Saturn, much like those of Galileo in 1610-1620, showed that advances in the telescope had opened the way to a new round of discoveries

a. All the technical complications and headaches associated with new telescopes worth the effort
b. And, although comparatively few measurements, enough to provide a major impetus toward the telescope becoming an indispensable instrument of measure in astronomy -- the beginning of the end of Tycho's standard

III. Astronomy in a New Context: 1650s to 1670s

A. Cassini on the Sun and on Jupiter and its Satellites

1. Huygens was not the only person to be taking advantage of the improvements in the technology of the astronomical telescope in the late 1650's; Cassini was doing so too, along with other things
   a. Cassini joined Bologna faculty in 1650, where he was a colleague of Riccioli and Grimaldi
   b. During the 1650's he initiated a careful effort on the motion of the Sun, measuring meridian altitudes throughout the year using a specially constructed large gnomen at San Petronio
   c. As part of this effort, carried out impressively precise measurements to confirm Kepler's bi-section of the Earth-Sun orbit (convincing Riccioli, as well) (see Heilbron, pp. 102-119)
   d. These results revealed a discrepancy in the position of the celestial equator that led him to question both the solar parallax and refraction corrections used by Tycho
   e. (Horrocks had questioned these for reasons having to do with discrepancies in Kepler's orbits)
2. In the late 1650's Cassini began using telescopes by Campani, with truly superior lenses -- the highest quality of the era (along with Divini's), which others tried in vain to match
   a. In the early 1660's established that Mars, Venus, and Jupiter rotate on their axes, with Mars having a period a little longer than 24 hours and Venus a little under 24 hours (1666)
   b. Also confirmed a conjecture by Hooke that Jupiter is slightly flattened -- he estimated by 14/15
3. In 1650 undertook the project of working out detailed orbits for the four Galilean moons of Jupiter
   a. Others had determined periods and some elements, but precise distances from Jupiter could not be established without a micrometer; Kepler's suggestion that his third law holds for these satellites amounted to nothing more than that the periods are somewhere between the first and third power of the radii
   b. 15 years of observations, beginning with a copy of Torricelli's telescope in 1652, but making his most rapid progress in 1664 with the aid of 17 foot and 34 foot telescopes by Campani
   c. Able then to observe shadows of the satellites on Jupiter, from which he could determine velo-cities to a much higher accuracy
4. Cassini's tables giving ephemerides of the satellites of Jupiter were published in 1668, the first detailed accurate account of these orbits; useful for determining longitudes from eclipses
   a. Adopted circular orbits with uniform circular motion throughout, which he could get away with in the case of these four (e=0.000, 0.000, 0.002, 0.008)

b. Success in predicting eclipses depended mostly on his account of latitudes, which included an approximately 6 deg movement of the line of nodes per sidereal revolution of Jupiter

5. These tables attracted a good deal of attention in both England and France, where published reviews confirmed their accuracy, helping to stamp Cassini as at the forefront of observational astronomy

a. So far as I have been able to tell, Cassini does not address the question of Kepler's third "law," which Wendelin had said holds exactly for these satellites in a letter to Riccioli (in 1640's)

b. (Question left for Flamsteed to resolve in 1670's and 1680's, prompted in part by his knowledge of Streete and Horrocks)

B. Streete's *Astronomia Carolina* (1661)

1. A step forward with the publication of Streete's *Astronomia Carolina* in 1661, written in English and named in honor of newly restored monarchy of King Charles of England

a. The best among the several British works on planetary astronomy in the twenty year period starting and ending with Wing's books

b. The most eclectic, picking and choosing in pursuit of the most accurate predictive system

2. Elliptical orbits, using Boulliau's 1657 method of determining true from mean anomaly, not the area rule, but with superior orbital elements, in large part under the influence of Horrocks

a. (Boulliau's method attributed to Streete's friend, Robert Anderson, in the book)

b. As Table (from Wilson) shows, Streete comes closest to "correct" elliptical elements at the time

c. Flamsteed remarks in 1669, "I esteem Mr Streete's numbers the exactest of any extant."

d. (See graphs in Wilson (1989) showing discrepancies in ephemerides for the 1650-1690 period)

3. Follows Horrocks's *Venus in sole visa* in reducing the solar parallax to about 15 sec and using Kepler's third law to determine mean distances from periods

a. Significant improvements for Mercury and Venus, as we already know from Horrocks

b. Adapts a procedure of Herigone's (1637) for circular orbits to simple elliptical orbits to obtain eccentricity and aphelia

c. Denies that aphelia and nodes move, provoking a major controversy with Wing that extended across the 1660's, focusing on solar parallax and correct precession of the equinoxes; whether orbits are stationary (unlike Moon's) later to become an important issue

d. Invokes magnetism as a physical basis rather than a geometrical basis for defending (see Appendix)

4. Streete important because he shows the potential for refinement through revision of some of the assumptions underlying the *Rudolphine Tables*

a. Makes Horrocks's discoveries public, in process calling attention to Horrocks, whose *Venus in sole visa* is published in 1662 by Hevelius, to whom Huygens had sent a copy of the manuscript

b. Streete the first of the group in the 1650's and 1660's to pursue empirical improvement over Kepler, and not just comparability