The Demodulation Code

For the 1st and 3rd stage of hierarchical searches and for targeted searches of known objects.

LIGO-G010328-00-Z

M.Alessandra Papa

for the AEI – Pulsar Search Team

GEO600 , Albert Einstein Institute,

Germany

Optimal Detection Technique

• if the noise were gaussian and our signal a sinusoid with phase Φ that was a known function of time, then the optimal statistic would be a monotonic function of

$$|y(f_0)| = \left|\sum_i x_i e^{-i\phi_i(f_0)}\right|$$

• if we assume for the signal in the rest frame of the source a simple model, i.e. a monochromatic signal with slow frequency drift, then Φ at the detector is defined by

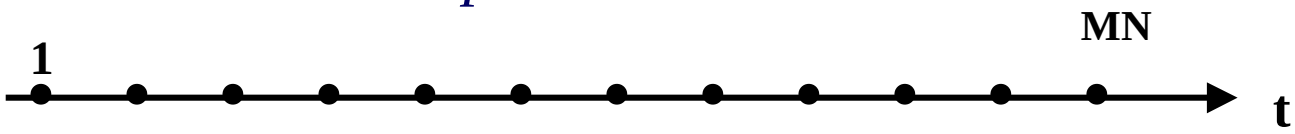
• sky position of source
• set of spin-down params
• intrinsic emission freq. at some fiducial time (f0)

• fix sky pos, set of spin-down params, intrinsic freq. search band. The demod. code computes y(f_0) for every f_0 in the intrinsic freq. search band.

Let's neglect for now the amplitude modulation. We'll consider it at the end – the scheme will not change.

Implementation

Our data: *NM samples*



TOTAL DATA SET:

Sampling rate ~ 2kHz

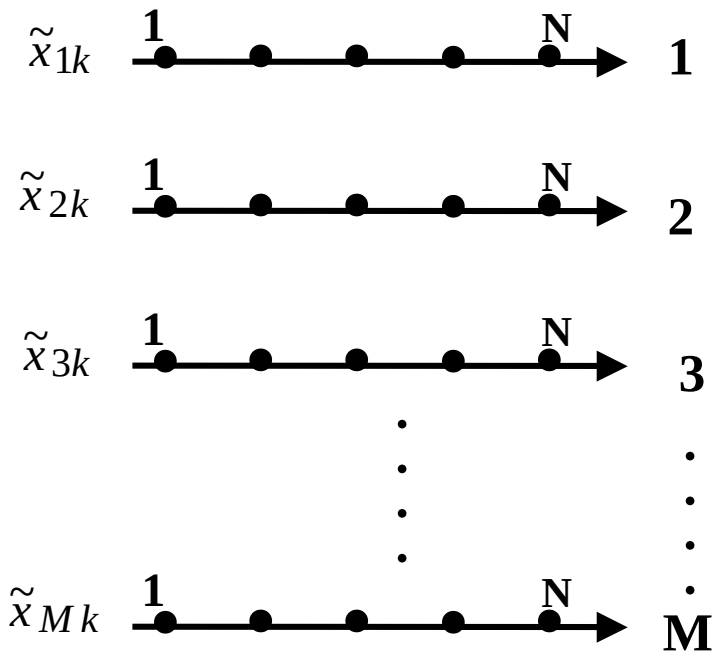
Tobs ~ 4 months

Size: ~ 80 GB

Band 0-1 kHz at 1e-7 Hz resolution.

Can also be divided in M chunks, each one having N samples. Each of these chunks can be FFT-ed, producing a set of short time-baseline FFTs (SFTS):

FFT
the chunks



this will take only a few hours on 1 GHz machine

EACH CHUNK:

Duration of a chunk ~ 1 h

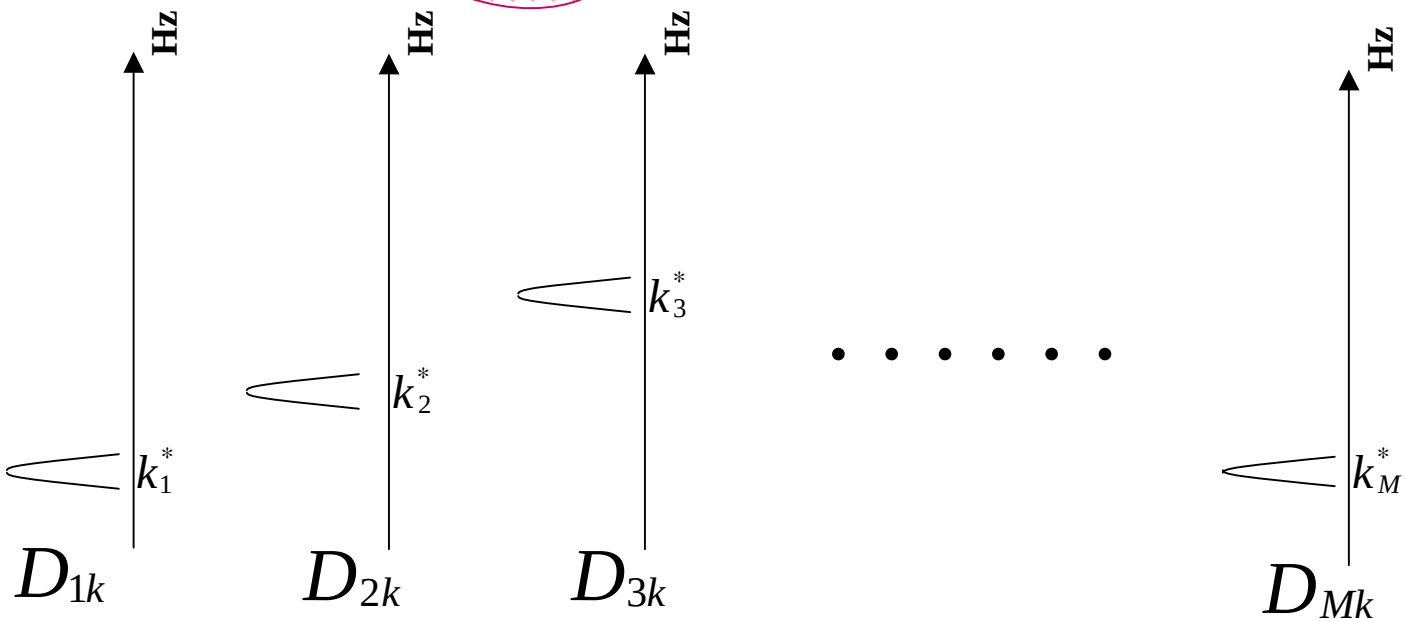
In 4 months ~ 3000 chunks

Each chunk ~28 MB

Band 0-1 kHz at 3E-4 Hz resolution.

Implementation

$$y(f_0) = \sum_{\alpha}^{M} e^{i\psi_\alpha} \sum_{k}^{N} \tilde{x}_{\alpha k} D_{\alpha k} \quad \Rightarrow \quad \sum_{\alpha}^{M} e^{i\psi_\alpha} \sum_{k^* \pm 8} \tilde{x}_{\alpha k} D_{\alpha k}$$



$D_{\alpha k}$ is the Dirichlet kernel centered at the instantaneous freq. at the mid time of every SFT (k*).

- implementation -

$$\sum_{\alpha}^{M} e^{i\psi_\alpha} \sum_{k^*\pm 8} \tilde{x}_{\alpha k} D_{\alpha k}$$

- ψ_α and $D_{\alpha k}$ depend:
  - explicitly on the template spin-down parameters
  - implicitly on the template sky-position through

    T(t) and dT(t)/dt

- T(t): time at SSB for the same wave front that impinges on the detector at detector (gps-)time t: $\Phi(T(t)) = \Phi'(t)$
- t $\longrightarrow$ T(t) for a given template source position is given by the barycentering code.

Status

- The code that performs *this* demodulation has been part of the LAL library since January.
- Steve Berukoff will give a demo of it on Thursday, in the LAL-demo session.
- Barycentering code is in the LAL CVS archive (not in the LAL library). Integration in/with the demod. code has *already* taken place and been (successfully) tested.

- If we had data available in SFT format, we could begin setting up an analysis NOW.

- The code has no LAL-wrapper. Greg Mendell is working on this for the UL cont.waves targeted search.s

Including the amplitude modulation

$$\begin{cases} y^a(f_0) = \sum_i a_i x_i e^{-i\phi_i(f_0)} \\ y^b(f_0) = \sum_i b_i x_i e^{-i\phi_i(f_0)} \end{cases}$$

a_i and b_i are the amplitude modulation functions that only depend on the template sky-position.

The optimal statistic consists in combining these two functions:

$$Y(f_0) = \frac{A\left|y^a(f_0)\right|^2 + B\left|y^b(f_0)\right|^2 + 2C\Re\left|y^a(f_0)\,y^{b*}(f_0)\right|}{D}$$

In every SFT the a_i and b_i can be considered constant. Thus we only have to multiply each SFT datum by the same number (different for each SFT) ⇒ we do not need to modify our demod. scheme

Following very much gr-qc/9804014, P. Jaranowski, A. Krolak, B.F. Schutz

a question:

Is someone (David Chin ?) working on the LAL-compliant routines for the a_i and b_i functions ?

(these are the functions that appear into the antenna beam patterns for cross and plus polarizations, they depend on the source position and on the detectors position and relative angle between the arms of the detector)