Detection as a statistical process

- The goal of data analysis is to distinguish between “signals” and “noise”
  - » One person’s signal is another’s noise:cf. LISA and CWDBs
- Measurement noise can only be characterized statisticallly
  - » Mean, variance, correlations, etc.
- *What data analysts need* are *characteristic features* of sought-for signals
  - » These are used to distinguish between signal & noise
  - » E.g., gamma-ray bursts immediately following grav-wave burst, energy spectrum of collapse vs. coalescence, characteristic cross-correlation between two separated detectors
  - » Much broader than “waveforms”

Things that go “bump” in the night

“There are more things in heaven and earth, Horatio, then are dreamt of in your philosophy”

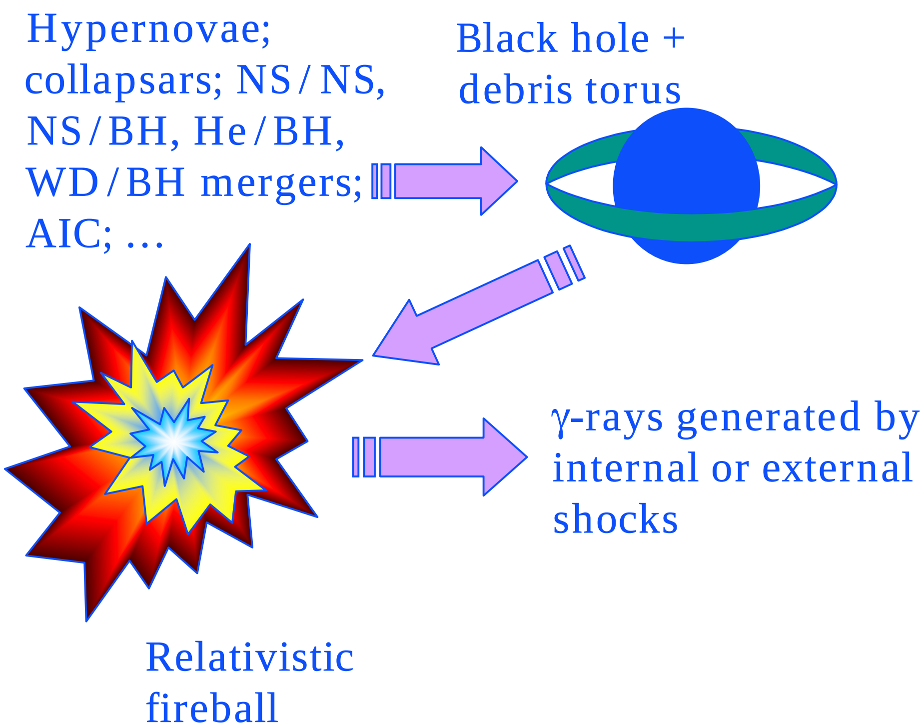
Seek and ye shall find - but what?

- Need analysis methods that are not tied to a specific source, or class of sources
  - » General physical principles? Impulsive excitation, frequency, damping time
- Detection involves distinguishing signal, noise
  - » “Signal from noise” or “noise from signal”?
  - » Exploit the noise model!
  - » Example: associating grav-waves with γ-ray bursts relies more on properties of noise than on signal

Beyond detection

- Detection is a milestone on the gravitational wave astronomy highway
  - » We *will* pass it … and leave it behind
- Interpretation - *what we do with observations* - is where the science is
  - » Not just detection: also upper limits that constrain theory
- What is needed for a successful interpretation program?
  - » Tools
    - – Simulation software, theoretical tools (e.g., Feynman diagrams!)
    - – And facility in their use
  - » Intuition
    - – Requires broad experience playing with tools
  - » Knowledge
    - – What are the theories, models, musings, etc., relevant to grav-waves and their sources
  - » Observations!

Example: Gravitational Waves and γ-ray bursts



- Progenitor mass, angular momentum
  - » Radiated power peaks at frequency related to black hole M, J
- Differentiate among progenitors
  - » Stellar collapse, binary coalescence have different gw intensity, spectra
- Internal vs. external shocks
  - » Elapsed time between gw, γ-ray burst tells us location, character of shocks

Other Examples

- Interpreting/identifying signals without sources
  - » Amplitude/rate (cf. Amplitude/number) relationships
  - » Features to (astro)physics
- Relativity tests
  - » “Graviton mass” measurements
  - » Black hole properties/no-hair theorem tests/spacetime “mappling”
- Multi-spectrum astronomy
  - » Constraining stellar population models
  - » “Silent” core collapse contribution to total core collapse rate
    - – Are there differences in grav.-rad character?

Burst Analysis Group: Current Focus

- Goal: sources without waveforms, signals without sources
- "Triggered" analysis
  - » What can we say about, e.g., association of grav.-waves with, e.g., γ-ray bursts
  - » Upper limit on signal strength
- "Instrumental" analysis
  - » Identify classes of similar-looking events
- "Astrophysically motivated" analysis
  - » Identify broad characteristics of, e.g., collapse waveforms, black-hole ringdown, etc., and look for those particularly.
- Results: excluded region in rate v. strength diagram

Inspiral Analysis Group: Current Focus

- Goals
  - » Upper limit on inspiraling compact, solar mass, binary systems rate density
    - – 1-3 Msol component masses: waveforms “trusted” in band
  - » Black hole “hunting”
    - – High(er) mass black holes: waveforms not “trusted” in band
- Coordination with burst group
  - » Actual inspiral always followed by merger/ ringdown (burst-like) events!
  - » Requiring “coincidence” drives down false event rate, leaves efficiency (relatively) unchanged: net win