

Analysis of Clumps in Saturn's F Ring from Voyager and Cassini

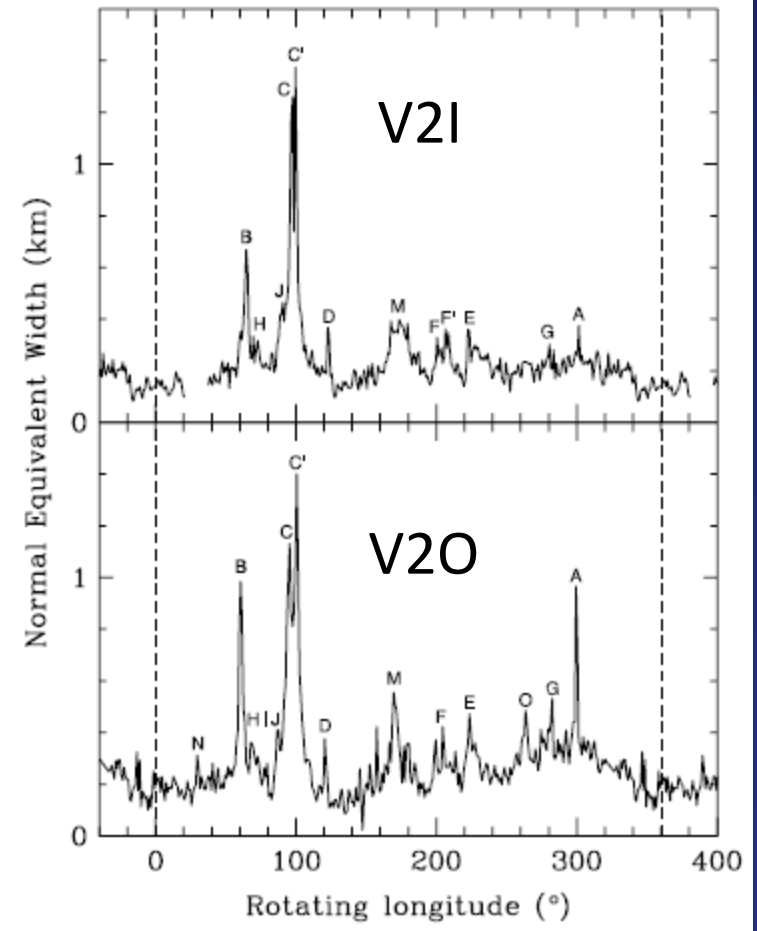
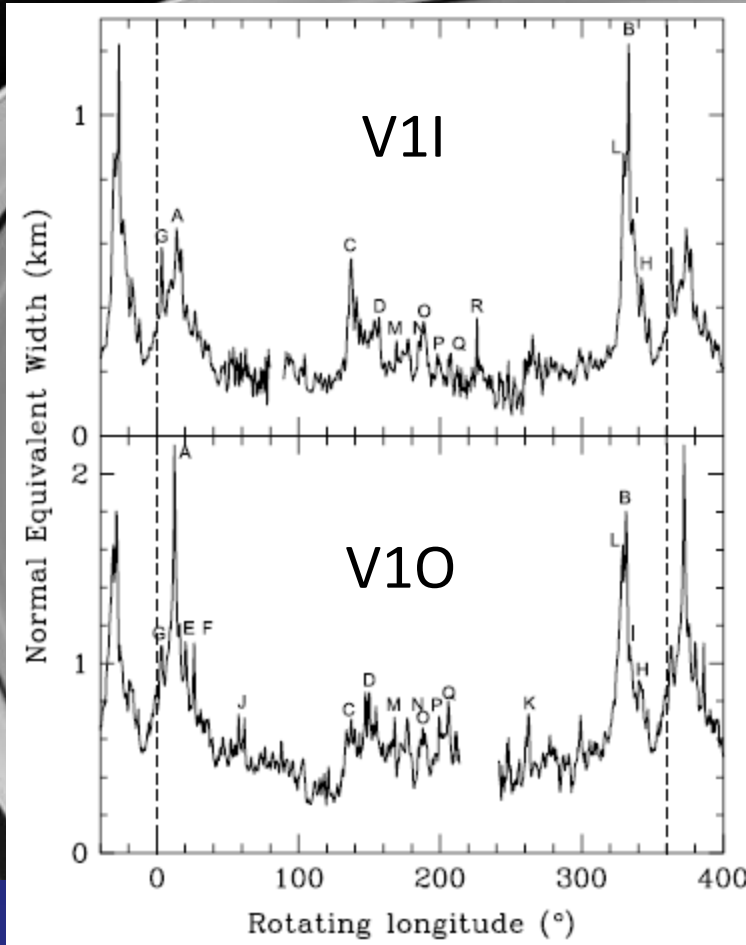
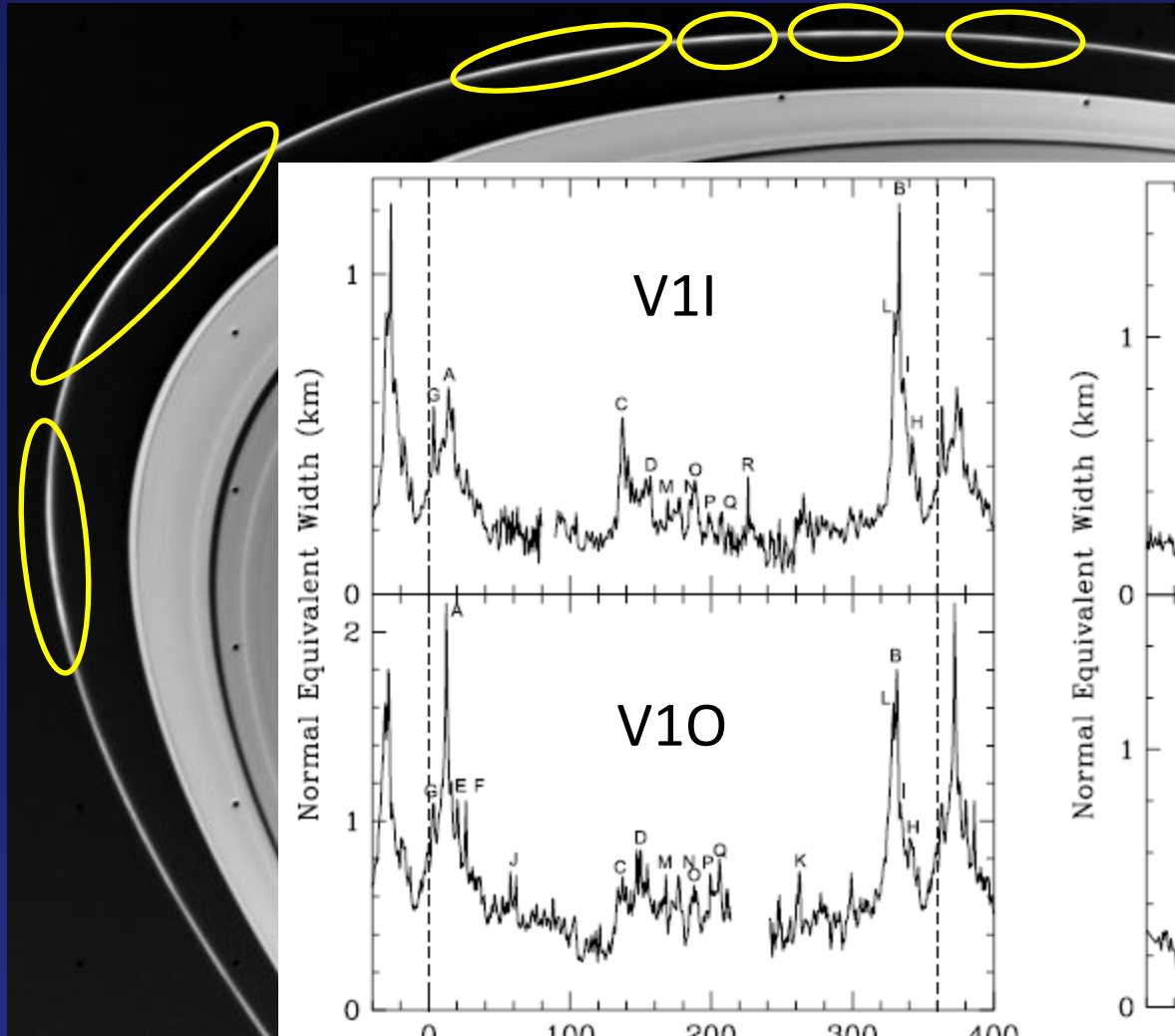
Observations
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Shannon K. Hicks, Mark R. Showalter,
Adrienne K. Antonsen, Douglas R. Packard

Planetary Rings Workshop – Boulder, CO
August 15, 2014

(French et al. *Icarus* 2014, 241, 200-220)

“Extended” Clumps Seen by Voyager

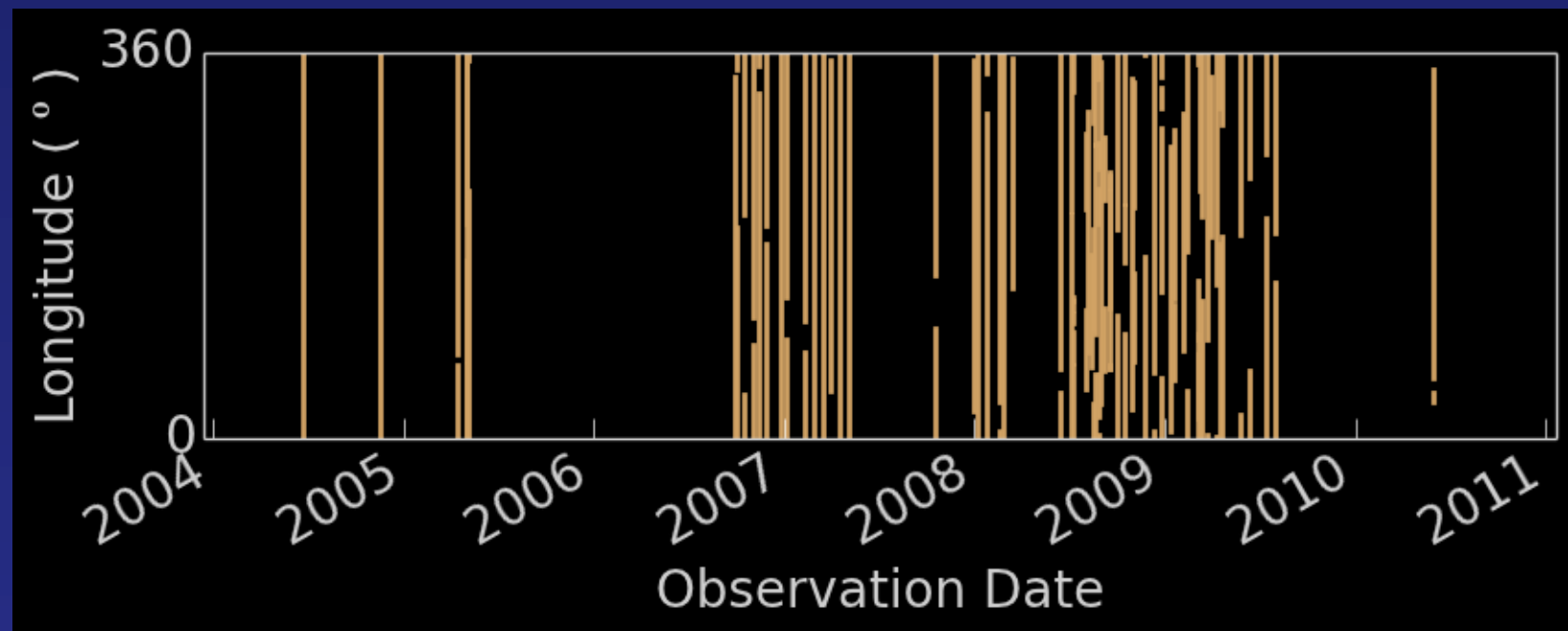


Showalter (2004)

Data Set

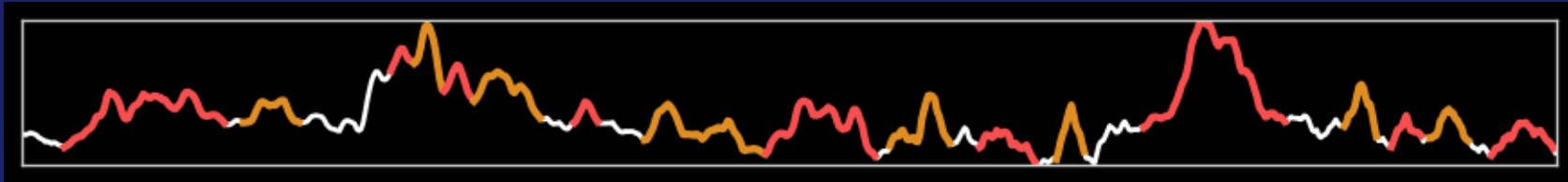
Voyager: 4 profiles 1980-1981
(two each, 9 months apart)

Cassini: 65 profiles 2004-2010



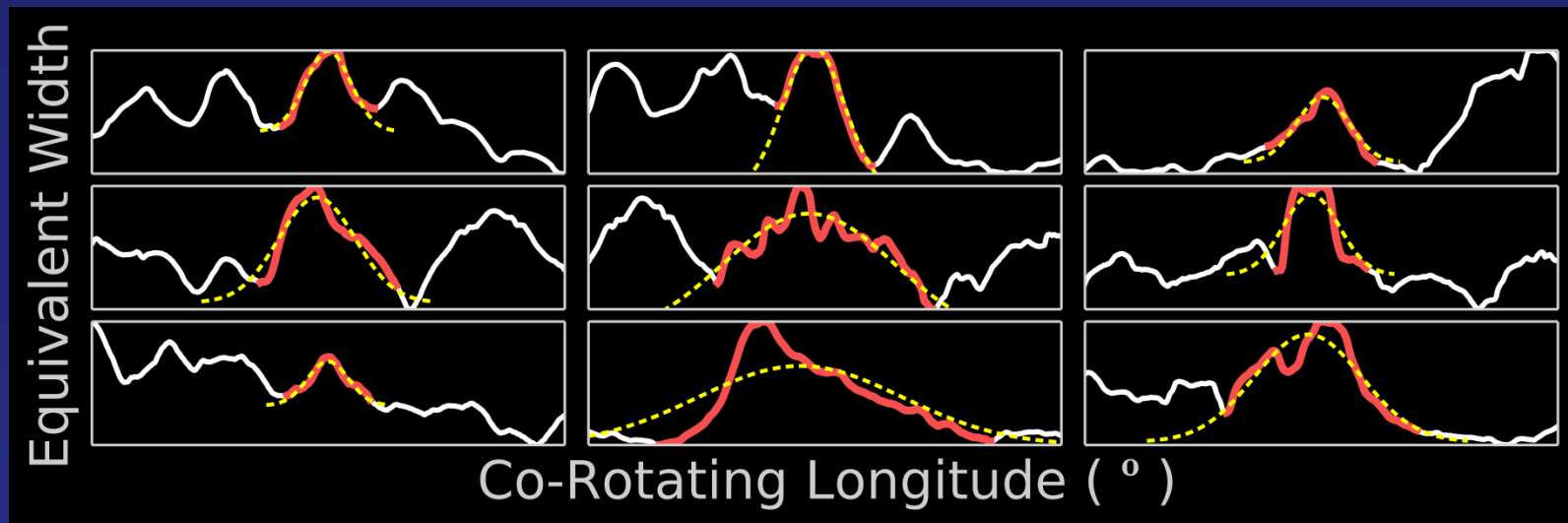
Clump Detection

- Used wavelets to detect clumps (3.5  - 40 )

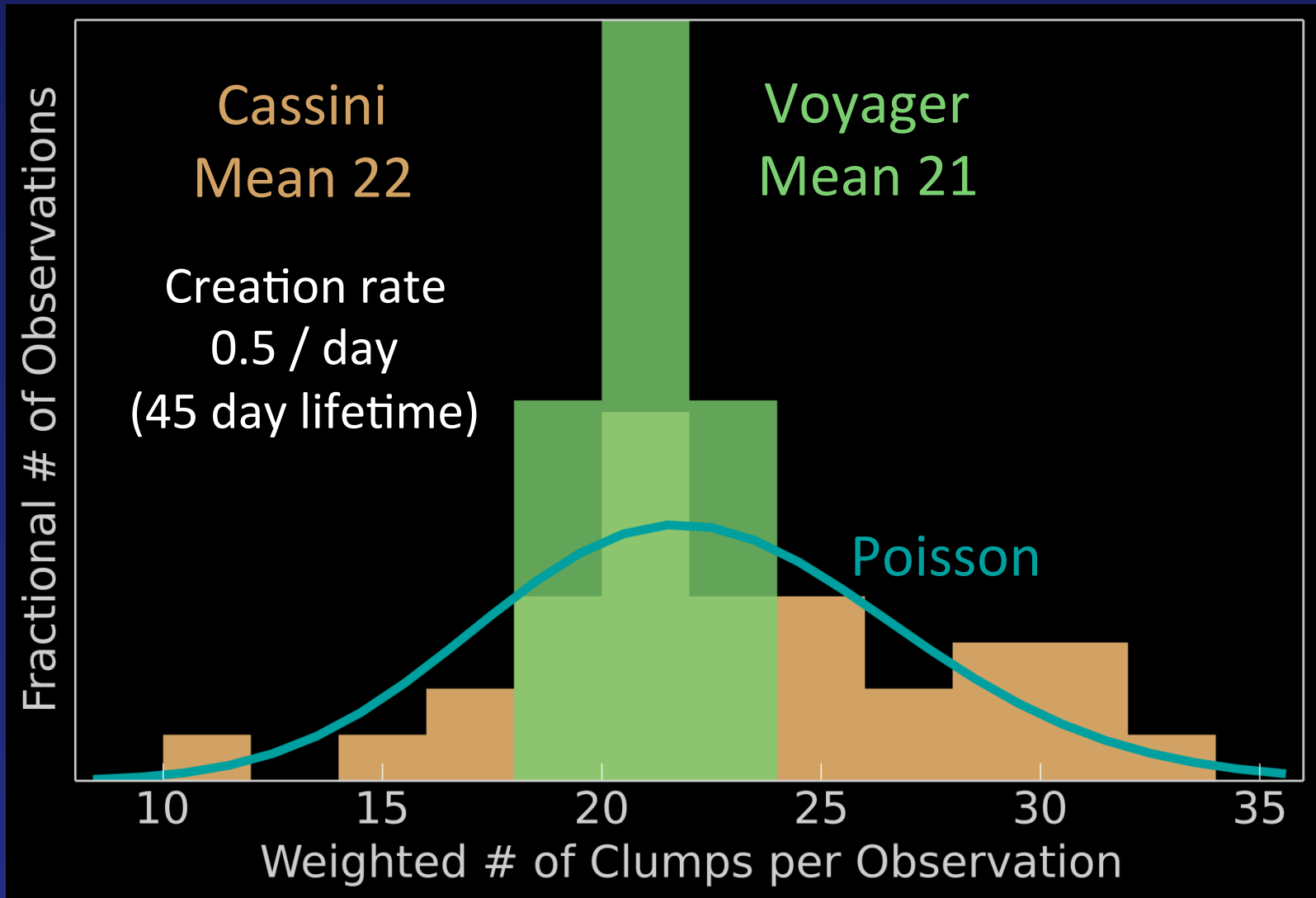


Clumps: Voyager 116, Cassini 2016

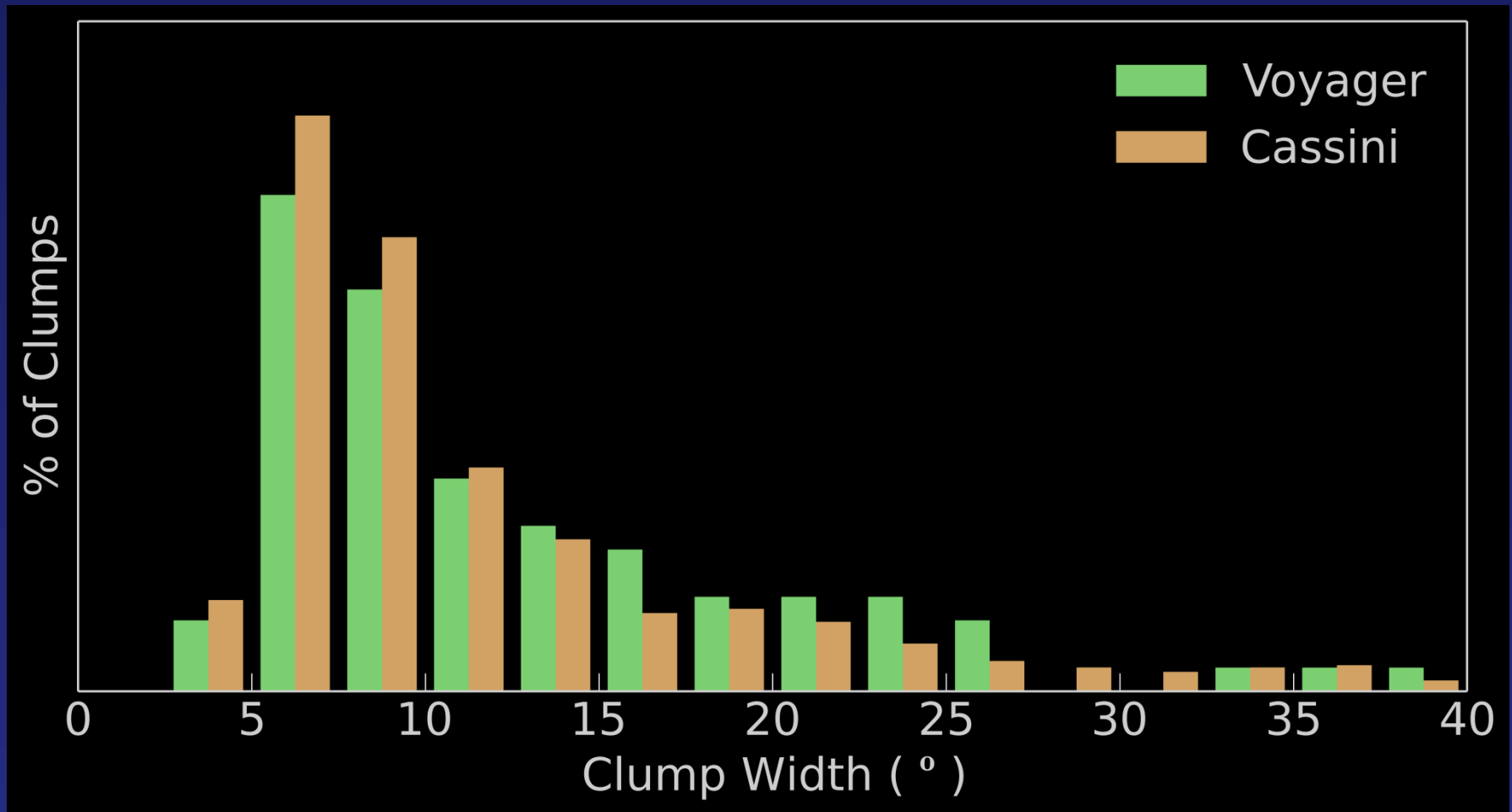
- Fit Gaussian to determine width and center



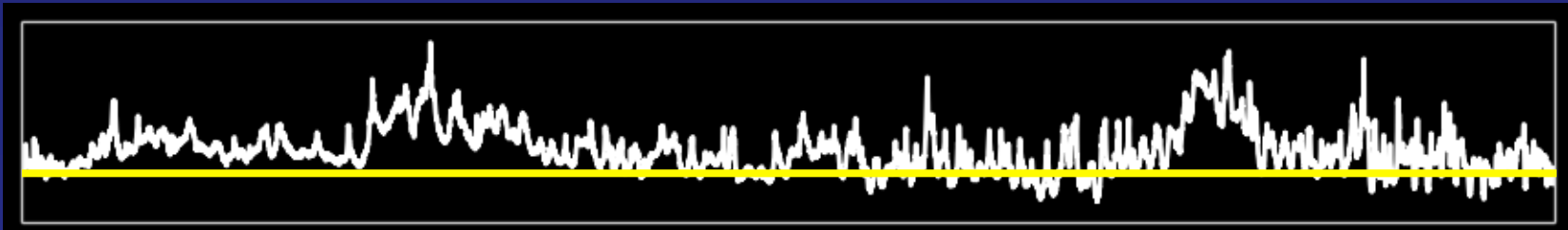
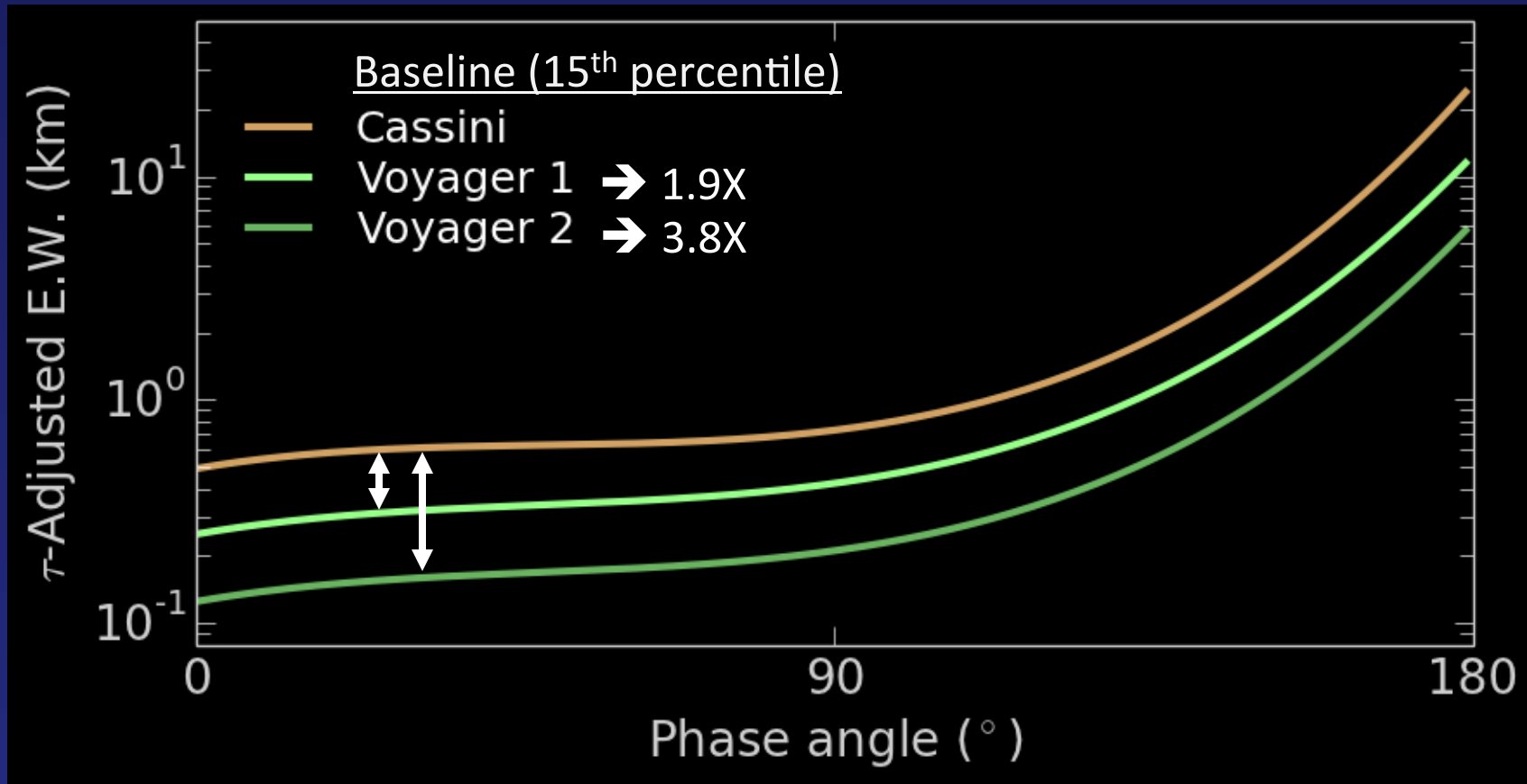
Number of Clumps



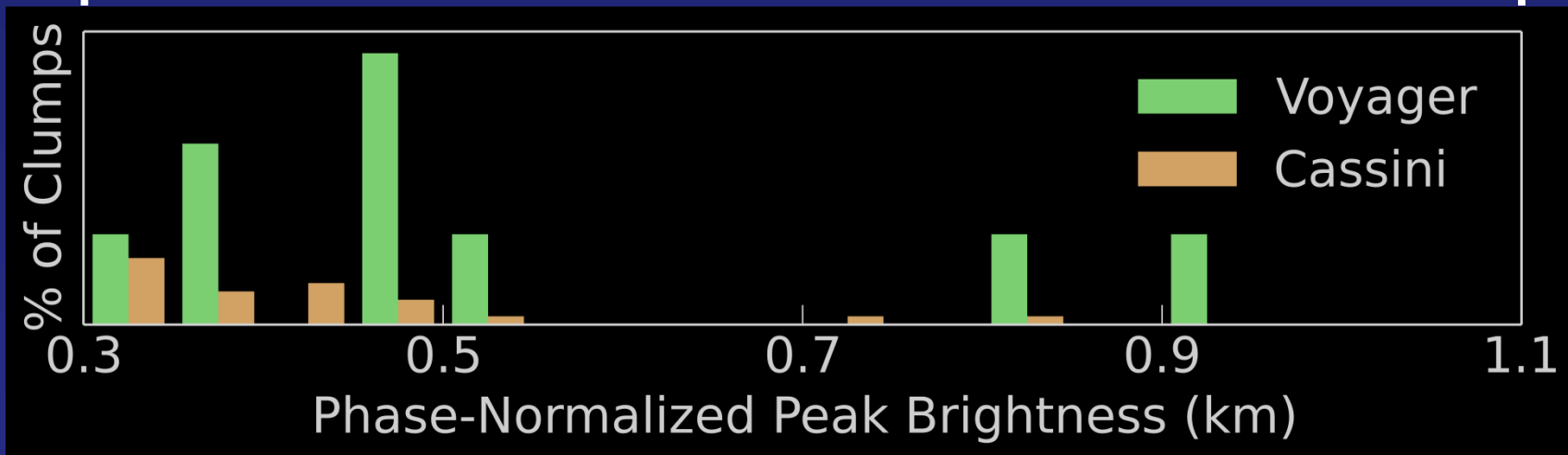
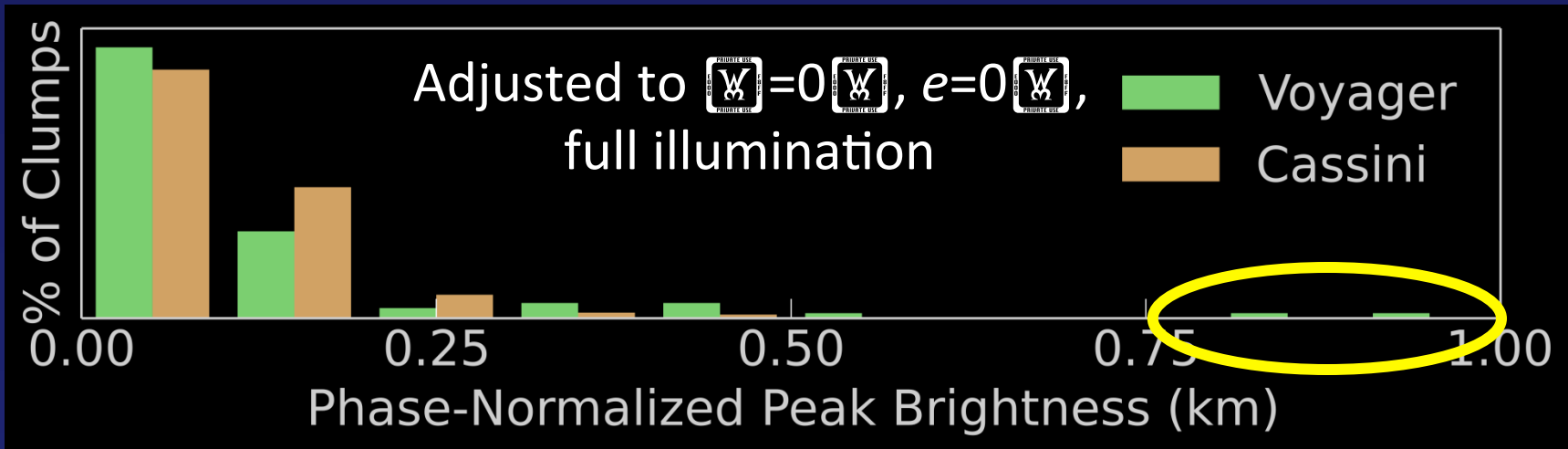
Angular Width



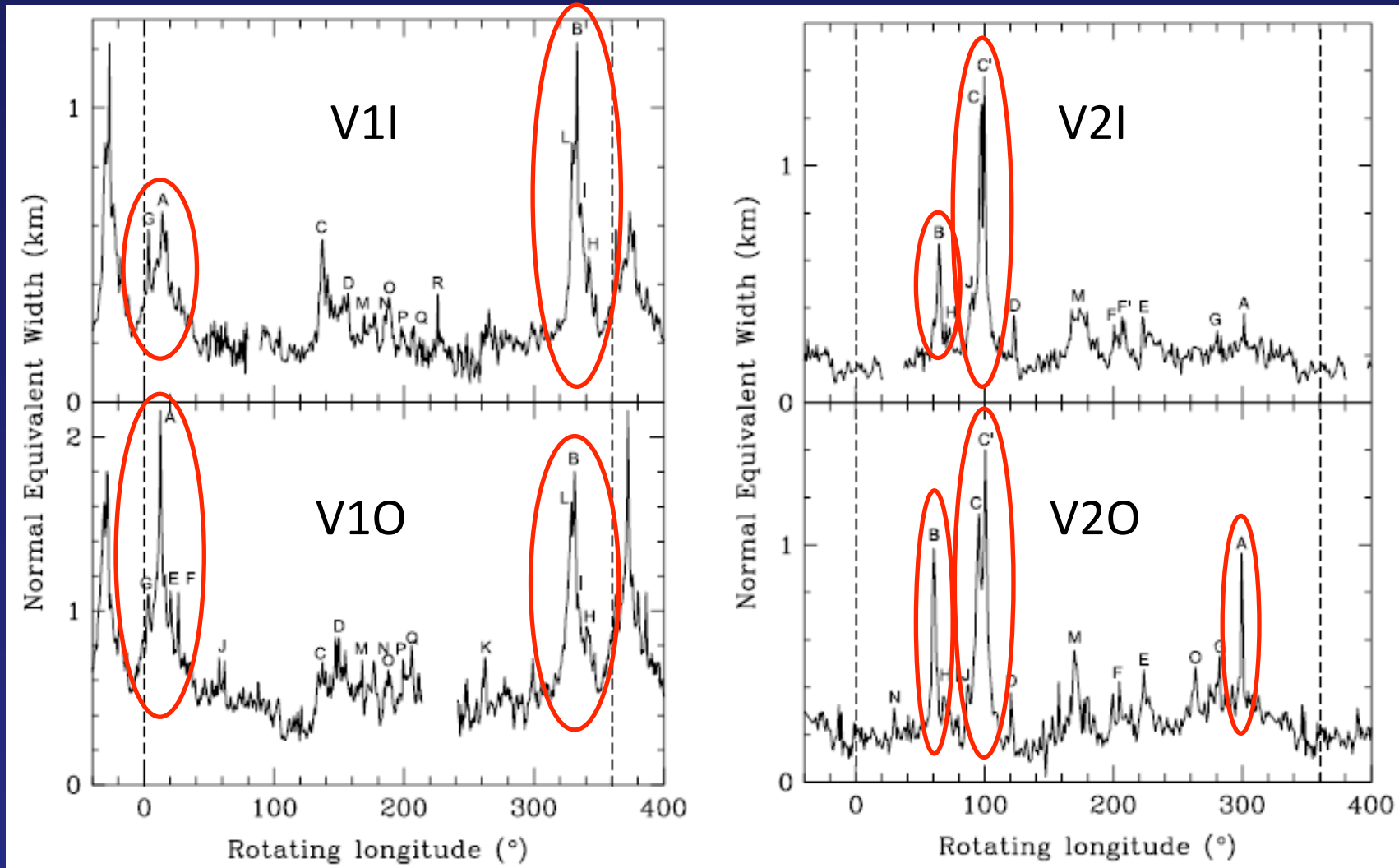
The Brightening of the F Ring



Peak Brightness



Bright Voyager Clumps



Significant or Statistical Fluke?

What is the probability that:

In each Voyager flyby we saw  2 bright clumps
AND
In the *entire* Cassini mission we saw  2 bright clumps

This depends on:

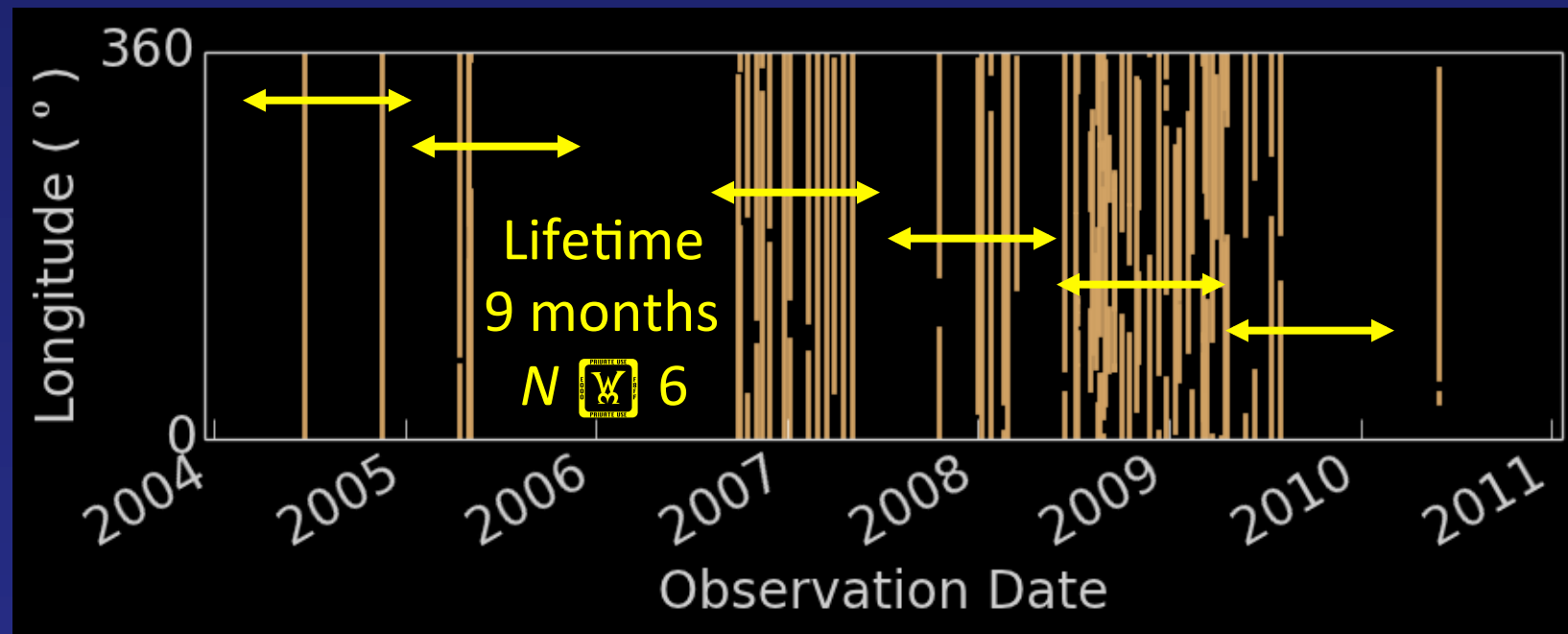
The *expected* number of simultaneous bright clumps ()

The number of *unique observation windows* (N)

Observation Windows

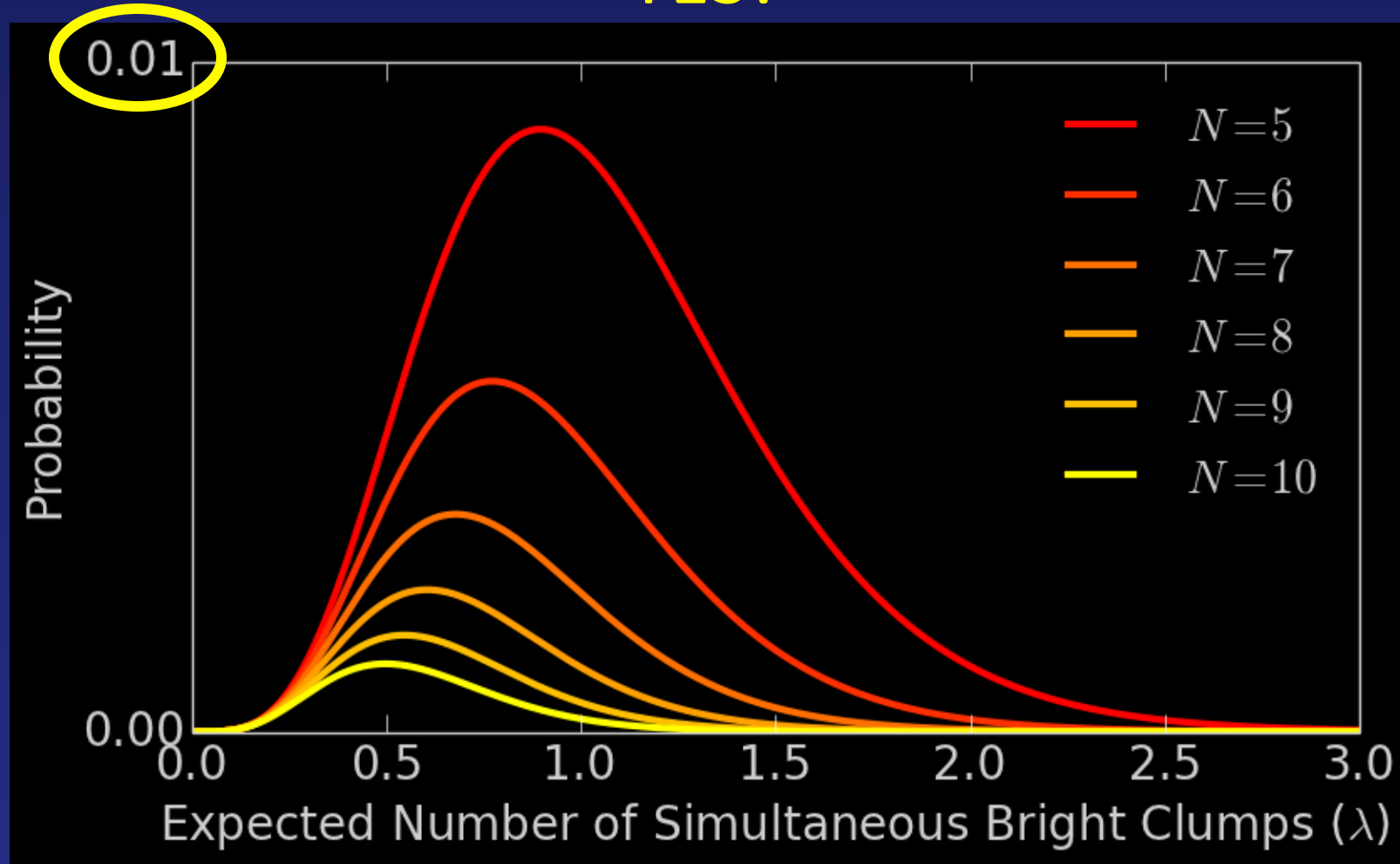
The number of unique viewing periods where no bright clump would survive from one period to the next

For Voyager $N = 2$

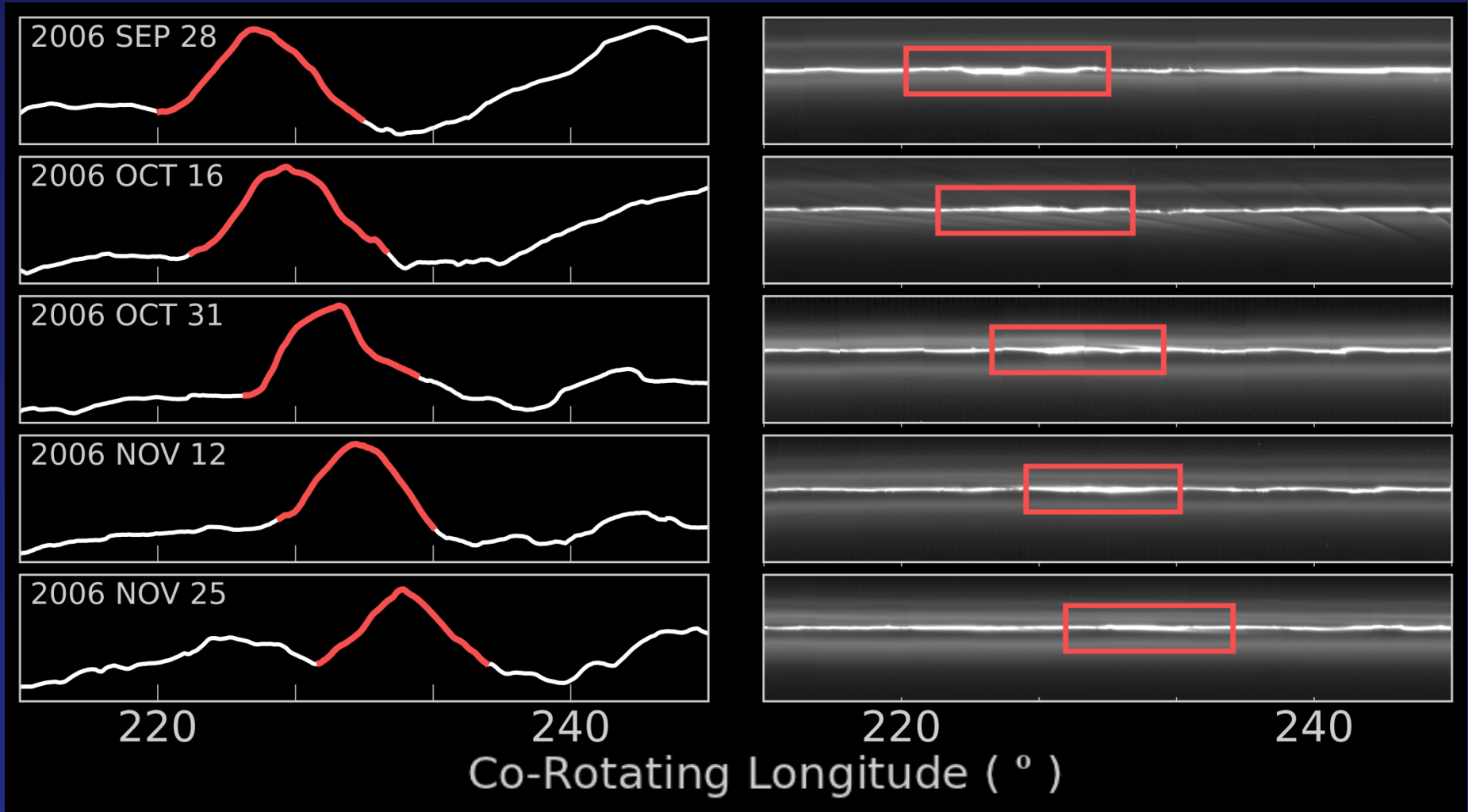


Is the Change Statistically Significant?

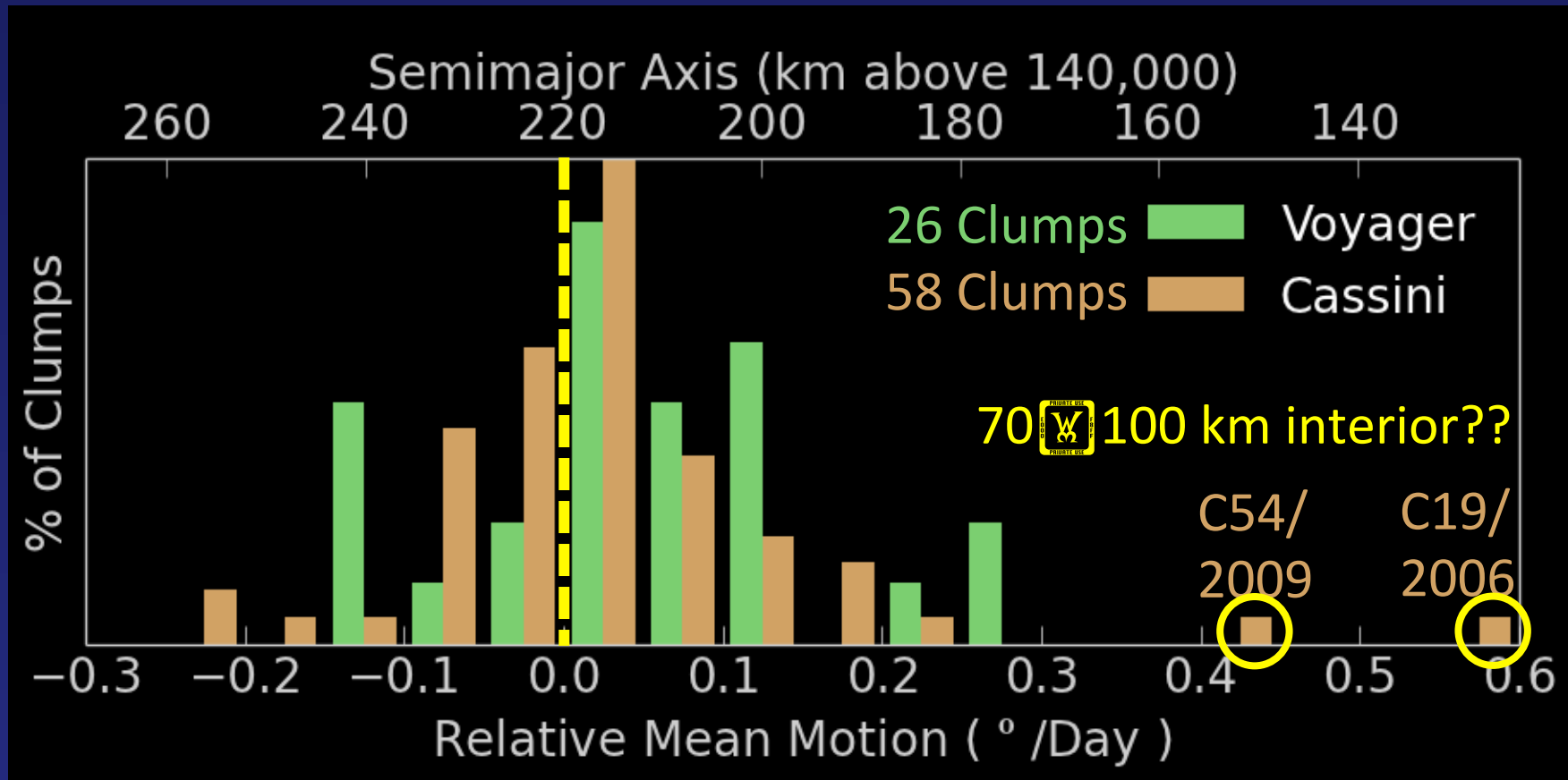
YES!



Clump Motion

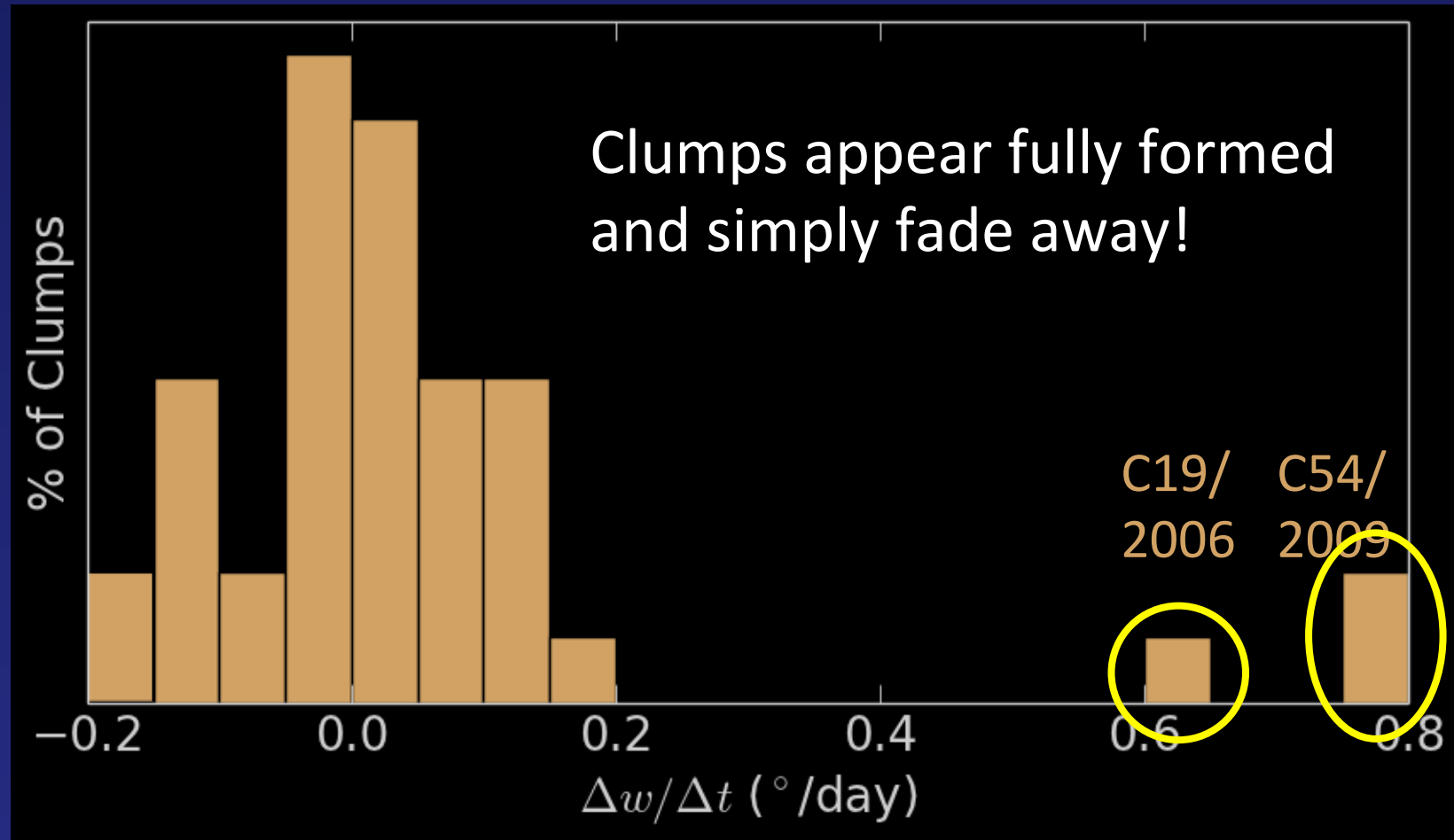


Clump Mean Motions

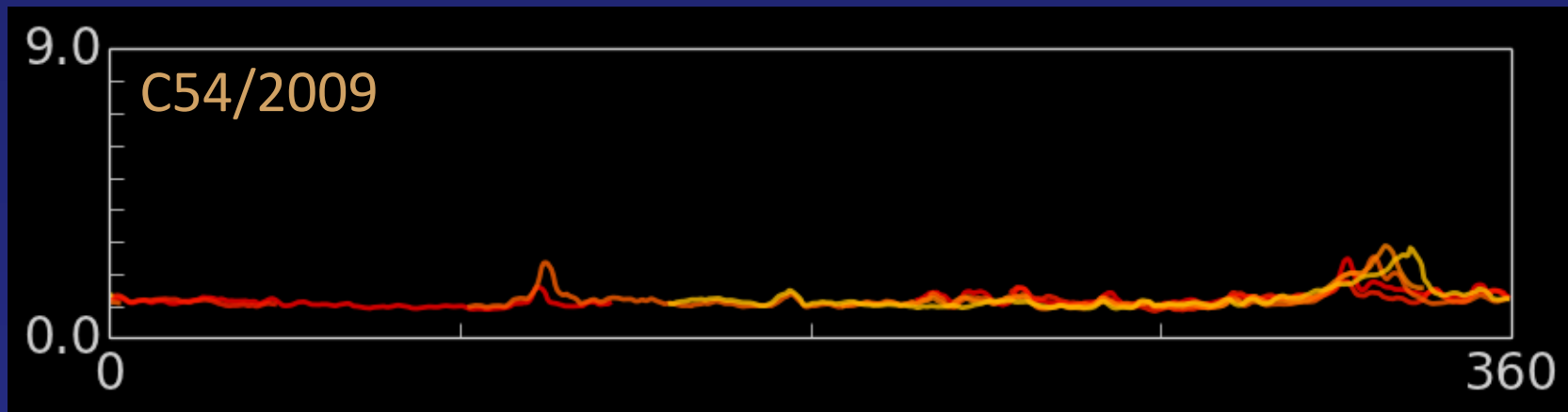
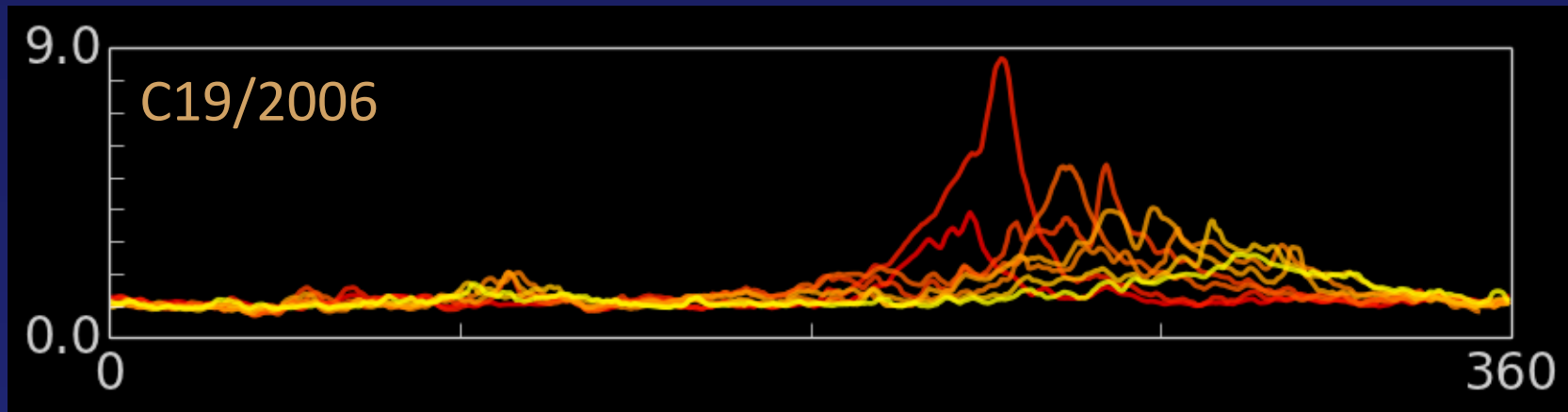


Cassini: 0.024 $\left[\frac{\text{W}}{\text{W}} \right]$ 0.126 $\left[\frac{\text{W}}{\text{W}} \right]$ /day
 Voyager: 0.048 $\left[\frac{\text{W}}{\text{W}} \right]$ 0.112 $\left[\frac{\text{W}}{\text{W}} \right]$ /day

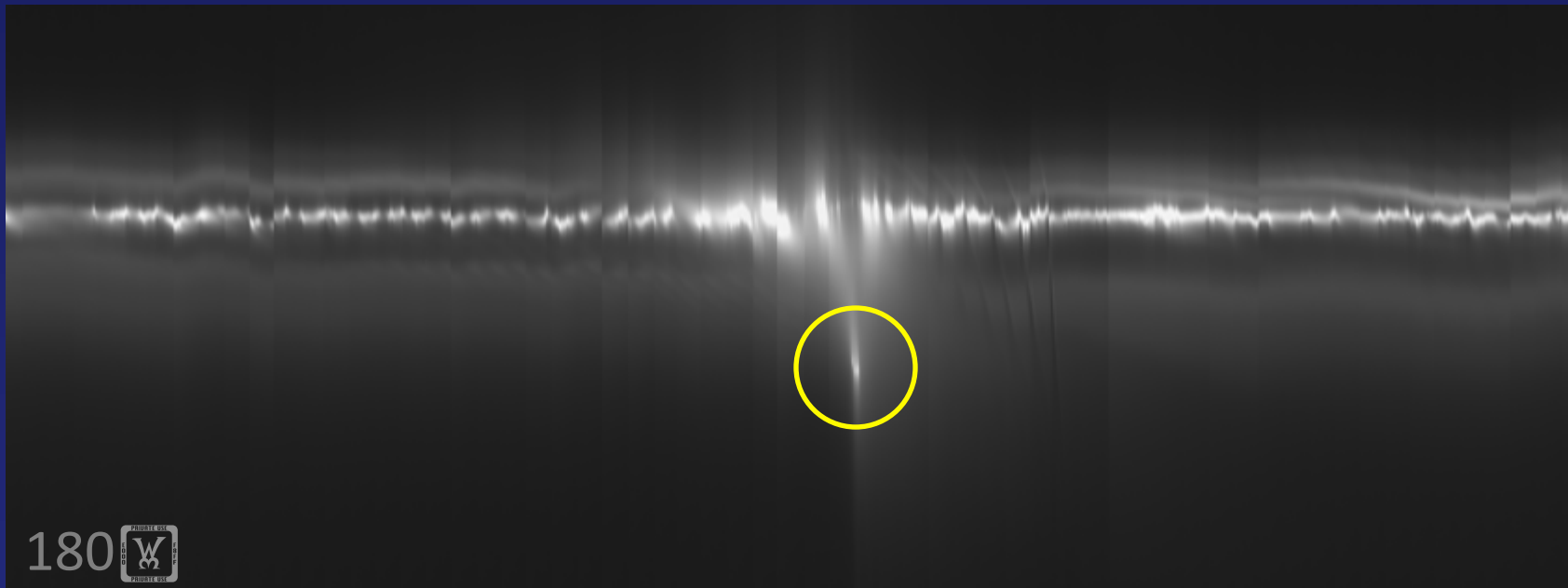
Change in Angular Width



Anomalous Clumps

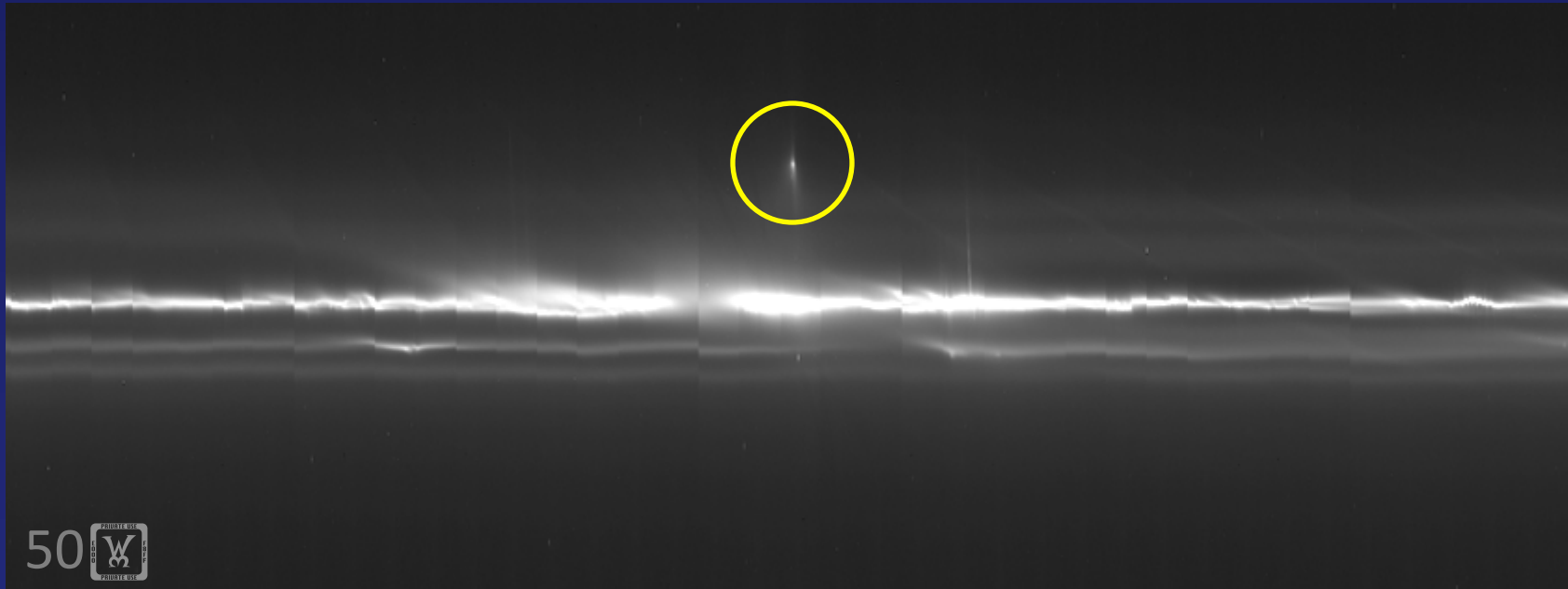


Anomalous Clump C19/2006



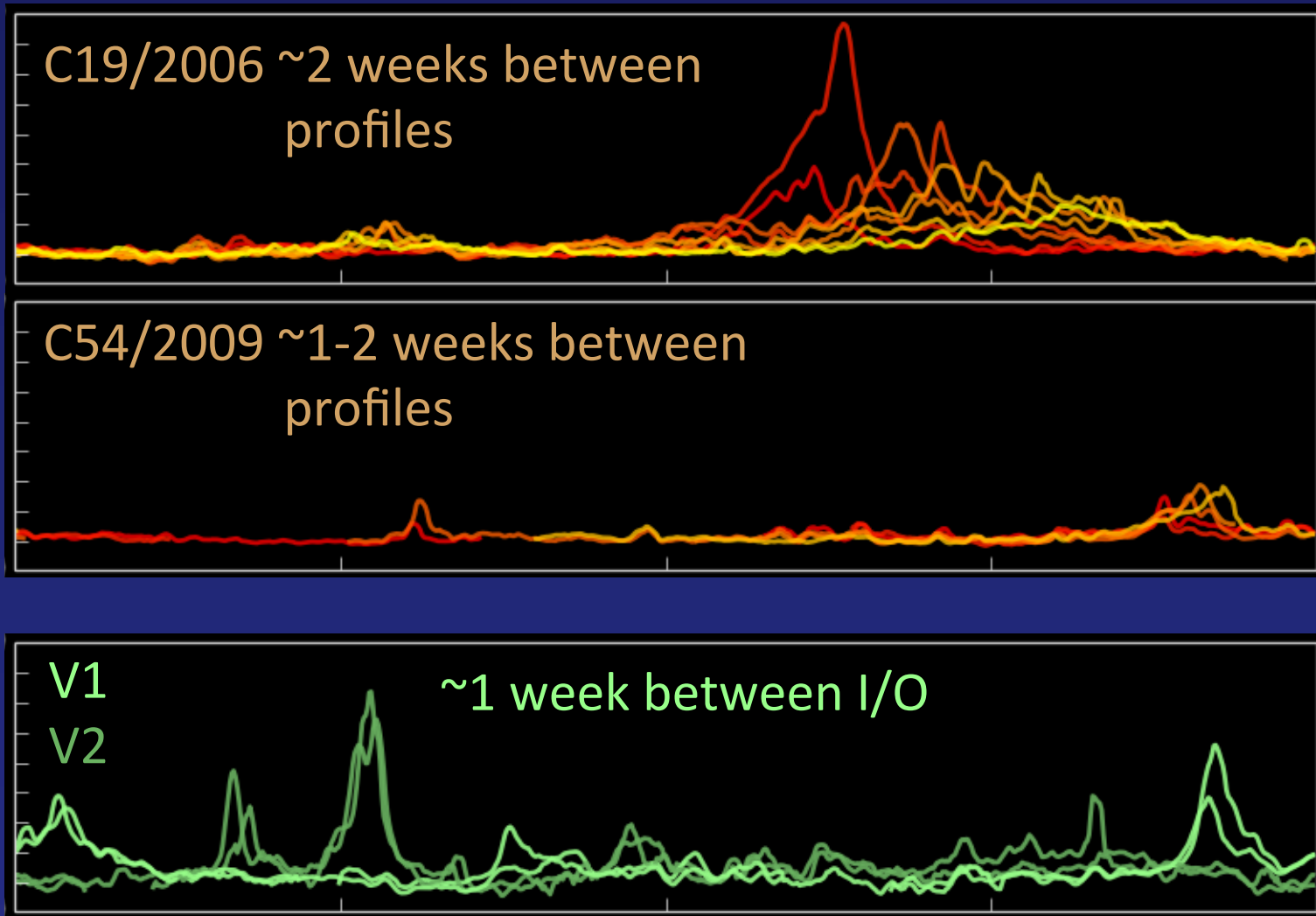
Perceived *high mean motion* and *change in width* caused by repeated collisions of S/2004 S6 with F ring core (different orbital periods)

Anomalous Clump C54/2009

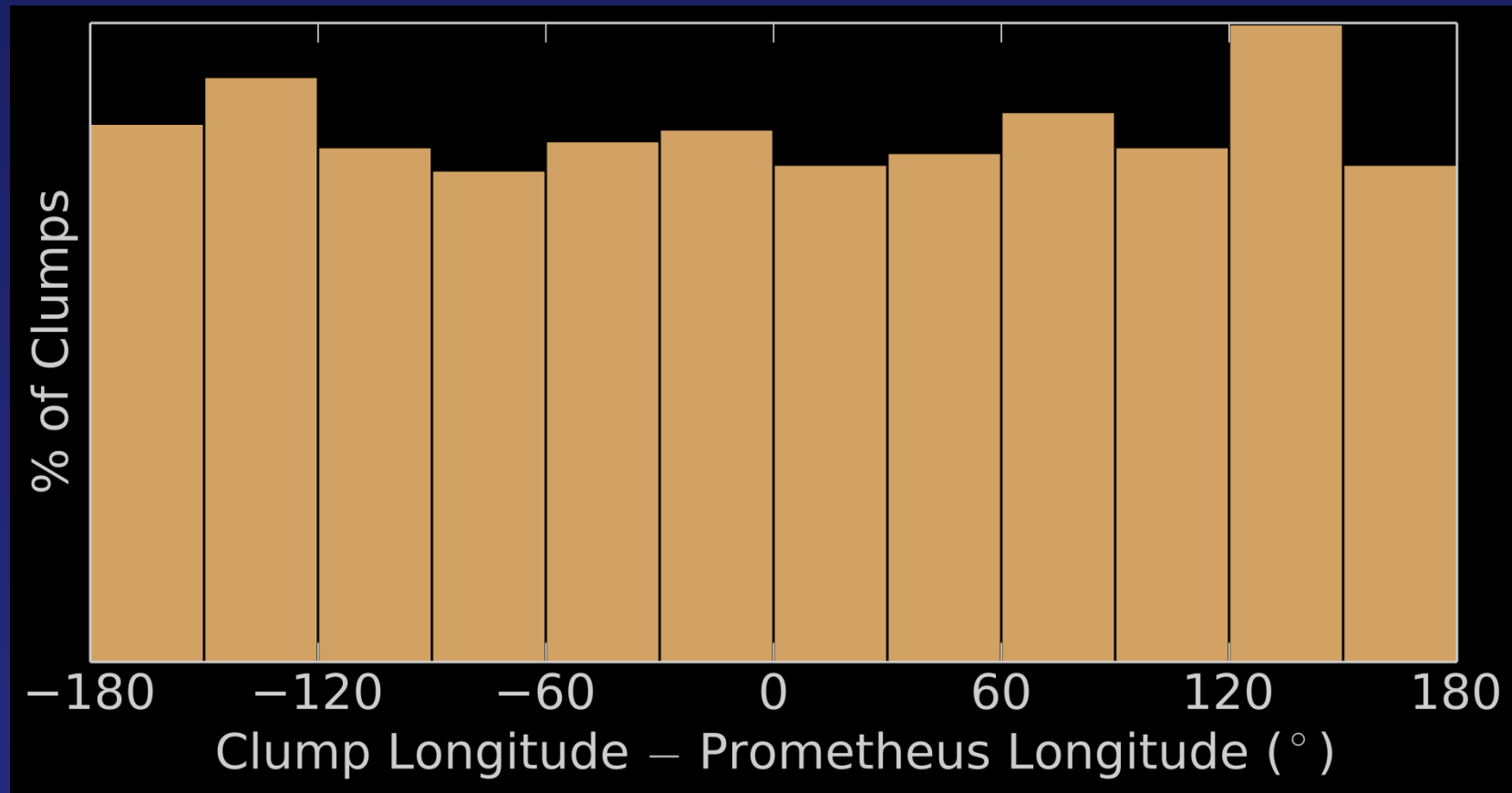


Perceived *high mean motion* and *change in width* caused by repeated collisions of ??? with F ring core (different orbital periods)

Bright Clumps: Cassini vs. Voyager



Does Prometheus Create Clumps?



Well, not directly...

Summary

- The F ring baseline has gotten 2-4X brighter from Voyager to Cassini
- “Normal” clumps seen by Cassini (vs. Voyager) have
 - ✓ The same width
 - ✓ The same brightness
 - ✓ The same number
 - ✓ The same semi-major axis distribution
- There is no evidence of *direct* influence by Prometheus
- **The number of very bright clumps has *decreased***
- **The bright clumps *may* be fundamentally different**

Gratuitous Equations

$$V(\lambda) = [1 - P_\lambda(0) - P_\lambda(1)]^2$$

$$C(\lambda, N) = P_\lambda(0)^N + NP_\lambda(0)^{N-1}P_\lambda(1) + \frac{N(N-1)}{2}P_\lambda(0)^{N-2}P_\lambda(1)^2 + NP_\lambda(0)^{N-1}P_\lambda(2)$$

$$\text{Joint} = V(\lambda)C(\lambda, N)$$