e. start a coincidence)
  - ROI condition is different (see next page)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Flight setting</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROI (ACD)</td>
<td>Tower-local veto, ~0.3 MIP</td>
<td>Not allowed to open wdw</td>
</tr>
<tr>
<td>TKR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAL-LO</td>
<td>100 MeV single log</td>
<td></td>
</tr>
<tr>
<td>CAL-HI</td>
<td>1 GeV single log</td>
<td></td>
</tr>
<tr>
<td>CNO</td>
<td>~20 MIPs single tile</td>
<td>What should flight threshold be?</td>
</tr>
<tr>
<td>Periodic</td>
<td>~1 Hz</td>
<td>Gives pedestals</td>
</tr>
<tr>
<td>Solicited</td>
<td>Special use</td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>Nothing connected!</td>
<td>Not allowed to open wdw</td>
</tr>
</tbody>
</table>
The ROI Trigger Condition is different
- Can be used as trigger source or veto of TKR
  - Globally applied to all Engines, all Regions of Interest
  - We’ve selected TKR-veto mode
    - Thus TKR=False and ROI=True should never occur
      » Forbidden by definition of ROI Condition in GEM
- Up to 16 Regions of Interest may be specified on board
  - Two candidate configs for flight
    - 16 “Tower-local” Regions
      » Corresponding to tiles nearest each Tower (sorta)
    - 1 “Global” Regions
      » Single region: all top tiles and first 2 layers of side tiles
  - We’ve selected the Tower-local Regions

Throughout the remainder of this presentation
- “ROI” is defined to be the tower-local veto signal
  - ROI = True = 1 means the relevant veto line for the hit TKR is asserted
  - ROI = False = 0 means the relevant veto line for the hit TKR is not asserted
More Trigger Logic

- **16 Trigger Engines are available**
  - For each engine, need to define “Trigger Context”
    - Trigger inhibit
      - Disables engine, if set
    - Data readout mode
      - Zero suppression on or off (for ACD and CAL together)
      - 4-range or 1-range readout (for CAL)
    - Programmable pre-scale
      - Max prescale depth is 256-to-1
    - User-defined “marker”
      - 3-bit numerical value to use, e.g., as a label
        » Note: 8 markers aren’t enough for unique map for engines used below

- **Scheduler table**
  - Points each of the 256 combinations of Conditions to a single Engine
    - No ambiguity
  - But 3 of those 8 Conditions aren’t interesting for today’s discussion
    - External, solicited, periodic
    - We’re left with $2^5 = 32$ to discuss
      - 8 of these are invalid, i.e. !TKR && ROI && anything else
      - 1 more is invalid, i.e. all Conditions false
  - Let’s specify the final 23...
### Flight Trigger Engine Mapping

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Condition Summary</th>
<th>Trigger Context</th>
<th>&lt;Rate&gt; (Hz)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>000011111</td>
<td>yes 4-mg 05200</td>
<td>200</td>
<td>GCR calibration</td>
</tr>
<tr>
<td>4</td>
<td>000011110001010000010110</td>
<td>yes 1-mg 255 7</td>
<td>5</td>
<td>Other &quot;CNO&quot; triggers</td>
</tr>
<tr>
<td>5</td>
<td>00001111000110100001111</td>
<td>yes 1-mg 02</td>
<td>100</td>
<td>HE gammas</td>
</tr>
<tr>
<td>6</td>
<td>00001111000110100001111</td>
<td>yes 1-mg 01</td>
<td>1500</td>
<td>Gammas</td>
</tr>
<tr>
<td>7</td>
<td>00001111000110100001111</td>
<td>yes 1-mg 04</td>
<td>400</td>
<td>CAL-only gammas</td>
</tr>
<tr>
<td>8</td>
<td>00001111000110100001111</td>
<td>yes 1-mg 03</td>
<td>700</td>
<td>Self-vetoed gammas</td>
</tr>
<tr>
<td>9</td>
<td>00001111000110100001111</td>
<td>yes 1-mg 255 6</td>
<td>20</td>
<td>Leakage of protons</td>
</tr>
</tbody>
</table>

- **Numbering**
  - Engines assigned in bit order of Conditions
    - Engines 0, 1, and 2 for External, Solicited, Periodic, and invalid combinations (i.e. ROI without TKR)
    - Markers assigned in order of photon usefulness, sorta

- **Deadtime**
  - Minimized rate with 4-range readout to minimize deadtime
  - Prescaled the Engines dominated by protons and other "CNO" triggers

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Total rate for all Engines

- Sum of rate from all Engines
  - Note
    - Dropouts in SAA, where triggering is disabled
    - Peak rates occur away from SAA
    - Histogram includes only time outside SAA
  - Mean ~ 3 kHz
  - Peak ~ 6 kHz

- Compare to Ritz Configuration 2
  - (TKR && (!ROI || CALLO)) || CALHI
    - Mean ~ 2.6 kHz
  - Here I've added CNO
Engine by engine

- Let's now step from engine to engine
  - In order of decreasing trigger rate
Engine 6 rate

- **Content**
  - Gammas
  - Albedo gammas, LE albedo protons and electrons

- **Condition**
  - TKR && !ROI && !CNO && !CALHI && (CALLO don’t care)
    - TKR hit with no veto and no really big signals in ACD or CAL

- **Context**
  - 1-range, zero-suppressed
  - Marker = 1

- **Rates**
  - Mean ~ 1500 Hz
  - Peak ~ 2500 Hz

- **Note:**
  - Primary engine for gammas
Engine 8 rate

- **Content**
  - Self-vetoed gammas, recovered with CALLO
  - Interacting protons
- **Condition**
  - TKR && ROI && CALLO && !CNO && !CALHI
    - Local-vetoed TKR hit with max xtal E between 100 MeV and 1 GeV, but no big signals in ACD
- **Context**
  - 1-range, zero-suppressed
  - Marker = 3
- **Rates after prescale**
  - Mean ~ 700 Hz
  - Peak ~ 2100 Hz
- **Note:**
  - Candidate for prescaling?
Engine 7 rate

- **Content**
  - Gammas that didn't convert in TKR
  - Interacting sideways protons

- **Condition**
  - CALLO && !TKR && !ROI && !CNO && !CALHI
    - Big CAL hit with nothing else

- **Context**
  - 1-range, zero-suppressed
  - Marker = 4

- **Rates after prescale**
  - Mean ~ 400 Hz
  - Peak ~ 1200 Hz

- **Note:**
  - Strong orbital modulation of protons
Engine 3 rate

- Content
  - CAL calibration with GCRs

- Condition
  - CNO && CALLO && TKR && ROI
    - Local-vetoed TKR hit with big signal in ACD and CAL

- Context
  - 4-range, unsuppressed readout
  - Marker = 5

- Rates
  - Mean ~ 215 Hz
  - Peak ~ 600 Hz

- Note: Minimize deadtime fraction
  - 65 us readout deadtime
    - ~1.5% deadtime fraction
  - Keep CNO threshold high
    - Capture 36 MIPs and up
Engine 5 rate

- **Content**
  - HE gammas
  - Proton splats, ...

- **Condition**
  - CALHI & & !CNO & & (don’t care)
    - Big signal in CAL, but no big signal in ACD

- **Context**
  - 1-range, zero-suppressed
  - Marker = 2

- **Rates**
  - Mean ~ 100 Hz
  - Peak ~ 200 Hz

- **Note:**
  - Rate of single xtal > 1 GeV is modest
Engine 9 rate

- **Content**
  - Pre-scaled leakage of protons

- **Condition**
  - TKR && ROI && !CALLO && !CALHI && !CNO
    - Local-vetoed TKR hit with no big signals in ACD or CAL

- **Context**
  - 1-range, zero-suppressed
  - Prescale 256:1
    - Max possible in h/w
  - Marker = 6

- **Rates after prescale**
  - Mean ~ 20 Hz
  - Peak ~ 35 Hz

- **Note:**
  - Very modest burden on FSW

- **Note:** zoomed scale
Engine 4 rate

- Content
  - Other “CNO” triggers, garbage
  - LE protons, electrons
- Condition
  - CNO && (don’t care)
  - Except eng 3 combination
- Context
  - 1-range, zero-suppressed
  - Prescaled by 256
  - Marker = 7
- Rates
  - Mean ~ 5 Hz
  - Peak ~ 14 Hz
- Note: why keep these?
  - Need to study this class further to be sure we’re not suppressing gammas

Note: zoomed scale
Conclusions

- Proposed Trigger Scheduler and Engine definitions
  - Engines cover all trigger sources
    - Gammas, including self-vetoes
    - Heavy ions for CAL calibrations
    - Leakage of protons for alignment and calibration
  - Rates high but acceptable(?)
    - Mean ~ 3 kHz
    - Peak ~ 6 kHz

- SLAC running (e.g. test case LAT701)
  - Use this Scheduler
    - Contains all configurations we need, including External
  - Change Trigger Context
    - Remove prescale of Engine 9, TKR && ROI && !CALLO && !CALHI && !CNO, since it’s our primary source of muons
    - Remove prescale of Engine 4 so we’re sure to see one if it occurs