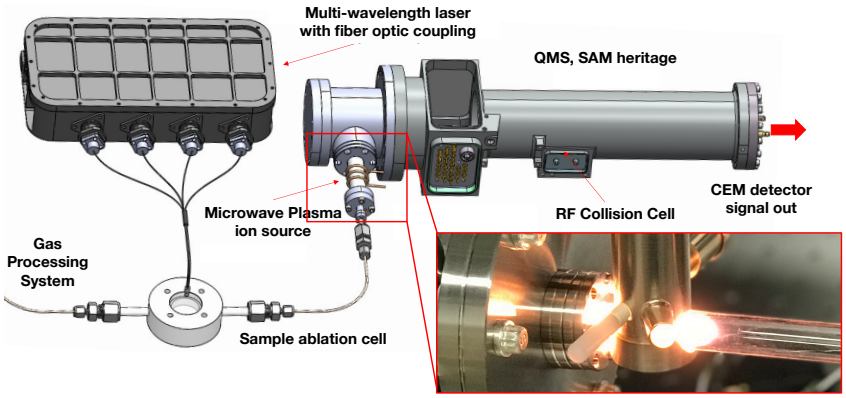
THE PULSED LASER ABLATION SAMPLING MASS ANALYSIS (PLASMA) INSTRUMENT: A PLASMA MASS SPECTROMETER FOR TRACE ELEMENT ANALYSIS OF LUNAR SURFACE MATERIAL. B. J. Farcy[1], W. F. McDonough[1,2], R.D. Arevalo[1], M. Taghioskoui[3], C. Gundersen[4], J. Llano[4], R. Danell[5], M. Fahey[6], B. Cohen[6], P. Mahaffy[6] and the [6]PLASMA Science team. [1]University of Maryland, College Park, Department of Geology (bfarcy@umd.edu), [2]Tohoku University, Sendai Japan, [3]TraceMatters Inc., Somerville MA, [4]AMU Engineering, Miami FL, [5]Danell Consulting Inc., Winterville NC, [6]NASA Goddard Space Flight Center, Greenbelt MD.

Introduction: The PLASMA instrument is a new generation of spaceflight mass spectrometer, designed for in situ analysis of geologic materials. Funded through the NASA DALI program, PLASMA is a miniature inductively coupled plasma mass spectrometer (ICPMS) that will target trace element abundances and isotope ratios in lunar surface materials. A spaceflight-qualified version of the instrument is scheduled for construction, the science goals of a mission utilizing PLASMA have been identified, and a landing site analysis has been carried out to maximize the science return of a landed lunar mission.



Instrument Overview: The Mini ICPMS described here uses a low-pressure plasma as an ion source to atomize and ionize ablated geologic material introduced via laser ablation. The architecture of the PLASMA ion source mirrors that of commercial ICP ion sources while consuming a small fraction of the resources when operating. The plasma operates at reduced pressure and requires <40 W of power and <600 mL/min of He to process the sample for mass spectral analysis [1]. The PLASMA instrument suite will include a multi-wavelength laser to target a variety of sample types, including:

- 1064 nm – An IR wavelength for coupling with water-rich matrices
- 532 nm – to support Raman spectroscopy
- 266 nm – to couple with meteoritic organic material stored in lunar regolith, and
- 213 nm – for ablation of silicate material.

PLASMA will further leverage a gas collision cell to be used as a means of chemically separating isobaric interferences within the ion beamline. Isotopes with similar m/z ratios, such as ^{87}Rb and ^{87}Sr, normally require chemical preprocessing to separate their overlapping peaks. Instead, passing an ion beam through a background gas can chemically separate Rb from Sr, allowing precise geochronology while only requiring single-m/z resolution.

The laser ablation ICP ion source and sample introduction system will be interfaced with a quadrupole mass spectrometer, with heritage to the Sample Analysis on Mars instrument onboard the Mars Science Lab Curiosity rover. This ruggedized, flight qualified mass spectrometer will minimize mission risk while delivering measurements of the mass range of the entire periodic table (^{6}Li to ^{238}U).

Scientific Investigation: The science goals of the PLASMA instrument are to analyze previously inaccessible lithologies on the lunar farside, addressing questions about the structure and formation history of the lunar farside mantle.

Science goals of PLASMA: A trace element analysis of farside materials can provide insights into the structure and composition of the lunar farside mantle. First row transition element ratios can provide melting depth and mineralogical information on the source region of mare basalts, potentially revealing a cross section of the farside mantle [2,3]. K, Th, and U abundances of farside impact melts can inform on a thermal asymmetry of the early lunar magma ocean, and radiometric isotope dating can provide ages for major structures such as the South Pole Aitken Basin [4].

Landing site analysis: A landing site that would maximize the scientific return of a mission using PLASMA would include: 1.) Impact melt in the basin of a crater floor, 2.) later emplaced mare basalts, and 3.) limited hazard terrain. The suitable farside targets have been identified as Moscoviense, Von Karman, Leibnitz, and Apollo craters [5].

References: [1] Farcy et al. (2021a) *JAAS 35 2740* [2] Putirka (2008) *Rev. Min. Geochem. 69* [3] Le Roux et al. (2011), *EPSL 307 395*. [4] Bottke & Norman (2017), *AREPS 4, 619* [5] Farcy et al. (2021b) *PSJ 2, 2*.