Berkeley Accelerator Space Effects (BASE) Light Ion Facility Upgrade

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The BASE Facility provides well-characterized beams of protons, heavy ions and other medium energy particles that simulate the space environment. Previously, all proton runs were completed in Cave 3 and all heavy ions in Cave 4B. For customers requiring both protons and heavy ions, this arrangement necessitated moving test equipment between the two locations. This major inconvenience has been mitigated by moving the entire Light Ion Facility to Cave 4A, immediately adjacent to the Heavy Ion Facility. At the same time, the maximum beam size was increased to 15 cm and both the hardware and software was upgraded.

Under standard operating conditions, using a position-sensitive ion chamber for online dosimetry, the BASE Light Ion Facility is capable of providing flux densities from $1\text{x}10^3$ to $1\text{x}10^{10}$ protons/cm^2-sec at beam diameters of up to 15 cm. Proton testing is normally performed in air. Standard proton energies include 13.5, 20, 30, 40, 50, and 55 MeV, though energies between these values are also available. All energy changes are accomplished by performing a 1-hour retune of the Cyclotron, enabling precise energy values to be obtained.

To tune the beam into the cave, protons created at our ion source are accelerated through the Cyclotron and sent down the beamline. The beam is then spread out evenly on the cave phosphor with focusing magnets and foils by the Control Room Operator. Beam efficiency from the beam stop at the exit of the Cyclotron to the Faraday cup in Cave 4A, with a fully-spread beam, is approximately 30%. The beam exits the vacuum envelope through an innovative new 15-cm diameter thin-film window [2], constructed of 5-mil Kapton. This new window, which allows for testing larger quantities or sizes of parts compared to our previous window, is a significant improvement for many of our customers desiring greater exposure area. An ion chamber continuously monitors beam flux density and uniformity with six concentric rings (with diameters of 1, 2, 4, 6, 8, and 10 cm) and four quadrants. Final processing and display is performed with recently upgraded LabView software, which consolidated previous versions and provides an intuitive interface for the customer. Additionally, we are currently designing a procedure to calibrate the ion chamber which will conform to the industry standards presently under discussion.

The customer can choose to control and monitor the beam by fluence and silicon dose (for chip testers), or by water dose (for biology experiments). Fluence or dose limits can be set that will stop the beam at the ion source upon reaching the desired level. New logging capabilities have been added to automatically record run data, which is stored on the computer desktop and easily retrievable by the user.

As a quality assurance measure to verify ion chamber performance, we recently developed software that analyzes the Gafchromic RTQA proton films taken at the beginning of each run. First, the films are scanned in to a desktop computer as a grayscale image, where each pixel is assigned an integer value between 0 and 255. Then, using our new "Filmalyzer" software developed by Cyclotron staff, the boundaries and shape (square or round) of the region of interest are selected by the experimenter. Based on the desired resolution, the image is automatically sorted into a calculated number of 400-pixel (20x20) blocks. Each block is then summed and divided by 400. This process creates manageable arrays of sufficient resolution, while reducing noise due to dust, film blemishes, and faulty pixels. Background points are selected to serve as a reference, and a "percent flatness" is determined. Maximum and minimum exposure points are displayed in both a three-dimensional graph and a profile plot, with typical flatness values of +/-5% for an 8 cm beam diameter (Table 1). This data is now printed and provided to the customer at the beginning of each run.

Additional testing was performed to determine the correct exposure point for the film. Film samples (2.5 cm diameter) were exposed to 50 MeV protons in 25 Rad increments, from 25 to 300 Rads, as measured by the ion chamber. The samples were then analyzed with the "Filmalyzer" software to determine the mean (film) pixel exposure. Results from this analysis indicate that doses of 75 to 100 Rads provide relatively linear exposure characteristics and are well-suited for verifying ion chamber performance. Future work will investigate differences in film exposure to varying proton energies.

Table 1. Percent Flatness Results

Date	Proton Energy (MeV)	%Flatness(+)	%Flatness(-)
3/13/06	50	2.62	4.24
5/22/06	50	4.25	4.97
6/9/06	50	3.08	2.62
6/19/06	50	2.76	1.88

REFERENCES

[1] M.B. Johnson, M.A. McMahan, T.L. Gimpel, W.S. Tiffany, Berkeley Accelerator Space Effects (BASE) Light Ion Facility Upgrade (Paper W-30), International Nuclear & Space Radiation Effects Conference (NSREC) 2006, Ponte Vedra Beach, FL, USA.

[2] J.L. Western, Mechanical Safety Subcommittee Guideline for Design of Thin Windows for Vacuum Vessels (FERMILAB-TM-1380), Fermi Ntnl. Accelerator Laboratory, Batavia, IL, USA.