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LAT Beam Test Matrices		

Change History Log

Revision	Effective Date	Description of Changes

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1.1. Test Units

The units used for the tests are defined below

Test Unit	# Of Towers	ACD	1.1.1.1 Tracker	Calorimeter
Engineering Model (EM)	1	13 tiles (3 remain in the EM 10 will be used in the CU)	Non-instrumented trays <ul style="list-style-type: none"> • Thin 3% (13) • Thick 18% (2) Instrumented trays <ul style="list-style-type: none"> • Thin 3% (2) • Thick 18% (2) 	Fully instrumented?
Qualifying Units (QUAL)	1 or 2	? Tiles	Fully instrumented	Fully instrumented
Calibration Unit (CU)	4	10 tiles	Fully instrumented	Fully instrumented
LAT Flight (LAT)	16	Fully instrumented	Fully instrumented	Fully instrumented

For the calibration unit (CU) we envisage two configurations.



1 x 4



2 x 2

1.2. Overview

1.2.1. Photon Beam

Science Parameters: Effective area, PSF, Energy Resolution and Field of View

Focus: off axis performance and precise measurement for the ratio PSF95/PSF68 for on axis incidence, energy resolution < 200 MeV.

Tagged Photon Energy : 20 MeV to 20 GeV

Beam Type: incoherent brehmstrahlung

Calibration Unit: 4 towers

Verification Method: Data up to 20 GeV is used in conjunction with Monte Carlo simulations to estimate the science parameters at all energies.

Location: SLAC

Date: November 2003

Duration: 6-7 months

Issues to be addressed

- With the current baseline the beam test duration will cause significant impact in the schedule. We shall study as soon as possible the feasibility of a coherent brehmstrahlung or channeling beam at SLAC. Preliminary discussions indicate that beam test duration can be reduced to about 3 months. Main issues to resolve time availability of beam (since it does not exist but it is in SLAC plans to implement it), technique for tagging photons to guarantee 50% energy resolution < 100 MeV and 10% above > 100 MeV.
- We shall investigate the possibility of using a Van der Graaf generator to provide photons < 50 MeV, that can be used as a test set-up during integration to test individual towers and tower modules.
- The proposed test matrix shall be revisited using the PDR software simulation.

1.2.2. Positron Beam

Science Parameters: Background Rejection, Energy Resolution, Time Accuracy, Deadtime

Focus: rejection of electron background from backsplash, development of electron showers between towers

Positron Energy : 500 MeV to 20 GeV

Beam Type:

Calibration Unit: 1, and/or 2 and/or 4 towers (TBR)

Verification Method: Data up to 20 GeV is used in conjunction with Monte Carlo simulations to estimate the science parameters at all energies.

Location: SLAC

Date: October 2003

Duration: 1 month

Issues to be addressed

- There are minor technical difficulties at SLAC to produce a beam with energies < 2 GeV. We need an assessment of the few modifications needed in some elements of the beam line. Main issues to resolve: whether we can start with this beam test with 1 or 2 tower units and then upgrade it to the 4 tower configuration.

- Extrapolation with Monte Carlo simulations may not be sufficient to address shower effects and leakage at high energies >100 GeV. We need to assess the need for such high energy beam test that cannot be done at SLAC and how many towers are needed for that.
- There is a known ($\sim 10\%$) disagreement in shower profiles for high energies, one must revisit its impact on the science requirement. The proposed test matrix shall be revisited using the PDR software simulation.

1.2.3. Proton Beam

Science Parameters: Background Rejection

Focus: obtain rejection of proton background to $10^3:1$ level (does not rely on the ACD), study effects due to material between towers

Proton Energy : 1 GeV to 13 GeV

Beam Type:

Calibration Unit: 4 towers

Verification Method: Data up to 13 GeV is used in conjunction with Monte Carlo simulations to estimate the science parameters at all energies.

Location: SLAC

Date: August 2003

Duration: 1 month

Issues to be addressed

- There are minor technical difficulties at SLAC to produce a beam with energies < 2 GeV. We need an assessment of the few modifications needed in some elements of the beam line. Main issues to resolve: we assume the ACD performance has already been validated in the Monte Carlo and the ACD efficiency is well measured and does not change significantly in the energy region we are testing.
- The proposed test matrix shall be revisited using the PDR software simulation.
- One shall study the feasibility of using a hardener to produce neutrons and to study this background as well.
- Heavy ion beam test done by the calorimeter team in a single tower (outside SLAC) is sufficient to validate the Monte Carlo for the full LAT.

1.2.4. Cosmic Ray Test

Science Parameters: None.

Focus: system integration and functional testing, e.g..calibration, data loading, rates, data throughput, alignment

Energy : TBD (depends on the set up)

Beam Type: None

Calibration Unit: all (from single towers to full LAT)

Verification Method: Tests are carried out in a presence of tower simulators (include pattern generators and charge injection calibration modes)

Location: SLAC

Date: 2002 - 2004

Duration: 24 months. Tests are done during the entire LAT integration, before and after beam tests.

Issues to be addressed

- We identified a cosmic ray set-up that can be used for tests. We shall work the details of its implementation in our clean room and decide on the relevant energy bins.
- The plan for environmental and functionality tests shall provide guidelines for the usage of the cosmic ray set-up in terms of test procedures, cost and schedule. Its impact on test beam plan has yet to be evaluated.

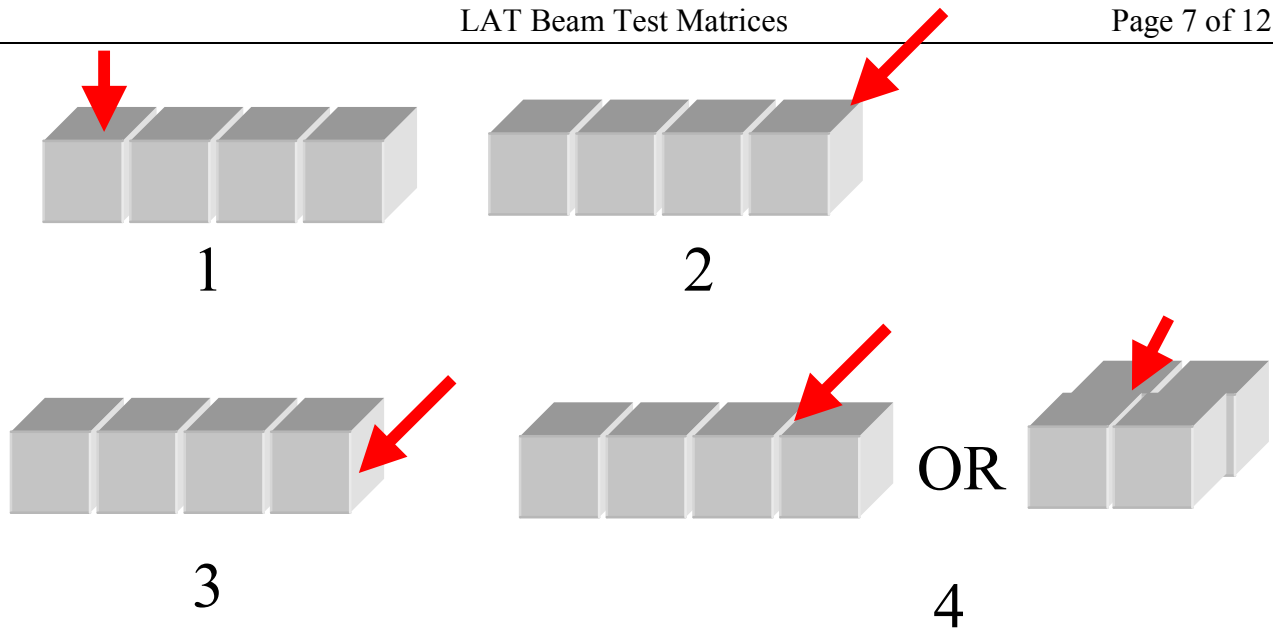
1.3. Test Matrices

1.3.1. Photon Beam High Energy (>100 MeV)

For every point in the test matrix (energy and polar angle) we require 4000 reconstructed tagged photons (TBR). We estimate the necessary number of photons per energy bin based on the incoherent brehmstrahlung tagged photon beam used for tests at SLAC in 1999/2000. All measurements are to be performed at least one azimuth angle (45 deg) and possibly two (22.5 deg and 45 deg)(TBR).

	$\phi=0^{\circ}$				$\phi=45^{\circ}$			
	$\theta=0^{\circ}$	$\theta=30^{\circ}$	$\theta=55^{\circ}$	$\theta=70^{\circ}$	$\theta=0^{\circ}$	$\theta=30^{\circ}$	$\theta=55^{\circ}$	$\theta=70^{\circ}$
200 MeV	1	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4
1 GeV	1	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4
10 GeV	1	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4

Each entry in the table represents a given configuration depicted in the figure below.



1. on-axis incidence, impact point at center of tower 1. High statistics run to characterize the ratio of PSF95/PSF68.
2. Impact point with respect to the top corner of the tower at the end of the 1 x 4 stack. Characterize off axis behavior on trays with thin converter.
3. Impact point 30 cm (TBR) below the top corner of the tower at the end of the 1 x 4 stack. Characterize off axis behavior on trays with thin converter.
4. Impact point at the center of first two adjacent towers 1 x 4 stack or 2 x 2 stack. Study effects from walls and gap between towers.

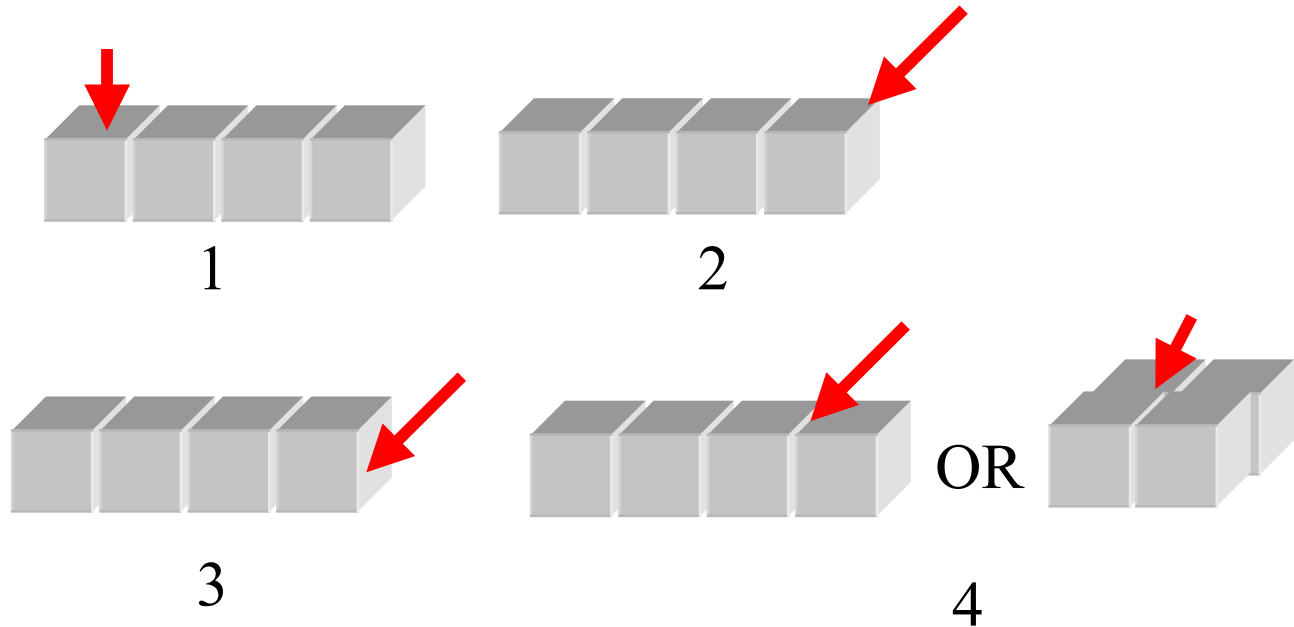
Option 4 shows two configurations, preference is for 2x 2,. Nevertheless, the choice will be dictated by how complicated it is to produce a fixture and MC simulations (TBR).

1.3.2. Photon Beam Low Energy (<100 MeV)

For every point in the test matrix (energy and polar angle) we require 4000 reconstructed tagged photons (TBR). We estimate the necessary number of photons per energy bin based on the incoherent brehmstrahlung tagged photon beam used for tests at SLAC in 1999/2000. That beam was only capable to generate photons up to 50 MeV, so the calculation for the 19.8 MeV may not be accurate and needs revision. All measurements are to be performed at least one azimuth angle (45 deg) and possibly two (22.5 deg and 45 deg). The energy points for this beam depend on the availability of the beam either a Van Der Graaf or a channeling beam.

	$\phi=0^{\circ}$				$\phi=45^{\circ}$			
	$\theta=0^{\circ}$	$\theta=30^{\circ}$	$\theta=55^{\circ}$	$\theta=70^{\circ}$	$\theta=0^{\circ}$	$\theta=30^{\circ}$	$\theta=55^{\circ}$	$\theta=70^{\circ}$
19.8 MeV (TBR)								

70 MeV (TBR)								
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- 2 energies on-axis incidence, impact point at center of tower 1. High statistics run to characterize the ratio of PSF95/PSF68, not yet validated in the Monte Carlo.
- 2 energies and 3 polar angles, impact point with respect to the top corner of the tower at the end of the 1 x 4 stack. Characterize off axis behavior on trays with thin converter.
- 2 energies and 3 polar angles, impact point 30 cm (TBR) below the top corner of the tower at the end of the 1 x 4 stack. Characterize off axis behavior on trays with thin converter.
- 2 energies and 3 polar angles, impact point at the center of first two adjacent towers 1 x 4 stack or 2 x 2 stack. Study effects from walls and gap between towers.

Option 4 shows two configurations, the choice will be dictated by how complicated it is to produce a fixture and MC simulations (TBR).

1.3.3. Positron Beam

The test matrix focuses on trajectories that intersect the calorimeter. A summary slide is shown below.

Tentative Test Matrix (updated)

Use of the 2x2 configuration only

4 energies: .5-2-5-20 GeV

Intercalibration of the 4 towers: $\Theta=0^\circ$: 9 positions per tower**Entrance face:** $\Theta=0^\circ$ 13 points $\phi=0^\circ$, $\Theta=20^\circ$: 8 points, $\Theta=40^\circ$: 3 points $\phi=22.5^\circ(?)$, $30^\circ, 45^\circ$, $\Theta=20^\circ$: 6 points, $\Theta=40^\circ$: 3 points

Total: 42 (+9)

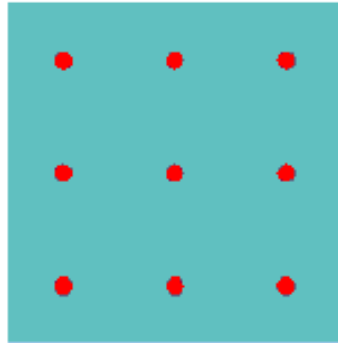
Side face:3 ϕ angles ($0^\circ, 30^\circ, 45^\circ$) \times 3 vert. positions \times 3 hor. positions
 \times 2 Θ angles :54 points**Back face:** all energies ? $\Theta \sim 0^\circ$: 13 points ?

with additional material (spacecraft) 13 points?

Total: $\sim(4 \times 9 + 105 \text{ points}) \times 4 + 26 \text{ points}$

There are three configurations, characterized by the impact point.
For configuration 1 with the beam entering the front side of the calorimeter.

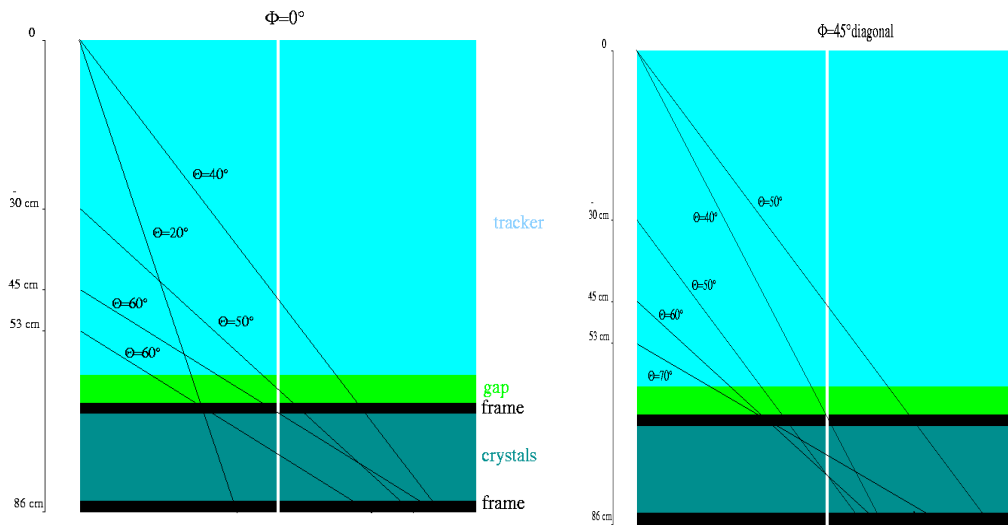
Energy (GeV)	$\theta=0^\circ$
0.5 (TBR)	4 towers x 9 points = 36 points
2	4 x 9 = 36
5	4 x 9 = 36
20	4 x 9 = 36



Top View of One face of one calorimeter tower. Dots correspond to beam impact points.

For configuration 2, the beam enters on the side of the towers. The following matrix applies

	$\phi=0^0$	$\phi=22.5^0$		$\phi=45^0$	
	$\theta=0^0$	$\theta=20^0$	$\theta=40^0$	$\theta=20^0$	$\theta=40^0$
500 MeV (TBR)	13 points	9	5	9	5
2 GeV	13	9	5	9	5
5 GeV	13	9	5	9	5
20 GeV	13	9	5	9	5



Side View of two calorimeter towers

1.3.4. Proton Beam High Energy (>20 GeV)

	$\phi=0^0$			$\phi=45^0$		
	$\theta=0^0$	$\theta=45^0$	$\theta=87^0$	$\theta=0^0$	$\theta=45^0$	$\theta=87^0$
50 GeV (TBR)						
100 GeV (TBR)						
250 GeV (TBR)						

1.3.5. Proton Beam Low Energy (<20 GeV)

	$\phi=0^0$			$\phi=45^0$		
	$\theta=0^0$	$\theta=45^0$	$\theta=87^0$	$\theta=0^0$	$\theta=45^0$	$\theta=87^0$
2 GeV (TBR)						
5 GeV (TBR)						
13 GeV (TBR)						