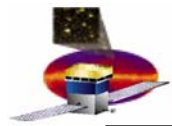


# GLAST Large Area Telescope: I & T Peer Review

## Science Verification, Analysis and Calibration

Elliott Bloom  
SU-SLAC  
Subsystem Manager

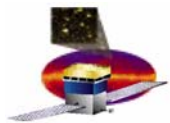
[elliott@slac.stanford.edu](mailto:elliott@slac.stanford.edu)  
650-926-2469



# Outline

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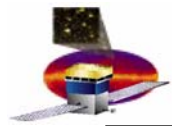
- SVAC system Responsibilities**
- Requirements Flow**
- Timeline**
- Operations Flow**
- On Orbit Calibration**



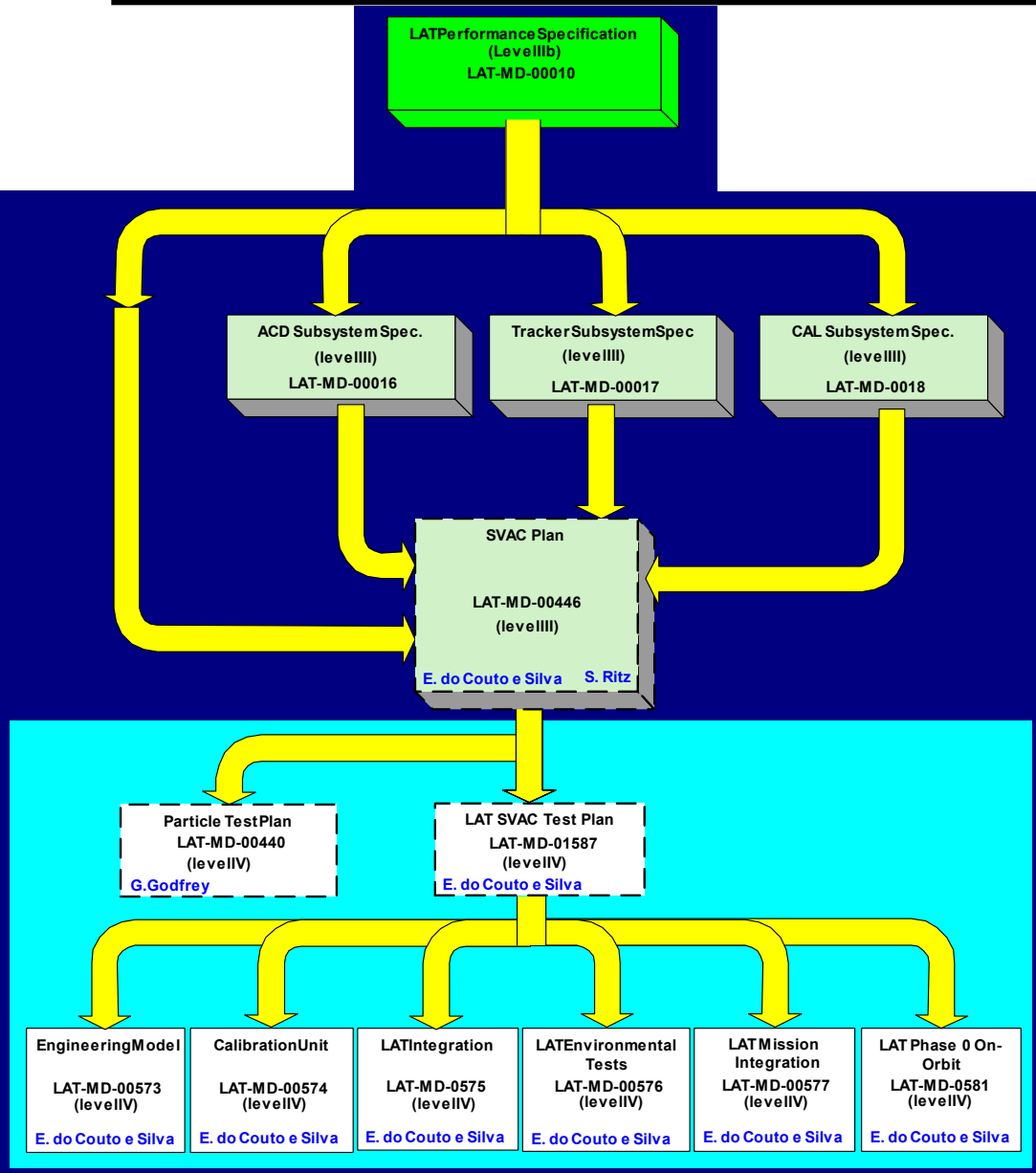
# SVAC System Responsibilities

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- Capture Science and Calibration requirements from Subsystems Plans. (LAT-MD-00446)
- Prepare the SVAC plan (with review from subsystems). (LAT-MD-00446)
  - To verify Science and Calibration Requirements
  - Provide the final I&T calibration products to SAS and IOC
  - Develop Calibration Compliance Matrices for pre and post launch operations
- Coordinate Data Analysis (with support from subsystems LAT-MD-00613) using data obtained from particle beams and cosmic rays during LAT assembly, environmental and spacecraft integration tests
- Demonstrate that the LAT is calibrated prior to launch and perform the first on-orbit calibration prior to hand off to IOC after fabrication phase is completed

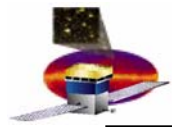


# Science Performance (SE, IS, and I&T)



- Particle tests
- Calibration
- Science verification tests

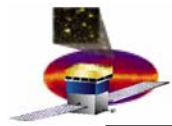
**Produce a Scientifically Working Instrument**



# Level IV Technical Documents – Contents

## Using Engineering Model as an example

- **Test Plan/Results**
  - **LAT-MD-00573 – SVAC EM Plan**
    - Describes the hardware data taking configurations, infrastructure needed for calibrations, calibration types, data analysis requirements. Run time estimation using MC simulation
  - **LAT-MD-01593 – SVAC Results from the Engineering Model Test**
    - Describes the results and how requirements were met
- **Calibrations**
  - **LAT-TD-01588 – Calibration Algorithms for the Engineering Model**
    - Describes the calibration algorithms developed in conjunction with SAS and subsystems
- **Simulations**
  - **LAT-TD-00582 – EM Geometry for the Monte Carlo Simulation**
    - Describes the geometry used in the simulation, includes table to translate nomenclature from software developers to engineers and also contains traceability
- **Database**
  - **LAT-TD-00578 – SVAC Database for the Engineering Model**
    - Describes the table schema and how a web based engine will allow access to a subset of calibration data for the purpose of tracking changes in time.
- **Interfaces**
  - **LAT-TD-00571 – SVAC/SAS Interface Control Document**
    - Describes the responsibilities between SAS and SVAC for data analysis (Statement of work)
  - **LAT-TD-01340 – SAS Calibration Infrastructure**
    - Describes SAS calibration infrastructure that hold the primary calibration data



# Main Documents - Contents

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## Co owned with Project Scientist, Level 3.

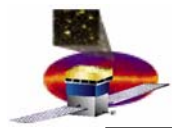
- **LAT-MD-00446 - SVAC Plan**
  - Instrument Calibrations
  - SVAC Compliance
  - Pre Launch Test Matrix
  - Post Launch Test Matrix

## Contributed Manpower Plan Level 3

- **LAT-MD-00613 - SVAC Plan**
  - Engineering Model
    - TKR,CAL,SAS
  - Calibration Unit
    - ACD,TKR,CAL,SAS,IOC, Contributed Manpower from GLAST collaboration.
  - LAT
    - ACD,TKR,CAL,SAS,IOC, Contributed Manpower from GLAST collaboration.

## Internal I&T Doc level 4.

- **LAT-MD-01587 – SVAC Test Plan**
  - Hardware Required
  - Flight Software Required
  - Test Configuration
  - EGSE Required
  - MGSE Required
  - Test Software
  - Support Instrumentation
  - Test Data Record
  - Data Format
  - Test Products
  - Analysis Activities
  - Environmental Conditions
  - Test performance Procedures
  - Facility Requirements
  - Quality Program Performance Requirements
  - System Assurance Requirements
  - Test Equipment Calibration



# SVAC Plans and Technical Documents

## LEVEL III

**LAT-MD-00446**

Co-owned with Project Scientist

**LAT-MD-00613**

Contributed Manpower Plan

**LAT-TD-00570,1,2**

I&T-SAS ICDs, EM, CU, LAT

## LEVEL IV

**LAT-MD-01587**

SVAC Test Plan

Existing docs are shown in **red boldface**

**Hardware Test**

**Plan/Results**

**Calibrations**

**Simulations**

**Databases**

**Interfaces**

**Engineering Model  
EM**

**LAT-MD-00573**

LAT-TD-01593

**LAT-TD-01588**

**LAT-TD-00582**

**LAT-TD-00578**

**LAT-TD-01340**

**Calibration Unit  
CU**

LAT-MD-00574

LAT-TD-01594

LAT-TD-01589

LAT-TD-00583

LAT-TD-00578

LAT-TD-01340

**LAT**

LAT-MD-00575

LAT-MD-00576

LAT-MD-00577

**LAT-MD-00581** ←

LAT-TD-01595

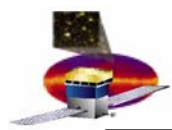
LAT-TD-01590

SAS responsibility

LAT-TD-00580

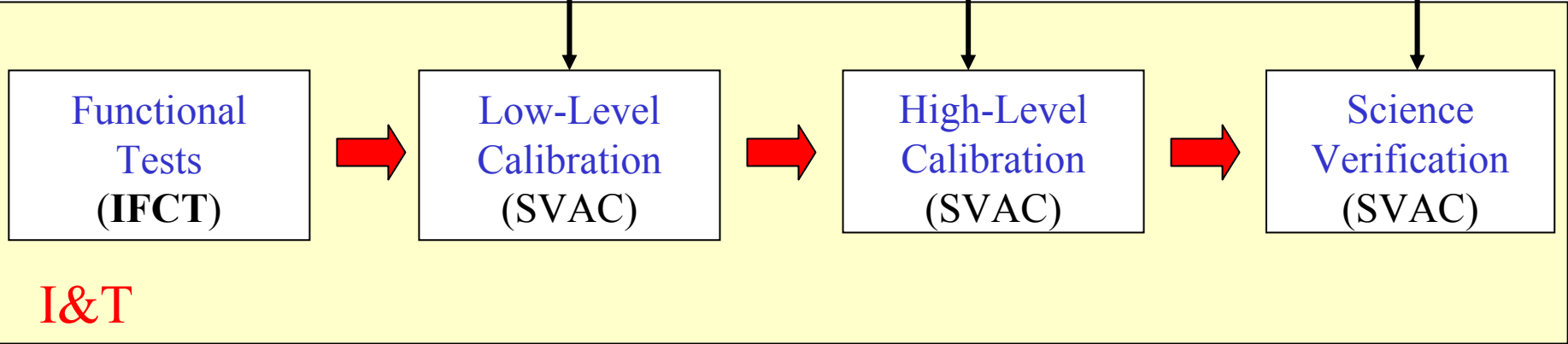
LAT-TD-01340

Co owned with Instrument Operations Center



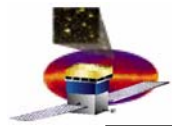
# Functional Test -> Calibration, Science Verification flow

Reconstruction and Monte Carlo Software  
(SAS)



LAT subsystems hardware , EGSE scripts  
and reference calibration datasets  
(ACD,CAL,TKR,ELX)





# SVAC Timeline

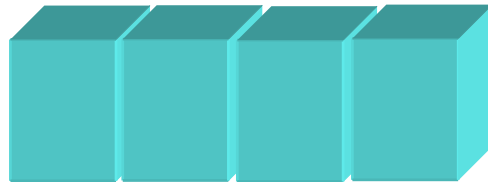
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**2003 Engineering Model 1**



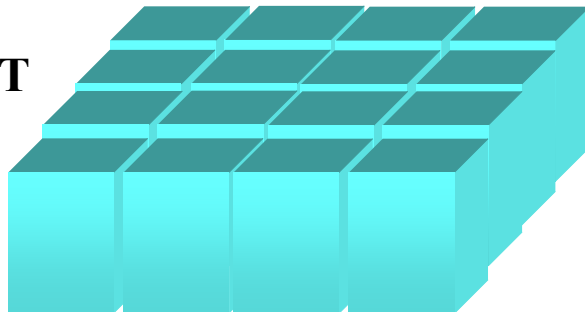
Prototype algorithms and database infrastructure  
Prototype interface with EGSE and SAS  
Calibrations

**2004 Calibration Unit**

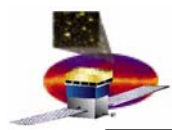


Calibrations (prototype inter tower alignment)  
Science Verification (Monte Carlo Validation)  
Validate SVAC database design  
Prototype of on-orbit low level calibration scheme

**2004 LAT  
2005**

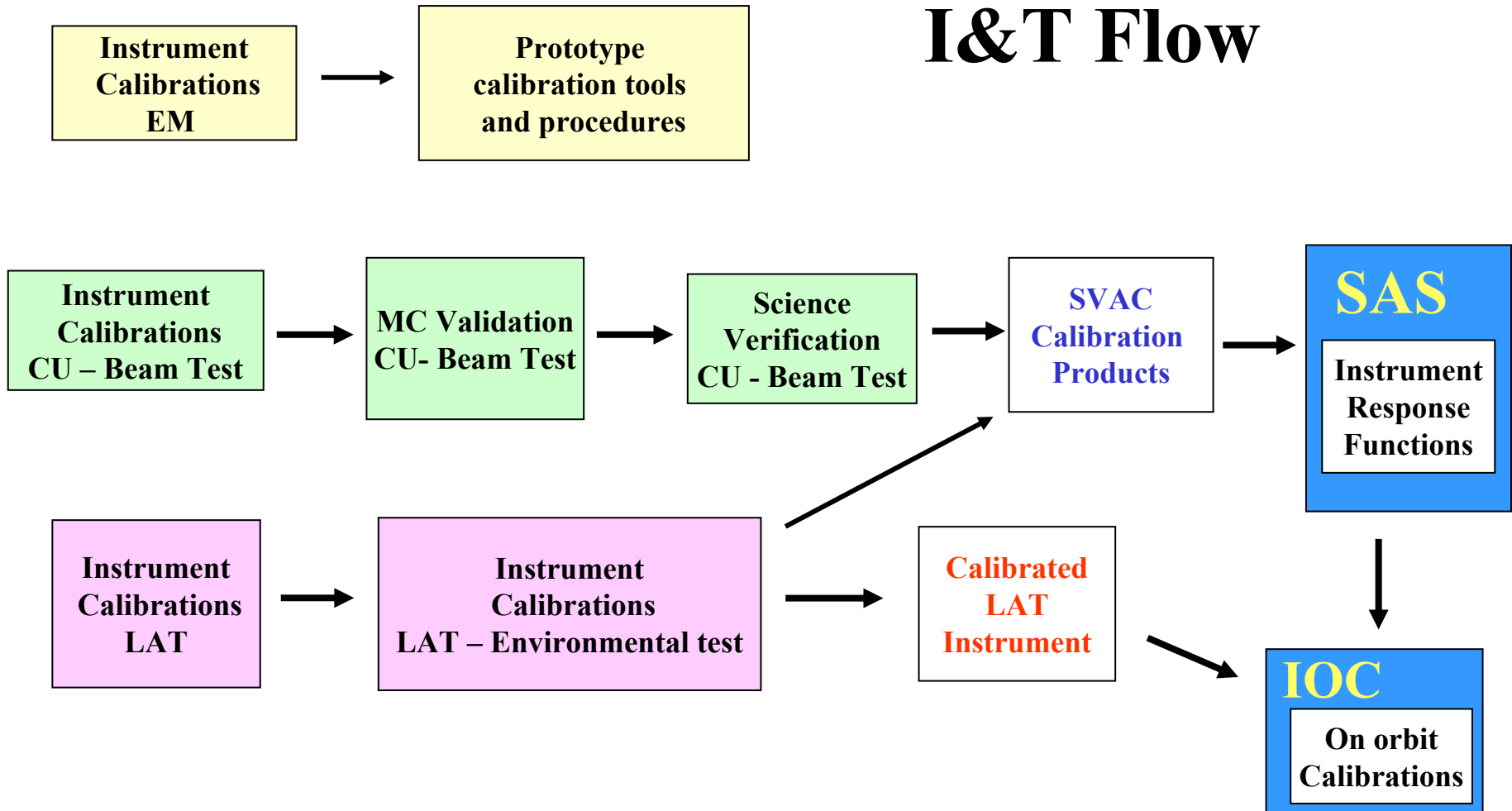


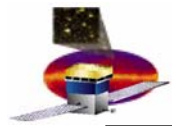
Final alignment  
Validation of on orbit calibration scheme  
Calibration dependence on environment  
Calibration time history prior to launch



# SVAC Operations Flow

## I&T Flow

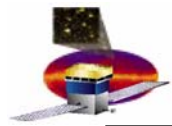




# Science Verification

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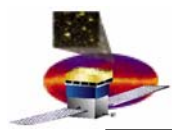
- **Science verification relies on a LAT-wide collaboration effort and on the guidance from the LAT Instrument Scientist**
  - Individual Subsystems and Science Requirements are captured in a compliance matrix in LAT-MD-00446
  - Contributed Manpower is described in LAT-MD-00613
  - Infrastructure needed is described in LAT-MD-001587
- **Science Verification is a 3-step Process**
  1. **Preparation**
    - Develop and Test Monte Carlo Simulations prior to particle beam tests
    - Calibrate Beam Test Modules
  2. **Validation with Particle Beams**
    - Use beam test data with calibrated modules to validate Monte Carlo simulations for a set of energies, incident angles and impact points.
  3. **Demonstration by Analysis**
    - Prove that we met the Science Requirements by evaluating the LAT performance in a larger set of energies, angles and impact points



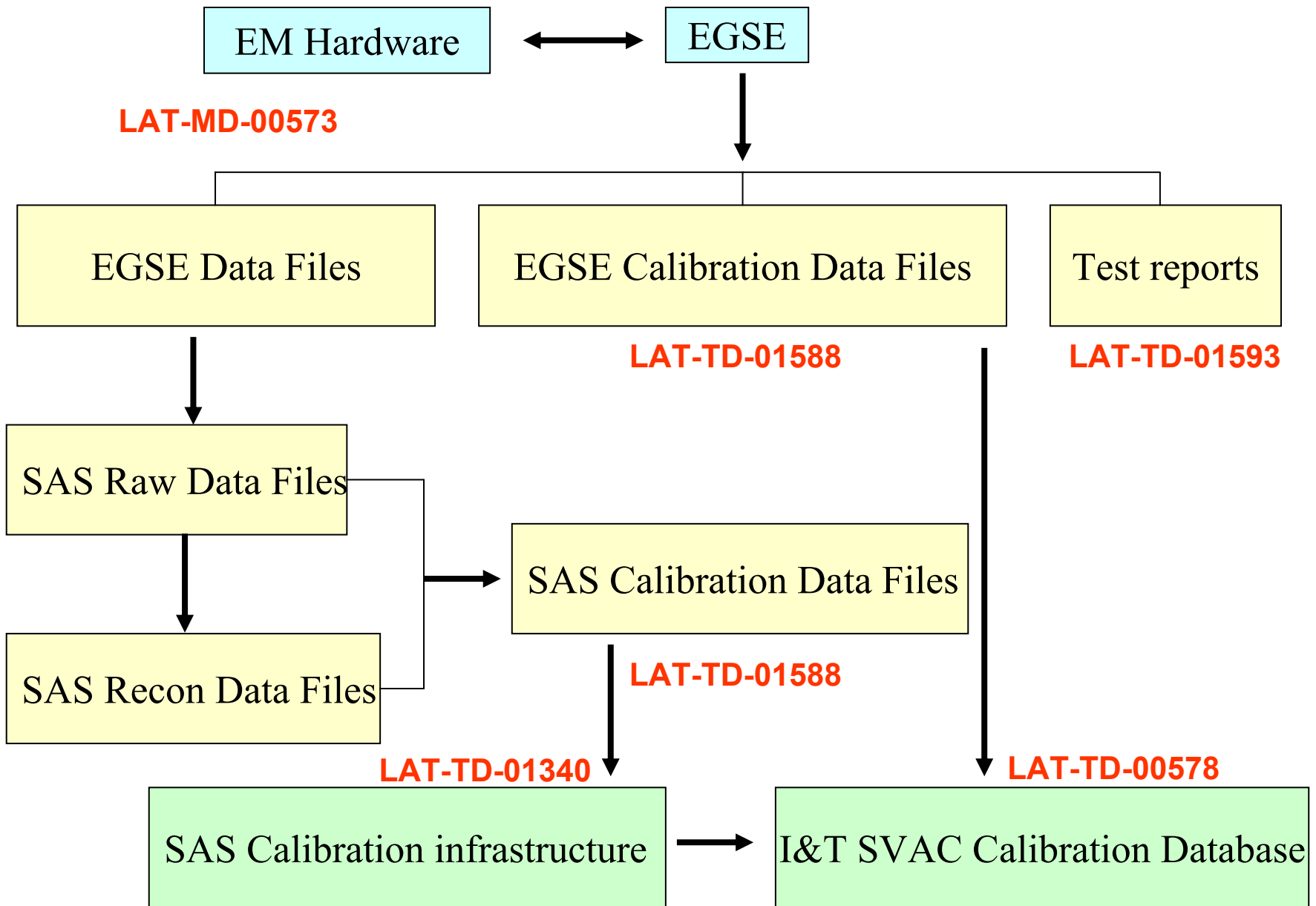
# Data Analysis

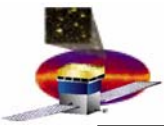
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- **SVAC analysis is essentially offline and relies on reduced data produced by the**
  - **GSE software for calibration purposes**
  - **SAS software for calibration purposes**
    - **For calibration types, which can be performed with both GSE and SAS software, results from the former are used as a reference.**
  - **SAS software for Science Verification**
- **Two important aspects of the data analysis**
  - 1. Calibration Data**
    - **Verify the electronics requirements, thus calibrate the instrument**
    - **Provide pre-launch history of calibration (including changes due to environmental effects)**
    - **Provide a metric to monitor procedures during Integration and Test**
    - **Provide required input to the SAS software used for Science Verification**
  - 2. Science Verification Data**
    - **Determine the LAT performance**



# Data Analysis – EM Example (calibration only)

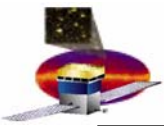




# Calibration

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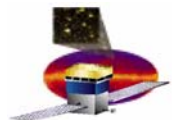
- **Calibration relies on a LAT-wide collaboration effort and cooperation with the LAT Instrument Scientist, System Engineering and the Instrument Operations Center**
  - Individual Subsystems and Science Requirements are captured in a compliance matrix in LAT-MD-00446
  - Contributed Manpower is described in LAT-MD-00613
  - Infrastructure needed is described in LAT-MD-001587
- **Calibration is a 3-step Process**
  - 1. Preparation**
    - Develop and Test GSE scripts, calibration algorithms, databases, report capabilities using the Engineering Model
    - Update tools and calibrations to provide a calibrated unit (4 modules) for science verification
    - Develop concepts for on-orbit calibrations
  - 2. Demonstration by pre launch tests**
    - Prove that we met the Calibration Requirements by calibrating the LAT on the ground
    - Test and Verify concepts for on-orbit calibrations
  - 3. Demonstration by post launch tests**
    - Update calibrations by perform on-orbit calibrations during checkout phase
    - Implement procedures within the IOC framework



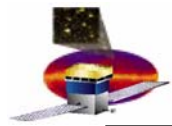
# On-orbit Calibration

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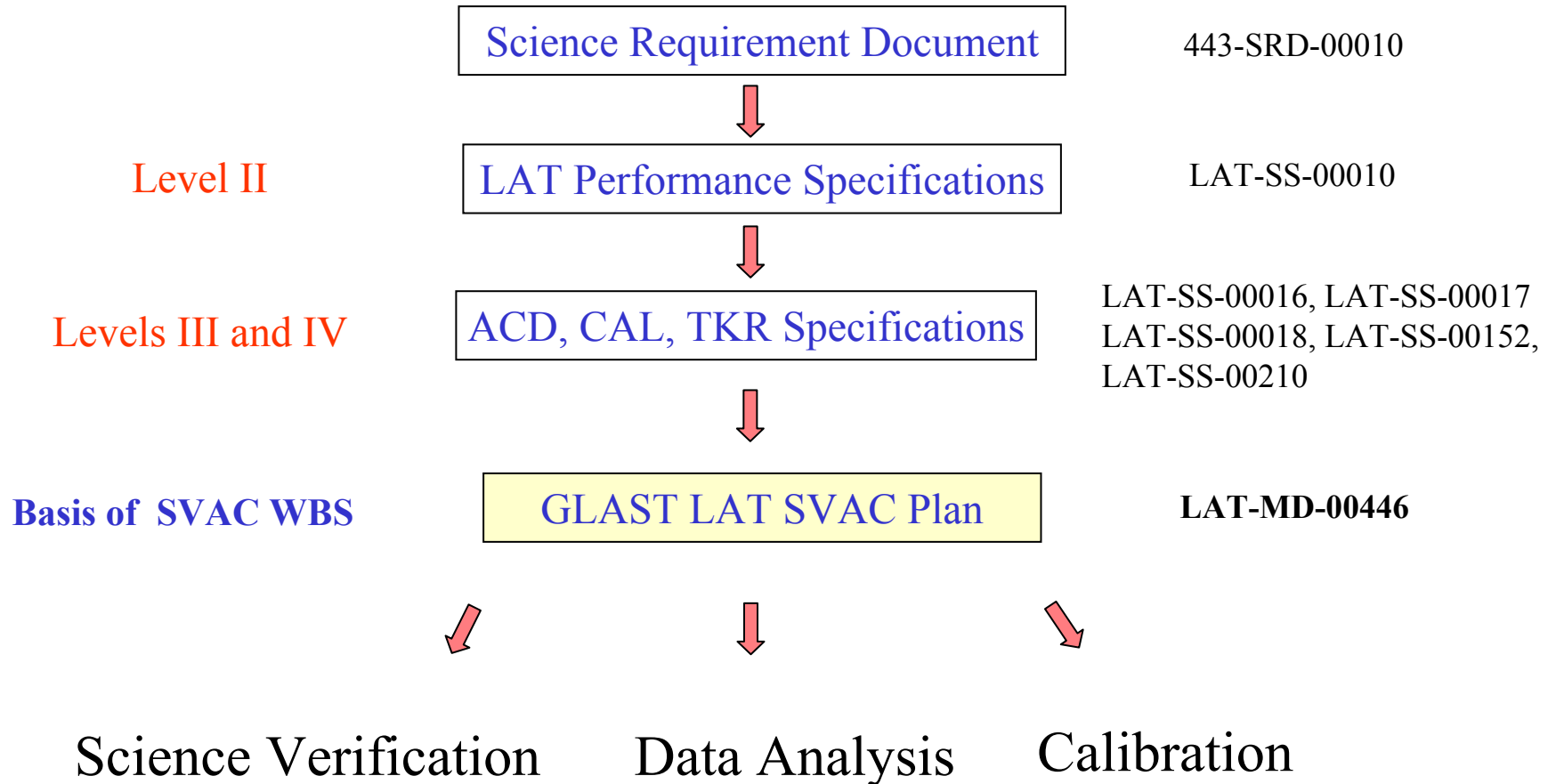
- **On-orbit Calibration relies on a LAT-wide collaboration effort and leadership from Instrument Operations Center. The I&T participation is strong since**
  - **I&T and IOC will share a scientist to ensure a smooth transition between pre and post launch operations**
  - **I&T will support the development and testing of operational concepts during the pre launch activities (e.g. data monitoring, diagnostics and trend analysis)**
  - **I&T will deliver a calibrated instrument to the IOC after commissioning on orbit.**
  
- **On orbit Calibration Strategy (these must be revised as IOC enters in its CDR phase)**
  - 1. There two special data taking modes**
    - **Selected events from Galactic Cosmic Rays (survey, energy calibration,...)**
    - **Charge injection to verify front-end electronics (low level calibration)**
  - 2. Post launch Calibration tasks**
    - **Are identified in LAT-MD-00446**
    - **The following tasks will be fully defined by the IOC CDR**
      - **whether data is reduced on-orbit or on the ground**
      - **the frequency that calibrations are to be performed**

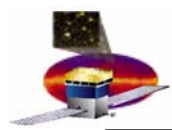


## **Back up slides – EM example**



# Science Verification, Analysis and Calibration (SVAC) System





# SVAC Activities Flow

