GLAST Large Area Telescope:

Science Analysis Software
WBS 4.1.D

Richard Dubois
SLAC
Subsystem Manager

richard@slac.stanford.edu
650-926-3824
Outline

- Overview
- Results from January PDR/Baseline review
  - Findings and recommendations
  - Actions since the review
- Schedule and Budget
- Summary
Our Mission

• shall perform prompt processing of Level 0 data through to Level 1
• shall provide near real time monitoring information to the IOC.
• shall facilitate monitoring and updating instrument calibrations.
• shall maintain state and performance tracking.

• shall create high level science products from Level 1 for the PI team.
• shall perform reprocessing of instrument data.
• shall provide access to event and photon data for higher level analysis.
• shall perform production of Monte Carlo simulations.

• shall interface with mirror PI team site(s) (sharing data and algorithms).
• shall interface with the SSC (sharing data and algorithms).
• shall support design of LAT instrument with simulations.

• Production event processing is performed in the Data Processing Facility (DPF).
Big Picture

Mission Ops Center (MOC)
- Raw data from Malindi
- S/C, LAT and GBM Level 0 processing
- Spacecraft health and safety
- Instrument safety
- Commanding
- Alert data handling
- Ground station/TDRSS scheduling
- Acquisition data generation

Science Support Center (SSC)
- High level data processing
- Science data distribution
- Data archiving
- Calibration archiving
- Software archiving
- Observation planning and scheduling
- Target of Opportunity selection
- Exposure maps
- Participation in LAT software generation
- Multi mission analysis tools
- Level 1 processing for GBM
- Backup Level 1 processing for LAT

HEASARC
- Data and Software Archive

LAT Instrument Ops Center (IOC)
- Instrument monitoring
- Instrument ops planning
- Instrument calibration
- Instrument command load generation
- Instrument software generation
- Ground algorithms/software
- Instrument team product generation
- Level 1 processing
- Selected higher level processing
- Maintenance of calibration files and tools
- Transient detection

GBM Instrument Ops Center
- Instrument monitoring
- Instrument ops planning
- Instrument calibration
- Etc, etc

HEASARC
- Level 0 data
- Spacecraft data
- Level 0 data
- Instrument Procedures
- Level 0 data
- Spacecraft data

High level products

Level 1 data
- High level products
- Instrument Schedules
- Response Functions
- Processing Software
- Calibration Data
- DPF function
- IOF function
Data Flow

Data recon + MC on disk. Abstract full-recon output into L1 DB for analysis

Fully automated server, with RDB for data catalogue + processing state. Uses SLAC batch CPU and disk farms.

Parts of L2 processing also automated
Instrument Simulations and Reconstruction

3 GeV gamma interaction

Source Fluxes

Particle Transport

“Raw” Data

Instrument data

Geometry

Recon

Background Rejection - Particle ID

CAL Detail

3 GeV gamma recon

3 GeV gamma interaction
Processing Pipeline

 IOC  Level 0

 HSM

 Automated Tape Archive

 Level 0

 Level 1, diagnostics

 Batch system

 ~50 CPUs; ~50 TB disk by 2010

 Section 7.8 SAS Overview
Sim/Recon Toolset

- Root, IDL – analysis
- gismo – simulation package
- Root – object I/O
- Gaudi – code framework
- VC++ – Windows IDE
- gnu tools - Linux
- CMT – package version management
- cvs – file version management
- ssh – secure cvs access
- vcmt – Windows gui
- xml – geometry, parameters
- TkrRecon, CalRecon, AcdRecon – test beam era versions; Rewrites being planned & executed
- GEANT4
- utilities
Design Considerations for Science Tools

- High-level analysis of LAT data is fundamentally model fitting
  - Driven by: limited # of $\gamma$s, modest angular resolution
- Characterization of LAT is complicated
  - IRFs depend on energy, angles, conversion position, background cuts
  - Large FOV and scanning obs. also complicate analysis
  - $\gamma$-ray data access will be by region of the sky first, not time order
    - Level 1 data volume 1–2 Tb/yr
- Interstellar emission model is essential
- Likelihood analysis is central
  - Acceptable degree of data binning to be studied
  - Efficient, flexible exposure calculations are needed
  - Need efficient, flexible event selection
  - Not likely to distribute all event data to LAT team/GIs
Data Flow for Science Analysis

- **Processing and databases**

  **Low-Level**
  - Source Sim
  - Timeline
  - Event Summ
  - Bkgnd Rej
  - Level 0
  - Exp Hst
  - Extract
  - Calib w/ CRs
  - Low-Level Calib
  - Source Sim Gen
  - Level 1
  - Ev Disp
  - Bkgnd Rej
  - Timeline
  - Part of Data Processing Facility

  **High-Level**
  - Event Summ
  - Event Extract
  - Exposure Gen
  - Bkgnd Rej
  - Calib w/ CRs
  - Map Gen
  - Interactive Analysis
  - Sky Maps
  - Interactive Analysis
  - Transient Detect
  - Catalog Gen & Src. ID
  - High-Level Calib
  - Bkgnd Model Server
  - Em. Model Server
  - Pt. Src. Search
  - Diffuse Em. Model
  - Diffuse Em. Model
  - High-Level Calib
  - Event Summ Gen
  - Event Summ

Source Sim. is a phony Level 0 database

Mirror sites (within LAT team and SSC) will reproduce from here forward

10’s of Mbytes passed out of Analysis Interface Layer for a typical analysis: \( \sim 10^6 \) \( \gamma \)'s + \( \sim 10^7 \) element exposure table

More details to follow
SAS Organization

Instrument Project Office

R. Dubois
Manager
4.1.D
SLAC

T. Burnett
Sim/Recon
4.1.D.1
UW

T. Burnett
Architect
UW

E. do Couto e Silva
Calibrations
4.1.D.6
SLAC

S. Digel
Science Tools
4.1.D.4
Stanford

H. Kelly
Analysis Tools
4.1.D.2
GSFC

Performance Tune & Mon
4.1.D.2.8

H. Kelly
ACD
4.1.D.1.5
GSFC

M. Strickman
CAL
4.1.D.1.6
NRL, France

T. Usher
TKR
4.1.D.1.7
SLAC, UCSC, Italy

Y. Fukazawa
Sources
4.1.D.1.1
Hiroshima, Stanford

A. de Angelis
GEANT4
4.1.D.1.4
Italy

A. Schlessinger
DPF
4.1.D.5
SLAC

Performance Metrics
in conjunction with
S. Ritz GSFC

K. Young
Release Management
4.1.D.2.9
SLAC

Trigger Simulation
4.1.D.1.8

Background Rejection
4.1.D.1.9

Document: LAT-PR-00859-00
New Since January

- **Sim/Recon/Pipeline**
  - Beta release of Gleam – latest sim/recon package
  - Added G4
  - New ACD, TKR recons
  - Detailed object I/O from separated processing steps
  - Revised data structures
  - Pipeline db, server specs written
    - db in place
    - interfaces being planned now

- **Infrastructure**
  - Monthly code reviews (4 done)
  - Doc Task Force revising all aspects of doc
  - Two iterations of Release Manager + nightly builds
  - System test plan being implemented

- **User Analysis Group**
  - Started in May
  - Power users exercising the tools and giving feedback

- **Science Tools**
  - Formally created LAT-SSC working group
    - Joint oversight of work
    - Weekly meetings
  - Wrote requirements for all tools in scope of project
  - Trade studies on Level 1 DB technology and performance
  - LAT+SSC workshop held in June
    - Iterated on scope definition
    - Iterated on requirements (documents) for the tools
  - Target is external review of scope and requirements in September
  - More detail from Seth Digel
The Next Six Months

- Production release of Gleam in October time frame
  - Full iteration on Tkr recon, digi
  - Update to Cal Recon
  - Iterations from summer’s experience
- System tests in place
  - Suite of tests run on every release
    - Includes G4 validation in our environment
    - Connected to Release Manager
- Provide calibration algorithms for EM unit
- Support instrument performance evaluation for CDR
  - Start December time frame
- Prepare for CDR
  - ICDs with IOC and SSC
- External review of Science Tools scope & requirements
- First prototypes of tools
Responses to Baseline Recommendations

• Recommend Baseline Approval: Technical, Cost, Schedule, Management
  – Agreed!

• With SSC, move forward with planning for implementation of Science Analysis Tools
  – In progress
  – joint LAT-SSC working group has been formed to plan and oversee the implementation of the Science Analysis Tools.

• Improve depth of organization at level of S/W architect and S/W engineers
  – Engineer added at Ecole Polytechnique
  – Reducing non-architect workload on architect

• Fill the user support position
  – Funds are budgeted for FY 2003

• Note: due to French reorganization
  – Changed lead at NRL; reviving effort in France
  – Planning meeting held in mid-July

Quote from PDR Report on SAS:
*It is not a technically challenging project*, yet it is vital to the successful operation of the instrument. *ie a low risk project.*
Risk Assessment & Mitigation

• There are no significant technical risks
  – We are not doing anything ‘new’ and are not pushing any envelopes – data volumes are small by current standards

• Risks are in ‘implementation’
  – We have the people to execute the plan
  – Core group is adequate, with little cross coverage.

• Mitigation
  – Need to keep the risks low – create ‘good-enough’ tools ASAP and make them better over time
    • Sim/Recon/Calibs now; then pipeline; then Science Tools
## Key Milestones

<table>
<thead>
<tr>
<th>Activity Description</th>
<th>AV: Early Finish</th>
<th>Float</th>
<th>Baseline Finish</th>
<th>FY02</th>
<th>FY03</th>
<th>FY04</th>
<th>FY05</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1. D Science Analysis Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Major Release of Sim/Recon (SAS to I &amp; T)</td>
<td>06/12/02</td>
<td>0</td>
<td>06/12/02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracker Dead/Noisy Strips (SAS to I &amp; T)</td>
<td>06/21/02</td>
<td>0</td>
<td>06/21/02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calorimeter Calibration Prototype Coding SAS-I&amp;T</td>
<td>07/08/02</td>
<td>0</td>
<td>07/08/02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracker Tower &amp; Tray Alignment (SAS to I&amp;T)</td>
<td>01/06/03</td>
<td>11</td>
<td>01/22/03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CU Monte Carlo sim from SAS to I&amp;T/SVAC</td>
<td>11/05/02</td>
<td>146</td>
<td>06/13/03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAT Calibr algorithms &amp; Doc- SAS to I&amp;T SVAC</td>
<td>06/26/03</td>
<td>280</td>
<td>08/12/04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAT Monte Carlo simulation by SAS to I&amp;T SVAC</td>
<td>01/27/04</td>
<td>200</td>
<td>11/08/04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cost & Commitments

4.1.D Science Analysis Software

<table>
<thead>
<tr>
<th>FY00</th>
<th>FY01</th>
<th>FY02</th>
<th>FY03</th>
<th>FY04</th>
<th>FY05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

($M)

Legend:
- **ACWP**
- **Actual Commits**
- **BCWS**
- **Budget + Commits**
Cost Profile

4.1.D Science Analysis Software

![Diagram showing cost profile for 4.1.D Science Analysis Software from FY00 to FY05.](image-url)

- **LABOR**, **TRAVEL**, **MATERIALS & SERVICES**, **MPS & LAB TAX**

Cost Profile

- **FY00**, **FY01**, **FY02**, **FY03**, **FY04**, **FY05**
Manpower Plan

4.1.D Science Analysis Software

<table>
<thead>
<tr>
<th>FY00</th>
<th>FY01</th>
<th>FY02</th>
<th>FY03</th>
<th>FY04</th>
<th>FY05</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2.0</td>
<td>8.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
</tr>
</tbody>
</table>

- **FTES**
- **DOE + NASA Project**
- **Collaborators**

Document: LAT-PR-00859-00
Summary

• Technical Progress
  – Sim/Recon/Infrastructure retooling since AO is done
    • Concentrate on content
    • Small iterations on ‘system’
  – QA/QC in place
    • Nightly builds
    • Release Manager
    • Code reviews
    • Continue to improve all these
    • Test plan being implemented – unit and system test

• Pipeline
  – First spec has been written
  – Underlying DB exists – being tried out
  – Goal is to use prototype pipeline for Critical Design Review performance evaluation

• Science Tools
  – Tools scope and requirements being iterated

• Schedule/Cost
  – Manpower driven
  – Will have Sim/Recon/Pipeline ready for test units
  – Science Tools will be our next major focus area