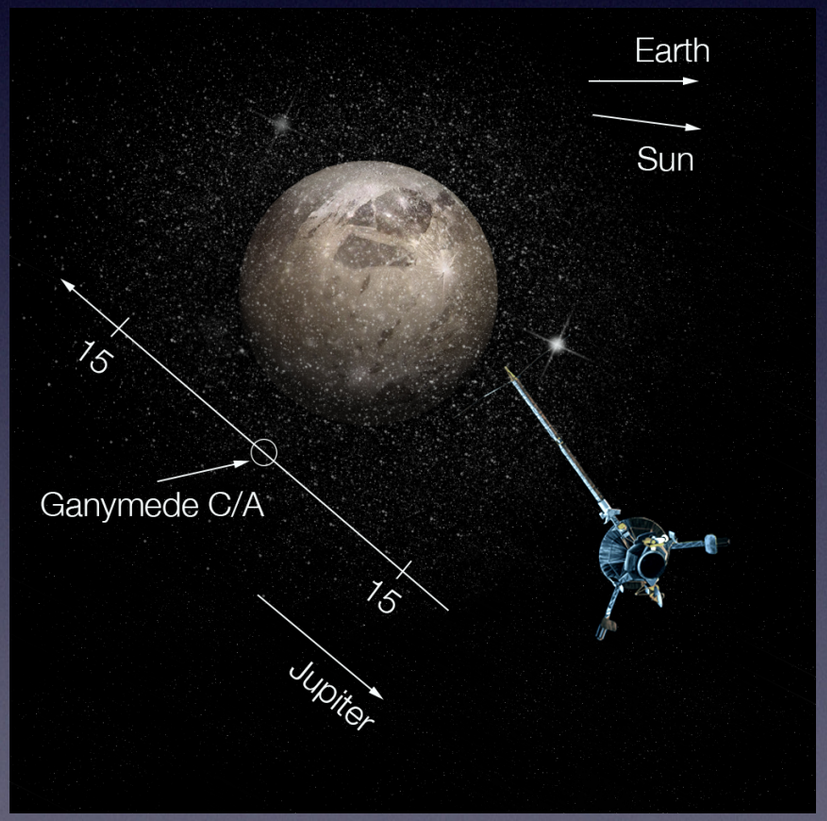

SUDA

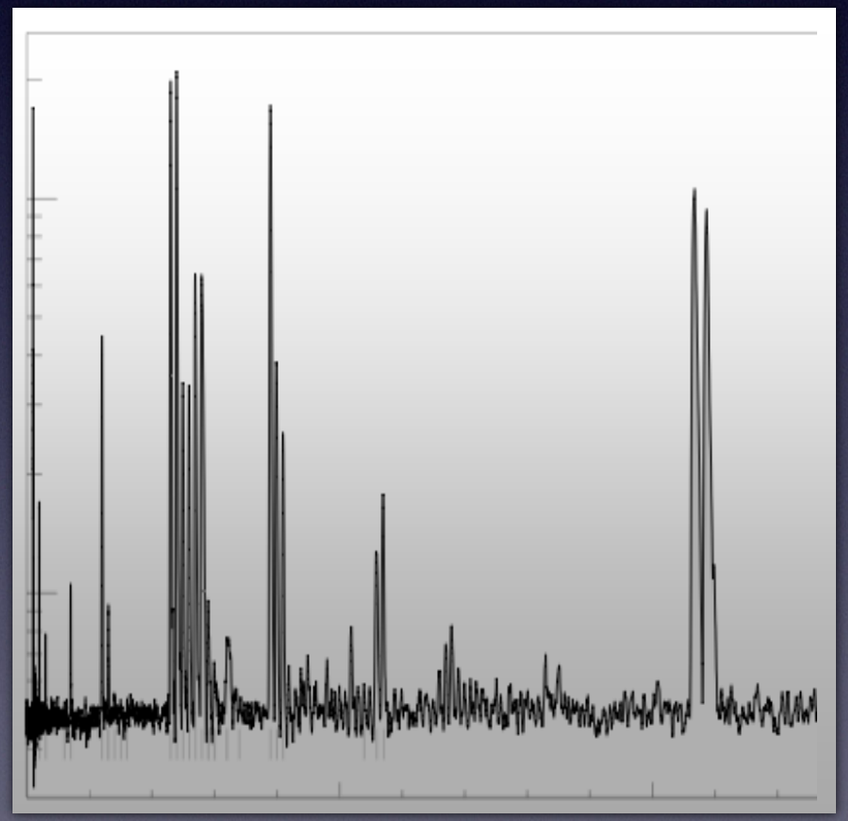
Compositional Mapping

Determine Surface Composition from Orbit „in-situ“

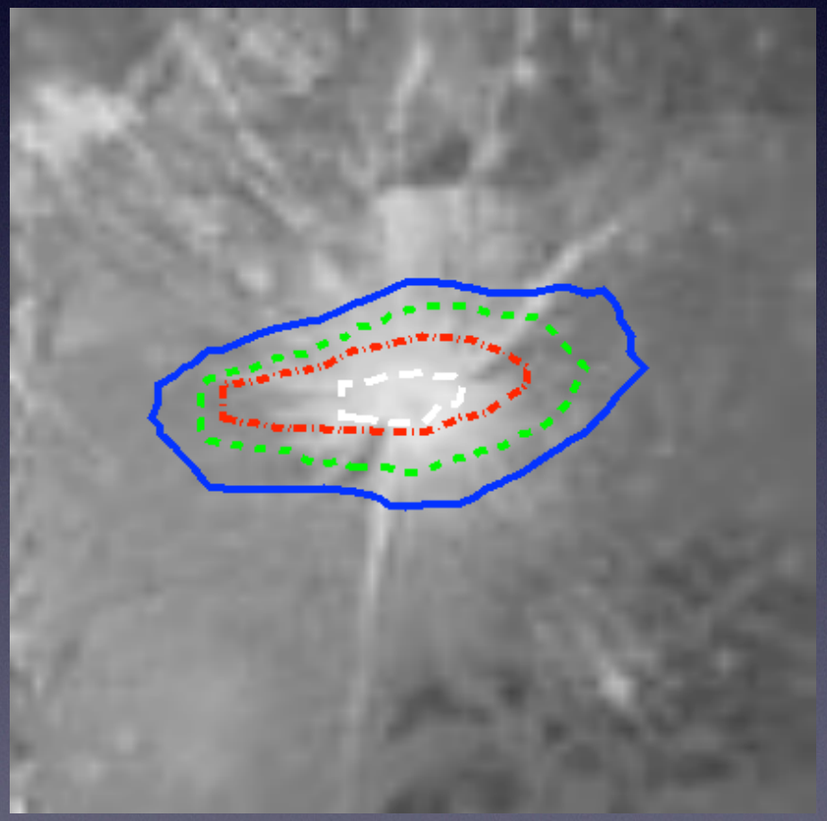
Ejecta Clouds



Ejecta Composition



Ejecta Backtracking

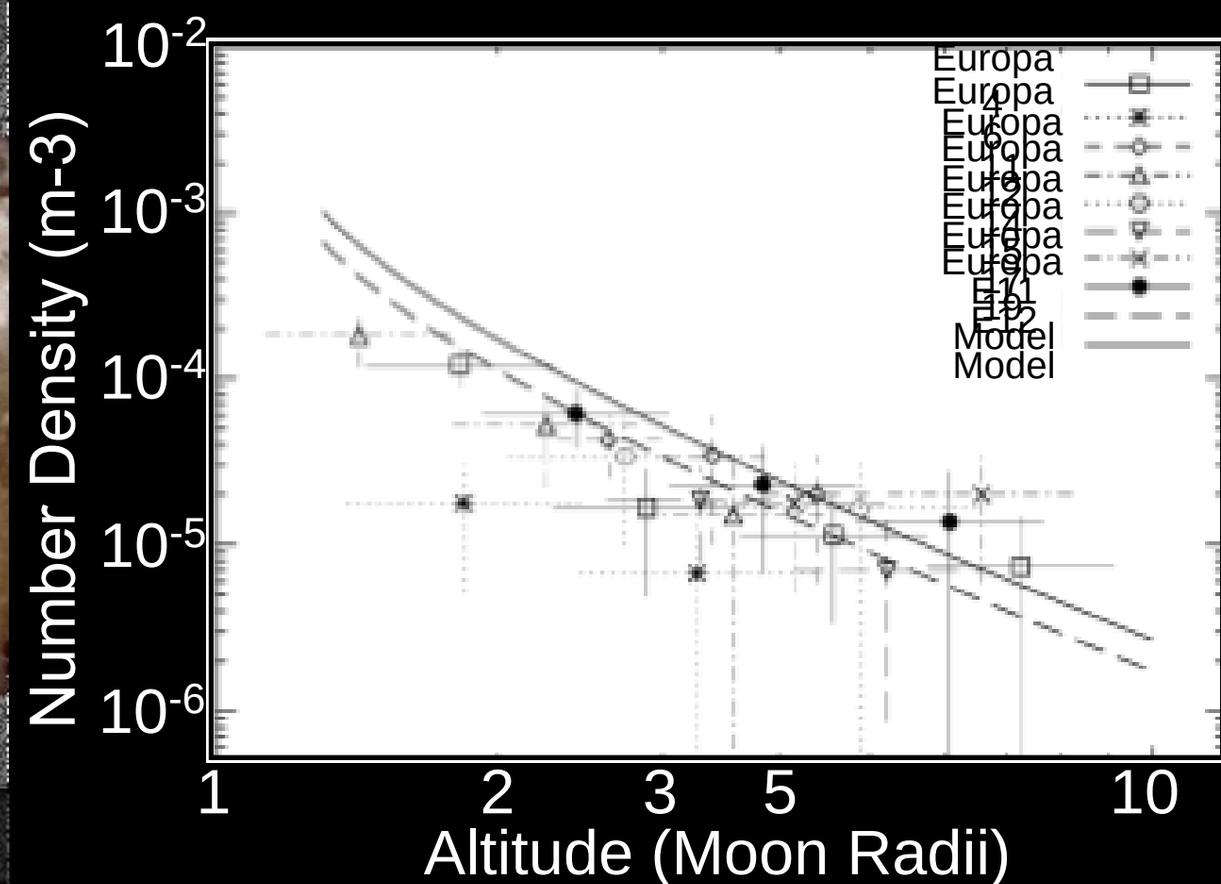


The Next Best Thing to a Lander

1: Ejecta Clouds

Galileo Dust Detector: Galilean Satellites Wrapped in Dust Clouds

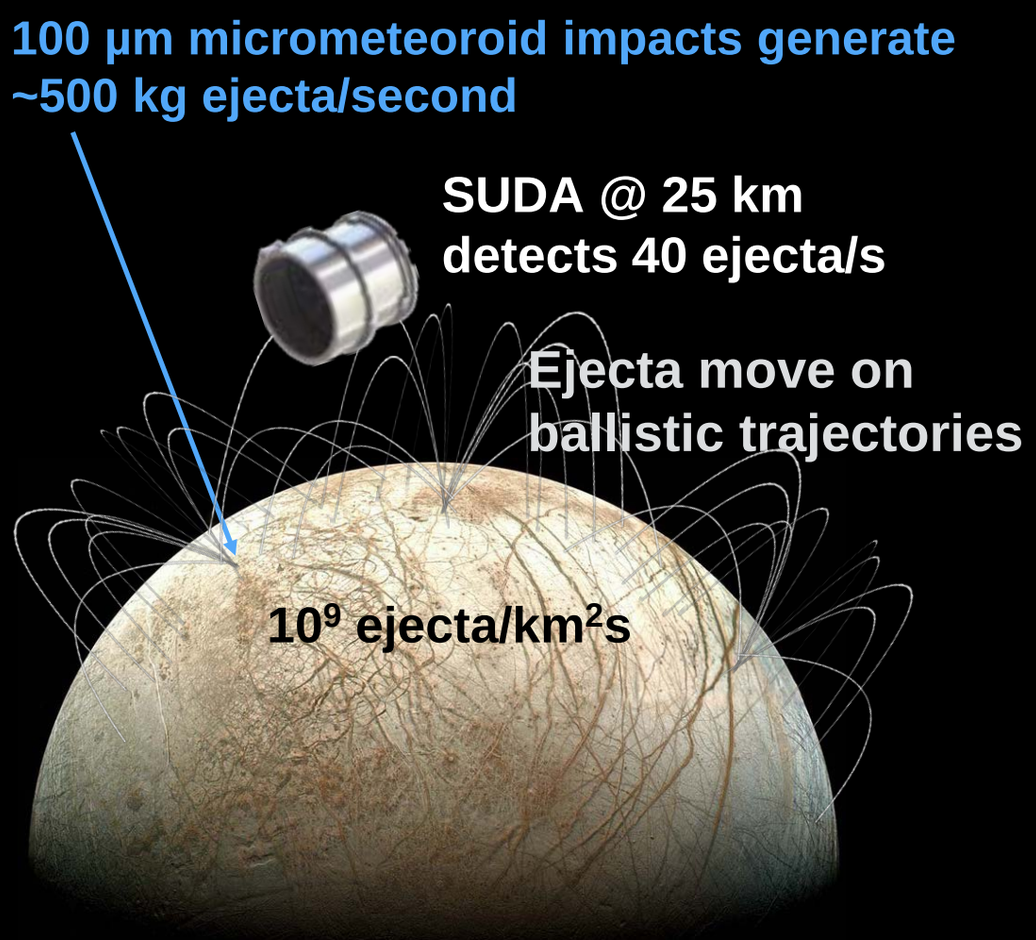
(Krüger et al., Nature, 1999)



Almost Isotropic Clouds Composed of Surface Ejecta

Ejecta Production

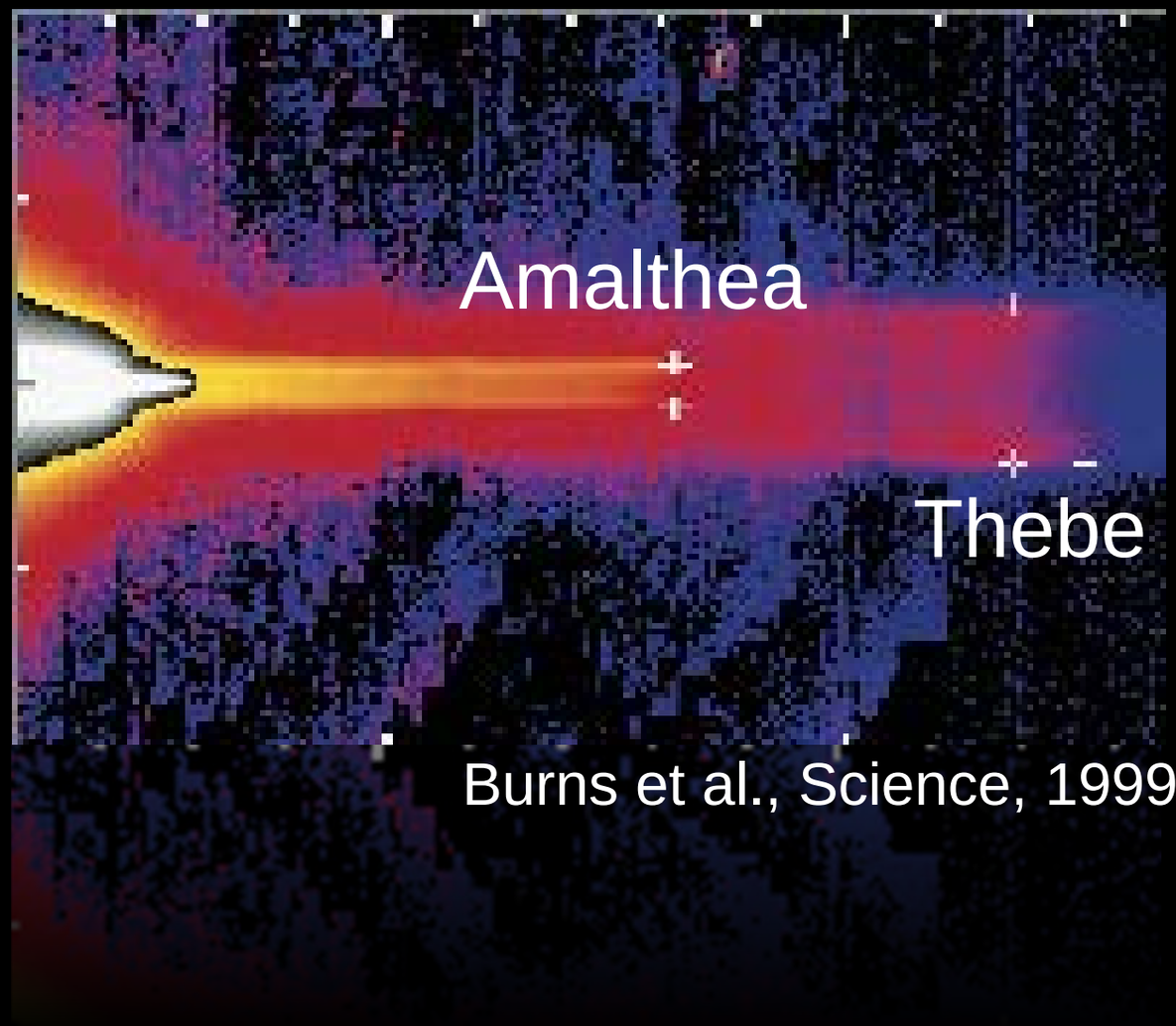
Meteoroid Impacts Produce Surface Ejecta



Mass Yield ~ 4000

Koschny & Grün, Icarus, 2001; Krivov et al., Icarus, 2003

Ejecta Escaping from Moon's Gravity feed Rings



Burns et al., Science, 1999

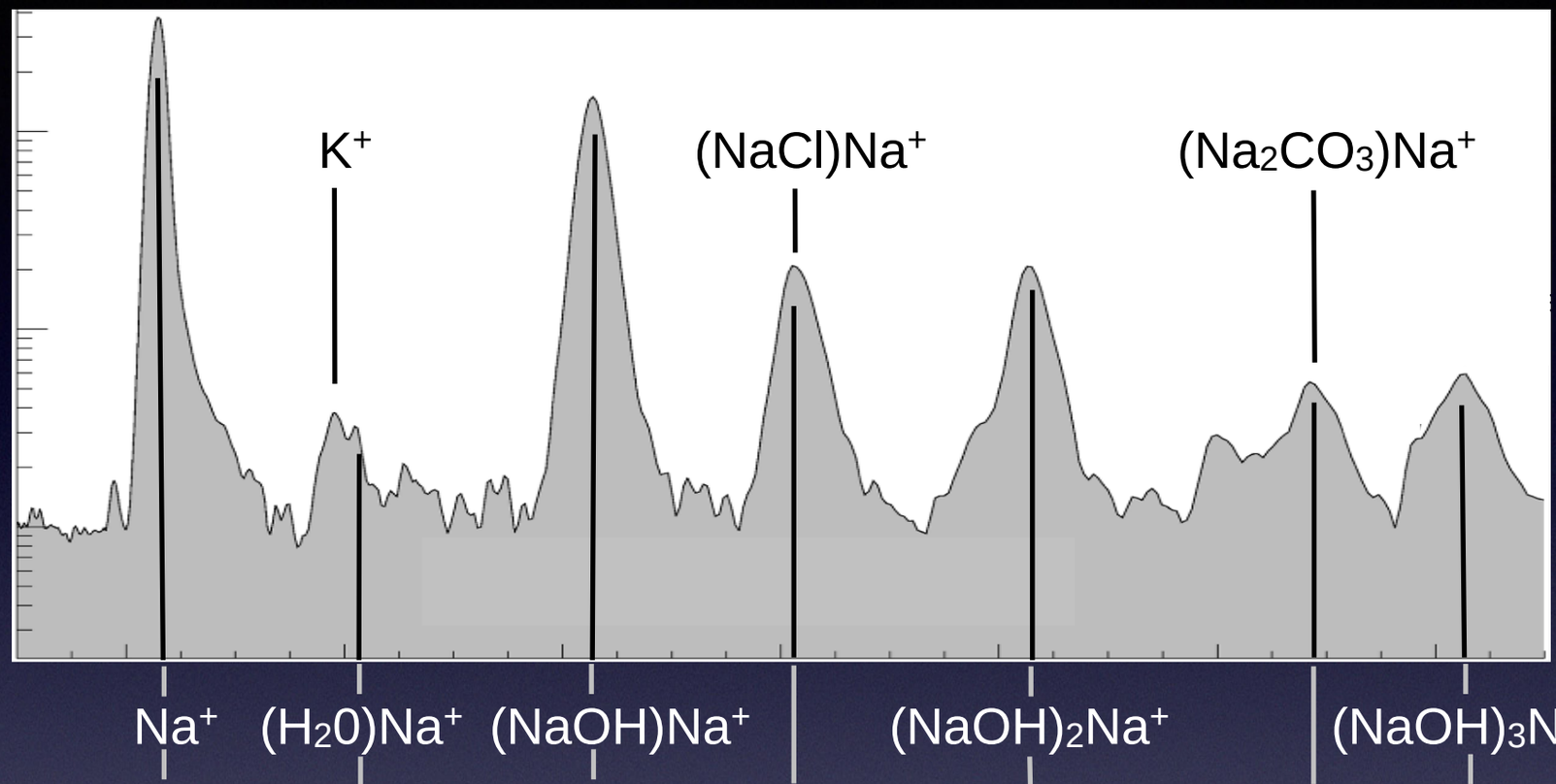
Dust Composition

Cassini Dust Detector
CDA

Composition of Enceladus
Plume Particles

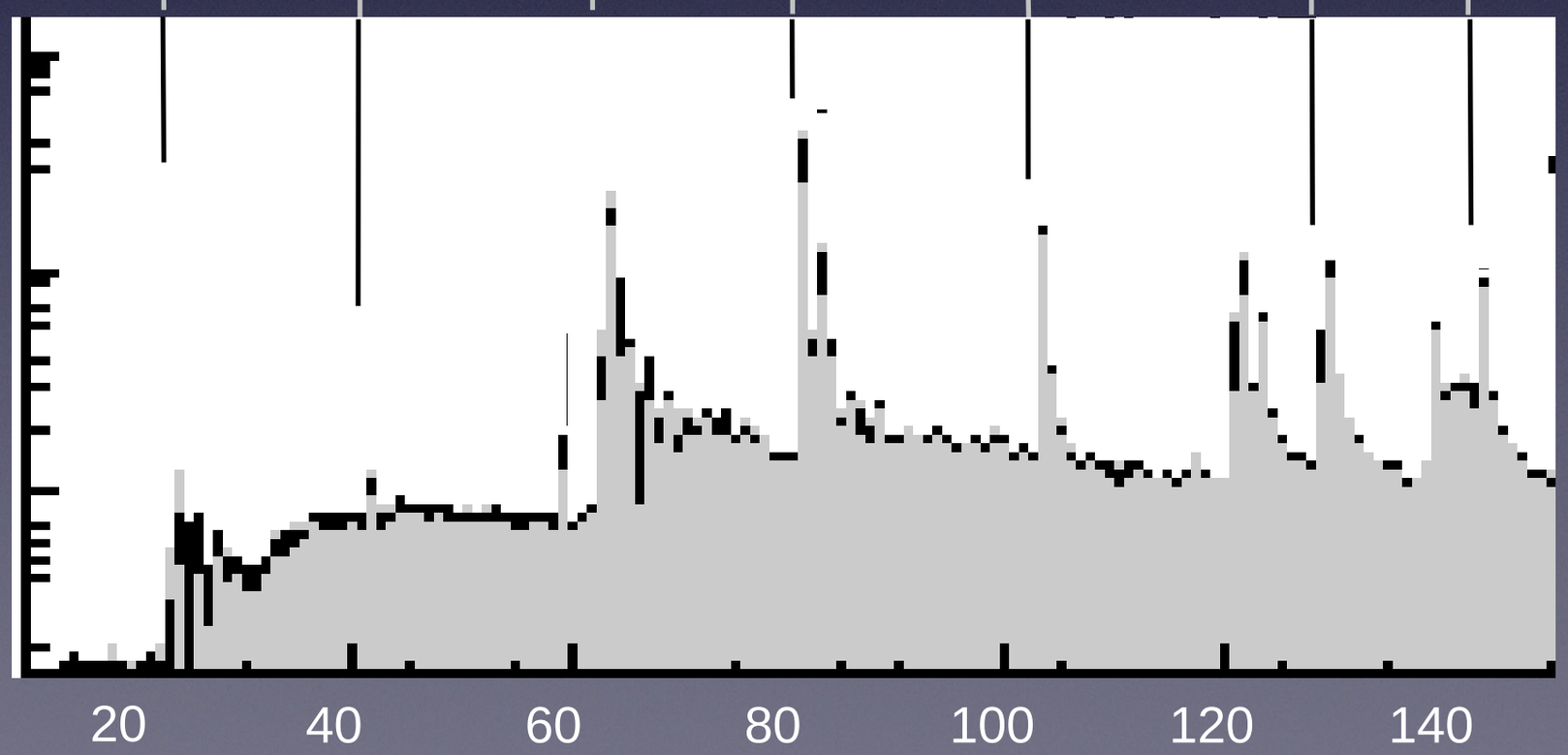
NASA/JPL/Space Science Inst.

Enceladus Dust Composition



Co-Added CDA Spectrum:

Salt-rich Geyser Ice Grains (6%)

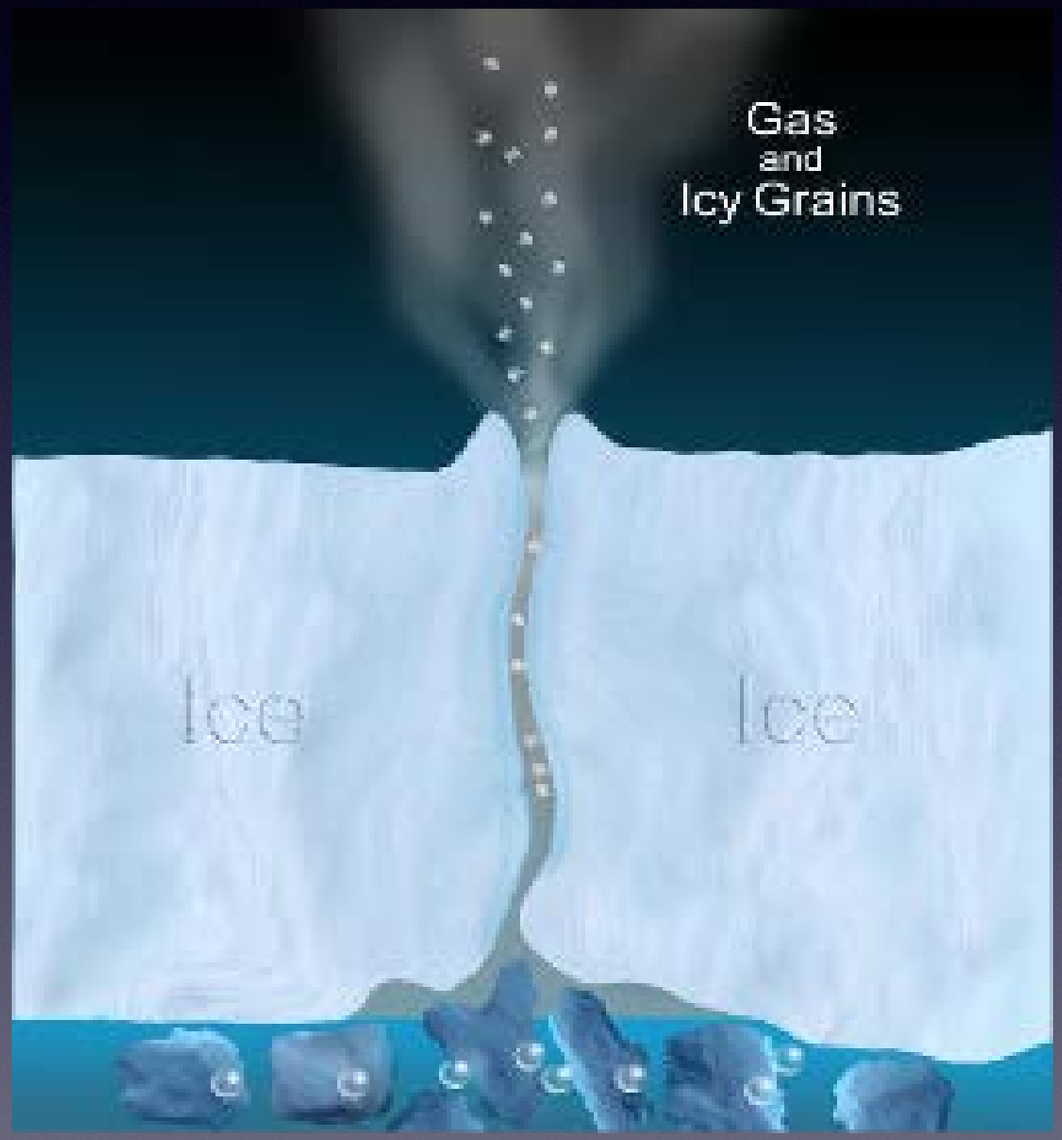


Lab Spectrum:

Laser Dispersion of Salt Water

Postberg et al., Nature, 2009

The Enceladus Ocean



„Soda“ Ocean

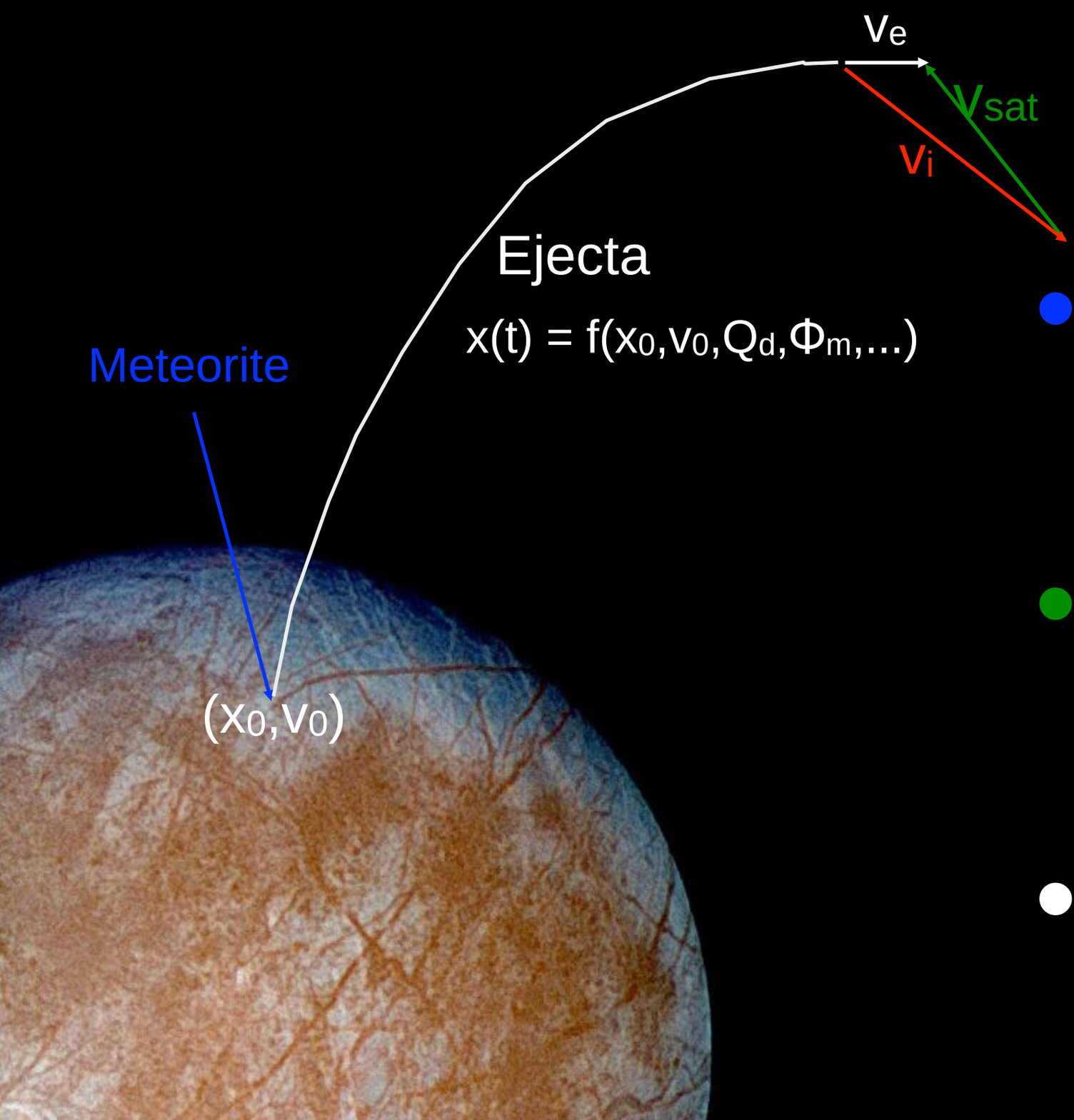
Rich in Carbonates

pH ~ 9

Salinity ~1% (Earth 1...4%)

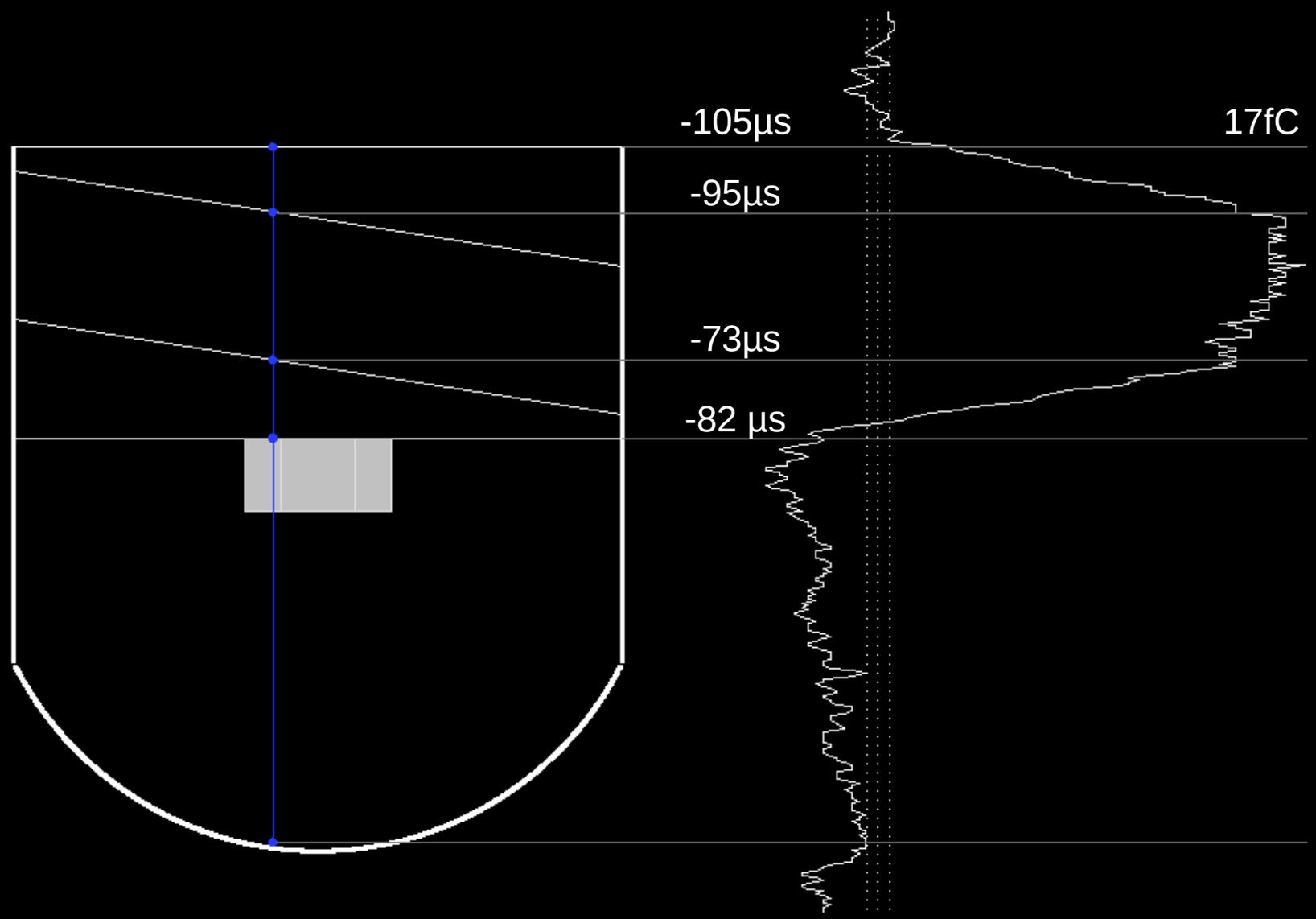
Postberg et al., Nature, 2009

Ejecta Backtracking



- Meteorite impact splashes up multiple ejecta
- Satellite moves relative to ejecta:
  $v_i = v_e - v_{sat}$ (≈Apex)
- Know Starting Position:
  $x_0 = f(x_i, v_i, Q_d(t_i), t_i, ...)$

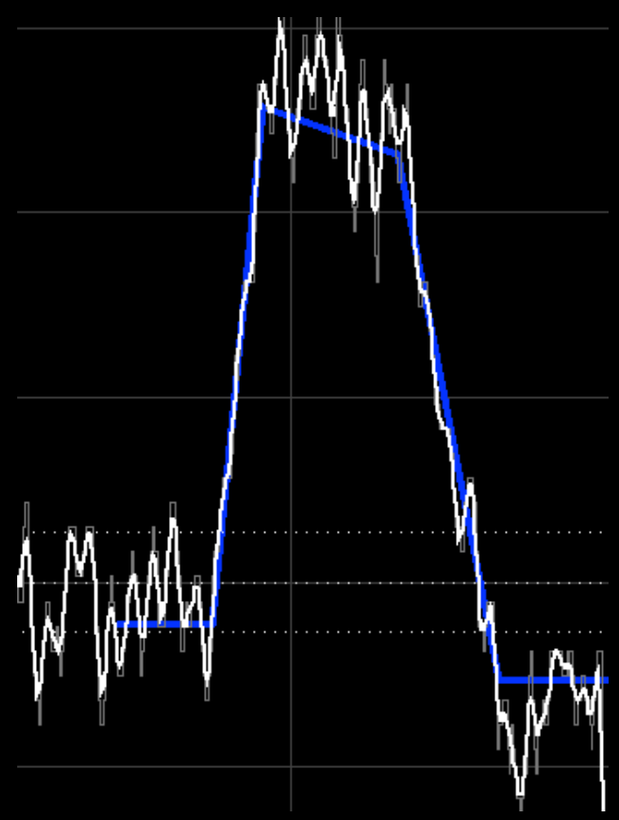
CDA Measures Velocity of Charged Dust



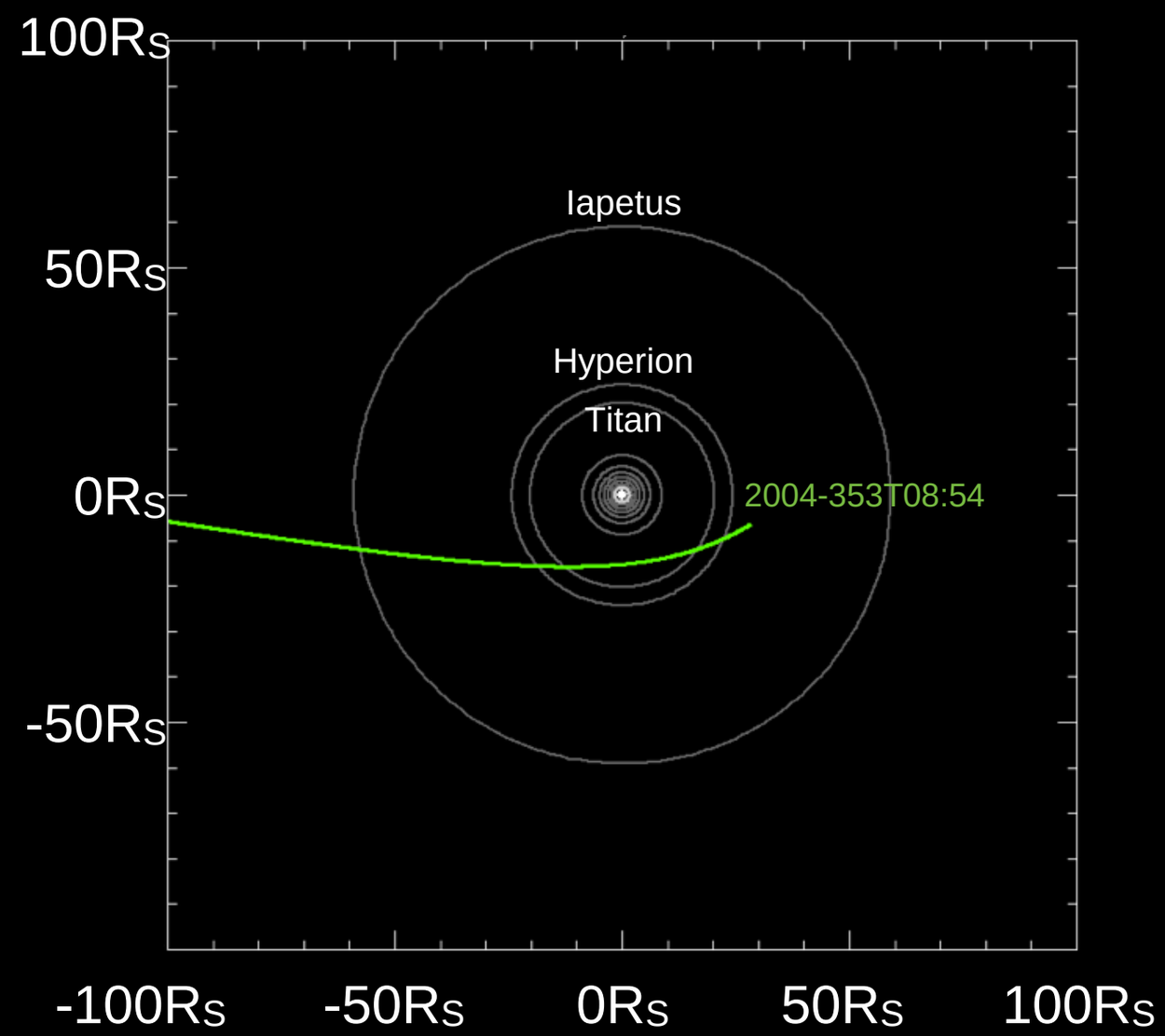
v_d = 4.3 km/s R_d = 0.6 µm

Dust Orbit Reconstruction

2004-353T08:54



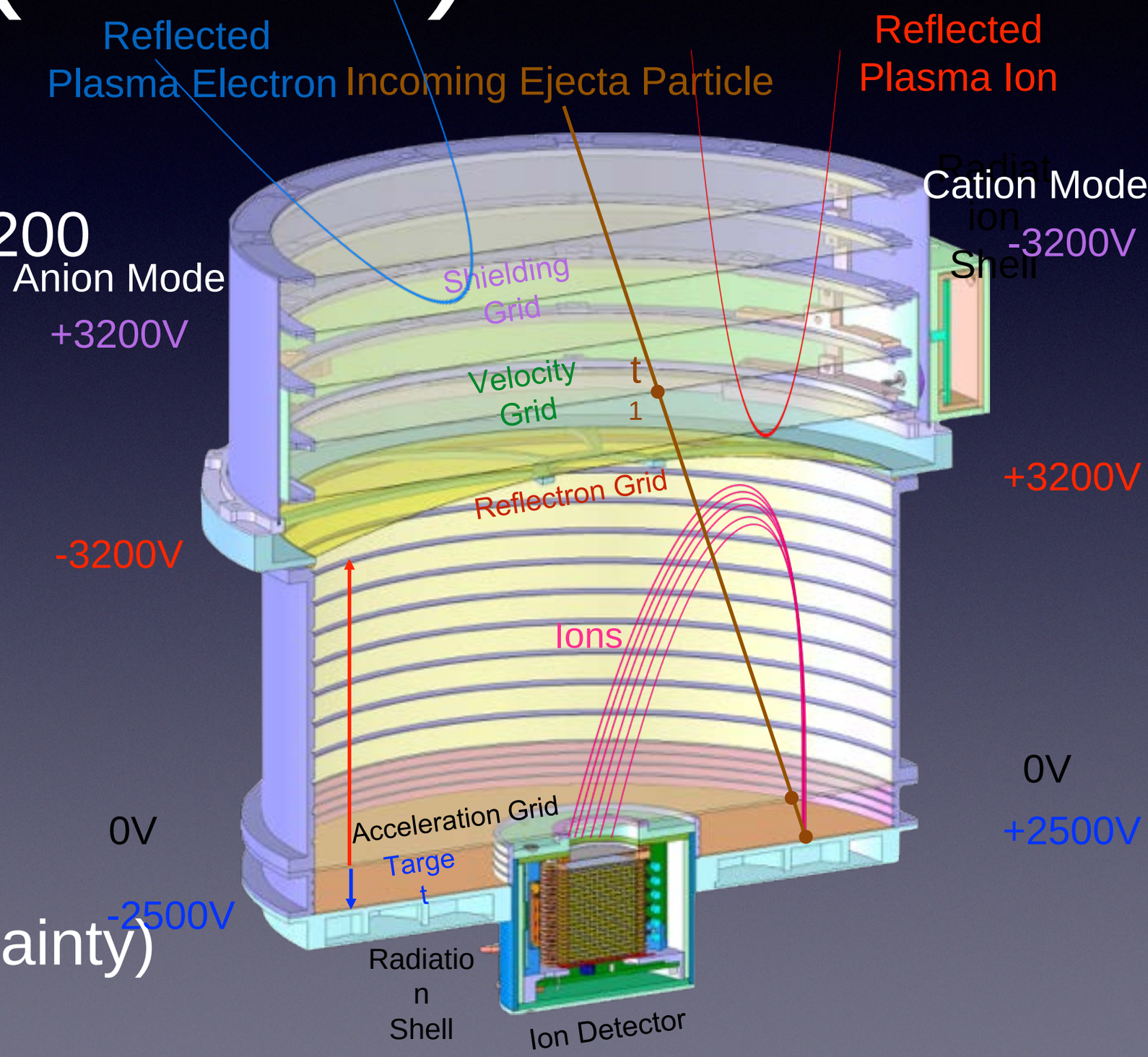
R=18.2μm Q=5.7fC Φ=+2.8V



Kuiper Belt Particle

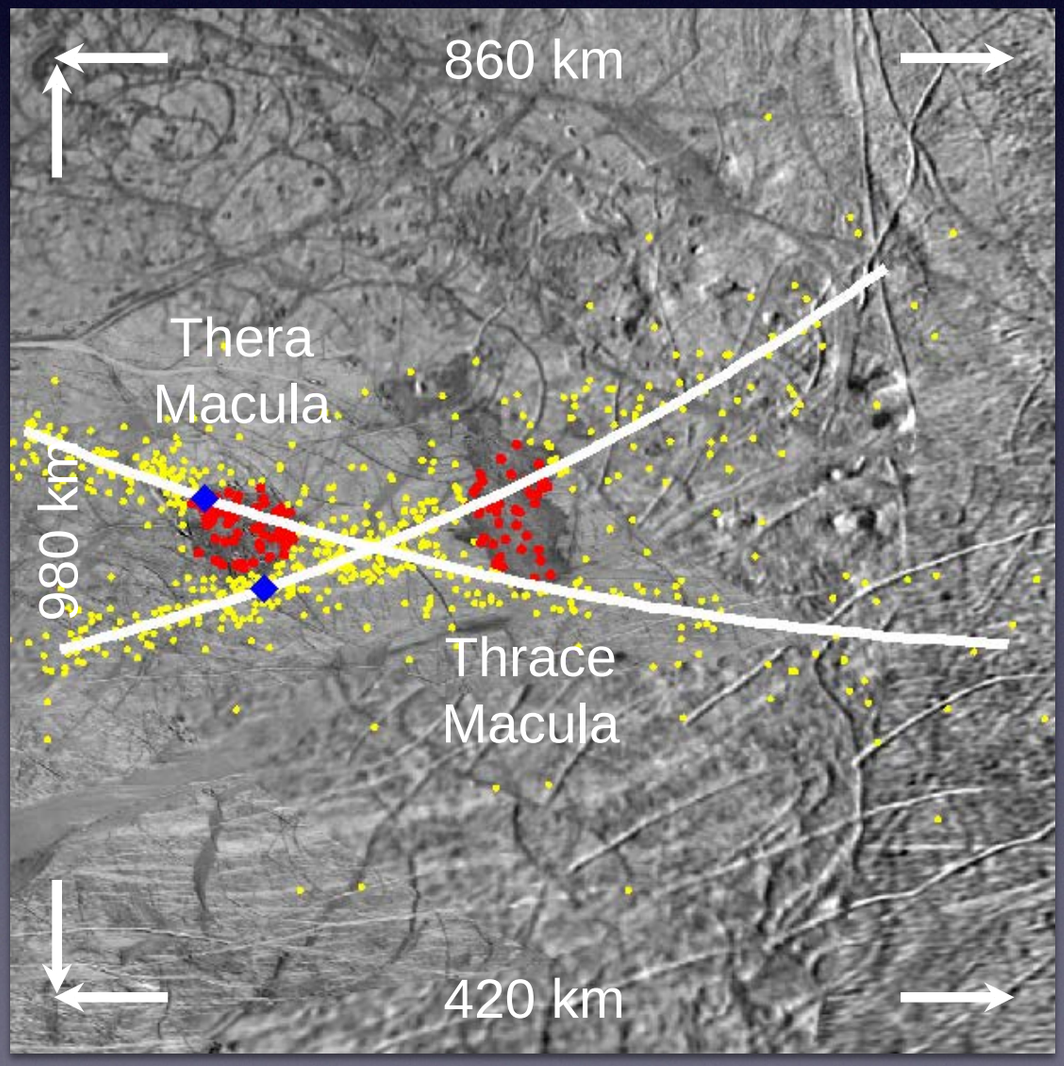
SUrface Dust Analyzer (SUDA)

- Mass Spectrometer:
  - Mass Resolution ~ 200
  - Electrostatic Mirror:
    - Parabolic Grid
    - Ring Electrodes
  - ± Polarity
- Trajectory Sensor:
  - Velocity (1% Uncertainty)

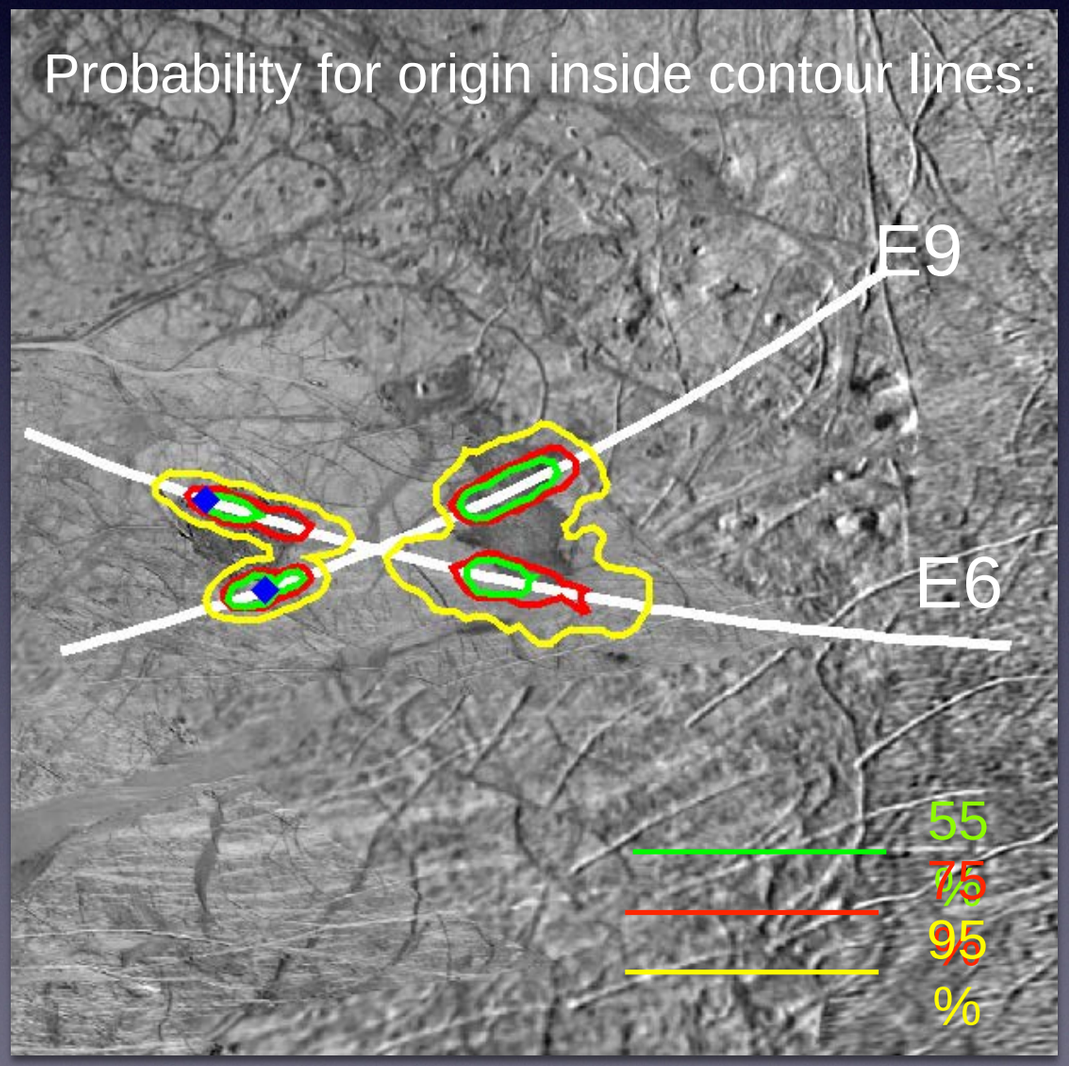


SUDA Composition Map

Dark Lobated Features Thrace Macula and Thera Macula on Europa



MC Simulation for SUDA Compositional Mapping



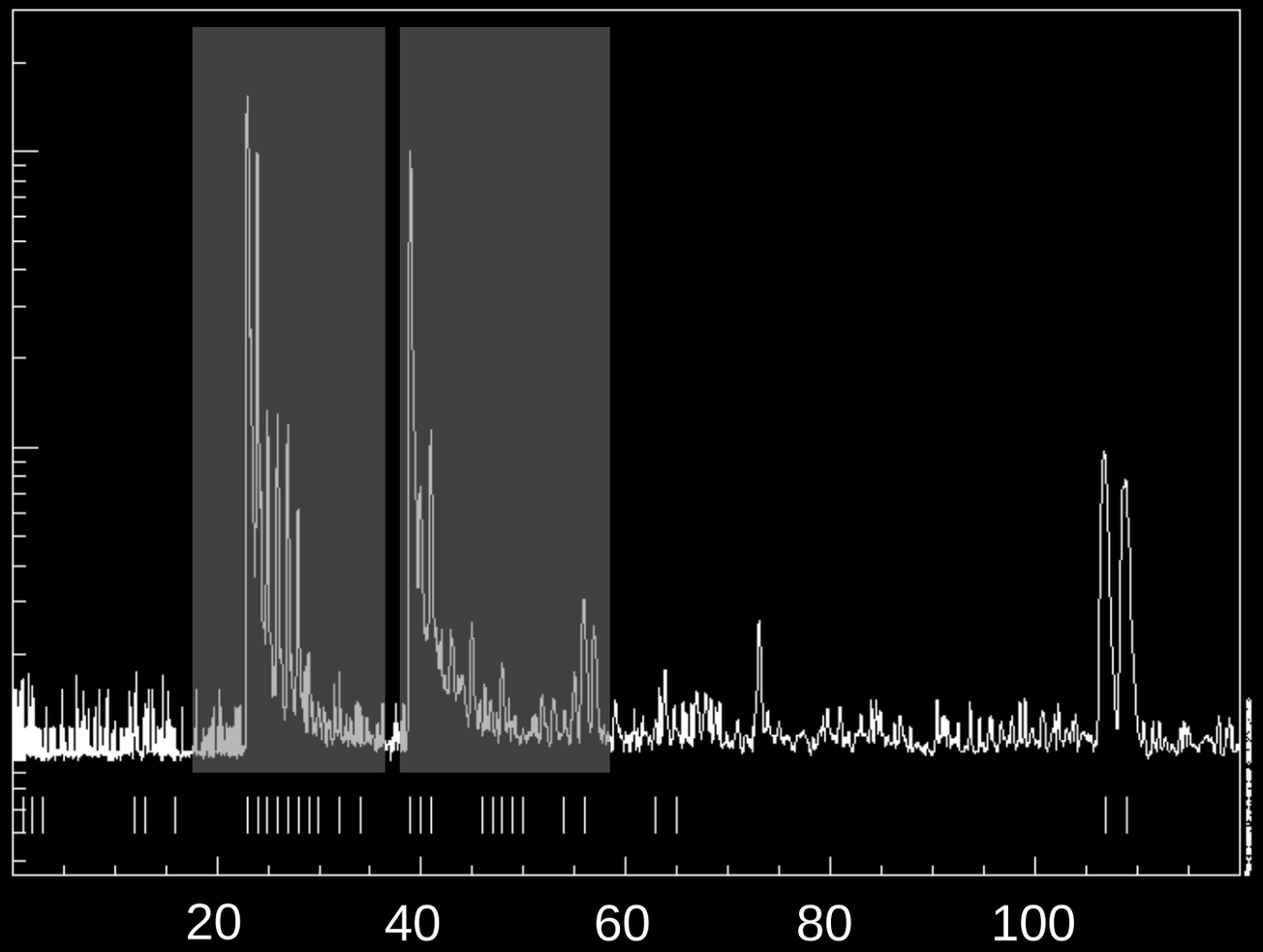
SUDA Will Collect

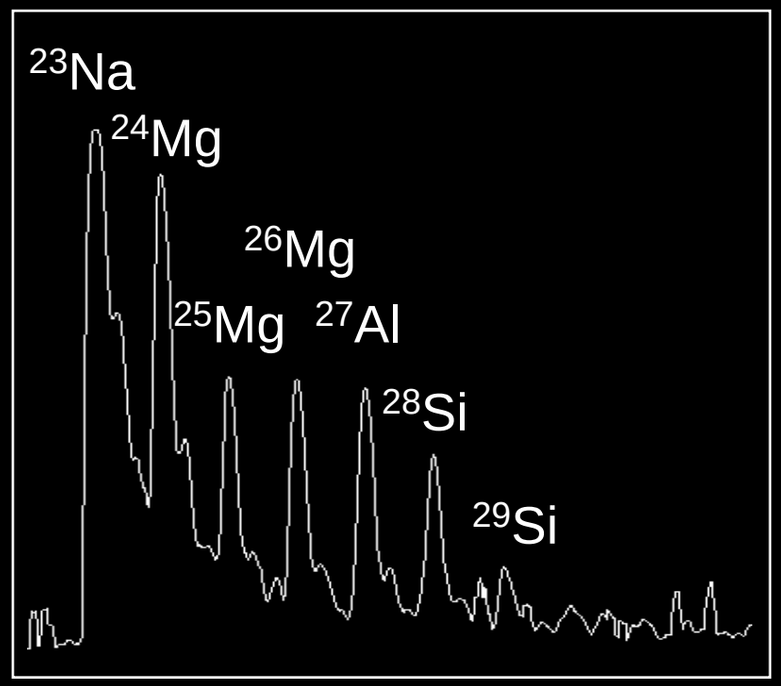
Europa Clipper Flybys:

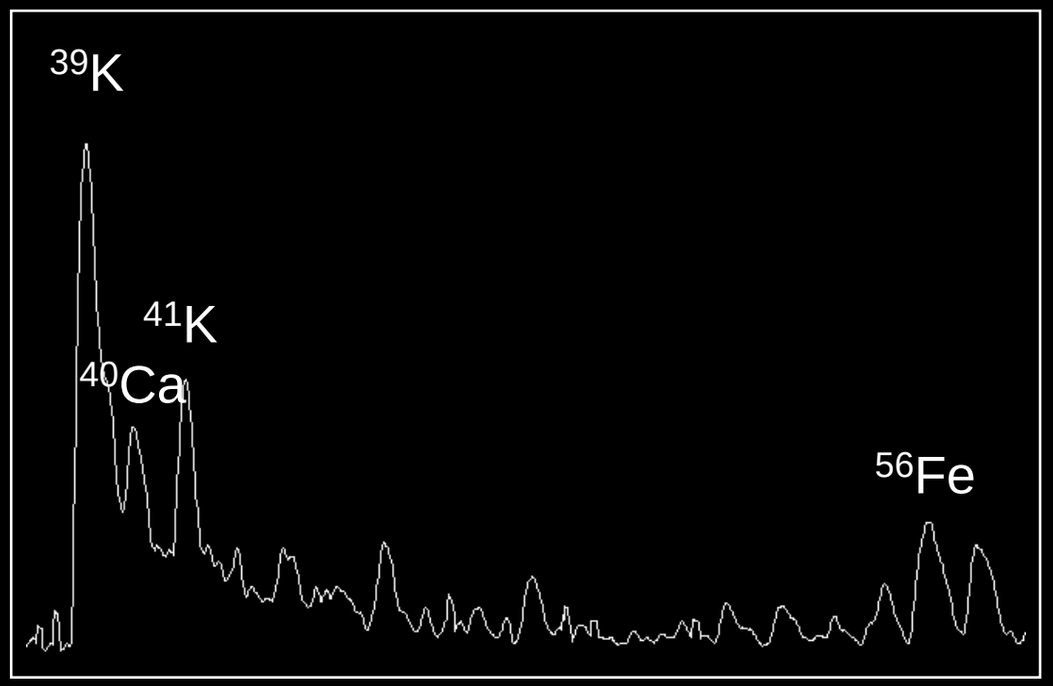
Flyby	Impact Rate	Total Sample #
Europa 25 km	40 per second	5300
Europa 50 km	14 per second	2700
Europa 100 km	3 per second	1350

In total, SUDA will collect about 120,000 samples from Europa's surface

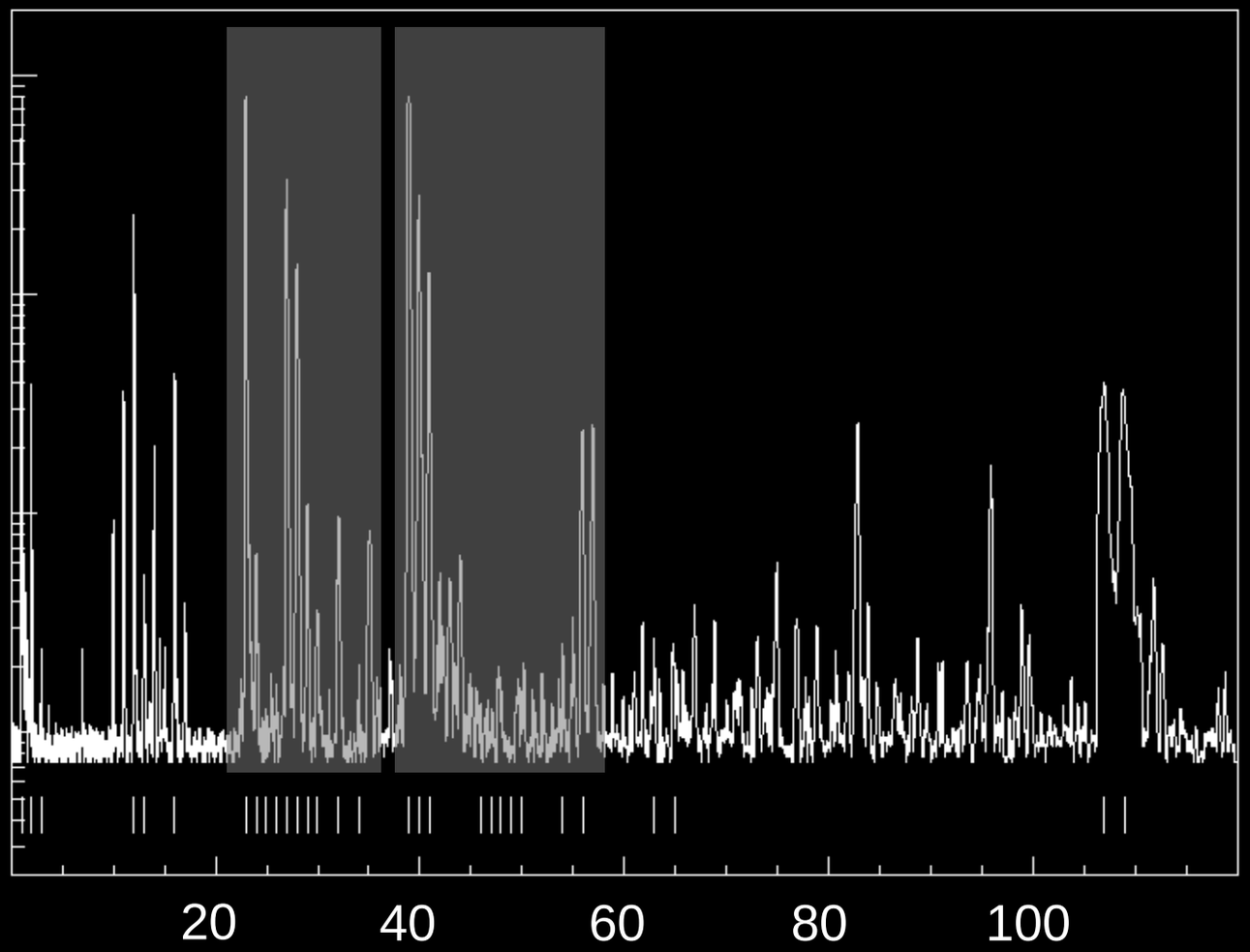
Pyroxene

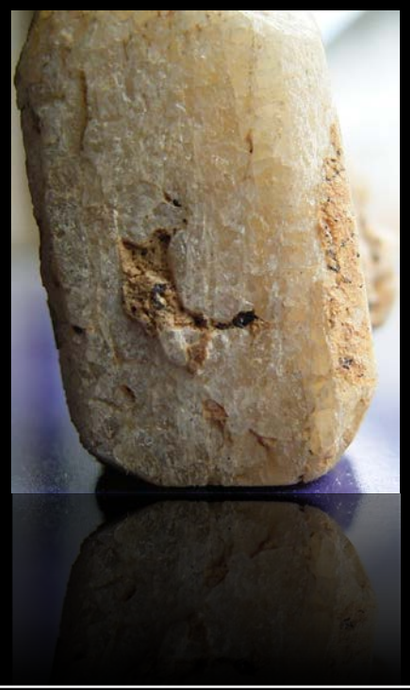

20
40
60
80
100

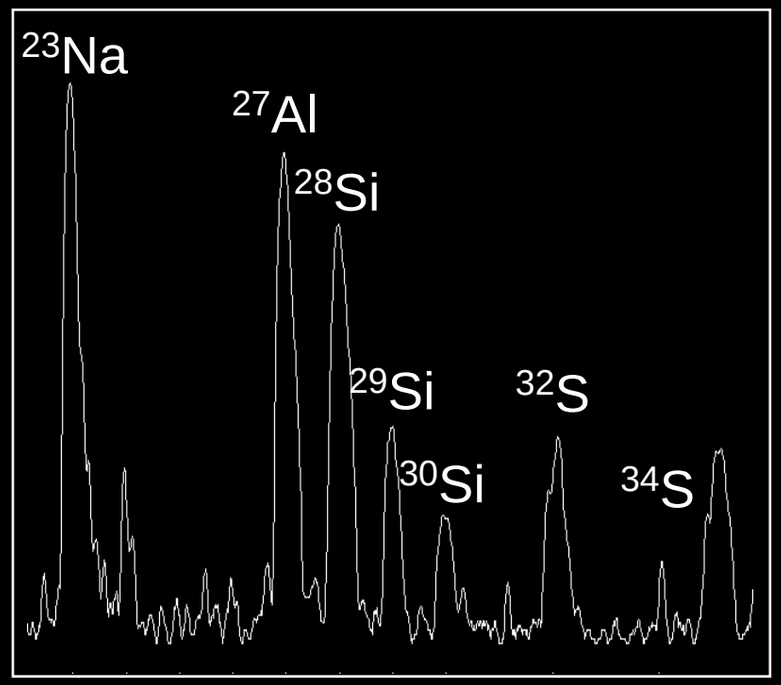

^{23}Na
^{24}Mg
^{26}Mg
^{25}Mg
^{27}Al
^{28}Si
^{29}Si

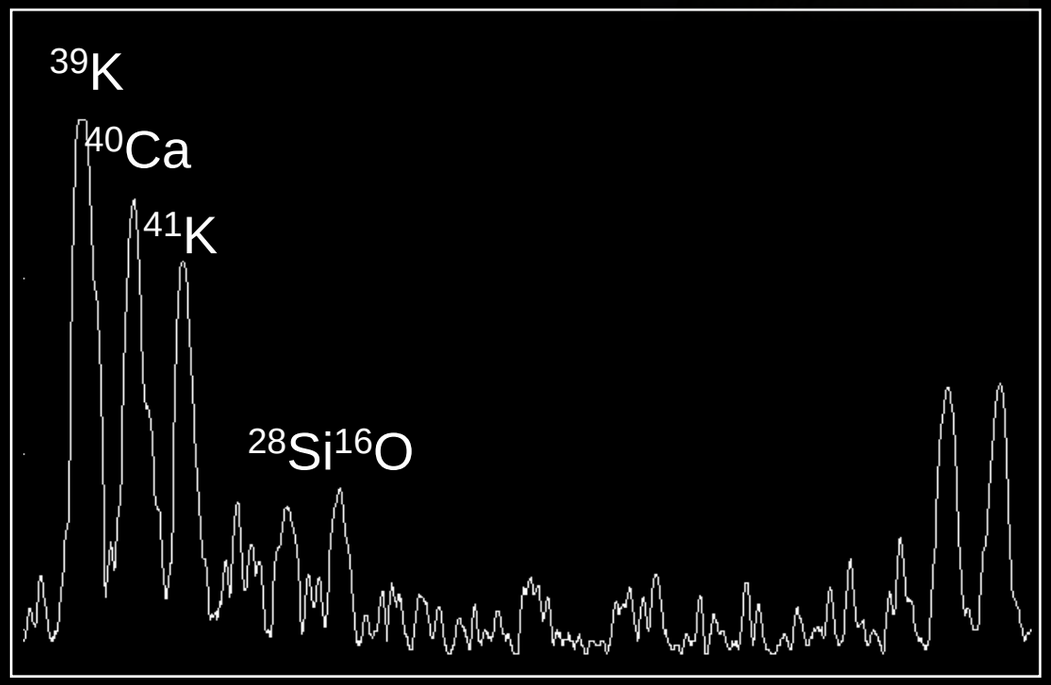

^{39}K
^{41}K
^{40}Ca
^{56}Fe

Anorthite
$CaAl_2Si_2O_8$







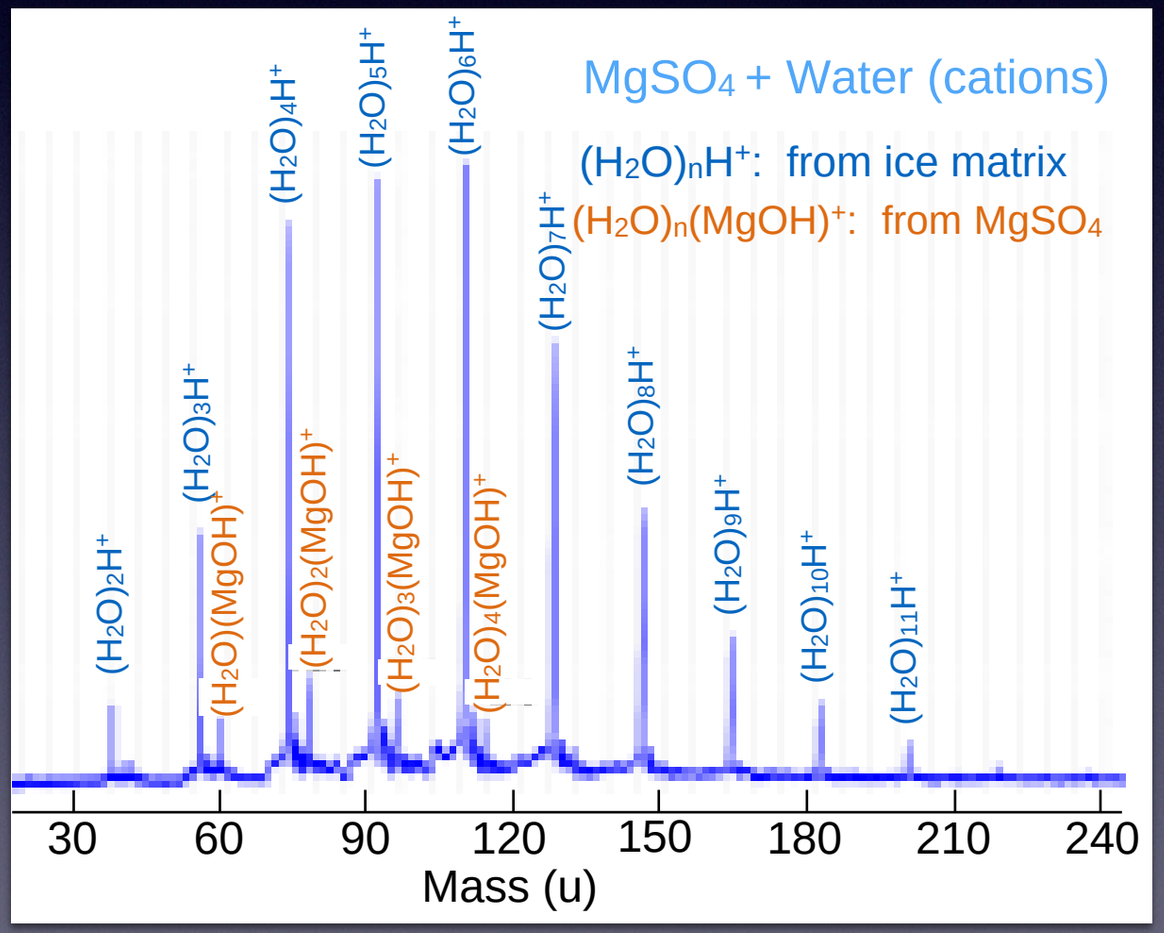


Hillier et al., GRL, 2012

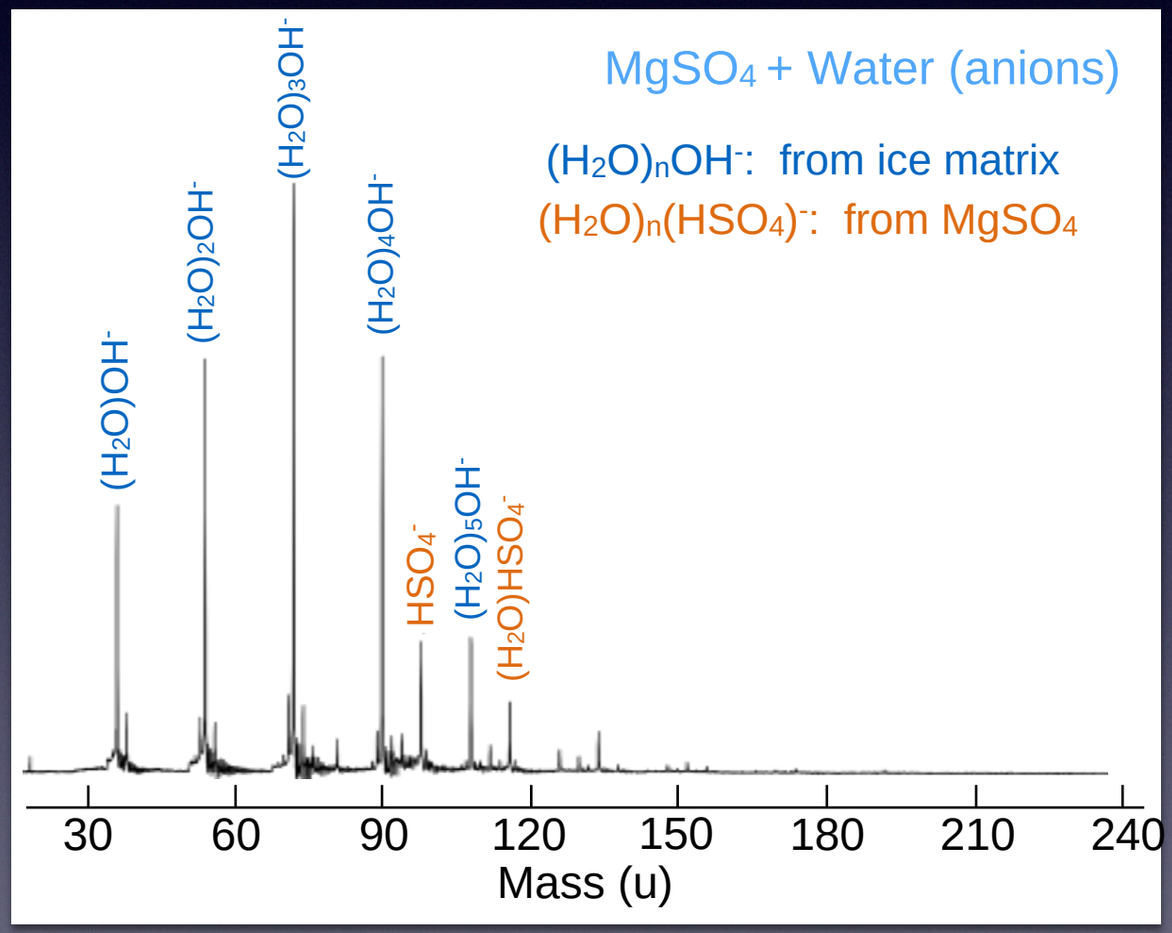
SUDA @ Europa

Water + $MgSO_4$

Cations:



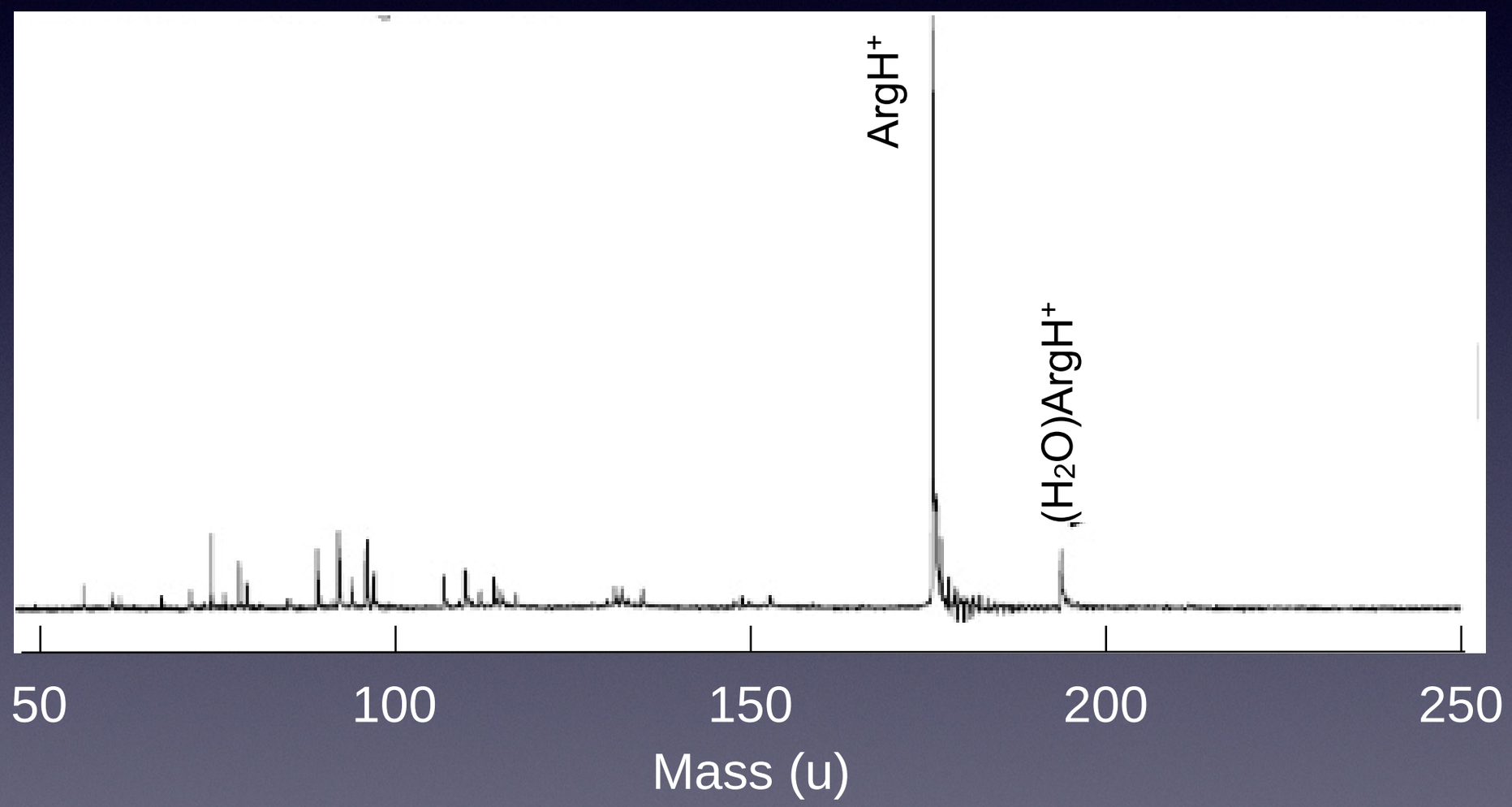
Anions:



Laser–assisted dispersion spectra of $MgSO_4$ at a concentration of 0.1 ppm in water

SUDA @ Europa

Argenine + Water (Cations)

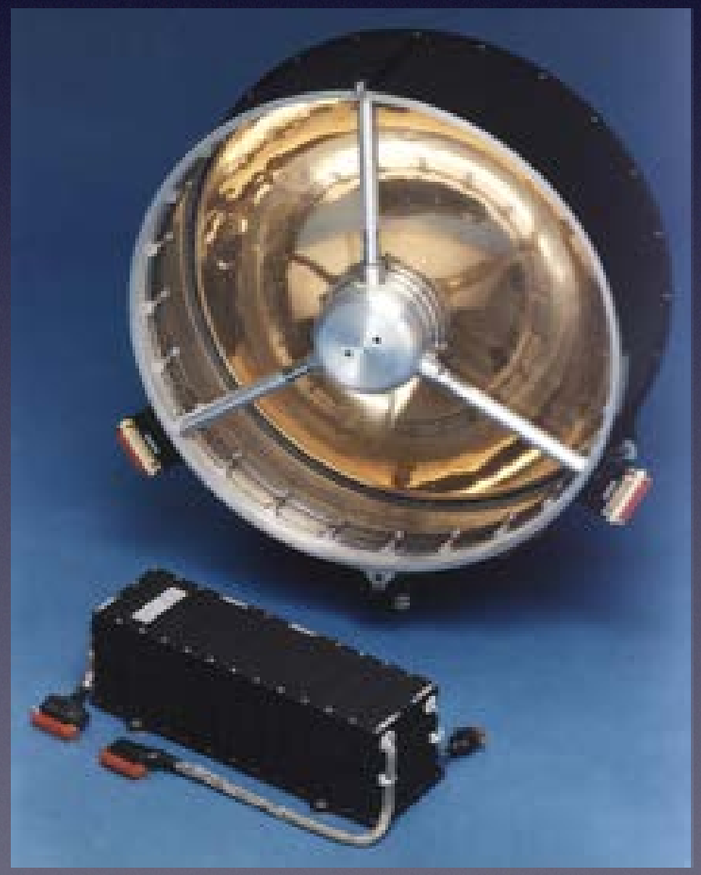


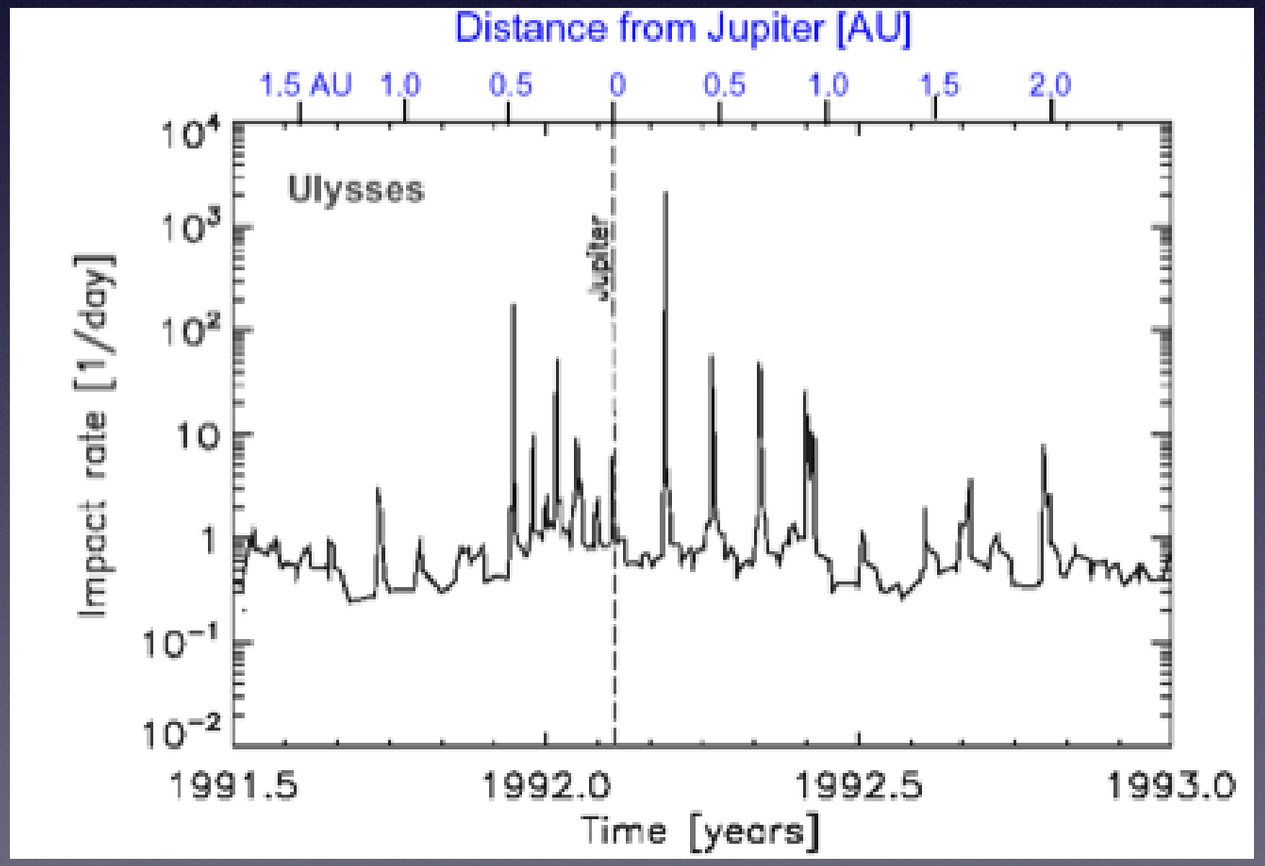
Laser–assisted dispersion cation spectrum of the amino acid arginine ($C_6H_{14}N_4O_2$) dissolved in water at a concentration of 10^{-4} mol/l.


SUDA

SUDA Europa Science Starts at the Asteroid Belt

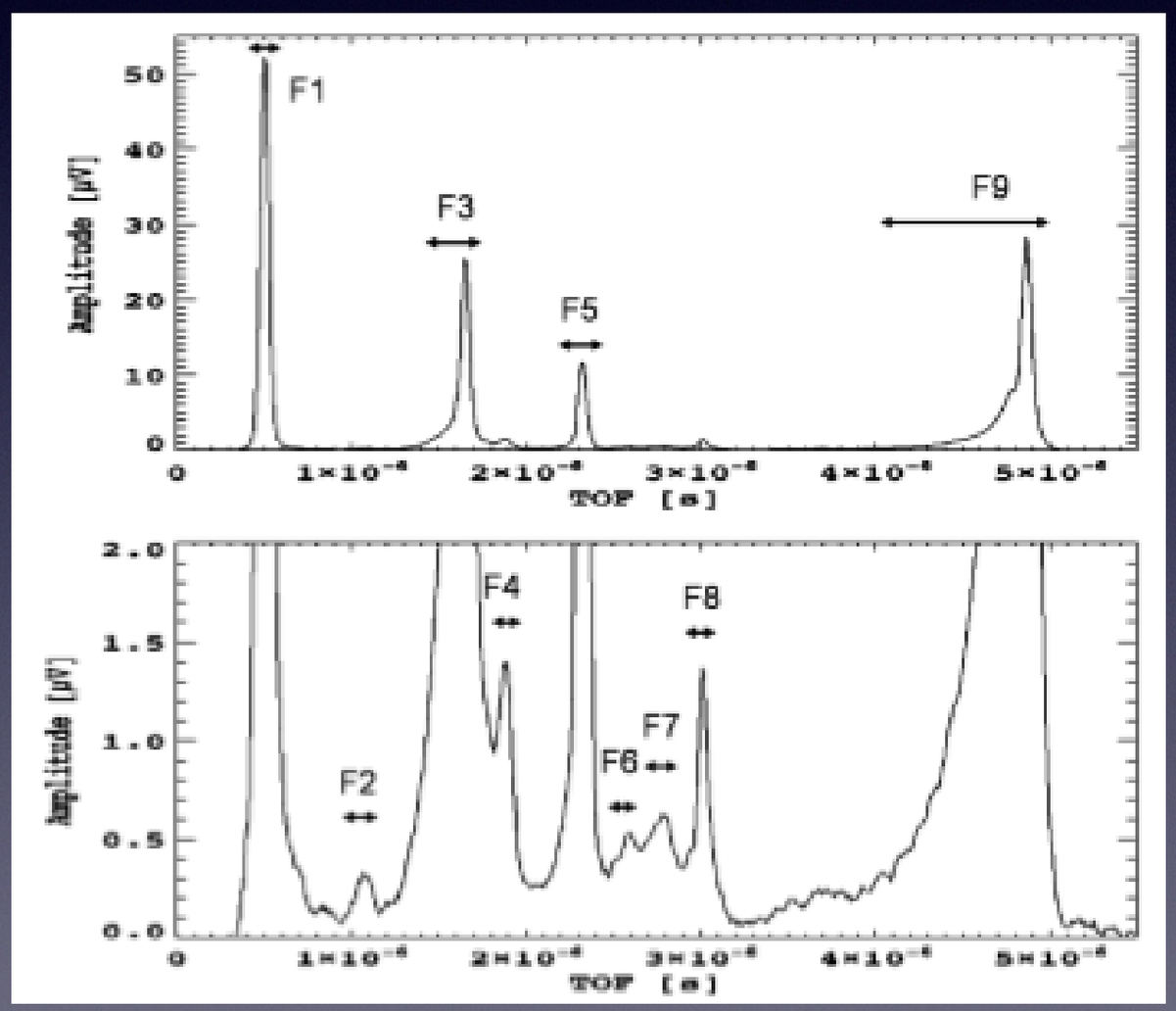
Ulysses discovered "periodic streams" of nano-dust emerging from the Jovian system





Grün et al., 1993, Nature, 362

Cassini Determined the Nano-Dust Composition



Postberg et al., 2006, Icarus, 183

- Primary source: Io's volcanoes
- Composition: NaCl