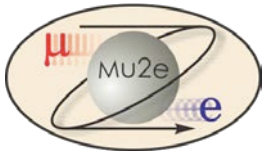
Fermilab

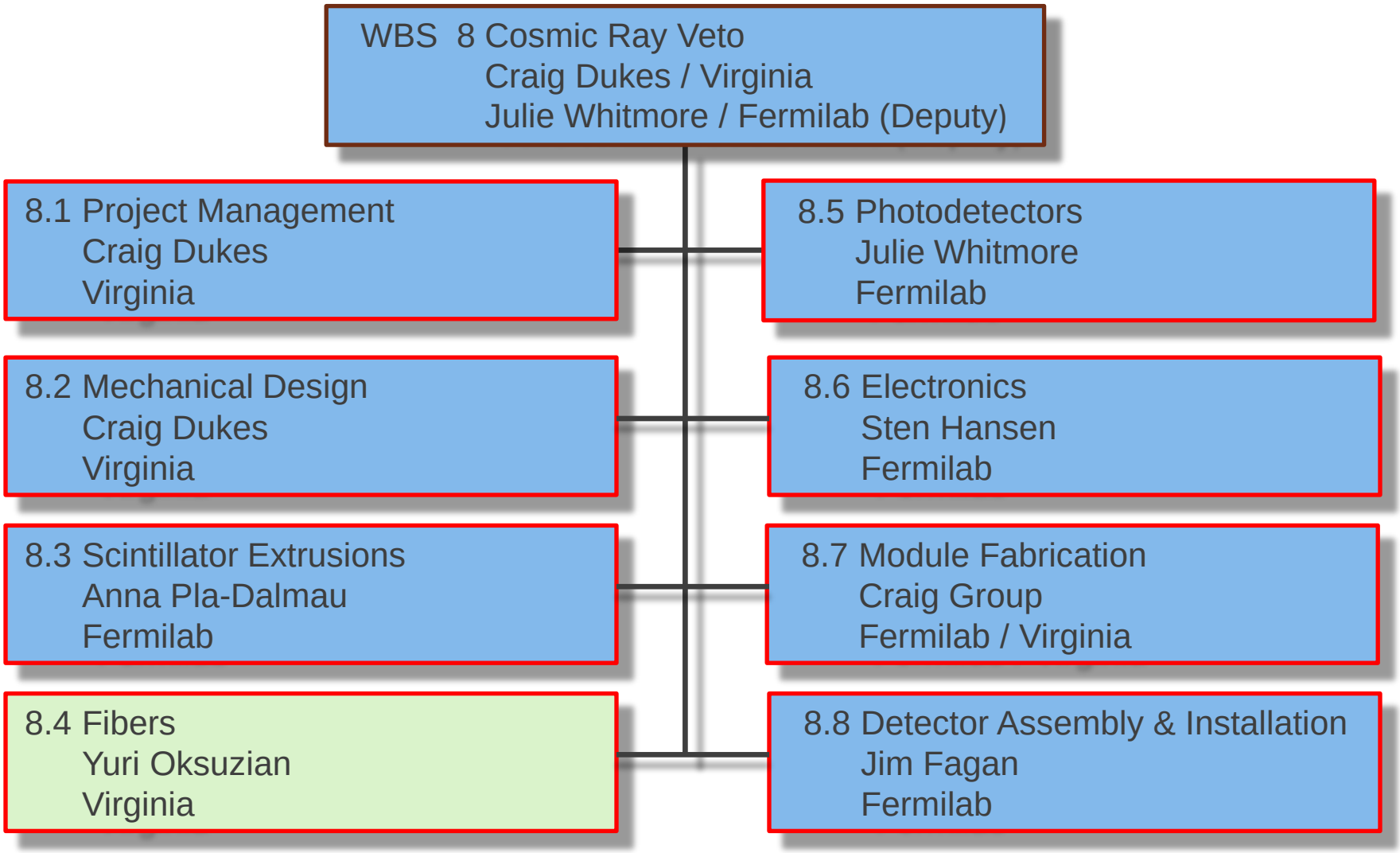
U.S. DEPARTMENT OF ENERGY Office of Science

Mu2e Cosmic Ray Veto
8.4 Fibers

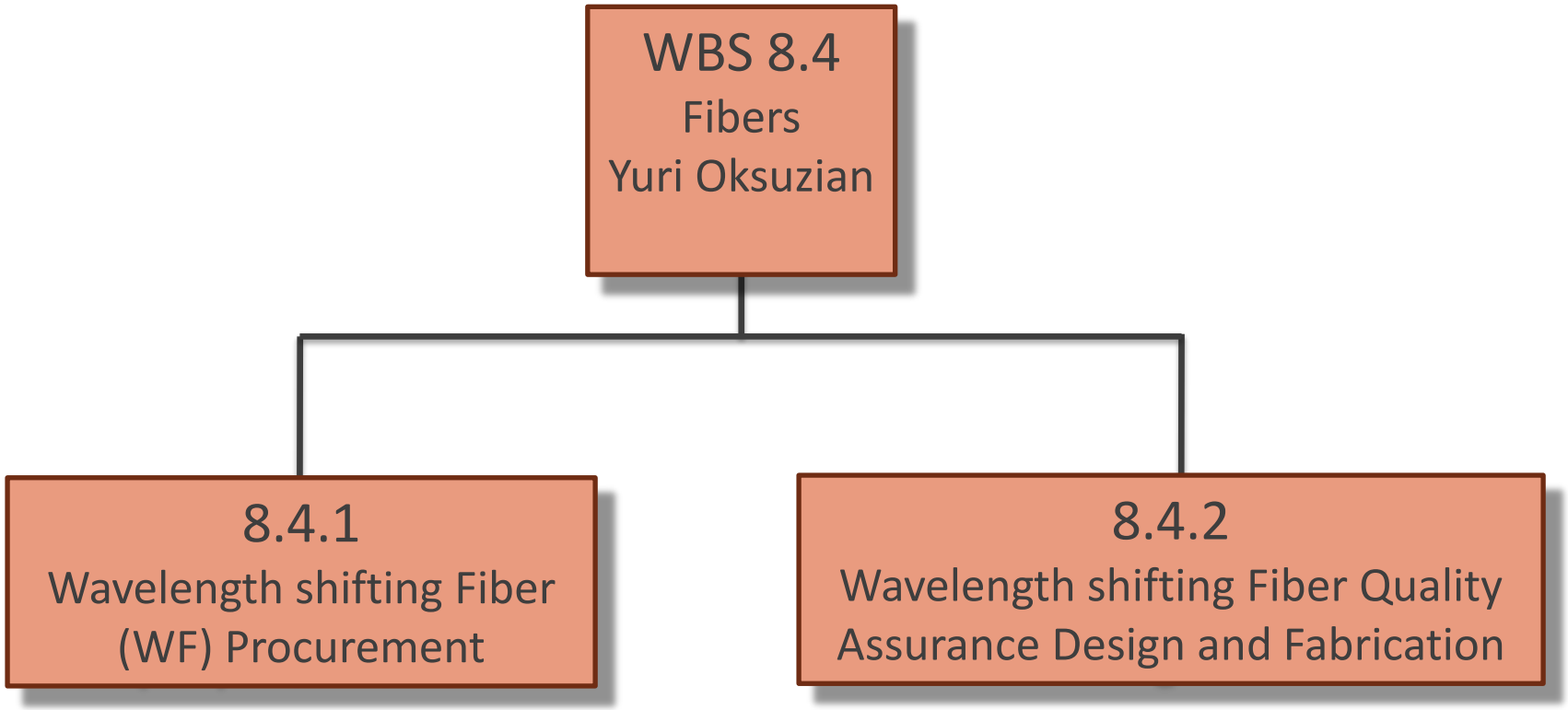


Yuri Oksuzian
Level 3 Manager
July 8, 2014

Organizational Breakdown



Organizational Breakdown



WBS Dictionary for 8.4

- **475.08.04.01 Wavelength shifting Fiber (WF) Procurement:** This task covers the specification, selection, procurement, and testing of wavelength shifting fibers for the prototypes and production counters.

- **475.08.04.02 Wavelength shifting Fiber Quality Assurance Design and Fabrication:** The purpose of this task is to develop the quality control testing procedures, and to design and fabricate the equipment for testing the wavelength shifting fiber.

Requirements

- Wavelength shifting (WLS) fiber collects the light from scintillator and transports the light to the photo-multiplier
- High performance and quality control

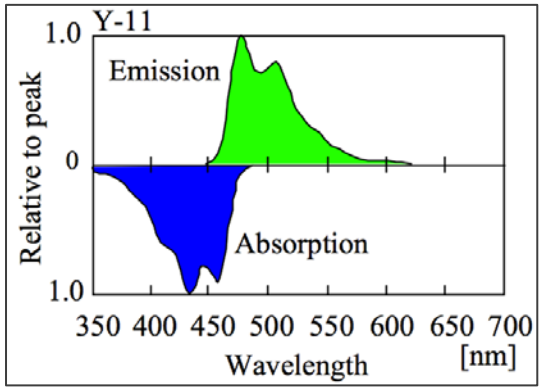
- Absorbs the blue light from scintillator and re-emits in green region

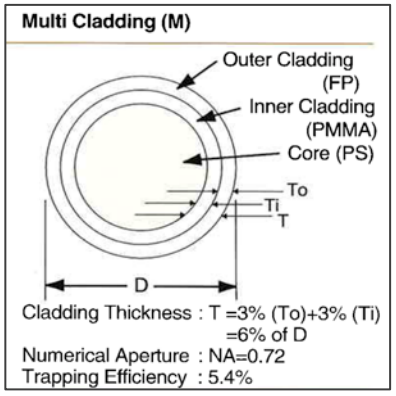
- Sufficient light yield, high trapping efficiency and long attenuation length

- Ionizing radiation damage levels have to be lower than 1kGy

Design

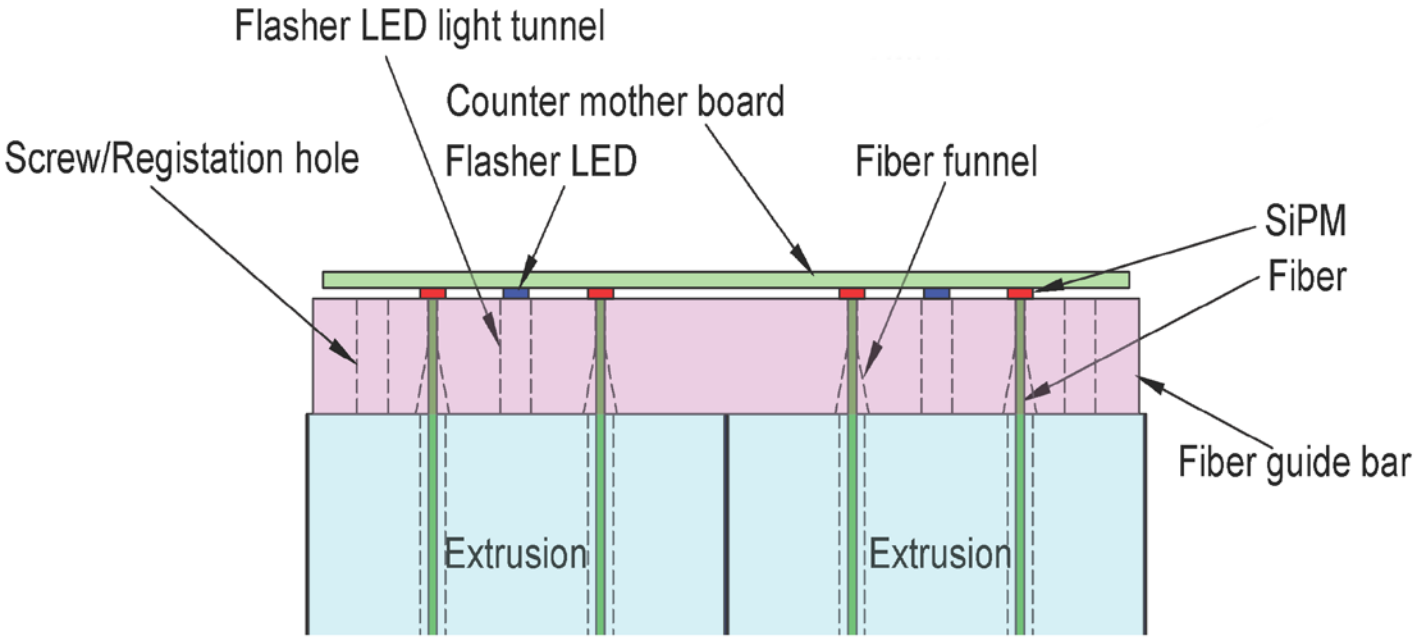
- Wavelength shifting (WLS) fiber collects the light from scintillator and transports the light to the photo-multiplier
- High performance and quality control
  - **Kuraray**
- Absorbs the blue light from scintillator and re-emits in green region
  - **Y11**
- Sufficient light yield, high trapping efficiency and long attenuation length
  - **1.4 mmD, non-S, multi-clad fiber with 175 ppm fluorescent compound**
- Ionizing radiation damage levels have to be lower than 1kGy
  - **The radiation levels are lower than 10 Gy**





Design

- The fiber is glued to the fiber guide bar and loose along the counter
- The fiber guide bar is fly cut
- The total amount of WLS fiber needed:
  - 760 (320) m of 1.4 (1.8) mmD fiber for prototypes
  - 1,600 m for 2 medium sized pre-production modules
  - 63,000 m for production modules, including spares and wastage



Changes since CD-1

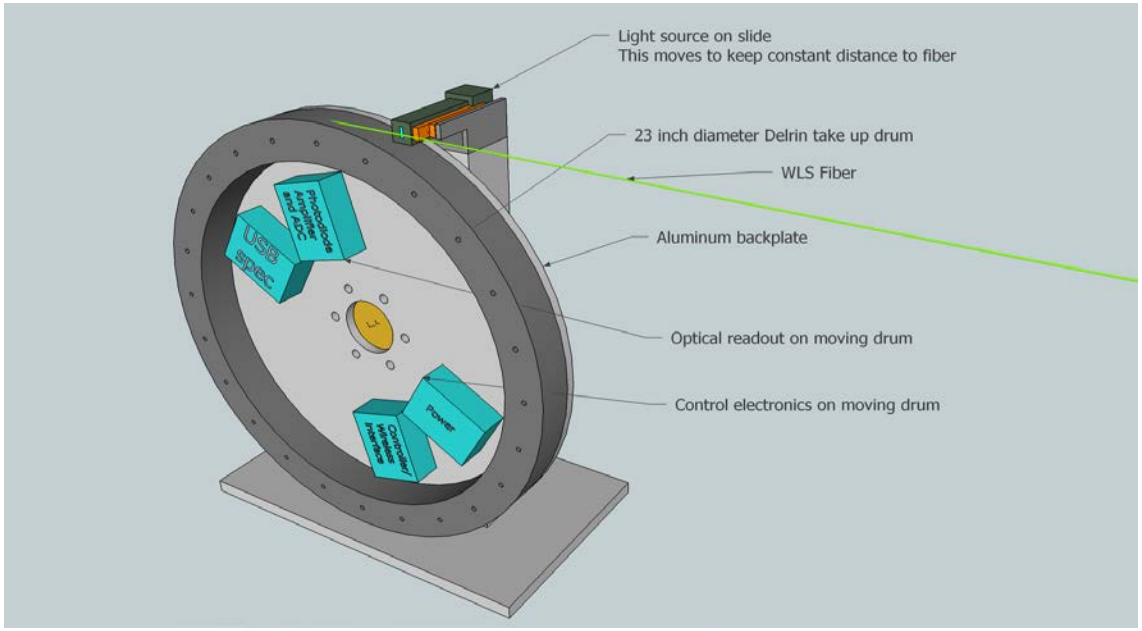
- The baseline fiber thickness was 1.0 mmD at CD-1
- The latest test beam results with di-counter prototypes suggest we need 1.4 mmD fiber to reach required light yield
- The QA test jig design has been modified to accommodate thicker fiber

Remaining work before CD-3

- Select the fiber size, using the measurement with prototypes:
  - 1.4 and 1.8 mmD fiber
  - 5x2 cm^2 di-counter prototypes
  - 2x2 mm^2 SiPM
- Produce fiber QA test jig
  - Evaluate the prototype fiber

Quality Assurance

- Former MSU technician will design the fiber test jig which can test fibers up to ~2.5 mm diameter
- Extract up to 25 meters of fiber from a factory supply spool
- Stimulate the fiber with a blue LED light source during the extraction
- Measure light output by two different readout devices:
  - Spectrophotometer (spectral attenuation)
  - Large-area photodiode (absolute scale and attenuation)



Risks

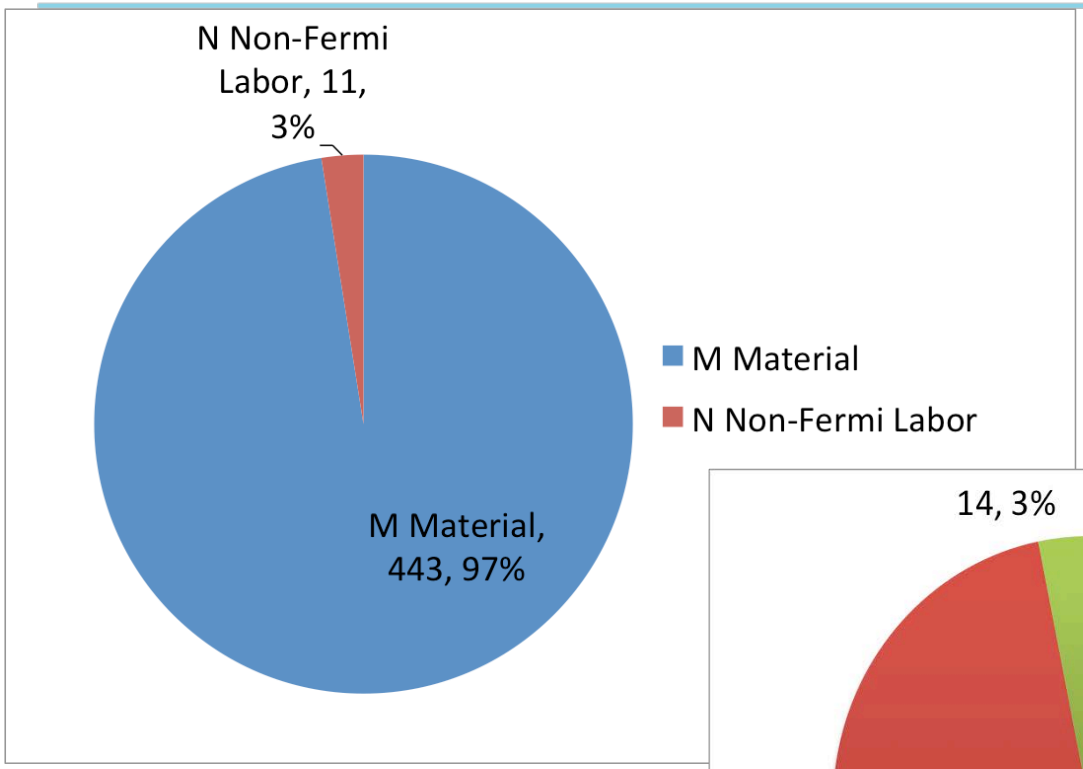
- Light yield is not sufficient
  - Increase the diameter of the fiber
- Kuraray goes off the market
  - Switch to Saint-Gobain fiber

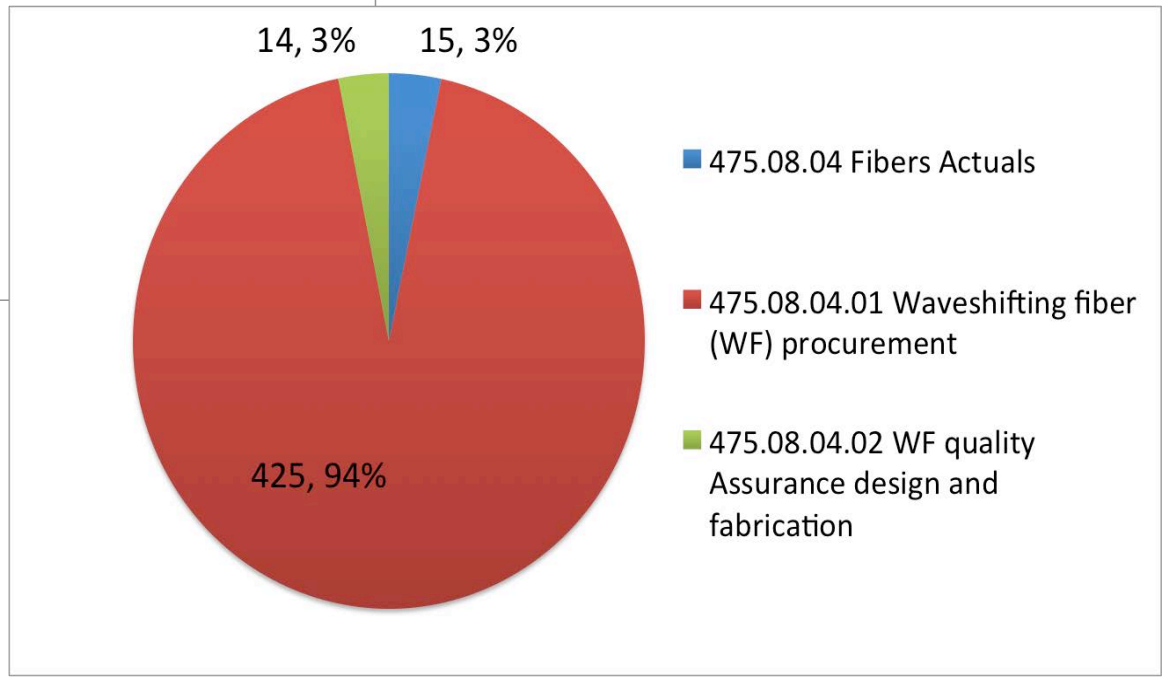
Cost Table

	Base Cost (AY k$)					
	M&S	Labor*	Total	Estimate Uncertainty (on remaining costs)	% Contingency on ETC	Total Cost
475.08 Cosmic Ray Veto						
475.08.04 Fibers						
475.08.04 Fibers Actuals	15		15			15
475.08.04.01 Waveshifting fiber (WF) procurement	425		425	103	24%	528
475.08.04.02 WF quality Assurance design and fabrication	14		14	1	10%	16
Grand Total	455		455	105	24%	559

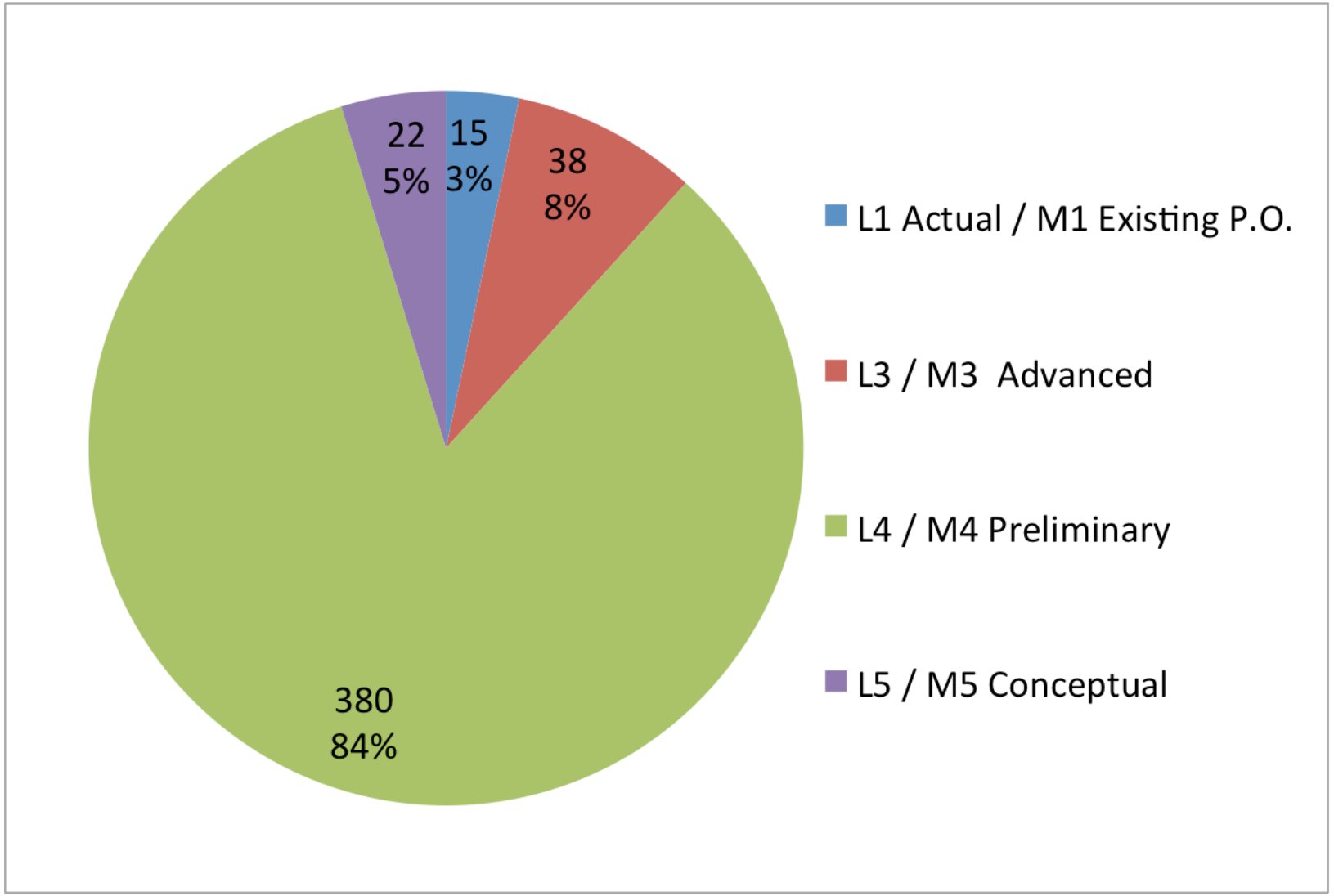
*Fermilab labor only

Cost Breakdown

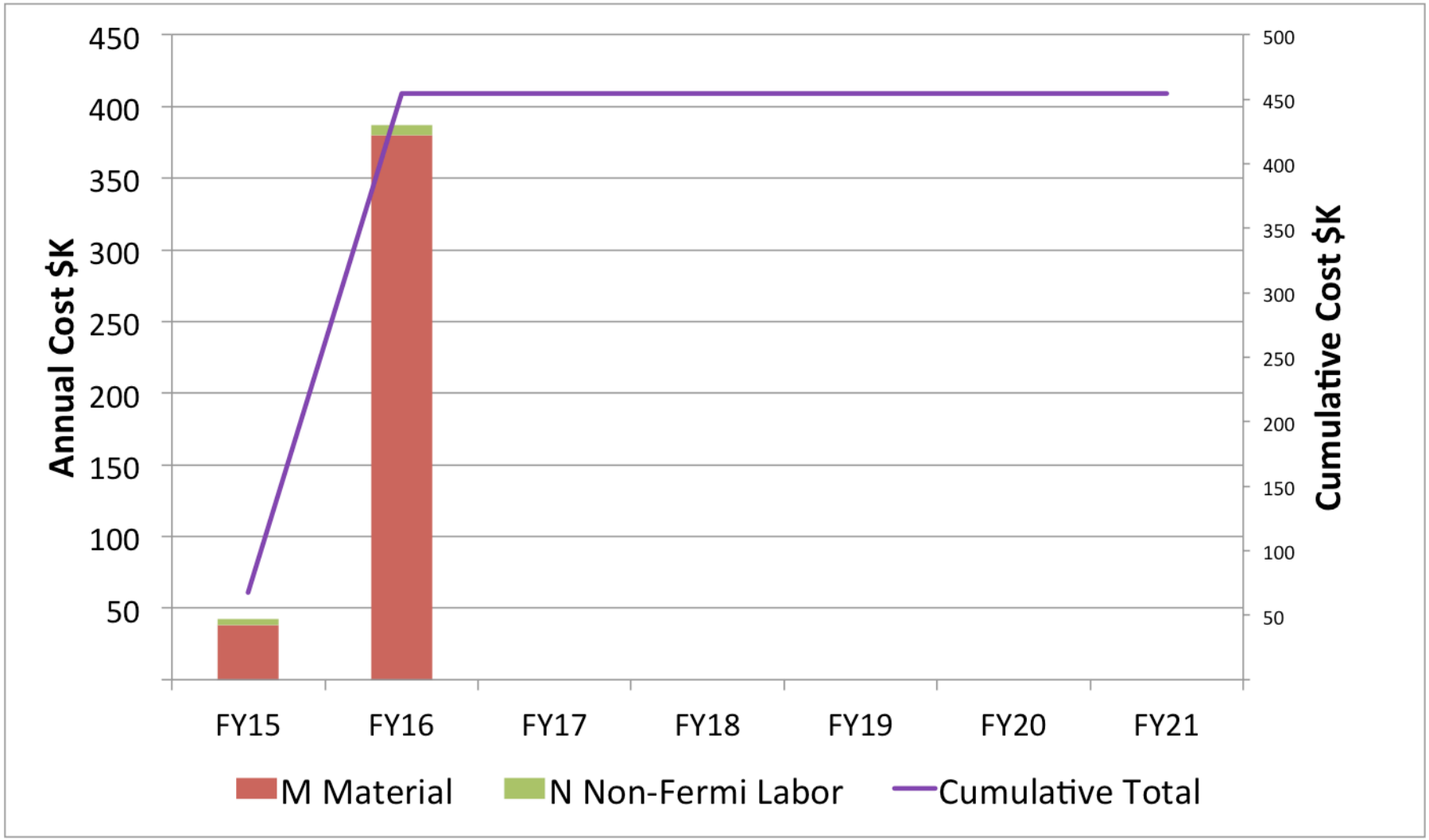




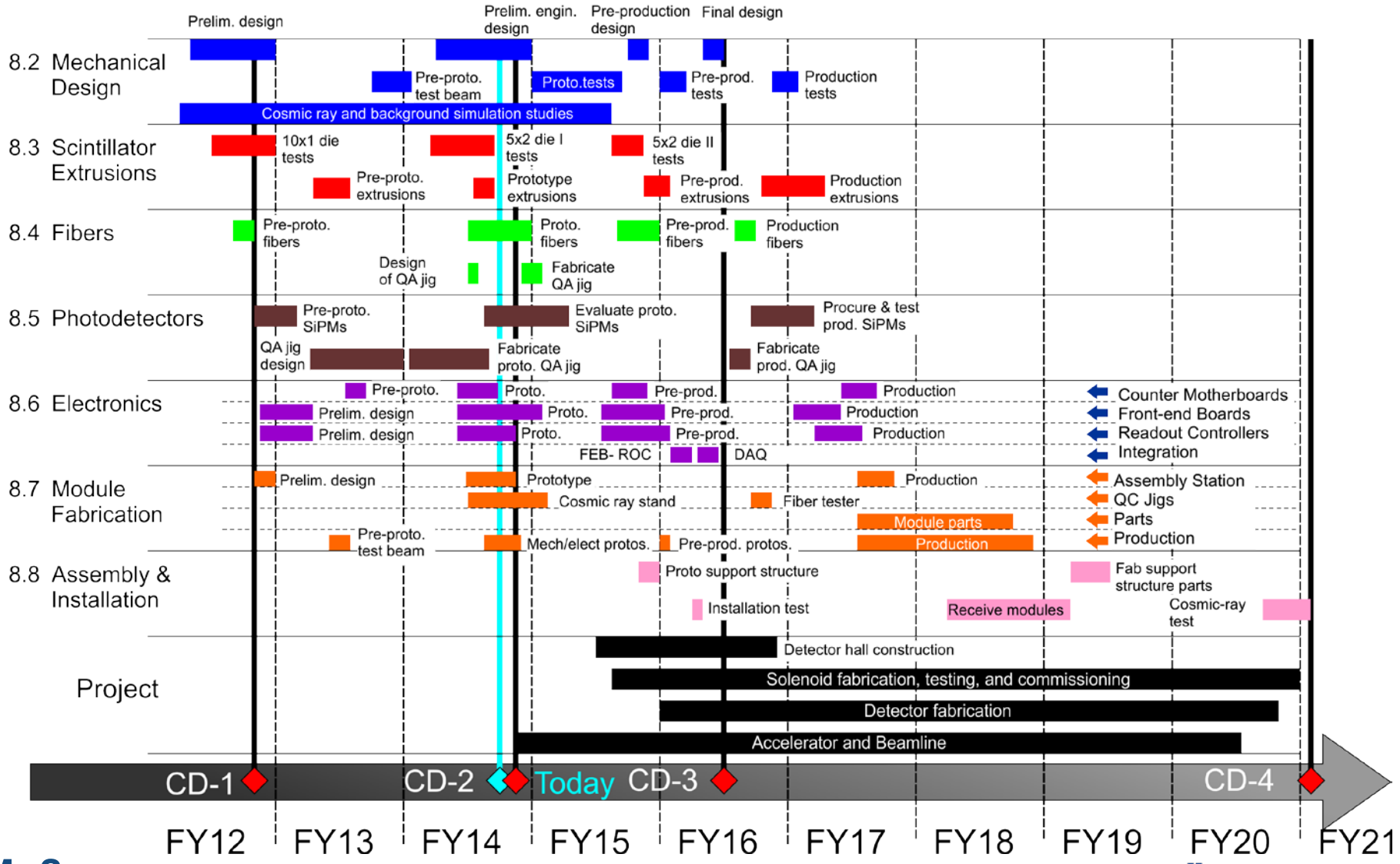
Quality of Estimate



Labor Resources by FY



Schedule


Prelim. design
Prelim. engin. design
Pre-production design
Final design
8.2 Mechanical Design
Pre-proto. test beam
Proto.tests
Pre-prod. tests
Production tests
Cosmic ray and background simulation studies
8.3 Scintillator Extrusions
10x1 die tests
5x2 die I tests
5x2 die II tests
Pre-proto. extrusions
Prototype extrusions
Pre-prod. extrusions
Production extrusions
8.4 Fibers
Pre-proto. fibers
Proto. fibers
Pre-prod. fibers
Production fibers
Design of QA jig
Fabricate QA jig
8.5 Photodetectors
Pre-proto. SiPMs
Evaluate proto. SiPMs
Procure & test prod. SiPMs
QA jig design
Fabricate proto. QA jig
Fabricate prod. QA jig
8.6 Electronics
Pre-proto.
Proto.
Pre-prod.
Production
Prelim. design
Counter Motherboards
Front-end Boards
Readout Controllers
Integration
FEB- ROC
DAQ
8.7 Module Fabrication
Prototype
Cosmic ray stand
Fiber tester
Module parts
Assembly Station
QC Jigs
Parts
Production
Pre-proto. test beam
Mech/elect protos.
Pre-prod. protos.
8.8 Assembly & Installation
Proto support structure
Fab support structure parts
Installation test
Receive modules
Cosmic-ray test
Project
Detector hall construction
Solenoid fabrication, testing, and commissioning
Detector fabrication
Accelerator and Beamline
CD-1
CD-2
Today
CD-3
CD-4
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21

Summary

- The requirements and the design for WLS fibers are well understood
- The baseline fiber: Kuraray, 1.4 mmD, 175 ppm, non-S type
- We plan to produce the prototype to select the final fiber size
  - Fiber for prototypes has been ordered
- The risk associated with the larger fiber diameter is implemented
- The QA test jig will be produced this Fall. The QA procedures are well understood