INSTRUMENT DESIGN AND FIRST DATA FROM THE 3D PRINTED CRUCIFORM TUNABLE HETERODYNE RAMAN SPECTROMETER. K. J. Nowicki[1,2] and A. H. Parker[1,2], [1]Southwest Research Institute, [2]Project ESPRESSO. (knowicki@boulder.swri.edu).

Introduction: Spatial heterodyne spectrometers are a family of compact, high-throughput instruments that have been used for spectroscopic measurements across the visible spectrum, and have lately been of keen interest for fluorescence and Raman spectroscopy and other laser-based spectral probing of materials for both in situ and remote measurements. Spatial heterodyne spectrometers convert a narrow passband of spectral information into 2D field of spatial frequencies by converting a single spatial point or line source into a fan of spatially-diverging spectrally-resolved collimated beams which are then recombined and mutually interfered using a two-arm interferometer and imaged onto a 2D focal plane array. The 1D (and in some implementations, 2D) Fourier transform of each line of the field of spatial frequencies is computed independently which produces the spectrum of the point source. The spectral lines can then be added together to increase SNR and eliminate cumulative phase offsets between lines.

One of the fundamental limitations of heterodyne spectrometers is that the spectral passband of the instrument is limited to the spatial frequencies resolvable on the 2D focal plane array. Typically, the instrument is optically aligned to set the illumination laser wavelength to coincide with the DC spatial frequency. The maximum resolvable spectral width is then set by the resolution of the spectrometer and the Nyquist spatial frequency of the focal plane array. The spectrometer is built and aligned with a single central wavelength and passband, and altering this spectral response requires at the very least a highly precise optical re-alignment and often a replacement of the dispersive element and spectral filters to match the new laser wavelength. As part of the Project for Exploration Science Pathfinder Research for Enhancing Solar System Observations (Project ESPRESSO) SSERVI node, we report the development of a heterodyne spectrometer that uses a low-precision 3D printed chassis that permits the user to retune the central wavelength (and thus the resolvable spectral passband) by hand with a single actuator that shifts the mapping of spatial frequencies to spectral components while retaining all optical alignment.

Tuning of the Spectral Passband:

The goal of this effort was to generate an inexpensive, adjustable heterodyne spectrometer for use in stand-off laser-activated spectroscopy of materials in airless bodies. Although the high precision opto-mechanical components holding the dispersive and other optical elements are currently off-the-shelf products from Thorlabs, the chassis that allows for tuning and optical alignment is 3D printed. The entire instrument contains 6 degrees of freedom, five of which are set in initial alignment and need never be adjusted again. The final degree of freedom is adjustable by hand and the center wavelength can be set by eye.

We will describe the instrument design and operation of the 3D printed cruciform tunable heterodyne Raman spectrometer. We will also present a wide Raman spectrum produced using the tuning function of the spectrometer.