CAL Detector Knobs to Turn Or Eduardo Don't Touch That!!!!

J. Eric Grove
Naval Research Lab, Washington DC

j.eric.grove@nrl.navy.mil
(202) 767-3112

CAL Knobs

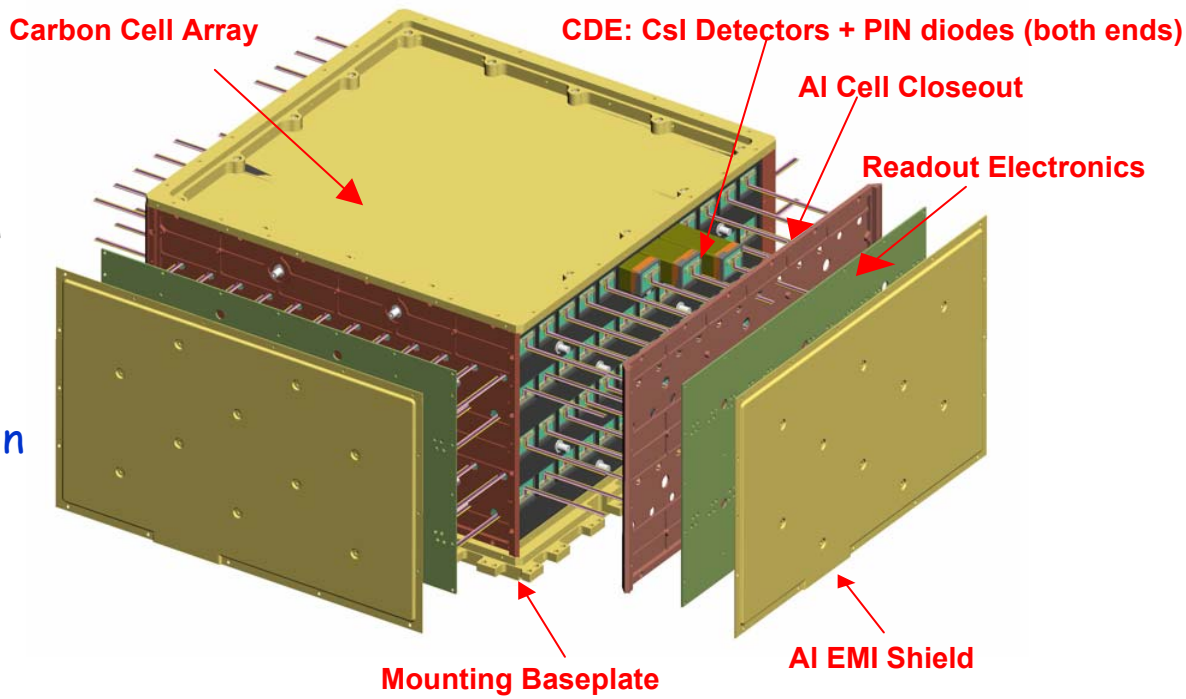
- Outline
  - Assumptions
  - CAL reminder
  - What knobs does CAL have?
    - Three themes
  - Basic operating modes
    - Flight mode
    - Ground modes
  - Known "features"
    - More to come, I'm sure

Assumptions

- What are my assumptions?
  - CAL modules arrive fully tested and calibrated with EM2 EGSE TEMs
    - Comprehensive Functional Test script exercises "everything"
      - Data are analyzed by on-line s/w
      - Test reports are generated
    - CAL-only muon and charge-injection data
      - Data are analyzed by Python scripts
      - Calibration tables are delivered with each Module
  - Value added from Two Tower test and SAS tools
    - Integrated system performance [2 x (TKR+CAL)]
    - More detailed CAL light taper maps from TKR+CAL
  - Tests, configurations, and tools
    - Defined. Debated. Detailed.
    - '"Just because you can" doesn't mean "you should".' Neil Johnson, Axioms for Life

CAL Module

- 8 layers of 12 CsI(Tl) crystals
  - Crystal dimensions
    - 27 x 20 x 326 mm
  - Hodoscopic stacking
    - alternating orthogonal layers
  - Dual PIN photodiode on each end of crystals
- Mechanical packaging
  - Carbon Composite cell structure
  - Al base plate and side cell closeouts



- Electronics boards attached to each side
  - Interface connectors to TEM at base of calorimeter
- Outer wall is EMI shield and provides structural stiffness as well

CAL Knobs

- What knobs can be turned?
  - Note: not "What knobs can *you* turn?"
    not "What knobs *should* you turn?"
  - Three themes
    - Gain
      - LE gain
      - HE gain
      - Time to peak
    - Triggering
      - FLE enable/disable and threshold
      - FHE enable/disable and threshold
    - Data volume
      - Range readout (auto/commanded, one/four)
      - Zero suppression enable/disable and threshold

CAL Knobs

- Calorimeter Gain knobs
  - Preamp gain adjustable to meet Lev IV specs on energy coverage of LEX1 and HEX1 ranges
    - LE gain
      - 8 programmable settings, cover x3 in gain
      - One setting per CAL face (= 16 towers x 4 faces)
    - HE gain
      - 9 programmable settings, cover x3 in gain + test gain for muons
      - One setting per CAL face
    - Optimal settings determined with on-line s/w
      - No SAS analysis needed to find the setting
  - Time to peak
    - Adjusted so that track-and-hold occurs at peak of shaped signal
      - One setting per tower
      - Different setting for muons and charge injection
    - Optimal setting determined with on-line s/w
      - No SAS analysis needed

CAL Knobs

- Calorimeter Triggering knobs
  - Fast-shaped discriminator on all 4 channels of each CDE
    - FLE enable/disable
    - FLE threshold
      - 64 fine + 64 coarse programmable DAC settings
        - » Cover up to ~200 MeV
      - One setting per CAL xtal end (= 1536 xtals x 2 faces)
    - FHE enable/disable
    - FHE threshold
      - 64 fine + 64 coarse programmable DAC settings
        - » Cover up to ~25 GeV
      - One setting per CAL xtal end (= 1536 xtals x 2 faces)
    - Optimal settings determined with on-line s/w
      - No SAS analysis needed

CAL Knobs

- Calorimeter Data Volume knobs
  - Range readout
    - Auto range or commanded range
    - One range or four ranges
  - Zero suppression
    - LAC ("log accept") enable/disable
    - LAC threshold
      - 64 fine + 64 coarse programmable DAC settings
        - » Cover up to ~20 MeV in ~$\frac{1}{4}$ MeV steps
      - One setting per CAL xtal end (= 1536 xtals x 2 faces)
    - Optimal settings determined with on-line s/w
      - No SAS analysis needed

CAL Knobs

- Other CAL knobs, not for use
  - Range discriminators
    - ULD for X8-X1 selection
  - GCRC timers
    - GCFE range settling time
    - ADC sample time
    - ADC conversion time
  - GCFE range enable/disable
  - Others…

Modes of Operation

- CAL configuration must be set by goal of test
  - "Just because you can …."
- Functional testing during I&T exercises "all" configurations
  - Standard test suites, analyzed by existing on-line software
  - SAS can analyze, but this shouldn't be driver
- Most I&T operations will be in one of a few modes
  1. Flight mode: tests of flight ops
     - Best guess of configuration on orbit
  2. Ground mode: calibrations, daily health
     - High gain in HE channels to see muons, VDG gammas
     - Thresholds low enough for CAL to trigger on muons, VDG gammas

Modes of Operation

- Flight mode
  - Ground test of flight operations
    - Flight trigger
      - TKR trigger enabled (i.e. flight trigger)
      - CAL trigger thresholds set high (i.e. flight trigger)
        - » FLE ~ 100 MeV but disabled
        - » FHE ~ 1 GeV (??), enabled (??)
    - Flight gain
      - LE rails at ~ 1.6 GeV (i.e. flight gain)
      - HE rails at ~ 100 GeV (i.e. flight gain)
    - Minimize data volume
      - Auto-range, one-range readout (i.e. flight readout)
      - Zero-suppression enabled (i.e. flight readout)
        - » LAC threshold ~ 2 MeV or below

Modes of Operation

- Ground test with muons visible in HE ranges
  - Daily muon runs to test aliveness and stability
  - Energy calibration with muons
    - Flight trigger
      - TKR trigger enabled (i.e. flight trigger)
      - CAL trigger thresholds set high (i.e. flight trigger)
        - » FLE ~ 100 MeV, but disabled
        - » FHE ~ 1 GeV (??), enabled (??)
    - Muon gain
      - LE rails at ~ 1.6 GeV (i.e. flight gain)
      - HE rails at ~ 4 GeV (i.e. muon test gain)
    - Intermediate data volume
      - Auto-range, four-range readout (i.e. see all ranges)
      - Zero-suppression enabled (i.e. flight setting)
        - » LAC threshold ~ 2 MeV or below

Modes of Operation

- Ground test with muons visible in HE ranges
  - Ground test of CAL self-trigger
    - CAL trigger
      - TKR trigger disabled (or no TKR connected)
      - CAL thresholds set low to trigger on muons or VDG photons
        - » FLE ~ 2 MeV and FHE ~ 1 GeV (trig on FLE)
        - » FLE ~ 100 MeV and FHE < 10 MeV (trig on FHE)
    - Muon gain
      - LE rails at ~ 1.6 GeV (i.e. flight gain)
      - HE rails at ~ 10 GeV (i.e. muon test gain)
    - Intermediate data volume
      - Auto-range, four-range readout (i.e. see all ranges)
      - Zero-suppression enabled (i.e. flight setting)
        - » LAC threshold ~ 2 MeV or below

Known "Features"

- Readout time can be long
  - 4-range, unsuppressed CAL readout ~ 600 us
  - Because of the TEM readout buffer logic, one of these events does indeed paralyze the entire system for ~ 600 us.
    - FIFO has space for less than 2 of these events
    - Readout is paralyzed if space for less than 1 remains.
  - Beware!

- Solicited triggers with zero suppression enabled…
  - CAL data will be null!
    - Either set the LAC threshold low that some pedestals sneak through, or inject charge in some specific channels
  - Remember the readout time is a function of the CAL data volume.
    - Tests with high-rate, Poisson solicited triggers must be carefully posed.

Known "Features"

- CAL can retrigger
  - If CAL self-trigger is enabled with a low threshold and zero suppression is enabled, CAL may double-trigger
    - Trigger gets re-enabled before it settles
    - Retrigger does not occur with zero supp disabled (i.e. large CAL data volume) because TEM readout is slow enough that FLE has had time to settle
- CAL trigger biases energy
  - If FLE fires (whether or not it's enabled), about 2 MeV gets added to LEX8 and LEX1 signals.
    - Don't calibrate gain scale with FLE set low for CAL self-trigger on muons or VDG photons.
  - Similar effect for FHE firing
    - Adds ~ 20 MeV

Status of Flight CAL

- Parts
  - ~80% of crystals have arrived at NRL
  - ~50% of CDEs have been assembled
  - First flight AFEE boards have been assembled
- Four towers are fully populated with CDEs
  - Checked with GSE electronics
  - Each has 1.5 to 6 million good muons
- First integration of AFEE boards by end of month
- CAL Module environmental test begins in July
- …