GLAST Large Area Telescope

Instrument Flight Software
Quick Look Review
29 January 2004

Testing

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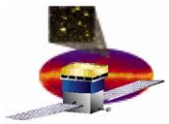
Test Plan Status

- **First Release of Test Plan Document: LAT-TD-00786**
  - **Major features still accurate**
    - **Identifies functionality expected at EM1, EM2, FU**
    - **Traces tests to requirements**
  - **Needs revising**
    - **Reflect improved knowledge of final system**
    - **Add specificity to formal tests to be executed for FU**

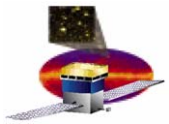
Testing

- Unit Testing
  - Software only testing
    - Example - PBS package (Processor Basic Services)
  - Software testing on target hardware
    - Example - LCB package (LAT Communications Board)
  - Uses test executives (LTX/LATTE)
- Build testing
  - Is tested on target hardware
  - Uses LTX/LATTE
- Formal Testing for ISIS & FU Releases
  - Includes
    - Formal requirement sign-off
    - Released test procedures
    - Released test report
  - If any test fails in formal testing:
    - Fix
    - Perform regression testing



Algorithmic Code Example: PBS Package

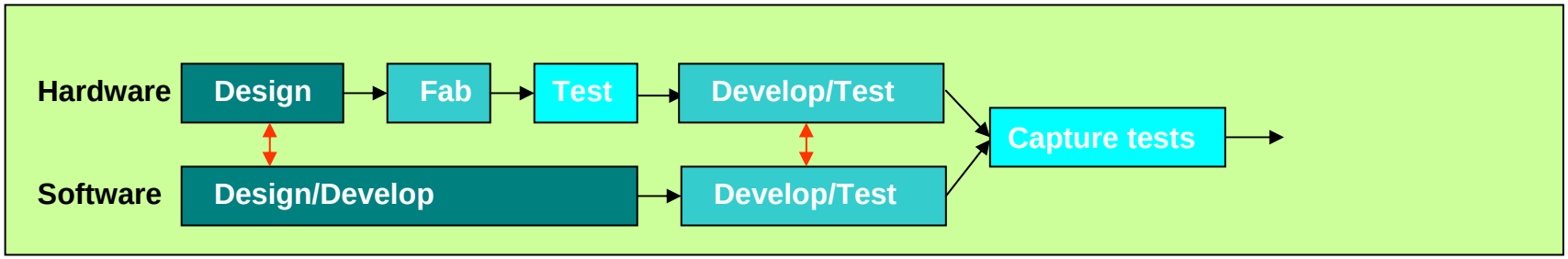
- Step 1: Define Package Objectives, e.g.
  - PBS forms an interface layer between user code and the OS
    - PBS provides rudimentary portability between VxWorks and host based OSs
      - PBS is not meant to be a UNIX implementation of VxWorks
      - Implementation design choices always favor VxWorks
- Step 2: Design/Sketch Facilities and Interfaces , e.g.
  - PBS facilities include
    - Memory managers
    - Interlocked queue routines
    - Fine-grained timers, etc
- Step 3 & 4: Code a little…, test a little, then iterate
  - Test code written simultaneously
  - Checks that the interfaces are clean and easy to use
  - Checks code integrity
- Step 5: Capture final test set in LTX scripts
  - Tests are reproducible
  - Tests produce an audit trail



Driver Code Example: LCB Package

- Write hardware design document
  - Iterate with team members as a sounding board for the design
- Give design to electronics engineers and flight software group
  - Electronics: Build real hardware
  - Software: Design hardware driver, code first implementation
- Hardware available, software driver available: start iterating
  - Write test code and run it
    - Correct hardware/software as necessary and loop
  - Start with simple tests (check register interface)
  - Increase complexity
    - Asynchronous behaviour
    - List processing capabilities
- Capture most useful test code into LTX scripts
  - Aimed at testing the integrity of the software
- Write hardware tests in LATTE
  - Aimed at verifying the integrity of the hardware

Test & Verification



- Hardware and software development closely integrated
  - Design of hardware versus software complexity optimized continuously
  - Software runs at LAT engineering model electronics stage
  - Continuous hardware versus software verification
- Hardware and software development extends throughout the organization
  - Frequent hardware/software exchanges between collaborating institutions
    - For over a year, the following exchanges have been routine
      - ACD hardware, TKR hardware, CAL hardware: from institutions to SLAC
      - DAQ hardware, Flight software, I&T software: from SLAC to institutions
      - ACD Scripts, TKR scripts, CAL scripts, DAQ scripts: all to all
    - Provides independent verification process
  - Components integrated early and often
    - No surprises late in the game
- Code management already in operation at this stage
  - FSW code distributions are CVS tagged and annotated in a "builds" web page/document
  - FSW code has built-in self-identification (automatically generated by the build engine)
    - Can ask a running system what code/version is being run

Test Executives: LTX and LATTE

- Unfortunate name clash … both stand for LAT Test Executive
- They are NOT competitors:
  - LTX (low level interface)
    - Flight software product
    - Sees LAT processors through a VxWorks shell task
      - Can load and run test-only code in VxWorks context
      - Can do anything allowed at the shell prompt (memory dumps, …)
    - Well suited to flight software internals testing
  - LATTE (high level interface)
    - I&T product
    - Sees LAT through spacecraft-like interface (CTDB)
      - Can only access what flight software provides
        - » FSW currently providing register level access to hardware
    - Well suited to interface level testing
- FSW chooses one or the other as appropriate to the test in question
  - LTX: Low level utilities, performance testing, …
  - LATTE: Otherwise (eases transfer to I&T)

LTX Design and Status

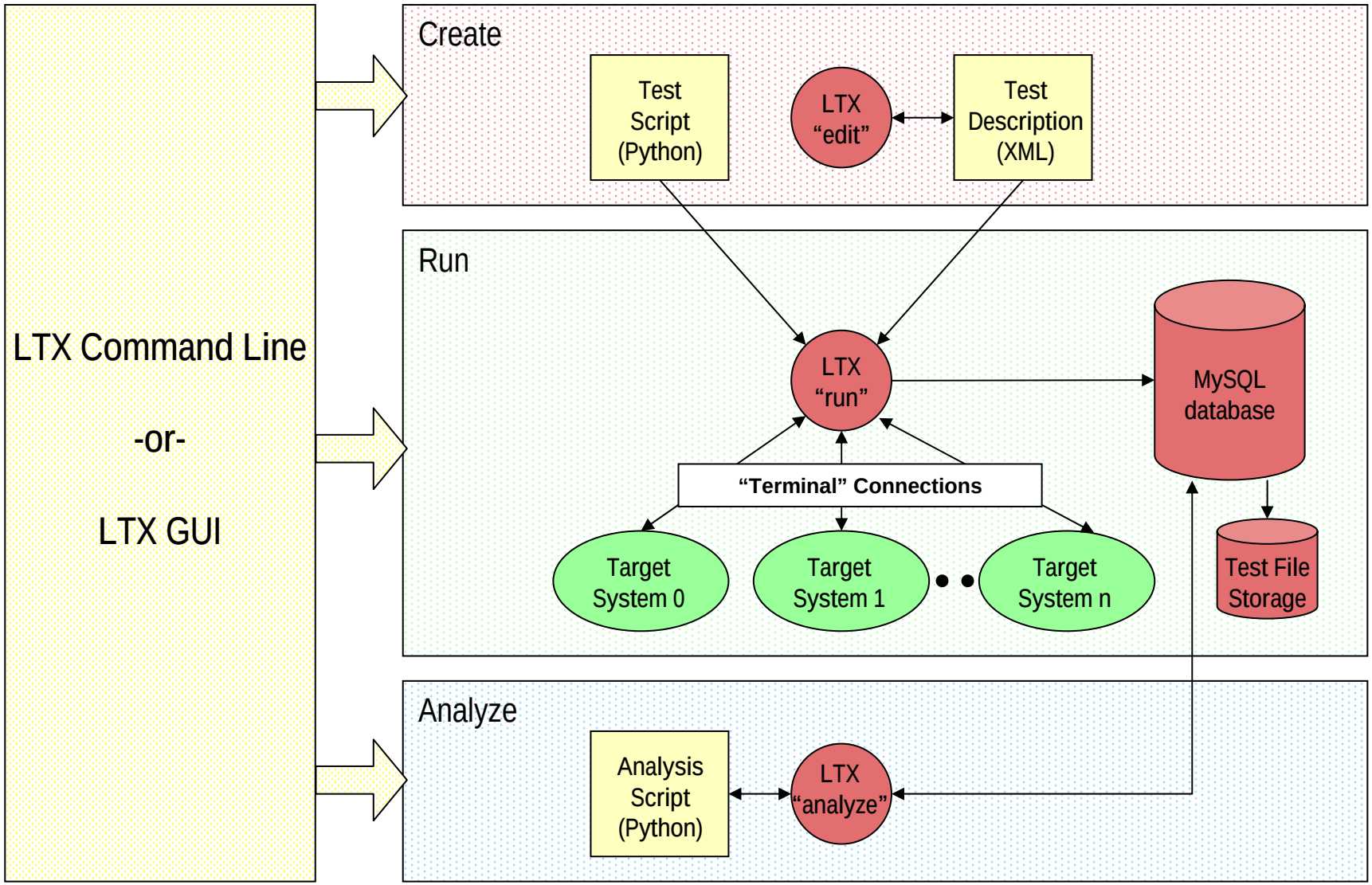
- LAT Test Executive (LTX) provides uniform methods to:
  - Create and track a test description/procedure (computer format)
    - Test developer prepares two files
      - Test description (an XML file, LTX provides the editor)
      - Test script (in Python)

    Done
    - Test descriptions/scripts code managed in FSW packages
      - All code management principles apply
  - Run a test and capture the results into persistent storage
    - Results captured into a random access database (MySQL)
      - All test instances uniquely identified
      - All hardware/software versions (discovered at run time) saved
      - Test associated files (e.g. terminal logs) saved in protected area and referenced by entries in the database

    Done
  - Attach an analysis suite to a test output
    - Code developer writes an analysis script
    - Analysis products indexed to original test

    Done
- Example Files:
  - Example XML test description
  - Example test script

LTX


LTX Command Line
-or-
LTX GUI
Create
Test Script (Python)
LTX "edit"
Test Description (XML)
Run
LTX "run"
MySQL database
"Terminal" Connections
Target System 0
Target System 1
Target System n
Test File Storage
Analyze
Analysis Script (Python)
LTX "analyze"

Formal Testing

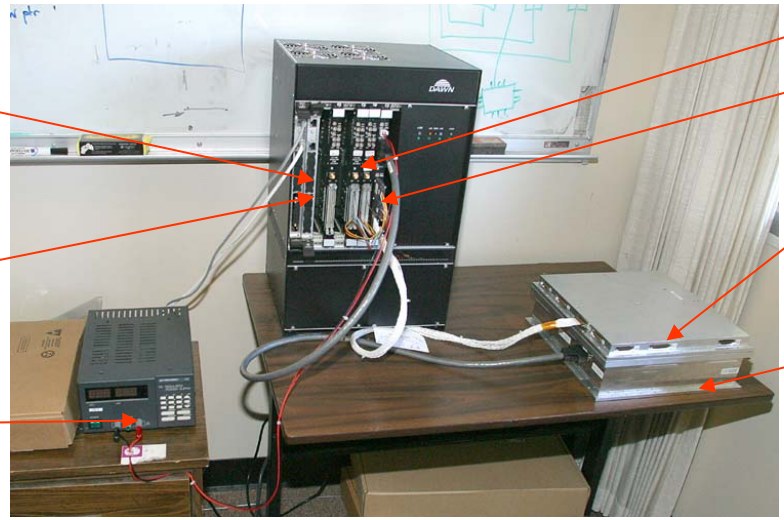
- Formal qualification testing will occur on formal deliverables
  - ISIS (delivery to Spectrum Astro)
  - Flight Load (delivery to I&T)
- Formal qualification incorporates
  - Test to requirement mapping
  - Approved test procedures
  - Test reports

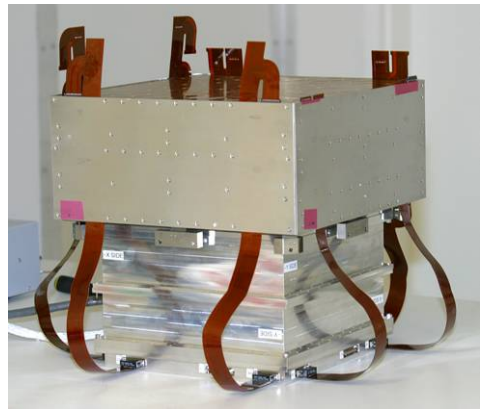
Test Stand Overview

- **Test stands running for many months:**
  - **LAT instrument test stands**
  - **Boot development & spacecraft communications test stand**

- **Test stands in progress:**
  - **Full test-bed**
  - **ISIS**
  - **Mini-tower including:**
    - **Real calorimeter sensors**
    - **Real tracker sensors**

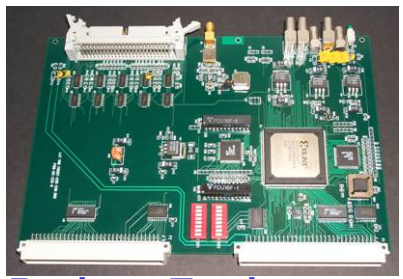
Instrument Test Stand





TKR Engineering Tower with TEM

- Processor: Motorola PowerPC
- Flight Software
- PMC LAT Communication Board for
  - LAT Communication
  - (replaces LAT Com Board)
- Transition Board
  - Trigger, power control
- TEM DAQ Assembly
- TEM Power Supply Assembly
- 28-V Supply
- LAT-TD-00861



Instrument Test Stand Status

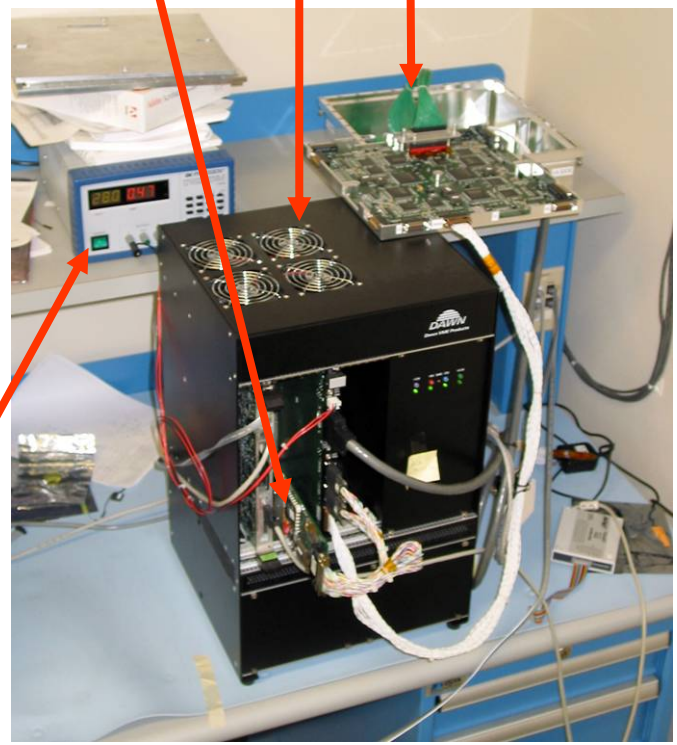
- **Configurable to match target hardware:**
  - **DAQ Tower Electronics Module (at SLAC)**
  - **Complete CAL electronics (at NRL)**
  - **Complete TKR tower (in Italy and at UCSC)**
  - **Single ACD FREE Card (at GSFC)**
  - **Combined TKR/CAL engineering tower**
    - **The EM1 test run by I&T in the SLAC clean room**
- **20 copies in the field (SLAC, NRL, GSFC, Italy)**
  - **Identical flight software running on all test stands regardless of hardware configuration**
    - **All flight software version controlled**
  - **FSW provides register level access to hardware**
  - **This generation of test stands configured with LAT Com Boards**
- **In the process of building**
  - **60 copies of generation two test stands**
  - **LCB board replaces the LAT Com Boards**
  - **FSW has LCB software in hand and running at SLAC**

LCB Development Test Stand

Tower Electronics Module (TEM) with PS (open)

VME Test Stand

LAT Communications Board
(PMC form factor, on extender)



cPCI Test Stand
(for development of cPCI form factor LCB)

28V Supply

PC running LATTE

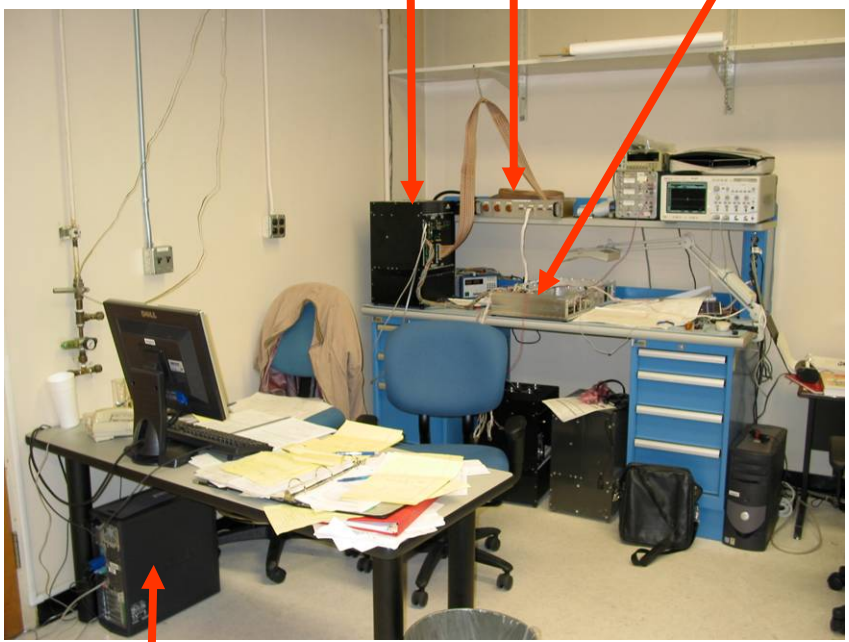
GASU Development Test Stand

Trigger Signal Breakout Box (for Global Trigger Module Testing)

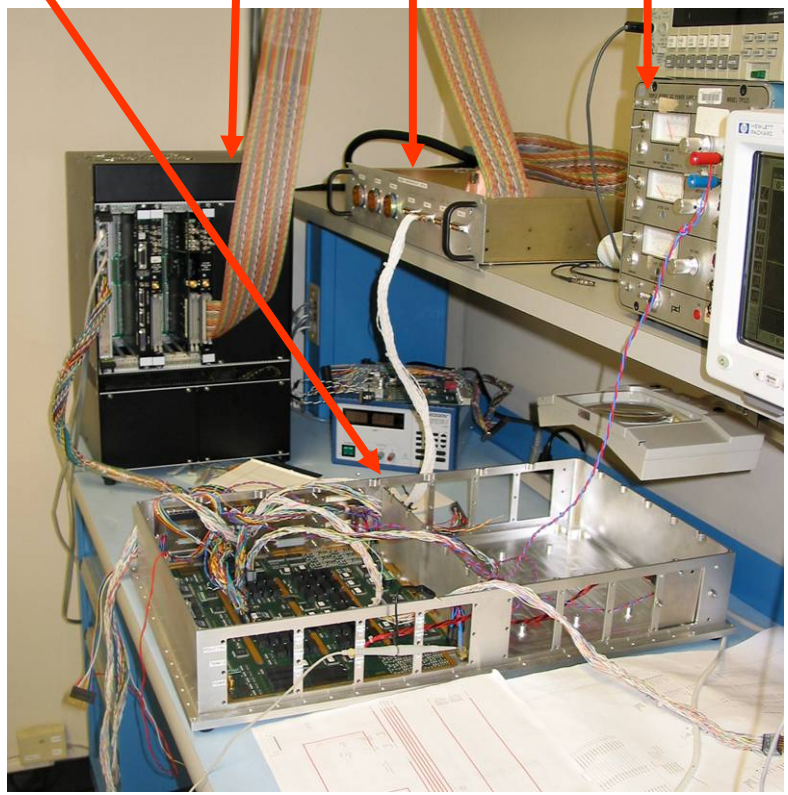
VME Test Stand

28V Supply

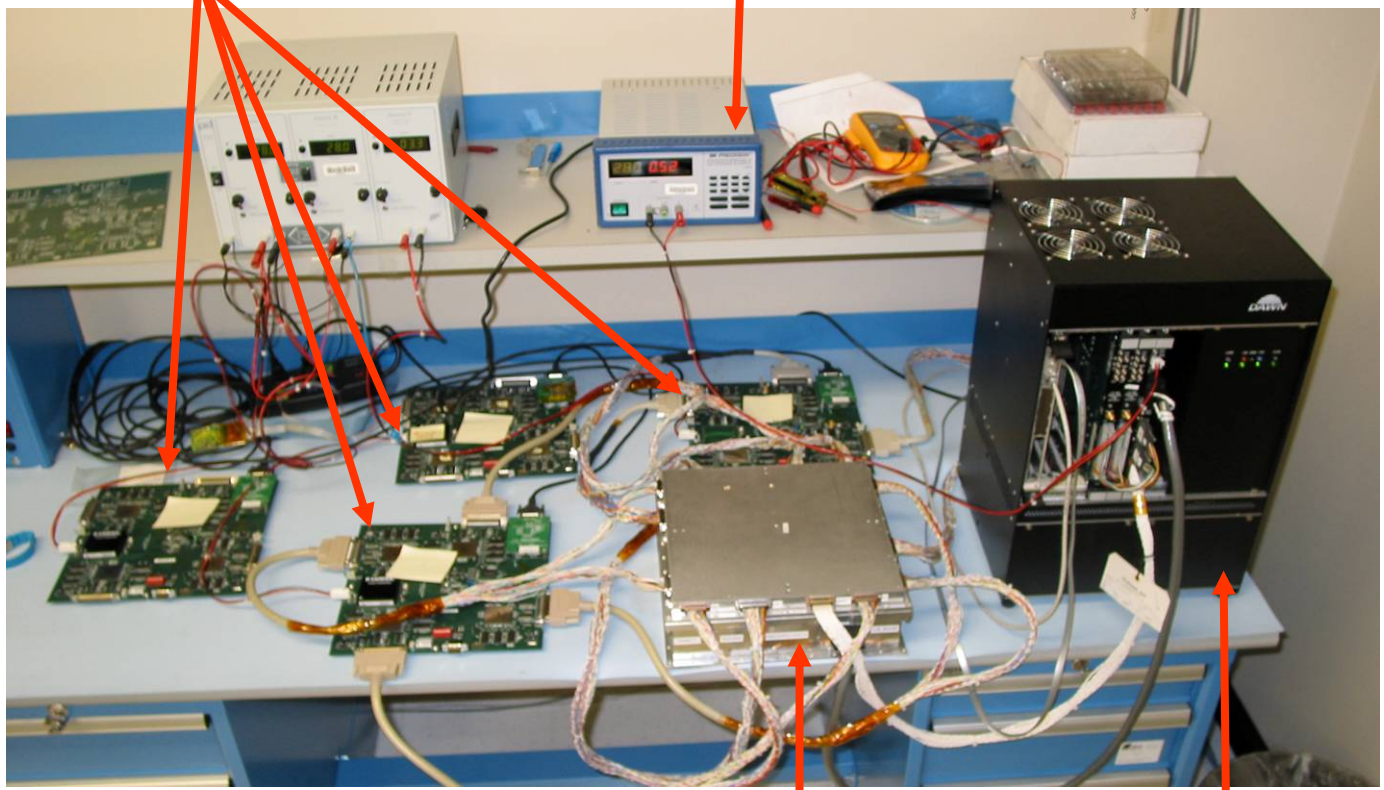
GASU (partially populated)



PC running LATTE



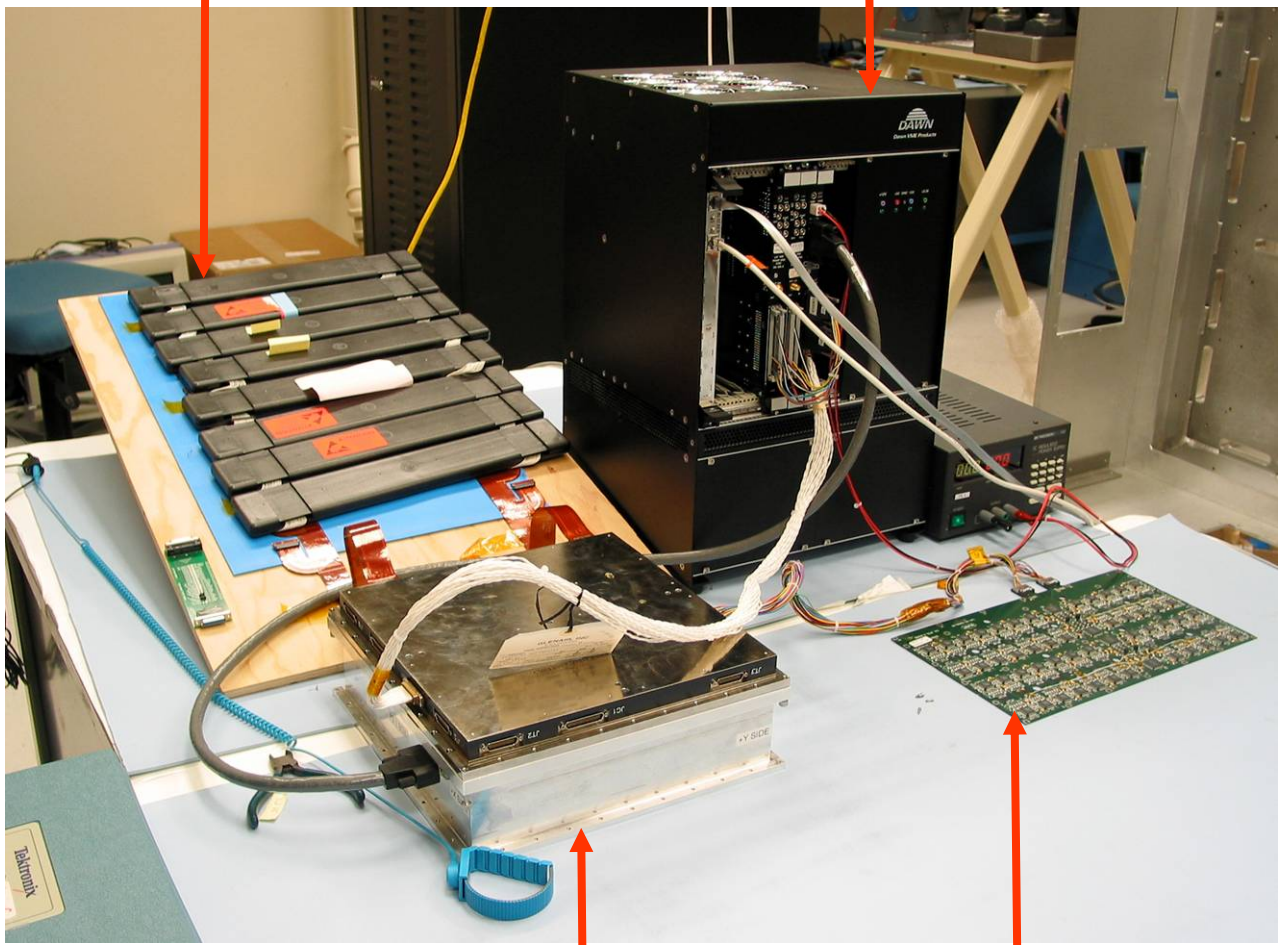
FES Development Test Stand



“Full String” Development Test Stand

TKR MCMs (~one face of a tower)

VME Test Stand

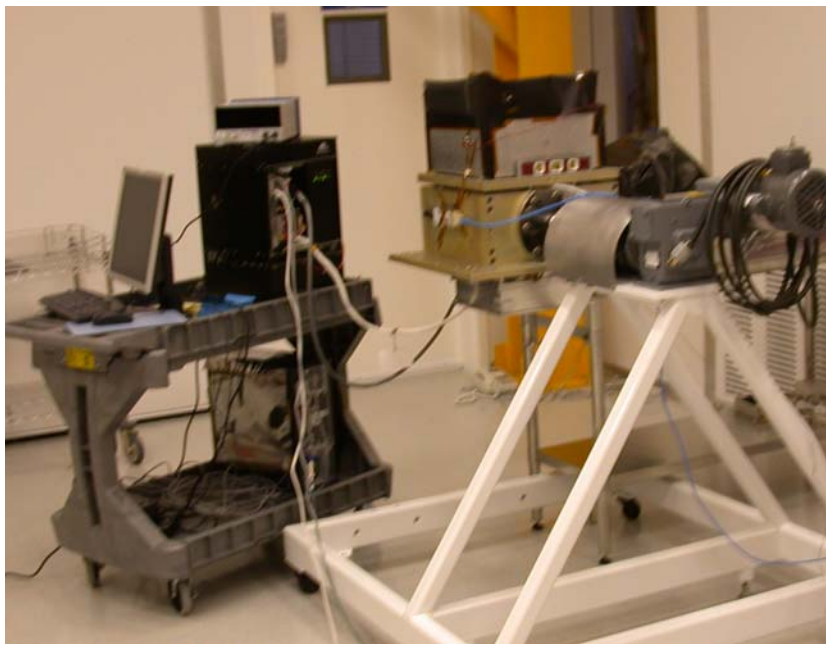


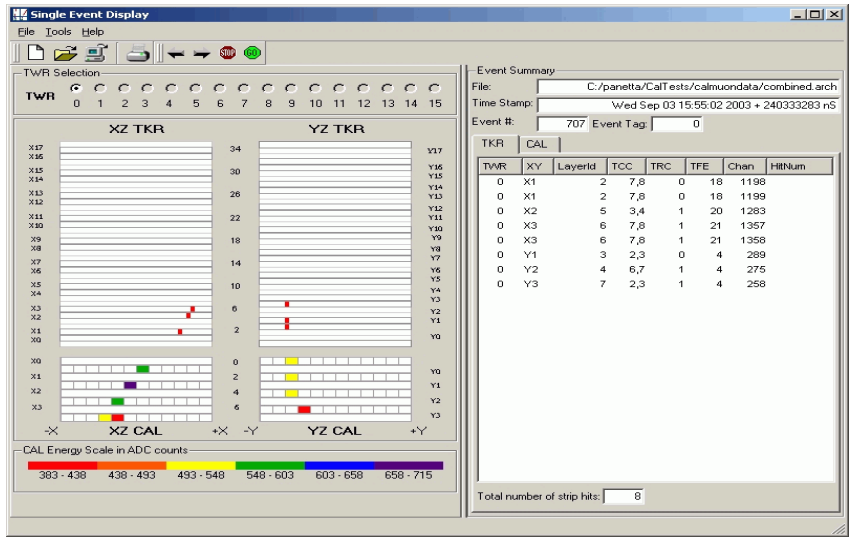
Tower Electronics Module with PS

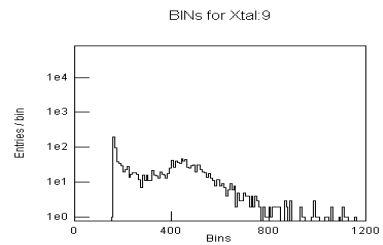
CAL AFEE board (one face of a tower)

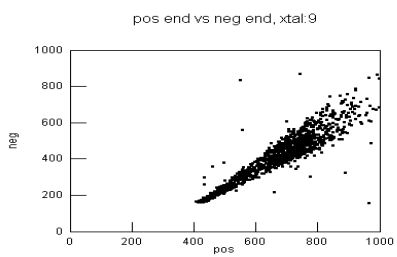
EM1 Test Stand

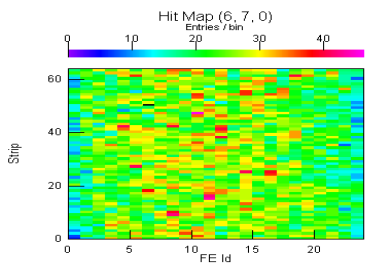
- **From EM1 testing as performed by I&T in the SLAC clean room**
  - **Displays courtesy of the I&T group and LATTE**

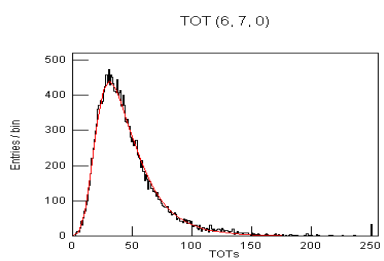




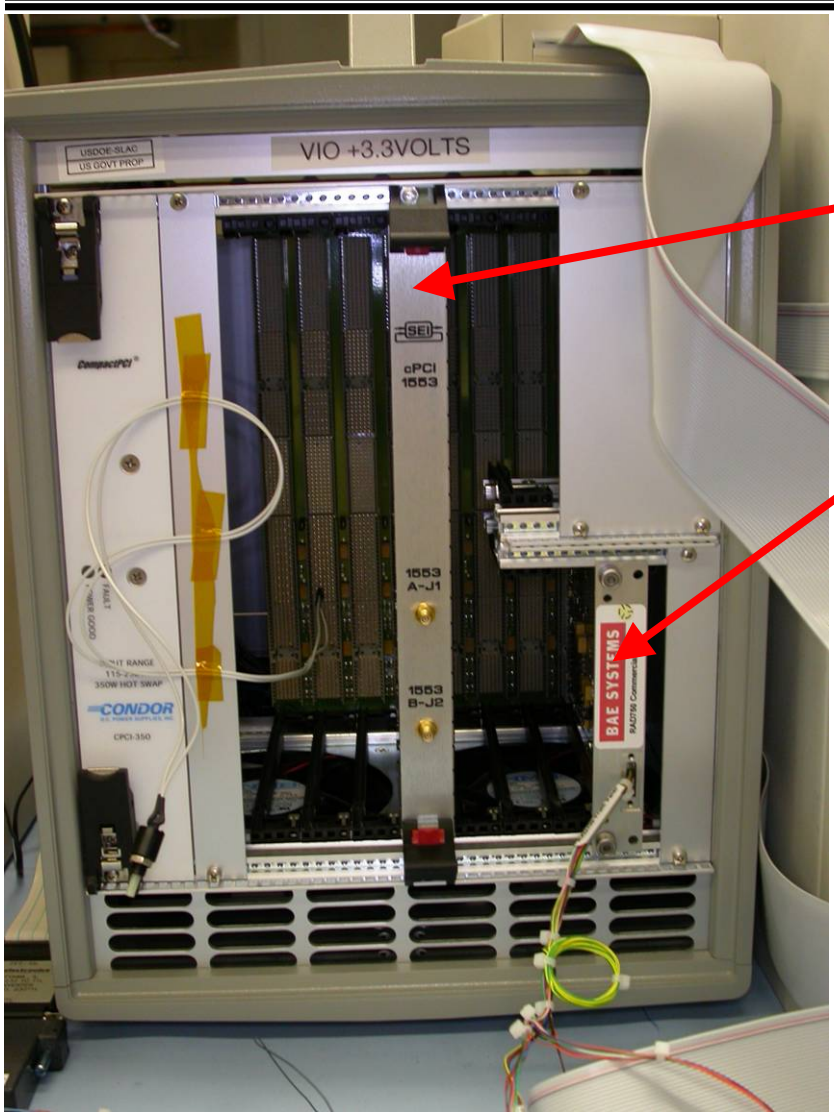








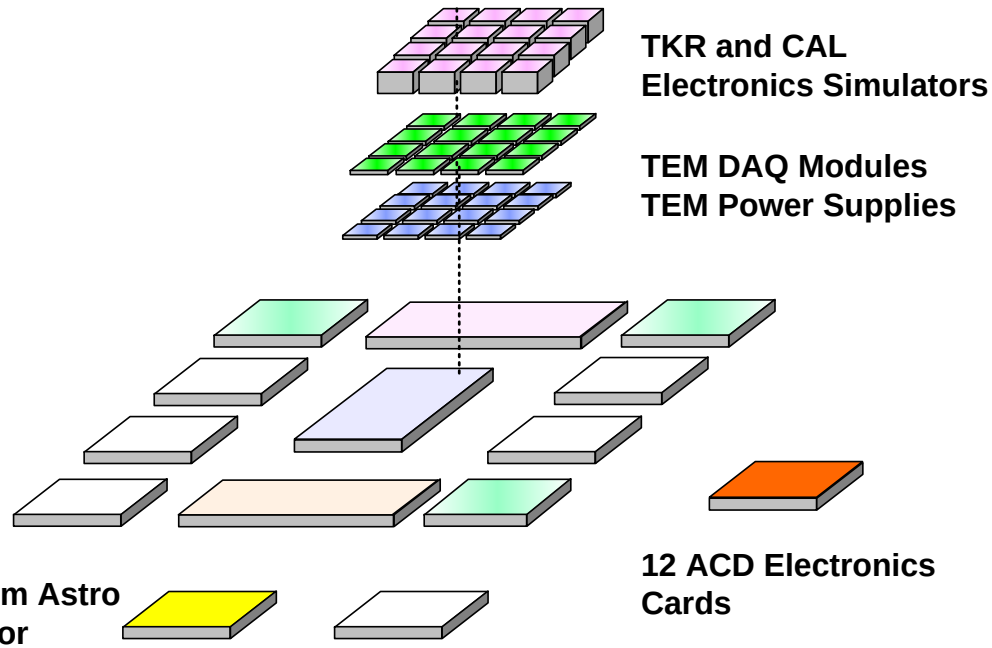
Boot & Spacecraft Communications Test Stand



- **Core hardware**
  - 1 cPCI crate
  - 1 Storage & Interface Board (SIB) (engineering model)
    - 1553
    - EEPROM
  - 1 BAE RAD750 single board computer (engineering model)
- **External hardware**
  - JTAG programming system (hardware and software)
  - Spacecraft-Instrument Interface Simulator (SIIS)
- **Located at NRL**

Software Test-Bed (1)

- **Provides a full DAQ system with EM2 hardware (interfaces and functionality identical to flight) before flight hardware is available**
  - **16 TEMs and 16 TEM power supplies**
  - **Full TKR and CAL front-end electronics for one tower**
  - **Front end simulators for remaining 15 towers**
  - **Full ACD EM2 electronics**
  - **Full GASU and PDU**
  - **Full complement of CPUs**
  - **Spectrum Astro SIIS**
- **Excellent software test-bed**



Software Test-Bed (2)

- **Hardware status:**
  - **Support structure in place**
  - **16 TEM/TEM-PS units in hand (under test)**
  - **Electronics for PDU/GASU in debugging**
  - **Enclosures for crates on order**
  - **RAD750's in hand**
  - **First SIB in hand, additional SIBs in fabrication**
  - **First (cPCI) LCB in commissioning**
- **Plan**
  - **Commissioned and under configuration control by late spring 2004**

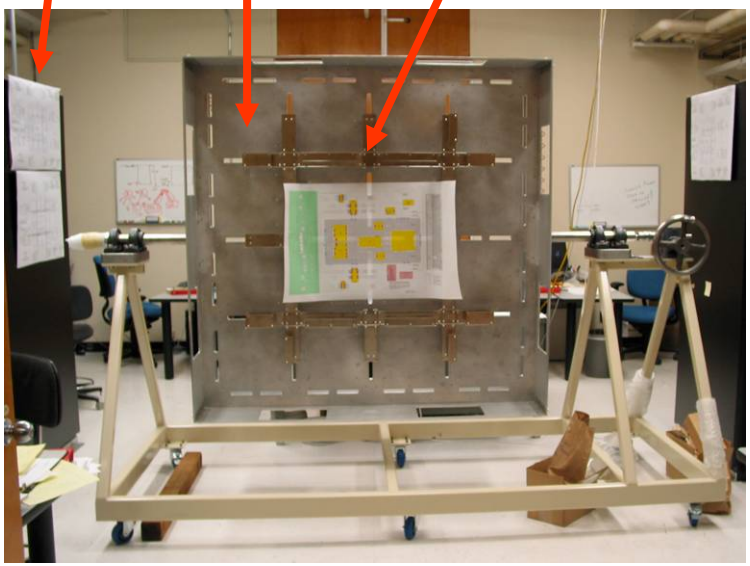
Software Test-Bed (3)

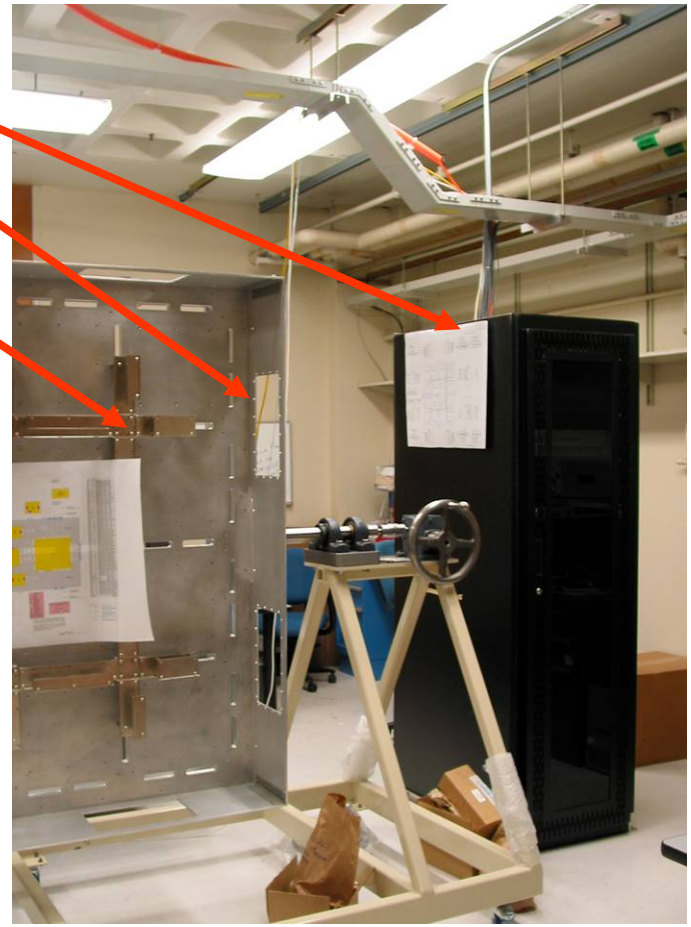
Racks for FES “feeder” CPUs

4x4 grid for electronics mounting

Cable feedthroughs (as flight)

Cable management (as flight)





Mini Tower

- **Some tests require real sensors**
  - **Timing tests**
  - **Estimation of noise/backgrounds**
- **Many such tests will be done by I&T during LAT integration**
  - **Instrument must be characterized before flight**
  - ***BUT:* the real instrument is *not* an investigative tool**
- **The Mini Tower:**
  - **Is a miniature but otherwise real (with sensors) environment**
  - **Comes available before the real instrument**
    - **Currently expected by April**
  - ***Can* be used as an investigative tool**
  - **Is dedicated to use by flight software**