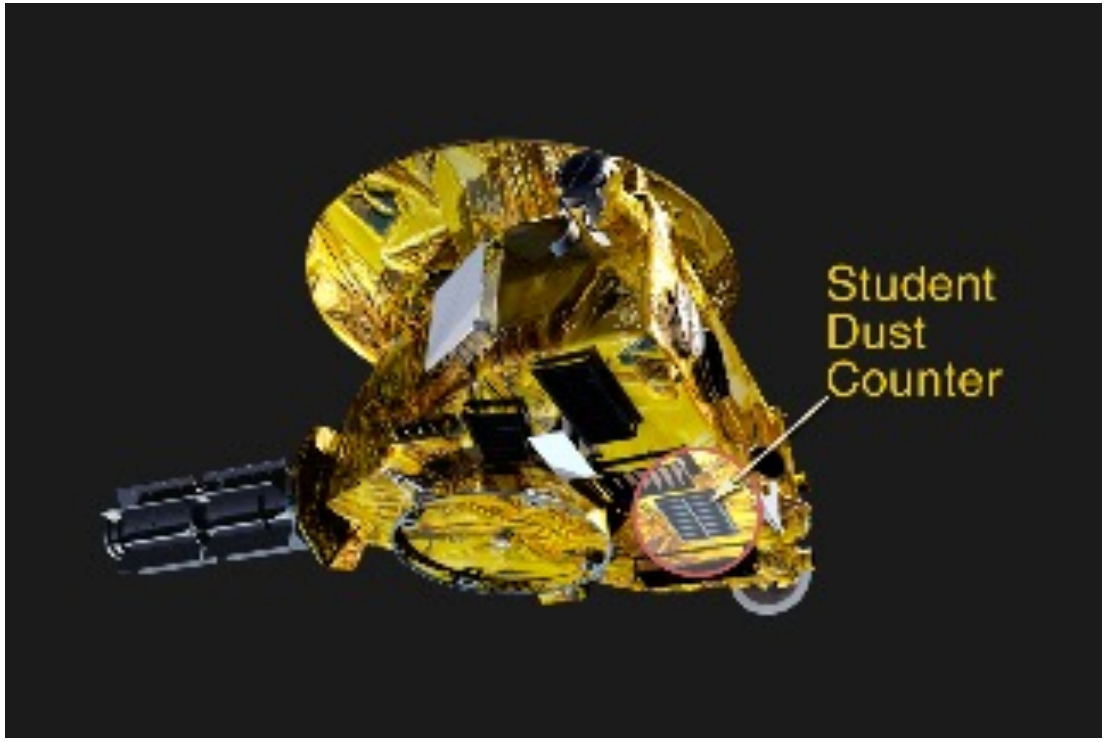
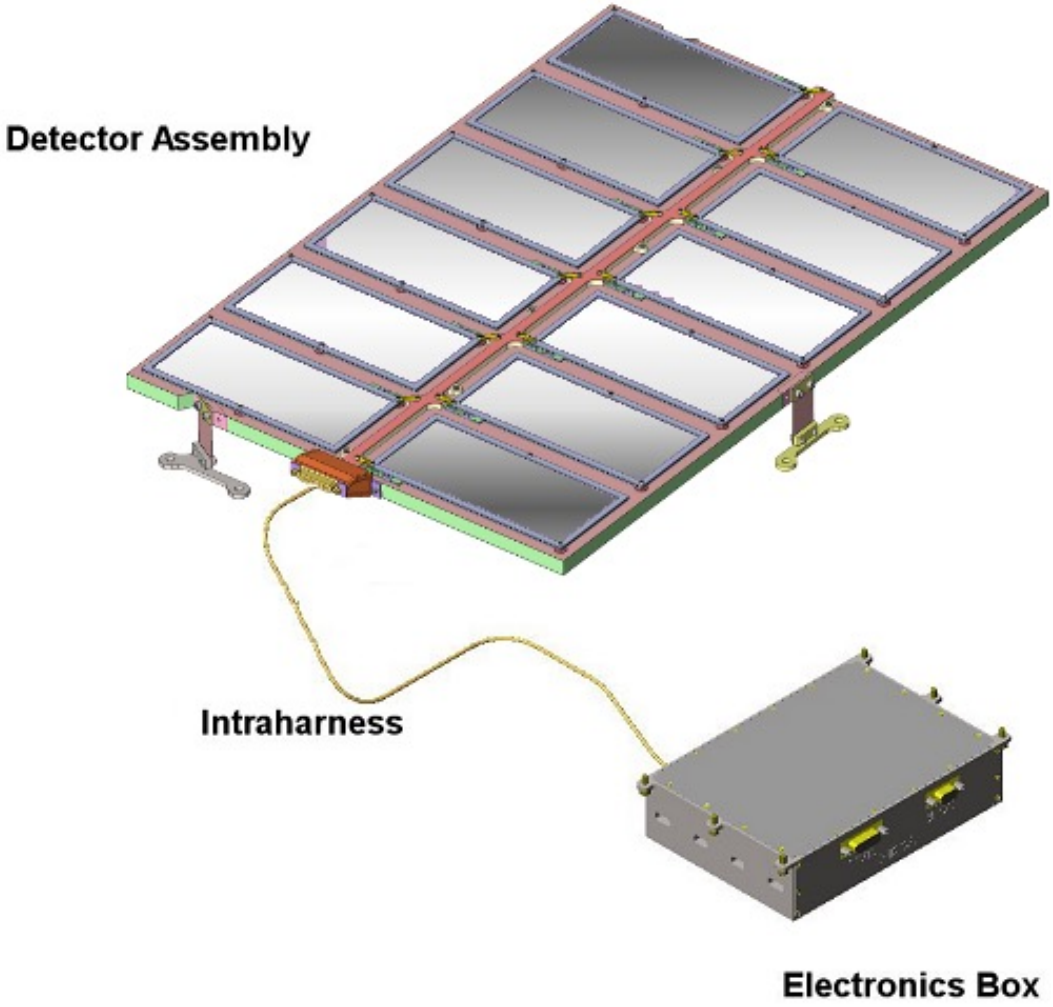
SDC Findings and Interpretations

Alex Doner & SDC TEAM

8) Alex Doner
7) Edwin Bernardoni
6) Marcus Piquette
5) Jamey Szalay
4) Andrew Poppe
3) Dong Han
2) David James
1) Colin Mitchell



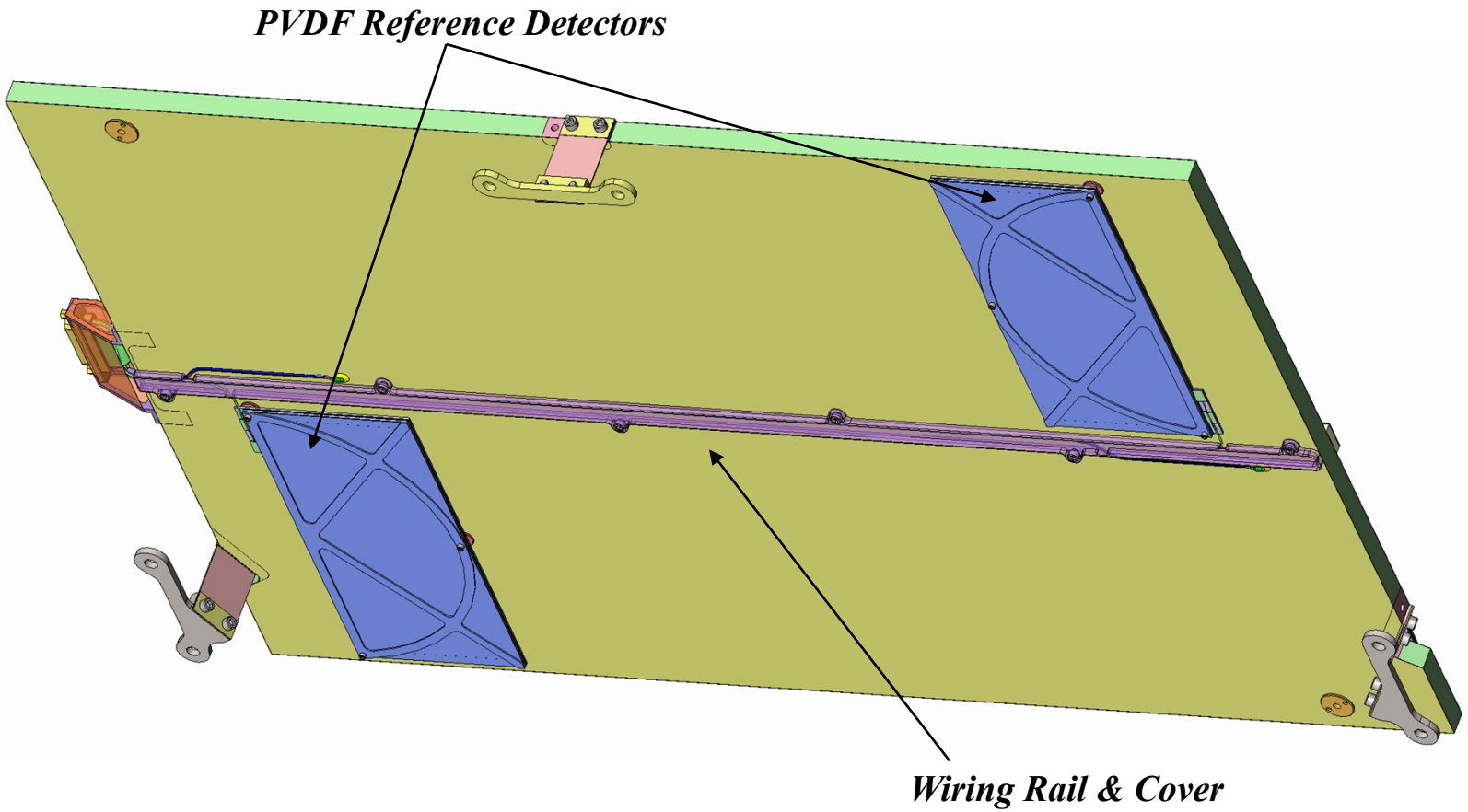
Student Dust Counter (SDC): Instrument Design



Key Properties

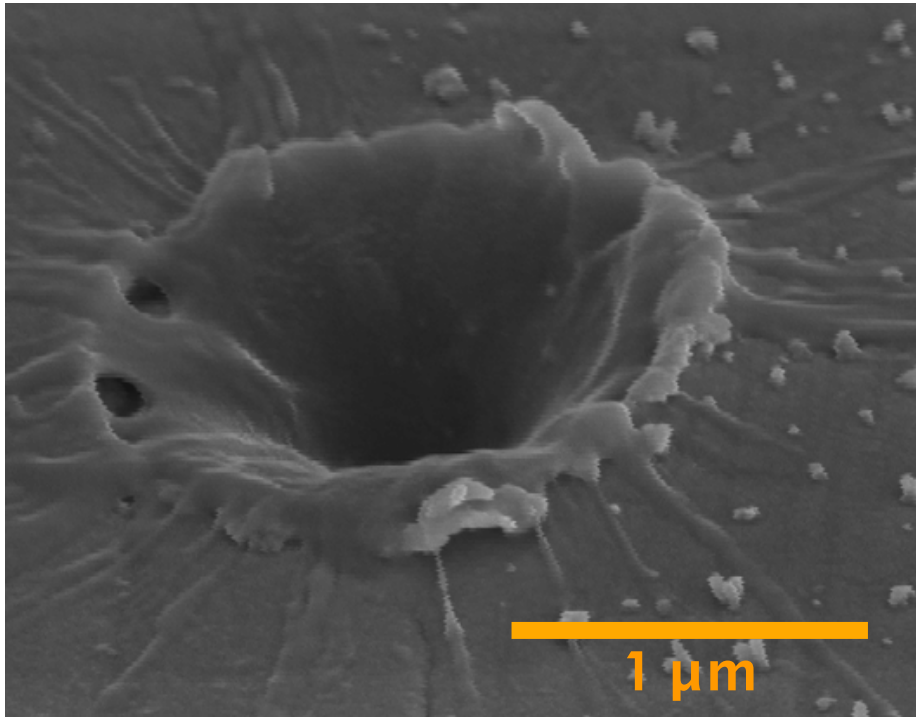
Active area	0.1 m^2
Mass	1.6 kg
Power	5 w

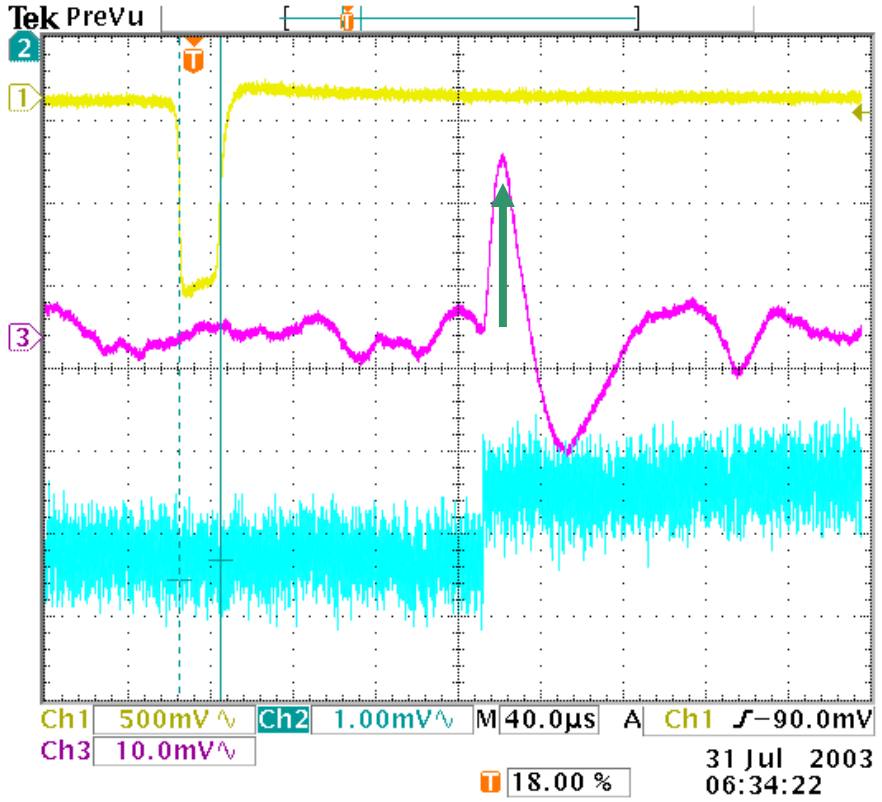
Student Dust Counter (SDC): Instrument Design

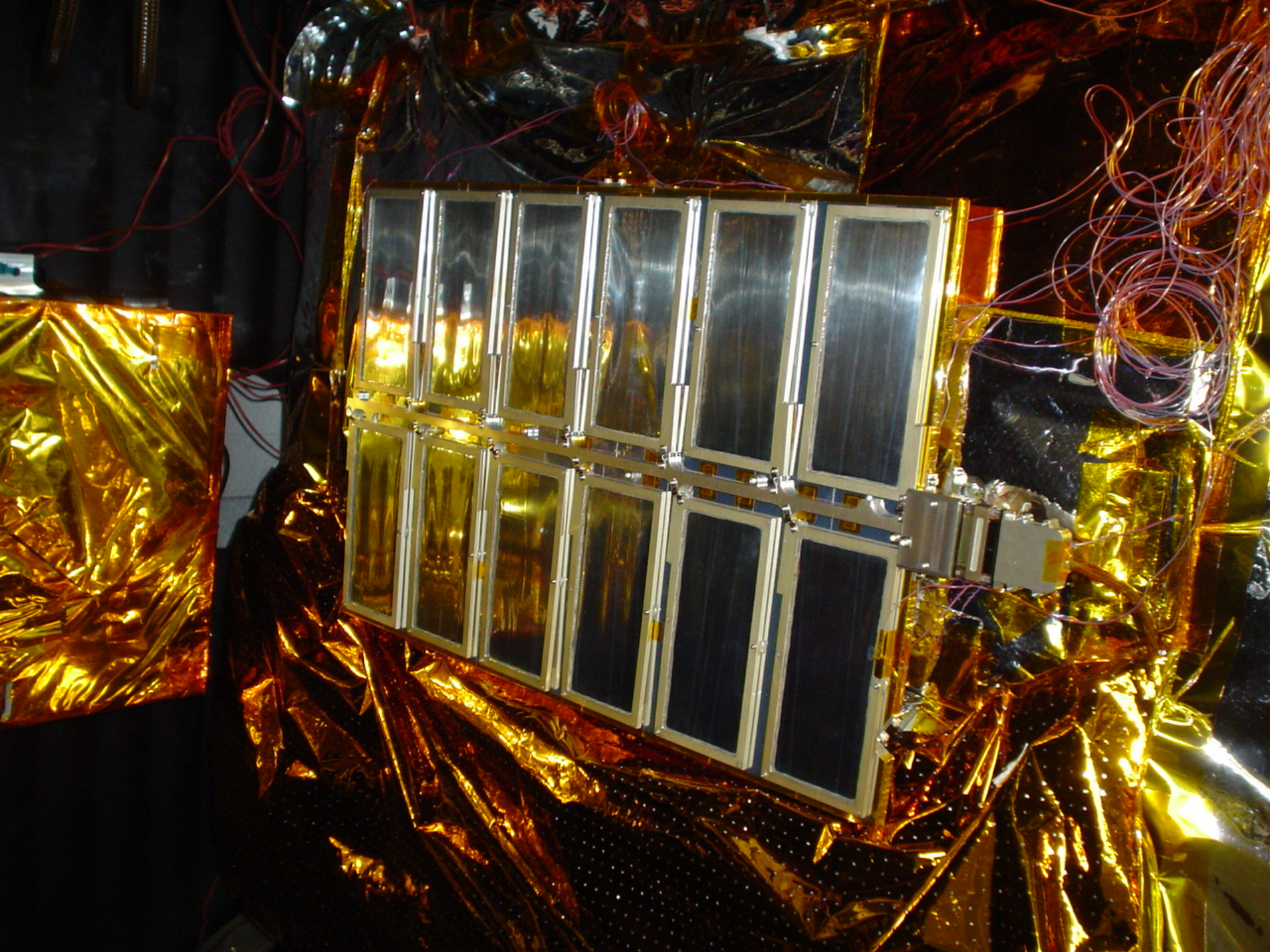


PVDF Principle of Operation

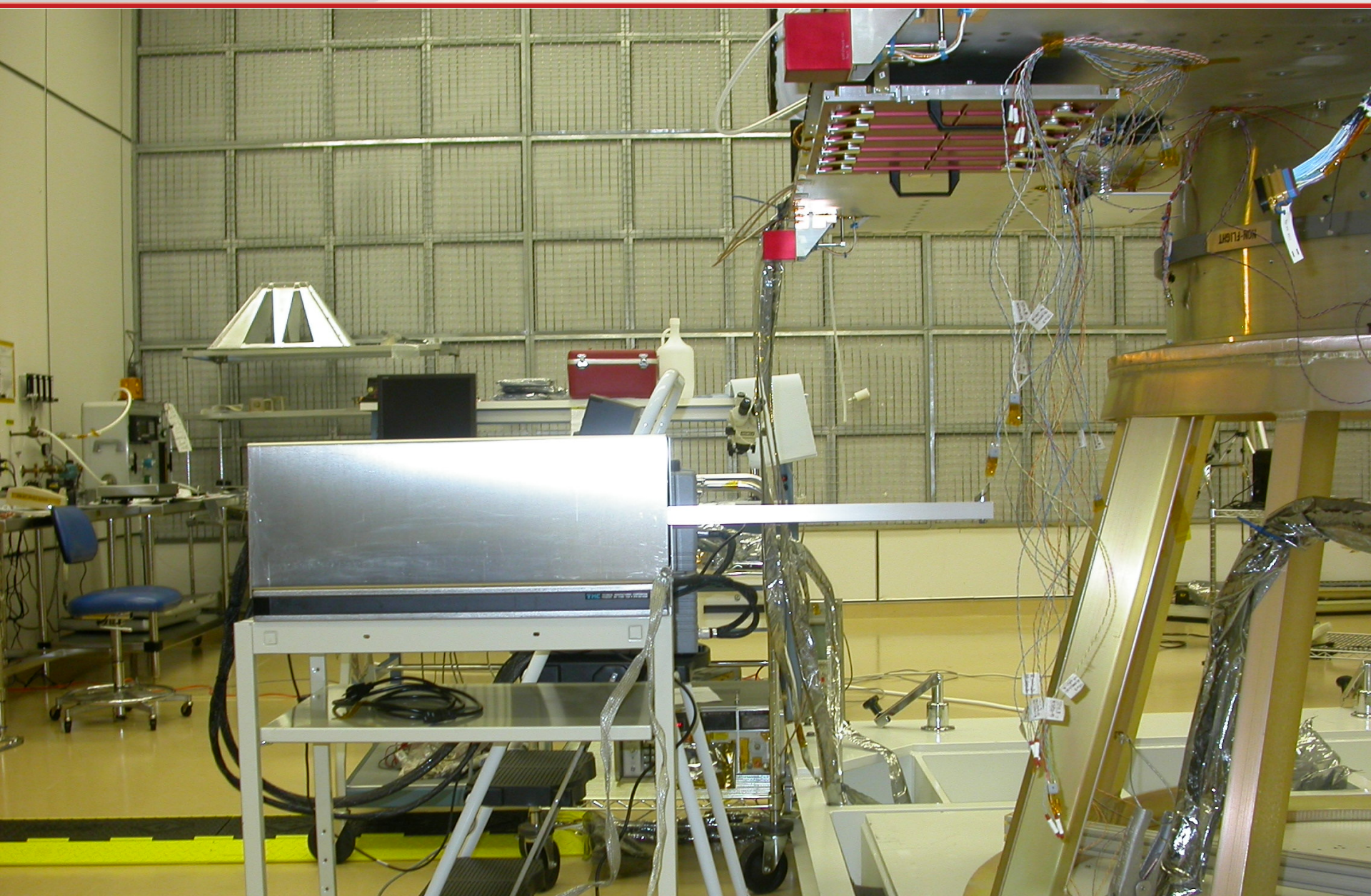
$$N_e = C\ m^{1.3}\ v^{3.0}$$



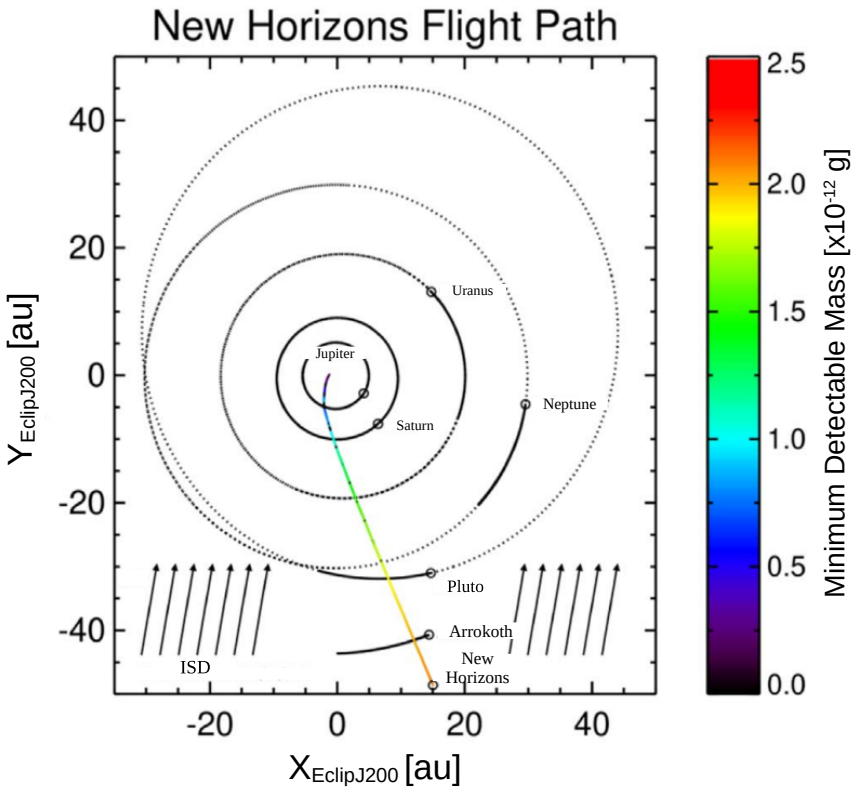


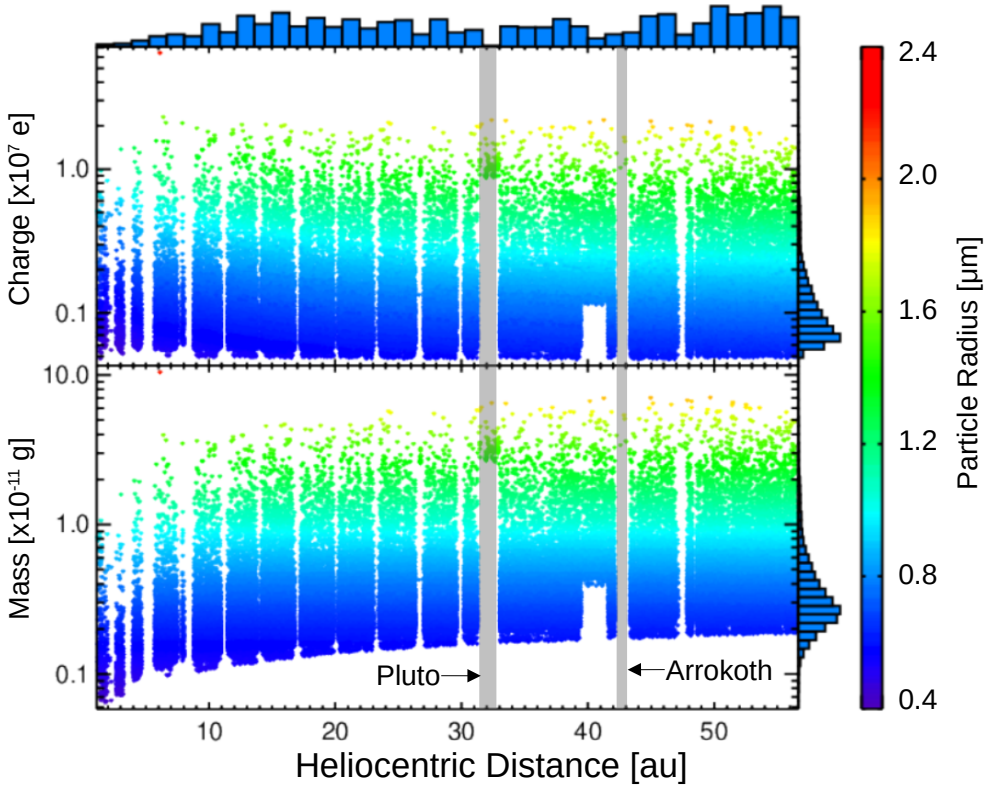


PVDF Test Setup APL 11/2004



Data Collection





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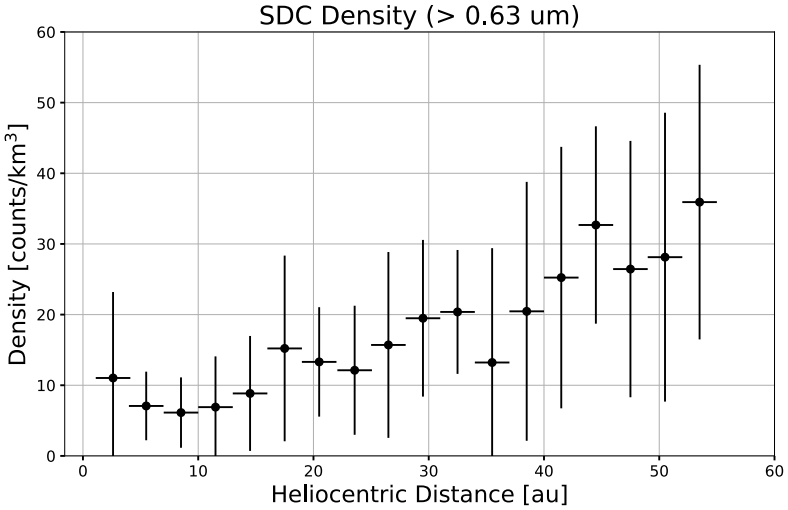

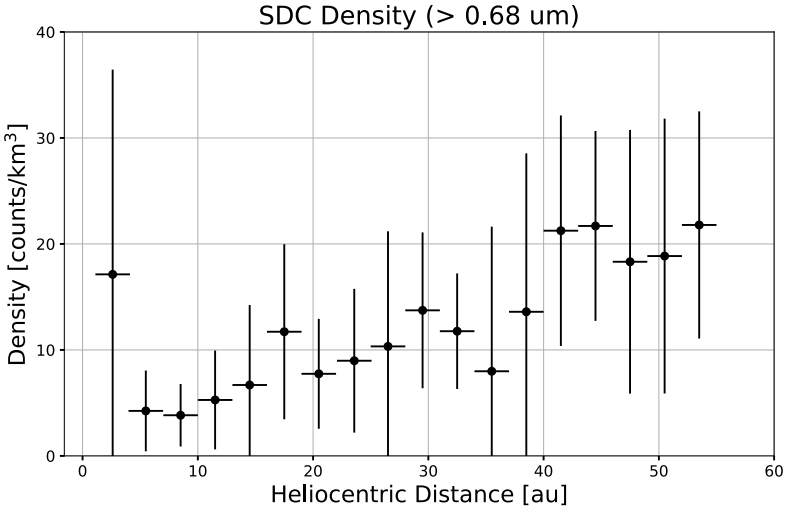

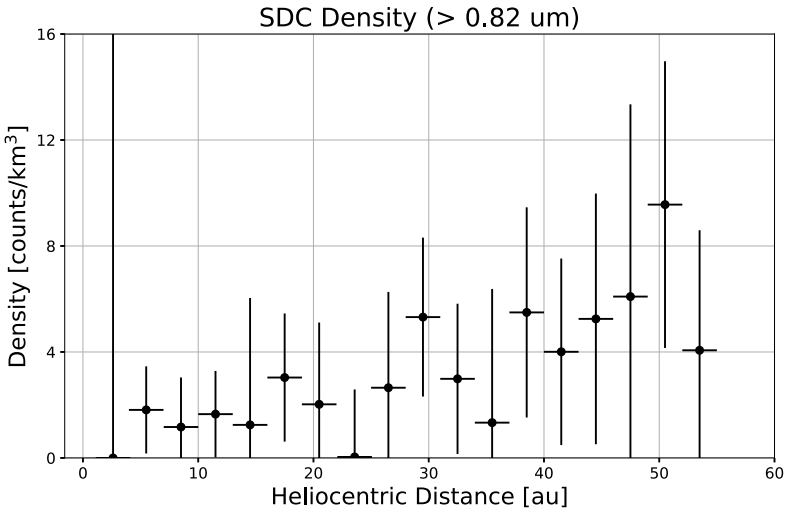

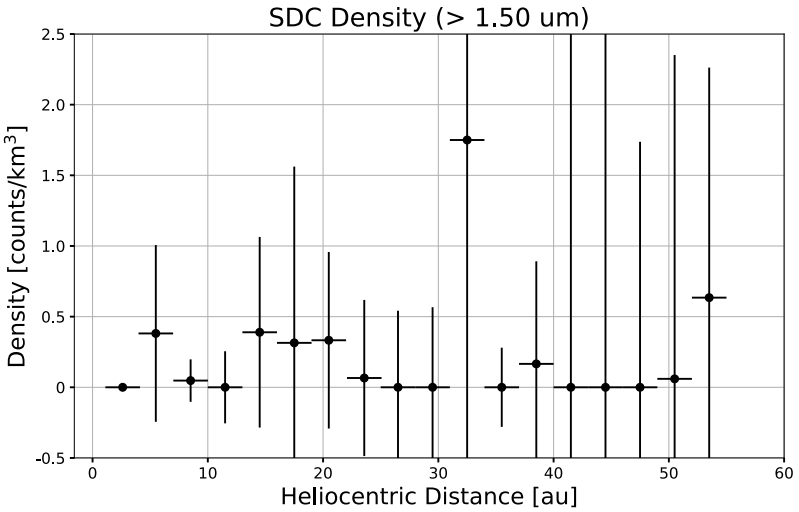

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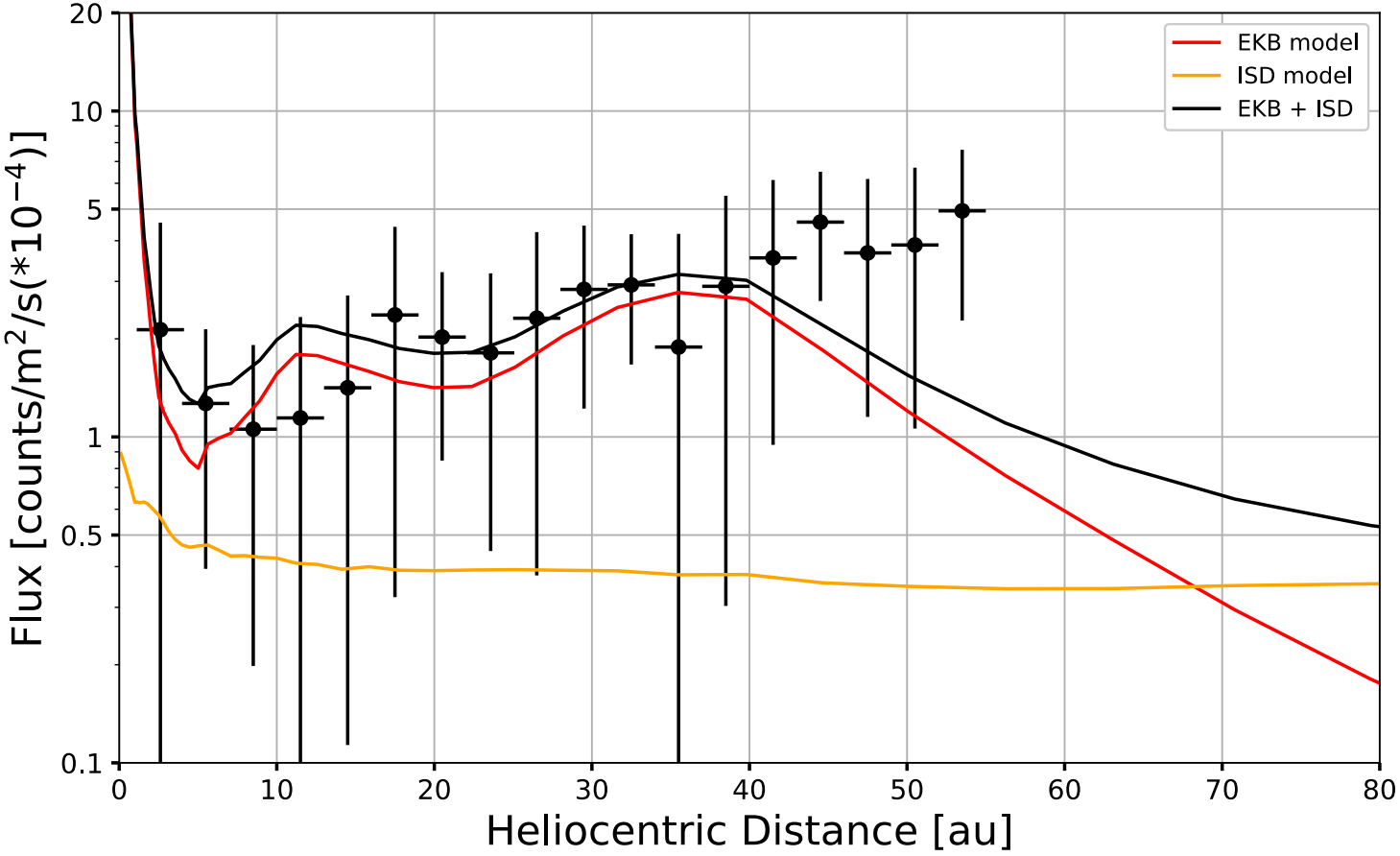
SDC Measured Flux (>0.63 μm)



Radiation Pressure

- **Dust is generated by collisions and ISD bombardment.**
- **Radiation pressure alters the orbital elements.**

β = radiation pressure / solar gravity

$$E^* = \frac{1}{2}(\dot{r}^2 + r^2\dot{\theta}^2) - \frac{(1-\beta)\mu}{r} = E + \frac{\beta\mu}{r},$$

$$J^* = r^2\dot{\theta} = J,$$

$$a^* = \frac{(1-\beta)ar}{r - 2\beta a} \qquad e^* = \sqrt{1 - \frac{(1-e^2)(r-2\beta a)}{(1-\beta)^2 r}}$$

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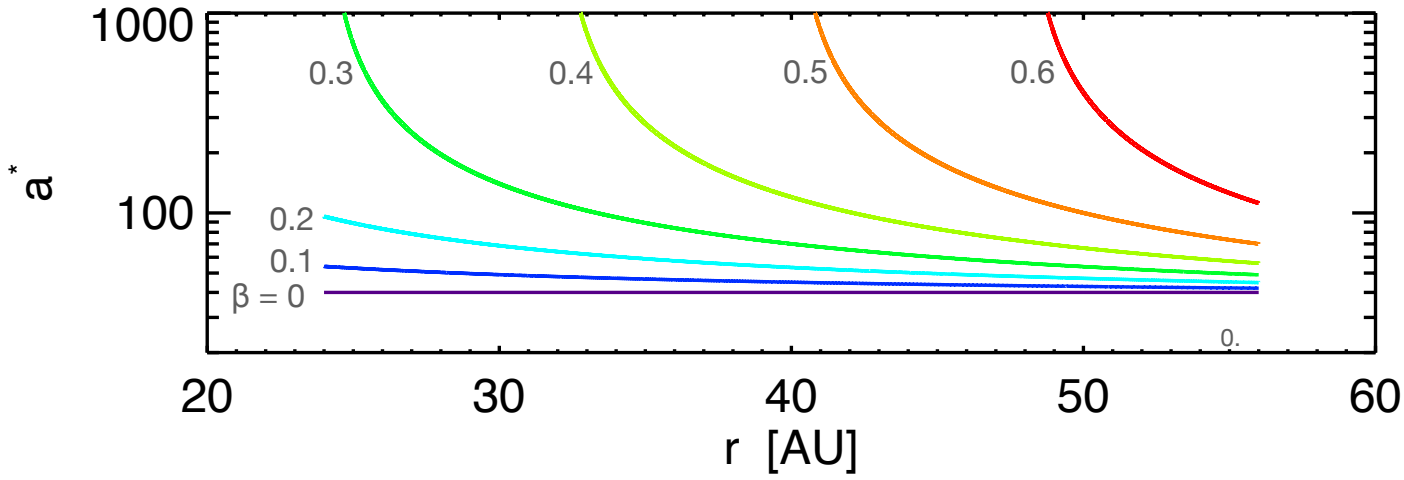
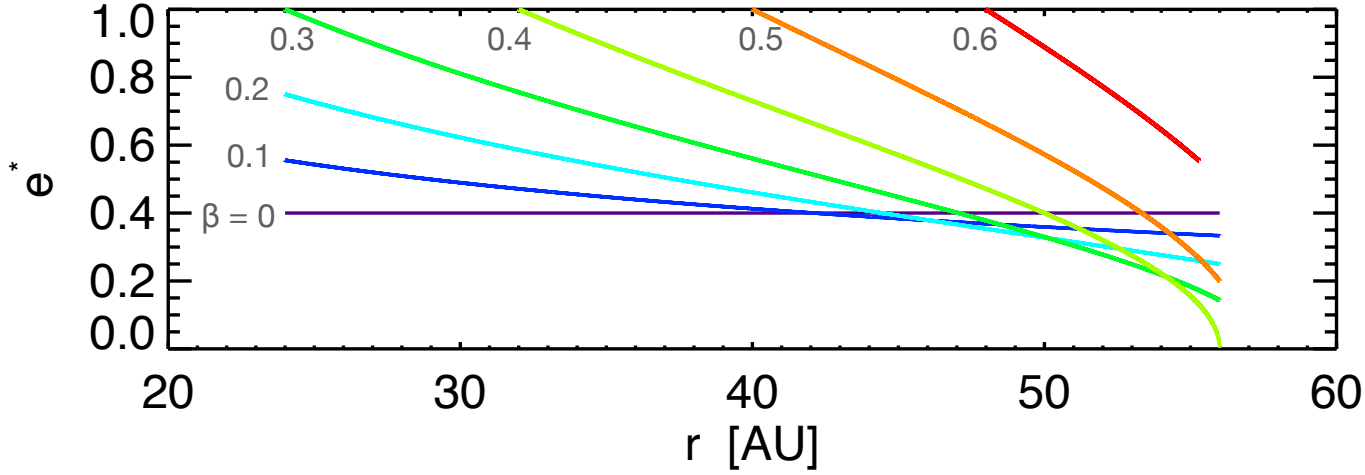


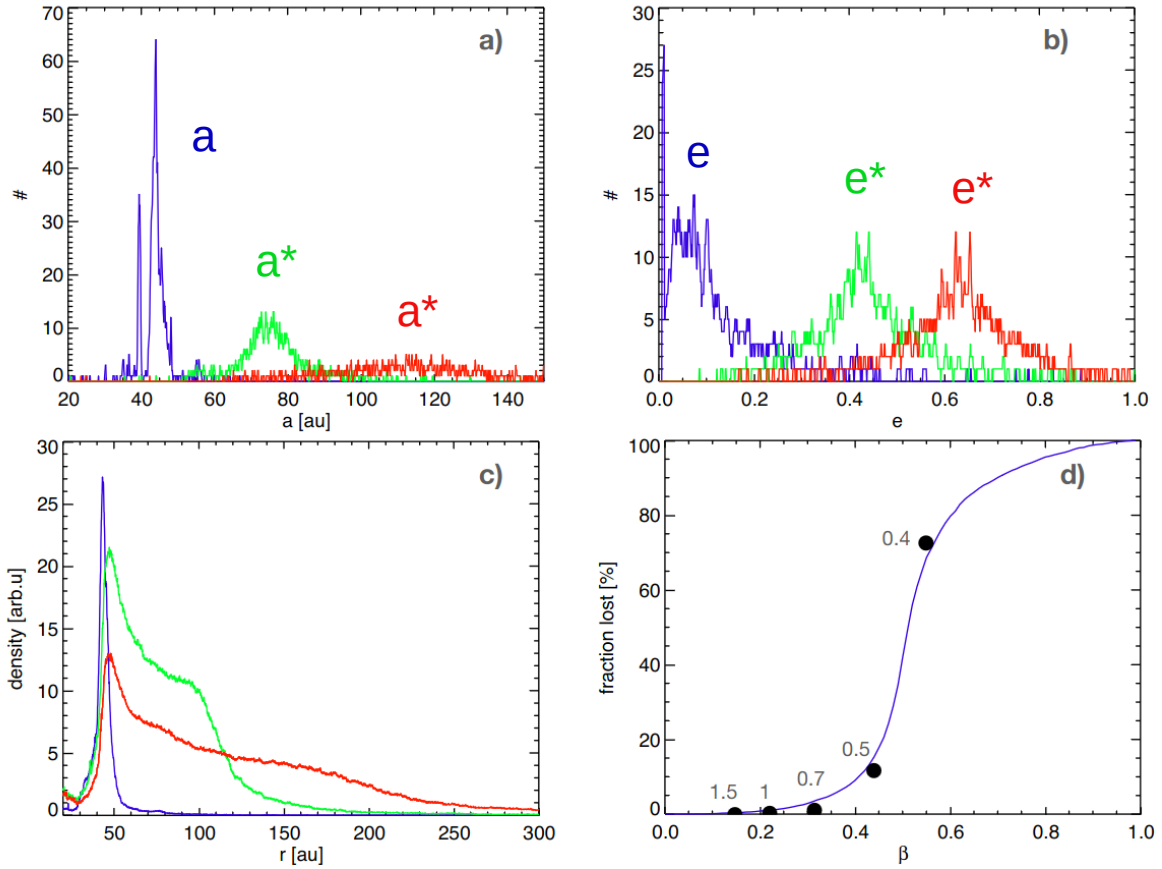
Source
$a_0 = 40$
$e_0 = 0.4$



Initial Dust Density Distribution

Orbital parameter distribution of dust producing bodies and representative dust grains

KBO Source Bodies
Created Dust: β=0.3
Created Dust: β=0.4

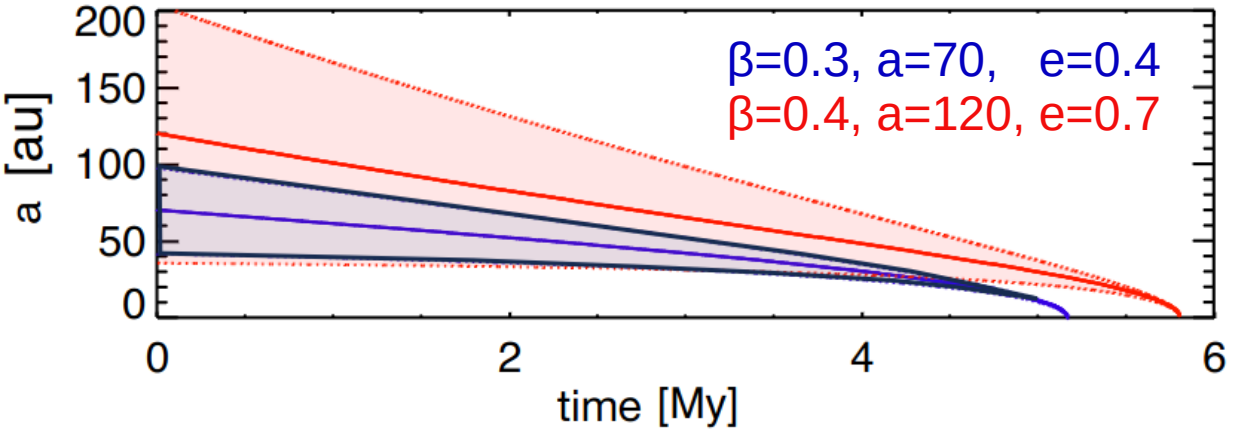


Orbital Evolution

Poynting-Robertson Drag

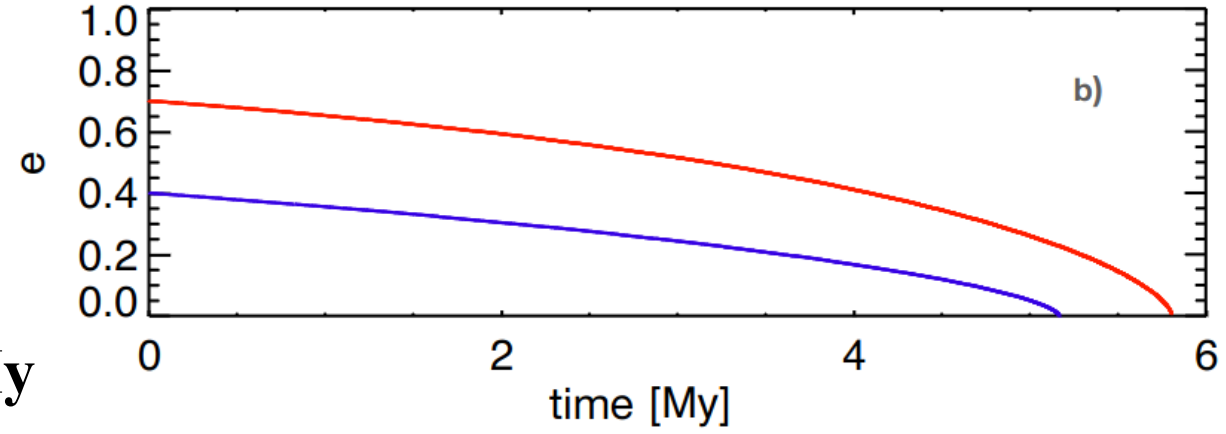
$$\frac{da}{dt} = -c\,\frac{\beta}{a}\,\frac{(2+3e^2)}{(1-e^2)^{3/2}}$$

$$\frac{de}{dt} = -c\,\frac{\beta}{a^2}\,\frac{5e}{2(1-e^2)^{1/}}$$



Particles slowly circularize as they migrate to the Sun.

Typical lifetime ~ 5 My

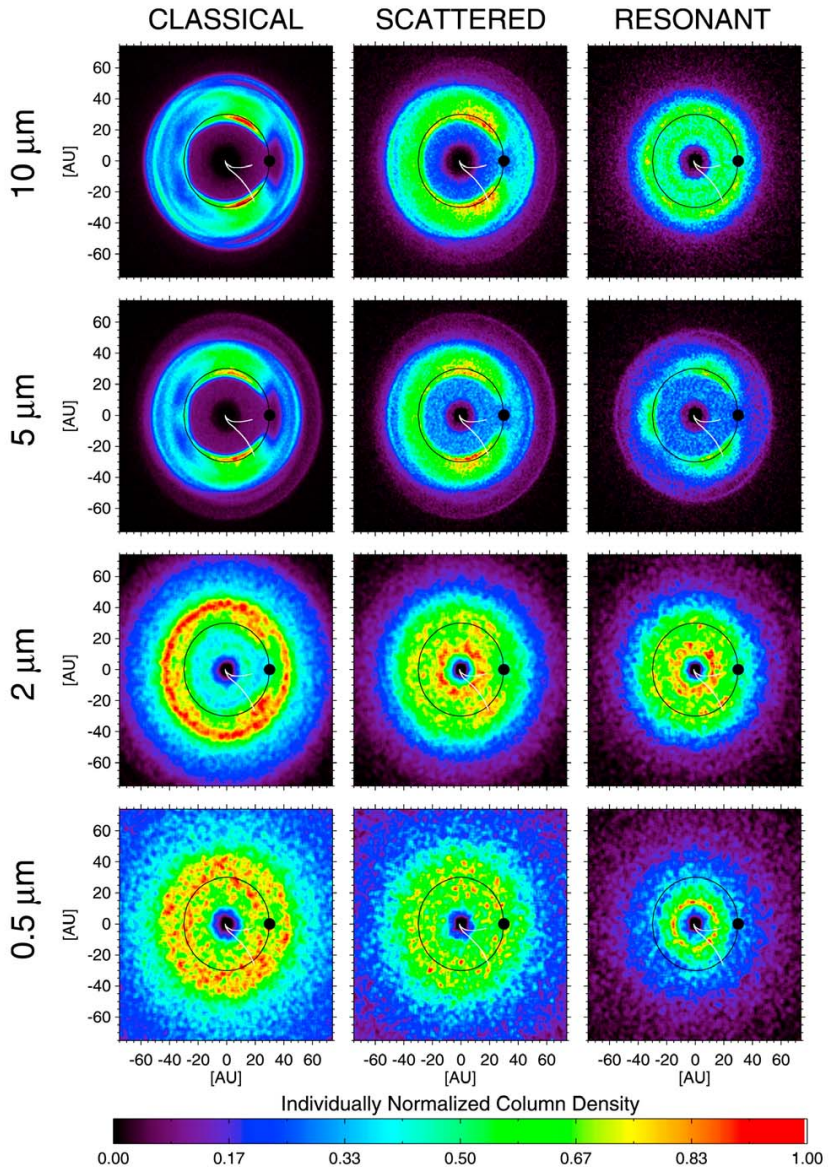


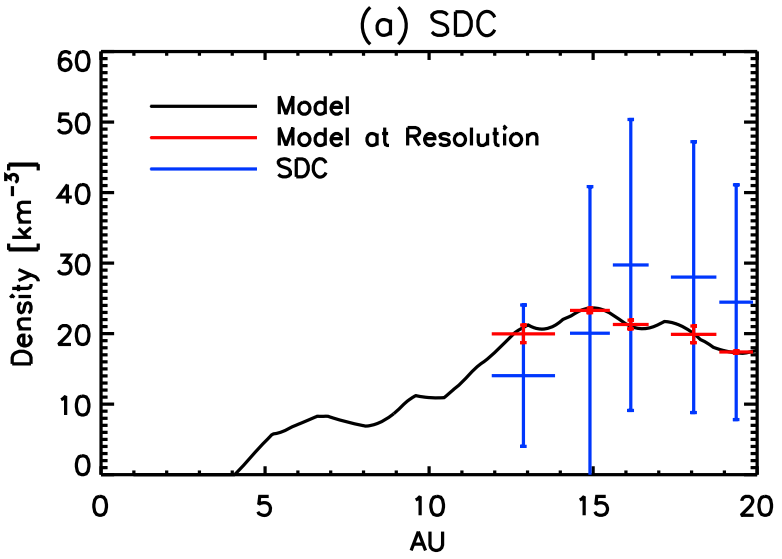
Constraints on dust production in the Edgeworth-Kuiper Belt from Pioneer 10 and New Horizons measurements

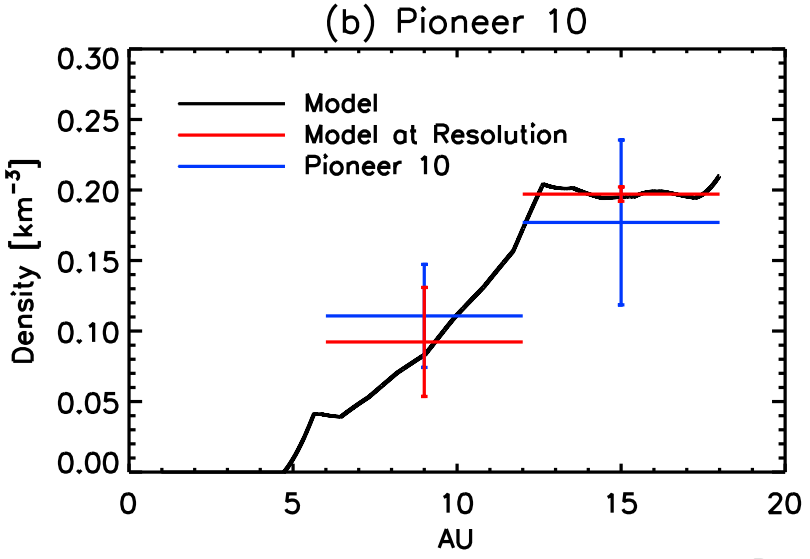
Dong Han,[1] Andrew R. Poppe,[2] Marcus Piquette,[1] Eberhard Grün,[1] and Mihály Horányi[1,3]

Received 24 October 2011; revised 10 November 2011; accepted 13 November 2011; published 28 December 2011.

2011







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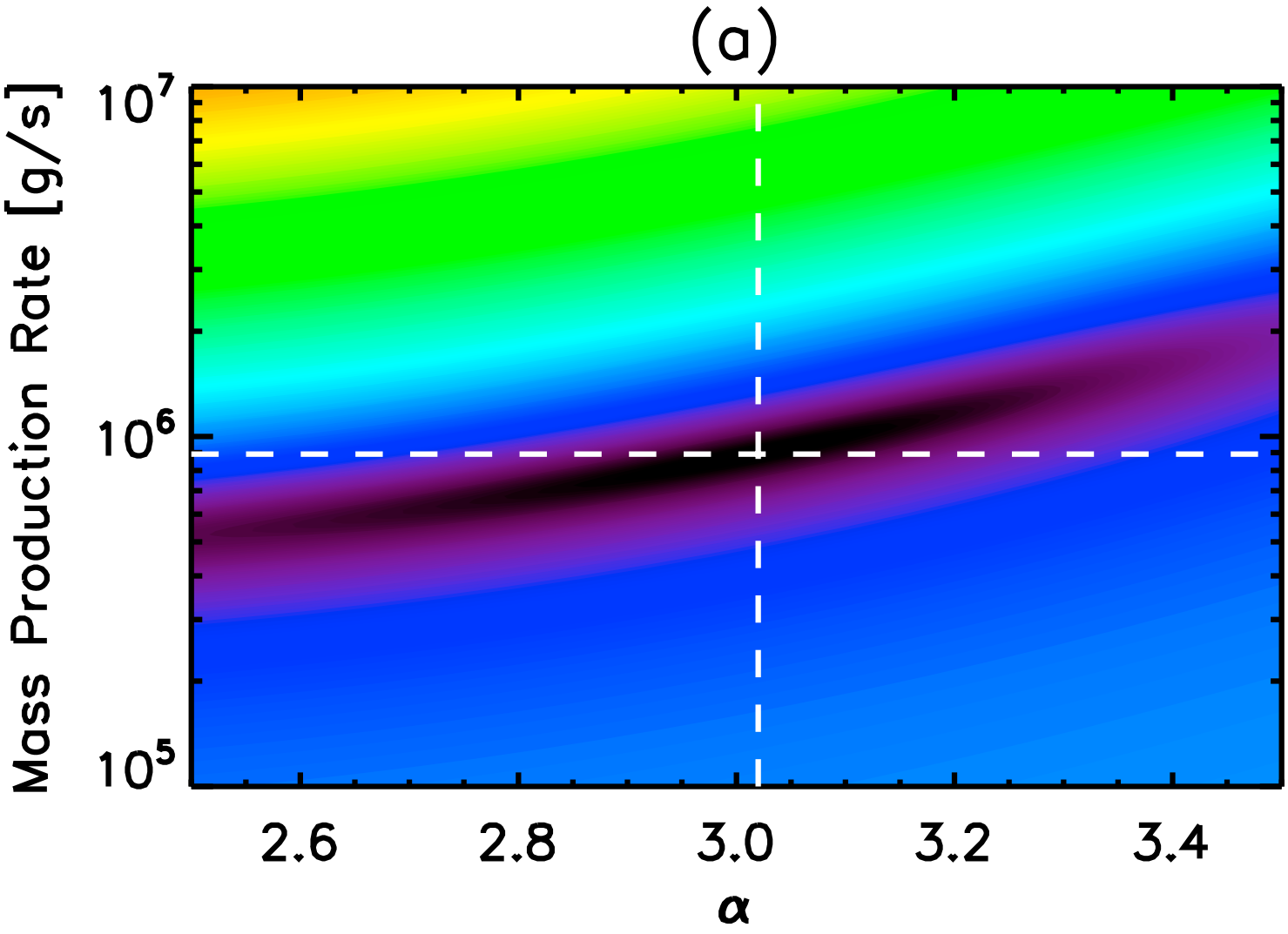

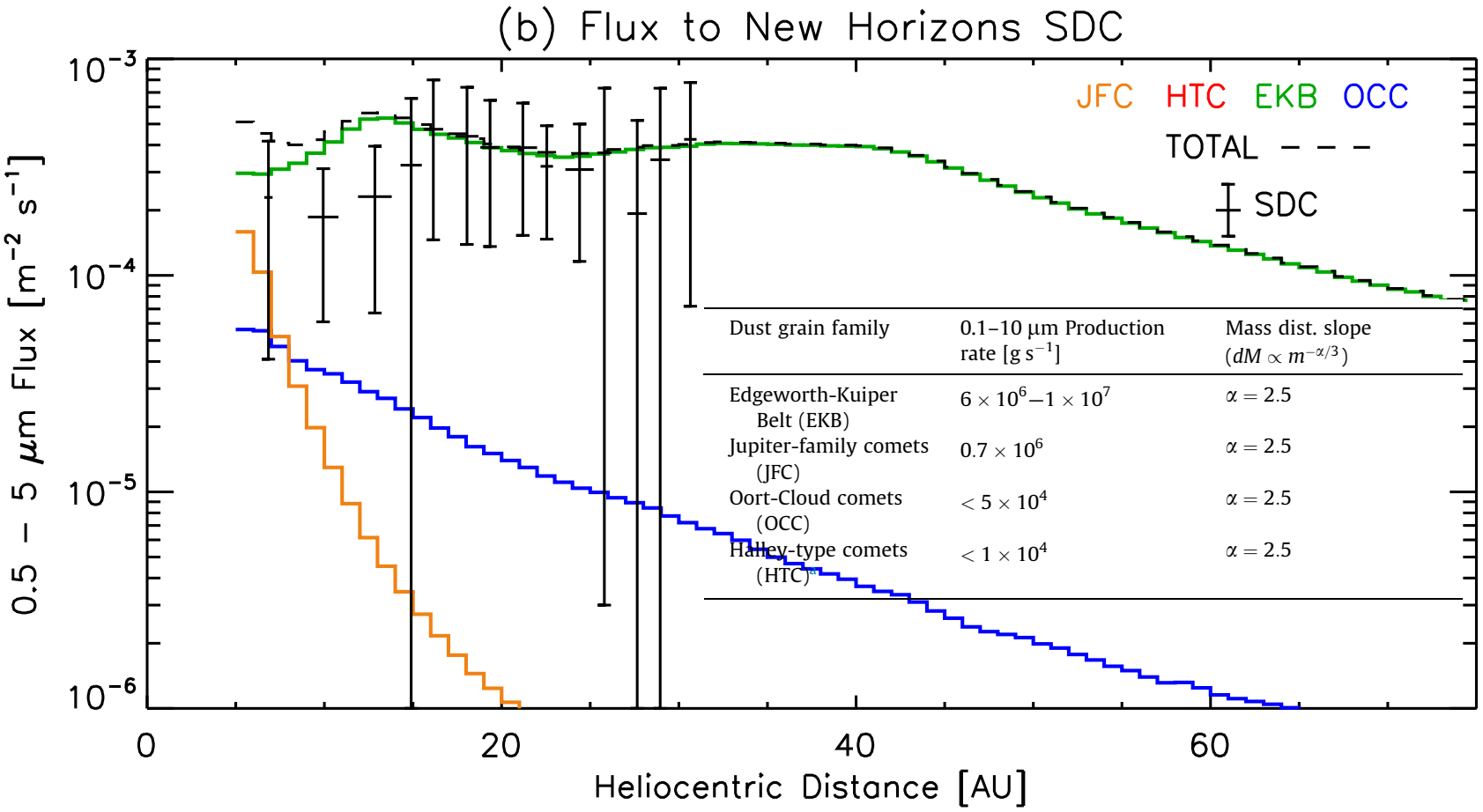

Dust grain family	0.1–10 μm Production rate [g s^{-1}]	Mass dist. slope ($dM \propto m^{-\alpha/3}$)
Edgeworth-Kuiper Belt (EKB)	6×10^6–1×10^7	$\alpha = 2.5$
Jupiter-family comets (JFC)	0.7×10^6	$\alpha = 2.5$
Oort-Cloud comets (OCC)	$< 5 \times 10^4$	$\alpha = 2.5$
Halley-type comets (HTC)	$< 1 \times 10^4$	$\alpha = 2.5$

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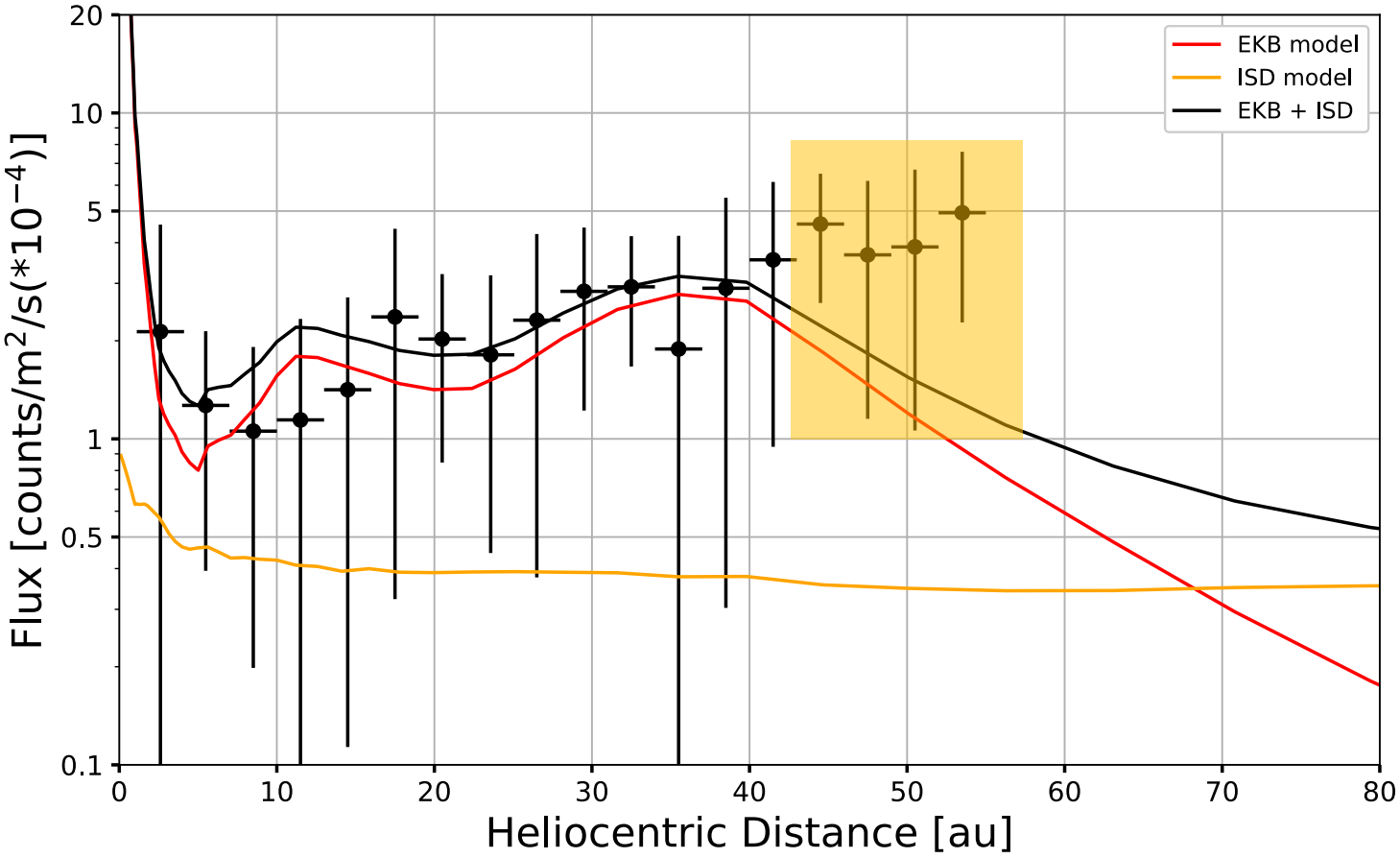
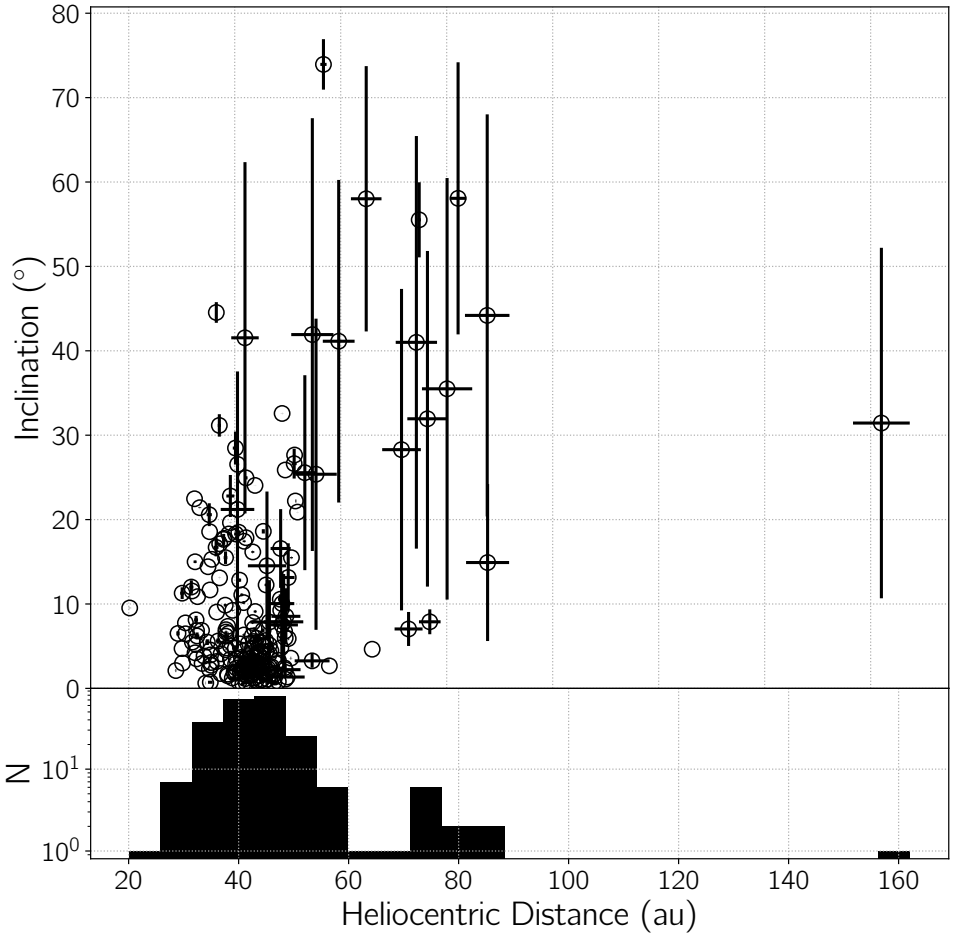


Extended Kuiper Belt ?

New Horizons KBO Detections

Wesley C. Fraser,[1,2] Simon B. Porter,[3] Lowell Peltier,[1,2,4] JJ Kavelaars,[1,2]
Anne J. Verbiscer,[5,3] Marc W. Buie,[3] S. Alan Stern,[3] Susan D. Benecchi,[6] Takashi Ito,[7]
Fumi Yoshida,[8,9] David W. Gerdes,[10,11] Kevin J. Napier,[10] Hsing Wen Lin,[10]
Sebastien Fabbro,[1,2] and Hayden Smotherman[12]



New Population of KB Dust?

$$\frac{da}{dt} = -c\,\frac{\beta}{a}\,\frac{(2+3e^2)}{(1-e^2)^{3/2}}$$

$$\frac{de}{dt} = -c\,\frac{\beta}{a^2}\,\frac{5e}{2(1-e^2)^{1/2}}$$

$$\frac{dr_g}{dt} \simeq 0.4/d^2 \quad \text{cm/My}$$

$$\hookrightarrow + \frac{d\beta}{dt}$$

a(t=0) = 45 & e(t=0) = 0.1

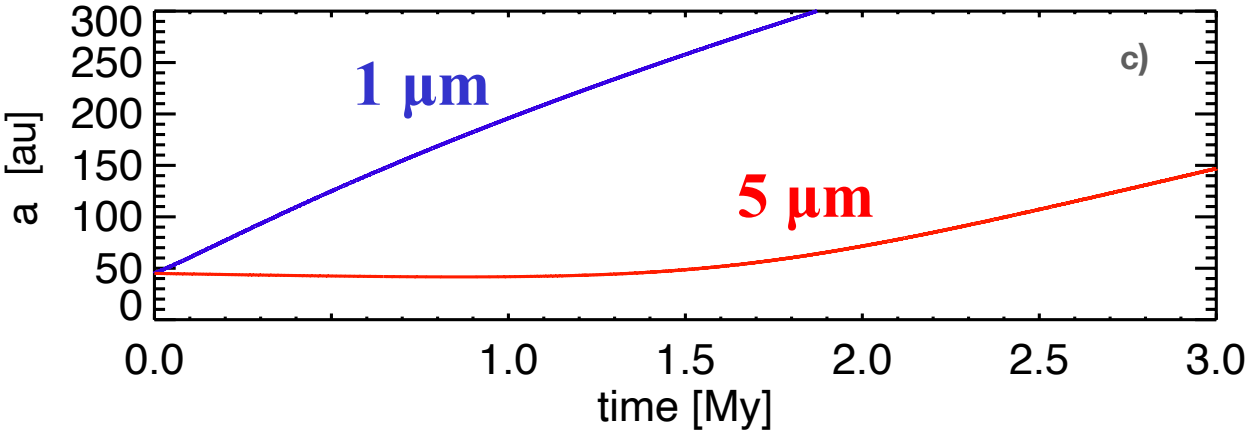
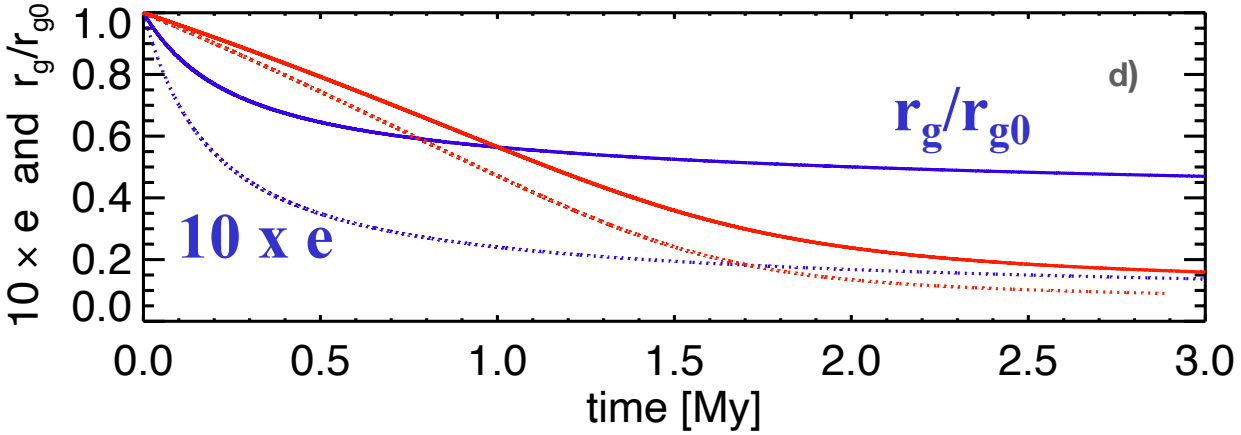


Photo-sputtering of ice grains?

These never leave the KB.



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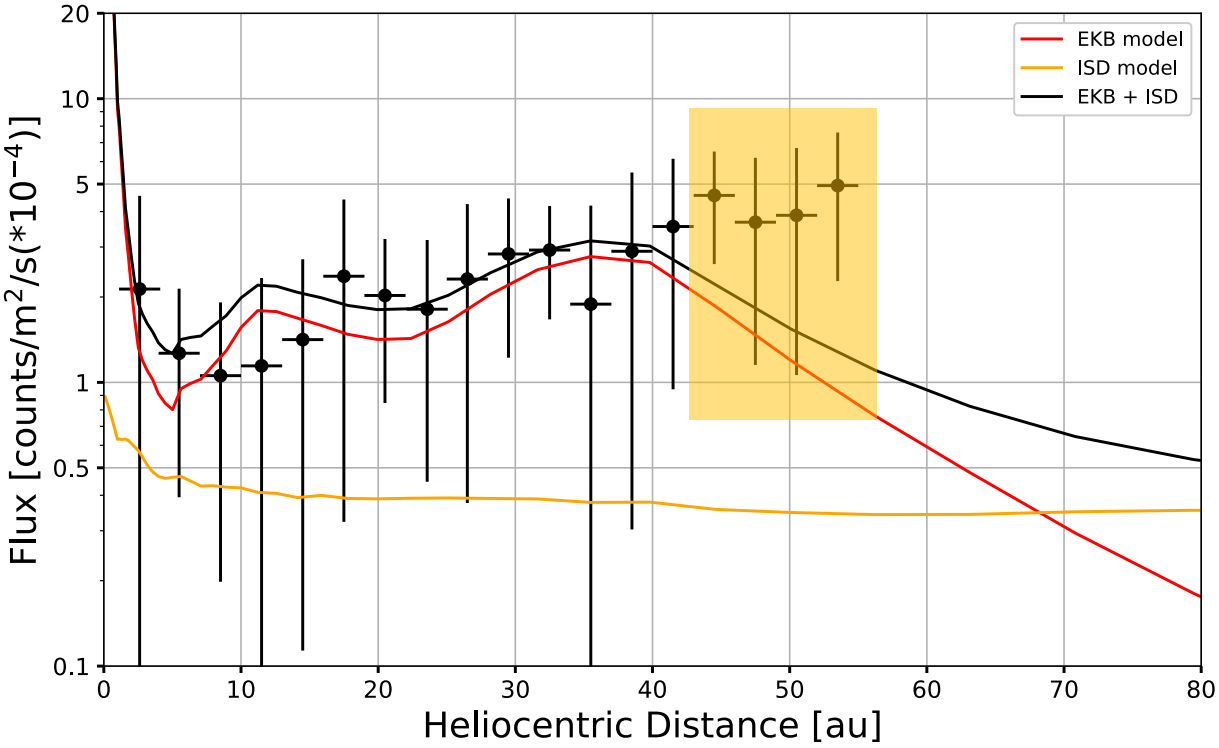

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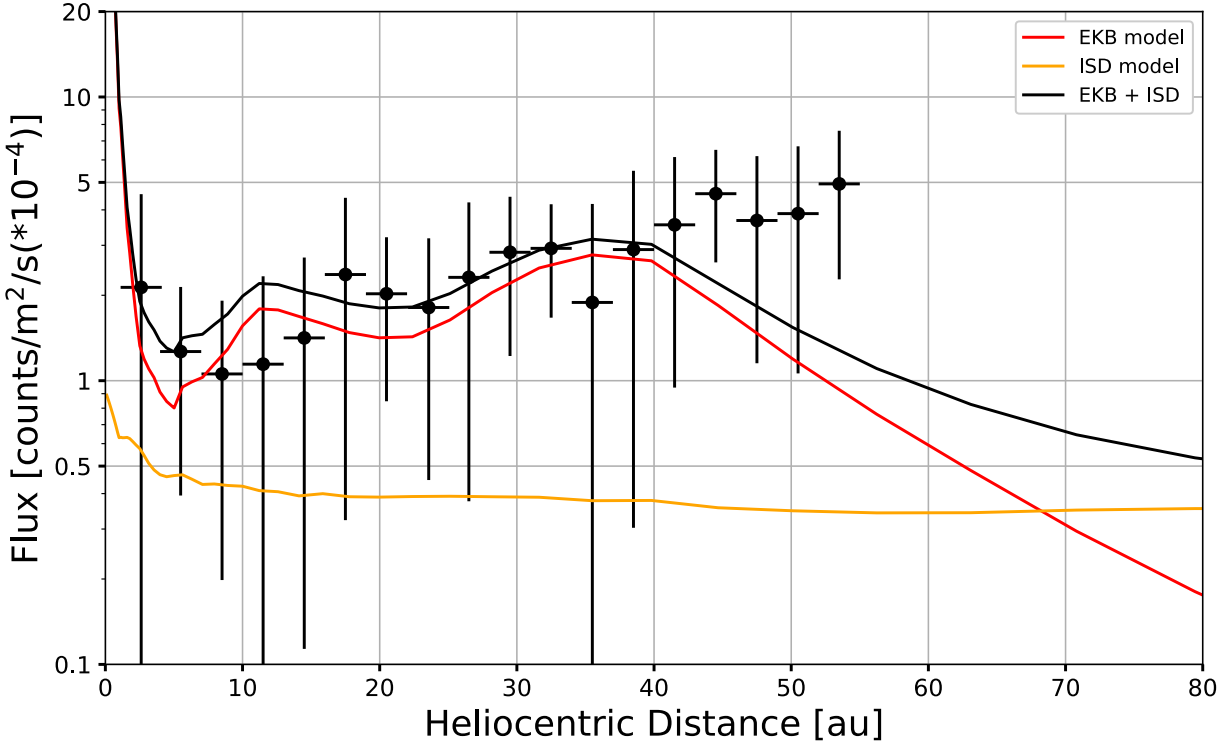

a) Extended Kuiper Belt

b) Compositional gradients

c) …….

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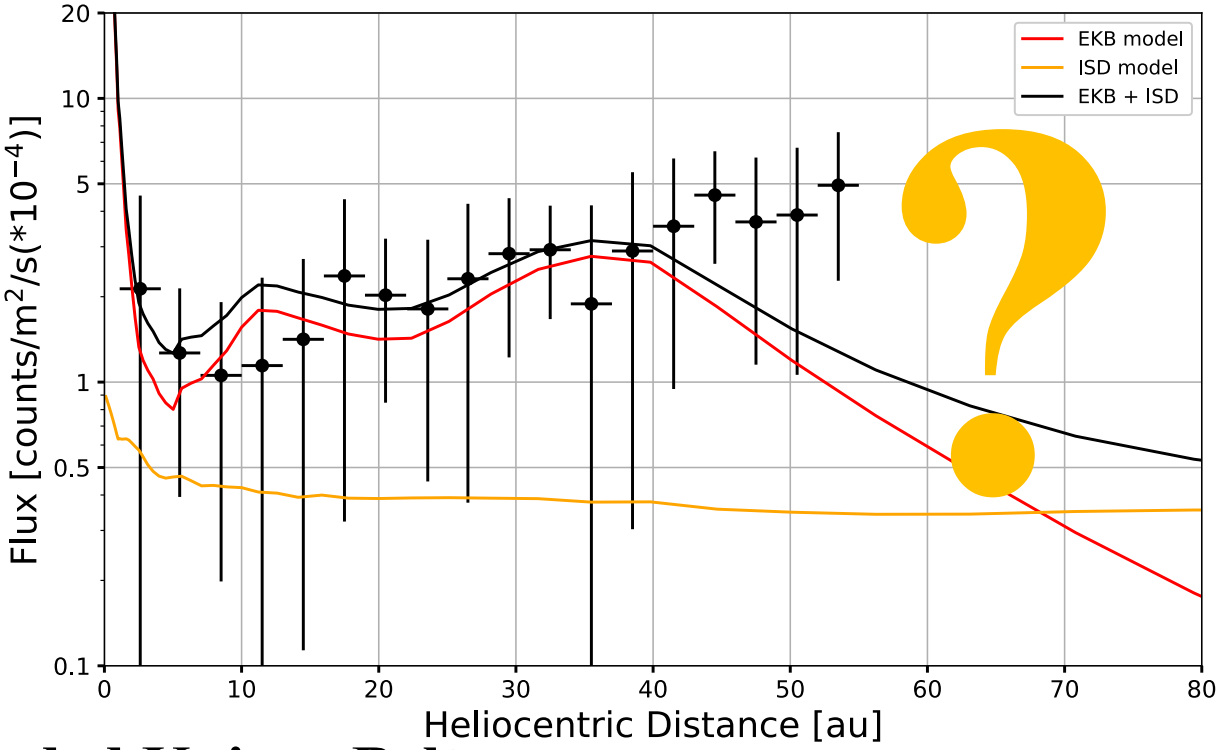

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