GW pulsars in binary systems
Sco X-1

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THE UNIVERSITY OF BIRMINGHAM

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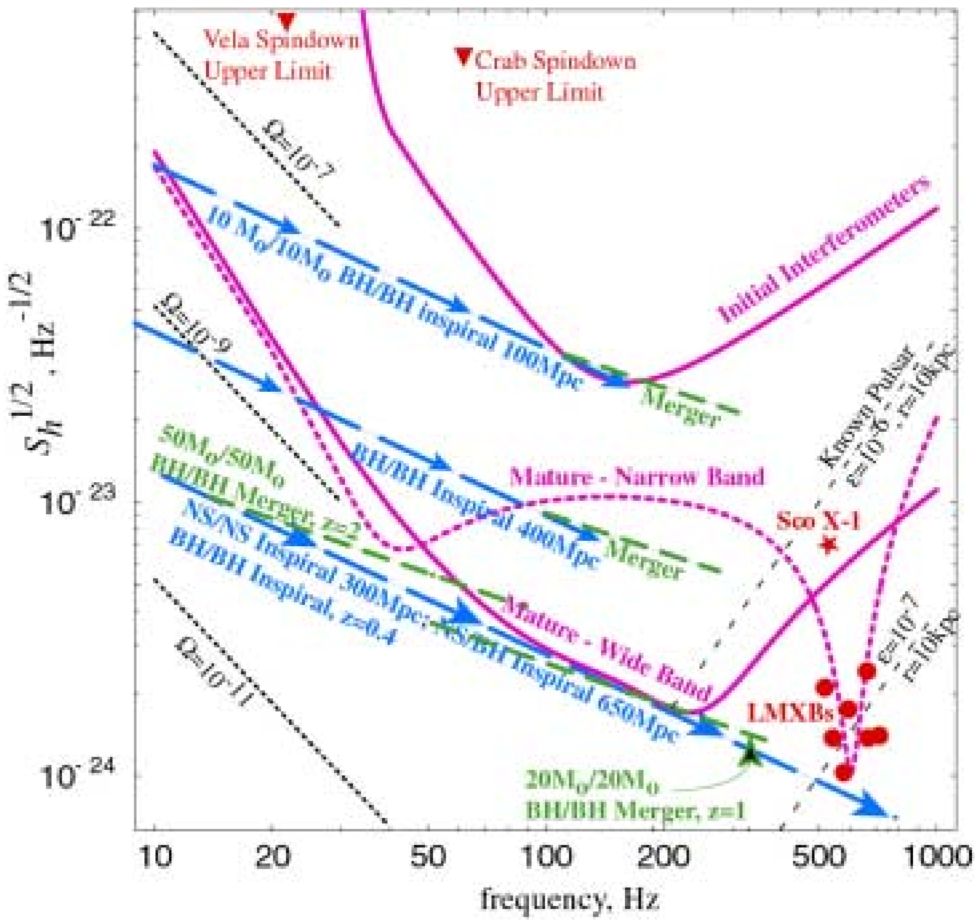
GW pulsars in binary systems

- Accretion always considered a viable mechanism to sustain GW emission (Wagoner, 1984)
- LMXB frequencies are clustered. It is quite possible that what's at work is loss of angular momentum through GWs
  - Bildsten (1998), and Ushomirsky et al. (2000)
  - Wagoner (2002)
  - LMXBs could be detected by advanced LIGO
- More in general, we aim at extending the range of application of present search codes



(from Cutler and Thorne, 2002)

GEO 600

The data analysis problem

- We need to take into account the additional Doppler effect produced by the source motion, which actually dominates Earth orbit and rotation:
  - 3 parameters for circular orbit
  - 5 parameters for eccentric orbit
  - and relativistic corrections if the system is "hard" enough
- In the short term, we concentrate on Sco X-1, therefore <u>for the time being the search is simpler because:</u>
  - We know where the source is: <u>no search over position</u>
  - We integrate only over a short period (~ 1 week) so that the signal is monochromatic: <u>no search over spin-down parameters</u>
  - We target a source that is in circular orbit and whose period is fairly well known: <u>no search over P for T < 1 month</u>
    - **The search problem for Sco X-1 in S1 data: search over 2 orbital parameters (discrete mesh) + frequency**
- The search is **intrinsically wide-band and over a parameter space**

Code development

1. **LALDemodBinary and LALComputeSkyBinary**
   – Completed and tested using Teviet's injection code
   – We loose < 1% of the SNR (not clear yet where it comes from)
   – Final testing and validation starting next week
2. **LALBinaryMesh**
   – Conceived to handle template placement for a metric not necessarily flat, and with $N_D > 2$
   – At present we use it for a 2D flat grid (clearly, we could have used Tevient's code)
      – Thoroughly tested
      – Final test/validation in progress: detection of signals with the expected loss of SNR
   – Plan for the near future: extend the testing/validation to include spin-down parameters

Generalization of frequency domain search

Data analysis strategy

Data
GEO/LIGO

Pre-processing

Divide the data set in chunks for short FFTs

For Sco X-1: $T < 300$ s

`LALComputeSkyBinary`

$t_{IFO} \longleftrightarrow t_b$

$(A_{sa}\ B_{sa}$ and $C_{sa}\ D_{sa})$

NB: uses LALBarycenter (which is unchanged)

`LALBinaryMesh`

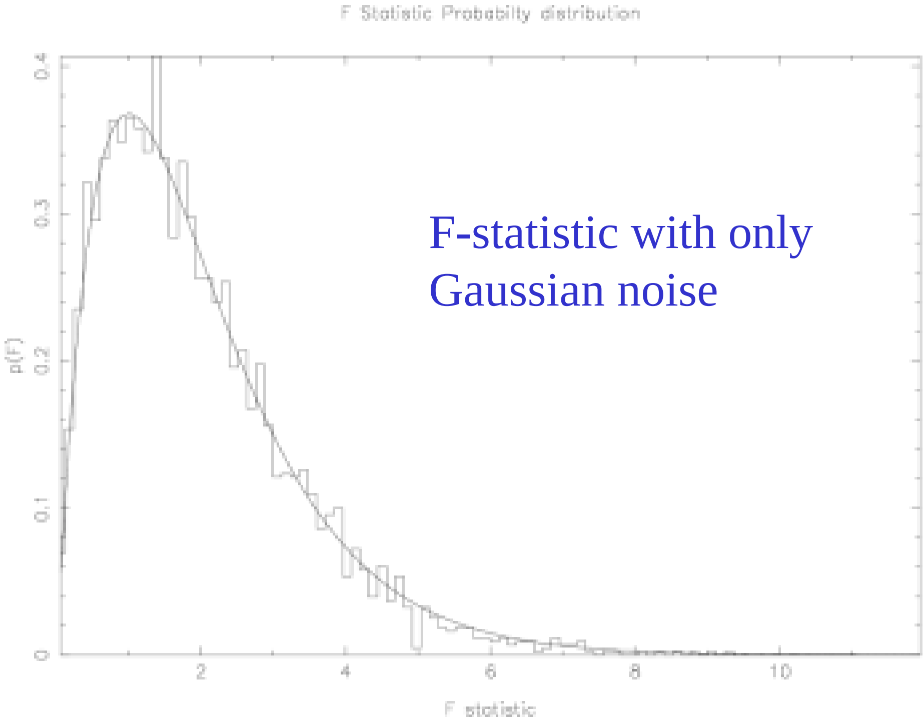
Template placing

`LALDemodBinary`

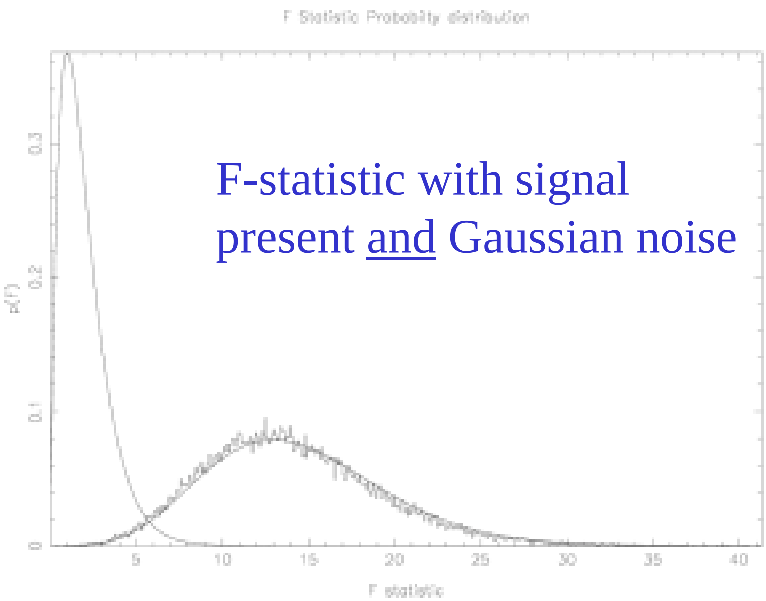
Compute F statistic

Set upper-limit

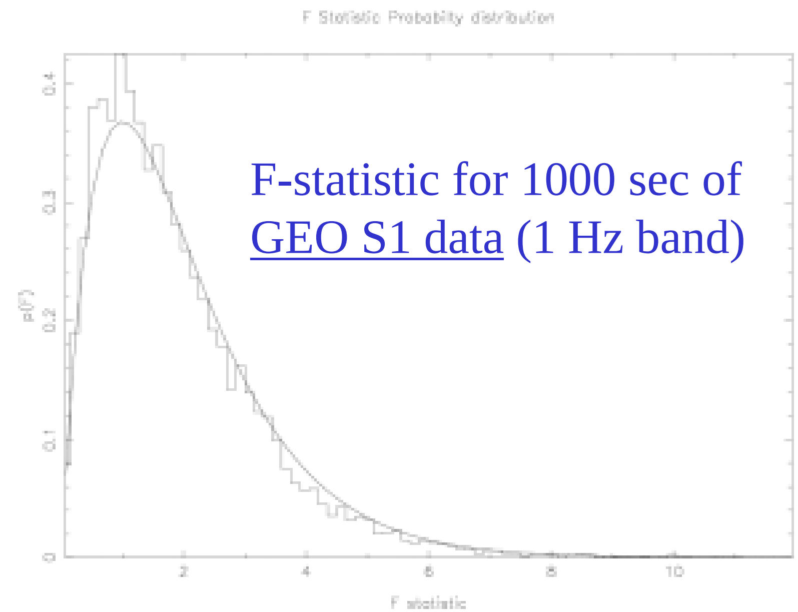
Tests on Gaussian stationary noise



Tests with/without signal

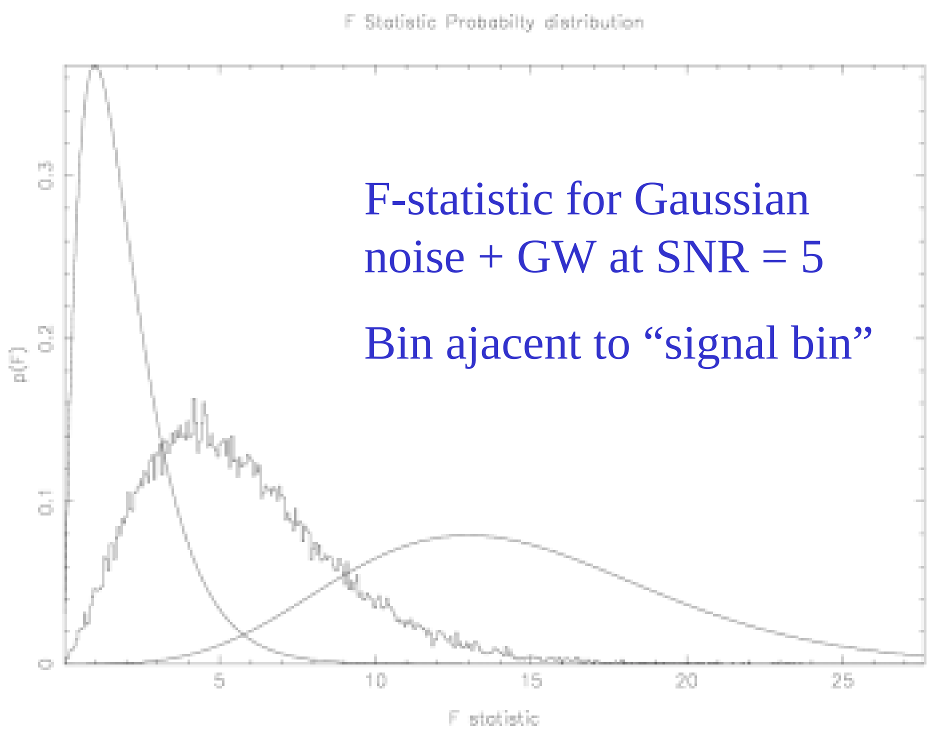


F-statistic with signal present <u>and</u> Gaussian noise



F-statistic for 1000 sec of <u>GEO S1 data</u> (1 Hz band)

Distribution in the "adjacent bin"



We don't fully understand yet this behaviour

Activity for the immediate future

- Complete testing and validation of the demodulation code and computation of F-statistic:
  - Investigate SNR loss
  - Check distribution with and without signal
    - Wide variety of orbital parameters
    - Observation time
    - Length of short FFT
- Full testing and validation of template placement code:
  - So far tested only on Sco X-1 parameters T < 1 day
  - Need to increase observation time and wider range of parameters
- Ephemeris
  - Phase of Sco X-1 on the orbit at a given epoch
- “Loop” over bandwidth

Work plan

- Main goal:
  - Code for coherent search over large bandwidth (10-100 Hz) for monochromatic signals and orbital parameters for e = 0
    - Upper-limit on Sco X-1 using S1 data
    - Ready to analyse S2 data
- Include spin-down
- Extend to other LMXBs (?)
- …