An introduction to

Ground-based Telescopes

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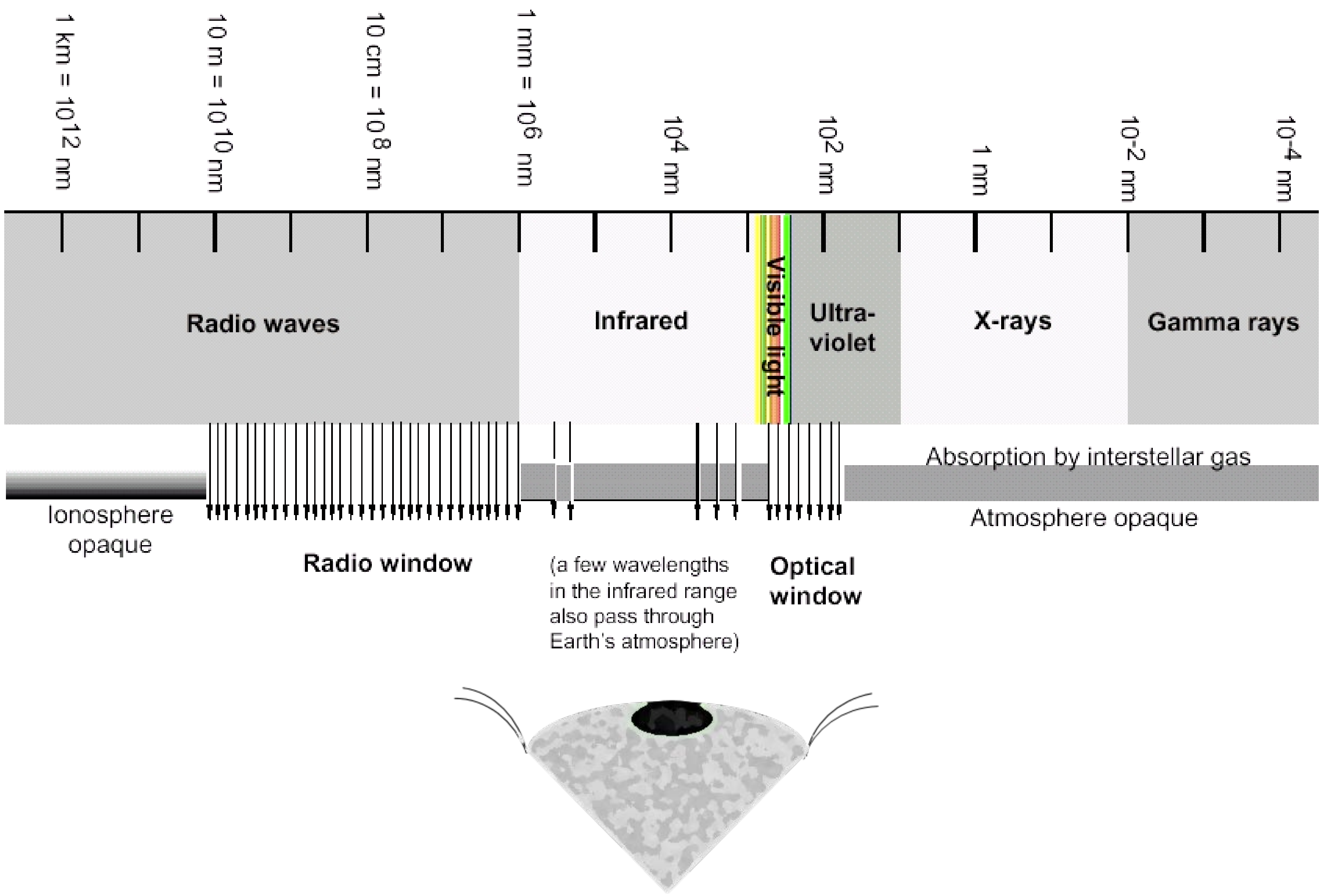
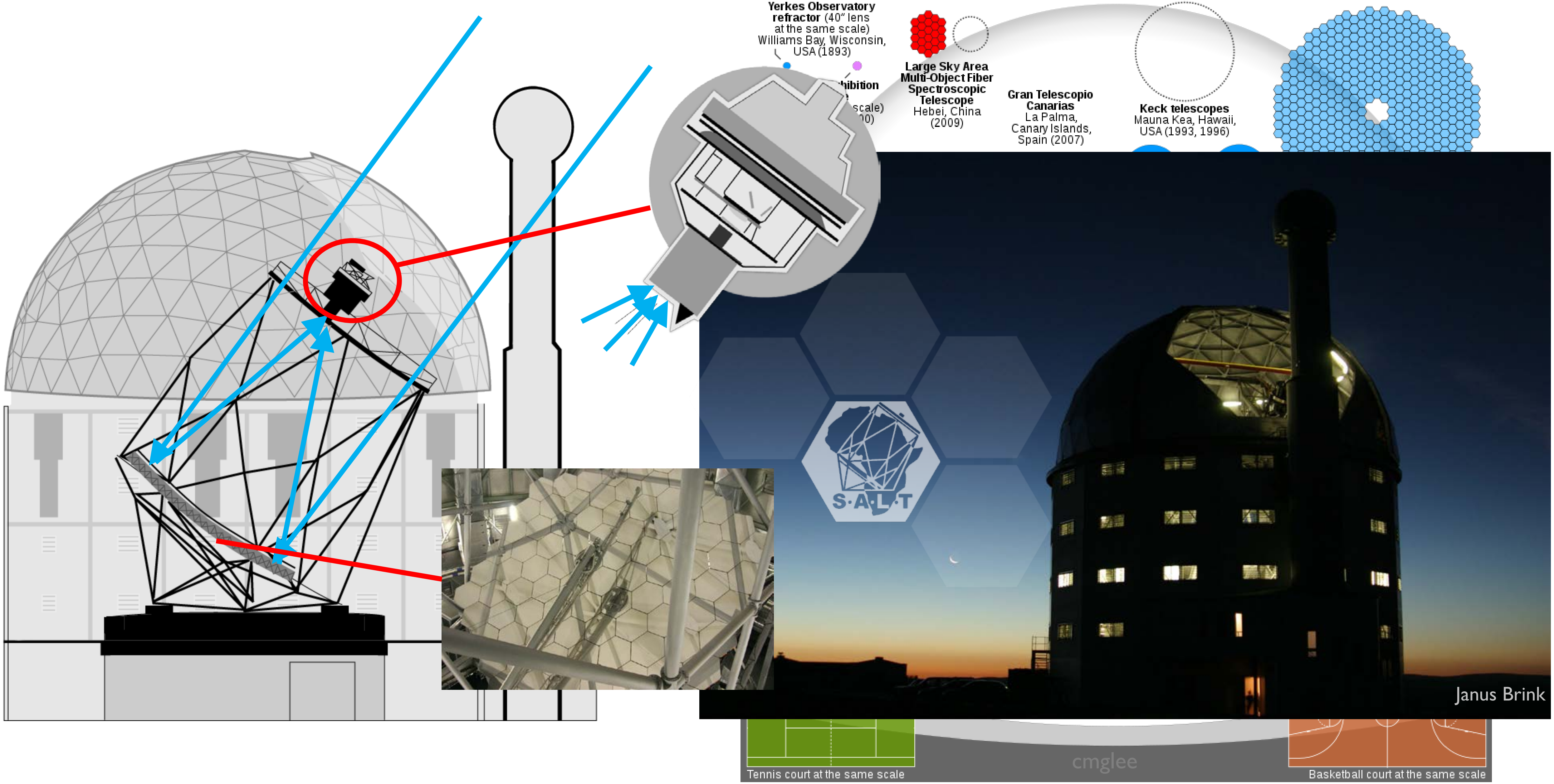
Why isn't every telescope on the ground?

- Only a portion of the electromagnetic spectrum can readily make it through the atmosphere without significant (or complete) absorption
  …which is mostly a good thing!

- The two wavelength regimes we can observe from the ground are
  - the optical window: mostly visible, but also some UV and infrared
  - the radio window



Optical telescope example: *SALT*



Environmental factors for optical telescopes

- Clouds are bad
  - ➢Go to a tropical place
- Humidity is bad
  - ➢Go to a dry place
- City lights are bad
  - ➢Go to a remote place
- Turbulent air is bad
  - ➢Go to high altitudes

Adaptive optics (i.e. tilting and warping the mirrors based on real-time atmospheric measurements) can help overcome remaining issues.
…or for a cool $4.7 billion, you can go into space (HST)

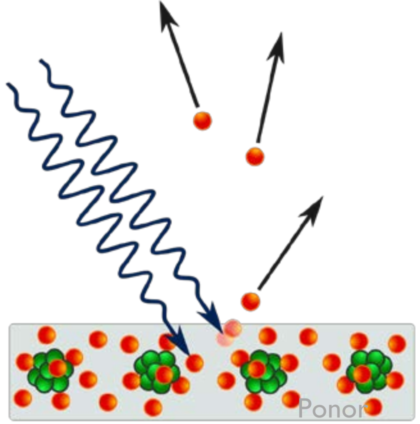
Kitt Peak (Arizona)

Keck (Hawaii)

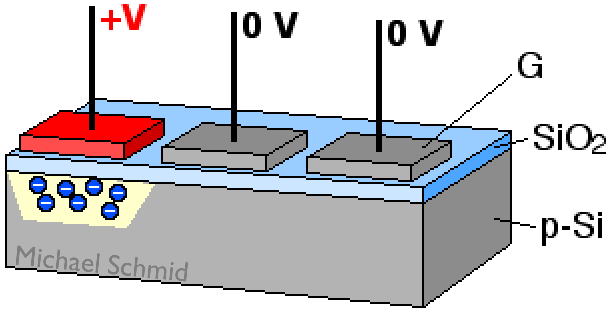
VLT (Chile)

GTC (Canary Islands)

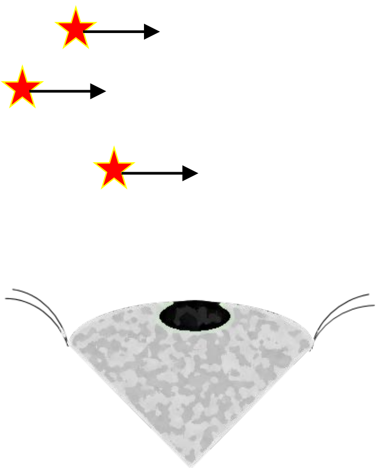
Optical light detection: *CCDs*

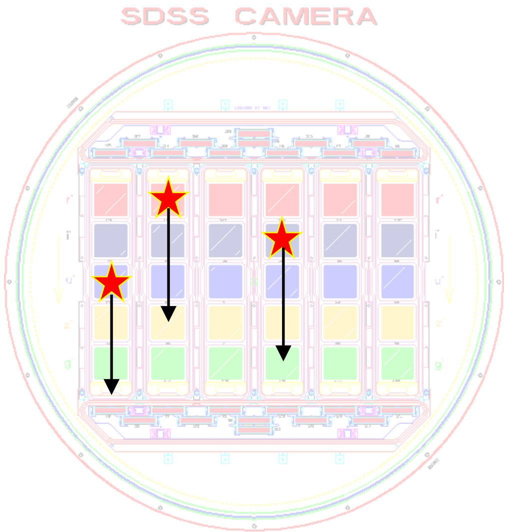


- Charged-couple devices (CCDs), like in nice digital cameras, are the light detector of choice in the optical
- The process is the following:
  1. Light hits the sensor and a photon frees electrons, which is the photoelectric effect
  2. Those electrons are trapped in place by a voltage
  3. The electrons are transported to an amplifier, which converts the charge to voltage, which can then be processed as a signal



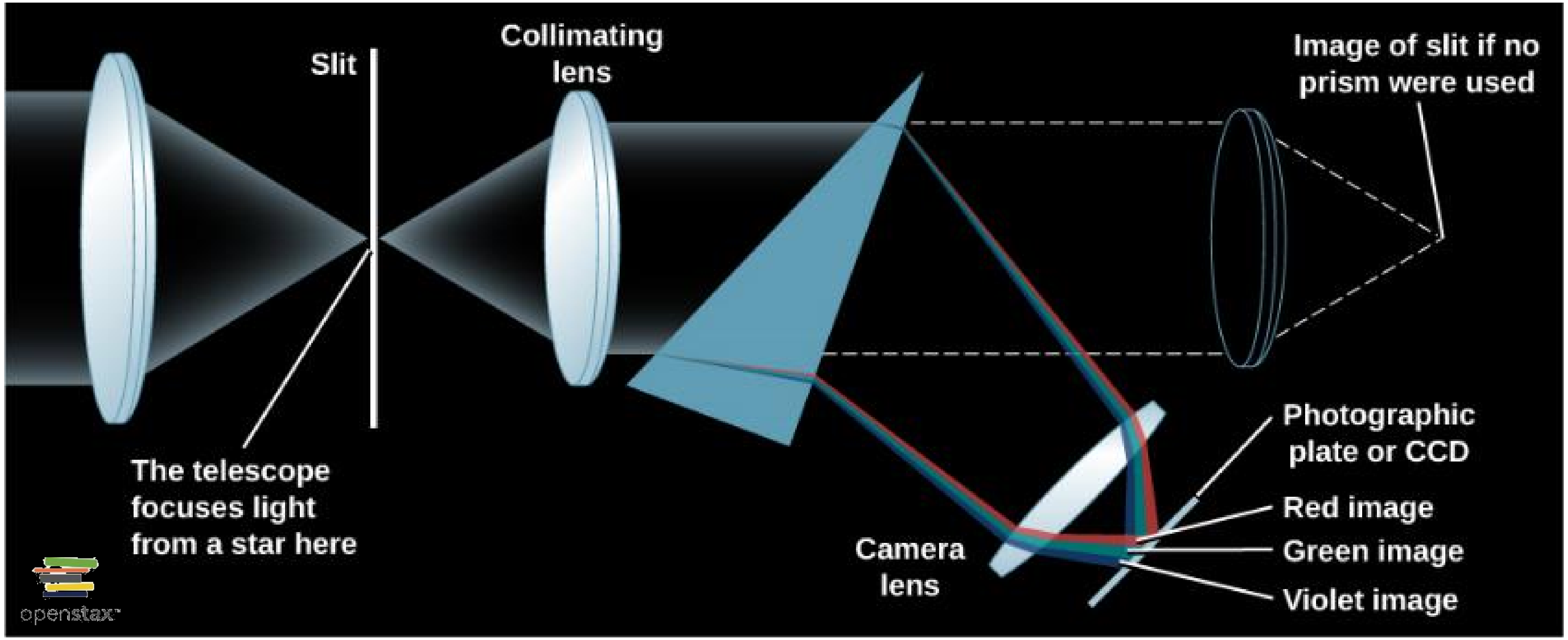
- Longer exposures over a larger field of view can be collected than would otherwise be possible, since the charges can be transferred at the rate that the sky moves across the face of the telescope.
  This is "drift scanning".



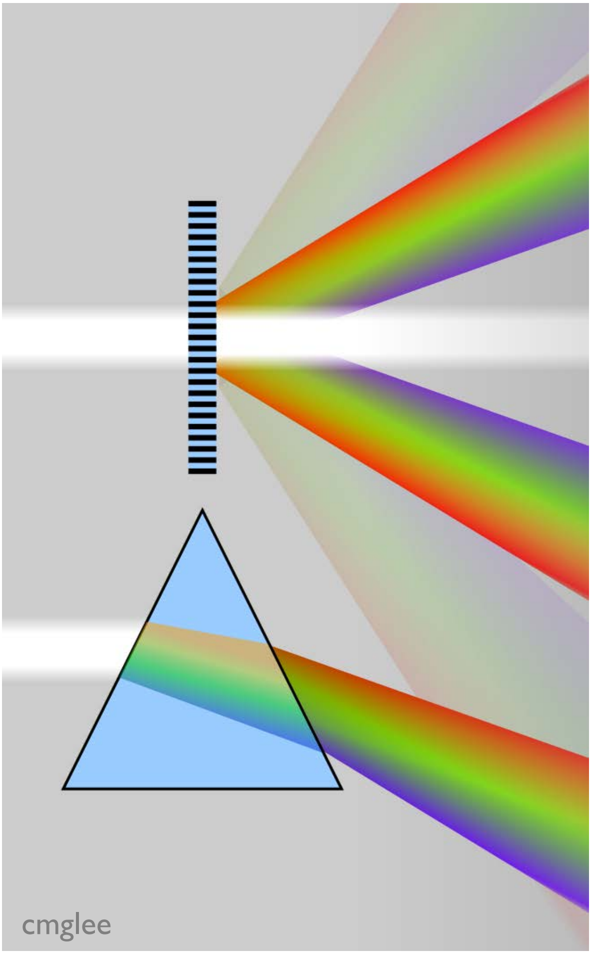


Spectrometry: *separating light by λ*

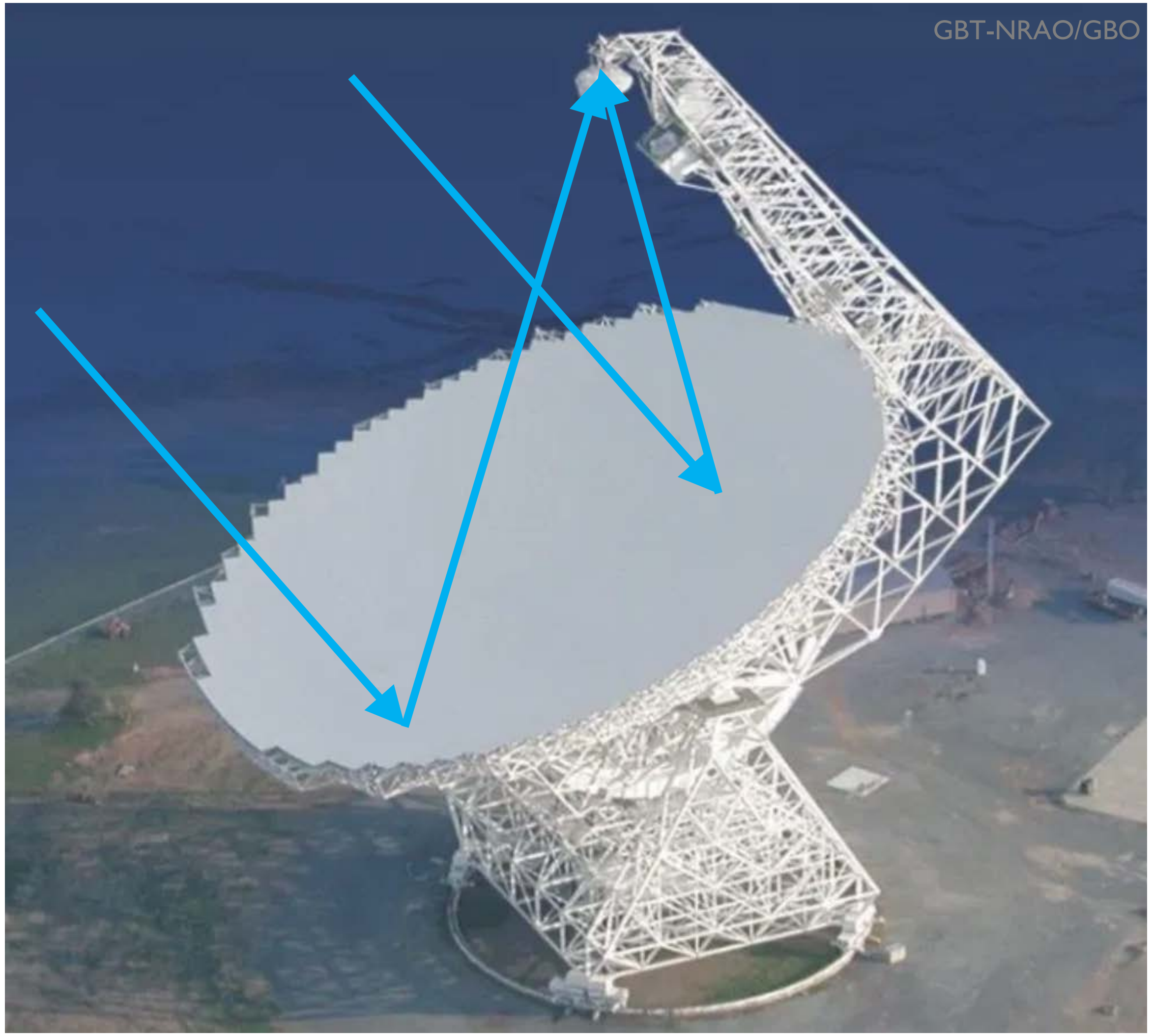
The old school way:



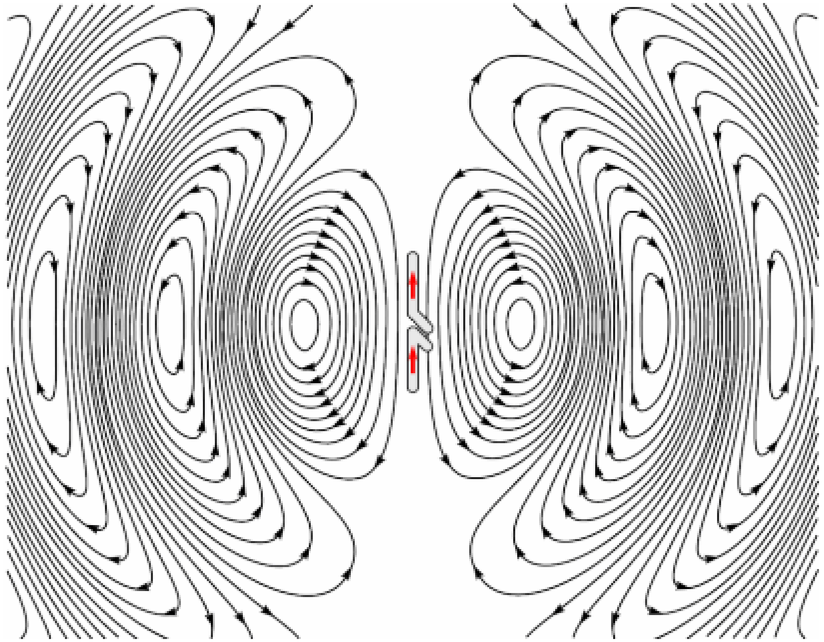
The modern way:



Radio telescope example: *Green Bank*

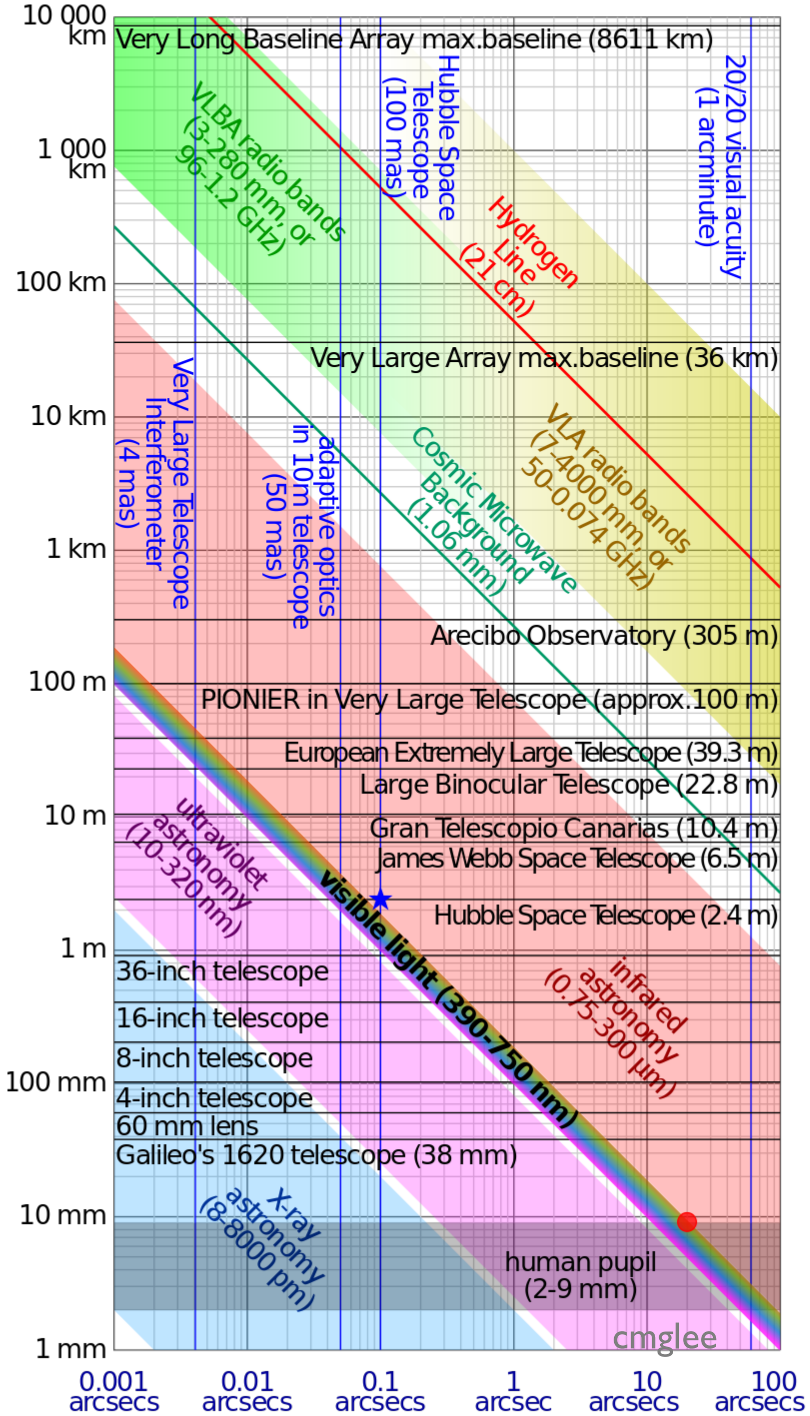


Antenna principle for *radiating* radio waves



Ratio telescope resolution limits

- Recall $R \approx \frac{\lambda}{D}$.
- Since λ meters or more, the aperture diameter has to be huge to have adequate resolution
  - Option 1: build a huge telescope
  - Option 2: build an array of telescopes



Radio interferometry

- This increases the resolution (*though not the collecting area*): $R \approx \frac{\lambda}{B}$ where B is the telescope separation
- For example, the Very Line Baseline Array (VLBA) has $B{\sim}8600\ km$ and the λ of interest is $\sim 1\ m$, so $R \approx 10^{-7}$ (~22 milliarcseconds)

- 1 arc minute = 1/60 of a degree.
- 1 arc second = 1/3600 of a degree