Stellar Occultation Measurements of Particles in Saturn's Rings

Rebecca Harbison & Philip Nicholson

August 14, 2014

VIMS Stellar Occultation Measurements of Particles in Saturn's A Ring

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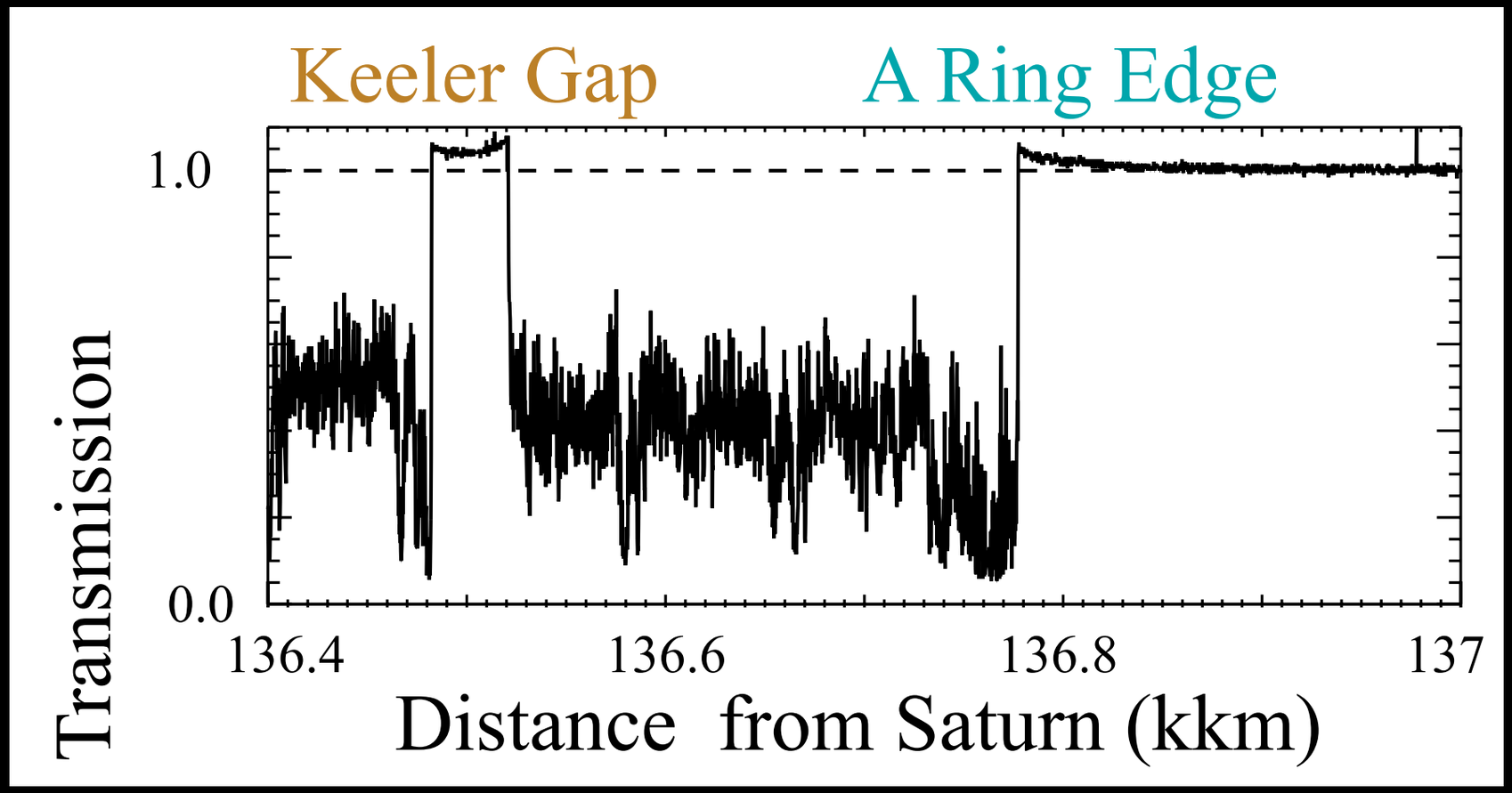
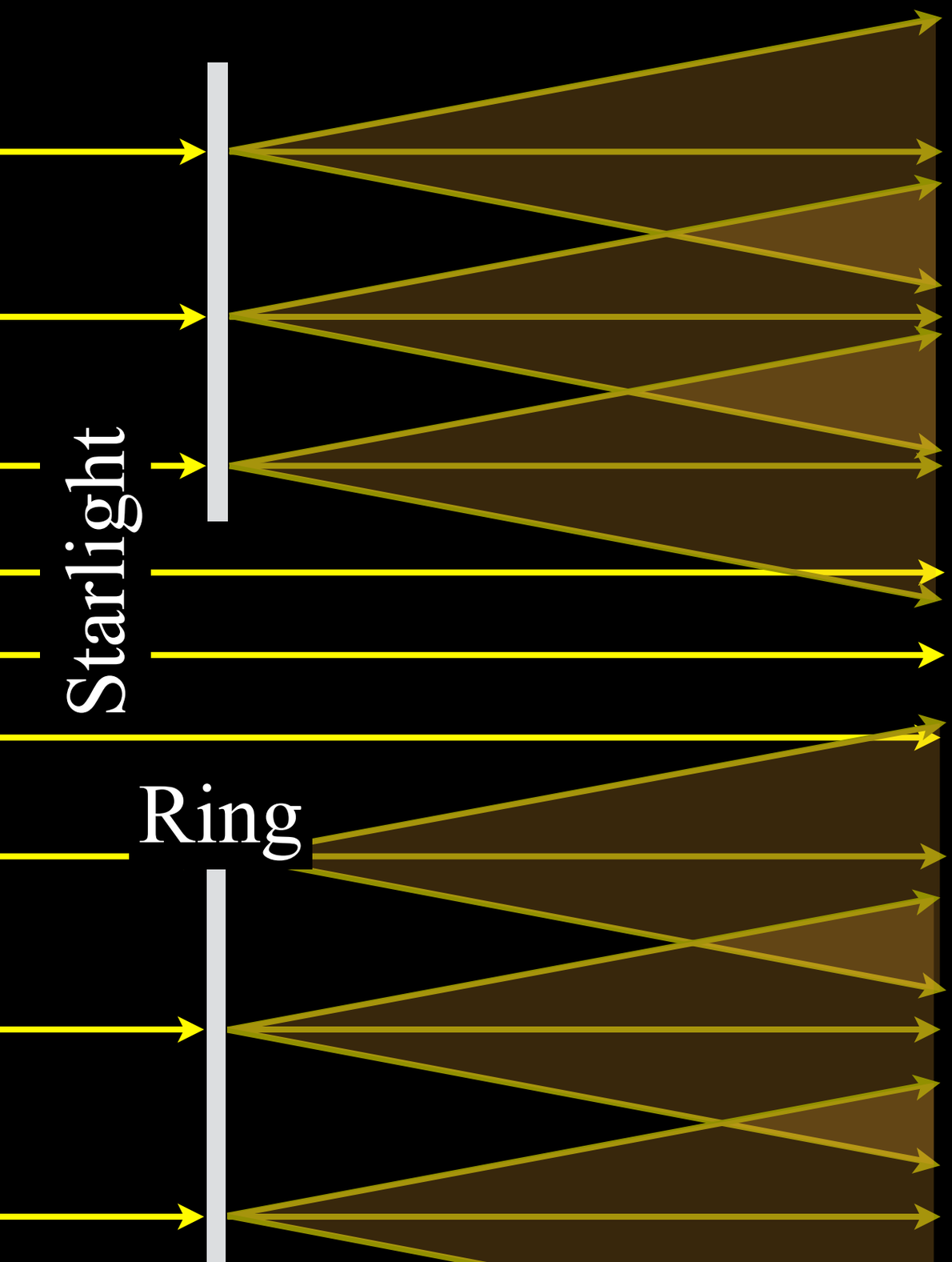
Stellar Ring Occultations



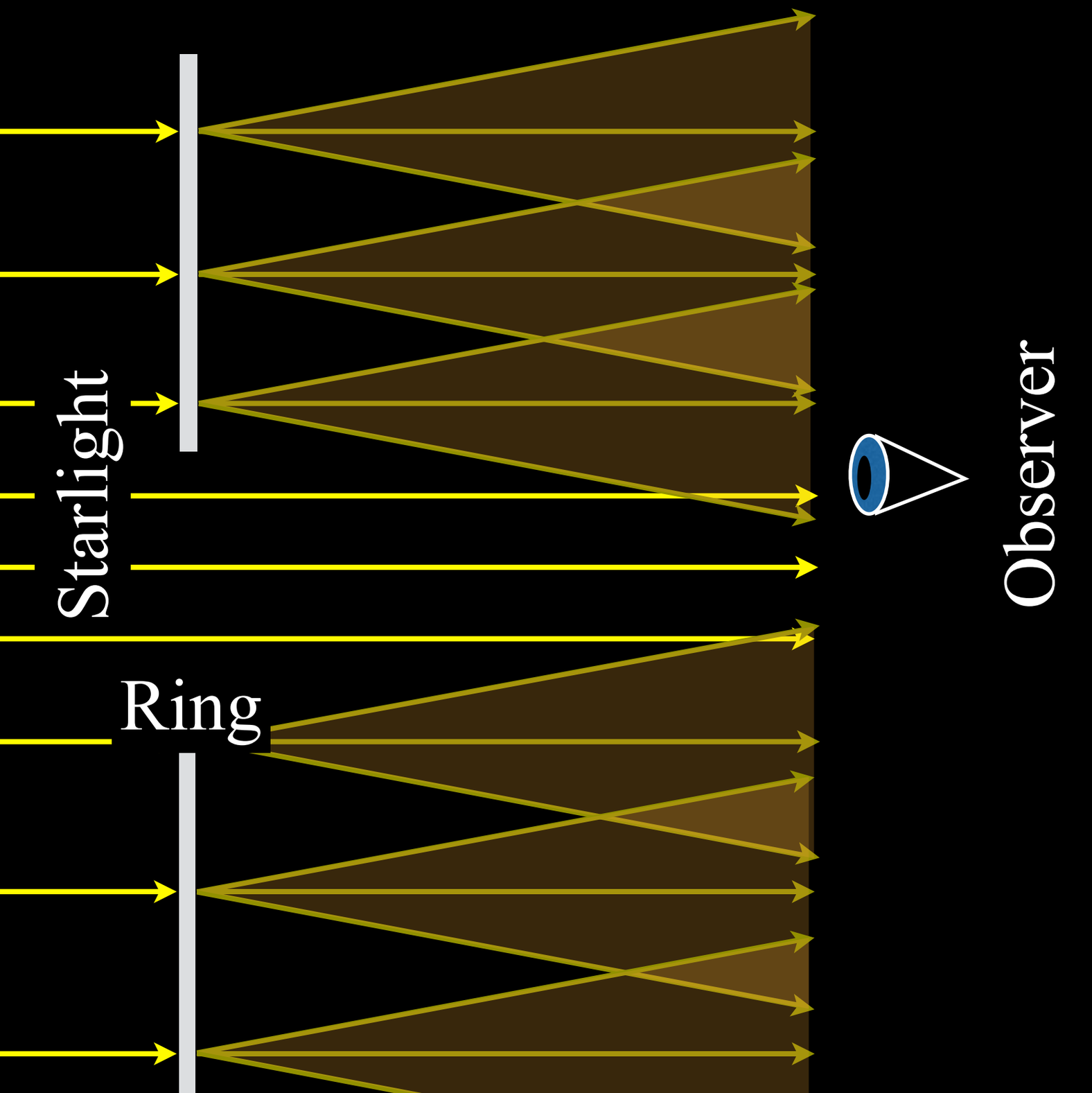
Stellar occultation at 2.9 microns.

(VIMS covers 0.9 to 5.2 microns.)

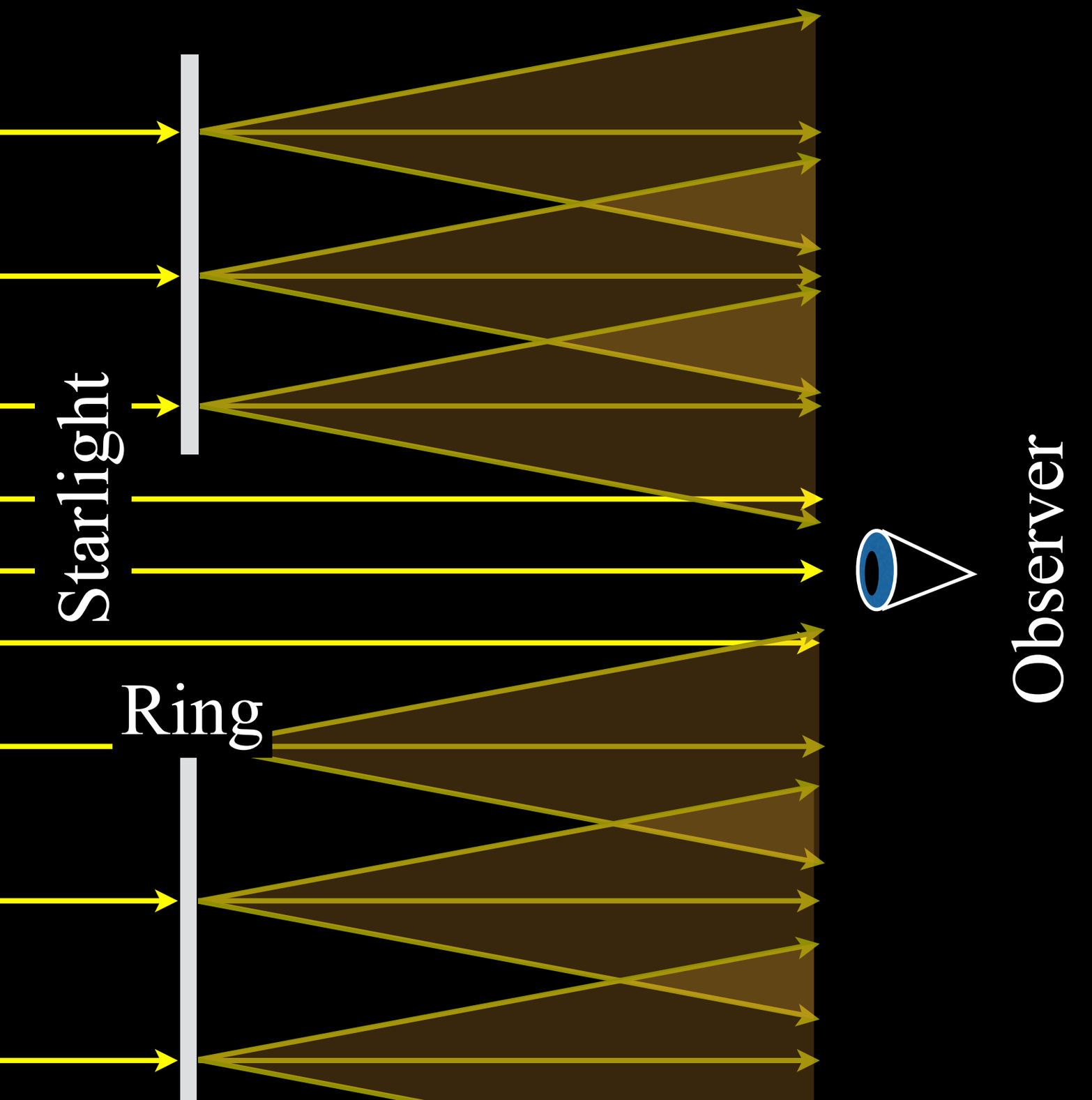
Diffraction Effects



Diffraction Effects



Diffraction Effects

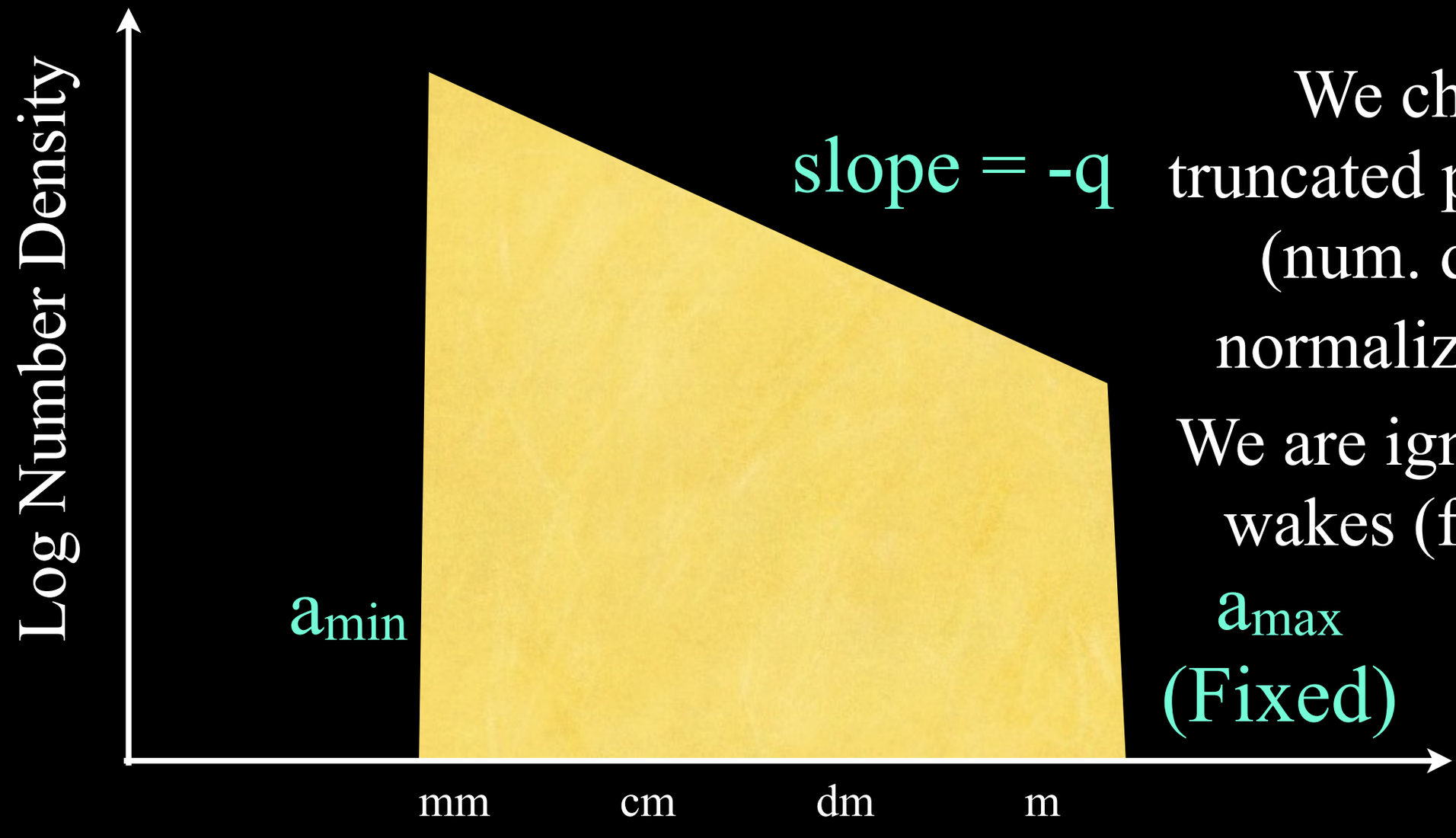


VIMS pixel: 0.5 x 0.25 mrad
Movement of star ~ 0.0003 mrad/point

Diffraction @ 3 microns from 10-cm ring particle: 3 μm/ 0.1 m ~ 0.03 mrad

$\theta \sim \lambda/a$

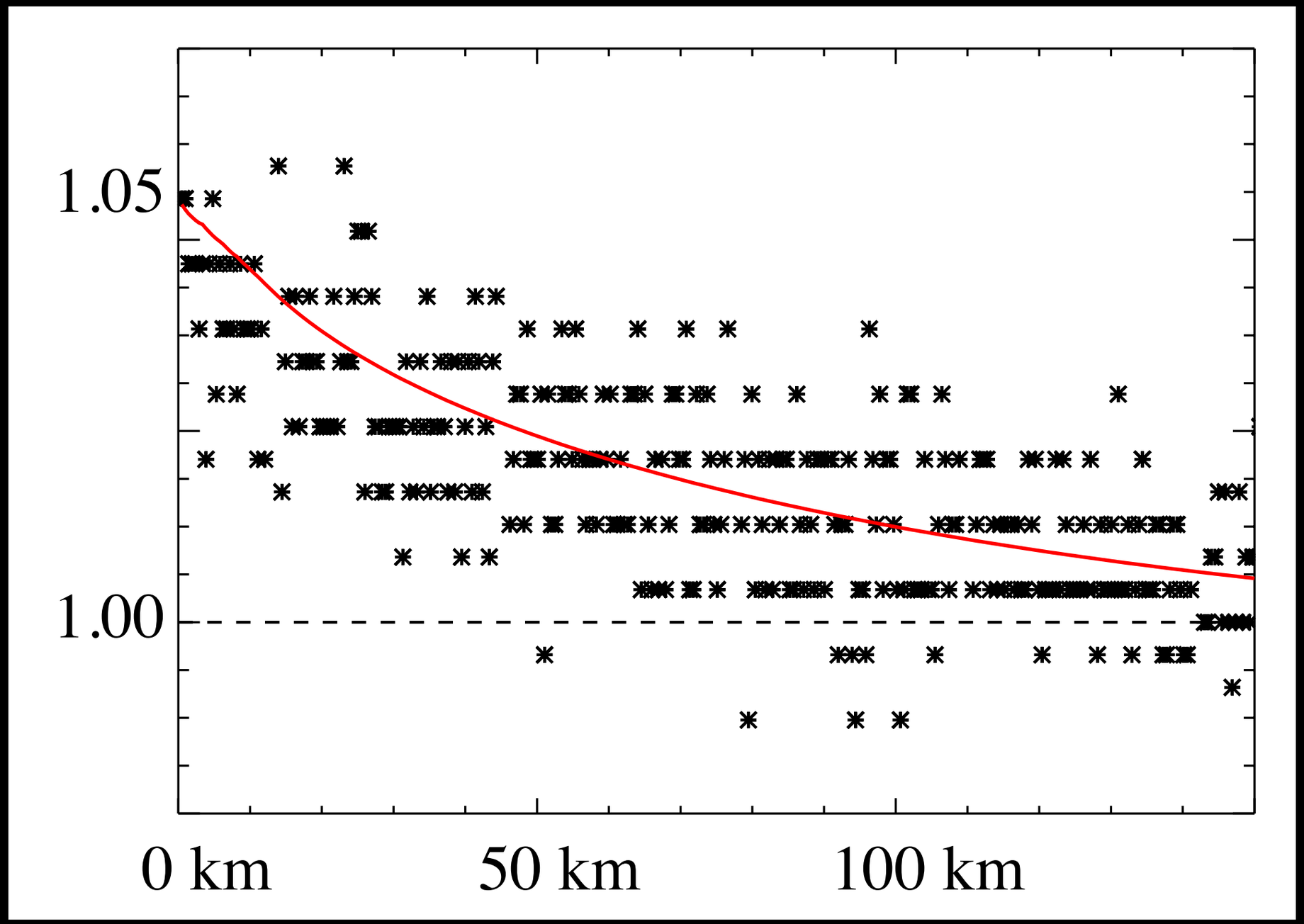
The Model: Particle-Size Distribution



We chose a truncated power law (num. density normalized by τ)

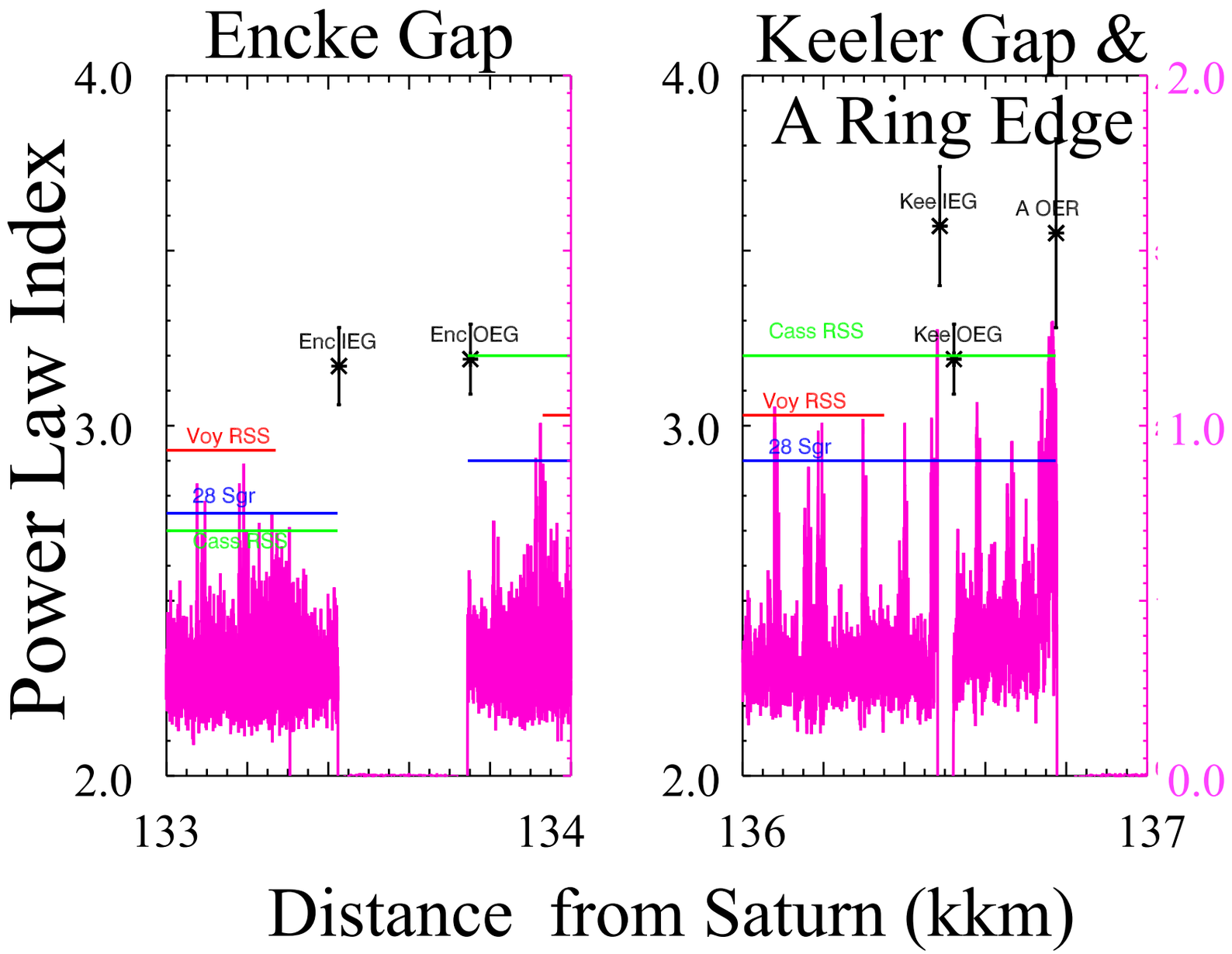
We are ignoring SG wakes (for now)

Sample Fit: A Ring Edge



Between 6 and 10 occs return good fits (as measured by chi squared < 1.5 per DOF)

Mean Power Law Index



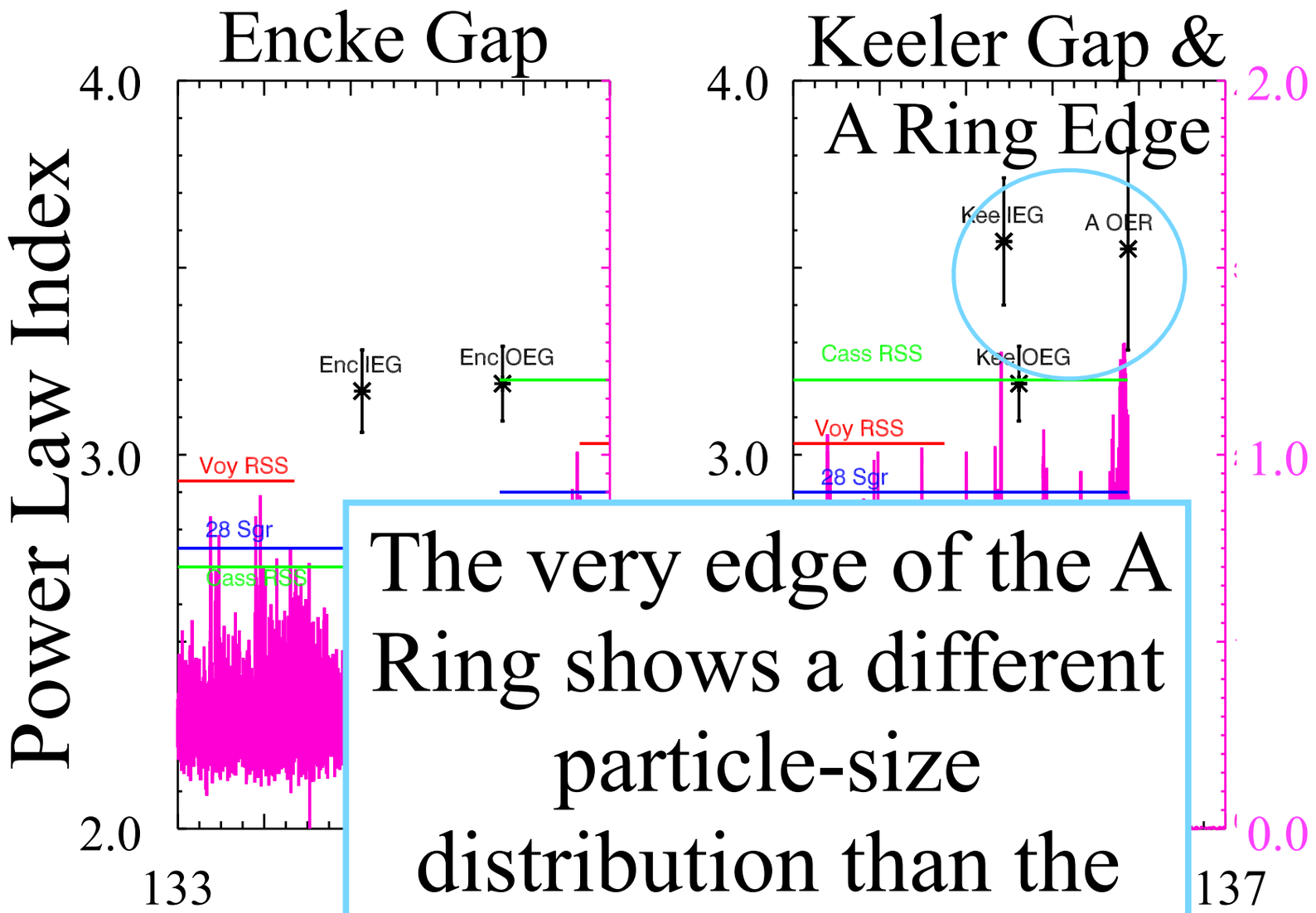
* This Work

Voyager Radio Occultation (Marouf et al., 1983, Zebker et al., 1985)

Earth-based Stellar (28 Sgr) Occultation (French & Nicholson, 2000)

Preliminary Cassini Radio Occultation (Marouf et al., 1998)

Mean Power Law Index



The very edge of the A Ring shows a different particle-size distribution than the rest of the A ring.

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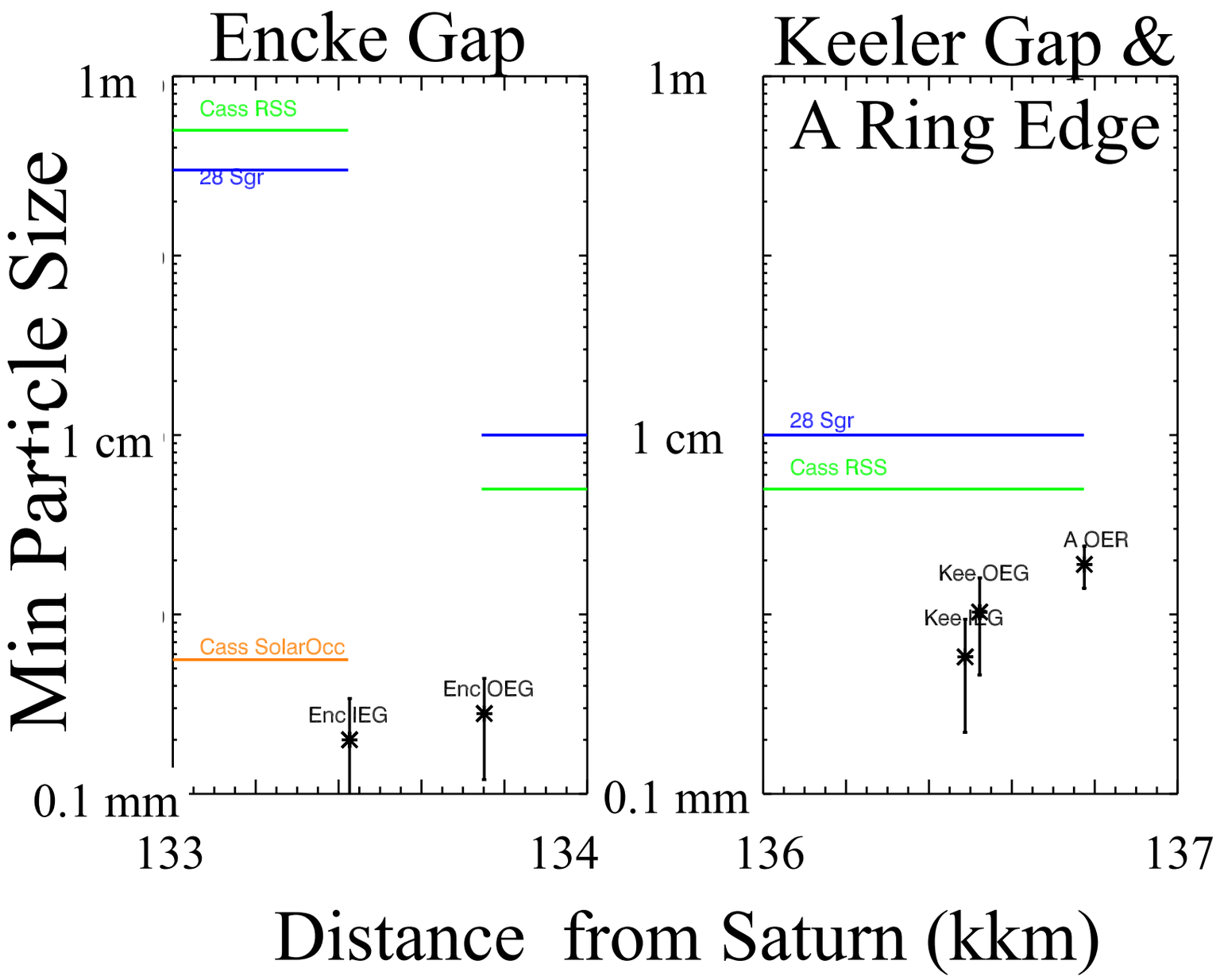
Mean Minimum Particle Size



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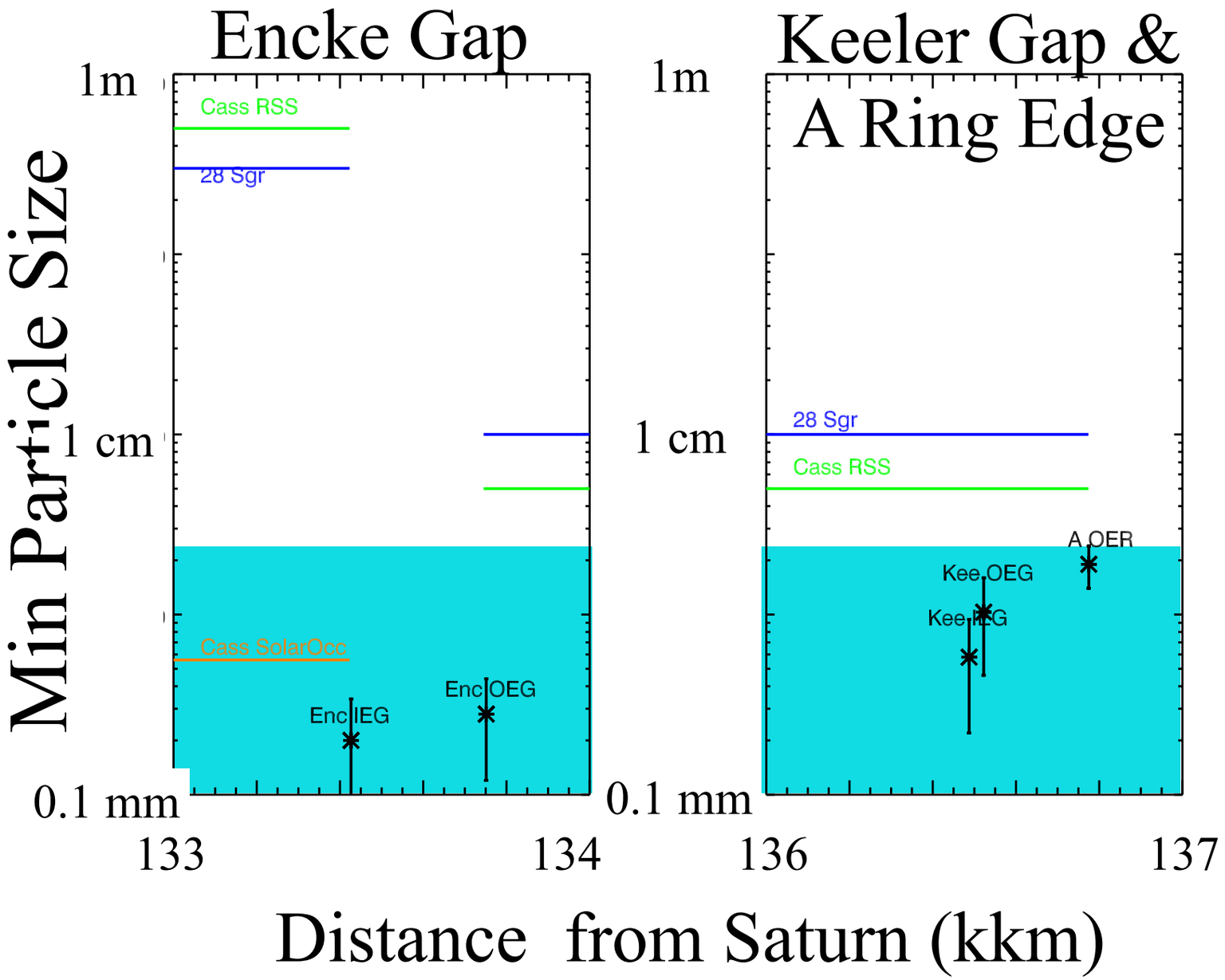
VIMS Solar Occultations (Harbison et al., 2013)

Mean Minimum Particle Size



* This Work

Earth-based

The shaded area is where light is scattered outside 1 VIMS pixel

VIMS Solar Occultations

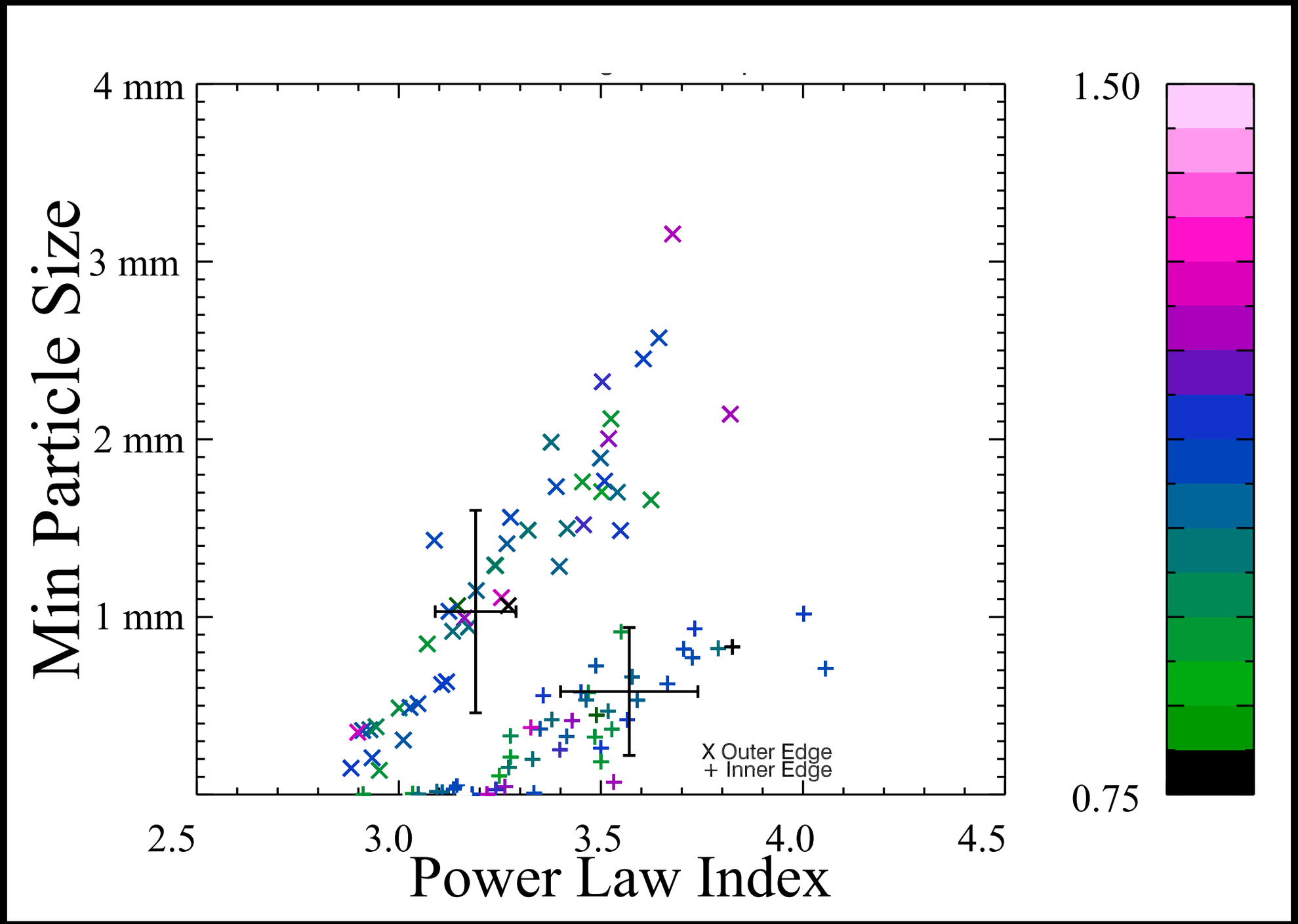
(Harbison et al., 2013)

Can our model still fit the data?

- Because a_{min} still effects the amount of missing light, we might still be able to measure it when it is small.

- We created simulated data using our models plus Gaussian noise and ran that though our fitting routine to check.

We can’t fit independent parameters in Encke and Keeler Gaps



But… We Don't Just Have VIMS

- UVIS can also see diffraction from the A Ring; it has both a larger aperture and light scatters at smaller angles.

- VIMS is more sensitive to larger particles and has better signal to noise, but misses mm-sized particles (in stellar occultations).

Conclusions

- The edge of the A Ring is unlike any other area of Saturn's rings, with power law index of q = 3.55 ± 0.27 and amin of 1.9 ± 0.5 mm

- Particles in the outer A Ring are sufficiently small (less than a few mm) that they scatter outside a VIMS pixel.

- Particle size distributions often can't be defined by only one instrument.

Future Work

- Fit the gaps and ringlets in the Cassini Division and C Ring.
  - Care must be taken, as the Cassini Division has a shallow q (so a_{min} is hard to fit)
- Test an optical depth model that includes the effects of self-gravity wakes in the A Ring.
  - Preliminary results don't improve the model fits, a change in optical depth can look like missing light from a small a_{min}.
- Check parameter values in Encke and Keeler Gaps with the location of Pan and Daphnis.