The case for entire LAT in a beam

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May 24, 2001

1. Introduction

Among the calibration tasks one finds

- To characterize physics performance of the instrument
- To validate Monte Carlo Simulations
- To verify systems performance of trigger, data acquisition and front-end electronics.

From the present discussions in the Calibration and Integration committee it seems that we can address the first two items from beam tests on single or four tower modules. However, the last issue has not yet been widely discussed and this is the intent of this note. The issue we are addressing is: **What can we learn in a beam test of the LAT (16 towers) that we cannot learn with a cosmic ray set up?**

The parameter space we are concerned involves

- Asynchronous rate
- Hit multiplicity and distribution
- Energy deposition

2. Tower simulator

The tower simulator essentially uses a pattern generator to load the inputs of the tower DAQ by dumping a lot of memory (no detectors attached). There are two problems there:

1. Events are empty (therefore one lower thresholds if there is a detector connected such as the BFEM, but with no detector and only a single tower simulator this would not be possible)
2. Pattern is very regular; therefore if there are events with non-regular patterns that could hang the entire system we will not study them.

In the light of recent problems with the BFEM, the pattern generator has been very useful in identifying problems. For instance one could not sustain a 5 KHz rate for too long due to effects caused by faulty behavior of the controller chips in the tracker. The problems found in the BFEM may depend on

- Trigger rate
- Temperature
- Hit multiplicity

What cannot be addressed with a tower simulator are changes in data due to changes in the event interval (pile-up). We can dismiss the tower simulator as the final answer on systems integration issues.

3. Cosmic ray test

Testing 16 towers in a cosmic ray by itself is not sufficient since the particle rates will be of about 100 Hz only. Hartmut has proposed to use a pulse generator to input calibration signals at the same time (logical OR) as we are testing the set up in cosmic rays. One needs to inject signals into tracker the calorimeter and the ACD. Apparently only the former two allow for a calibration injection mode at the front-end level. If that is accomplished a question still remains, **how does one make the coincidence between charge injection pulses and trigger pulses?** This may be a daunting task for the data acquisition system. After all that one can then study the high rate environment. Lowering detector thresholds and allowing more noisy hits in the detector address the hit multiplicity question. For the energy deposition, pulse shapes could then be simulated. It may seem possible to address a large fraction of the DAQ issues using this test, but we clearly do not test the full parameter space. Front-end electronics will certainly be more thoroughly tested that they have been either from previous beam tests or for the balloon flight. Nevertheless these tests will be done at the module level. If we believe this is a linear problem and systems integration do scale up from modular tests, we should be satisfied with the Cosmic Ray set-up.

4. LAT in a beam

We believe the proposed cosmic ray test is essential but not sufficient. Optimization of single modules may not necessarily lead to the optimization of the entire system. The first argument lies on the fact that everyone who has built detectors in the past knows that is **essential to do an end-to-end test** in an environment that is as close as possible to the real environment. The second has to do with throughput, as calibration unit in the beam will deal with only ¼ of the data.

The pulse generator allows one to test rates and hit multiplicities at the same time, but one cannot decouple both problems. The parameter space enlarges if one takes into account the amount of energy deposited in a given event over the entire LAT.
In principle pulse shapes can be generated with a given time structure. However this may not be representative of the situation we encounter in space. If for given GRB's we may have bursts lasting from ms to seconds, it could eventually saturate buffers. How do we guarantee that the system does not "hang" due to a combination of front electronics and data acquisition effects?

To study a large parameter space in one shot we propose to place the entire LAT in a charged particle beam. The beam should be continuous (a flat top of about a second or more) so that we read continuously and simulate an asynchronous rate, wide (1 m x 1 m)

so that we have a large fraction of the LAT exposed at the same time (we may have a problem with radiation safety here). If possible with a large spectrum of energies and particles, but this may also be limited the bema set up. And finally it would be ideal to add a spacecraft simulator. Another possibility (Al Odian) with a more realistic environment is to do a beam dump experiment. We certainly could have the high rates needed if we are located far away from the shields and we would not require beam time planning. However one depends on coordination of schedule to access the area before and after tests to install
and remove the LAT.

Acknowledgements

Discussions with E. Bloom, G. Haller, W. Kroger, D. Lauben, Al. Odian, J.J Russell, H. Sadrozinski, T. Waite and J. Wallace are warmly acknowledged.