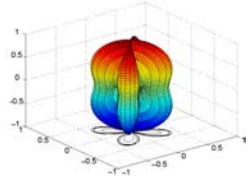

A Global Network of Antennas

ACIGA Meeting, Perth, April 2004

All sky coverage and source reconstruction of transient sources requires four geographically well-separated antennas:
Sky location, polarization amplitudes, and distance

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Science Potentials of a Network

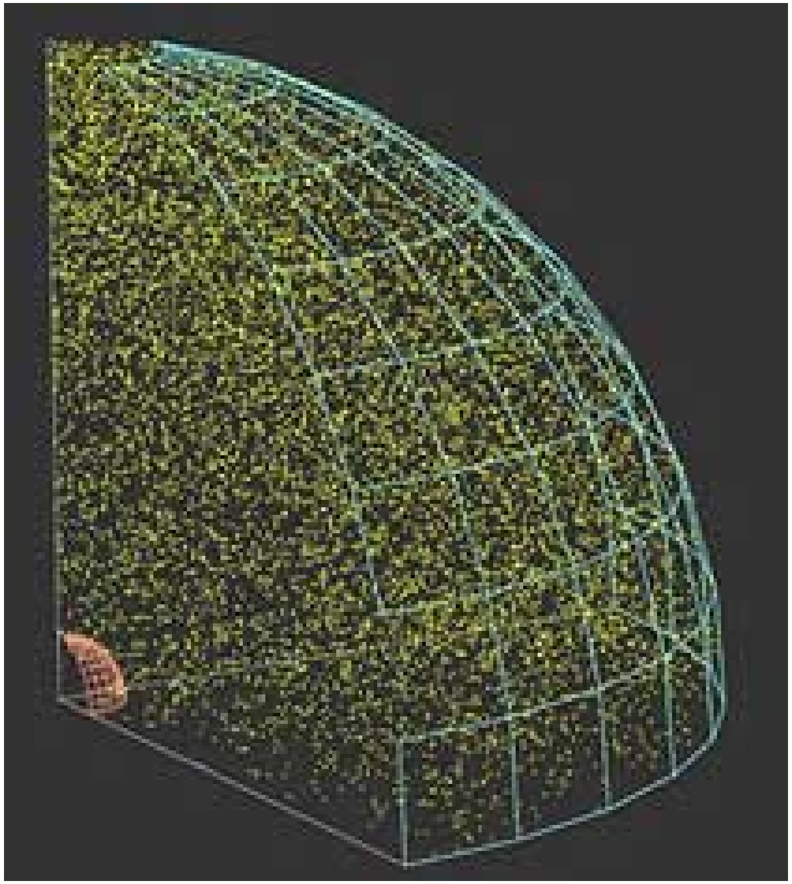
Astrophysics
- Origin of gamma-rays, star formation rate, NS/BH population
- Dark matter in Halos – MACHO objects
- Galactic neutron star population, LMXB's, QPO's
- Neutron star equation of state and structure
- Supernovae and other transient sources
- Astrophysical stochastic backgrounds
- Unknown sources

Relativity
- Confirm speed of gravitational waves and constrain graviton mass
- Measure polarization and test general relativity
- Map space-time geometry around Kerr black holes
- Relativistic instabilities

Cosmology
- Cosmological parameters and their variation with red-shift
- Dark energy – equation of state and nature
- Primordial backgrounds: Early-Universe phase transitions, cosmic strings, …

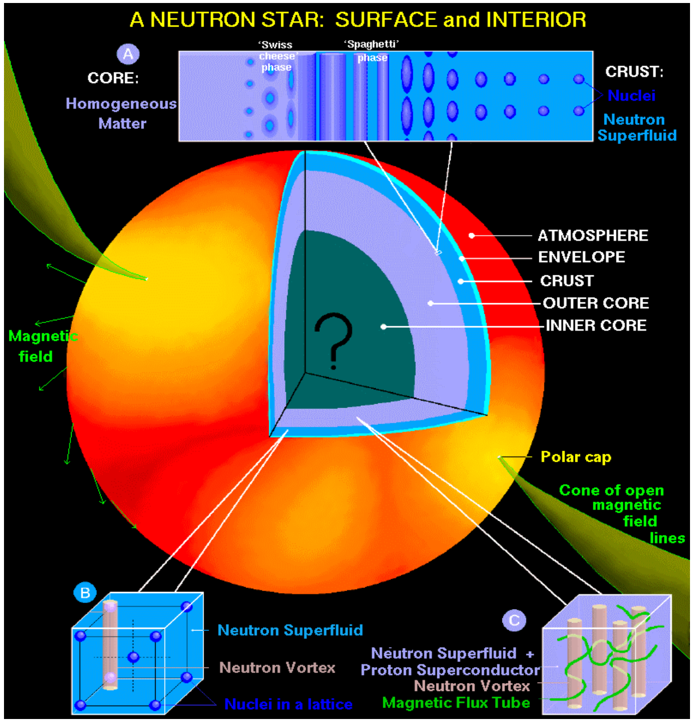
Compact Binaries

- NS-NS binaries
  - **300Mpc: 10's / day**
  - The discovery of a new binary pulsar have increased the rate upwards by an order of magnitude
  - Association with gamma-ray bursts
- NS-BH binaries
  - **650 Mpc, 2/yr to many/day**
  - Neutron star disruption and equation of state
- BH-BH binaries
  - **z=0.4, 8 / month to 40 / day**
  - BH-BH rate > NS-NS rate
  - Star formation rate, BH population

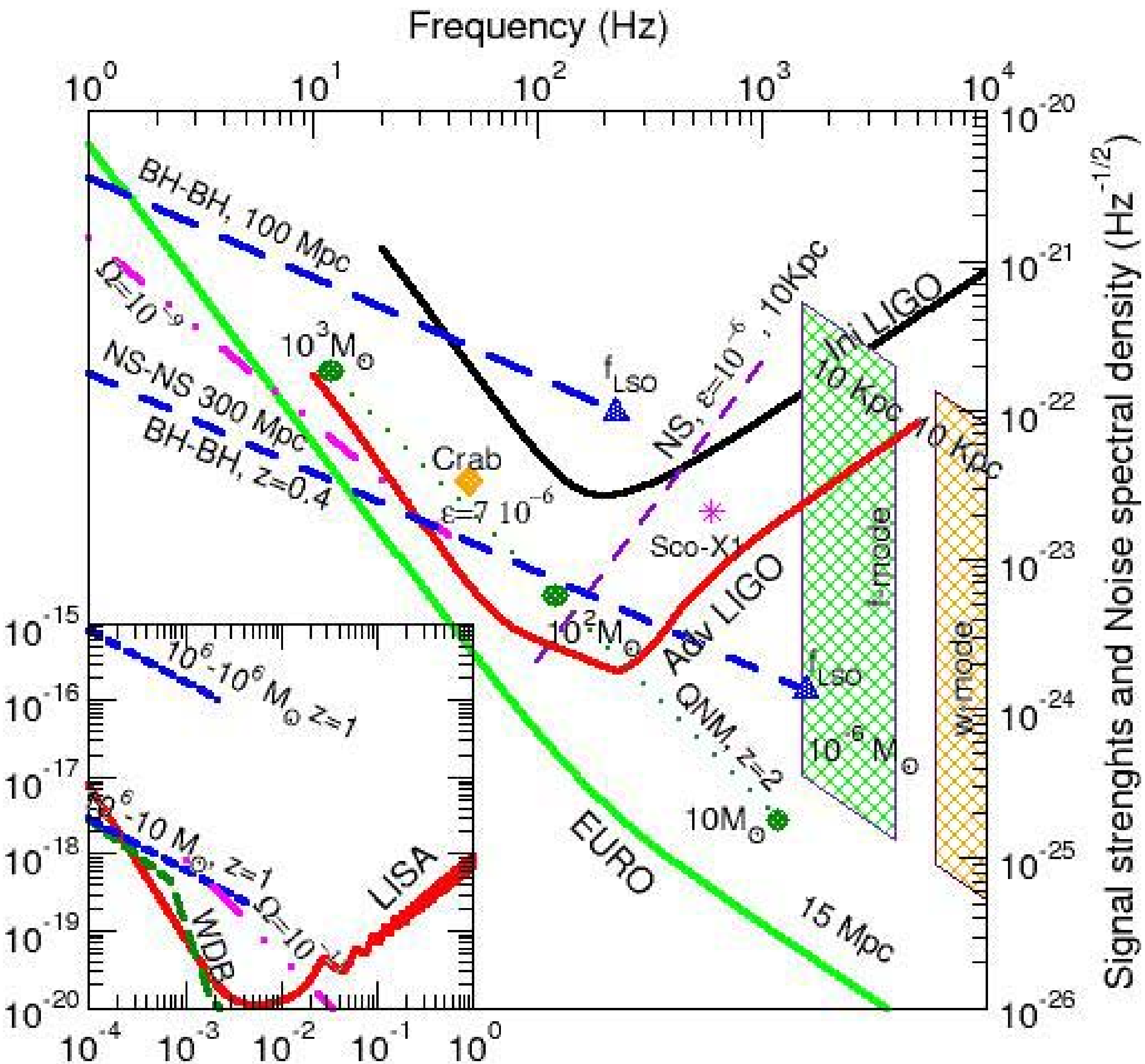


Neutron Stars Sources

- Continuous-wave (CW) radiation; expect low amplitudes, require long integration times
- Many objects with known frequency and position (pulsars), some more with known positions (X-ray sources)
- Great interest in detecting radiation: physics of such stars is poorly understood.
  - After 35 years we still don't know what makes pulsars pulse.
  - Interior properties not understood: equation of state, superfluidity, superconductivity, solid core, source of magnetic field.
  - May not even be neutron stars: could be made of strange matter!



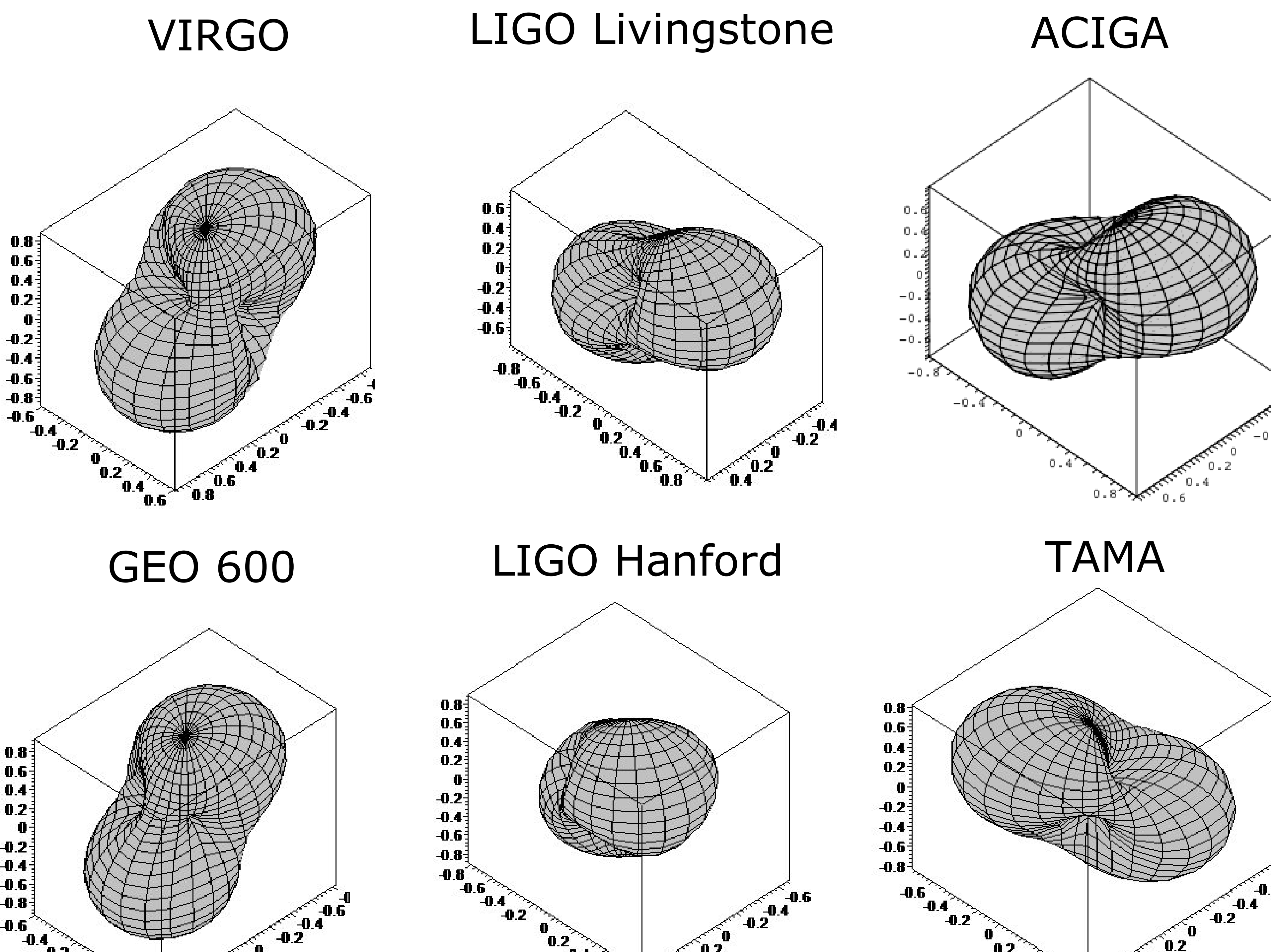
Summary of Sources



Beam Pattern Function

$$F_i(\theta_i,\phi_i) = C_i \left[\left(\frac{1+\cos^2(\theta_i)}{2} \cos(2\phi_i) \right)^2 + \cos^2(\theta_i)\sin^2(2\phi_i) \right]^{1/2},$$

- Beam pattern of a detector is the sensitivity of an antenna to un-polarized radiation as a function of the direction of the incoming wave
- (θ_i , ϕ_i) source coordinates wrt with *i*-th detector, and the factor C_i is a constant used to mimic the difference in the strain sensitivity of different antennas.
- In order to compare different detectors it is necessary to choose a single coordinate system (Θ, Φ) with respect to which we shall consider the various detector responses


VIRGO
LIGO Livingstone
ACIGA
GEO 600
LIGO Hanford
TAMA

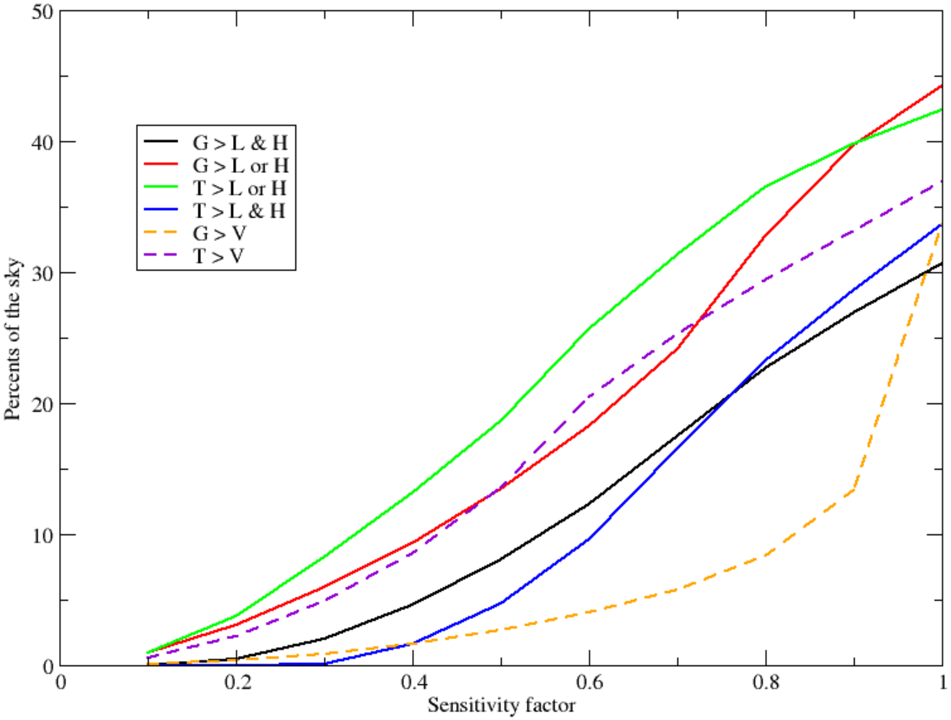
Sky Coverage – One Detector

$$A(k) = \int F_i \Theta(F_i - kF_j)\, d\Omega$$

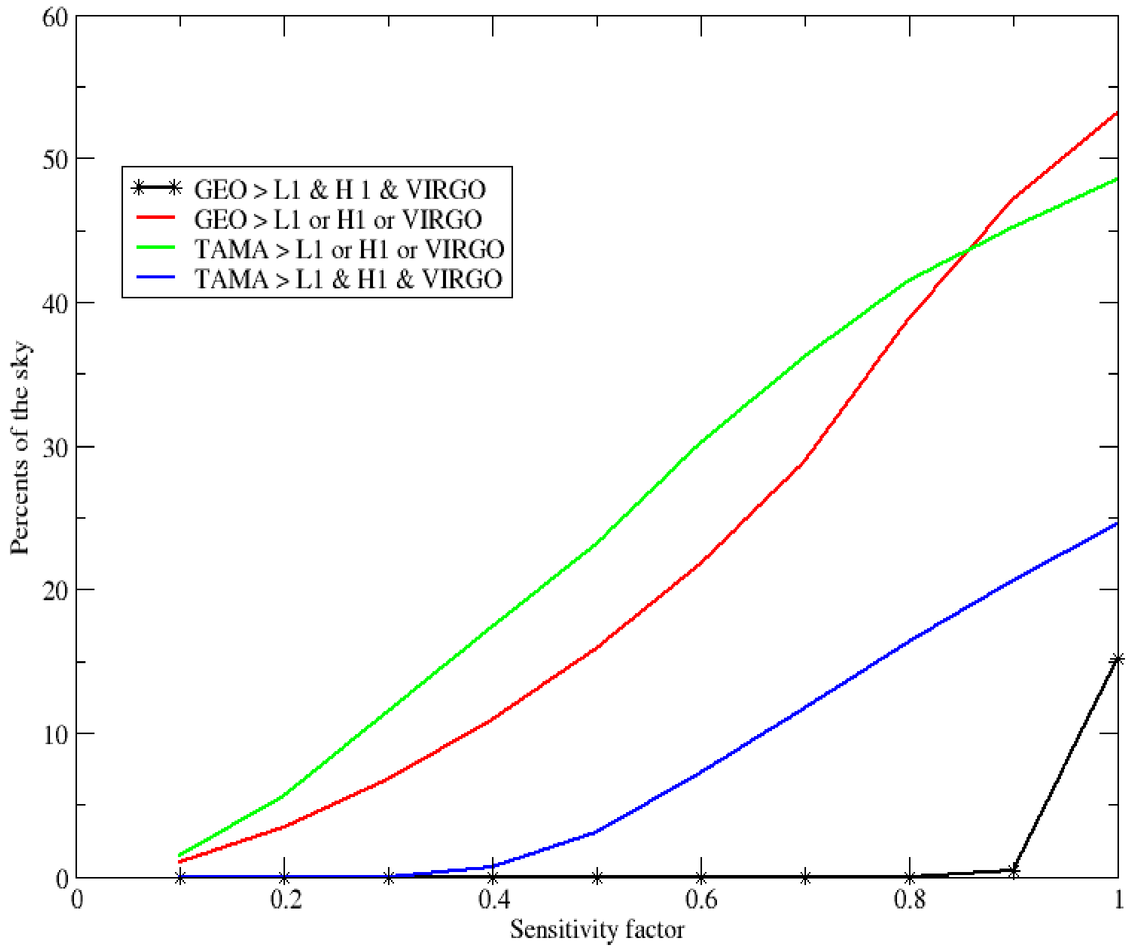
Θ is a Heaviside step-function.

$A(k)$ gives fraction of the sky where detector i is more sensitive than j.

k reflects different sensitivity of detectors.



Two or More Detectors

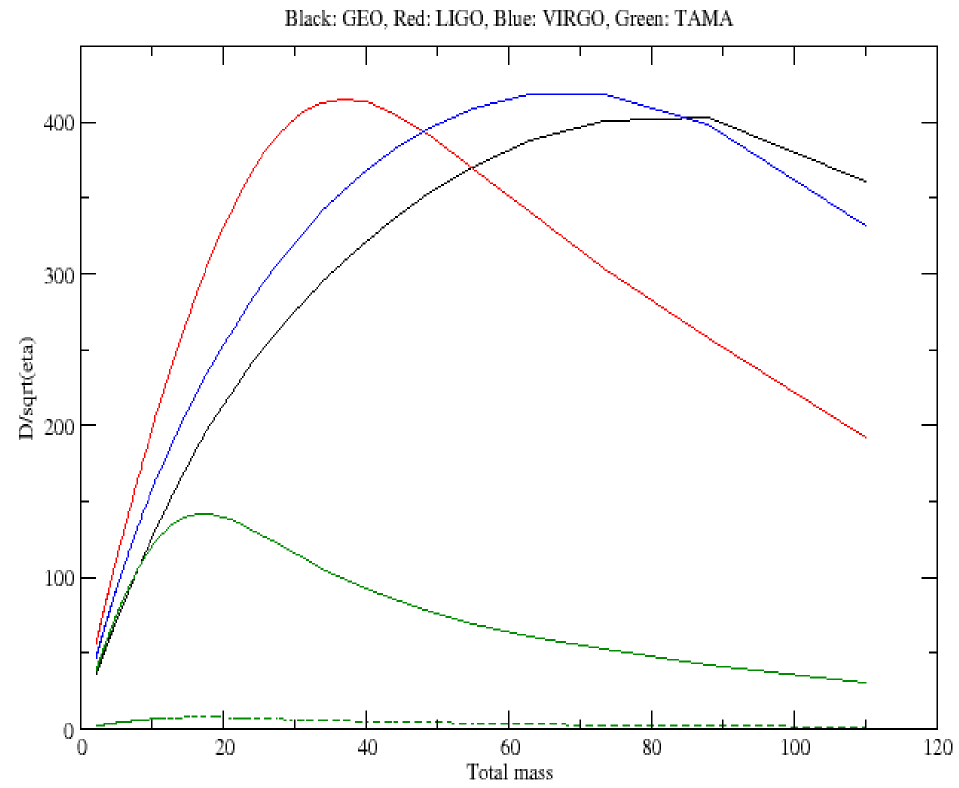


Sky Coverage for Binary Inspirals

Define sensitivity factor k using distance coverage of the two antennas:

$$k = D_i(M)/D_j(M),$$

so that $A(k)$ we have area of the sky where detector i is more sensitive than j for a specific source (in this case a binary) as a function of M.



Conclusions

1. For full coverage of the sky it is essential to have a detector in Japan and Australia
2. Small detectors have great potentials to increase sky coverage but science is extracted with detectors of comparable sensitivity
3. Possibility to have coincidence with EM counterpart with accurate sky location