Risk, Safety and Quality Control

Vic Scarpine

PIP-II Beam Instrumentation Laser Wire
Final Design Review

May 2, 2024

A Partnership of:
US/DOE
India/DAE
Italy/INFN
UK/UKRI-STFC
France/CEA, CNRS/IN2P3
Poland/WUST

Outline

- Laserwire project risks
- Prevention through design
- Laser safety
- Quality control

PIP-II Risk Register (PIP-II docDB 1233)

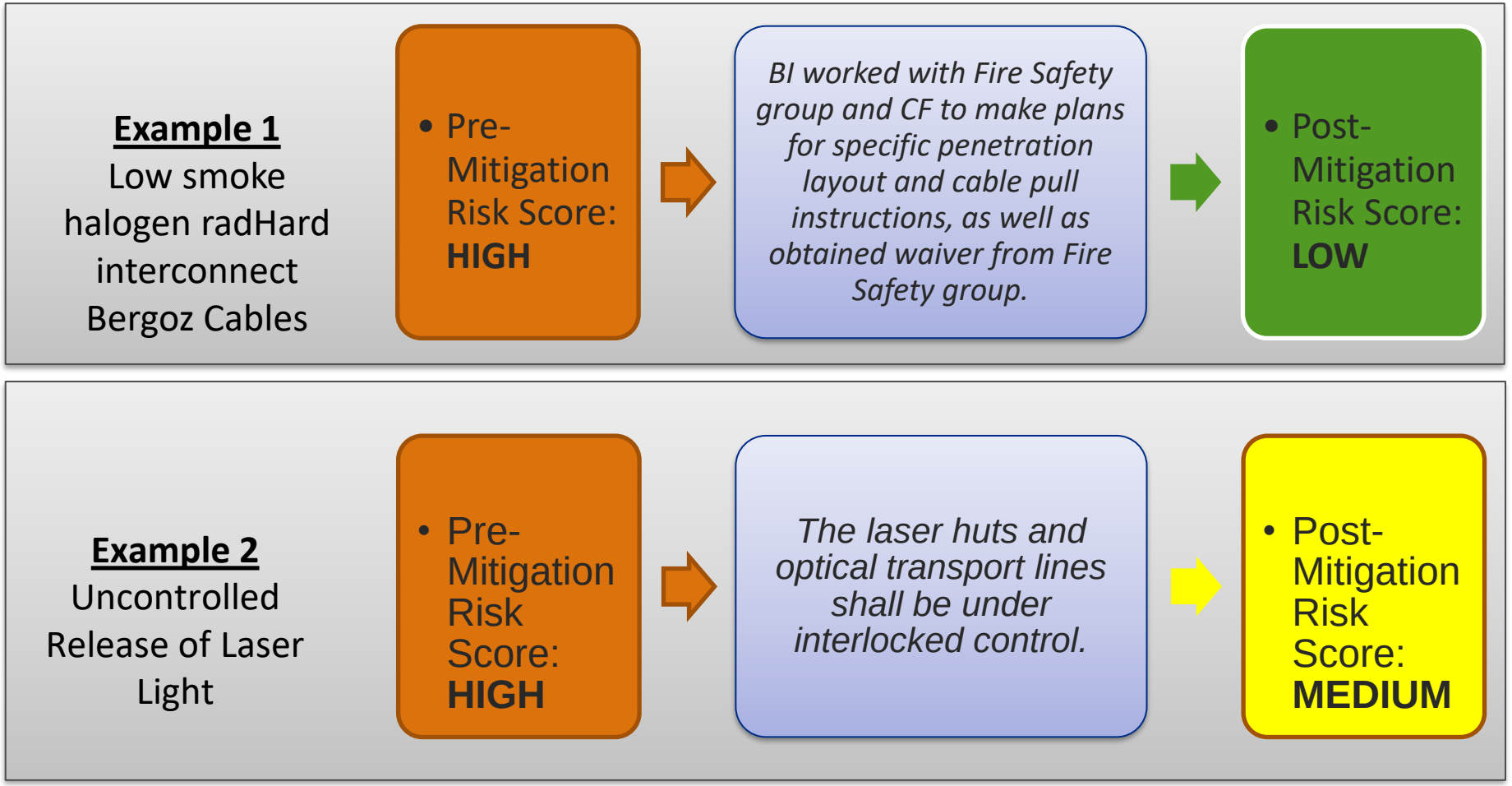
- Any new or emerging risks shall be managed per the PIP-II Risk Management Plan (PIP-II docDB 163)
- Identified critical project risks are documented in the PIP-II Risk Register (PIP-II docDB 1233)
- During PIP2IT, Beam Instrumentation had two laserwire risk register entries retired
  - Preferred Laser profiling technology/transport mode does not adequately measure profiles – retired based on PIP2IT
    - Fiber-based system works but low signal-to-noise
  - Premature aging of laser profile transport components - retired
    - Optical fibers no longer being used
- Added a new risk related to the laser profile transport
  - Laser transport vacuum failure (next slide)

Remaining Laserwire Risk

1. (Low)RT-121-03-048 AccS: Laser transport vacuum window failure
   - Only remaining open BI entry in Risk Register
   - Risk from laser induced damage to optical vacuum window seal or glass
   - Addressing through Prevention through Design
     - Design laser transport system to prevent overfocusing laser (see Laser Transport Optics and Alignment talk)
       - Industry standard limits laser power density to < 10 J/cm^2. We plan to limit ours to < 3 J/cm^2
         - 150mJ/cm^2 in 10µs at 20Hz
   - Addressing through simulations
     - Use thermal mechanical models to simulate laser-glass interactions – ANSYS (see Laser Wire Mechanical Design talk)
   - Addressing through lab tests
     - Test sample of vacuum windows under intense laser power to study induced damage
   - Investigating thermal-cycling of production vacuum windows to reduce possible failures
   - Goal to retire risk by end of 2024

Prevention Through Design

9 Safety risks to personnel were assessed using Prevention Through Design" (PTD) approach (ED0015598)



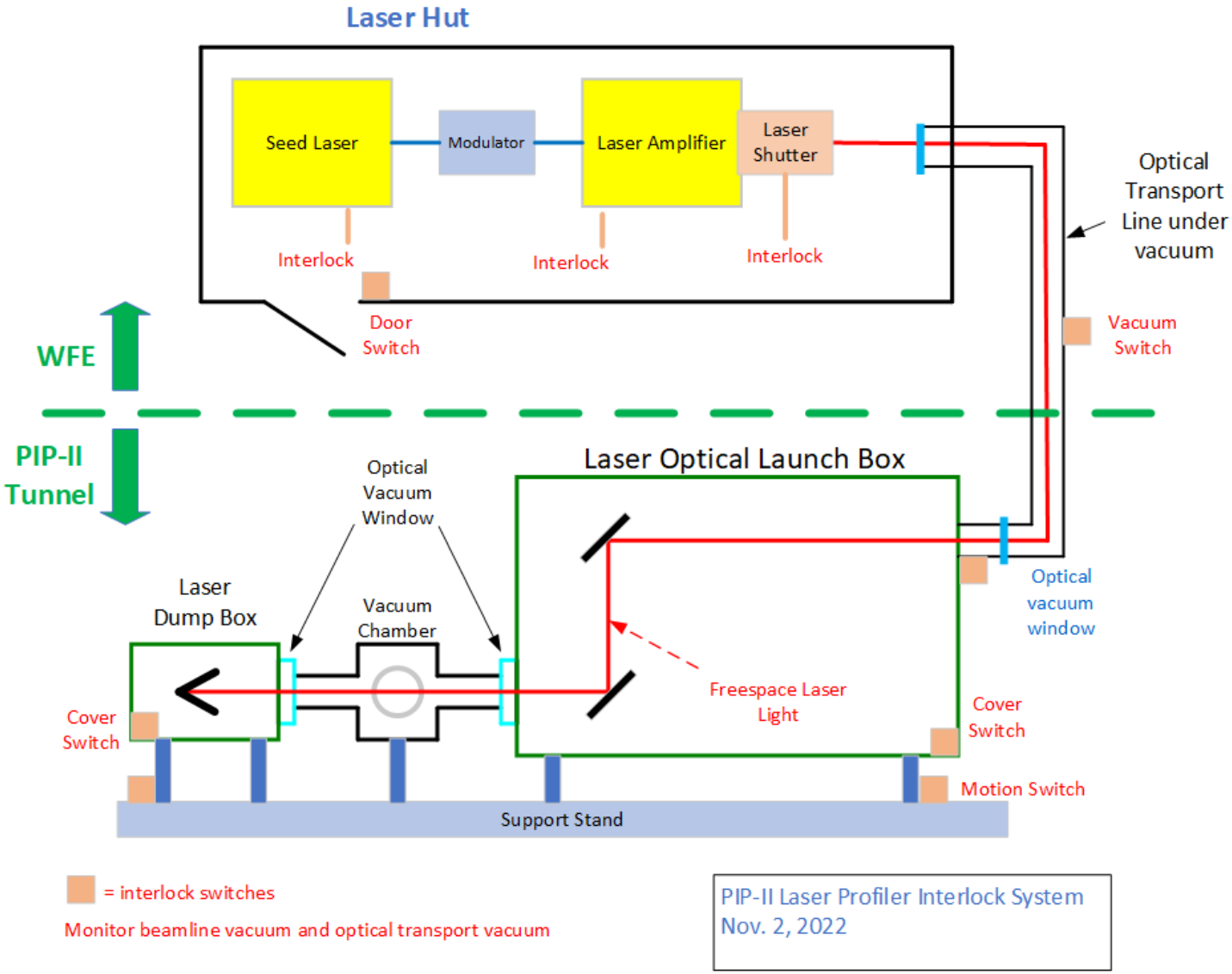
Beam Instrumentation Prevention Through Design Items

Risk	Mitigation
Small injuries on equipment extending from the beam line	"Caution" signage affixed to equipment and/or protection material (e.g. foam) wrapped around parts of the component posing some risk.
Electrical shock (HV) during testing, maintenance or repairs	All electrical connectors will have plastic/Plexiglas covers preventing contact with them by accident. Standard (or written) LOTO procedures as applicable. In addition, designs will address improper grounding of electronics and power supplies, isolation from high voltage, and protection resistors to bias components. Review required PPE. Have engineering reviews of schematics as well as inspections of all connections after installation.
Low smoke halogen radHard interconnect Bergoz Cables	BI worked with Fire Safety group and CF to make plans for specific penetration layout and cable pull instructions, and obtain waiver from Fire Safety group
Uncontrolled release of laser light	The laser huts and optical transport lines shall be under interlocked control.
Pinching injuries on movable parts	Design include removable pinch guarding, physical guarding to protect from incidental contact, cable motion and strain relief; Have engineering reviews of schematics as well as inspections of all connections after installation
Injury during installation / replacement of Instruments	Added lifting and hoisting hooks to design; Have engineering reviews of schematics, procedures, and training; Inspections of all connections after installation; Provide installation plans, Lift plans, and Hazard Analysis; Review of risks and procedures when storing components as well as movement to/from storage
Trips on cabling/tubing	Cables will be dressed appropriately, and platforms will be installed over cables/pipes crossing traffic path. If needed, Signs indicating tripping hazards will be affixed as appropriate.
Electrical shock (personnel) or property damage due to mislabeling of cables	Quality control when pulling cables, repairing connectors, terminating connectors; continuity checks before powering up; Review of required PPE, assembly procedures and system designs/inventories. Standard (or written) LOTO procedures as applicable.
Radiation Hazards near Dumps and activated elements	All BI systems shall follow standard FNAL ESHQ policies and procedure, to cover radiation and ODH hazards. All personnel must take and maintain the necessary ESHQ training courses. LI, with input from BI, will be responsible for all HA/IMPACT forms during installation activities, as well as coordinating those activities with commission. Since BI will support installation/repair activites (e.g. dis-/connecting cables), connecting plates/panels shall be used to address time/distance/location issues when needed.

Laserwire Operational Safety

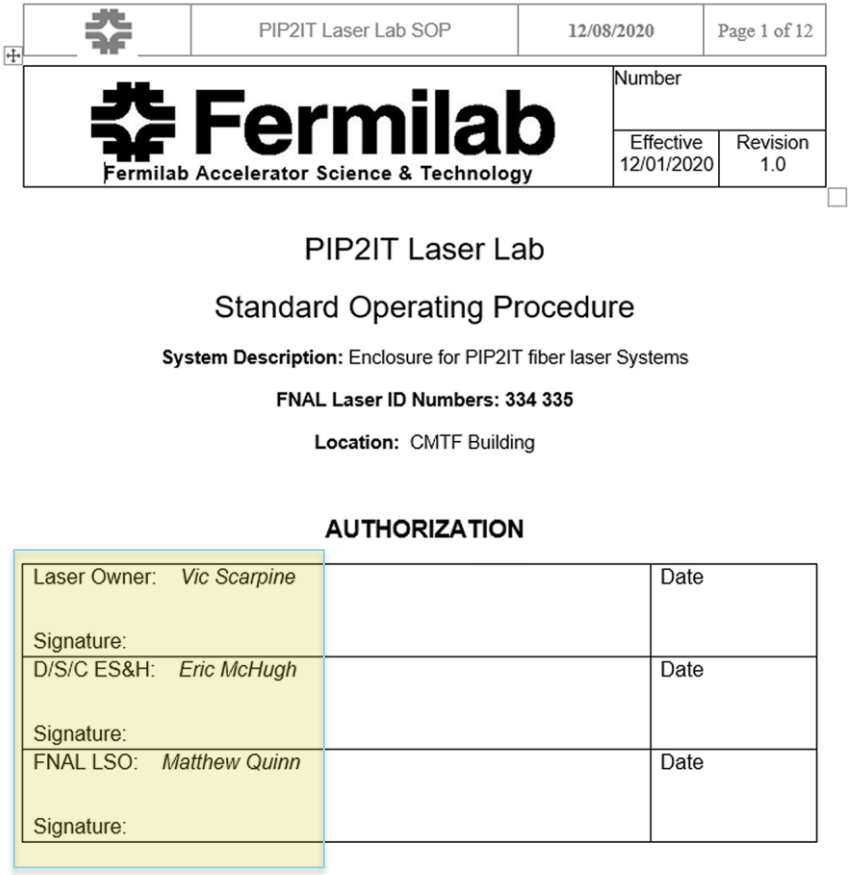
- Laser safety system protects personnel
- Laserwire safety is controlled by interlock system. Primary monitored components of interlock system are:
  - Laser hut door switches
  - Optical transport line vacuum switch
  - Beamline laserwire station switches
  - Beamline vacuum switch
- Control release of laser light from laser hut via
  - Closing optical shutter
  - Dropping of laser interlocks
- PIP2IT laserwire interlock system will be the bases for PIP-II laserwire interlock system.
  - Similar to accelerator interlock safety system
- Fermilab laser safety officer (LSO) approval needed for laser operation

PIP-II Laserwire Interlock System



Laser Safety Operation for PIP2IT Laserwire

PIP2IT Laser Interlock access control and status



PIP2IT Laser Lab SOP	12/08/2020	Page 1 of 12

Fermilab
Fermilab Accelerator Science & Technology

Number	
Effective 12/01/2020	Revision 1.0

PIP2IT Laser Lab

Standard Operating Procedure

System Description: Enclosure for PIP2IT fiber laser Systems

FNAL Laser ID Numbers: 334 335

Location: CMTF Building

AUTHORIZATION

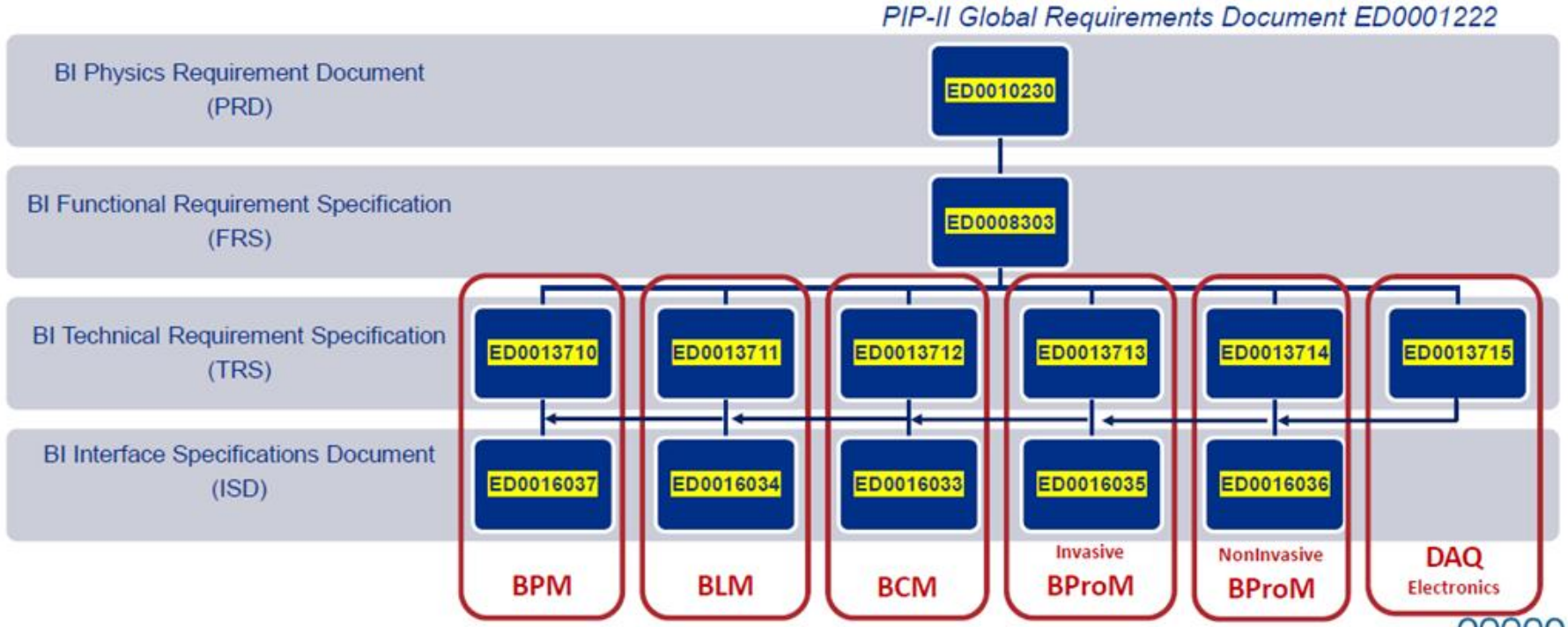
Laser Owner: *Vic Scarpine* Signature:		Date
D/S/C ES&H: *Eric McHugh* Signature:		Date
FNAL LSO: *Matthew Quinn* Signature:		Date

PIP2IT Laser Operation Procedure

Quality Control

- PIP-II Beam Instrumentation Quality Control Plan (PIP-II docDB 5520) host tables, in which all acceptance documents, verification procedures, and travelers are enumerated, for each BI system.

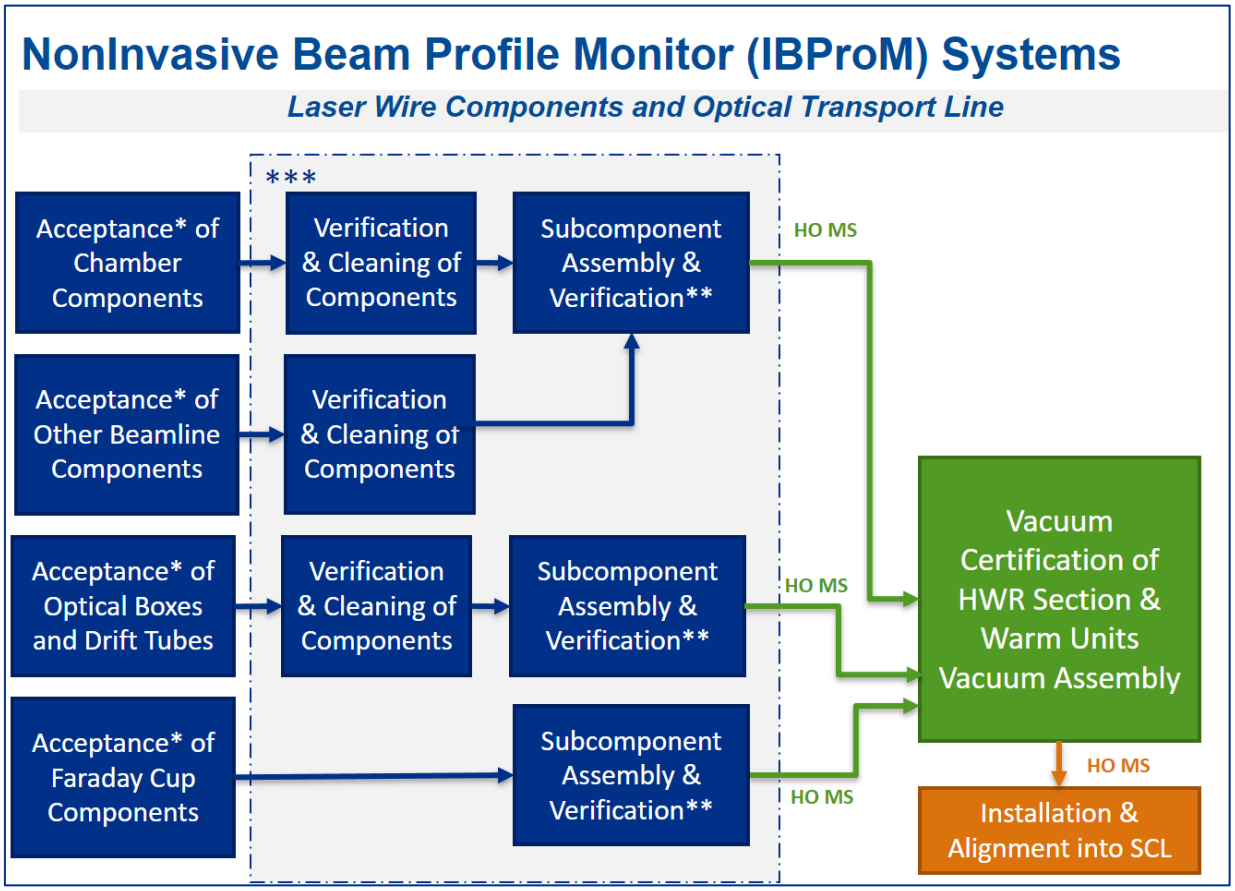
Figure 5-1 - Diagram depicting Traceability of BI Requirements and Specifications



UHV Vacuum Chamber Assembly and QC
(from Mechanical Design talk)

- Vacuum chamber will be fabricated, cleaned and assembled following AD-Mechanical Support Department procedures for particle-free UHV

Particle-free UHV Assembly and QC process. Courtesy of Aisha Ibrahim



Laserwire QC Documentation Identified

Table 6-5- Acceptance Documents For Noninvasive BProM System

Document	Document #
Optical Transport Line System Acceptance Procedure	TBD
Laser Hut System Acceptance Procedure	TBD
Acceptance Procedure for Laserwire Beamline Optical Units	TBD
Acceptance Procedure for Laserwire Beamline Vacuum Units	TBD
Laserwire Application-Specific Software Acceptance Procedures	TBD

Table 8-5- Verification and Validation Documents for Noninvasive BProM System

Document	Document #
Laser Source Operational and Test Procedures for LW	TBD
Stand-alone Test Procedure for Individual Optical Units	TBD
Test Procedure for Individual Optical Transport Line	TBD
Test Procedure for Laser Hut Interlocks	TBD
LW System Software and DAQ Test Procedure	TBD

Table 9-5 : Travelers/Checklists and Related Documents for Noninvasive BProM System

Document	Document #
Acceptance Traveler for Laser Hut Components	TBD
Acceptance Traveler for Optical Transport Line Components	TBD
Acceptance Traveler for Laserwire Beam Profile and Components	TBD
Installation Checklist for Laser Hut System	TBD
Installation Checklist for Optical Transport Line	TBD
Installation Checklist for Laserwire System	TBD
Inventory of Noninvasive BProM Systems and Serialized Subassemblies	TBD