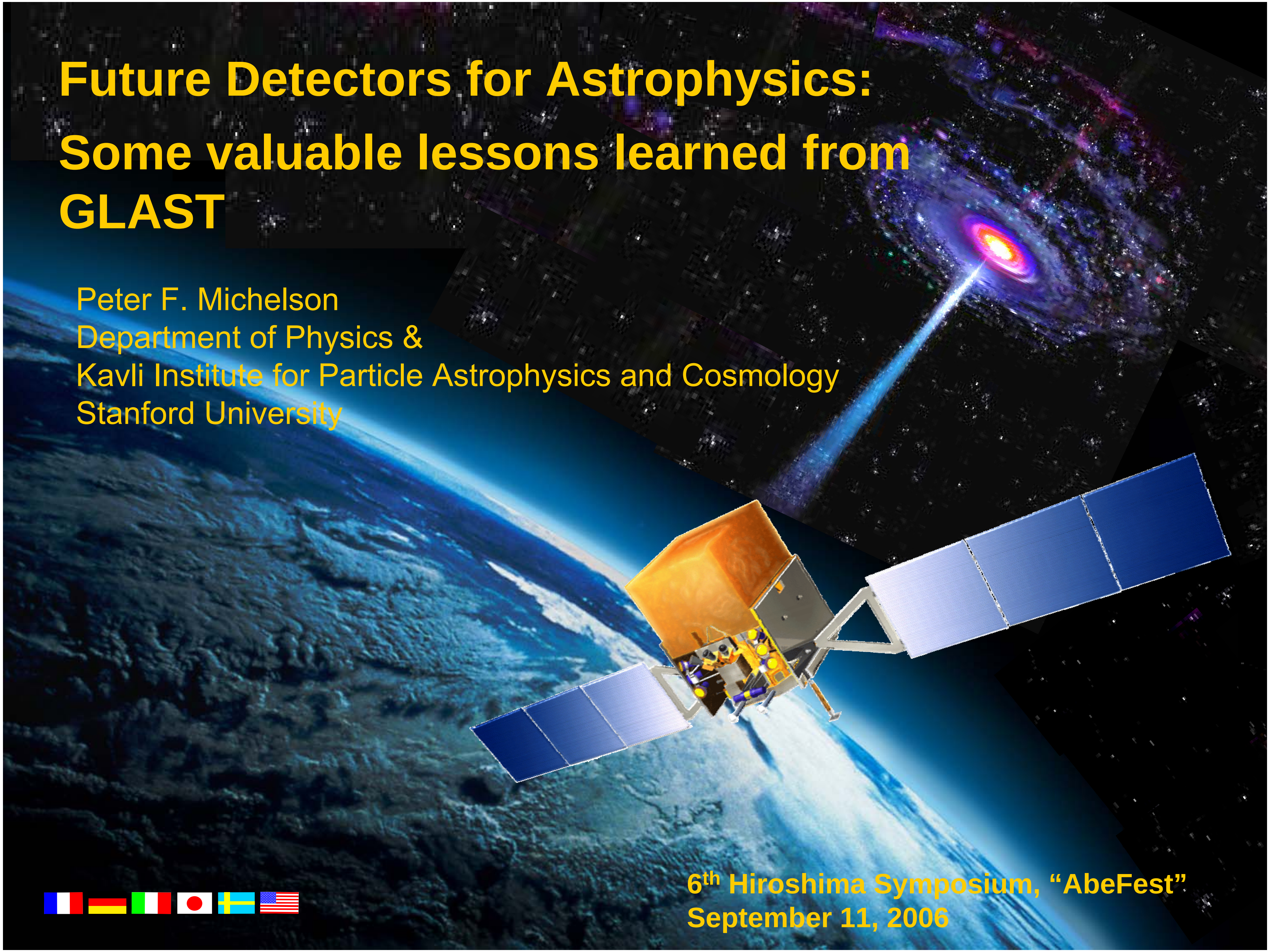
Future Detectors for Astrophysics:
Some valuable lessons learned from
GLAST
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Department of Physics &
Kavli Institute for Particle Astrophysics and Cosmology
Stanford University
6th Hiroshima Symposium, “AbeFest”
September 11, 2006

Why study γ's?

- *γ rays offer a direct view into Nature's largest accelerators.*
- *the Universe is mainly transparent to γ rays: can probe cosmological volumes. Any opacity is energy-dependent ($\gamma + \gamma \rightarrow e^+ + e^-$).*
- *conversely, γ rays readily interact in detectors, with a clear signature.*
- *γ rays are neutral: no complications due to magnetic fields. Point directly back to sources, etc.*

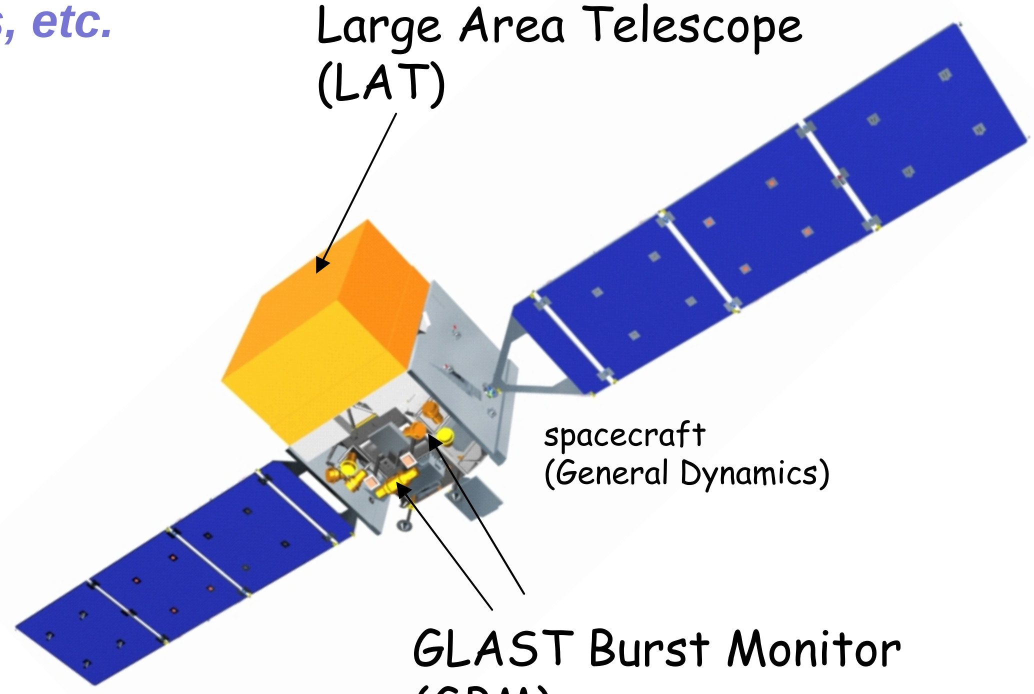
Two GLAST instruments:

LAT: 20 MeV – >300 GeV

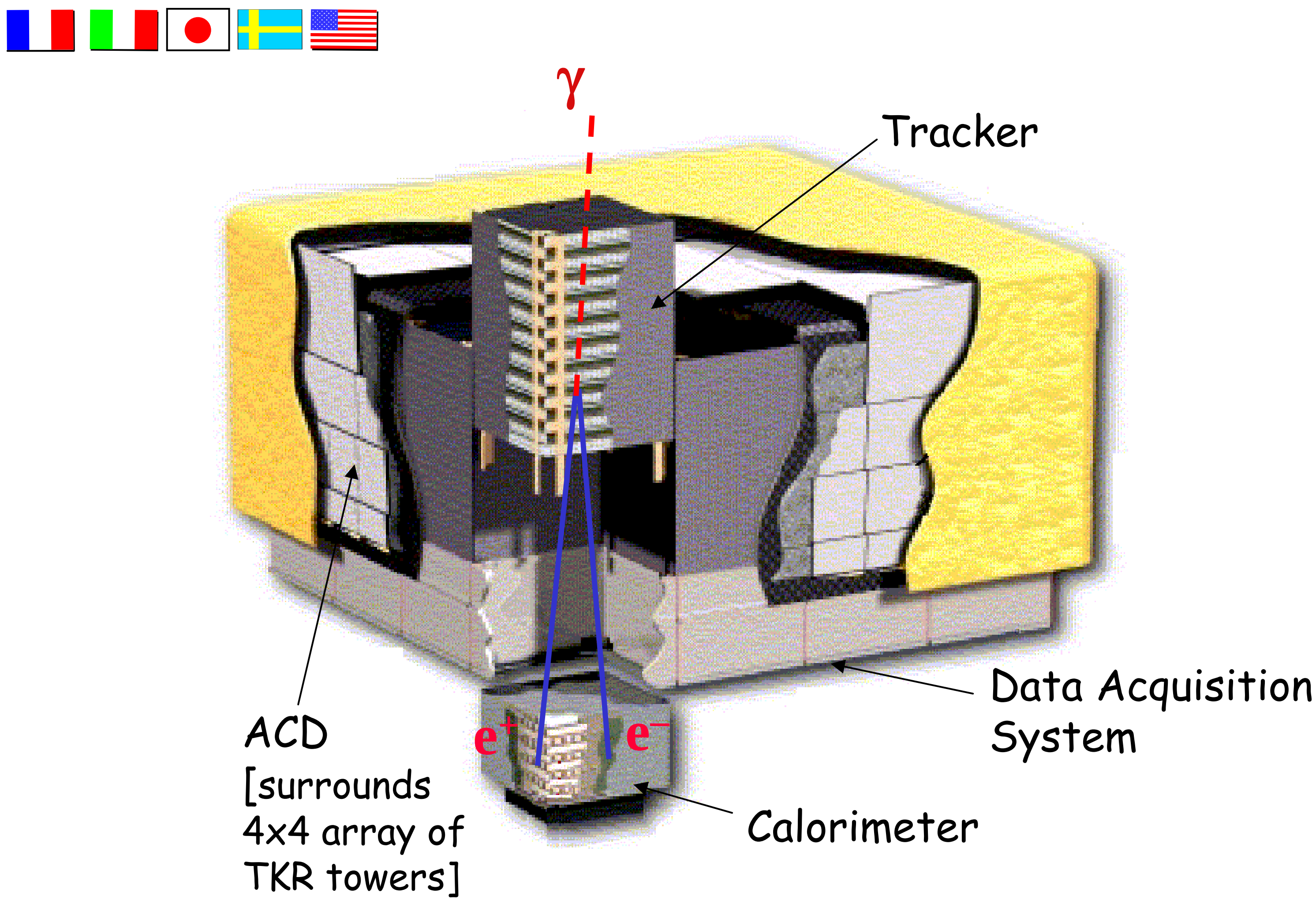
GBM: 10 keV – 25 MeV

Launch: Autumn 2007

5-year mission (10-year goal)



The Large Area Telescope



GLAST LAT Collaboration

Astrophysics – Particle Physics Partnership

United States

- *California State University at Sonoma*
- *University of California at Santa Cruz - Santa Cruz Institute of Particle Physics*
- *Goddard Space Flight Center – Laboratory for High Energy Astrophysics*
- *Naval Research Laboratory*
- *Ohio State University*
- *Stanford University (SLAC and HEPL/Physics)*
- *University of Washington*
- *Washington University, St. Louis*

France

- *IN2P3, CEA/Saclay*

Italy

- *INFN, ASI*

Japanese GLAST Collaboration

- *Hiroshima University*
- *ISAS, RIKEN*

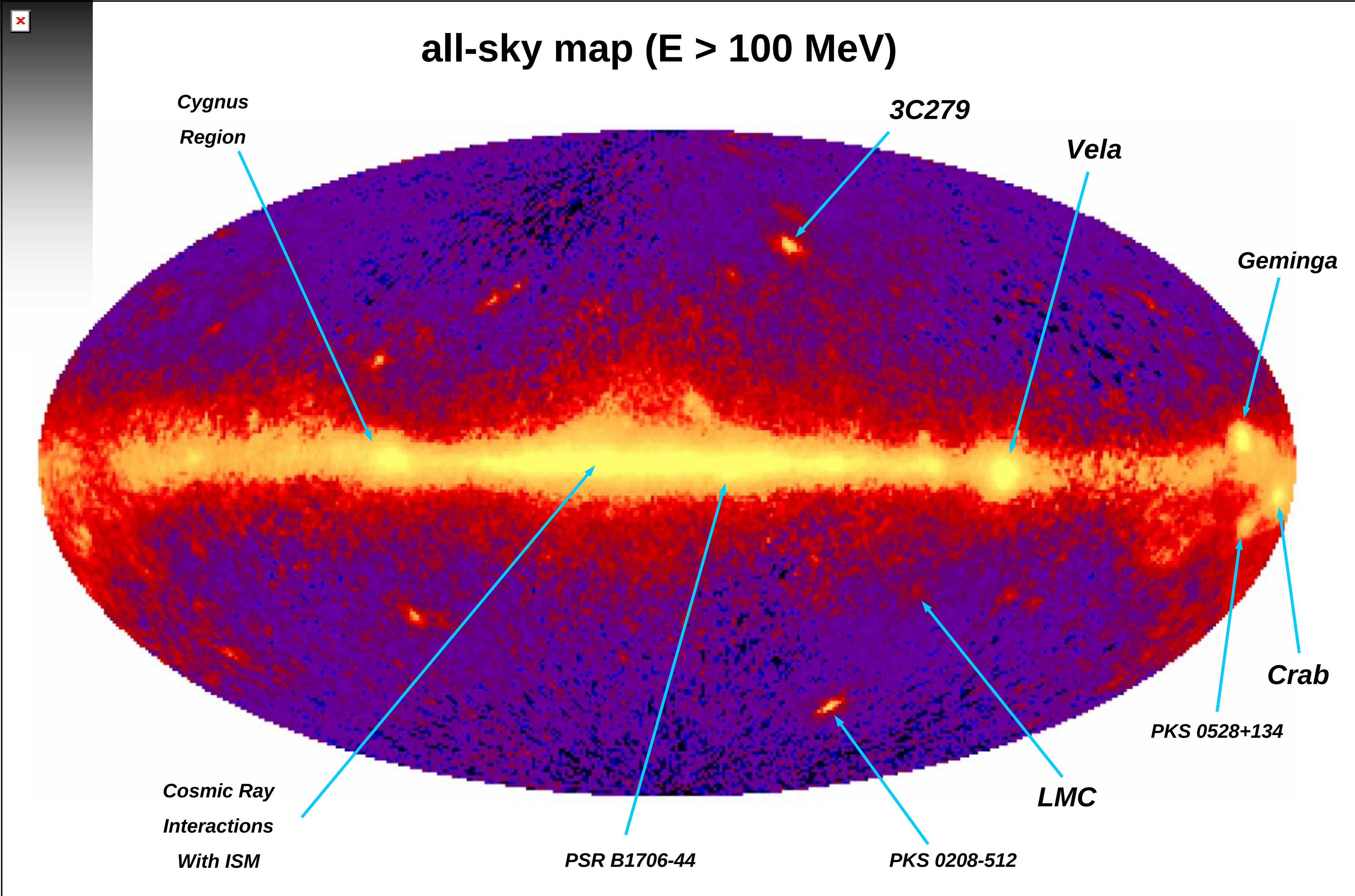
Swedish GLAST Collaboration

- *Royal Institute of Technology (KTH)*
- *Stockholm University*

LAT possible because of partnership between

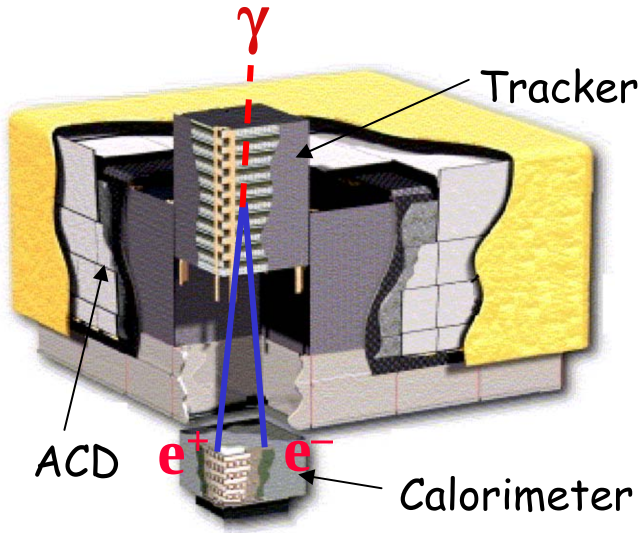
- ***engineers & scientists: from particle physics & astrophysics,***
- ***laboratories: SLAC, GSFC, and collaborating labs***
- ***agencies and institutes***

The CGRO-EGRET legacy



GLAST development status

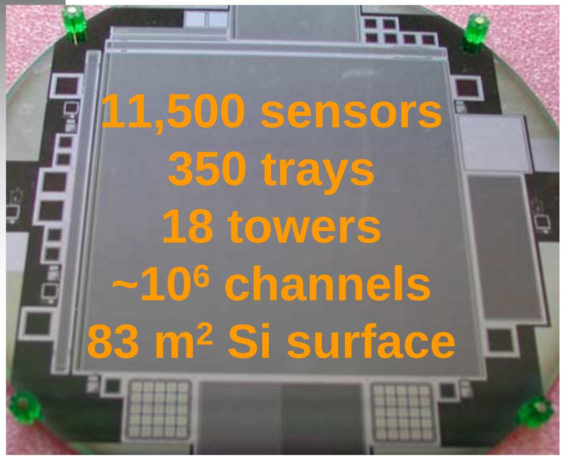
- ***assembly of all science instrument elements complete:***
  - ***Large Area Telescope (LAT) undergoing instrument-level environmental test; delivery expected before end of September***
  - ***GLAST Burst Monitor (GBM) delivered for observatory integration***
- ***beam test of LAT spare flight modules underway at CERN***
- ***Observatory integration and test – Fall 2006 to Fall 2007***
- ***first GLAST International Science Symposium will be at Stanford University, Feb 5-8, 2007***
- ***GLAST launch in last quarter of 2007***
- ***Science operations begin within 60 days of launch***

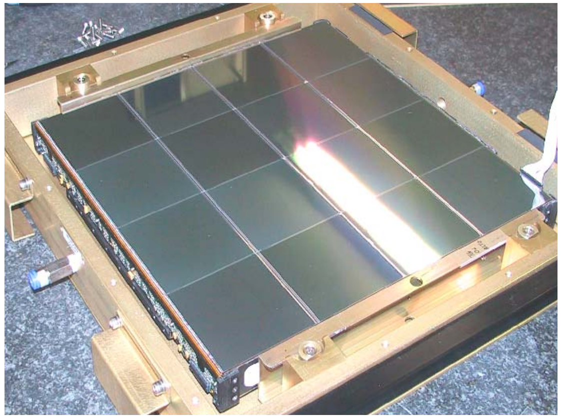


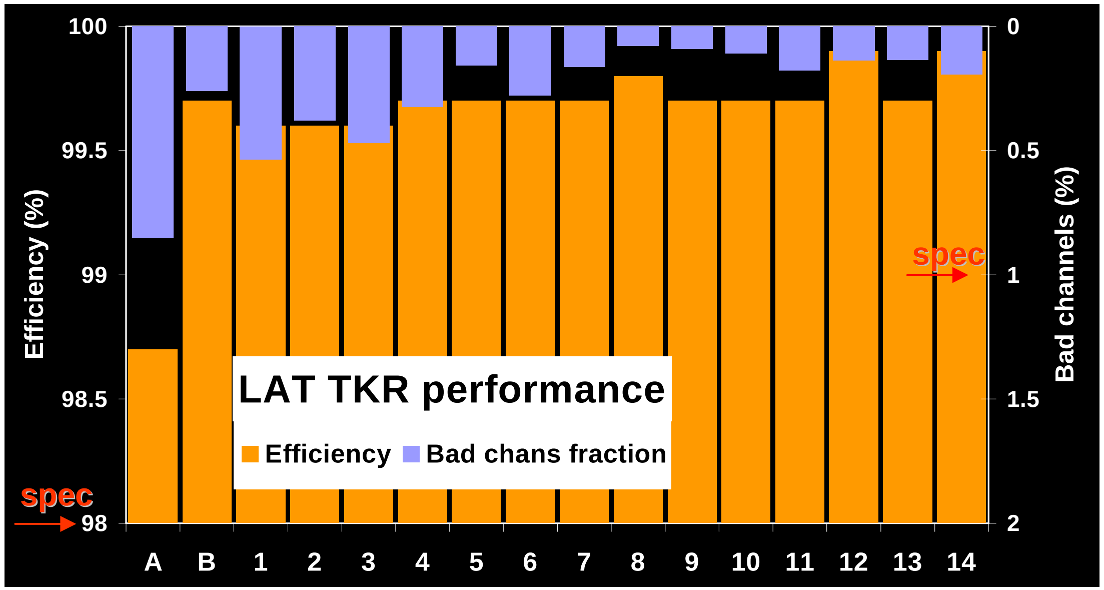
GLAST spacecraft being assembled

LAT Silicon Tracker

team effort involving ~70 physicists and engineers from Italy (INFN & ASI), the United States, and Japan

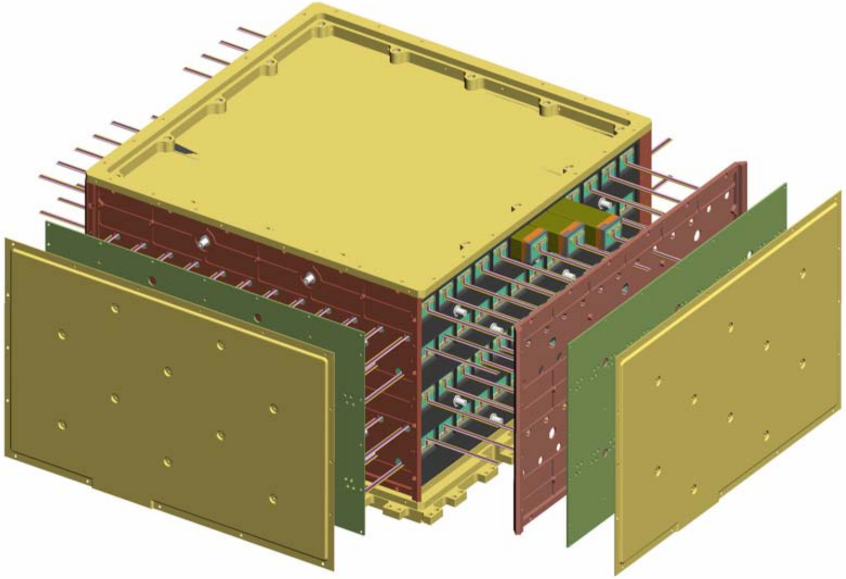


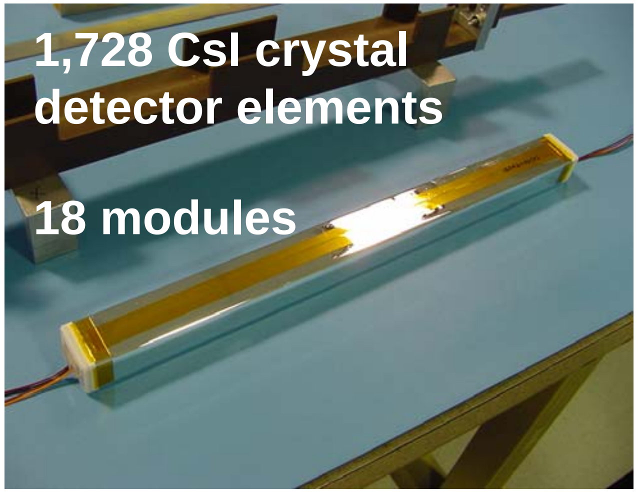


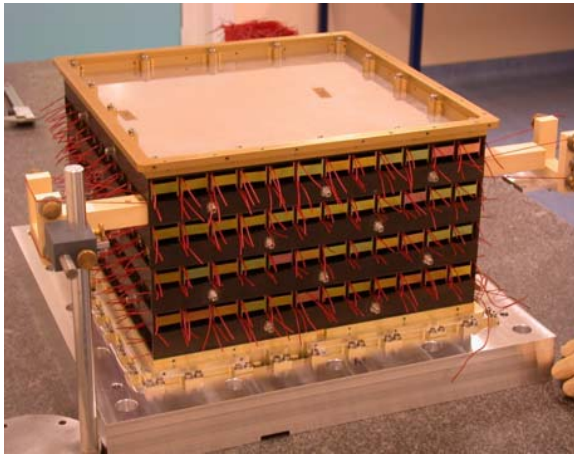


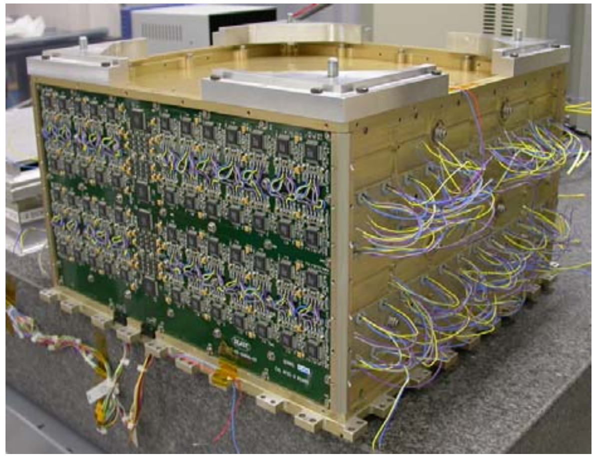
LAT Calorimeter

team effort involving physicists and engineers from the United States, France (IN2P3 & CEA), and Sweden









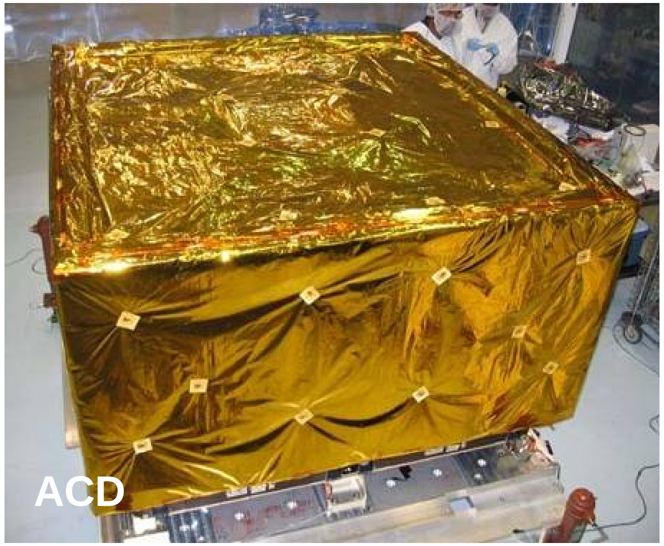
LAT Anti-Coincidence Detector

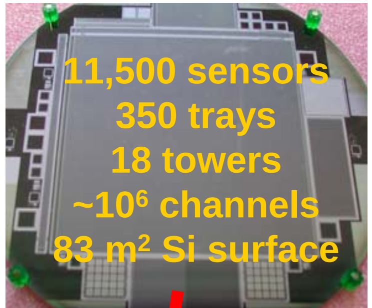
team effort involving physicists and engineers from Goddard Space Flight Center, SLAC, and Fermi Lab

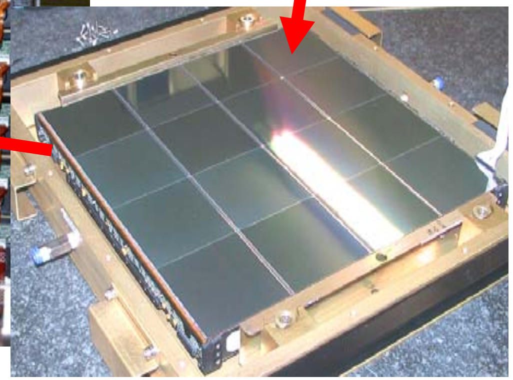
ACD before installation of Micrometeoroid Shield

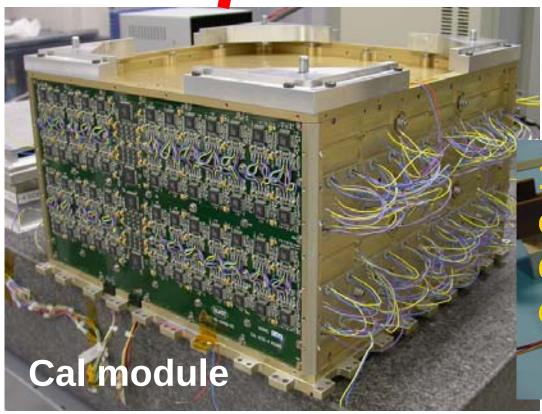
ACD with Micrometeoroid Shield and Multi-Layer Insulation (but without Germanium Kapton outer layer)

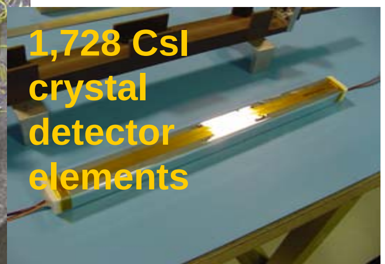
LAT is assembled

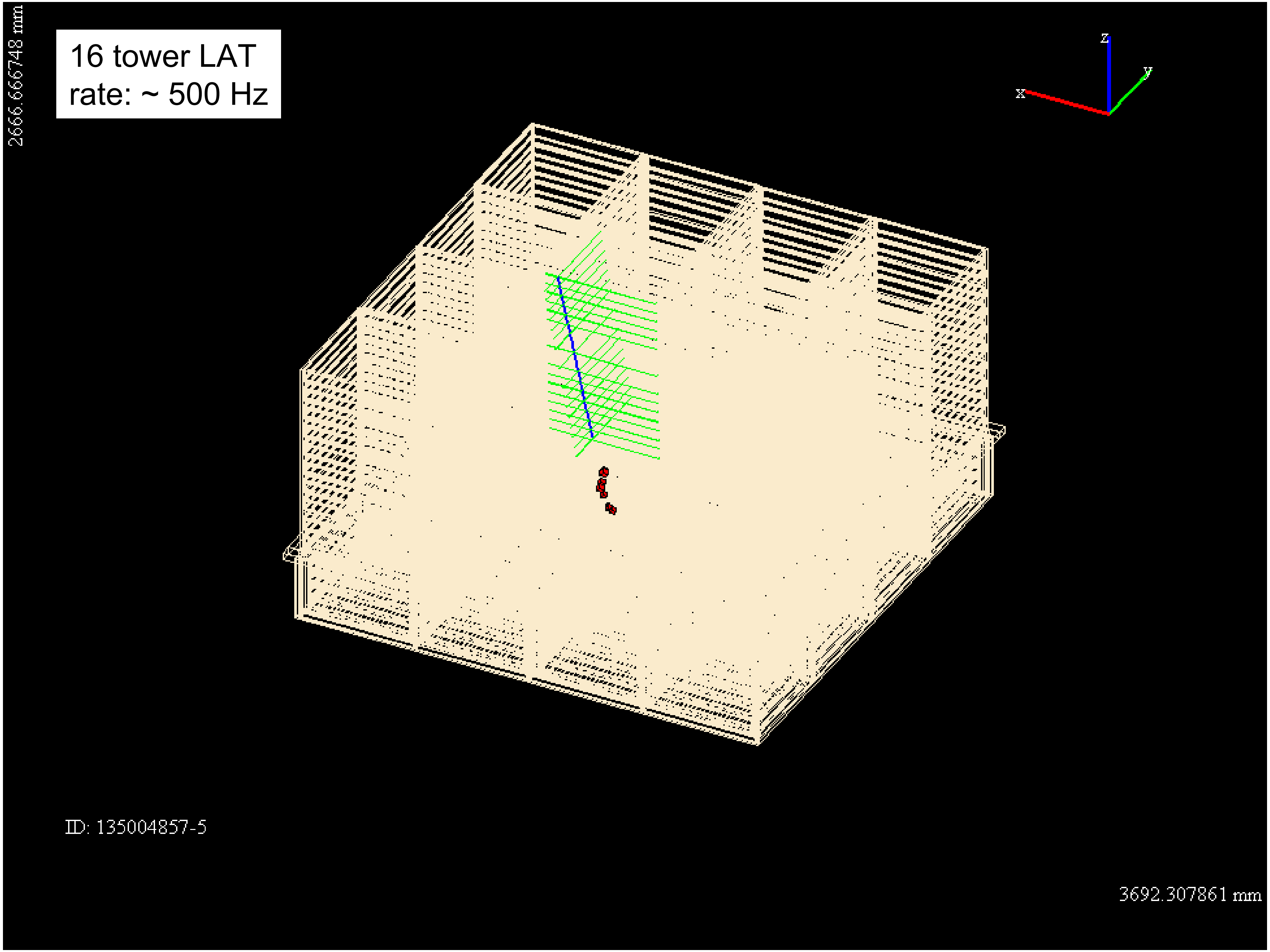











16 tower LAT
rate: ~ 500 Hz
2666.666748 mm
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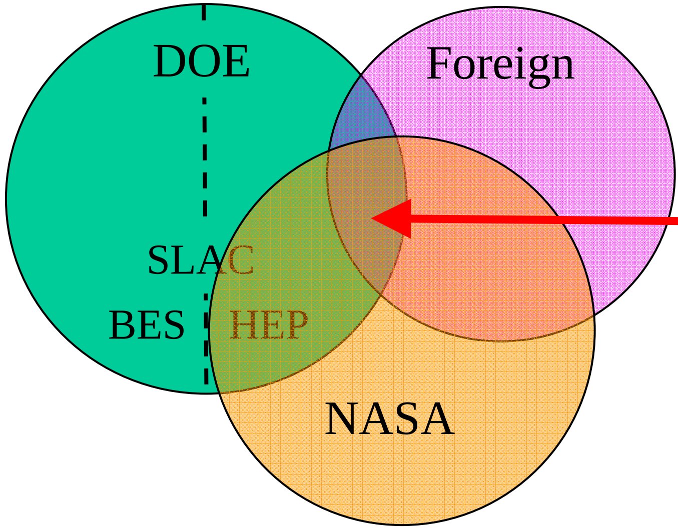
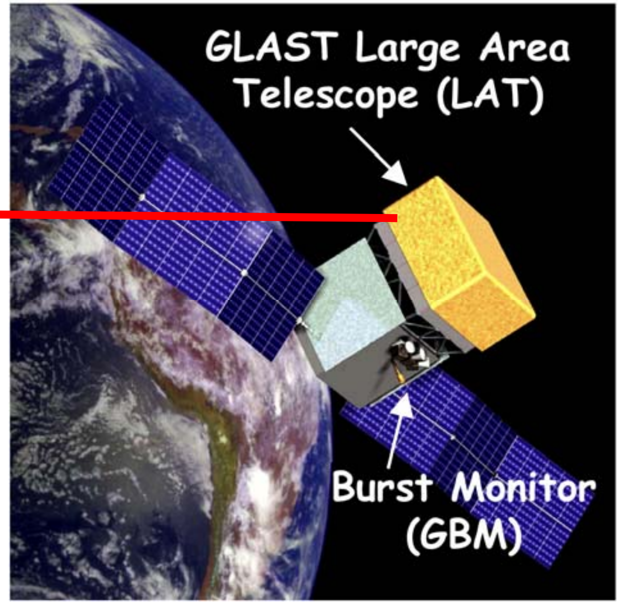
GLAST & DOE-NASA-International Interactions





Considerations:

– differences in strategic planning and science peer review processes

– funding sources; phasing of funds, "colors" of money; definition of significant project milestones

– allocation and management of contingency

– oversight: Joint? Is one agency the lead?

– Project Management

– Project Reviews

NASA and DOE fund LAT (in US)

Participation from France, Italy, Japan, and Sweden

Agency/Cultural Differences

- At the risk of oversimplification:

	DOE/Particle Physics	NASA/Space Astrophysics
Scale of Projects	Several; can manage large projects	Several; can manage large projects
Role of scientists in design, construction	large role in designing/building/testing scientific apparatus	large role in designing, building, & testing scientific apparatus; but S/C and integration/test almost always controlled by engineering org. QA is a big driver.
Size of Collaborations	Typically large (>200); many institutions	Typically smaller (<50); fewer institutions
Data "Rights"	Access to data typically limited to collaboration; publications controlled by collaboration review board	Historically, access limited to instrument team for ≤ 1 yr; current trend: all data public immediately or within a few months
Funding for scientists	For scientists at universities, funding from base program support; laboratory (ie, SLAC) scientists supported on lab operating budgets	Mission-oriented; scientists on instrument team supported by project funds (full cost accounting); data analysis support to community through Guest Investigator Program

Agency/Cultural Differences - 2

	DOE/Particle Physics	NASA/Space Astrophysics
funding, contingency mgmt and overruns	strong emphasis on evaluating adequacy of contingency when project baselined; typically, project manages contingency and also controls cost by controlling scope rebaselining to deal with cost growth is strongly discouraged science preparation and "commissioning" are not part of project cost; provides some flexibility in controlling project costs	cost growth is more common; contingency held by project management (for GLAST, by GSFC), but often used to fix problems in other projects; in early phases, funding profiles typically not driven by minimizing overall cost (i.e. fit in a wedge); "full" cost accounting on projects; i.e. at GSFC, civil servants now full-cost accounted; scientists part of project cost
foreign agreements	lab and collaboration take the lead, negotiate MoAs	agency-to-agency agreements; LoAs, formal state department MoUs.

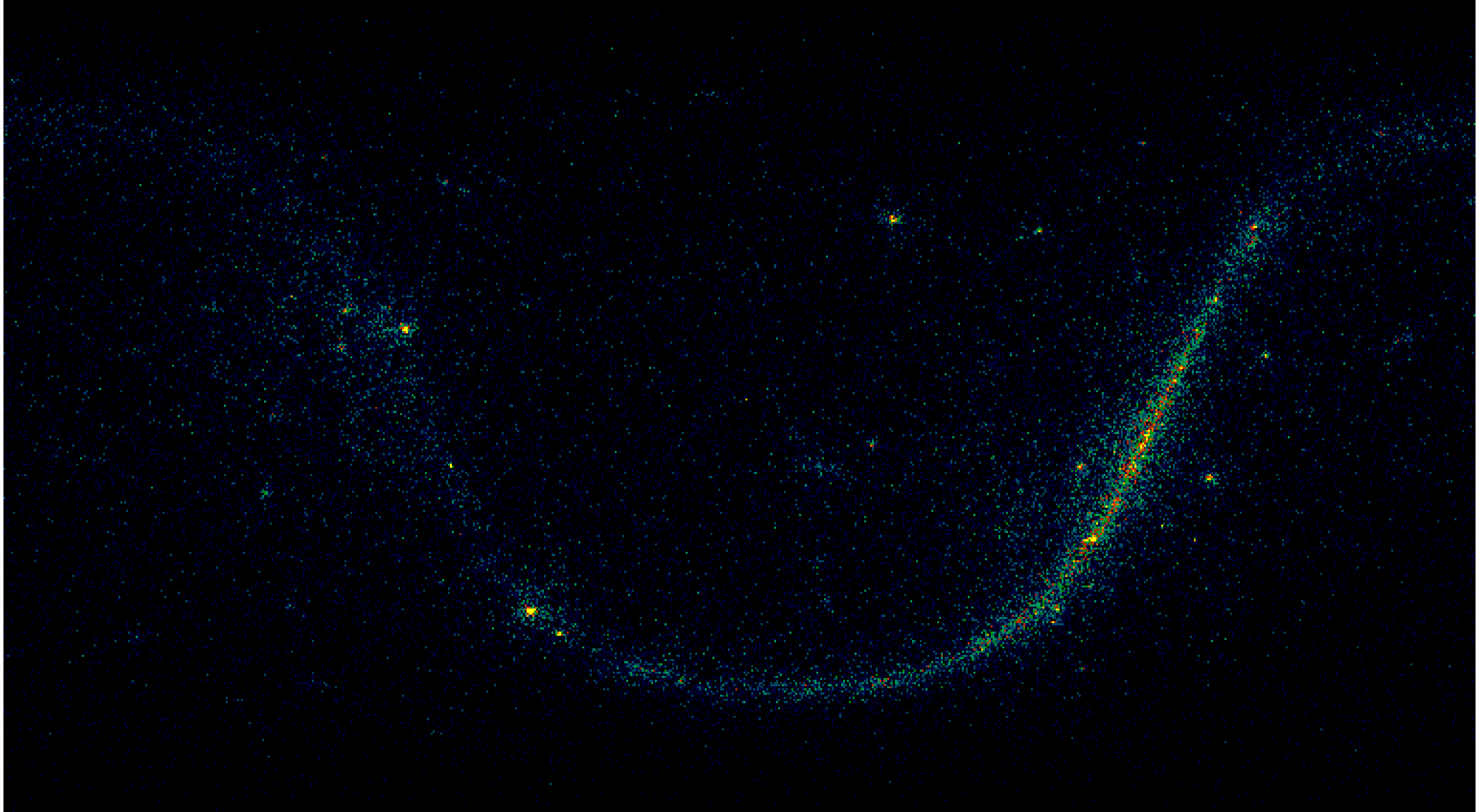
Lessons Learned

Lesson #1: Avoid cultural judgments and oversimplifications such as "the way we do things in space science / particle physics {pick one}.."

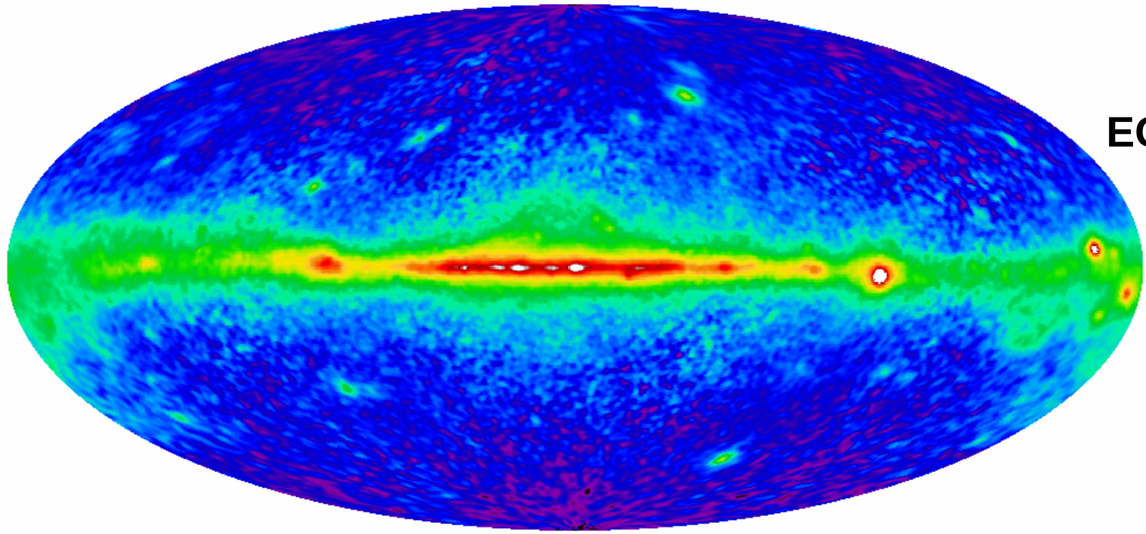
Both parties should have something of value (other than money) to contribute that the other party recognizes and also values.

GLAST Large Area Telescope made possible by important and complementary contributions from the HEP and space astrophysics communities; not possible without both

All-Sky Simulation of 55 days of GLAST observations



Science opportunities & multiwavelength needs



EGRET (>100 MeV)

60% galactic diffuse emission

30% isotropic emission

10% point sources

Many opportunities for exciting discoveries:

- *determine the origin(s) of the high-energy extragalactic diffuse background*
- *measure extragalactic background light to $z > 3$*
- *detect γ-ray emission from clusters of galaxies; cosmic-ray acceleration on large scales*
- *detect γ-rays from Ultra-Luminous Infrared Galaxies; cosmic ray acceleration efficiency and star formation rate*
- *detect high-latitude Galactic Inverse-Compton emission and thereby measure TeV-scale CR electrons in the Galaxy*
- *study high-energy emission from Galactic pulsars*
- *the unknown!*