ET Science Quo Vadis

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Vision Document: Purpose

- Clearly state the science questions that ET, for that matter any 3G detector, should address
  - The era of GW Astronomy is firmly in 3G
  - 2G detectors could do some ground breaking science but will have limited event rates
- Identify problems that must be explored in more detail during the design study
  - Mass function of
- Identify computational and data analysis challenges
  - Inspiral signals could be in band for periods up to a day - data sets of order $N \sim 10^9$, millions of templates
- Prioritize the science to help with trade-studies

Vision Document

- Some 74 pages long
  - Executive summary (1 page)
  - Science Requirements (3 pages)
  - Sources (20 pages)
- Four science Sections
  - Fundamental Physics (9 pages)
  - Astrophysics (15 pages)
  - Cosmology (6 pages)
  - Data Analysis and Computational Challenges (6 pages)
- An Appendix on ET sensitivity curve (5 pages)
- More than 200 references (7 pages)

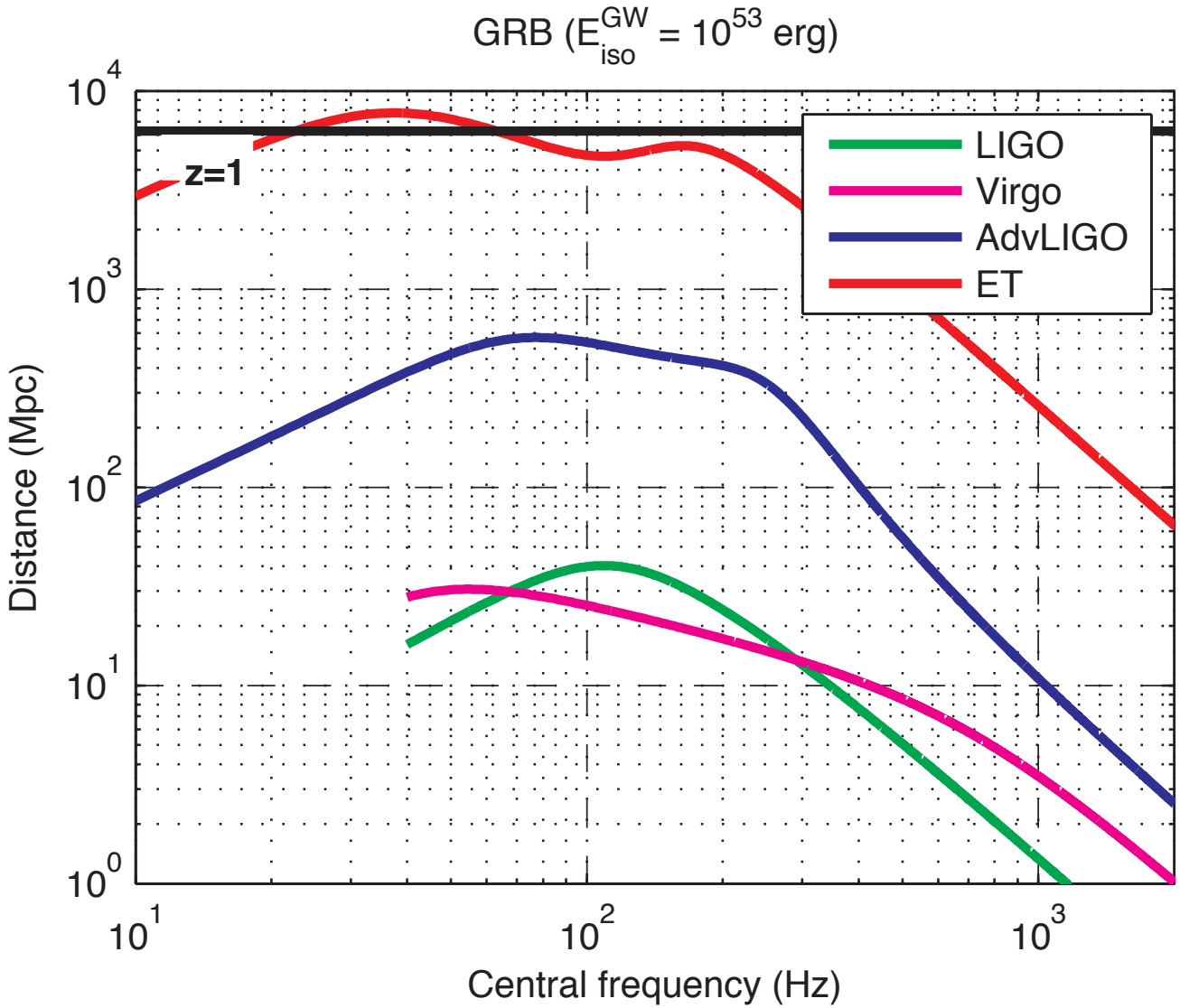
Future of the Vision Document

- Many interesting problems in fundamental physics, astrophysics and cosmology
  - However, we need more quantitative evaluation of the science ET can do
- The document lacks clarity on prioritization of science and what theoretical progress is necessary to take advantage of ET
- Should probably aim at producing a glossy, shorter version that could be used for outreach and lobbying?
  - Exploring the Extremes of Physics with ET

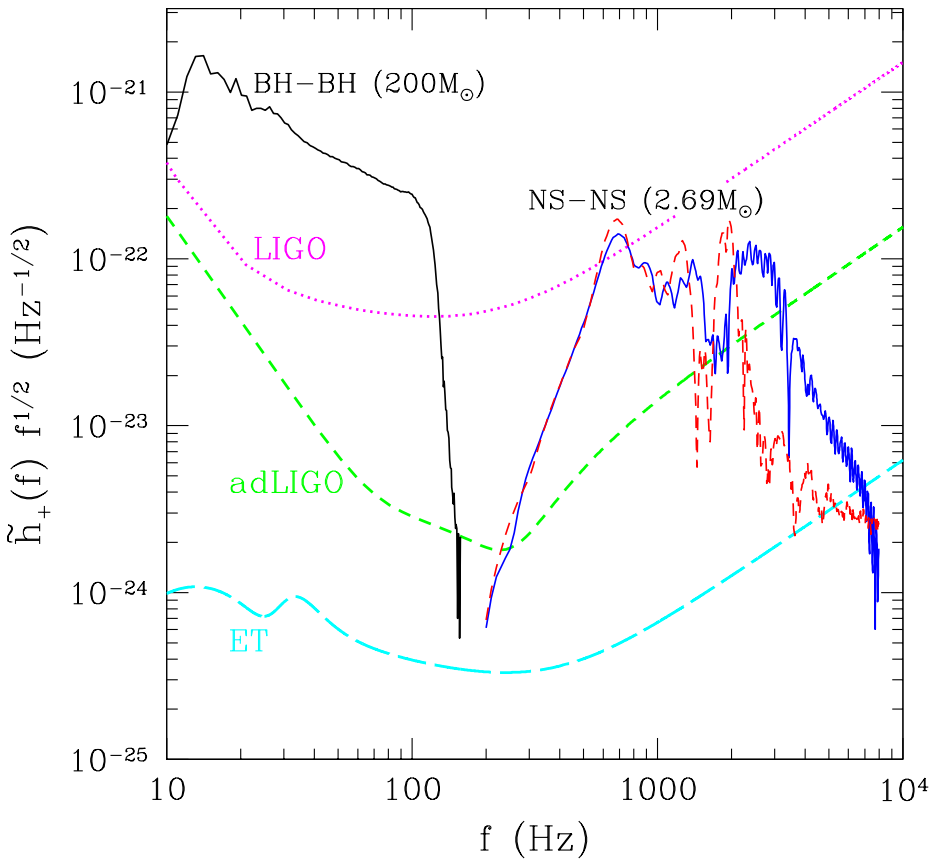
Summary of ET Science

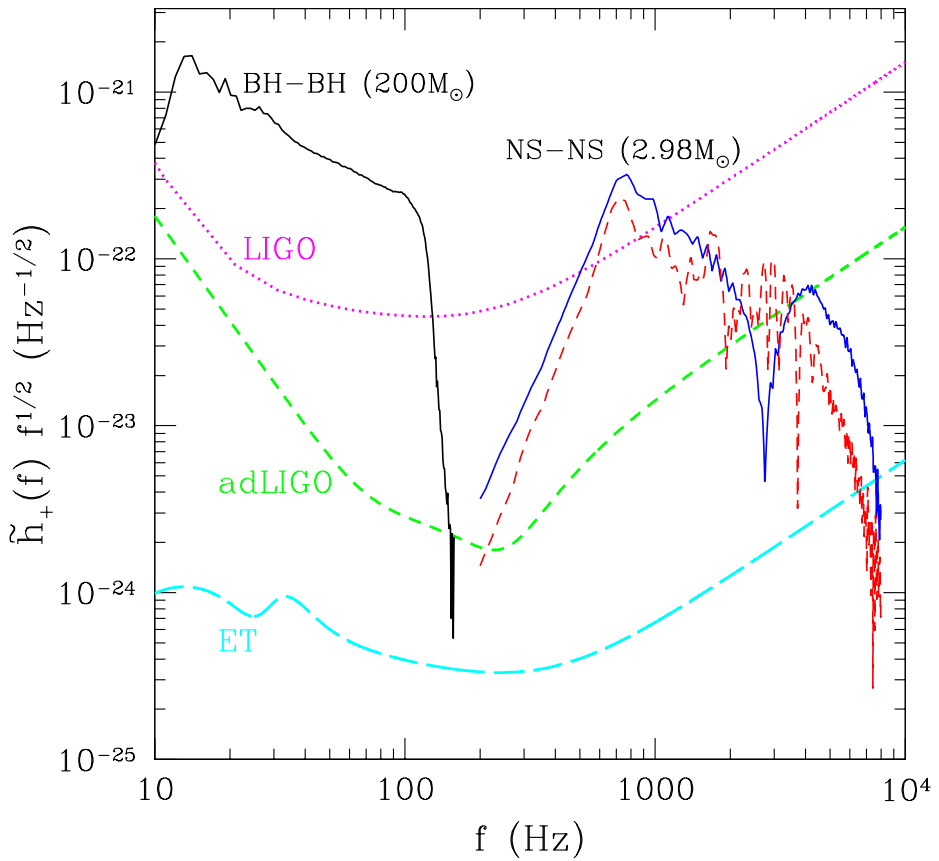
- Fundamental physics
  - Upper limits on the graviton mass, dark energy equation of state, polarization states of GW, black hole no-hair theorem, signature of string theory
- Astrophysics
  - GRB progenitors, mass function of NS, history of star formation rate, NS normal modes (glitching pulsars, flaring magnetars), NS equation-of-state from mergers
- Cosmology
  - Cosmological parameters, seed black holes, intermediate-mass black holes,

Gamma-ray bursts

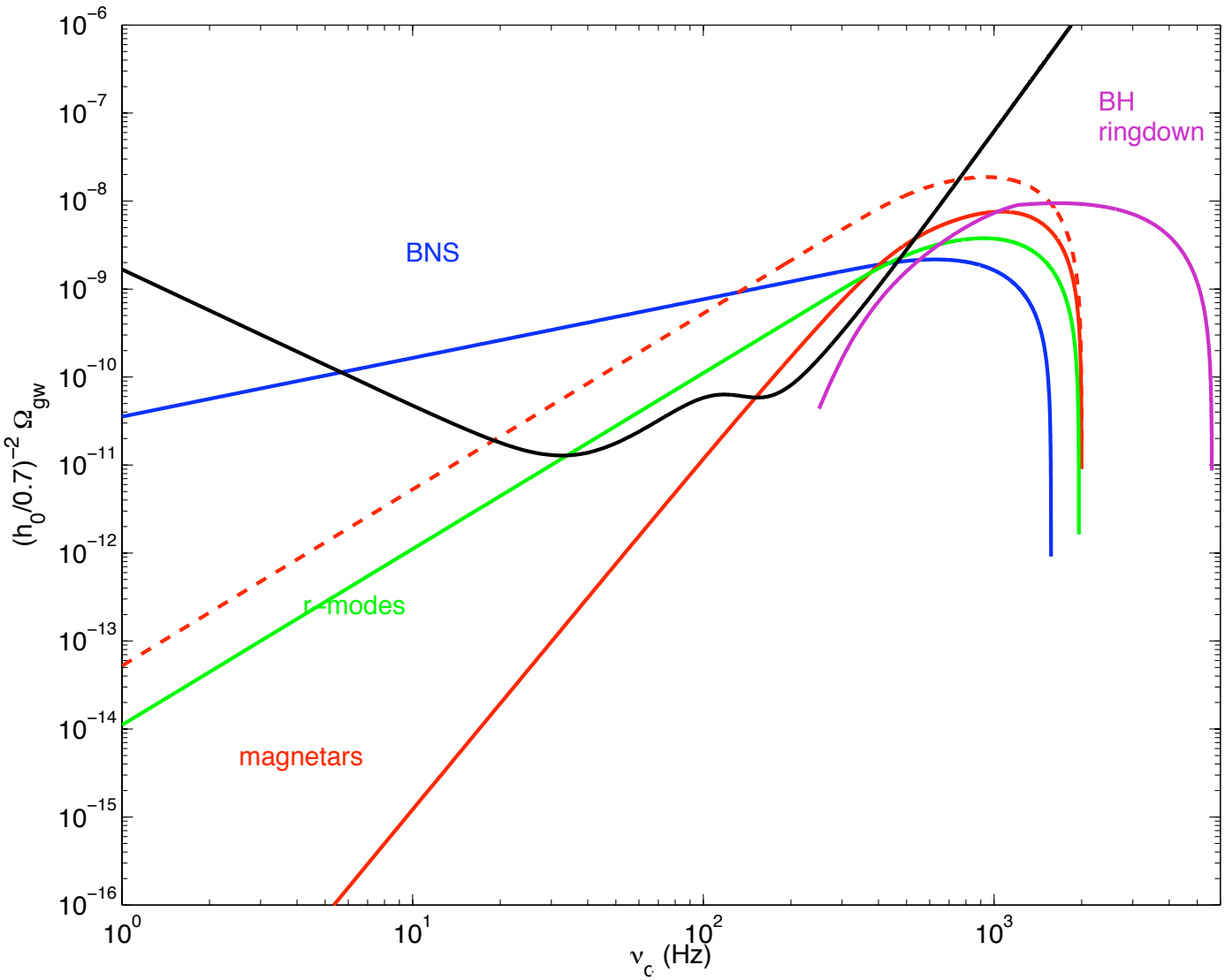


Double Neutron Star Mergers

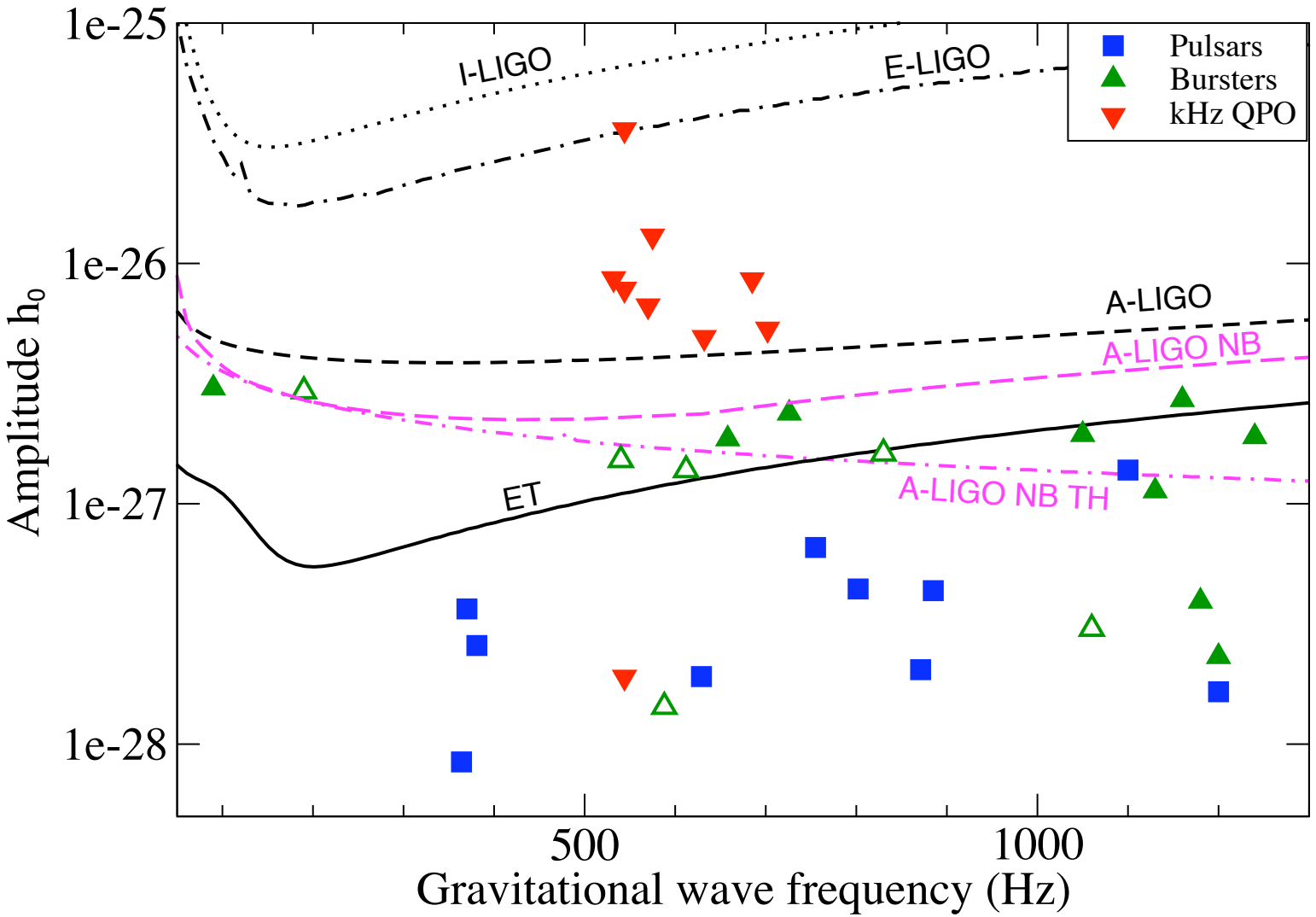




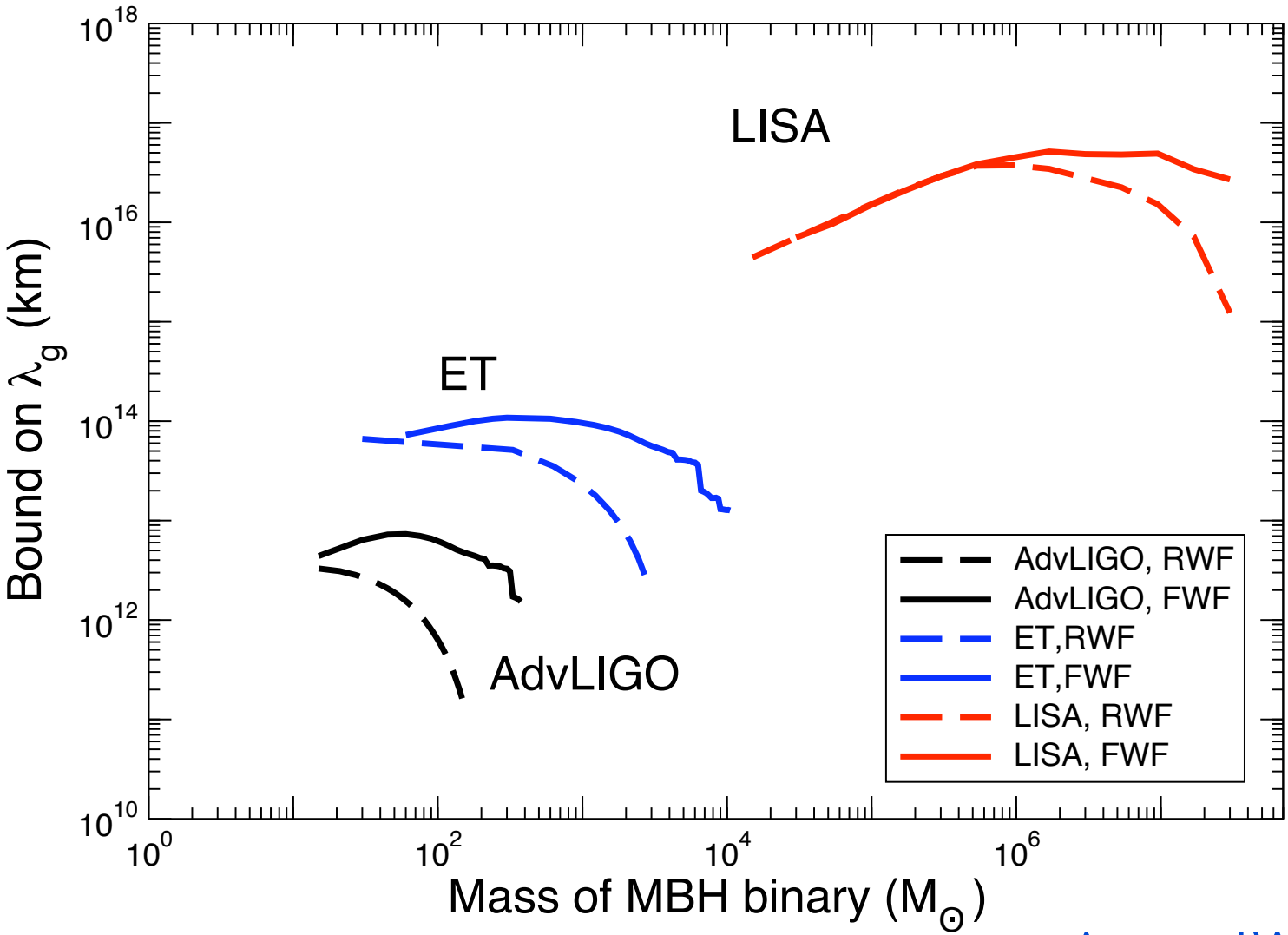
Astrophysical Backgrounds



Accreting Neutron Stars

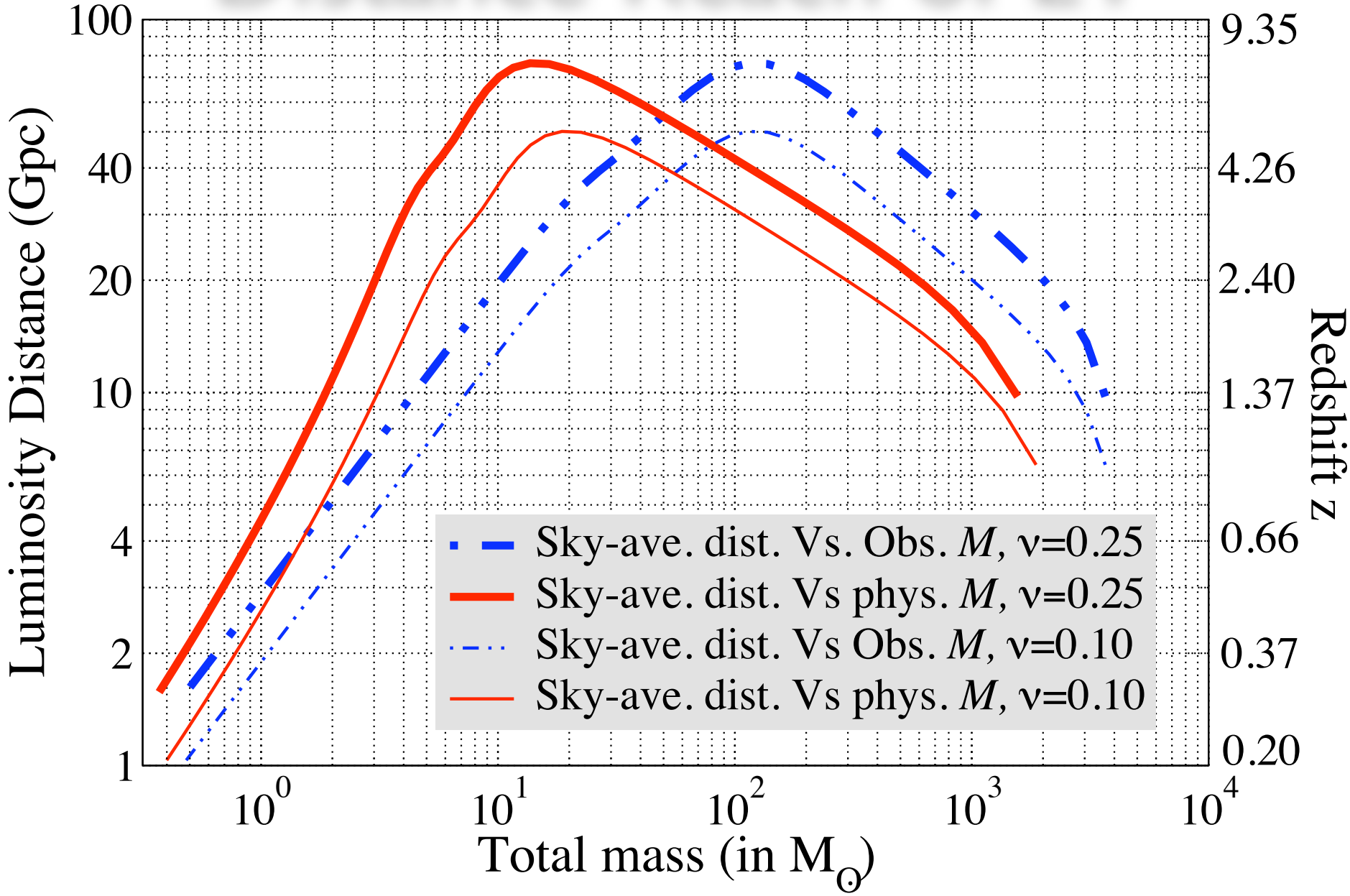


Bounds on Graviton Mass



Arun and Will (2009)

Distance Reach of ET



A list of WG4 problems

Open but easy problems

- A systematic and well-document study of the angular resolution of ET for BNS, BBH, NSBH
- A systematic study of the error in luminosity distance with red-shift
- The number of galaxies within the error box of ET on the sky
- Trade studies with different ET designs
  - A single site triangle versus multiple site L-shaped detectors
- Can ET operate usefully in coincidence with advanced detectors? What about BBO/DECIGO?

Science with BBH mergers

- ET should be able to see thousands of BBH mergers at z~1 with an SNR of 100 or more
- Within z~5-8, ET should detect millions of these sources
- Challenges:
  - Can we disentangle these sources from everything else
  - Not looked at the science potential of such a large number of events
- Obvious things to do
  - Mass function of black hole binaries, star formation rate, strong field tests of GR
  - How well can we determine cosmological parameters statistically?

Multi-messengers and ET

- What optical, radio, x-ray, gamma-ray, neutrino telescopes/detectors will be operating on the 2025 time scale that are capable of good sky-coverage
- If we want to follow-up ET BNS/BBH coalescences what sort of optical telescopes would we need, how many of them to cover the entire globe, etc.
  - Create a database of "small" (3 m class) telescopes around the world
  - Record all the necessary information about every potential telescope that could be useful for us

Large scale structure of the Universe

- From a large sample of measurements of the Hubble parameter it should be possible to deduce large-scale anisotropy
  - Dipole anisotropy can be measured to an accuracy of fraction of a percent
  - Residuals can be used to test anisotropic Bianchi Type I models

Sensitivity to Stochastic Background

- Can ET's sensitivity to SBG improved beyond the standard cross-correlation-based values
- Can one construct "noise-only" channels from ET's three detectors?
- How well can we subtract the noise to improve sensitivity to SBG?
- What lessons have been learned from H1-H2 common noise?