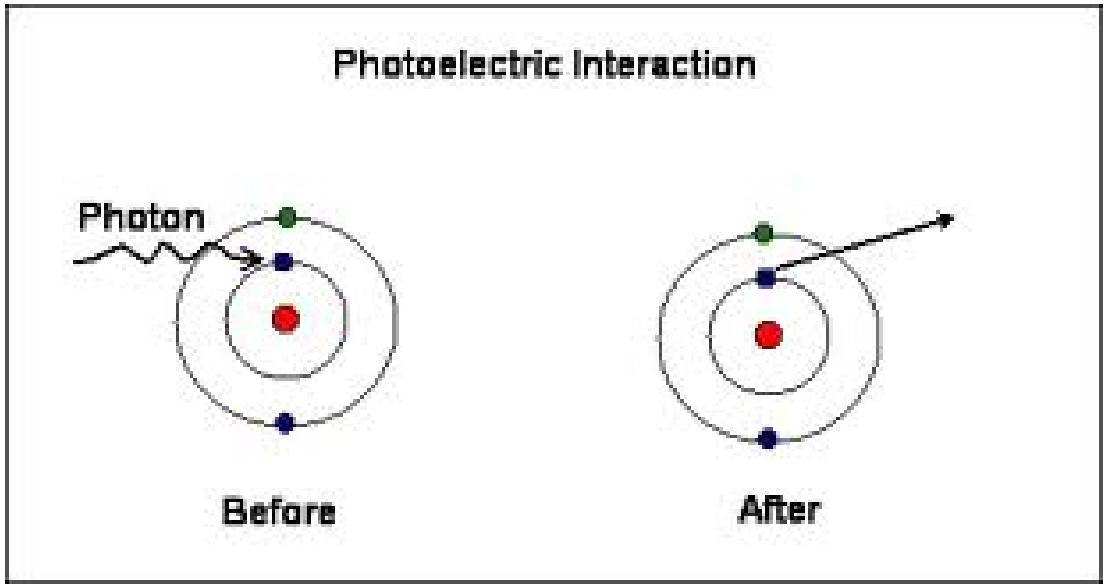
Detecting photons

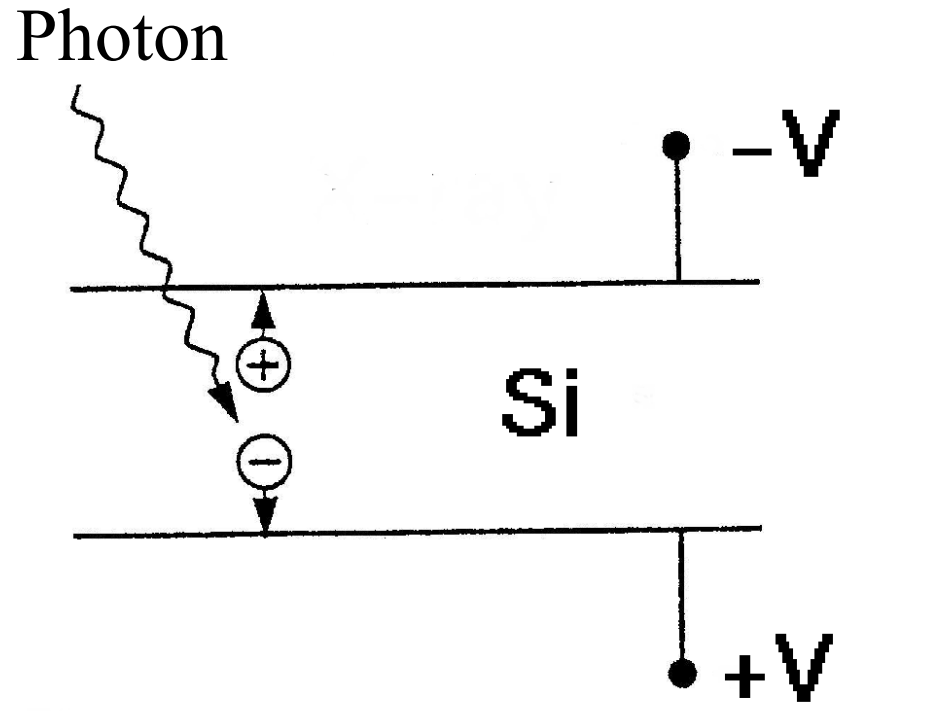
- Interactions of photons with matter
- Properties of CCD detectors

Interaction of visible photons with matter



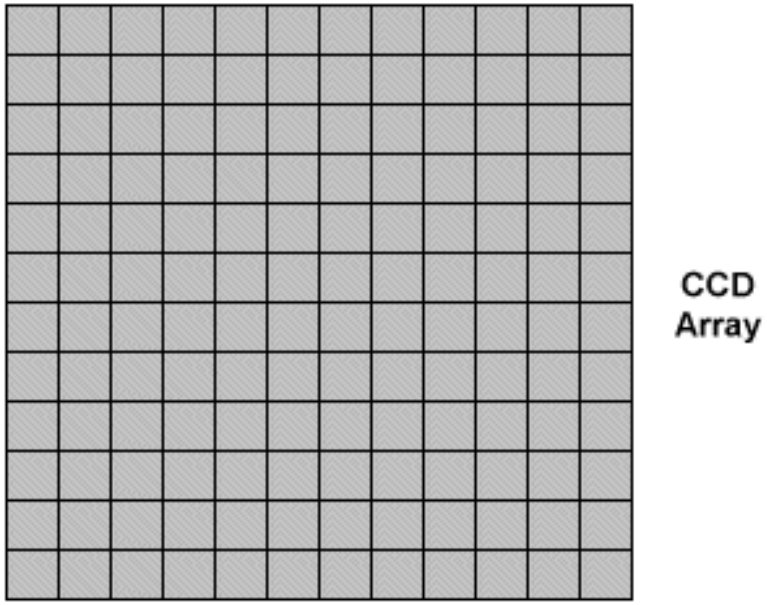
- Photoelectric absorption
  - Photon interacts with atom, ejects an electron

Solid State Detectors



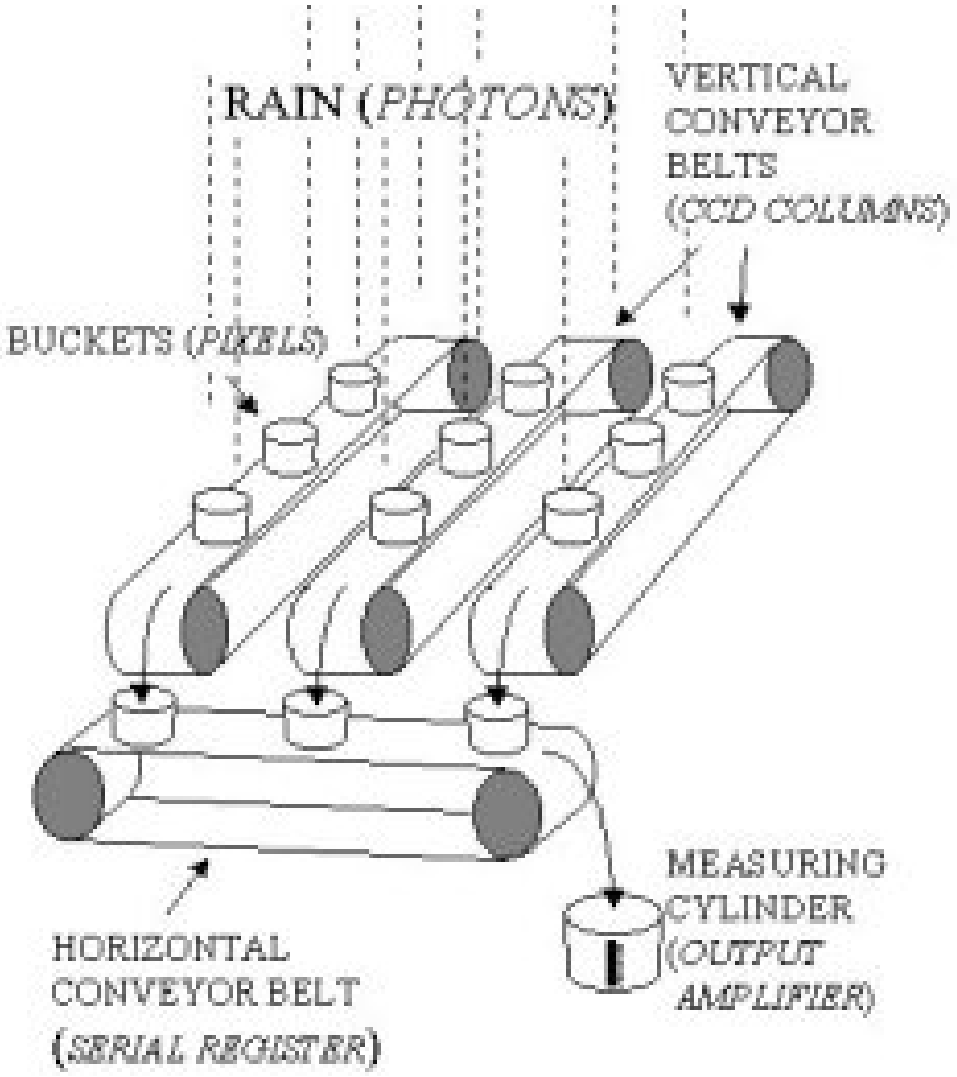
Photon interacts in material, usually silicon, to produce photoelectrons which are collected by applying an electric field.

Charge Coupled Device (CCD)



- Lots of little boxes of silicon.
- Photon will leave charge in the box in which it interacts.
- Distribution of photons = image = distribution of charges.
- Need to collect charge from each box.

Charge Coupled Devices



Charge Transfer in CCDs

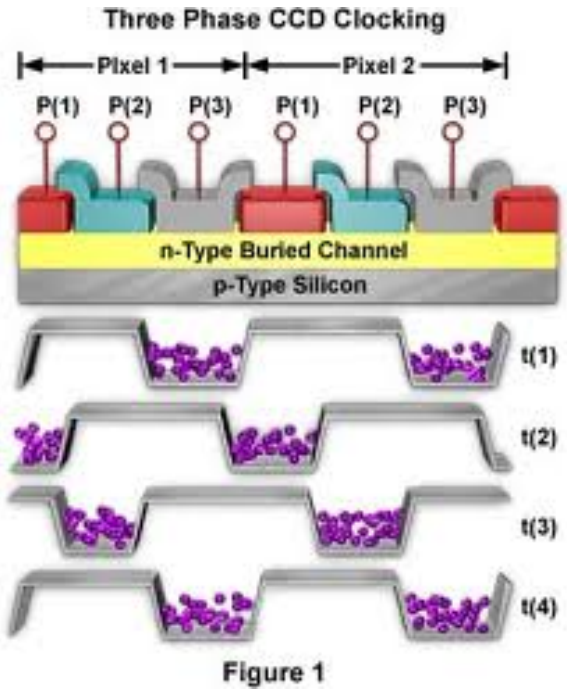
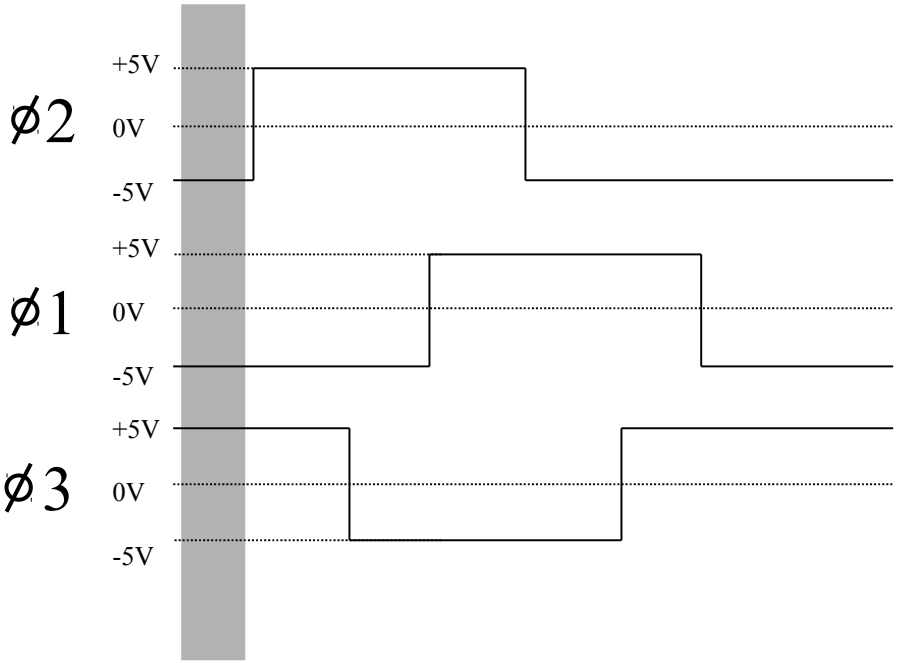
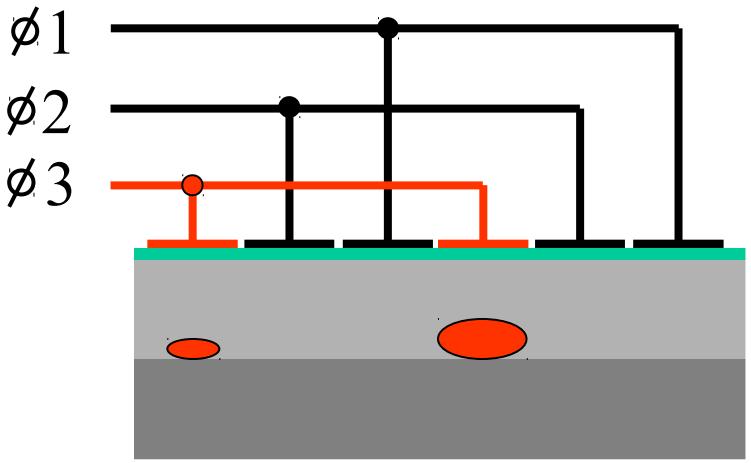


Figure 1





Time-slice shown in diagram

Measuring the Charge

- After moving the charge from bucket to bucket, we then need to measure the charge.
- Use amplifier to convert charge to voltage.
- Use analog to digital converter (**ADC**) to convert voltage into a digital value (Analog to Digital Unit = **ADU**).
- **Gain** = # electrons/ADU.
- **Noise** = fluctuations in charge measurement = # electrons.
- Output from CCD is a list of ADU values. Knowing the number of rows and columns in the CCD, we can convert the list into a 2-d image.

CCD Properties

- Quantum efficiency = QE = probability that a photon of a particular wavelength with produce an electron in the CCD.
  - eye ~ 10%, film ~ 2%, modern CCD 60%-90%

- Readout noise
  - Depends on CCD and operating temperature
  - 2-5 electrons with good CCD cooled to low temperature

- Bandpass – range of wavelengths with high QE
  - Eye 4500-6500 Å, CCD UV (1500 Å) to near IR (10,000 Å)