



Stellar Explosions

Amy Lien

Goddard Space Flight Center



ASTR 288C, Lecture 2

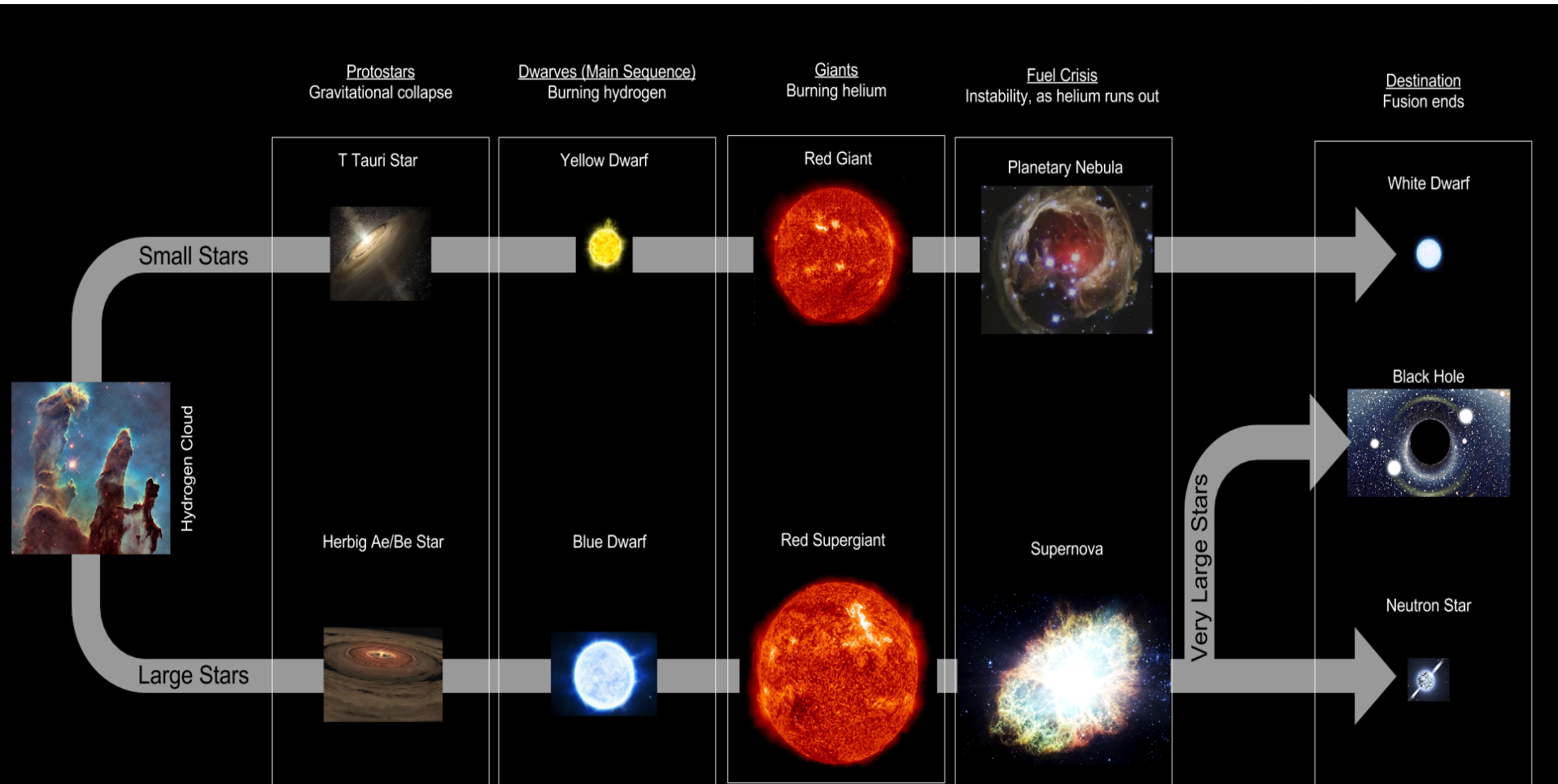
New Office Hour
Friday: 4:30-5:30 pm

Article in homework

- What are the testable statements?
- What are the evidences you found that either support or reject the statements?

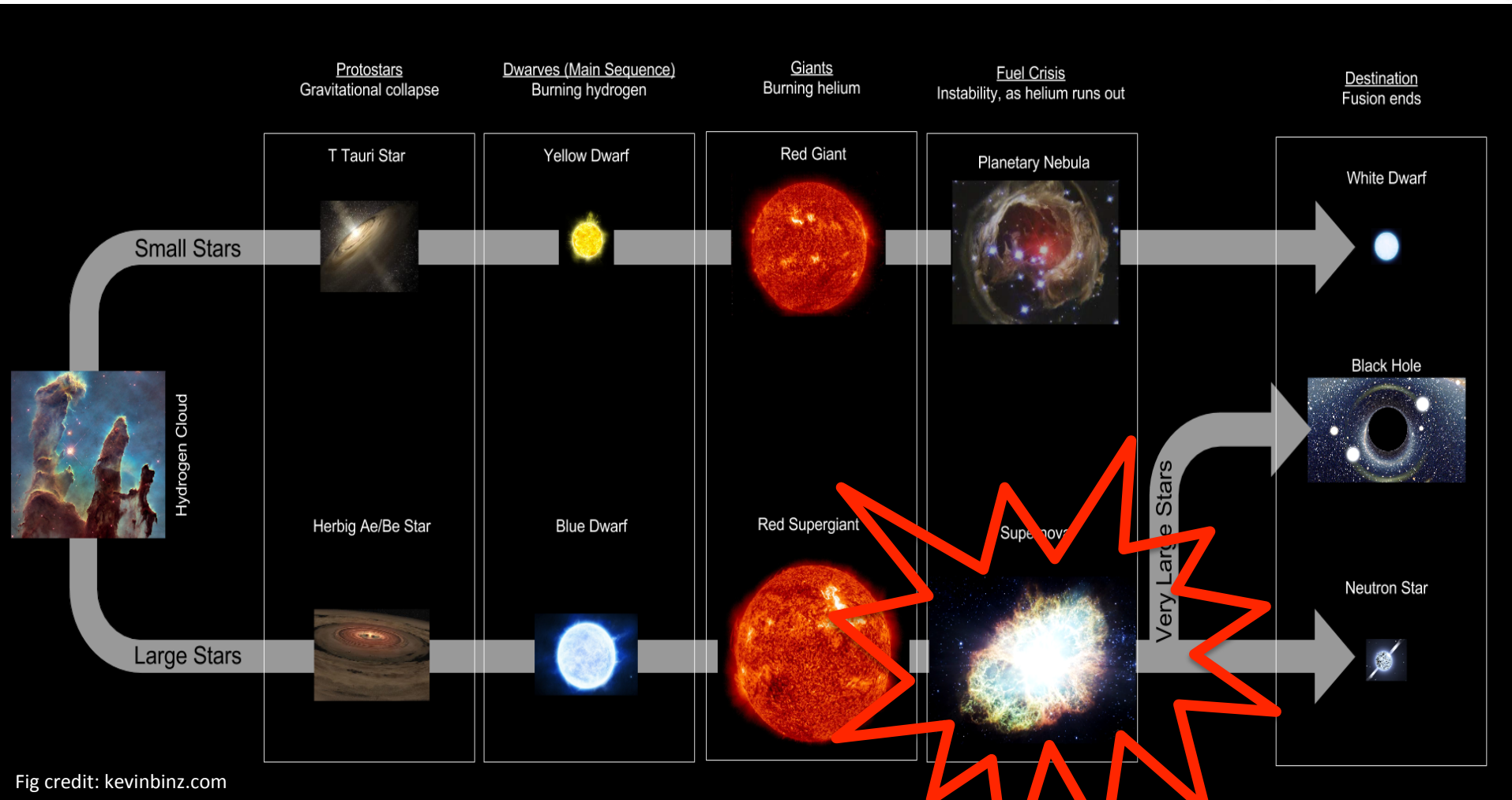
Life of a Star

Compact objects



Life of a Star

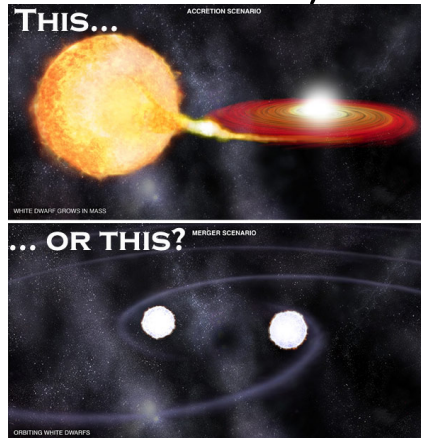
Compact objects



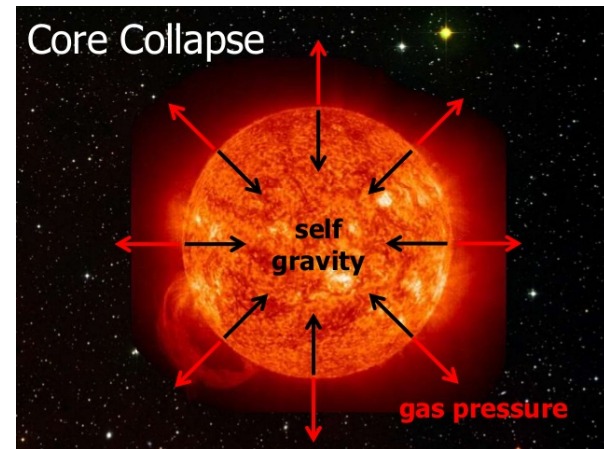
Stellar explosions

that are related to the death of a star....

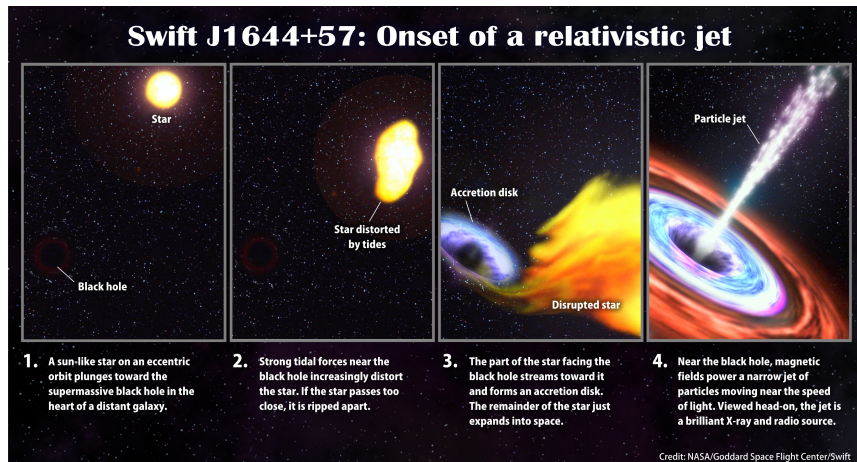
Type Ia Supernova (Thermonuclear SNe)



Core-collapse Supernova



Tidal disruption event



Gamma-ray Bursts

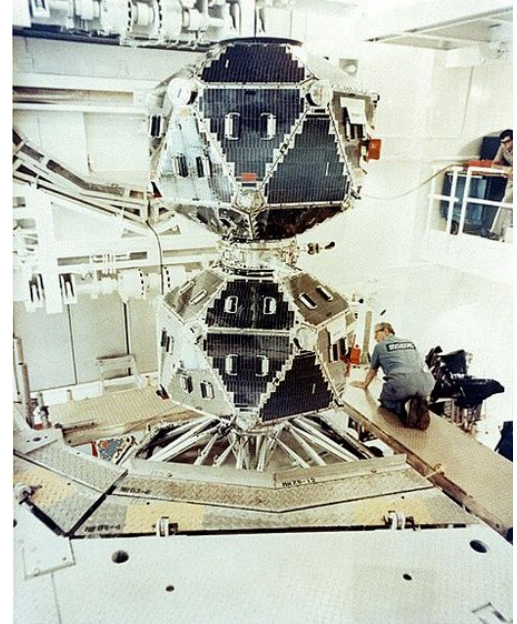


What are gamma-ray bursts?

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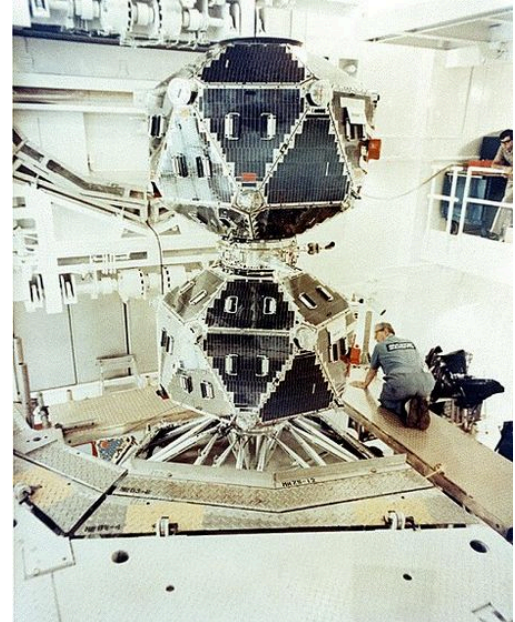
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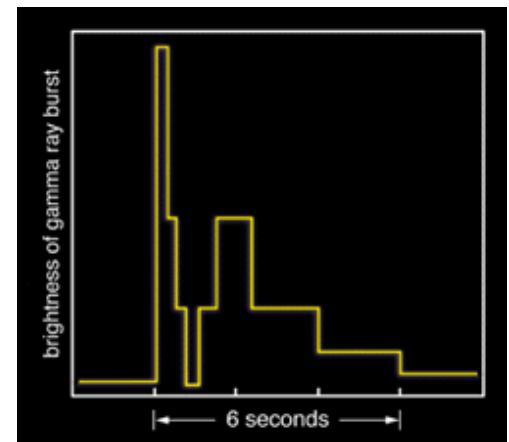
(Courtesy of LANL)

What are gamma-ray bursts?

- 1960: First observed by the U.S. Vela Satellite



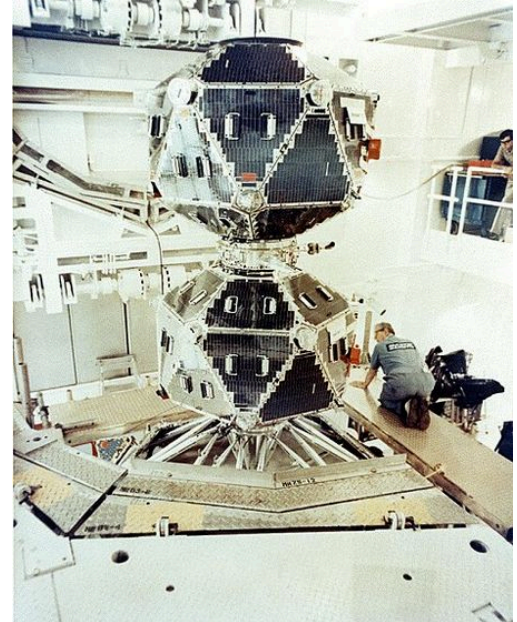
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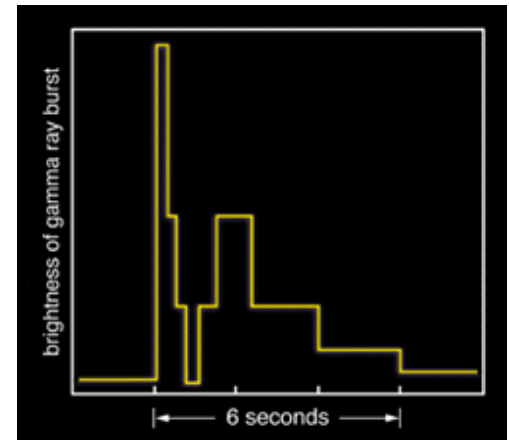
(Courtesy of NASA/GSFC/CGRO documents)

What are gamma-ray bursts?

- 1960: First observed by the U.S. Vela Satellite
 - Not terrestrial or solar origin



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OBSERVATIONS OF GAMMA-RAY BURSTS OF COSMIC ORIGIN

RAY W. KLEBESADEL, IAN B. STRONG, AND ROY A. OLSON

University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico

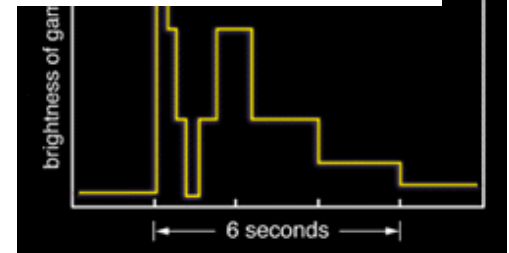
Received 1973 March 16; revised 1973 April 2

ABSTRACT

Sixteen short bursts of photons in the energy range 0.2–1.5 MeV have been observed between 1969 July and 1972 July using widely separated spacecraft. Burst durations ranged from less than 0.1 s to ~ 30 s, and time-integrated flux densities from $\sim 10^{-5}$ ergs cm^{-2} to $\sim 2 \times 10^{-4}$ ergs cm^{-2} in the energy range given. Significant time structure within bursts was observed. Directional information eliminates the Earth and Sun as sources.



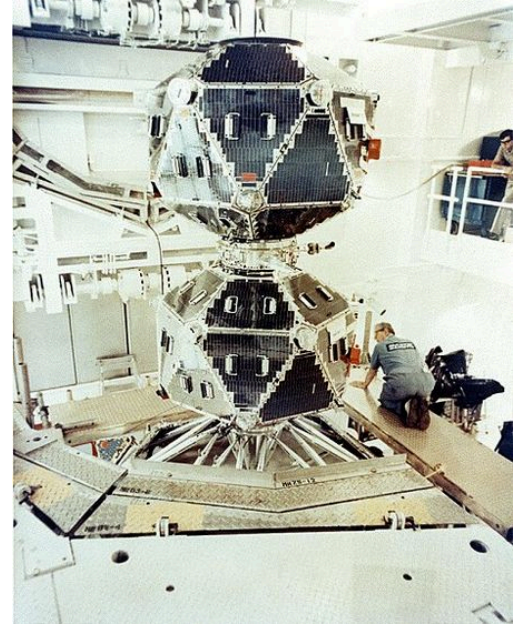
NL)



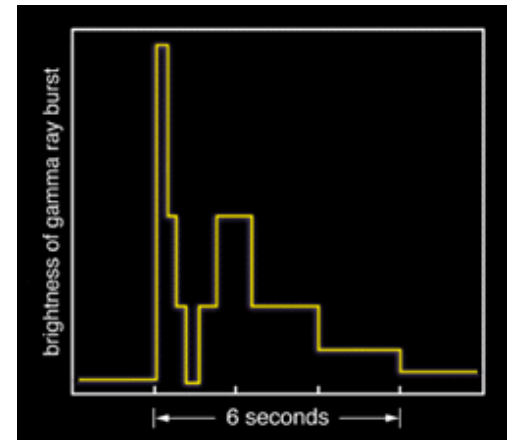
(Courtesy of NASA/GSFC/CGRO documents)

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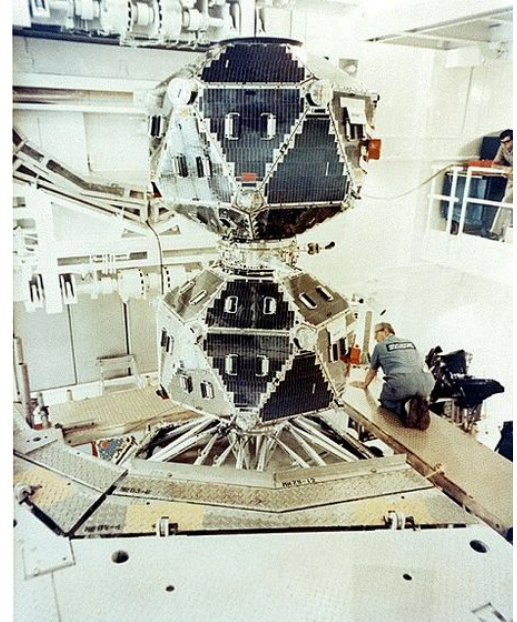
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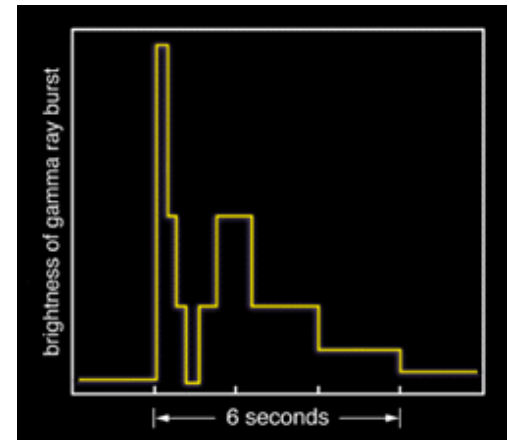
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What are gamma-ray bursts?

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 - Galactic or extragalactic?



(Courtesy of LANL)

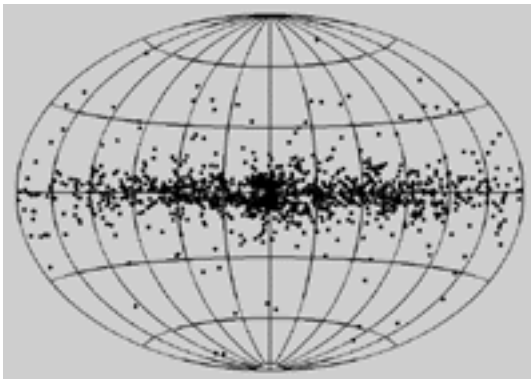


(Courtesy of NASA/GSFC/CGRO documents)

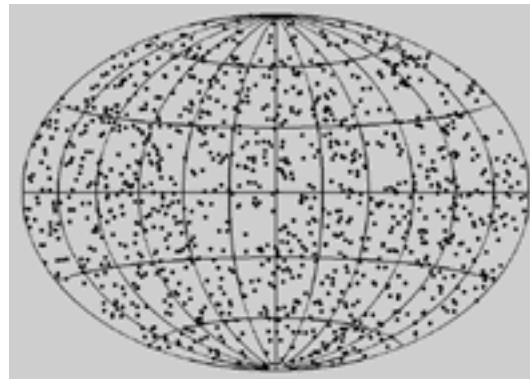
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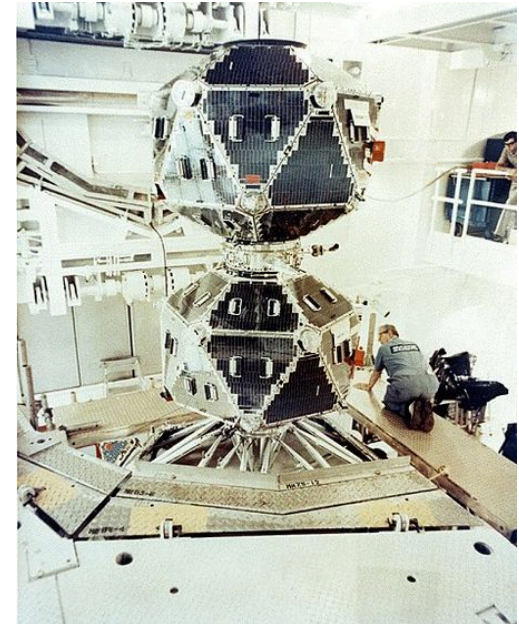
Galactic



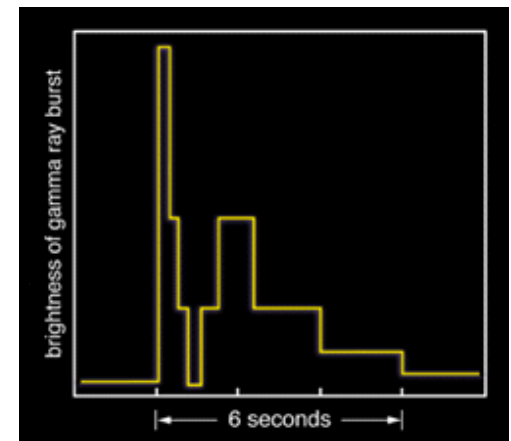
Extragalactic



(Courtesy of NASA/GSFC/CGRO documents)



(Courtesy of LANL)



What are gamma-ray bursts?

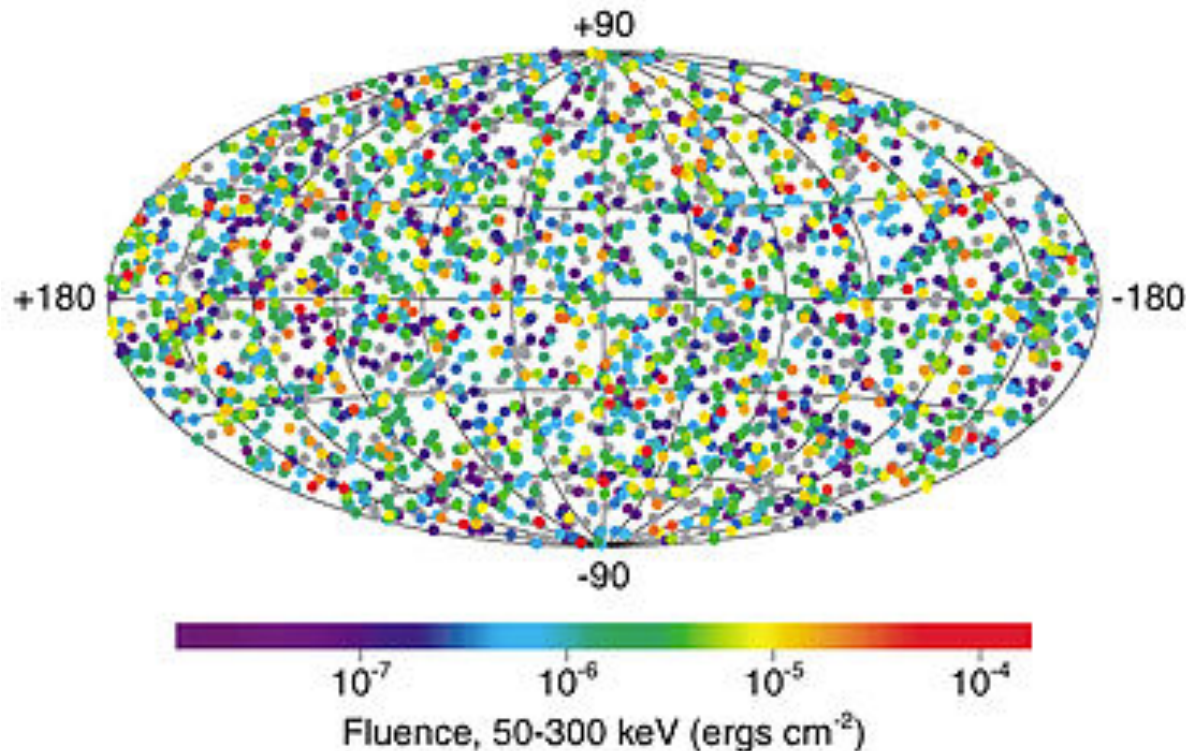
- 1991-2000: Compton Gamma Ray Observatory/
Burst and Transient Source Experiment (BATSE)



What are gamma-ray bursts?

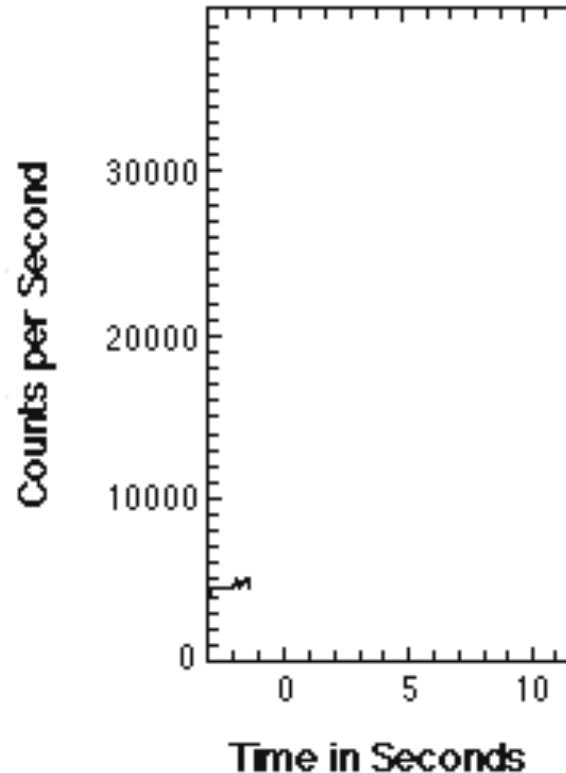
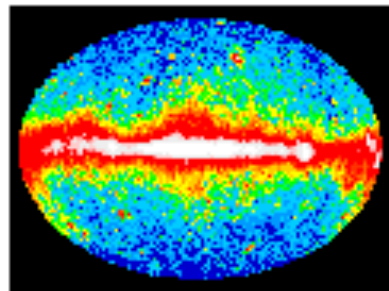
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2704 BATSE Gamma-Ray Bursts



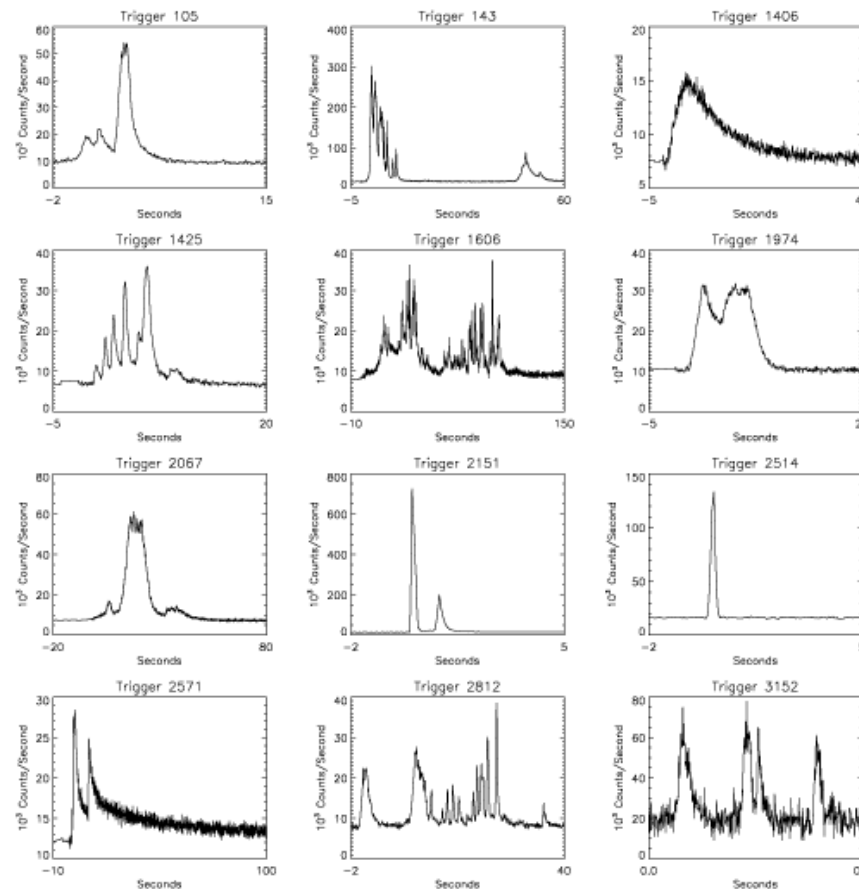
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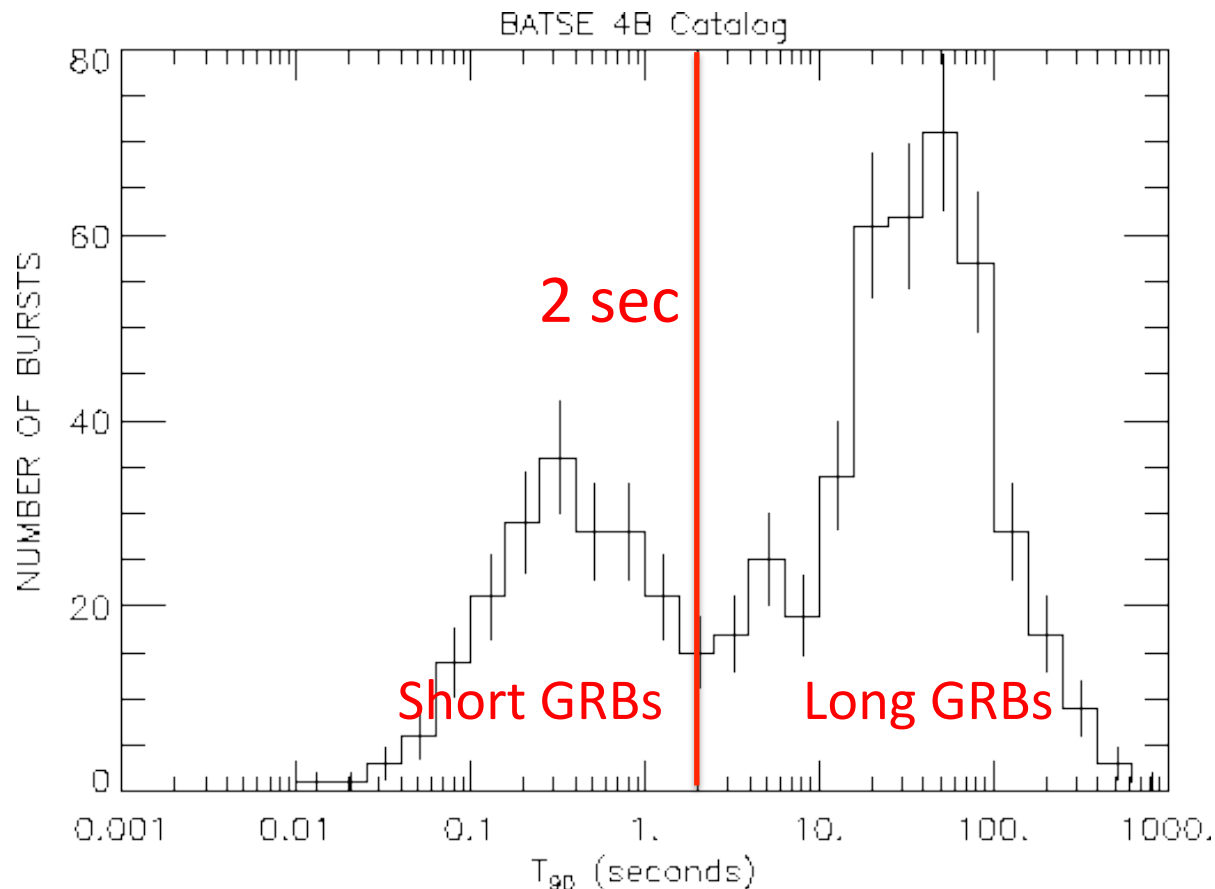
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(Courtesy of J. T. Bonnell)

What are gamma-ray bursts?

- 1991-2000: Compton Gamma Ray Observatory/
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What are gamma-ray bursts?

- Searching for candidate sources and afterglows in other wavelengths
 - White dwarfs, pulsars, supernovae, globular clusters, Seyfert galaxies, BL Lac.....
 - Not successful → better instrument and faster communication needed

What are gamma-ray bursts?

- 1997-2002: BeppoSAX

- Italian-Dutch satellite
- Large energy range (0.1 – 300 keV)
- Good energy resolution and imaging capabilities



→ First x-ray afterglow! (GRB970228)

- Located the burst
- Followed up by optical telescopes and found optical counterparts and a faint, distant host galaxy.

→ First distant measurement! (GRB970508)

→ $z = 0.835$

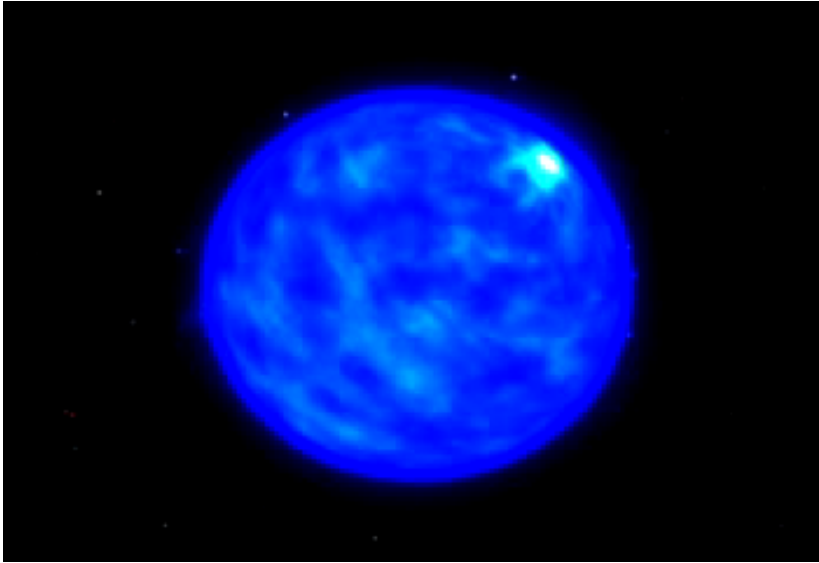
GRBs are extragalactic!

→ First coincidental supernova! (GRB980425 & SN1998bw)

(long) GRBs are related to massive stars!

What are gamma-ray bursts?

Long GRBs



- Deaths of massive Stars
- Supernovae
- Black holes
- High-energy photons and particles

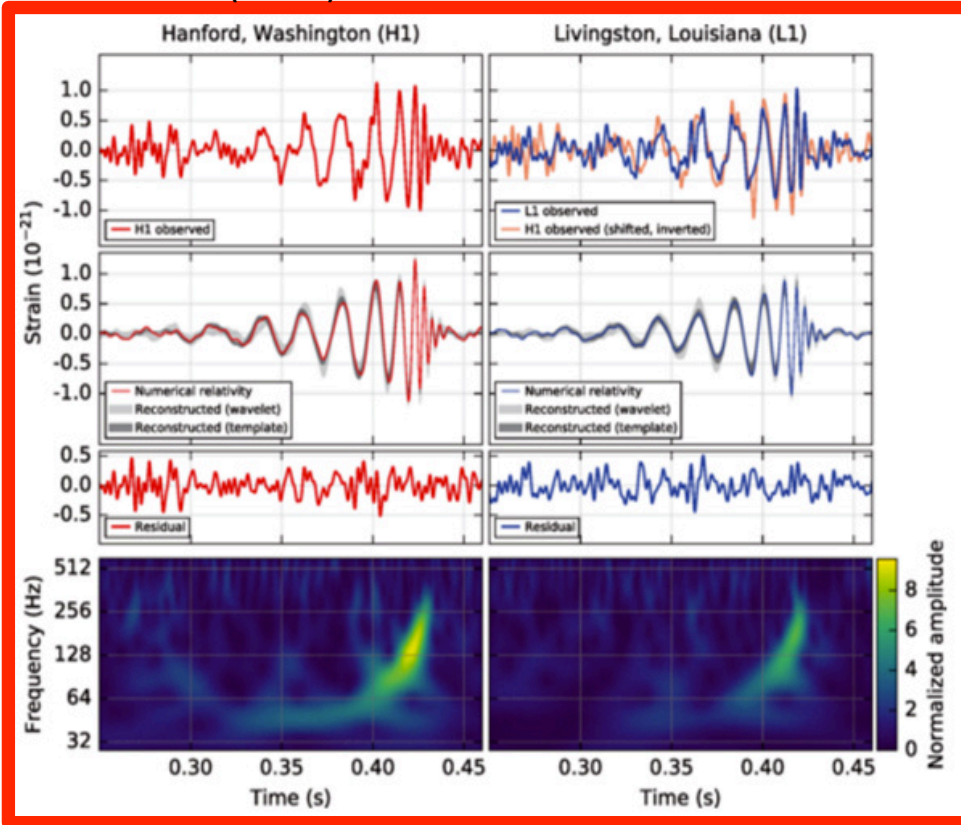
Short GRBs



- Compact-object mergers
 - Black holes
 - Neutron stars
- Gravitational wave

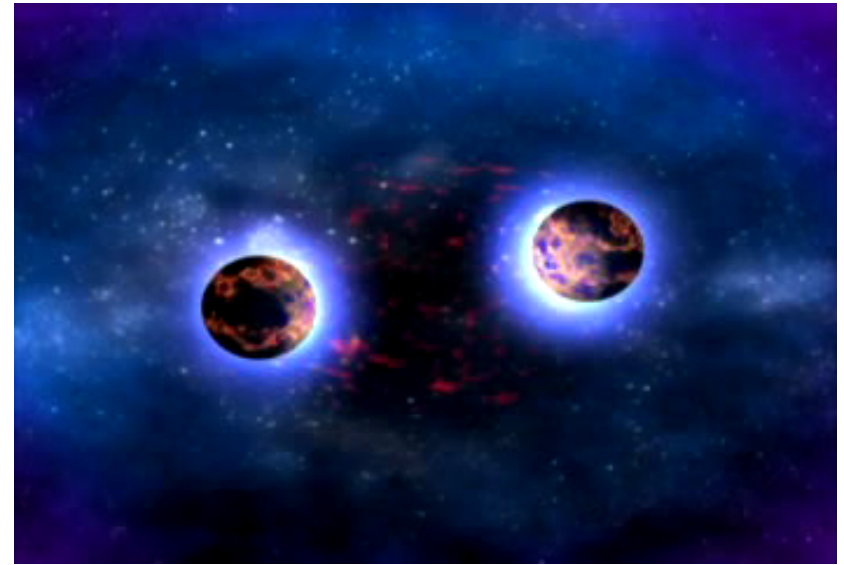
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Abbott et al. (2016)



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Lab2

Literature Search and References