Database for functionality tests

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1.Introduction

During functionality tests the time dependence of some quantities will have to be monitored through the LAT integration (involves beam tests, cosmic array tests, etc…). Using tracker as an example one may be interested in monitoring the leakage current throughout integration and this can easily be done by GSE. As far as monitoring if strip 344 in layer 2 in the tracker is dead or not, may be a role to the SAS. In either case a database that stores all information with queries that allows us to track these quantities is really crucial. This is what this note is all about.

2 Calibration Levels

From the software point of view we define four levels of calibration. This choice here is dictated first by the level of complexity required to obtain the data and second, whenever possible, by the time it happens during the mission.

- **Level 0** - involves **functionality** tests of a sub detector **before tower integratio**n. The calibration files contain information about electronic gains, linearities, dead and/or noisy channels, status flags for crucial components (or a subset of) such as readout chips. Data mostly from the construction phase, while the treatment of **in-flight housekeeping** data is also included here since I belive it is very similar.
- **Level 1** - involves **functionality tests and raw data** information related to individual sub detector validation **after tower integration**. These calibration files may contain a subset (TBD) of the Level 0 data.
- **Level 2** - involves **reconstructed data**. These are obtained through the software reconstruction packages that include the simulation of the LAT (GLASTSIM). There are two sets, one that consists of calibration parameters defined in Section 4.2, which are derived from the other subset described in section 5.3
- **Level 3 -** These are the **instrument response matrices** (maybe functions?). These are obtained through manipulation of data from previous level and are stored in the Reference Calibration Files for sub-orbital calibration. Flight Calibration Files, are analogous to those Reference Files **but in a format that is adequate for science data analyses**.

3 Calibration Timeline

Another logical choice would have been to distinguish levels by time of assembly, pre-flight (before and after integration) and in-orbit.

- **Subsystem integration** - involves **functionality** tests of a sub detector before tower integration.
- **Tower integration** - involves **functionality tests, raw data and reconstructed data** after tower integration. Includes several levels of testing, e.g., environmental, sea level muons, beam tests. From these we obtain the **instrument response matrices and calibration files.**
- **In-orbit** - involves offline analyses of housekeeping data and updating of calibration files using the ground calibration files as a reference for comparisons
- **On-board LAT**- involves calibration done by the on-line software. .

We will return to the timeline as we discuss Calibration Activities later in this document.

4. Offline Software

This overview does not discuss the Calibration Files and the knowledge of their details are crucial for the software development. The offline software, hereafter software, must be developed to support three main activities, namely

- Calibration Database
- Automated Calibration Analyses
- Manual Calibration Analyses

Throughout the Calibration Program, the following components may exist

- **Engineering Models -** single tower not fully instrumented with detectors
- **Flight Units -** single tower fully instrumented with detectors
- **LAT calibration Unit -** four towers fully instrumented with detectors
- **LAT Flight Unit -** sixteen towers fully instrumented with detectors

The software must provide the flexibility to perform and compare the calibrations using these different geometries and produce calibration files (TBD). Additional software modifications are required in case these are tested in particle beams.

4.1 Calibration Database

The calibration database must store data from ground and in-orbit calibrations in a database (maybe relational). Data must be stored with details of the test configuration and must be accessible at all times. The speed required for data retrieval and processing will depend on details of the calibration program (TBD). The database must also supply a set of queries (TBD) to sort the existing data. There must be a programmatic interface so that the software reconstruction program can get the right constants. These constants must be at least be selectable by time window.

4.2 Automated Calibration Analyses

To characterize environmental and time dependent effects on data from Level 0 and most of the data from Level 1, an automated analyses procedure can be defined. The software tools shall access the database, sort the relevant data and compare results from different measurements. The analyses tools shall provide a statistical analysis of the data (TBD), study trends and produce a report for future reference. The software tools must be able to analyze data obtained at all times during the integration of the LAT.

4.3 Manual Calibration Analyses

To determine the performance of the LAT a manual analyzes procedure (including algorithms) must be defined. This involves manipulation of data at Levels 1 and 2 to produce input data for Levels 3 and 4. Most of this data will be available during sub-orbital integration and will be stored in the Reference Calibration Files (RFC). During data taking (in-orbit) these files will be replaced by the Flight Calibration Files (FCF) , which correspond to an updated description of the RFC. Software must be developed to support these updates. The scheme for updating the FCF will be defined depending on the knowledge of the time dependent performance of the LAT. The software tools shall access the database, sort the relevant data and provide algorithms to study and characterize the LAT performance (e.g., parametrization of the point spread function as a function of energy). The analyses tools shall provide a statistical analysis of the data (TBD) , study trends and produce a report

5. Calibration Measurements and Data

To reader this section with the software perspective, means that one must have software available to perform these measurements. The required accuracy for that is not yet clear for most of items. The calibration measurements below provide the input to obtain performance parameters for the science analyses. These data **do not** correspond to all data stored at the sub system level, rather represents the relevant functionality data to be checked after instrument integration, beam tests and in-orbit . These data will not only require dedicated software for analyses , but also depend on algorithms that will search the database and study correlations in time, after environmental tests and other integration tests (TBD). A sub set of these data may also be physically located in construction databases at different LAT institutions and the process of migration of relevant data and procedures (TBD) will set the requirements for the algorithms. The list below is not definitive and depends on input from subsystems (TBR), and for the CAL we used their presentation at the Jan 2001 Software meeting (Eric Grove). Calibration levels have been defined in Section 2.1.

5.1 Level 0

Here we describe the measurements and data that will flow from the subsystems to the integration activities (4.1.2). Not only dedicated software, algorithms and analyses tools are needed but also a database with an interface to study correlations throughout the integration activities. Level 0 may appear several times during the activities from Section 4.1.2. The frequency and the needed correlations can only be defined after that Section is completed. The data at this level also overlaps in content with most of the housekeeping data and procedures to compare on ground with in-orbit data can only be defined after Section 4.2 is finsihed.

5.1.1 ACD

- Pulse heights - conversion from ADC units to MeV (uniformity across a tile)
- Status flag of readout chips (good/bad, on/off)
- Status flags of tiles (good/bad ?)
- Pedestals and corresponding widths
- Electronic Gains

5.1.2 TRK

- Read out chip thresholds
- Leakage current per cable
- Status flag for all chips
- Number of dead readout channels
- Noisy readout channels (define noisy in terms of occupancy ?)
- TEM redundant readout scheme (Left or Right controller chip ?)

5.1.3 CAL

- Pulse heights - conversion from ADC units to MeV
- Status flag of readout chips (good/bad, on/off)
- Pedestals and corresponding widths
- Differential Linearity Correction
- Integral Linearity - conversion from ADC to fC - charge injection
- Electronic Gains range for each PIN diode to 3% (TBD) - charge injection

5.2 Level 1

Since this is NOT a timeline description we do not need to include Level 0 data as a subset of Level 1. However is to be understood that when looking at the calibration activities , Level 0 and Level 1 data may appear in the same period in time (in a given testing procedure). Therefore we define Level 1 measurements and data as those that are only needed after a tower has been built and **do not** involve reconstruction software.

5.2.1 ACD

- Temperature from all sensors
- Detector operational voltages (since they may affect efficiencies later)
- Status flag for DATA and TRIGGER modes.

5.2.2 TRK

- Temperature from all sensors
- Detector operational voltages (since they may affect efficiencies later)
- Occupancy versus threshold
- Status flag for DATA and TRIGGER modes.

5.2.3 CAL

- Temperature from all sensors
- Detector operational voltages (since they may affect efficiencies later)
- Occupancy versus threshold
- Status flag for DATA and TRIGGER modes.

5.3 Level 2

There are two sets of Level 2 measurements and they both require reconstruction software. One set is related to calibration parameters and has been described in Section 3.2. Those parameters depend on the second set described below. These data are mostly obtained from sea level muons and Galactic Cosmic Rays if doing in-orbit calibrations. These data shall be studied for its dependence on: Energy of the incident particle, incidence angles (azimuth and inclination) and conversion point (front or back section of the tracker)

5.3.1 ACD

5.3.2 TRK

- Spatial alignment and resolution (offsets as function of temperature)
- Hit efficiencies
- Hit multiplicity

- Track reconstruction efficiencies
- Conversion point reconstruction efficiencies
- Energy range and resolution as measured by TRK only events

5.3.3 CAL

- Scintillation efficiency of logs
- Absolute Light yield to 3% (TBD)
- Light asymmetry for each end of a log and for the sum of both ends to 10% (collection efficiency as function of longitudinal position)
- Gain -conversion from fC to MeV - optical conversion efficiency
- Light attenuation model [Mev(center) to MeV[position])
- Leakage correction
- Energy range and resolution as measured by CAL only events
- Spatial resolution for CAL only events.

5.3.4 Cross subsystems (needs more than one detector)

- ACD single hit efficiencies
- Matching efficiencies (CAL+TRK)
- Matching efficiencies (TRK+ACD)
- Energy resolution (CAL+TRK) - initial energy, Landau fluctuations, nuclear interactions , uncertainties in dL/dE
- C,N,O, discrimination

5.4 Level 3

At this level most of the measurements rely on cross subsystem calibrations and are focused in extracting the instrument response matrices (functions). Few things shall be considered

- Needed parameters for different analyses , especially likelihood analysis
- The scanning mode of GLAST, which increases the number of response matrices and dictates a need for an averaging scheme (TBD)