LIGO

Broadband Search for Continuous-Wave Gravitation Radiation with LIGO

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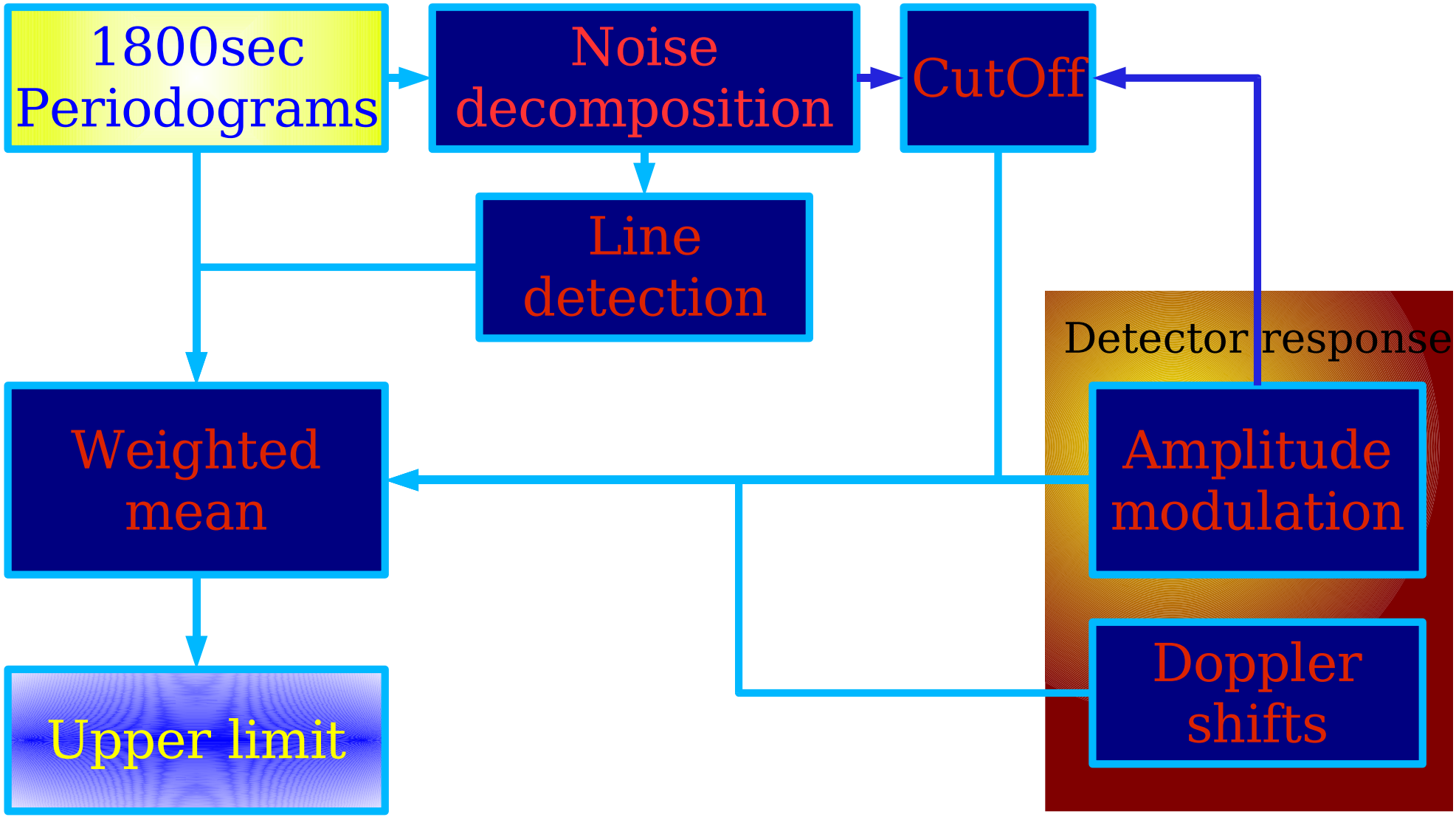
Challenges of search for CW gravitational waves

- Gravitational waves are weak – need to average over long time periods
- Several parameters to search for: frequency, sky position, spindown, polarization
- Coherent methods are very sensitive, but result in enormous search space size – broadband, all sky search is impractical for large time base
- PowerFlux – place sky-dependent upper limits and detect signals by averaging power. Practical for all-sky broadband searches.

PowerFlux analysis pipeline

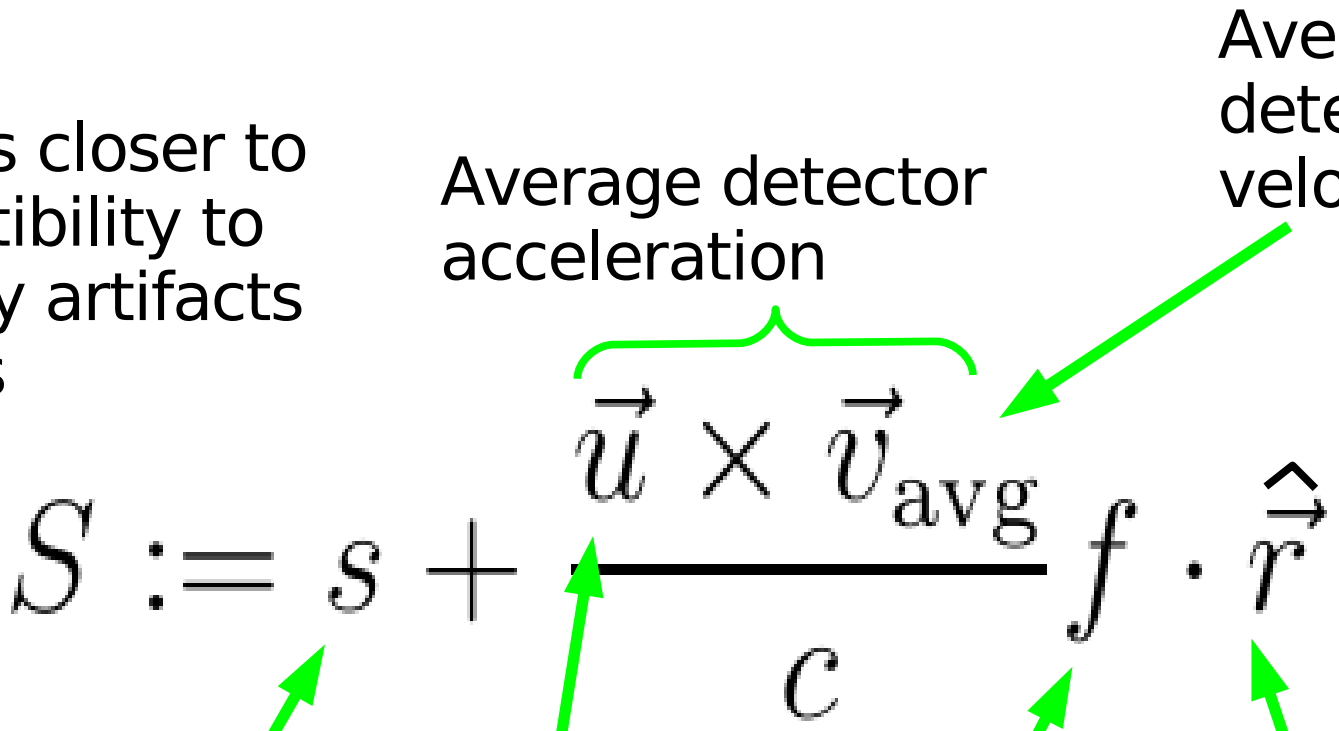


PowerFlux results

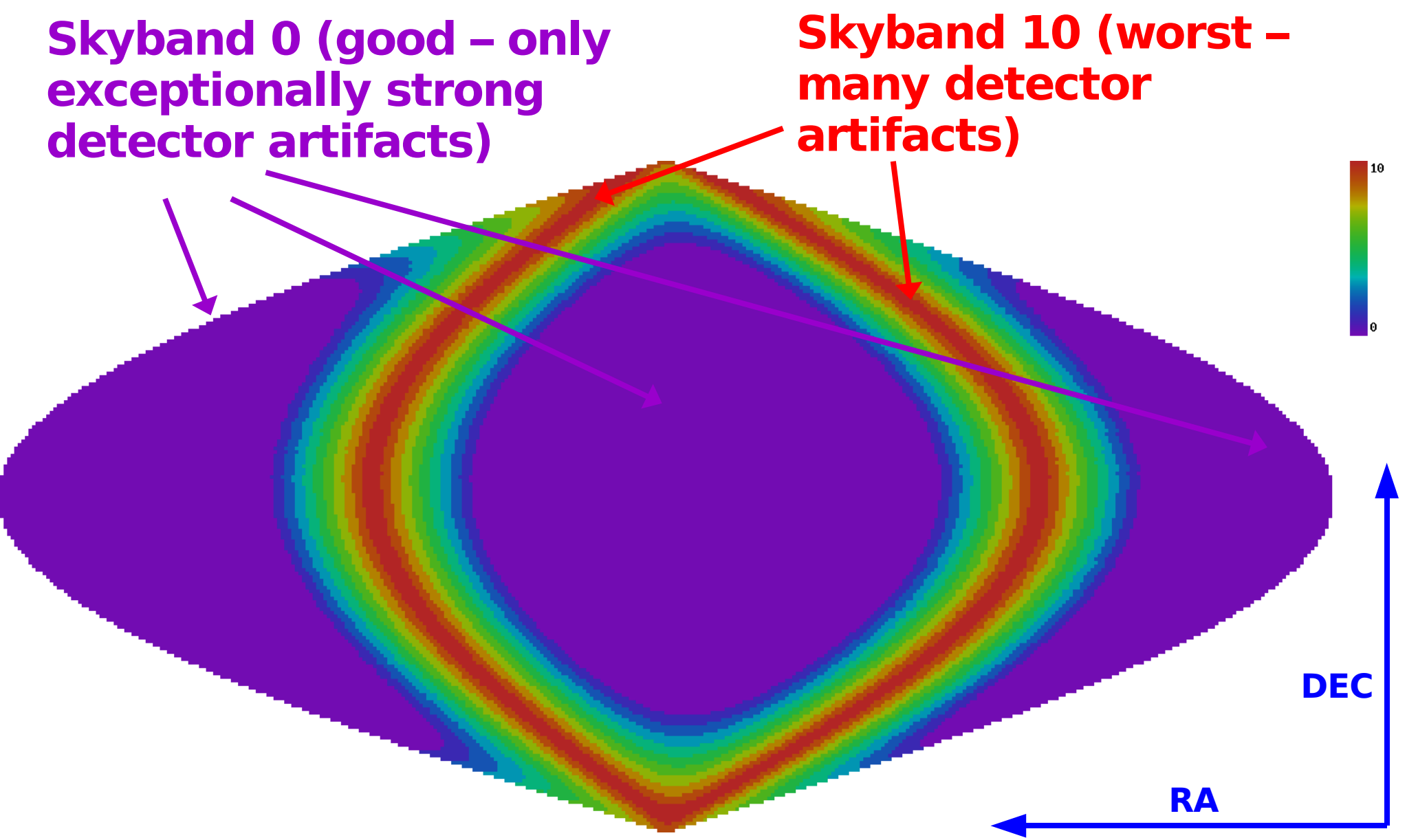
- PowerFlux produces a 95% CL upper limit for a particular frequency, sky position, spindown and polarization.
- Too much data to store, let alone present – the number of sky positions alone is ~10^5 at low frequencies and grows quadratically with frequency
- The upper limit plots show maximum over spindown range, all polarizations and a particular spindown-dependent sky area
- We also present a simple formula that approximates background curve within ±50%

“S parameter”

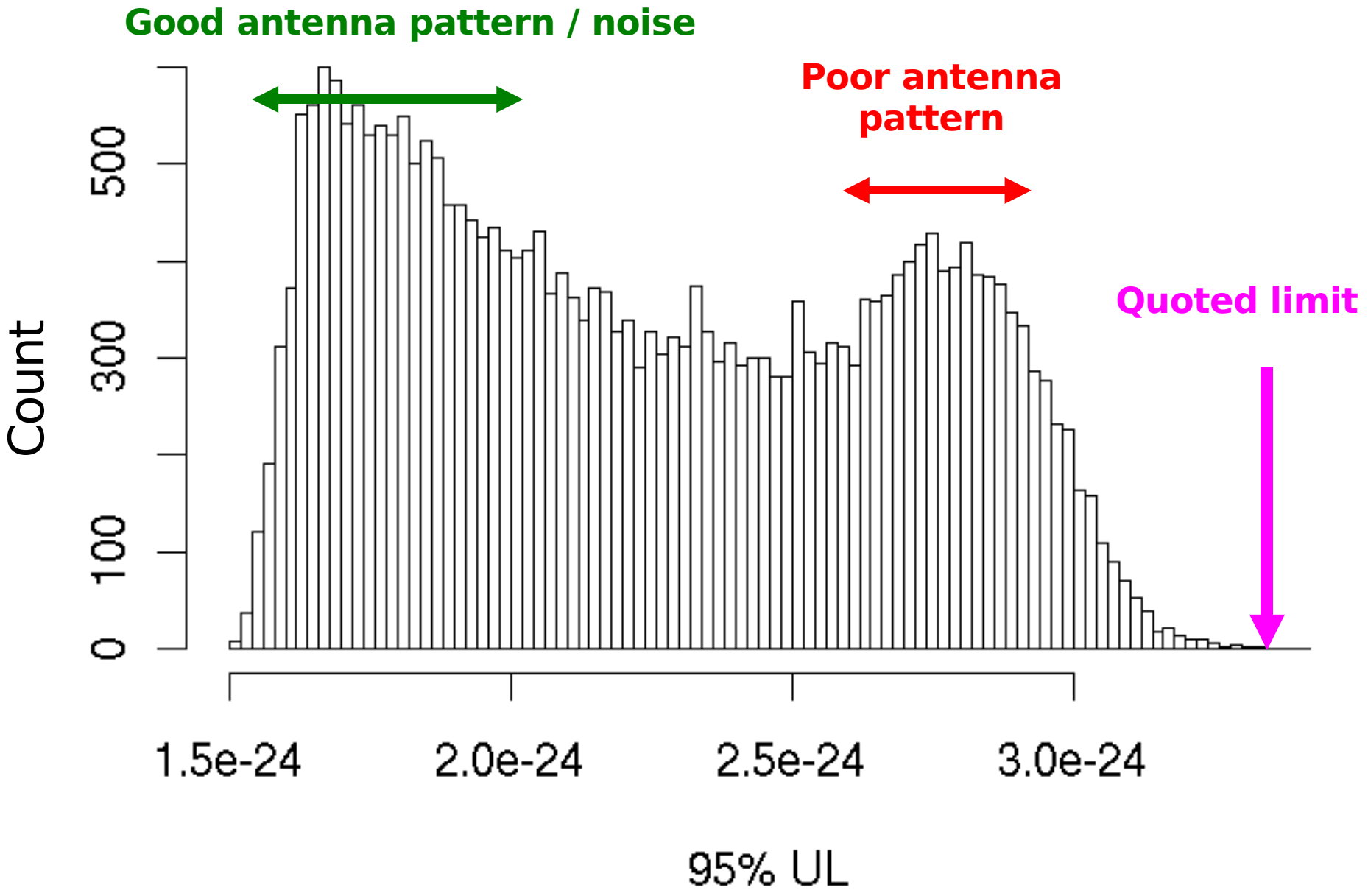
When S is closer to 0 susceptibility to stationary artifacts increases



Doppler Skybands

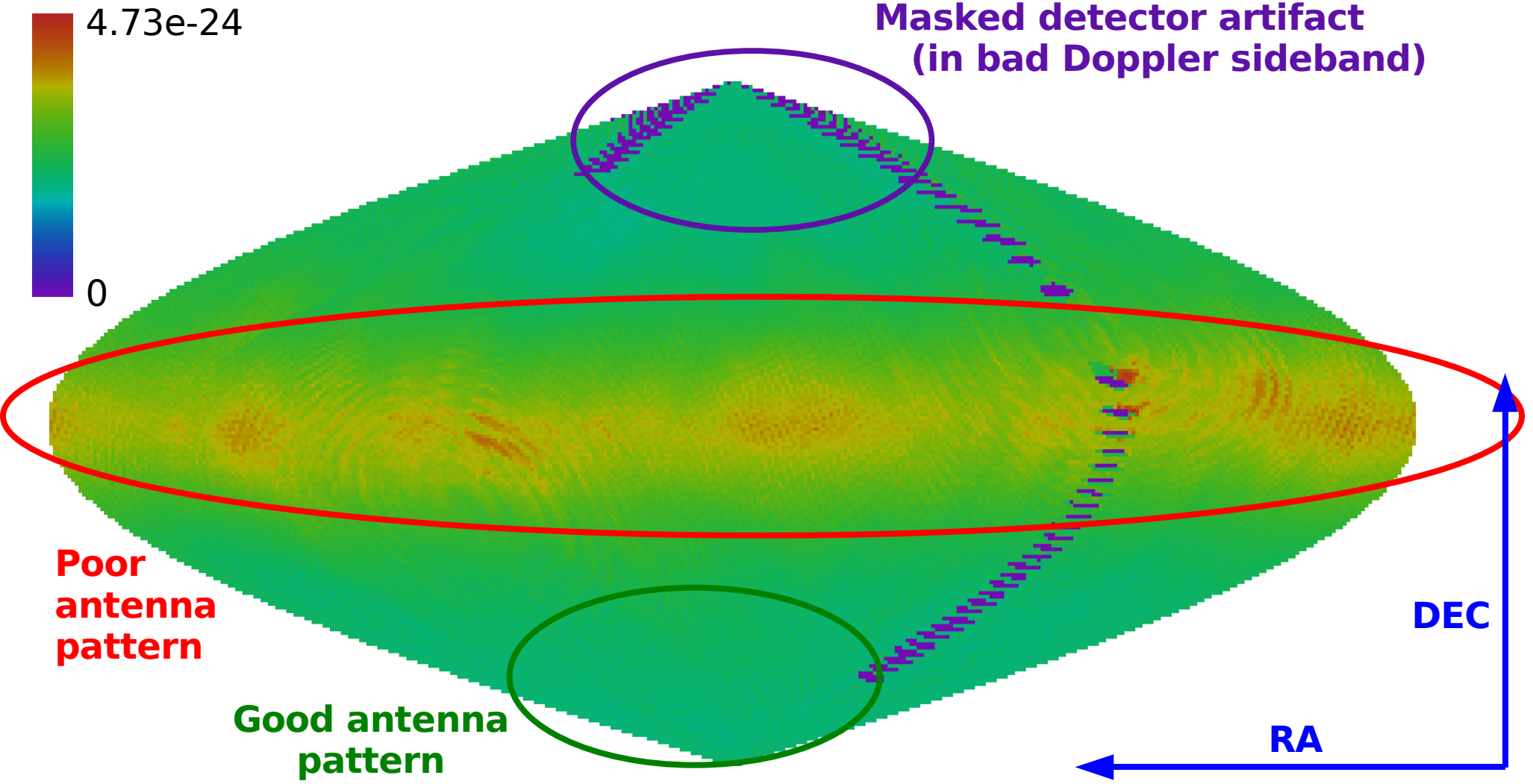


Sample of 95% CL Upper Limits on $h_{linear}=0.5*h_{0\text{-worst case}}$ (sky band 0)

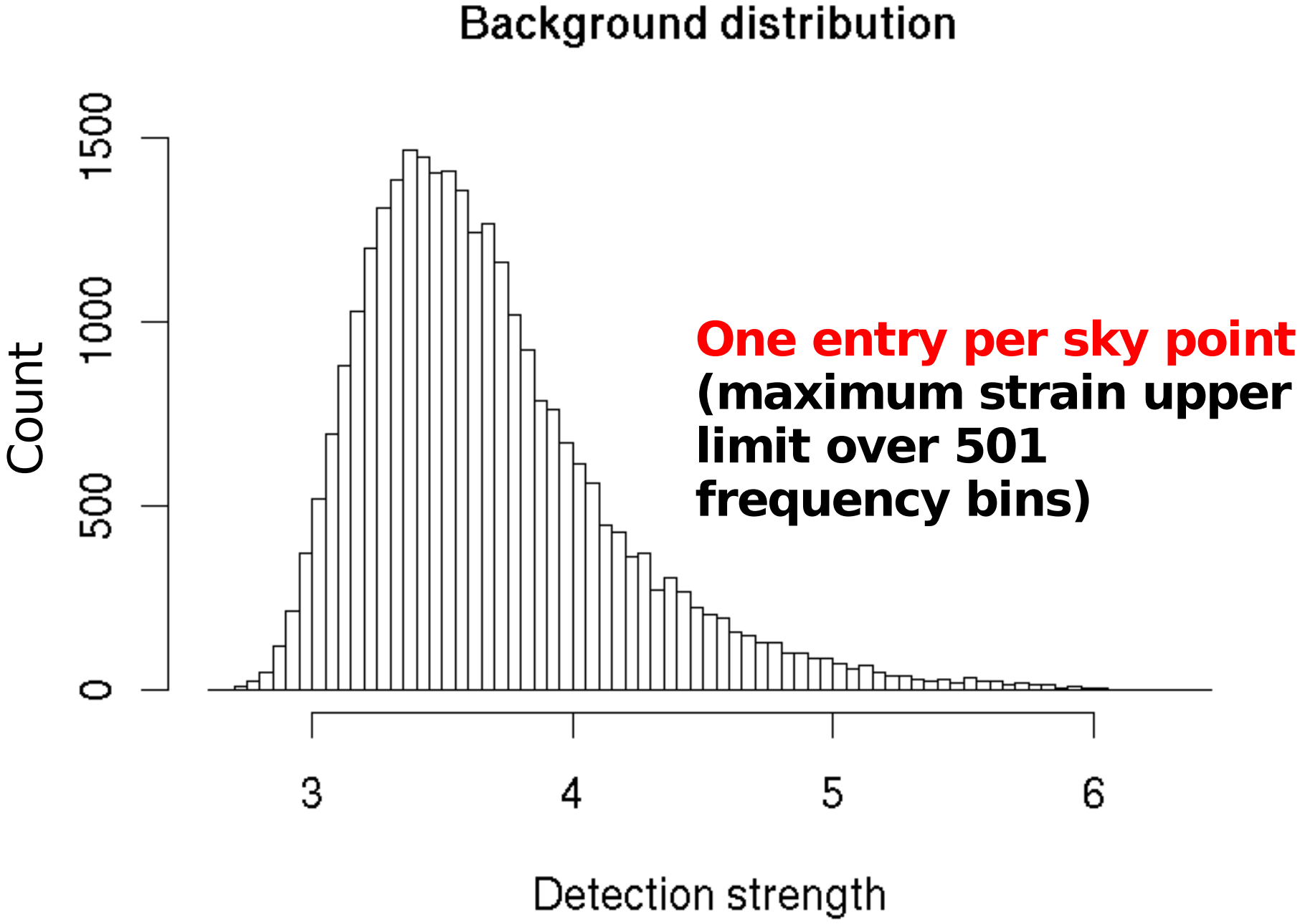


Corresponding skymap of strain limits

(Hanford 4km, 149-149.25 Hz, spindown 0)



Corresponding Signal-to-Noise Ratios



S4 run summary

- Frequency range: 50-1000 Hz
- Spindown range: 0 through -1e-8 Hz/s
- Background (cyan curve) can be described by the following formula:

$$Strain = 4 \cdot 10^{-26} \cdot f^{0.9} + \frac{3 \cdot 10^{-17}}{f^{3.5}}$$

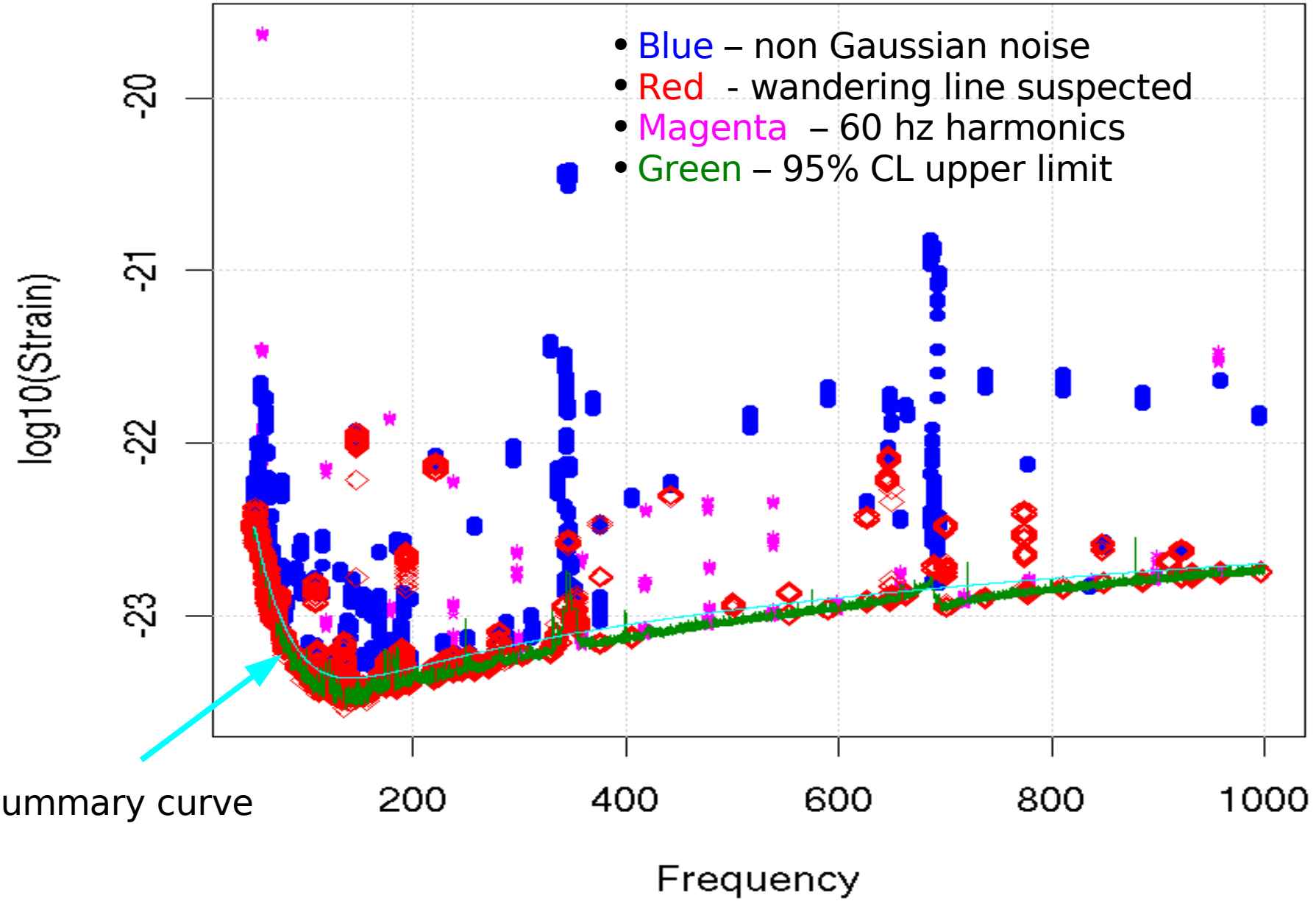
Here f is frequency in Hz

- Skyband 0 (maximum over which is shown on plots) is defined by

abs(S)>3.08e-9 Hz/s

S4 run results
Livingston 4km

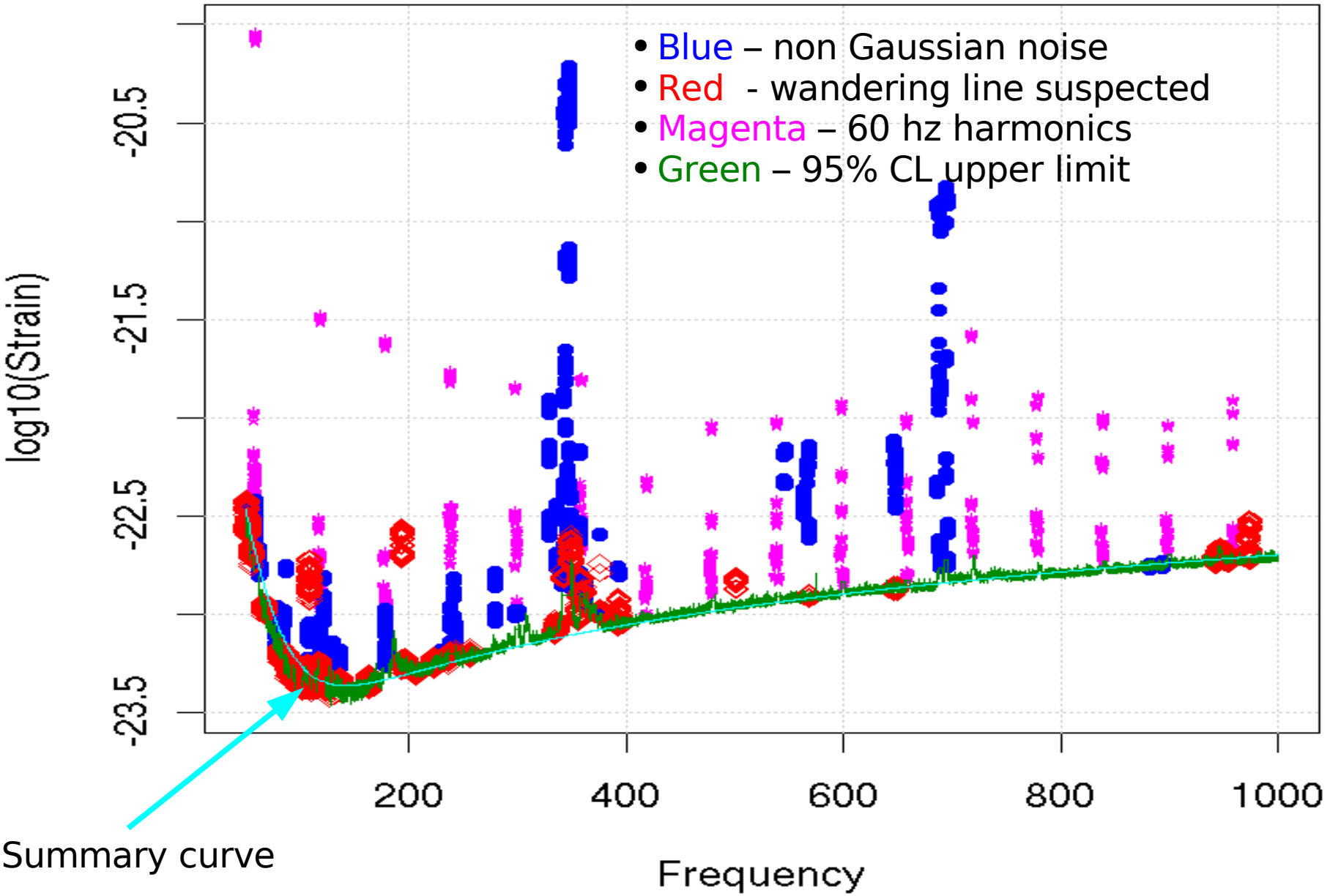
Livingston 4km upper limits are slightly lower than the summary curve, but not as clean in low frequency range



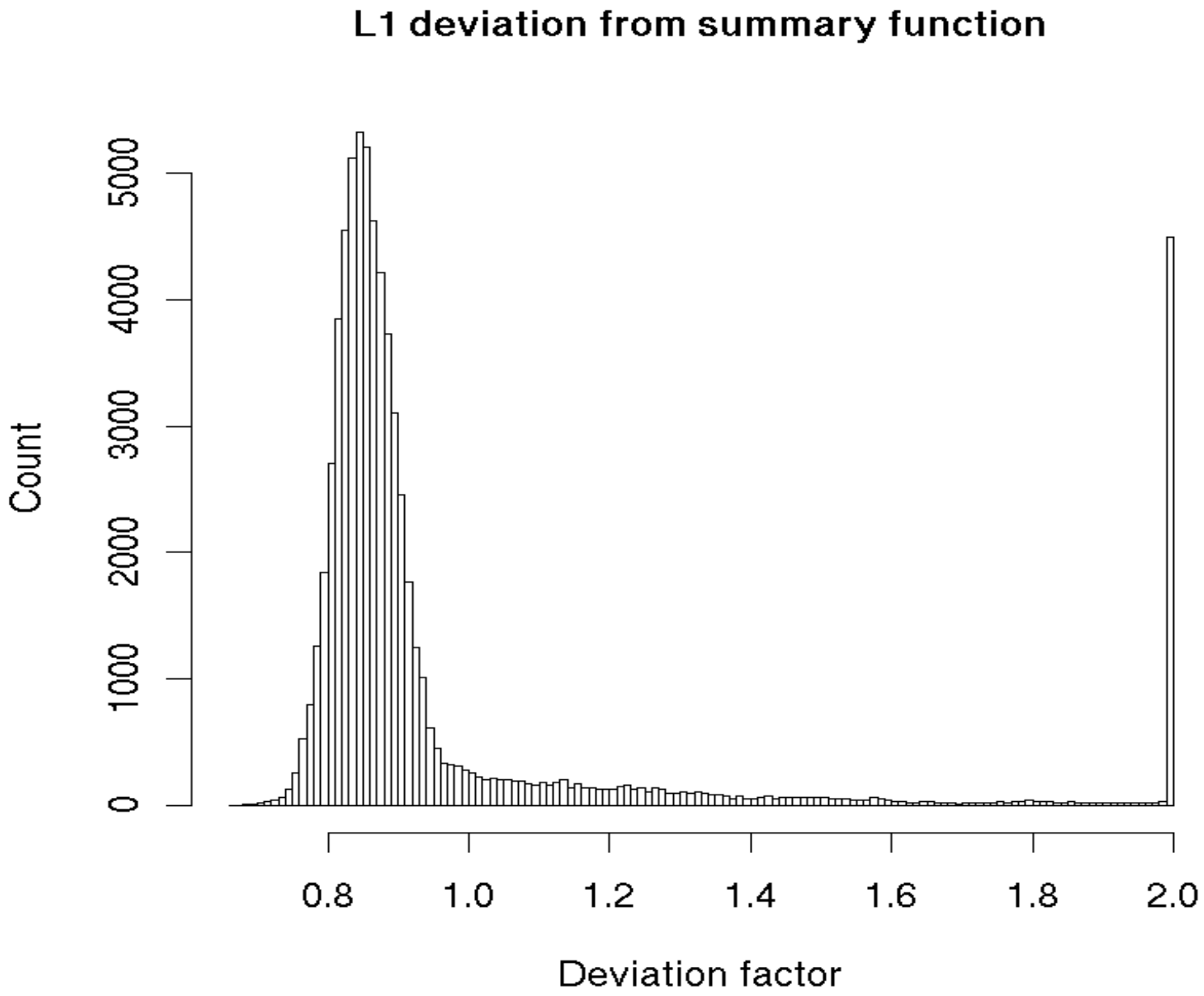
Summary curve

S4 run results
Hanford 4km

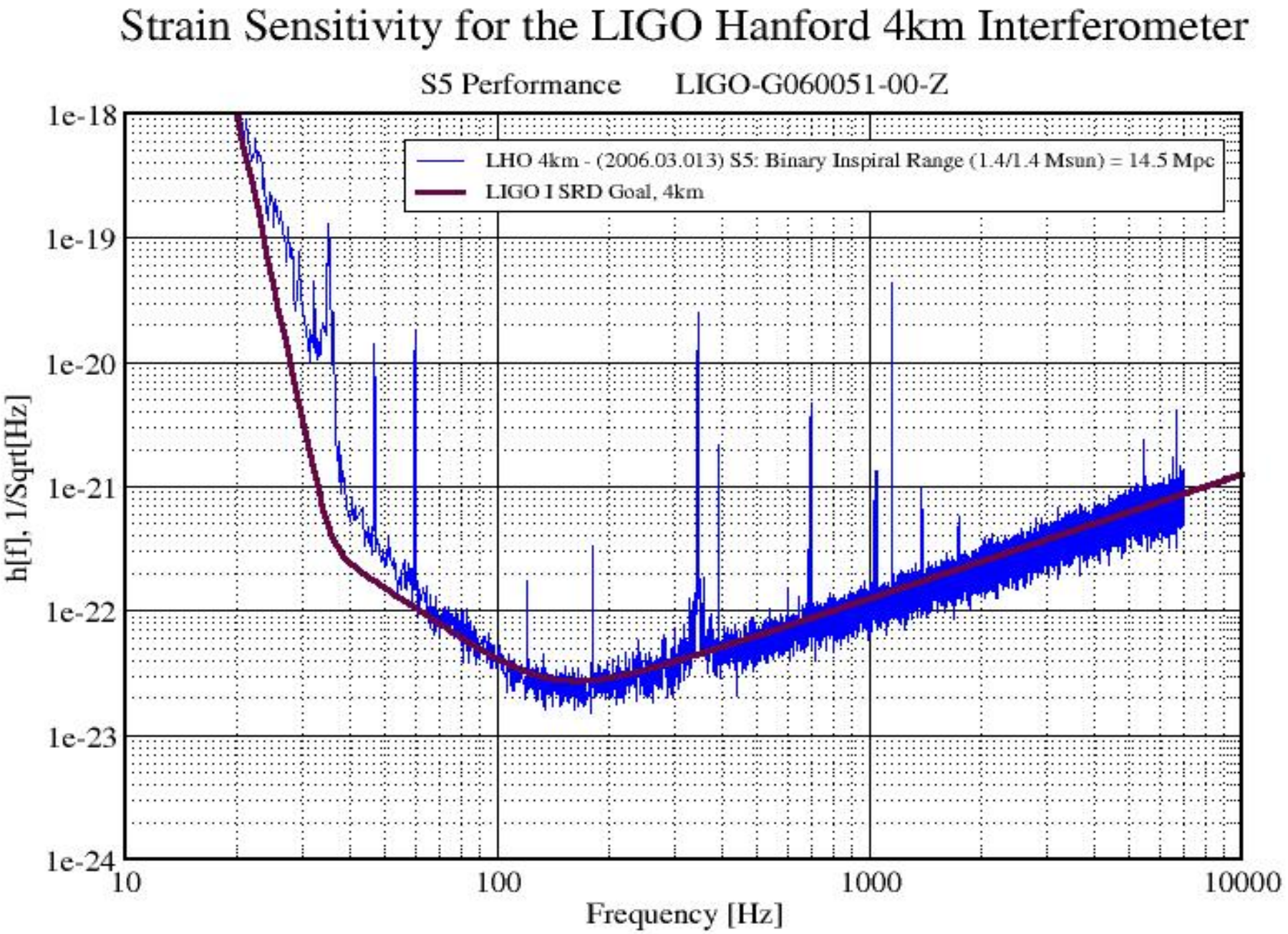
Hanford 4km upper limits are slightly higher than the summary curve, but much cleaner in low frequency range



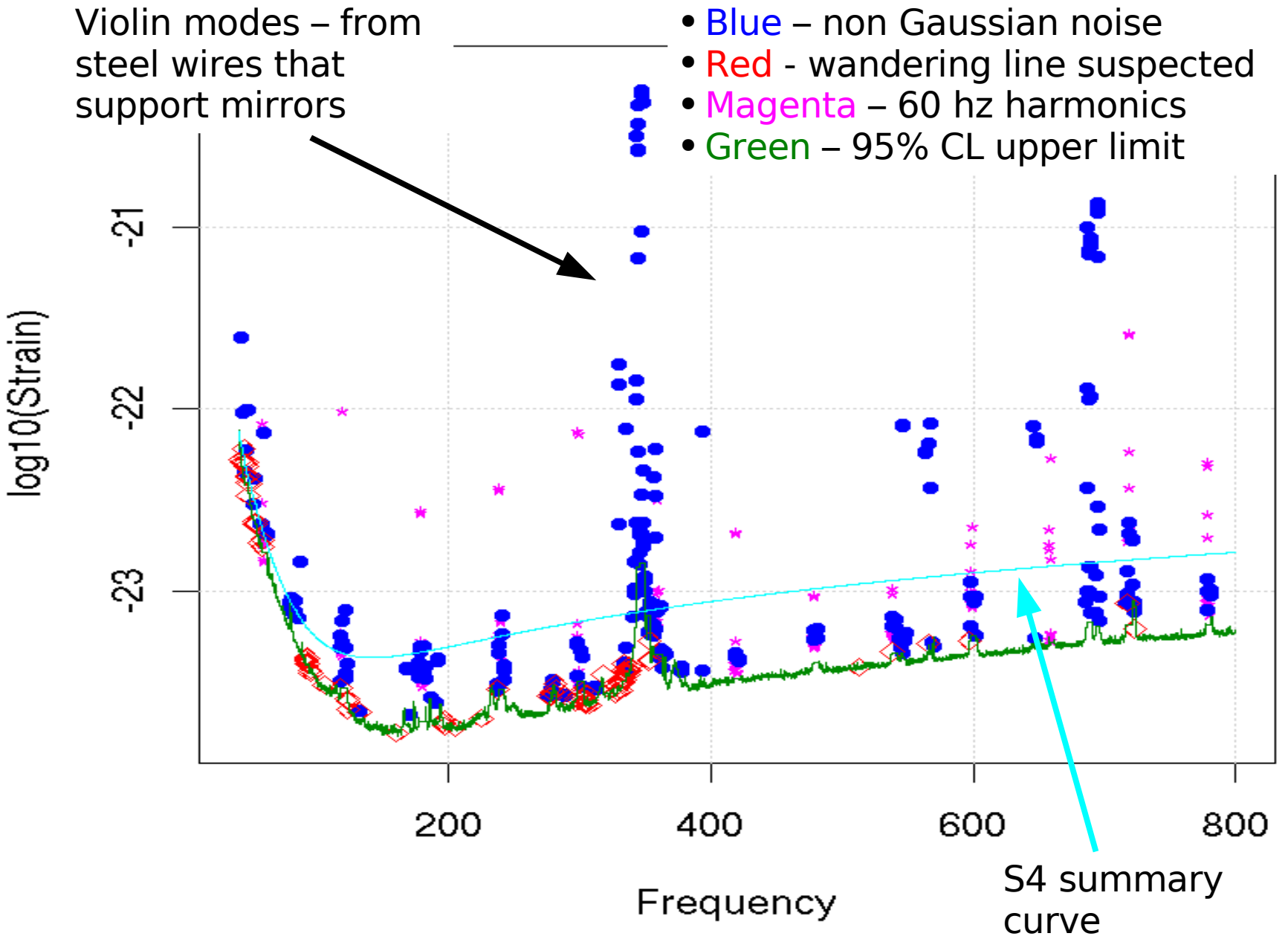
Summary curve deviation



Current S5 sensitivity



Early S5 Hanford 4km Preliminary Results 40-800 Hz (spindown 0)



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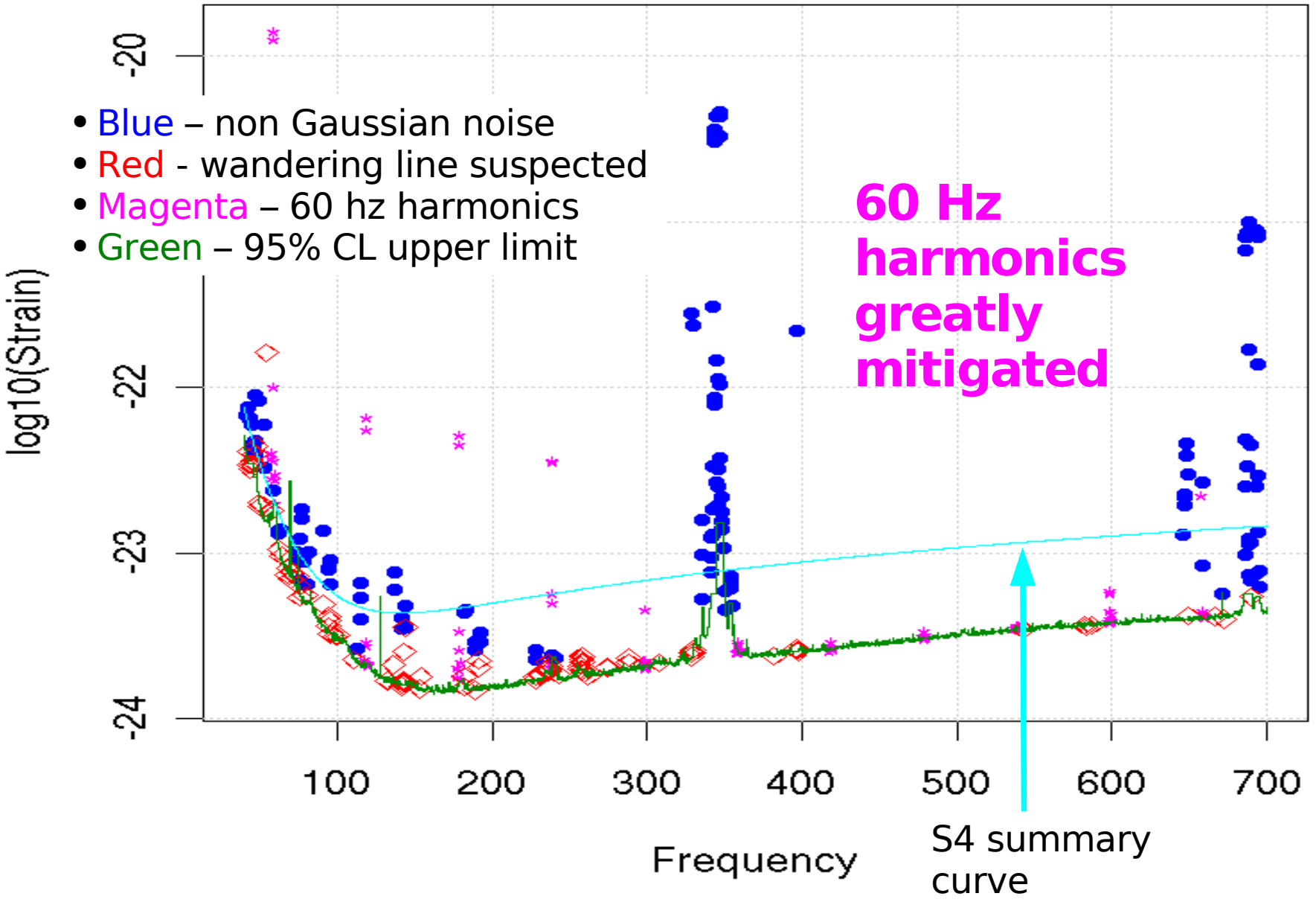

Conclusion

- Low-SNR coincidence algorithm under development
- S5 run is still underway – more data is being collected