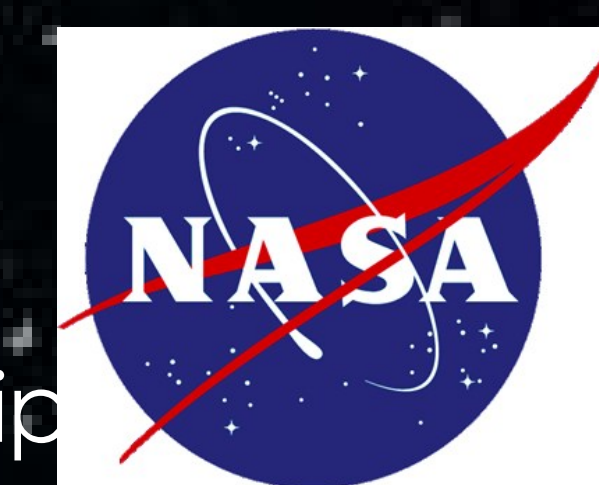


# Probing the Composition of Primitive Solar System Materials with a Compact Laser Mass Spectrometer

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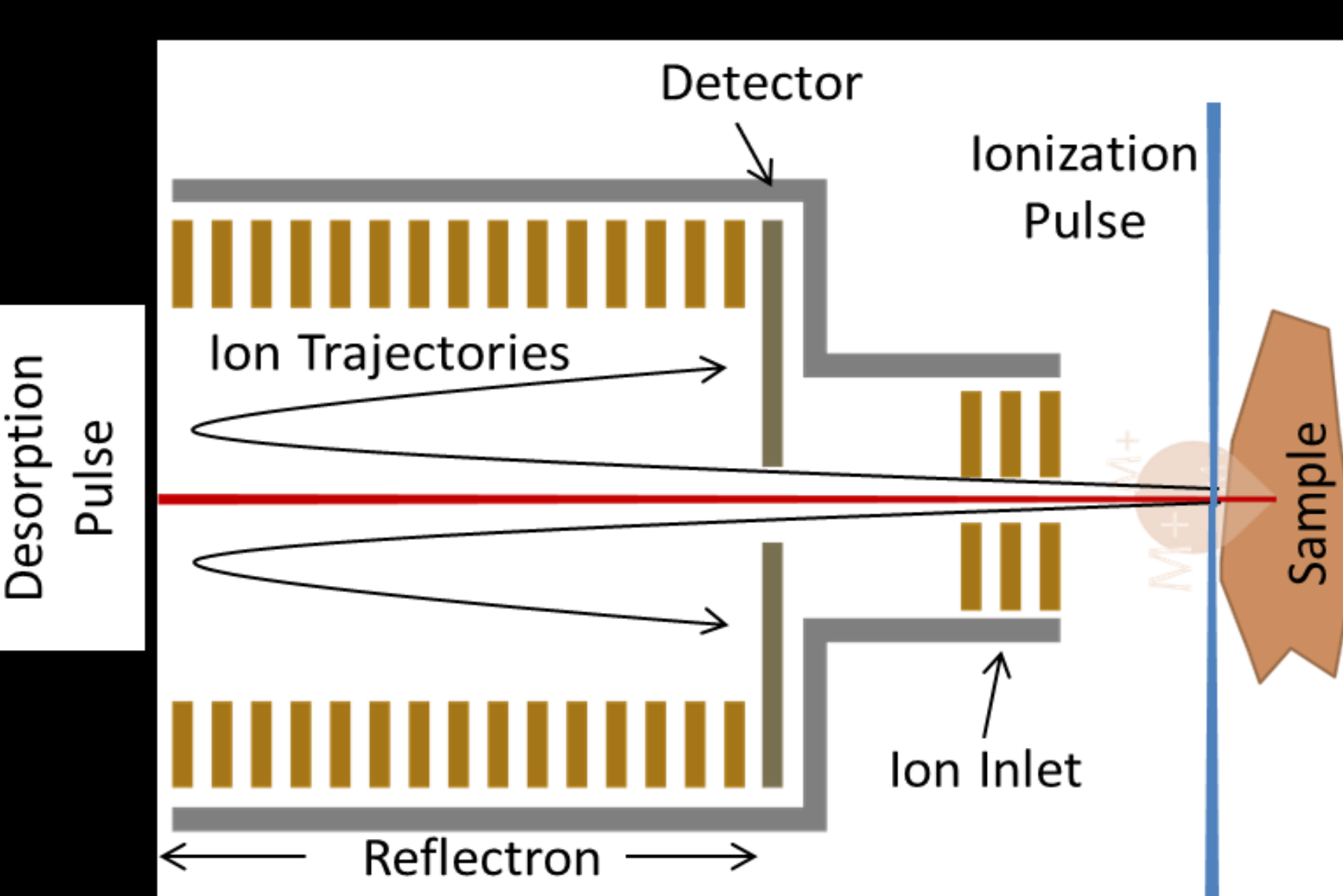
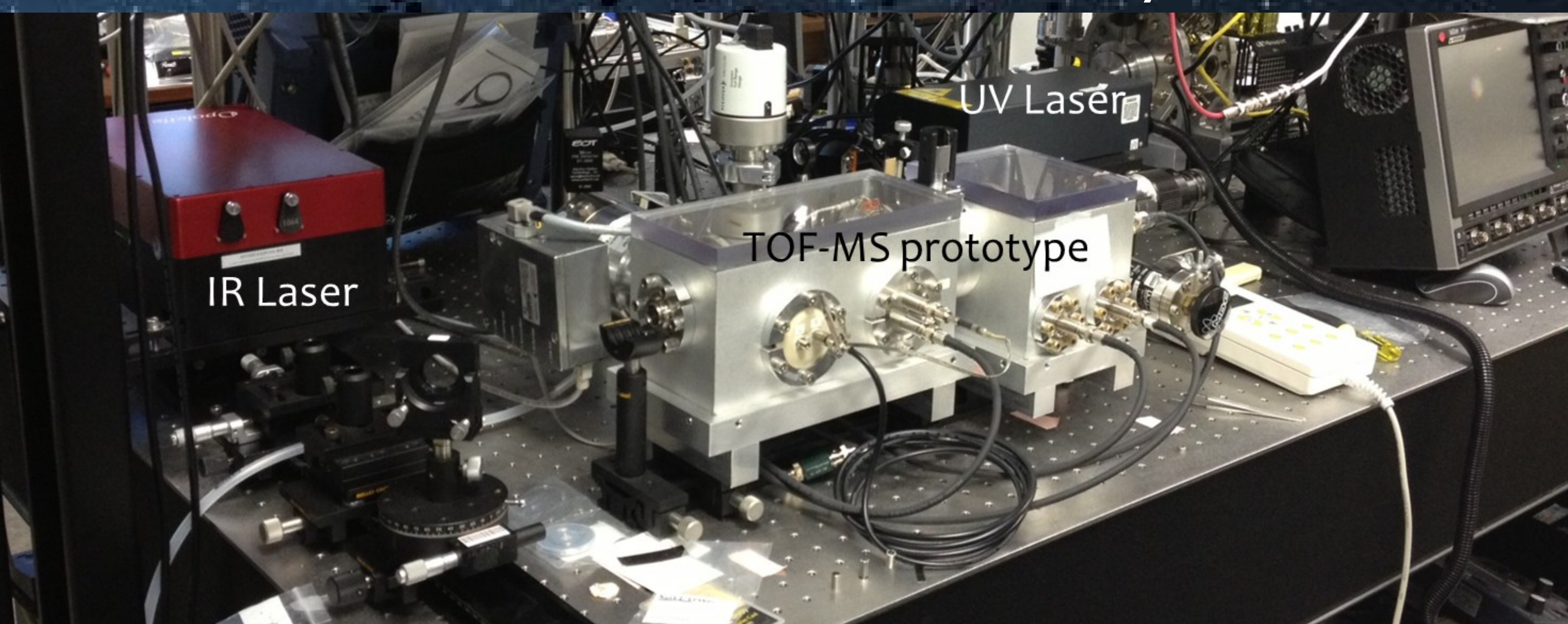
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## Introduction

To contribute to and complement our understanding of the processes governing the formation, distribution, and evolution of primitive materials throughout the solar system, it will be critical to form connections between broad remote sensing spectroscopic surveys, laboratory measurements of analogs and samples delivered to Earth, and *in situ* measurements of the surface composition on future primitive body missions. Recently, a laboratory prototype employing resonance two-step laser mass spectrometry [Getty *et al.*, 2012] has been coupled to a cryogenic sample stage to enable measurements of analog samples that are relevant to these fundamental questions. Analyses of mineral-aromatic mixtures and meteorite powders will be presented. Our goals are twofold: (1) to conduct laboratory studies on solar system analog, meteoritic, and potentially returned samples to elucidate composition, and (2) to provide a compact but capable analytical instrument for discovery-driven *in situ* interrogation of surface chemistry on a future mission, such as to a Trojan asteroid, comet, or icy moon.

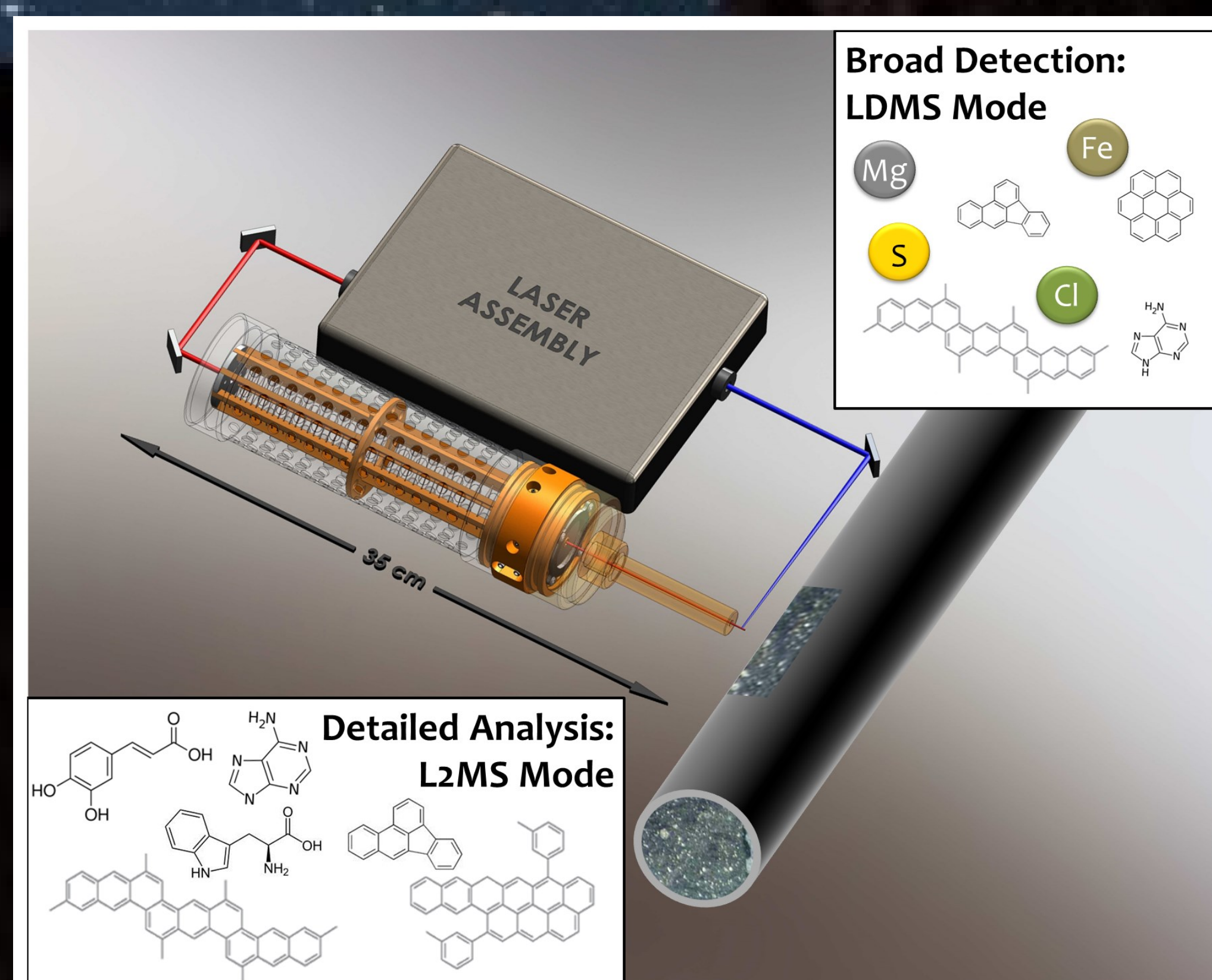
## Two-step Laser Mass Spectrometry: In the Lab and as Part of an In Situ Payload



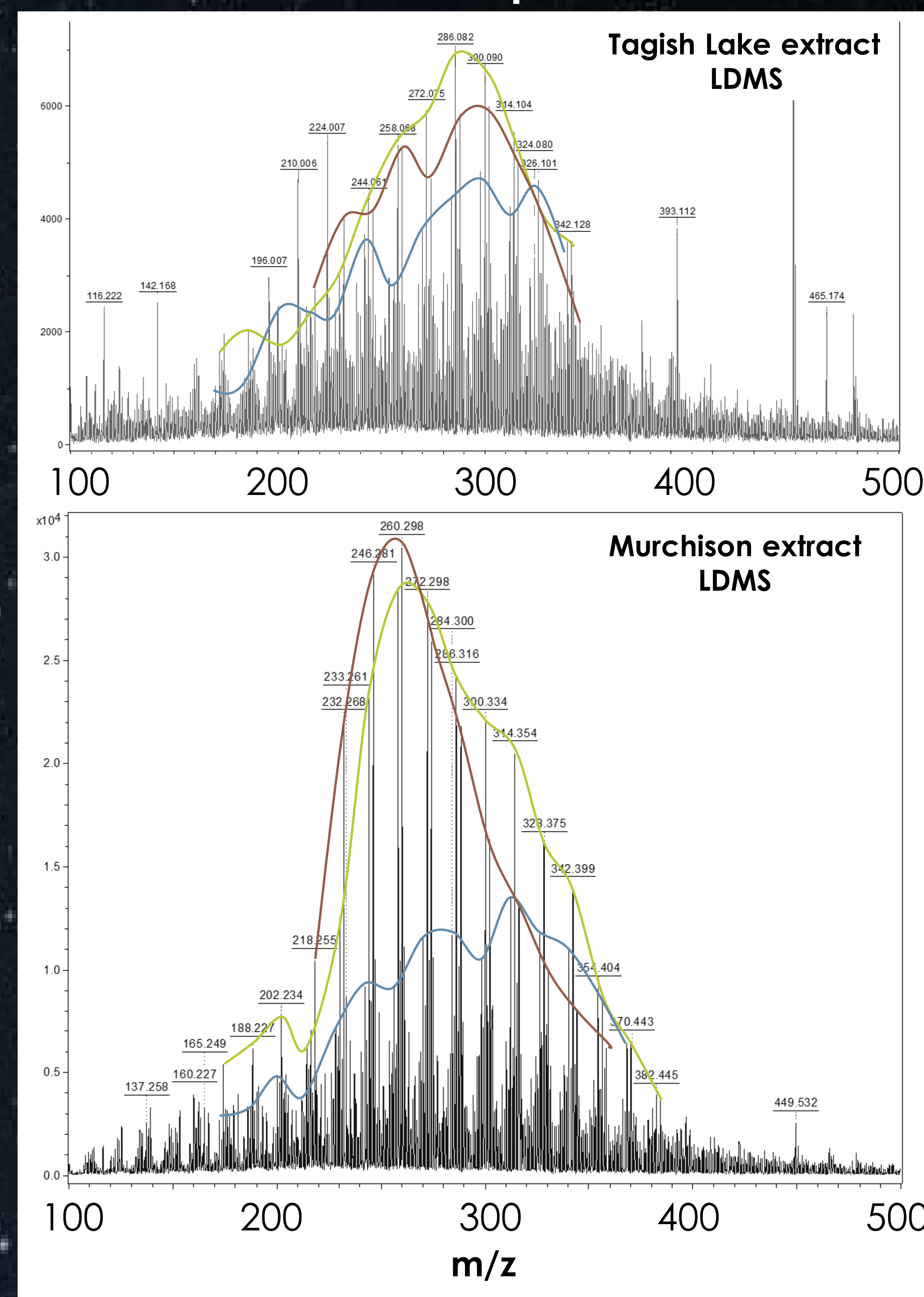
In L2MS, desorbed neutrals are produced from the solid surface using a pulsed infrared laser at infrared wavelengths (the Nd:YAG fundamental 1064nm and a tunable laser from 2.7 to 3.1 $\mu$ m have been used). After a delay of  $\geq 100$ ns relative to the IR pulse, a focused UV pulse (266nm) is directed orthogonally to the desorption laser to produce resonance-enhanced multiphoton post-ionization. The mass analyzer is based on a curved-field reflectron TOF with microchannel plate detectors.

L2MS Mass Estimate	
Subsystem	Mass/g
1. TOF-MS	700
1.1 Mass Analyzer	330
1.2 Housing	370
2. Laser	1693
3. Optical	380
4. Electronics	1826
4.1 Comm/Data	291
4.2 Power Supply	585
4.3 Pulsed HV	440
4.4 Detector	260
4.5 Harness	250
SUBTOTAL (airless body)	4599
5. Turbo Pump*	550
5.1 Pump, 200 krpm	200
5.2 Controller	350
TOTAL	5149

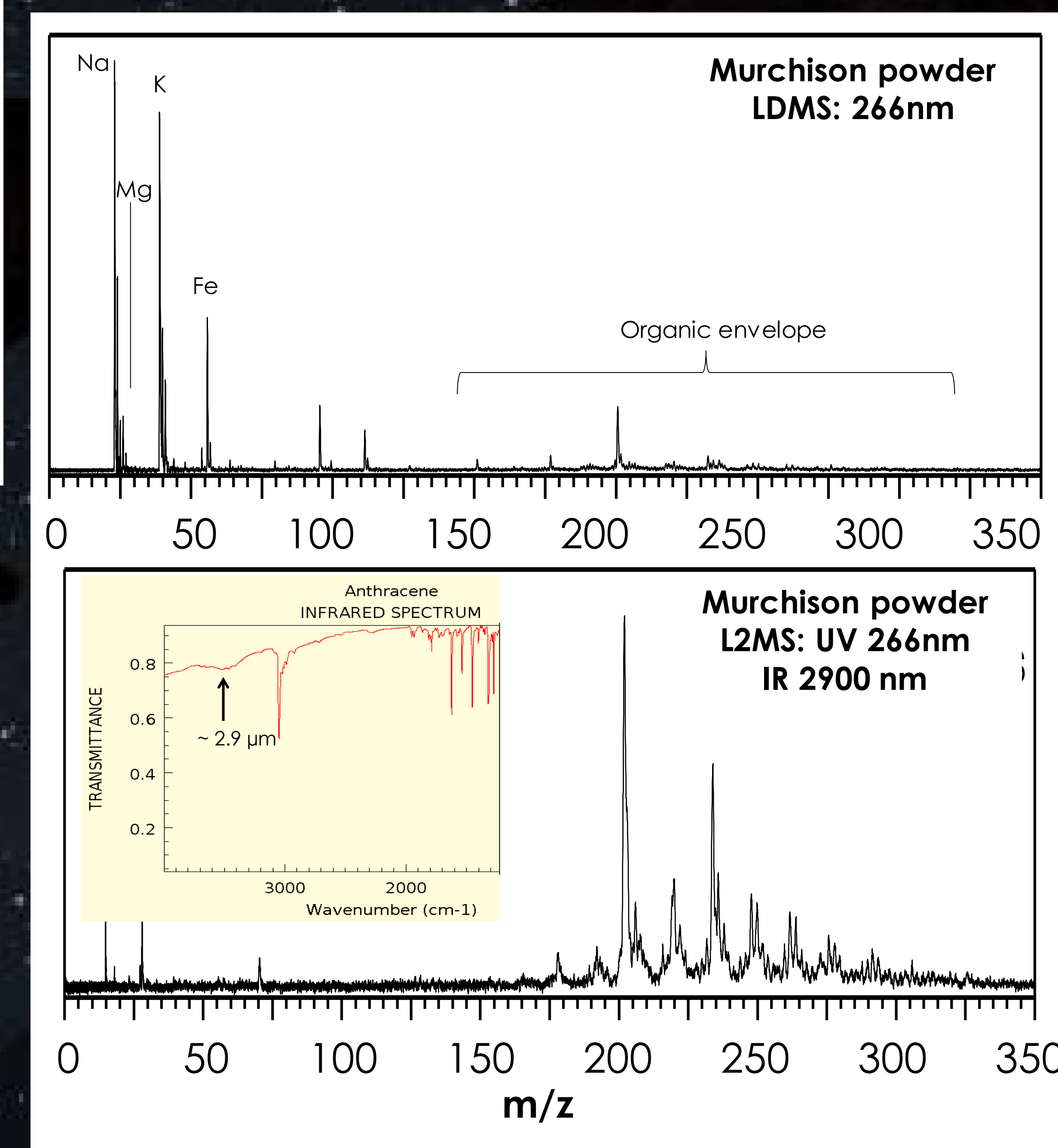
Two-step laser time-of-flight mass spectrometry is compatible with *in situ* science with a 5 kg-class instrument. Two modes are possible to allow study of inorganic and organic composition over a wide mass range, sensitivities, and structural selectivities. All components are high maturity, building upon proven designs of the analyzer, electronics, and lasers.



## Comparison: Murchison and Tagish Lake Meteorites



(Left) LDMS allows comparison of the Tagish Lake and Murchison meteorites (Bruker Autoflex Speed; solvent extracts). The Tagish Lake parent body is thought to be more primitive than that of the Murchison meteorite, which has seen a greater degree of aqueous alteration. Both meteorites show a familiar pattern of aromatic hydrocarbons (including naphthalene, anthracene, phenanthrene, pyrene, fluoranthene, chrysene, coronene, and others), and their methylated homologues. Though the organic distribution is similar between these two meteorites, a lower degree of methylation is seen for the Tagish Lake. Three common PAH methylation series are highlighted here with guides to the eye in green, blue, and brown. The correlation of increased methylation with a greater degree of aqueous processing has been previously observed by Elsila *et al.* (2005).



(Right) In contrast to the extracts, a direct LDMS measurement on Murchison powder provides insight into the mineralogical composition, including Mg and Fe, but these inorganic signatures dominate over the organic envelope of peaks between 150 and 350 Da. L2MS on unextracted powder allows the direct, sensitive, selective analysis of the aromatic organic fraction of the powder. In fact, the use of a tunable desorption wavelength provides additional selectivity based on the vibrational resonances of the organics present. Since anthracene exhibits an IR resonance at the 2900 nm wavelength used here, we conclude that the  $m/z$  178 signal is due to purely anthracene, without interference from isobaric phenanthrene, which does not exhibit such a resonance.

## References:

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