# LAT Newsletter

## LAT Newsletter contributions from Beam Test Team

### Issue 10, march 2008

Joint report with C&A on the C&A-SciOps workshop

### Issue 9 - submitted december 25 (DRAFT)

**Simulation highlights**

- BT simulations were successfully ported to the Pipeline II environment by Johan; this ensures a consistent platform with other LAT simulations for data generation, archival and storage, which will allow efficient use of the BT data well after launch. A number of test simulations are now available from the data catalog, and any new simulation will be generated using Pipeline II.
- the H4 line simulation was double-checked and updated by Francesco as to extend the simulation up to the last bending magnet in the line. No significant difference was found in the energy distribution
- a comprehensive comparison with EGS5 from David showed very good agreement with Geant4
- scaling variables: we started looking into ways for scaling the MC data to match our data; Johan explored the consequences of changing CAL calibration constants, Luca scaled the ntuple variables and started looking at consequences of the scaling in the event classification, Carmelo showed the consequences of changing the incoming beam energy by the measured discrepancy. We will have further discussions on this topic in the CA-SO workshop in Bari, and plan to agree on a way to implement this

**Analysis highlights**

- bad position measurements in the CAL were studied by Philippe and Sasha; a possible explanation for these could be event pile-up, but it requires some more analysis to be confirmed
- TKR cuts are being revised in the light of the new variables introduced for the neutral energy events
- LAC thresholds behave in a different way in data and simulation : potentially due to pedestal drift, issue is under investigation

### Issue 8 - submitted december 4 (DRAFT)

The status of the beam test analysis was summarized in the last collaboration meeting in the session devoted to illustrate all the source of systematics that can impact our science anlysis. The focus was on clarifying which results are complete and solid and what are the open issues which we still have to address. It is clear that the current difference in the calorimeter variables (see below) is a concern and calls for a final effort for being solved. In parallel, we should constrain that into a quantitative statement on the resulting systematic error on the energy measurement, and a similar approach should be pursued for the TKR variables.
Below are some details of the recent progress.

**Simulation status**: we are moving to the v71215p0 release, with the following major changes

- pass5 variables from the current event classification analysis are added to the Merit Tuple and replace old pass4 variables; this allow a subsystem specific data-MC comparison for the relevant variables for background rejection
- vertex variables in the tuples are modified to describe also neutral energy events; this requires a thorough check of the usual TKR cuts that were used so far in the TKR analysis, and in particular Tkr1 variables should replace Vtx variables for analysis of all charged tracks
- list of golden runs : we are adding some new reference runs after we discovered that many of the runs we used are showing a weird structure in the TkrYdir_vs_TkrY correlation plot as a consequence of a large dead area in plane 35 of Tower 2 that the beam crossed and noisy strips around that area
- a pressure scan in the cerenkov detectors along the SPS H4 line was performed as a quick way to simulate effects of different material along the line
- the high energy SPS runs (E>5GeV) were re-simulated with the correct pressure (0.1bar) and gas (He) in the cerenkov detectors along the H4 line
- along with moving to v71215p0, synchronized with GR v12r15, Beamtest MC software is going to be updated to run on the pipeline II, in particular to use the new standard ways to store data on xroots and access them via the data catalog.

**Analysis highlights**:

- geant4-EGS5 comparison: a first check was documented by David Paneque, and shows a reassuring agreement for both the longitudinal and transverse EM shower shape, at least for a simple CAL geometry with no gaps
- but we heard that Babar had seen similar EM shower shape issues between their beam test Data and GEANT4 MC
- studies with extra material along the beamline : the average energy overestimation between data and MC is about 7%, but it is higher for the first layers of the calorimeter than for the last; this seems to indicate that the showers start earlier in the data than in the MC, tracing extra material along the beamline that is not described in the simulation. We have tested this idea by simulating different pressures in the Cherenkov and looking for the amount of extra-material that could account for the current disagreement between data and MC. When considering most of the SPS configurations, we find that 10% of radiation length would help, though it doesn't solve the discrepancy for all configurations and only 5% of radiation length seems necessary for the tracker variables
- a preliminary comparison of the pass5 variables performed within Insightful Miner for a specific run shows that these are fairly well reproduced in the MC, except for the calorimeter related variables. This is certainly due to the transverse size of the showers which is larger in the data than in the MC.
- the PSF with tagged photons was recomputed and shown to agree with the full bremsstrahlung analysis when using the same cuts
- TKR hits and cluster summary: a different behaviour with photons wrt electrons was observed after the simulation/reprocessing with the current BTRelease (v7r11117p1); while electrons show the usual lower number of hits and cluster in the MC, photons have now a larger number of hits; the analysis must be repeated with updated cuts. Scans along X and Y show a negligible dependence of the discrepancy with the position
- high energy electrons : an initial stab at modifying CAL variables to match the data was tested in the context of an event classification study to tag high energy electrons, and it was shown that the effect of the current discprepancy, mostly from the CalTransRms variable, on the algorithm that separated electrons from hadrons is non-negligible

## Issue 7 - submitted 16 October

**Simulation status**: we have now a stable BTRelease and are producing all the interesting configurations with that. We are following a list of golden runs th at people mostly used for analysis and for which we have already tuned the MC and data beam spots. For each run we automatically produce a system test report which allow instant comparison of data and MC, and post it in the runs list. A prototype higher level data-MC agreement matrix was presented and is being improved. The Low-Energy Geant4 simulations which seemed to produce a different energy deposit in the CAL are now back to the standard energy deposit we get with standard Geant4 libraries, after having fixed a bug which Francesco and Johan identified. A thourough material audit was conducted for the CAL, and modifications will have to be made in the detector geometry which will probably add some minimal extra radiation length wrt to the current model.

**Analysis**: a new iteration of the PSF analysis was preented by Nicola, who improved on the results in the high energy tail (above 1GeV) by aligning the CU and the incoming electron beam. A comparison of the angular dispersion plot with photons and electron was also presented.

**Conferences**: two contributions were presented and very well received at the ICATPP conference in Como.

## Issue 6 - submitted 12 september

*Luca Latronico*
*September 12 2007*

Since the final goal of the beam testa analysis is to validate and improve the LAT simulation-reconstruction package (GlastRelease, GR), we started tracking our progress and planning through a list of deliverables that have flown or will flow into GR.
The tables below reflect the state of the art of our work, including near term plans.
The first one is a list of the achievments that are now in place for the next Service Challenge run, while the second contains studies in progress and for the next months

| Topic | Software update | Description | Notes |
|---|---|---|---|
| TKR Digi | TkrDigi v2r6 | includes charge sharing and ion signal | two available routines, not enough to recover TKR hit deficit in MC |
| ACD Digi | GR-v11 | better single photo-electron signal simulation by extending Poisson fluctuations to first dynodes amplification | |
| CAL Calibration Procedure | column-wise charge injection in CAL CPT online scripts | correct non-linearities in charge injection | improved CAL calibration but did not solve energy shift; will be default calibration mode for the LAT, not relevant for simulation |
| CalRecon | GR-v11 | correct logs and inter-range cross-talk | require mapping of cross-talk for the LAT |
| Hadronic physics list | GR-v12 | | improved model for hadronic interactions (Bertini model up tp 10GeV, QGSP model up to 20GeV) |
| TKR material audit | GR-v12 | real TKR thin converter thickness | 8% lower wrt to original design |

List of planned deliverables and expected delivery

| Topic | Expected delivery | Description | Notes |
|---|---|---|---|
| TKR material audit | end september | update mass of passive material to real values from measurements | known missing mass in current model mostly around active area |
| CAL material audit | end september | check and update CAL mass and materials | preliminary surveys indicate good model |
| TKR alignment in MC | quick fix available in GR-v12 | fix bug in MC alignment | checking out alternative alignment strategy |
| New mass simulation | end september | with latest sim-recon package | will be used to re-evaluate TKR hits deficit and CAL energy shift in simulation |
| Special TKR geometry simulation | in progress | vacuum layer between silicon layers and tray core | performed to check penetration of delta rays in a more realistic geometry; preliminary results indicate little effect on TKR hits |
| Low-energy simulations | in progress | systematic test of LE EM physics list in G4 and range cutoff studies | preliminary results indicate no effect of range cutoffs and a non-perfect control of LE physics list in our simulation |
| background simulations with higher TKR hits | end september | increase artificially number of TKR hits to mimick BT data | will use alignment bug and will check effect on background rejection |
| background simulation with shifted CAL energies | end september | artificially scale simulated CAL energies and most important CAL variables to mimick BT data | will check effect on background rejection and reconstruction algorithms |
| final best physics list | november | final MC tuning | should flow into the Service Challenge 1 year run. it will includes best physics list and modification to geometry |

A very useful tool that we recently developed to check rapidly the effect of the many changes we are recently testing in the simulation is a BtSystemTest toolkit, which is a collection of the most sensitive plots produced so far by our team that are automatically produced for each MC generation, so that we can quickly evaluate the effect of changes.

Recently some effort went into use of BT data to check the expected behaviour of trigger primitives from the calorimeter with large energy deposit, which are not avaible with standard cosmic ray data from the LAT.

## Issue 5 - submitted 25 july

*Luca Latronico*
*July 25 2007*

In the past two months the team performed much work behind the lines on the core software, to reorganize the BT sim/recon package (BTRelease), verify the consistency of the Geant4 simulation and better support the analysis. The main areas of activity have been:

- synchronization with GlastRelease and updates of core packages (hadronic physics list management, G4Generator), which will help transferring BT results to the main LAT simulation
- beam spot tuning from real data and transfer to the simulation
- comparison with mars15 simulation and interaction with developers, which revealed inadequacy of the mars15 code wrt G4 for describing a simple EM cascade
- study of the CAL response with different segmentations of the log, which did not show any dependance of the simulated CAL signal on the level of segmentation

The attempt to summarize the results and map the still existing discrepancies between data and MC, mostly in the TKR hit counts and the CAL energy deposit, continued and will be presented in the collaboration meeting talk:

- summary of the TKR hit and cluster MC simulation for hadronic events and comparison with data
- stability check of the CAL response in similar electron runs revealed dependancies of the relative CAL-TKR position and the effect of tkr converter gaps in the shower development; this confirms the importance of a good matching of the beam profile for comparison with the simulation
- cal response to pion runs
- angular resolution studies with high energy electrons and low energy tagged photons to complete the characterization of the TKR performance over the whole spectrum
- PSF studies with covariance matrix
- started collecting existing and new ideas towards a set of selected runs and plots to produce for each new MC production

In order to start transferring our results to the LAT simulation as soon as possible and without delaying the production of the one year data simulation of the Service Challenge, we plan to provide now the existing improvements of the simulation to GR, and keep on evaluating the impact of the discrepancies through the production of custom files for the LAT with built-in discrepancies and potential new fixes we may find, to assess the impact of such discrepancies to background rejection and the LAT performances.

## Issue 4 - submitted 31 may

*Luca Latronico*
*May 31 2007*

The Calibration Unit worldwide tour was successfully concluded in the beginning of April, when the module was sent to SLAC and handed off to ISOC-SO that will turn it into a test bed to for studying flight hardware response to flight software.
This was the last step of a successfull series of CU operations carried on by the beam test team since its first integration just about one year ago .
We are happy to deliver such a valuable instrument to the ISOC, and completion of data analysis is now our only target.

On this ground, three main activites were pursued during the last month:

- re-evaluation of data-MC discrepancies after the last data reprocess and updates to the simulation
- completion of the standalone single-tower simulation and comparison with our standard Gleam MC
- systematic exploration of available hadronic physics lists

The most recent changes to our simulation/reconstruction package (BTRelease) include the adjacent crystal cross-talk correction for the calorimeter energy measurement, two alternative Tracker digitization algorithms with description of charge sharing and large signal induced cross-talks, and a correct use of the tracker calibration database.
These last improvements did not significantly improve the data/MC agreement in the CAL energy and in the number of tracker hits, but provided a very accurate description of the measured ToT distribution.

The standalone Geant4 simulation was completed with a realistic tracker tray honeycomb description, as opposed to a density-averaged homogeneuous material. No effect was observed in the total number of hits and in the EM shower development, which is also very similar to the one produced by Gleam. Our conclusions are that Gleam and a standalone Geant4 simulation generate similar EM shower profiles, and a more realistic tray description does not solve either the CAL energy or TKR hits discrepancy.

A more complete survey of the available hadronic physics list in Geant4 was performed, and the currently best results are obtained with the Bertini model up tp 10GeV, and the QGSP libraries above 20GeV. Mor models are being studied now

## Issue 3 - submitted 30 april

*Luca Latronico, Philippe Bruel*
*April 30 2007*

A very detailed status report of the beam test data analysis was presented at the last collaboration meeting, in a dedicated session which was very well received by the collaboration.
The CU response to irradiation was described in specific talks, as well as the changes suggested for the MonteCarlo simulation of the subsystems in order to get a better agreement with data.
The overall status was summarized in a final talk for the collaboration, where the main outcomes that we expect to deliver to the LAT simulation were presented. These include

- a new TKR digitization algorithm, including charge sharing, and cross talk effects for large signals (heavy ions saturating input charge amplifier); this will partly cure the discrepancy
- a new CAL modules calibration procedure that takes into account electronics cross talks and charge injection asimmetries
- an optimized hadronic physics list that identifies the best Geant4 simulation engines for hadronic interactions in the LAT
- a comprehensive material review extending to all subsystems

The schedule for these deliverables was later discussed inside our working group, and we agreed to release a first round of these changes by the end of april, to be able to evaluate the effects on data-MC comparison and support the implementation in GlastRelease.
As this issues goes in press, we are in fact going through a massive data reprocessing and MC generation with an updated version of our simulation /reconstruction package (BTRelease), which incorporates the latest calibrations, a new TKR digitization algorithm and the xtalk correction in the CAL.

Studies on hadronic phyisics are an on-going hot topic, as is a standalone G4 simulation with a realistic honeycomb structure that aims at testing the difference between homogeneous, distributed materials versus isolated material (like the TKR honeycomb). Preliminary results indicate no effect on the CAL energy deposition, while the impact on the TKR hit discrepancy is under evaluation.

Finally, the proceedings of the four contributions we submitted to the First Glast Symposium have been combined into a single paper and submitted for publication.

## Issue 2 - Studying the ACD Backsplash with beam test Data

The capability of the LAT to measure photon energies up to 300 GeV with good energy resolution requires the presence of a heavy calorimeter to absorb enough of the electromagnetic cascade produced by the incident gamma-ray. Unfortunately, a small fraction of secondary particles in the shower can travel backwards from the calorimeter into the tracker and up to the Anti-Coincidence Detector (ACD). This backsplash radiation consist mostly of 100-1000 keV photons and represent a potential problem since it can generate a signal in the ACD that would cause the gamma-ray to be interpreted as background and therefore rejected.

For this reason, the LAT ACD was designed as a segmented detector, so that only the ACD segment intersected by the backwards projected path of the particle is used to veto the event. In this way, the ACD area that contributes to backsplash is relatively small. The ACD hit probability per unit area as a function of energy and distance backwards from the shower has been studied with past beam tests (Moiseev, A. A., et al. 2004, Astroparticle Physics, 22, 275) and used to optimize the level of segmentation in the ACD design. The backsplash probability was measured with the *as-built* detector in the Calibration Unit Beam Test campaign in summer 2006, and the capability of the LAT Monte Carlo simulations to reproduce backsplash effect has been verified.

A careful analysis conducted by Luis C. Reyes demonstrated that the current LAT simulations reproduce well the backsplash effect. The LAT simulations take into consideration the energy loss fluctuations in the ACD tile, the Poisson fluctuations in the number of photoelectrons created in the readout photo-multiplier, and the corrections due to the non-uniform light collection at the edge of each tile. The latter currently represents the largest source of uncertainty in the present simulation, as it has not been measured yet for the ACD tiles installed on the LAT calibration unit. The expected backsplash distribution is therefore bracketed in the analysis by considering the maximum and minimum light collection efficiency measured for the tiles in the LAT (Moiseev et al, ACD paper, in preparation).

The result is shown in figure 1, and a beautiful reassuring agreement can be seen.

Details of this analysis will be shown at the collaboration meeting at GSFC next week, in a dedicated plenary session from the Beam Test Team where the state of the art of Data-MonteCarlo comparison will be presented to the collaboration.

Figure 1 - see attachment jpg
Figure 1 explanation: Backsplash probability distribution for an ACD tile as obtained from beam test data (black points) and Monte Carlo expectations. In every case, backsplash is expressed as the fraction of events for which the signal in the tile is above a given threshold. The error bars in the data are statistical 1 *sigma*. Monte Carlo simulations consider two extreme scenarios of light collection efficiency through the tile edge. In the MIN collection efficiency scenario, the collection efficiency decreases linearly from 100% (3 cm away from the edge) to 70% at the tile edge. In the MAX case, the light collection decreases linearly from 100% (1 cm away from the edge) to 90% at the tile edge. Both scenarios are shown in the backsplash distribution as *ban ds* that bracket the expected backsplash distribution. The width of each band is given by twice the statistical error 2 _sigma_obtained from the simulation.

## Issue 1 - Fine-tuning the LAT

See the released issue here