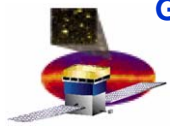


GLAST Large Area Telescope

EMI/EMC Test Readiness Review

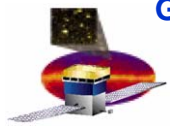
**Michael Lovellette, Test Director
NRL**

**June 9, 2006 @ 1300 EDT
NRL, HESE Conference Room - B209, Rm 321A**



Purpose / Contents

- **Demonstrate readiness to proceed with EMI/EMC testing of the integrated flight instrument, i.e. the LAT:**
 - **Test requirements are complete**
 - **LAT has been appropriately tested at lower levels of assembly**
 - **Passes comprehensive systems test**
 - **EMI/EMC test plans and procedures complete**
 - **Facilities readiness and certification verified**
 - **STE and MGSE complete, fabricated, and ready for use**
 - **Manpower is sufficient to cover all planned for activities**

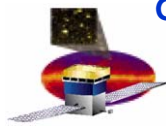


Requirements complete

- ❑ All flight system design analyses and unit testing have been successfully completed
 - Mission System Spec → 433-SPEC-0005
 - EMI Environments
 - LAT Environmental Requirements Spec → LAT-SS-00778
 - EMI Environments
 - LAT Performance Verification Plan → LAT-MD-00408-04c
 - Verification test definition
 - EMI Test Plan → LAT-MD-02726-01

- ❑ LAT EMI-specific operating modes have been defined
 - LICOS scripts and supporting displays are complete

- ❑ LAT subsystem support for susceptibility data review has been obtained



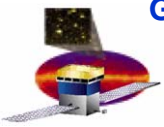
Subsystem EMI/EMC Test Summary

	RE101	RE102	CE101	CECM	CS102	CS06	RS101	RS103	St. Mag	
TKR										
ProtoFlight	X	X	X	X	X	X	X	X	X	0
Flight (Acpt)			X		X					0
CAL										
ProtoFlight	X	X	X	X	X	X	X	X	X	0
Flight (Acpt)			X		X					0
ACD										
Qual BEA	X	X	X	X	X	X	X	X	X	
ProtoFlight										(a)
T&DF										
Qual	X	X	X	X	X	X	X	X	X	3(b)
Flight (Acpt)			X		X					0
Mech (Radiators)										
ProtoFlight		X								(c)

(a) ACD Subsystem EMI testing Waivered - LAT-XR-06733

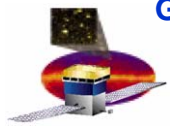
(b) Qual TEM/TPS, GASU exceeded radiated emissions spec (RE102) in S band, GPS notch; HCB exceeded CECM spec

(c) Radiator subsystem test of VCHP heater power source deferred to LAT level configuration



Radiator Subsystem EMI/EMC Test

- ❑ **VCHP heater Radiated Emissions testing**
 - **S/C power source for LAT VCHP heaters is an unfiltered DC-DC converter.**
 - **Concern is the conducted noise for this power source will become radiated emission issue for LAT system test.**
 - **This issue shall be resolved by special subsystem (Radiator) test – RE102 – using simulated S/C power source.**
 - **The test will be performed just prior to LAT system EMI/EMC test.**
 - **Preliminary testing of this at SLAC gives reasonable confidence that there is no significant issue here.**
- ❑ **Not formally part of the LAT level EMI test, performed on an STR**



LAT EMI Test

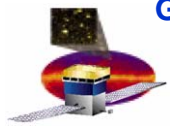
LAT test levels derived from LAT-SS-0778

□ Test Suite:

- CE102 Conducted Emissions, Power Leads, 10 kHz to 10 MHz, MIL-STD-462, CE03
- CECM & CEDM Conducted Emissions, Time Domain, 150 MHz Bandwidth
- CS102 Conducted Susceptibility, Power Leads, 10 kHz to 10 MHz, MIL-STD-462, CS02
- CSCM Conducted Susceptibility, Common Mode, 30 Hz to 150 MHz, MIL-STD-462, CS02
- CS06 Conducted Susceptibility, Spike, Power Leads, MIL-STD-462
- RE101 Radiated Emissions, Magnetic Field, 20 Hz to 50 kHz
- RE102 Radiated Emissions, Electric Field, 10 kHz to 18 GHz, MIL-STD-461E
- RS101 Radiated Susceptibility, Magnetic Field, 20 Hz to 50 kHz
- RS103 Radiated Susceptibility, Electric Field, 30 MHz to 18 GHz

□ Verify by Analysis:

- RS103 Radiated Susceptibility, Electric Field, 18 GHz to 40 GHz
- Static Magnetic Field



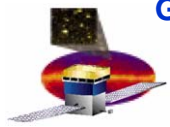
LAT Power Interfaces

□ SC-LAT Power Interfaces

- SC PRU (P) - LAT PDU
- SC PRU (R) - LAT PDU
- SC PRU (P) - LAT SIU (P)
- SC PRU (R) - LAT SIU (R)
- SC PRU (P) - LAT VCHP +Y Heaters
- SC PRU (P) - LAT VCHP –Y Heaters
- SC PRU (R) - LAT VCHP +Y Heaters
- SC PRU (R) - LAT VCHP –Y Heaters
- SC PDU (P) - LAT Makeup Heaters (Survival)
- SC PDU (R) - LAT Makeup Heaters (Survival)

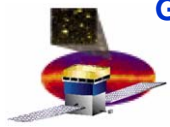
Makeup circuit power interfaces are not tested.

VCHP heater testing limited to RE102



Test Limitations

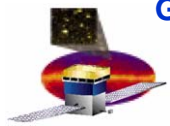
- ❑ **RS103 upper limit of 18GHz (40GHz)**
 - **18 – 40 GHz addressed by analysis.**
- ❑ **Limited area of RS101 test**
 - **Requires scanning each 10cm x 10cm area, ~16min/scan**
 - **~1450 scans for the LAT, another ~1200 for the radiators (~29 days)**
 - **Scan selected locations around connectors, PMTs, BEA**
- ❑ **Redundant side testing limited to Conducted Emissions (CE102) and Conducted Susceptibility (CS102)**



Nominal Test Sequence

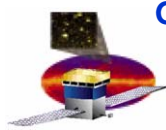
- ❑ Radiator EMI test
- ❑ Radiated Emissions
- ❑ Radiated Susceptibility
 - Allows maximum time to evaluate data off line before EMI complete
- ❑ Primary side Conducted Emissions and Susceptibility
 - Organized to minimize required LAT power cycles
- ❑ Redundant side Conducted Emissions and Susceptibility
 - Organized to minimize required LAT power cycles
- ❑ Time for power cycle is important
 - Non-optimized CE/CS testing requires 32 LAT power on/off cycles

Option: Begin with CE/CS (redundant side) in tent to accommodate delayed radiator installation



CE & CS Tests

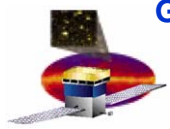
Test	System	Primary	Red.	Bands	Power cycles
CE102	SIU	+28, Ret.	+28, Ret.	1	4
CE102	DAQ	+28, Ret.	+28, Ret.	1	4
CECM	SIU	+28-Ret.		1	1
CECM	DAQ	+28-Ret.		1	1
CEDM	SIU	+28-Ret.		1	1
CEDM	DAQ	+28-Ret.		1	1
CS102	SIU	+28, Ret.	+28, Ret.	2	8
CS102	DAQ	+28, Ret.	+28, Ret.	2	8
CS06	SIU	+28-Ret.		1	1
CS06	DAQ	+28-Ret.		1	1
CSCM	SIU	+28-Ret.		1	1
CSCM	DAQ	+28-Ret.		1	1
Total		16	8		32



Test Durations

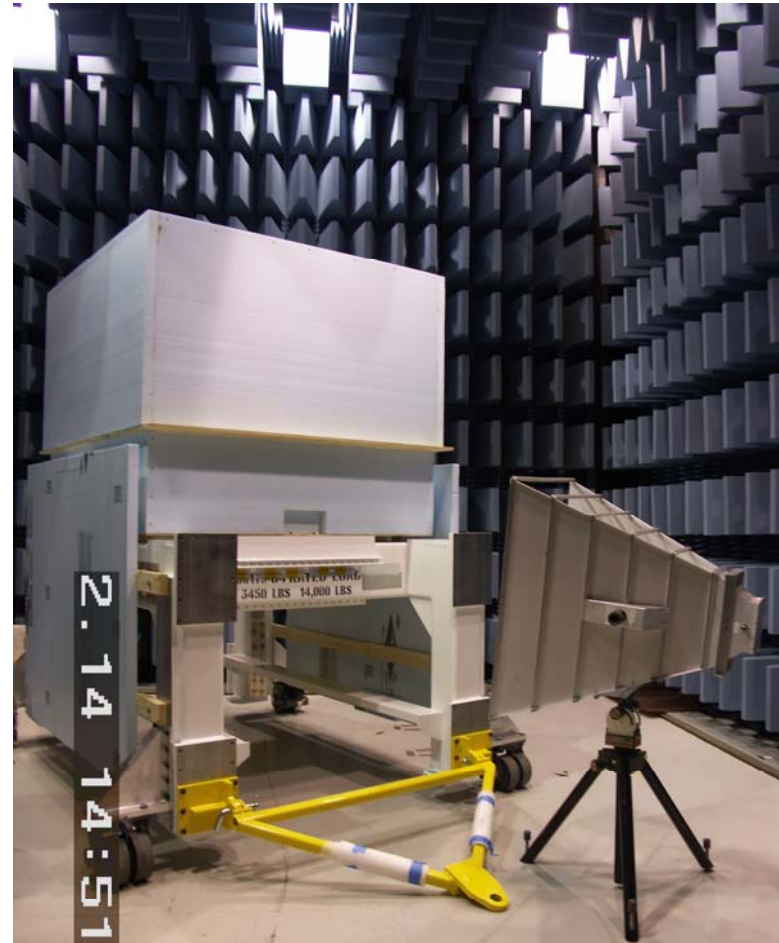
- Times include test time includes EMI facility set up and calibration, overhead for LAT ops is estimated separately
 - Schedule allows 11 days or 132 hours

Test	Duration (hrs)	# of cable configs.	LAT overhead	Total test time (hrs)
CE102	6	2	25% + 0.5	19
CECM	6	1	“	7
CEDM	6	1	“	7
CS102	8	2	50% + 0.5 h	32
CSCM	6	1	“	10
CS06	6	1	“	10
RE101& 103	6	1	25% + 0.5 h	8
RS101& 103	16	1	50% + 0.5 h	24
Rad Test	12	1	0%	12
Total				129

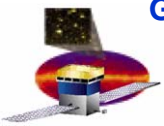


EMI Test Configuration

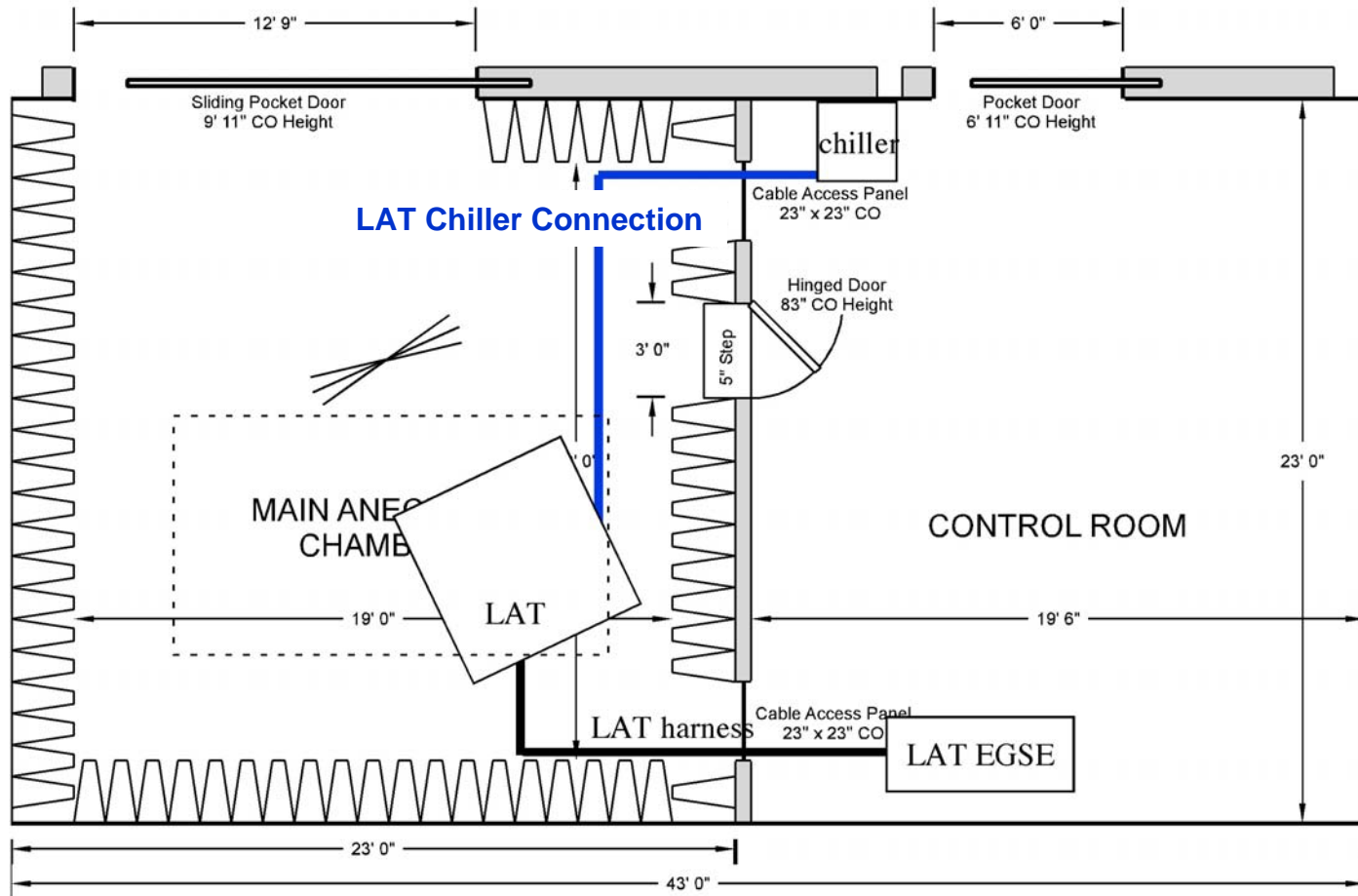
- ❑ Performed in NRL anechoic chamber
 - ESD coverings will be removed from sides during active radiated testing. Bags in place for conducted tests, transport and inactive periods. The top of the LAT will remain covered at all times.
 - GN2 purge to control humidity
 - Active cooling w/ LAT chiller system
 - Portable HEPA filters running in non-test periods

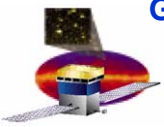


Path finder of LAT instrument on the test stand in NRL's anechoic chamber



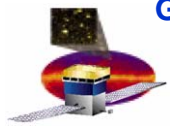
Test Layout





Conducted Test Considerations

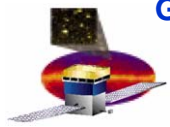
- ❑ **Fully test Primary:**
 - SC PRU (P) - LAT PDU (P)
 - SC PRU (P) - LAT SIU (P)
- ❑ **Limited test of Redundant: (CE102, CS102)**
 - SC PRU (R) - LAT PDU (R)
 - SC PRU (R) - LAT SIU (R)
- ❑ **No plan to test PDU - LAT Survival Heaters**
 - Thermostatic control, open circuit at LAT operating temp
 - Not active with LAT operating in Mission
- ❑ **No plan to test PRU - VCHP Heaters**



Test Harnesses

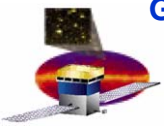
- ❑ **Radiated testing will use nominal EGSE cables**
 - **Harness is fully shielded**
 - **Includes all connector savers**
 - **All test ports are closed out**
 - **Fly away test harnesses are shielded**
 - **Accelerometers**
 - **TCs & thermistors**

- ❑ **Breakout cables required for conducted emissions testing**
 - **LAT-DS-06531 LSC to RF shield, SIU power**
 - **LAT-DS-06530 BPU PNL to LSC, SIU power**
 - **LAT-DS-06528 BPU PNL to LSC, LSC to DAQ, DAQ power**



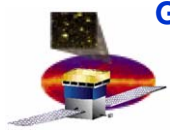
LAT configuration

- **Instrument configuration for EMI/EMC tests**
 - **Principle: want flight-like output and sensitivity**
 - Use flight thresholds, trigger logic, gains, readouts, ...
 - Use same configuration for emissions (LAT17x) and susceptibility (LAT18x) tests
 - **LAT17x, 18x configuration**
 - **Same as on-orbit configuration, except**
 - Periodic triggers read out at 50 Hz rather than 10 Hz
 - » Gives faster measurement of pedestal width, centroid
 - Gamma filter is disabled
 - » Allows sea-level muons to pass
 - **Gives similar LAT data throughput as on orbit**



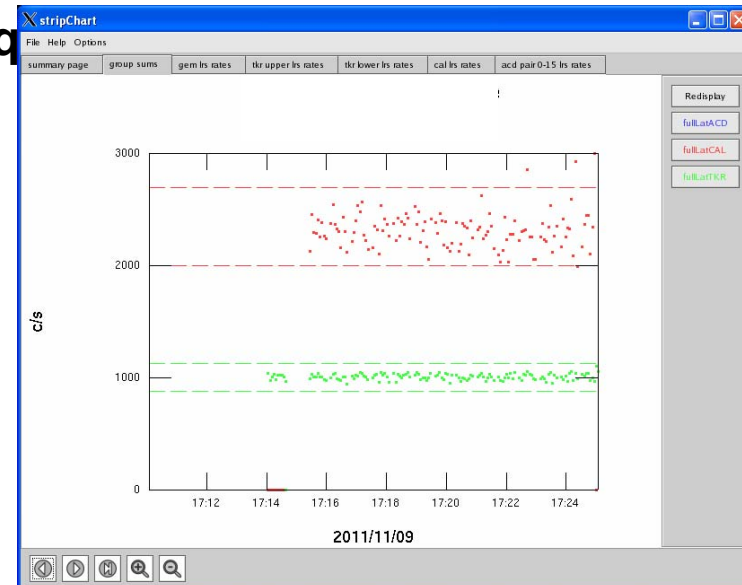
Test Software

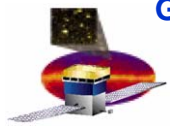
- ❑ **Emissions Testing – Script # LAT-171**
 - LAT configured to collect muons with additional periodic trigger to appropriately populate the T&DF data flow and science data stream to the VSC.
- ❑ **Susceptibility Testing – Script # LAT-181:**
 - LAT configured to collect muons with CAL triggers (flight level) and ACD vetos enabled.
 - Susceptibility monitoring
 - TKR event occupancy
 - CAL pedestal widths (noise) and trigger rates
 - ACD pedestal widths (noise) and veto rates
 - T&DF commanding and data flow errors
 - Real time monitoring
 - Strip chart of LAT trigger rate and deadtime
 - Diagnostic error messages
 - Post processing
 - Global TKR occupancy vs time
 - Global CAL, ACD pedestal widths vs time
 - Correlate post processing events with log of frequency vs time



Realtime displays

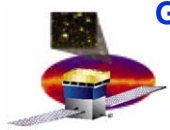
- Realtime monitoring of diagnostic hsk
 - Strip charts of LRS counters and summary
 - Typical rates and rms derived from baseline runs
 - Low-Rate Science (LRS) counters
 - GEM: trigger “sent” rate
 - ACD: 2 counters, multiplexed, of veto requests
 - CAL: 16 counters of trigger requests
 - TKR: 16 counters of trigger requests
 - Summary page
 - Number of counters exceeding nominal + 5 sigma





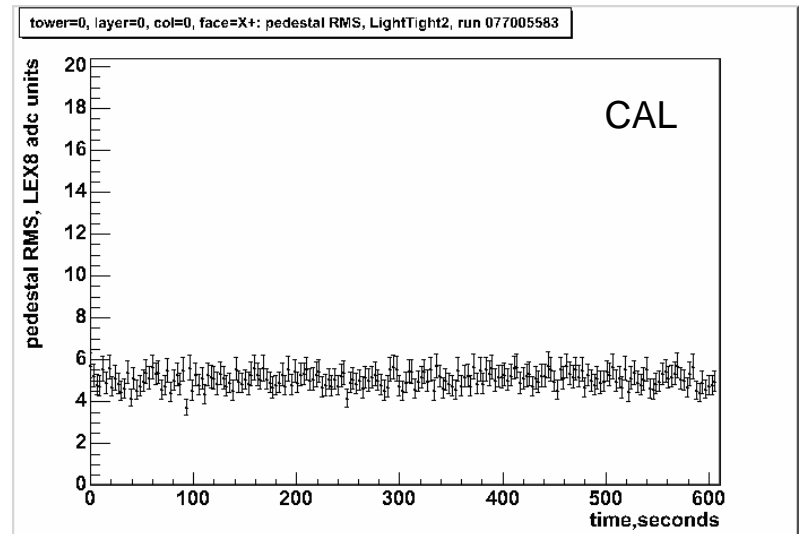
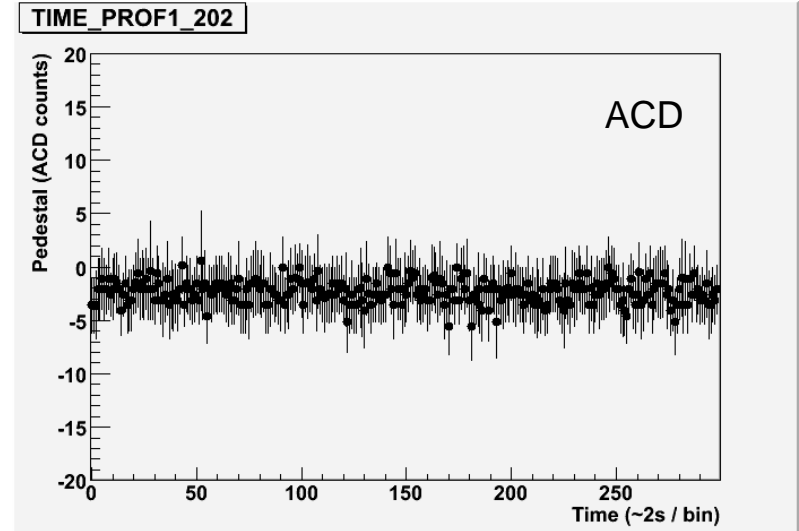
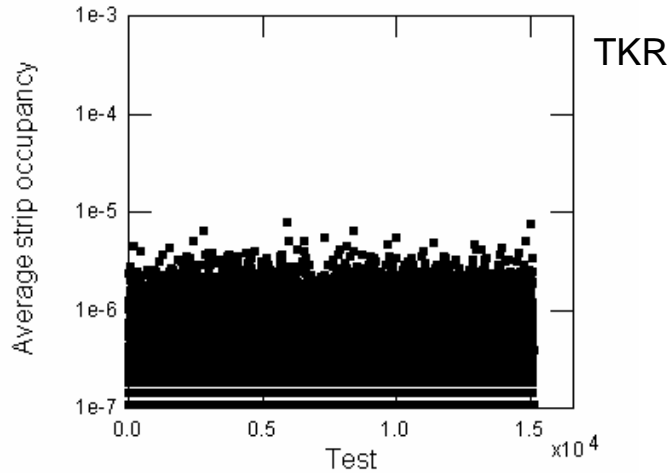
Offline analysis

- ❑ **Susceptibility pass criteria**
 - **No reproducible increase in transport errors, noise triggers**
 - **Detectors meet noise occupancy or noise floor specs**
- ❑ **Offline analysis**
 - **Performed with offline data products, available ~1-3 hr after acquisition**
 - **Analyst from each subsystem on East and West coasts**
 - **Offline reports for each run**
 - **Transport error count**
 - **Trigger rate summary and strip chart**
 - **ACD strip charts**
 - **Pedestal centroid and width (= noise floor)**
 - **Hit and veto occupancy**
 - **CAL strip charts**
 - **Pedestal centroid and width (= noise floor)**
 - **CAL-LO and CAL-HI trig request rate, by Tower**
 - **TKR strip charts**
 - **Hit occupancy and trig request rate, by Tower**

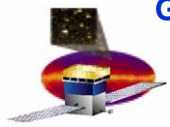


Sample strip charts

Noise Occupancy Monitor : tower TkrFM 15



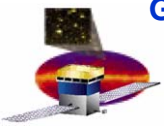
- One example per subsystem
 - Pass criteria derived from Level III specs
 - ACD
 - Pedestal rms < 30 bins, single chan
 - CAL
 - Pedestal rms < 30 bins, single chan
 - TKR
 - Noise occupancy < 10^{-4}
- Reference: extensive trending history and baseline runs



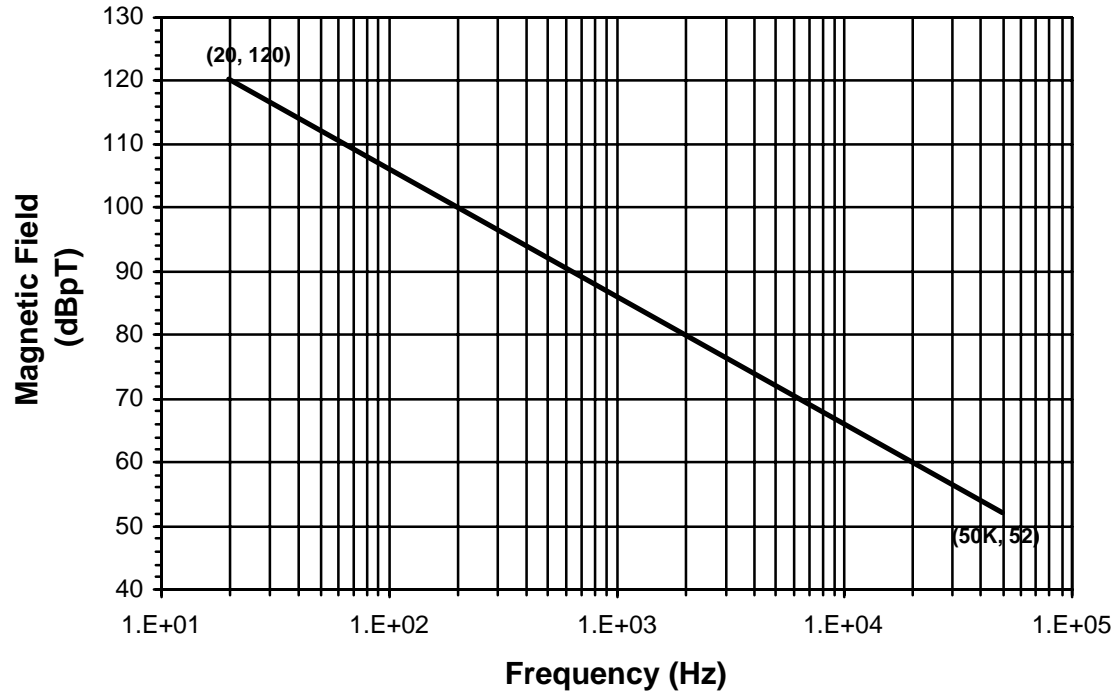
Personnel

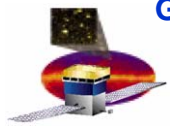
- ❑ **EMI/EMC Test Director - Michael Lovellette**
- ❑ **EMI/EMC Facility Operations**
 - **Mike Obara - Test Conductor**
 - **Tony Grey - Test Conductor**

- ❑ **LAT Instrument Operations**
 - **Brian Grist – Operations Lead**
 - **Standard LAT I&T Operators and Online analysis support**
 - **Anders Borgland – Offline instrument analysis lead**
 - **Elliott Bloom – LAT181 analysis lead**

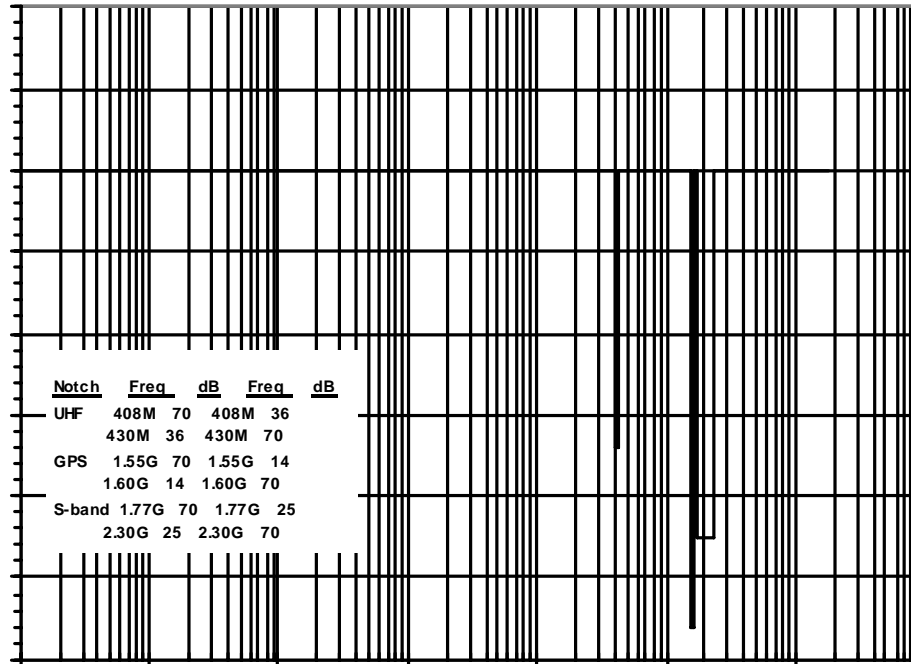


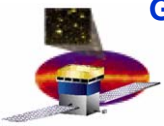
RE101 – All LAT Equipment



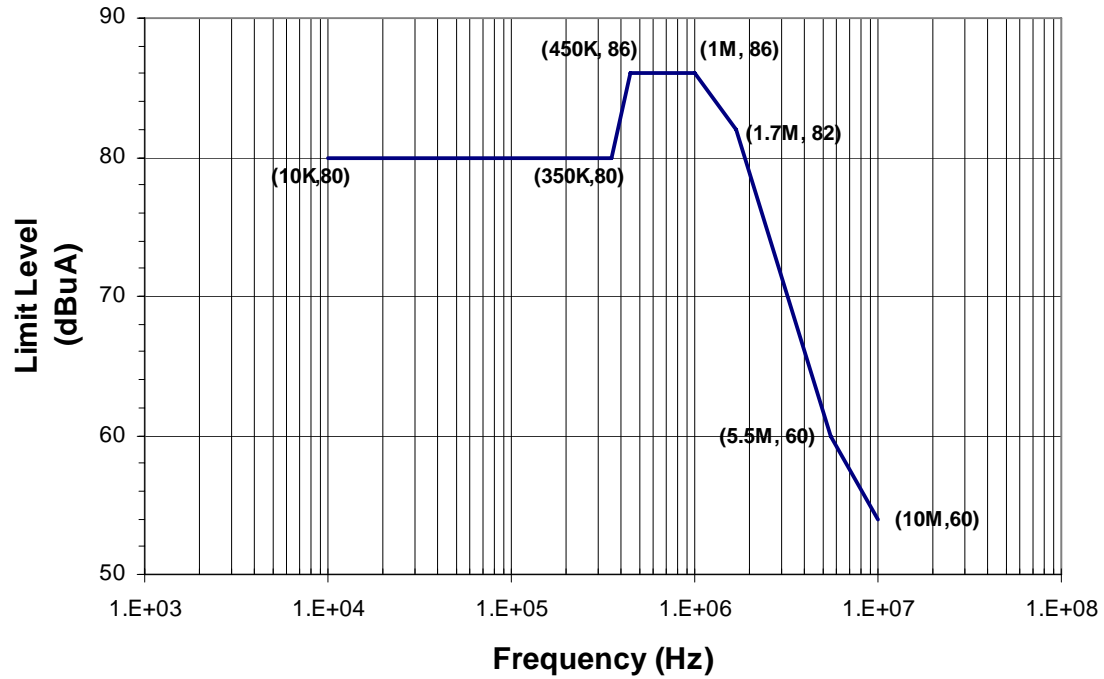


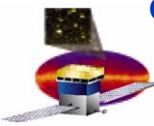
RE102 - Integrated LAT



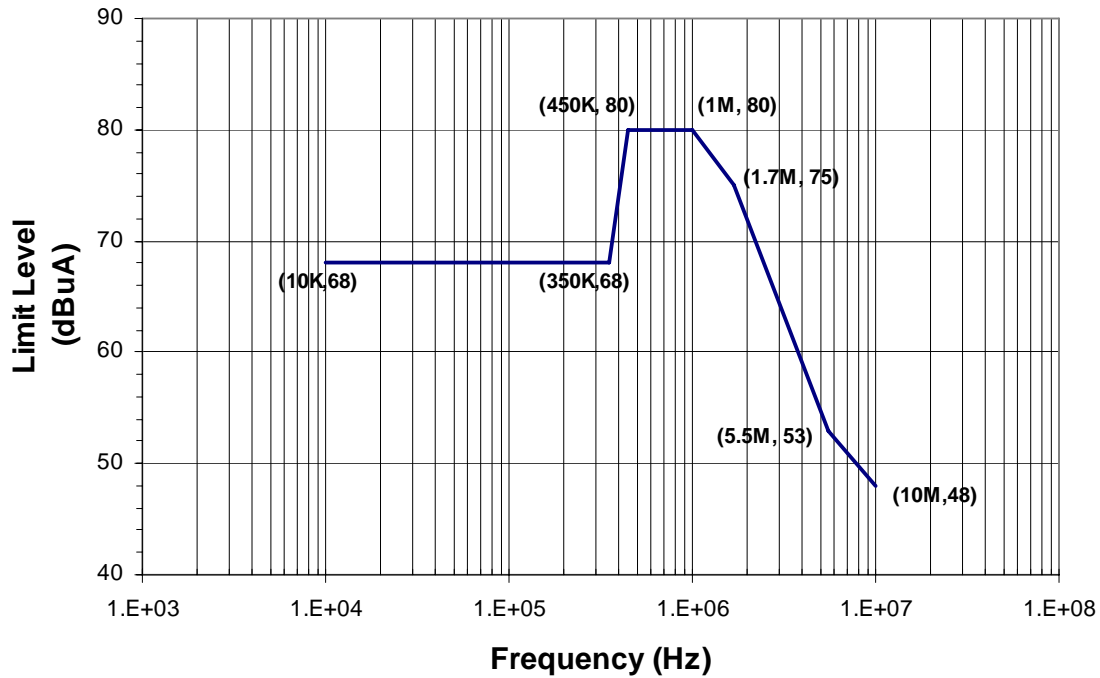


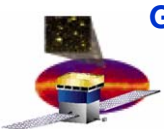
CE102 Spacecraft PRU – LAT DAQ



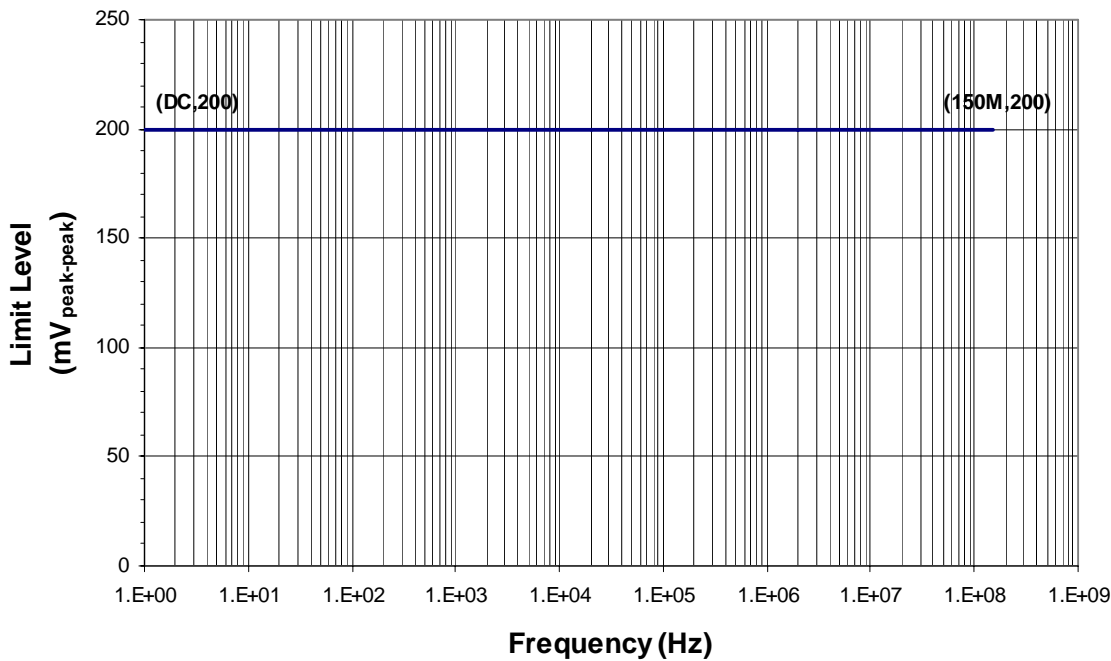


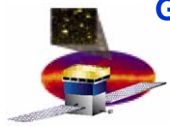
CE102 Spacecraft PRU – LAT SIU, VCHP Htrs



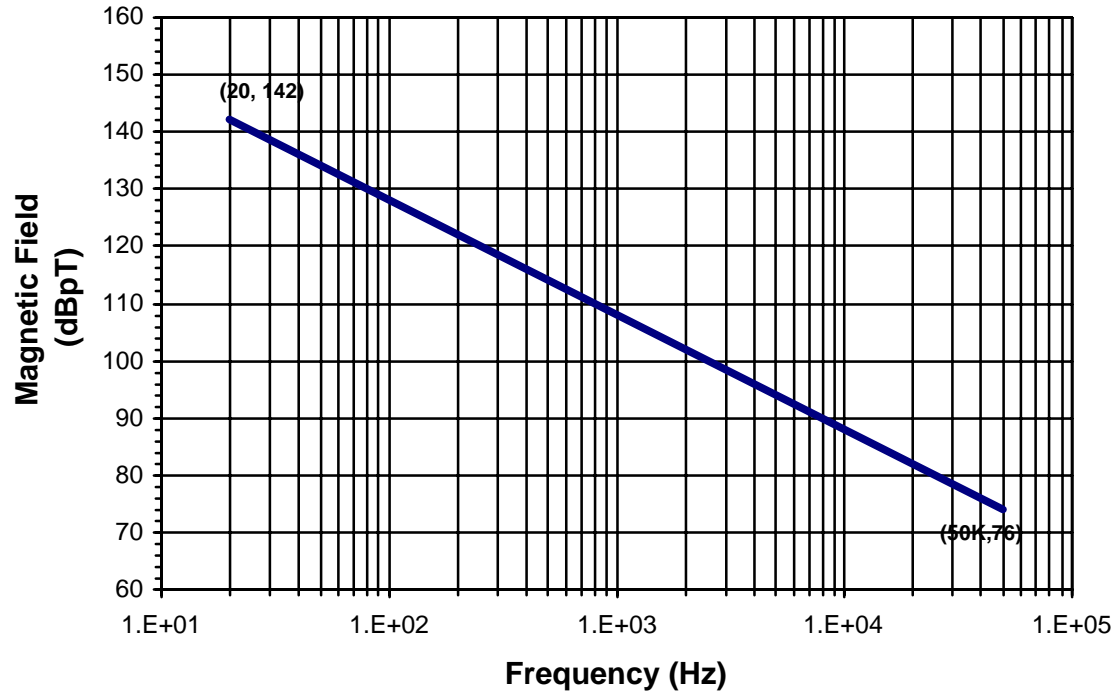


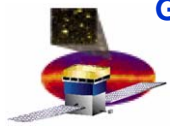
Conducted Emissions Common Mode – All LAT Equipment



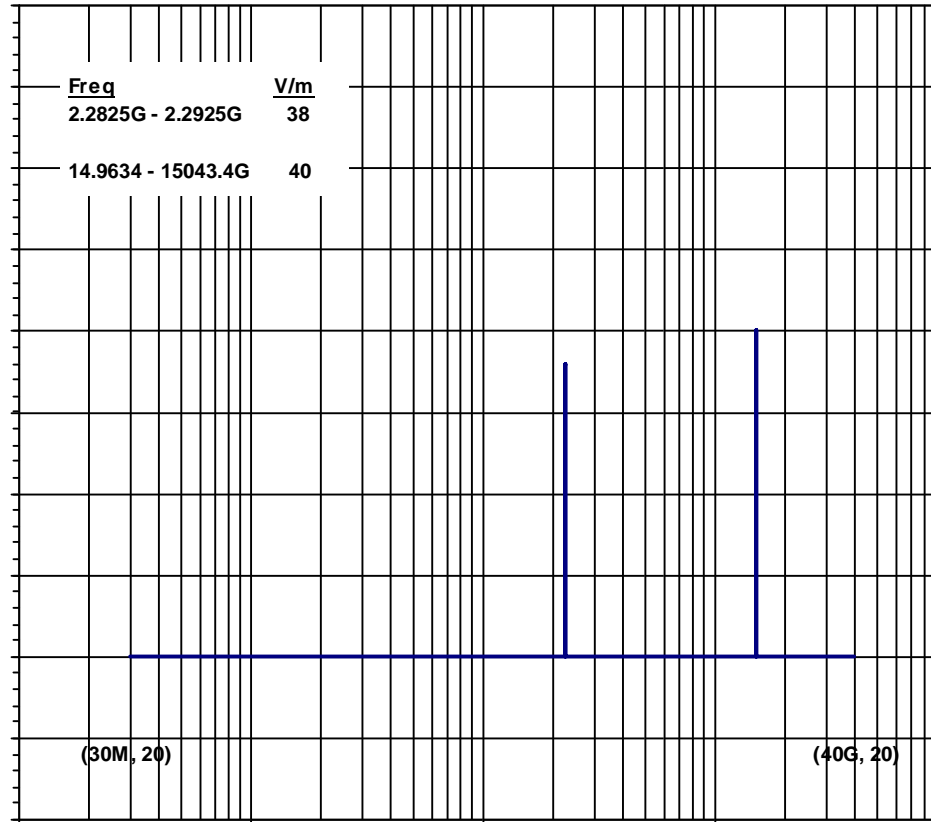


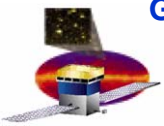
RS101 Perform – LAT



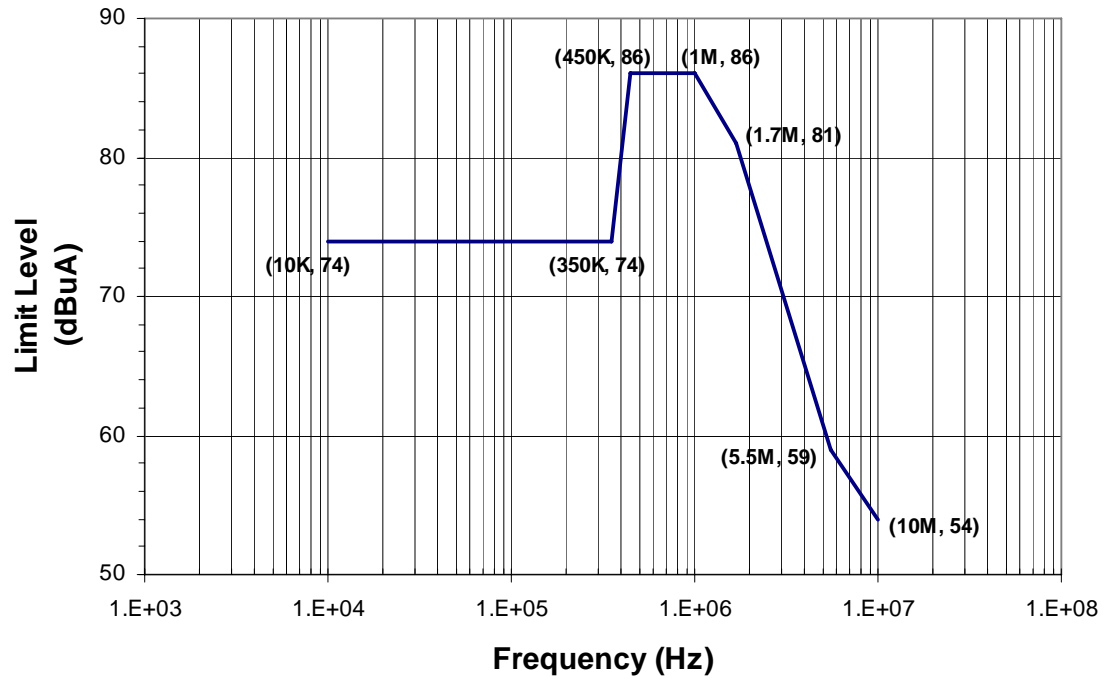


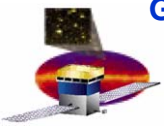
RS103 Perform – LAT



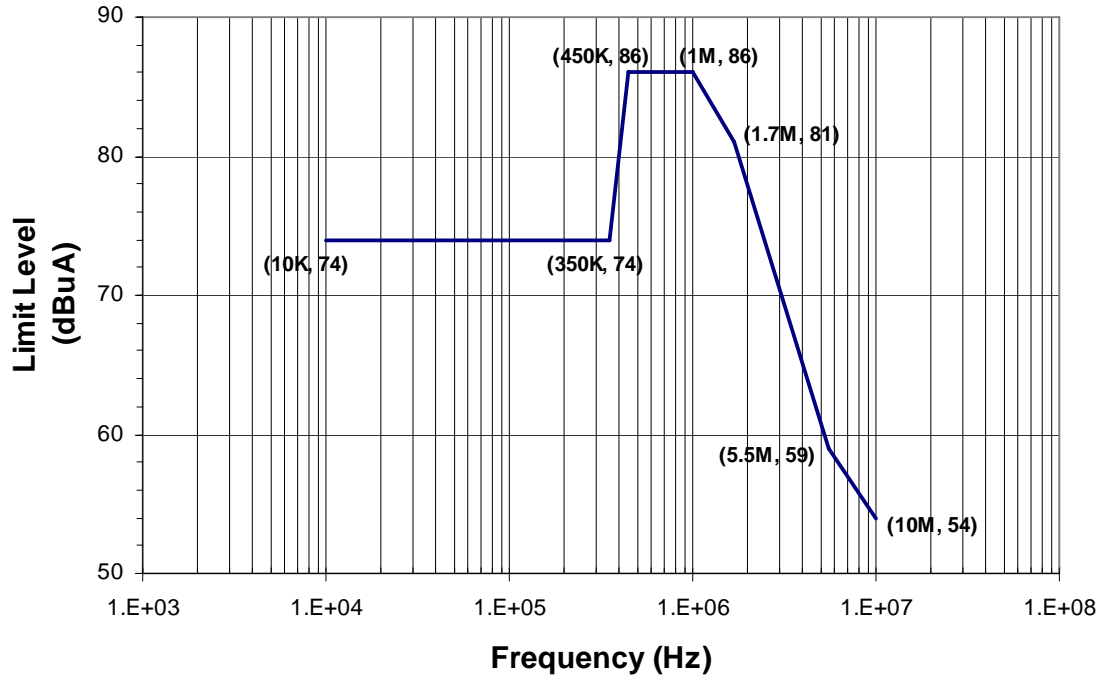


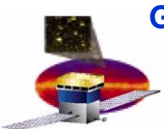
CS102 Spacecraft PRU – LAT DAQ



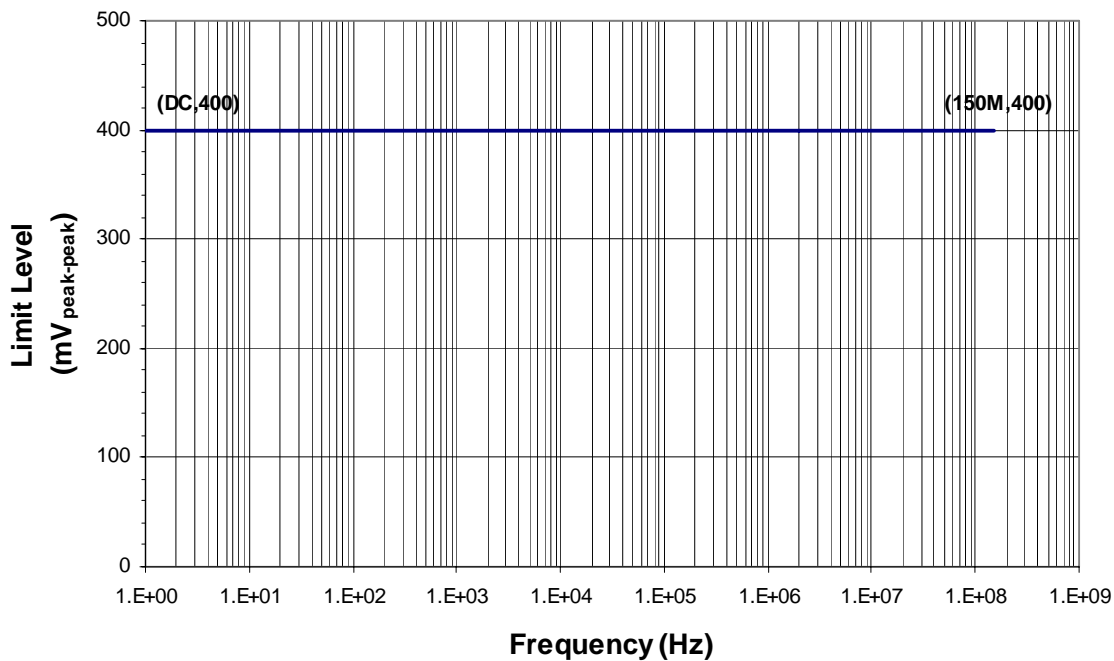


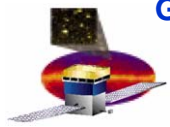
CS102 Spacecraft PRU – LAT SIU, VCHP Htrs



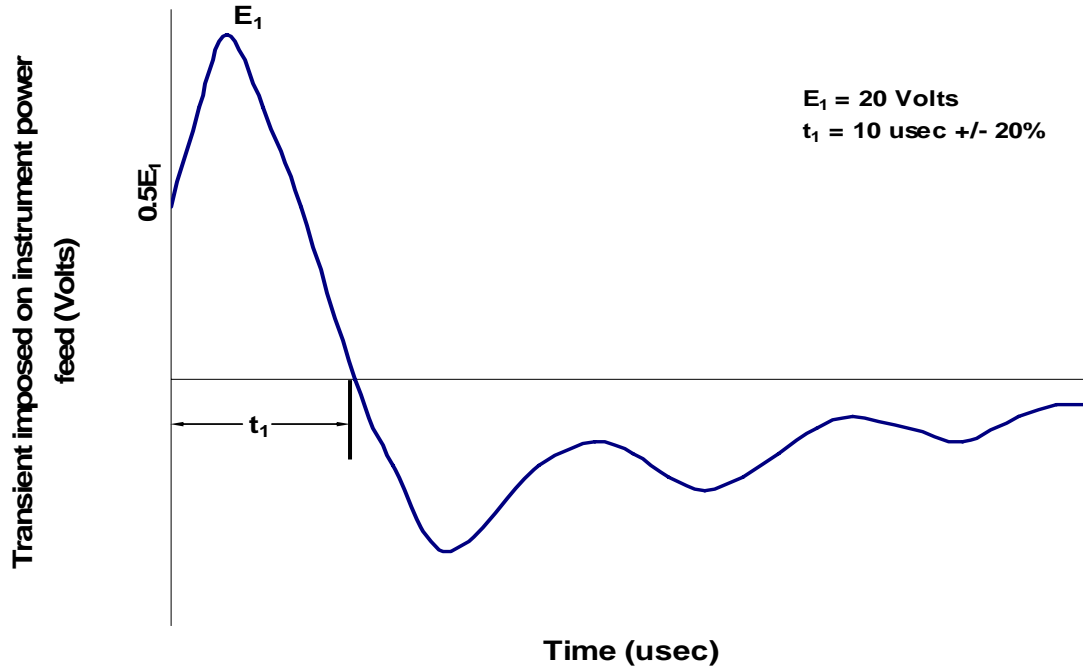


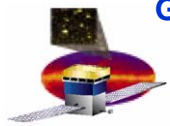
Conducted Susceptibility Common Mode – All LAT Equipment



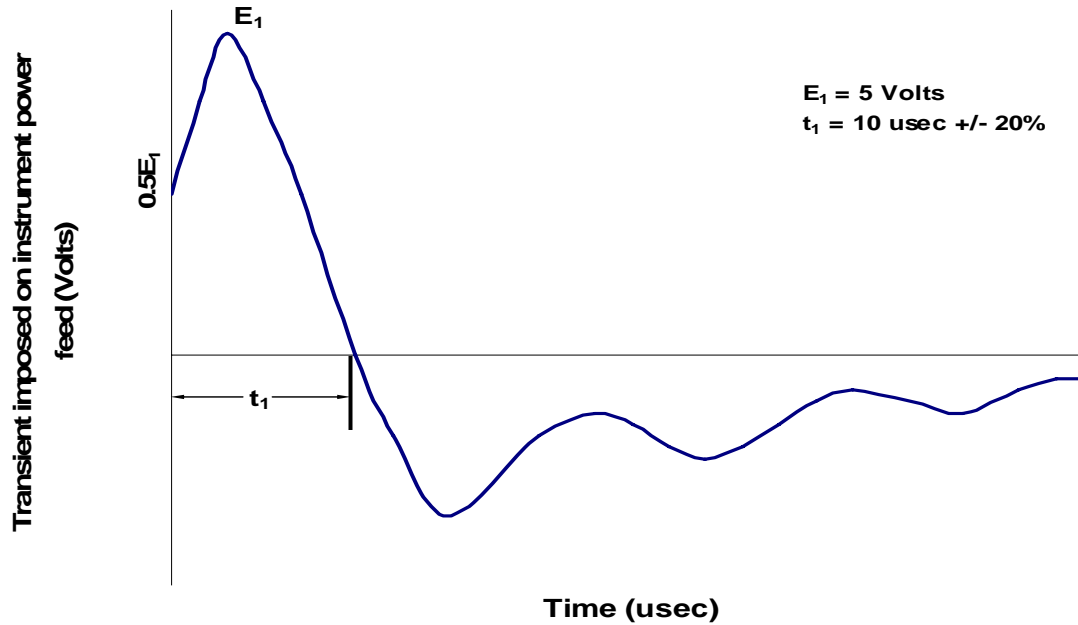


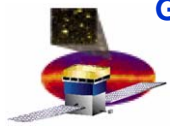
CS06 Operate – All LAT Equipment





CS06 Perform – All LAT Equipment





EMI/EMC Test Summary

- **Ready to test**
 - **Facility ready to support test**
 - **No outstanding issues with subsystem testing except completion of radiator VCHP heater CS / RE verification**
 - **Supporting analyses for static magnetic field have been accepted by Blanchette for GLAST project**
 - **Supporting analysis for RS103 18 – 40 GHz performance is in release.**