Mu2e WBS 5.3 Collimators CD-2 Director's Review

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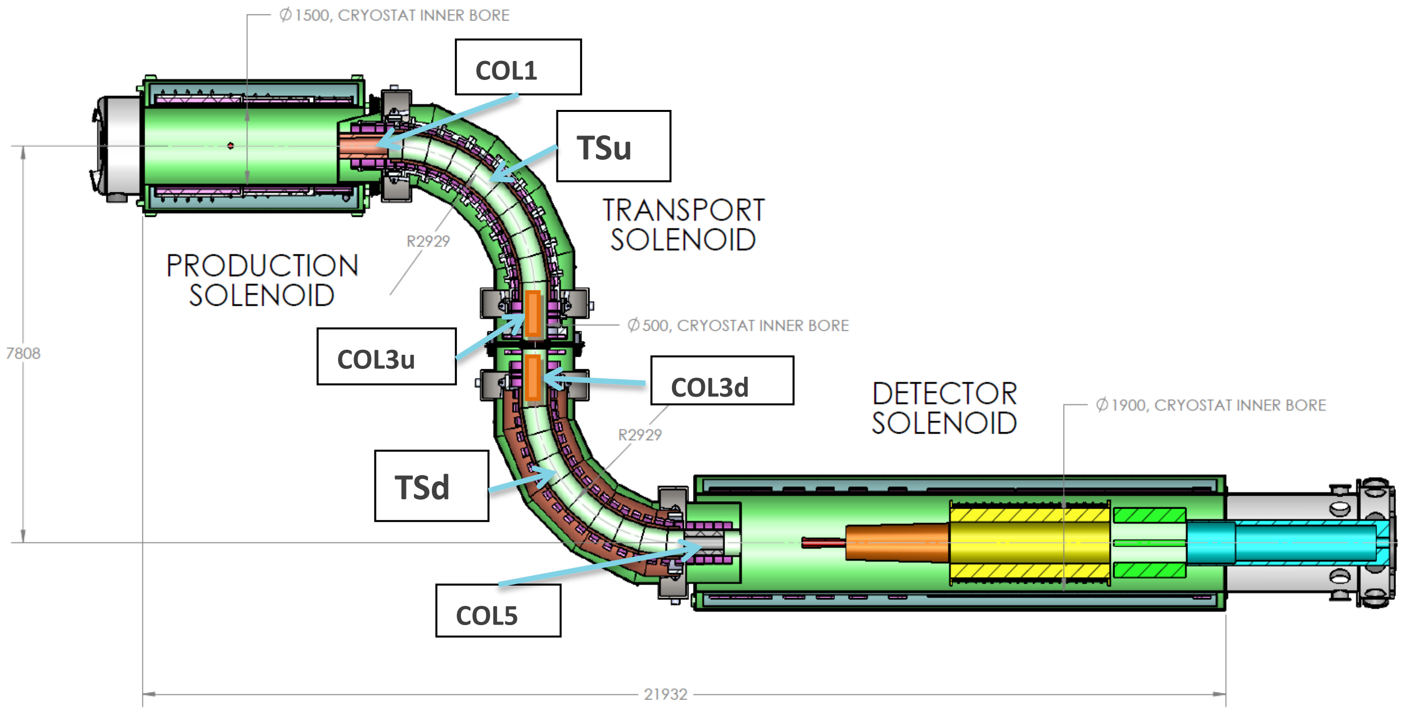
Requirements

- The muon beamline collimators filter the beam as it passes through the Transport Solenoids (TSu and TSd), selecting muons of the desired charge and momentum range to optimize the probability of their capture in the muon stopping target .



Requirements

- Muon's selection is achieved by a vertical offset of the aperture in the two central collimators (COL3u and COL3d) with respect to the horizontal center plane to take advantage of "curvature drift" in the two TS bends formed by the two toroidal sections. In this curved B-field negatively charged particles are deflected upward in the first curved section and pass through the offset central collimator aperture and are deflected back onto the nominal beam line in the second curved section.

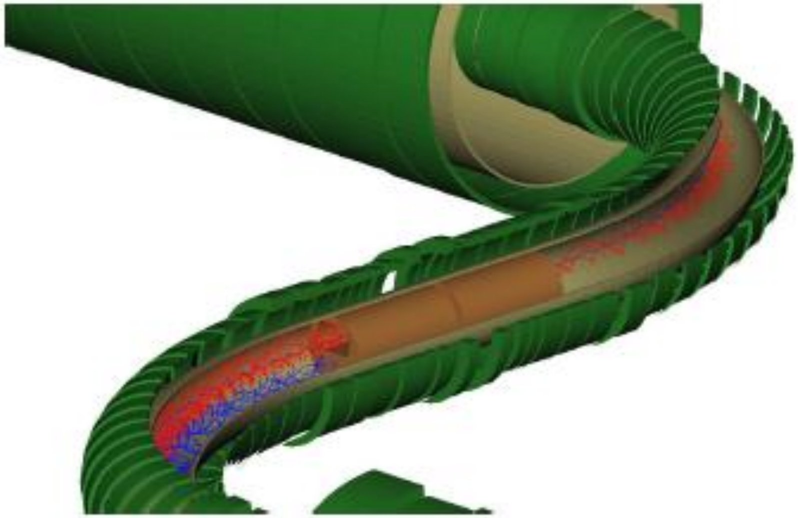
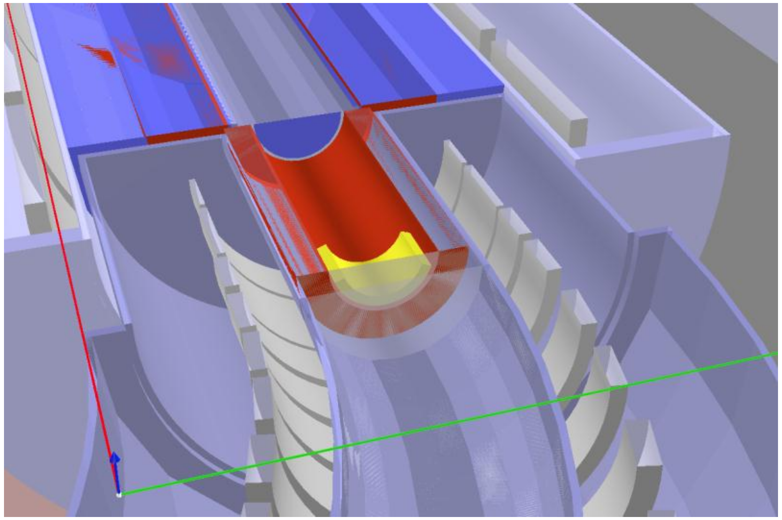


Figure 2.5: Cutaway view of the Transport Solenoid in the region of the asymmetric collimator. The upper spiraling negative muons (red) pass through, the lower positive muons (blue) are stopped.

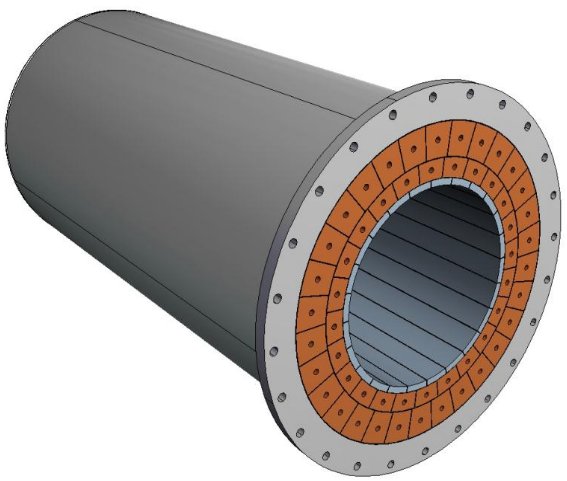
Requirements

- Antiprotons (p-bar), if allowed to continue on to the muon stopping target, would produce a serious physics background .There are several ways to decrease p-bar induced backgrounds. The Mu2e approach is to introduce thin windows in the transport solenoid region. The windows need to be thick enough to reduce the probability for p-bar passage through the windows but also thin enough to not substantially decrease the muon yield.
- Recent efforts to further suppress antiproton transmission incorporated an additional 20cm long arc of graphite (yellow) at the downstream end of COL1 as illustrated below

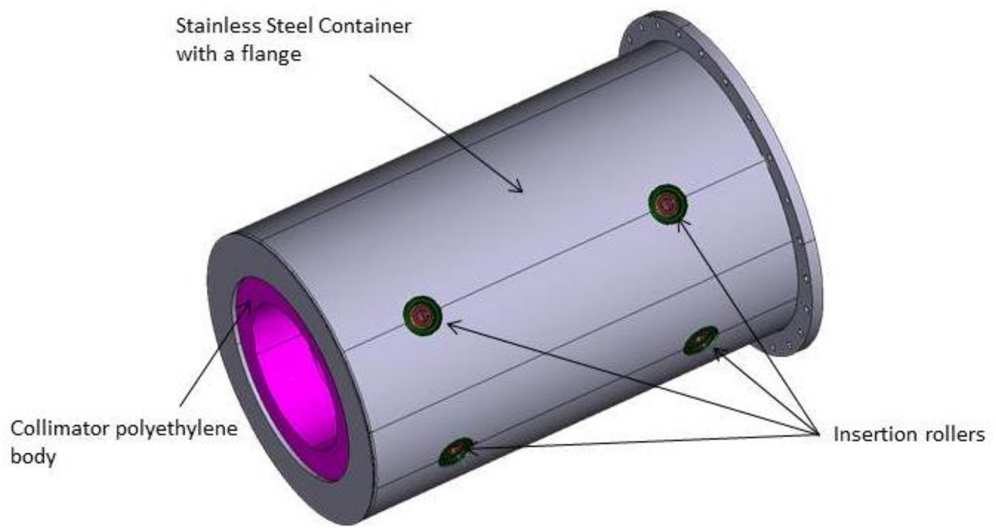


Design

- **<u>There are two types of collimator assembly configurations:</u>**
- **First type - stationary collimator**: COL1 and COL5, specified collimator material will be assembled into stainless steel containers which serve as the housings for the collimator and includes insertion rollers to facilitate installation in the TS bore.



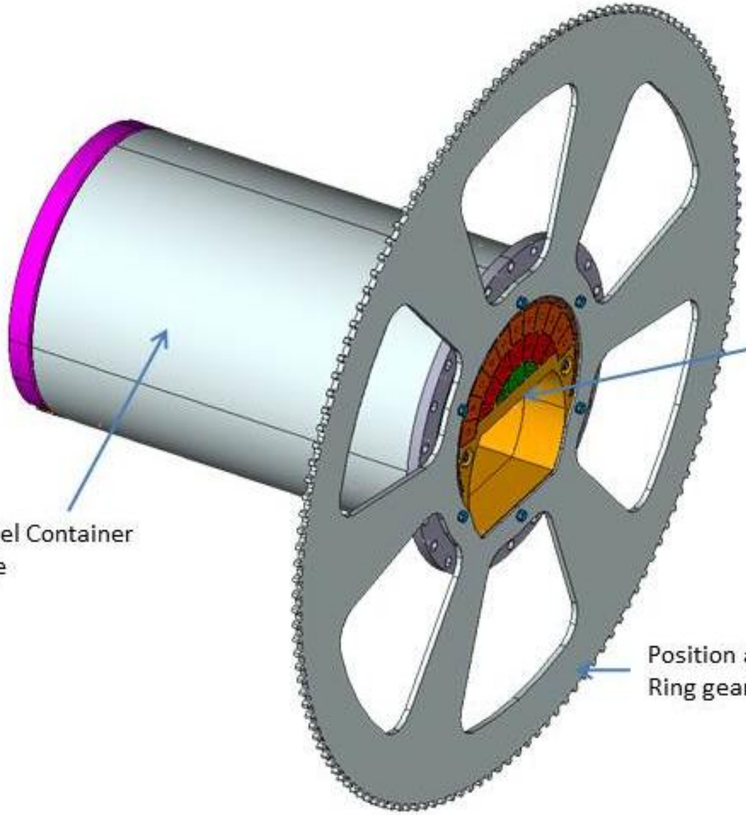
View of the COL1 as seen from the upstream end, illustrating the individual copper pieces inserted into the stainless steel housing and the segmented innermost graphite layer.



View of COL5 as seen from below, highlighting the insertion rollers embedded in the stainless steel collimator housing.

Design

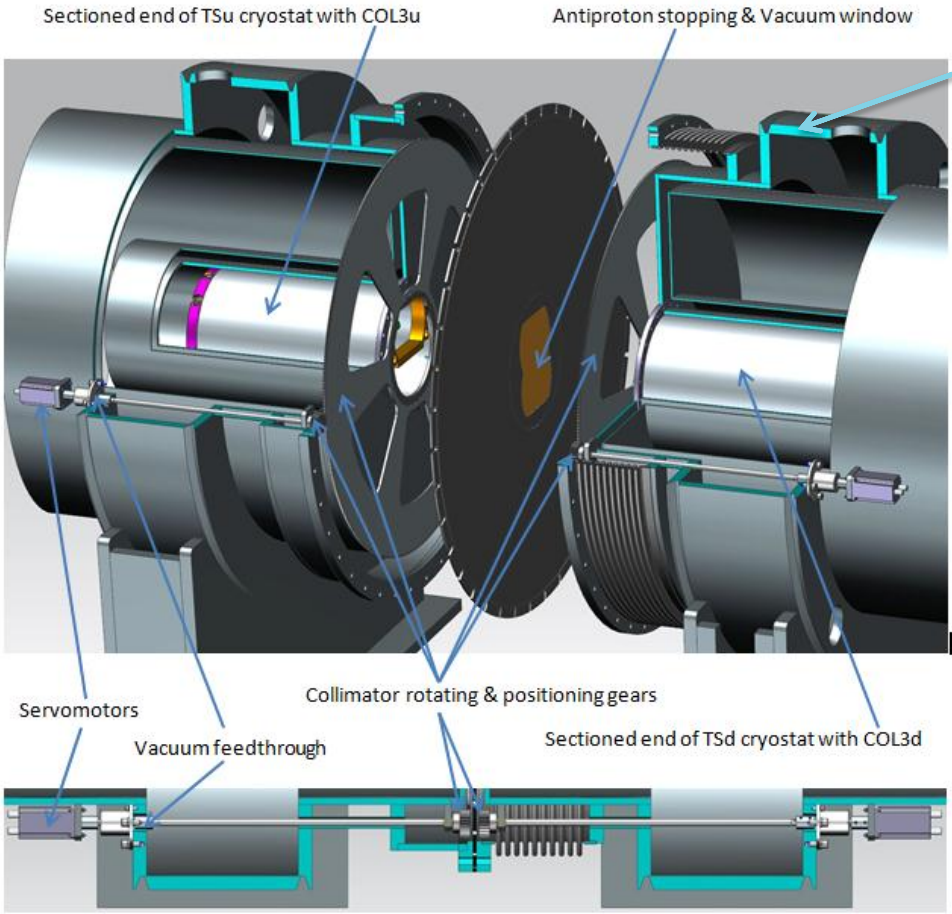
- **Second type - rotatable collimators: COL3u and COL3d**



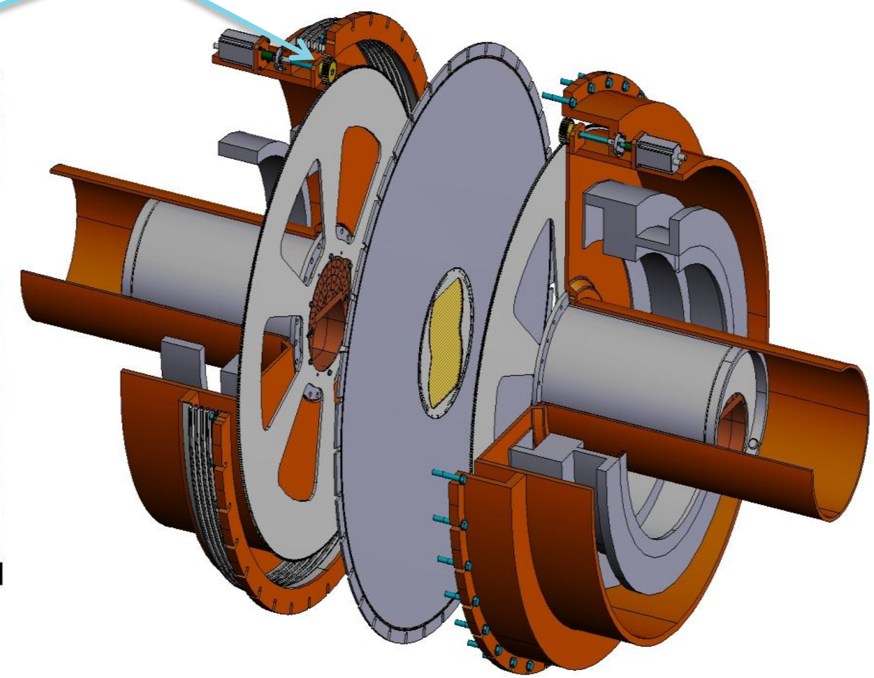
A large gear will be attached to the inner housing of collimators to provide easy azimuthal rotation of the inner housing, containing the copper body of collimator, with respect to the outer container which will be attached to the TS cryostat flange.

Changes since CD-1

Preliminary Design of TS3 Collimators



Different TS cryostat design and adaptation of Collimator part for it.



CD-1 Design of TS3 Collimators

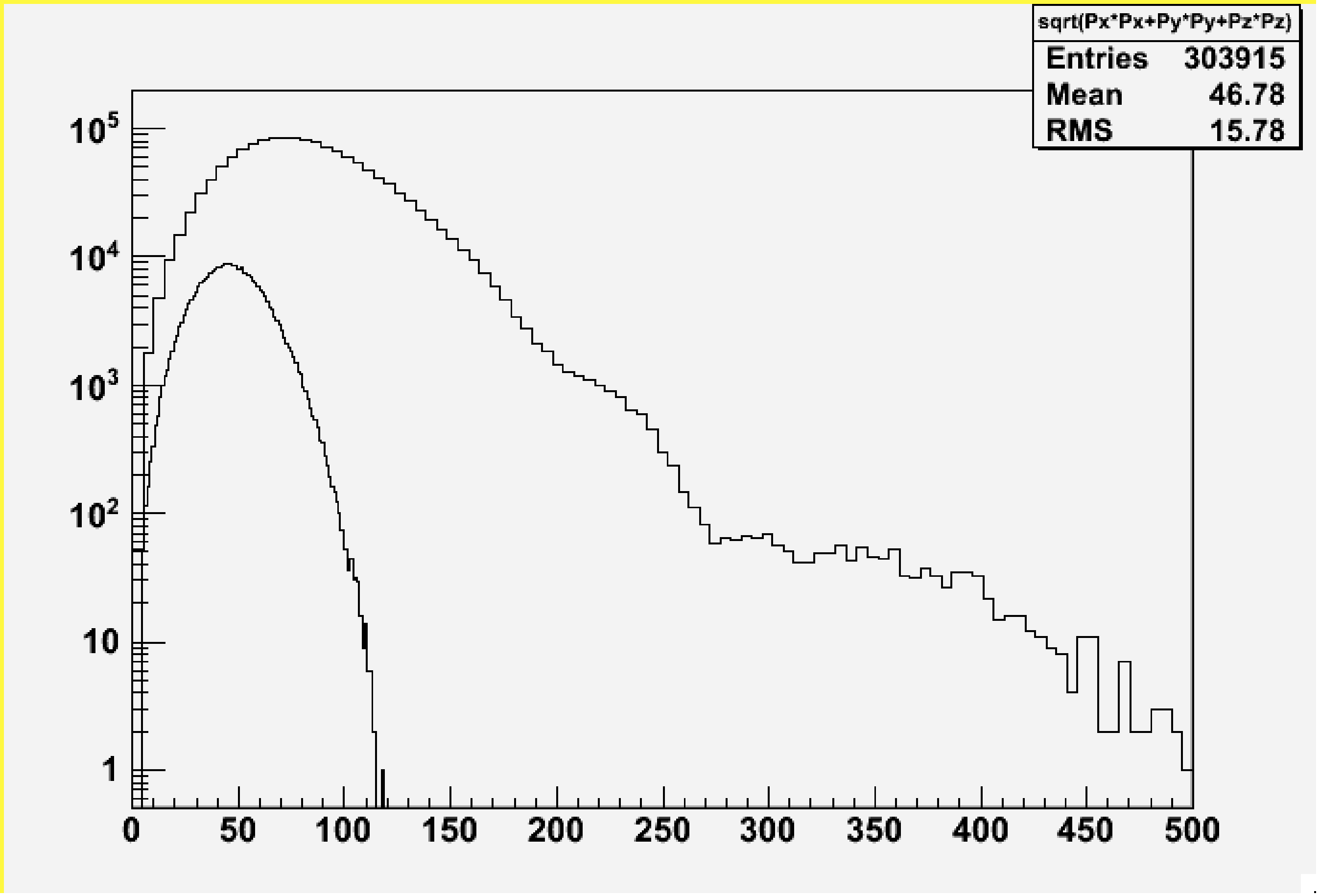
Value Engineering since CD-1

- Integration of magnetic mapping instrumentation inside all collimators
- Instrumentation/ports to verify COL3u and COL3d orientation
- Optimization of Collimator Drive/rotate system design for new TS cryostat design

Downselects

- Explored and eliminated poly liner within TS warm bore
- Confirmed copper as the material of choice for COL3
- Confirmed poly as the material of choice for COL5

Performance



Negative Muon Flux Exiting PS and Entering Detector

Remaining work before CD-3

- Finalize material choices
- Design COL1 antiproton window
- Finalize COL3u/COL3d interface region
- Complete integration of magnetic field mapping instrumentation

Quality Assurance

Quality Assurance in the Collimator system 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

Technical Risks

- Anti-proton stopping window at the TSu/TSd interface will be made from a beryllium plate whose thickness is 0.2 mm and will be 300 mm in diameter.
- This window will absorb the anti-protons in the middle of TS3 and will have radiation damage and after some time of work will need a replacement.
- This window serves as a vacuum separator in the middle of the beamline to prevent radioactive molecules migrating down stream into the detector solenoid. It will be challenging to keep equal pressure on both sides of this window-membrane if some vacuum leak will opened in the beamline.
- All above concerns present the technical risks that are being mitigated during design development of TS3 Collimator System , intended to support (relatively) easy replacement of the window.
  - the vacuum system will regulate pressure differential across the window.

ES&H

ENVIRONMENTAL HAZARDS

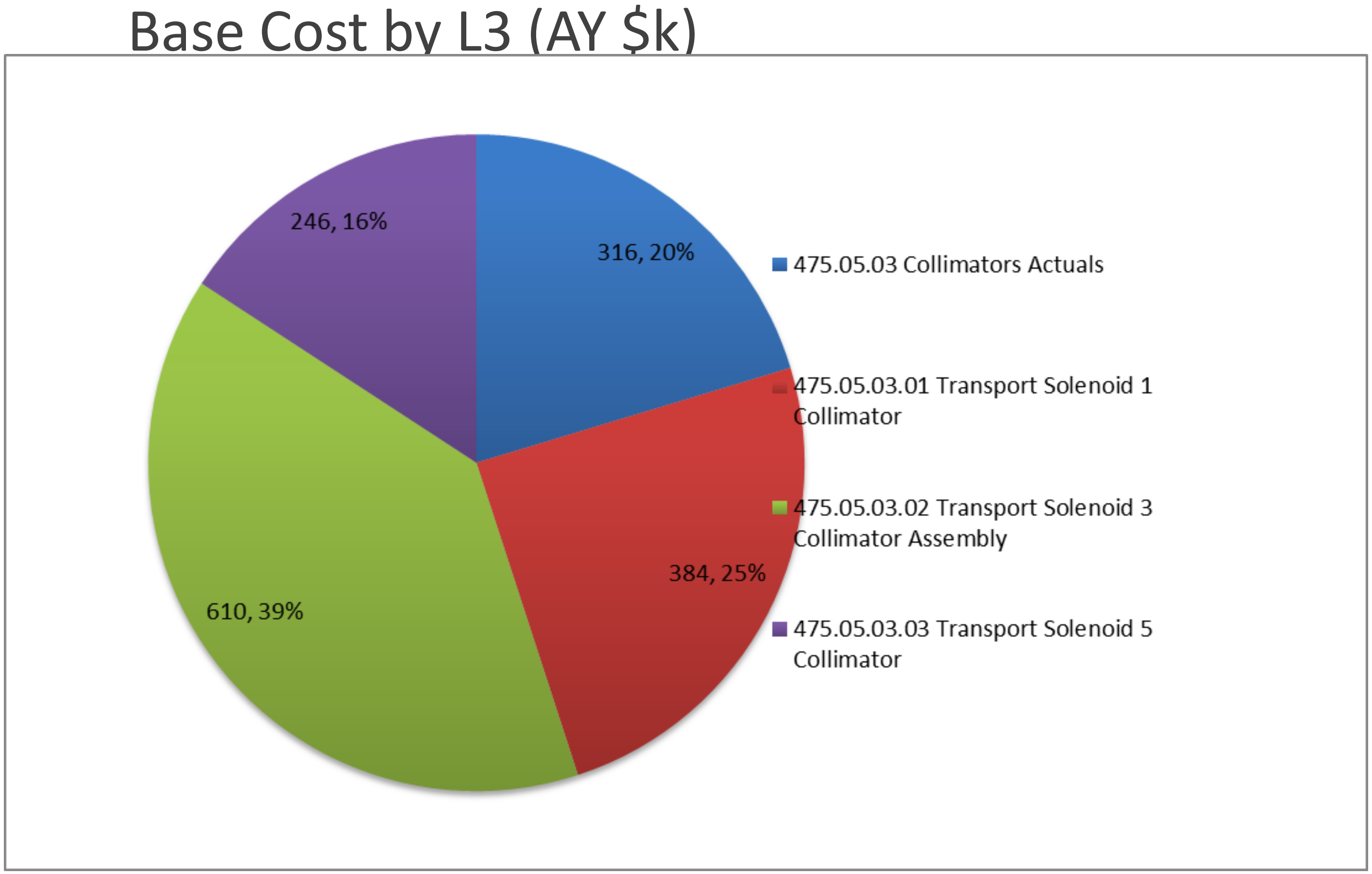
- **RELATED TO RADIATION ENVIRONMENT**
  - Radiation levels will need to be monitored.
- **RELATED TO IRRADIATED MATERIAL AFTER OPERATION**

  Radiation level of components will need to be monitored before removal. Several factors need to be considered:
  - Materials can not be used which can become poisonous after activation.
  - The characteristic decay time of irradiated components should be small enough to permit access after no more than 24 hours.
  - Components must remain dimensionally stable until decommissioning is complete.

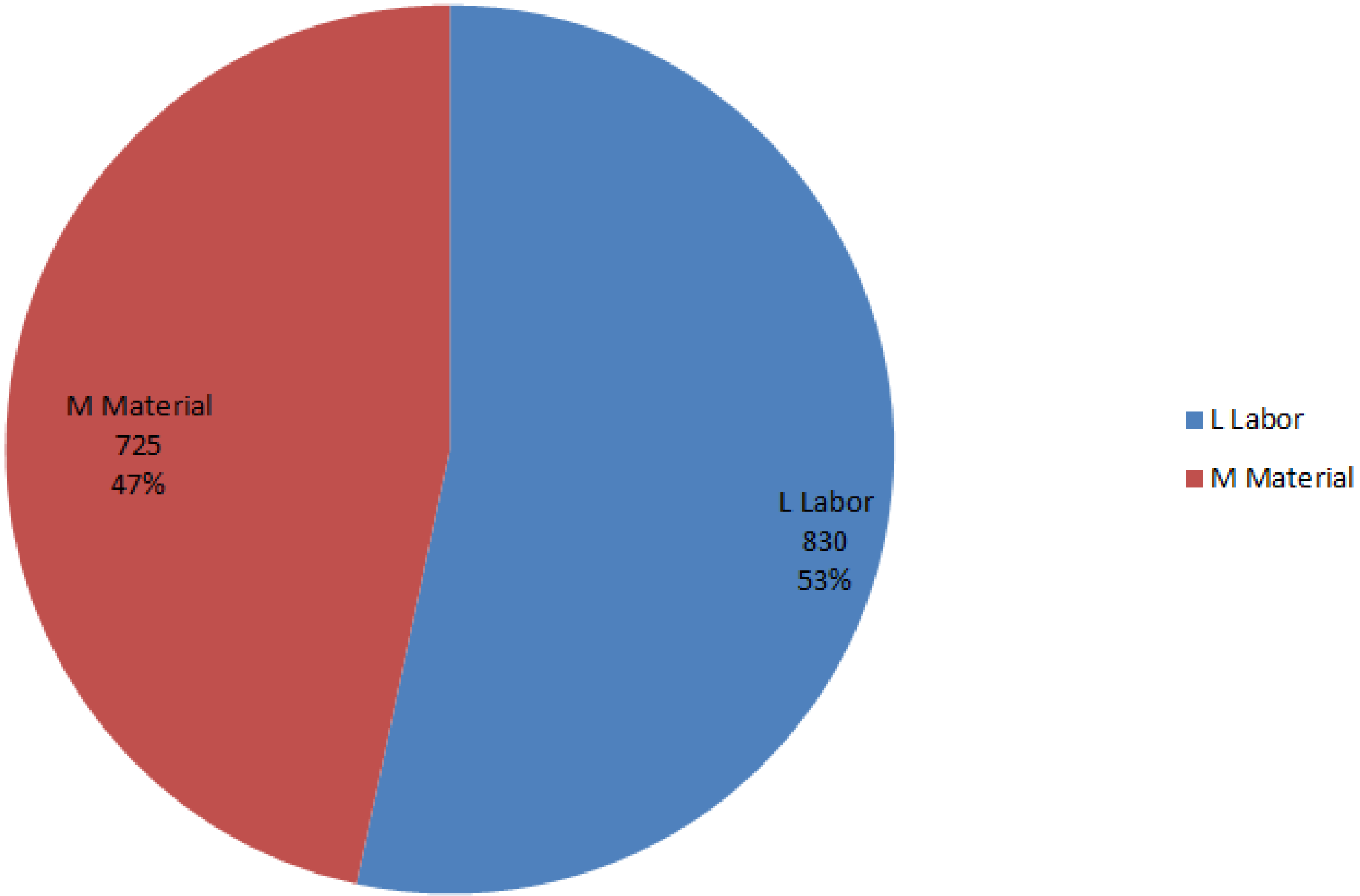
SAFETY HAZARDS

- **HEAVY LIFTING**
  - The collimators are heavy objects, so during installation special care should be taken to follow Fermilab safety procedures for working with lifting equipment.

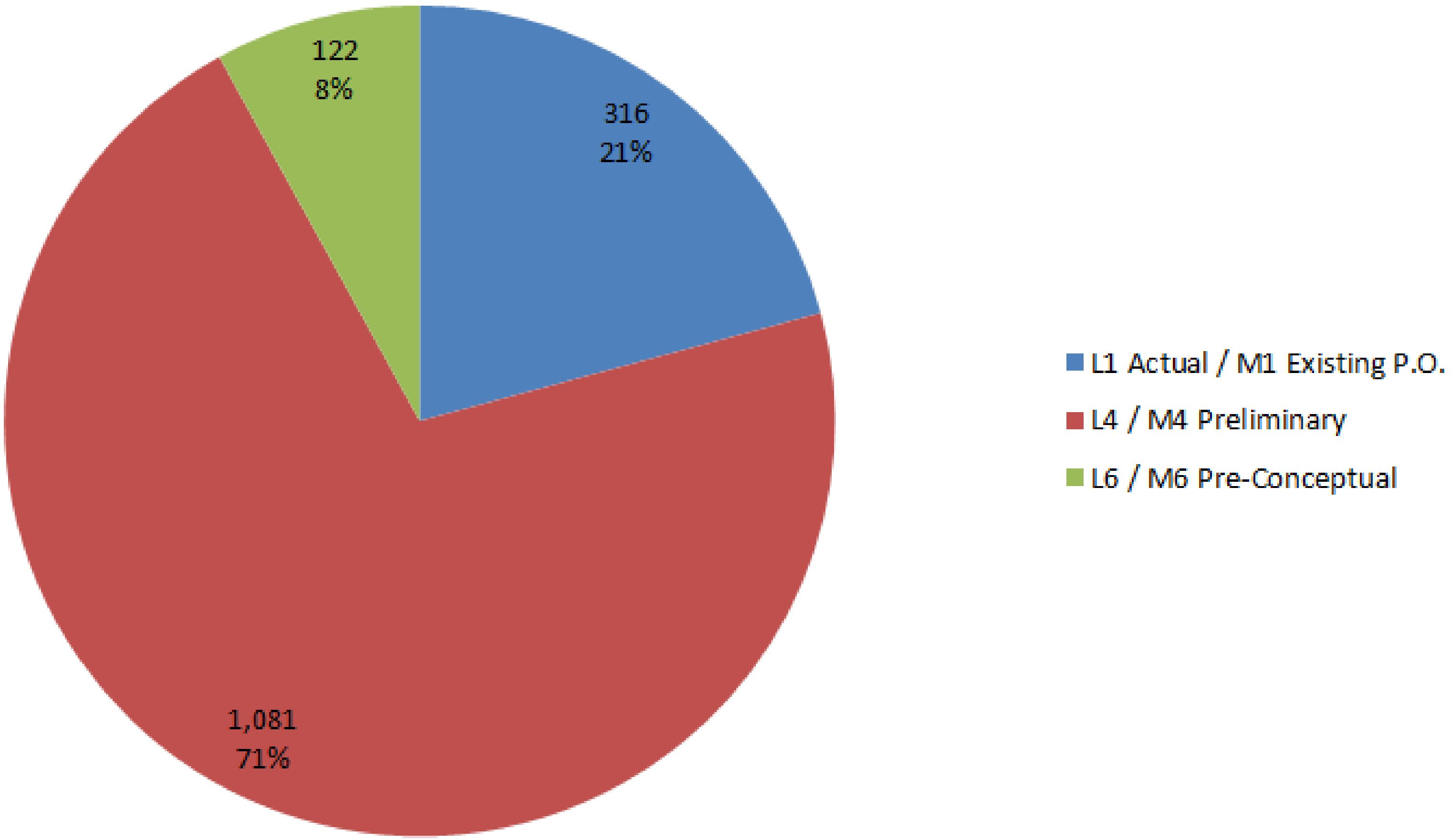
Cost Distribution for 475.05.03 Collimators



Cost Distribution by Resource Type

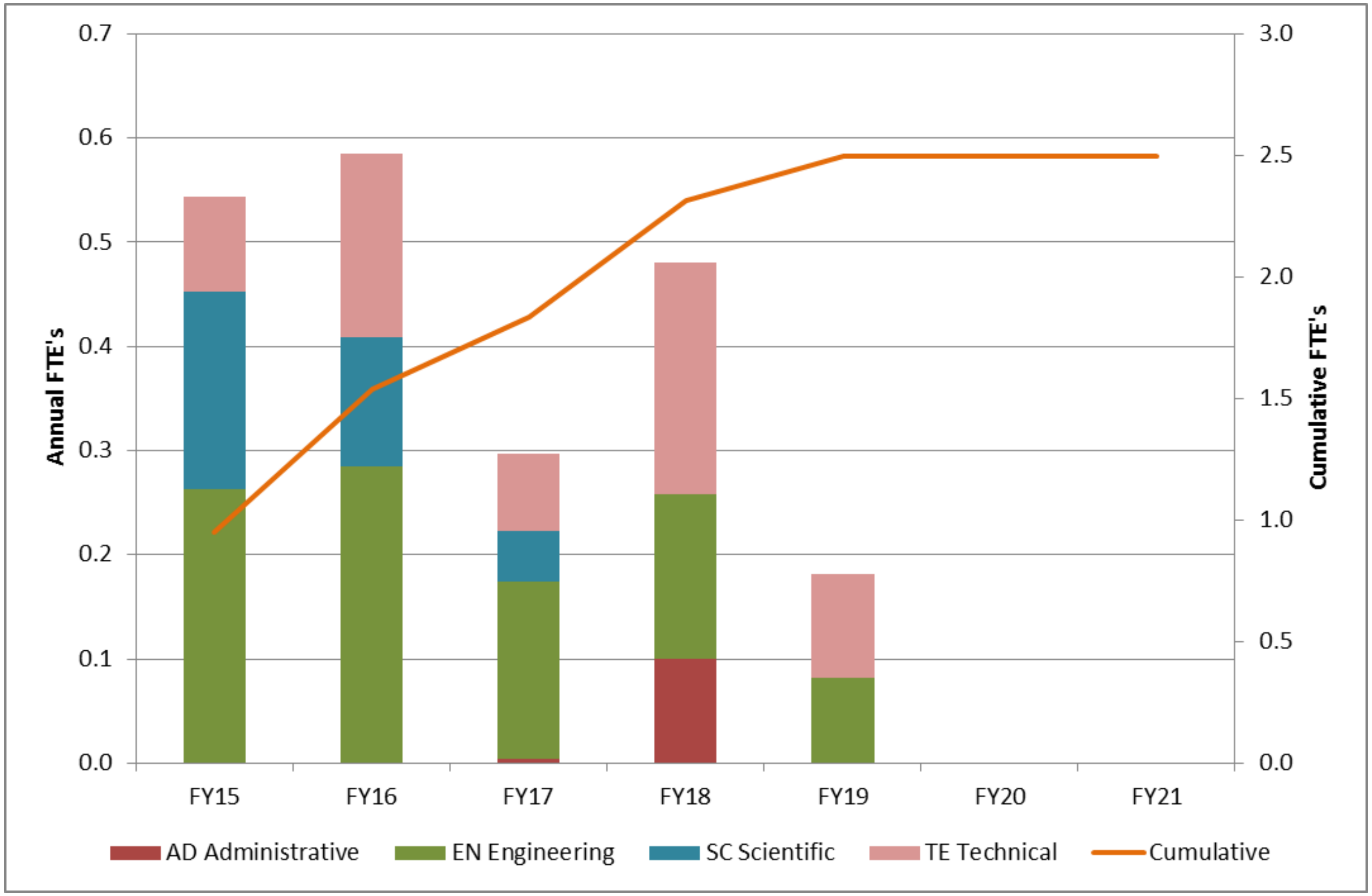


Quality of Estimate



Labor Resources by FY

- FTE’s by Discipline for 475.05.03 Collimators

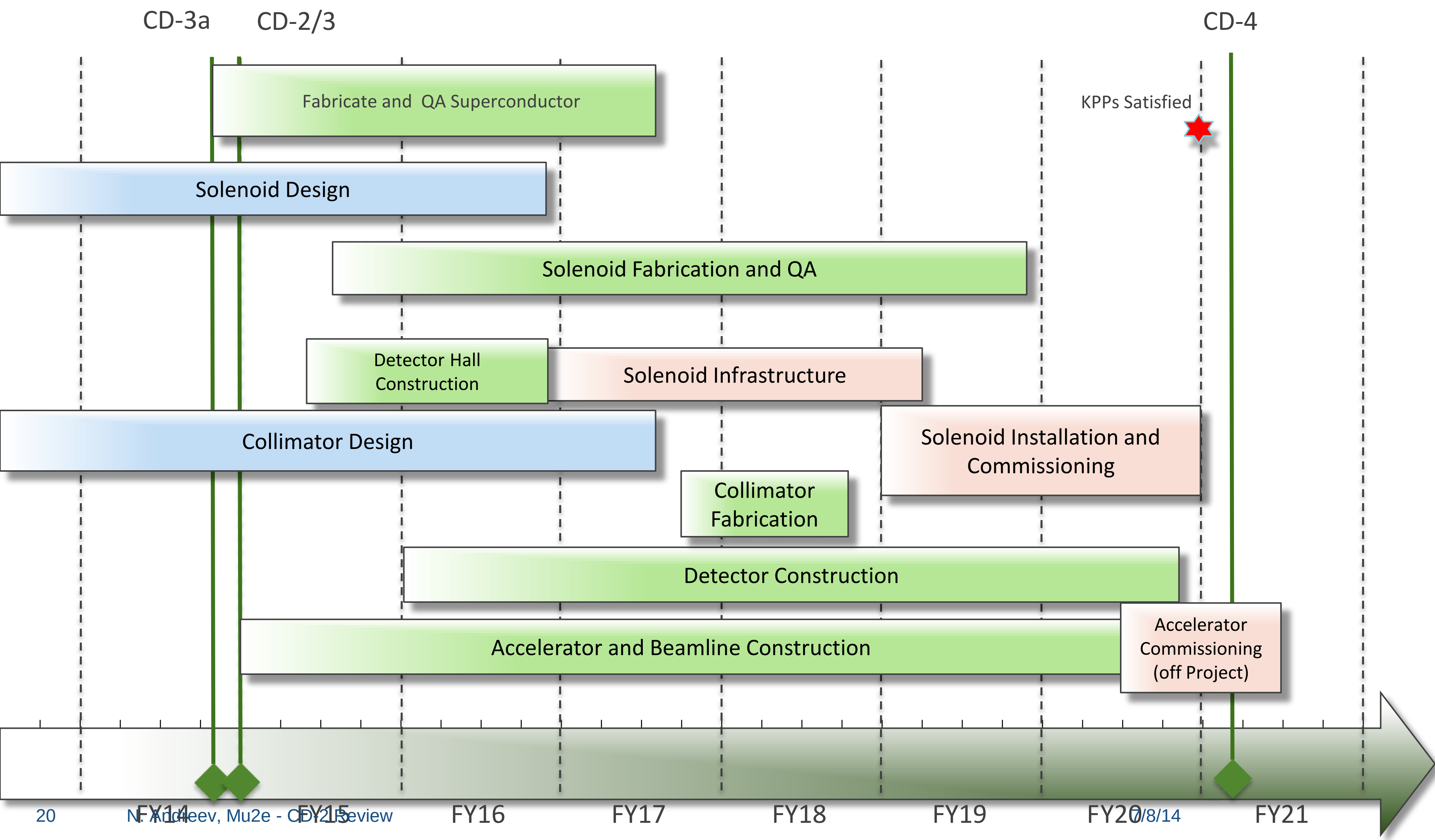


Cost Table for 475.05.03 Collimators

Costs are fully burdened in AY $k

	M&S	Labor	Total	Estimate Uncertainty (on remaining costs)	% Contingency on ETC	Total Cost
475.05 Muon Beamline						
475.05.03 Collimators						
475.05.03 Collimators Actuals	1	316	316			316
475.05.03.01 Transport Solenoid 1 Collimator	188	196	384	214	56%	597
475.05.03.02 Transport Solenoid 3 Collimator Assembly	388	222	610	214	35%	824
475.05.03.03 Transport Solenoid 5 Collimator	149	97	246	87	35%	332
Grand Total	725	830	1,555	515	42%	2,070

Schedule



CD-3a
CD-2/3
CD-4
Fabricate and QA Superconductor
KPPs Satisfied
Solenoid Design
Solenoid Fabrication and QA
Detector Hall Construction
Solenoid Infrastructure
Collimator Design
Solenoid Installation and Commissioning
Collimator Fabrication
Detector Construction
Accelerator and Beamline Construction
Accelerator Commissioning (off Project)
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21

Summary

- Requirements & Specifications have been completed for 2nd iteration of the preliminary design of the TS collimators,

  Doc-db1044
- 3-D model of the preliminary design of the TS collimators have been developed
- No specific limitations for the collimator production, test and installation have been identified