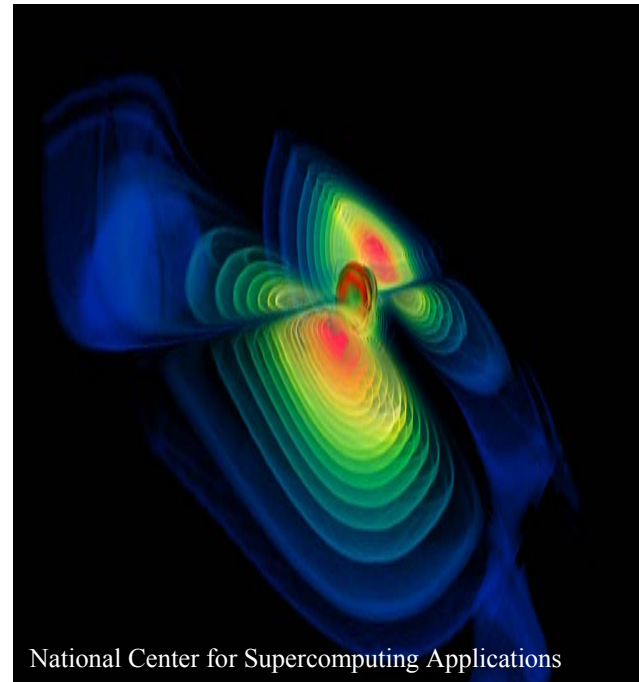


Status of LIGO

Patrick J. Sutton
LIGO-Caltech

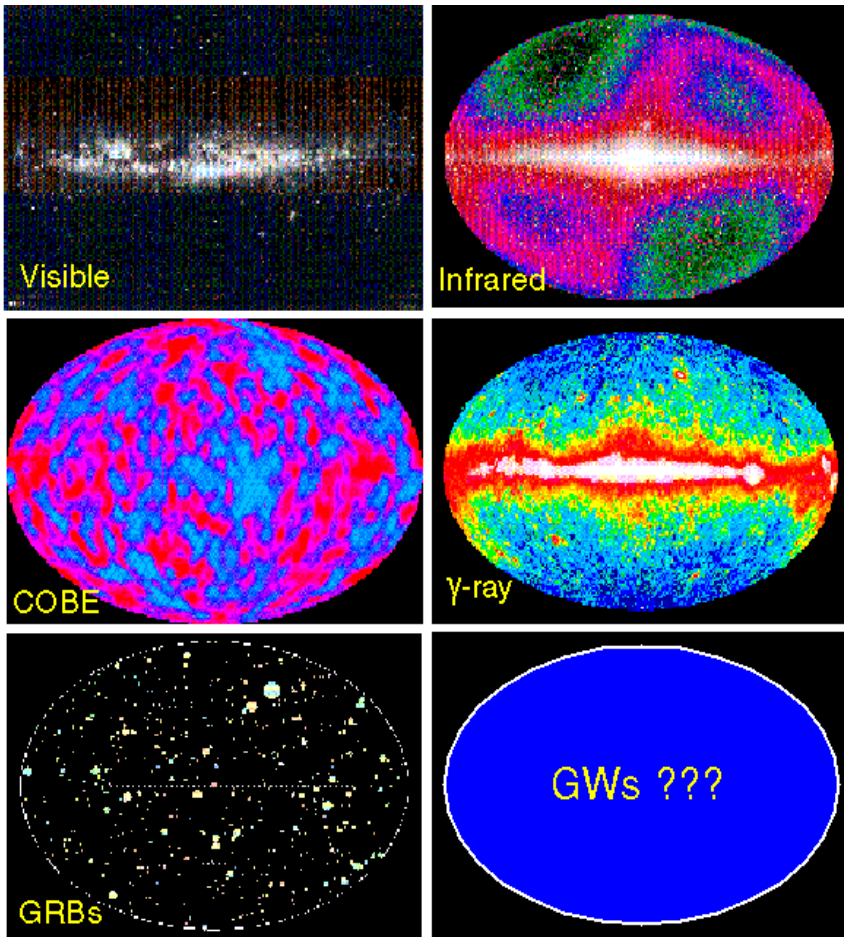


National Center for Supercomputing Applications

Outline

- Gravitational Waves
- LIGO Project
- LIGO Searches
- Searching for Gravitational–Wave Bursts
- Outlook

A New Window on the Universe



Gravitational waves provide a new and unique view on the universe.

Produced by coherent motion of bulk matter; information content is complementary to that in EM waves

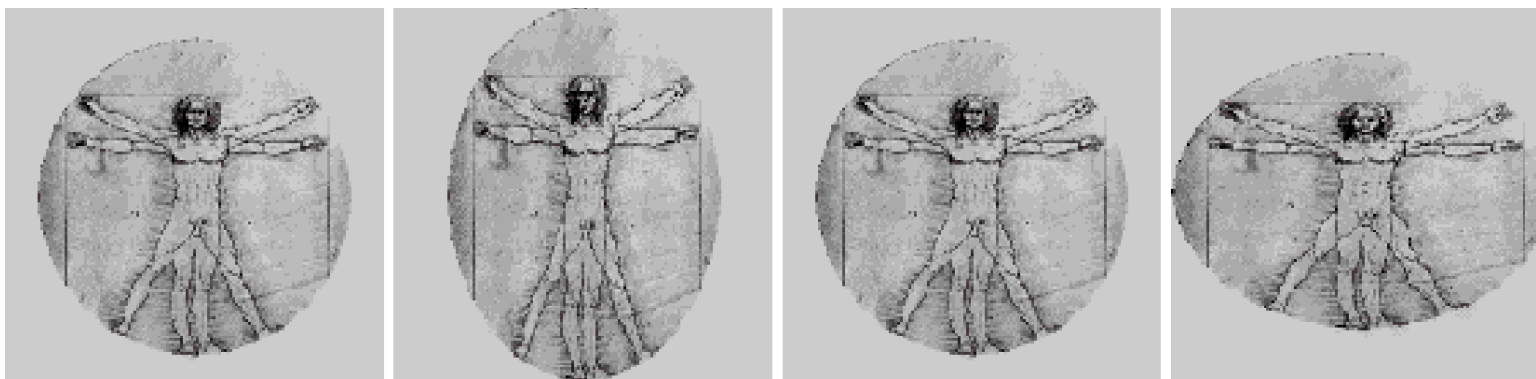
Expected signals & sources:

- » Transients: supernovae, inspiraling binaries, black-hole ringing
- » Stochastic background: big bang
- » Continuous monochromatic: pulsars

Possibility for the unexpected is very real!

Gravitational Waves

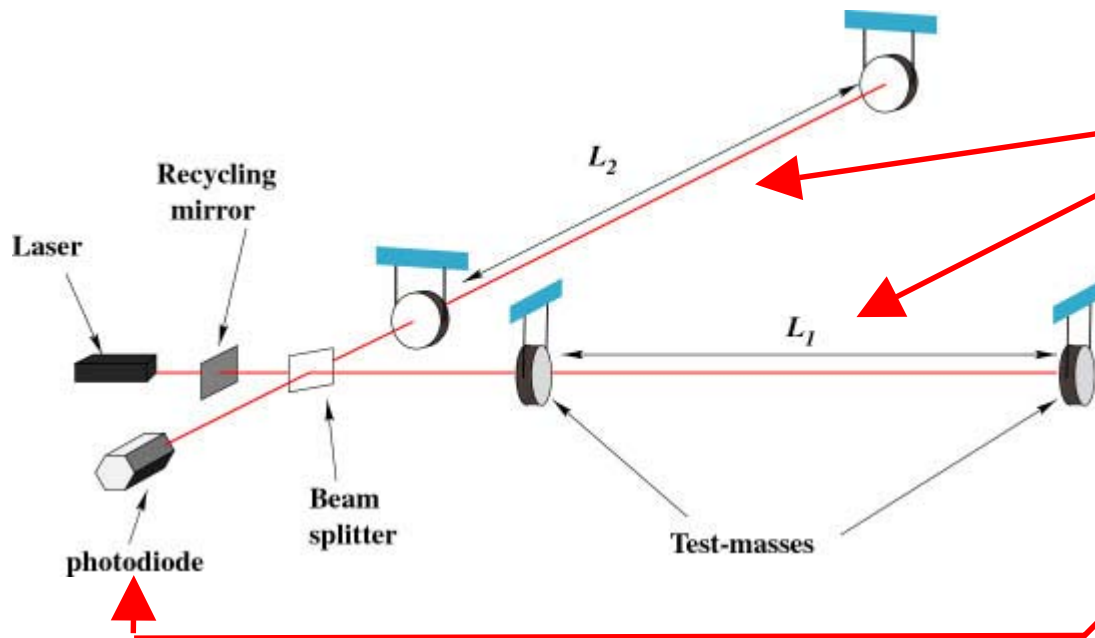
- Quadrupolar fluctuations in geometry of space.
- Effect of gravitational wave coming out of screen on da Vinci's Vitruvian Man:



- Second polarization is rotated by 45° about direction of propagation.

Interferometric GW Detectors

- A laser is used to measure the relative lengths of two orthogonal cavities (or arms).



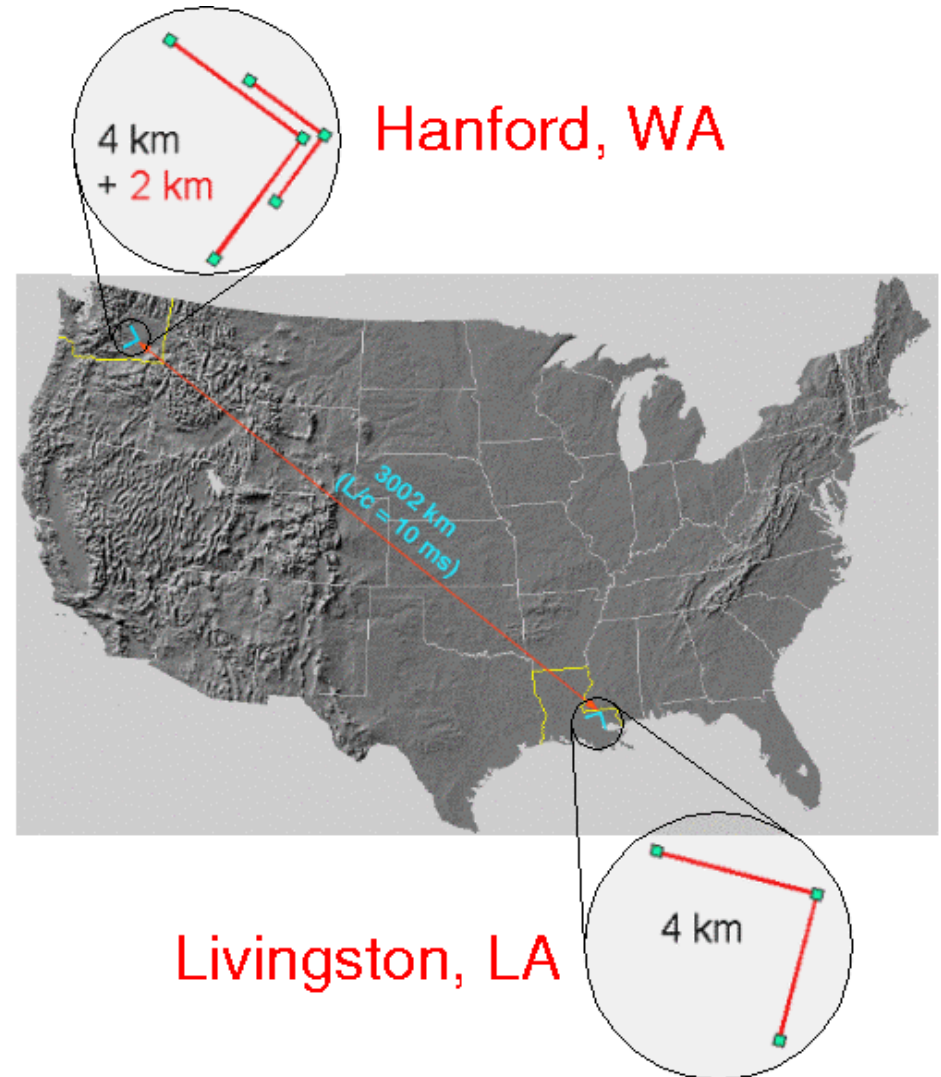
As a wave passes, the arm lengths change in different ways....

...causing the interference pattern to change at the photodiode.

- LIGO: Current technology allows one to measure $\delta L/L \sim 10^{-22}$.

The LIGO Project

- Flagship project of NSF.
- 3 detectors at 2 sites.
- First operations 1999.
- Scientific data taking runs:
 - » Aug–Sept 2002
 - » Feb-Apr 2003
 - » Oct 2003 – Jan 2004



LIGO Hanford Observatory



LIGO

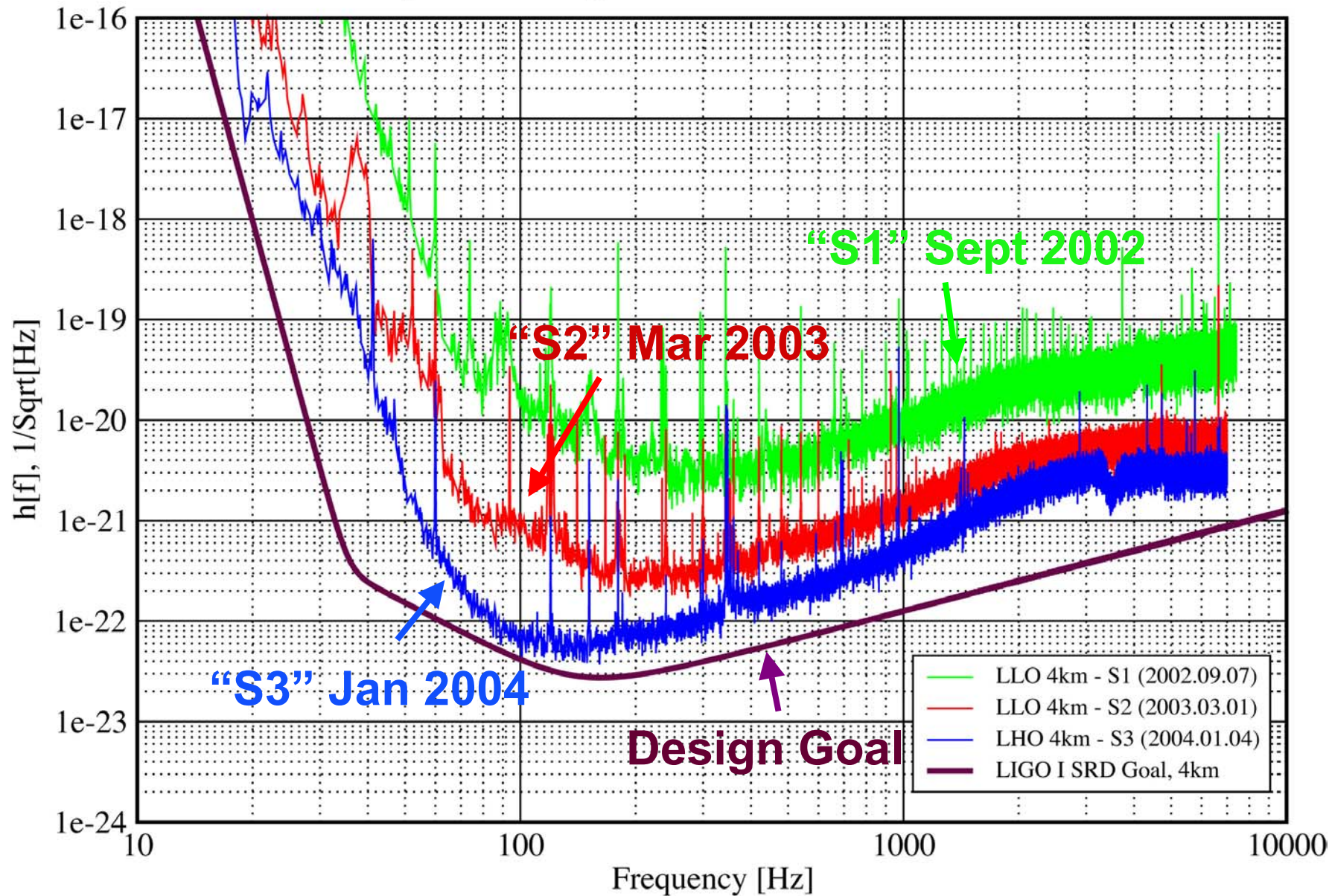
LIGO Livingston Observatory



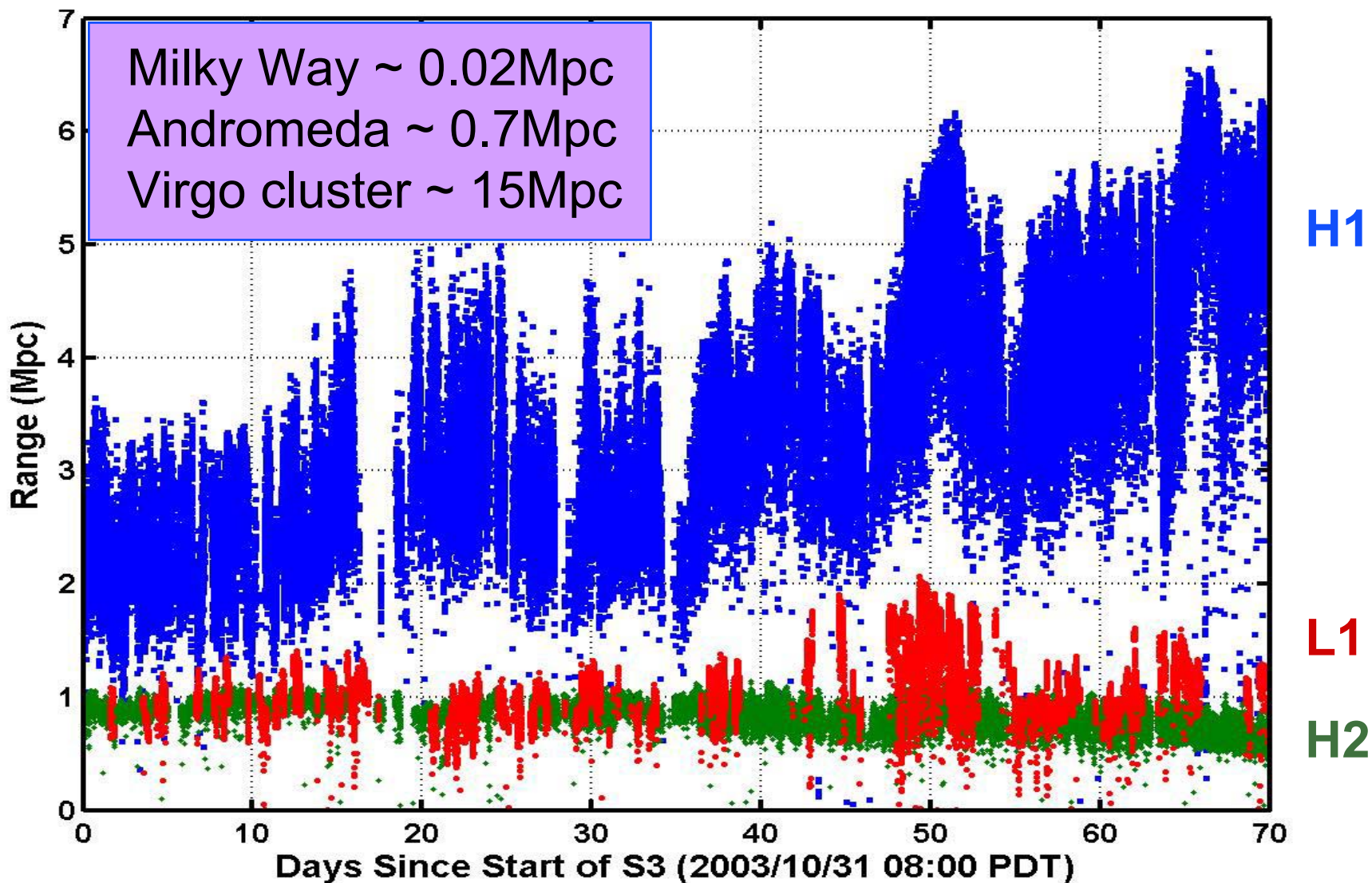
Best Strain Sensivities for the LIGO Interferometers

Comparisons among S1, S2, S3

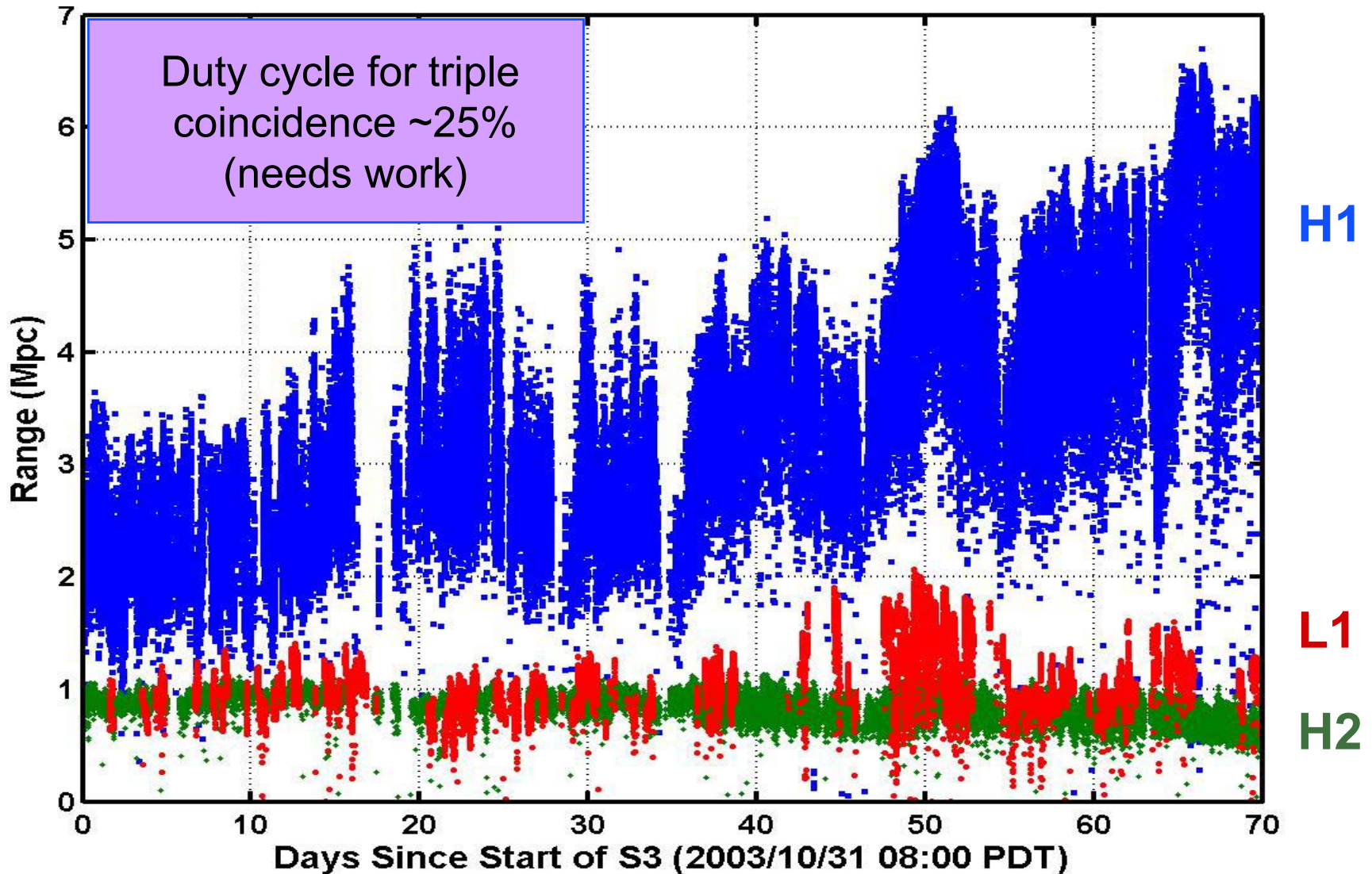
LIGO-G030548-02-E



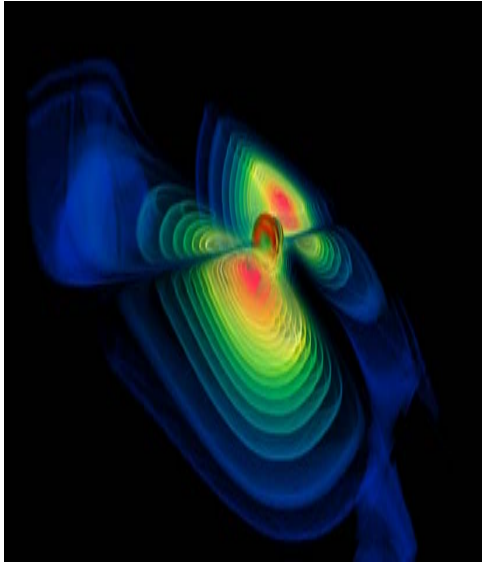
Sky-Averaged Sensitivity to Inspiring Neutron Star Binaries (S3)



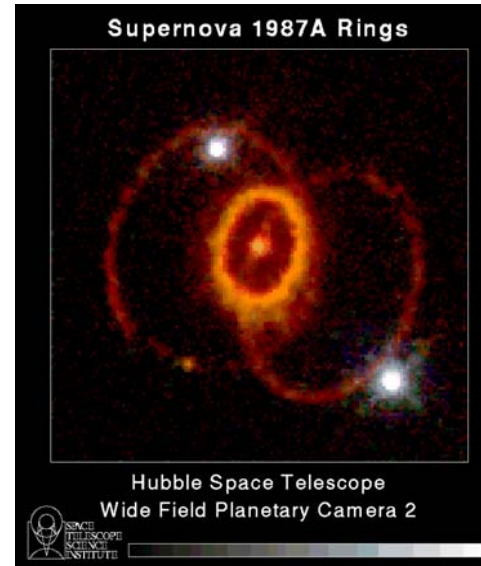
Sky-Averaged Sensitivity to Inspiring Neutron Star Binaries (S3)



Sensitivity to GW Bursts (S3)

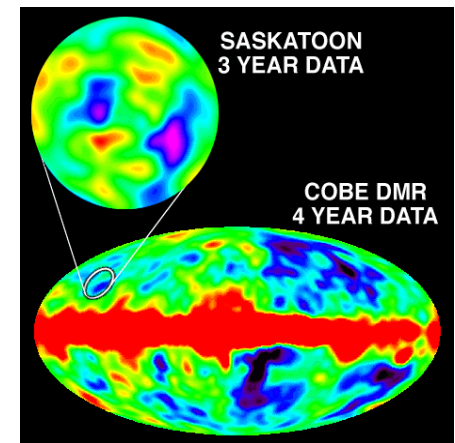
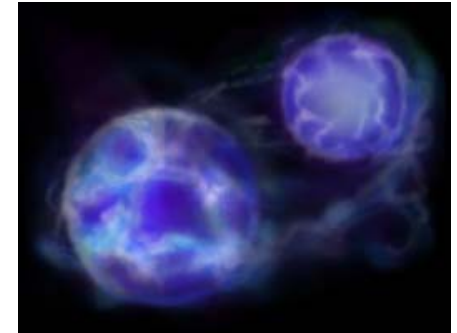


- Black-hole binary merger & ringdown ~ few Mpc



- Supernovae ~ few kpc

- Four Search Groups:
 - » Inspirals (eg, neutron-star binaries) - Shawhan
 - » Bursts (unspecified signals) - Marka
 - » Periodic (eg, pulsars)
 - » Stochastic Background (eg, big bang)
- Formal publications from S1 in press.
- S2 analysis in final stages, S3 in progress.
- Collaborative searches with other projects:
 - » GEO600
 - » TAMA300
 - » Virgo (in negotiation)



Summary

- LIGO is up and running, and approaching initial design sensitivity.
 - » Upgrades to seismic isolation & many other systems in progress
 - » Better duty cycle & sensitivity expected
- First “S1” searches conducted
 - » **No detections yet!** Set upper limits on GWs.
 - » Served as testing ground for analysis techniques.
- Further analyses in progress
 - » S2, S3 data: 10-100 times more sensitive, ~4 times longer than S1.
- International partnerships are strengthening
 - » TAMA300, GEO600, Virgo

Looking Ahead

- One year of integrated data at design sensitivity by the end of 2006.
- Advanced detectors with dramatically improved sensitivity in 2007+.
 - » Advanced LIGO is under active consideration by the National Science Board
- First detections: ???