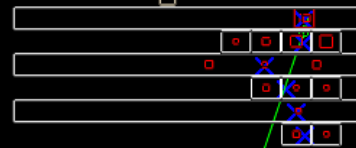
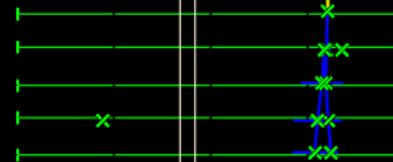


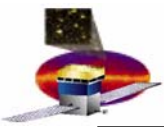
# Introduction to Instrument Workshop 6

Eduardo do Couto e Silva

Feb 27, 2006

ID: 135005347-254114





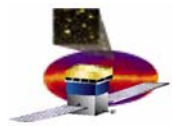
# Goals for this Workshop Series

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## Prepare for Instrument Data Analysis

- Familiarizing LAT Collaborators with the
  - LAT instrument
    - Front-End Electronics
    - Trigger and Data Acquisition
    - Data Analysis Software
  - Data taking plans during LAT integration using
    - Cosmic rays
    - Van de Graaff photons
- Create a forum to
  - exchange knowledge between all subsystems and “hardware and software oriented people”
- Use simulated and real Data to
  - exercise reconstruction algorithms (mostly with real data)
  - exercise the data analysis tools and provide feedback to developers
- Develop expertise to
  - uncover and quantify any instrumental effects
    - could have an impact on the LAT science data
  - lay foundations of the LAT Science Operations Group of the ISOC
  - create a core and trained group to participate in the beam tests analysis effort
    - after instrument delivery

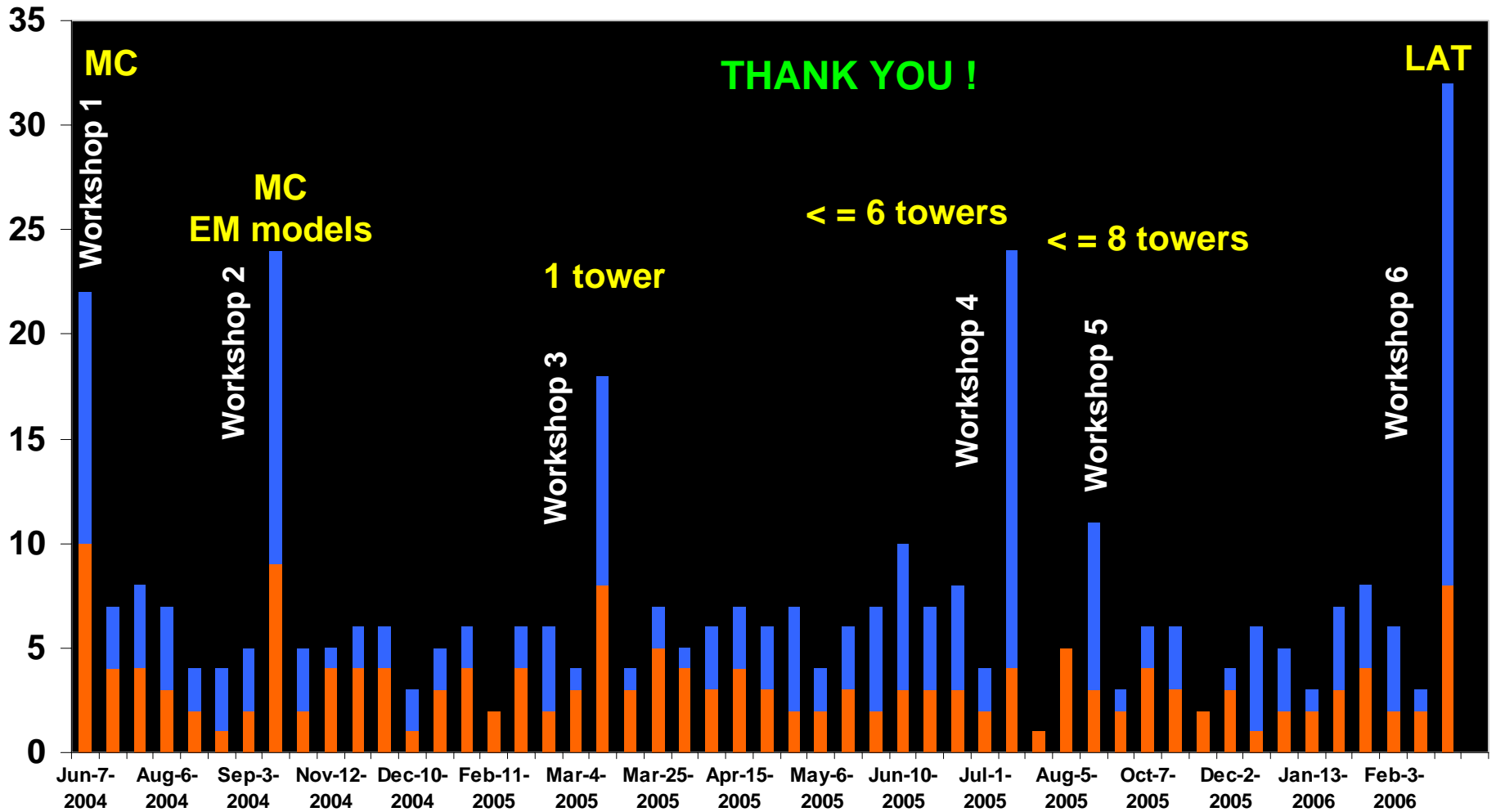
## Develop ownership of the LAT instrument



# Number of Talks in the IA Weekly Meetings/Workshops

After 20 months, here we are....

SVAC LAT Collaboration

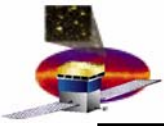




# The Instrument Analysis Workshop Series

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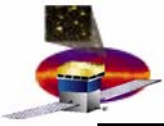
- **Workshop 1 (June 7-8, 2004)**
  - Kick off meeting
  - Homogenize the knowledge from people who will do the data analysis
  - Assign “projects” using Monte Carlo simulated data
- **Workshop 2 (September 27, 2004 )**
  - Discuss results from MC projects assigned during Workshop 1
  - Discuss results from projects derived from REAL data collected with the Engineering Models (CAL and TKR)
- **Workshop 3 (March 10, 2005)**
  - Analysis of real data from the first tower
- **Workshop 4 (July 14-15, 2005 )**
  - Analysis of real data up to 6 towers
- **Workshop 5 (August 29, 2005)**
  - Analysis of real data up to 8 towers
  - ACD Monte Carlo studies
- **Workshop 6 (February 2006)**
  - Preparations for final LAT Data Analysis
    - no FSW
- **Workshop 7 (May/June 2006 - TBR : depends on DC2, beam test and LAT Delivery to NRL)**
  - LAT Data Analysis
    - FSW included



# Frequently Asked Question...

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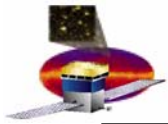
- **Aren't you bored to analyze cosmic ray data for so long?**
  - **Yes...**
    - **irrespective of being astrophysicist or particle physicist**
- **So why do you do it ?**
  - **For four reasons**
    - **uncover hardware problems**
    - **identify software bugs**
    - **acquire experience with instrument**
    - **to reduce (hopefully) debugging time while in orbit**
- **Was it worth it ?**
  - **Check the next slides and draw your own conclusion...**



# Summary of Accomplishments

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- **Instrument Performance**
  - Correlation between detectors
  - Independent trigger studies
  - Different particle types
    - Muon candidates
    - Photons candidates
- **Calibrations**
  - Generation and refinement of constants
  - Trending
- **Instrument Operations**
  - Experience with operational settings
    - several corners of the allowed parameter space
  - Development and Debugging of Low Level Infrastructure
    - Software/Database Development
    - Data Monitoring/Server



# What have we accomplished? (1)

---

- **Infrastructure**
  - **New TKR recon (IA3)**
    - removed hard-coding of parameters and geometry
    - simplify infrastructure – easy to maintain
    - incomplete description of track objects
  - **New CAL Recon (IA3)**
    - no multi tower support
    - no threshold calibrations
  - **Improved GEM (IA3)**
    - arrival times for trigger conditions
    - triggering on edge instead of level (avoid retriggering)
    - added delta Window open time
    - added GemDeadZone (counts “missed” triggers that occurred within 2 counts of trigger window)



# What have we accomplished? (2)

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- **Trigger Studies (efficiencies, arrival time...)**
  - **Compared, to a few% level, MC TriggerAlg for TKR with GEM information by enabling TEM diagnostics (IA3)**
  - **TKR hit and trigger efficiencies**
    - Variations of Trigger efficiencies at tens of % level (Pisa vs SLAC) due to amount of material above the TKR and tower orientation (upside down) (IA3)
    - Data and MC agreement within 2-3% for events crossing towers (IA4)
  - **TRK uniformity compared using SLAC and Pisa runs (IA4)**
  - **Tower Efficiencies trended up to 8 tower tests (max changes seen +/- 0.05%) (IA5)**
- **Timing Properties and Deadtime**
  - **First pass at trigger alignment (IA3)**
  - **In the absence of GPS time we defined EvtTicks to determine better the time between events (IA4)**
    - used to cross check settings of different TACK delays between CAL modules (IA4)
  - **Deadtime shown to be consistent with expectations for runs (IA4)**
    - with and without flight configuration
    - with small and large data volume
    - with and without presence of additional high external trigger rates
- **Noise occupancies**
  - **Studied TKR noise occupancy (IA3)**
  - **Look for off-track clusters to estimate noise in TKR from PDU voltage changes**
    - no differences within 2% level (IA4)
  - **Measured TKR noise occupancy (from  $10^{-7}$  to  $10^{-6}$ ) versus maximum distance between clusters in a plane for towers in Pisa (IA4)**

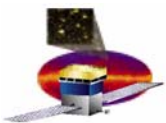




# What have we accomplished? (3)

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- **Calibrations (and related things)**
  - **TKR noisy and dead strips**
    - Calculated TKR noisy, dead, partially disconnected, intermittent strips (IA3)
    - TKR large threshold dispersion (IA3)
      - » improved by 10 % by calibrating it with muon peaks and TOT charge scale, gain and charge scale shown to be stable within that range (IA4)
  - **TKR TOT Gains**
    - TOT charge scale recalibrated and incident angle correction applied (agrees with MC within 1%) (IA5)
  - **CAL Pedestals**
    - CAL pedestals affected by changes in the 3.3 Volt which induced 1% gain changes (IA3)
    - CAL pedestal positions and widths for 3 phases (pre and post ship to SLAC and 8 tower tests) (IA5)
      - » there is more there
  - **CAL MIP peaks**
    - CAL Muon peaks agreed with 2% with MC (IA3)
    - Differences of 2% shift in CAL muon peaks for CAL only vs TKR only data (IA4)
    - No differences in positions of CAL Muon peaks, width of Landau,  $\Delta x$ ,  $\Delta y$  within 2% error (IA4)
      - » Odd and Even bays (IA4)
      - » PDU voltages  $\pm 1V$  from nominal (IA4)
      - » additional trigger rates (ext) 20 KHz (IA4)
      - » large size events (no zero-suppressed 4 range readout) (IA4)
      - » consistent within 4% when comparing with MC (IA4)
  - **ACD Calibrations**
    - Prepared tools for ACD calibrations of veto thresholds offline and Track extrapolation into ACD (IA5)



# What have we accomplished? (4)

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- **Performance (multiplicities, alignment...)**
  - **Extrapolated tracks into CAL to predict hit positions and to compare with CAL measurement of longitudinal positions in a crystal (IA3)**
    - same study as function of energy (IA4)
  - **Compared TKR runs with readout from Left or Right cables only and from both cables**
    - no differences within tens of % when triggering on one tower and studying events on the adjacent tower (IA4)
    - no differences within 10% level on average TOT distributions, hit multiplicities and angular distribution (IA4)
  - **Studied TKR number of strips/per cluster vs angle of incidence for planes with single clusters for runs from Pisa only (IA4)**
  - **Measured Intratower residuals, rotations and shifts**
    - using hardcoded geometry and single tower runs (IA4)
  - **Identified wrong usage of alignment constants in MC via “PSF” muon analysis (IA5)**
- **Cosmic Ray Shower Studies**
  - **Selected photon candidates**
    - studied cleanest photon vertex topology (efficiency ~0.5%) (IA5)
  - **Showed that TEM CC Error events are consistent with showers (effect is the level of  $10^{-4}$ )(IA5)**
  - **Showed that TOT distributions between muons and shower events are consistent with expectations (IA4)**



# What have we accomplished? (5)

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- **Instrument Operations**
  - **Trigger**
    - Learned relation between TEM diagnostics enabled and trigger alignment by doing studies to a few% level (IA3)
    - TKR Studies on TACK differences from non-GASU to GASU based system (IA4)
    - Some studies showed confusion between how trigger works (used MC words instead of Gem info for trigger efficiency) (IA4)
  - **Deadtime**
    - In the absence of GPS could not use GEMDeltaEventTime for some timing studies and defined a new variable EvtTicks: this is the last event that triggered and if you have cuts then information is lost) (IA4)
  - **TKR**
    - Changed TKR settings and turned one-shots ON
      - » if off whole towers could be dead until the trigger request goes low
    - TKR recommended
      - » usage of random triggers for noise studies (IA3)
      - » to trend thresholds, channels, and tot parameters (IA5)
  - **CAL**
    - Learned about CAL\_LE retriggering close to the noise floor
      - » not a problem for operations in orbit
    - Studied tail of pulse produced in the analog part of the FE by the digital readout from the CAL AFEE to the TEM (IA4)
      - » Shaped readout noise could contribute to energy measurement error and probability is higher for high trigger rate (since most of these events come closer in time)
  - **ACD**
    - soon to come...

# Suggestions for Instrument Analysis Workshop 7 (1)

**We will revisit these at the end of this workshop**

- Update needed
  - System Wide
    - Provide final and validated list of calibration constants and operational settings for final tests at SLAC
    - Make tomography of all 3 detector systems for a final geometry validation
    - Study system level occupancies (TKR,CAL and ACD) by analyzing periodic triggers
      - » Philippe already started a preliminary analysis this week
    - Compare runs with changes in PDU settings
    - Compare runs with changes in trigger rates (by adding external pulser)
  - TKR
    - Look for off-track clusters to estimate noise in TKR from PDU voltage changes
    - Study TKR number of strips/per cluster vs angle of incidence for planes with single clusters
    - Measure TKR noise occupancy versus maximum distance between clusters in a plane
    - Update data analysis with new limits to the TKR CC buffer
    - Verify that TEM TKR CC Error event rate is consistent with previous analysis
    - Intratower residuals, rotations and shifts for all towers
    - Verify that TOT distributions between muons and shower events are consistent with expectations
      - » study events with ToT = 250 and 255 counts separately
  - Trending
    - TKR trigger and hit efficiencies for all modules
      - » study events crossing towers
    - TKR noisy, dead, partially dead strips
  - CAL
    - Verify stability of position and width of muon peaks for events in all trigger engines (when applicable)
      - » with and without track extrapolation
    - Measure CAL muon peaks, width of Landau, longitudinal and transverse positions using extrapolated tracks
      - » study inefficiencies (edges. gaps...)
    - Trending
      - CAL trigger and hit efficiencies for all modules
      - CAL noisy channels with operation settings (if any)
  - ACD
    - Measure ACD muon peaks using extrapolated tracks
      - » study inefficiencies (edges. gaps...)
    - Trending
      - ACD calibration constants

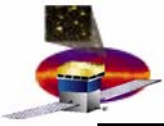


# Suggestions for Instrument Analysis Workshop 7 (2)

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## We will revisit these at the end of this workshop

- **New Analysis**
  - **Modify/adapt your analysis scripts for telemetry data**
    - multiple trigger engine is coming and will affect your code...
  - **Intratower residuals, rotations and shifts**
    - inter tower alignment needed for assessing XY translations and rotation between towers (without hardcoded geometry)
      - » useful @ NRL to verify stability of alignment in different environmental conditions
      - » how about shearing and vertical (Z) displacements? Should we care?
  - **Deadtime**
    - presence of GPS for reference
    - multiple trigger engines complicate deadtime calculations
    - the variable EvtTicks will need new algorithm
  - **Verify track resolution by studying position distributions between ACD gaps**
    - inefficiencies inside tiles, “resolutions” outside
  - **CAL Triggers**
    - Verify arrival time distributions for CAL\_LE and CAL HE triggers using muons and photon candidates when LAT is oriented horizontally
  - **Verify if we have enough statistics to study CNO events with ground data**
  - **Decode all error contributions into offline analysis files**
    - study their occurrence and compare with expectations (ISOC)
  - **Correlate science data with housekeeping (ISOC?)**
    - correlate with hit multiplicities, efficiencies and noise occupancies
      - » needed for NRL



# Logistics

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- **No Workshop Dinner!**
  - **we will benefit from the DC2 dinner**
- **Make sure you registered and paid**
  - **see Debbie during coffee break**
- **There will be talks during Lunch time !**
- **Beam test Informal Meeting**
  - **18:00 today !**