

SUDA:

A Dust Mass Spectrometer for Compositional Surface Mapping for the JUICE Mission to the Galilean Moons

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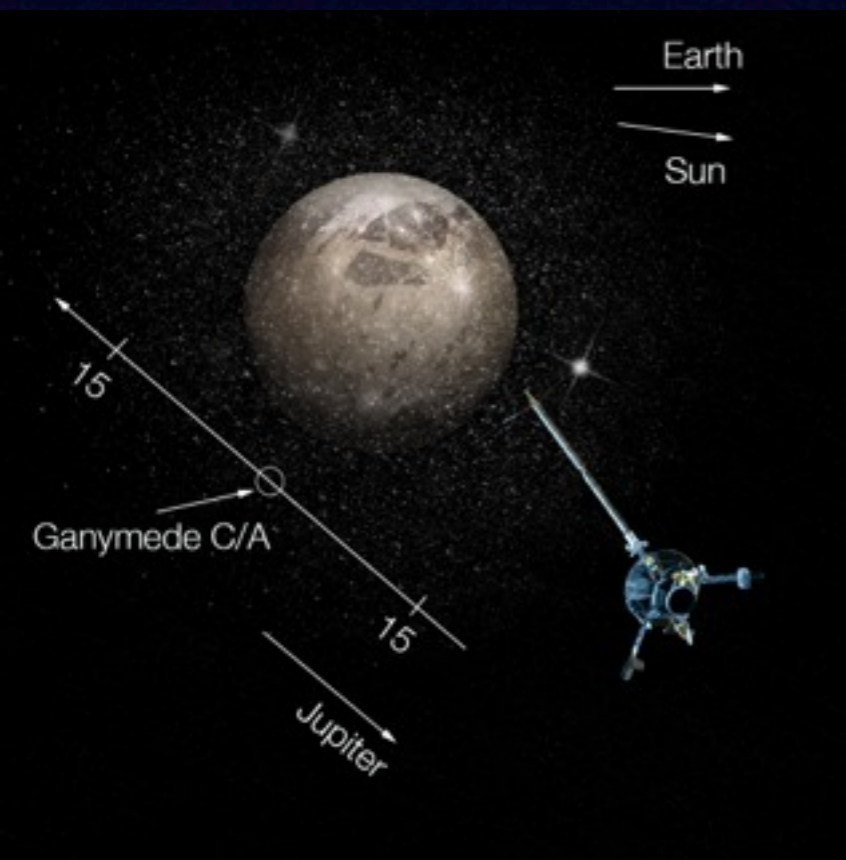
Compositional Mapping

Determine Surface Composition from Orbit „in-situ“

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Determine Surface Composition from Orbit „in-situ“

Ejecta Clouds

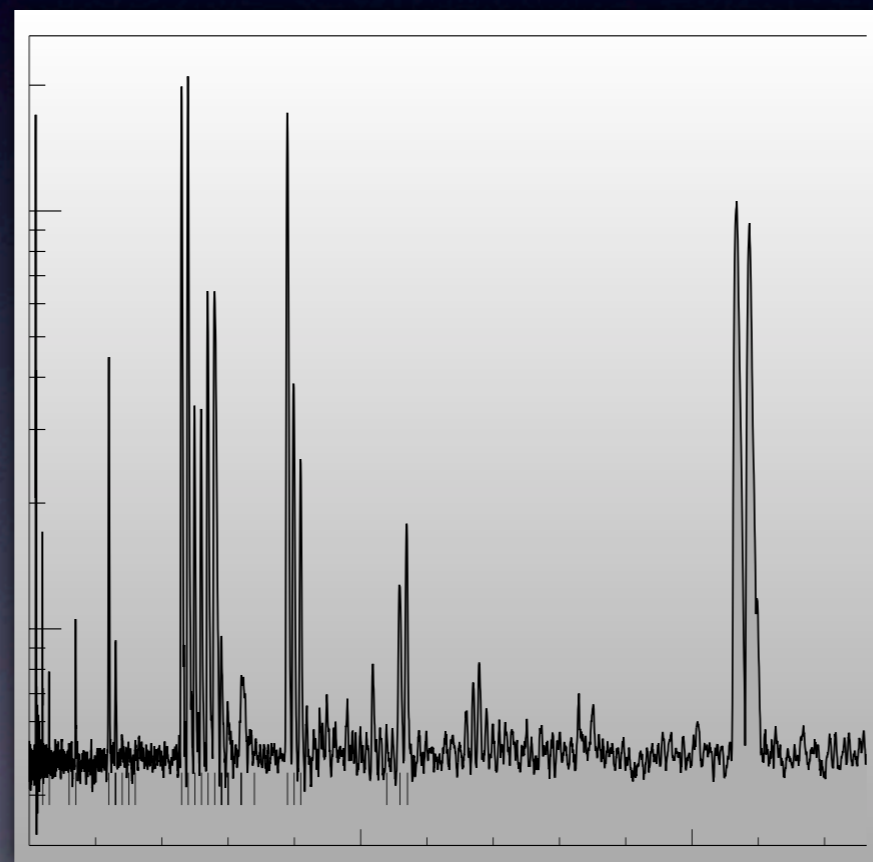
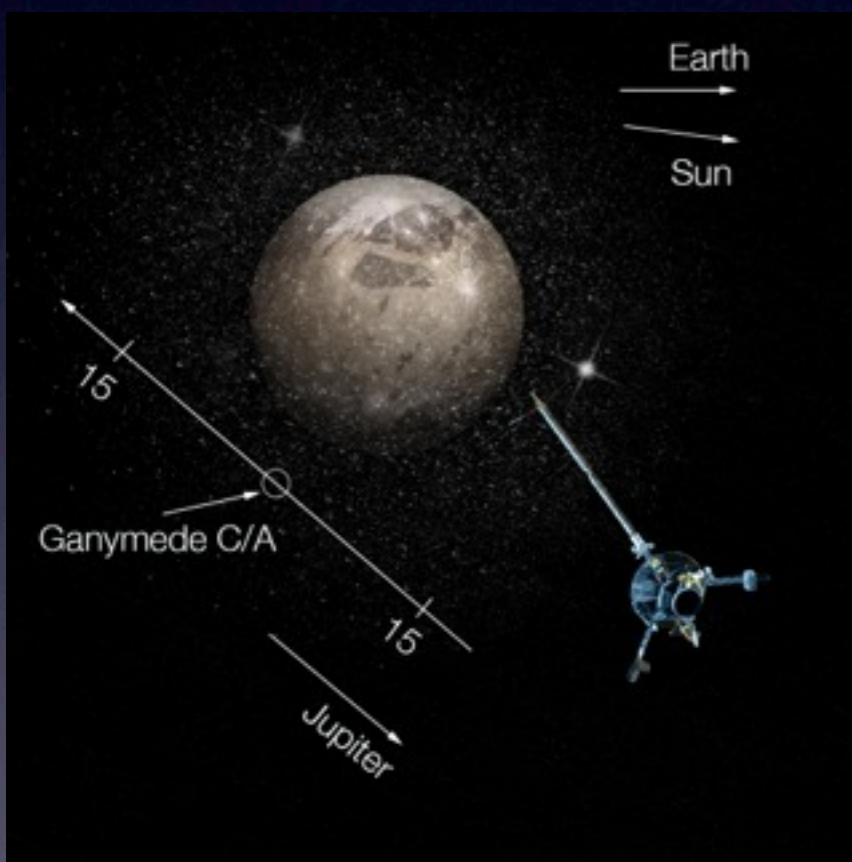


Compositional Mapping

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Ejecta Clouds

Ejecta Composition



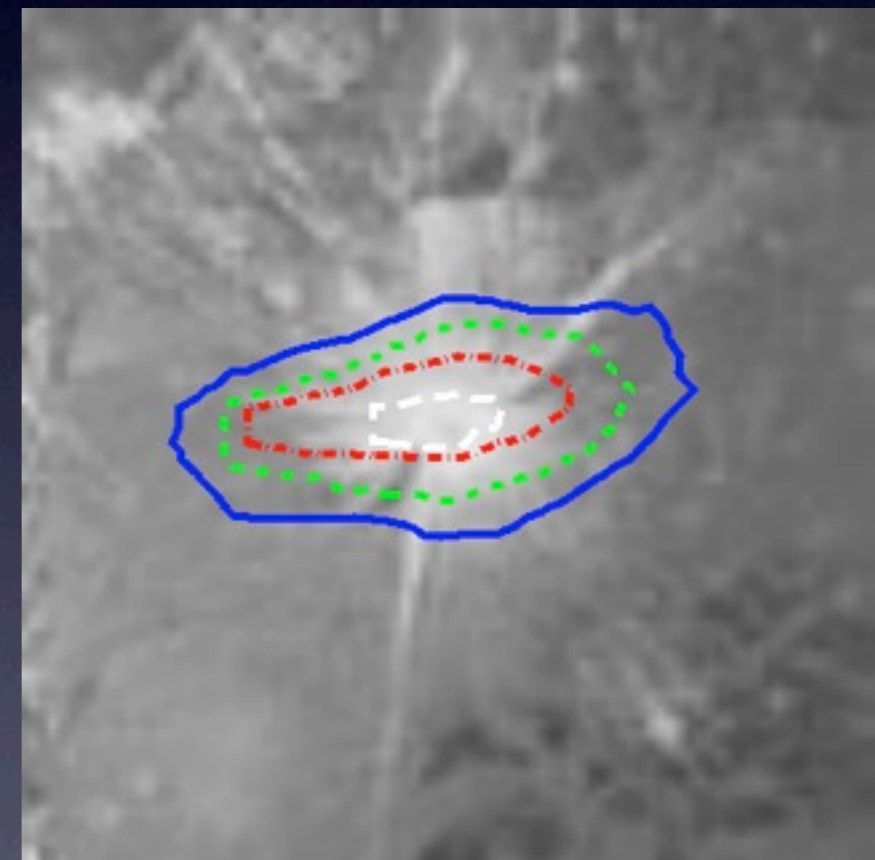
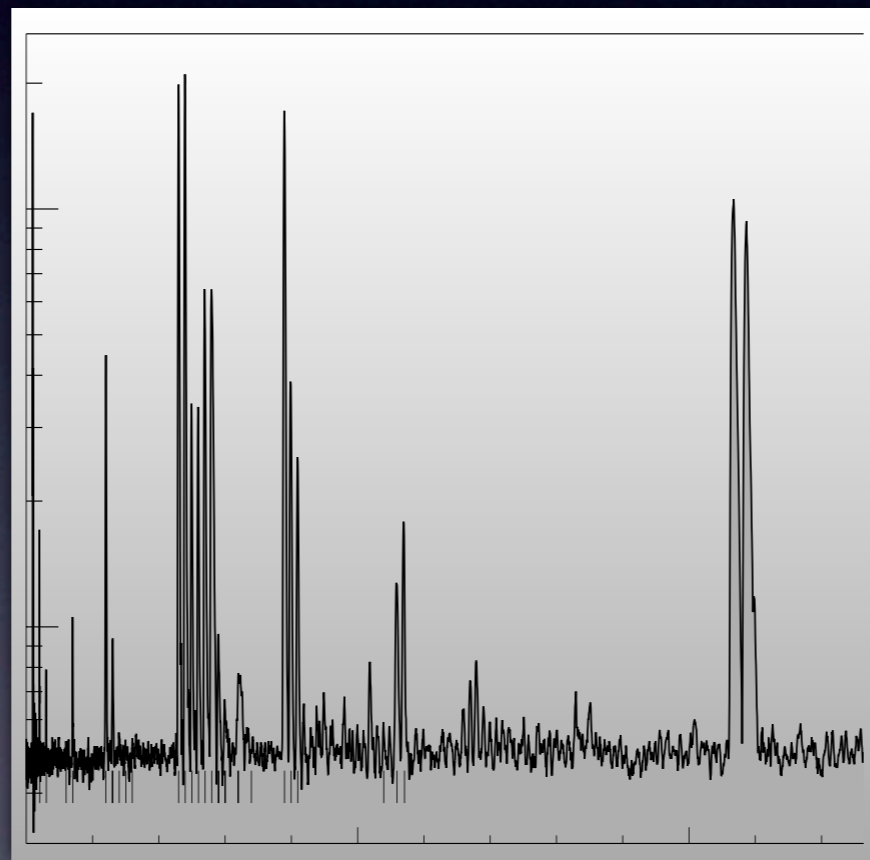
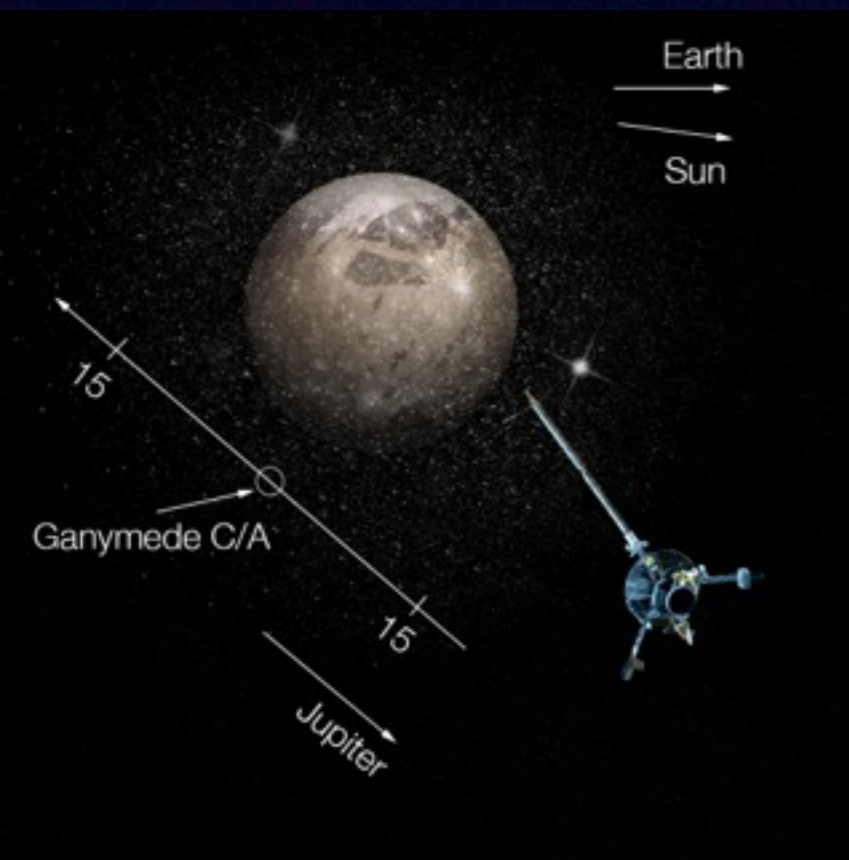
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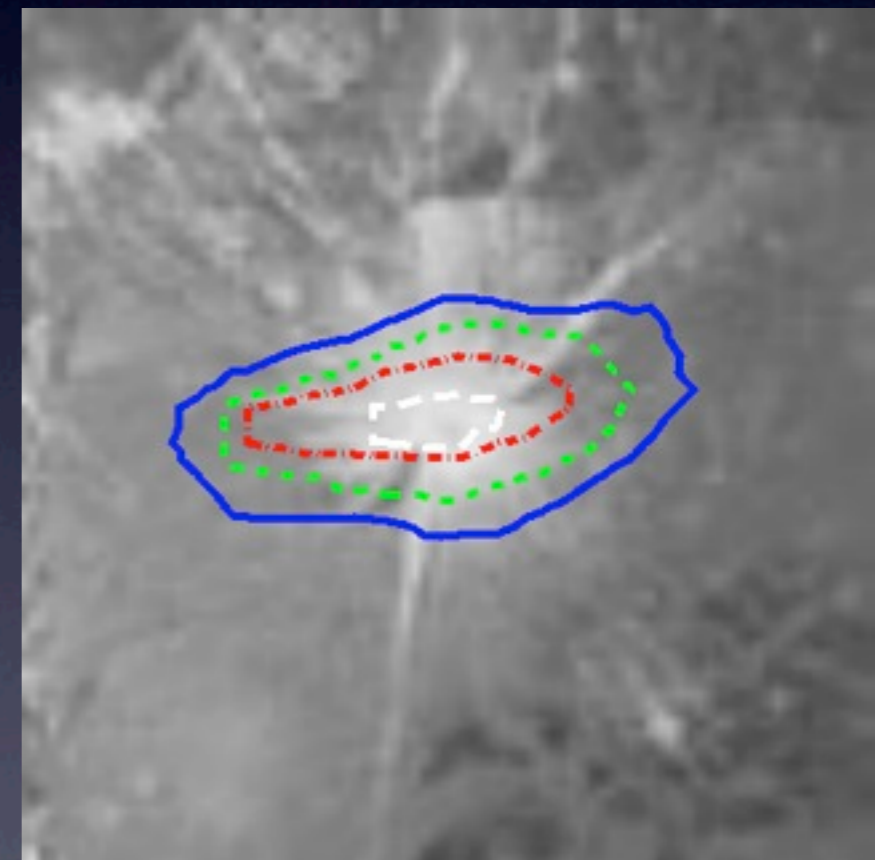
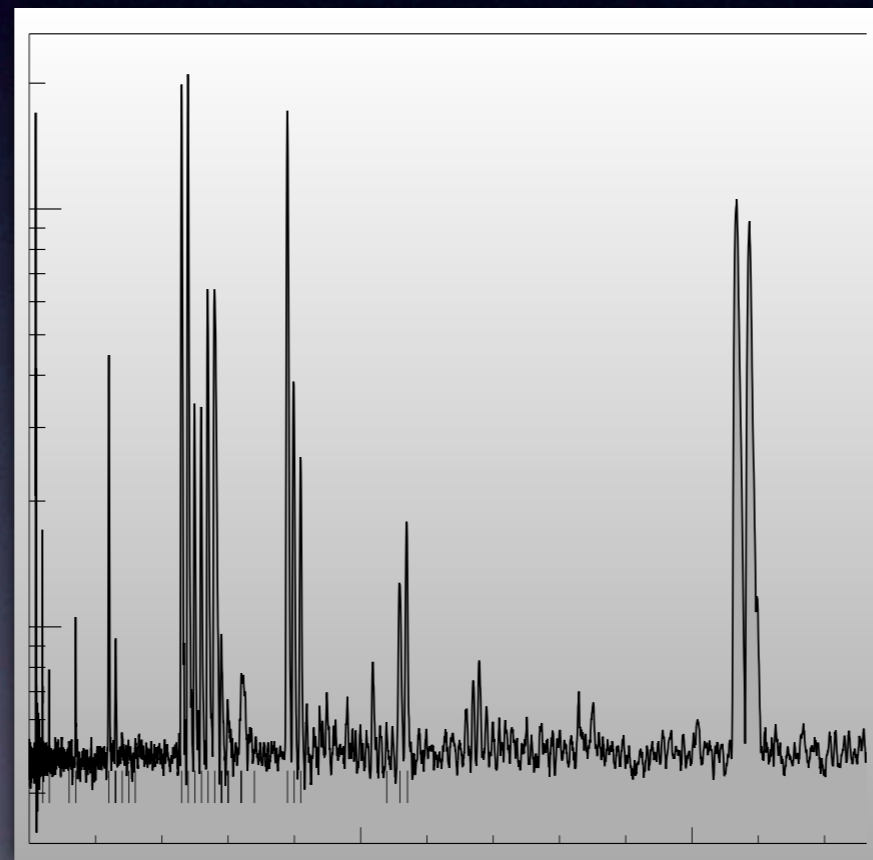
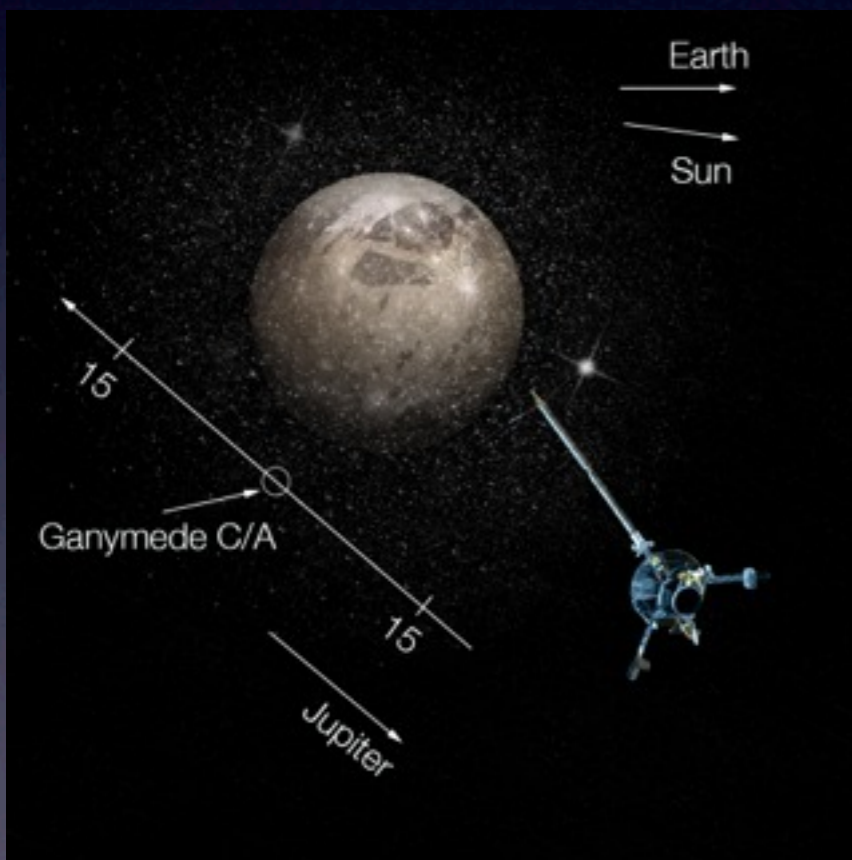
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The Next Best Thing to a Lander

I: Ejecta Clouds

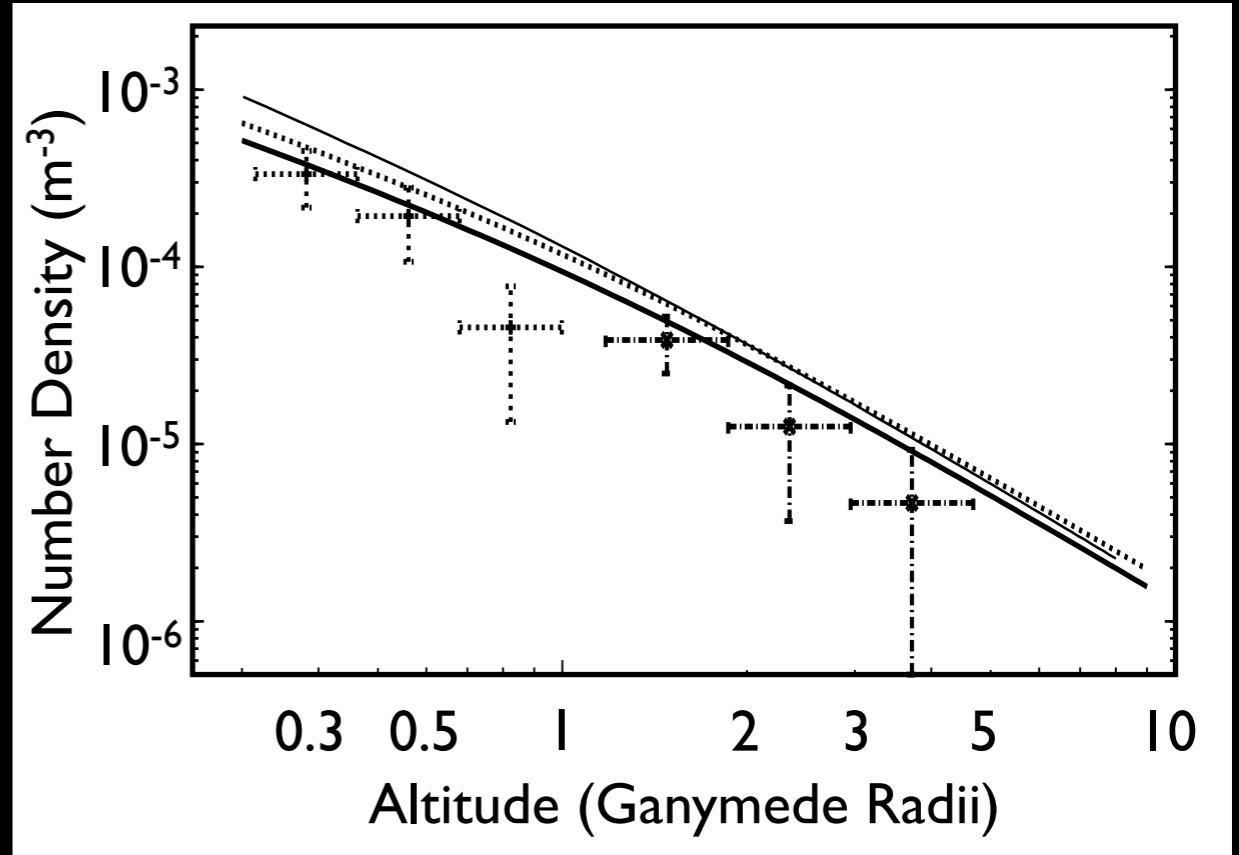


Galileo Dust Detector:
Galilean Satellites
Wrapped in Dust Clouds
(Krüger et al., Nature, 1999)

I: Ejecta Clouds



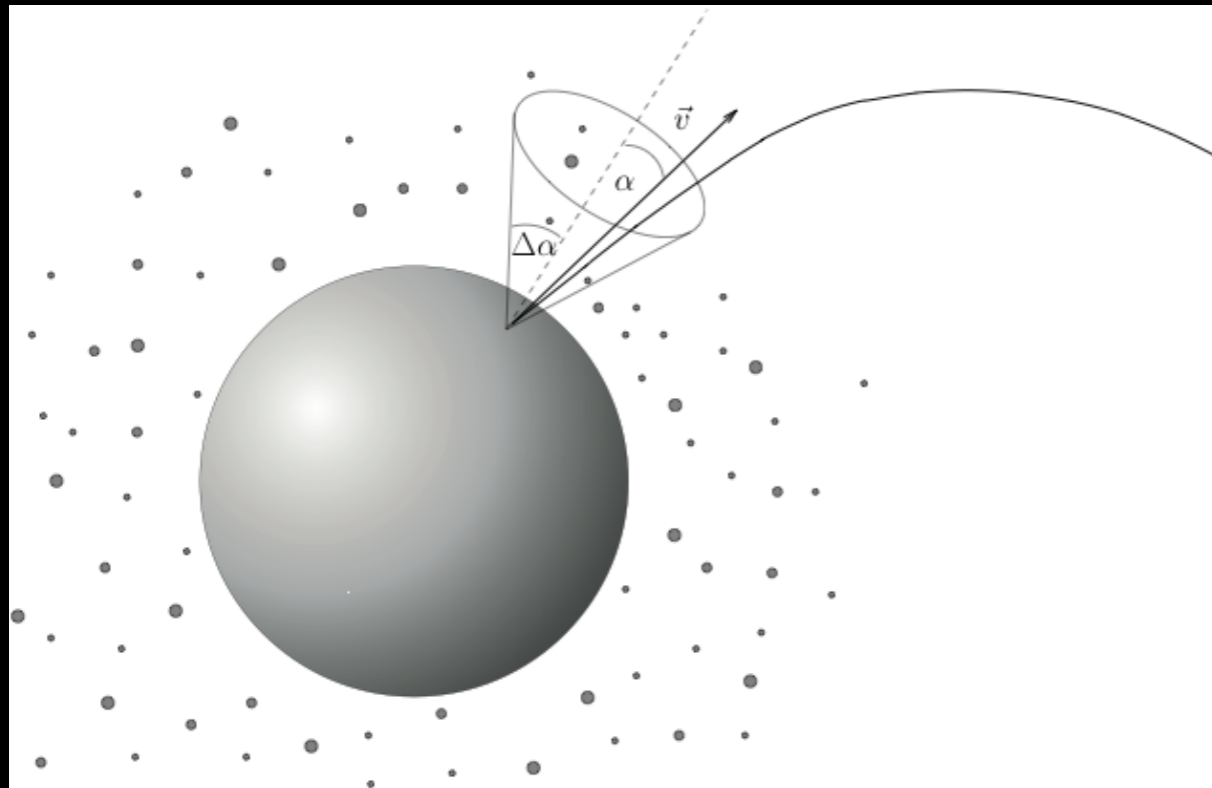
Galileo Dust Detector:
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Wrapped in Dust Clouds
(Krüger et al., Nature, 1999)



Almost Isotropic Clouds
Composed of Surface
Ejecta

Ejecta Production

Meteoroid Impacts
Produce Surface Ejecta



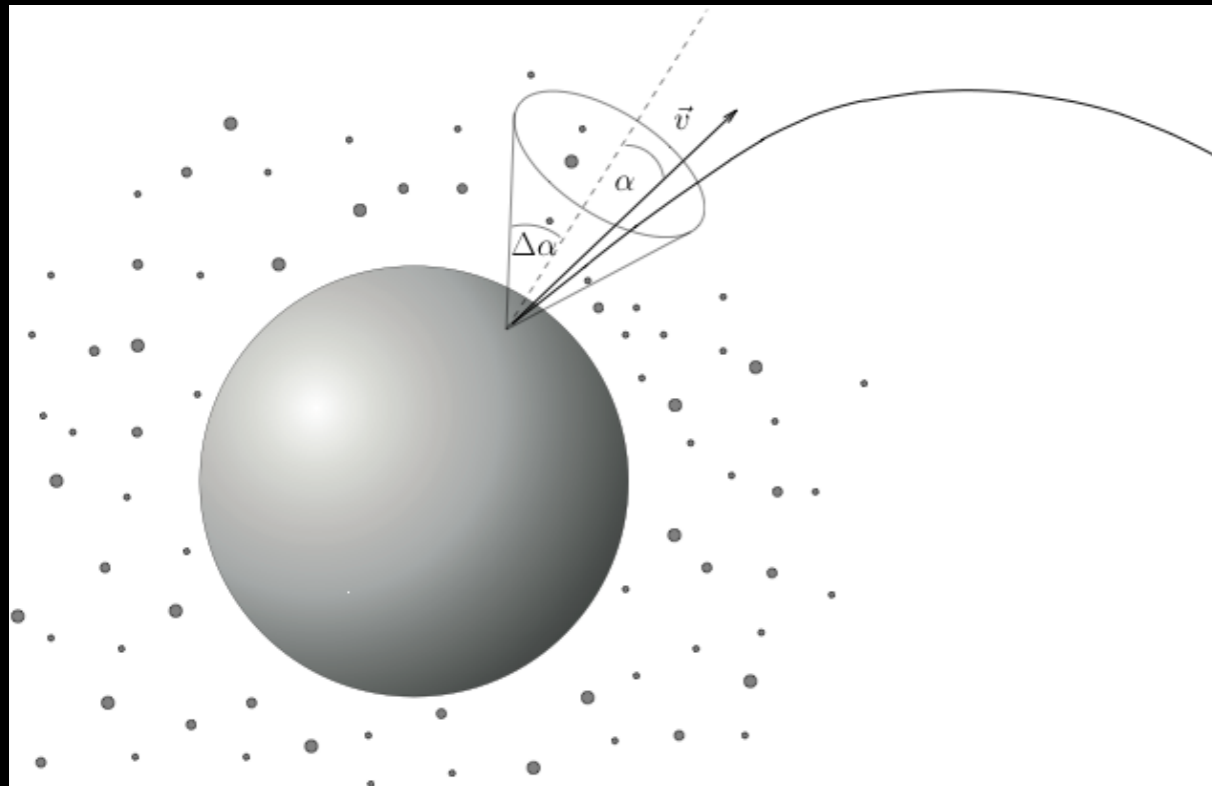
Sremcevic et al., Icarus, 2005

Mass Yield \sim 4000

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

Ejecta Production

Meteoroid Impacts
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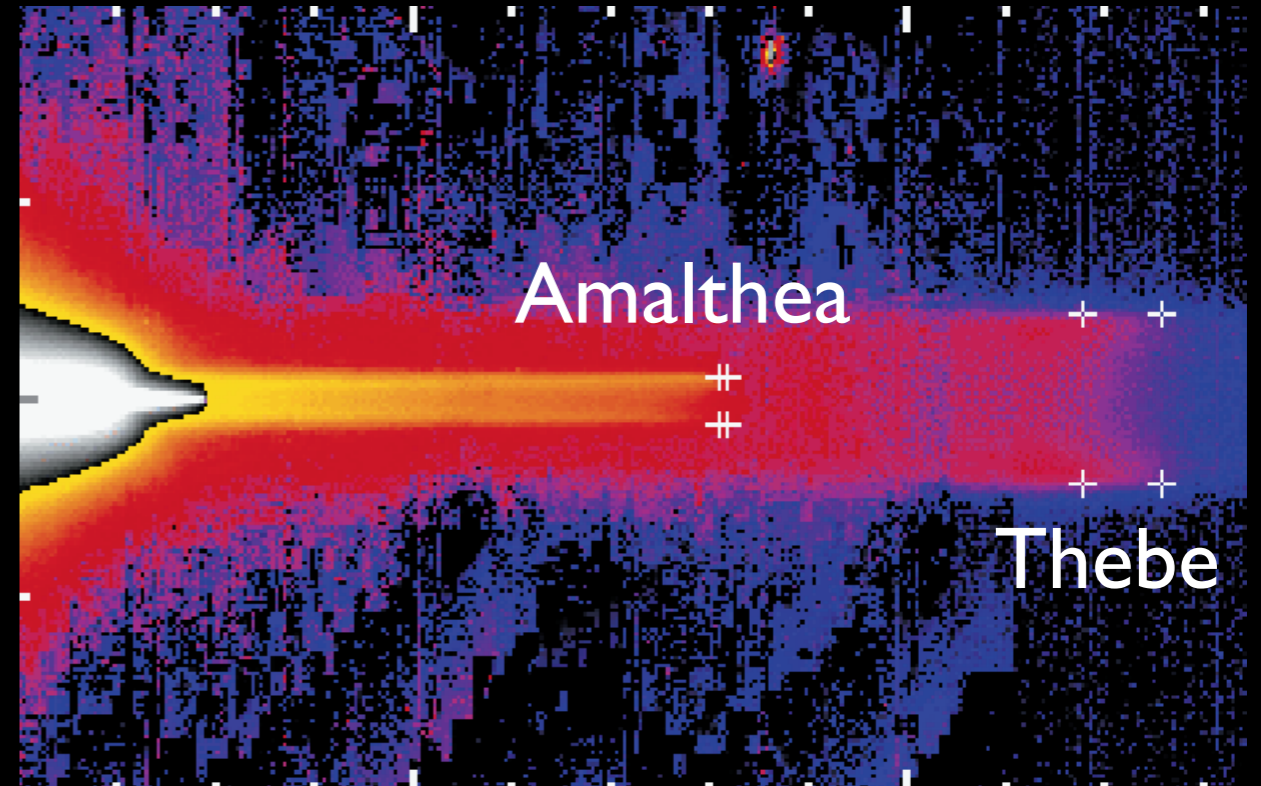


Sremcevic et al., Icarus, 2005

Mass Yield ~ 4000

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

Ejecta Escaping from
Moon's Gravity feed Rings



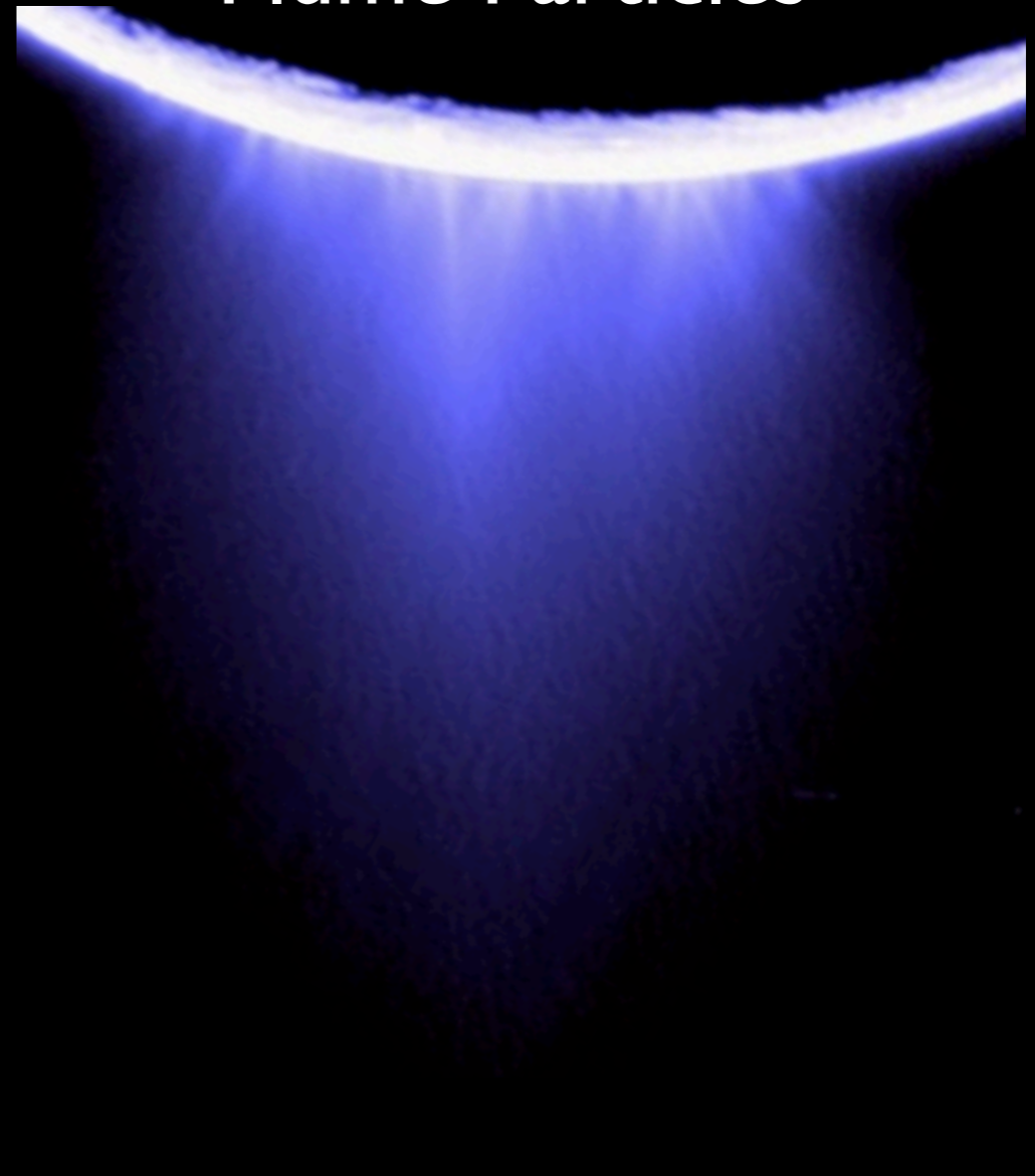
Burns et al., Science, 1999

Dust Composition

Cassini Dust Detector CDA

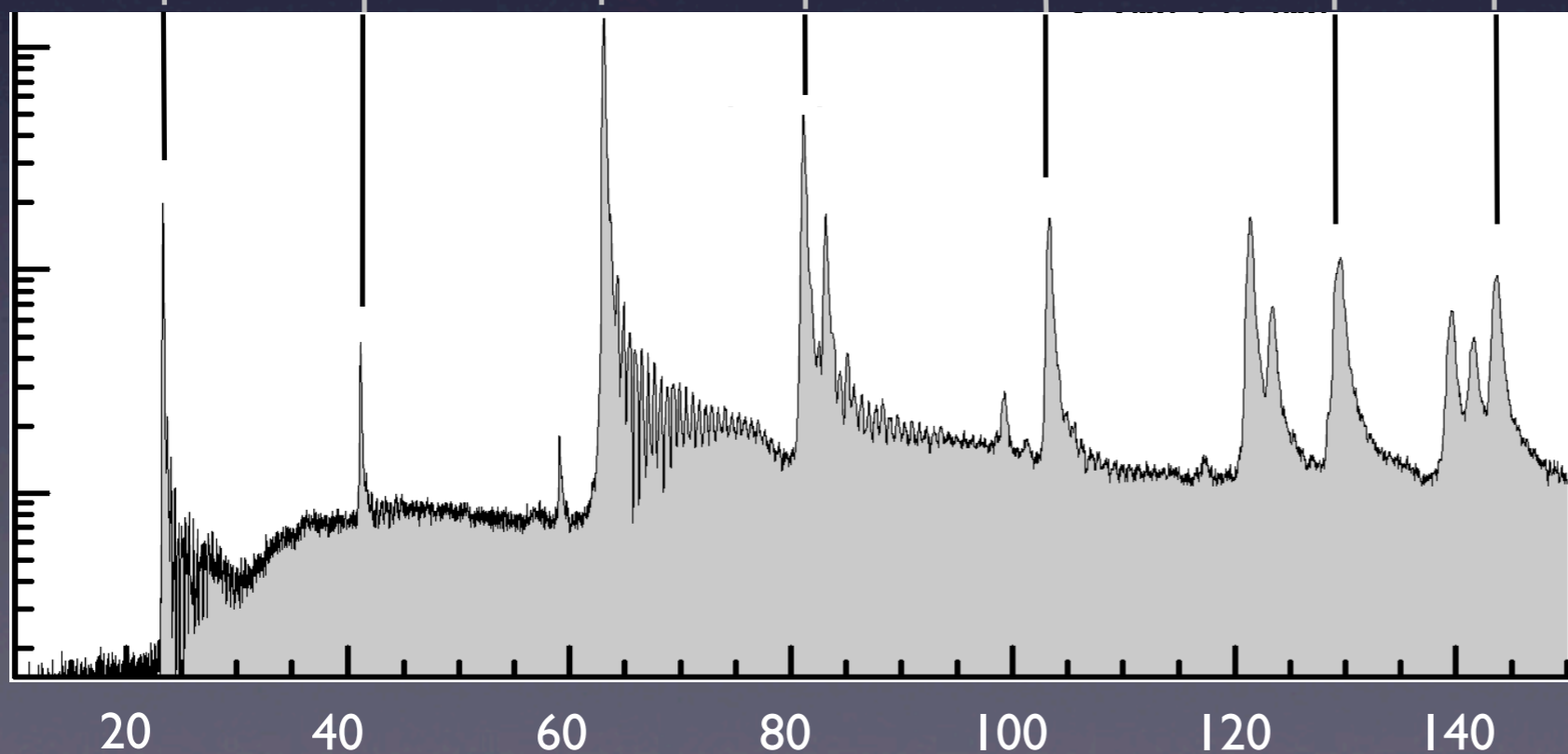
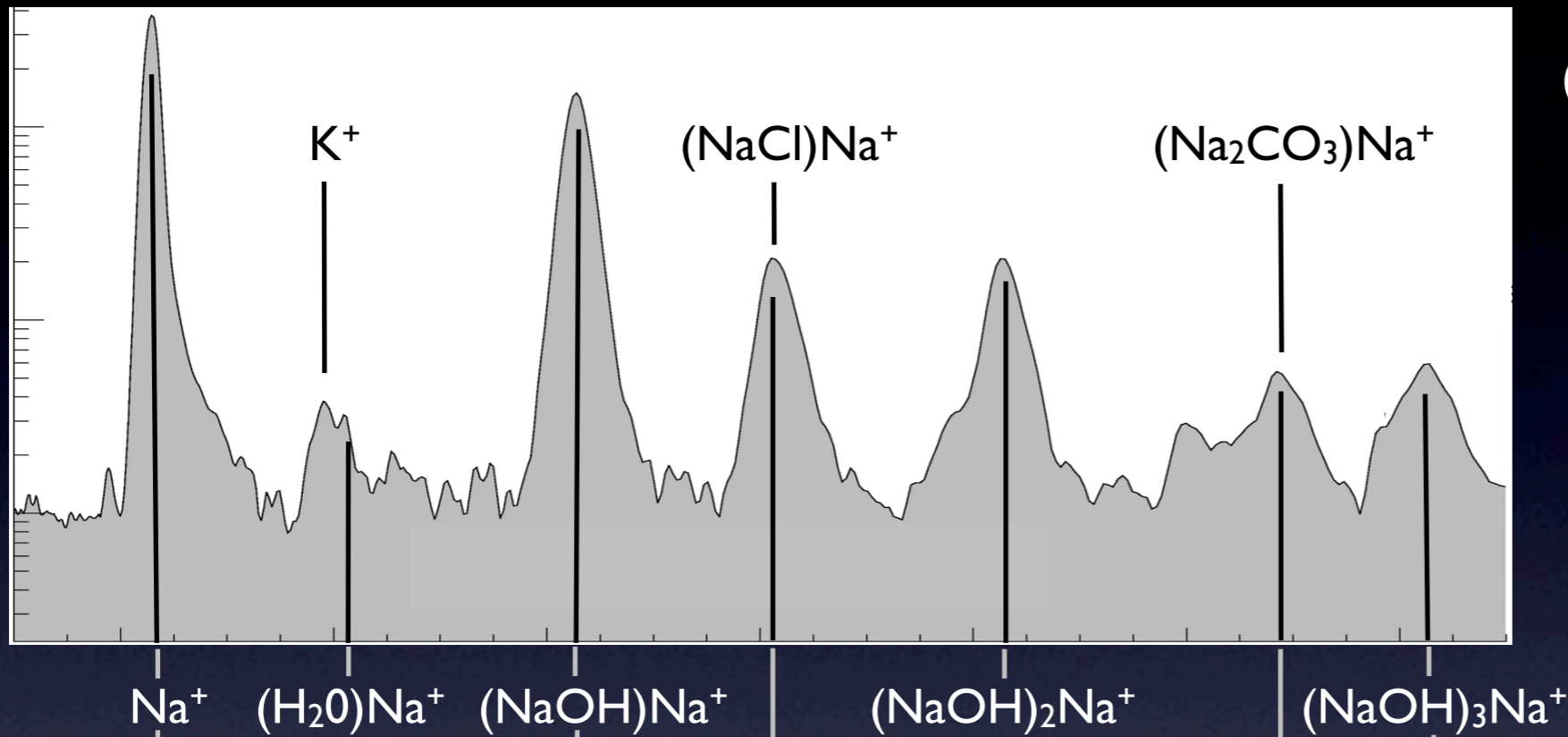


Composition of Enceladus
Plume Particles



NASA/JPL/Space Science Inst.

Enceladus Dust Composition



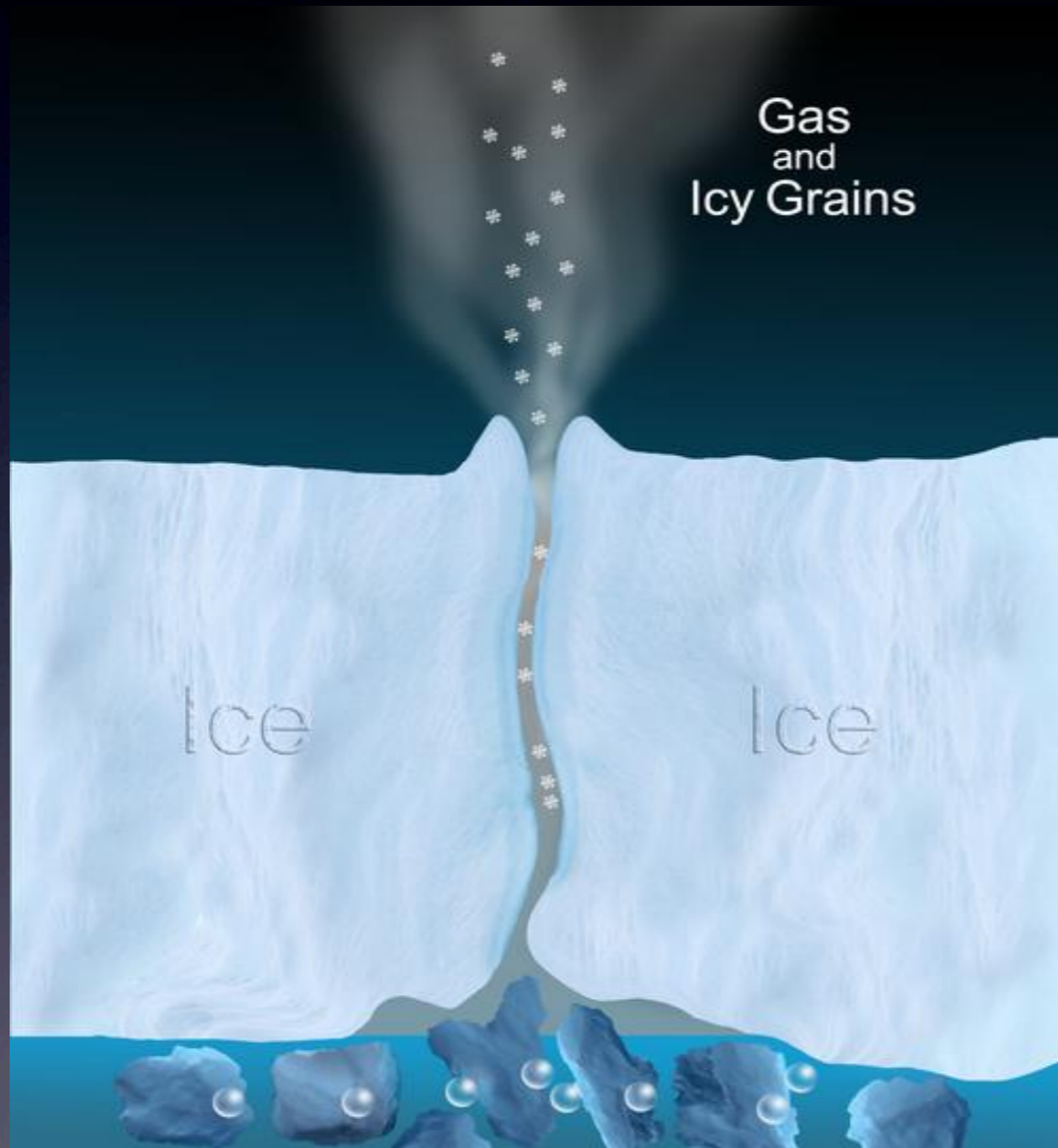
Co-Added CDA
Spectrum:

Salt-rich Geyser
Ice Grains
(6%)

Lab Spectrum:

Laser Dispersion
of Salt Water

The Enceladus Ocean



„Soda“ Ocean

Rich in Carbonates

pH ~ 9

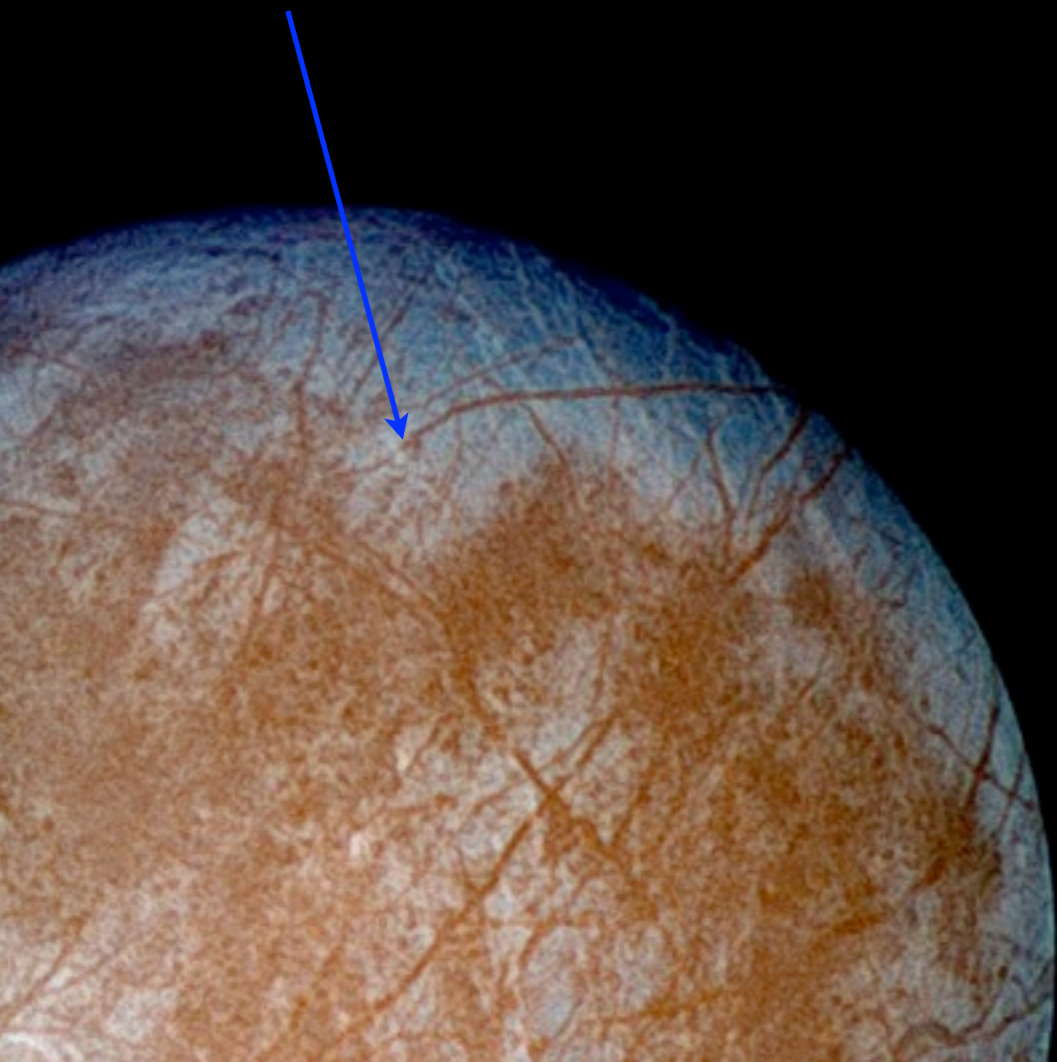
Salinity ~ 1% (Earth 1...4%)

Ejecta Backtracking



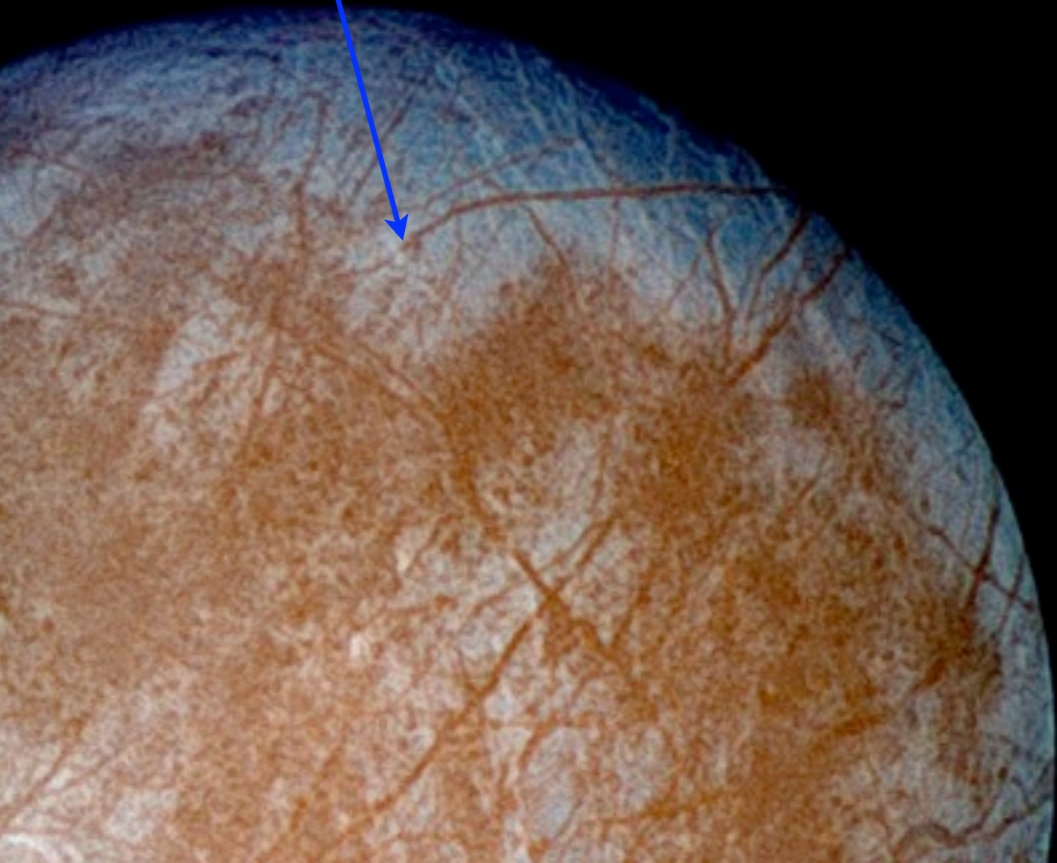
Ejecta Backtracking

Meteorite



Ejecta Backtracking

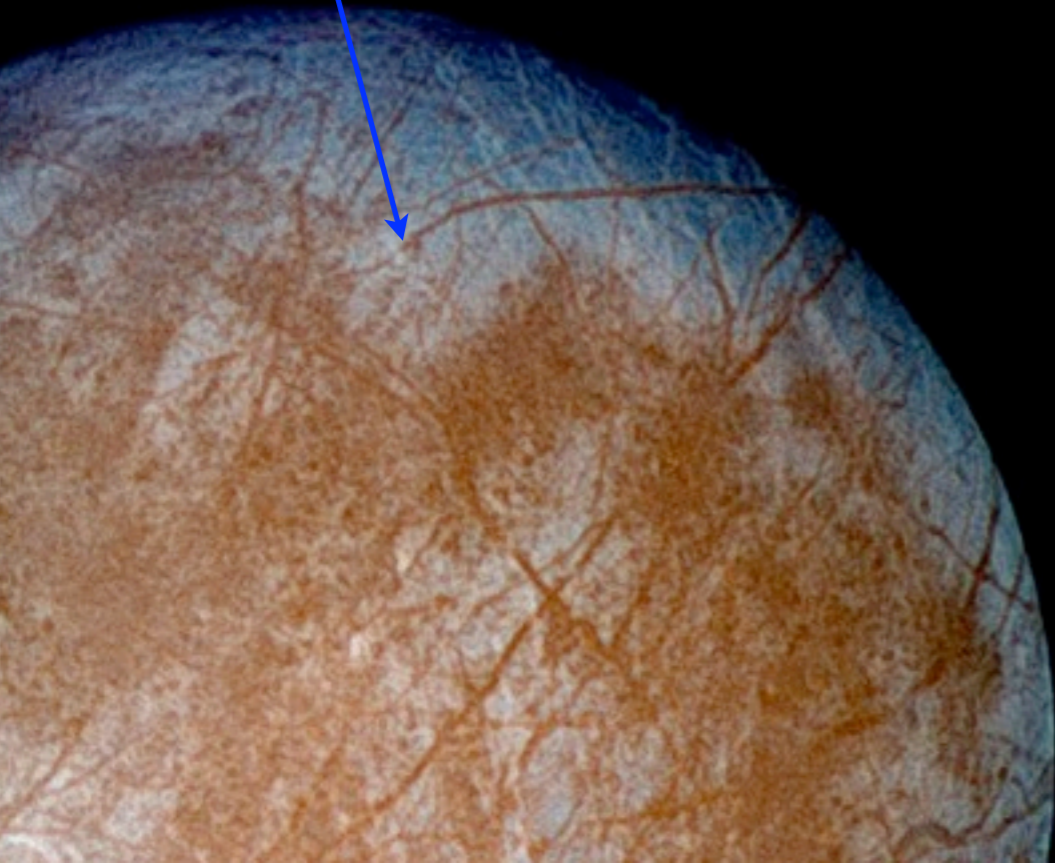
Meteorite



- **Meteorite** impact splashes up multiple ejecta

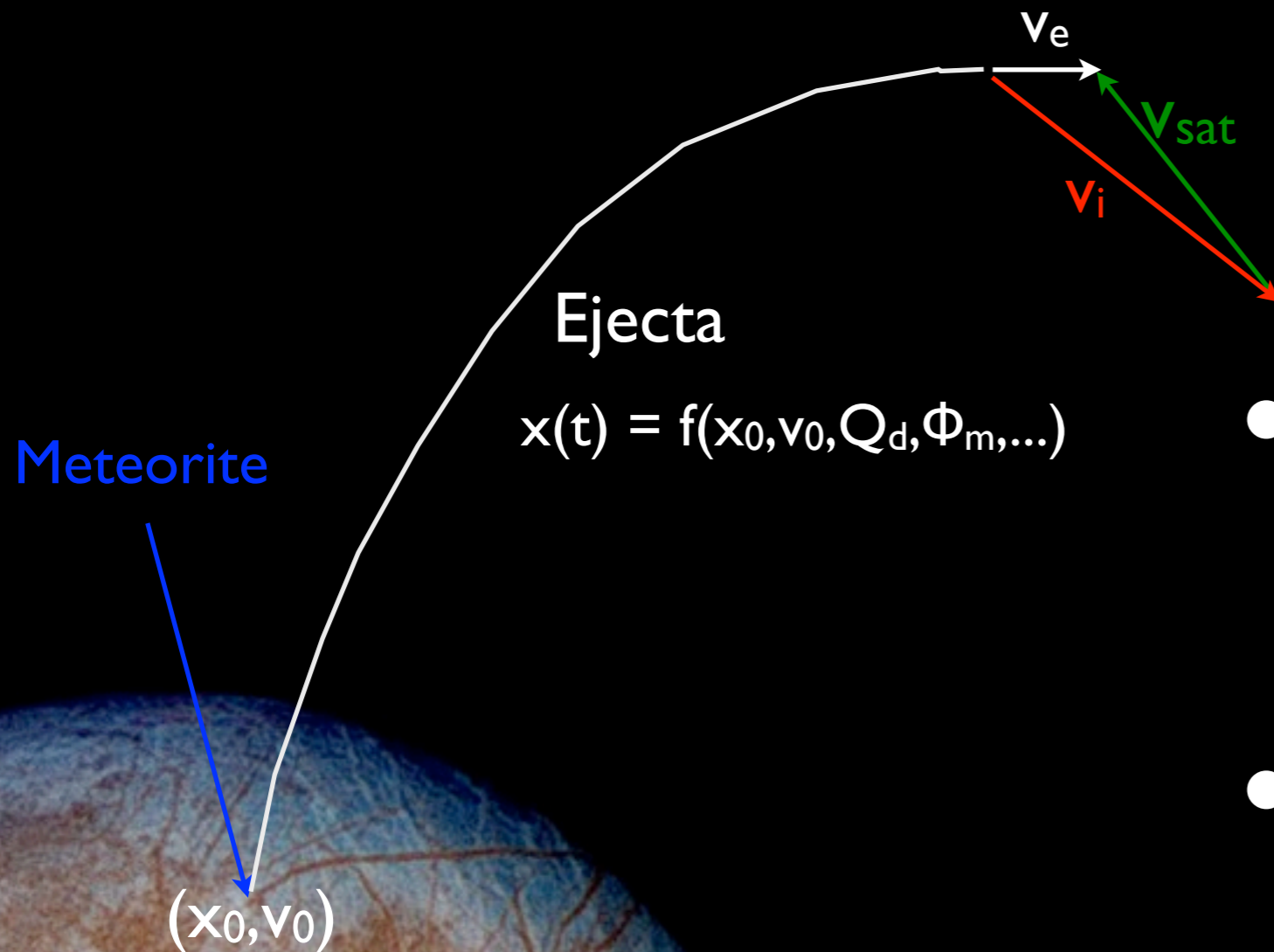
Ejecta Backtracking

Meteorite



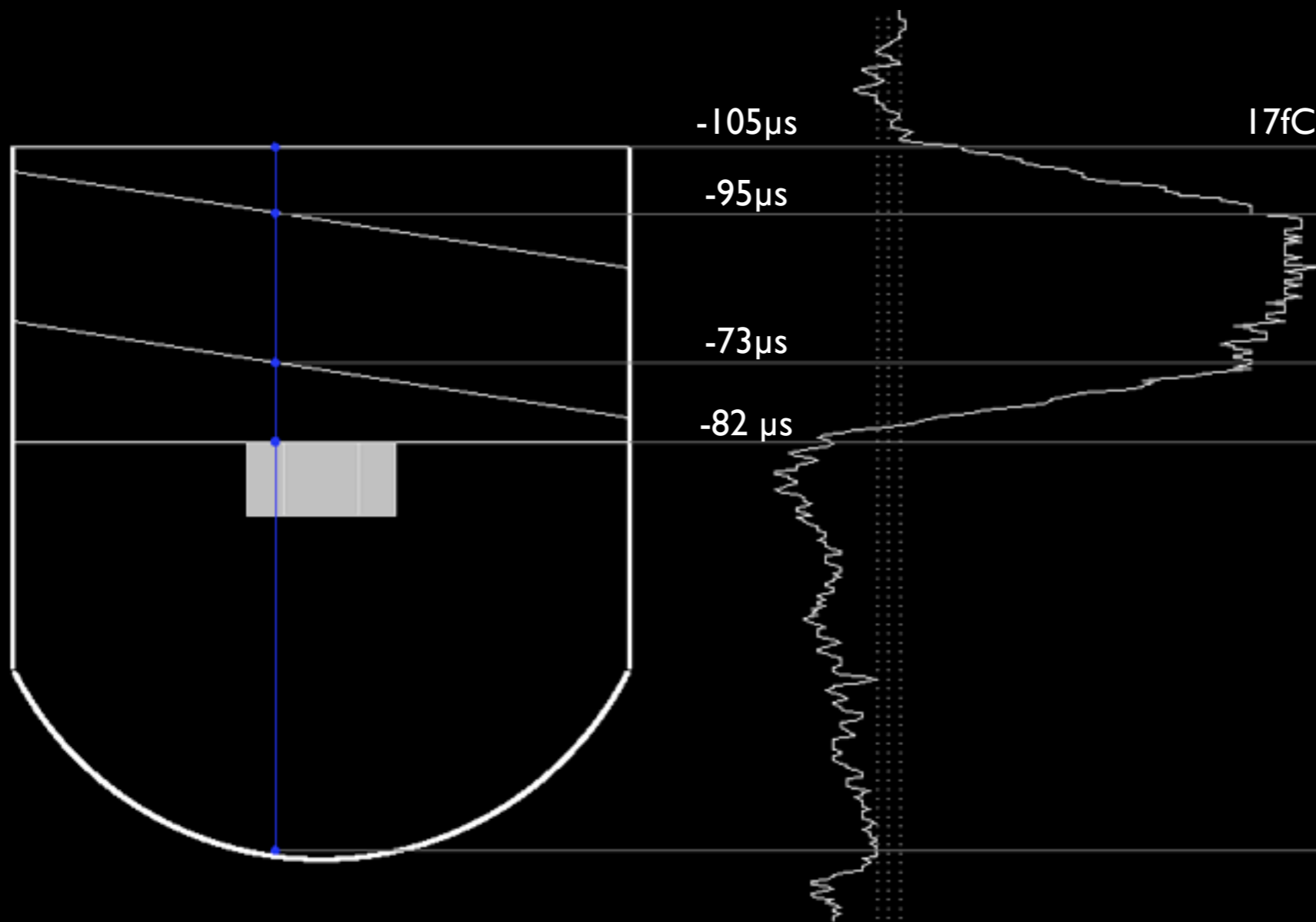
- **Meteorite** impact splashes up multiple ejecta
- **Satellite** moves relative to ejecta:
 $v_i = v_e - v_{sat} \quad (\approx \text{Apex})$

Ejecta Backtracking



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

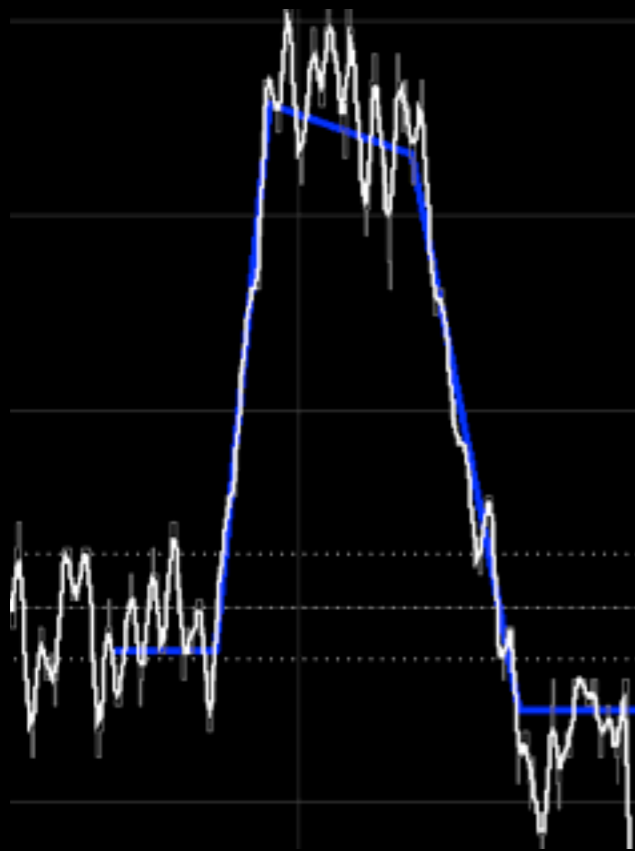
CDA Measures Velocity of Charged Dust



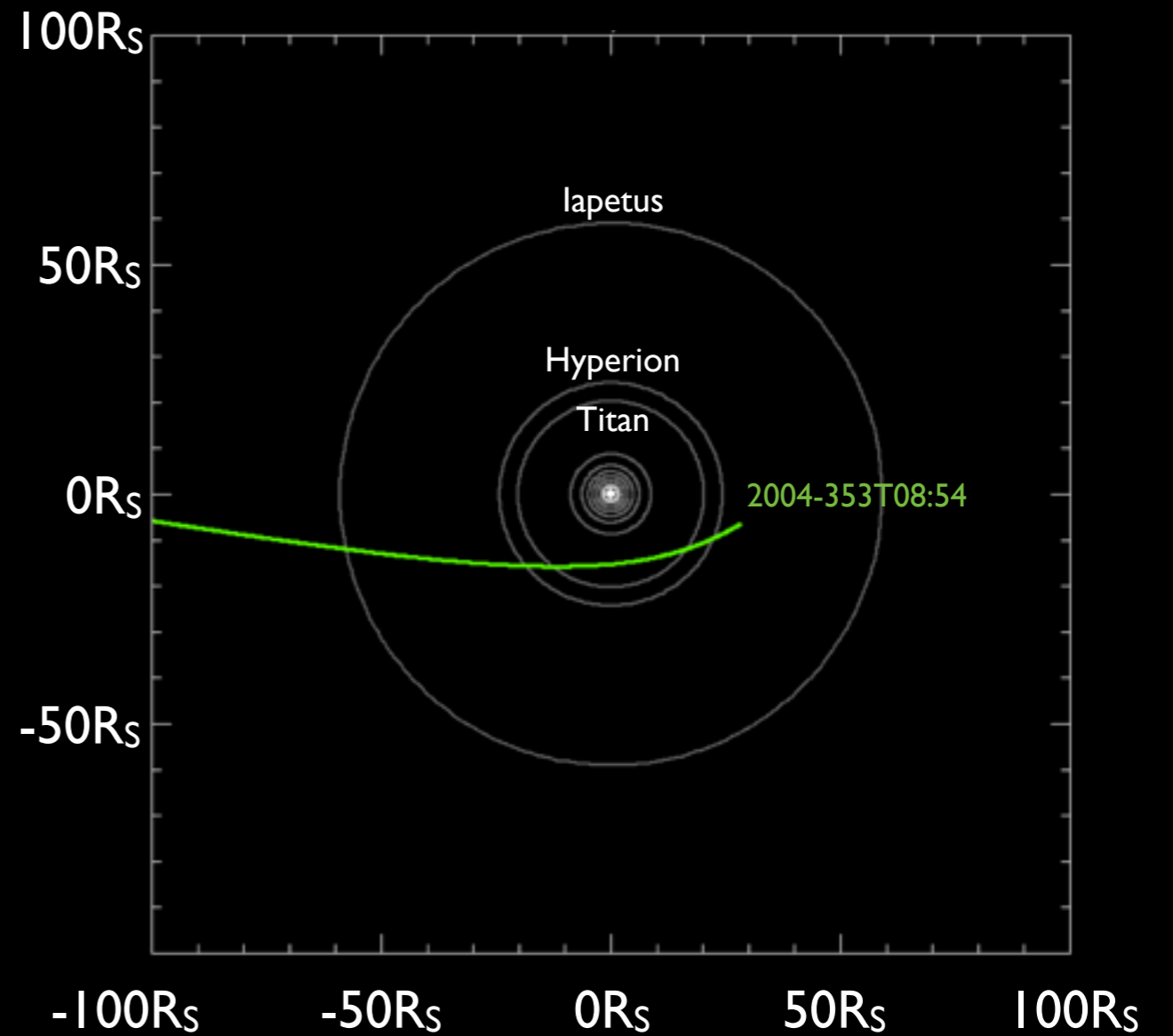
$v_d = 4.3 \text{ km/s}$ $R_d = 0.6 \mu\text{m}$

Dust Orbit Reconstruction

2004-353T08:54

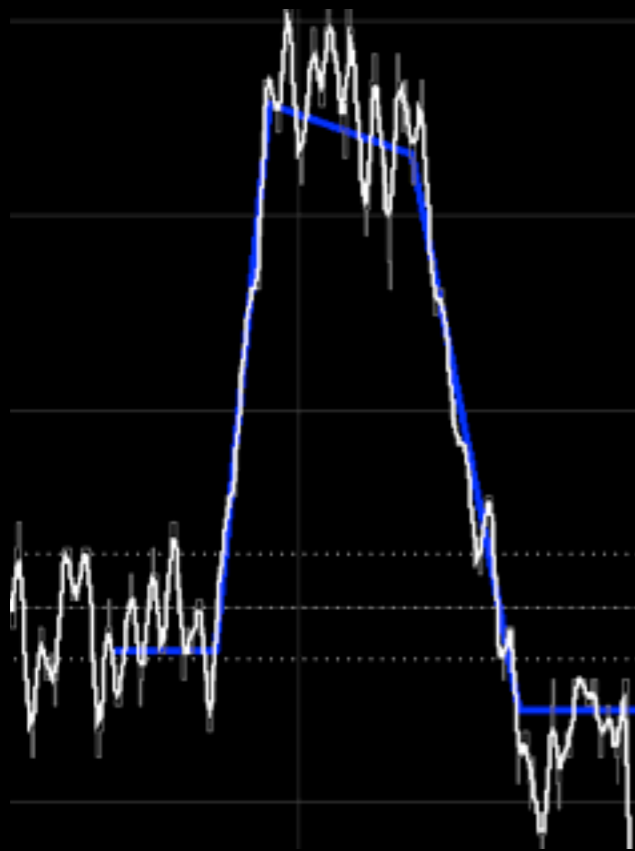


$R=18.2\mu\text{m}$ $Q=5.7\text{fC}$ $\Phi=+2.8\text{V}$

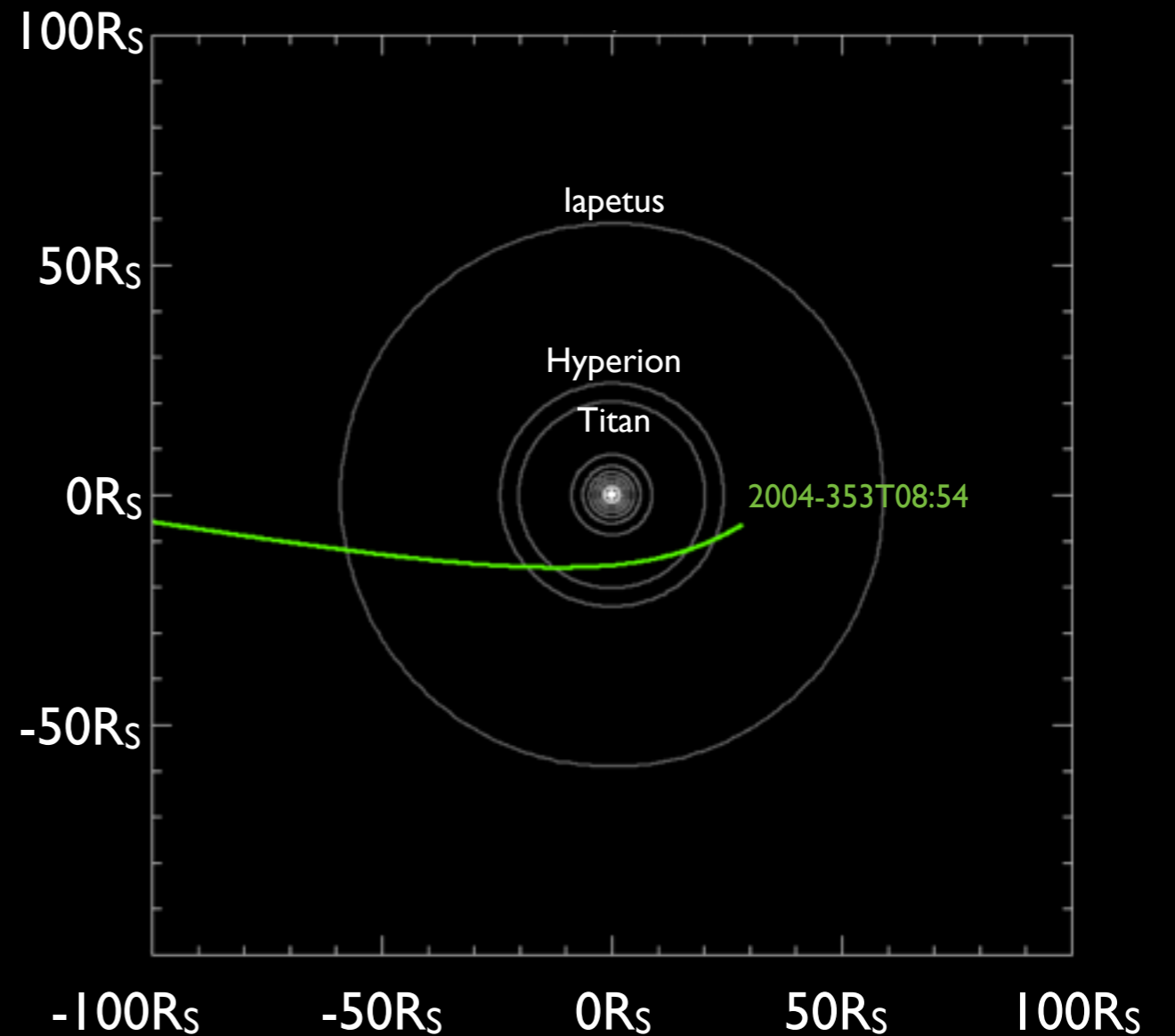


Dust Orbit Reconstruction

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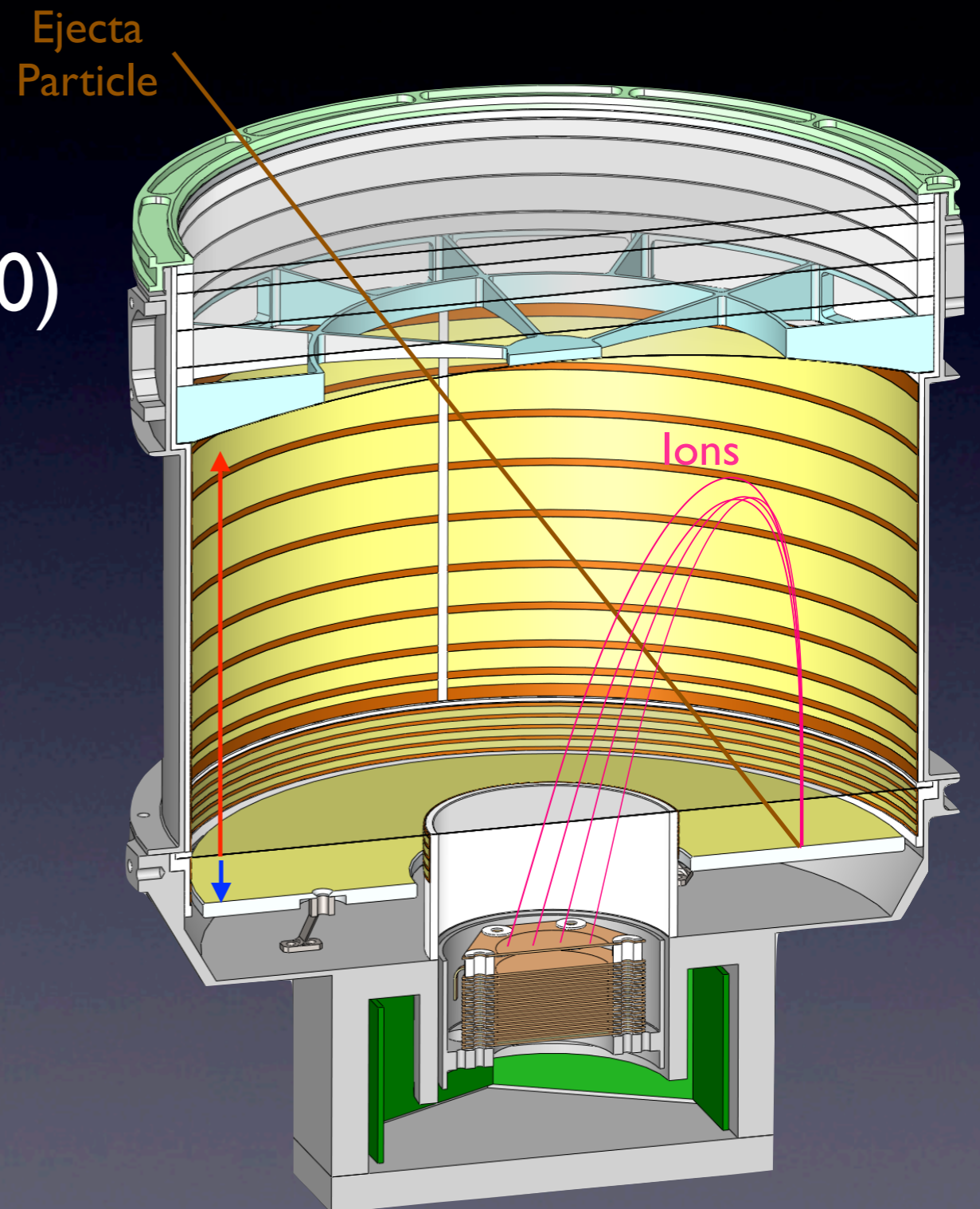
$R=18.2\mu\text{m}$ $Q=5.7\text{fC}$ $\Phi=+2.8\text{V}$



Kuiper Belt Particle

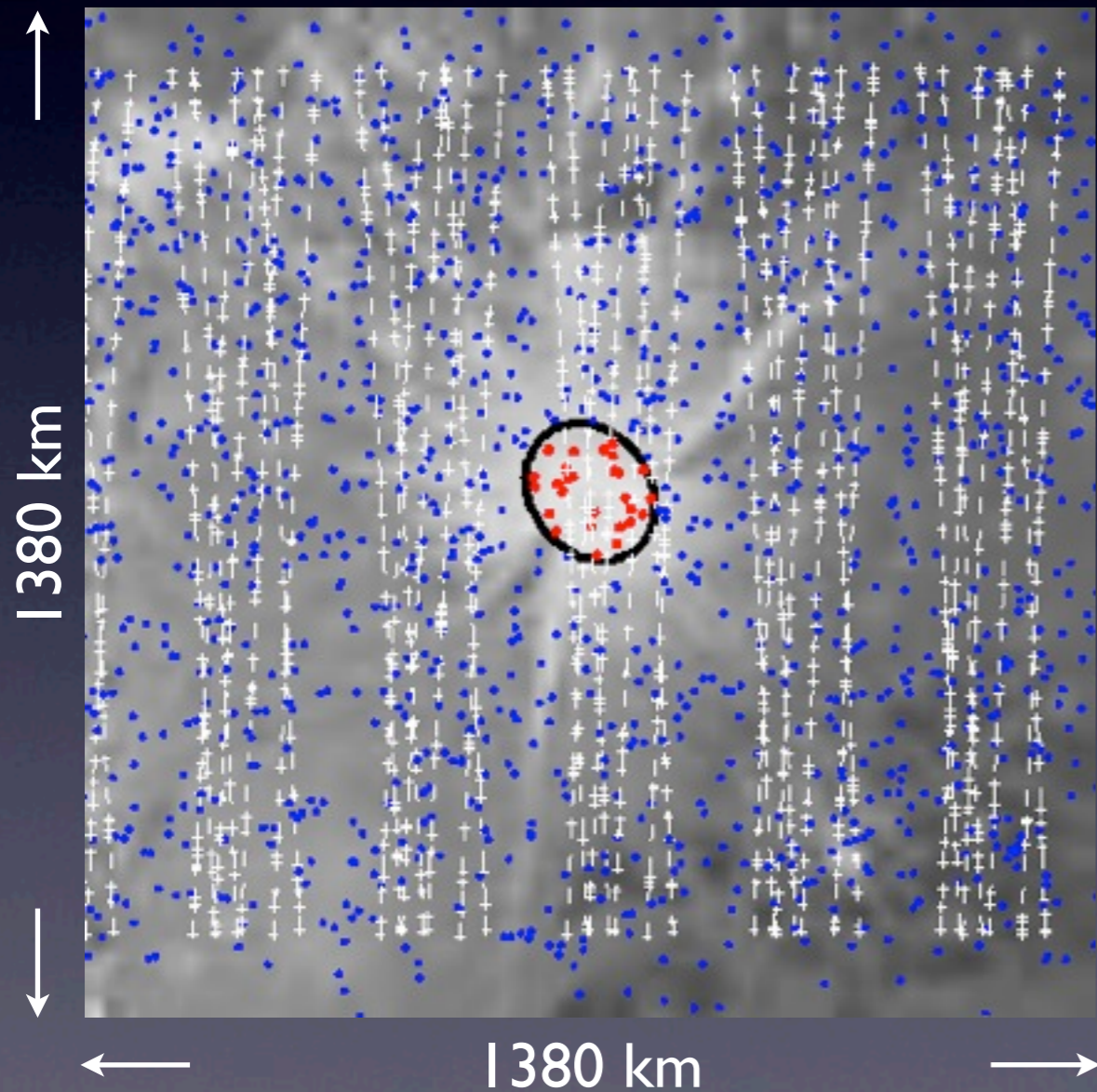
SURFACE DUST ANALYZER (SUDA)

- Mass Spectrometer:
 - Mass Resolution ~ 200 (600)
 - Electrostatic Mirror:
 - Parabolic Grid
 - Ring Electrodes
 - \pm Polarity
- Trajectory Sensor:
 - Velocity (1% Uncertainty)



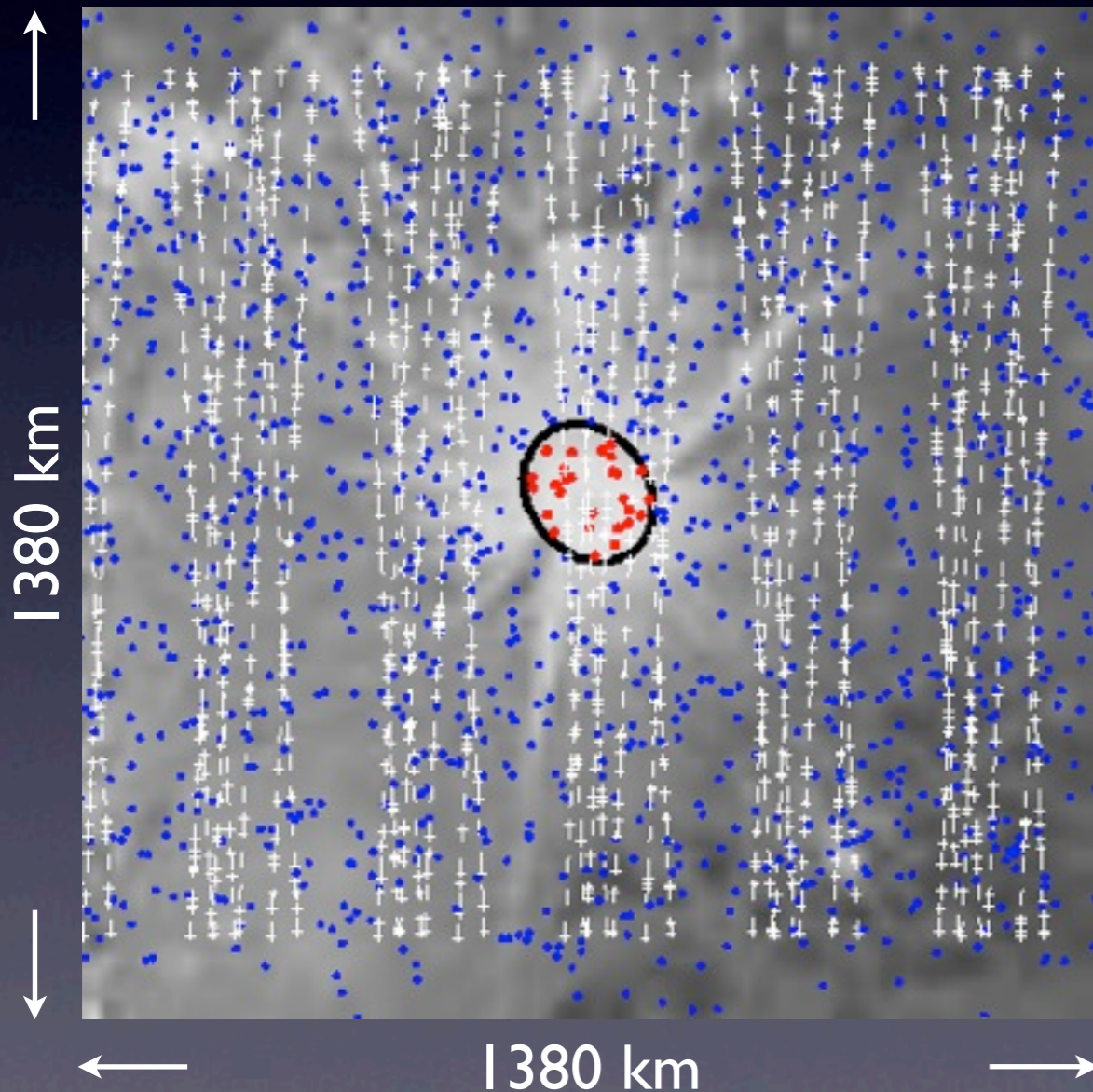
SUDA Composition Map

Bright-rayed Crater Tros on
Ganymede (90 km)

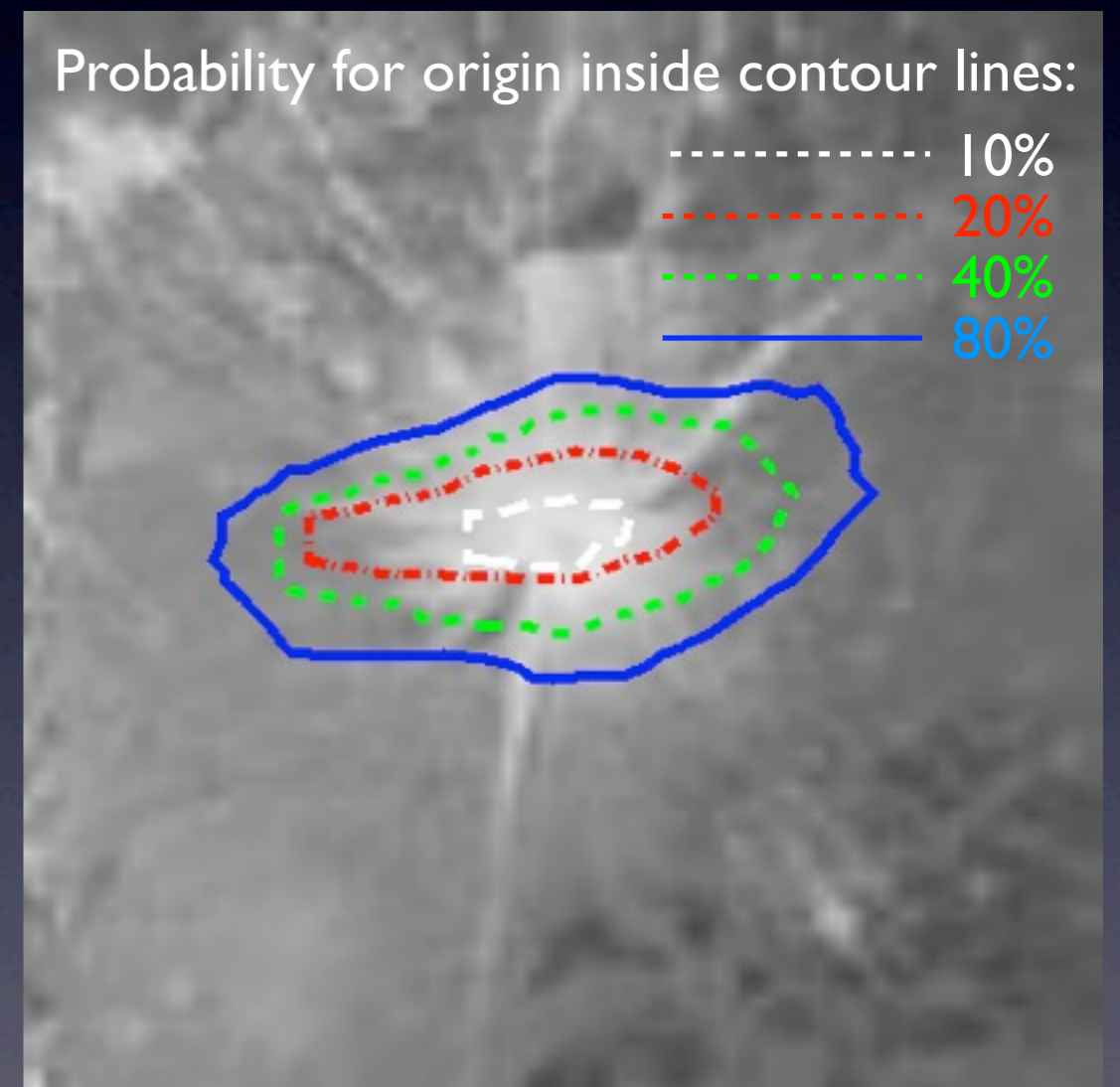


SUDA Composition Map

Bright-rayed Crater Tros on Ganymede (90 km)



MC Simulation for SUDA Compositional Mapping



SUDA Will Collect

Ganymede Mission Phase:

Altitude	Impact Rate	Total Sample #
5000 km	6 per hour	13,000
500 km	7 per minute	1,000,000
200 km	29 per minute	1,400,000

1 Surface Sample per 35 km²

SUDA Will Collect

Ganymede Mission Phase:

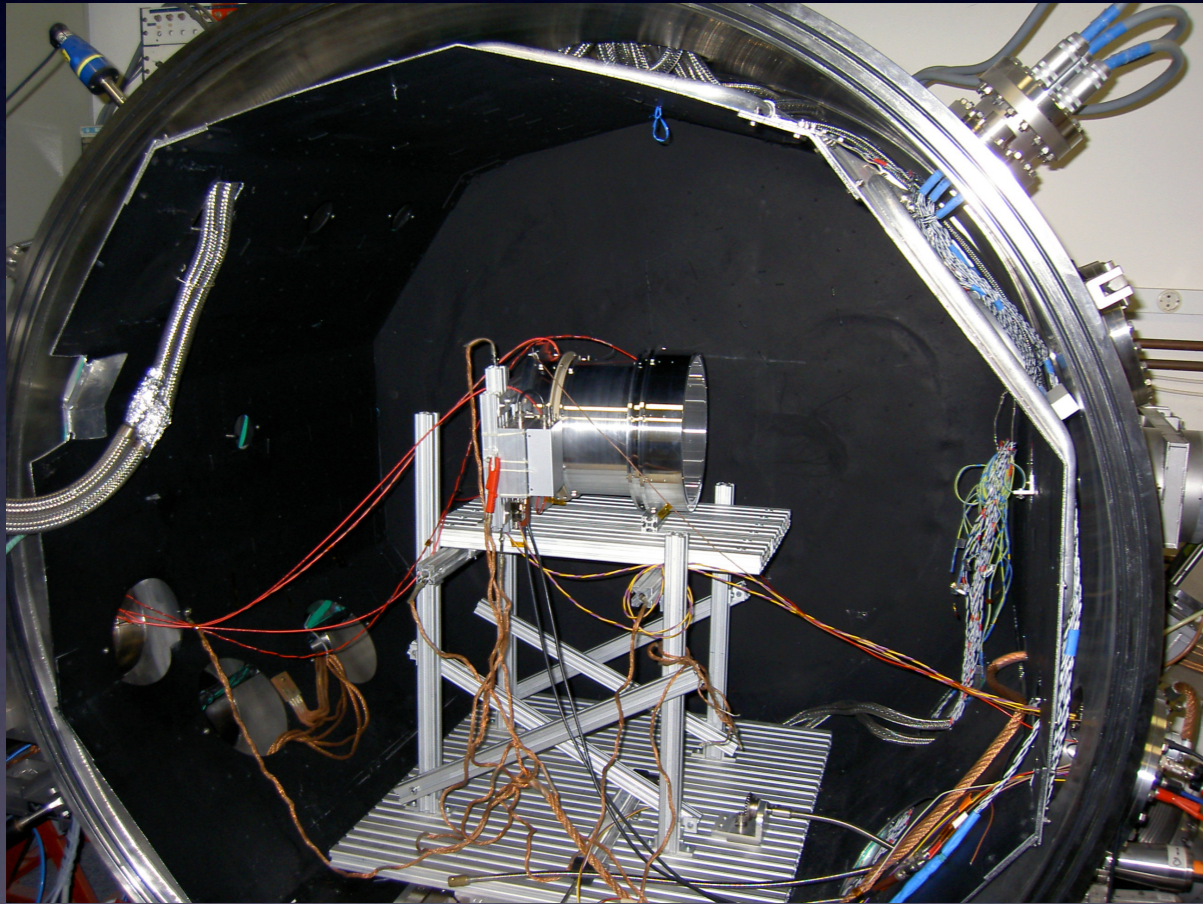
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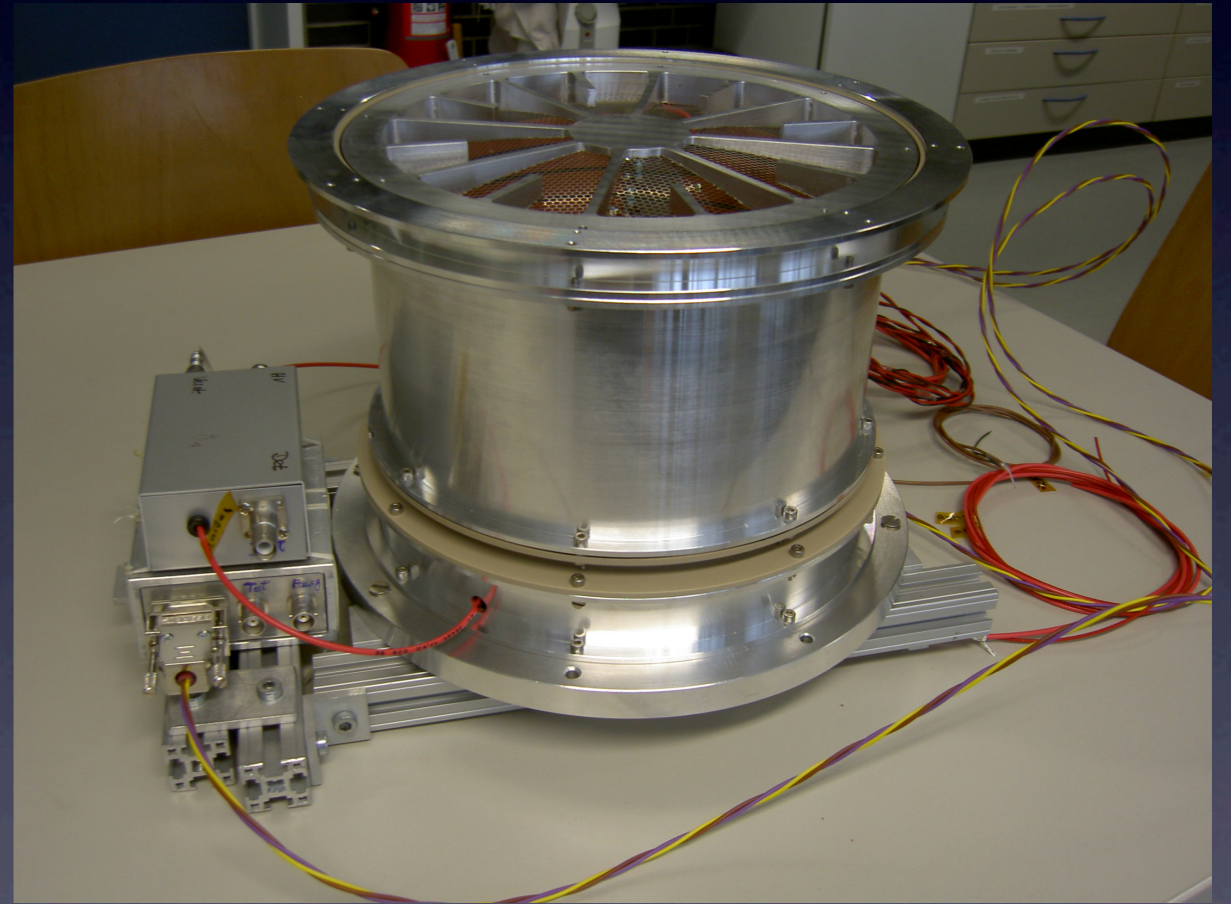
During Flybys:

Flyby	Impact Rate	Total Sample #
Europa 400 km	3 per second	5,800
Callisto 200 km	80 per minute	2,200
Ganymede 300 km	2 per second	3,800

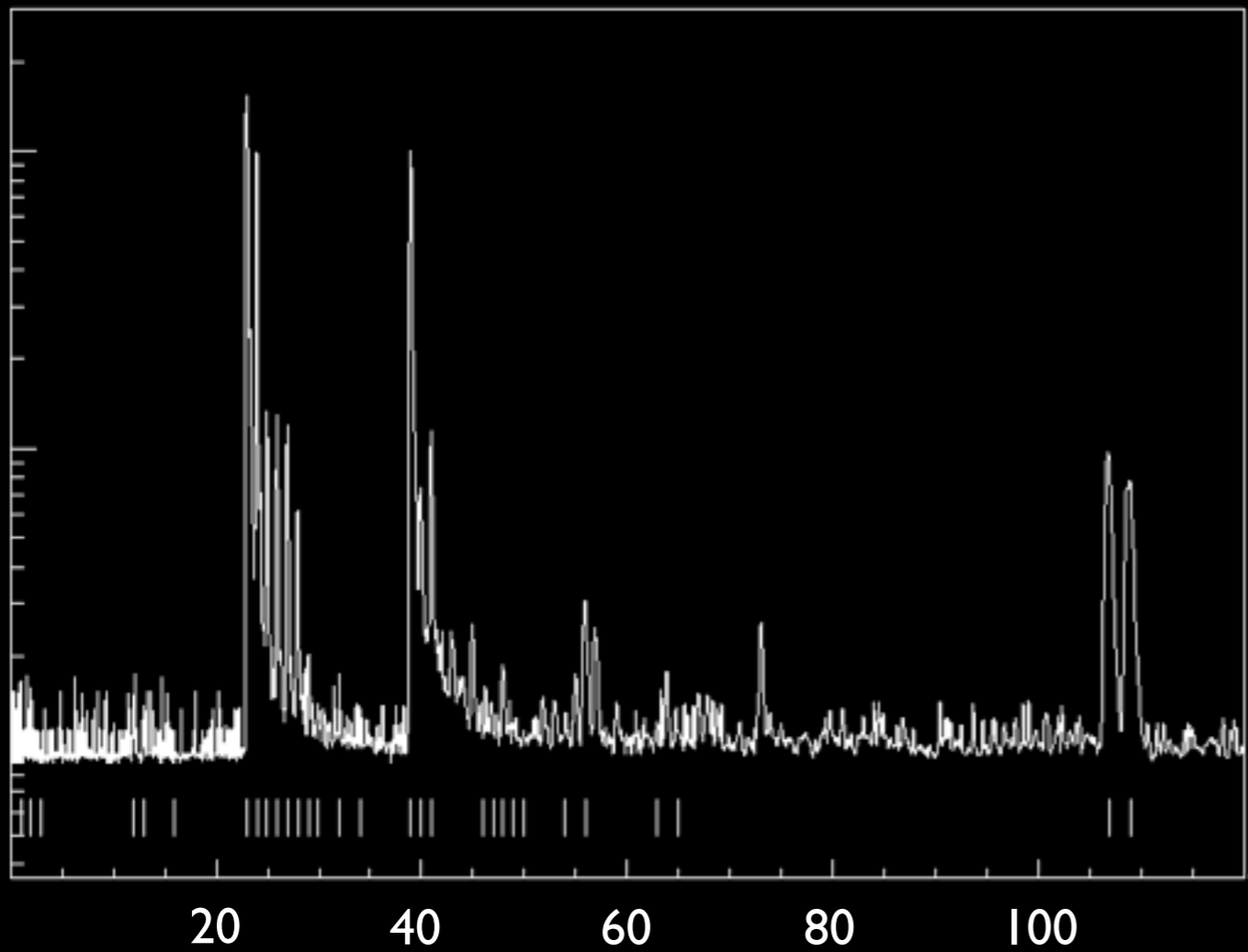
SUDA Prototype



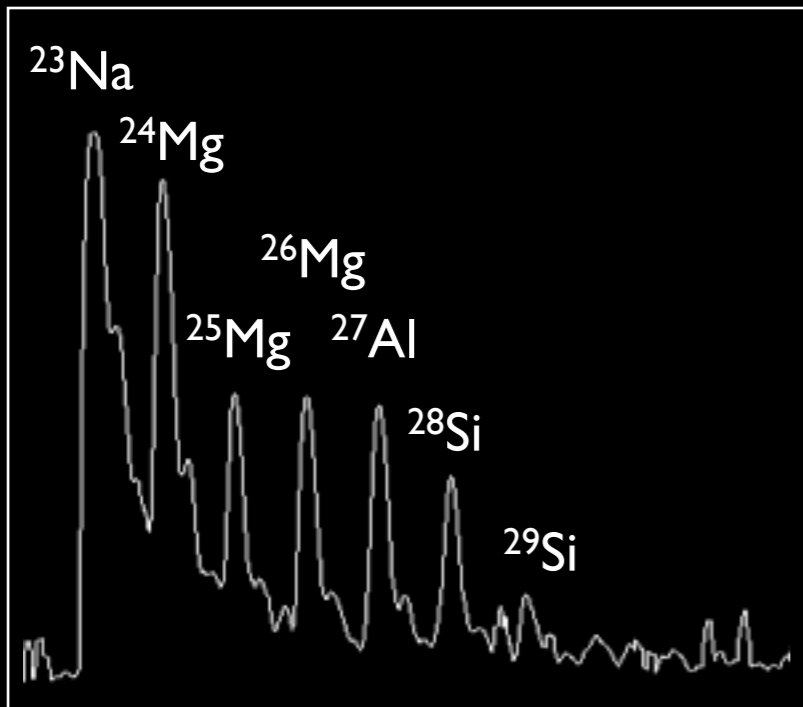
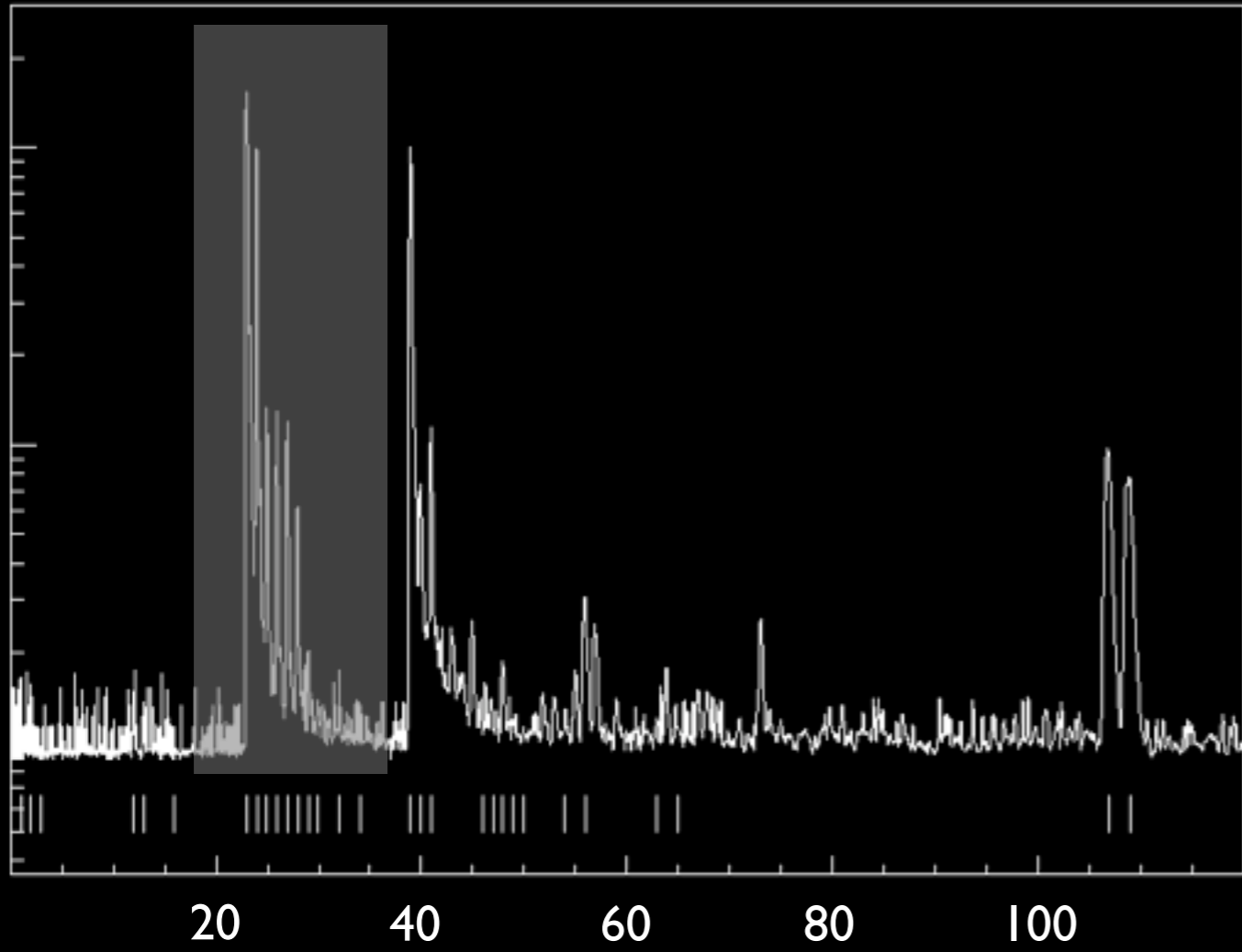
SUDA in Dust Accelerator



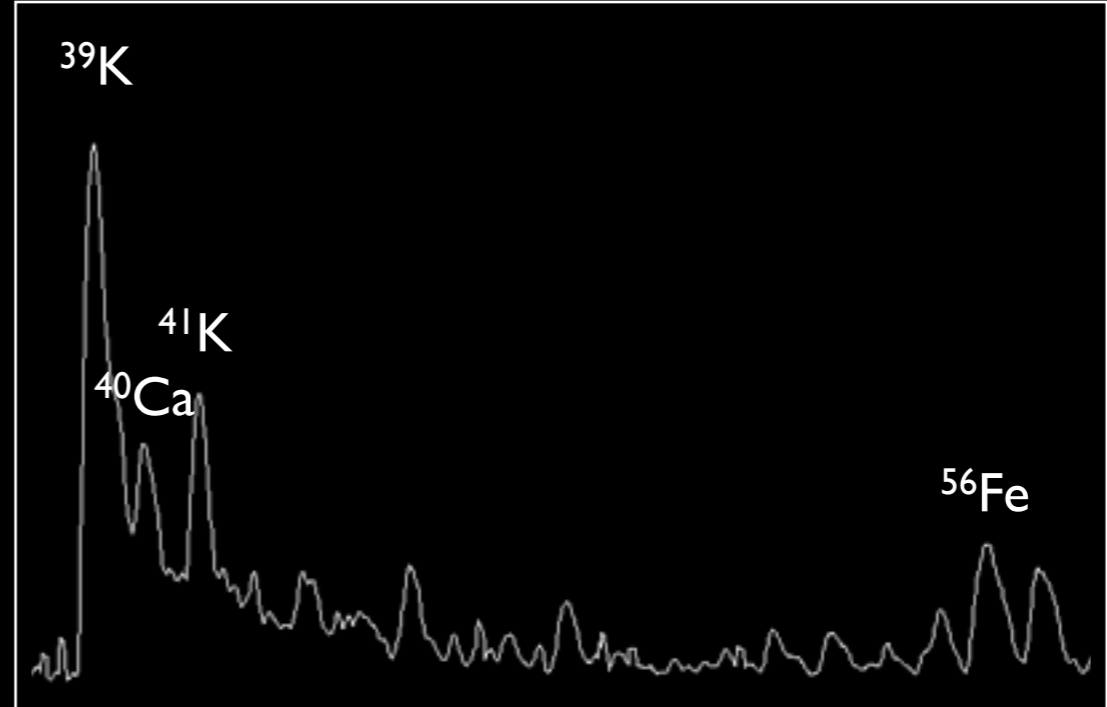
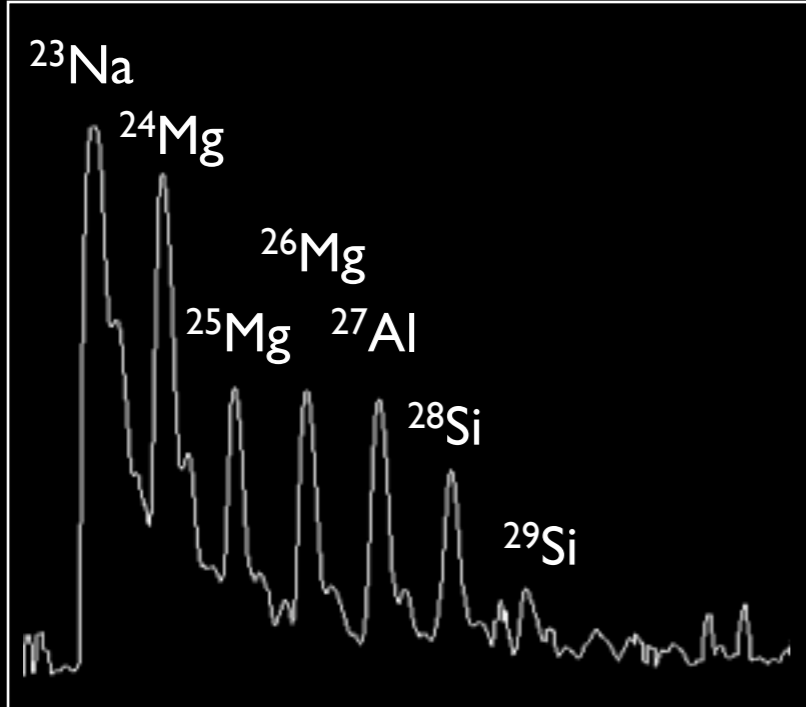
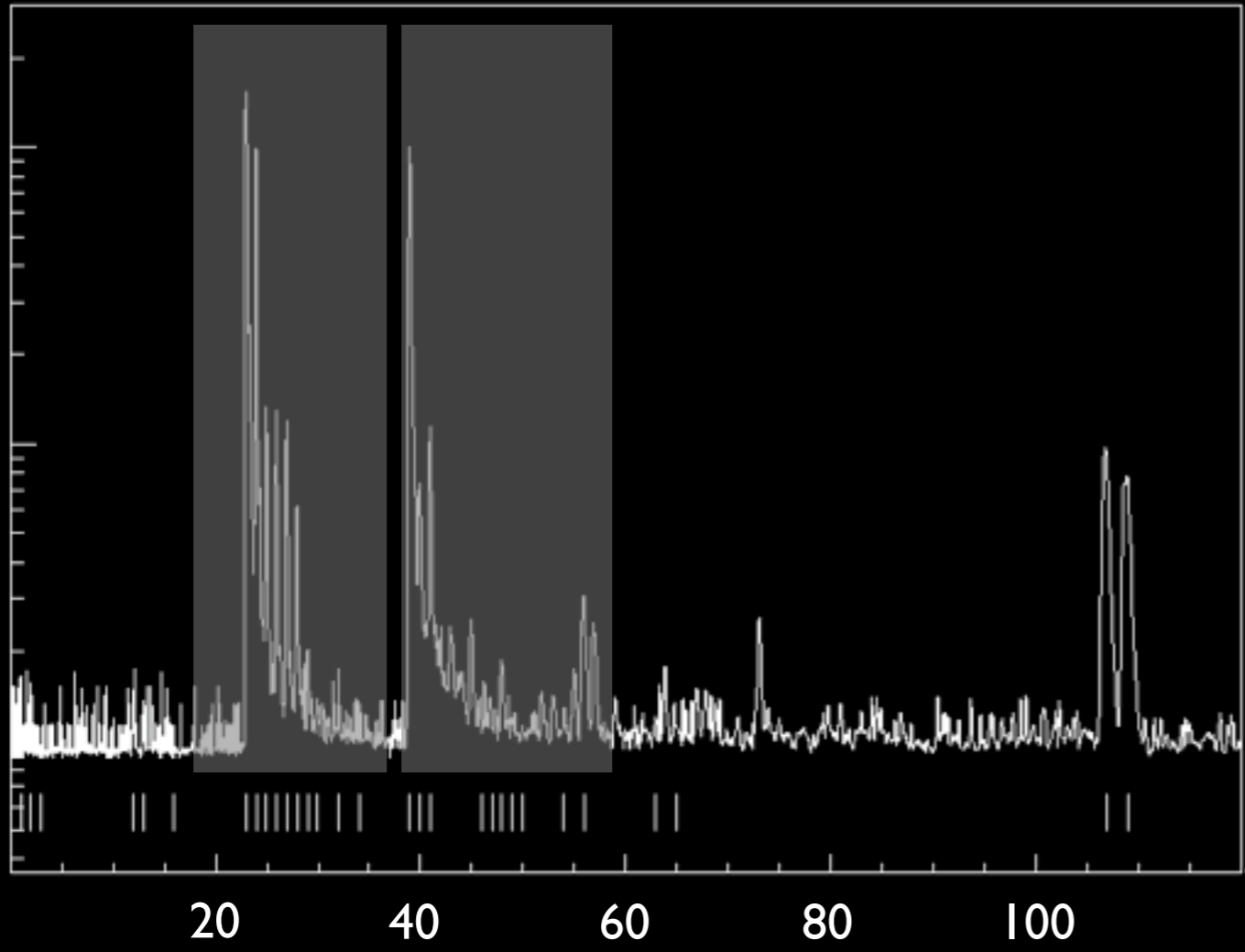
Pyroxene



Pyroxene

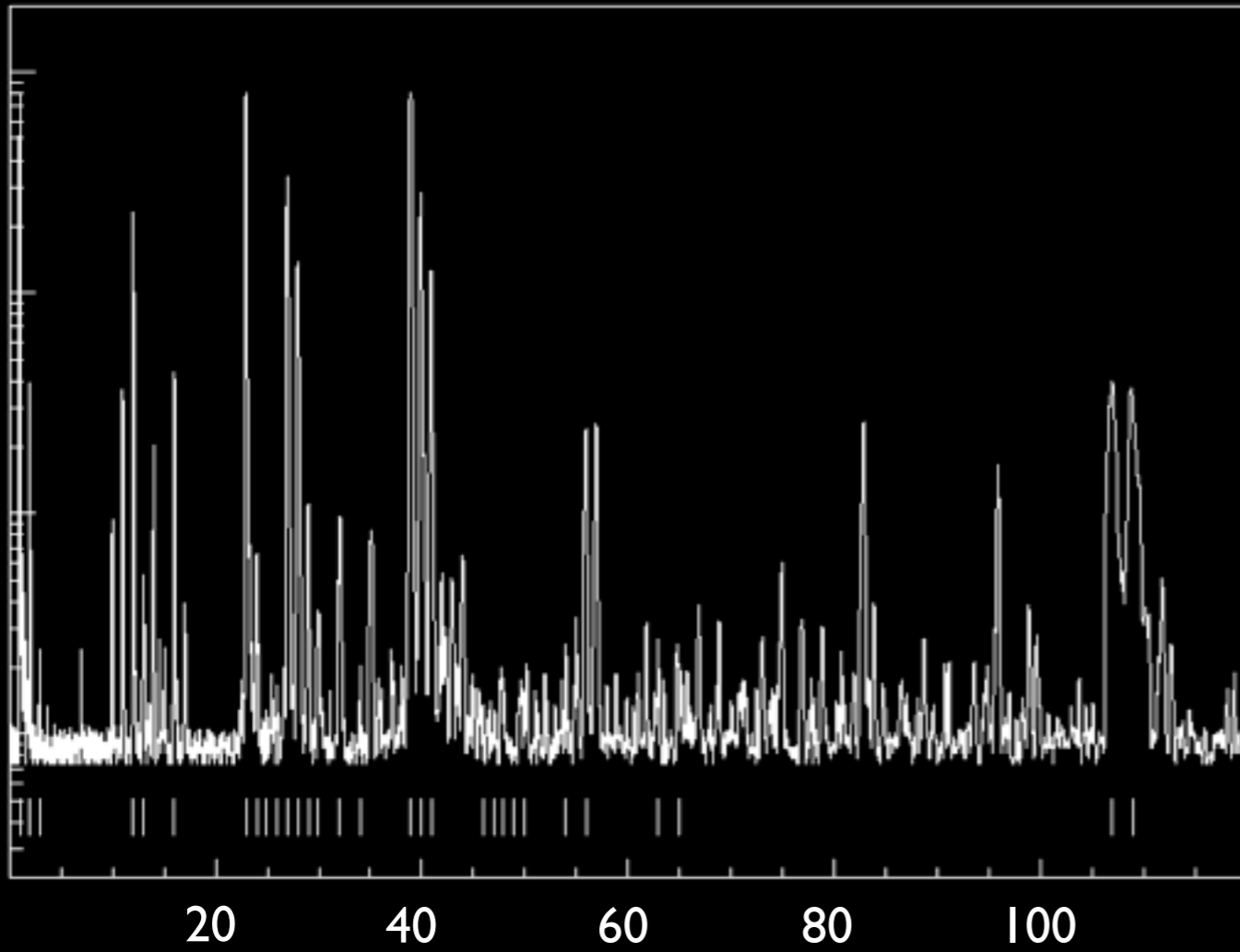


Pyroxene



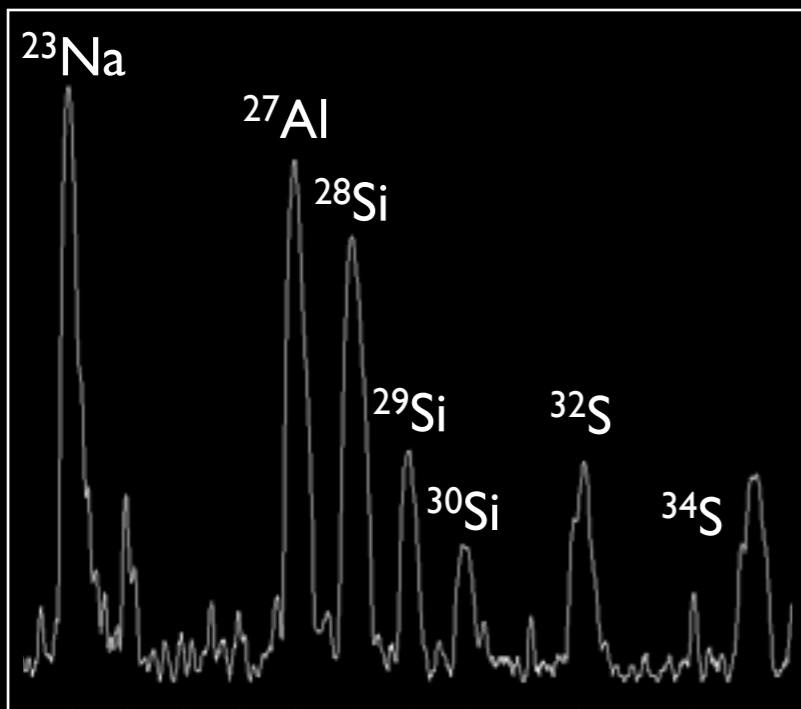
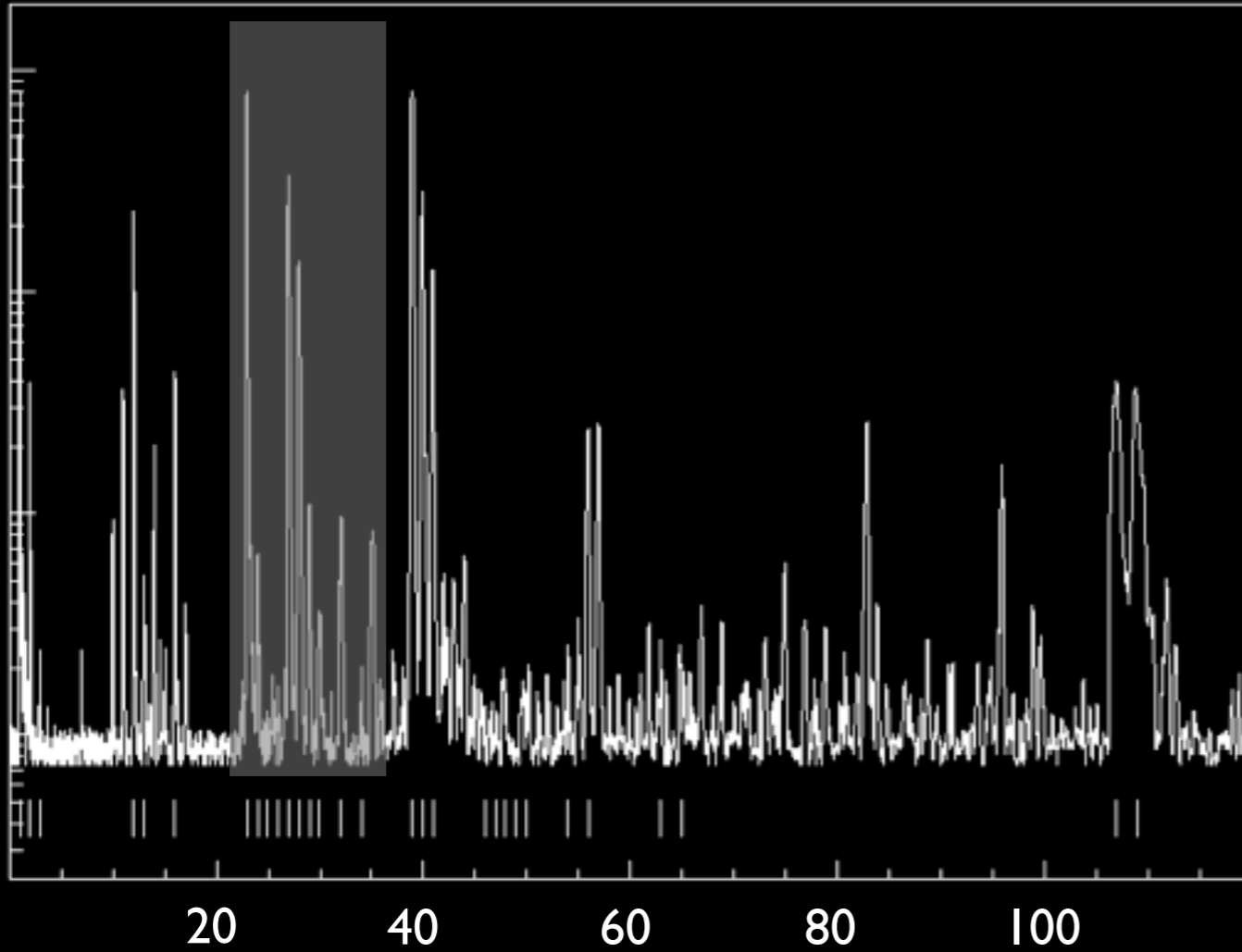
Anorthite

$\text{CaAl}_2\text{Si}_2\text{O}_8$



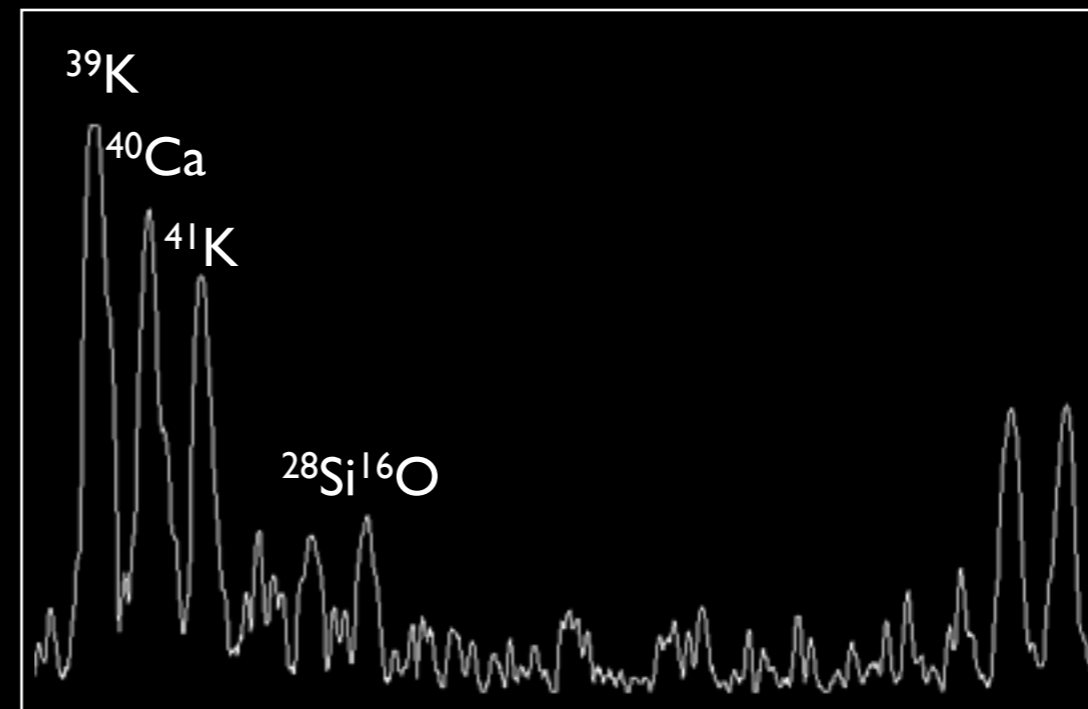
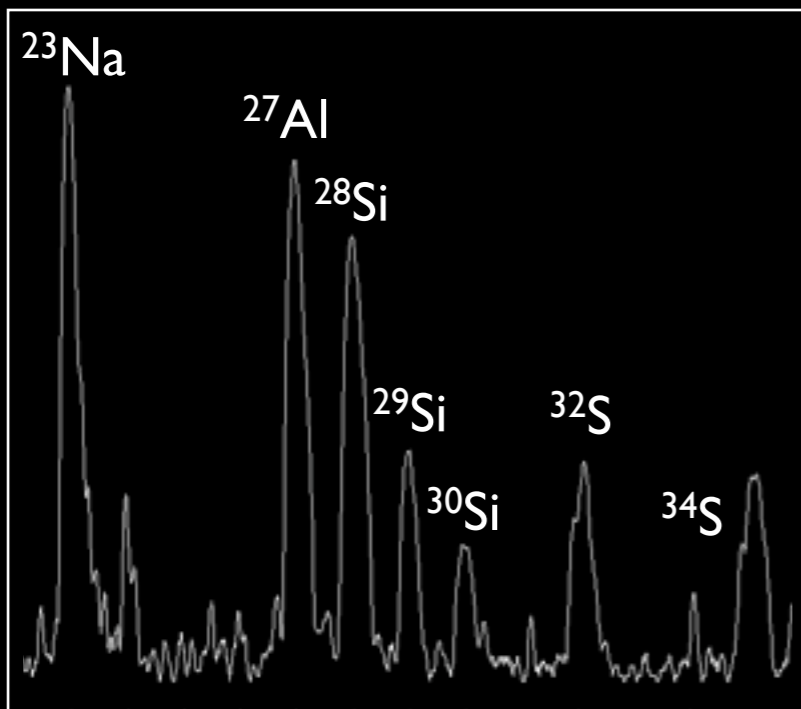
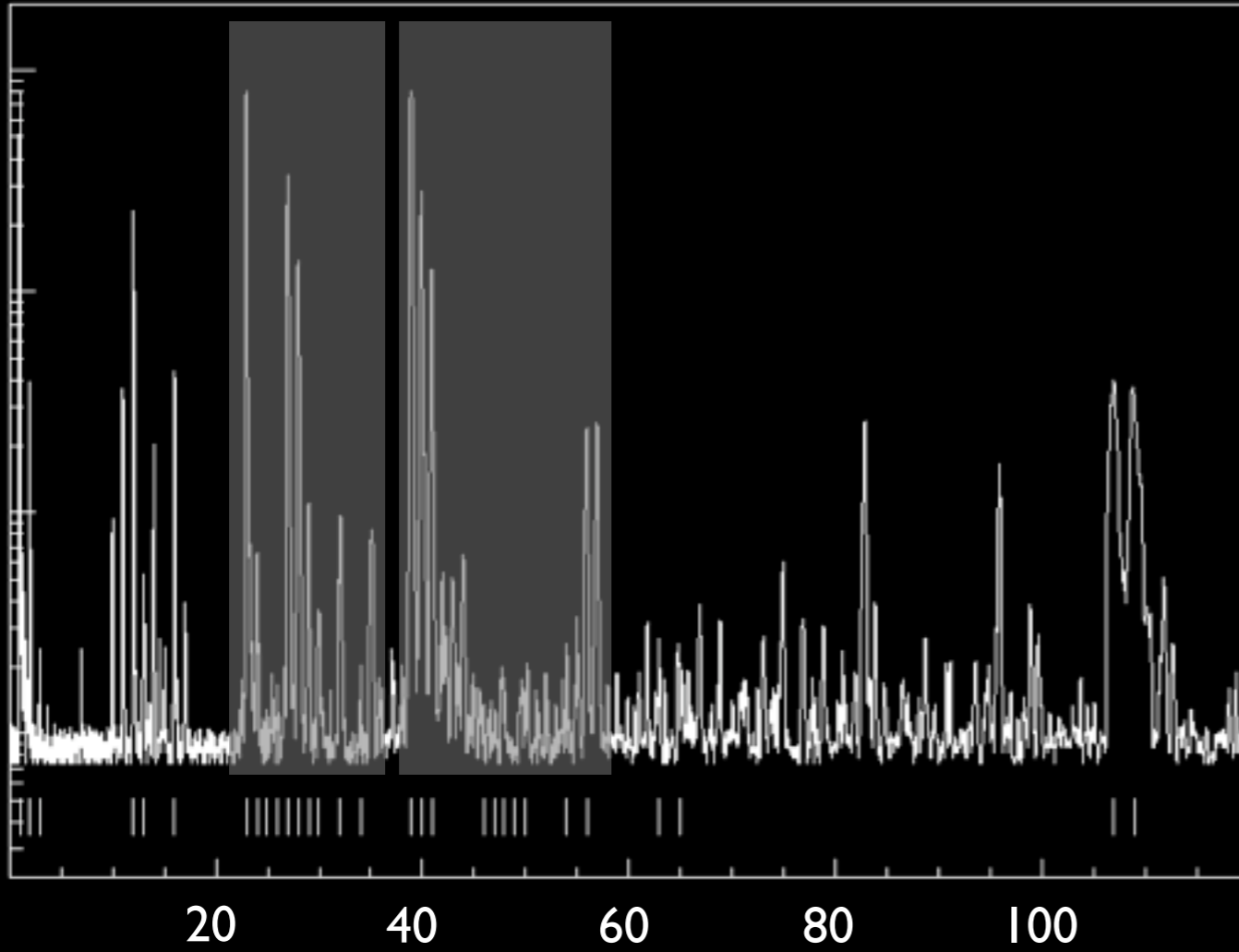
Anorthite

$\text{CaAl}_2\text{Si}_2\text{O}_8$



Anorthite

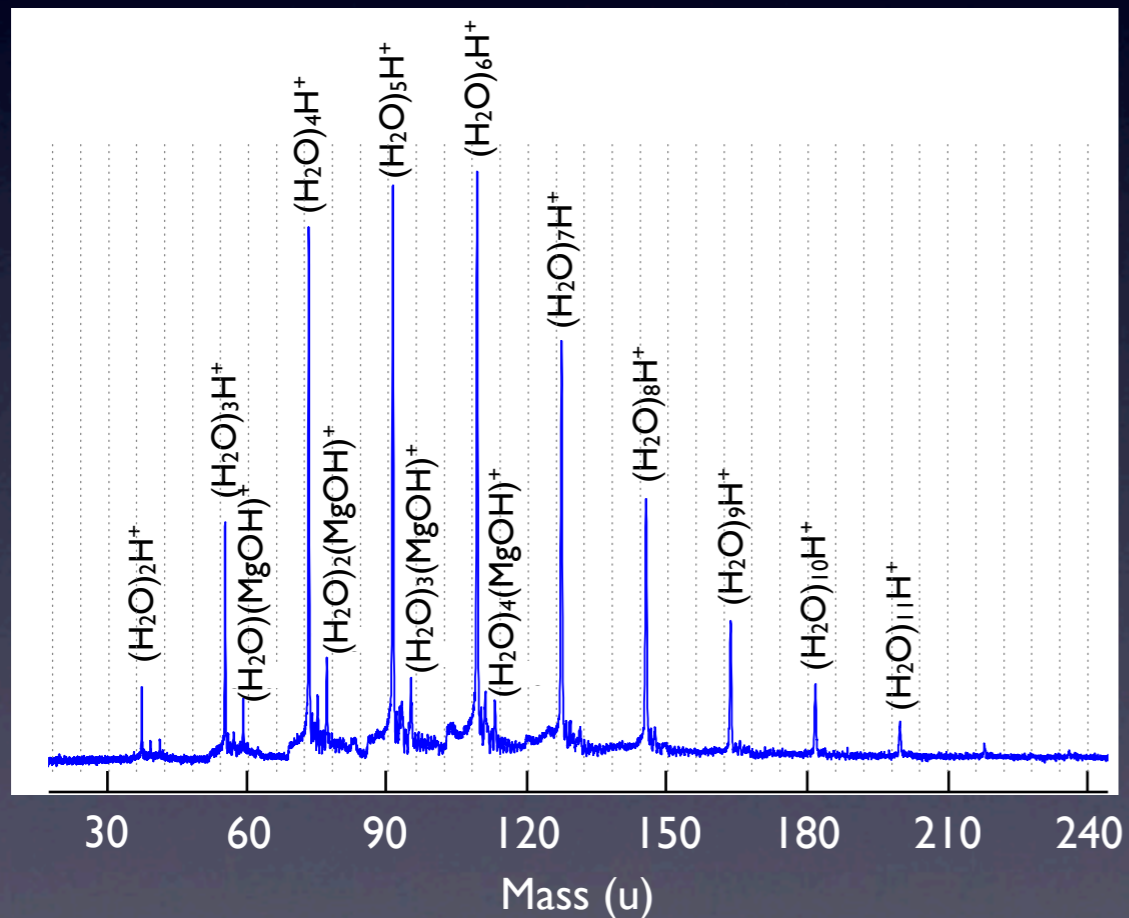
$\text{CaAl}_2\text{Si}_2\text{O}_8$



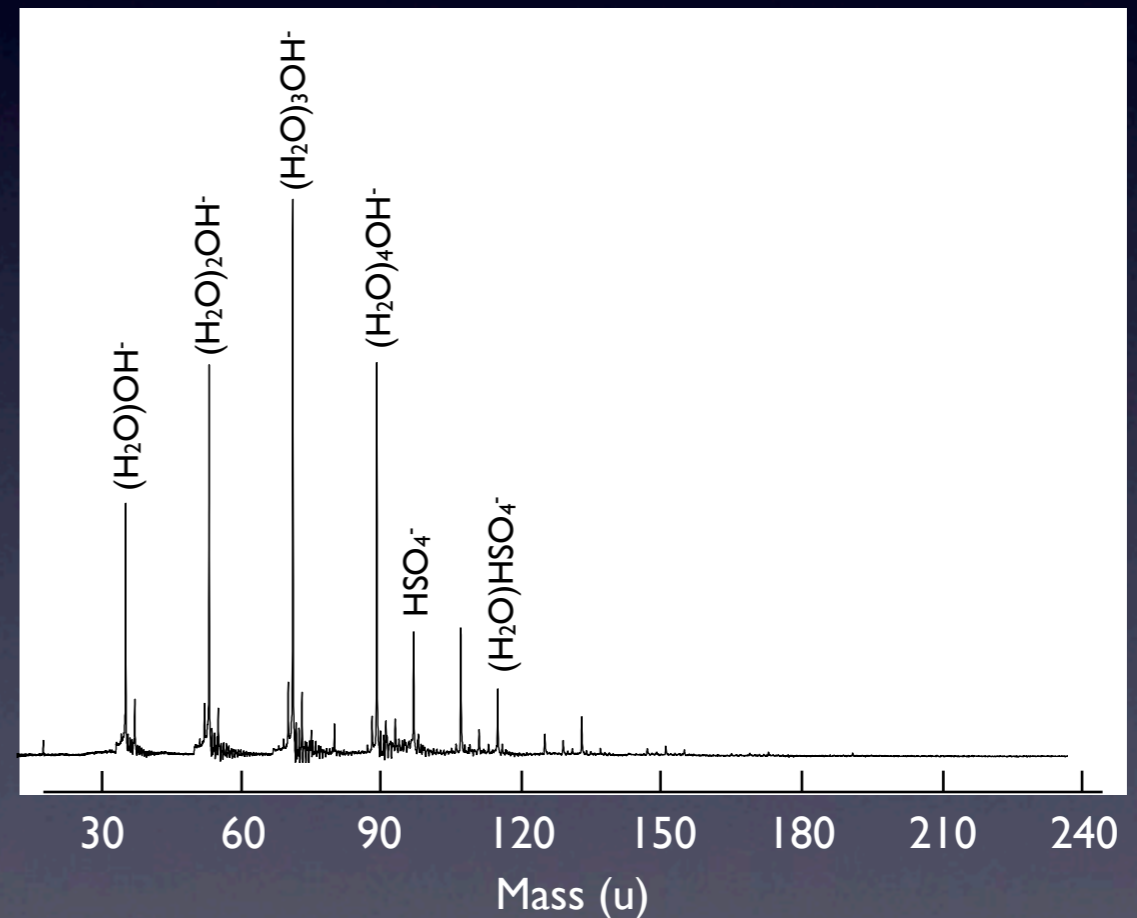
SUDA @ Ganymede

Water + MgSO₄

Cations



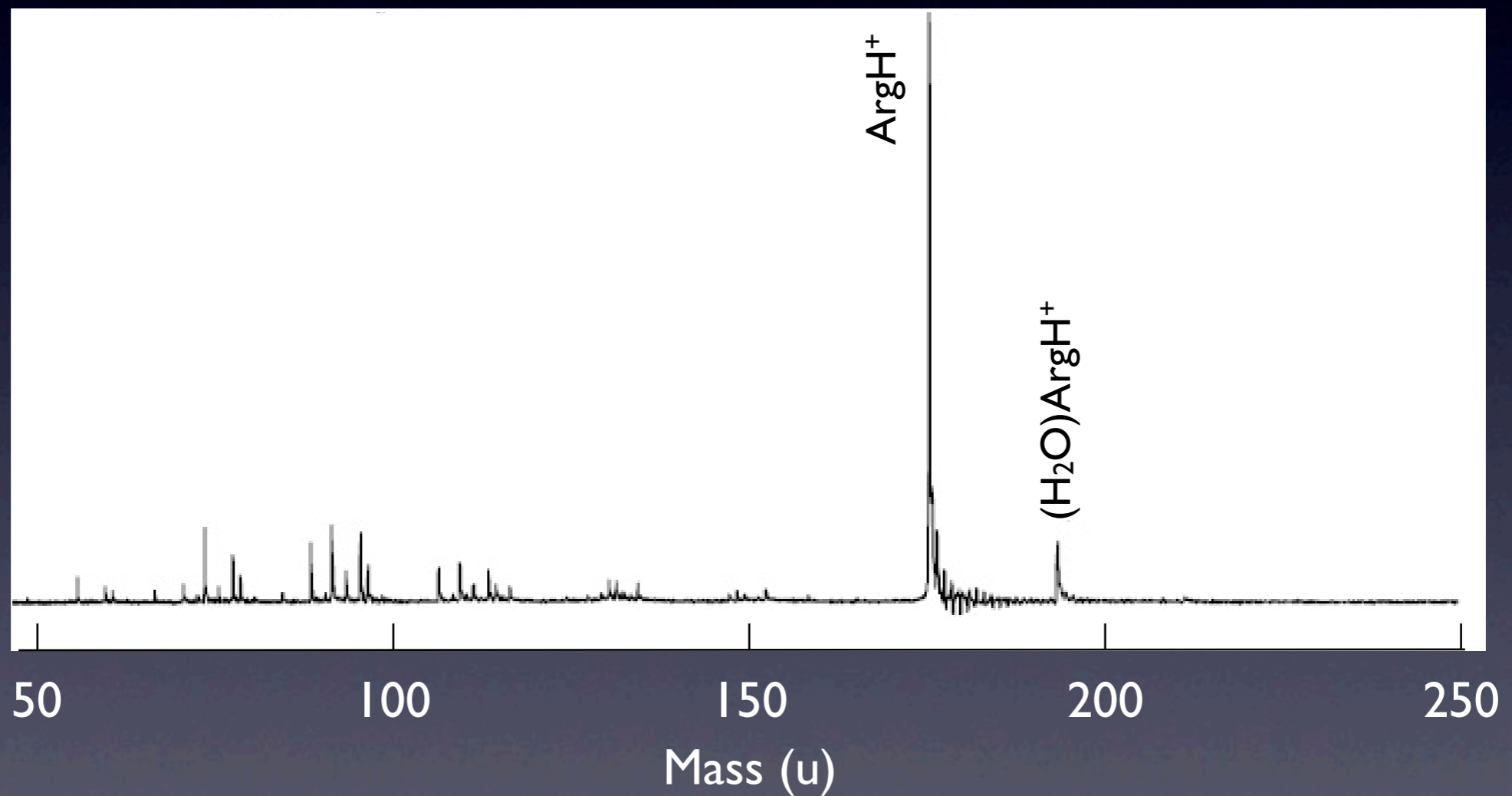
Anions



Laser-assisted dispersion spectra of MgSO₄ at a concentration of 0.1 ppm in water

SUDA @ Ganymede

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.

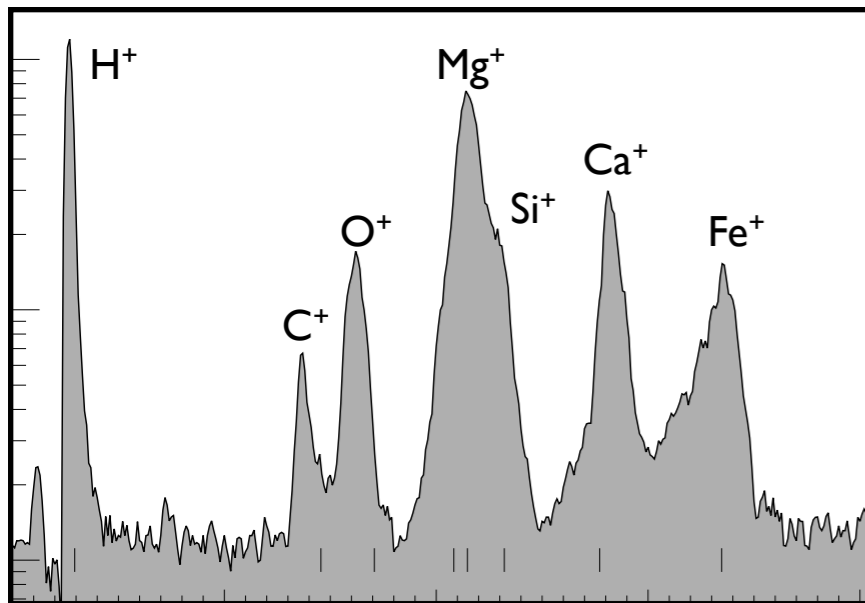
SUDA Key Parameters

Resources		Best Estimate + Reserves
Mass	Instrument	7.1 kg
	Additional Shielding	4.6 kg
Power	Nominal Operation	7.1W
	Survival Mode	0.4W
Data Rate		< 13 kbit/s

Cassini CDA



$m/\Delta m < 50$



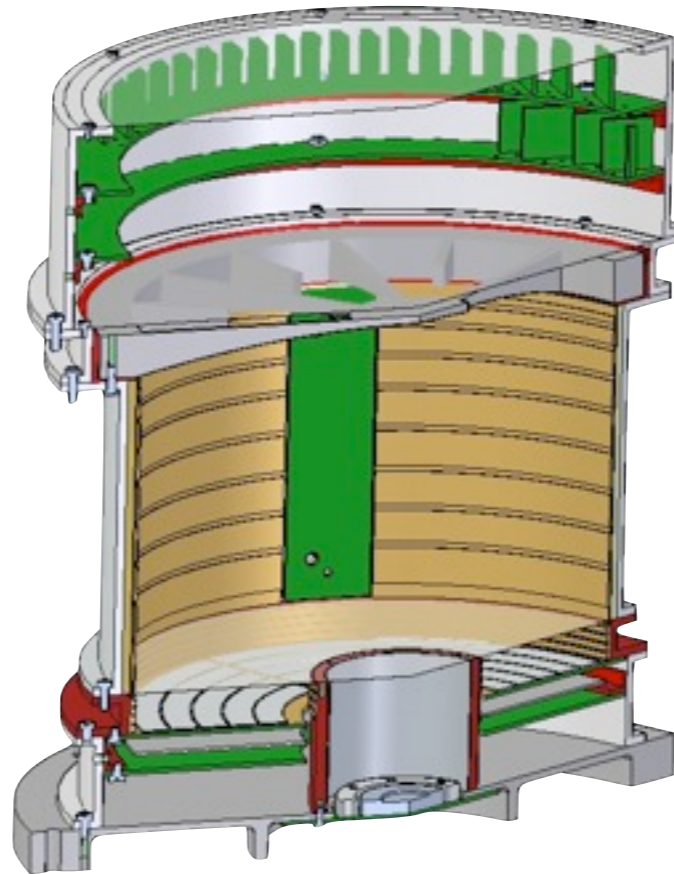
Interstellar Dust Spectrum

Cassini CDA

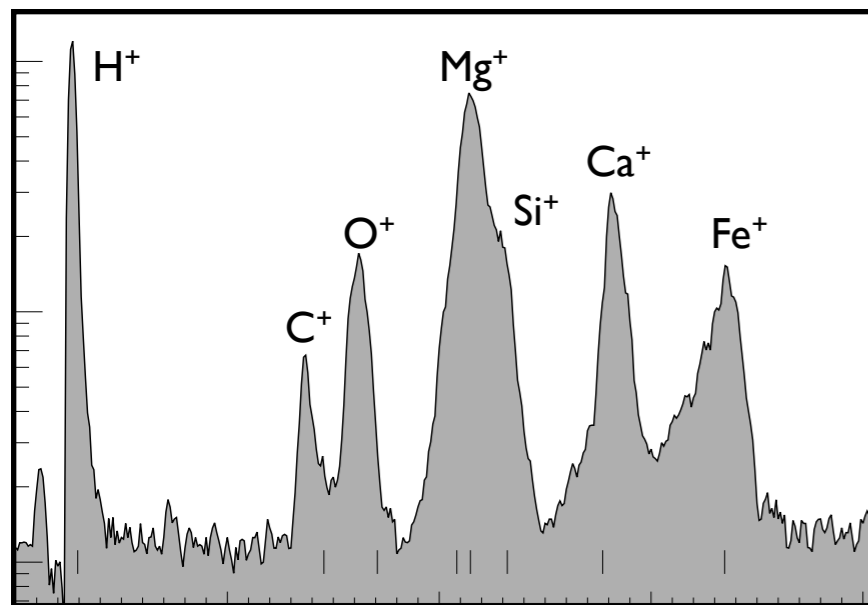


$m/\Delta m < 50$

SUDA: Reflectron



$m/\Delta m < 250$



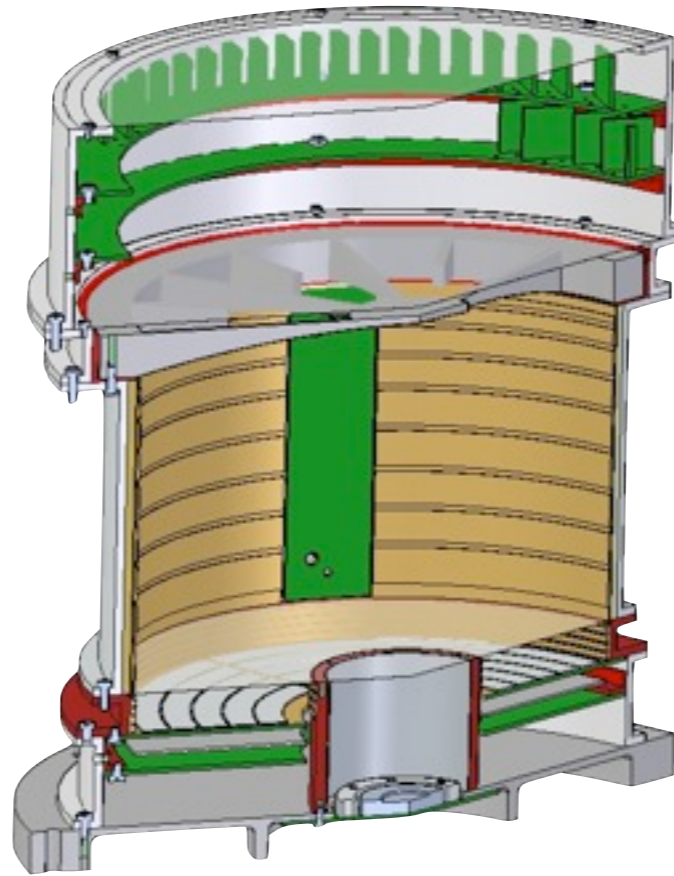
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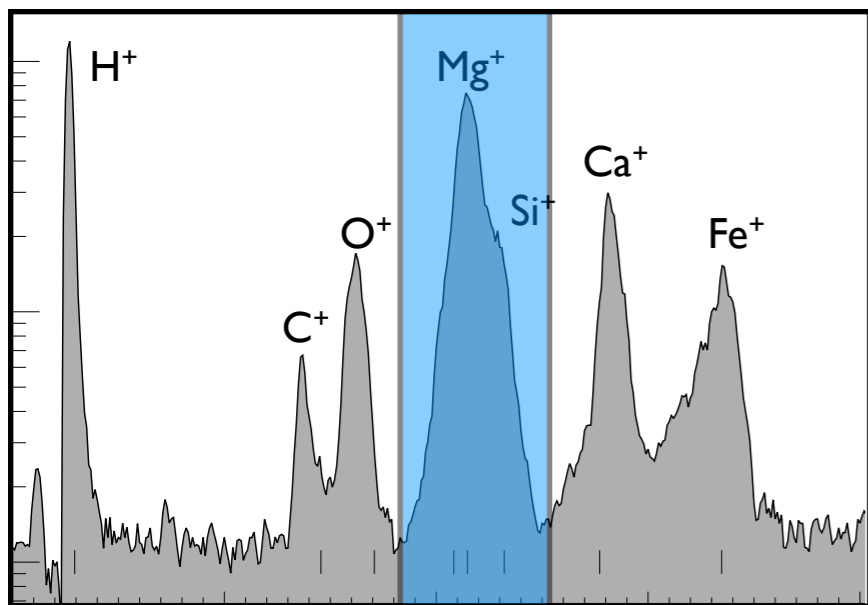


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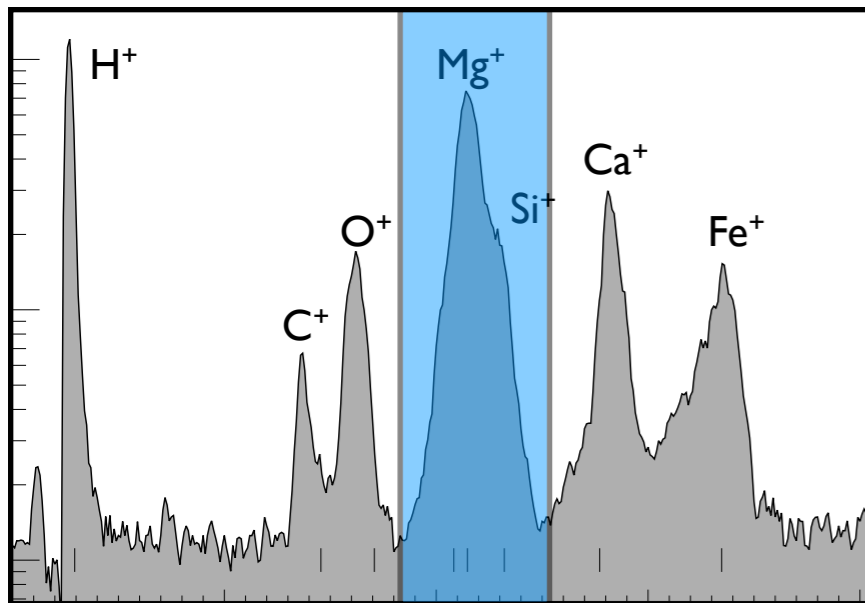


Interstellar Dust Spectrum

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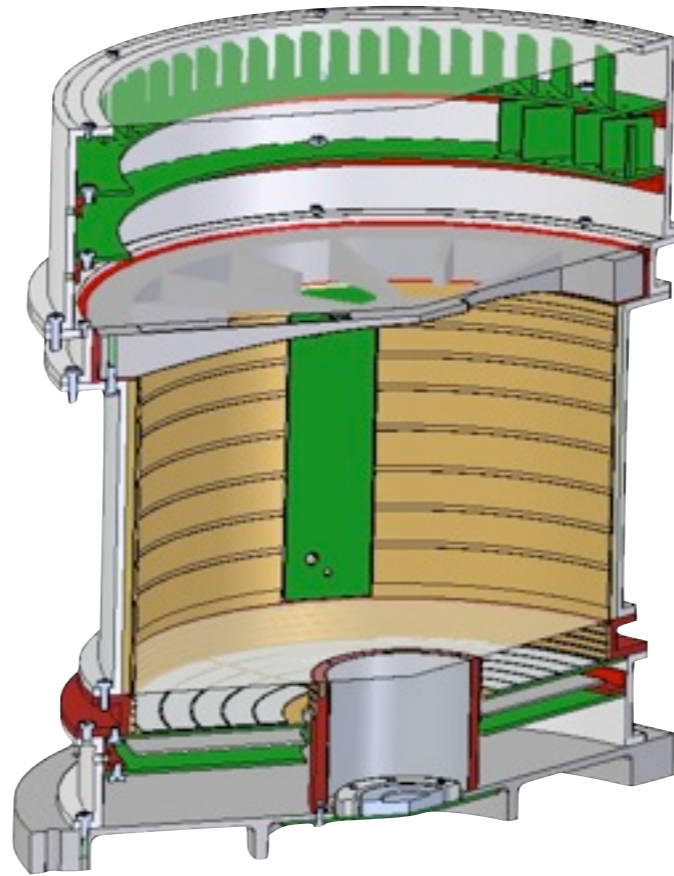


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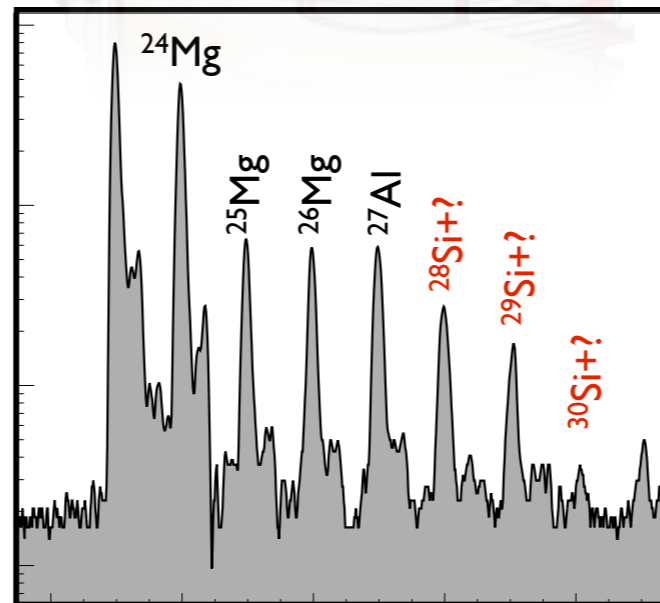


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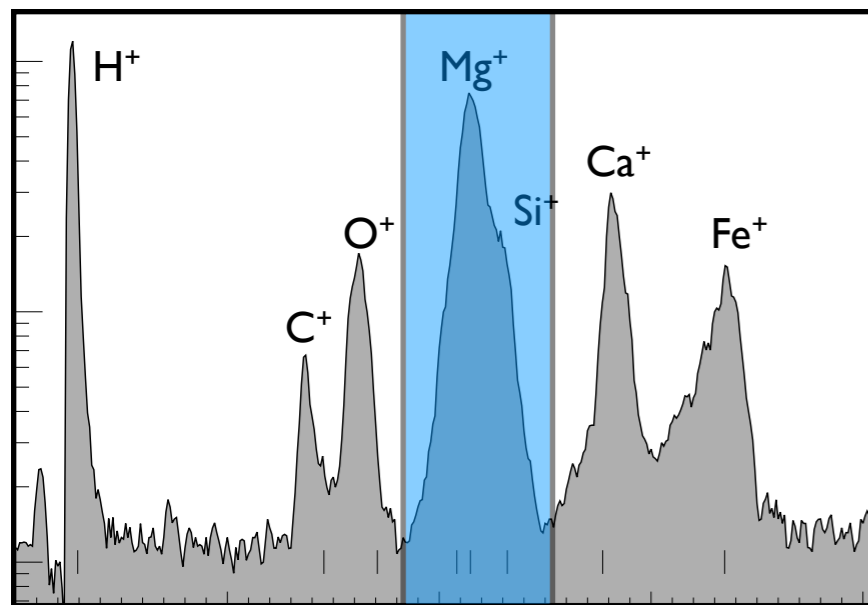


Lab: Orthopyroxene

Cassini CDA

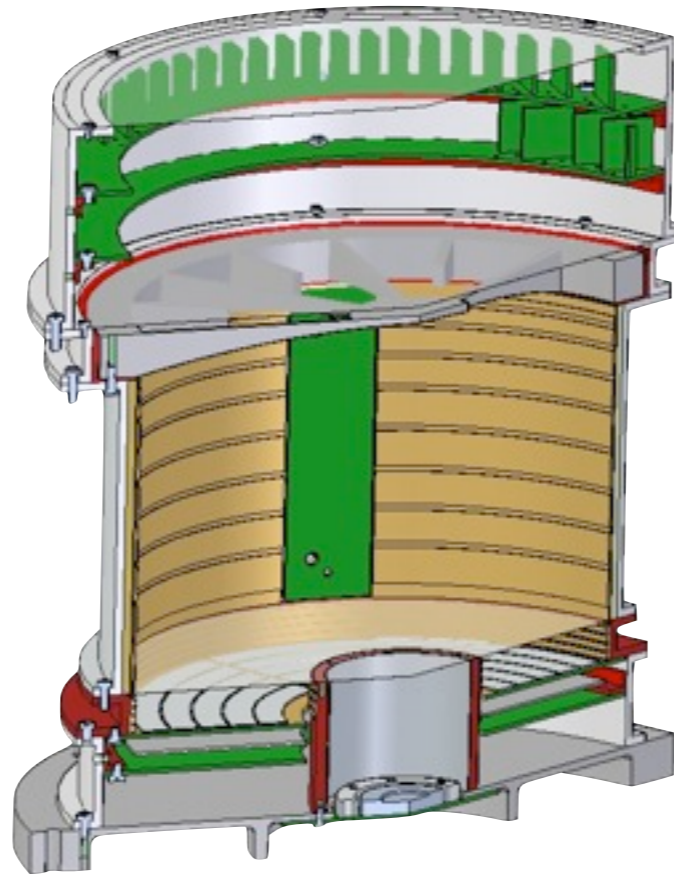


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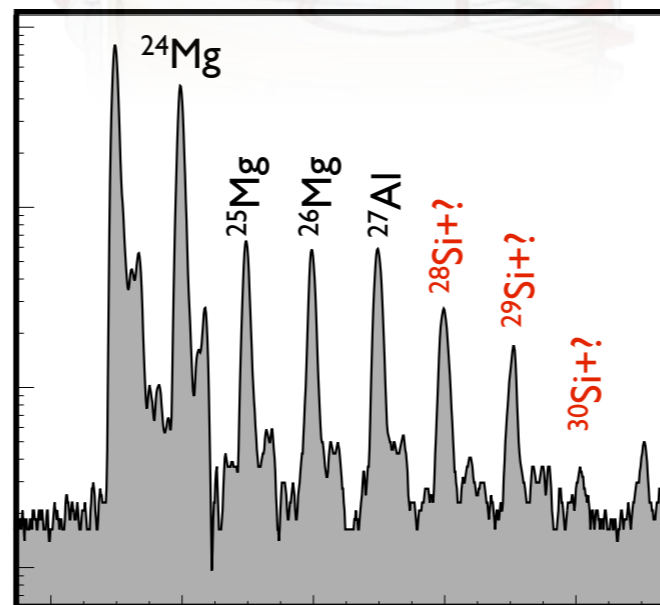


Interstellar Dust Spectrum

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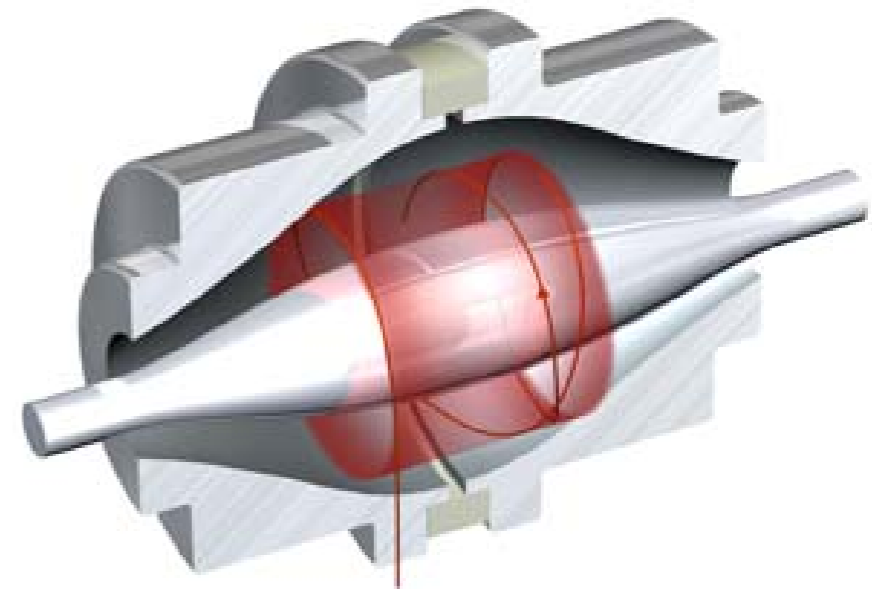


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Lab: Orthopyroxene

DOTS: Orbitrap

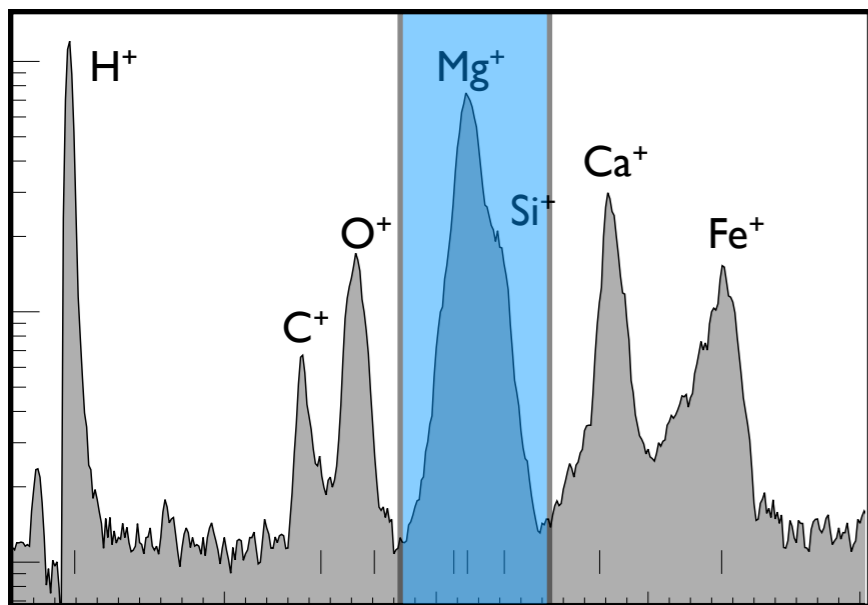


$m/\Delta m < 600,000$

Cassini CDA

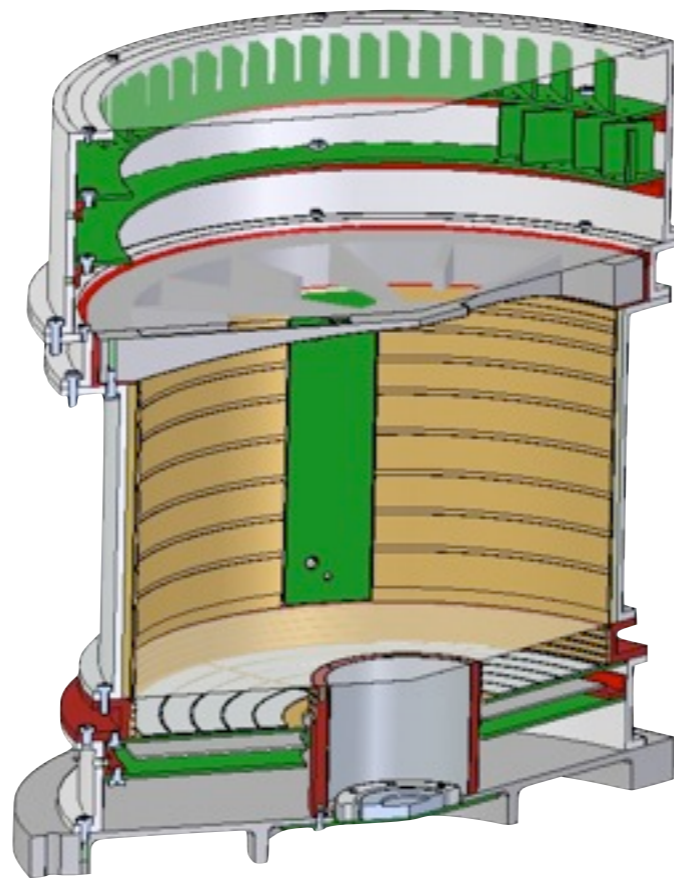


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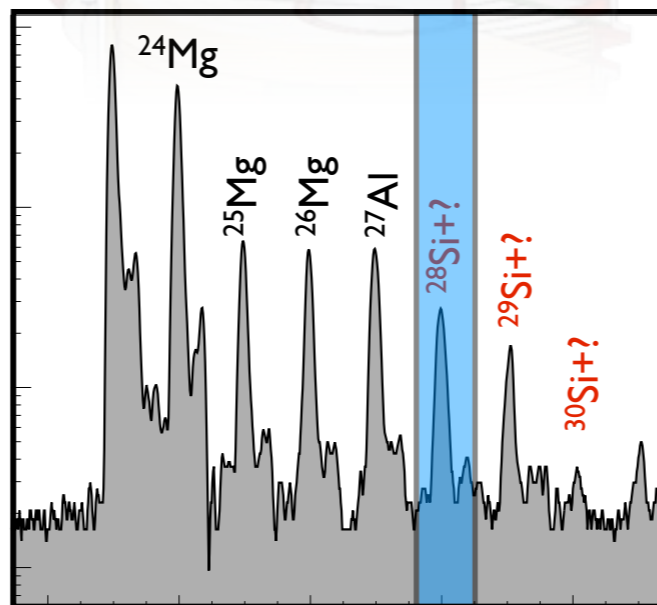


Interstellar Dust Spectrum

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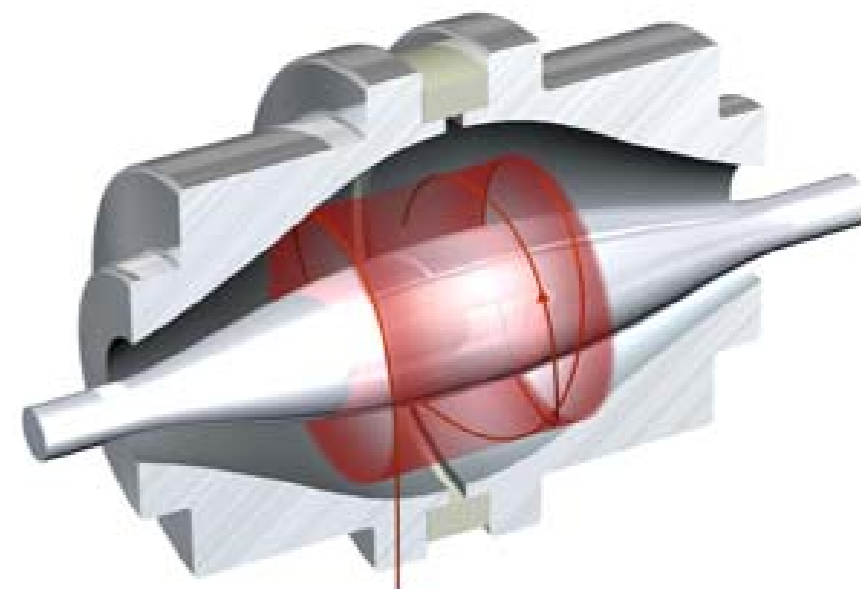


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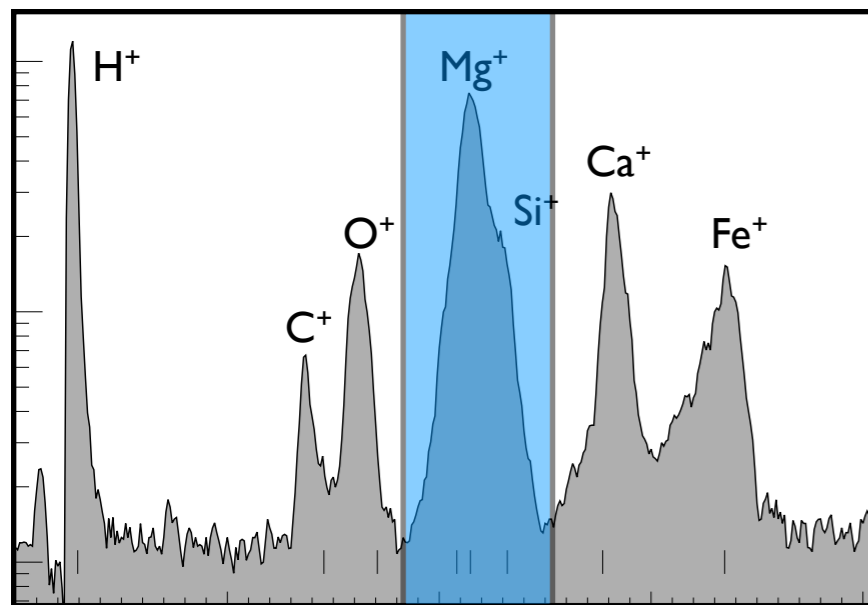


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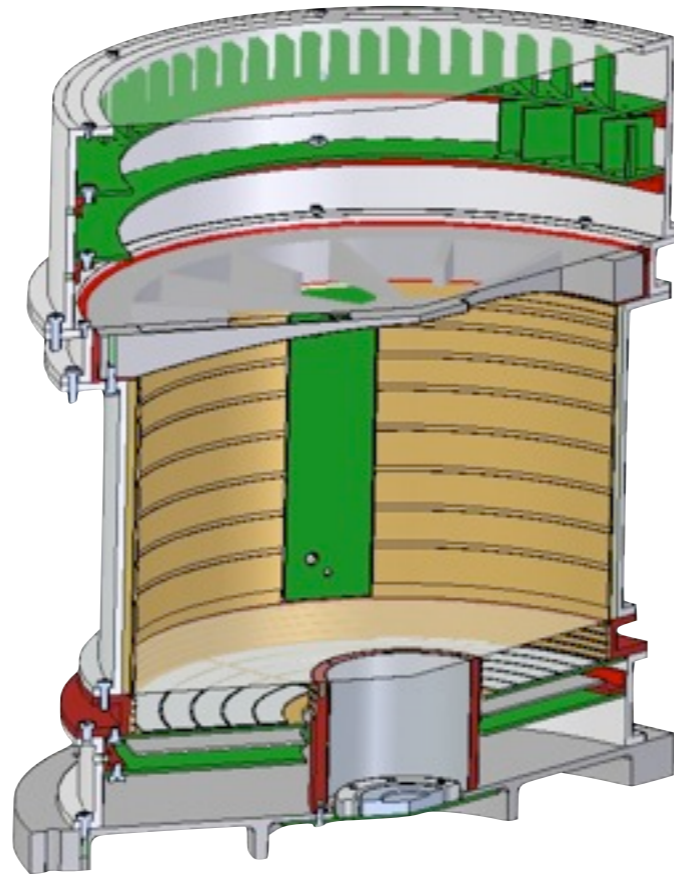


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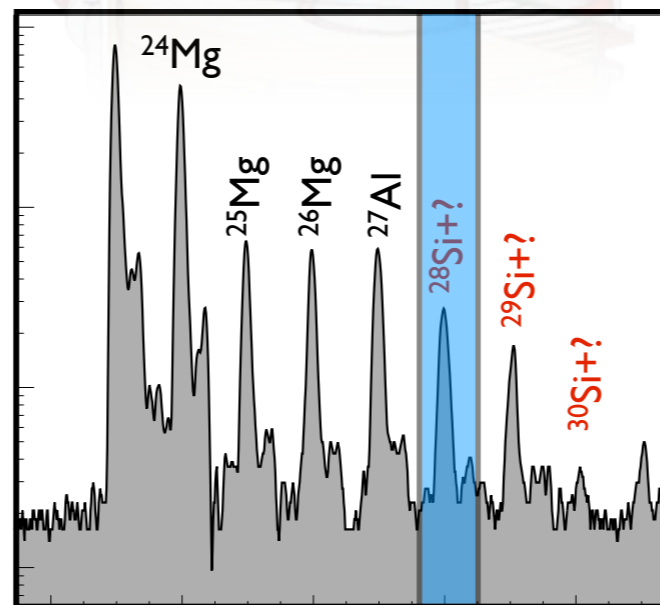


Interstellar Dust Spectrum

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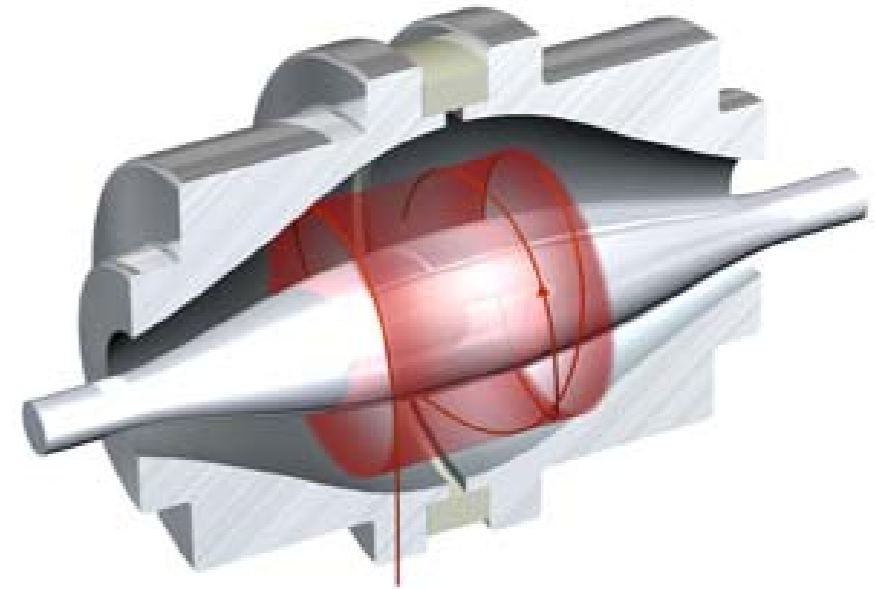


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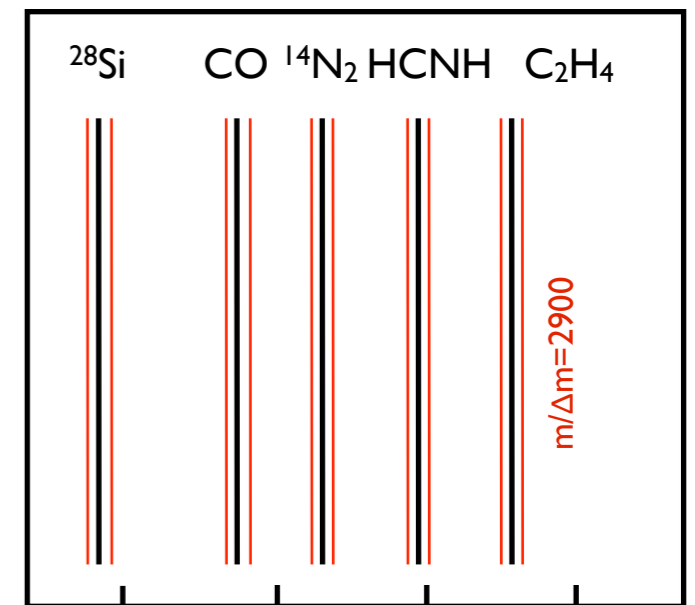


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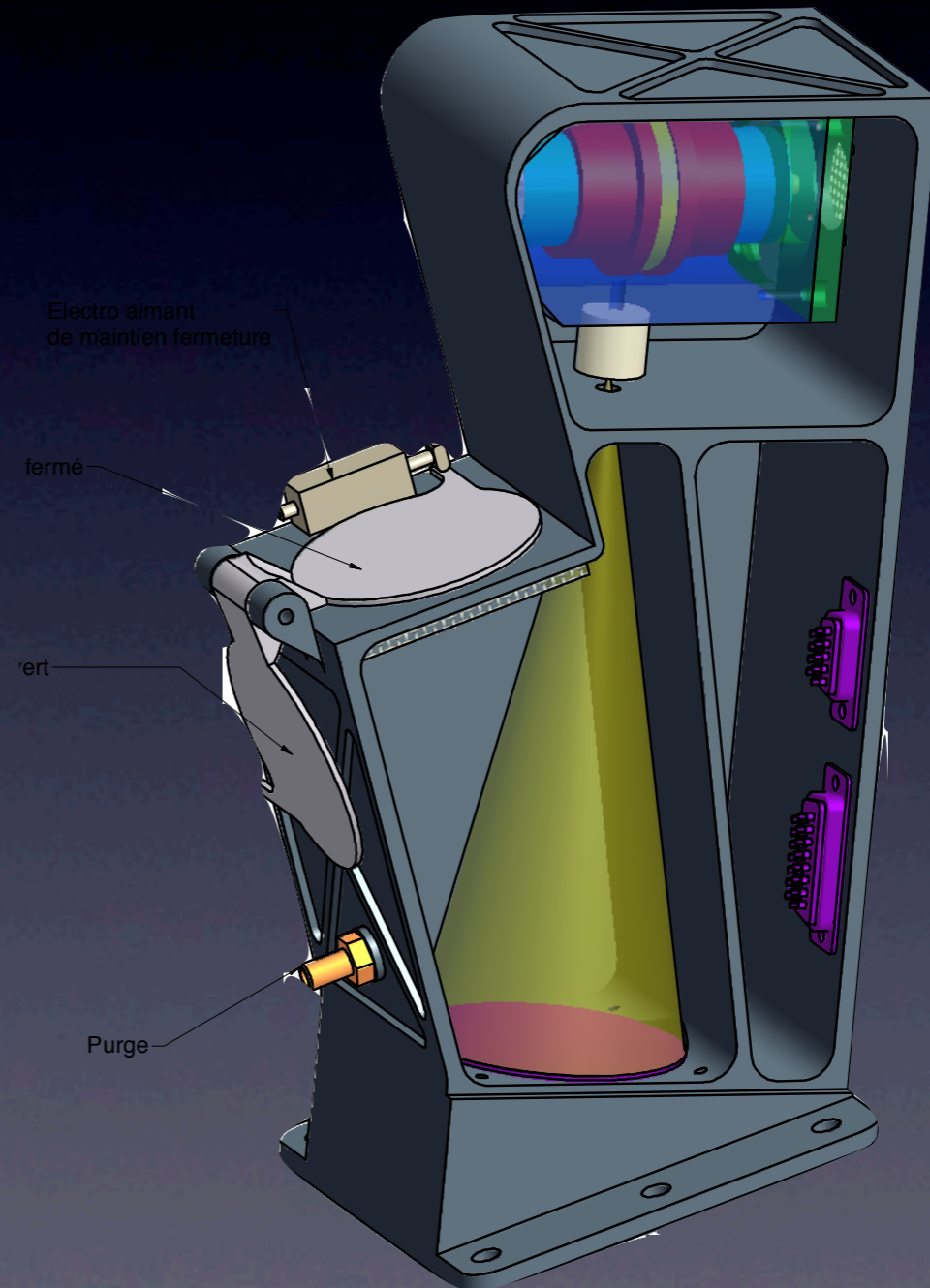
$m/\Delta m < 600,000$

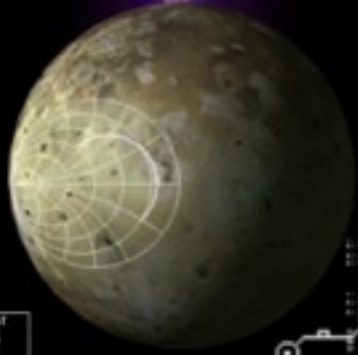


27.98u 28.00u 28.02u 28.04u

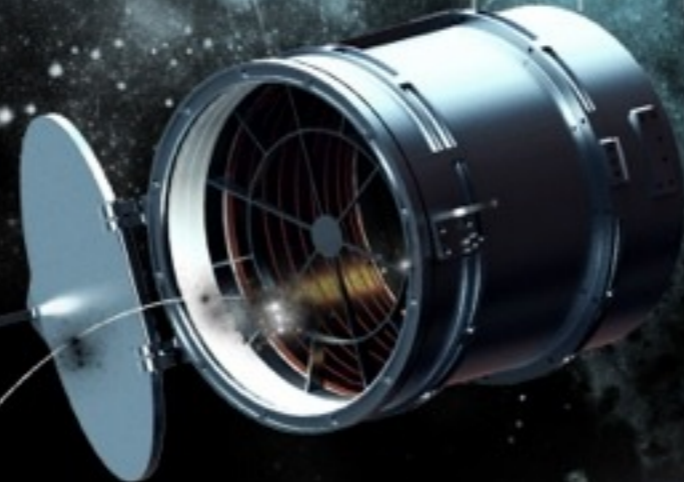
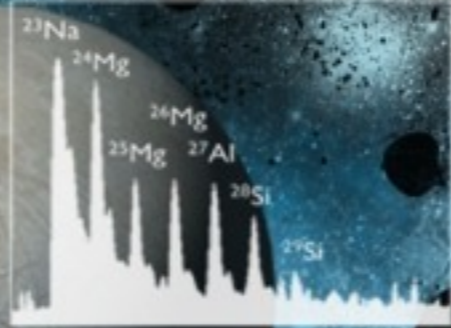
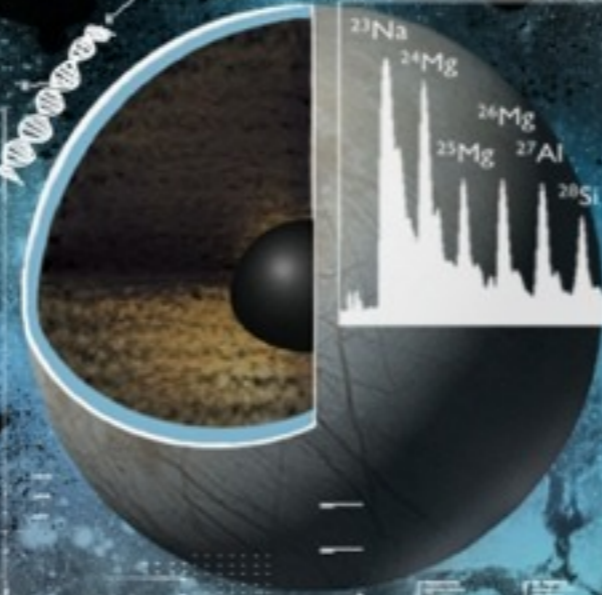
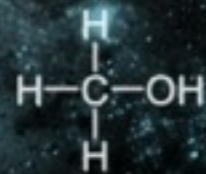
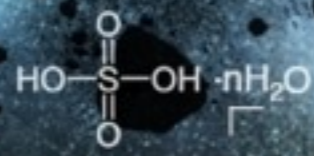
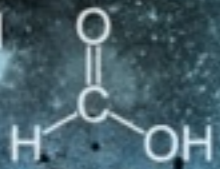
Possible Add On: DOTS

- Sensitive Area: 20 cm²
- Mass: 4 kg
- Resolution: > 6000





INSTRUMENT
16
S
32.085



SUDA