LISA Symposium
05.09.16

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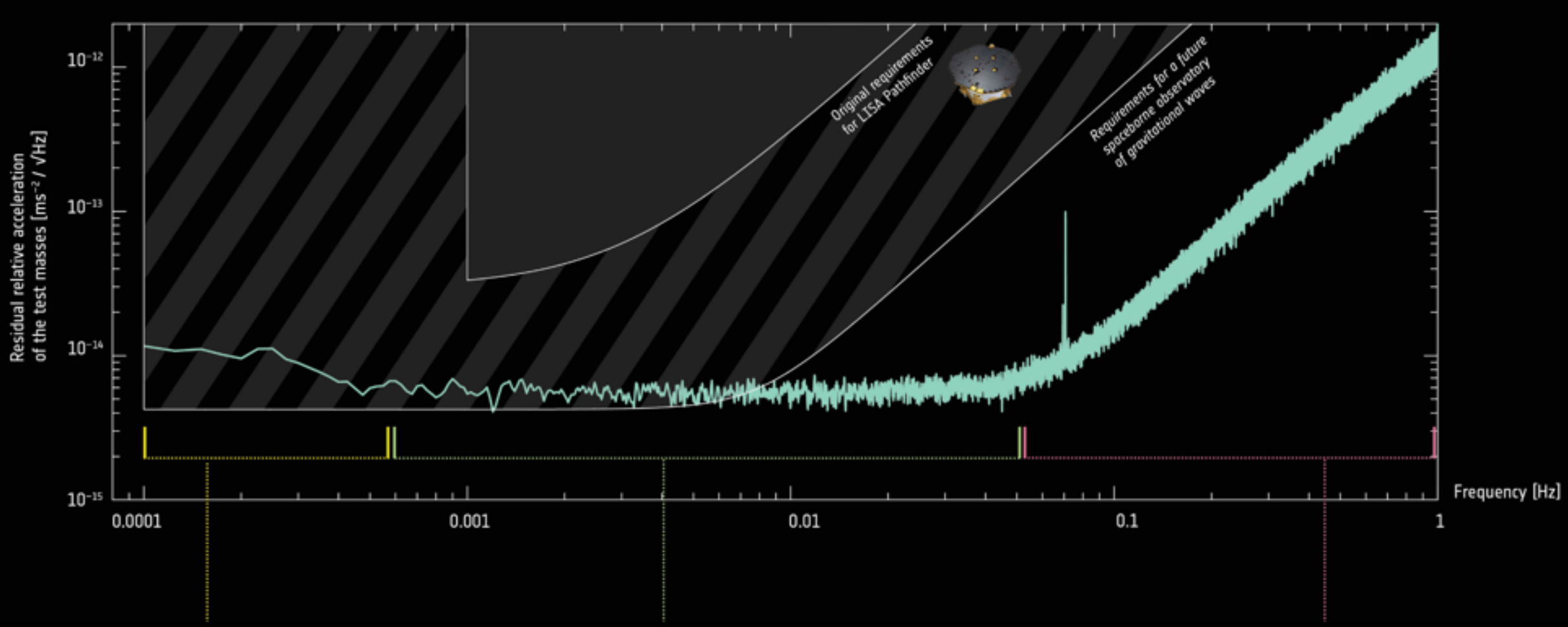
LISA SCIENCE AFTER GW150914 AND LPF

→ LISA PATHFINDER EXCEEDS EXPECTATIONS



2016 CHANGED EVERYTHING

- LIGO proved:
  - that GWs exist (if you didn't believe binary pulsars!)
  - that laser interferometry can detect them
  - that black holes behave dynamically as GR predicts
  - that even the first GW detection provides science surprises
  - and that the public are wowed by it all!
- LPF showed:
  - that the LISA technology is viable
  - that the LISA community's experimental team is top quality!
- This was reinforced by the strong endorsement to ESA from the GOAT.

SCIENCE EVENT OF THE DECADE!

On NYC's Highline in May:

B F Schutz
Albert Einstein Institute/Cardiff University

05.09.2016

(Credit: Rachel Schutz 2016)

LIGO + LPF: IMPACT

- The GW game has changed
  - Strong international interest: NASA, JAXA, China
  - Strong motivation for bringing L3 closer
  - Strong motivation for doing a 3-arm, 6-link mission
  - Realisation that there is joint science to be done by ground-based and space-based observatories
  - Confirmation that GW observations do astronomy as well as probe the fundamental nature of spacetime

LIGO'S LESSONS FOR LISA

- Kate has covered the remarkable LIGO observations. What, then, does LIGO tell us about LISA and the LISA era? A few thoughts —
  - Stellar BHs are more massive and more plentiful than we have assumed. Potential implications for EMRIs, IMRIs.
  - Astrophysical stochastic background stronger!
  - LIGO + Virgo may be able by 2020 to measure local H_0 to accuracies similar to current uncertainties.
  - Detection in the acoustic band (> 1 Hz) will get much better soon, with upgrades to LIGO, more detectors, and then ET and Voyager possibly contemporary with LISA.
  - LSC may change its membership rules soon, and data will become open soon. Maybe see LISA and LSC communities become mixed together.

MORE MASSIVE EMRI'S

Freyer, Belczynski, et al arXiv:1110.1762

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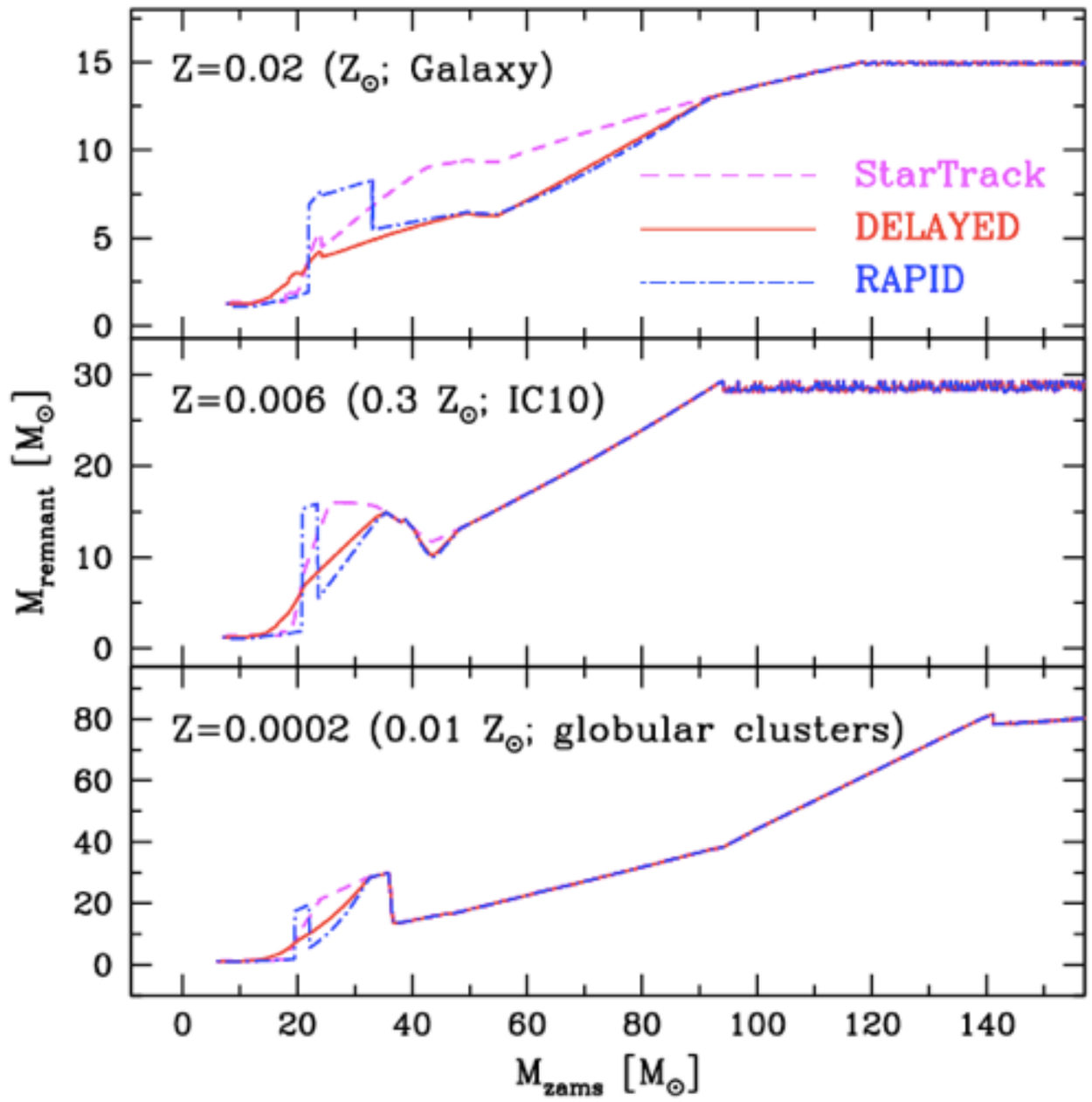
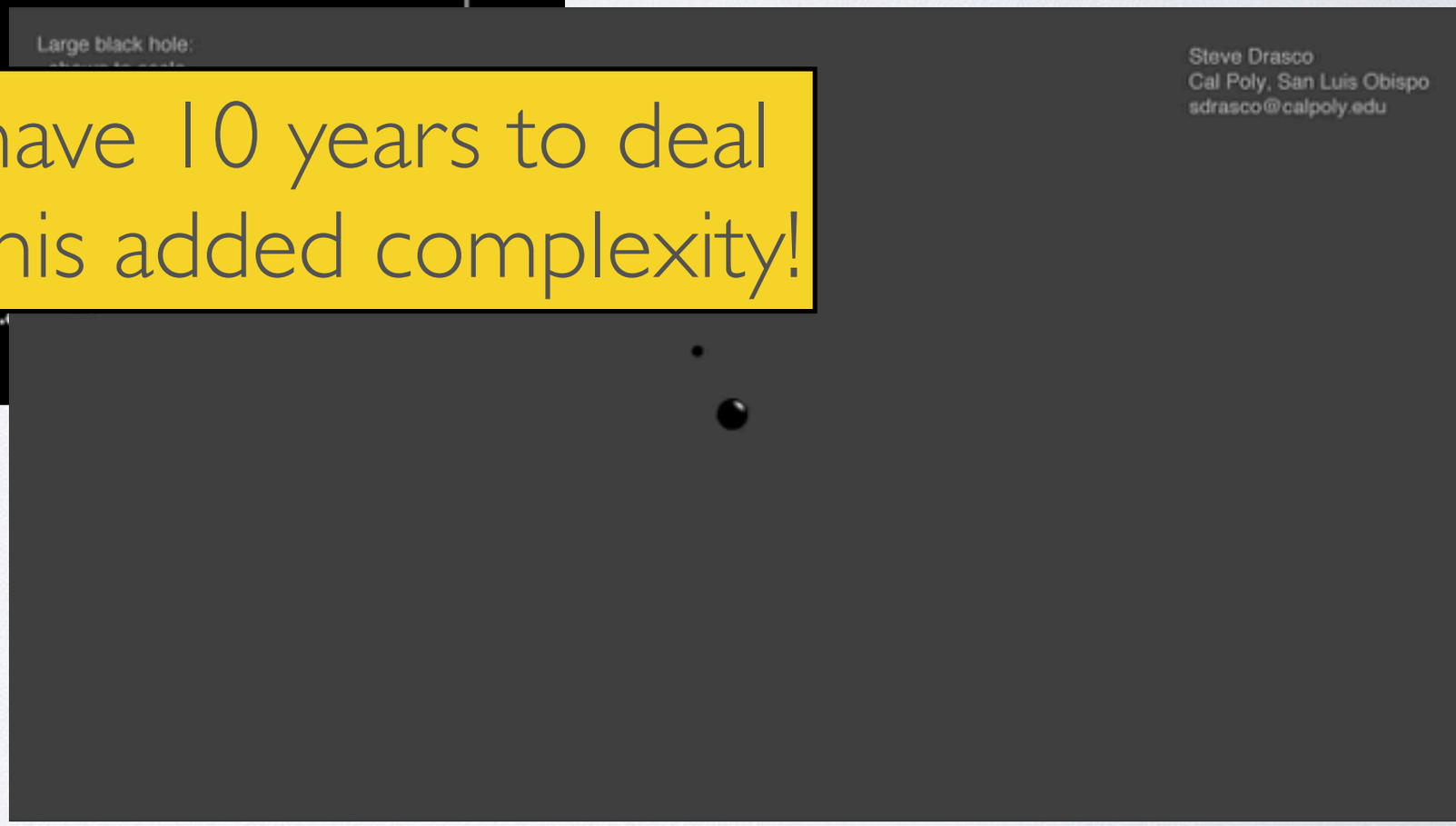


Fig. 13.— Metallicity dependence of final compact object masses for single star evolution using our 3 calculation schemes for binary population synthesis.

EMRI'S & IMRI'S

- These larger masses formed at high-z so are only part of the BH population, but for EMRIs they might dominate if, in the hierarchical MBH formation scenario, they are carried along and preferentially inhabit the clusters around successive merged MBHs.
- If EMRIs are 3× more massive, their amplitudes are 3× higher and their inspiral times are 3× shorter. So they can be seen ~ $\sqrt{3}$ further away, for a ~5× larger event rate.
- At the upper end, we might see 50-80 $M_\odot$ BHs spiralling into 10^4 $M_\odot$ MBHs. At these IMRI mass ratios $\mu \sim 10^{-3}$, standard perturbation theory for computing template waveforms will be seriously challenged.
- The EMRI/IMRI template challenge is still far from being solved!

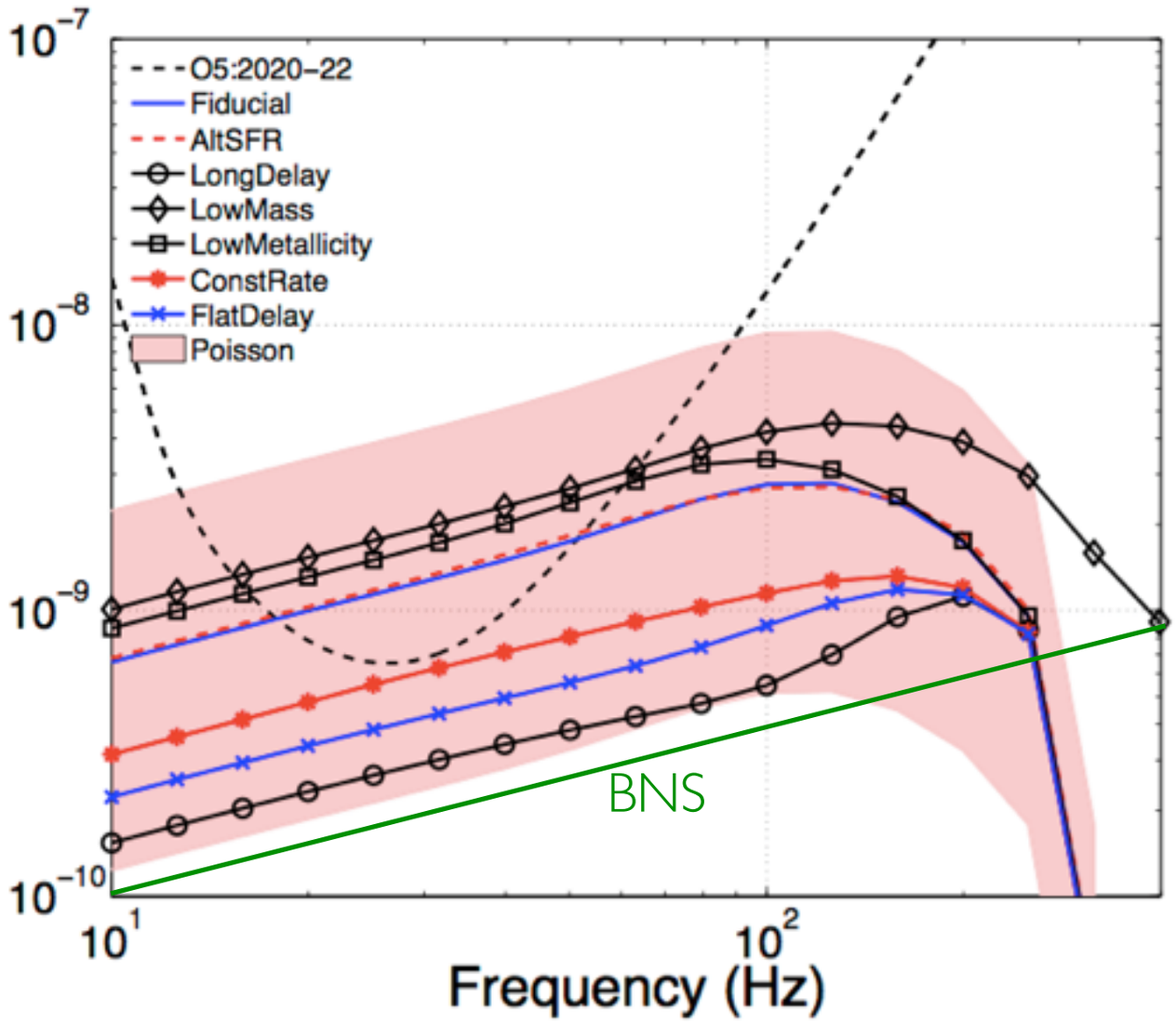
LISTEN TO THE DIFFERENCE!



We have 10 years to deal with this added complexity!

STOCHASTIC

- LIGO's BBHs may form a slightly stronger astrophysical stochastic background than we have anticipated in the past. Maybe 3× higher than BNS, with same slope to lower *f*.



L-V, Phys. Rev. Lett. 116, 131102 (2016)

COSMOGRAPHY

- When Virgo joins LIGO (early 2017) the network will begin to get better positions and eventually to measure luminosity distances to BBHs to ~5%.
- As sensitivities improve, we can expect >100 BBHs by 2020, with *z* out to 0.2.
- Even without identified counterparts, this could be enough to get the local H_0 to close to 1%. Will be interesting to see how this fits with measurements by other means.
- A big challenge to LIGO will be *calibration*. It will be hard to push it to 1%. As a systematic error, it does not average away over many BBH events, so eventually it may limit the accuracy of LIGO's statistics.
- There is plenty for LISA to do that LIGO can't address, and consistency between the two will be important. LISA does not have the calibration problem. It is self-calibrating at least to the 0.01% level required to support SNR ~ 10^4.

LISA AND LIGO (+…)

- LISA's possible partners on the ground:
  - Ground-based network is planning a series of upgrades. KAGRA in 2020, A+ in 2023 (factor ~2), LIGO-India in 2024.
    - European ET and US Voyager 3G new builds might be operational by 2030? (Sathyaprakash talk.)
  - Sesana (talk) has shown the exciting potential for joint observations of LIGO's BBH sources. This gets even better if there is a complementary mission flying, like DECIGO (Sato talk), gLISA (Tinto talk), or a possible Chinese mission (Jin talk).
  - ET and LISA have an interesting overlapping sensitivity for IMBH binaries. Again this will be improved by other missions.

LIGO AND LISA COMMUNITIES

- The LSC is discussing a number of options for revising its membership rules, and is hoping to agree changes next year.
- The LSC is also discussion when to open its full data. It is already releasing snips around events, but this is not enough to allow one to judge significance.
- Over the next couple of years, non-LV LISA community members might get more access to real data, and might have the opportunity to collaborate with current LV members on its interpretation.
- Once LISA's design is fixed and a date for launch agreed, then it would also be sensible for LISA scientists to work with ET/Voyager teams to ensure that potential joint observing is taken into account in designing 3G detectors.

WE SHALL CONTINUE TO LISTEN TO OUR UNIVERSE!