GLAST Large Area Telescope
Calorimeter Subsystem

Requirements Review, Test Flow

J. Eric Grove

Naval Research Lab
Washington DC

Derived Requirements

- LAT CAL Subsystem Level III Specification (LAT-SS-00018)
  - Contains 29 performance requirements for CAL
- LAT CAL Subsystem Level IV Specification (LAT-SS-00210)
  - Contains 167 design requirements derived from CAL Level III Specification (LAT-SS-00018)

- LAT CAL Verification & Environmental Test Plan (LAT-MD-01345)
  - Contains verification matrix
  - Gives approach to verifying each Level III, IV requirement
    - Lists verification methods used
      - 69 verified by test
      - 127 requirements verified by analysis/inspection
    - Assembly levels at which verification is performed

Verification Level

- Level at which verification occurs
  - Component: AFEE board, CDE, Composite Structure, …
  - Module: CAL with EM2 TEM/TPS
  - LAT: shorthand for LAT-level *and* everything after NRL

Verification Level	Specifications
Component	0 level III 111 level IV
Module	10 level III 56 level IV
LAT	19 level III 0 level IV

Verification Level – Module Detail

- Breakout of verification at Module level
  - Tests to be conducted after successful TRR

Module Environmental Test	Number of specs to be verified
EMC/EMI	0 Level III 1 Level IV
Vibration	0 Level III 5 Level IV
Thermal-vacuum	0 Level III 5 Level IV
Mass properties	0 Level III 3 Level IV
Pre-ship functional	4 Level III 18 Level IV
Pre-ship review	6 Level III 24 Level IV

Verification Status

- Flight verification well in progress
  - Test, analysis, and inspection reports being generated
- Engineering Model CAL
  - EM completed full environmental/functional test program
  - Demonstrated compliance with specs

Level	Specifications	Status (demonstrated compliance)
Component	0 level III 111 level IV	111 flight EM demo
Module	10 level III 56 level IV	2 flight 8 EM demo 20 flight 29 EM demo
LAT	19 level III 0 level IV	10 flight 5 EM demo

- Some flight verif. is done, but documentation (test, inspection, or analysis report) incomplete

Verification Status (cont.)

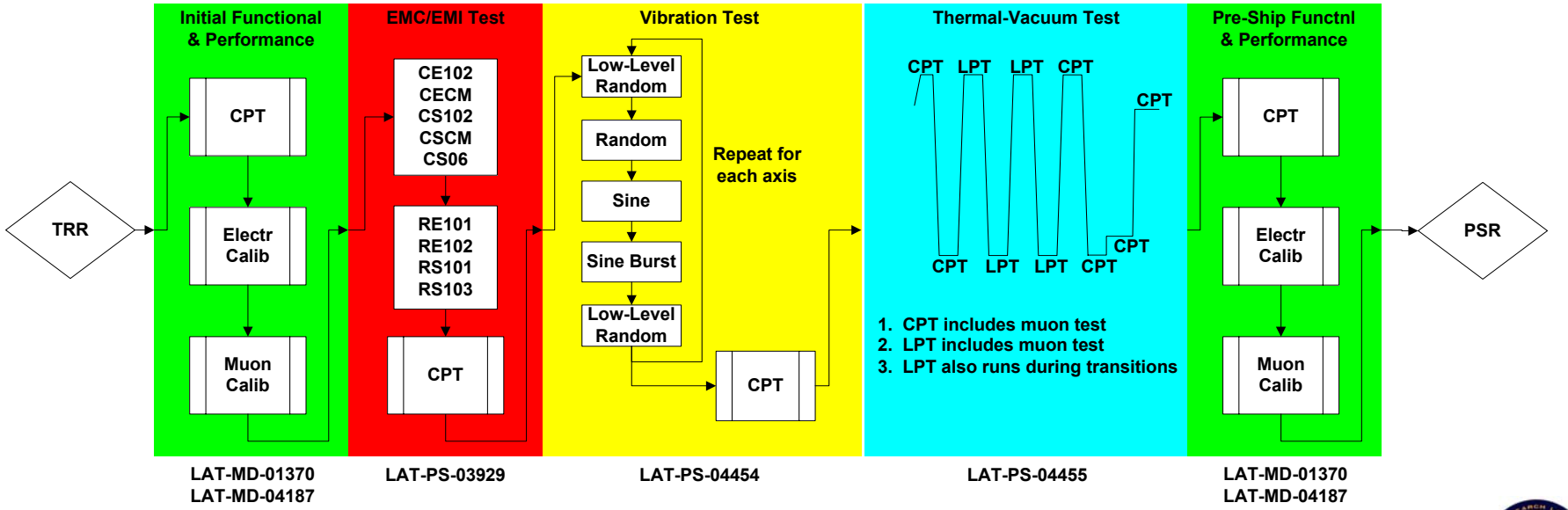
- What has never been verified or demonstrated?
  - No Monte Carlo simulation, no EM demonstration, and no FM in progress

Level	Spec count	Specification
Component	0 level III 0 level IV	(all verified or demonstrated)
Module	0 level III 7 level IV	EMC/EMI: EM with EM TEM/TPS failed TVAC: power-up at –30C failed (EM TPS) Energy range: LEX8 – HEX1 not in compliance
LAT	4 level III 0 level IV	GCR calibration: algorithms in development Lifetime, Reliability: updating FMEA CDE energy range: 100 GeV not demonstrated

System Test Plan

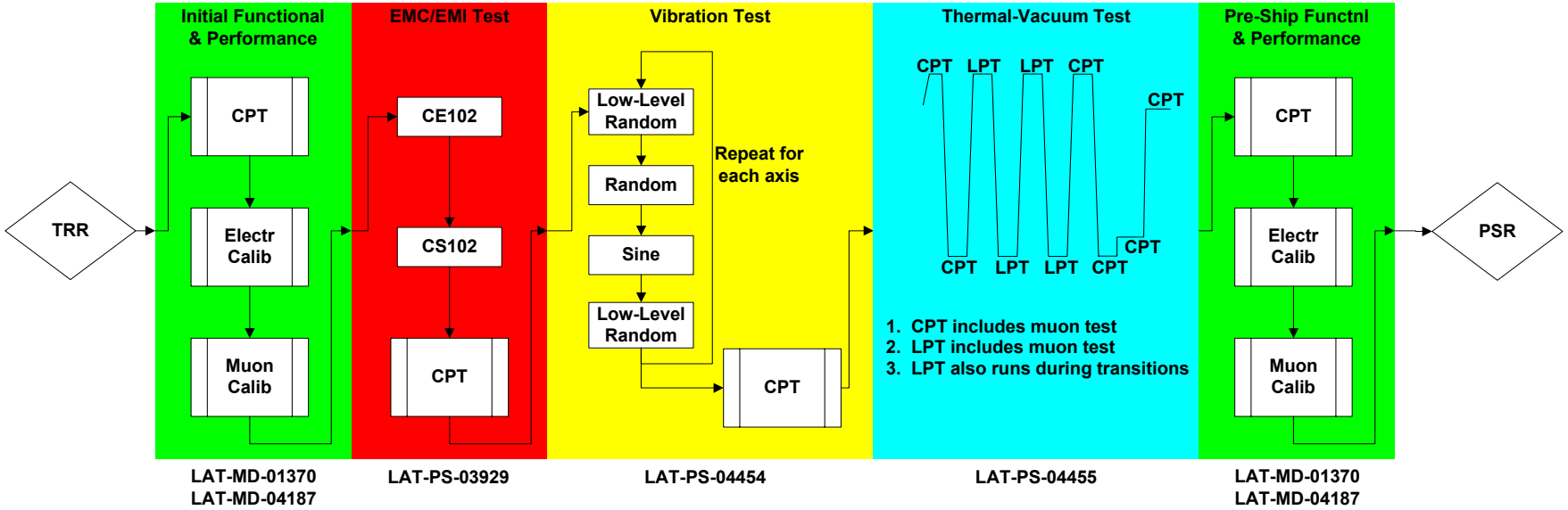
- Consistent with LAT-MD-00408
  - Assembly and Test Plan LAT-MD-00262
  - Verification and Environmental Test Plan LAT-MD-01345

- Proto-flight Test Flow
  - Applicable to FMA = QM



System Test Plan (cont.)

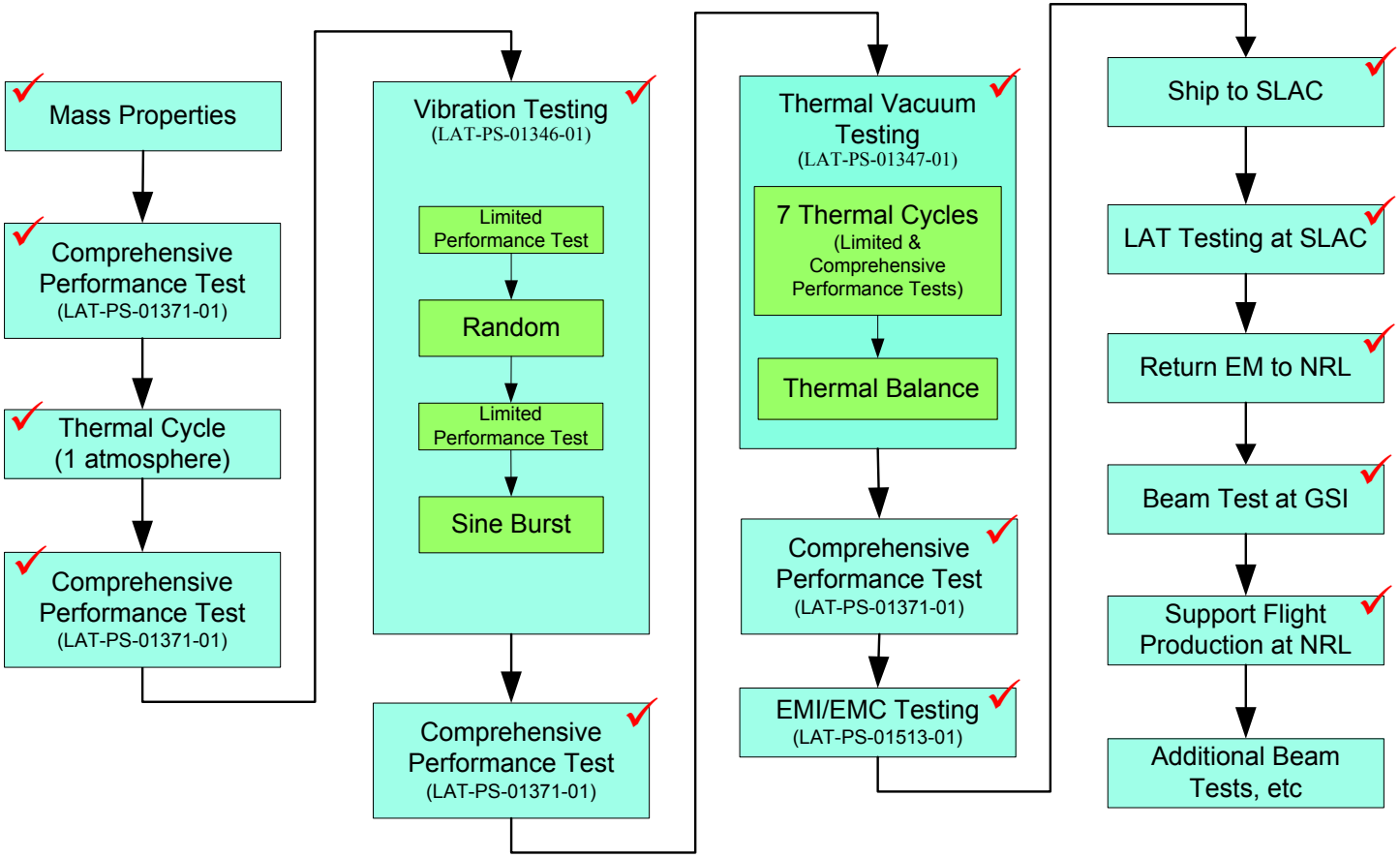
- Acceptance Test Flow
  - Applicable to FMB – FM16



  - Test to Acceptance levels, consistent with LAT-MD-00408
    - EMC/EMI tests simplified, shortened
    - Vibe drops sine burst
    - TVAC drops thermal balance

Reminder: Engineering Model

- Dry run of complete environmental test program with full Module

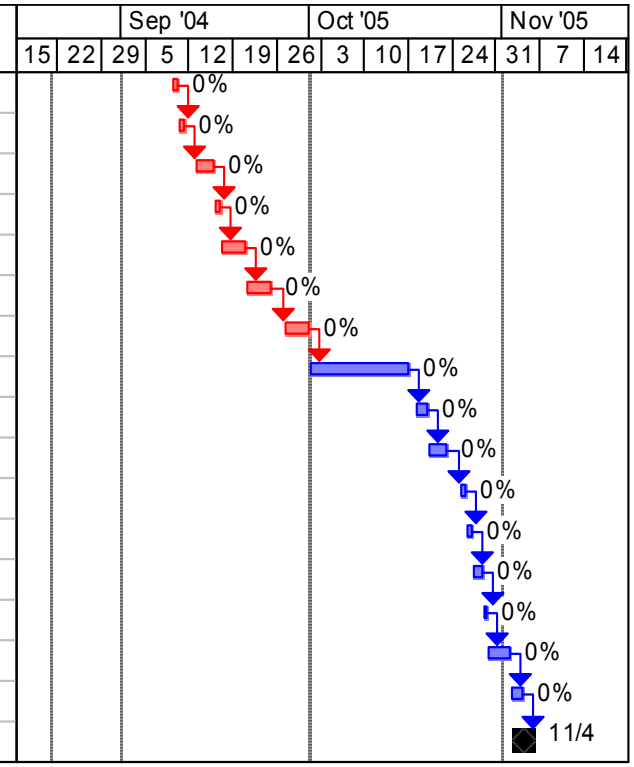


Test Facilities

- Naval Research Laboratory
  - Electronics Fabrication & Test Facility, Building 209
    - Acceptance Test Clean Room
    - Thermal Cycling Facility
    - TEM/TPS Checkout Facility
  - Payload Check-Out Facility, Building A-59
    - CAL Assy & Test Clean room
    - EMI Anechoic Test Chamber
    - Vibration Test Laboratory
    - Thermal-Vacuum Test Laboratory

CAL FMA Test Schedule

ID	Task Name	Duration	Start	Finish
28	Limited Functional	1 day	Thu 9/9/04	Thu 9/9/04
29	Electronic calib	1 day	Fri 9/10/04	Fri 9/10/04
30	Muon calibration #2	3 days	Mon 9/13/04	Wed 9/15/04
31	Mass Properties #1	1 day	Thu 9/16/04	Thu 9/16/04
32	EMC/EMI test	2 days	Fri 9/17/04	Mon 9/20/04
33	Additional EMC/EMI test	4 days	Tue 9/21/04	Fri 9/24/04
34	Vibration test	4 days	Mon 9/27/04	Thu 9/30/04
35	**A Thermal Vac Test (NEW)**	16 days	Fri 10/1/04	Sat 10/16/04
36	Muon calibration #3 (PSR)	2 days	Mon 10/18/04	Tue 10/19/04
37	PSR Muon calibration - external trigger	3 days	Wed 10/20/04	Fri 10/22/04
38	Comprehensive Func Test #2 (PSR)	1 day	Mon 10/25/04	Mon 10/25/04
39	PSR Mass properties	1 day	Tue 10/26/04	Tue 10/26/04
40	Preship review and signoff	2 days	Wed 10/27/04	Thu 10/28/04
41	margin	0.1 days	Fri 10/29/04	Fri 10/29/04
42	Ship to SLAC	2 days	Fri 10/29/04	Tue 11/2/04
43	Post Ship Functional	2 days	Tue 11/2/04	Thu 11/4/04
44	AV: Calorimeter Module ARFI	0 days	Thu 11/4/04	Thu 11/4/04



- **Working this weekend will bring us back on schedule**

Staffing Plans

- All staff requirements are fully populated

4	System Engineering / Test Directors
4	Electrical Engineering support
2	Mechanical Engineering support
1	Software
8	I&T / Electrical technicians
4	R&QA Engineers / Inspectors
-	Facilities support, provided by NCST as needed
6	Science / Performance Analysis

Numbers represent available CAL staff – not necessarily dedicated to module testing. Many support module assembly as well.

GSE Status

MGSE Description	Dwg Status	Hardware Status
CAL Lifting Fixture	Complete	Complete
CAL Handling Fixture Assembly	Complete	Complete
CAL Turnover Dolly	Complete	Complete
Shipping Container Assembly	Complete	In Assy
CAL Vibration Test Fixture Assembly	Complete	In Assy
CAL TVAC Test Fixture Assembly	Complete	In Assy

- **EGSE Status**
  - **See Functional Test presentation**

Module Test Documents

DOCUMENT NUMBER	DOCUMENT TITLE
LAT-MD-00408	LAT Program Instrument Performance Verification Plan
LAT-SS-00778	GLAST LAT Environmental Specification
LAT-DS-04536	CAL Tower Module Assembly Drawing
LAT-DS-00916	CAL Module Assembly Drawing
LAT-MD-00262	GLAST LAT Calorimeter Module Assembly and Test Plan
LAT-MD-01345	GLAST LAT CAL Verification Environmental Test Plan
LAT-MD-01370	Calorimeter Comprehensive and Limited Functional Test Definition
LAT-MD-04187	Calorimeter Electronic and Muon Calibration Test Definition
LAT-PS-04237	Calorimeter Handling Procedure
LAT-PS-03929	Calorimeter EMI Test Procedure
LAT-PS-04454	Calorimeter Vibration Test Procedure
LAT-PS-04455	Calorimeter Thermal-Vacuum Test Procedure
LAT-TD-04351	CAL Subsystem Acceptance Data Test Package Contents

Supplemental Slides

- More detailed breakout of specs follows

CAL Level III Requirements

Reference: LAT-SS-00018

Parameter	Requirement	Verification	Expected Performance
Energy Range	20 MeV – 300 GeV 20 MeV – 1 TeV (goal) 5 MeV – 100 GeV, single crystal	Simulation, Beam Tests	Required performance ~2 MeV threshold (BOM)
Energy Resolution (1 sigma)	< 20% (20 MeV < E < 100 MeV) < 10% (100 MeV < E < 10 GeV) < 6% (10 GeV < E < 300 GeV, incidence angle > 60 deg)	Simulations and EM and LAT calib unit Beam Tests	Simulations demonstrate required performance
Energy Resolution (1 sig) Single Crystal	< 2% for Carbon Ions of energy >100 MeV/nuc at a point.	EM (and Calib Unit) beam test	< 0.5% (correlation of ends removes Landau)
Design	Modular, hodoscopic, CsI > 8.4 RL of CsI on axis	Inspection	8.6 RL
Active Area	>1050 cm^2 per module < 16% of total mass is passive mtrl.	Inspection	1080 cm^2 per module < 14% is passive
Position Resolution	< 3 cm in 3 dims, min ionizing particles, incident angle < 45 deg.	Test with cosmic muons, all modules	< 1.5 cm in longitudinal measurement
Angular Resolution	15 × cos(θ) deg, for cosmic muons in 8 layers	Test with cosmic muons, all modules	8 × cos(θ) deg
Dead Time	< 100 μs per event < 20 μs per event (goal)	Test	< 19 μs per event

CAL Level III Requirements (cont.)

Parameter	Requirement	Verification	Expected Performance
Low Energy Trigger	>90% efficiency for 1 GeV photons traversing 6 RL of CsI < 2 μs trigger latency	Simulations	> 93% < 1 μs
High Energy Trigger	>90% efficiency for 20 GeV photons depositing at least 10 GeV < 2 μs trigger latency	Simulations, Calib unit test in beams	> 91% < 1 μs
Size (module)	< 364 mm in width (stay clear) < 224.3 mm in height (stay clear)	Inspection	363 mm 224 mm
Mass	< 1440 kg (90.0 kg/module)	Test	1376 kg
Power	< 65 Watts (conditioned) (4.05 W/module)	Test	< 54 Watts (conditioned)
Temperature Range	– 10 to +25 C, operational – 20 to +40 C, storage – 30 to +50 C, qualification	Subsystem TV Test 4 cycles, acceptance 12 cycles, qualification	Required performance
Reliability	> 96% in five years	Analysis	> 98% in five years (15/16 modules) LAT-TD-00464-03