First Look at Multiple Trigger Engine Runs

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(with the help of Eduardo)

SLAC April 07 2006
Summary

• I have used the Engine Definition Table and the SVAC config report to obtain the rate for each Trigger Engine for RUN 600001190 (no flight SW)
  – Engine definition may be Run dependent but on orbit after some time it should be stable

• I have studied the Energy Distributions in the Calorimeter for each Trg Engine
  – looked for muon peaks

• I have obtained the rate for each Trigger Engine also for 4 Flight Software Runs
Engine Definition

The Engines are characterized by:

- **Trigger type**
  - external, solicited, periodic, CNO, CAL_HI, CAL_LO, TKR, ROI

- **Zero Suppression**
  - Enable: record events above threshold
  - Disable: record all events

- **CAL readout mode**
  - 1 Range:
  - 4 Range:

- **Prescale**
  - A fraction of the events maybe thrown away

- **Marker**
  - Identifier in the event stream (For the moment, no need to worry about that for data analysis)
### Condition Summary for Trigger Engines

| Engine number | X0 | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | Xa | Xb | Xc | Xd | Xe | Xf | Notes |
|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------|
| 0             | 0  | 1  | X  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Run 600001190 No FSW |
| 1             | 0  | 1  | X  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Enable 1-range 0 0 0 |
| 2             | 0  | 1  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Enable 1-range 0 0 0 |
| 3             | 0  | 0  | 1  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Disable 4-range 0 0 |
| 4             | 0  | 0  | 0  | 1  | x  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | Enable 4-range 0 1 |
| 5             | 0  | 0  | 0  | 0  | 1  | x  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Enable 1-range 0 0 0 |
| 6             | 0  | 0  | 0  | 0  | 0  | 1  | x  | x  | x  | x  | x  | x  | x  | x  | x  | Enable 1-range 0 0 2 |
| 7             | 0  | 0  | 0  | 0  | 0  | 0  | x  | 1  | 0  | Enable 1-range 0 0 3 |
| 8             | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | Enable 1-range 0 0 4 |
| 9             | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | Enable 1-range 0 0 0 |
| 10            | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | Enable 1-range 0 0 0 |
| 11            | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | Enable 1-range 0 0 7 |

**Trigger Engines**

- **Run 600001190 No FSW**
- **From SVAC config report**
- **Shall never happen**
- **Forbidden condition; Should never happen**
- **Solicited triggers for a special purpose**
- **Pedestals, both clean pedestals and random sample of typical LAT state**
- **Want to restrict 4-range readout to useful CNO**
- **Rate of CNO-only is ~750 Hz so let's keep only a trickle of these (prescale=255) on orbit. On ground: set prescale=0**
- **CAL-HI photons with and without backsplash. Primary science HE photons**
- **Primary science photons with or without CAL-LO**
- **Mostly CAL-only photons**
- **Medium-energy photons with backsplash and some medium GCRs**
- **Deliberate leakage of GCR protons but for ground ops the prescale is 0**
- **Should never happen**
Engine 0 & 1

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solic period</th>
<th>CNO</th>
<th>CAL-HI</th>
<th>CAL-LO</th>
<th>TKR</th>
<th>ROI</th>
<th>Zero Supp.</th>
<th>CAL FE</th>
<th>Prescale</th>
<th>Marker</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>Enable</td>
<td>1-range</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>X</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>Enable</td>
<td>1-range</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- As expected Engines 0 and 1 have 0 counts
  - Engine 0: In this Run there aren't External triggers
  - Engine 1: It is not possible to have a trigger in ROI a not in TKR because the ROI was configured to shadow the TKR
    - the ROI trigger in a group of tiles is associated with the tower they shadow
Engine 10 (highest rate)

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext</th>
<th>solic period</th>
<th>CNO</th>
<th>CAL-HI</th>
<th>CAL-LO</th>
<th>TKR</th>
<th>ROI</th>
<th>Zero Supp.</th>
<th>Trigger Engine</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>x</td>
<td>1</td>
<td>0</td>
<td>Enable</td>
<td>102</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Enable</td>
<td>392.7</td>
</tr>
</tbody>
</table>

- The largest rate is from Engine 10
  - Engine 10 requires just TKR=1 and ROI=1
  - We clearly see muon peak around ~12MeV
  - 2MeV zero suppression
    - We will come back to this at the end
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Engine 7 (second largest rate)

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Condition Summary for Trigger Engines</th>
<th>Trigger Engine</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Ext 0 0 0 0 0 x 1 0</td>
<td>Enable 1-range</td>
<td>102</td>
</tr>
<tr>
<td>10</td>
<td>Ext 0 0 0 0 0 0 1 1</td>
<td>Enable 1-range</td>
<td>392.7</td>
</tr>
</tbody>
</table>

- The second largest rate is from Engine 7
  - Engine 7 requires just TKR=1 and ROI=0
  - We clearly see muon peak around ~12MeV
  - 2MeV zero suppression
    - We will come back to this at the end
### Engine 4 & 5

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solic period</th>
<th>CNO</th>
<th>CAL-HI</th>
<th>CAL-LO</th>
<th>TKR</th>
<th>ROI</th>
<th>Zero Supp.</th>
<th>Trigger Engine</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0 0 0 0 1 x 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Enable</td>
<td>4-range 0 1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0 0 0 0 1 x x x x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Enable</td>
<td>1-range 0 0</td>
<td>17.44</td>
</tr>
</tbody>
</table>

- **Why we have no events in the Engine 4?**
  - Engine 4 and 5 are quite similar, but engine 4 is more restrictive
  - why so many events with the CNO bit set?
  - Which ACD threshold was used? 8 or 20 MIPs?
  - tried to figure it out from ACD data, but variable was empty in the SVAC ntuple!

In simulations of surface muons we expect ~10% of events to have CNO triggers for an ACD threshold of 8MIPs, but here we see ~5% of the events have CNO trigger. Can we conclude the ACD threshold was set to 20 MIPs?
### Engine 3

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solic period</th>
<th>CNO CAL-HI CAL-LO TKR ROI</th>
<th>Zero Supp.</th>
<th>Trigger Engine CAL FE Prescale Marker</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0 1 x x x x x x</td>
<td></td>
<td>Enable</td>
<td>1-range 0 0</td>
<td>9.69</td>
</tr>
<tr>
<td>3</td>
<td>0 0 1 x x x x x</td>
<td></td>
<td>Disable</td>
<td>4-range 0 0</td>
<td>9.86</td>
</tr>
</tbody>
</table>

- **In this Run solicited and periodic triggers have the same rate of ~10Hz**
  - we know the periodic was meant to be 10Hz
  - What about the solicited?
- **These events can be used to study noise occupancy**
  - However may have some muons too...

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### Engine 2

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solic period</th>
<th>CNO CAL-HI</th>
<th>CAL-LO TKR ROI</th>
<th>Zero Supp.</th>
<th>Trigger Engine CAL FE Prescale Marker</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0 1 x</td>
<td>x</td>
<td>x</td>
<td>x x x x x</td>
<td>Enable 1-range 0 0</td>
<td>9.69</td>
</tr>
<tr>
<td>3</td>
<td>0 0 1</td>
<td>x</td>
<td>x</td>
<td>x x x x x</td>
<td>Disable 4-range 0 0</td>
<td>9.86</td>
</tr>
</tbody>
</table>

- There is an event that has both solicited and periodic triggers
  - It looks strange, any suggestion?
Engine 9

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solicit period</th>
<th>CNO</th>
<th>CAL-HI</th>
<th>CAL-LO</th>
<th>TKR</th>
<th>ROI</th>
<th>Zero Supp.</th>
<th>Trigger Engine</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Enable</td>
<td>2.34</td>
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<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Enable</td>
<td>3.02</td>
</tr>
</tbody>
</table>

- This is just a clean muon
  - it could have also hit the CAL diode and have a large energy deposit (tail of distribution)
  - Need to check that
Some muons don't cross the TKR but trigger the CAL
- What is the third peak?
- Maybe horizontal muons
  - Need to check that
Engine 6 (lowest non zero rate)

<table>
<thead>
<tr>
<th>Engine number</th>
<th>Ext solic period</th>
<th>CNO</th>
<th>CAL-HI</th>
<th>CAL-LO</th>
<th>TKR</th>
<th>ROI</th>
<th>Zero Supp.</th>
<th>CAL FE</th>
<th>Prescale</th>
<th>Marker</th>
<th>Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>Enable</td>
<td>1-range</td>
<td>0</td>
</tr>
</tbody>
</table>

Why we have in Engine 6 some events that has triggered just CAL_HI and not CAL_LO?

- Most likely events that hit the diodes?
- see Jane's presentation in IA6 Workshop
GLAST LAT Project

XTAL Energy Distribution per Engine

1. Xtal Energy Distribution for Engine 1
2. Xtal Energy Distribution for Engine 2
3. Xtal Energy Distribution for Engine 3
4. Xtal Energy Distribution for Engine 4
5. Xtal Energy Distribution for Engine 5
6. Xtal Energy Distribution for Engine 6
7. Xtal Energy Distribution for Engine 7
8. Xtal Energy Distribution for Engine 8
9. Xtal Energy Distribution for Engine 9
10. Xtal Energy Distribution for Engine 10
Questions & Considerations

- We can see that there are two types of CAL energy distribution
  - 2 peaks for engines 5, 7, 10
  - 3 peaks for engines 6, 8, 9
  - Engine 2 and 3 have low statistics to discriminate between types

- The shape difference is due to the CAL_LO trigger
  - CAL_LO=0 => 2 peaks
  - CAL_LO=1 => 3 peaks

- In the distribution with 2 peaks
  - the relative height of the peaks is different for different engines
  - Looking at the TrgCondition distribution (the blue plots) we can see that this difference is due to the presence of the ROI bit in the trigger (e.g. compare engines 7,10)

- In the next slides
  - to study this difference I have plotted the CAL energy distribution for different ROI and CAL_LO trigger conditions
Crystal Energy for different CAL_LO and ROI conditions

- **CAL_LO = 0**
  - First peak ~2MeV: Pedestal
  - Second peak ~12MeV: Muon peak
- The fraction of events in the Pedestal doesn't change
  - See the number of entries
- The fraction of events in the muon peak is ~5 times greater when ROI is required (ROI=1)
  - Why?
  - Is it possible the ROI=0 is mostly photons?
- **CAL_LO = 1**
  - First peak ~2MeV: Pedestal
  - Second peak ~12MeV: Muon peak
  - Third peak? Maybe events that hit the diodes?

- Third peak is more significant in the case ROI = 0
- See slide 4 for Engine Definition Table
- Remember that in Xtal Energy Distribution
  - Engine 5, 7, 10 has 2 peaks
  - Engine 6, 8, 9 has 3 peaks
First look at Flight Software Runs

• In the FSW Run there aren't solicited and periodic triggers
• Lets note that in the FSW Run the rate of Engine 6 is ~10 time the rate in Run 900001190 no FSW
  - note the Y axis scale
  - Engine 6: CAL_HI requested
Conclusions

• Non Flight Software Run
  – we understand the rate for all trigger Engines, except for Engine 5 (CNO required)
    – data indicates CNO threshold was high (20MIPs?)
  – for Engines that require CAL_LO
    – the Xtal Energy Distribution have a peak above the muon peak
    – the Sum Energy Distribution have a peak at ~1GeV
    » to be investigated

• Flight Software Runs
  – rate per Engine is similar to that of Non FSW Run except for Engine 6 (CAL_HI required)
    – need to quantify this statement
  – No periodic/solicited triggers