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# Supplementary Materials for

## Pluto's interaction with its space environment: Solar wind, energetic particles, and dust

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**This PDF file includes:**

## Materials and Methods

VBSDC operations summary

New Horizons typically operates to face SDC in the direction of motion of the spacecraft (ram). SDC consists of 14 permanently polarized Polyvinylidene-fluoride (PVDF) films. Each film is 14.2 cm x 6.5 cm x 28 $\mu$m with conducting contacts on both surfaces [*5*]. The PVDF films work by detecting the change in charge density on the surface of the detectors due to the excavation of material from permanently polarized PVDF from dust impacts [*57*, *58*]. PVDF exhibits both pyro-electric and piezoelectric properties and is affected by both changes in temperature and acoustic noise aboard the spacecraft from thruster firings and other mechanical operations [*57*]. For this reason, SDC was designed with two additional detectors mounted on the backside of the instrument that remain unexposed to dust. These two detectors serve as the 'reference' or 'control' detectors, while the 12 forward facing channels serve as the 'science' detectors. By taking the difference in rates between the science and reference sides, a true impact rate is calculated.

SDC has had a nominal threshold for detecting impact generated charges Q ~ $5 \times 10^5$ *e*, corresponding to a particle radius of $r \sim 0.5$ $\mu$m, assuming a characteristic density $\rho = 2.5$ g/cm$^3$ [*59*]. As the impact generated charge is a function of both the speed and the mass of the impacting dust particles, the SDC charge threshold corresponds to a slowly increasing smallest detectable dust size, due to the slowdown of New Horizons. Figure 6 shows all of the SDC recorded signals that were single events, and non-coincident with thruster firings. The density of interplanetary dust particles is estimated by subtracting the impact rates detected on our reference from the science channels.

## Supplementary Text

Dust density estimate in the Pluto system

To estimate the dust density *n* near Pluto we calculate the total volume *V* carved out by SDC through the encounter

$$V = \int_{t_1}^{t_2} A\big((\mathbf{v}_{\mathrm{sc}} - \mathbf{v_d}) \cdot \hat{\mathbf{n}}, t\big) |\mathbf{v}_{\mathrm{sc}} - \mathbf{v_d}| \; dt \qquad \text{Eqn. 3}$$

where $\mathbf{v}_{sc}$ is the spacecraft velocity vector, $\mathbf{v}_d = 0$ is the dust velocity, $\hat{\mathrm{n}}$ is the unit normal vector to SDC's sensitive surface area *A* . Through the ±5 days, SDC carved out a total volume of $V \sim 0.83$ km$^{-3}$. Following counting statistics (Figure S2), the probability of detecting exactly one particle as function of the dust density is

$$P = (\mathrm{n}V)e^{-(\mathrm{n}V)} \qquad \text{Eqn. 4}$$

indicating a most likely density of 1.2 km$^{-3}$, and a 90% confidence level for the density to be in the range of $0.6 < n < 4.6$ km$^{-3}$.

**Fig. S1.**

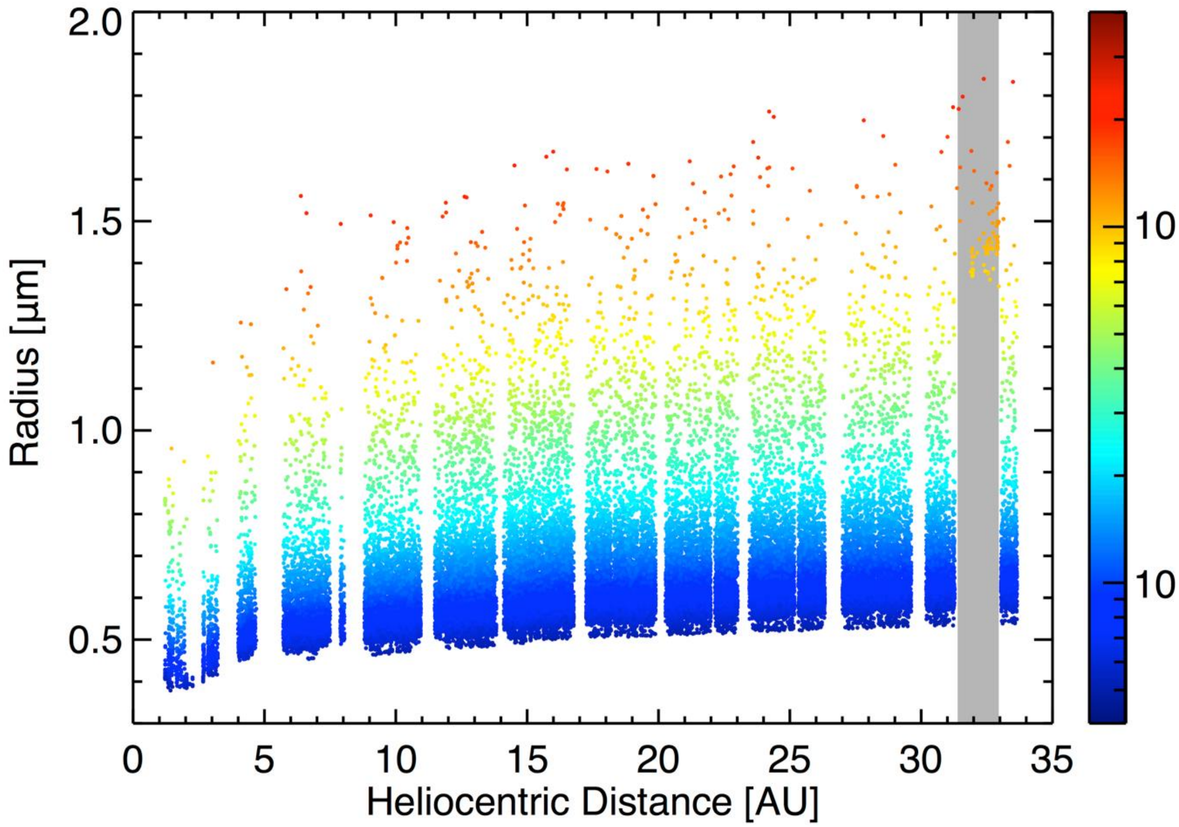


***Fig.S1. Dust impact events since launch.*** *The SDC recorded candidate events since April 2006 as function of distance from the Sun. The color code represents the impact-generated charge, and the size of the corresponding dust particle is calculated based on laboratory calibrations [5]. The intermittent short data gaps are due to periods when SDC was not operating. The gray bar indicates the period (2014-364 to 2015-211) when SDC was set to higher thresholds to minimize its noise susceptibility during the Pluto encounter.*

**Fig. S2**

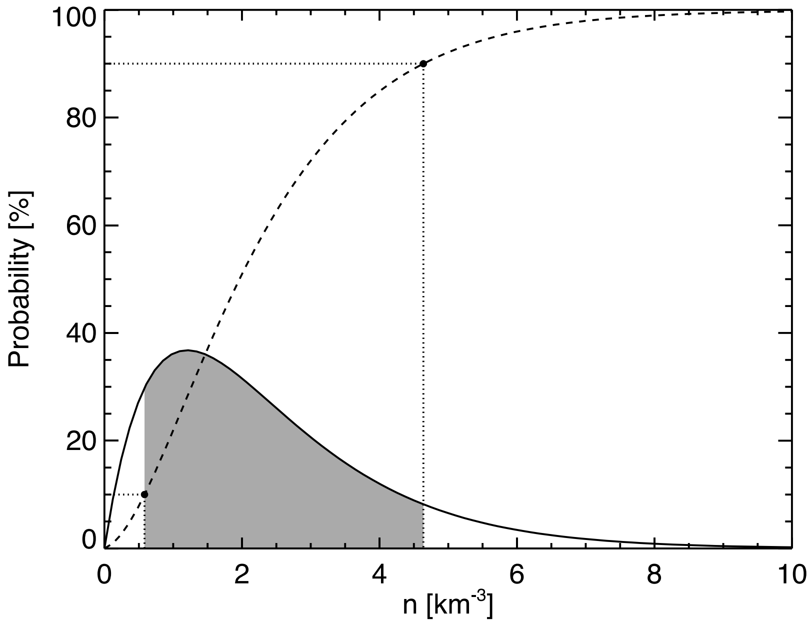


***Fig. S2. Statistics of Dust Detection.*** *The probability distribution (continuous line) and the cumulative distribution functions (dashed line) for detecting exactly one particle as function of the dust density near Pluto, indicating a most likely density of 1.2 km$^{-3}$, with a 90% confidence level for the density to be in the range of $0.6 < n < 4.6$ km$^{-3}$.*

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## References and Notes


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