Improving the Effective Resolution of the Deep Impact Imaging of Comet 9P/Tempel 1.
D. D. Wellnitz[1] and the EPOXI DIXI Science Team, [1]Department of Astronomy, University of Maryland, College Park MD 20742-2421 USA, wellnitz@astro.umd.edu.

Introduction: The Medium Resolution Instrument (MRI) and Impactor Targeting Sensor (ITS) visible camera systems of the Deep Impact (DI) Flyby and Impactor spacecraft were constructed to be nearly identical, the only significant difference being the inclusion of a 9-position filter wheel on the MRI visible camera [1]. Within about 400 pixels of the centers of their respective fields of view, the point spread functions (PSFs) of the unfiltered ITS and the clear-filtered MRI are essentially identical and also independent of location, with a full-width-half-max (FWHM) of about 1.5 pixels. As a result, all white-light images taken with these cameras are undersampled with respect to the PSF, so it should be possible to construct higher-resolution images of an unchanging scene if multiple dithered images are combined. [2]

A Useful Image Set: As the DI Impactor spacecraft approached the surface of comet 9P/Tempel 1 on 2005 July 4, the ITS camera captured a series of images of the surface from a nearly unchanging viewpoint over a sufficiently short time interval that the illumination of the surface did not change significantly. These images were dithered by the slightly changing orientation of the spacecraft due to its use of thrusters to maintain its orientation, but the images also slowly changed in pixel scale due to the inexorable approach of the comet to the spacecraft. As a result, to extract higher-resolution information from this data set we need to treat not only the dithering but also the slowly changing pixel scale: an extension of the standard dithering approach is needed.

To see how well this approach works, we can compare the results to images taken closer to the surface, which as a result attain the higher surface resolution we are trying to extract, but only over a small fraction of the area covered by earlier approach images, due to the decreasing fraction of the surface within the field of view of the camera. Once this approach to extracting higher effective resolution has been verified, we may then know how much to trust the enhanced resolution images in areas in which we did not directly obtain higher-resolution imaging.

Other Useful Image Sets: During the flyby of comet 9P/Tempel 1, the MRI visible camera of the Flyby spacecraft took multiple images of the surface of the comet sufficiently rapidly that the only significant change between images was the slowly changing pixel scale plus a small pseudo-random dither introduced by the attitude determination and control system. Once the processing algorithm has been validated using the ITS data, it should be possible to process the MRI images in the same way, once again creating a higher-resolution image of the surface by combining several images of a nearly unchanging scene.

Also, during EPOXI's Deep Impact eXtended Investigation (DIXI) flyby of comet 109P/Hartley 2, centered on 2010 November 4, there are some sequences of MRI images to which we may be able to apply this technique to gain higher effective resolution, particularly on approach and lookback.

Further Development: Increased effective resolution images can be extremely useful to understanding what is actually being seen on a surface. Although it is clear that a factor of 2 or 3 in resolution often opens our eyes to new realms of understanding, there may be times when a smaller amount of improvement in effective resolution may permit us to better characterize a surface and extract more useful information, provided that we understand what we should and should not trust in the enhanced image. This work provides not only enhanced resolution, but also a check on the reliability of the enhancement technique. Once we have images with higher effective resolution, it will be interesting to see whether we can extract any additional science from the images.

Acknowledgements: This work was funded by NASA through the Discovery and New Frontiers Program Office. The work reported here was started during the Deep Impact mission and further inspired by the image analyses done for the EPOXI mission, especially the additional calibrations and additional instrument characterization and experience gained during the Deep Impact eXtended Investigation (DIXI).

References: [1] Hampton D. L. et al. (2005) *Space Science Reviews*, *117*, 43-93. [2] Fruchter A. and Sosey M. et al. (2009) "The MultiDrizzle Handbook", version 3.0, (Baltimore, STScI).