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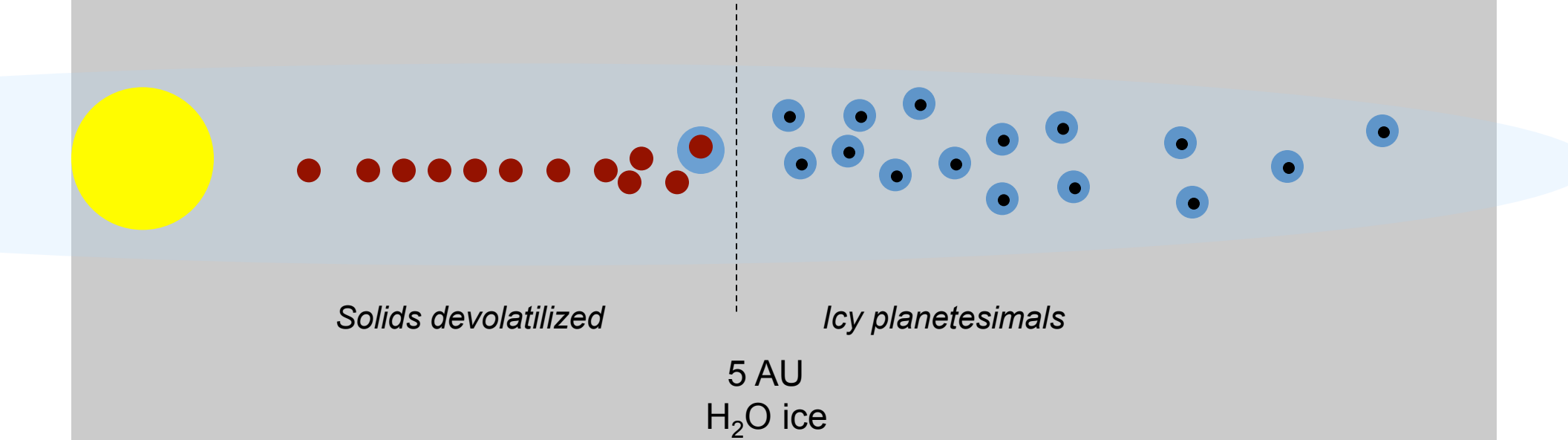
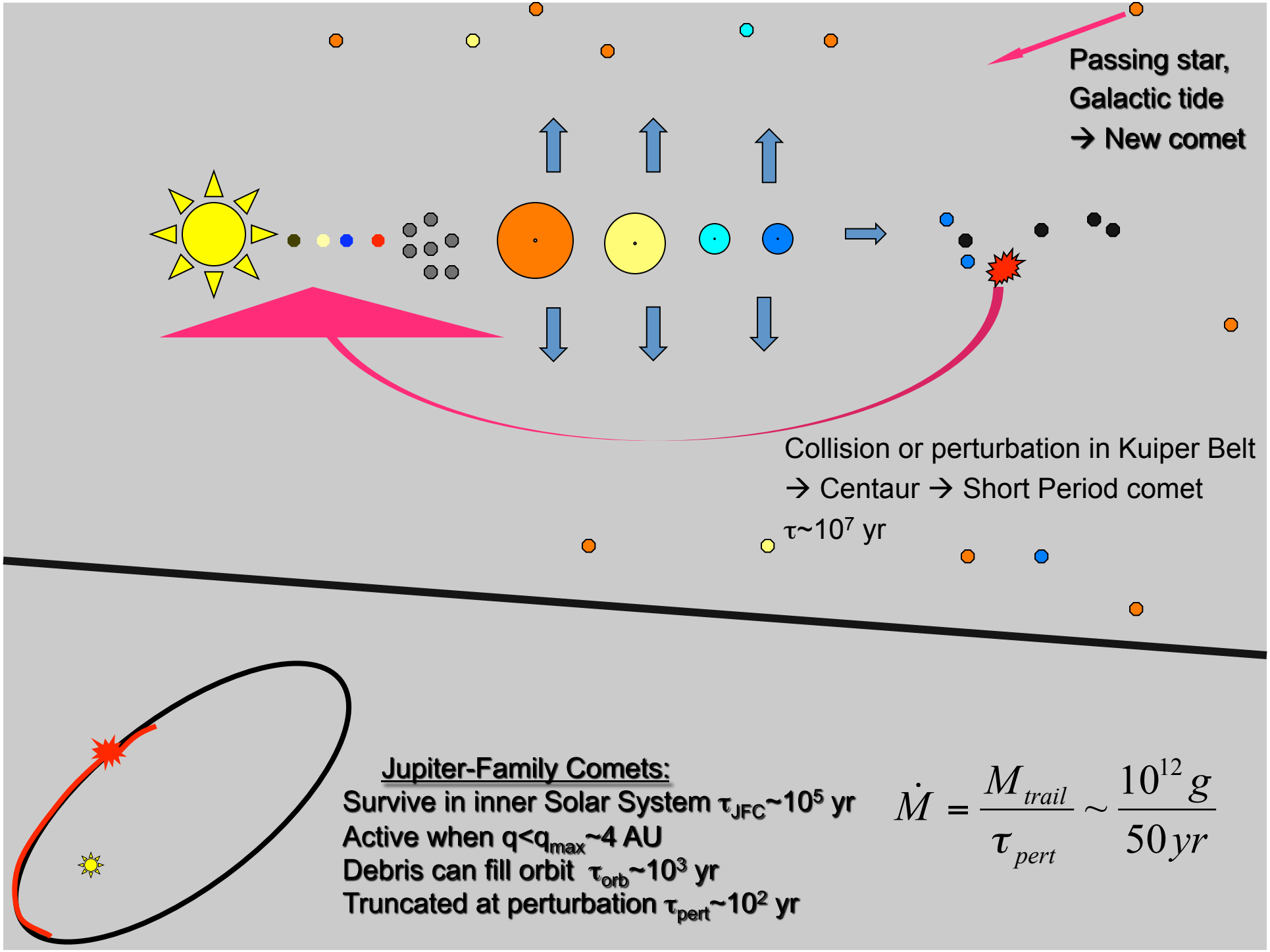
Zodiacal and Exozodiacal Light

- Exozodis can reveal what the solar system might have looked like
- Local zodiacal light observations relevant to these studies as templates
  - empirical (shape, density, variability)
  - Physical (parent bodies, dynamics, resonances)

Asteroidal and Cometary Planetsesimals in the Solar Nebula





Jupiter-Family Comets:

Survive in inner Solar System τ_{JFC}~10^5 yr

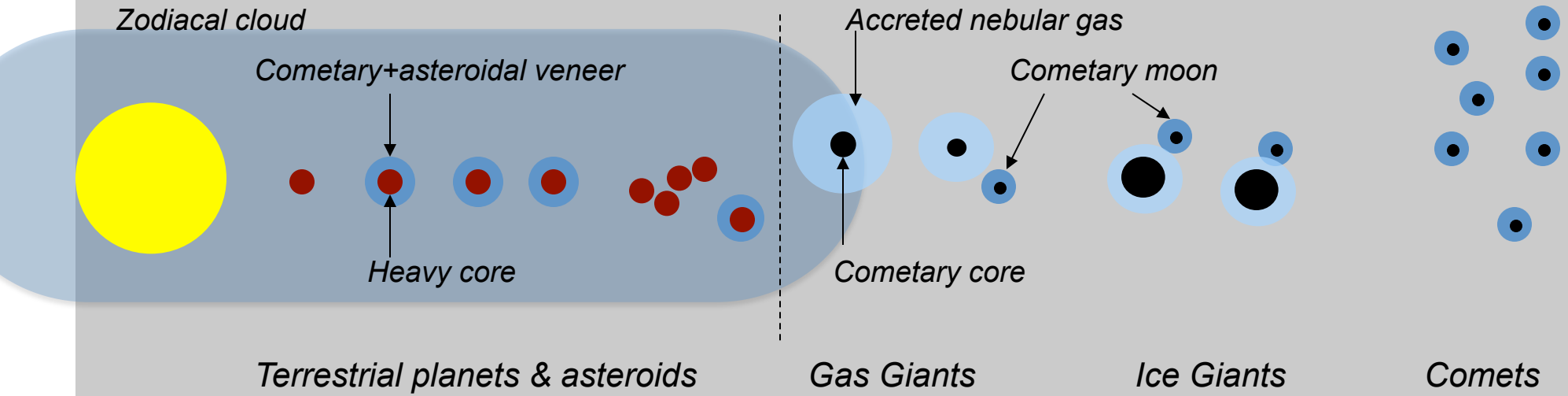
Active when $q<q_{max}$~4 AU

Debris can fill orbit τ_{orb}~10^3 yr

Truncated at perturbation τ_{pert}~10^2 yr

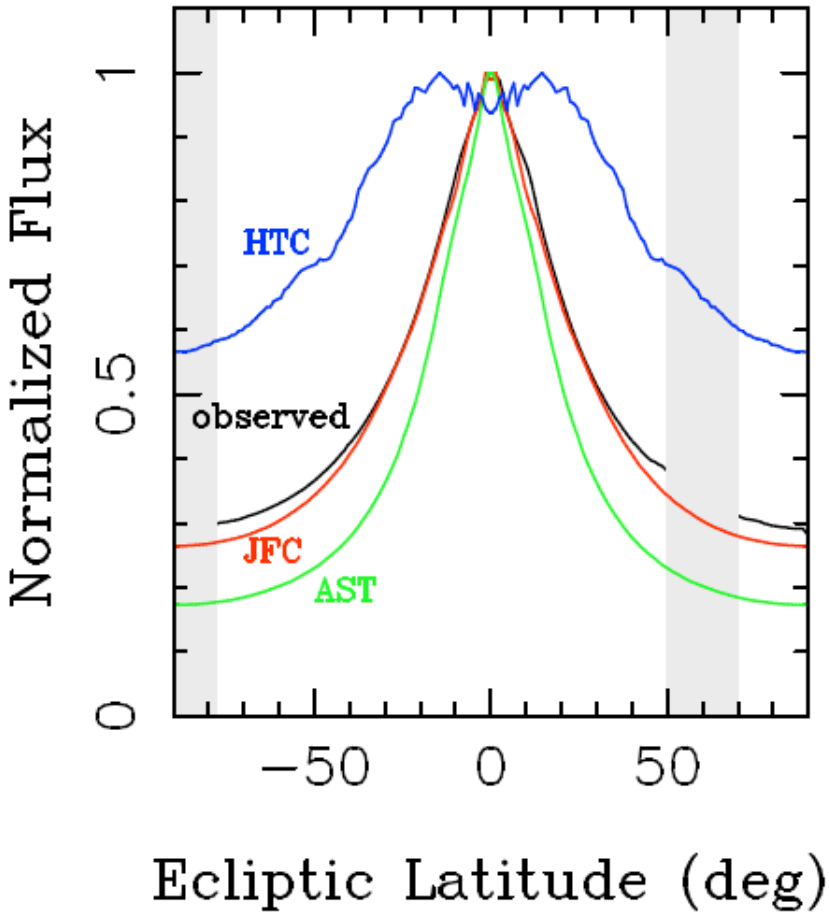
$$\dot{M} = \frac{M_{trail}}{\tau_{pert}} \sim \frac{10^{12}\,g}{50\,yr}$$

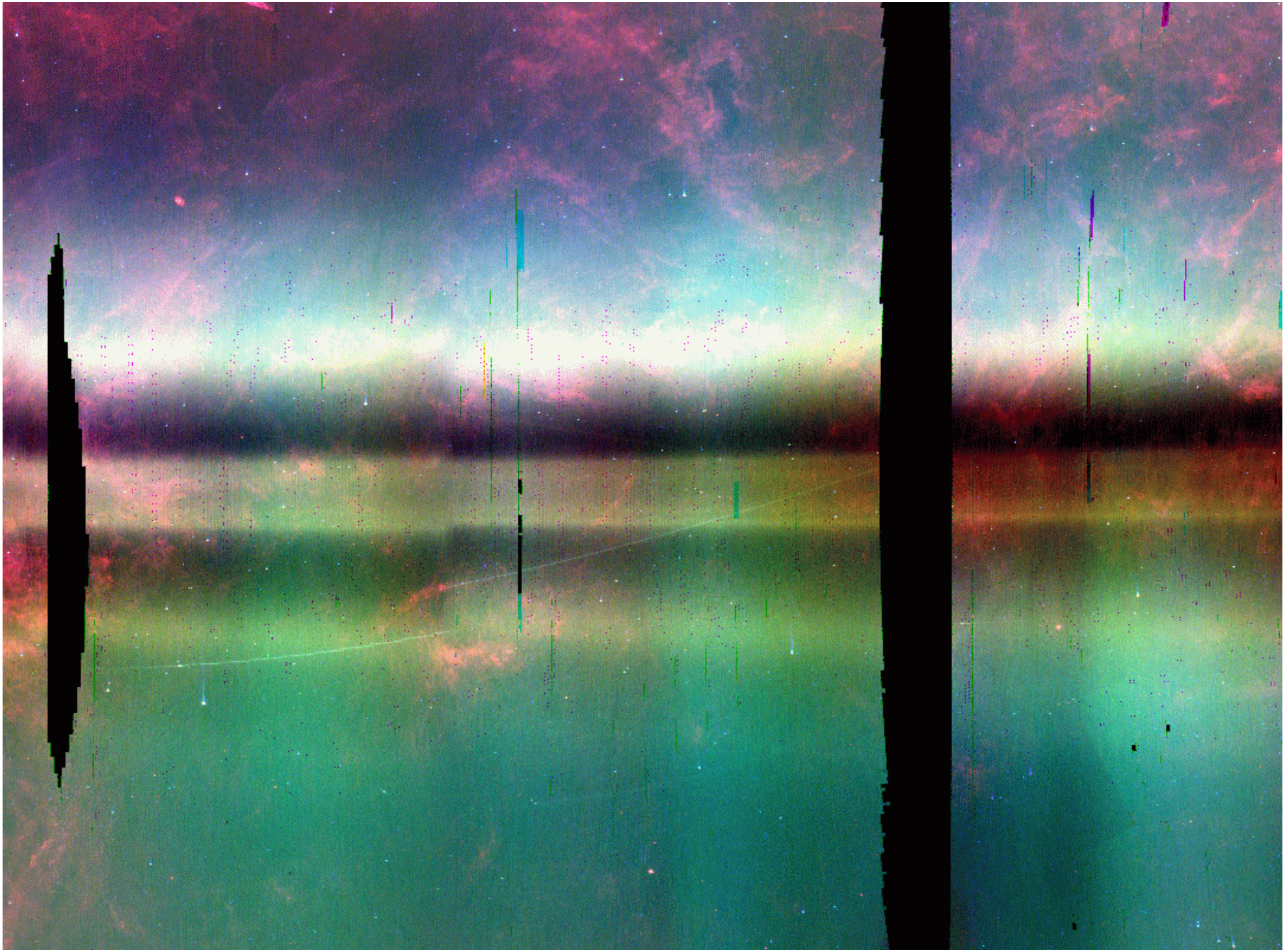
Cometary Material in Present Solar System



Parent Bodies: Comets or Asteroids?

- Nesvorny et al 2009
  - >90% comets
  - Based on latitude profile
- Nesvorny et al. 2003
  - Asteroidal contribution
  - Dust Bands = debris from young (<few Myr) families



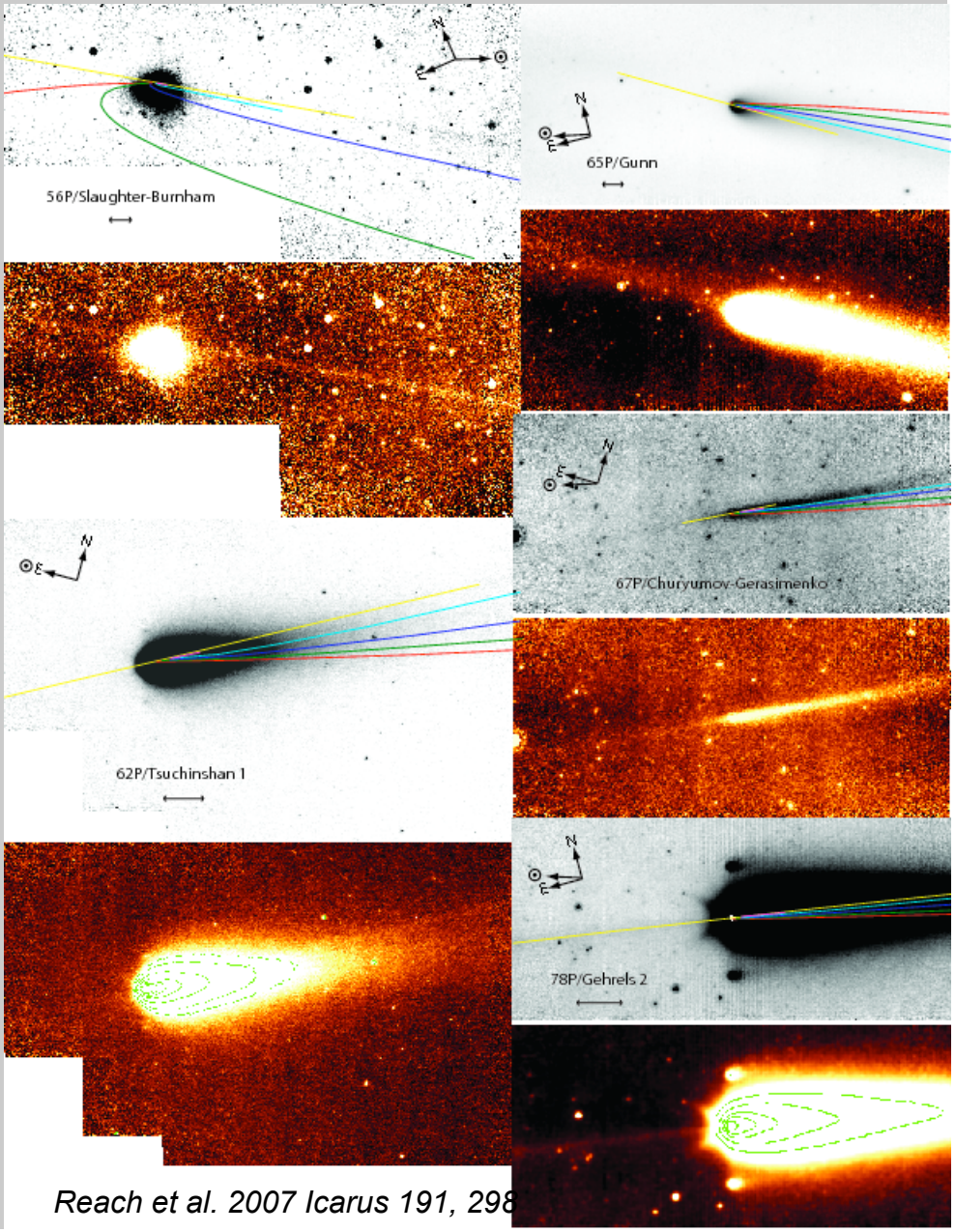


Recent Asteroid Collisions

Age	Source	Feature	Reference
50-250 kyr	1999 YC2		Nesvorny (2006 AJ 132, 1950)
220±2 kyr	Emilkowalski		
300-800 kyr	Lucasavin		
450 kyr	Datura	trail?	Nesvorny (2006 Sci 312, 1490)
<5 Myr	Beagle	1.4°band	Nesvorny (2008 ApJ 679, L143)
5.0±0.2 Myr	Karin	2.1°band	Nesvorny (2006 Icarus 183, 296)
8.3±0.5 Myr	Veritas	9.3°band	Nesvorny (2003 ApJ 591, 486) Farley (2006 Nature 432, 295)
~10 Myr	Semajoki	17°band	Nesvorny (2003 ApJ 591, 486)
35 Myr (Eocene)	Comet shower	Chesapeake Bay, Popigai crater	Farley (1998 Sci 280, 1250)

Cometary dust production

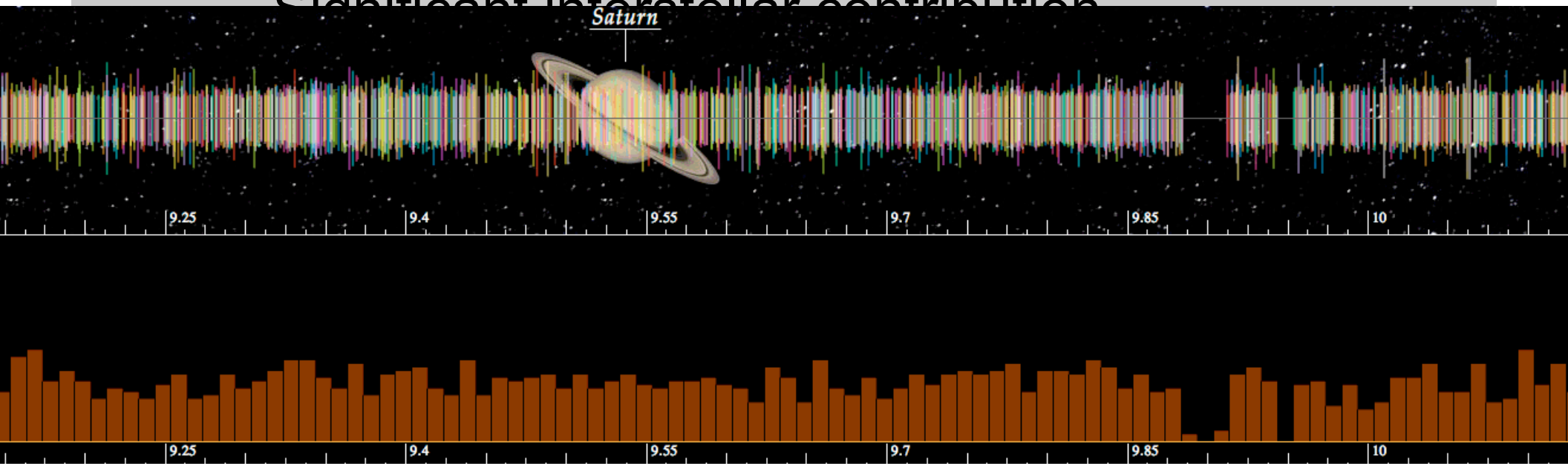
- Current dust production readily observed in tails ($\beta>10^{-2}$) and trails ($\beta<10^{-3}$)
- Many features commonly called “tails” are trails
- Trail ~ meteor storm
- Mid-infrared survey: >80% comets have trails
- 2 kg/s typical orbit-averaged
- 50 yr typical dynamical lifetime
- Need ~10^6 comets to maintain cloud of ~5×10^{18} g (Fixsen & Dwek 2002)



Reach et al. 2007 Icarus 191, 298

Empirical: Outer Solar System

- Impact detectors *Pioneer* 10, *Ulysses*, *Galileo* , *New Horizons* Student Dust Counter (below)
  - Nearly constant density out to 20 AU
  - Significant interstellar contribution



Kuiper Belt Dust Production

- Virtually unknown
- Theoretical: collisions among KBOs
  - Existence of Haumea collisional family
  - Subsequent comminution of fragments
- Need to get beyond 5 AU
- Possibility to join Jupiter/Europa +Ganymede, Saturn/Titan missions

www.physics.uci.edu/5AU

The View from 5 AU: Measuring the Diffuse Sky Brightness from the Outer Solar System

March 25-26th, 2010

6th annual workshop organized and hosted by:
The Center for Cosmology, University of California, Irvine

physics@uci

workshop goals

a) To establish the scientific goals of measuring the diffuse sky brightness from the vantage point of the outer Solar system, pertaining to the cosmic infrared background and interplanetary dust.
(b) To establish astrophysical sciences enabled by simultaneous observations at 1 AU and a small aperture telescope at 5AU.
(c) To establish the practical means for cruise-phase science for a small aperture optical to near-infrared telescope on an outer planets mission.
(d) To establish instrumentation priorities and priorities and specifications.

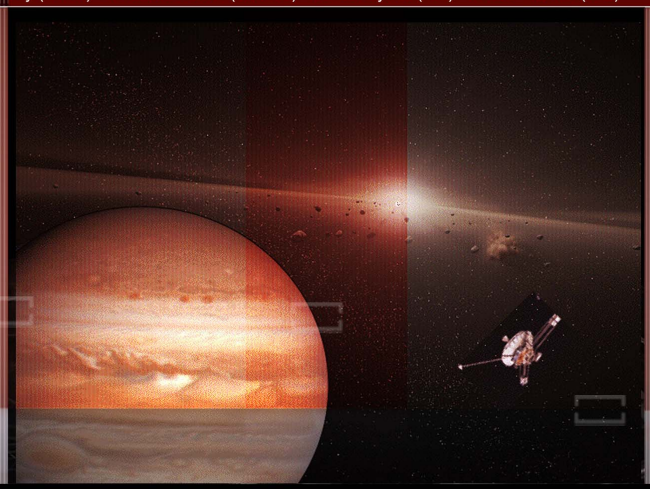
topics

:: Extragalactic Background
:: Galaxy Evolution Models
:: Reionization
:: Oort Cloud, Kuiper Belt and Trans Neptunian Objects
:: Zodiacal Light Models
:: Microlensing and similar applications
:: The Search for Exoplanets
:: Instrument Concepts

organizing committee

:: Charles Beichman (Caltech) :: Jamie Bock (JPL) :: Mike Brown (Caltech)
:: Ranga Chary (Caltech) :: Asantha Cooray (UC Irvine) :: Giovanni Fazio (Harvard/.CfA)
:: Mike Hauser (STsCI) :: John Mather (NASA GSFC) :: Toshio Matsumoto (JAXA/ISAS)
:: David Nesvorny (SWRI) :: William Reach (Caltech) :: Mark Sykes (PSI) :: Mike Werner (JPL)

welcome!



website: http://www.physics.uci.edu/5AU
contact: asantha cooray, uc irvine : acooray@uci.edu

workshopSPONSORS

NORTHROP GRUMMAN

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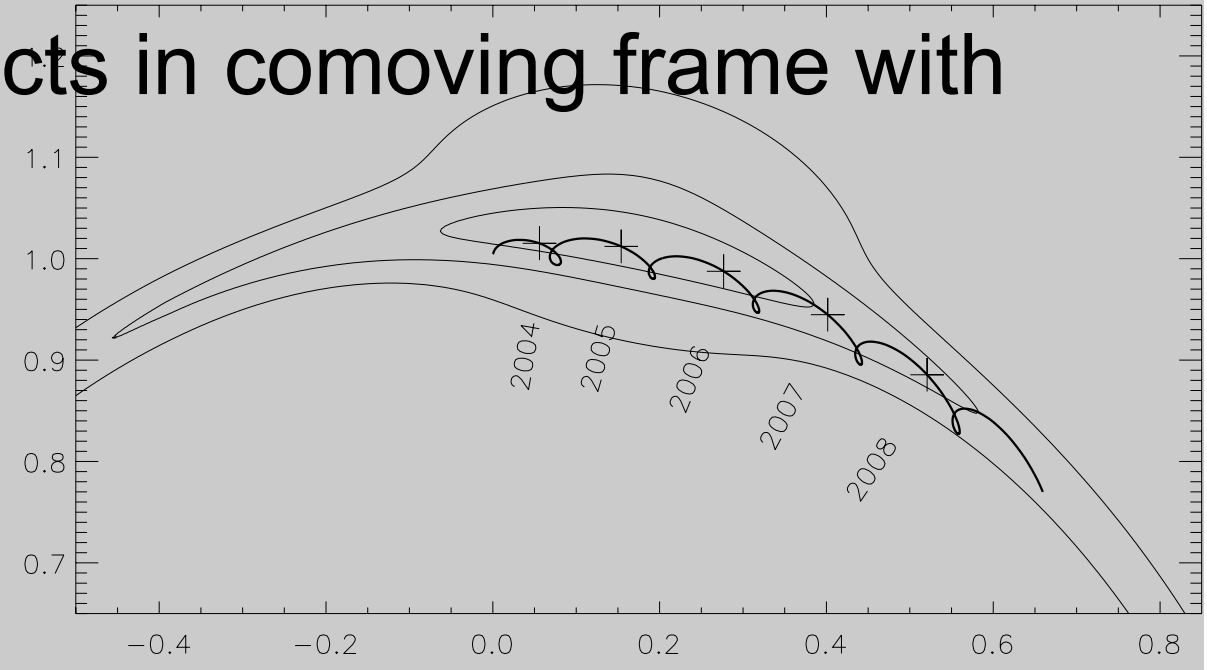
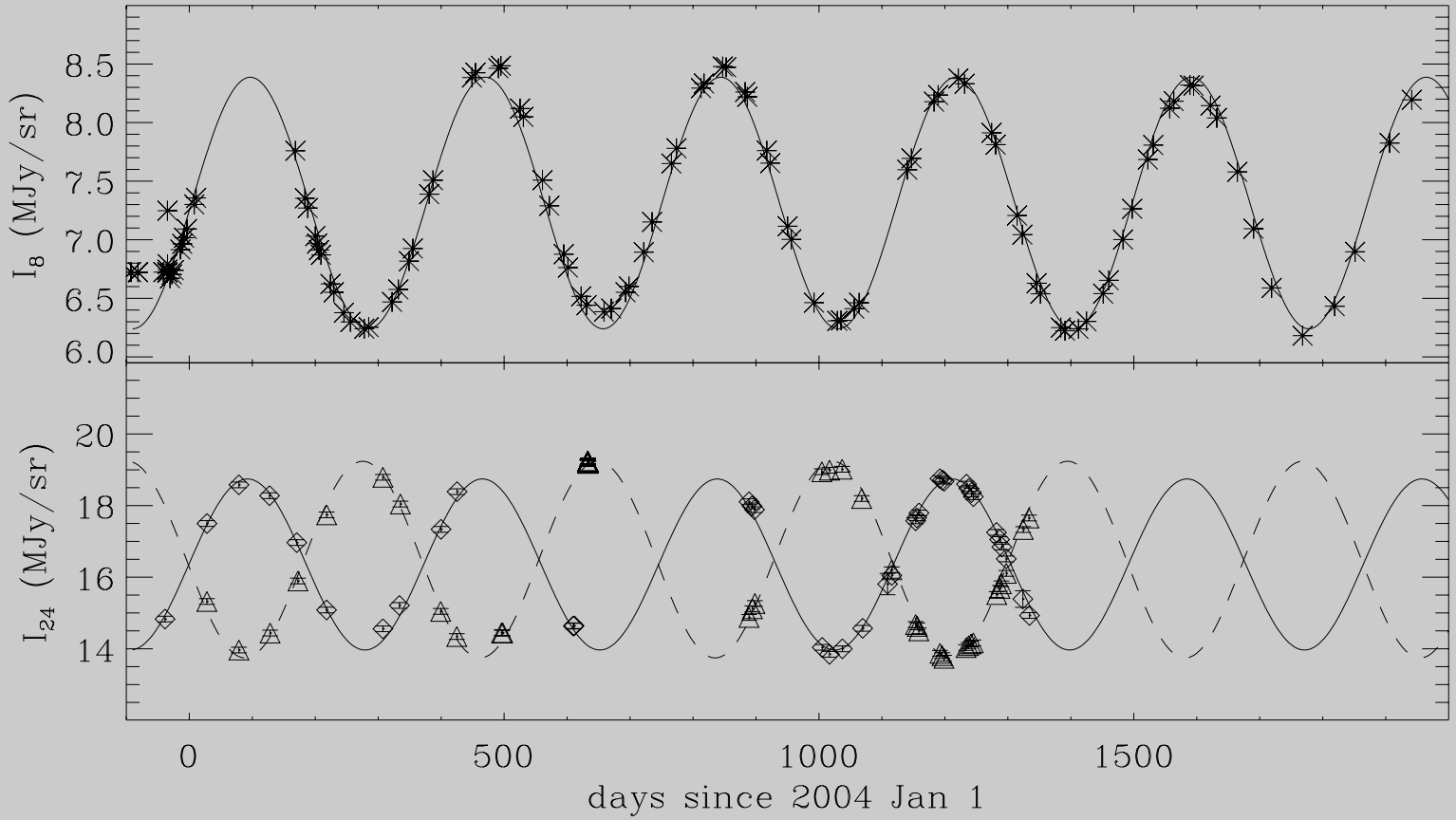
The Zody Cloud is not static

- Smooth cloud traces mean orbital elements
  - Node randomized by Jupiter in 10^6 yr so only secular long-time-averaged perturbations survive
- Resonant effects in comoving frame with planet

- *Spitzer Earth Ring experiment*
- Frame comoving with Earth
- Contours of the COBE/DIRBE zodiacal cloud model
- Trajectory of Spitzer (thick) with crosses every year
- Able to probe azimuthal structure of zoiacal cloud

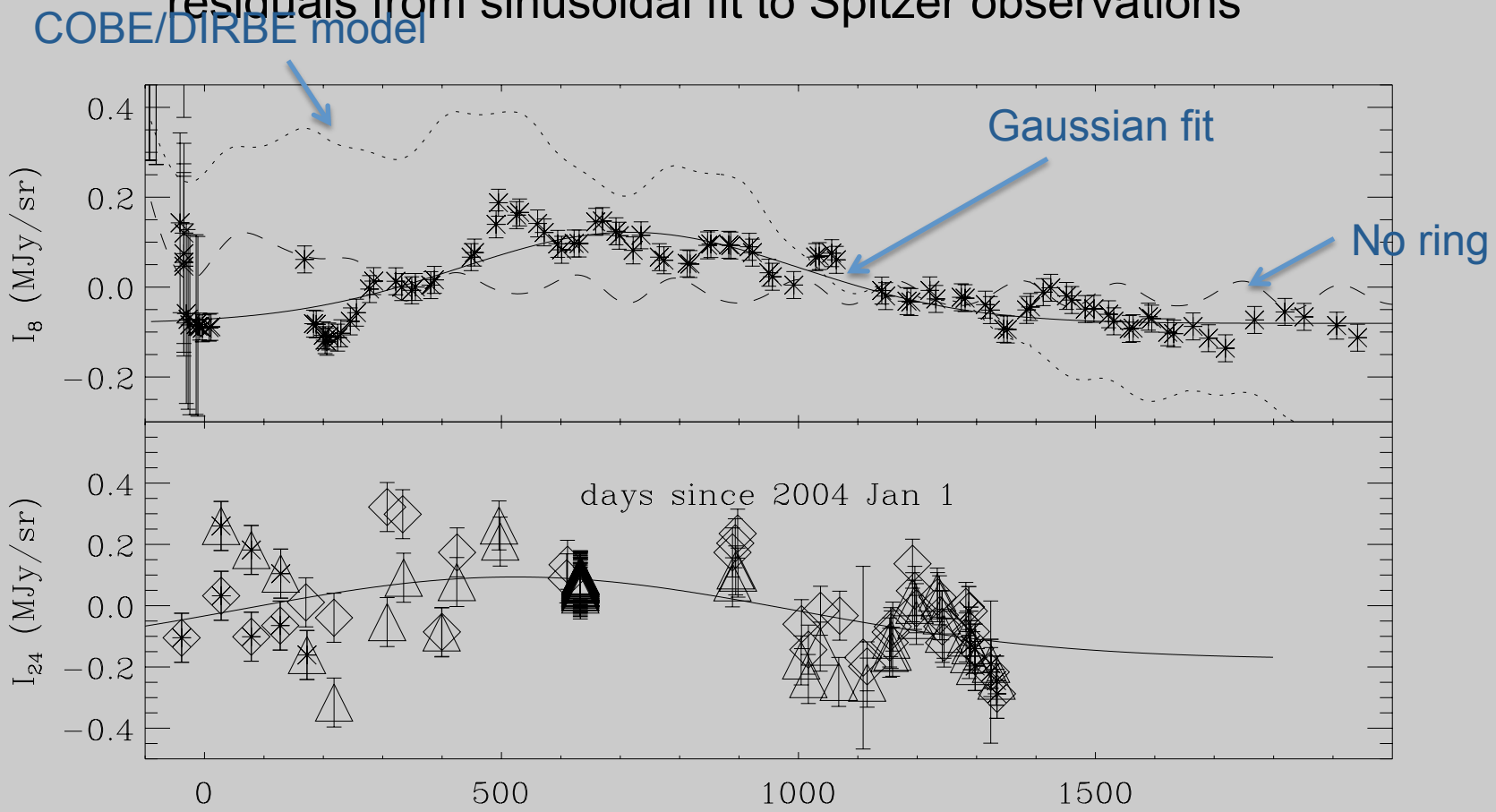


Annual Variation of Polar Brightness at 1 AU



Azimuthal asymmetries in Zody Cloud

residuals from sinusoidal fit to Spitzer observations



Conclusions

- Parent bodies
  - Comets dominate meteors and most zodiacal light
  - Recent asteroid collisions make dust bands
- Dynamics
  - Radial profile set mostly by PR drag
  - Circumsolar ring of dust in mean motion resonance with Earth
- Outer Solar System
  - We need to get out there to see KB collisional dust
  - We need support of exoplanet community for future experiments to observe zodiacal light from the outer solar system