LIGO

Broadband Search for Continuous-Wave Gravitational Radiation with LIGO

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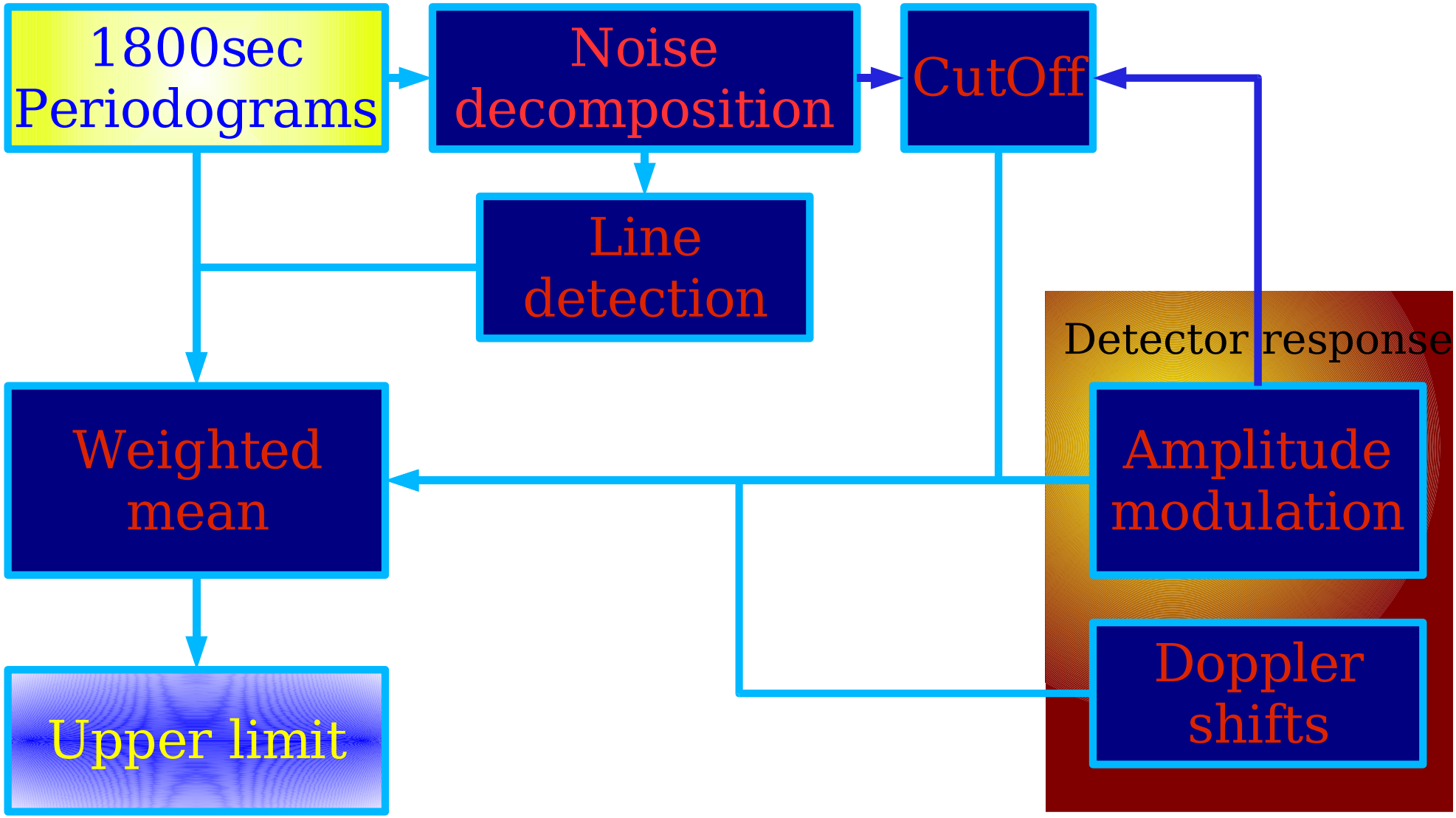
Challenges of search for CW gravitational waves

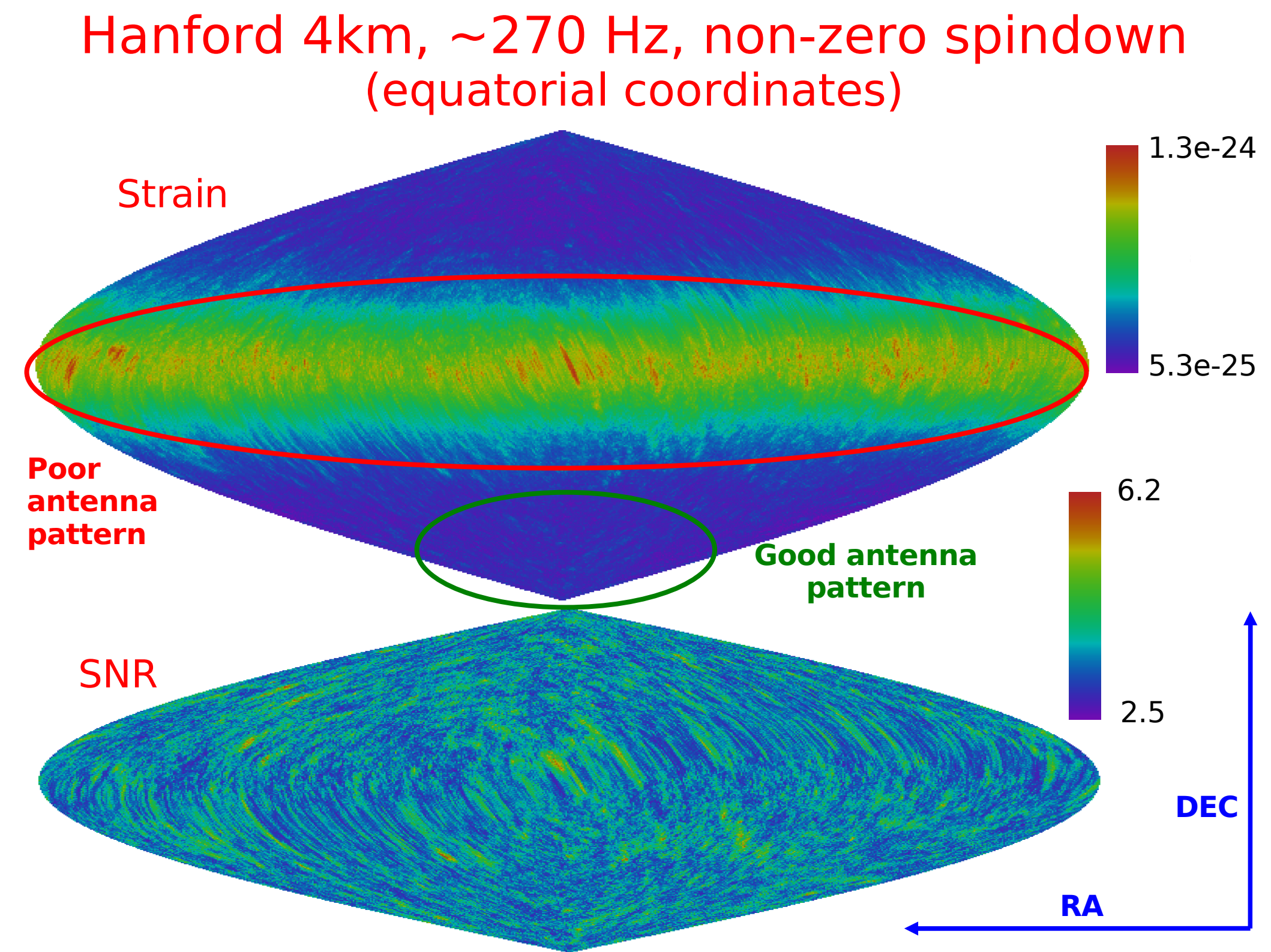
- Gravitational waves from spinning neutron stars are expected to be weak – need to average over long time periods
- Several parameters to search for: frequency, sky position, spindown, polarization
- Coherent methods are very sensitive, but result in enormous search space size – broadband, all sky search 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



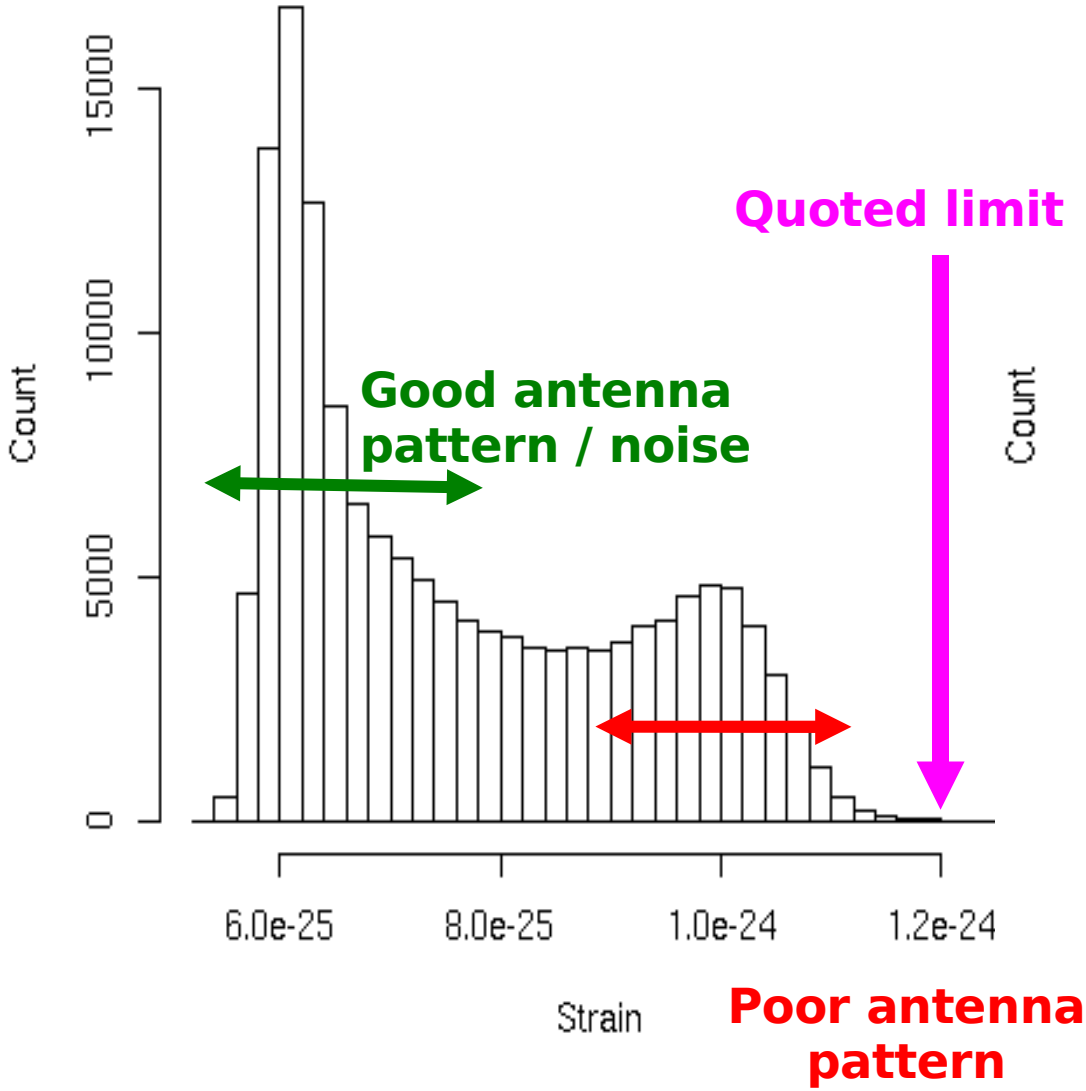
PowerFlux results

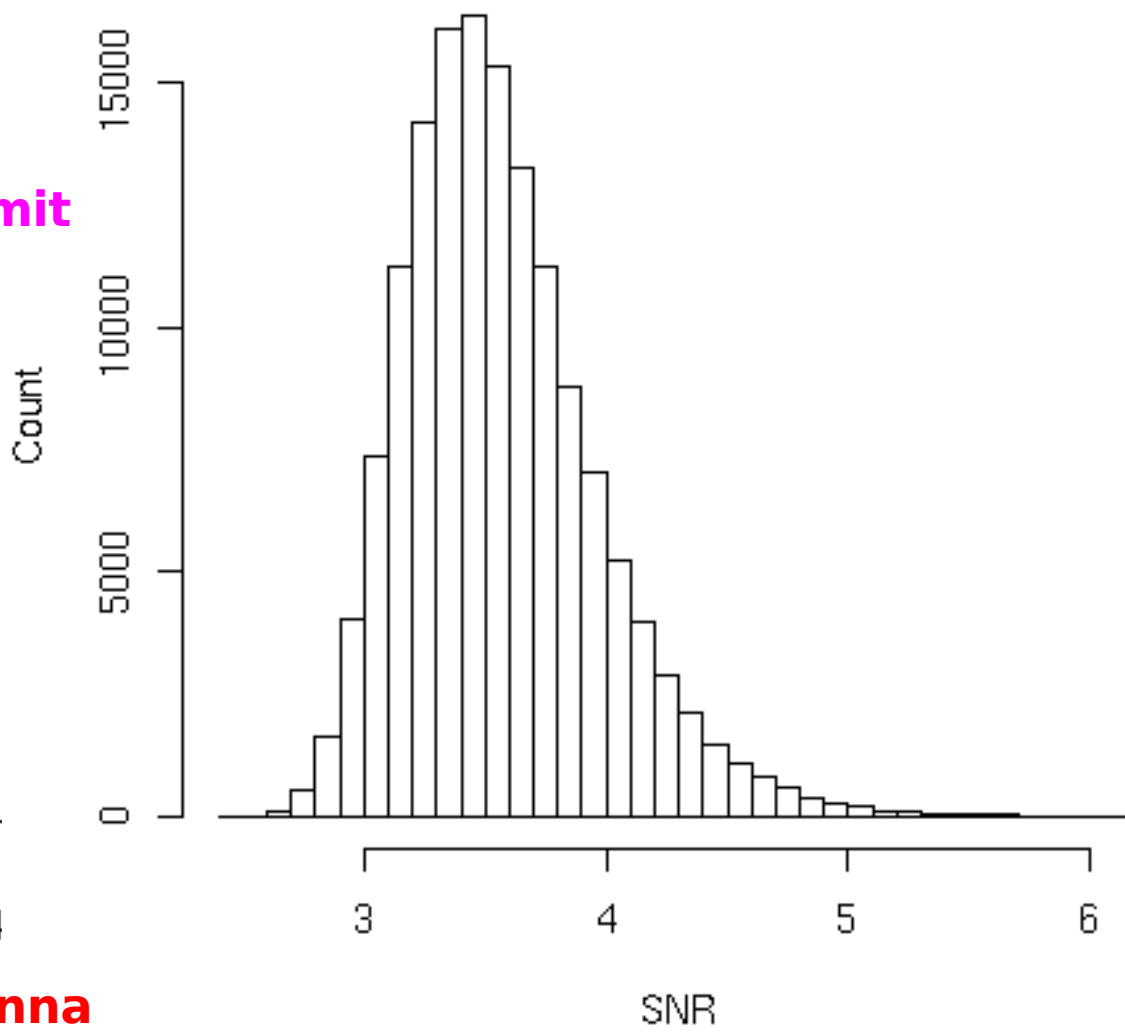
- PowerFlux produces a 95% CL upper limit for a particular frequency, sky position, spindown and polarization.
- Too much data to store, let alone present – the number of sky positions alone is ~10^5 at low frequencies and grows quadratically with frequency
- The upper limit plots show maximum over spindown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


Hanford 4km, ~270 Hz, non-zero spindown
(equatorial coordinates)
Strain
1.3e-24
5.3e-25
Poor antenna pattern
Good antenna pattern
SNR
6.2
2.5
DEC
RA

Histograms

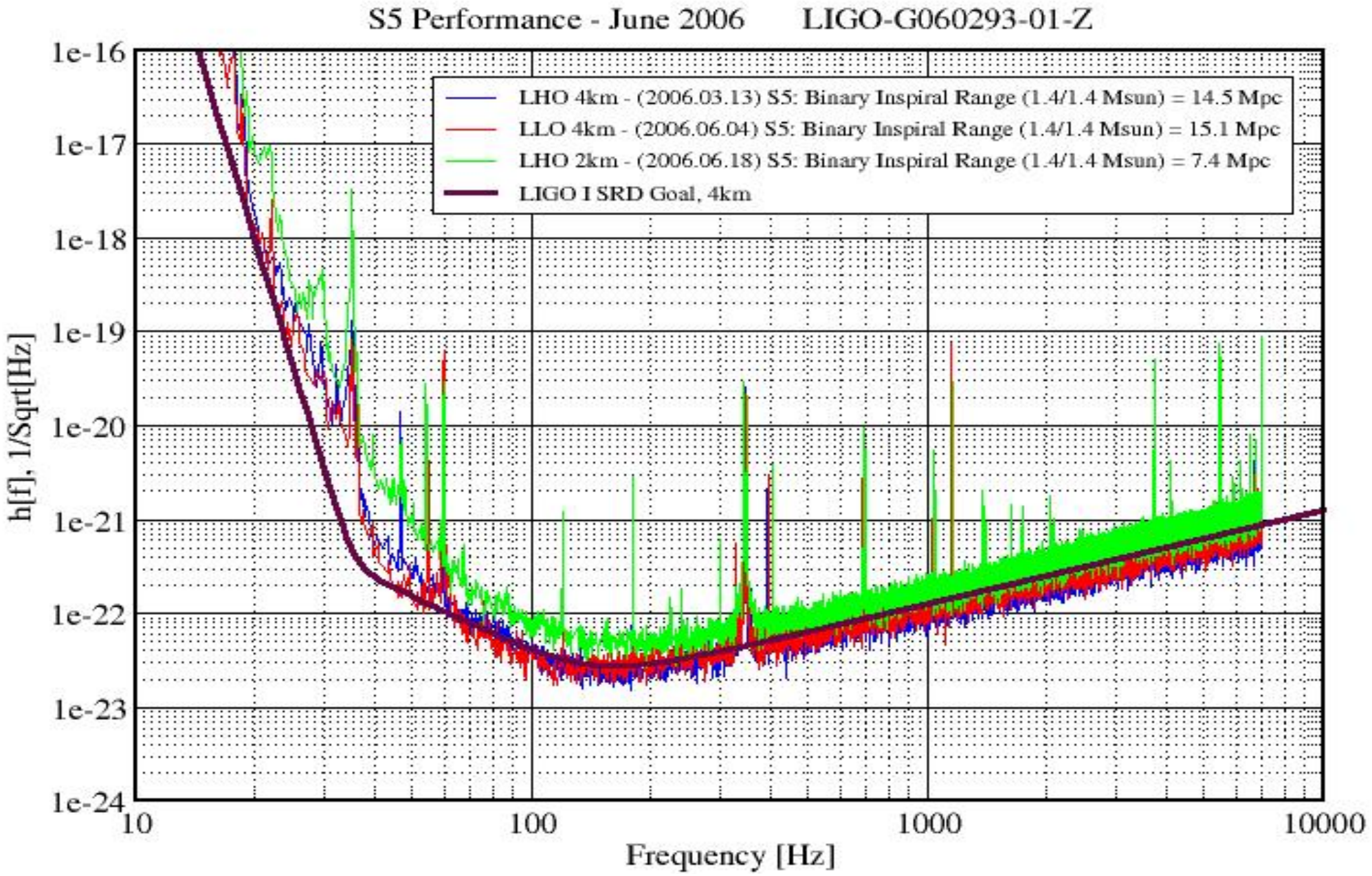
(one entry per sky point)



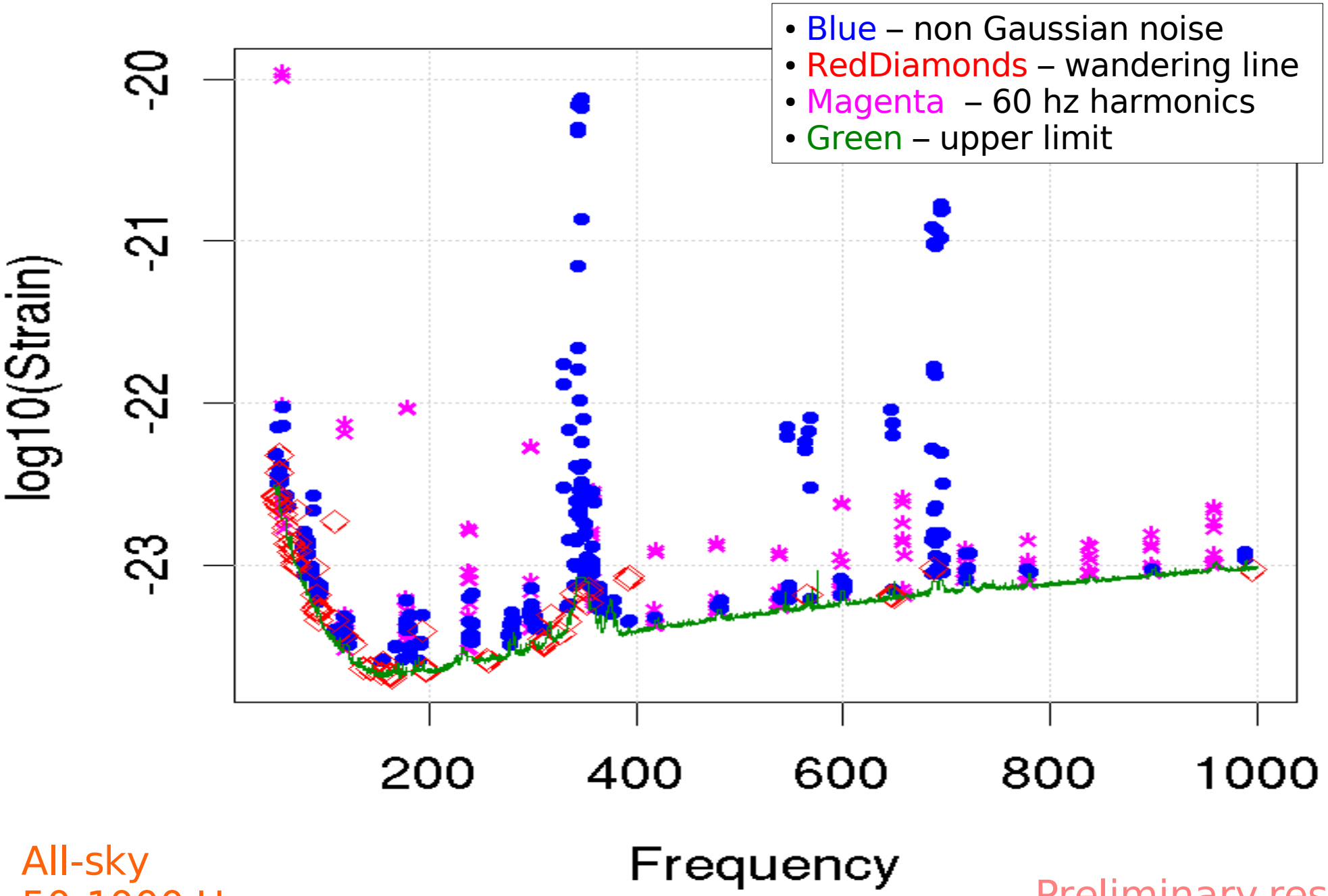


Preliminary results

S5 science run sensitivity



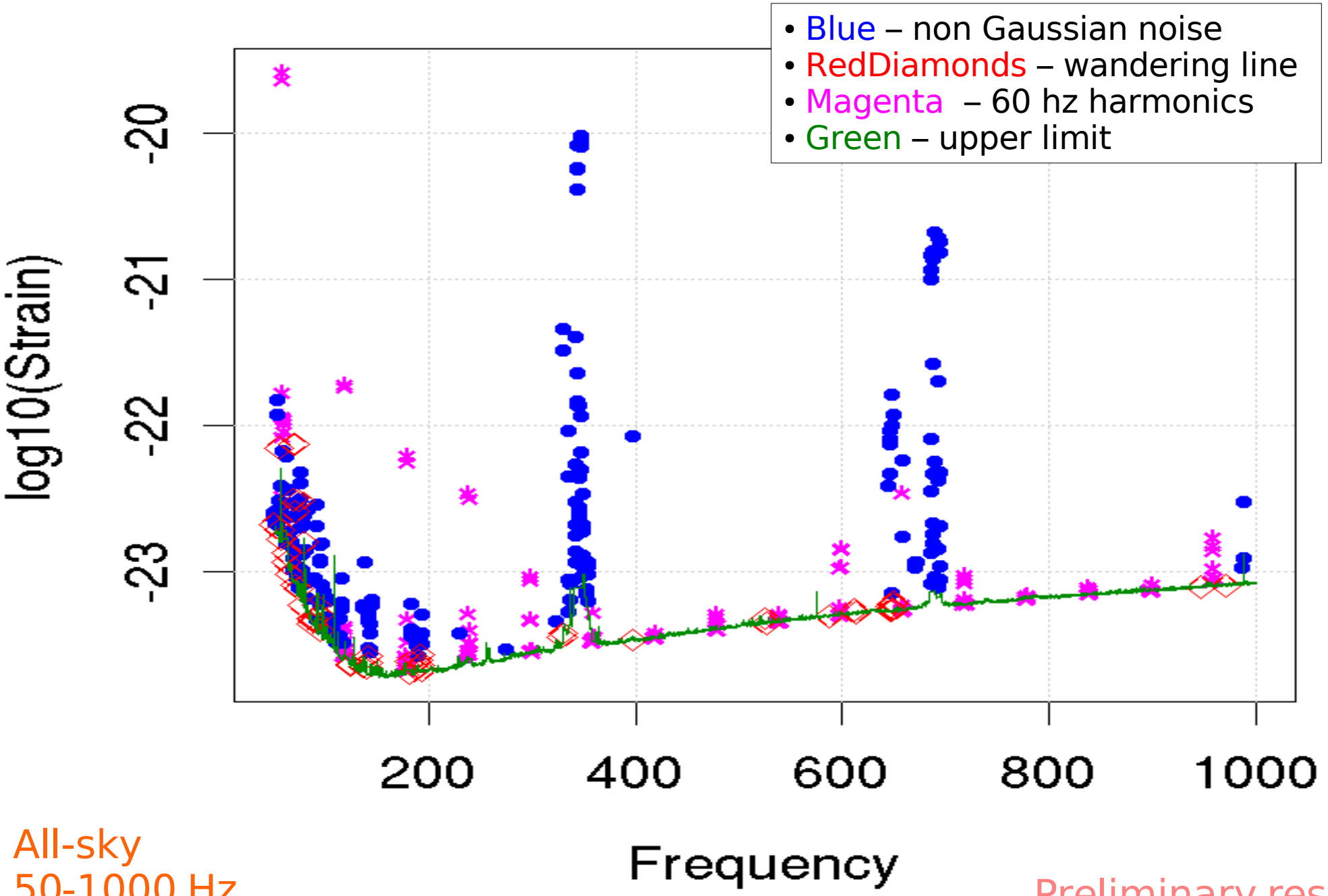
H1 S5 0-spindown run



All-sky
50-1000 Hz

Preliminary results

L1 S5 0-spindown run



All-sky
50-1000 Hz

Preliminary results

Partial sky (targeted) run

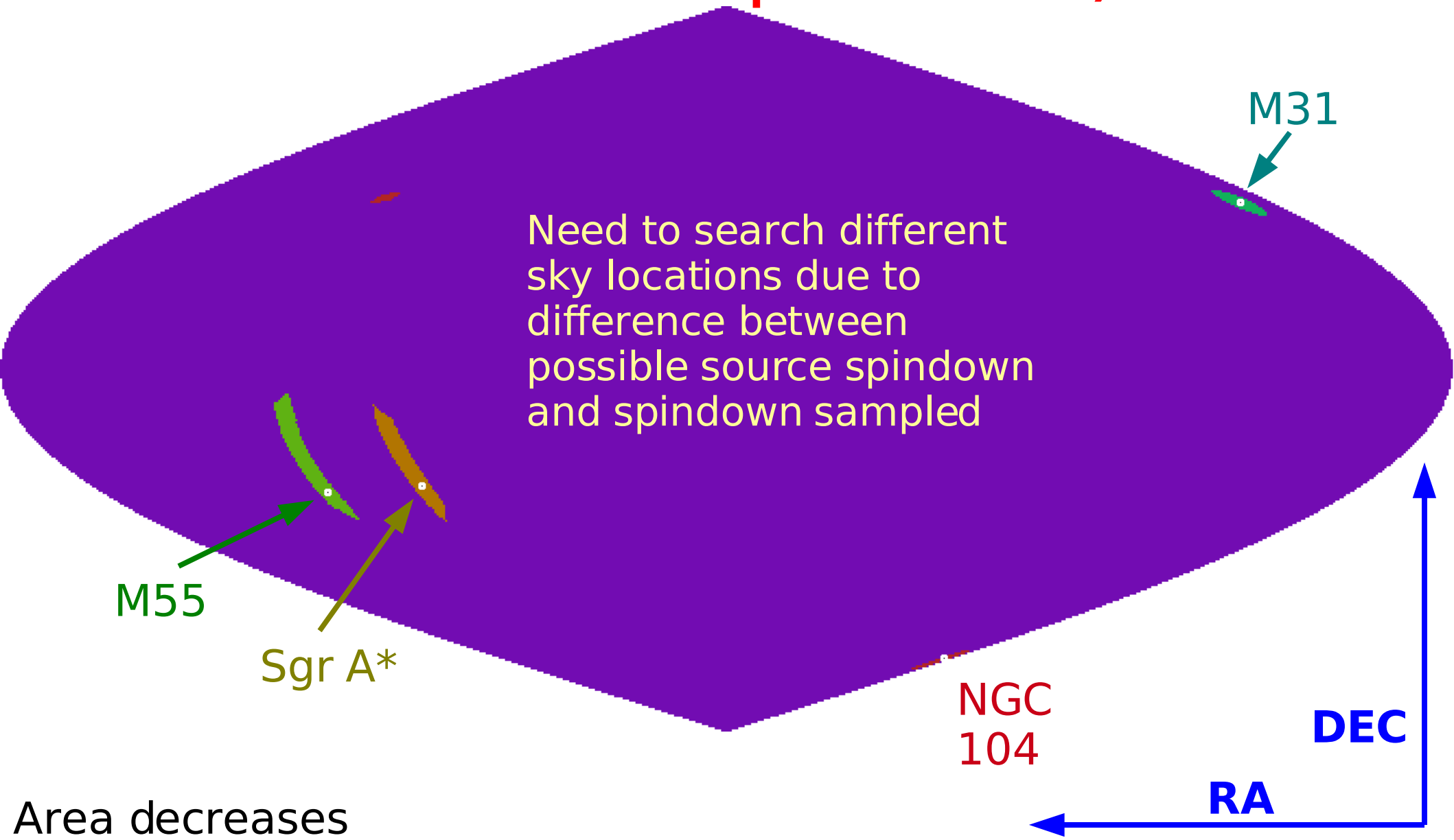
- Searched sky around
  - globular clusters M55, NGC104
  - galactic center Sgr A*
  - Andromeda M31 (control)
- 100-700 Hz (clusters continuing to compute to 1000 Hz)
- -1.01e-8 Hz/s through 1.01e-8 Hz/s in 2e-10 Hz/s steps
- Background (cyan curve) can be described by the following formula:

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

Here f is frequency and f0=132 Hz

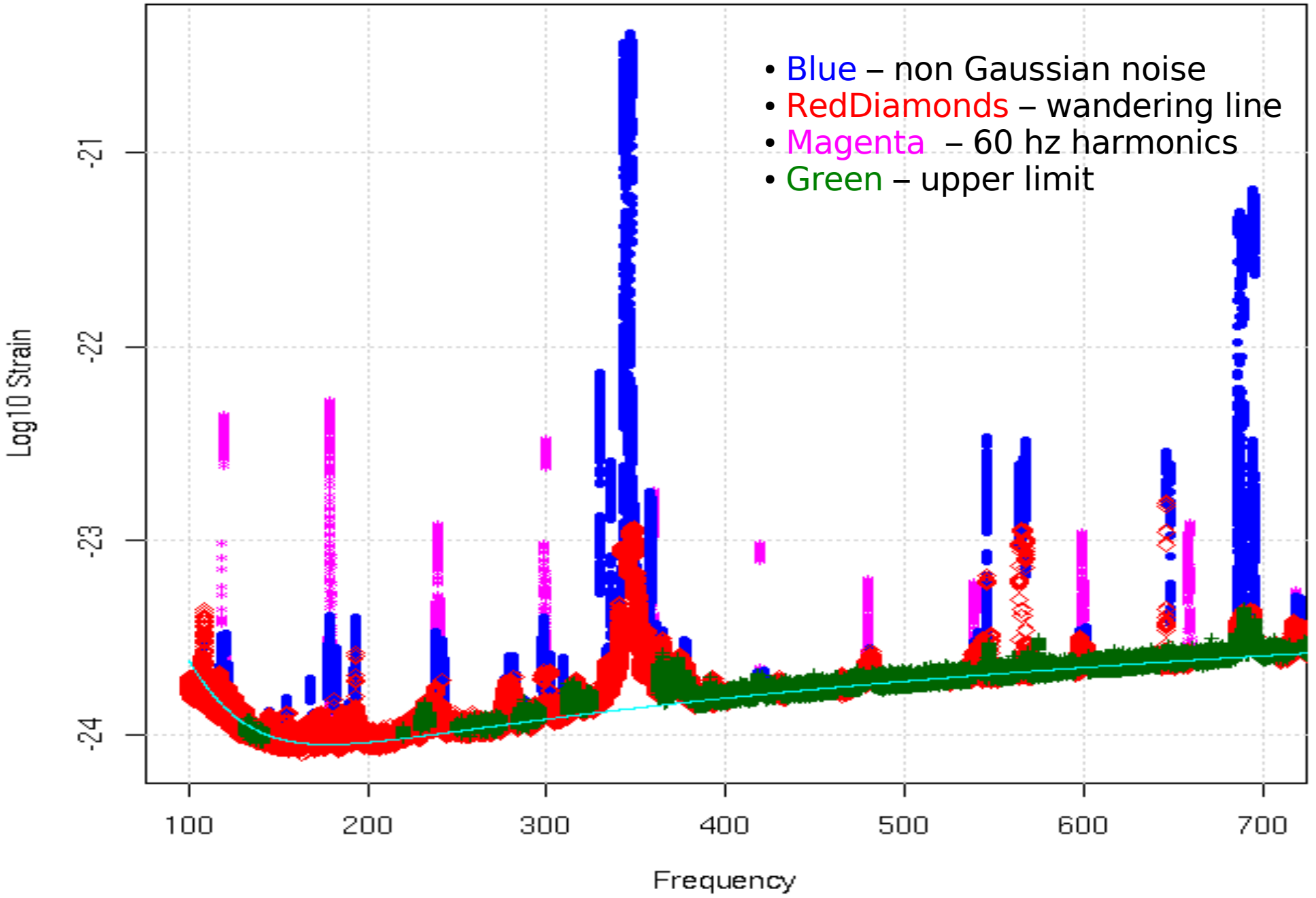
Fresh results – followup not finished

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



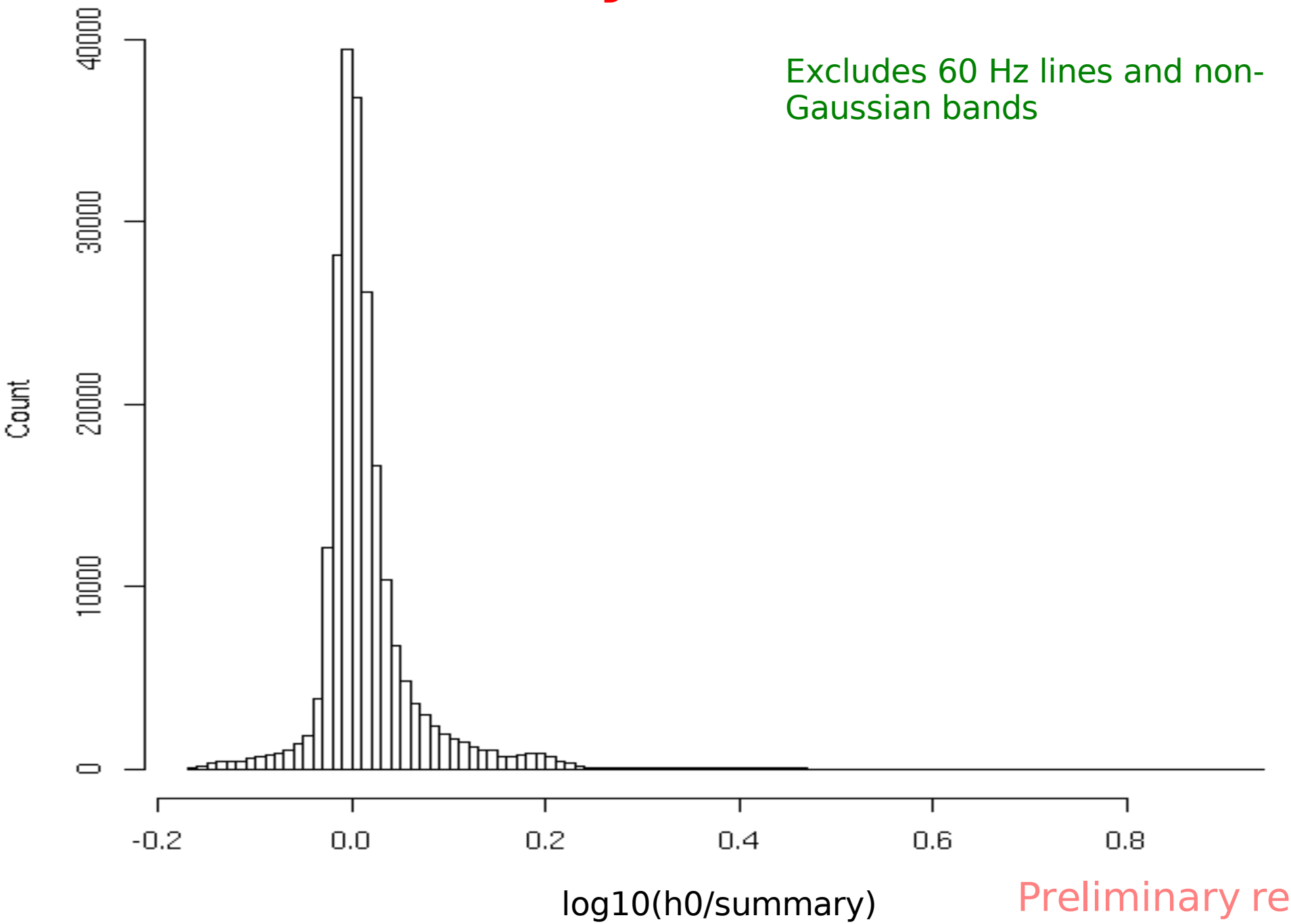
Area decreases with frequency

H1 Sgr A* upper limits



Preliminary results

S5 summary curve deviation



Preliminary results

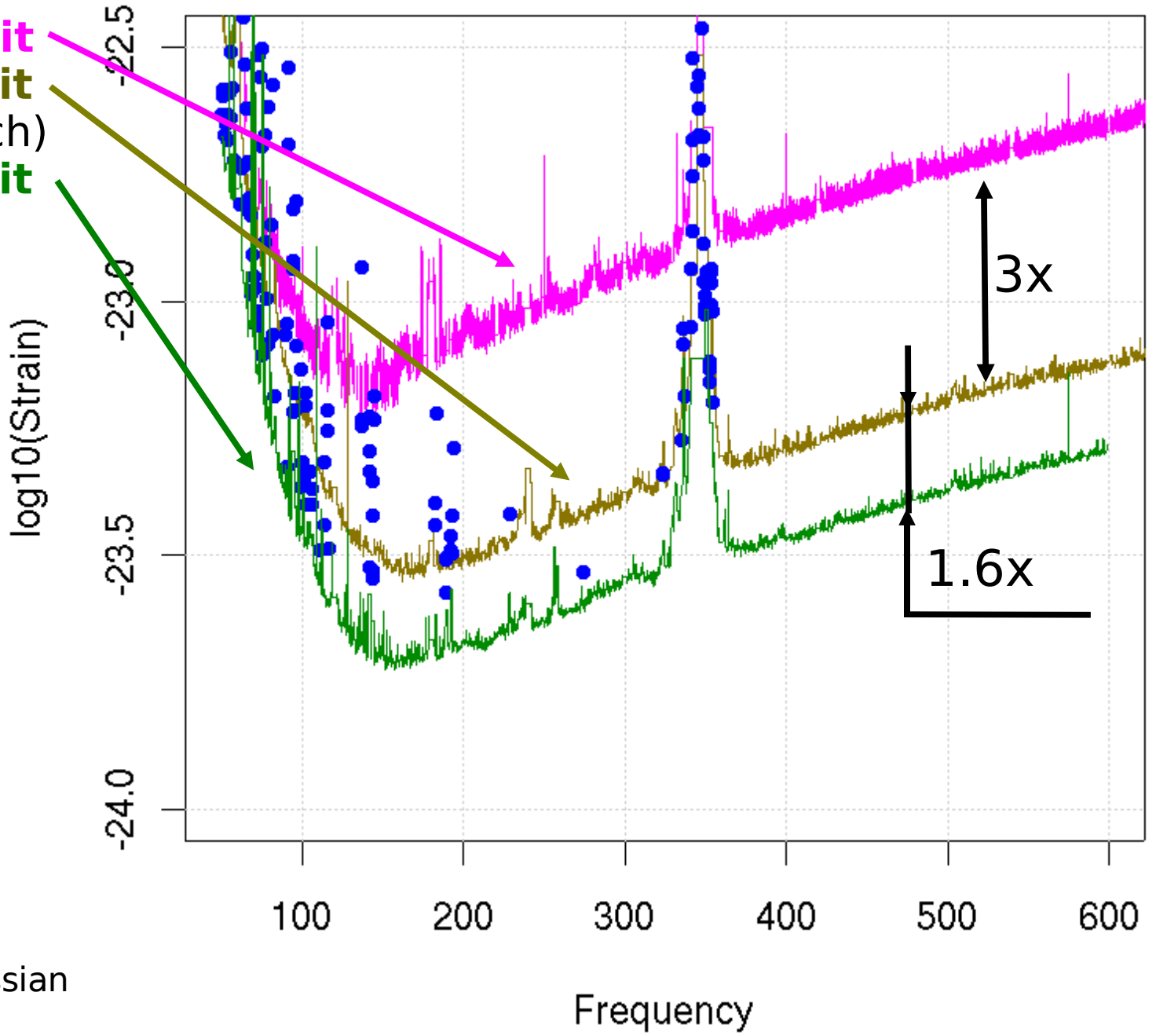
Conclusion

- 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

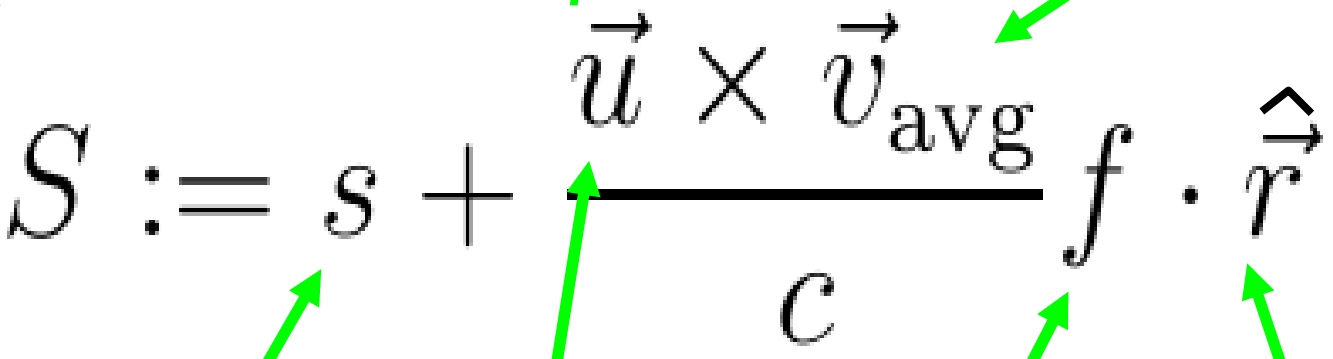
- 60 Hz lines excluded
- Blue points – non-gaussian noise in July run

“S parameter”

When S is closer to 0 susceptibility to stationary artifacts increases

Average detector acceleration

Average detector velocity



Spindown (Hz/s)

Earth orbit angular velocity

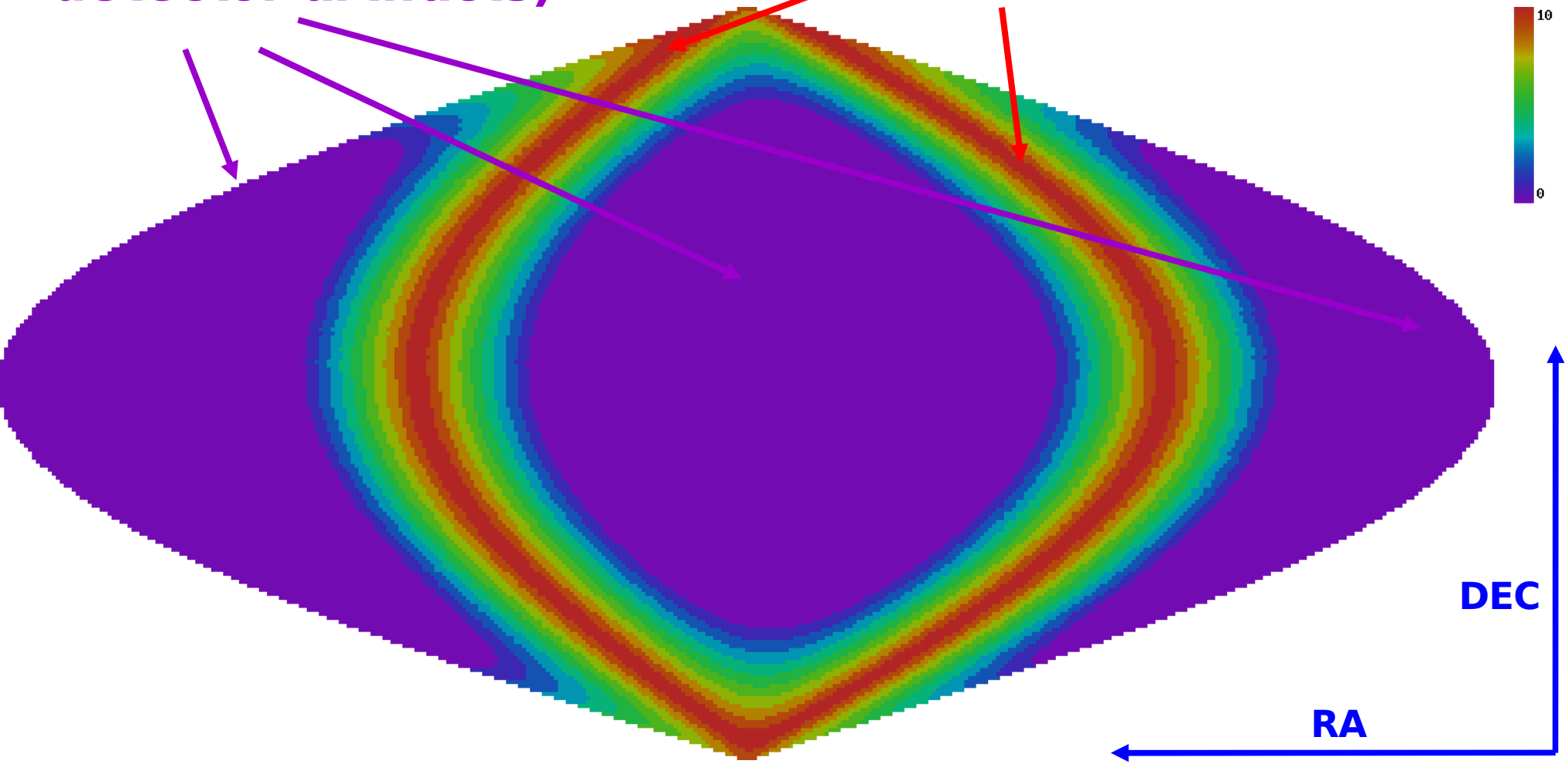
Frequency

Unit sky position vector

Doppler Skybands

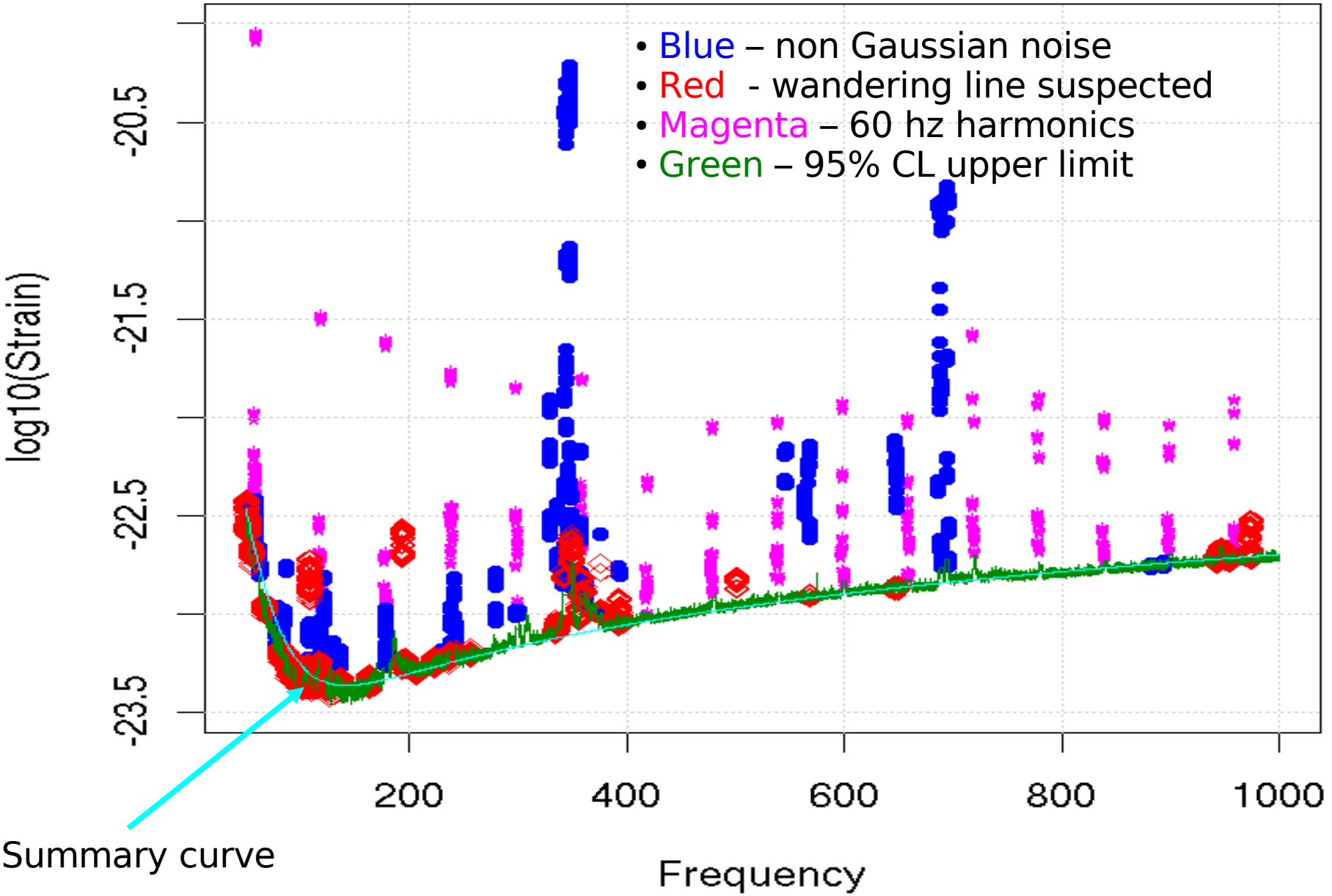
Skyband 0 (good – only exceptionally strong detector artifacts)

Skyband 10 (worst – many detector artifacts)



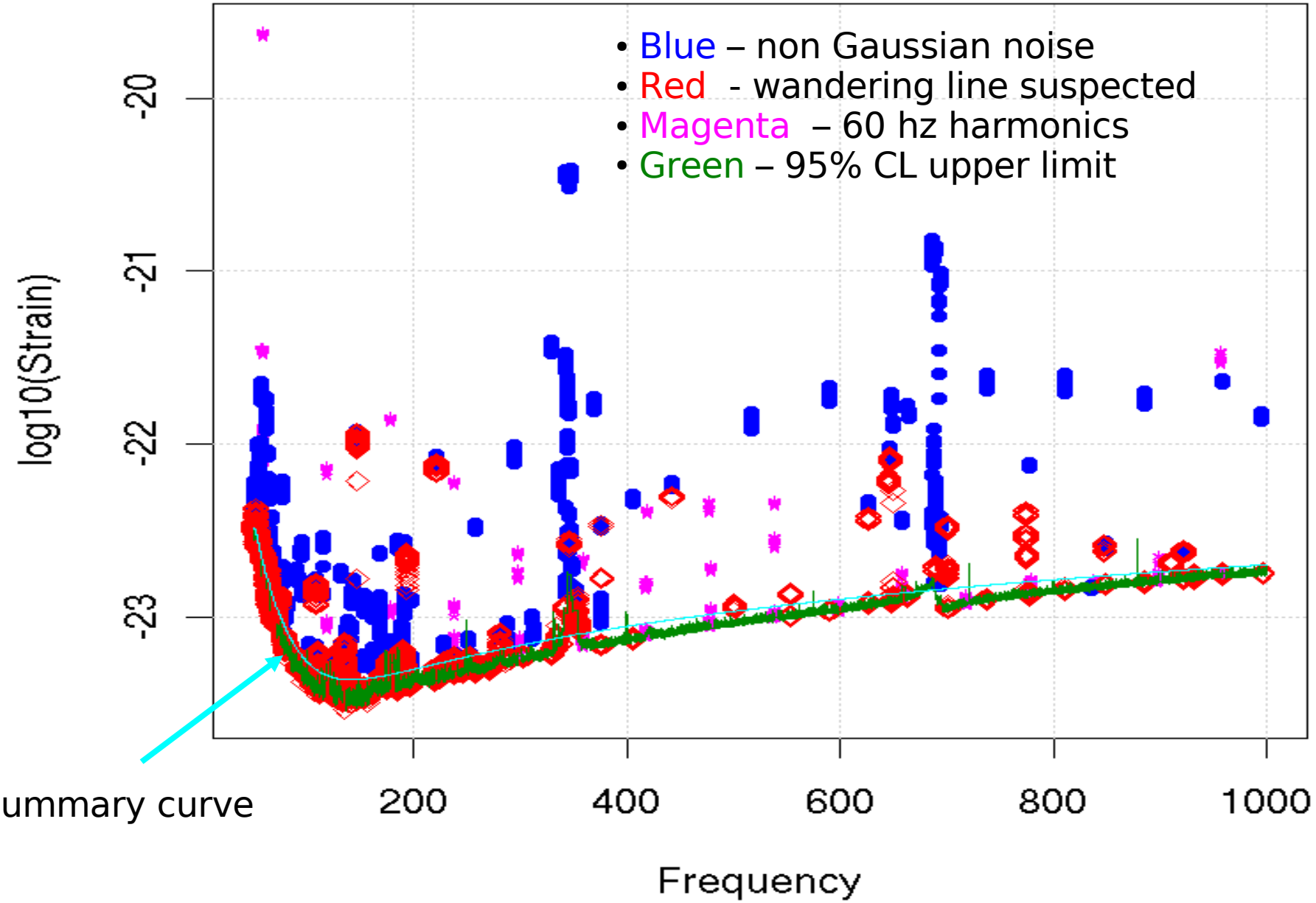
S4 run results
Hanford 4km

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



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