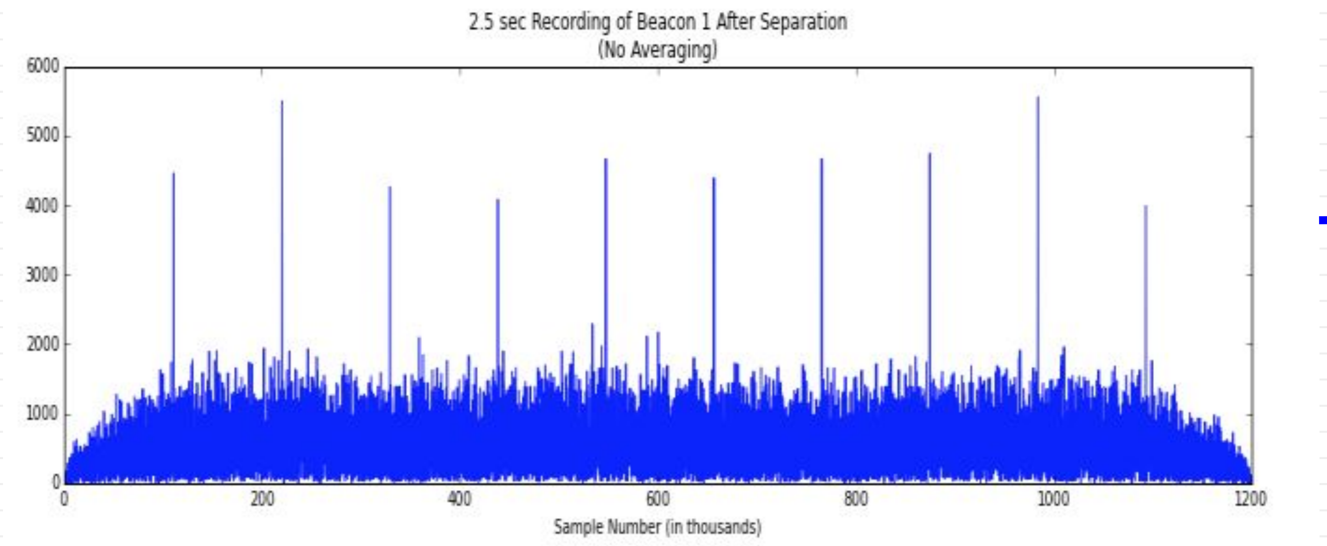
EE16A Lab: APS 2 -- LAST LAB!

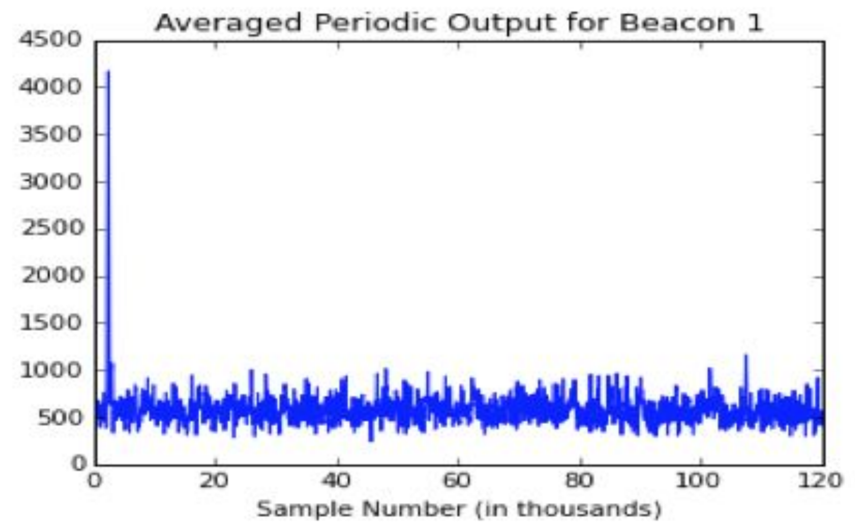
Announcements!

- This is the **last lab!!!**
- Buffer week next week
- Memes.jpg
- Final: 12/11 3-6pm
- Make sure to email for DSP if needed
- **GOOD LUCK ON YOUR EXAMS**

Last lab

- ✘ Averaging Function
  - ✗ Reduced noise, higher accuracy in determining peaks



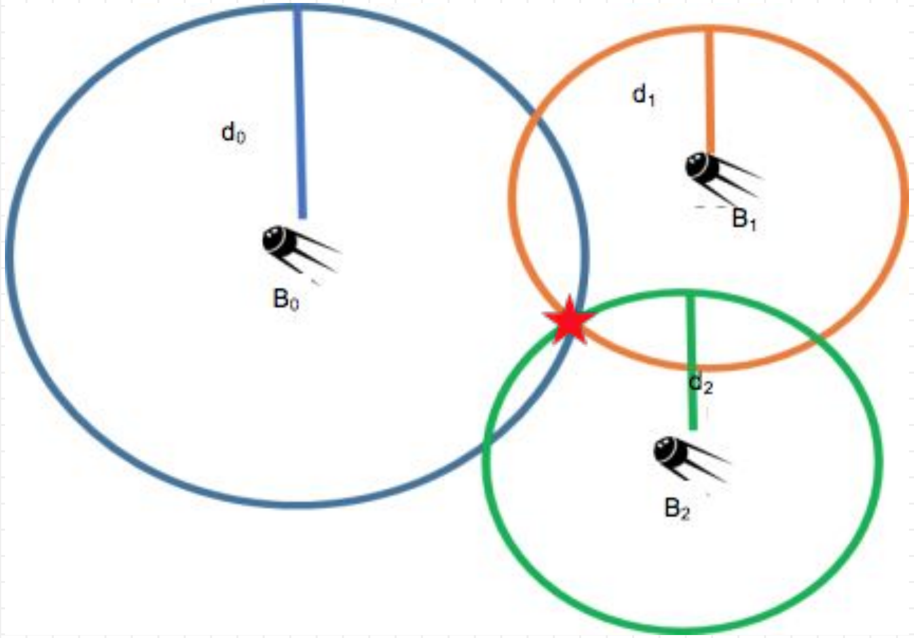


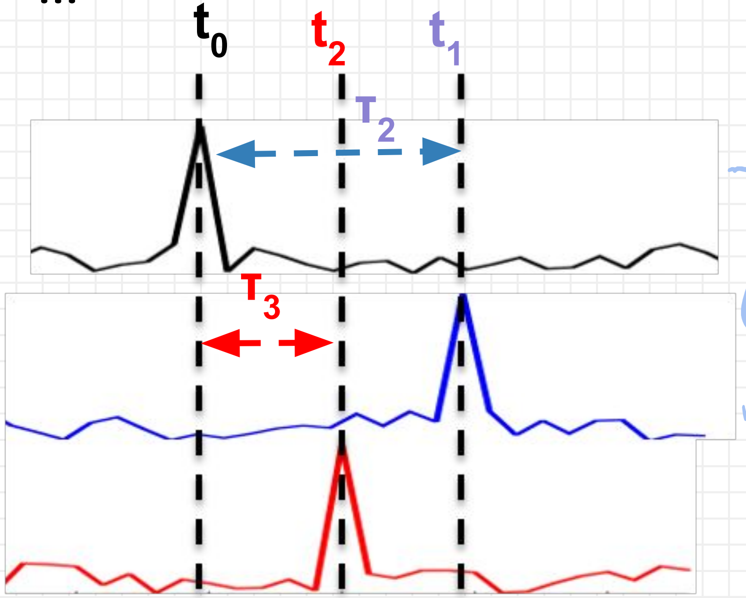
- ✘ Signal_to_distances(raw_signal, t0)
  - ✗ We don't usually have t0 known

3 Beacon example

- Let beacon centers be: (x_0, y_0), (x_1, y_1) and (x_2, y_2)
- Time of arrivals: t_0, t_1, t_2
- Distance of beacon m $(m = 0, 1, 2)$ is $d_m = vt_m = R_m$ (circle radii)

Circle equations: $(x - x_m)^2 + (y - y_m)^2 = d^2_m$

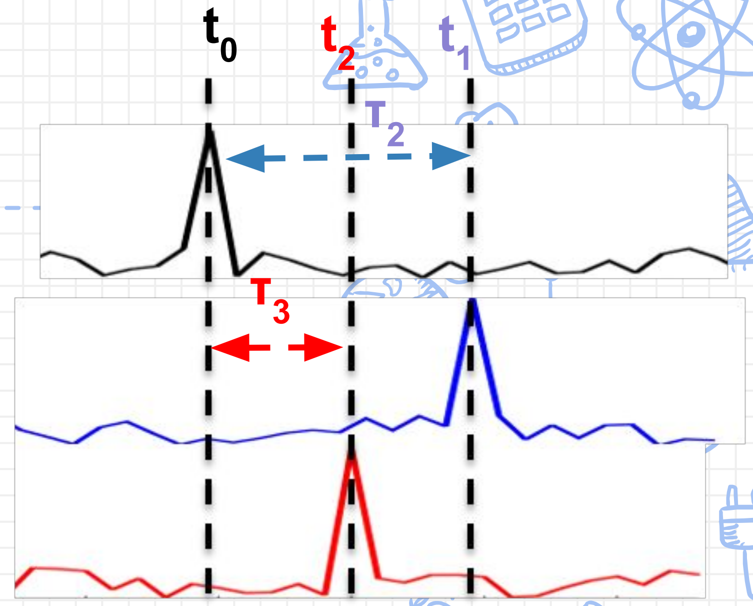




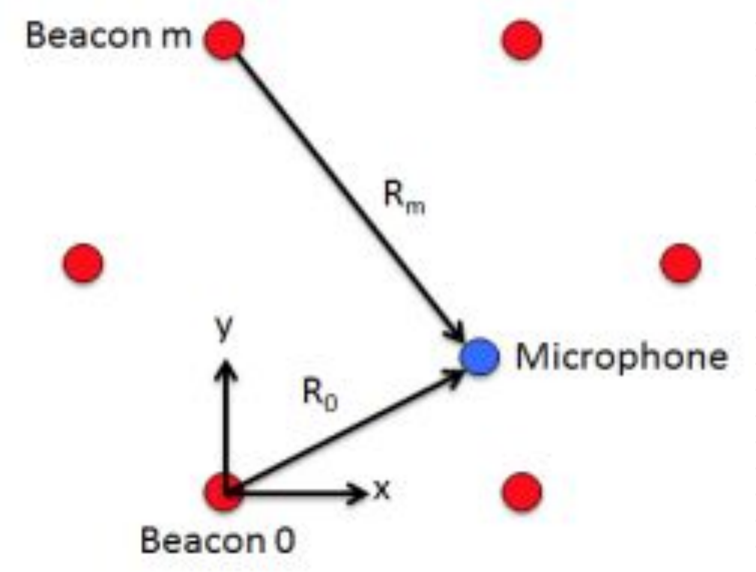
CC of received signal and beacons

Problem: We do not know t_0

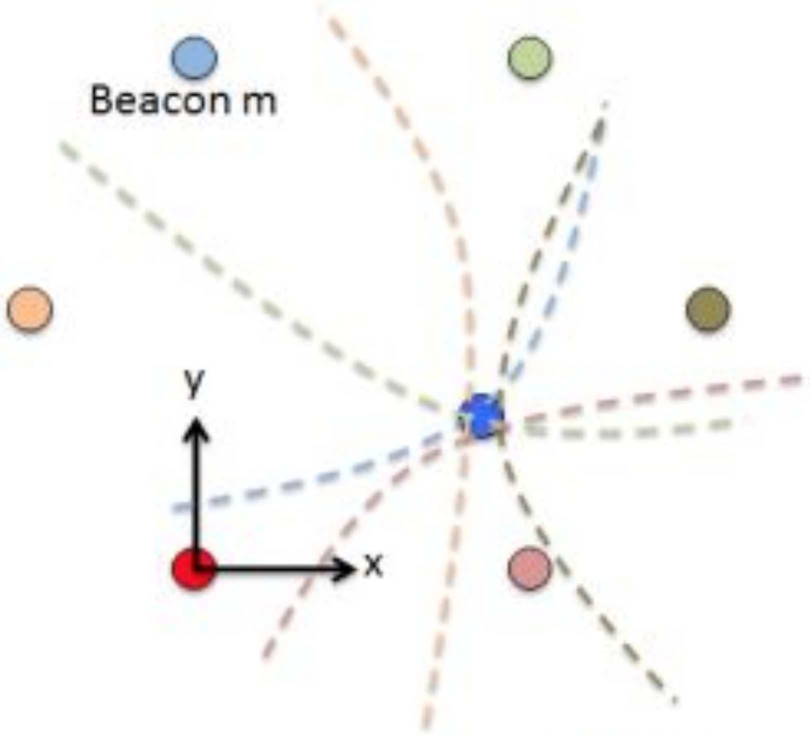
- Only know time offsets: $\tau_m = t_m - t_0$
- $R_m = \sqrt{(x-x_m)^2+(y-y_m)^2} = v_s t_m$
- $R_0 = \sqrt{(x)^2+(y)^2} = v_s t_0$ (Beacon 0 is at origin)
- $R_m - R_0 = v_s\,(t_m - t_0) = v_s \tau_m$



CC of received signal and beacons



Setting up n-1 hyperbolic equations



Beacon 0 is not used for locationing since it acts as the reference signal.

$$R_m - R_0 = v_s \tau_m$$

simplify!

$$v_s \tau_m = \frac{-2x_m x + {x_m}^2 - 2y_m y + {y_m}^2}{v_s \tau_m} - 2\sqrt{x^2 + y^2}$$

- ✘ $m \neq 0$ (as $\tau_0 = 0$)
- ✘ This is the equation for a hyperbola
- ✘ :(This is hard to solve tho

Making it linear:

- ✘ Same trick: subtract first equation from others

$$v_s\tau_m = \frac{-2x_m x + x_m{}^2 - 2y_m y + y_m{}^2}{v_s\tau_m} - 2\sqrt{x^2+y^2}$$

Not linear :(

$$\downarrow$$

$$v_s\tau_m - v_s\tau_1 = [\frac{-2x_m x + x_m{}^2 - 2y_m y + y_m{}^2}{v_s\tau_m} - 2\sqrt{x^2+y^2}] - [\frac{-2x_1 x + x_1{}^2 - 2y_1 y + y_1{}^2}{v_s\tau_1} - 2\sqrt{x^2+y^2}]$$

Linear! $\downarrow$ **simplify!** $m \neq 0, m \neq 1$

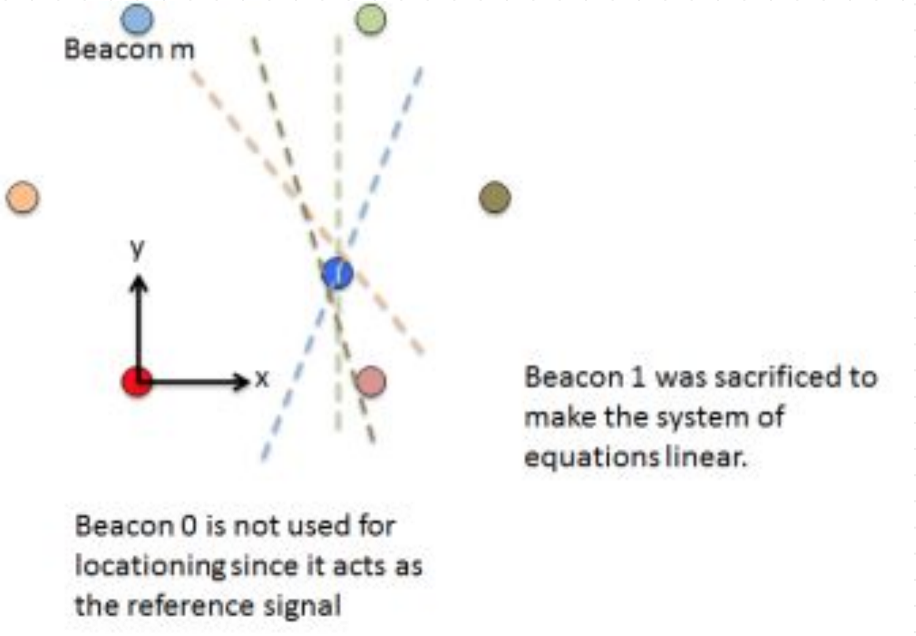
$$(\frac{2x_m}{v_s\tau_m} - \frac{2x_1}{v_s\tau_1})x + (\frac{2y_m}{v_s\tau_m} - \frac{2y_1}{v_s\tau_1})y = (\frac{x_m{}^2 + y_m{}^2}{v_s\tau_m} - \frac{x_1{}^2 + y_1{}^2}{v_s\tau_1}) - (v_s\tau_m - v_s\tau_1)$$

$$m \neq 0,\ m \neq 1$$

Making it linear:

$$\left(\frac{2x_m}{v_s\tau_m} - \frac{2x_1}{v_s\tau_1}\right)x + \left(\frac{2y_m}{v_s\tau_m} - \frac{2y_1}{v_s\tau_1}\right)y = \left(\frac{x_m^2 + y_m^2}{v_s\tau_m} - \frac{x_1^2 + y_1^2}{v_s\tau_1}\right) - (v_s\tau_m - v_s\tau_1)$$

- ✘ After simplifying, we have n-2 linear equations
- ✘ Can do least-squares regardless of number of beacons
  - ✗ Best estimate of location if measurements are inconsistent
  - ✗ If there is no exact point of intersection bc of error or noise



$$Ax = b$$

$$A^T A x = A^T b$$

Important Notes

- ✘ Read over the math **carefully**, We'll be asking you about it!
- ✘ Optional (Task 3c): If you want to take your own recording, come bother us and we will help you take a recording you can test on your own code!