Extracting Asteroid Regolith Properties from Solar System Dust Bands

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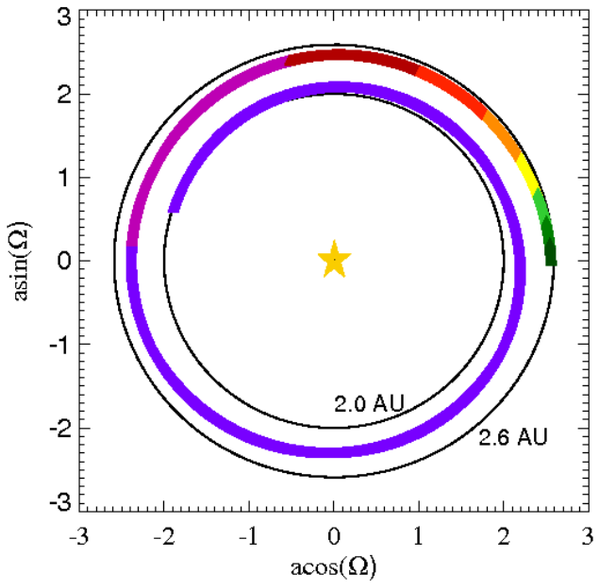
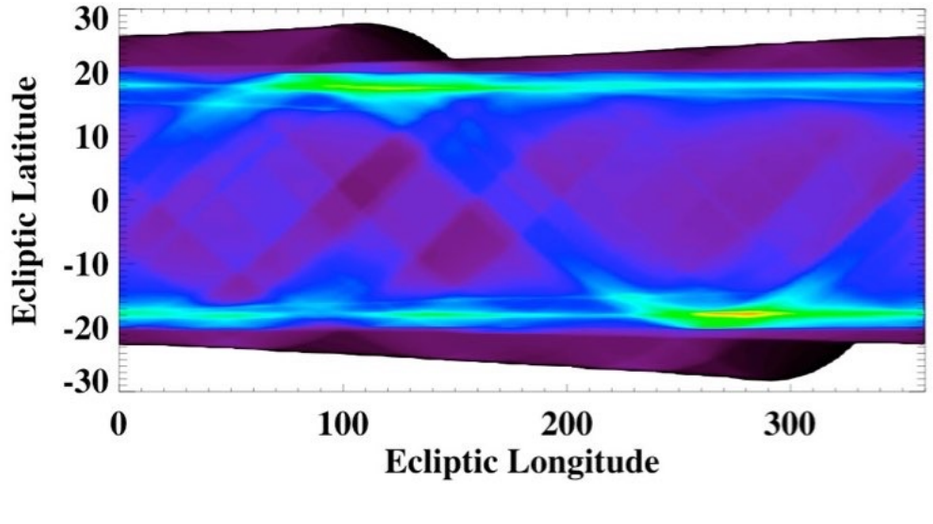
Overview

catastrophic asteroid disruption



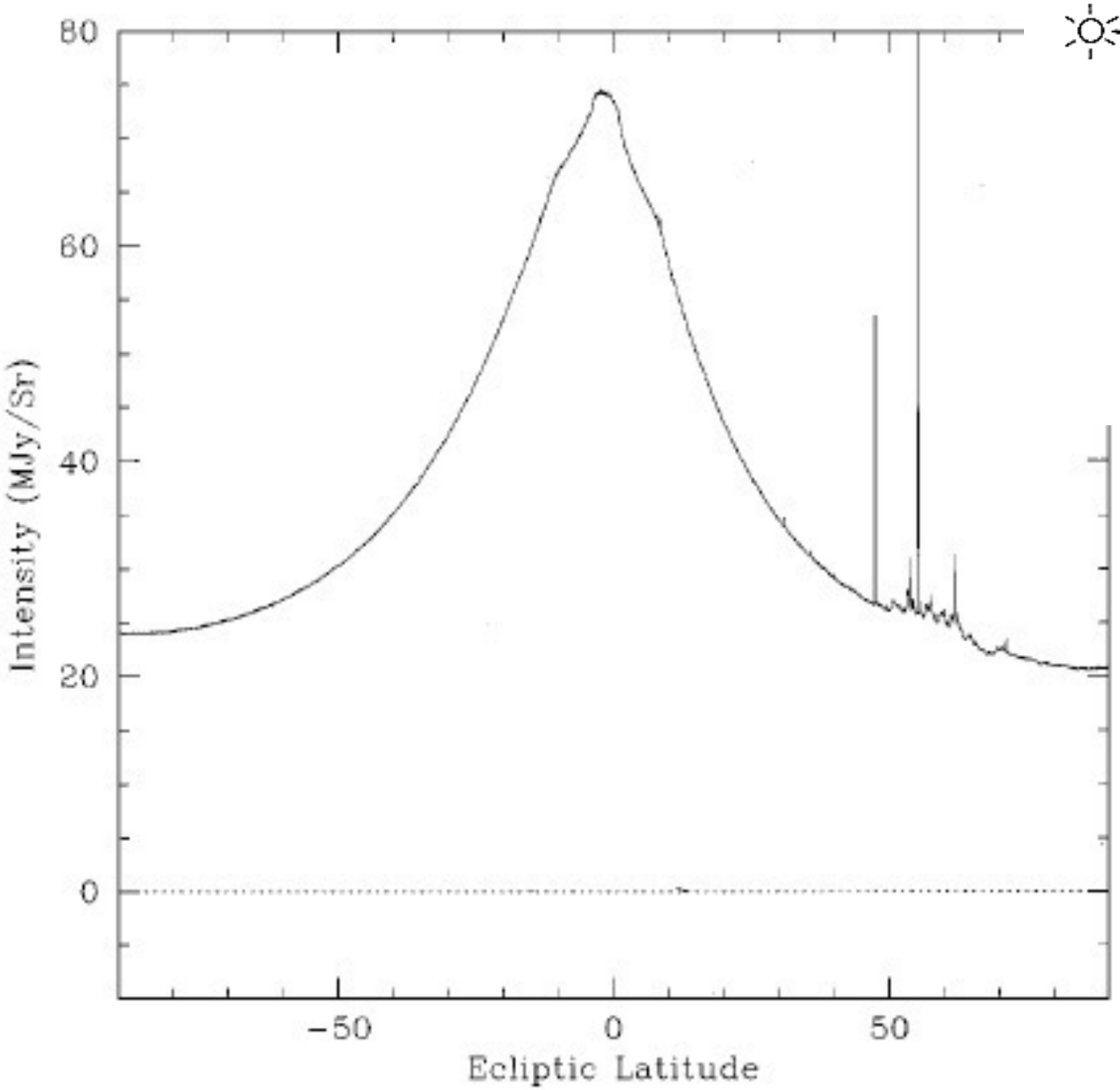
released regolith particles spiral into inner solar system

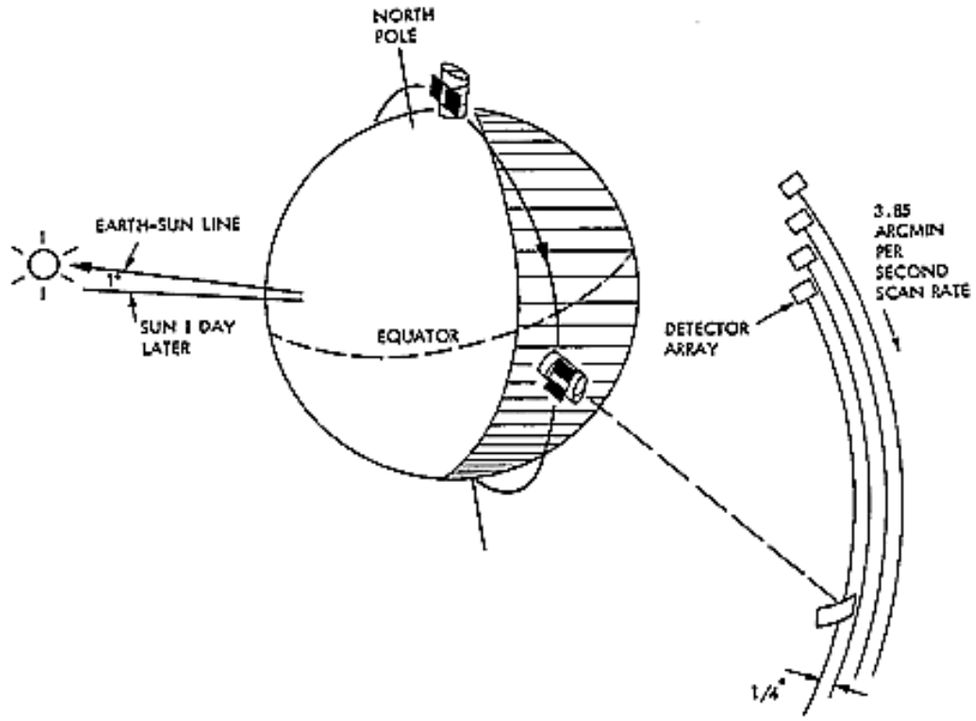


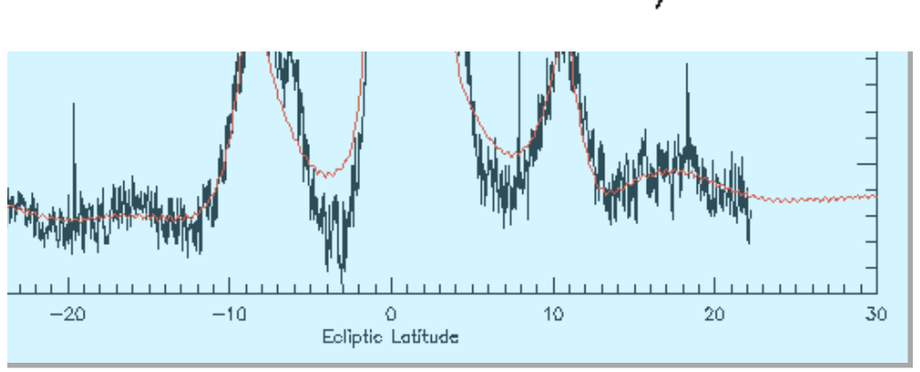
this material is dynamically sculpted into observable structures - dust bands

modeling these dust bands and comparing the models to infrared observations allows us to constrain the properties of the dust particles and begin to reconstruct the structure of the regolith that was on the surface of the disrupted asteroid

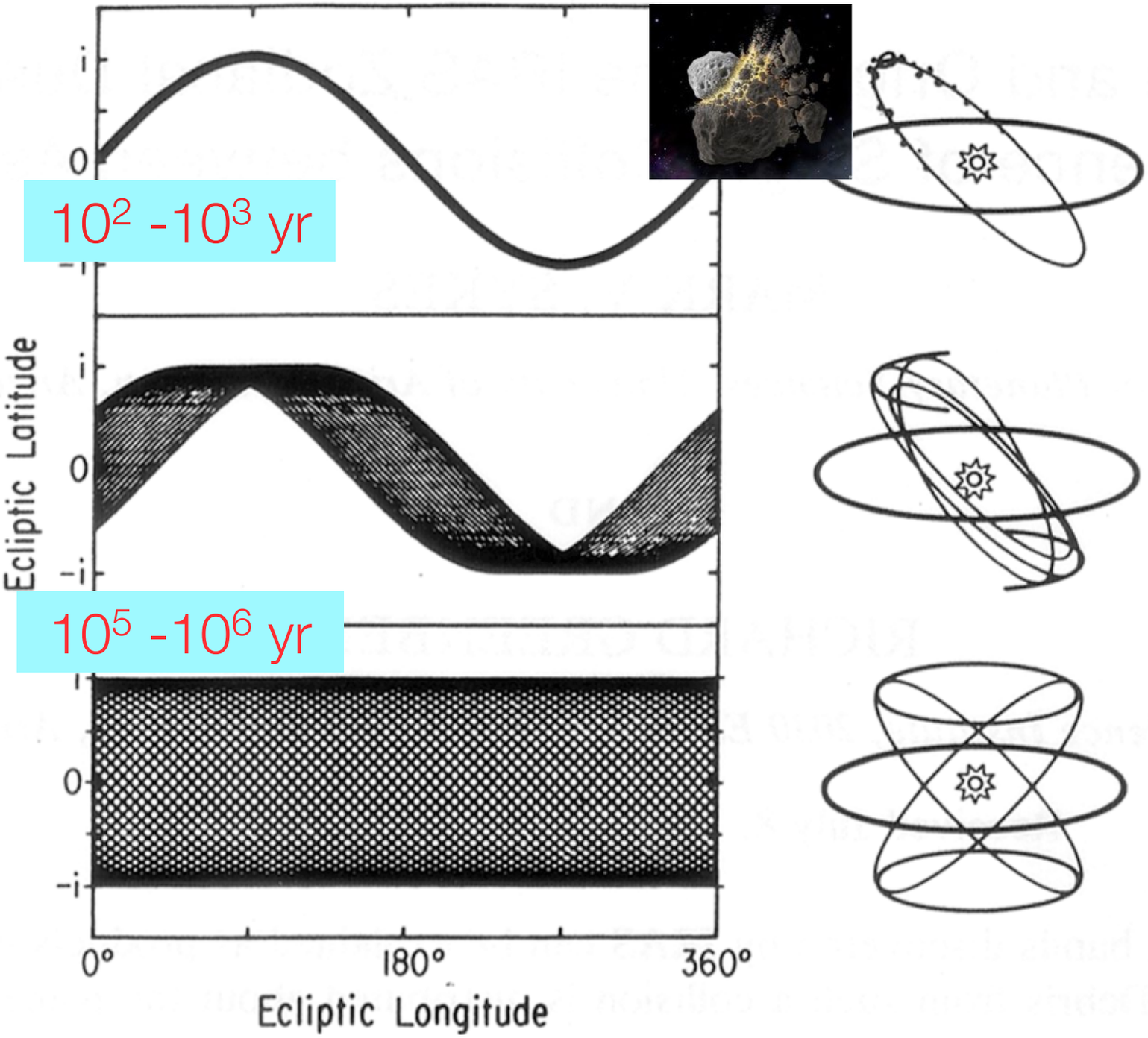
Dust Bands


80
60
40
20
0
Intensity (MJy/Sr)
−50
0
50
Ecliptic Latitude


NORTH POLE
EARTH-SUN LINE
SUN 1 DAY LATER
EQUATOR
DETECTOR ARRAY
3.85 ARCMIN PER SECOND SCAN RATE
1/4°

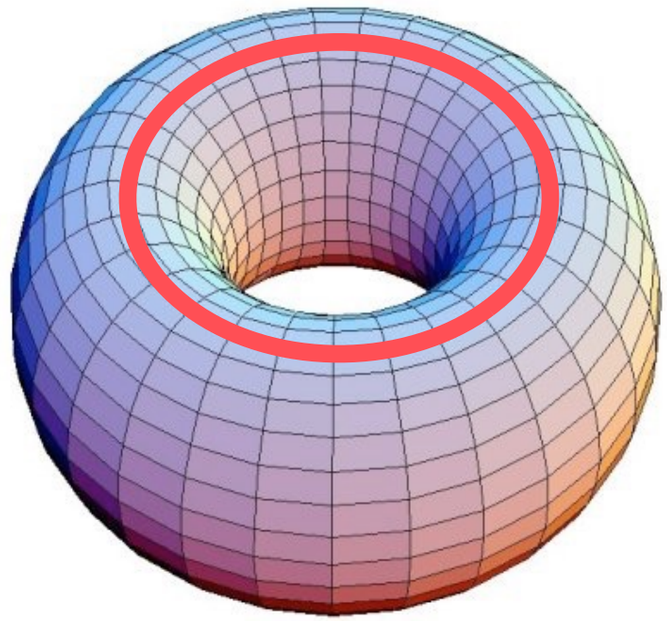

−20
−10
0
10
20
30
Ecliptic Latitude

Formation of a Dust Band



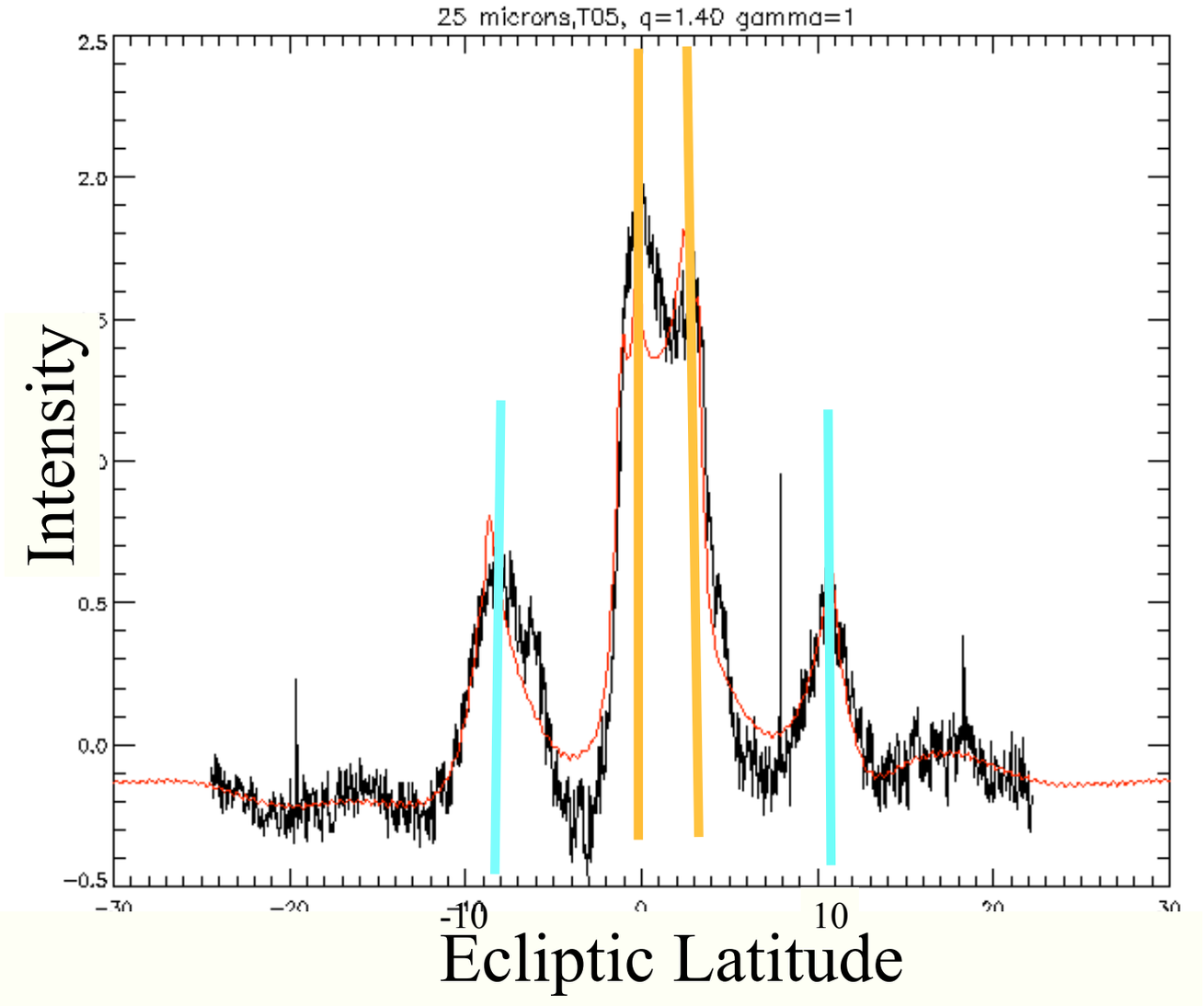
10^2 -10^3 yr

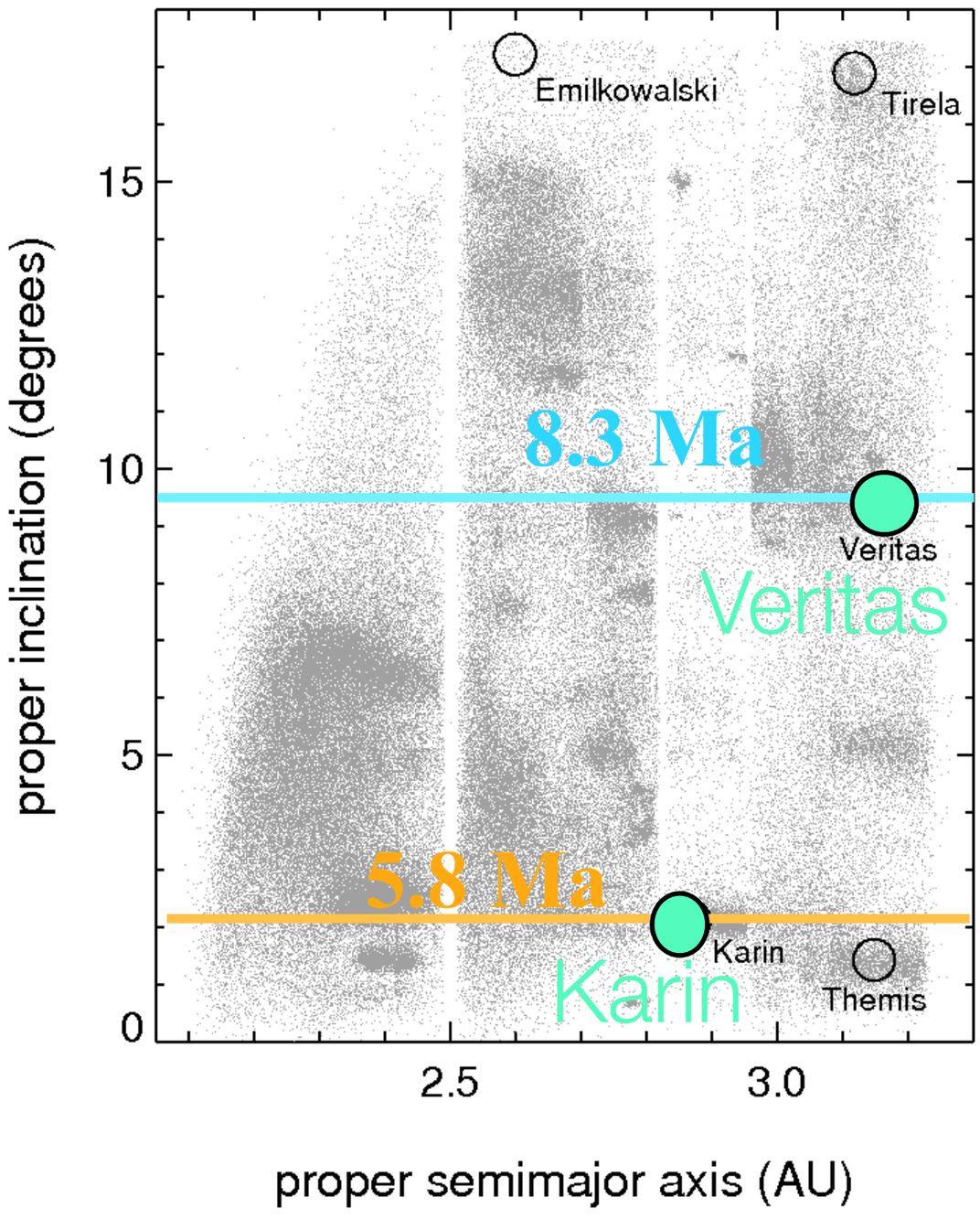
10^5 -10^6 yr



Sykes and Greenberg, 1986

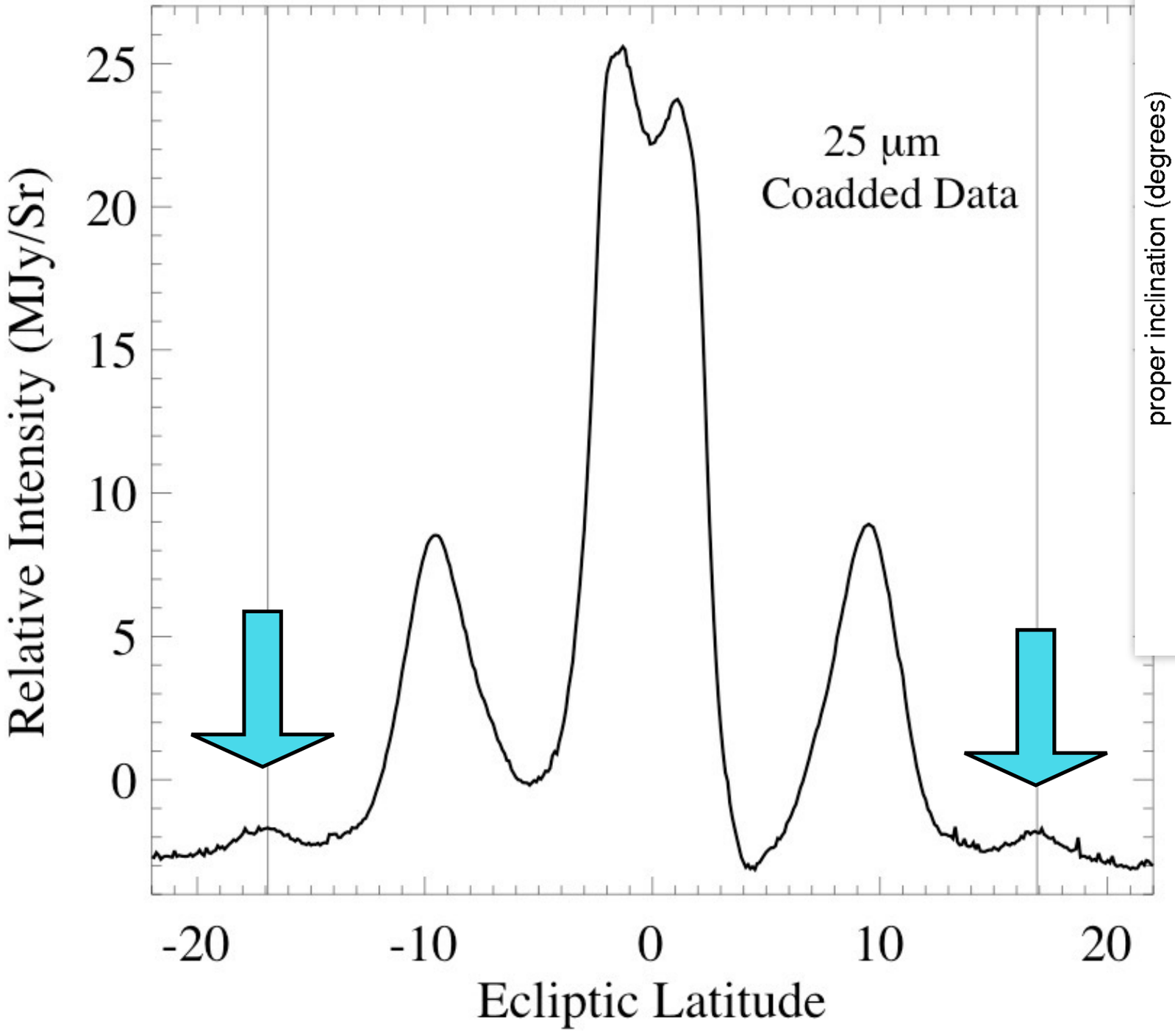
Sources - Asteroid Families

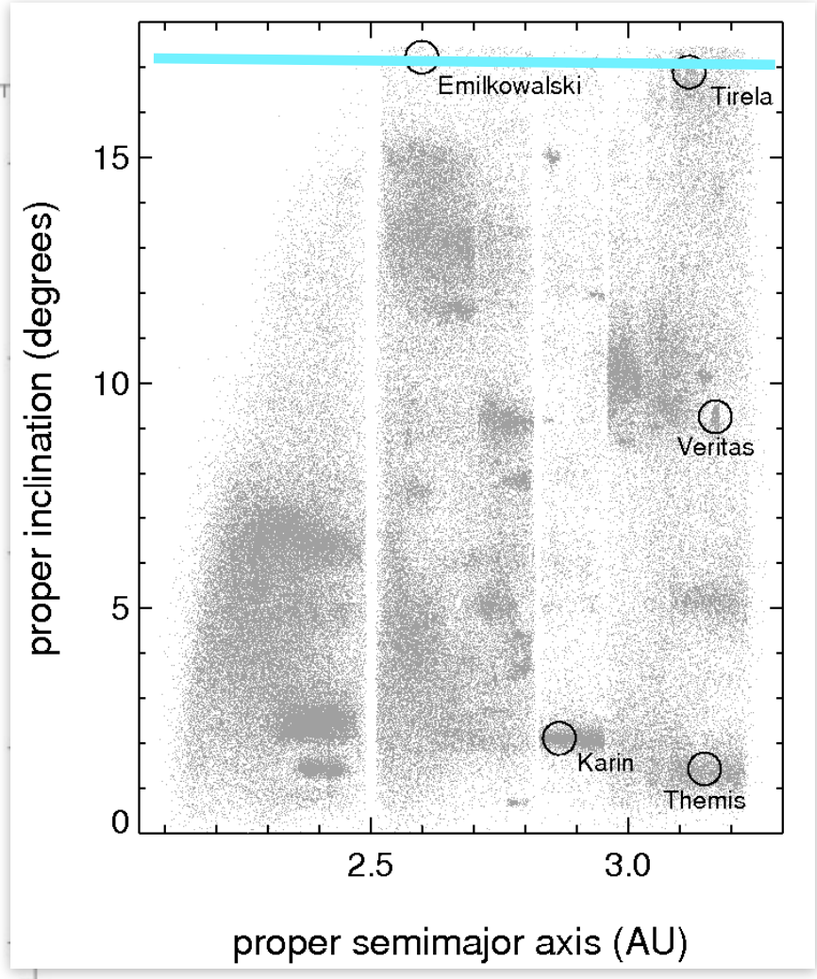




Grogan, Dermott, Durda, 2001 Dermott et al., 2002 Nesvorny et al., 2003, 2008

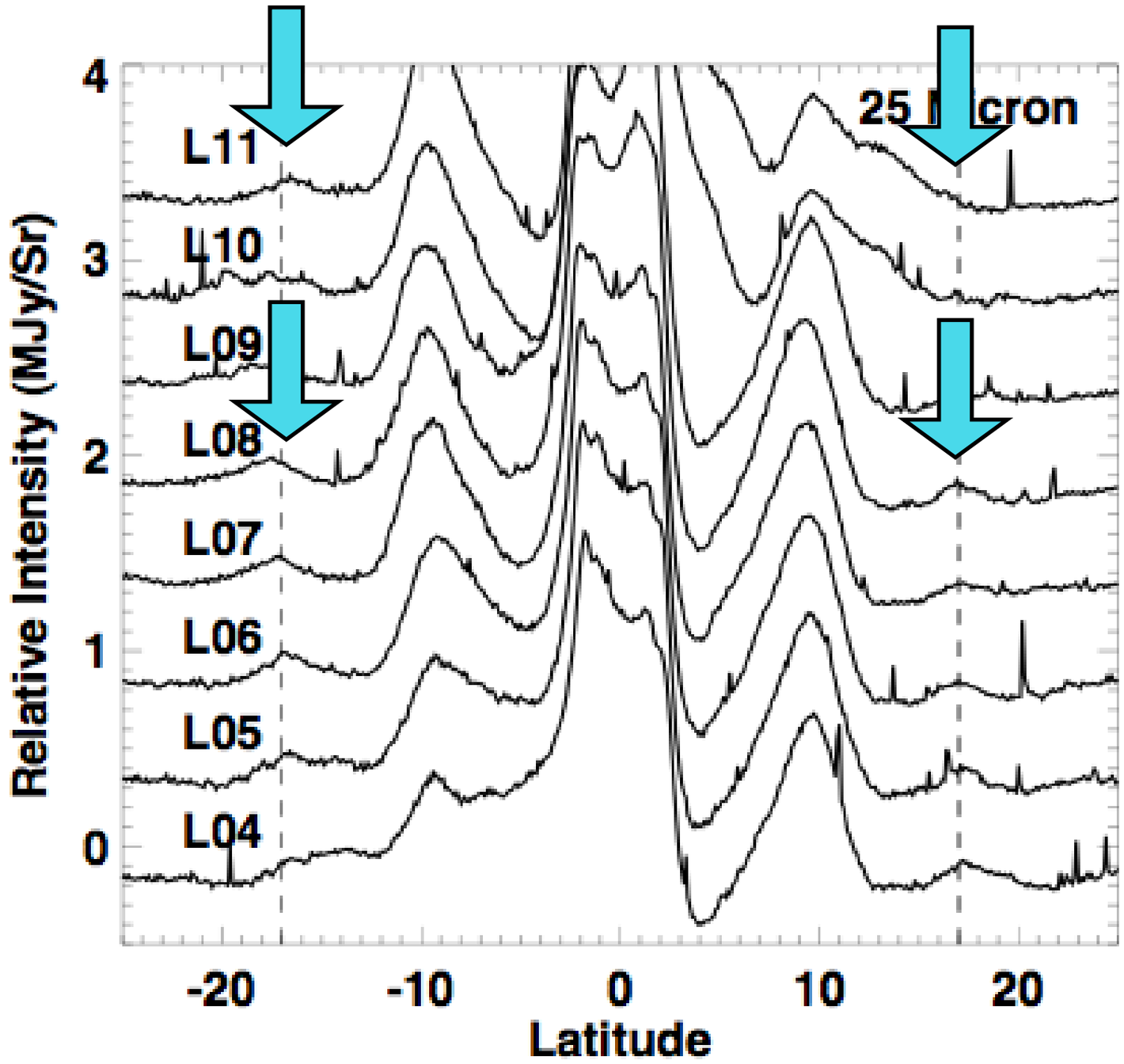
Co-added IRAS Data





Nesvorny and Vokrouhlicky 2006

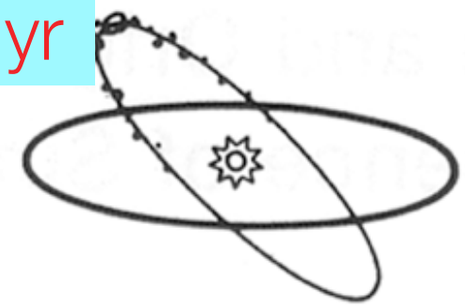
Evidence for a Partial Band



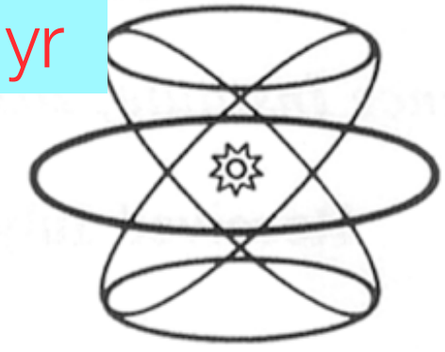
Formation of a Dust Band

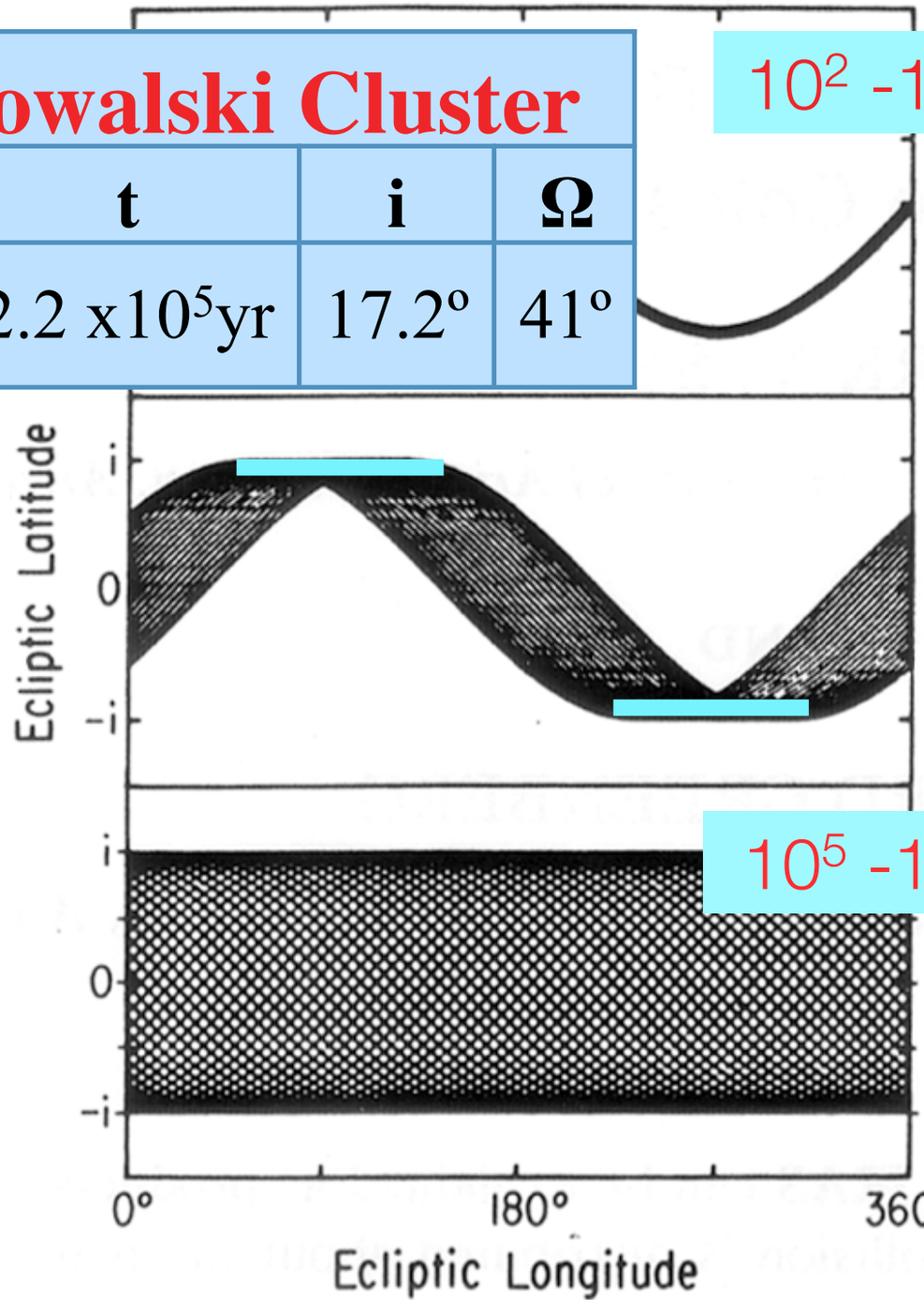
Emilkowalski Cluster			
a	**t**	**i**	**Ω**
2.59AU	2.2 x10^5yr	17.2°	41°

10^2 -10^3 yr



10^5 -10^6 yr

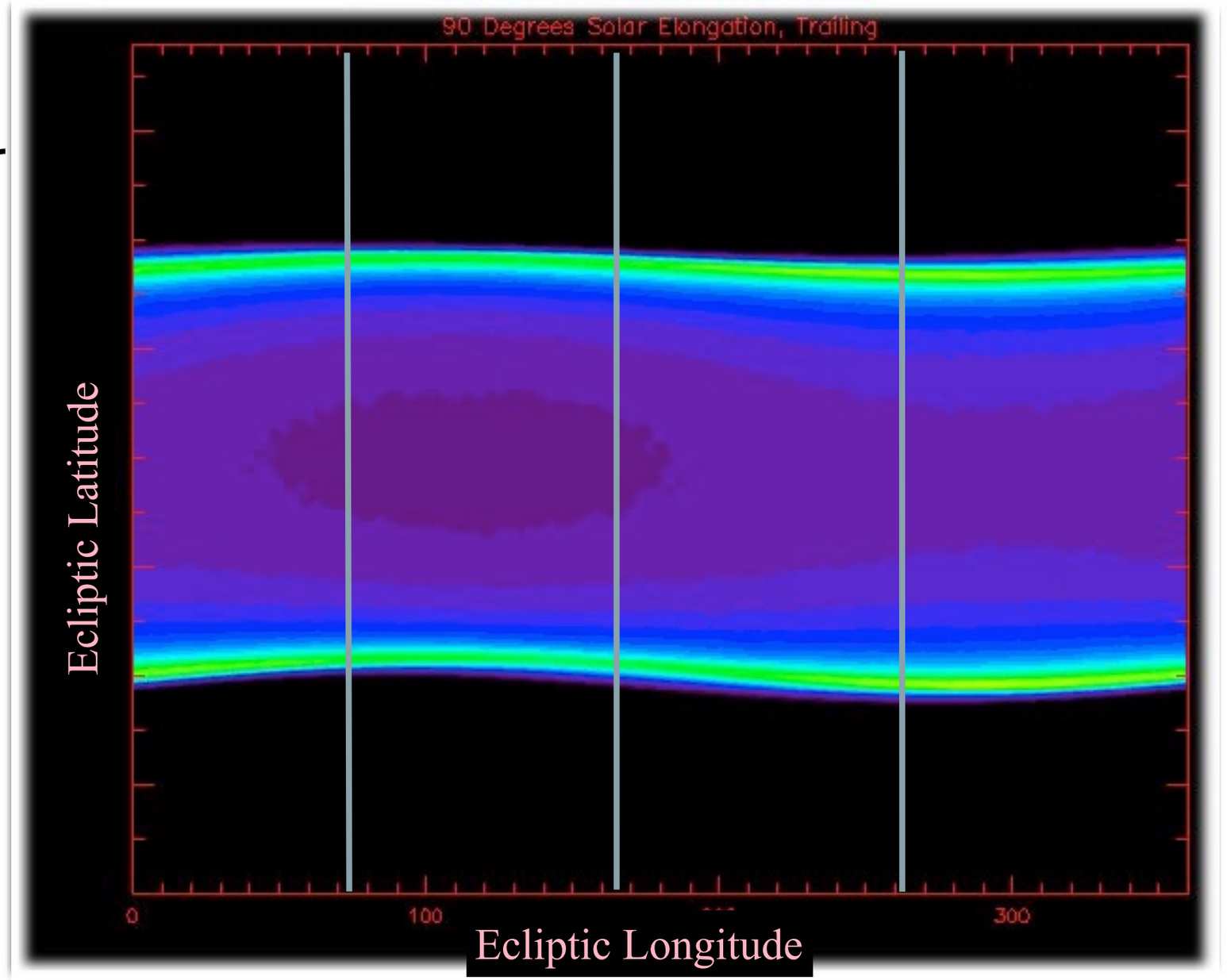




Sykes and Greenberg, 1986

Simple Model

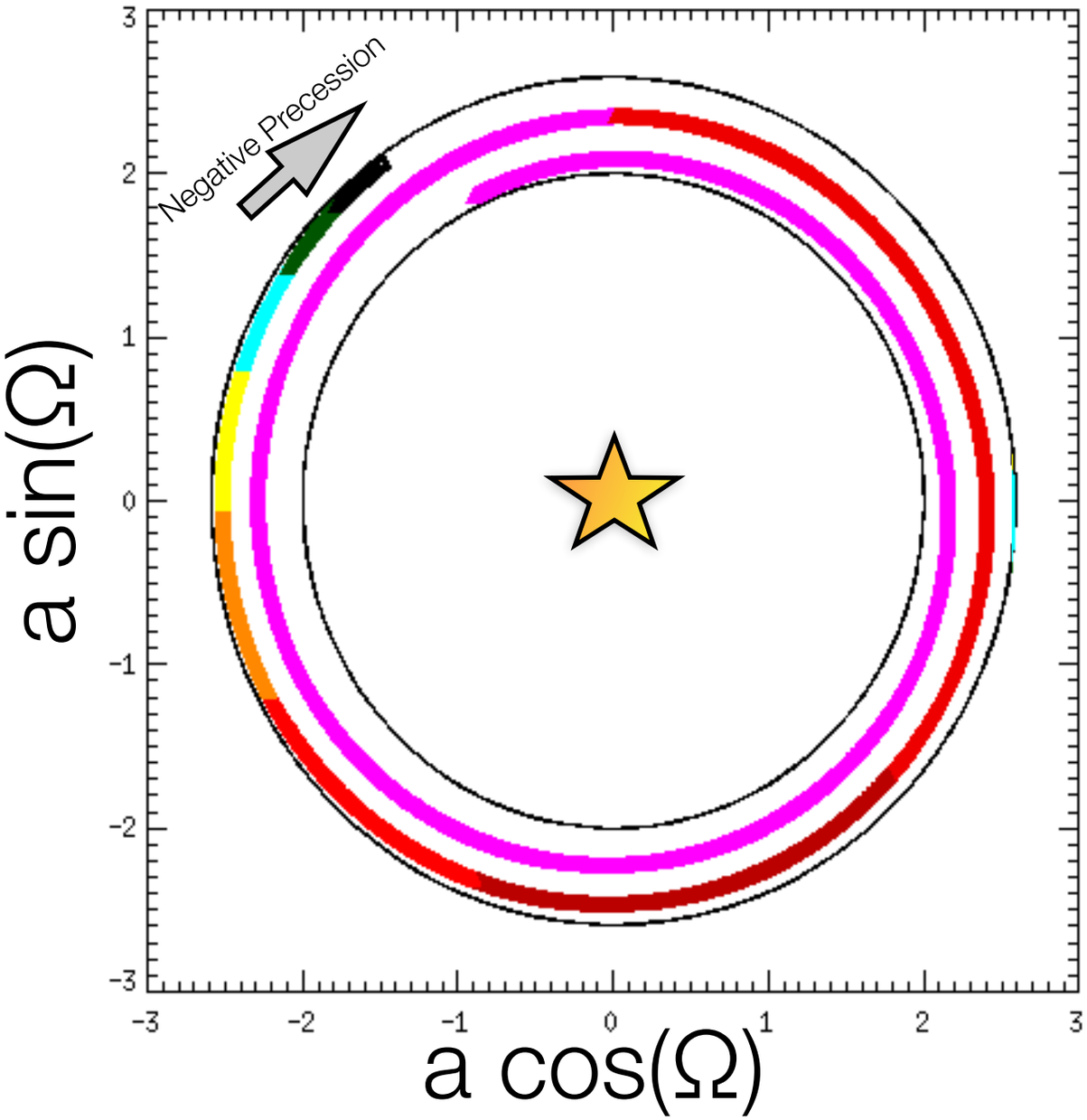
200 μm diameter particles



~~3.3~~ x 10^{5} yr

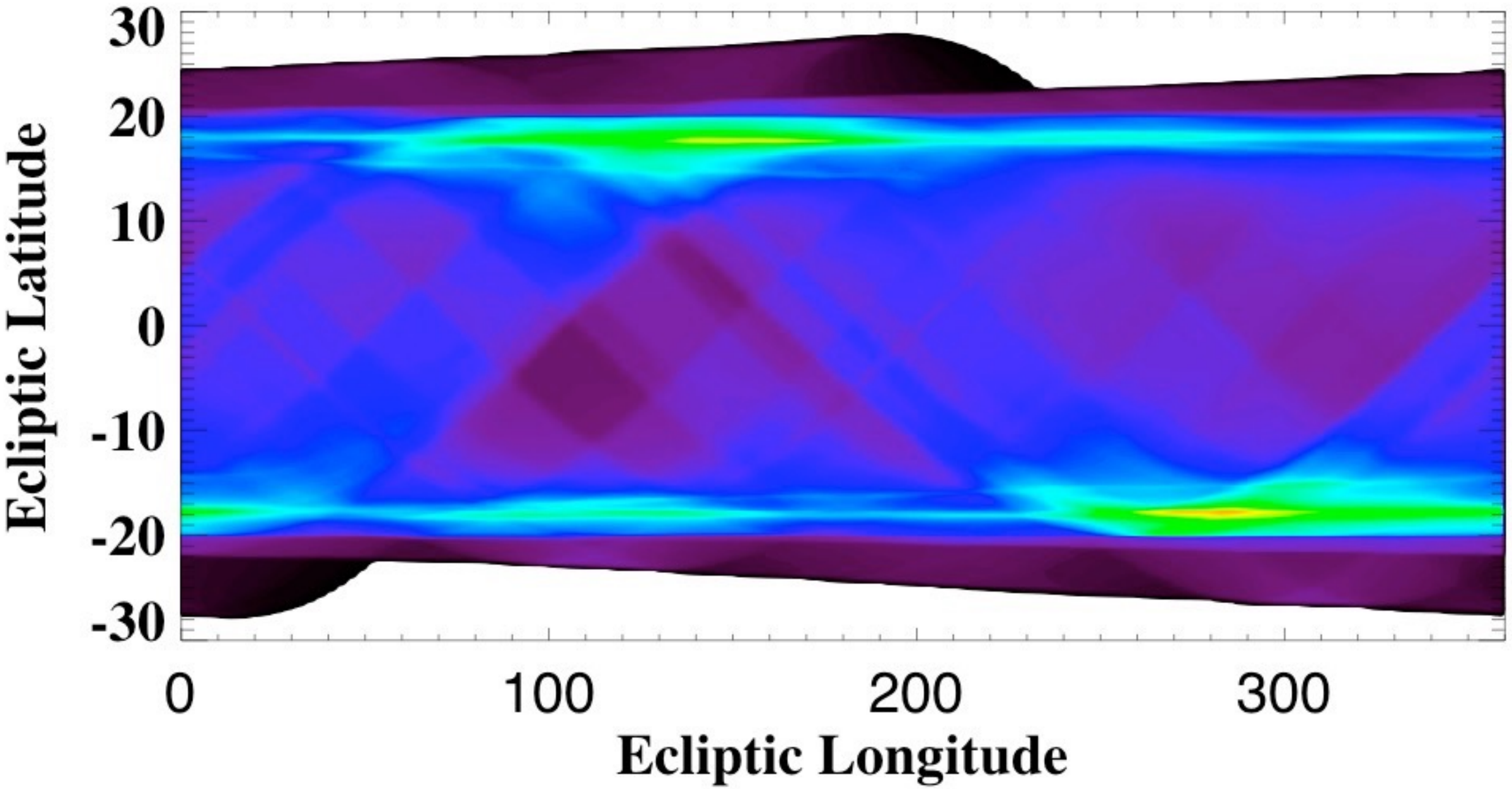
Nodal Precession

100-200μm
200-300μm
300-400μm
400-500μm
600-700μm
700-800μm
800-900μm
900-1000μm



199,000 yr

Full Model


30
20
10
0
-10
-20
-30
Ecliptic Latitude
0
100
200
300
Ecliptic Longitude

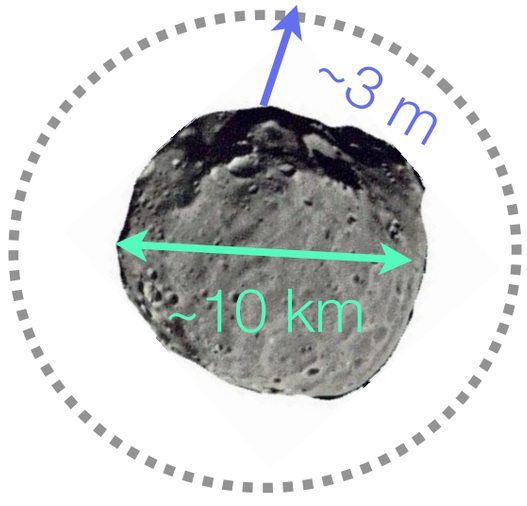
Dust Parameters for the Emilkowalski Partial Band

- Cross-sectional area of dust (accounting for loss) is O(10^7 km^2)

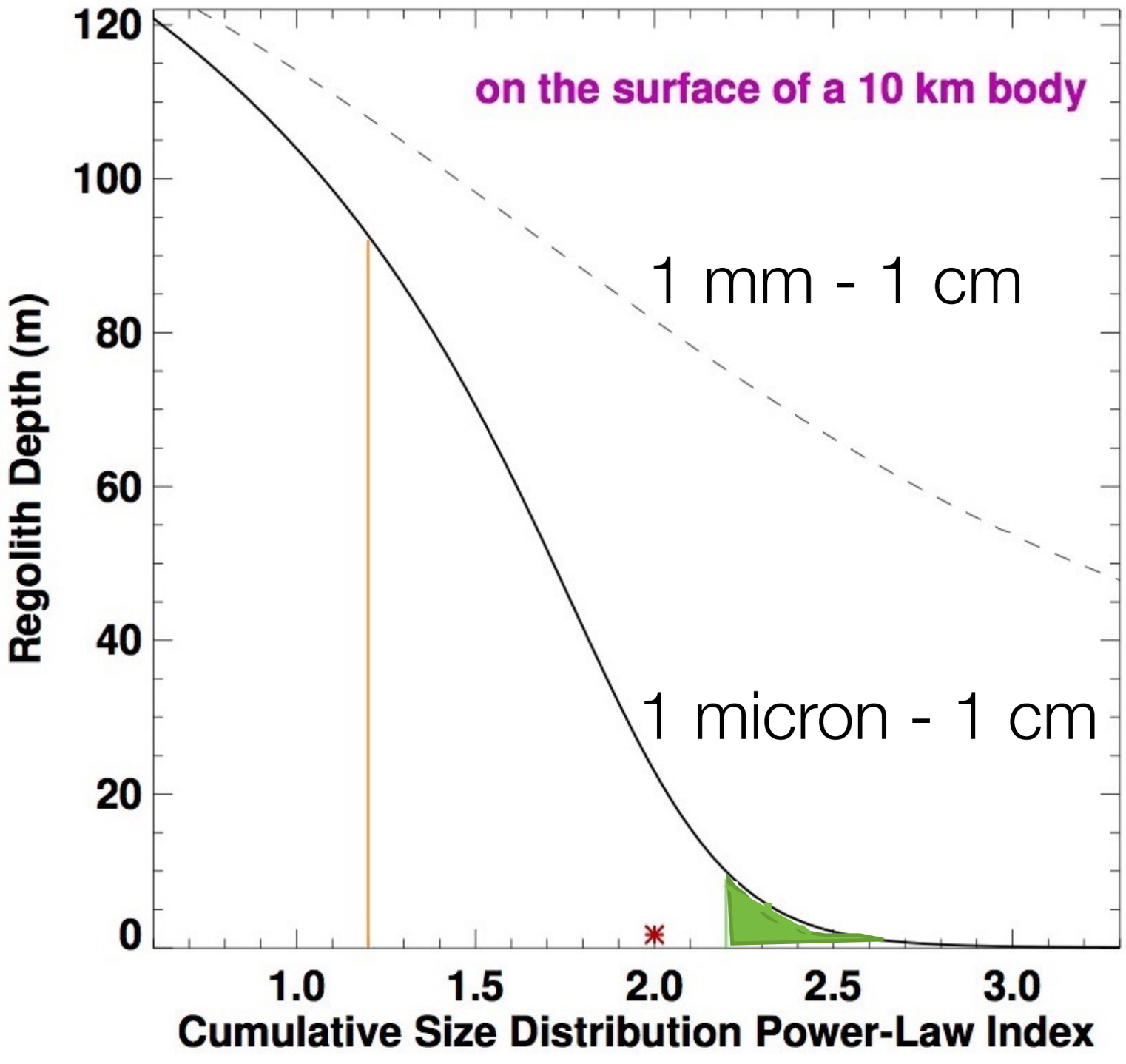
- Size-distribution of particles present has a lower bound of q=1.7 which corresponds to a cumulative inverse power-law size-frequency distribution index of >2.1 (220 kyr old)

- As compared to a cumulative index of 1.2 for the older bands (~10 Myr old)

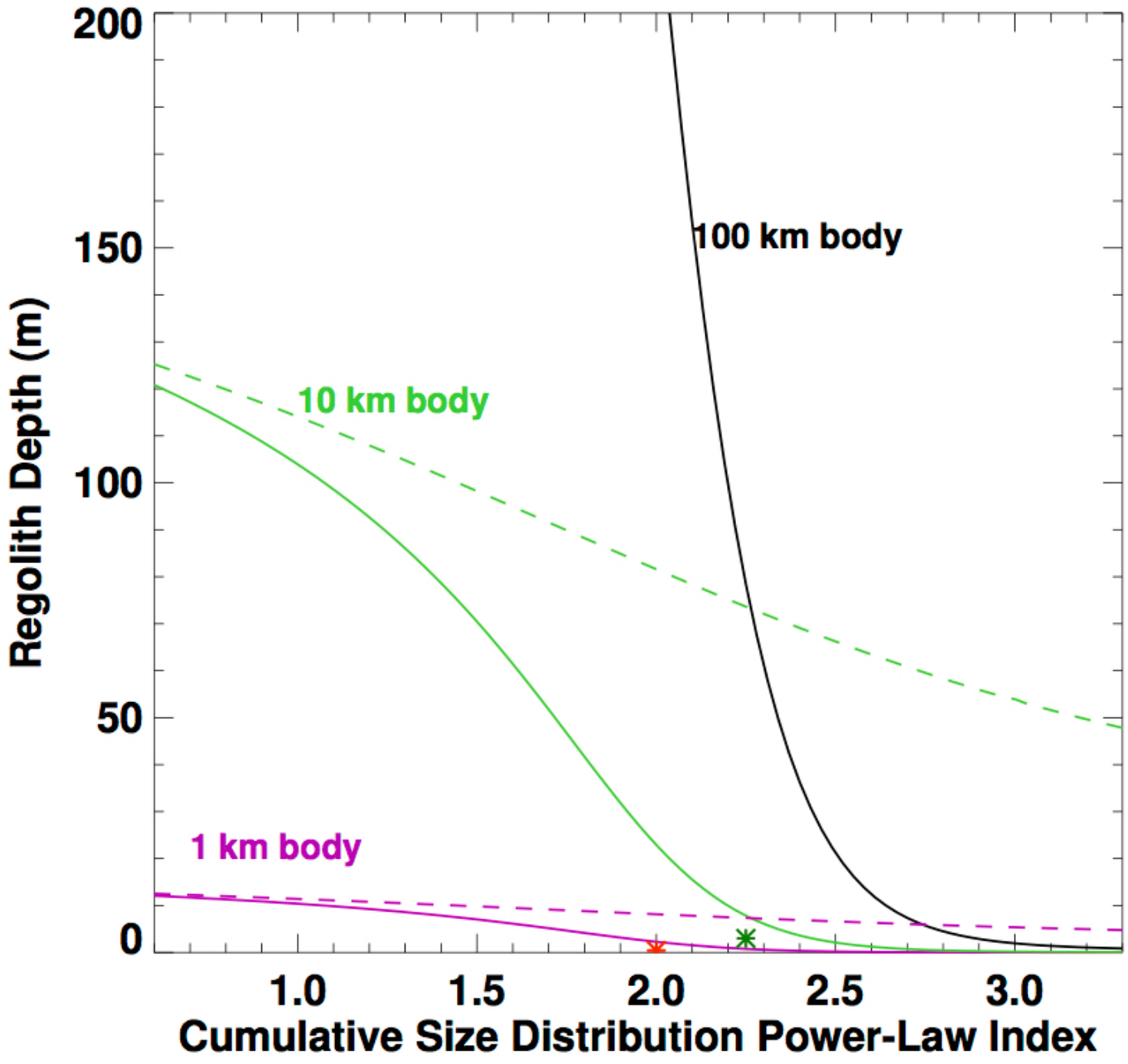
- Corresponds to a ~3 m deep layer of regolith on the ~10 km diameter parent body



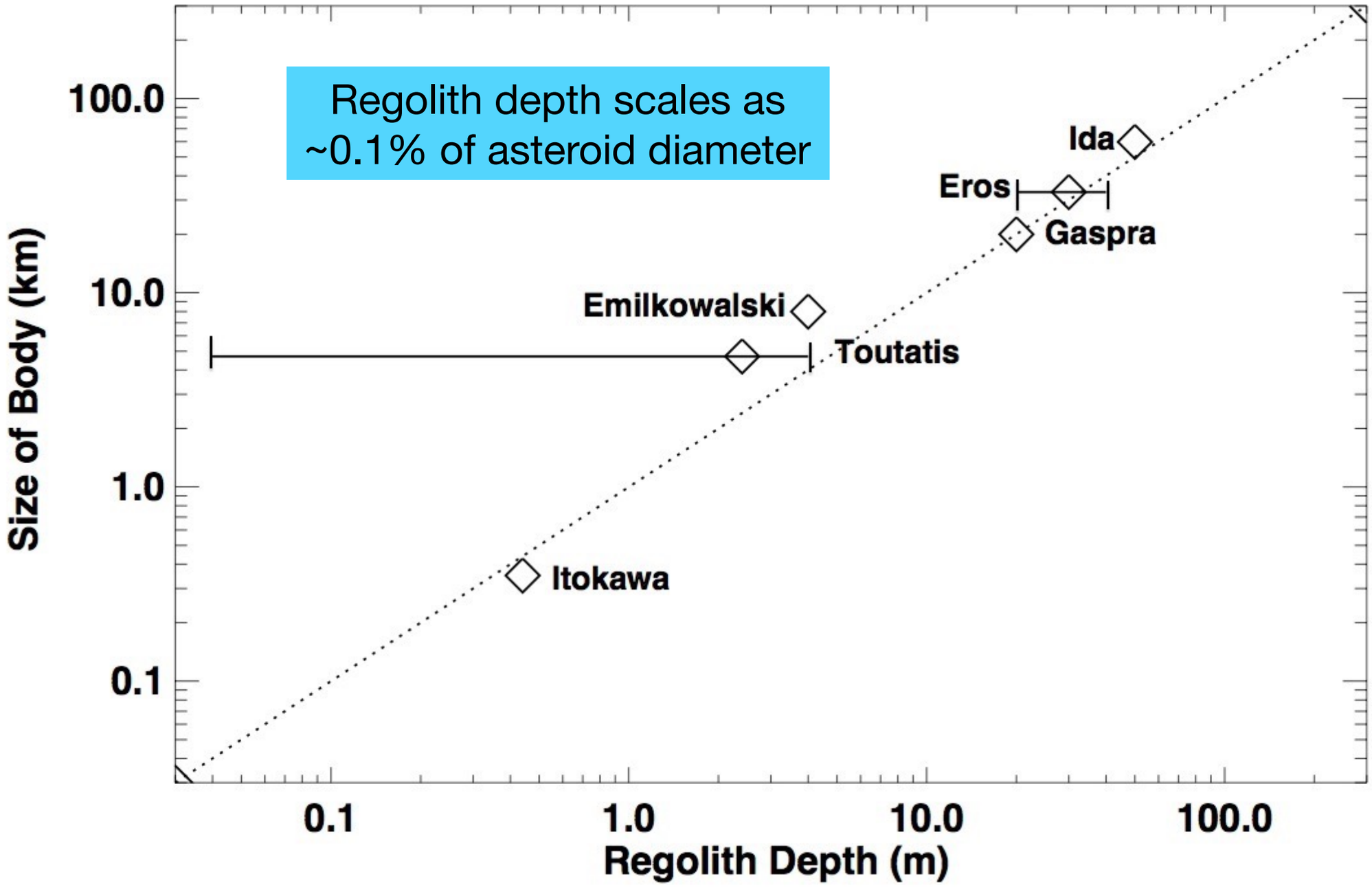
Variation of Regolith Depth



Variation of Regolith Depth with Parent Body Size



Scaling of Regolith Depth with Asteroid Diameter



Summary and Conclusions

- Using dynamical modeling of a recent asteroid collisional disruption constrained by infrared observations, we have determined the regolith depth and particle size-frequency distribution on the surface of an asteroid

- The depth of regolith is ~3 m on the surface of the 10 km Emilkowalski asteroid

- The cumulative inverse power-law size-frequency distribution index of particles is >2.1, implying domination by small particles

- This value is markedly different from that found for the much older (~10 Myr old), processed material from other asteroid family disruptions which would misrepresent the depth of the regolith

- These parameters are very important for missions to asteroid surfaces. Cohesive forces are dependent on particle size distribution. The ability of robotic missions to extract boulders will depend on correctly establishing the regolith parameters

- Our results agree well with values obtained from in situ and remote measurements and we find that the depth of regolith on the surface of an asteroid scales as ~0.1% of the asteroid diameter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