Fermi National Accelerator Laboratory

Fermilab

Warm Front End Installation Plan

Document number: ED0020527

Managed by Fermi Research Alliance, LLC for the
U.S. Department of Energy Office of Science
www.fnal.gov

U.S. DEPARTMENT OF ENERGY | Office of Science

Document Approval

Signatures Required	Date Approved
Originators: Mike Geelhoed, Linac Installation & Commissioning Deputy L2 Manager Lionel Prost, WFE L3 Manager Tyler Funk, Mechanical Engineer	
Reviewer: Curt Baffes, Linac Installation L3 Manager	
Reviewer: Lidija Kokoska, Project Engineer	
Reviewer:	
Reviewer:	
Reviewer:	
Reviewer:	
Reviewer:	
Reviewer:	
Approver: Jerry Leibfritz, Linac Installation & Commissioning L2 Manager	

Revision History

Revision	Date Released	Description
Draft V0	12/5/2022	Initial Draft

Table of Contents

Scope and Context

This document is the Warm Front End (WFE) Installation Plan for PIP-II. It was developed in conjunction with Linac Installation (LI) and WFE groups. It covers the general components and sequence of the PIP-II WFE beamline elements for transport, installation, and connections both in the Tunnel and in the Linac Gallery (LG) and High Bay Building (HBB). This document is a series of broad sequence logic steps that is to be followed based on Project activities and milestones. The detailed descriptions of each step will be captured in Travelers as co-developed by LI and WFE under the guidance of the PIP-II Quality team.

The general methodology of this installation sequence is broken into three large "Batches". The 1st batch includes the RFQ, Low Energy Beam Transport (LEBT) line and Ion Sources. The 2nd batch includes most girders from the Medium Energy Beam Transport (MEBT) line. The 3rd, and last batch, is the remaining girder and components of the WFE all the way to the first cryomodule known as the Half-Wave Resonator (HWR). It is located on the Superconducting Linac (SCL) tunnel side of the shield wall. Also, this sequence of installation of batches allows for adequate time for commissioning the WFE between the 2nd and 3rd batches. In parallel to commissioning the first 4 MEBT girders, Batch 3 will be installed.

The term "girder" will be used when describing the installation sequence. At PIP2IT, PIP-II's Injector Test for validating hardware and reducing project's technology risks, the WFE beamline components were installed sequentially in groups following the availability of those components. When a group of beamline components were ready for installation, they were positioned on larger sections of stands rather than individually mounted. These girders provide natural breaks along the beam line to ease installation.

Prior to any batches of beamline equipment being installed in the HBB or Linac tunnel, general services will be installed to any technical component beyond Conventional Facilities' (CF) scope. These general services installations include systems such as special water-cooling skids, cooling manifolds, the alignment reference network, electronic racks, grounding, etc. All of this scope resides either with Building Infrastructure (BLDGI) or Linac Installation WBSs.

The initial positioning of girders and other beamline equipment is determined by reference marks created by the Alignment & Metrology Group (AMG) during the general services activities. This will increase efficiency of installation activities. These staked-out positions still allow for component tolerances and acceptable misalignments [X]. The stake out marks indicate the position and elevation of the first and last element on the girder or piece of individual equipment.

Gallery Installation

In parallel to the effort for installing beam line components, supporting equipment will be installed in the electronics racks as planned for as indicated in Figure 1 and Figure 2. Cable pulls and rack allocations are coordinated between Linac Installation and Building Infrastructure. Once all the tasks associated with the connection of the utilities (water, electrical power, RF power) are complete, other control and readback connections will be made. These connections will be made by the Beam Instrumentation team (e.g. EIDs, NCPTs, ACCT, scrapers), Power Supplies team (e.g. magnets, solenoids) or Controls (e.g. PLC, motion control) from the component to their respective gallery equipment located in the electronics racks. Other connections from gallery-to-gallery equipment are the responsibility of those WBS captured in Connections travelers such as LLRF to HPRF and LLRF to Beam Instrumentation among others.

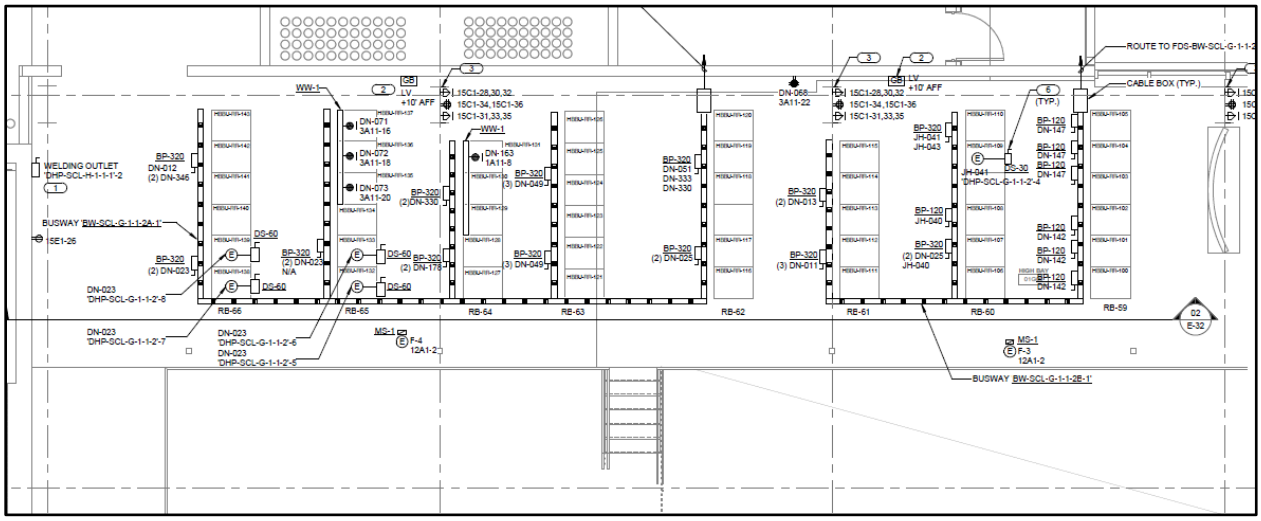

Figure 1: WFE Gallery Electronic Rack Layout

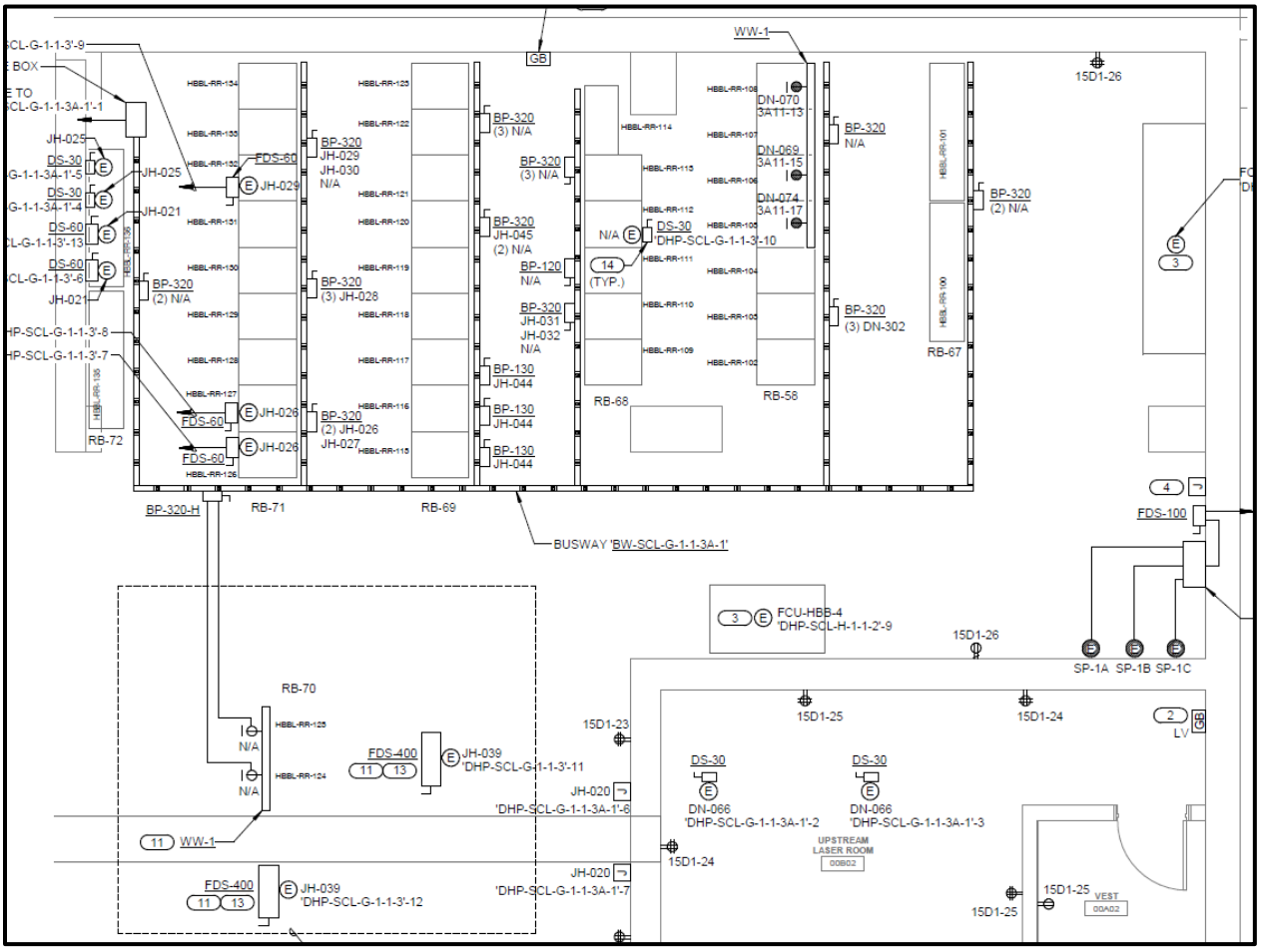

Figure 2: HBB pit Electronic Rack Layout

Installation of Batch 1

a. RFQ

Transport and Install

The first beamline component to be installed within the WFE is the RFQ (Figure 3). Its positioning will be centric to the location of other upstream and downstream beamline elements. It will be secured and wrapped in plastic film from the PIP2IT cave. Additional restraints are positioned on the RF couplers. These restraints are connected to the RFQ. The RFQ will be removed from PIP2IT/CMTF and transported to the PIP-II HBB using an existing transport frame. The truck will be backed into the HBB loading dock, and technicians will use the overhead crane to move the RFQ from the truck and place it in the staging area of the HBB using the appropriate lift plan.

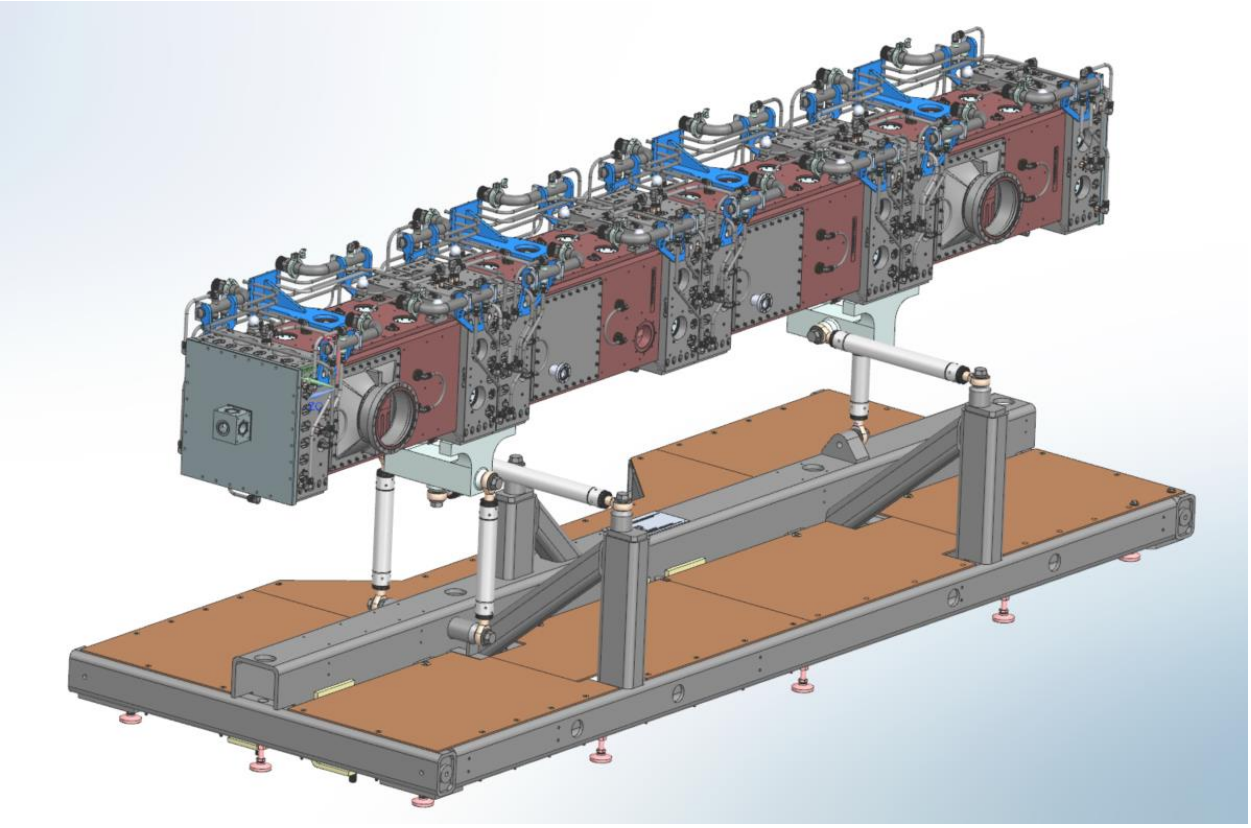

Figure 3: RFQ CAD model

From there, the plastic wrap will be removed and the RFQ will be lowered into the WFE area where the RFQ will be set in its stakeout markers. Technicians will anchor and fasten the RFQ to the ground once the RFQ is roughed aligned to the stakeout marks.

Connections

The Linac Installation team will connect the two vacuum pumps already on the main body of the RFQ to their power supplies in the gallery for initial pump down to ensure good vacuum can be achieved after the previous steps were completed. Associated local controls and readbacks of the pumping station will be on the side, but at this time connections for remote readbacks will be made.

The water connections from the RFQ Wall and Vane skids to the RFQ water manifold will be made by members of the Fluids team. They will place the associated water instrumentation on the manifolds and verify the connections.

With all the fluids and vacuum connections made to the RFQ, and after final alignment, the support pedestrian decking around the RFQ will be installed. This allows for better work environment for ergonomics of future connections like instrumentation, cables, and the RF coaxial cables.

The HPRF team will lead the effort in connecting the RF coaxial cables to both the left and the right RFQ RF coupler assemblies. The coaxial cables will be installed in their designated paths back to the RF amplifiers. Once completed the RFQ is ready for an Operational Readiness Clearance (ORC) review.

b. Installation of 3 LEBT Girders

Transport and Install

The LEBT is composed of 3 girders as shown in Figure 4. These girders are combined in a Y-shaped configuration.

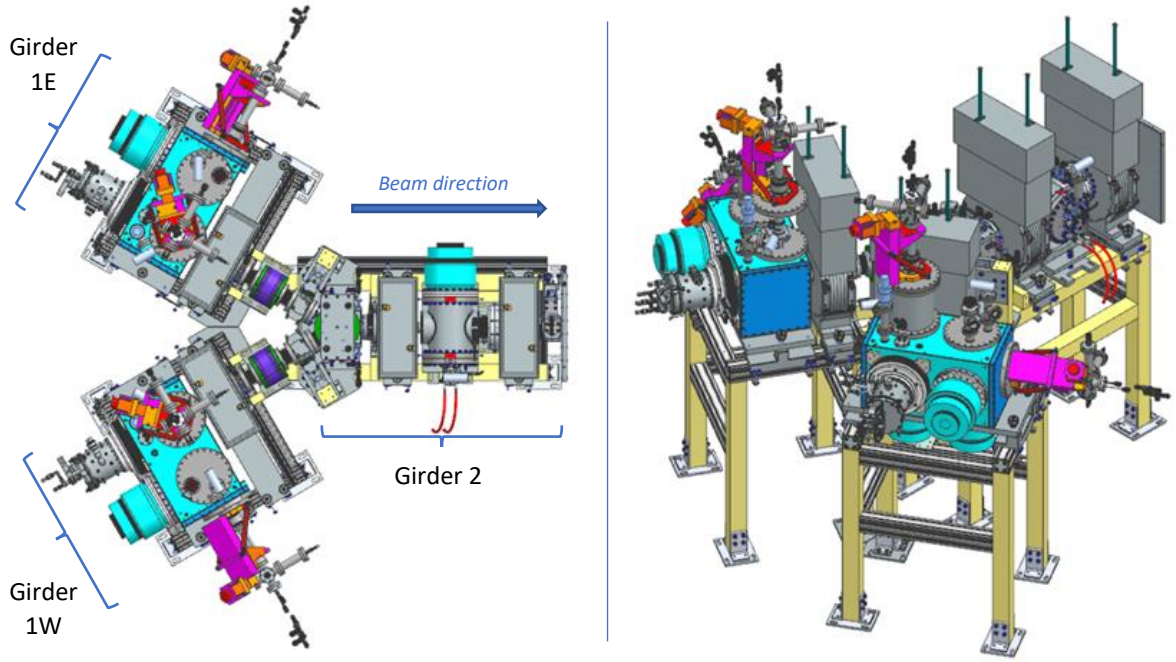

Figure 4: LEBT Girders CAD model

The vacuum valves on the upstream end of the bending dipole are installed on the downstream girder (a.k.a. Girder 2) and are the interfaces to the other 2 girders (Girder 1E (east) and Girder 1W (west)). Two of the 3 girders have been built and used at PIP2IT. Larger components (e.g. solenoids) remain on those girders, which are stored at PIP2IT. Beam Instrumentation did remove some of their equipment, which will be replaced by new assemblies for PIP-II. Those are an ACCT (Pearson toroid) on the downstream girder and an old DCCT on the upstream girder. The downstream girder will be slightly modified to accommodate the bending dipole, which was installed on an extension of the upstream girder at PIP2IT and is not adequate for the two ion sources setup. Consequently, the bending dipole assembly with the

gate valve will be removed from that extension and transported separately. Gate valves isolating the upstream girders from the downstream girder will also be mounted onto the downstream girder as shown in Figure 5.

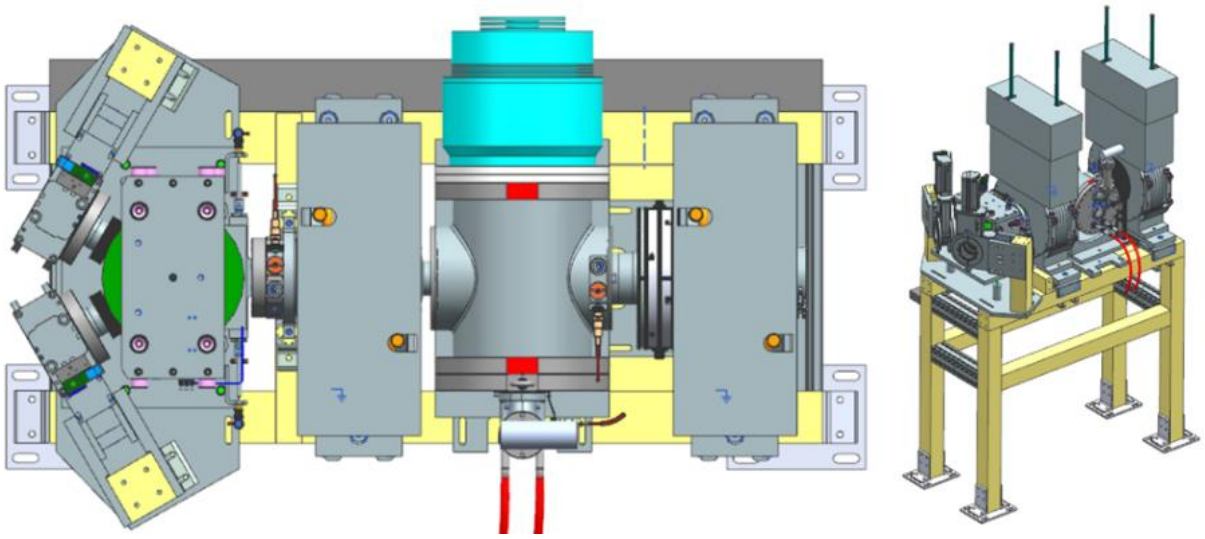

Figure 5: New (extended) LEBT Girder 2

Thus, the upstream girder can be reused as-is at PIP-II and should be positioned as Girder #1E. The 2nd leg (upstream) will be a mirror image of the latter as shown in Figure 6.

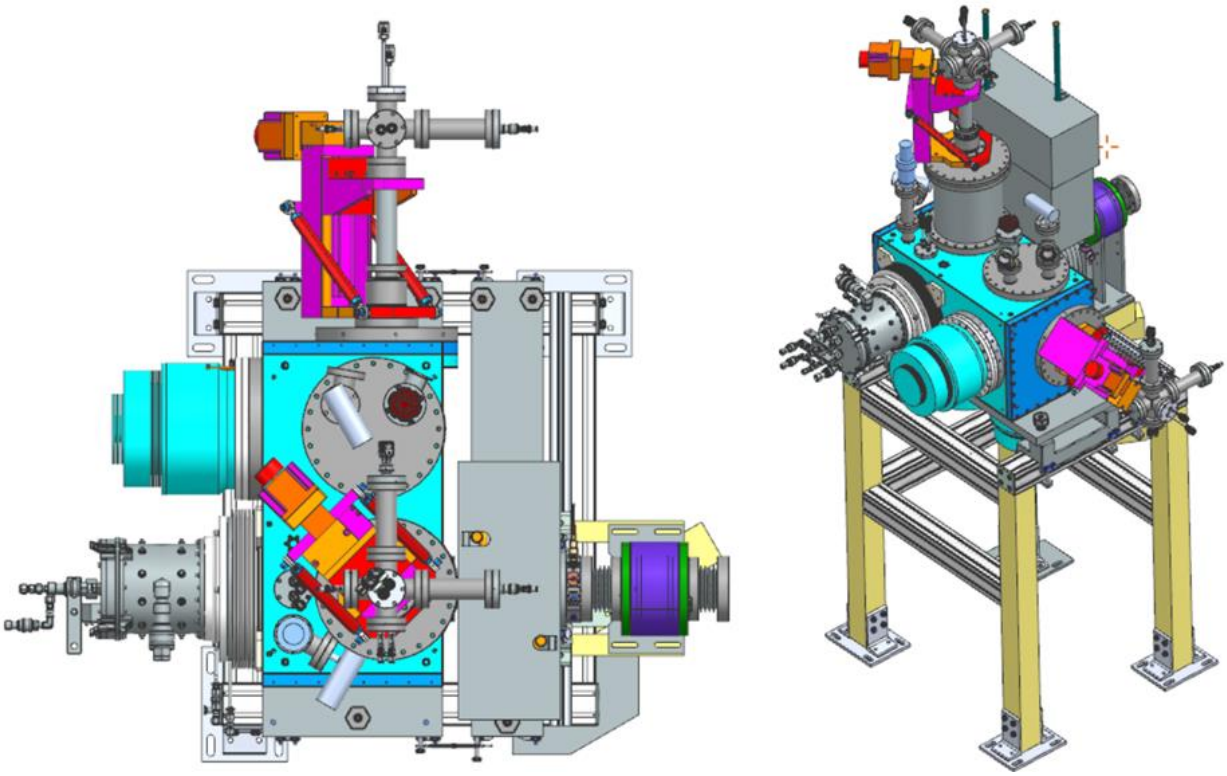

Figure 6: CAD models for LEBT Girder 1E (left) and 1W (right)

Downstream LEBT Girder (LEBT Girder #2)

The modifications to LEBT Girder #2 from PIP2IT to PIP-II mainly consists in increasing its length. The components located on that girder will have to be removed and transferred to the longer girder. Thus, all cables and water tubing will be disconnected from both solenoids, the EID, the collimator, and the LEBT chopper. The LEBT chopper chassis and -5kV power supply are currently mounted on the girder, below the chopper. They will be disconnected, removed, and when transported to A0, they will be sent separately (The -5kV PS will be replaced by a new one and relocated in a rack). Vacuum equipment (on the LEBT chopper assembly) will be disconnected, and the vacuum chamber will be blanked off. The vacuum beam pipe will be disconnected from the bending dipole vacuum chamber (downstream) and blanked off along with the vacuum valves on the upstream end.

At this stage, PIP2IT's LEBT Girder #2 is ready for transportation to the A0 assembly area. Once there, all the components still on that girder will be dismounted and the girder partly disassembled. Then, the new, slightly longer, girder can be assembled, reusing most of the previous girder stands. LEBT Girder #2 will support each gate valve to the bending dipole, the bending dipole proper, one EID, Solenoid 2, LEBT Chopper, ACCT, and Solenoid 3.

In parallel to the existing equipment, new equipment can be installed as well. With all equipment placed on the new girder, the beamline elements will go through a rough alignment so that the vacuum connections are made. Prior to the girder being transported to the PIP-II HBB the new girder will be handed off to Linac Installation following a BI-LI IRR.

Once LEBT Girder #2 is lowered into the enclosure, its initial placement will be aligned with the RFQ, and the upstream floor markings previously established by AMG. These markings will indicate the beam pipe vacuum connection with the upstream vacuum connections with the other LEBT girders. The adjustable feet will be used for this rough alignment. The girder is then to be fastened to the floor.

Upstream LEBT Girders (Girder 1E and Girder 1W)

Before transportation of the old upstream girder 1W from PIP2IT to the A0 assembly area, all cables and water tubing will be disconnected from the beamline components (solenoid, EID #1, ion source). Compressed air tubing will be disconnected from the gate valve's actuator. Vacuum equipment (on the ion source vacuum chamber) will be disconnected, and the vacuum chamber will be blanked off. The 300V power supply currently attached to a leg of the girder will be removed and returned to Beam Instrumentation ownership. At this stage, the upstream Girder 1W is ready for transportation to the A0 assembly area. Girder 1W may be transported with a blank off flange for the Ion Source body. The 2nd PIP-II upstream LEBT girder (Girder 1E) is a duplicate of Girder 1W, which remains to be fabricated.

The upstream girders will be comprised of a NPCT assembly (a.k.a. DCCT), an EID assembly, one solenoid, a vacuum chamber and, an Ion Source body. At this point, the elements should be rough aligned on the girder so that the vacuum connections are made. For the 3 turbo pumps on Girder 1E and 1W blank off flanges will be installed for transportation to PIP-II and installation. These turbos will be delivered by the vacuum group once procured and through their IRR. The new girders will be handed off to Linac Installation following a BI-LI IRR.

When ready either girder can be transported and craned down into place, just upstream of the downstream girder. It is beneficial to place the east side girder first in the area. Once down in the pit of

the HBB, the girders will be moved into place to align with the stake out marks provided by AMG. These marks match the girders so that the beamline vacuum connections with the bending dipole vacuum valves can take place. The adjustable feet will be used for this rough alignment. The girder is then to be fastened to the floor. Once the upstream Girders 1E and 1W are fastened to the ground the ion source bodies, turbo pumps, emittance scanner actuators and insulators are brought in for installation.

Connections

The equipment connections of all three LEBT girders will be completed together given the lack of room associated with all of the crews required. This process of making connections will be started once all LEBT girders are installed.

The equipment installed on the girders at PIP2IT mentioned previously, such as the LEBT chopper chassis, will be reinstalled underneath on the girder and connected to the chopper. Note that the -5kV PS and the 300V PS, located under the beam line at PIP2IT will be located in a rack for PIP-II. Appropriate cabling shall be pulled accordingly, and connections made.

LEBT Girder #2 vacuum connection can be made to the scraper body attached to the RFQ. It is advised to continue the vacuum connections to Girders 1E and 1W at this time with the dipole gate valves closed. Once the vacuum connections are made the equipment will go through a vacuum leak check after a baseline vacuum level is achieved from connecting the turbos and associated backing pumps to their controllers. Once the beamline equipment passes its leak check final alignment can be completed for all LEBT components.

With the vacuum leak check completed, connection to utilities to components begin. The main effort here are the water connections to those associated devices. LCW can be connected to the four electrically isolated electrodes (EIDs), Solenoids, LEBT scraper, LEBT chopper, and bending dipole collectors. Gate valve actuators will be connected to the compressed air system, and Controls will connect the signal cables. Beam Instrumentation will connect the emittance scanners, NPCTs, and ACCT. Electrical support will connect the power supplies to the solenoids, dipole, and LEBT chopper. With all connections completed all 3 LEBT girders are ready for an ORC.

c. Ion Sources system

The ion source system is broken up into several parts; the hydrogen supply, the high voltage cabinet, the low voltage cabinet, the high voltage cable bridge, and the ion source enclosure which contains the ion source head that the high voltage leads, hydrogen line, and water lines connect to. Since the LEBT supports two ion sources, as shown in Figure 7, there are two semi-identical ion source systems. Some portions of the PIP-II IT ion source system (excluding the LEBT) can be reused: the ion source enclosure, some devices within the high and low voltage cabinets, and components which are part of the hydrogen supply (such as valves and electronics).

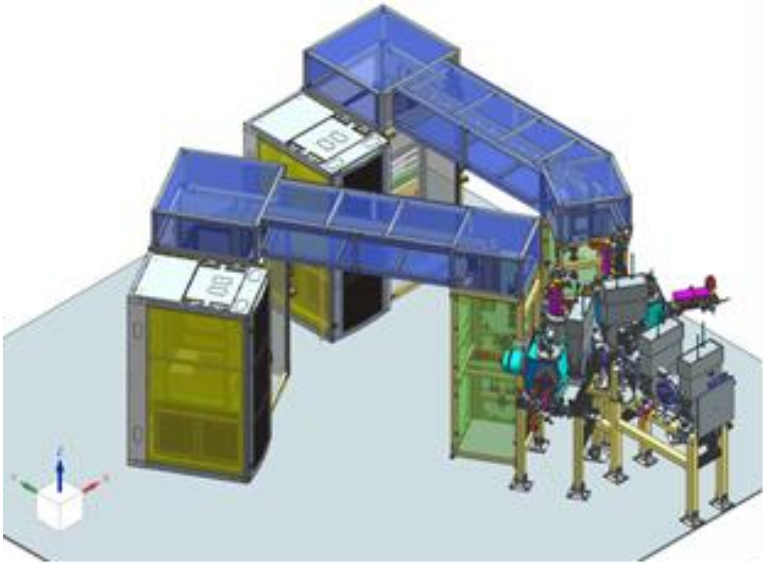

Figure 7: CAD model of the setup with both Ion Sources in a Y-configuration

Install Hydrogen System

The hydrogen supply is divided into the storage area and the experiment area. The storage area is in the high-bay alcove neighboring the gallery. It's comprised of a storage cabinet to house two hydrogen bottles, .25" stainless steel tubing, and various components in line with the tubing. The experiment area is the ion source enclosure. Installation of the hydrogen supply can be completed in parallel to the entire WFE installation plan except for connecting to the experiment section. The storage cabinet should have mounting holes drilled into it for securing various components (valves, regulator, mass flow meter) as seen in the 3D model (Figure 8) and the corresponding P&ID [X].

The cabinet gets placed in the southeast corner of the alcove (farthest from the opening to the gallery). Every 10 feet of tubing will need a union connection to the next piece of tubing. There should be a union connection near the cabinet and on either side of the alcove wall which the tubing passes through. The hydrogen tubing should be secured to the wall using clamps connected to the Unistrut installed into the wall around the alcove. A PVC tube will act as a shield for the suspended tubing leading from the alcove to the ion source enclosure. It should not contain any union connections. The PVC should be secured at two points to the alcove wall.

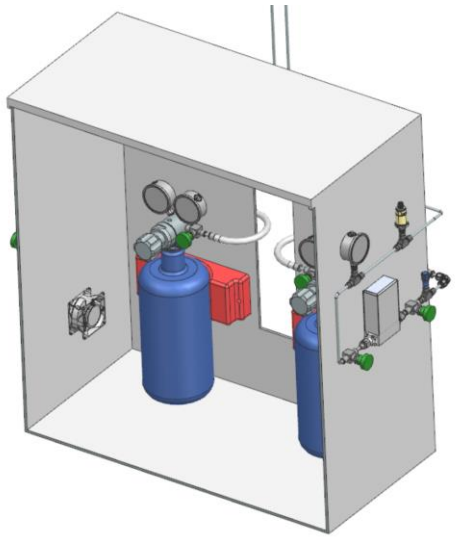

Figure 8: Hydrogen Supply cabinet

Install Power Cabinets

The ion source enclosure that comes from PIP2IT will need to be modified and rebuilt to reduce the height and prepare it for its bridge section (right portion of Figure 9). A semi-mirrored version (Figure 10) of the enclosure should be made for the other ion source. Only the bridge sections that are directly above the ion source enclosures should be installed (without perforated steel and cable tray) The enclosures should be placed with respect to marks on the floor which are based on the LEBT position. If the ion source head is not installed on the LEBT yet, the ion source installation rails and trolley can be installed in the enclosure and the ion source can be slid and fastened into place.

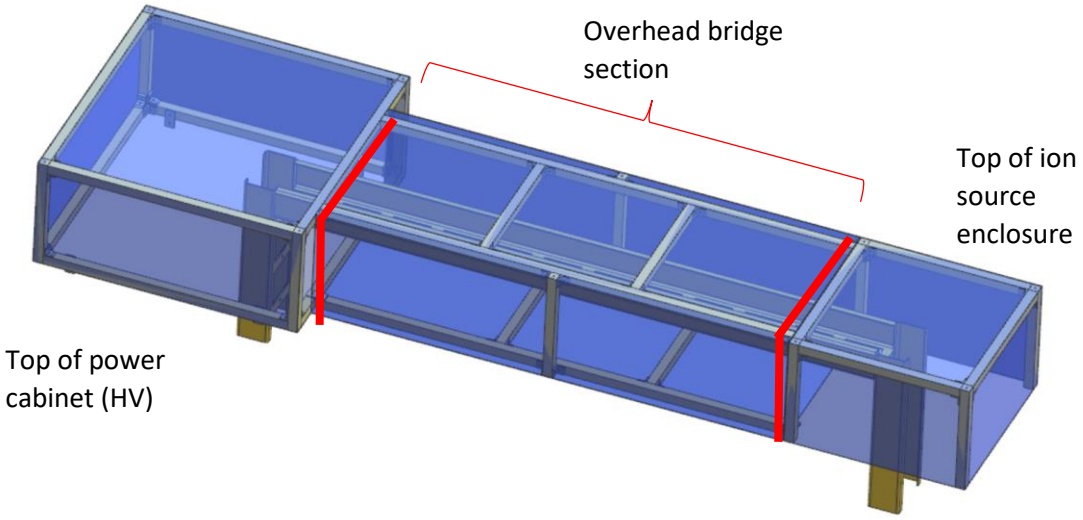

Figure 9: West high voltage cable bridge

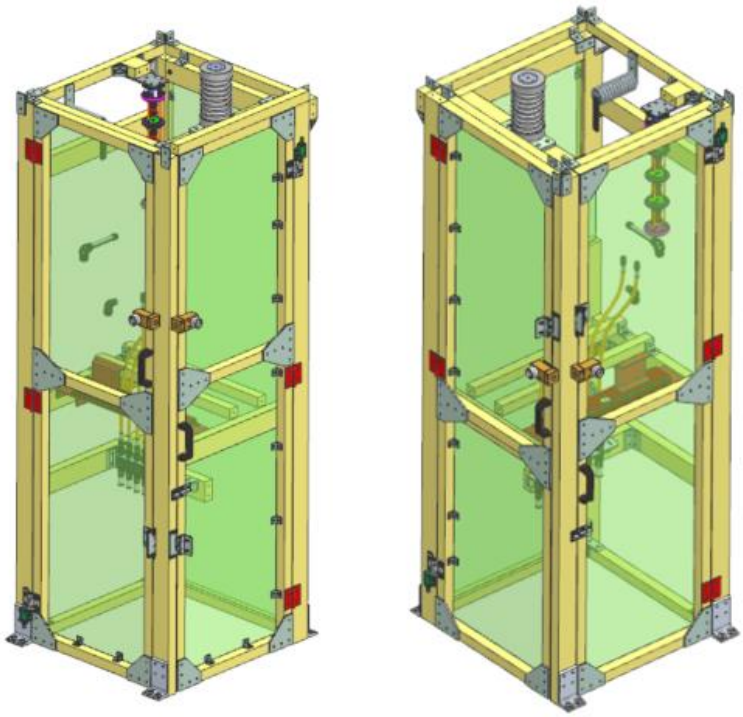

Figure 10: West (left) and east (right) ion source enclosures

Each high voltage cabinet (Figure 11) should have their respective bridge sections installed (without perforated steel, left portion of Figure 9) before the cabinets are placed in their final location. The cabinet should be placed ~1.9 meters from their respective ion source enclosures (cabinet front door faces enclosure front door). The overhead bridge section (the middle portion in Figure 9) can then be lifted into position and secured at both ends. The cable tray and high voltage cables should get fed into the bridge sections, connected to the ceramic isolators, and then connected to each other (i.e. the cable tray for the overhead section should not be fully pre-assembled). After this, the perforated steel can be added to the bridge sections. Then, the high voltage device rack can be placed inside the cabinet and leveled.

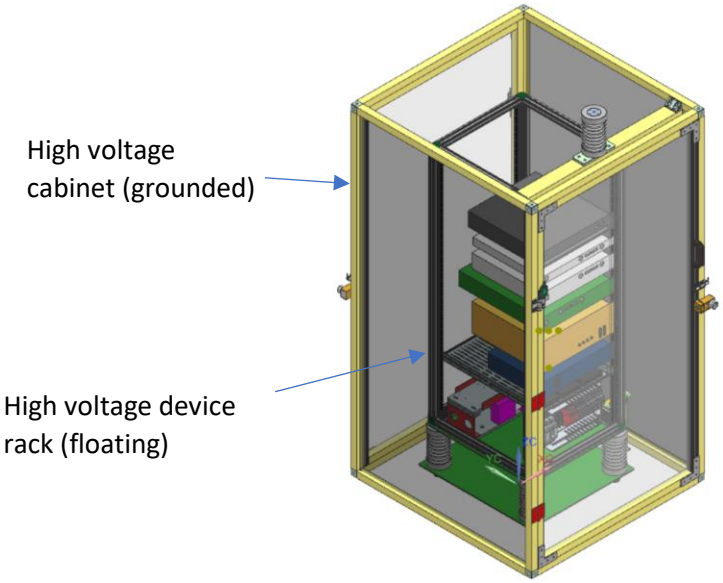

Figure 11: High voltage cabinet

The low voltage cabinets (Figure 12) get placed west of their respective high voltage cabinet and up against the cabinet's side. The high voltage and low voltage cabinets need to get connected to one another via a feedthrough, so a hole should be cut through both walls of the cabinets. The isolation transformer frame goes inside the low voltage cabinet and the transformers get wired and placed inside the frame afterwards. Then the frame gets enclosed using plexiglass and aluminum. A feedthrough needs to be cut into the frame for the transformer cables. Once the transformer frame is enclosed, the low voltage device frame can be placed on top of it.

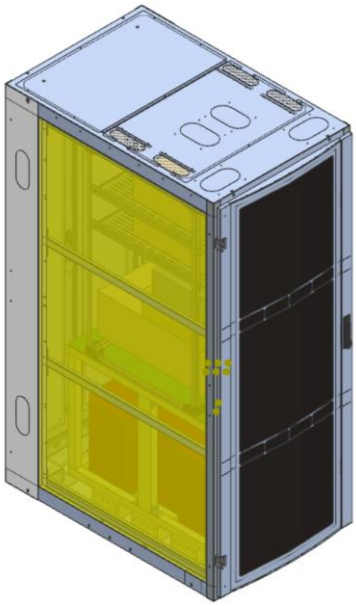

Figure 12: Low voltage cabinet

At this point, the reused devices from the PIP2IT cabinets and the new/duplicate devices can be placed in the high and low voltage cabinets and wired accordingly. The high voltage leads, hydrogen line, and water

lines can all be connected to the ion source head. A leak check of the hydrogen supply lines should be performed with the needle valve (located inside the enclosure) closed. Tests and programming of the devices in the hydrogen line and high and low voltage cabinets should also be performed.

Installation of Batch 2

The MEBT is composed of 5 girders: 4 of them are located in the HBB pit; the 5th girder is located in the SCL tunnel (Figure 13). Batch 2 refers to Girders 1 through 4, including the beam pipe going through the shielding wall. The majority of the Girders from PIP2IT have some modification to them prior to PIP-II MEBT Installation. All girders will be "pre-assembled" prior to transportation and installation into their corresponding location. For now, a room in the A0 service building has been allocated for this work.

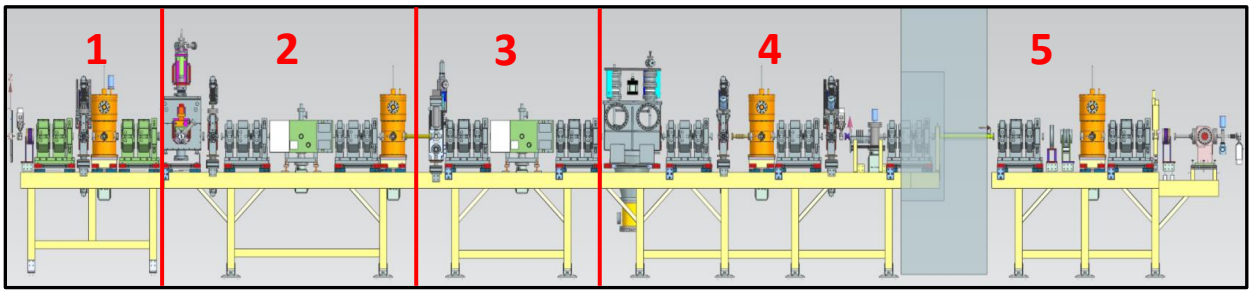

Figure 13: MEBT line (side view) indicating the delimitation of the 5 girders

a. MEBT Girder 1

Transport and Install

MEBT Girder 1 originates from PIP2IT and will have minimal updates for PIP-II. The girder contains a vacuum valve, ACCT, 2 quadrupole doublets with corrector dipoles, the 1st scrapers set and the 1st Bunching cavity (Figure 14). The ACCT replaces a Pearson current transformer (a.k.a. toroid), which has been removed. The vacuum chamber for the scrapers will also have been removed prior to transportation. With the remaining components still mounted onto the girder, the latter will be transported to A0 via a flatbed truck. It will be unloaded using the overhead crane and slings will be used for rigging.

Once at A0, a new scraping station (4 scrapers and actuators mounted on a vacuum chamber, as well as one wire scanner mounted on the 45° port) will be installed on the girder. This installation will be conducted once the hardware passes the WFE-LI IRR. A new ACCT with stand is provided by Beam Instrumentation. There is a direct hand off to Linac Installation following a BI-LI IRR. In the staging area, the ACCT will be installed. Once all elements are installed on the girder, the vacuum connections between the components will be made prior to being transported to the HBB.

Once the Girder is lowered into the HBB pit, its initial placement will be aligned with floor markings previously established by AMG. These markings will indicate the beam pipe vacuum connection with the RFQ on the upstream end. The adjustable feet will be used for this rough alignment. The girder is then to be fastened to the floor. Once fastened to the floor, the beam tube connection to the RFQ gate valve can take place and the beam line pumped down with a standard pumping cart connected to the downstream end.

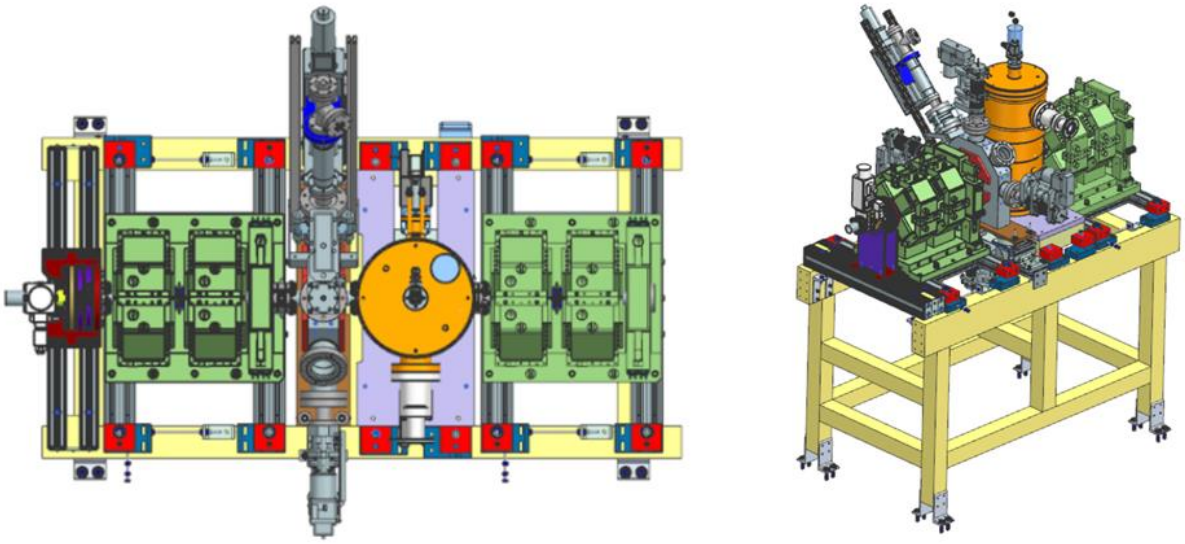

Figure 14: MEBT Girder 1

Connections

After a successful leak check then final alignment, cooling water lines can be connected to the scrapers vacuum chamber and bunching cavity. Electrical support will connect the power cables to the doublets and corrector dipoles. Beam Instrumentation will connect the ACCT. Gate valve actuators will be connected to the compressed air system, and Controls will connect the motion and signal cables. HPRF will connect the RF to the 1st Bunching cavity. With all connections completed Girder 1 is ready for an ORC.

b. MEBT Girder 2

Transport and Install

MEBT Girder 2 is a new build. The Girder will be built in the A0 assembly area. It includes an Emittance scanner, the 2nd scrapers set, 2 quadrupole triplets with corrector dipoles, one Kicker module, and the 2nd Bunching cavity (Figure 15). Most of the beamline equipment are reused from PIP2IT, however there are 2 new components: the emittance scanner and the bunching cavity.

Once those pieces of equipment are integrated onto the girder, the girder vacuum connections will be made. The girder is ready to be transported to the HBB. Once there, the girder will be unloaded from the flatbed truck via the overhead crane. It will be lowered into the HBB pit using the overhead crane and slings will be used for rigging.

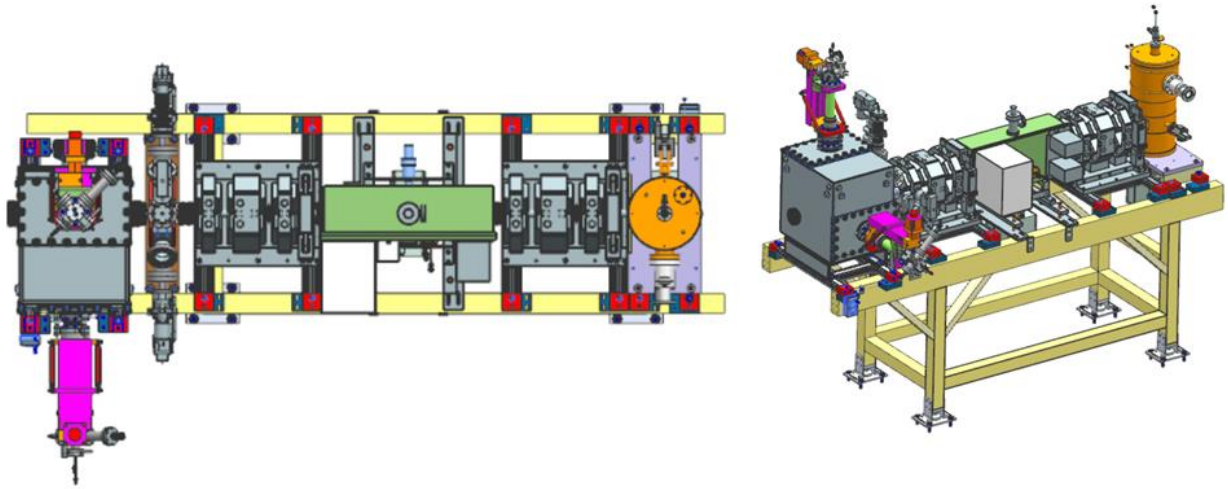

Figure 15: MEBT Girder 2

Once the Girder is lowered into the pit, its initial placement will be aligned with floor markings previously established by AMG. These markings will indicate the beam pipe vacuum connection with MEBT Girder 1 on the upstream end and MEBT Girder 2 on the downstream end. The adjustable feet will be used for this rough alignment. The girder is then to be fastened to the floor. Once fastened to the floor, the beamline elements will be final aligned by AMG once all girders are in place and under vacuum.

Connections

After a successful leak check and final alignment, cooling water lines can be connected to the emittance scanner, scrapers vacuum chamber, kicker, and the bunching cavity. Electrical support will connect the power cables to the triplets and corrector dipoles. Kicker experts will connect the power to the Kicker. Beam Instrumentation will connect the emittance scanner. Gate valve actuators will be connected to the compressed air system, and Controls will connect the motion and signal cables. HPRF will connect the RF to the 2nd Bunching cavity. With all connections completed Girder 2 is ready for an ORC.

c. MEBT Girder 4

Transport and Install

MEBT Girder 4 will be installed next due to the physical limitations of the shield wall. The girder is a new build and will be built in the A0 assembly area. The girder contains the MEBT Absorber, 3 quadrupole triplets with corrector dipoles, 2 scrapers sets, the 3rd Bunching cavity, a 'slow' vacuum valve and the differential pumping insert (Figure 16). Most of the beamline equipment is reused from PIP2IT, however there are new triplet magnets and a new order of components (with respect to the PIP2IT beam line).

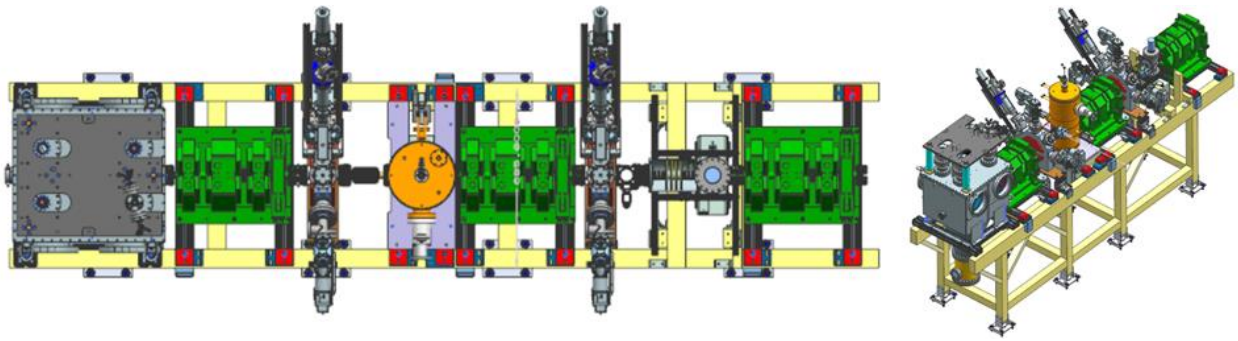

Figure 16: MEBT Girder 4

The Absorber has a new lid thus a new alignment reference, the beam pipe just downstream of the Absorber is a new water jacketed beam pipe. The last triplet will be new magnets to the beamline. These devices will all go through their respective IRR prior to installation. The downstream portion, past the DPI, of the girder will be built following the Low-Particulate UHV Cleaning and Assembly Procedure [X]. Once those pieces of equipment are integrated onto the girder, the girder vacuum connections will be made, except for the spool piece connecting the upstream scraping station to the bunching cavity. This "air gap" is required to start beam commissioning of the MEBT. At the end of the girder is the beampipe that traverses through the shield wall. This beampipe is supported by a frame during transportation.

The girder is ready to be transported to HBB. Once there, the girder will be unloaded from the flatbed truck via the overhead crane. It will be lowered into the pit using the overhead crane and slings will be used for rigging.

Once the Girder is lowered into the pit, its initial placement will be aligned transversely with the shield wall hole. The transportation frame will then be removed, and the girder will be shifted longitudinally towards the hole in the shield wall. The downstream beampipe will be brought into position on the SCL side of the wall. The upstream end will then align with the floor marking previous established by AMG. These markings will indicate the beam pipe vacuum connection with Girder 3 on the upstream end. Once the girder is in position, and the adjustable feet are used for the rough elevation alignment, the Girder is fastened to the floor. Once fastened to the floor, the beamline elements will be final aligned by AMG once all girders are in place and under vacuum.

The proper configuration for WFE Commissioning of this girder will require the beam pipe to be initially removed between the upstream scrapers set and the 3rd Bunching cavity. A blank off flange will be installed on both the scrapers vacuum chamber and the bunching cavity.

Connections

After a successful leak check and final alignment, cooling water lines can be connected to the MEBT Absorber, jacketed beam pipe, scrapers vacuum chambers and the bunching cavity. Electrical support will connect the power cables to the triplets and corrector dipoles. Beam Instrumentation will connect the MEBT absorber, DPI, and scraper paddles while Controls will connect the motion and signal cables. HPRF will connect the RF to the 3rd Bunching cavity. With all connections completed Girder 4 is ready for an ORC.

d. MEBT Girder 3

Transport and Install

MEBT Girder 3 is a new build and will be built in the A0 assembly area with most of the equipment that was used at PIP2IT. The girder contains the Fast Faraday Cup, 2 quadrupole triplets with corrector dipoles, and the 2nd Kicker (Figure 17).

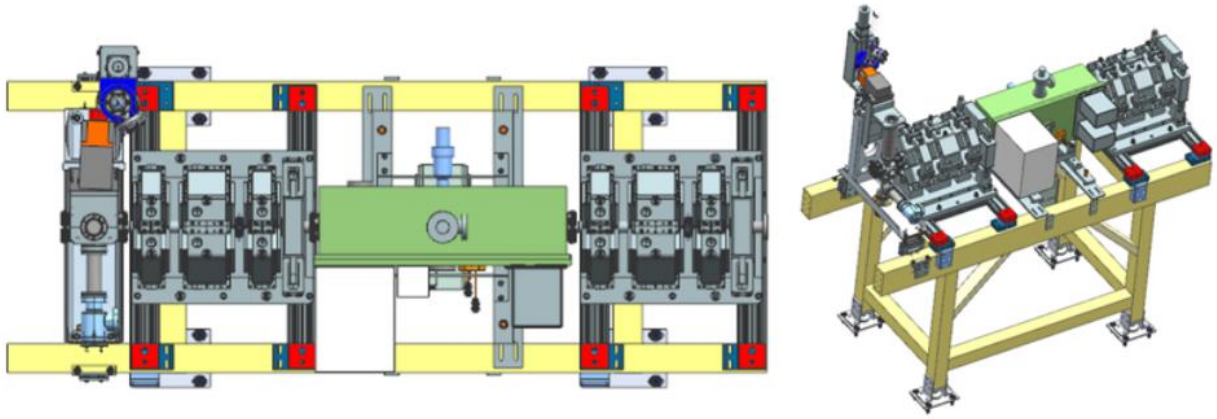

Figure 17: MEBT Girder 3

Once those pieces of equipment are integrated into the girder, the girder vacuum connections will be made. The girder is ready to be transported to HBB. The girder will be unloaded from the flatbed truck via the overhead crane. It will be lowered into the HBB pit using the overhead crane and slings will be used for rigging.

Once the girder is lowered into the pit, its initial placement will be aligned with floor markings previously established by AMG. These markings will indicate the beam pipe vacuum connection with Girder 2 on the upstream end and Girder 4 on the downstream end. The Kicker drives and resistive loads are placed when the girder has been final aligned in the beamline. The girder is then to be fastened to the floor. Once fastened to the floor, the beamline elements will be final aligned by AMG once all girders are in place and under vacuum.

Connections

After a successful leak check and final alignment, cooling water lines can be connected to the kicker. Electrical support will connect the power cables to the triplets and corrector dipoles. Kicker experts will connect the power to the Kicker. Beam Instrumentation will connect the fast faraday cup and kicker protection electrodes while Controls will connect the motion and signal cables. With all connections completed Girder 3 is ready for an ORC.

Installation of Batch 3

a. Installation of MEBT Girder 5 (In progress)

Transport and Install

MEBT Girder 5 will be a new girder build and the girder structure will go through its own IRR with LI. The equipment will be handed off from the other L3s to be integrated onto the girder after they go through

their own IRR with LI. Girder 5 will be built in the A0 assembly area. The girder contains 2 quadrupole triplets with corrector dipoles, a Resistive Wall Current Monitor (RWCM), a DCCT, the 4th Bunching cavity, a fast-acting vacuum valve, an ACCT, a Laser Profile Monitor (LPM) and a pumping station that connects to the valve downstream towards the HWR (Figure 18).

Once those pieces of equipment are integrated on the girder, the girder vacuum connections will be made. The girder will be built using the Low-Particulate UHV Cleaning and Assembly Procedure [X]. The girder is ready to be transported to HBB. The girder will be unloaded from the flatbed truck via the overhead crane. It will be lowered into the HBB pit using the overhead crane and slings will be used for rigging. Once on the floor of the pit it will be rolled through the opened HBB Shield Door and transversely placed into position.`

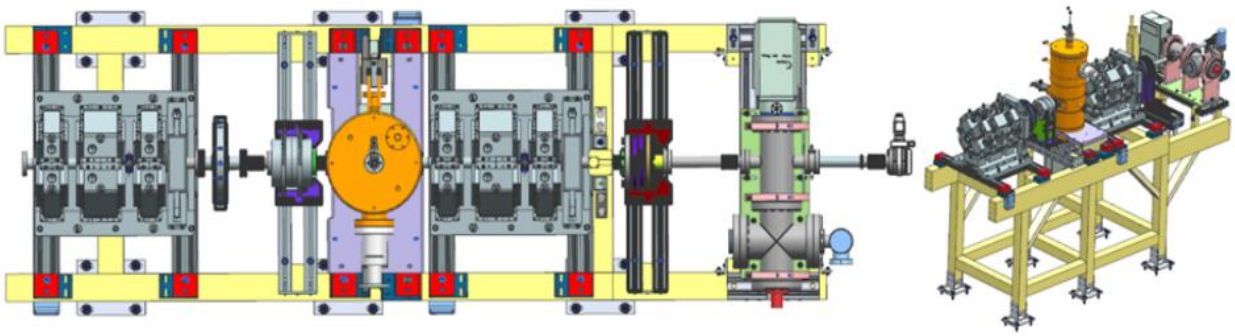

Figure 18: MEBT Girder 5

Its initial placement will be aligned with floor markings previously established by AMG. These markings will indicate the beam pipe vacuum connection with Girder 4 on the upstream end from the shield wall opening and the HWR cryomodule on the downstream end. The girder is then to be fastened to the floor. Once fastened to the floor, the beamline elements will be final aligned by AMG once all girders are in place and under vacuum.

Connections

Both vacuum connections from Girder 5 are particle free vacuum connections following the Low-Particulate UHV Cleaning and Assembly Procedure. After a successful leak check and final alignment, cooling water lines can be connected to the bunching cavity. Electrical support will connect the power cables to the triplets and corrector dipoles. Beam Instrumentation will connect the Resistive Wall Current Monitor, DCCT, ACCT, and Laser Profile Monitor. Controls will connect signals to the fast-acting vacuum valve. HPRF will connect the RF to the 4th Bunching cavity. With all connections completed Girder 5 is ready for an ORC.

References

PIP-II Intermediate RFQ LCW Cooling Skid P&ID F10165158
PIP-II RFQ Cooling System P&ID Wall and PI Rods F10165140
PIP-II RFQ Vane Cooling System P&ID F10165157
PIP-II Misalignment Tolerances document ED0010231
PIP-II Medium Energy Beam Transfer lines Interface Specification Document (ISD) ED00XXXXX
Low-Particulate UHV Cleaning and Assembly Procedure ED0003571

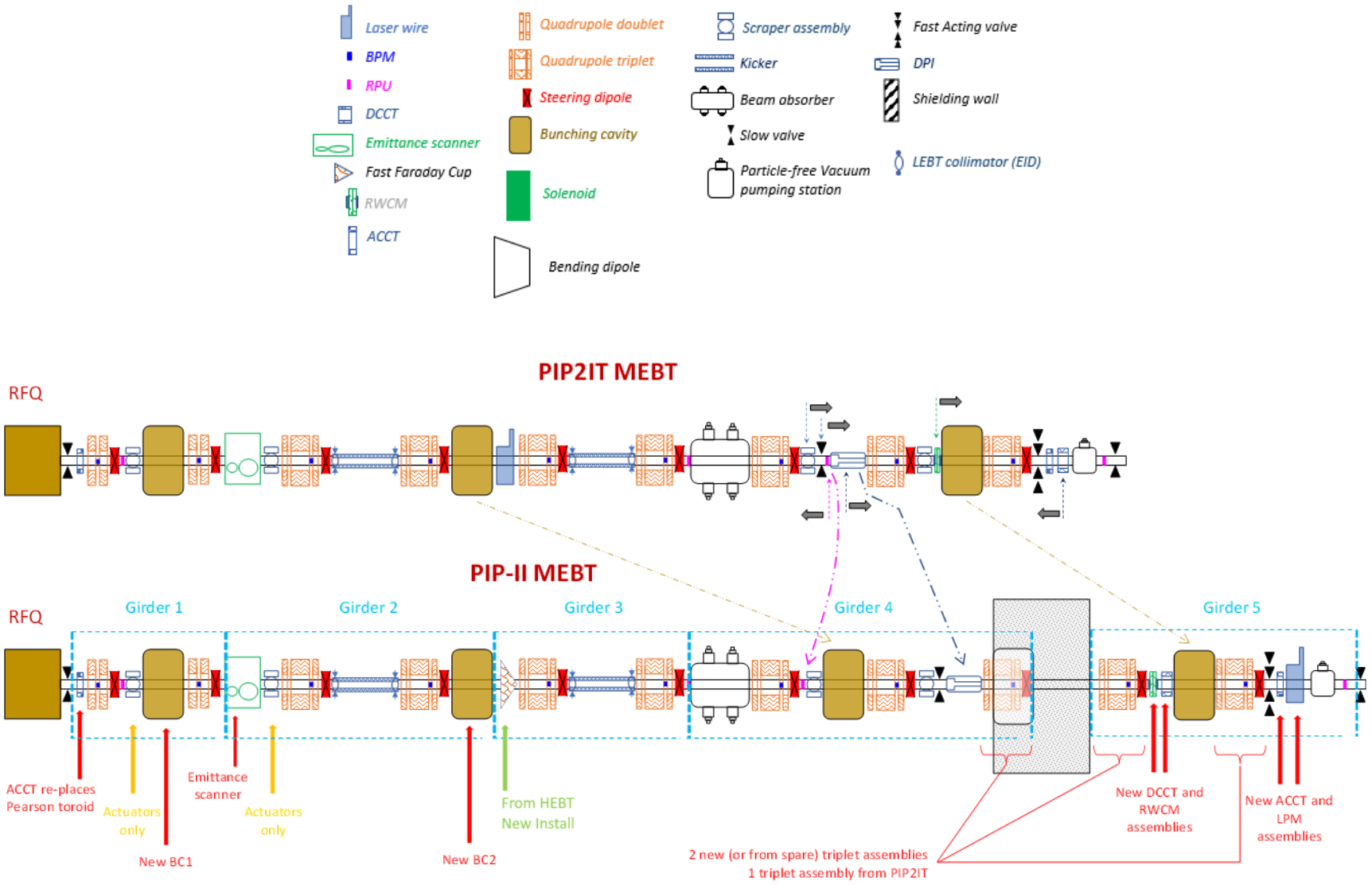

Figure 19: Changes from PIP2IT to PIP-II