

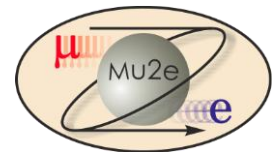


Mu2e External Beamline Cost & Schedule 475.02.07 CD-2 Review

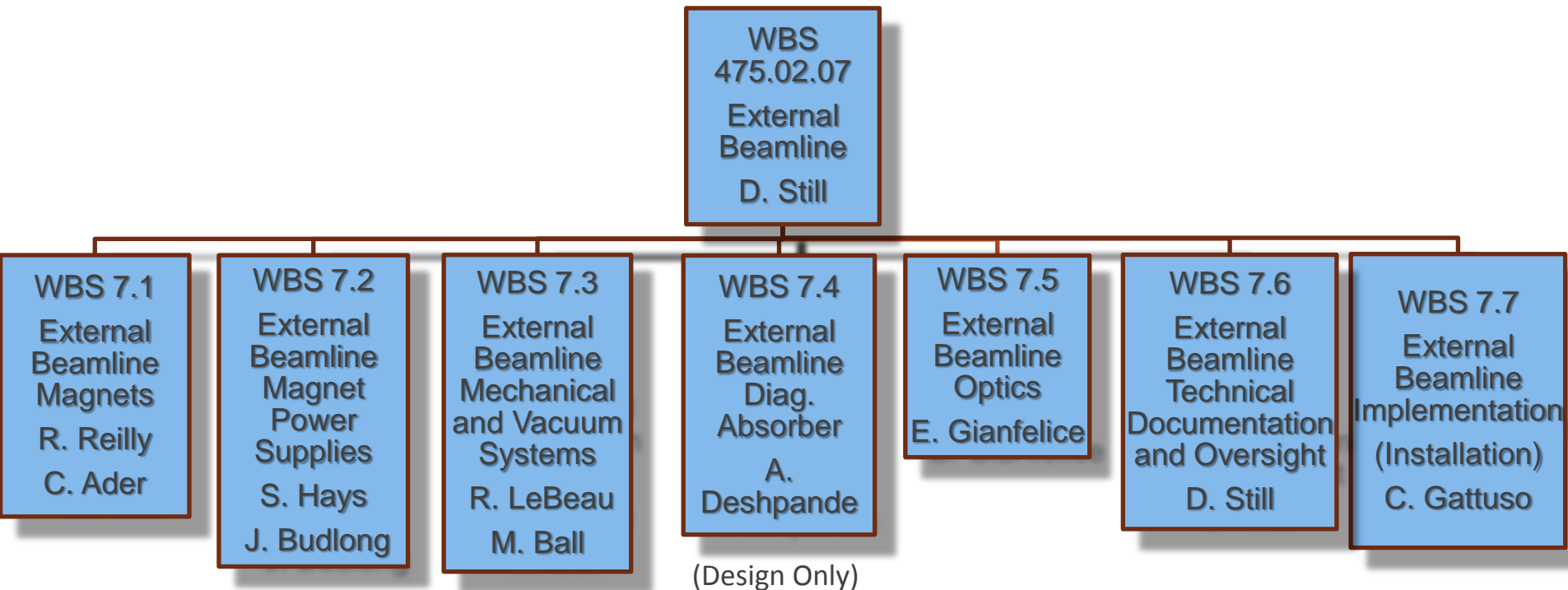
Dean Still

L3 Manager

10/22/2014

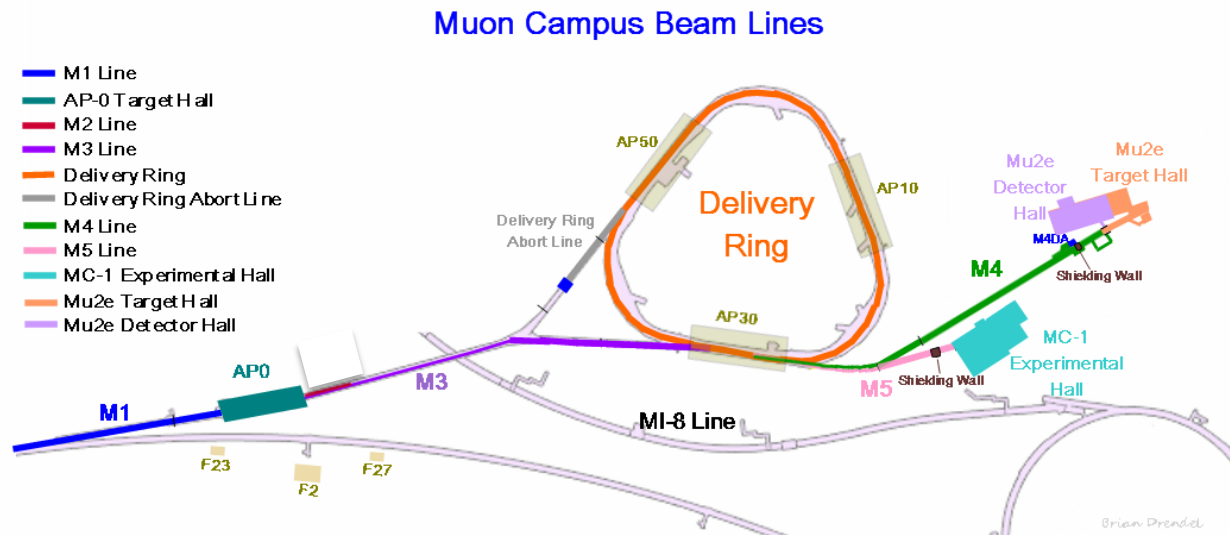


Organizational Breakdown

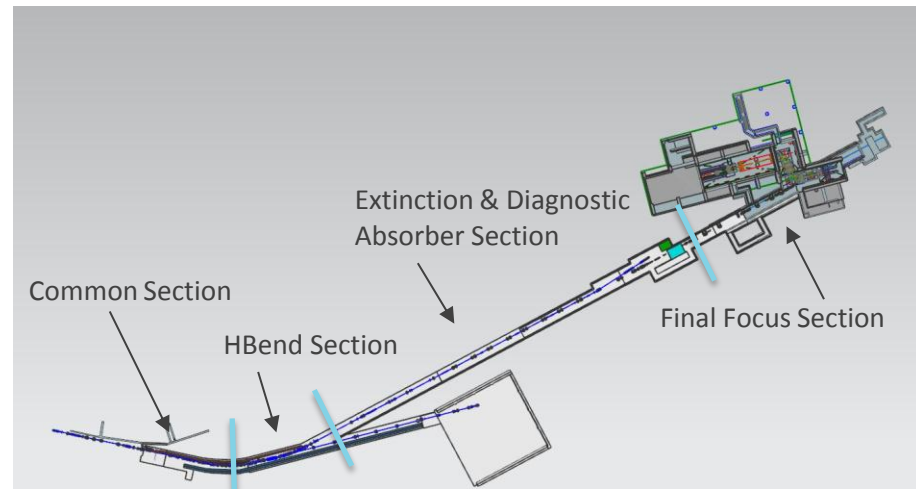


WBS 475.02.07 External Beamline Scope

- The Mu2e external beamline includes transport of protons at 8Gev resonantly extracted from the Delivery Ring for normal operation. (Single turn extraction for an initial tune up and commissioning to the diagnostic absorber)
- Technical details were presents in talk *External Beamline Design* by E. Prebys .
- Beamline shares the upstream part of the beamline with g-2.
- Installation includes elements in the M4 beamline, AP30 , MC-1 and Mu2e service buildings.
- Many components and hardware will be reused and repurposed from the Antiproton source as a cost savings & value engineering.

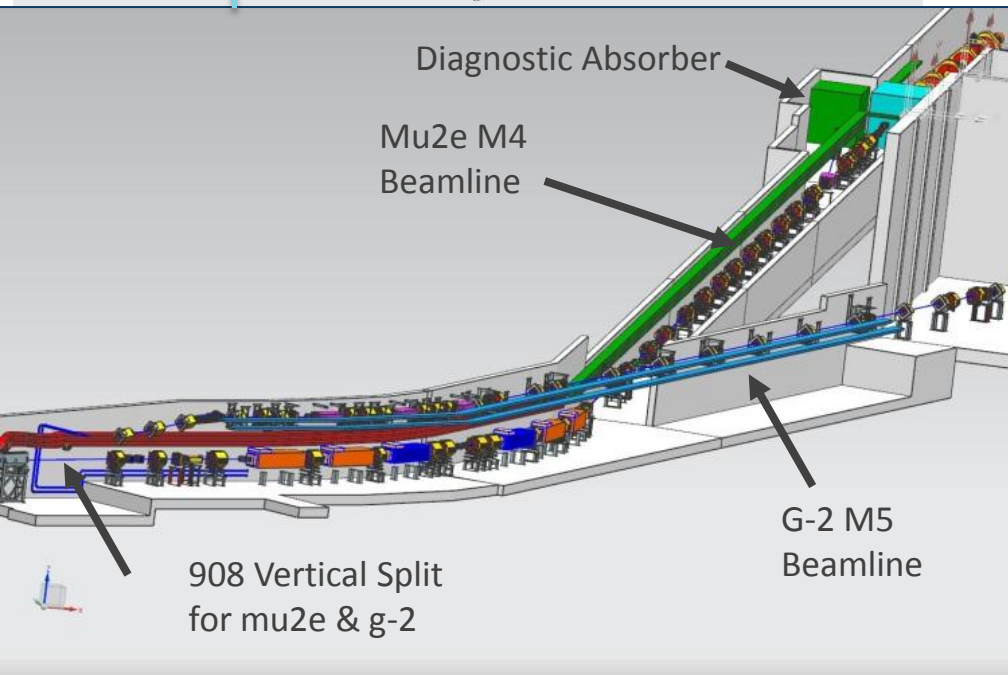


Mu2e Section of the M4 Beamline



The beamline is broken into 4 distinct sections for beam function & installation.

Part of the M4 beamline is shared with g-2. Split is at 908. Mu2e will be responsible for on the cost of installation of the M4 beamline from 908 to 952.



Installation will include all magnets, magnet supports, main & trim power supplies, vacuum system & controls, LCW and compressed air for tunnel and Mu2e building as well as two beam stops.

The schedules have pushed together so that g-2 running will overlap Mu2e installation 2017 - 2019

Summary of Installed Components

M4 Magnetic Element

Row Labels	Count of Location	Row Labels	Vacuum	Needed
Fabricated:	1	New:		879
MDC	1	5.5" to 4' beam tube reducer		20
Refurbished:	6	Beamtube, large, special, transitional		20
CDA	6	Fittings:		21
Repurposed:	69	Flange Gaskets:		150
3Q120	2	Flanges:		99
LQC	4	Gauges:		14
LQD	2	KF40		10
NDA	11	Stands:		28
SDF	2	Valves:		17
SDFW	4	Beamtube, 4" round, laser welded, 316L SS (ft)		400
SQA	20	Beamtube, 6" round, laser welded, 316L SS (ft)		100
SQB	7	Repurposed:		250
SQC	5	Gauges:		14
SQD	5	Ion Pumps:		18
SQE	2	Rough Pumps:		4
VDPA	5	Stands:		47
Grand Total	76	Valves:		16
		Windows:		3
		Bellows:		48
		Beamtube, 5-1/2" round, 316L SS (ft)		100
		Grand Total		1129

Magnet Supports

Row Labels	Count of Magnet
new motorized	3
new stand and adjustors	26
repurposed adjustors with height modification	47
New Instrumentation stand	24
Grand Total	100

New Main & Trim Power Supply

Row Labels	Count of P.S. CIRCUIT
AP30:	8
SCR	1
SWITCH MODE	7
MC-1:	20
SCR	1
SWITCH MODE	19
Trim power supply	
(repurposed)	15
Mu2e Bld.:	10
SCR	1
SWITCH MODE	9
Grand Total	38

- Fabricate 1 beam stop
- Modify 1 beam stop
- All LCW & Compressed Air Systems are new

M4 Diagnostic Absorber & GPP



Assembled M4 Diagnostic Absorber waiting to be installed on the tunnel GPP.

- The M4 Diagnostic Absorber was designed on External Beamline WBS 475.02.07.04 .
- The steel for the absorber has been and cut , prepared, assembled and will be installed in the tunnel walls surrounded by concrete. The for installation has been transferred for Mu2e project to the tunnel GPP.
- The absorber is complete and ready for GPP installation.

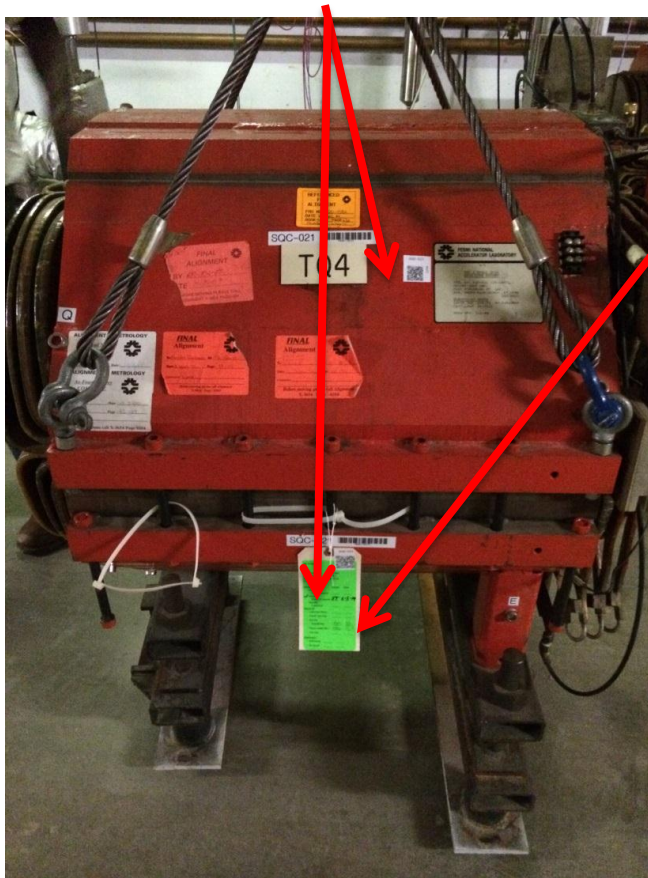
Quality Assurance

- All installation work in the M4 beamline has high engineering oversight and coordination in order to ensure quality to design. C. Gattuso is installation coordinator for all Muon Campus Work.
- A Component Tagging system has been put in place to keep track of components and ensure quality control of work that needs to be complete for individual components.
- Utilize standard adherence to the Fermilab Engineering Manual.
- There is a good history of operating experience with similar of repurposed devices of purchasing quality components to ensure quality and predetermined performance. There is Mechanical Engineering QA summary document of practices, policy and procedures in [Mu2e-doc-4646](#).
- There is an adequate testing period after installation is complete and built into the schedule to confirm systems can operate at designed performance. (power supply, vacuum, LCW)

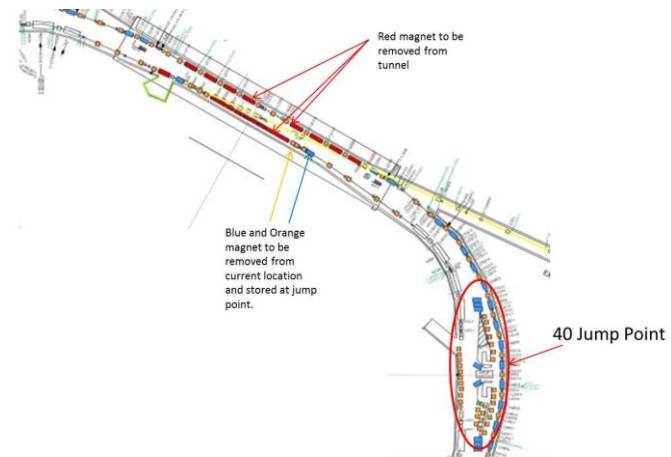
Quality Assurance – Tagging

QR Codes

- Electronic coding system to keep track of the status of each magnet

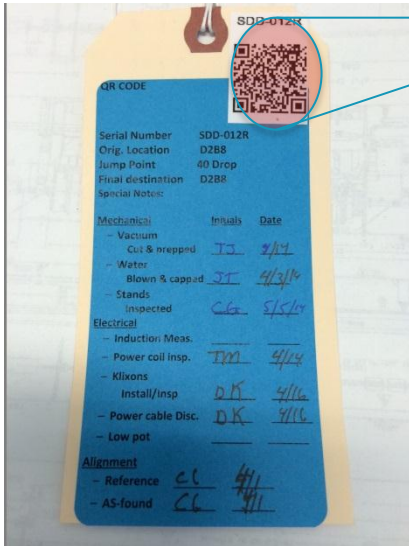


- **Red:** Components to be removed from tunnel
 - Storage or
 - Rad waste
- **Blue:** Components to be removed from current location and installed back to their original location.
 - Magnet in the Delivery ring 30 section for example
- **Green:** Components to be removed from current location and store at its jump point prior to being re-installed elsewhere
 - Magnets being moved from the Accumulator to the M2/M3 or M4/M5 lines



QA – Component Tagging (2)

- QA tag for SDD-012R in the 30 straight section located on magnet



Cellphone app

**Comprehensive Parts Repository
Debuncher
Already Generated QR Codes**

Help

Toggle Selections - note that if in a tabbed view, selections in other tabs will also be toggled

Export

Accelerator System	Location	Tunnel Name	ACNET Name	Device Install (Serial)	Master Position	Position at Location	Family	Type	Model (Series)
Debuncher	D30Q	DR30Q		SQC-208-9	2	2	Magnet	Quadrupole	SQC
Debuncher	D30Q	DR301KT		KT001	6	6	Instrumentation	Cooling	Stochastic Cooling Kicker
Debuncher	D30Q	DR301P		IP128	7	7	Vacuum	Ion Pump	270 L
Debuncher	D202	DR202		SQC-114	9	1	Magnet	Quadrupole	SQC
Debuncher	D202	DR202P	D/IP202	IP033	12	4	Vacuum	Ion Pump	270 L
Debuncher	D202	DR203KT		KT002	13	5	Instrumentation	Cooling	Stochastic Cooling Kicker
Debuncher	D203	DR203		SQC-107	15	2	Magnet	Quadrupole	SQC
Debuncher	D203	DR203P	D/IP203	IP034	18	4	Vacuum	Ion Pump	270 L
Debuncher	D203	DR203KT		KT003	19	5	Instrumentation	Cooling	Stochastic Cooling Kicker
Debuncher	D204	DR204		SQC-111	21	1	Magnet	Quadrupole	SQC

Information added via phone app that reads the QR code, which then allows user to update and populate the entries

Update QA Report

Success updating report.

QA Report for SDD-012R

New Started: 06/05/2014
Michele McCusker-Whiting (x3536)

Task	Sign Off	Date
AD / Electrical/Electronic Support		
Induction Measure	FNAL ID	06/05/2014
kilns	09563N David Kilhken (x3535)	06/05/2014
Low pot	FNAL ID	06/05/2014
Power cable Disc.	09563N David Kilhken (x3535)	04/16/2014
Power coil insp.	08022N Consolato Gattuso (x6331)	04/14/2014
AD / Mechanical Support Department		
Stands Inspected	08022N Consolato Gattuso (x6331)	05/05/2014
Vacuum Cut & prepped	11671N Philip Crabtree (x4436)	04/14/2014
Water Flushed & capped	13209N John Todd (x4731)	04/14/2014
PPD / Alignment and Metrology		
As-found	08022N Consolato Gattuso (x6331)	04/11/2014
Reference	08022N Consolato Gattuso (x6331)	04/11/2014

Each magnet type has a custom setup

Individual fields then can be populated and updated via this interface

Risks

Registry contains 2 risks:

- ACCEL-200 - Mu2e-doc-4589 : Additional power supply circuits needed for modified optics for the change in the extinction section due to extinction design change.
 - High probability with up to \$400K cost impact
- ACCEL-201 - Mu2e-doc-4590: Additional magnet needed to be fabricated for modified optics for the change in the extinction section due to extinction design change.
 - Moderate probability with \$200K cost impact.

Registry contains 1 risk removed where a Threat is Avoided:

- ACCEL-033 Mu2e-doc-3832: Inability to stage magnets in the Accumulator enclosure during g-2 operation

Registry contains 1 opportunity:

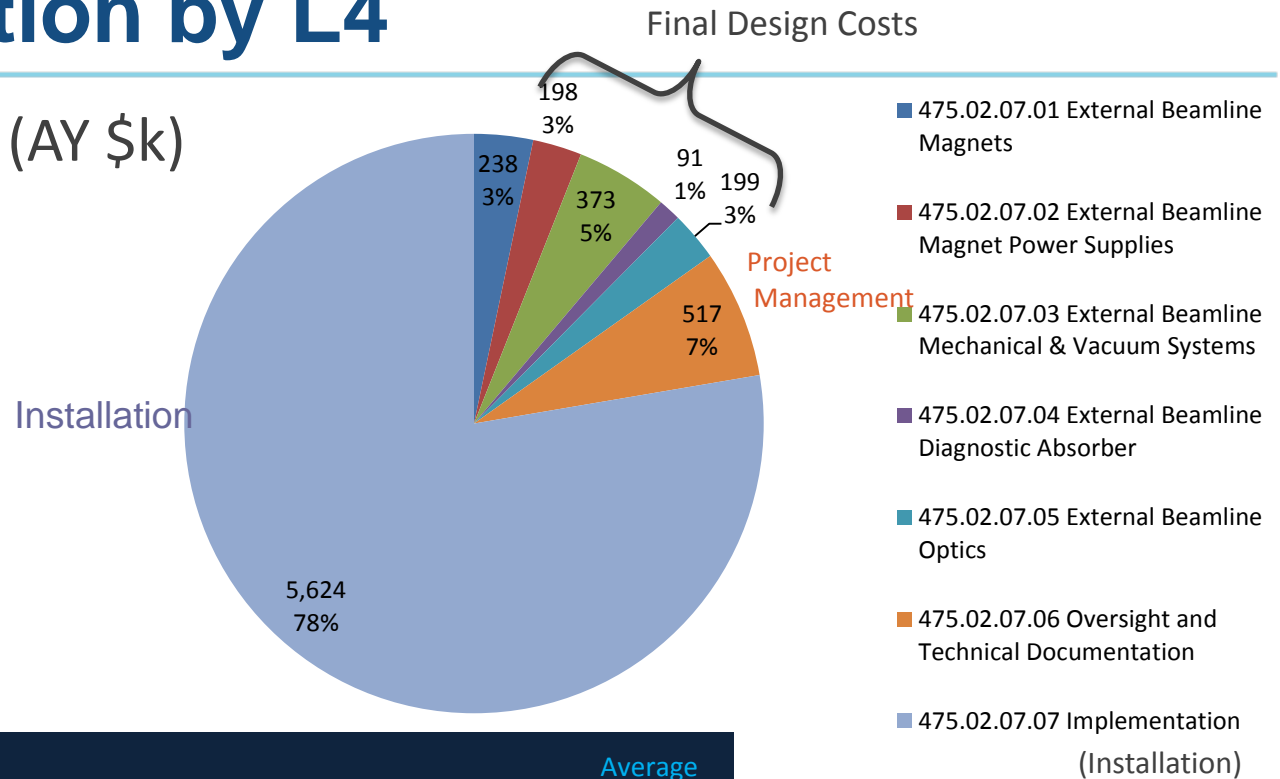
- ACCEL-202 - Mu2e-doc-4591: Replace current MDC magnet for diagnostic absorber line with an existing SDC magnet.
 - Moderate probability with \$110K cost impact.

ES&H

- Laboratory safety practices will be observed for all work, including the handling and installation of magnets, vacuum systems, power supplies and other accelerator components.
- Job hazard analyses will be performed for installation and other appropriate work.
- The new tunnel enclosure will conform to standards for radiation safety including prompt dose, residual dose, air activation and ground water activation. These hazards are addressed in the Hazard Analysis Report [Mu2e-doc-4229](#).
- Installation Coordinator will ensure work is properly coordinated to avoid conflicts

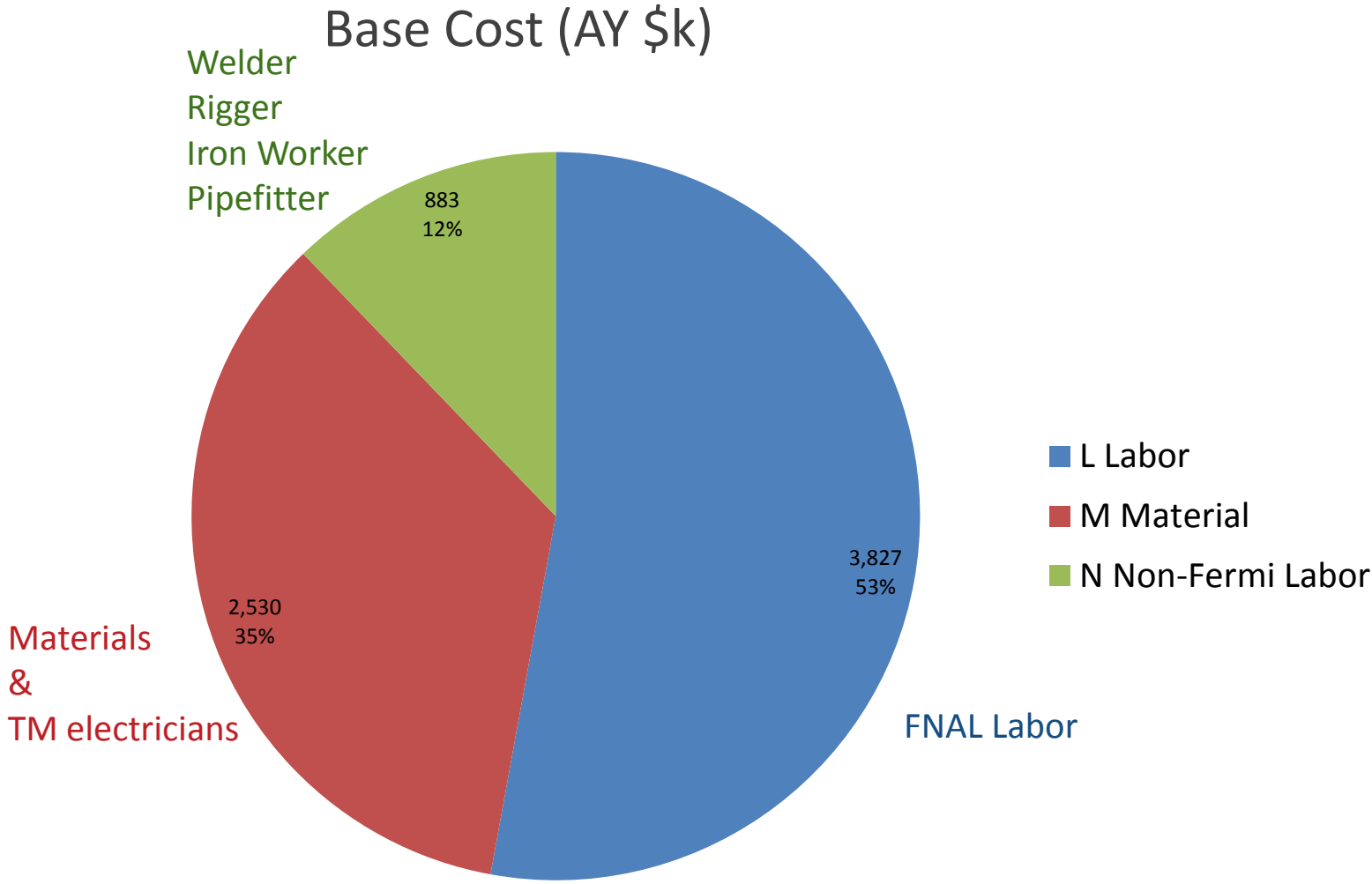
Cost Distribution by L4

Base Cost by L4 (AY \$k)



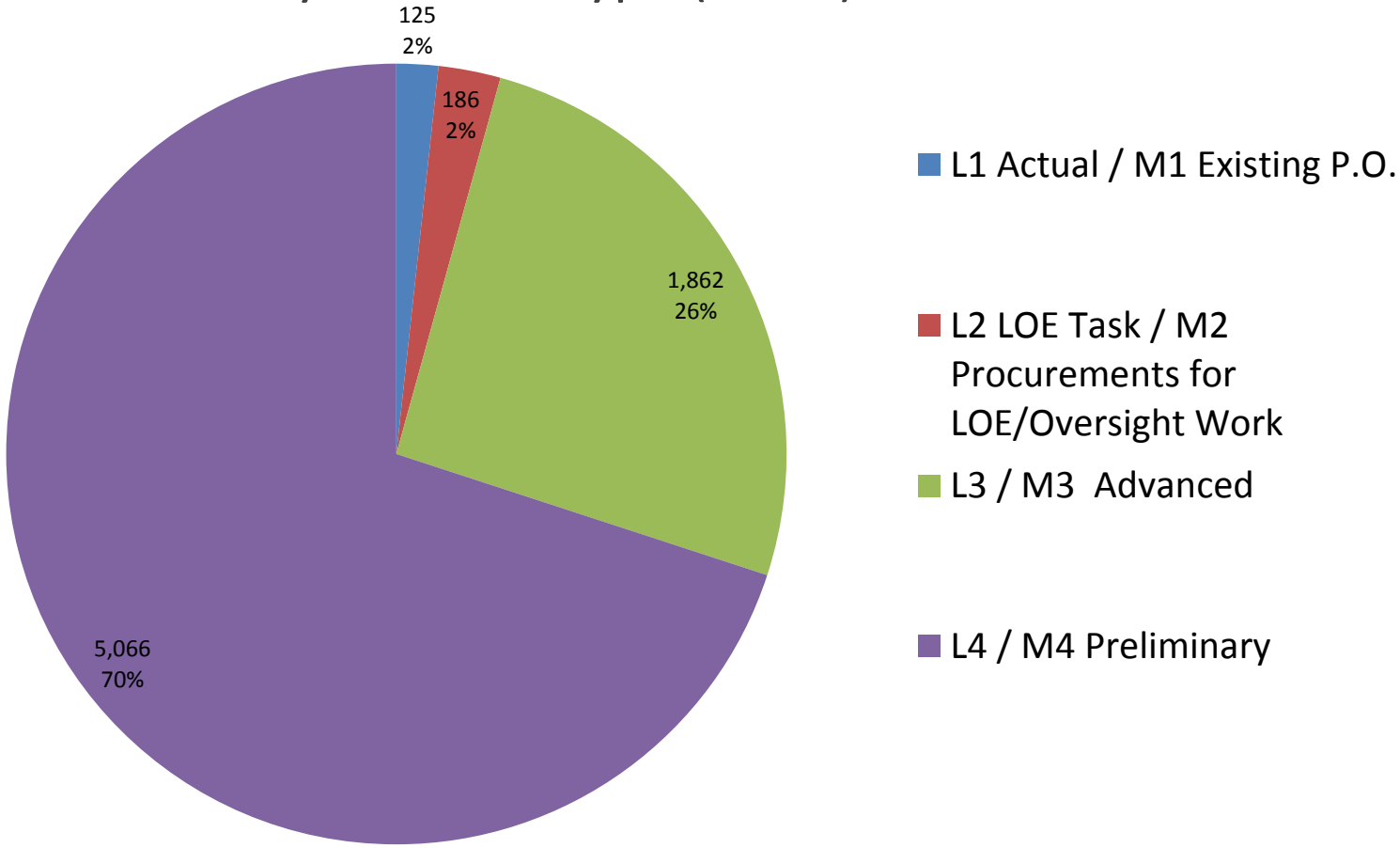
WBS Breakout of Implementation		Direct M&S	B A C	Estimate Uncertainty	Total	Average Contingency on remaining budget
475.02.07	Power Supply	1,286,200	2,537,885	698,597	3,236,484	28%
475.02.07	Magnets	278,400	1,843,114	547,534	2,390,650	30%
475.02.07	LCW & Compressed Air	162,700	596,180	178,855	775,038	30%
475.02.07	Vacuum	131,400	458,437	137,530	595,968	30%
475.02.07	Magnet Supports & Beam Stops	104,700	159,688	50,488	210,176	31%
475.02.07	Optics	0	28,406	8,522	36,927	30%
Total		1,963,400	5,623,710	1,621,526	7,245,243	30%

Cost Distribution by Resource Type



Quality of Estimate

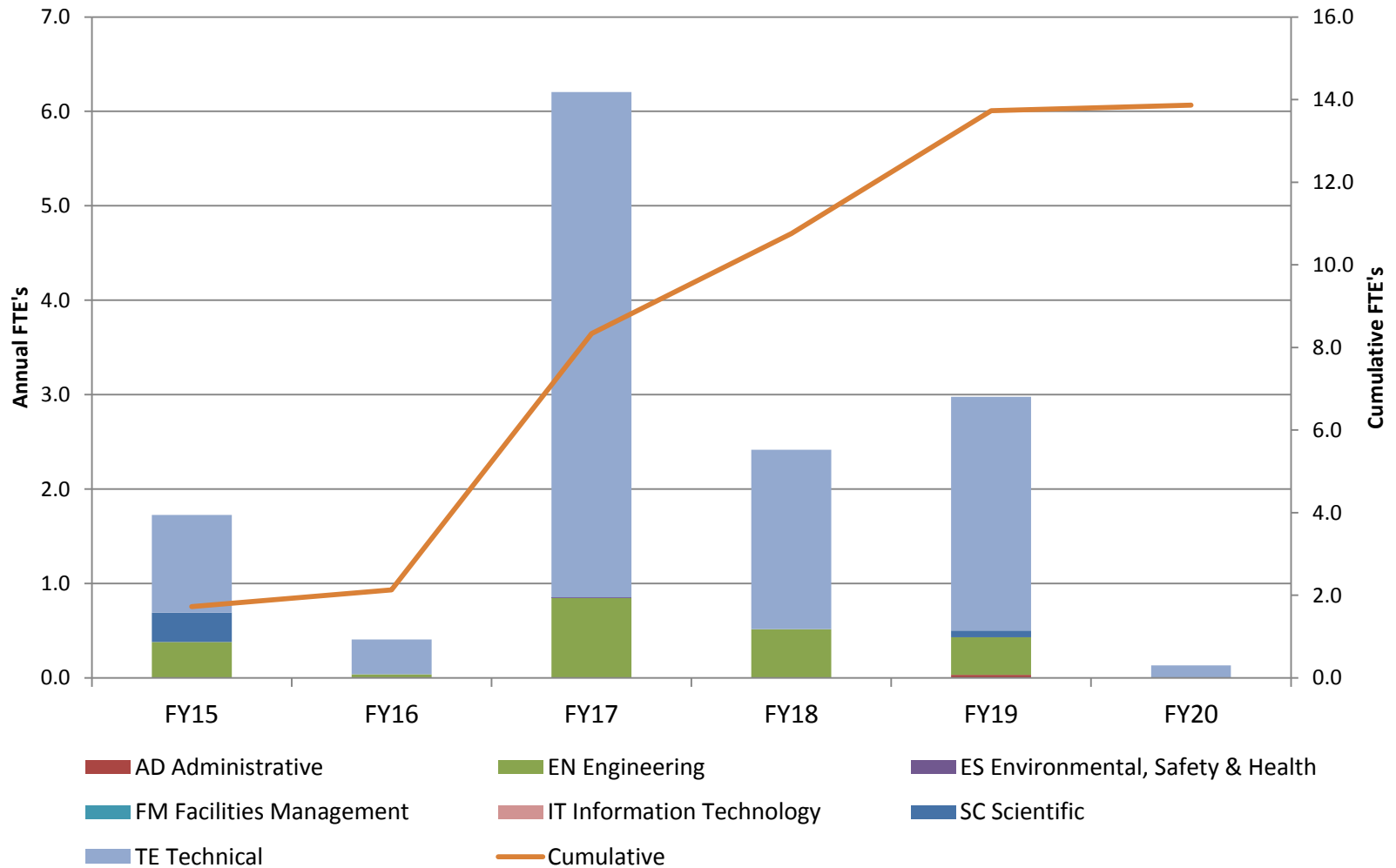
Base Cost by Estimate Type (AY \$k)



100% of cost is at the Preliminary Design level or better .

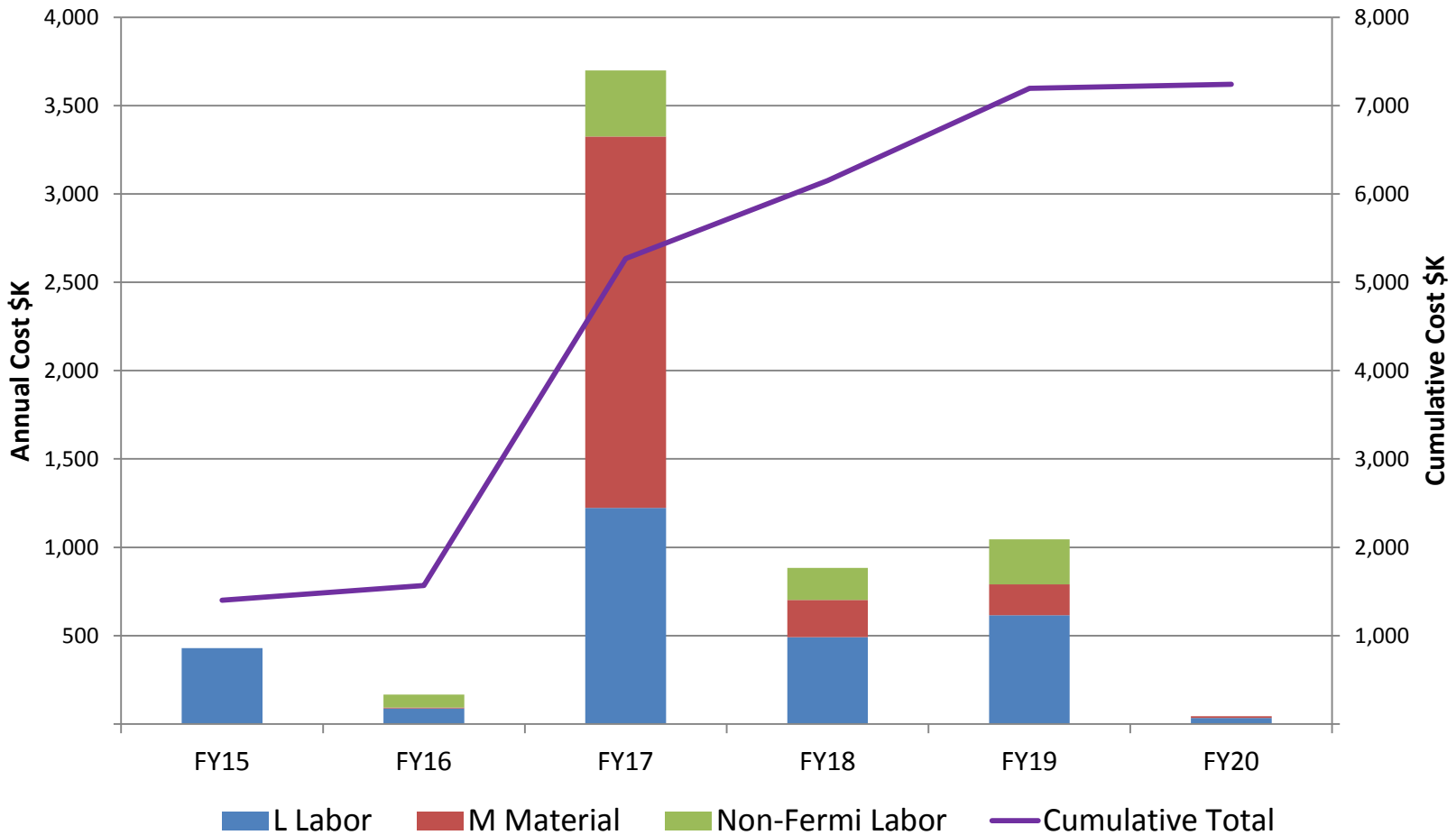
Labor Resources

FTEs by Discipline



Labor / Material Breakdown

Base Cost by Estimate Type (AY \$k)



Cost Table

Base Cost (AY K\$)

	M&S	Labor	Total	Estimate Uncertainty (on remaining budget)	% Contingency (on remaining budget)	Total Cost
475.02.07.01 External Beamline Magnets		238	238	42	30%	280
475.02.07.02 External Beamline Magnet Power Supplies		198	198	22	30%	220
475.02.07.03 External Beamline Mechanical & Vacuum Systems		373	373	36	33%	409
475.02.07.04 External Beamline Diagnostic Absorber	26	65	91		0%	91
475.02.07.05 External Beamline Optics		199	199	38	32%	237
475.02.07.06 Oversight and Technical Documentation		517	517	70	22%	587
475.02.07.07 Implementation	3,387	2,237	5,624	1,622	29%	7,245
Grand Total	3,412	3,827	7,240	1,830	29%	9,069

M4 External Beamline from CD2 Dir. Review

- At the CD2 Directors Review in July there was a comment in the Cost and Schedule section — *“There is a mismatch between some BOEs and P6. This is recognized and the path forward is under discussion. For example, the accelerator management team stated there is \$1-2M more in the BOEs for the magnets and power supplies than s shown in the schedule”*

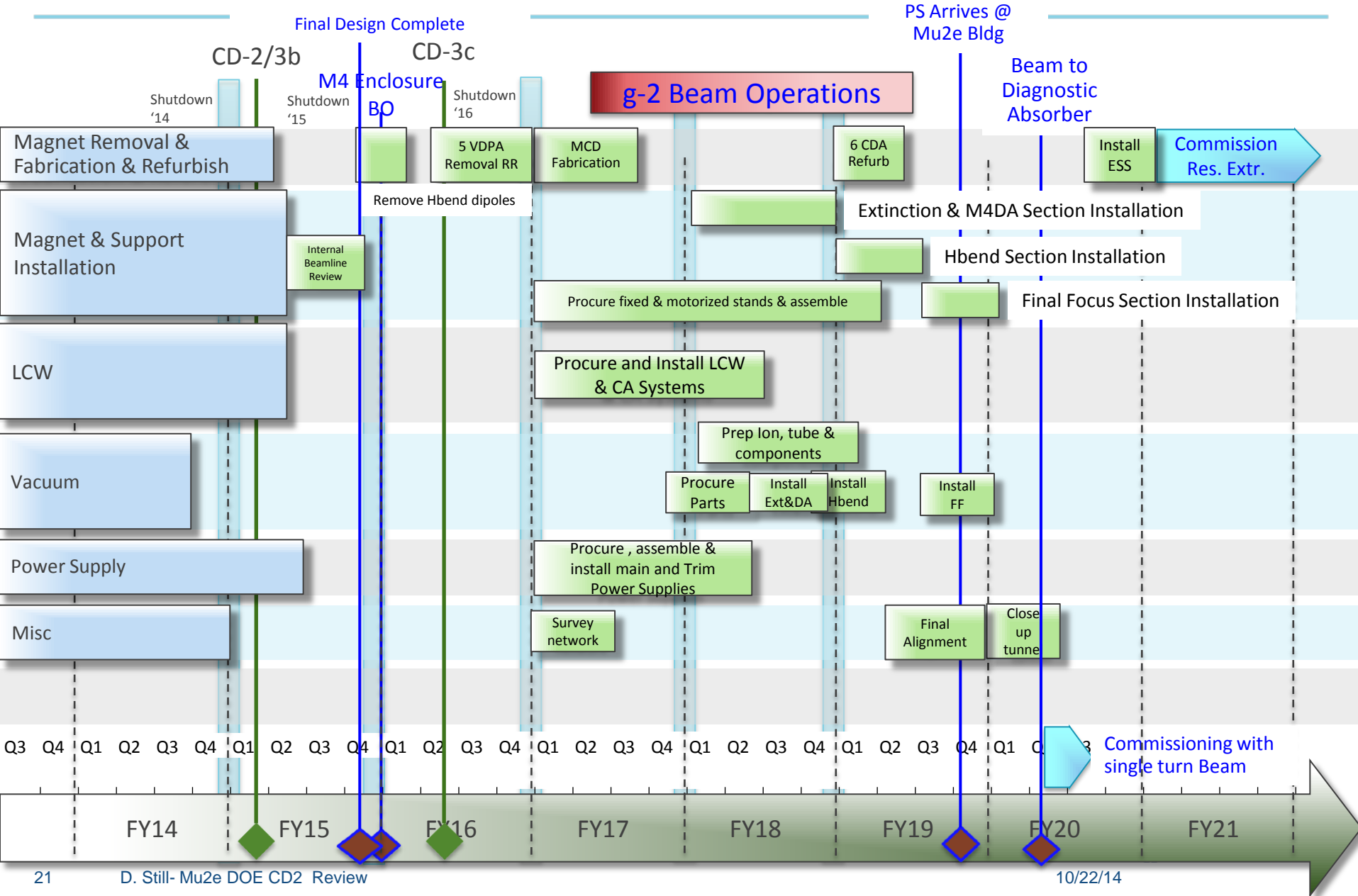
http://www.fnal.gov/directorate/OPMO/Projects/Mu2e/DirRev/2014/20140708/FINAL_Closeout_Presentation_Mu2e_2014_07_08.pdf

- Since July 2014, a “ground up” reevaluation of the M4 external beamline cost has been completed. Reevaluation cost \$9.1M from \$7.2M.
- That reevaluation of the cost was presented to the Mu2e Accelerator Management for changes.
- An Accelerator Division Independent cost review of M4 External Beamline was conducted on Sept 8-12, 2014.
- Internal Review Final Report can be found in [Mu2e-doc-4511](#) (link on review website)

Major Milestones

Activity ID	Activity Name	Start	Finish	Milestone
				Tier
47502.07.001010	T5 - Mu2e External Beamline Preliminary Design Complete		1-May-14	T5
47502.07.001200	TX5 - FY15 Maintenance Shutdown (Accelerator Complex)	08-Sep-15*		T5
47502.07.001050	TX4 - M4 External Beamline Enclosure Complete (by GPP)		30-Sep-15	T4
47502.07.001020	T5 - Mu2e External Beamline Final Design Complete		6-Nov-15	T5
47502.07.001030	T5 - DOE CD-3 Accelerator Beam Line Mini-Review Approval	24-Feb-16		T5
47502.07.01.004025	T5 - Start External Beamline Magnet Stand Procurement & Fabrication	3-Oct-16		T5
47502.07.07.002500	T5 - Start of MDC Dipole Fabrication	3-Oct-16		T5
47502.07.07.004070	T5 - Start of External Beamline Power Supply Procurement	3-Oct-16		T5
47502.07.07.002630	T5 - Start External Beamline Magnet Fixed Stand Assembly and Installation	31-Oct-16		T5
47502.07.07.004180	T5 - External Beamline Power Supply Fabrication and Installation Start	29-Mar-17		T5
47502.07.1240	TX5 - FY17 Maintenance Shutdown (Accelerator Complex)	5-Sep-17		T5
47502.07.07.004230	T5 - External Beamline Mechanical & Vacuum Procurement Start	2-Oct-17		T5
47502.07.07.003060	T5 - Start External Beamline Ext. & M4DA section Installation	31-Oct-17		T5
47502.07.07.004220	T5 - External Beamline Power Supply Installation Complete		12-Dec-17	T5
47502.07.07.004345	T5 - External Beamline Ext. & M4DA section Instalation Complete		14-Sep-18	T5
47502.07.07.004330	T5 - Start External Beamline HBend Installation	17-Sep-18		T5
47502.07.07.002530	T5 - Start CDA Dipole Magnet Refurbishment	1-Oct-18		T5
47502.07.07.004320	T5 - External Beamline HBend Installation Complete		14-Jan-19	T5
47502.07.07.002700	T5 - Start External Beamline Final Focus Installation	30-Jan-19		T5
47502.07.07.002560	T5 - External Beamline Final Focus Installation Complete		26-Mar-19	T5
47502.07.001240	T5 - Mu2e External Beamline Installation and Close-out Complete		25-Nov-19	T5
47502.07.001230	T5 - Mu2e External Beamline ready for beam to diagnostic absorber		29-Jan-20	T5

Schedule – External Beamline



Summary

- The design of the beamline is at a preliminary or better design stage.
- The installation schedule is at a preliminary design that has considerations to funding and lab resources.
- The M4 beamline is divided into three sections to allow for installation during g-2 operation.
- Installation of the beamline has allowed for the priority to commission beam the M4 diagnostic absorber.
- The cost of the M4 external beamline is \$9.1M
- The External Beamline L4 is ready to baseline.