

*Measuring sub-centimeter particles in
Saturn's A ring with Cassini UVIS
stellar occultations*

Tracy M. Becker¹

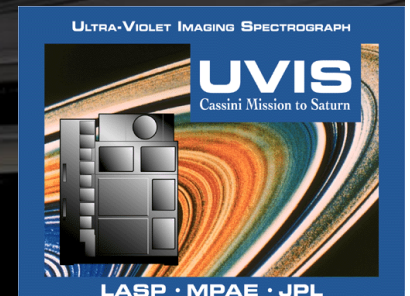
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Boulder; LASP



Planetary Rings Workshop 2014



Introduction

Diffraction Spikes at Encke Gap, Keeler Gap, and the outer edge of A ring

Constrain particle size distribution

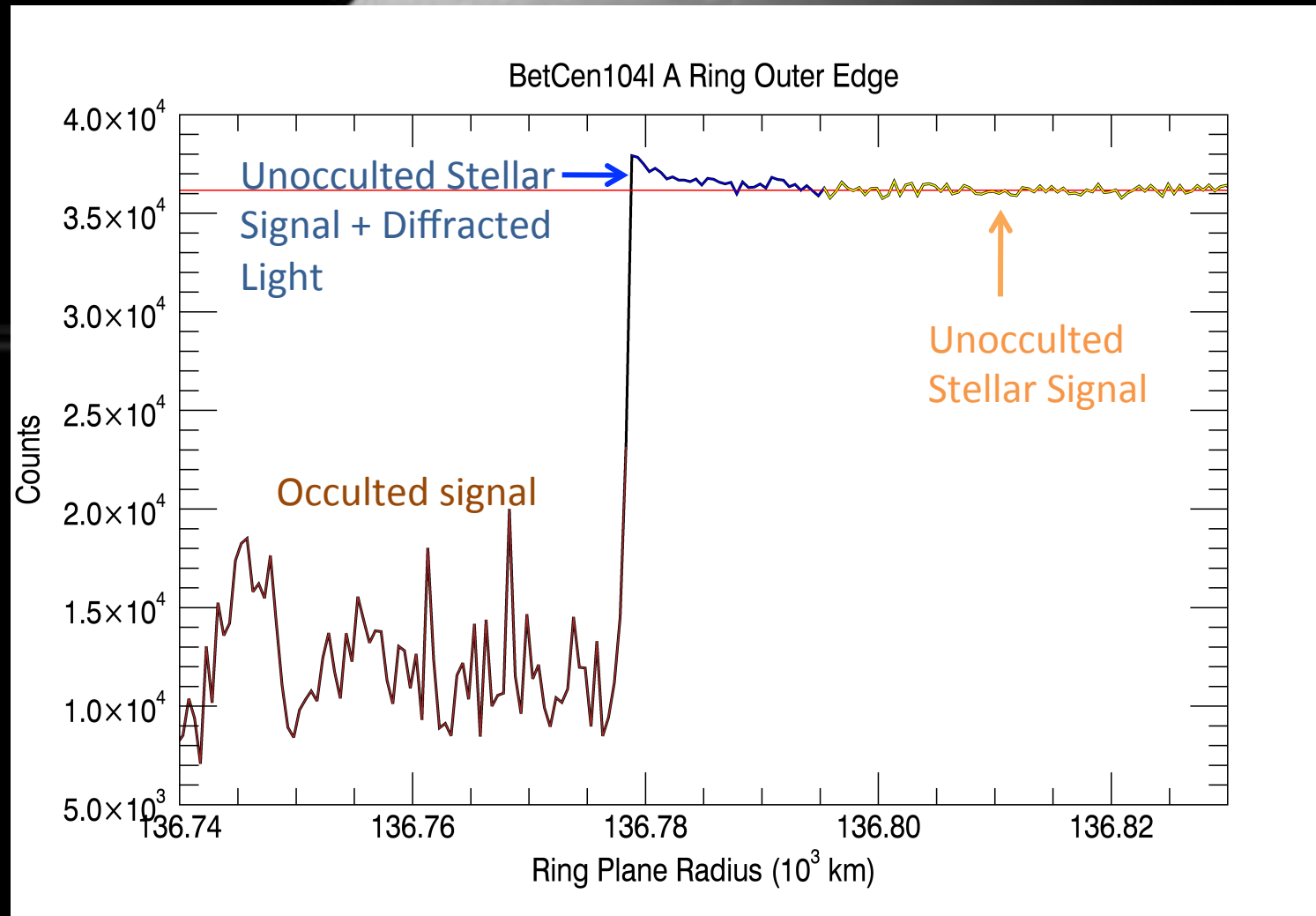
UVIS Stellar Occultations

*UVIS wavelength = 150 nm

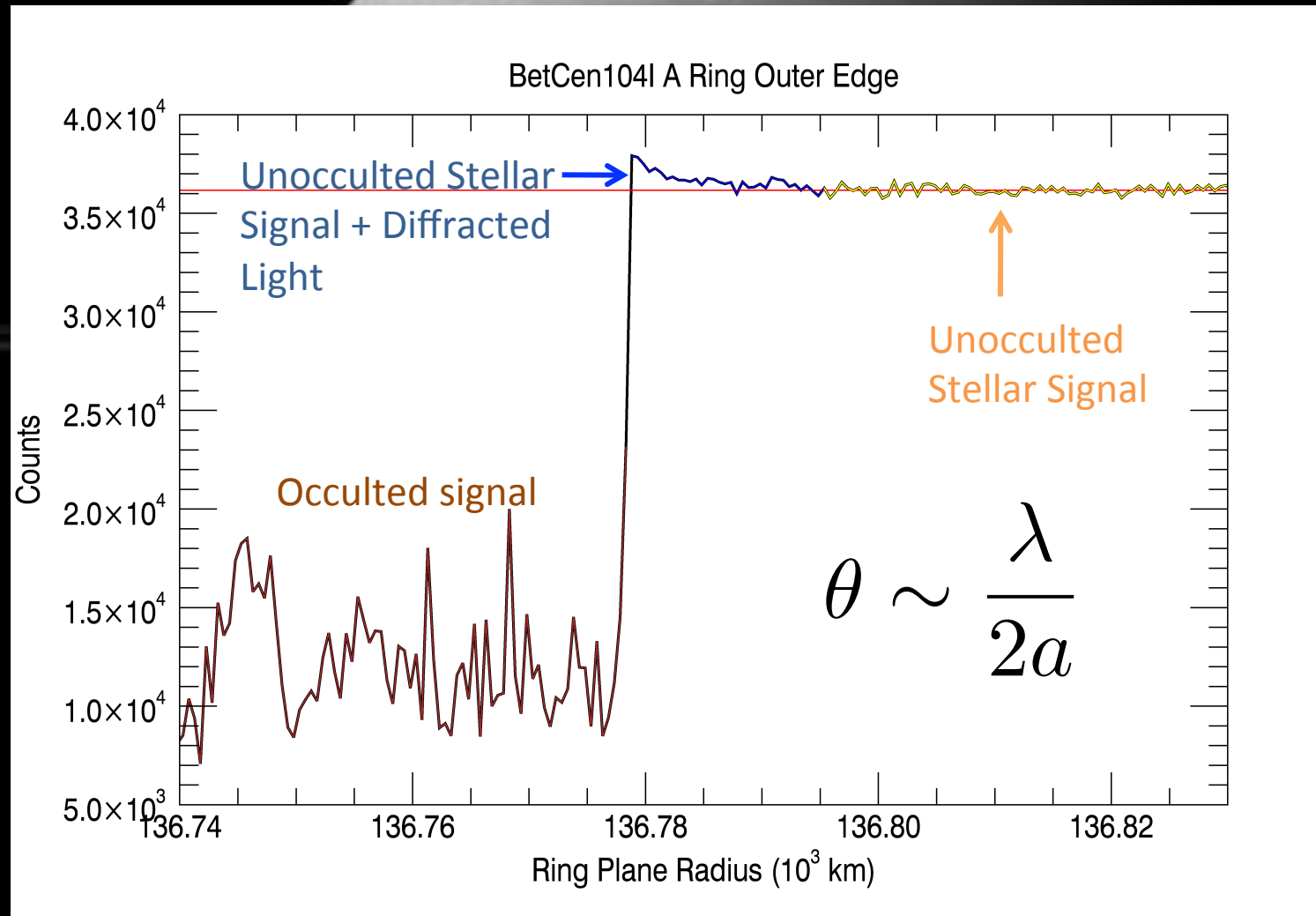
*UVIS FOV 6 mrad x 6 mrad

Compare diffraction models with observations

Diffraction Spikes

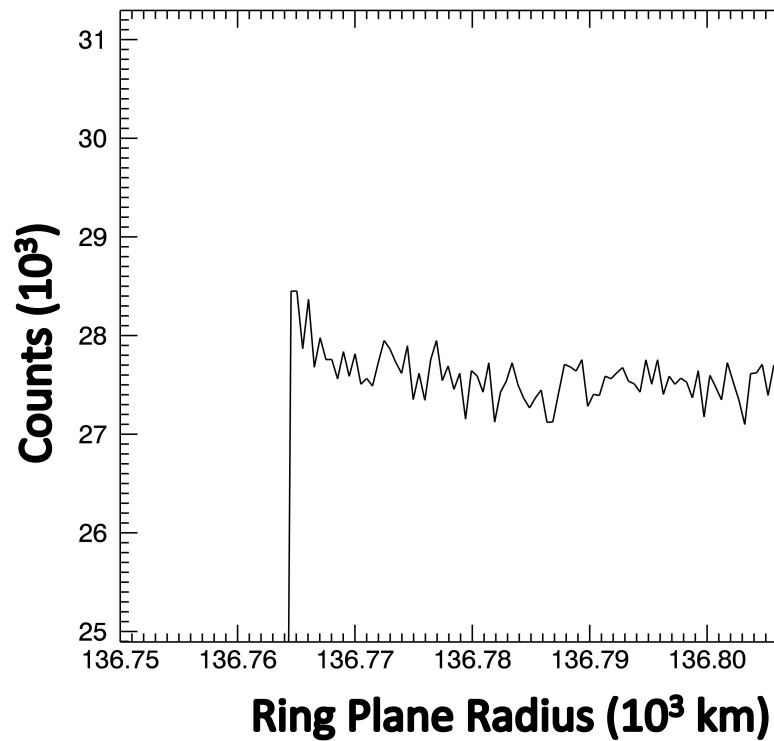


Diffraction Spikes



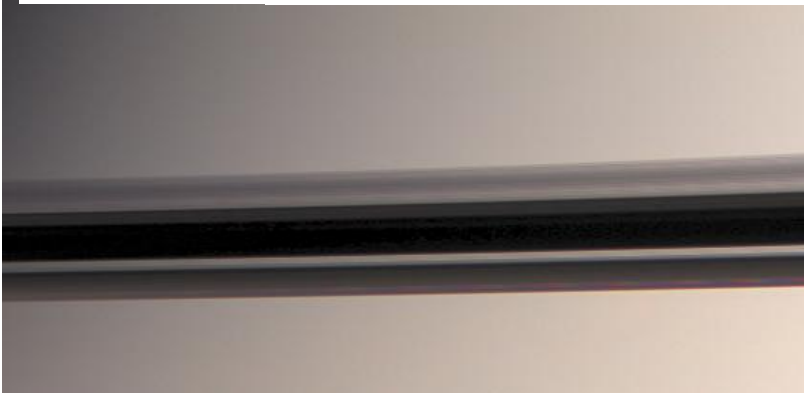
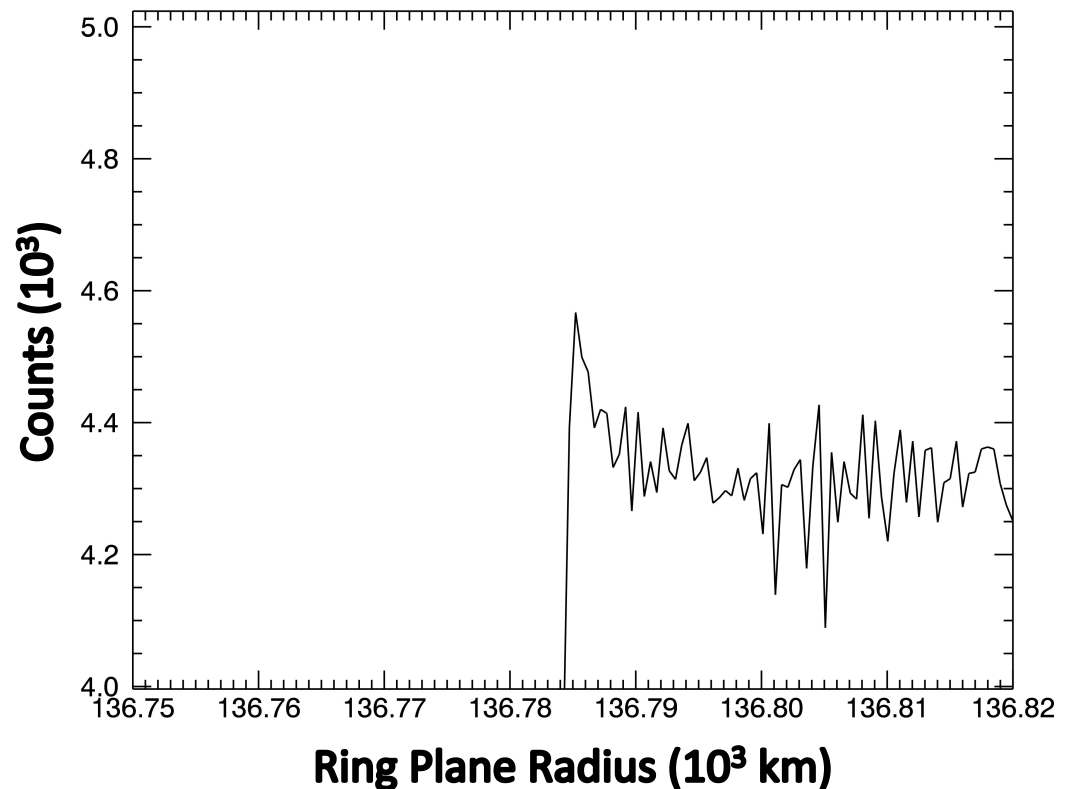
Examples: A Ring Outer Edge

BetCen102



5% increase in signal
Extend up to 30 km from edge
Particles 3-7 mm

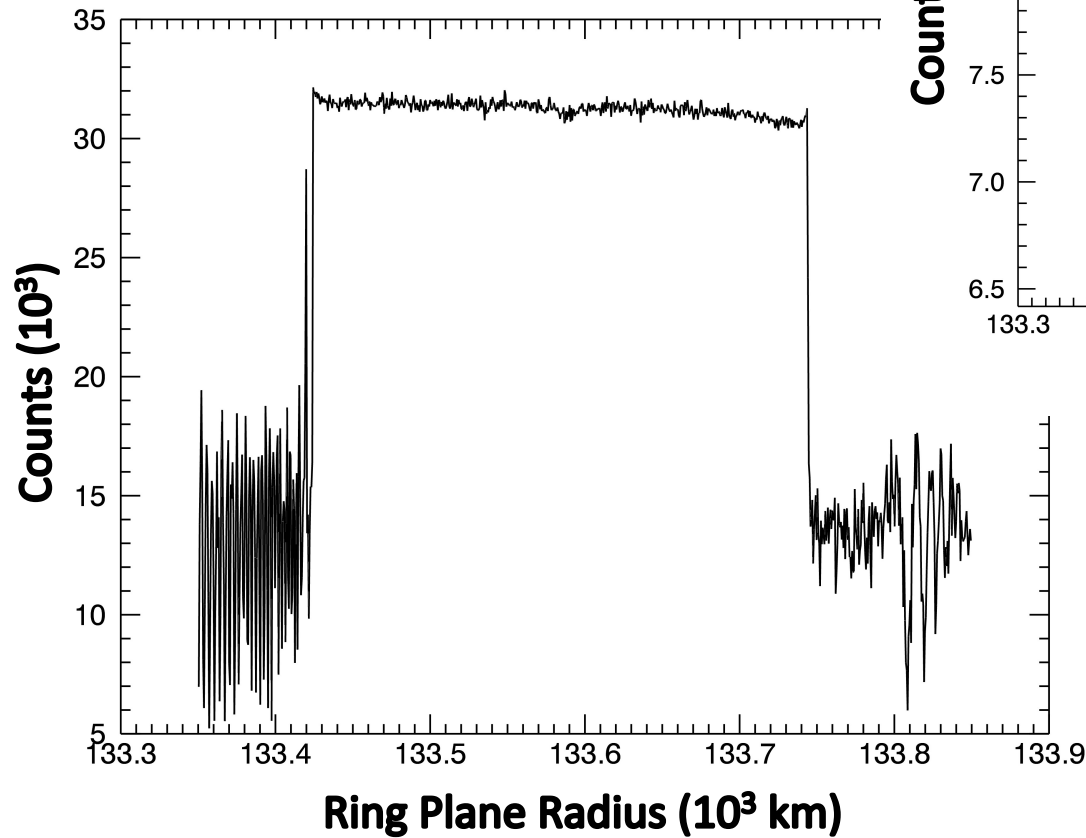
ZetCen112



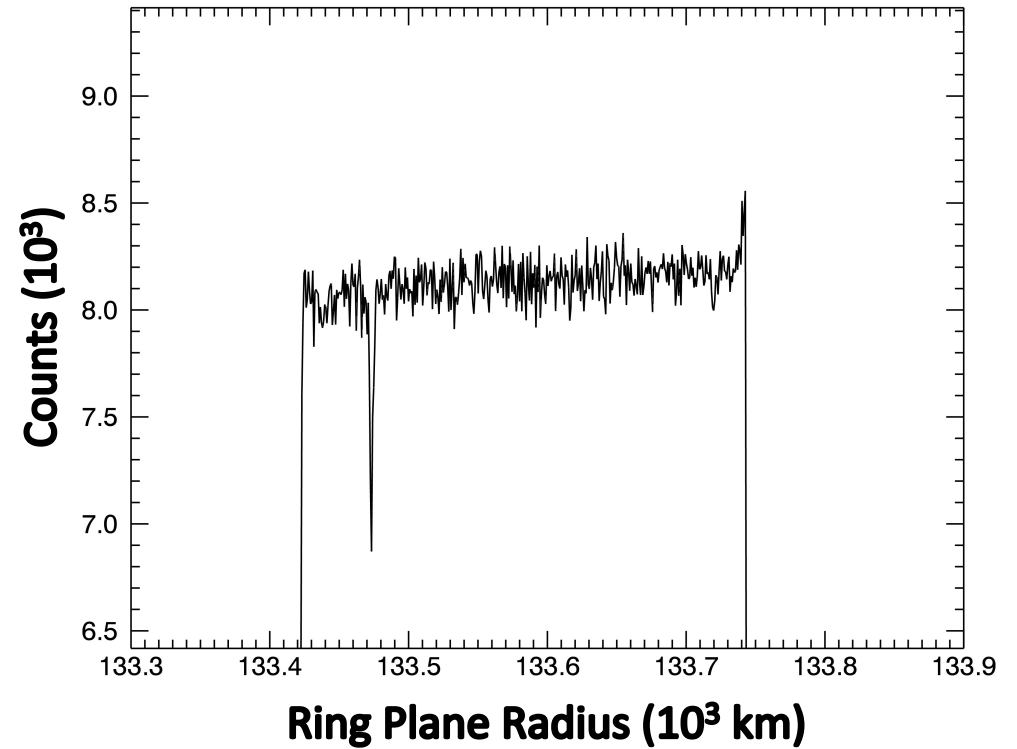
Examples: Encke Gap



LamSco044



EpsLup037E

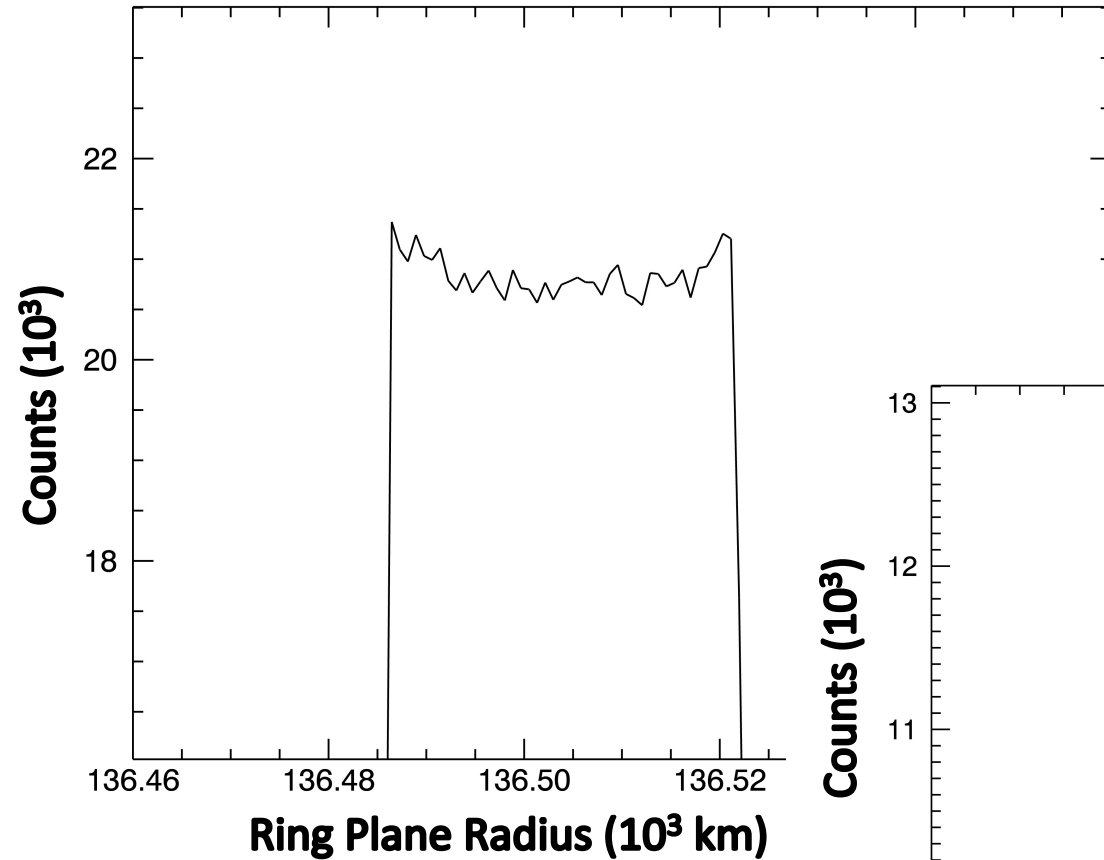


Ring Plane Radius (10^3 km)

3% increase in signal
Extend up to 15 km from
edge
Particles 5-15 mm

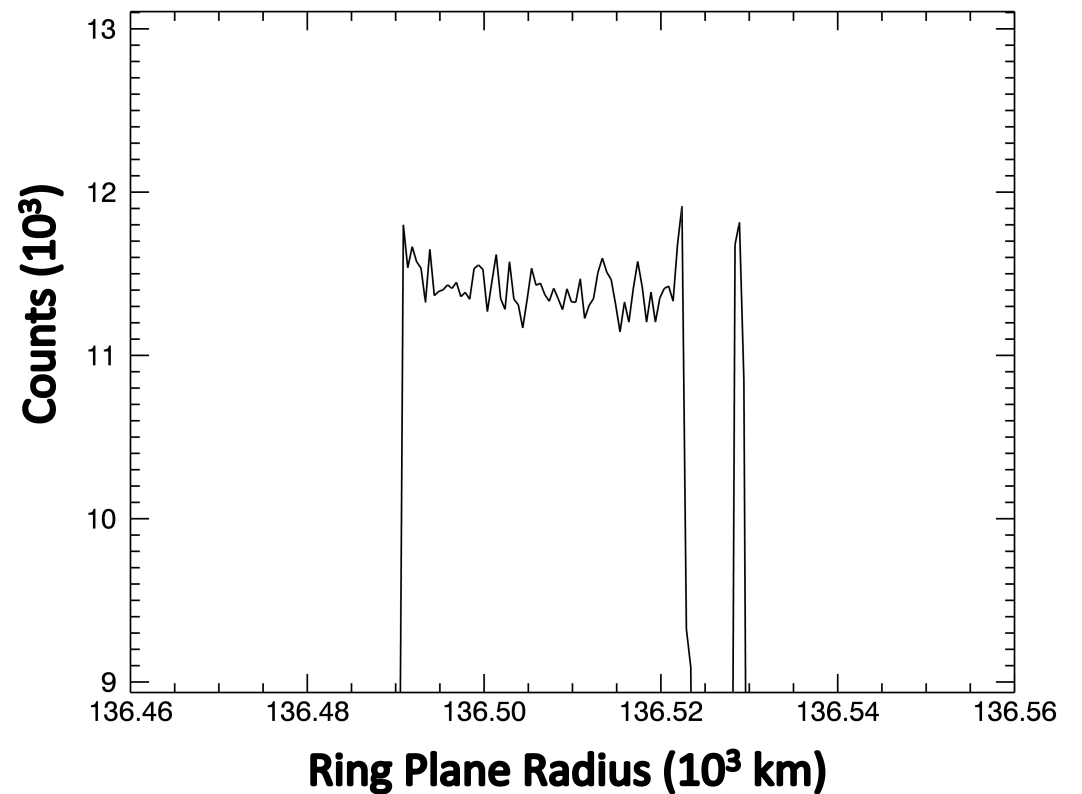
Examples: Keeler Gap

KapCen042I

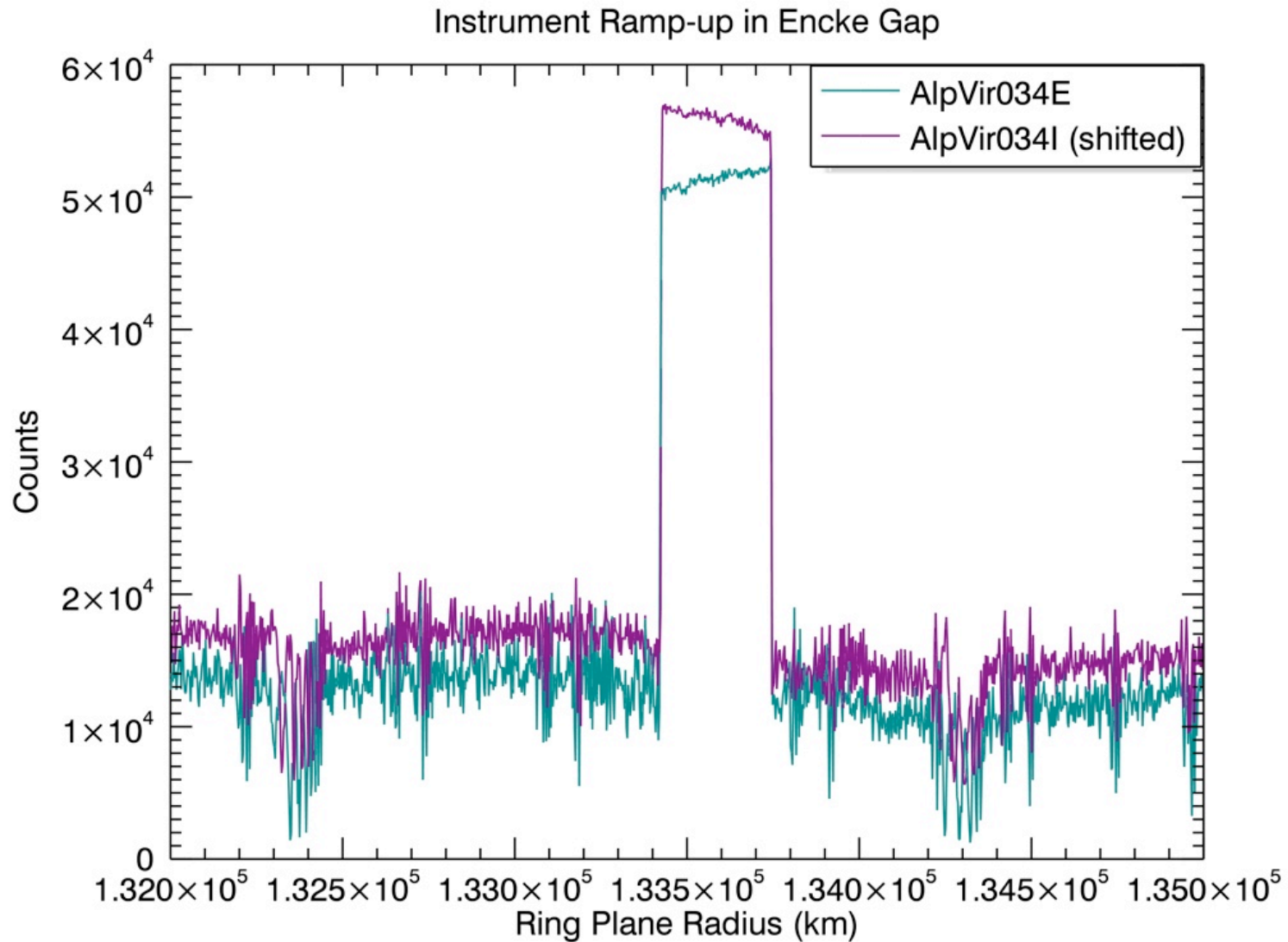


Diffracted light detected across the gap

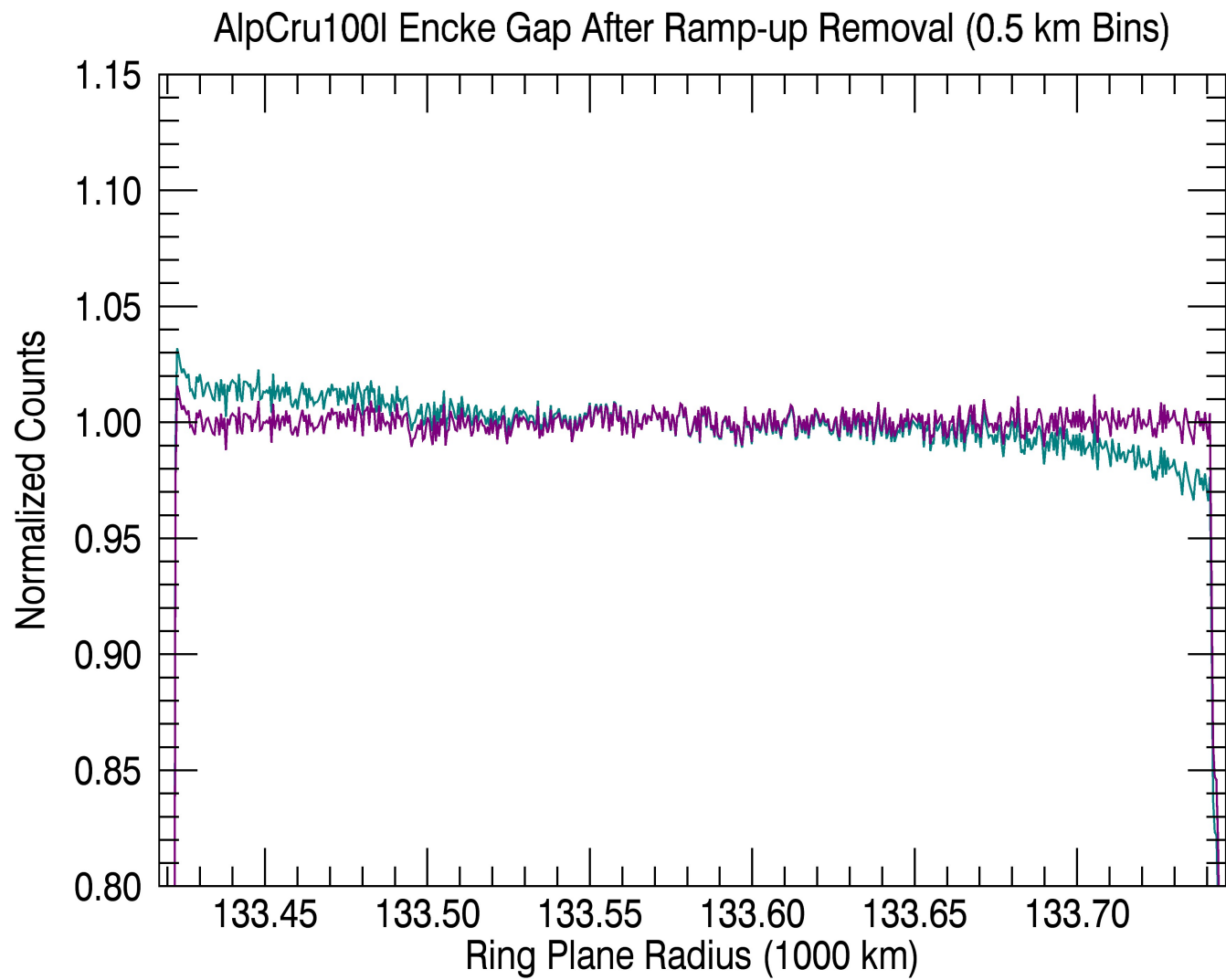
ZetCen060



Instrument Effects



Ramp-up Removal



Model Calculations

$$\frac{I_1(\theta, \lambda)}{I_i} = \frac{e^{-\tau/\mu_0}}{4\pi\mu_0} \int_{a_c}^{\infty} \pi a^2 \left[\frac{2J_1\left(\frac{2\pi a}{\lambda} \sin \theta\right)}{\sin \theta} \right]^2 n(a) da$$

$$\tau(\lambda) = \int_0^{\infty} \pi a^2 Q_e(a, \lambda) n(a) da$$

$$n(a) da = C a^{-q}$$

τ Optical Depth

λ Wavelength (150 nm)

a Particle Size

Q_e Extinction efficiency

θ Scattering Angle

μ_0 Sine of ring opening angle

Cuzzi et al., 2009

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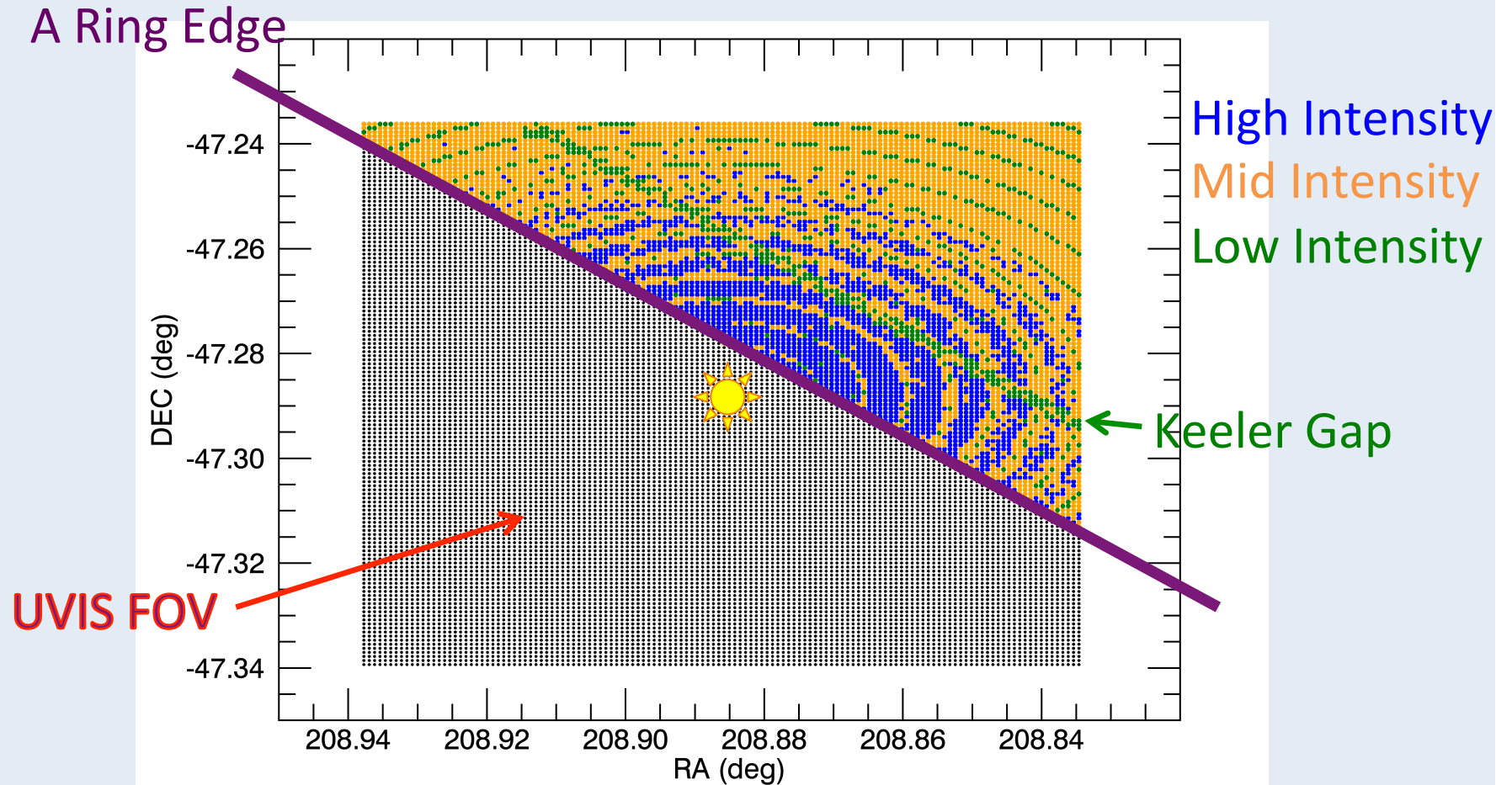
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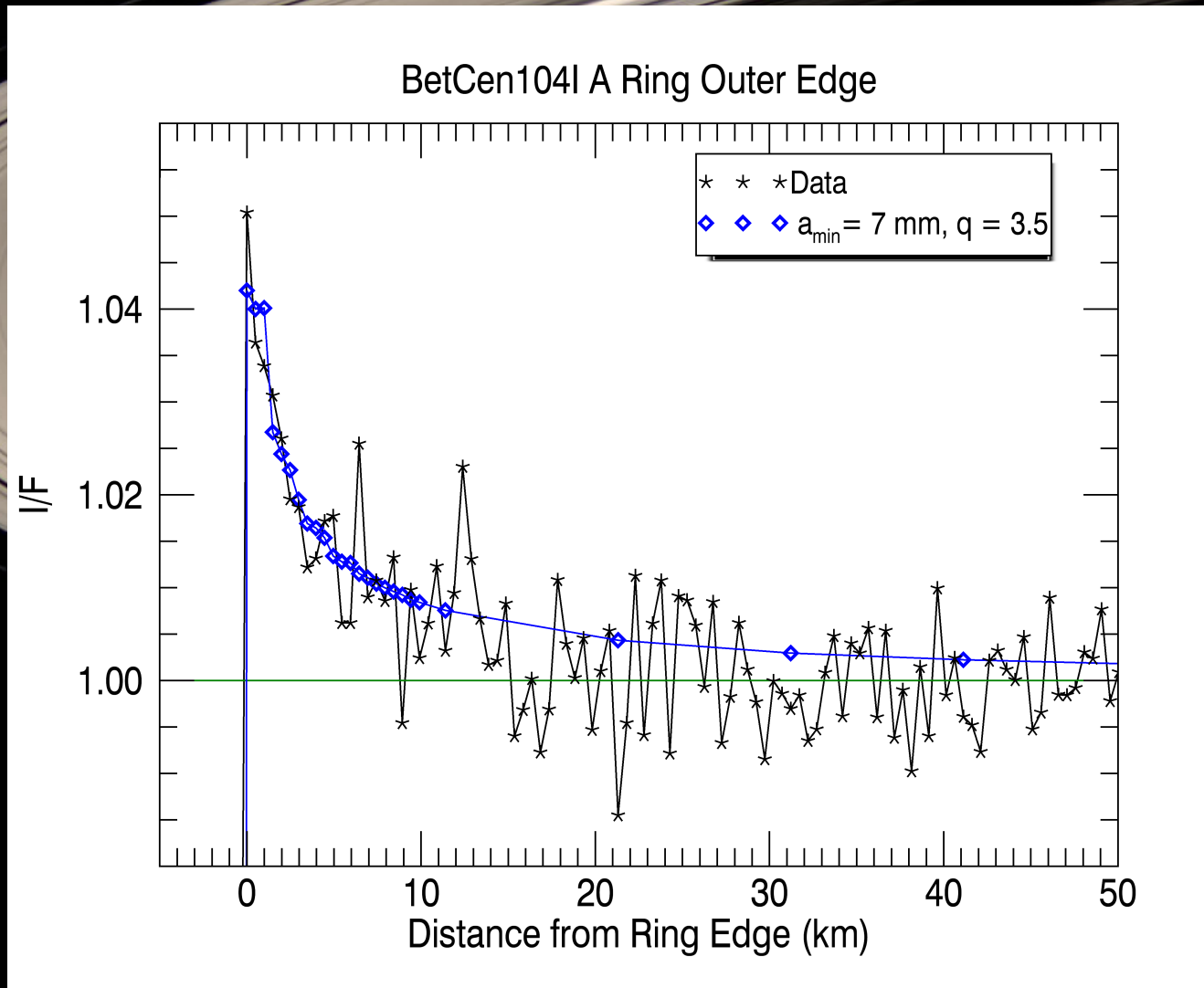
Cuzzi et al., 2009

Diffraction Model

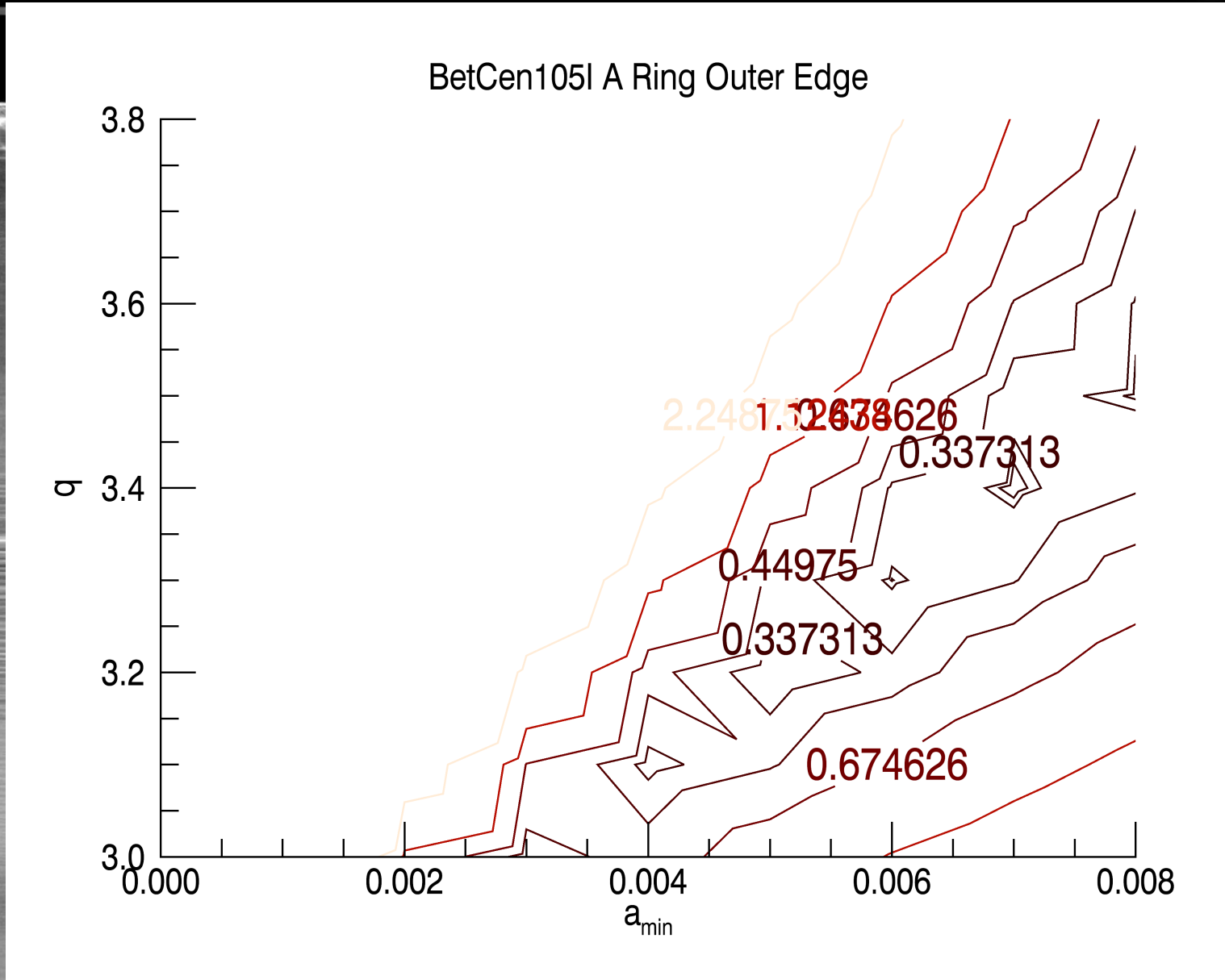


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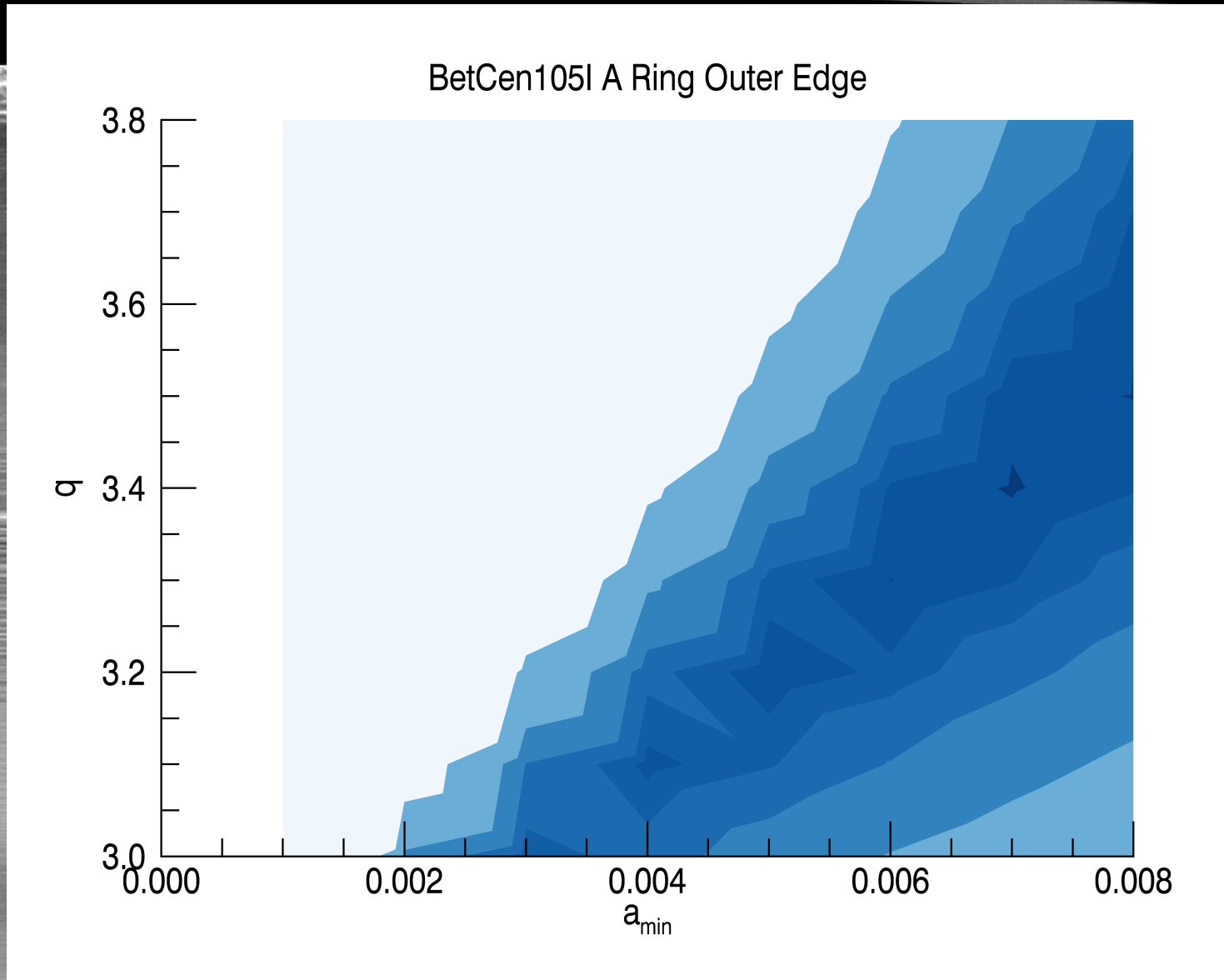
Best Fit Models



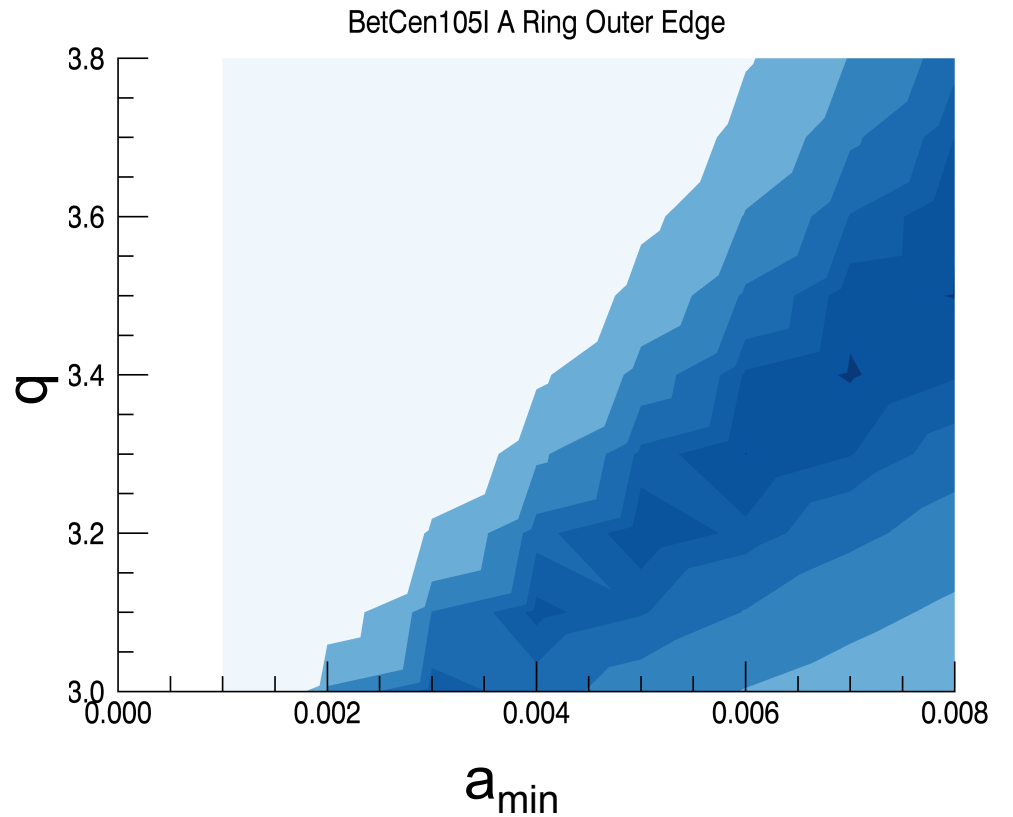
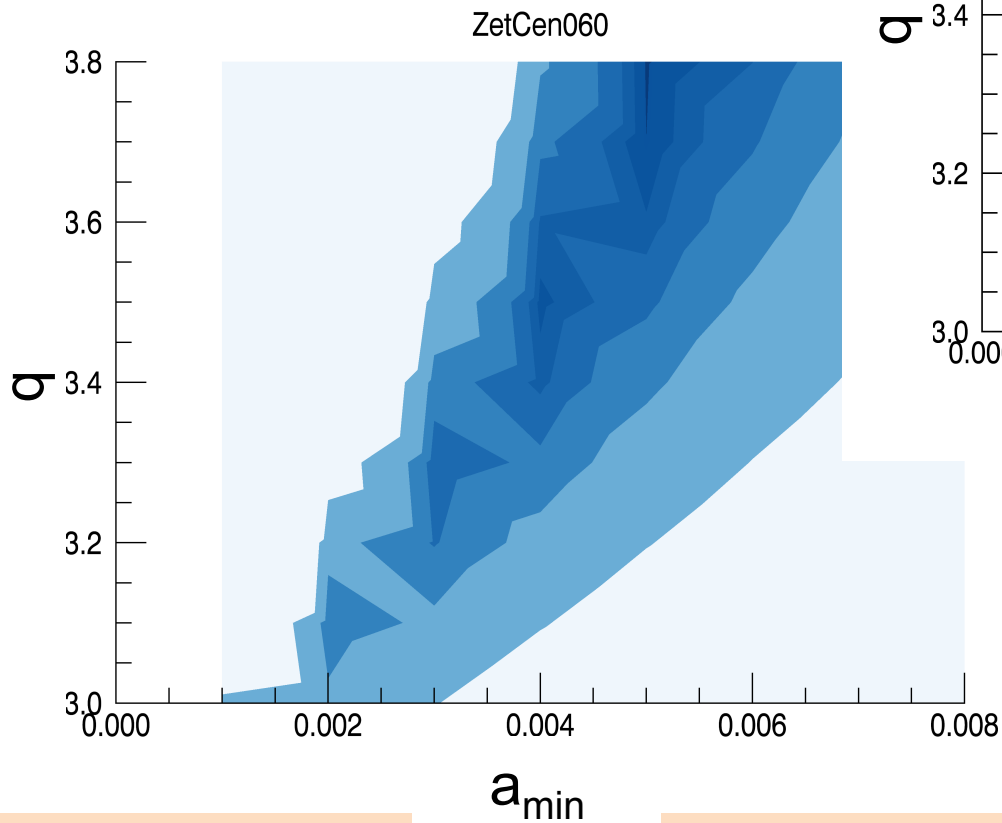
Reduced χ^2 Map



Reduced χ^2 Map

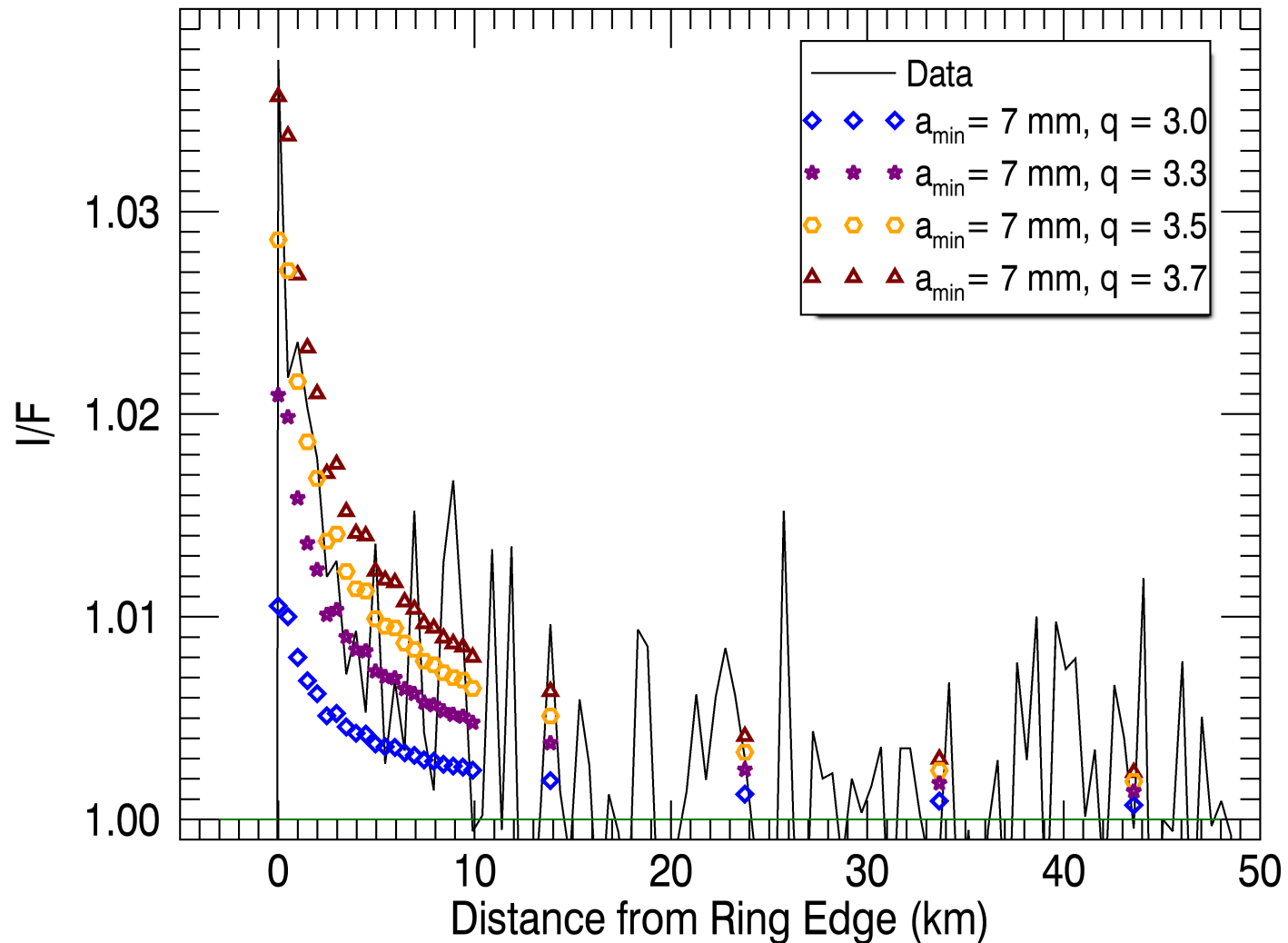


Variations in Best Fits



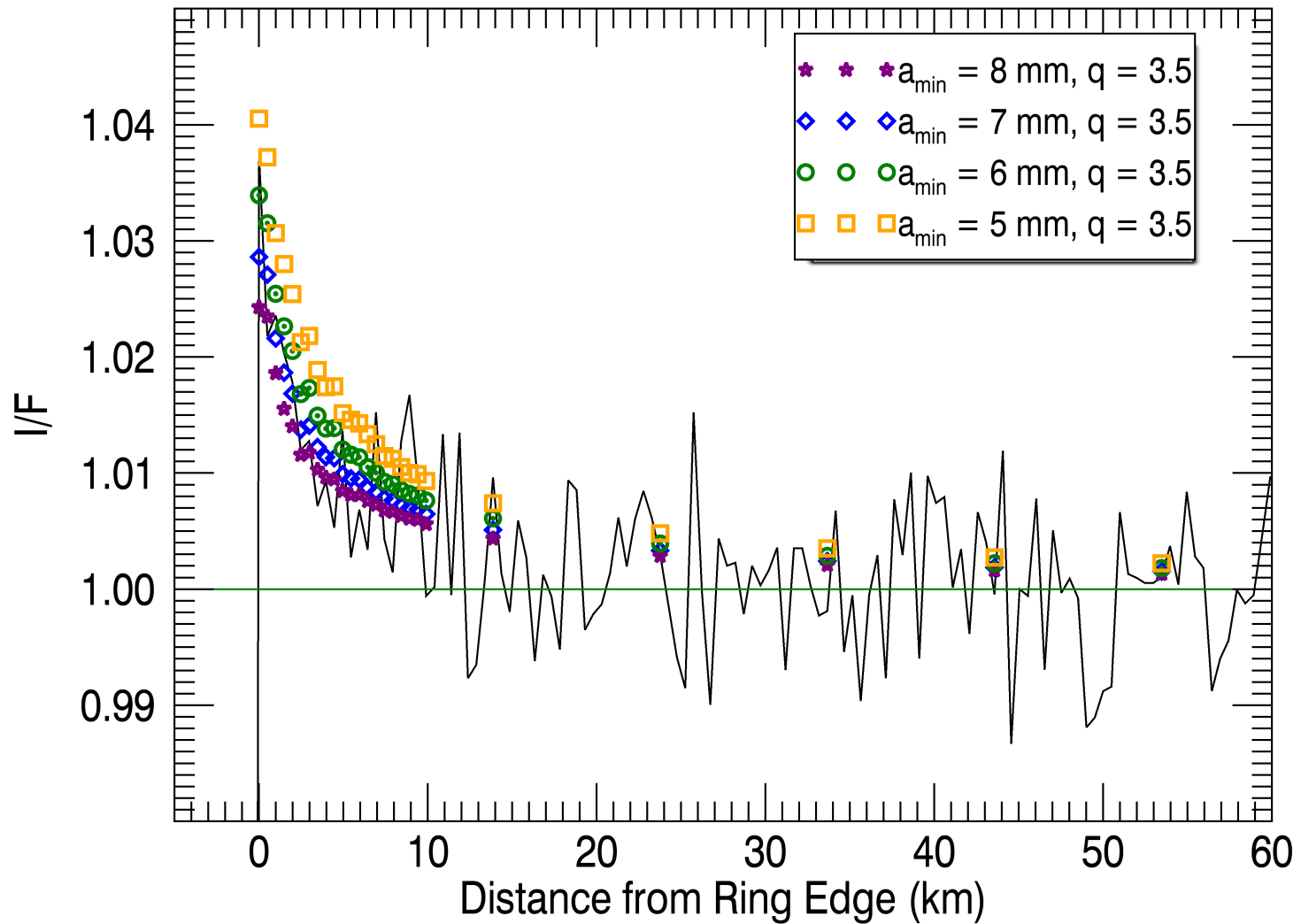
Model Variations of 'q'

BetCen105I A Ring Outer Edge



Model Variations of a_{\min}

BetCen105I A Ring Outer Edge



Results

- **Linear dependence between q & a_{\min}**
- **Smallest Particle Sizes:**
 - **Outer Edge of A Ring: 3 - 9 mm**
 - **Encke Gap: 6 - 15 mm particles**
- **Slope of size distribution**
 - **Outer Edge of A Ring: 3.3-3.7**
 - **Encke Gap: 3.3 – 3.6**

Results

- Decrease of the smallest particle size in outer A ring with radial distance from Saturn.

Smaller particles produced by higher interparticle collisions in this region.

- Variation of the size distribution at each edge
- We have not found any correlation with a *detection* of a signal and the relative longitude of satellites.

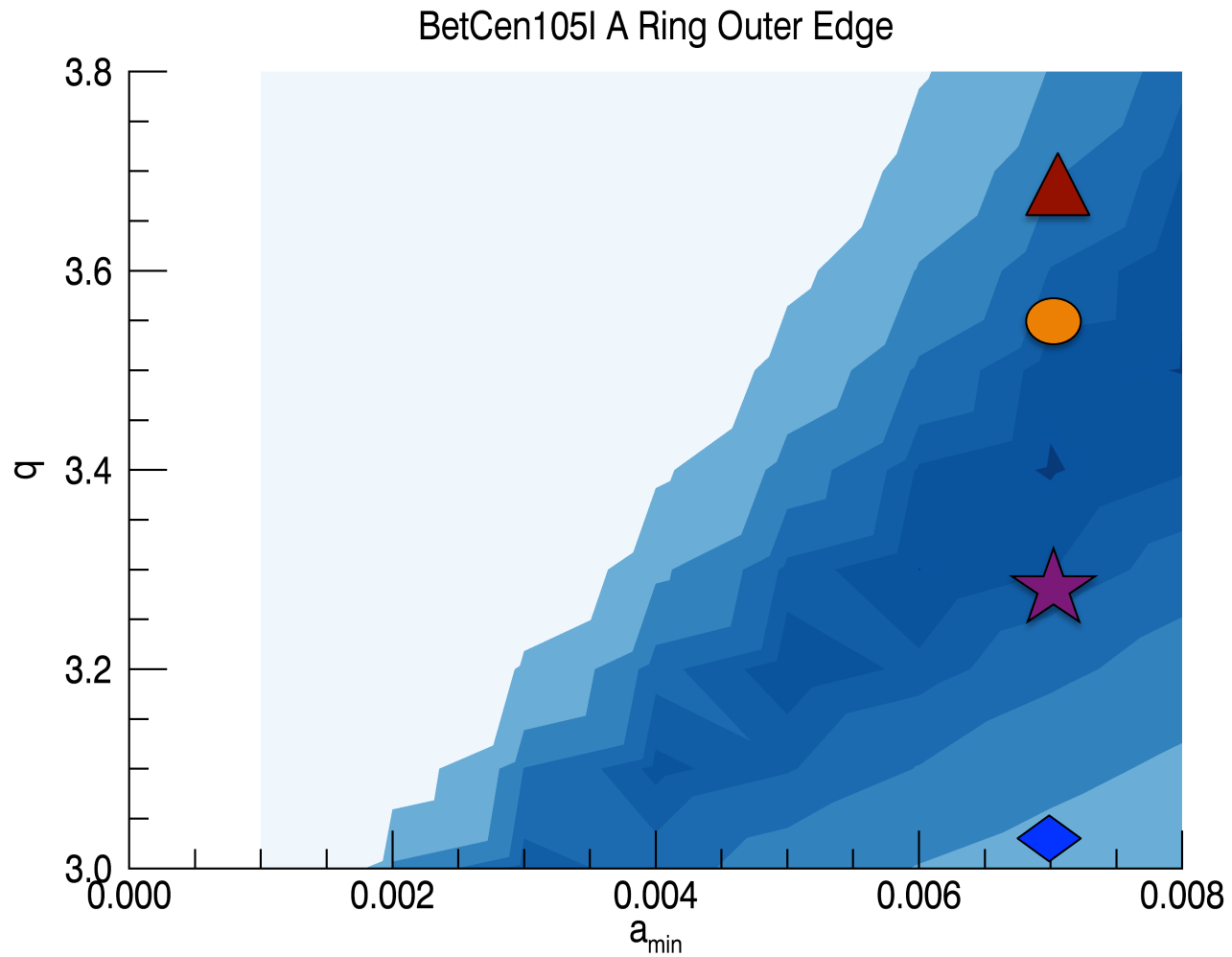
Future Work

- **Compare variations in particle size and q with relative longitude to moons.**
- **Apply diffraction detection method to other regions in the rings.**

Model Assumptions

- $a_{\max} = 8.9$ meters
- Diffraction signals add linearly
- $Q_{\text{ext}} = 1.5$ near edges
($Q_{\text{ext}} = 1$ in Keeler Gap)
- No break in the linear size distribution

Model Variations of 'q'



Model Variations of a_{\min}

