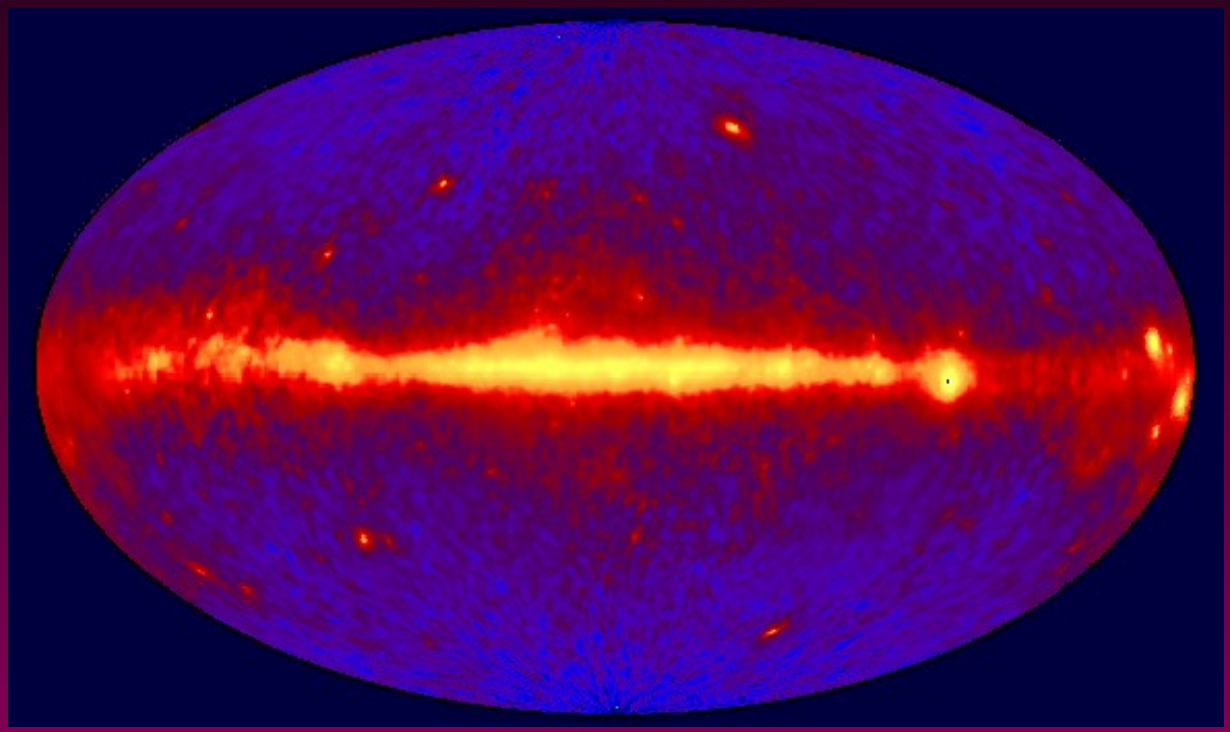
Gamma-ray Astronomy

(The Short Story…)

The Big Picture

- Whole sky glows
- Extreme environments
- Probes of the Universe

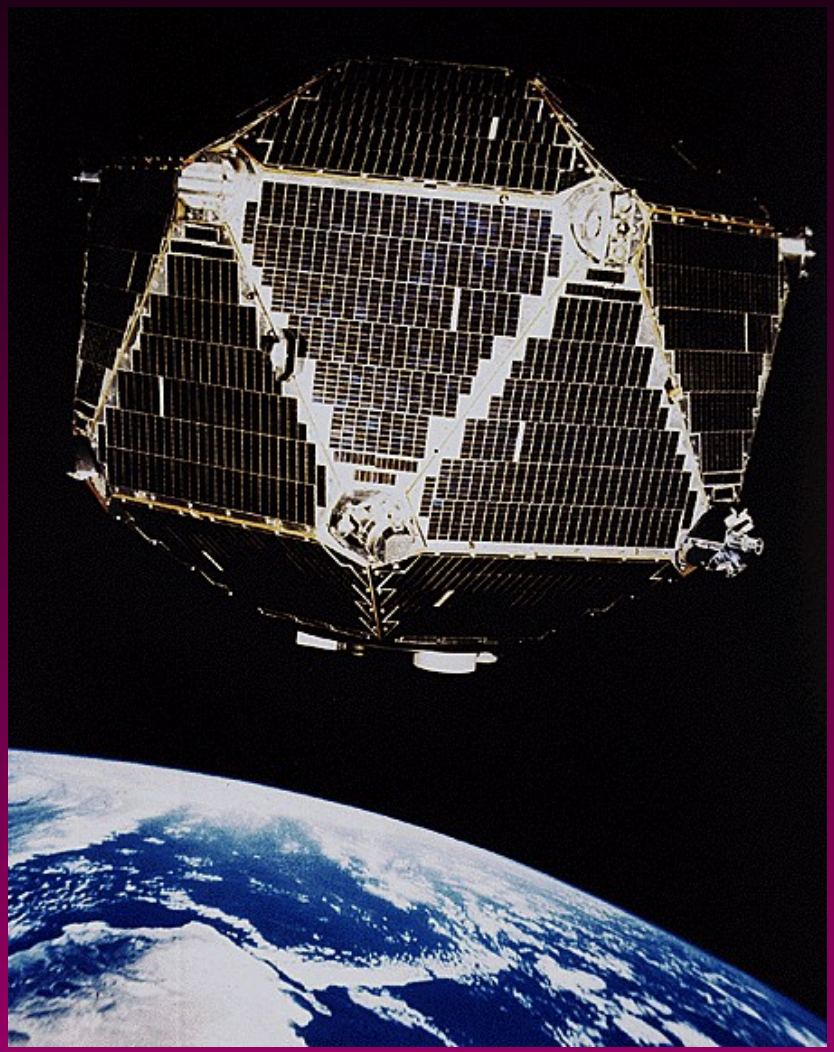


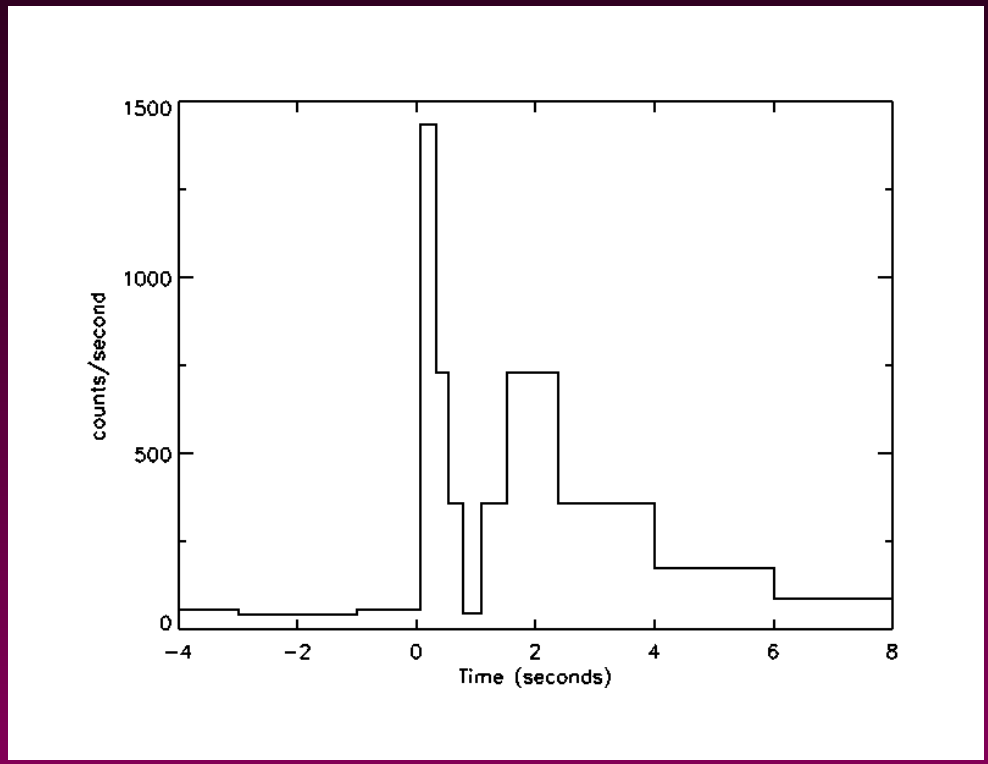
CGRO/EGRET All Sky Map

Early Gamma-ray Astronomy

- Gamma-ray Bursts
  - Vela Program : A Bomb or Not a Bomb?
  - A few hundred events, a few hundred theories
- Gamma-ray Sources
  - SAS-2 – discovered 2 pulsars (1972)
  - COS-B – about 25 sources (1975-82)
  - Most unidentified, but 1 quasar
  - Diffuse extra-galactic background

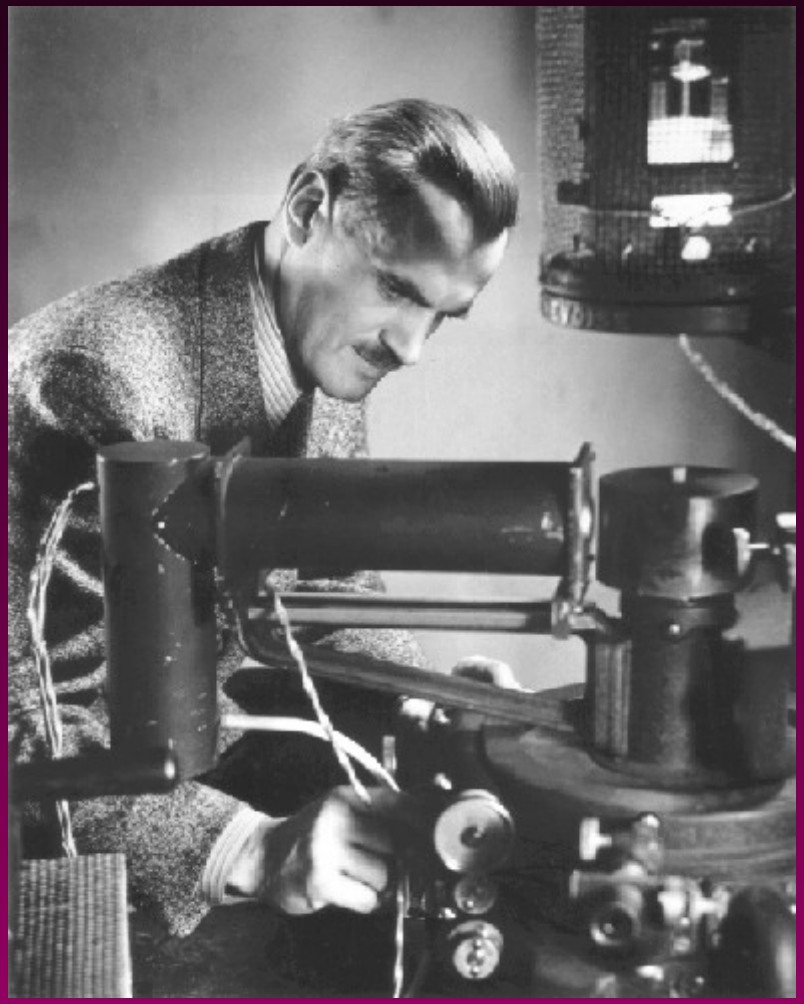
Vela Program (1969-1979)





CGRO (1991-2000)

Dr. Arthur Holly Compton

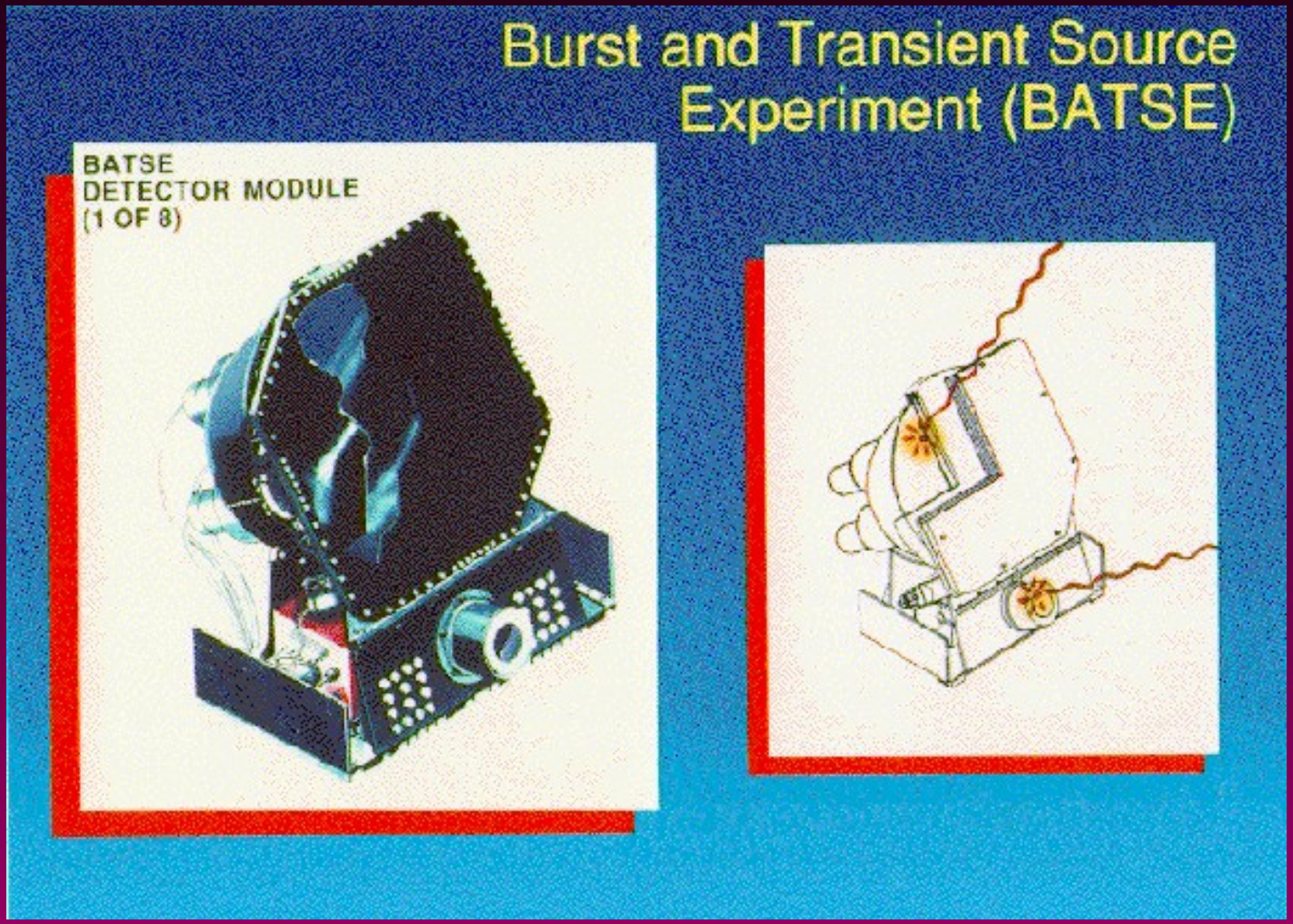


- 1927 Nobel Prize for Compton Effect
- First experimental proof of dual wave and particle nature of light

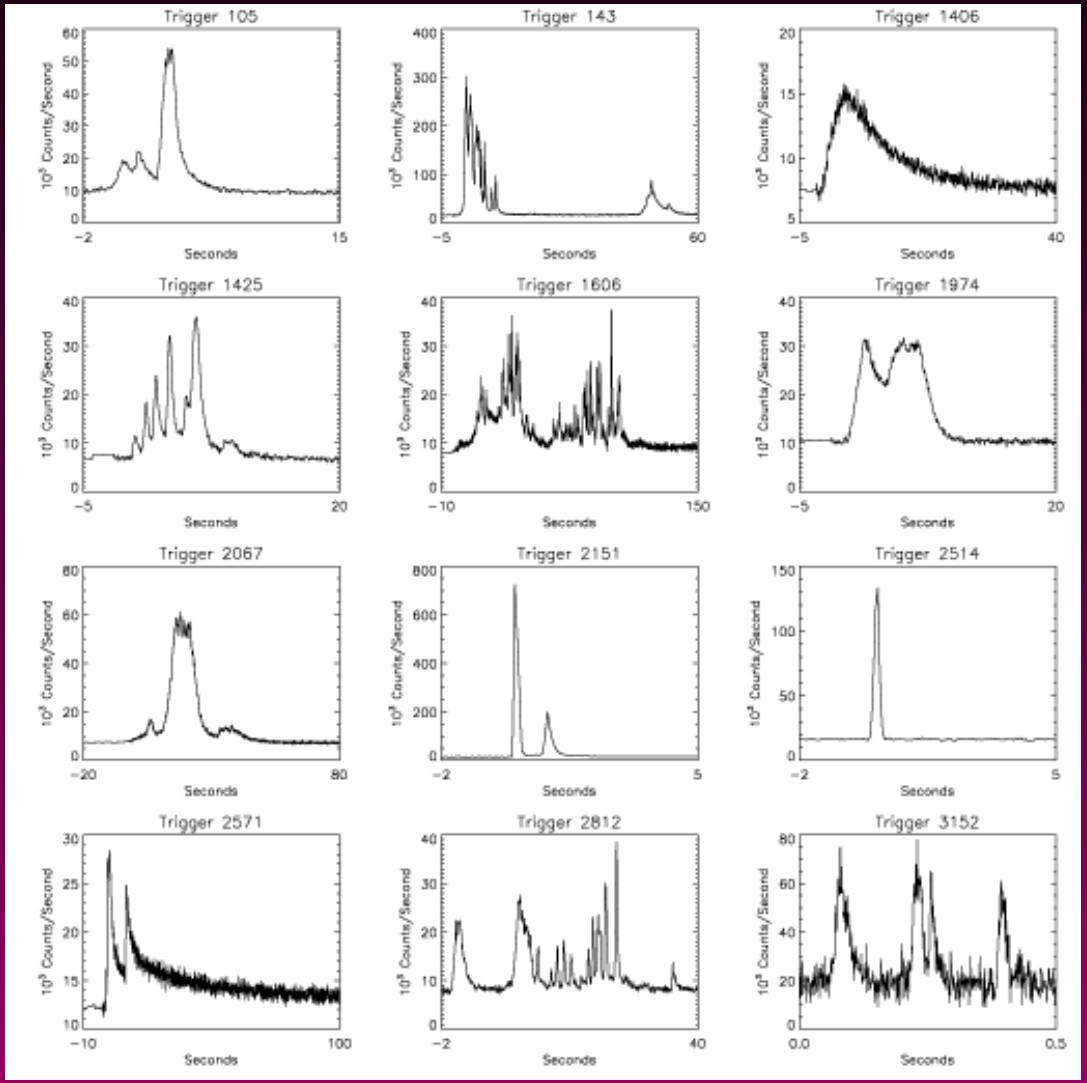
Sources of γ-ray Emission

- **Black holes**
- **Active Galaxies**
- **Pulsars**
- **Gamma-ray bursts**
- **Diffuse emission**
- **Supernovae**
- **Unidentified**

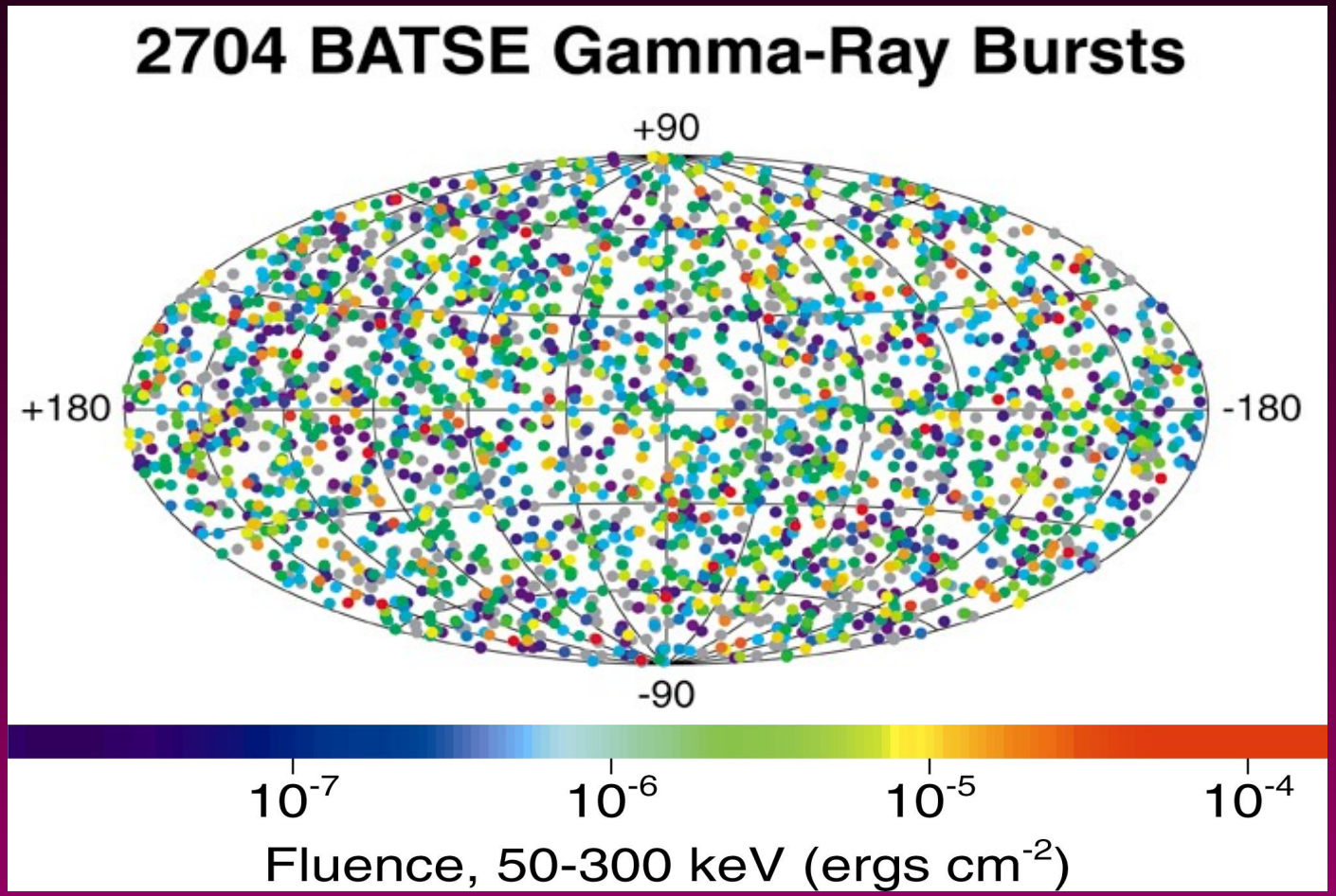
BATSE


Burst and Transient Source Experiment (BATSE)
BATSE
DETECTOR MODULE
(1 OF 8)

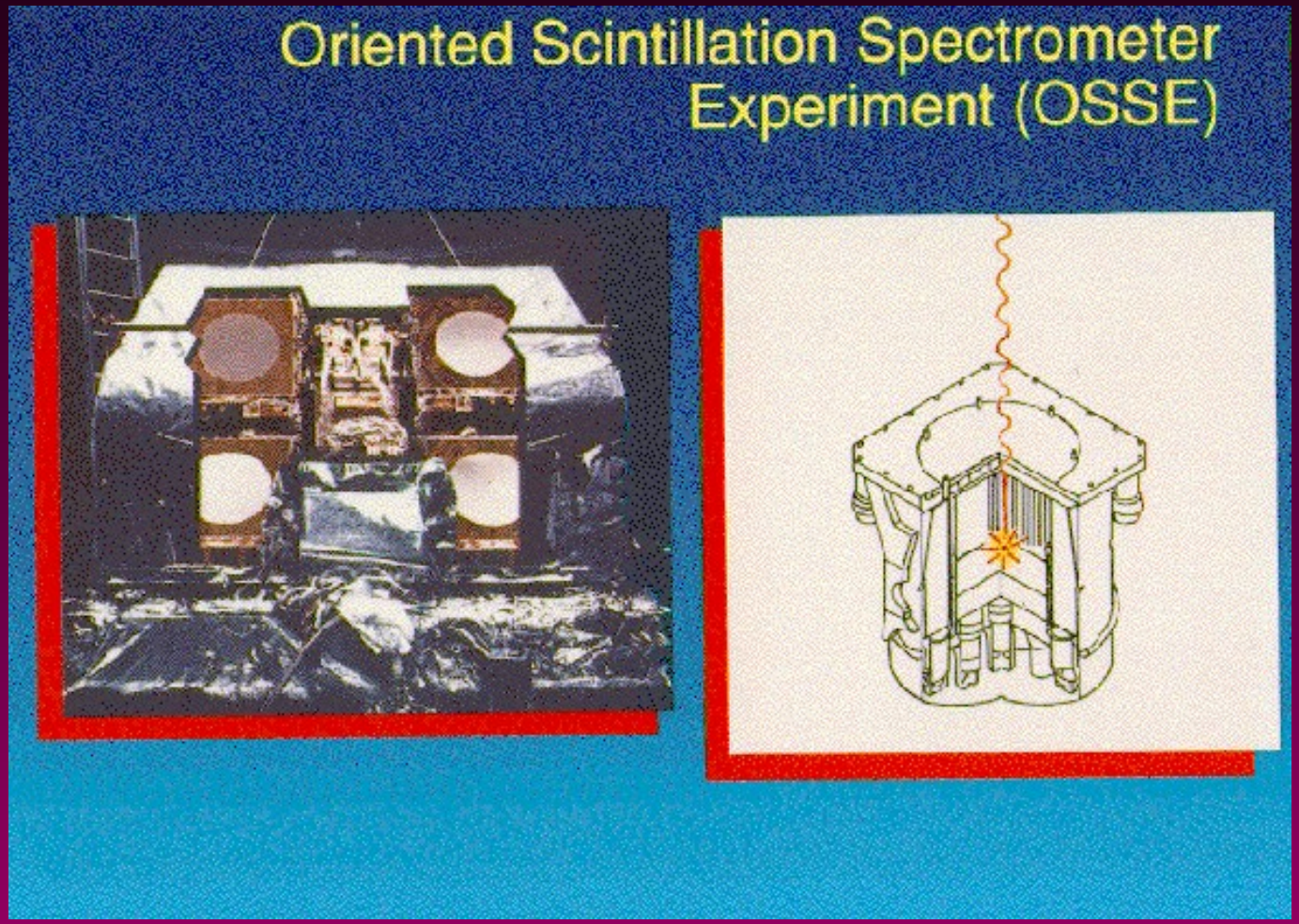
Gamma-Ray Bursts



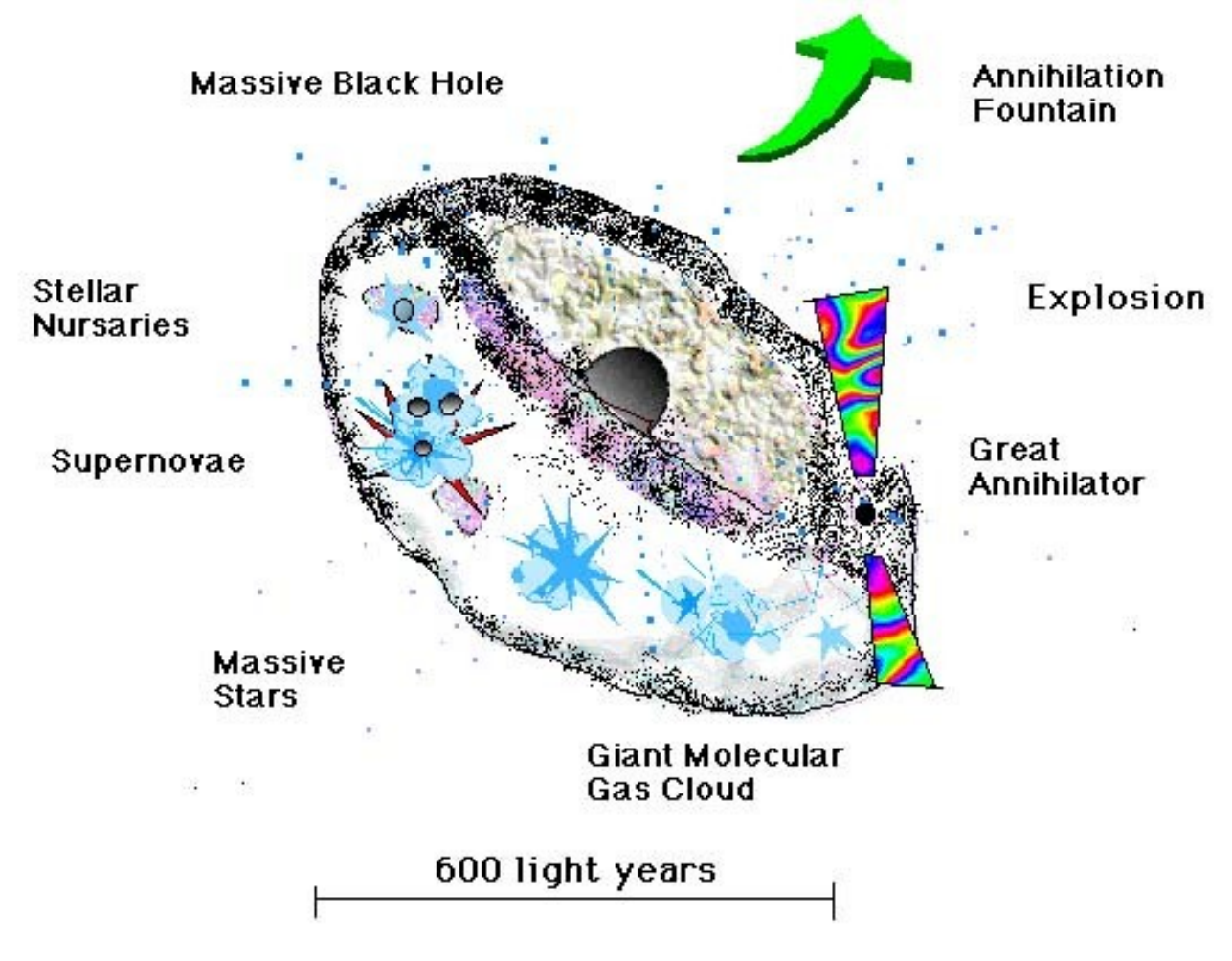
Distribution of GRBs in the Sky



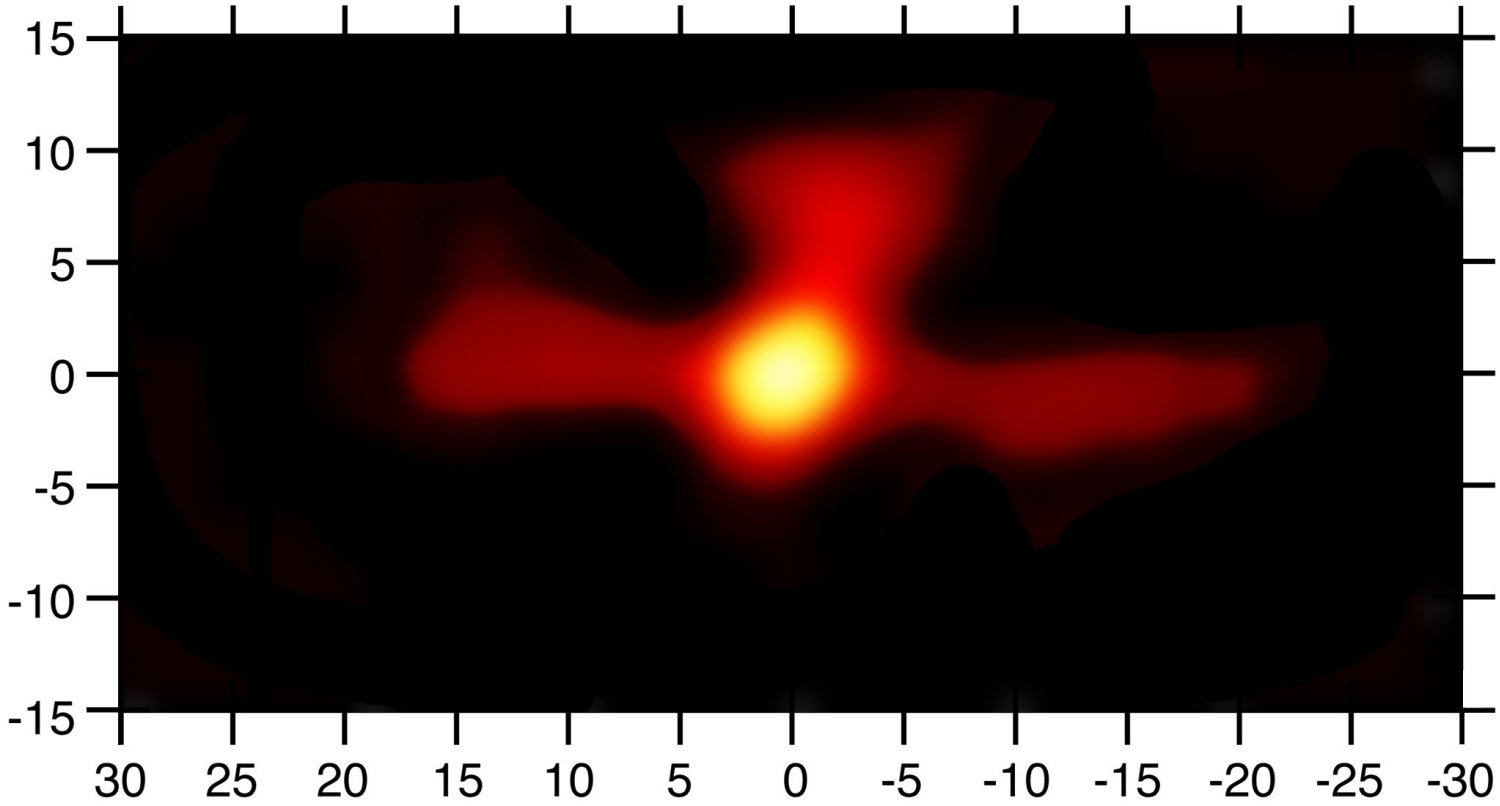
OSSE



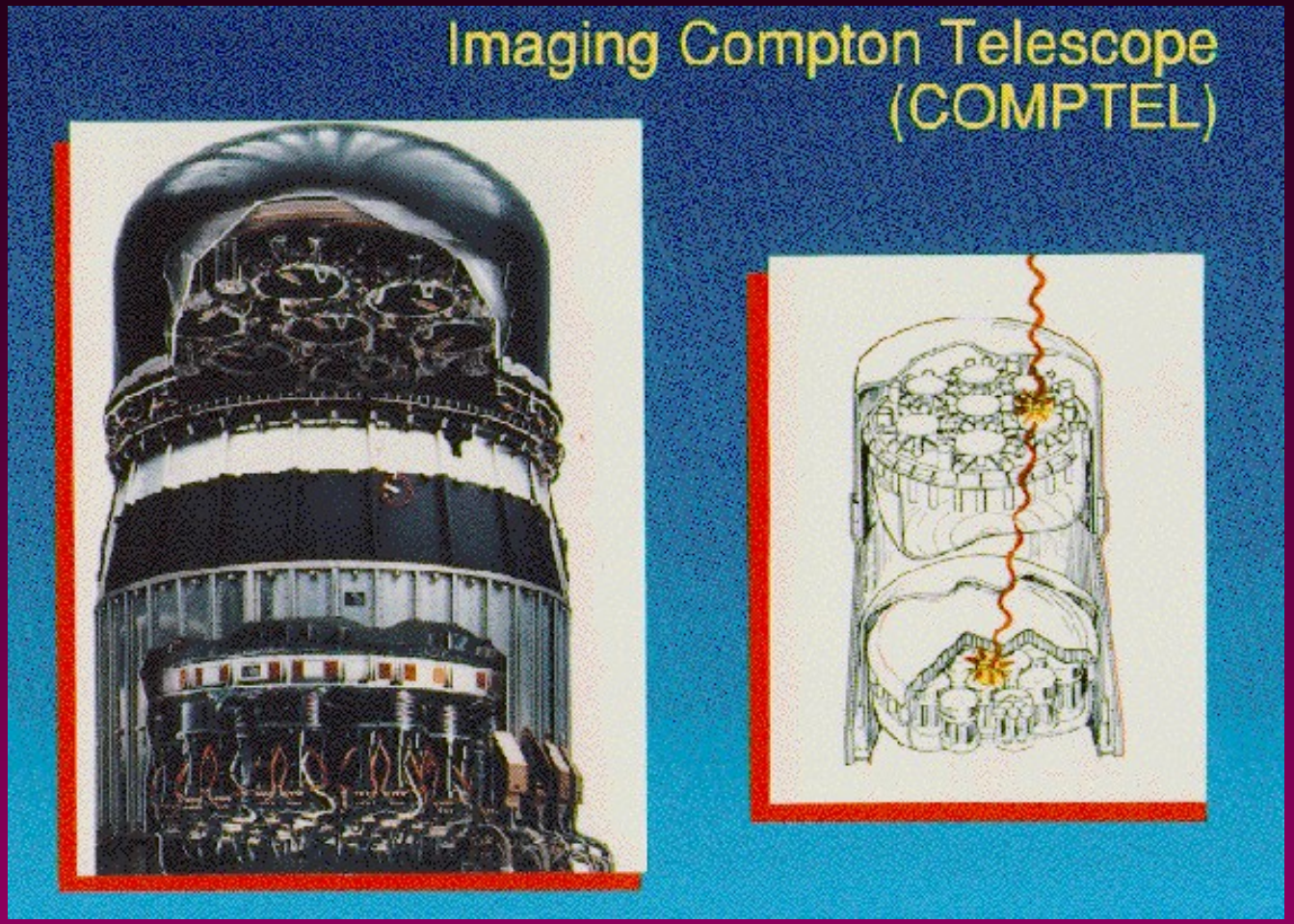
The Galactic Center Region



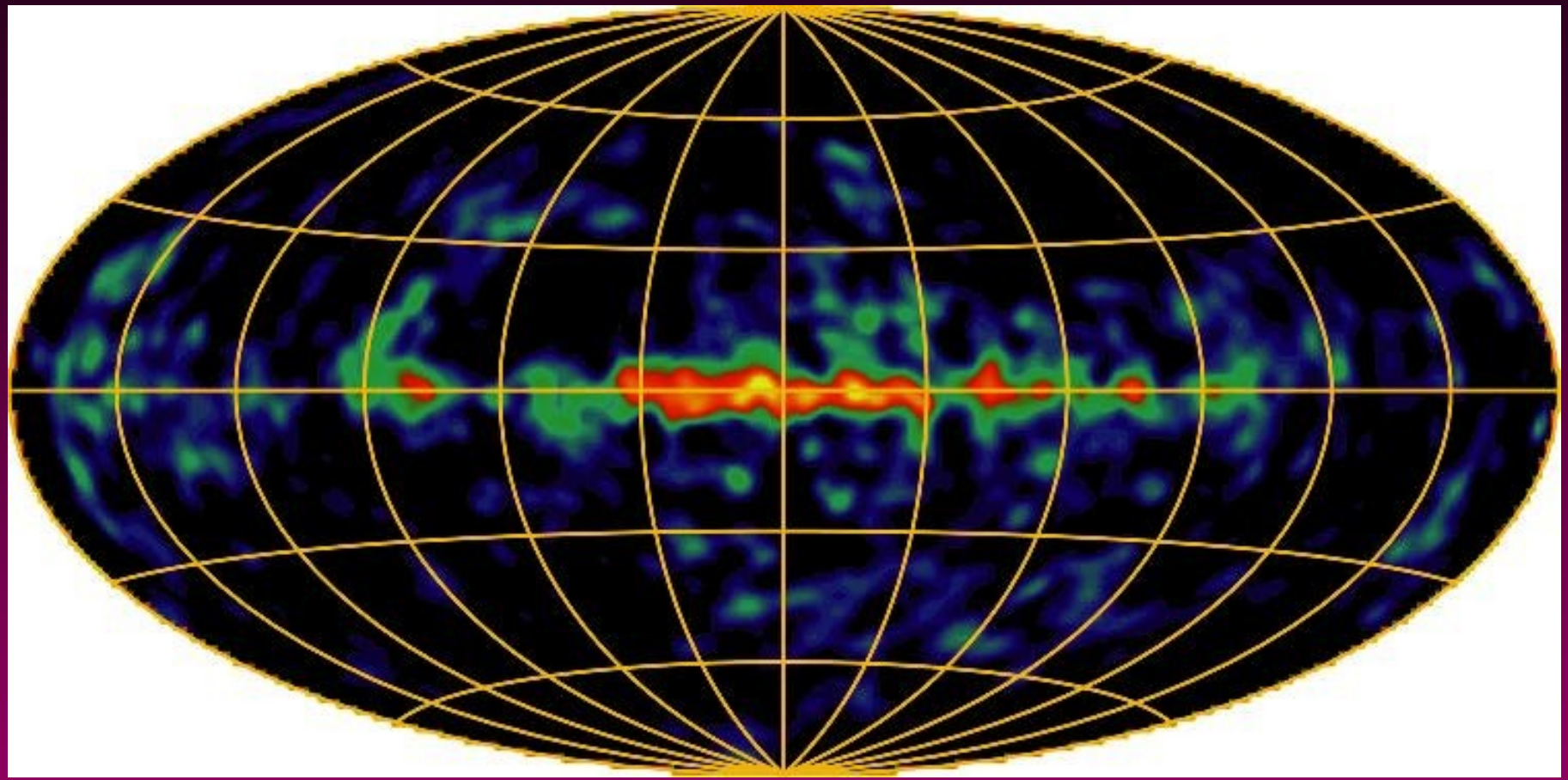
Antimatter Fountain in the Center of Milky Way



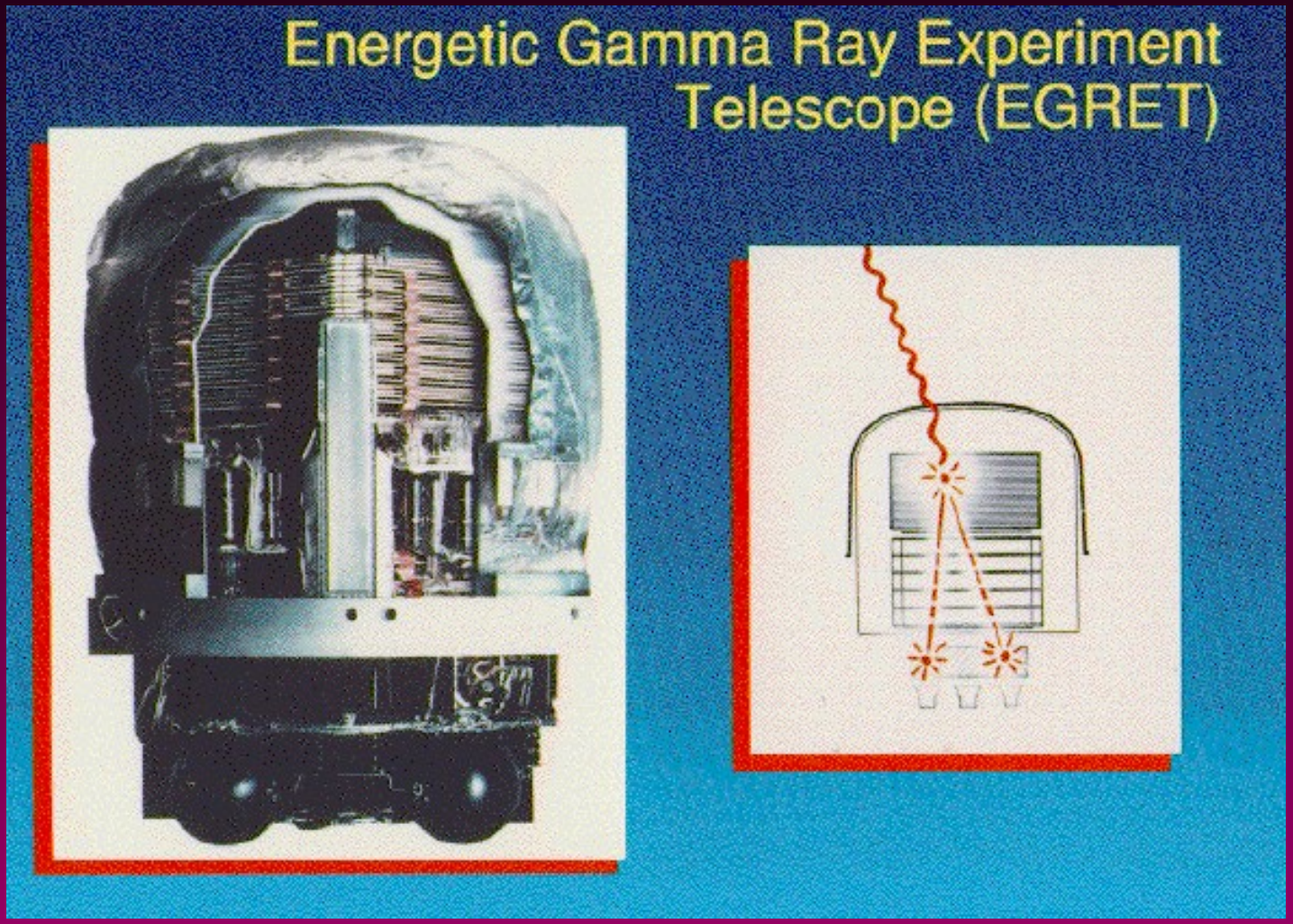
COMPTEL



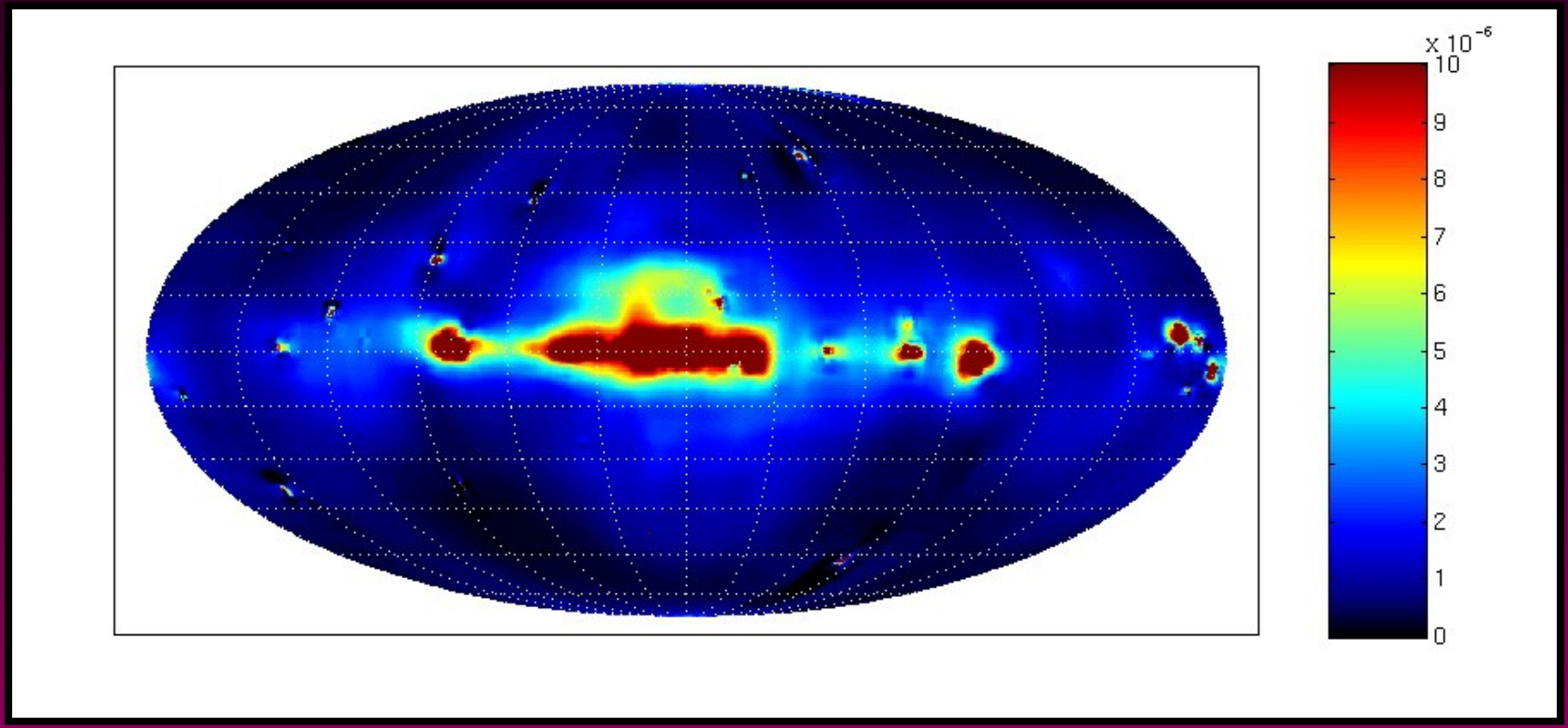
^{26}Al COMPTEL sky map



EGRET



High Energy Halo around Milky Way

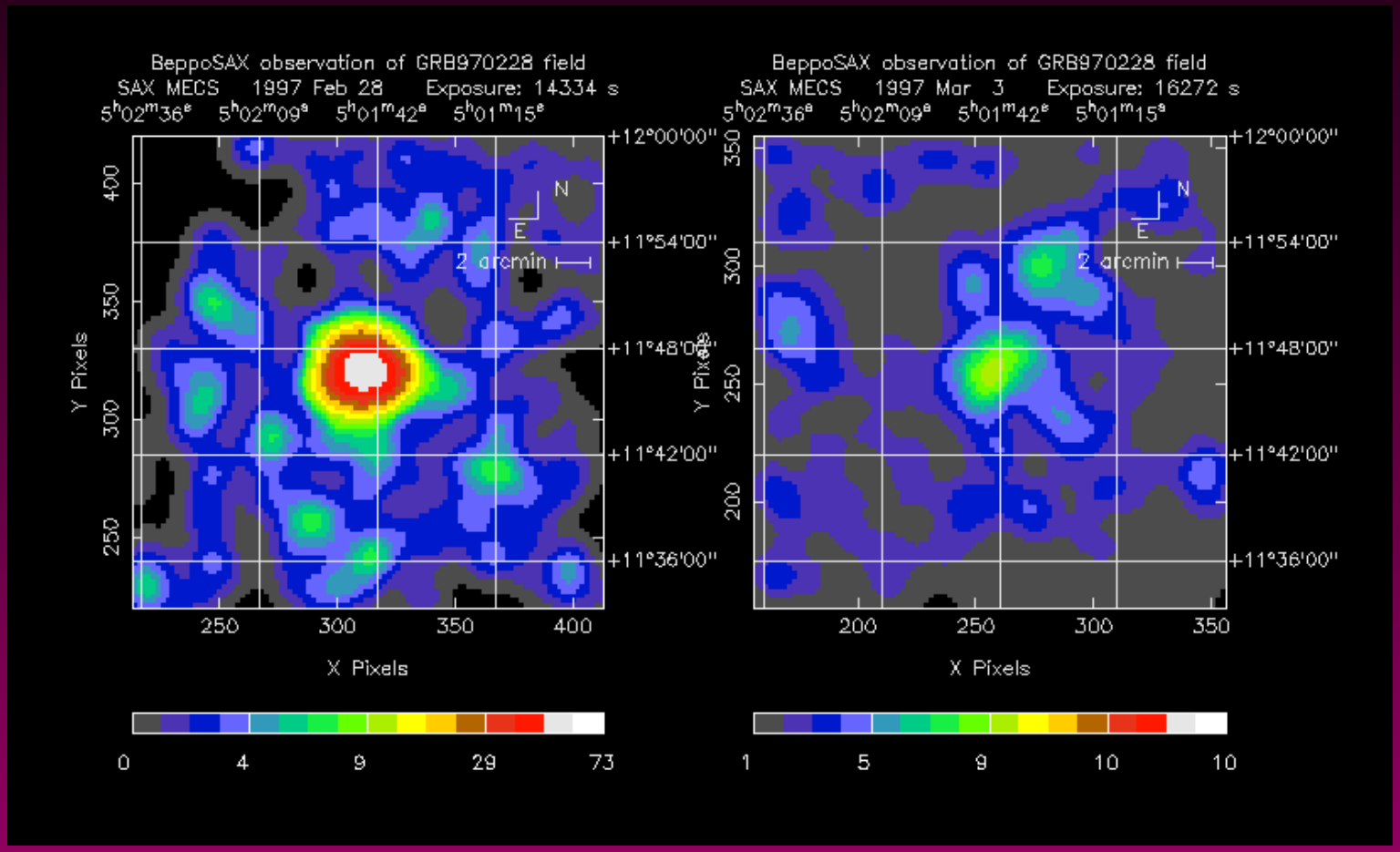


Courtesy of D. Dixon, University of California, Riverside

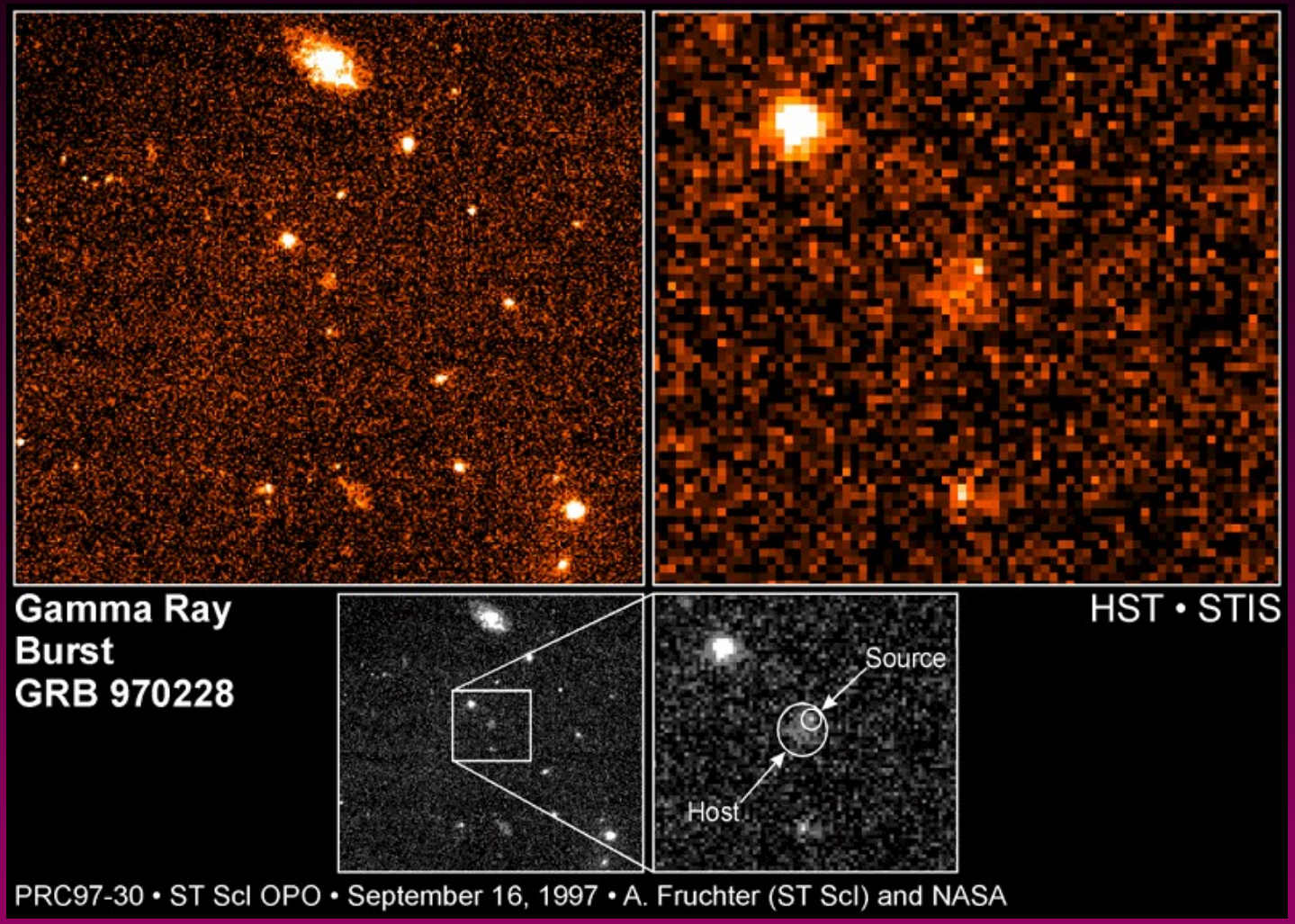
Gamma-ray Burst Progress

- Beppo/SAX finds evidence for X-ray afterglow from several GRBs (2/28/97)
- Jan van Paradijs finds optical afterglow
- Redshifts indicate cosmological distances (Keck, HST)
- ROTSE catches GRB in the act at visible wavelengths (1/23/99)
- Evidence mounts for two types of GRBs

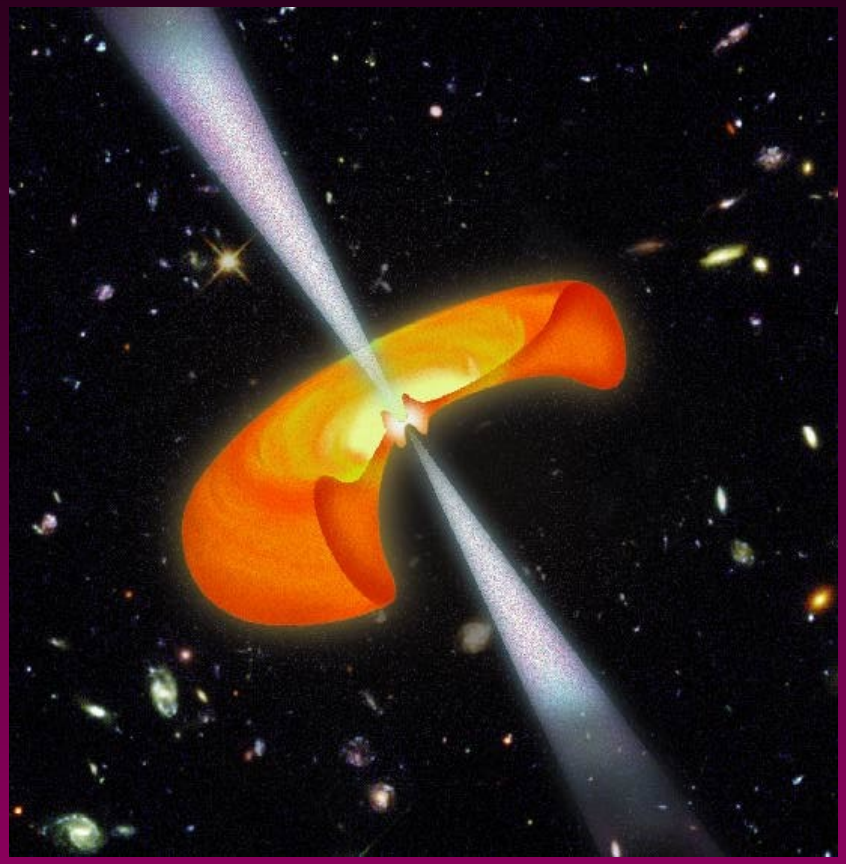
What BeppoSAX Saw



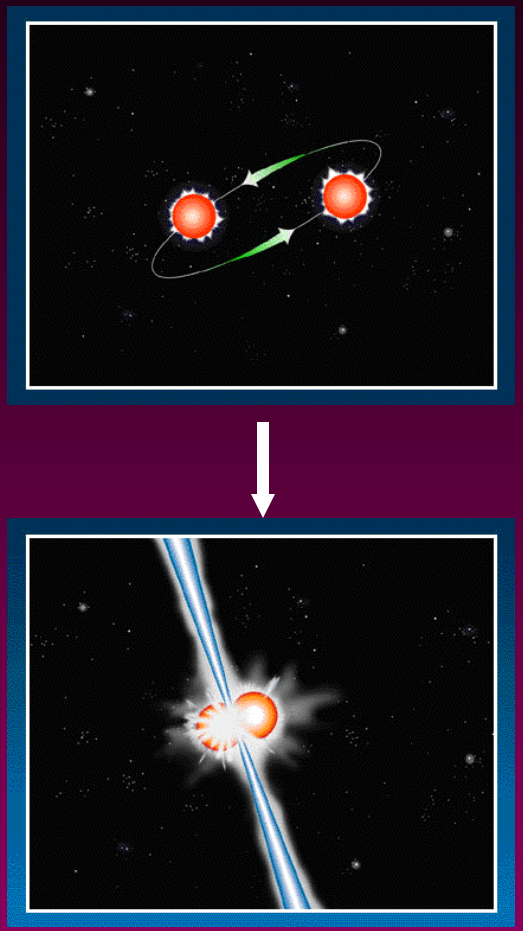
What HST Saw (Much Later)



Models for GRBs



Hypernova



Merging Neutron Stars

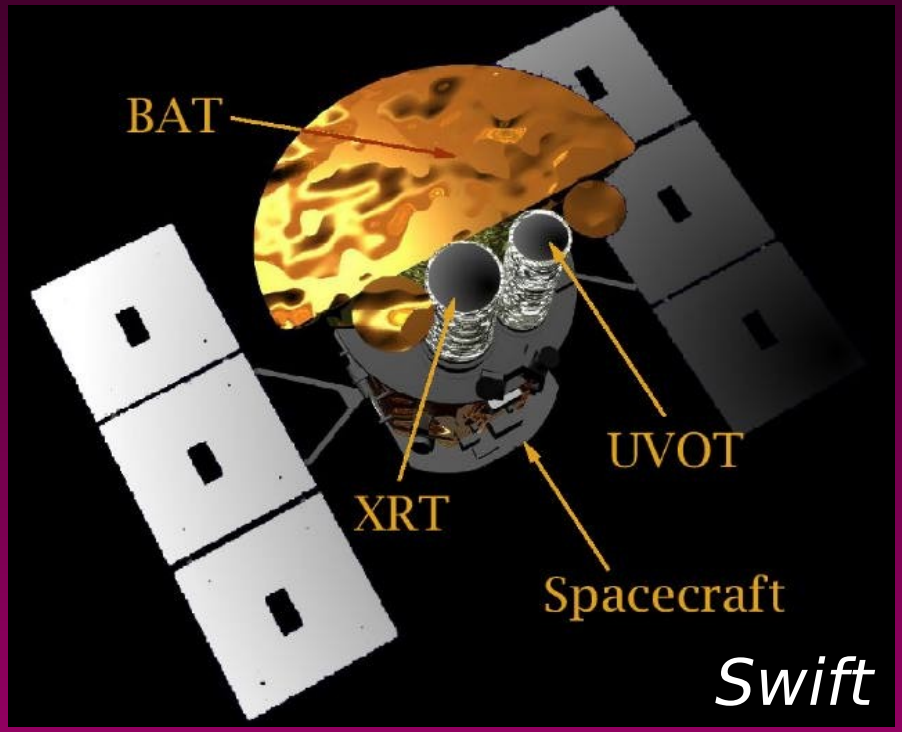
New Missions = Better Data

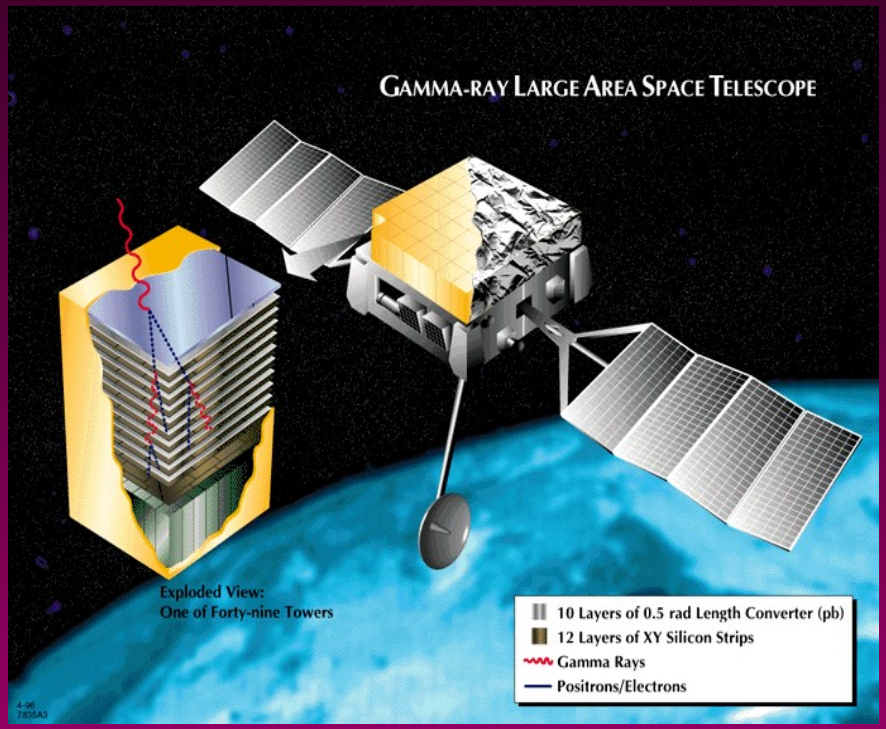
HETE II (launched 10/9/00)

INTEGRAL (2001)

Swift (2003)

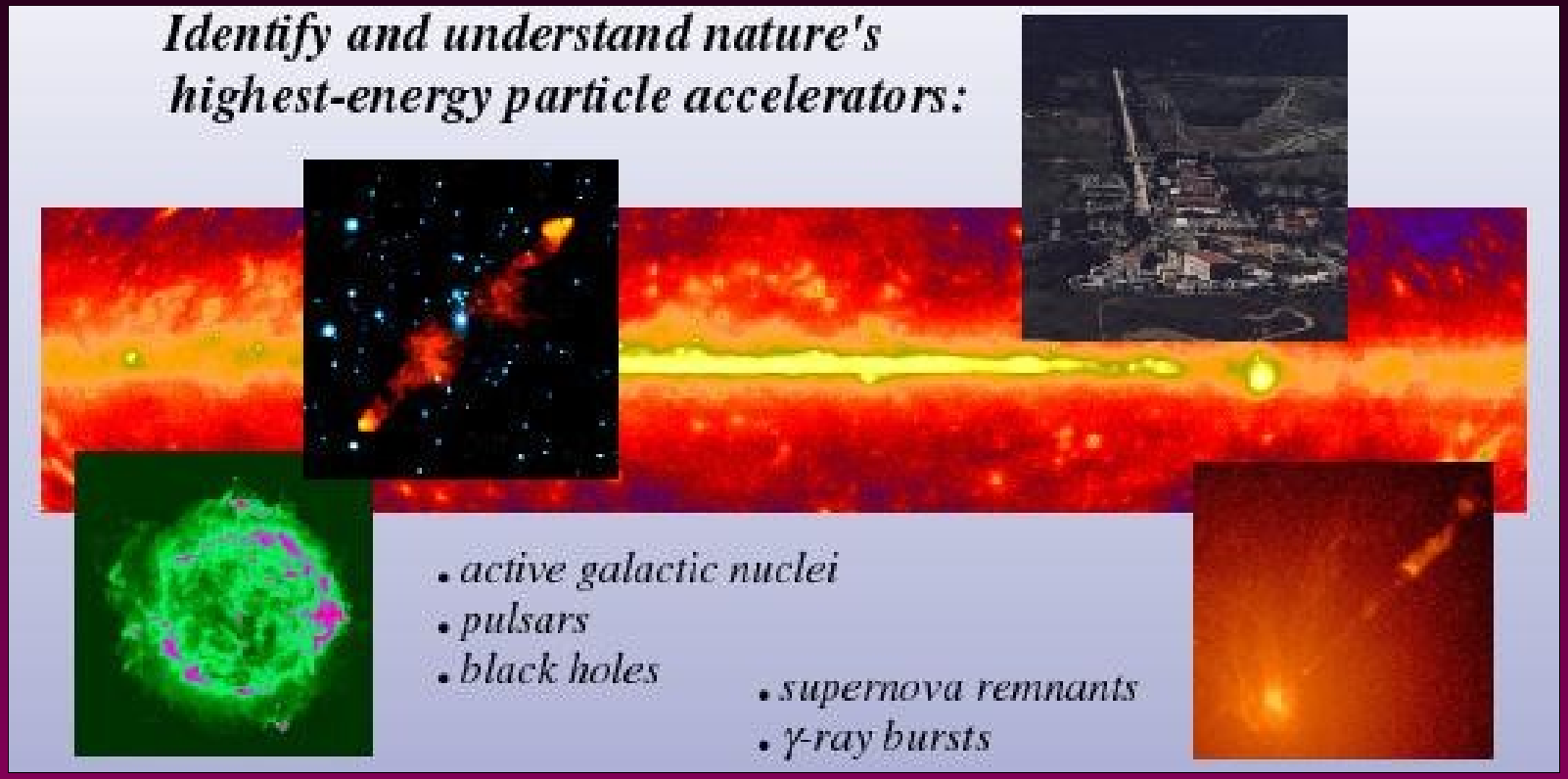
GLAST (2005)





- Repoints within 50 s after detecting GRB to obtain X-ray and optical data
- Detects about 300 GRBs per year and their afterglows
- Sends initial coordinates of burst to ground within 15 s
- Sends high resolution coordinates of GRB to ground within 50 s
- Determines distance to burst within 1000 seconds

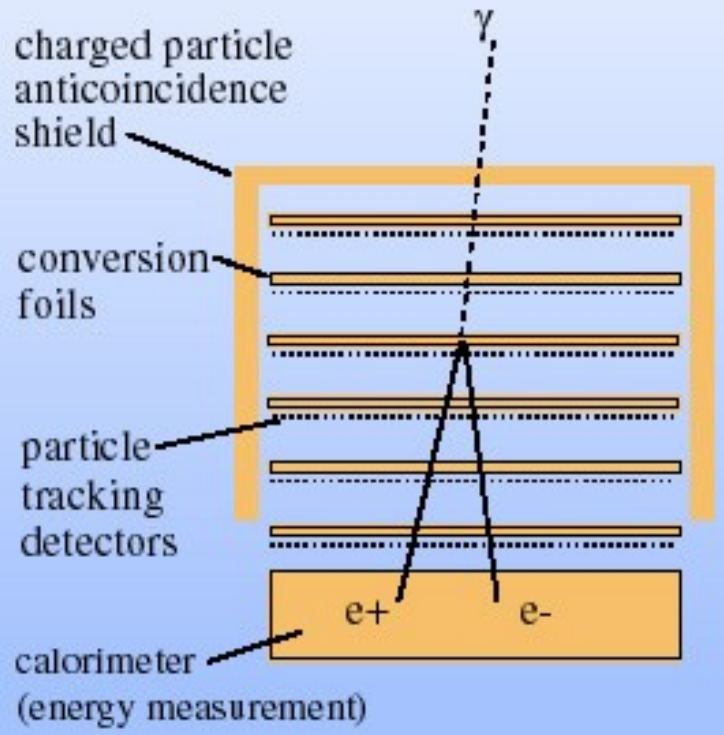
Science



Explore the era of star formation in the universe, the physics of dark matter and the creation and evolution of galaxies

GLAST design

elements of a pair-conversion telescope

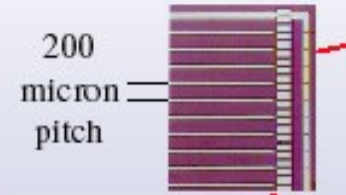


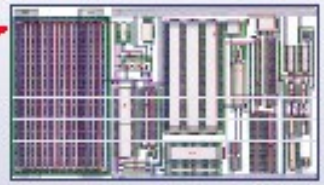
- photons materialize into matter-antimatter pairs:

$$E_\gamma \rightarrow m_{e^+}c^2 + m_{e^-}c^2$$

- electron and positron carry information about the direction, energy and polarization of the γ-ray

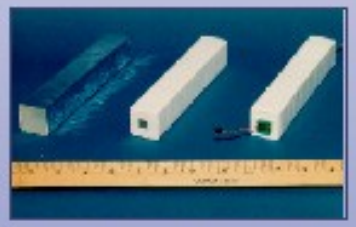
GLAST Technologies



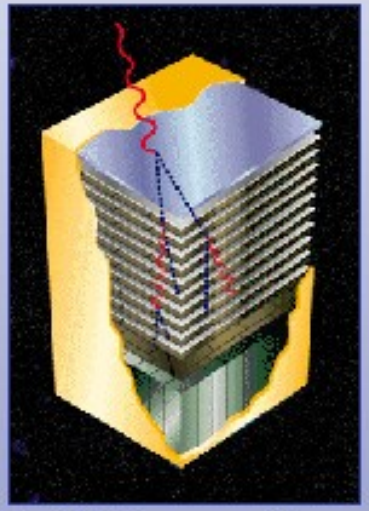


Low-Power Megachannel VLSI Readout Electronics

Silicon Strip Detector Tracker Plane



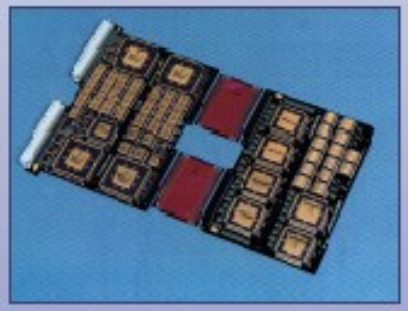
Cesium Iodide Imaging Spectrometer Elements



GLAST Telescope Module

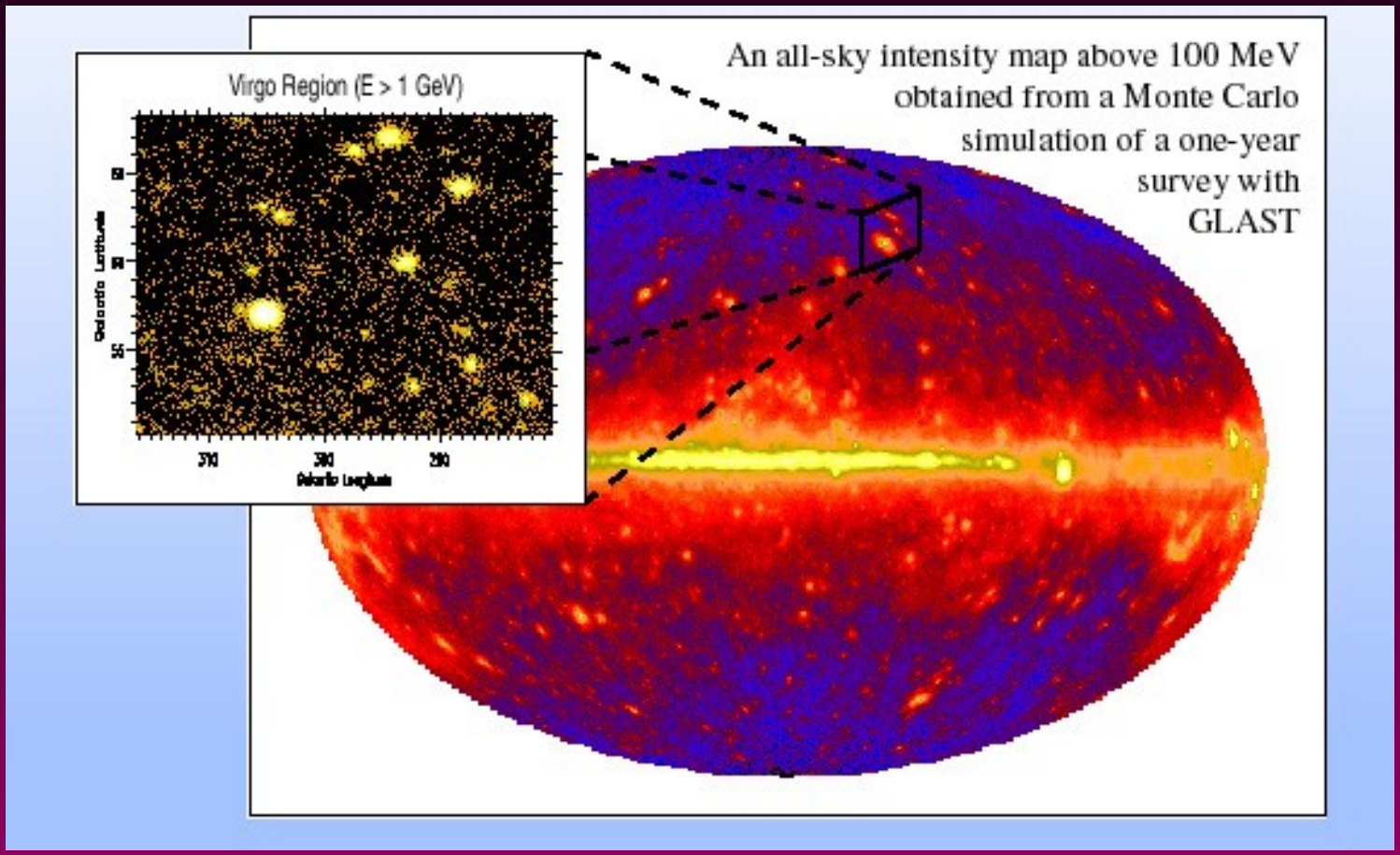
CHALLENGES:

- Largest silicon strip detector array ever assembled (1.5 million channels from total of 90 m^2 of silicon detectors)
- On-board data system sophistication: distributed, adaptable, programmable trigger



32-bit Radiation-Hard Processor

GLAST All Sky Map



For More Information

- Imagine the Universe! - http://imagine.gsfc.nasa.gov/
- Swift Mission - http://swift.sonoma.edu/
- GLAST Mission - http://ww-glast.sonoma.edu/
- CGRO Mission - http://cossc.gsfc.nasa.gov