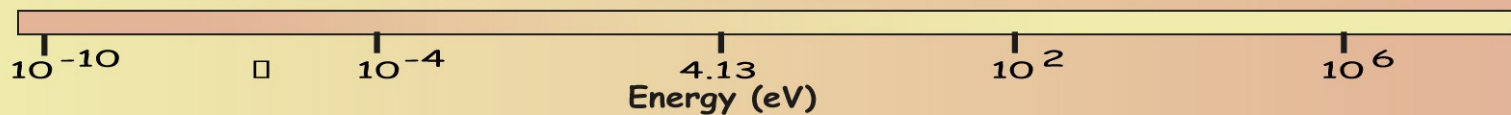
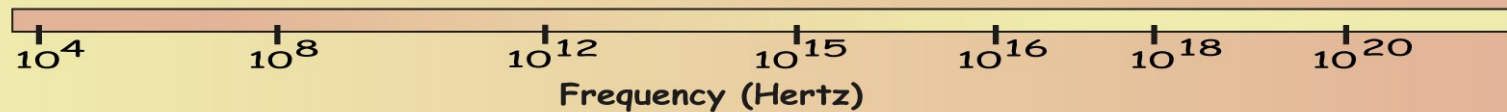
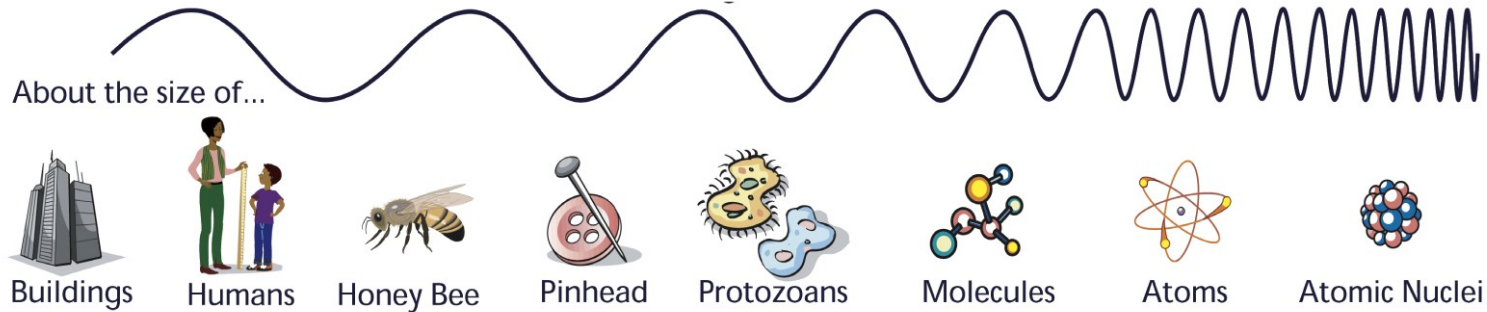
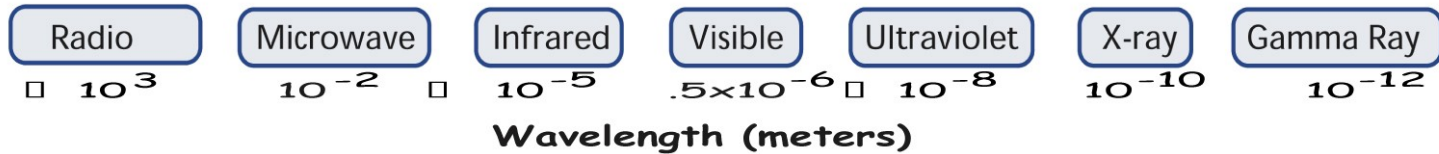


The Extreme Universe of Gamma-ray Astronomy

Professor Lynn Cominsky
Department of Physics and
Astronomy
Sonoma State University

What are Gamma rays?





Why study gamma rays?

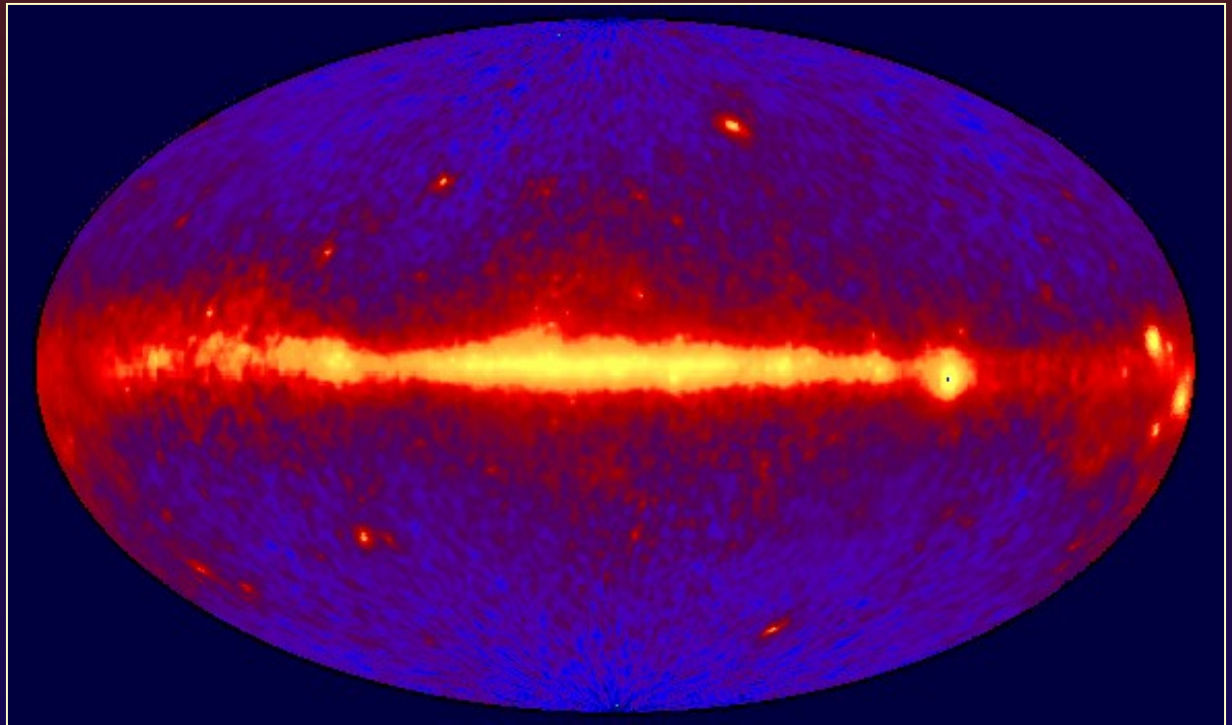


- ❖ Universe as seen by eye is peaceful



The Gamma-ray Sky

- ❖ Gamma ray sky shows us the most exotic and extreme creatures in the cosmic zoo



CGRO/EGRET All Sky Map



Compton Gamma-ray Observatory (1991-2000)

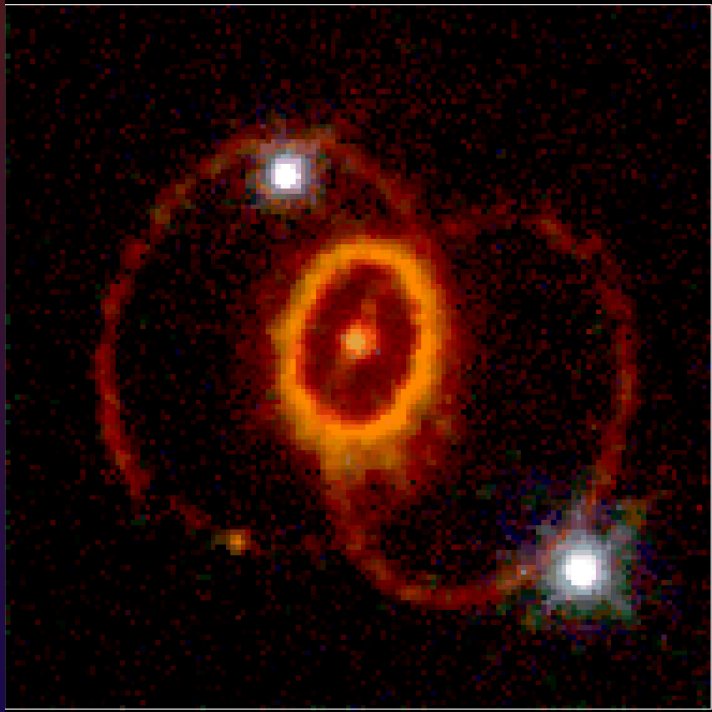
- ❖ Burst And Transient Source Experiment (BATSE)
- ❖ Oriented Scintillation Spectrometer Experiment (OSSE)
- ❖ Imaging Compton Telescope (COMPTEL)
- ❖ Energetic Gamma-Ray Experiment Telescope (EGRET)



CGRO being placed into orbit by the robotic arm on the Space Shuttle



Exploding Stars

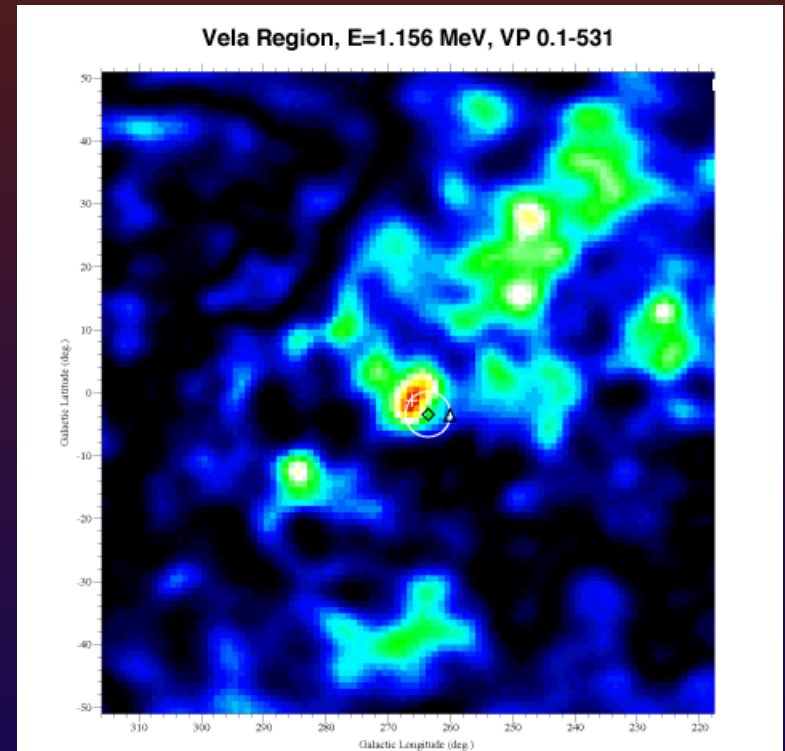


Supernova 1987A in
Large Magellanic Cloud
HST/WFPC2

- ❖ At the end of a star's life, if it is large enough, it will end with a bang (and not a whimper!)

Supernova Remnants

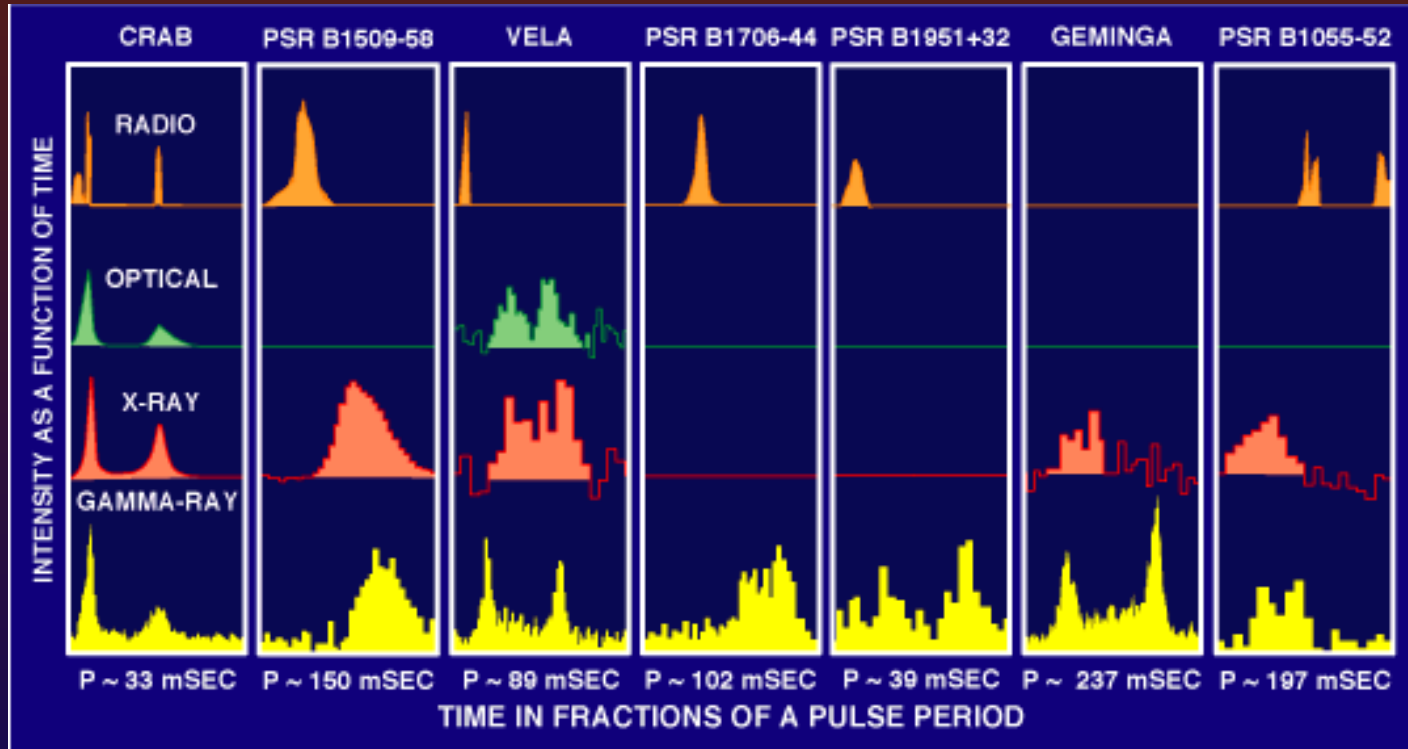
Vela Region
CGRO/Comptel



- ❖ Radioactive decay of chemical elements created by the supernova explosion



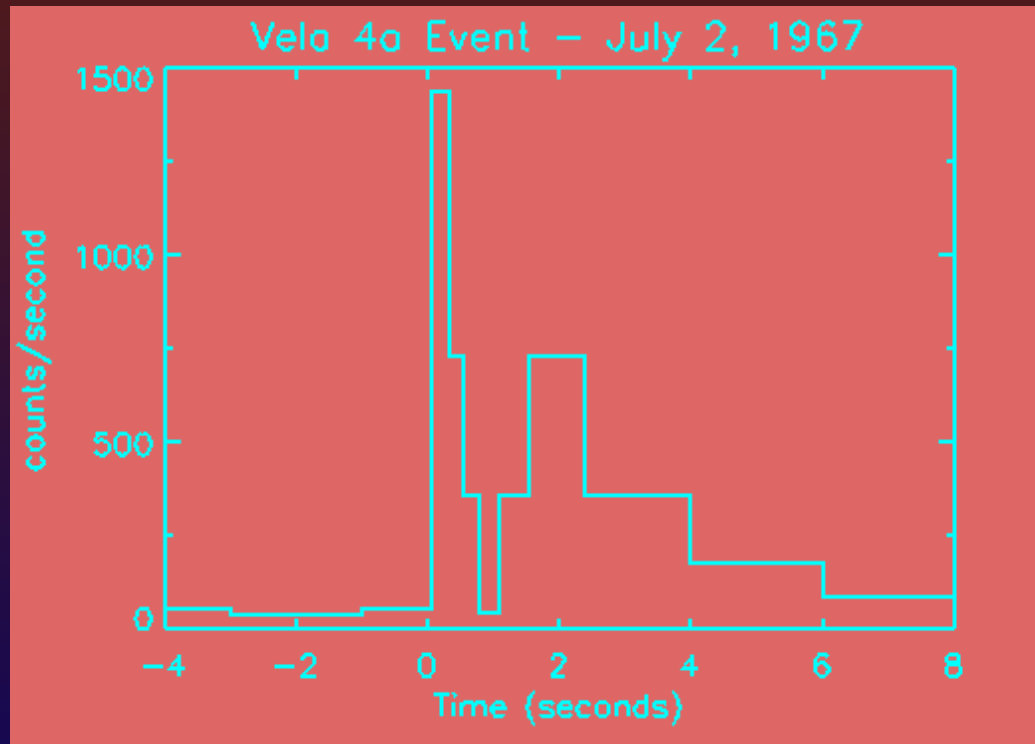
Pulsars



- ❖ Stellar corpses - size of a city, mass of the Sun, spinning up to 1000 times per second



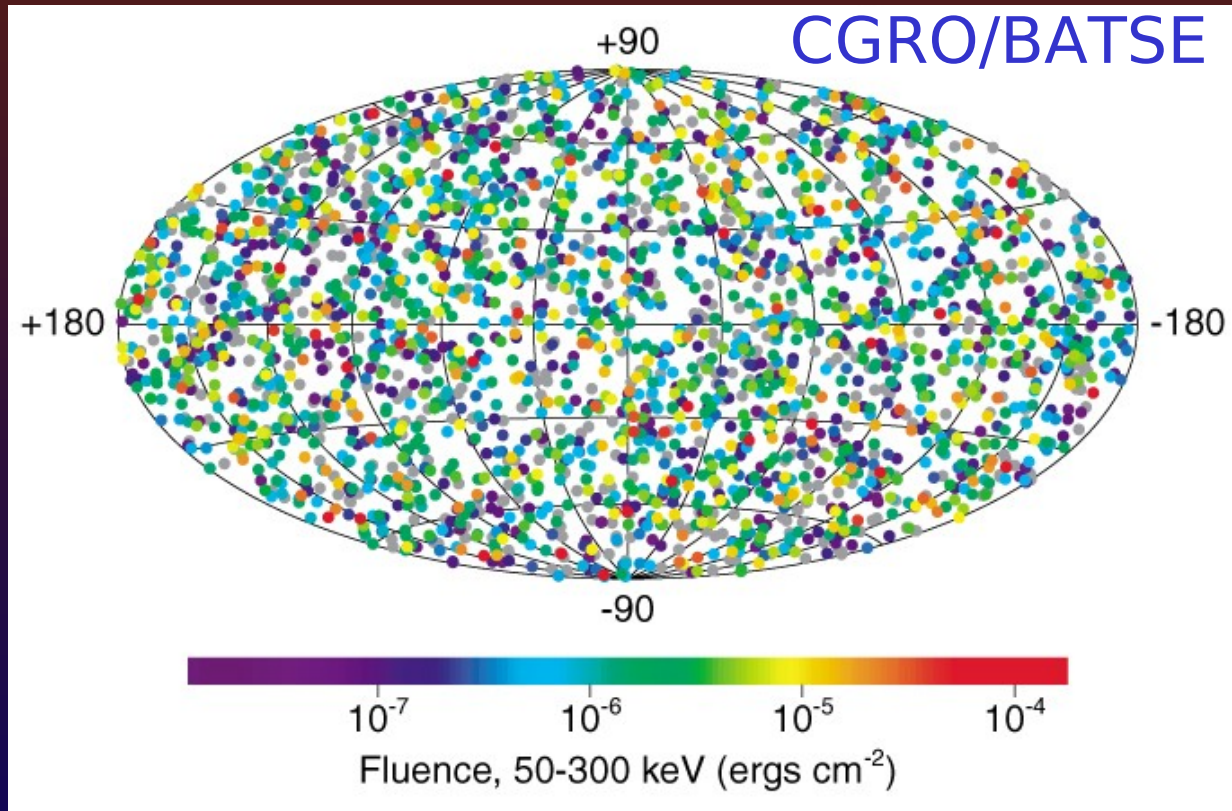
Gamma-ray Bursts



- ❖ Discovered in 1967 while looking for nuclear test explosions - a 30+ year old mystery!



Gamma-ray Burst Sky

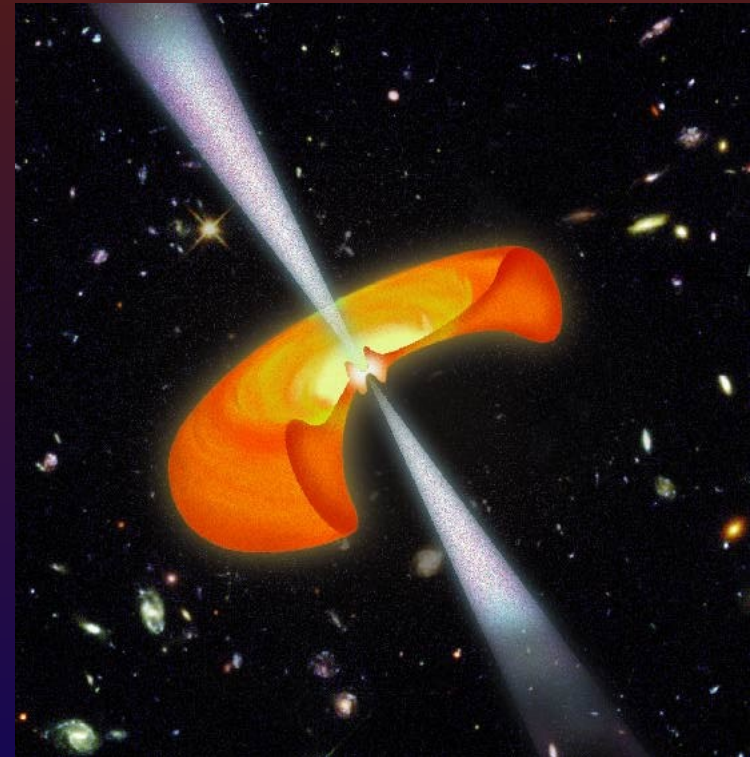


❖ Once a day, somewhere in the Universe



Hypernova

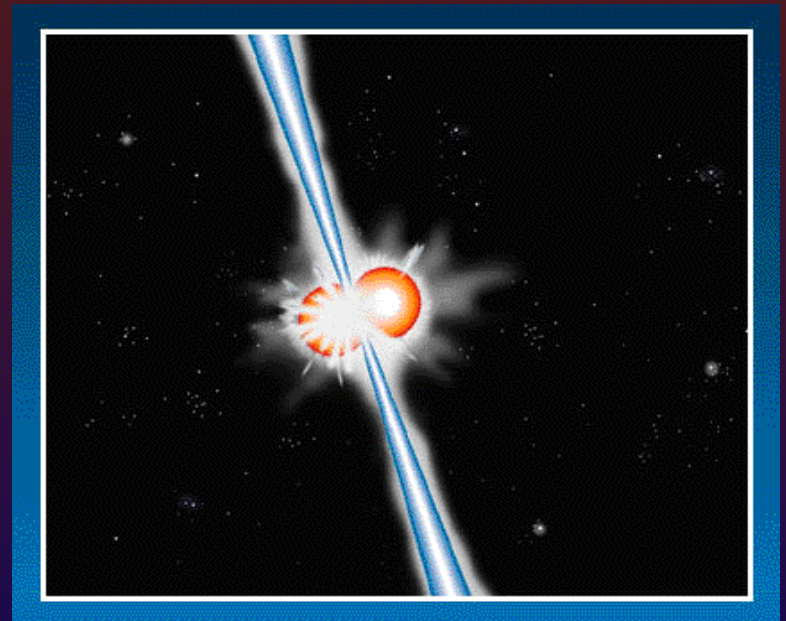
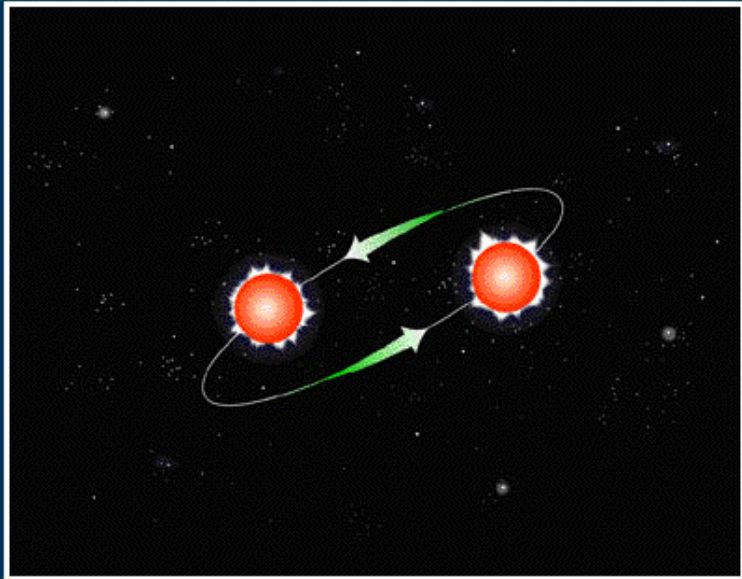
The end of the life of a star that had 100 times the mass of our Sun



❖ A billion trillion times the power from the Sun

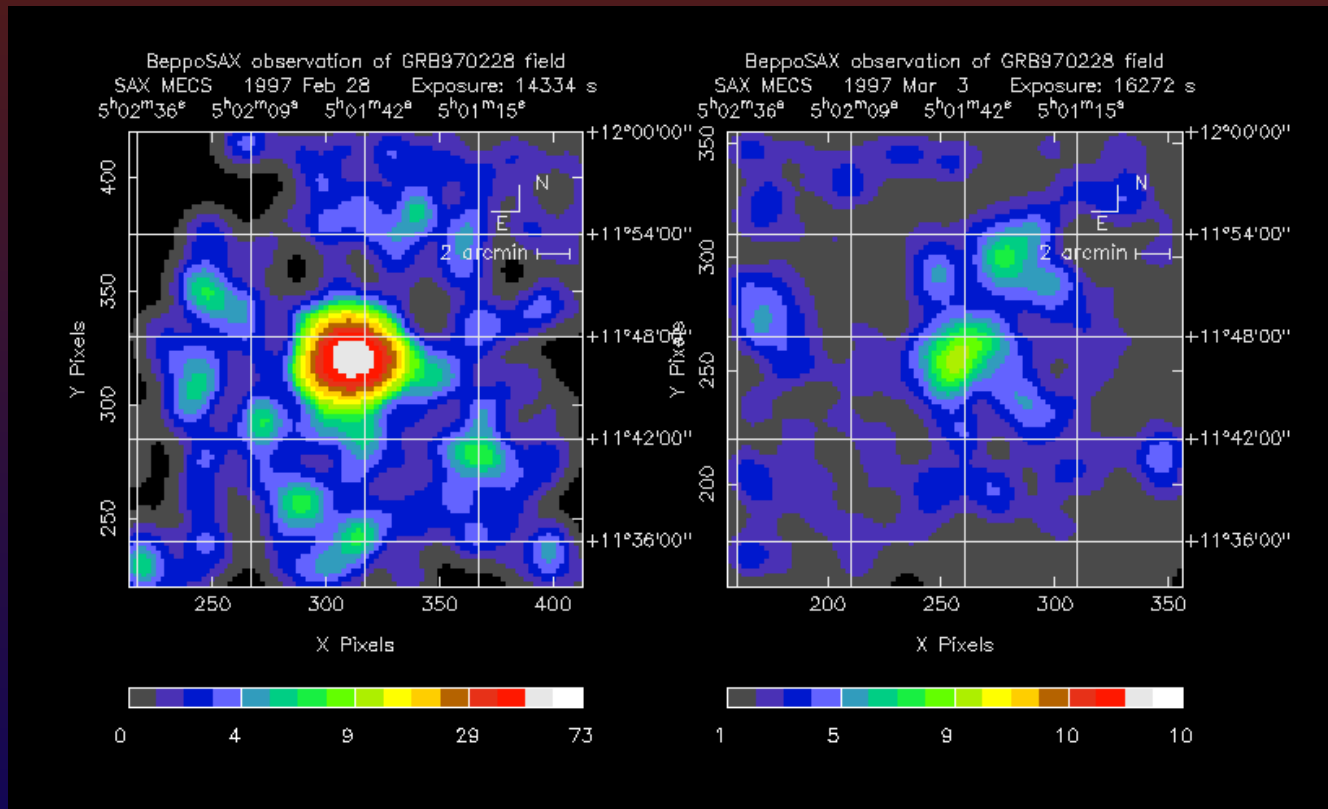


Catastrophic Mergers



- ❖ Death spiral of 2 neutron stars or black holes

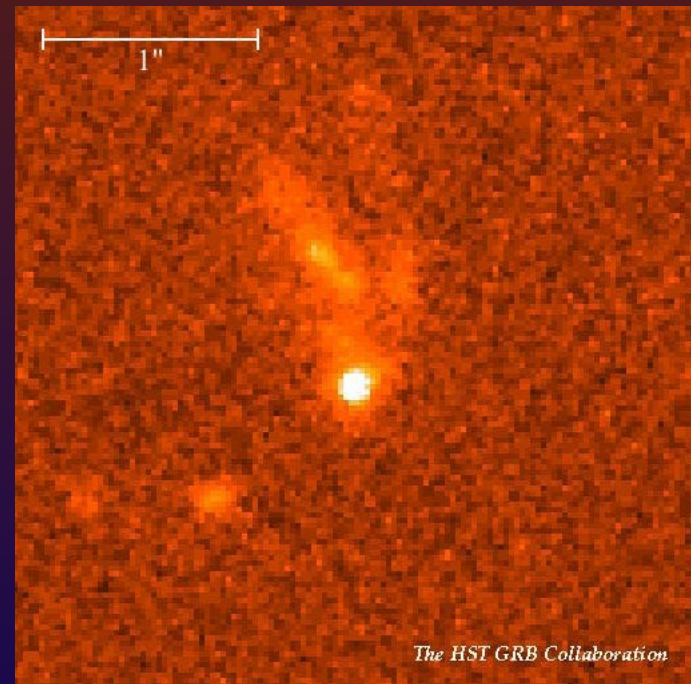
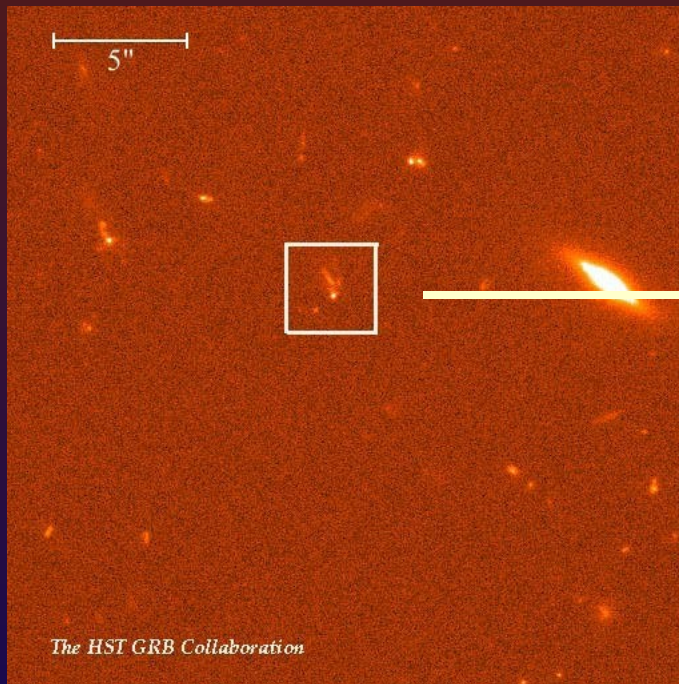
Afterglow



❖ Discovered in 1997 by BeppoSAX satellite



Afterglow



❖ Cooling ashes in distant galaxies



Gamma-ray Bursts

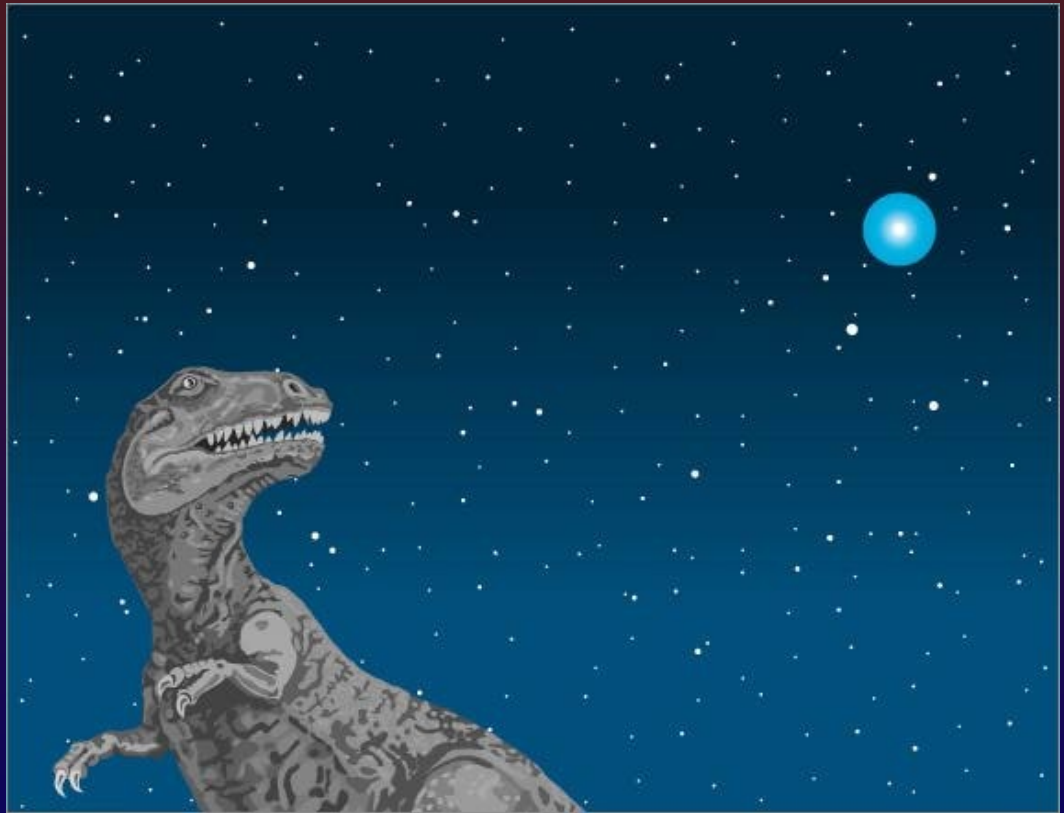


- ❖ Signal the birth of a black hole?



Gamma-ray Bursts

- ❖ Or the death of life on Earth?

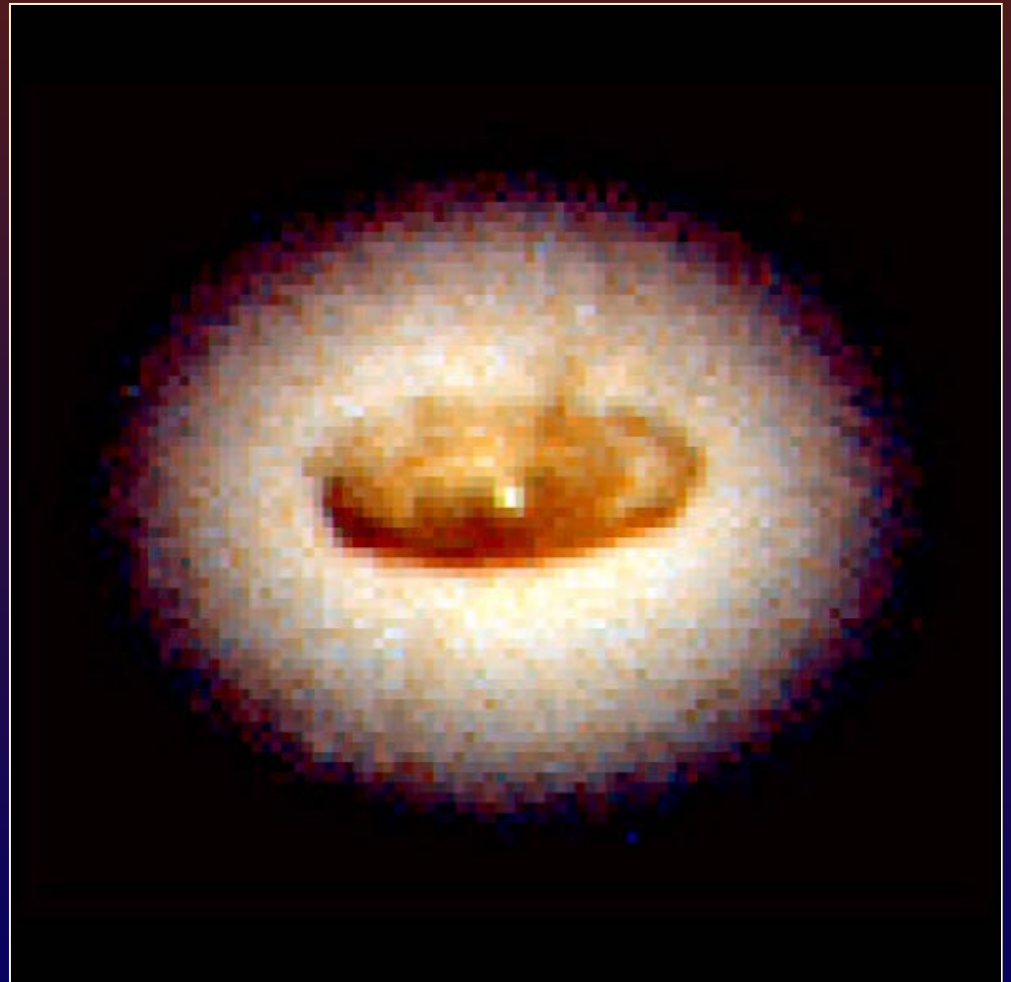




Monstrous black holes

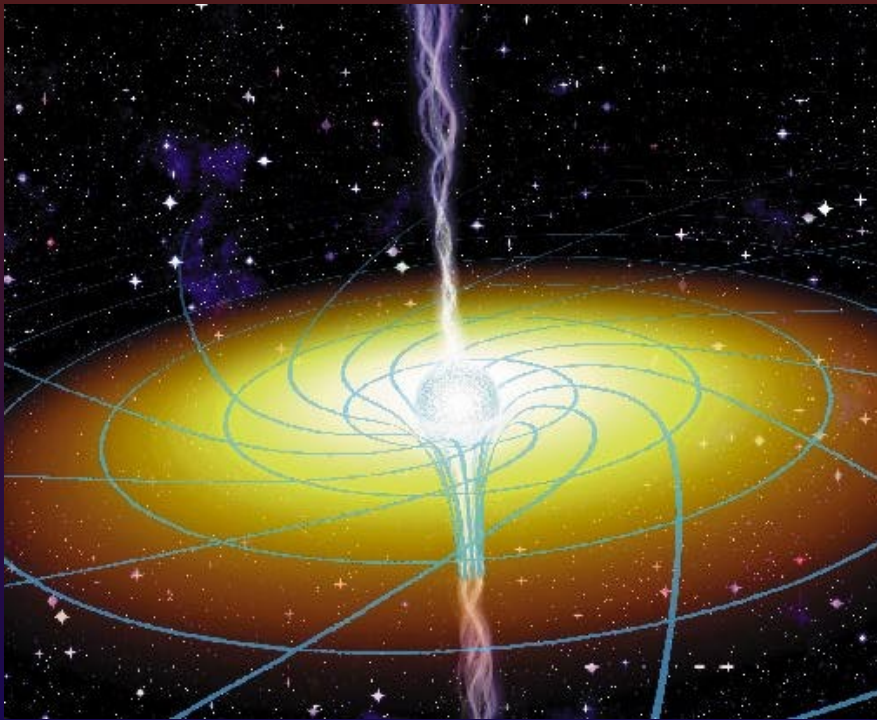
- ❖ At the heart of every galaxy lies a black hole, millions to billions times the mass of our Sun

HST/NGC
4261





Blazing Galaxies



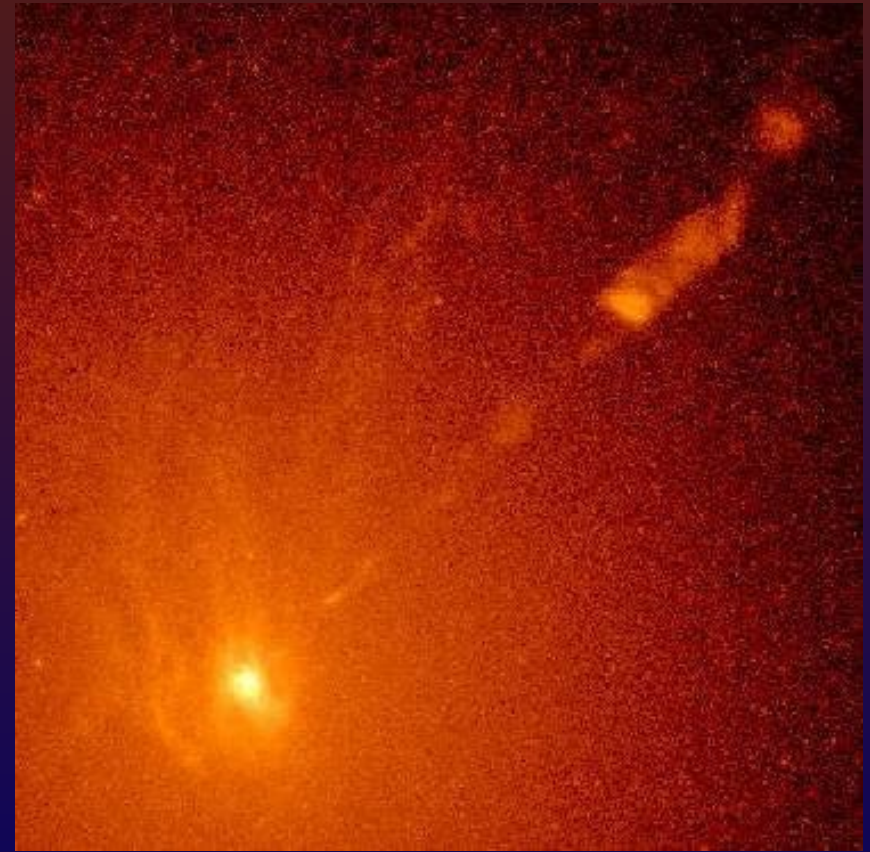
Credit: J.
Bergeron Sky &
Telescope

- ❖ Gravity is so strong inside its “event horizon” that not even light can escape

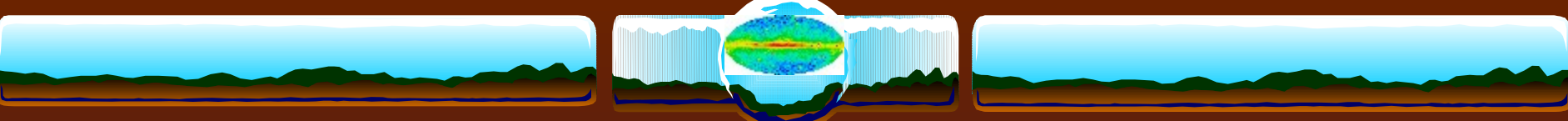


Jet Mysteries

- ❖ So, how do black holes emit jets of particles and light?
- ❖ And, how do the particles in the jets accelerate to near light speed?

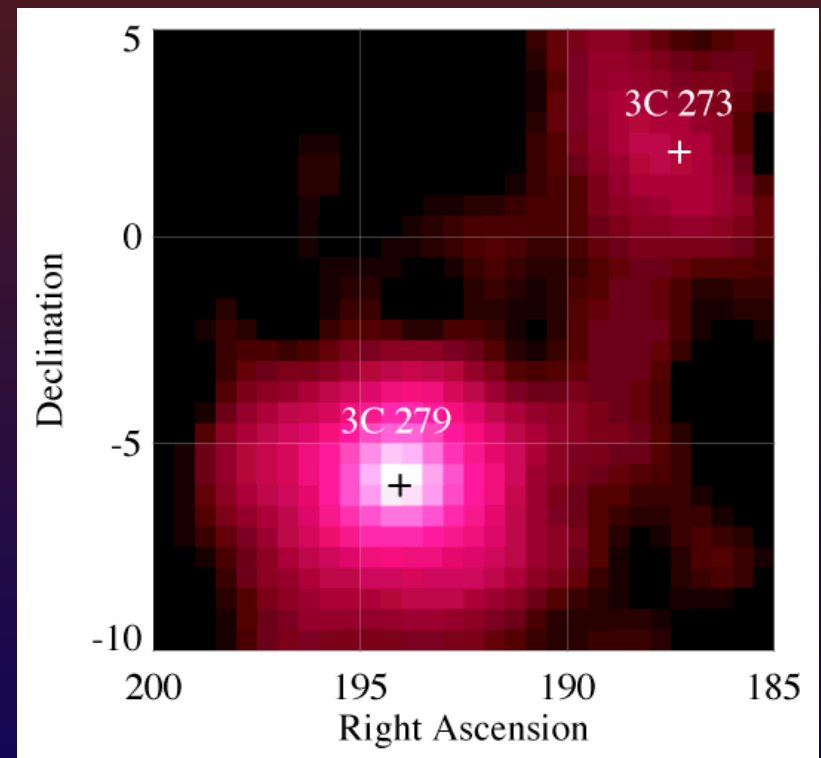


HST/ M87



Gamma-ray Jets

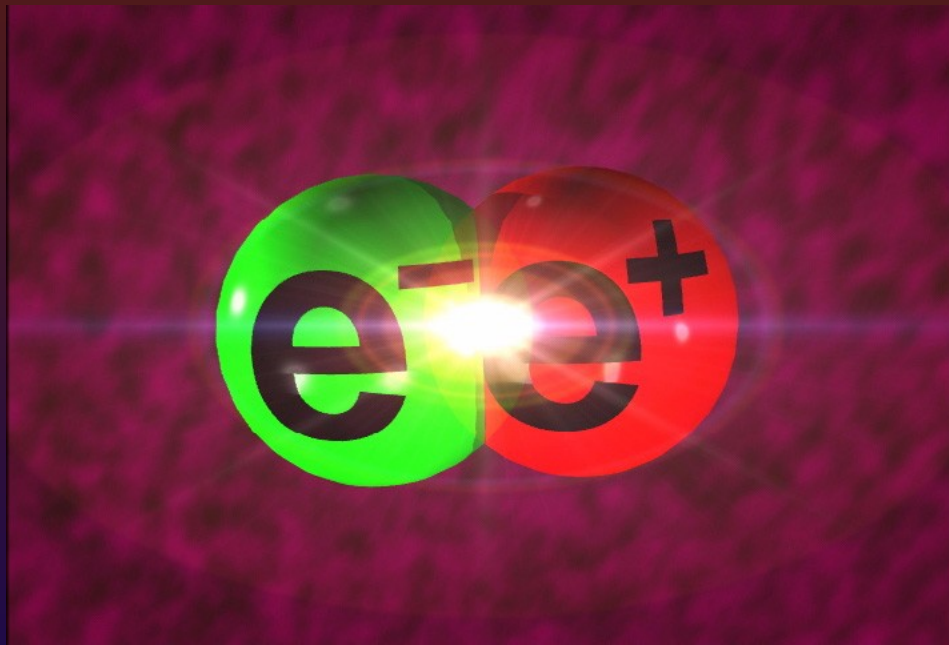
- ❖ Jets flare dramatically in gamma rays
- ❖ Galaxies that point their jets at us are called “blazars”



EGRET/ 3C279 and 3C273



Anti-matter

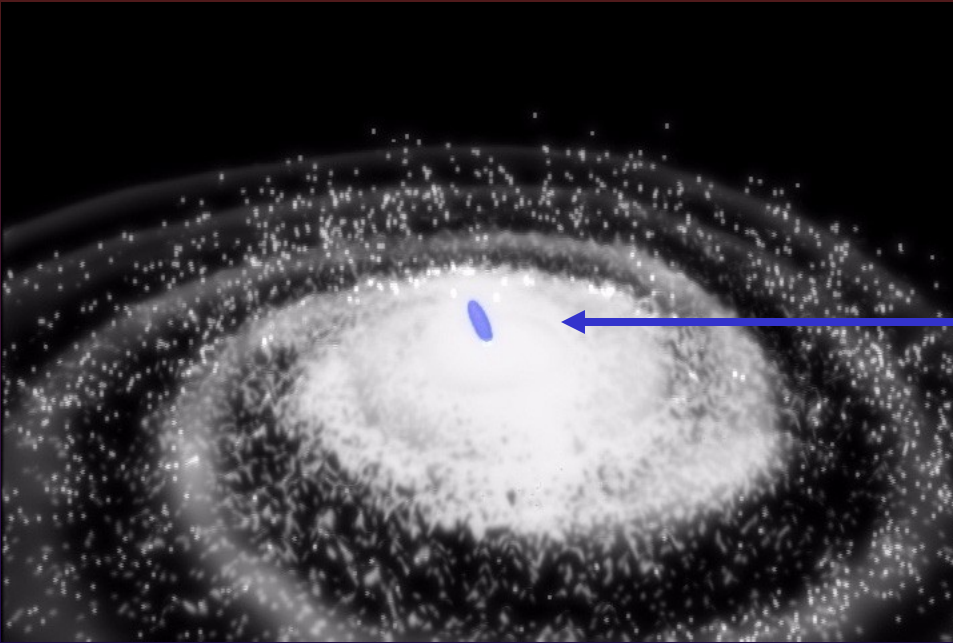


$$E = mc^2$$

- ❖ Positrons are anti-electrons
- ❖ When they meet, they annihilate each other!



Anti-matter fountain

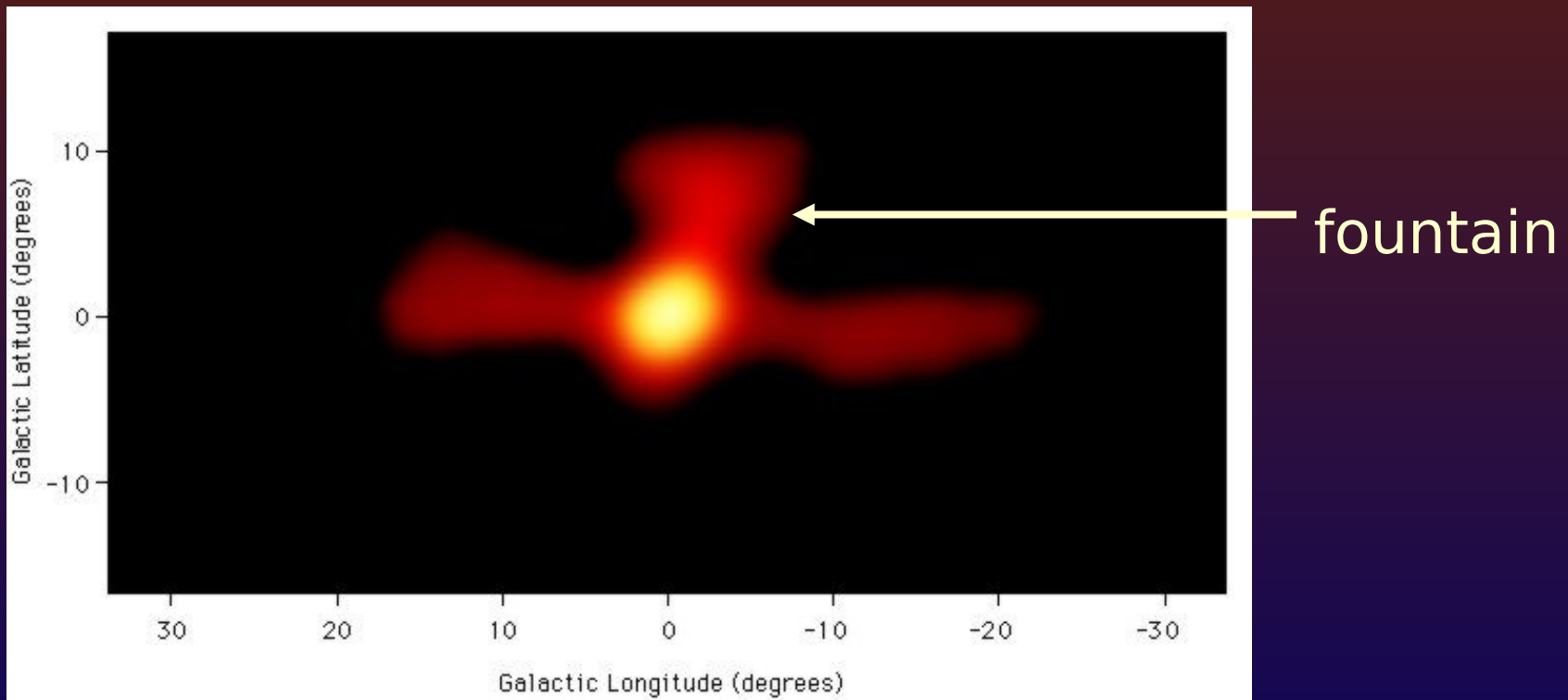


An artist's view
of the fountain

- ❖ Annihilation near the center of our galaxy creates a fountain of gamma rays



Annihilation gamma rays



❖ Discovered by CGRO-OSSE in 1997



How to study Gamma rays?

- ❖ Absorbed by the Earth's atmosphere
- ❖ Use rockets, balloons or satellites
- ❖ Can't image or focus gamma rays
- ❖ Special detectors: crystals, silicon-strips



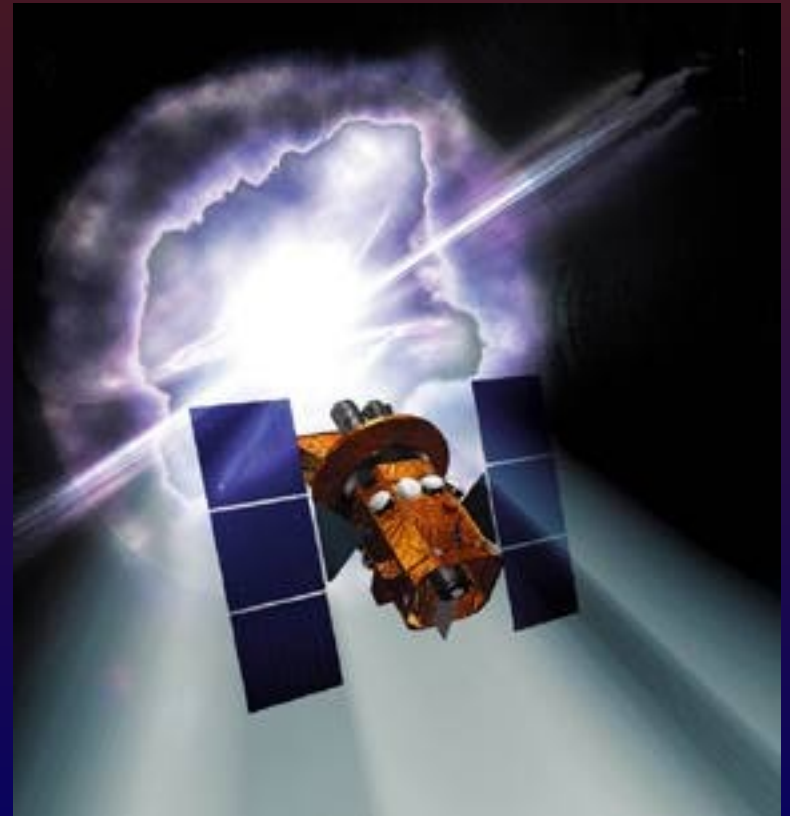
GLAST
balloon
test



Swift Mission

To be launched in 2003

- ❖ Burst Alert Telescope (BAT)
- ❖ Ultraviolet/Optical Telescope (UVOT)
- ❖ X-ray Telescope (XRT)



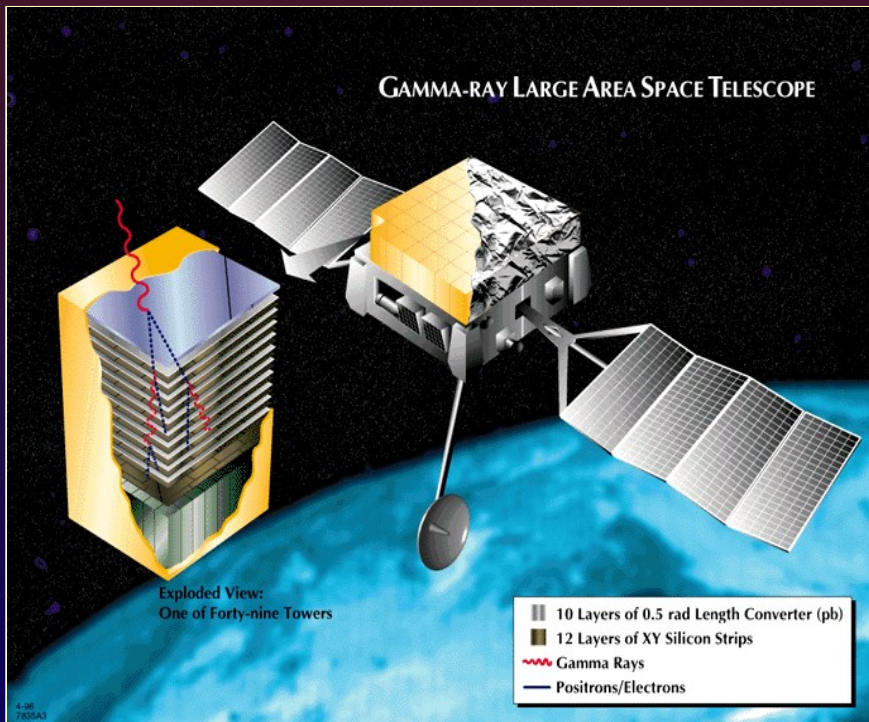


Swift Mission

- ❖ Will study GRBs with “swift” response
- ❖ Survey of “hard” X-ray sky
- ❖ To be launched in 2003
- ❖ Nominal 3-year lifetime
- ❖ Will see ~ 300 GRBs per year



Gamma-ray Large Area Space Telescope (GLAST)

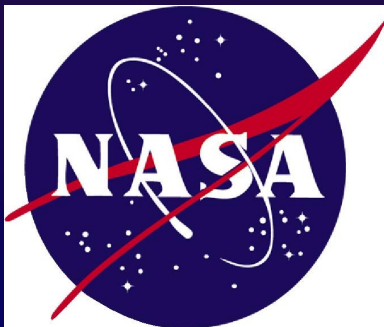


- ❖ GLAST Burst Monitor (GBM)
- ❖ Large Area Telescope (LAT)

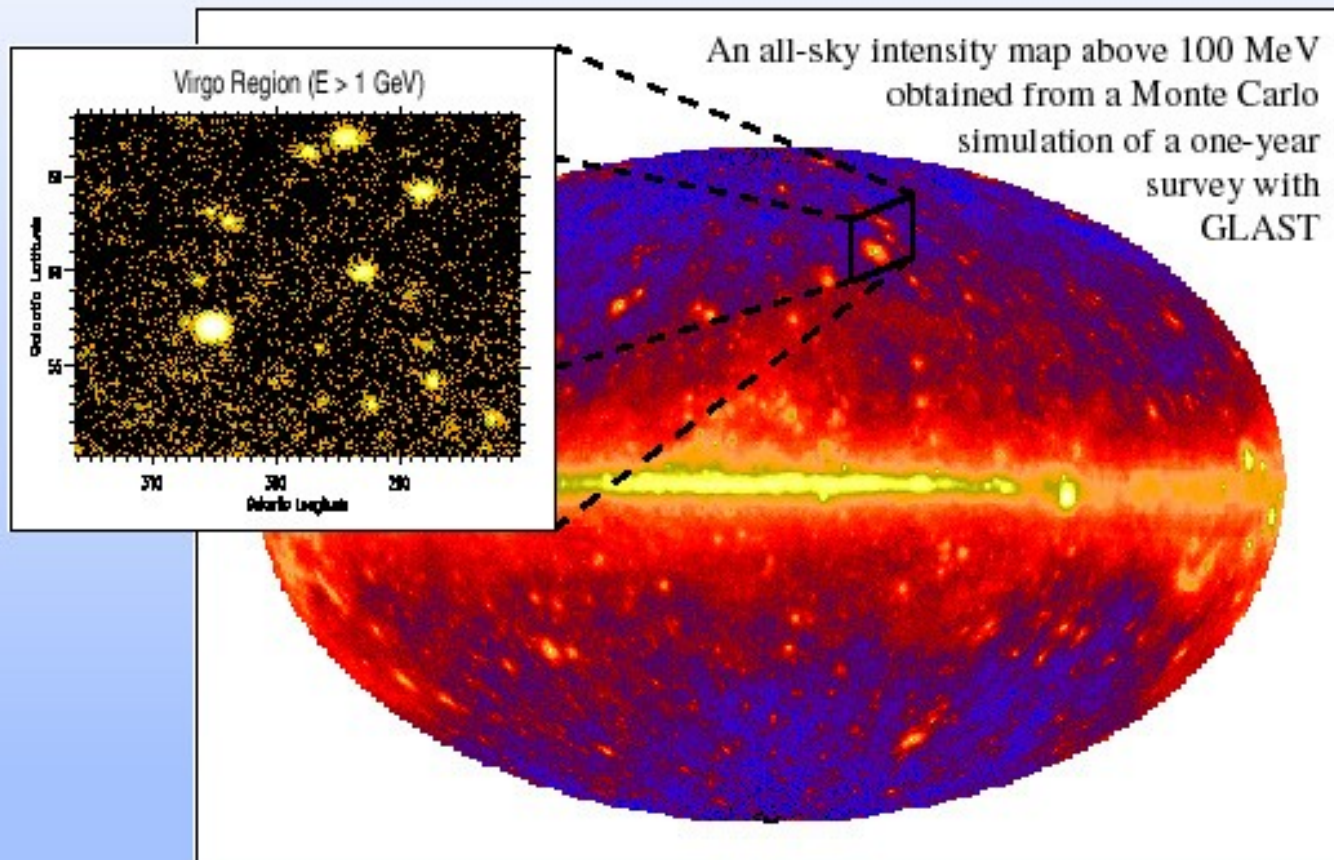


GLAST Mission

- ❖ First space-based collaboration between astrophysics and particle physics communities
- ❖ Launch expected in 2006
- ❖ Expected duration 5-10 years
- ❖ Over 3000 gamma-ray sources will be seen



GLAST Sky Map



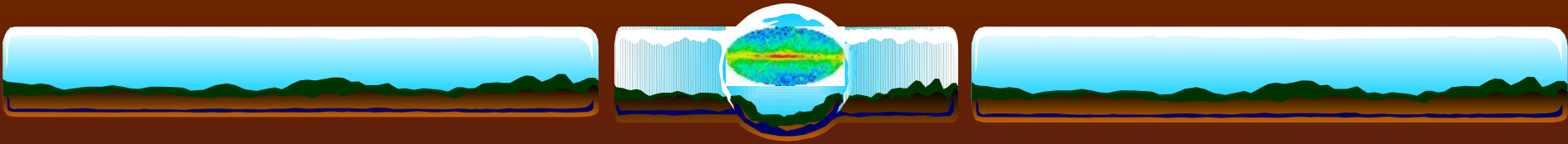


Dark Matter



- ❖ Dark Matter makes up over 90% of the matter in the Universe
- ❖ You can't see it, but you can feel it!

HST/CL0024+1654



Shining light on dark matter

- ❖ Dark Matter can be traced by studying X-rays from hot gas in clusters of galaxies

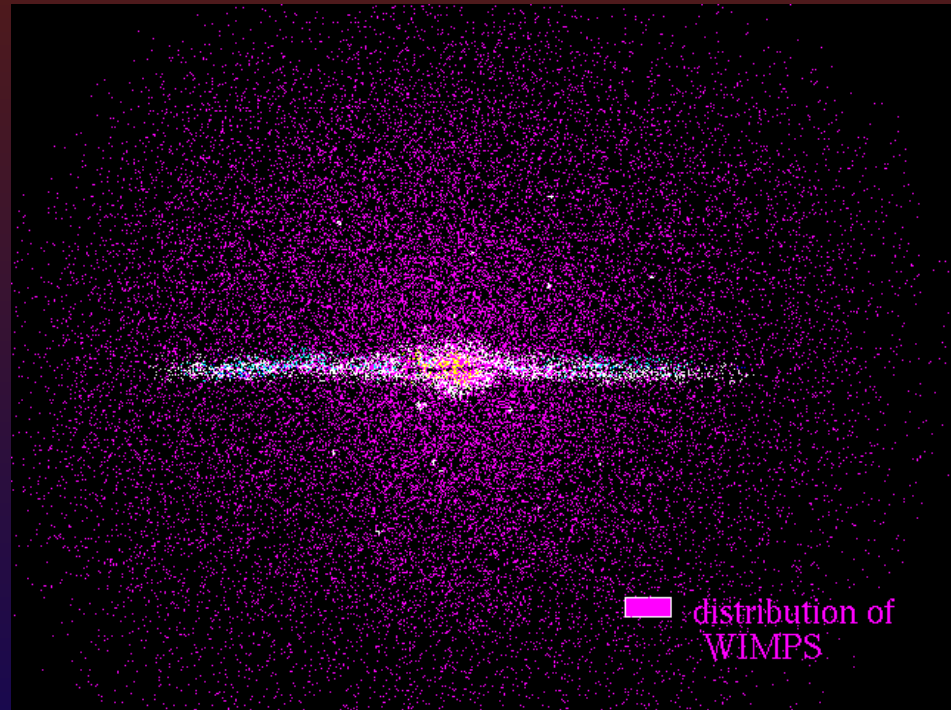


ROSAT X-ray over visible light image



WIMPs

A calculation of
WIMPs around
our galaxy



- ❖ Dark matter may be Weakly Interacting Massive Particles



Our Cosmic Destiny

- ❖ The amount of dark matter in the Universe influences its ultimate fate
- ❖ WIMPs may determine our Cosmic Destiny!
- ❖ GLAST should be able to see gamma rays from WIMPs within 3 years of observations

*"As for the question of the end of it
I advise: Wait and see!" - A. Einstein*



For more information:

- ❖ <http://www-glast.sonoma.edu>
- ❖ <http://swift.gsfc.nasa.gov>
- ❖ <http://imagine.gsfc.nasa.gov>
- ❖ <http://zebu.uoregon.edu/~soper/Mass/WIMPS.html>