



U.S. DEPARTMENT OF
ENERGY Office of
Science

Cosmic Ray Veto

Mu2e Independent Cost Estimate

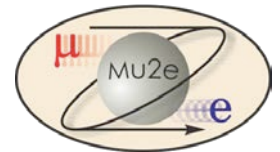
E. Craig Dukes (University of Virginia)

Cosmic Ray Veto (CRV) Project Manager

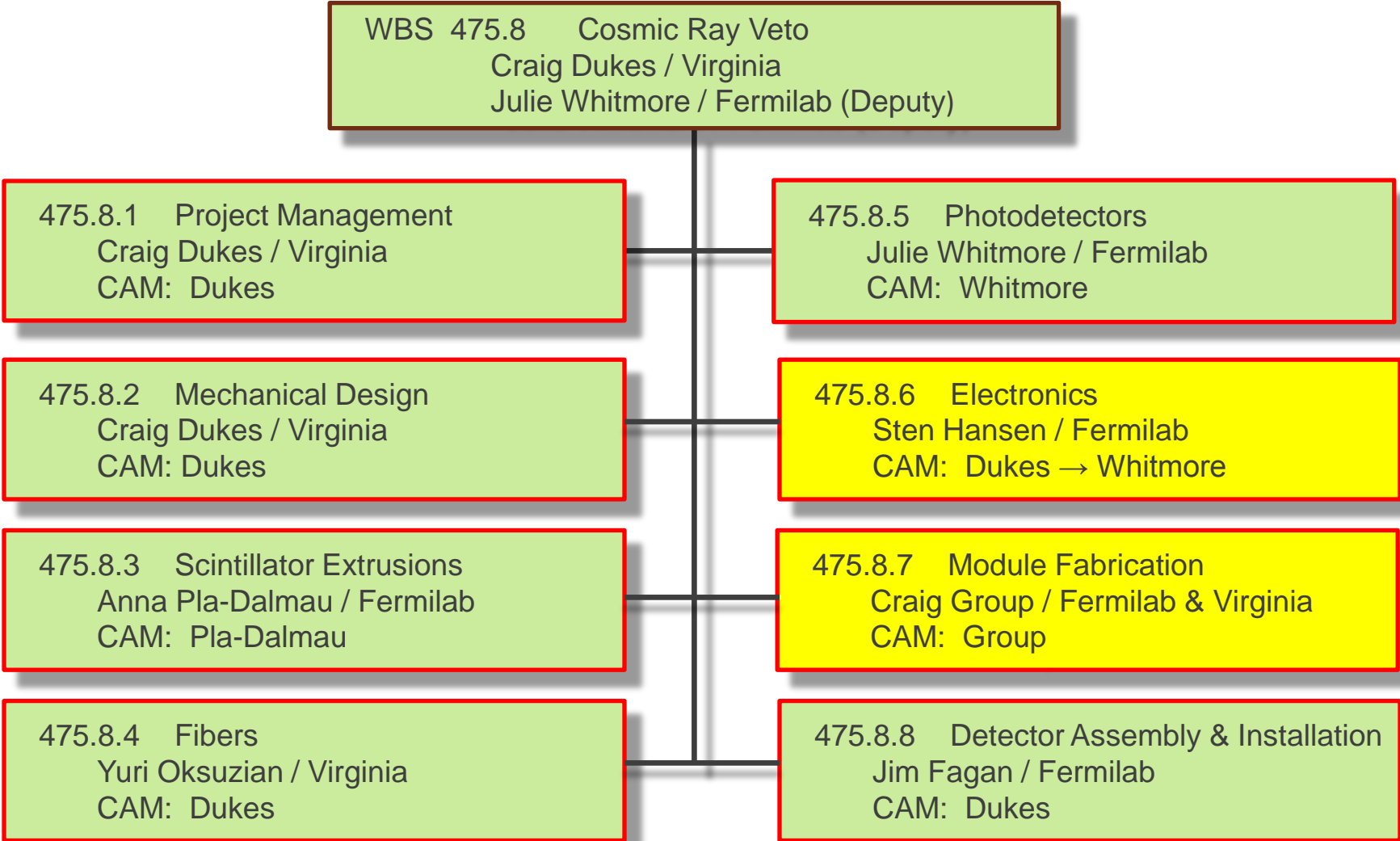
J. Whitmore (Fermilab)

Cosmic Ray Veto (CRV) Deputy Project Manager

8/26/2014



Organization



Requirements

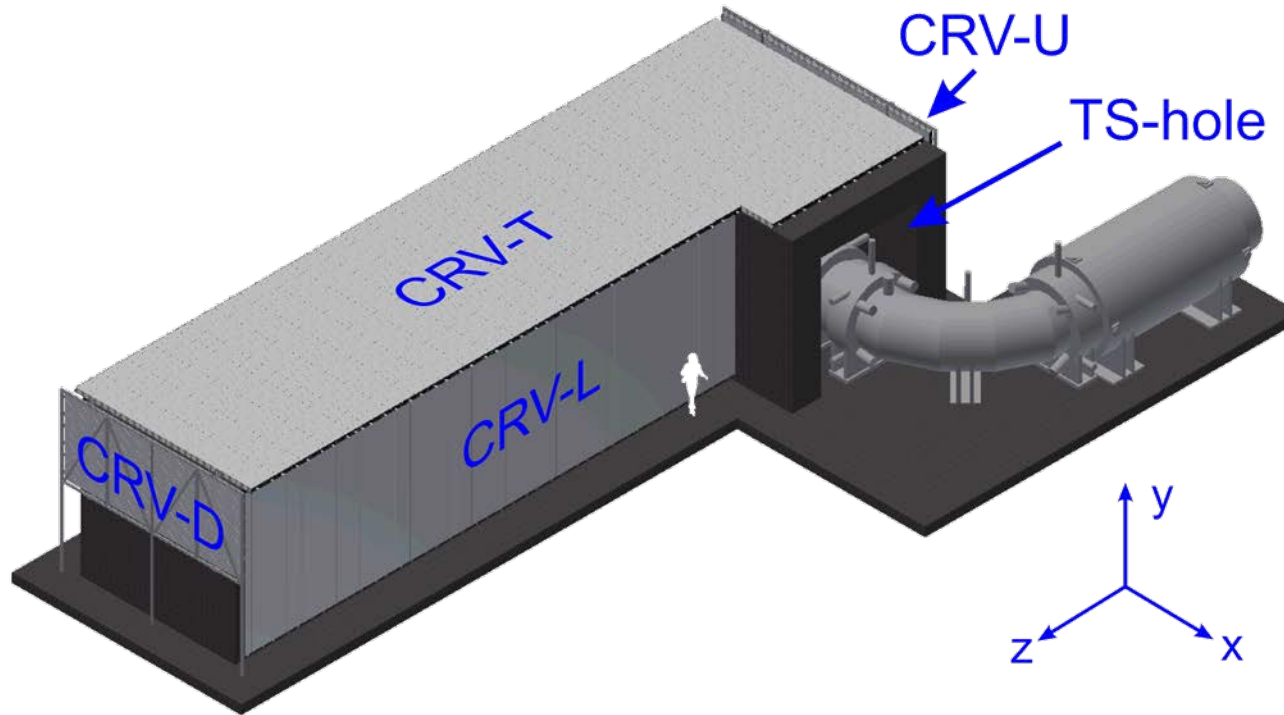
The Mu2e Cosmic Ray Veto is driven by a requirements document that is under Configuration Management.

- Mu2e Science Requirements Mu2e-doc-4381
- CRV Requirements Mu2e-doc-944

The requirements document is split into two parts:

- Fundamental (detector independent) requirements
- Derived (detector dependent) requirements

Scope



Design vetted in
outside CRV-Review
(June 3, 2014)

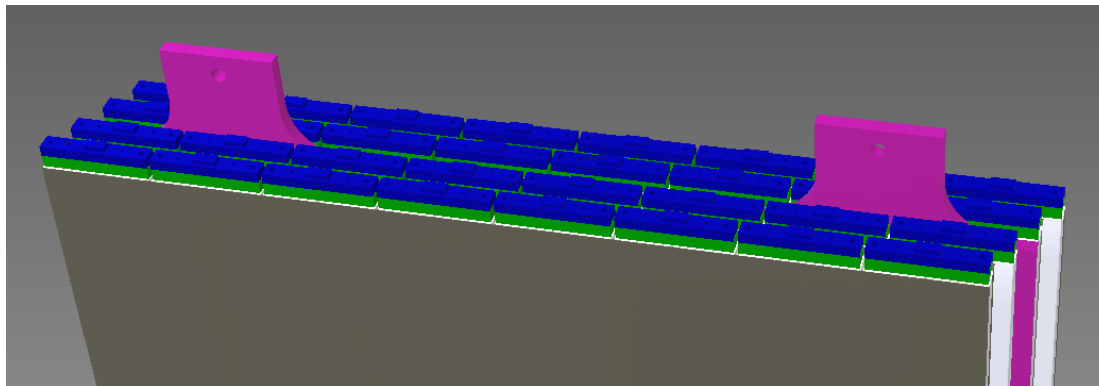
Details:

- Area: 323 m²
- 82 modules 7 sizes
- 5,152 counters
- 10,254 fibers
- 18,944 SiPMs

- CRV identifies cosmic ray muons that produce conversion-like backgrounds.
- Design driven by need for excellent efficiency, large area, small gaps, high rates, access to electronics, and constrained space.
- Technology: Four layers of extruded polystyrene scintillator counters with embedded wavelength shifting fibers, read out with SiPM photodetectors.
- A track stub in 3/4 layers, localized in time and space produces a veto.

WBS 475.8.2 Mechanical Design

- This task covers the design of the CRV and associated infrastructure, fabrication and testing of the CRV counter prototypes to validate that they meet the requirements, and the simulation work needed to determine the Cosmic Ray Veto requirements.
 - 475.08.02.01 Detector Design (\$65k)
 - 475.08.02.02 Fabricate and Test Counter Prototypes (\$56k)
 - 475.08.02.03 Cosmic Ray Veto Simulations (\$18k)
- Basis of Estimate
 - Design estimates based on quotes; fabrication based on pre-prototypes; simulations a rough estimate.

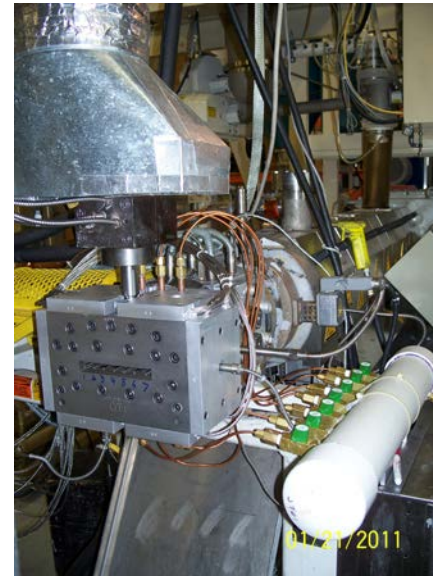


WBS 475.8.3 Scintillator Extrusions

- This task covers all aspects of the production of the scintillator to be used to fabricate the cosmic ray veto counters.
 - 475.08.03.01 Die Design and Procurement (\$234k)
 - 475.08.03.02 Scintillator Extrusion Production (\$790k)
- Basis of Estimate
 - Die design estimates based on very similar previous die designs.
 - Scintillator extrusion estimates based on a long history of extrusion productions.



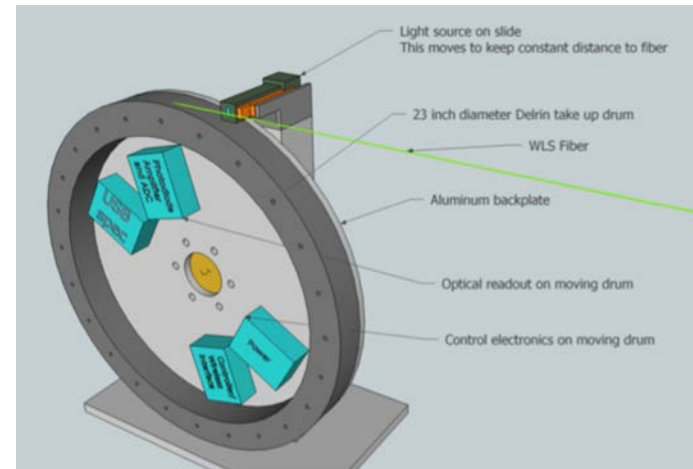
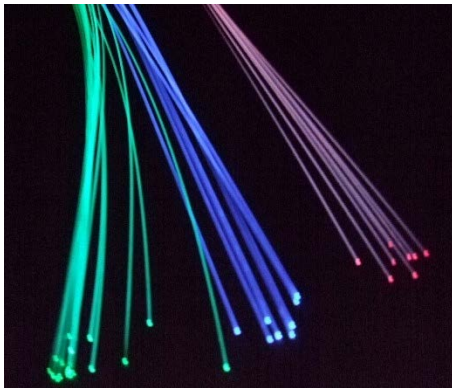
5152
extrusions



Fermilab/
NIU
NICADD
Facility

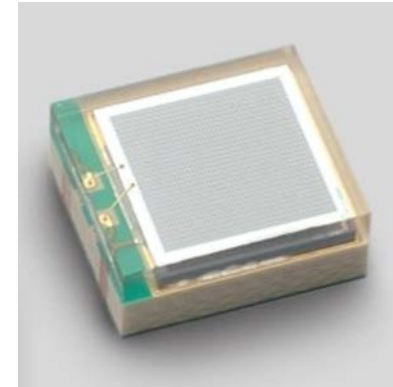
WBS 475.8.4 Fibers

- This task covers the specification, selection, procurement, and testing of wavelength shifting fibers for the prototypes and production counters.
 - 475.08.04.01 Wavelength shifting Fiber (WF) Procurement (\$440k)
 - 475.08.04.02 Wavelength Shifting Fiber Quality Assurance Design and Fabrication (\$14k)
- Basis of Estimate
 - Fiber and QA jig estimates from quotes; labor for testing from experience testing pre-production fiber .



WBS 475.8.5 Photodetectors

- This task covers the selection, evaluation, procurement, and testing of the photodetectors for the cosmic ray veto scintillation counters.
 - 475.08.05.01 Photodetector Procurement (\$443k)
 - 475.08.05.02 Photodetector Quality Assurance Design and Fabrication (\$324k)
- Basis of Estimate
 - Procurement M&S estimates based on vendor quotes; labor estimates for testing based on the Proton Tomography detector at the Central DuPage Hospital (CDH) Proton Therapy Center that CRV collaborators from Fermilab and NIU have worked on.
 - Photodetector QA jig estimate based on engineering estimates.



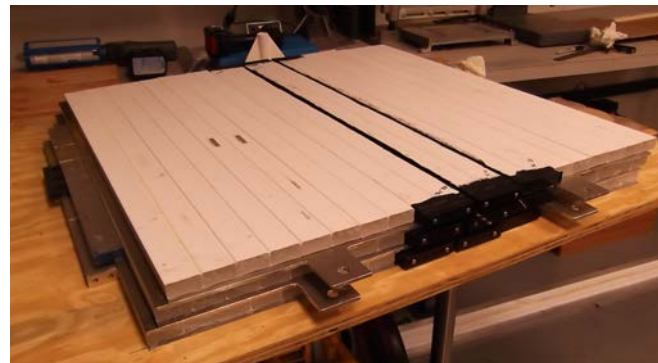
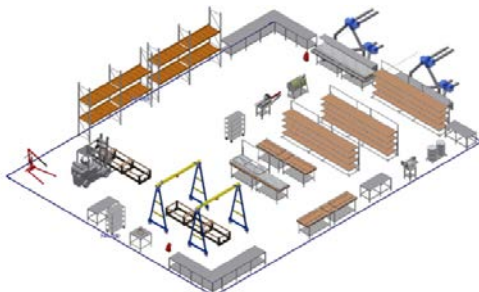
WBS 475.8.6 Electronics

- This task covers all aspects of the electronics needed to control and read out the cosmic ray veto, up to those covered by the data acquisition system.
 - 475.08.06.01 Counter Mother Boards (\$347k)
 - 475.08.06.02 Front End Boards (\$1,000k)
 - 475.08.06.03 Readout Controllers (\$266k)
 - 475.08.06.04 Integration with DAQ (\$115k)
- Basis of Estimate
 - Note: all parts COTS.
 - Counter motherboard estimates based on pre-prototype cost and catalog prices.
 - Front-end board and readout controller estimates based on similar Meson Test Beam drift chamber readout cost and catalog prices.
 - Integration with DAQ all labor: rough estimate.



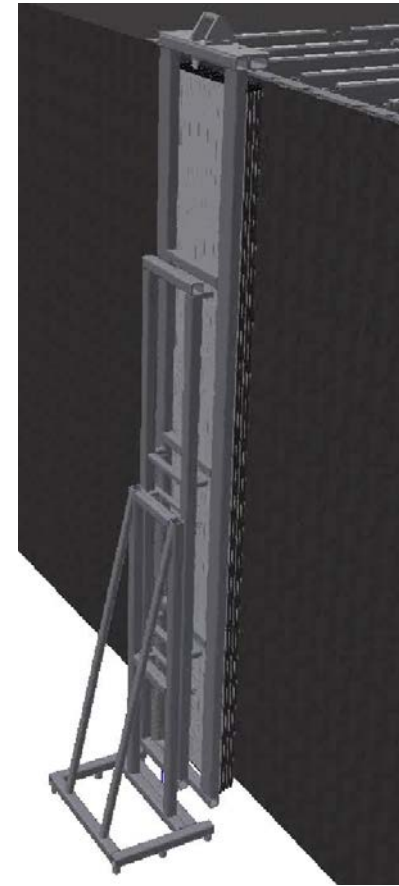
WBS 475.8.7 Module Fabrication

- This task covers all aspects of the counter and module fabrication.
 - 475.08.07.01 Design and Fabricate Assembly Station (\$161k)
 - 475.08.07.02 Assembly Station Quality Assurance Design and Fabrication (\$106k)
 - 475.08.07.03 Fabrication of Module Parts (\$448k)
 - 475.08.07.04 Module Production, Testing, and Shipping (\$733k)
 - 475.08.07.05 Breakdown of Module Factory (\$27k)
- Basis of Estimate
 - Fabrication of module parts based on vendor quotes.
 - Module production based on prototype module fabrication time and motion studies and quotes.



WBS 475.8.8 Detector Assembly & Installation

- This task includes fabricating the module mounting fixtures and mounting jigs, mounting the assembled modules on the detector, installing the electronics, cabling and installing the electronics, and testing the mounted modules.
 - 475.08.08.01 Test Installation (\$21k)
 - 475.08.08.02 Receive Production Modules at Fermilab (\$18k)
 - 475.08.08.03 Cosmic Ray Test (\$36k)
 - 475.08.08.04 Module Support Structure (\$131k)
 - 475.10.08.05 Detector Installation and Testing (Off-Project)
- Basis of Estimate
 - Fabrication of support structure based on vendor quotes.
 - Labor estimates from similar installation tasks done at Fermilab.



Risks & Opportunities

There are no major cost or schedule risks

- More sophisticated simulations indicate higher rates
 - Risk: low
 - Mitigation: more shielding in targeted areas
- Photoelectron yield too low / too high
 - Risk/Opportunity: low/moderate
 - Mitigation: tune fiber diameter
- Fiber vender goes out of business
 - Risk: low
 - Mitigation: order fiber asap; use larger diameter inferior fibers
- Simulations indicate that more CRV coverage needed
 - Risk: moderate
 - Mitigation: fabricate several extra modules

Cost

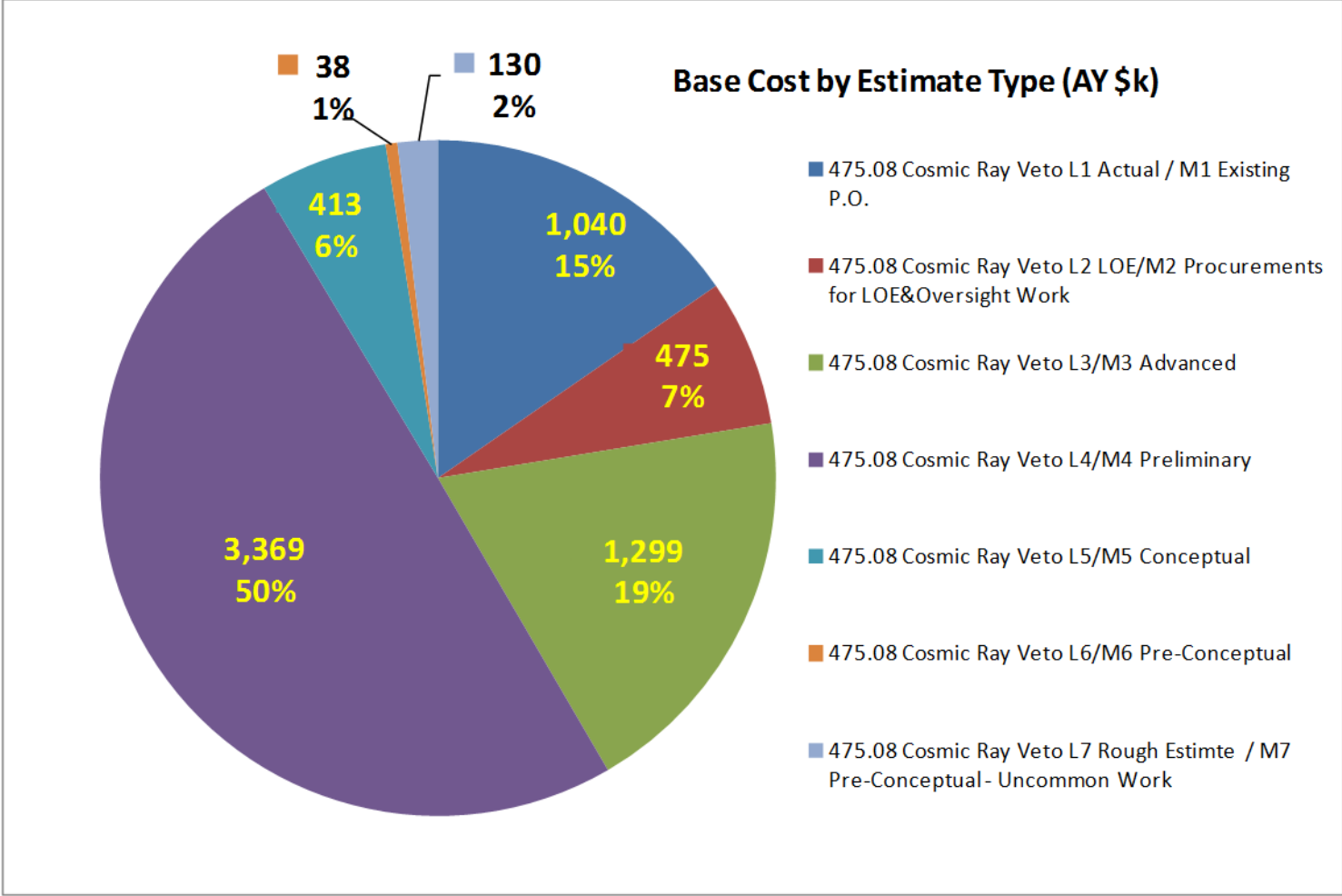
Costs are fully burdened in AY \$k
Includes actuals

Note: Labor Fermilab only;
Univ. labor captured in M&S.

	M & S	Labor	Base Cost	Estimate Uncertainty	% Contingency on ETC	Total
475.08.01 Project Management	271	178	450	75	20%	525
475.08.02 Mechanical Design	136	3	139	24	29%	163
475.08.03 Scintillator extrusions	565	459	1,024	208	22%	1,232
475.08.04 Fibers	455		455	105	24%	559
475.08.05 Silicon Photomultipliers (SiPMs)	461	305	766	189	36%	955
475.08.06 Electronics	1,319	409	1,728	513	32%	2,242
475.08.07 Module Fabrication	1,466	8	1,474	460	33%	1,935
475.08.08 Detector assembly and installation	125	80	206	64	35%	269
475.08.09 Cosmic Ray Veto Conceptual Design/R&D	270	252	523		0%	523
475.08.99 Risk Based Contingency				323		323
Total	5,069	1,695	6,764	1,961	35%	8,726

Quality of Estimate

Base Cost by Estimate Type (AY \$k)



Summary

- The design is simple and relies on technologies that have been proven in several recent Fermilab experiments.
- Estimates for the Cosmic Ray Veto are complete
 - 92% of cost understood at the Preliminary Design level or higher
- Most estimates based on very similar systems, with the same personnel, that have recently been built at Fermilab: Meson Test Beam drift chamber readout system, MINERvA detector, Proton Tomography detector at the Central DuPage Hospital.
- Risks are minor and understood, mitigated where possible.
- Estimates are traceable
 - Comprehensive set of BOEs with backup information.