Instrument Analysis Workshop VI Summary

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Science Verification, Analysis and Calibrations / ISOC
Introduction

• Instrument Analysis Workshops:
  – Workshop 1: June 7-8 2004
  – ......
  – Workshop 6: Monday-Tuesday this week

• If you ever feel that we're not making progress in with the LAT:
  – Compare the (topics of the) talks from the first and last workshop!
  – We have come a long way in understanding this instrument ......

• LAT SVAC Muon runs with the full LAT!
  – January 13-16
  – ~37M triggers

• This week for Workshop VI:
  – 58 participants
  – 30 talks!
    – That leaves me 20 seconds per talk .....
Day 1

DAY 1: February 27

- 08:00-08:30 - Registration and breakfast.

- 08:30-12:00 - Session 1: LAT Introduction and CAL
  - 08:30-09:00 Introduction to Workshop 6 (pdf) (ppt) - Eduardo
  - 09:00-09:30 Overview of LAT data taking (pdf) (ppt) - Anders
  - 09:30-09:45 LAT trigger and Timing results (pdf) - Martin
  - 09:45-10:00 CAL MIP Conversion and PSP for muons (pdf) (ppt) - Dave
  - 10:00-10:20 Coffee break
  - 10:20-10:45 Trenching CAL performance and mapping crystals (pdf) (ppt) - Fred/Edin
  - 10:45-11:00 CAL features and idiosyncrasies: What are they and how to cope? (pdf) (ppt) - Sasha
  - 11:00-11:20 Review of ACD Pre-flight tests (pdf) (ppt) - Alex
  - 11:20-11:40 Overview of ACD Recon (pdf) (ppt) - Eric

- 12:05-13:30 - Lunch Talk hosted by Eric Charles
  - Overview of ACD variables in SVAC ntuple (web page) - Eric

- 13:30-15:00 - Session 2 - ACD
  - 13:30-13:50 ACD Performance in LAT much runs - Alex
  - 13:50-14:10 ACD Data Analysis (pdf) (ppt) - Eric
  - 14:10-14:30 ACD Studies (pdf) (ppt) (pdf) - Luis
  - 14:30-14:50 ACD Noise Studies (pdf) (ppt) - Larry
  - 14:45-15:15 Coffee break

- 15:15-17:00 - Session 3 - TKR
  - 15:15-15:45 TKR data processing overview (pdf) (ppt) - Hiro
  - 15:45-16:15 TKR noise occupancy monitoring (pdf) (ppt) - Mutsumi
  - 16:15-16:45 TKR parameters trending (pdf) (ppt) - Mizuno
  - 16:45-17:00 TDI Analysis (pdf) (ppt) - Bart Group
  - 17:00-17:20 PSP with Muons (pdf) (ppt) - Perugia Group

- 18:00 - Informal Beam test discussions in preparations for Pisa Workshop
Day 2

DAY 2: February 28

- **08:00-09:00** - Registration and breakfast

- **09:00-12:00** - **Session 4: Short data Analysis Talks**
  - 09:00-09:20  VDG Data/MC comparison (pdf) (ppt) - Gary
  - 09:20-09:40  An attempt to efficiently determine whether two data sets are "equivalent" (pdf) (ppt) - Felix
  - 09:40-10:00  Searching for Photons in the LAT (pdf) (ppt) - Franz Betta
  - 10:00-10:20  TEM and GEM: what you always wanted to know but never asked (pdf) (ppt) - Croag
  - 10:20-10:40  Coffee break
  - 10:40-11:00  CAL TE trigger behavior for short and long track events (pdf)(ppt) - Jane
  - 11:00-11:40  Testing CAL TE and CAL HE triggers with muons and photons (pdf)(ppt) - Eduardo
  - 11:40-12:00  A preliminary look at the alignment (pdf) (ppt) - Michael

- **12:00-13:30** - **Lunch Talk hosted by Anders**
  - Overview of GEM variables in the SVAC ntuple (ppt)
  - Q/A on SVAC and Morit Variances

- **13:30-15:00** - **Session 5 - More Talks**
  - 13:30-13:50  LAT Deadtime and Livetime (pdf) (xsi) - Warren
  - 13:50-14:10  Fitting LAT Data Taking with FSW @ SLAC (pdf) (ppt) - Eduardo/Eric
  - 14:10-14:30  Taking cosmic rays @ NRL (pdf) (ppt) - Eric Grove
  - 14:30-14:50  Calibrating the CAT in High Galactic Cosmic Ray Calibration (pdf) (ppt) - Mark
  - 14:50-15:15  Coffee break

- **15:15-17:00** - **Session 6 - Getting ready for ISOC...**
  - 15:15-15:30  Backgrounds and Trigger Rates on Orbit (pdf) (ppt) - Steve
  - 15:30-15:50  Flight Software on-board tester - Richard
  - 15:50-16:10  Importance of running LAT prior to launch (pdf) (ppt) - Bill
  - 16:10-17:00  Final remarks with Data Quality Monitoring - Eduardo

- **17:00** - **Dark Matter and New Physics Working Group meeting**
Again mip peak position thermal variation – now at increased temperature (+35C), or 12C higher, caused ~10% of mip peak position decrease – same 0.8-0.9%/degree C

**Rough estimate of temperature monitoring in flight:** we want to set VETO thresholds (in off-line analysis, where it has to be more precise) with the precision of better than 0.05 \( \text{mip} \). This corresponds to a maximum 7C temperature change, and to the requirement that the temperature stability has to be monitored with 5C precision to maintain 0.05 \( \text{mip} \) VETO (off-line) threshold stability.
Overview of Acd Reconstruction

- Digitization (AcdDigi in digiRootData)
  - Merge data from different electronics cards into physical space
  - Preserve all data sent off the detector
- Apply MIP Calibration (AcdHit)
  - Remove pedestal (baseline counts) and factor in different electronics gains
  - Express hits in terms of MIPS and MeV
- Extrapolate Tracks to Acd (AcdTkrlrIntersectionTool)
  - Use GEANT geometry, calculation only as good as input
- Calculate distance from extrapolated track to hit elements and known gaps (AcdRecon / AcdTkrlrPocaTool)
  - Extract Tile edges and Ribbons locations from GEANT model
  - Calculates miss distance is track doesn't hit element
- Make monitoring plots for SVAC report

See Monday Lunch talk for plots of all the new variables!
ACD Distance variables in AcdRecon/ Merit

CAVEAT
- Lots of deprecated/ Monte Carlo stuff around
  - AcdDoca, AcdActiveDistance (old), AcdEnergy (MC)

ActiveDistance3D
- Positive: 2D distance to edge of element if track passes inside
- Negative: 3D distance from track to edge or corner
  - NOTE: calculation changes as we cross tile edge

HitRibbonDistance
- Same as active distance always 2D, w/ simplified ribbon geometry
  - Ribbons made up of 3-segments, top & 2 sides

CornerDoca
- 3D distance to the gaps along the corner edges of the ACD
- Sign takes into account direction of overlaps, as tile extends beyond edge in one direction
For this channel the VETO turn on point is ~495 PHA counts. This is about 55 counts above pedestal.

The set points delivered by the ACD group have the VETO signals starting about 60 counts above pedestals.
Looking for holes (screws) in the ACD Data

- Existence of holes (screws holding the tile) is one of the distinctive features of the ACD (not in the geometry yet)
- The very large and “pure” sample of MIPs should be useful to gather some of this information

With most of the same cuts as before but allowing events from the edges, let's plot the point of Track+Tile intersection for events with energy deposition in the tile below zero suppression:
Holes and leaks in top ACD (threshold at 0.3MIP)
• e2e 4-3 (~10kHz trigger rate)  
• Periodic trigger, no TKR hits  
• ADC<30 for “other” PMT on the tile

23% of events have at least one tile with ADC>15 (~0.05MIP)  
2.5% of events have at least 1 tile with ADC>30 (~0.1MIP)  
0.12% of events have at least 1 tile with ADC>100 (~0.3MIP)
Pedestal vs GEM delta event

time

50μs

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Fraction of events with at least 1 tile > 
~0.1MIP vs GEM delta event time
Tracker Readout 2

• After the Read Event command is sent, the GTIU token signal is sent to the first TRC on each cable.
  – 3 bits: Start Bit, GTRC buffer, Parity
• GTCC then receives the data from each GTRC in turn and fills the GTCC FIFOs as appropriate
• The GTIU is responsible for asserting BUSY to the GEM when the TKR is unable to buffer another event
  – It keeps track of how many buffers are occupied in the GTFEs and GTRCs
  – It keeps track of the “almost full” flags on the GTCC FIFOs
    • It is important to remember that the GTCC FIFOs are filling and emptying as events are being triggered, we should expect the number of words in the FIFOs to fluctuate based on trigger rate and backpressure.

If one were to limit the maximum number of hits in a GTRC buffer to 14 (max hits of 126 per GTCC) with the goal of eliminating FIFO overflows, one would have to set the “almost full” flag of the Data FIFO to generate back pressure whenever it contains 3 or more words. This would negatively affect the TKR deadtime.
Full LAT B/2 Deadtime

- Minimum = 529 ticks (26.45 µs)
  - This is the predicted value
- 10.8M measured times
- 238 of them != 529
- Max = 5697 ticks (285 µs)
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**B2 Run: Timing Diagram?**

**TREQ delay + RC/FE delays**

- ACD Trigger primitive (veto) to scheduler (4) + veto delay (16)
  - 20 x 50 ns = 1000 ns

**ACD Trigger primitive to GEMCC (2) + TREQ Delay (0)**

- CAL Trigger primitive to GCCC (2) + TREQ Delay (0)
  - 8x 50 ns = 400 ns

**Coincidence Window**

- 12 x 50 ns = 600 ns

**Window latency (1) for signals to be integrated into the GEM before opening the trigger window**

- 1 x 50 ns (50 ns)

**TACK delay**

- Time since ACD Trigger primitive is issued 76 x 50 ns (800 ns)

**_CW+_TAM+TACK formation**

- (12 + 3 + 2 = 17)
  - 17 x 50 ns = 650 ns

**GARC latency (2) + register TAM at AEM, register zero suppression, form TACK(7) + hold S&H delay in GAR(24) + overhead (6)**

- 39 x 50 ns = 1950 ns

**TACK latency (5) + TACK delay(0) + GCFE/GCRC latency (5)**

- 10 x 50 ns = 500 ns

**Trigger Accept Message**

- Look up engine number (1) + propagate window signal and engine number from scheduler to TAM chip (1) + check prescaler, engine inhibit, and BUSY to decide to issue a trigger (1)
  - 3 x 50 ns = 150 ns

**Trigger Accept Message latency from the TAM chip to the TEM or the AEM ~ 1 x 50 ns (50 ns)**

**Eduardo**
Long list of unexpected features …

• Retriggering
  – Seen at low FLE/FHE thresholds or at high gain
  – Is not a problem at flight configuration

• Nonlinearity
  – Preamp nonlinearity – measured by charge injection and taken into account
  – Crosstalk from FLE/FHE discriminator to preamp – significant at low FLE/FHE, but could be neglected at flight configuration

• Some additional nonlinearity features, necessary to explain charge injection measurements with different gains and charge injection capacitors (ongoing study)
  – Nonlinearity of Charge injection DAC
  – DAC “pedestal” (DAC=0 injects nonzero charge)

• Incorrect best range selection or range numbering
  – Seen in Engineering Module beam test data from GSI: some crystals have end to end ratio ~8 (data specify the same range numbers for both ends, but in reality they were different).
  – Could be related to incorrect setting of range decision delay
  – Never tested for LAT (need high energy depositions at significant rate and data collection with “auto-ranging”)

• Shaped readout noise
  – Affects energy and position measurements
  – Could be calibrated for LAT (see later in this talk) and should be corrected in reconstruction

• Crosstalk from LE diode to HE diode
  – Seen for FM119
  – Could affect nonlinearity in HEX8 and HEX1 ranges
  – Should be calibrated for LAT (modification of calibGen script required) and corrected in reconstruction
  – Should be verified by test beam linearity measurement (in the energy range 0.4- 8.0 GeV)
Examples of histograms

- Big noise
- Medium noise
- Typical noise
- Negative noise
CAL level 3 req’t 5.5.5: <3cm xyz position resolution per layer

5.5.5 Position Resolution

[Derived from LAT SS-00010 5.2.2, 5.2.12]

Each layer of the calorimeter shall position the centroid of a Minimum Ionizing charged particle energy deposition to less than 3.0 cm (1σ) in all three dimensions for particle incident angles of less than 45 degrees off axis.

This is an even layer...

...so the x-direction is the longitudinal meas’t (light ratio from the two crystal ends)...

...whereas the y-direction is just the transverse crystal profile.

Z-direction like y.

Dave
All rms’s << 30 mm: req’t met

dX, odd layers

dY, evens

rmsX, odd layers

rmsY, evens

Dave
Study of transient noise behavior (Noise Flare)

Use cosmic-ray trigger data (500 Hz)

- To detect short term noise increases (flares), noise occupancies for each 1000 event triggers (~2 sec) are investigated.
- If the layer-average noise occupancy exceeds $5 \times 10^{-5}$, it is labeled as ‘Noise Flare’.
- Noise flares are detected in 4 silicon layers.
  - Tower #2 Layer 17(Y8)
  - Tower #7 Layer 29(Y14)
  - Tower #10 Layer 34(X17)
  - Tower #15 Layer 22(X11)
- These noise flares have common features.
  - Related with silicon ladder
  - Large multiplicity
It’s not an academic exercise only!

From Sara’s presentation at IAWS5:

- Monte Carlo
- Real Tower A data

without alignment

with alignment (in MC)
Alignment

- Misalignment has an impact on data analysis!
- LeaningTower:
  - aligns planes vertically and horizontally with high accuracy
  - determines rotations around z properly (NEW!)
  - can handle multi-tower runs (NEW!)
  - doesn’t do some things (yet)
  - needs help from inter-tower alignment
  - TkrAlignmentSvc files are available, and (NEW!) the signs are validated
- Actions items:
  - Intra-tower: implement the method of LeaningTower in a proper way
  - Inter-tower: fix the bugs in the code
  - How do we feed the alignment constants into the analysis? Calibration database?

Michael
Finding Photons In The LAT

Final Selections (cumulative):

3. TkrNumTracks > 0
5. VtxAngle > 0.
6. Tkr1ToTFirst > 1.
7. Tkr1SSDVeto > 1
8. Tkr1ToTTrAve > 1.3
9. VtxStatus = 162
Conclusions

• We have muon data with the ACD and 16 towers!
  – Learning things about the ACD behaviour after integration into the LAT!
  – Use TKR tracks to study the ACD:
    – How to find screws in the ACD using muons
• There are still interesting 'features' with the other subsystems (CAL, TKR):
  – TKR noise flares
  – CAL shaped readout noise
• Subsystems are maturing:
  – Trending and Monitoring
• Alignment:
  – 'Starting up' again
  – Intra-tower alignment maturing
  – Inter-tower alignment is the next step
• Data analysis talks:
  – Understanding the LAT
  – Finding photons with the LAT!