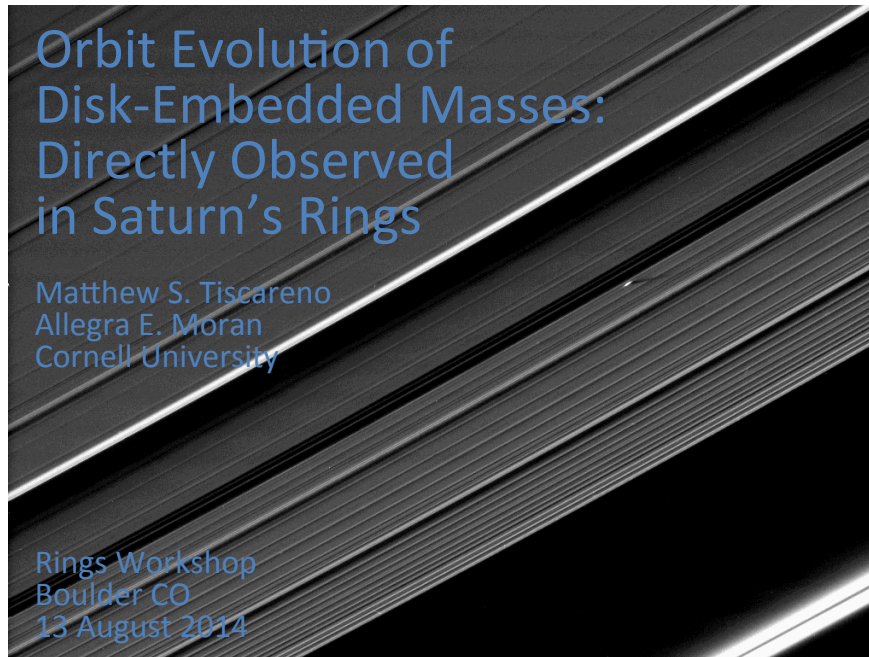


Orbit Evolution of Disk-Embedded Masses: Directly Observed in Saturn's Rings

Matthew S. Tiscareno
Allegra E. Moran
Cornell University

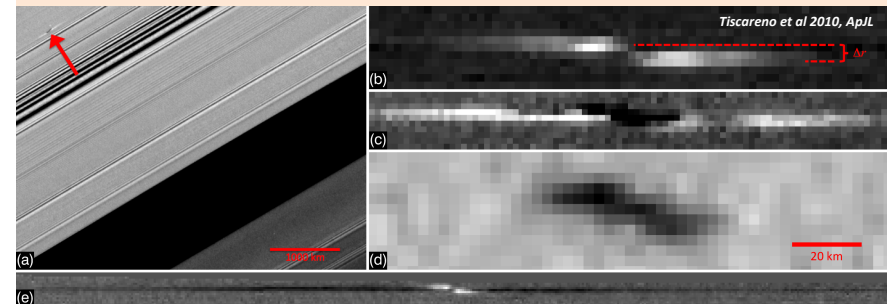
Rings Workshop
Boulder CO
13 August 2014



Tiscareno (2/13)

Propellers

- Moonlets embedded in the disk (Tiscareno et al. 2006, Nature)
- We see a “propeller-shaped” disturbance around the moonlet (itself unseen)
- First time ever tracking the orbit of an object moving within a disk, rather than in free space (Tiscareno et al. 2010, ApJL)
- Orbits are observed to change on ~yr timescales
 - Interacting with the disk? Implications for Type I migration?




Tiscareno (3/13)

Propeller Nicknames

- For ease of tracking, propellers have been informally nicknamed after aviation pioneers
- Blériot is the biggest and best-tracked, will discuss most
- Will also show orbit data for the following:
 - Santos-Dumont
 - Sikorsky
 - Post
 - Earhart: Photogenic (on this slide, title slide)

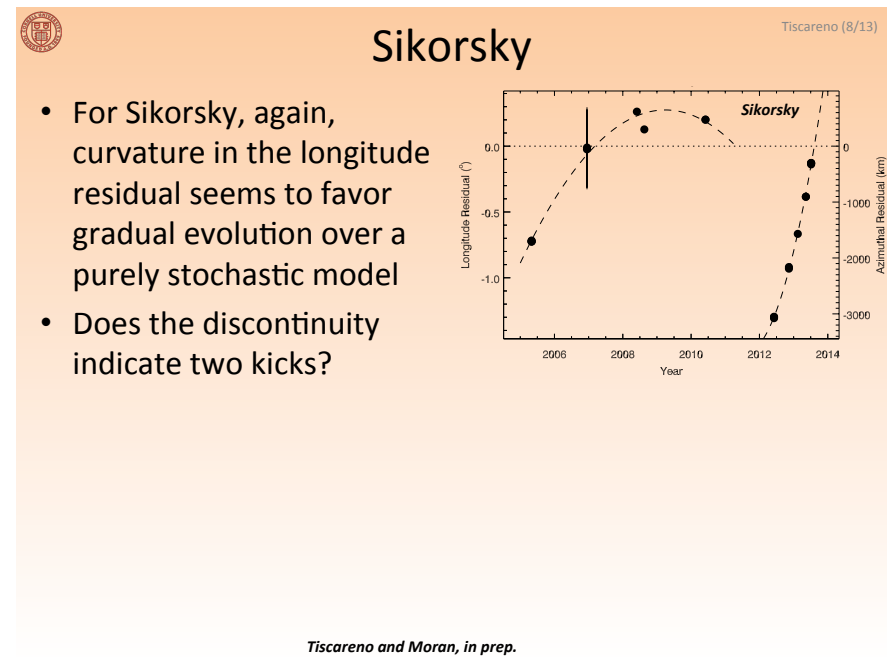
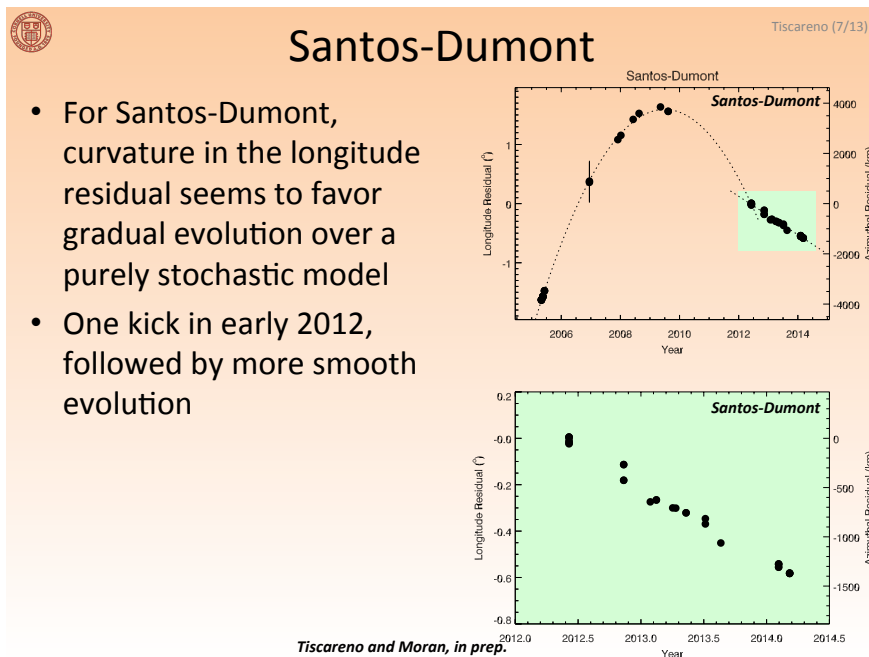
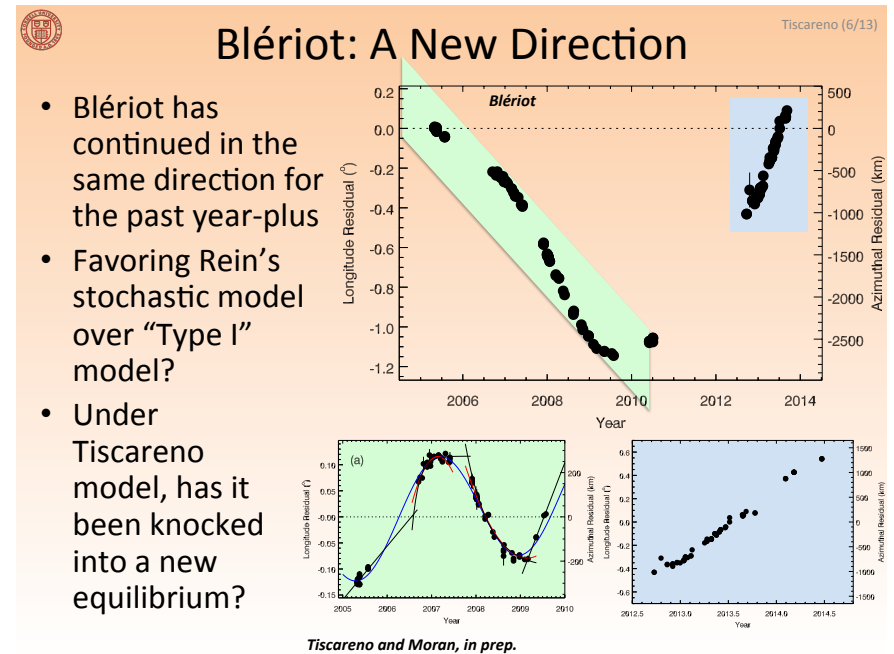
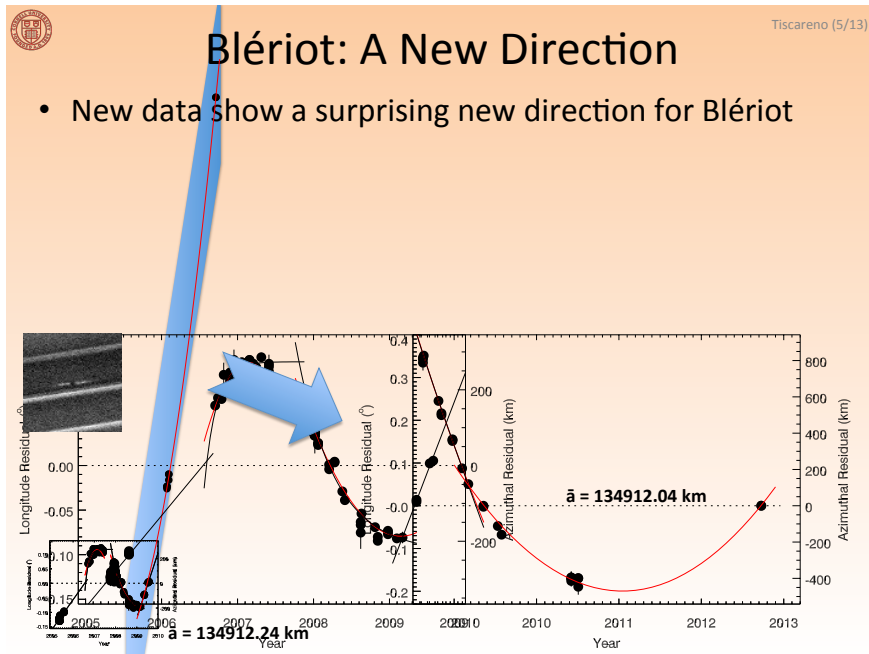
Louis Blériot
(1872-1936)
First man to fly across the English Channel (1909)



Tiscareno (4/13)

Why do the orbits change?

- Several explanations for propeller orbit evolution have been proposed
 - Smooth interactions with the disk?
Crida et al. (2010, AJ), Pan and Chiang (2010, ApJ; 2012, AJ)
 - Stochastic/catastrophic interactions with particles or wakes?
Rein and Papaloizou (2010, A&A), Pan et al. (2012, MNRAS)
 - The first, punctuated by the second?
Tiscareno (2012, P&SS)
 - Resonances with moons?
Sremcevic (2014, this meeting)
- Since 2012, Cassini has detected propellers more frequently
- New data show a surprising new direction

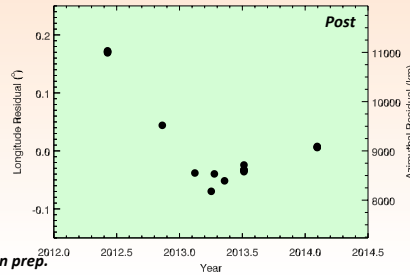
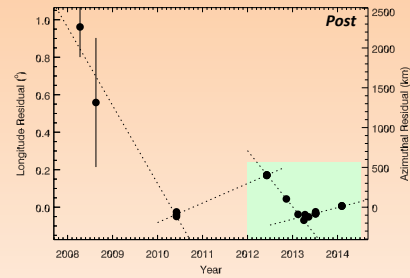




Post

Tiscareno (9/13)

- For Post, apparently abrupt “kick” captured with unprecedented temporal resolution
- More error analysis needed



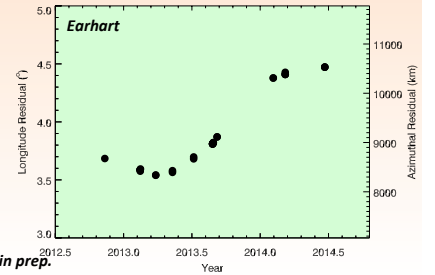
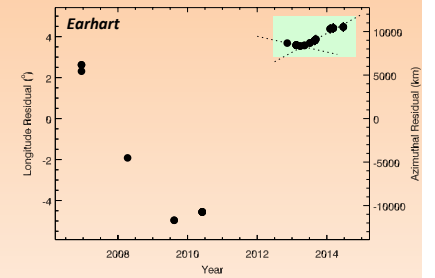
Tiscareno and Moran, in prep.



Earhart

Tiscareno (10/13)

- For Earhart, two “kicks” since 2012 with curvature in between?
- If sinusoidal (per Sremcevic) what about pre-2012?



Tiscareno and Moran, in prep.



Asymmetric Structure

Tiscareno (11/13)

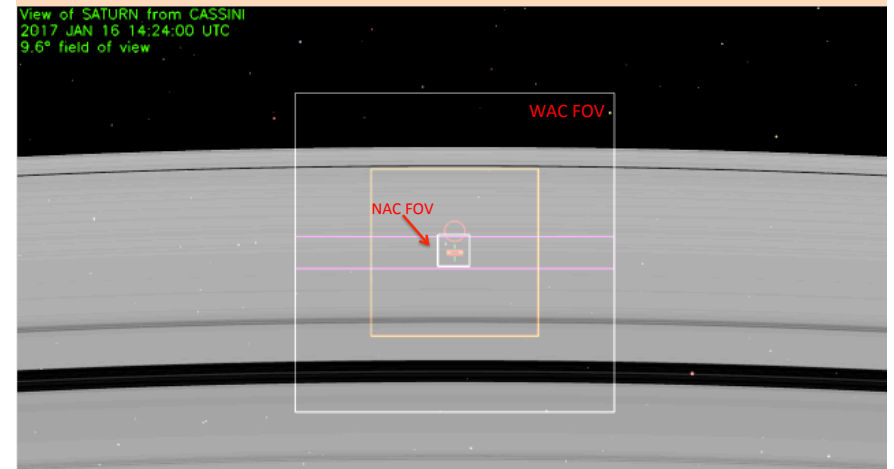
- The outward/trailing lobe sometimes appears wider, brighter



More to Come!

Tiscareno (12/13)

- Will target individual propellers, as well as Propeller Belts, during Grand Finale





Conclusions

- A new direction for Bleriot
 - Persistent new semimajor axis, ~ 0.2 km inward
- Other propellers also show non-keplerian motion
 - Both smooth and episodic evolution seem evident
- Propellers seem to appear and/or disappear
 - Is it real, or a trick of the light?
- Some propellers exhibit asymmetric structure
 - Outward/trailing lobe is wider and brighter
- Exciting observations planned for Grand Finale

