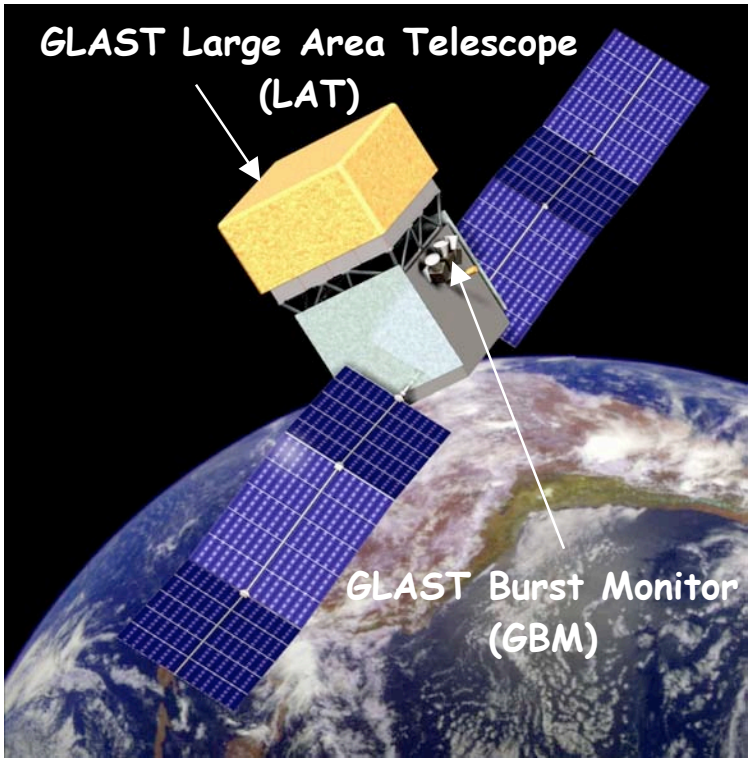


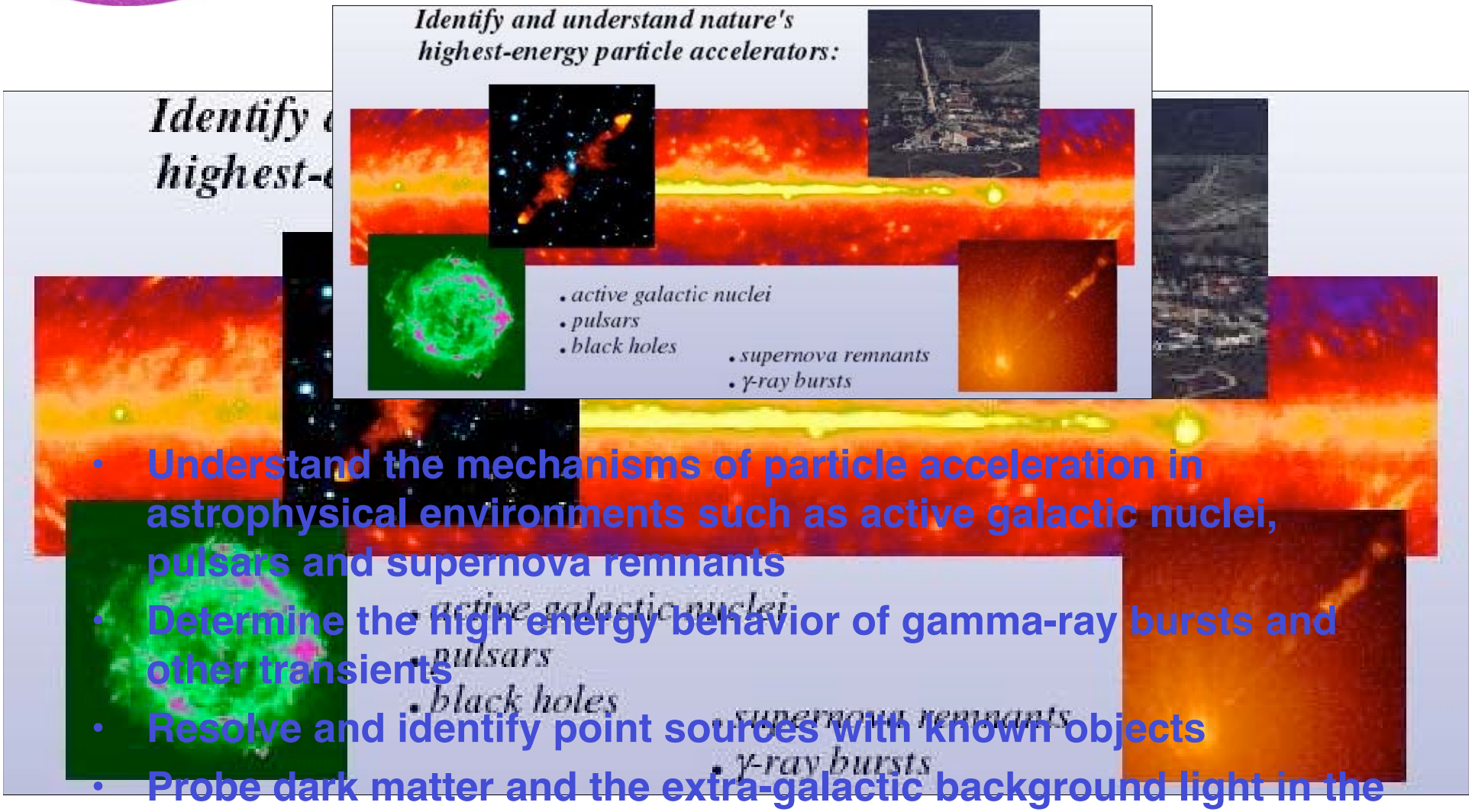
GLAST
Mission Formulation

Jonathan Ormes
Project Scientist

Jonathan.F.Ormes@nasa.gov

GLAST Users Group
GSFC, October 22, 2003

Mission Objectives



- Understand the mechanisms of particle acceleration in astrophysical environments such as active galactic nuclei, pulsars and supernova remnants
- Determine the high energy behavior of gamma-ray bursts and other transients
- Resolve and identify point sources with known objects
- Probe dark matter and the extra-galactic background light in the early universe

Department of Energy Office of Science

Understand the nature of matter at the most fundamental level and to explore the evolution and fate of the universe through fundamental interactions of energy, matter, time and space.

NASA - Office of Space Science

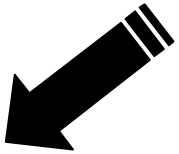
Chart the evolution of the universe, from origins to destiny

1. Understand the structure of the universe

2. Explore the ultimate limits of gravity and and energy in the universe

3. Learn how galaxies, stars and planets form, interact and evolve

Particle physics



Astronomy/astrophysics

Gamma ray Large Area Space Telescope (GLAST)

An astro-particle physics partnership to explore the high-energy universe

GLAST is an International Mission

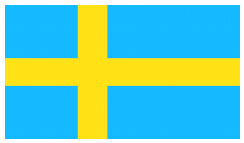
NASA - DoE Partnership on LAT

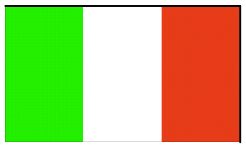
LAT is being built by an international team

- **Si Tracker:** Stanford, UCSC, Japan, Italy
- **CsI Calorimeter:** NRL, France, Sweden
- **Anticoincidence:** GSFC
- **Data Acquisition System:** Stanford, NRL

GBM is being built by US and Germany

- **Detectors:** MPE


Sweden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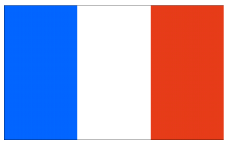
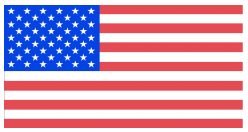
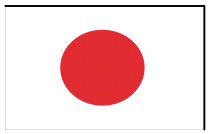
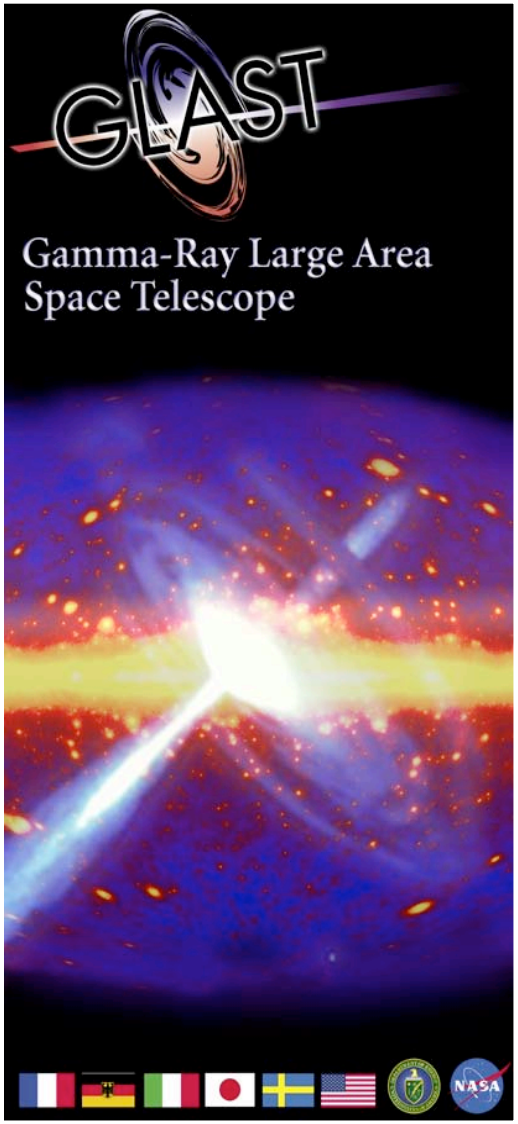

France

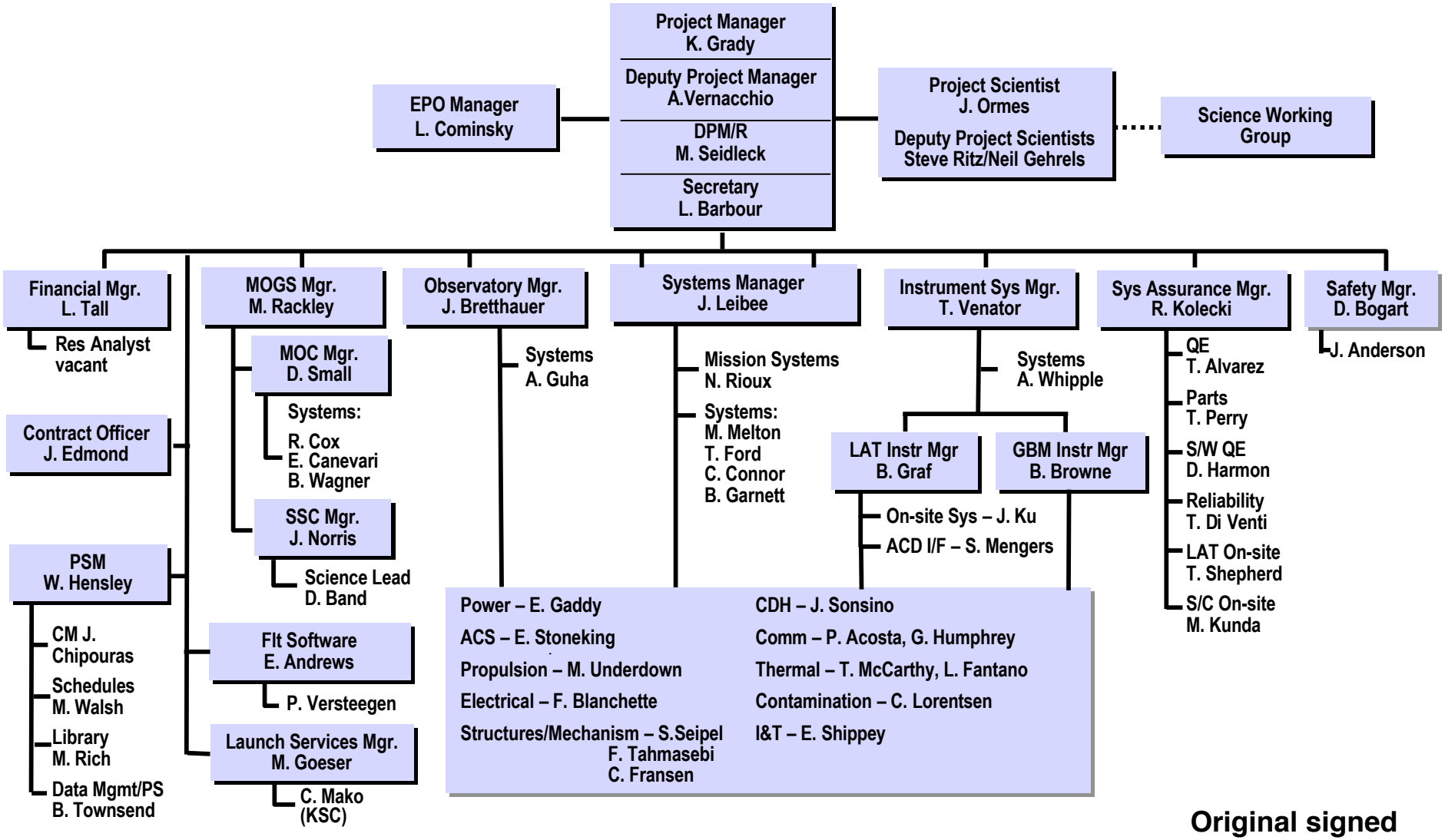

Germany


USA


Japan



GLAST Project Organization



Original signed

Kevin Grady
GLAST Project Manager
September 9, 2003

Science Requirements

- **High Energy Gamma Rays: 20 MeV - > 300 GeV**
  - **Source location <0.5 arcmin**
    - **High latitude source of 10^{-7} cm^{-2} s^{-1} flux, E^{-2} spectrum,**
      - **1 σ radius, after 1 yr survey**
  - **Point source sensitivity < 6 x 10^{-9} cm^{-2} s^{-1}**
    - **High latitude source after 1 yr survey, 5 σ detection**
  - **Background to be < 10% of extragalactic high latitude diffuse emission**
- **Conduct broad band study of gamma ray bursts**
  - **Determine burst spectra from <10 keV to ~30 GeV**
  - **Determine burst locations <15 degrees and send to the GRB notification network (GCN) within 7 seconds**

Mission Requirements and Observing Plan

- **Spacecraft**
  - Pointing knowledge < 10 arcseconds (1σ)
  - Observatory is designed to "point anywhere, anytime"
    - Operate without pointing at the Earth
    - Reorient quickly and autonomously to follow a transient or respond to a target of opportunity
      - Slew 75 degrees in 10 minutes
  - 3 normal operational modes
    - Scan (baseline)
    - Inertial pointing
    - Scan pointing - takes advantage of the wide field of view to optimize time on sky
- **Mission Lifetime 5 years, Goal 10 years** (subject to Senior Review)
  - Observatory checkout 30-60 days
  - First year is scanning to make all sky survey
    - Planned observations subject to interruption for extraordinary transients
  - Second year and beyond - operational mode driven by competitive proposals

Guest Investigator Program

- GI program starts during the survey
  - 10-15 GIs
- Will grow to ~100 Guest Investigations funded by NASA each year.
- GLAST Fellows program

- Continue Interdisciplinary Scientist (IDS) Program
  - C. Dermer (NRL) - non-thermal universe
  - B. Dingus (Los Alamos) - transients
  - M. Pohl (Iowa State U.) - diffuse galactic
  - S. Thorsett (UCSC) - pulsars

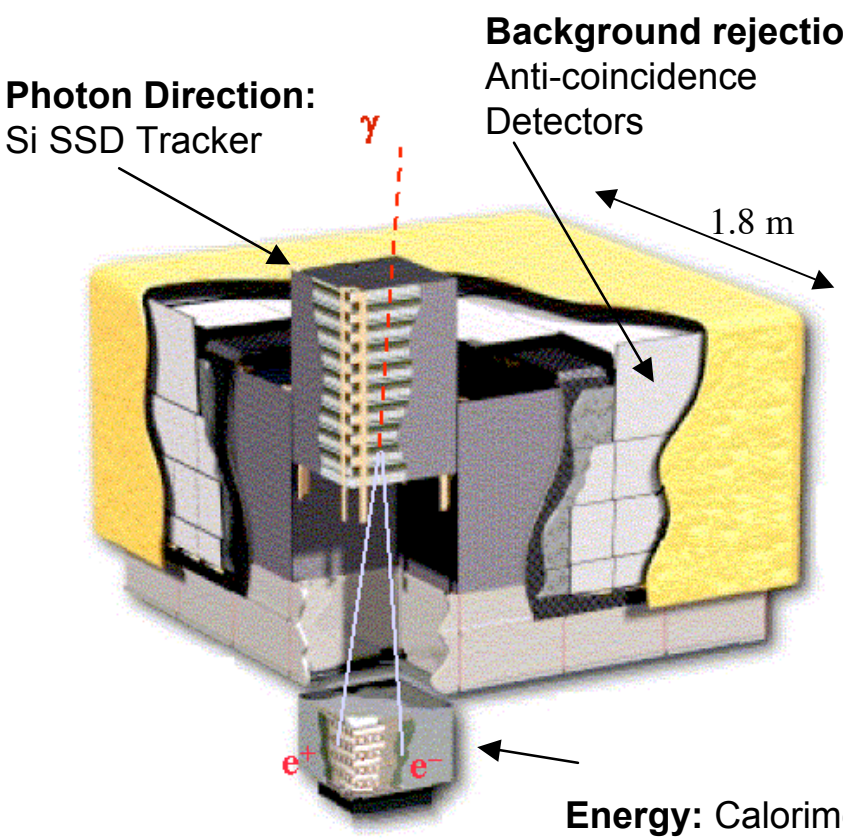
- Program of Education and Public Outreach continues throughout the mission

Science Review History Highlights

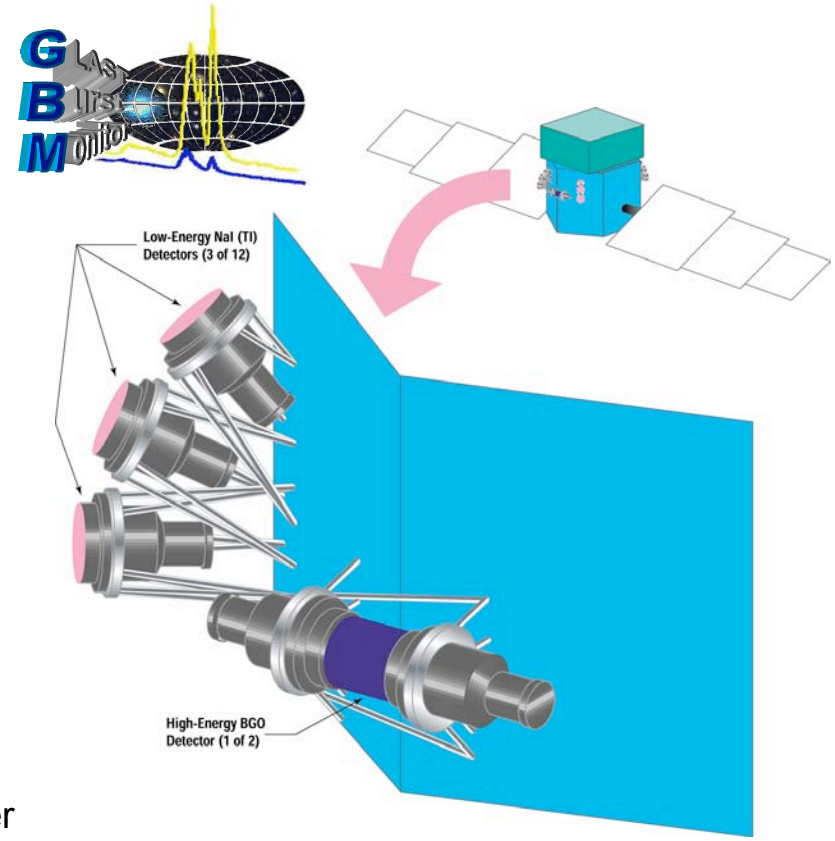
- Selected as mission concept study, 1994 (PI: Michelson, Stanford)
- Endorsed by Gamma-Ray Astronomy Program Working Group as highest priority in gamma-ray astronomy, 1996
- Chosen as top priority (with Constellation-X) by Structure and Evolution of the Universe Subcommittee, 1997
- Reviewed by SAGENAP, presented to HEPAP, and approved by DoE, 1998
- Science Requirements Document, drafted by Facility Science Team, signed in July 1999.
- NASA AO: August 1999. Selections: February-March 2000.
- **GLAST is the highest-ranked Moderate Size space-based initiative in the National Academy of Sciences 2000 Decadal Survey Report.**

GLAST Instruments

Large Area Telescope (LAT)
PI: Peter Michelson
Stanford University



GLAST Burst Monitor (GBM)
PI: Charles Meegan
Marshall Space Flight Center



Large Area Telescope Parameters

	CGRO/EGRET	GLAST/LAT	Change
Energy Range	20 MeV - 30 GeV	20 MeV - > 300 GeV	10 to 300 GeV
Energy Resolution ($\Delta E/E$)	0.1	0.1	
Effective Area (1GeV)	1500 cm^2	10,000 cm^2	6.6
Field of View	0.5 sr	2.4 sr	4.8
Angular Resolution	5.8° @ 100 MeV 0.5° @ 10 GeV	~ 3.5° @ 100 MeV ~ 0.1° @ 10 GeV	Area = 1/2.7 Area = 1/25
Sensitivity (> 100 MeV)*	~ 10^{-7} cm^{-2} s^{-1}	~ 3×10^{-9} cm^{-2} s^{-1}	1/30
Deadtime	100 ms	<10 μs	> 5
Mass	1810 kg	3000 kg	
Lifetime	1991 - 1997	2006 - 2016	

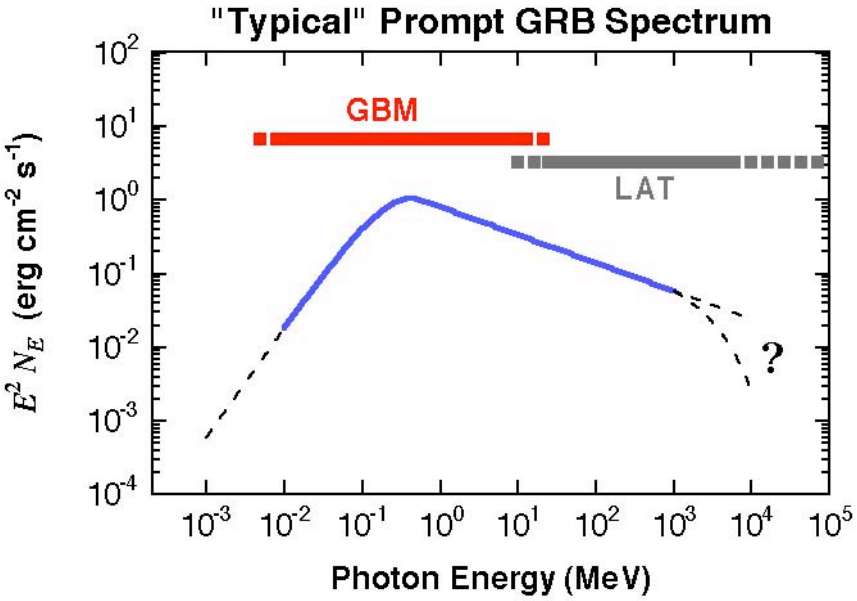
* 1 year survey at high latitudes

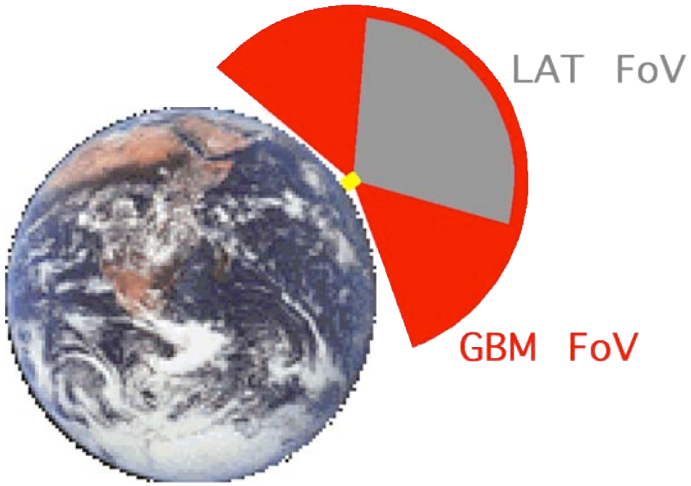
Increased area, field of view, angular resolution, extended energy range and operational efficiency provide a powerful combination!

GLAST Burst Monitoring

- **LAT and GBM work synergistically to make new GRB observations**

- **GBM provides low-energy context measurements with high time resolution**
  - **Broad-band spectral sensitivity**
  - **Contemporaneous low-energy & high-energy measurements**
  - **Continuity with current GRB knowledge-base (GRO-BATSE)**

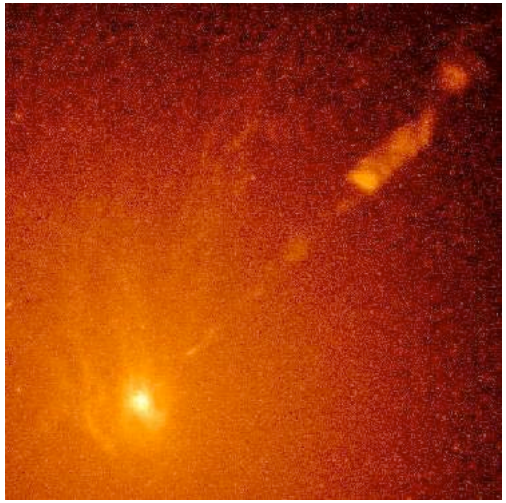


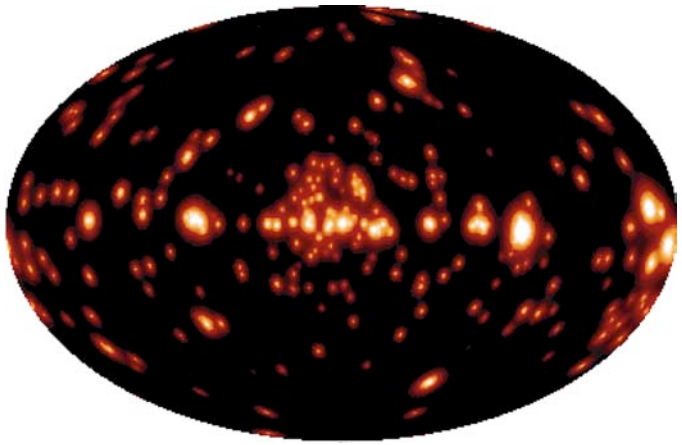


- **Provides rapid GRB timing & location triggers w/FoV > LAT FoV**
  - **Improved sensitivity and response time for weak bursts**
  - **Follow particularly interesting bursts for afterglow observations**
  - **Provide rapid locations for ground/space follow-up**

Science Topics

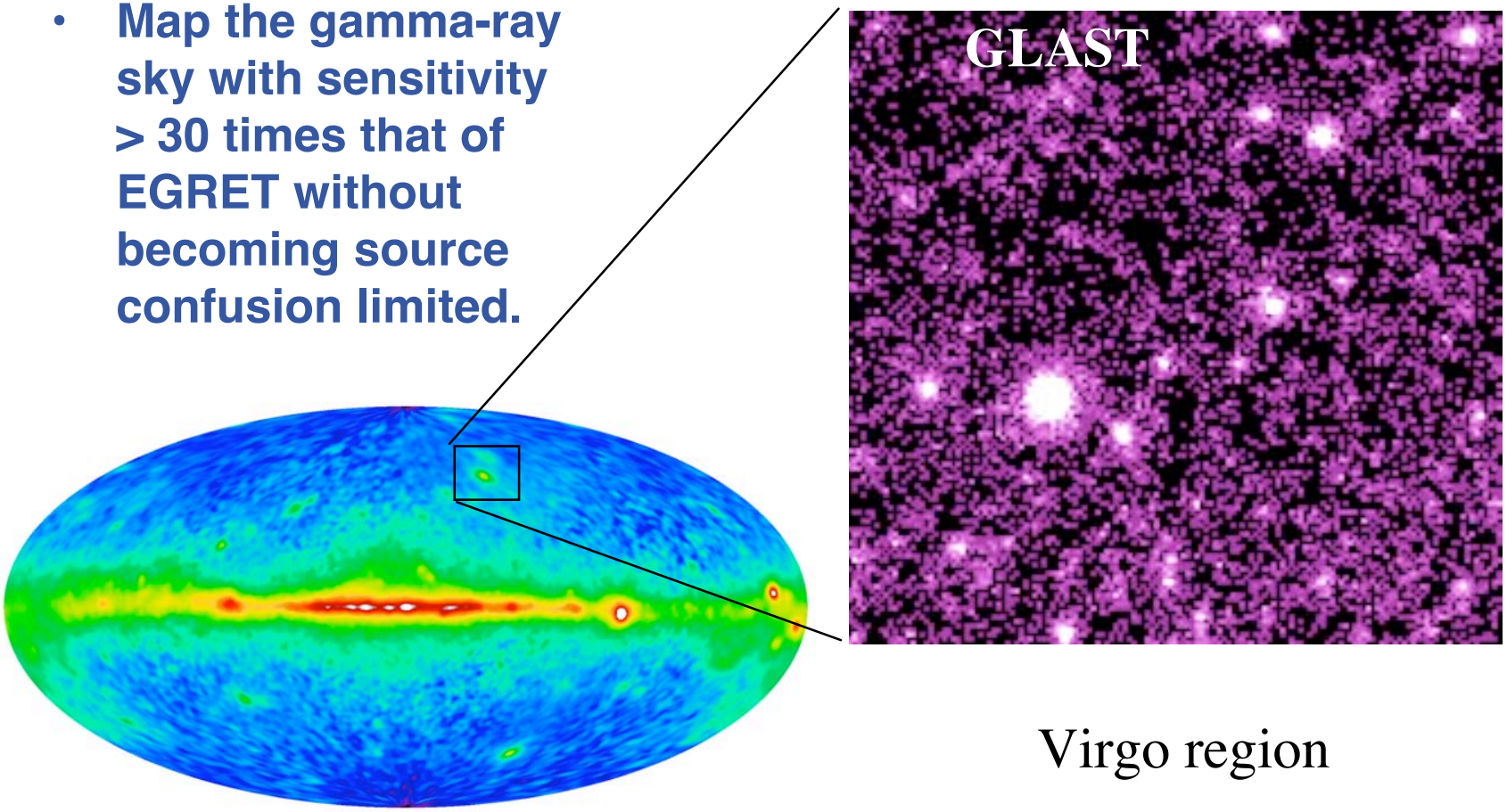
- Active Galactic Nuclei
- Isotropic Diffuse Background Radiation
- Cosmic Ray Production:
  - Molecular Clouds
  - Supernova Remnants
  - Normal Galaxies
- Endpoints of Stellar Evolution
  - Neutron Stars/Pulsars
  - Black Holes
- Unidentified Gamma-ray Sources
- Dark Matter
- Solar Physics
- Gamma-Ray Bursts





From EGRET to GLAST (>100 MeV)

- Map the gamma-ray sky with sensitivity > 30 times that of EGRET without becoming source confusion limited.



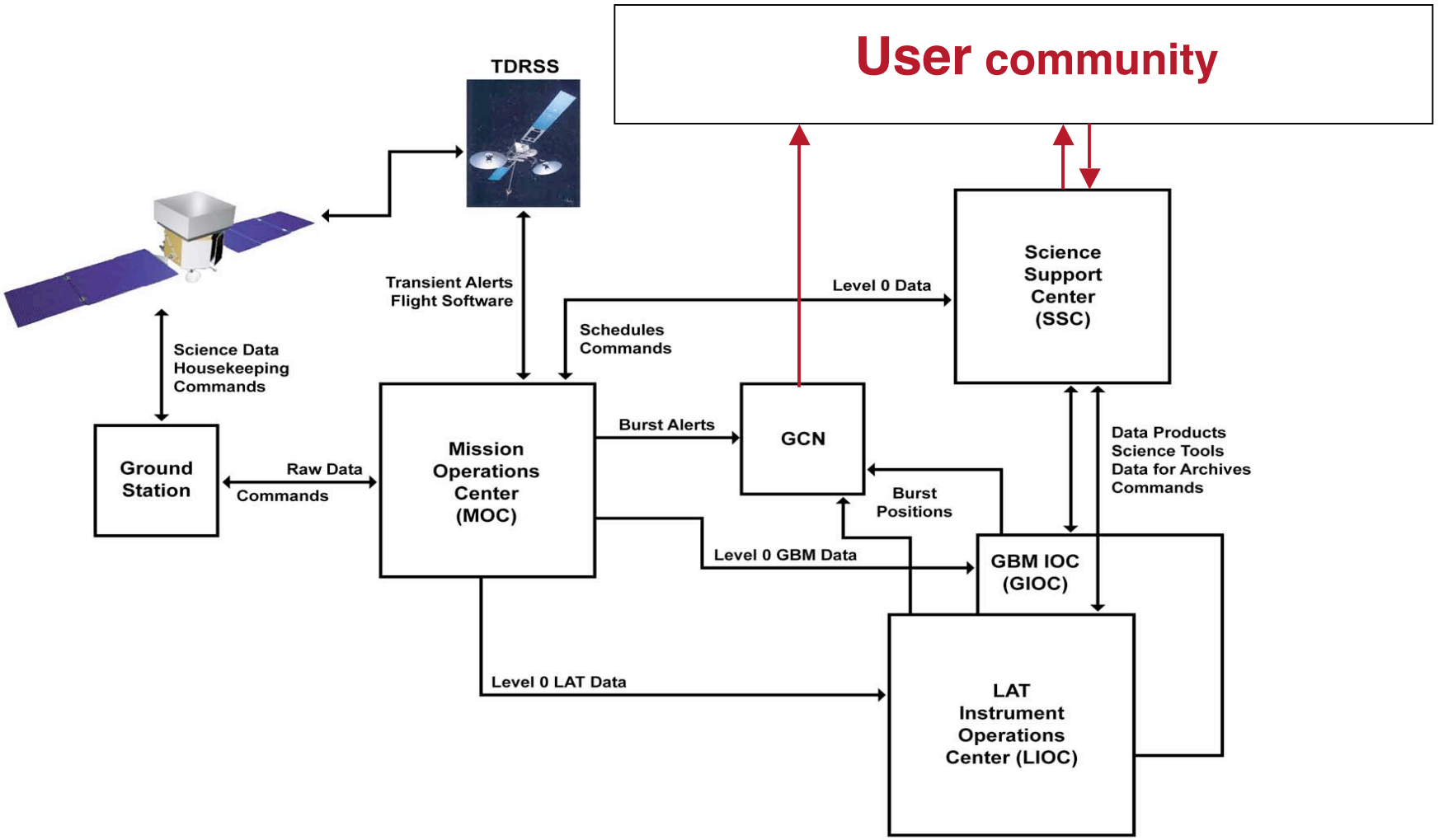
Virgo region

Total Mission All-Sky Map (E > 100 MeV)

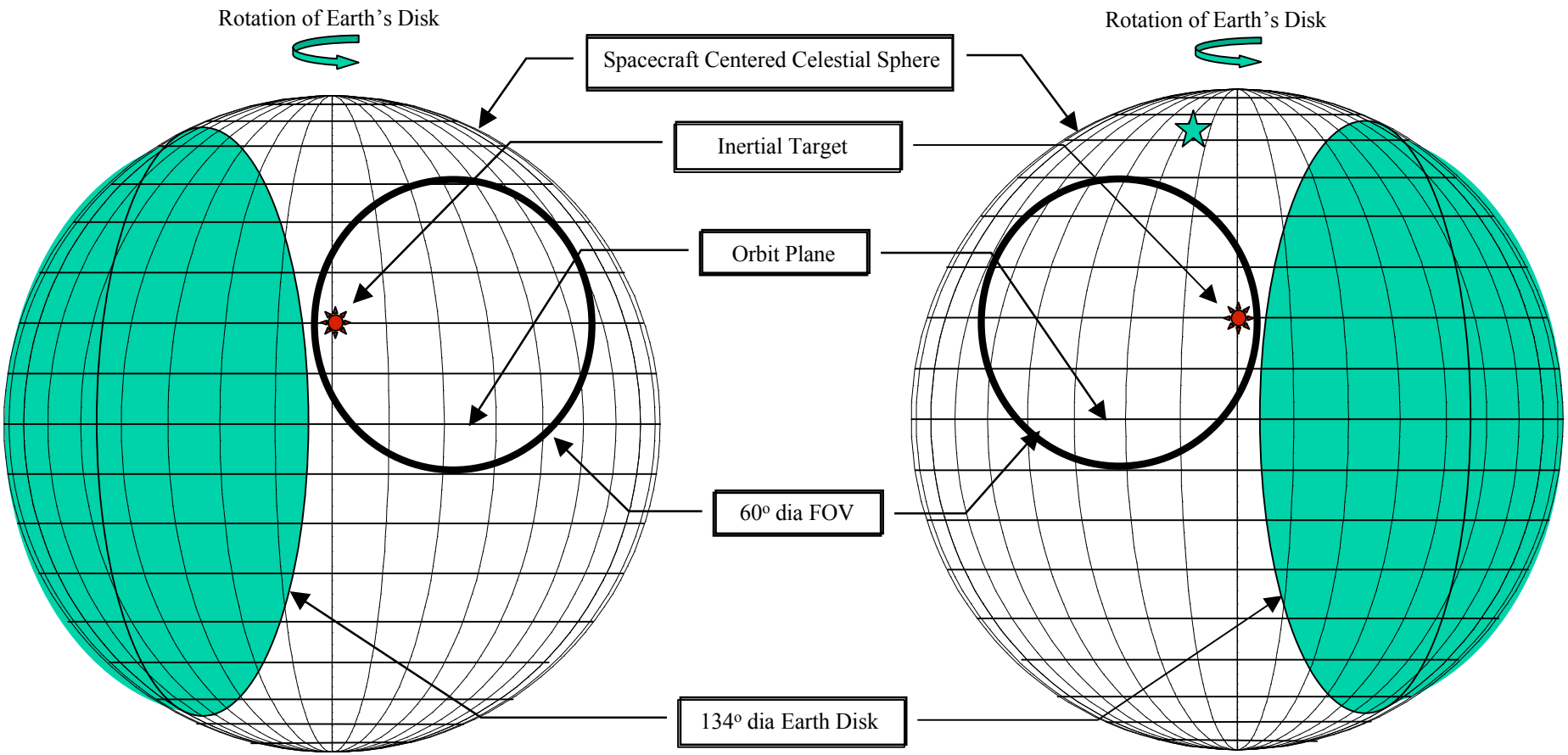
GLAST Project Master Schedule

- Instrument preliminary Design Reviews completed
- Spacecraft contractor selected: Spectrum-Astro
  - S/C PDR May 2003
- Critical Design Reviews for instruments
  - Held LAT May 2003
  - GBM June 2004
- CDR for Spacecraft scheduled for spring 2004
- Instrument deliveries in 2005
  - GBM fall
  - LAT December
- Launch in Feb 2007

GLAST Ground System



Earth Avoidance for Pointed Observations



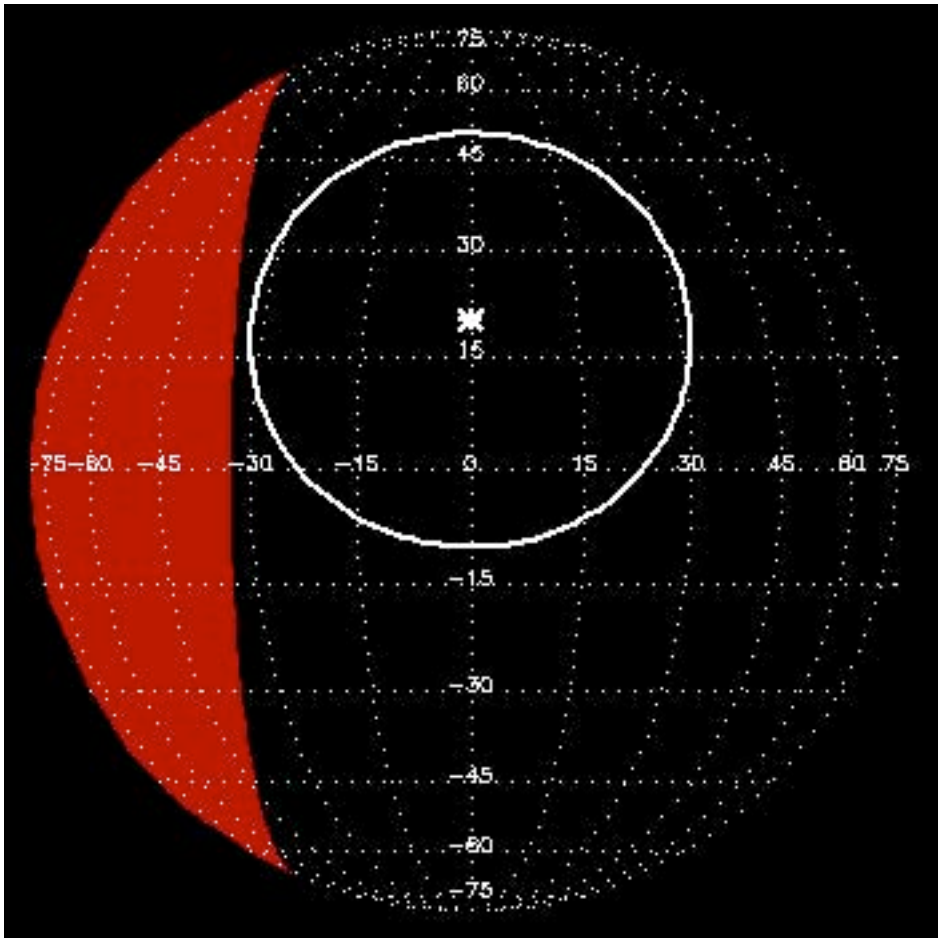
Before Occultation

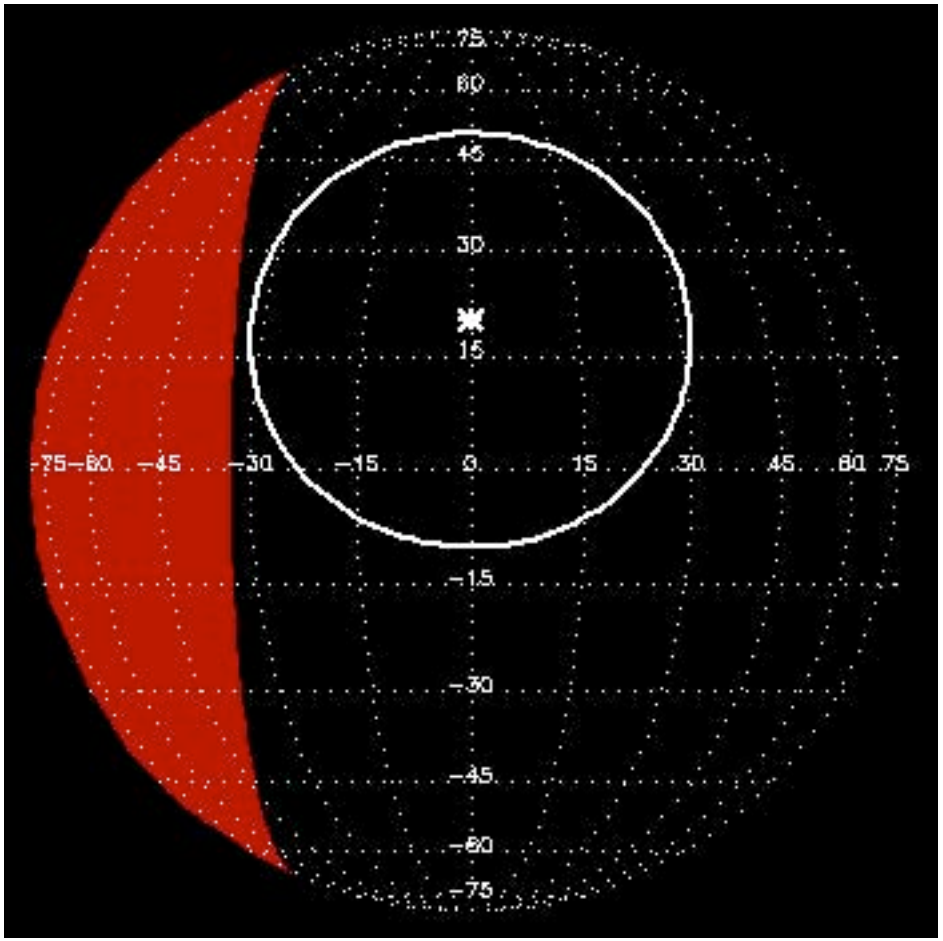
- Earth's disk is approaching from the left
- FOV is losing inertial target

After Occultation

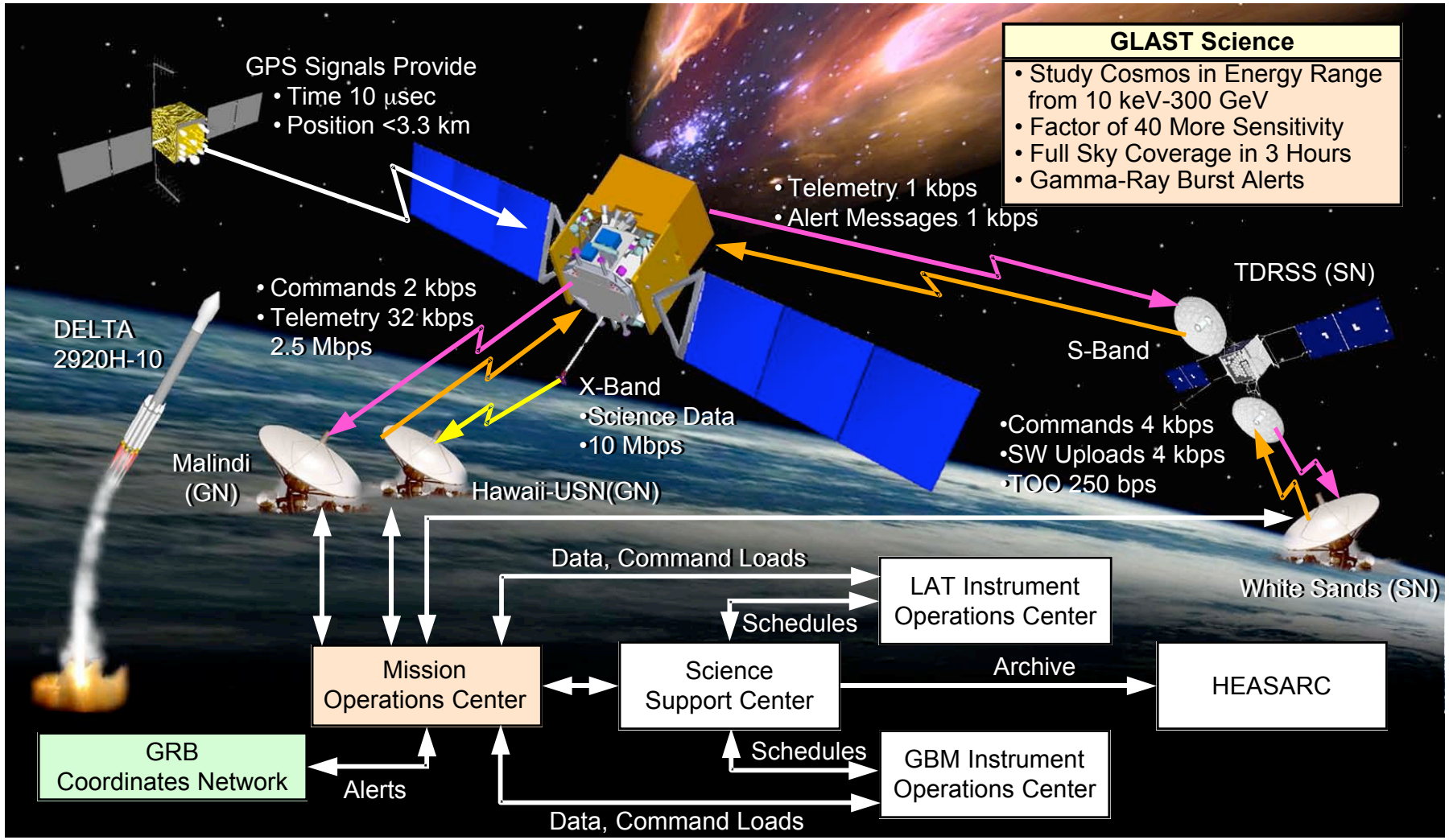
- Earth's disk is receding to the right
- FOV is picking up inertial target

Scan-pointing





GLAST Mission Overview



Summary of Capabilities

- Huge FOV (20% of sky) allows primarily scanning operations
- Opens unexplored region > 10 GeV
- Unprecedented PSF for gamma rays (factor 5 better than EGRET at 10 GeV)
- Expect to find new classes of gamma-ray sources with the improved sensitivity
- No expendables ∧ potential for long mission without degradation
- Large sensitive area (> 6× EGRET) for transients
- Quick reaction to gamma-ray bursts and other transients

GBM Capabilities

	BATSE	GBM - Requirement	GBM - Current Design
Energy Range	25 keV – 10 MeV	<10 keV – >25 MeV	6 keV - 30 MeV
Field of View	All sky not occulted by Earth	>8 sr	8.7 sr
Energy Resolution	<10%	<10% (0.1-1.0 MeV, 1σ on-axis)	7% (100 keV) 5% (1 MeV)
Deadtime		< 10 μs/event	2.5 μs/event
Burst Sensitivity - Ground (5σ, 50-300 keV)	0.2 cm^{-2} s^{-1}	<0.5 cm^{-2} s^{-1}	0.45 cm^{-2} s^{-1}
Burst Sensitivity - On-board (5σ, 50-300 keV, 50% efficiency)		<1.0 cm^{-2} s^{-1}	0.78 cm^{-2} s^{-1}
GRB Alert Location	~25°	-	<15°
GRB Final Location	1.7°	-	<1.5°
GRB Notification Time to Spacecraft		<2s	2s (arbitrarily selectable, trade-off between speed & accuracy)

LAT Capabilities

	EGRET	LAT - Requirement	LAT - Current Design
Energy Range	20 MeV – 30 GeV	20 MeV – 300 GeV	20 MeV - 300 GeV
Energy Resolution	10 %	<10%, 0.1–100 GeV (1σ, on-axis)	~9%, 0.1–100 GeV
Effective Area	1500 cm^2	>8000 cm^2 (maximum value, 1-10GeV)	10,000 cm^2 at 10 GeV
Point Source Sensitivity (5σ, >100 MeV)	~1 × 10^{-7} cm^{-2} s^{-s}	<6 × 10^{-9} cm^{-2} s^{-2} (at high gal. latitude for 1-year sky survy, for photon index of -2)	3 × 10^{-9} cm^{-2} s^{-2}
Angular Resolution	5.8° (100 MeV)	<3.5° (100 MeV) <0.15° (>10 GeV)	3.4° (100 MeV) 0.086° (>10 GeV)
Source Location Determination	15 arcmin	<0.5 arcmin (1σ radius, flux 10^{-7} cm^{-2} s^{-1} at 100 MeV, high gal latitude)	0.4 arcmin
Field-of-view	0.5 sr	>2 sr	2.4 sr
Timing Accuracy	100 μs	<10 μs	TBD
Deadtime	100 ms/event	<100 μs/event	TBD
GRB Location Accuracy On-Board		<10 arcmin	5 arcmin
GRB Notification Time to Spacecraft		<5 s	TBD