Beam Instrumentation

Document number: ED0011271, Rev B

Document Approval

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| Signatures Required | Date Approved |
| Originator: Kyle Kendziora, LI Engineer | See Teamcenter |
| Reviewer: Victor Scarpine, BI L3 Manager |  |
| Reviewer: Lionel Prost, L3 Manager |  |
| Reviewer: , L3 Manager |  |
| Reviewer: Denton Morris, BTL L3 Manager |  |
| Reviewer: Lucy Nobrega, VAC L3 Manager |  |
| Reviewer: |  |
| Approver: Victor Scarpine, BI L3 Manager |  |
| Approver: Sherese Humphrey, BI CAM |  |
| Approver: Mike Geelhoed, LI CAM |  |

Revision History

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| --- | --- | --- |
| Revision | Date Released | Description |
| - | 2020-08-04 | Initial release |
| A | 2023 – May | Updated for Invasive BProM FDR |
| B | 2024 – May | Updated for Integrated Vacuum Review and BI DAQ Electronics FDR |
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# Introduction

This document is a shared document between the Beam Instrumentation (BI) and various integrator and installation teams, as defined by the Work Breakdown Structure(WBS)[1] and the Master Control Interface Document(MICD)[3].

Additional details regarding scheduling and resources for integration and installation phases are provided in PIP-II Baseline Schedule[7]. It is important to note that WBS scope is not reflective of who shall do the work. All integration and installation work shall be in done in coordination with BI subject matter experts.

## Assumptions

Key cost, schedule, technical and programmatic assumptions are provided in PIP-II Project Assumptions[2].

## Purpose

The purpose of this document is to list the agreed upon deliverables, at hand-off milestones. These deliverables include all components needed for the design, procurement, fabrication, and testing of the following 5 BI subsystems.:

* Beam Position Monitors (BPM)
* Beam Loss Monitors (BLM)
* Beam Current Monitors (BCM)
* Beam Profile Monitors (BProM)
* BI Data Acquisition System (DAQ)

This document also summarizes details, such quantities, configurations, conditions, relevant documentation, and required procedures/travelers for each deliverable. In addition, this document also becomes a template for the data to be reviewed at an Installation Readiness Review (IRR), as shown in the PIP-II LI Installation Plan[8].

# Acronyms

|  |  |
| --- | --- |
| ACCT | AC Current Transformer |
| AES | Allison Emittance Scanner |
| AMG | Alignment and Metrology Group |
| BCM | Beam Current Monitor |
| BAL | Booster Absorber Line |
| BI | Beam Instrumentation (WBS) |
| BLM | Beam Loss Monitor |
| BPM | Beam Position Monitor |
| BProM | Beam Profile Monitor |
| BSM | Bunch Shape Monitor |
| BTL | Booster Transfer Line Installation |
| BLDGI | Building Infrastructure (WBS) |
| BTLBA | Booster Transfer Line and Beam Absorber (WBS) |
| CAD | Computer Aided Design |
| COMM | Commissioning (WBS) |
| DAQ | Data Acquisition |
| DCCT | DC Current Transformer |
| FESHM | Fermilab Environment Safety and Health Manual |
| FRS | Functional Requirement Specifications |
| GRD | Global Requirements Documents |
| IDL | Installation Deliverables List |
| IRR | Installation Readiness Review |
| ISD | Interface Specification Document |
| L3 | Level 3 (PIP-II Project Subsystem) |
| L3M | Level 3 Manager |
| L4M | Level 4 Manager |
| LI | SCL Installation (WBS) |
| MICD | Master Interface Control Document |
| ORC | Operational Readiness Clearance |
| PIP2IT | PIP-II Injector Test |
| PIP-II | Proton Improvement Plan II |
| PMT | Photomultiplier Tube |
| PRD | Physics Requirement Document |
| QA | Quality Assurance |
| QC | Quality Control |
| RWCM | Resistive Wall Current Monitor |
| SCL | Superconducting Linac |
| TRS | Technical Requirement Specifications |
| TWS | Transverse Wire Scanner |
| VAC | Vacuum (WBS) |
| WBS | Work Breakdown Structure |
| WFE | Warm Front End (WBS) |

# References

## Table 3‑1 : PIP-II Project-Level Documentation

|  |  |  |
| --- | --- | --- |
| # | PIP-II Project Documents | Document # |
|  | PIP-II WBS Dictionary | PIP-II-docDB 599 |
|  | PIP-II Project Assumptions | PIP-II-docDB 144 |
|  | PIP-II Master Interface Control Document | ED0010433 |
|  | PIP-II Global Requirements Document (GRD) | ED001222 |
|  | PIP-II Parameters Physics Requirements Document (PRD) | ED0010216 |
|  | PIP-II 121.03 Accelerator Systems Quality Assurance (QA) Plan | PIP-II-docDB 4805 |
|  | PIP-II Baseline Schedule | PIP-II-docDB 4095 |
|  | PIP-II Linac Installation Plan | ED0007915 |
|  | PIP-II Misalignment Tolerances PRD | ED0010231 |
|  | PIP-II Commissioning Plan | PIP-II-docDB 5420 |

## Table 3‑2 : PIP-II BI Documentation

|  |  |  |
| --- | --- | --- |
| # | PIP-II BI Documents | Document # |
|  | PIP-II BI PRD | ED0010230 |
|  | PIP-II BI FRS | ED0008303 |
|  | PIP-II BI Phase Reference Line FRS | ED0030105 |
|  | PIP-II BI Phase Reference Line TRS | ED0030047 |
|  | PIP-II BI BPM TRS | ED0013710 |
|  | PIP-II BI BPM ISD | ED0016037 |
|  | PIP-II BI BLM TRS | ED0013711 |
|  | PIP-II BI BLM ISD | ED0016034 |
|  | PIP-II BI BCM TRS | ED0013712 |
|  | PIP-II BI BCM ISD | ED0016033 |
|  | PIP-II BI Invasive BProM TRS | ED0013713 |
|  | PIP-II BI Invasive BProM ISD | ED0016035 |
|  | PIP-II BI NonInvasive BProM TRS | ED0013714 |
|  | PIP-II BI NonInvasive BProM ISD | ED0016036 |
|  | PIP-II BI DAQ Electronics TRS | ED0013715 |
|  | PIP-II BI Quality Control (QC) Plan | PIP-II-docDB 5520 |

## Table 3‑3 : PIP-II Installation Deliverable Lists

|  |  |  |
| --- | --- | --- |
| # | PIP-II BI Documents | Document # |
|  | PIP-II Installation Deliverables List : Bldg-LI | ED0011281 |
|  | PIP-II Installation Deliverables List : WFE-LI | ED0010230 |
|  | PIP-II Installation Deliverables List : VAC-LI | ED0008303 |
|  | PIP-II Installation Deliverables List : BTLBA-LI | ED0011845 |
|  | PIP-II Installation Deliverables List : COMM-LI | ED0030105 |

## Table 3‑4 : FESHM Chapter Documentation

|  |  |  |
| --- | --- | --- |
| # | PIP-II BI Documents | Document # |
|  | FESHM Chapter 10210 Equipment Transport | ESH-docDB 6970 |
|  | FESHM Chapter 2100 - Fermilab Energy Control Program (Lockout/Tagout) | ESH-docDB 393 |

# Documentation Deliverables Definitions

Each deliverable shall be accompanied by documentation that provides relevant details, such quantities, configurations, conditions, relevant procedures, and required checklists/travelers.

While this section defines the documentation categories, Section 5 indicates the relevant documentation for each BI deliverable.

## FRS/TRS Checklist

Functional requirements of BI deliverables are specified in the BI FRS [12] and BI Phase Reference Line FRS[13].

Technical requirements of BI deliverables are elaborated within several TRS documents [14][15][17][19][21][23][25].

Together, these FRS and TRS documents provide the basis for each BI subsystem-specific ISD as well as any acceptance criteria, verification procedures, checklists/travelers, and other associated procedures for BI deliverables.

## Interfaces MICD

All interfaces, between WBS teams, are uniquely identified, and captured globally in the PIP-II MICD[3]. This document provides an interface description, identifies interface stakeholders and integrators WBS teams, and summarizes the scope of those WBS teams.

## Connections, ORC & Checkout Travelers

These documents describe the connections across both physical and data pathway interfaces between WBS teams. These interfaces are elaborated within BI subsystem-specific ISDs [16][18][20][22][24]. Furthermore, ISDs are traceable to the PIP-II GRD[4] and Parameters PRD[5], BI PRD [11], BI FRSs[12][13], and TRSs [14][15][17][19][21][23][25]. Related traveler or checklists, which define validation plans for operational readiness of BI deliverables, are listed in the PIP-II BI QC Plan[26].

## Alignment Reference

If the hardware interacts with the beam, as in installed in the beamline, a deliverable has been referenced with its own fiducials. This exterior fiducial map is required for final alignment within the PIP-II tunnel enclosure. This reference ensures the installation teams that a deliverable has been reviewed by the AMG team.

At a minimum, PIP-II Misalignment Tolerances PRD [9] shall be followed to define alignment references. Any additional system-specific alignment specifications are documented in that BI subsystem’s TRS [14][15][17][19][21][23][25] and/or ISD [16][18][20][22][24].

## CAD Models & Drawings

CAD models and or drawings provide both technical, mechanical, and assembly details for BI hardware deliverables. These models and drawings should be produced for historical content and shall be associated with documentation for a transition to operations where applicable. These are provided are references in tables with the appropriate BI subsystem’s ISD [16][18][20][22][24]..

## Control System List

This document lists the associated devices to be created within the control system, for each electronics deliverable. In addition, a description of the devices as well any required parameters for general control, readback, alarms, etc. shall be provided.

## Cable Database

Entries within this database shall enumerate all cable needed for each deliverable, except for short interconnect and jumper cables. This should include cable counts, cable types, cable identifiers, and cable pathways (i.e. start location, end location, penetration, etc.).

## Assembly, Test & QC-QA

The PIP-II BI QC plan covers the various acceptance and testing steps required to ensure project deliverables are completed while maintaining the required specifications. This plan is consistent with the overarching Accelerator Systems QA Plan [6]. If inconsistencies between these two documents are discovered, Accelerator Systems QA Plan has precedence.

Specific documents, which define acceptance criteria, verification procedure, assembly procedures, bench test procedures, and associated checklists or travelers for all BI deliverables, are listed within tables in the PIP-II BI QC Plan [26].

## Transportation & Installation

These documents articulate the transfer and installation of BI deliverables. In general, transportation and installation plans are BI-system specific, and are created by BI as procedure or checklist, which is referenced in a larger traveler. All transportation and installation plans are provided in tables with the PIP-II BI QC Plan[26].

These documents should include the following information:

* Starting and ending location of the deliverable during transport
* Point of contact for staring and destination facilities, if applicable
* The physical path and special handing requirements during transport
* Description of work/responsibility at facility (i.e. assembly, cleaning, storage, installation)
* Space and equipment requirements (i.e. duration, environmental, handling, rack locations etc.)
* Documentation and resources to direct work required at facility.

In addition, these documents should follow the guidance of FESHM Chapter 10210 Equipment Transport)[32].

## Operational Documentation

This documentation should provide Beam Commissioning the necessary information and procedure to incorporate and operate any beamline deliverable, during the PIP-II Commissioning Plan[10].This documentation shall also be incorporated with a transition to operations.

## Potential Energy Isolation

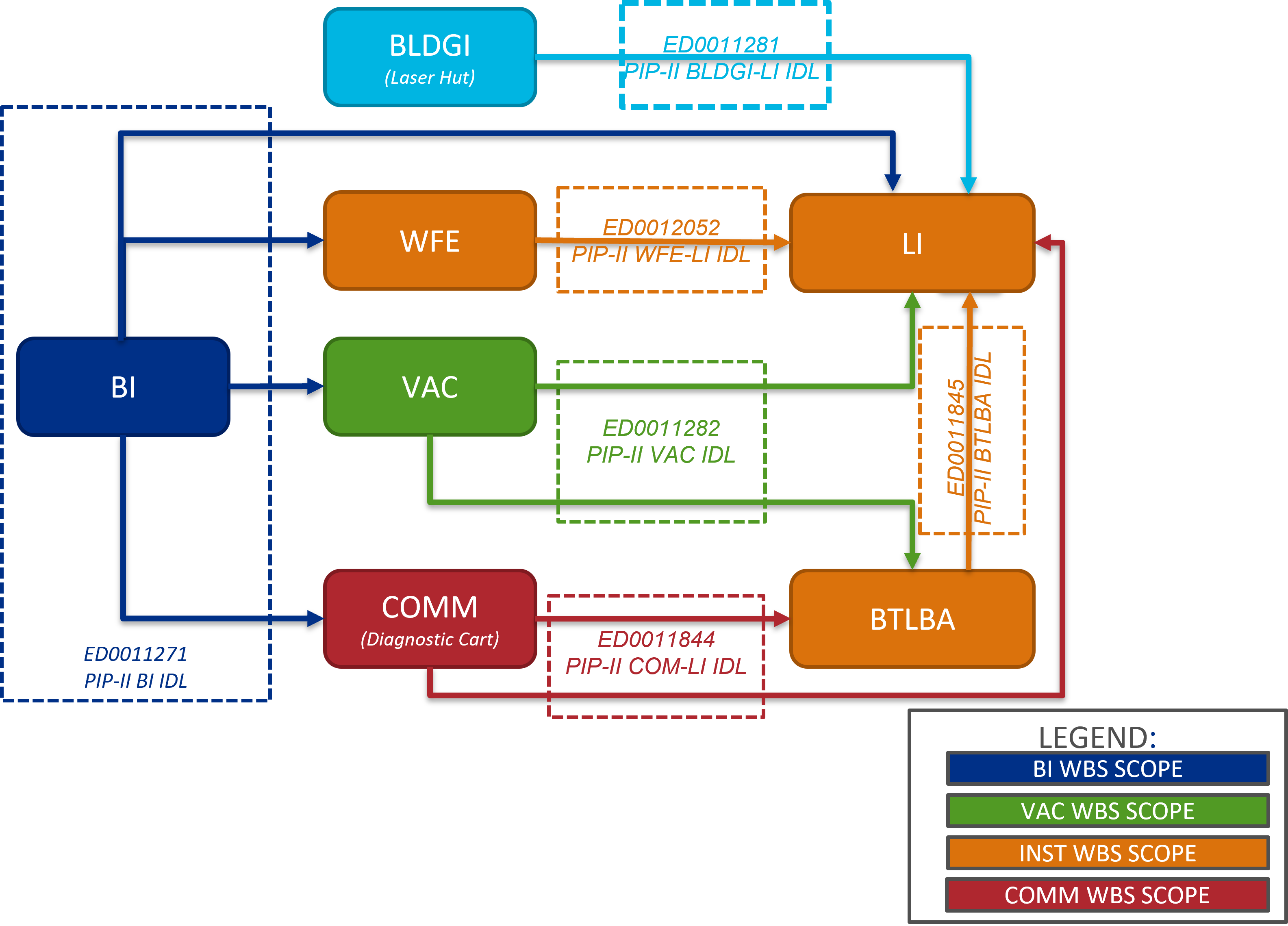
The document identifies a deliverable’s potential energy and describes how to safely isolate that potential energy for operational maintenance or repair. This documentation shall be included for a transition to operations. The document should follow the guidance of FESHM Chapter 2100 - Fermilab Energy Control Program (Lockout/Tagout)[33].

# Deliverable and Scope Definition

BI deliverables shall be hand-off other WBS teams for integration and installation. Hand-offs are depended on BI system type as well as location within the PIP-II accelerator. Figure 5‑1 identifies the installation deliverables at the various hand-offs between BI and other WBS teams.

Furthermore, this section details the descriptions, counts, and associated documentation for deliverable for each of these hand-offs. It is important to reiterate that hand-offs mark a transition of WBS scope and does not necessarily reflect a shift of resources. BI experts will be involved in subsequent integration, installation, and commissioning activities for BI systems.

## Figure 5‑1 : Mapping of Various WBS Installation Deliverables List



## BI Deliverables to WFE

This section elaborates the BI deliverables to WFE, who shall incorporate them into integrated beamline assemblies to be installed in the Ion Source, LEBT, and MEBT beamline sections.

### BPM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| 1.25” MEBT BPM Pickup | 11 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Serialized and assembled BPM pickup with cleaned buttons and housing, which has been leak-check and UHV certified.  No vacuum ports or pumps will be provided with BPM pickups | BPM pickups will be integrated into MEBT vacuum assemblies.  Integrated MEBT vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BPM TRS [15] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |
| BI Reference Line Tap | 6 | High-bay Dock | Each set contains mountable enclosed directional coupler and associated mounting hardware | Serialized and assembled self-counted unit. | BI Reference tap pickup will be mounted onto enclosure ceiling or floor, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI Phase Reference Line FRS [13]  PIP-II BI Phase Reference Line TRS [14] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |

### BLM

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| BLM Neutron Detector Pickup | 2 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |

### BCM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| LEBT DCCT Pickups | 2 | PIP-II cleanroom or LEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into LEBT vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7058 |
| Potential Energy Isolation | (not applicable) |
| MEBT DCCT Pickups | 1 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into MEBT vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7058 |
| Potential Energy Isolation | (not applicable) |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| LEBT ACCT Pickups | 1 | PIP-II cleanroom or LEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into LEBT vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |
| MEBT ACCT Pickups | 2 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into MEBT vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| MEBT RWCM Pickup | 1 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into MEBT vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |
| Protection Resistors for MEBT Invasive BCM Electrodes | 34 | High-bay Dock | Each set contains protection resistors (and its associated mounting hardware and tools) | Assembled, serialized, and enclosed component | Protection Resistor will be installed at each invasive BCM electrode in the MEBT, external to beam line, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

### Invasive BProM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| LEBT AES Subassemblies | 2 | PIP-II cleanroom or Ion Source Unit Integration Location or LEBT Unit Integration Location | Each set contains assembled major AES subcomponents | Assembled and serialized AES subcomponents (e.g. actuator, scanner, load-bearing stand). The ion source housing, provided by WFE, serves as the LEBT AES vacuum chamber.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans. LEBT AES are installed into ion source housings provided by WFE.  Only vacuum ports will be provided by BI in AES subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |
| MEBT AES Subassemblies | 4 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains assembled major AES subcomponents | Assembled and serialized AES subcomponents (e.g. actuator, scanner, vacuum chamber, load-bearing stand).  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans.  Only vacuum ports will be provided by BI in AES subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| MEBT TWS Subassemblies | 4 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains assembled major TWS subcomponents | Assembled and serialized AES subcomponents (e.g. actuator, scanner, load-bearing stand). The scrapper housing, provided by WFE, serves as the TWS vacuum chamber.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans. MEBT TWS are installed into scraper housings provided by WFE.  Only vacuum ports will be provided by BI in TWS subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

### Noninvasive BProM

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| MEBT Laserwire Subassemblies | 1 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains assembled major subcomponents, to be installed in MEBT beamline | Assembled and serialized Laserwire subcomponents, including protected vacuum viewports.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified for low-particulate conditions. | Subcomponents to be integrated into stand and supports following lifting and assembly plans.  Integrated vacuum assemblies for the beamline section as well as intersection with optical transport line will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Noninvasive BProM ISD [24] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Noninvasive BProM ISD [24] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |
| Optical Mirror Box | 1 | PIP-II cleanroom or MEBT Unit Integration Location | Each set contains assembled major subcomponents, to be installed in optical transport line | Assembled and serialized Laserwire subcomponents, including protected vacuum viewports.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified for low-particulate conditions. | Subcomponents to be integrated into stand and supports following lifting and assembly plans.  Integrated vacuum assemblies for the beamline section as well as intersection with optical transport line will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Noninvasive BProM ISD [24] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Noninvasive BProM ISD [24] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

## BI Deliverables to VAC

This section elaborates the BI deliverables to VAC, who shall incorporate them into integrated beamline assemblies to be installed in HWR, SCL warm units, and BTL beamline sections (but not “borrowed” by Diagnostic Cart).

### BPM

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| 2” Warm SCL BPM Pickup | 14 | PIP-II cleanroom or SCL Warm Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Serialized and assembled BPM pickup with cleaned buttons and housing, which has been leak-check and UHV certified.  No vacuum ports or pumps will be provided with BPM pickups | BPM pickups will be integrated into SCL vacuum assemblies.  Integrated vacuum assemblies for the beamline sections will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BPM TRS [15] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |
| BI Reference Line Tap | 7 | High-bay Dock | Each set contains mountable enclosed directional coupler and associated mounting hardware | Serialized and assembled self-counted unit. | BI Reference tap pickup will be mounted onto enclosure ceiling or floor, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI Phase Reference Line FRS [13]  PIP-II BI Phase Reference Line TRS [14] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| 2” Warm BTL BPM Pickup | 56 | PIP-II cleanroom or BTL Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Serialized and assembled BPM pickup with cleaned buttons and housing, which has been leak-check and UHV certified.  No vacuum ports or pumps will be provided with BPM pickups | BPM pickups will be integrated into BTL vacuum assemblies.  Integrated vacuum assemblies for the beamline sections will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BPM TRS [15] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |
| Large Aperture BTL BPM Pickup | 2 | PIP-II cleanroom or BTL Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Serialized and assembled BPM pickup with cleaned buttons and housing, which has been leak-check and UHV certified.  No vacuum ports or pumps will be provided with BPM pickups | BPM pickups will be integrated into BTL vacuum assemblies.  Integrated vacuum assemblies for the beamline sections will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BPM TRS [15] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |

### BCM

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| SCL ACCT Pickups | 2 | PIP-II cleanroom or Warm Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into SCL vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |
| End of SCL ACCT Pickup | 1 | PIP-II cleanroom or End of SCL Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into SCL vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| End of SCL DCCT Pickups | 1 | PIP-II cleanroom or Warm Unit Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into SCL vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7058 |
| Potential Energy Isolation | (not applicable) |

### Invasive BProM

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| End of SCL TWS Subassemblies | 2 | PIP-II cleanroom or BTL Integration Location | Each set contains assembled major TWS subcomponents | Assembled and serialized TWS subcomponents (e.g. actuator, scanner, vacuum chamber, load-bearing stand).  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans.  Only vacuum ports will be provided by BI in TWS subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |
| BTL TWS Subassemblies | 16 | PIP-II cleanroom or BTL Integration Location | Each set contains assembled major TWS subcomponents | Assembled and serialized TWS subcomponents (e.g. actuator, scanner, vacuum chamber, load-bearing stand).  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans.  Only vacuum ports will be provided by BI in TWS subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

### Noninvasive BProM

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| SCL Laserwire Subassemblies | 12 | PIP-II cleanroom or Warm Unit Integration Location | Each set contains assembled major subcomponents, to be installed in MEBT beamline | Assembled and serialized Laserwire subcomponents, including protected vacuum viewports.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified for low-particulate conditions. | Subcomponents to be integrated into stand and supports following lifting and assembly plans.  Integrated vacuum assemblies for the beamline section as well as intersection with optical transport line will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Noninvasive BProM ISD [24] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Noninvasive BProM ISD [24] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |
| Optical Mirror Box | 12 | PIP-II cleanroom or Warm Unit Unit Integration Location | Each set contains assembled major subcomponents, to be installed in optical transport line | Assembled and serialized Laserwire subcomponents, including protected vacuum viewports.  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified for low-particulate conditions. | Subcomponents to be integrated into stand and supports following lifting and assembly plans.  Integrated vacuum assemblies for the beamline section as well as intersection with optical transport line will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Noninvasive BProM ISD [24] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Noninvasive BProM ISD [24] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

## BI Deliverables to COM (Diagnostic Cart)

This section elaborates the BI deliverables to COM, who shall incorporate them into integrated beamline assemblies for the diagnostic cart during phased commissioning. These BI deliverables will later reinstalled in the end of SCL or BTLBA.

### BPM

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| End of SCL 2” Warm BPM Pickup | 6 | PIP-II cleanroom or Diagnostic Cart Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Serialized and assembled BPM pickup with cleaned buttons and housing, which has been leak-check and UHV certified.  No vacuum ports or pumps will be provided with BPM pickups | BPM pickups will be integrated into diagnostic cart vacuum assemblies.  Integrated vacuum assemblies for the beamline sections will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BPM TRS [15] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BPM ISD [16]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BPM ISD [16] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BPM ISD [16] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |

### BCM

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| BTL ACCT Pickup | 2 | PIP-II cleanroom or Diagnostic Cart Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into diagnostic cart vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |
| End of SCL RWCM Pickup | 1 | PIP-II cleanroom or Diagnostic Cart Integration Location | Each set contains beamline pickup unit, individually capped and backfilled, and associated mounting hardware | Assembled and serialized flanged BCM pickup, which has been leak-check and UHV certified, with load-bearing stand  No vacuum ports or pumps will be provided with BCM pickups | BCM pickups will be integrated into diagnostic cart vacuum assemblies.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | (not applicable) |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Protection Resistors for Invasive BCM Electrodes | 5 | PIP-II cleanroom or Diagnostic Cart Integration Location | Each set contains protection resistors (and its associated mounting hardware and tools) | Assembled, serialized, and enclosed component | Protection Resistor will be installed at each invasive BCM electrode, external to beam line, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |

### Invasive BProM

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| BTL TWS Subassemblies | 4 | PIP-II cleanroom or Diagnostic Cart Integration Location | Each set contains assembled major TWS subcomponents | Assembled and serialized TWS subcomponents (e.g. actuator, scanner, vacuum chamber, load-bearing stand).  All individual subcomponents to be subjected to vacuum has been leak-check and UHV certified. | Subcomponents will be integrated into stand and supports following lifting and assembly plans.  Only vacuum ports will be provided by BI in TWS subcomponents.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |
| BSM | 1 | PIP-II cleanroom or Diagnostic Cart Integration Location | Boxed set from vendor | vendor-provided units and associated mounting stand hardware | Subcomponents will be integrated into stand and supports following lifting and assembly plans.  Integrated vacuum assemblies for the beamline section will need to be aligned and vacuumed certified. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Invasive BProM TRS [21] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Invasive BProM ISD [22]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Invasive BProM ISD [22] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI Invasive BProM ISD [22] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (vendor-provided) |
| Potential Energy Isolation | Section 4.11 |

## BI Deliverables to LI

This section elaborates the BI deliverables to LI.

### BLM

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| SCL BLM Neutron Detector Pickup | 23 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |
| SCL BLM PMT Detector Pickup | 27 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| SCL BLM Ion Chamber Detector Pickup | 64 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |
| BTL BLM Ion Chamber Detector Pickup | 68 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| End of SCL BLM Ion Chamber Detector Pickup | 13 | High-bay Dock | Each set contains a loss monitor pickup and associated mounting hardware | Serialized and validated self-contained loss-monitor pickup units, with load-bearing stand | BLM stands will need to be integrated into girder assembly.  BLM pickup will be mounted onto  stand, external to beamline, and do not require alignment or UHV certification. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BLM TRS [17] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BLM ISD [18]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | (not applicable) |
| CAD Models & Drawings | PIP-II BI BLM ISD [18] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BLM ISD [18] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II docDB 7041 |
| Potential Energy Isolation | Section 4.11 |

### Cables

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Bergoz ACCT Interconnect cable | 16 | Hi-Bay or Gallery Dock | Boxed set of cables, from vendor | Pre-terminated cables, cut to 30m | Cable will need to be pulled early, using agreed LSZH mitigation strategy between BLDGI, BI, and Fire Safety Committee | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |
| Bergoz DCCT Interconnect cable | 4 | Hi-Bay or Gallery Dock | Boxed set of cables, from vendor | Pre-terminated cables, cut to 70m | Cable will need to be pulled early, using agreed LSZH mitigation strategy between BLDGI, BI, and Fire Safety Committee | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7058 |
| Potential Energy Isolation | (not applicable) |

### Electronics & Equipment

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Bergoz ACCT Electronics Module | 8 | Hi-Bay or Gallery Dock | Individual Units | Wall-/girder-/cable tray- mountable electronics enclosure box, containing vendor-assembled module. Each module is uniquely matched to a specific interconnect cable and pickup into the tunnel. | BI will handle the installation of the electronics near gallery penetrations, due to interconnect cable length restriction. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7055 |
| Potential Energy Isolation | (not applicable) |
| Bergoz DCCT Electronics Module | 4 | Hi-Bay or Gallery Dock | Individual Units | Vendor-assembled rack-wide chassis, which is uniquely matched to a specific interconnect cable and pickup into the tunnel. | BI will handle the installation of the electronics into the pre-allocated relay racks. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI BCM ISD [20] |
| Control System List | (see electronics deliverable) |
| Cable Database | PIP-II BI BCM ISD [20] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | PIP-II-docDB 7058 |
| Potential Energy Isolation | (not applicable) |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| BI DAQ Servers | 2 | Hi-Bay or Gallery Dock | Boxed set of electronics components, from vendor | Rack-wide servers and installation supports | Installation into server room is required. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI DAQ Electronics TRS [25] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (vendor provided) |
| Potential Energy Isolation |  |
| BI DAQ Network Switches | 15 | Hi-Bay or Gallery Dock | Boxed set of electronics components, from vendor | Rack-wide aggregate and rack network switches and installation supports | Installation into preallocated BI rack space. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI DAQ Electronics TRS [25] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (vendor provided) |
| Potential Energy Isolation |  |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Invasive BCM Biasing Electronics | 5 | Hi-Bay or Gallery Dock | Each set contains of rack-mountable chassis, with patch panels, jumper cables, mounting hardware, 1 Bias Scrapper Electronics Controller Card, and Bias Scrapper Electronics Monitor/readout cards (8,max) | Rack-wide network switches and installation supports | Installation into preallocated BI rack space. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI BCM ISD [20]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation |  |
| Potential Energy Isolation |  |
| DAQ Electronics | 15 | Hi-Bay or Gallery Dock | Each set contains rack-mountable chassis, with patch panels, jumper cables, mounting hardware, AMC cards, RTM cards, Timing modules, and require MTCA platform infrastructure | Rack-wide network switches and installation supports | Installation into preallocated BI rack space. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI BCM TRS [19] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (vendor provided) |
| Potential Energy Isolation |  |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Lifting Fixture for warm unit laser wire optical benches | 1 | Hi-Bay or Gallery Dock | Lab equipment and various assembled units | Note released and legal for use at FNAL. | Delivering L3 provides interface fasteners | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation |  |
| Potential Energy Isolation | FESHM Chapter 2100 [33]  PIP-II BI QC Plan [26] : Section 9 |
| Specialty tooling, fixtures or test equipment for BI | TBD | Hi-Bay or Gallery Dock | Lab equipment and various assembled units | Note released and legal for use at FNAL. | Anything non-standard must be provided by BI | FRS/TRS Checklist |  |  |
| Interfaces MICD |  |
| Connections, ORC & Checkout | PIP-II BI QC Plan [26] |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] |
| Transportation & Installation | Section 4.9 |
| Operational Documentation |  |
| Potential Energy Isolation | FESHM Chapter 2100 [33]  PIP-II BI QC Plan [26] : Section 9 |

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| Deliverable | Qty | Delivery/Handoff Location and Delivery trigger | Shipping/Packaging Configuration | Configuration at Handoff | Support Hardware, Labor, and Logistics | Documentation  (to be presented at IRR) | Notes and Comments  (to be presented at IRR) | Accepted for Installation  (to be filled at IRR) |
| Warm Unit girders and adjustable stands | 25 | Hi-Bay or Gallery Dock | Palletized | Support stand kits and 80/20 mounting hardware | LI provides girders and interface fasteners instrumentation-to-stand interface | FRS/TRS Checklist |  |  |
| Interfaces MICD |  |
| Connections, ORC & Checkout | PIP-II BI QC Plan [26] |
| Alignment Reference |  |
| CAD Models & Drawings |  |
| Control System List |  |
| Cable Database |  |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] |
| Transportation & Installation | Section 4.9 |
| Operational Documentation |  |
| Potential Energy Isolation |  |
| Laser Hut Optics and Equipment | 1 | Hi-Bay or Gallery Dock | A set of commercial components, including a Class IV seed laser, laser fiber amplifier, free-space laser amplifier, optical table, optical components for table | Validated vendor-provided components | Installation into laser hut, and integration with safety system is required. | FRS/TRS Checklist | PIP-II BI FRS [12]  PIP-II BI Noninvasive BProM TRS [23] |  |
| Interfaces MICD | PIP-II MICD [3] |
| Connections, ORC & Checkout | PIP-II BI Noninvasive BProM ISD [24]  PIP-II BI QC Plan [26] : Section 9 |
| Alignment Reference | Section 4.4 |
| CAD Models & Drawings | PIP-II BI Noninvasive BProM ISD [24] |
| Control System List |  |
| Cable Database | PIP-II BI Noninvasive BProM ISD [24] |
| Assembly, Test & QC-QA | PIP-II BI QC Plan [26] : Section 6 & 8 |
| Transportation & Installation | Section 4.9 |
| Operational Documentation | (not applicable) |
| Potential Energy Isolation | Section 4.11 |