UNIBEAM - BEAM PROFILER FOR BEAM CHARACTERIZATION AND POSITION FEEDBACK

D. E. Potkins†, M. P. Dehnel, D-Pace Inc., Nelson, BC, V1L 4B6, Canada
N. Lobanov, The Australia National University, Canberra, ACT 2601, Australia
T. Kubley, O. Toader, Michigan Ion Beam Laboratory, Ann Arbor, MI 48109, USA

Abstract

A beam profiler called UniBEaM is based on passing 200 micron cerium-doped optical fibers through a charged particle beam and measuring the scintillation light. In order to characterize UniBEaM over its entire kinetic energy range: keV to GeV; current range: pA to mA; and particle type range: light ions to heavy ions, and electrons, an Early Adopter Programme (EAP) was established to test UniBEaM’s performance. EAP’s: Australia National University (ANU) and Michigan Ion Beam Laboratory (MIBL) report on their use of UniBEaM at their facilities.

INTRODUCTION

A beam profiler based on doped SiO$_2$ optical fibers was designed and tested at the Albert Einstein Center for Fundamental Physics (AEC), Laboratory for High Energy Physics (LHEP), University of Bern, Switzerland [1]. This beam profiler, called the Universal Beam Monitor (UniBEaM™) was licensed and commercialized by D-Pace Inc., Canada. This paper provides example measurements made by two early adopters of this device: the Department of Nuclear Physics of the Australian National University (ANU), and the Michigan Ion Beam Laboratory (MIBL).

SYSTEM DESCRIPTION

D-Pace’s commercial version of UniBEaM was described in detail by Potkins et al. [2].

TESTING

Signal to Noise Assessment with 1MeV 16O$^{+1}$

ANU installed UniBEaM on the beam line of a high energy ion implanter. The implanter utilizes an NEC 1.7 MV tandem accelerator able to reach energies up to 10 MeV. The BPM provides the feedback required for the operator to produce a well-focused and aligned beam on the target, and to measure the beam response to beam steering devices.

ANU utilized UniBEaM to measure beam profiles at a 16O$^{+1}$, 1 MeV beam at low beam currents to investigate the noise floor of UniBEaM and compare the results with profiles acquired using an NEC BPM 80 helical wire scanner. UniBEaM plots separate profiles for the orthogonal X and Y scans. The X and Y profiles may be scanned and displayed individually, or in the same plot. The horizontal axis of the UniBEaM plots are in mm. Figure 3 shows a scan of a 16O$^{+1}$, 1 MeV, 80pA beam to evaluate the noise floor of UniBEaM for this beam.

Figure 1: UniBEaM Probe.

Figure 2: Internal view of UniBEaM showing the X & Y scintillating sensor fibers and fiber connector.
The NEC helical wire scanner uses a rotating wire helix to collect secondary electrons from the grounded scanning wire. It has a nominal beam pipe diameter 10 cm with a 2.54 cm molybdenum beam entrance aperture. It produces a single plot representing pseudo-orthogonal X & Y profiles in a single oscilloscope trace, along with a second trace to allow the user to calibrate the horizontal axis time units displayed on the scope into approximate distance units [Fig. 4].

Comparing the two scans shown in Fig. 3 and Fig. 4, the UniBEaM and helical wire scanners have similar signal-to-noise ratios for the 16O⁺ beam. Figures 5 and 6 show profiles for the same 16O⁺ 1 MeV beam when the beam current was increased to 2.6 nA.

In the nA current range, the UniBEaM exhibited better signal-to-noise and spatial resolution than the NEC BPM 80 (Fig. 8 & 9).

**Low Energy Beams**

ANU also utilized UniBEaM on low energy beams after the inflection magnet, before injection into their 14UD electrostatic pelletron accelerator. Negative beams of H, Ni, O, Al₂O₃ and S were tested.
**Figure 9:** NEC BMP 80 profiles. 32S for 150keV 300nA beam.

**Raster Scanning Feedback**

The Michigan Ion Beam Laboratory (MIBL) used UniBEaM to profile ion implanter (Ar, Ag, Fe and Ni) beams. Figure 10 shows a UniBEaM scan where 107Ag and 109Ag are resolved in the beam profile.

**Figure 10:** 107Ag and 109Ag, 370keV 3uA. Resolved peaks in Y profile scan of beam.

Figures 11, 12 and 13 show UniBEaM profiles taken for focussed, rastered, and defocussed Argon beams, where UniBEaM was used as a tool to assess beam uniformity for ion implanting.

**Figure 11:** Ar 370keV 3uA, Y profile of focussed beam.

**Figure 12:** Ar 370keV 3uA, Y profile of rastered beam with 6mm x 6mm aperture.

**Figure 13:** Ar 370keV 3uA, X & Y profiles of rastered beam with no aperture.

**FURTHER DEVELOPMENTS**

Further investigation will be required to determine if the properties of the sensor fibers change as a result of ion implantation into the sensor fibers themselves, thereby changing their optical or emission properties. D-Pace will investigate the utility of an optional collimator to limit the exposure of the sensor fibers where beam characteristics allow particles to reach the optical fiber in its parked position. D-Pace is developing a version of UniBEaM for pulsed beams, where sensor fiber movements and measurements are synchronized with the beam pulses, for pulse rates up to 1000 pulses per minute. D-Pace is working on a high sensitivity version of UniBEaM where a photon counting approach is used to further improve signal-to-noise for low current beams. The University of Bern utilizes photon counting methods.

**CONCLUSION**

UniBEaM is an alternative to conventional wire scanners, and offers the particle accelerator industry a compact and cost effective means of measuring charged particle, electron and x-ray beam intensity profiles over a large range of currents and beam energies.

**ACKNOWLEDGMENTS**

On behalf of D-Pace, the author gratefully acknowledges the financial contributions of the following Canadian government programmes: SRED and NRC. In addition, the author wishes to express his appreciation to the AEC-LHEP, University of Bern for their ongoing support with the commercialization of UniBEaM, and to the Department of Materials Science, University of Milano-Bicocca for their expertise in scintillating optical fibers. D-Pace also thanks Buckley Systems (Auckland, NZ) for their financial support of this project.

**REFERENCES**
