



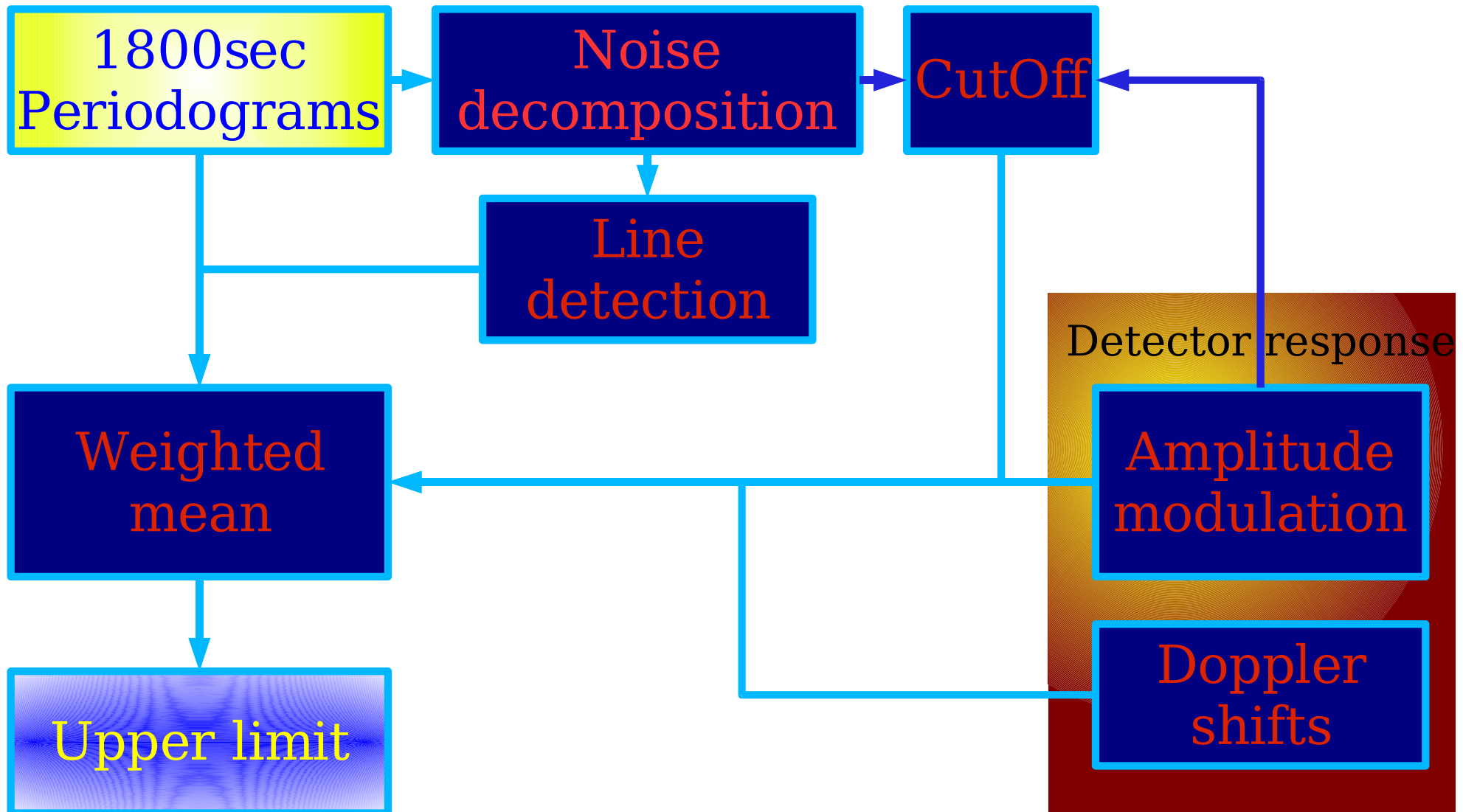
Broadband Search for Continuous-Wave Gravitational Radiation with LIGO

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Challenges of search for CW gravitational waves

- Gravitational waves from spinning neutron stars are expected to be 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.

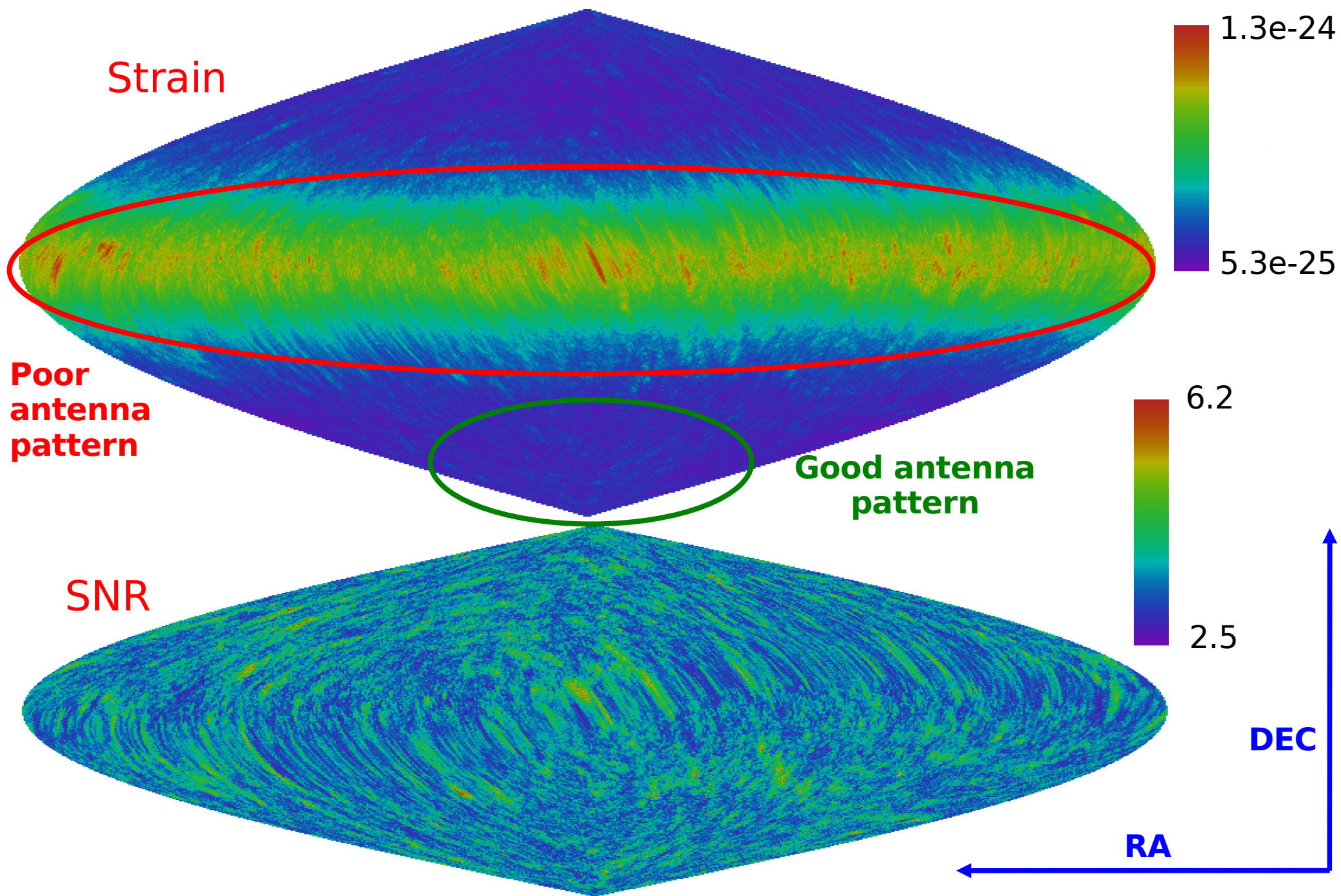
PowerFlux analysis pipeline



PowerFlux results

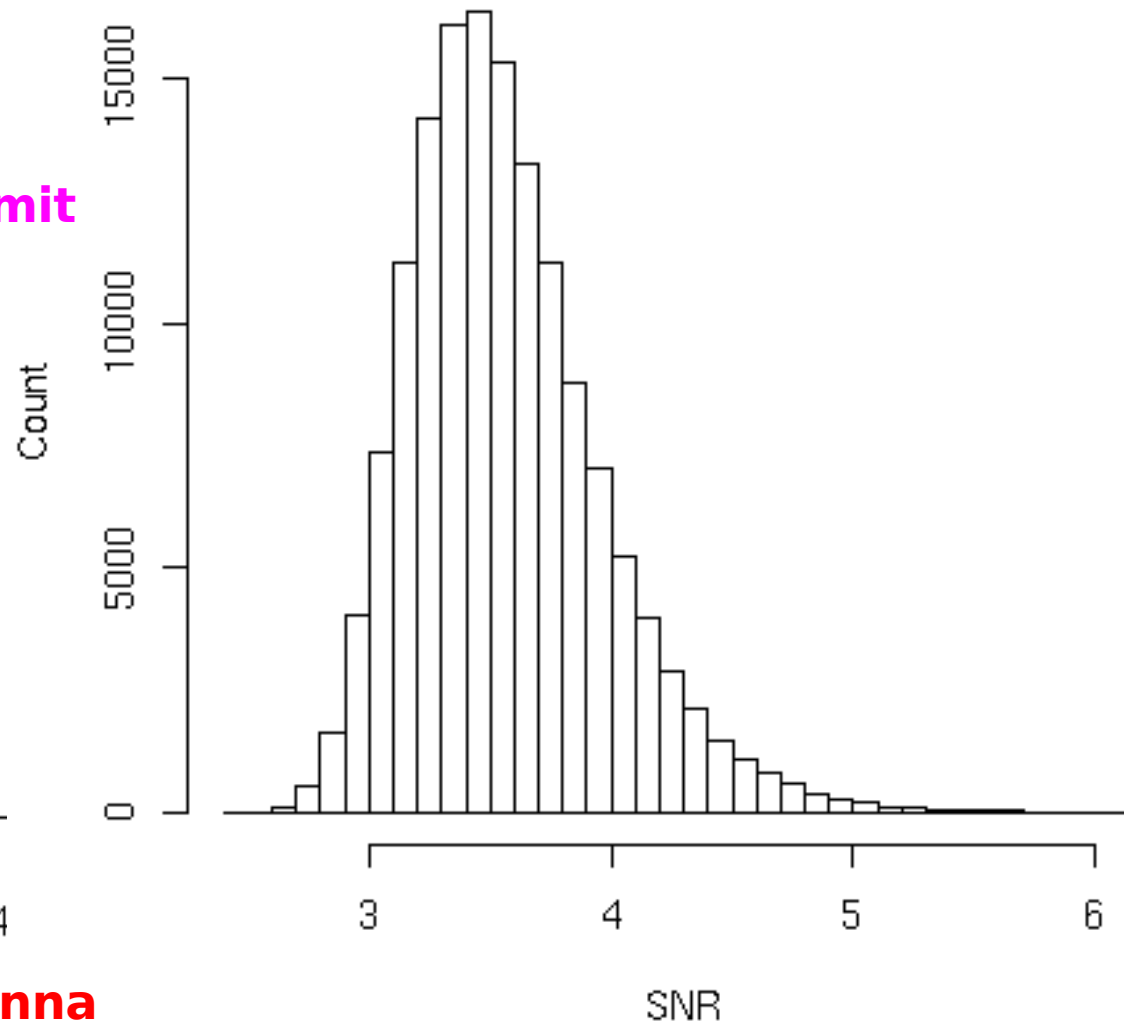
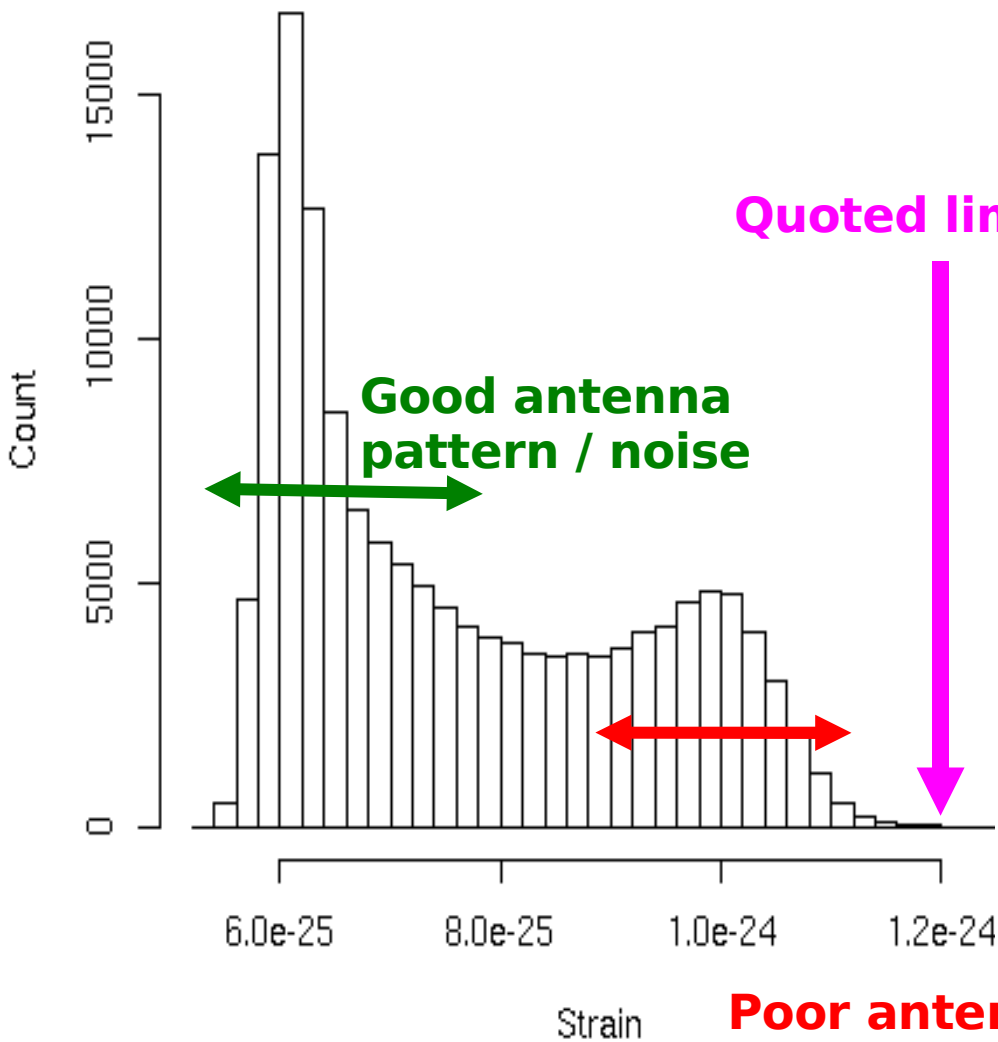
- PowerFlux produces a 95% CL upper limit for a particular frequency, sky position, spindown and polarization.
- Too much data to store, let alone present – the number of sky positions alone is $\sim 10^5$ at low frequencies and grows quadratically with frequency
- The upper limit plots show maximum over spindown range, sky and all polarizations
- We also present a simple formula that approximates background curve within $\pm 50\%$
- Data from S5 science run: 7 Nov 2005 through 20 July 2006

Hanford 4km, ~ 270 Hz, non-zero spindown (equatorial coordinates)



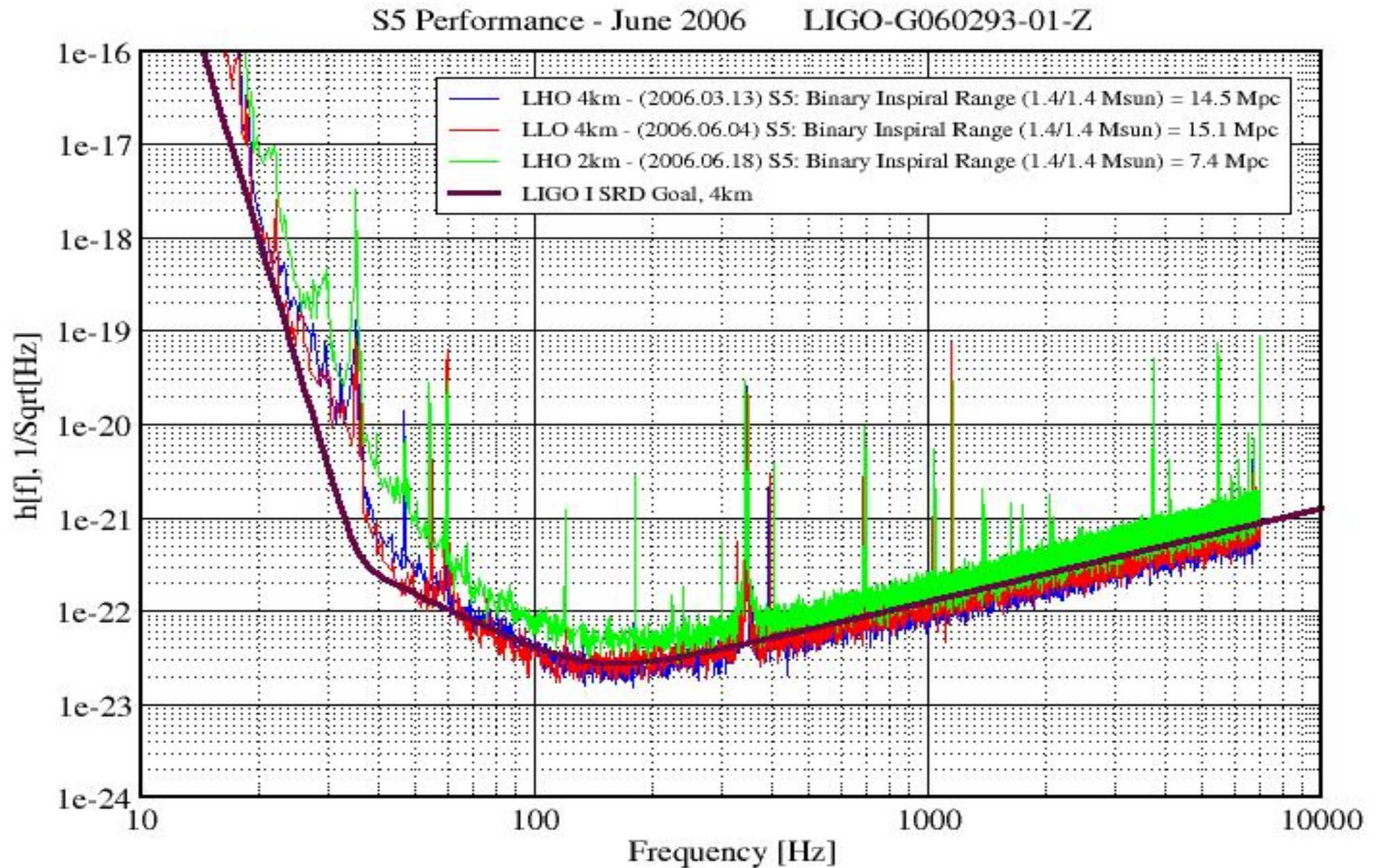
Histograms

(one entry per sky point)

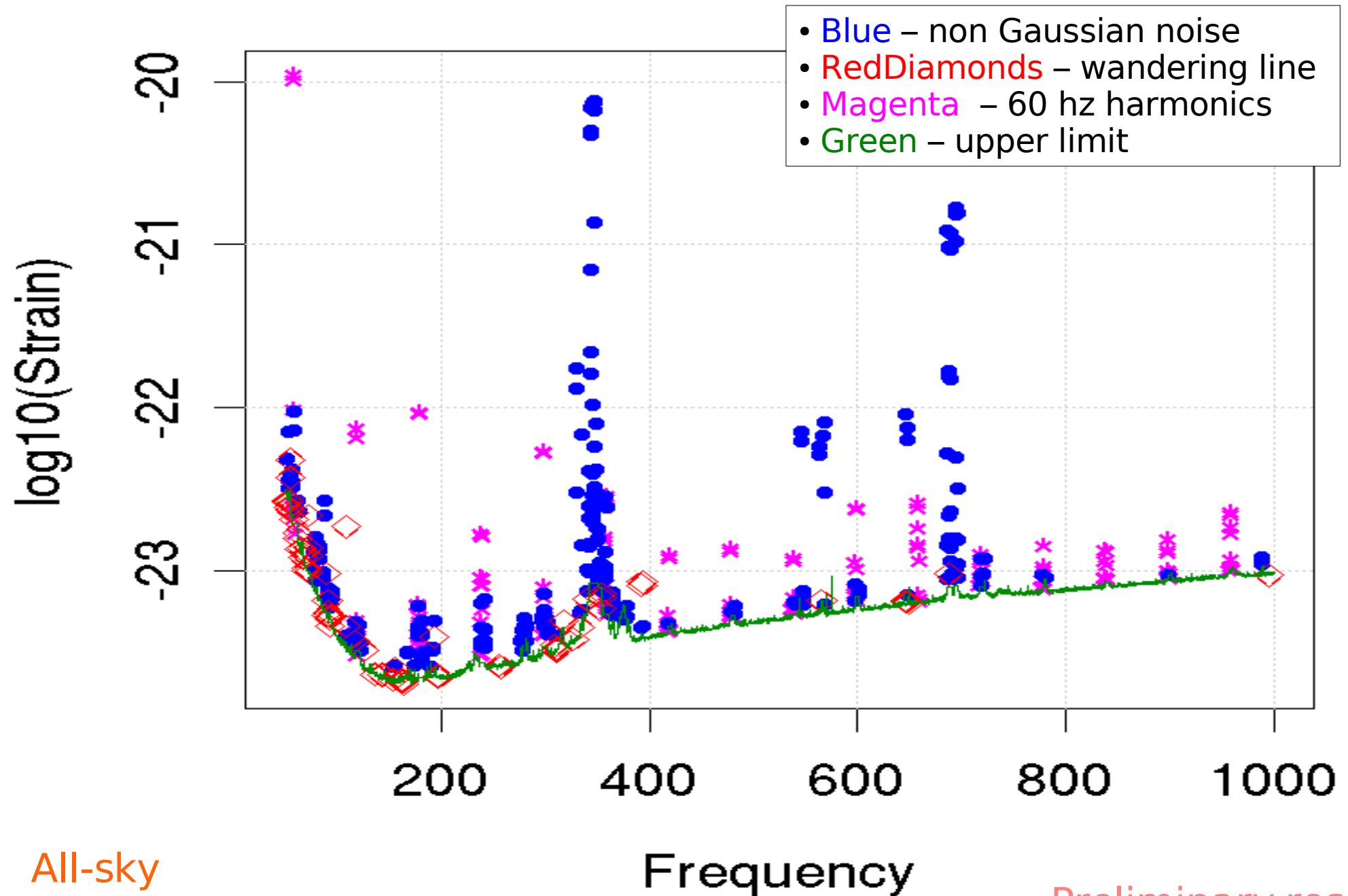


Preliminary results

S5 science run sensitivity



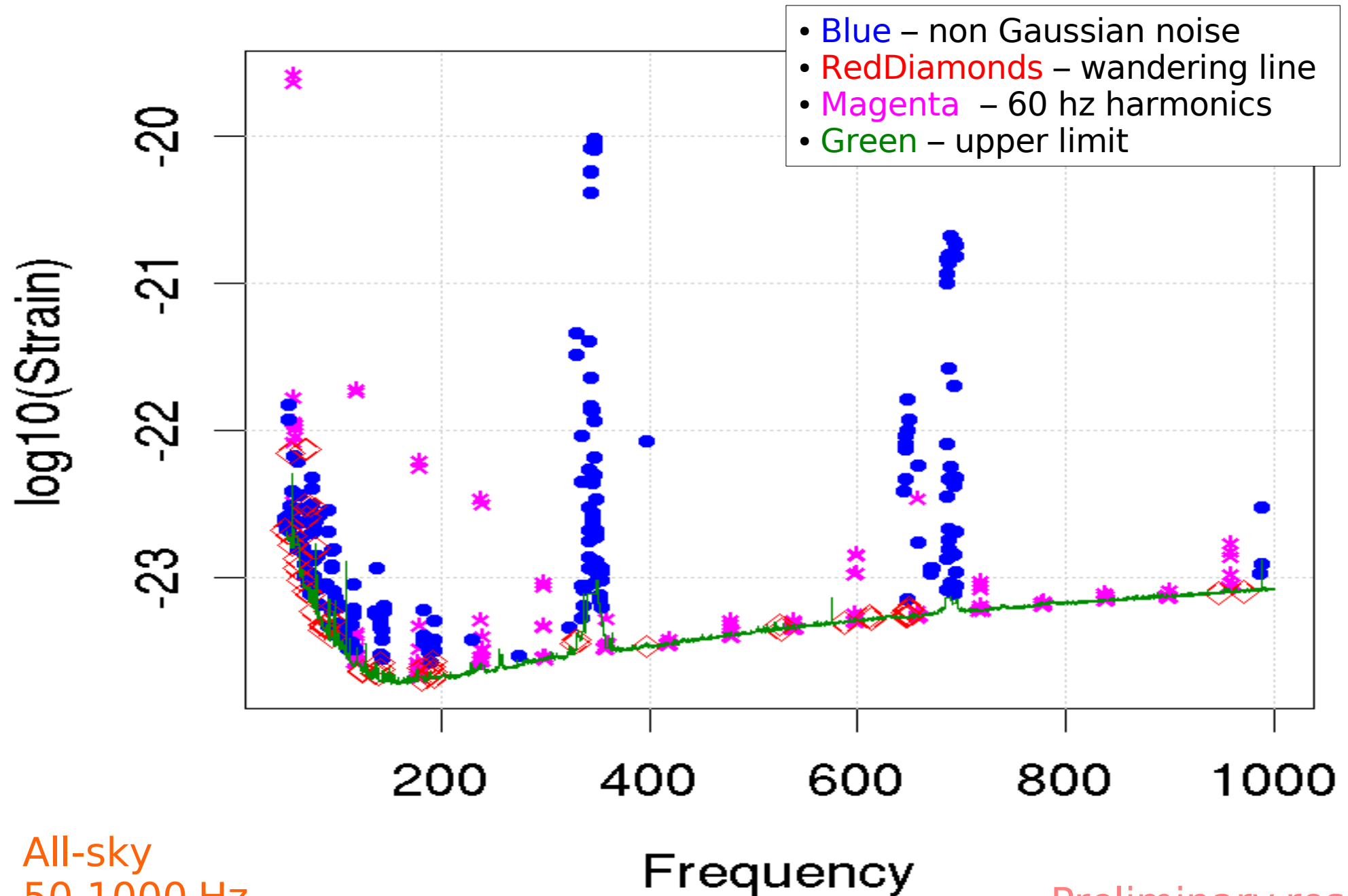
H1 S5 0-spindown run



All-sky
50-1000 Hz

Preliminary results

L1 S5 0-spindown run



All-sky
50-1000 Hz

Preliminary results

Partial sky (targeted) run

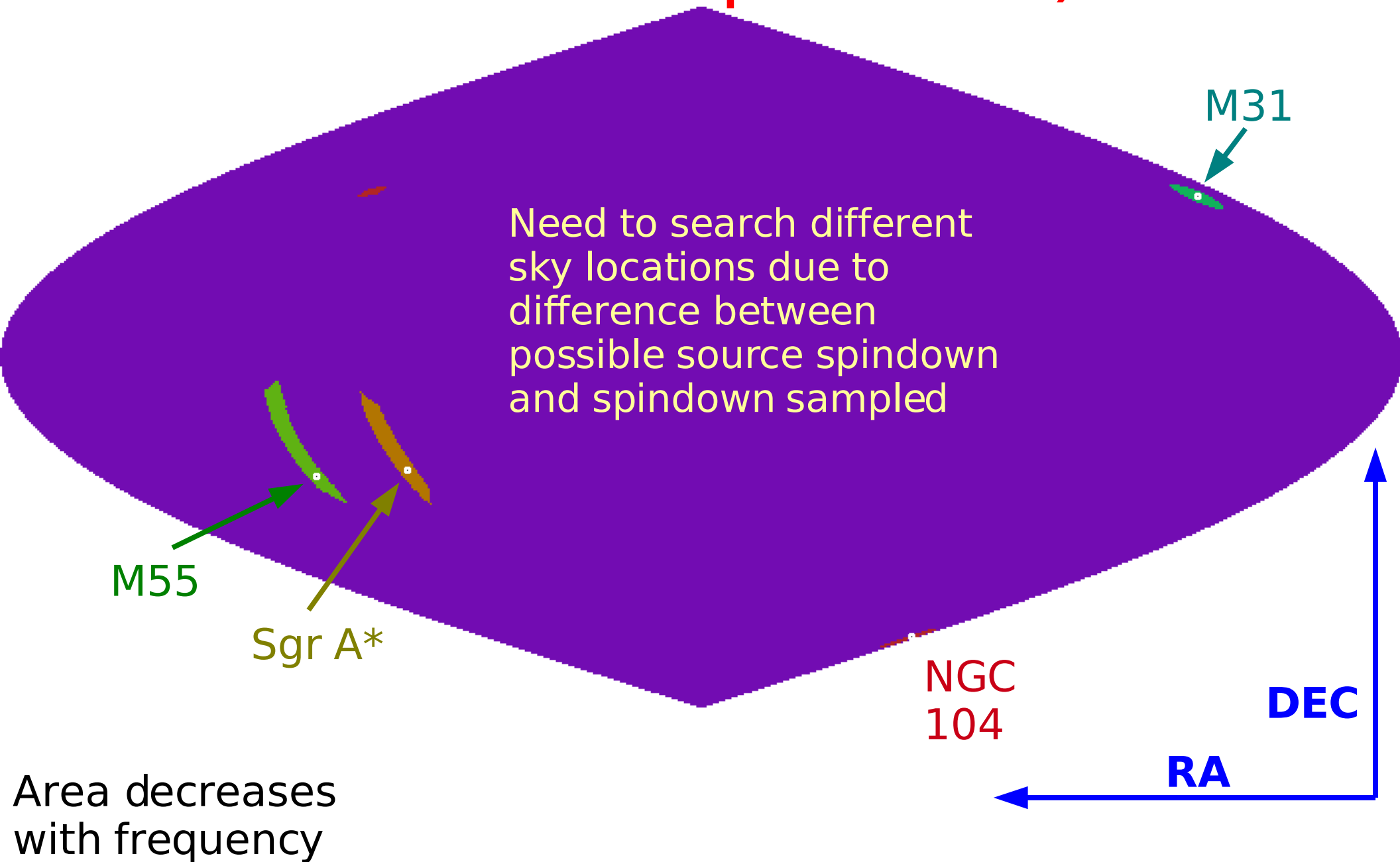
- Searched sky around
 - globular clusters M55, NGC104
 - galactic center Sgr A*
 - Andromeda M31 (control)
- 100-700 Hz (clusters continuing to compute to 1000 Hz)
- -1.01e-8 Hz/s through 1.01e-8 Hz/s in 2e-10 Hz/s steps
- Background (cyan curve) can be described by the following formula:

$$Strain = 5.7 \cdot 10^{-25} \cdot \left[\left(\frac{f}{f_0} \right)^{0.9} + \left(\frac{f}{f_0} \right)^{-4.5} \right]$$

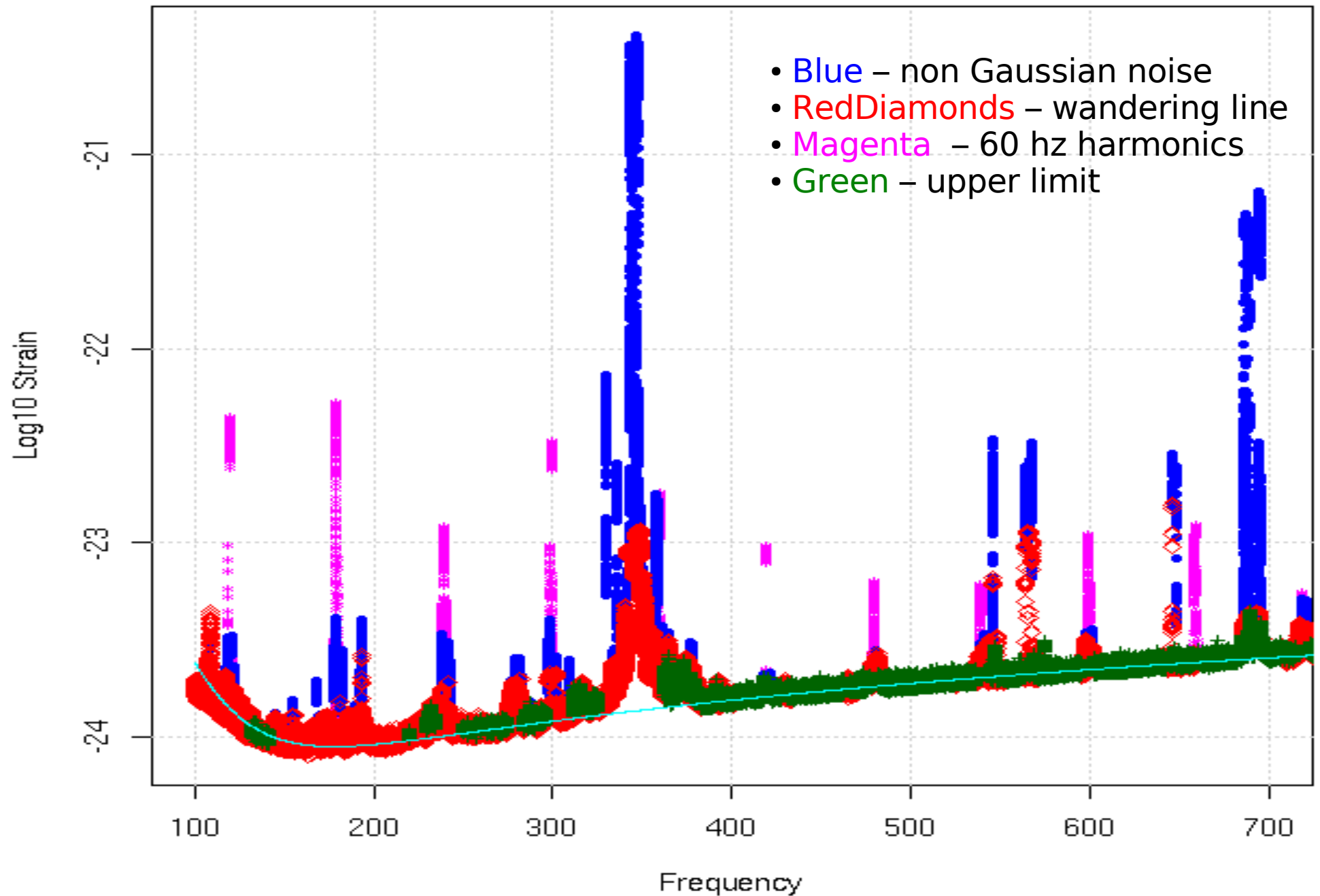
Here f is frequency and $f_0=132$ Hz

Fresh results –
followup not finished

Search area (for ~ 270 Hz, non-zero spindown)

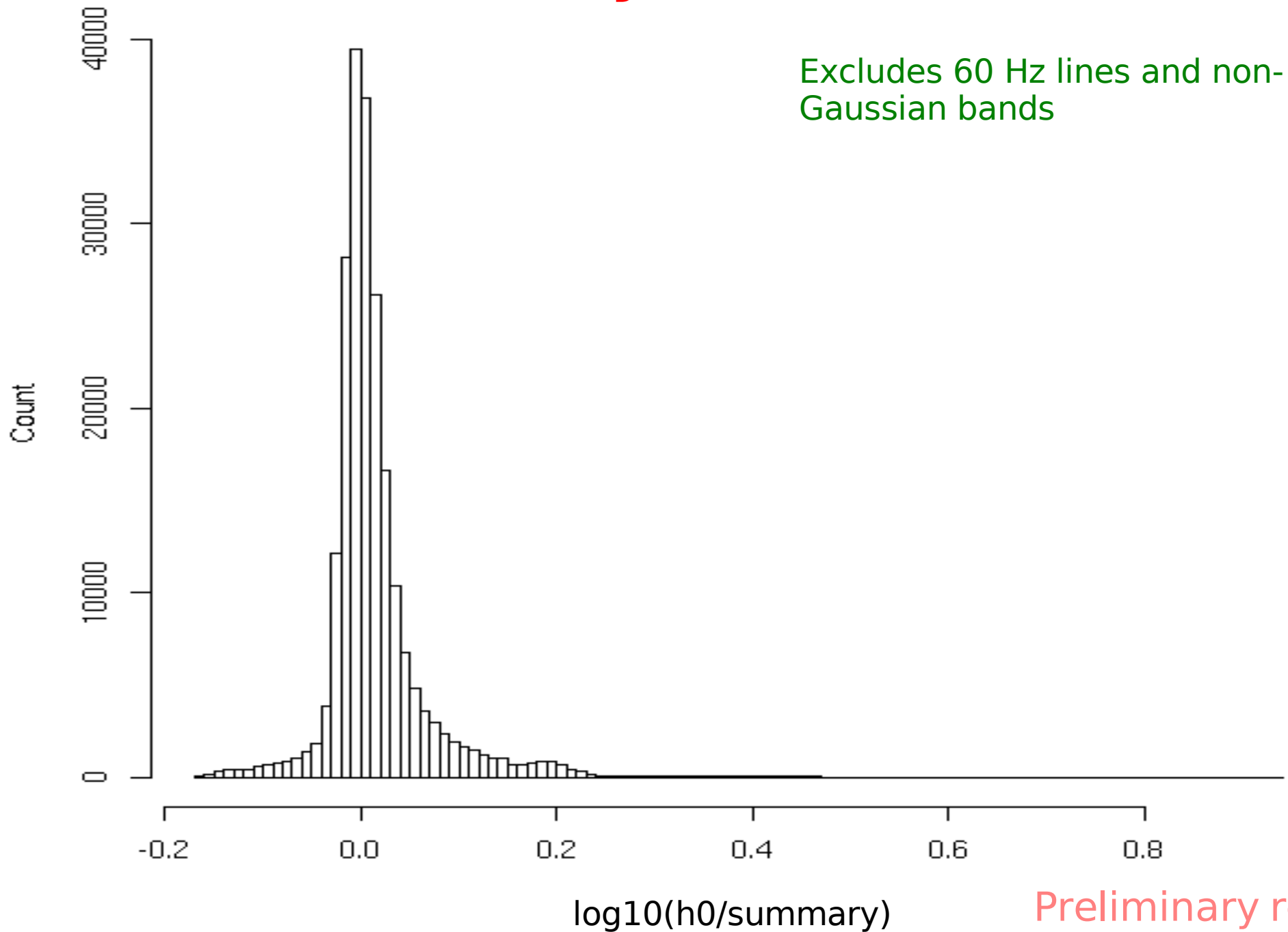


H1 Sgr A* upper limits



Preliminary results

S5 summary curve deviation



Conclusion

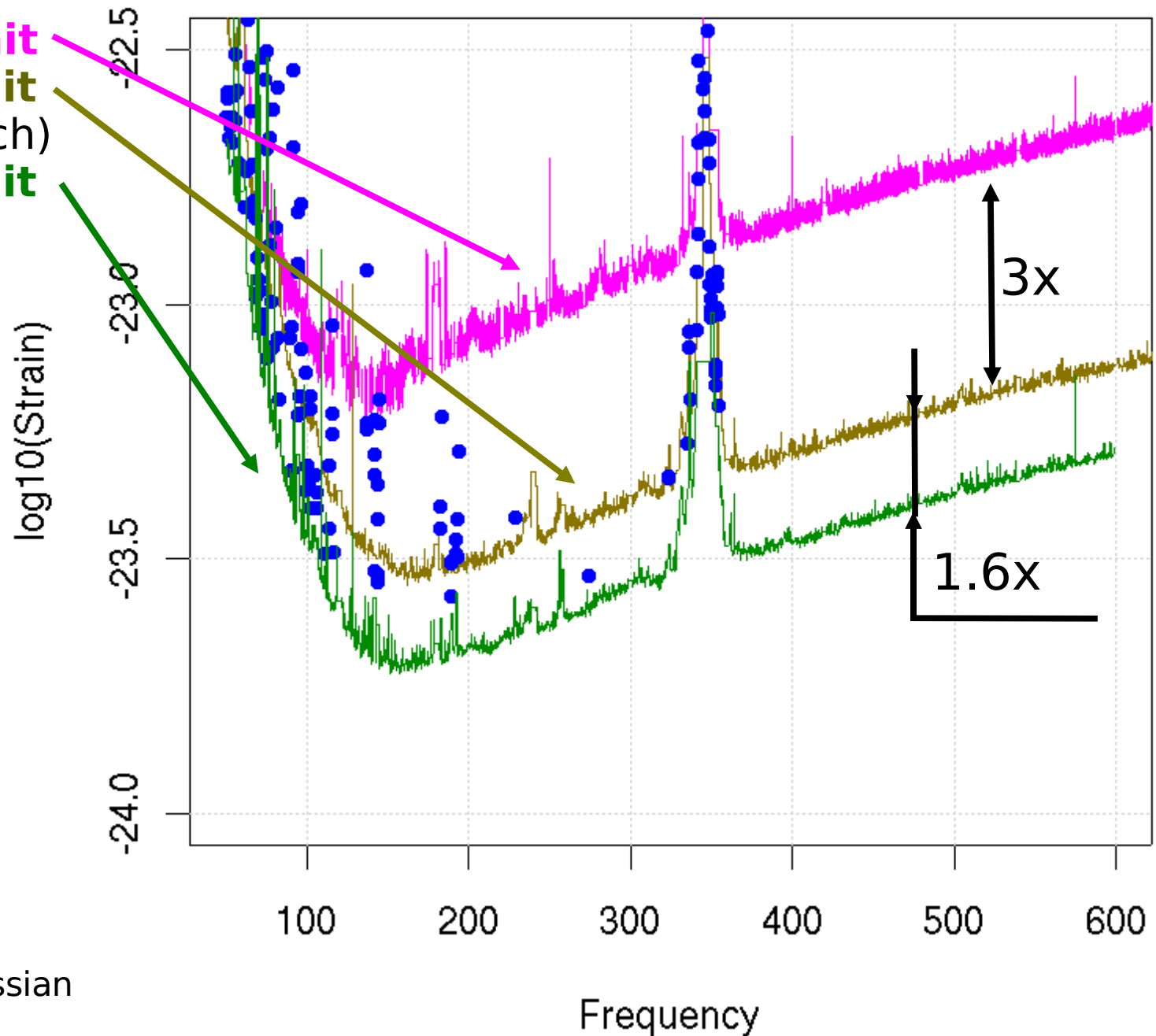
- S5 run is still underway – more data is being collected
- All-sky run multiple-spindown run to follow
- Looking in detail at the output of low-SNR coincidence algorithm

End of talk

S5 spindown-0 run

- **S4 L1 upper limit**
- **S5 L1 upper limit**
(data through March)
- **S5 L1 upper limit**
(data through July)

July L1 SFTs=
3x March SFTs



- 60 Hz lines excluded
- Blue points – non-gaussian noise in July run

“S parameter”

When S is closer to 0 susceptibility to stationary artifacts increases

$$S := s + \frac{\vec{u} \times \vec{v}_{\text{avg}}}{c} f \cdot \hat{r}$$

Average detector acceleration

Average detector velocity

Spindown (Hz/s)

Earth orbit angular velocity

Frequency

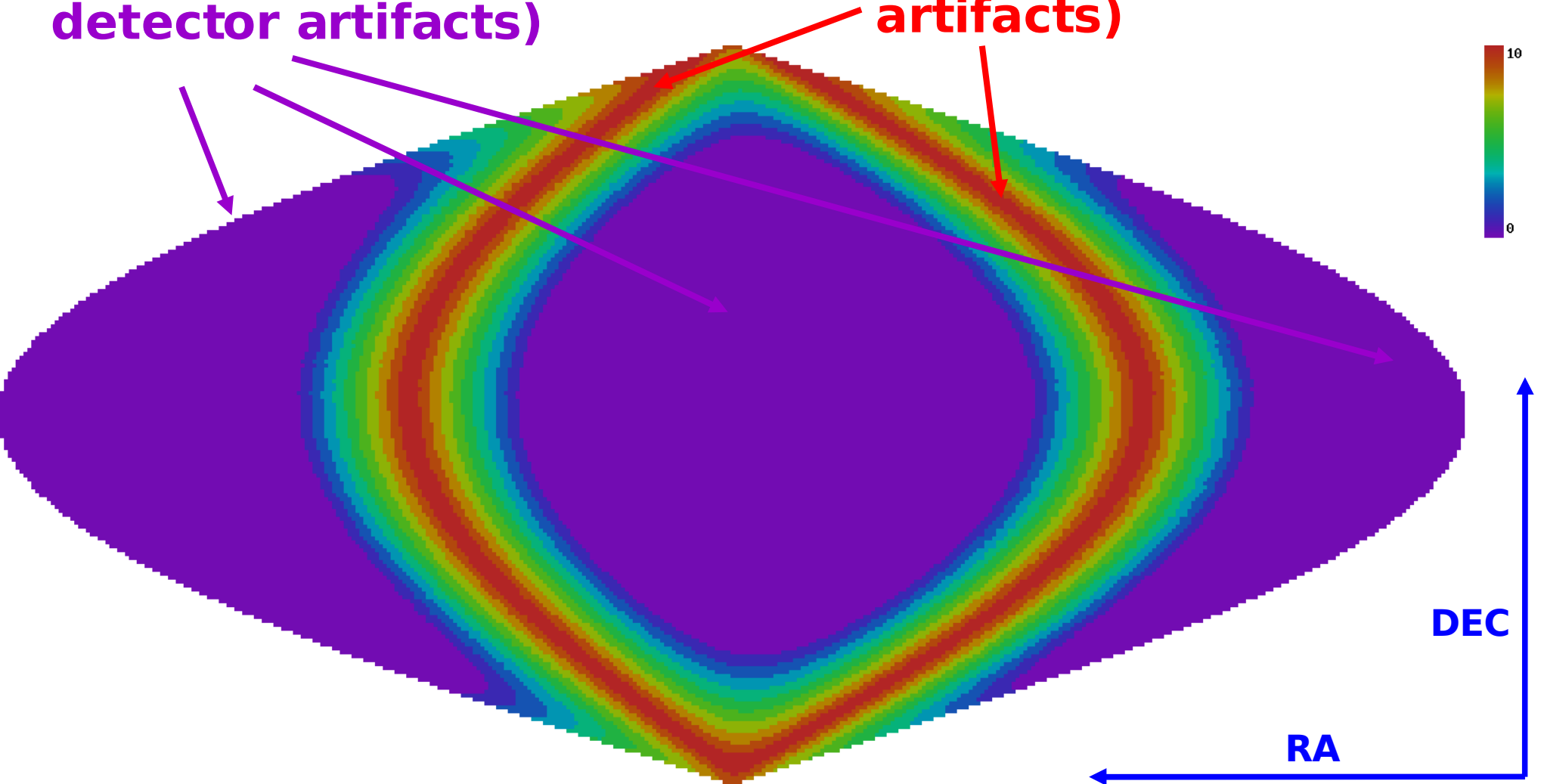
Unit sky position vector

The diagram shows the equation $S := s + \frac{\vec{u} \times \vec{v}_{\text{avg}}}{c} f \cdot \hat{r}$. Green arrows point from descriptive text to parts of the equation: 'Spindown (Hz/s)' points to s ; 'Earth orbit angular velocity' points to $\vec{u}$; 'Average detector acceleration' points to the cross product $\vec{u} \times \vec{v}_{\text{avg}}$; 'Frequency' points to f ; 'Average detector velocity' points to $\vec{v}_{\text{avg}}$; and 'Unit sky position vector' points to $\hat{r}$.

Doppler Skybands

Skyband 0 (good – only exceptionally strong detector artifacts)

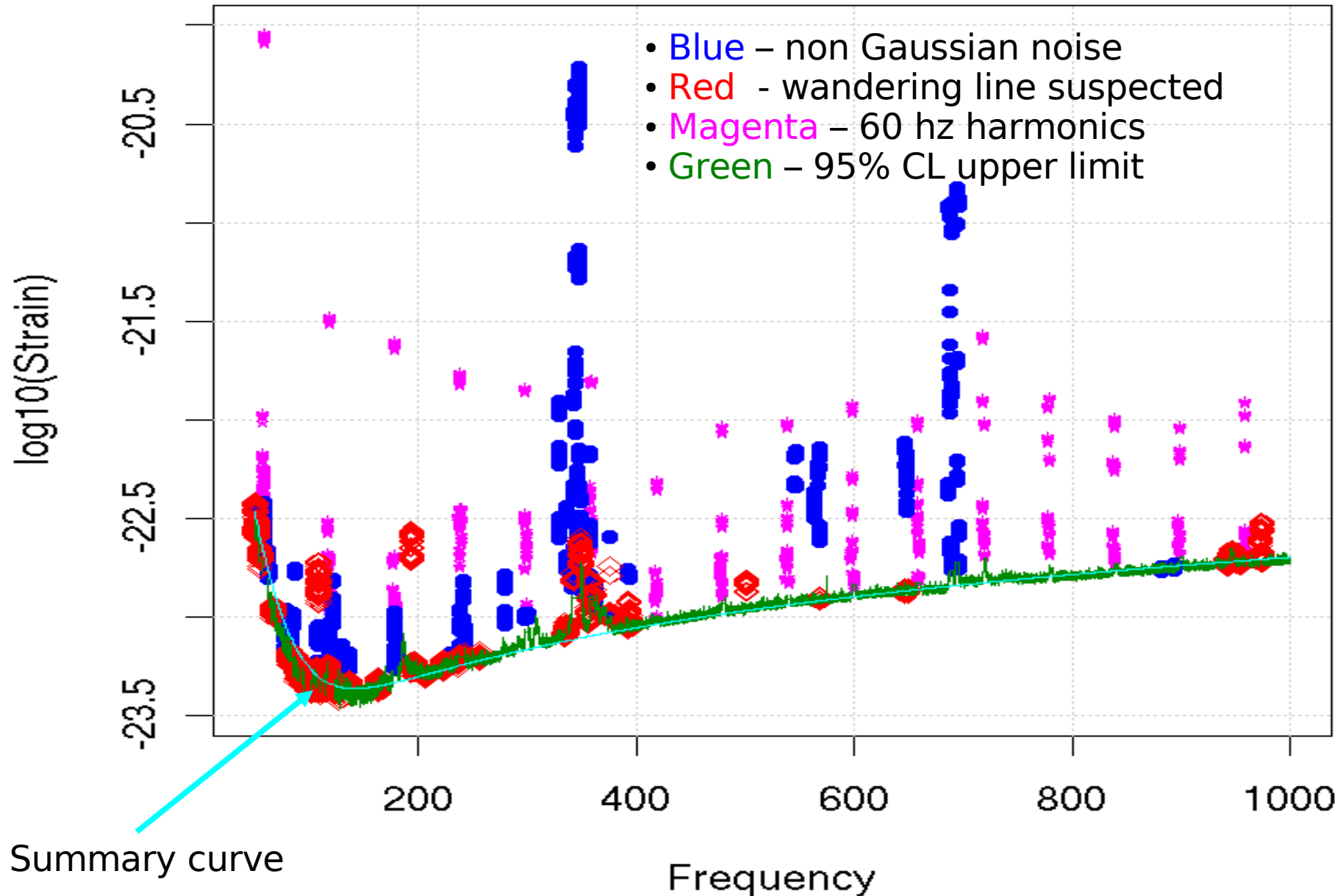
Skyband 10 (worst – many detector artifacts)



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

S4 run results

Hanford 4km



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

S4 run results

Livingston 4km

