EE123
Digital Signal Processing

Lecture 11
Time-Freq
and Lab I + II

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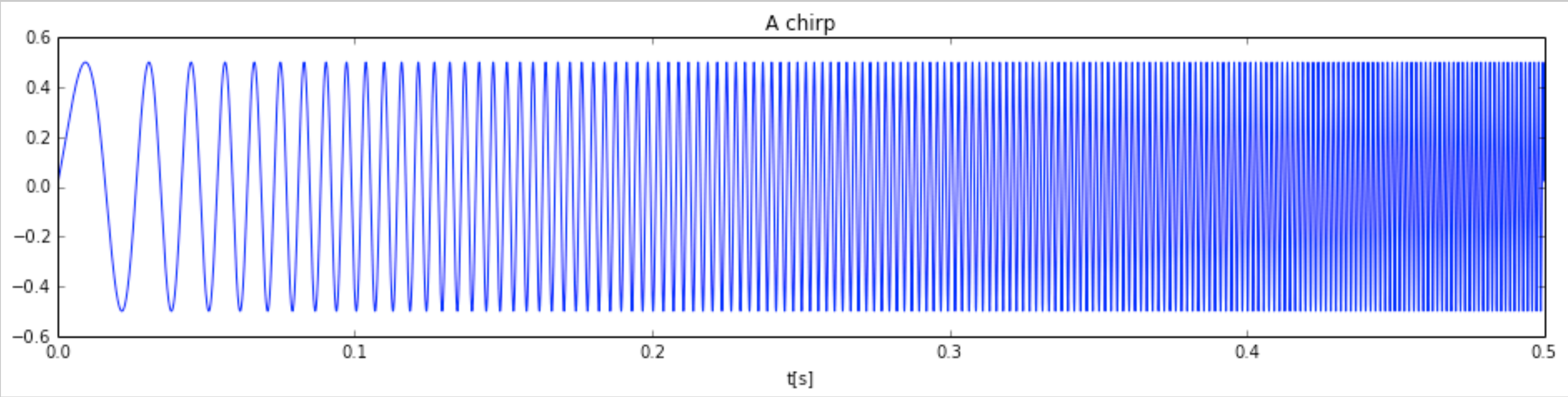
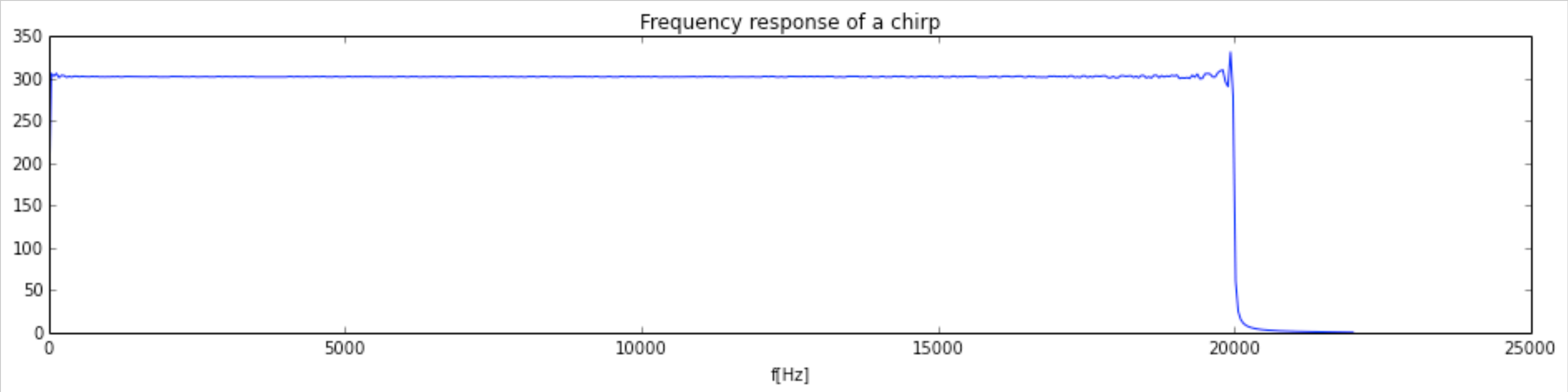
Announcements

- Lab I
  - Deadline extended to Sunday night
- Lab 2
  - Out Friday, due next Friday (SDR)
- Midterm
  - Friday 3-5pm. Be on time, open everything
  - Conflicts make sure send an email to ALL of us

Lab1

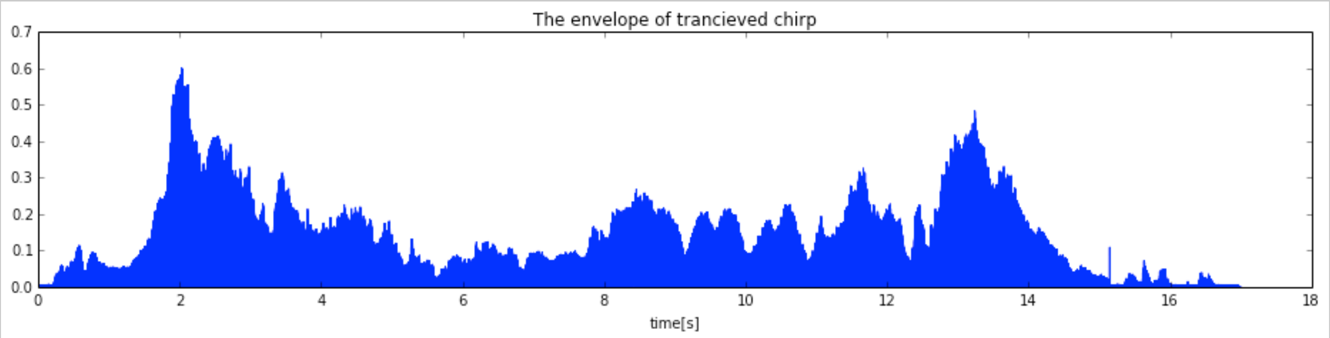
- Generate a chirp

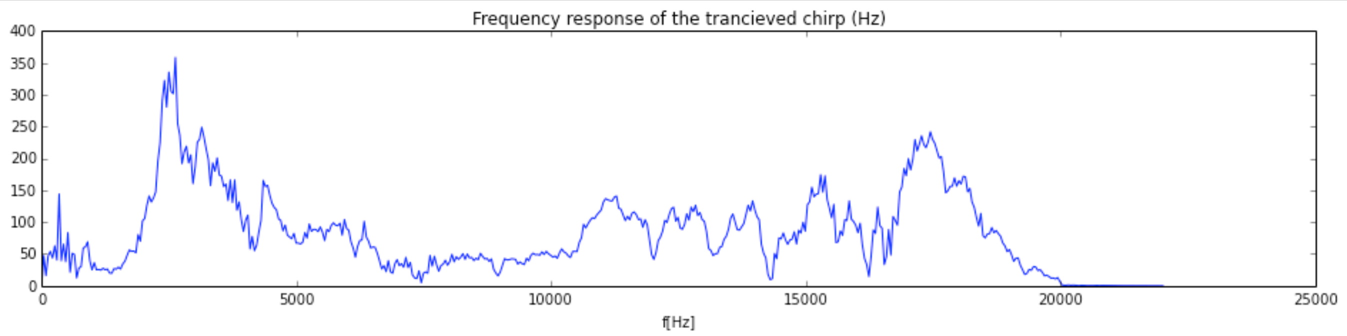


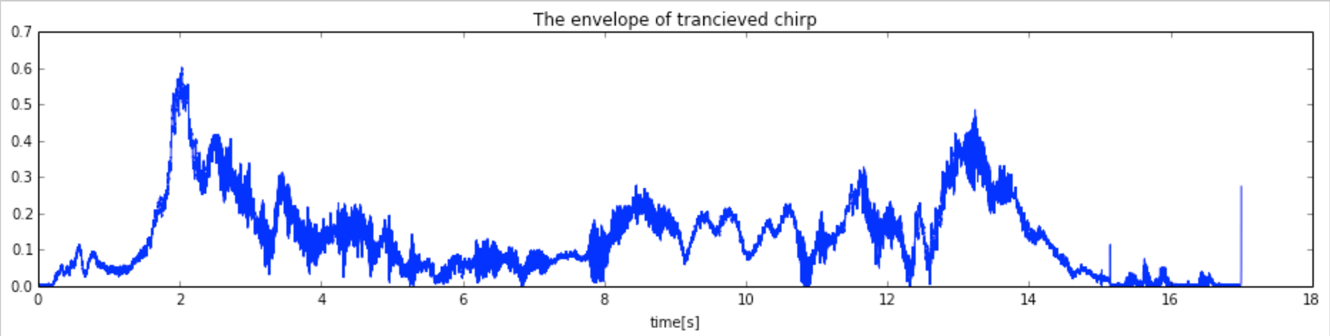


Lab1

- Play and record chirp

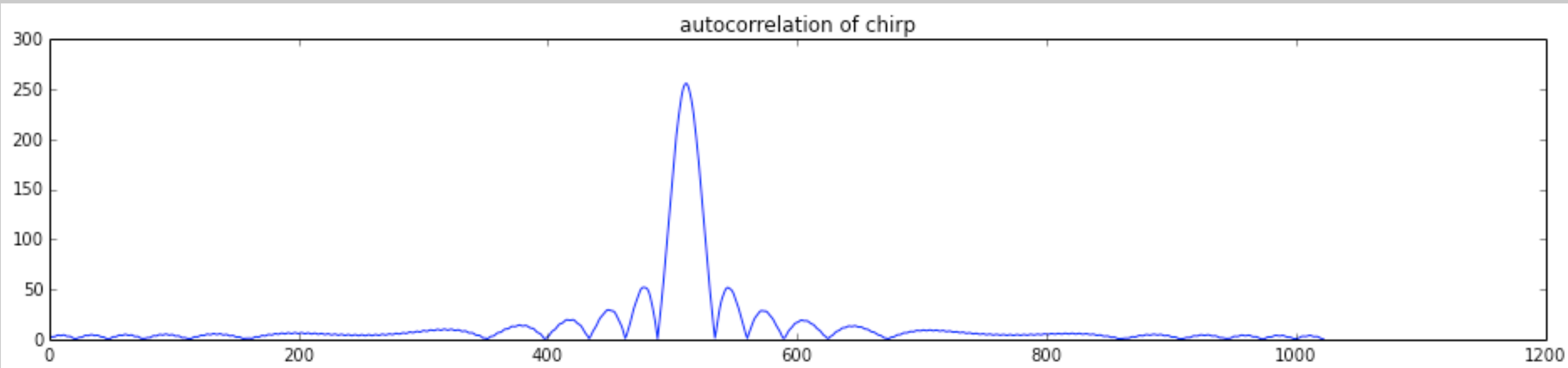


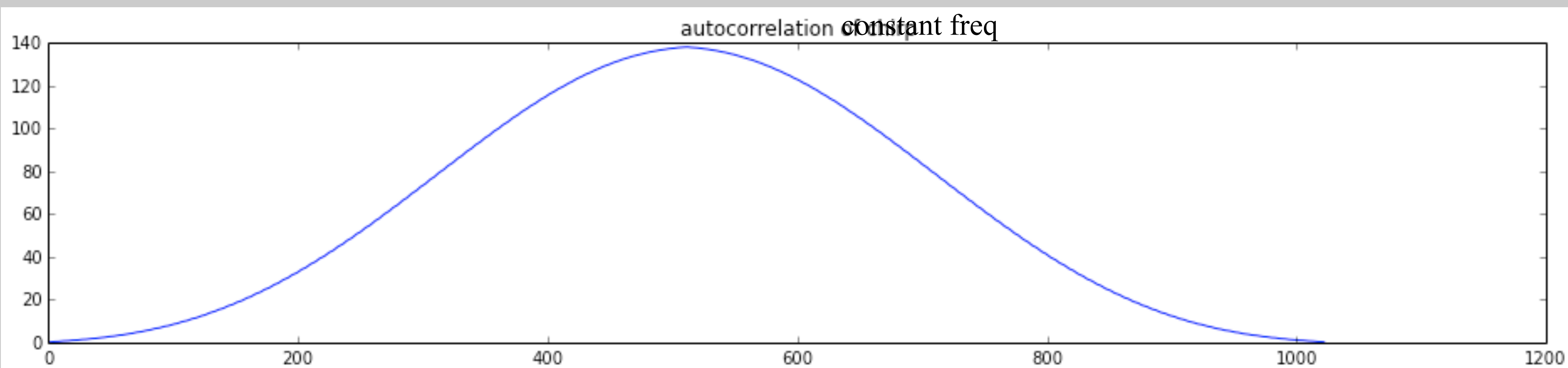




Lab 1

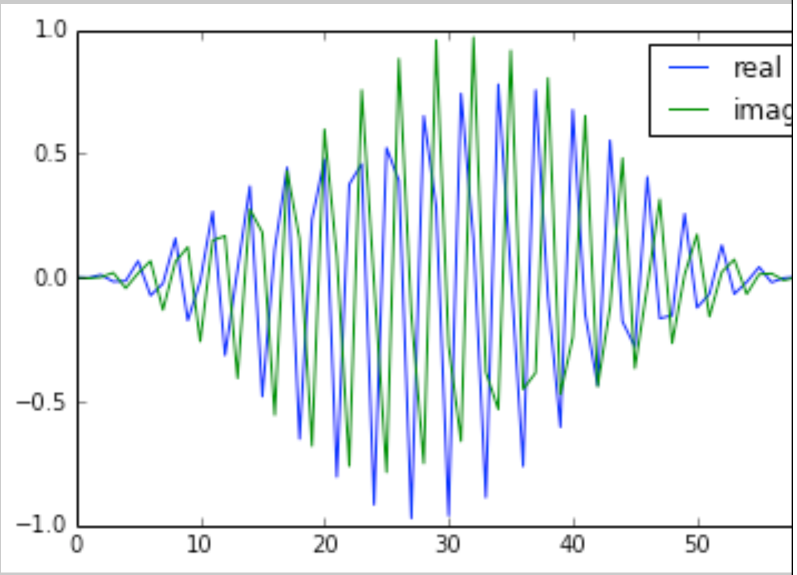
- Auto-correlation of a chirp - pulse compression



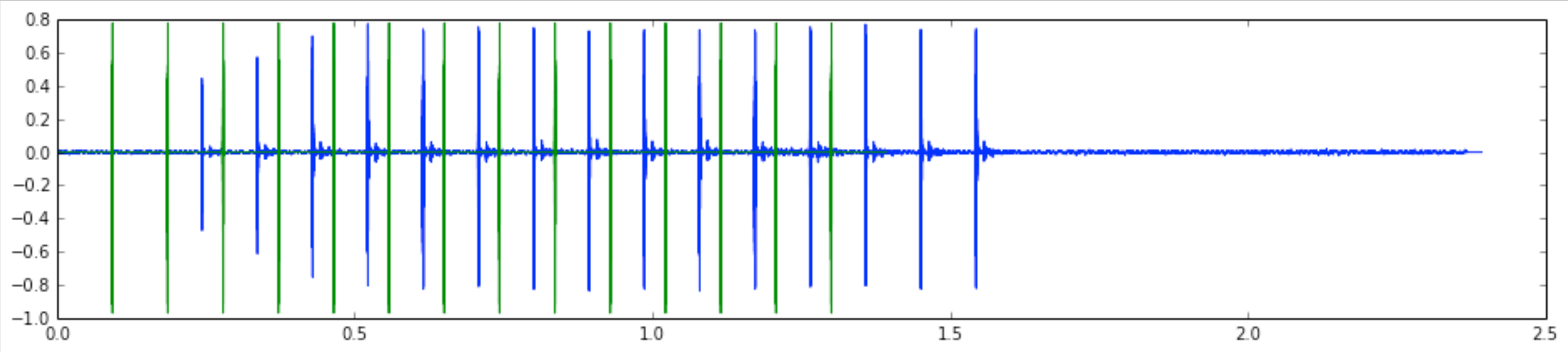


Lab I part II - Sonar

- Generate a pulse - analytic
- Use real part for pulse train
- Transmit and record

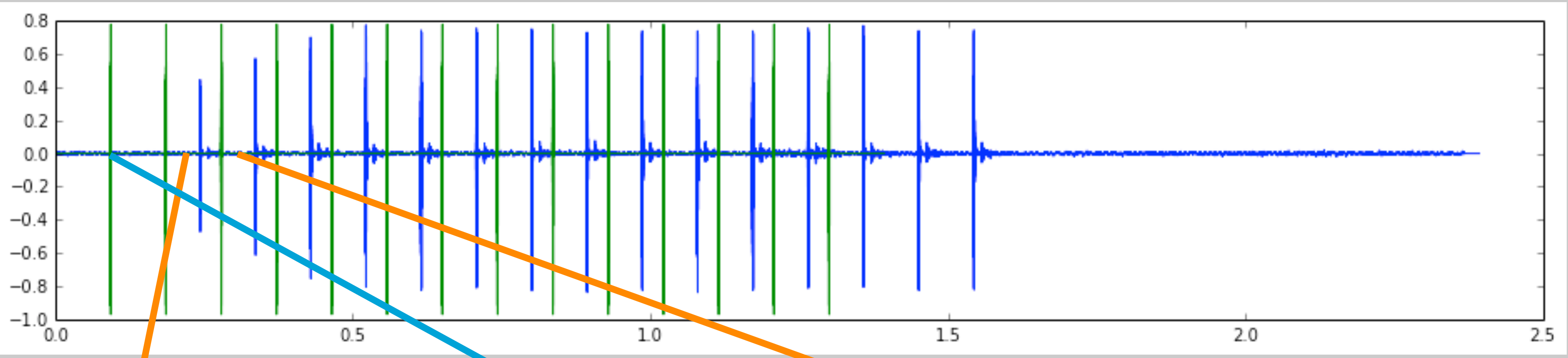


Sent and recorded:

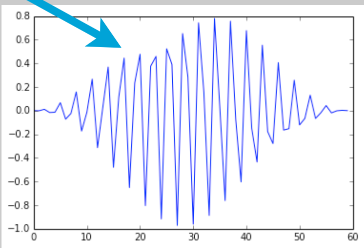


Lab I part II - Sonar

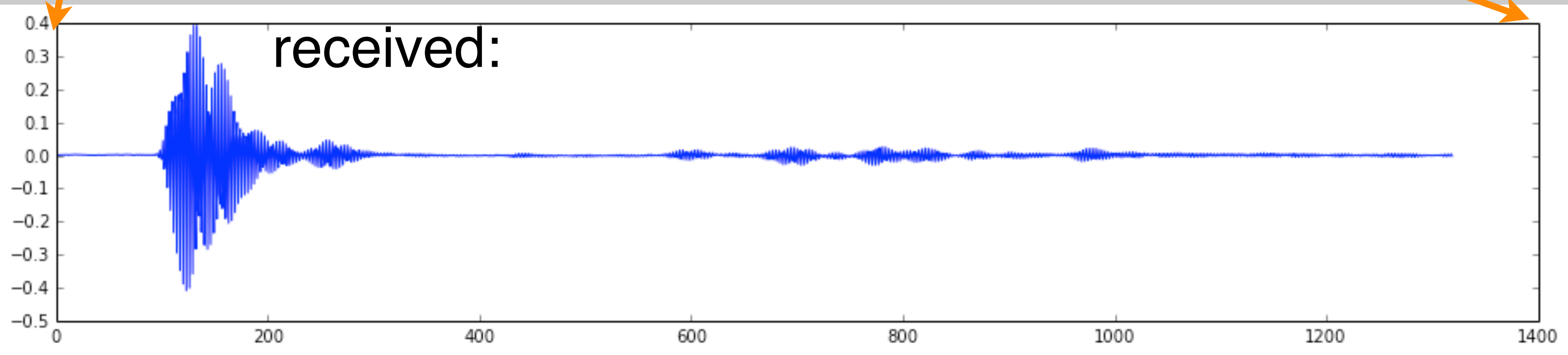
- Extract a pulse



sent:

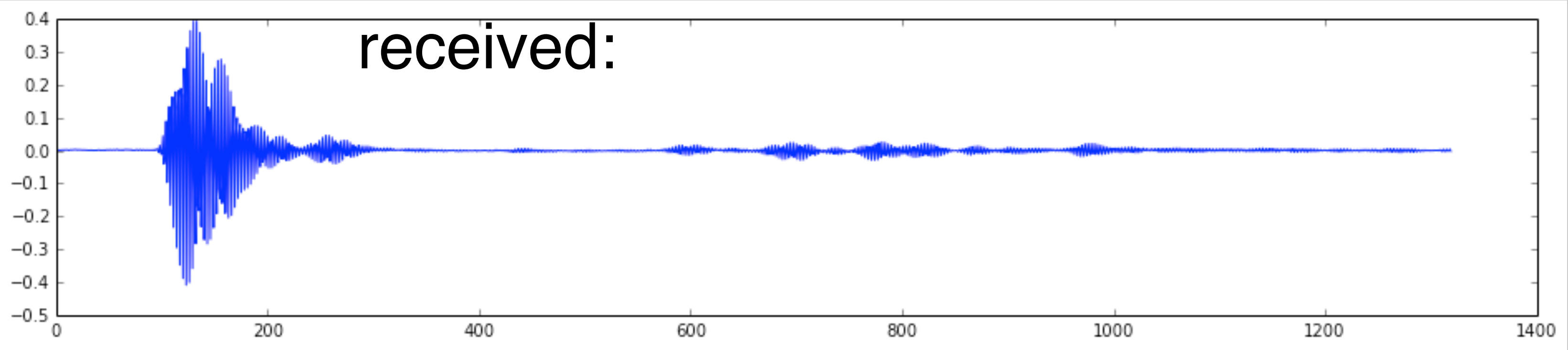


received:

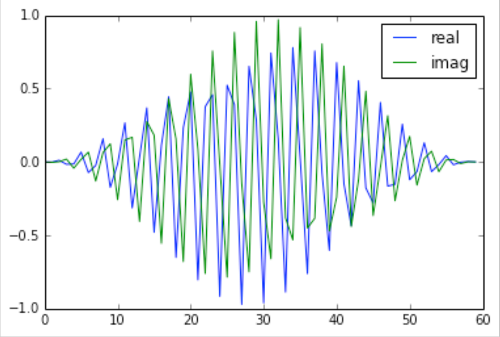


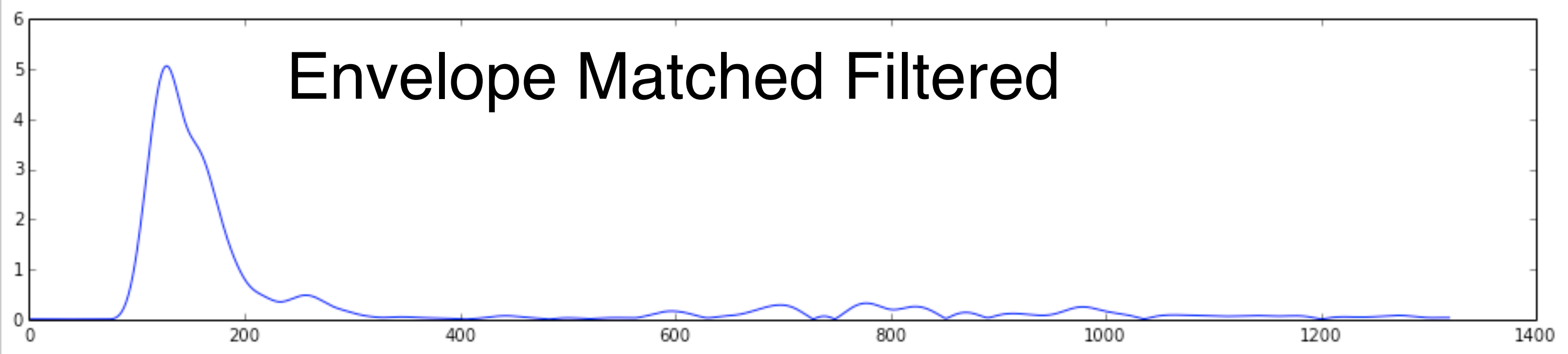
Lab I part II - Sonar

- Matched Filtering



Filter:

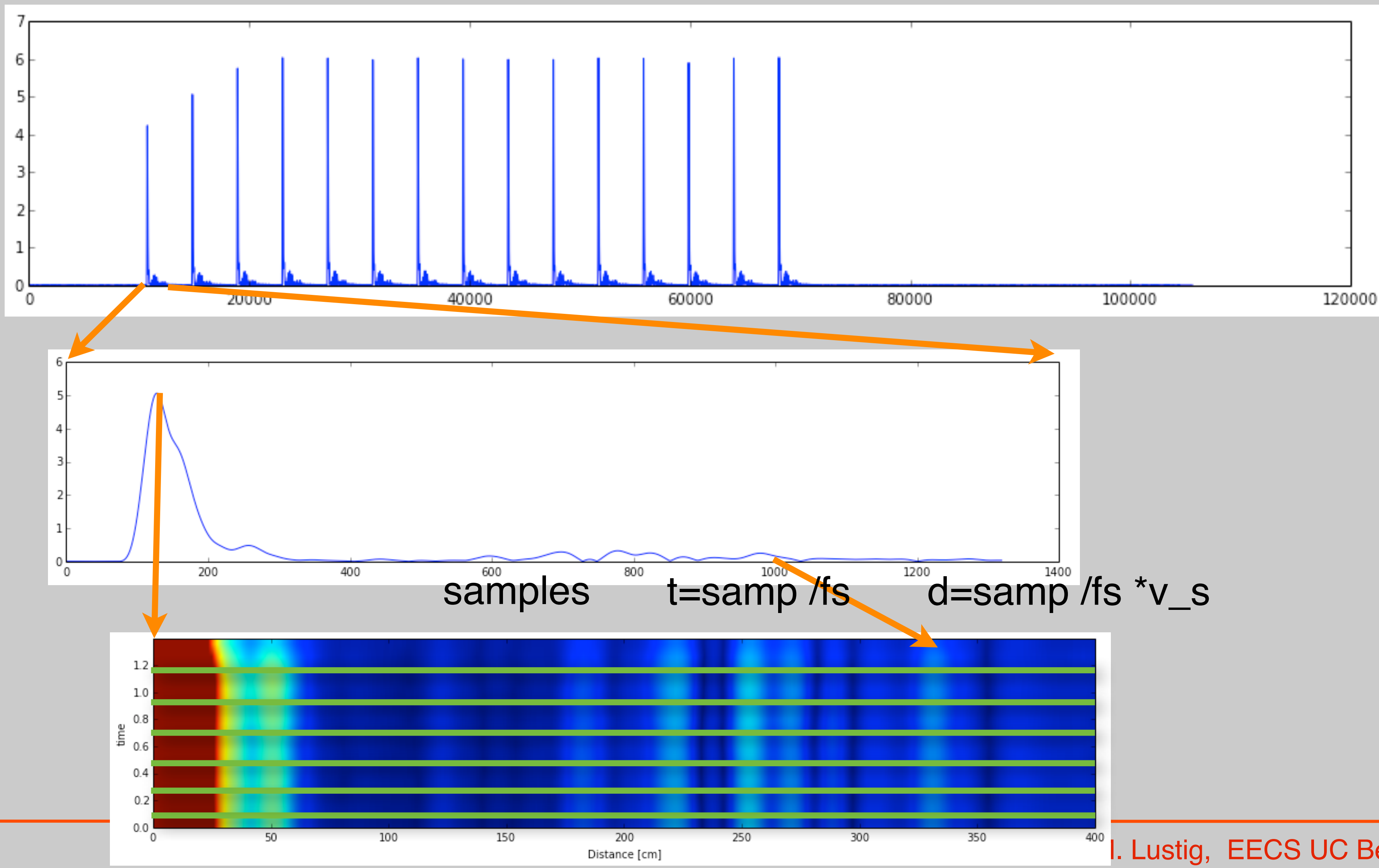




Lab I part II - Sonar

- Display echos vs distance

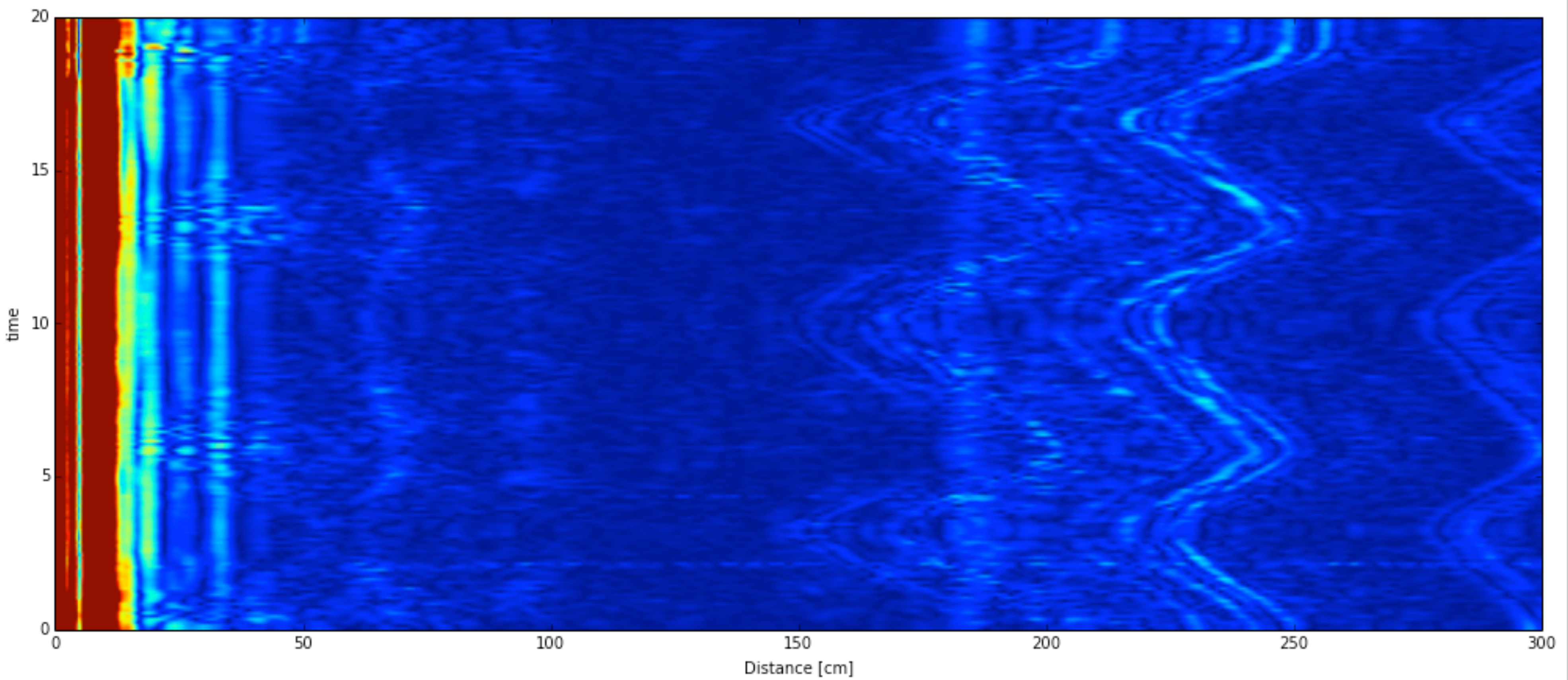
Matched Filter:



Lab I part II - Sonar

- def sonar(Npulse, f0, f1, fs, Nseg, Nrep, T=20,maxDist=400,vmax=0.2):

- Play with different parameters: f0-f1 10,000 - 19000 Npulse = 300
  – change range of frequencies, change pulse length



SDR Stuff

- Samples you measure from the SDR are COMPLEX!   WHY?
- Aren't physical signals real??????

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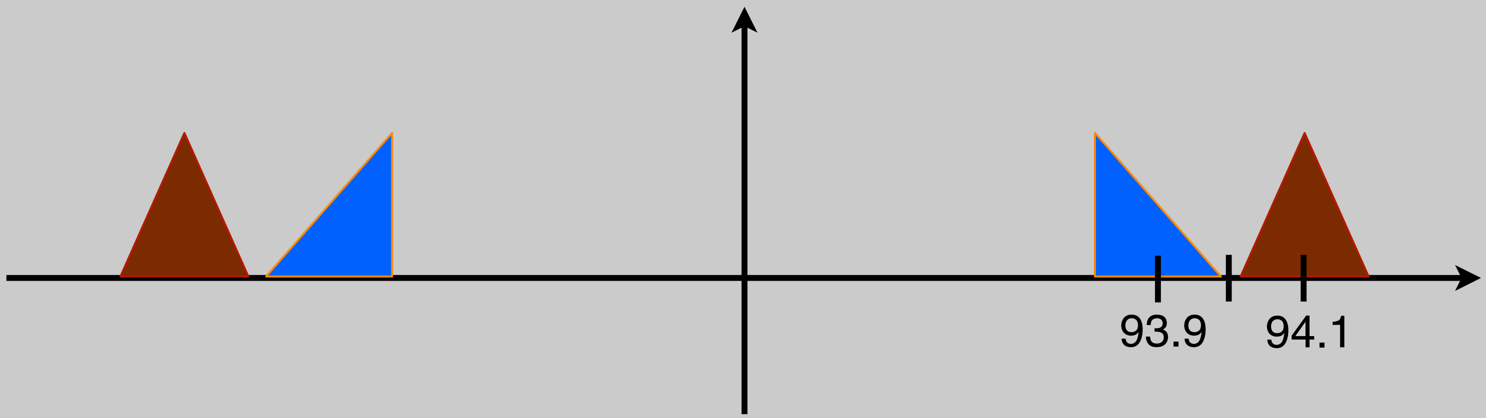
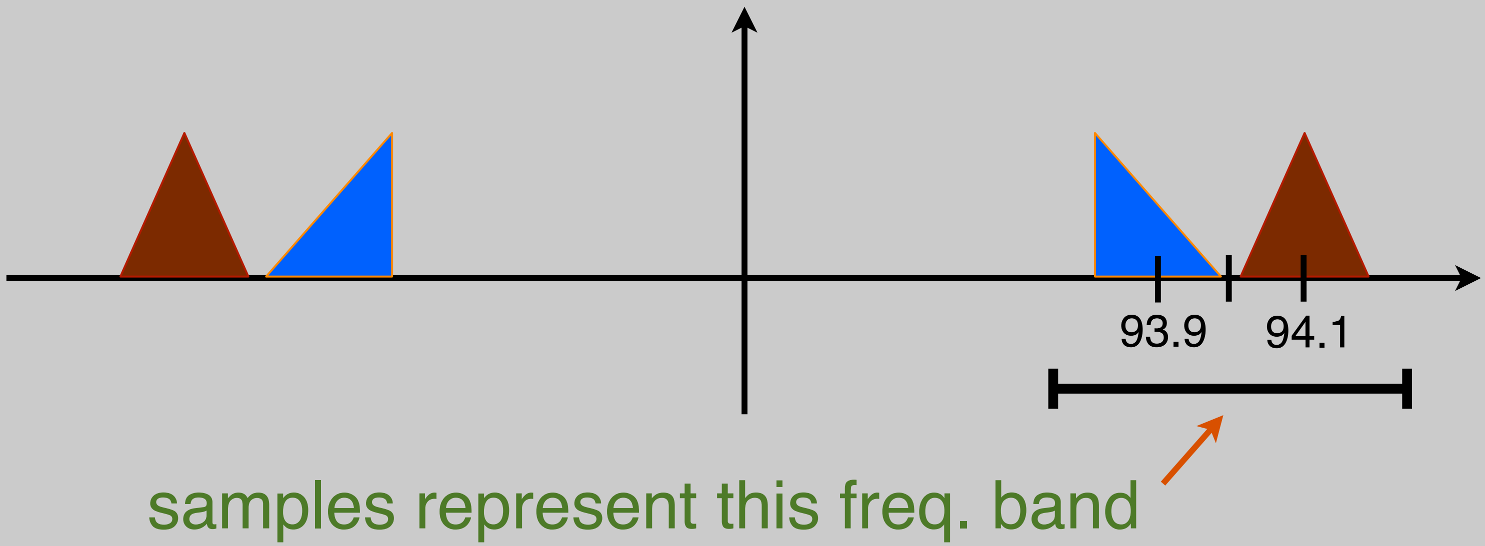
- Aren’t physical signals real??????



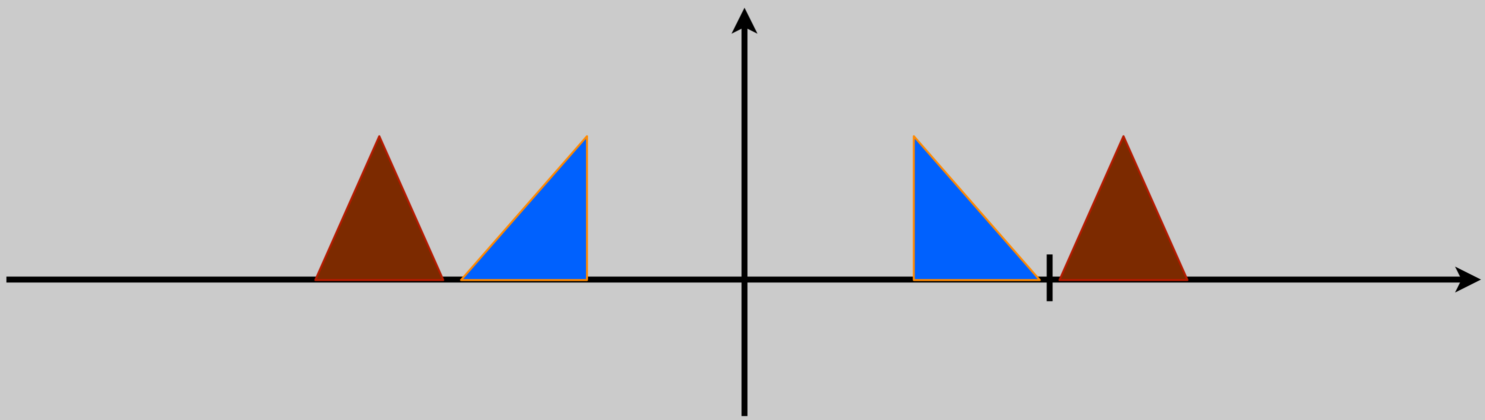
SDR Stuff

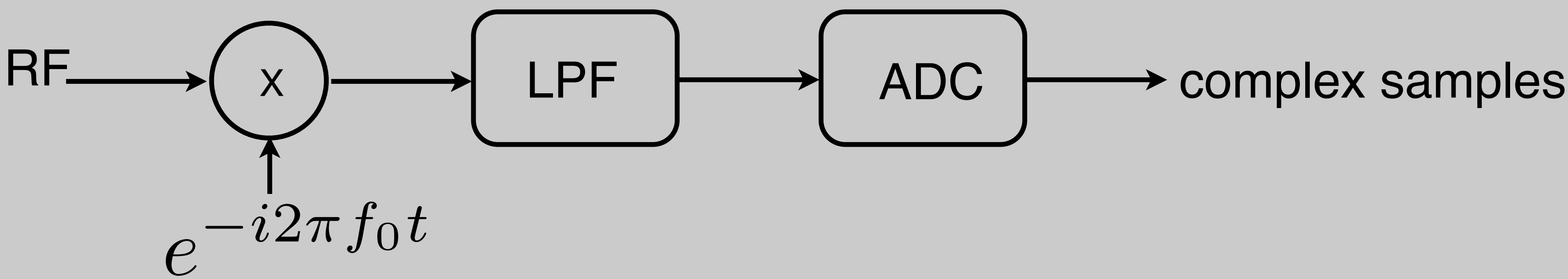
- With the SDR we look at part of the spectrum
- Example:
  >> rtl_sdr -f 94e6 -s 5e5



SDR Stuff

- How is it implemented?





SDR Stuff

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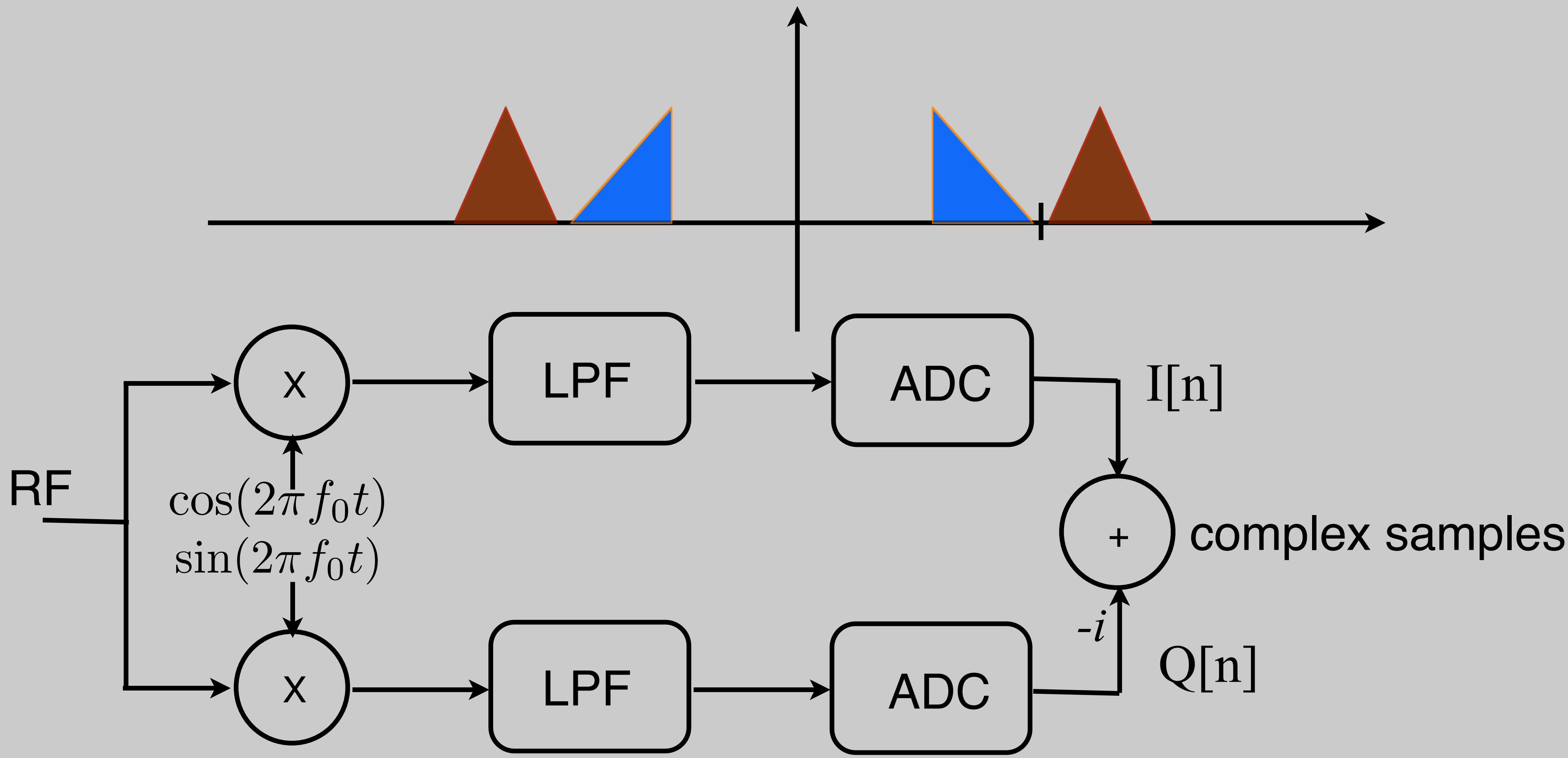

$$e^{-i2\pi f_0 t} = \cos(2\pi f_0 t) - i\sin(2\pi f_0 t)$$

SDR Stuff

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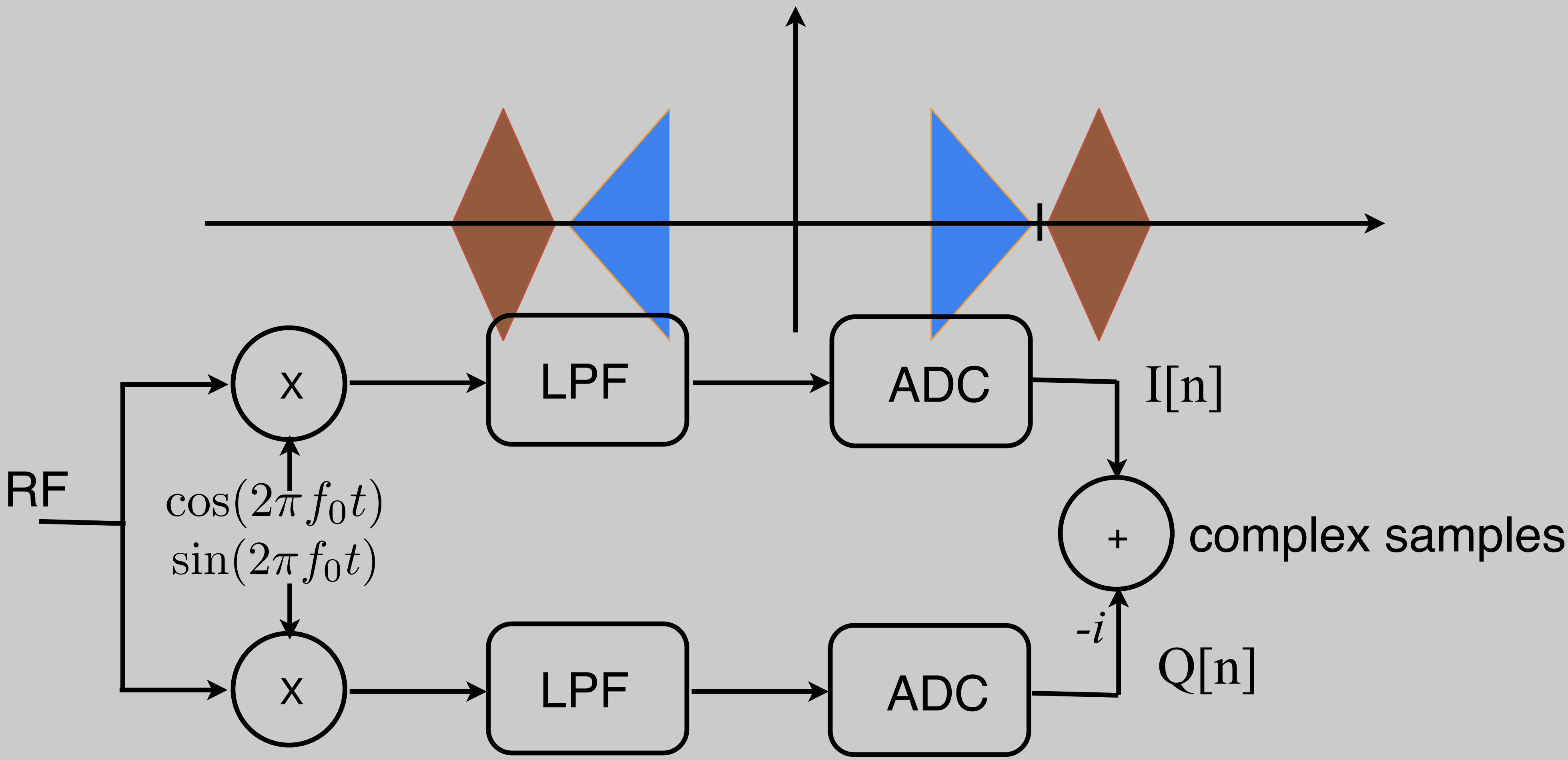

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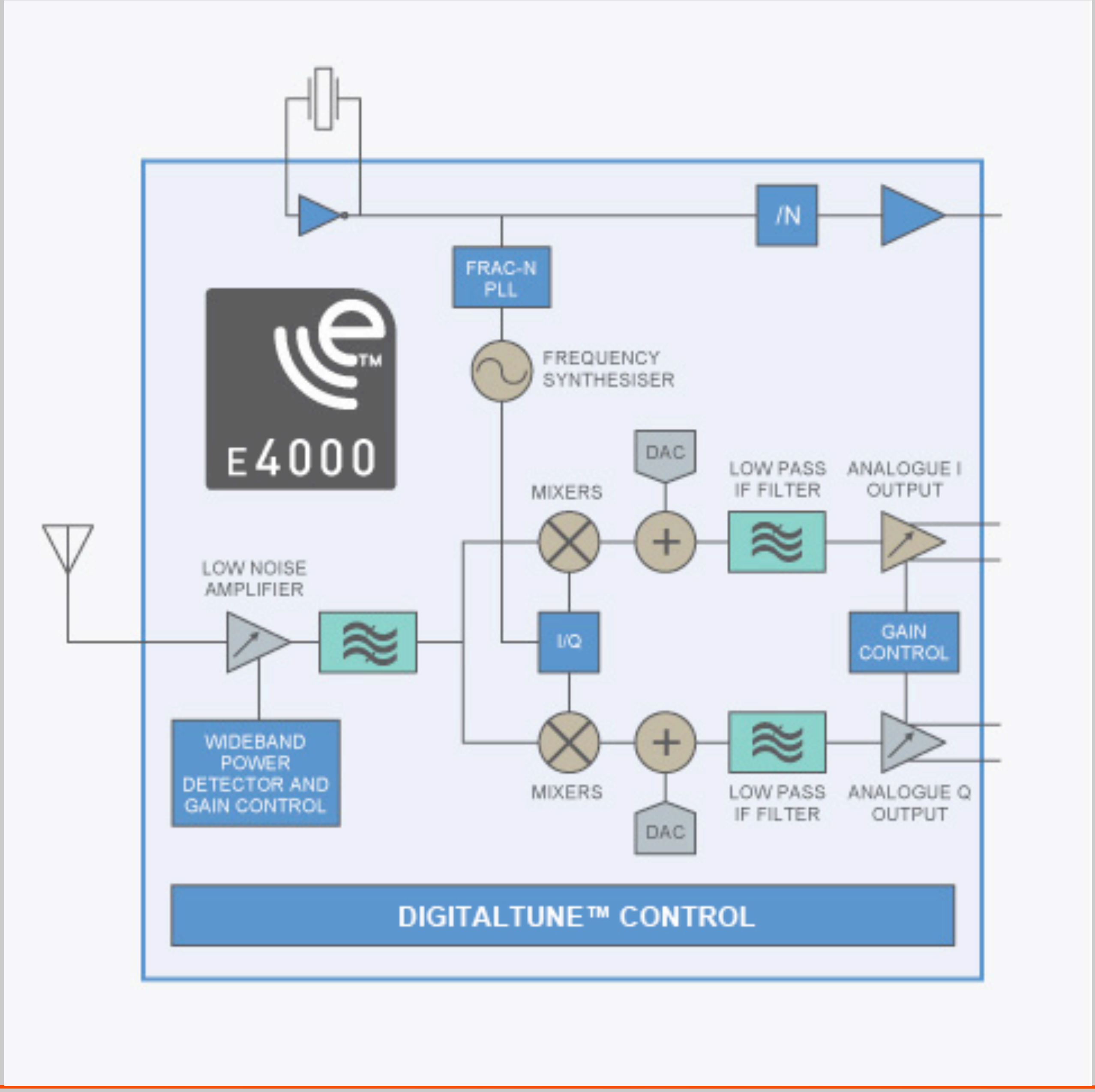
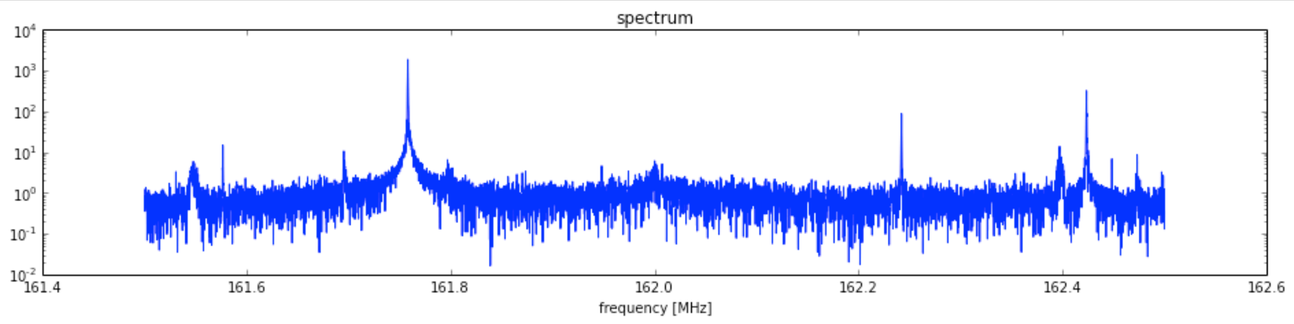
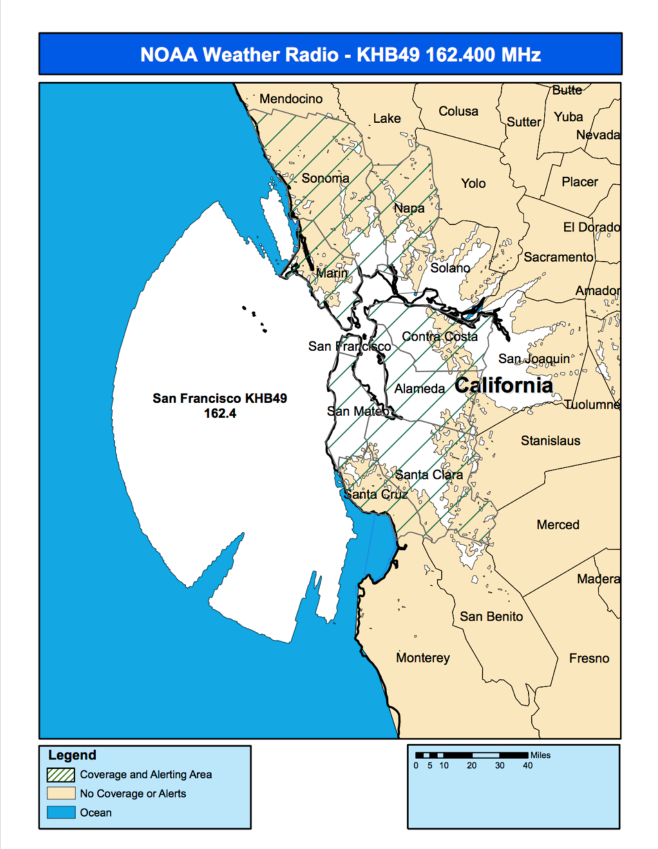


/N
FRAC-N PLL
FREQUENCY SYNTHESISER
E4000
DAC
LOW PASS IF FILTER
ANALOGUE I OUTPUT
MIXERS
LOW NOISE AMPLIFIER
I/Q
GAIN CONTROL
WIDEBAND POWER DETECTOR AND GAIN CONTROL
MIXERS
LOW PASS IF FILTER
ANALOGUE Q OUTPUT
DAC
DIGITALTUNE™ CONTROL

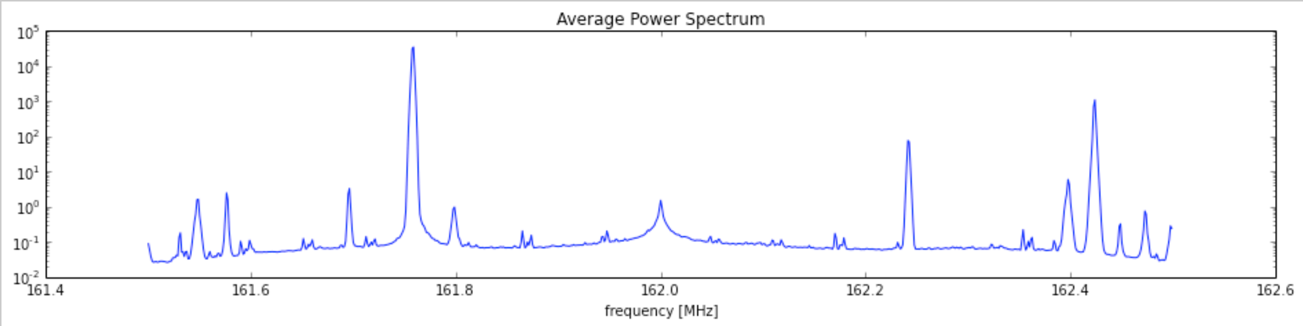
Lab I part III - SDR

- Get samples around 162Mhz
  - –Compute DFT 8000



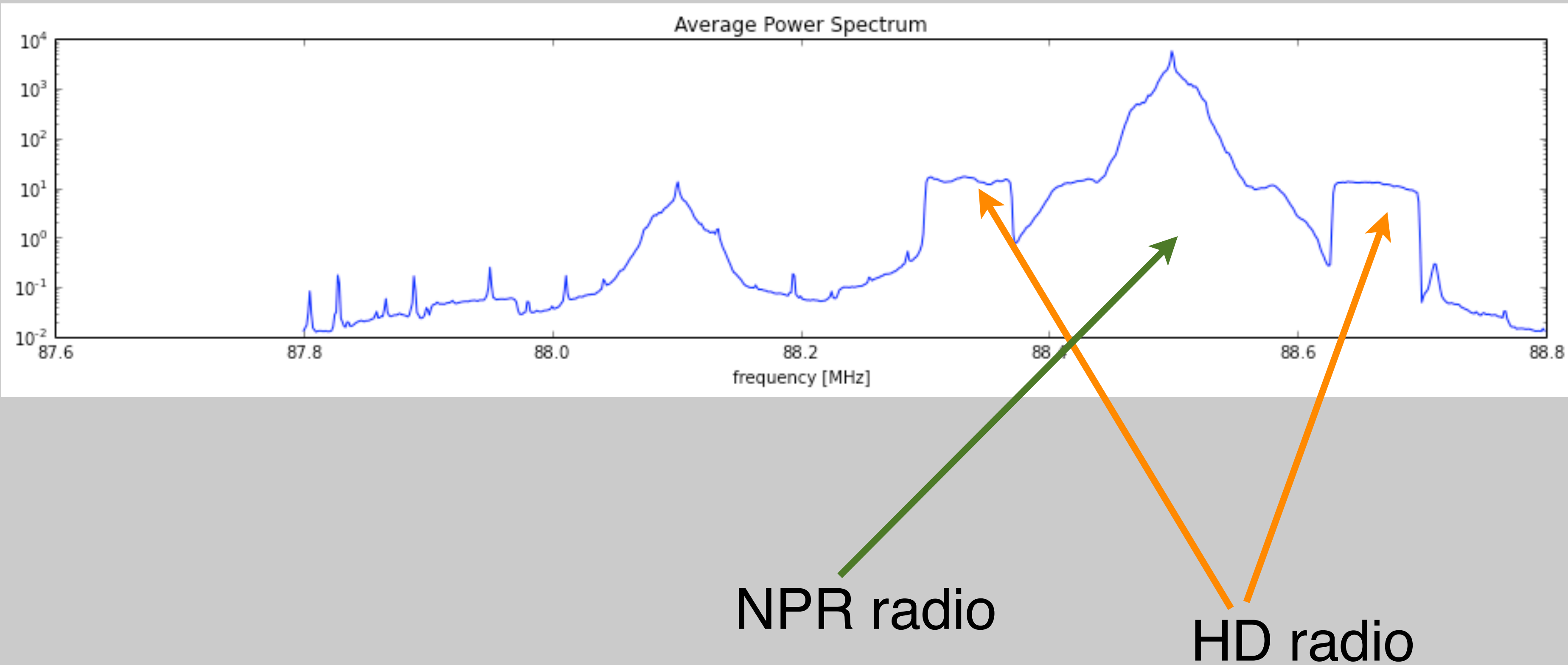


  - –Compute average DFT of many windows size 800

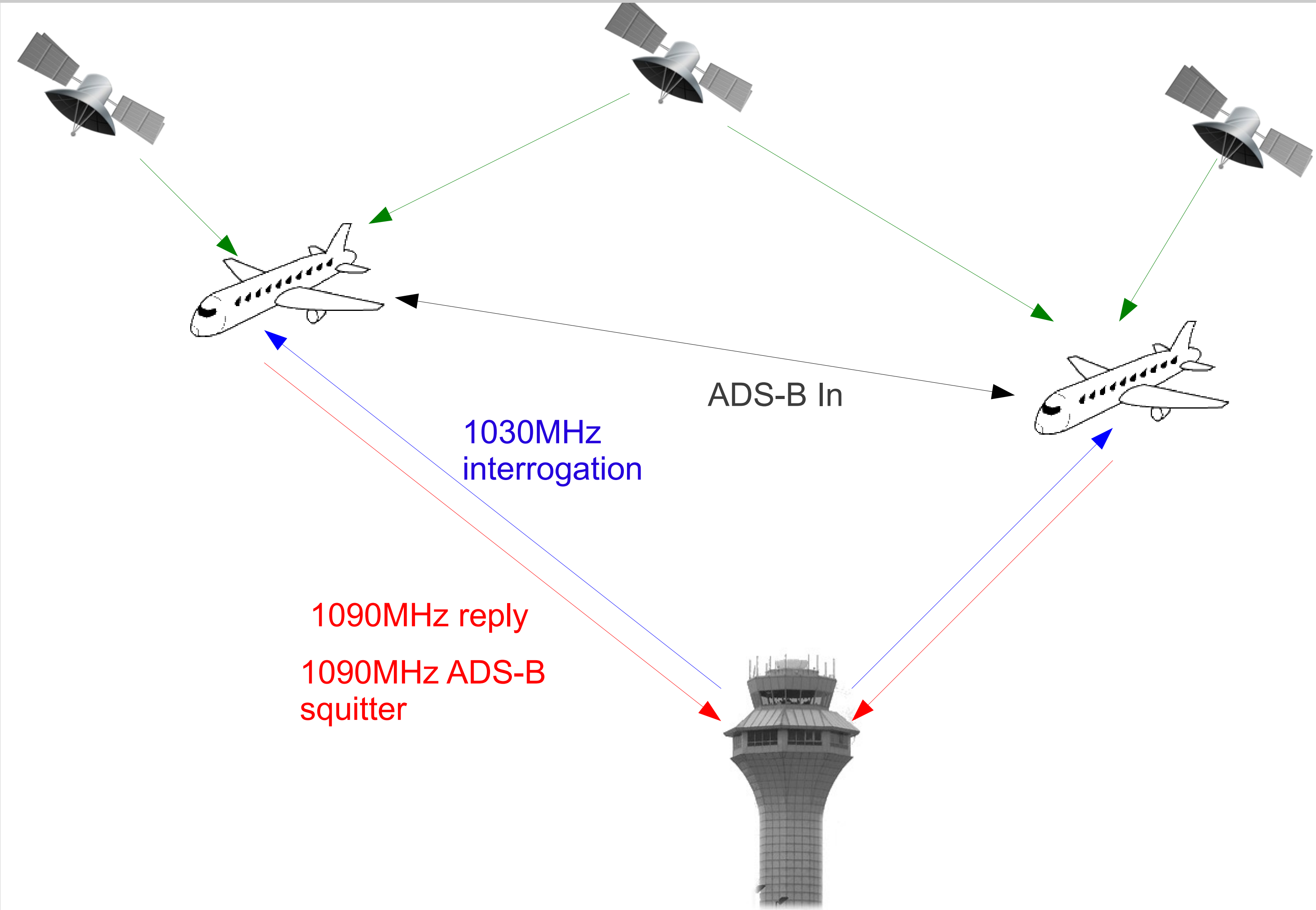


Lab I part III - SDR

- Compute spectrum of FM radio around 88.3MHz

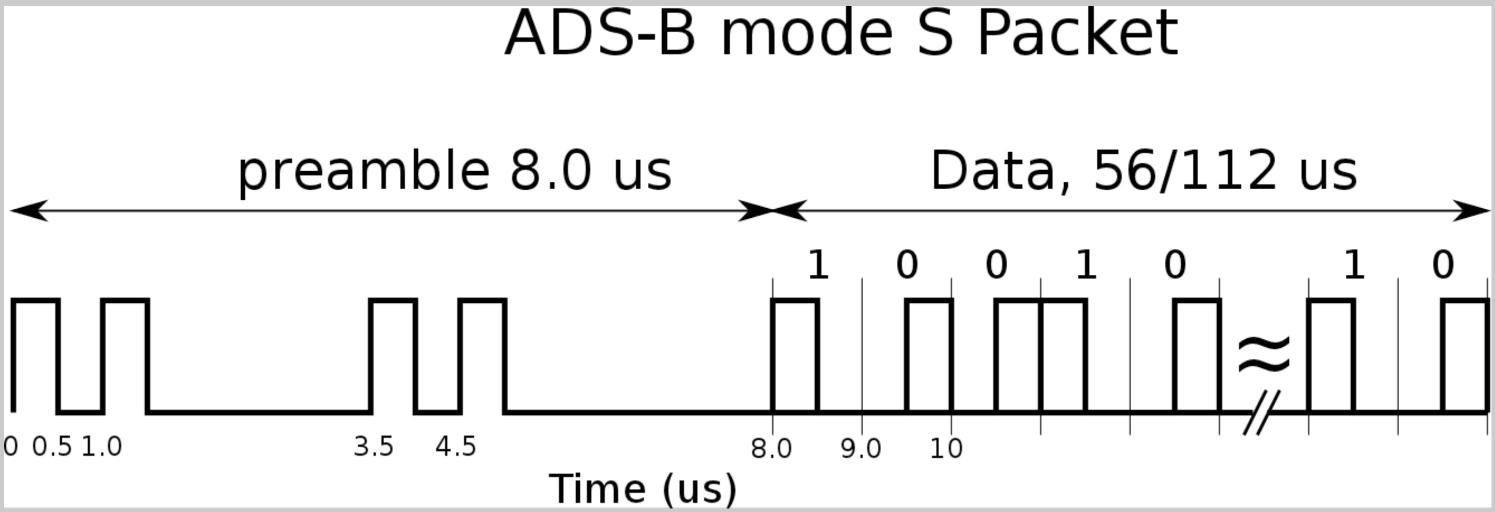


ADS-B

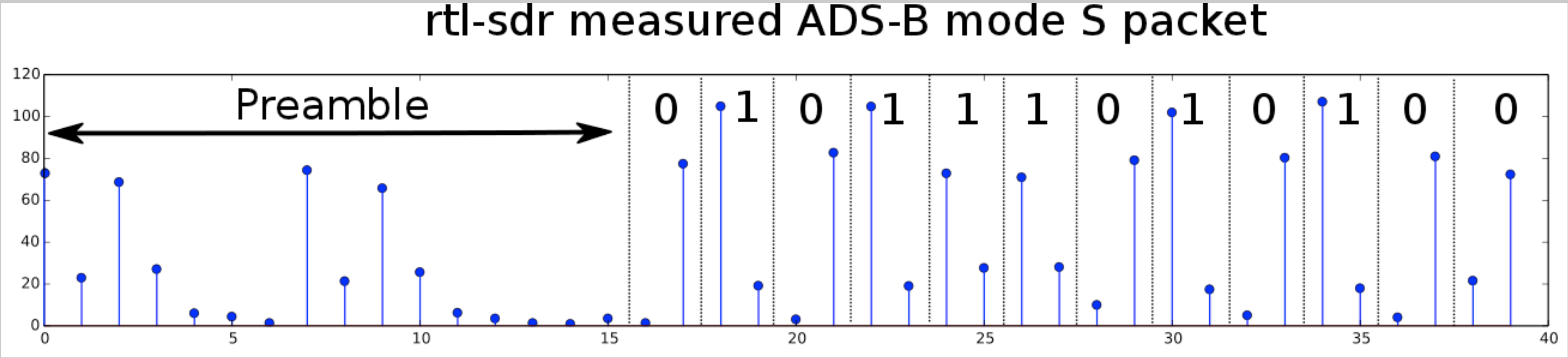


ADS-B In
1030MHz
interrogation
1090MHz reply
1090MHz ADS-B
squitter

ADS-B



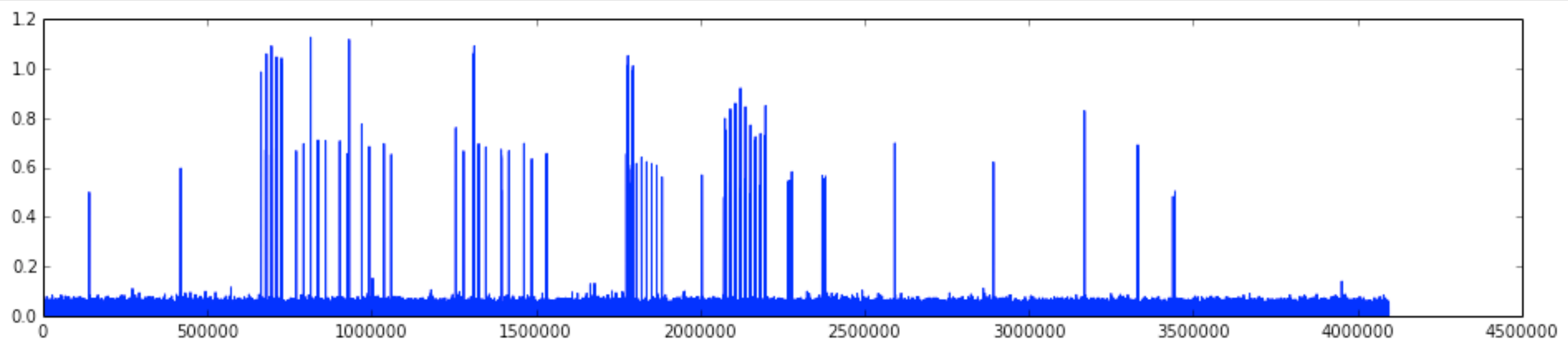
ADS-B mode S Packet
preamble 8.0 us
Data, 56/112 us
1 0 0 1 0 1 0
0 0.5 1.0
3.5
4.5
8.0
9.0
10
Time (us)



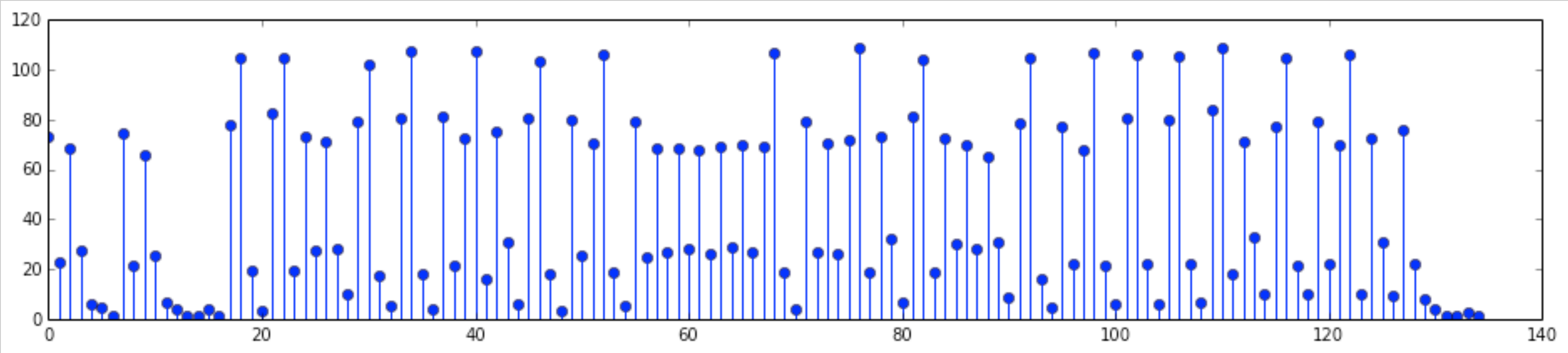
rtl-sdr measured ADS-B mode S packet
Preamble
0 1 0 1 1 1 0 1 0 1 0 0

ADS-B

- Acquire 1 seconds

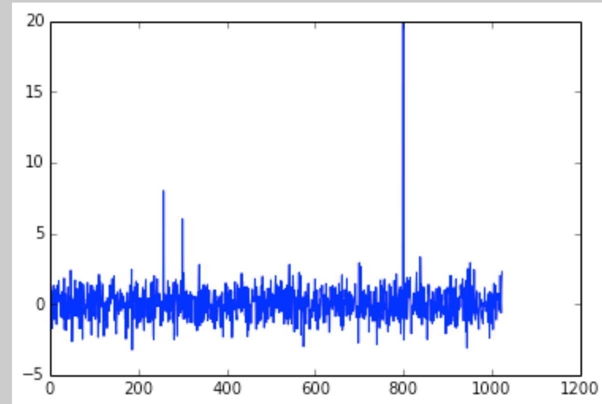


- Extract 1 packet

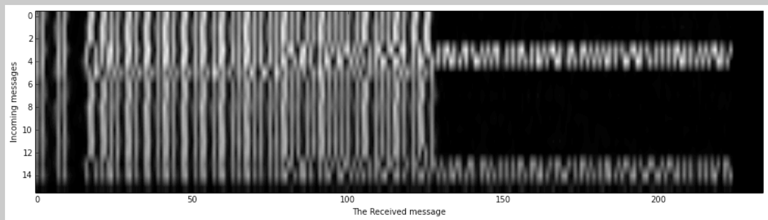


Detect Preamble

- Energy:
  - –Median and MAD to estimate noise
  - – Set threshold based on noise



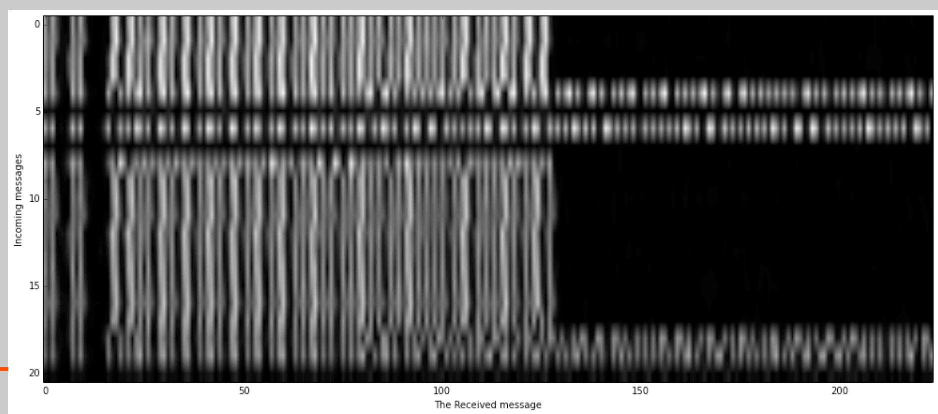
- Using cross correlation



$$\hat{R}_{xy}[n] = \frac{\sum_{k=0}^{15}(x[n+k] - \hat{x}_n)(y[k] - \hat{y})}{\|x[n] - \hat{x}_n\| \cdot \|y - \hat{y}\|}$$

- Using Logic

1’s bigger than 0’s



See airplane position