

GWIC

Gravitational Wave International Committee

SCIENCE CASE FOR 3G

VICKY KALOGERA (NORTHWESTERN)

B.S. SATHYAPRAKASH (PENN STATE AND CARDIFF)

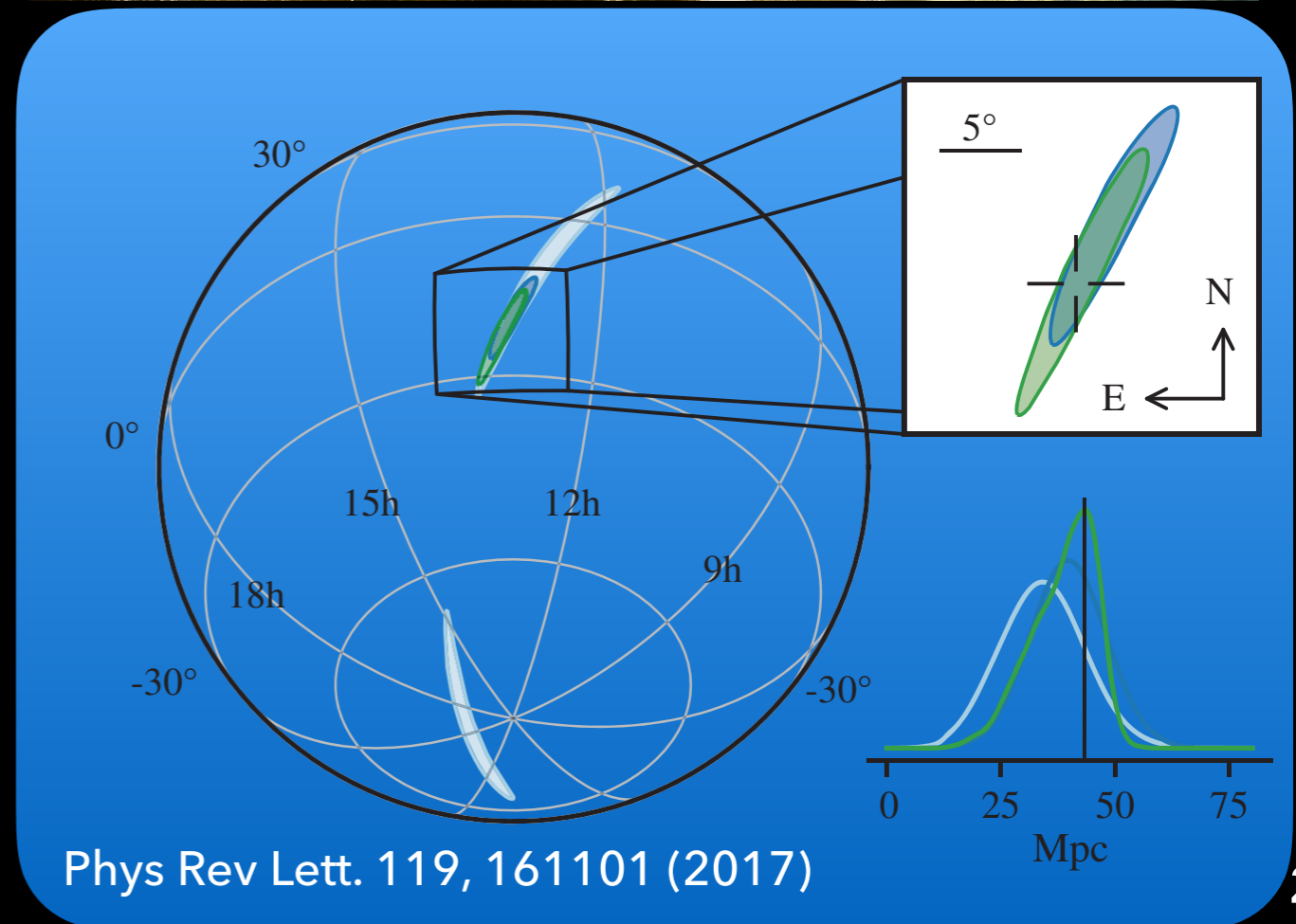
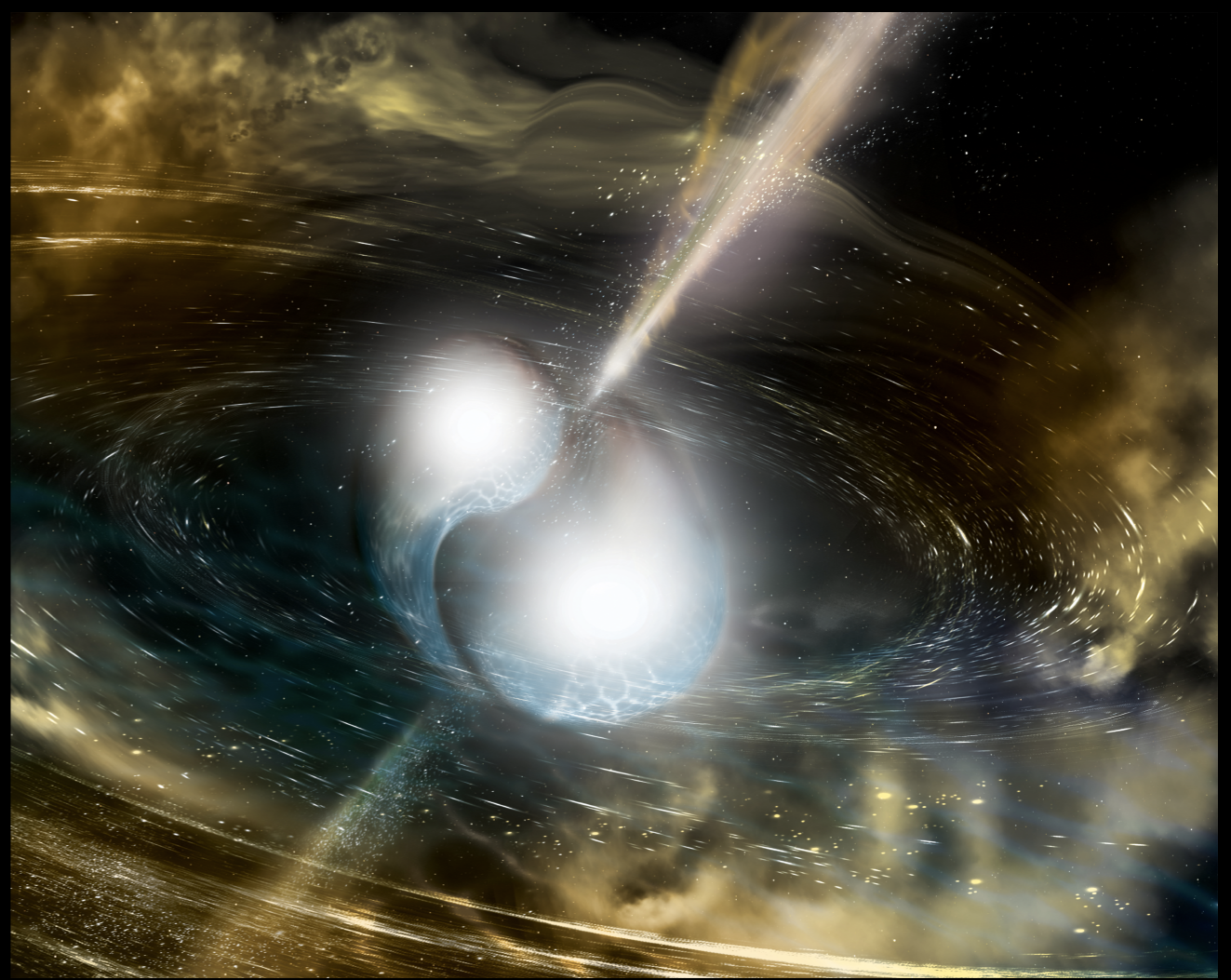
ON BEHALF OF

GWIC 3G COMMITTEE & 3G SCIENCE CASE TEAM



CONTEXT

- ❖ gravitational wave observations have ushered in a new era of scientific discovery
- ❖ will advance the exploration of extremes of astrophysics and gravity
- ❖ solve open questions in fundamental physics and astronomy
- ❖ provide insights into most powerful events in the Universe
- ❖ boost the impact of multi-messenger astronomy
- ❖ likely to reveal new objects and phenomena



WHY 3G, WHY NOW?

- ❖ LIGO and Virgo both have facility-imposed limits on sensitivity
 - ❖ at best x 3 improvements in strain sensitivity, relative to advanced detectors, possible; gravity gradient limits sensitivity at < 10 Hz
 - ❖ there is a compelling case to build detectors that can observe deeper into the cosmos
- ❖ LIGO and Virgo took ~ 15 years each for initial and advanced configuration
 - ❖ vision to build a facility that's good ~ 30 -40 yrs after construction
 - ❖ need to explore/understand funding scenarios in different regions
- ❖ to succeed it is critical to have a common/shared global vision
 - ❖ articulate for the excellent science we know is possible from a strong platform

SCOPE

- ❖ to fully exploit the GW window we will need new facilities
- ❖ GWIC formed a subcommittee to develop a vision for the next generation of ground-based detectors
- ❖ one of the charges to the GWIC subcommittee is:
 - ❖ *“commission a study of ground-based gravitational wave science from the global scientific community, investigating potential science vs. architecture vs. network configuration vs. cost trade-offs, ...”*
 - ❖ GWIC subcommittee has constituted five 3G subgroups:
 - ❖ (1) Science Case Team (3G-SCT), (2) R&D Coordination, (3) Governance, (4) Agency Interfacing, (5) Community Networking
- ❖ the Science Case will be developed by an international consortium of scientists under the leadership of the 3G-SCT

OPEN CALL IN JULY 2017 TO HELP DEVELOP 3G SCIENCE CASE ...



(David) Ian
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Up to date



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RESULTED IN A MEMBERSHIP OF 212 AND STILL GROWING ...



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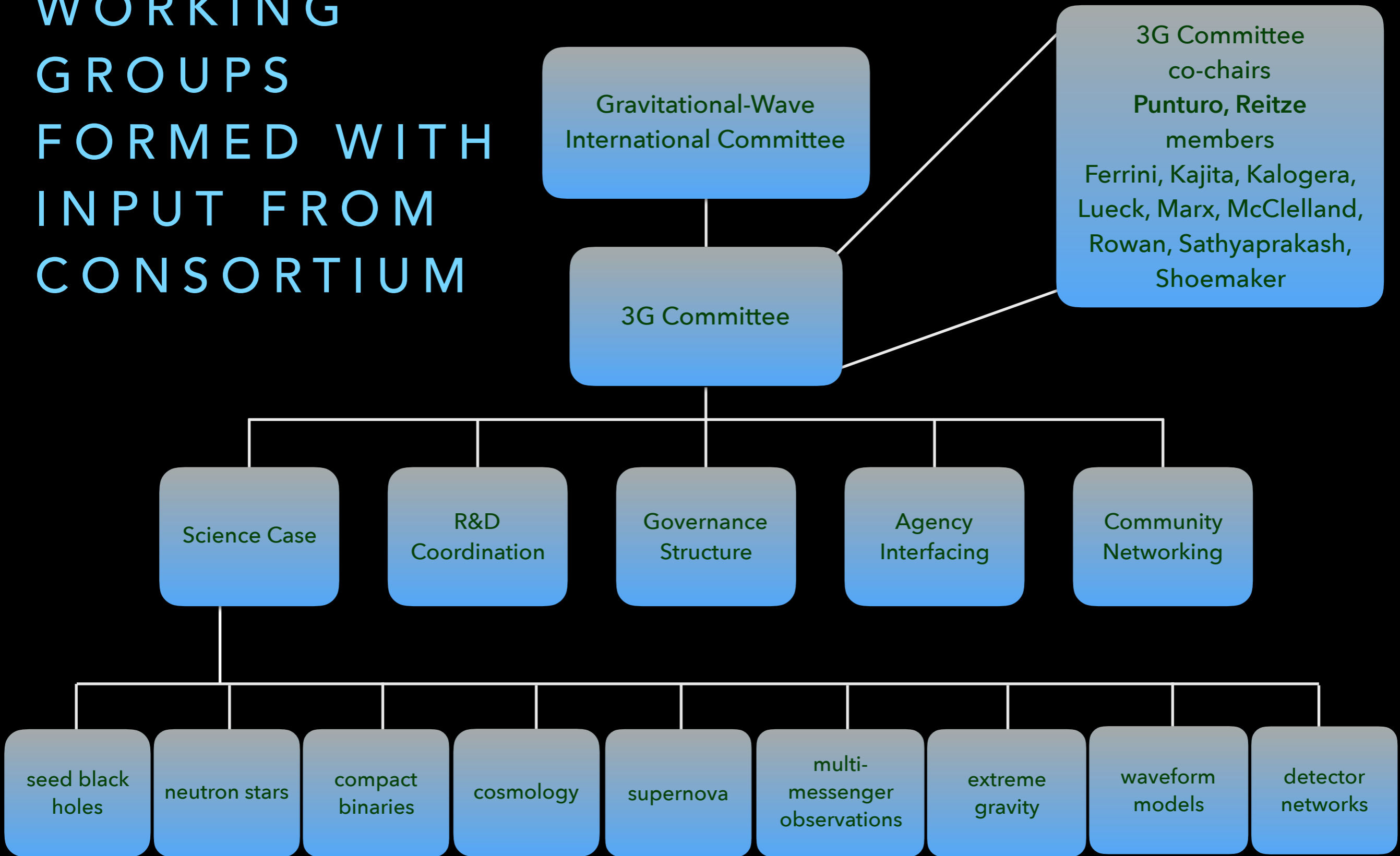


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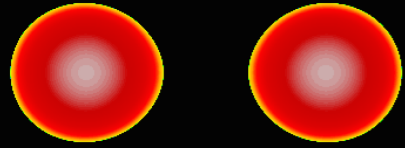
WORKING GROUPS FORMED WITH INPUT FROM CONSORTIUM



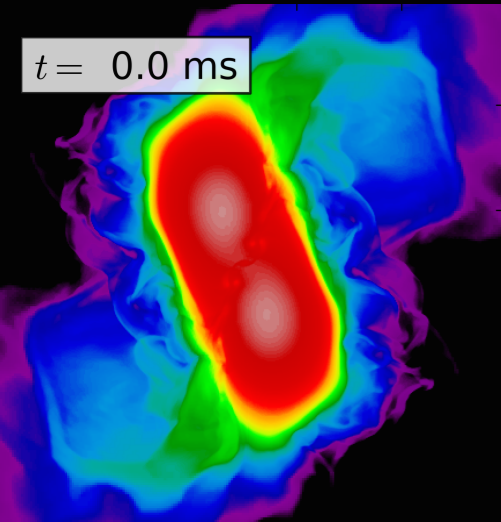
for membership of committees see: <https://gwic.ligo.org/3Gsubcomm/>

KEY QUESTIONS THAT
MOTIVATE THE SCIENCE
CASE

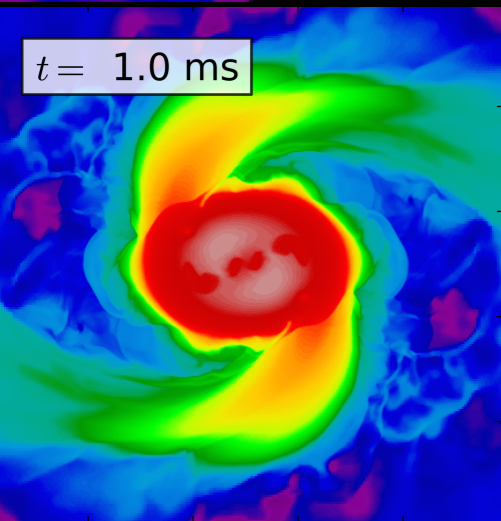
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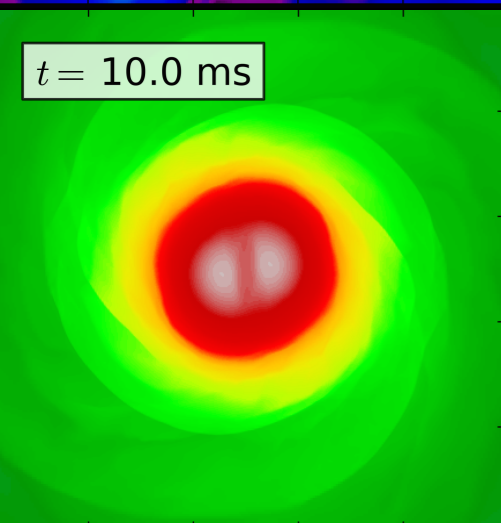
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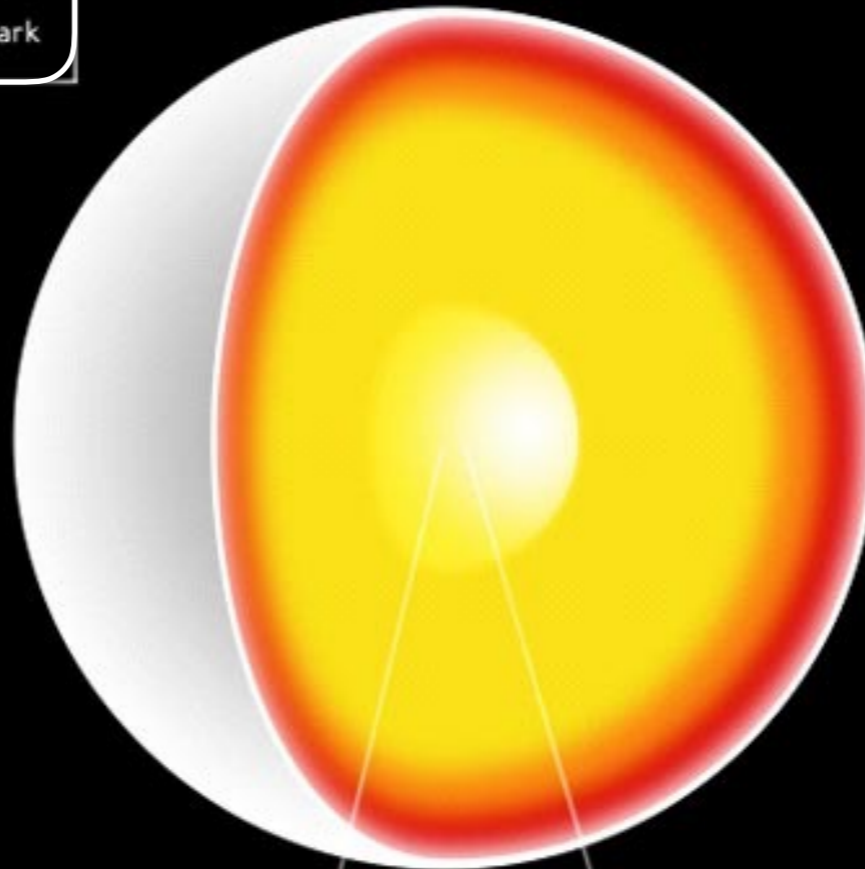


NEUTRON STARS

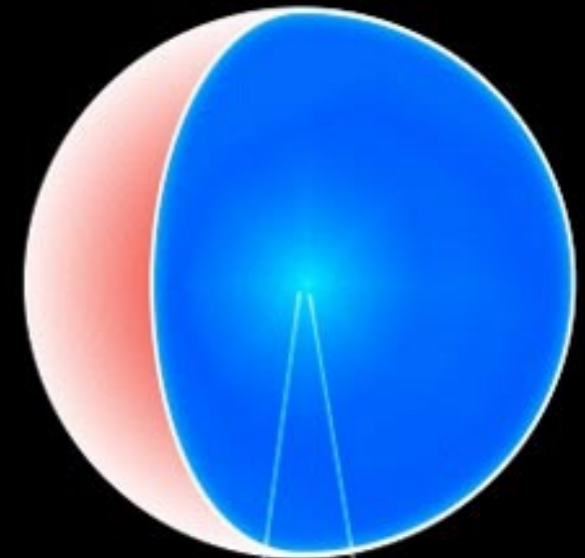
PAPA, REDDY, ROSSWOG



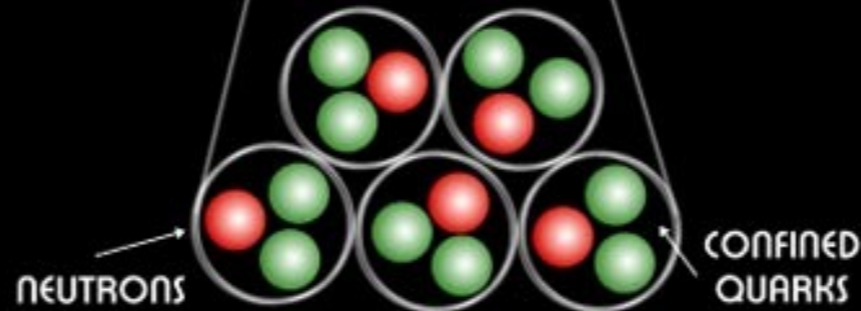
Neutron Star



Strange Quark Star

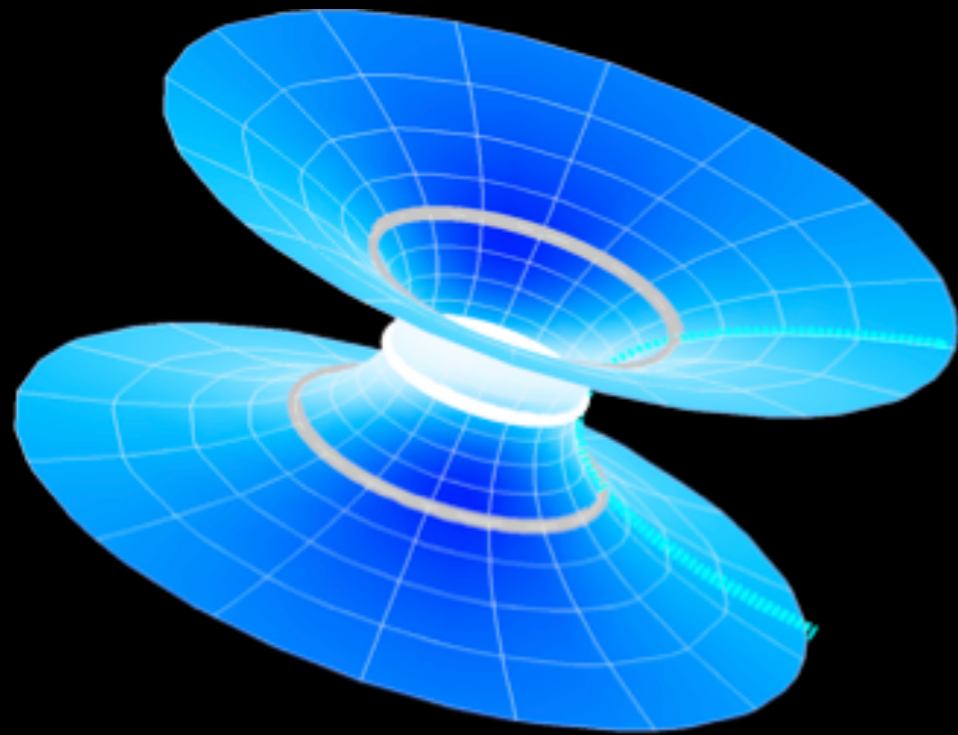


Densities $\sim 4 \times 10^{17} \text{ kg/m}^3$

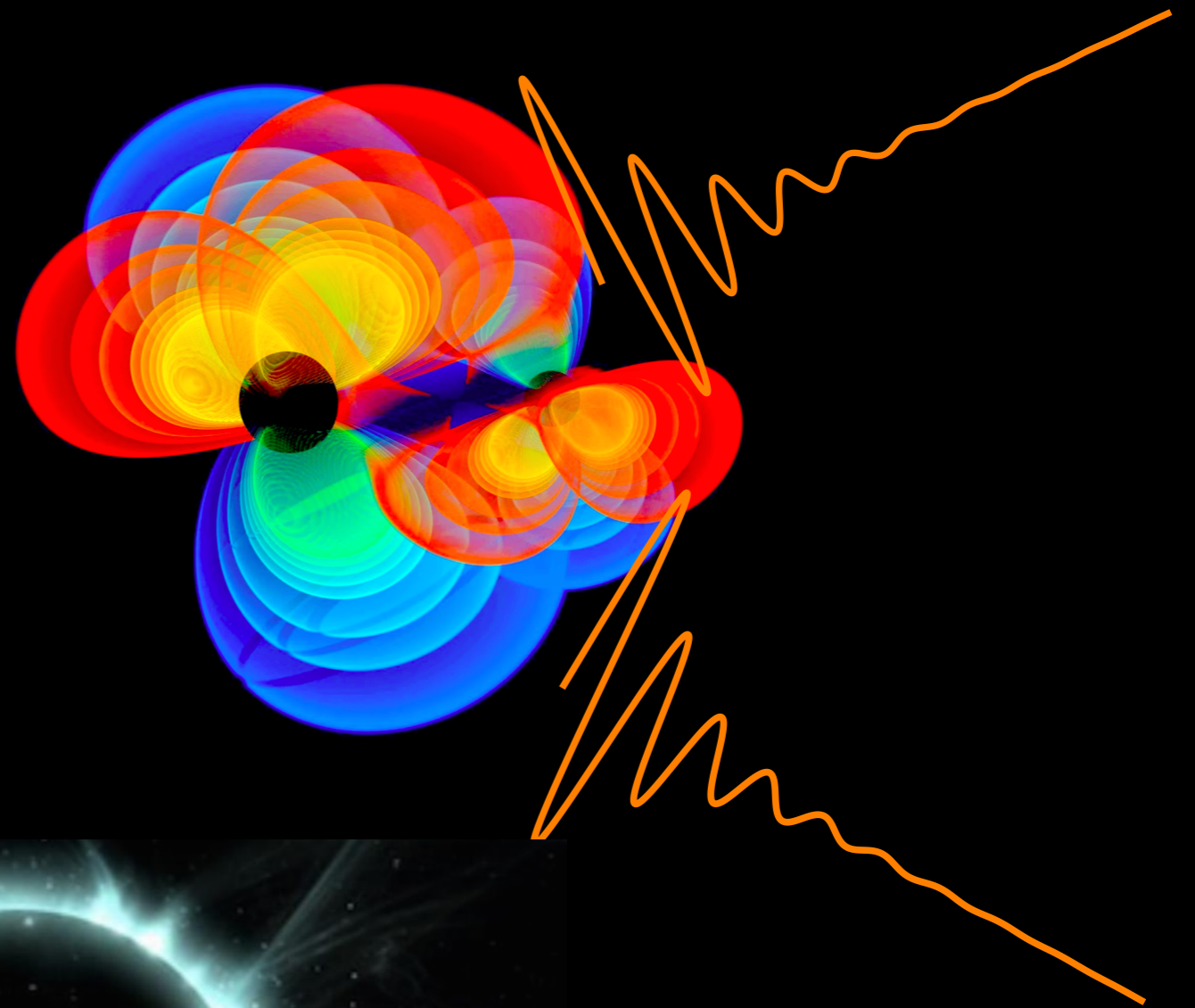


EXTREME GRAVITY, DYNAMICAL SPACETIMES

BUONANNO, LEHNER, VAN DEN BROECK



Phys. Rev. Lett.

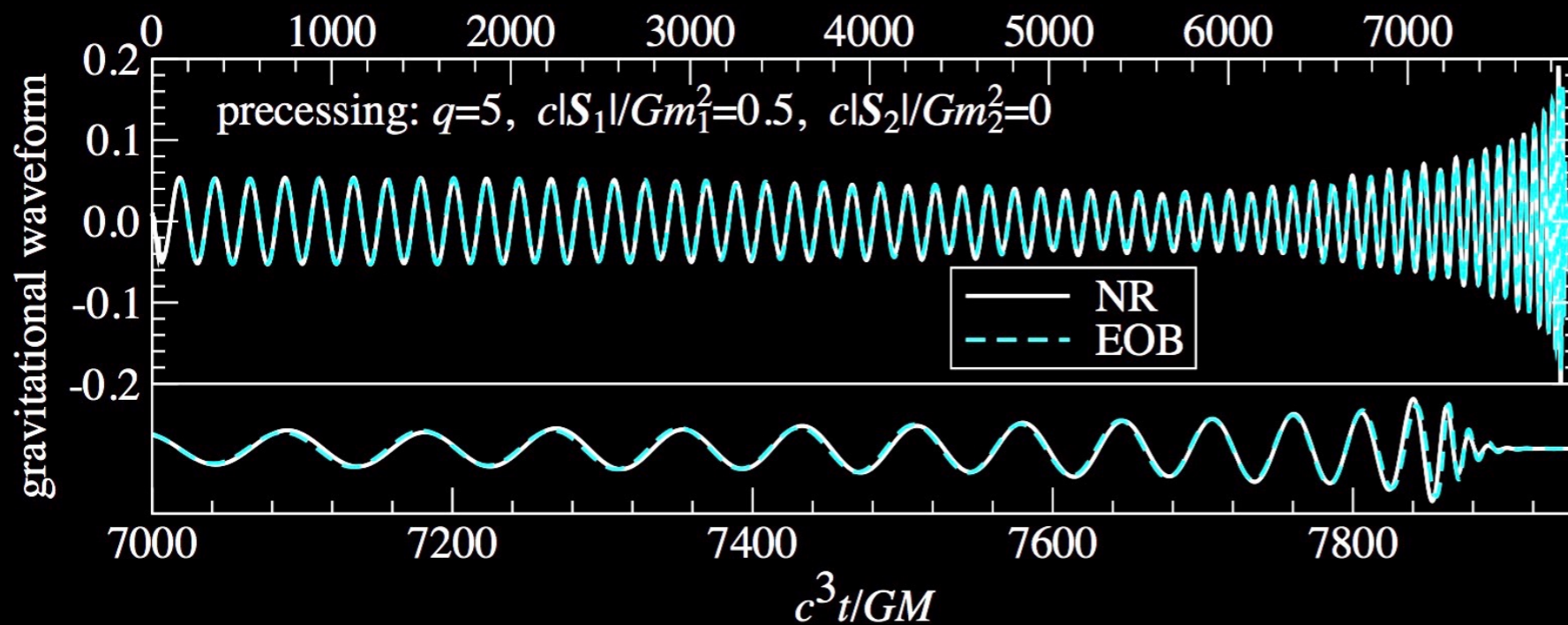


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WAVEFORM MODELS

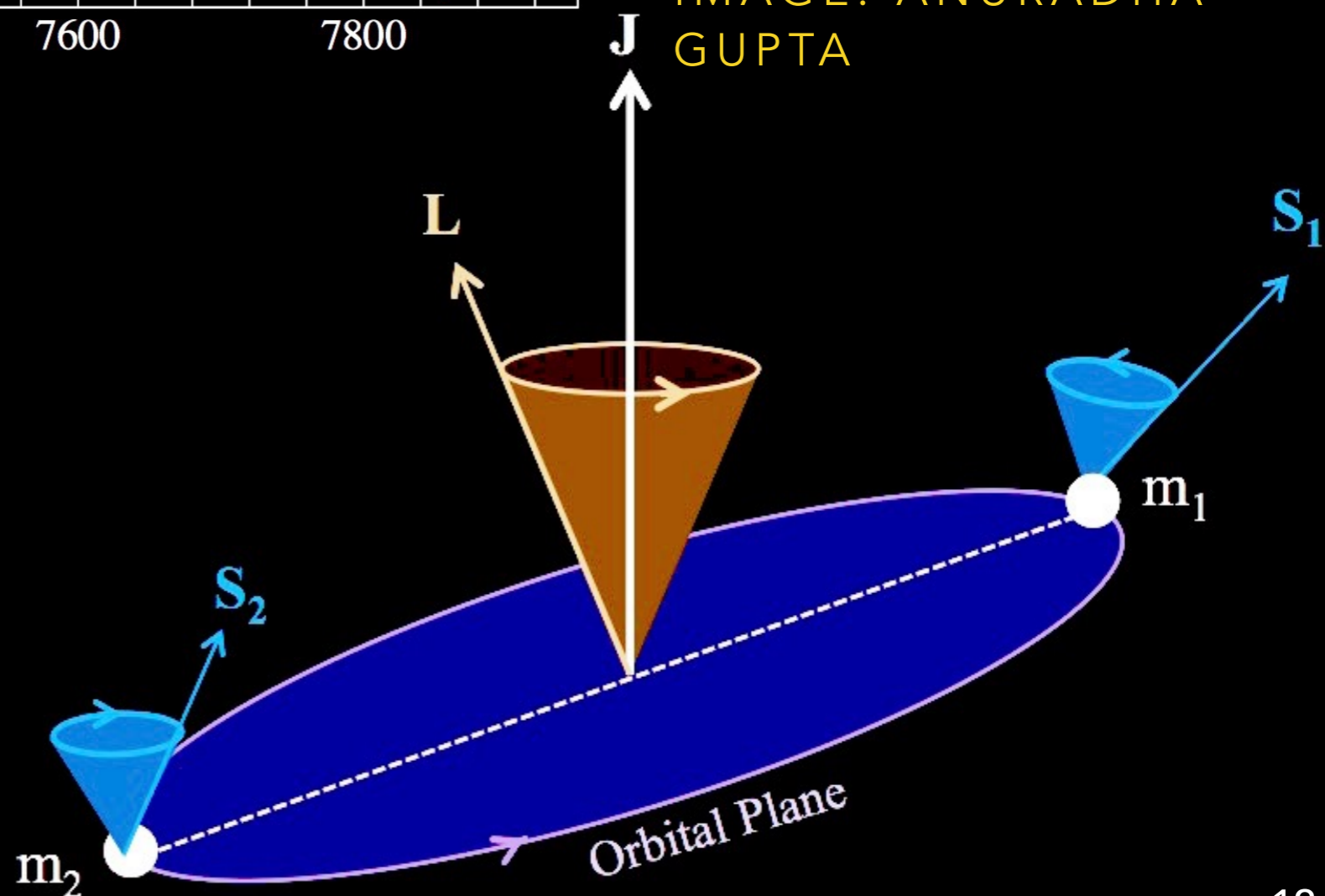
BUONANNO, LEHNER, VAN DEN BROECK



WAVEFORM: SXS,
FROM BUONANNO
AND SATHYAPRAKASH

IMAGE: ANURADHA
GUPTA

- ❖ challenges in waveform modelling:
 - ❖ relativistic effects in binary black holes
 - ❖ matter effects in binary neutron stars
 - ❖ supernova signals



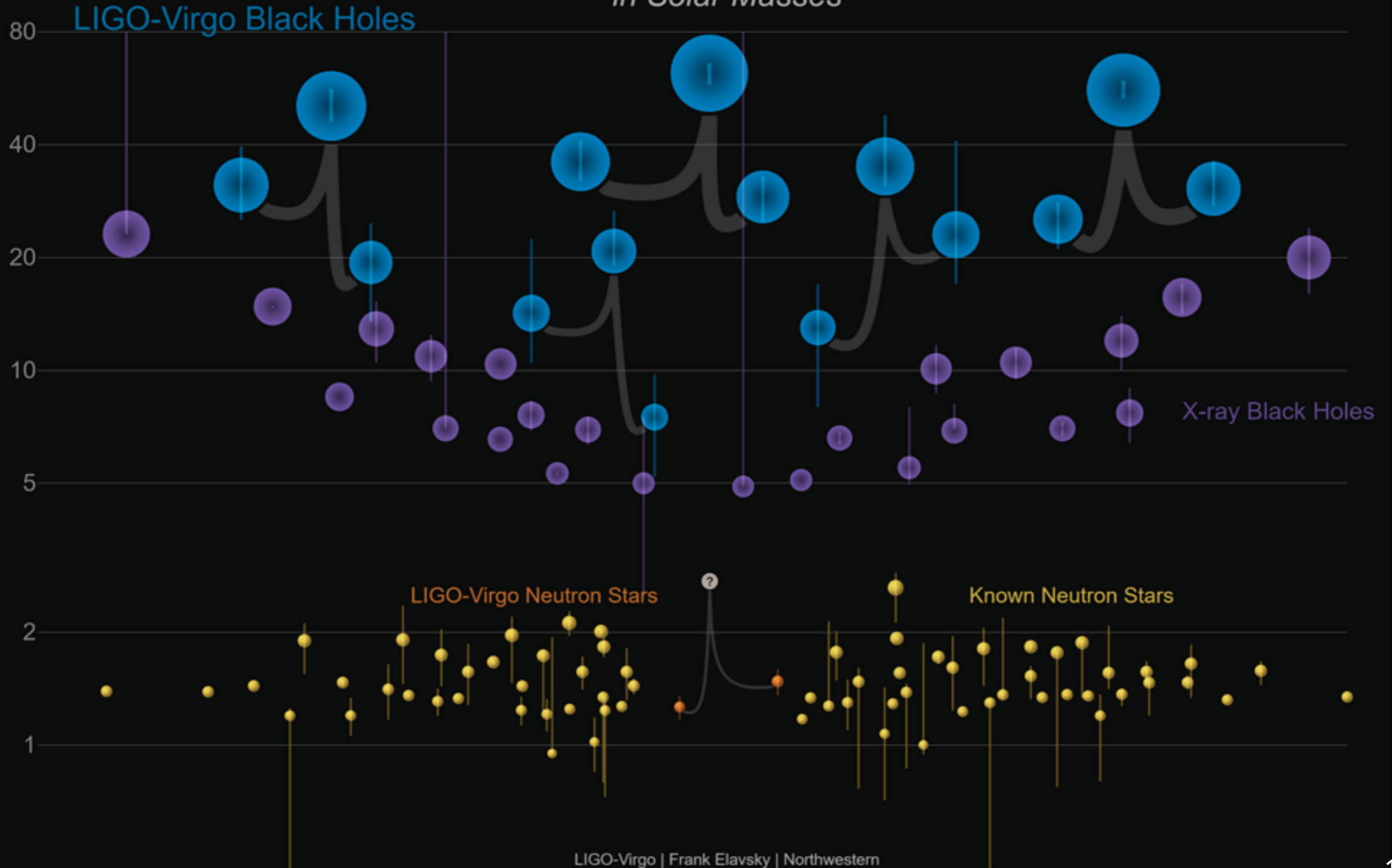
THEMES

- ❖ Exotic objects and phenomena
 - ❖ dipole radiation, spin-induced quadrupole, tidal heating (absence of horizon), tidal deformability, quasi-normal modes, ...
 - ❖ GW signatures and observables
- ❖ post-ringdown
- ❖ challenges in waveform modeling
- ❖ challenges in data analysis

COMPACT BINARIES

BAILES, KALOGERA, MANDEL

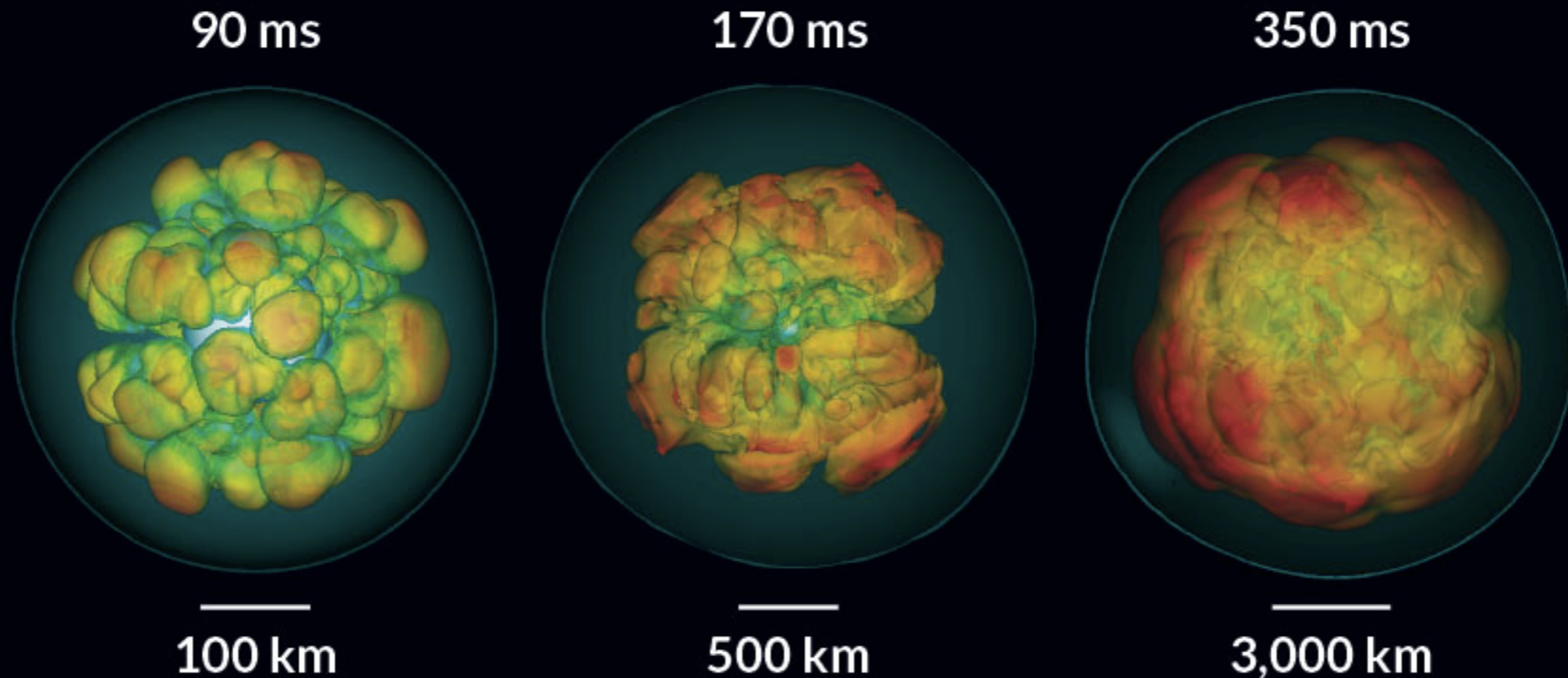
in Solar Masses



SUPERNOVAE

BIZOURD, BURROWS

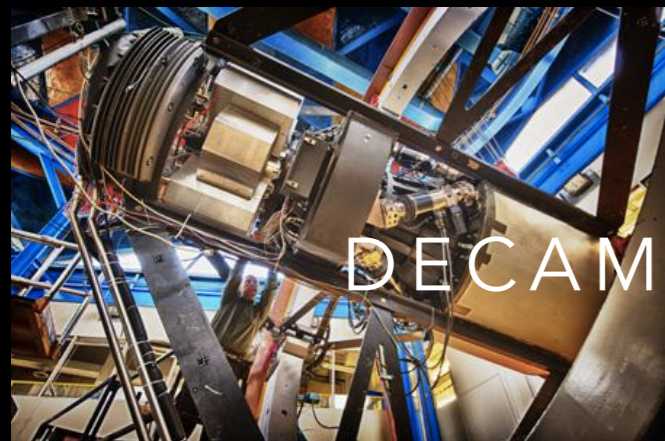
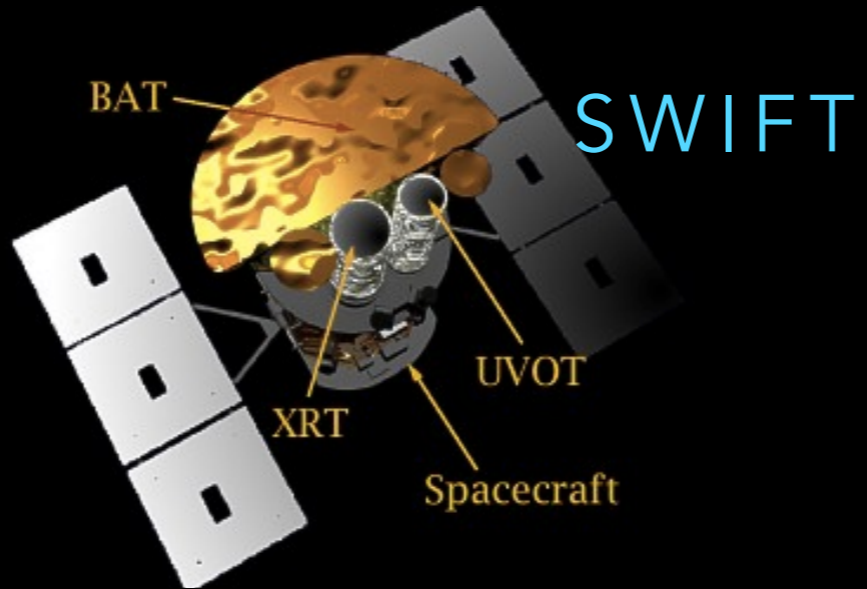
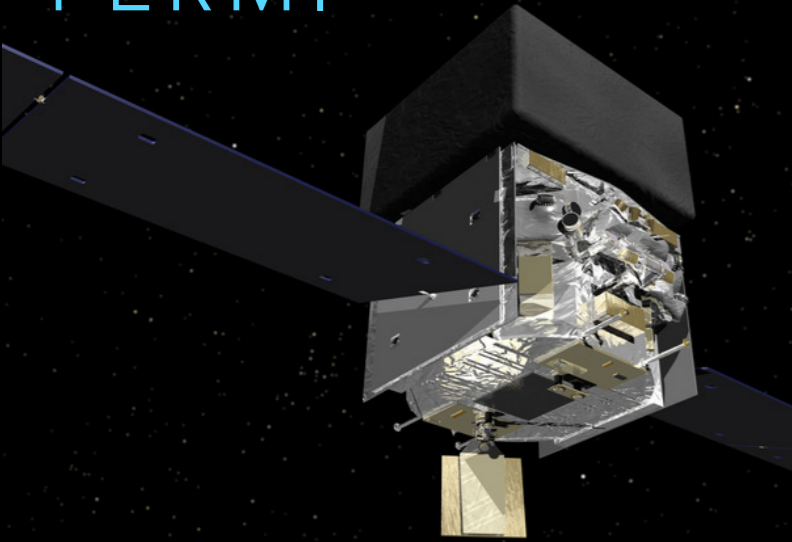
- ❖ Energy reservoir
 - ❖ few $\times 10^{53}$ erg
- ❖ Explosion energy
 - ❖ 10^{51} erg
- ❖ Time frame for explosion
 - ❖ 300 - 1500 ms after bounce
- ❖ Formation of black hole
 - ❖ At baryonic mass $> 1.8-2.5 M$



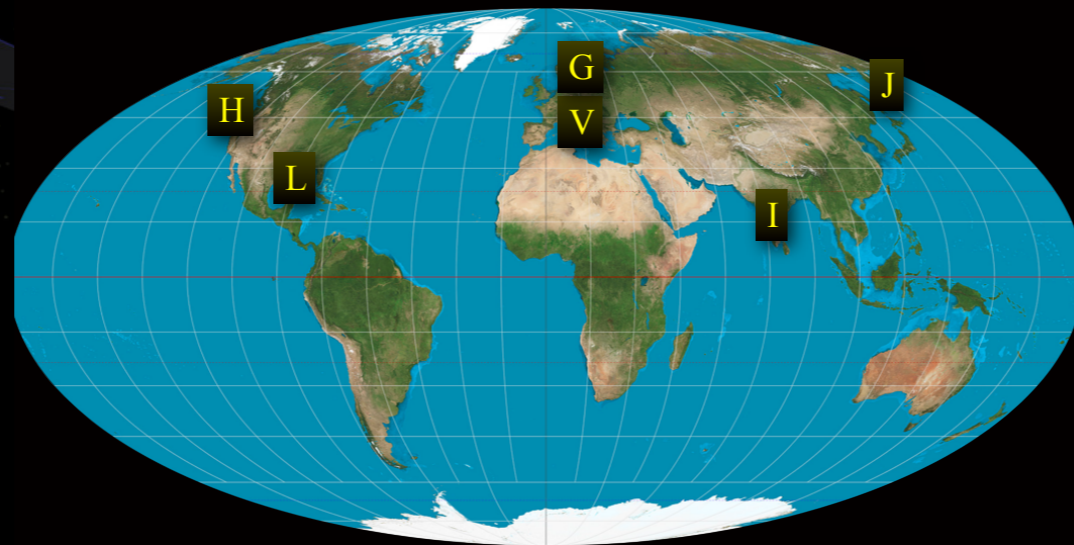
MULTI-MESSENGER ASTROPHYSICS

BAILES, KASLIWAL

FERMI

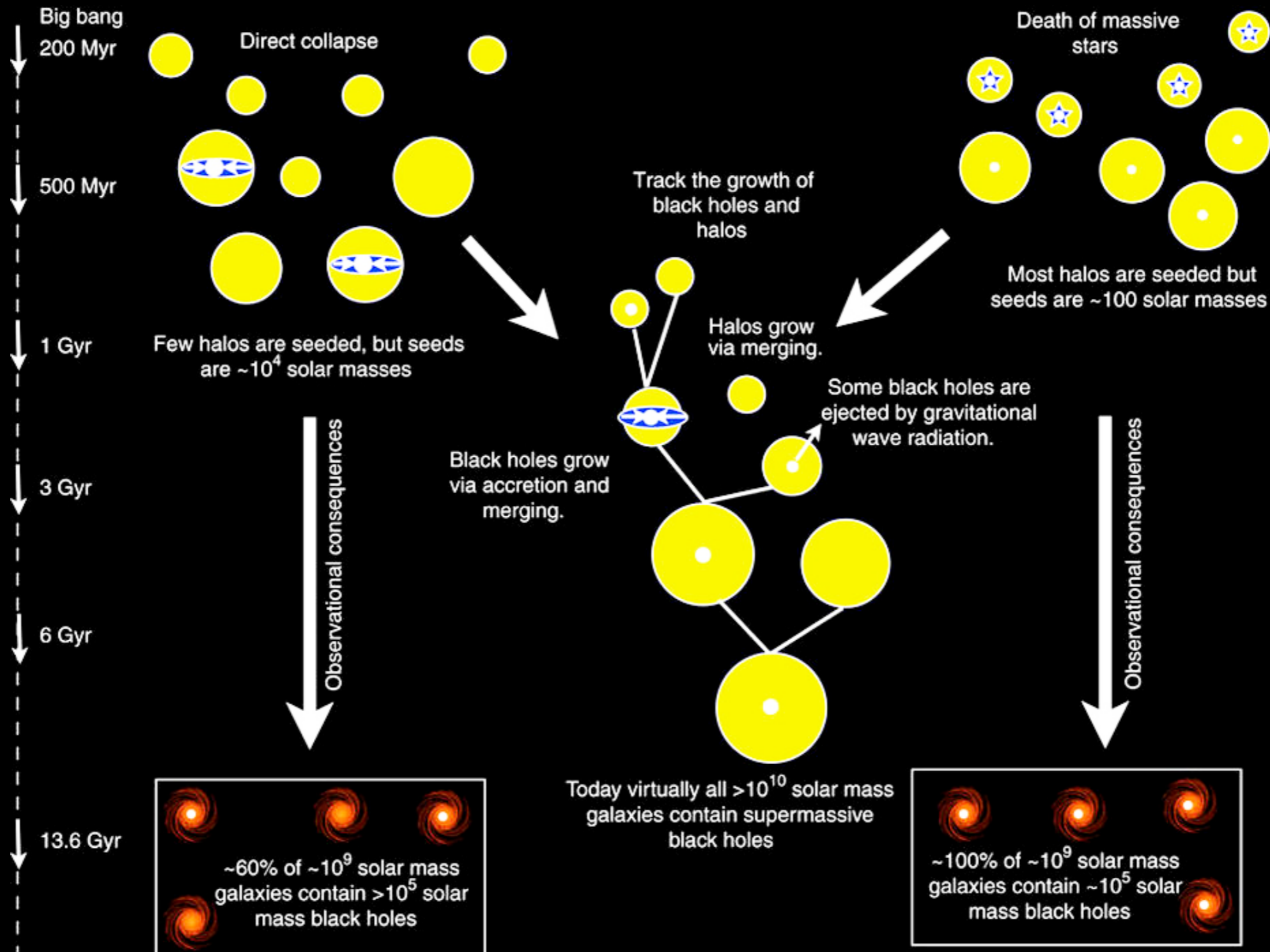


DECAM

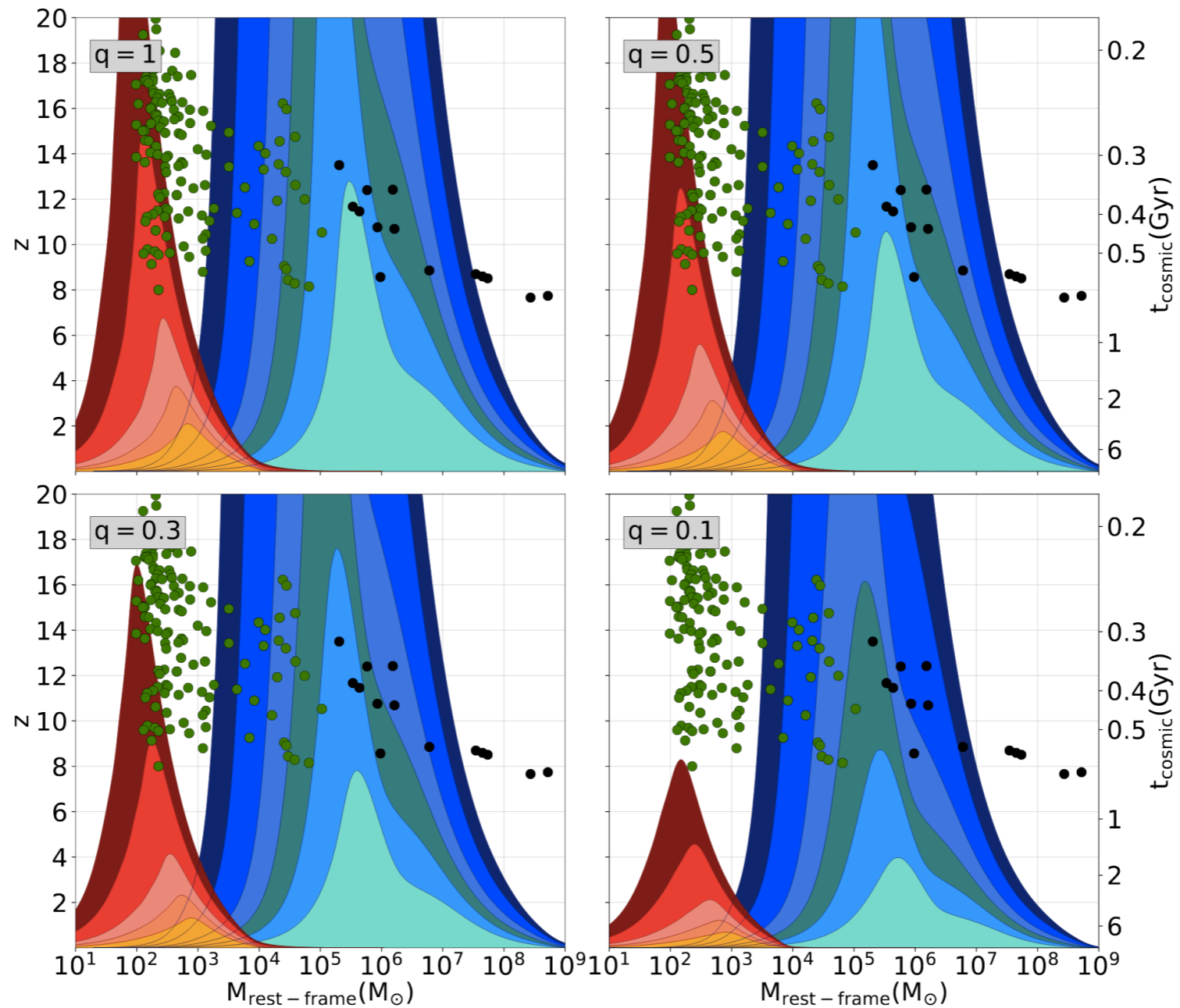


SEED BLACK HOLES

COLPI, FAIRHURST



SEED BLACK HOLE GROWTH



COSMOLOGY

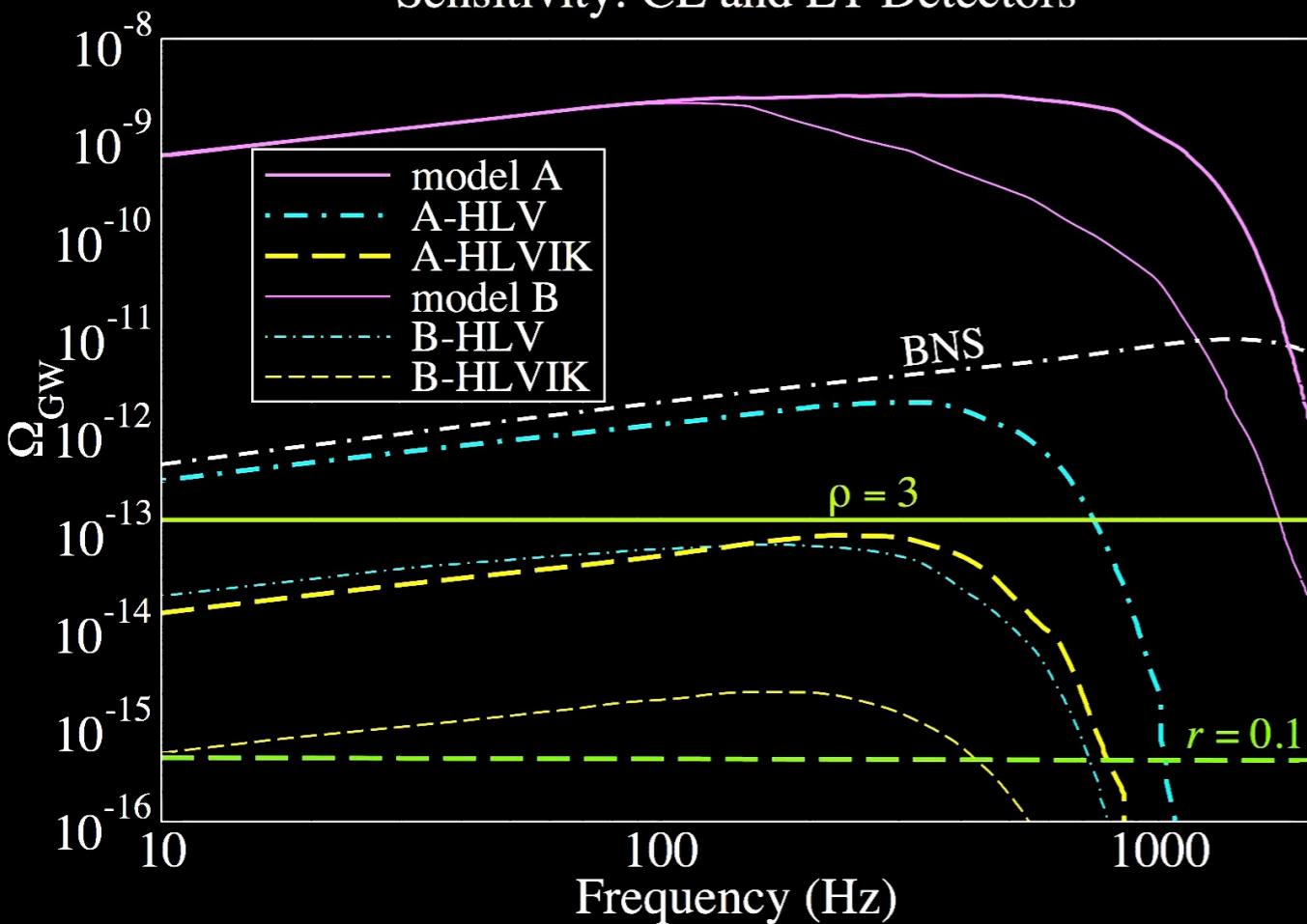
MANDIC, SATHYAPRAKASH

- ❖ Compact binaries are standard sirens; GW observations can measure the luminosity distance
- ❖ Can measure distance **and** redshift from GW observations of binary neutron stars

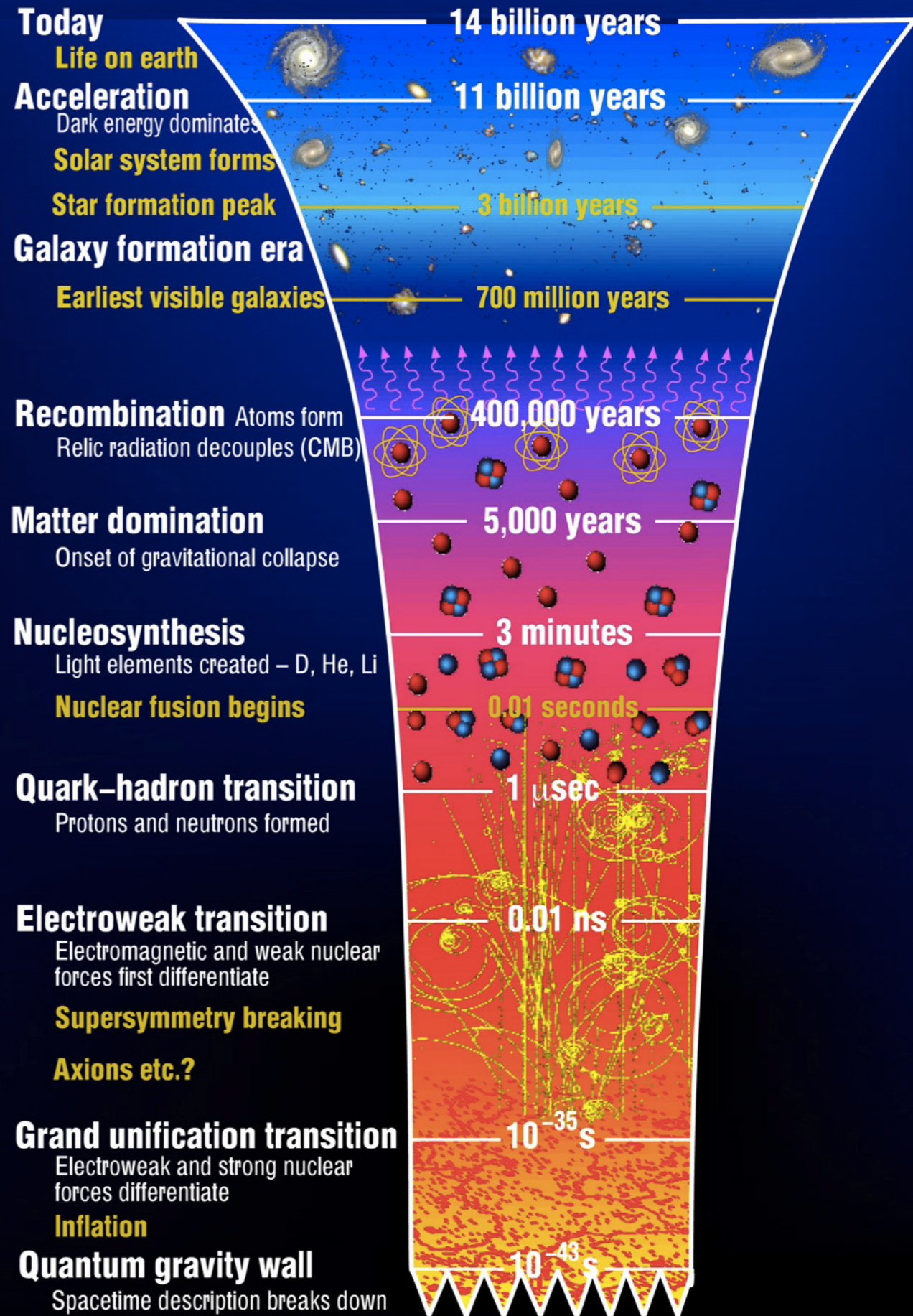


ASTROPHYSICAL AND PRIMORDIAL STOCHASTIC BACKGROUNDS

Sensitivity: CE and ET Detectors



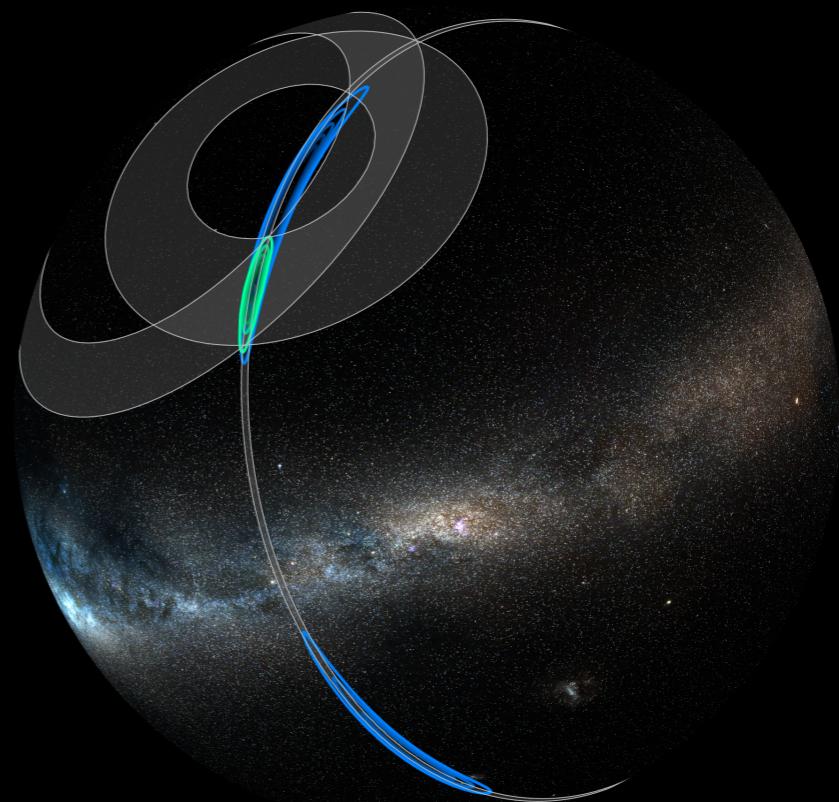
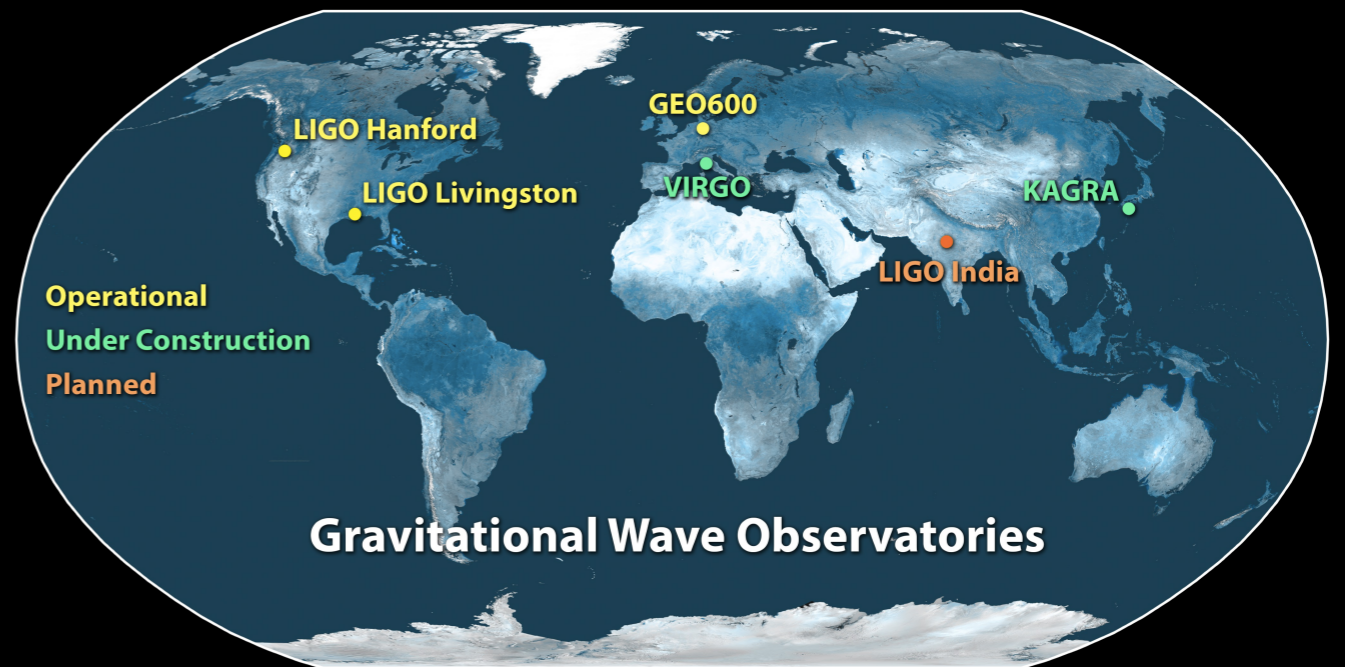
Regimbau+ PRL 2017



DETECTOR NETWORKS AND FIGURES OF MERIT

EVANS, FAIRHURST, HILD

- ❖ detector networks
 - ❖ how many detectors do we need
- ❖ heterogeneous detector networks
 - ❖ what is the role of less sensitive detectors
- ❖ what are the different figures-of-merit to sum-up detector performance?
 - ❖ distance reach, angular resolution, ability to measure specific parameters, ...



JOINING THE 3G SCIENCE CASE CONSORTIUM

- ❖ open to anyone who wishes to contribute to the development of the science case for 3G
- ❖ send a one-page CV and research interests relevant to 3G to:
 - ❖ B.S. Sathyaprakash bss25@psu.edu or Vicky Kalogera <vicky@northwestern.edu>

WALK THROUGH 3G SCT GITHUB

- <https://github.com/gwic-3g/3g-science-case>
- if you don't have access please provide github username and we will add you as a collaborator

ACTIVITIES OF THE GROUPS

- ❖ bi-weekly teleconferences
 - ❖ agenda and minutes on github
- ❖ individuals or groups charged to write the science case
 - ❖ first draft expected by the end of June (original target was mid-June)
- ❖ coherent chapters by August
- ❖ integration of the chapters by October
- ❖ face-to-face meeting of the consortium
 - ❖ October 1, 2; AEI Potsdam