Introduction to Imaging

Imaging

- **Everyone knows about cameras…**

- **What else might you be interested in “imaging”?**

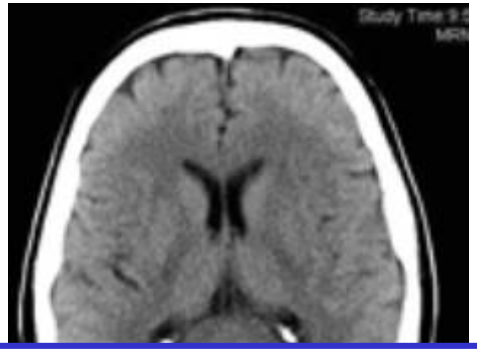
Medical Imaging ca. 1895

- **Need to find a way to see inside without "light"**

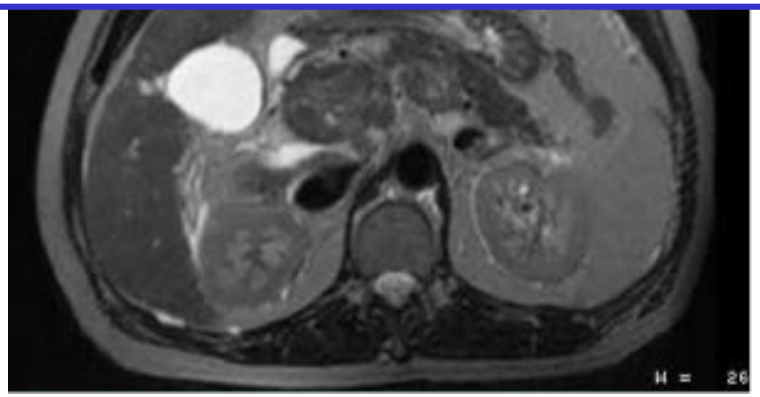
Medical Imaging Today

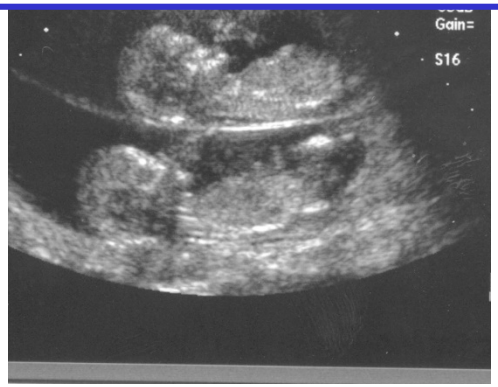
X-Ray

CT

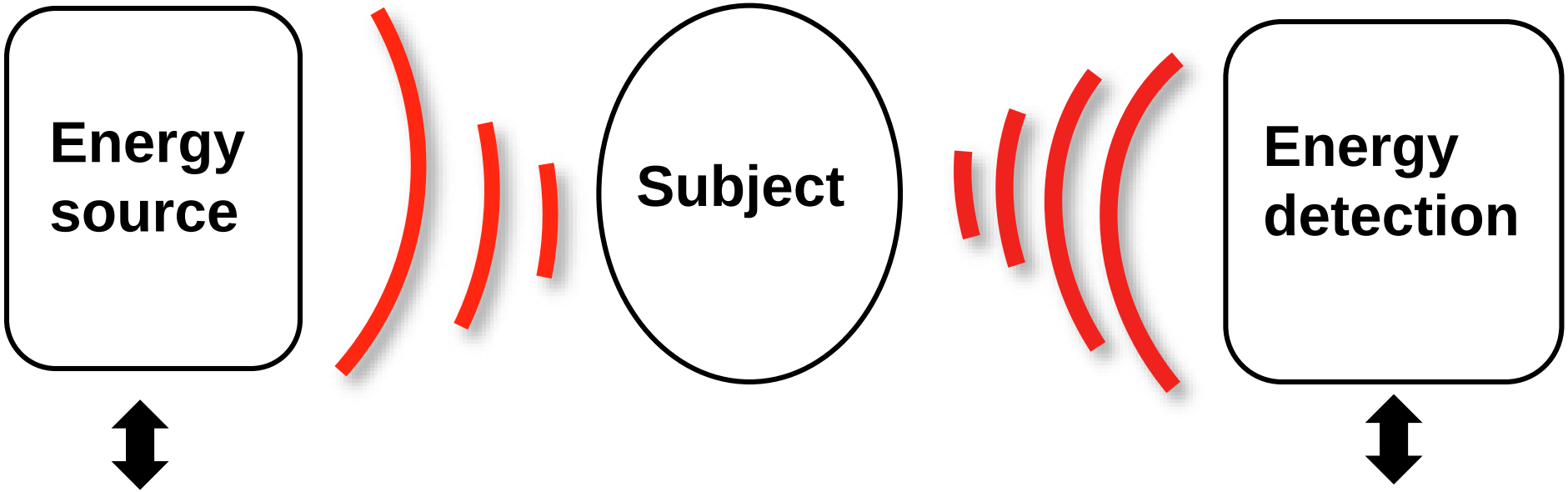


All of these were enabled/dramatically advanced by the mathematical and hardware design techniques you will learn in this class!





Imaging In General



Simplest Imaging System

- **What is the absolute smallest number of components you need to make an imaging system?**

Simple Imager Example

Simple Imager Example

Actual Imager: Your Cellphone Camera

- **What is the source of light?**
- **Does it use any moving components?**
- **How does it figure out which point is which?**

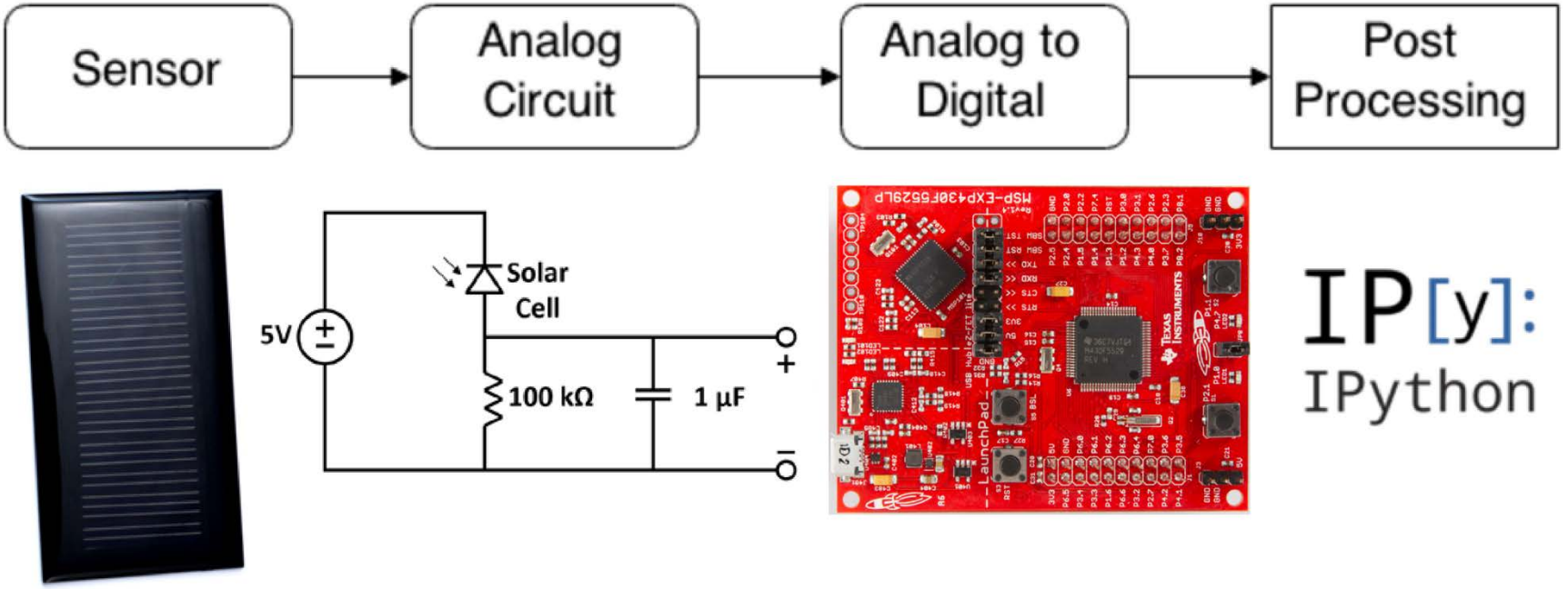
Another Example: Ultrasound Imaging

- **Sound waves travel into body and an echo signal is recorded. This echo is due to changes in material properties (fat, muscle, fluid, ...)**

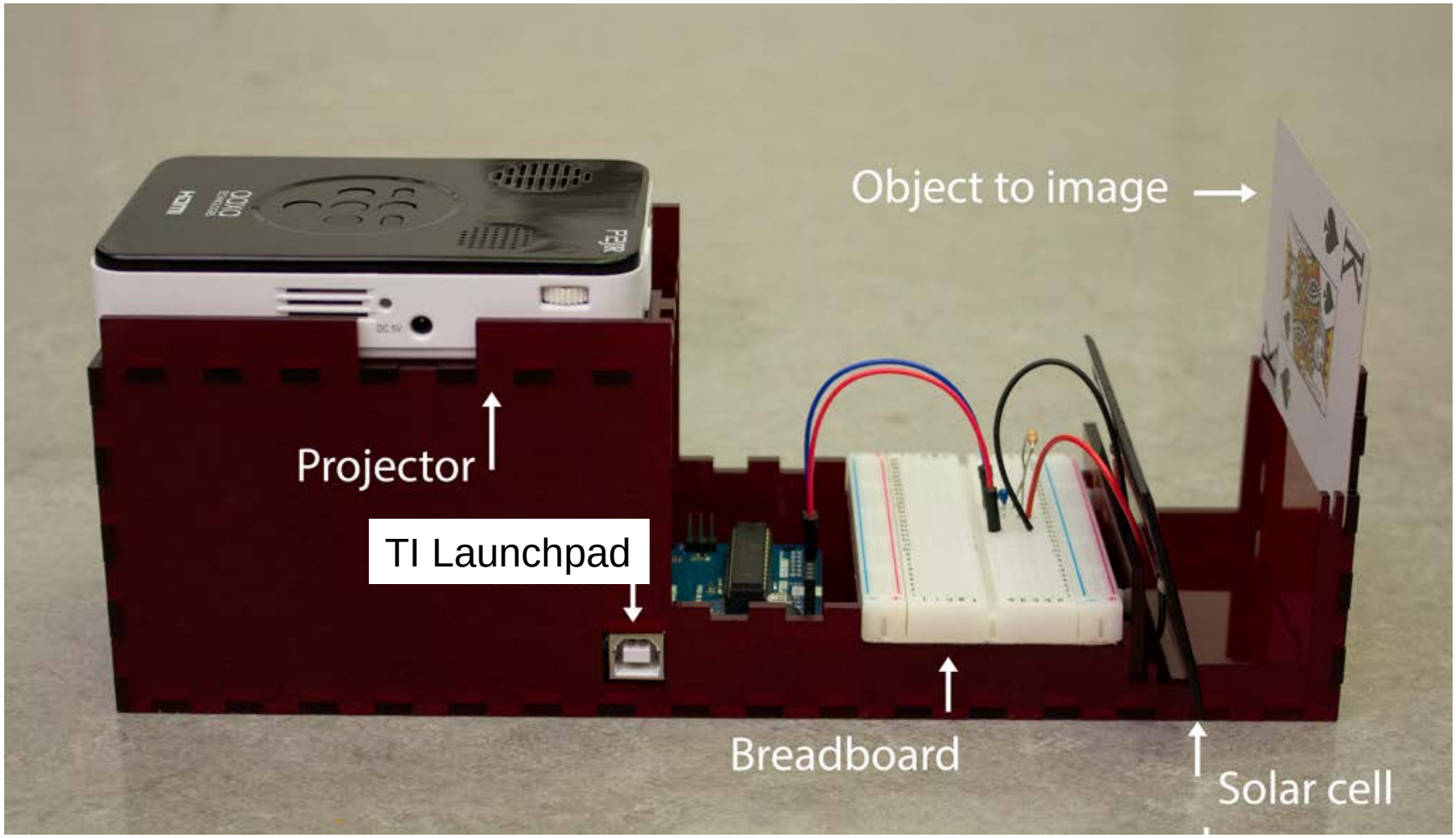
- **The depth dimension is recovered by keeping track of how long it took the echo to come back**

- **The x-y dimensions are recovered by electronically focusing and steering the sound waves**
  - I.e., no moving parts needed (except for the transducer itself)

Imaging Lab #1



Your Setup


Object to image
Projector
TI Launchpad
Breadboard
Solar cell

An Imager with Just One Sensor?

- **After all, today's cameras have millions of pixels…**
- **Great teaching vehicle: you can actually get a lot out of surprisingly simple designs**
  - Once you know the right techniques!
- **In some systems the sources and/or detectors might actually be expensive**
  - Take this opportunity to learn a little more about how detectors usually work
  - And how we get them to "talk" to our electronic systems

Photodetector Basics

- **Let's focus on light as our example source**
  - Same basic principles apply to many other detectors
- **Turns out that light comes in discrete packets called photons**
  - The brighter a source of light is
  - The more photons it is emitting over a given period of time
- **An electronic photodetector captures these photons and converts them to electrons**
  - Electrons are the basic unit of **electrical charge (Q)**

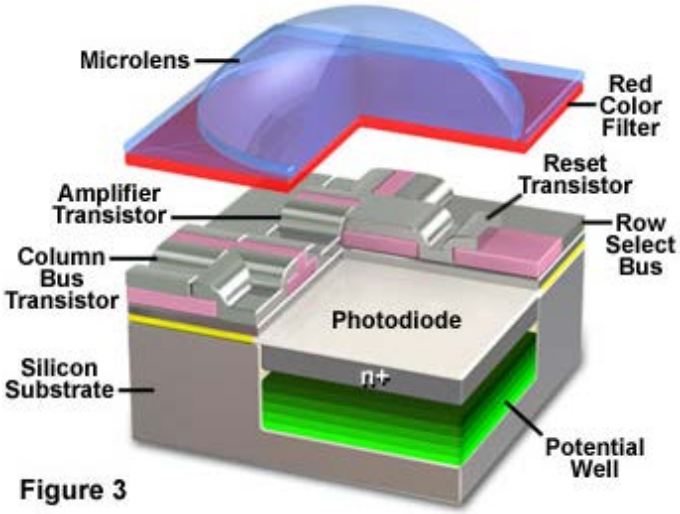


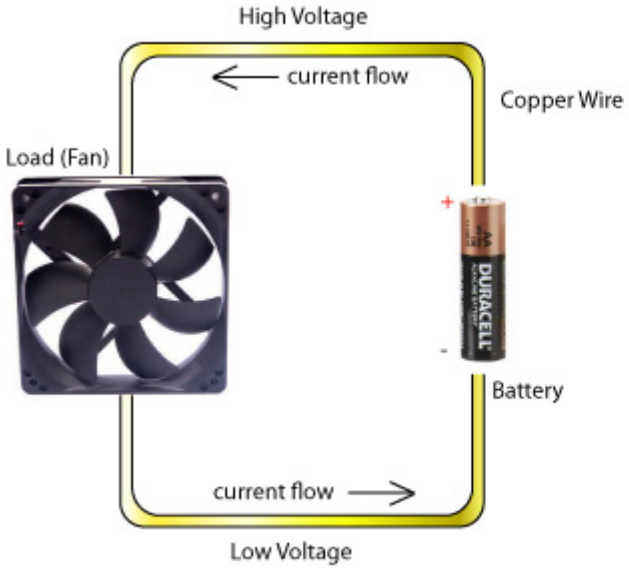
Figure 3

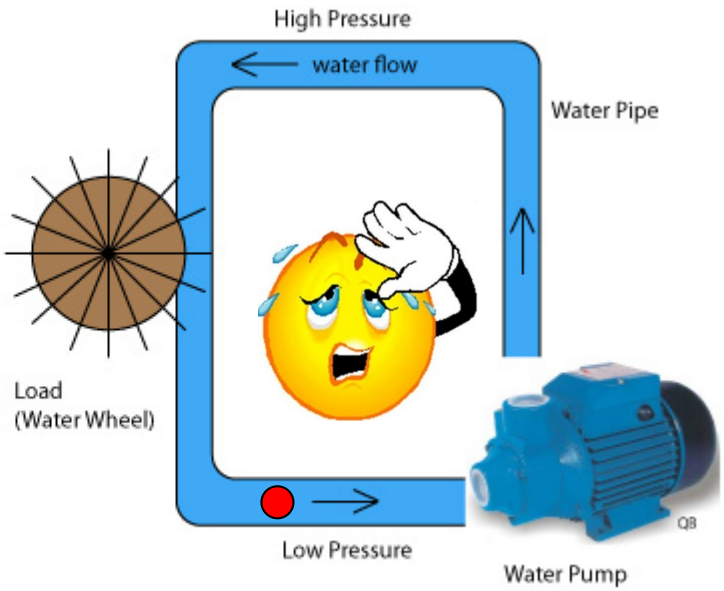
So What Do We Do With Those Electrons?

- **Simplest option might be to let those electrons build up somewhere over a period of time**
  - And then count how many we accumulated

- **All electrical elements (including the photodetectors themselves) can actually build up charge (electrons)**
  - The more charge they store, the higher the **voltage (V)** across them
  - The relationship between the amount of charge and the voltage is known as **capacitance (C)**
    - Defined by **Q = C*V**
  - The number of electrons flowing through the device per unit time is defined as the **current (I)**

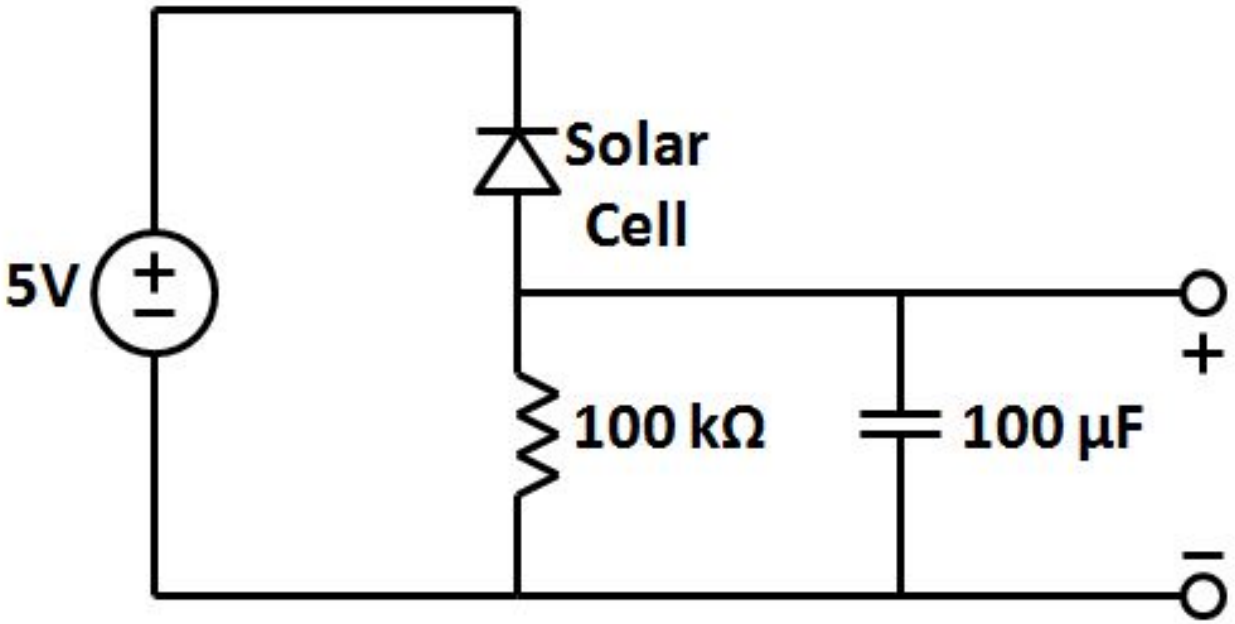
An Analogy (More Later)





- **Key points for now:**
  - **Current flows from high to low voltage (high pressure to low pressure)**
  - **These are called “circuits” for a reason – the loop has to be closed**

Photodetector:
The Actual Circuit You'll Use



More Complex Imaging Scenario

- What if we can't shine light (i.e., focus energy) either uniformly on all spots or in just one spot?

- The signal we receive on our detector will be a **linear combination** of several features of the image from different points.

- Can we recover the original image?
  - In many cases, yes!
  - Will start to see how next…