The Johns Hopkins University Applied Physics Laboratory's Planetary Impact Laboratory. O.S. Barnouin[1], C.M. Ernst[1], A.M. Stickle[1], A. Lennon[1], and K.T. Ramesh[2] . [1]The Johns Hopkins University Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD, USA; [2]Hopkins Extreme Materials Institute (HEMI), Johns Hopkins University, Baltimore, MD, USA.

Introduction: The Johns Hopkins University Applied Physics Laboratory (JHU/APL), the Hopkins Extreme Material Institute (JHU/HEMI) and the NASA Mars Fundamental Researcher Program have all supported the development of the Planetary Impact Laboratory (PIL) at the Johns Hopkins University Applied Physics Laboratory. This fairly new and unique laboratory allows to investigate the cratering and ejecta emplacement process in a laboratory setting. Its main users have been students completing PhD projects in the JHU Earth and Planetary Science Department, several scientists involved with the Asteroid Impact and Deflection Assessment (AIDA) mission, and members of the media who have been interested in planetary defense. The facility has also been extensively used to demonstrate aspects of the impact cratering process to students and teachers at several JHUAPL annual teacher and student summer workshops. The PIL is composed of two main facilities: an ejecta simulator and a low speed (<0.8km/s) vertical gun range capable of firing at multiple angles.

The PIL's ejecta simulator is the only facility of its kind in the world to study the emplacement of ejecta generated by impact. The PIL's vertical gun resembles a facility that exits at the Univ. of Tokyo, and is comparable to, but not identical to several impact facilities that exist in the United States.

Vertical Gun Range: This facility (Figure 1) permits investigating impact cratering resulting from the collision of projectiles with targets launched at 80 to 800 m/s using a high powered air gun. Small projectiles can be launched ranging from a few mm to 1 cm in diameter. The design of the gun is such that a very rapid and uniform pressure rise is generated by the launch mechanism to maximize the velocity achievable. The facility makes use of a sabots to launch projectiles that do not allow gas flow to follow the projectile. Gas flow has frequently been an issue with both air guns and single- and multiple-stage light gas guns used for planetary investigations.

The test chamber is fairly large, with a base circumference of 1m and a height of about ~1.5m. Several view ports allow the researcher to view experiments with high-speed cameras and to install diagnostic tools and lighting. Each port ranges in diameter from 20 to 50 cms in diameter and is covered by 1-inch-thick Plexiglas. The chamber can be placed under various planetary (e.g., Mars, Earth) and vacuum conditions (<10 Pa; highly dependent on the target materials employed). The chamber also possesses several ports that allow the barrel to be placed at multiple angles.

The diagnostics available include several high-speed cameras (Vision Research Phantom v12 - from JHU/HEMI - and Miro 4 from JHU/APL) permitting visualization of various cratering and fracturing processes (Figure 2) from 1000 to 1,000,000 frames per second. Laser sheets are available to accurately measure the displacement of a target surface during impact, and particle interferometry software is available for measuring the velocity and displacement of ejecta and disruption fragments from the high speed video. Pressure and strain gauges, as well as high-speed analog-to-digital converters can be used to measure pressure changes and stress within a target, or experienced by a container holding the target material

The PIL's vertical gun resembles a facility that exists at the Univ. of Tokyo, and is complementary but not identical to several facilities that exist in the United States (e.g., NASA AMES and JSC vertical gun range). Aside from fundamental science, one of its purposes is to provide scientists who are primarily located in the mid-Atlantic region an easily accessible and relatively inexpensive facility to test out experimental ideas as well as impact-related diagnostic tools before proposing them to NASA for use at other more distant and costly but also more capable NASA facilities.

Ejecta Simulator: This facility (Figure 3) permits investigating the physics of emplacement of large amounts of debris (4–100kg) such as those excavated during impact and explosion cratering, that cannot be typically investigated during small-scale laboratory experiments. Material is launched from a curved plate that measures 1.5x1.5m, using a series of massive springs, onto a 4x4m target. The debris can be launched in excess of 5m/s and can simulate ejecta excavated from a crater of about ~2–8 m in diameter. Such a large facility is typically needed as granular processes are highly volume dependent [1]. The facility allows investigating the emplacement process of planetary ejecta for various terrain types and internal rheologies [see 2, 3]. Pressure gauges, laser sheet, high-speed cameras, and particle velocity interferometry techniques (Figure 4) are shared between the Vertical Gun Range and this facility to investigate the ejecta emplacement process.

The PIL is open to any scientists or student with an interest in planetary cratering or the impact process in

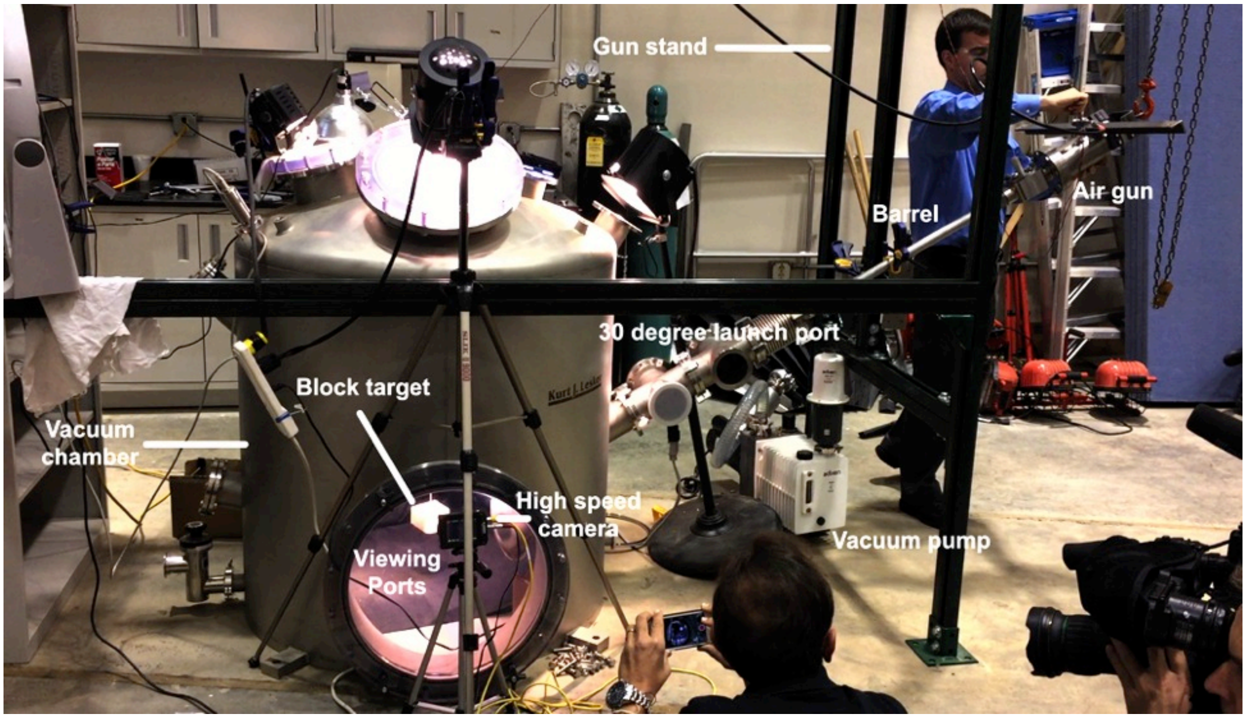

Figure 1: The JHUAPL PIL's Vertical Gun Range. Preparing to fire into a solid block.

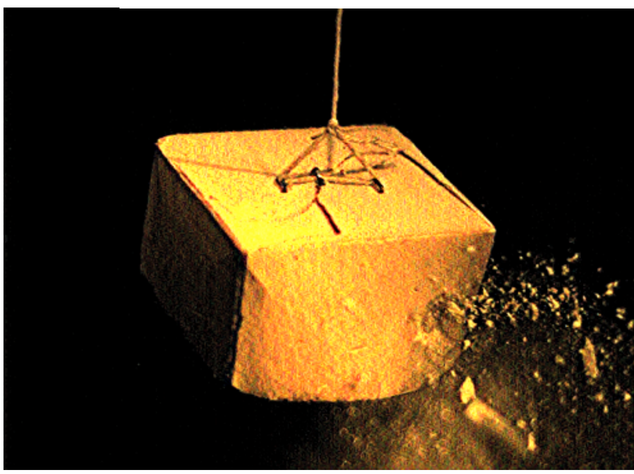

Figure 2: Cratering into a solid plaster block by ~2g projectile at 220m/s.

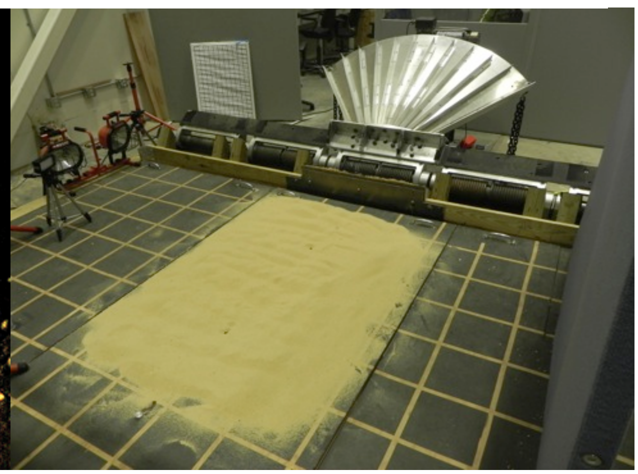

Figure 3: Ejecta simulator

general. Interested users should contact Dr. Barnouin, Dr. Ernst, Dr. Stickle or Dr. KT Ramesh with any reasonable projects, and for detailed explanation on the usage, operation and funding of the PIL. Simple initial tests can probably done with minimal to no fee. More elaborate efforts may need appropriate funding and the help from JHUAPL or JHU staff. Scientist are welcome to propose to NASA to use the PIL, with an approporiate JHUAPL budget.

References: [1] Iverson, R.M., 1997, Rev. of Geophys., 35, 3, p. 245-296. [2] Barnouin, O.S., et al., 2012, GSA Abstract vo. 44, no. 7, p. 482. [3] Runyon, K.D., Barnouin, O.S., 2013, LPSC Abstract #2163.

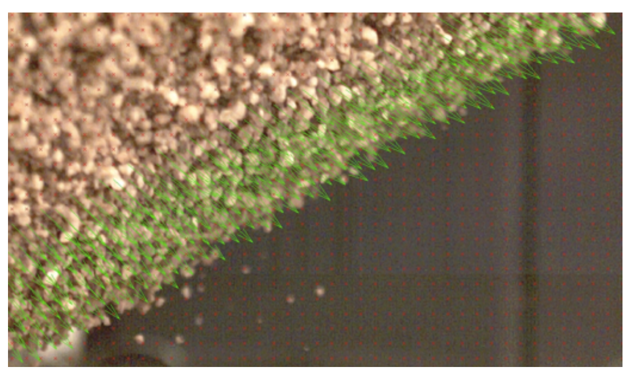

Figure 4: Ejecta speeds for a simulated ejecta curtain obtained using our particle-tracking algorithm. Longest vectors correspond to ~4m/s.