EXPERIMENTAL TRADEOFFS OF MINIMALIZED LASER TOMOGRAPHY FOR LARGE AND SMALL PARTICLE SIZE PARAMETERS USING GRAVETAS. K. J. Nowicki[1,2], A. Soto[1,2] and A. H. Parker[1,2], [1]Southwest Research Institute, [2]Project ESPRESSO. (knowicki@boulder.swri.edu).

Introduction: The Grain Velocimeter and Tomography Analysis System (GraVeTAS) is a laser-based instrument under development and in use as part of the Project for Exploration Science Pathfinder Research for Enhancing Solar System Observations (Project ESPRESSO) SSERVI node. GraVeTAS combines an optically and computationally minimalized variant of the family of techniques that use scattered laser light to compute the shape and size of small suspended particles with standing wave laser velocimetry to directly measure the 3D velocity components of each particle trajectory. We have used implementations of GraVeTAS to measure natural dust grains lifted in terrestrial environments, calibrated particles in laboratory conditions, and most recently to pursue the measurement of the shapes and velocities of impact ejecta at speeds less than 100 m/s in a vacuum chamber environment. This latest implementation is being developed for use in microgravity flights (see accompanied submission, Soto et al.).

Instrument implementations using laser scattering particle sizing techniques are designed to target a prespecified range of particle size parameters, defined as the ratio between the particle diameter and the wavelength of light interacting with the particle. The limits of instrumental function are determined by the physics of the scattering regime, which is most commonly described by the Fresnel number F, where $F << 1$ defines the far-field regime where the assumptions of Fraunhofer diffraction hold, and $F > 1$, the near-field regime described by Fresnel diffraction approximation. These two approximations become more error prone as F approaches unity and diffraction calculations on either side of the transition must be handled with a different apparatus. Impacts with sufficient energy can generate ejecta plumes that contain a population of particles on either side of this regime change and in many cases can generate populations that straddle the transition. GraVeTAS was designed with the expectation that particle size parameters generated in our experiments would be distributed across the diffractive regimes.

Instrumental Tradeoffs: The different diffractive regimes described above present a challenge in constructing a single generalized instrument architecture. The two functions of velocimetry and particle tomography require different instrumental components, and we exploit these to resolve ambiguities and errors associated with the two measurements. For example, the particle sizing calculation is most accurate in the far-field, which is in direct conflict with the velocity component measurements which are more reliable at short distances with an unobscured path to a restricted measurement volume. Another example is that Fourier sampling schemes require precise knowledge of the sample with respect to the DC component, and we utilize the computed 3D location of the particle from the velocimetry architecture to address this.

We will derive and present the instrumental tradeoffs and errors inherent in the instrument architecture. We will also describe the synergistic solutions baked into the current GraVeTAS implementations that allow us to overcome weaknesses in progenitor and competitor instruments.