

Effects of Calibration Errors on Astrophysical Searches: Detection and Parameter Estimation

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References

- T960189-00-E
LIGO Calibration Accuracy
Bruce Allen
- T970101-A-D
Strain Calibration in LIGO
Daniel Sigg

What is the effect of a calibration error on an astrophysical search?

- For “Detection Problem” (Is there a SB at 100 Hz? Have we seen a binary inspiral? Have we found GW emission from a known pulsar?):
 - » Calibration error δ has effect $O(\delta^2)$. So a 10% calibration error means you call the New York Times (or fail to call them) incorrectly only 1% of the time.
- For “Parameter Estimation Problem” (What is the energy-density of the SB? How far away is the binary system? What is h_0 for pulsar?)
 - » Calibration error δ has effect $O(\delta)$. So a 10% calibration error means that you will incorrectly answer the **next** NYT question 10% of the time.

Notation/Definitions

- Calibration: $h(f) = R(f)v(f)$
- Signal: $S = \int df \frac{Rvh_{Template}^*}{RR^*S_v} = \int df \frac{vh_{Template}^*}{R^*S_v}$
- Noise: $N = S - \langle S \rangle = \int df \frac{v_{Detector}h_{Template}^*}{R^*S_v}$
- rms Noise: $\langle N^2 \rangle^{1/2} = \left[\int df \frac{|h_{Template}|^2}{|R|^2 S_v} \right]^{1/2}$

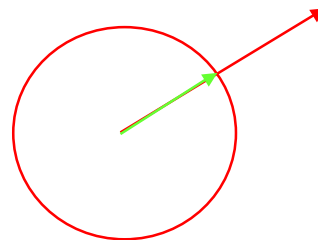
Variation of SNR is second-order in calibration errors δR

- Signal/Noise = $\int df \frac{v h_{Template}^*}{R^* S_v}$

δ $\left[\int df \frac{|h_{Template}|^2}{|R|^2 S_v} \right]^{1/2}$

Variation w.r.t. R vanishes to lowest order.
Hence S/N variation is **second order** in δR .

Note: like $\delta\left(\frac{z}{|z|}\right) = O(\delta z^2)$



(distance to source, strain amplitude, Ω_0)

Example - estimated distance:

$$(A | B) = \int df \frac{A^* B}{S_h}$$

$$\frac{1}{d} = \frac{(h | x)}{(h | h)} \frac{1}{d_{h\text{-template}}}$$

$$= \frac{\int df \frac{v h_{\text{Template}}^*}{R^* S_v}}{\int df \frac{|h|_{\text{Template}}^2}{|R|^2 S_v}} \frac{1}{d_{h\text{-template}}}$$

Varies to first order with δR