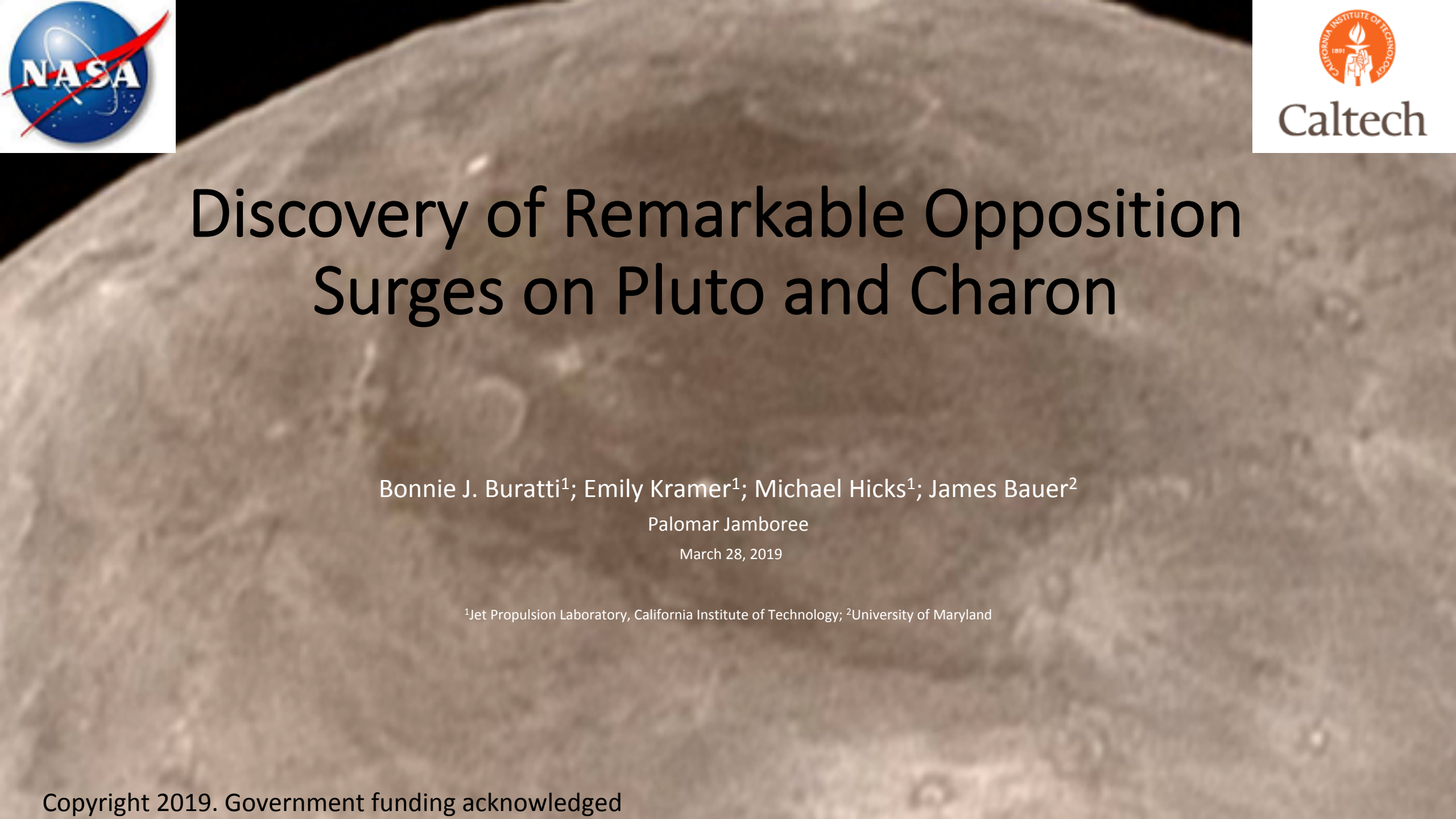

Discovery of Remarkable Opposition Surges on Pluto and Charon

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Palomar Jamboree

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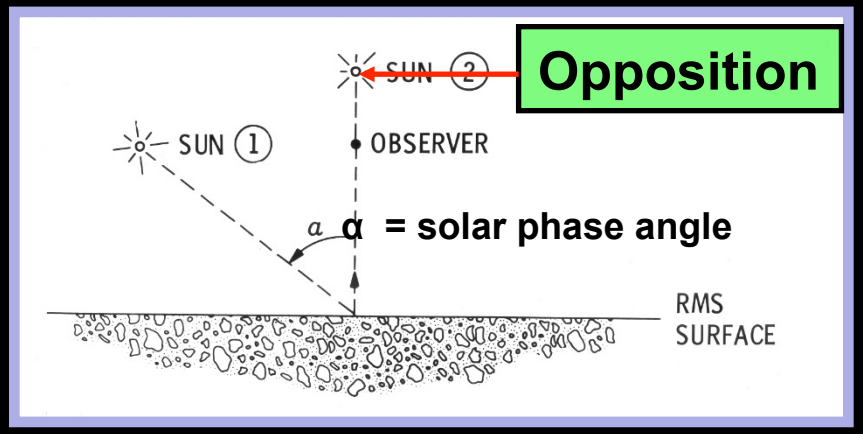
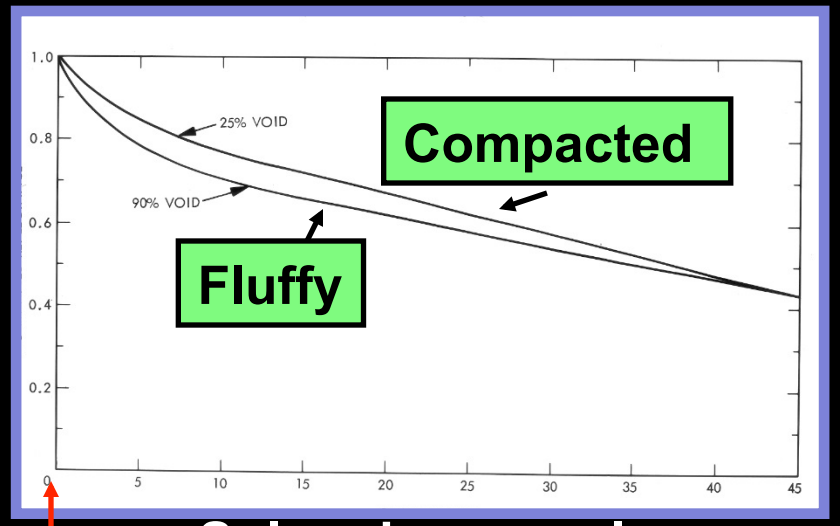
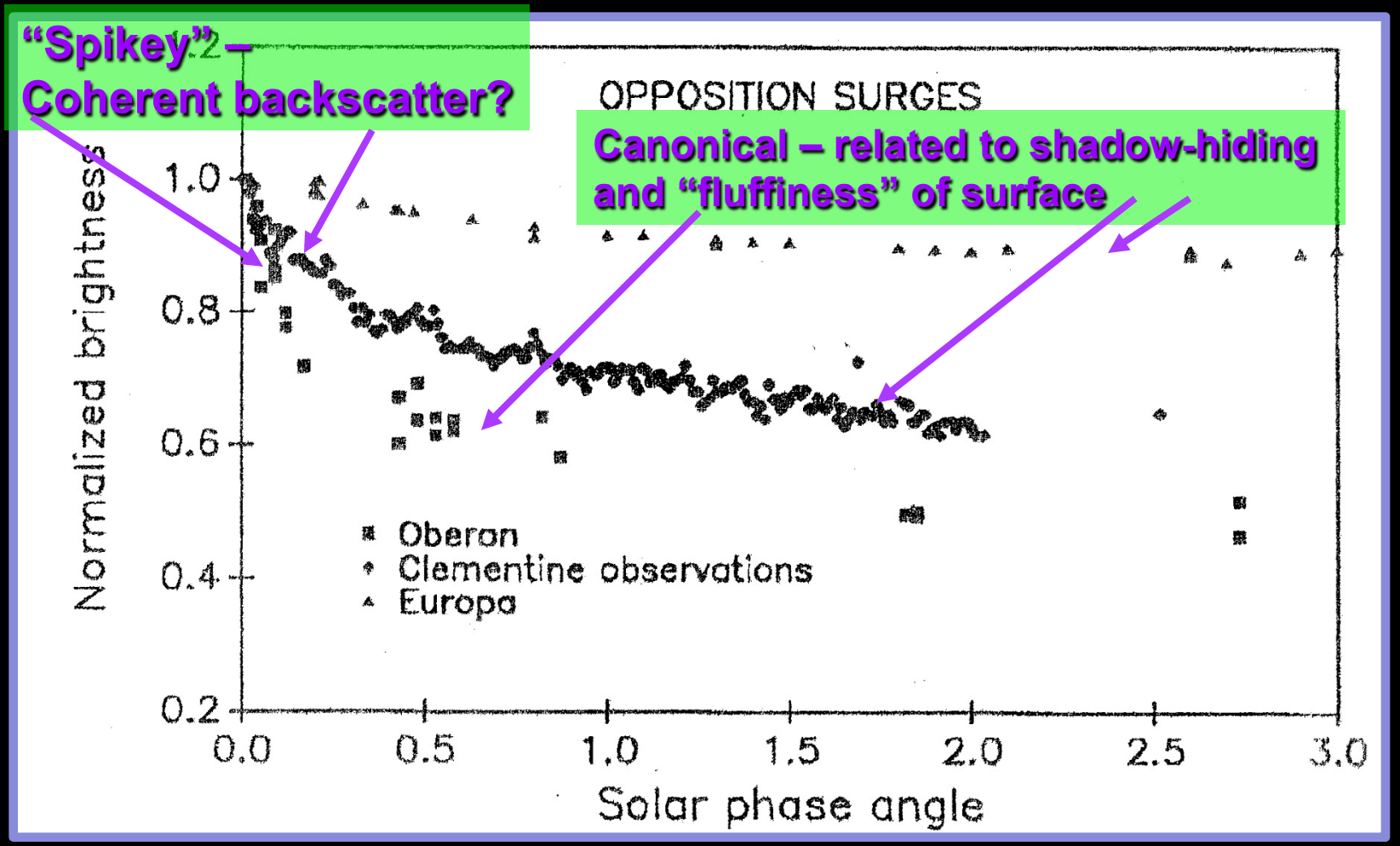
What is an opposition surge?

- The opposition surge is the anomalous increase in brightness as a body becomes fully illuminated to an observer, when the solar phase angle (α) = 0°
- The canonical explanation (Irvine, 1966; Hapke, 1983) is the disappearance of mutual shadows among regolith particles
- Large surges are exhibited by fluffy surfaces, while a lack of a surge means a compact surface. The surge depends on the fraction of void space in the regolith



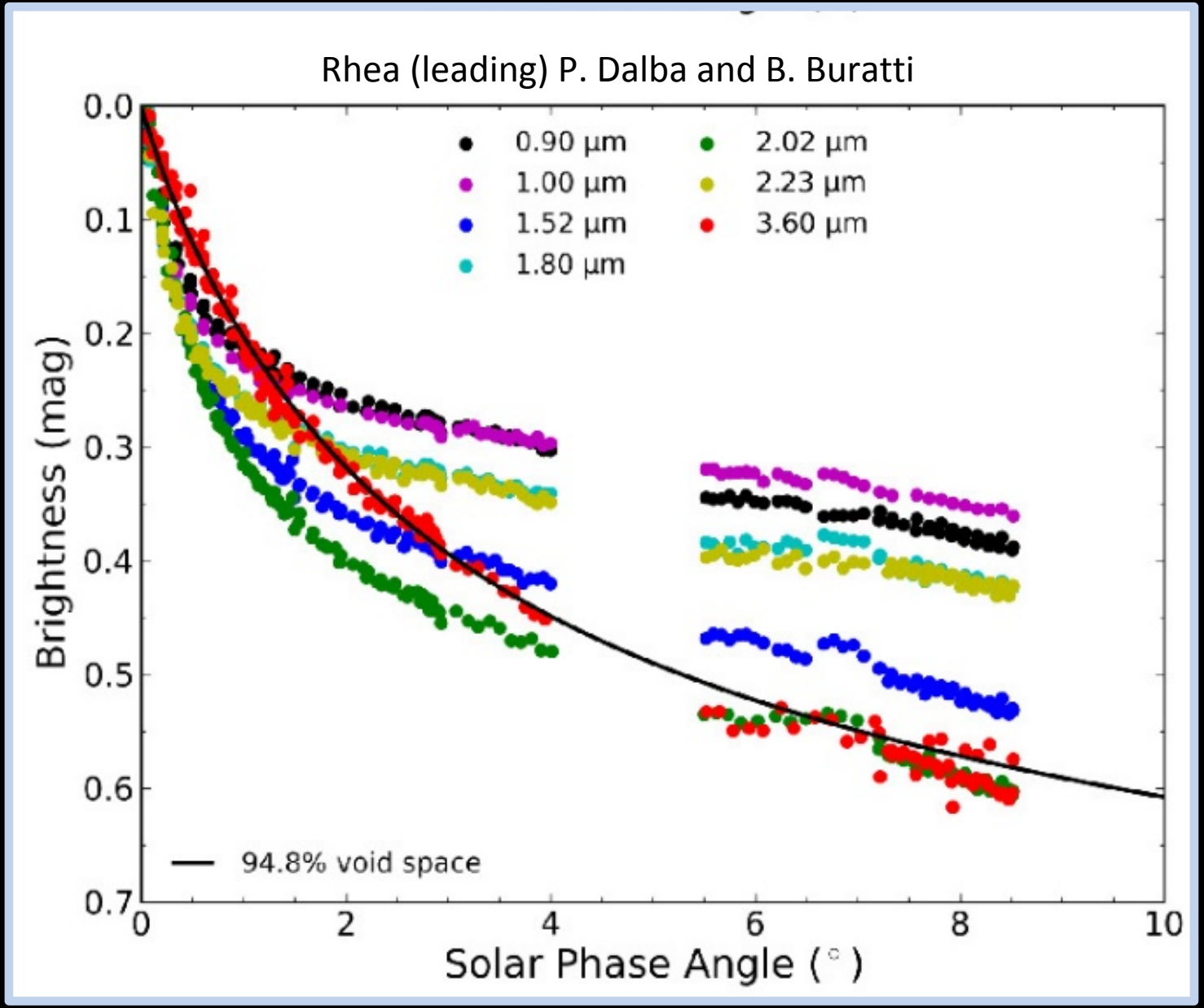


Two types of surges



Lockwood and Thompson (1992); Buratti et al. (1992; 1996)

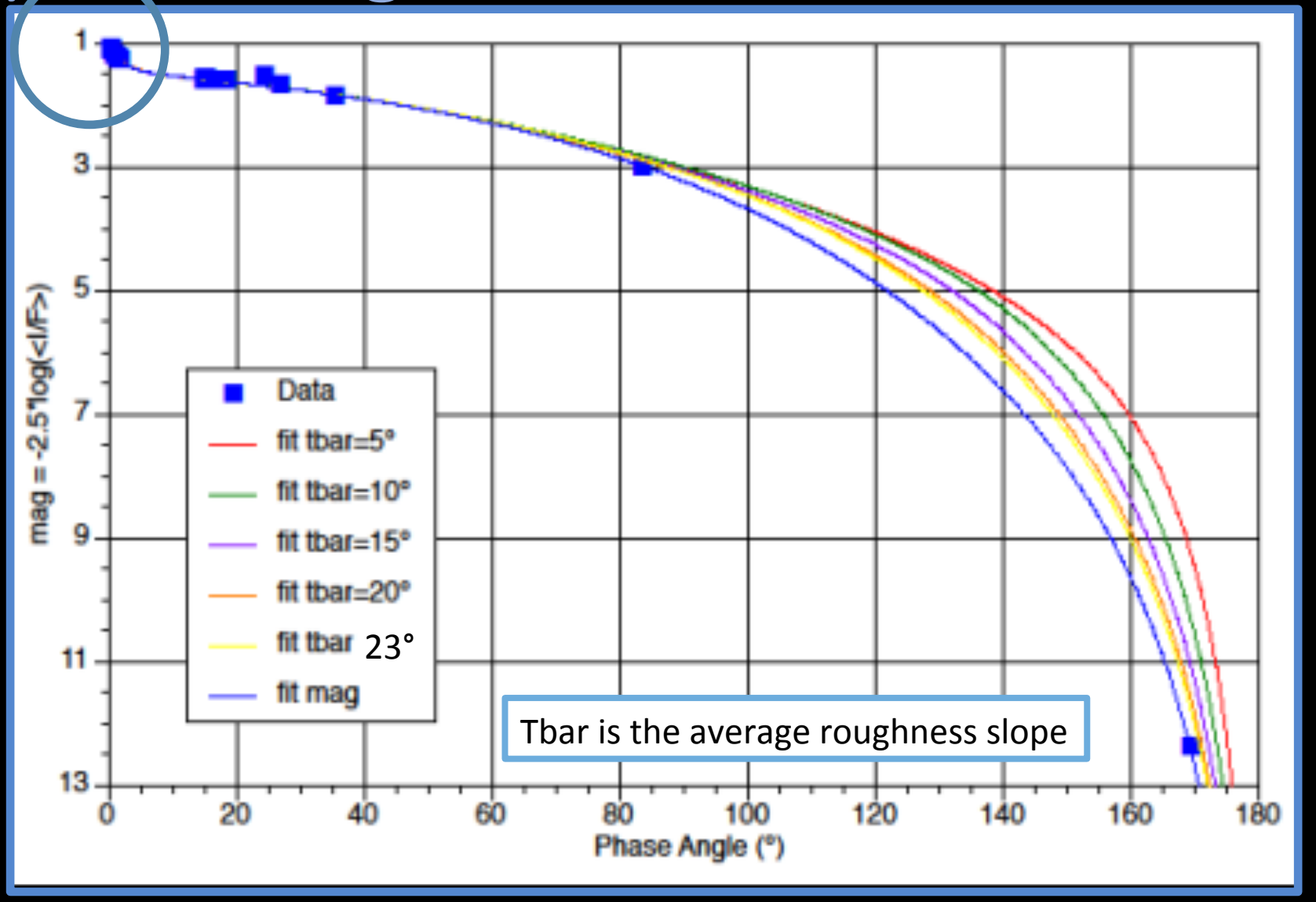
Example of observations and modeling: Rhea



***Cassini* Visual Infrared Mapping Spectrometer**

Full phase curve of Charon (*New Horizons* and *Hubble*) with roughness models

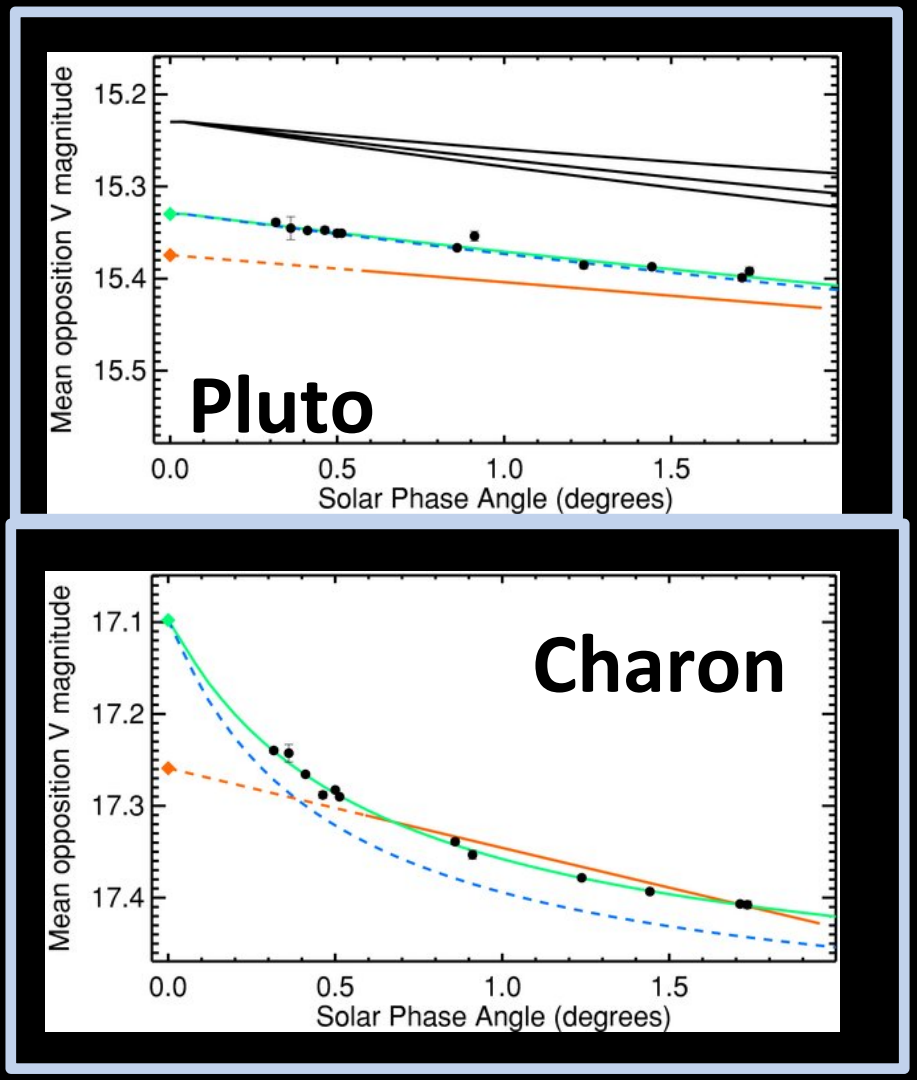
***HST* data**
Buie et al., 2010
rest is *New Horizons*



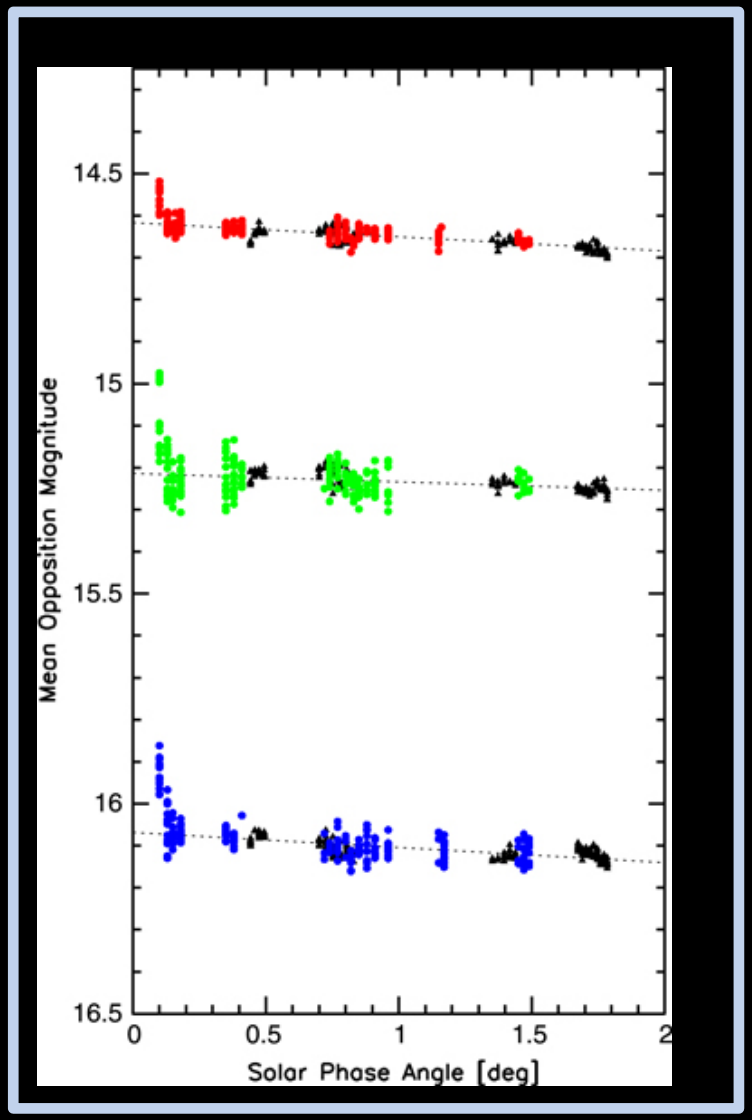
Buratti et al. Ap. J. Lett
2019 accepted
Model: J. Hillier

Pluto's and Charon's phase curve at small phase angles prior to "true opposition" in July 2018 at a 161-year low of 0.0061°

Buie et al. 2010 (HST)



Buratti et al. 2015 (combined; Table Mt. Observatory)



Palomar Adaptive Optics (JHK) Observations 2018

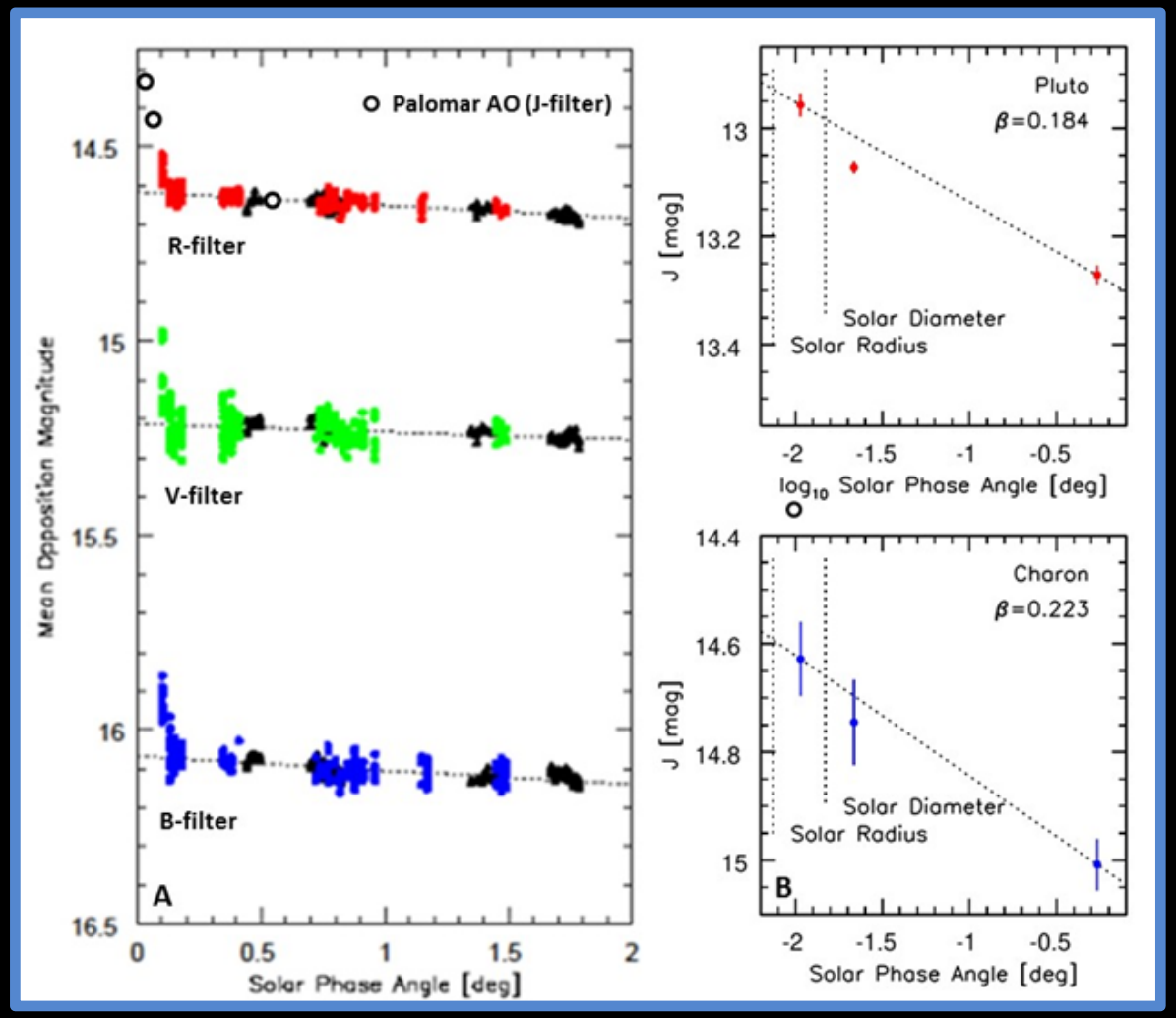
1.2, 1.6, 2.2µm

Time (civil)	Solar phase angle	Longitude	Comments
July 11, 2018	0.008	35	See typical image below
July 12	0.022	340	Lowest phase in 161 years
July 29	0.51	105	Cirussy
July 30	0.54	50	

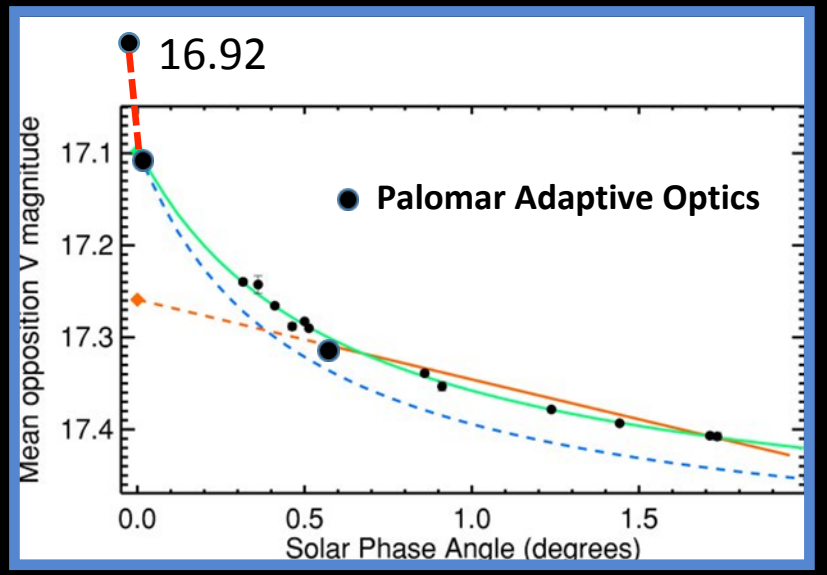
Data analysis: standard, plus on-chip standards from the 2MASS catalogue (Aladin)

July 2018 observations (J-band, 1.2 μm)

Pluto:



Charon:



Conclusions so far and upcoming observations

- **The surge in J filter is about 30% between a solar phase angle of 0.54° and opposition (phase angle of 0°) for both Pluto and Charon; about double that observed on icy moons; not enough data yet to model**
- **The surge in K filter is also about 30%**
- **Within the errors, there is no color dependence**
- **This work (including the *New Horizons* data) is the first observation and analysis of a non-water icy body (Pluto): how do its surface properties compare?**
- **We have 6 nights between May and July 2019. Thanks to Palomar TAC for awarding us all our requested time!**

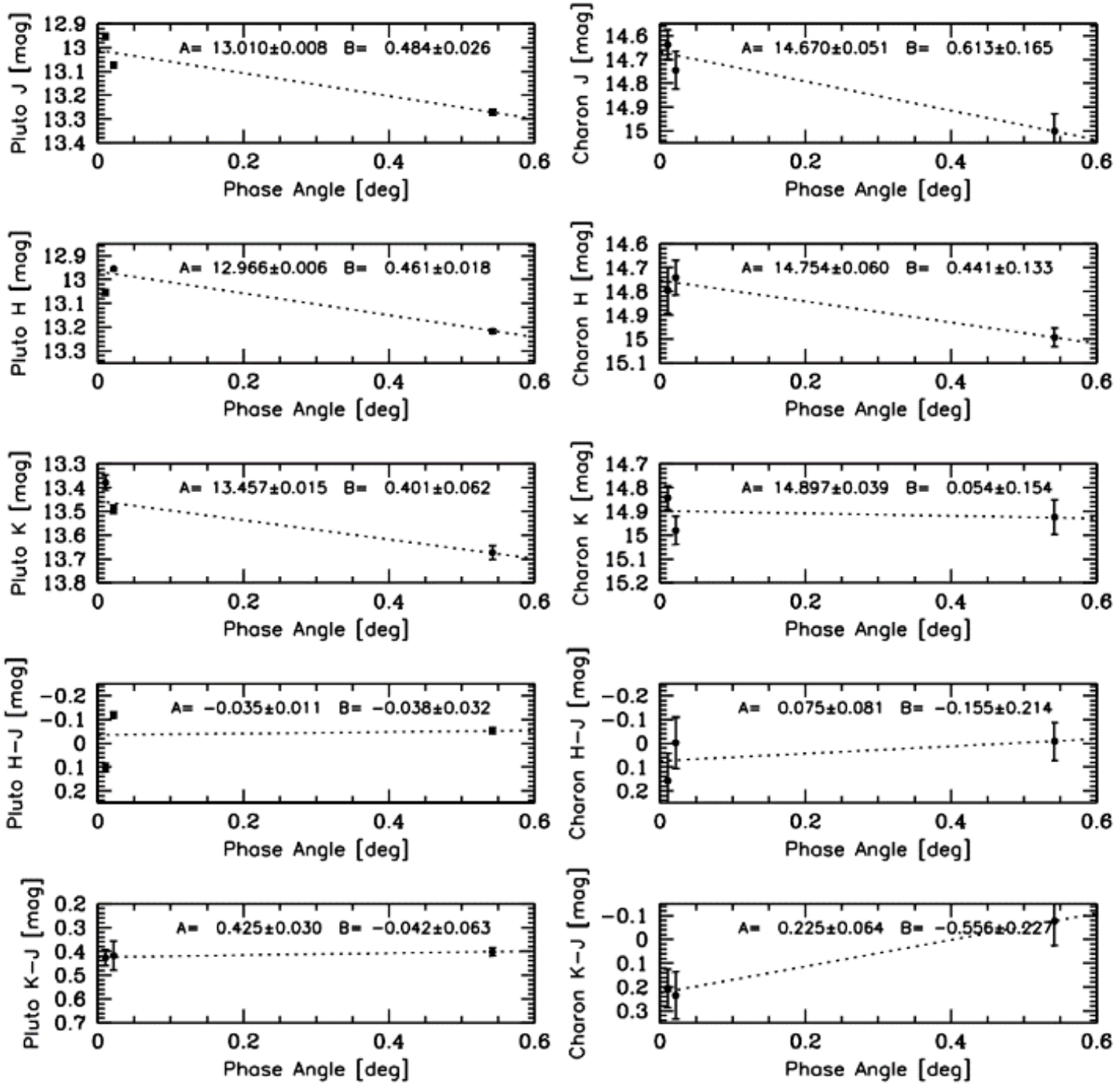
Summary so far

Look here Not here

The surge in J filter is about 30%
between 0.54° and opposition
For both Pluto and Charon

The surge in K filter is also about 30%

Within the errors, no color dependence



Requests for 2019: All were granted! (One each from the lilac squares, and July 12 and 13, 2019 for six nights). We will need observations in 2020 to complete this project; AO being refurbished right after opposition.

Phase angle, α(°)	Heart of Pluto (135-225°; subobserver surface longitude)	"Antiheart" (0-100°)	Comments
~1.7°	Not visible this period	Not visible this period	
~1.5°	May 15	Not visible this period	
~1.0°	May 28,29; June 4,10,11	May 26, 31, June 1,7,13	
~0.1-0.5°	June 23,29; July 6	July 2,3; June 26,27	Antiheart already obtained on July 30-31 (UT), 2018
~0°	July 12, 13 Need both half nights	Already obtained 38°, as well as 340°, the region between heart and antiheart	Require both half nights of July 12,13; This is the most important, unique observation; lowest phase angle on July 13