GWIC

Gravitational Wave International Committee

SCIENCE CASE FOR 3G

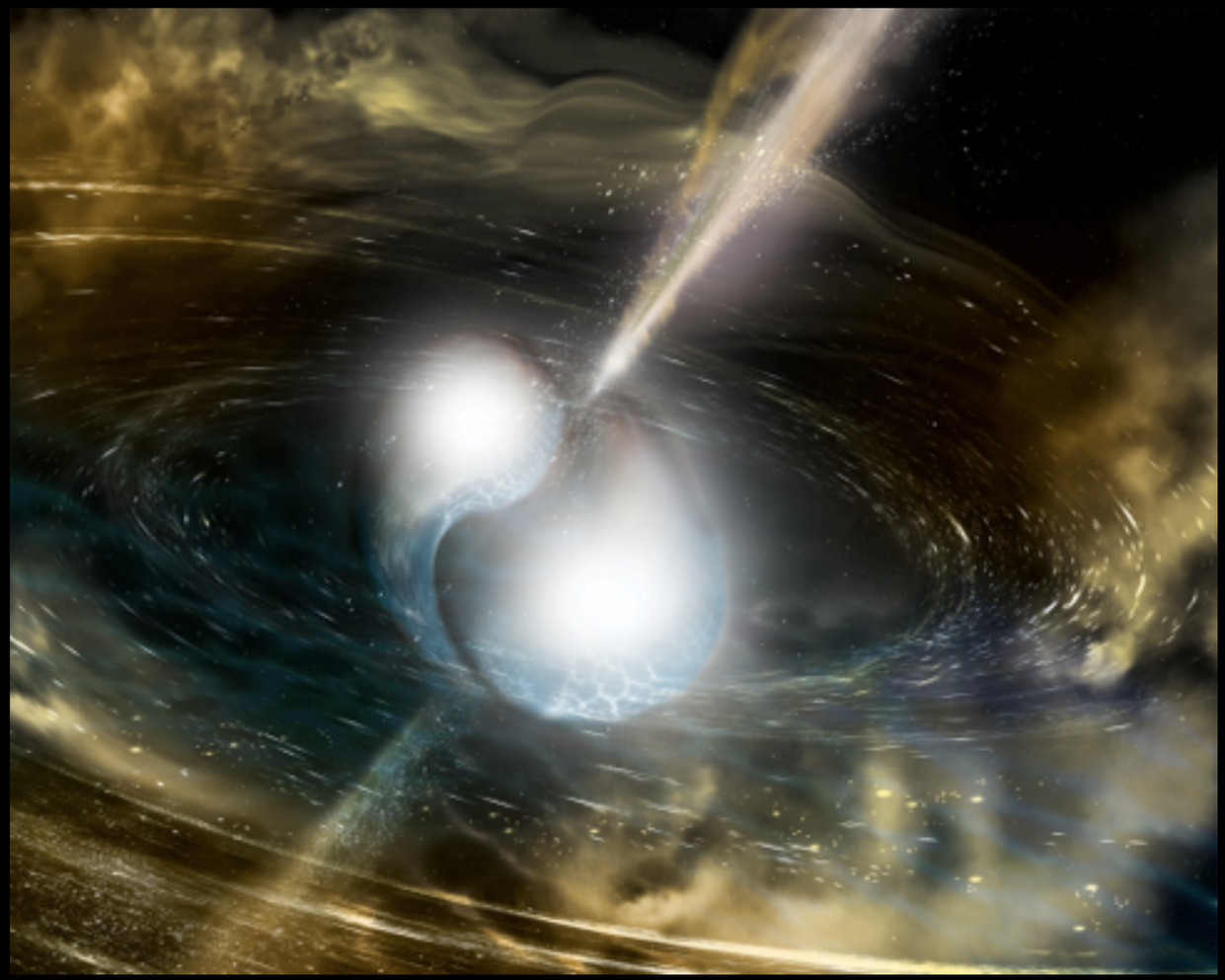
VICKY KALOGERA (NORTHWESTERN)
B.S. SATHYAPRAKASH (PENN STATE AND CARDIFF)

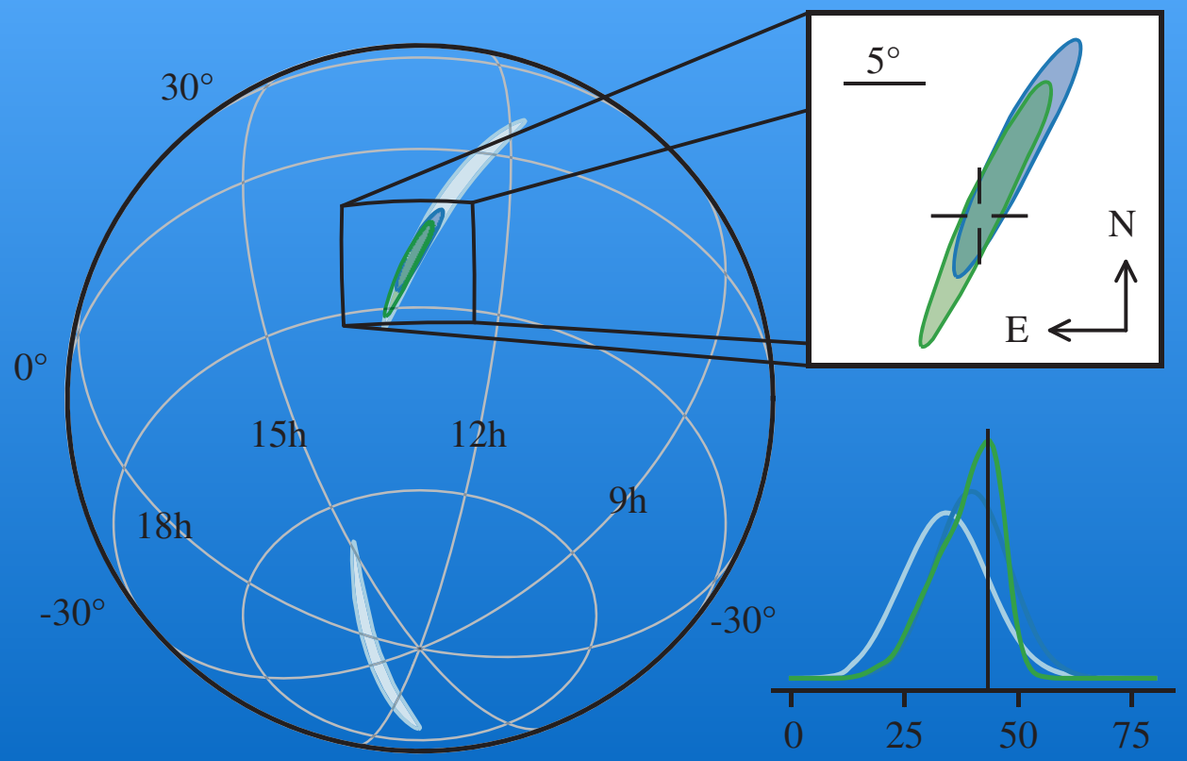
ON BEHALF OF

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





Phys Rev Lett. 119, 161101 (2017)

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 ...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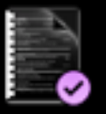
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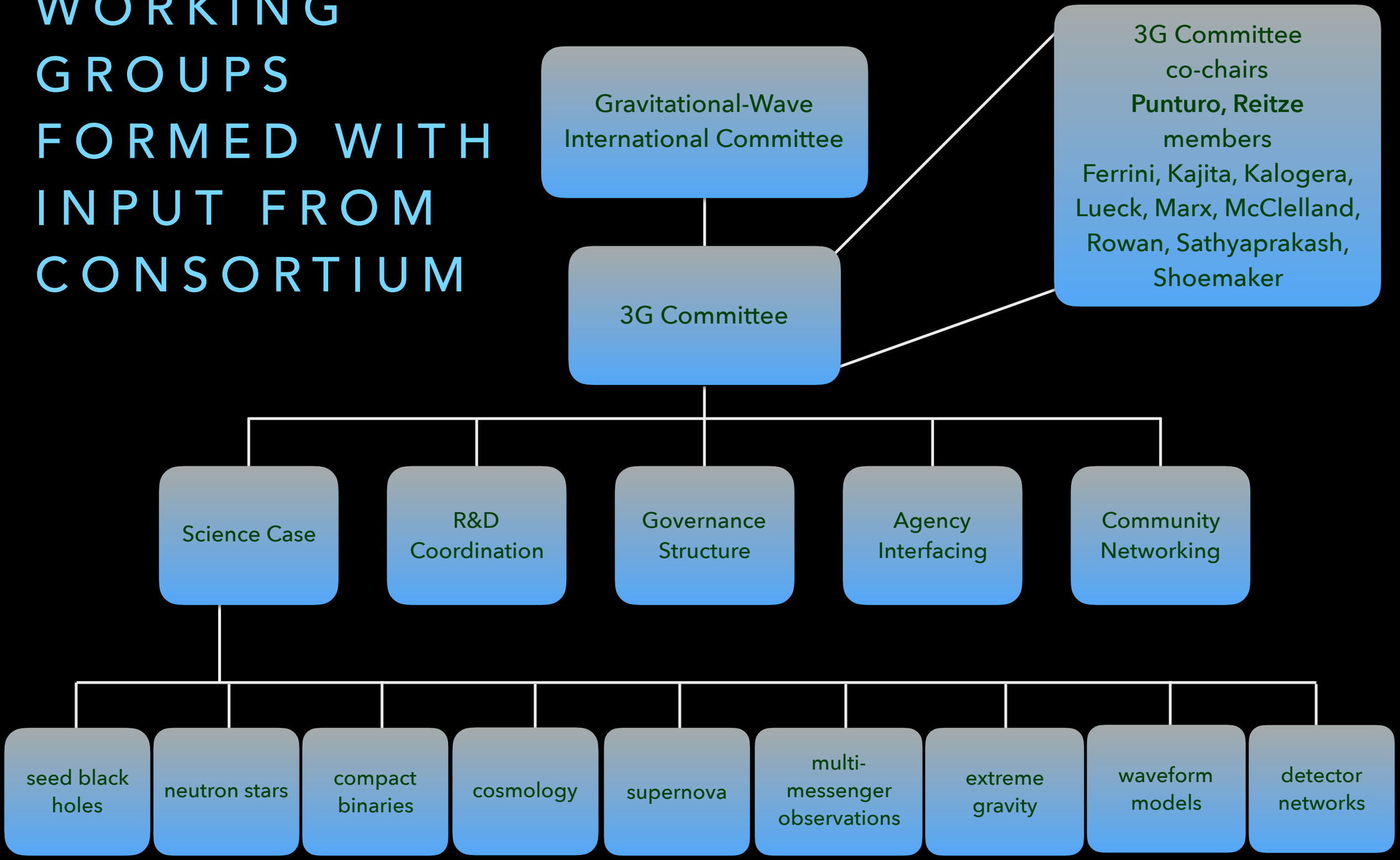
WORKING GROUPS FORMED WITH INPUT FROM CONSORTIUM

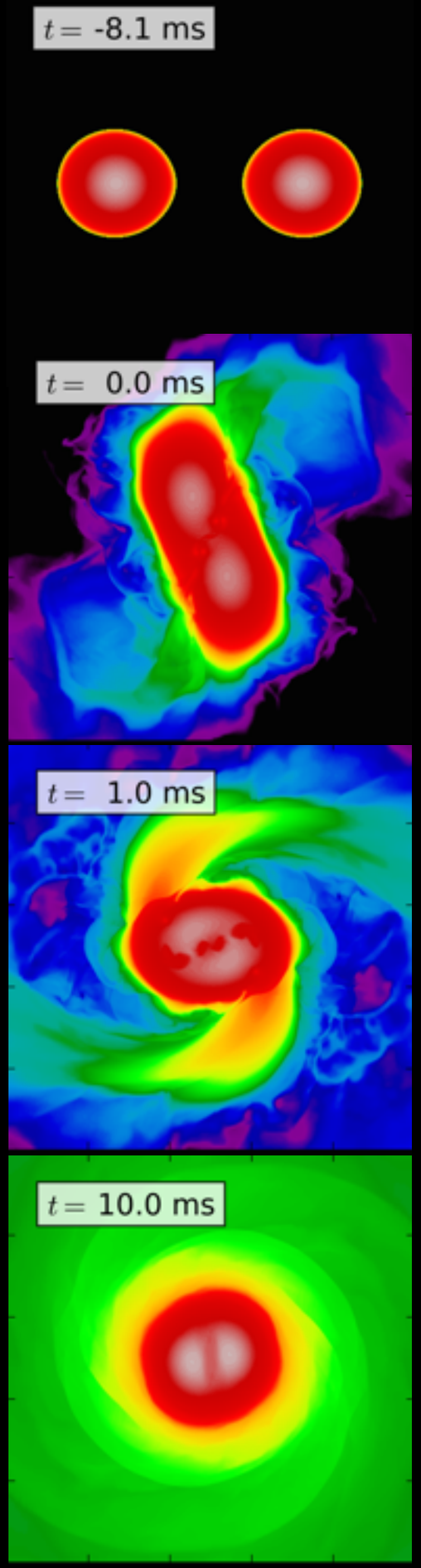


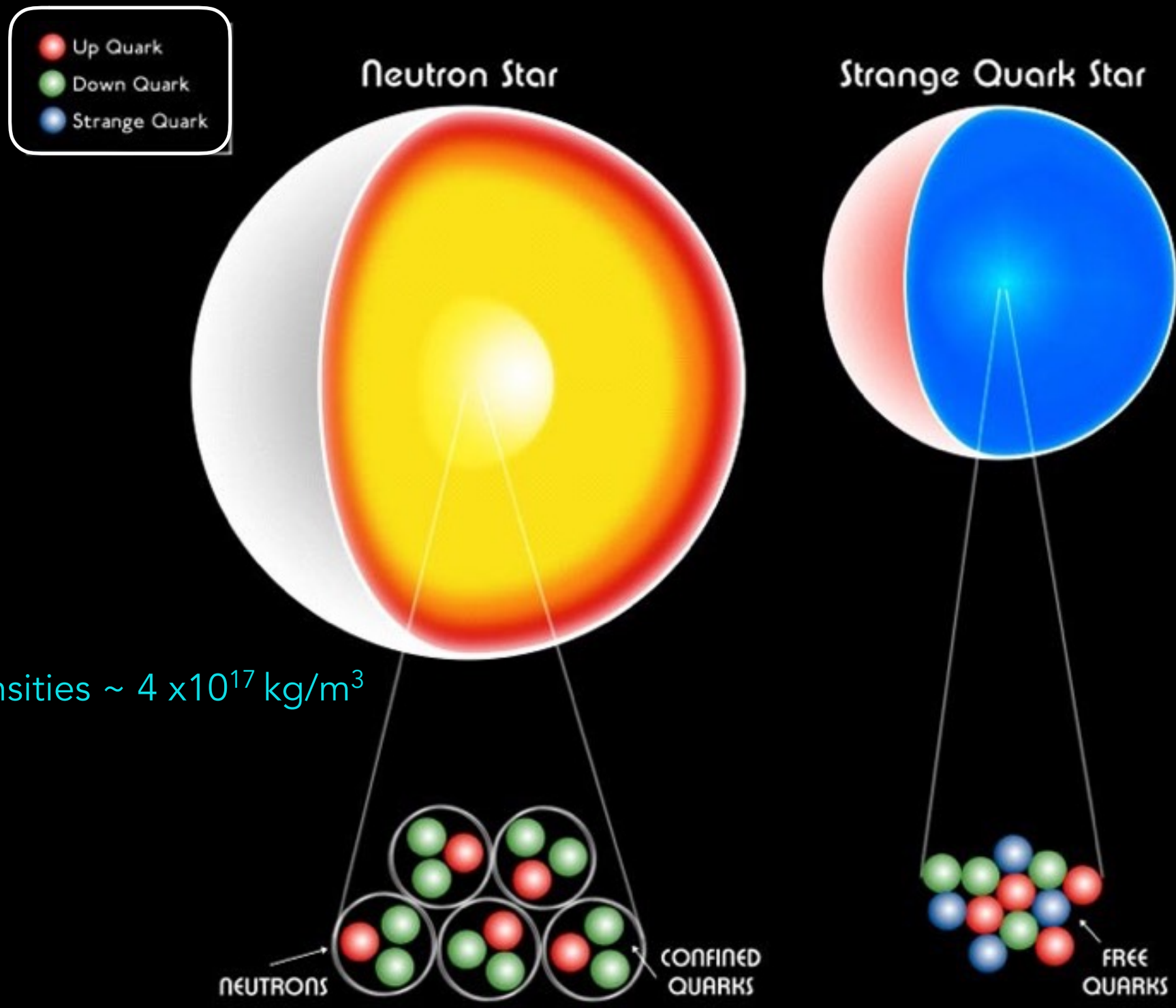
for membership of committees see: https://gwic.ligo.org/3Gsubcomm/

KEY QUESTIONS THAT MOTIVATE THE SCIENCE CASE

NEUTRON STARS

PAPA, REDDY, ROSSWOG

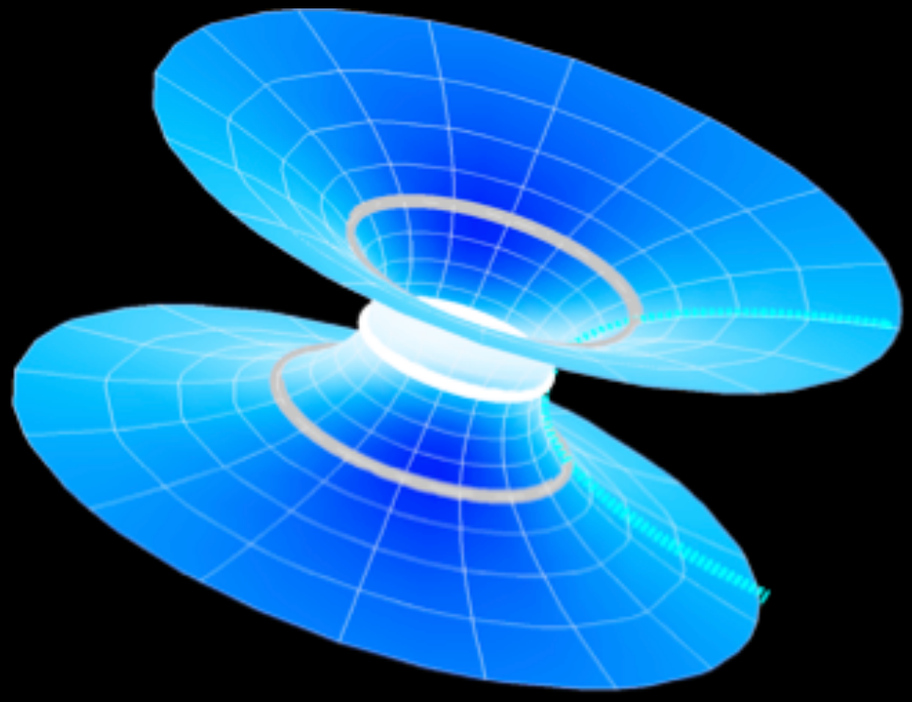


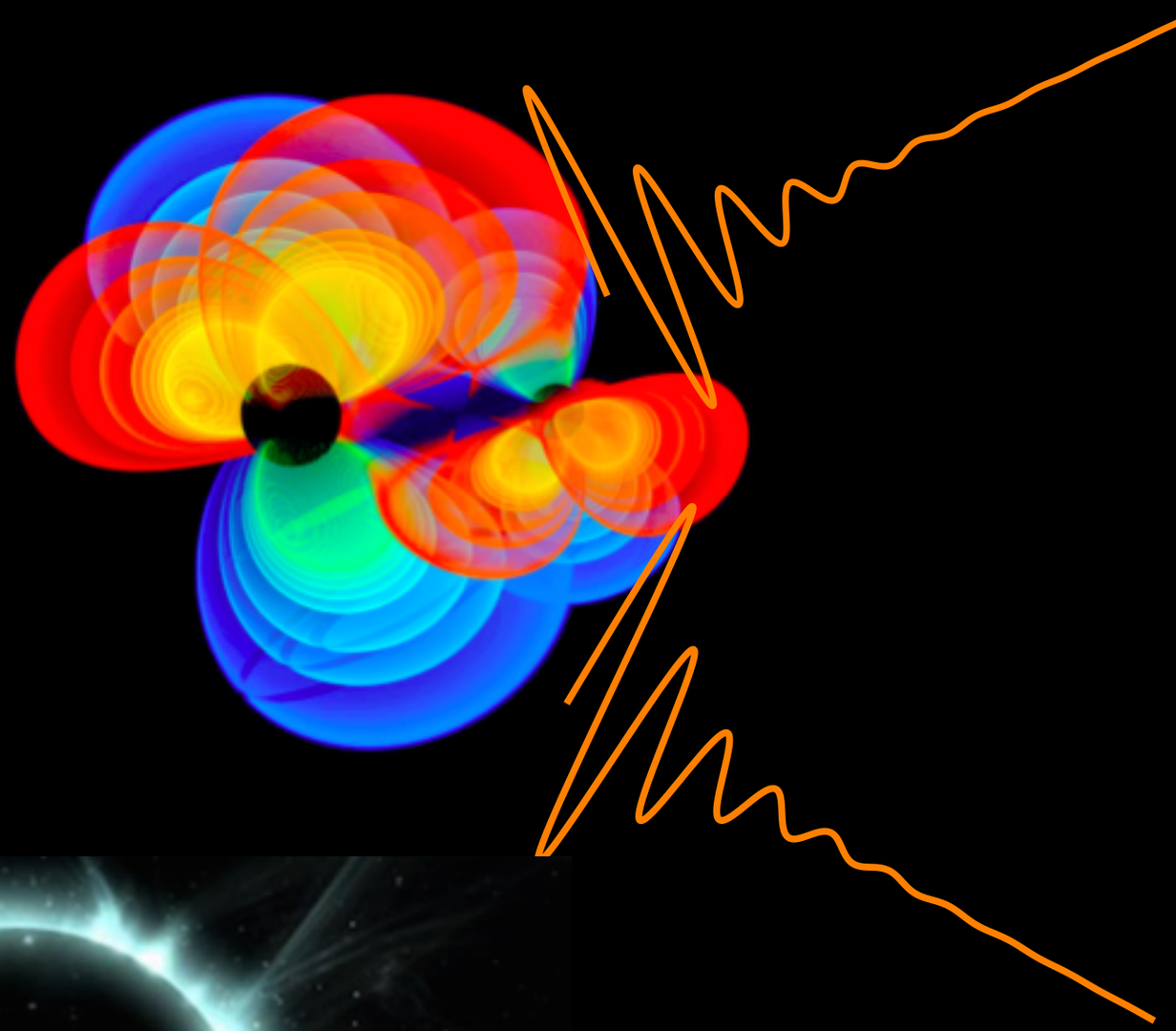


Densities ~ 4 x10^{17} kg/m^3

EXTREME GRAVITY, DYNAMICAL SPACETIMES

BUONANNO, LEHNER, VAN DEN BROECK



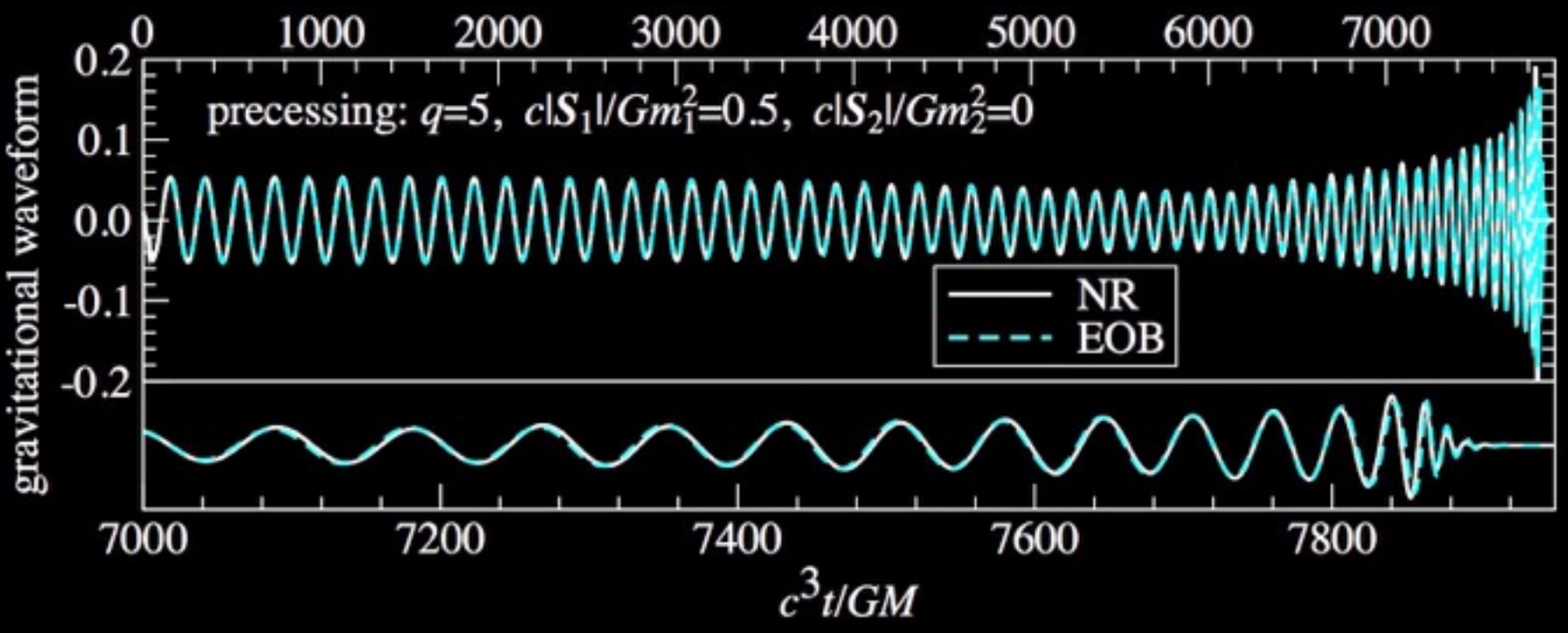


Phys. Rev. Lett.

Univ. Frankfurt

WAVEFORM MODELS

BUONANNO, LEHNER, VAN DEN BROECK



WAVEFORM: SXS, FROM BUONANNO AND SATHYAPRAKASH

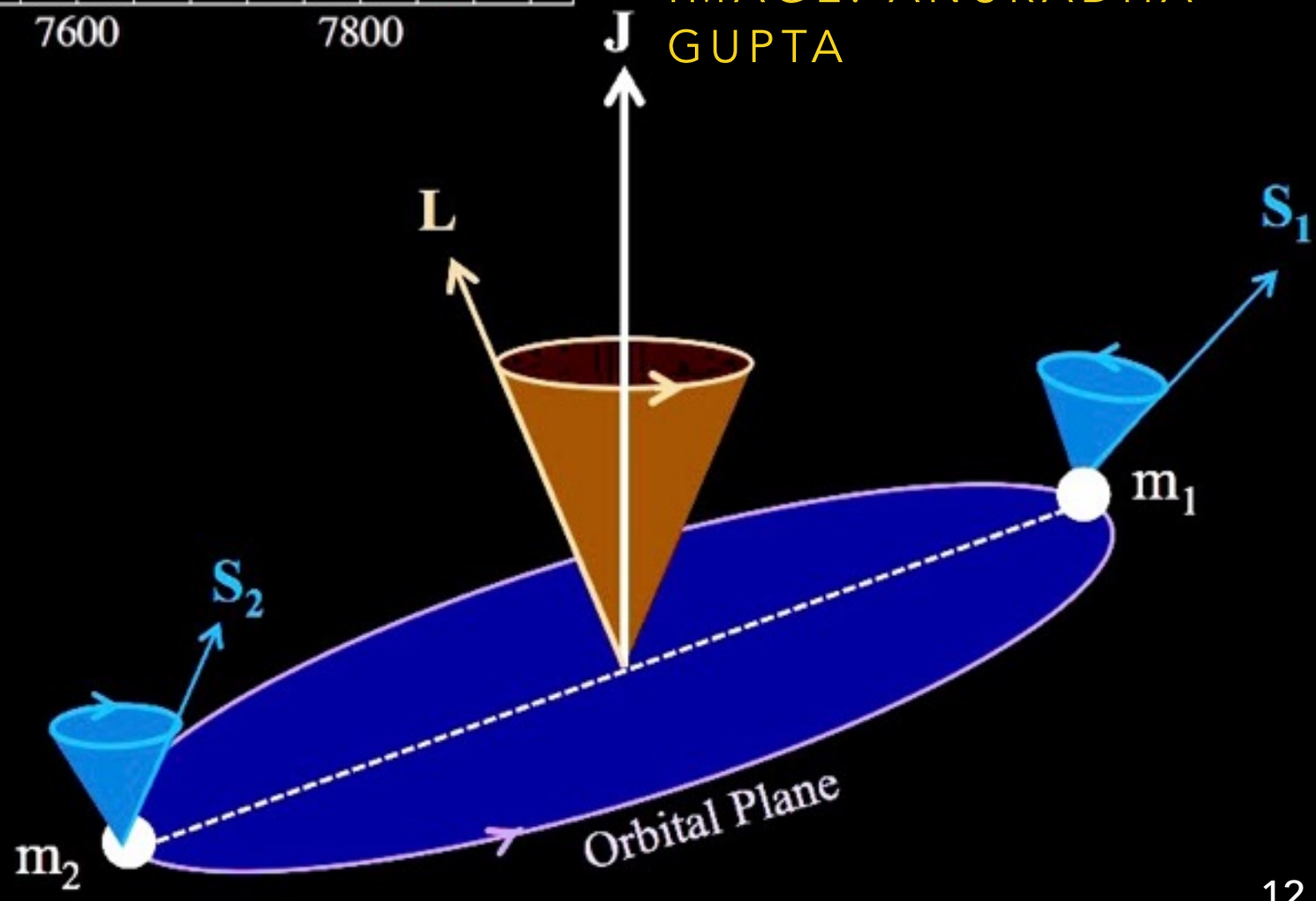


IMAGE: ANURADHA GUPTA

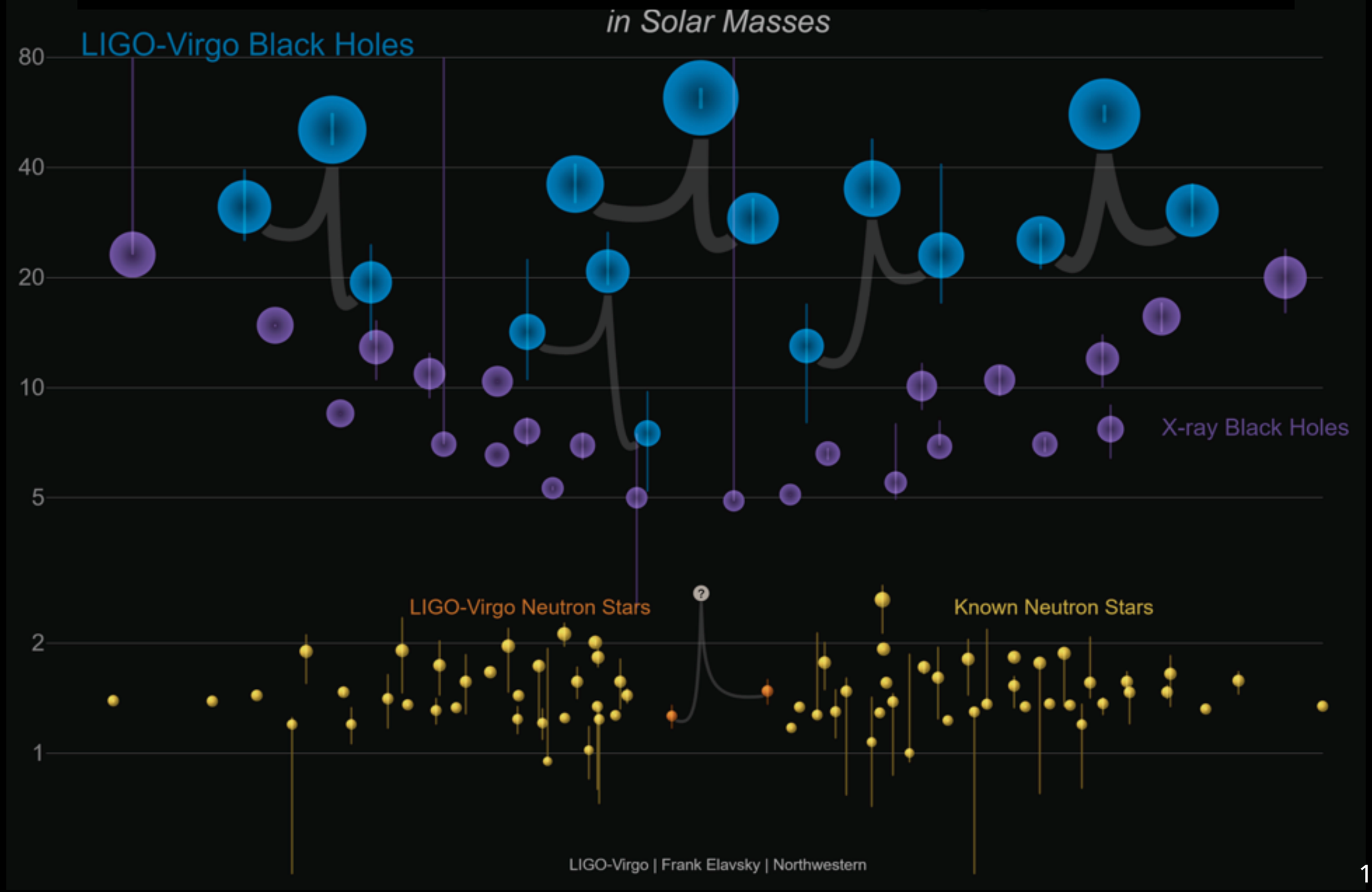
- challenges in waveform modelling:
  - relativistic effects in binary black holes
  - matter effects in binary neutron stars
  - supernova signals

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

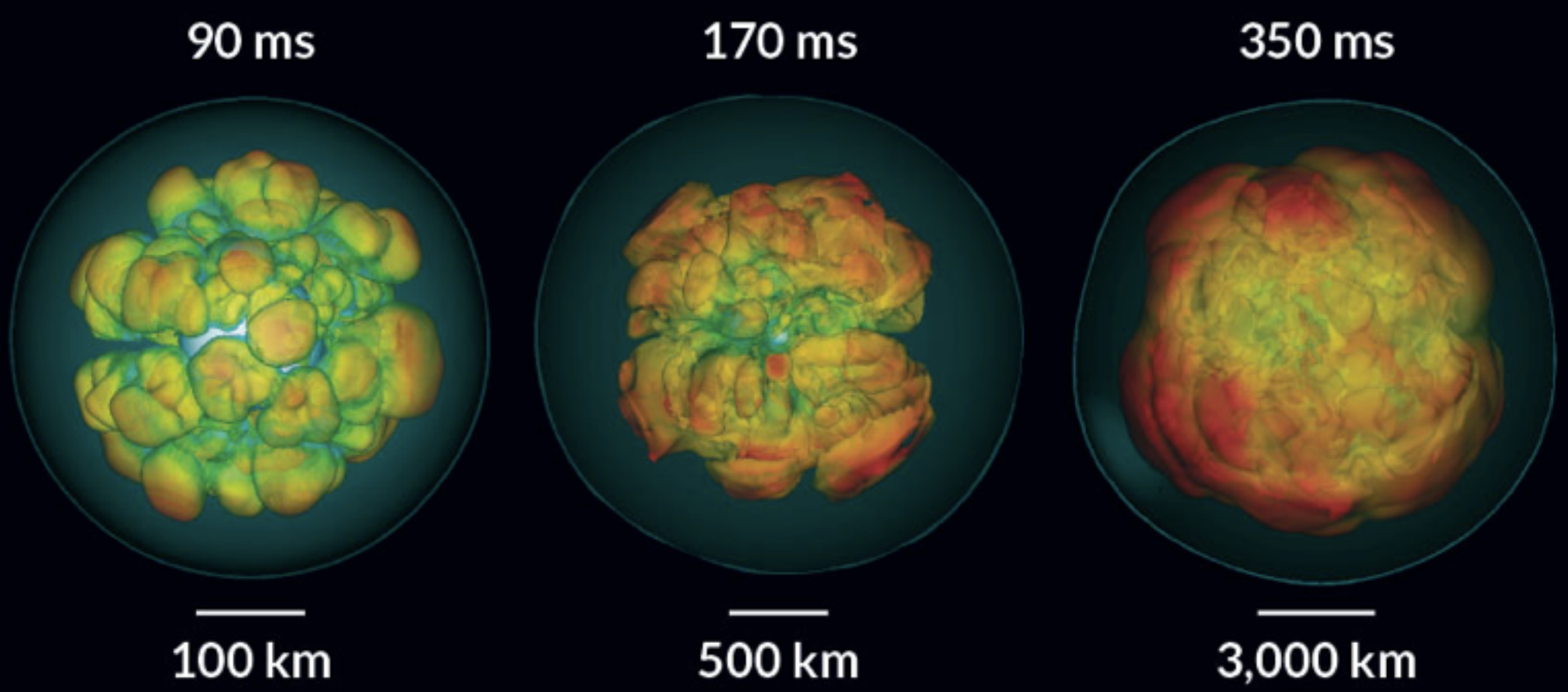
BAILES, KALOGERA, MANDEL



SUPERNOVAE

BIZOURD, BURROWS

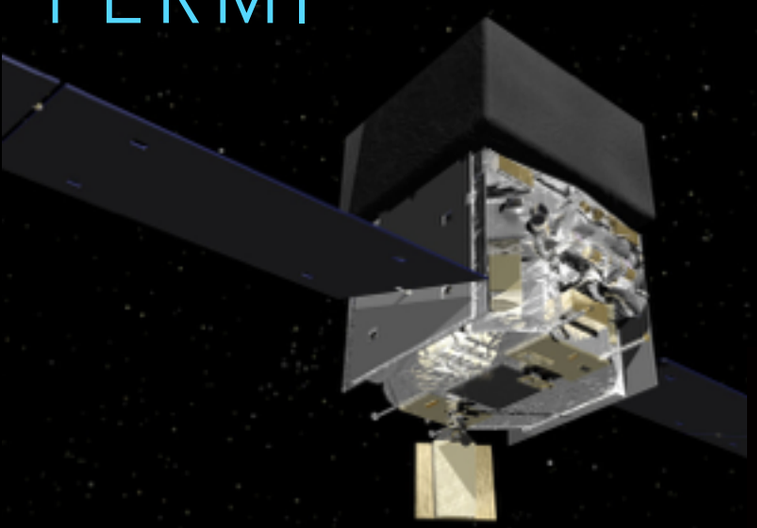
- Energy reservoir
  - few x 10^{53} erg
- Explosion energy
  - 10^{51} erg
- Time frame for explosion
  - 300 - 1500 ms after bounce
- Formation of black hole
  - At baryonic mass > 1.8-2.5 M

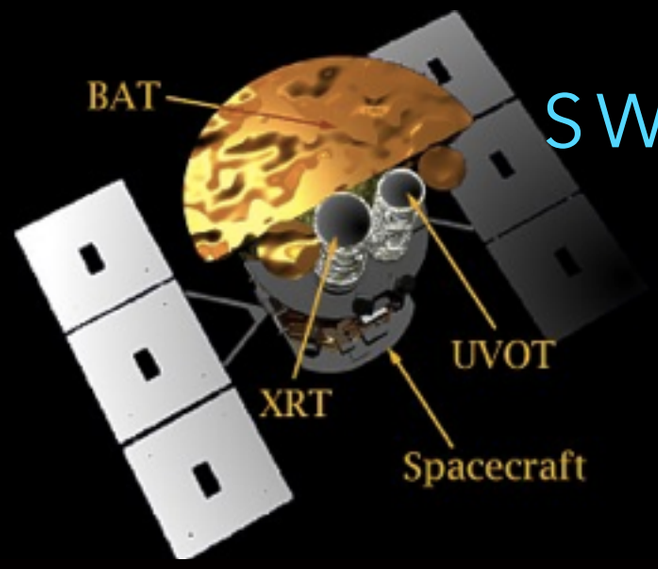


MULTI-MESSENGER ASTROPHYSICS

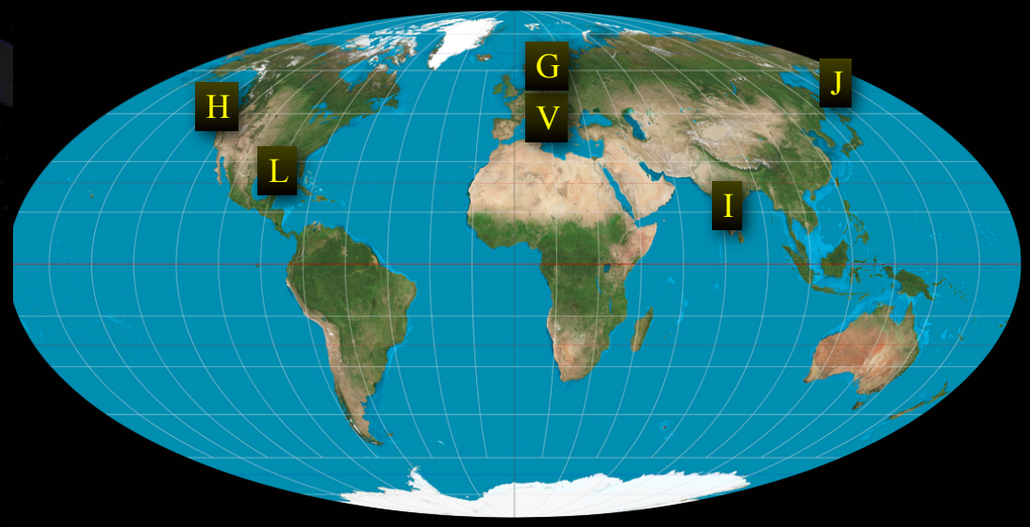
BAILES, KASLIWAL, NISSANKE

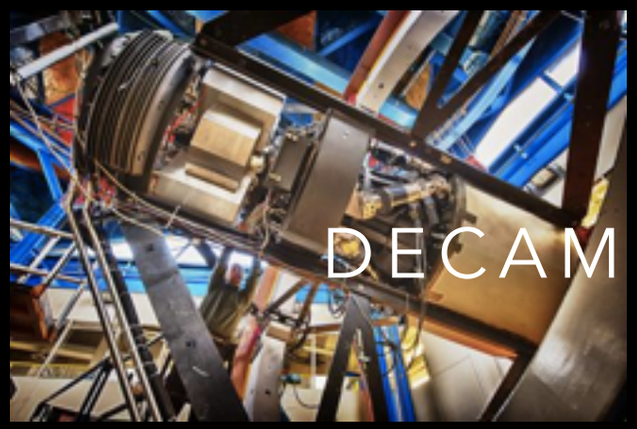
FERMI





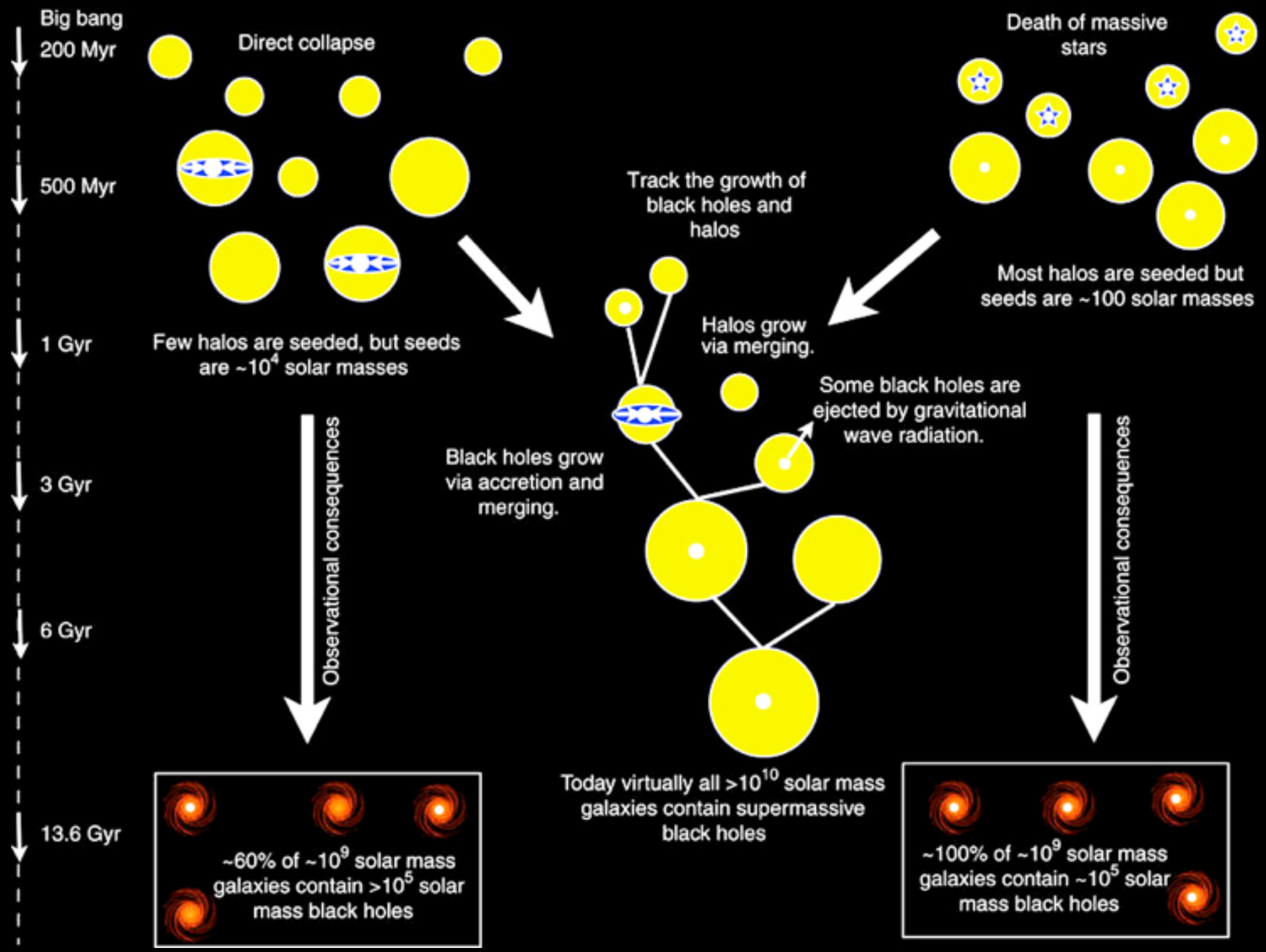
SWIFT





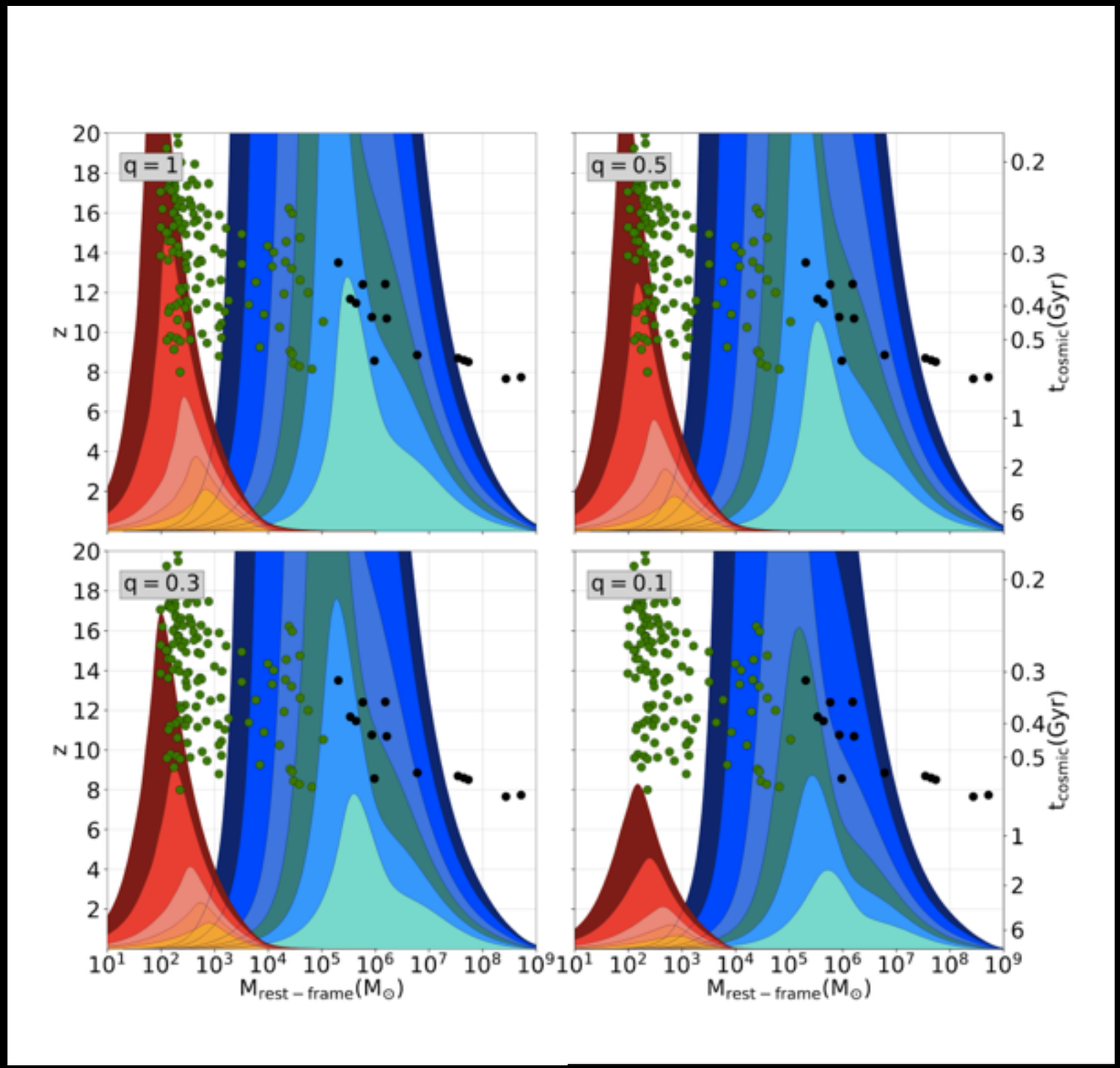
SEED BLACK HOLES

COLPI, FAIRHURST



graphic: Jenny Green Nature Comm. 2012

SEED BLACK HOLE GROWTH



graphic: Colpi+

COSMOLOGY

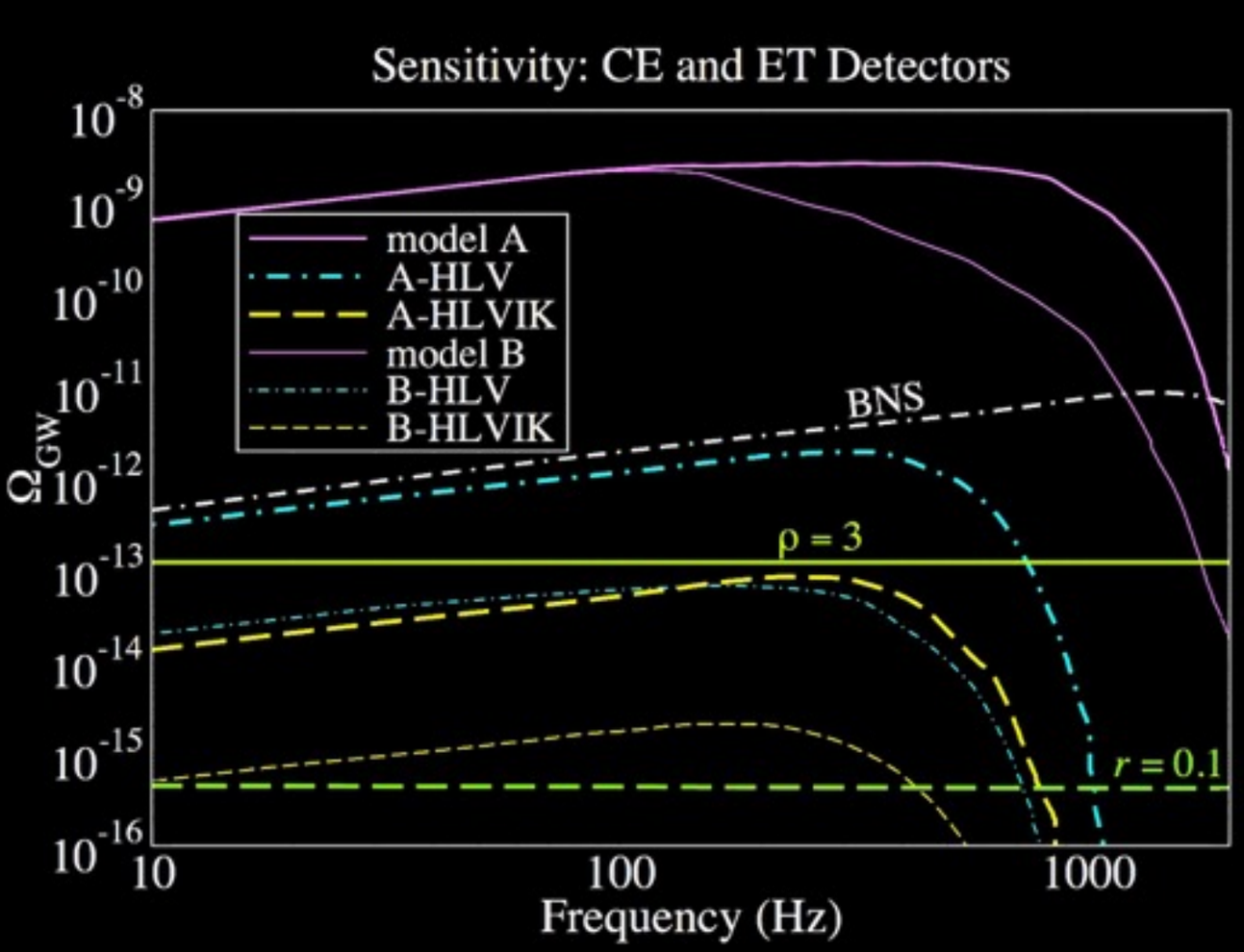
MANDIC, SATHYAPRAKASH

- Compact binaries are standard sirens; GW observations can measure the luminosity distance

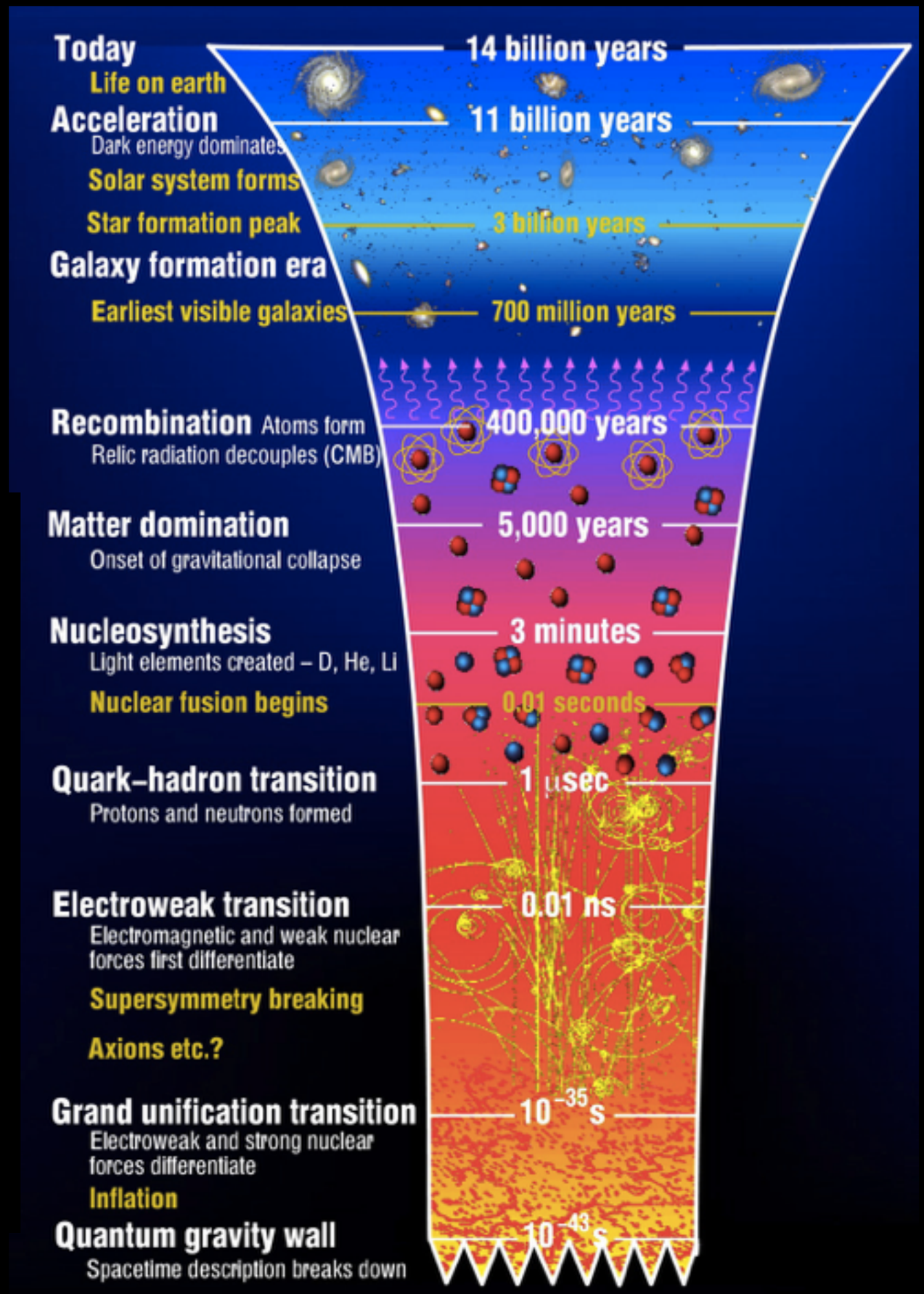
- Can measure distance and redshift from GW observations of binary neutron stars

Schutz; Read and Messenger PRL 2012; Messenger+ PRX 2014

ASTROPHYSICAL AND PRIMORDIAL STOCHASTIC BACKGROUNDS



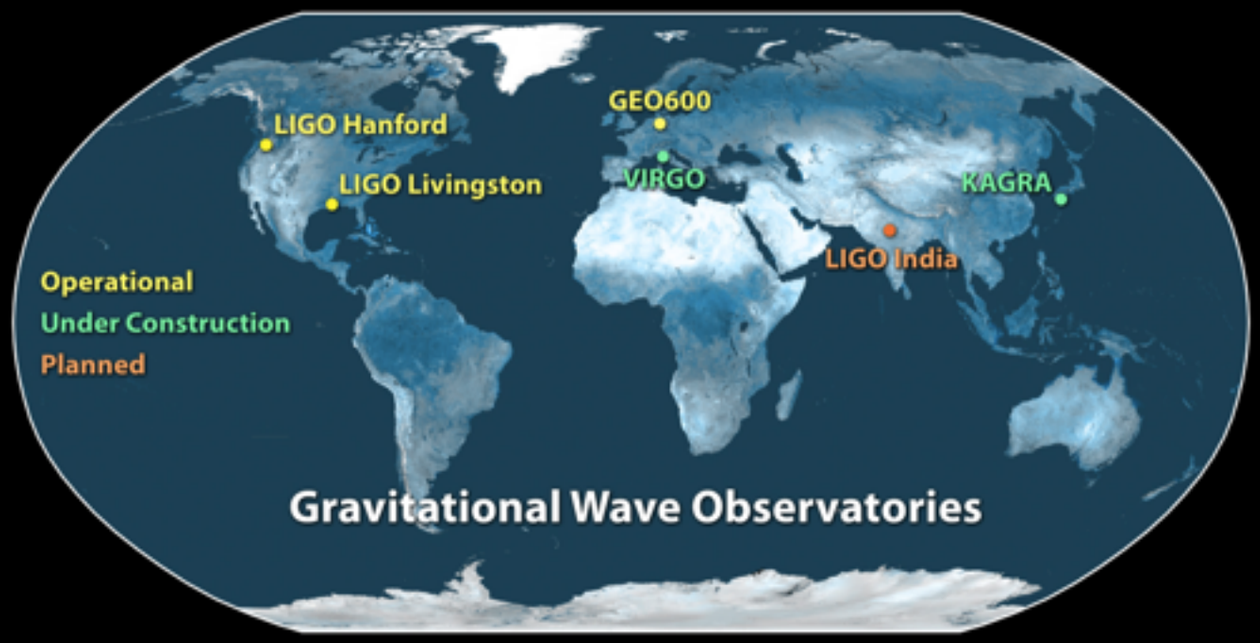
Regimbau+ PRL 2017

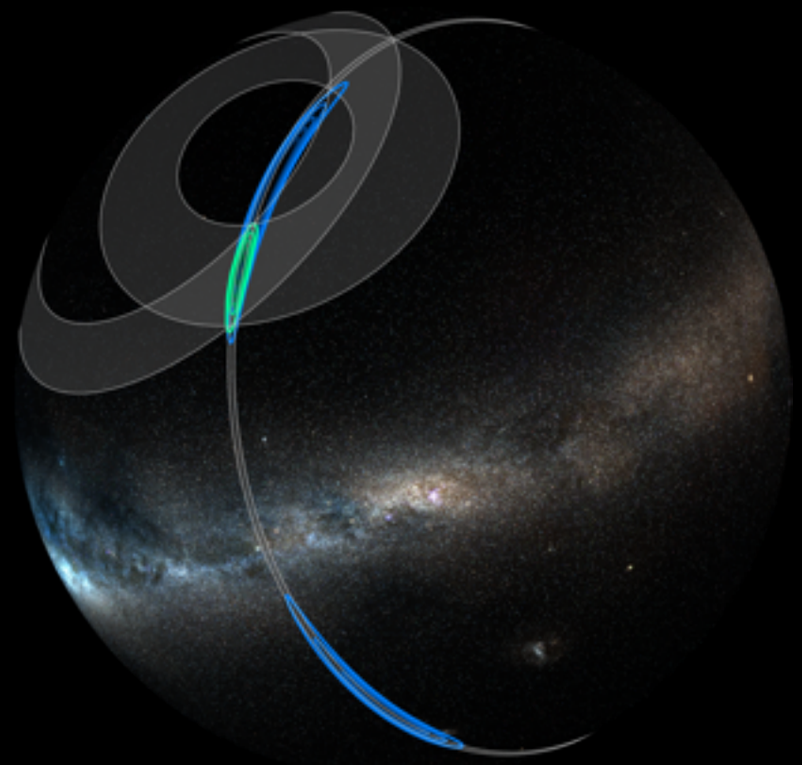


DETECTOR NETWORKS AND FIGURES OF MERIT

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