S2/E10 pulsar injection analysis

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LSC Meeting, LHO

Outline

1. S2 injections and parameter estimation
2. Preliminary look at E10 data

S2 Pulsar Injection Parameters

- Signal is sum of two different pulsars, **P1** and **P2**

P1: Constant Intrinsic Frequency

Sky position: **0.3766960246** latitude (radians)
5.1471621319 longitude (radians)
Signal parameters are defined at SSB GPS time **733967667.026112310** which corresponds to a wavefront passing:
LHO at GPS time **733967713.000000000**
LLO at GPS time **733967713.007730720**
In the SSB the signal is defined by
f = 1279.123456789012 Hz
fdot = 0
phi = 0
A+ = 1.0 x 10^{-21}
Ax = 0 [equivalent to iota=pi/2]

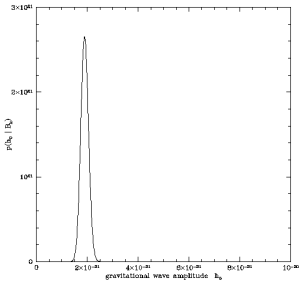
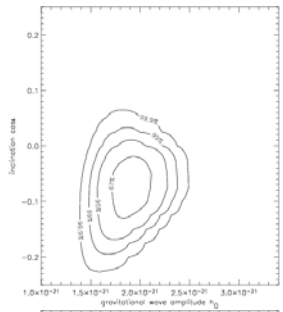
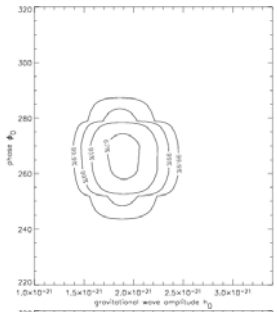
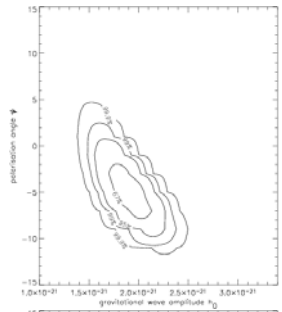
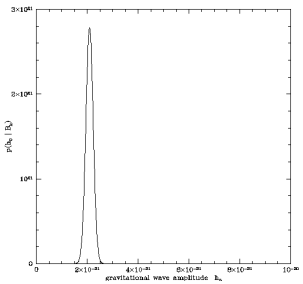
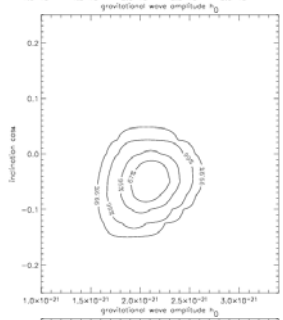
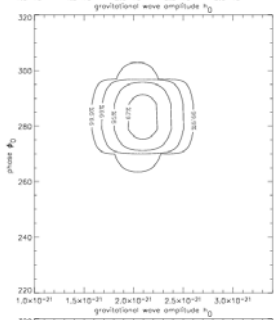
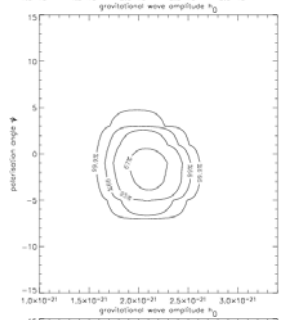
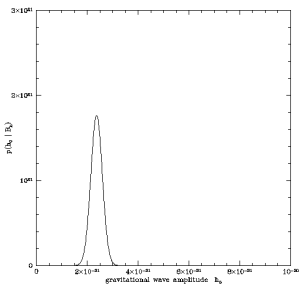
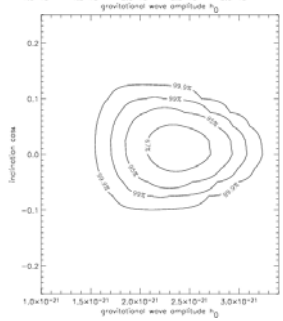
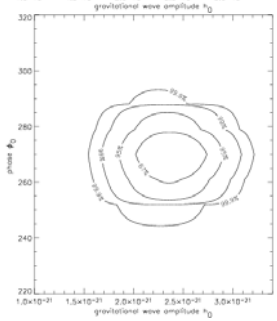
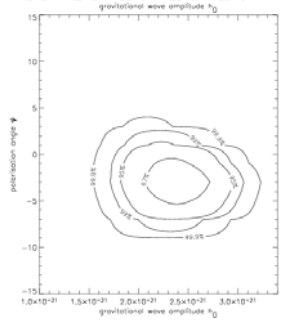
P2: Spinning Down

Sky position: **1.23456789012345** latitude (radians)
2.345678901234567890 longitude (radians)
Signal parameters are defined at SSB GPS time:
SSB **733967751.522490380**, which corresponds to a wavefront passing:
LHO at GPS time **733967713.000000000**
LLO at GPS time **733967713.001640320**
In the SSB at that moment the signal is defined by
f=1288.901234567890123
fdot = -10^{-8} [phase=2 pi (f dt+1/2 fdot dt^2+...)]
phi = 0
A+ = 1.0 x 10^{-21}
Ax = 0 [equivalent to iota=pi/2]

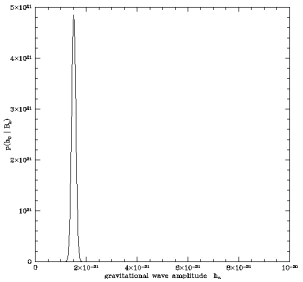
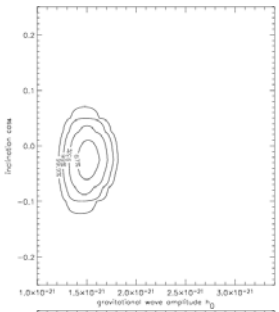
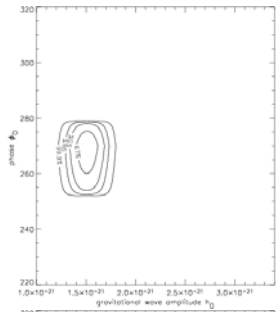
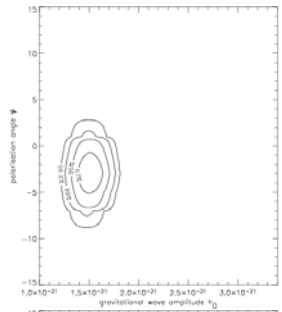
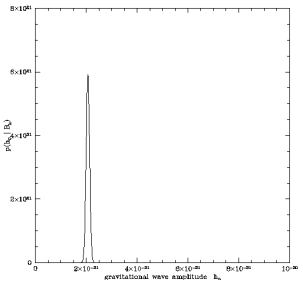
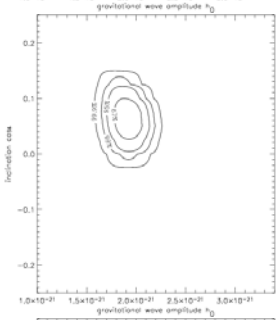
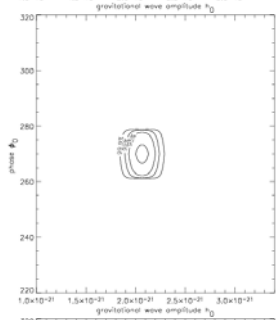
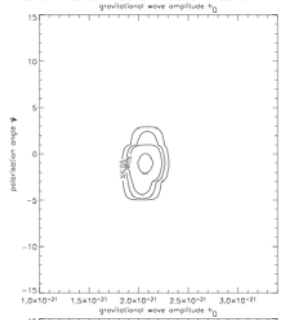
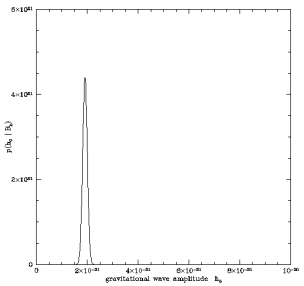
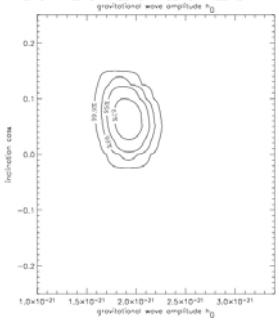
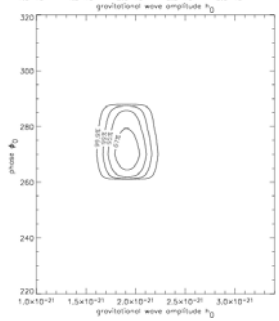
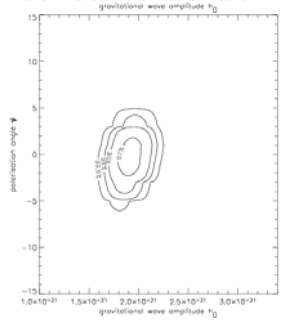
Time Domain Bayesian Analysis

- For each signal all parameters were successfully inferred (except a constant 90 degrees phase shift)
- Four plots were produced for each signal:
  1. posterior probability density function of h_0 given the data (marginalized over the other parameters)
  2. confidence contour plot of \cos\iota vs h_0 with levels at 67%, 95%, 99%, and 99.9%
  3. confidence contour plot of polarisation angle \psi vs h_0 with levels at 67%, 95%, 99%, and 99.9%
  4. confidence contour plot of phase \phi_0 vs h_0 with levels at 67%, 95%, 99%, and 99.9%
- Coherent analysis using data from all sites showed that phase was conserved between sites
- Full results (with larger images) are posted at http://www.astro.gla.ac.uk/users/rejean/lsc/S2injections (lsc/lsconly)

Results for signal P1

	$p(h_0 \mid B_k)$	$p(h_0, \cos\iota \mid B_k)$	$p(h_0, \phi_0 \mid B_k)$	$p(h_0, \psi \mid B_k)$
L1:				
H1:				
H2:				

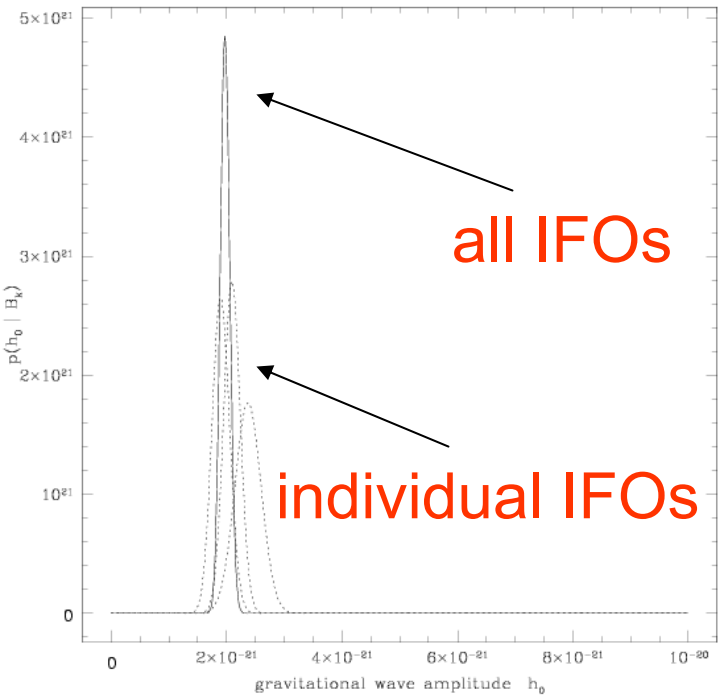
Results for signal P2

	$p(h_0 \mid B_k)$	$p(h_0, \cos\iota \mid B_k)$	$p(h_0, \phi_0 \mid B_k)$	$p(h_0, \psi \mid B_k)$
L1:				
H1:				
H2:				

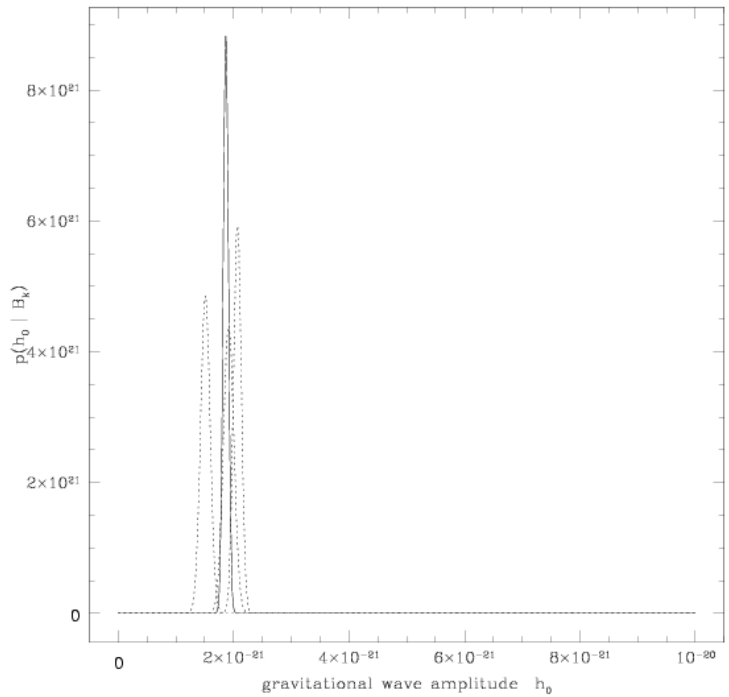
Joint Coherent Analysis

p(**a**|all data) = p(**a**|H1) p(**a**|H2) p(**a**|L1)

Signal P1



Signal P2



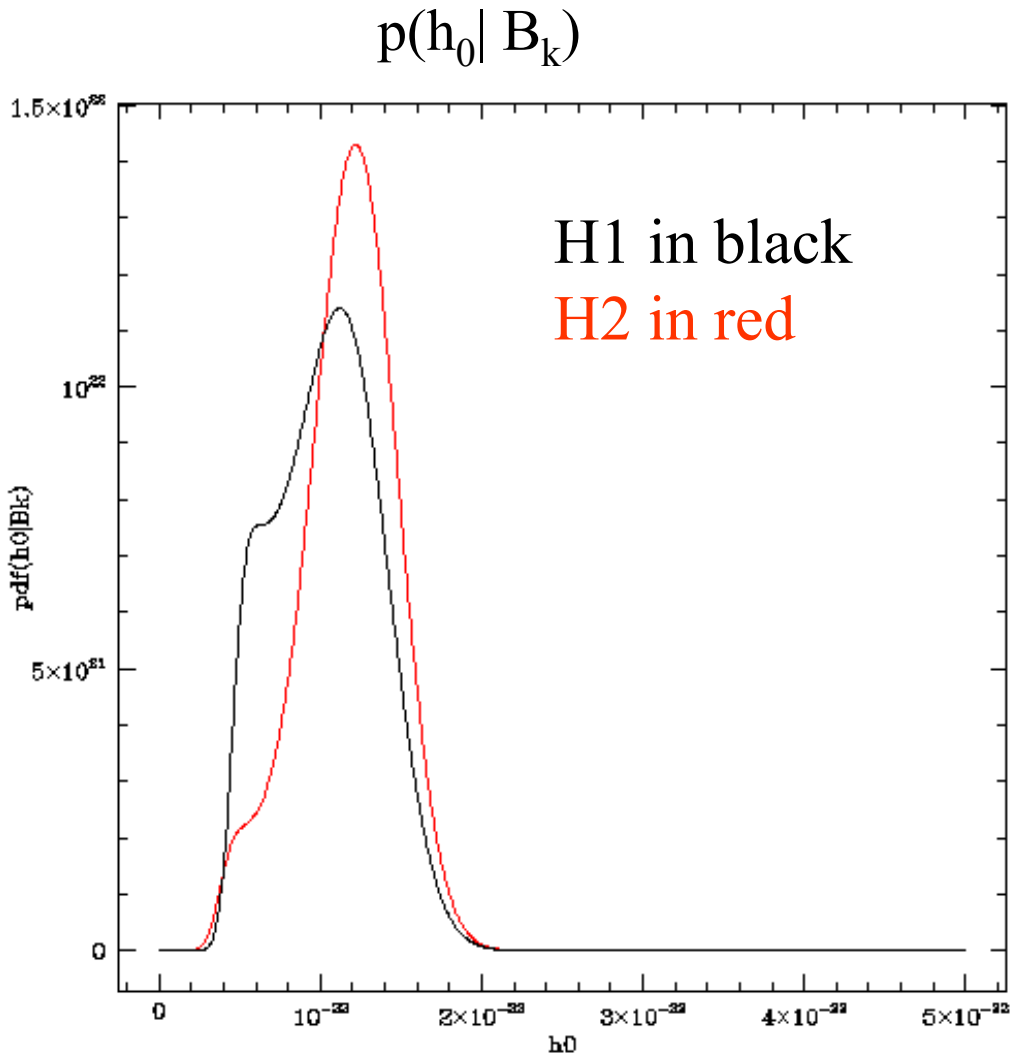
E10 Pulsar injection parameters

- Injected a total of 10 pulsars; 5 to be reserved for blind searches
- Locked data only available from H1 and H2

Pulsar 0	Pulsar 1	Pulsar 2	Pulsar 3	Pulsar 4
f ≈ 265.6 Hz	f ≈ 849.1 Hz	f ≈ 575.2 Hz	f ≈ 108.9 Hz	f ≈ 1403.2 Hz
$\phi_0 \approx 2.66$	$\phi_0 \approx 1.28$	$\phi_0 \approx 4.03$	$\phi_0 \approx 5.53$	$\phi_0 \approx 4.83$
$\psi \approx 0.77$	$\psi \approx 0.36$	$\psi \approx -0.22$	$\psi \approx 0.44$	$\psi \approx -0.65$
$\cos\iota \approx 0.80$	$\cos\iota \approx 0.46$	$\cos\iota \approx -0.93$	$\cos\iota \approx -0.08$	$\cos\iota \approx 0.28$
RA ≈ 1.25	RA ≈ 0.65	RA ≈ 3.76	RA ≈ 3.11	RA ≈ 4.89
DEC ≈ -0.98	DEC ≈ -0.51	DEC ≈ 0.06	DEC ≈ -0.58	DEC ≈ -0.22

Pulsar 1

- PDFs are peaked near $h_0 = 10^{-22}$
- Approx. 850 minutes of locked data on last day of E10
- Injected h_0 = ?

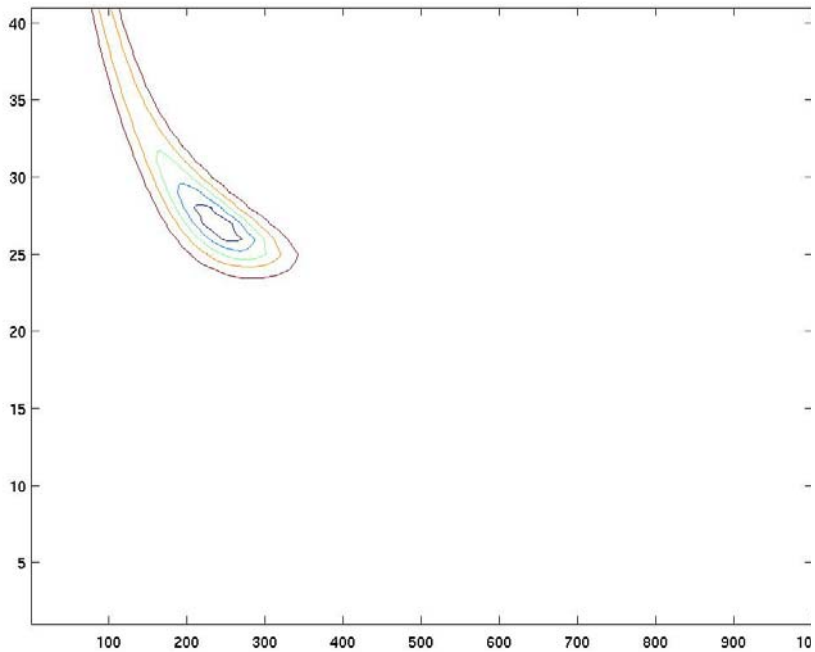


Pulsar 1 - $p(h_0,\cos\iota \mid B_k)$

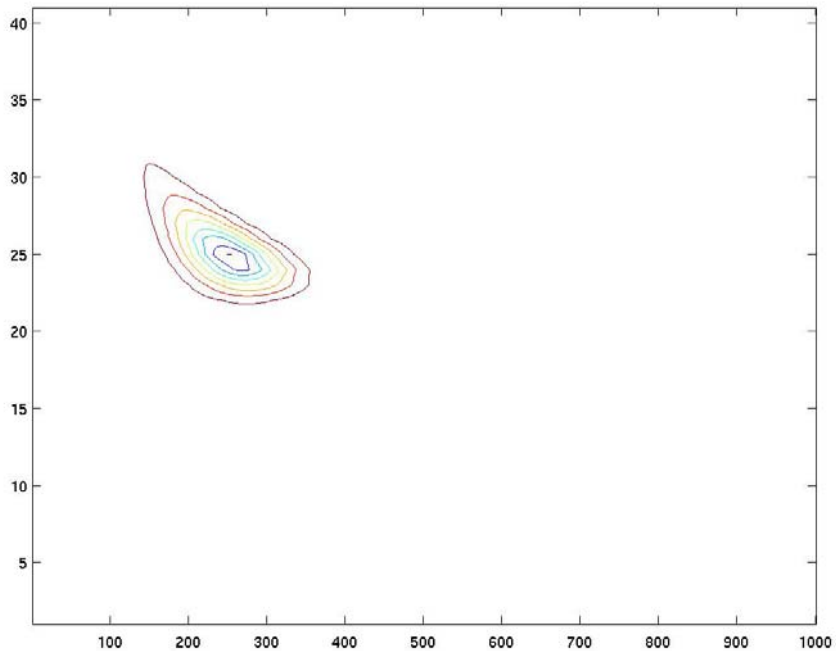
Injected: $\cos\iota \approx 0.46$

Y-axis range: -1 to 1

H1



H2

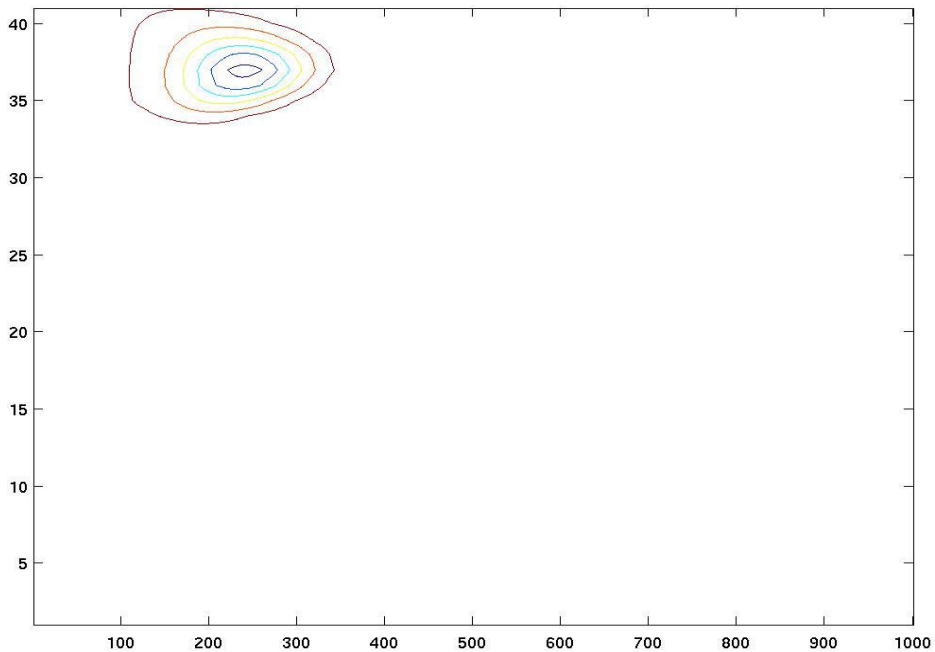


Pulsar 1 - $p(h_0,\phi_0 \mid B_k)$

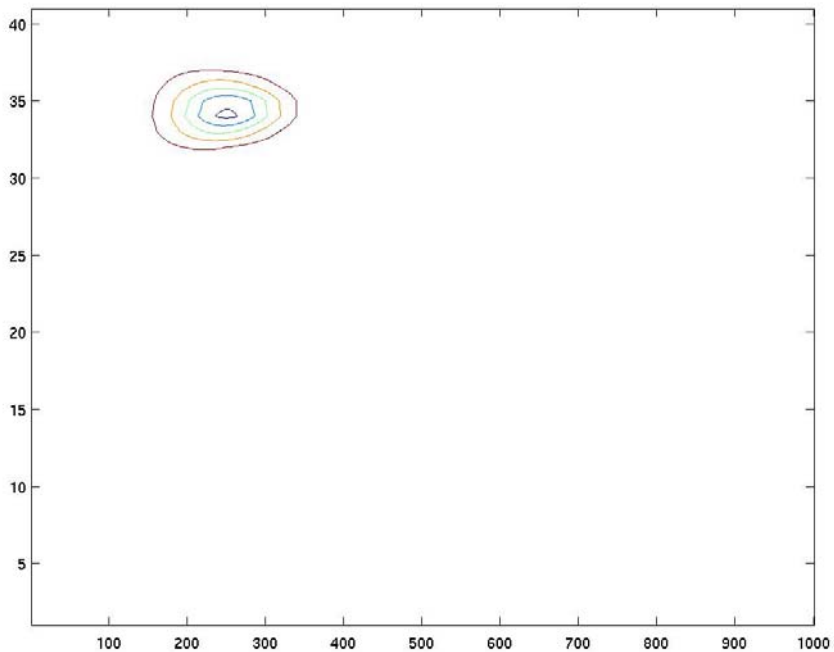
Injected: $\phi_0 \approx 1.28$

Y-axis range: 0 to 2pi

H1



H2

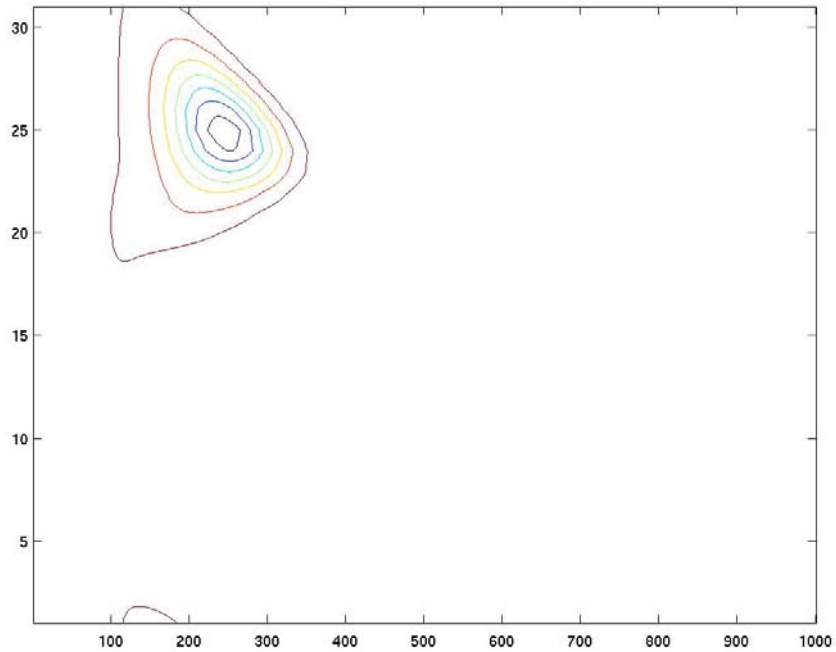


Pulsar 1 - $p(h_0,\psi \mid B_k)$

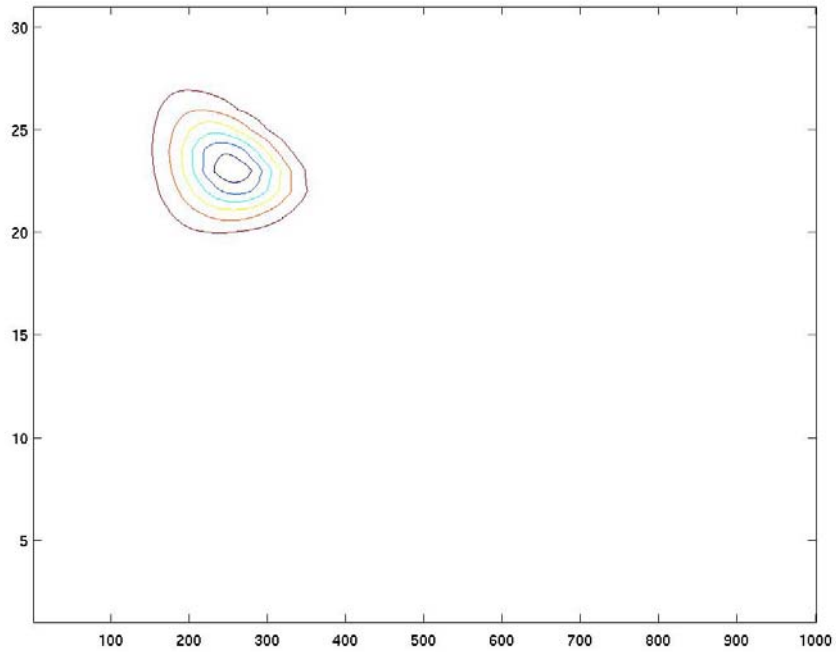
Injected: $\psi \approx 0.36$

Y-axis range: -pi/4 to pi/4

H1



H2



To do

- Study E10 data more carefully
- Use MCMC approach for semi-*blind* search
- Analyze S3 data