# TECHNICAL APPROACHES TO LASER MASS SPECTROMETRY AT MARS.

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Overview. Laser mass spectrometry may be a key element of future astrobiological investigations at Mars. A focused laser can evaporate sample from small spots (microns to mm) which may be selected with contextual data from a microscope and other probes. The point-by-point elemental and molecular composition obtained through subsequent mass spectrometry is vital to (i) determine the spatial associations of potential biosignatures with structures and/or mineral phases, and (ii) detect high molecular weight compounds that may be highly localized. The broad-band analysis of complex samples by laser mass spectrometry is well-documented, but for implementation at Mars a number of key technical areas have required special attention.

Sample Processing. Laser desorption (LD) has the advantage of sampling an unacquired/unprepared surface from a stand-off position. While this suggests a highly simple implementation on airless bodies, the thick atmosphere on Mars necessitates additional considerations and approaches. It is possible to perform laser desorption at ambient pressure and draw neutrals/ions into an evacuated mass spectrometer using only a pressure gradient [1]. The advantage is that no sample acquisition would be required. The challenge is that the inlet must be placed very close (mm-scale) to the surface to achieve good sensitivity. Alternately, samples are acquired and placed in vacuum through a load lock. This approach permits precise manipulation and processing of the sample, if required, and achieves high sensitivity, but does require a robust, repeatable mechanical sealing system [2]. Hybrid approaches, such as acquiring and positioning samples at ambient pressure, followed by laser desorption, are also being considered.

Pulsed Lasers. Pulsed LD, such as using diode-pumped or semiconductor YAG-based systems with a Q switch, comprise an enormously powerful enabling technology for *in situ* astrobiology. Short pulse lengths (ps to ns scale) enable the volatilization and ionization of high-mass "parent" compounds, from geological samples, that would be uniquely diagnostic of the current organic complexity of Mars; this is difficult to do with non-laser methods. Relatively simple "direct" LD can evaporate and ionize with a single laser shot. Multi-laser methods such as resonance ionization offer improved sensitivity and selectivity at increased complexity. Because flight-qualifying a particular system is a complex and expensive task, brassboard work on alternate approaches is being conducted in the laboratory to determine the most effective route for Mars.

Mass Analyzers and Detectors. The applicability of various analyzer types (time-of-flight, ion trap, quadrupole, etc.) to specific analytical challenges on Mars is being investigated. Each has its advantages (high mass, tandem capability, sensitivity, etc.) and the best approach is likely a carefully-tailored and streamlined combination of these [2]. Quite miniature analyzers have been developed in recent years, and space implementation may now be equally dependent on key supporting technologies such as vacuum pumps and electronics. For instance, a single-board, low-power, rad-tolerant, high-bandwidth waveform digitizer, under development at JHU/APL, is required to resolve and integrate the tightly-spaced peaks of a time-of-flight mass spectrum.

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References.

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