DATA ANALYSIS AND ASTROPHYSICS
Recommended Actions

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Transients: if first detections are as anticipated

e.g. BH-BH with expected masses and spins, NS-NS or NS-BH inspirals with a number of infrared/optical transients, as counterpart candidates, NS tidal terms weakly constrained, SNR values of 12-15.

- Invest in more automated detector characterization to enable going deeper into noise, and increase our sample of events
- Continued focused development for fast waveforms with more physics valid across parameter space
- Extend prompt online analysis to use simple-precession waveforms and eliminate biases (in sky location, masses)
- Develop quantitative methods for moving from observed sample to underlying source properties (modeling of pipeline selection biases)
- Continued development to achieve comprehensive GR tests (BHs, “perfect” waveforms, wide parameter priors)
- How do we deal with the absence of any firm EM counterparts?

Transients: if first detections are sources we currently consider unlikely

e.g. Low-mass NS inspirals (< 1.25Msun); High NS spins (> 0.1-0.4); Evidence for significant eccentricity (>0.1); Massive BH (> ~12-15Msun); IMBH signals

Need a shift in focus:

- Extend search parameter space in the unlikely region
- Investigate different parameter priors for PE
- Explore implications for CBC formation

Transients: if first events have no EM counterpart or robust inspiral signature (Burst)

- Need astro guidance beyond EM followup; classes of GW signals predictions that we can compare a detection to.

- Baseline: to at least exclude some models we need info on duration of the signal, frequency content, frequency evolution with time (if any). The total GW energy would be an incredibly useful quantity to have to rule out models but in the absence of EM counterpart this is going to be hard because of the lack distance estimate.

- Pursue selection studies to associate burst candidates to families of sources/waveforms, using state of the art simulation. Enhance simulations with matter.

- State of the art simulations.

CW: Connection with Astro and Modeling

- Getting as much information as possible about potential sources greatly helps increase sensitivity even without actual detector improvements
  - we need radio, X-ray, gamma-ray timing of as many known pulsars, including access to any newly discovered sources
  - encourage and advocate for X-ray timing of LMXBs (and other potential sources) to try and get rotation periods
  - encourage wide-sky surveys (optical & X-ray) to identify potential nearby neutron stars
- Keep close links with these communities to have access to the most recent surveys, and advocate for any new satellites/observatories. Investigate what's required for multi-wavelength EM follow-ups of any detections to exploit maximum physics output
- advocate for further theoretical work on modelling realistic mechanism that can produce and sustain ellipticities on neutron stars - this will provide more realistic metrics for detections

From Data to Instrument

Say we get a few marginal detections. Based on statistical arguments, can we say anything about astrophysical source population?

- Build populations from our finite detections to guide choices in instrument development. Lead time needed, so urgent now.

- Develop a metric for each science goal to assess the impact of incremental improvements to the instrument (we have range for BNS, spindown for CW, but we need more sophistication and how to do so may become clearer in early detection era).

Detector Configuration

- **CBC**: improve high-frequency sensitivity to focus on NS EOS and GR tests *OR* low-frequency to expand BBH reach
- **BURST**: A factor of 2 in high frequency helps for SGR giant flares, possible core-collapse signatures, and any other things that are not CBC and have low event rates.
- **CW**: we learned there is no strong case for narrow banding detectors - sensitivity gains are minimal and we do not know where would be best to narrow band. Single detector running is fine for CW searches - we don’t require coincidence for detection. Squeezing offers the same benefits as narrow-banding, but over a broad band, because optical loss in the squeezer is the limitation for both techniques.
- Action item: starting from the 3 configurations/noise curves we saw yesterday, produce a summary of new science that would be uncovered.

Collaboration Modes

- How much astrophysics do we want to do as a collaboration?
- Can Guest Investigator programs help ensuring that EM partners share their results so that smaller FOV facilities can also follow-up? Not entirely clear that it would...
- RECOMMENDED ACTION: continue exploring collaboration modes that enable innovative data analysis approaches without jeopardizing mission-critical tasks for first detections