Gamma-ray Large Area Space Telescope

Overview of LAT/GLAST and Collaboration Roles

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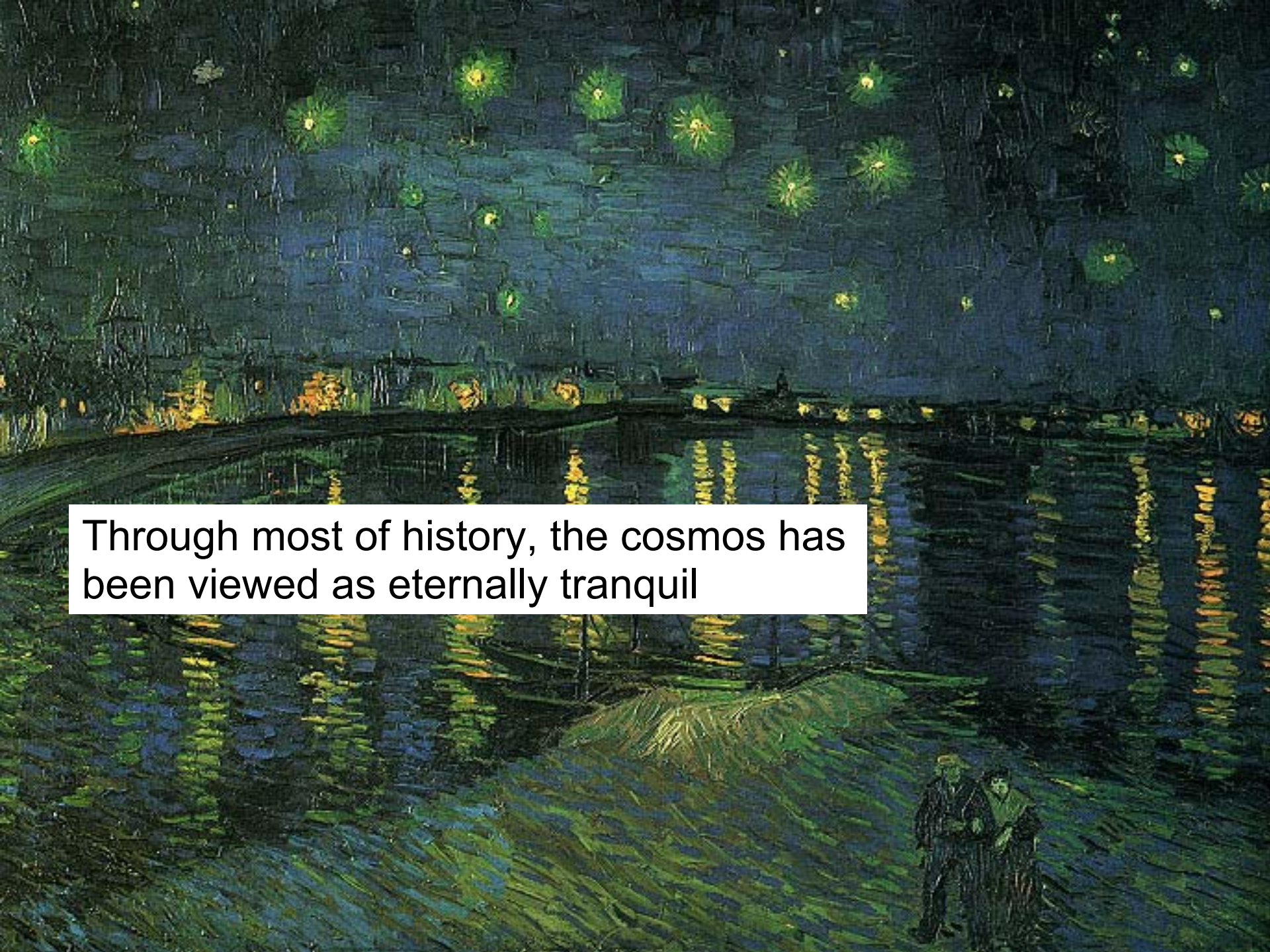
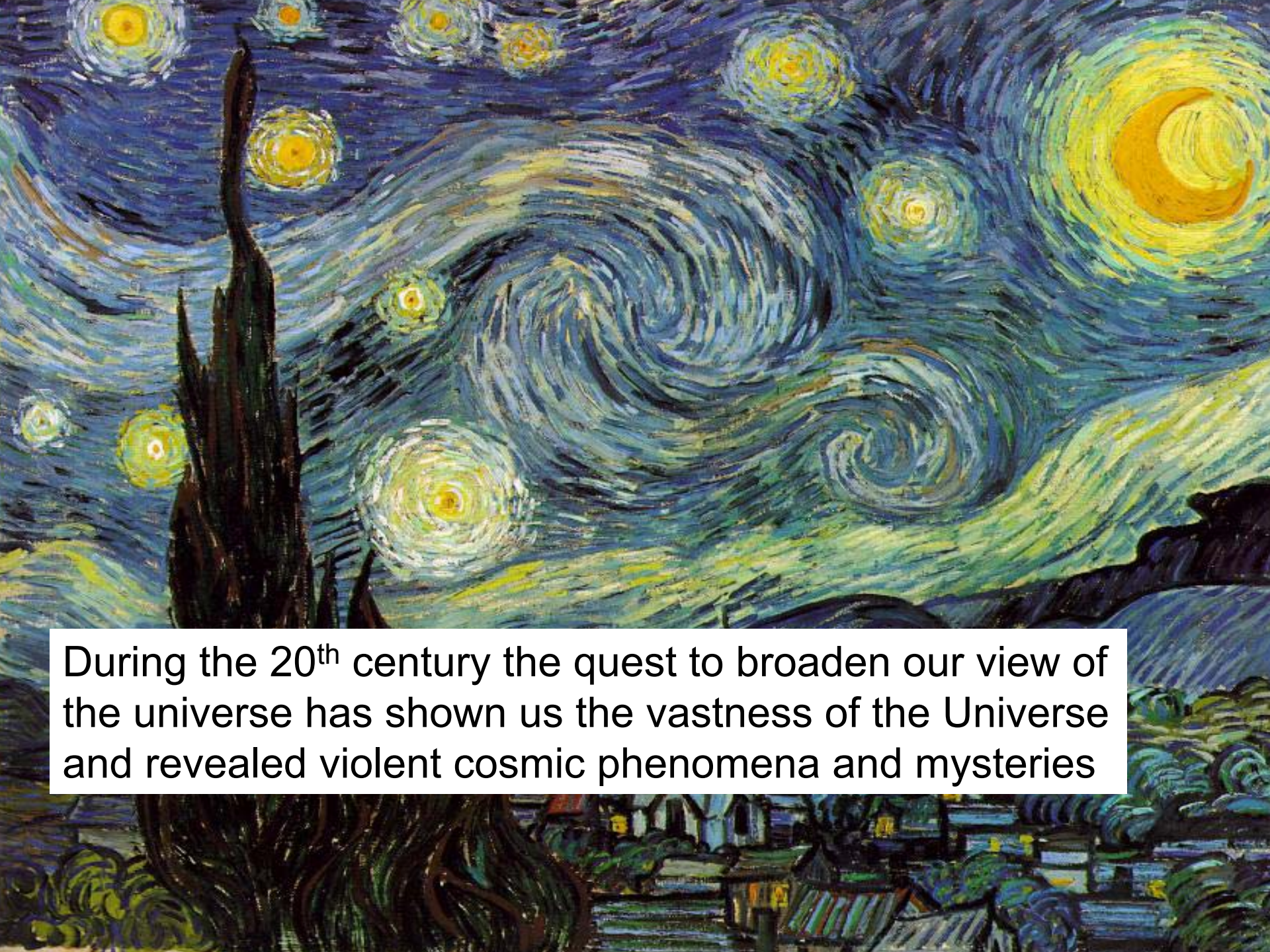
Principal Investigator / Spokesperson
Stanford University

GLAST International Finance Committee
SLAC, Stanford University
February 18-19, 2003

Outline

- GLAST Mission overview
- Large Area Telescope (LAT)
- GLAST LAT Collaboration
- Science overview

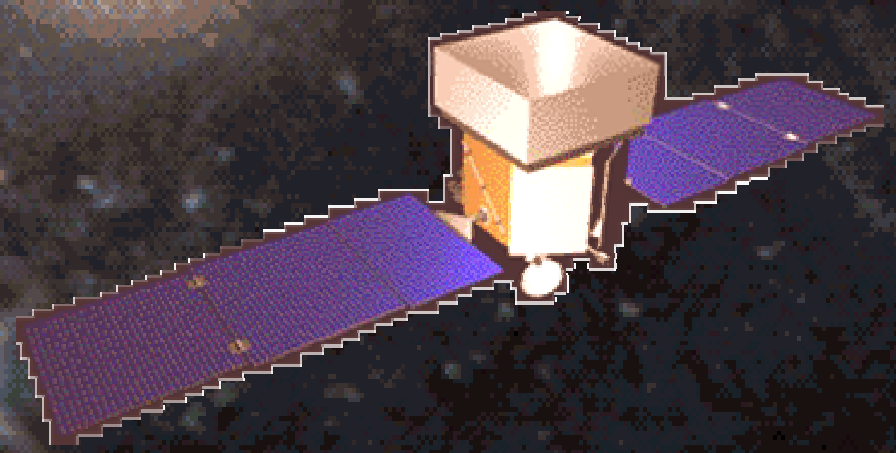

Through most of history, the cosmos has been viewed as eternally tranquil



During the 20th century the quest to broaden our view of the universe has shown us the vastness of the Universe and revealed violent cosmic phenomena and mysteries

GLAST is an important part of the continuing quest to broaden our view of the universe.

- observe, with unprecedented detail, cosmic arenas of extreme violence
- explore Nature's highest energy processes (10 keV – 300 GeV)



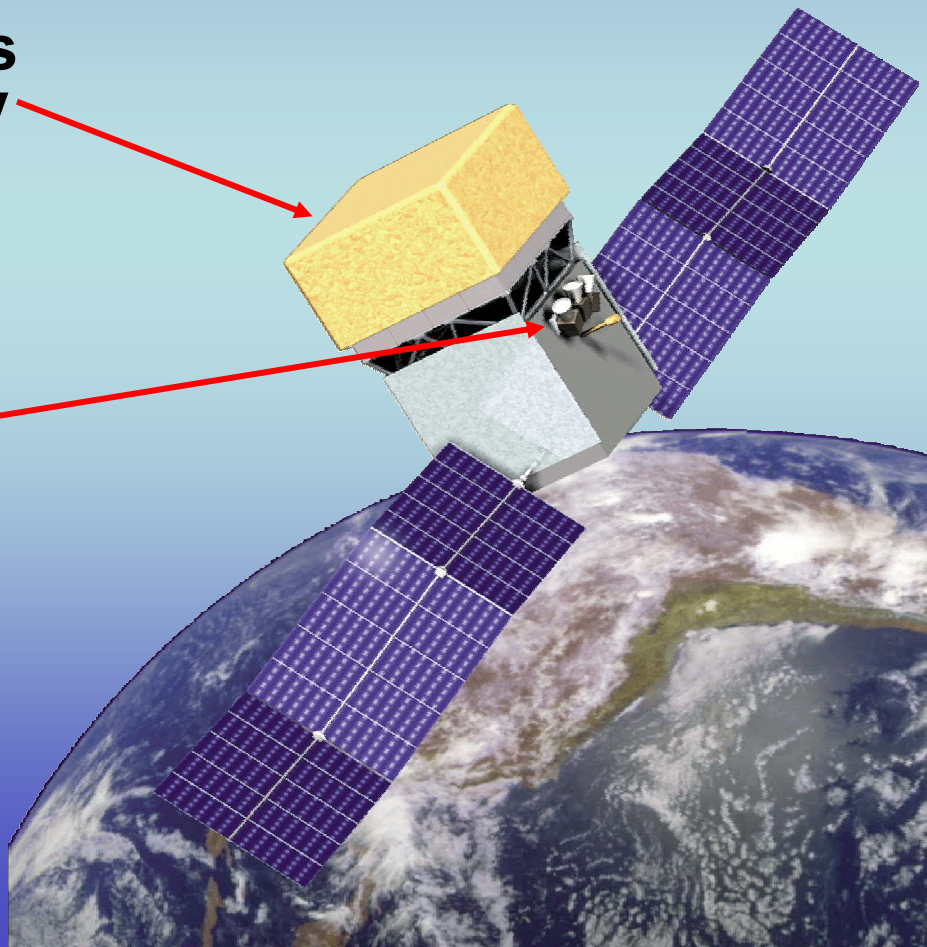
LAUNCH: September 2006

GLAST

GLAST measures the direction, energy & arrival time of celestial gamma rays

- LAT measures gamma-rays in the energy range ~20 MeV - >300 GeV

- GBM provides correlative observations of transient events in the energy range ~20 keV – 20 MeV

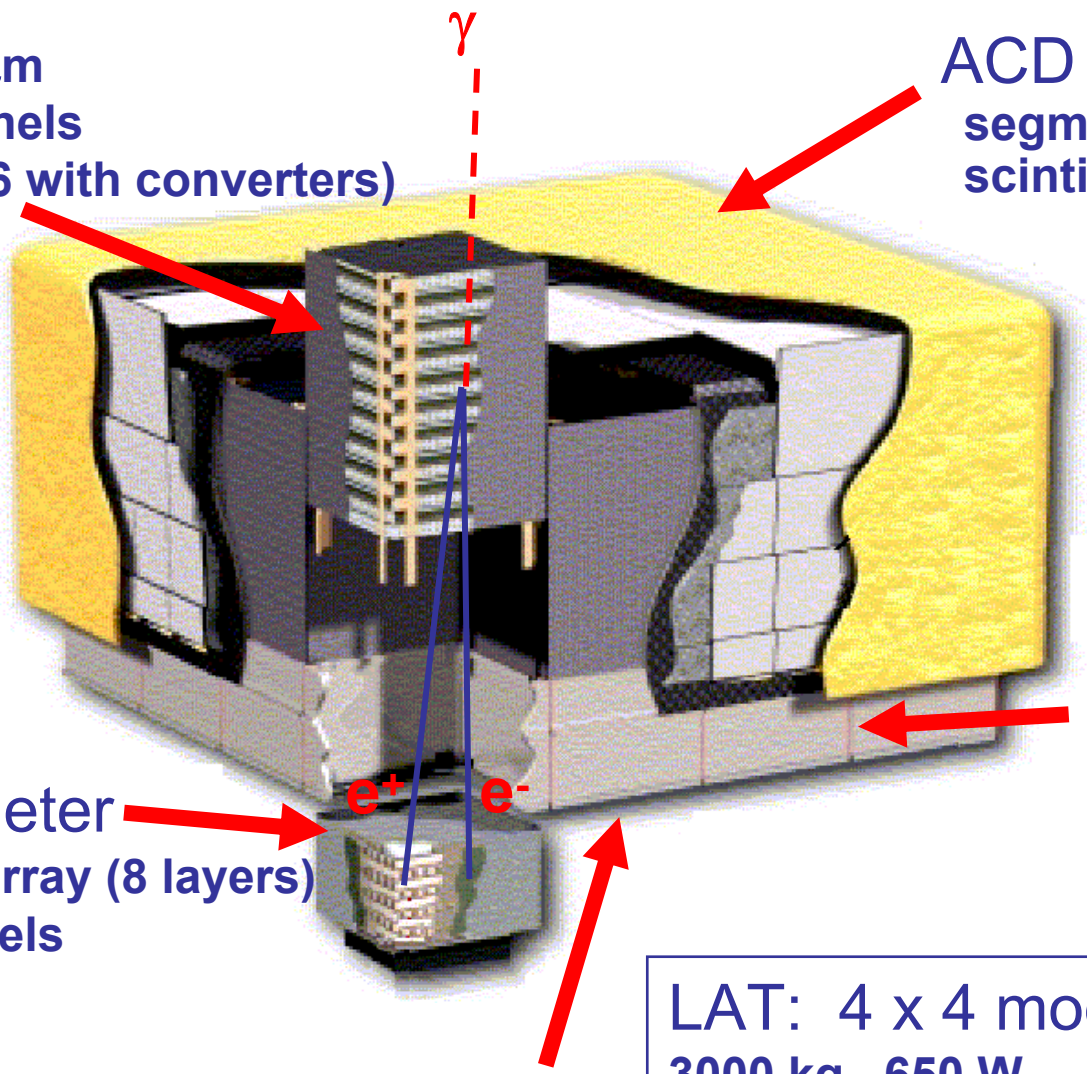


Si Tracker

pitch = 228 μm
8.8 10^5 channels
18 planes (16 with converters)

ACD

segmented scintillator tiles



Grid

mechanical backbone

CsI Calorimeter

hodoscopic array (8 layers)
6.1 10^4 channels

Data Acquisition

LAT: 4 x 4 modular array

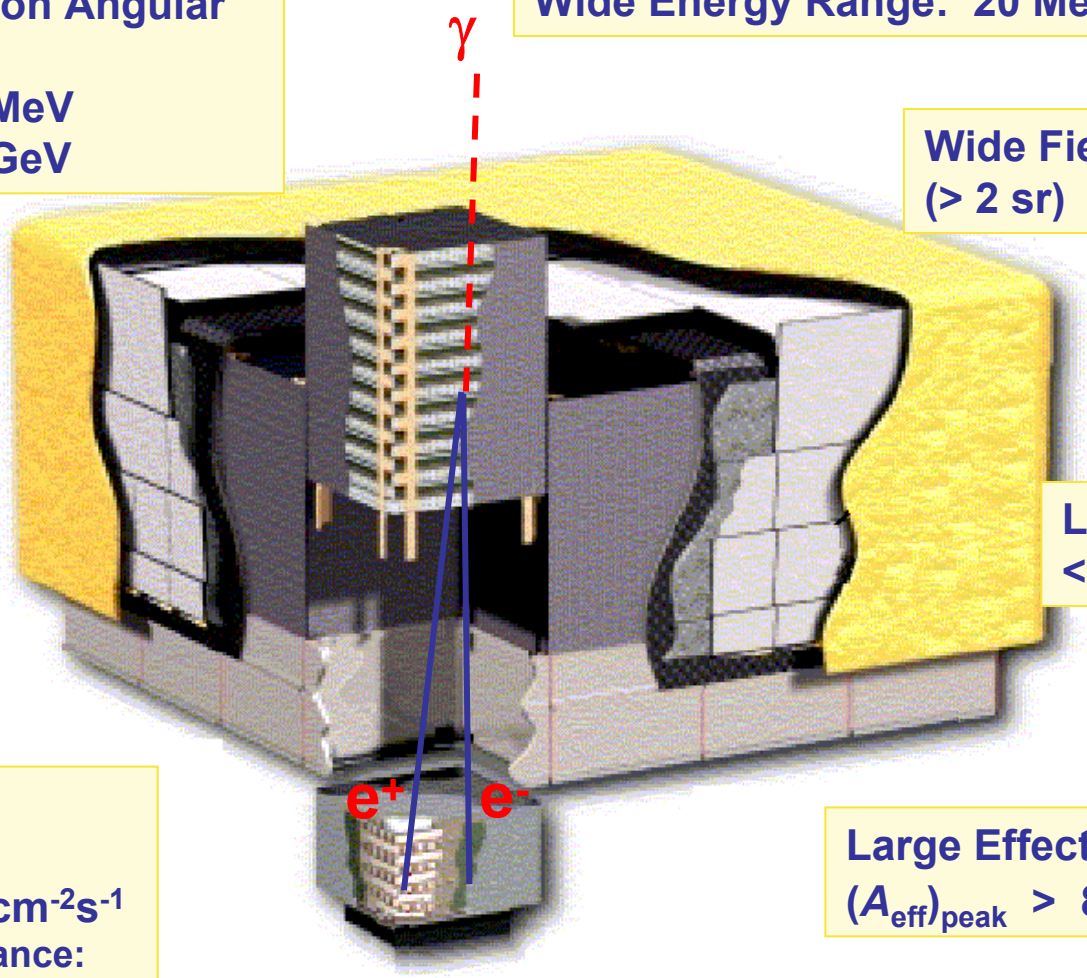
3000 kg, 650 W
20 MeV – 300 GeV

Single Photon Angular Resolution
3.5° @ 100 MeV
0.15° @ 10 GeV

Wide Energy Range: 20 MeV - >300 GeV

Wide Field of View (> 2 sr)

40 times EGRET's sensitivity and extends energy range to 300 GeV



Low dead time: < 100 μs/event

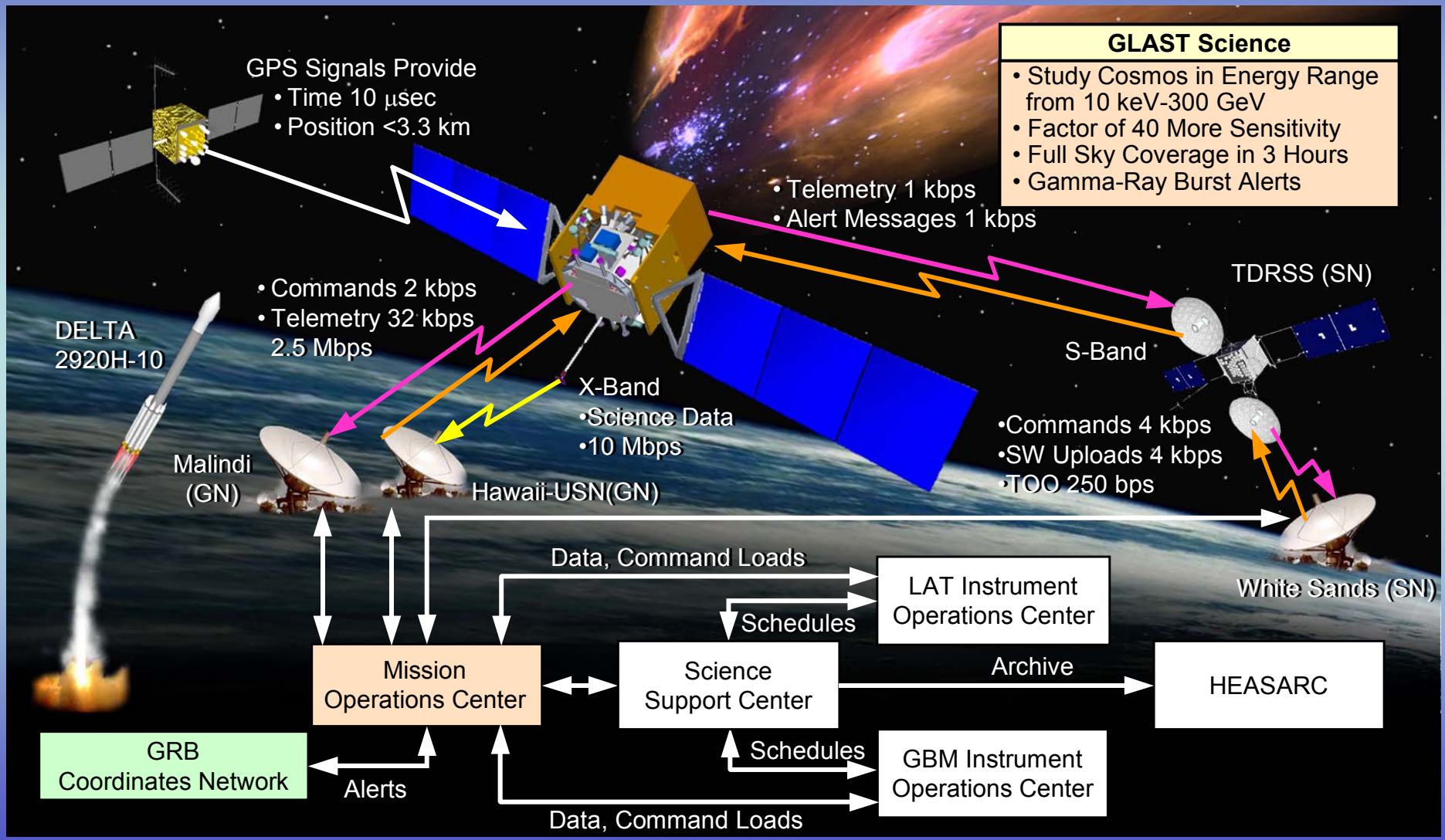
Point Source Sensitivity:
$< 6 \times 10^{-9}$ ph cm^{-2}s^{-1}
(est. performance: $< 3 \times 10^{-9}$ ph cm^{-2}s^{-1})

Source Localization:
0.3' – 1'

Large Effective Area
$(A_{eff})_{peak} > 8{,}000$ cm^2

Good Energy Resolution
$\Delta E/E \sim$ 10%; 100 MeV – 10 GeV
~ < 20%; 10 GeV – 300 GeV

GLAST Mission Overview



Summary of GLAST Project History

- **from its conception, GLAST developed by a collaboration of astrophysicists and particle physicists**
- **major leap in capability brought by modern detector technology**

- **LAT concept & technology in development by collaboration since 1992**
  - extensive beam tests of LAT elements, including high-altitude balloon flight of prototype LAT tower; validation of Monte Carlo model
- **GLAST endorsed by NASA Space Science Advisory Committee, Nov 1997**
- **Presented to DOE HEPAP, Jan 1997; submitted proposal for LAT to DOE, Feb 1998; reviewed by SAGENAP, April 1998**
- **Collaboration Proposal for LAT Flight Instrument accepted by NASA, Feb 2000**
  - proposal endorsed by CNES, CEA, IN2P3, ASI, INFN, JGC, SGC
  - subsequently, LoAs, MoAs signed or in final-draft form to formalize agreements
- **NRC Decadal Astronomy & Astrophysics Review ranks GLAST highest priority "moderate-size" space mission for next decade, Sept 2000**

GLAST LAT Collaboration

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
- Stanford University – Hanson Experimental Physics Laboratory
- Stanford University - Stanford Linear Accelerator Center
- Texas A&M University – Kingsville
- University of Washington
- Washington University, St. Louis

France
- Centre National de la Recherche Scientifique / Institut National de Physique Nucléaire et de Physique des Particules
- Commissariat à l'Energie Atomique / Direction des Sciences de la Matière/ Département d'Astrophysique, de physique des Particules, de physique Nucléaire et de l'Instrumentation Associée

Italy
- Agenzia Spaziale Italiana (ASI), Science Data Center
- Istituto di Astrofisica Spaziale, (IASF, CNR)
- Istituto Nazionale di Fisica Nucleare (INFN)

Japan GLAST Collaboration
- Hiroshima University
- Institute for Space and Astronautical Science
- RIKEN

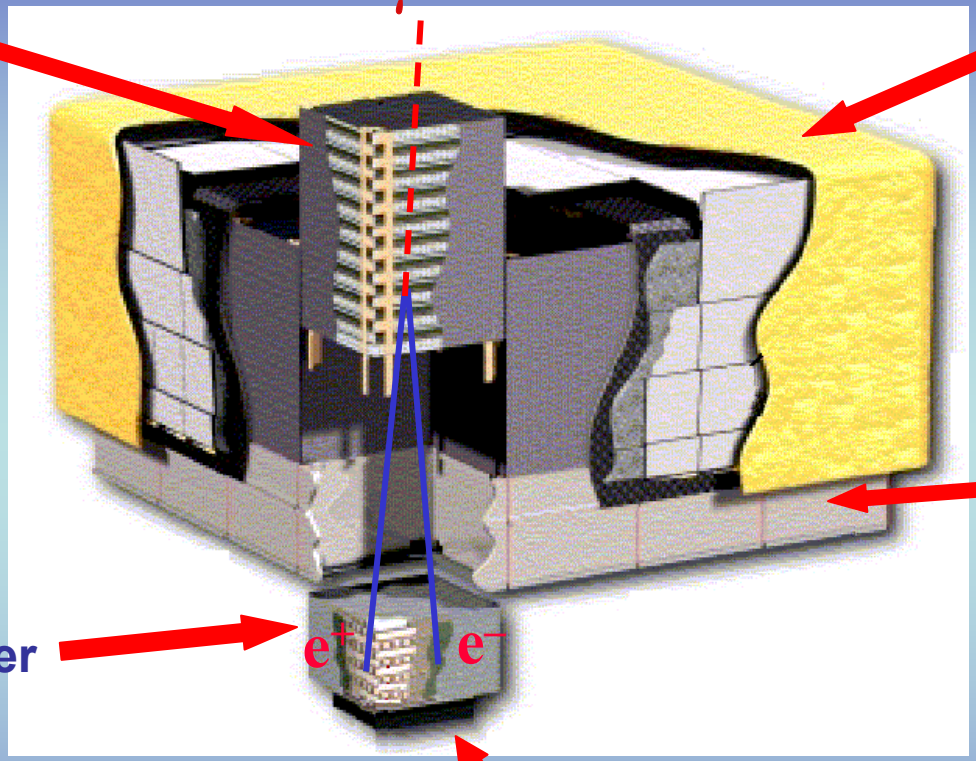
Swedish GLAST Consortium
- Royal Institute of Technology (KTH)
- Stockholm University

124 Members (including 60 Affiliated Scientists)

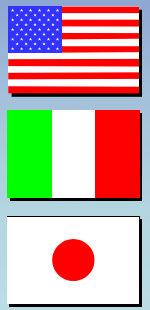
18 Postdoctoral Students

22 Graduate Students

International Contributions to the LAT



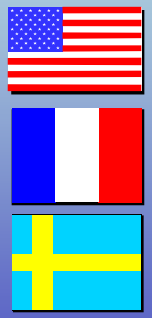
Si Tracker



ACD

Grid (& Thermal Radiators)

CsI Calorimeter



Electronics, Data Acquisition & Flight Software

Collaboration Organization

Senior Scientist Advisory Committee

– membership

- N. Gehrels, Chair
- P. Michelson, PI/Spokesperson
- G. Barbiellini, Italy
- R. Bellazzini, Italy
- E. Bloom, U.S.
- T. Burnett, U.S.
- P. Carlson, Sweden
- R. Dubois, U.S.
- I. Grenier, France
- N. Johnson, U.S.
- R. Johnson, U.S.
- T. Kamae, Japan
- J. Ormes, U.S.
- S. Ritz, U.S.
- H. Sadrozinski, U.S.
- D. Smith, France
- D. Thompson, U.S.
- K. Wood, U.S.

SSAC Charter

- **Advise PI/Spokesperson on the conduct of the LAT Science Investigation**
- **Implement collaboration membership policy and publication policy**
- **Advise PI and LAT Management on LAT design issues that critically impact science performance**
- **Meet monthly**

International Memoranda of Agreement

MoAs between Stanford Univ-SLAC and:	Status
• INFN, ASI, Italy	pending signature
• IN2P3, France; NRL	√ signed
• CEA/DSM/DAPNIA, France; NRL	√ signed
• Royal Inst. of Technology & Stockholm Univ., Sweden; NRL	√ signed
• Hiroshima Univ., ISAS & RIKEN, Japan; UCSC/SCIPP	√ signed

Purposes of Agreements

- establish areas of responsibility and commitments to LAT Project (e.g. deliverables, science participation,)
- establish International Finance Committee to review status of commitments

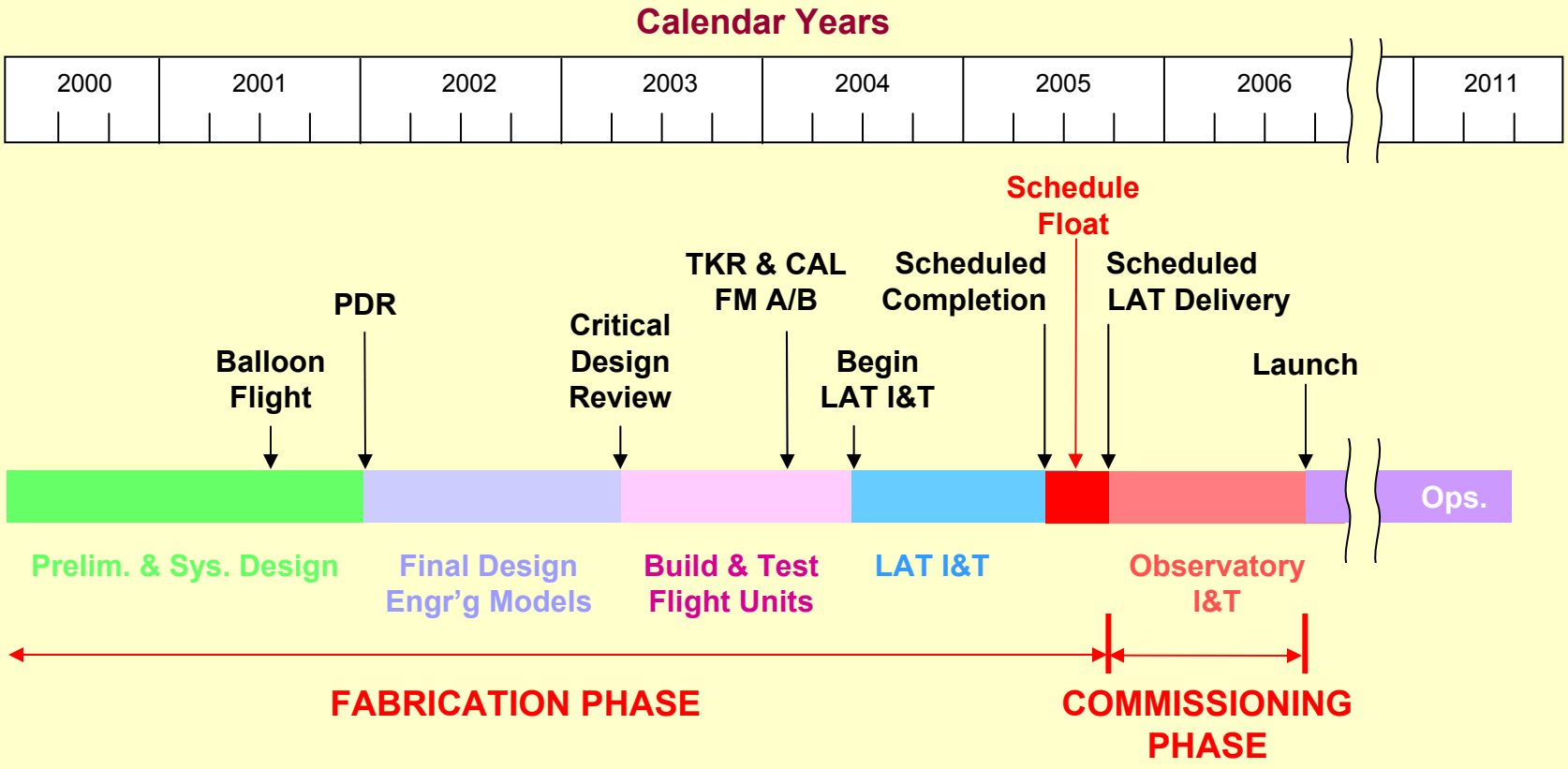
Agreements available on Web:

www-glast.slac.stanford.edu/LAT-Details/MOAs/MOAList.htm

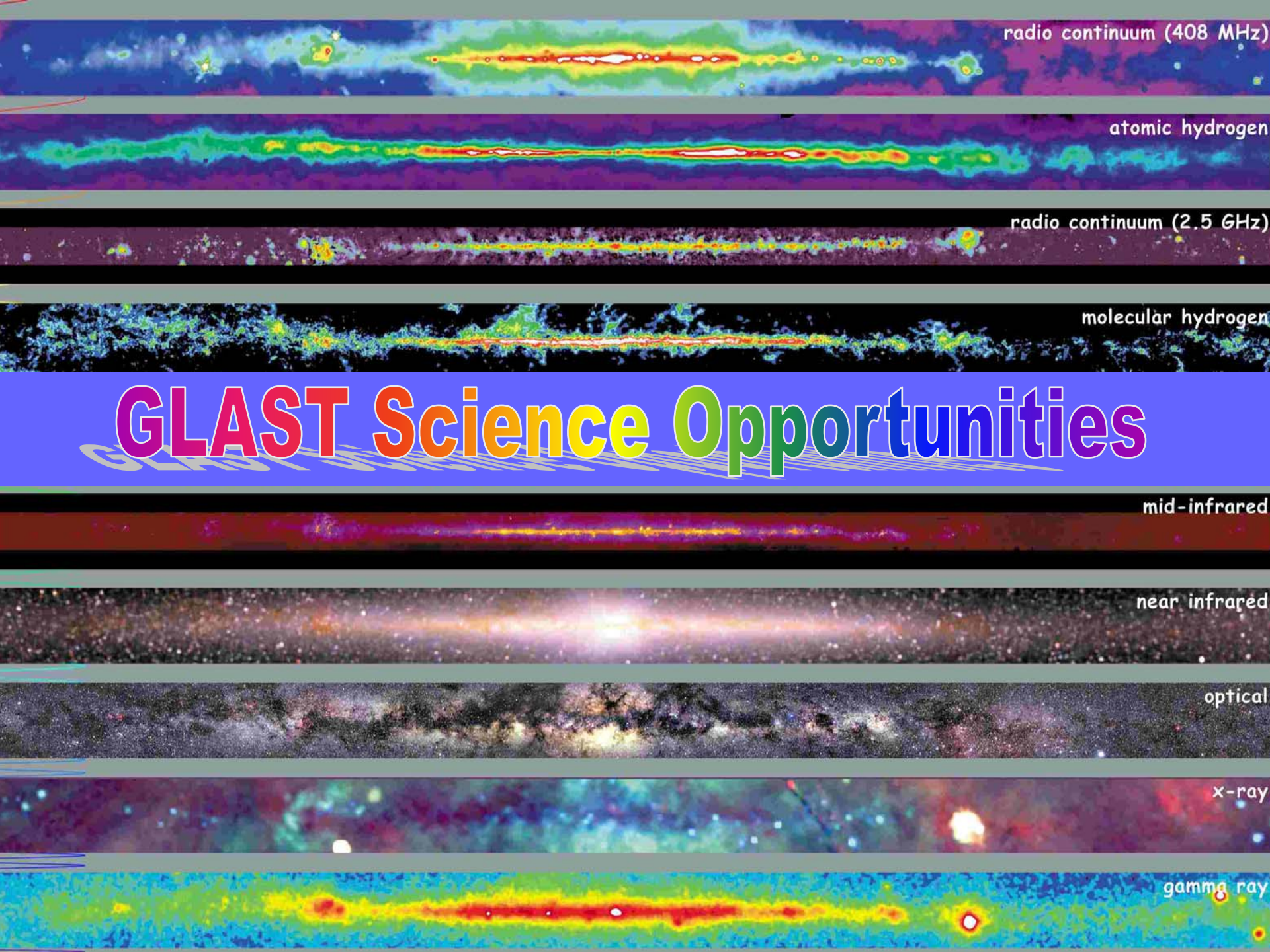
Status of Agency Level Agreements

Agreement:	Status
• NASA – Department Of Energy	√ signed
• NASA – CNES Agreement	pending signature
• NASA – ASI Agreement	pending signature
• NASA – Japan	draft in process
• NASA – Sweden	draft in process

LAT Schedule Highlights

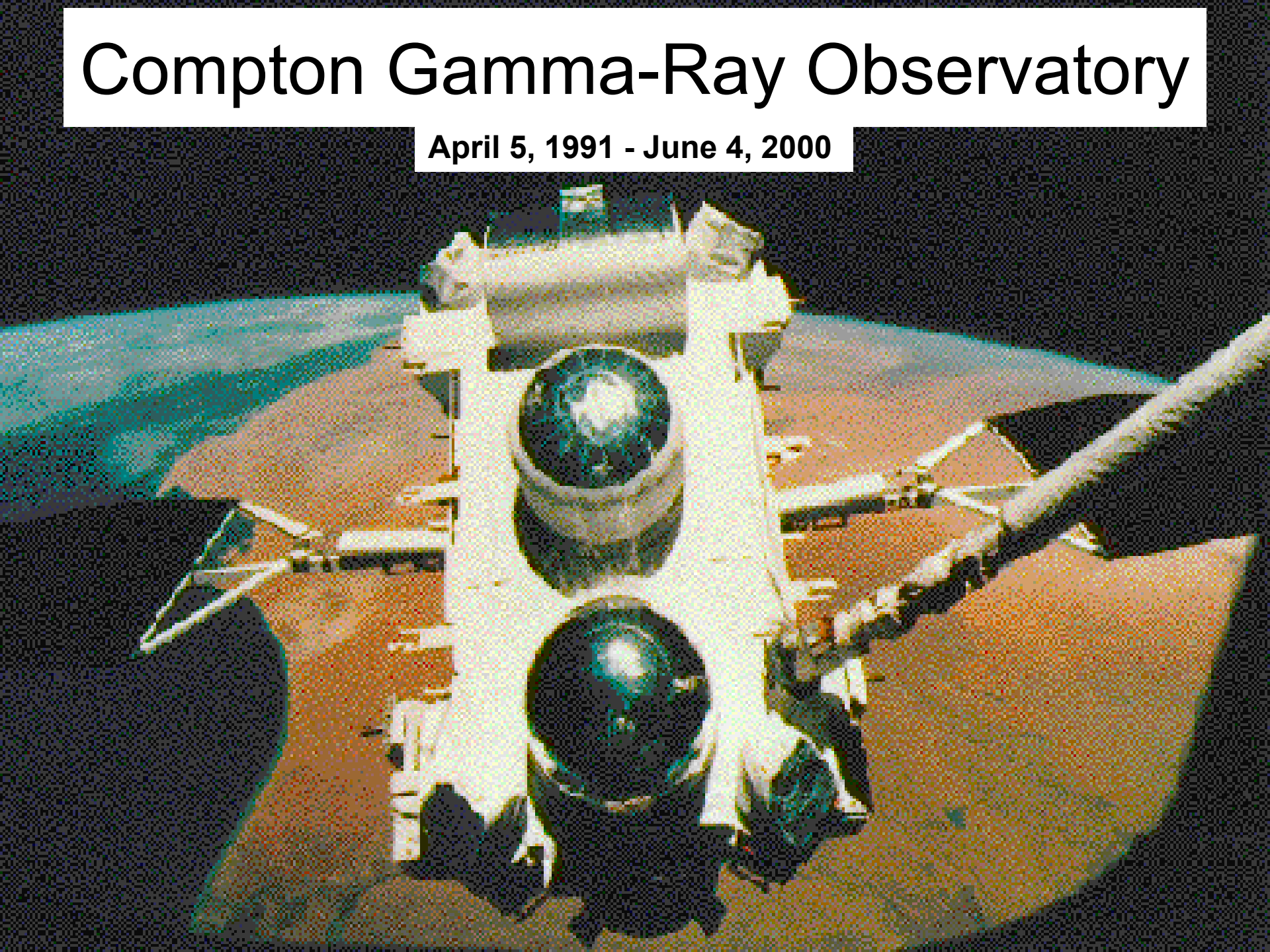


GLAST scheduled for launch in September 2006

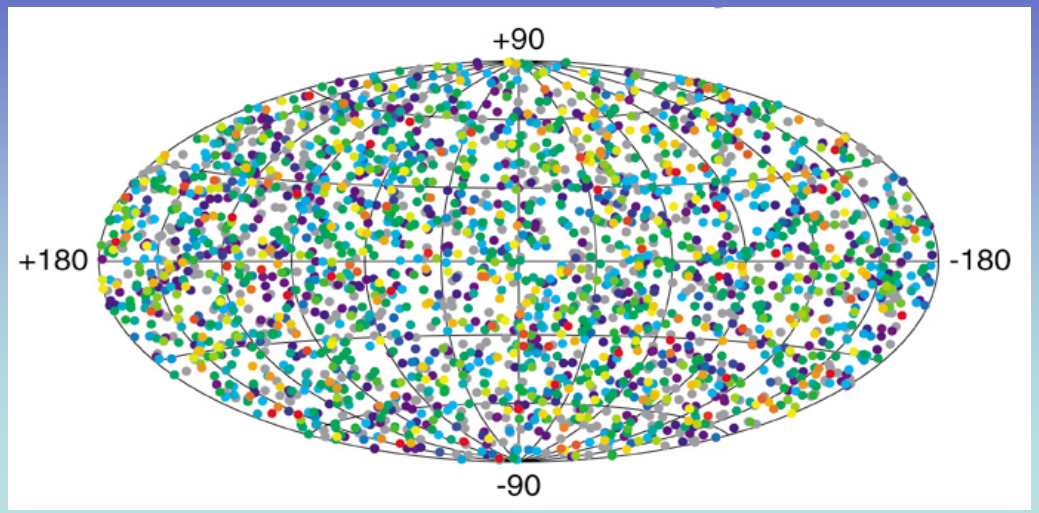

radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
GLAST Science Opportunities
mid-infrared
near infrared
optical
x-ray
gamma ray

Compton Gamma-Ray Observatory

April 5, 1991 - June 4, 2000



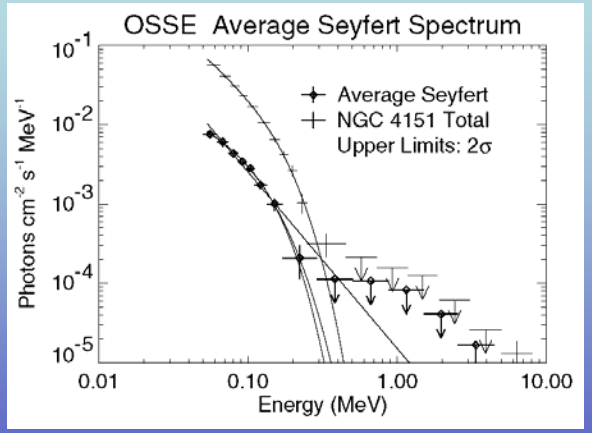
CGRO – Science Legacy



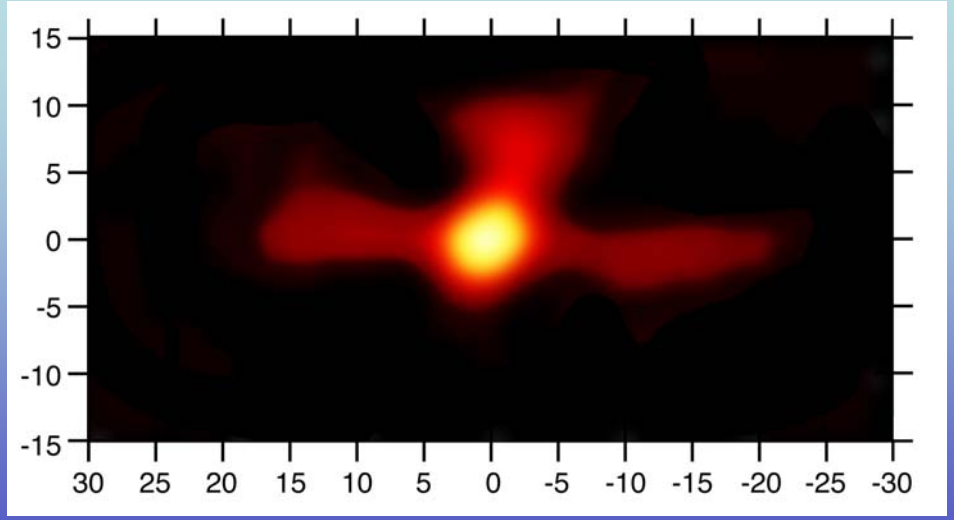
BATSE

2704 gamma-ray bursts: isotropic distribution

OSSE

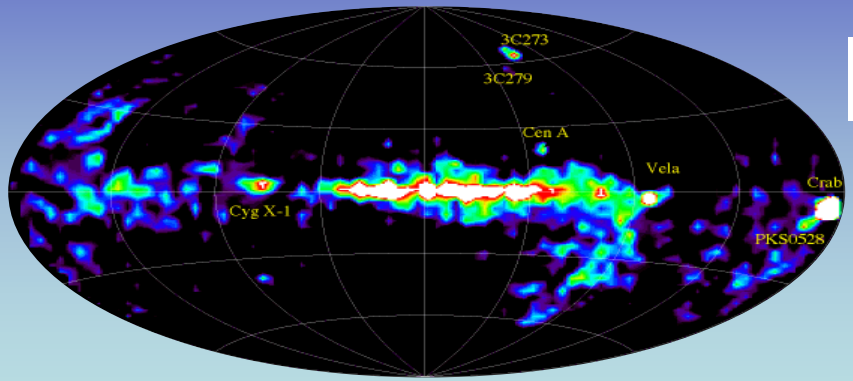


average spectrum of Seyfert galaxies



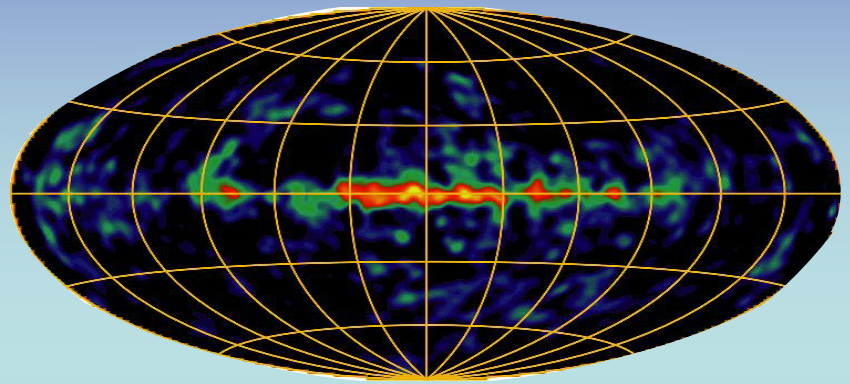
map of the Galactic center at 511 keV

CGRO – Science Legacy



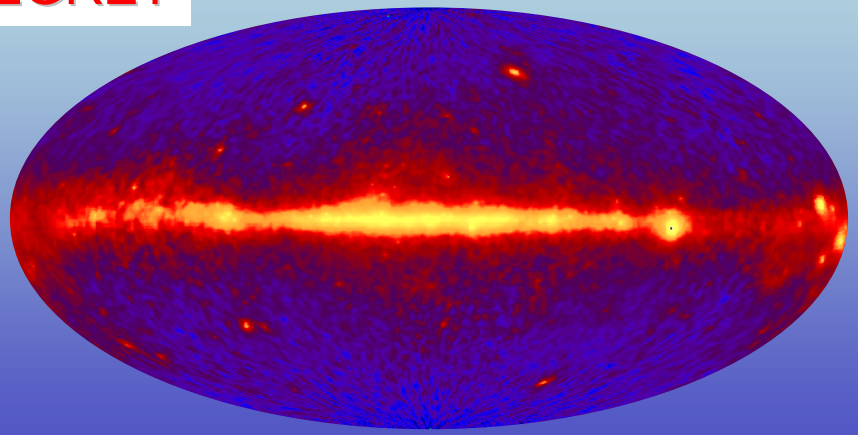
1-30 MeV map of Galaxy

COMPTEL



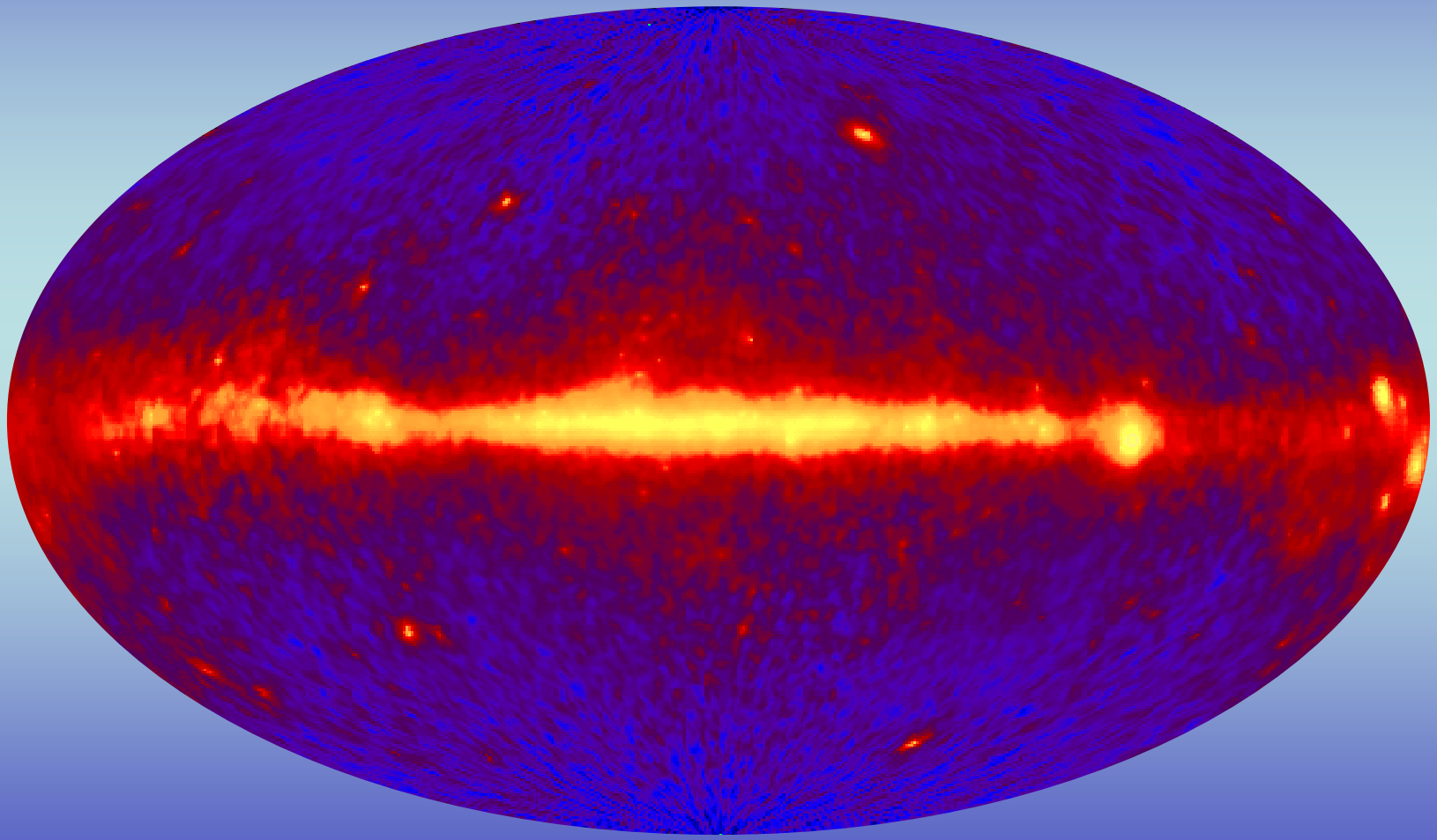
Al^{26} map of Galaxy - 1.809 MeV relic of Galactic nucleosynthesis over past few million years

EGRET

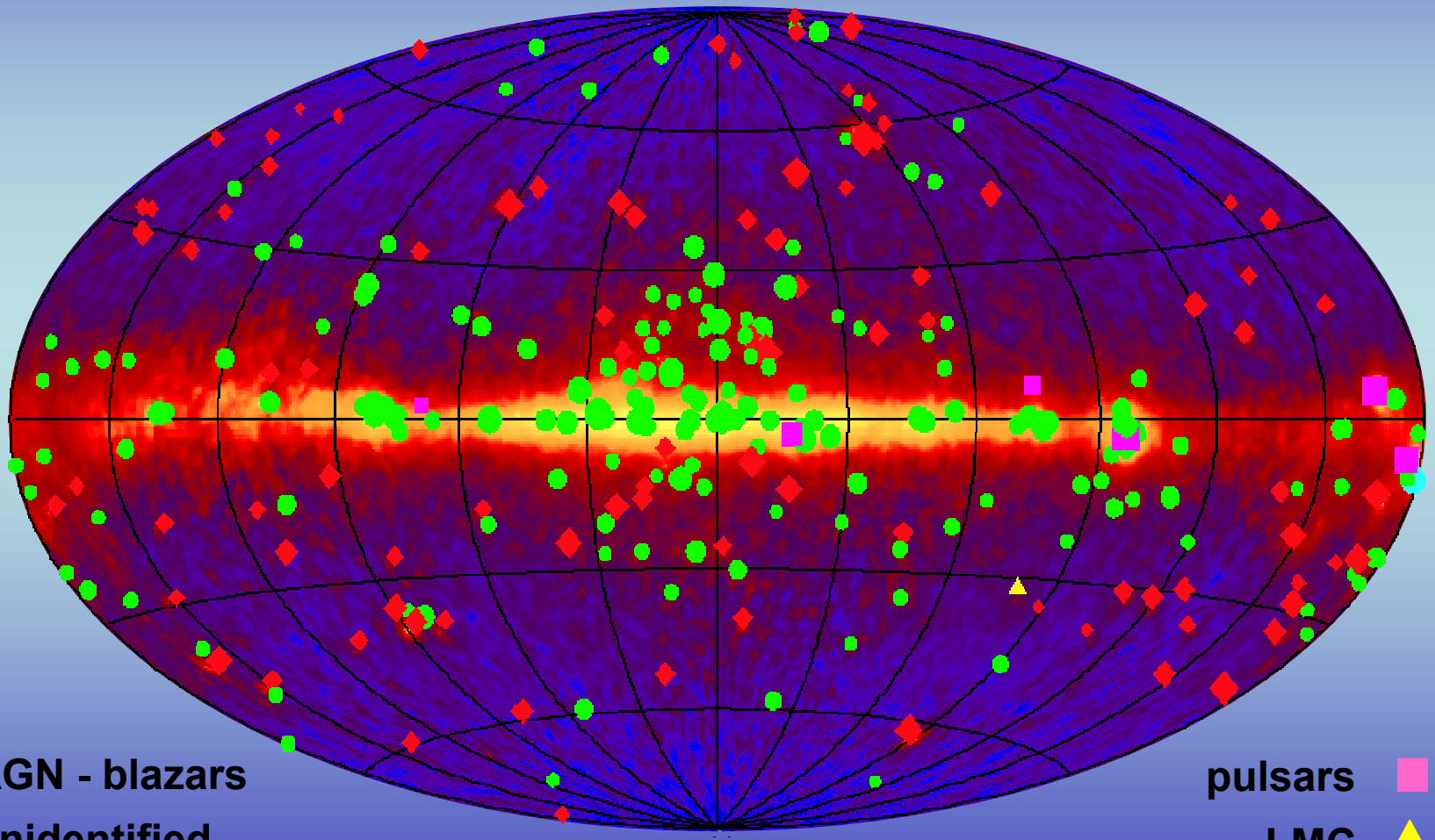


All-sky survey
(70 MeV – 10 GeV)

EGRET all-sky survey
(70 MeV – 10 GeV)



3rd EGRET Catalog



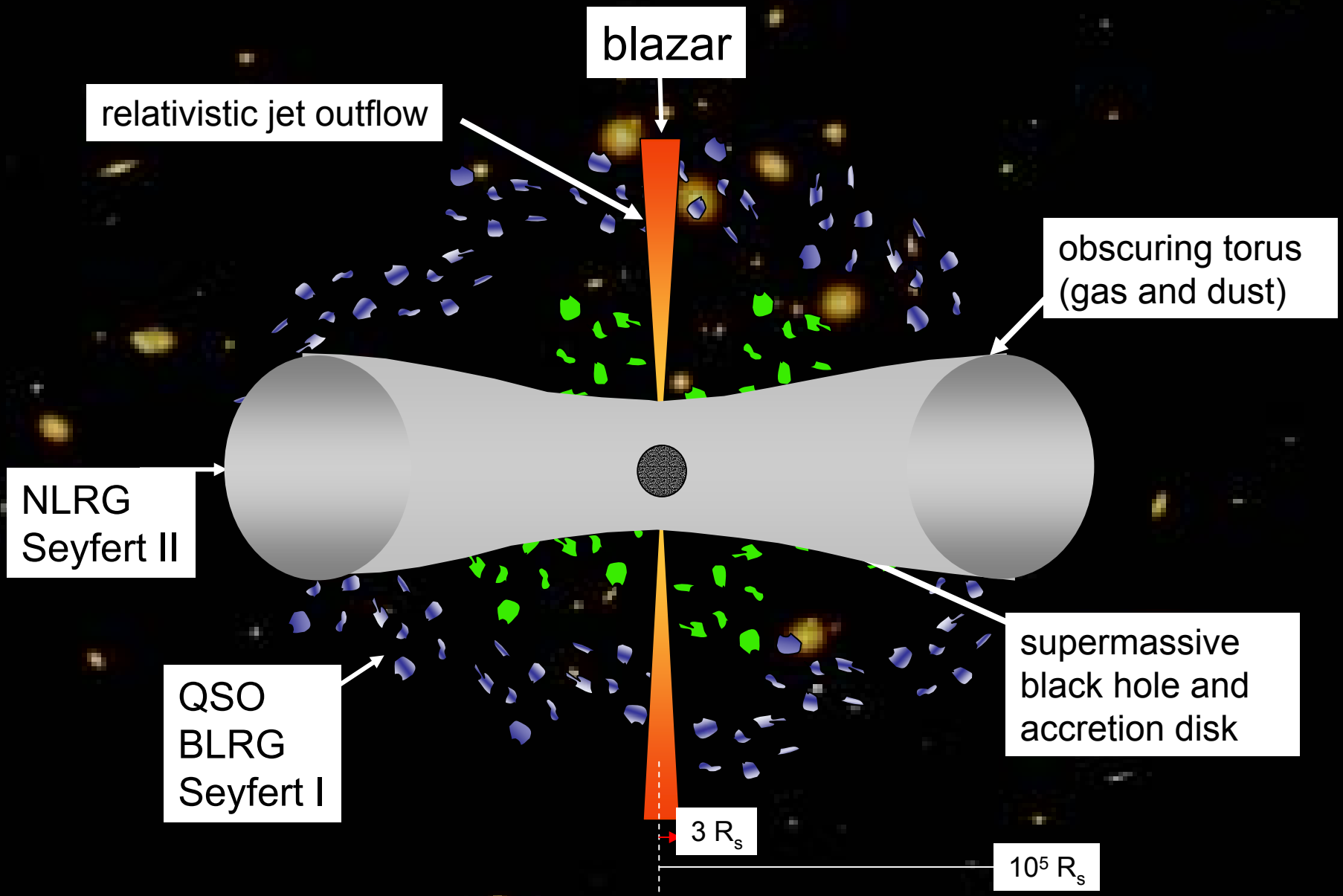
AGN - blazars

unidentified

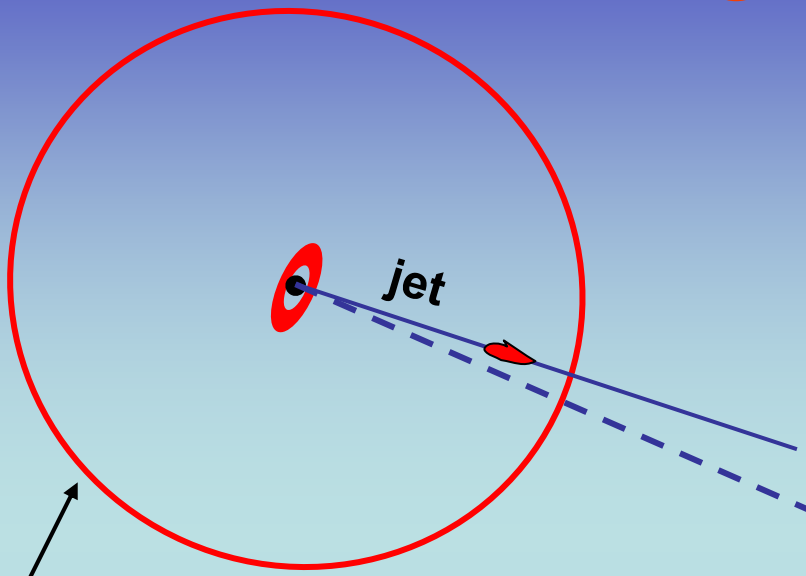
pulsars

LMC

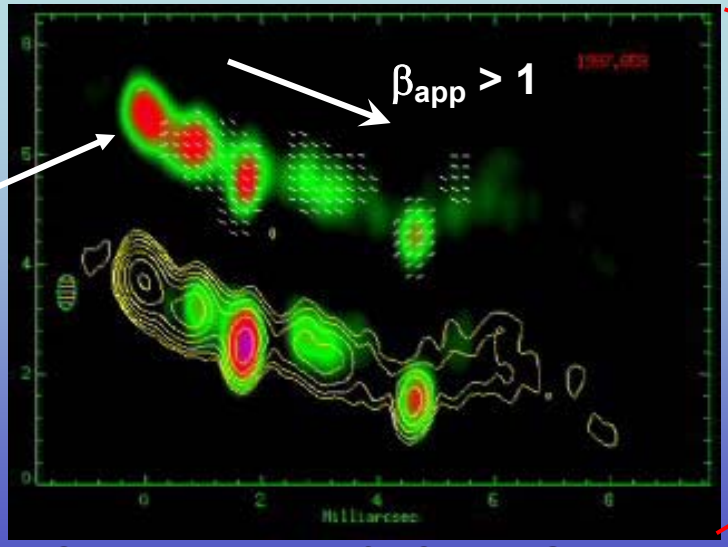
Active Galactic Nuclei: unified models



Blazar geometry

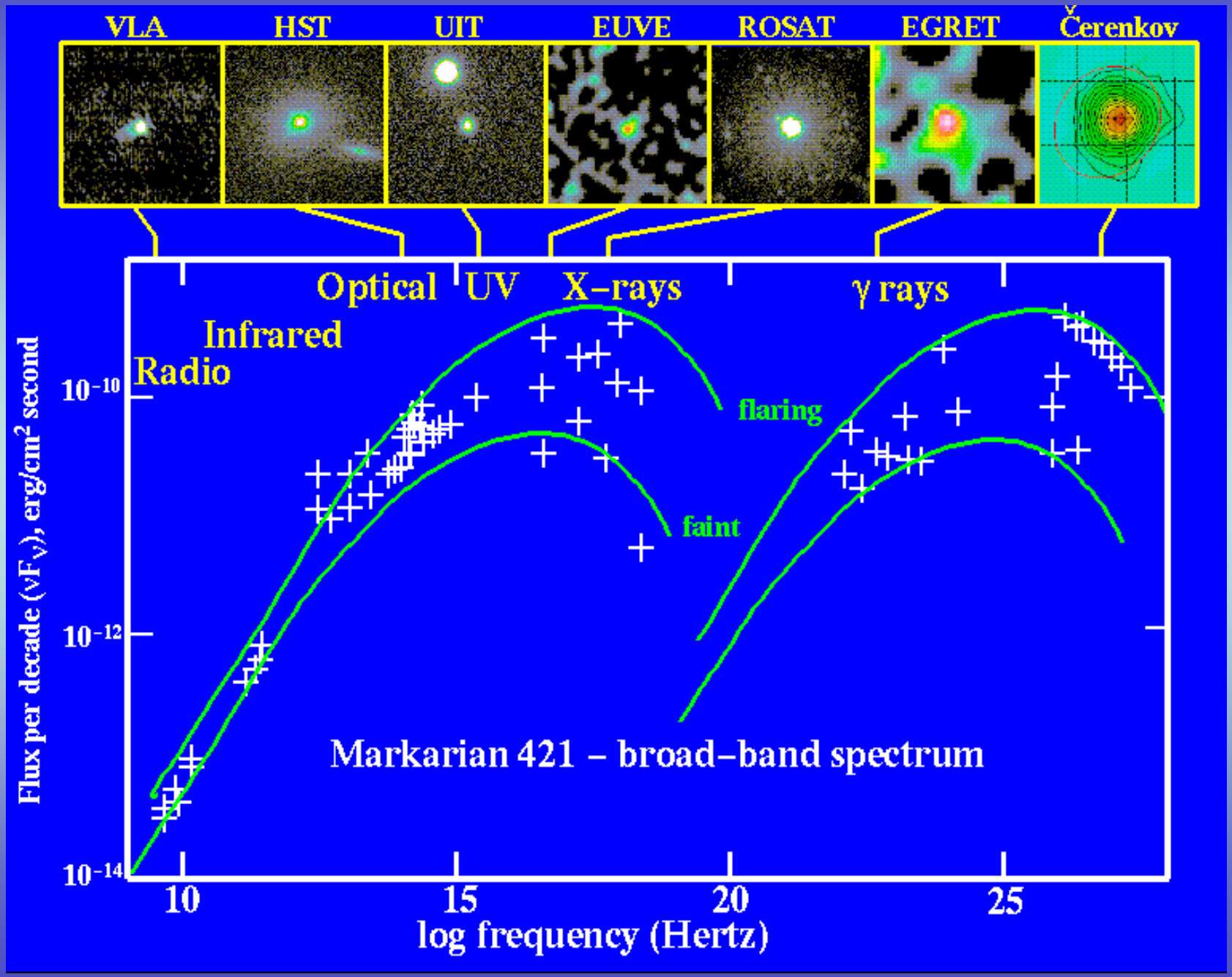


galaxy



core-dominated
(flat spectrum)

VLBA Observations of 3C120 (Gomez, et al)


VLA
HST
UIT
EUVE
ROSAT
EGRET
Čerenkov
Optical
UV
X–rays
γ rays
Infrared
Radio
flaring
faint
Markarian 421 – broad–band spectrum
Flux per decade (νF_ν), erg/cm² second
10⁻¹⁰
10⁻¹²
10⁻¹⁴
10
15
20
25
log frequency (Hertz)

3rd EGRET Catalog

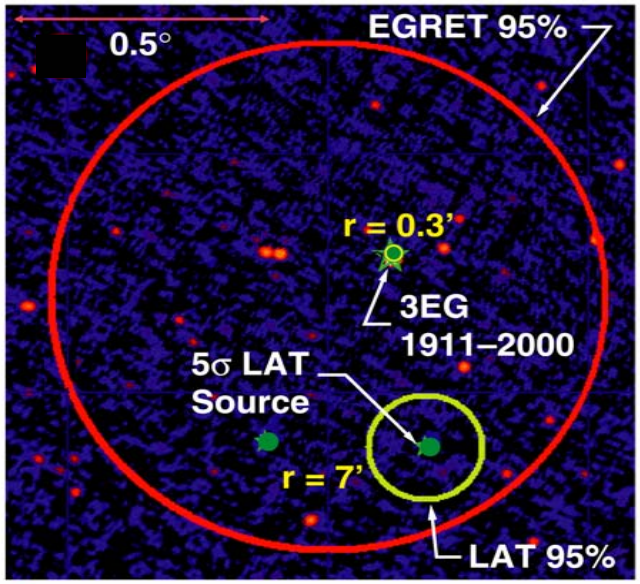
Unidentified Sources

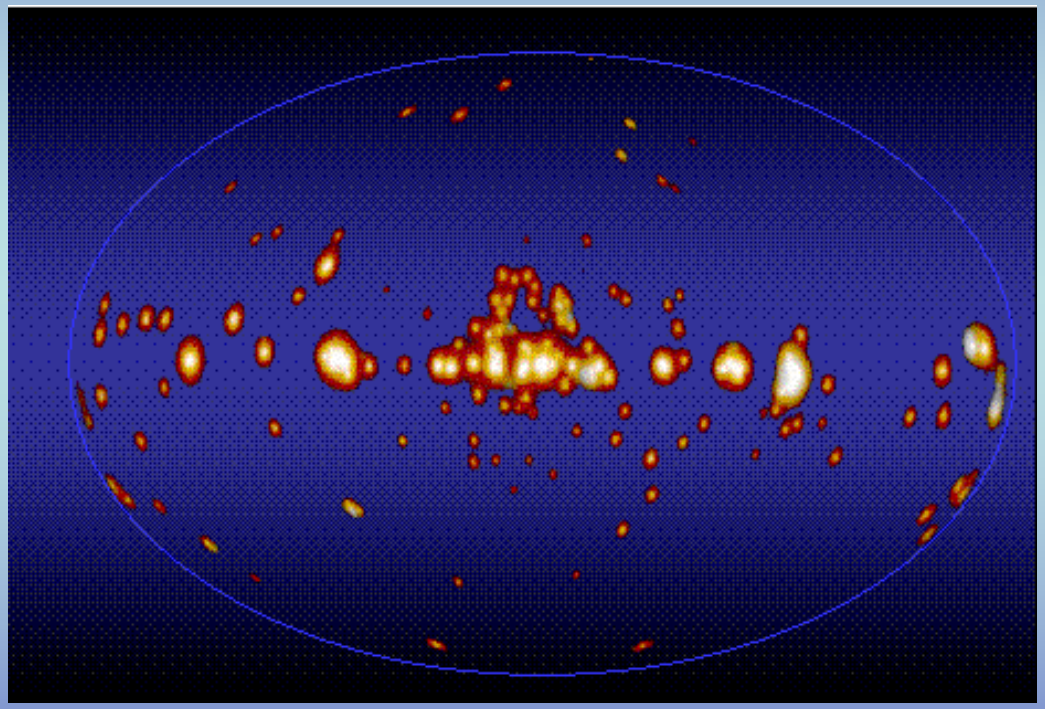
- **young population along Galactic plane**
- **intermediate latitude excess, especially in direction of Galactic bulge → older Galactic population**
- **possible Gould Belt association with 'persistent' sources; nearby population**
- **high latitude sources with no AGN identifications**

LAT science capabilities - resolution

source identification requires a multiwavelength approach
- **localization**
- **variability**

source localization (68% radius)
- γ-ray bursts: 1 to tens arcminutes
- unid EGRET sources: 0.3' – 1'



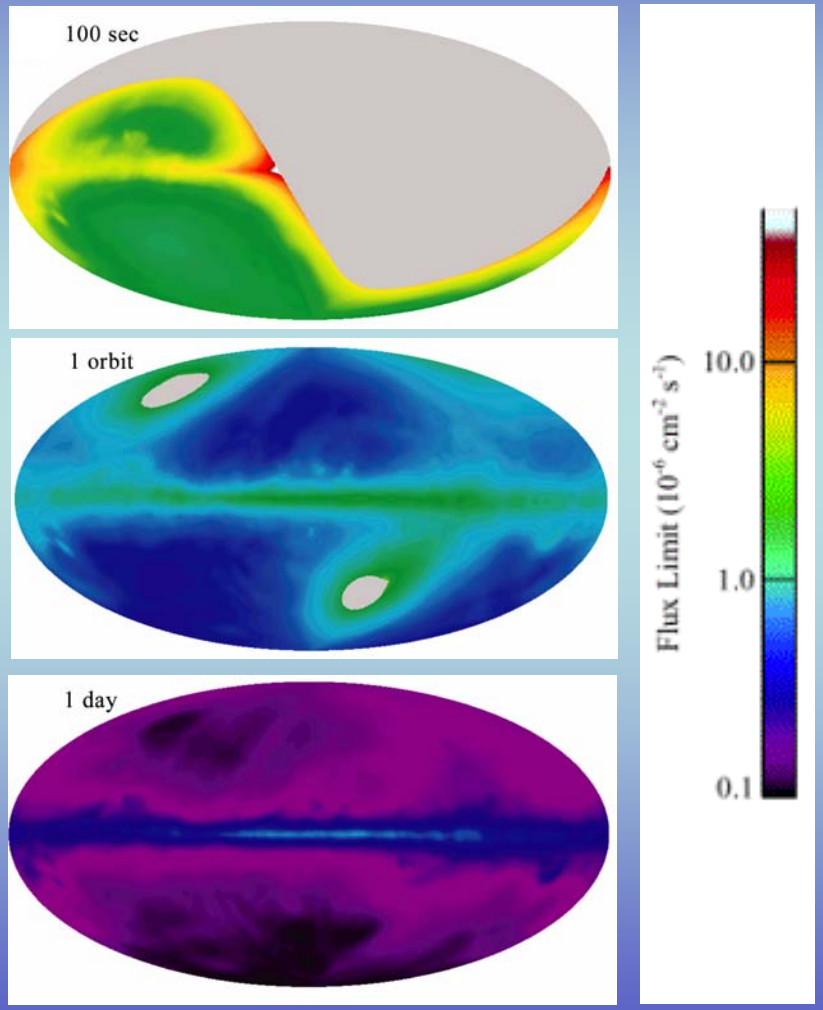


Unidentified EGRET sources

evidence for at least 2 unidentified Galactic populations
time variable Galactic population
persistent Gould belt population

LAT science capabilities – transient sensitivity

enabling LAT capabilities
- **wide field-of-view**
- **low deadtime (for light curve)**



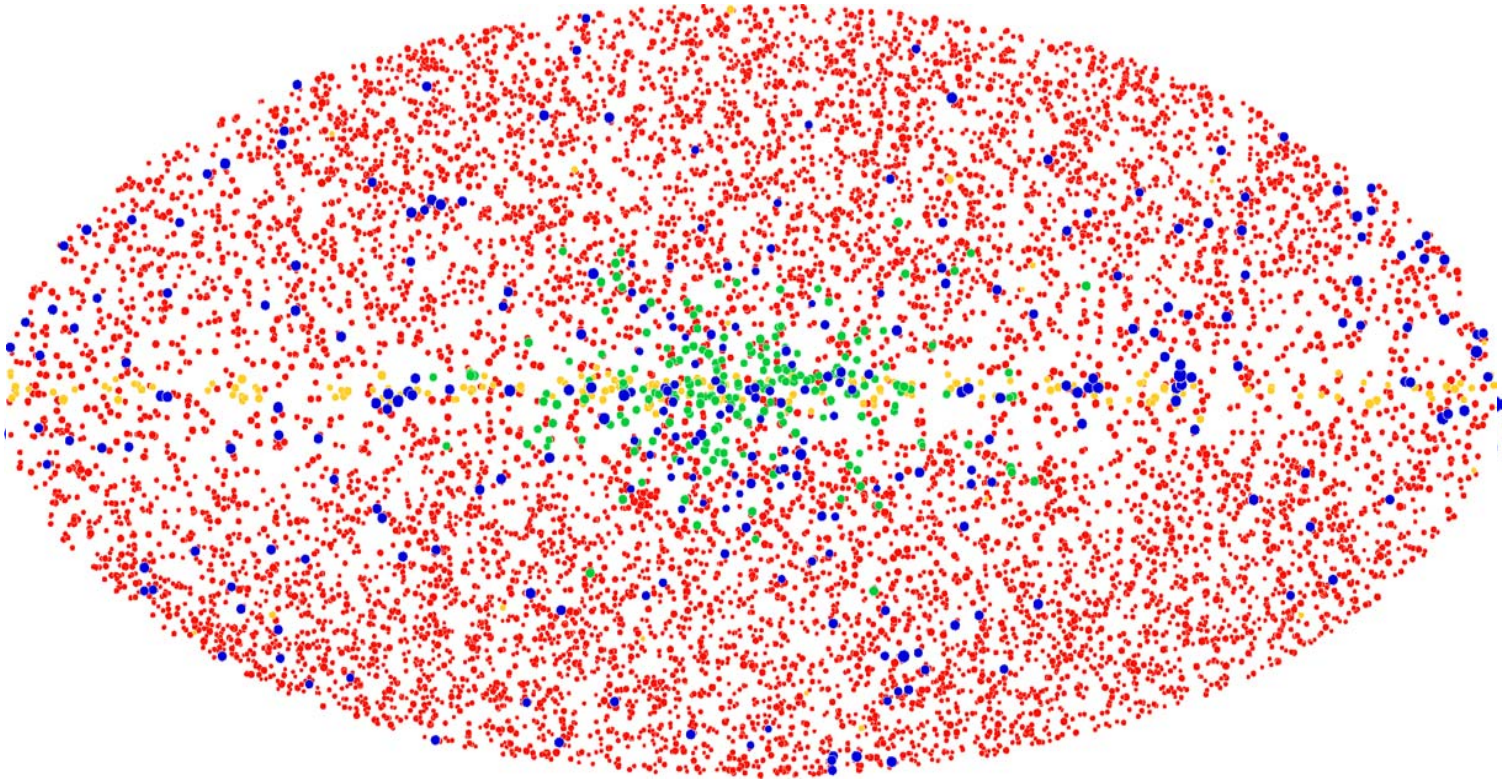
- **GRB940217 (100sec)**
- **PKS 1622-287 flare**
- **3C279 flare**
- **Vela Pulsar**

- **Crab Pulsar**
- **3EG 2020+40 (SNR γ Cygni?)**

- **3EG 1835+59**
- **3C279 lowest 5σ detection**
- **3EG 1911-2000 (AGN)**
- **Mrk 421**
- **Weakest 5σ EGRET source**

detect all EGRET sources after ~day
~200 γ-bursts/year
AGN flares >few minutes

GLAST Survey: ~10,000 sources (2 years)



gamma-rays probe the extragalactic IR-optical-UV background light

Photons with E>10 GeV are attenuated by the diffuse field of UV-Optical-IR extragalactic background light (EBL)

GLAST will detect thousands of AGN to z ~ 4-5

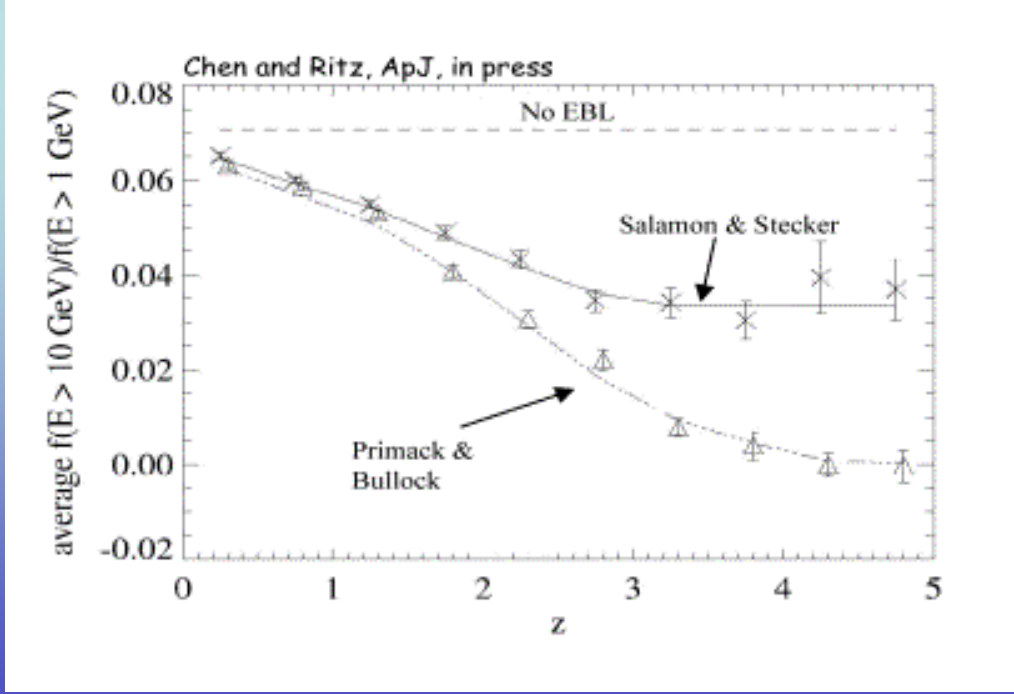
New cosmological probe of star-forming activity as a function of redshift

More local due to opacity

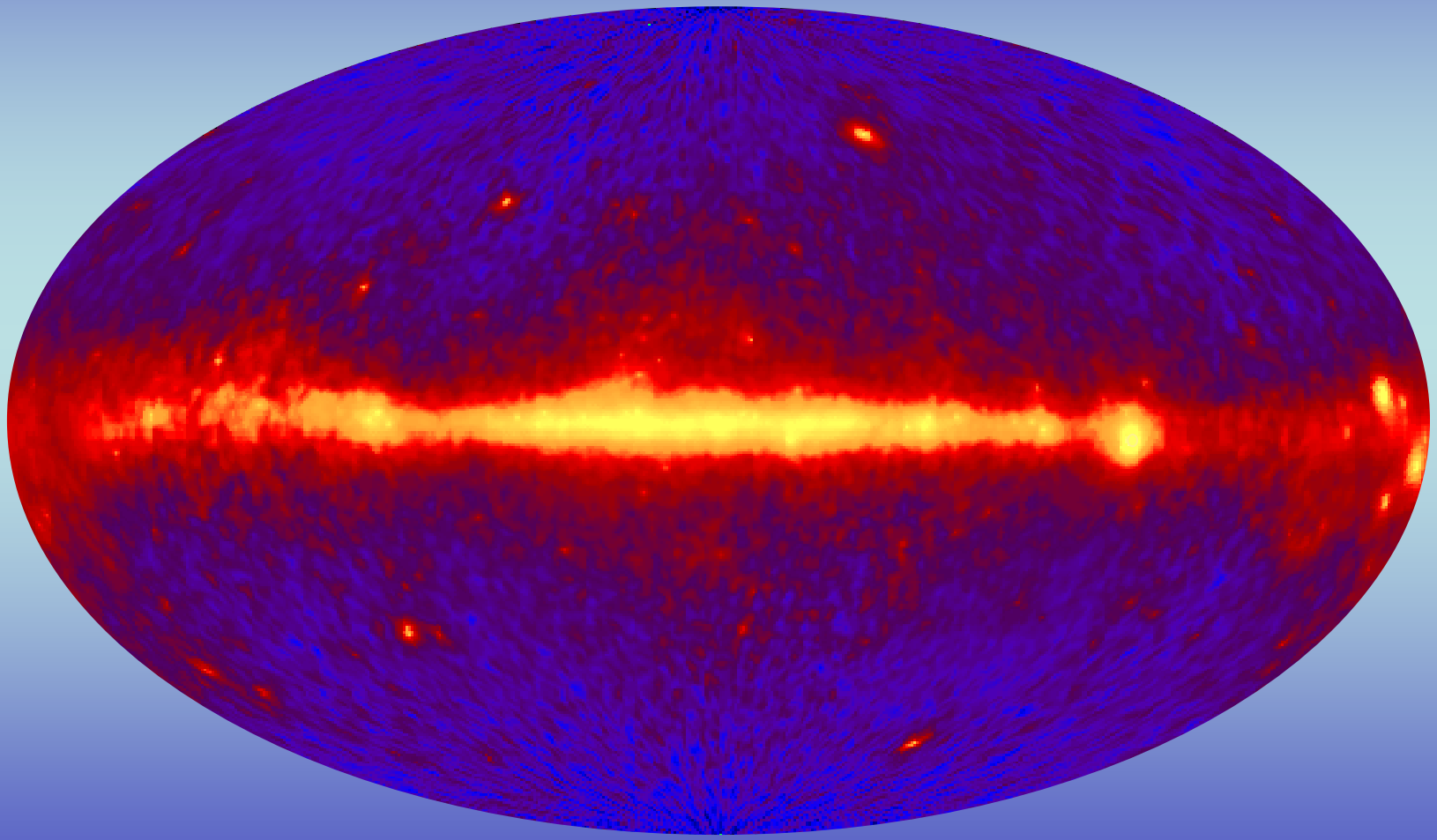
TeV γ's sensitive to IR

Key energy range for cosmological distances

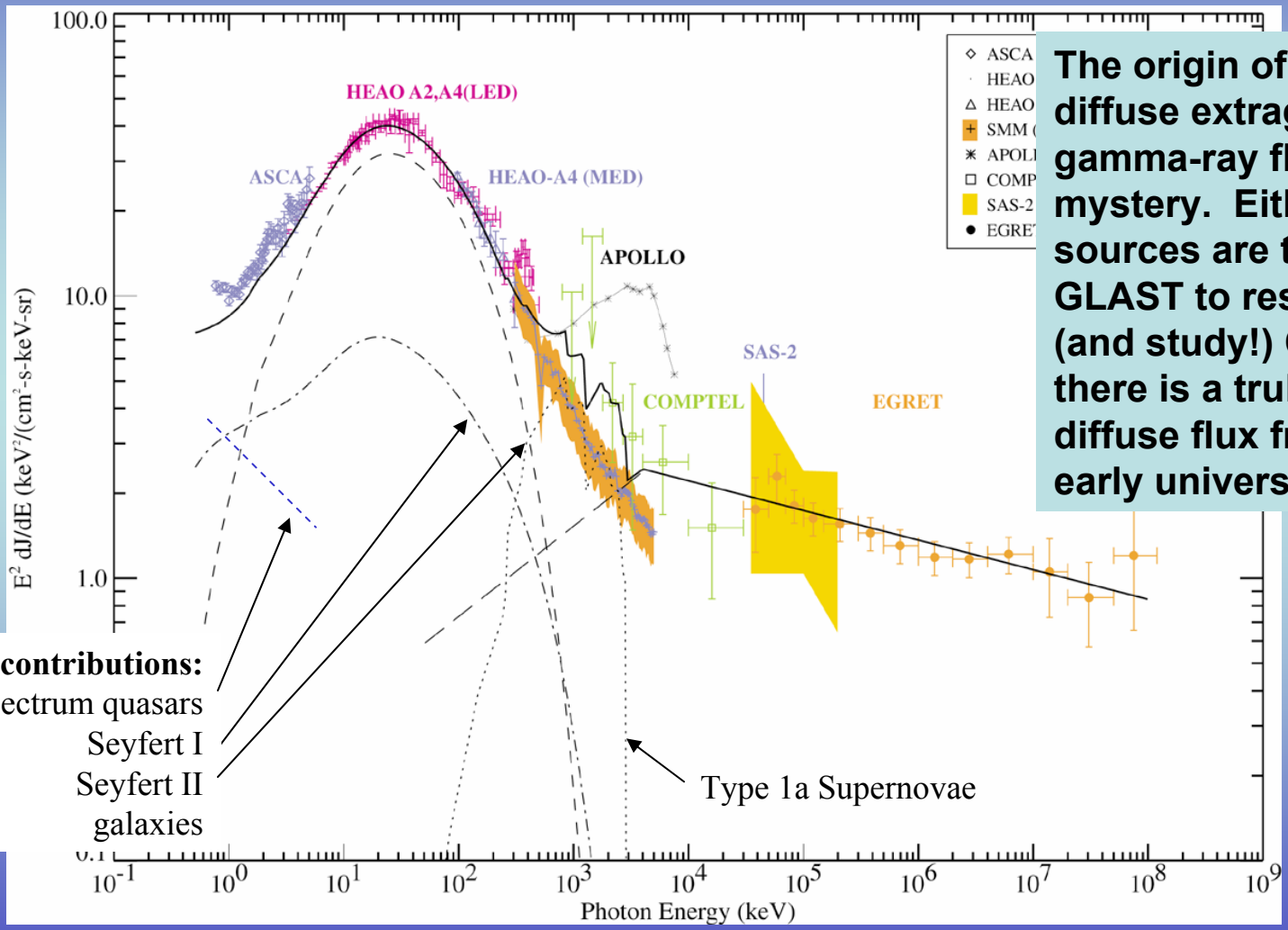
GeV γ's sensitive to UV



EGRET all-sky survey
(70 MeV – 10 GeV)



high-energy isotropic diffuse radiation from x-rays to gamma-rays



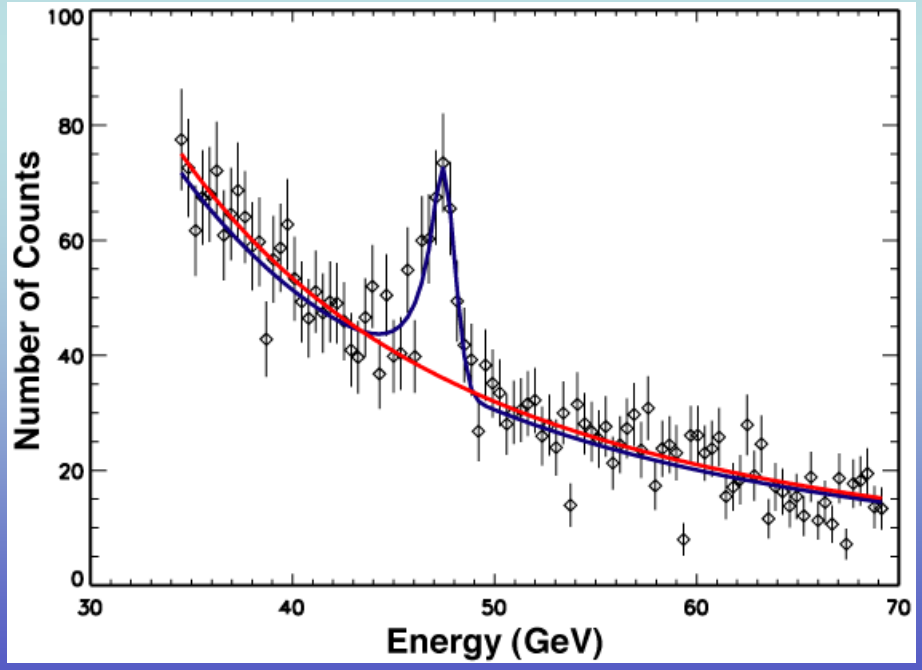
The origin of the diffuse extragalactic gamma-ray flux is a mystery. Either sources are there for GLAST to resolve (and study!) OR there is a truly diffuse flux from the early universe

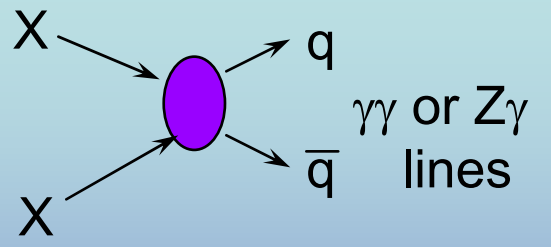
Estimated contributions:
Steep-spectrum quasars
Seyfert I
Seyfert II
galaxies

Type 1a Supernovae

discovery potential: dark matter

- Constrain cold dark matter candidates
- Identify relatively narrow spectral lines
  - Requires energy range with response to at least 300 GeV
  - Requires spectral resolution:
    5% at energies above 10 GeV (goal of 3%)





e.g. halo WIMP annihilation

Collaboration Science Working Groups

I. Working Group I: Extended Sources and Diffuse Radiation

Galactic Diffuse Radiation and Emission from Normal Galaxies
Gamma-ray Emission from Molecular Clouds
Cosmic Ray Acceleration and Gamma-ray Emission from SNR shells and Plerions
High-Energy Emission from Galaxy Clusters

II. Working Group II: Galactic Sources and Unidentified Sources

Particle Acceleration and Gamma-ray Emission in Pulsars and Binary Systems
Unidentified Sources: Population Studies
Unidentified Sources: Radio/optical/X-ray identifications
High-Energy Emission from Stellar-Mass Galactic Black Hole Candidates
The Galactic Center

III. Working Group III: Extragalactic Sources

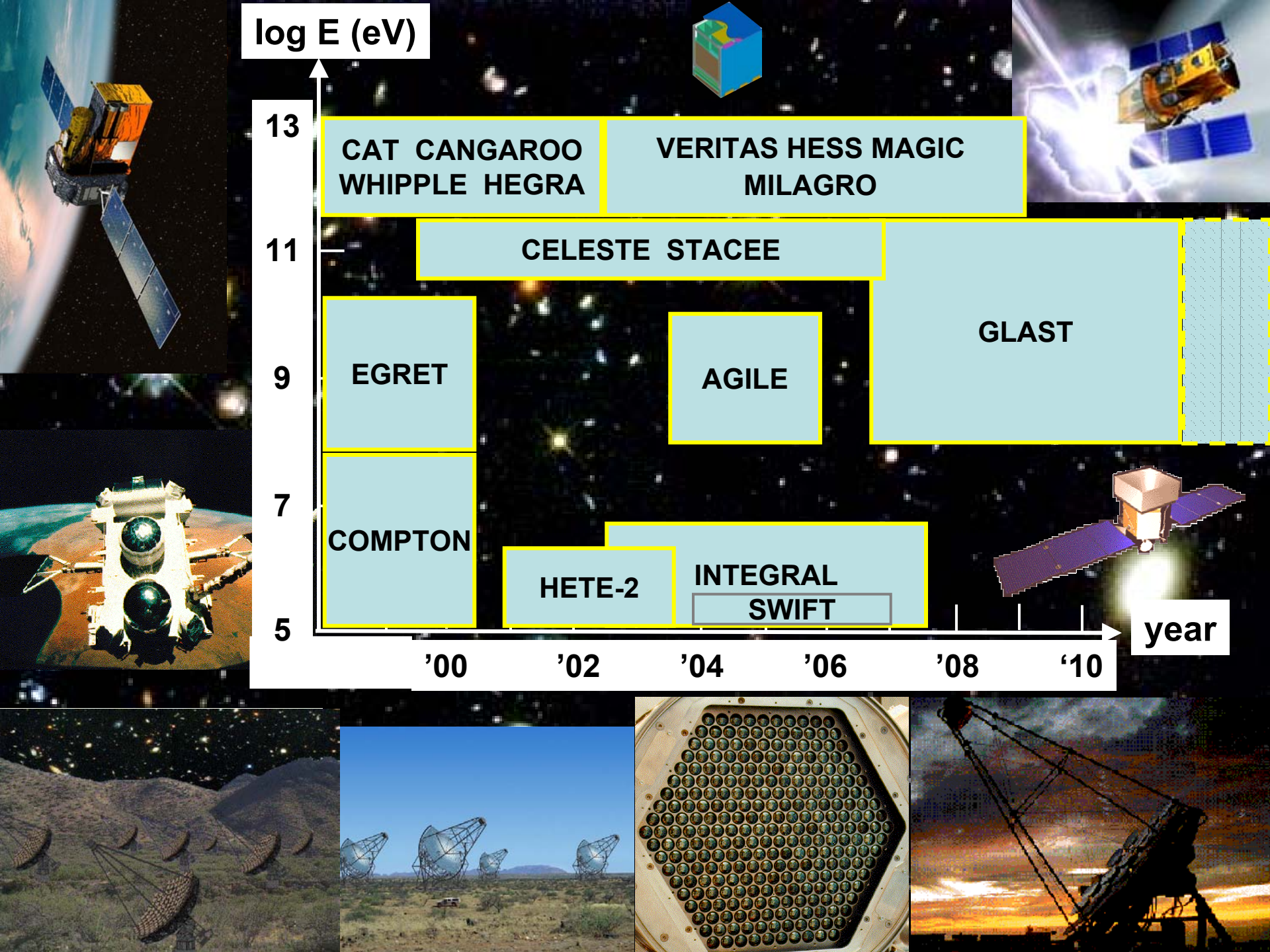
Extragalactic Diffuse Radiation and LogN-LogS of Extragalactic Sources
Gamma-ray Emission Mechanisms in Blazar AGNS
Cosmic Evolution of AGN Blazars and Spectral Cutoffs: Population and EBL Studies
High-Energy Emission from Seyfert galaxies and Radio galaxies

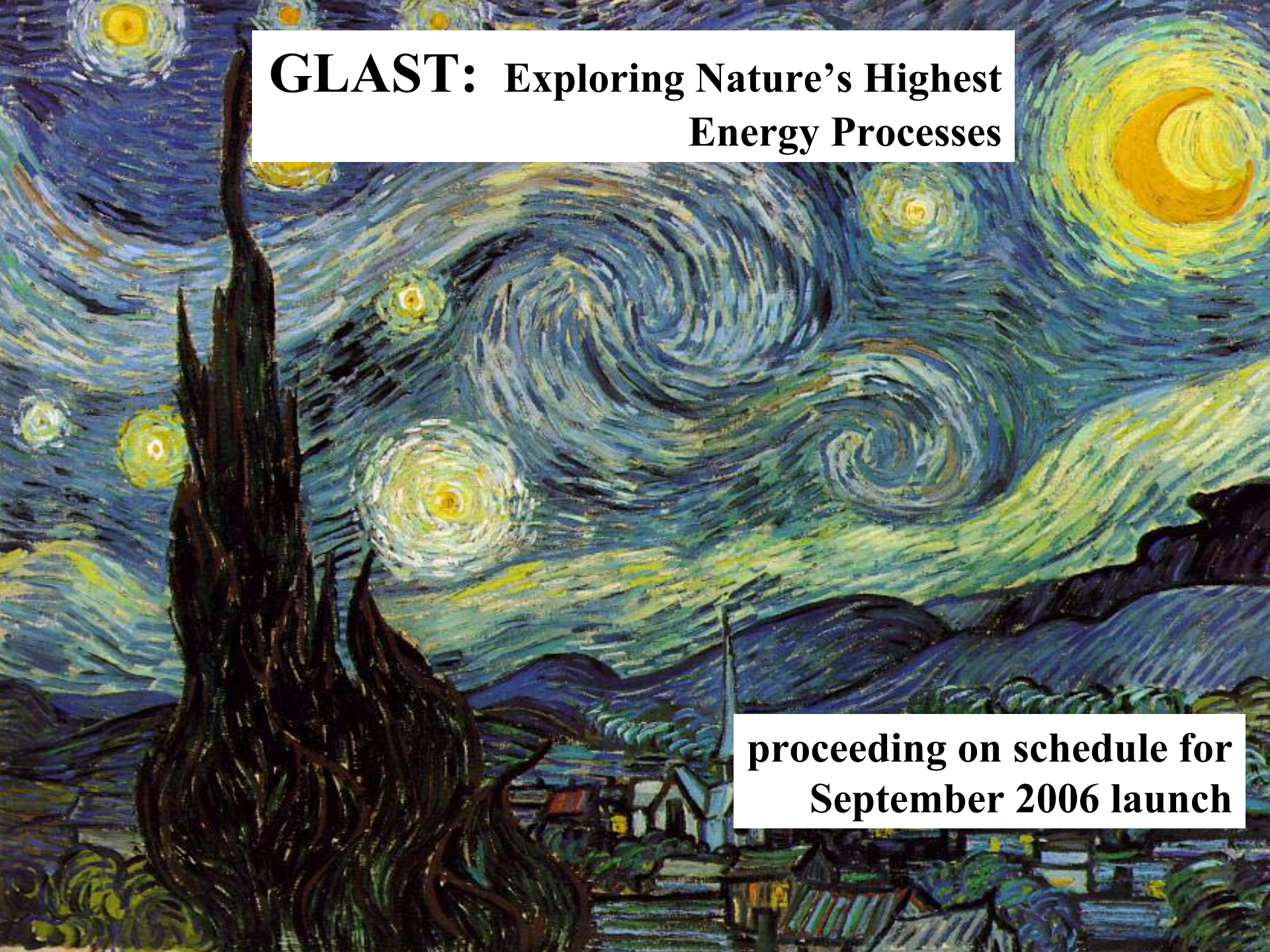
IV. Working Group IV: Searches for New Physics

Searches for Dark Matter
Search for Signatures of Quantum Gravity
Search for Primordial Black Hole Evaporation

V. Working Group V: GRBs and Solar Flares

Gamma-Ray Bursts: Testing emission models; afterglows and multiwavelength observations
Solar Flares


log E (eV)
13
11
9
7
5
CAT CANGAROO
WHIPPLE HEGRA
VERITAS HESS MAGIC
MILAGRO
CELESTE STACEE
EGRET
AGILE
GLAST
COMPTON
HETE-2
INTEGRAL
SWIFT
year
'00
'02
'04
'06
'08
'10



GLAST: Exploring Nature's Highest Energy Processes

proceeding on schedule for September 2006 launch