

GLAST Large Area Telescope:

W.B.S 4.1.7 Electronics, Data Acquisition & Flight Software

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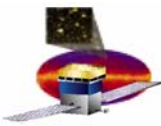
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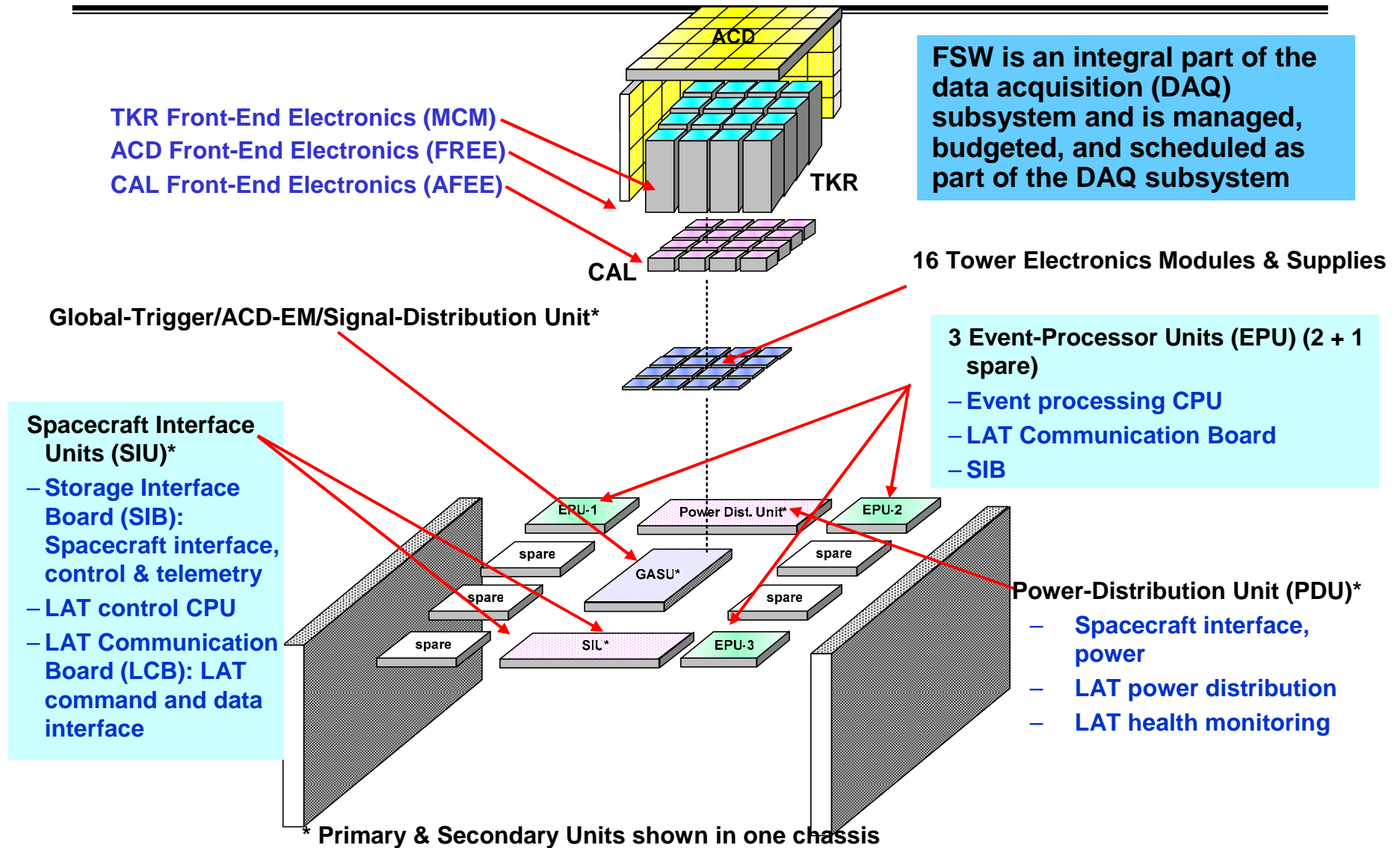


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- **Roadmap to Flight Hardware/Software**
- **Schedule**
- **Cost and Budget**
- **Summary**



LAT Electronics Hardware and Flight Software

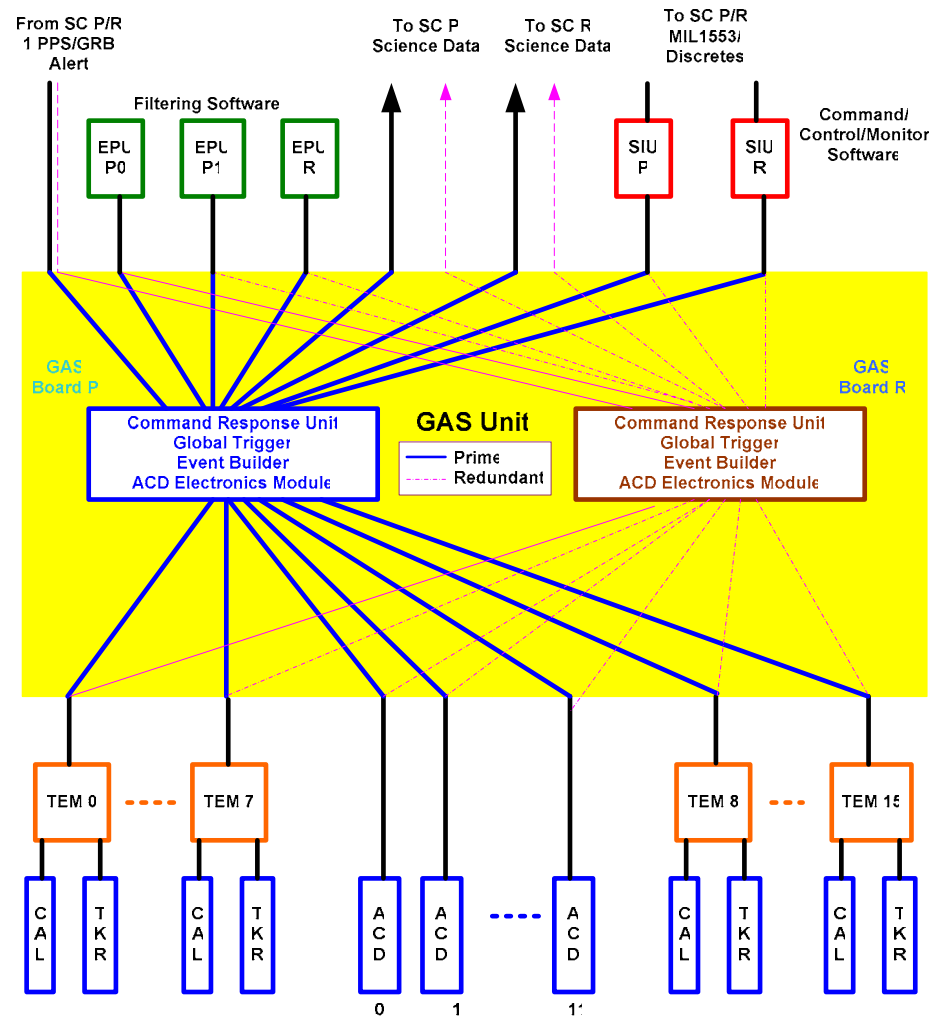


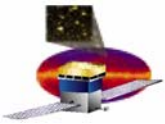


LAT Electronics

- **TKR: Tracker**
- **CAL: Calorimeter**
- **ACD: Anti-Coincidence Detector**
- **TEM: Tower Electronics Module**
- **EPU: Event Processor Unit**
- **SIU: Spacecraft Interface Unit**
- **GAS Unit: Global Trigger-ACD-Signal Distribution Unit**
 - **CRU: Command/Response Unit**
 - **EBM: Event Builder Module**
 - **GEM: Global trigger Electronics Module**
 - **AEM: ACD Electronics Module**

- **Flight Software running on RAD750 processors in SIU and EPU cPCI crates**





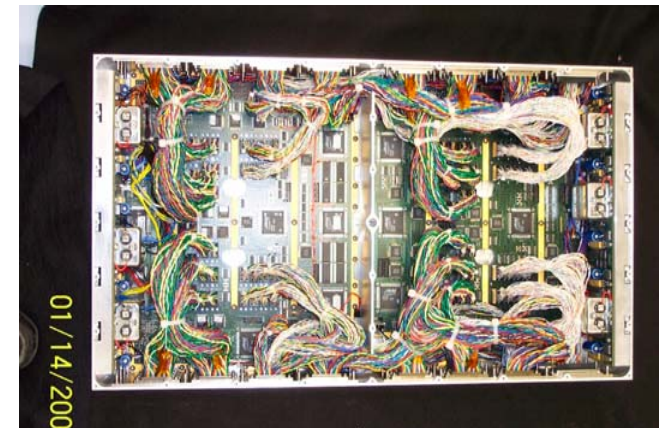
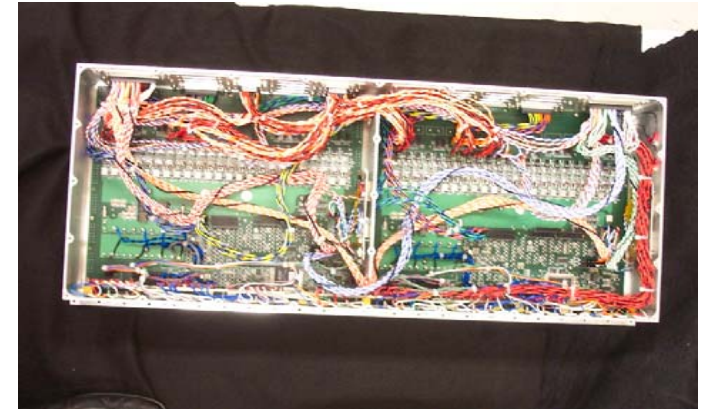
Components

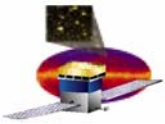
- Power Distribution Unit (PDU)
- GASU
 - GASU DAQ board with GASU ASICs & power-supply board
- Tower Electronics Module (TEM) incl. TEM ASIC's
- Tower Power Supply (TPS)
- Spacecraft Interface Unit (SIU) /Event-Processor Unit (EPU)
 - Includes 4 custom boards
- Heater Control Unit
- Harness
- Software
- Front-End Simulator
- Test-bed/EGSE (Electrical Ground Support Equipment)



PDU & GASU & GASU-ASIC

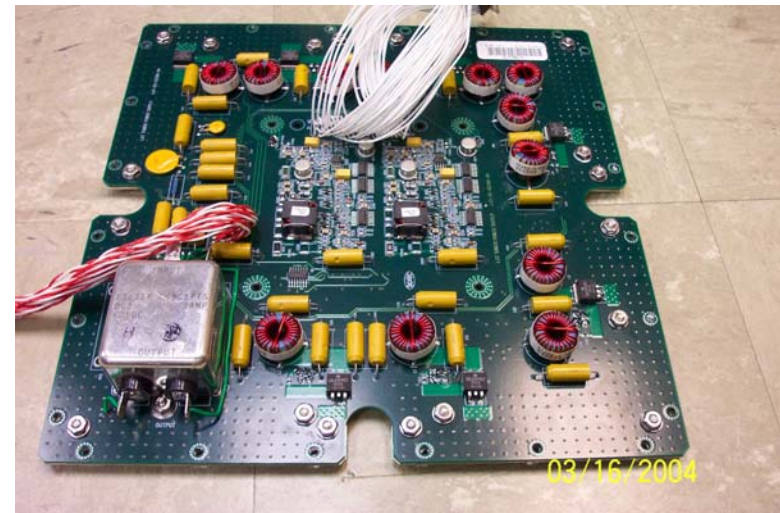
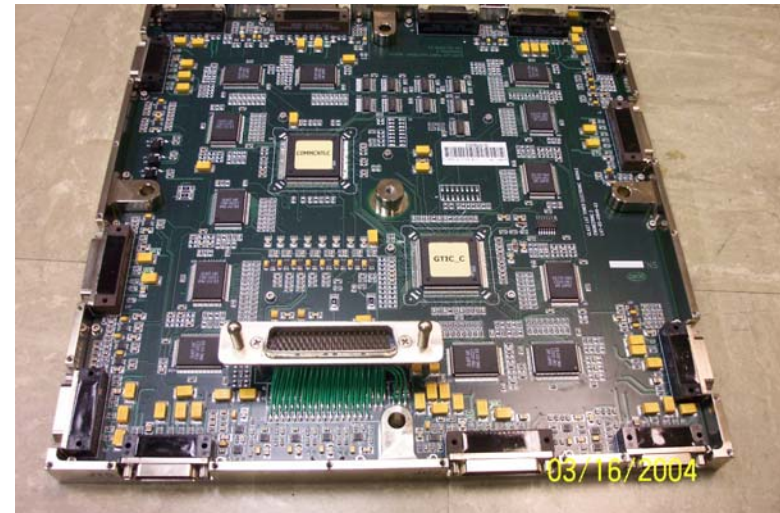
- **Power Distribution Unit**
 - Switches power to TEM's, GASU, EPU crates
 - Digitizes temperatures to be used for thermal control
- **GASU**
 - Global trigger, event builder, command-response unit, ACD control/monitoring/data-readout
- **GASU Power Supply**
 - Supplies power to GASU and ACD from 28V
- **Accomplishments**
 - Designed/fabricated/assembled full enclosures (primary and redundant) with flight-like components.
 - Functionality tested incl. FSW
 - More detailed tests in progress
 - Being incorporated in DAQ/FSW test-bed
 - Qualification model with modifications incorporated in layout
- **GASU DAQ ASIC (GLTC2)**
 - Full production fabricated/packaged
 - Screening has started at SLAC





TEM & TEM ASIC's & TPS

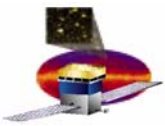
- Tower Electronics Module (TEM)
 - Control/readout/monitoring of TKR and CAL sub-system
- Tower Power Supply (TPS)
 - Supply power to TEM/CAL/TKR from 28V
- Accomplishments
 - 16 sets of engineering models were fabricated and assembled
 - Being tested and incorporated in DAQ/FSW test-bed
 - Out for RFP for flight fab/assembly, 1st article is used for qualification
- TEM ASIC's (GTCC1 & GCCC1)
 - Full production was fabricated/packaged
 - Have started screening at SLAC
 - Qualification will start at GSFC next month



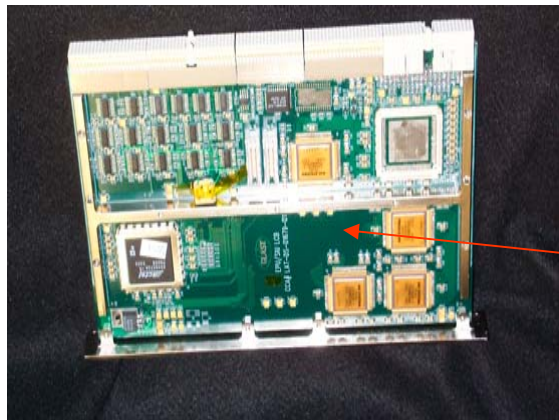
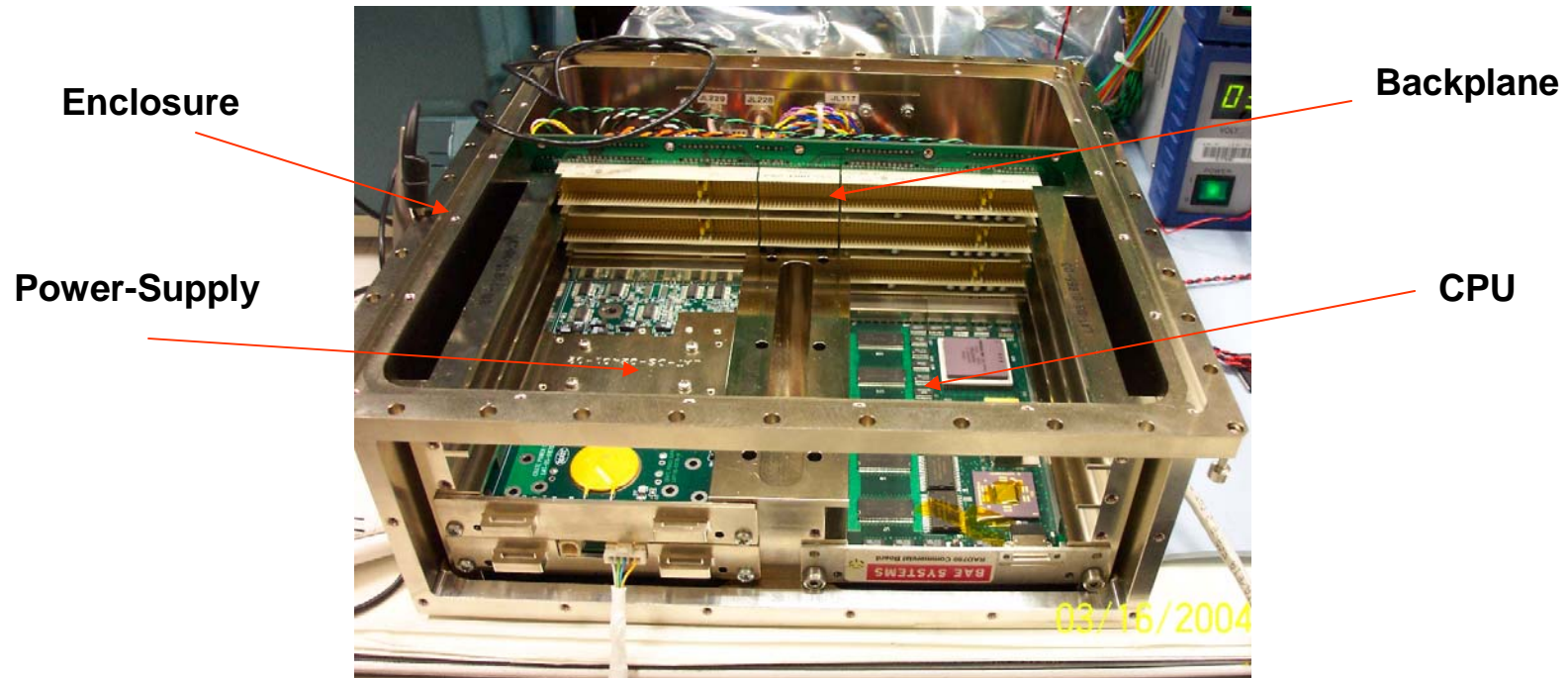


SIU/EPU (1)

- **Modules**
 - Custom Enclosure (cPCI crate)
 - Holds modules
 - Custom cCPI Backplane (CBP)
 - Interconnects modules
 - British AeroSpace 750 PPC processor board
 - CPU
 - Custom LAT Communication Board (LCB)
 - Control/event interface from cPCI processor to LAT
 - Custom Storage Interface Board (SIB)
 - MIL1553 interface to spacecraft, EEPROM storage in crates
 - Custom Crate Power Supply (CPS)
 - Supply power to PCI modules from 28V
- **Accomplishments**
 - Designed/fabricated/assembled fully functioning engineering modules with flight-like components
 - Integrated in crate with BAE 750 processor
 - Tests in progress using flight software
 - Being integrated in DAQ/FSW test-bed
 - Some layout modifications in progress for qualification board fabrication

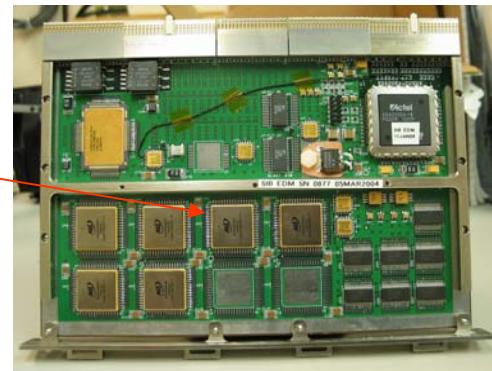


SIU/EPU (2)



LCB

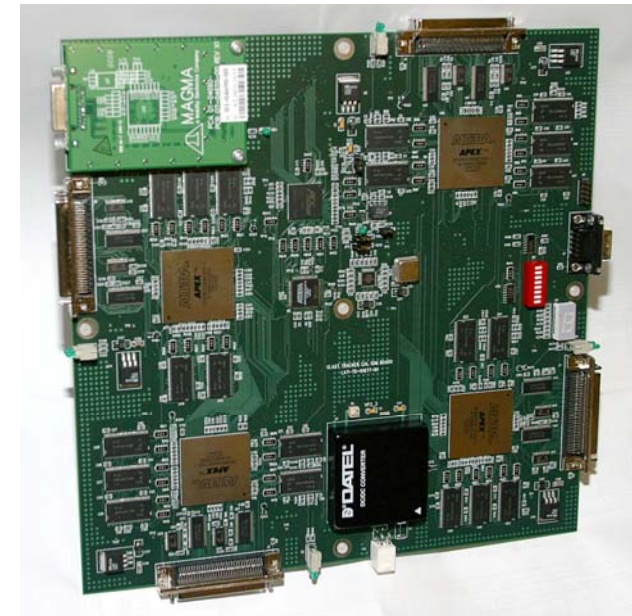
SIB





Harness & Heater Control Unit & FES & EGSE

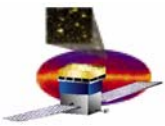
- **Point-to-Point Cables (“Harness”)**
 - Designed & ordered complete set of cables for test-bed
 - Ready to integrate when available
 - Preparing package for RFP for flight order
- **Heater Control Unit**
 - Designed/fabricated/assembled first-version engineering module
 - Ready to test
- **Front-End Simulator**
 - Emulates CAL/TKR/ACD sub-systems for use on DAQ/FSW test-bed
 - Designed/fabricated/assembled/tested front-end simulator board prototype
 - Testing in progress, being integrated on test-bed
 - Fabricated/assembled 34 copies



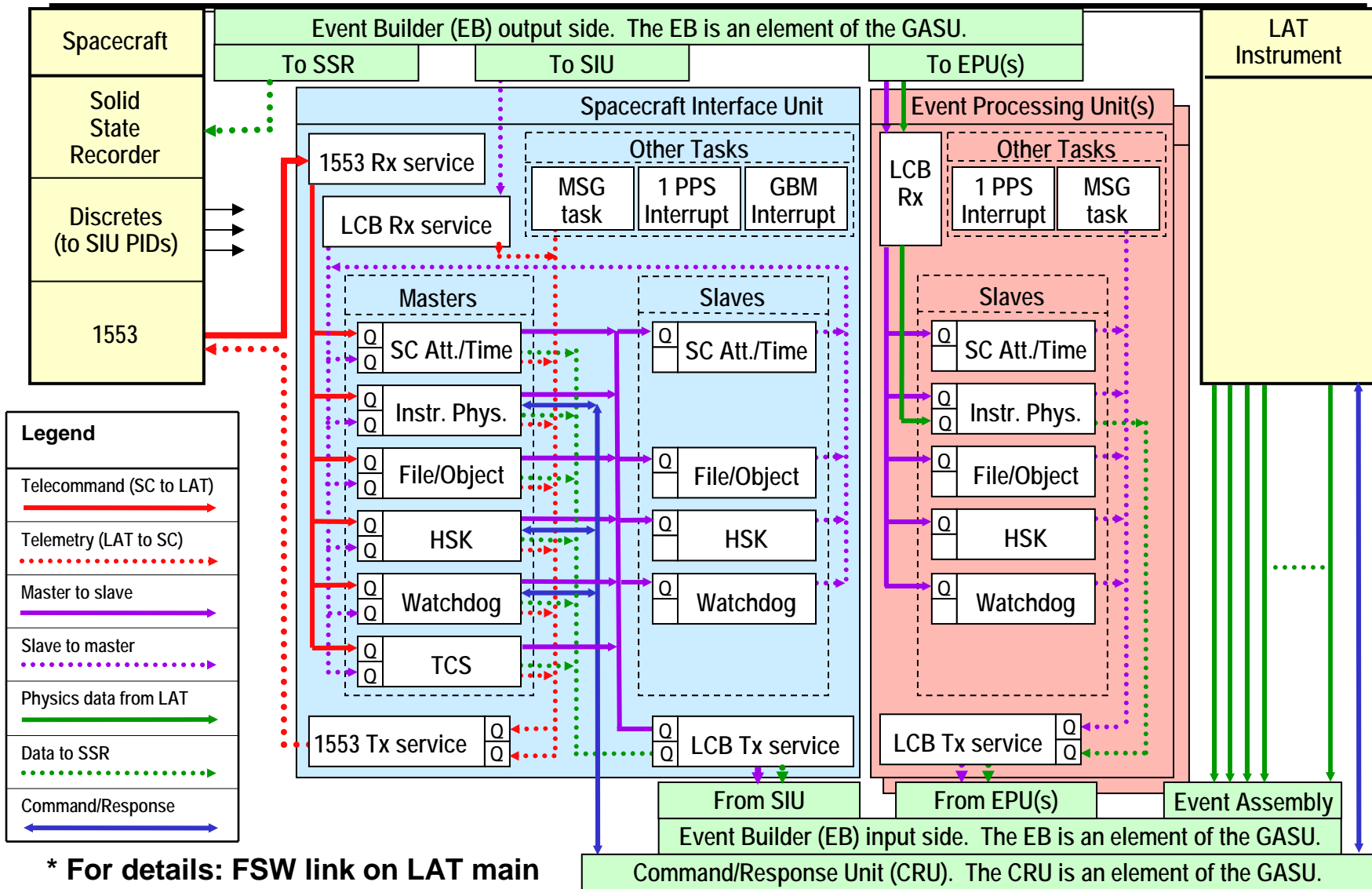


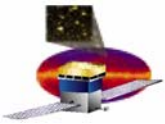
Flight Software

- **Incremental FSW builds coincide with the hardware builds as follows:**
 - **Engineering Model 1**
 - **Run single tower, single CPU**
 - Used for EGSE test-stands for hardware development (built, tested, done)
 - Used for LAT single-tower engineering unit by I&T group (built, tested, done)
 - **Engineering Model 2**
 - **Multiple towers, GASU, single CPU**
 - Used for EGSE test-stands for hardware development (in progress)
 - Used as test-bed for hardware and software development & test (in progress)
 - **ISIS (Instrument Spacecraft Interface Simulator) Build & Release**
 - To be delivered to the Spacecraft vendor (Formal Release)
 - **Full LAT Build & Release**
 - **Complete set of 16 towers, GASU, full set of CPU's**
 - Used as test-bed for hardware and software development & test
 - To be delivered to I&T for full-LAT testing (Formal Release)



LAT FSW Architecture





FSW Engineering Model 1

- **Accomplishments**
 - **Designed/tested/delivered EM1 SW built**
 - **Software to run full tower**
 - **Configuration of tracker, calorimeter, TEM**
 - **Solicited Housekeeping**
 - **Event Delivery**
 - **Also major progress in primary boot code of RAD750**

TEM

VME CPU with software



Full set TKR front-end electronics

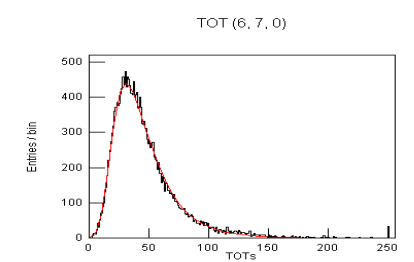
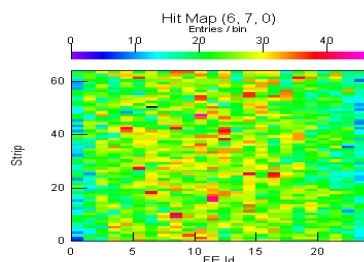
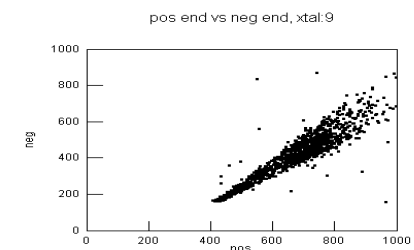
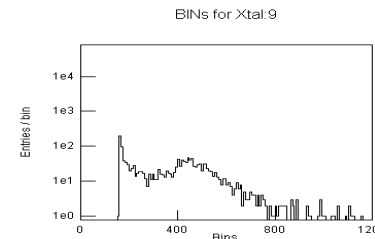
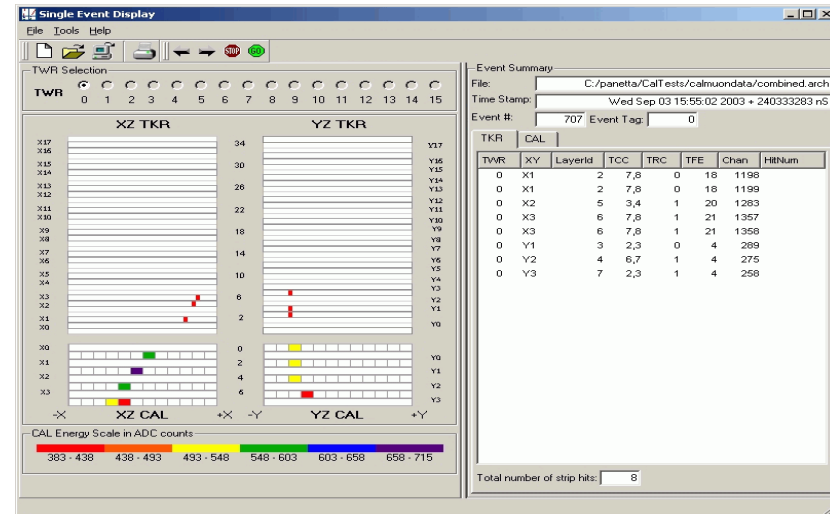
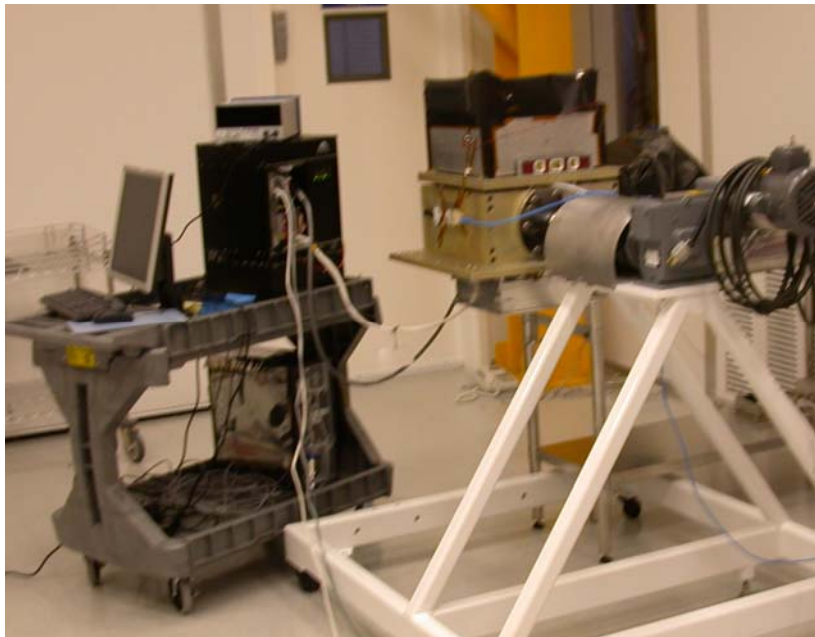
Full set CAL front-end electronics

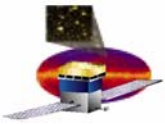
* The test-stand shown does not have physics detectors



Data-Taking with EM1

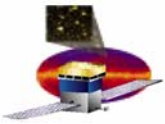
- From EM1 testing as performed by I&T in the SLAC clean room
 - Includes physics detectors
 - Displays courtesy of the I&T group and LATTE



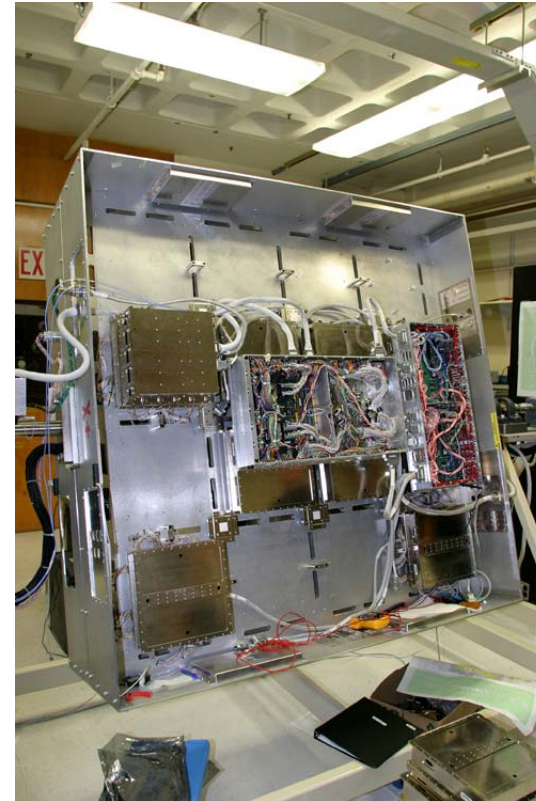
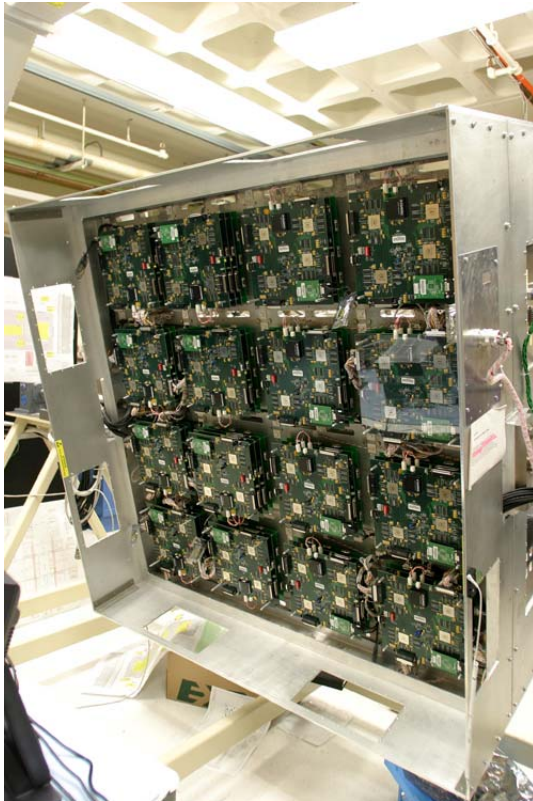


Electrical Ground Support Equipment

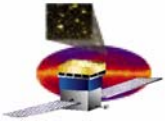
- **EGSE test-stand copies for ACD, CAL, TKR, DAQ HW & SW effort (60 total)**
- **Accomplishments**
 - **Ordered and received**
 - **VME crates & single-board computers**
 - **VME SLAC custom transition board**
 - **Custom PCI Mezzanine Card (PMC) LCB's**
 - **Connectors for cables**
 - **TEM & TEM PS boards and enclosures (for TKR/CAL/DAQ setups)**
 - **GASU board and enclosure (for ACD/DAQ setups)**
 - **28V-power supplies**
 - **Have started testing and shipping of new test-stands**



FSW/DAQ Test-Bed

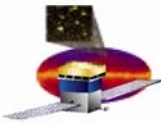


- Includes full set of DAQ modules/harness plus front-end simulator boards to emulate CAL/TKR/ACD front-end system
- Accomplishments
 - Produced DAQ modules for testbed
 - Started to integrate modules
 - Ready to start using FSW on the testbed mid/end April



Roadmap to Flight Hardware

- **Fabrication of printed circuit boards**
 - **2 vendors selected**
- **Fabrication of enclosures**
 - **1 Vendor selected**
- **Assembly of boards and modules**
 - **2 vendors evaluated/qualified**
- **Harness**
 - **2 vendors selected**



Modules for Qualification Test and Flight Delivery

Qualification Unit	Drawing Release	Start Fab/Assembly	Start Qual Program	End Testing
TEM & TEM-PS	Mar-17	Apr-17	Jun-25	Aug-2*
PDU	Apr-9	May-10	Aug-16	Oct-14
GASU	May-24	Jun-23	Aug-31	Oct-27
EPU/SIU	Apr-27	May-26	Sept-1	Nov-1
Harness	Mar-30	Apr-30	May-21	Jun-21

Flight Unit	Drawing Release	Start Fab/Assembly	Start FLT Accept. Program	I&T Delivery
TEM & TEM-PS	Apr-17	May-21	Jul-16	Aug-30
PDU	Jul-16	Aug-16	Nov-18	Jan-1
GASU	Jul-27	Aug-27	Nov-19	Jan-19
EPU/SIU	Aug-1	Sep-1	Nov-16	Jan-16
Harness	Aug-13	Jul-13	Aug-10	Aug-20

* TEM proto-flight is used for first 2 towers



Roadmap to Flight Software

- **EM2 Flight Software design was reviewed by NASA/DOE committee 2/26/04**
 - **Assessment was very positive**
 - **Started to implement EM2 designs**

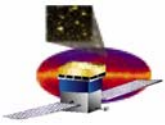
- **Functions added for EM2**
 - **GASU/PDU configuration**
 - **Streaming housekeeping**
 - **Inter-task communication**
 - **Primary/secondary boot of RAD750**
 - **MIL 1553 communication**
 - **Telecommand / telemetry**
 - **Software watchdog**

- **Functions added for Flight Unit**
 - **Event-filtering/compression**
 - **Event monitoring**
 - **Charge injection calibration**
 - **Diagnostics**
 - **Thermal control**
 - **Full command and telemetry support**
 - **Time services**
 - **Gamma-Ray-Burst (GRB) detection/alert**
 - **SC repointing request**



Software Key Milestones for I&T/ISIS

- **June 04**
 - I&T requires software to control/readout multi-tower (i.e. GASU) configuration (EM2)
- **July 04**
 - Instrument Spacecraft Interface Simulator (ISIS) to Spectrum Astro
- **August 04**
 - Demo to LAT system engineering on fully instrumented test-bed
- **December 04**
 - I&T requires tested software to control/readout full LAT
 - FU SW build to I&T
- **December 04**
 - FU build finish and transition to formal test
 - FU Formal test complete Feb 05
- **February 05**
 - I&T requires FU software release to operate/test (whole LAT is integrated)
 - Start of system testing
- **May 05**
 - End of system test
- **July 05**
 - Ship LAT to NRL for environmental test
- **Functional demonstrations every month to show progress**



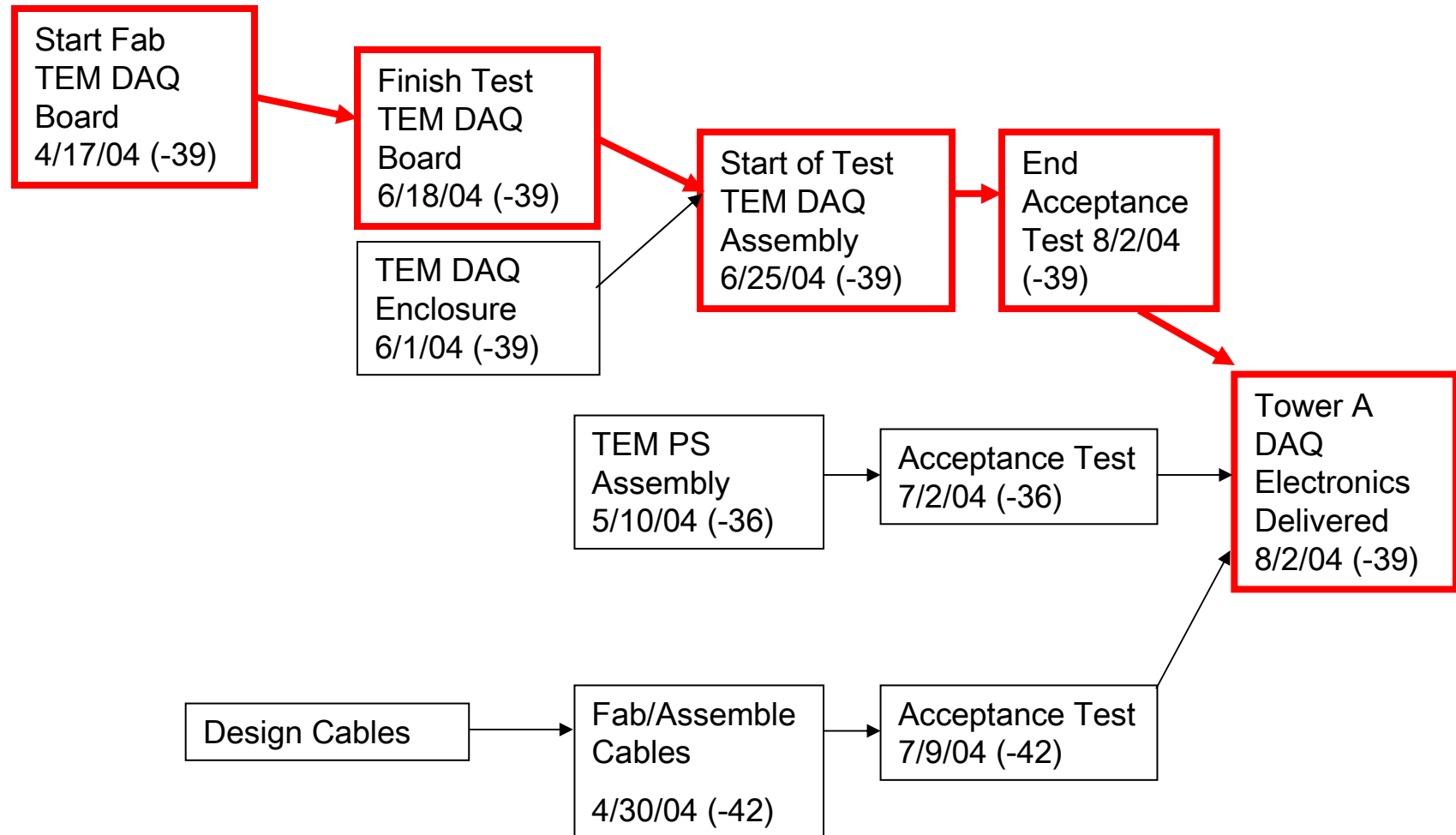
Open Issues, Technical Risks and Mitigations

- **FSW**
 - **BAE RAD750 flight processor might be different than BAE engineering module in respect to operation**
 - **Scheduled to receive first flight processor in May**
 - **Software needs to be shown to work on integrated instrument**
 - **Tests and demonstrations are planned on integrated test-bed**
- **HW**
 - **Couple of components still need to be TID radiation tested (DAQ ASIC's, National transceiver)**
 - **Radiation tests planned for April/May**
 - **Overall inter-system timing in respect to trigger needs to be shown to work**
 - **Test planned on test-bed once complete**

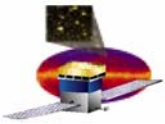


Critical Path for TEM DAQ Electronics to Tower A

Critical Path in Red



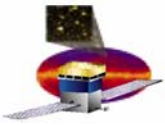
Completion Dates (baseline variance)



Approved Cost Changes Since Rebaseline

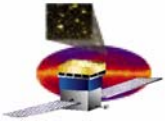
	(k\$)
4.1.7 Baseline, November 03	\$18,733
Changes:	
• Additional FSW Manpower	\$ 747*
• Additional EGSE	\$ 457
• SIU Cost Variance Reduction	\$ 258
• Stanford Benefits Rate Increase	<u>\$ 155</u>
Total Change	\$ 1,617
4.1.7 Baseline, February 04	\$20,350
 Approved Changes in March 04	
• ISIS Upgrade	\$ 94*

**Corresponding NASA funding increase*



Schedule/Budget

- Total budget: \$20,350
- Work Scheduled up to date: \$11,472
- Work Performed: \$11,912
- Actuals: \$11,352
- Schedule Variance \$440k or 2.1% of total budget (ahead of schedule)
 - Some flight components were delivered earlier than expected
- Cost Variance: \$560k or 2.7% of total budget (under budget)
 - Latency of invoicing/payment for components received



Summary

- **Technical:**
 - **No technical issues which would risk sub-system**
- **Schedule**
 - **Hardware is on track to provide flight hardware in time**
 - **Software schedule is aggressive but feasible**
- **Cost**
 - **No additional cost increases beyond what was discussed are identified**
 - **Remaining budget should be sufficient to deliver sub-system**