GLAST

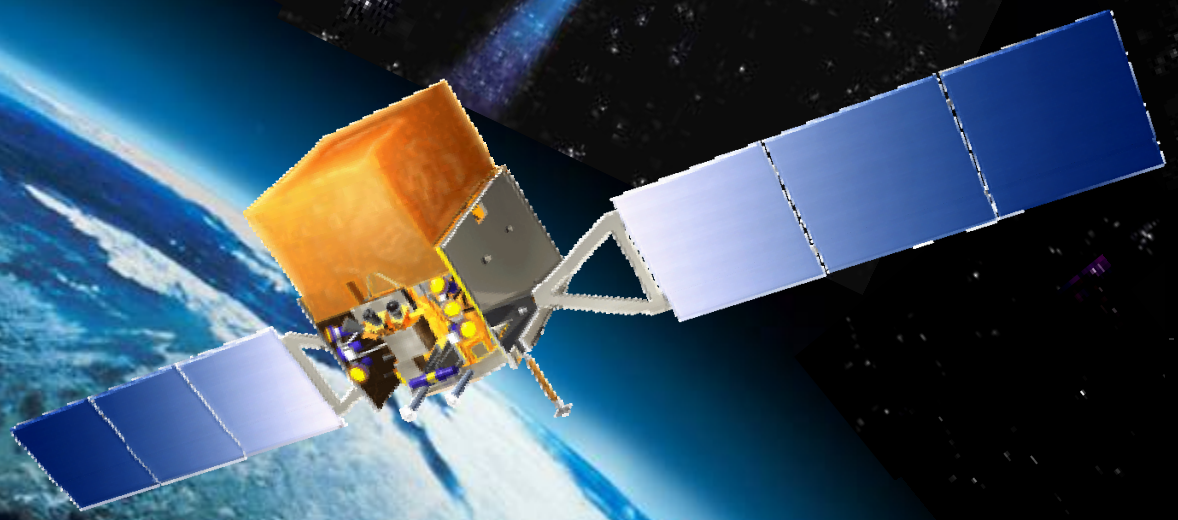
Overview of Project Status,

Collaboration Status,

- Membership

- Science Analysis Groups

- Multiwavelength planning



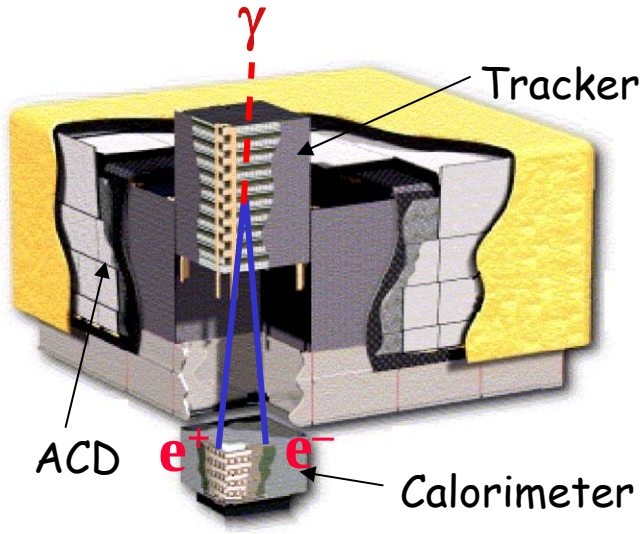
Peter F. Michelson
GLAST LAT Spokesperson
Stanford University
peterm@stanford.edu

GLAST LAT International Finance Committee
September 4, 2006

Overview of Project Status

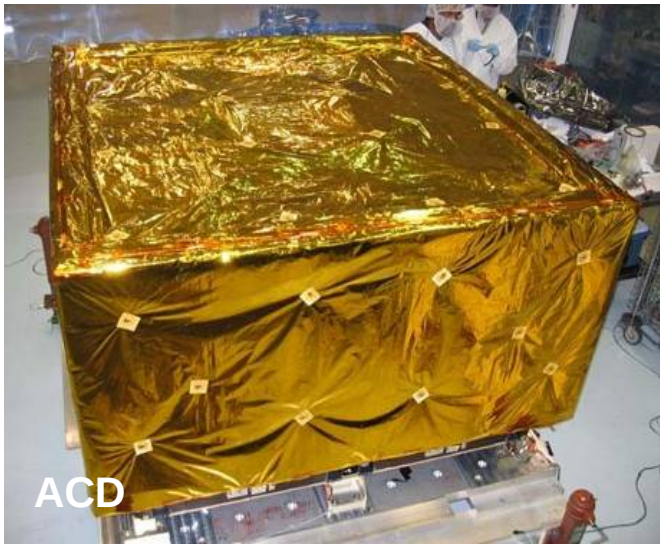
GLAST development status

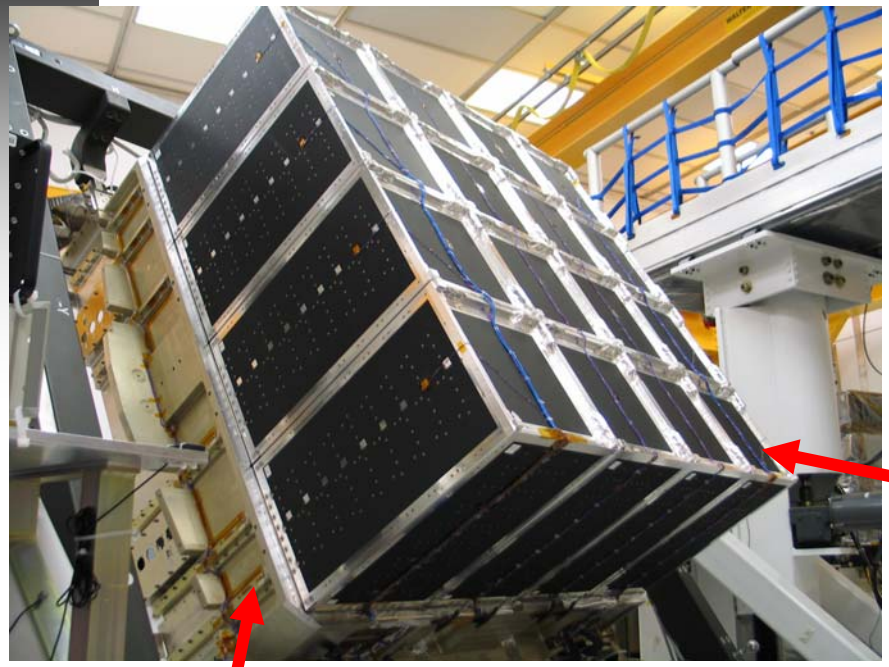
- ***assembly of all science instrument elements complete:***
  - ***Large Area Telescope (LAT) undergoing instrument-level environmental test; delivery expected before end of September***
  - ***GLAST Burst Monitor (GBM) delivered for observatory integration***
- ***beam test of LAT spare flight modules 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***

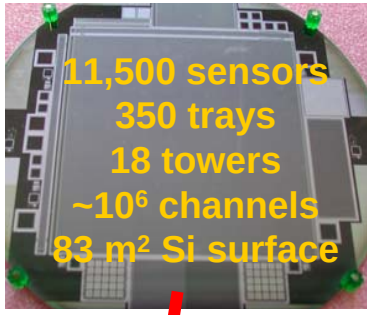


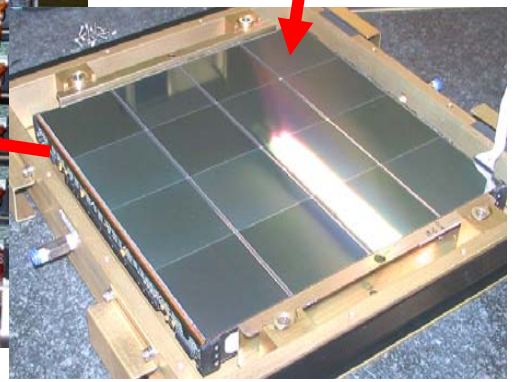
GLAST spacecraft being assembled

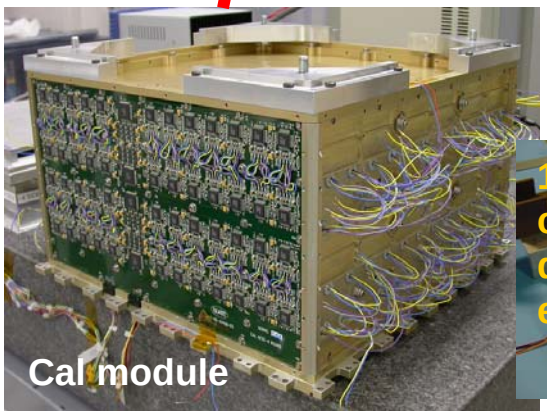
LAT is assembled

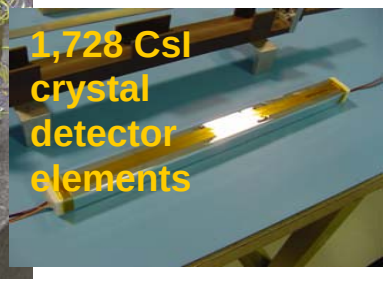


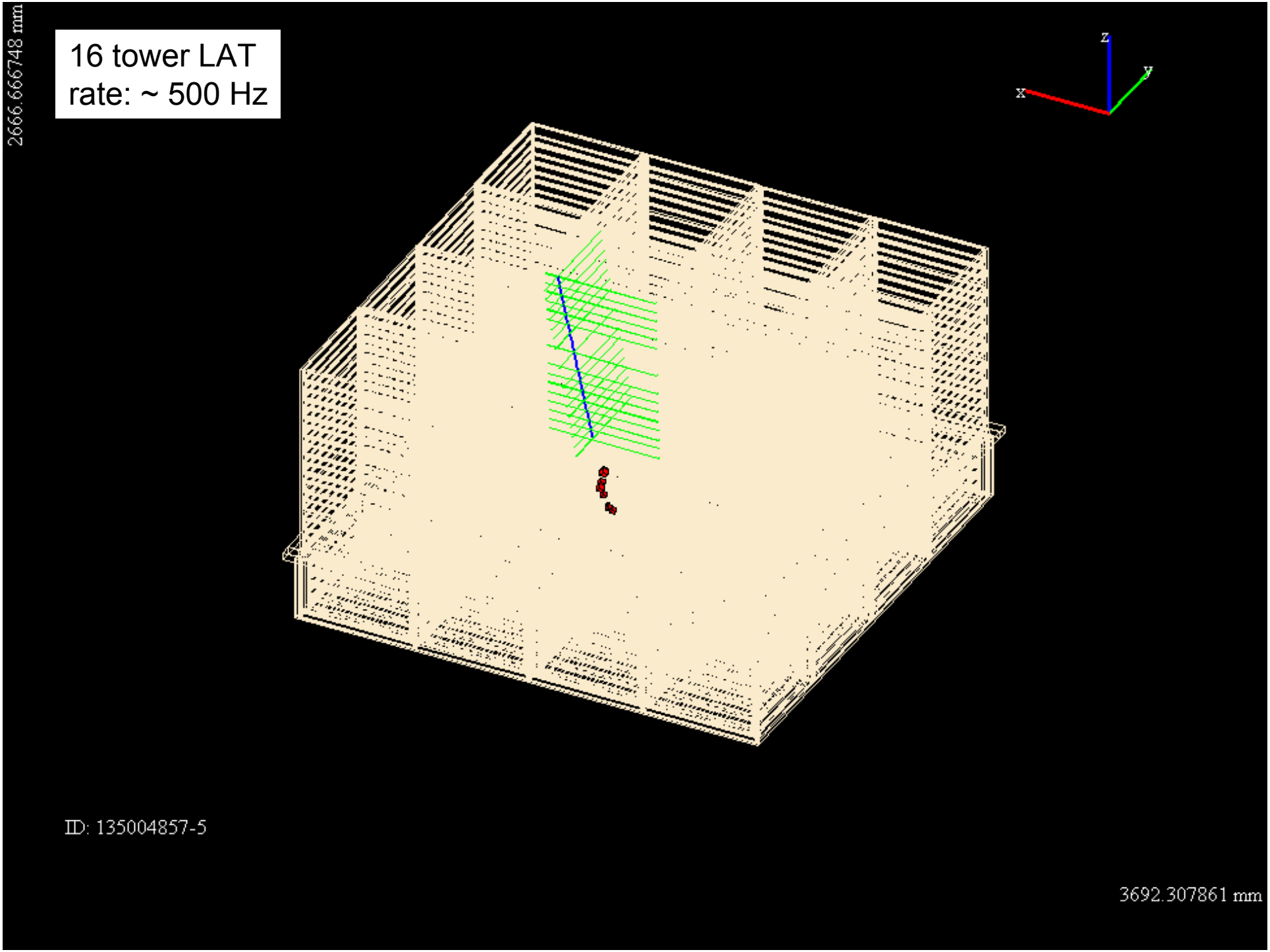




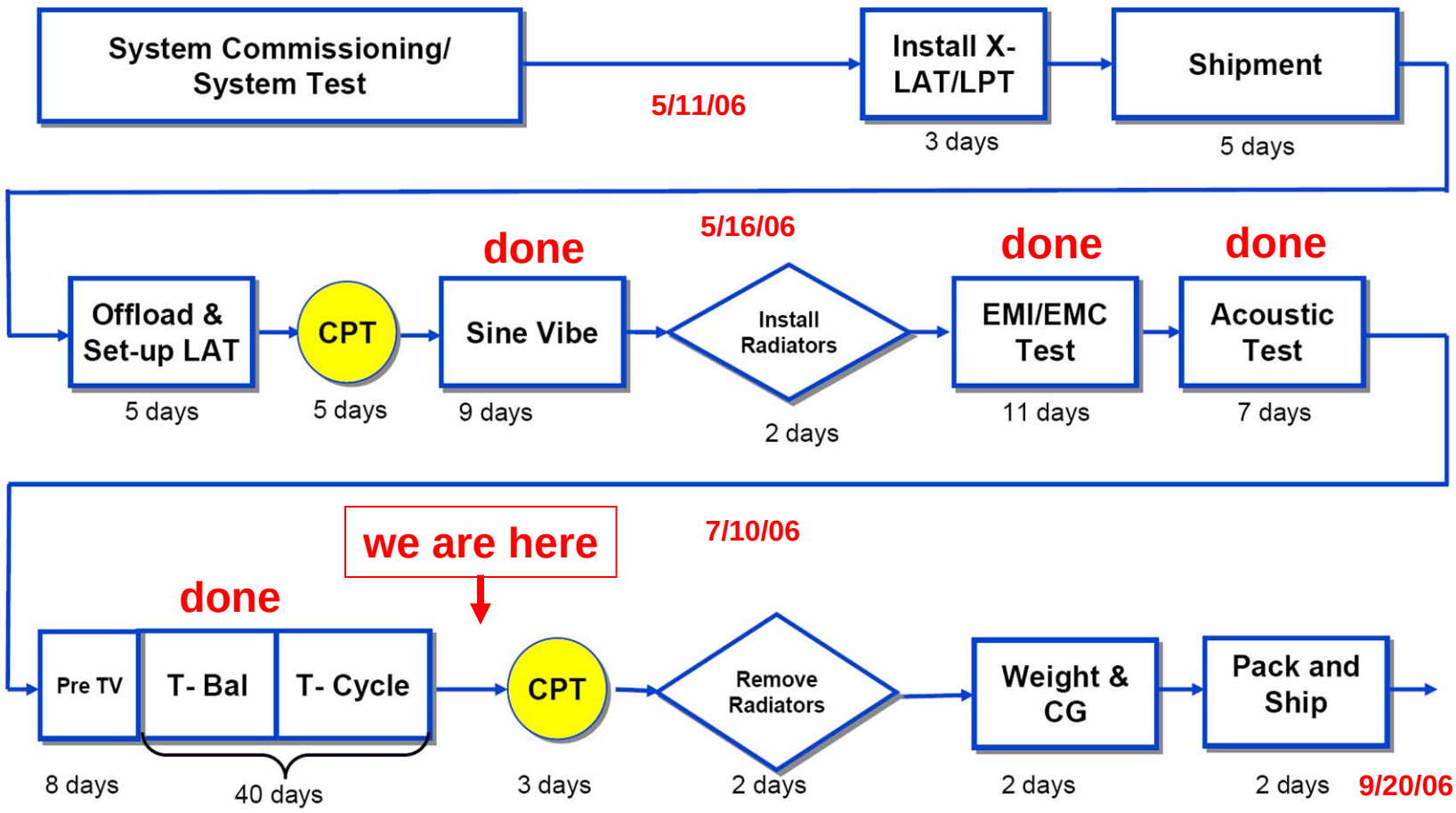







16 tower LAT
rate: ~ 500 Hz
2666.666748 mm
z
y
x
ID: 135004857-5
3692.307861 mm

LAT Test Flow



NOTE: Durations for moving and setup have been incorporated into the total duration for the test. SIIS Verification will be worked in as appropriate.

pre-ship review: Sept 15, 2007

GLAST LAT Collaboration status:

- collaboration demographics

- science analysis groups, DC-2 activities
  (Julie McEnery will cover in detail)

- Speaker's Bureau

- progress on multiwavelength planning

collaboration demographics, 03/06

Country	membership category		
	Member	Affiliated	Postdoc
France	12	5	1
Germany		3	
Italy	14	26	14
Australia		1	
Japan	6	3	3
Sweden	1	6	
USA	51	34	4
Total	84	78	22

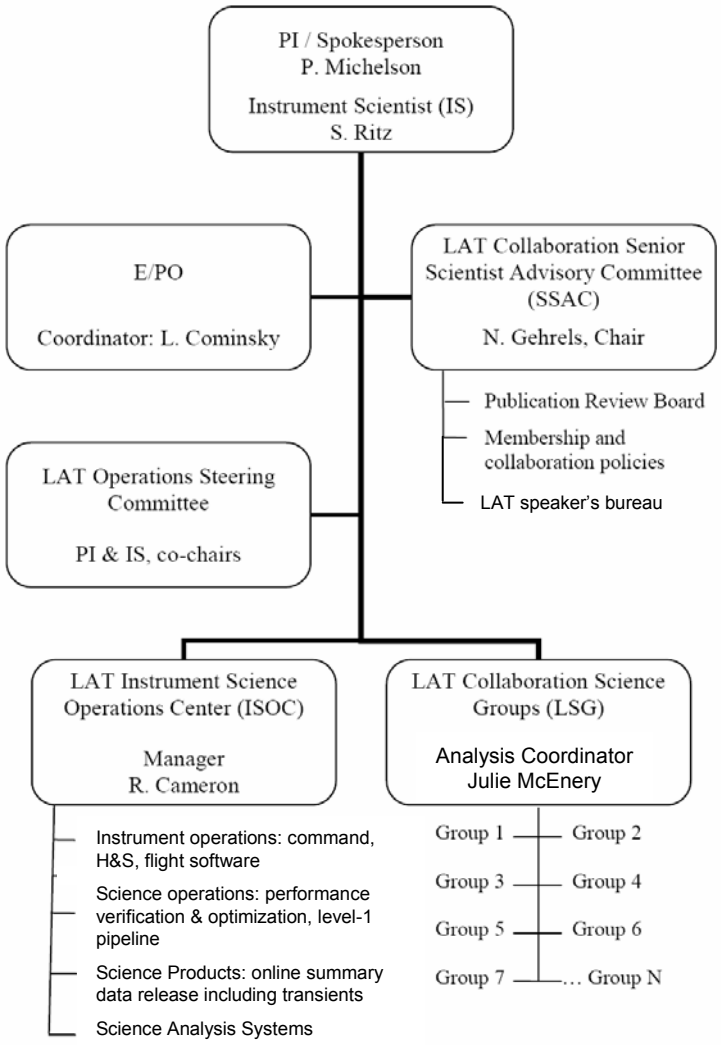
current collaboration demographics

Country	membership category		
	Member	Affiliated	Postdoc
France	14	5	1
Germany		4	
Italy	14	27	14
Australia		1	
Japan	6	3	3
Sweden	1	6	
Great Britain		1	
USA	51	38	5
Total	86	85	23

current collaboration demographics

Country	membership category		
	Full Member	Affiliated Scientist	Postdoc
France			
CEA	6	4	0
IN2P3	8	1	0
Italy			
ASI	2	15	1
INFN	12	12	13
Japan	6	3	3
Sweden	1	6	0
USA			
DOE	29	9	2
NASA	18	15	1
other	4	14	1
Australia		1	
Germany		4	
Great Britain		1	
Total	86	85	21

LAT Collaboration Organization



- ***Instrument Science Ops Center (ISOC)***
  - *responsible for instrument operation (monitoring, configuration management, flight software, calibration, science analysis software, etc) and operation of Level 1 Data Pipeline*
  - *performance analysis and tools development are coordinated across the Collaboration by the ISOC*
- ***LAT Collaboration Science Groups***
  - *responsible for collaboration's analysis and extraction of science results from LAT data; including galactic diffuse model and source catalogs*
  - *Science Groups plus Multi-λ Coordination Working Group*
  - *each science group to have 2 coordinators; with one resident at Stanford (in particular during 1st year)*
  - *day-to-day efforts coordinated by Analysis Coordinator, also resident at Stanford-SLAC during sky-survey phase*

Status of Science Groups

- *first science analysis coordinator named in March: Julie McEnery*
  - *rotating position; serve for 1 year*
- *websites established and linked to Collaboration webpage*
- *periodic meetings of groups; face-to-face meetings held at Collaboration meeting in Stockholm: August 28 – September 1*

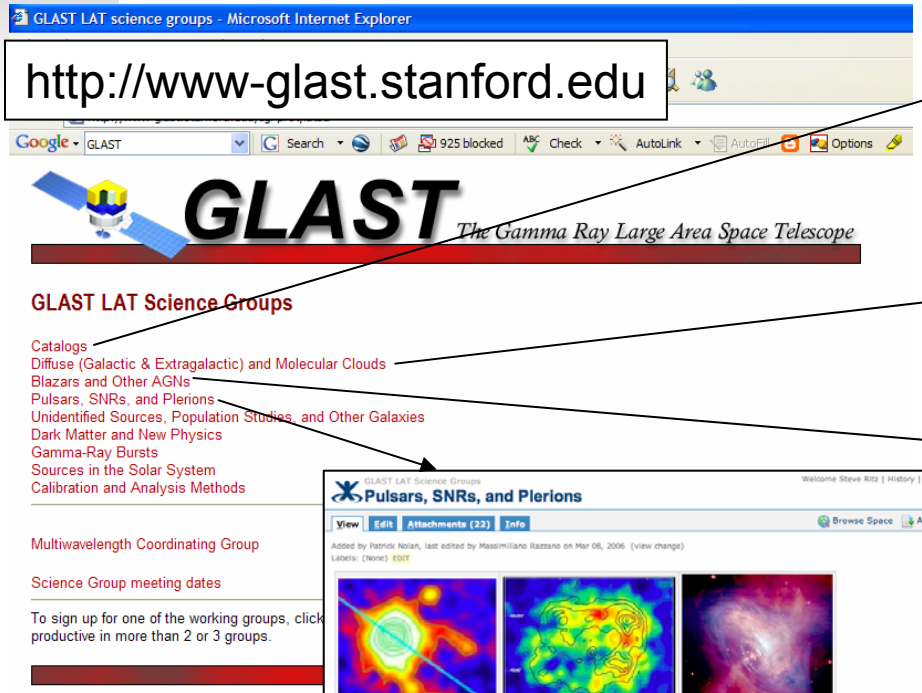
Group	Current Coordinators	# participants
Catalog	S. Digel, I. Grenier	21
Diffuse Radiation	S. Digel, I. Grenier	30
Blazars & AGNs	P. Giommi, B. Lott	50
Pulsars, SNRs, & Plerions	R. Romani, D. Thompson	46
Unidentified Sources, Population Studies, and Other Galaxies	P. Caraveo, O. Reimer	37
Dark Matter & Exotic Physics	E. Bloom, A. Morselli	47
Gamma-Ray Bursts	J. Norris, N. Omodei	62
Solar	G. Share	10
Calibration & Analysis Methods	W. Atwood, S. Ritz	66

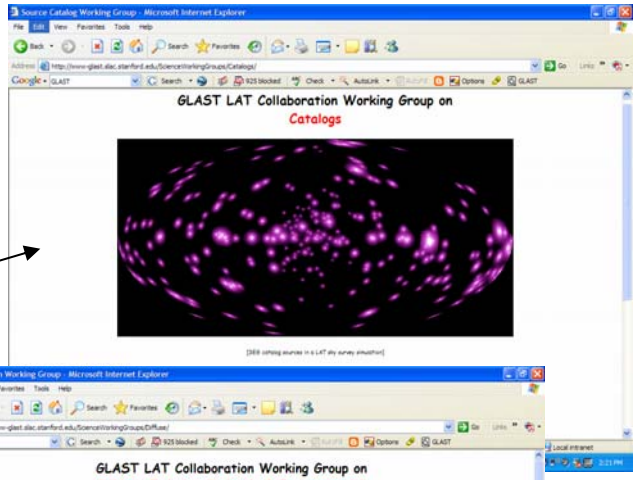
on average, each collaboration member participates in 2 to 3 science groups

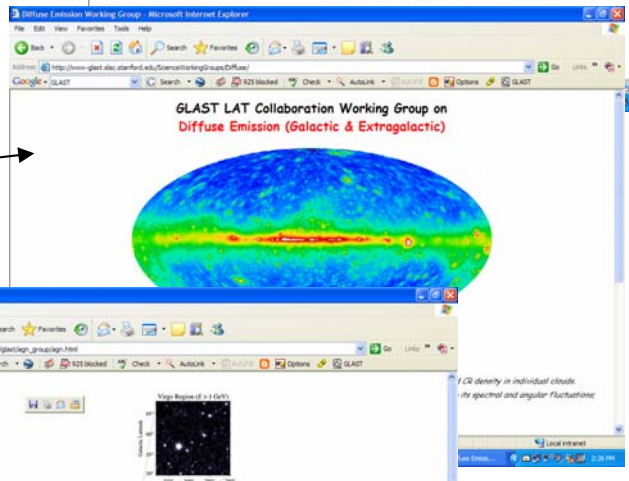
coordinator positions will be rotated ~annually; 1st rotations by Feb 2007

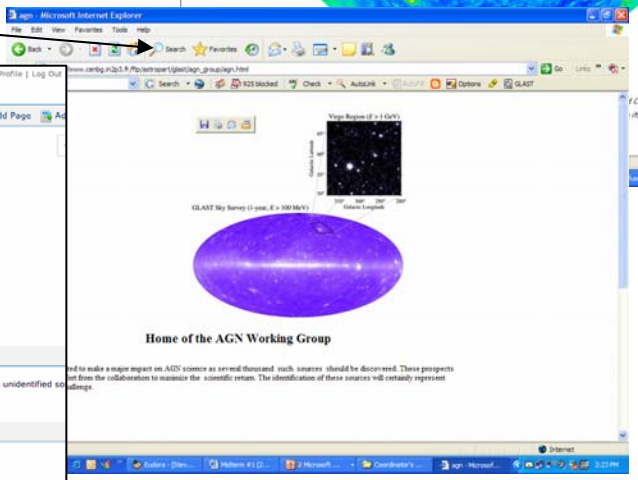
Science Groups all very active

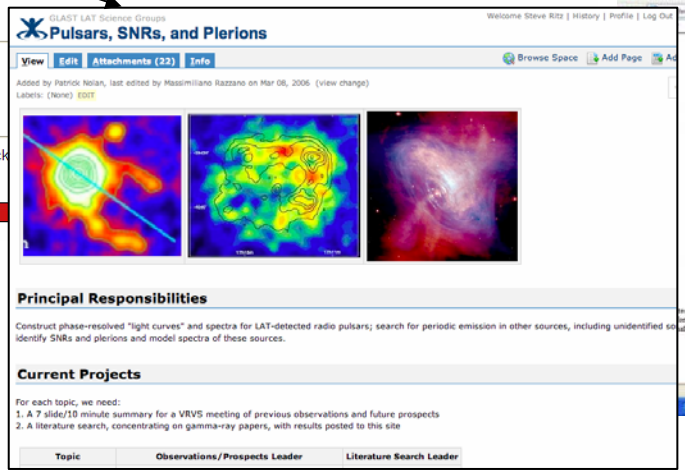
- *planning, coordinating, and reviewing papers (pre- and post-launch)*
- *talks, posters*
- *analyses*
- *simulations, studies*
- *developing public/private web pages*









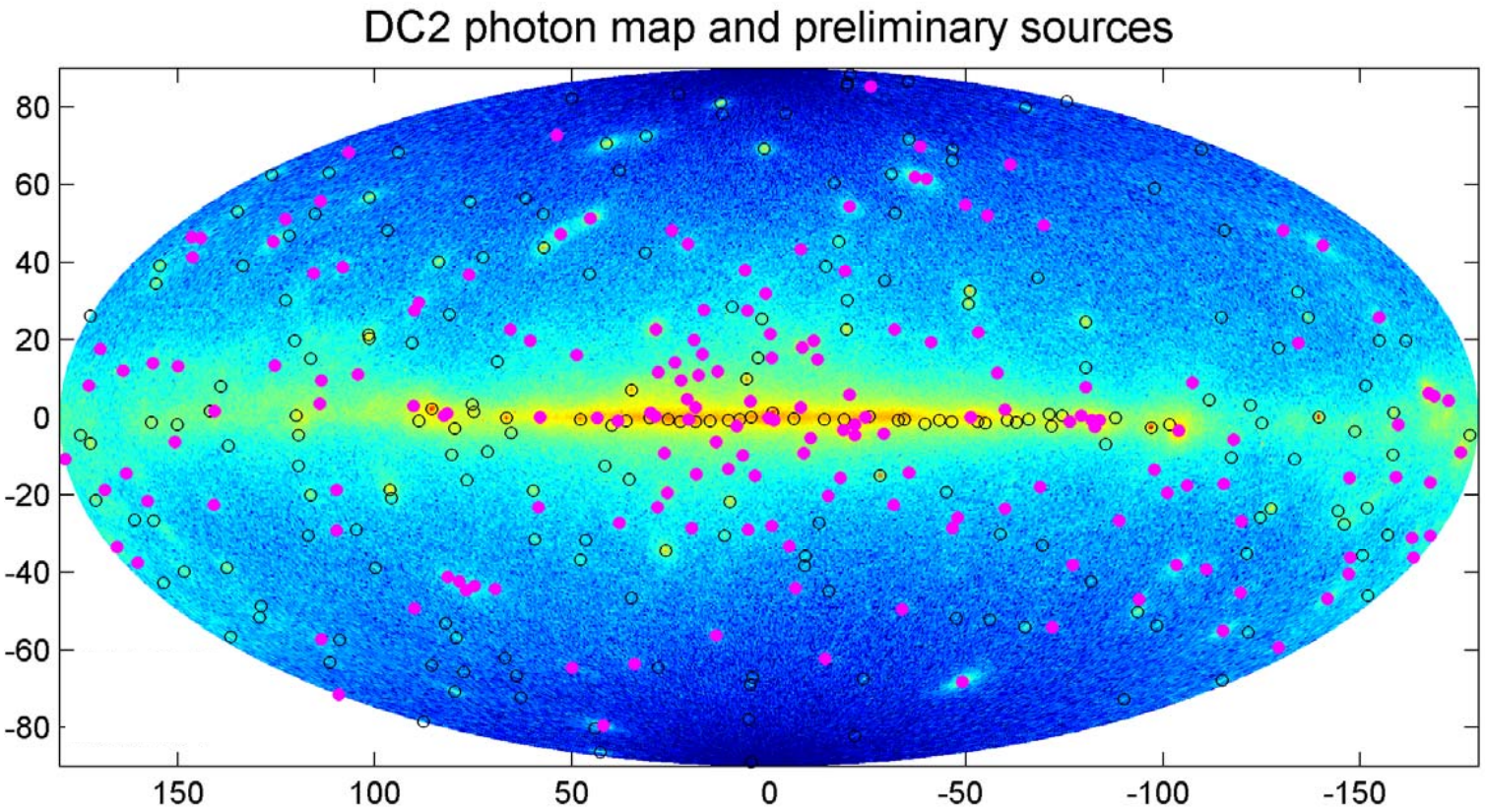


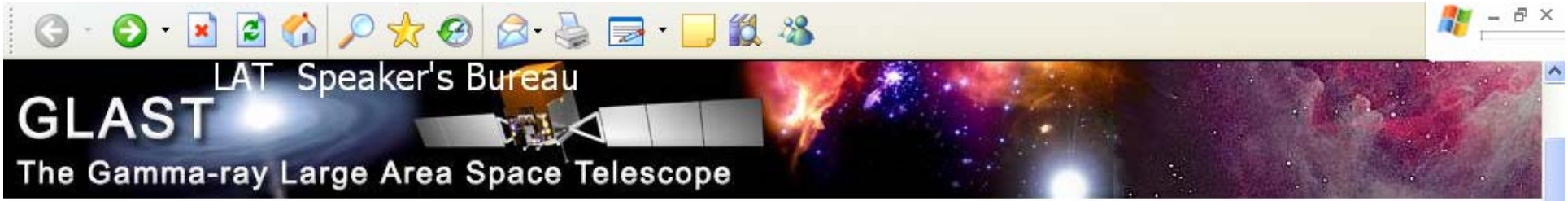
Data Challenge II

DC-1: 1 simulated day
included GRBs
a few surprises
first look at major science tools

DC-2: 2 simulated months
backgrounds included
more realistic GRBs
pulsars, variable AGNs
more elaborate surprises
full suite of science tools

DC-2 kickoff meeting: March 1-3, 2006
closeout meeting: May 31 – June 2, 2006





ARCHIVE OF GLAST-LAT TALKS | UPCOMING CONFERENCES | COLLABORATION WEBPAGE | GLAST-PISA HOME PAGE
GUIDELINES | UPCOMING SPEAKERS | USEFUL LINKS | HOME

This web site concerns the activities of the GLAST LAT Speaker's Bureau to plan for LAT Collaboration participation in Conferences and Symposia.

As the LAT instrument nears completion and the LAT Collaboration is focused on preparations for science analysis and operations the necessity of guidelines concerning conference presentations has become of primary importance.
Main purpose is:

- to provide a process by which presentations that will report results generated within the GLAST LAT Collaboration are reviewed within the collaboration prior to presentation or release at a conference or seminar.
- to insure that opportunities for giving presentations are available on an equitable basis to collaboration members.
- to encourage participation in relevant scientific meetings in order to disseminate LAT results to the broader science community and to maintain the visibility of GLAST in the community.

A Draft of the GLAST-LAT Collaboration guidelines can be found <A href="Guidelines.pdf" target = _main" ">here.

Speaker's Bureau coordinators serve for 1 year
Ronaldo Bellazzini (chair)
Tuneyoshi Kamae
Charles Dermer

Analysis Coordinator (Julie McEnery) is now ex-officio member

Comprehensive pre-launch paper on LAT

- comprehensive paper in preparation with contributions from all of the collaboration science groups
- paper provides overview of LAT design, its science performance, and an overview of the science addressed with LAT
- plan is to publish (Astrophysical Journal) LAT paper simultaneously with GLAST Mission Overview paper and GBM paper – submission in October 2006

The *Large Area Telescope* on the *GLAST* Mission

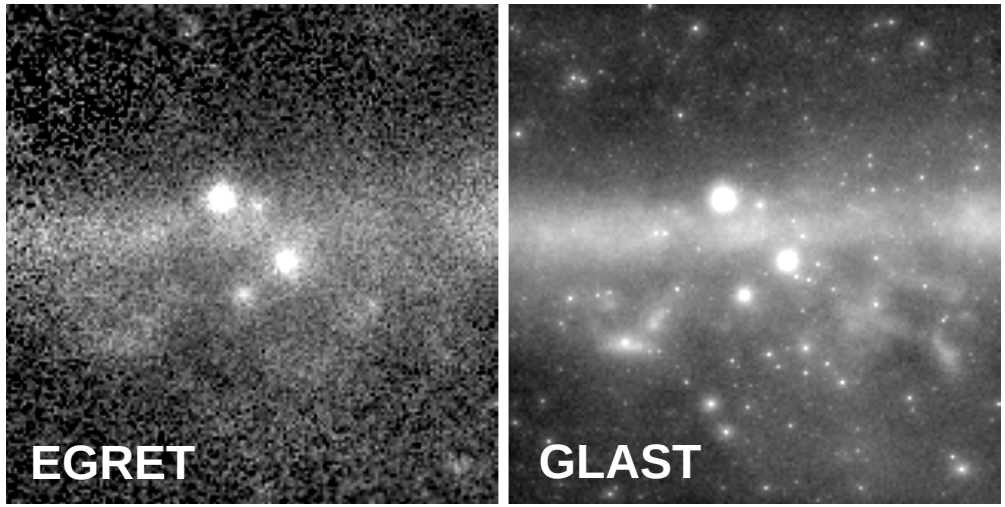
ABSTRACT

The Large Area Telescope (LAT), one of two instruments on the Gamma-ray Large Area Space Telescope (GLAST) mission, scheduled for launch by NASA in 2007, is an imaging, wide field-of-view, high-energy gamma-ray telescope, covering the approximate energy range from 20 MeV to more than 300 GeV. The LAT is being built by an international collaboration with contributions from space agencies, high-energy particle physics institutes, and universities in France, Italy, Japan, Sweden and the United States. The scientific objectives the LAT will address include (1) resolving the high-energy gamma-ray sky and determining the nature of the unidentified gamma-ray sources and the origin of the apparently isotropic diffuse emission seen by EGRET, (2) understanding the mechanisms of particle acceleration in celestial sources, including active galactic nuclei, pulsars, and supernovae remnants, (3) studying the high-energy behavior of gamma-ray bursts and transients, (4) using high-energy gamma-rays to probe the early universe to $z \geq 6$, and (5) probing the nature of dark matter. The LAT is a pair-conversion telescope with a precision tracker and calorimeter, each consisting of a 4×4 array of 16 modules, a segmented anticoincidence shield that covers the tracker array, and a programmable trigger and data acquisition system. Each tracker module has 18 *x,y* tracking planes, consisting of two planes (*x* and *y*) of single-sided silicon strip detectors (228 mm pitch) and high-z converter material (tungsten). Each calorimeter module has 96 CsI(Tl) crystals, arranged in an 8 layer hodoscopic configuration with a total depth of 8.5 radiation lengths, giving both longitudinal and transverse information about the energy deposition pattern. The calorimeter's depth and segmentation enable the high-energy reach of the LAT and contribute significantly to background rejection. The aspect ratio of the tracker (height/width) is 0.4, allowing a large field-of-view and ensuring that nearly all pair-conversion showers initiated in the tracker will pass into the calorimeter for energy measurement. Data obtained with the LAT will (i) provide rapid notification of high-energy transients, (ii) yield an extensive catalog of several thousand high-energy sources obtained from an all-sky survey, (iii) measure spectra from 20 MeV to more than 50 GeV for several hundred sources, (iv) localize point sources to 0.3 – 2 arcminutes, (v) map and obtain spectra of extended sources such as SNRs, molecular clouds, and nearby galaxies, and (vi) measure the diffuse isotropic gamma-ray background up to TeV energies.

Multiwavelength Planning

- much progress in several areas since last IFC meeting
- in addition to the Collaboration Multiwavelength Coordination Group, there are informal wavelength-specific discussion groups
  - TeV
  - X-Ray
  - IR/Optical/UV
  - Radio Discussion Group

Science opportunities

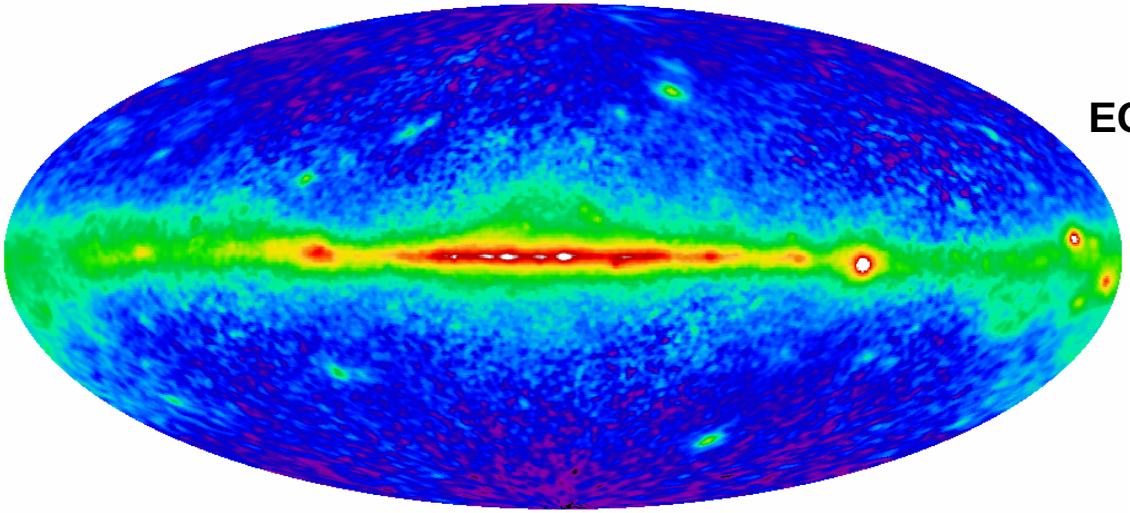


anti-center region
(E > 100 MeV)

Many opportunities for exciting discoveries:

- *origin(s) of the high-energy extragalactic diffuse background*
- *extragalactic background starlight to z > 3*
- *new physics & the unknown! (e.g. dark matter, extra dimensions, Lorentz invariance violation)*
- *γ-ray emission from clusters of galaxies; cosmic-ray acceleration and confinement on large scales*
- *γ-rays from Ultra-Luminous Infrared Galaxies; cosmic ray acceleration efficiency and star formation rate*
- *high-latitude Galactic Inverse-Compton emission and thereby measure TeV-scale CR electrons in the Galaxy*
- *high-energy emission from Galactic pulsars and their birth places*

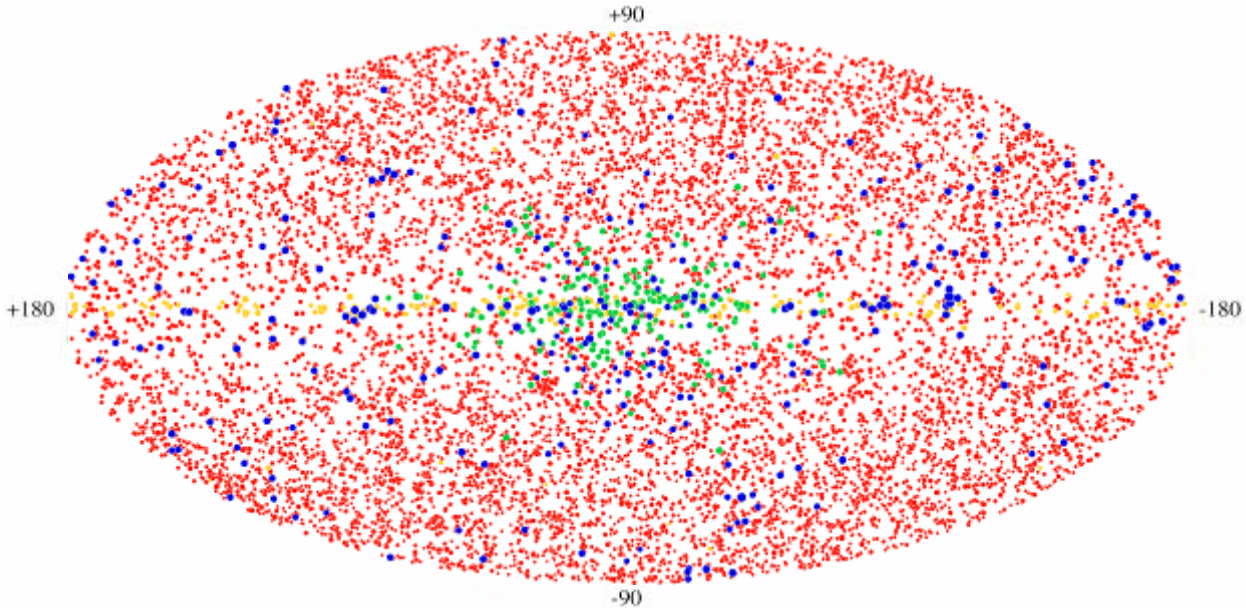
Science opportunities & multiwavelength needs



EGRET (>100 MeV)

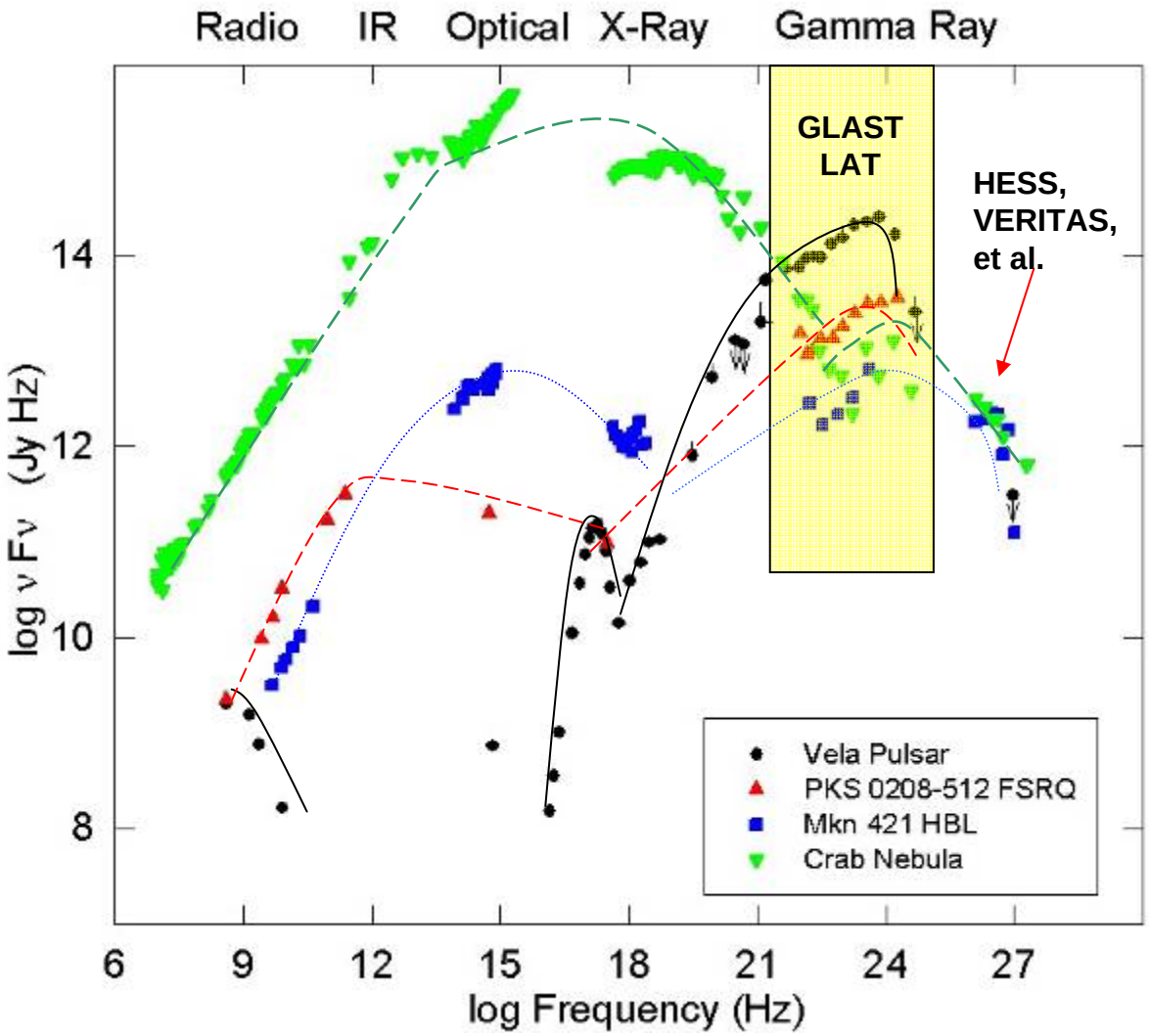
- **85% galactic diffuse emission**
- **~5% isotropic emission**
- **10% point sources**

GLAST all-sky survey
(~10^4 sources)



Understanding γ-ray Sources: multiwavelength needs

radiation produced by high-energy particles



- *Nature rarely produces mono-energetic particle beams. Broad range of particle energies leads to broad range of photon energies.*
  - *example: π^0 production*
- *Charged particles rarely interact by only one process. Different processes radiate in different energy bands.*
  - *example: synchrotron-Compton processes*
- *High-energy particles producing gamma rays radiate in lower-energy bands as they lose energy.*
  - *example: gamma-ray burst afterglows*

Summary of Important Multiwavelength Needs

Science Objective	GLAST provides	multi-λ requirements
Differential measurement (vs *Z*) of extragalactic background light to *Z* ~5.5	Measurement of blazar spectra in band where cutoffs are expected from $\gamma + \gamma_{ebl} \rightarrow e^+ + e^-$	Broadband contemporaneous / simultaneous spectral measurements (radio, optical, X-ray, TeV) of blazar spectra, particularly around the synchrotron peak;
Resolve origin of particle acceleration and emission mechanisms in systems with relativistic jets, supermassive black holes	All-sky monitoring coverage of blazar flares and GRBs	radio and optical surveys of flat-spectrum radio sources to extend blazar catalogs
Reliable model of Milky Way diffuse emission required for accurate source localization and to facilitate search for dark matter	Mapping of cosmic ray interactions with all forms of interstellar matter.	Extend CO surveys to high galactic latitude; survey special directions (eg. spiral arms, galactic center) with optically thin tracer (e.g. $C^{18}O$)
Understand particle acceleration and emission mechanisms in extreme environment (gravity, electric and magnetic fields) of rotating neutron stars	Spectra and light curves resulting from primary interactions of the most energetic particles.	Contemporaneous radio and X-ray pulsar timing observations

Collaboration and multiwavelength needs

- *coordination efforts led by Dave Thompson, multi-λ coordinator, and PI*
- *each collaboration science group is/has assessed needs*
- *reaching out to community for help; adding affiliated scientists as appropriate:*

blazars

- *Tony Readhead, Caltech, brings 40 m OVRO telescope for dedicated radio monitoring of ~1000 sources @ 15 GHz (blazars) per day for GLAST & SWIFT; opens opportunity for Keck and Palomar time;*
- *Anton Zensus, Max Planck, Bonn: Effelsberg blazar observations (10 quasi-simultaneous flux measurements between 1.4 GHz and 86 GHz) on the most interesting OVRO sources*
- *Greg Taylor, et al., UNM and NRAO, organized VIPS survey of ~10^3 blazar candidates with VLBA; planning to continue during 1st year*

diffuse bkgrd

- *Yasuo Fukui, Nagoya University: CO survey data from NANTEN-II survey*
- *(Pat Thaddeus, SAO: high-latitude CO survey data)*

pulsars

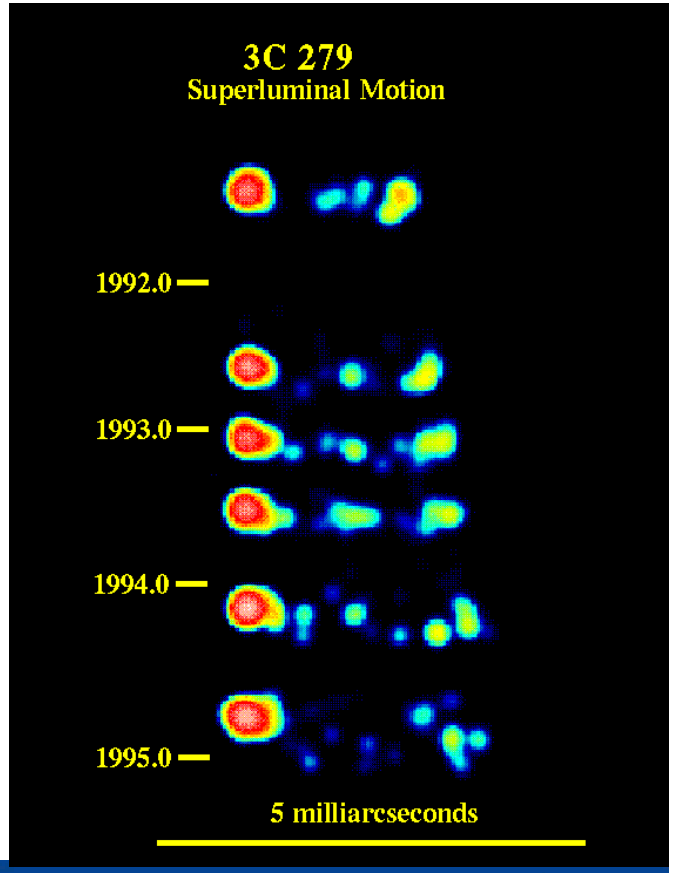
- *Simon Johnston, ATNF/Parkes: Southern Hemisphere radio pulsar timing with Parkes*
- *Michael Kramer, Jodrell Bank: Northern Hemisphere radio pulsar timing*
- *Gilles Theureau & Ismael Cognard, CNRS-Orleans: Nancay radio pulsar timing*

Collaboration and multiwavelength needs

- *in some cases, collaborating institutions have found resources to facilitate critical observational work;*
  - *e.g. completion of high-latitude CfA CO survey (SLAC & CEA)*
  - *1.5 meter telescope at Hiroshima University*
  - *"guaranteed" VLT-VSIR time for demonstration study of selected blazars (CEA)*
  - *Hobby-Eberly telescope time for identification and redshifts of blazars (Stanford University)*
- *needs in other critical areas would be helped with modest additional resources (e.g. postdoc);*
  - *e.g. pulsar timing (Parkes in Southern hemisphere is critical)*
  - *GBT observations of young, high-spin down rate, weak radio pulsars*
- *collaboration prepared to generate proposals for competitively-awarded Guest observer time on facilities such as XMM-Newton, Chandra, Spitzer, HST, and SWIFT*
- *discussions underway with Ravi Manchanda, Project Scientist, Tata Institute, about coordinated observations with ASTROSAT (launch in January 2008)*

Blazar Jet Monitoring

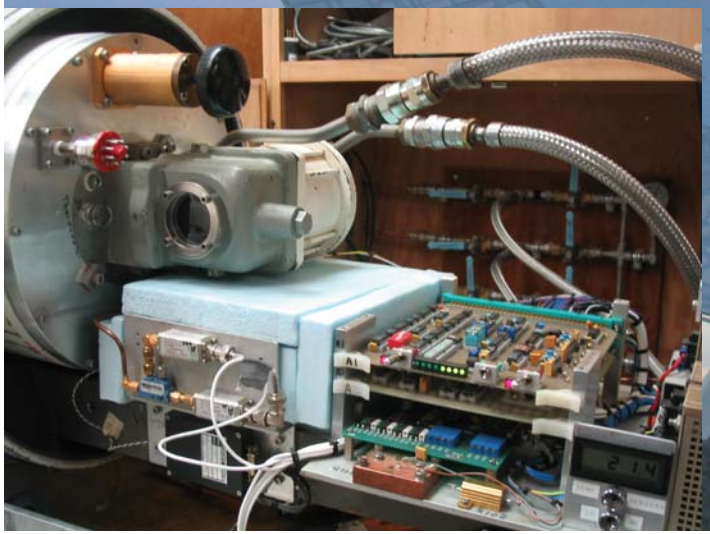
- VLBI monitoring to get δ
  - Comparison of δ at γ-ray (0.1pc) and VLBI (~1pc) scales
  - HBL: VLBI δ < 4c (Giroletti et 03)
    - But δ~50–100 needed to model TeV!
  - FSRQ (EGRET Blazars): VLBI δ peaks at 10-12 (Marscher & Co)
    - Compare w/ 2-3 for RQSO in general
- Key Question:
  VLBI ejection vs. γ flare
  - GLAST cont. coverage essential
  - Secondary issue: δ vs. GeV power



3C120 -- VLBI

15 GHz Monitoring w/ OVRO 40m

- **lead is Tony Readhead (affiliated member)**
- **45% Surface Efficiency**
- **35K Tsys**
- **1 *mJy* rms in 1 min**
- **700 Sources per Day**
- **Monitoring starts in December ‘06**



ATA monitoring program?

- Uses ATA-42
  - ~40m equivalent
  - ~0.5mJy rms,
  - 75”x40” beam @ 5GHz
  - coming on-line now
- All-sky (not source list)
- Likely 1.5-5GHz, complements OVRO 40m

Proposing for Time on Other Telescopes

The time has come! Proposals due in the next six months will cover the early phase of the GLAST mission. See the GLAMGOG Confluence page for more information.

Facility and Cycle	Proposal Deadline	When Observations Scheduled	Notes
Swift Cycle 3	28 July, 2006 - PASSED	April, 2007 - April, 2008	TOO Proposals only. Blazar TOO proposal submitted
NRAO Large Proposals	**2 Oct., 2006**	May, 2007 – **March, 2008**	GBT, VLA, VLBA - Includes VIPS and MOJAVE blazar studies
XMM AO-6	**6 Oct., 2006**	May 2007 - **April 2008**	
INTEGRAL Key Programme - AO5	**17 Nov., 2006**	Aug. 2007 - **Aug. 2008**	Large Requests, see Announcement
Suzaku Cycle 2	**1 Dec. 2006**	April, 2007 - **April, 2008**	NOI due 15 Sept., 2006
RXTE Cycle 12 (last?)	26 Jan., 2007	Summer, 2007 – **February, 2009**	NOI due 27 Nov., 2006
Spitzer Cycle 4	14 Feb. 2007	July, 2007 - **June, 2008**	One cycle after this before cryogen runs out
Chandra Cycle 9	March, 2007	Dec. 2007 - **Dec. 2008**	Coordinated Observation Programs?
NRAO Regular Programs	1 Feb., 1 June, 1 Oct.	Trimester after deadline	
NOAO Regular Programs	30 Sept., 31 March	Feb.-July, Aug.-Jan.	
NOAO Survey Programs	15 March		

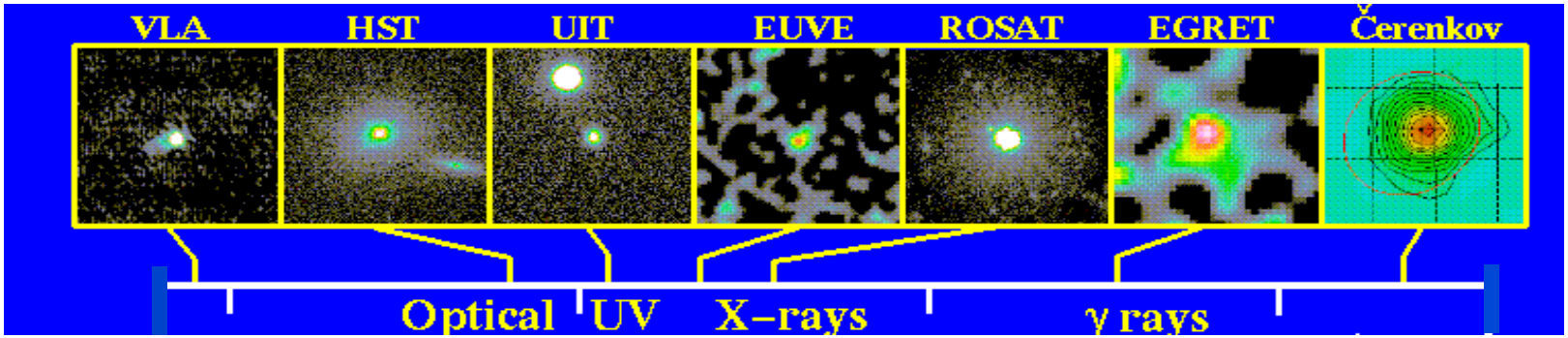
Summary

- ***LAT is assembled and works! environmental testing about to be completed; shipment to observatory integration by the end of September***
  - ***International partnership a success. THANKS TO ALL !***
- ***GLAST will provide a major new capability for addressing important science questions***
  - *extensive coordinated and, in some cases, simultaneous observations from radio to TeV energies, are needed to fully exploit GLAST data;*
  - *LAT collaboration actively pursuing multiwavelength opportunities to fill critical needs*
- ***Collaboration looking forward to launch of GLAST and beginning of science operations in the Fall of 2007***
  - *science analysis groups very active; DC II a success; refinement of analysis tools continuing; pre-launch papers underway*
  - *collaboration meeting in Stockholm was a success*

Multiwavelength observations are important for GLAST

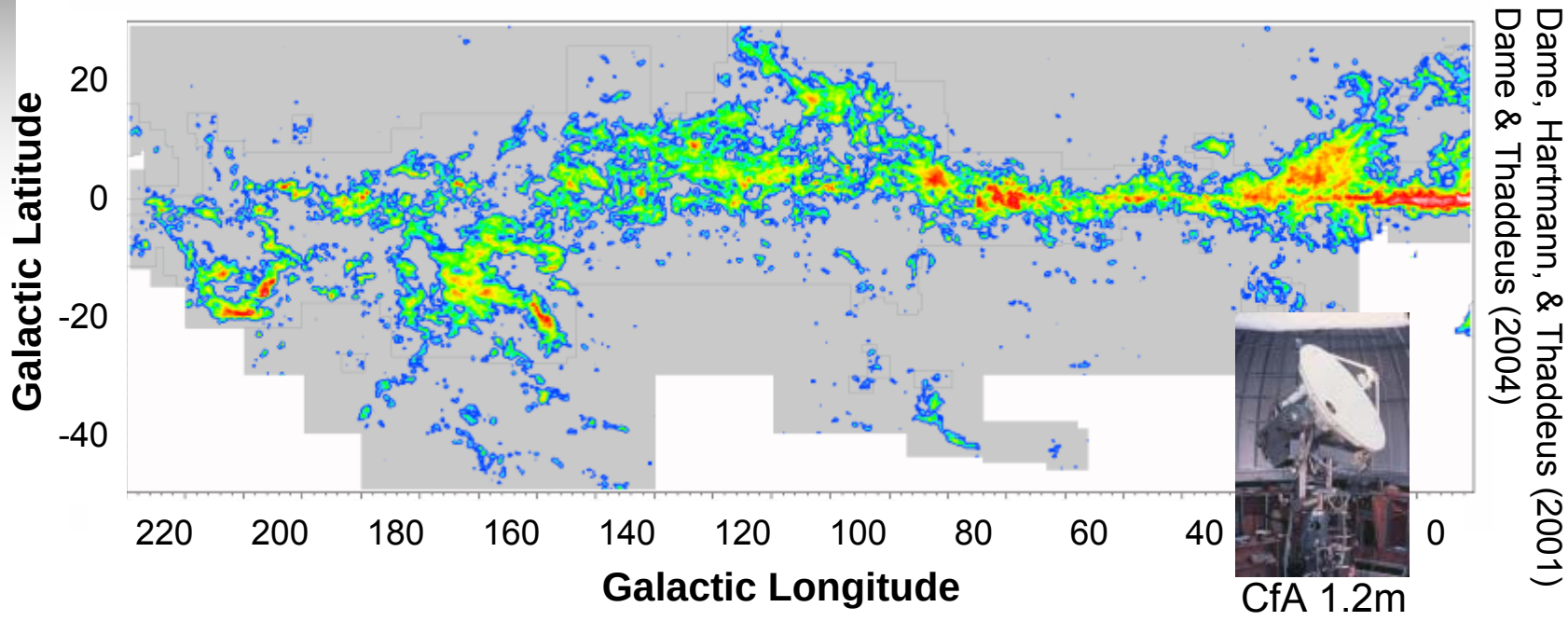
- *Multiwavelength observations needed for*
  - *understanding the high-energy diffuse emission of the Milky Way*
  - *source identification and population studies*
  - *intensive exploration of the brightest and most variable sources that will allow deep study of the source physics*
  - *rapid follow-up on transients (e.g. GRBs, blazar flares)*
    - *GLAST mission designed to support rapid notification for follow-up*

example: Markarian 421



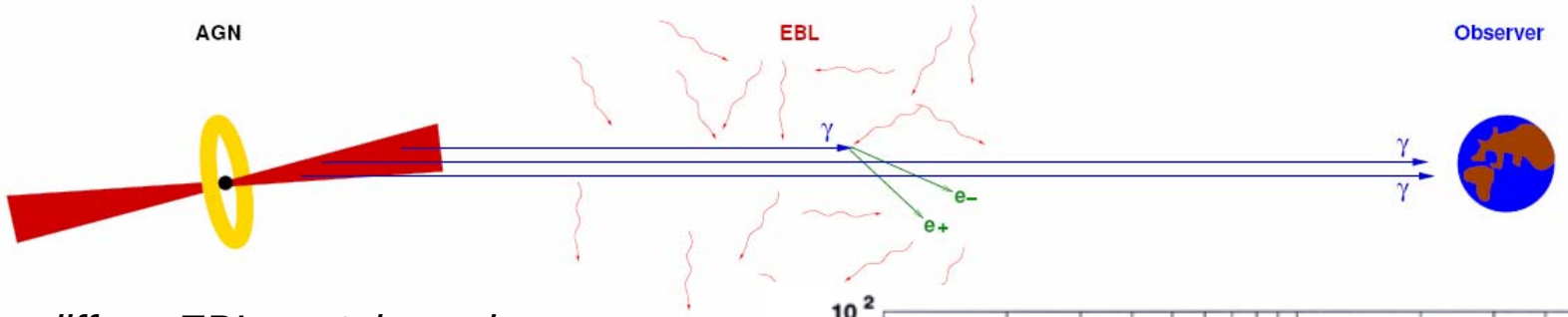
Modeling diffuse emission: need for new data

- ***Extend CO surveys to high latitudes***
  - *newly-found small molecular clouds will otherwise be interpreted as unidentified sources, and clearly limit dark matter studies*



- ***$C^{18}O$ observations (optically thin tracer) of special directions (e.g. Galactic center, arm tangents)***
  - *assess whether velocity crowding is affecting calculations of molecular column density, and for carefully pinning down the diffuse emission*

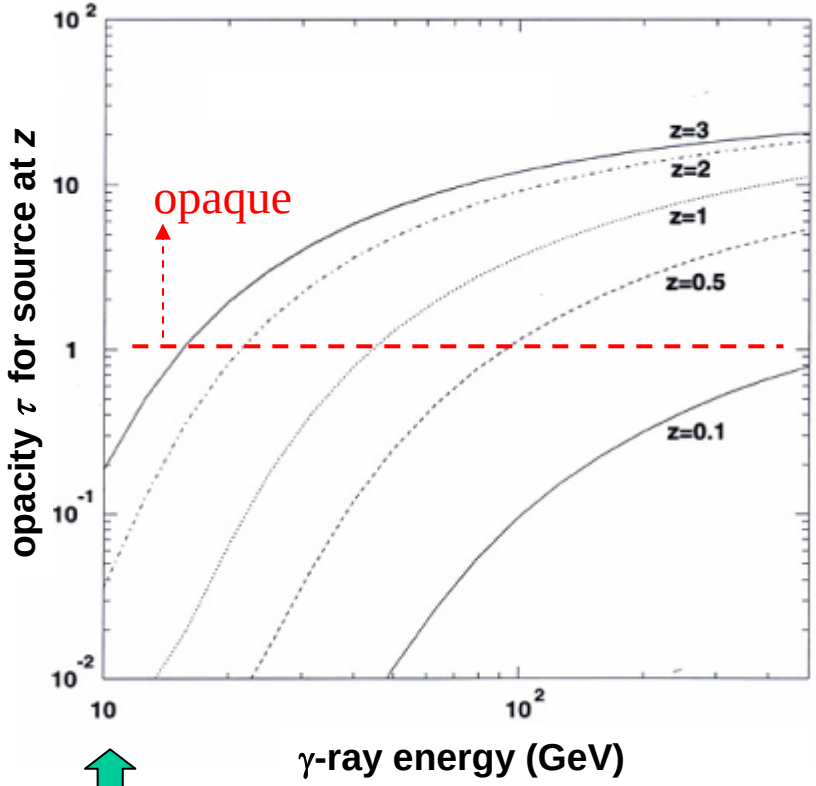
Probing Extragalactic Background StarLight with Blazars



- *diffuse EBL contains unique information about the epochs of formation and the evolution of galaxies and in what environments the stars of the universe formed*
- *direct EBL measurements require accurate model-based subtraction of bright foregrounds (e.g., zodiacal light)*
- *alternative approach: extract imprint of EBL absorption, as function of redshift, from high-energy spectra of extragalactic sources*

  $\gamma\gamma \rightarrow e^+e^-$, *maximum when*

  $\varepsilon_{EBL} \sim ½ \text{ (1000 GeV / } E_\gamma\text{) eV}$



No significant attenuation below 10 GeV

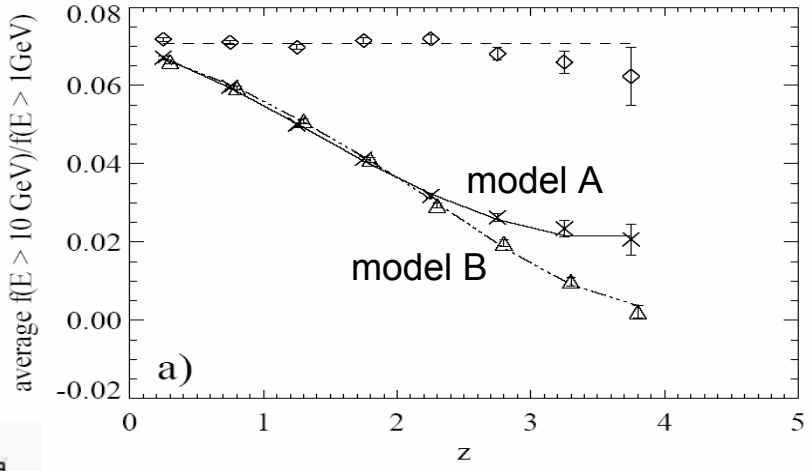
Probing Extragalactic Background StarLight with Blazars

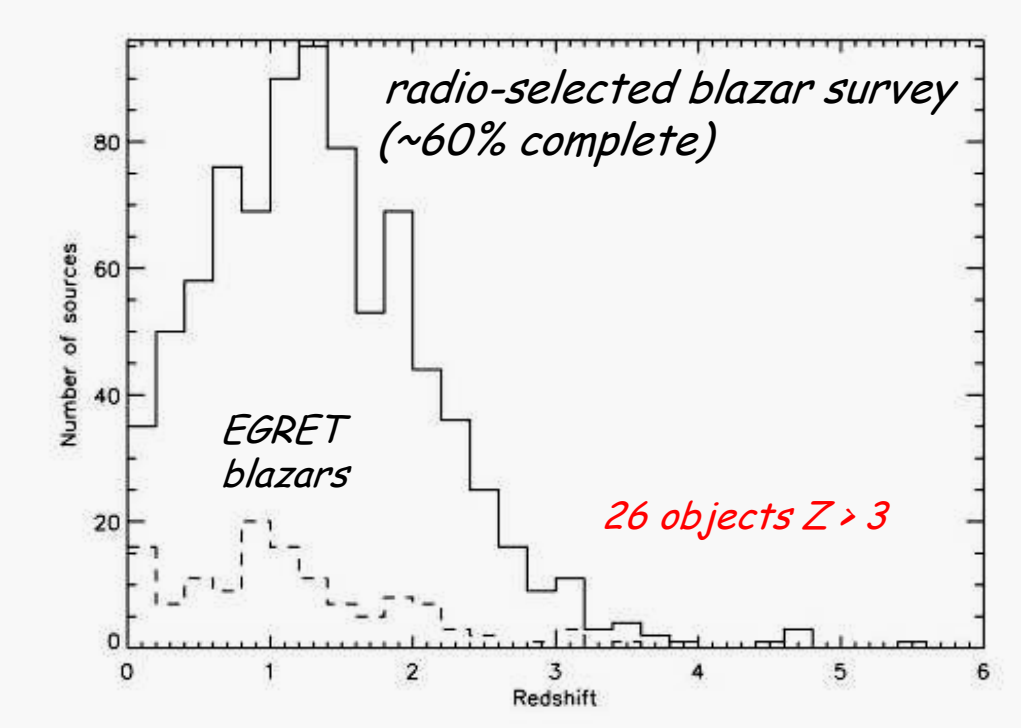
- *measure redshift dependence of flux attenuation above 10 GeV*
- *GLAST will sample high-z blazars*

sensitive to optical-UV EBL;

complements TeV measurements of nearby blazars that constrain the optical-NIR EBL

measure flux E>10 GeV/flux E>1 GeV





70% of EGRET sources (|b|>10°) are blazars

4.8 GHz radio survey; chose bright flat-spectrum sources

95% of radio-selected sources are blazars