INVESTIGATION OF THE DART IMPACT EVENT FROM NASA'S LUCY SPACECRAFT. H.A. Weaver[1], J.R. Spencer[2], S. Marchi[2], S. Mottola[3], N. Dello Russo[1], O.S. Barnouin[1], H.F. Levison[2], K.S. Noll[4], T.S. Statler[5], J.M. Sunshine[6], A.F. Cheng[1], C.M. Ernst[1], E.G. Fahnestock[7], T.L. Farnham[5], A. Fitzsimmons[8], M.M. Knight[9], J-Y. Li[10], N.A. Moskovitz[11], C.B. Olkin[12], C.A. Thomas[13], the Lucy Science Team, and the DART Investigation Team. [1]JHU-APL, [2]SwRI, [3]DLR/Germany, [4]NASA-GSFC, [5]NASA HQ, [6]U Maryland, [7]Caltech-JPL, [8]Queen's U Belfast, [9]USNA, [10]PSI, [11]Lowell Obs., [12]Muon Space, [13]NAU.

Introduction: NASA's Lucy mission is the first to provide flyby reconnaissance of the Jovian trojan asteroids [1]. Since its successful launch on 2021-Oct-16, the Lucy spacecraft has been orbiting the sun within the inner solar system. The DART kinetic impact on the secondary body of the Didymos-Dimorphos binary system occurred 20 days prior to Lucy's first Earth Gravity Assist (EGA), when the Lucy spacecraft was well-placed to observe it.

Observations: Lucy carries a sensitive panchromatic camera, the Lucy LOng Range Reconnaissance Imager (L'LORRI [2]), which detected the binary system with good signal-to-noise ratio and with temporal cadences as fast as once per second. The observing geometry from Lucy was complementary to that from the Earth: the range to the Didymos system was 0.126 au from Lucy vs 0.0757 au from Earth, and the solar phase angle was 31.9 deg from Lucy vs 53.2 deg from Earth.

The L'LORRI investigation of the DART impact event was divided into eight separate observational phases, starting 12 h before the impact and ending 24 h afterwards. L'LORRI could not resolve the binary, but instead recorded the total brightness, which increased significantly after the DART impact due to reflected sunlight from the ejecta. The first two phases obtained baseline photometry of the Didymos system covering both the Didymos-Dimorphos mutual orbit period (11.92 h) and the rotational period of Didymos (2.26 h). Phase 3 covered the impact event itself at one second cadence, starting 3 minutes before impact and ending 4 minutes afterwards. L'LORRI observations during phases 4 through 8 were designed to monitor the temporal and spatial evolution of ejecta associated with the impact event. For maximum sensitivity, all L'LORRI images were taken using the camera's lower resolution CCD format (4×4 binning during readout; 4 arcsec/pixel).

Results: Lucy had a clear view of the predicted DART impact site, and L'LORRI was exposing an image at the exact time of impact, theoretically enabling L'LORRI to detect a thermally-generated optical flash from hot debris. No such flash was detected, and we place upper limits on its brightness and duration.

Contrary to our original expectation that the ejecta might not leave the central pixel within the 24 h of the Lucy post-impact observing period (i.e., the ejecta would be unresolved), L'LORRI clearly detected relatively fast-moving material outside the region near Didymos where the slower moving ejecta were concentrated (Fig. 1). Photometry showed that the initial brightness increase observed by L'LORRI was significantly smaller than seen by most Earth-based facilities (~4.2× increase at Lucy vs ~6.3× at Earth), which we use to constrain the scattering properties of the ejected material.

References: [1] Levison, H. F. et al. (2021) *PSJ.* [2] Olkin, C.A. et al. (2021) *PSJ.*

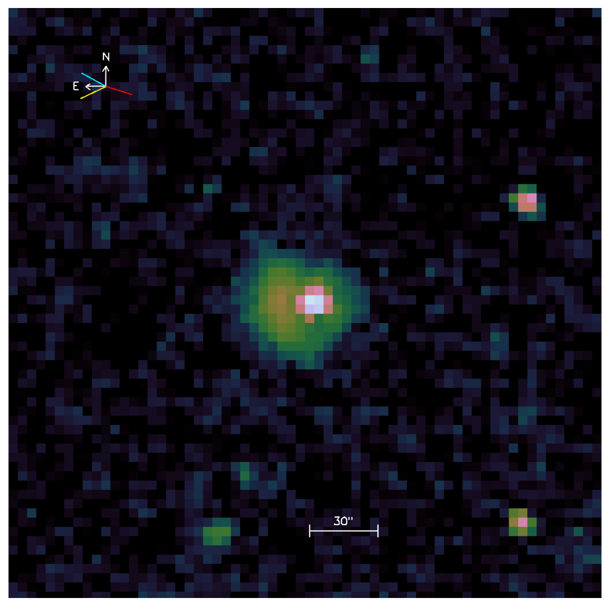

Fig. 1: Composite of five L'LORRI images of the Didymos system, each with t_{exp}=9.9 s, after subtraction of the pre-impact image of Didymos to reveal the ejecta morphology. The image is displayed using an ASINH intensity stretch and a cubehelix color scheme. The mid-exposure time was 14m 56.8s after the DART impact. The frame is centered on Didymos; each pixel subtends 373 km at Didymos. Slower moving dust is located near Didymos, but there is also a shell of early-released, fast-moving (up to ~1.8 km/s projected) ejecta that is more concentrated to the east. Projected directions to the Sun (yellow), Didymos' heliocentric velocity (cyan), and the DART spacecraft velocity (red) are shown; the compass shows celestial north (N) and east (E). Other objects in the field are stars.