Species Syzygy: Which Animal Has Seen the Most Total Solar Eclipses?

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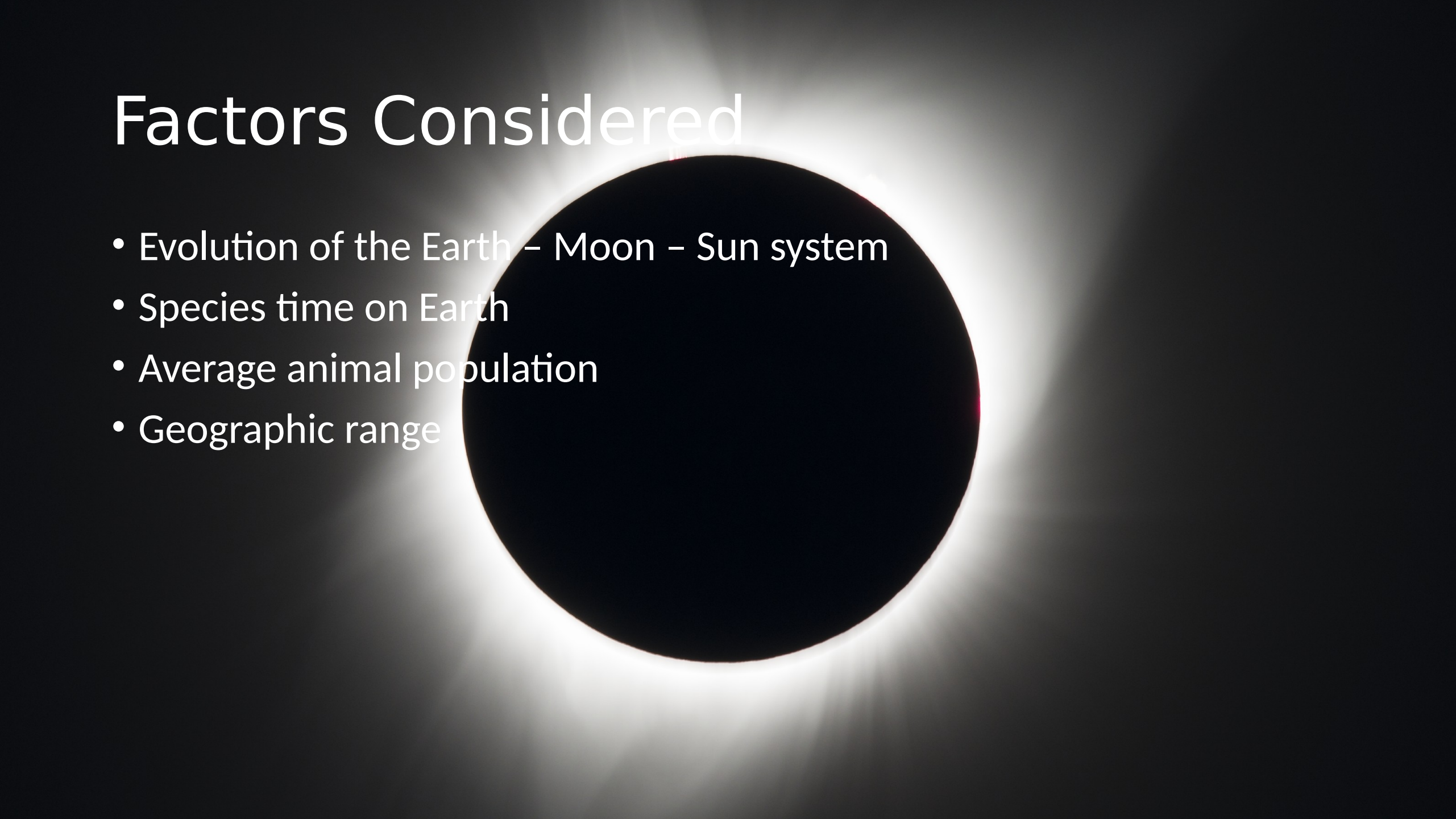
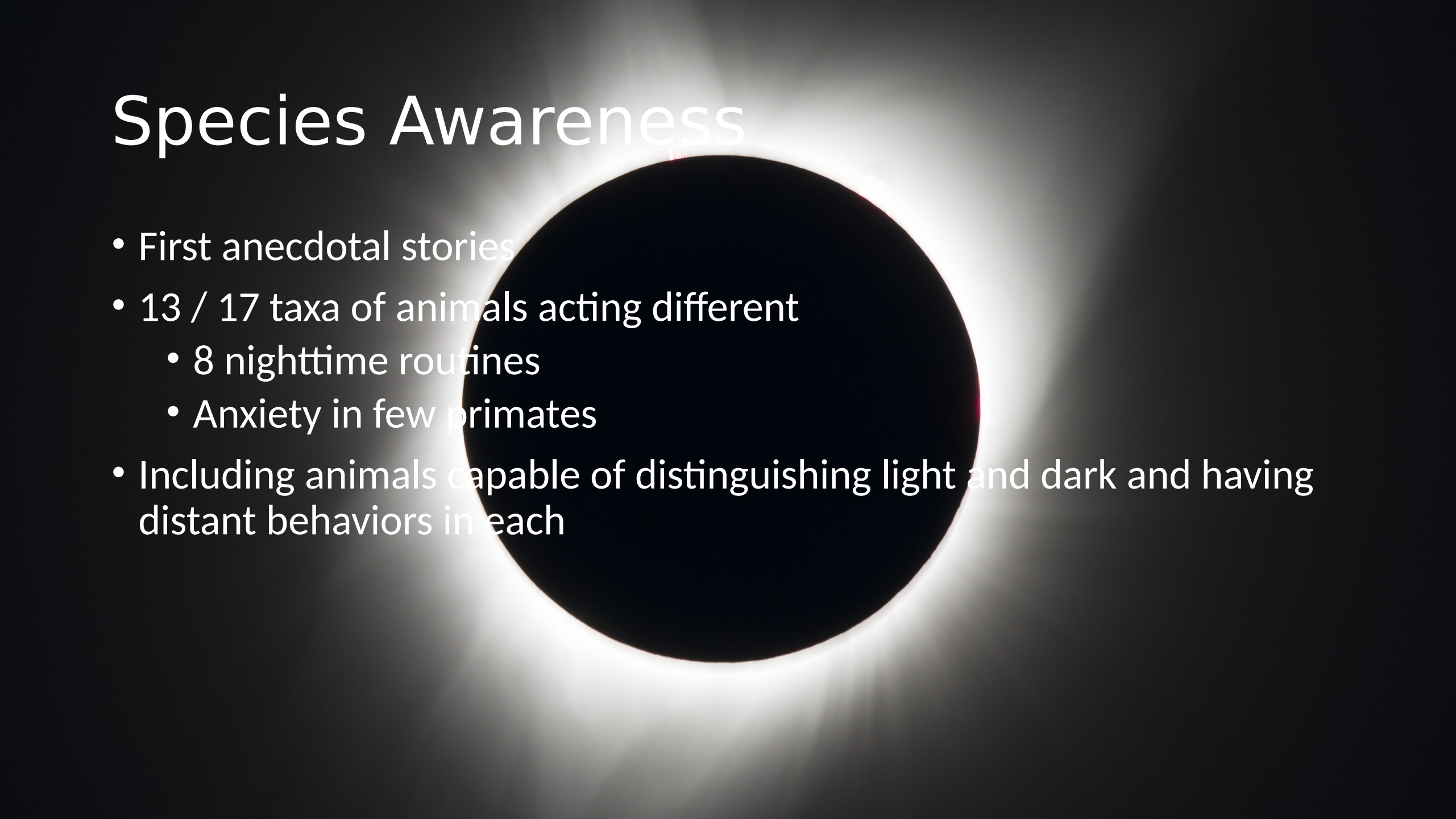
Factors Considered



- Evolution of the Earth – Moon – Sun system
- Species time on Earth
- Average animal population
- Geographic range

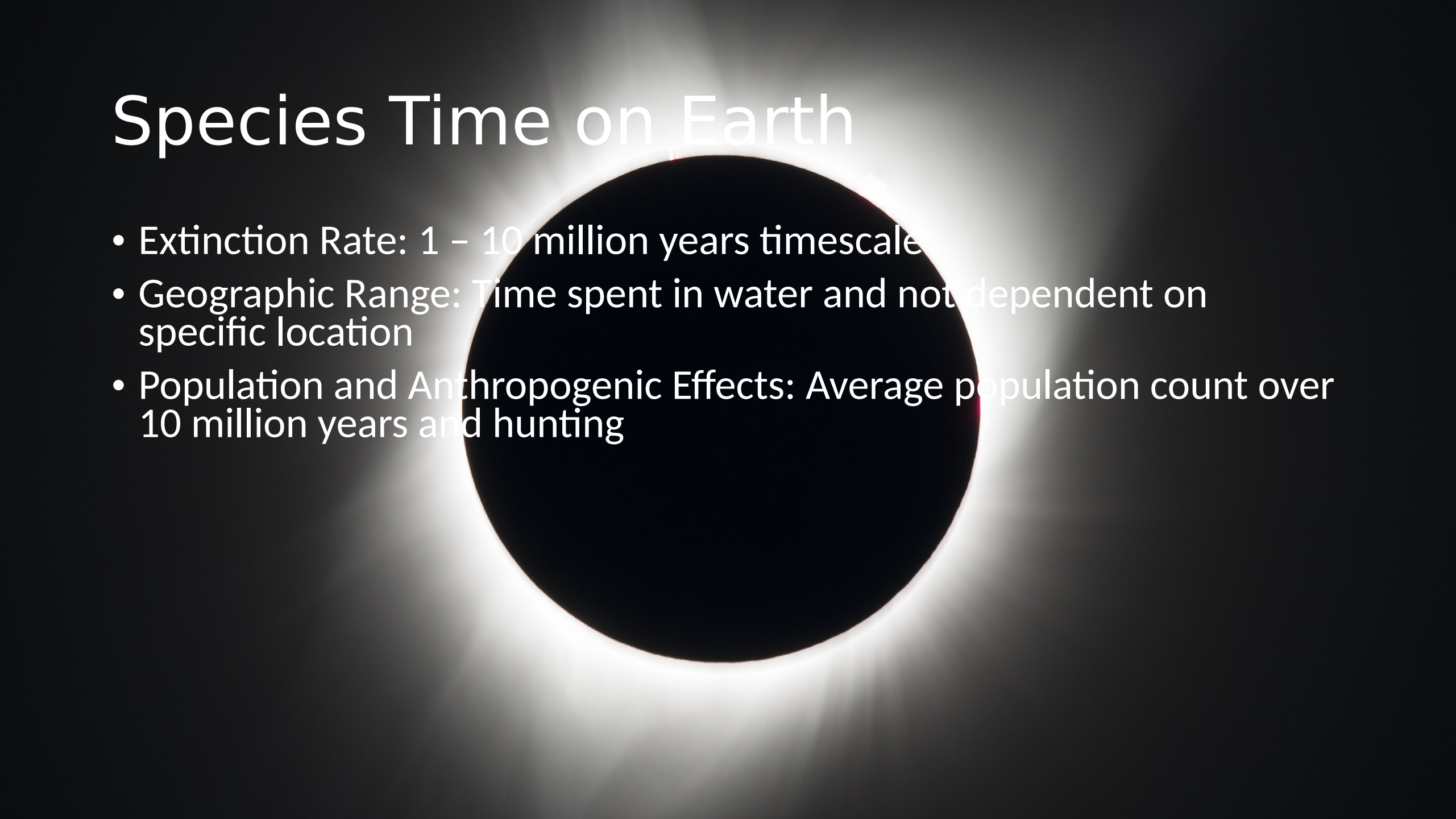
Species Awareness



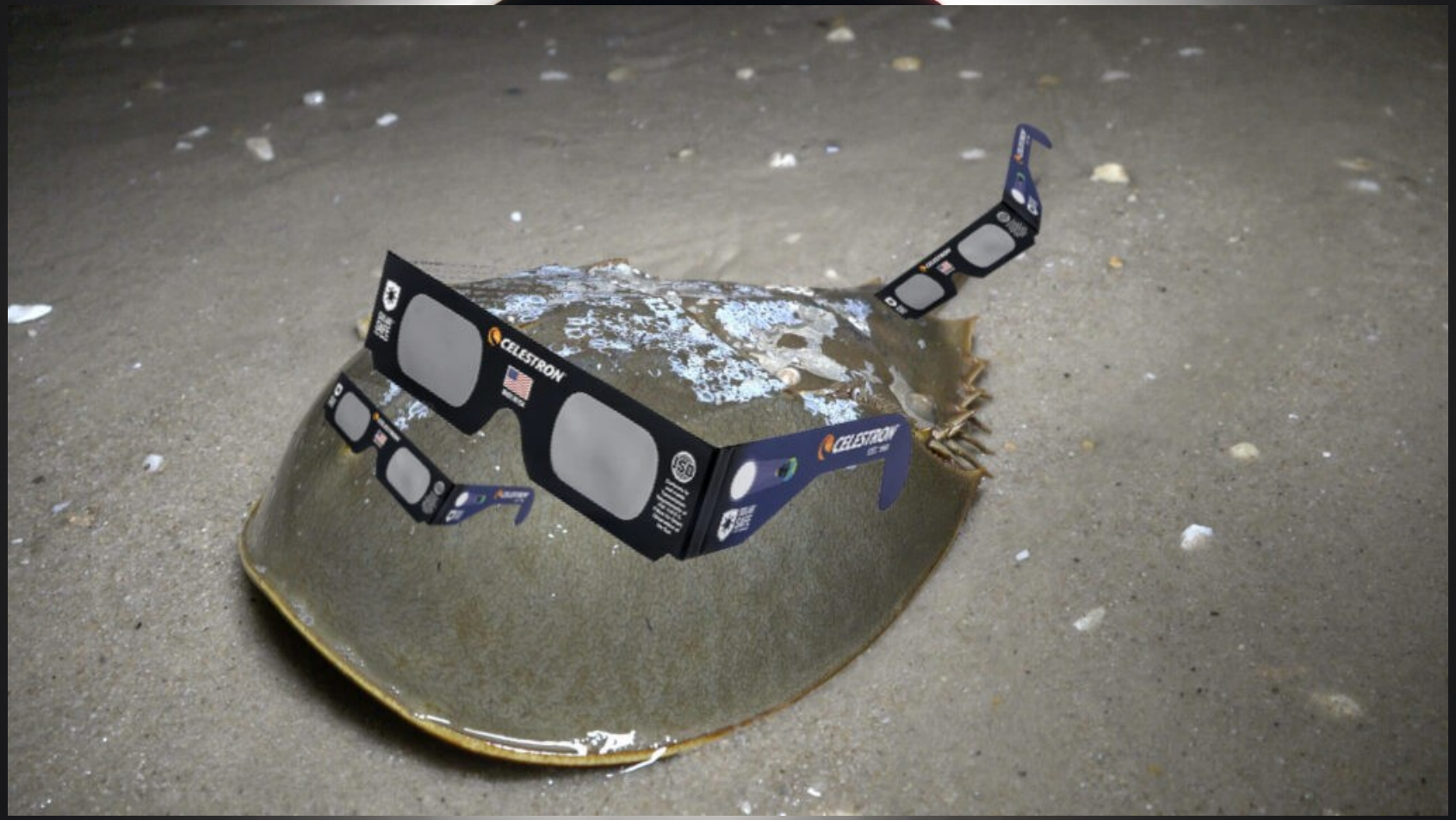
- First anecdotal stories
- 13 / 17 taxa of animals acting different
  - 8 nighttime routines
  - Anxiety in few primates
- Including animals capable of distinguishing light and dark and having distant behaviors in each

Species Time on Earth

- Extinction Rate: 1 – 10 million years timescale
- Geographic Range: Time spent in water and not dependent on specific location
- Population and Anthropogenic Effects: Average population count over 10 million years and hunting



Horseshoe Crab

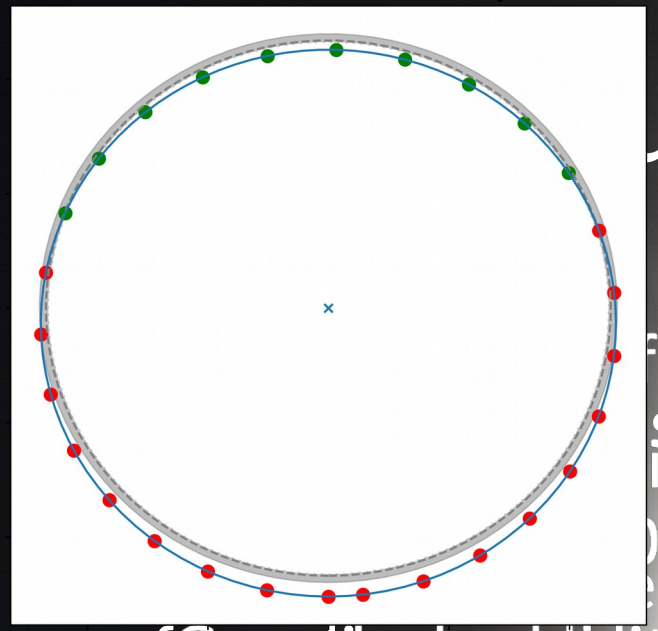


Horseshoe Crab

- Capable of observing
- 10 eyes
- On beach in March and July
- Fossil record 480 million years ago
- Nearly no evolution in 200 million years
- 4 species: Limulidae

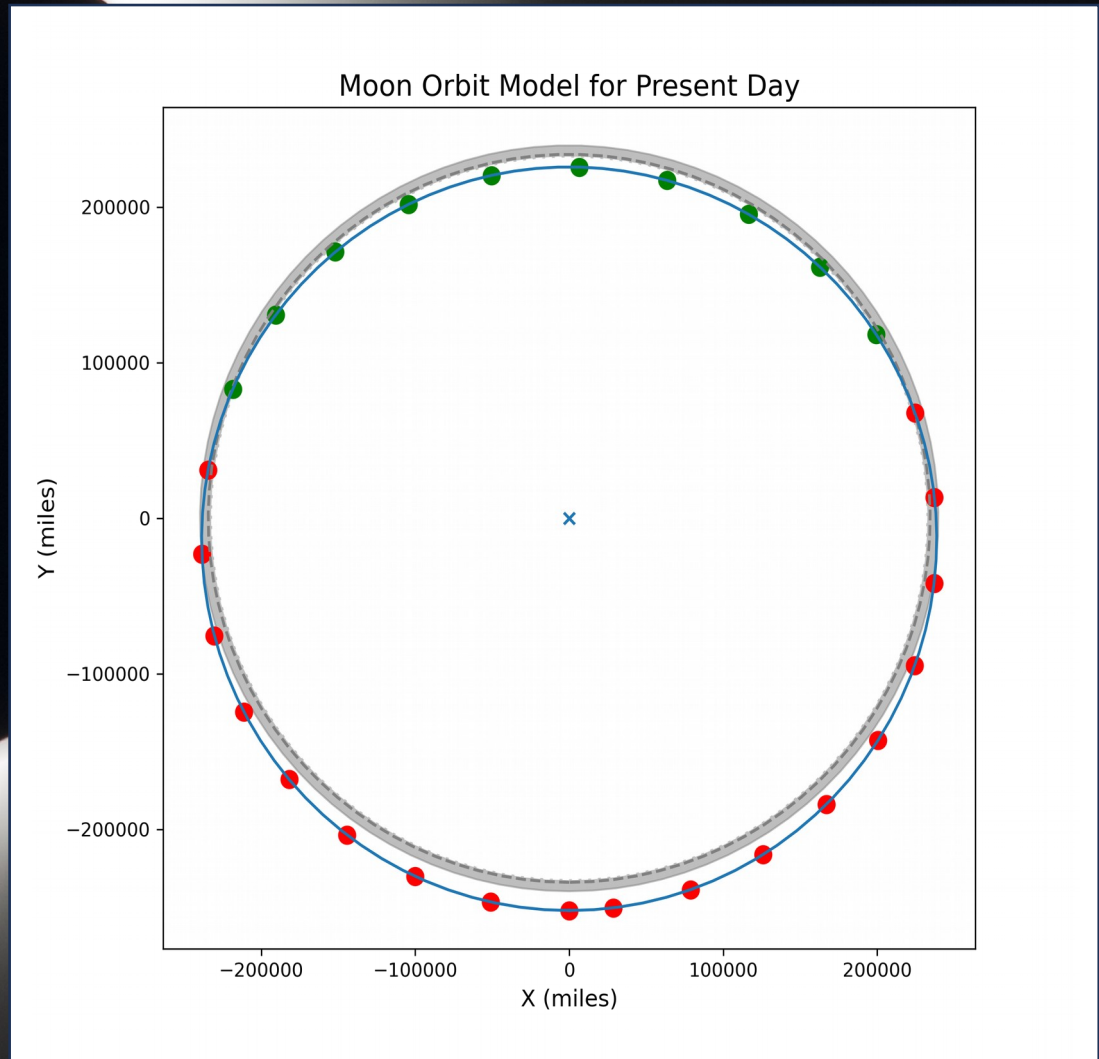
Evolution of the Sun – Earth – Moon System

- Tidal effects of the Moon on the Earth
- Averaging over: precession rates, Saros cycles, and eccentricity variations
- Use average eccentricities of Earth and Moon orbit

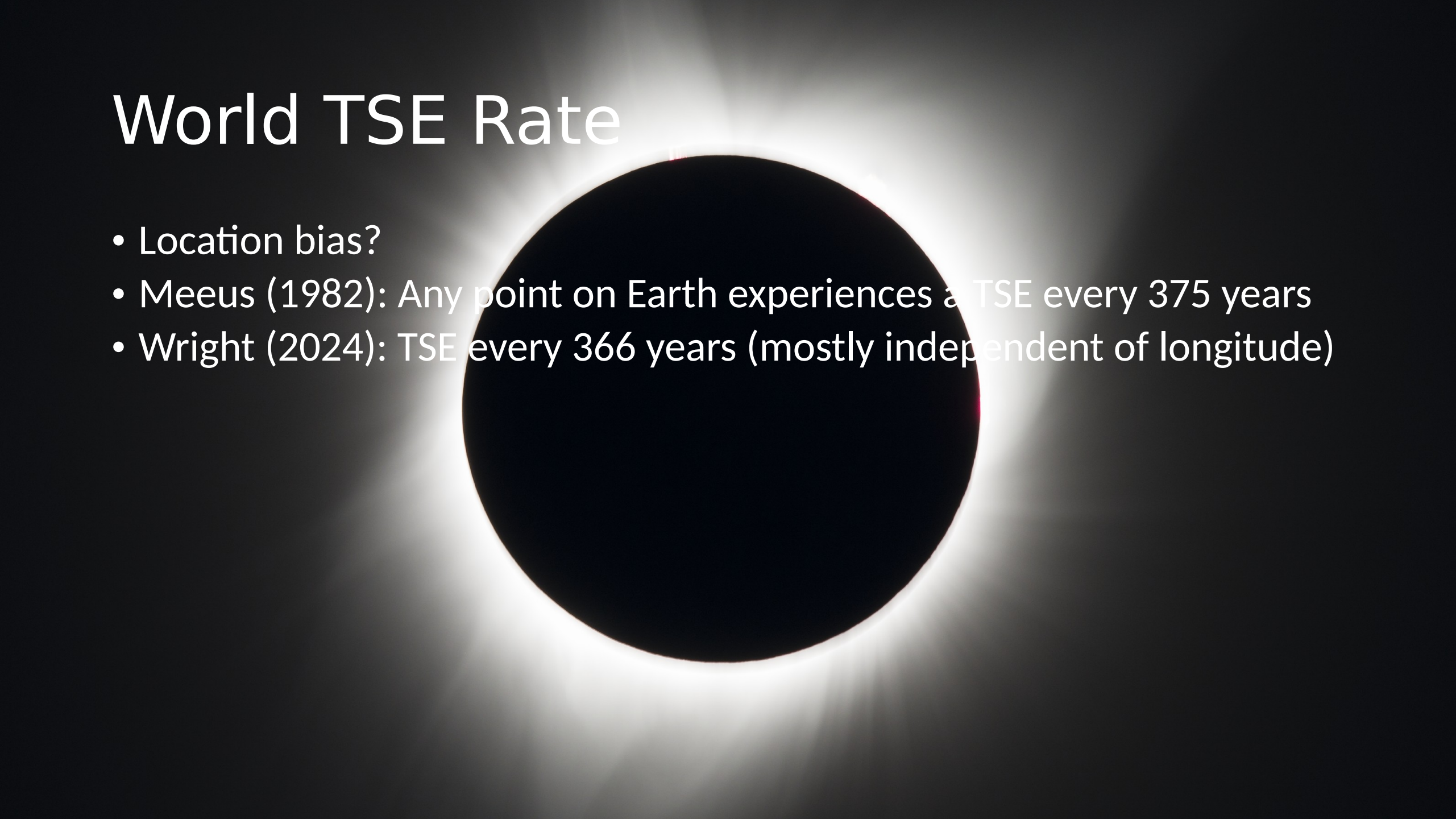


uency

- Moon orbit
- Moon orbit
- s: 239000 miles
- is: 239000 miles
- km)
- km)
- e = max orbit distance
- Grey dashed line = max orbit distance for eclipse conditions
- Blue solid line = elliptical orbit
- Blue solid line = elliptical orbit
- Frequency 35% of orbit
- Frequency 35% of orbit
- 2 syzygy opportunities per year
- 2 syzygy opportunities per year
- 1 TSE every 1.4 years
- 1 TSE every 1.4 years



World TSE Rate

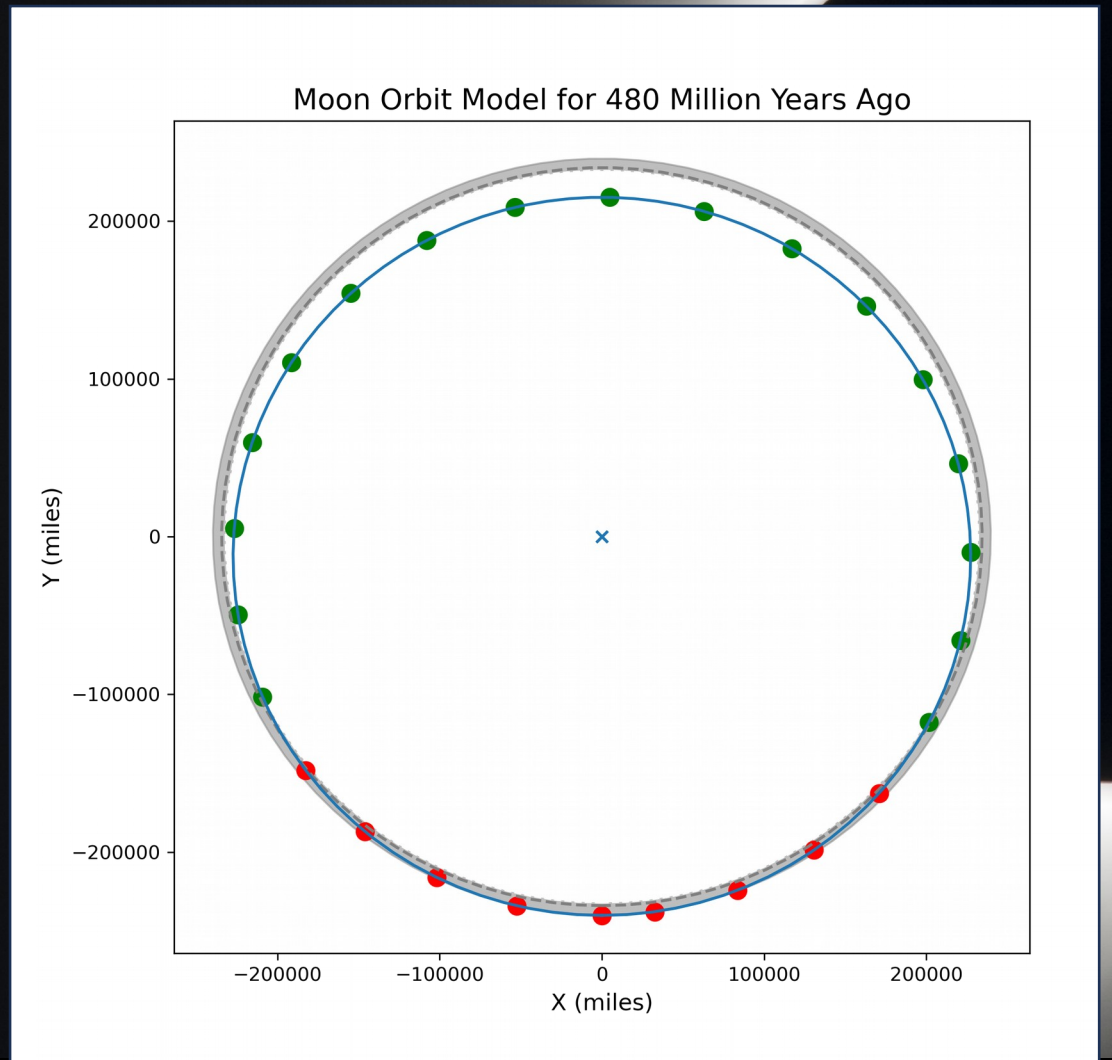


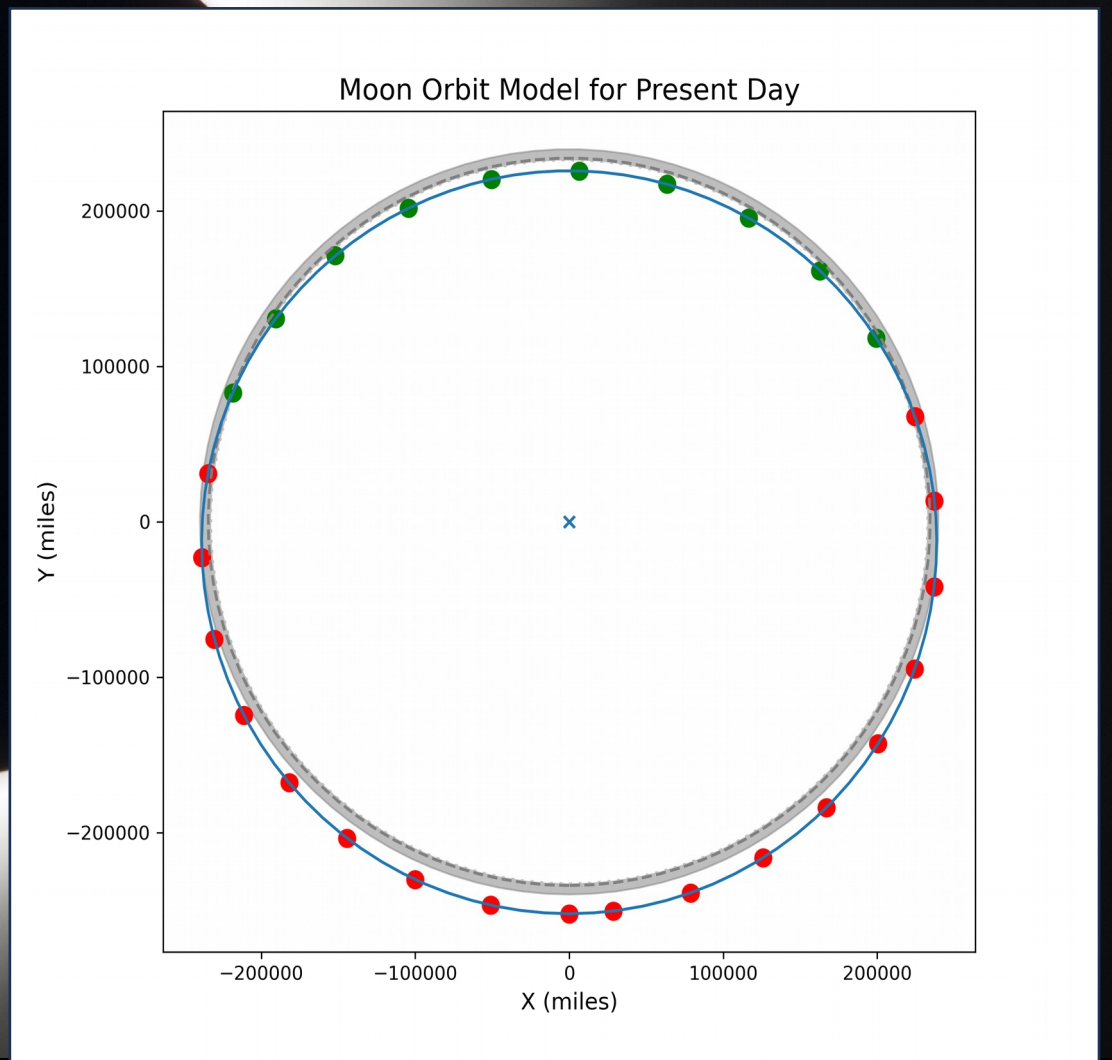
- Location bias?
- Meeus (1982): Any point on Earth experiences a TSE every 375 years
- Wright (2024): TSE every 366 years (mostly independent of longitude)

AWESOME Time

- Astronomical World Eclipse Surface cOverage Metric
- Average time it takes the entire surface of Earth to experience a TSE
- Normalized over geometric range
- Most TSE paths: 100 miles across + stretch 10,000 miles on Earth's surface = ~ 1 million square miles
- Earth surface area: 196 million square miles
- AWESOME time: 326 years

Moon Orbit

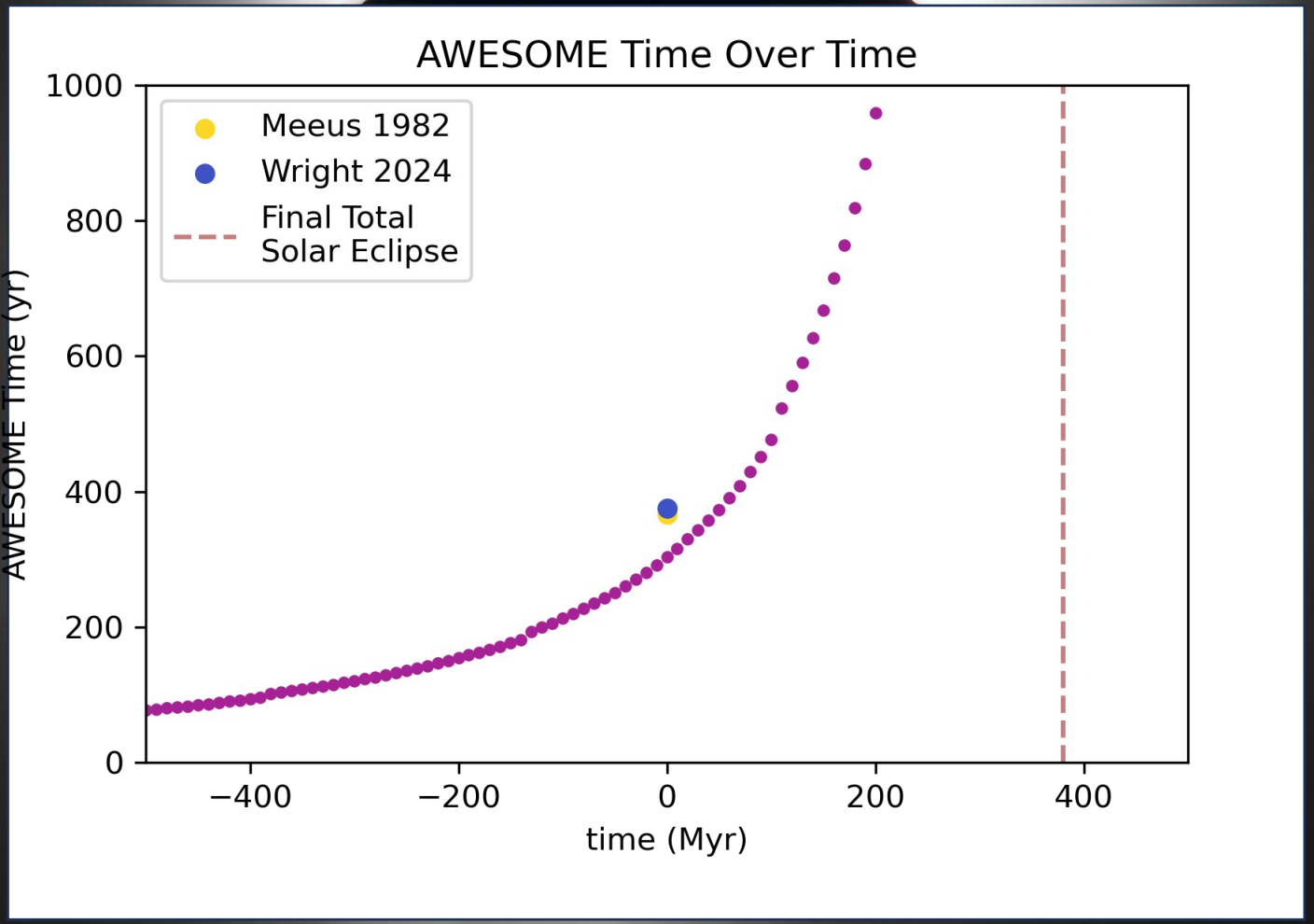

Moon Orbit Model for 480 Million Years Ago
200000
100000
0
−100000
−200000
Y (miles)
−200000
−100000
0
100000
200000
X (miles)


Moon Orbit Model for Present Day
200000
100000
0
−100000
−200000
Y (miles)
−200000
−100000
0
100000
200000
X (miles)

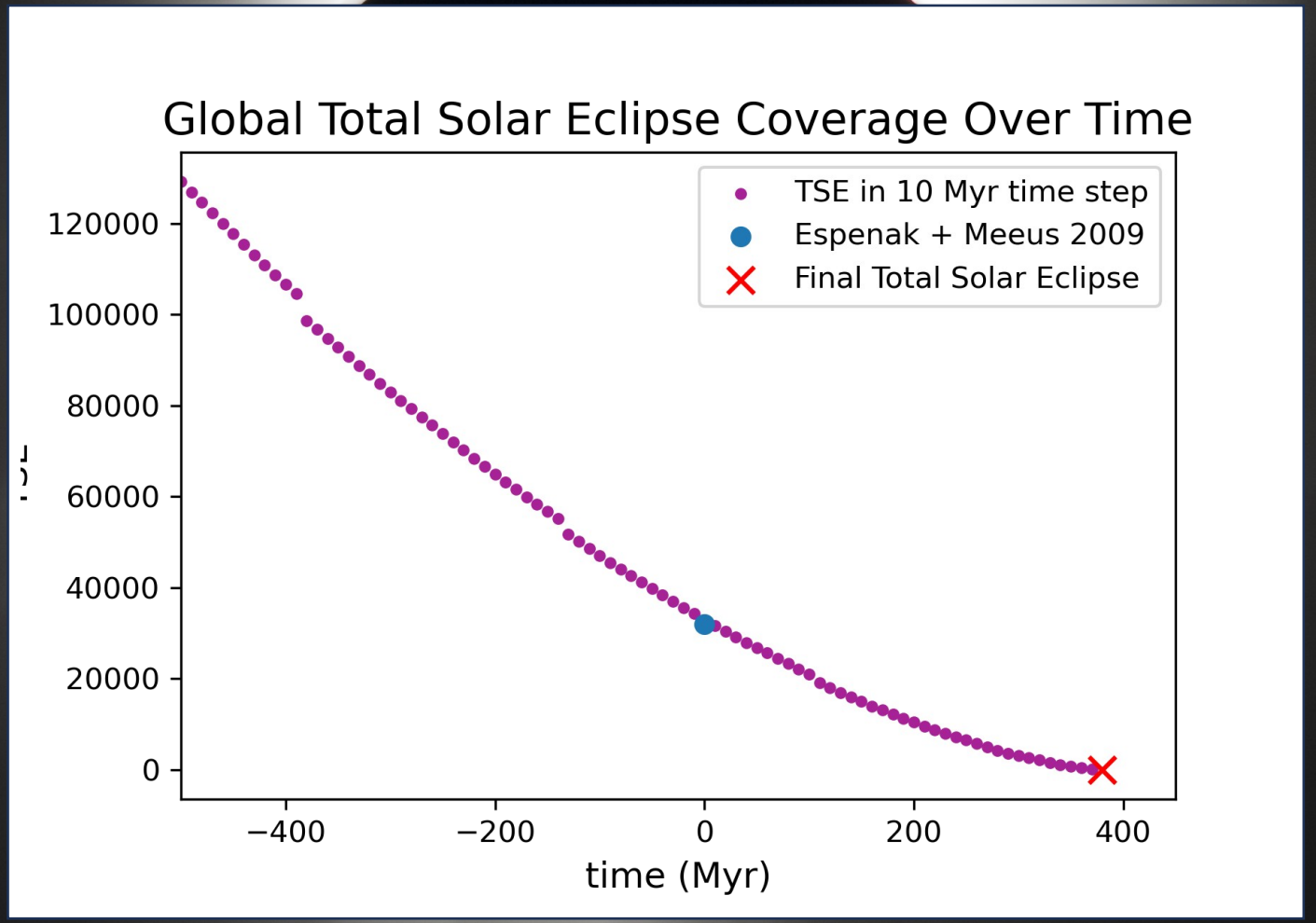
TSE per Species

1. For each time step, make Moon orbit model
2. Calculate the number of orbit positions within min radius
3. Calculate time between eclipses & average shadow radius/surface area
4. Calculate AWESOME time

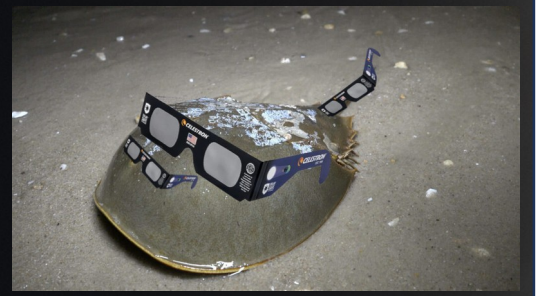
AWESOME Time over Earth Time

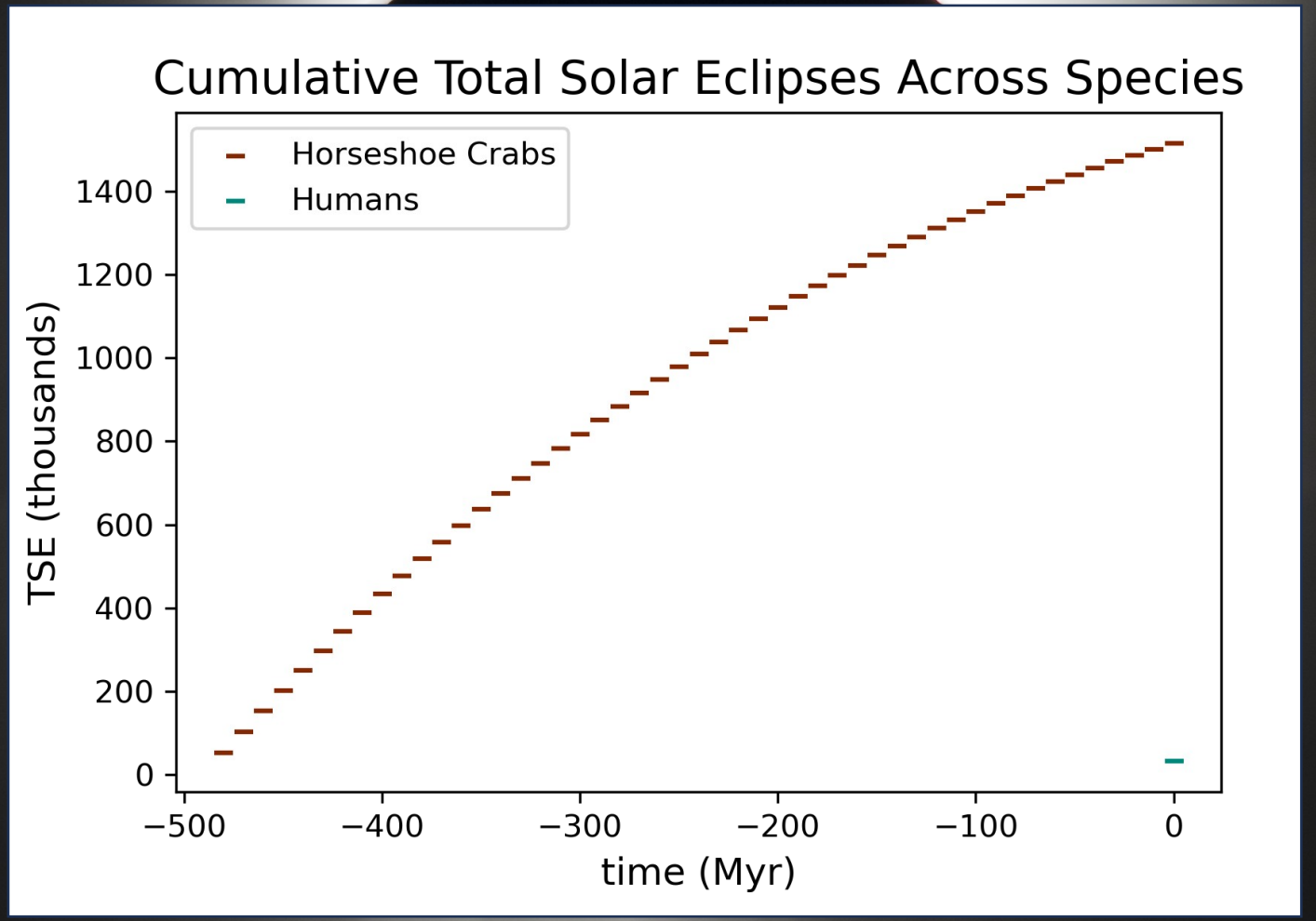


Global Total Solar Eclipses Coverages

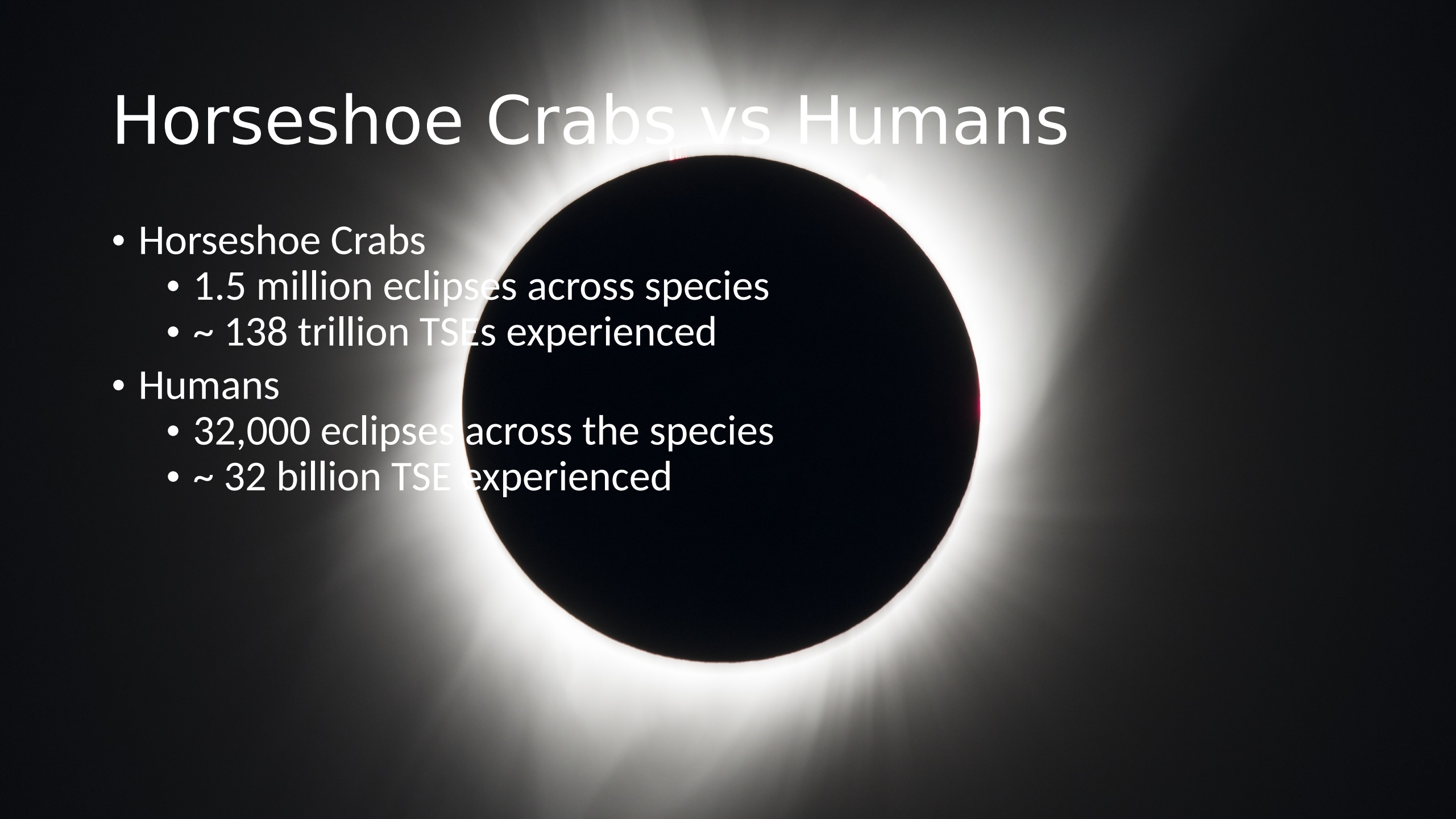


Horseshoe Crabs vs Humans





Horseshoe Crabs vs Humans



- Horseshoe Crabs
  - 1.5 million eclipses across species
  - ~ 138 trillion TSEs experienced
- Humans
  - 32,000 eclipses across the species
  - ~ 32 billion TSE experienced

Summary

- AWESOME time = average time between TSEs for a given point on Earth & average time for whole Earth to experience one TSE
- TSEs have changed over time
- Last TSE = 380 million years from now
- Method to calculate TSE per species
- Horseshoe crabs across the species had 138 trillion experiences and humans only 38 billion
- Humans will beat horseshoe crabs in less than 10 million years


TimeOut


TimeOut


TimeOut


TimeOut


TimeOut


TimeOut