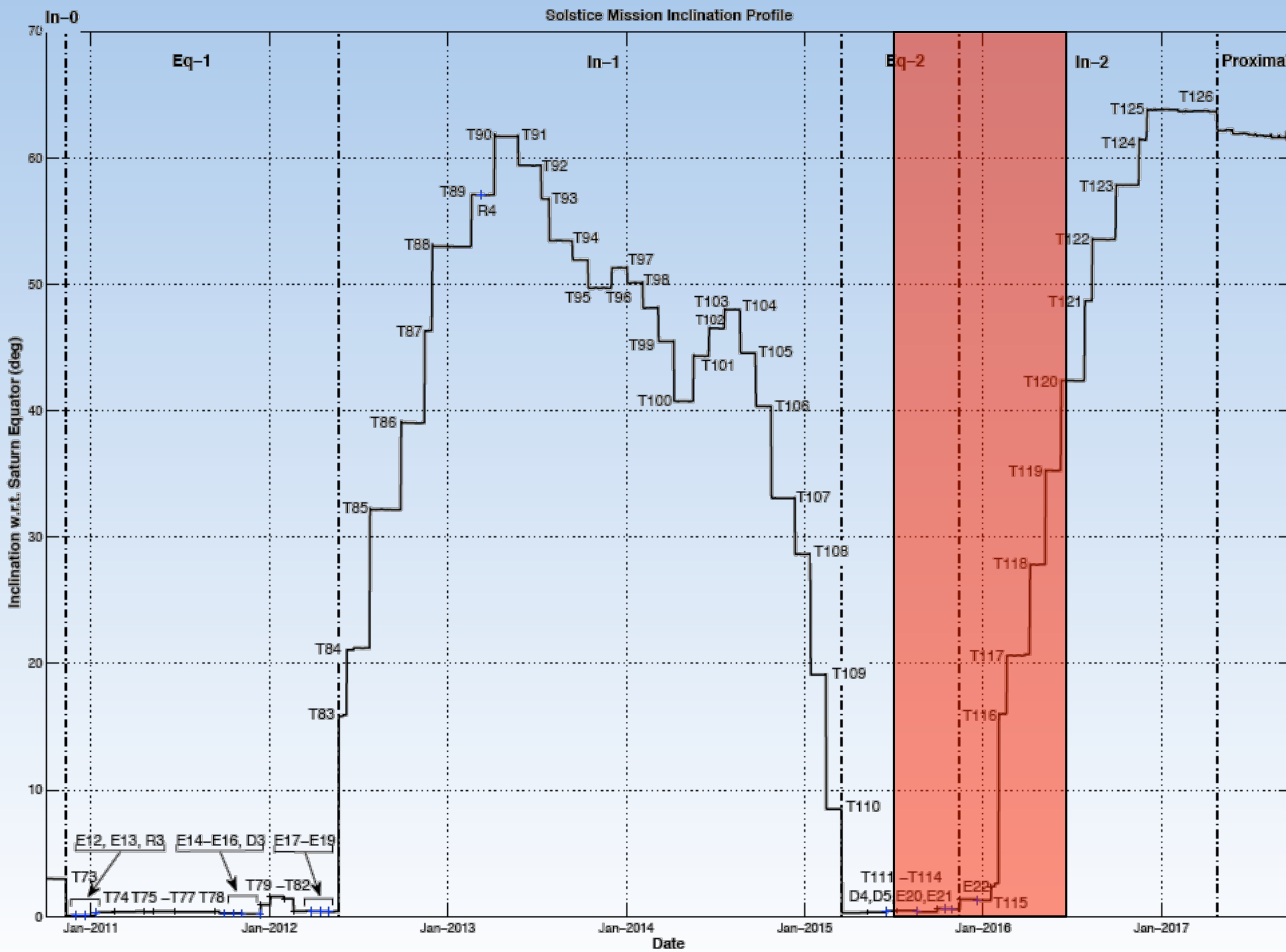
Rings Update

CHARM Telecon 8/2016

Matthew S. Tiscareno, SETI Institute

Now ascending towards the Grand Finale!



Talk Highlights

- A new method for measuring density waves and weighing the B ring ***(Matt Hedman)***
- Meteoroid mass flux ***(Sascha Kempf)***
- Rocky material in the mid-C ring ***(Zhimeng "ZZ" Zhang)***
- Ring particles stay cool in each others' shadows ***(Estelle Deau)***
- Shepherd moons in the main ring gaps ***(Joe Spitale)***
- Update on "Peggy" ***(Carl Murray)***
- *Planetary Ring Systems* book
- Grand Finale plans

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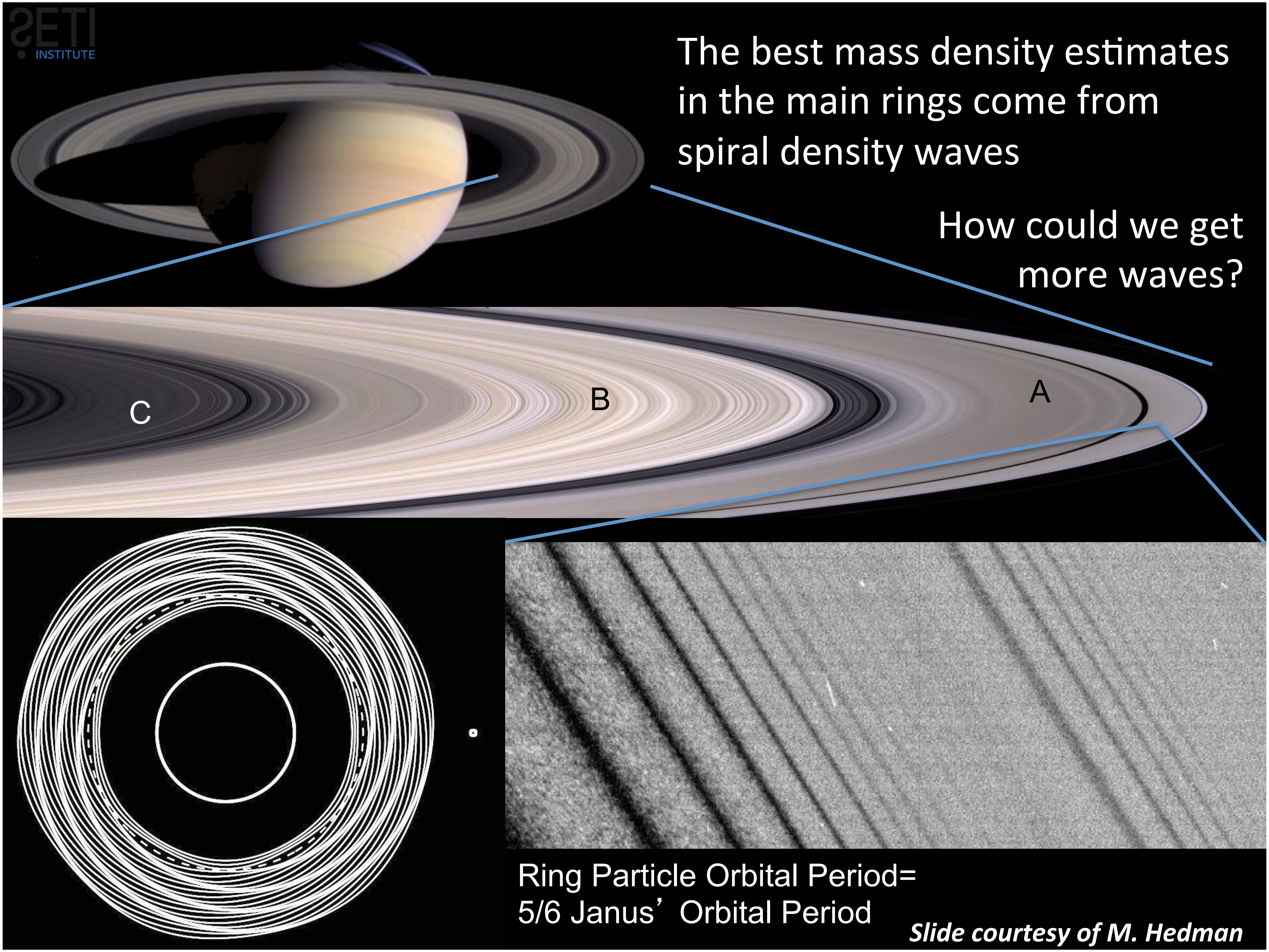
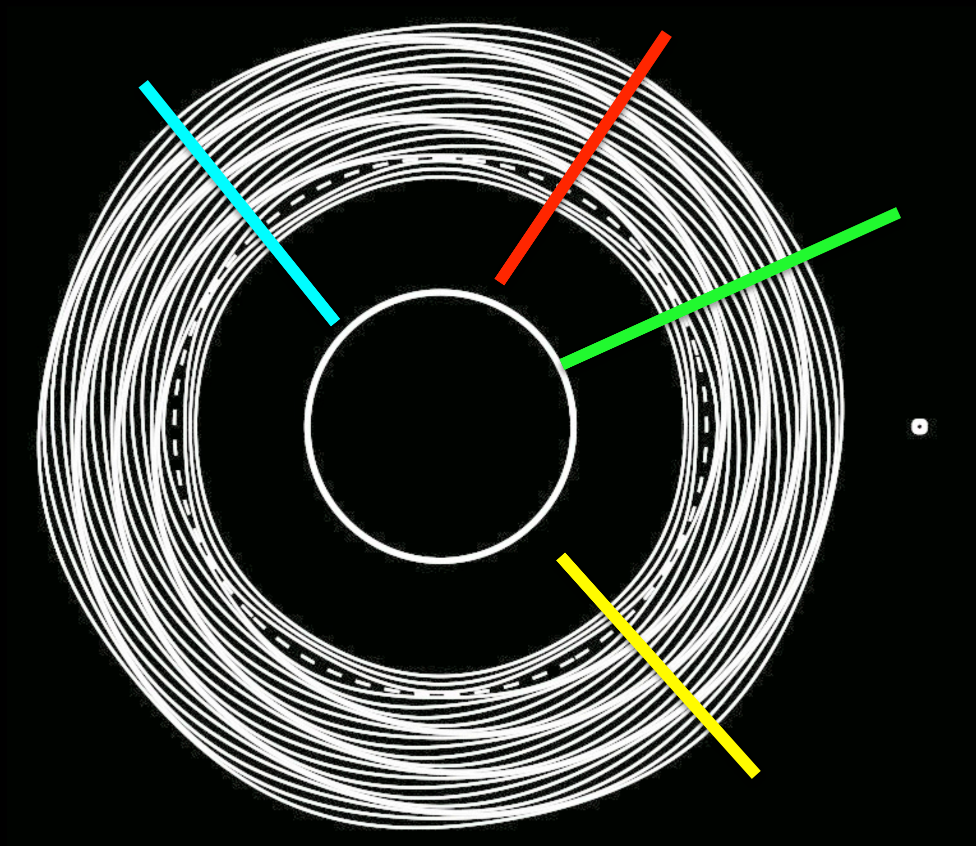
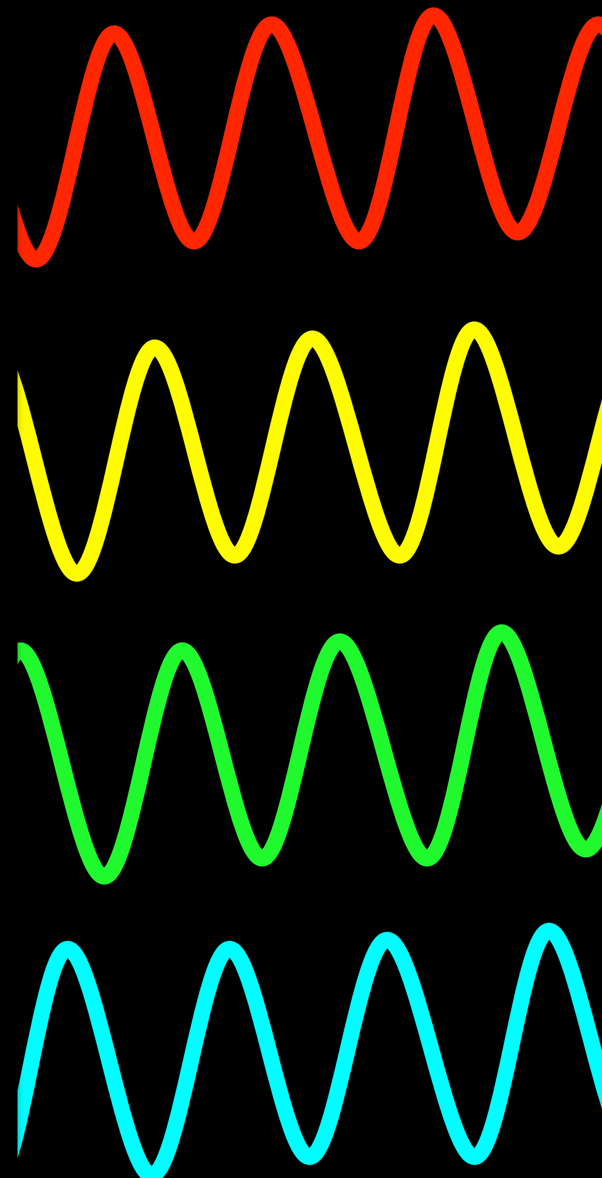

SETI INSTITUTE
The best mass density estimates in the main rings come from spiral density waves
How could we get more waves?
C
B
A
Ring Particle Orbital Period=
5/6 Janus' Orbital Period
Slide courtesy of M. Hedman

Data from multiple occultations can be used to isolate signals from particular density waves.

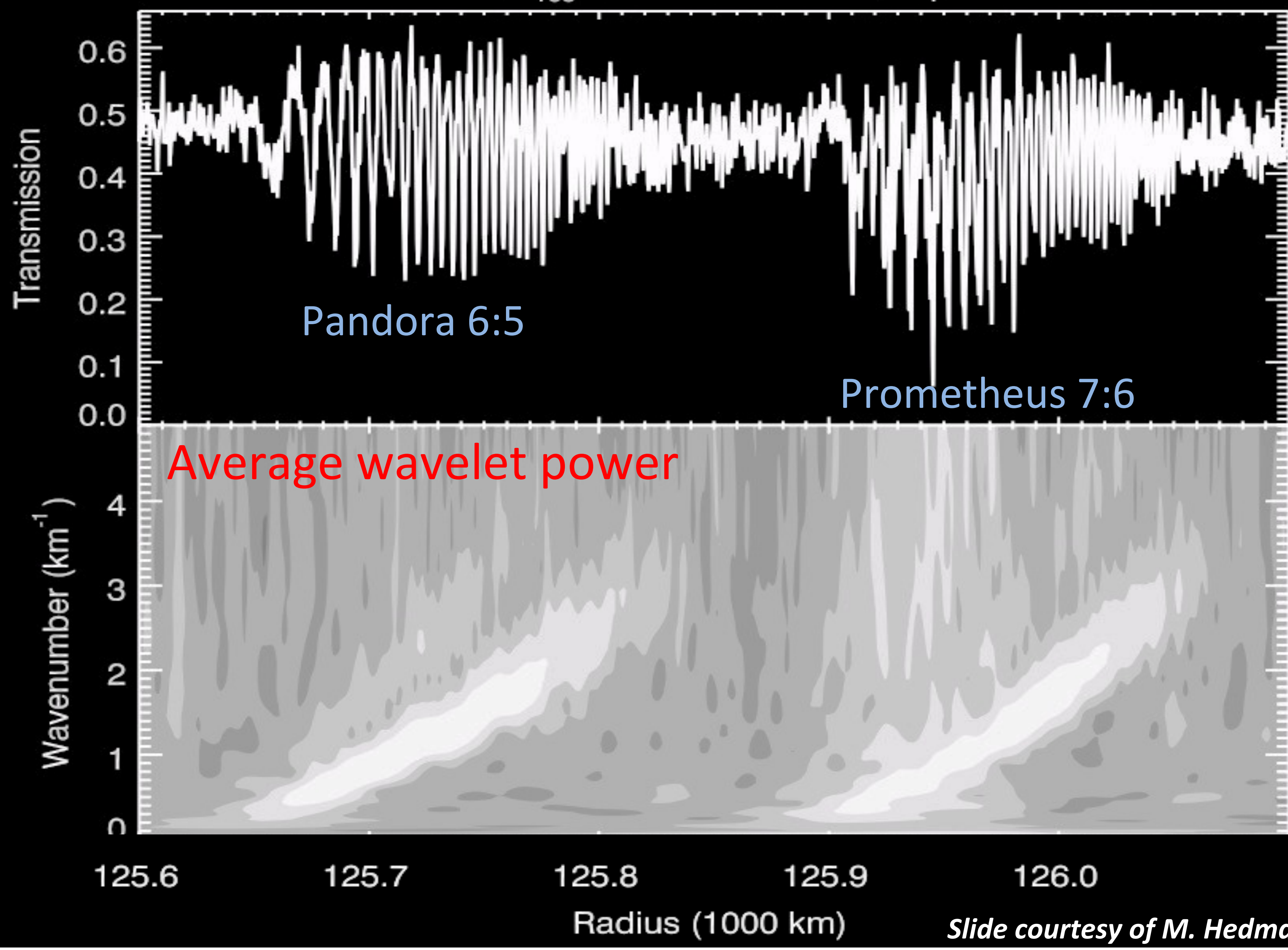




At any given wavelength and location, we can see if the phase-shifts in the signal are consistent with a particular spiral pattern.

Slide courtesy of M. Hedman

These phase corrections can isolate signals with specific pattern speeds



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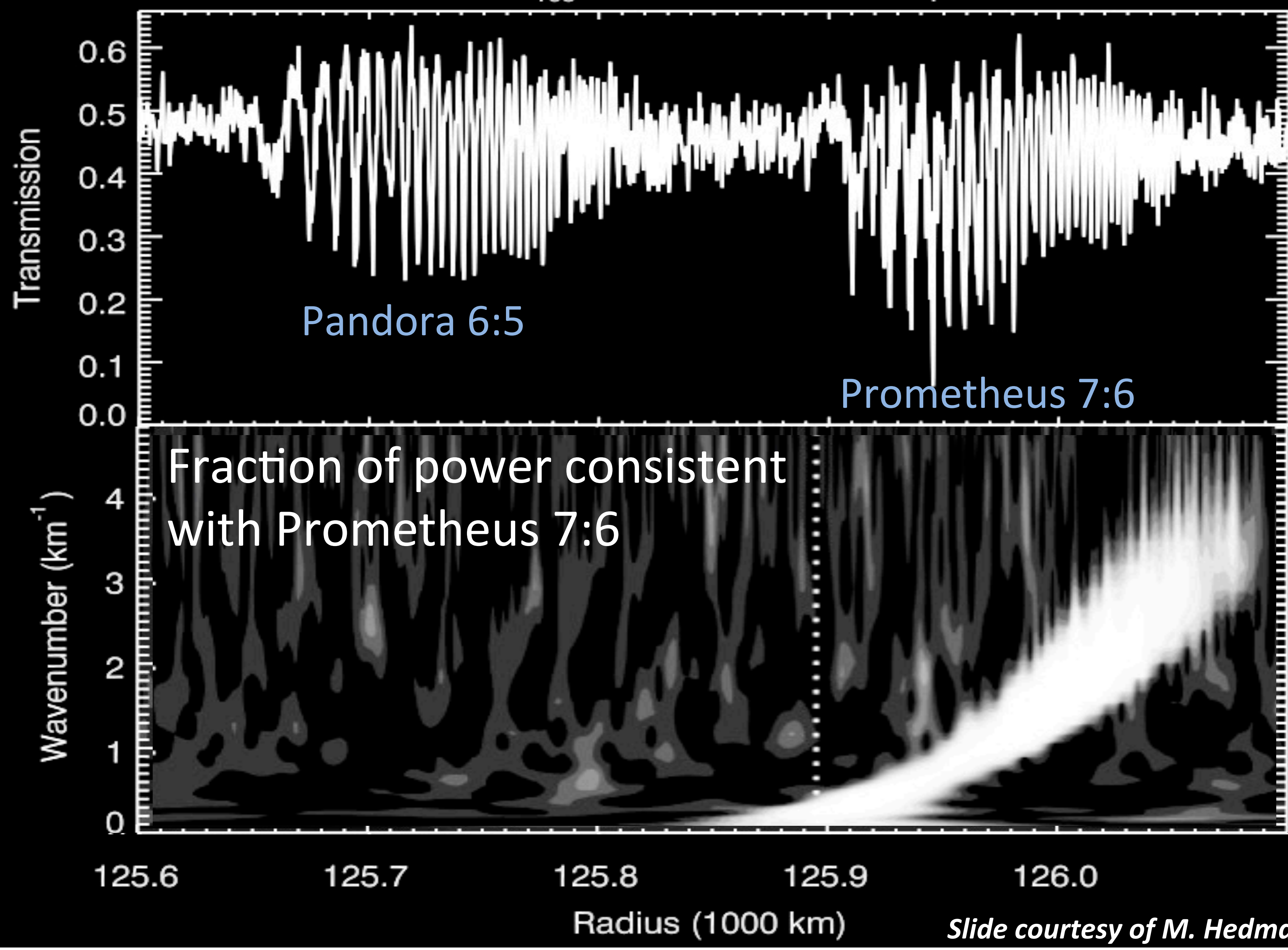
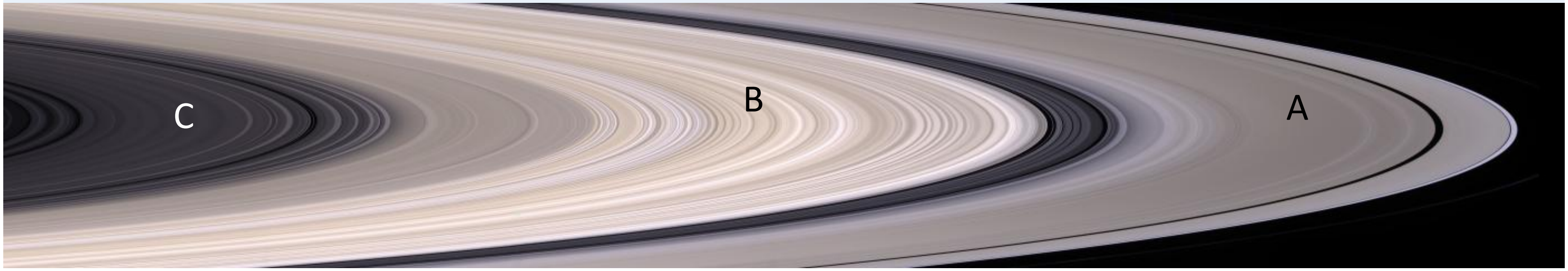


Slide courtesy of M. Hedman

The surface density of the B ring

- Very few density waves have been identified in the B ring
  - Very optically thick (less than 1% of light gets through it)
  - Lots of structure we don't understand gets in the way
- This method has measured the B ring's surface density at 6 different locations
- Surprisingly, the surface density is not much less than that of the A ring!
  - Wildly different optical depths, similar densities, indicates particle sizes or other particle properties are different
  - Total mass is smaller, indicates rings are likely young

Hedman and Nicholson (2016, arXiv:1601.07955)



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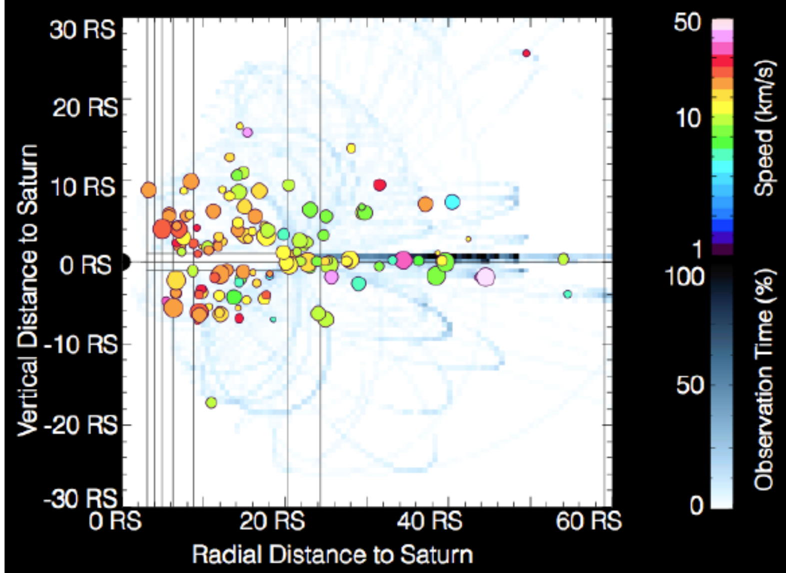
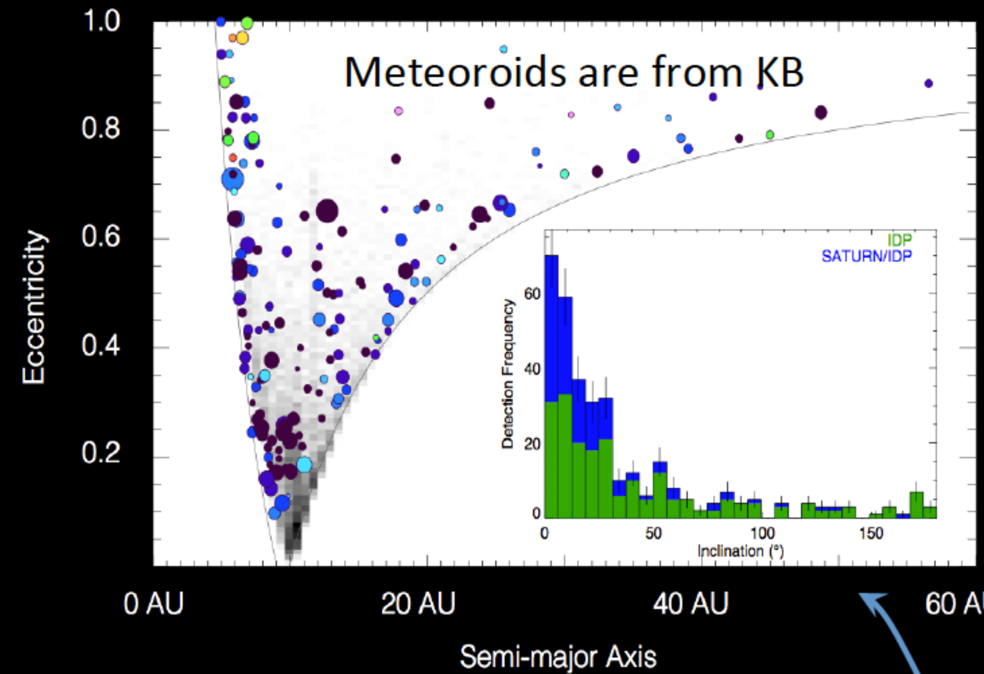
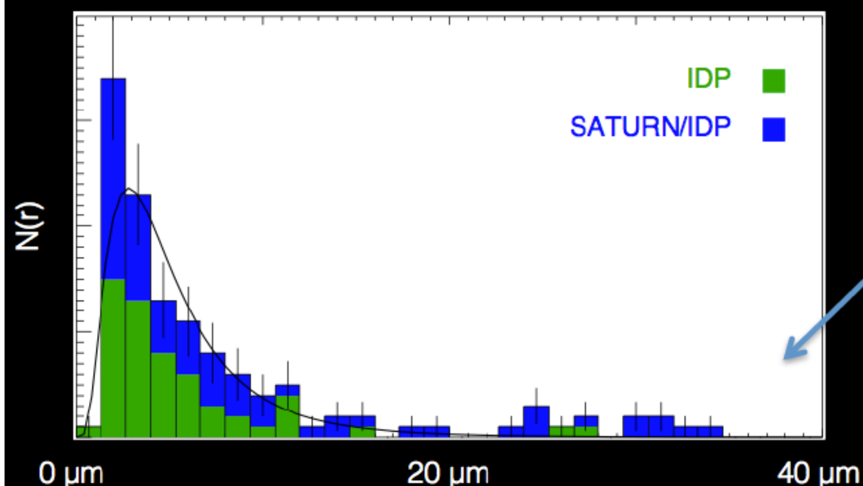
“Final” Meteoroid mass flux: CDA (Kempf, Srama, Altobelli)







This corresponds of a mass flux of
$4.2 \cdot 10^{-15}$ kg/m^{2}s $\leq F_\infty \leq 3.6 \cdot 10^{-16}$ kg/m^{2}s

Lower limit is close to Voyager-era estimate, but new identification as KBOs implies low encounter velocity so focussed flux at rings is almost 10x higher than Voyager-era values. If ring mass is comparable to Mimas, rings are probably young. Eagerly await ring mass measurement in FPROX!!

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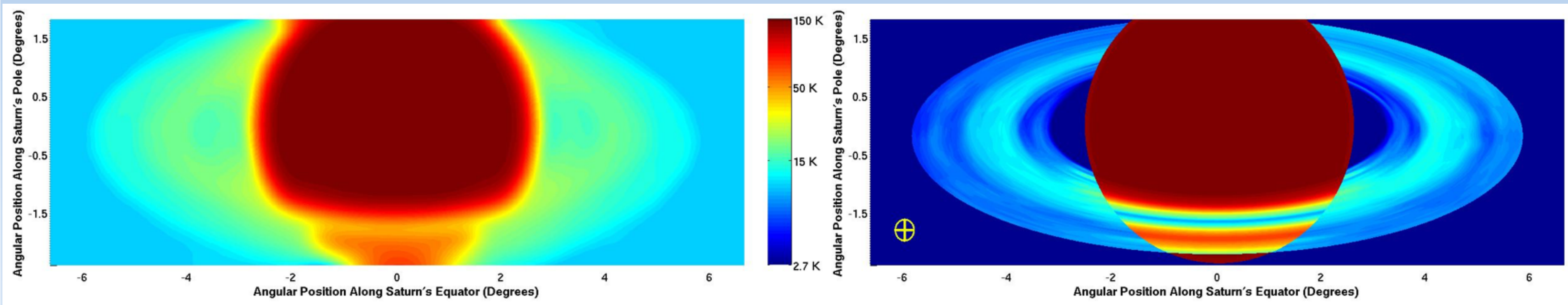
Radio images of Saturn’s rings

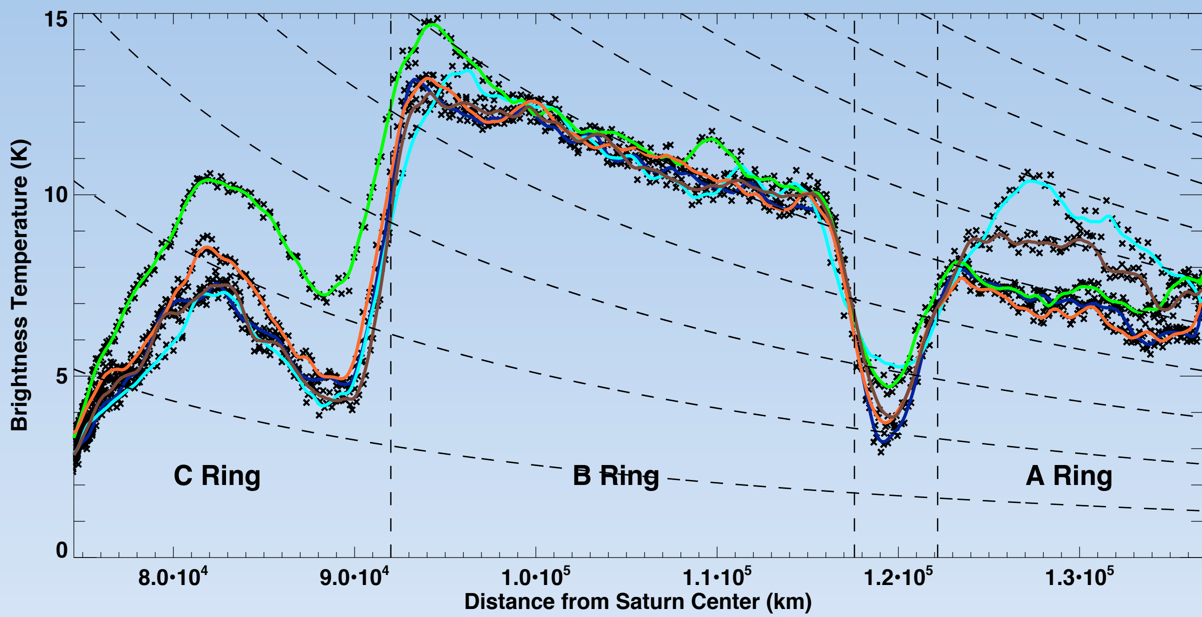
- Processing and calibration of radio images



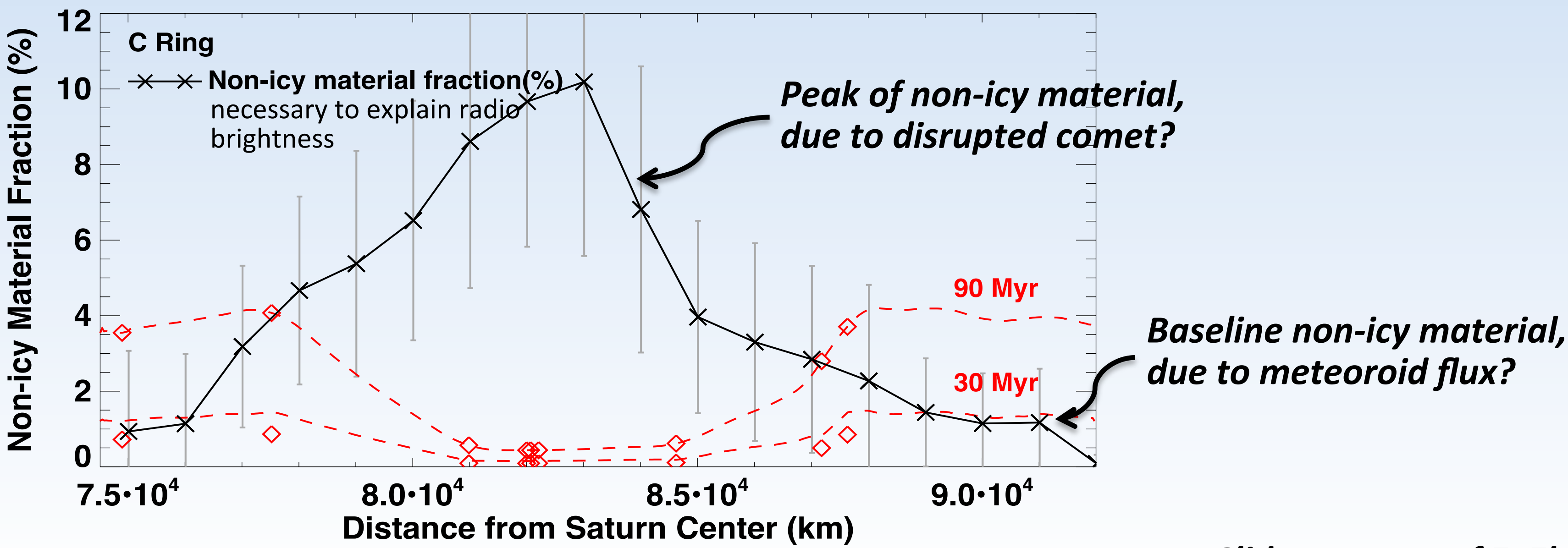
BEFORE **AFTER**

Slide courtesy of Z. Zhang

Radio images of Saturn's rings



- A and B rings consistent with reflected light from Saturn
- C ring requires thermal emission



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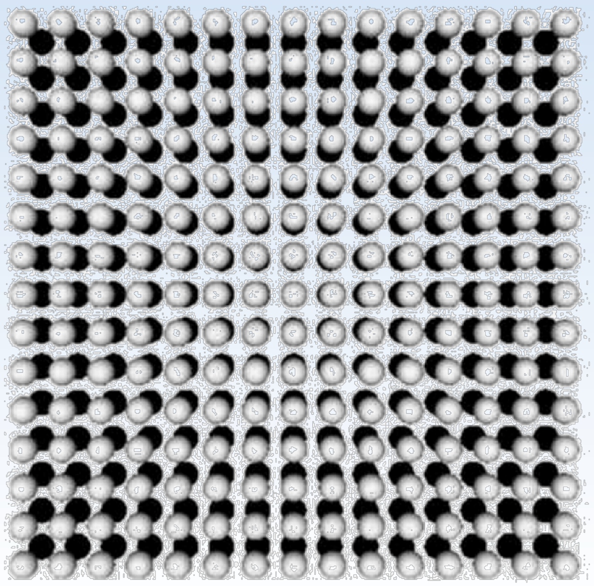
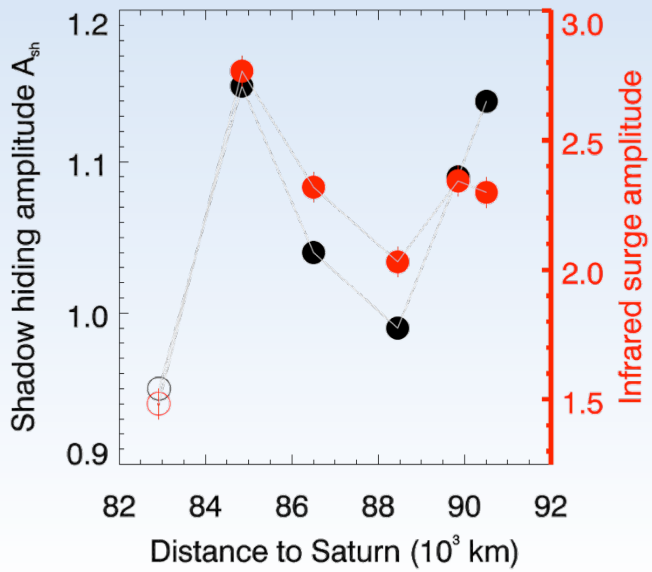
Shadows cool ring particles

- "Opposition Effect": Target is brighter when the Sun is directly behind you
  - Partly because you see only sunlit faces; shadows are hidden
  - Partly because of quantum interactions between in-going and out-going photons
- Shadow-hiding plays a role: Ring particle temperatures (per thermal infrared) correlate with shadow models

Figures courtesy E. Deau





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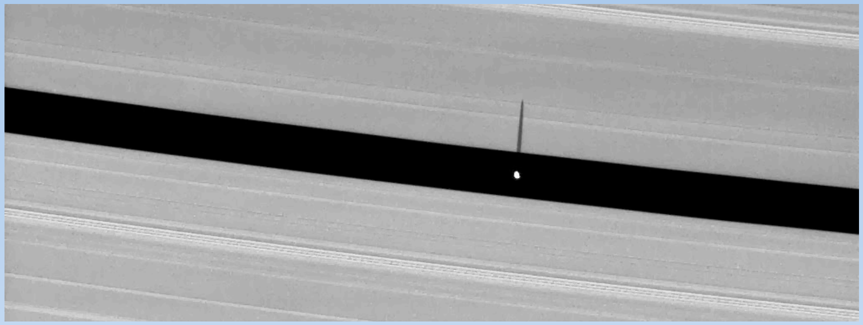
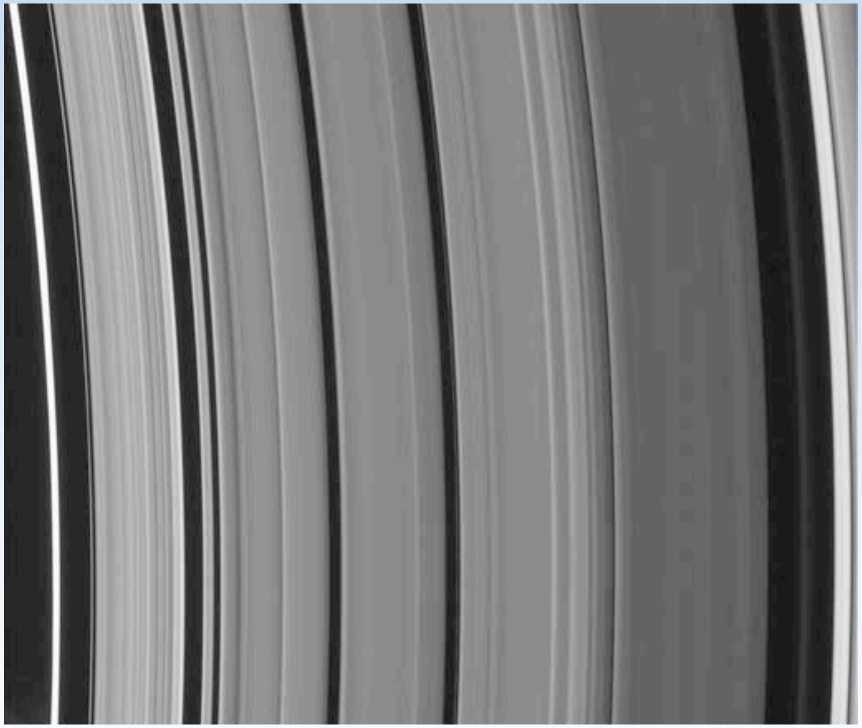
Do the gaps have shepherds?

- An embedded moon is the simplest way we know to hold open a gap in the rings
- Cassini campaign to image gaps, find shepherd moons



The moon Pan in the Encke Gap

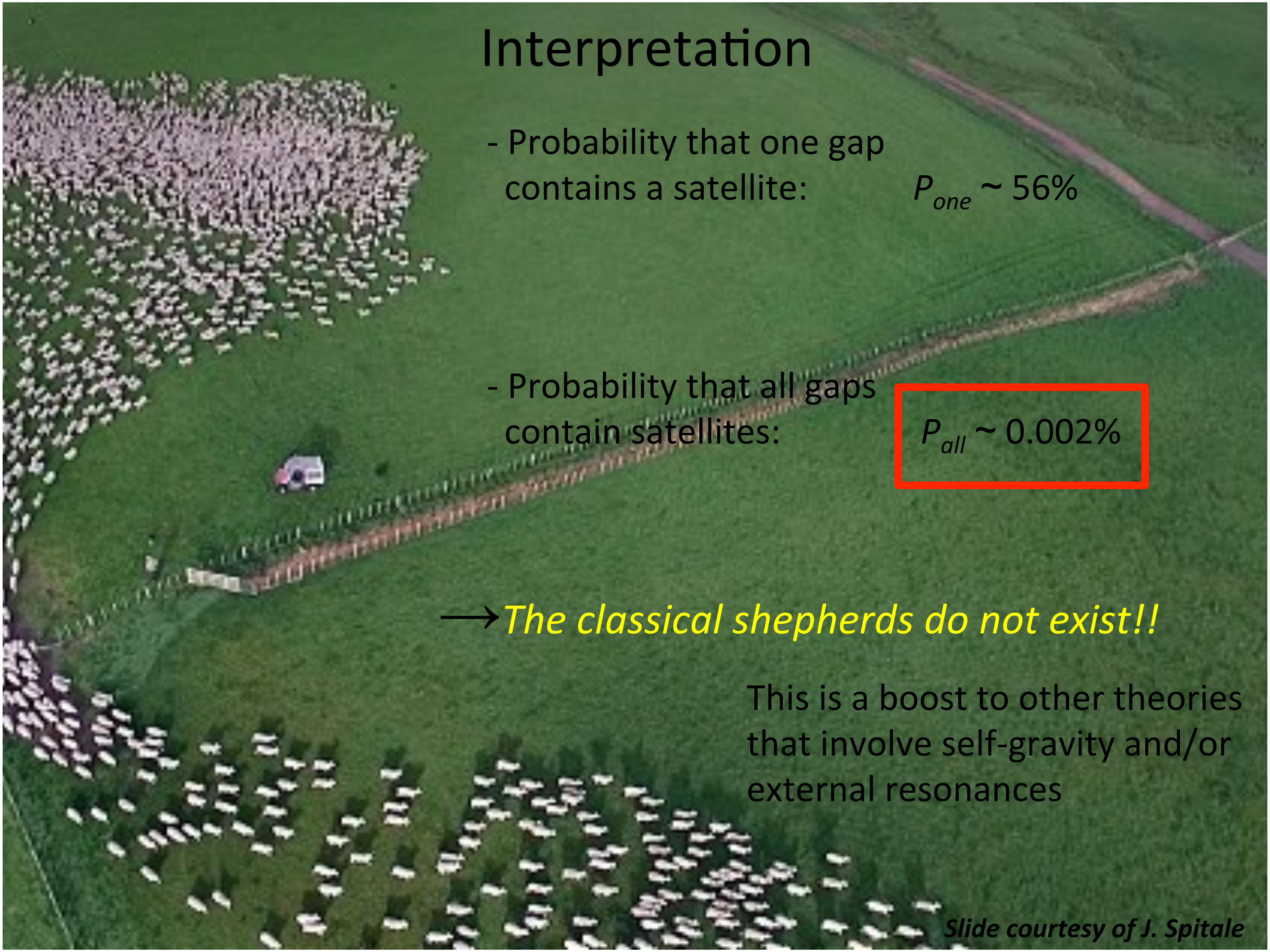


The Cassini Division has many gaps

List of newly discovered shepherds

Slide courtesy of J. Spitale

Interpretation



- Probability that one gap contains a satellite: $P_{one} \sim 56\%$

- Probability that all gaps contain satellites: $P_{all} \sim 0.002\%$

⟶*The classical shepherds do not exist!!*

This is a boost to other theories that involve self-gravity and/or external resonances

Slide courtesy of J. Spitale

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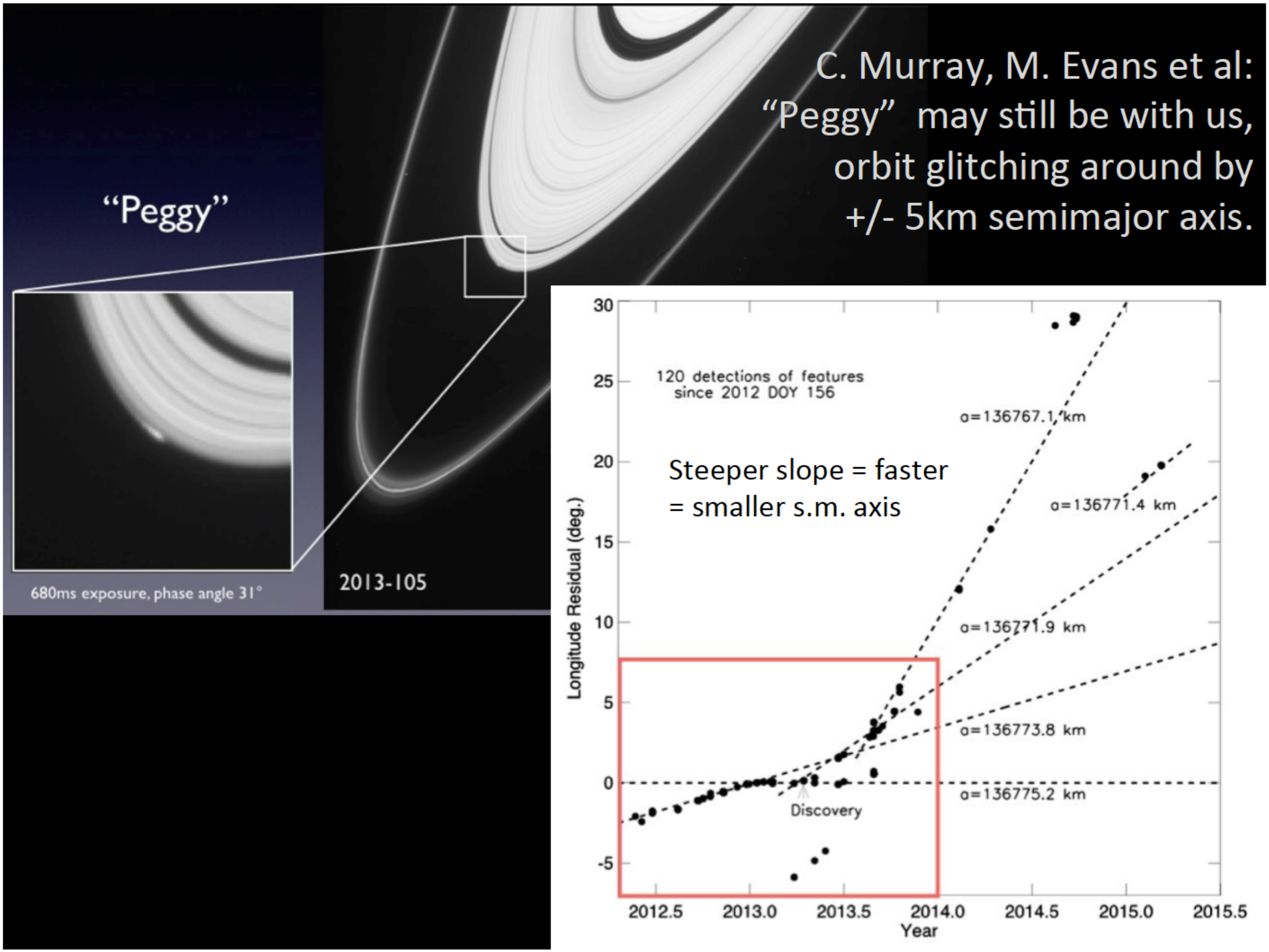
C. Murray, M. Evans et al:
"Peggy" may still be with us,
orbit glitching around by
+/- 5km semimajor axis.
"Peggy"
680ms exposure, phase angle 31°
2013-105
120 detections of features
since 2012 DOY 156
Steeper slope = faster
= smaller s.m. axis
a=136767.1 km
a=136771.4 km
a=136771.9 km
a=136773.8 km
a=136775.2 km
Discovery
Longitude Residual (deg.)
Year
30
25
20
15
10
5
0
-5
2012.5
2013.0
2013.5
2014.0
2014.5
2015.0
2015.5

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Planetary Ring Systems

- Publisher: Cambridge University Press
  Editors: Matthew Tiscareno and Carl Murray
  Advisory Board: J. Burns, J. Cuzzi, L. Esposito, P. Nicholson
- Definitive scholarly book, aiming to succeed the classic book edited by Greenberg and Brahic (1984)
- Scope includes all rings systems, not just Saturn
  - Most chapters to focus on ring types or characteristics in a way that cuts across the known ring-bearing planet systems
- Time frame
  - To be published this winter
  - Tentative plan: 2nd edition ~2020
- 650 pp, B/W figures in the text w/color plates in the back

Planetary Ring Systems

http://planetaryringsystems.astro.cornell.edu

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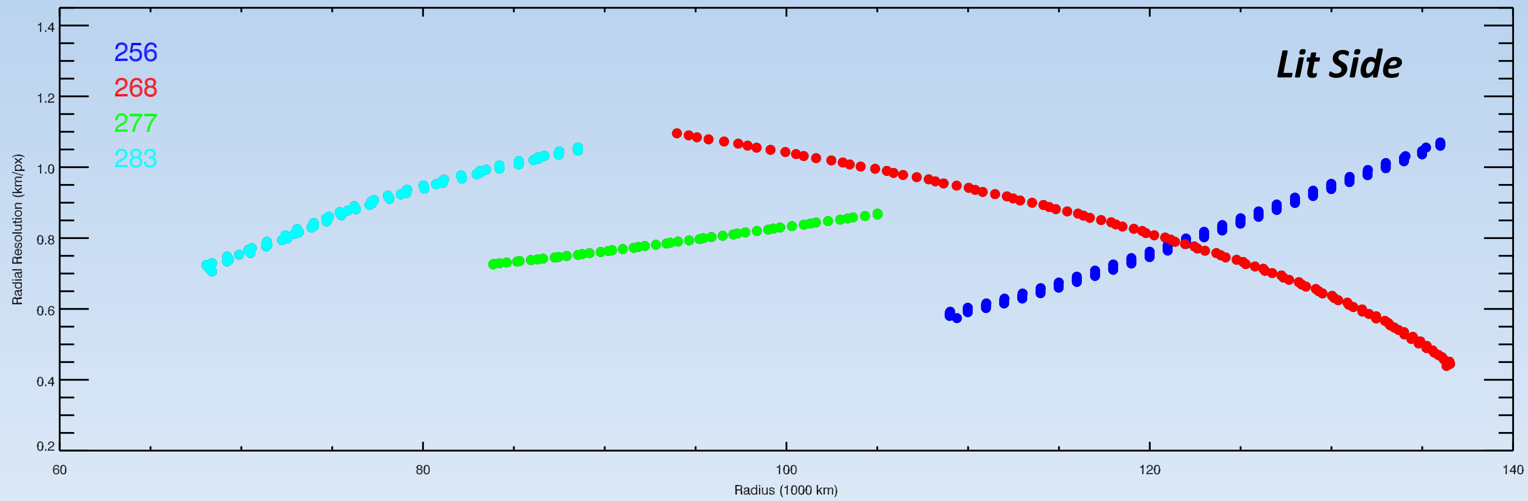
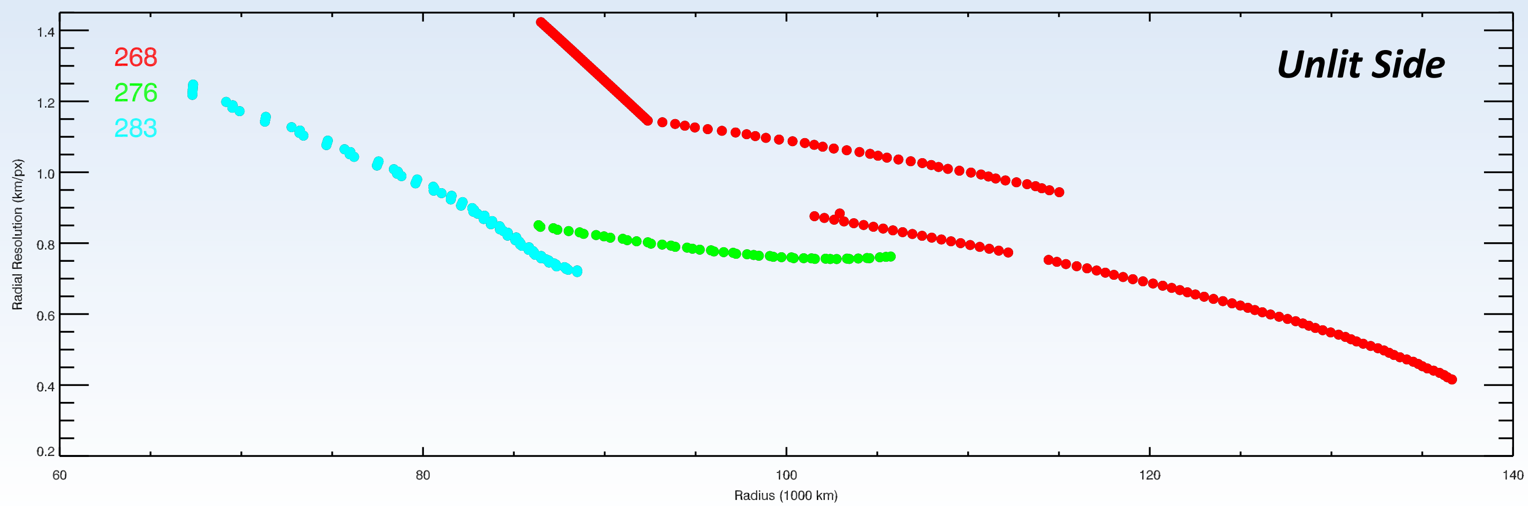
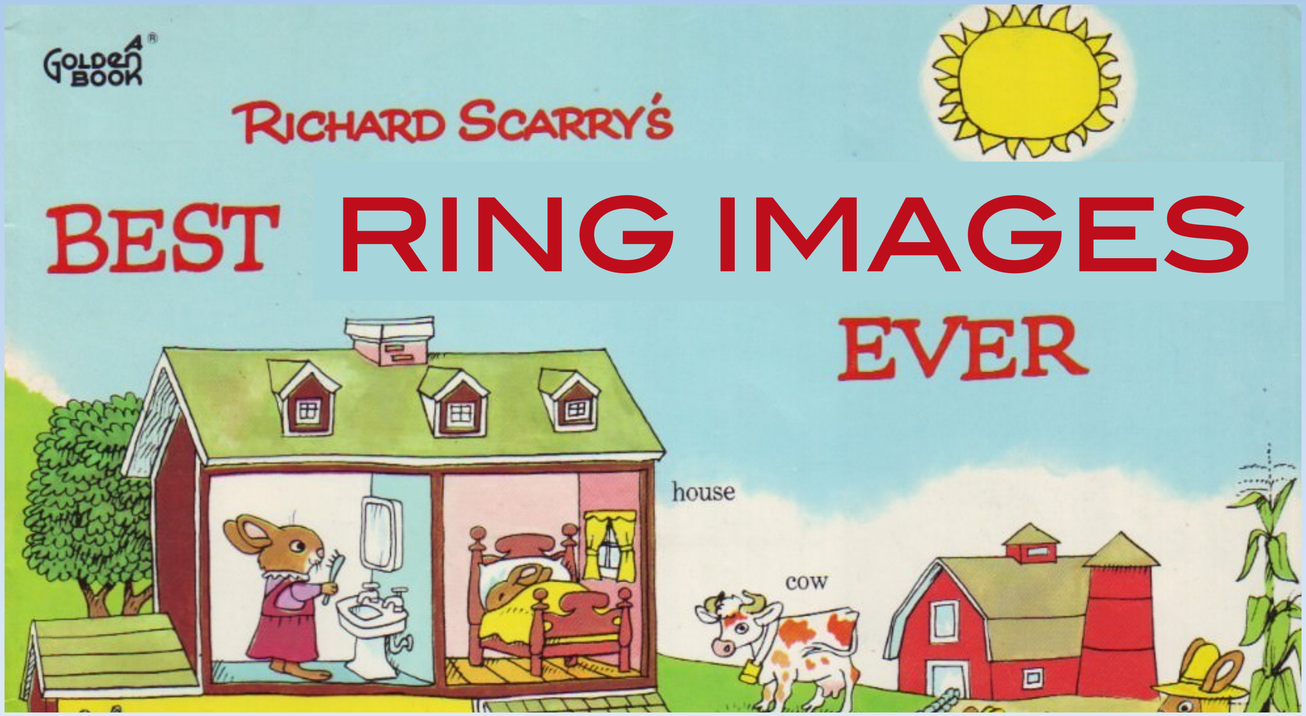
Grand Finale

- High-resolution radial scan
- Will build up coverage over multiple passes





Grand Finale



- Super high-res images of interesting ring structure
  - Propeller Belts
  - Density wave "straw"
  - Viscous overstability
  - C ring plateaus
- Retargetting known propellers at ~0.5 km/px