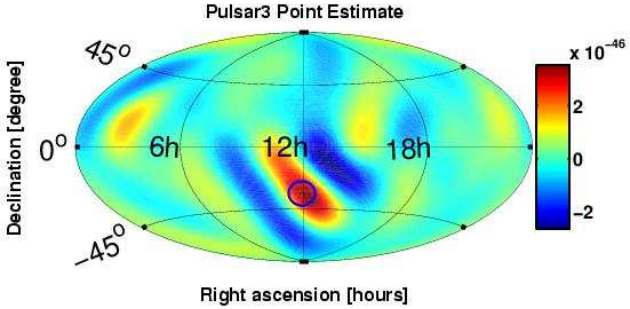
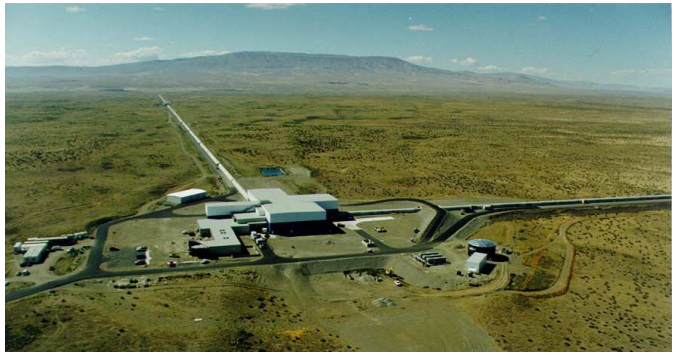
The Radiometer Update

Stefan Ballmer



Presented at the
LSC meeting
March 20, 2006



Radiometer search H1-L1

Reminder

- Method:
  - Design optimal x-correlation kernel for unpolarized point source
  - Otherwise identical to isotropic stochastic search
  - More details in gr-qc/0510096

- Reminder from Nov LSC meeting:
  - Code checked with
    - Software injections of point source
    - All-Sky integral = isotropic result
  - Code run on S4
    - 60 second segments, 0.25Hz bin width
    - Timing transient subtracted in time domain.

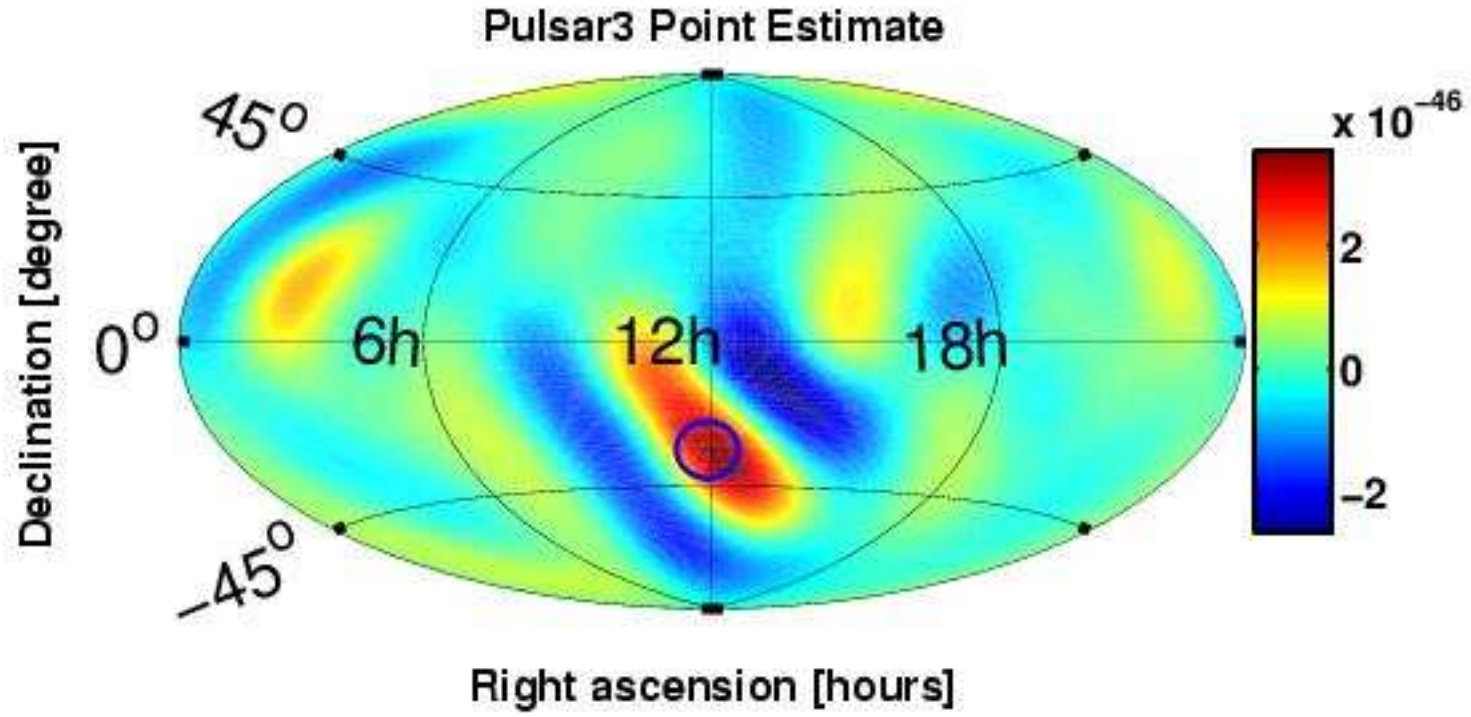
Injected pulsars

- Injected pulsars can be used as independent check, but:
  - Pulsars are polarized - radiometer looks for unpol. Source:
  - Conversion depends on observation time and sensitivity

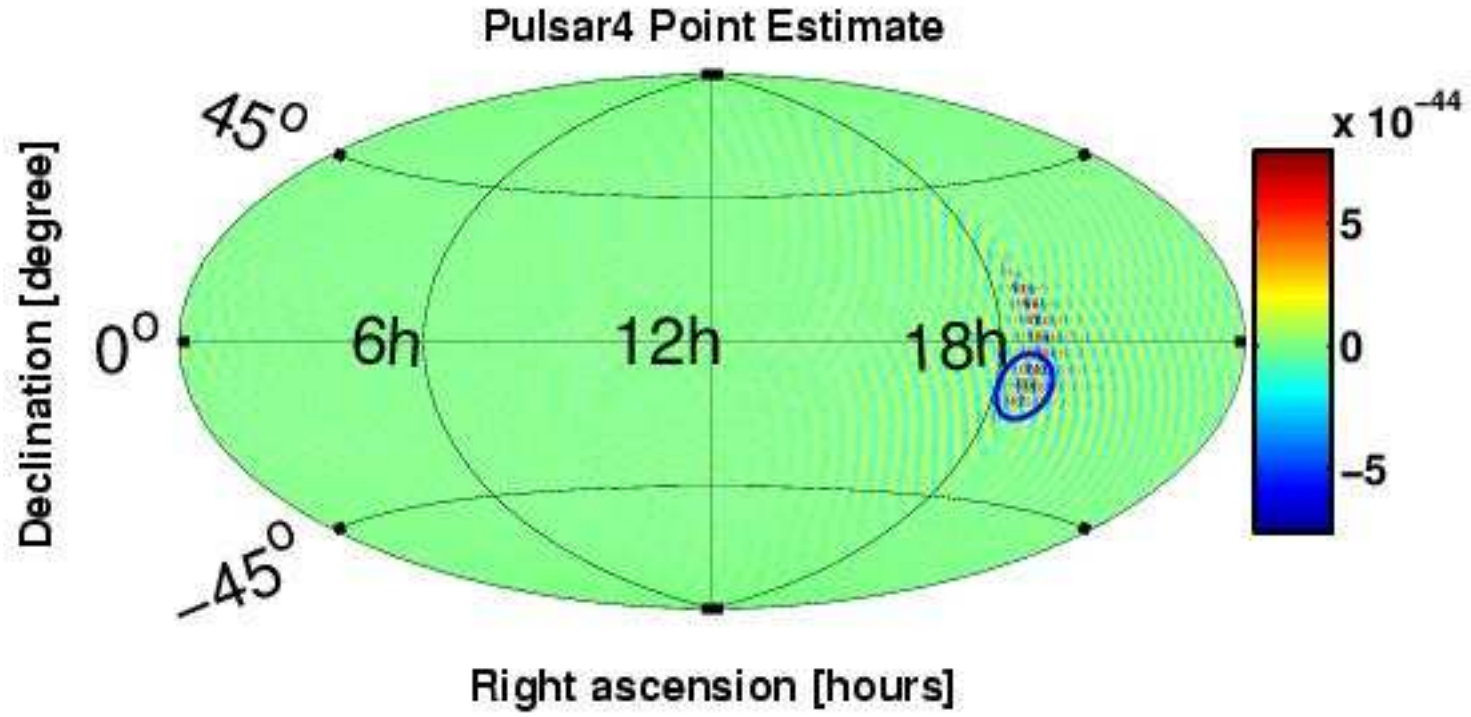
$$H(f)df = \frac{\sum_{t_i}(E_1^+E_2^+ + E_1^\times E_2^\times)(E_1^+E_2^+h_+^2 + E_1^\times E_2^\times h_\times^2)}{\sum_{t_i}(E_1^+E_2^+ + E_1^\times E_2^\times)^2}$$

Strongest injected pulsars during S4			
Parameter	Pulsar3	Pulsar4	Pulsar8
Freq. during S4	108.86 Hz	1402.20 Hz	193.94 Hz
h_+	6.5532×10^{-20}	9.8258×10^{-19}	6.3851×10^{-20}
$h_\times$	-1.0504×10^{-20}	5.0606×10^{-19}	9.3864×10^{-21}
Right ascension	$11h\ 53m\ 29.4s$	$18h\ 39m\ 57.0s$	$23h\ 25m\ 33.5s$
Declination	$-33d\ 26'\ 11.8''$	$-12d\ 27'\ 59.8''$	$-33d\ 25'\ 6.7''$
Hdf $^{(*)}$	1.74×10^{-46}	4.28×10^{-44}	1.54×10^{-46}

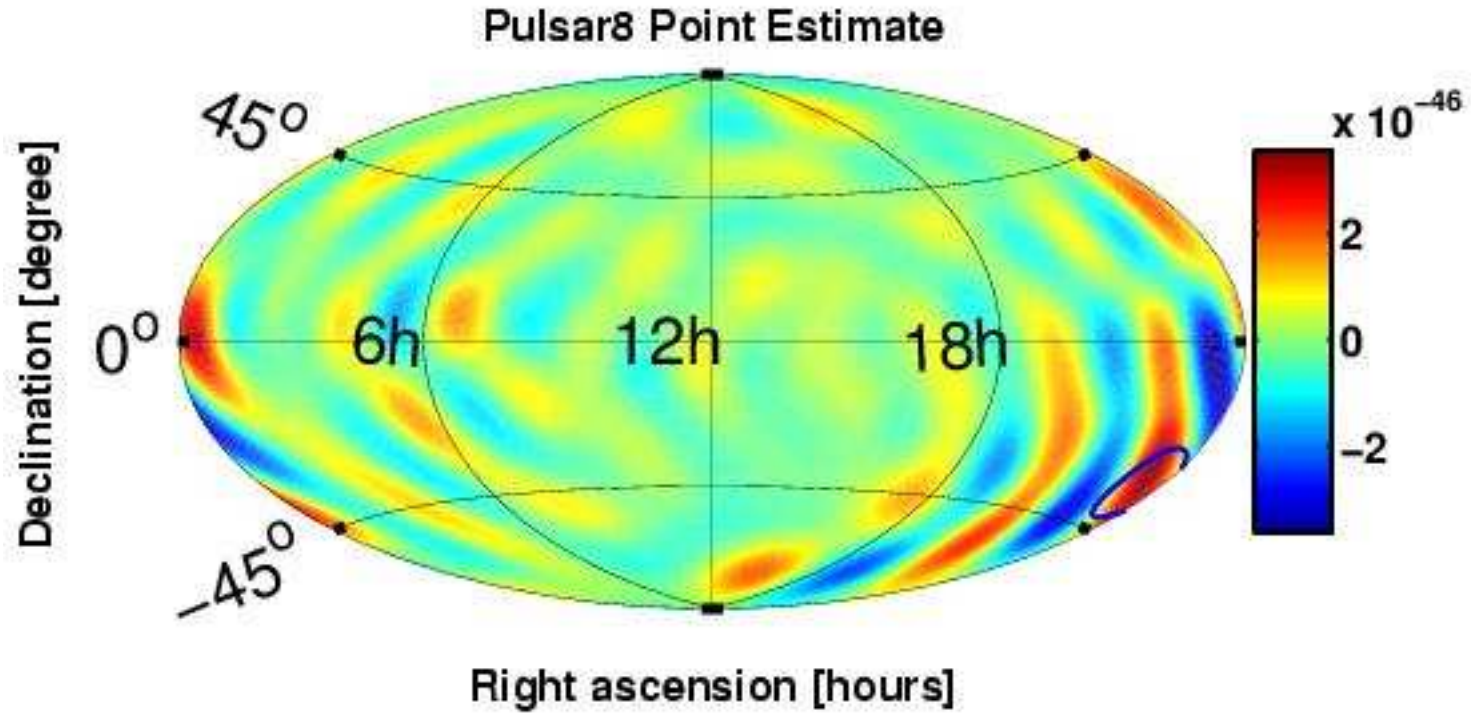
Pulsar 3 108.86Hz (0.5Hz BW)



Pulsar 4 1402.20Hz (0.5Hz BW)



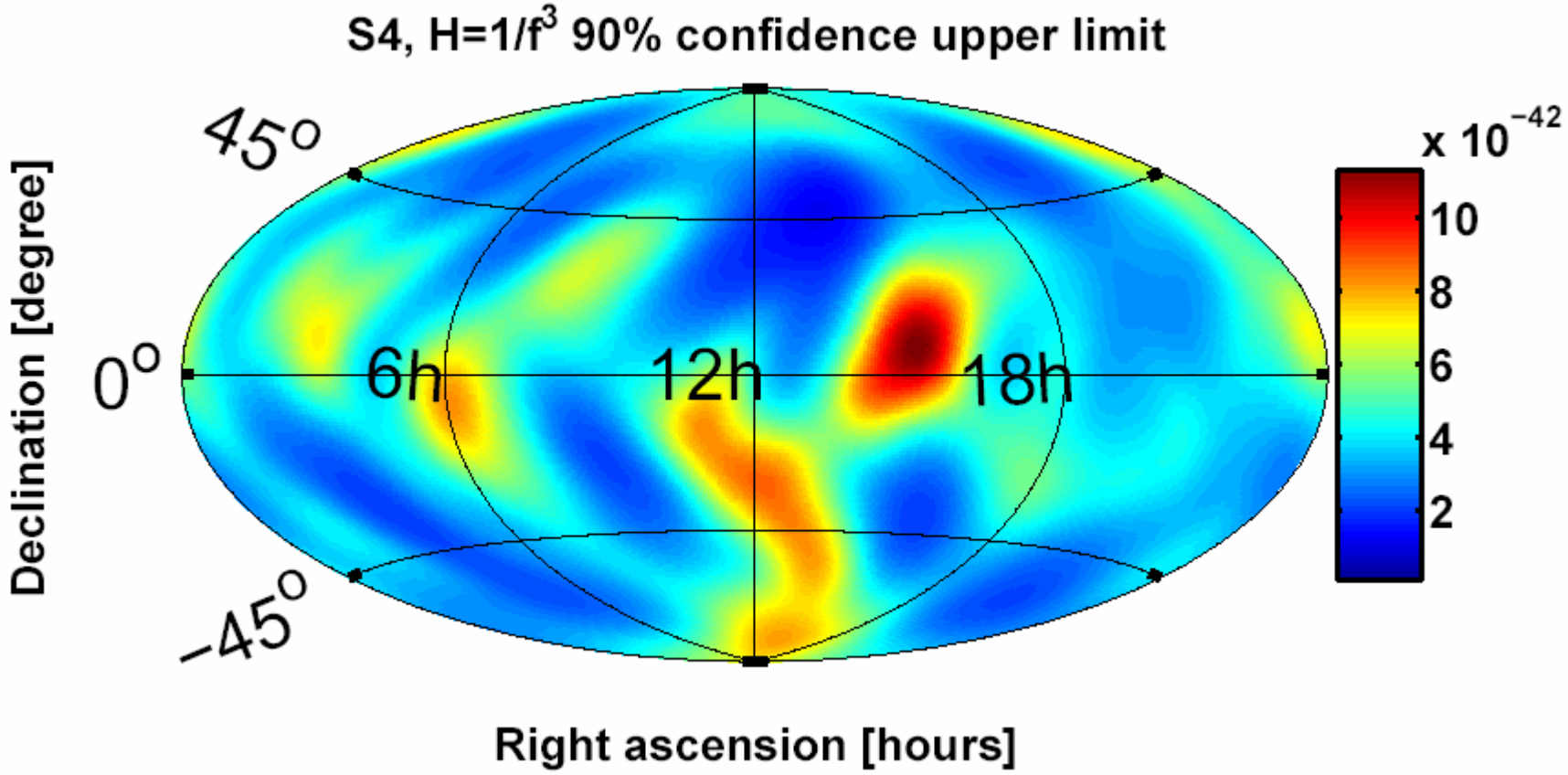
Pulsar 8 193.94Hz (0.5Hz BW)



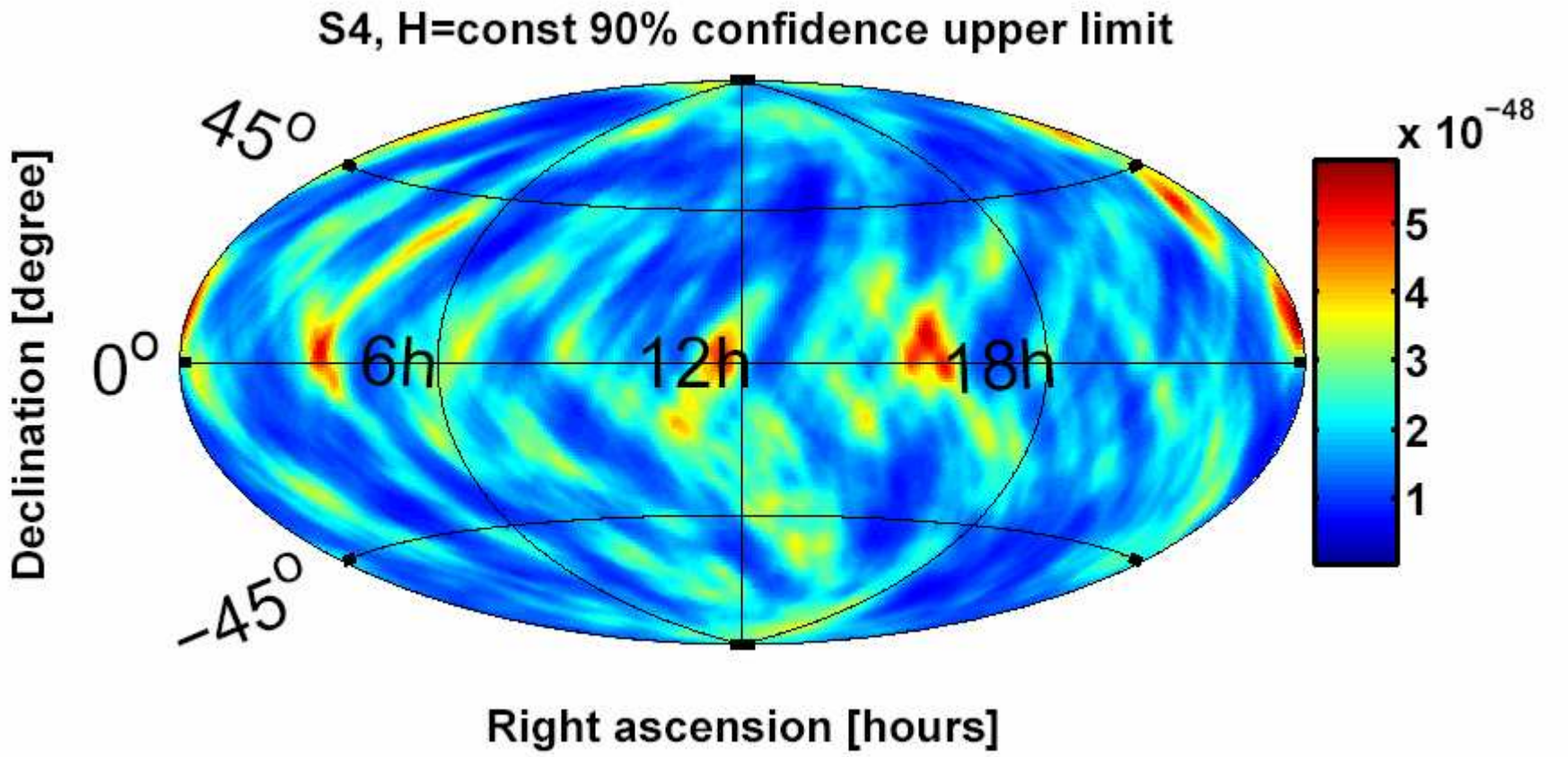
Recovered pulsars

Pulsars Hardware Injection			
Parameter	Pulsar3	Pulsar4	Pulsar8
Freq. during S4	108.86 Hz	1402.20 Hz	193.94 Hz
Max. SNR at	$12h\ 12m$ $-37d$	$18h\ 40m$ $-13d$	$23h\ 16m$ $-32d$
Max. estimate at	$12h\ 12m$ $-36d$	$18h\ 40m$ $-12d$	$23h\ 12m$ $-31d$
Max estimate Hdf	1.80×10^{-46}	4.05×10^{-44}	1.82×10^{-46}
Estimate Hdf on source	1.74×10^{-46}	4.05×10^{-44}	1.79×10^{-46}
Error bar	1.89×10^{-47}	6.04×10^{-46}	1.73×10^{-47}
SNR	9.2	67.1	10.3
inj. Hdf	1.74×10^{-46}	4.28×10^{-44}	1.54×10^{-46}

Upper Limit map



Upper Limit map



Frequency dependent UL

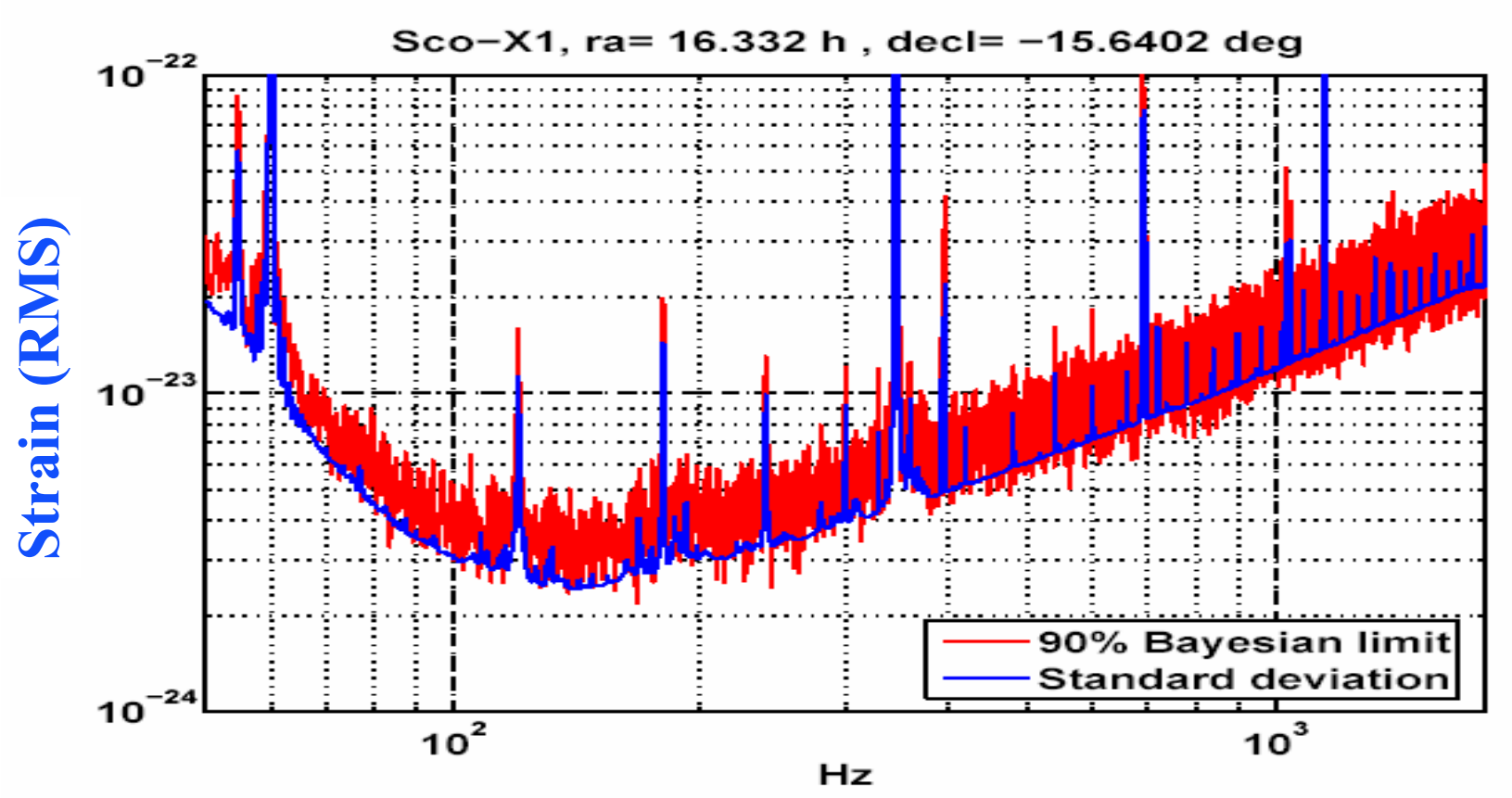
- Optimal X-correlation kernel for each frequency bin
- Example: Sco-X1:
  - Is brightest X-ray source in sky
  - Is Low Mass X-ray Binary (LMXB)
  - Low magnetic field (~10^7 Gauss)
  - If GW balanced:

$$L_{GW} = \frac{\omega}{\omega_{\mathrm{Kepler}}} L_X$$

  - Spin frequency unknown

Sco-X1	
Parameter	Value
Right ascension	16h 19m 55.0850s
Declination	-15° 38' 24.9"s
Distance	2.8 ± 0.3 kpc
X-ray luminosity	2.3×10^{38} erg/sec
X-ray flux at earth	2.5×10^{-7} erg/sec/cm^2
Magnetic field near NS	$\approx 1 \times 10^7$ Gauss
Orbital period	68023.84 ± 0.08 sec
Orbital velocity	40 ± 5 km/sec
Eccentricity	≈ 0
Companion star mass	$\approx 0.42 M_\odot$

Frequency dependent UL
Sco-X1



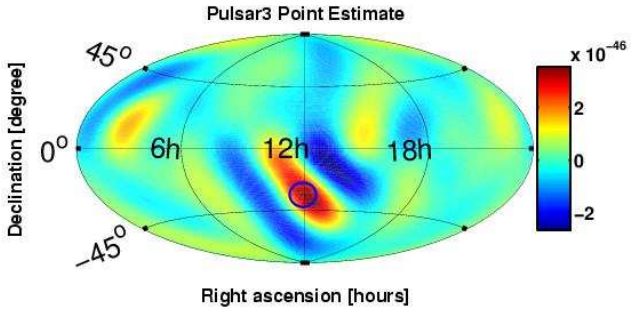
Frequency dependent UL
Sco-X1

- Comparison to expected strain (above 200Hz)

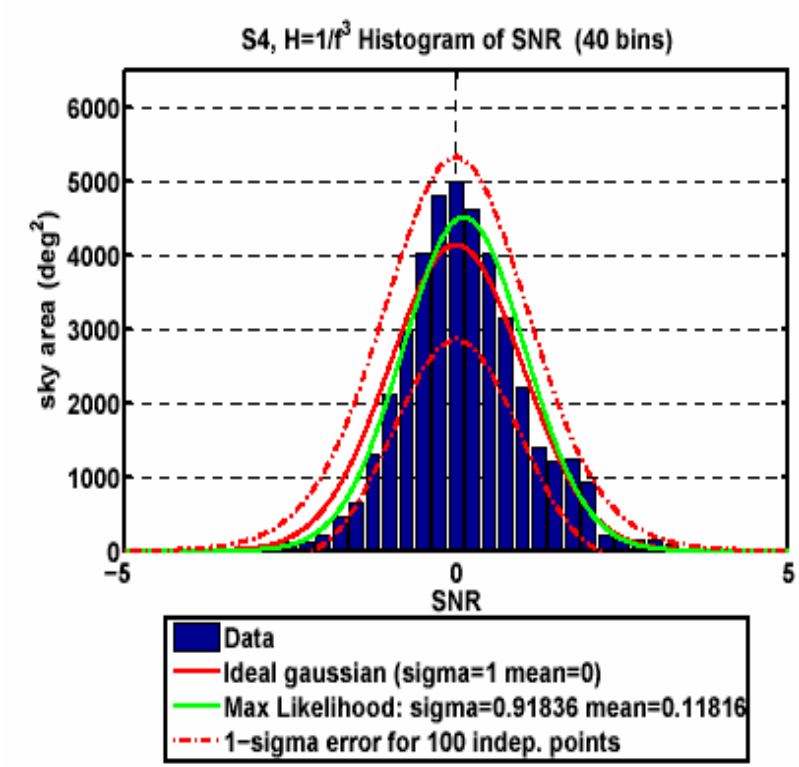
$$\frac{h_{\mathrm{RMS}}^{(90\%)}}{h_{\mathrm{RMS}}^{L_X}} \approx 440 \left(\frac{f}{500\ \mathrm{Hz}} \right)^{\frac{3}{2}}$$

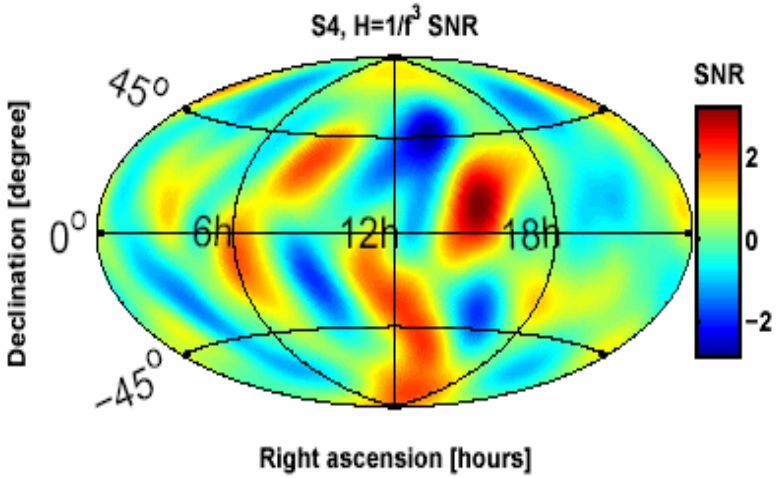
The End


The End

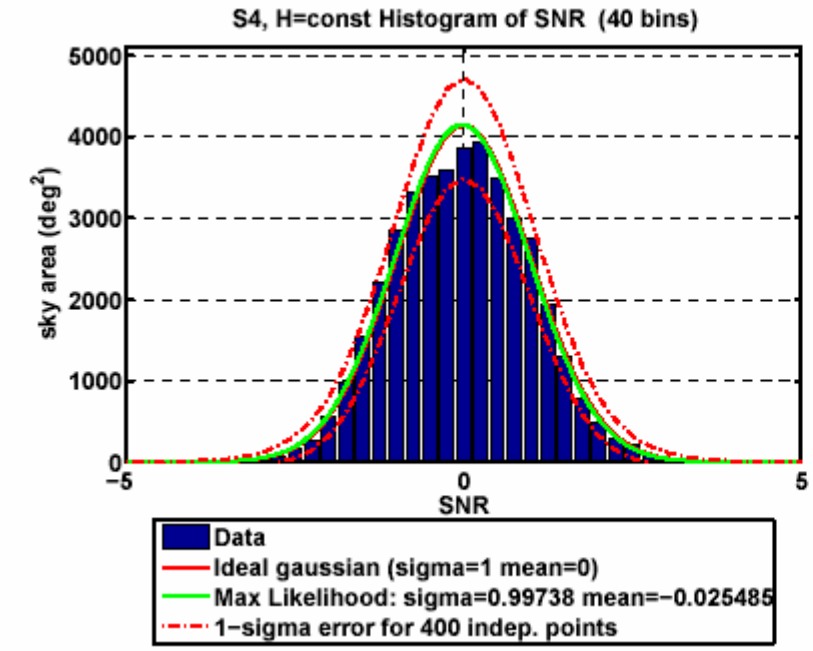

Pulsar3 Point Estimate
45°
0°
−45°
6h
12h
18h
Declination [degree]
Right ascension [hours]
x 10^-46
2
0
−2

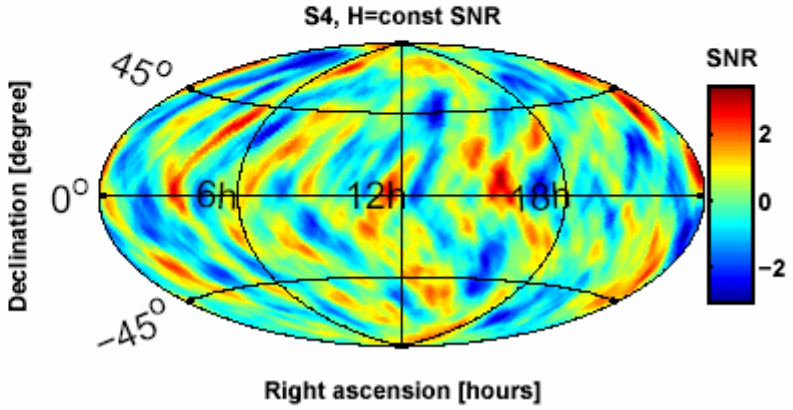
SNR


S4, H=1/f^3 Histogram of SNR (40 bins)
sky area (deg^2)
6000
5000
4000
3000
2000
1000
0
−5
0
5
SNR
Data
Ideal gaussian (sigma=1 mean=0)
Max Likelihood: sigma=0.91836 mean=0.11816
1−sigma error for 100 indep. points


S4, H=1/f^3 SNR
SNR
2
0
−2
45°
0°
−45°
6h
12h
18h
Declination [degree]
Right ascension [hours]

SNR


S4, H=const Histogram of SNR (40 bins)
sky area (deg^2)
5000
4000
3000
2000
1000
0
−5
0
5
SNR
Data
Ideal gaussian (sigma=1 mean=0)
Max Likelihood: sigma=0.99738 mean=−0.025485
1−sigma error for 400 indep. points


S4, H=const SNR
SNR
2
0
−2
45°
0°
−45°
6h
12h
18h
Declination [degree]
Right ascension [hours]