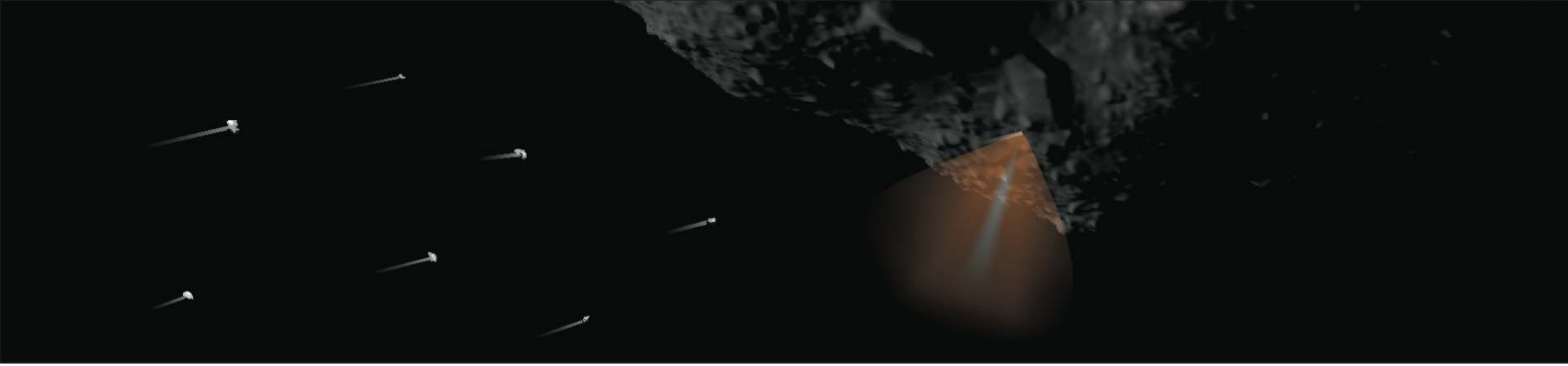


Meteoroid Impact Detection for Exploration of Asteroids (MIDEA): A concept for asteroid prospecting

Nicolas Lee and Sigrid Close

June 10, 2016

Meteoroids 2016, Noordwijk

Stanford University

Motivation

Stanford University

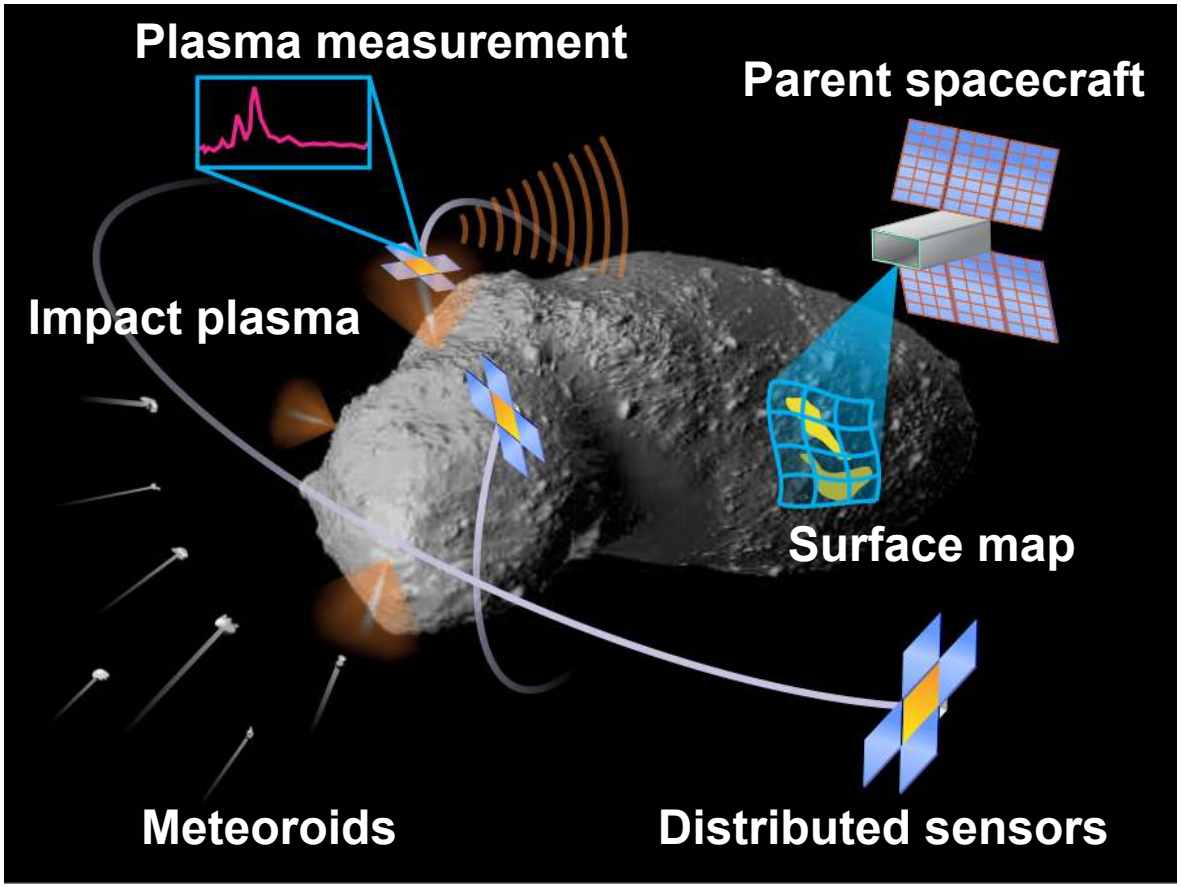
- **Solar system science**
  - Meteoroid and dust dynamics
  - Geology and chemistry of primitive bodies
- **In situ resource characterization/utilization**
  - Candidate asteroid selection for retrieval
  - Target surface regions for exploitation

NASA

Concept overview

Stanford University

- Use natural meteoroid population to probe asteroid surface through impacts
- Measure impact plasma to characterize surface



Concept overview

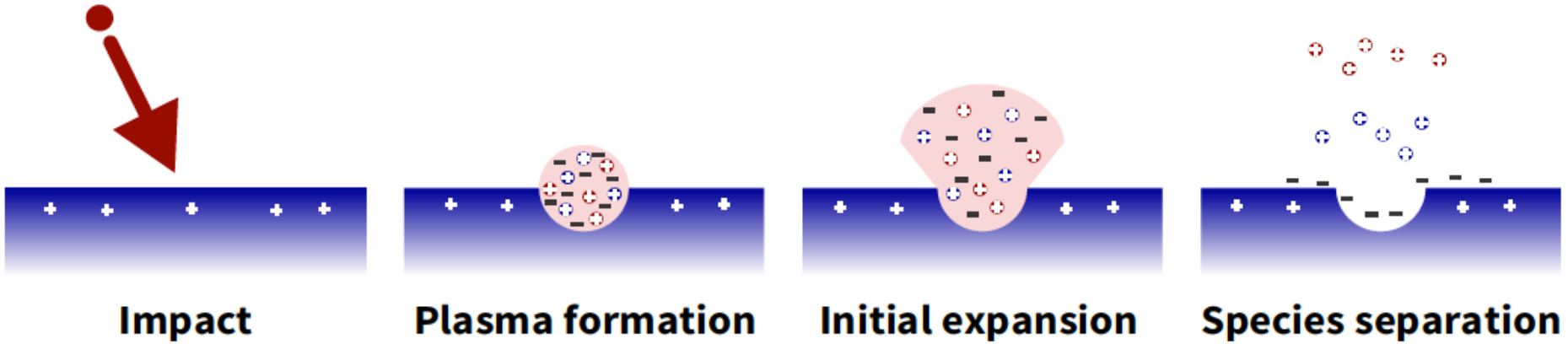
Stanford University

- **Meteoroid Impact Detection for Exploration of Asteroids: MIDEA**
- **Targeting 100–300 m asteroids**
- **Nanogram-sized meteoroid impactors**
- **Single small (6–12U) parent spacecraft to asteroid**
- **5–10 deployable free-flying sensors orbiting at 100–300 m altitude**

Hypervelocity impact

Stanford University

- Impact at speed greater than sound speed in the material
- Results in vaporization and ionization of the impactor and target



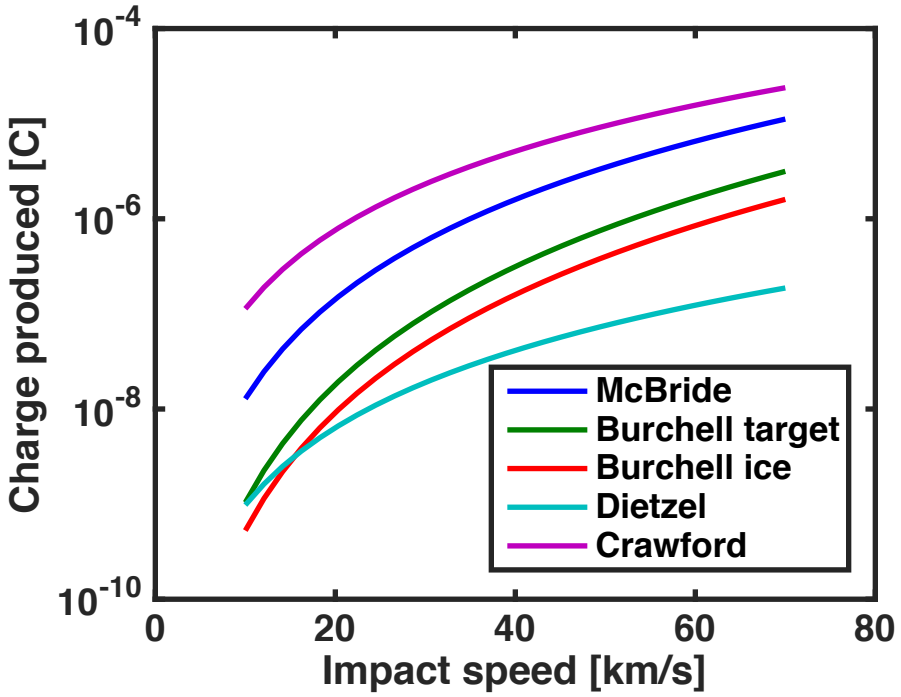
Impact ionization

Stanford University

- **Charge production based on power law**

$$Q = Cm^{\alpha} v^{\beta}$$

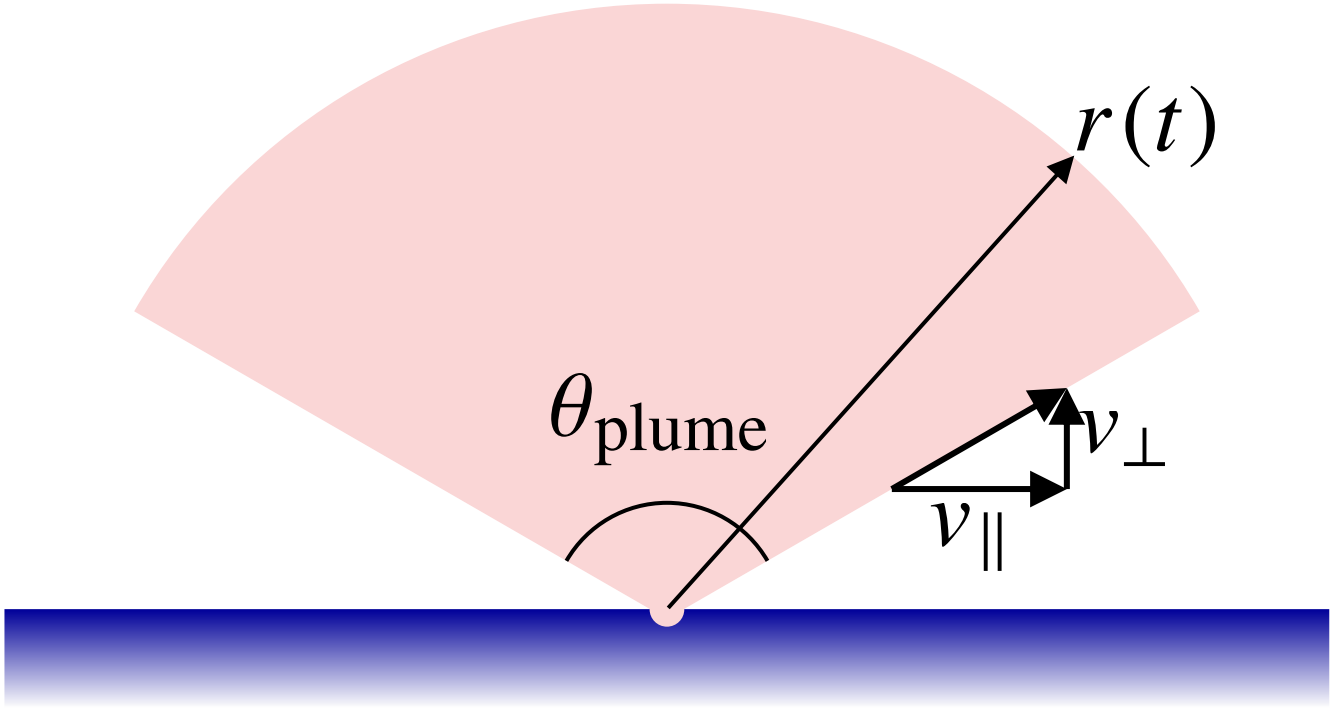
- **Wide range of experimental values obtained for C and β**



Plasma expansion

Stanford University

- Nearly hemispherical plume expanding at 20 km/s
- Density falls off with distance (inverse cubic)
- Expected detection threshold at about 300–500 m
- Determine composition through ion time-of-flight

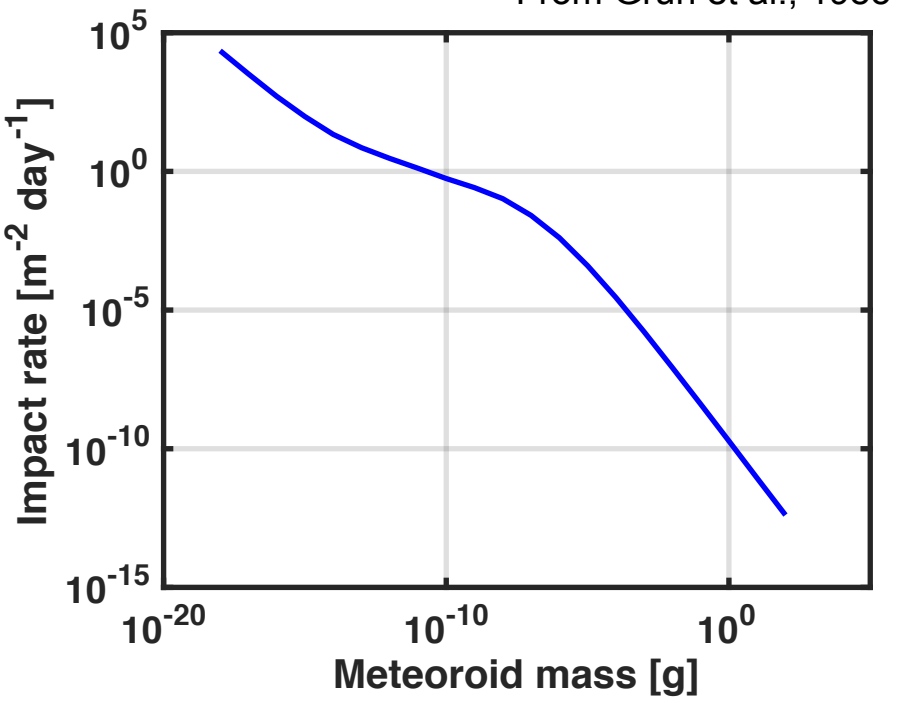


Grun interplanetary flux model

Stanford University

- **Applicable near 1 AU, 10^{-18} to 100 g**
- **Based on lunar craters, zodiacal light, in situ measurements**

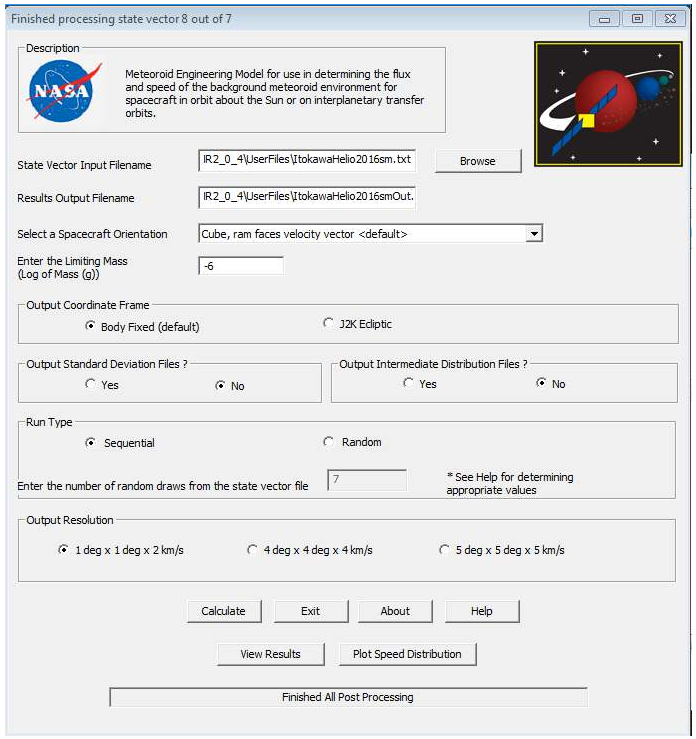
From Grun et al., 1985

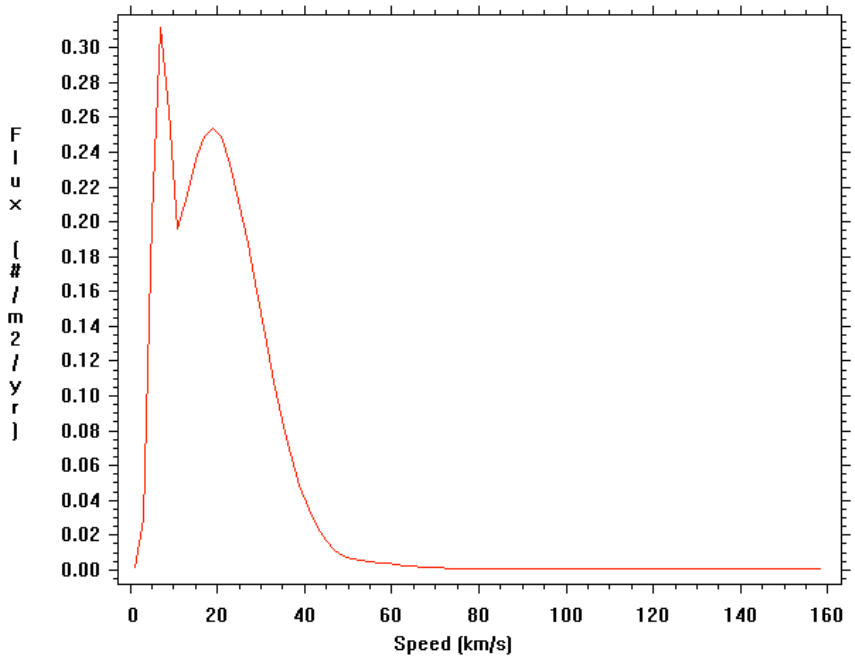


Meteoroid Engineering Model

Stanford University

- **Based on meteor radar, calibrated to Grun model near 1 AU**
- **Applicable from 0.2 to 2 AU, 10^{-6} to 10 g**
- **Would like to compare with IMEM**

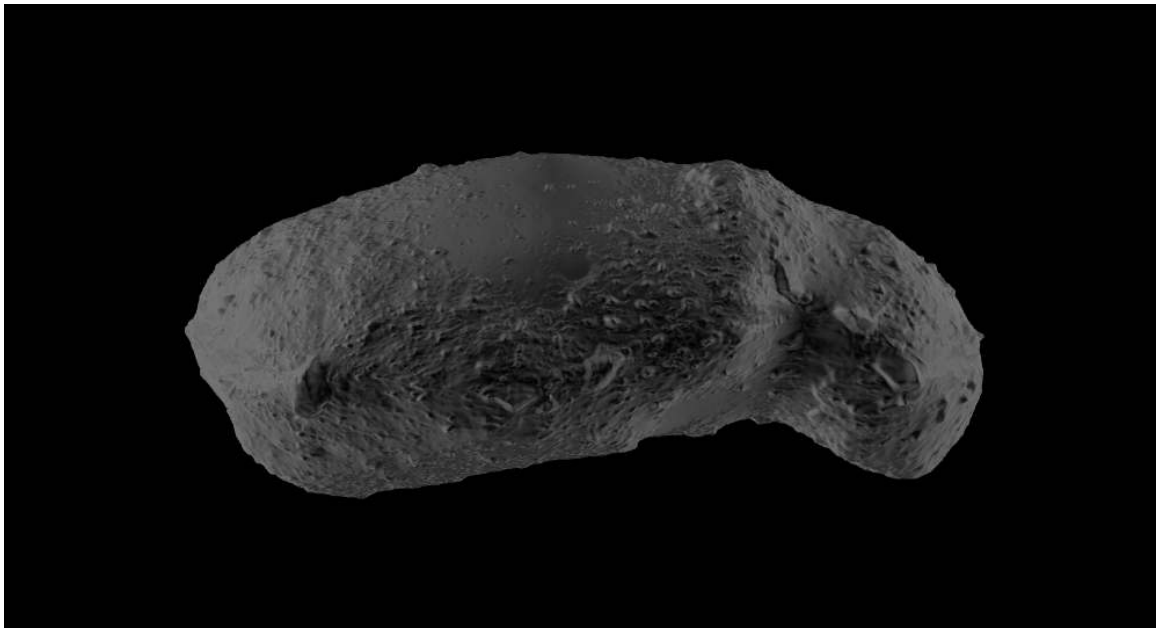




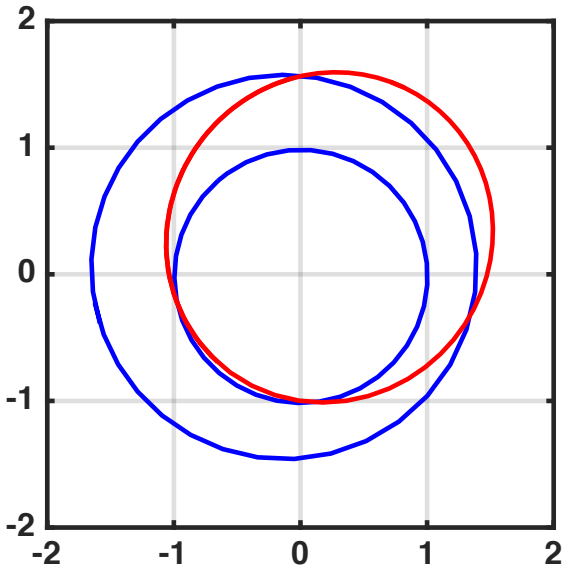
Reference asteroid: Itokawa

Stanford University

- Discovered in 1998, visited by Hayabusa in 2005
- S-type asteroid, possibly contact binary
- 535 x 294 x 209 m
- 0.95 to 1.7 AU orbit



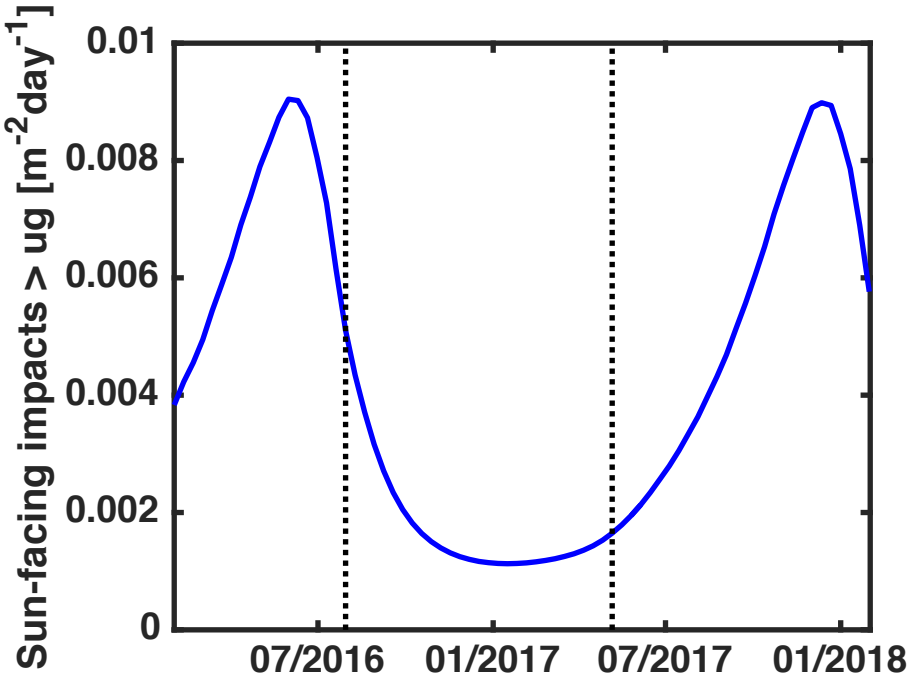
Generated from Gaskell Itokawa Shape Model

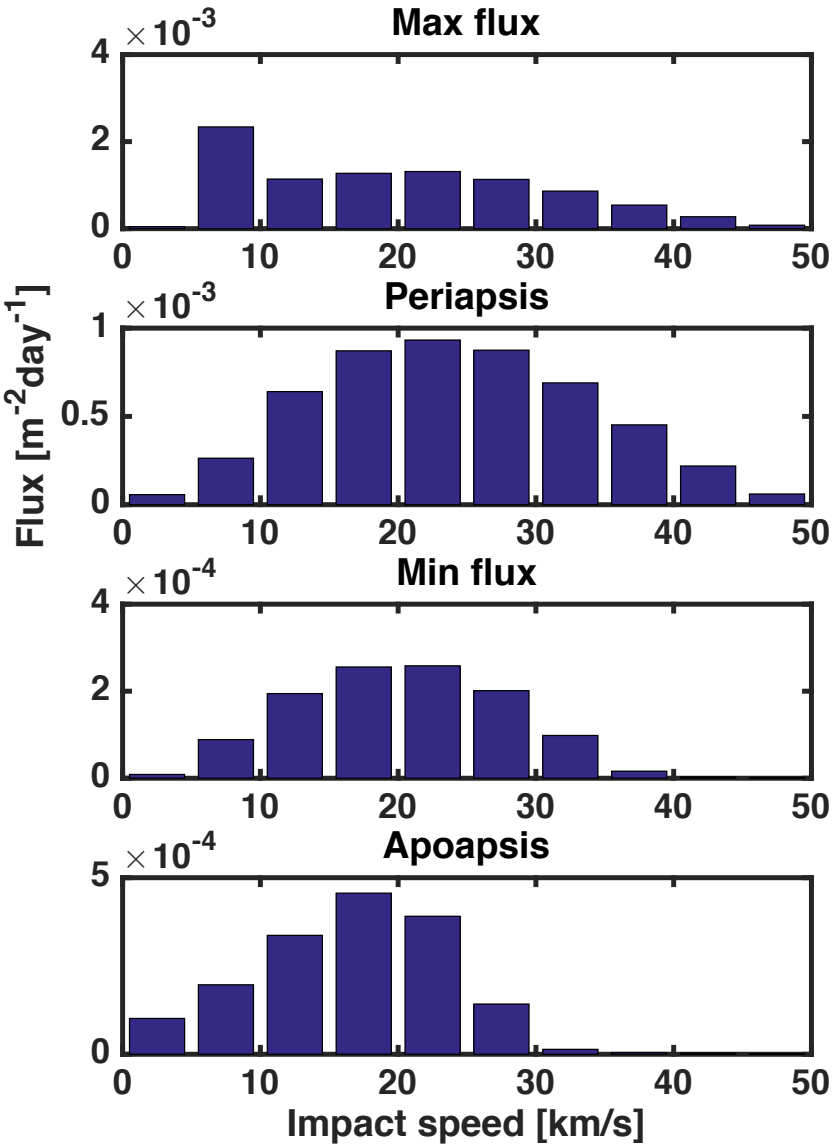


Itokawa meteoroid environment

Stanford University

- **Sun-facing flux**

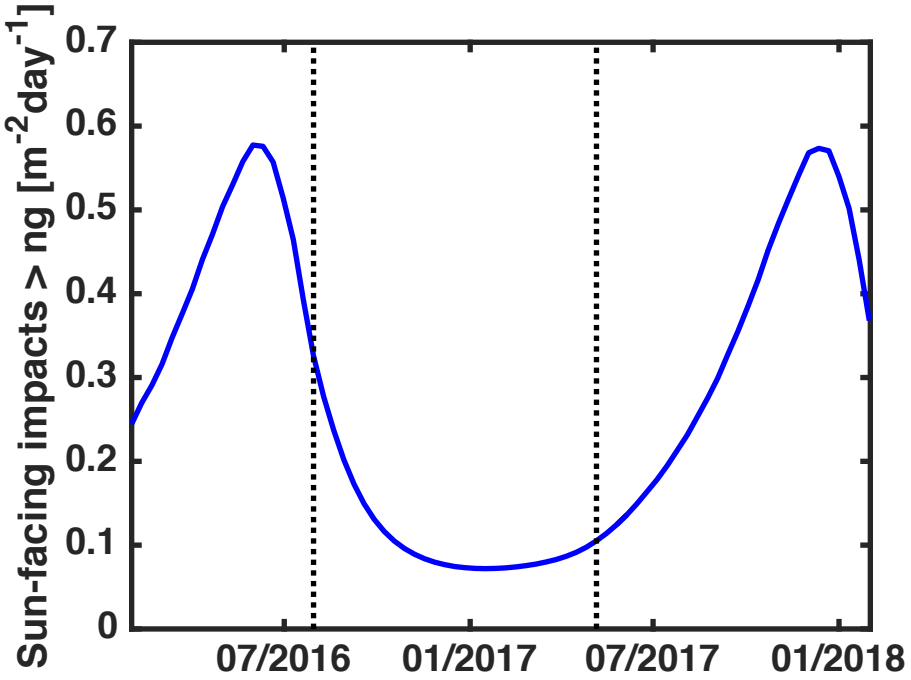




Itokawa meteoroid environment

Stanford University

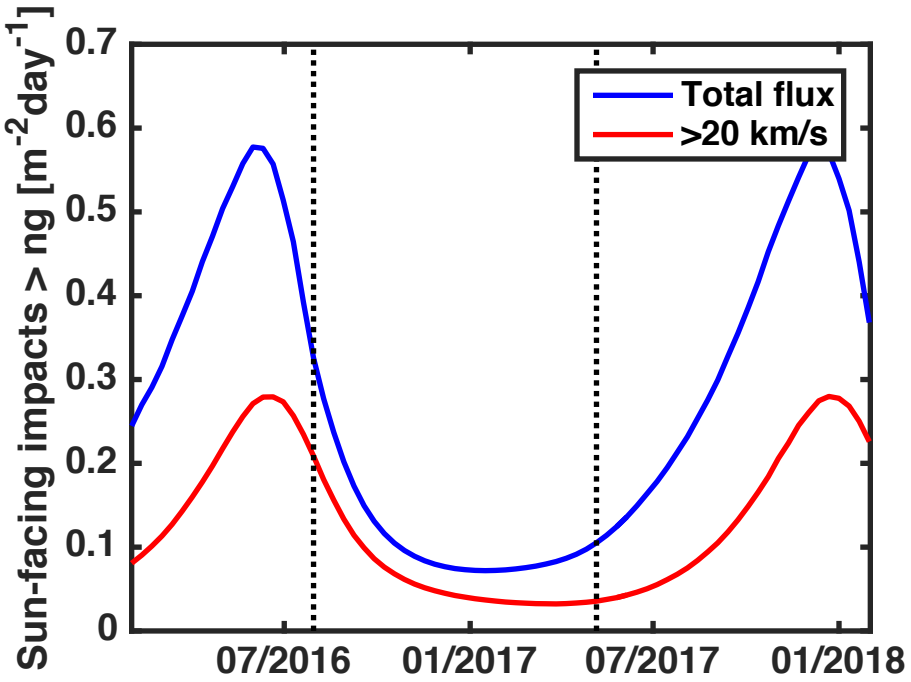
- **Sun-facing flux**
- **Scale from MEM microgram limit to nanogram (~5–10 μm) using Grun model**



Itokawa meteoroid environment

Stanford University

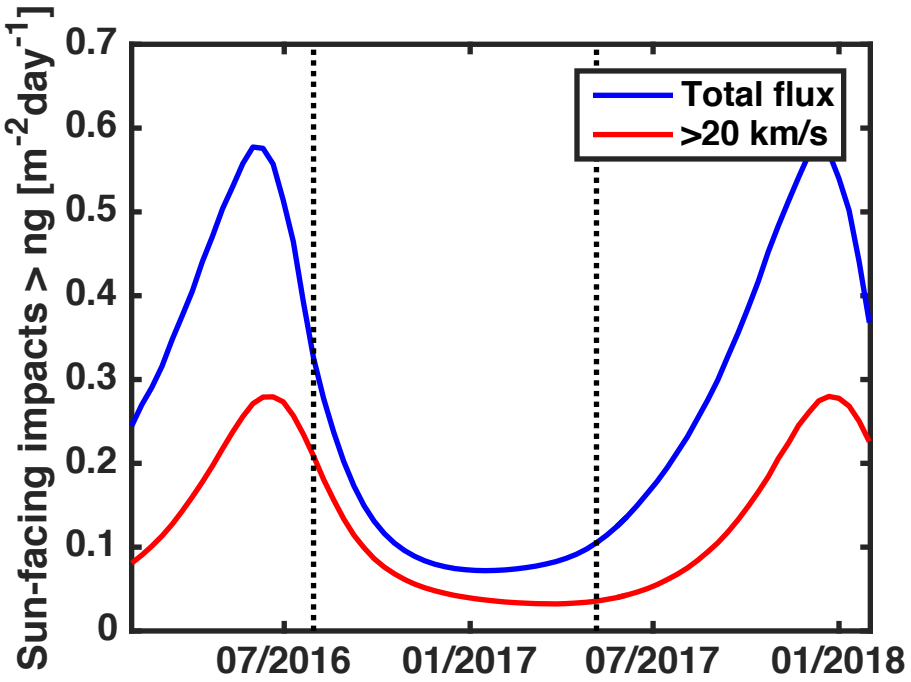
- Sun-facing flux
- Scale from MEM microgram limit to nanogram (~5–10 μm) using Grun model
- Apply velocity threshold of 20 km/s



Mission parameters

Stanford University

- 0.1–0.3 impacts per square meter per day
- One impact detection every few seconds
- Every square meter covered in 3–10 days



Potential meteoroid research

Stanford University

- Identification of new meteoroid streams intersecting asteroid path
- Determination of background flux
- Selection of asteroid targets corresponding to intersection with known meteoroid streams

Conclusions

Stanford University

- Meteoroids, typically treated as a threat, can serve as useful probes into composition of asteroids
- Nanogram-sized meteoroids impact at reasonably frequent rate
- Impact plasma sensors provide a low-mass/cost alternative to spectroscopy for preliminary exploration