Our Place In the Galaxy & Navigating using the Stars

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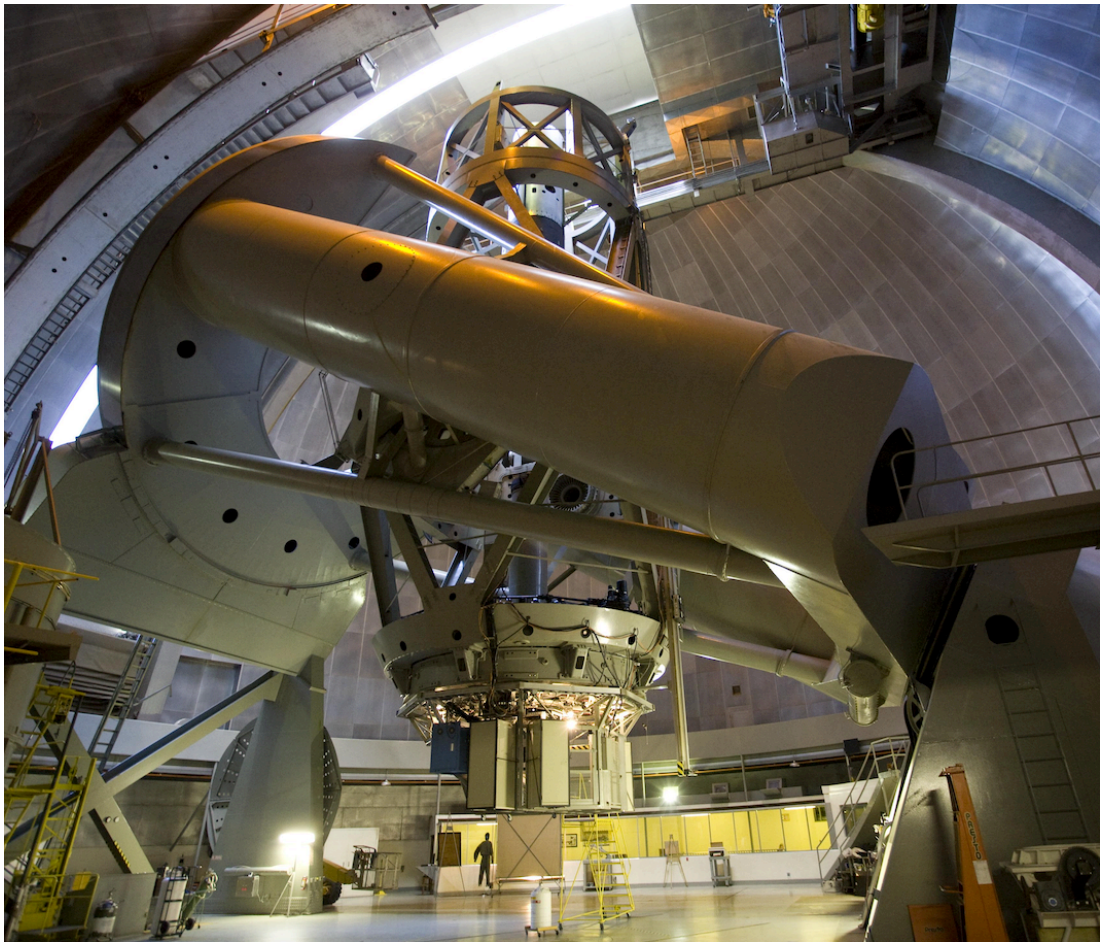
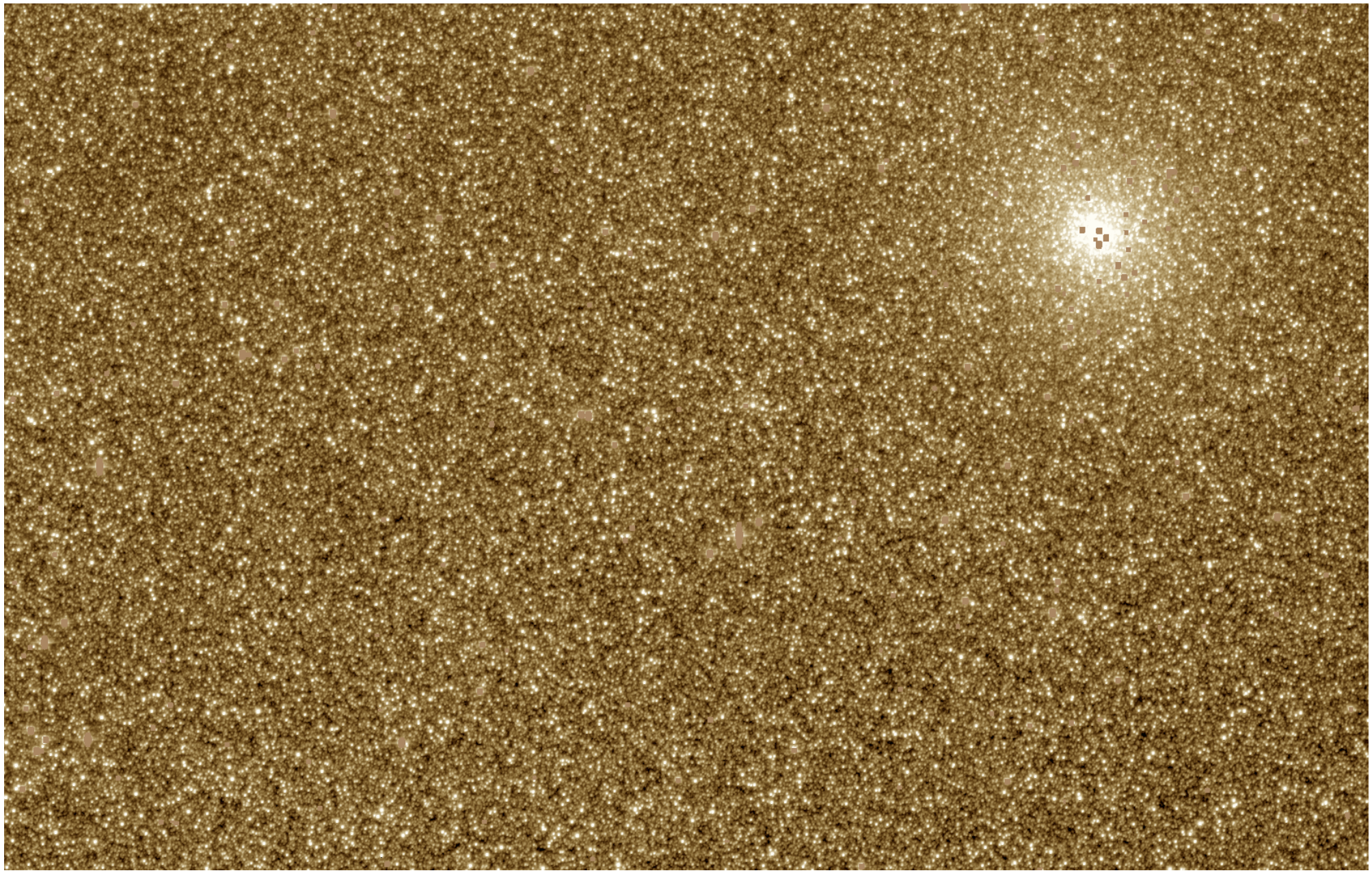
Troop4 Meeting, May 10, 2021

Something About Me

- I am an astronomer at Caltech in Pasadena (since 1998).
- Received a lot of training in math, physics, computer science, and programming.
- Analyze images taken with big telescopes around the world using AI, Machine Learning.
- Goal: discover objects - new types of exploding stars (supernovae), asteroids, galaxies.

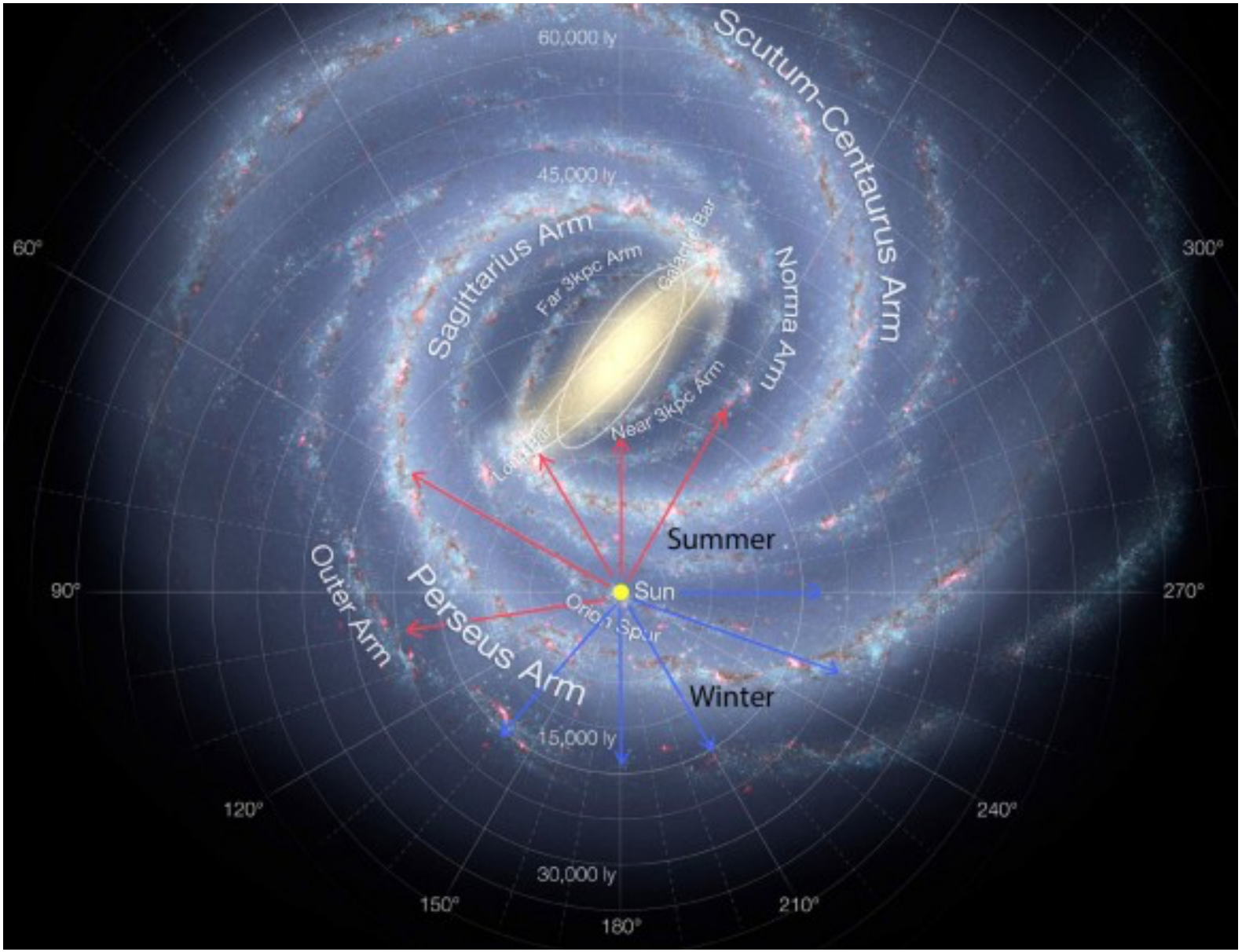


An example image from Mt. Palomar Observatory



We can see about 2500 stars on a clear moonless night, away from city lights!

Our Milky Way Galaxy "from above"

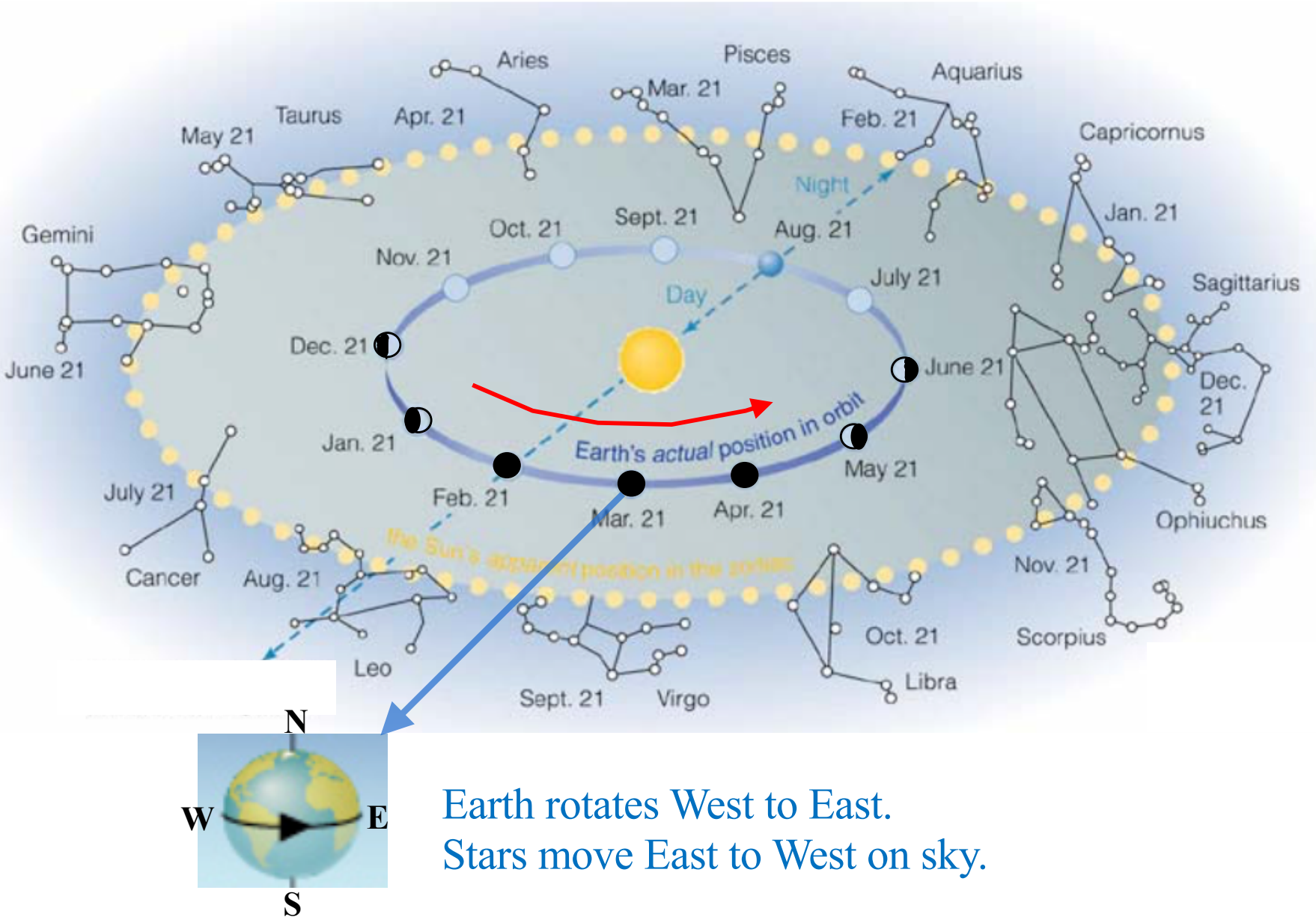


diameter is ~ 100,000 light years!

1 light year ~ 6 trillion miles

we move at 140 miles/sec. around center

We see different stars and constellations during the year and during a night

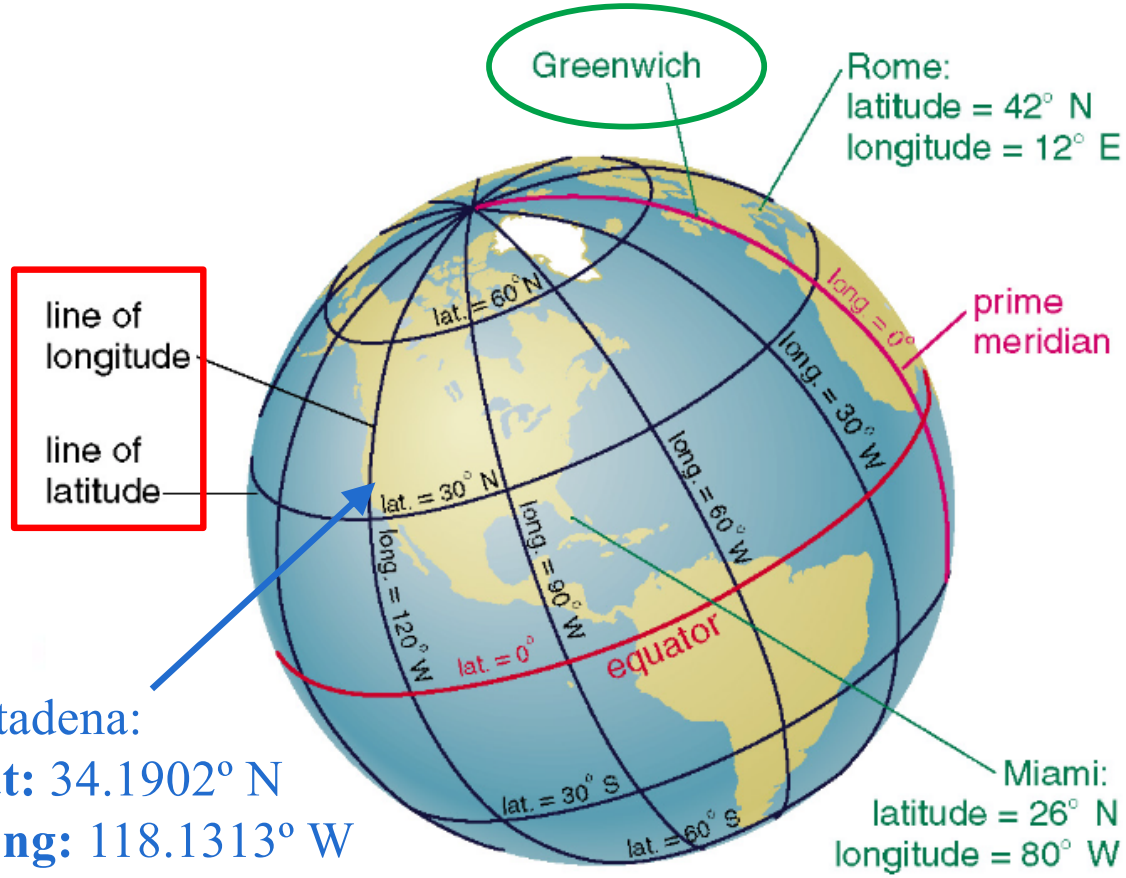


Earth rotates West to East.
Stars move East to West on sky.

Review: coordinates on Earth

Two numbers are needed to specify your location:

- **Latitude:** position north or south of the equator: these lines are parallel
- **Longitude:** position east or west of the prime meridian (through Greenwich, England)



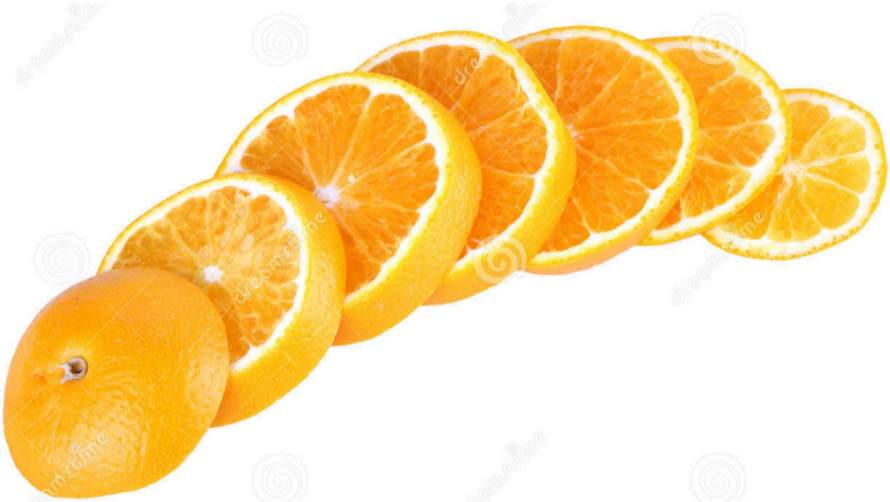
Altadena:
Lat: 34.1902° N
Long: 118.1313° W

Building on the prime meridian in Greenwich

How to remember Latitude & Longitude directions?

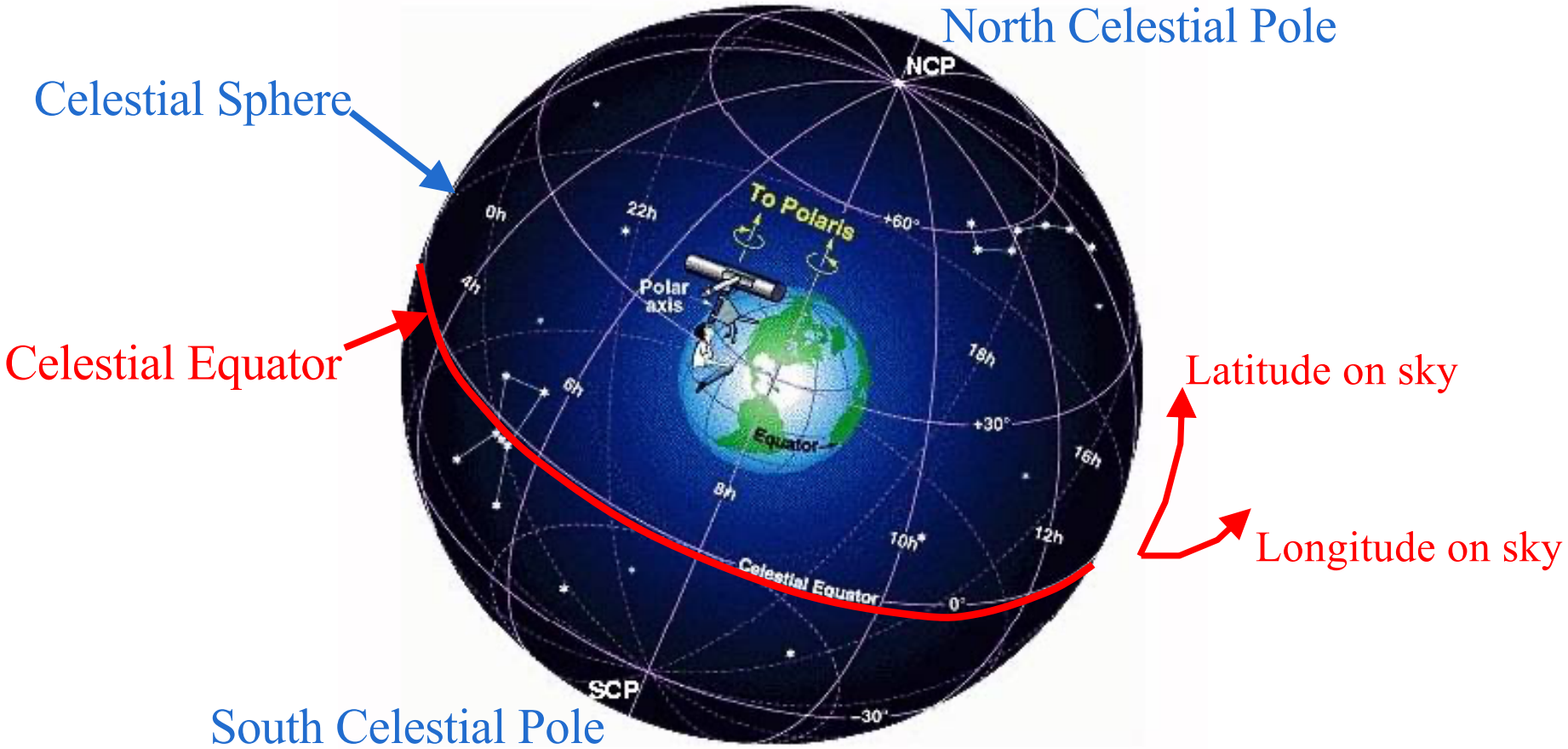
Slices in Longitude

Slices in Latitude

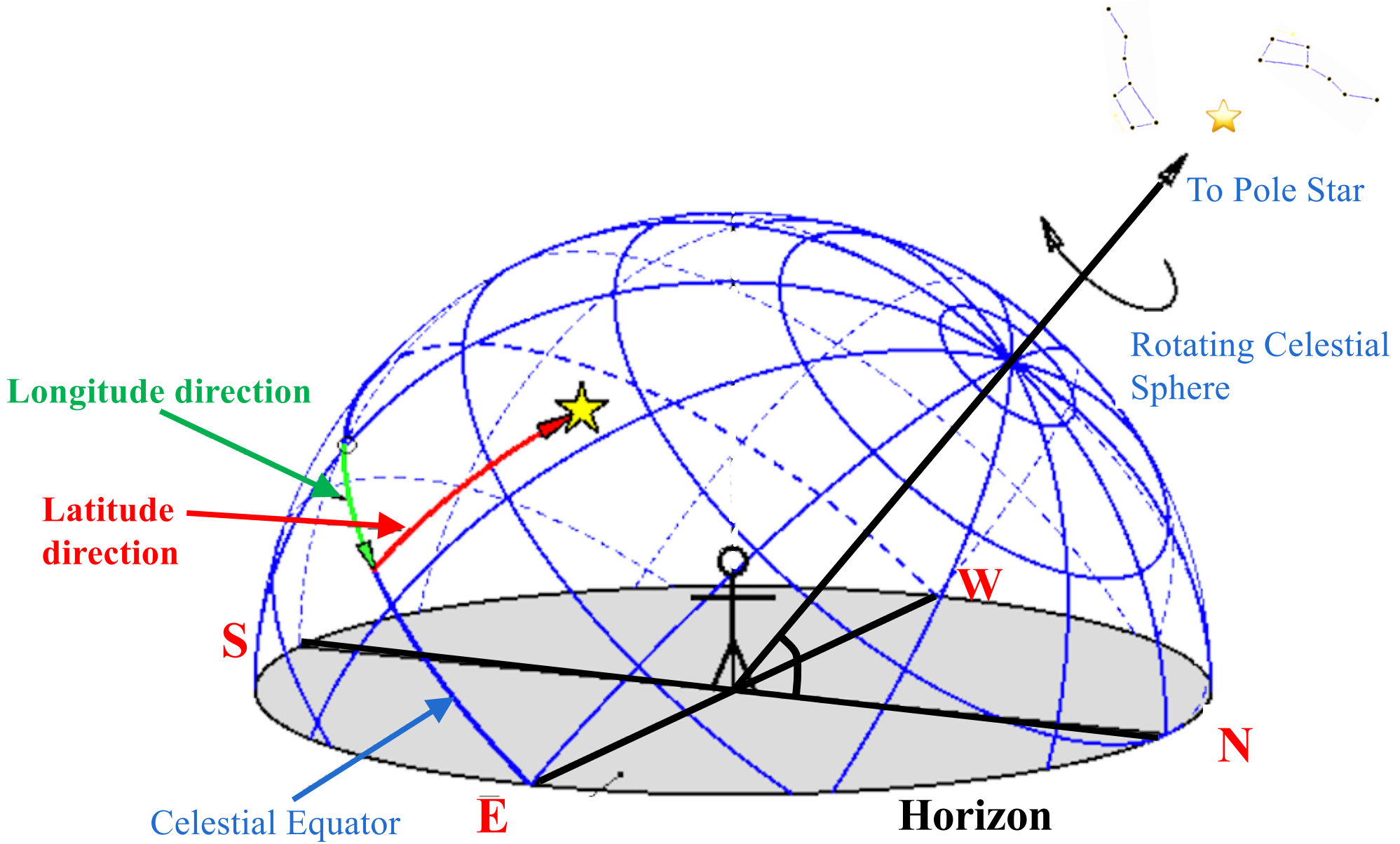


Latitude & Longitude on Earth can be projected onto the sky

- Stars on the sky are fixed on a sphere that's called the **Celestial Sphere.**
- Latitude & Longitude lines projected onto the sky can be used to locate known stars.
- These stars can then be mapped back to Earth to find your location. How cool is that!

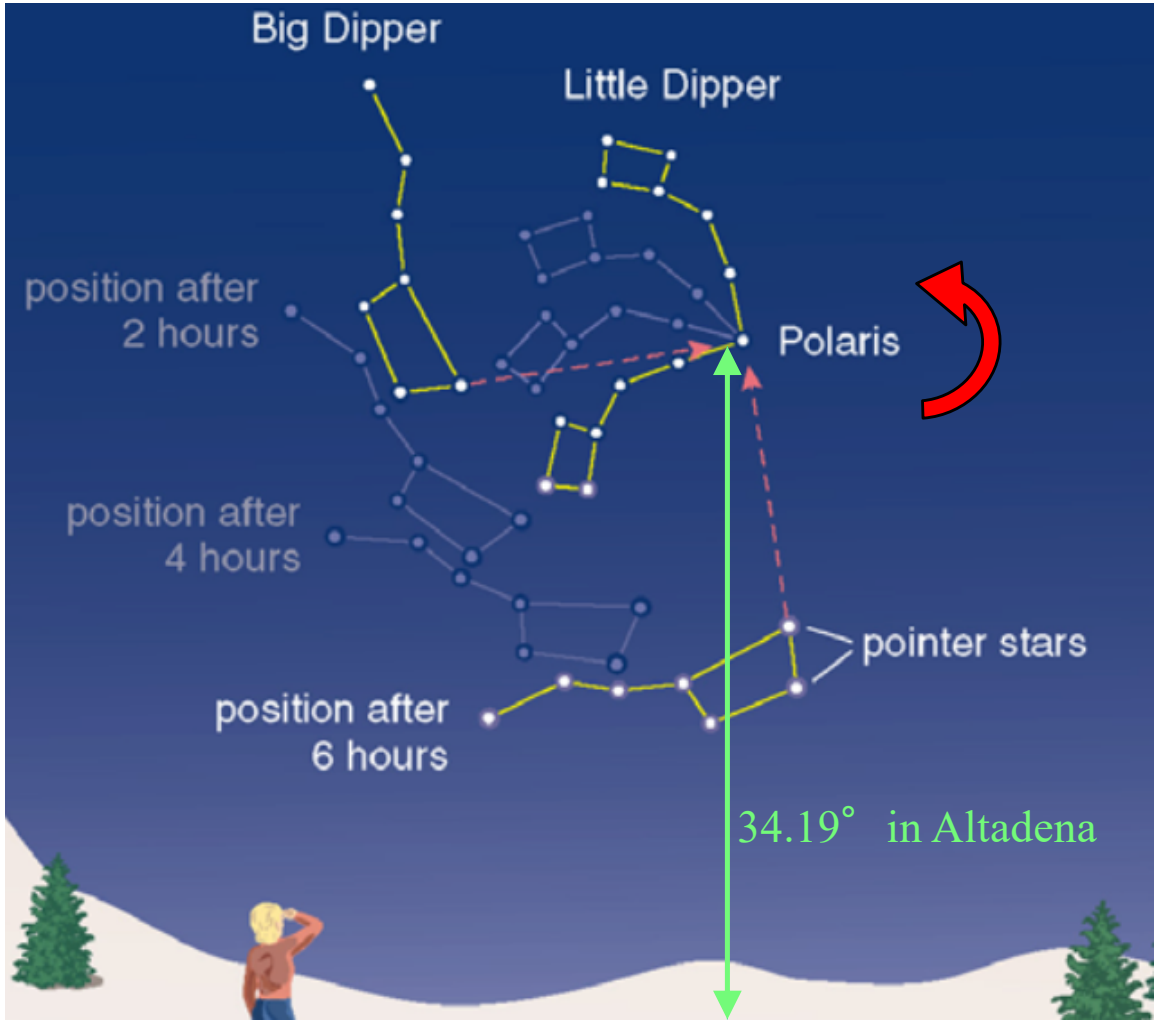


The Celestial Sphere as seen by a person on Earth



Interesting facts about your **latitude** on Earth

- The stars you will ***always*** be able to see during the year depends on your latitude only.
- Stars above a specific latitude on the sky **will never rise or set**: always visible during night.
- **The height of the pole star above your horizon in degrees = your latitude on Earth!**



How to measure angles on the sky

How to measure the angle of the pole star above your horizon?

Hence know your latitude.

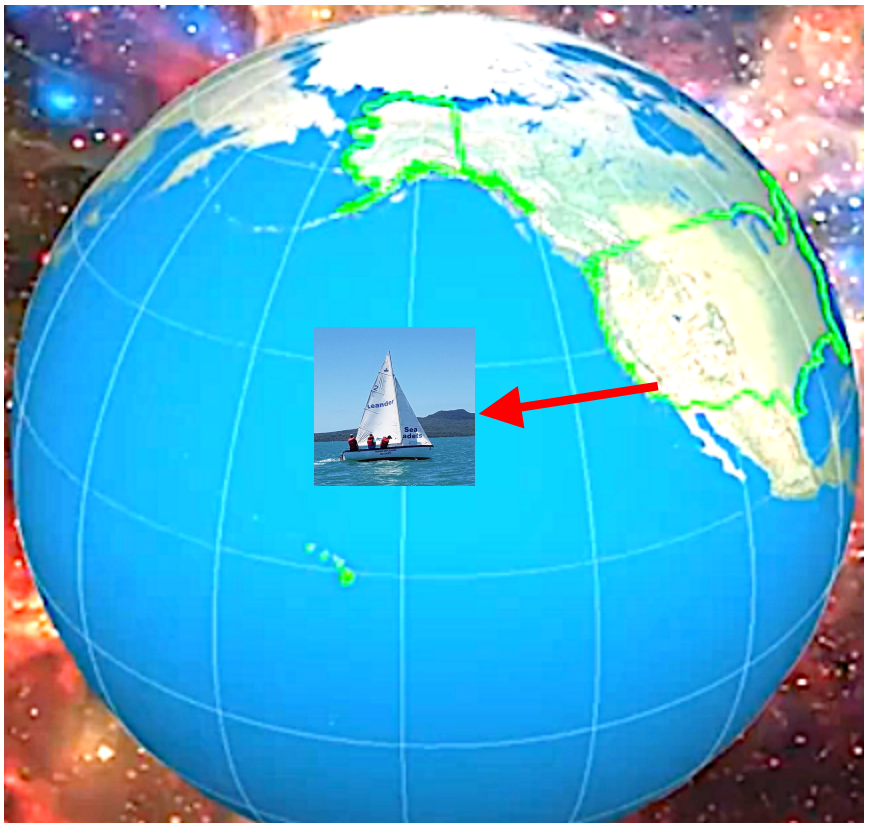
Approximate method using your hand

Stretch out your arm as shown here.

More accurate: use a fancy tool: *Sextant*
Used by mariners going back 400 years

Finding your **longitude** using the stars

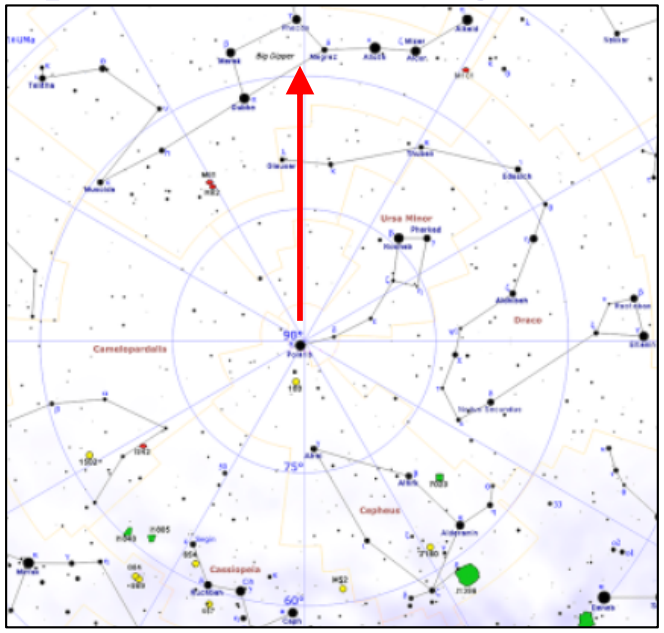
- **Previous slides:** find the pole star, measure its angle above horizon, know your latitude.
- Finding your longitude is harder because the longitude line on the sky directly above your head changes as the Earth rotates and orbits the sun. You can only find *changes* in longitude
- One way to find your longitude during a jouney is to use stars that circle the pole.
  - A method used by ancient mariners at sea.
- For example, suppose we set sail from California in a Westerly direction into the Pacific.



Finding your **longitude** using the stars

- Before we leave home and set sail, we:
  1. Draw or take a photo of the stars around the north celestial pole and note the time, say 9PM.
  2. Make a note of your longitude at your place of departure (your home).
  3. Take an accurate clock or watch with you. This is important!
- To find your longitude during your journey:
  1. Take a photo of the same stars at exactly the same time back at home: 9PM next evening.
  2. Using the two pictures, measure the change in angle of these stars around the pole.
  3. Add this change to your longitude back home and you have your local longitude!

photo before leaving home



Travel west about
2000 miles

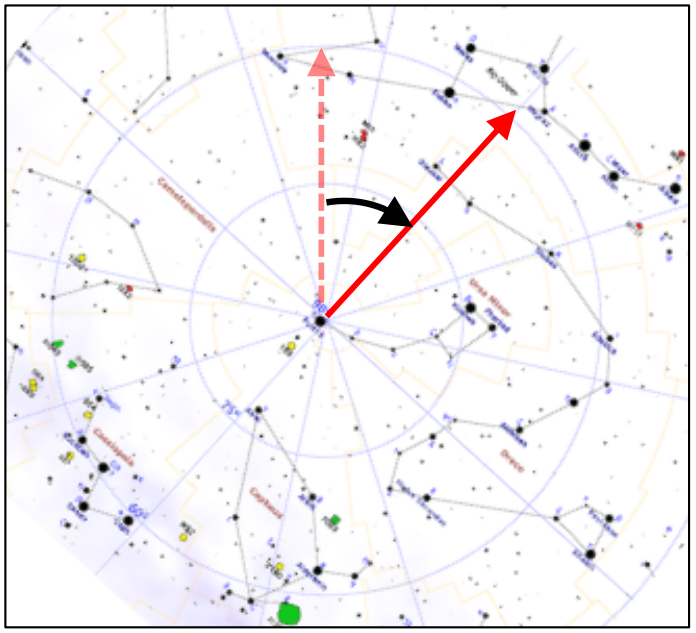
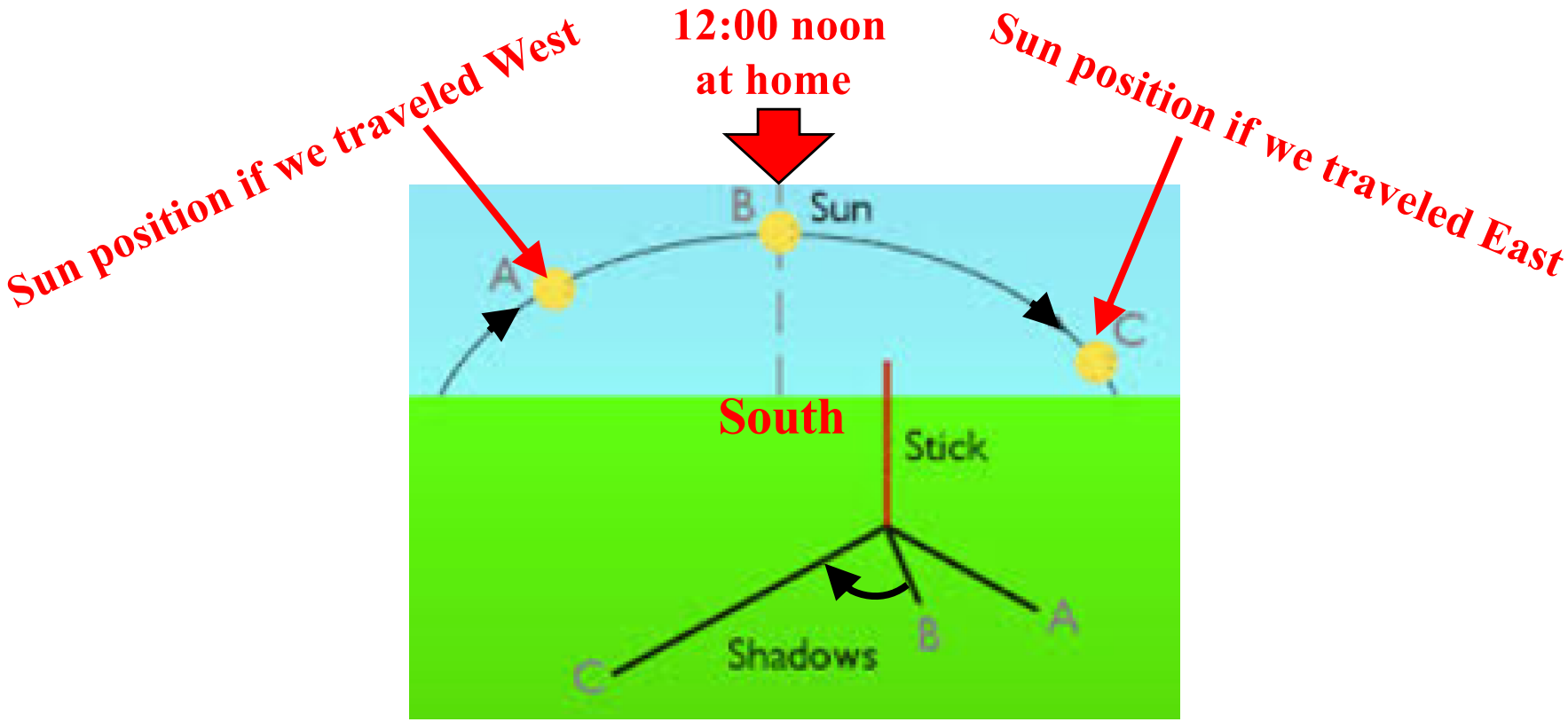


photo at same time, next day

Finding your **longitude** using the Sun

- What happens if you cannot see the stars?
- Concept is the same: during your journey, you would measure the *change* in the angle of a stick‘s shadow at a fixed time each day.
- Ancient mariners used instruments like *Sextants* and *Quadrants* to measure Sun‘s position.
- You still need to take with you an accurate clock or time-keeping device.

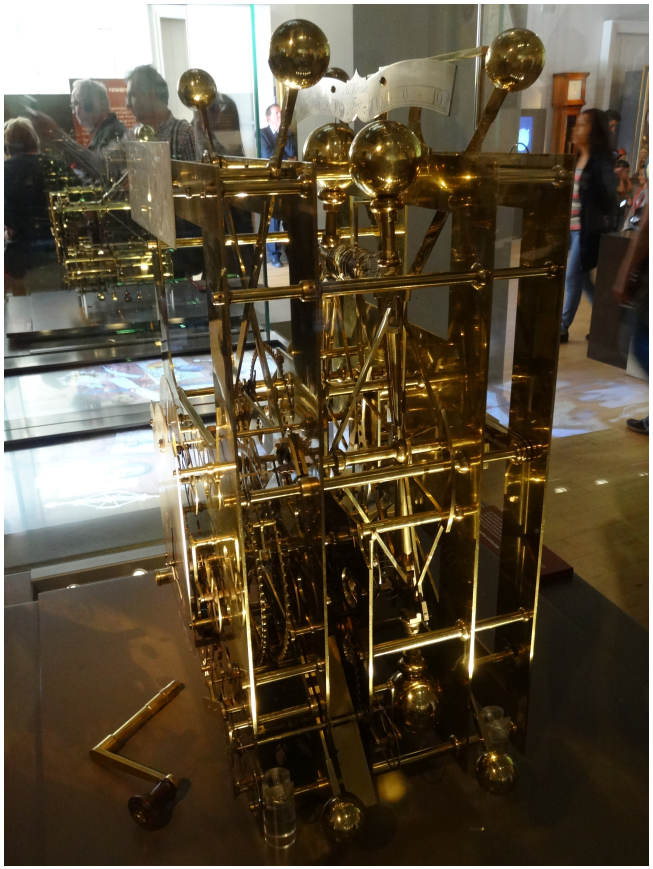


The Quest for Longitude at Sea

- Finding longitude required an accurate clock that lost no more than 1 minute over 6 months.
- The race to measure longitude in the 1700s turned into a race to build the most accurate clock
- John Harrison was a clock maker from Yorkshire, England. Received over US $3.2 million!

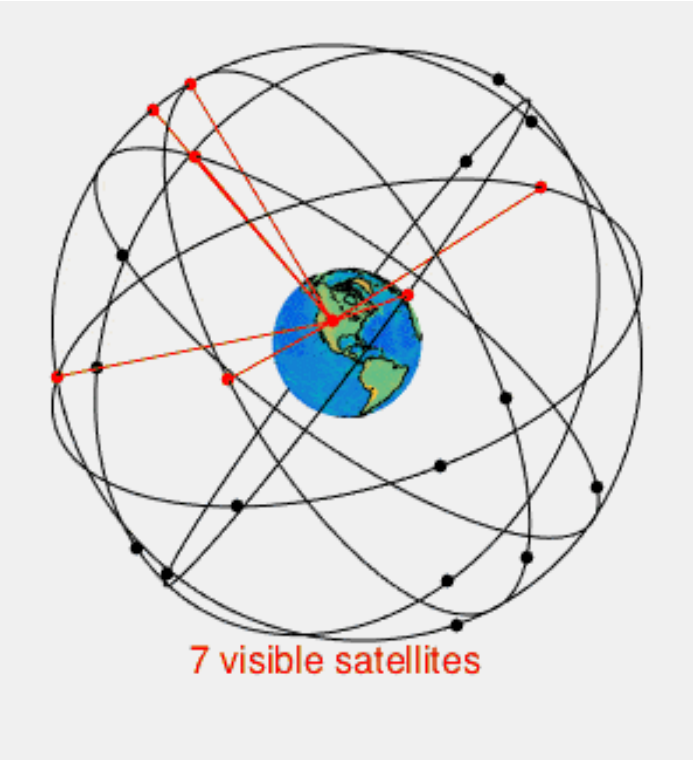
John Harrison, 1693 – 1776

One of Harrison's clocks



Welcome Technology!

- 1° in latitude (or longitude on the equator) equates to about 69 miles on Earth.
- Best stellar navigation methods, using the best instruments, can get you to within 2 miles.
- A device called a GPS (Global Positioning System) can get you to within a few feet.



Network of 24 GPS Satellites

GPS Receiver

Summary

- Stellar navigation is a big topic and I‘ve only scratched the surface.

- **Latitude:** angle of the North (or South) Celestial Pole above your horizon (e.g., Polaris).
- **Longitude:** measured from the change in a star‘s (Sun‘s) position at a fixed time each day.

- We‘ve come a long way since ancient times in refining methods for navigating the Earth.

- When you hold an electronic gadget in your hand, think how lucky you are!

- Before travelling into the wilderness, remember to bring:
  - A compass and a map, and know how to use them
  - If you have one, a GPS receiver or cell phone set in GPS-only mode
  - Batteries or extra power-banks
  - I also like to bring a planisphere

Planisphere