1. Landed Missions: Outer Solar System

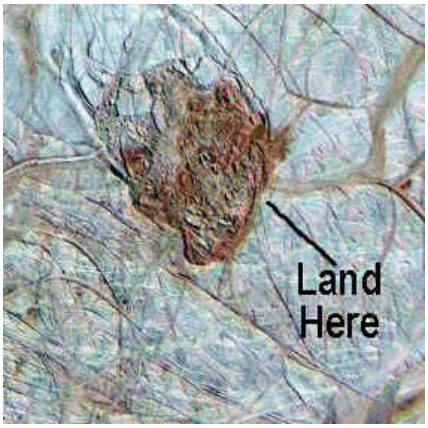
Several Outer Planetary objectives are addressable with mass spectrometry of near-surface materials.

Comets

Giotto/HMC, MPAE

- relation to solar/C1
- volatile vs. refractory
- organic/polymeric
- surface weathering

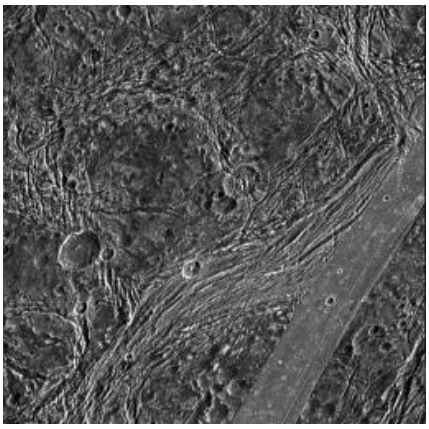
Europa



Galileo/PIA02099, PIRL

- dark phase origin
- pre-biotic organics
- source of sulfur
- ice, ocean interface

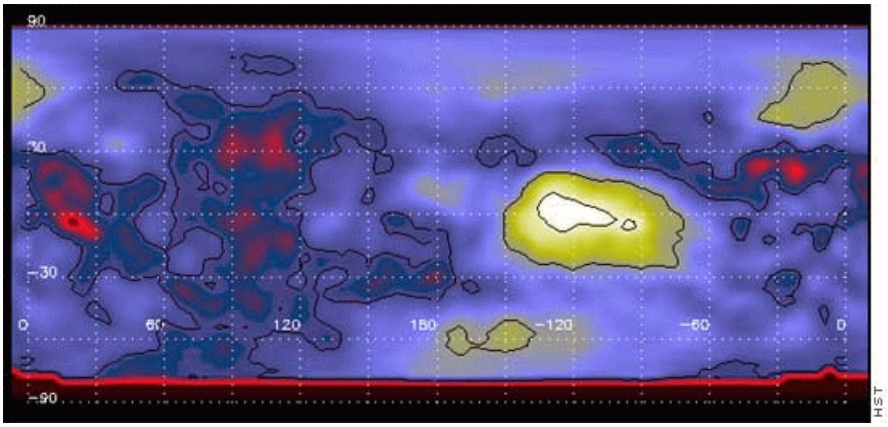
Ganymede



Galileo/PIA01613, PIRL

- dark vs. light origin
- ice composition
- SO_2, H_2O frost
- exogenous flux

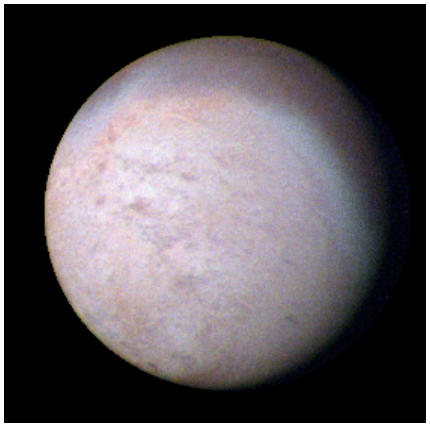
Titan



HST/WFPC2, LPL

- abundance and complexity of pre-biotic organics
- composition of ices, liquids
- detailed studies hinging on Huygens Probe!

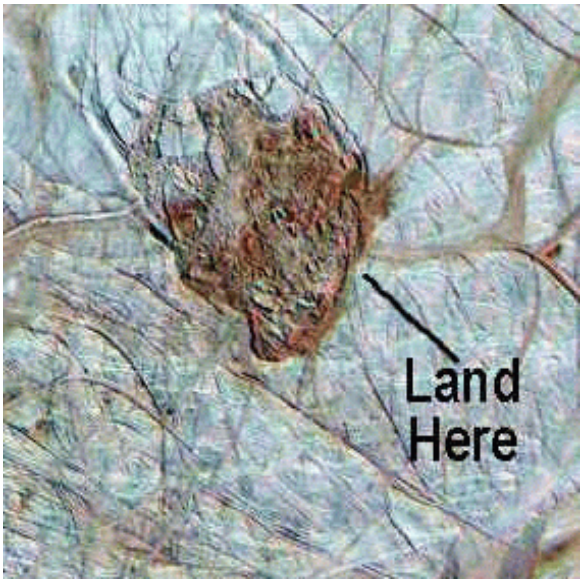
Triton



Voyager 2/ISS, JPL

- volatile inventory
- organic molecules
- seasonal composition

1. Landed Missions: Europa Composition



Galileo/PIA02099, LPL/PIRL

Surface missions to Europa are a high priority.

- What lies beneath?
- Does it ever surface, or “talk” to the surface?
- What external factors contribute to surface composition?

Such missions would benefit from mass spectrometry.

- Chemical, isotopic, and organic composition analyses
- Bulk and fine-scale studies possible
- Complements and calibrates mineralogical analyses
- Efficient data stream – initial spectra give rapid assay

But, high performance MS on Europa is very challenging!

- Extremely constrained surface payload likely
- Limited mobility, radiation-limited lifetime, and expensive

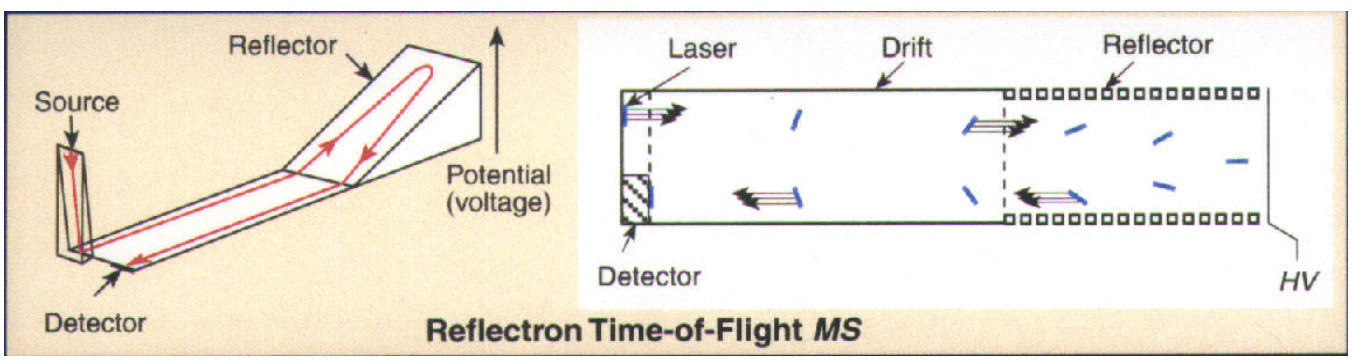
2. TOF-MS Basics

GENERAL FEATURES

- Nearly simultaneous recording of all species – no scanning
- Ions arrive at detector with TOF $\propto (m/z)^{1/2}$ (within 50 μs)
- No intrinsic limit on mass range: elements to large organics
- High resolution obtained with ion reflectrons
- Extremely simple, rugged instruments; can be miniaturized

LASER TOF-MS

- TOF-MS couples naturally to pulsed radiation
- Laser deposits fixed energy in a small spot without charging
- Short pulse widths (0.1 - 10 ns) enhance mass resolution
- Laser can directly volatilize and ionize surface material
- Variable spot sizes 10-200 μm permit grain-bulk analyses

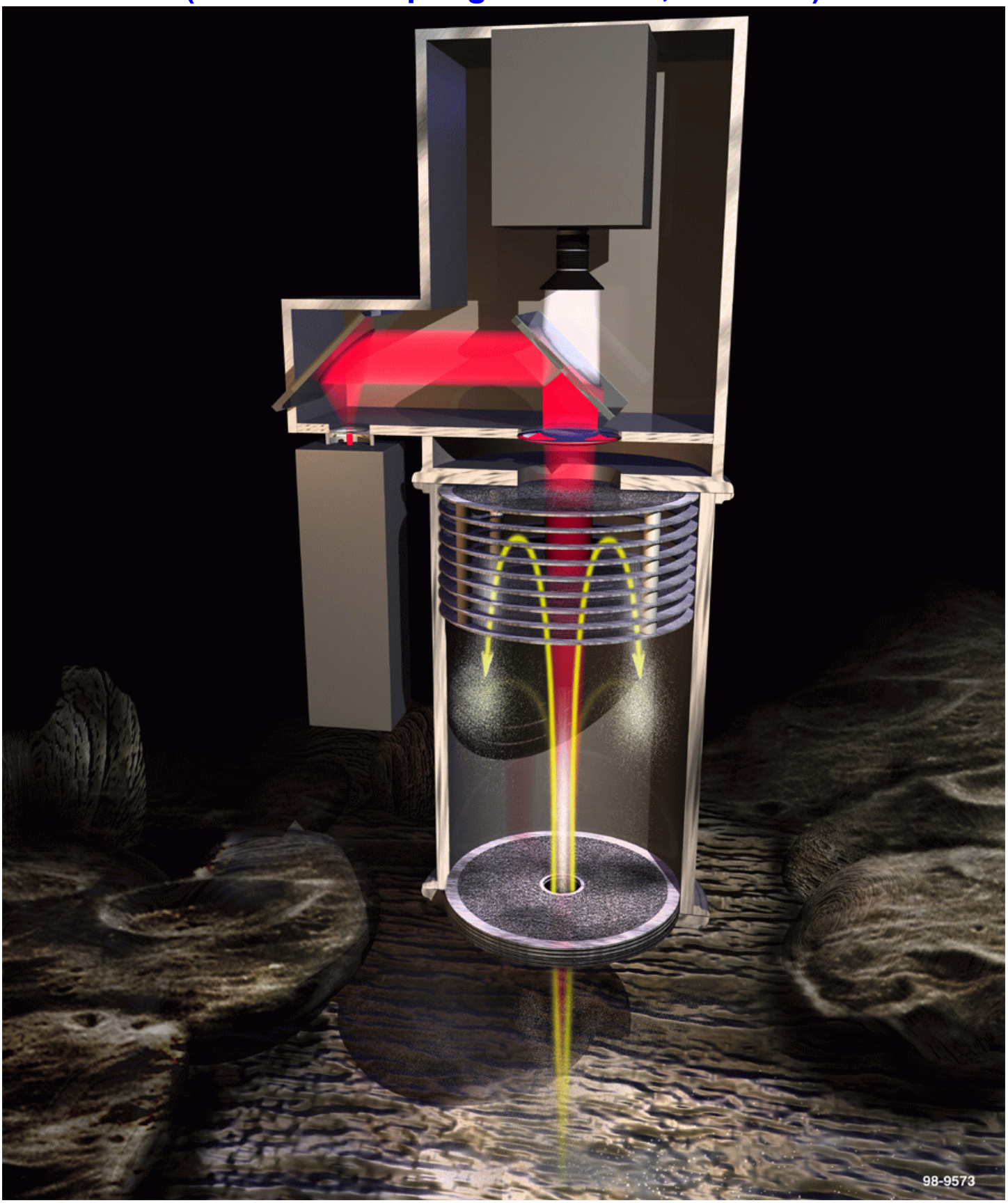


JHU/APL INSTRUMENTS

- Highly miniaturized designs (< 20 cm length) for deployment on a range of missions to asteroids, comets, moons, planets
- Two basic methods LAMS and LDMS cover measurements

Laser Ablation TOF-MS operating on airless body.

(Standoff sampling – no muss, no fuss!)



LAMS Meteorite Spectrum - Single Shot