https://ntrs.nasa.gov/search.jsp?R=20180002181 2018-05-23T00:56:10+00:00Z

DIRECT CHARACTERIZATION OF COMETS AND ASTEROIDS VIA COSMIC DUST ANALYSIS FROM THE DEEP SPACE GATEWAY.
M. Fries[1], K. Fisher[1]. [1]NASA Johnson Space Center, Houston TX 77059, Email: marc.d.fries@nasa.gov

Introduction: The Deep Space Gateway (DSG) may provide a platform for direct sampling of a large number of comets and asteroids, through employment of an instrument for characterizing dust from these bodies. Every year, the Earth traverses through debris streams of dust and small particles from comets and asteroids in Earth-crossing orbits, generating short-lived outbursts of meteor activity commonly known as "meteor showers" (Figure 1)[1]. The material in each debris stream originates from a distinct parent body, many of which have been identified. By sampling this material, it is possible to quantitatively analyze the composition of a dozen or more comets and asteroids (See Figure 2, following page) without leaving cislunar space.

The DSG would be well suited to this task, because the flux of material from these bodies is low. DSG could employ the instrument for the long time (several years) necessary to collect a statistically significant amount of material.

For the purposes of this abstract, the instrument will be referred to as Dust Analyzer (DA).

Science Description: The purpose of a DA in this concept is to analyze the elemental composition, and potentially isotopic composition, of comets and asteroids which generate significant meteor showers on Earth by analyzing dust from those bodies. The dust environment in cislunar space consists of a "sporadic" background with relatively steady flux and no clear parent body, periodic meteor shower-generating dust/debris originating from specific parent bodies, and possibly a small component of lunar-origin dust in the Moon's vicinity (which was the target of the LDEX instrument on LADEE[2]). Since the parent bodies of most debris streams are identified, analyzing the composition of dust in those streams is a direct measure of the composition of the parent asteroid/comet, and analyzing this dust will give us valuable new data on the composition of a large number of comets and asteroids with Earth-proximity orbits.

The measurements this instrument would produce would be of significant scientific interest to the meteoritics, planetary astronomy, and planetary science communities. First off, the data will give valuable insight on the nature of previously unvisited comets and asteroids. Secondly, NASA maintains a Cosmic Dust collection composed of material collected using high-altitude aircraft, but the parent bodies of that material are poorly constrained. DA measurements collected from DSG would substantially improve the scientific value of the NASA Cosmic Dust collection by identifying the composition of the various bodies that contribute to Earth's cosmic dust inventory, allowing correlation between individual dust particles and comets and asteroids.

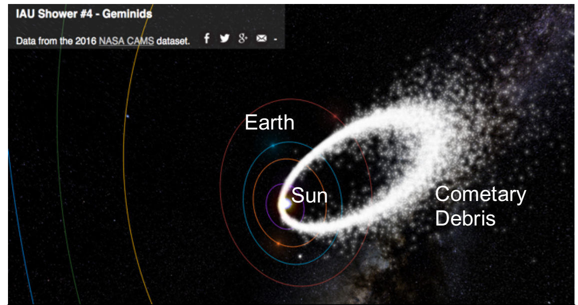

Figure 1: Still image from an animation showing the motion of cometary debris. The white material represents dust and small debris from asteroid 3200 Phaeton, the parent body for the Geminid meteor shower. These debris cross Earth's orbit and can be sampled directly, allowing analysis of the composition of 3200 Phaeton without leaving cislunar space. Similarly, the composition of all cometary and asteroidal parent bodies that cause meteor showers on Earth can be analyzed. Source: American Meteor Society, using NASA CAMS data.

Instrument Operations: The DA would need to 1) measure elemental, and possibly isotopic, composition of dust from periodic meteor showers, 2) discern periodic dust from the sporadic background, and 3) collect a statistically useful number of dust measurements. The former will require collecting material from a given debris stream, which probably necessitates the capability to gimbal the instrument so it is pointed into the radiant of an active shower. Meeting the latter requirement will necessitate collection over a long time, probably a period of several years.

Dust analyzer instruments have very high heritage. Previous missions that have included a dust analysis capability include Cassini-Huygens[3], Stardust [4], Rosetta[5], LADEE[2], New Horizons[6], Ulysses[7], and Galileo[8].

Dust from these debris streams enters cislunar space at velocities between ~30-80 km/s. This is too high for collection with current methods, but actually facilitates analysis by a DA instrument. Dust strikes the DA's target plate at high velocity and to produce an ionized gas. The ions travel to a charged detector, producing a time-of-flight detection of the mass and relative abundance of the particles. This allows measurement of the bulk composition of the particles from an identified parent body.

Resources Needed: If we assume DA is similar to the Cassini Dust Analyzer (CDA) [3], the instrument will require approximately 0.5 kbits/s data rate, a peak operating power of 20 W, and average power of 12 W. Dimensions of CDA are 81x67x45 cm with a mass of ~17 kg. DA will be placed on the outside of the spacecraft with a view of the sky that is preferentially unobstructed by hardware. This is offered as an example; actual requirements and parameters of the necessary instrument should follow from a more detailed study.

Meteor Shower	**Parent Body**
Quadrantids	C/1490 Y1, 2003 EH_1
Lyrids	Comet Thatcher
Pi Puppids	Comet 26P/Grigg-Skjellerup
Eta Aquariids	Comet 1P/Halley
Arietids	Comet 96P/Machholz
June Bootids	Comet 7P/Pons-Winnecke
Southern Delta Aquariids	Comet 96P/Machholz
Alpha Capricornids	Comet 169P/NEAT
Perseids	Comet 109P/Swift-Tuttle
Kappa Cygnids	Asteroid 2008 ED69
Draconids	Comet 21P/Giacobini-Zinner
Orionids	Comet 1P/Halley
Southern Taurids	Comet 2P/Encke
Northern Taurids	Minor planet 2004 TG_{10}
Andromedids	Comet 3D/Biela
Alpha Monocerotids	unknown
Leonids	Comet 55P/Tempel-Tuttle
Phoenicids	Comet 289P/Blanpain
Geminids	Asteroid 3200 Phaeton
Ursids	Comet 8P/Tuttle

Figure 2: List of major meteor showers on Earth and their parent bodies. Material from all of these comets intersects Earth's orbit to produce meteor showers, and may be captured and analyzed to study the list of comets and asteroids on the right. Truncated from Wikipedia, "Meteor Shower".

References:[1] Jackson, A. A., and H. A. Zook. *Icarus* 97.1 (1992): 70-84. [2] Horányi, M., et al. *Space Science Reviews* 185.1-4 (2014): 93-113. [3] Srama, Ralf, et al. *The Cassini-Huygens Mission*. Springer Netherlands, 2004. 465-518. [4] Kissel, J., et al. *Science* 304.5678 (2004): 1774-1776. [5] Kissel, Jochen, et al. *Space Science Reviews* 128.1 (2007): 823-867. [6] Horanyi, M., et al. *New Horizons*. Springer, New York, NY, 2009. 387-402. [7] Grün, E., et al. *Astronomy and Astrophysics Supplement Series* 92 (1992): 411-423. [8] Grün, Eberhard, et al. *The Galileo Mission*. Springer Netherlands, 1992. 317-340.