Tower Simulators and Beam Tests

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0 Introduction

The I&T subcommittee has been very active in pursuing test methods for verifying instrument performance (both in engineering terms and the instrument's ability to perform as a physics acquisition device). The consensus seems to be that (for physics acquisition at least) the verification matrix can be satisfied using a combination of tower simulators and beam tests using a reduced (four tower) instrument.

This document considers the idea that the verification matrix only addresses individual points in the measurement phase space and that none of these points approach the environment the instrument will encounter in orbit. The logic (hope?) is that the individual verification measurements are neatly decoupled and that they provide a satisfactory predictor of whole instrument behaviour. This has not always proven to be true and many subtle effects have turned up after an instrument is fully integrated. To satisfy ourselves that the instrument will work in the real environment of space, we should consider doing a whole or near whole instrument beam stress test.

1 Comparison Of Testing Methods

Testing will occur at all stages of the building of the LAT, but in the context of the I&T discussion of verifying the LAT's physics performance, there are only really two methods available: tower simulators and test beams.

1.0 Tower Simulators

Tower simulators operate at the level of the cables dropping off the towers. Thus they are purely digital devices. There are several questions concerning their operation that need to be answered (e.g. how do they deal with "data stutter" due to long TOT's in the TKR), but lacking an extant simulator design, those questions cannot yet be answered. On the other hand, being digital devices, their fidelity to the "ideal" (as distinct from "observed") data format dropping off the cables can be reasonably assured.

1.0.1 Advantages Of Tower Simulators

Tower simulators will (we presume!) be highly programmable and very flexible objects. They can be used to simulate:

- High trigger rates
- Asymmetric data distribution (in a typical event, the data are contained in just one or two towers with the remaining towers essentially spectators).
- Noisy data environments.
- Event filtering. The full LAT DAQ will likely receive 3-5 KHz and will have to filter out most of the charge particle triggers by associating ACD and TRK. The event filtering scheme can by tested with a memory pattern generator loaded with events at highest foreseeable rate.

1.0.2 Disadvantages Of Tower Simulators

Tower simulators are *not* real towers. Any discrepancy between the data delivered by a simulator and by a real tower could easily mislead us into believing that we're doing better than we really are. Our experience with the BFEM should be a salutary lesson.

They do not simulate anything on the "far side" of the data cables. They cannot be used to test:

- The trigger.
- Any interference between the digital and analog components of the front end electronics.
- Any analog effects of high trigger rates (e.g. pile up).
- Any analog effects of very large signals (e.g. recovery of railed amplifiers).

There is also the seemingly trivial but very fraught question of what patterns are programmed into the simulators. This is not an issue for focused tests like measuring that DAQ's ability to deal with asymmetric data, but becomes a very real issue when trying to decide how to simulate the space like physics environment. MC data is notoriously too clean. Adding simple salt and pepper noise never adequately captures the correlated noise we're used to seeing in real data. As an aside, the BFEM data may be useful here in that it should produce a wealth of "zoo" events, though all of them "triggered" (no spectator-like tower data).

1.1 Beam Tests

I don't think a description of beam tests is necessary for this audience!

1.1.1 Advantages Of Beam Tests

- Beam tests frequently provide the only viable method for testing elements of the verification matrix.
- By their very nature, beam tests exercise the instrument from the detector elements themselves through the DAQ electronics and software to persistent media (disk, tape, etc.).

1.1.2 Disadvantages Of Beam Tests

- Beam tests are elaborate undertakings. They can significantly impact cost and schedule.
- The nature of the beam often determines the instrument parameter space explored. This can be an advantage when the characteristics of the beam are closely matched to the goals of the measurement, but is a disadvantage if the goal is to emulate a wide variety of environments. Looking back, it now seems obvious that our BTEM experience with 10 and 30 Hz beam repetition rates did not prepare us for the BFEM.
- Just as the beam can govern the nature of the stress applied to the system, so can the goals of the experiment. A beam test designed to measure, for instance, Point Spread Function is unlikely to be run at high rates or to use the flight software trigger filtering algorithms. The test may well achieve its goal of measuring Point Spread Function, but it has done little to explore the full performance envelope.

2 Another Beam Test

To even approach the full performance envelope, either the full LAT or the Calibration Unit should be exposed to a much more filthy environment. It's not possible to reproduce the true space environment in a test beam, but a reasonable approximation might be possible by degrading a particle beam with something as simple as a concrete block! The particle beam should not have any internal timing structure which mandates the "flat top"-, "one second spill"-style accelerator (Fermilab? Brookhaven? CERN? (not SLAC)). Experts can no doubt come up with a better design to produce a beam flux with the following characteristics:

- 10^4 to 10^5 uncorrelated particles per second through the test unit.
- A variety of particle species (including some photons).
- A large spectrum of particle energies.

A far larger problem will probably be to persuade the equivalent of SLAC's Occupational Health Physics department at the host accelerator that this isn't a terrible idea. Such an experimental environment would be akin to a beam dump!