PARALLAX AND ABERRATION:
EVALUATING ROBERT HOOKE'S 1669 PARALLAX MEASUREMENT

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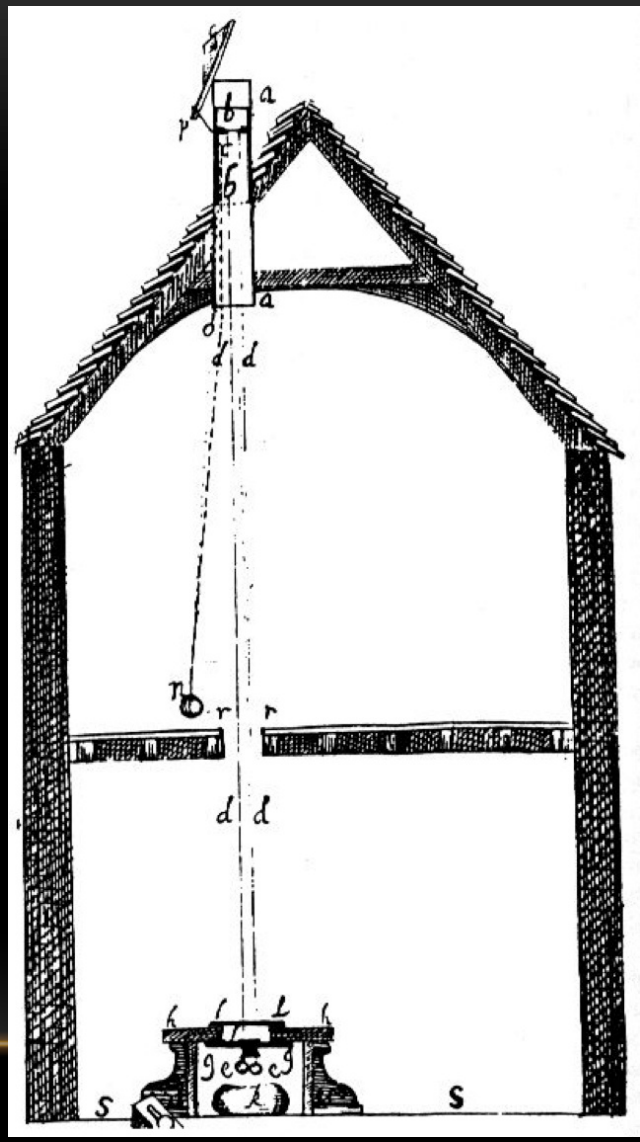
THE IMPORTANCE OF ERROR

- Students need to know how science is done, not just what it says.
- Science is self-correcting (hopefully).
- Usually we focus on correcting theoretical errors, but sometimes it is the DATA that is wrong!
- Example: Robert Hooke's claimed measurement of annual parallax in 1669.

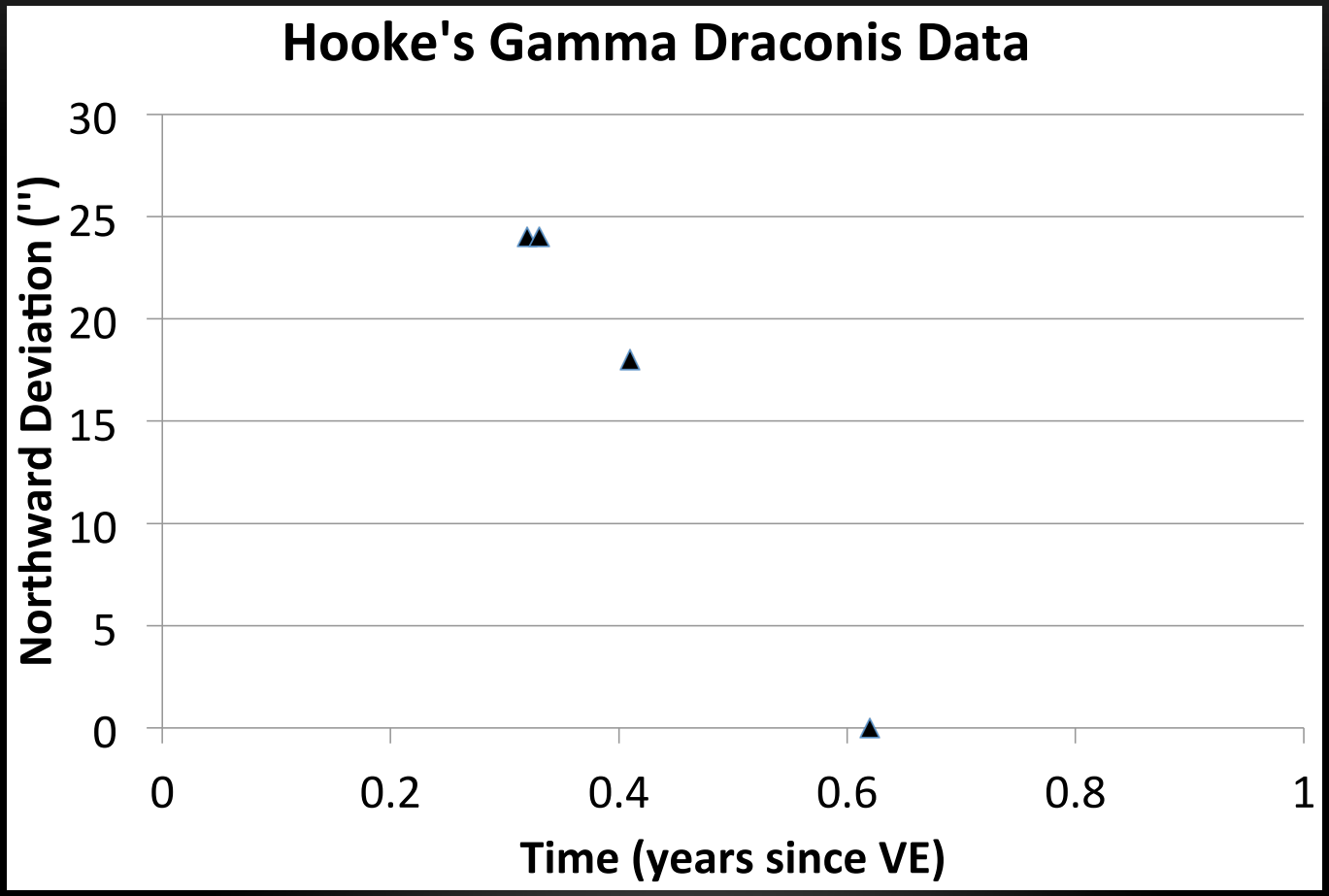
HOOKE'S 1669 PARALLAX MEASUREMENT

- Big questions in 17th century: does Earth really orbit the Sun? How far away are the stars?
- In 1669 Robert Hooke attempted to measure the annual parallax of the star gamma Draconis.
- Built a zenith telescope to measure north-south variations in transit position (changes in declination).
- Published an account of his careful measurement procedures and his results in *An Attempt to Prove the Motions of Earth by Observations* in 1674.
- Reported only four measurements, showing variation of about 25".
- "Tis manifest then by the observations … that there is a sensible parallax of Earth's Orb to the fixt Star in the head of *Draco*, and consequently a confirmation of the Copernican System against the *Ptolomaick* and *Tichonick*."
- Implied a distance to gamma Draconis of no more than 16,500 AU (0.26 light years).



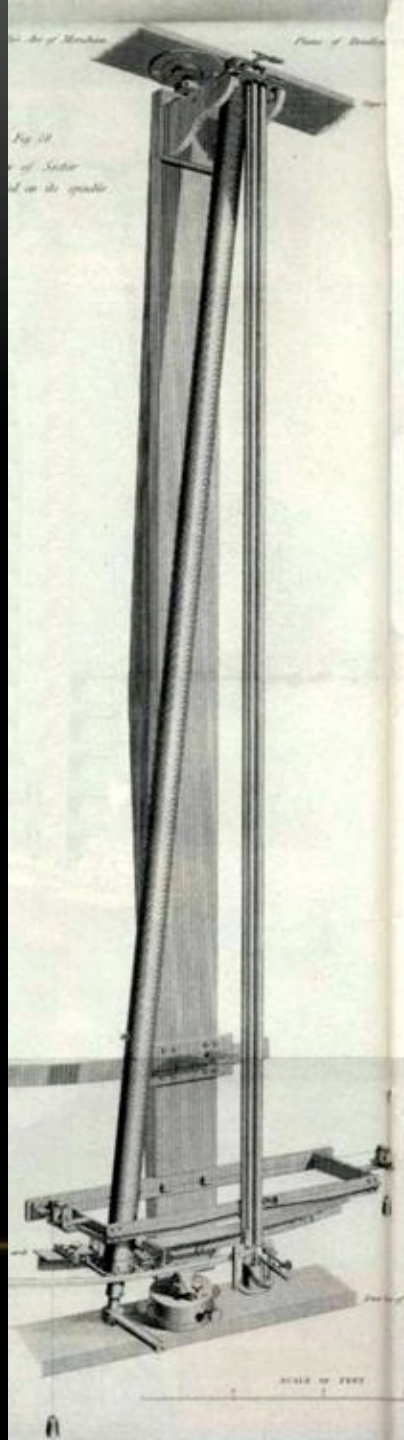
HOOKE'S DATA

- Seems to fit the pattern for the parallax of gamma Draconis.



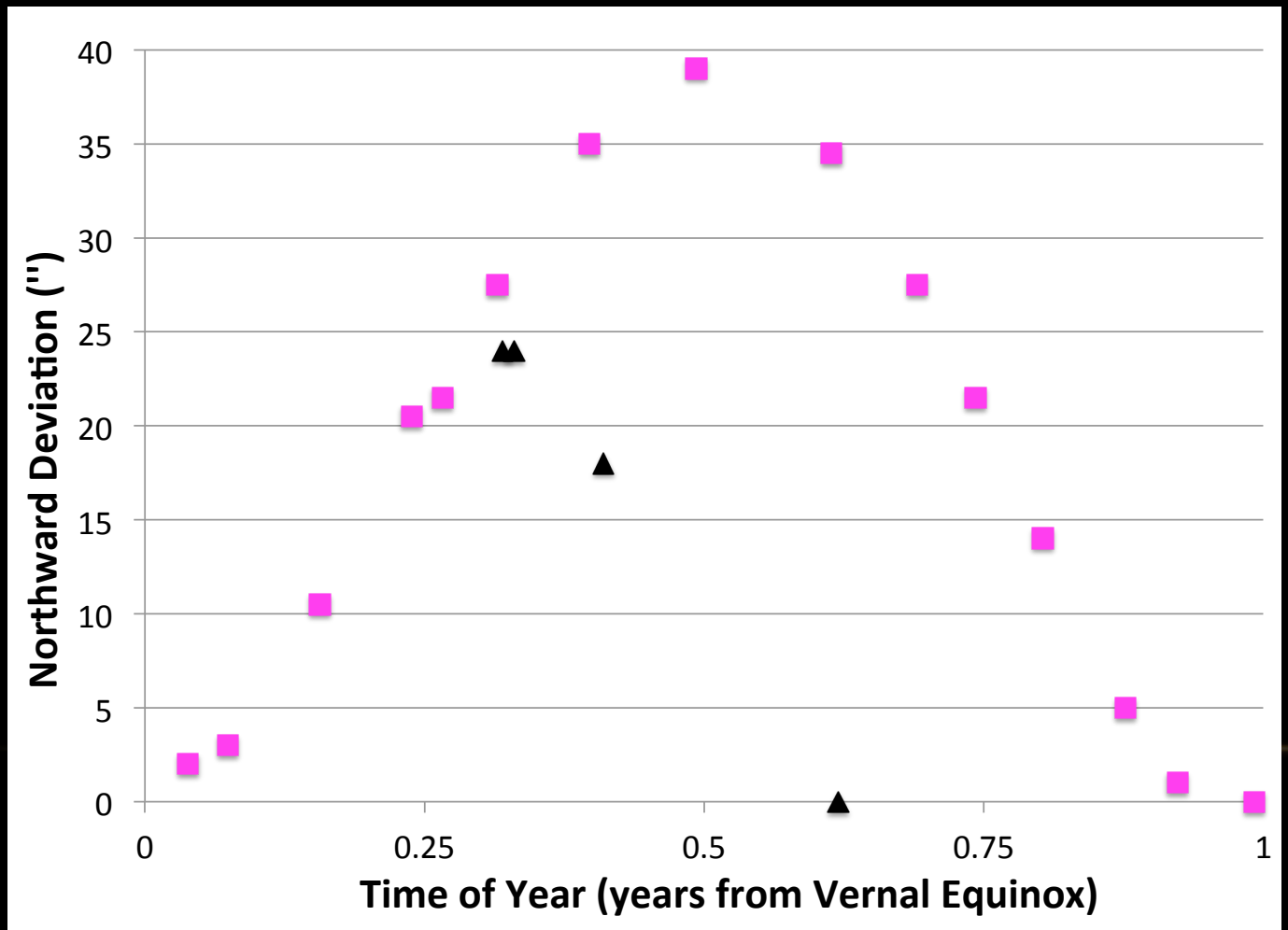
EVALUATING HOOKE'S MEASUREMENT

- Unreliable telescope.
- Only four measurements.
- Flamsteed's parallax for Polaris (40'' variation).
- Cassini: Flamsteed's data didn't fit the expected pattern.
- Bradley: aberration of starlight, due to Earth's orbital motion and finite speed of light.
- Flamsteed's data fits the pattern for aberration, but what about Hooke's?



HOOKE AND BRADLEY ON GAMMA DRACONIS

- Hooke's data (triangles) does not match Bradley's (squares), nor the expected pattern for aberration.
- It DOES fit the pattern for parallax. Hooke was looking for an effect that was smaller than his instrument could detect and seeing what he wanted to see.



CONCLUSIONS

- False measurements are not failures of science, they are part of the normal process. When science works well, incorrect results will be corrected.
- Bad data may lead us to false (or even true!) conclusions, but eventually other data and successful theories will conflict with the bad data or the false conclusions.
- We may throw out bad data because it conflicts with better data of the same type (Bradley's observations of gamma Draconis versus Hooke's) OR because it conflicts with conclusions drawn from theories we trust (Bradley's theory of aberration).
- Science progresses not only by establishing new measurements and new theories, but also by correcting bad measurements and discarding false theories.
- In the end, Bradley demonstrated the orbital motion of Earth by aberration of starlight. Annual parallax was not measured until Bessel's observations of 61 Cygni in 1838, which showed that this star was 657,700 AU (10.3 light years) away.
- See upcoming paper ("Seeing Earth's Orbit in the Stars") in *The Physics Teacher* for more information.
- Simulations available in Open Source Physics collection: http://www.compadre.org/osp/