Gamma Ray Bursts
The Case

- Sudden, intense flashes of gamma rays come from nowhere and disappear without a trace.
- Incredibly powerful: A single gamma ray burst is hundreds of times brighter than a supernova.
- Appear at random intervals, from seemingly random directions.
- Two distinct types: Short and Long.
The Suspects: Usual and Otherwise

- Neutron Stars
  - Magnetars
  - Comets
  - Starquakes
  - Internal phase transition
- AGN’s / Super Massive Blackholes
- Colliding Binaries
- Supernovae
The Investigation

- Who
- Where
- When
- What
- Why
- How
Who

- Vela (1960’s)
  - Looking for arms testing, found gamma ray bursts
- Compton Gamma Ray Observatory (1990’s)
- BeppoSAX (1997)
  - Afterglow era
- GLAST (2008 ?)
Where

- Assumed to be in the galaxy due to tremendous luminosity
- CGRO gives spatial distribution
- BeppoSAX sees afterglow
  - March 1997 Hubble sees source at galaxy edge, among normal stars.
  - May 1997 Keck measures redshift of 0.8
  - Billions of parsecs away, instead of 100’s: luminosity falls of as $r^2$, so GRB’s around $10^{14}$ times more powerful than if galactic!
When

- They occur about once every 100,000 years per galaxy
- Once every 4 billion years near the earth
- Swift measured a GRB with a red shift of 6.4!
  - About 500 myr - 1 gyr after the Big Bang
  - Only other object as old is Quasar (~billion solar masses)
What

- Long Duration GRBs come from the explosion of very massive supernovae, called ‘hypernovae’, ‘collapsars’ or ‘fireball model’
  - Failed supernovae, instead of exploding collapse to black holes.

- Short Duration GRBs are created by an unknown mechanism, and have only recently exhibited afterglow
Why

- Hundreds of times brighter than supernova
  - Larger Mass
- Creates Black Hole
  - Black hole would simple capture all the material
- Collapsar
  - Large Angular Momentum
  - Low Metallicity
  - No Hydrogen Envelope
How

- Collimated Jets at polar regions
  - Much smaller energy needs, but also more frequent
  - Highly relativistic: Lorentz factor 150
- Gamma Rays produced when relativistic matter collides with shell of star
  - Mechanism still unclear
- After glow is when it interacts with ISM
- Short Duration burst might be collision of neutron stars
Important Gamma Ray Bursts

- 670702 : First ever detected
- 970508 : First with measured redshift
- 980425 : First with associated supernova
- 030329 : (z=.168) unambiguous supernova
- 050509 : First short burst with host l.d.
- 050724 : short burst with evidence of n* - BH
- 050904 : most distant GRB redshift 6.29
- 060505/060614 : recent long GRBs w no SN
Wrapping Up

Could be tracer in very ancient universe

- Ly-alpha
- Star Formation

- Extinctions on Earth?