Fermilab

U.S. DEPARTMENT OF ENERGY Office of Science

Mu2e WBS 5.8 Muon Beam Stop Director's CD-2 Review

Rodger Bossert
Muon Beamline Level 3 Manager – Mu2e Muon Beam Stop

7/8/2014

Requirements

The Muon Beam Stop (MBS) will be located within the bore of the Detector Solenoid (DS), and is designed to absorb beam particles, which consist mainly of electrons and muons, that reach the downstream end of the solenoid while minimizing the background to the surrounding detectors resulting from muon decays and captures in the beam stop.

The Mu2e Muon Beam Stop requirements and specifications are documented in Mu2e-doc-1351.

Requirements

Physics Requirements

- Shielding should ensure that the rate seen by the CRV from particles originating in the MBS should not be larger than the rate from the stopping target. Satisfying this requirement is the joint performance of the MBS and the Downstream External Shielding.
- Backsplash particles from the MBS should not produce delayed signals that could be mistaken for conversion electrons in the Tracker.
- The MBS should not produce secondary particles with a larger radiation impact on the calorimeter than those that arise from the stopping target.
- A clear line-of-sight is required from the muon stopping target, through the muon beam stop to the muon stopping target monitor, which is to be located well downstream of the MBS.

Requirements

Mechanical Requirements

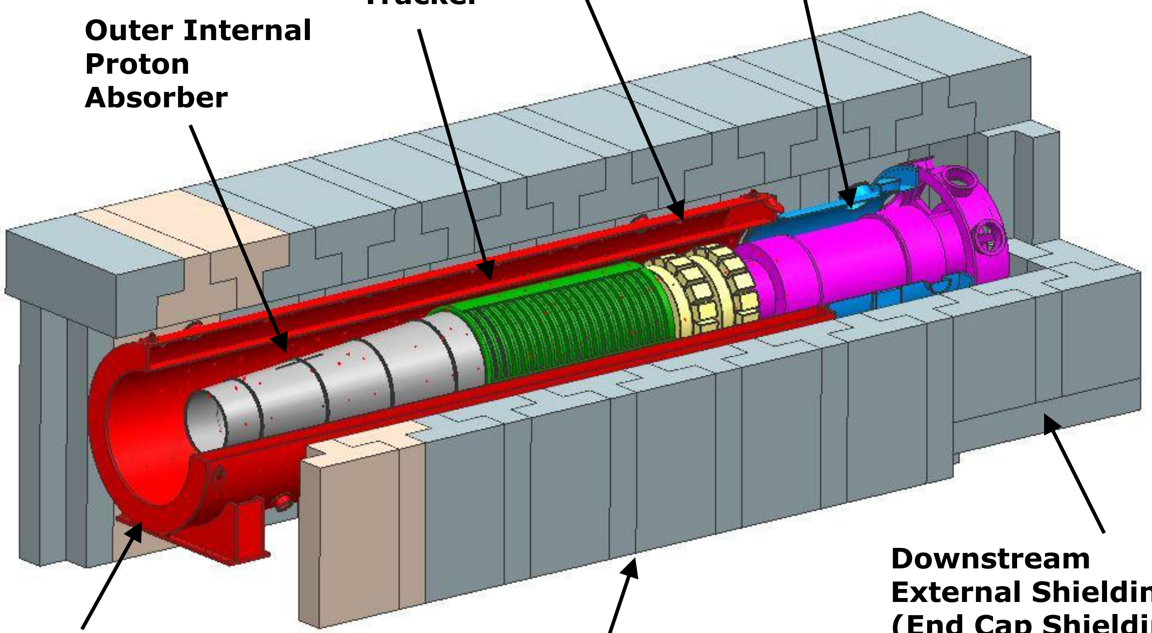
- The Beam Stop and support structure must be designed to accommodate and support cabling, cooling tubes and source tubes from the Tracker and Calorimeter.

- Total mass of the Beam Stop must not exceed the load requirements of the DS internal bore.

- The Beam Stop must provide a connection between the IFB (Instrumentation Feed Through Bulkhead) and the other internal detector components which will allow a longitudinal position reproducibility within 1 mm.

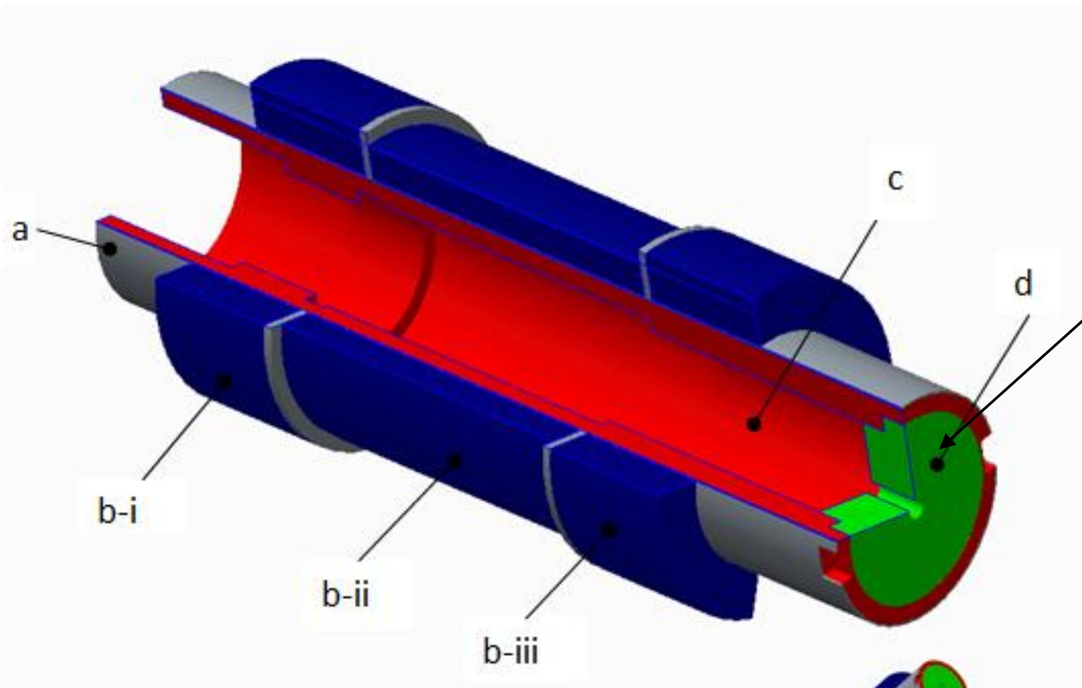
Design

The Muon Beam Stop will be located within the bore of the Detector Solenoid, and will be located longitudinally between the IFB and the Calorimeter.



Design

This preliminary design of the MBS consists of several concentric cylindrical structures of stainless steel and high density polyethylene.



a. Stainless steel tube and rings (gray)
b. Exterior absorber (blue)
c. Interior absorber (red)
d. End plug with axial hole (green)

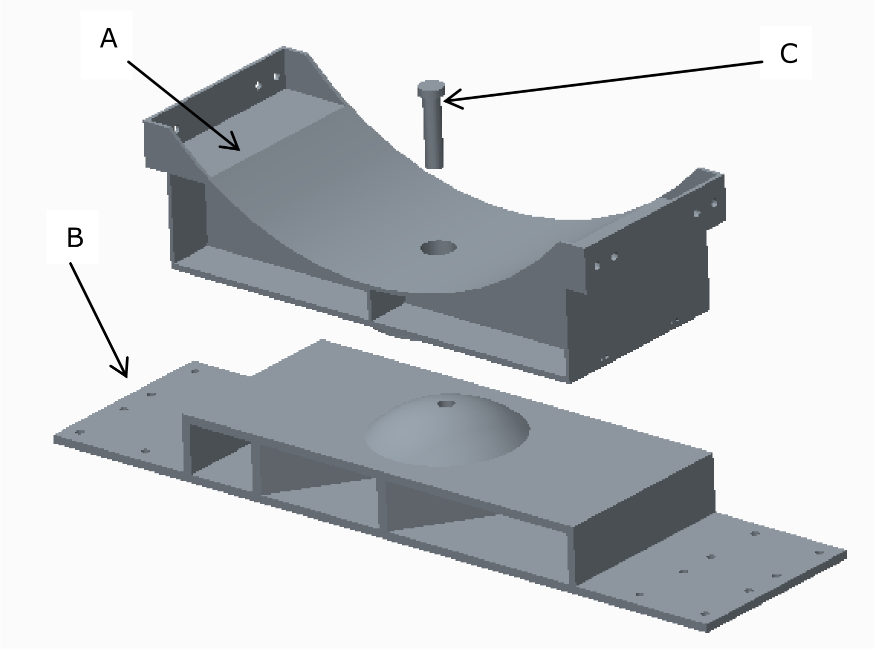
The poly end plug contains an 80mm diameter hole to allow line-of-sight from the stopping target to the stopping target monitor.

Some areas of polyethylene are cut away to allow space for support structures, cooling tubes and source tubes from the detectors.

Design

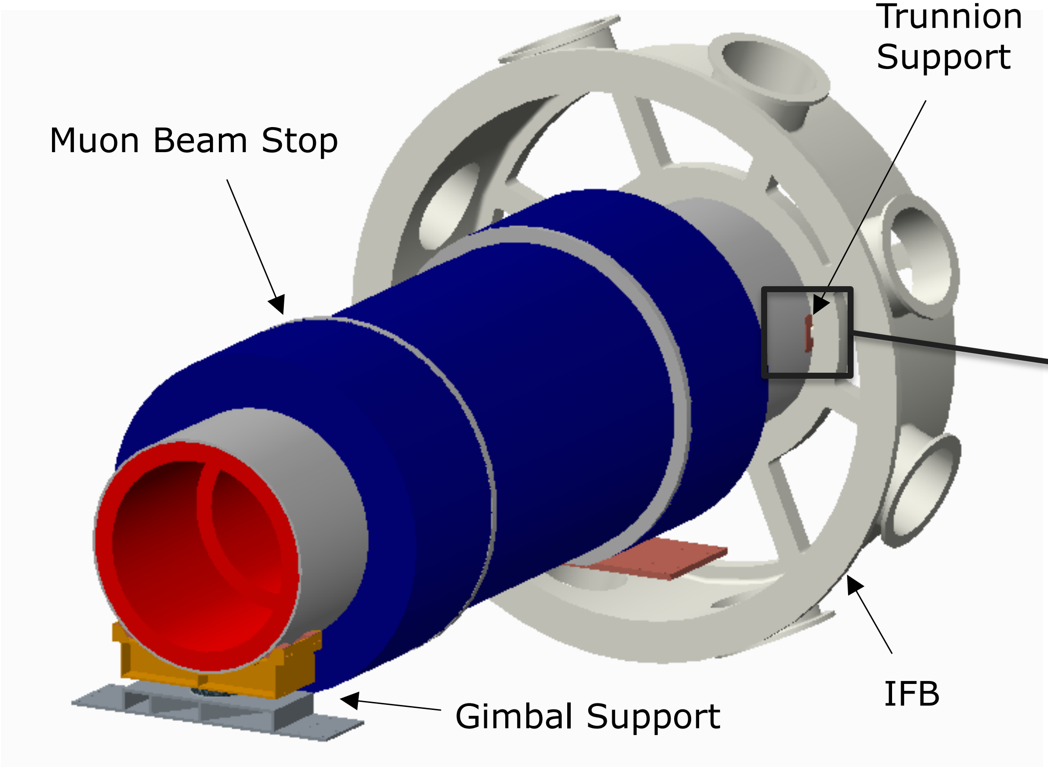
The beam stop is supported on the internal rail system by a “gimbal support” on the upstream end   It is supported on the downstream end by the IFB through a “trunnion assembly”.

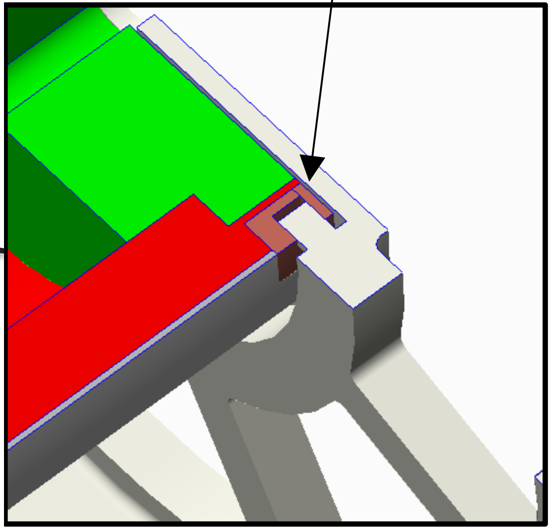
The 3-part gimbal support allows the upstream end of the MBS to remain accurately placed on the rails while still accommodating the larger movement of the downstream end during detector train insertion.



Design

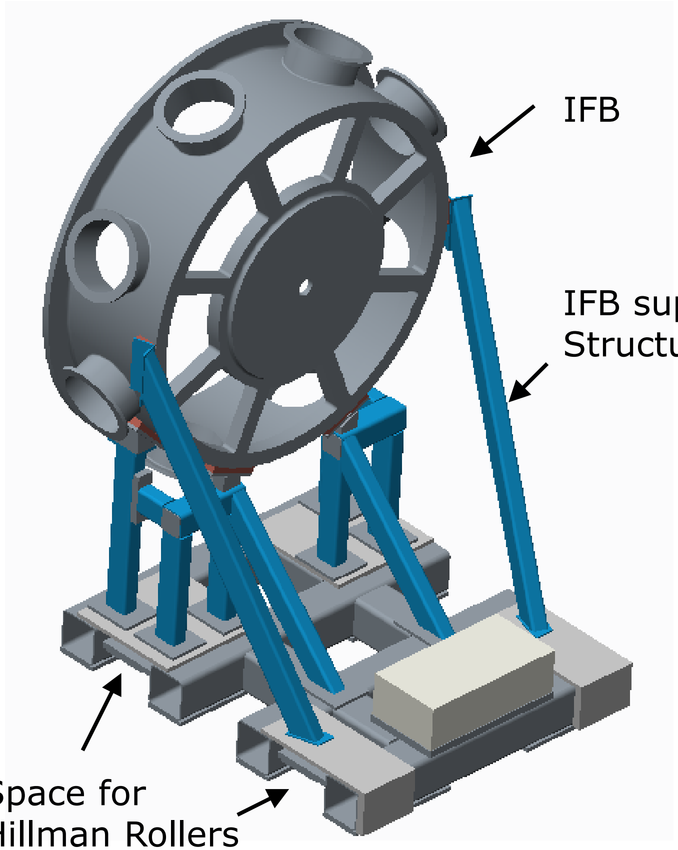
On the downstream end, the trunnion attaches to the IFB, which is supported separately from the rest of the internal detector components.





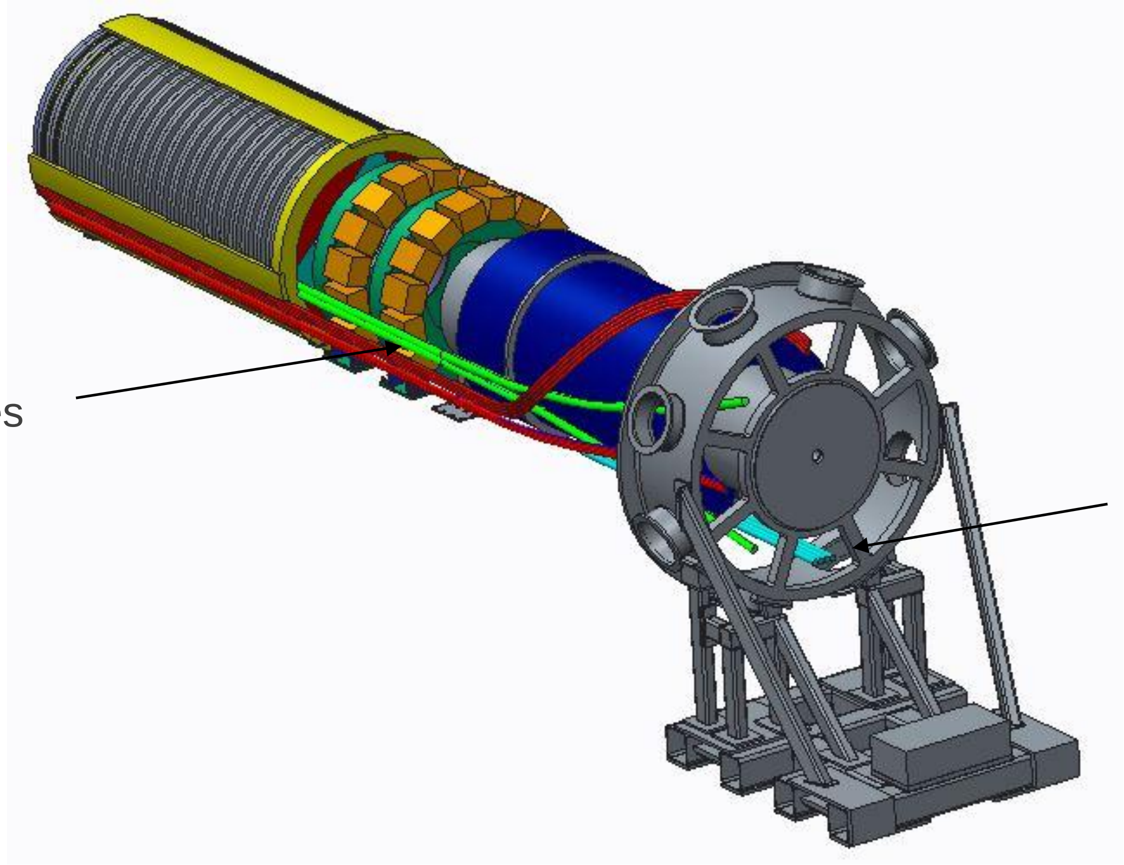
Design

The trunnion attaches to the IFB, which is supported separately from the rest of the internal detector components, and rides on Hilman rollers, on a separate floor track.



Design

The Muon Beam Stop must accommodate the cables, cooling tubes and source tubes from the calorimeter and the tracker, which will extend over the length of the MBS and be terminated at and permanently attached to the IFB.



Changes since CD-1

– Optimizing design to enhance performance

- An extensive series of simulations
- Lead has been eliminated
- Mass has increased, with more polyethylene

– Support of downstream end transferred from rails to enclosure

- Reduces number of individual external stands required in detector support and installation system

Value Engineering since CD-1

Redesign of support system to allow downstream end of MBS to be supported by IFB allows simplification of the external support system, but requires an additional temporary support for the downstream end of the MBS prior to transferring the load to the IFB.

Performance

- Preliminary configuration of the beam stop and the end cap shielding satisfy the performance criteria, however, optimization continues in an attempt to enhance the margin.

- New support system satisfies the vertical, lateral, and longitudinal criteria for placement.

- Mass of MBS does not exceed the maximum load necessary for DS bore, although some structural calculations are still pending.

- Current configuration of MBS and supports allow for routing of services from Tracker and Calorimeter.

Remaining work before CD-3

- Continue simulations to establish final geometry and optimize material selections.
- Test “gimbal-trunnion” support system on rail system mockup.
- Continue and document all structural calculations.
- Complete layout and design of cable and tube routing along the MBS.
- Refine and complete documentation of Installation procedure.

Quality Assurance

- Quality Assurance in the Muon Beam Stop efforts will rely about the following tools :
  - Fermilab Quality Assurance Manual
  - Fermilab Engineering Manual
  - Documented engineering calculations and drawings
    - reviewed, approved and released
  - Verification of physics simulations
    - Comparisons between MARS and GEANT4
  - Prototypes and mockups as appropriate
  - Documentation of procedures
  - Delivered materials will be inspected for conformance to the specifications

Risks

There are no moderate or high risks which involve the Muon Beam Stop.

There is a low risk that the fit of the polyethylene parts into and over the stainless tube is not adequate to allow the structure to be assembled. This will be mitigated by ordering the stainless steel structural member first, and using the measured values to specify the sizes of the HDPE parts (as described above). If time does not allow this to be done, careful tolerances and inspection of the parts before arrival will mitigate this risk.

There is a low risk that the “gimbal and trunnion” assembly, which is meant to allow for any variations in movement of the IFB on Hilman rollers does not work as planned. This risk will be mitigated by a test of the system on an existing rail system mockup.

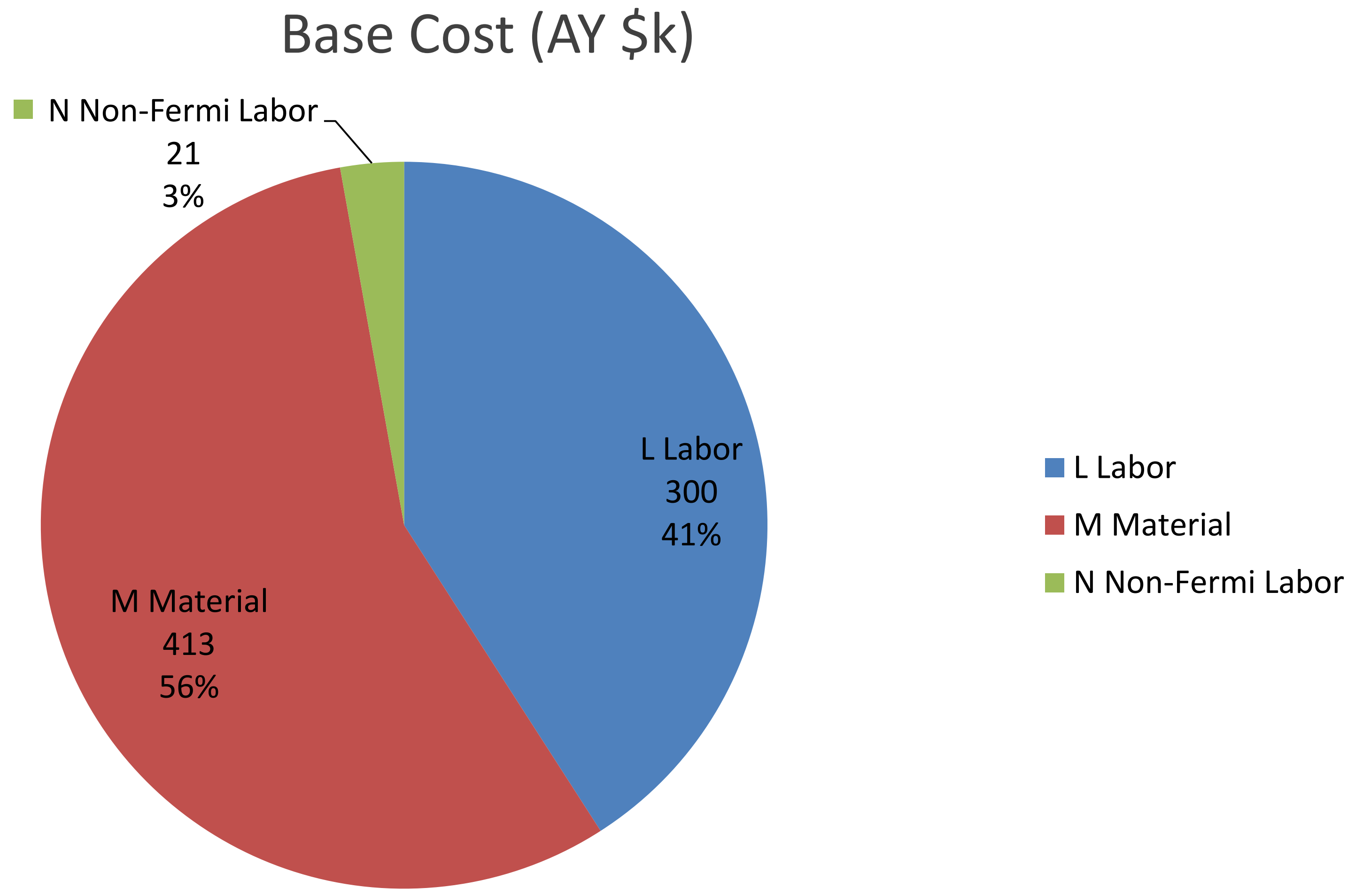
There also is a low risk that the weld between the stainless structural tube and the reinforcing rings will have a magnetic permeability higher than the requirements specify. This will be mitigated by performing tests on weld samples with the materials before manufacturing, and testing the MBS welds for permeability as part of the incoming inspection process.

ES&H

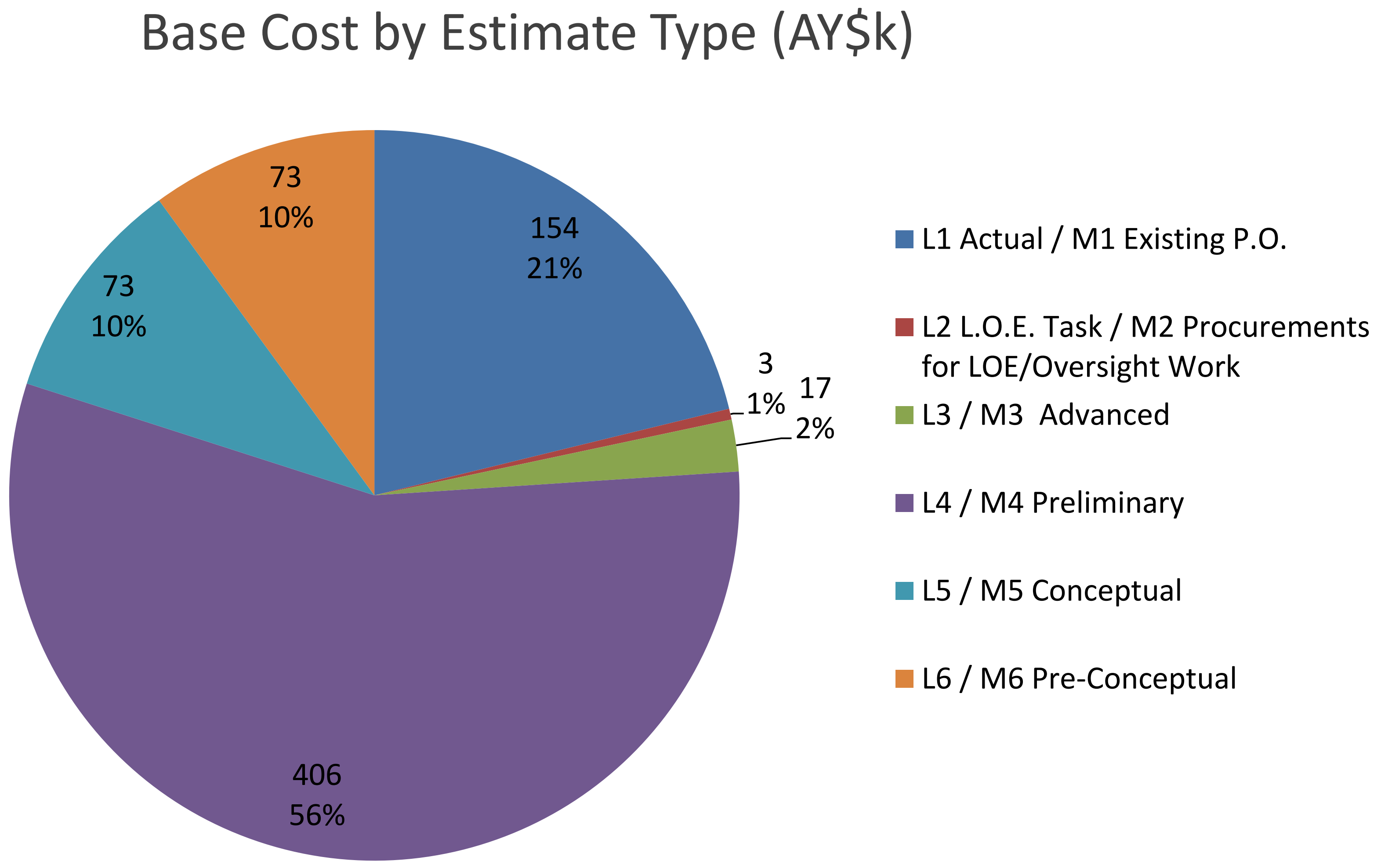
To perform Muon Beam Stop activities safely will require appropriate planning (JHA), attention to ES&H considerations and FESHM and FRCM requirements

- Accessing confined space FESHM 5063
- Crane, hoist, and forklift use FESHM 5021
  - Including lifts beyond direct crane coverage
- Fall Hazards FESHM 5066
- Magnetic fields FESHM 5062.2
- Electrical hazards FESHM 5042
- Fire hazards
- Hydraulic and perhaps pneumatic systems (and potential stored energy)
- Radiation hazards FRCM
  - Activation by beam
- And possibly ODH
  - FESHM 5064

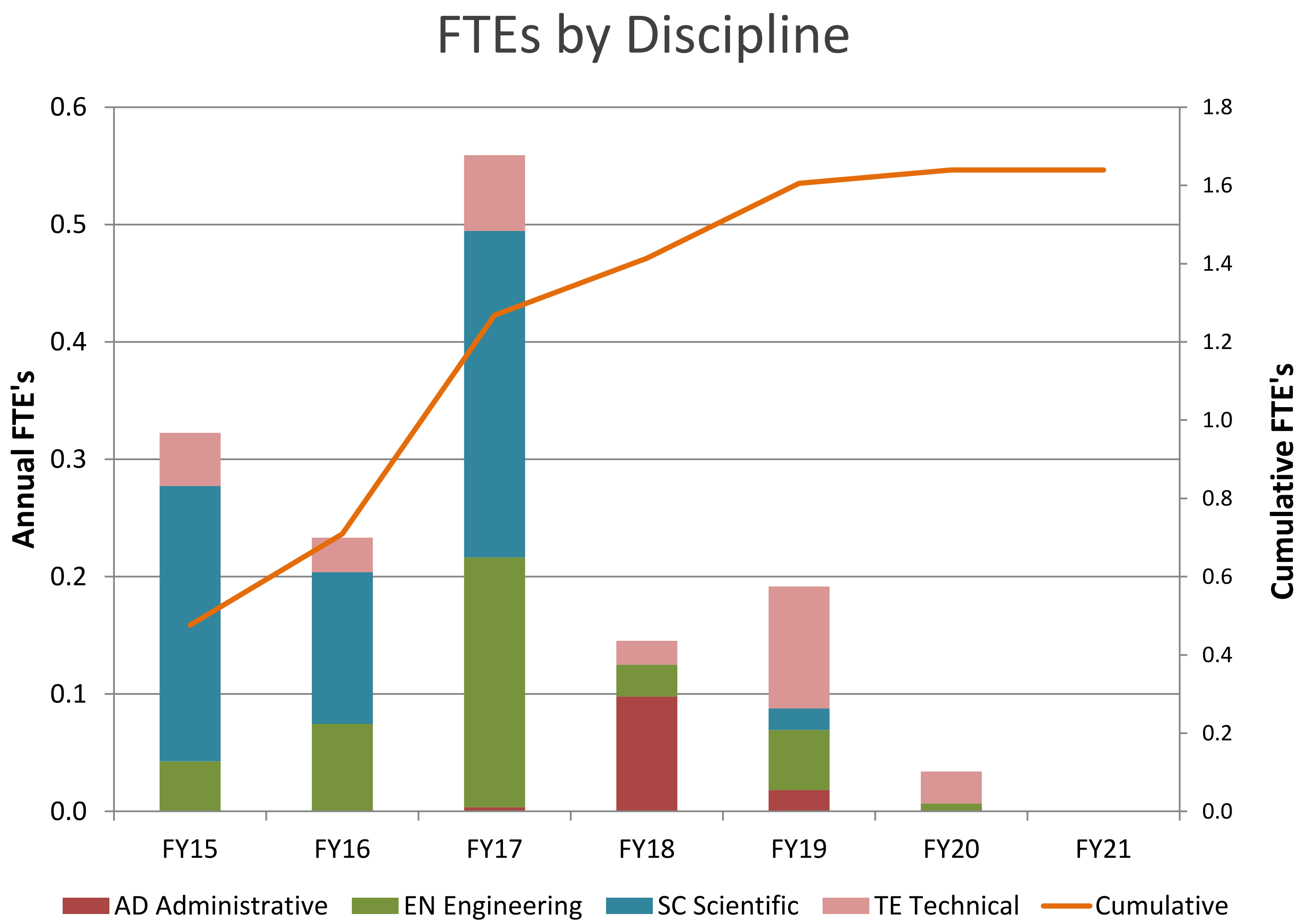
Cost Distribution by Resource Type



Quality of Estimate



Labor Resources



Cost Table

WBS 5.8 Muon Beam Stop

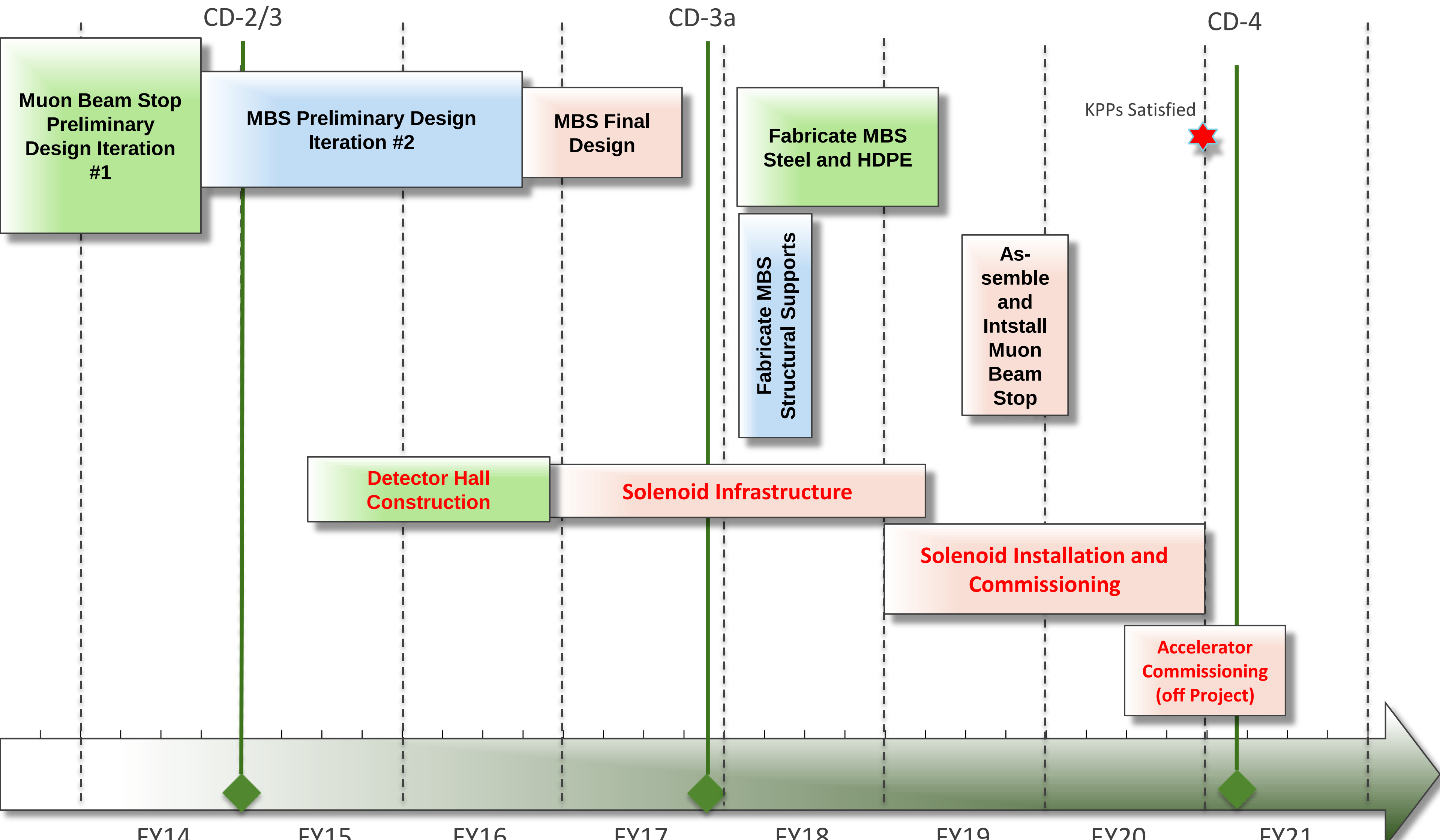
Costs are fully burdened in AY k$

	Base Cost (AYk$)					
	M&S	Labor	BAC	Estimate Uncertainty (on remaining costs)	% contingency on ETC	Total
475.05 Muon Beamline						
475.05.08 Muon Beam Stop	433	300	734	206	36%	940
Grand Total	**433**	**300**	**734**	**206**	**36%**	**940**

Major Milestones

Activity ID	Milestone Name	Milestone Date
47505.8.001844	Muon Beam Stop ready for CD 3a Review	August 9, 2017
47505.8.001845	CD 3a Approval Muon Beam Stop.	August 23, 2017
47505.8.031010	Muon Beam Stop and Structural Supports arrive at FNAL	May 22, 2018
47505.8.031040	Muon Beam Stop ready for CD-4	November 25, 2019

Schedule



CD-2/3
CD-3a
CD-4
Muon Beam Stop Preliminary Design Iteration #1
MBS Preliminary Design Iteration #2
MBS Final Design
Fabricate MBS Steel and HDPE
Fabricate MBS Structural Supports
As-semble and Intstall Muon Beam Stop
KPPs Satisfied
Detector Hall Construction
Solenoid Infrastructure
Solenoid Installation and Commissioning
Accelerator Commissioning (off Project)
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21

Summary

- Have made substantial progress since CD-1
  - Preliminary design of MBS meets the current requirements from simulations
  - Many designs have been significantly refined/optimized
    - MBS Materials.
    - Gimbal-Trunnion support system
    - Cable and tube routing scenario

- Still several tasks to complete
  - Continue refining/optimizing the design via simulation studies.
  - Test support system on mockup.
  - Complete cable and tube routing plan.
  - Refine installation procedure.

Backup Slide