Trigger and SVAC Tests During LAT integration

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This Presentation

- **Part 1**
  - **Overview of trigger tests**
    - **There are 4 tests**
      - » **FLE scan with muons was added as part of those**
- **Part 2**
  - **Overview of SVAC tests**
    - **There are 17 tests**
      - » **Merged nomenclature with Gary's table**
      - » **Addresses ACD tests (for completeness), no need to talk about them today**
- **What do we expect to achieve today?**
  - **Agreement on the definition of these tests**
  - **Define action items for issues we may raise**

To be Addressed Today

- We do not know if a trigger primitive fired within the trigger window if the TEM diagnostics are disabled
  - In the GEM summary word we only know which tower issue the trigger primitives, but do not know which layer (end) issued the trigger primitives.
- Unbiased sample of triggers only exist with muon telescope
  - we can not analyze data with multiple trigger lines enabled (needed for efficiency studies)
- Can not test CAL FHE with muon spectrum
  - not enough high energy events
- Testing CAL FLE with muons requires lowering the on-orbit settings
  - Need to determine optimal operation point
    - beware of retriggering

Trigger Tests (1)

- 1.0 GEM Timing Alignment
  - Purpose
    - To verify the timing alignment and jitter for each GEM trigger input
  - Duration
    - 4 hours (EXT AND CAL_LO)
    - 4 hours (EXT AND TKR)
  - Configuration
    - muon data taking configuration.
    - Trigger on EXT trigger (muon telescope) AND TKR or CAL (only one trigger input under test each time)
  - Procedure
    - Scan TREQ delay for the trigger test (across the allowable range)
    - Take 5000 events for each of the 16 allowed points.
    - Compute the coincidence of external trigger and trigger under test at each step
    - Compute center time and jitter.

Trigger Tests (2)

- 2.0 Subsystem TACK Delay Test
  - Purpose
    - To determines the optimal trigger output (TACK) delay for each subsystem.
  - Duration
    - 4 hours
  - Configuration
    - muon data taking configuration.
    - Trigger on EXT trigger ONLY (muon telescope)
  - Procedure
    - Scan TACK delays for the TKR and CAL over the applicable range simultaneously
    - Record 5000 events for each of the 8 steps
    - Determined the optimal TACK delay will by analysis
      - » Use pulse heights for the CAL and hit multiplicity for the TKR

Trigger Tests (3)

- **3.0 FLE Muon Scan**
  - **Purpose**
    - **To determines the optimal setting for the FLE for some of the muon data taking.**
  - **Duration**
    - **12 hours**
  - **Configuration**
    - **muon data taking configuration.**
    - **Trigger on EXT (muon telescope), TKR and CAL_LO trigger**
  - **Procedure**
    - **Use procedure from CAL as baseline LAT-MD-04187-01**
    - **Alternative proposal**
      - » **Scan FLE DAC setting for the CAL over the applicable range**
      - » **Record 5000 (TBR) EXT triggered events for each of the 3 steps (TBR)**
      - » **Determined the optimal FLE by analysis**

Trigger Tests (4)

- 4.0 Trigger efficiency
  - Purpose
    - To determine the trigger efficiency
  - Duration
    - 4 hours
  - Configuration
    - muon data taking configuration.
    - Can be combined with the SVAC test B4
    - Trigger on EXT (muon telescope), TKR and CAL_LO trigger
  - Procedure
    - Analysis offline

Trigger Primitives

- Available when TEM diagnostics are enabled
  - Allows one to know which layer (end) issued a trigger request
- The GEM summary words tell which trigger occurred in a particular tower/ACD
  - TKR, CAL_LO, CAL_HI, CNO, ROI, EXT, Periodic, Solicited
- Default on orbit
  - TEM diagnostics OFF
- Default for SVAC tests for full LAT
  - TEM diagnostics OFF
- Default for SVAC tests of partially populated LAT and tests outside flight grid and trigger tests
  - TEM diagnostics ON

Trigger window – current implementation

- Trigger window is of fixed time
  - Configurable (250 – ~ 1600 ns)
  - the first trigger type to appear can open the trigger window
    - If the *window open mask* register for that type was enabled
- How do I know a trigger primitive fired?
  - After the window closes it will appear in the GEM condition summary word, from which the L1 trigger is formed, only if
    - a trigger type signal was HIGH during the time the window was open
- What if the *window open mask* register for a given type was disabled but the signal was HIGH?
  - It will be in the GEM condition summary word
    - Provided some other trigger will open the window at a compatible time!

Muon Data Taking for Trigger Tests

- **Single towers outside/inside the flight grid and LAT**
  - **Main Register settings**
    - **CAL Readout range: ONE or FOUR?**
    - **CAL High energy muon gain: OFF or ON?**
    - **Zero suppression: ON**
    - **TEM trigger diagnostic data: ON**

SVAC Tests - Summary

- Before SVAC tests
  - Integrated tower is timed in and nominal settings are known
- SVAC tests
- SVAC B1-B3 Flight configuration for LAT
- SVAC B4-B5 Main configuration for LAT Calibrations
- SVAC B6-B7 FLE trigger on muons for trigger tests
- SVAC B8-B9 Main configuration for partially populated LAT
- SVAC B10 No zero suppression for partially populated LAT
- SVAC B11 No zero suppression for LAT
- SVAC B12 Main configuration for LAT VDG tests
- SVAC B13 Main VDG configuration for partially populated LAT
- SVAC B14 ACD Veto functionality
- SVAC B15-B17 ACD Calibrations
- Trade-off between fast throughput in data processing and convenience for users suggested that the
  - SVAC Data Taking scripts should be limited to 100-200 MB runs
    - Implies in ~30 min runs for 1 tower

SVAC tests – Charge Injection

- To support the SVAC offline calibrations with muons the following charge injection tests will be performed just prior to the muon data taking
  - TKR
    - TE701 – Threshold Dispersion
    - TE601 – Threshold Calibrations
    - TE602 – TOR conversion parameter calibrations
  - CAL
    - Name? – FLE/FHE characterization charge injection
      - To "calibrate out the cross talk" effect from the FLE (using SAS calibGenCAL v3), the following trigger test is needed
        - Name? – FLE characterization with muons

SVAC Tests – B1 to B3

- **SVAC B1-B3 (Flight configuration for LAT)**
  - **Purpose**
    - Record cosmic ray triggers to compare offline calibrations and performance with results from default ground muon configuration (B2).
    - This is the default flight configuration for the LAT
  - **Test/Duration**
    - B1: Single tower outside the flight grid (Towers A and B only): 2 hours
    - B1: Each single tower once it is installed inside the flight grid: 4 hours
    - B1: LAT in vertical orientation: 5 x 24 hours = 120 hours
    - B2: LAT in horizontal orientation (prior to VDG tests): 3 hours
    - B3: LAT in horizontal orientation: 5 x 24 hours = 120 hours
  - **Configuration**
    - CAL
      - Auto range: ON
      - Readout range: ONE
      - High energy muon gain: OFF
    - Zero suppression ON
      - CAL LAC 1 MeV
      - ACD PHA 0.3 MIP
    - TEM trigger diagnostics: OFF
    - Trigger on logical OR
      - EXT trigger (muon telescope) if accessible
      - TKR set to ¼ MIP
      - CAL_LO set to 100 MeV
      - CAL_HI set to 1 GeV
      - ACD_HLD set to 1 MIP

SVAC Tests – B4-B5

- **SVAC B4-B5 (Main configuration for LAT Calibrations)**
  - **Purpose**
    - Record cosmic ray triggers to produce offline calibrations, to evaluate performance and compare with MC simulations.
    - This is the default and official configuration for LAT calibrations and includes measurement of response of both CAL PIN diodes.
  - **Test/Duration**
    - B4: LAT in vertical orientation: 6 x 24 hours = 144 hours
    - B5: LAT in horizontal orientation for baseline prior to Environmental Tests= 16 hours
  - **Configuration**
    - CAL
      - Auto range: ON
      - Readout range: FOUR
      - High energy muon gain: ON
    - Zero suppression ON
      - CAL LAC 1 MeV
      - ACD PHA 0.3 MIP
    - TEM trigger diagnostics: OFF
    - Trigger on logical OR
      - EXT trigger (muon telescope) if accessible
      - TKR set to ¼ MIP
      - CAL_LO set to 100 MeV
      - CAL_HI set to 1 GeV
      - ACD_HLD set to 1 MIP

SVAC Tests – B6

- **SVAC B6 (FLE trigger on muons to support trigger tests)**
  - **Purpose**
    - **Record cosmic ray triggers to verify performance**
    - **Trigger efficiency tests for trigger group**
    - **This is the low energy FLE configuration for the LAT**
  - **Duration**
    - **Single tower outside the flight grid vertical orientation (tower A and B only): 1 hour**
    - **Single tower inside the flight grid vertical orientation (TBR depends on first two tower tests)**
    - **LAT in vertical orientation: 8 hours (TBR depends on first two tower tests)**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: ONE**
      - » **High energy muon gain: OFF**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: ON**
    - **Trigger on logical OR**
      - » **EXT trigger (muon telescope) if accessible**
      - » **TKR set to ¼ MIP**
      - » **CAL_LO set to 6 MeV (TBD by trigger tests)**
      - » **CAL_HI set to 1 GeV**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B7

- **SVAC B7 (FLE trigger on muons to support trigger tests)**
  - **Purpose**
    - **Record cosmic ray triggers with the low energy FLE configuration with TEM diagnostics disabled, to confirm that we only need configuration B6 for the LAT**
  - **Duration**
    - **Single tower outside the flight grid vertical orientation (tower A and B only): 1 hour**
    - **Single tower inside the flight grid (TBR depends on first two tower tests)**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: ONE**
      - » **High energy muon gain: OFF**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on logical OR**
      - » **EXT trigger (muon telescope) if accessible**
      - » **TKR set to ¼ MIP**
      - » **CAL_LO set to 6 MeV (TBD by trigger tests)**
      - » **CAL_HI set to 1 GeV**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B8-B9

- **SVAC B8-B9 (Main configuration for partially populated LAT)**
  - **Purpose**
    - **Record cosmic ray triggers to produce offline calibrations, to evaluate performance and compare with MC simulations with TEM diagnostics enabled**
    - **This is the default and official configuration for partially populated LAT calibrations and includes measurement of response of both CAL PIN diodes.**
  - **Duration**
    - **B8: Single tower outside grid vertical orientation (Towers A and B only): 2 hours**
    - **B8: Partially populated LAT inside flight grid vertical orientation: 15 hours**
    - **B9: Two-Towers (A,B) inside grid in horizontal orientation (prior to VDG tests): 3 hours**
  - **Configuration**
    - **CAL**
      - **Auto range: ON**
      - **Readout range: FOUR**
      - **High energy muon gain: ON**
    - **Zero suppression ON**
      - **CAL LAC 1 MeV**
      - **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: ON**
    - **Trigger on logical OR**
      - **EXT trigger (muon telescope) if accessible**
      - **TKR set to ¼ MIP**
      - **CAL_LO set to 100 MeV**
      - **CAL_HI set to 1 GeV**
      - **ACD_HLD set to 1 MIP**

SVAC Tests – B10

- SVAC B10 (No zero suppression for partially populated LAT)
  - Purpose
    - Record cosmic ray triggers to produce offline calibrations that require no zero suppression with the TEM diagnostics enabled
  - Duration
    - Single tower outside flight grid in vertical orientation: 1 hour
    - Partially populated LAT and/or Single tower inside flight grid in vertical orientation: 1 hour
  - Configuration
    - CAL
      - » Auto range: ON
      - » Readout range: FOUR
      - » High energy muon gain: ON
    - Zero suppression OFF
    - TEM trigger diagnostics: ON
    - Trigger on logical OR
      - » EXT trigger (muon telescope) if accessible
      - » TKR set to ¼ MIP
      - » CAL_LO set to 100 MeV
      - » CAL_HI set to 1 GeV
      - » ACD_HLD set to 1 MIP

SVAC Tests – B11

- **SVAC B11 (No zero suppression for LAT)**
  - **Purpose**
    - **Record cosmic ray triggers to produce offline calibrations that require no zero suppression with the TEM diagnostics disabled**
  - **Duration**
    - **LAT in vertical orientation: 1 x 16 hours = 16 hours**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: FOUR**
      - » **High energy muon gain: ON**
    - **Zero suppression OFF**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on logical OR**
      - » **TKR set to ¼ MIP**
      - » **CAL_LO set to 100 MeV**
      - » **CAL_HI set to 1 GeV**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B12

- **SVAC B12 (Main configuration for LAT VDG tests)**
  - **Purpose**
    - **Record VDG photons to measure performance**
  - **Duration**
    - **LAT in horizontal orientation: 16 hours**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: ONE**
      - » **High energy muon gain: OFF**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on**
      - » **TKR set to ¼ MIP**

SVAC Tests – B13

- **SVAC B13 (Main VDG configuration for partially populated LAT)**
  - **Purpose**
    - **Record photons to evaluate performance**
  - **Duration**
    - **Tower A outside grid in horizontal orientation: 16 hour**
    - **Tower A and B inside grid in horizontal orientation: 16 hours**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: FOUR**
      - » **High energy muon gain: ON**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: ON**
    - **Trigger on**
      - » **TKR set to ¼ MIP**

SVAC Tests – B14

- **SVAC B14 ACD (veto functionality)**
  - **Purpose**
    - **Record cosmics for veto functionality**
  - **Duration**
    - **LAT in vertical orientation: 1-8 hours (TBR)**
  - **Configuration**
    - **CAL**
      - » **Auto range: ON**
      - » **Readout range: ONE**
      - » **High energy muon gain: OFF**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on logical OR**
      - » **EXT trigger (muon telescope) if accessible**
      - » **TKR set to ¼ MIP**
      - » **CAL_LO set to 100 MeV**
      - » **CAL_HI set to 1 GeV**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B15

- **SVAC B15 ACD Calibrations**
  - **Purpose**
    - **Record cosmics for ROI 1**
  - **Duration**
    - **LAT in vertical orientation: 6 hours**
  - **Configuration (as in flight for TKR and CAL)**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on ACD**
      - » **ACD_veto set to 0.1 MIP**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B16

- **SVAC B16 ACD Calibrations**
  - **Purpose**
    - **Record cosmics for RO2 2**
  - **Duration**
    - **LAT in vertical orientation: 6 hours**
  - **Configuration (as in flight for TKR and CAL)**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on ACD**
      - » **ACD_veto set to 0.1 MIP**
      - » **ACD_HLD set to 1 MIP**

SVAC Tests – B17

- **SVAC B17 ACD Calibrations**
  - **Purpose**
    - **Record cosmics for ROI 3**
  - **Duration**
    - **LAT in vertical orientation: 6 hours**
  - **Configuration (as in flight for TKR and CAL)**
    - **Zero suppression ON**
      - » **CAL LAC 1 MeV**
      - » **ACD PHA 0.3 MIP**
    - **TEM trigger diagnostics: OFF**
    - **Trigger on ACD**
      - » **ACD_veto set to 0.1 MIP**
      - » **ACD_HLD set to 1 MIP**

Yet To be addressed …

- External trigger efficiency ~ 1 to 4 Hz
  - This needs to be understood before data taking time is finalized
- Testing STRETCH_OR in the GTRC needs to be added to the TKR tests
  - This needs to be understood before data taking time is finalized
- Redundancy between sides A and B of ELX boxes needs to be added
  - This needs to be understood before data taking time is finalized

Trigger window – proposal

- The trigger primitive information should always flow into the GEM condition summary word
  - irrespective of the status of the window open register

- Benefits
  - Add flexibility to the system for on-orbit operations
    - Case 1
      - Disallow CAL_HI to open the window (in case it has a significant trigger time slew which is energy dependent)
      - CAL_HI APPEARS in the GEM event summary word as long as TKR or CAL_LO opens the window
    - Case 2
      - Disallow CAL_LO to open the window (in case retriggering is an issue)
      - CAL_LO APPEARS in the GEM event summary word as long as TKR opens the window
      - Rely on TKR for low energy spectrum
        - » Not good situation and need careful study of systematics