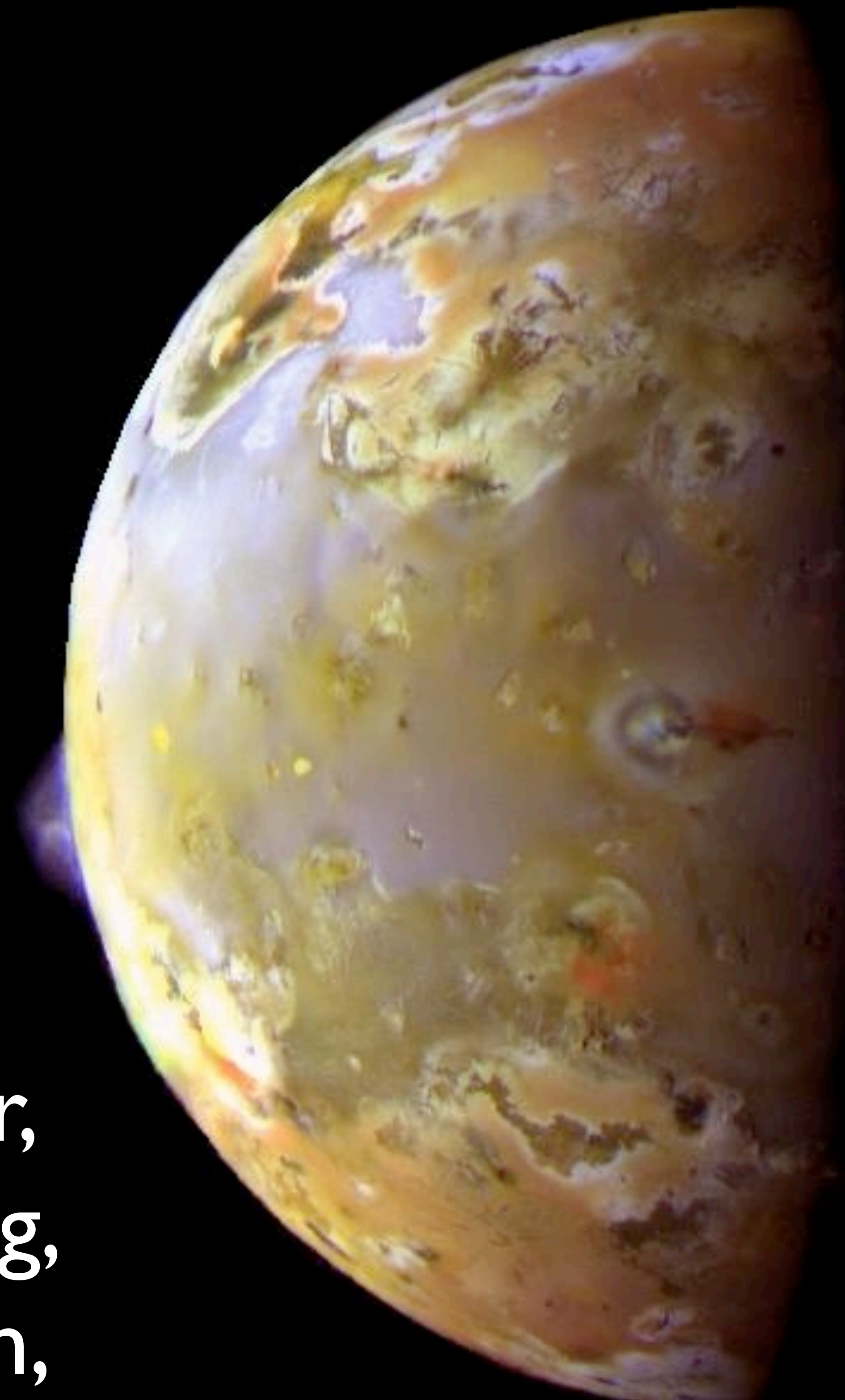
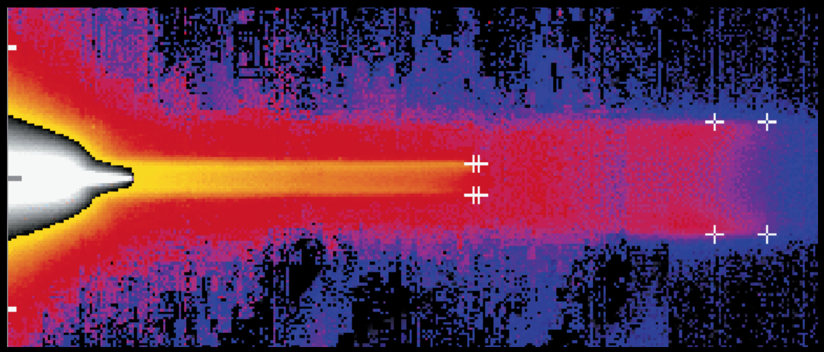
Dust at Jupiter

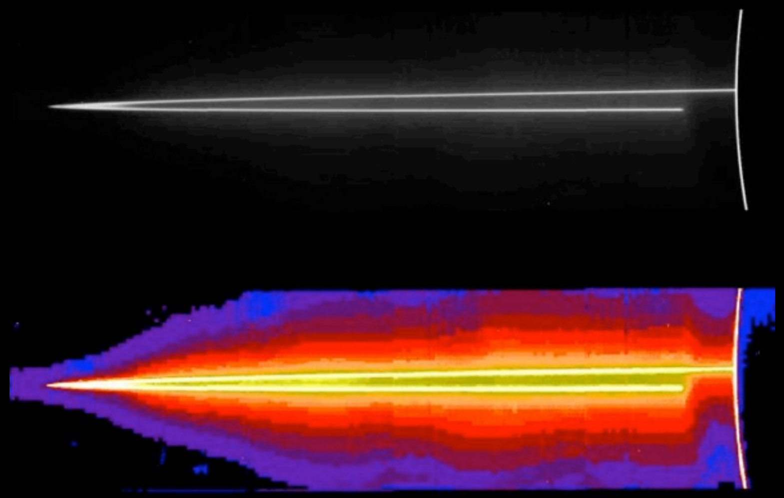


S. Kempf, R. Srama, H. Krüger, F. Spahn, J. Schmidt, F. Postberg, A. Graps, M. Horanyi, E. Grün, B. Abel, A. Krivov, ...

Dust in the Jovian System

Ring System



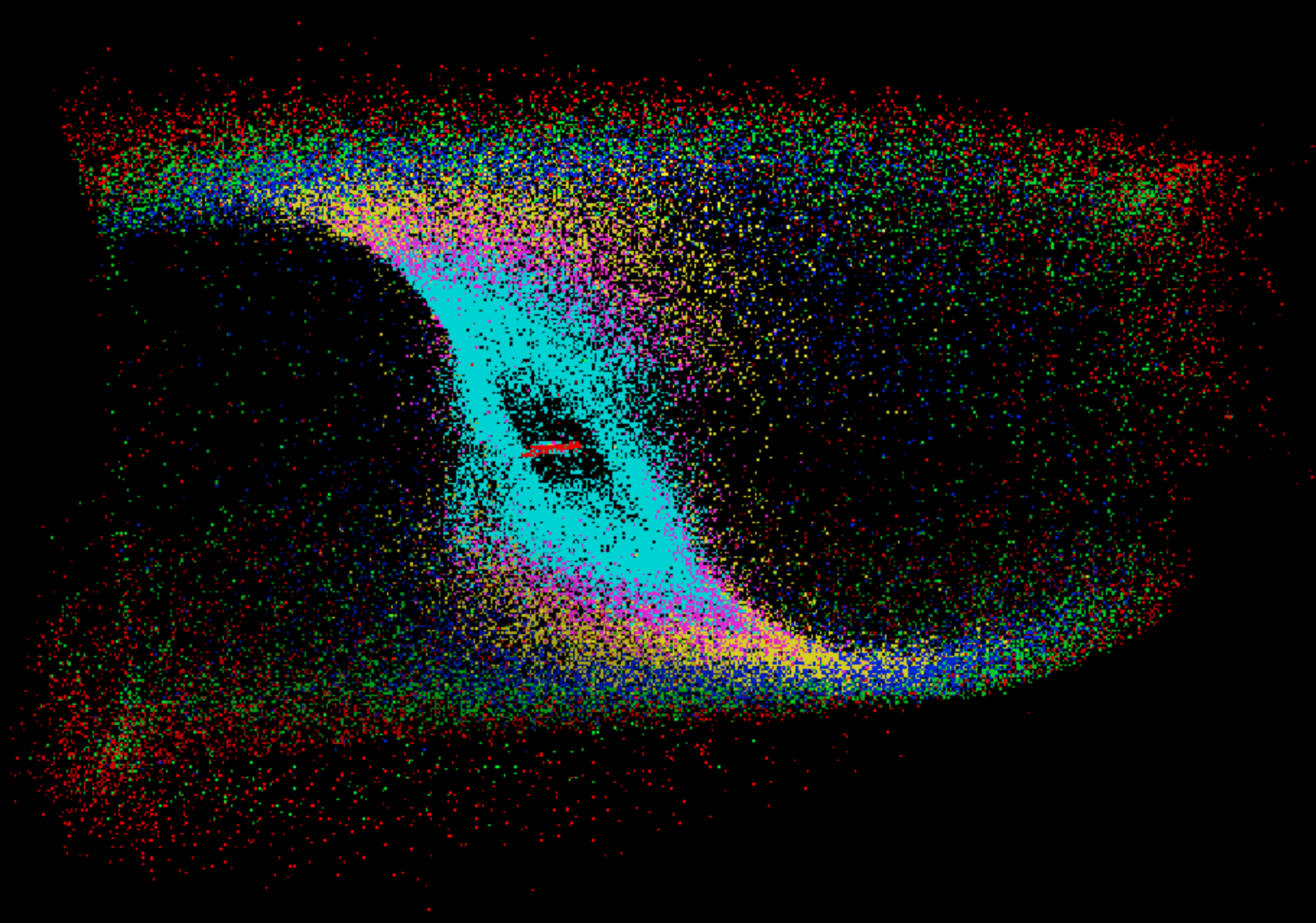


Ejecta Clouds

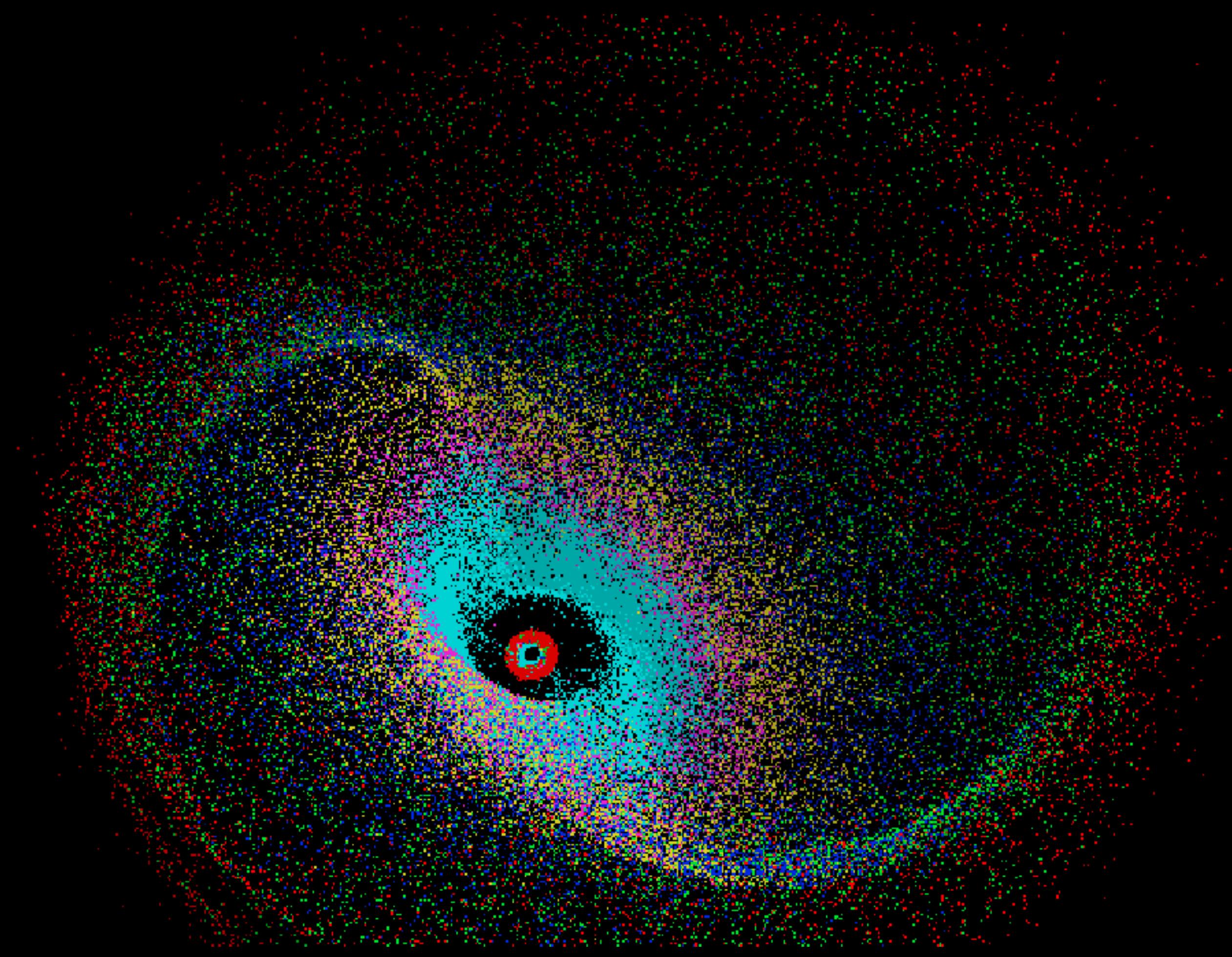
„Io Ashes“

Interplanetary / Interstellar Dust

Io as a Dust Source: Nano-Dust Coupling to Magnetosphere



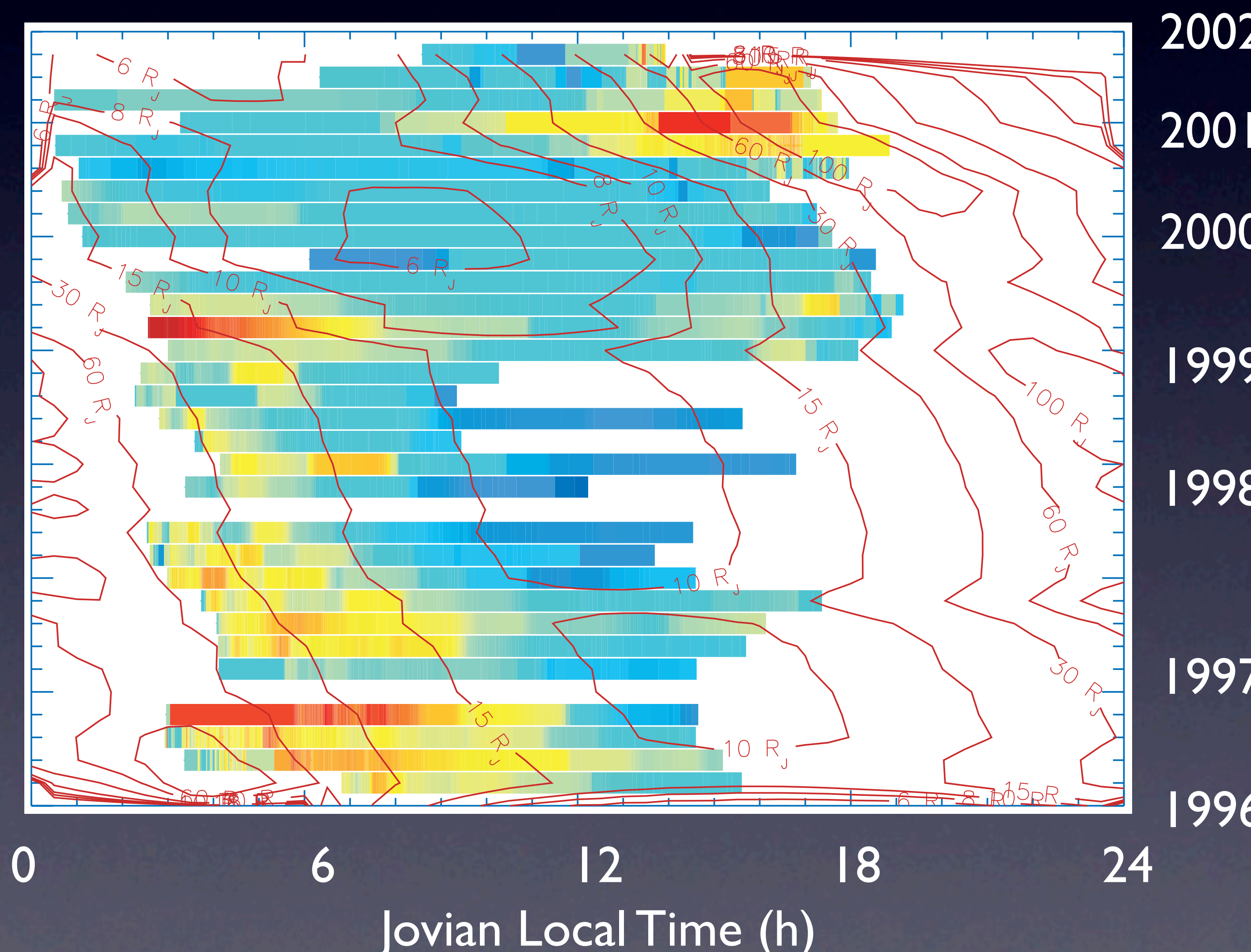
Side View



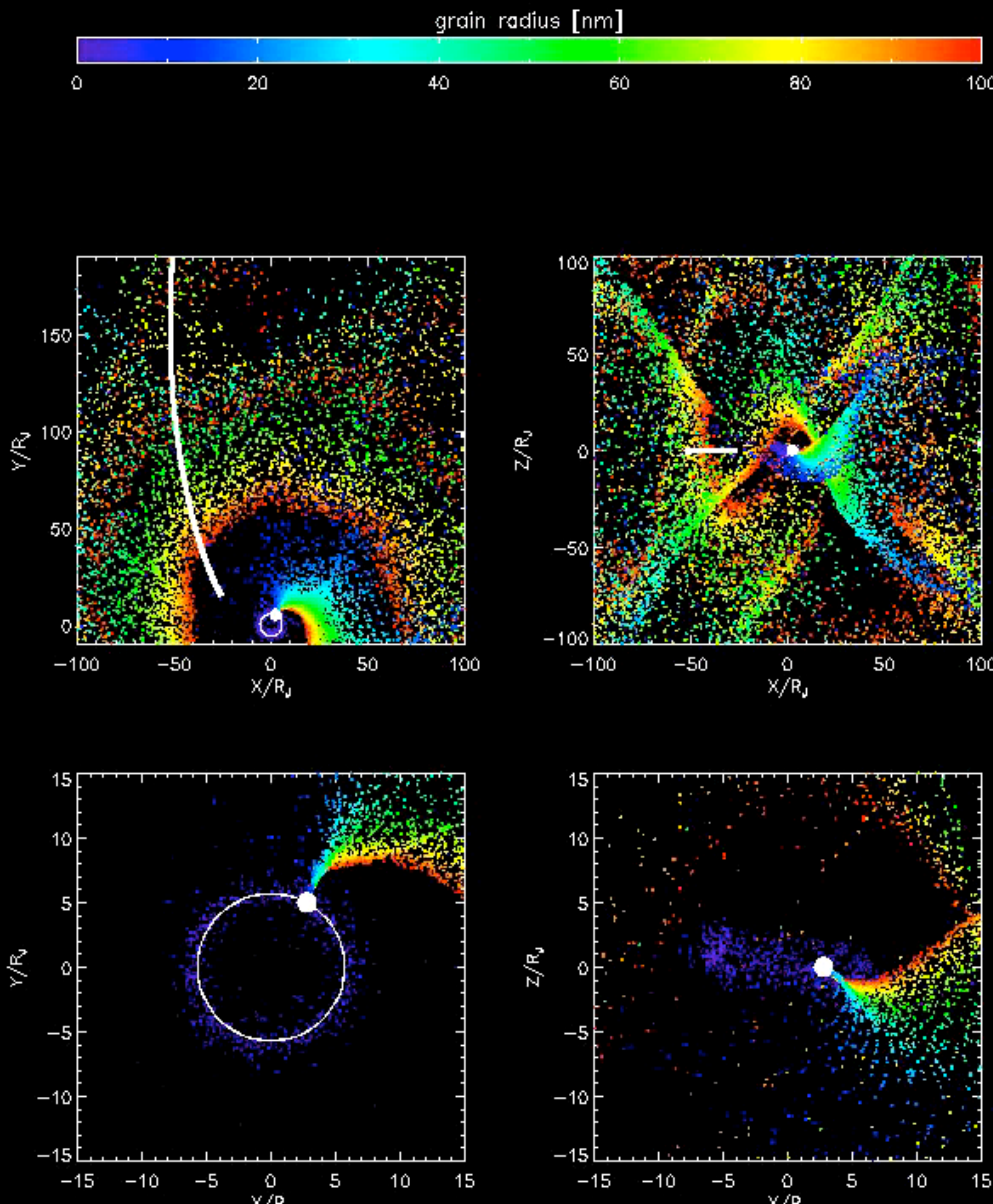
Top View

„Io Ashes“ - Stream Particles

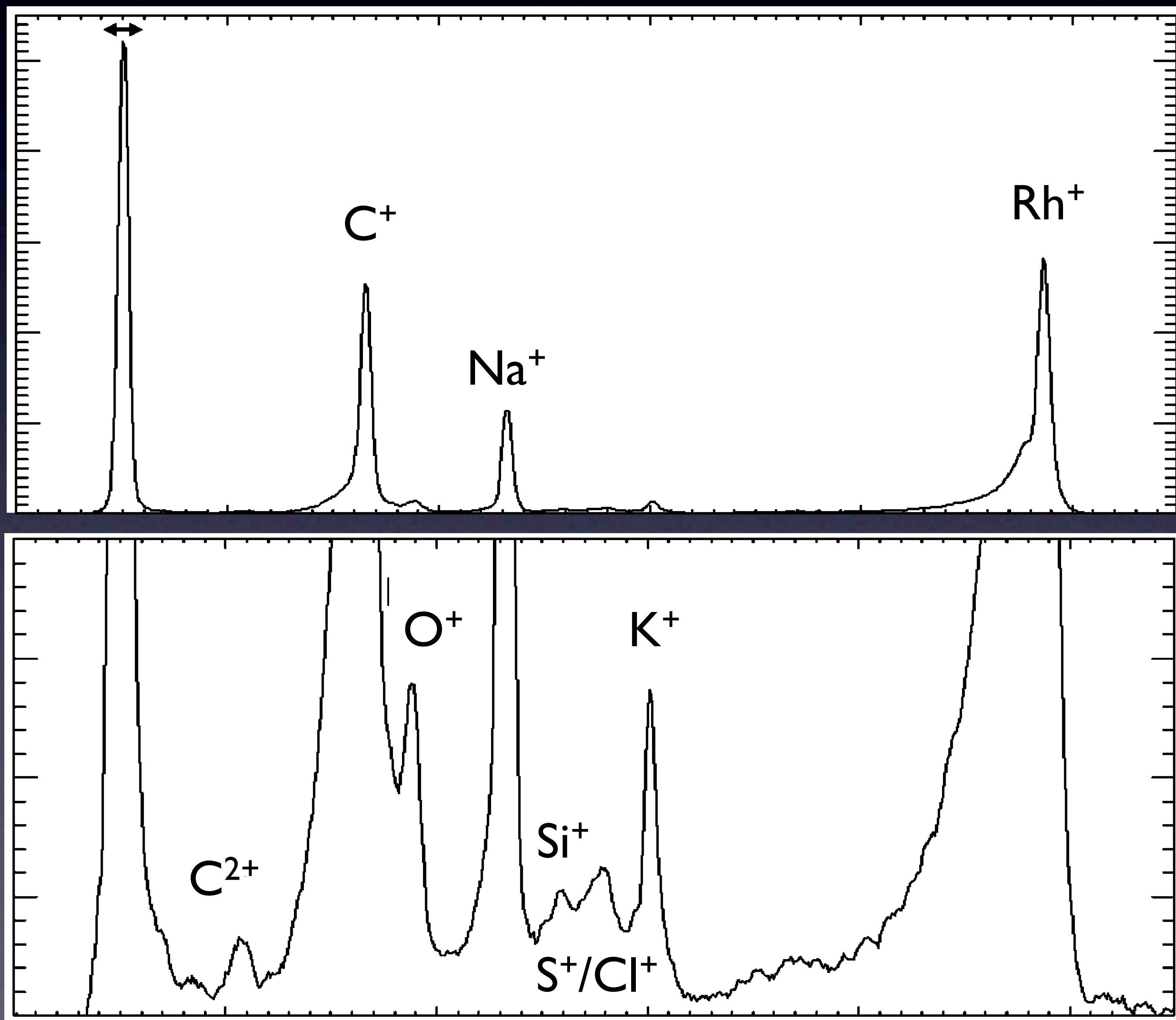
- Origin: Io Volcanoes
- Size: 10 ... 40 nm
- Dynamics Dominated by EM Forces
- Fast Enough to Escape From Jovian System
- Allow to Monitor Io Activity



Krüger et al., GRL, 2003


grain radius [nm]
0
20
40
60
80
100
Y/R$_J$
X/R$_J$
Z/R$_J$
X/R$_J$
Y/R$_J$
X/R$_J$
Z/R$_J$
X/R$_J$

Composition Of Io‘s Volcanic Matter

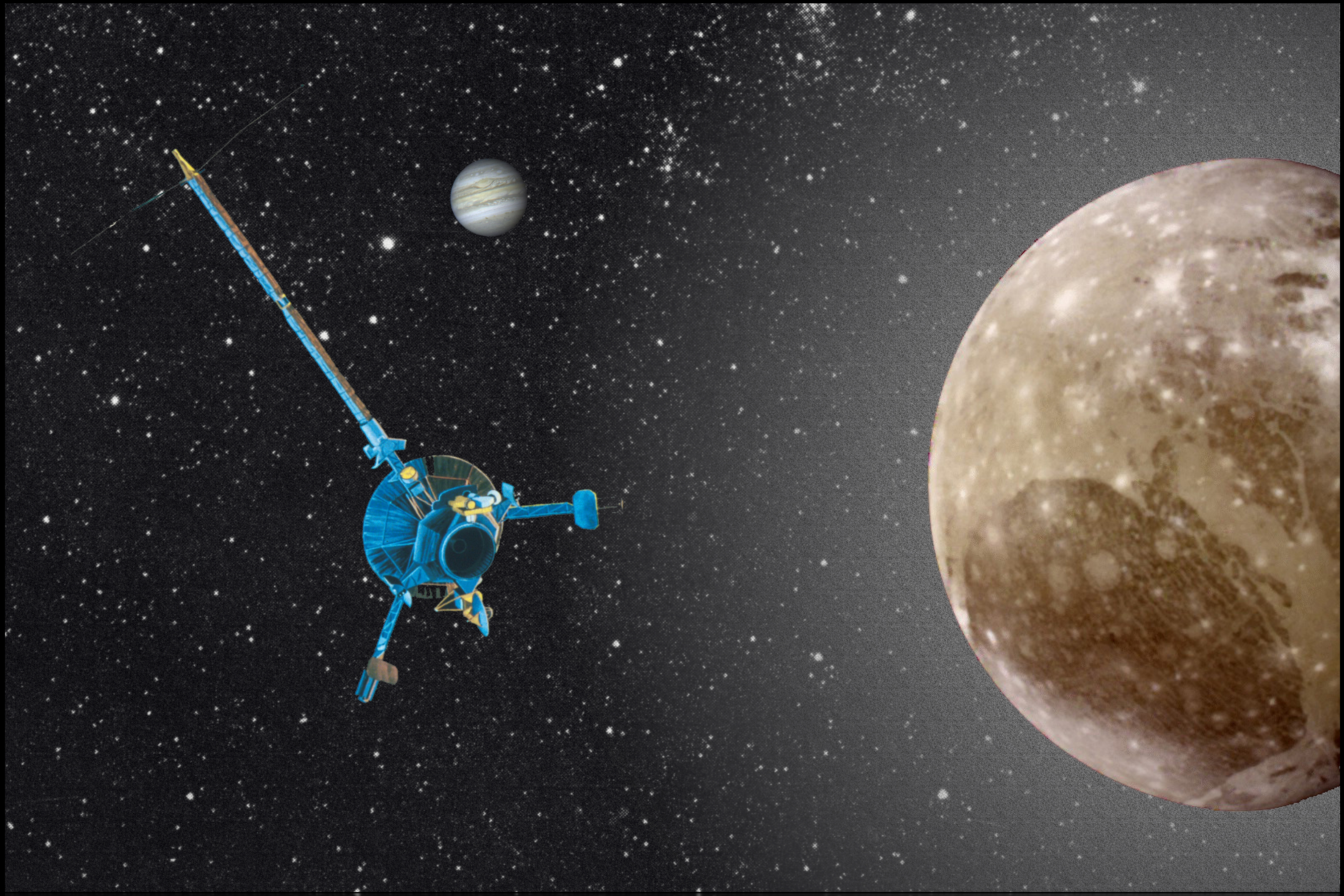


Time of Flight

Io Ashes Mostly NaCl Crystals

Postberg et al., Icarus, 2006

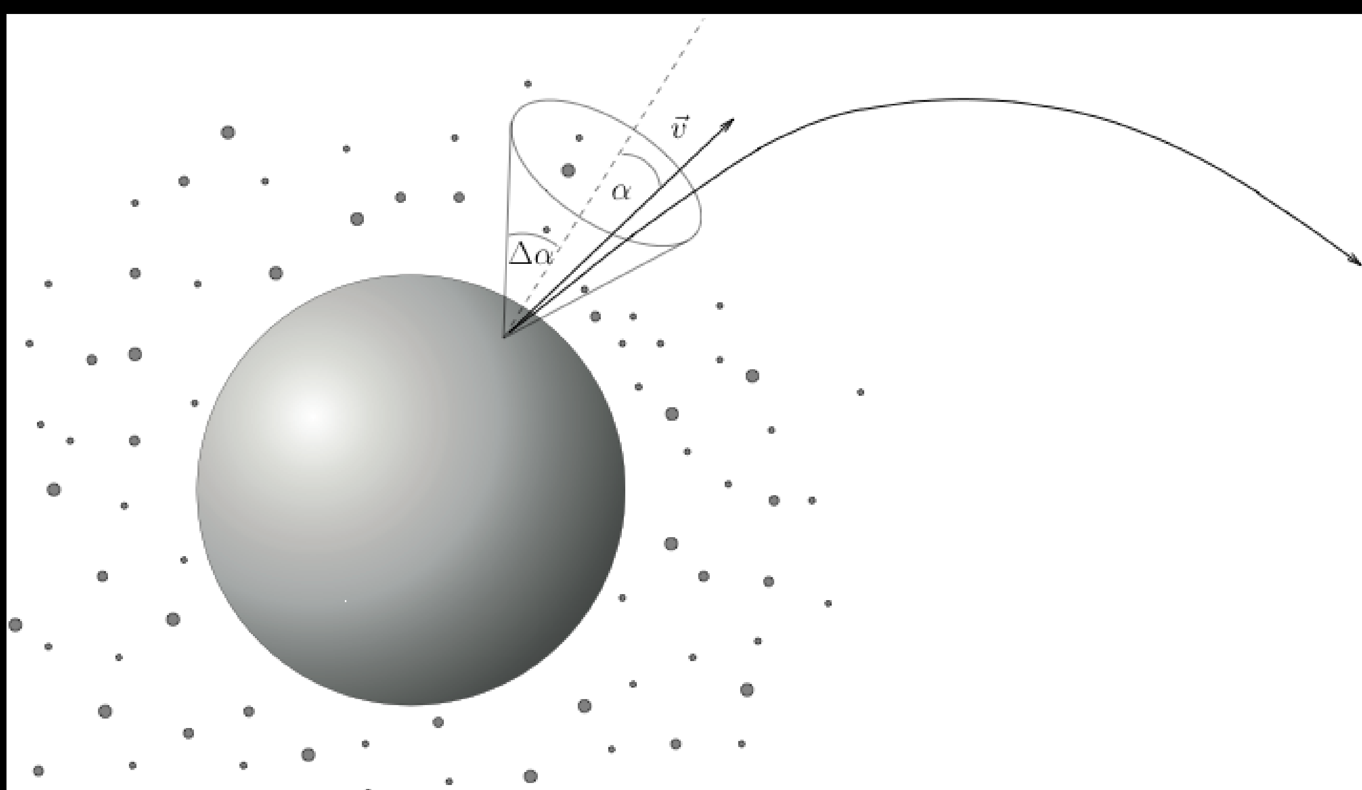
Ejecta Clouds



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

Ejecta Production

Meteoroid Impacts Splash up Ejecta



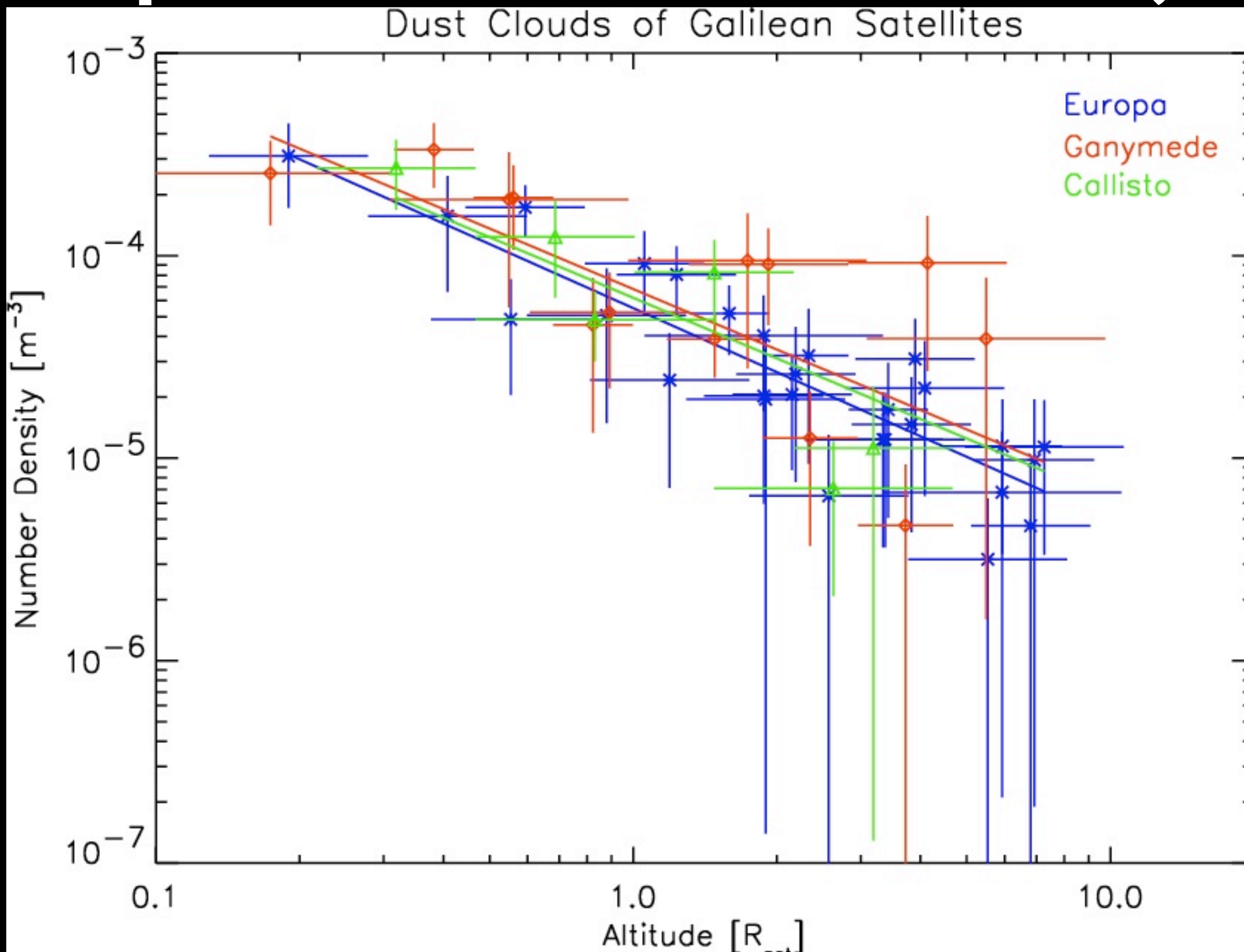
Sremcevic et al., Icarus, 2005

Mass Yield ~ 4000

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

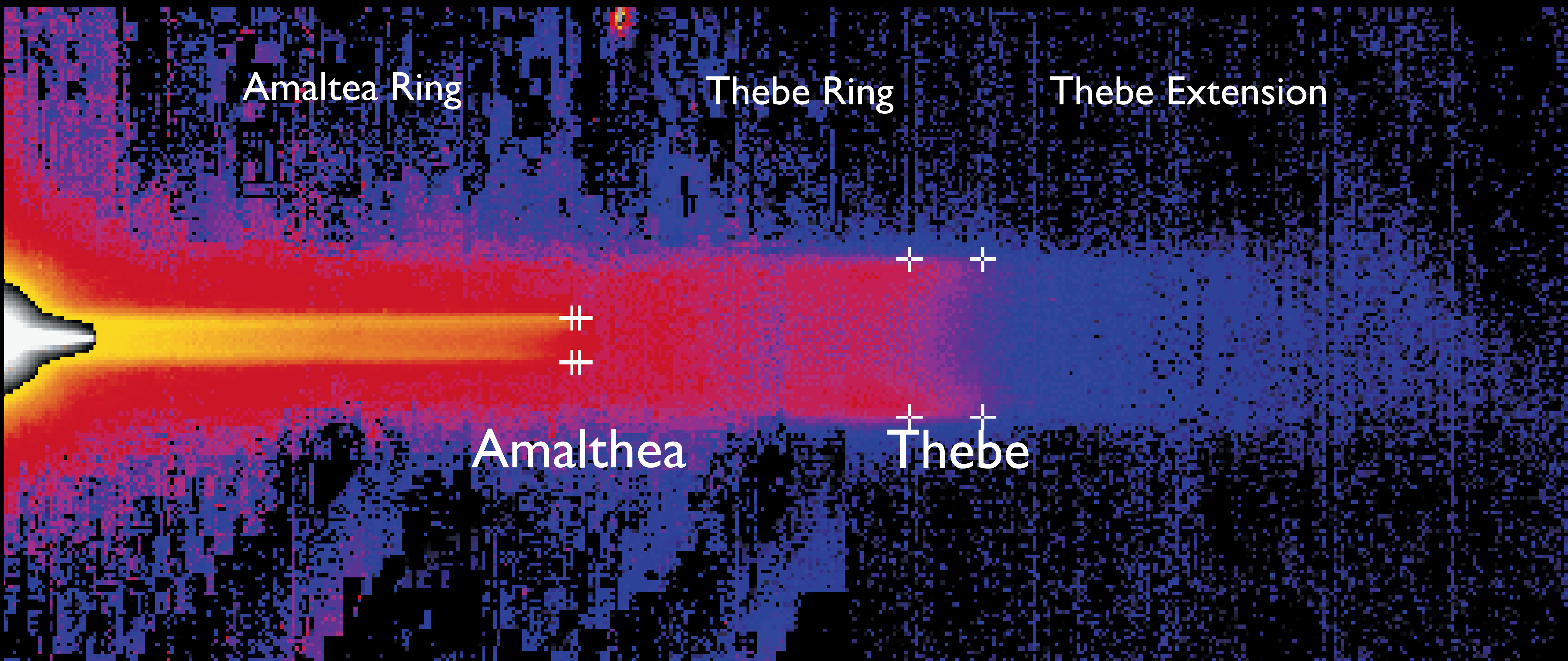
- Gravitationally Bound Ejecta Populate Cloud
- Some Ejecta Escape:
  - Feed Rings
  - Mass Loss Mechanism
  - Transport of compositional information

Almost Isotropic Dust Cloud Composed of Surface Ejecta



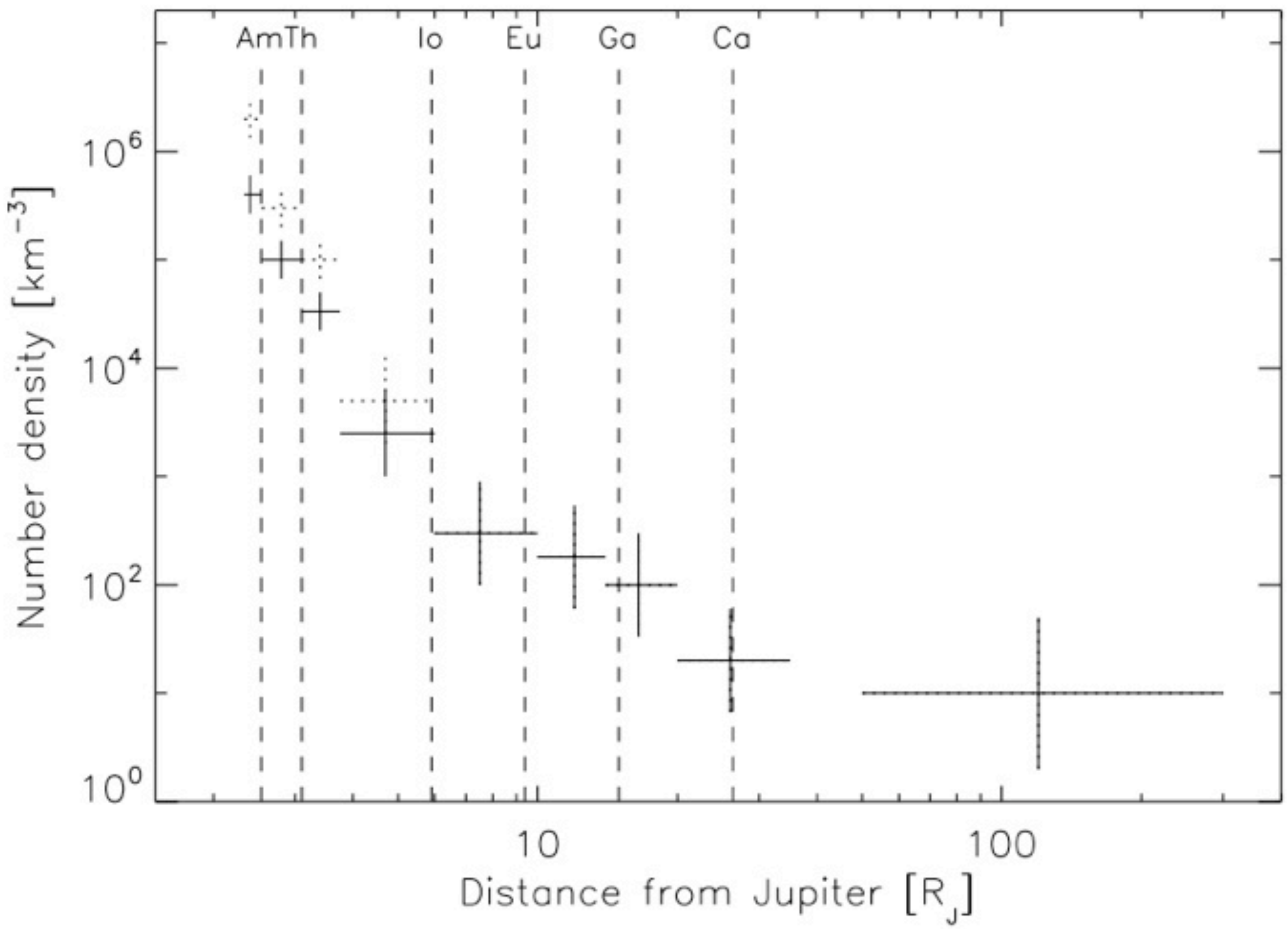
Dust Moon „at Work“

Gosammer Rings



Burns et al., Science, 1999

Jupiter's Dust Disk



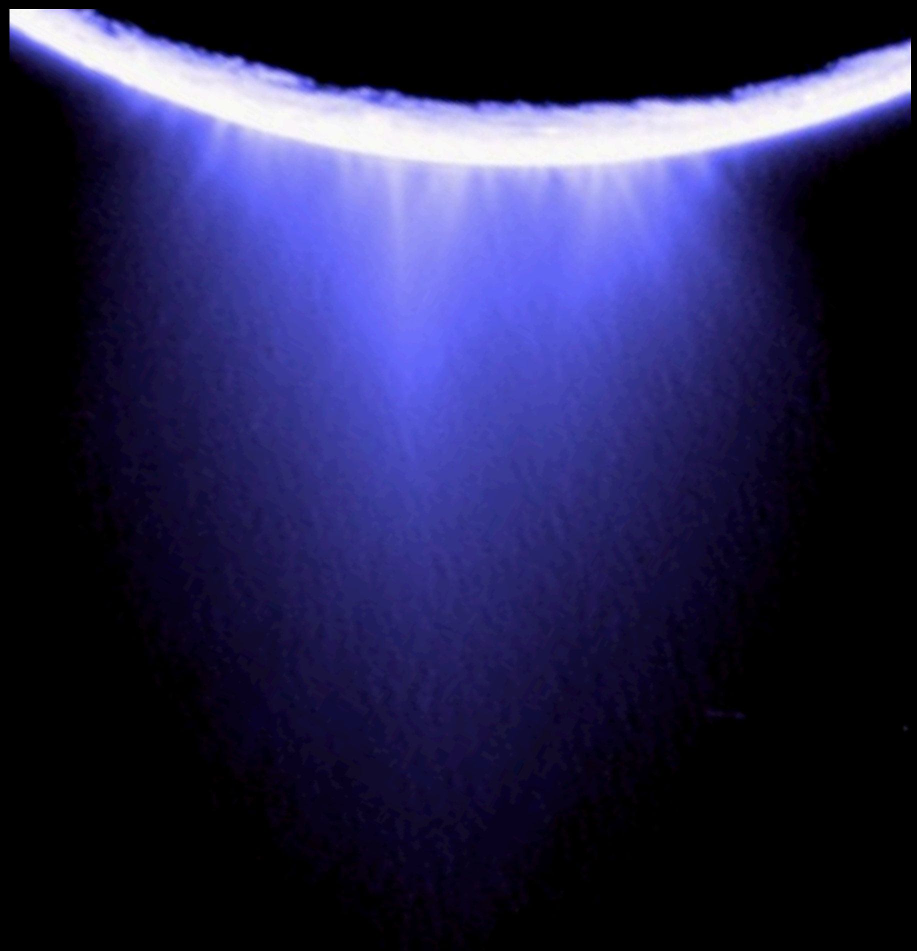
Population	Jovicentric distance (R_J)	Particle radii (μm)	Number density (km^{-3})	Mass density ($kg\,m^{-3}$)	Dust mass in small grains (kg)	Reference
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Amalthea ring	2.33 – 2.54	0.2 – 5	$\sim 2 \times 10^6$	$\sim 4 \times 10^{-18}$	$\sim 10^6$	This work
Thebe ring	2.54 – 3.1	0.2 – 5	$\sim 3 \times 10^5$	$\sim 10^{-18}$	$\sim 2 \times 10^6$	This work
Thebe ring extension	3.1 – 3.75	0.2 – 5	$\sim 10^5$	$\sim 4 \times 10^{-19}$	$\sim 10^6$	This work
Io to ring limit	3.75 – 6	0.2 – 2	$\sim 5 \times 10^3$	$\sim 5 \times 10^{-21}$	$\approx 5 \times 10^4$	This work
Galilean ring	10 – 30	0.6 – 3	$10^2 - 10^3$	$10^{-21} - 10^{-20}$		Krivov et al. (2002a)
Captured particles	10 – 20	0.5 – 1.5	$\sim 10^2$	$\sim 10^{-21}$		Thiessenhusen et al. (2000)
Distant ring	≥ 50	1 – 2	$\sim 10^1$	$\sim 10^{-22}$		Krivov et al. (2002b)

Clouds are a Treasure Trove

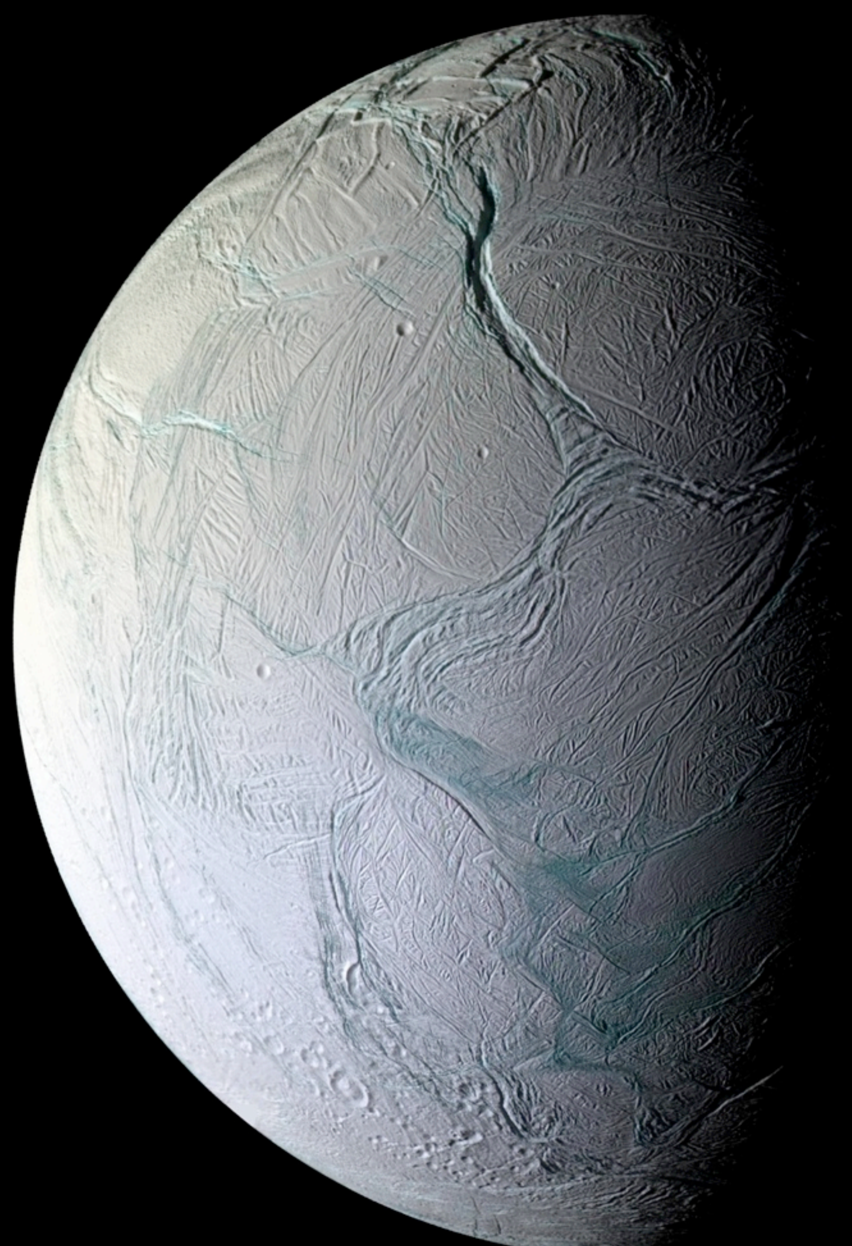
Information about:

- Satellite's Surface
- Satellite's Interior
- Satellite's Mass Production
- Plasma / Magnetic Field
- Mass Flux into Solar System

Enceladus Ice Jets



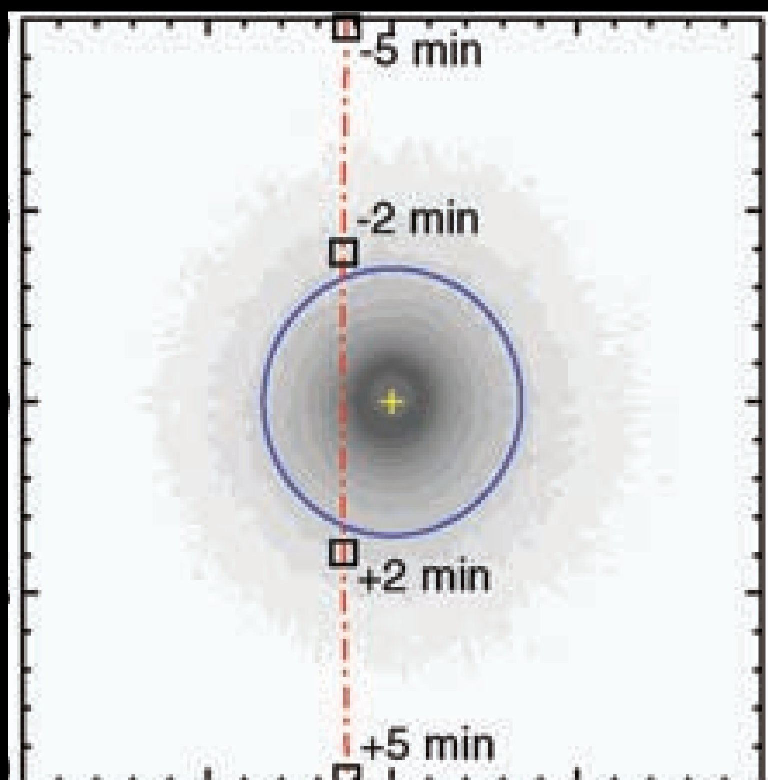
Example: Enceladus



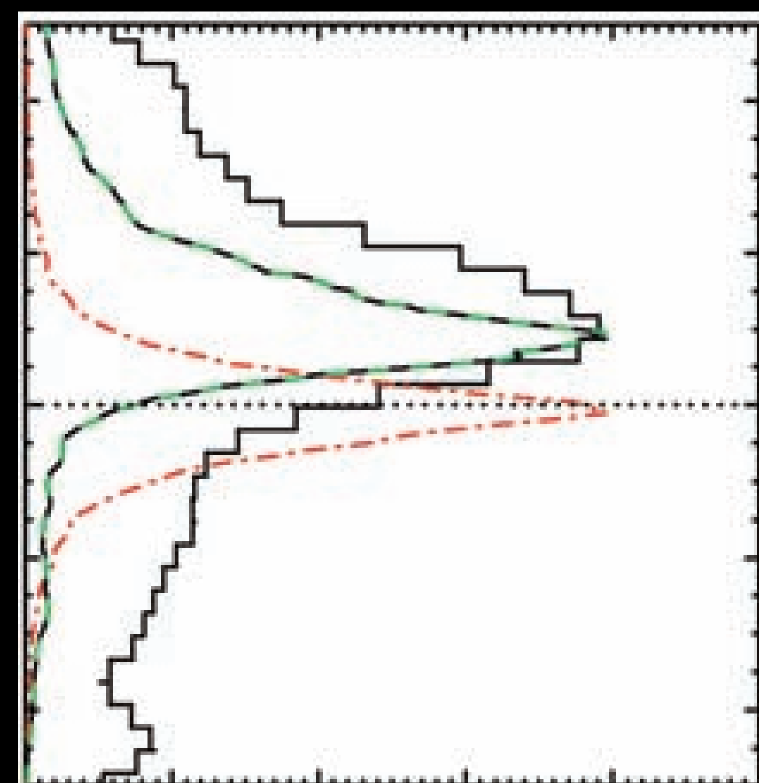
- Size: 499 km
- Density: 1600 kg/m^3
- 70 km Ice Crust on Rocky Core

South Pole Ice Geysers

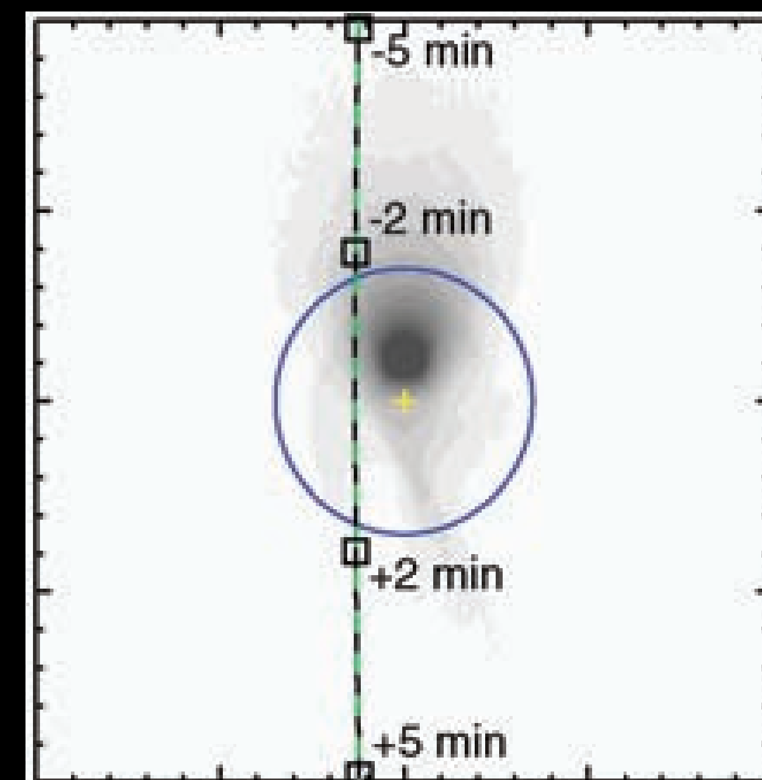
Dust Cloud



Dust Data

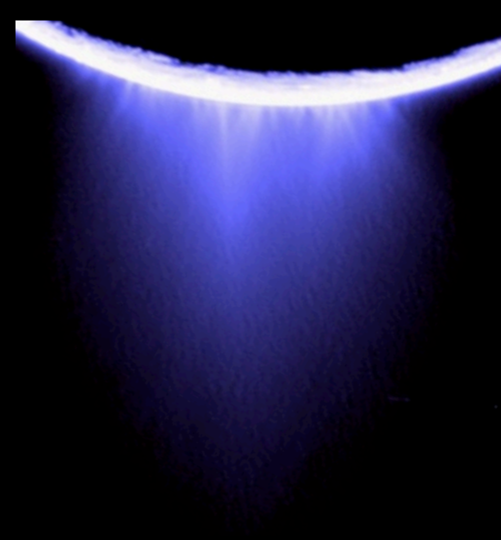


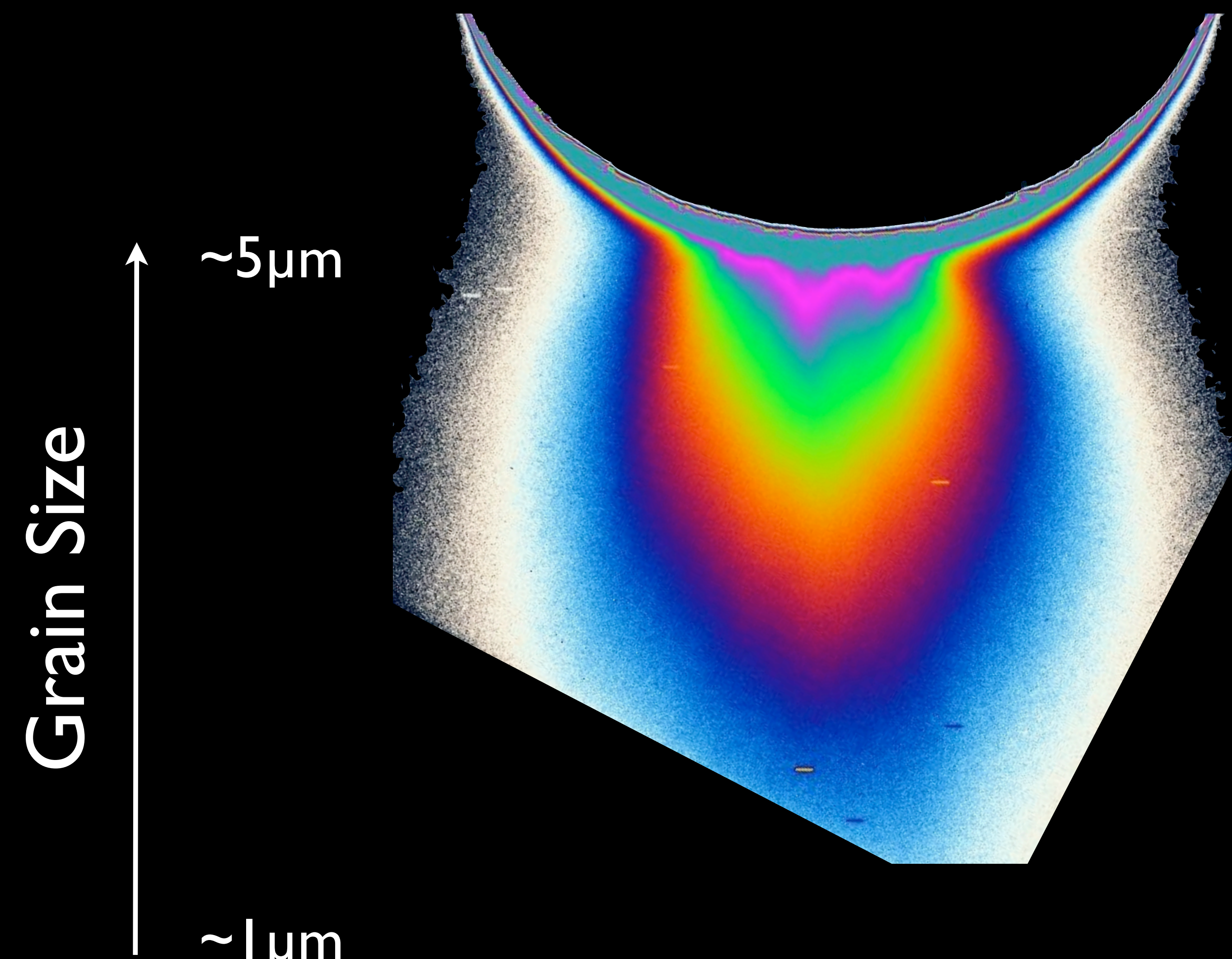
Dust Plume



Spahn et al., Science, 311, 2006

Geyser Grains Slower Than Escape Speed

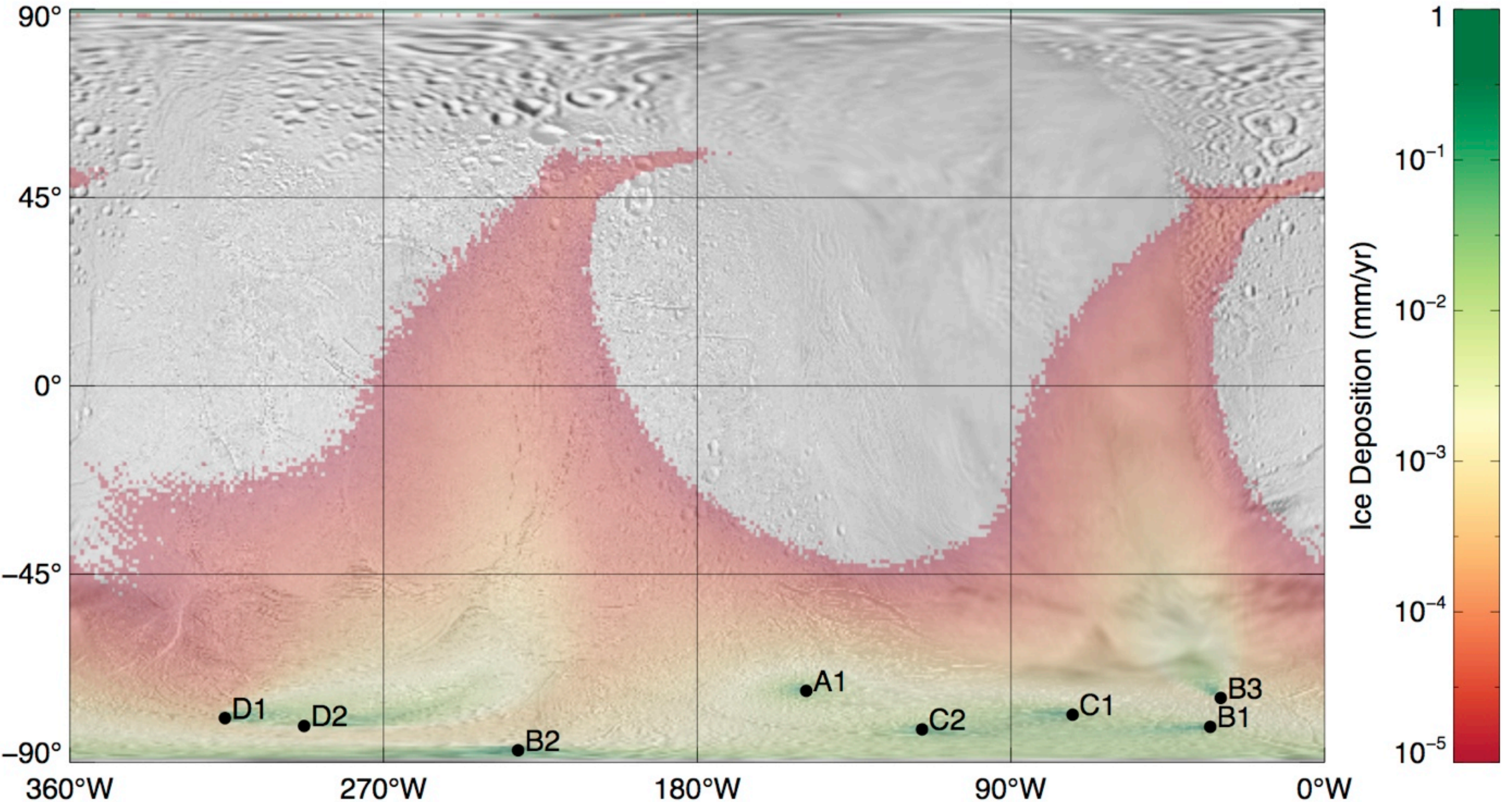




Hill Radius ~ 950 km

Escape Speed ~ 207 m/s

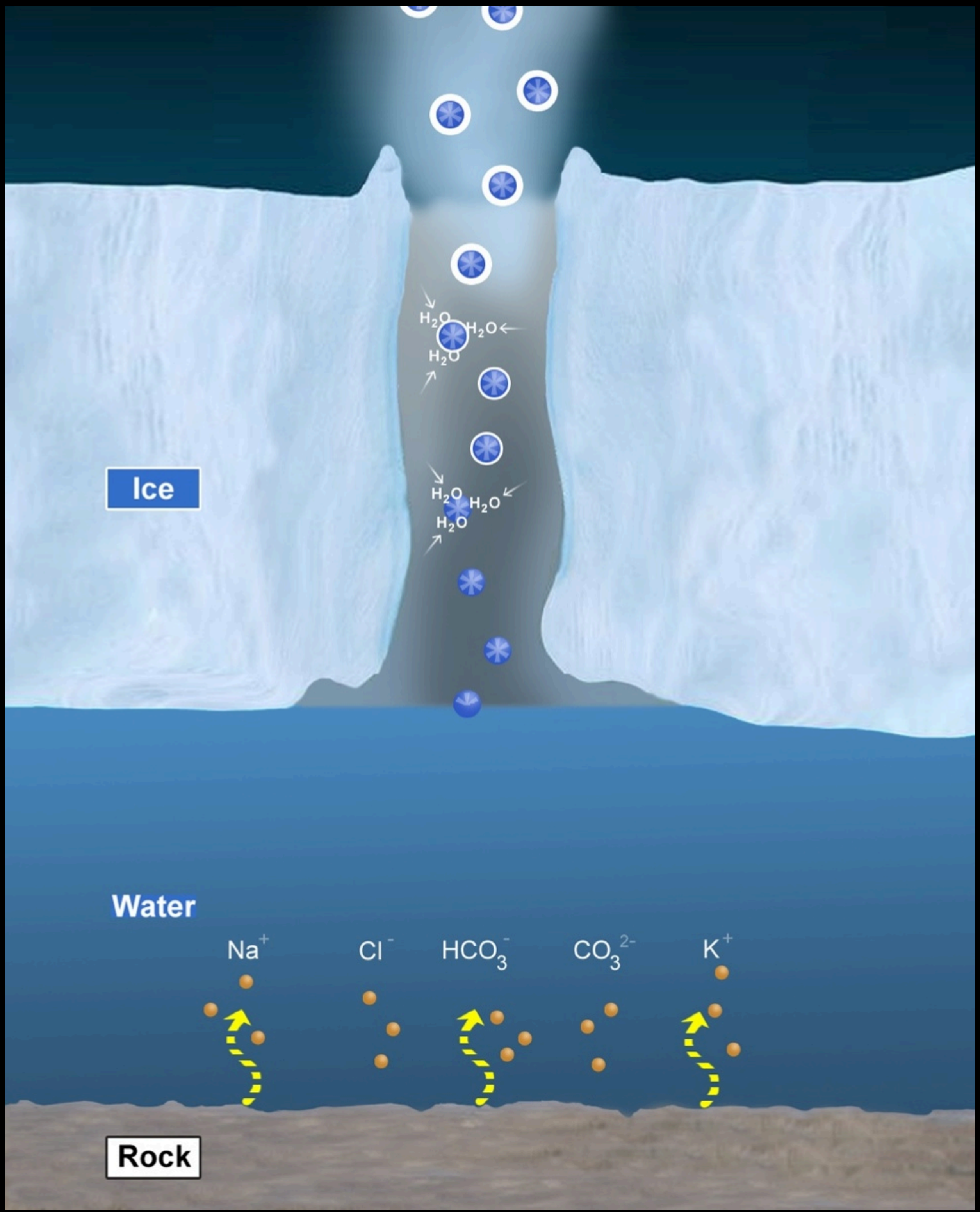
Snow !



Kempf et al., 2009

Salty icy grains : Direct Evidence for Subsurface Liquid Water Reservoir

Water + Rocky Core



Water Dissolves Akali Salts

Zolotov, Geophys. Res. Lett., 34, 2007

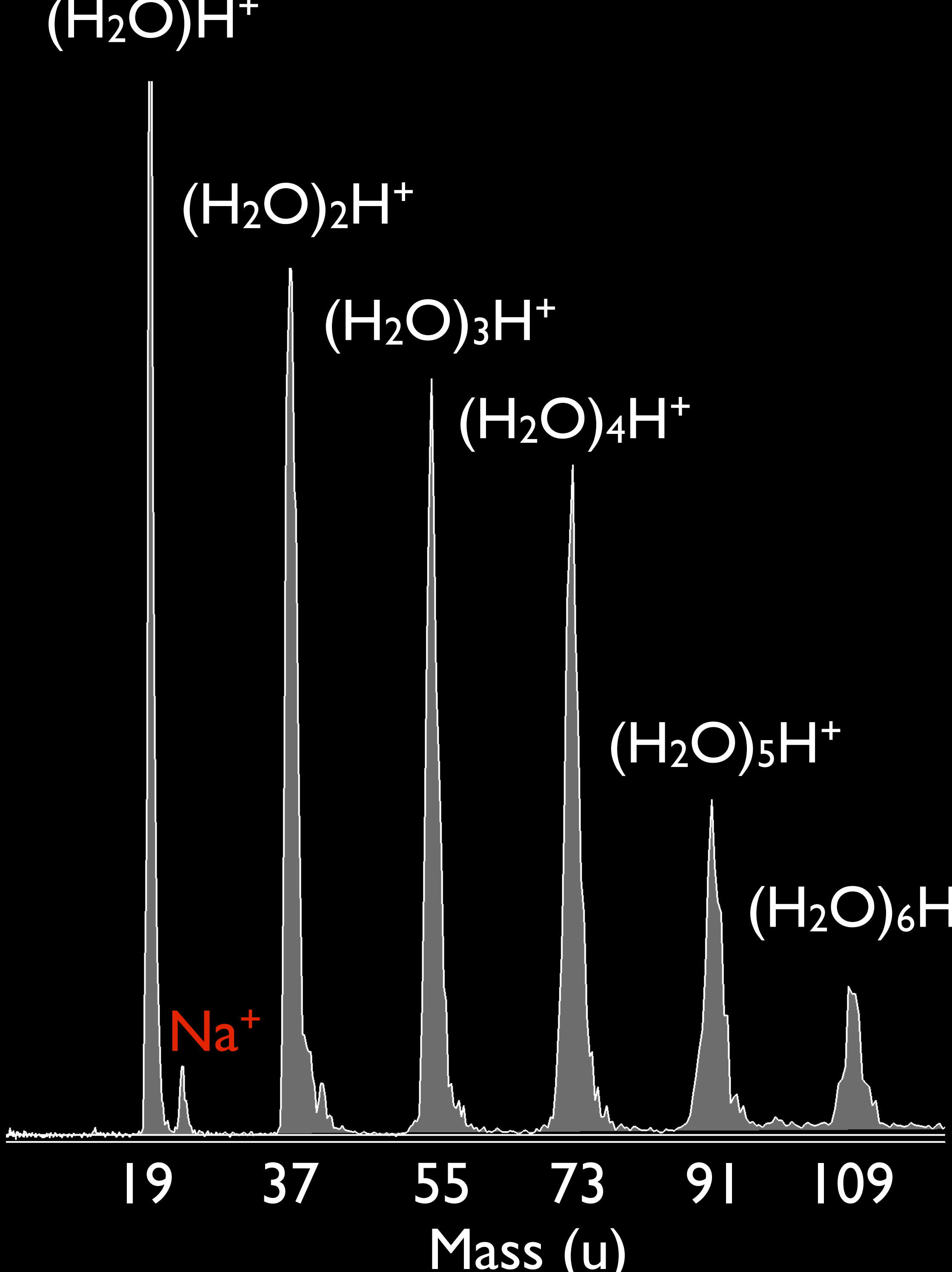
↓

Ice Grains Should be Salty!

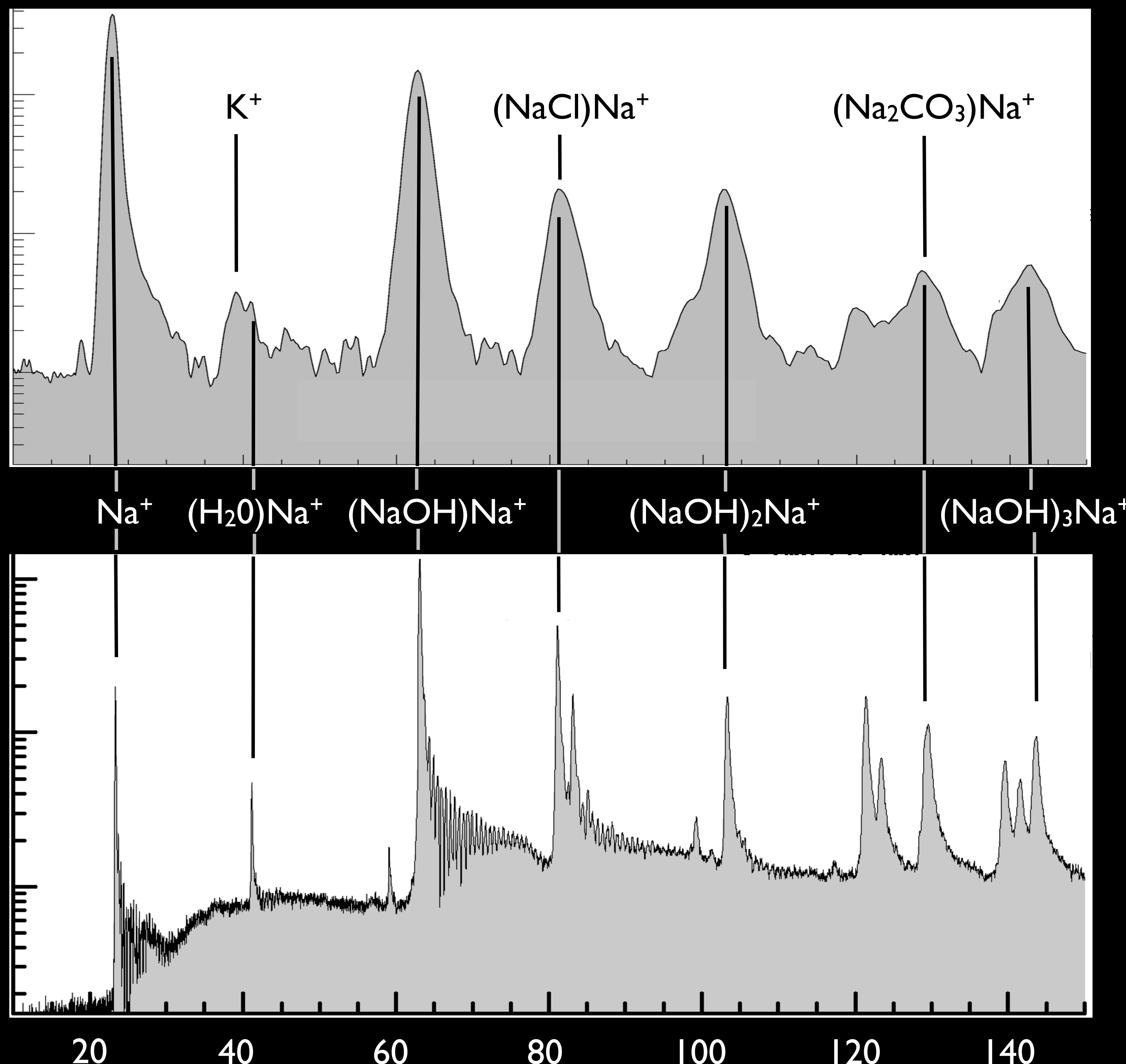
Dust Composition

Cassini Dust Detector CDA

Geyser Water Ice Grain



Salty Ice Grains



Co-Added CDA Spectrum:

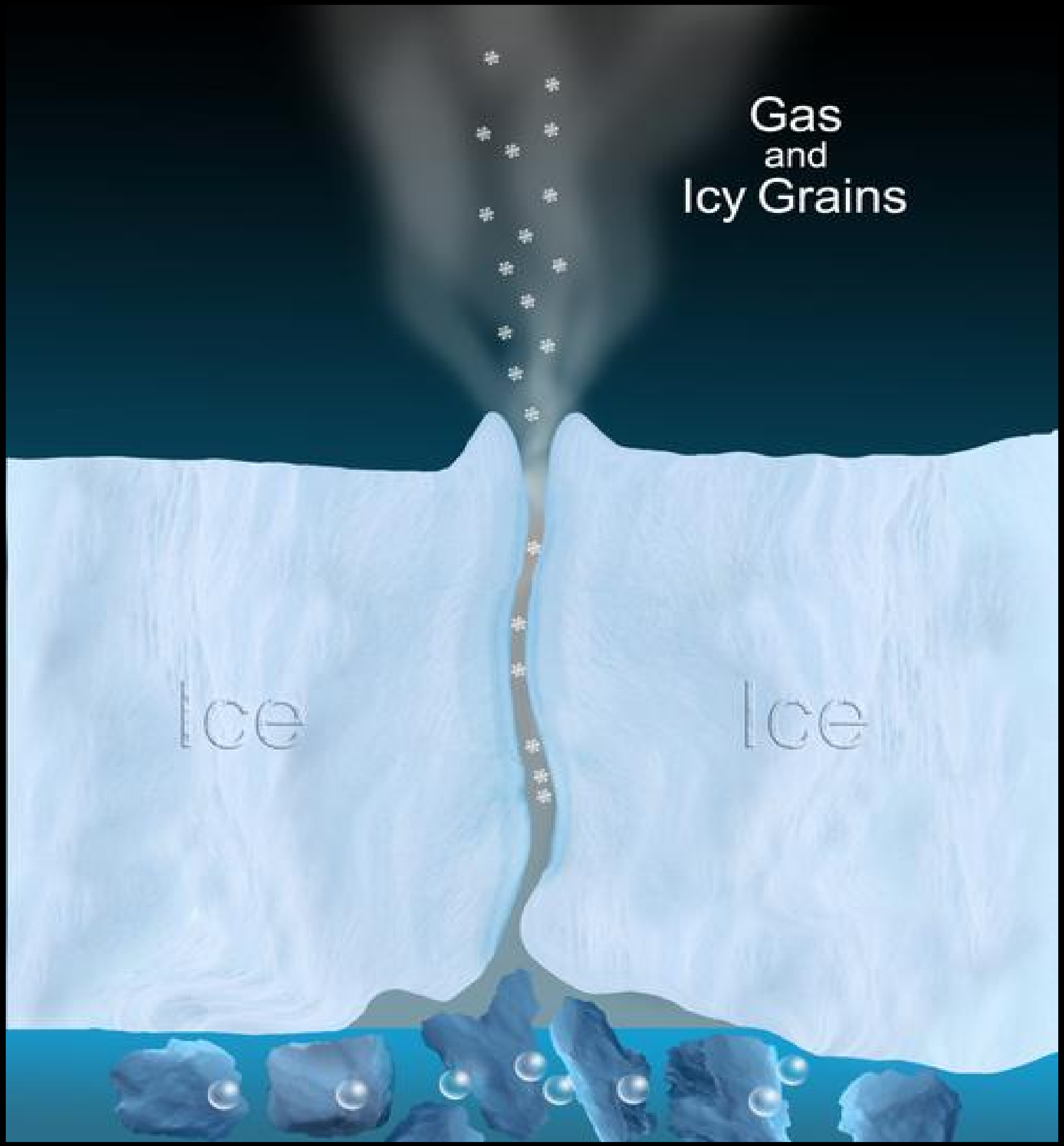
Salt-rich Geyser Ice Grains (6%)

Lab Spectrum:

Laser Dispersion of Salt Water

Postberg et al., Nature, 2009

The Enceladus Ocean



„Soda“ Ocean

Rich in Carbonates

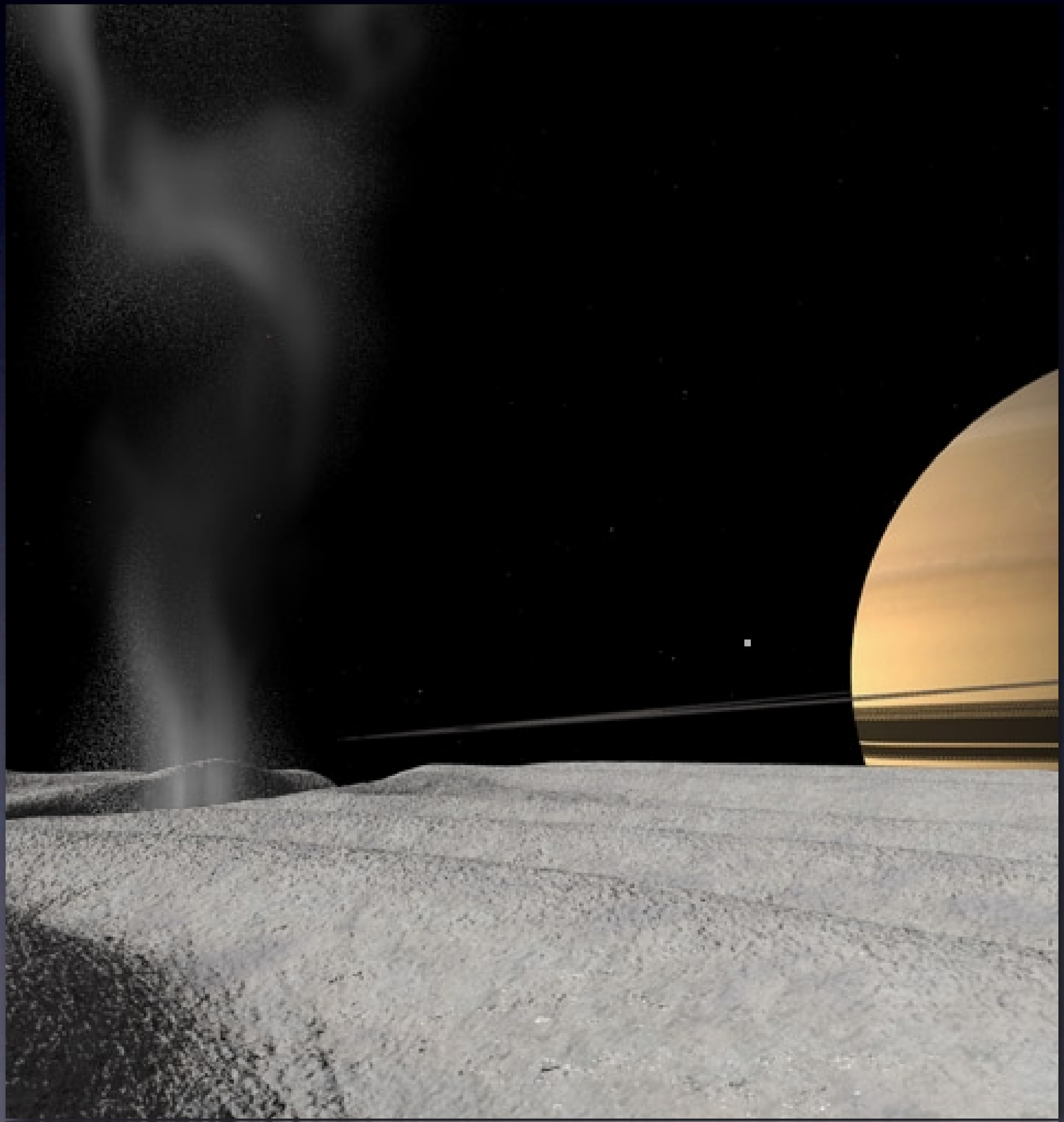
pH ~ 9

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

Postberg et al., Nature, 2009

Enceladus Lesson Learned

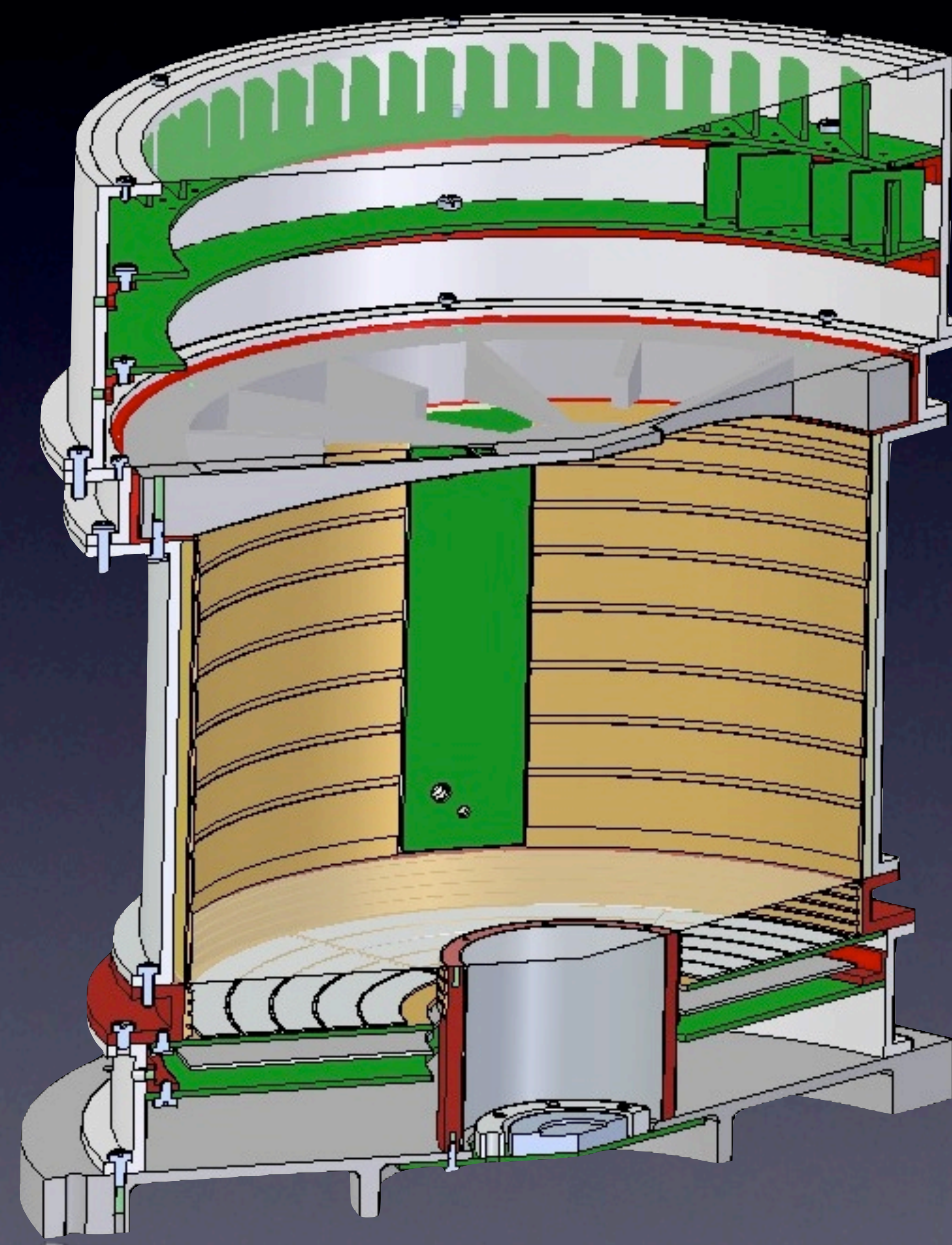
- to Understand Active Bodies the Properties of ALL Exhaust Products Need to be Known
- Without Dust Data the Conclusions Will be WRONG:
  - e.g. Kiefer et al., Science, 2006



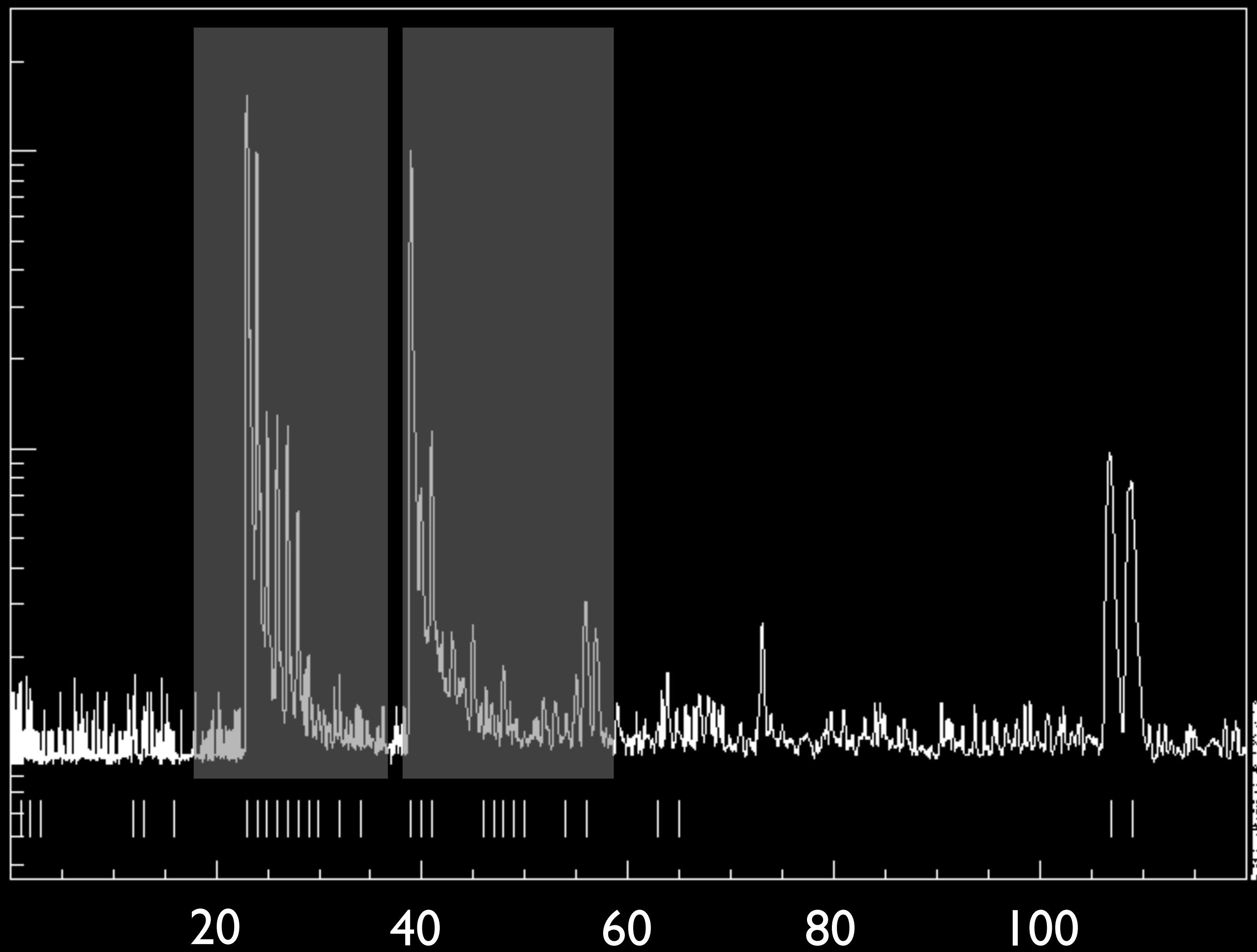
The Dust Spectrometer

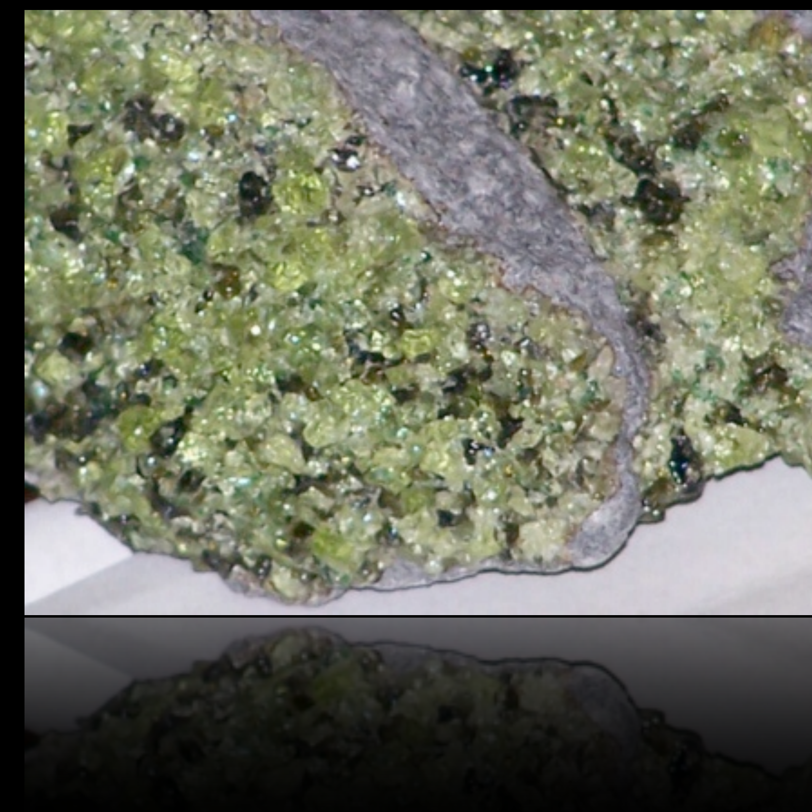
TOF Mass Spectrometer

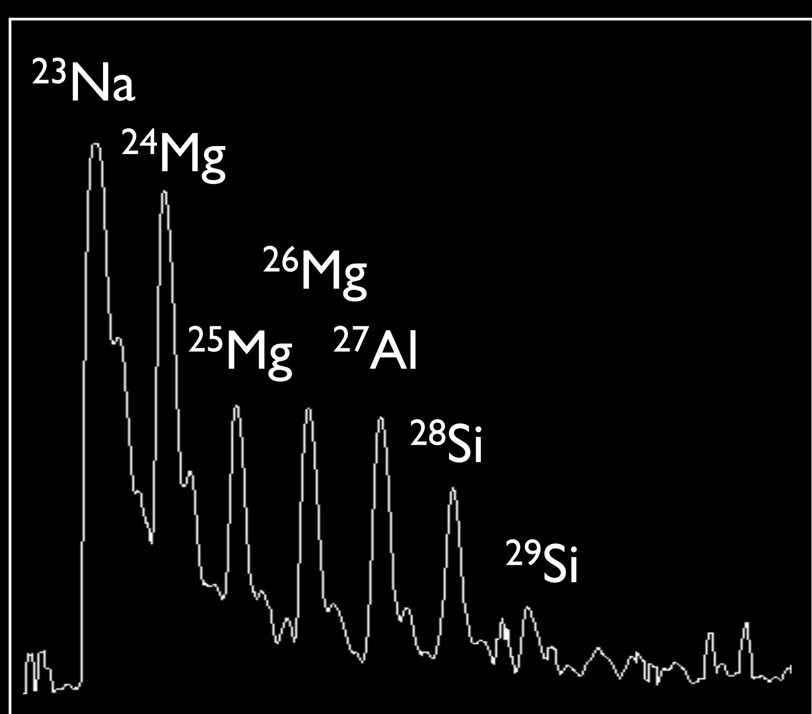
- Mass Resolution ~ 200
- Field Optics:
  - Parabolic Grid
  - Ring Electrodes
- ± Polarity

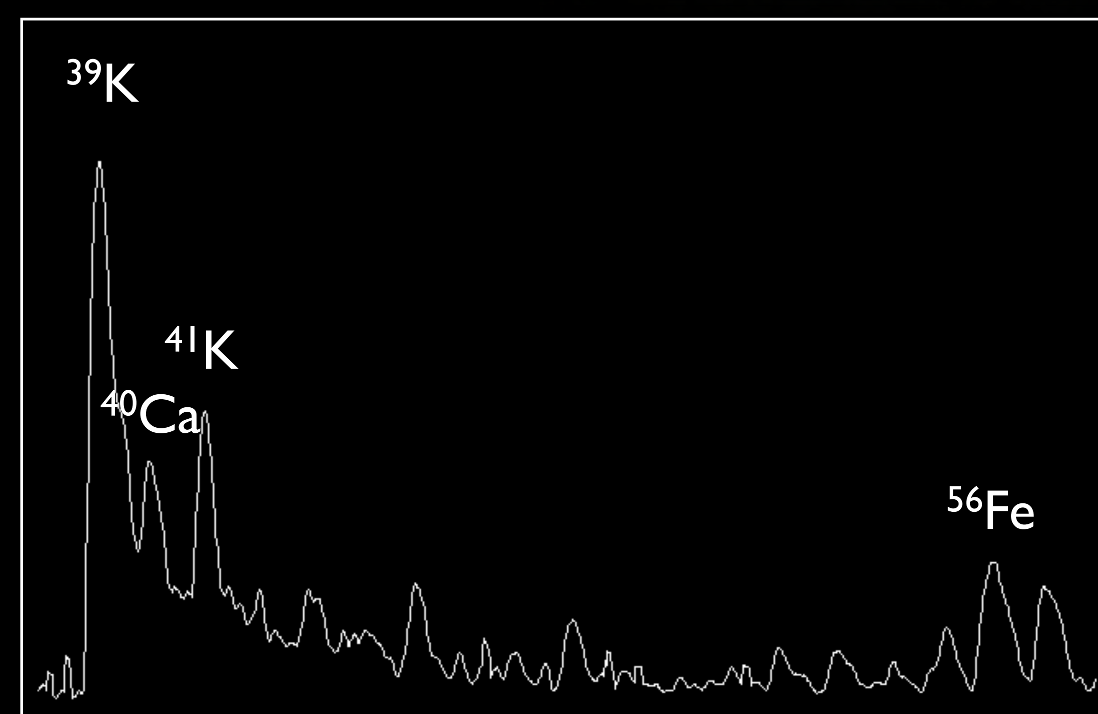


Orthopyroxene

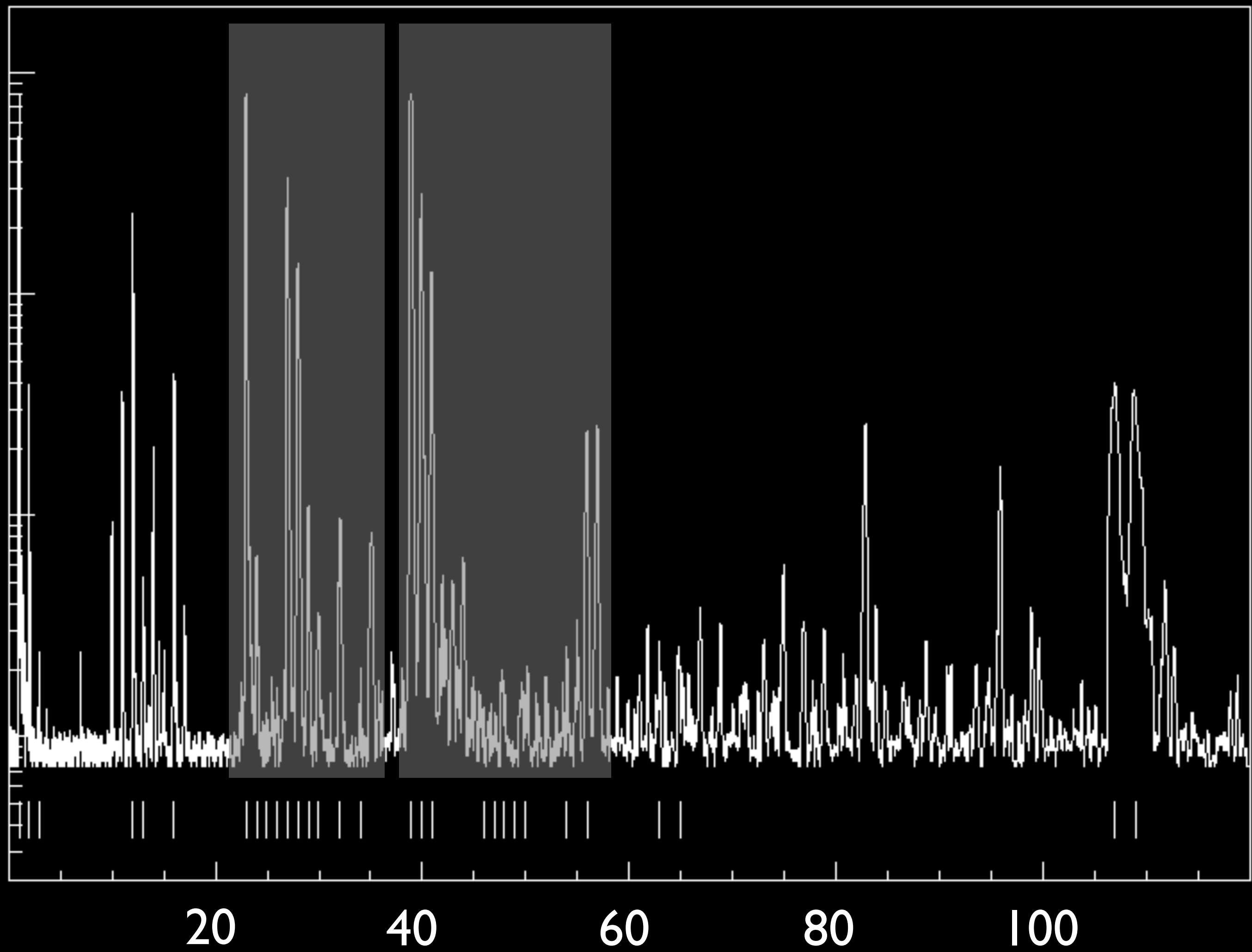


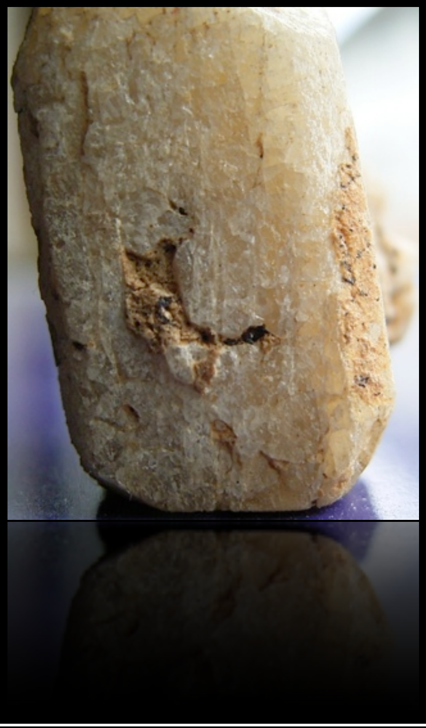


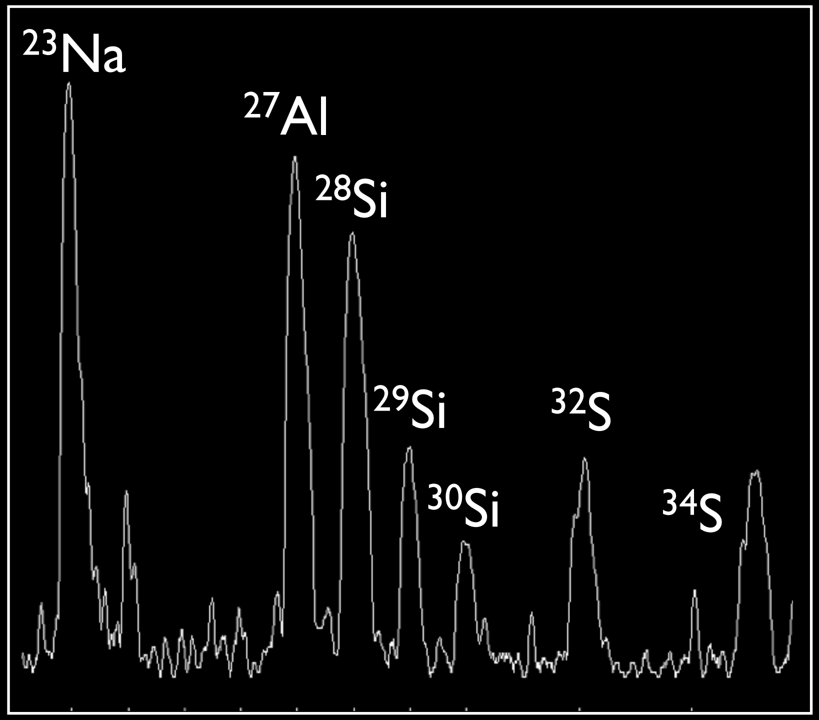


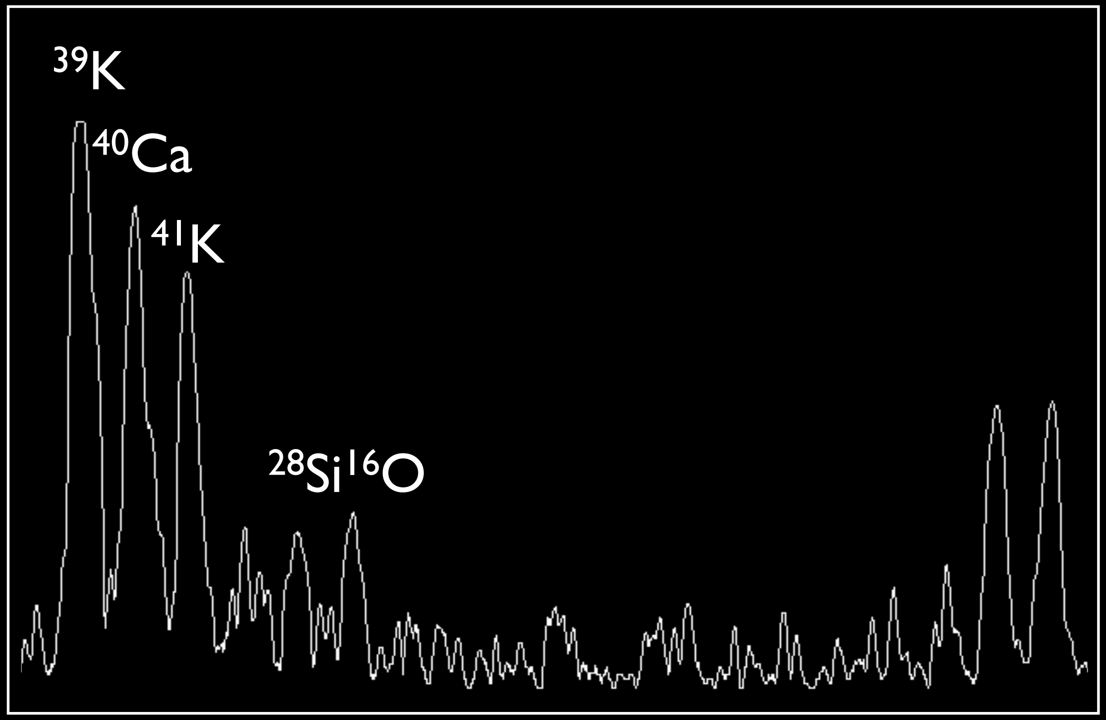


Anorthite
$CaAl_2Si_2O_8$









Three (new) reasons for dust measurements

- New instrumentation (TOF spectrometer with 10-times higher mass resolution than Cassini-CDA)
- Ionisation at low impact velocities works (~2 km/s), especially for water ice grains
- Liquid ocean with carbonates, salts and organics can be detected by dust compositional measurements in the moon vicinity

Dust Research in Jupiter‘s Environment

- Discovery of dust clouds around moons
- In-situ characterization of the Gossamer Ring
- Discovery and characterization of nano-dust (Io ash)

NEXT

- Search for active sources (geysers)
- Characterize dust charging / plasma interaction
- Compositional characterization of salts, carbonates, organics in ice grains : liquid water
- Look into moons (volcanoes, geysers) & onto surfaces