
# GLAST

## The Gamma-ray Large Area Space Telescope

## Exploring the Extreme Universe

### Kennedy Space Center

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see http://www.nasa.gov/glast

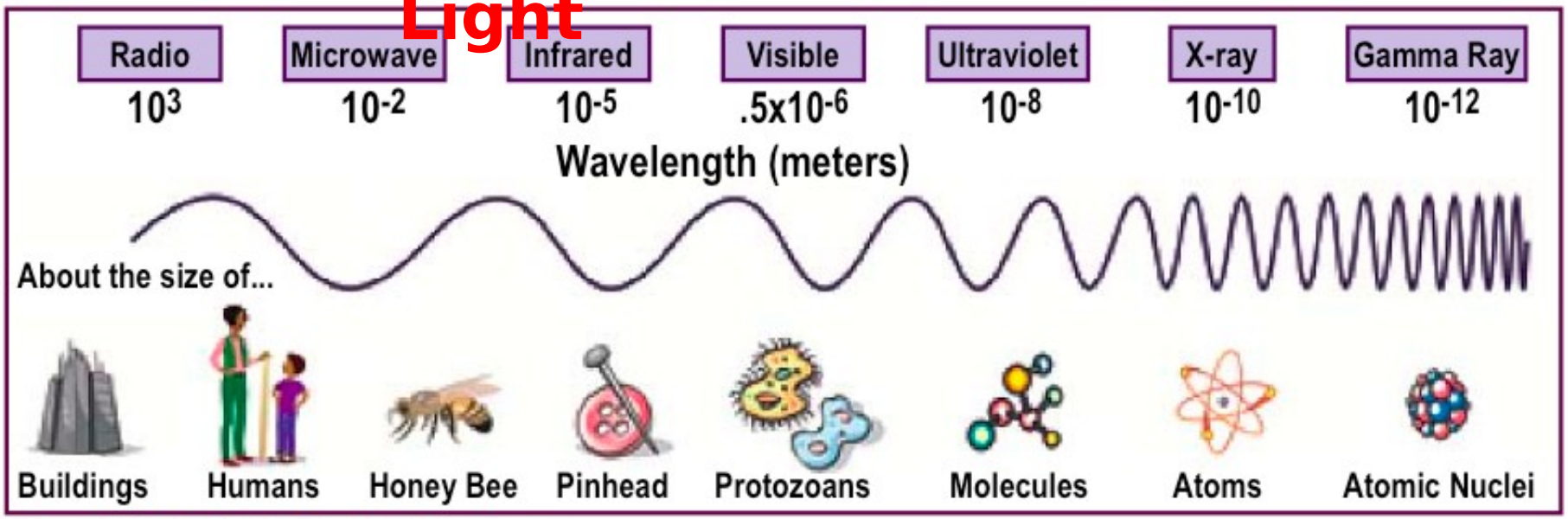

What first turned David Banner into the Hulk?

Gamma Rays!

Because gamma rays are powerful

# The Electromagnetic Spectrum

## The Many Forms of Light

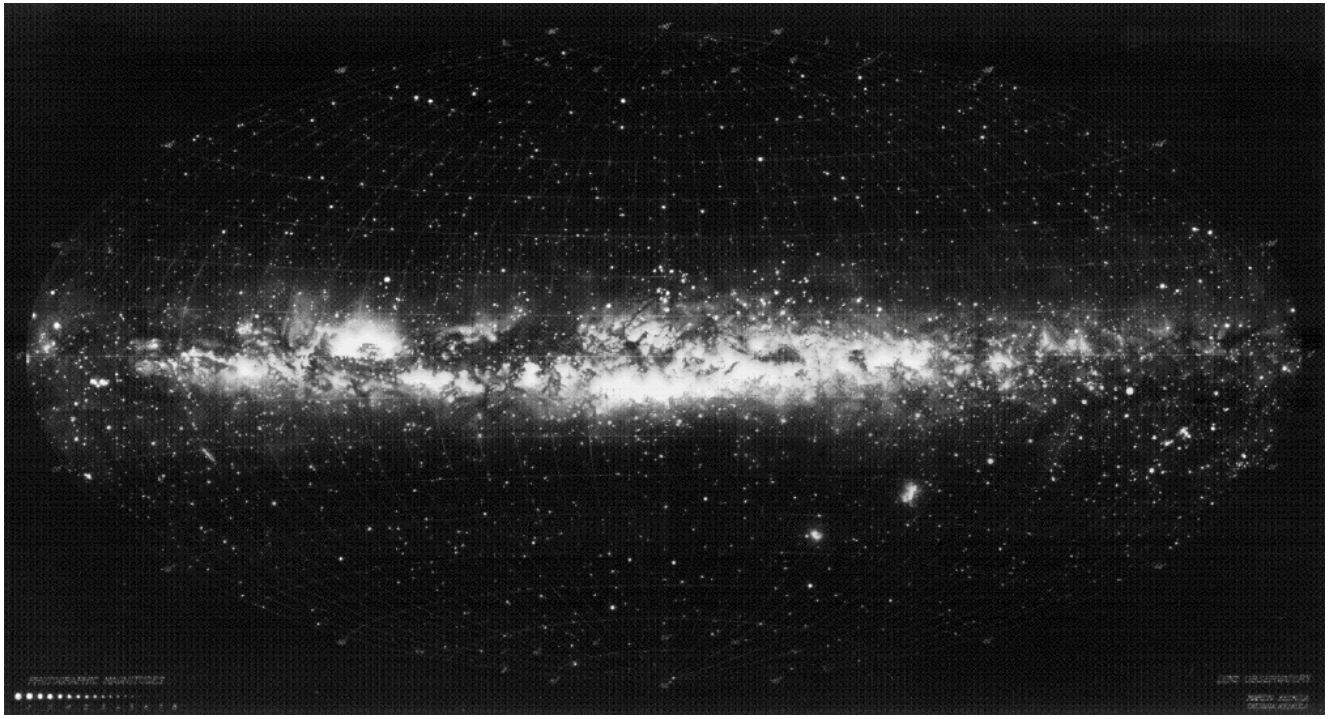



*Credit: NASA / Ruth Jennings*

**Each type of light carries different information.**

**Gamma rays, the highest-energy type of light, tell us about the most energetic processes in the Universe.**

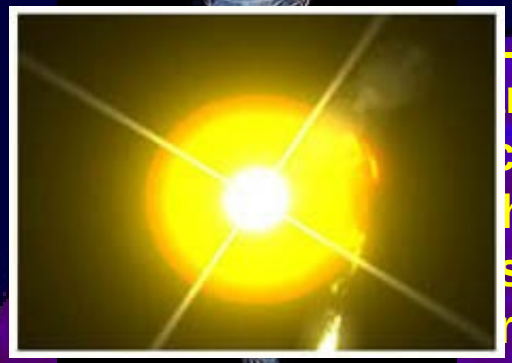
# Why study gamma rays?



- **Universe as seen by eye is peaceful**


But what if you had gamma-ray vision?

# The Gamma-ray Sky in False Color – from EGRET/Compton Gamma Ray Observatory



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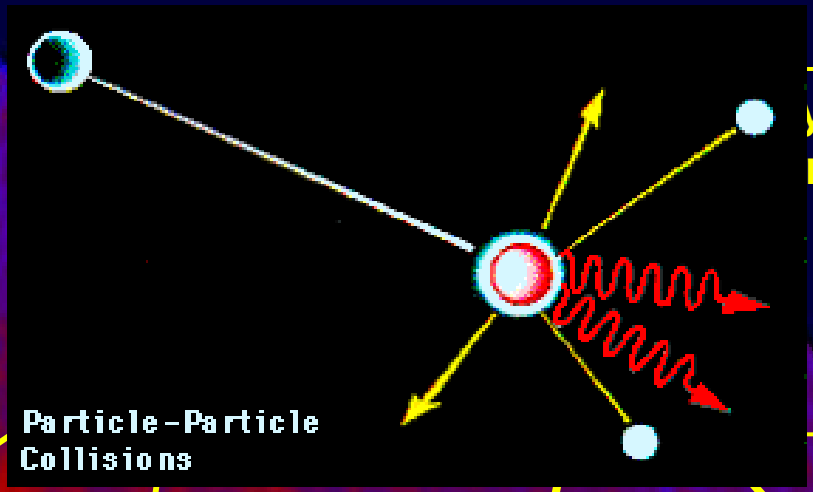


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The Unknown – over half the sources seen by EGRET remain mysterious

Blazars – supermassive black holes with huge jets of particles and radiation pointed right at Earth.

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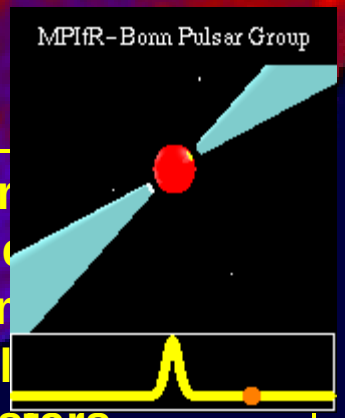
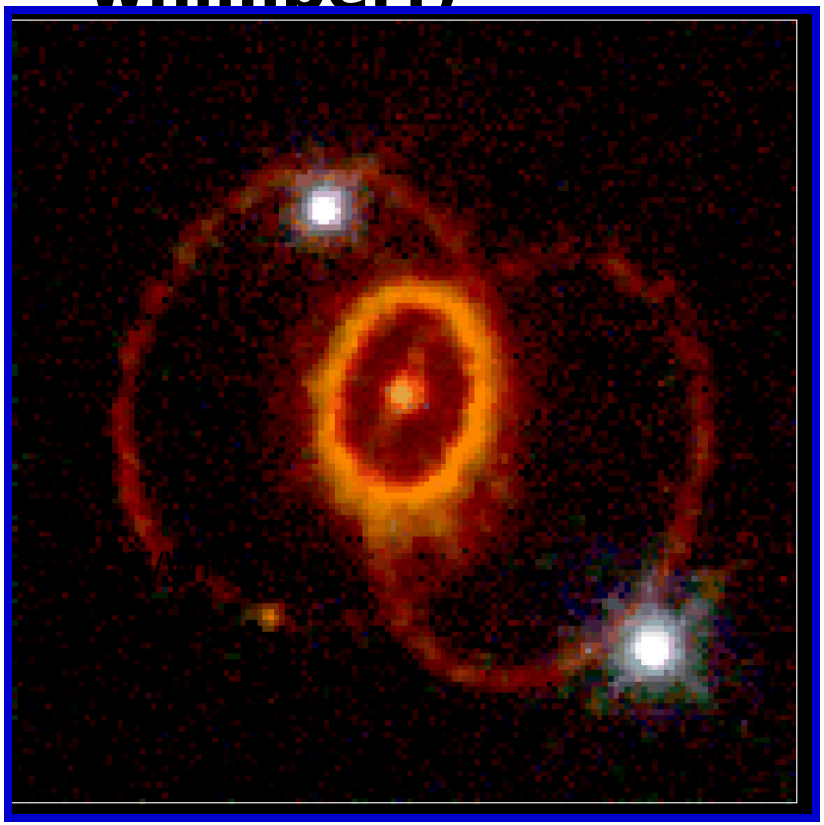
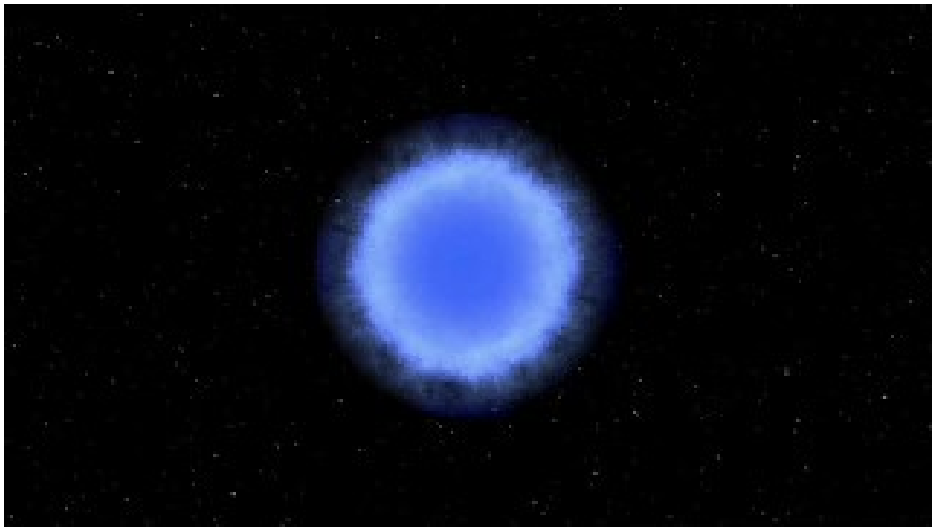


# Exploding Stars

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



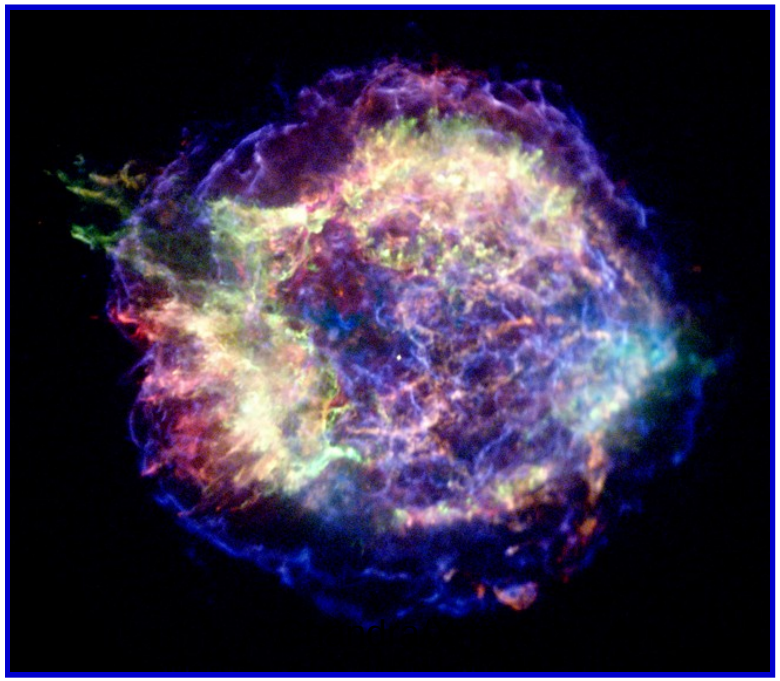
SN1987A - HST

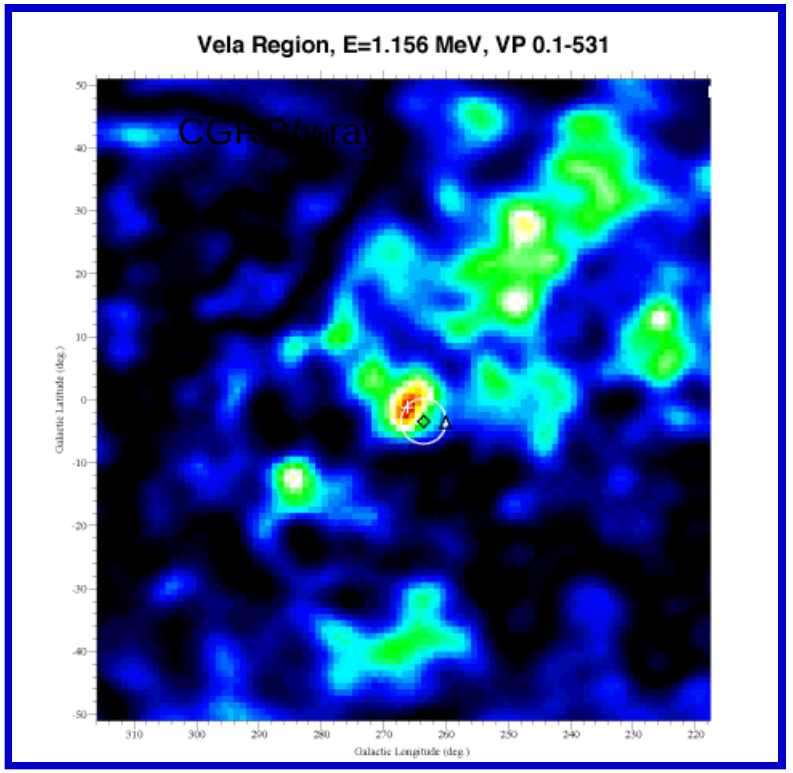


Credit: Dana Berry

# Supernova Remnants

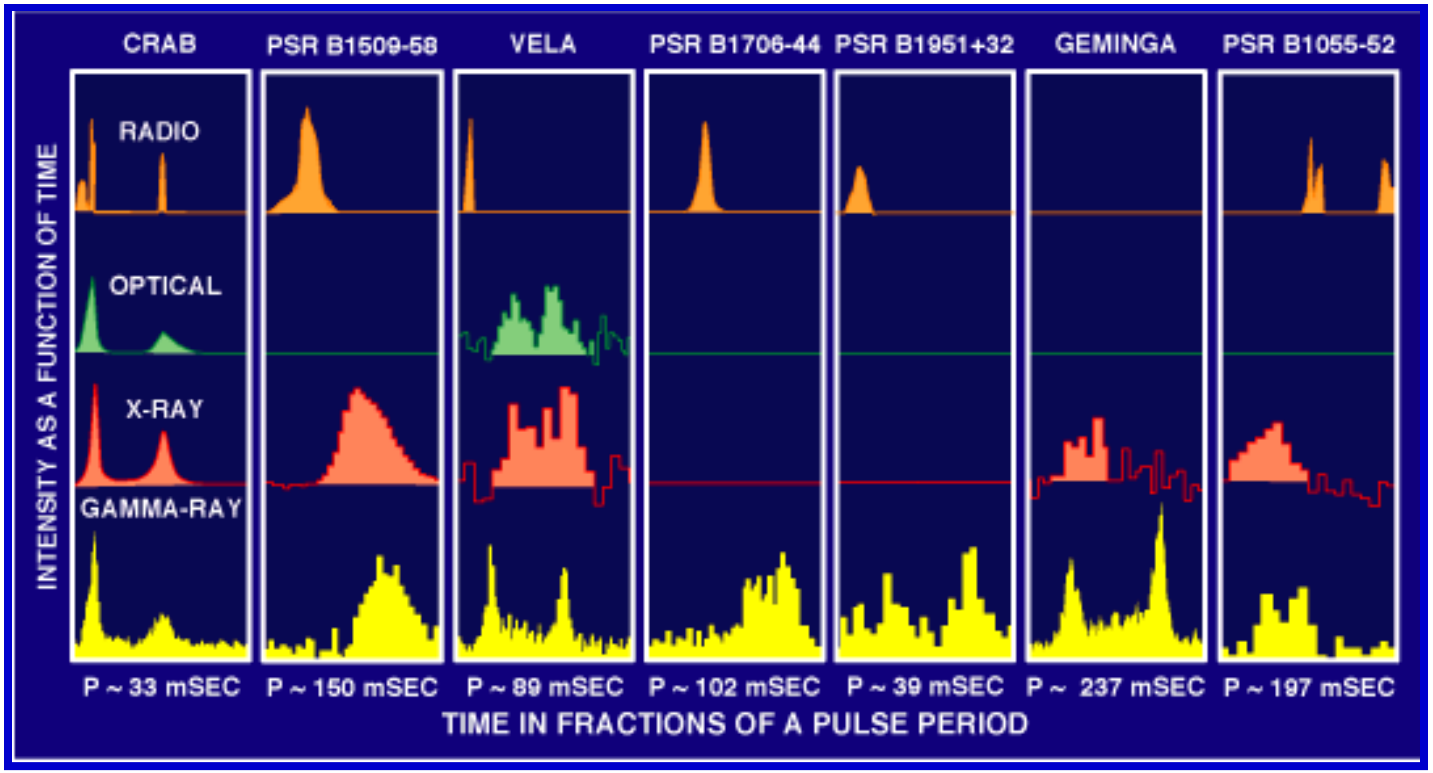
Cas A - Chandra





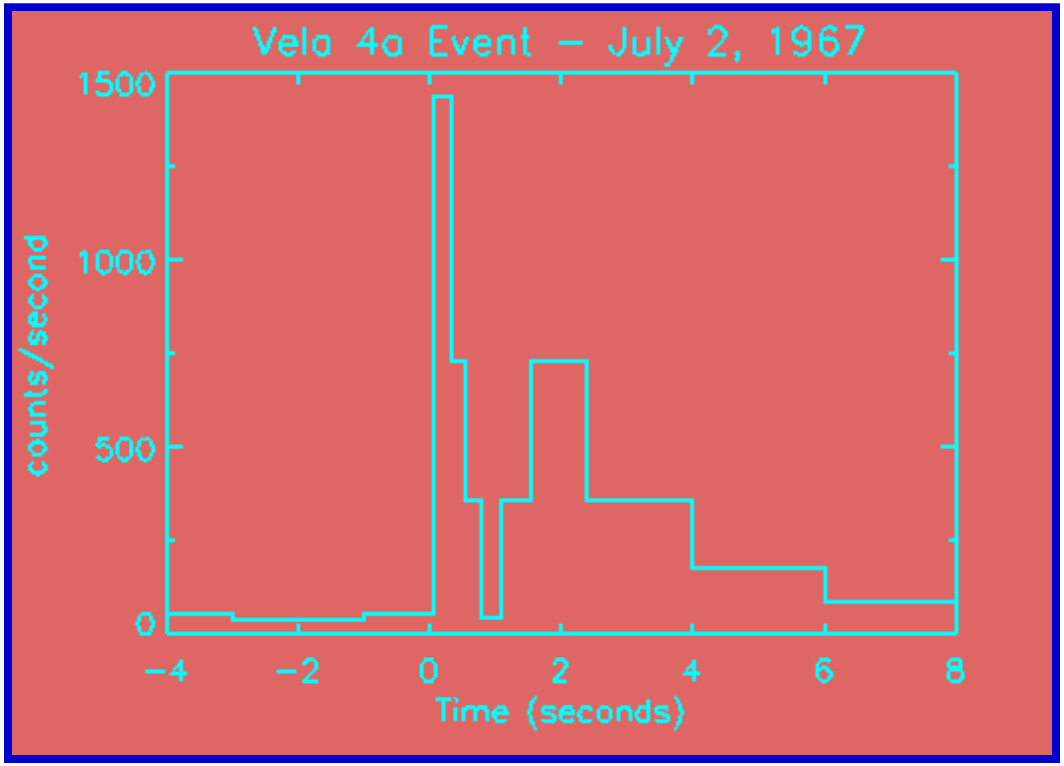

- **Radioactive decay of chemical elements created by the supernova explosion**

# Pulsars



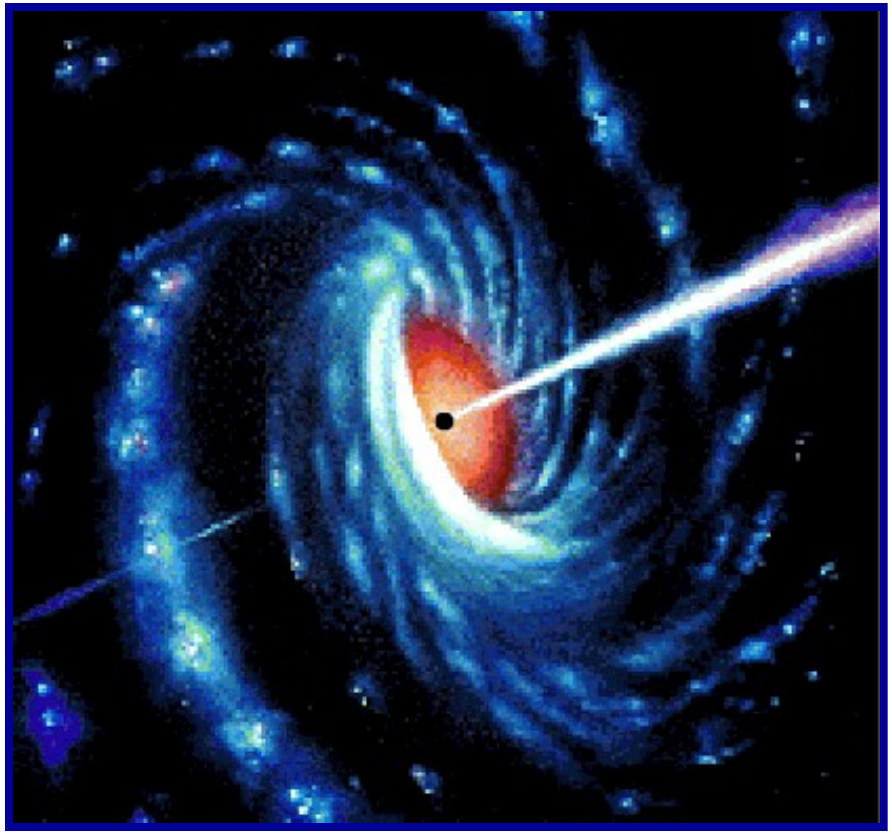

- **Stellar corpses - size of a city, mass of the Sun, spinning up to 1000 times per second**

# Gamma-ray Bursts




- **Discovered in 1967 while looking for nuclear test explosions**

# Gamma-ray Bursts

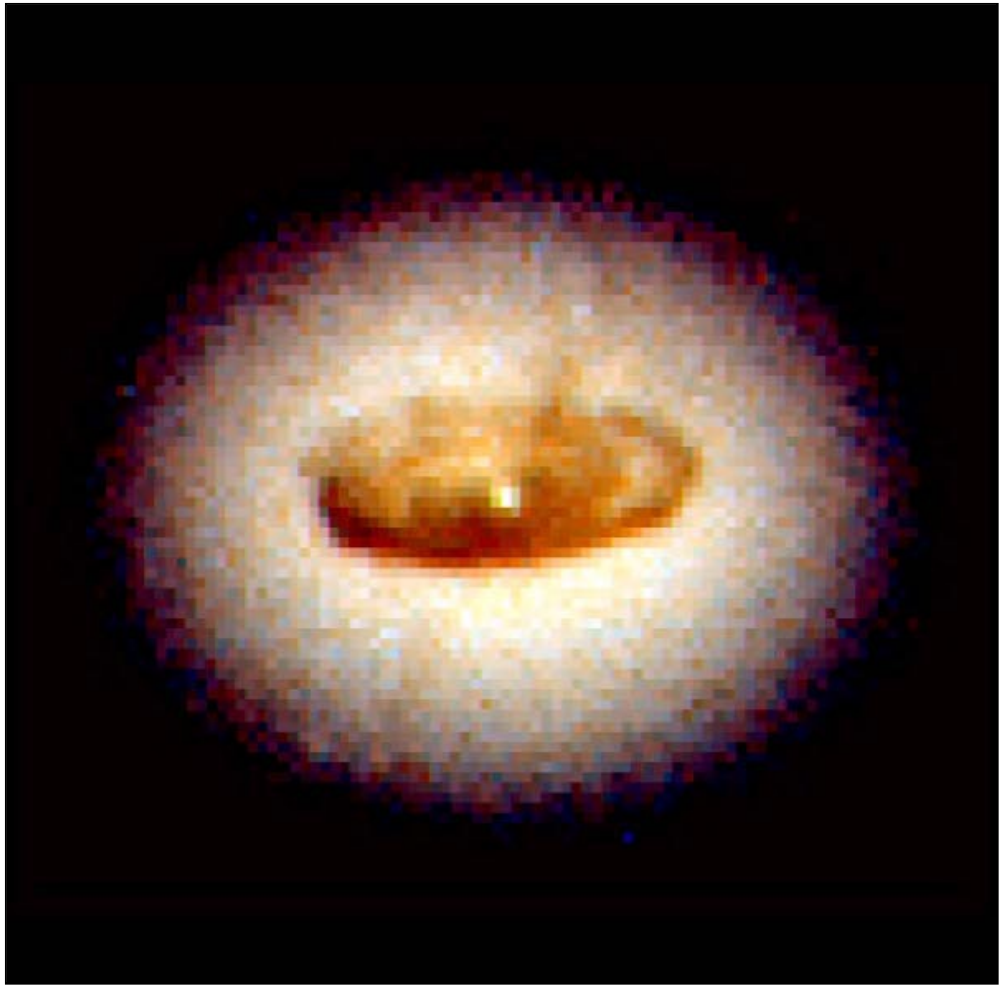


- **Signal the birth of a black hole?**

- **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**

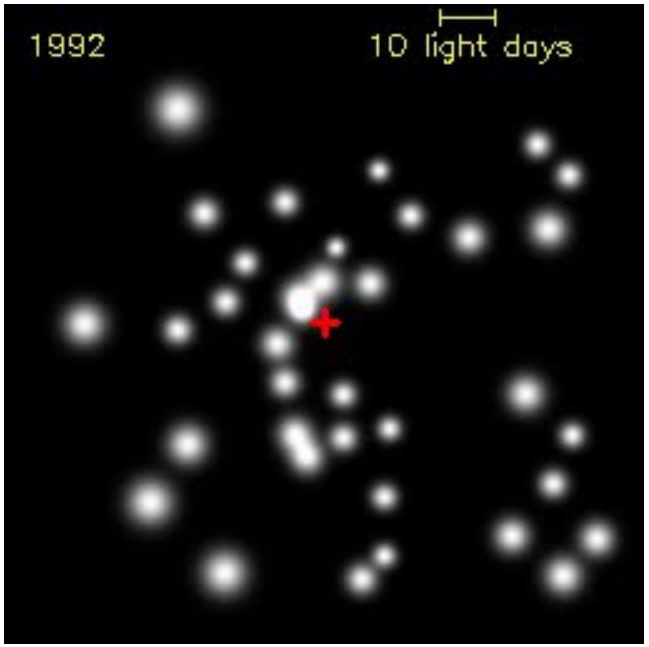


HST/NGC 4261

# Blazing Galaxies

- **Gravity is so strong inside its "event horizon" that not even light can escape**

Credit: Genzel et al.

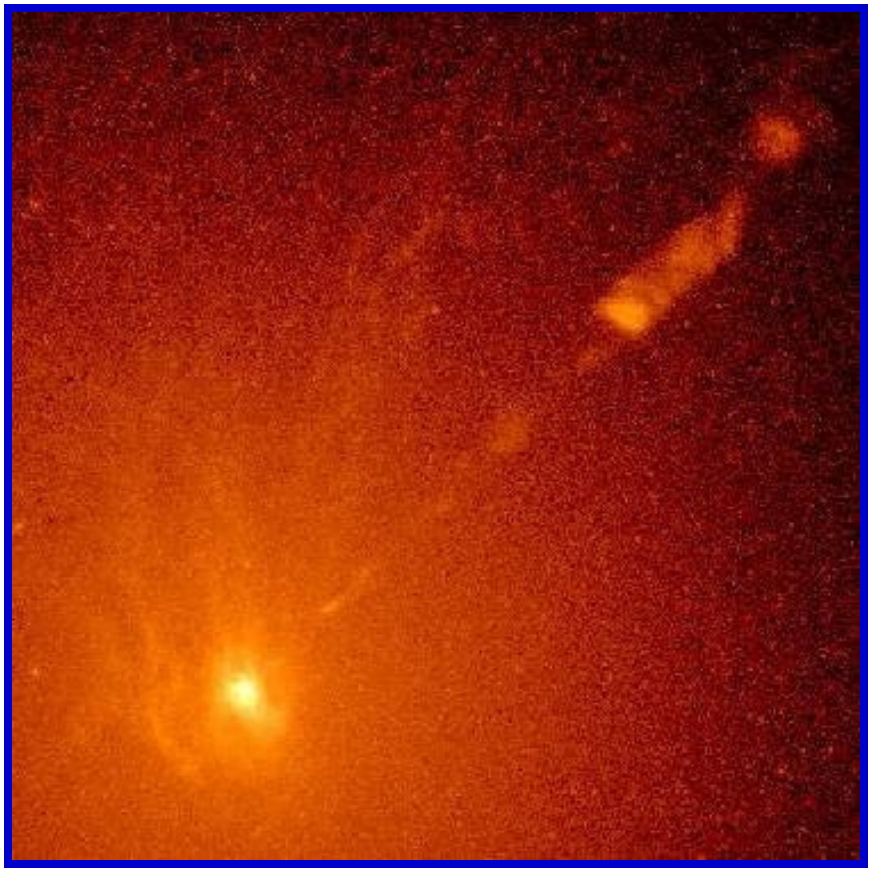



Stars orbiting the Black Hole in the center of the Milky Way

Credit: Dana Berry

# Jet Mysteries

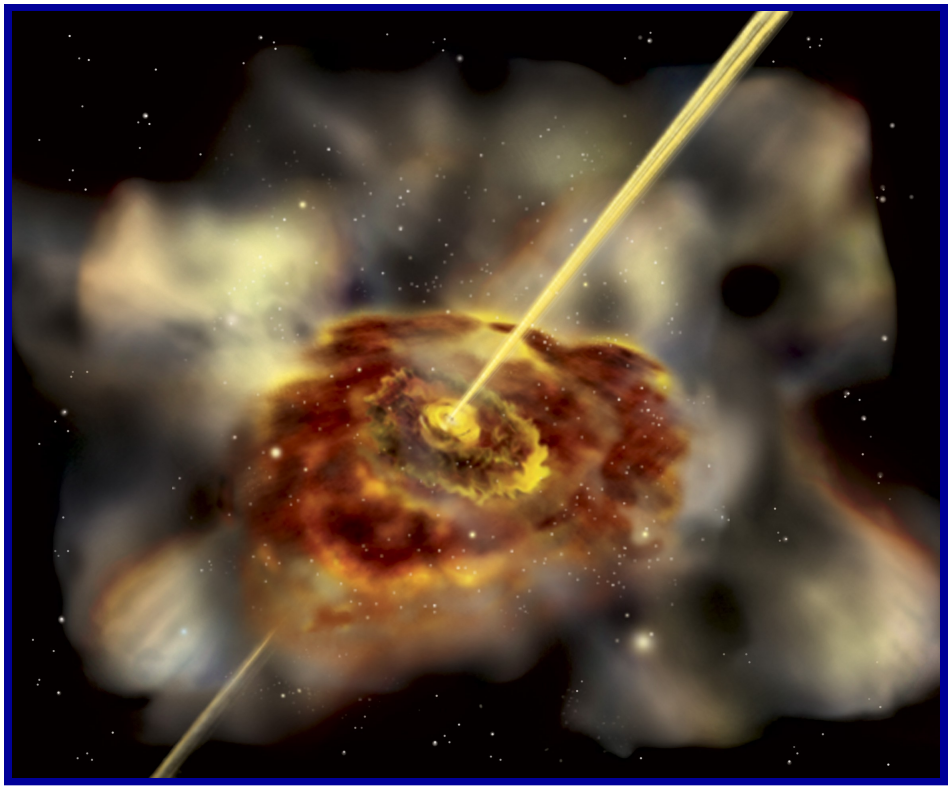
- So, how do black holes emit jets of particles and light?
- And, how do the particles in the jets accelerate to near light speed?



HST/ M87

# Gamma-ray Jets

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



Credit: Aurore Simonnet

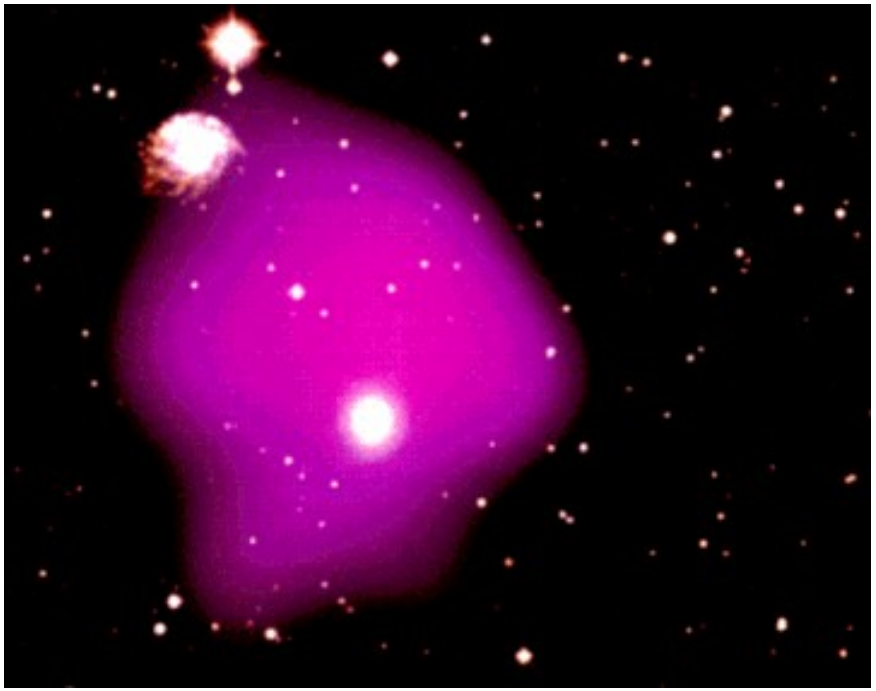
# Dark Matter

HST/CL0024+1654

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

# Shining light on dark matter

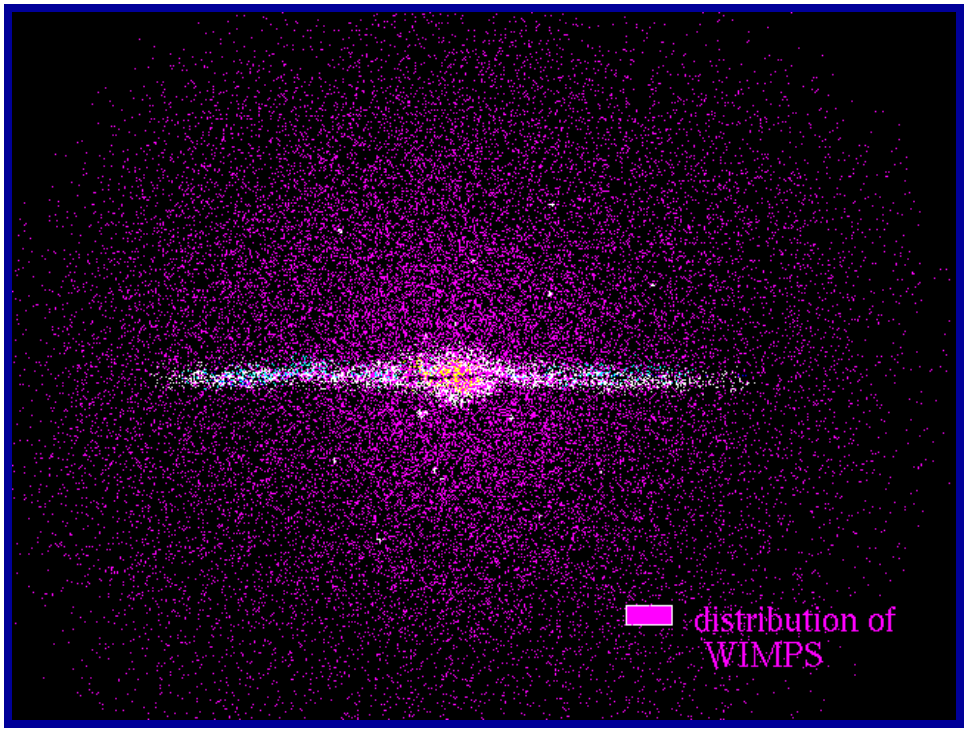
- **Dark Matter can be traced by studying X-rays from hot gas in clusters of galaxies**



ROSAT X-ray over visible light image

# WIMPs

- **Dark matter may be Weakly Interacting Massive Particles**
- **Annihilating WIMPs may produce gamma rays**




A calculation of WIMPs around our galaxy


# The Gamma-ray Sky – An Overview

**We know some of the "what," "when," and "where" – the Universe is populated with powerful, exotic objects and processes that produce gamma rays. Many are variable, and some of these are at cosmological distances.**

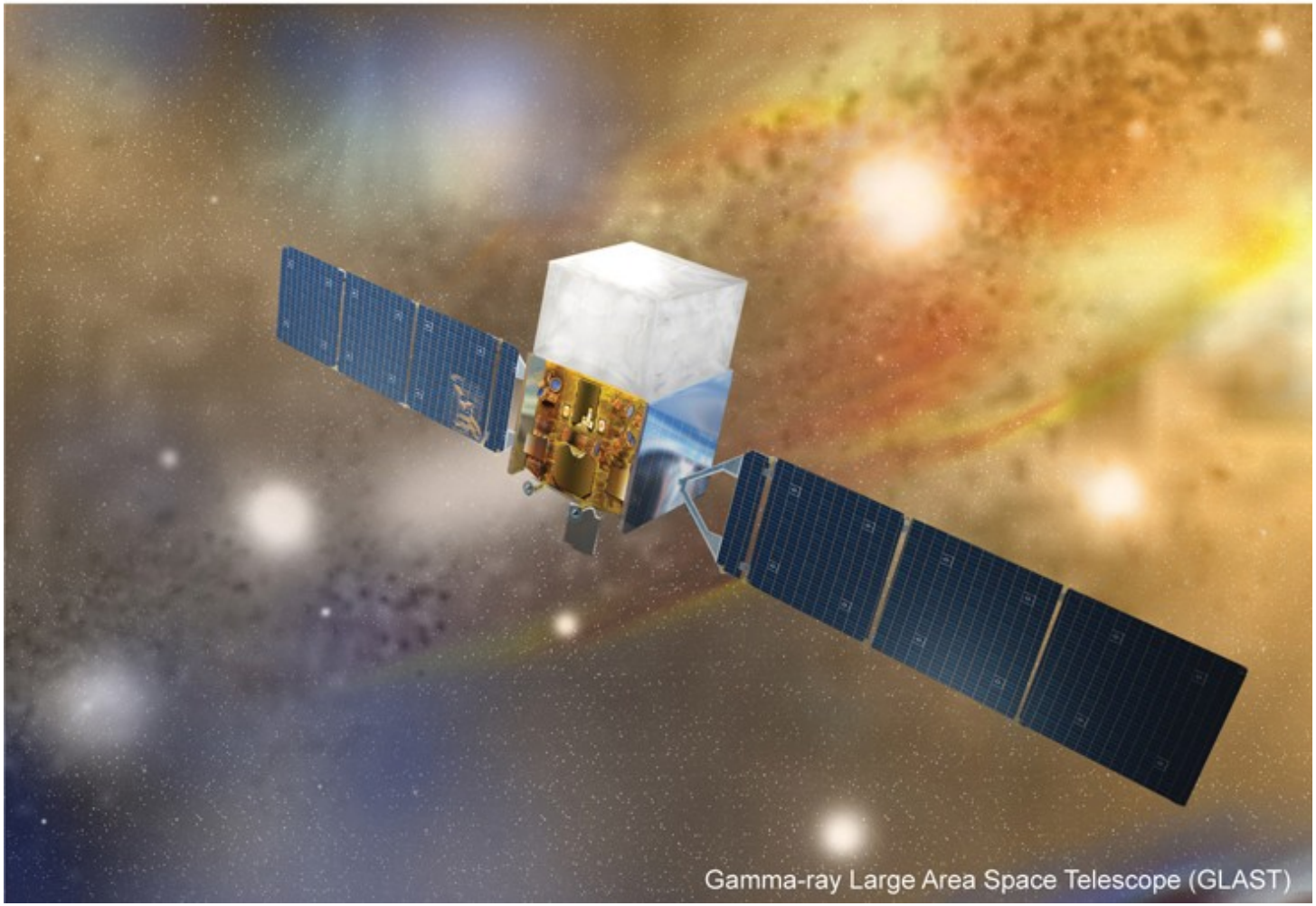
**We have only scratched the surface of "how" and "why" for these gamma-ray phenomena. We have much to learn about how they work and affect the Universe.**

# How to study Gamma rays?

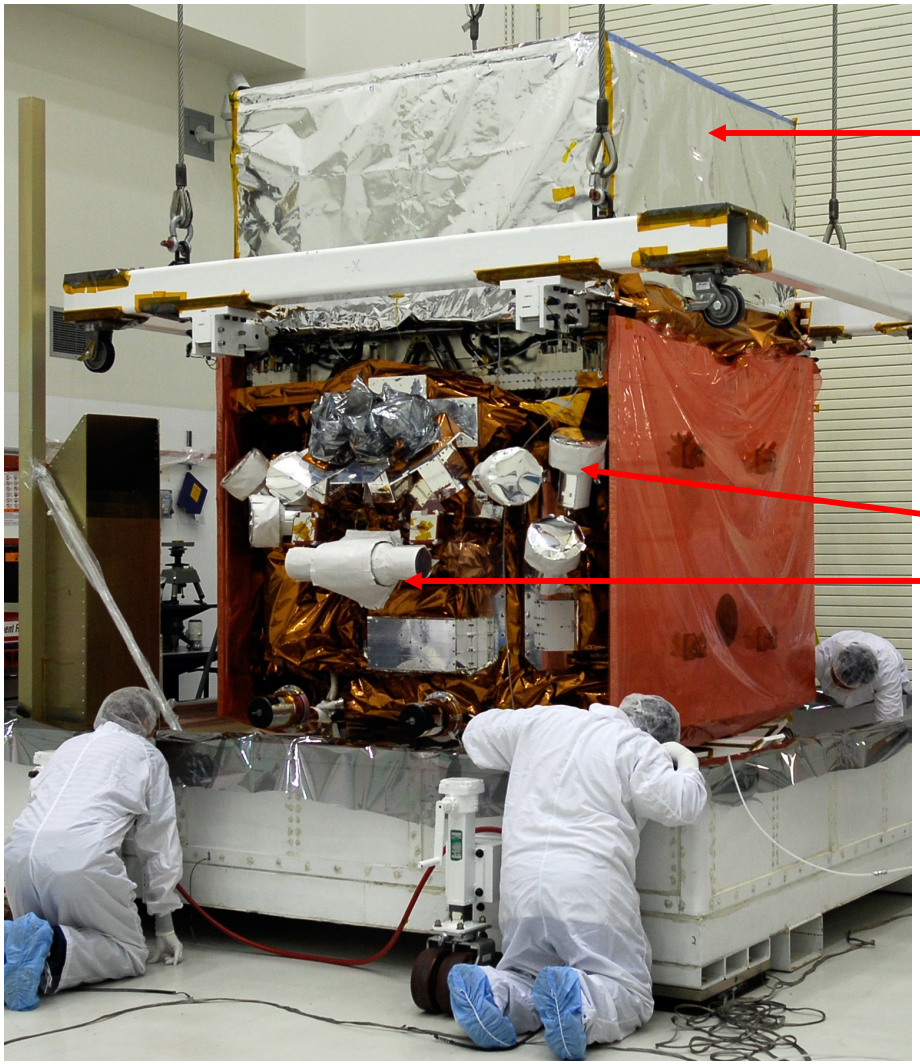
- **Absorbed by the Earth's atmosphere**
- **Use rockets, balloons or satellites**
- **Can't image or focus gamma rays**
- **Special detectors: CCDs, crystals, silicon-strips**

Balloon experiment

# Gamma-ray Large Area Space Telescope



# GLAST instruments

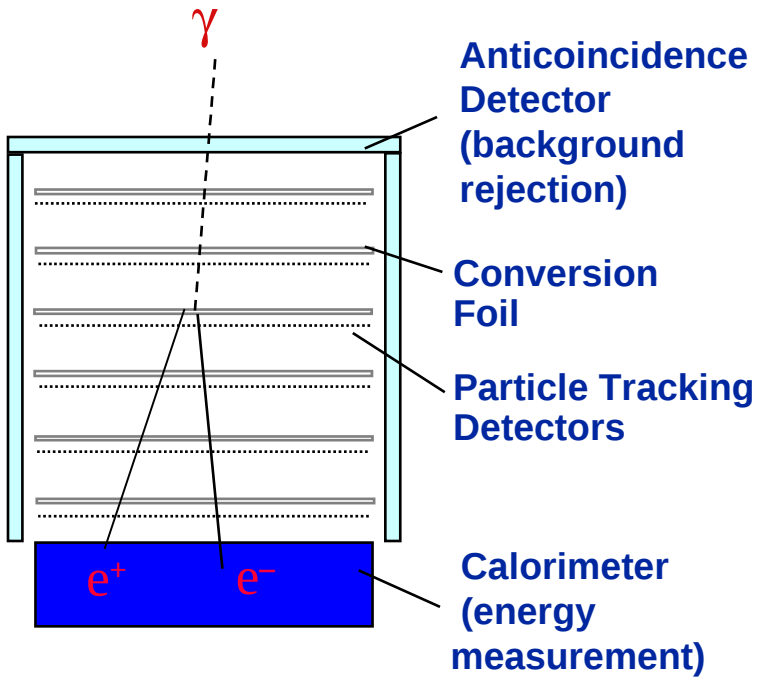


Large Area Telescope

GLAST Burst Monitor

# How does a gamma-ray telescope work?

- The key is "high-energy"
- A gamma ray is a packet of energy – lots of energy.
- Who do we call for help?



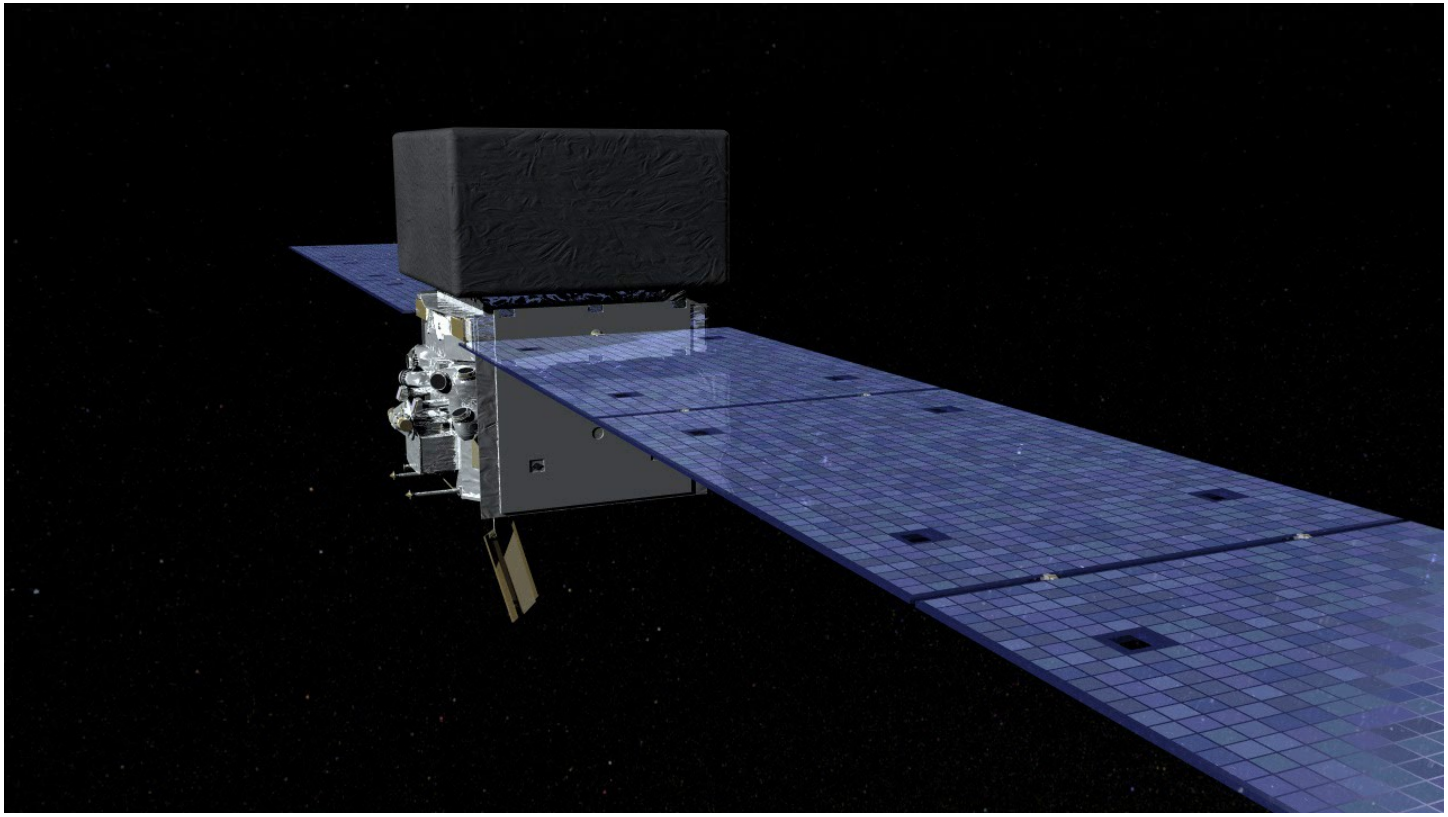

**Prof. Einstein, what do we do with something that is just a large amount of energy?**

**Energy? That's E, and $E = mc^2$**

**Convert the energy to mass.**

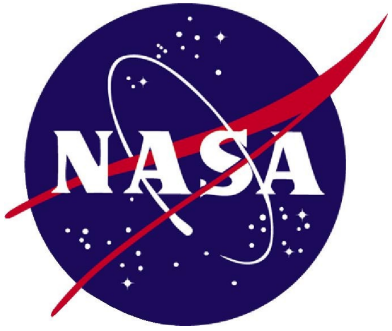
# Large Area Telescope

- **Has 16 towers – each uses $E=mc^2$ to detect gamma-rays**

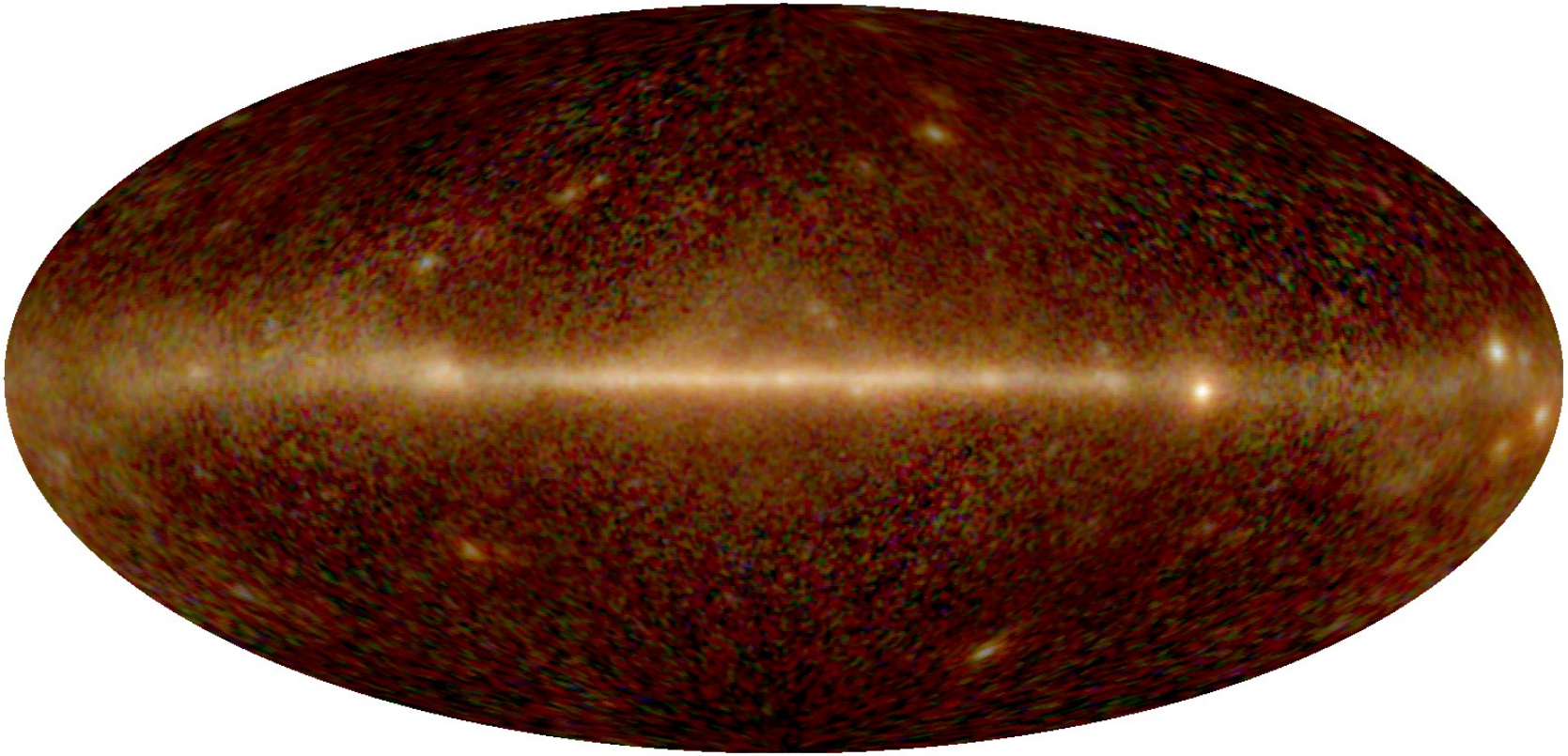


# GLAST Mission

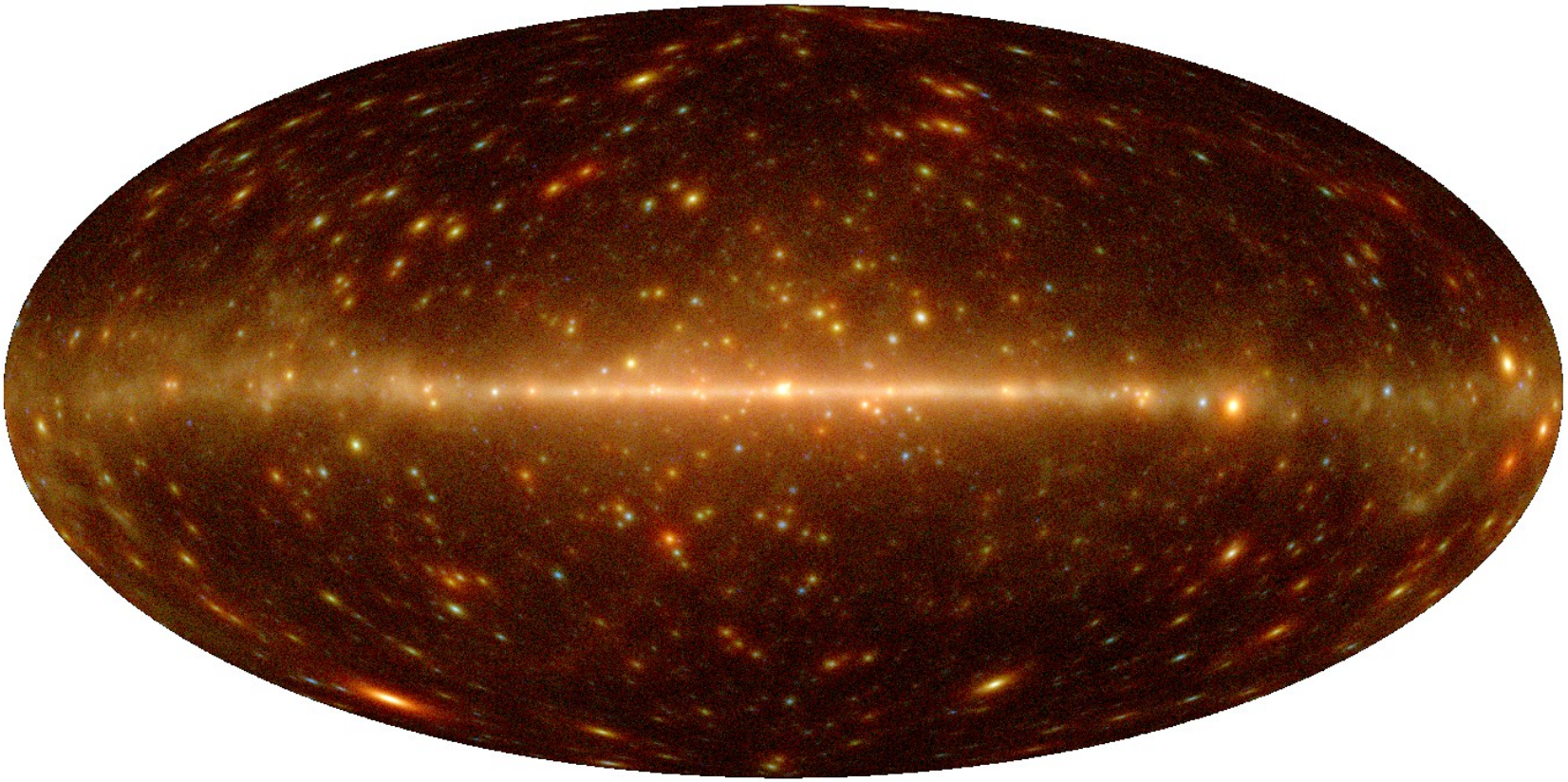
- **First space-based collaboration between astrophysics and particle physics communities**
- **Launch expected SOON!**
- **Expected duration 5-10 years**
- **Over 3000 gamma-ray sources will be seen**




# CGRO/EGRET View of the Universe



# GLAST view of the Universe

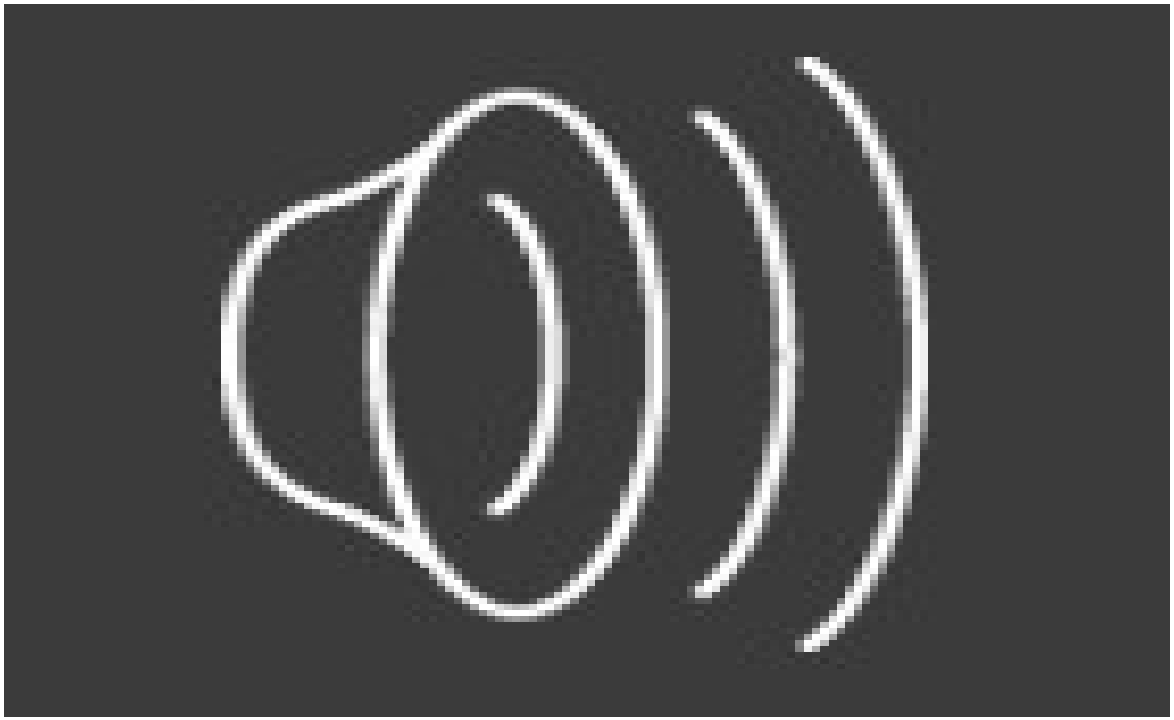


- **GLAST expects to see thousands of sources!**


**GLAST's Delta II Rocket at Cape Canaveral Air Force Station.**

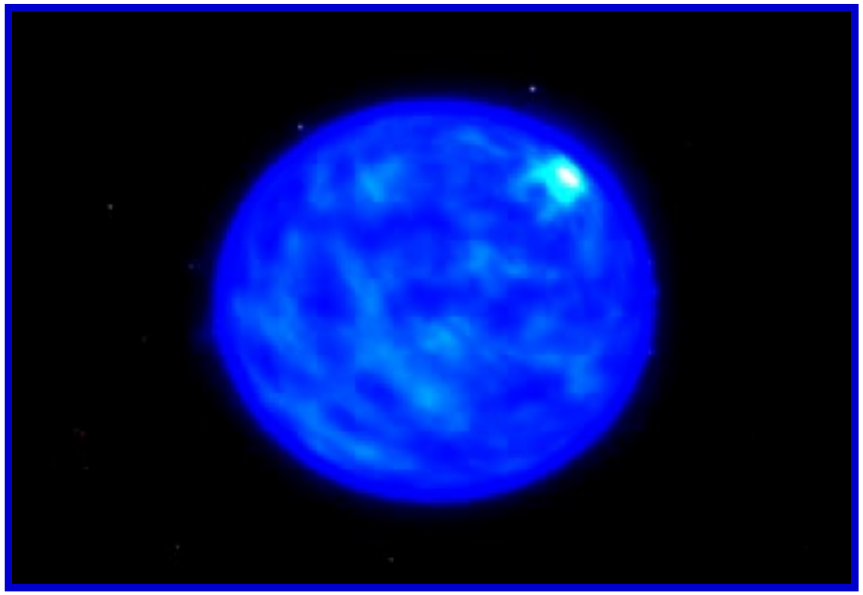
# GLAST in Space

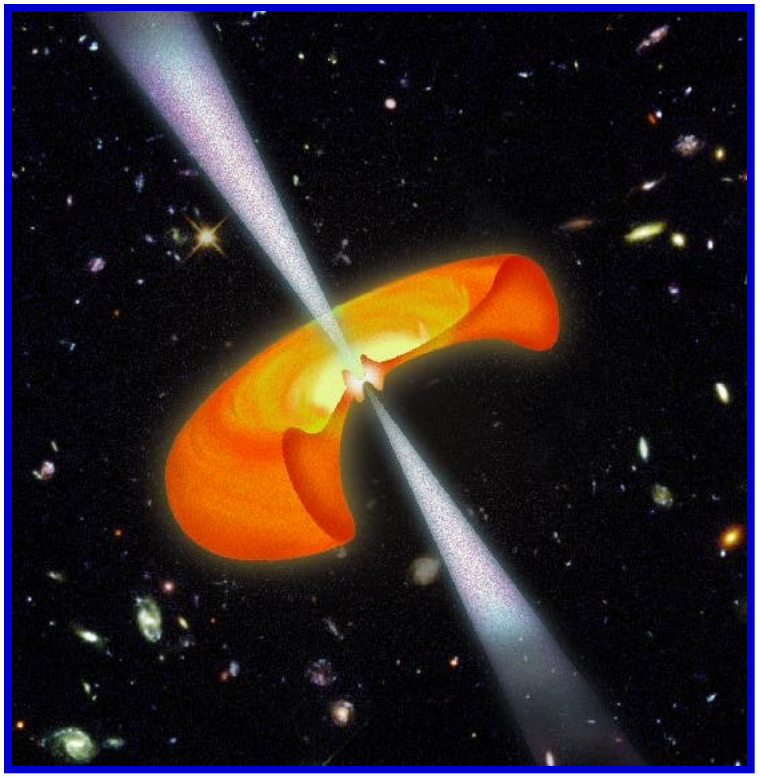
- **This animation shows GLAST launching into Earth orbit and observing the sky in gamma rays**




# Backups Follow

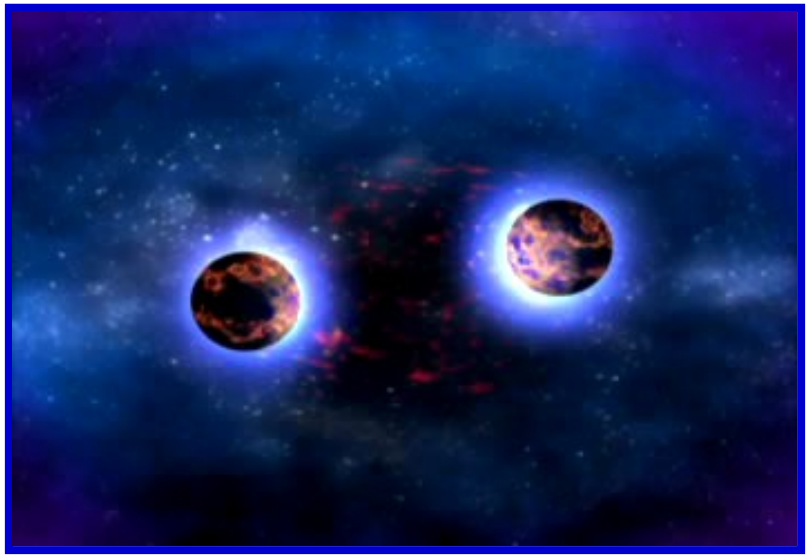
# Hypernova

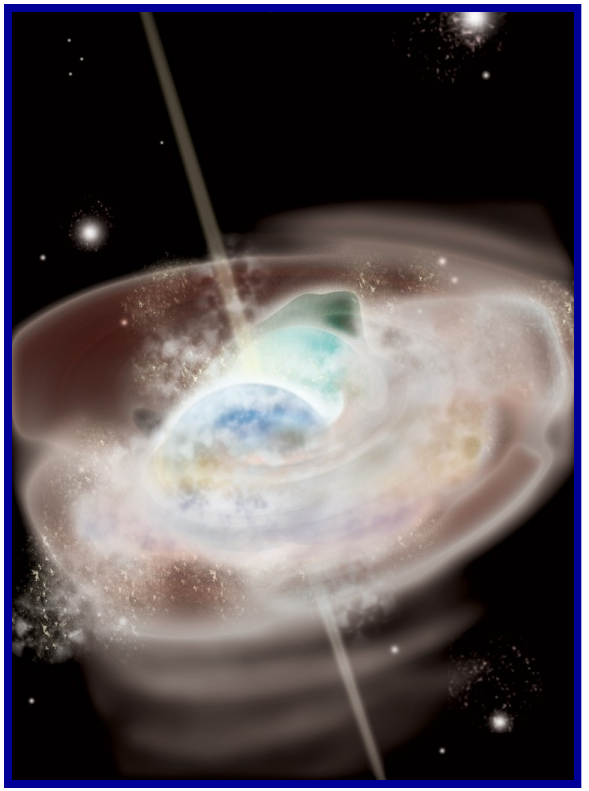




- **A billion trillion times the power from the Sun**

# Catastrophic Mergers





- **Death spiral of 2 neutron stars or black holes**

# GLAST and WIMPs

- **If WIMPs are the dark matter and…**
- **If WIMPs self-annihilate producing GeV gamma rays….**
- **Then GLAST should be able to see gamma rays from WIMPs within 3 years of observations**

*"The most incomprehensible thing about the Universe is that it is comprehensible" - A. Einstein*

# Summary - Watch for GLAST!


**The GLAST observatory is in Florida waiting for launch.**

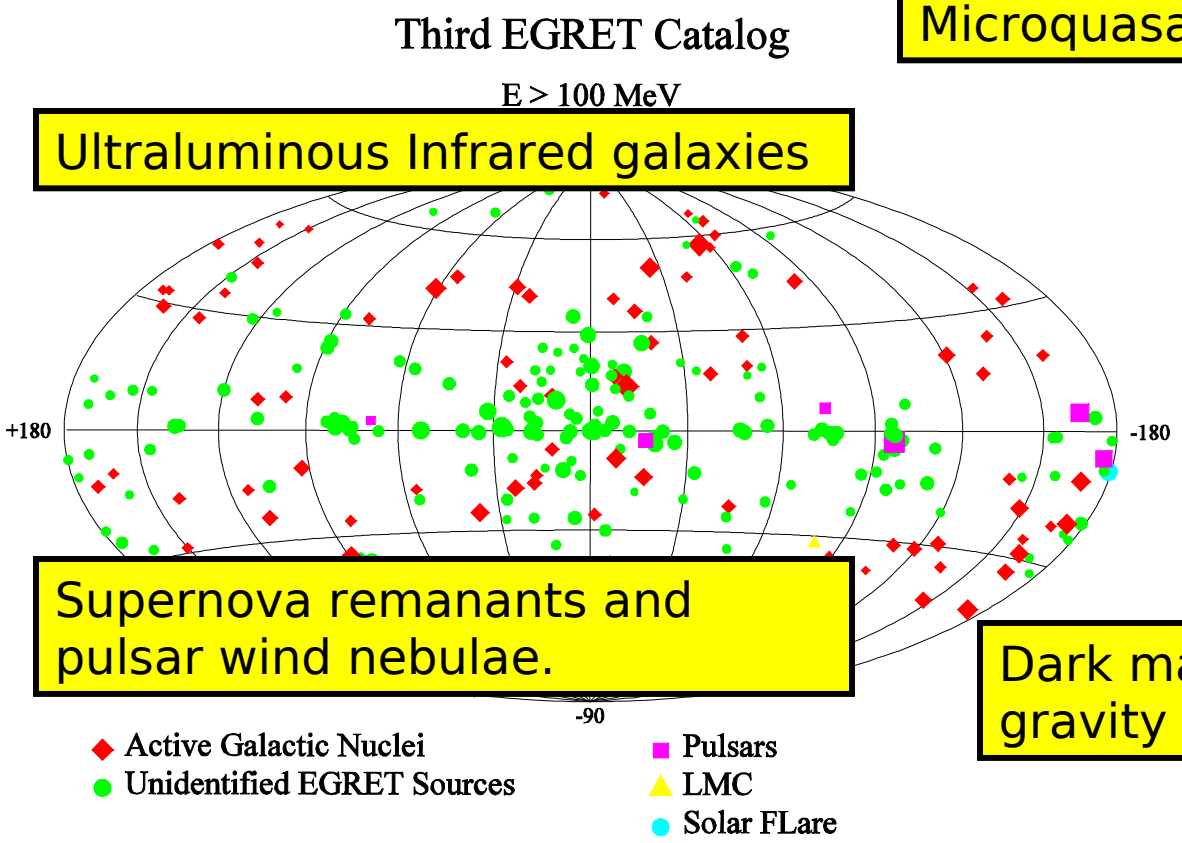
**Follow the progress at**

www.nasa.gov/glast

## Extra Slides

www.nasa.gov/glast

# The Unknown




Microquasars and other HMXBs

Ultraluminous Infrared galaxies

Supernova remanants and pulsar wind nebulae.

Dark matter clumps, quantum gravity effects, other exotica

**Over half the sources in the third EGRET catalog remain unidentified, despite significant efforts.**

**GLAST will detect many more sources.**

**Identifying and understanding such sources will be a multiwavelength**

What other types of objects produce high-energy gamma rays?

# Mission Messages

- NASA's GLAST mission is an astrophysics and particle physics partnership, developed in collaboration with the U.S. Department of Energy, along with important contributions from academic institutions and partners in France, Germany, Italy, Japan, Sweden, and the U.S.
- NASA's Gamma-ray Large Area Space Telescope (GLAST) is a powerful space observatory that will:
  - Explore the most extreme environments in the Universe, where nature harnesses energies far beyond anything possible on Earth.
  - Search for signs of new laws of physics and what composes the mysterious Dark Matter.
  - Explain how black holes accelerate immense jets of material to nearly light speed.
  - Help crack the mysteries of the stupendously powerful explosions known as gamma-ray bursts.
  - Answer long-standing questions across a broad range of topics, including solar flares, pulsars and the origin of cosmic rays.