Functional Testing

Functional testing of the LAT instrument covers the entire range of tests from simple command/response tests that verify the functionality of certain instrument capabilities to complete verification of the overall instrument performance. At the latter end of the spectrum functional testing could be considered to encompass calibration as well because a properly functioning system must be capable of calibration. Functional testing also provides a performance baseline that allows trending of significant instrument parameters from the beginning of integration through on-orbit operations. It is important that functional testing exercise ALL capabilities of the instrument.

While some functional tests may require beamlines or other specialized GSE, the core series of functional tests should be capable of being performed with only the instrument hardware and its normal command and communications links. This allows functional testing as late in the system flow as possible and provides the greatest amount of data for system trending. This places some constraints on the subsystems tests which comprise the overall system functional test. Another constraint comes from the need for reasonably quick determination of pass/fail criteria. Functional testing often occurs as part of instrument environmental testing or as a part of a larger vehicle or mission level systems test where it is important be to able to expeditiously give the go ahead to break configuration and continue with the next portion of the test.

The overall instrument functional test suite has been divided into three sections to allow tailoring to match various system test criteria. These sections are aliveness, limited functional test and full functional test. The aliveness test verifies that the instrument controller and the subsystems power on, configure correctly, and are capable of the nominal response to command stimulus. The limited functional test provides a top level view of the scientific functionality of each subsystem. This provides verification that the instrument is producing meaningful data. It is expected that this test will be the workhorse of integrated system testing. The full functional test adds additional science data collection to provide verification that the system performance is correct.

Performance tests of the calorimeter

There are two basic types of tests that can be performed on the calorimeter at any time to check its performance. These are tests that do not involve beams and can be performed during and after environmental tests.

Muon tests use the cosmic ray background to self-trigger the calorimeter and read it out. It tests the entire trigger and read out chain while at the same time providing a calibration point for the lowest energy range of the calorimeter read out. It does not substantially test higher energy ranges, and the rate is limited to ~ 20 Hz per calorimeter module.

Charge injection tests use a built in charge injection system to simulate an event by injecting charge in the front end of the calorimeter read out electronics. This system can be fired at a high rate and can simulate the entire range of energy signals. It does not however test the detector performance, only the electronic performance.

The calorimeter team therefore plans to use both testing methods in conjunction as much as time will allow. The following test plans are an initial guess at tests for aliveness, limited performance, and full performance.

Performance tests of the tracker

Performance tests of the ACD

Performance tests of the instrument controller

The instrument control requires little dedicated testing once the system has completed boot and initial configuration. It does, however, provide the support for all other functional tests, and is therefore critical for system performance. It is important that functional tests provide a method for localizing any discrepancies that occur. The system boot/startup incorporates self-test which provides the equivalent to a functional test. This test includes, memory test, verification of all data in nonvolatile memory, test of vehicle interface status for the 1553 bus, verification of input command link, and verification of housekeeping acquisition.

1. Aliveness

Verify:

ability to provide instrument power on A side systems
all voltages, currents in range
temperatures consistent with environment

correct boot up and application software load of all processors
correct response to processor startup diagnostics, memory tests, etc

instrument command and low rate telemetry interface
command path to all subsystem elements
housekeeping path to all subsystem elements

ability to configure instrument for nominal operation
initiate data acquisition, ACD HV on, other bias voltages set
verify overall instrument trigger rates nominal
verify nonzero data from all subsystem elements

data test pattern

verify high rate data link

Calorimeter:

Assuming we are limited to ~ 20 minutes, we would:
- spend 2 minutes testing commands to turn on/off/adjust detector and electronics powers, thresholds, gains, DACs, etc.
- spend ~ 8 minutes performing pulser tests. Each of the four sides of a calorimeter is tested separately, but all calorimeters are tested simultaneously. We therefore would have ~ 2 minutes per side. We would pulse at ~ 100 Hz and spend ~ 10 seconds per point (~5 of data, a few of seconds of overhead). [The 100 Hz depends the interrupt clock from the TDF system and how it is to be shared with the other subsystems. Since that is unknown, we will stick with 100 Hz for now.] We would test 3 amplitudes optimally selected in each of the 4 energy ranges. Because of energy range overlaps, we would end up with ~4 good points per energy range.
- spend 10 minutes collecting cosmic ray muons. Each calorimeter fires at ~ 20 Hz on cosmic ray muons, and an event typically energizes 8 crystals. We would therefore collect ~12 000 events, and ~ 100 000 crystal hits, or ~ 64 hits per crystal. This amount of data is not sufficient to calibrate a crystal, but it is sufficient to know whether each detector is alive. Operating in a mode that suppresses the zero suppress will allow us to determine the noise levels in logs readout when not hit by cosmic rays.

ACD:

In addition to the voltage, currents, commands, for the ACD the best aliveness test is to turn on the HV and make sure that all the rates are non-zero.

Tracker:

switchover to B side commanding

perform nominal powerdown sequence over B side

power up on B side power

verify nominal power up sequence

2. Limited functional

Verify:

ability to provide instrument power on A side systems
all voltages, currents in range
temperatures consistent with environment

correct boot up and application software load of all processors
correct response to processor startup diagnostics, memory tests, etc
instrument command and low rate telemetry interface
command path to all subsystem elements
housekeeping path to all subsystem elements

ability to configure instrument for nominal operation
initiate data acquisition, ACD HV on, other bias voltages set
verify overall instrument trigger rates nominal
verfiy nonzero data from all subsystem elements

Perform subsystem specific functional tests

ACD:

Depending on how extensive the other subsystems want to test, the ACD can take one of two approaches:

a. In a short time, the rates for each of the ACD tube/tiles can be compared with a reference. That's a pretty good measure of the basic functionality of the ACD.

b. If the test is longer, we can accumulate a PHA spectrum for each of the tiles, just using its own internal trigger (unless use of this trigger interferes with other tests).

Tracker:

Trigger rate for each tower
Time over threshold verification
Nominal tracker noise occupancy

Calorimeter:

Limited testing would involve (assuming 2 hours for the test):
- spend ~ 10 minutes checking commands, gains, DACs, thresholds,…
- spend ~20 minutes on pulser tests. This would provide us with ~ 10 points per range.
- spend ~ 100 minutes collecting muons. This is sufficient to determine the gain of a log, and therefore determine the quality of a PIN-diode optical bond. If we run in calibration mode with the high-energy range test feedback system "IN" and digitize all ranges, we will test both the large and small diodes at the same time. However, this amount of time is not sufficient to map the light yield across a log.

Verify ability to reconfigure instrument (one tower if this is a long process)

Perform Aliveness Test starting on B side

3. Full functional

Verify:

ability to provide instrument power on A side systems
all voltages, currents in range
temperatures consistent with environment

correct boot up and application software load of all processors
correct response to processor startup diagnostics, memory tests, etc
instrument command and low rate telemetry interface
command path to all subsystem elements
housekeeping path to all subsystem elements

ability to configure instrument for nominal operation
initiate data acquisition, ACD HV on, other bias voltages set
verify overall instrument trigger rates nominal
verfiy nonzero data from all subsystem elements

Perform subsystem specific functional tests

ACD:

Acquire PHA spectrum for each tile, and perhaps for each tube (2/tile).
Verify ability to change thresholds by command
Verify ability to change HV by command, measuring the change by the rates and/or PHA each time.
(The question is whether the PHA can be accumulated while other subsystems are testing. If we have to use the L1T generated by the general system from 3 in a row or CAL, the rate in any ACD tile will be much lower and the test will take longer. We may have to ask for several hours of dedicated time to run in a free-trigger mode for the ACD tiles.)
Tracker:

Calorimeter:

Full performance testing would involve a full pulser scan and a long muon collection and would take 12-14 hours. A full test of the commanding would also happen, but the time requirement is small compared to the time requirements of the other two tests.

Full pulser testing is expected to take 2 hours.
A muon test sufficient to confirm the calorimeter performance would take ~ 10-12 hours of collection. This collection time is sufficient to determine and map the light yield of the crystals

Trigger:

Measure internal alignment of TKR with charged tracks
Measure TOT for charged particles

Perform limited functional test on B side