Line characterization

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K. Ueno (Osaka Univ.)

Basic Algorithm

1) FFT the given time series x(n) and find the frequency which gives the largest amplitude.

2) You somehow minimize the following cost function about A,f, and ϕ,

$$F(A, f, \varphi) = \frac{1}{N} \sum_{n=0}^{N-1} \left\{ x(n) - A\cos\left(2\pi \frac{f}{f_s} n + \varphi \right) \right\}^2$$

starting from A and f estimated at 1). This is just a least square fit with a sinusoidal function.

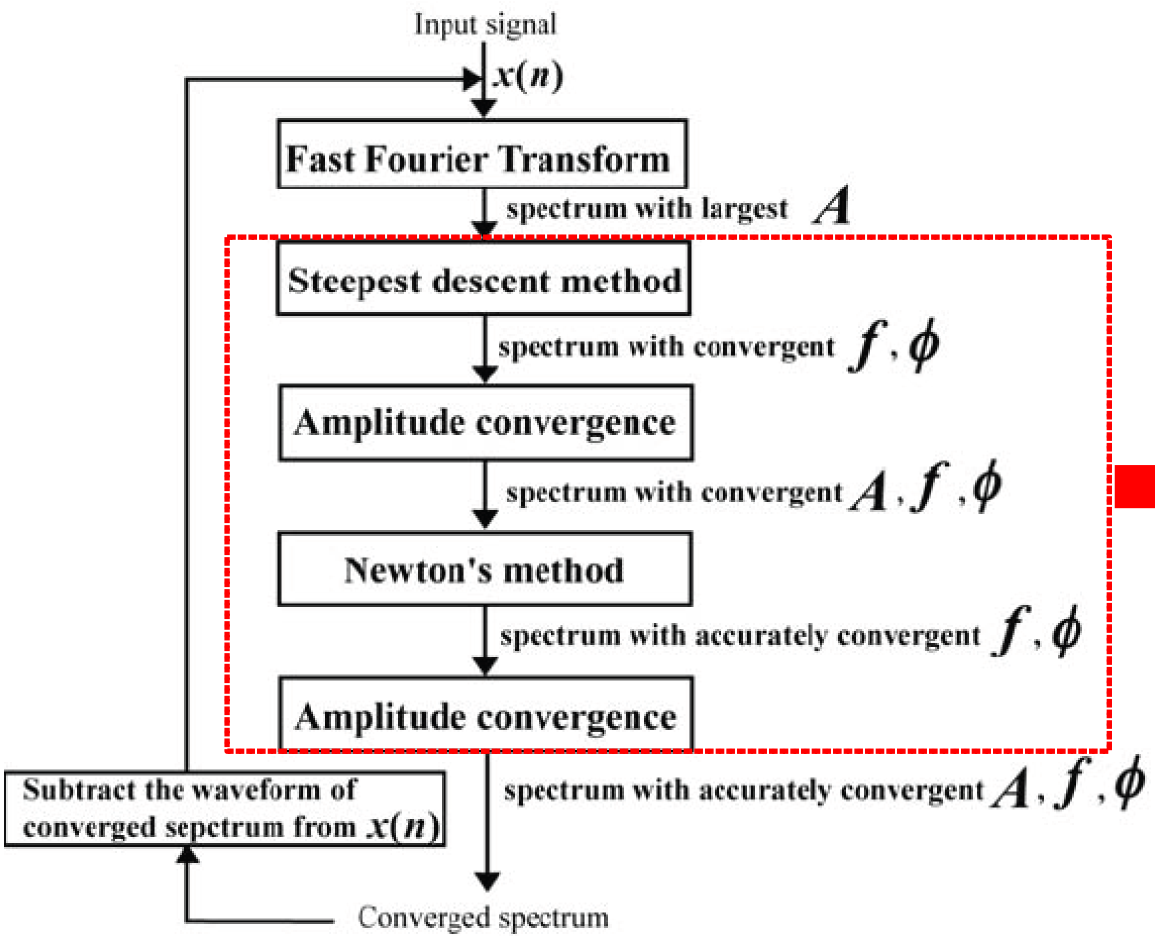
3) Once the best-fit values of A,f, and ϕ are found, the waveform of converged spectrum is subtracted from x(n).

4) Repeat the procedure 1 〜 3 as many times as one would like.

Difference from NHA's paper

NHA paper

Iterative Least Square (ILS)



At one time with
3D Newton's method

Computational cost

$$T_{data} \cong T_{frame} \times \frac{N_{data}}{N_{shift}}$$

$$T_{frame} \cong 0.35\,\mathrm{sec} \times \frac{N_{frame}}{128} \times \frac{N_{spec}}{10} \times \frac{N_{iter}}{1000}$$

（新学術マシン）

T_{data} : time to process given data
T_{frame} : time to process one frame
N_{data} : data length
N_{frame} : frame length
N_{shift} : shift length (frame interval)
N_{spec} : the number of spectra to be extracted
N_{iter} : the number of iteration to identify each signal

Computational cost (cont'd)

$$T_{data} \cong T_{frame} \times \frac{N_{data}}{N_{shift}}$$

$$T_{frame} \cong 0.35\,\mathrm{sec} \times \frac{N_{frame}}{128} \times \frac{N_{spec}}{10} \times \frac{N_{iter}}{1000}$$

（新学術マシン）

Example

For 128 s data @ fs=2048 Hz, N_{data} = 2048 x 128 = 262144

So if you set N_{shift} = 1, then T_{data} = 25.5 hrs

~ 1 hour for 32CPU

However,...

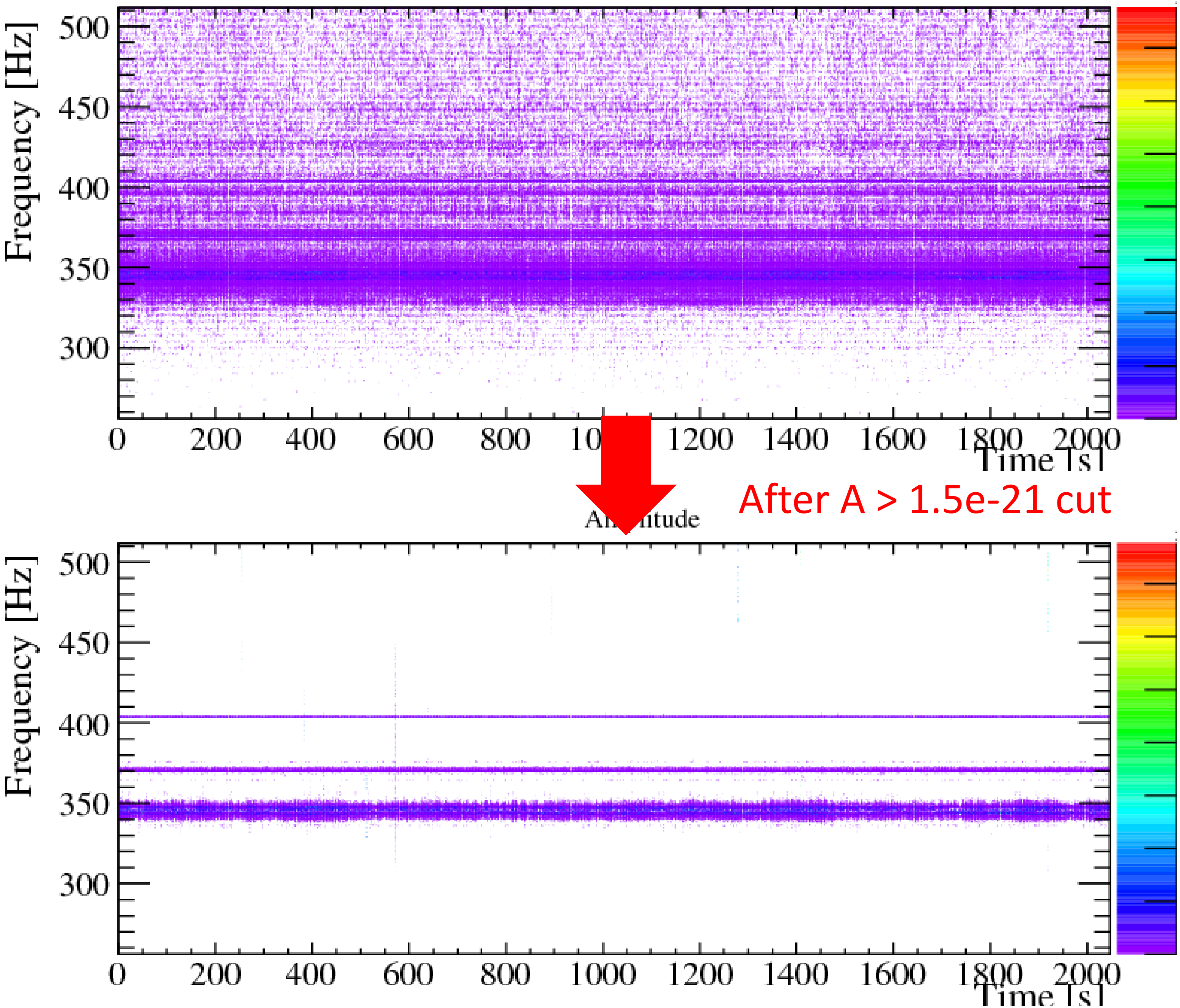
- When you focus only on some lines, e.g., those around 400 Hz, you can
  - f_s= 2048 Hz → 1024 Hz
  - N_{shift} = 1 → (N_{frame}/8 =) 16 or (N_{frame}/4 =) 32

- Then, the cost becomes smaller at least by 1/32, i.e., T_{data} ~ 2min for 32CPU
  - So even realtime analysis might be possible!

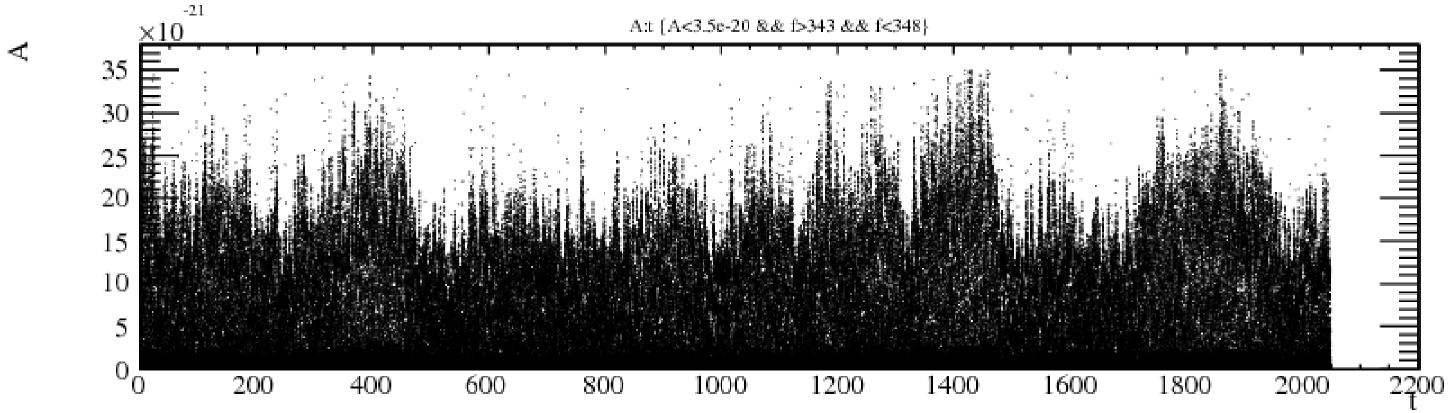
    (though it is necessary to apply a bandpass filter beforehand)

Backups

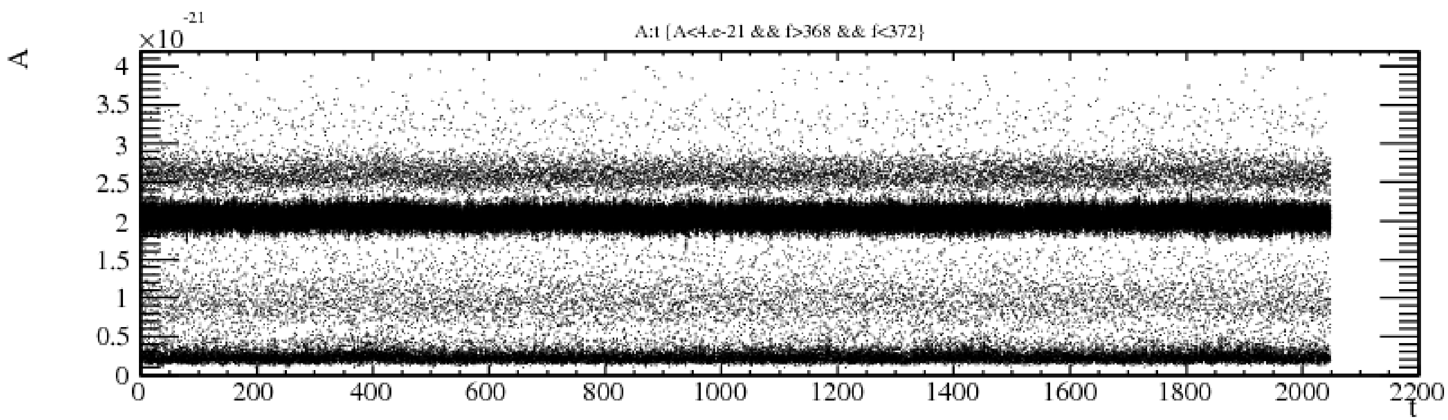
fs=1024Hz; frame=256; shift=16; #spectrum=20



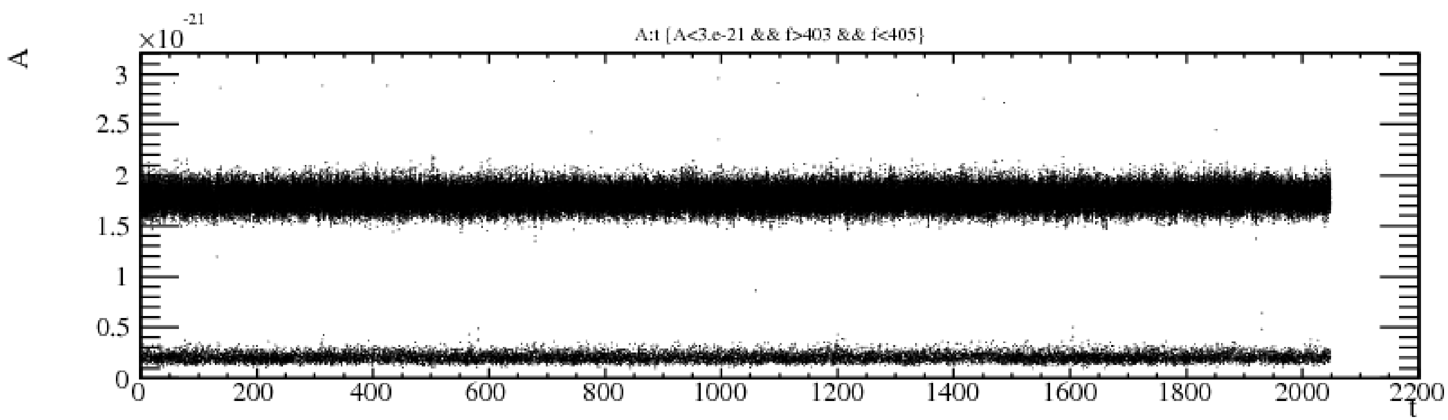
Time variation of amplitudes



~ 345 Hz

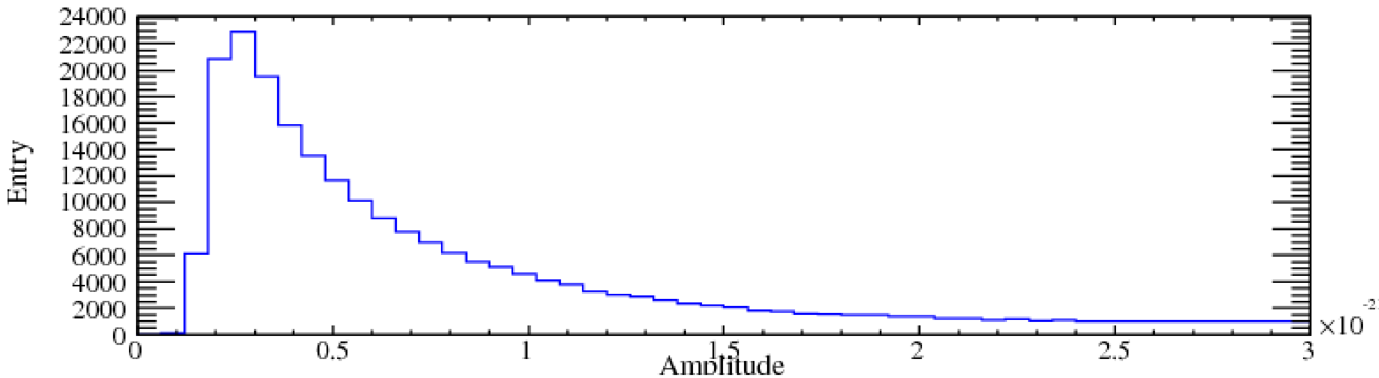


~370 Hz

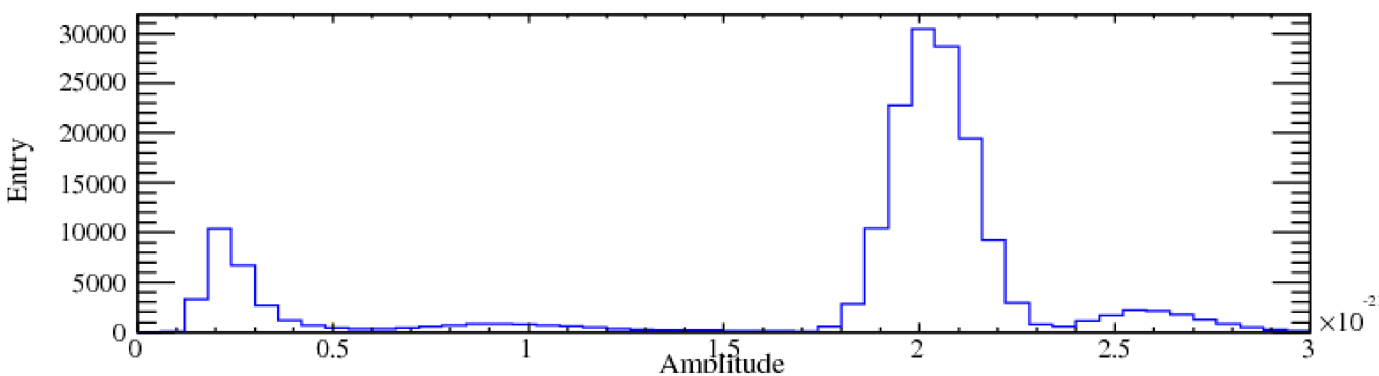


~403 Hz

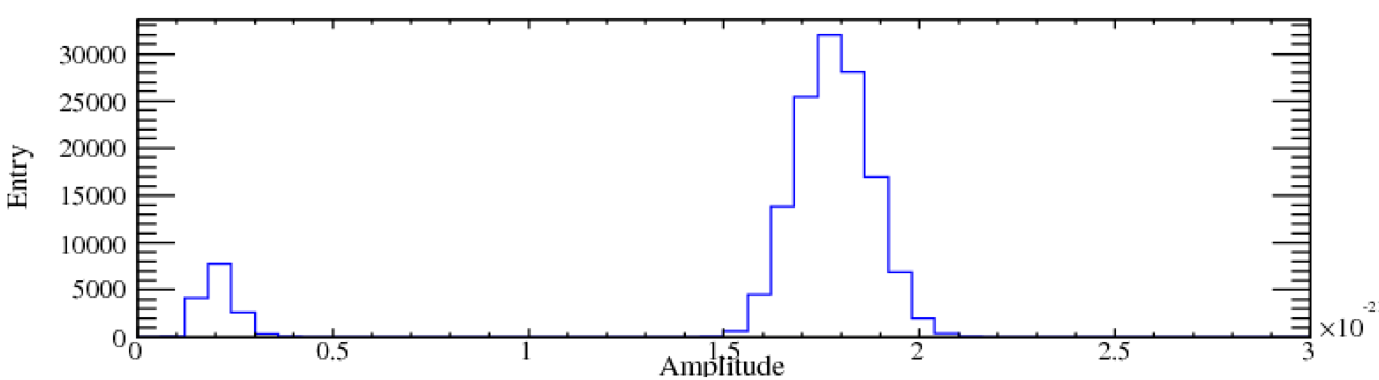
Amplitude distribution



~ 345 Hz

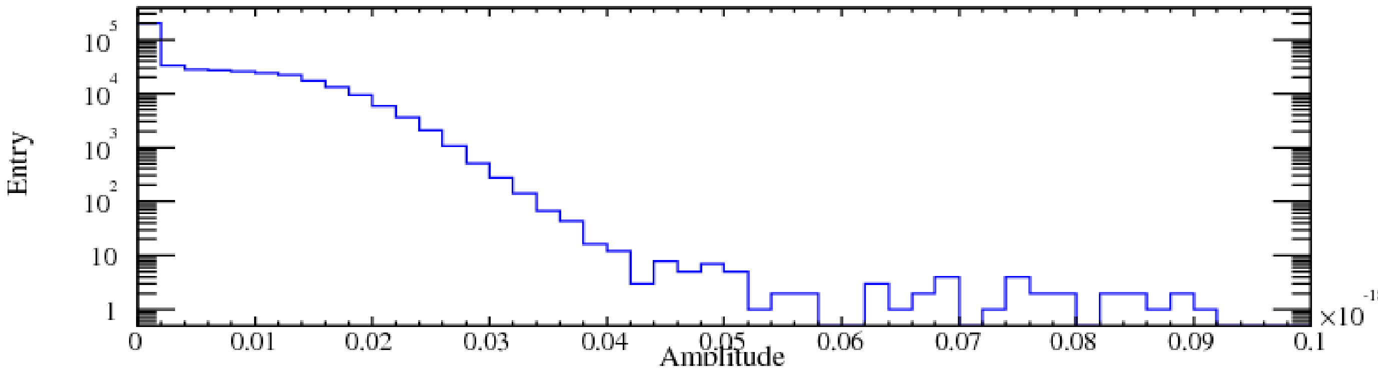


~370 Hz

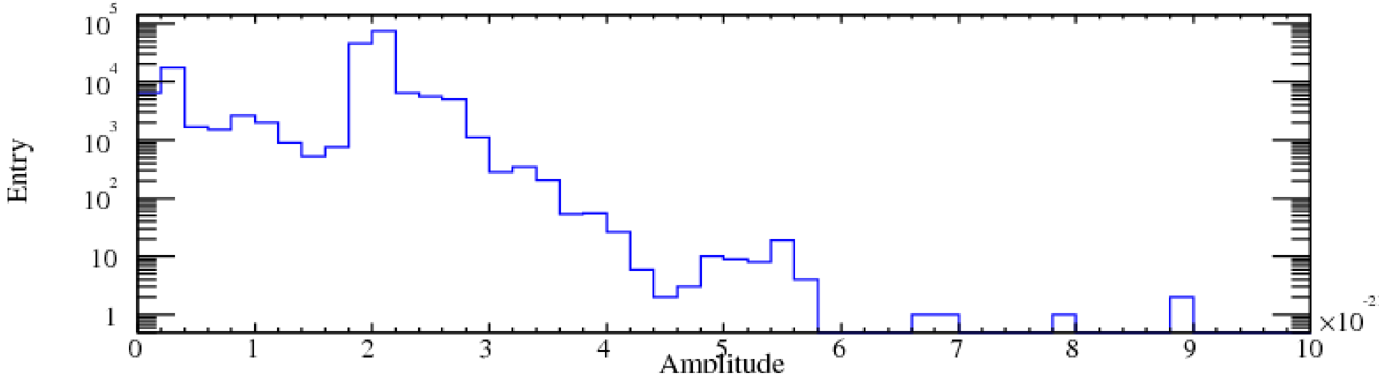


~403 Hz

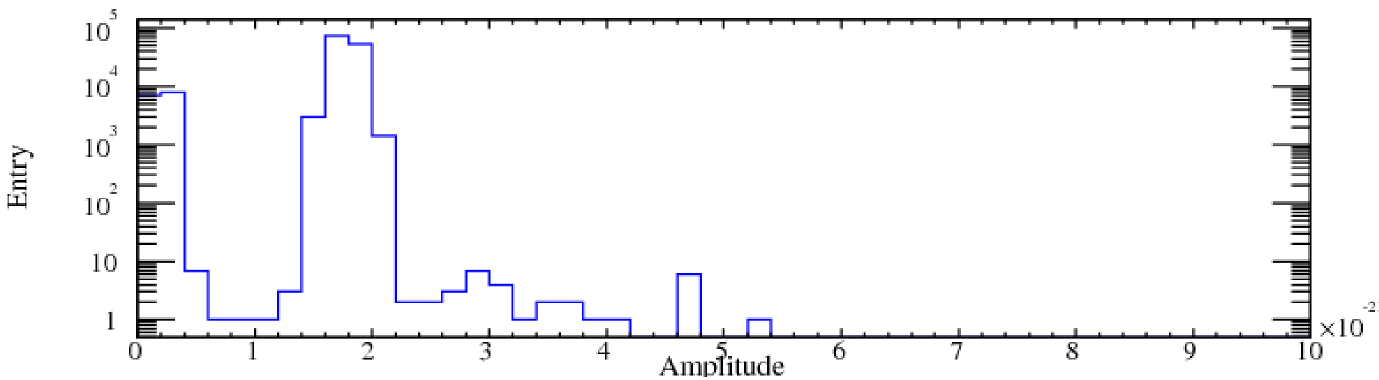
Amplitude distribution (logy)



~ 345 Hz



~370 Hz



~403 Hz