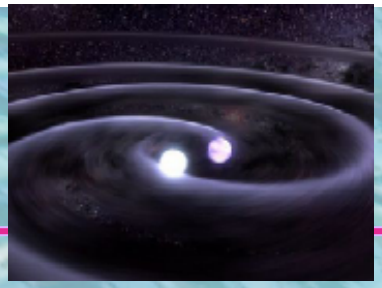


LIGO detectors: past, present and future

Gabriela González,
Louisiana State University
For the LIGO Scientific Collaboration and the Virgo Collaboration

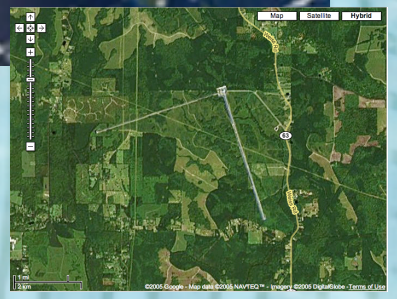
LIGO-G1100555

The LIGO project

Hanford, WA
4km, 2km
H1, H2 ifos

Lunch time at LSC Summit

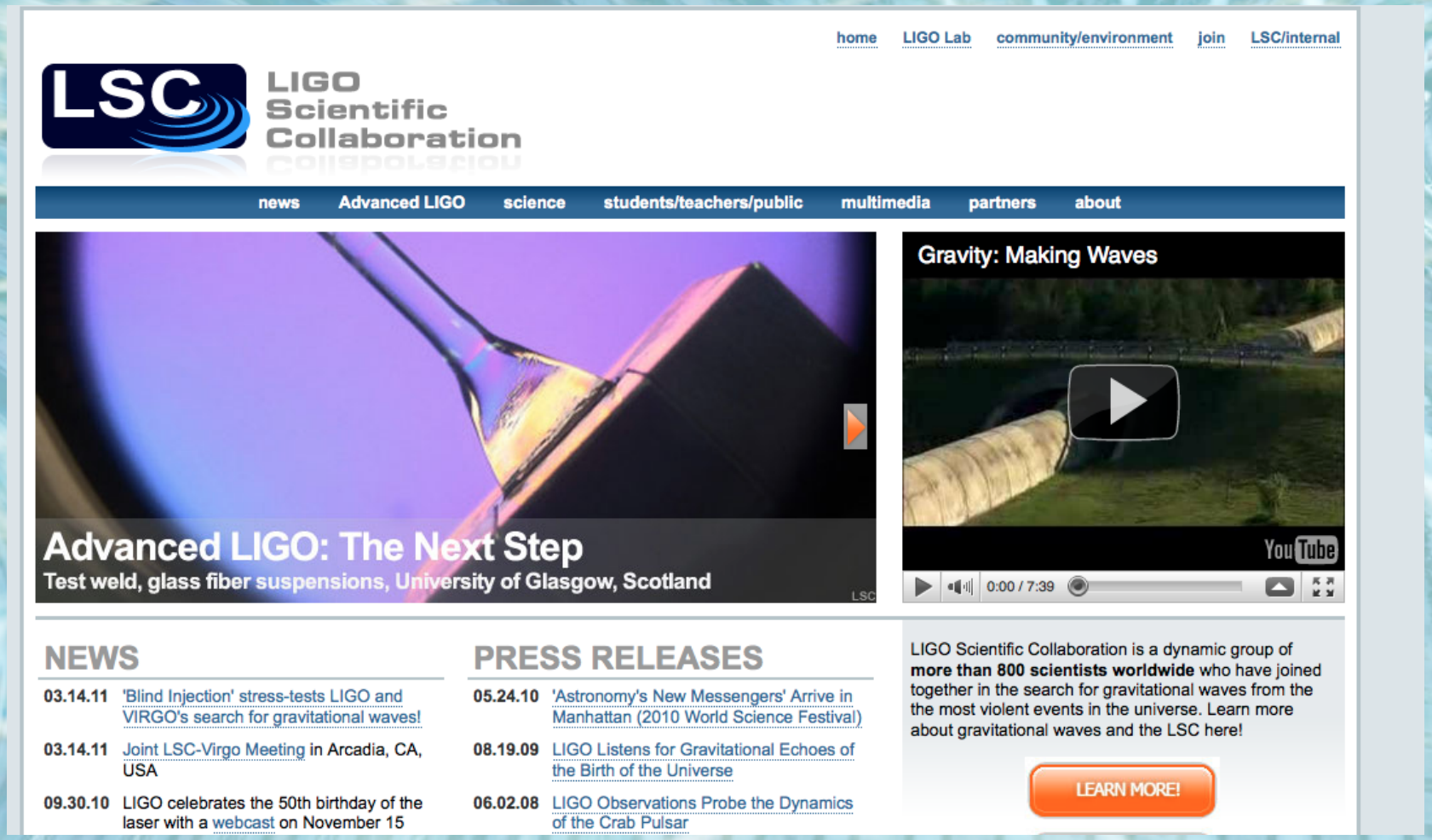
Livingston, LA
4 km ifo L1



800+ people in US, Europe, Asia and Australia
working on the experiment and looking at the data:
LIGO Scientific Collaboration
www.ligo.org

LIGO Scientific Collaboration

www.ligo.org


home
LIGO Lab
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LSC/internal
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science
students/teachers/public
multimedia
partners
about
Advanced LIGO: The Next Step
Test weld, glass fiber suspensions, University of Glasgow, Scotland
Gravity: Making Waves
0:00 / 7:39
NEWS
03.14.11 'Blind Injection' stress-tests LIGO and VIRGO's search for gravitational waves!
03.14.11 Joint LSC-Virgo Meeting in Arcadia, CA, USA
09.30.10 LIGO celebrates the 50th birthday of the laser with a webcast on November 15
PRESS RELEASES
05.24.10 'Astronomy's New Messengers' Arrive in Manhattan (2010 World Science Festival)
08.19.09 LIGO Listens for Gravitational Echoes of the Birth of the Universe
06.02.08 LIGO Observations Probe the Dynamics of the Crab Pulsar
LIGO Scientific Collaboration is a dynamic group of more than 800 scientists worldwide who have joined together in the search for gravitational waves from the the most violent events in the universe. Learn more about gravitational waves and the LSC here!
LEARN MORE!

Past/present GW network

LIGO Hanford Observatory
H1: 4km arms
H2: 2km arms

10 ms

LIGO Livingston Observatory
L1: 4km arms

GEO600
G1: 600m arms

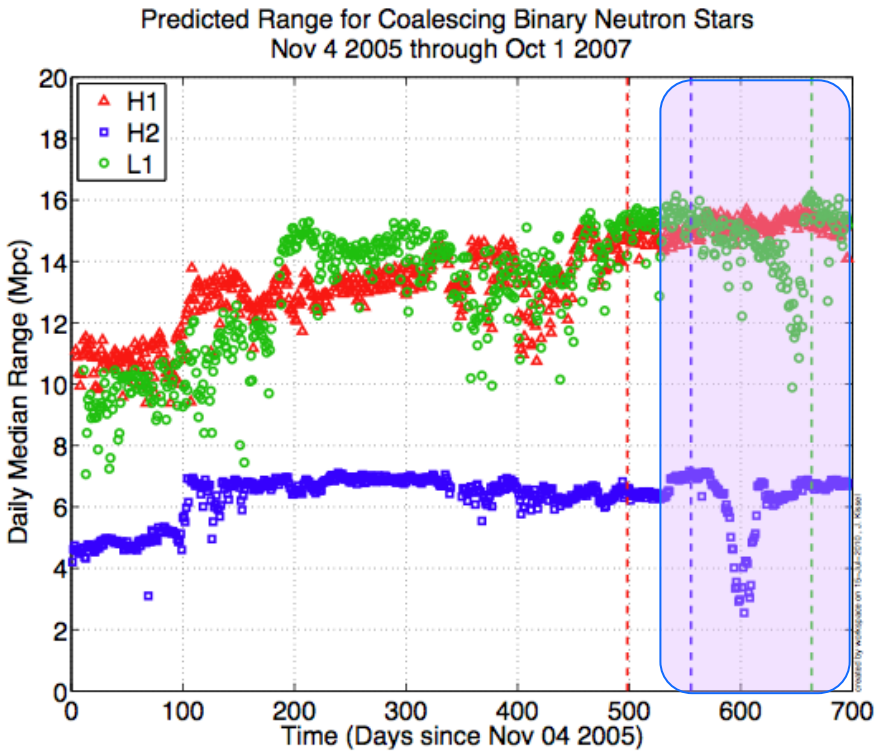
Virgo
V1: 3km arms

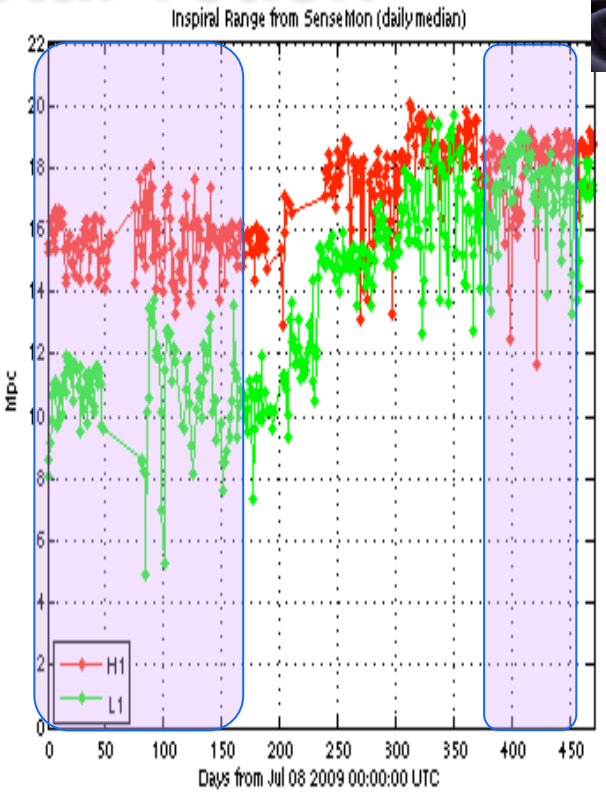
TAMA300
T1: 300m arms

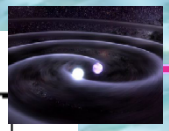
AIGO
cornerstatio

world map credit: NASA's Earth Observatory

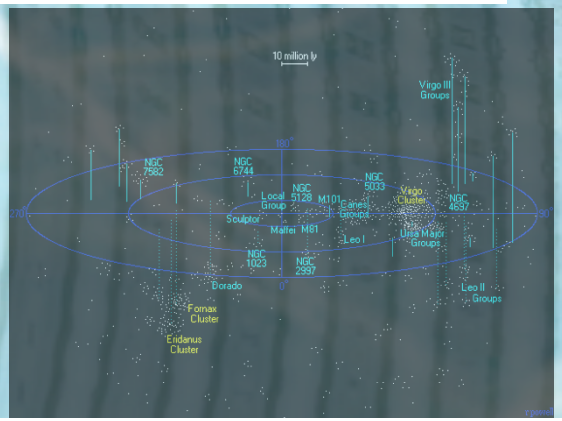
Recent past: binary neutron star reach







Sensitivity to coalescences in Virgo cluster: thousands of galaxies!

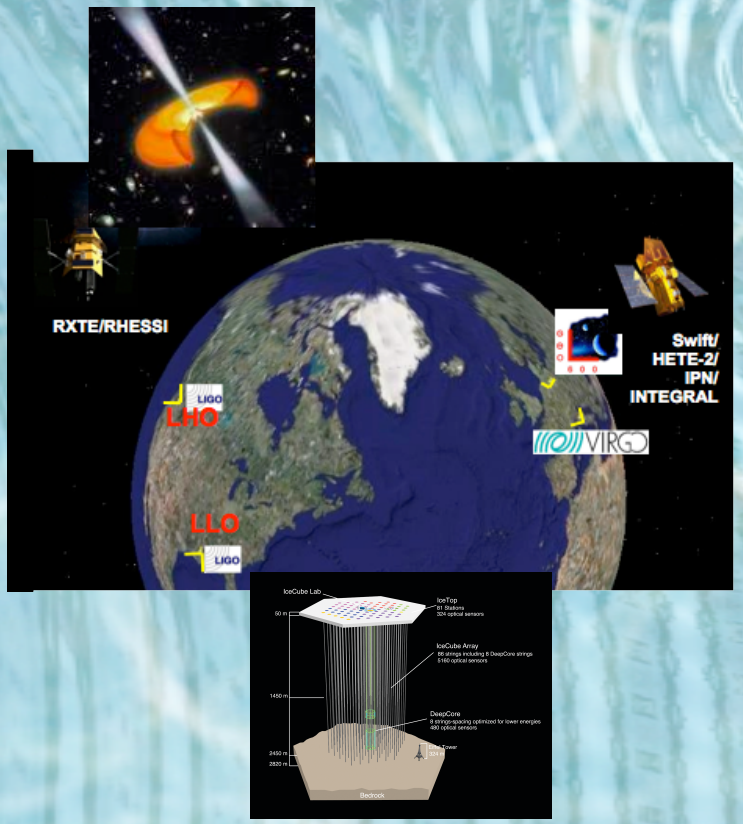


http://www.atlasoftheuniverse.com/virgo.html

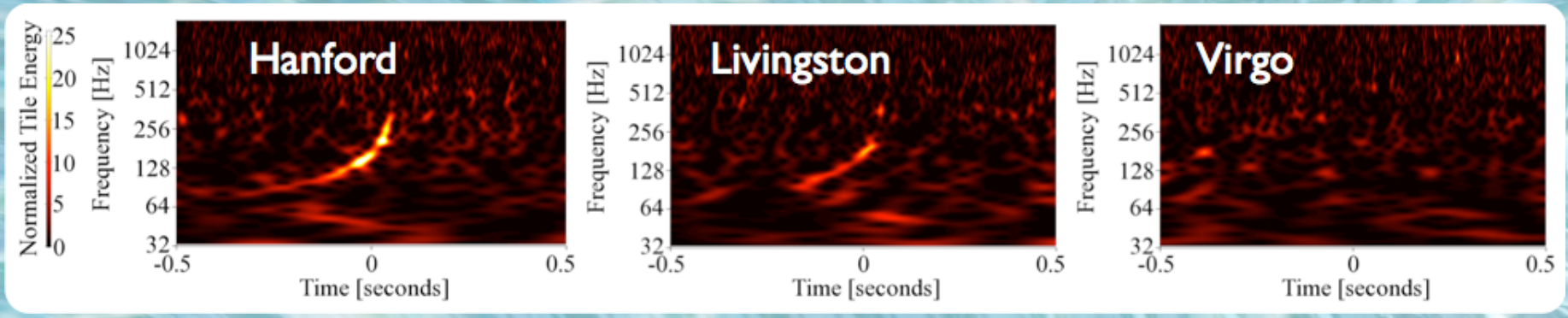
Recent past effort: Multi messenger astronomy

LSC/Virgo current agreements with:

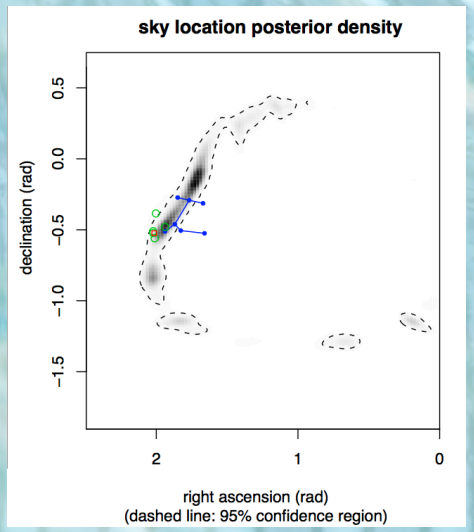
- γ-rays: SWIFT, Fermi GBM, LAT
- X-rays: RXTE
- Neutrinos: Antares, IceCube
- Wide-field Optical: QUEST, ROTSE, TAROT, Pi of theSky, SkyMapper, PTF
- Radio: LOFAR



Recent past results: An experiment on detection



- Sept 16, 2010: A candidate signal detected in HLV network!
- Most likely position: Canis Major; consistent with d=20-60 Mpc
- Signal sent at T+42min to ROTSE, TAROT, Skymapper, Zadko) and the Swift X-ray space telescope
- March, 2011: NOT a signal – a blind injection



A network in action!

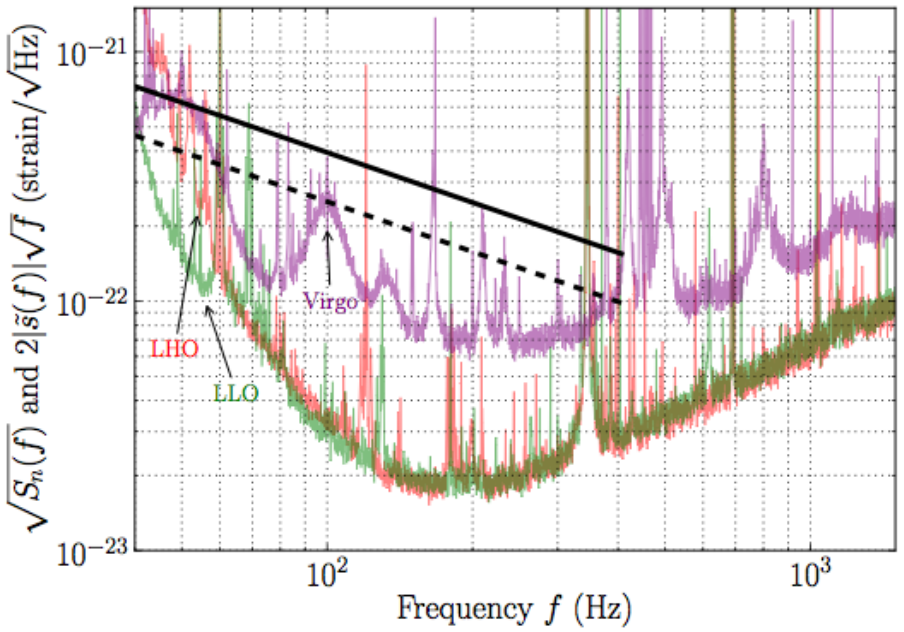
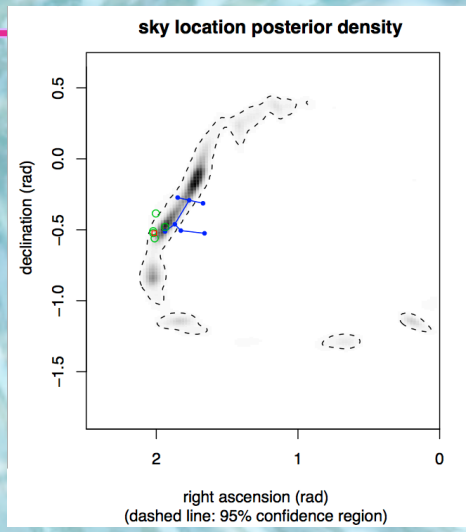
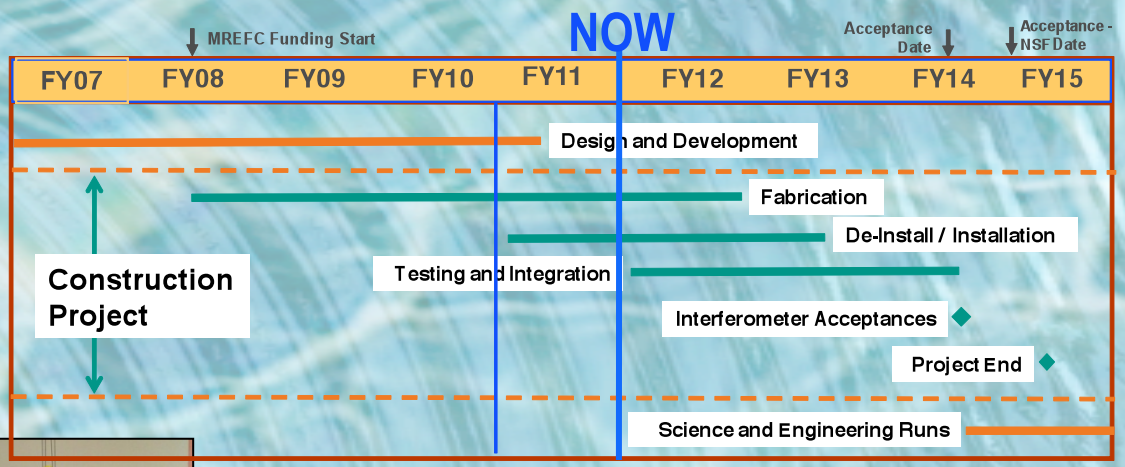


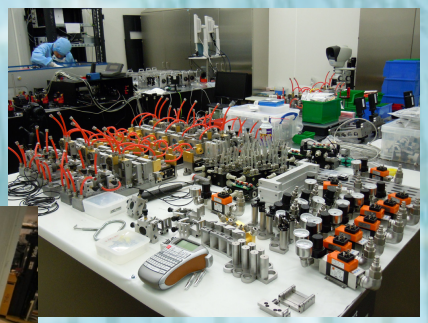
FIG. 1: Detector strain amplitude spectrum around the time of the observed event: LHO in red, LLO in green and Virgo in magenta. At these noise levels, an optimally located and oriented (5,5)$M_\odot$ binary would give a matched-filter signal-to-noise ratio (SNR) of 8 at distances of 120, 130 and 30 Mpc in LHO, LLO and Virgo respectively. The diagonal lines show the strength of binary coalescence signals observed in the LHO (solid) and LLO (dashed) detectors with SNRs of 15 and 10, respectively, as explained in the text.

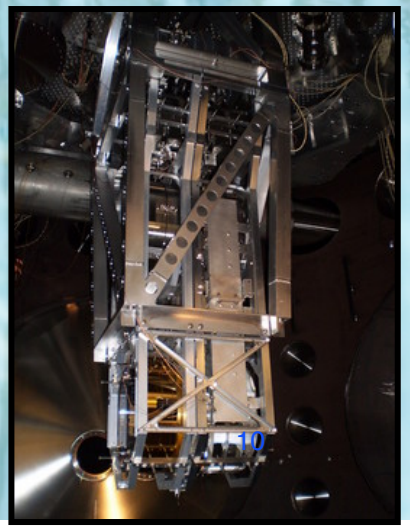


Present: Advanced LIGO detectors

Funding in place, installation already in progress, end of construction in 2015.







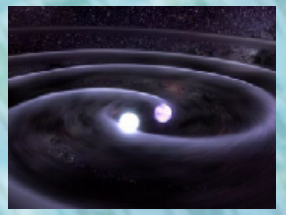
Future: Science with Advanced LIGO detectors

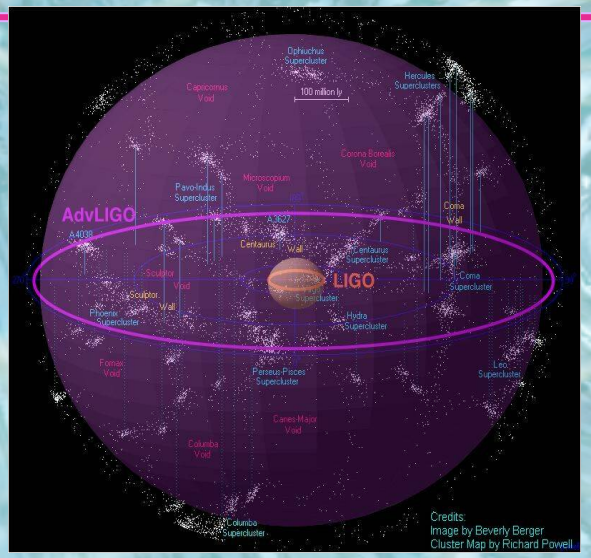
Neutron Star Binaries:

Initial LIGO: ~15 Mpc → rate ~1/50yrs

Advanced LIGO: ~ 200 Mpc

Realistic rate ~ 40/year !

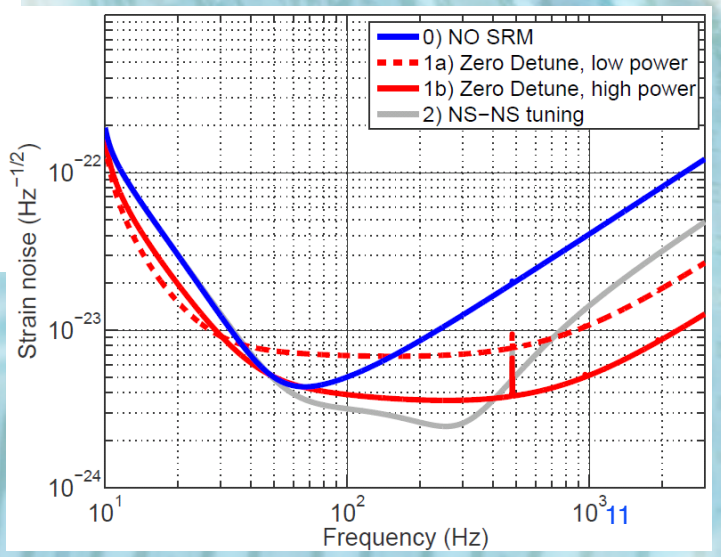




Class. Quant. Grav. **27**, 173001 (2010)

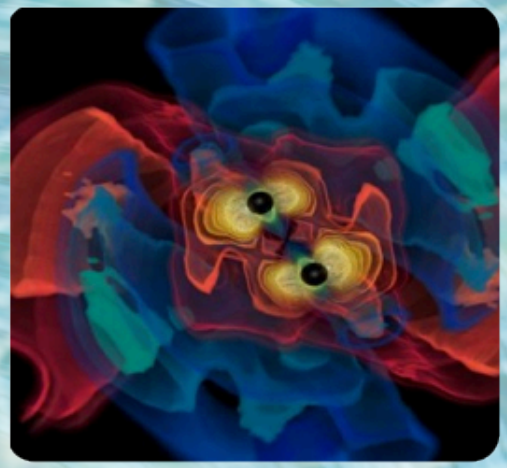
Table 5. Detection rates for compact binary coalescence sources.

IFO	Source[a]	$\dot{N}_{low}$ yr^{-1}	$\dot{N}_{re}$ yr^{-1}	$\dot{N}_{high}$ yr^{-1}	$\dot{N}_{max}$ yr^{-1}
Initial	NS–NS	2×10^{-4}	0.02	0.2	0.6
	NS–BH	7×10^{-5}	0.004	0.1	
	BH–BH	2×10^{-4}	0.007	0.5	
	IMRI into IMBH			<0.001[b]	0.01[c]
	IMBH-IMBH			10^{-4}[d]	10^{-3}[e]
Advanced	NS–NS	0.4	40	400	1000
	NS–BH	0.2	10	300	
	BH–BH	0.4	20	1000	
	IMRI into IMBH			10[b]	300[c]
	IMBH-IMBH			0.1[d]	1[e]



Detections are in our near future!

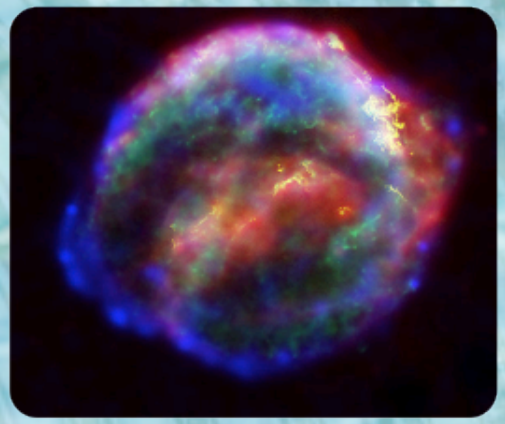
GW sources: not just binary systems!



Credit: AEI, CCT, LSU

Coalescing Binary Systems

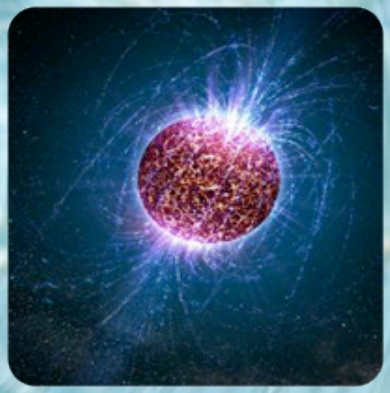
Neutron Stars, Black Holes



Credit: Chandra X-ray Observatory

'Bursts'

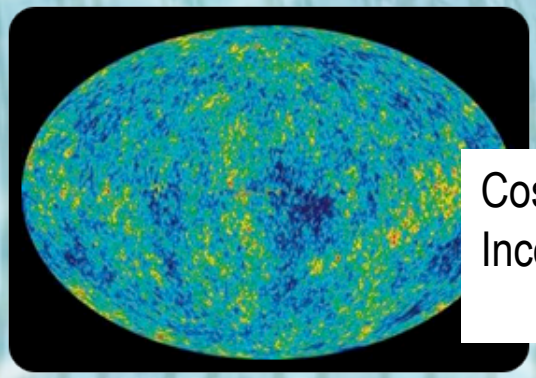
Core collapse SN, cosmic strings, ???



Casey Reed, Penn State

Continuous Sources

Spinning neutron stars, crustal deformations, accretion



NASA/WMAP Science Team

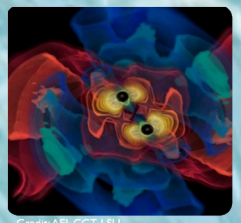
Cosmic GW background

Cosmological background
Incoherent background

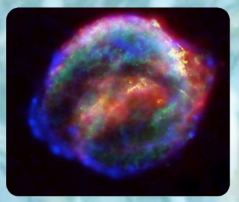
With increasing sensitivity, increasing kinds of sources!

LSC working groups: past, present and future

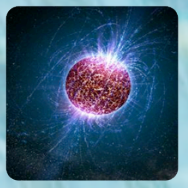
- Data analysis groups:
  - Burst sources
  - Compact Binary systems
  - Stochastic Background
  - Continuous waves
- Instrumental working groups:
  - Detector characterization
  - Light sources
  - Quantum Noise
  - Suspensions, Seismic Isolation
  - Optics
  - Advanced Interferometer configuration :


Credit: AEI, CCT, LSU

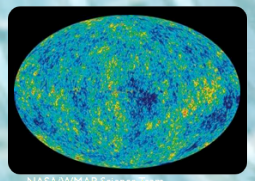
Coalescing Binary Systems
Neutron Stars, Black Holes


Credit: Chandra X-ray Observatory

'Bursts'
asymmetric core collapse supernovae, cosmic strings ???

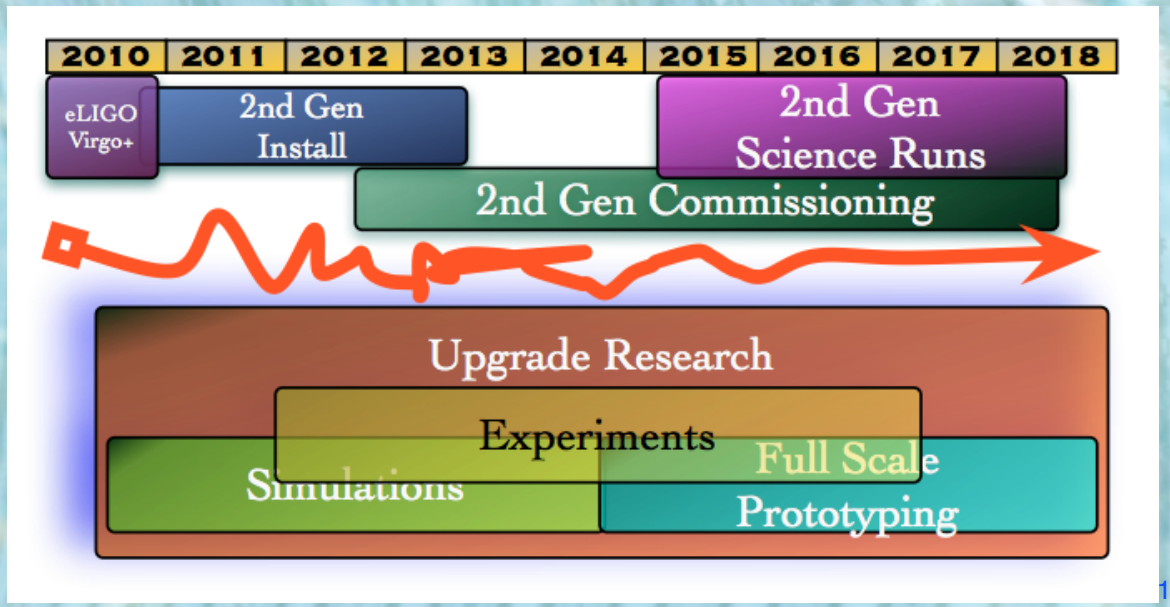

Casey Reed, Penn State

Continuous Sources
Spinning neutron stars crustal deformations, accretion


NASA/WMAP Science Team

Cosmic GW background
stochastic, incoherent background

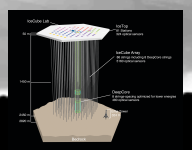
12

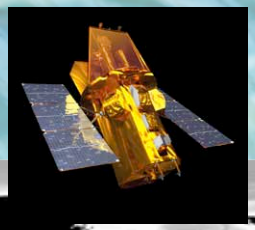


Future: Science with international, MM network

LIGO Hanford Observatory
H1, H2: 4km arms

LIGO Livingston Observatory
L1: 4km arms



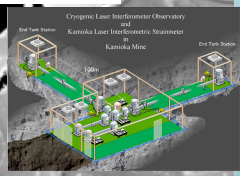


ET !

GEO600
G1: 600m arms

Virgo
V1: 3km arms

LCGT
3km arms



LIGO Australia?
A1: 4km arms