Flexing our MUSCLES: the HST Mega-MUSCLES Treasury Survey. C. S. Froning[1], K. France,[2] R. P. Loyd[2], A. Youngblood[2], A. Brown[2], J. S. Pindea[2], P. C. Schneider[3], and A. Roberge[4]. [1]McDonald Observatory, University of Texas at Austin, Austin, TX, cfroning@astro.as.utexas.edu; [2]University of Colorado at Boulder; Boulder, Co; 3Hamburgder Sternwarte, University of Hamburg, Germany; [4]Goddard Space Flight Center, Greenbelt, MD

Introduction: Understanding what happens to rocky planets and their atmospheres in the habitable zones (HZs) of low mass stars is currently one of the greatest astronomical challenges. The nearest Earth mass planets in the HZ orbit M dwarfs, and these are prime targets for spectroscopic biomarker searches in the next decade. The ultraviolet (UV) stellar spectrum drives atmospheric heating and chemistry on Earth-like planets. At present, we do not have sufficient observations and panchromatic stellar models to accurately predict the UV spectrum of a particular M dwarf. Without the stellar UV spectrum or the means to infer it, we will not be able to interpret observations of the atmospheres of potentially habitable planets in these systems.

MUSCLES: To address this shortfall, we initiated the MUSCLES (Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems) Treasury Survey with HST, Chandra, XMM, and ground-based observatories. With MUSCLES, we measured the spectrally and temporally resolved UV radiation fields of seven M and four K dwarf exoplanet host stars [1,2,3,4,5,6] and obtained new panchromatic observations of these nearby exoplanet hosts to provide a comprehensive picture of their energetic radiation environments. The 5 Å – 5.5μm broadband SEDs were compiled and provided to the astronomical community for observational and modeling inputs. The MUSCLES data products have become key inputs for studies of stellar and exoplanet evolution, habitability, and the production of biomarkers [7,8,9,10].

Looking Ahead: the Mega-MUSCLES Treasury Survey: Building on the success of the MUSCLES survey, we have initiated the Mega-MUSCLES program, an approved HST Cycle 25 large Treasury program. With Mega-MUSCLES, we will expand the sample of panchromatic stellar spectra to include: (a) new M dwarf exoplanet hosts with varying properties; (b) reference M dwarfs below 0.3 solar masses that may be used as proxies for M dwarf planet hosts discovered after HST's lifetime; and (c) more rapidly rotating stars to probe XUV evolution over gigayear timescales. We will gather the first panchromatic SEDs of rocky planet hosts GJ1132 and Trappist-1. The sample is particulary selected to provide the information necessary to interpret observations of rocky planets around M stars that are the likely focus of upcoming TESS and JWST observations. To do so, we must understand the high-energy SED of their host stars: X-ray/EUV irradiation can erode a planet's gaseous envelope and FUV/NUV-driven photochemistry shapes an atmosphere's molecular abundances, including potential biomarkers like O2, O3, and CH4.

In this presentation, we will give an overview of the results of the MUSCLES survey, including: a) determinations of the energetic radiation environment around M star exoplanet hosts; b) measurements of flare activity, energetics, and particle fluxes; c) calculations of habitable zone exoplanet irradiance and atmophotospheric dissociation rates; and d) results of modeling exoplanet atmospheres with these data to trace evolution and habitability effects and predict biomarker signatures. Finally, we will give initial results from the Mega-MUSCLES program and show how the upcoming survey will inform future observations of Earth-like exoplanets around low mass stars.

References:

[1] France et al. (2012) ApJL, 750, 32. [2] France et al. (2013) ApJ, 763, 149. [3] France et al. (2016) ApJ, 820, 89. [4] Youngblood et al. (2016), ApJ, 824, 101. [5] Youngblood et al. (2017), ApJ, accepted. [6] Loyd et al. (2016), ApJ, 824, 102. [7] Tian et al. (2014), E&PSL, 385, 22. [8] Miguel et al. (2015), MN, 446, 345. [9] Rugheimer et al. (2015), ApJ, 809, 57. [10] Fontenla et al. (2016), ApJ, 820, 89.