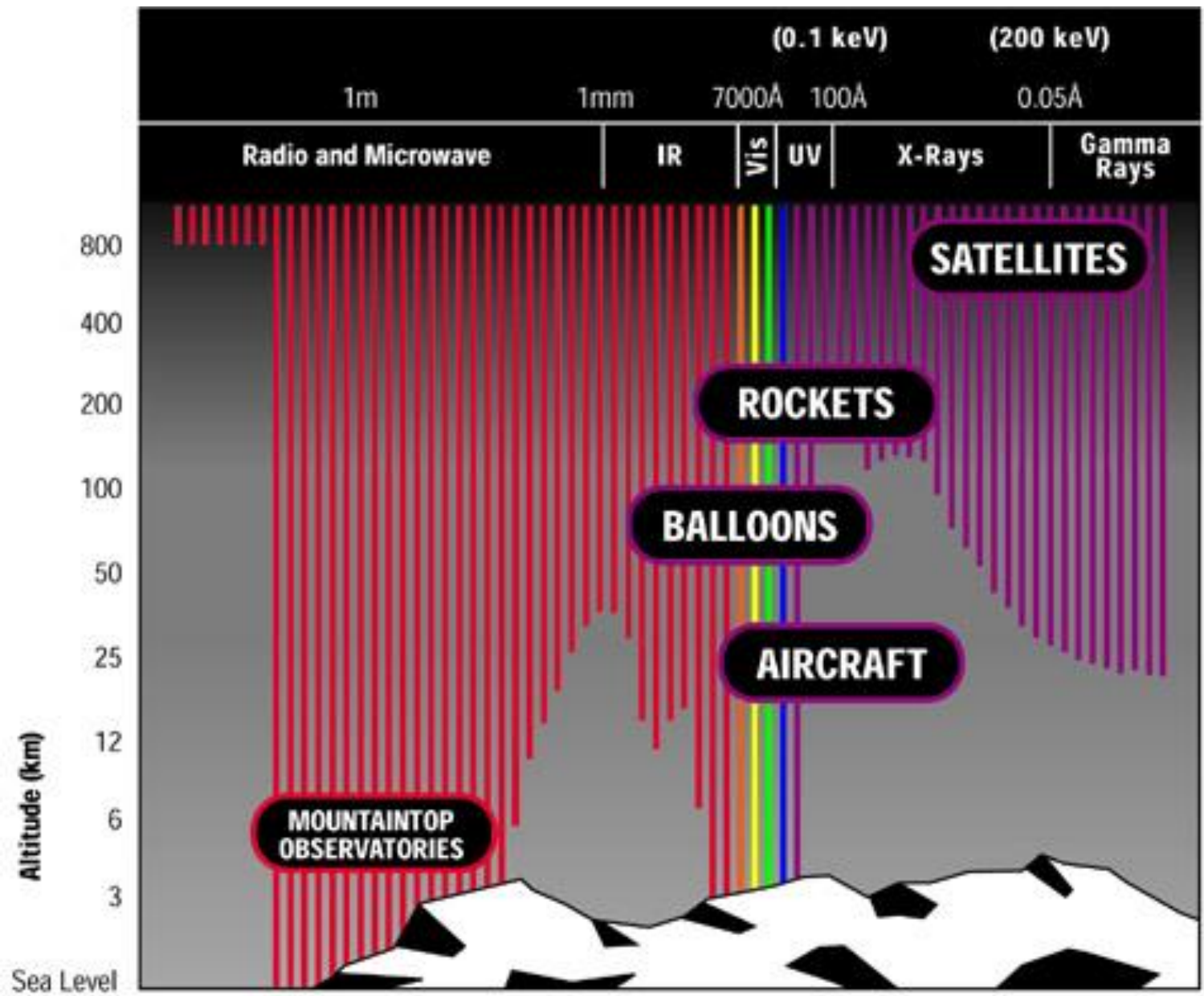


# Gamma-Ray Bursts

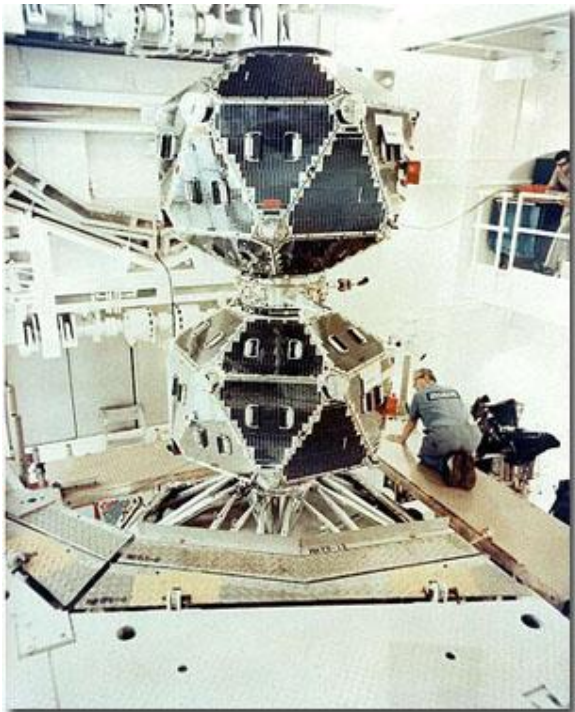
**Gerald J. (Jerry) Fishman**

NASA-Marshall Space Flight Center  
Huntsville, AL USA

*Physics Department  
University of Missouri  
March 19, 2012*

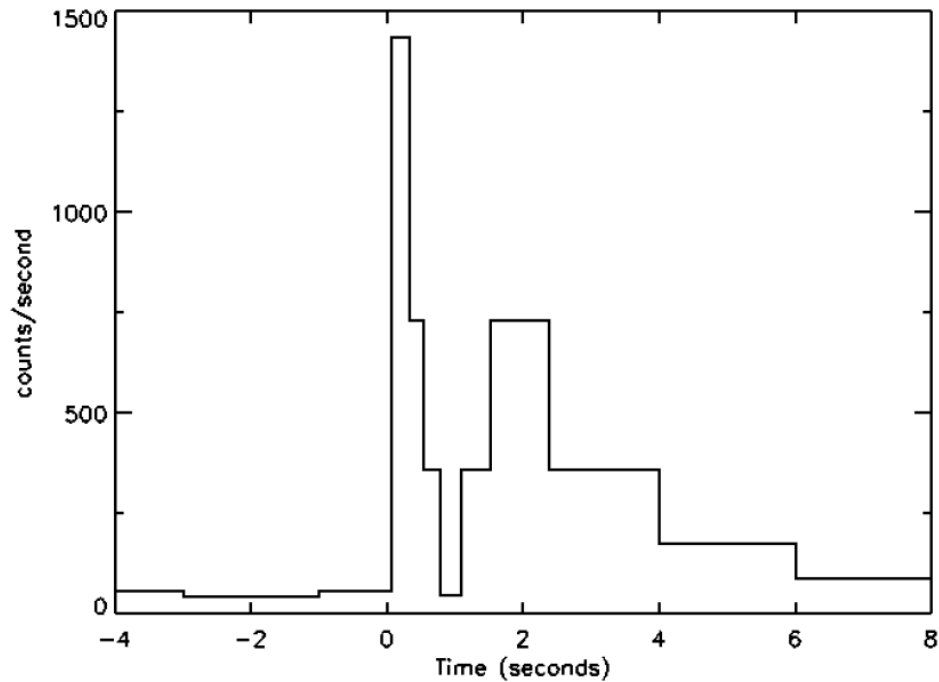


# Vela Spacecraft for Nuclear Bomb Detection in Space



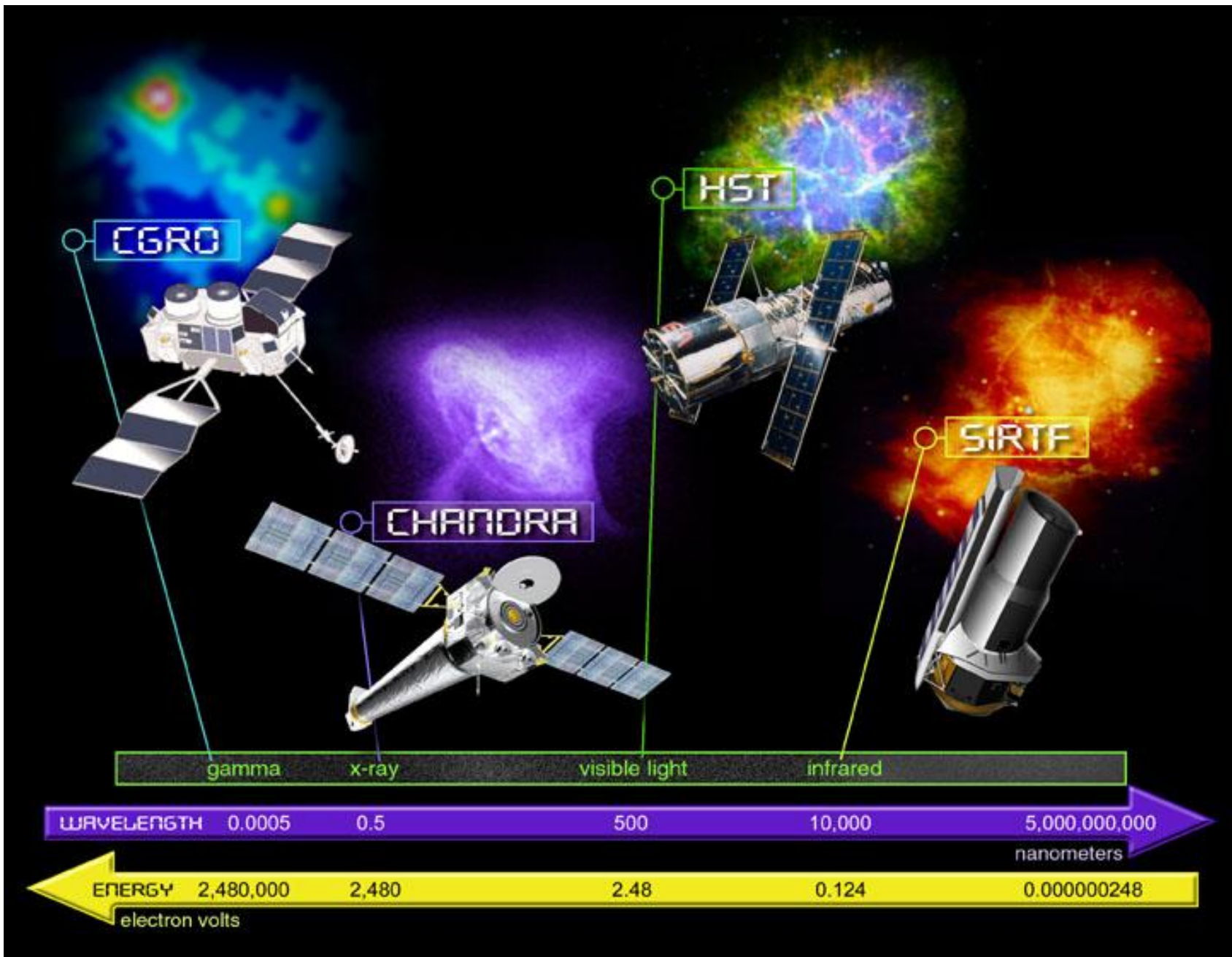
# The First Gamma-ray Burst (GRB) Observed with Vela Spacecraft

1967



# NASA's Four Great Observatories:

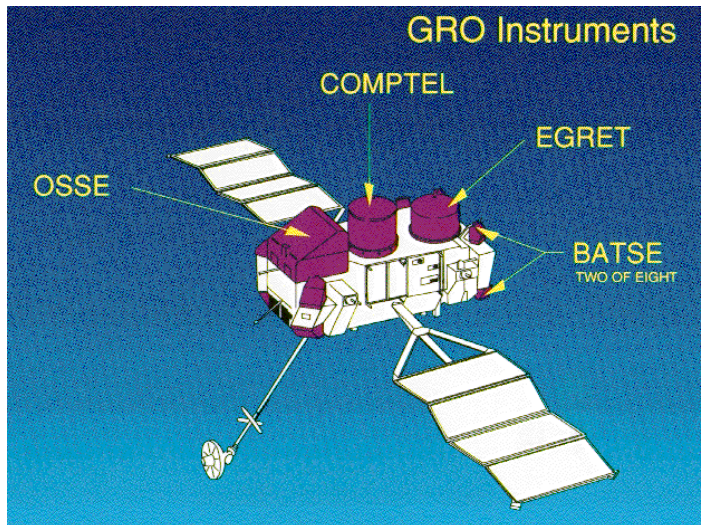
	<u>Launch - End</u>
Hubble Space Telescope	1990 - ~2015
<b>Compton Gamma-Ray Observatory</b>	<b>1991 - 2000</b>
Chandra X-Ray Observatory	1999 - ~2020
Spitzer Space Infrared Telescope	2003 - ~2015



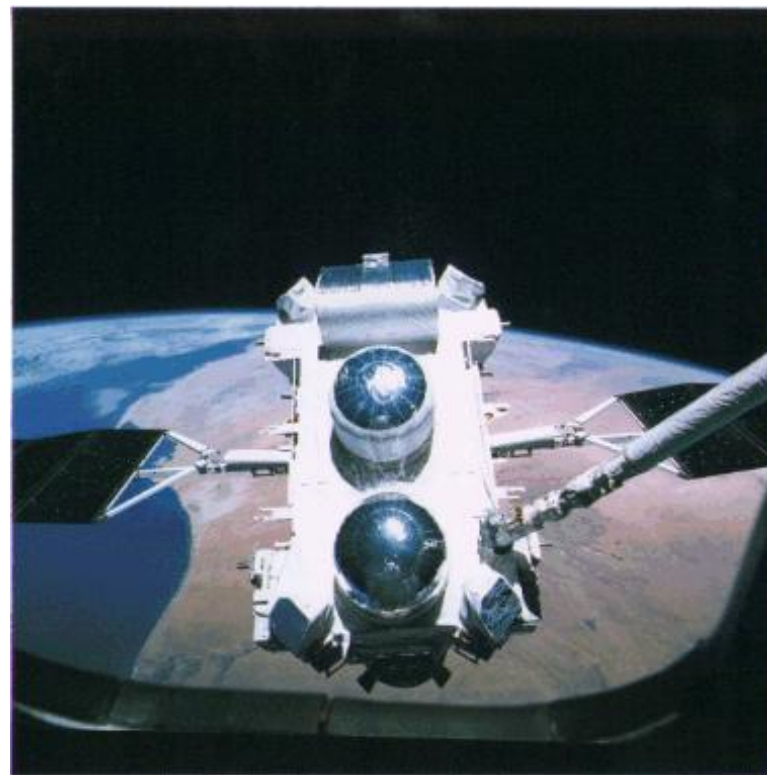
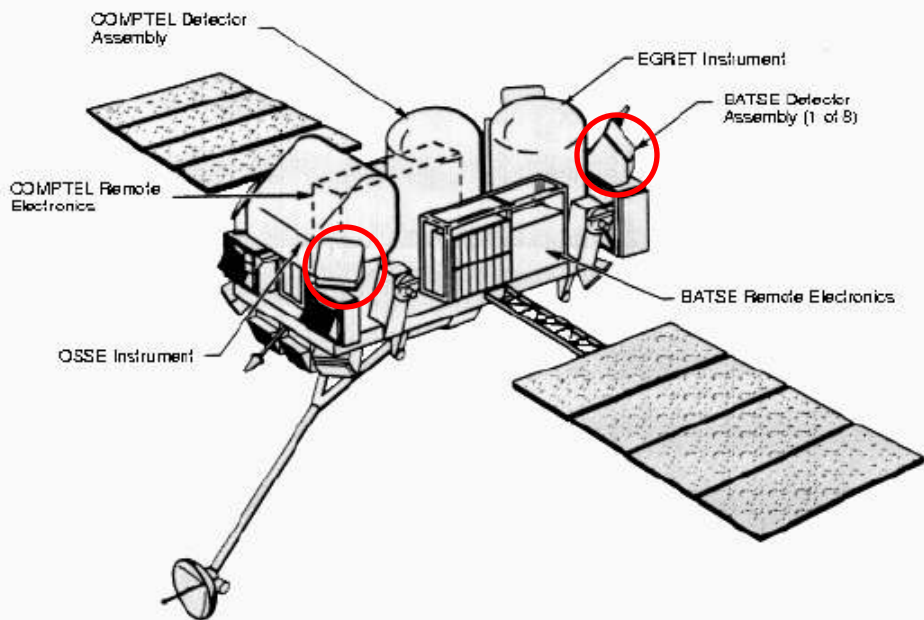


# 1991 - CGRO

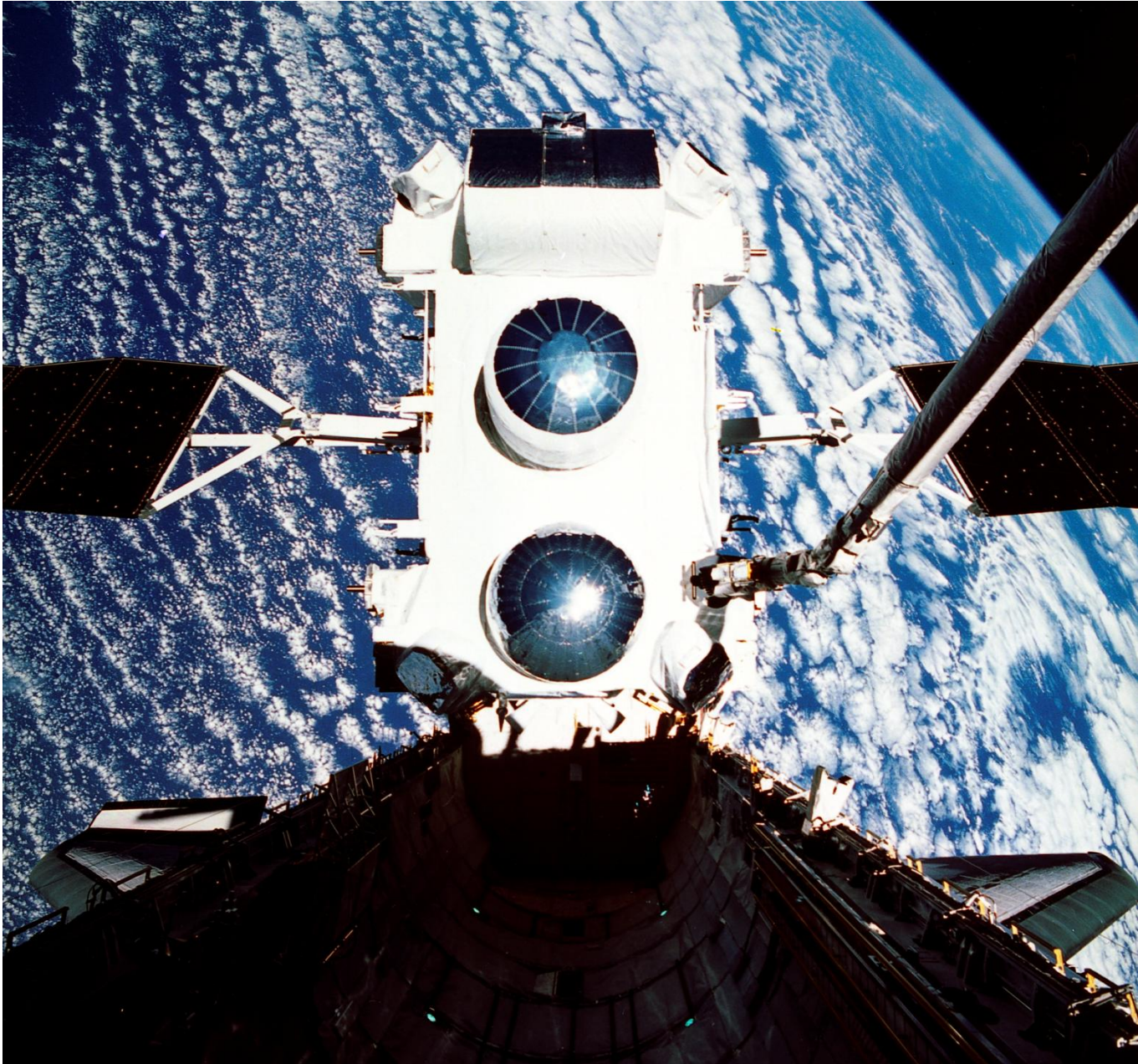
NASA launched the  
Compton Gamma Ray  
Observatory (CGRO)



# Burst and Transient Source Experiment (BATSE) on the Compton Observatory











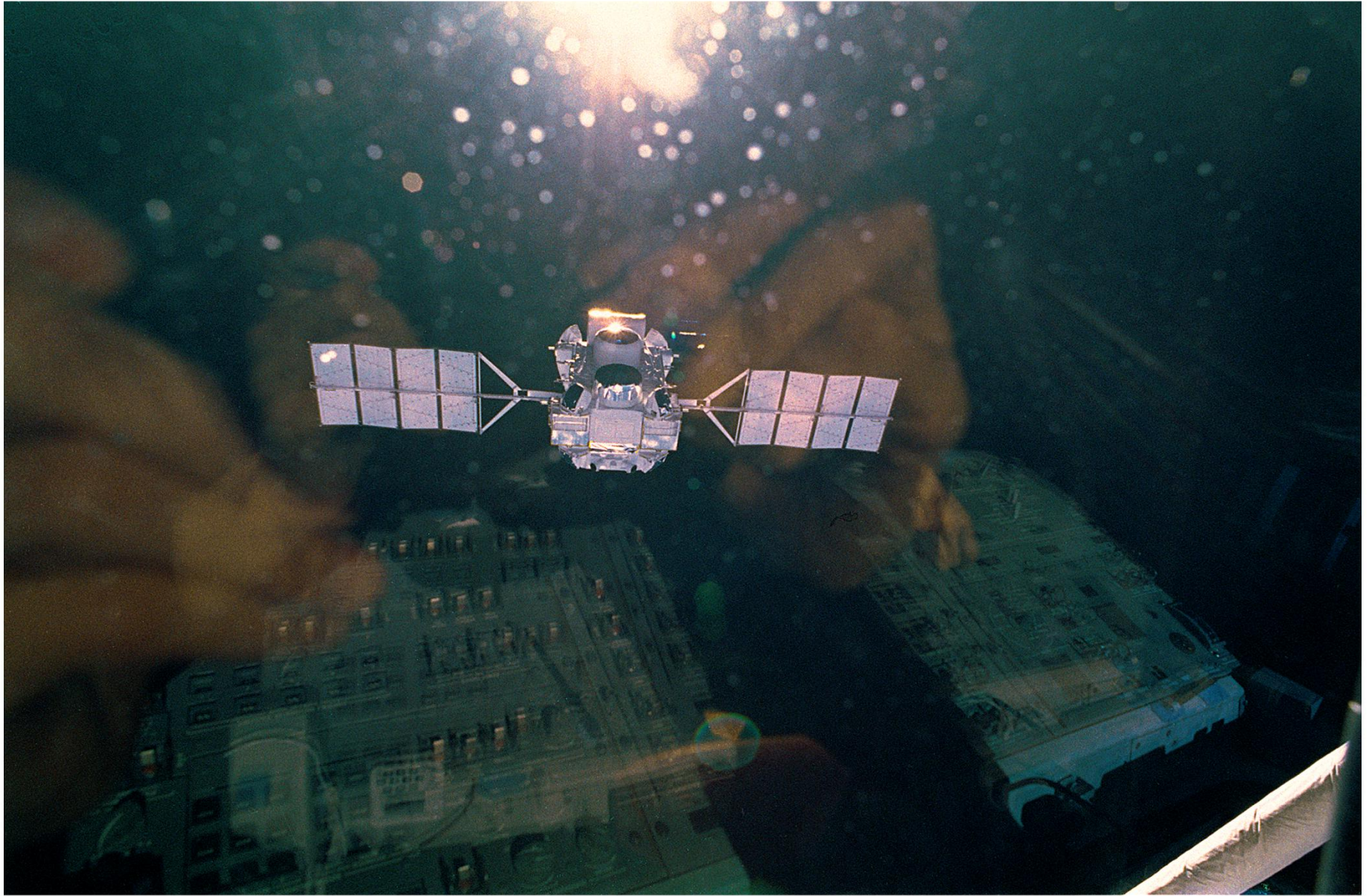






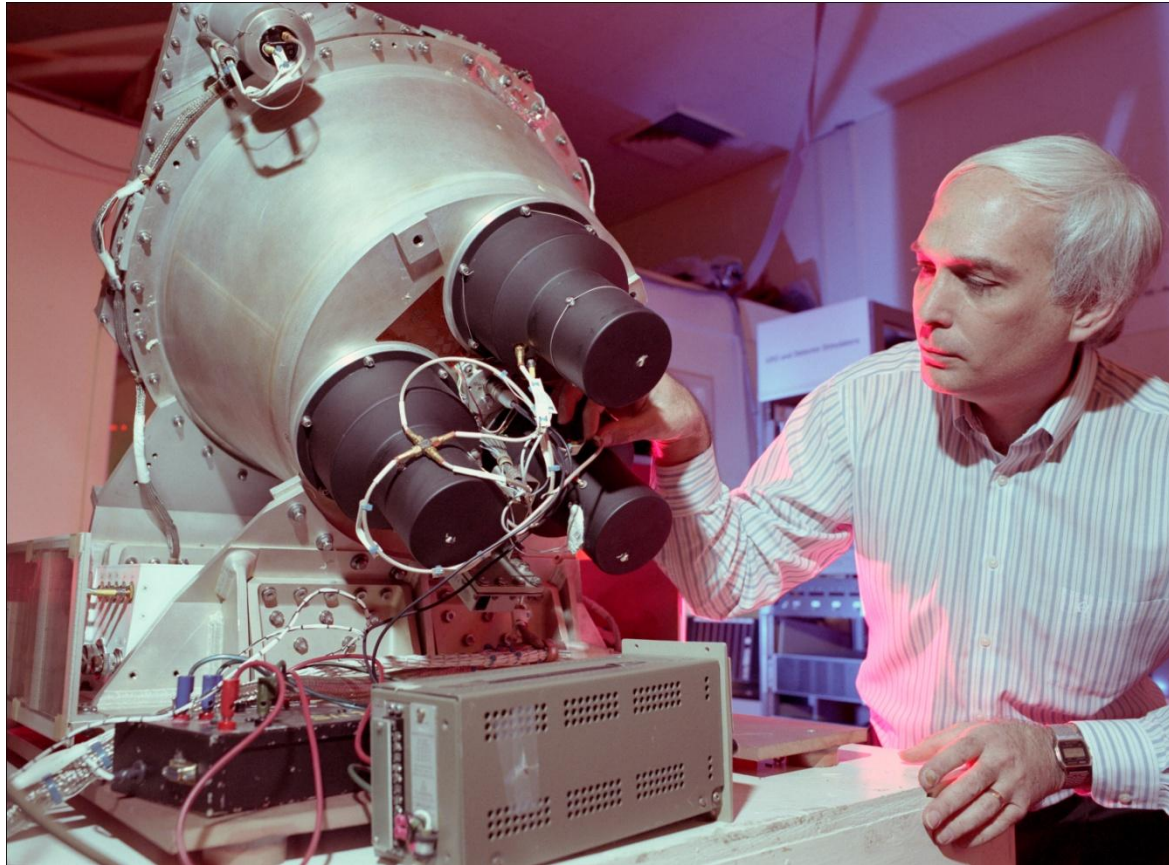




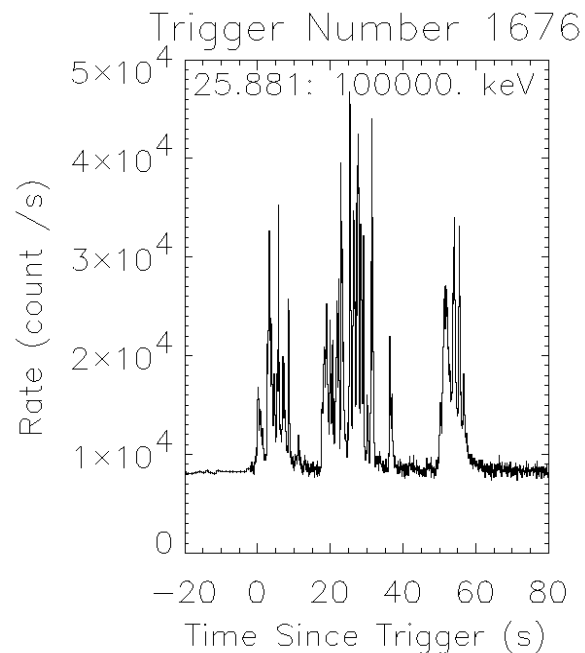
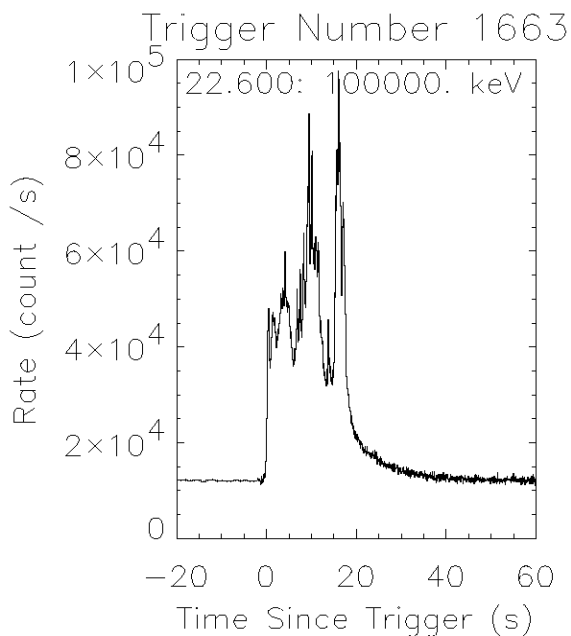
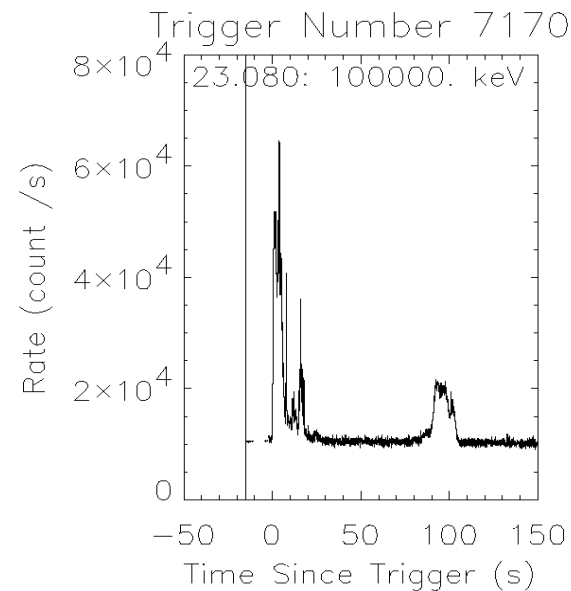
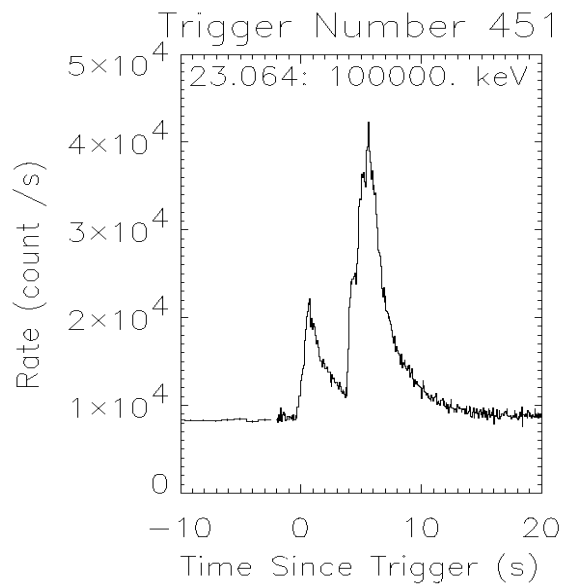
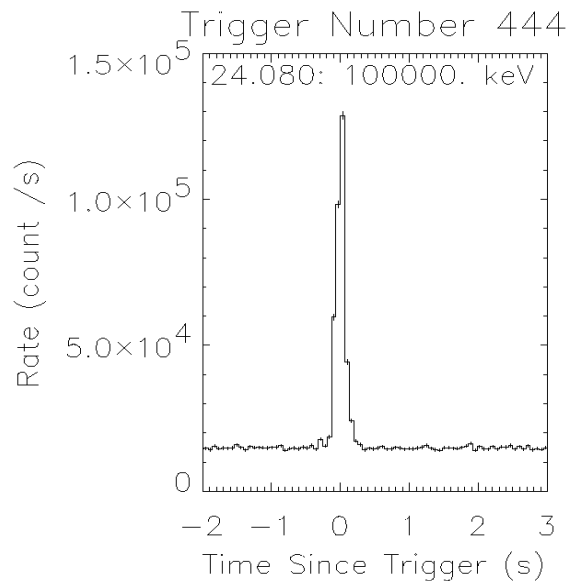


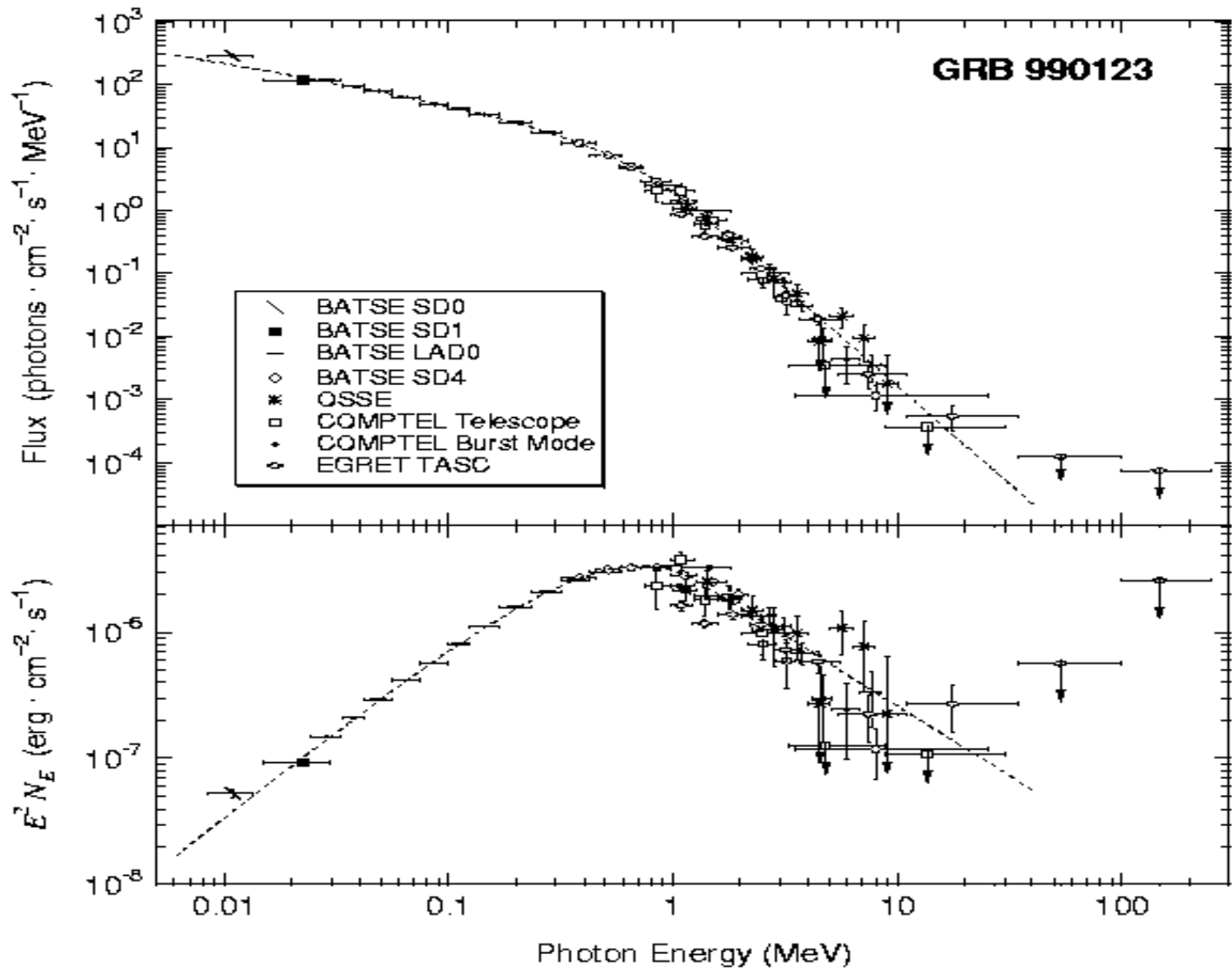


# BATSE Detector Module

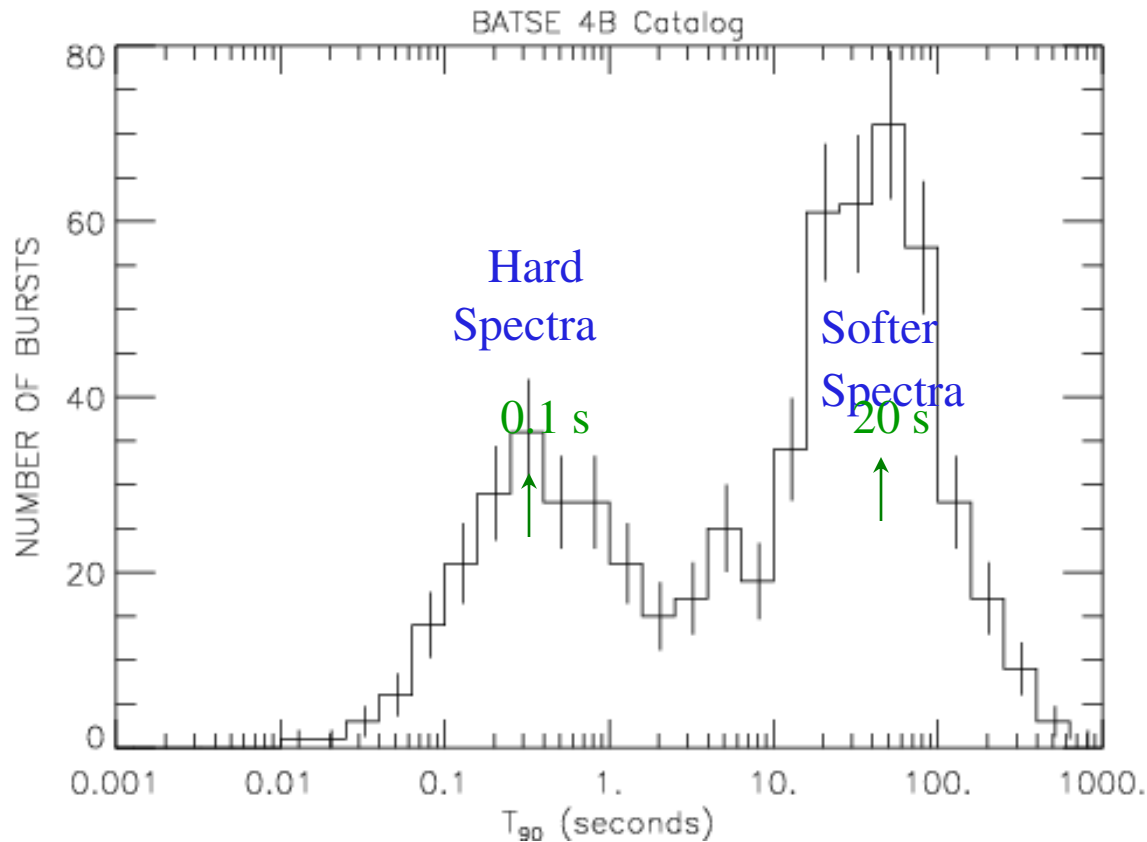


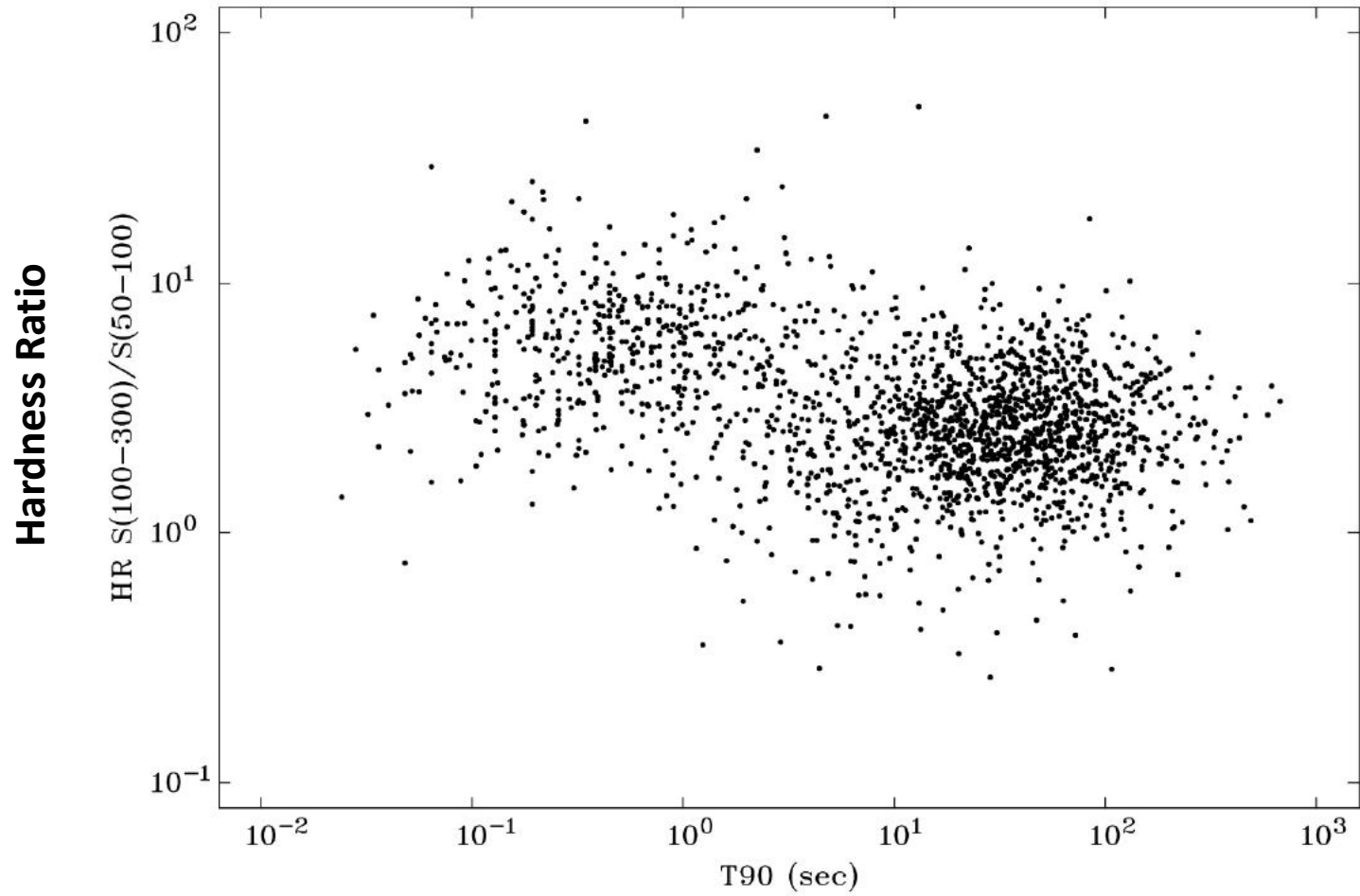
# Diversity of GRB Profiles





# Two Distinct subclasses of $\gamma$ -ray bursts: short/hard & long/soft

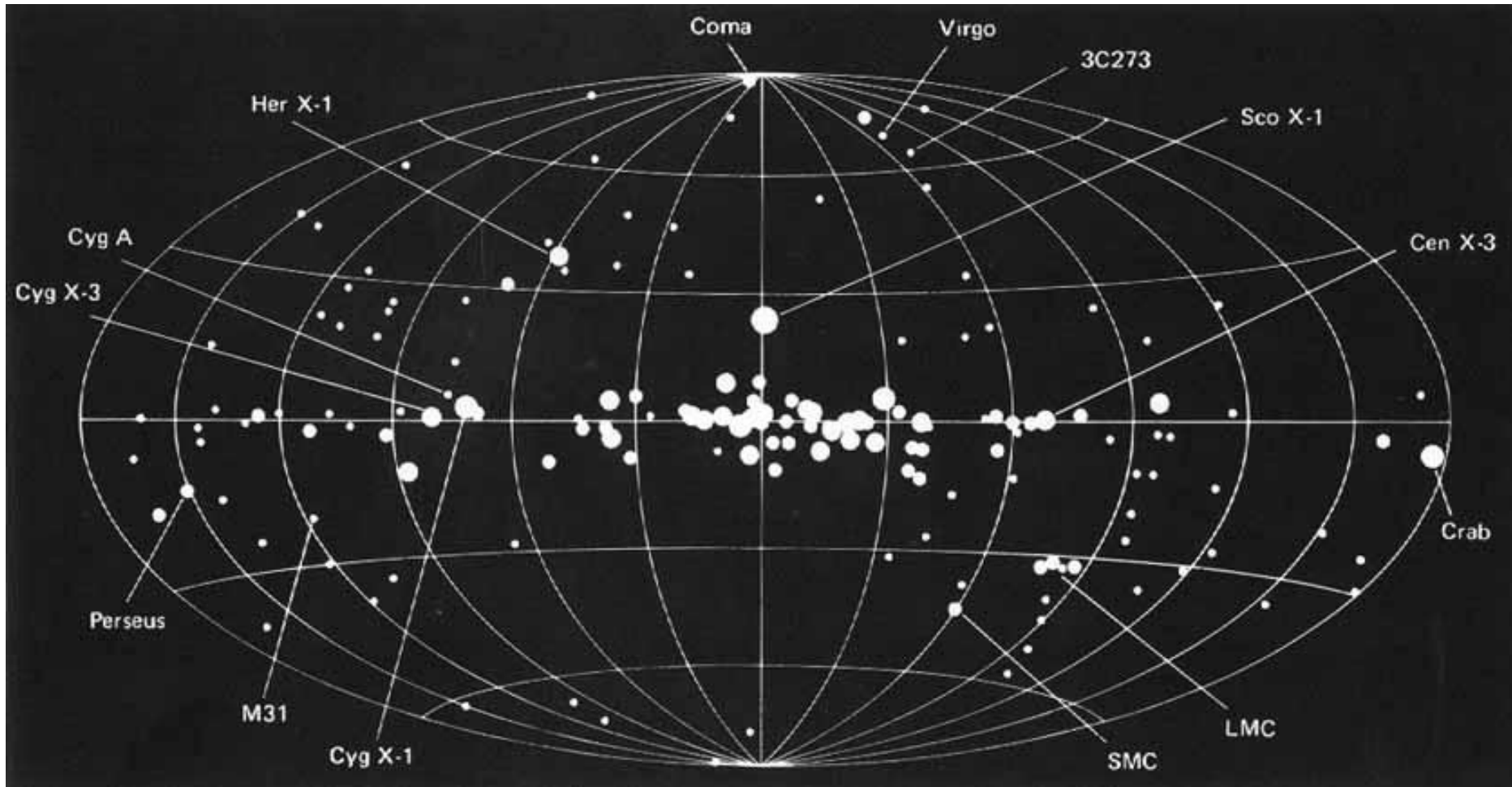


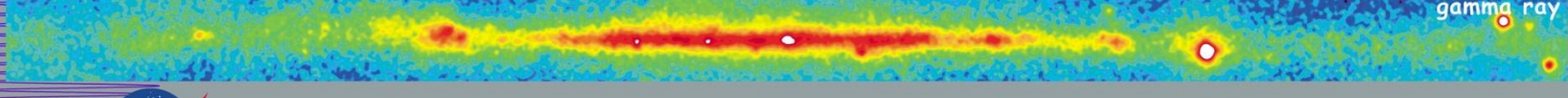
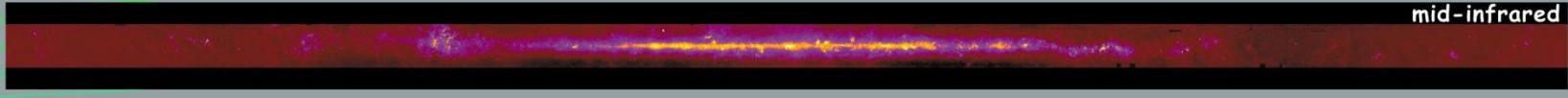
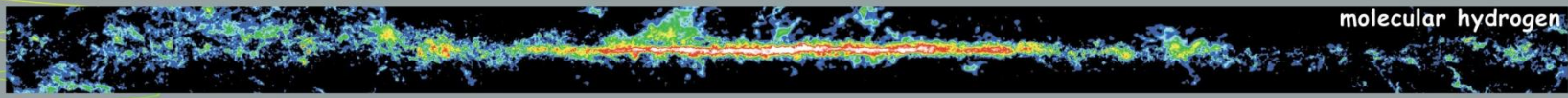
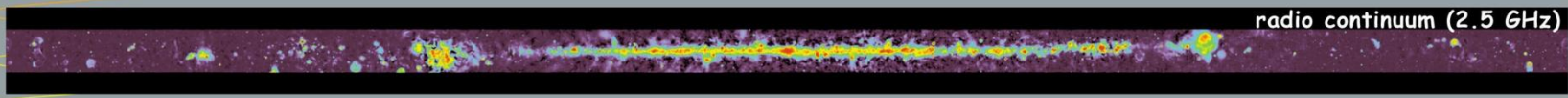
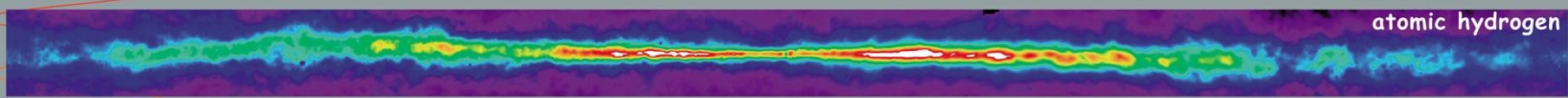


**Duration of Gamma-ray Bursts (sec)**

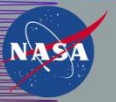


# X-ray Objects in the Sky

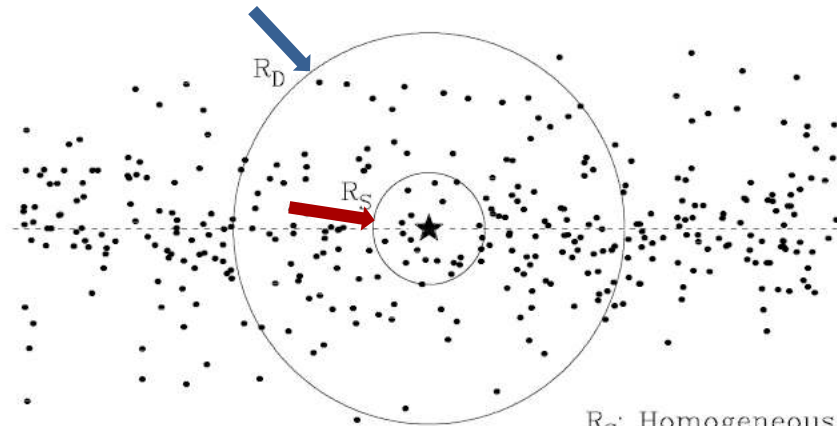




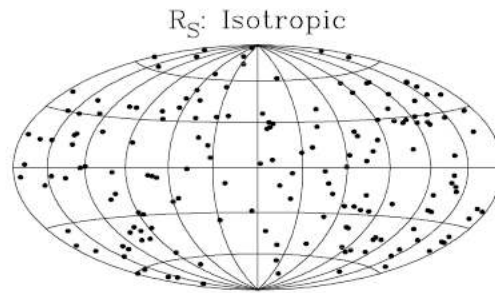
<http://adc.gsfc.nasa.gov/mw>



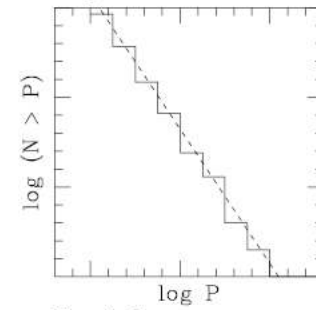
# Multiwavelength Milky Way



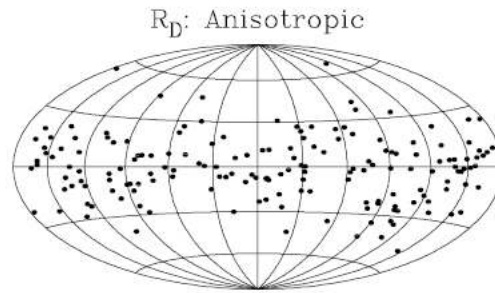
$R_S$  - Galactic, Nearby



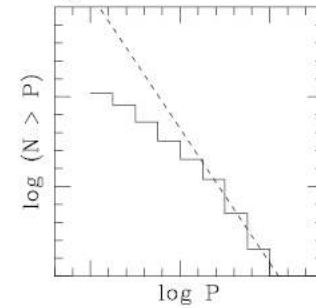
$R_S$ : Homogeneous



$R_D$  - Galactic, Far away

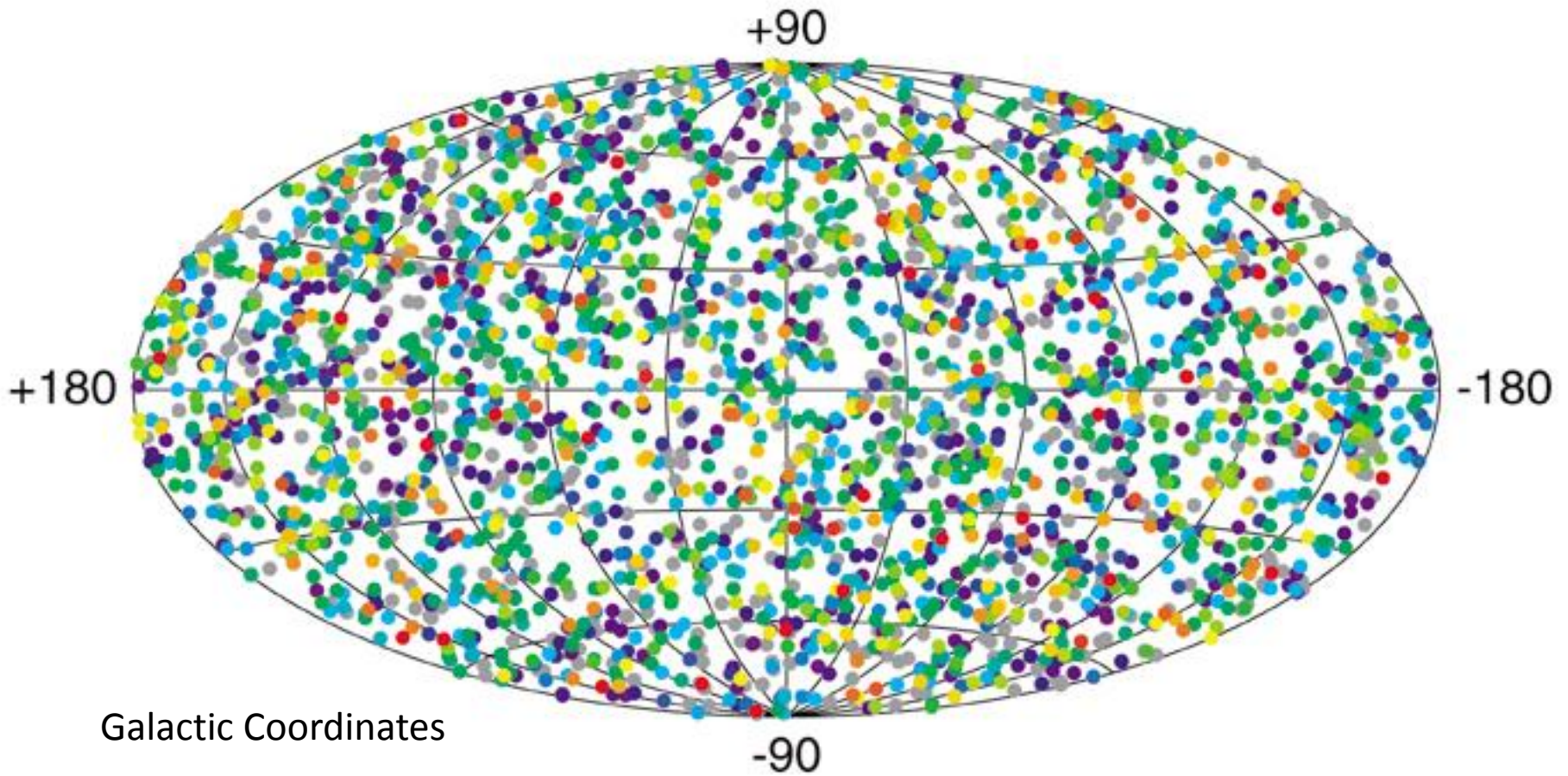


$R_D$ : Inhomogeneous

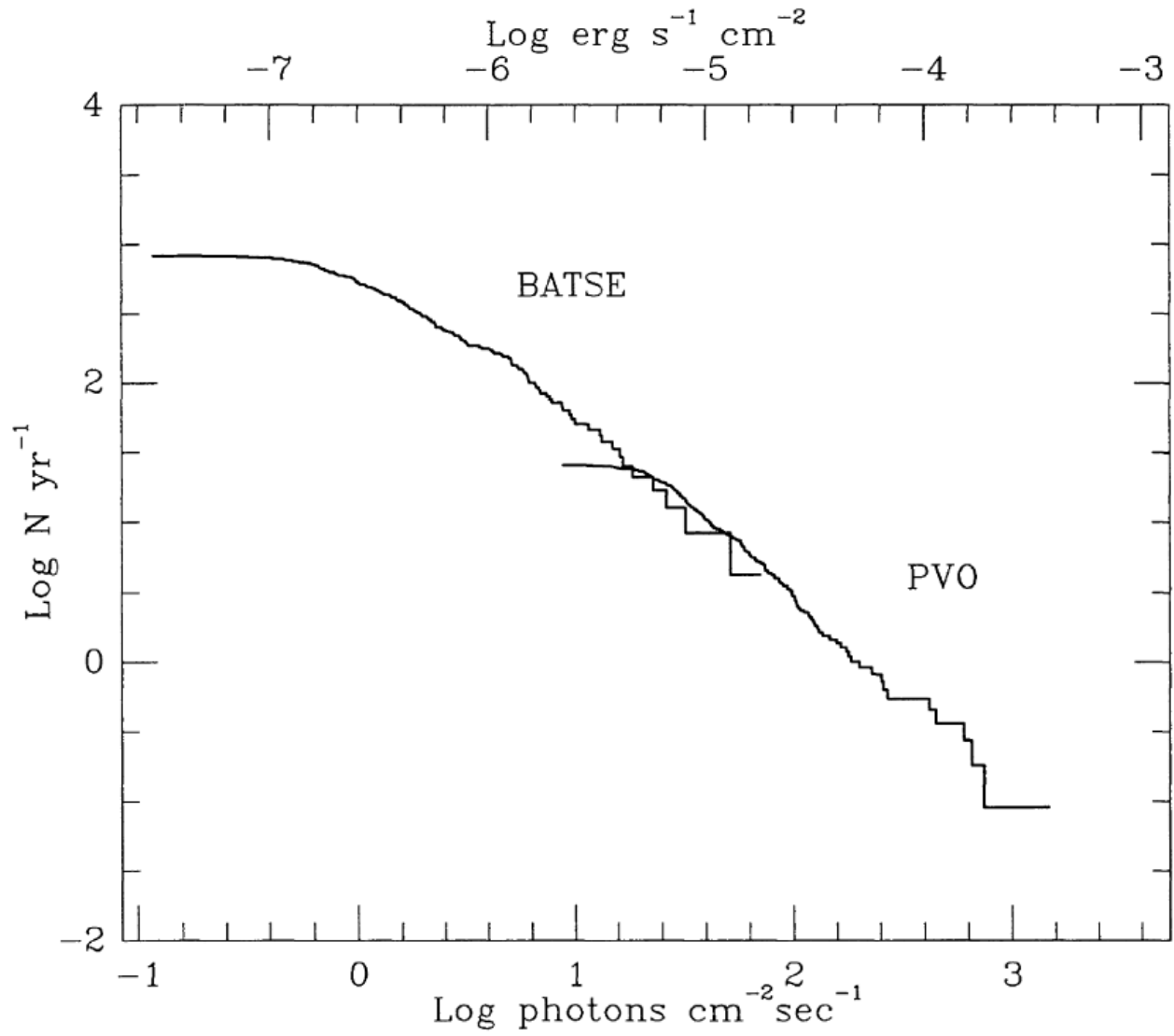




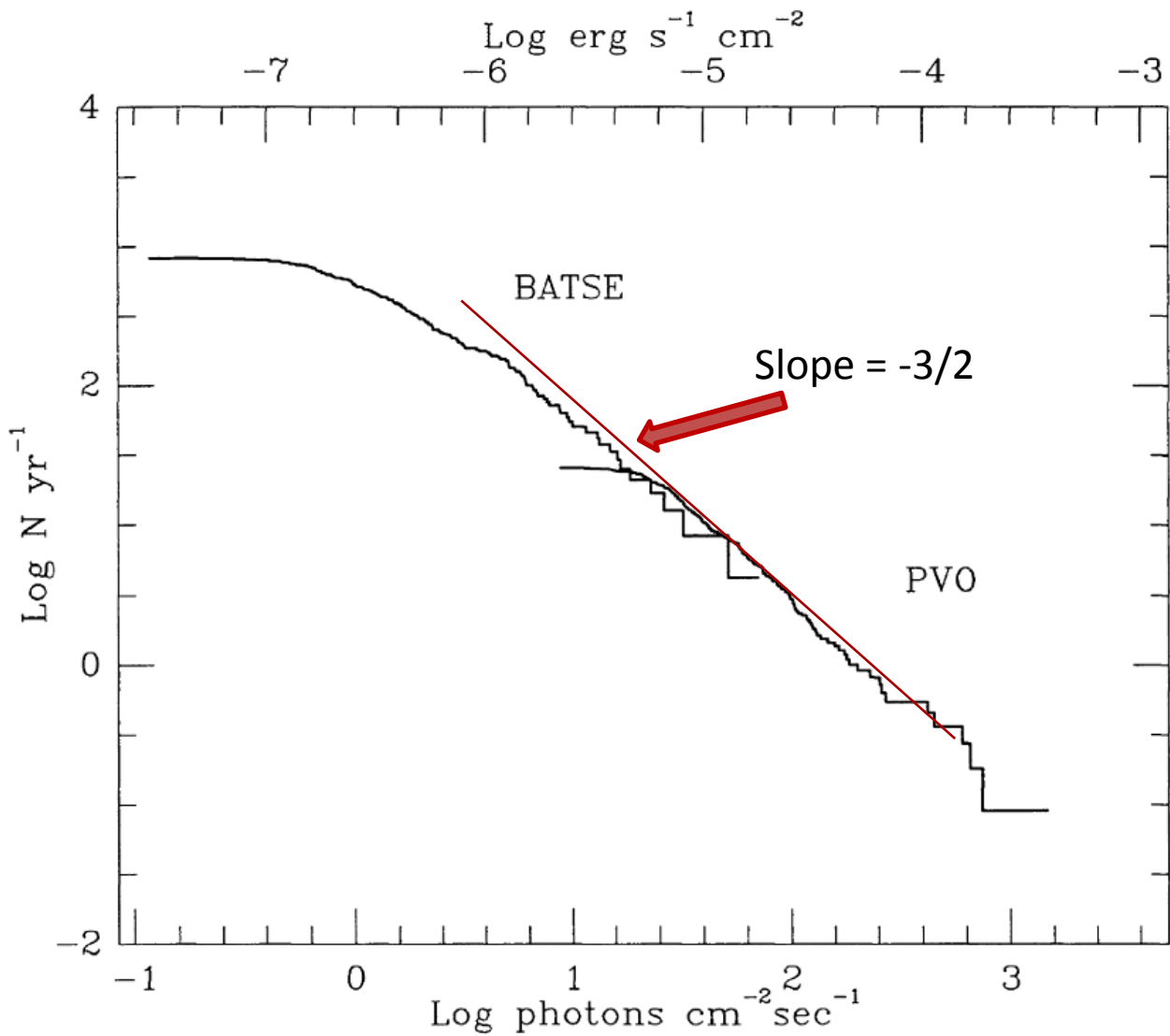
# 2704 BATSE Gamma-Ray Bursts

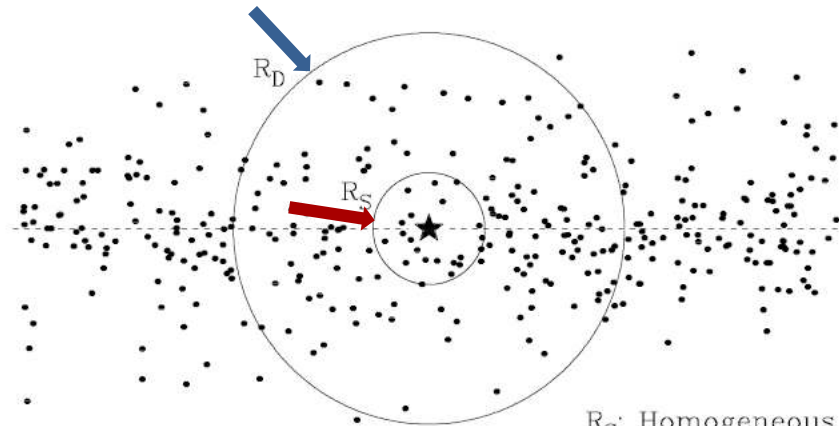


Apr. 1991 – May 2000

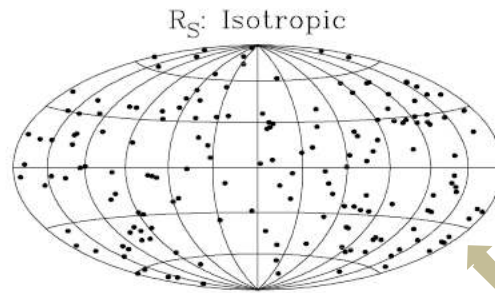




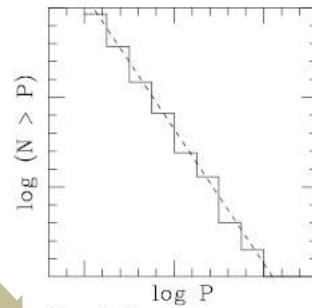




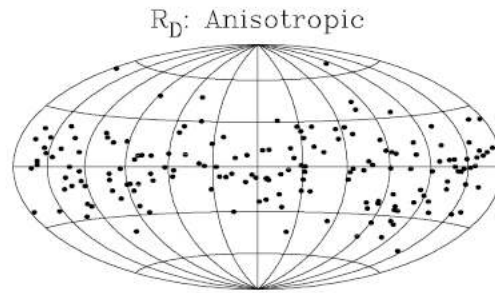
$R_S$  - Galactic, Nearby



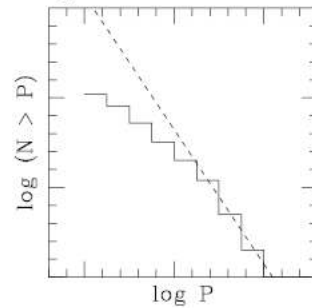
$R_S$ : Homogeneous



$R_D$  - Galactic, Far away



$R_D$ : Inhomogeneous



# From BATSE Observations:

The Gamma-ray Burst Distribution  
is not like that of  
*any known* Objects in our Galaxy  
and thus they are *likely* at  
Cosmological Distances\*

\* - Near the Edge of the Observable Universe

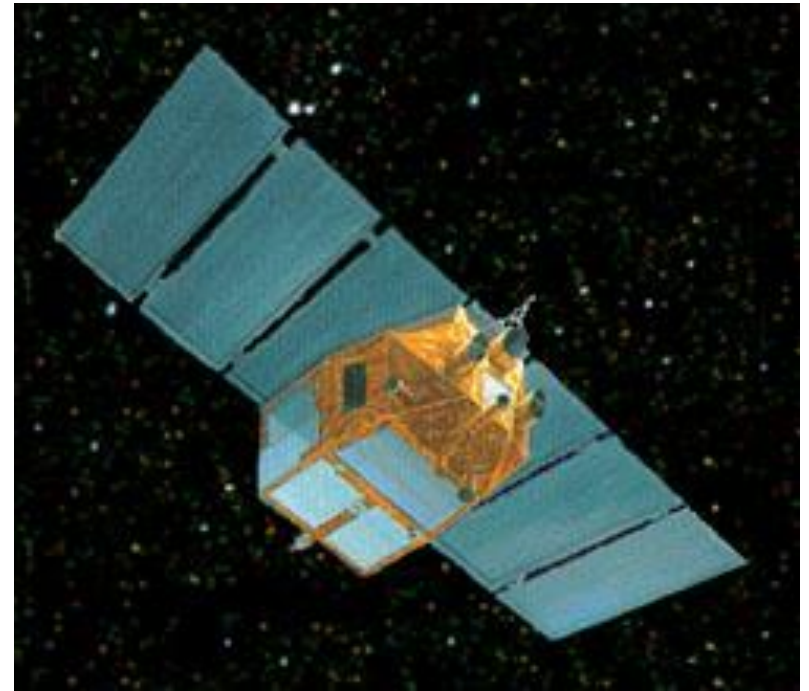
**1992-1996:**

**Hiatus in the GRB Field**

- A Breakthrough is needed**

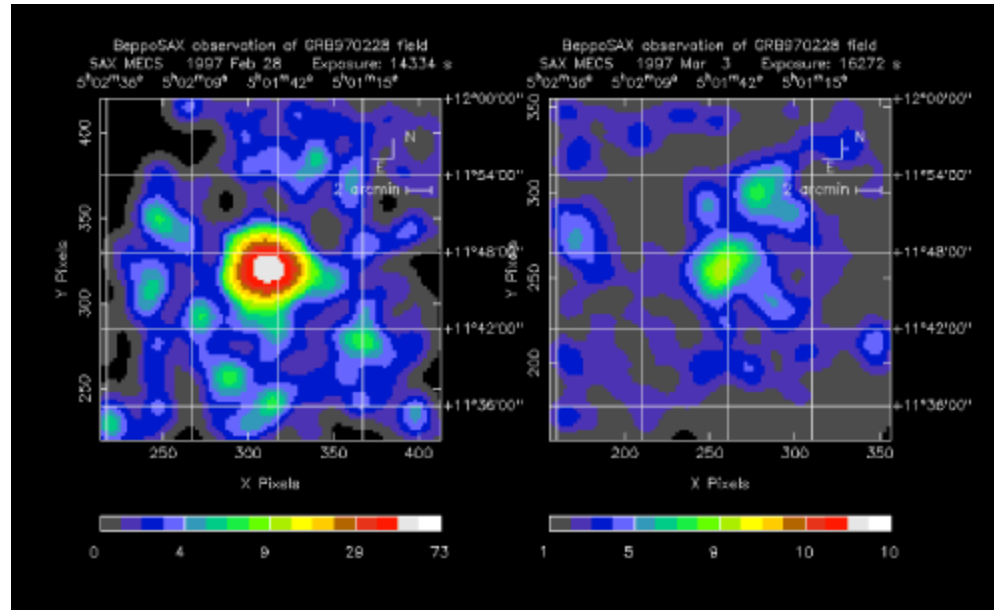
# Observational Breakthrough in 1997: BeppoSAX

- **Italian/Dutch satellite detected GRB 970228 and an X-ray source at the same position that decays over time.**
- **A visible light afterglow was found at the same position.**





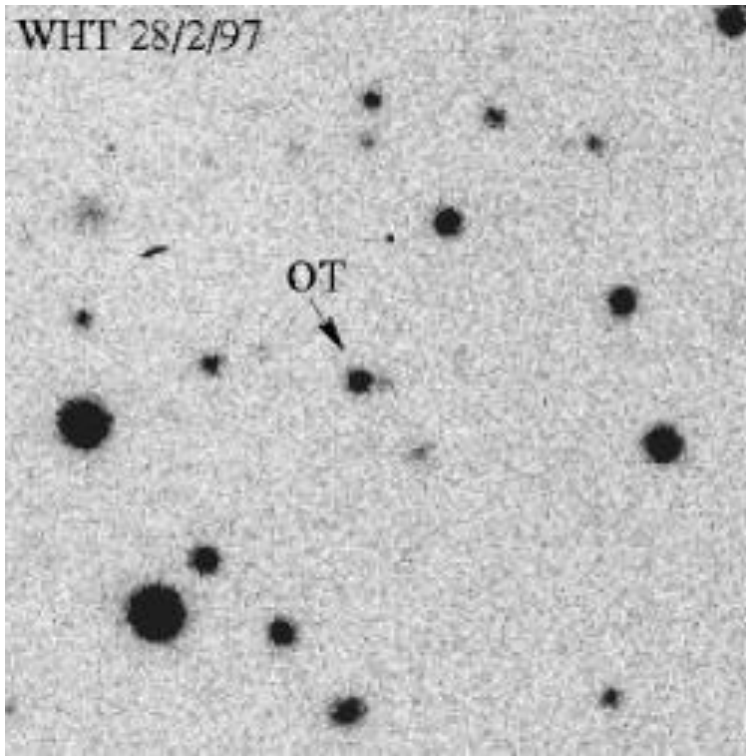
# Observational Breakthrough in 1997: BeppoSAX Satellite



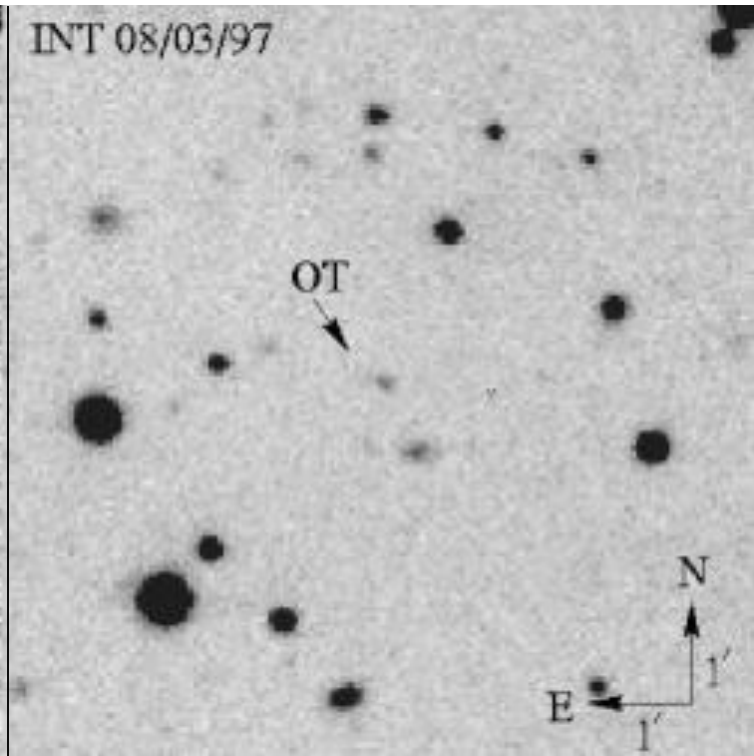
Feb. 28, 1997

Mar. 3, 1997

## GRB970228 : X-ray Observations

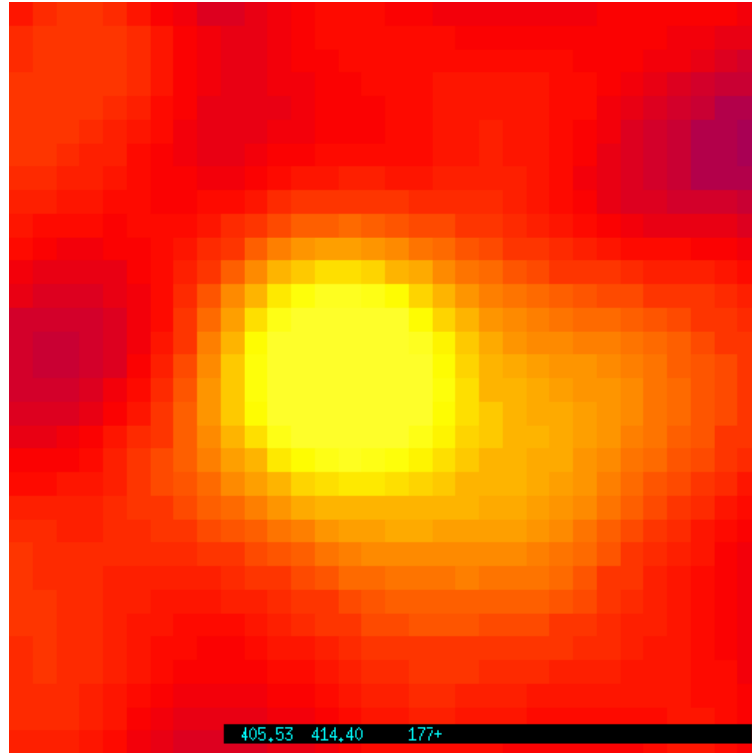


Feb. 28, 1997



Mar. 8, 1997

# GRB970228 : Optical Observations

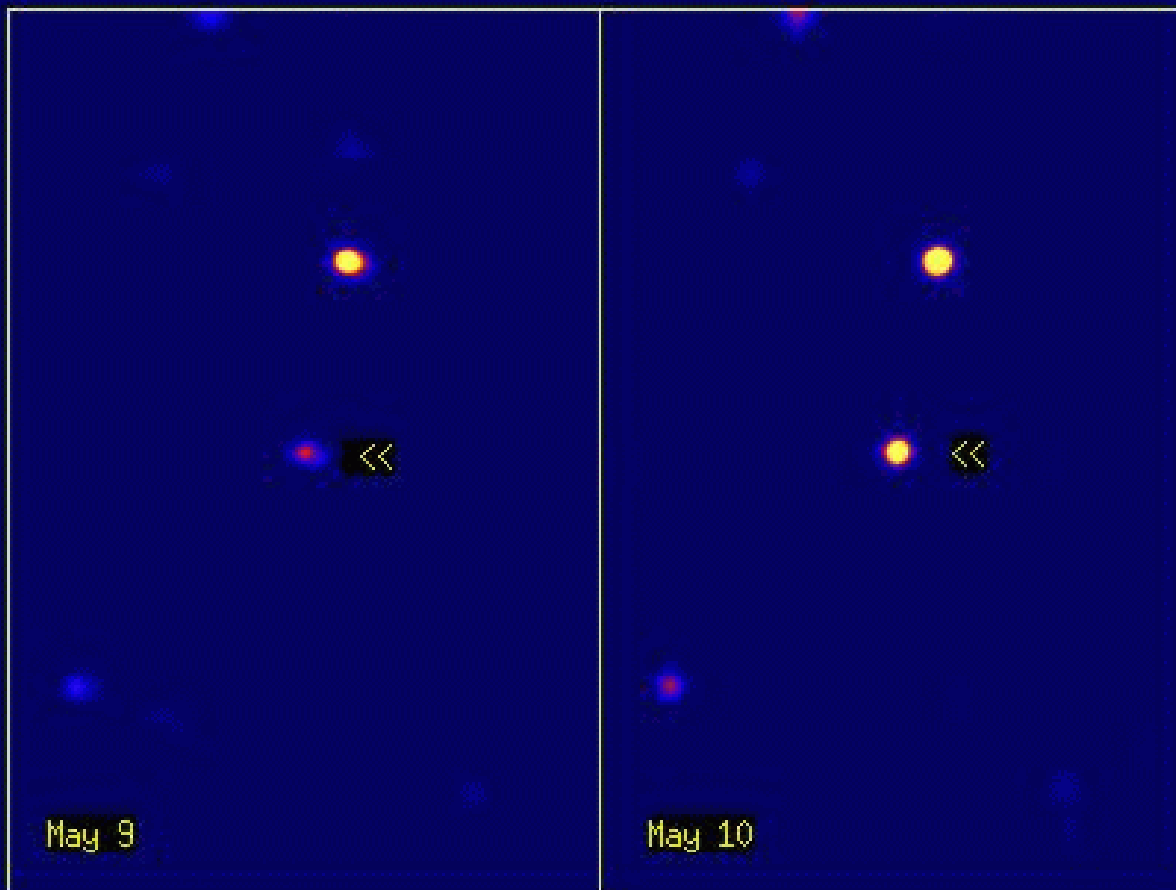


**Mar. 5, 1997**

# **Hubble Space Telescope Image of GRB970228**

(Note Faint, Fuzzy Galaxy to Lower Right)

GRB 970508 Optical Counterpart



Palomar Observatory

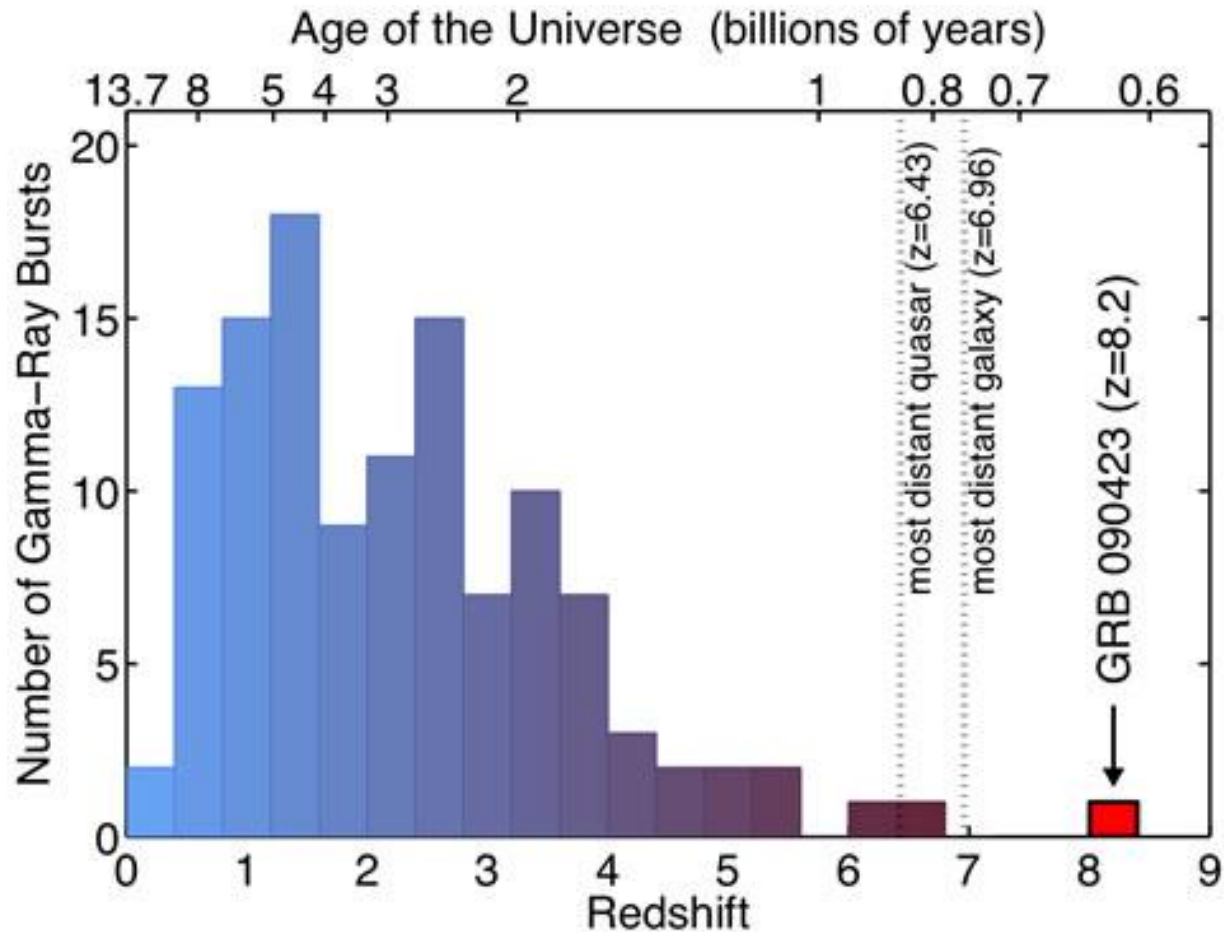
# GRBs are the Most Powerful Objects in the Universe!

GRB 990123 power (calculated from its peak magnitude and red-shift) was  $\sim 2 \times 10^{54}$  ergs/sec

= 3 Billion Galaxies' Total Energy Output per sec  
(1 Galaxy = 100 Billion stars)



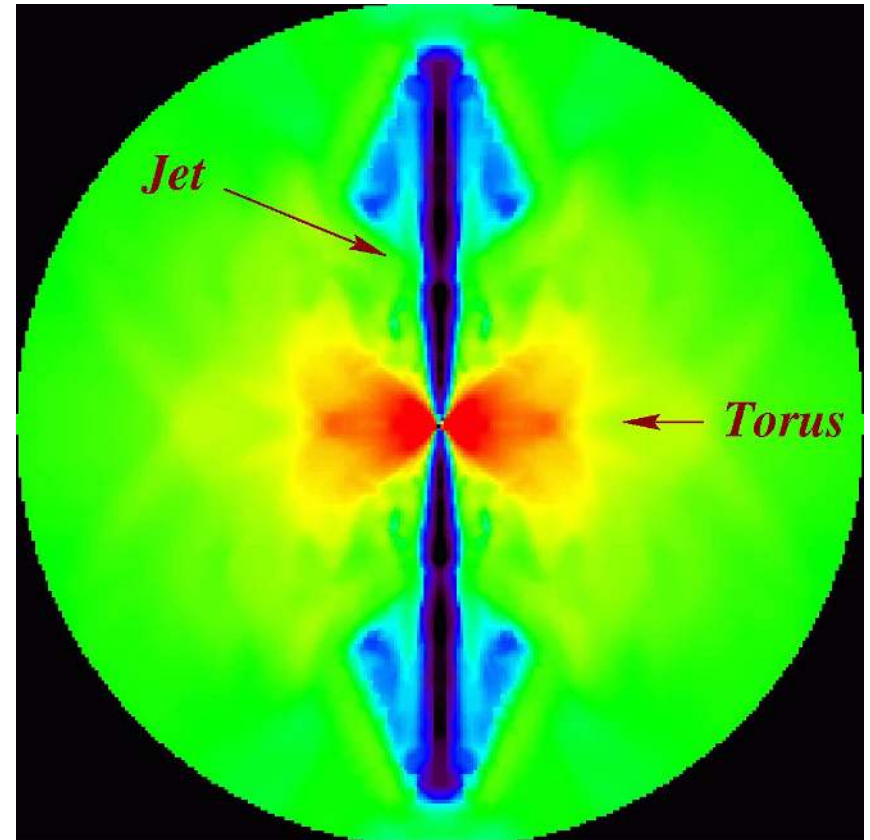
# GRBs: The Most Distant Objects in the Universe

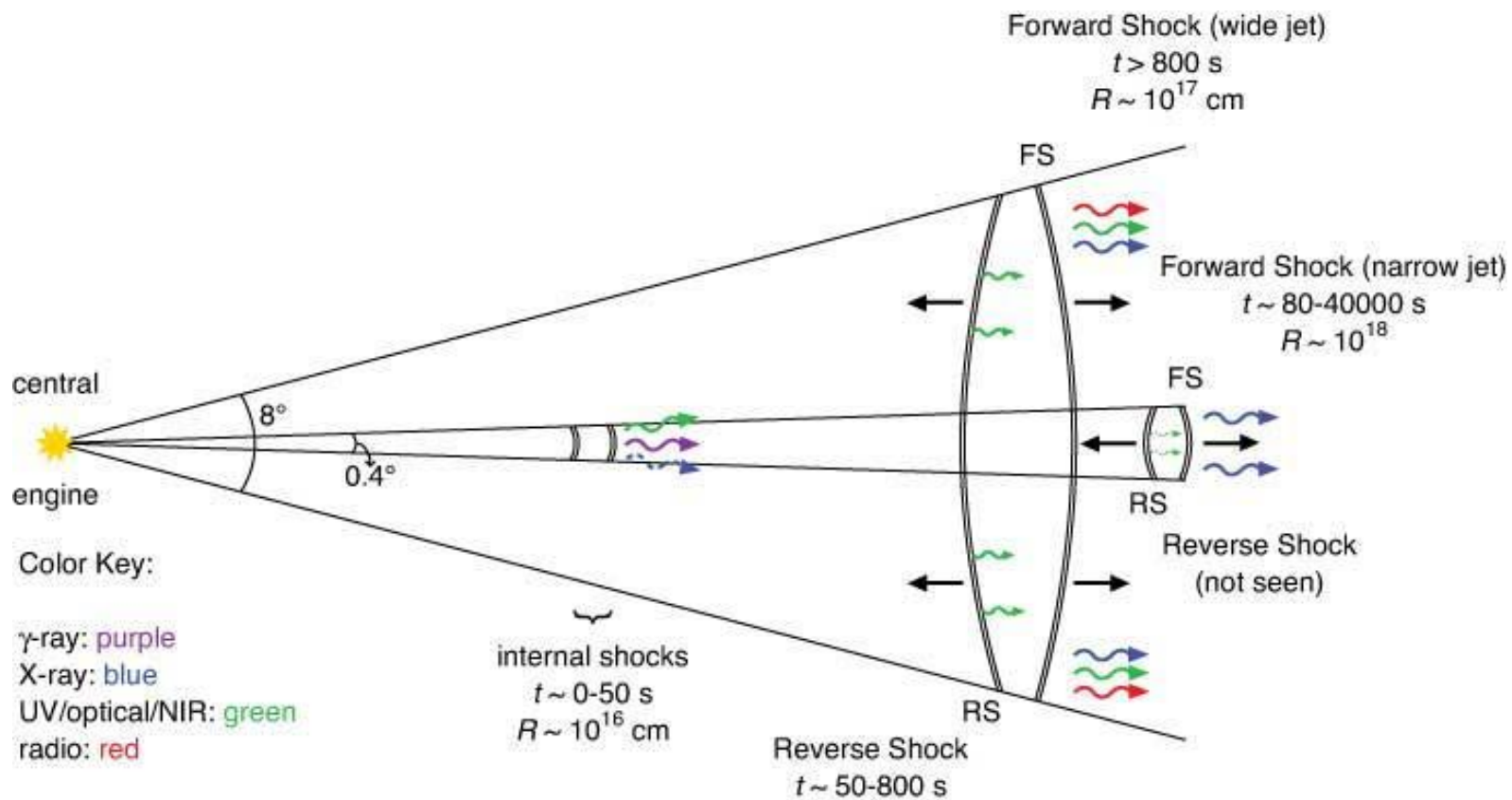


Credit: Edo Berger (Harvard/CfA)

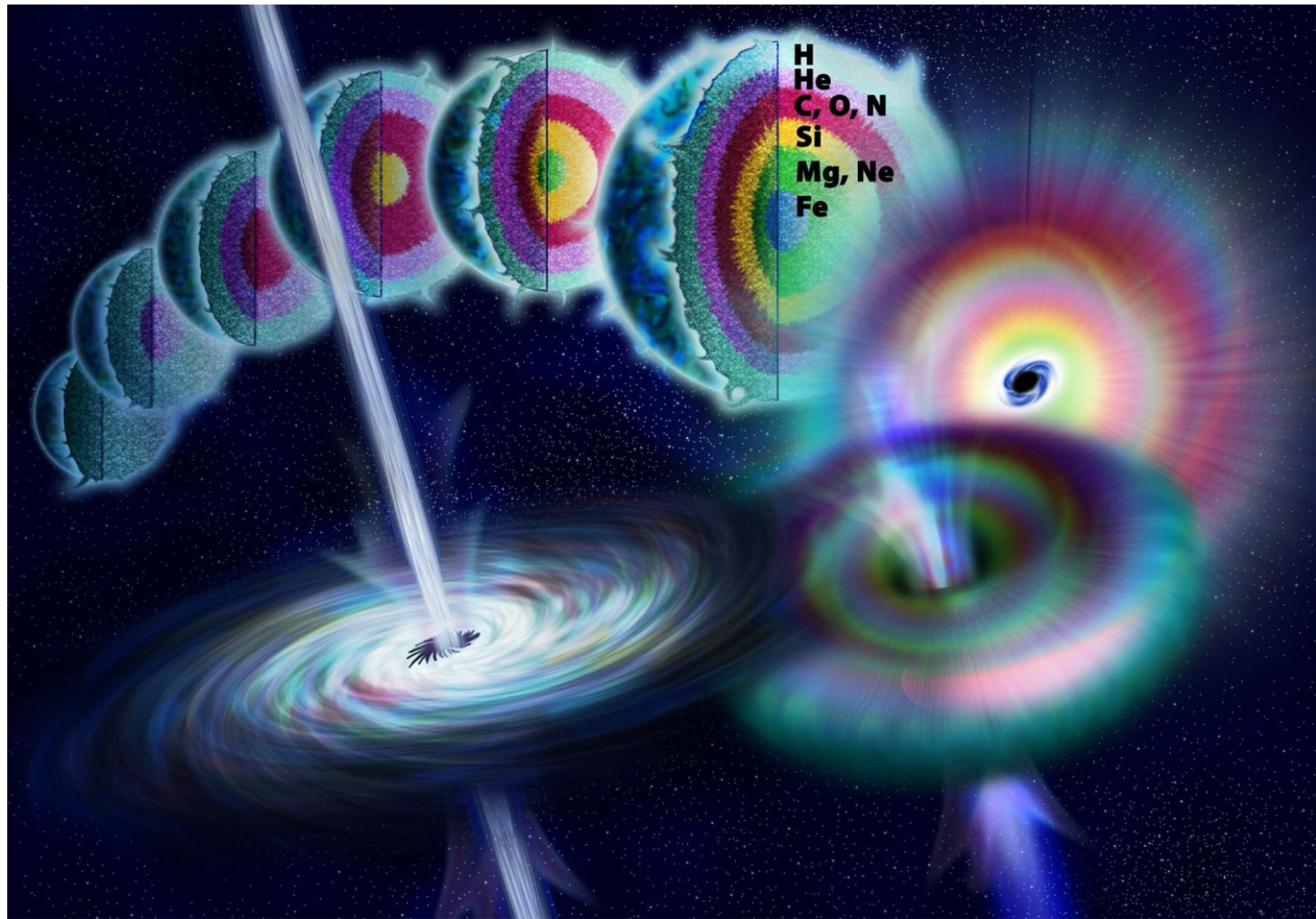
# Conditions for Collapsar (Hypernova)

- At least  $40 M_{\text{sun}}$  to form a black hole
- Star must be rapidly rotating to develop an accretion torus launching a jet





# Model of a Gamma-ray Burst

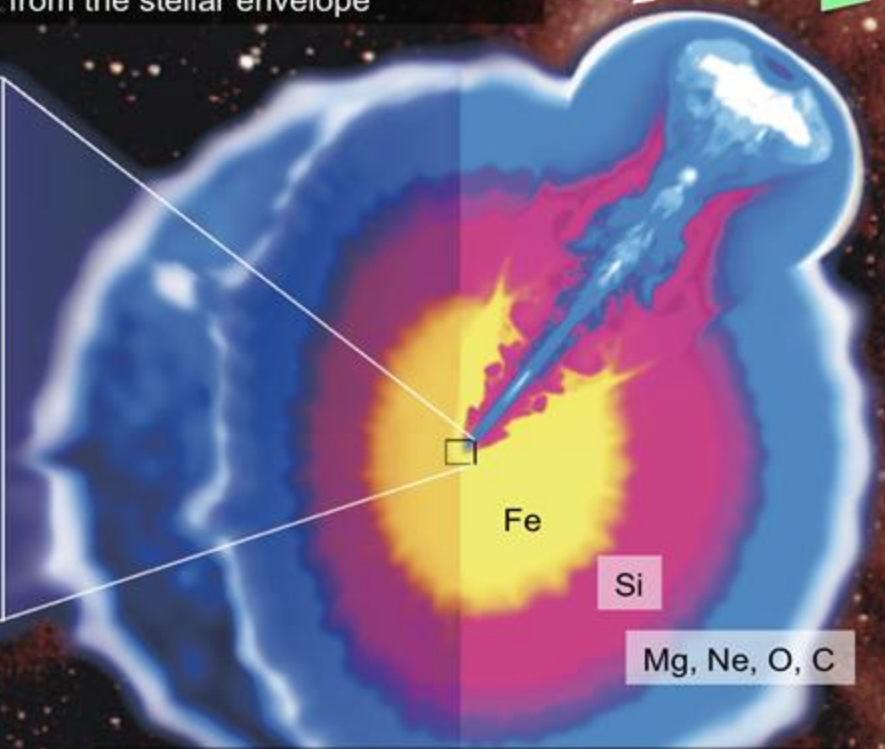
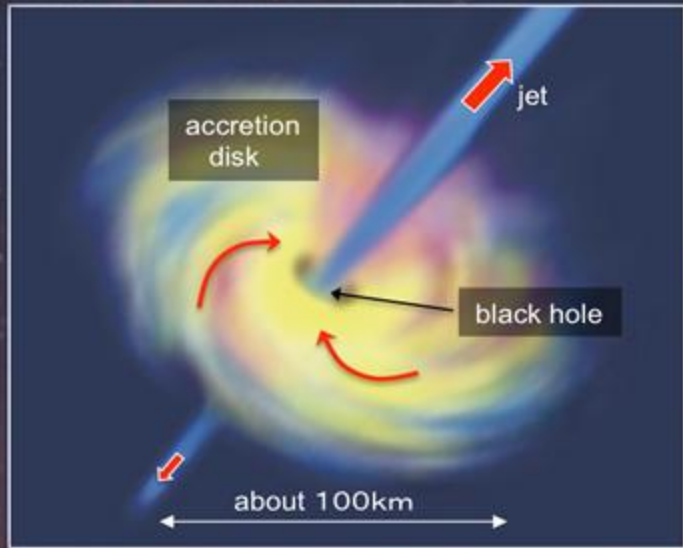




# Gamma-Ray Bursts (Imaginary Picture)

gamma-rays are produced when the jet (close to the light speed) breaks out from the stellar envelope

Observer 

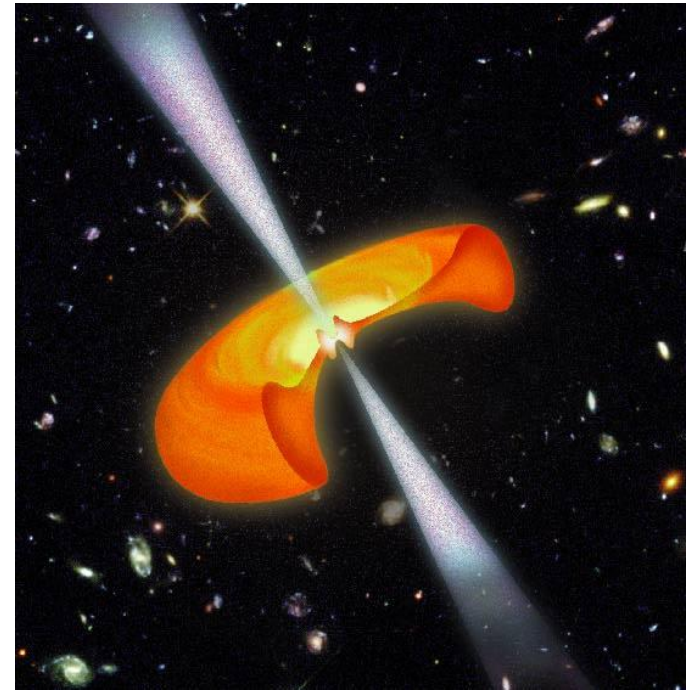


A black hole, accretion disk and jet are formed by the gravitational collapse of the stellar core

A very massive star (more than 20 solar mass), whose outer envelope (hydrogen and helium) has been removed

# GRB Energy is Directed (Beamed)

- Many high energy objects in the early universe produce jets.
- If a jet is pointed at Earth, the energy would be concentrated like a flashlight beam.



# Did a Gamma-ray Burst Kill the Dinosaurs??





**The End**







Dr. Gerald J. Fishman  
SHAW PRIZE



THE  
SHAW PRIZE





# SHAW PRIZE

