Stan's problem for the pulsar group:

In an unbiased search (i.e., searching over a range of frequencies and f-dots) aimed at the galactic center, the S2 data show a possible signal at an h of 3×10^{-24} at a frequency of 380 Hz in the L1 detector. The level of significance is not overwhelming, about 80% confidence level. H1 and H2 have poorer sensitivity, are consistent with the L1 signal, but don't add significantly to the confidence. If the best estimate of f-dot is attributed entirely due to slowing due to gravitational waves, the distance to the (presumed) neutron star source is 300 pc.

S3: Use of a template with the observed f and f-dot in the s3 data shows no evidence of a signal. However, if the same f-dot and an f which is increased by 0.7 mHz are used. L1 sees a signal of 2×10^{-24} at a confidence level of 90%. H1 sees a signal of 1.5×10^{-24} at a confidence level of 85%. H2 is consistent, but with a higher noise level that does not add to the confidence in a significant way.

Our response

• The scenario is an interesting one as it highlights some remarkable features of all-sky searches, and the importance of a clear understanding of confidence levels.

S2 data

•We interpret ‘a confidence level of 80%’ as meaning *‘a value as high or higher will occur by chance anywhere in the searched parameter space in only 20% of equivalent science runs’*. This is therefore a remarkable measurement. It would be expected to happen by chance *for a particular template* with a probability of only 0.2 divided by the number of templates. We estimate that a full search towards the galactic centre corresponds to ~ 10^{17} independent templates (~10^{8} directional, ~10^{9} in frequency), so the snr of this signal (if it is a signal) must be large: about 9.5

•The fact that this signal is identified *at all* in the H1 and H2 searches indicates the snr is similar (though lower) in these IFOs. The chances of a fluctuation at this level appearing in all three by chance is essentially zero. Even if the confidence levels were only 10% in all three IFOs as defined above, the joint probability that the signals so identified are consistent with noise is only about 0.9 x (0.9×10^{-17}) x (0.9×10^{-17}) ~10^{-34}! S3 is not needed to show there is something rather unusual here (note this result ignores possible contamination from instrumental lines).

S3 data

•A 0.7 mHz change in frequency corresponds to a fractional change of $2x10^{-6}$ – consistent with a (Vela-like) glitch: we should search over windows of this size for *any* follow-up observations, so the glitch is 'not a problem' and any signal this close to the original signal would be taken very seriously.

• We expect to have to search over a small hypercube of parameter space for the follow-up S3 observations (mostly in frequency). The scenario implies that the snr of the peak in L1 is about 10. The chance of a fluctuation at this level or more occurring in a predefined sky position in a ~2 mHz band about the original frequency is about 10^{-13}. Again, and even without H1/H2, the evidence for a non-noise source is overwhelming.

so…

•all-sky search sensitivity levels need to be interpreted with care

•targeted searches are by definition more sensitive than all-sky searches

•We shouldn't take Gaussian tails too seriously! (no real dataset is Gaussian at this level.)

Alternative scenario

•The question of how we would handle a marginal detection remains. Imagine a targeted search for a pulsar that delivers an snr of about 4 in both S2 and S3. Is this a real signal? Is it an instrumental line? Is it extraterrestrial?

Consistency checks

•Does the signal-to-noise ratio improve as root time?

•Is the signal consistent between interferometers? i.e., are the derived parameters the same within their uncertainties?

•Do the signals respond correctly to the diurnal antenna pattern?

•Are the individual IFO analyses consistent with a joint coherent analysis?