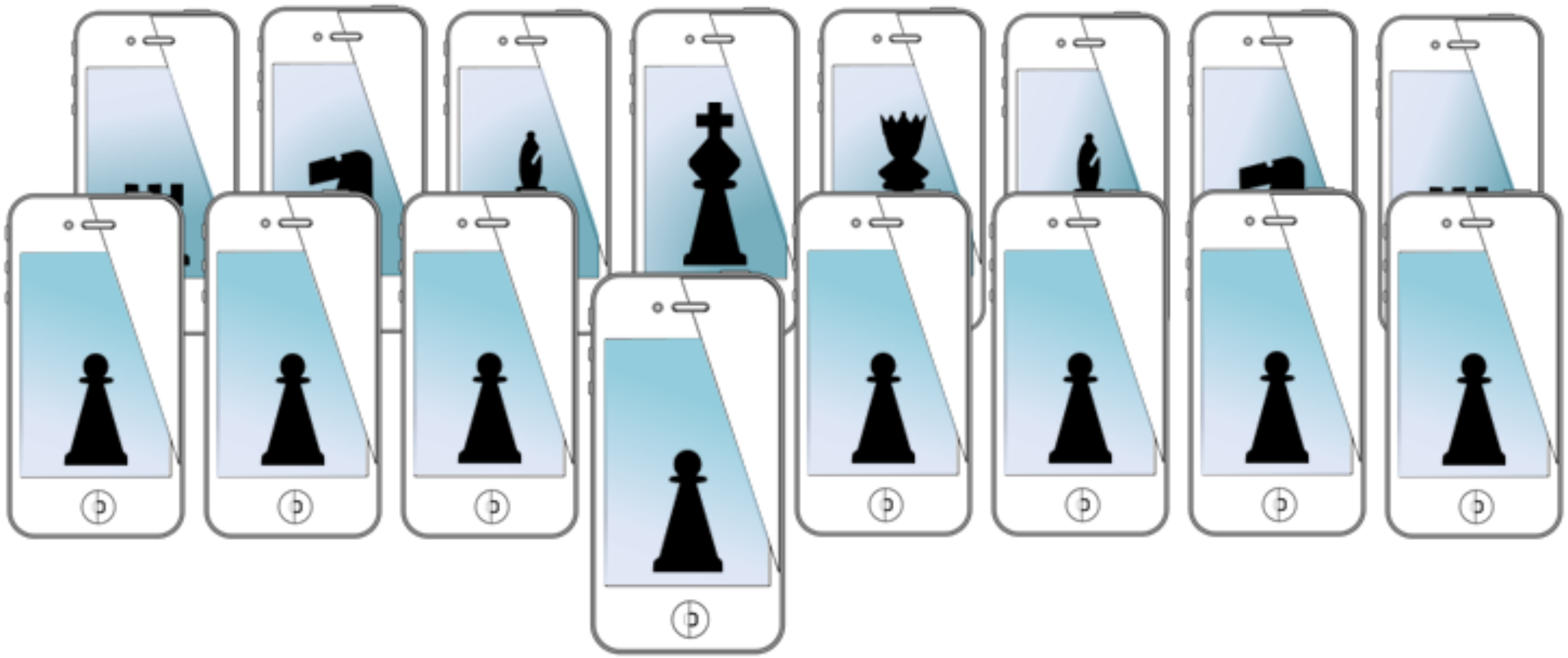
MOBILE SENSING LEARNING



CS5323 & 7323

Mobile Sensing and Learning

doppler and activity monitoring

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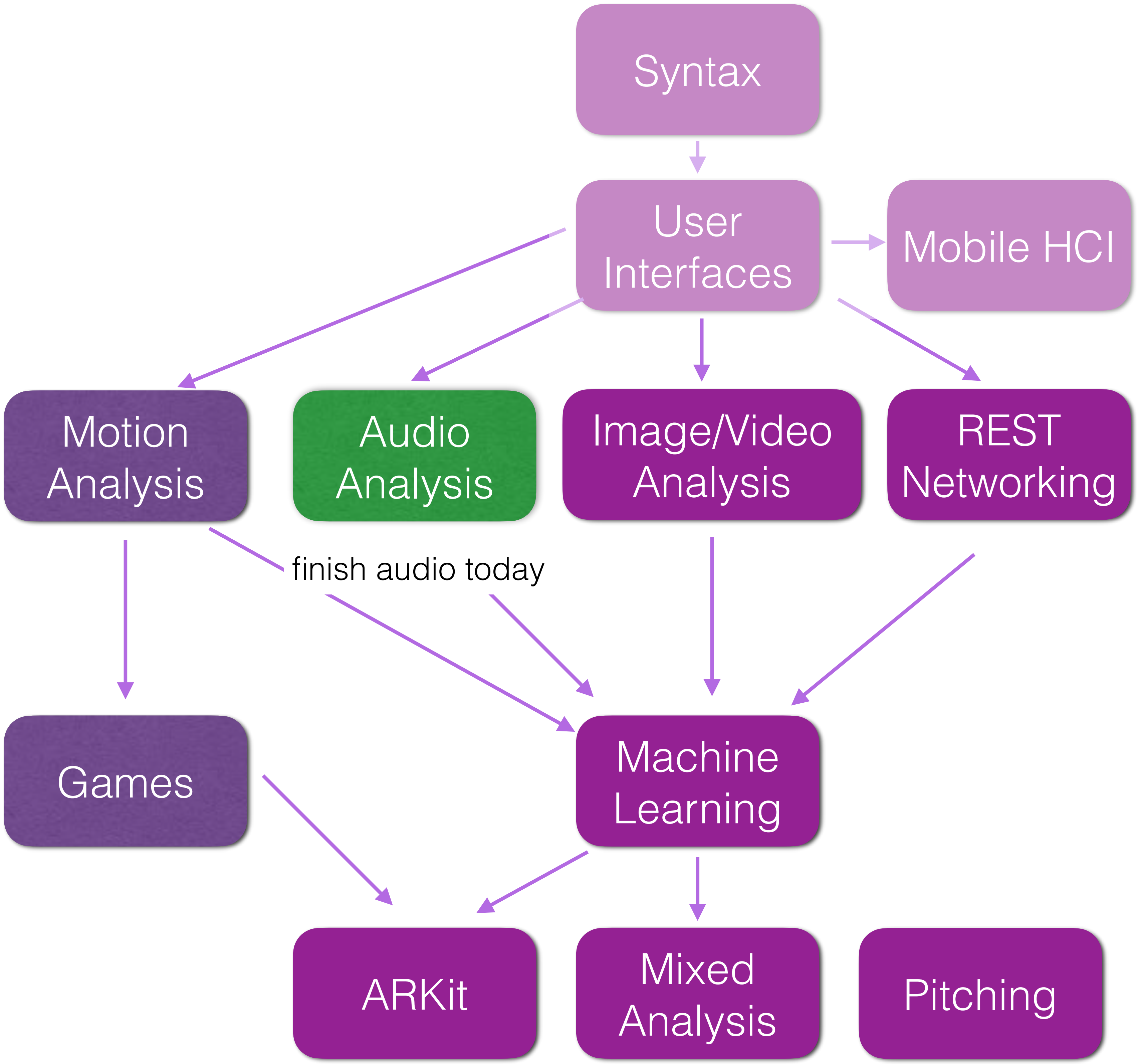
agenda and logistics

- logistics:
  - grades update
  - A2 is due soon!
- agenda:
  - A2 explanations
    - general FFT review
    - peak finding
    - the doppler effect
  - activity processing

class overview



FFT review

- sampling rate
  - dictates the time between each sample, (1 / Fs) (get from the Novocaine `audioManager`)
  - max frequency we can measure is half of sampling rate
- resolution in frequency
  - tradeoff between length of FFT and sampling rate
  - each frequency “bin” is an index in the FFT array
    - each bin represents (Fs / N) Hz
    - what does that mean for 6 Hz accuracy?

time and frequency

Note: the FFT class **ALWAYS** rounds to the next power of 2

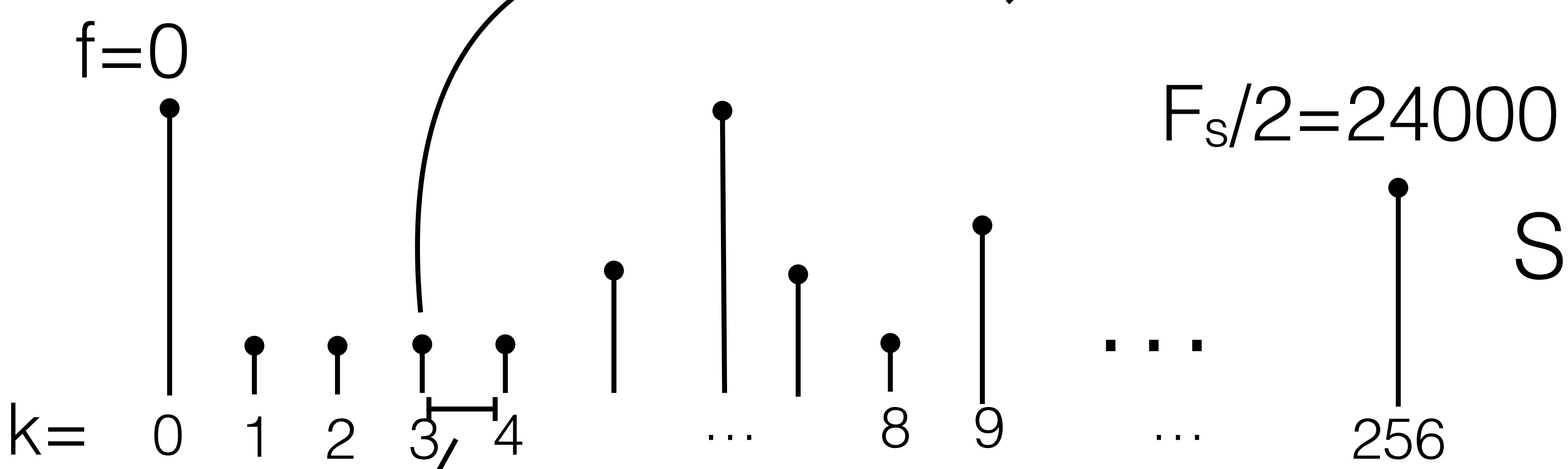
$$f_k = k\, {}^{F_s}\!/\!_{N}$$

time array, N = 512

FFT array, N = 512

Spectrum, N/2 = 256

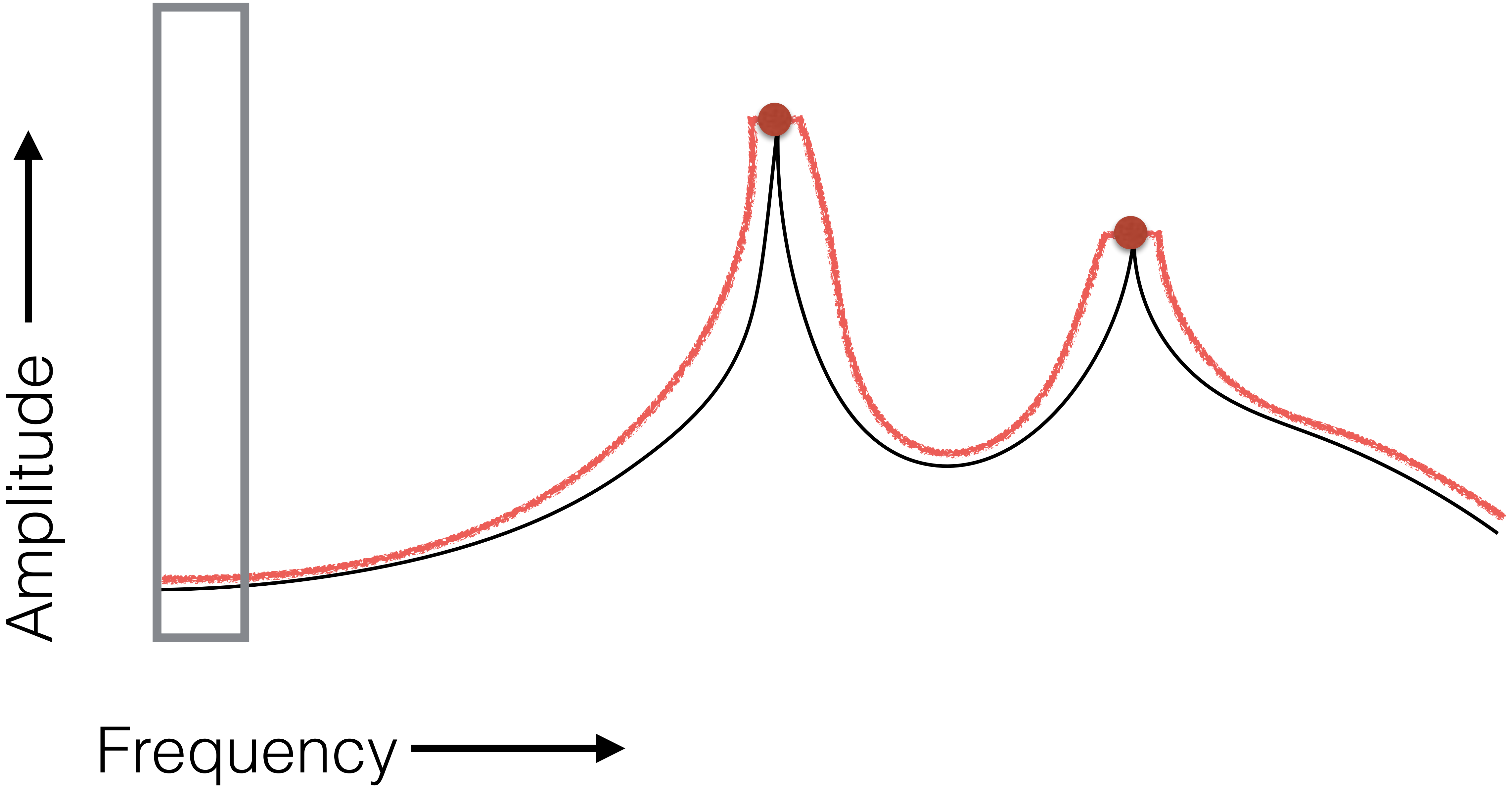
Fs = 48000 Hz



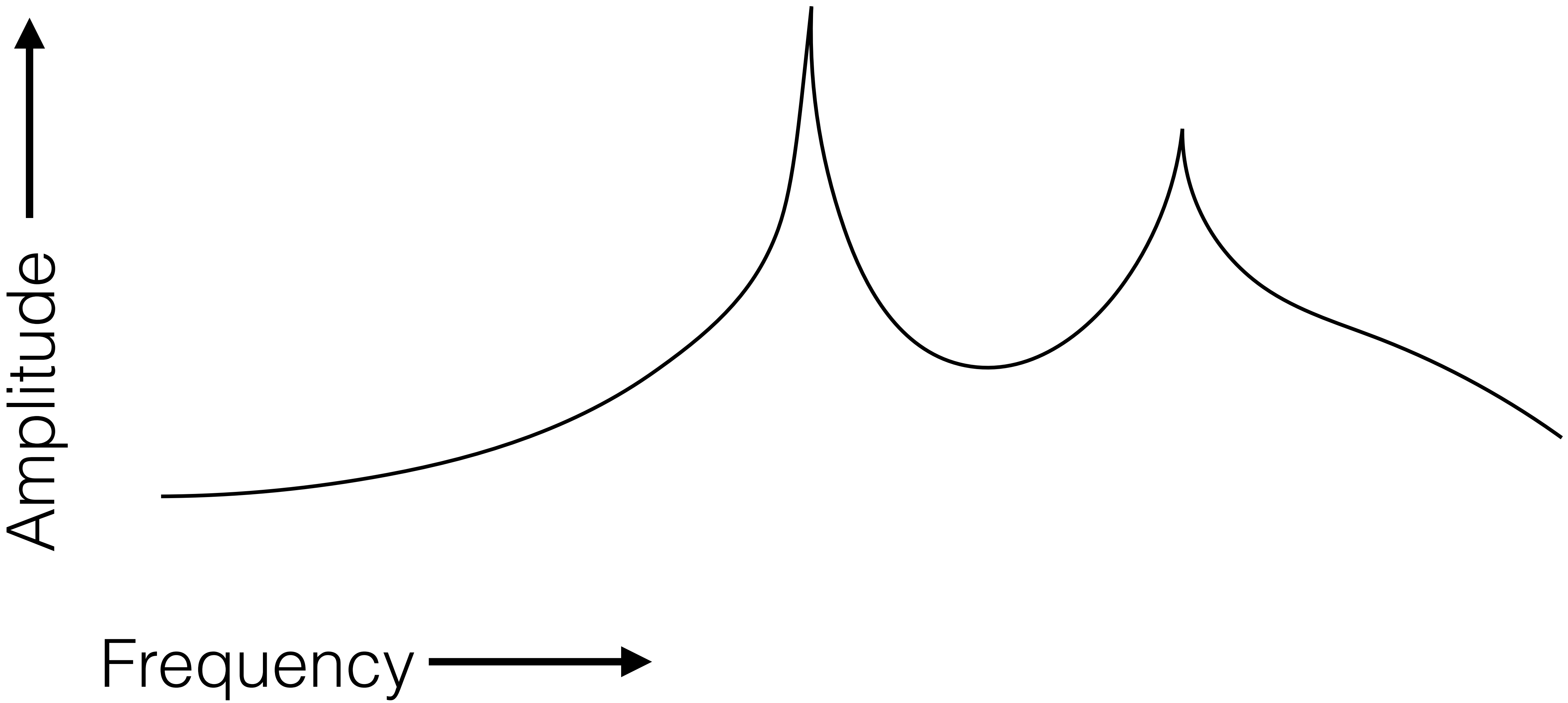
$$df = \frac{{}^{F_s}\!/\!_{2}}{{}^{N}\!/\!_{2}} = {}^{F_s}\!/\!_{N} = 48000/512 = \sim 93.75 \text{ Hz}$$

local peak finding

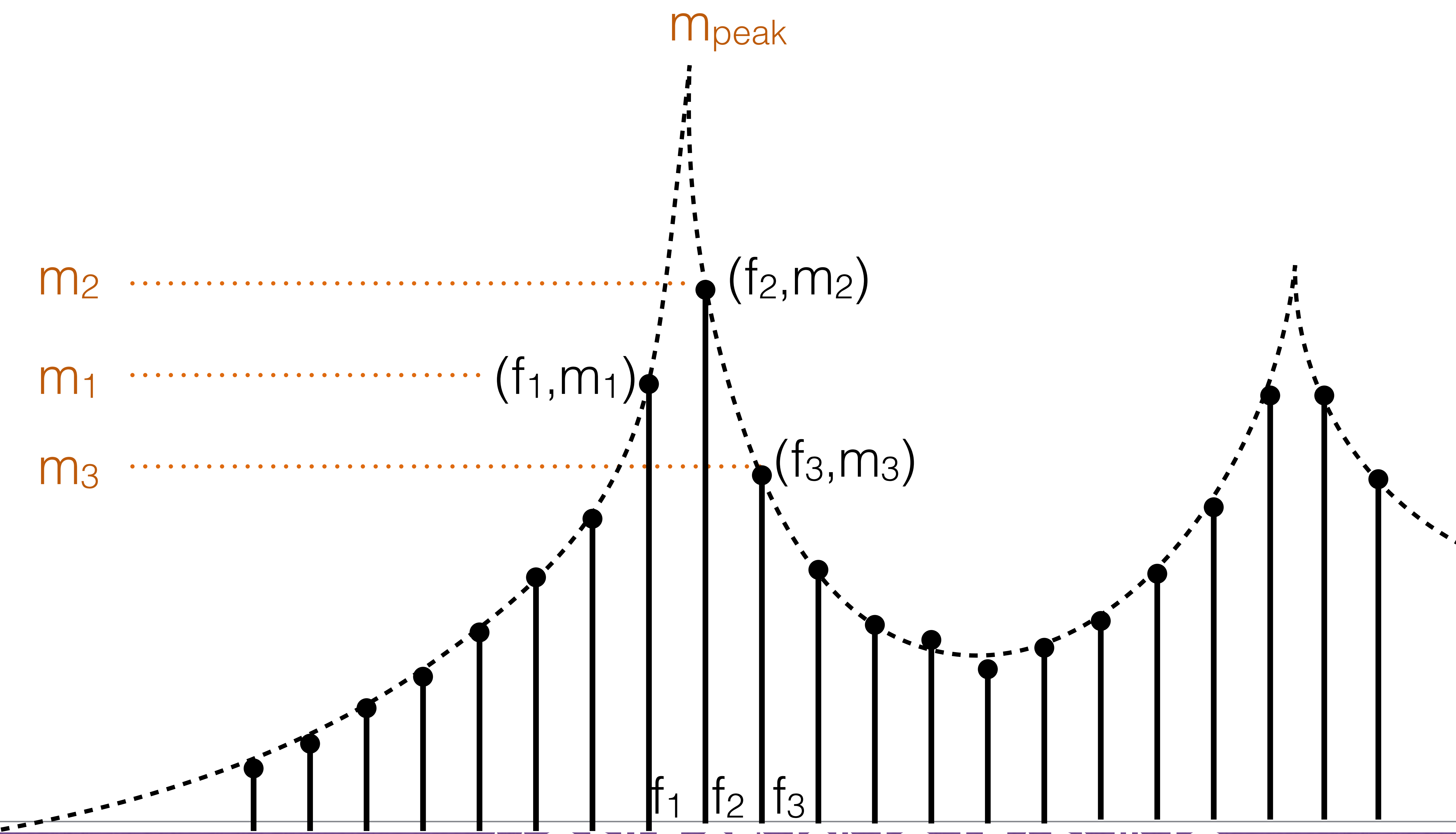
max in window



peak interpolation

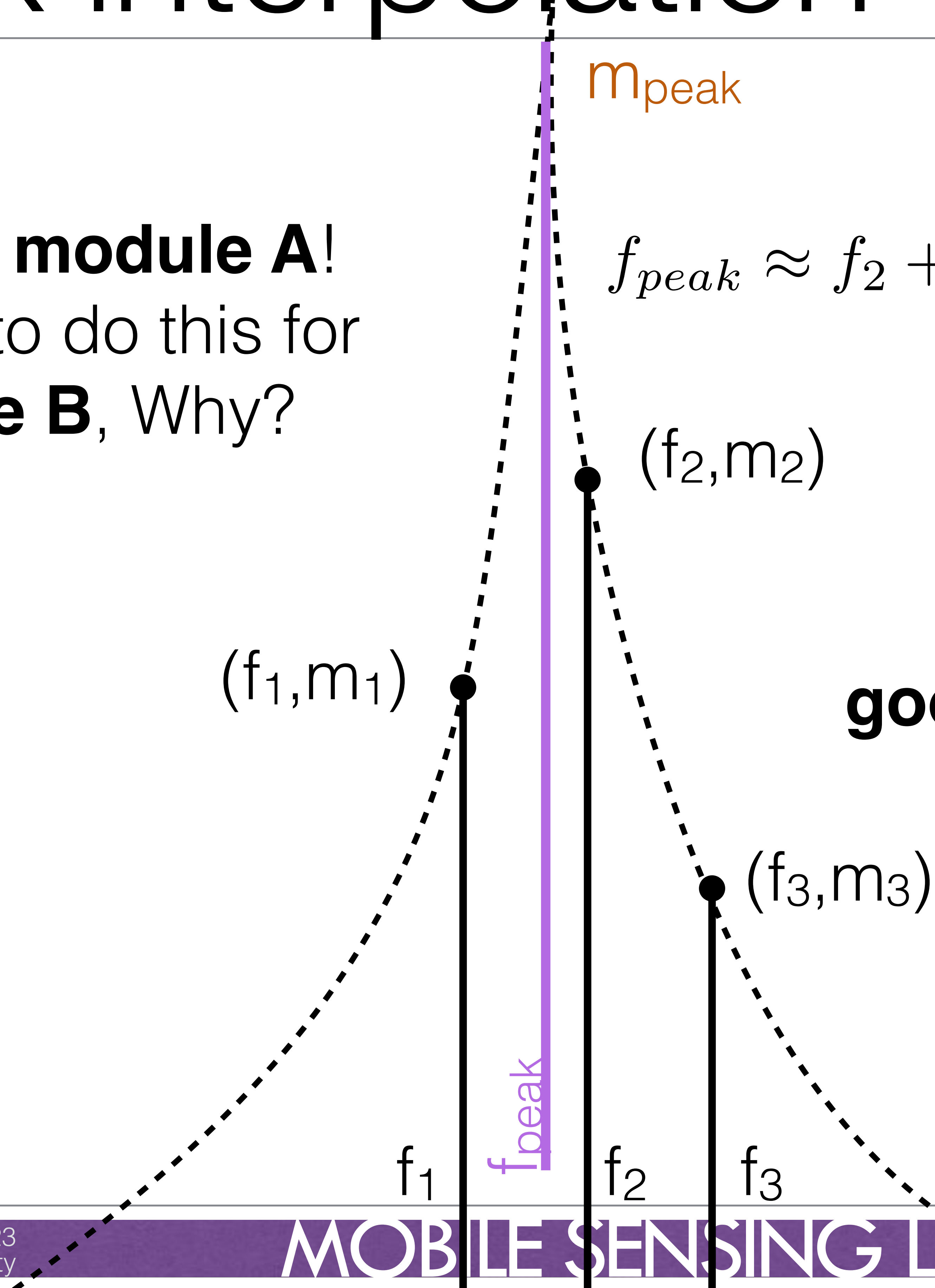


peak interpolation



peak interpolation

great for **module A**!
no need to do this for **module B**, Why?



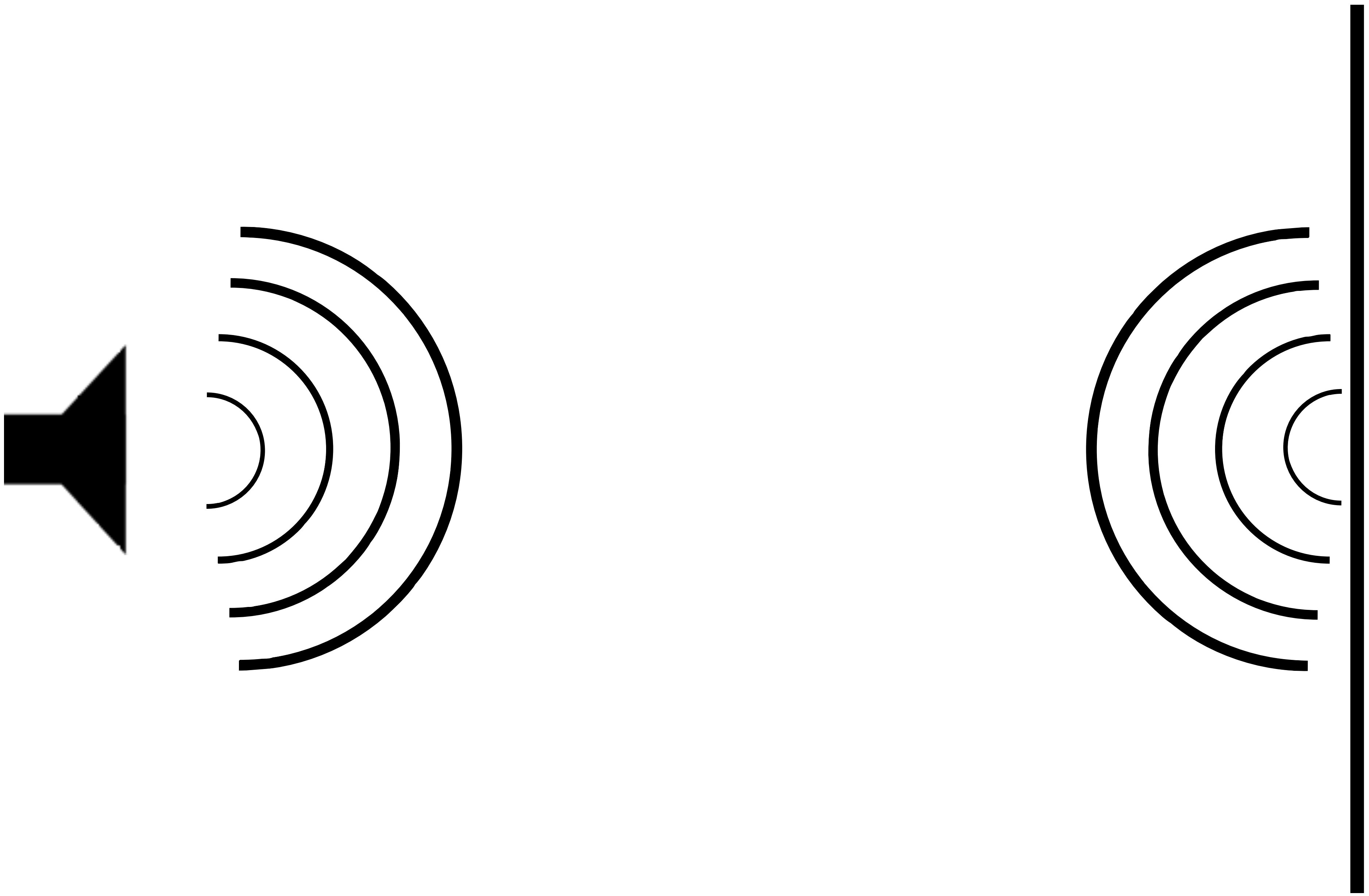
$$f_{peak} \approx f_2 + \frac{m_1 - m_3}{m_3 - 2m_2 + m_1} \frac{\Delta f}{2}$$

quadratic approximation

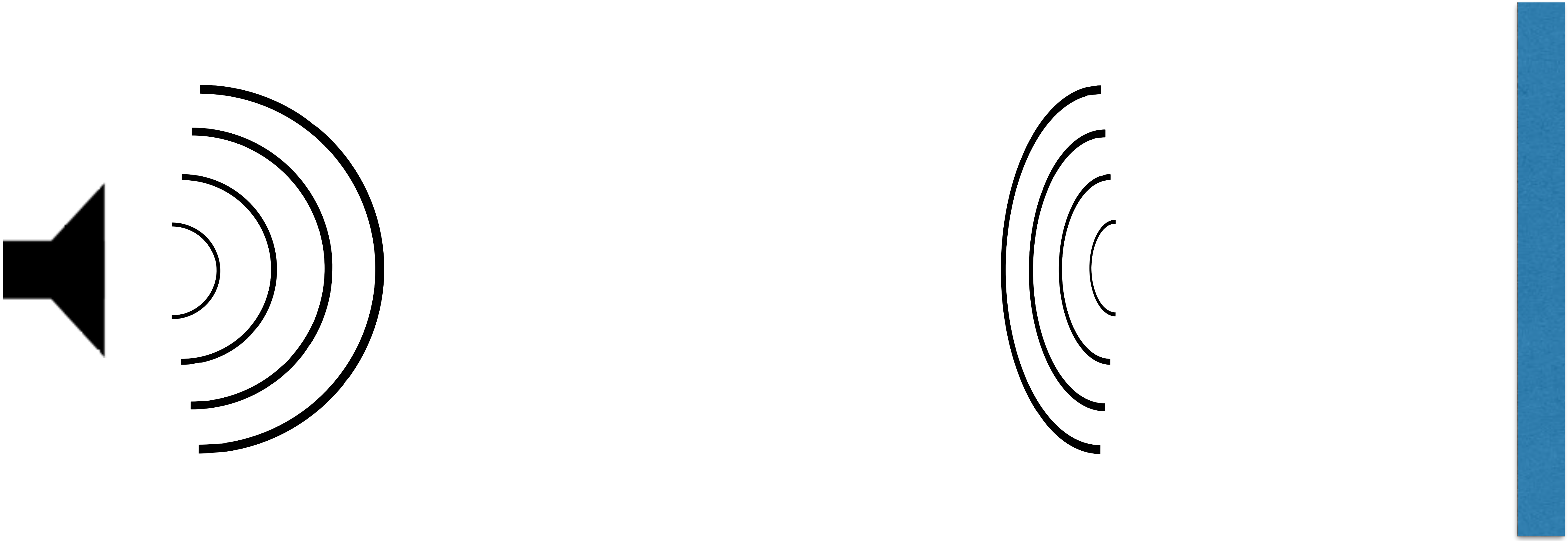
good resource:

https://www.dsprelated.com/freebooks/sasp/Quadratic_Interpolation_Spectral_Peaks.html

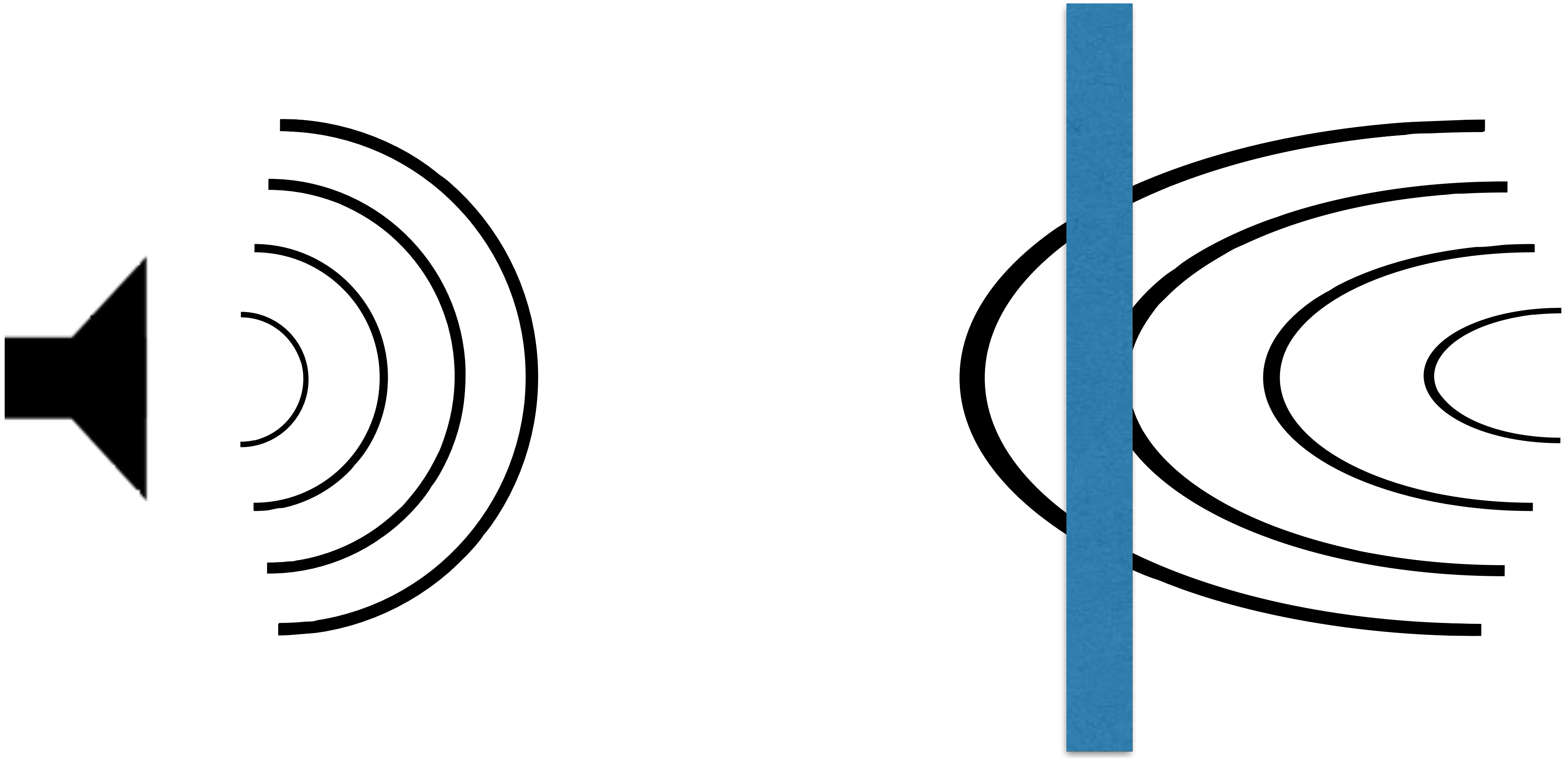
the doppler effect



the doppler effect



the doppler effect



the doppler effect

$$\Delta f = \frac{V_{object}}{c} f_0$$

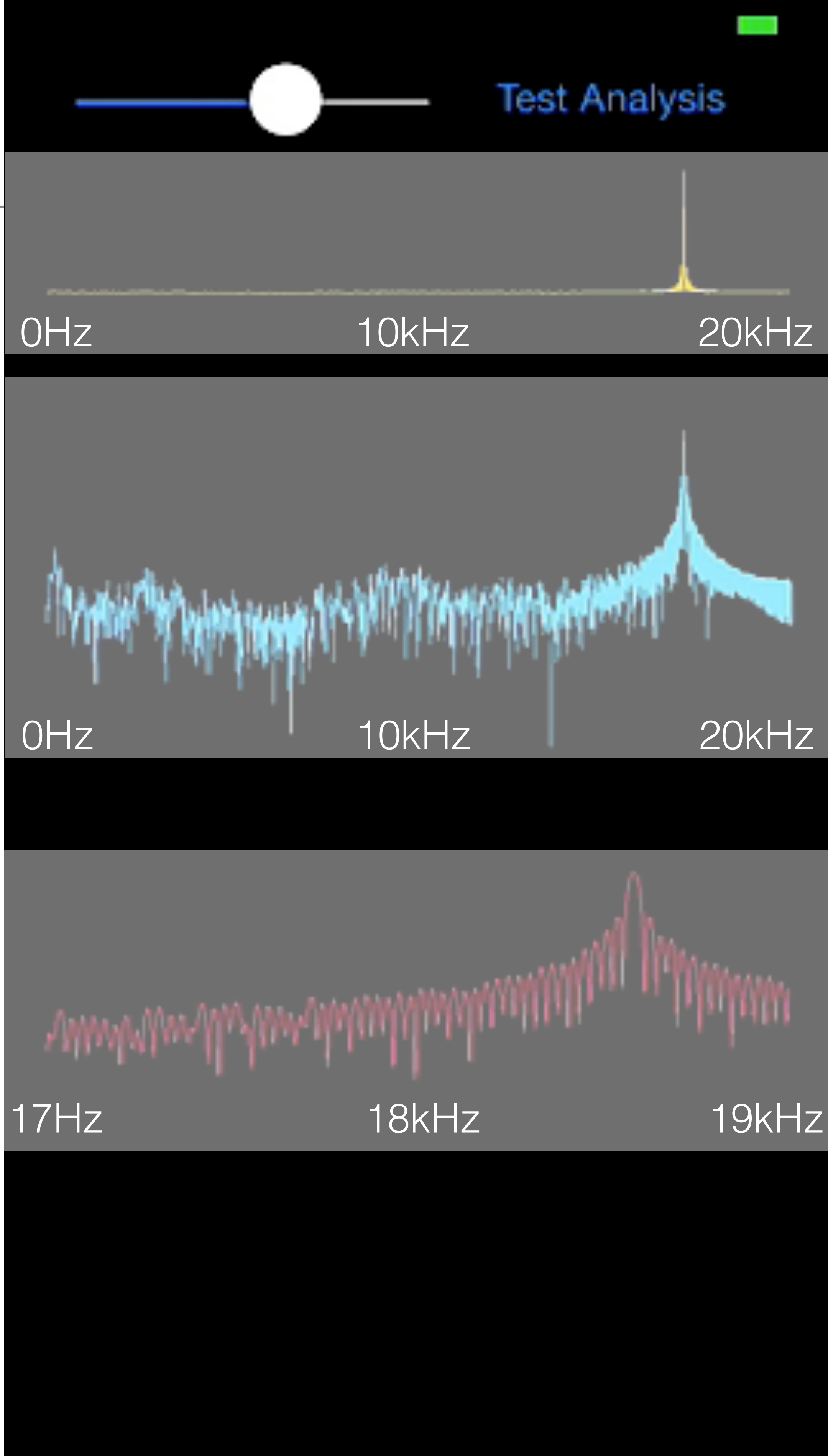
change in frequency

velocity of object

speed of sound

frequency of source

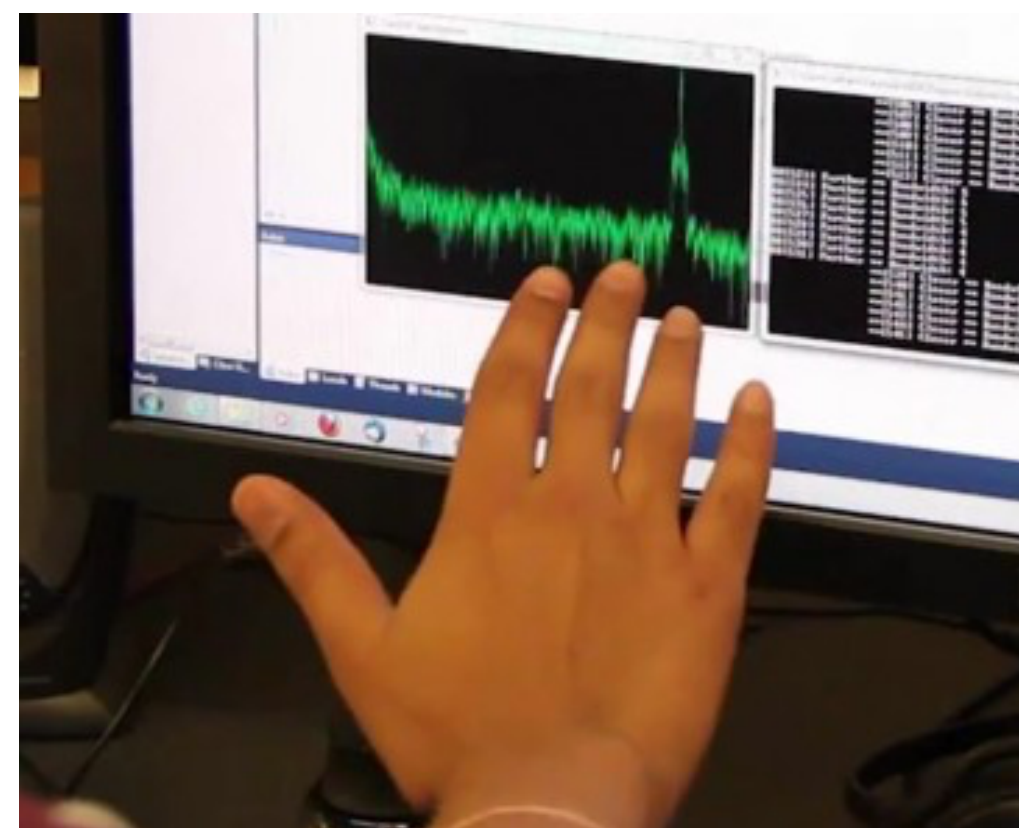
ifts fro



linear

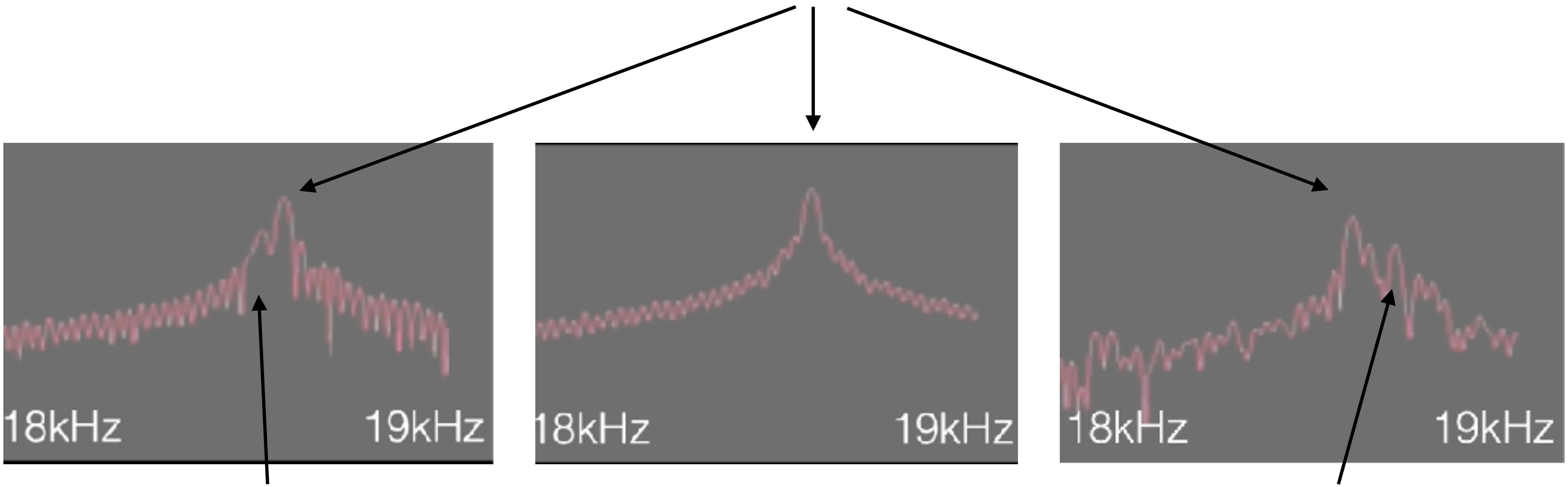
db

db zoomed (freq axis)



doppler shifts

18.75kHz playing



+reflection moving away

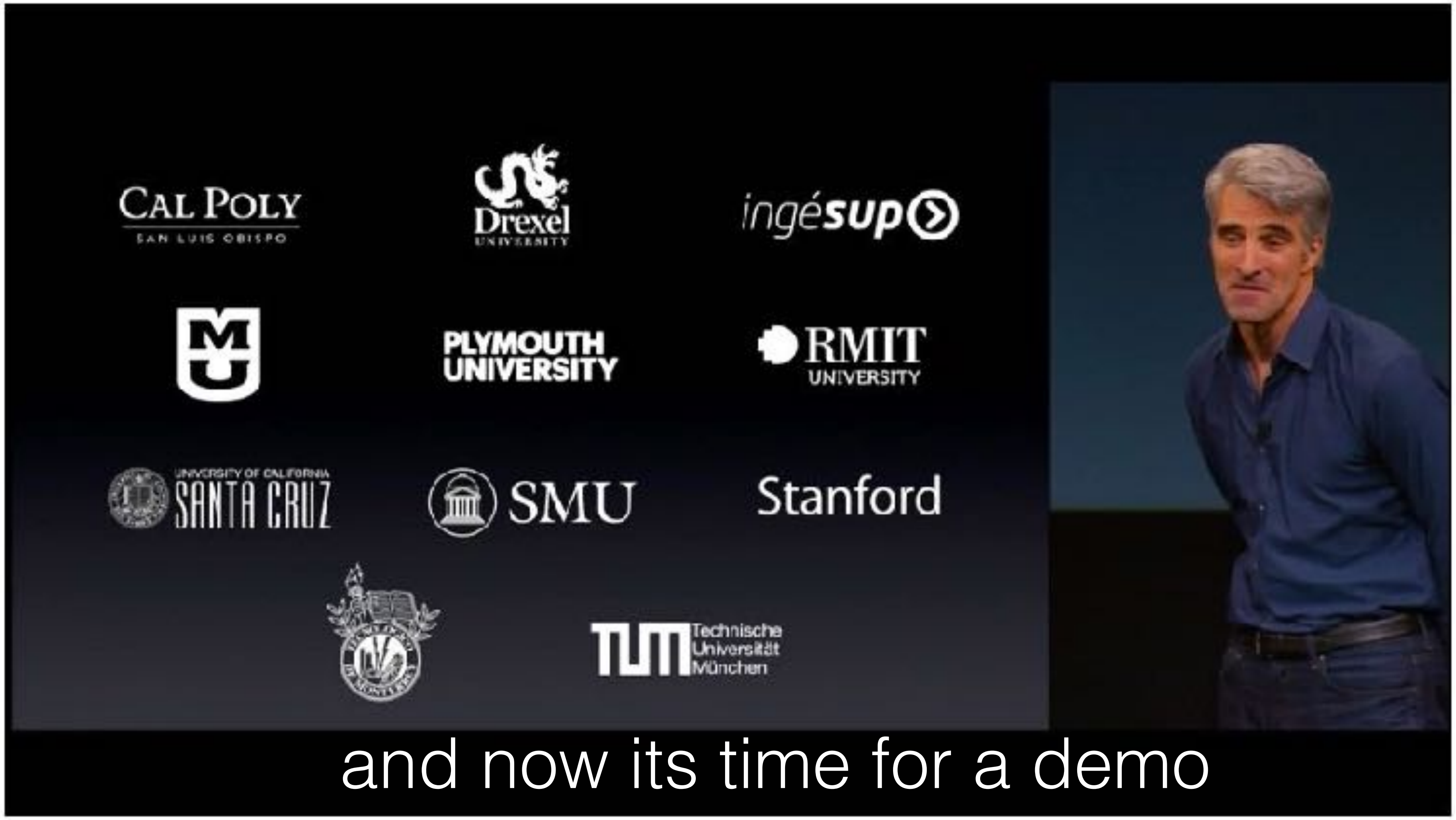
no reflections

+reflection moving toward

Questions on the FFT/audio

- we are about to move to motion processing…
- so ask now!
- …or later…

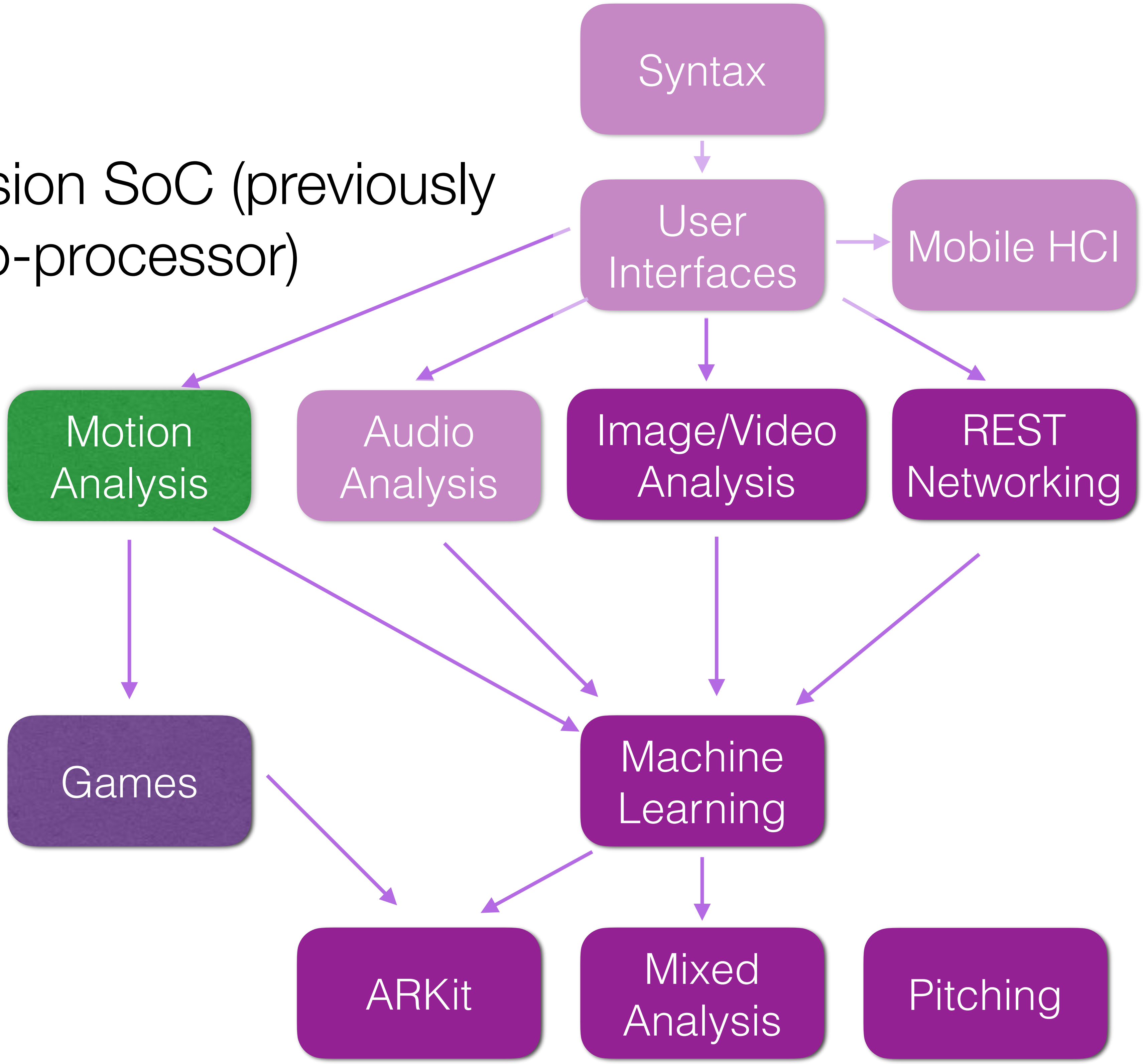
A2 specifications



Zoomed FFT

and now …

- core motion
  - A-series fusion SoC (previously M-series co-processor)

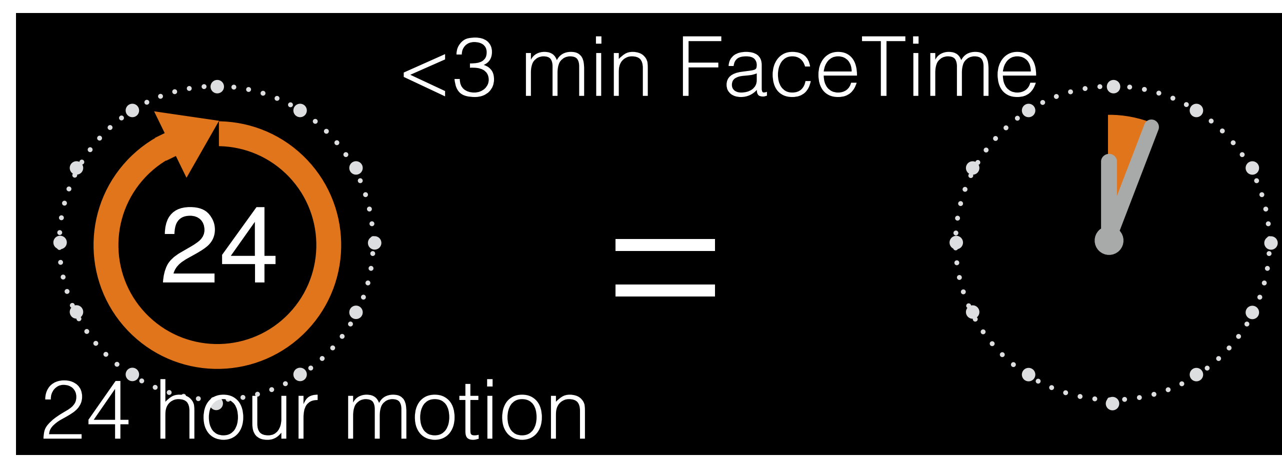


A-series fusion processor

- separate system on chip that reads all motion data from all "motion" sensors on the phone
    - accelerometer
    - magnetometer (compass)
    - gyroscope
    - barometer

- motion processor
- neural network engine
- GPU
- CPUs

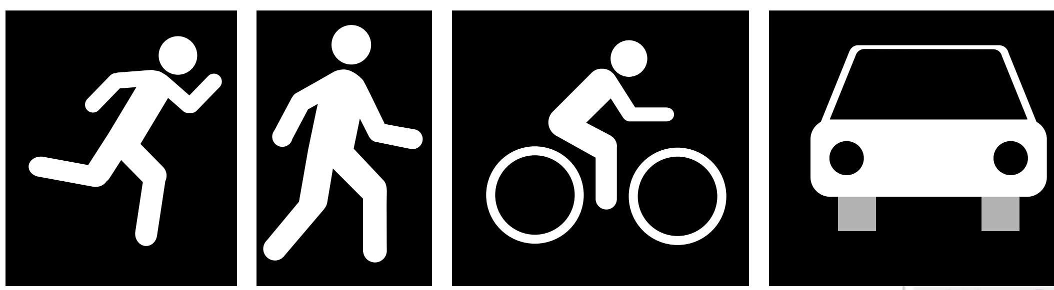
- mediates all access to data
    - battery life++
    - parallel processing++
    - overhead += 0, seriously

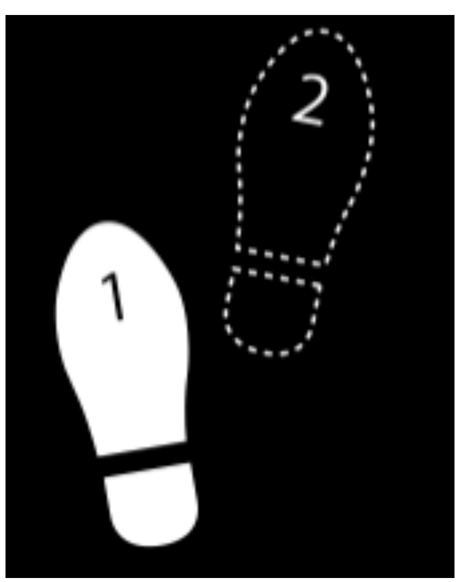


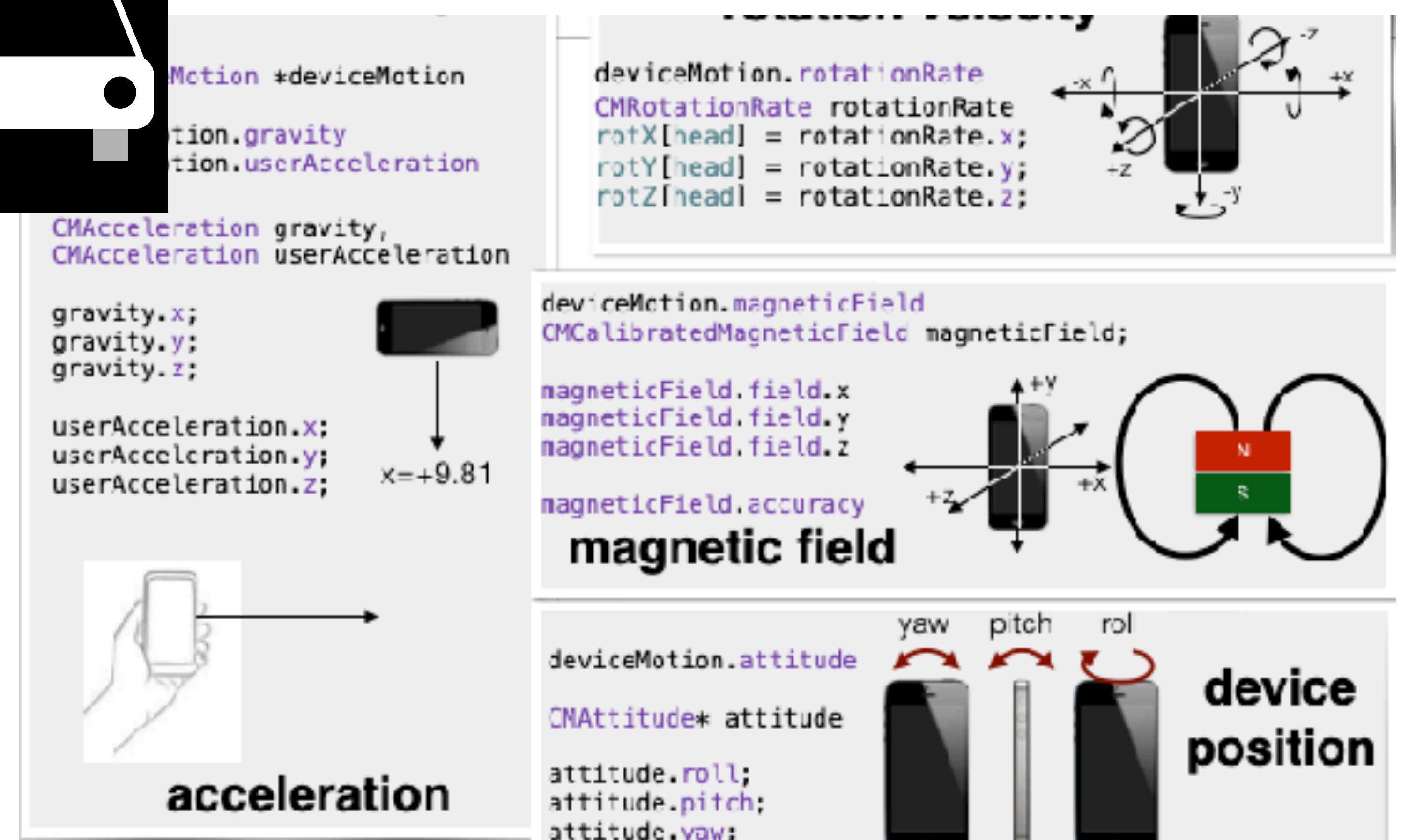
- sensor fusion for more accurate analysis, very cool

motion lecture agenda

- today: activity recognition through API
- today: pedometer step counting through API
- next time: raw motion data gathering

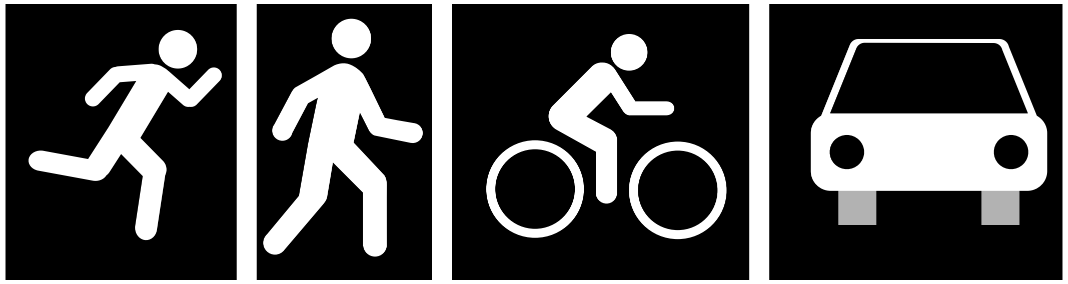






high level streams

- not just raw data!
    - the A-fusion series does sophisticated analysis of sensor data for you
    - enables naive access to “high level” information
- can register your app to receive “updates” from the co-processor unit
    - steps taken (and saved state of steps)
    - some common activity
        - running, walking, cycling, still, in car, unknown



activity from A-series

- uses the "core motion" framework (CM)
- mediated through the "CMActivityManager"
  - is device capable of activity?
  - query past activities (up to 7 days)
  - subscribe to changes
- interaction completely based on blocks and handlers

More help: https://developer.apple.com/videos/wwdc/2014/
Navigate to: **Motion Tracking and Core Motion Framework**

subscribe to activity

```
import CoreMotion

let activityManager = CMMotionActivityManager()
let customQueue = OperationQueue() // not the main

 override func viewDidLoad() {
     super.viewDidLoad()

     if CMMotionActivityManager.isActivityAvailable(){
         self.activityManager.startActivityUpdatesToQueue(customQueue)
         { (activity:CMMotionActivity?)  -> Void in
             NSLog("%@",activity!.description)
         }
     }
 }

 override func viewWillDisappear(animated: Bool) {
     if CMMotionActivityManager.isActivityAvailable() {
         self.activityManager.stopActivityUpdates()
     }
     super.viewWillDisappear(animated)
 }
```

import framework

declare activity manager

device capable?

closure to handle updates
(*this one just prints description*)

end subscription

what's in an update?

- updated when any part of activity estimate changes
- each update is a CMMotionActivity class instance
  - startDate (down to seconds)
  - walking {0,1}
  - stationary {0,1}
  - running {0,1}
  - cycling {0, 1}
  - automotive {0,1}
  - unknown {0,1}
  - confidence {Low, Medium, High}

```
startActivityUpdatesToQueue:[NSOperationQueue mainQueue]
                withHandler:^(CMMotionActivity *activity)
{
              // do something with the activity info!
                                  }];
```

```
self.activityManager.startActivityUpdatesToQueue(customQueue)
                { (activity:CMMotionActivity?)  -> Void in
                // do something with the activity info!
            }
```

example update

inside handler

```
startActivityUpdatesToQueue:[NSOperationQueue mainQueue]
                withHandler:^(CMMotionActivity *activity) {
              // do something with the activity info!
                                      }];


  // enum for confidence is 0=low,1=medium,2=high
NSLog(@" confidence:%ld \n stationary: %d \n walking: %d \n run: %d \n cycle %d \n in car: %d",
          activity.confidence,
          activity.stationary,
          activity.walking,
          activity.running,
          activity.cycling,
          activity.automotive);


       switch (activity.confidence) {
           case CMMotionActivityConfidenceLow:
               self.confidenceLabel.text = @"low";
               break;
           case CMMotionActivityConfidenceMedium:
               self.confidenceLabel.text = @"med.";
               break;
           case CMMotionActivityConfidenceHigh:
               self.confidenceLabel.text = @"high";
               break;
           default:
               break;
       }
```

from notification

access fields easily

look at confidence

past activity

- query for an array of CMMotionActivity activities

setup date range

set dates

set queue

```
// example of querying from certain dates
NSDate *now  = [NSDate date];
NSDate *from = [NSDate dateWithTimeInterval:-60*60*24 sinceDate:now];



[self.motionActivityManager queryActivityStartingFromDate:from
                 toDate:now
                 toQueue:[NSOperationQueue mainQueue]
  withHandler:^(NSArray *activities, NSError *error) {

     for(CMMotionActivity *cmAct in activities)
     {
         NSLog(@"At %@, user was walking %d",cmAct.startDate,cmAct.walking);
     }

}];
```

handle error!

handle output

- can you guess what the swift code looks like?

what's in an update?

Example Scenarios

Device scenarios	stationary	walking	running	automotive	cycling	unknown
On table	true	false	false	false	false	false
On runner's upper arm	false	false	true	false	false	false
In dash of idling vehicle	true	false	false	true	false	false
In dash of moving vehicle	false	false	false	true	false	false
Passenger checking email	false	false	false	false	false	false
Immediately after reboot	false	false	false	false	false	true
In zumba class	false	false	false	false	false	false

https://developer.apple.com/videos/wwdc/2014/

what's in an update?

Motion Activity

Walking

Performance is fairly insensitive to location

- Detection can be suppressed when device is in hand

Relatively low latency

Very accurate, on average

- Expect intermittent transitions into and out of walking state

https://developer.apple.com/videos/wwdc/2014/

what’s in an update?

Motion Activity

Running

Completely insensitive to location

Shortest latency

Most accurate classification

https://developer.apple.com/videos/wwdc/2014/

what's in an update?

Motion Activity

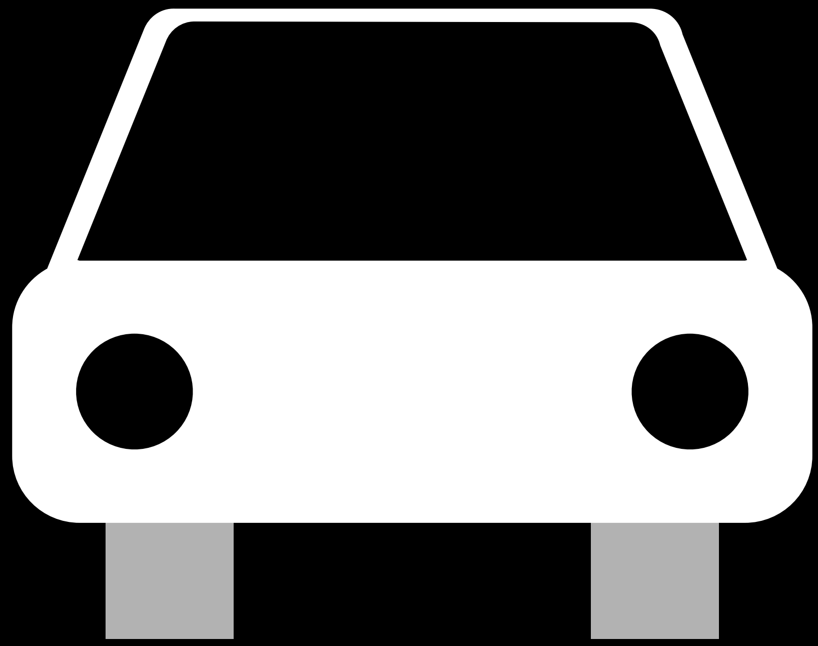
Automotive

Performance is sensitive to location

- Works best if device is mounted, or placed in dash or in cup holder

Variable latency

Relies on other information sources when available



https://developer.apple.com/videos/wwdc/2014/

what's in an update?

Motion Activity

Cycling

Performance is very sensitive to location

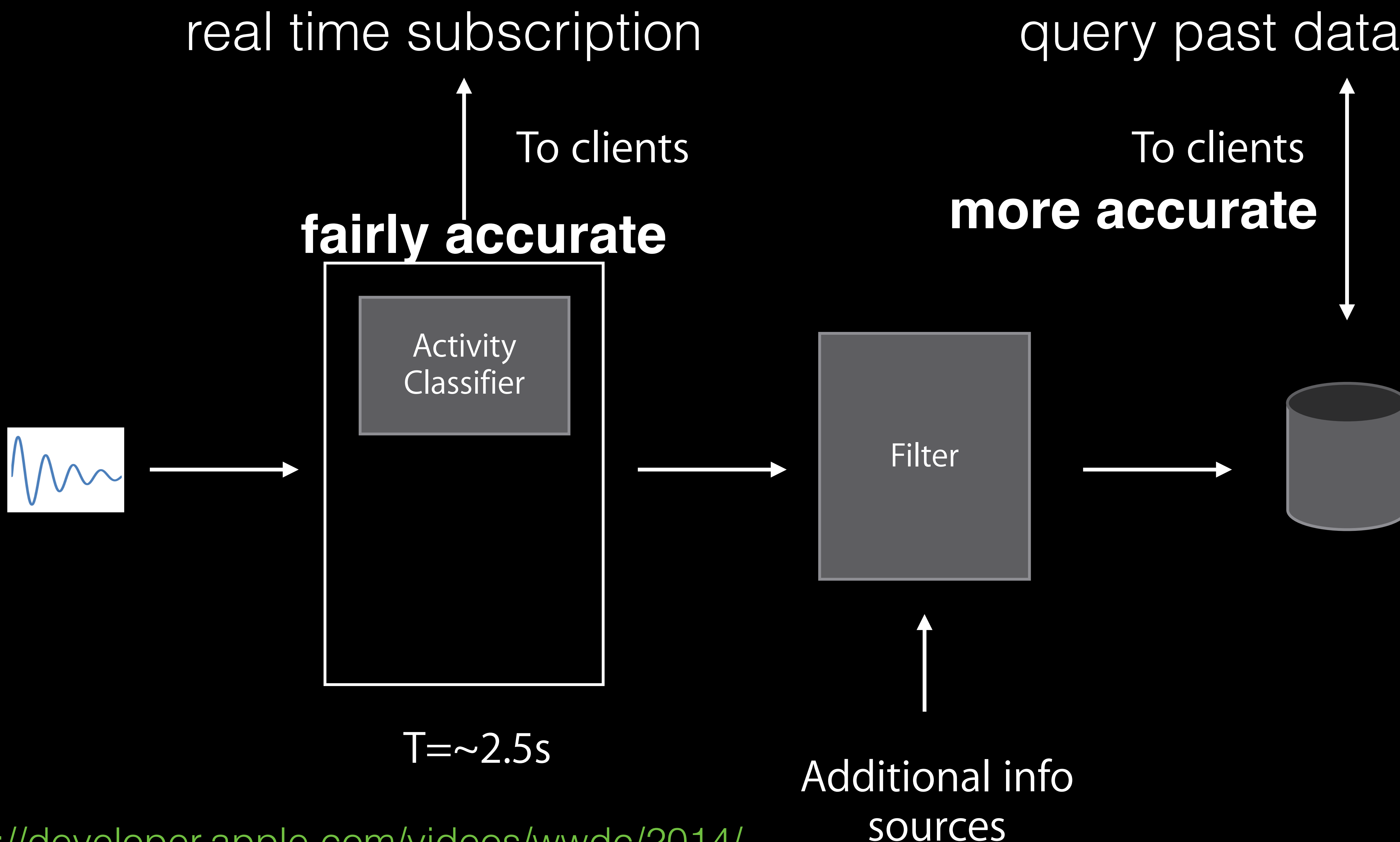
- Works best if device is worn on upper arm

Longest latency

- Best for retrospective use cases

https://developer.apple.com/videos/wwdc/2014/

Motion Processing Architecture



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