COMMERCIALLY AVAILABLE TRANSVERSE PROFILE MONITORS, THE IBIS

M. Ruelas*, R. Agustsson, I. Bacchus, A. Murokh, R. Tikhoplav, RadiaBeam Technologies, LLC, Santa Monica, CA 90404, U.S.A.

Abstract

With ever decreasing budgets, shorter delivery schedules and increased performance requirements for pending and future facilities, the need for cost effective yet high quality profile monitors is paramount to future advancement in the accelerator field. While individual facilities are capable of designing and fabricating these often custom devices, this is not always the most efficient or economical route. In response to the lack of commercially available profile monitors, RadiaBeam Technologies has been developing its line of Integrated Beam Imaging System (IBIS) over the past several years. Here, we report on these commercially available profile monitors.

INTRODUCTION

Measurement of the transverse profile of electron beams is of paramount importance in daily operation of all beamlines. Used to image the beam, transverse profile monitors, commonly referred to as flags, screens and other names, make use of various scintillating materials or other conversion mechanisms to allow centroid monitoring, emittance measurement and alignment. While nearly as ubiquitous as magnetic optics, profile monitors are usually produced by the end user and have not been available from commercial sources as are magnets and resonant structures. In response to this, RadiaBeam Technologies reports recent progress in its line of custom beam profile monitors, available to the accelerator community, the Integrated Beam Imaging System.

RadiaBeam Technologies' Integrated Beam Imaging System began as a single position diagnostic screen and accompanying optics optimized for high-brightness electron beams. With input from collaborators and customers, it has now grown into a line of custom-designed devices with multiple positions, long optical transports, larger apertures and improved vacuum performance. Throughout the development if the IBIS line, careful attention has been given to modularity, allowing cost and design to be minimized through the reuse of proven designs.

RECENT PROGRESS

Since 2004, RadiaBeam Technologies has delivered profile monitors to customers worldwide. However, it has become increasingly apparent that no one design can fulfill the needs of all users. With varying beam properties and user needs, the requirements of the profile monitor design and its accompanying optical transport and camera vary greatly. The additional requirement of facility needs, such as camera interface (analog, 1394a/b, GigE, etc), actuator type (pneumatic, stepper driven, etc.) and vacuum level can rapidly increase the complexity and cost of the profile monitor.

While RadiaBeam can supply just the diagnostic plunger, delivery of flange-to-flange systems, which are ready for installation directly into a beampipe with the end user responsible solely for the control system, greatly simplifies integration of the device. Here, the diagnostic plunger, actuator, vacuum chamber, transport and imaging optics, alignment mechanisms, and support structure are delivered as a single package. This not only minimizes the need for the end-user to design and fabricate parts, but also capitalizes on RadiaBeam Technologies' experience.

The IBIS is available with viewable apertures ranging from 18mm to 40mm. The diagnostic plunger itself is designed to allow easy swapping of diagnostic screens without changing the focus position of the optics. Scintillating screen options include YAG:Ce, LYSO:Ce and Phosphor coatings. For OTR production, options include aluminized Silicon wafers, stretched foils with thicknesses down to 1 micron and polished metal discs. Additionally, pepperpot screens for emittance

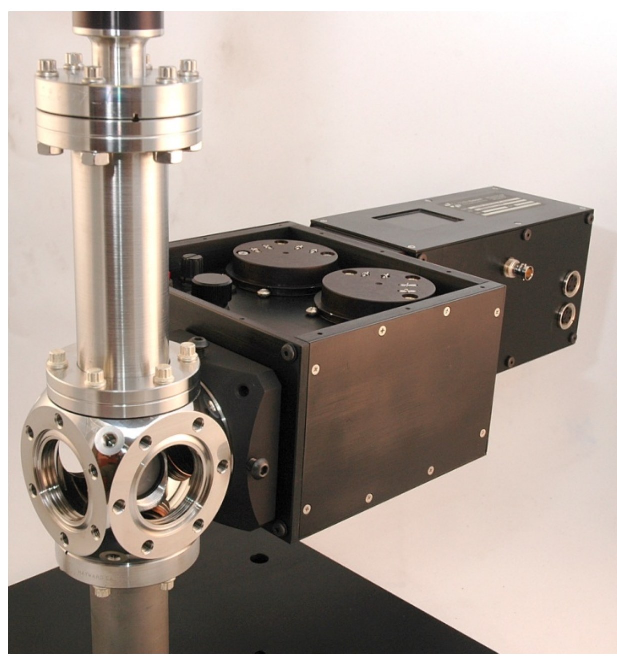

Figure 1: A simple flange-mounted optical transport is shown for an 18 mm aperture, with remotely controlled 3-motor zoom lens, alignment periscope and local viewing screen. Upgrades include local viewing, integrated light ring and virtual target system (not shown).

*ruelas@radiabeam.com

measurement and energy slits can also be installed into the plunger. In some cases, both the pepperpot and imaging screen can be installed into a single unit, allowing highly repeatable measurements with reduced impact on the facility infrastructure since only one vacuum port is used.

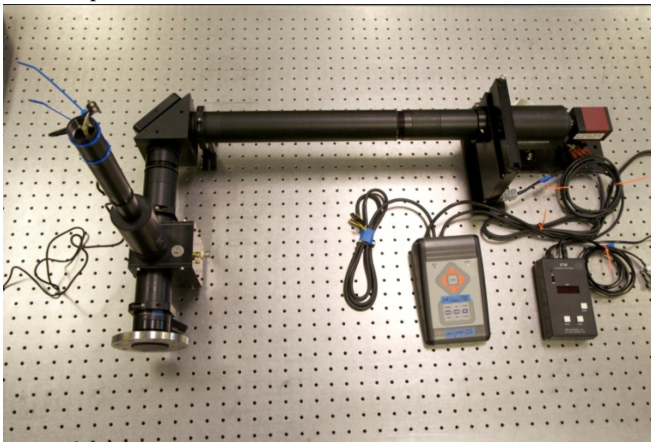

Figure 2: A meter long, achromatic, light tight transport with flappable virtual target remotely-controlled filter wheel, 3-motor zoom lens and megapixel GigE camera.

Each flange-to-flange system also includes collecting optics. The optical systems range in complexity from simple on-flange optics with a non-unity relay for magnification and a periscope for alignment, housed in a light-tight box, such as shown in Figure 1. More recently, meter-long achromatic transports are regularly requested and delivered. For high-radiation environments, the long transport allows the camera to be placed below the radiation plane in a shielded location, prolonging the life of the often-expensive CCD camera. For these long transports, shown in Figure 2, virtual targets and remotely controlled filter wheels are integrated easily into the system. A 3-motor zoom lens with position readback allows for selectable magnification (and the resulting resolution enhancement). Alternatively, a megapixel camera and matching optics can allow for system resolution approaching 10 microns even with large fields of view. The modular construction allows for easy integration of the optics into the destination facility, with near infinite configuration of each transport possible.

Of note is fiducialization of the optical system and in-vacuum diagnostic plunger. It is often of interest to measure not only the beam parameters with respect to some fixed point, but also to have confirmation of the system resolution. Various methods are used to realize these requirements using targets of chrome on glass or other methods. The most direct and preferred method is to install an in-vacuum target at an optical position coincident to that of the screen, allowing a full characterization of the beam. However, this is often precluded by the cost of an additional stop on the actuator.

An alternative method is the use of a virtual target system, where the target is imaged via a flappable mirror or a >90% transmission beamsplitter. In the case of the beamsplitter method, the virtual target is only viewable when the integral illumination is remotely switched on. This virtual target method allows near-identical representation of the primary imaging path as with an in-vacuum target at a reduced cost and with improved vacuum characteristics, but requires precise calibration of the virtual and real optical path lengths. Other fiducial methods are available, such as direct imprint of fiducials on the screen or a mask viewable along the periphery of the field of view. However, these do not allow for on-line confirmation of resolution. At present, for cost and ease of integration, a virtual target viewed through a fixed beamsplitter is preferred.

The final important design option is actuation of the device. Stepper driven actuators can be used with either rotary or linear encoders. These are beneficial in that they allow increased numbers of diagnostic positions, but require significant infrastructure upgrades for control and feedback. In contrast, a pneumatic actuator allows for simple integration, with simple control (DC control) and readback (magnetic reed switches or micro switches) with repeatability in the 10s of microns. For very simple one or two position diagnostics, they can be very inexpensive. In cases where there is concern over rotational and positional repeatability, such as with pinhole screens, upgraded, guided actuators are available, with sub-micron adjustability of up to four positions with readback to 25 microns.

Other available options include light sources for viewing the in-vacuum plunger, side-mounted actuators and remotely controlled filter wheels, stocked with any mixture of color filters, polarizers and neutral density filters. Another major improvement has been the introduction of impedance-shielding cages, which are inserted into the beamline during normal beam operation. These cages minimize wakefield effects from the change in impedance seen by the beam as it travels from a beam tube to the open volume of the chamber. They also allow for failsafe operation, where a loss of compressed air pushes allows atmospheric pressure to push the impedance shield into the beamline, allowing normal beam operation to continue.

COST EFFECTIVENESS

Based off experience, the price of flange-to-flange systems, complete with optical transport, scales approximately with the viewable area. The addition of options, especially those that require extensive testing, such as actuators with increased repeatability or plungers with impedance cages, can increase price significantly. However, RadiaBeam is developing its expertise and often passes only a fraction of its development costs to the end-user, ultimately self-funding the development of the IBIS.

OUTLOOK

The development of the IBIS is continuing and there remain continuing issues to resolve. Problems with vendor items, material availability and production time are all issues that continually plague IBIS development. It has been our experience that vendors require extensive oversight to ensure timely delivery, full specification fulfillment and proper quality. However, the largest concern is locating vendors who are willing to submit to quality assurance flow-down and to deliver customized products on a timely basis. However, as RadiaBeam continues its development of its IBIS, each delivery becomes smoother and the best path is more defined. For instance, design re-use greatly decreases engineering and fabrication time, allowing for delivery times which are now often limited by the availability of vendor-procured items.

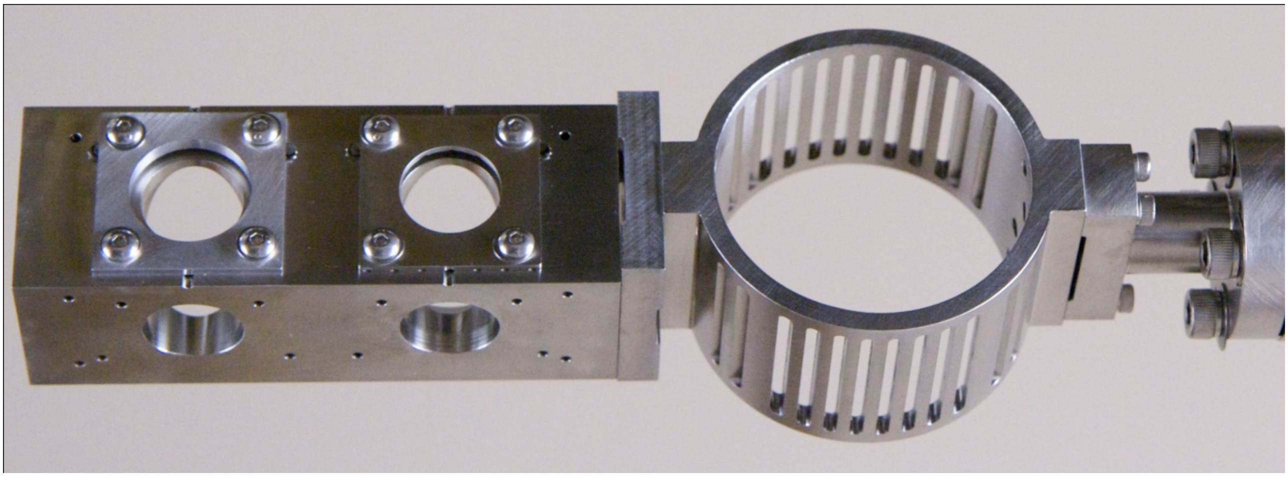

Figure 3: A custom 15mm viewable aperture plunger, part of a flange-to-flange system, with impedance cage for a 2" beampipe. Also shown are switchable mounts for a YAG screen and aluminized silicon wafer and 1 and 25 micron stretched foils for OTR production.

Additionally, navigating the often-conflicting requirements of different facilities remains an issue. Of particular concern is vacuum preparation of devices, for it has been found that one facility may expressly prohibit what another recommends. This requires an increase in infrastructure that is ongoing to accommodate various requirements.

Currently, RadiaBeam Technologies is working with several laboratories in developing their profile monitor needs. Based off earlier work, these projects are able to proceed with tighter delivery schedules, with decreased cost and increased complexity. RadiaBeam looks forward to the continued development of its IBIS and to providing the accelerator community with reliable and quality devices at a fraction of the cost and time required for in-house design time.