LSC software verification notes
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These notes summarise my verification of the LAL & LALapps software on my machine (Guinan) at UniMelb (i686 Linux Ubuntu).

1 VERIFICATION

I have been unable to find much information about how to test whether the code is working. For starters, the easiest thing to do is run

> lalapps_hello

which should output “hello, LSC!”.

The next step is to generate some fake data and run it through the code. The following section explains how to generate “frequency domain” data which is used in blind searches and is closely based on instructions by Karl Wette (ANU).

1.1 FREQUENCY DOMAIN FAKE DATA TESTING

The frequency domain pulsar codes take as input pre-generated files called SFTs (Short Fourier Transforms), which are Fourier transforms of 30 minutes of h(t) which is the calibrated strain of the interferometers. The command to generate fake SFTs is lalapps_Makefakedata:

> lalapps_Makefakedata --IFO L1 --fmin 50 --Band 200 --Alpha 4.3 --Delta 2.1 --h0 1 --cosi 0.8 --psi 0.3 --phi0 1.7 --Freq 150 --noiseSigma 1 --startTime 800000000 --duration 18000 --ephemYear 05-09 --ephemDir "${LAL_PREFIX}/share/lal" --outSFTbname .

The options are as follows:

- --IFO L1 means generate data from Livingston
- --fmin 50 --Band 200 means the range of frequencies is from 50 to 250 Hz
- --Alpha 4.3 --Delta 2.1 are the coordinates of the source (Alpha is right ascension, Delta is declination)
- --h0 is the wave strain amplitude. The actual value isn't important as it's relative to the noise; for real data it's something < ~10e-24
- other nuisance parameters (--cosi 0.8 --psi 0.3 --phi0 1.7,
- --Freq 150 means there is a signal at 150 Hz
- --noiseSigma 1 with Gaussian noise
- --startTime 800000000 is the starting time in GPS seconds (all LIGO times are in GPS seconds). Conversions can be done with lalapps_tconvert, e.g. lalapps_tconvert 800000000 = Fri May 13 06:13:07 GMT 2005)
• duration 18000 means the data lasts 5 minutes, which should generate 10 files
• ephemYear 05-09 means we want to calculate the correct phase of the templates using ephemeris data from 2005-2009
• ephemDir "${LAL_PREFIX}/share/lal" is where the ephemeris data files are
• outSFTbname means we output the files to the current directory.

Rerunning the command with --IFO H1 instead will give another set of data from the 4k at Hanford. These should be the final generated files.

H-1_H1_1800SFT_mfdv4-800000000-1800.sft  H-1_H1_1800SFT_mfdv4-800009000-1800.sft  L-1_L1_1800SFT_mfdv4-800001800-1800.sft  L-1_L1_1800SFT_mfdv4-800010800-1800.sft
H-1_H1_1800SFT_mfdv4-80001800-1800.sft  H-1_H1_1800SFT_mfdv4-800012600-1800.sft  L-1_L1_1800SFT_mfdv4-800014400-1800.sft  L-1_L1_1800SFT_mfdv4-800016200-1800.sft
H-1_H1_1800SFT_mfdv4-800003600-1800.sft  H-1_H1_1800SFT_mfdv4-800012600-1800.sft  L-1_L1_1800SFT_mfdv4-800014400-1800.sft  L-1_L1_1800SFT_mfdv4-800016200-1800.sft
H-1_H1_1800SFT_mfdv4-800005400-1800.sft  H-1_H1_1800SFT_mfdv4-800014400-1800.sft  L-1_L1_1800SFT_mfdv4-800016200-1800.sft  L-1_L1_1800SFT_mfdv4-800016200-1800.sft

Then use the isolated pulsar code to do a coherent matched filter search for this template:

> ComputeFStatistic_v2 --Alpha 4.3 --Delta 2.1 --Freq 149.9 --FreqBand 0.2 --DataFiles "*.sft" --ephemDir "${LAL_PREFIX}/share/lal" --ephemYear 05-09 --gridType 2 --metricType 1 --metricMismatch 0.02 --outputFstat Fstats

This searches for the pulsar template at the same sky position (--Alpha 4.3 --Delta 2.1) over a frequency band of 0.1 Hz either side of the template (--Freq 149.9 --FreqBand 0.2) using SFTs from the current directory (--DataFiles "*.sft", the quotes are important to prevent Unix shells expanding the *), the same ephemeris stuff, using a parameter space metric (--gridType 2) based on the analytic Ptolemaic approximation (--metricType 1) to lay out the parameter space, generating a new template wherever the detection statistic drops away by more than 2% (--metricMismatch 0.02) and outputting the results (--outputFstat Fstats).

This should take a few seconds to run, and generate a file called Fstats which should look like this:

%% $Id: ComputeFStatistic_v2.c,v 1.244 2007/06/10 18:16:21 reinhard Exp $
%% --Alpha=4.3 --Delta=2.1 --Freq=149.9 --FreqBand=0.2 --DataFiles="*.sft" --ephemDir="/home/654/kww654/lscsoft/share/lal" --ephemYear="05-09" --gridType=2 --metricType=1 --metricMismatch=0.02
%% Started search: Tue Aug 21 02:01:46 2007
%% Loaded SFTs: [ H1:10, L1:10 ]
%% Start GPS time tStart = 800000000.000  (Fri May 13 06:13:07 2005 GMT)
%% Total time spanned = 18000.000 s (5.0 hours)
%% Pulsar-params refTime = 800000000.000
%% InternalRefTime = 800000000.000
%% Spin-range at internalRefTime: fkdots = [ 149.9:150.1, 0:0, 0:0, 0:0 ]
149.90074504361 1.158407346410207 1.041592653589793 0 0 0 10.364668
149.9007537069078 1.158407346410207 1.041592653589793 0 0 0 11.1511627
149.9007623702056 1.158407346410207 1.041592653589793 0 0 0 11.9224972
149.9007710335034 1.158407346410207 1.041592653589793 0 0 0 12.2896511
149.9007796968012 1.158407346410207 1.041592653589793 0 0 0 11.8134118
...
...

The last column is the F statistic, which is something proportional to the signal to noise - you should see it grow to ~50000 at 150 Hz (this is very unrealistic due to the low noise level).

Later on we will most likely be interested in “time domain” searches (targeted searches) which are run from source code in .../lal_src/lalapps/src/pulsar/TDS_isolated. There is a README file there that looks quite comprehensive.

1.2 Visualising the output

First, try playing with this frequency domain data (the .sft files). To “view” the data, use dumpSFT. Options are -h (help), -H (display header info), -n (display data without header info). Need to run

> dumpSFT [options] -i filename

The data is output in 3 columns: frequency, real component & imaginary component of the FT. Wrote an IDL script to plot these – this is what the first file looks like:
This is what the Fstats file looks like. At 150 Hz, it peaks at ~50000, this is zoomed in.