

# DOE Independent Cost Estimate Muon to Electron Conversion (Mu2e) Project

Project Briefing  
8/26/2014

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# Introduction

- Project Execution
- Acquisition Strategy/Plan
- Project Funding



# Project Execution-Background

- CD-0 Approve Mission Need, Nov. 2009
  - Conversion of a muon into an electron provides a unique window on potential new physics processes
  - Mu2e: fastest, cheapest path to broad discovery in this sector
- CD-1 Approve Alternative Selection and Cost Range, July 2012
  - Existing Fermilab accelerator complex to be adapted/re-purposed to provide required muon beam delivery for Mu2e
  - CD-1 cost range was \$200M to \$310M



# DOE OHEP Planning and Mu2e

- Particle Physics Project Prioritization Panel (P5) issued a report , “Building for Discovery, Strategic Plan for U.S. Particle Physics in the Global Context”
- High Energy Physics Advisory Panel approved P5 report on May 23, 2014
- Mu2e Project described as one of the “*immediate targets of opportunity in the drive to search for new physics...*”
- P5 recommends completing the Mu2e project



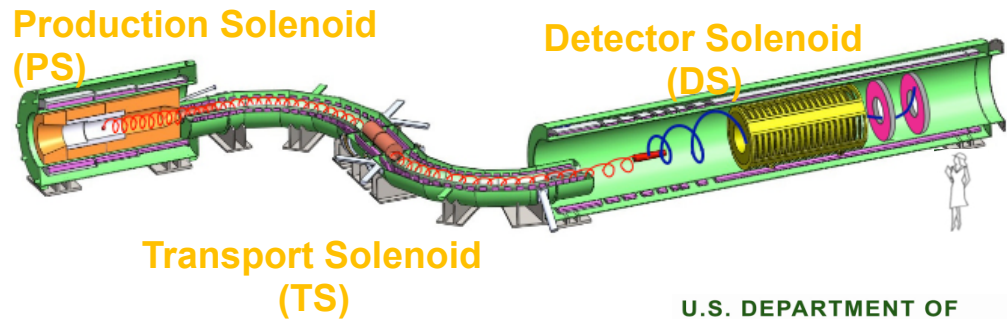
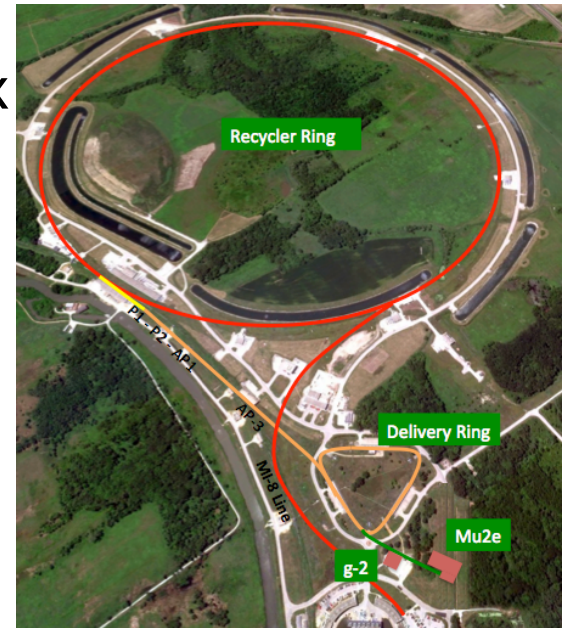
# Acquisition Strategy Overview

- Mu2e apparatus unique, highly complex scientific device
- DOE relies on FRA/FNAL to execute
  - FRA strong, successful relationship with HEP community, leadership (includes FNAL scientists)
  - Ensures close coordination between scientific collaboration and experienced FNAL project leaders
- FNAL responsible for oversight of contracts
  - Purchase of components from vendors
  - University groups to fabricate detector subsystems

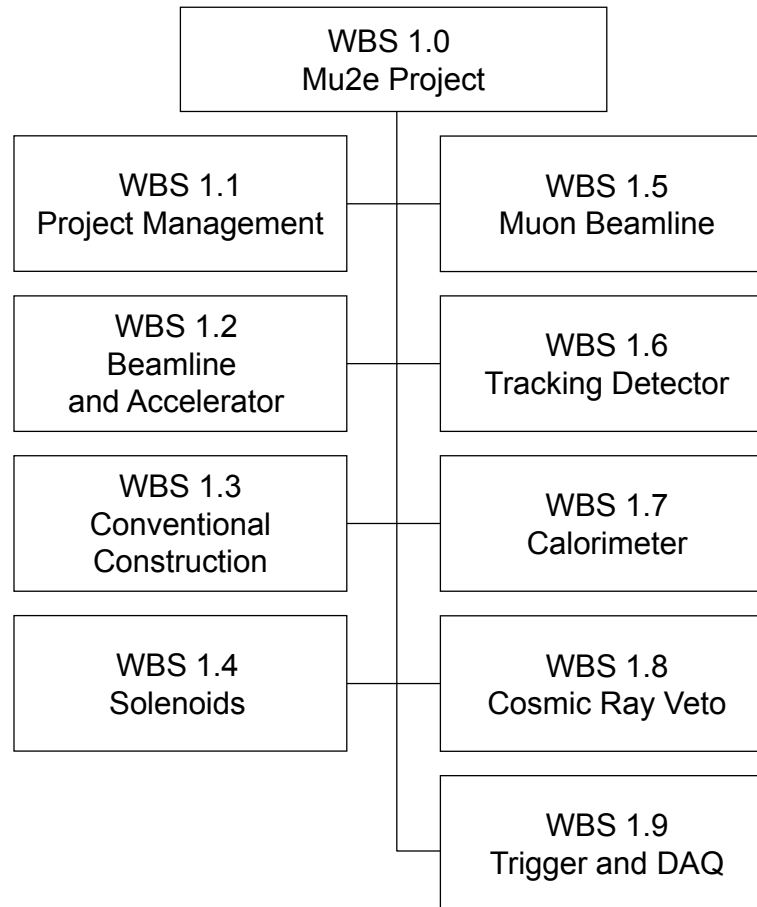


# Mu2e Project Scope Highlights

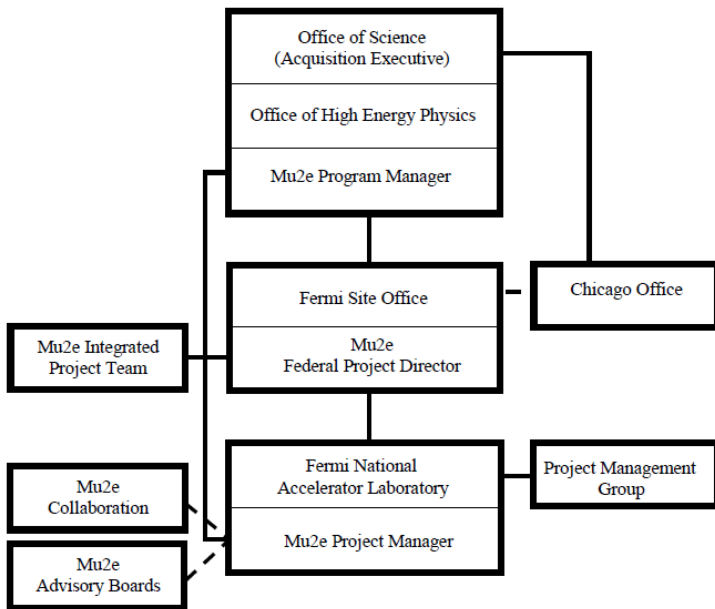
- Upgrades to existing accelerator complex
- Construction of a new beamline
- Mu2e Apparatus
  - 3 Superconducting solenoids
  - Tracker
  - Calorimeter
  - Cosmic Ray Veto
- New detector building



# Project Execution- WBS



# Project Execution-Organization

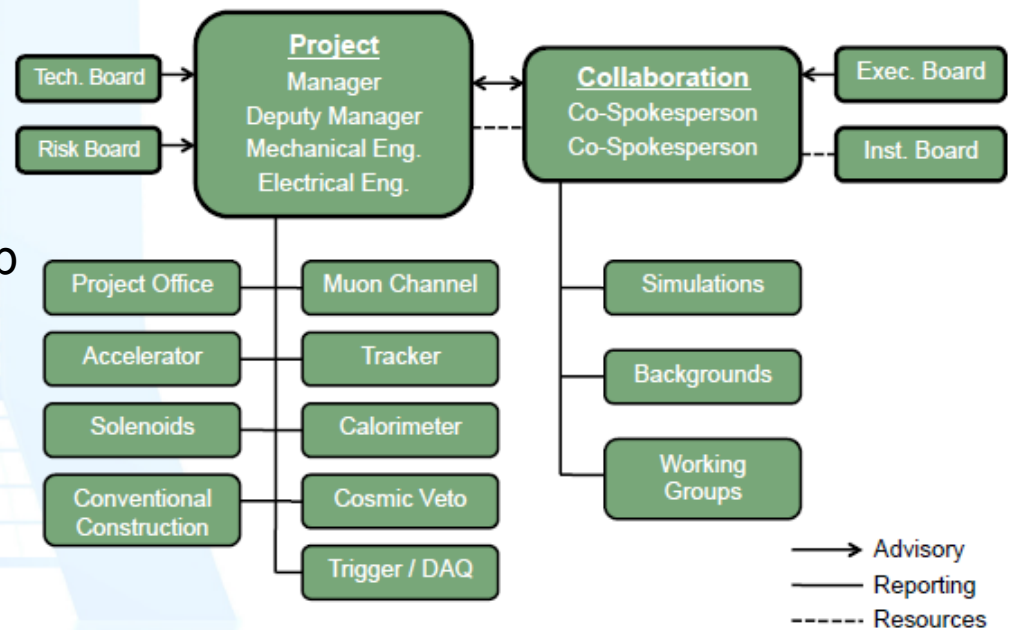


DOE Acquisition Executive: SC-2, P. Dehmer  
OHEP AD: Jim Siegrist  
DOE Program Manager: Ted Lavine  
DOE FPD/Deputy: Pepin Carolan/Paul Philp  
FNAL Project Manager: Ron Ray  
FNAL Deputy PM: Doug Glenzinski\*\*

- FNAL Project Management Group (Directorate oversight)
- Integrated Muon Program Team (oversee and manage interfaces among Mu2e, g-2, AIPs/GPPs)

\*\* Doug G elected Mu2e Collaboration Spokesperson

## Mu2e Organization



→ Advisory  
 — Reporting  
 - - - Resources





# Project Execution-Cost Drivers

WBS #	WBS Name	Base Cost (\$M)
<b>375.01</b>	<b>Project Management</b>	<b>\$20.75</b>
375.01.01	Conceptual Design (Prior to 01.01C)	\$4.94
375.01.02	Procurement & Final Design Phase to CD-375	\$4.77
375.01.04	Implementation & Close-out to CD-4	\$11.07
<b>375.02</b>	<b>Accelerator</b>	<b>\$40.94</b>
375.02.01	Accelerator Project Management	\$3.45
375.02.04	Instrumentation and Controls	\$9.49
375.02.04	Radiation Safety Improvements	\$21.18
375.02.05	Resonant Extraction System	\$5.51
375.02.06	Delivery Ring RF System	\$1.70
375.02.07	External Beamline	\$5.74
375.02.08	Extraction Systems	\$1.15
375.02.09	Target Station	\$10.86
375.02.10	Accelerator Conceptual Design/R&D	\$5.04
<b>375.03</b>	<b>Conventional Construction</b>	<b>\$20.62</b>
375.03.01	Conceptual Design	\$5.31
375.03.02	Production Final Design	\$1.26
375.03.03	Construction Phase Oversight	\$2.48
375.03.04	Construction	\$14.97
375.03.05	Project Close	\$3.86
<b>375.04</b>	<b>Solenoids</b>	<b>\$85.87</b>
375.04.01	Project Management	\$4.06
375.04.02	Production Solenoid	\$14.20
375.04.03	Transport Solenoids	\$23.18
375.04.04	Detector Solenoid	\$15.92
375.04.05	Cryogenic System	\$11.72
375.04.06	Magnet Power System	\$1.48
375.04.07	Magnet Quench Protection System	\$9.60
375.04.08	Magnetic Field Mapping System	\$1.15
375.04.09	Auxiliary Equipment	\$9.77
375.04.10	Muon Beamline Installation and Commissioning	\$4.84
375.04.11	Solenoids Conceptual Design/R&D	\$6.02
<b>375.05</b>	<b>Muon Beamline</b>	<b>\$19.71</b>
375.05.01	Muon Beamline Project Management	\$1.86
375.05.02	Vacuum System	\$3.89
375.05.03	Collimation	\$1.55
375.05.04	Upstream External Shielding	\$1.87
375.05.05	Stopping Target	\$1.7
375.05.06	Stopping Target Monitor	\$3.1
375.05.07	Detector Solenoid Internal Shielding	\$3.9
375.05.08	Muon Beam Stop	\$7.4
375.05.09	Downstream External Shielding	\$3.3
375.05.10	Detector Support Structure	\$9.34
375.05.11	Systems Integration, Test & Analysis	\$3.7
375.05.11	Muon Beamline Conceptual Design/R&D	\$1.96
<b>375.06</b>	<b>Tracker</b>	<b>\$13.75</b>
375.06.01	Project Management	\$1.80
375.06.02	Straws	\$1.41
375.06.03	Straw Assemblies	\$3.81
375.06.04	Power and Electronics	\$3.14
375.06.05	Infrastructure	\$9.5
375.06.06	Detector Assembly & Installation	\$6
375.06.07	Tracker Conceptual Design/R&D	\$1.58
<b>375.07</b>	<b>Calorimeter</b>	<b>\$5.44</b>
375.07.01	Project Management	\$2.4
375.07.02	Calorimeter	\$2.4
375.07.03	Mechanical Support	\$1.8
375.07.04	Photosectors	\$1.15
375.07.05	Digitizer	\$10
375.07.06	Calorimeter Systems	\$1
375.07.07	Power	\$
375.07.08	Installation	\$1.8
<b>375.08</b>	<b>Cosmic Ray Veto</b>	<b>\$6.73</b>
375.08.01	Project Management	\$45
375.08.02	Mechanical Design	\$1.8
375.08.03	Scintillator extrusions	\$1.01
375.08.04	Fibers	\$45
375.08.05	Silicon Photomultipliers (SiPMs)	\$76
375.08.06	Electronics	\$1.71
375.08.07	Module Fabrication	\$1.4
375.08.08	Detector assembly and installation	\$20
375.08.09	Cosmic Ray Veto Conceptual Design/R&D	\$1.1
<b>375.09</b>	<b>Trigger &amp; DAQ</b>	<b>\$4.81</b>
375.09.01	Project Management	\$85
375.09.02	System Design and Test	\$67
375.09.03	Data Acquisition	\$1.84
375.09.04	Data Processing	\$85
375.09.05	Controls and Networking	\$58
	Subtotal of Above	\$217.65
	Contingency	\$14.35
	<b>Total Project Cost</b>	<b>\$272.00</b>

- TPC of \$270M
- Cost Drivers: Solenoids, Accelerator, Conventional, Muon Beamline
  - ICE for Conventional
  - ICR drilldowns designed to look at cost drivers in technical subsystems



# Project Execution-Schedule Drivers

- Fabrication/installation of 3 Solenoids (PS,TS,DS) is the Critical Path, and depends on fabrication/delivery of superconductor
  - Long Lead Procurement (CD-3a) for superconductor procurement (July 2014)
  - Ensure available when needed, reduce risk
- Phased CD-3 part of Tailoring Strategy
- 24 months float planned on CD-4



# Project Execution-Tailoring Strategy

Phased Critical Decision 3 (CD-3) to allow for long lead procurement, and start of some construction activity before project-wide design finalized.

1) **CD-3a** for Approval of long-lead procurements prior to CD-2, to maximize cost and schedule savings possible by advancing critical path activity (i.e. purchasing superconductor cable needed for critical path solenoid fabrication).

2) **CD-3b** to Approve Construction Start. CD-3b would cover start of civil construction and any additional parts of the project ready to commence construction or fabrication. Allow s for a more cost-effective civil design effort and advances construction of key elements (such as the detector hall) needed to complete Mu2e project.

3) **CD-3c** to Approve Full Construction Start. CD-3c would cover balance of project (accelerator and muon beamline, solenoids, detector subsystems and trigger/DAQ); if some subsystems have remaining final design activities at time of CD-3c, project ensures remaining risk associated is sufficiently low and addressed through risk assessment and contingency.



# Project Execution-Systems & Tools

- DOE certified FNAL EVMS system
  - Lab-wide policies, procedures for cost estimating, scheduling, etc...
  - Undergoes regular surveillance
- Primavera P6/Cobra Cost Processor tools
- Lab Project Support Services office for support and expertise
- Lab in era of employing standard tools, common methods and sharing experiences and lessons across Projects



# Project Execution-Change Control

- Contingency Management Change Control Thresholds defined for Mu2e in PEP
- Consistent with DOE-SC PEP Template

	Deputy Director For Science Programs	Associate Director of Science for HEP	Federal Project Director	Fermilab Mu2e Project Manager
Cost	Any increase in TPC, TEC, or OPC.	Any contingency usage over \$5M for a single item or any cumulative change greater than 50% of a Level 2 WBS	Cumulative contingency use of \$1M	Any change that increases the cost of a single item by more than \$50k



# Project Execution-Risk Management

- Risk Management Plan provides structured, integrated process to identify risks
  - evaluate, track, mitigate cost/schedule/technical
  - Risk Management Board chaired by Project Manager meets regularly to identify risks, mitigation plans
- Risk Registry documents risks
  - Detailed risk forms for medium, high risks
  - ~50 risks actively managed (6 opportunities realized at \$1.7M savings; >\$6M spent to mitigate risks)
  - Monte Carlo performed → cost at 90% C.L. to cover risk
- Contingency estimate includes risk exposure + uncertainty estimates from BOE's



# Acquisition Strategy-Highlights

- Engineering/design, fabrication for 2 solenoids (PS, DS) contracted to industry
  - Similar to other solenoids fabricated by industry
- 3<sup>rd</sup> (unique) solenoid (TS) designed, fabricated by FNAL (no industry analog)
  - parts procured from industry
- 2 major civil construction contracts
  - A&E contract for design and cost estimate
  - General construction contract



# Acquisition Strategy-Highlights

- Solenoids
  - Positive response from several qualified vendors, and selection made
  - Interactions with ITER and other superconductor magnet project teams to gain from experience
  - Vendors working on long lead conductor production
- Civil Construction
  - ICE within ~2% of project estimate
  - Responses on building contract received, technical evaluation of bids and cost underway
  - Wrap up ICE this week





# Acquisition Planning

- Mu2e Procurement Management Plan
  - Identifies Significant/Major/Critical procurements requiring “Advanced Procurement Plan” (APP)
  - 3 Major (>\$5M); 24 Significant (>\$.5M); 17 Critical (>\$1M or high risk, complexity, including 2 Major, 12 Significant)
  - Includes requirements for planning, scheduling, solicitation, review, award, administration, oversight
- Dedicated Mu2e Procurement Manager/team
- Project schedule includes appropriate time for procurement processing based on cost estimate, complexity



# Acquisition Oversight & Tracking

- Mu2e Procurement Management Plan requires QC/Vendor Oversight plan by CAM
  - e.g. Conductor, Solenoid procurements (ITER experience)
- Project Manager establishes “Acquisition Oversight Committee” (AOC) when/where needed
  - e.g. established for conductor/solenoids with external superconducting magnet experts advising project team on procurement planning and execution
- Procurement actions tracked via Mu2e Project RLS from APP concluding with final delivery
  - payments tracked by Mu2e Financial Officer



# Project Funding

	Prior yrs.	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Total
<b>OPC</b>	<b>21.177</b>	<b>2.5</b>							<b>23.677</b>
<b>TEC-PED</b>	<b>24</b>	<b>8</b>	<b>15</b>						<b>47.000</b>
<b>TEC-Const.</b>			<b>20</b>	<b>25</b>	<b>35.1</b>	<b>45.6</b>	<b>46.0</b>	<b>28.623</b>	<b>200.323</b>
<b>Total</b>	<b>45.177</b>	<b>10.5</b>	<b>35</b>	<b>25</b>	<b>35.1</b>	<b>45.6</b>	<b>46.0</b>	<b>28.623</b>	<b>271.000</b>

- OHEP funding profile provided
- Project addressing reconciliation of obligation profile with funding profile
  - Small problem in FY15 and bigger problem in FY16
  - Actions to mitigate identified, not yet implemented

