PIP-II Project Assumptions

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CHANGE LOG

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Docdb #	Date	Person Responsible	Change Description
PIP-II-doc-144-v0	February 2017	Steve Holmes	Original document
	November 2017	Steve Holmes	Updated to reflect recommendations from the Director's Review

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1 OVERVIEW AND BACKGROUND

The Project Assumptions document provides clarity around the assumptions, dependencies, and commitments, which are needed to successfully deliver the Proton Improvement Plan-II (PIP-II) Project, and thereby improves transparency and establishes common expectations among all affected stakeholders. This document is prepared in advance of CD-1 in order to provide a firm basis for the development of the Conceptual Design and the associated cost/schedule range required at CD-1, and the further development and execution of the Project through CD-4.

This document is intended as a supplement to the following documents:

- *PIP-II Mission Need Statement* [1]
- *PIP-II Analysis of Alternatives* [2]
- *PIP-II Conceptual Design Report (draft)* [3]
- *PIP-II Project Management Plan (draft)* [4]
- *PIP-II Functional Requirements Specification* [5]
- *Fermilab Risk Management Procedure for Projects and PIP-II Risk Management Plan (draft)* [6]
- *PIP-II Preliminary Project Execution Plan (draft)* [7]

In October 2015 the U.S. Department of Energy/Office of Science (DOE/SC) issued a Mission Need Statement (MNS) for PIP-II. This was followed by CD-0 approval for the PIP-II Project in November 2015. The MNS identifies two primary project goals:

1. To reduce the time required for LBNF/DUNE to achieve world-first results.
2. To sustain high reliability operation of the Fermilab accelerator complex.

The MNS establishes 1.2 MW as the goal for proton beam power delivered from the Main Injector following implementation of PIP-II. The MNS also describes the need to implement PIP-II in a manner that will allow a subsequent doubling of power delivered from the Main Injector based on future upgrades, and the desirability of maintaining compatibility with a subsequent upgrade to continuous wave (CW) operations in support of a broader spectrum of particle physics research opportunities, including muons. The most straight-forward way to achieve these goals is through the replacement of the existing 400-MeV copper linac at Fermilab, with an 800-MeV linac based on superconducting radio frequency acceleration. This configuration has been selected by DOE as the preferred approach following completion of the Analysis of Alternatives process.

R&D aimed at developing the underlying technologies for a high power superconducting linac have been underway for a number of years at Fermilab. This R&D has been undertaken with partner labs in the U.S. and, since 2009, with four Department of Atomic Energy (DAE) laboratories in India. The collaboration with India is formalized via an Implementing Agreement written under the “Agreement on Science and Technology Cooperation between the Government of the United States of America and the Government of the Republic of India” (2005), and an Annex I to the Implementing Agreement outlining potential India/DAE contributions to the PIP-II R&D and construction phases.

PIP-II comprises two primary pieces: 1) an 800-MeV superconducting proton linac that will replace the existing 400-MeV room temperature linac; and 2) a set of improvements and upgrades to the existing accelerator complex required to capitalize on the new linac and meet the goals outlined in the MNS. The PIP-II Project is being developed utilizing Primavera (P6) to create an integrated resource-loaded schedule (RLS). Cobra will be used as the cost processing tool. Fermi Research Alliance (FRA) has a

certified earned value management system (EVMS) that will be used to monitor the DOE portion of PIP-II. Non-DOE contributions to each project are identified as such in the RLS and deliverables will be tracked using monitoring milestones.

PIP-II involves multiple countries and funding agencies. International partners currently include India/DAE and Italy/INFN. Participation of international partners is via in-kind contributions to the R&D phase, and is anticipated to continue to the construction phase. The DOE-managed project will develop a cost-to-DOE Total Project Cost (TPC) that incorporates in-kind contributions from international partners.

This Assumptions Document is a living document, initially reflecting conditions at the time it was written and approved. It is expected some of these assumptions will change as the project progresses. This document will be updated as required, with changes noted in the Change Log.

2 PROGRAMMATIC ASSUMPTIONS

Execution of the PIP-II Project involves multiple interested parties and must be integrated within the ongoing accelerator operations program at Fermilab. Assumptions related to Fermilab, DOE, and external institutions are listed here in order to establish consistent expectations, as required for successful completion of the PIP-II Project.

- PIP-II will be managed as a DOE O413.3b line item project by the DOE/Office of High Energy Physics (DOE/OHEP), with project execution the responsibility of the DOE/Fermi Site Office and Fermi Research Alliance.
- The performance requirements of PIP-II are documented in the PIP-II Functional Requirements Specification (FRS), which represents the application of the goals outlined in the MNS to the Fermilab accelerator complex.
- PIP-II will be constructed on the Fermilab site and will utilize the upgraded Booster, Recycler Ring, and Main Injector for the generation of a long baseline neutrino beam;
- The long baseline neutrino program will eventually require >2 MW of proton beam power at energies within the range 60-120 GeV. This will require eventual replacement of the existing 8-GeV Booster.
- The Mu2e program will eventually require ~100 kW of beam power on target, a factor of ten beyond the initial goal of that program. This beam will have to be provided at duty factors approaching CW.
- PIP-II will be situated to allow the delivery in the long term of 800-MeV protons to the Mu2e Hall on the Muon Campus and the eventual construction of a new accelerator to replace the 8-GeV Booster.
- India is strongly engaged with Fermilab in the R&D phase of PIP-II, and will make a significant in-kind contribution to the PIP-II construction phase. The scope of work for the R&D phase is described in the “Joint Project Document for the R&D Phase of the Indian Institutions and Fermilab Collaboration”. It is assumed that the deliverable dates in this document will be met.
- Agreements on in-kind contributions from international partners to the PIP-II construction phase will be formalized by the time of CD-2.
- The DOE/OHEP will provide budget authority in line with the anticipated funding profile as shown below in $M..

FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	TOTAL
19	15	20	35	60	80	100	102	90	85	50	9	665

- To the extent possible, the PIP-II Injector Test (PIP2IT) being developed as part of the R&D phase will be relocated to form the front end of the PIP-II linac once the required conventional facilities are available.
- Access to SRF infrastructure will be available and operable during the remainder of the R&D phase and throughout production as necessary to maintain schedule. In particular:
    - SRF Processing: cleanrooms, chemical facilities (ANL and FNAL)
    - Performance testing: VTS, HTS, STC, MTS, and CMTF
    - Cryogenic support for the above listed Test Stands
    - QC facilities, including Nb qualification, cavity inspection, and cavity tuning

  - Fabrication Facilities, including the Cryomodule Assembly Facility (MP-9 and ICB) and Lab 2
  -

- Operating funds will be available to support maintenance and operations of PIP2IT systems once commissioning of each system is completed.
- Operating funds will be available to support maintenance and operations of the 800-MeV linac, Booster, Recycler, and Main Injector once Key Performance Parameters (KPPs) associated with each of these systems is achieved.
- Improvements to the Booster, Recycler, and Main Injector required to support continuous improvement in capabilities within the ongoing neutrino research program will be supported via operating funds. Any such improvements will be implemented in a manner consistent with the PIP-II configuration.
- Development, fabrication, installation, and commissioning of a new Booster RF system is incorporated into the Proton Improvement Plan (PIP) and will be supported by operating funds. This system will be designed to be consistent with the needs of PIP-II. In the event that this does not happen PIP-II will utilize the existing Booster RF system.
- Installation and commissioning of new systems required for injection of 800-MeV protons into the Booster will be scheduled coincident with the interruption to accelerator operations in the Main Injector complex required for integration of the long baseline neutrino facility (LBNF).
- PIP-II will be operational by the end of the LBNF shutdown.
- The NEPA process will be complete by June 2018, in advance of CD-2.
- The PIP-II Project will develop an Interface Document with Fermilab, documenting the boundaries of responsibilities between the lab and the project, in advance of CD-1. The Interface Document will be based on this Assumptions Document.

3 SCOPE ASSUMPTIONS

Scope is defined as equipment and facilities to meet the requirements contained in the MNS and FRS, and necessary to meet the PIP-II Key Performance Parameters as defined in the *PIP-II Preliminary Project Execution Plan (PPEP)*. The scope is defined generally in the *PIP-II Conceptual Design Report*.

- PIP-II is organized via a work breakdown structure. This structure is shown in the *PIP-II Project Management Plan*.
- PIP-II will be based on an 800-MeV superconducting linac, constructed of CW-capable components, operated initially in pulsed mode, and accompanied by required modifications to the existing Booster, Recycler, and Main Injector.
- The scope of the PIP-II Project starts at the H- source and ends at the extraction kicker to the LBNF beamline in the Main Injector.
- For all PIP-II systems the scope includes research & development, design, fabrication, inspection and acceptance, installation, and commissioning activities. Commissioning is assumed complete upon meeting the project KPPs. Demolition and decommissioning is not included in the project.
- The PIP-II project will fabricate an adequate complement of spare components to achieve all threshold KPPs and supporting objective KPPs. Such spares will be included in the Project cost.
- In consultation with Accelerator Division, the Project will identify and fabricate an initial complement of spare components adequate to sustain operations. Such spares will be fabricated by the Project and then will be transferred to, and reimbursed from, the Fermilab special process spares account prior to CD-4.
- The PIP-II scope includes all project management activities over the period from CD-0 to CD-4.
- The scope of in-kind contributions assigned to India/DAE for the R&D phase has been formalized and is documented in the Joint Project Document for the R&D Phase. The scope assigned to India/DAE and other international partners for the construction phase will only be formalized by the time of CD-2. However, planning for the construction phase currently assumes the following scope for in-kind hardware contributions:

	Component Fraction Provided	
Component	India/DAE	Other Int'l
Dressed Cavities		
SSR2	50%	
LB650	50%	50%
HB650	50%	
Cryomodules		
LB650		100%
HB650		75%
Linac Warm Magnets	100%	
RF Amplifiers		
325 MHz	100%	
650 MHz	100%	
Controls Hardware*	50%	
LLRF, RFPI Hardware*	100%	
Instrumentation*	50%	
Cryoplant	100%	

* Percentages are approximate

- Possible consequences of non-conformance with standards of in-kind contributions will be captured in the PIP-II risk register.
- The enclosure for the superconducting linac will have sufficient length to accommodate two HB650 cryomodules beyond those nominally required for 800 MeV beam.

4 CONVENTIONAL FACILITIES ASSUMPTIONS

Conventional facilities include all facilities and systems required to house and provide utilities support for the technical equipment for PIP-II technical equipment. The conventional facilities are described in the *PIP-II Conceptual Design Report*, and extend existing Fermilab utility infrastructure to the project site. This section outlines the assumptions that are used in developing the estimates and budget for the conventional facilities.

- 1,400 gallons per minute of industrial cooling water (ICW) will be available for PIP-II process loads. This flow will be available in all operating conditions. The connection location from the existing site-wide ICW will be in the vicinity of AZero;
- ICW will be utilized for Fire Protection. The connection location will be in the vicinity of AZero;
- The PIP-II ICW return discharge will be routed to the existing AZero cooling pond. It is assumed that the existing system to pump the ICW to the Casey's Pond system is adequate for this flow.
- 250 tons of chilled water will be available from the Central Utility Building (CUB) for use by PIP-II. The connection point for the chilled water will be in the vicinity of CUB;
- PIP-II will require six (6) 13.8 electrical feeders, fed from the Master Substation (MSS);
- Existing feeder 46A, fed from the Kautz Road Substation, will be used for backup of critical PIP-II systems;
- PIP-II will install new electrical breakers at MSS;
- Existing electrical ductbanks will be utilized for PIP-II feeders from MSS to manhole P-71 in the main ring;
- New PIP-II electrical ductbanks will be extended from the existing electrical system at manhole P-71;
- New electrical ductbanks will follow the latest safety isolation standards;
- A new utility corridor with natural gas, domestic water supply (DWS), sanitary sewer, data/communications and chilled water will be extended from the vicinity of CUB to the PIP-II project site;
- Maintenance of systems/buildings/structures will be transferred from the PIP-II project to Fermilab at the time of Beneficial Occupancy;
- Conventional facilities will be responsible for the mechanical equipment required for oxygen deficiency hazard (ODH) mitigation. The design, installation and commissioning of the control portion of the ODH system will be accomplished by the Accelerator Division (AD) controls group;
- The maintenance interface point for systems utilizing ICW will be the heat exchanger. FESS will be responsible for operation and maintenance of the system up to and including the heat exchanger while AD will be responsible for the process side of the system as defined as the flanges on the process side of the heat exchanger;
- For systems utilizing ICW without heat exchangers, the interface point will be the strainer/filter. FESS will be responsible for operation and maintenance of the system up to and including the strainer/filter while AD will be responsible for the process site of the system as defined as the pipe flanges on the downstream side of the strainer/filter;
- The maintenance interface point for electrical systems will be the transformers. FESS will be responsible for the operation and maintenance of the system up to and including the transformers and secondary connections at the incoming service panelboards. AD will be responsible for the electrical distribution systems within the buildings.

- Compliance with “One-for-One” Replacement legislation will be accomplished by design the conventional facilities to meet design guidance and reporting of square footage to DOE through standard FESS methods [8].
- Where readily available, Fermilab will provide to the PIP-II project existing precast concrete shield blocks at no charge. The type and quantity will be determined as part of the refinement of the design of the conventional facilities. In the event substantial effort is required to access existing shielding, the project will be responsible for access.
- The existing Booster Tower Southeast (FIMS No. 208) will be demolished as part of the PIP-II project after decommissioning by Fermilab. Delineation of the responsibilities for this work are found in the PIP-II Fermilab Interface document [9].

5 COST/BUDGET ASSUMPTIONS

The processes by which cost estimates and budgets will be developed for PIP-II are documented in the *PIP-II Project Management Plan*. This section outlines the assumptions that are used in developing the estimates and budget.

- The PIP-II Project involves multiple countries and funding agencies. International participation to the development and construction of the facility will be via in-kind contributions. The PIP-II Project will establish costs in U.S. dollars while accounting appropriately for the in-kind contributions and any risk associated with their delivery. The accounting method described below is utilized to arrive at a "cost-to-DOE TPC".
    - The cost estimate for PIP-II is developed at the lowest level of the WBS by identifying the direct costs associated with required services and materials, and effort of laboratory personnel, for all components and systems exclusive of those identified as potential international in-kind contributions. Activities associated with the management, coordination, acceptance, and testing of in-kind contributions are included in this estimate.
    - The cost-to-DOE TPC is then calculated by applying laboratory overhead, escalation, and contingency to this estimate.
- If there were no in-kind contribution to PIP-II, the following technology choices would be modified:
    - 650 MHz RF power sources would be selected from among solid state amplifiers, inductive output devices (IOT), klystrons, or phase-locked magnetrons.
    - The cryoplant would be appropriately sized for low duty factor operations, and configured to allow subsequent upgrade to CW operations.
- The base estimate for the PIP-II Project direct cost will be maintained in FY2016 dollars.
- All scientific labor applied to the DOE-funded portion of the Project in the form of either technical or managerial tasks, will be charged against the Project.
- Earned value management will apply only to DOE-funded activities.
- The PIP-II cost-to-DOE TPC includes all costs starting in mid-January, 2016, shortly after the receipt of CD-0.
- Labor and M&S costs are estimated for each task and are documented in the BOEs. Labor hours are estimated as "touch labor".
- FTEs are calculated assuming 1 FTE=1768 hours/year of touch labor. A full year includes 2080 hours of paid time, with the difference allocated to vacation, sick leave, and breaks. These hours are accounted for in the fringe rate component of the laboratory SWF (salary, wages, and fringe) rates.
- Labor rates for each type of labor resource are captured Cobra, the resource hours are captured in the Resource Loaded Schedule.
- Fermilab ES&H support is off-project and is included in the overhead rate.
- Procurement support is off-project and is included in the overhead rate, with the exception of complex procurements.
- The project will not hold any cost contingency associated with in-kind contributions from international partners. The schedule risk associated with in-kind contributions will be identified in the PIP-II Risk Registry. Risks associated with finalizing international agreements to support the project via in-kind contributions will be held by the DOE Program Office.

- PIP-II will transition to operations as work is completed on the Project. A transition to operations plan that will capture the cost and labor necessary for operations will be developed before CD-2.
- Labor, M&S procurement, and pass-through indirect rates are applied to the project as calculated on an annual basis by the Fermilab Budget Office. The indirect rates are maintained in the Cobra cost processor and applied to the base resource information inputted from the cost estimates into P6. The Special Construction Line Item rate will be applied to all TEC-related expenditures, exclusive of PED.
- The project follows the standard FNAL policies and procedures governing escalation rates, which are determined by the Fermilab Budget Office and are applied to base resource information within P6, via the Cobra cost processor..

- DOE funding for the project in a "normal" year without continuing resolutions can be expected to be received by the project in accordance with standard OMB guidance, as conveyed by the DOE HEP Program Manager and shown in the table below. To provide some budget contingency, the project will assume in its planning a smaller amount in the first quarter. Funding will be assumed to be available to the project in the fourth week of each fiscal year quarter. In addition, to prepare for a potential continuing resolution it is assumed that the initiation of TEC supported activities will not occur in the first quarter of any fiscal year.

	FUNDING ASSUMPTIONS AS % OF ANNUAL DOE FUNDING	
	OMB/HEP GUIDANCE	PROJECT FUNDING ASSUMPTION
Q1	40%	35%
Q2	30%	30%
Q3	25%	25%
Q4	5 %	10%

- Prior to CD-2 the scope will be managed to a "rolling baseline" approach, which allows BCWS to change when schedules are statused. Periodically (quarterly or as necessary) during the pre-baseline period a change will be entered into the Change Request system and logged in the Change Request Log periodically to balance the Current Approved Value (BCWS) as reported in Cobra and the corresponding value in the CR Log.

6 PROCUREMENT ASSUMPTIONS

Due to the international nature of the PIP-II Project, multiple institutions will be procuring various materials and services. Generally, each institution will follow its own processes for procuring items in its work scope.

For DOE-funded scope, specific assumptions regarding procurement include:

- Competitive, best-value proposals will be sought for all major procurements.
- Work assigned to partner DOE labs will be procured through each lab's procurement departments and in accordance to those policies.
- All procurement contracts will be written in U.S. dollars.
- Conventional Facilities construction will primarily be accomplished through competitively solicited, fixed priced construction packages in order to achieve best value procurements. If appropriate and in the best interest of Fermilab, alternate delivery methods will be assessed and implemented. This will be done utilizing Acquisition Planning, and Fermilab's Procurement Department standard policies, procedures and practices. Acquisition Planning will begin as soon as Fermilab's needs are identified.
- Procurement approval cycles through all levels of DOE are incorporated into schedule duration planning based on guidance from the Fermilab Procurement Office, subject to modification on a case-by-case basis at the discretion of the level two/three manager, as follows:

Contract Value	**Procurement cycle duration for various types of contract (Requisition Approval to Purchase Order/Contract award)**
Commercial, off-the-shelf items and services from Domestic Sources	
<$10,000	10 calendar days
$10,000 - 50,000	14 calendar days
$50,000 – 1,000,000	40 calendar days
>$1,000,000	50 calendar days
Fabricated items (metal or electronic)	
<$10,000	30 calendar days
$50,000 – 1,000,000	40 calendar days
>$1,000,000	100 calendar days
Non-commercial	
University sub-contracts	30 calendar days
A&E and labor hour subcontracts	120 calendar days
Sole source foreign procurements	100 calendar days

Additional schedule duration is required to accommodate review by DOE for foreign procurements in excess of $0.5M, triggering the Buy American Act (BAA) review, and all contracts in excess of $5.0M. The additional schedule duration for major procurement subject to this DOE oversight is summarized as follows:

Contract Value	DOE office	Additional schedule duration
BAA>$500,000	DOE Headquarters	60 calendar days
$5,000,000 – 10,000,000	Fermi Site office	30 calendar days
$10,000,000 – 25,000,000	Fermi Site office	50 calendar days
$25,000,000 – 50,000,000	DOE Headquarters	120 calendar days

The PIP-II Project does not anticipate single procurements above $25M.

- The Finance Office will assign a dedicated point of contact for all PIP-II procurements with his/her effort covered by the overhead rate.
- The Finance Office will assign a dedicated Procurement Manager to the PIP-II Project as required to manage complex procurements, by the time of CD-2. The Procurement Manager will report his/her effort directly to the appropriate PIP-II Project task code.

7 SCHEDULE ASSUMPTIONS

The processes by which schedules will be developed for PIP-II are documented in the *Project Management Plan*. This section outlines the assumptions that are used in developing the schedule.

- The Resource Loaded Schedule will include all tasks required to complete the DOE funded scope of work and will be developed to meet all DOE and Laboratory reporting requirements.
- Deliverables from India/DAE, or other international partners, will be represented and tracked via International Tier 3 and 4 (I3 & 4) milestones. All such milestones will correspond to the deliverable dates established in approved international joint documents with three months of float added.
- The deliverable schedules for international in-kind contributions to the construction phase will be formalized by the time of CD-2.
- If project work scope is assigned to other DOE laboratories, their work activities will be included in the Resource Loaded Schedule with institution-specific resources.
- Long-lead procurements will be authorized via CD-3a coincident with establishment of the project baseline at CD-2. Long-lead procurements will include advanced purchases of Nb, initial superconducting cavity orders, and initiation of site preparation activities.
- The intent is to manage the project via one critical path, through the development, design, fabrication, installation, and commissioning of the linac superconducting cryomodules. All other activities will have at least one month of float relative to the critical path.
- All scheduled work will be managed via Primavera P6 and the Cobra cost processor. Tasks incorporated into the P6 schedule will include only DOE-funded activities.
- Milestones for DOE-funded work are tiered to project management levels and higher tier milestones owned by DOE, having schedule float from their early finish dates as follows:
    - Tier 2 – DOE Federal Project Director – 6 months
    - Tier 1 – DOE Program – 1 year
    - Tier 0 – DOE Acquisition Executive for Critical Decision – 2 years, 6 months (CD-4 only)
- The 800-MeV linac and transfer line can be installed and commissioned without interruption to accelerator operations.
- The accelerator shutdown required to connect the beam transfer line into the 8-GeV Booster will be coincident with the accelerator shutdown for LBNF connection into the Main Injector.
- The project schedule will be based on the funding profile shown in section 2.
- The schedule will include effort and materials resources required for the preparation and execution of project and engineering reviews.
- Schedule Risk Mitigations will be incorporated into the Resource Loaded Schedule.

8 RISK AND UNCERTAINTY ASSUMPTIONS

The process for risk management follows the *Fermilab Risk Management Procedure for* Projects with deviations associated with the PIP-II Risk Management Plan. PIP-II risks are captured in the Risk Registry. The process for PIP-II risk management is in accordance with the Fermilab procedure with specific information documented in the *Project Management Plan*. Specific risk assumptions are as follows:

- Assessment of cost and schedule risk impacts will be used to produce cost and schedule contingencies.
- Risks associated with delivery of international in-kind contributions will be identified within the PIP-II Risk Registry, and incorporated into the project schedule contingency. Risks associated with finalizing international agreements to support the Project are held by the DOE Program Office.
- Cost contingency directly related to identified risks will be used to assess the adequacy of the TPC at CD-1.
- The schedule contingency will be used to assess the adequacy of the schedule float on the DOE CD-4 milestone.
- Risks will be discussed at least monthly by the Project teams and actively managed.

9 REFERENCES

[1] "PIP-II Mission Need Statement (PIP-II Document 152)," October 2015. [Online]. Available: http://pip2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=152.

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[3] "PIP-II Conceptual Design Report (PIP-II Document 113)," November 2016. [Online]. Available: http://pip2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=113.

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[5] "PIP-II Functional Requirements Specification (TeamCenter Document ED0001222)," February 2017. [Online].

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[7] "PIP-II Preliminary Project Execution Plan (PIP-II Document 115)," October 2016. [Online]. Available: http://pip2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=115.

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[9] "PIP-II - Fermilab Interface Document," 2017 October. [Online]. Available: https://pip2-docdb.fnal.gov/cgi-bin/private/ShowDocument?docid=528.