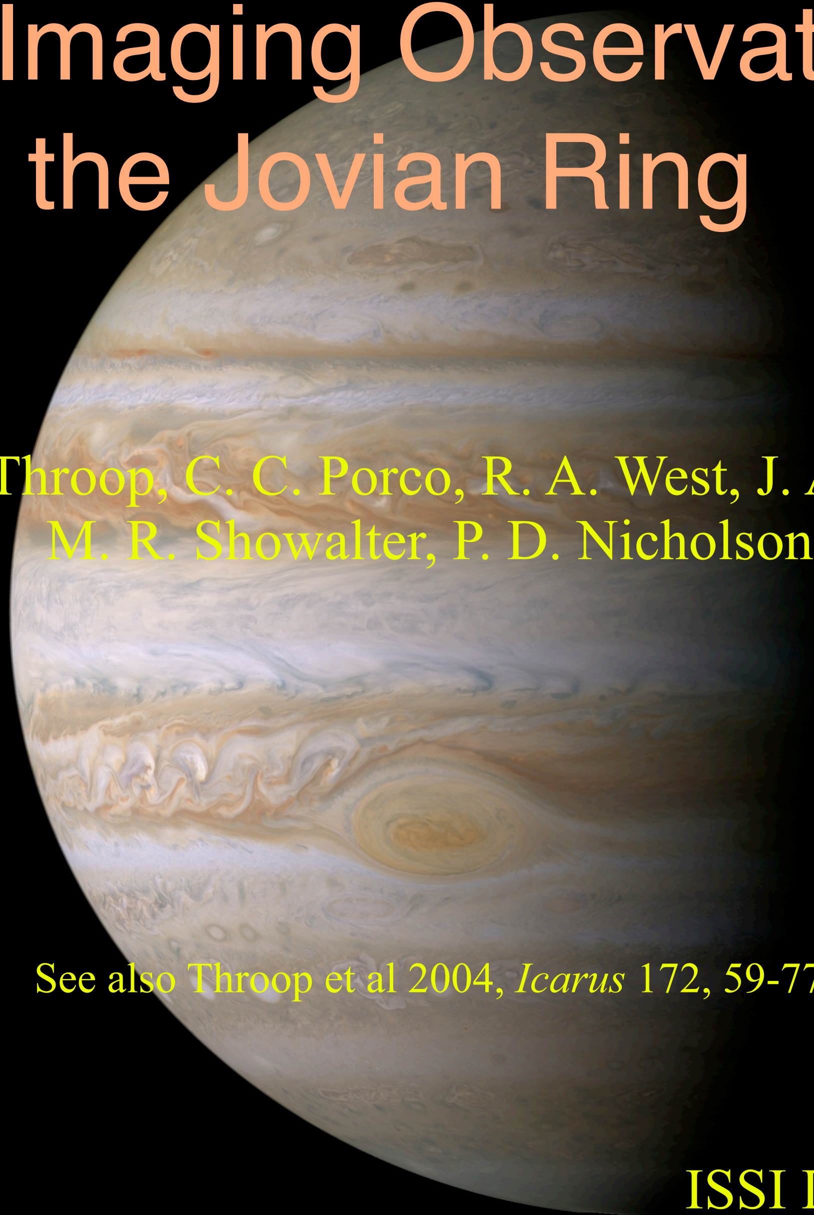
Cassini Imaging Observations of the Jovian Ring



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See also Throop et al 2004, *Icarus* 172, 59-77

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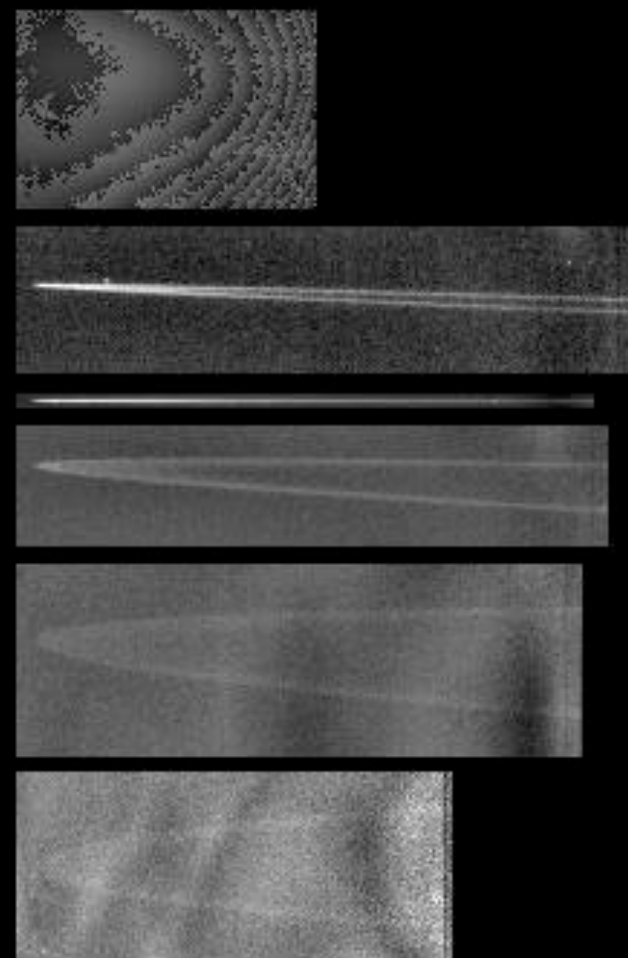
Cassini ISS Imaging Summary

- 1200 images of main ring
  - No halo or gossamer observations
- Mostly short exposures, < 5s
  - Frames co-added for highest SNR
- Closest approach = 136 R_J at ring plane crossing
- λ = 450 – 950 nm
- Phase angle 0.5 – 120 deg over 40-day encounter
- Radial profiles in forward-, back-scatter
- Phase, wavelength coverage fills holes in existing observations
- Stray light from Jupiter was significant



0 deg

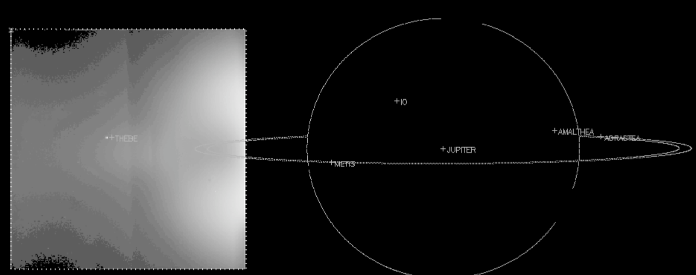
60 deg

62 deg

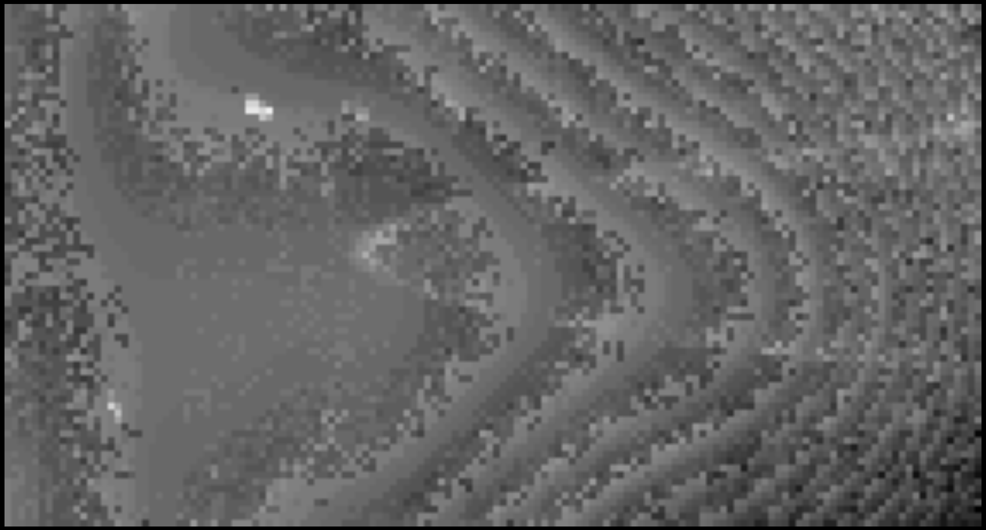
75 deg

94 deg

120 deg

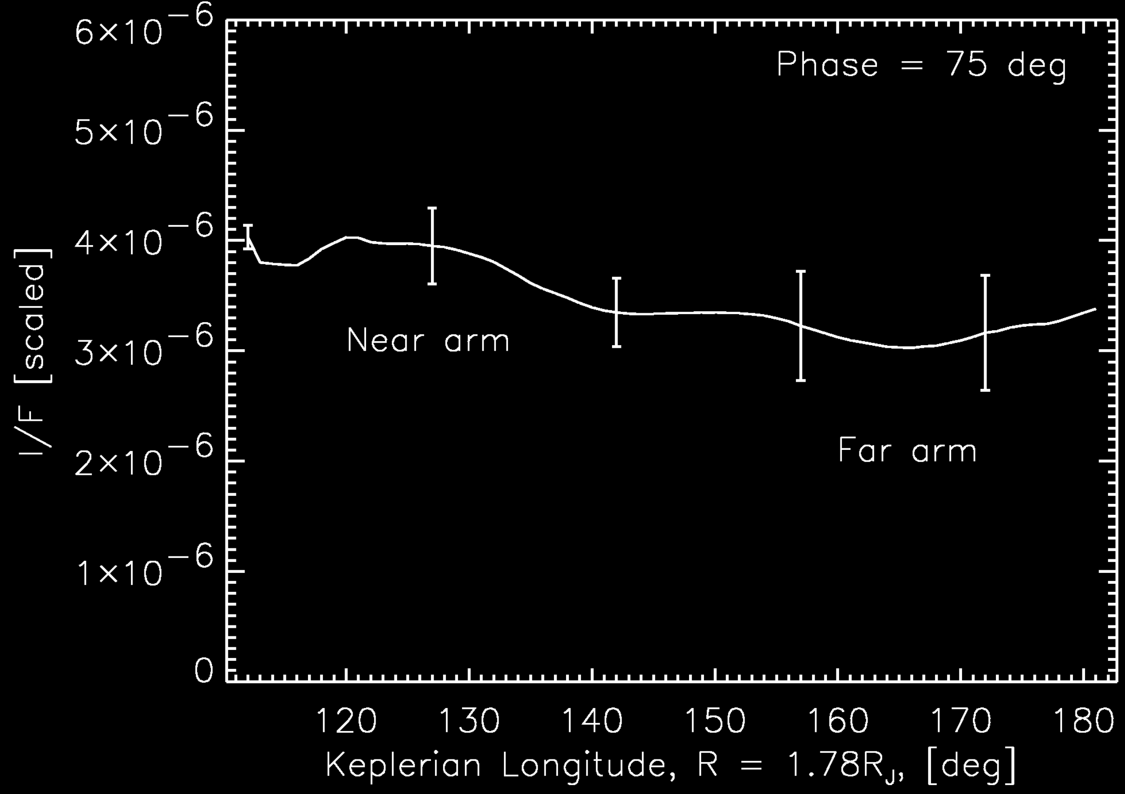


Ring Movie



- Movie shows 500 inbound frames, α=0.5 – 2.5 deg, t=2 sec, clear
- Metis (large) and Adrastea (small)

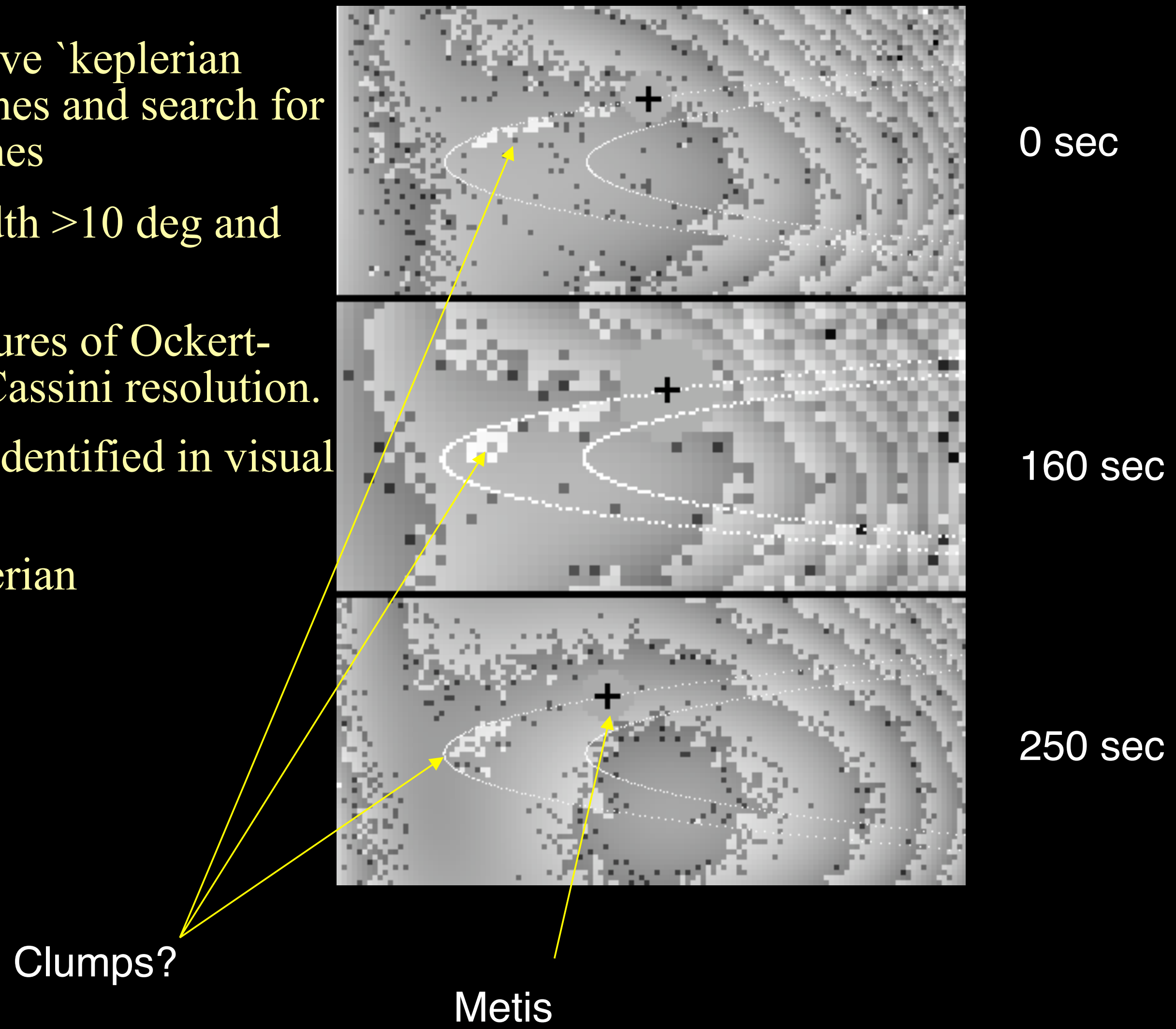
Azimuthal Asymmetry



- We searched for both near-far and left-right asymmetries
- Maximum asymmetry seen: 20% (1σ) near-far arm during 75 degree sequence
- <5% right-left ansa asymmetry seen during ring plane crossing
- No conclusive evidence for any systematic asymmetry

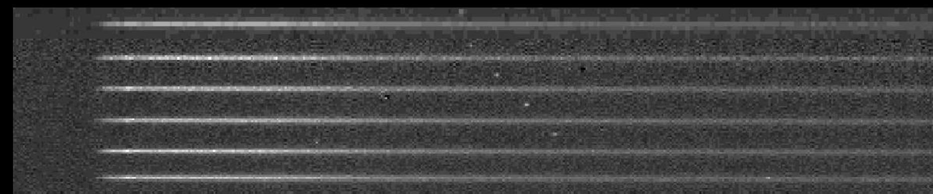
Azimuthal Features

- We performed comprehensive `keplerian deprojection' to co-add frames and search for clumps in 600 inbound frames
- No clumps identified of width >10 deg and brightness > 2x average.
- Galileo `checkerboard' features of Ockert-Bell not seen due to lower Cassini resolution.
- Possible azimuthal clumps identified in visual search (at right)
  - Motion is roughly keplerian
  - Detection is marginal



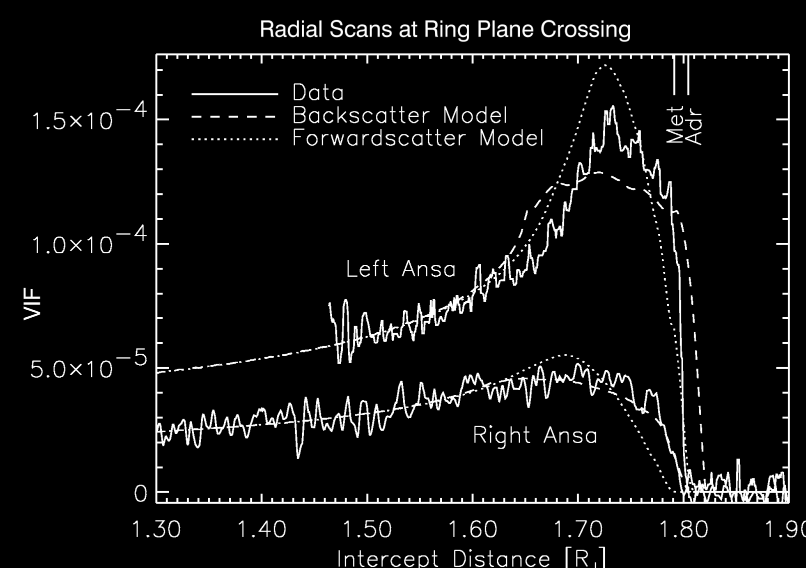
Ring Plane Crossing

- Observed for 30 minutes at lat = -0.02 deg, α=63 deg
- Deepest and closest obs of encounter
  - 32 sec, 137 R_J
- Ring thickness
  z/2 <= 40 km at sidescatter
  - Galileo z/2 <= 100 km
- There is at most a 5% intrinsic brightness difference between left and right ansae



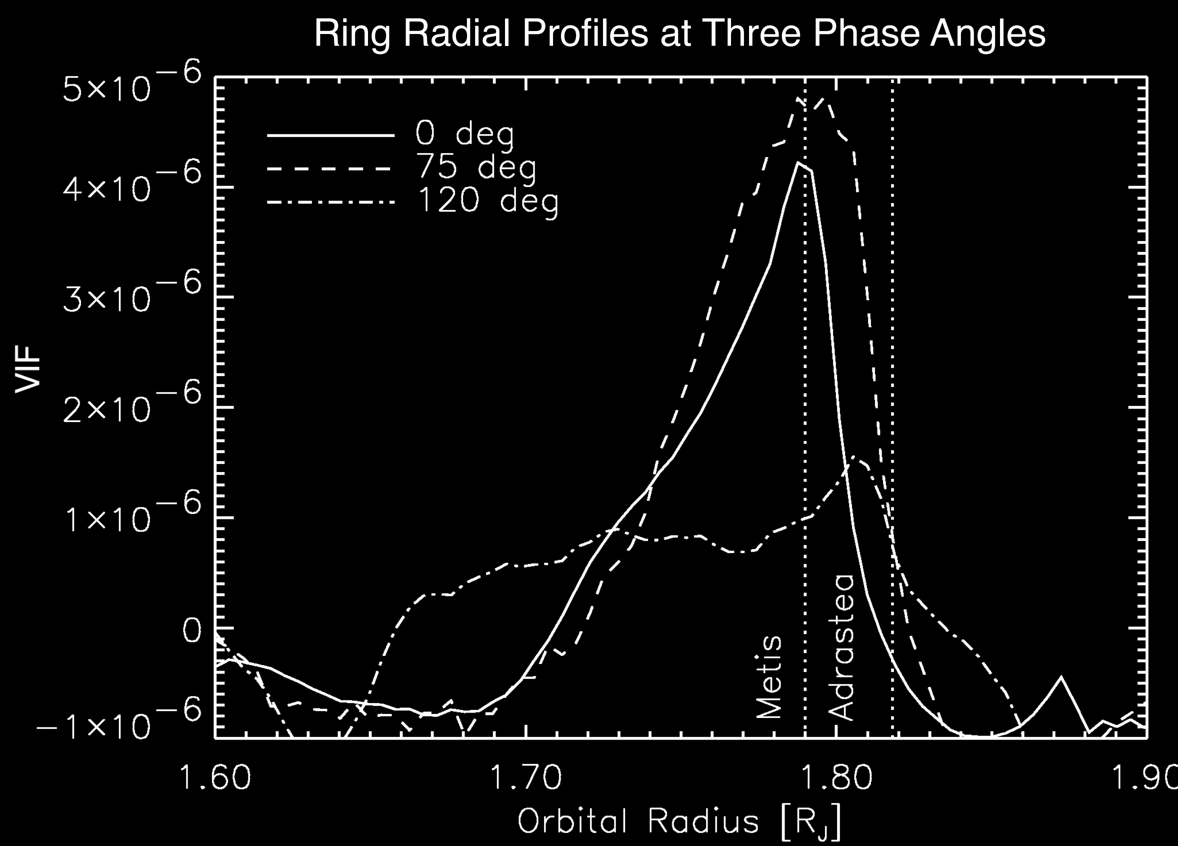
Left ansa (fully lit)

Right ansa (partially shaded)

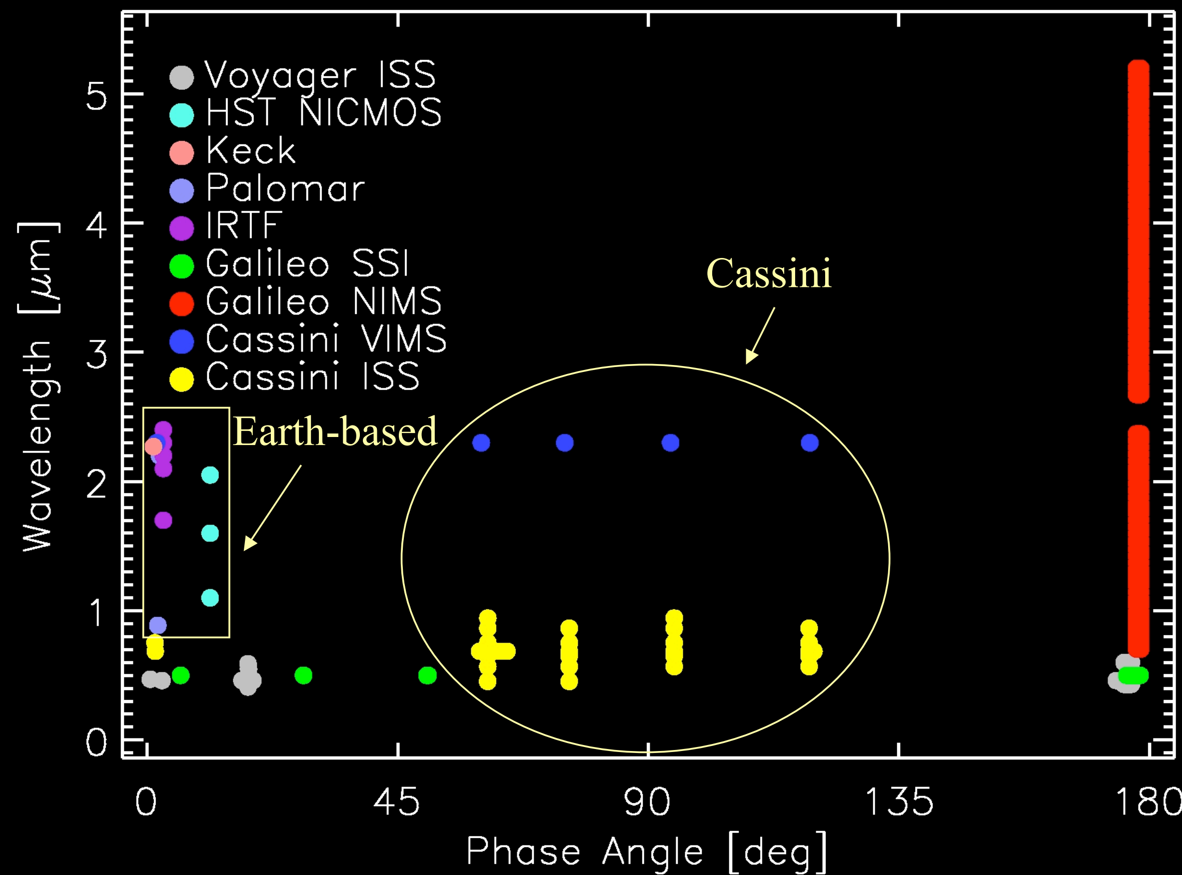


Radial Profiles

- Backscatter:
  Large bodies
- Forwardscatter:
  Dust
- Ring has substantial, radially-uniform large-body population
- Dust distribution drops off rapidly inward of Metis: loss process?



Photometry: Cassini in Context



- Cassini observations fill in large holes in phase angle coverage
- Main-ring observations 1979-2001 have measured ~1300 data points of I/F (λ,θ)

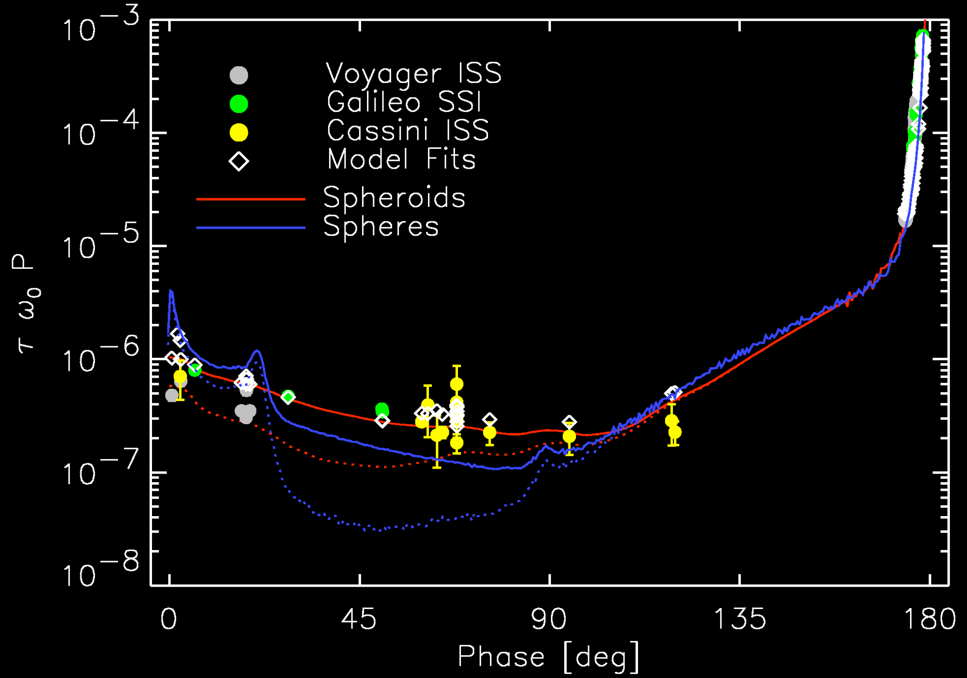
Photometry: Method of Fitting Observations

- Total I/F from ring is sum of two components
  - **Dust grains**
    - Optical depth $\boldsymbol{\tau}_D$
    - n = 1.5 + 0.001i
    - r = 0.01 – 100 μm
    - Non-spherical grains (Mishchenko & Travis 1998)
    - Various size distributions n(r)
  - **Large bodies**
    - Optical depth $\boldsymbol{\tau}_P$
    - Spectrum of Amalthea; phase function of Callisto
  - Free parameters $\boldsymbol{\tau}_D$, $\boldsymbol{\tau}_p$, n(r)
    - We iterate to find best fit solutions for the free parameters given the suite of all I/F observations.
  - Our model for determining size distribution considers all 1300 data points simultaneously -- e.g., spectrum and phase curve are fit together, not separately

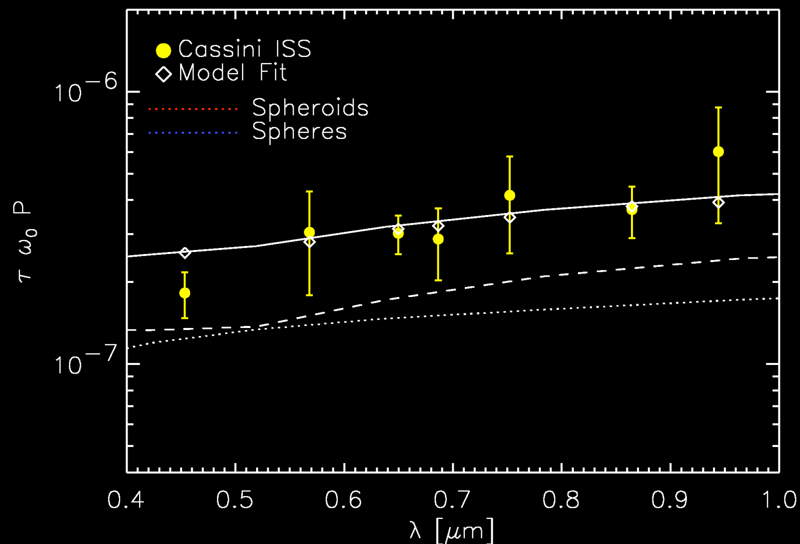
Ring Phase Curve and Size Distribution

- We fit data with two-component model of large bodies + dust
- Best fit:
  - **Large bodies: τ** ~ 1×10^{-6}
    - Must be very red (albedo linear with wavelength)
  - **Dust:** **τ** ~ 4×10^{-6}
    - $n(r)\,dr \sim r^{-2.5}\,dr$
    - $r^2\,n(r)$ peaked around 10-15 µm
    - Non-spherical particles (ε = 1.5 spheroids, Mishchenko & Travis) provide much better fit than spherical grains
    - Spherical grains are too bright near backscatter (`glory'): no opposition surge seen

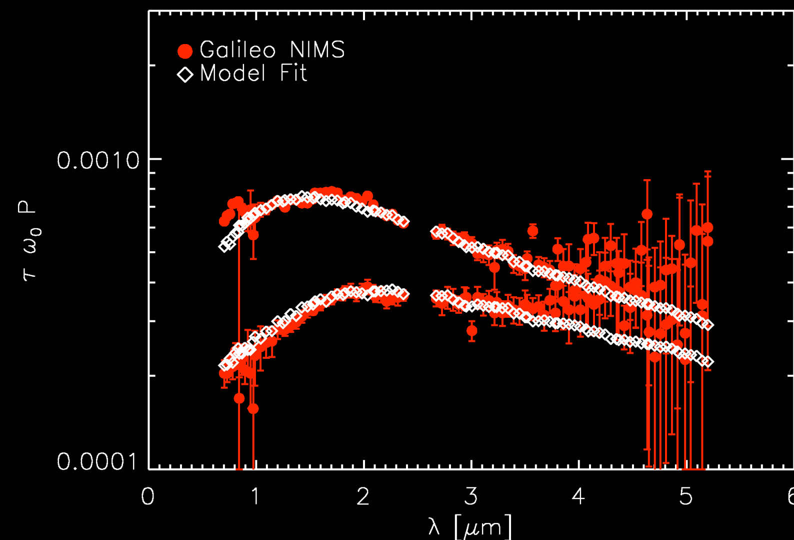
Visible Phase Curve



Ring Spectra and Size Distribution

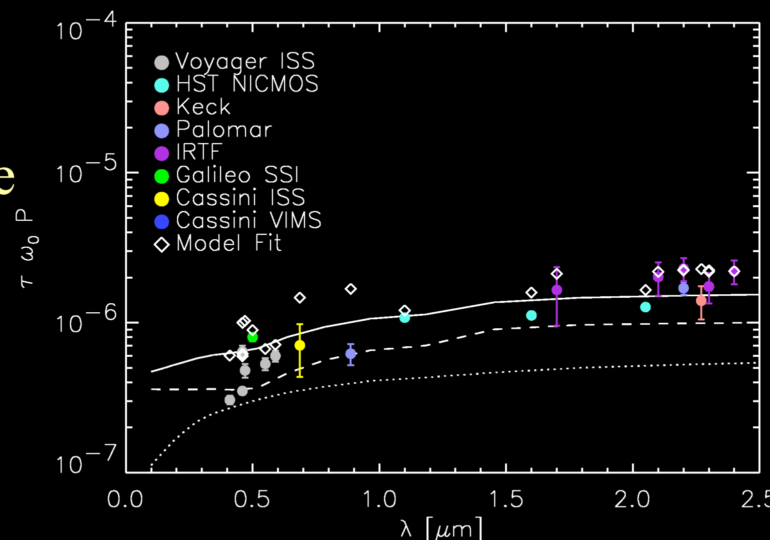


Sidescatter, 60 deg



Forwardscatter, 178 deg

- Size distribution most strongly constrained by NIMS data
- Brooks (2003) provides possible mechanism for selection of 15 μm grains: size is preferentially absorbed as they cross Metis' orbit due to drag-orbital resonance



Backscatter, ~3deg

Conclusions

- **Cassini ISS observations**
  - No strong detections of any asymmetry
    - Sketchy detection for keplerian-moving clumps
  - Improved upper-limit ring thickness ($z/2 <= 40$ km)
  - Improved radial profile measurements at three phase angles separate large, small bodies
  - Fills in major holes in wavelength, phase-angle space.
- **Photometry with Cassini + all previous observations**
  - 1300 data points from Cassini ISS & VIMS, Galileo SSI & NIMS, NICMOS, Keck, Palomar, HST
  - I/F for all data sets can be fit nearly self-consistently, if ring is modeled with two distinct components. Single-component models do not fit.
    - **Large bodies:** $\tau \sim 1.3 \times 10^{-6}$
      - Very red
    - **Dust:** $\boldsymbol{\tau} \sim 4.7 \times 10^{-6}$
      - r^2 n(r) peaked around **10-15 μm**
      - Best fit size dist: $n(r)\, dr \sim r^{-2.5}$,for r = 0.4, but most sensitive to peak size
      - Spherical grains do not fit, esp. near 0 deg