National Aeronautics and Space Administration

Miniature combination Mössbauer and X-ray fluorescence spectrometer for planetary geochemistry

Principal Investigator: Valerie Scott Kristof (389); Co-Investigators: Brent Fultz (Caltech), Risaku Toda (389), Yuki Maruyama (389), Laura Kerber (322), Jeff Delaune (347)

Program: FY22 R&TD Topics

Strategic Focus Area: Remote/In Situ/Life Detection Sensors and Instruments

Objectives:
Our overarching project goal is to demonstrate dual-operation of the envisioned combination Mössbauer/XRF spectrometer. Mössbauer and X-ray fluorescence (XRF) spectrometries offer an opportunity to combine two fundamental analytical techniques into a single, miniaturized, dual-mode instrument. These traditionally standalone instruments are key technologies in thegeochemist's toolbox and share exploitable technological similarities. XRF delivers simple, non-destructive, bulk analysis of rock and mineral elemental composition, while MS offers detailed mineralogical information about the oxidation state and chemical bonding environment of iron atoms in a sample. Versions of XRF have flown on nearly every major in situ planetarymission, and MS has also delivered key science findings about mineralogy in the Solar System. Notably, MS has never flown without an accompanying XRF instrument — elemental information is vital to deciphering the complex spectra collected with Mössbauer techniques. There is not a compact, bulk analysis, dual-mode instrument readily available to upcoming size-, mass-, and power-constrained missions.Task Objectives1) Successful demonstration of piezoelectrically-actuated Mossbauer spectrometer showing <8% Mossbauer peak distortions.2) Successful demonstration of harvesting Mossbauer signals using a silicon drift detector (SDD) resulting in spectra with <8% distortions.3) Successful collection of XRF spectra with <100 ppm trace element detection.

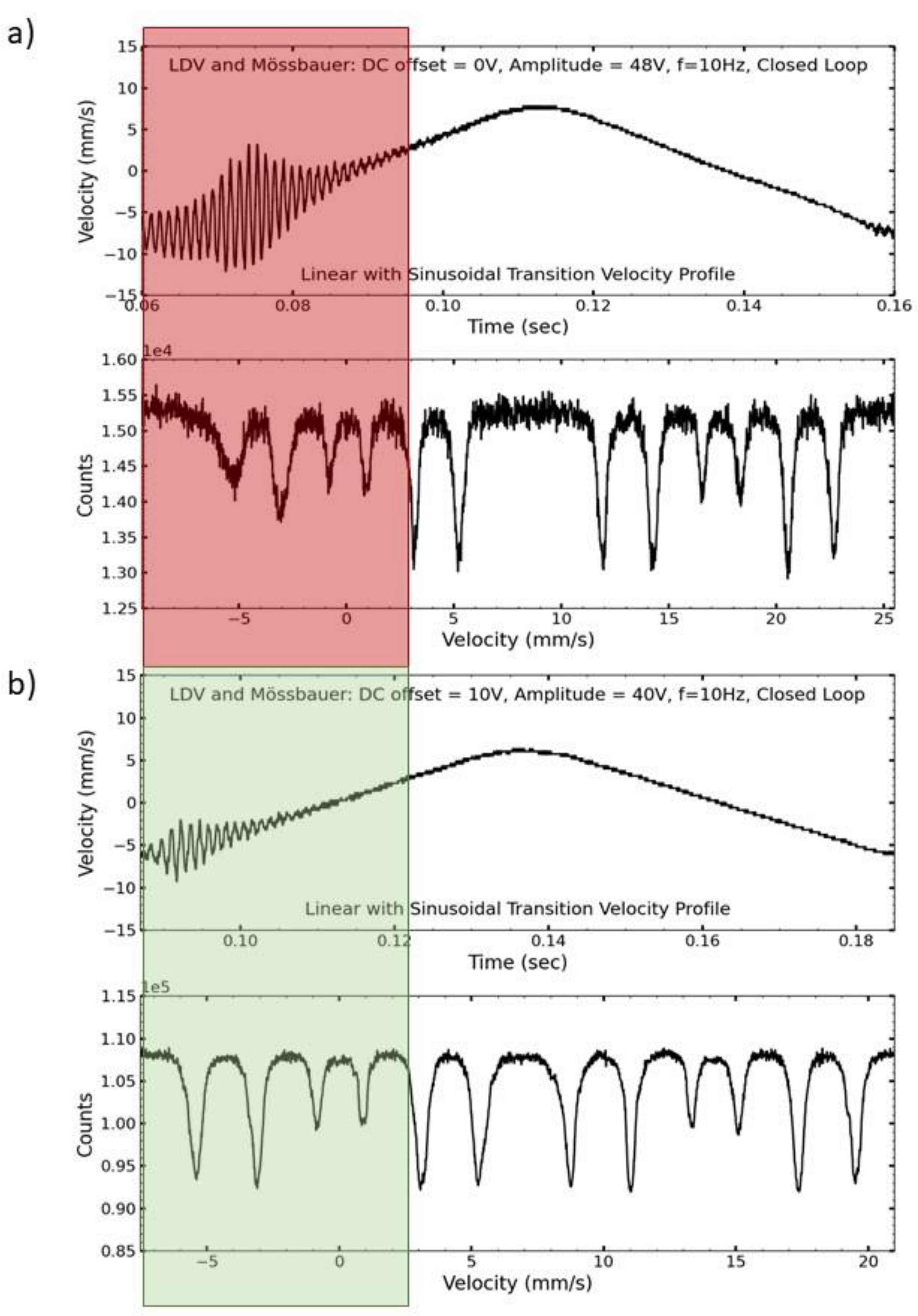

Figure 1. Laser Doppler Velocimeter (LDV) enabled identification of a) drive ringing that was distorting spectrum and a tool to b) optimizing performance.

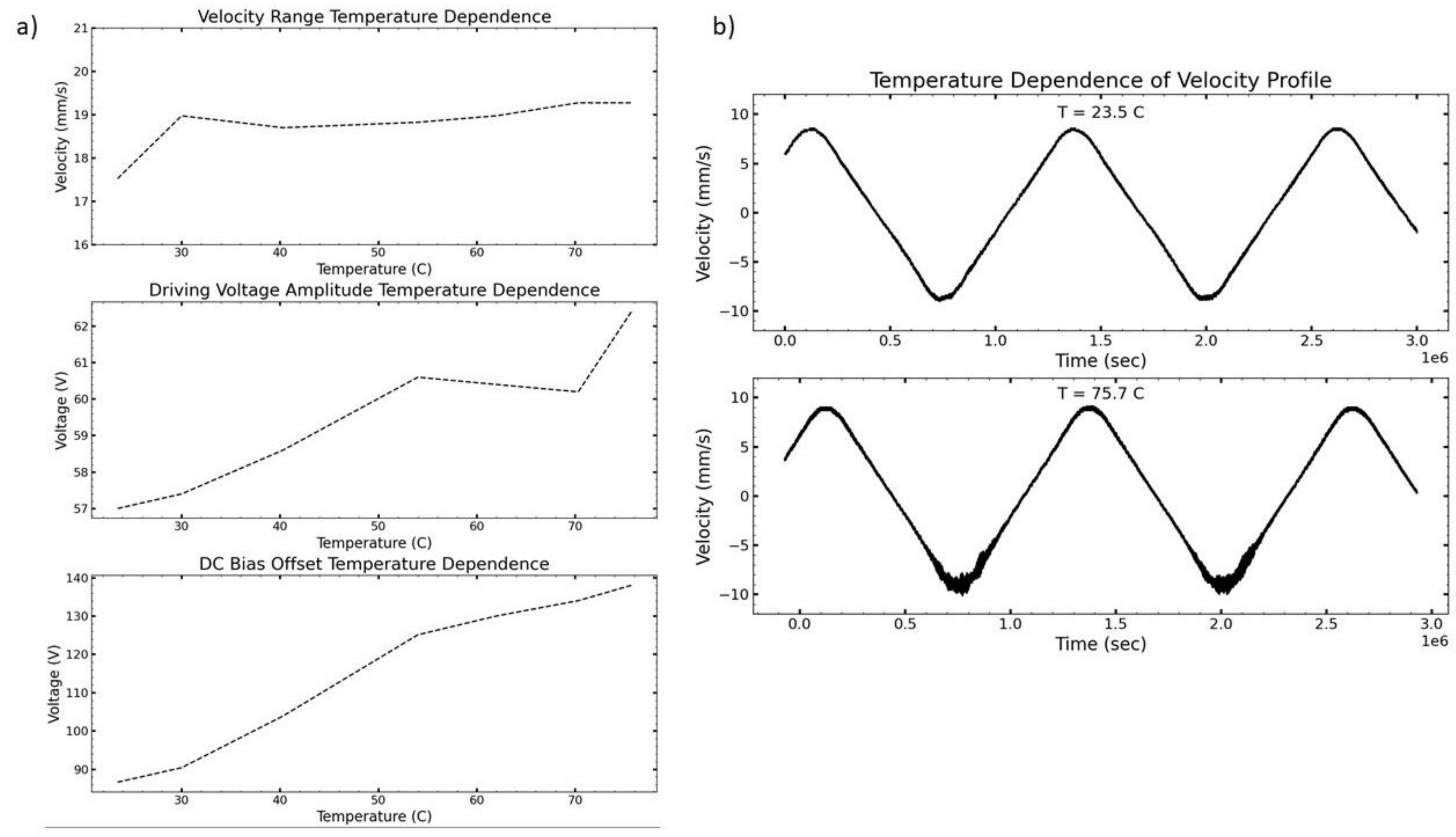

Figure 2. The piezoelectic Doppler drive was tested from 20 - 75 °C, and a) the feedback control compensated for these changes by adjusting driving and bias voltages, and b) the performance of the piezo drive as observed by LDV remained acceptable.

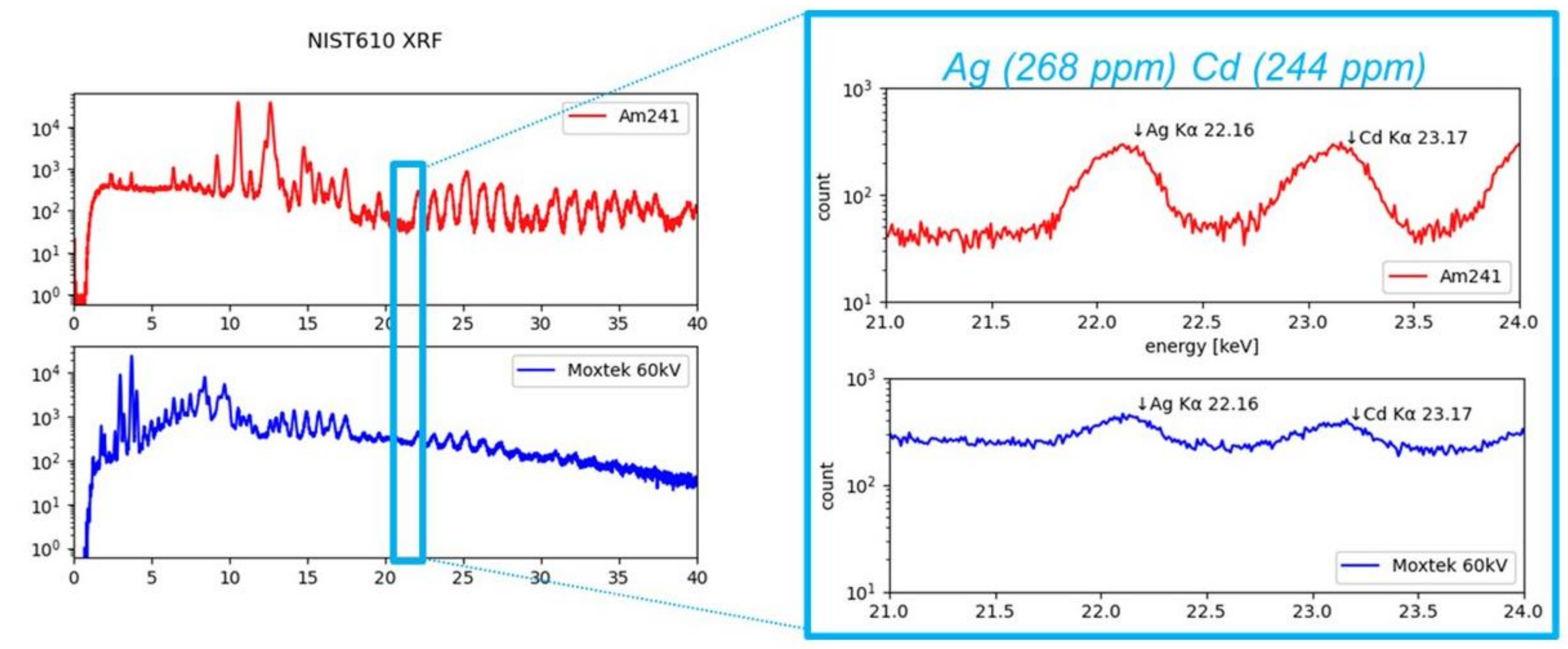

Figure 3. X-ray Fluorescence spectrometer functionality demonstrated the ability to detect elements at <100ppm levels.

Significance/Benefits to JPL and NASA:
Mössbauer and XRF spectrometries are routine techniques in geochemistry laboratories. Currently, NASA missions in need of either low size, mass, and power (SMAP) XRF or MS instruments must acquire individual instruments from foreign entities or build a custom instrument. As NASA makes way for smaller scale missions, readily available, low SMAP instruments to deliver routine science will become more valuableWhile the focus of this project is on the demonstration of a dual-mode instrument concept, the developments proposed here would allow for straight-forward design modifications to generate standalone instruments as well. The successful development of a small combination XRF/Mössbauer spectrometer built in-house at JPL would have many opportunities for infusion into flight.

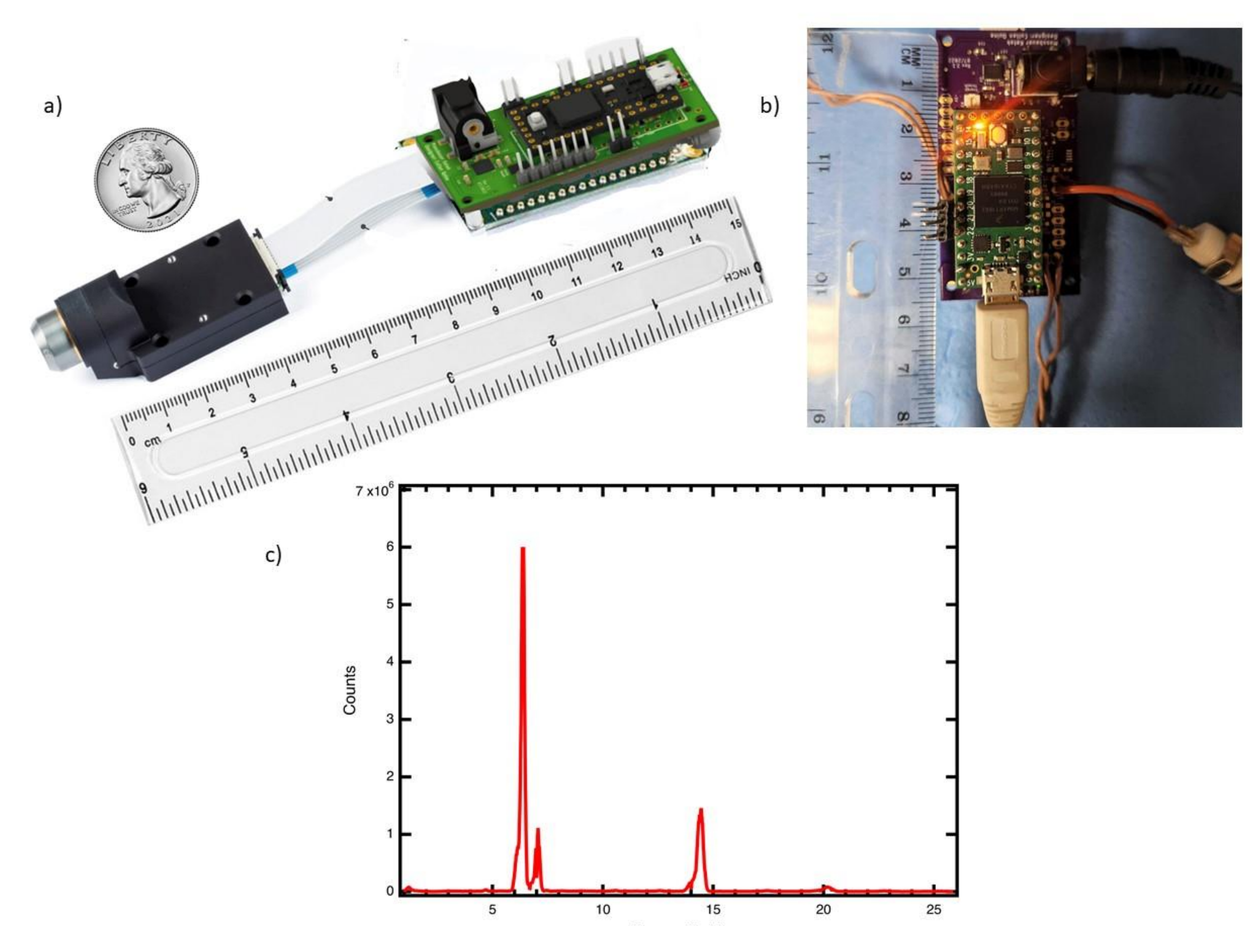

Figure 4. a) Custom electronics for Mössbauer and XRF spectroscopies are highly miniaturized, and b) when combined with COTS commercial electronics, fit inside an extremely small form factor, and c) enable quality spectra collection.

Publications:

P. Guzman, et al. *in prep.*

PI/Task Mgr. Contact Information:

Email: Valerie.J.Scott@jpl.nasa.gov

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Clearance Number: CL#
Poster Number: RPC#R21120