ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPME192

ASSEMBLY AND INSTALLATION OF BEAM INSTRUMENTATION FOR THE ASTA FRONT-END DIAGNOSTIC TABLE*

D. J. Crawford#, R. Andrews, B. Fellenz, D. Franck, T. Hamerla, J. Ruan, D. Snee,

Fermilab, Batavia, IL 60510, USA

Abstract

Early stages of commissioning the Advanced Superconducting Test Accelerator (ASTA) at Fermilab have begun. The front-end consists of a 1.5 cell normal conducting RF gun resonating at 1.3 GHz with a gradient of up to 40 MV/m, cathode for photoelectron production, laser light delivery system, and a Diagnostic table upon which instrumentation is mounted for measuring the characteristics of the photoelectron beam. We report on the design, construction, and early experience with the Diagnostic table.

INTRODUCTION

The ASTA front-end generates high brightness electron bunches by means of a 263 nm UV laser that illuminates a cesium telluride (Cs_2Te) photocathode on the upstream wall of the 1.5 cell copper RF Gun operating at 1.3 GHz [1]. A Diagnostic table is immediately downstream of the RF Gun. Figure 1 shows the layout of the ASTA front-end. The table contains 2 beam crosses (a 9-way cross and a 6-way cross), 2 cameras with associated lens tube hardware, 2 sets of horizontal and vertical beam position monitors (BPM), and a Wall Current Monitor (WCM).

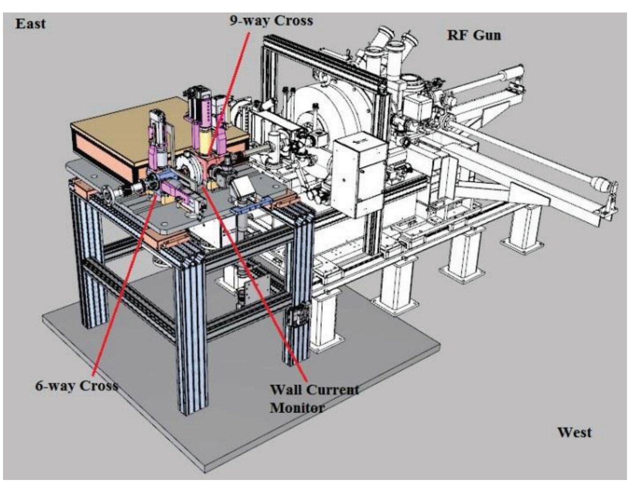

Figure 1: 3D model of the ASTA front-end. The Diagnostic table is shown with color.

The 9-way Cross provides many functions. The upstream east window has a specially coated fused-silica window to allow the 263 nm UV laser to enter the vacuum system and reflect off a polished aluminum mirror, directing it to the photocathode inside the RF Gun. The coating on the window allows for a transmission of 96.29% of the laser. A mirror can be inserted via an actuator to direct scattered UV to a CCD camera attached to the upstream west side coated fused-silica window [2]. This allows for visible images of the photocathode surface. A double actuator is mounted on the downstream end of the cross and moves a dual position holder contained within the edge-welded bellows. The first position inserted into the cross is the target, a piece of fused-silica glass 19 mm in diameter with concentric circles 1 mm apart. An LED inside the lens tube, affixed to the downstream west side of the cross, illuminates the target and allows the focus to be set on the networked camera connected to the lens tube. The next position in the holder is the 25.4 mm diameter cerium doped YAG crystal. Since the target and the crystal are in the same plane, the camera does not require any re-adjustment. Photoelectrons deposit their energy into the crystal, causing it to scintillate. The light is reflected to the CCD

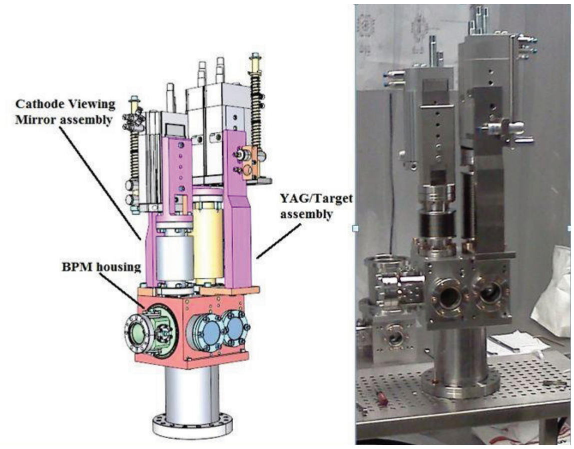

Figure 2: 3D CAD model of 9-way Cross and assembly in cleanroom.

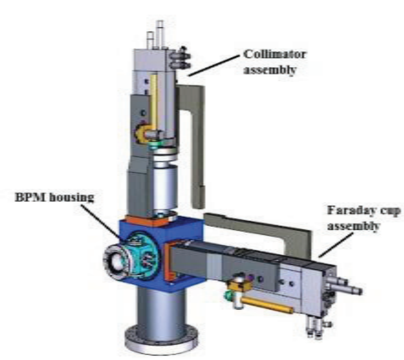

Figure 3: 3D model of 6-way Cross.

* Operated by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the United States Department of Energy.
# dcrawford@fnal.gov

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPME192

camera where the spot size is measured and transverse dimensions of the electron beam are calculated. A 3D CAD representation of the 9-way Cross is shown in Fig. 2.

The 6-way Cross contains one vertically mounted actuator and one horizontally mounted actuator. The vertical actuator inserts an electron beam collimator, a piece of copper with a 10 mm diameter hole through it. This will be used to collimate the electron beam if the dark current is too large and inducing quenches of the downstream superconducting cavities. The horizontal actuator is used for inserting a Faraday cup into the beam path. Only one device can be inserted at a time since the collimator and Faraday cup operate at the same z-position. Collision bars are affixed to the actuators in the event that an "in" command is issued to both. Figure 3 illustrates the layout of the 6-way Cross.

Each cross has a housing for horizontal and vertical button BPMs. The BPMs are located on the upstream side of the 9-way Cross and on the downstream side of the 6-way Cross.

A WCM, located between the 9-way and 6-way crosses, is used for determining the longitudinal profile of the photoelectrons. A ceramic gap allows the electron beam's image charge to be measured by the WCM. The signal is seen on a fast sampling scope in a relay rack outside of the ASTA beamline enclosure.

CONSTRUCTION AND ASSEMBLY

Because ASTA uses Superconducting RF cavities for electron beam acceleration downstream of the front-end, all components connected to the ultra-high vacuum (UHV) system are required to be cleaned, assembled, and installed in cleanrooms using particle free techniques. Once each cross assembly is completed, 2.75" blank conflat (CF) flanges are installed on the upstream and downstream beam tubes. The assemblies are then vacuum leak checked with helium to a sensitivity of 10^{-14} Amps.

All machined materials common to the UHV system are made from 316L stainless steel. This material has a low magnetic permeability and retains its hardness after repeated bakeouts.

9-way Cross

The heavily machined cross contains several blind threaded holes. Fastener hardware for the cross is all metric and made of titanium type 2 rolled threads or silicon-bronze. The vacuum port flange is a 6" CF and the BPM flanges are 1.33" mini-CF. All other flanges are 2.75" CF. The BPM housing is located on the upstream side of the cross.

Target and YAG Assembly

The target and YAG assembly consists of a 19 mm diameter x 1.5 mm thick fused-silica glass reticle with concentric circles 1 mm apart and a line thickness of 25 µm wide, a 20 mm diameter mirror, a 25.4 mm diameter cerium doped YAG crystal 100 microns thick, a 25 mm diameter mirror, a device holder, an actuator-flange connected to the pneumatic actuators, a 100 mm travel edge-welded bellows, a networked CCD camera with attached lens tube hardware, and a 2.75" fused-silica window. Layout of the target and YAG assembly is seen in Fig. 4.

A bracket holds the mirrors in place and collars secure the target and YAG to the device holder. The fastening hardware is titanium button head screws. The holder connects to the actuator-flange with 3 vented titanium screws.

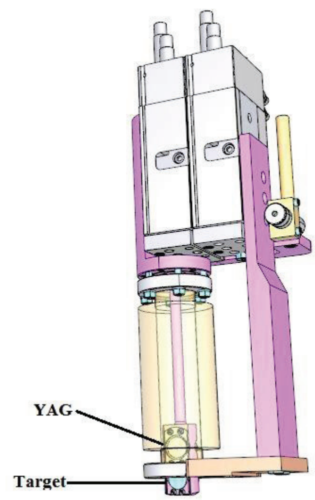

Figure 4: 3D CAD model of target and YAG assembly.

The target and YAG assembly is vertically mounted to the downstream end of the 9-way Cross with six titanium studs and silicon-bronze nuts. A 2.75" fused-silica window is connected to the downstream west side of the cross. A 1/8" thick O-ring is placed over the window flange to provide a light tight seal to the optics tube arm. A 5 megapixel GigE Vision interfaced camera is connected to the end of the optics arm.

6-way Cross

Just like the 9-way Cross, the 6-way Cross contains identical vacuum port flanging. The BPM housing is located on the downstream end of the cross. The horizontal actuator assembly contains the Faraday cup and is fastened to the cross with silicon-bronze socket head cap screws.

Faraday Cup Assembly

The Faraday cup is constructed from oxygen-free high thermal conductivity (OFHC) copper with dimensions of 1"W x 1.75"H x 0.5"T. In order to isolate the Faraday cup from ground, two ceramic stand-offs are connected between the holder and the cup. The Faraday cup signal is directed out of the UHV system by means of a 0.051" diameter stainless steel wire. The wire is secured to the copper with a 316 stainless steel socket head cap screw and the other end is secured to the actuator-flange feed-

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPME192

through via a copper-beryllium barrel connector. Figure 5 shows the Faraday cup during assembly in the cleanroom.

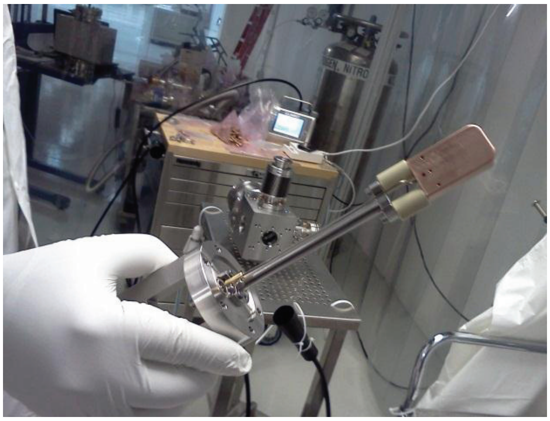

Figure 5: Faraday cup assembly prior to attachment of the edge-welded bellows.

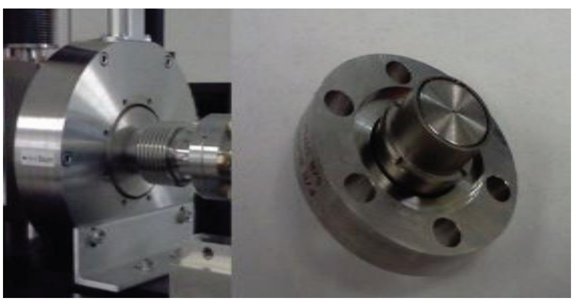

Figure 6: Wall Current Monitor (left) installed on Diagnostic Table and button BPM (right) prior to installation.

Wall Current Monitor

The WCM housing is low impedance and frequency tight in order to shield the output signal from ground currents. At the heart of the WCM is a ceramic break made from alumina (Al_2O_3) and Kovar®. The ceramic is sandwiched between two Kovar® sleeves and brazed together. A circuit board is attached across the Kovar® and the output is directed to a coaxial RF connector. A high permeability ferrite ring surrounds the ceramic break and forces the electron beam's image charge through the circuit board's resistors. The ends of the ceramic break are welded to the end flanges of the WCM. Figure 6 shows the WCM installed on the Diagnostic table.

Beam Position Monitors

Two horizontally and two vertically oriented button BPMs are part of each cross. The beam position pickup is 316L stainless steel, the electrical feed-through is constructed from molybdenum, and the electrical isolator is alumina. An SMA connector on the top of the flange has its gold-plated beryllium-copper center contact pin laser welded to the molybdenum feed-through. A copper canted coil spring keeps the flange grounded to the cross. A button BPM, prior to installation, is shown in Fig. 6.

INSTALLATION

Once the assembly of the 9-way Cross, 6-way Cross, WCM, and UHV system was completed, the Diagnostic table was transported into the ASTA enclosure. The stand was secured to the floor, vacuum connections were made to the RF Gun within a portable cleanroom, pneumatics were connected, and the UV Laser system was installed. Figure 7 shows the Diagnostic table after installation.

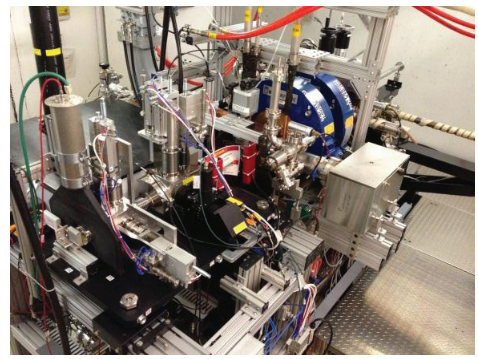

Figure 7: Diagnostic table fully assembled in the ASTA enclosure.

SUMMARY

Assembly of the Diagnostic table began on October 4th, 2012 and installation was completed by June 11th, 2013. Once all instrumentation was calibrated and connected to the control system, power was applied to the RF Gun. First UV laser light was established to the photocathode at 11:45 am on June 20th, 2013 followed by first detected photoelectrons at 4:00 pm.

The YAG crystal has been utilized in energy measurements of the photoelectrons at various RF Gun gradients. WCM charge calculations are in agreement with Faraday cup current measurements. Beam based alignment of the RF Gun solenoid magnets, utilizing the BPMs, will occur as downstream component installation schedules allow.

ACKNOWLEDGMENTS

The author recognizes the diverse and capable expertise of the technical staffs of the Fermilab Accelerator Division.

REFERENCES

[1] P. Garbincius et al., "Proposal for an Accelerator R&D User Facility at Fermilab's Advanced Superconducting Test Accelerator (ASTA)," Fermilab-TM-2568, 2013.

[2] D. Crawford, et al.," Assembly and Installation of the UV Laser Delivery and Diagnostic Platform and the Photocathode Imaging System for the ASTA Front-end," WEPRI059, this conference.