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| Delivery Ring Beam Loss Monitors AIP  **BASIS of ESTIMATE FORM (BoE)** | **Document Number:** Mu2e-doc-2226  **Date of Estimate:** 5/4/12  **Prepared by:**  Brian Drendel |

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| WBS Category Number: MuAIP.03.05.02  WBS Category Name: Ring Beam Loss Monitors  Control Account (number and name): |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |
| External Supporting Documents: B. Drendel, M. Olson, “BLM upgrades for Mu2e Storage Rings and Beam Lines,” Mu2e Documents Database #1179, Februrary 2012. |

Update the existing Delivery Ring Beam Loss Monitor System to enable beam loss measurement for both g-2 and Mu2e operations. Repurpose needed parts from the Tevatron Beam Loss Monitor system. Modify existing electronics, hardware and cabling to meet updated performance requirements.

**Preliminary Design:**

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| WBS Category Name: Preliminary Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The preliminary design will continue to develop requirements and specifications for improvements and upgrades to components/hardware and provide data for completing the design effort. The information will also establish data for use by project management to determine a high confidence level in the specifications. Effort will focus on providing documentation to determine if the proposed design meets project requirements.

**Preliminary Design Labor:**  Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.02.02 | Engineering oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 20 | 30% | 26 |
| MuAIP.03.05.02.02 | Engineering oversight | FNAD.ELEC.DESIGN.EN  (Electrical Design Engineer) | 25 | 30% | 33 |

(labor estimates assume 85% efficiency)

**Final Design Labor:**

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| WBS Category Name: Final Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The final design will provide the documents necessary to repurpose and upgrade required components/hardware. Effort will focus on finalization of documentation.

**Final Design Labor:** Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.02.03 | Engineering oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 20 | 30% | 26 |
| MuAIP.03.05.02.03 | Engineering oversight | FNAD.ELEC.DESIGN.EN  (Electrical Design Engineer) | 25 | 30% | 33 |

(labor estimates assume 85% efficiency)

**Implementation:**

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| WBS Category Name: Implementation of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

Implementation will include the installation of components and hardware necessary to support a fully functioning system. Effort will involve repurpose and refurbishing of components to meet project requirements. Included will be the installation and testing of items to ensure functionality.

**Implementation M&S and Labor:** Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3. M&S contingencies were determined by M&S contingency rule #5.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.02.04 | Refurbish Tevatron ion chambers and electronics | FN.M&S.STND | $1K | 50% | $1.5K |
| MuAIP.03.05.02.04 | Engineering oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 25 | 30% | 33 |
| MuAIP.03.05.02.04 | Engineering oversight | FNAD.ELEC.DESIGN.EN  (Electrical Design Engineer) | 25 | 30% | 33 |
| MuAIP.03.05.02.04 | Refurbish and installation of components | FNAD.ELEC.TECH  (Electrical Technician) | 68 | 30% | 88 |

(labor estimates assume 85% efficiency)**Additional Background Information**

Beam Loss Monitors (BLMs) will be the primary beam loss system in the Delivery Ring. The existing loss monitors hardware will be used for low loss secondaries expected for g-2 operations, but will need to be upgraded to handle the higher operational radiation levels for Mu2e operation. Labor and M&S cost estimates were determined via consultation with Accelerator Division Instrumentation experts and are documented in the BLM costing spreadsheets1, and include both materials as well as contract electricians for cable pulls.

* Base Plan: Assumes we repurpose six BLM chassis and 121 ion chambers from the Tevatron. All 121 BLM chambers are refurbished. Existing service building to tunnel cable infrastructure will be reused.
* Higher Cost Option: A second option was explored that would purchase new loss monitor components instead of recycling unused components from the Tevatron. In this plan we would purchase parts to build six new BLM chasses with BLM style backplanes. Each chassis will require six new Motorola processor boards, six new BLM controller cards, six new timing cards, six new abort cards, six new high voltage cards, and 36 digitizer cards. 121 new ion chambers will be purchased and built. This costing for this option was determined to be excessive, requiring additional M&S purchases as shown below and detailed in our costing documentation1. Given that unused components from the Tevatron provides a more economical option with similar functionality.

A comparison of the total labor and M&S costing for the two options mentioned above are given below1:

**Labor:** Total labor hours for preliminary design, final design and implementation stages of the project.

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| Total Hours | | |
|  | Base Plan | Higher Cost Option |
| Engineering Physicist | 65 | 90 |
| Electrical Engineer | 75 | 120 |
| Electrical Technician | 68 | 470 |
| Radiation Physics | 0 | 20 |

**M&S:** Total M&S for preliminary design, final design and implementation stages of the project.

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| Total M&S | | |
|  | Base Plan | Higher Cost Option |
| 6 VME Chassis | $0K | $21K |
| 6 VME Backplanes | $0K | $6K |
| 6 VME Processor Boards | $0K | $18K |
| 6 BLM Controller Cards | $0K | $12K |
| 6 BLM Timing Cards | $0K | $9K |
| 6 BLM Abort Cards | $0K | $9K |
| 6 BLM HV Cards | $0K | $6K |
| 35 BLM Digitizer Cards | $0K | $45K |
| 121 BLM Ion Chambers (purchase) | $0K | $25K |
| 121 BLM Ion Chambers (refurbish) | $1.0K | $0K |
| Totals | $1K | $151K |

References:

1. B. Drendel, M. Olson, “BLM upgrades for Mu2e Storage Rings and Beam Lines,” Mu2e Documents Database #1179, Februrary 2012.