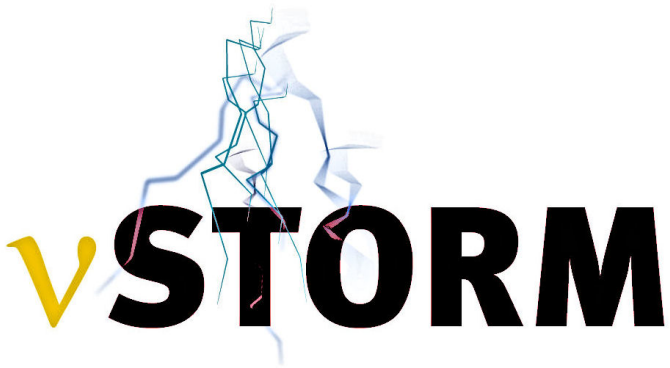
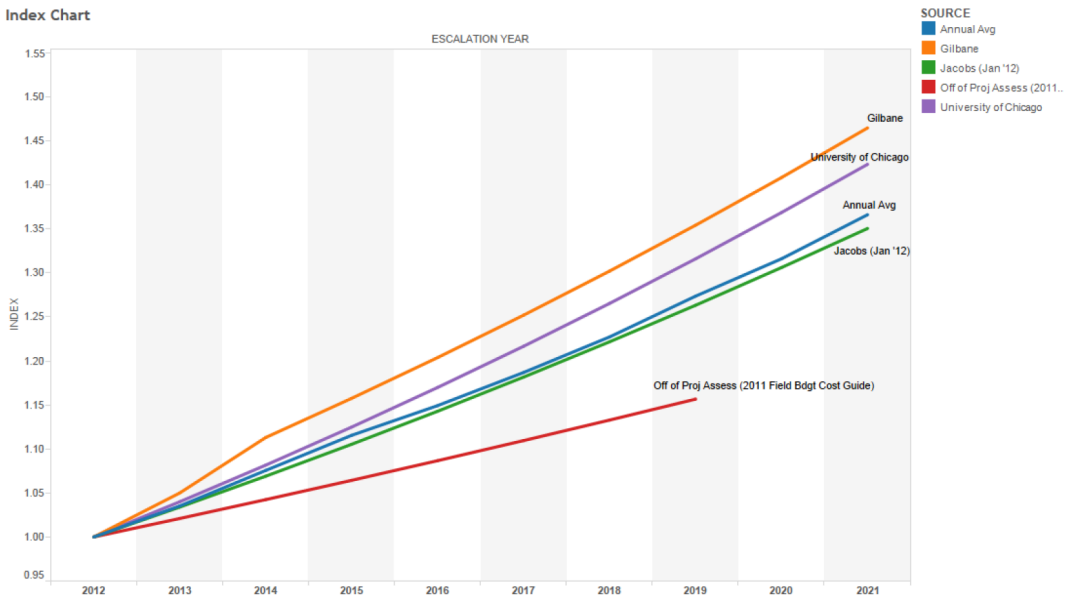


nuSTORM Costing Documentation

nuSTORM Costing

Overview

Detailed costing of the nuSTORM conventional facilities has been done by the Fermilab Facilities Engineering Services Section (FESS) and is reported on in the nuSTORM Project Definition Report (PDR) 6-13-1. Estimates for outfitting the primary proton beam line, the target station, the pion capture/transport line and decay ring are based on either experience from existing Fermilab infrastructure (NuMI) or is based on the detailed costing exercises for DOE CD-1 approval for future experiments (mu2e and LBNE). The detector costing utilized the Euronu costing for the Neutrino Factory Magnetized Iron Neutrino Detector (MIND), extrapolations from MINOS as-built costs and from recent vendor quotes. Costs included all manpower and are fully burdened (FY2013 dollars). The costs are not escalated, however, beyond the 5-year project timeline, since a project start for nuSTORM is unknown. Escalation can be estimated from various models (see Figure 1). LBNE has used the Jacob's model to determine their cost escalation [1].



Index Table

SOURCE	ESCALATION YEAR 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gilbane	1.0000	1.0500	1.1130	1.1575	1.2038	1.2520	1.3021	1.3541	1.4083	1.4646
Jacobs (Jan '12)	1.0000	1.0339	1.0690	1.1053	1.1428	1.1816	1.2217	1.2632	1.3061	1.3504
Off of Proj Assess (2011 Field Bdgt ..	1.0000	1.0210	1.0424	1.0643	1.0867	1.1095	1.1328	1.1566		
University of Chicago	1.0000	1.0400	1.0816	1.1249	1.1699	1.2167	1.2653	1.3159	1.3686	1.4233
Annual Avg	1.0000	1.0352	1.0756	1.1155	1.1492	1.1869	1.2272	1.2736	1.3160	1.3660

Figure 1. Cumulative Effect of Predictive Escalation Rate Models

The cost breakdown for nuSTORM is given in Table 1 and the overall costing details are given in Appendix 1.

Table 1. nuSTORM cost breakdown

Subsystem	Base cost	Contingency	Cost
Proton beam line	21,143,940	7,356,253	28,500,193
Target Station	26,674,694	11,225,150	37,899,844
Capture/transport	10,811,010	5,681,943	16,492,953
Decay ring	89,248,924	45,956,474	135,205,398
Near detector hall	16,778,572	6,711,429	23,490,001
Far detector hall	1,182,581	650,420	1,833,001
SuperBIND	21,057,070	4,190,528	25,247,598
Site work	17,429,678	9,586,323	27,526,000
CF other	1,804,286	721,714	2,526,000
TOTAL	**206,130,755**	**92,080,233**	**298,210,988**
Management			37,080,186
TPC		**45% contingency**	**335,291,175**

Cost Breakdown

The conventional facilities costs are detailed in the PDR and include construction, EDIA (Engineering, Design, Inspection and Administration/Management), contingency and indirect costs. The TPC has been estimated in FY13 dollars. The Indirect Costs are associated with laboratory rates, dated October 2012.

Costing for outfitting the various sub-systems is supported by estimates provided by:

1.	Michael Geelhoed	Primary beam line/transport line	Appendix 2
2.	Kris Anderson	Target Station	Appendix 3
3.	T.J. Gardner	Quadrupole magnets	Appendix 4
4.	Paul Soler	MIND costing (Euronu)	Appendix 5

In addition, cost estimates for the superconducting dipoles in the transport line and decay ring were provided by Vladimir Kashikhin, based on the Strauss-Green costing model [2]. Appendices 6 and 7 are vendor quotes for detector components (scintillator and wavelength shifting fiber, respectively). Management costs are based on LBNE costing and are 10% for the project office (does not include Top-down contingency), 9.4% for L1 management and 4% for L3 management.

[1] T. Lundin, "LBNE Conventional Facilities (CF) Approach to Cost Escalation", April 25, 2013.

[2] M.A. Green and B. P. Strauss, "The Cost of Superconducting Magnets as a Function of Stored Energy and Design Magnetic Induction Times the Field Volume", IEEE Trans. On Appl. Superconductivity, Vol. **18**, No. 2, June 2008.

Appendix 1

nuSTORM Work Breakdown Structure

WBS		Unit	Number	Cost/unit	Cost	Contingency factor	Contingency	Total	Sub-system cost	BOE
1	***Primary beam line***								**28,500,193**	
1.1	**Conventional Facilities**		1	10,130,714	10,130,714	1.40		14,183,000		PDR
1.1.1	Primary beam		1	11,013,226	11,013,226	1.30		14,317,194		AD estimate
					21,143,940		7,356,253			
2	***Target Station***								**37,899,844**	
2.1	**Conventional Facilities**		1	12,890,968	12,890,968	1.55		19,981,000		PDR
2.1.1	Target station outfitting		1	13,783,726	13,783,726	1.30		17,918,844		AD estimate
					26,674,694		11,225,150			
3	***Capture and transport***								**16,492,953**	
3.1	Conventional Facilities		1	2,764,375	2,764,375	1.60		4,423,000		PDR
3.1.1	Secondary beam line		1	8,046,635	8,046,635	1.50		12,069,953		AD/TD estimate
					10,811,010		5,681,943			
4	***Decay Ring***								**135,205,398**	
4.1	**Conventional Facilities**		1	36,733,750	36,733,750	1.60		58,774,000		PDR
4.2	RT magnets									
4.2.1	Quad A		40	88,624	3,544,960	1.60		5,671,936		TD estimate
4.2.2	Quad B		50	128,112	6,405,600	1.60		10,248,960		TD estimate
4.2.3	Quad C		28	115,957	3,246,796	1.60		5,194,874		TD estimate
4.2.4	Quad D		6	126,503	759,018	1.60		1,214,429		TD estimate
4.2.5	Quad power supplies		2	100,000	200,000	1.40		280,000		
4.3	SC magnets (dipoles)		16	1,668,750	26,700,000	1.35		36,045,000		TD estimate
4.3.1	SC magnet power supplies		2	50,000	100,000	1.40		140,000		
4.4	Beam pipe	m	480	6,560	3,148,800	1.50		4,723,200		
4.5	Cryo-plant		1	2,600,000	2,600,000	1.50		3,900,000		
4.6	Installation		1	945,000	945,000	1.50		1,417,500		
4.7	Cabling		1	1,080,000	1,080,000	1.50		1,620,000		
4.8	Water		1	1,275,000	1,275,000	1.50		1,912,500		
4.9	Controls		1	510,000	510,000	1.30		663,000		
4.1	Instrumentation		1	2,000,000	2,000,000	1.70		3,400,000		
					89,248,924		45,956,474			
5	***Near Detector Hall***									
5.1	**Conventional Facilities**		1	16,778,572	16,778,572	1.40		23,490,001	**23,490,001**	PDR
					16,778,572		6,711,429			
6	***Far Detector Hall***								**1,833,001**	
6.1	**Conventional Facilities**		1	1,182,581	1,182,581	1.55		1,833,001		PDR
					1,182,581		650,420			
7	***Far & Near Detectors***								**25,247,598**	
7.1	**Steel**									
7.1.1	Detector plane prototypes		1	500,000	500,000	1.30		650,000		
7.1.2	Steel procurement	ton	1500	850	1,275,000	1.25		1,593,750		Euronu costing document
7.1.3	Steel plate assembly	ton	1500	510	765,000	1.25		956,250		Euronu costing document
7.1.4	Steel transport	ton	1500	40	60,000	1.25		75,000		Euronu costing document
7.1.5	Steel support structures and handling fixtures	ton	1500	225	337,500	1.25		421,875		Euronu costing document
7.2	**Scintillator**									
7.2.1	Scintillator strips	ton	190	15,343	2,915,170	1.25		3,643,963		Vendor quote
7.2.2	WLS fibre	m	1,370,000	1.44	1,972,800	1.20		2,367,360		Vendor quote
7.2.3	Scintillator modules	planes	880	2,500	2,200,000	1.30		2,860,000		MINOS extrapolation
7.3	**Electronics, DAQ and database**									
7.3.1	SiPM		264,000	10	2,640,000	1.25		3,300,000		
7.3.2	Front end electronics		1	1,720,000	1,720,000	1.50		2,580,000		
7.3.2.1	ASIC/FE development		1	1,000,000	1,000,000					32ch readout ASIC- NOvA chip derivative
7.3.2.2	Production and testing		12000	30	360,000					
7.3.2.3	Interface		3000	120	360,000					
7.3.3	Readout Infrastructure			2,500,000		1.30		3,250,000		
7.3.3.1	L1 concentrator development		1	500,000	500,000					
7.3.3.2	L1 concentrator production		1000	1,500	1,500,000					
7.3.3.3	L2 concentrator development		1	300,000	300,000					
7.3.3.4	L2 concentrator production		80	2,500	200,000					
7.3.4	Data acquisition and triggering			90,000		1.30		117,000		
7.3.4.1	Online computer cluster		12	5,000	60,000					
7.3.4.2	Clock distribution and machine interface		1	30,000	30,000					
7.3.5	Software		1	500,000	500,000	1.50		750,000		
7.3.6	Integration		1	250,000	250,000	1.50		375,000		
7.3.7	Slow controls and monitoring		1	250,000	250,000	1.30		325,000		
7.3.8	Electronics management		1	300,000	300,000	1.30		390,000		
7.4	**Magnet**									
7.4.1	Engineering, design		1	280,000	280,000	1.50		420,000		TD estimate
7.4.2	STL fabrication		1	680,000	680,000	1.50		1,020,000		TD estimate
7.4.3	Superconductor	m	480	45	21,600	1.50		32,400		TD estimate
7.4.5	Power supplies		2	40,000	80,000	1.50		120,000		
					21,057,070		4,190,528			

8	***CF - Site Work***		1	17,429,678	17,429,678 **17,429,678**	1.55	9,586,323	27,016,001	**27,016,001**	PDR
9	***CF - Other Project Costs***		1	1,804,286	1,804,286 **1,804,286**	1.40	721,714	2,526,000	**2,526,000**	PDR
					Base Cost		**Contingency**		**Base + Contingency**	**Contingency/Base**
					206,130,755		**92,080,233**		**298,210,988**	**0.45**

Management applied to (Base+Contingency) -CF	145,984,986
Project Office	17,518,198
L2 Management	13,722,589
L3-4 Management	5,839,399
Management total	**37,080,186**

Conventional facilities sum
152,226,003

37,080,186

TOTAL PROJECT COST **335,291,175**

Appendix 2

Primary proton beam line, secondary beam line and target station

System	Subsystem	Department	phase	item/task	M&S Type	M&S Quantity	M&S cost	M&S Duration (days)	M&S unit rate ($/time) ($) ($/unit)	
Primary Beam line	Magnets	Non AD	install	magnets	rigging crew	1.00	115,000.00	23.00	5,000.00	
Primary Beam line	Magnets	Non AD	install	stands	rigging crew	1.00	200,000.00	40.00	5,000.00	
Primary Beam line	Magnets	MSD	procure	Dipoles	B2	8.00	920,000.00	0.00	115,000.00	
Primary Beam line	Magnets	MSD	procure	Dipoles	EDB	2.00	16,000.00	0.00	8,000.00	
Primary Beam line	Magnets	MSD	procure	Quadrupoles	3Q120	6.00	1,572,000.00	0.00	262,000.00	
Primary Beam line	Magnets	MSD	procure	Correctors	IDH	9.00	144,000.00	0.00	16,000.00	
Primary Beam line	Magnets	MSD	procure	Correctors	IDV	9.00	144,000.00	0.00	16,000.00	
Primary Beam line	Magnets	MSD	procure	kicker magnet	LBNE style	3.00	750,000.00	0.00	250,000.00	
Primary Beam line	Cables	Non AD	install	cable trays	Electricians	2.00	120,000.00	30.00	2,000.00	
Primary Beam line	Cables	Non AD	install	HV Power	Electricians	2.00	120,000.00	30.00	2,000.00	3,767,500.00
Primary Beam line	Cables	Non AD	install	Instrumentation	Electricians	2.00	120,000.00	30.00	2,000.00	
Primary Beam line	Power Supply	EE	install	supplies	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Power Supply	EE	procure	kicker	engineer	3.00	2,250,000.00	0.00	750,000.00	
Primary Beam line	Power Supply	EE	procure	PEI	MR style	1.00	150,000.00	0.00	150,000.00	
Primary Beam line	Power Supply	EE	procure	Abort Quads PS	PI	3.00	450,000.00	0.00	150,000.00	
Primary Beam line	Power Supply	EE	procure	NS1V1 NSHV1	PI	2.00	188,000.00	0.00	94,000.00	
Primary Beam line	Power Supply	EE	procure	Bartlesons	Bulk	2.00	20,000.00	0.00	10,000.00	
Primary Beam line	Power Supply	EE	procure	Regulator	Quad	5.00	17,500.00	0.00	3,500.00	
Primary Beam line	Power Supply	EE	procure	Regulator	Trims	18.00	45,000.00	0.00	2,500.00	
Primary Beam line	Instrumentation	MSD	install	Instrumentation	techs	0.00	0.00	0.00	0.00	
Primary Beam line	Instrumentation	Instrumenation	install	Instrumentation	techs	0.00	0.00	0.00	0.00	
Primary Beam line	Instrumentation	Instrumenation	procure	Multiwires	engineer	9.00	135,000.00	0.00	15,000.00	
Primary Beam line	Instrumentation	Instrumenation	procure	BPMs	engineer	12.00	72,000.00	0.00	6,000.00	
Primary Beam line	Instrumentation	Instrumenation	procure	BLMs	engineer	20.00	20,000.00	0.00	1,000.00	
Primary Beam line	Instrumentation	Instrumenation	procure	Toroids	engineer	3.00	60,000.00	0.00	20,000.00	
Primary Beam line	Instrumentation	Instrumenation	design	Multiwires	engineer	1.00	0.00	0.00	0.00	
Primary Beam line	Instrumentation	Instrumenation	design	BPMs	engineer	1.00	0.00	0.00	0.00	
Primary Beam line	Instrumentation	Instrumenation	design	BLMs	engineer	1.00	0.00	0.00	0.00	
Primary Beam line	Instrumentation	Instrumenation	design	Toroids	engineer	1.00	0.00	0.00	0.00	
Primary Beam line	Vacuum	Non AD	install	vacuum pipe	welder	2.00	40,000.00	20.00	1,000.00	
Primary Beam line	Vacuum	MSD	install	Roughing pumps	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Vacuum	MSD	install	Turbo pumps	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Vacuum	MSD	install	Ion Pumps	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Vacuum	MSD	install	ReadOuts	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Vacuum	MSD	procure	vacuum pipe	engineer	400.00	40,000.00	0.00	100.00	
Primary Beam line	Vacuum	MSD	procure	Roughing pumps	engineer	2.00	90,000.00	0.00	45,000.00	
Primary Beam line	Vacuum	MSD	procure	Scroll pumps	engineer	2.00	20,000.00	0.00	10,000.00	
Primary Beam line	Vacuum	MSD	procure	Ion Pumps	engineer	30.00	36,000.00	0.00	1,200.00	
Primary Beam line	Vacuum	MSD	procure	Beam Vales	engineer	3.00	15,000.00	0.00	5,000.00	
Primary Beam line	Vacuum	MSD	procure	ReadOuts	engineer	3.00	3,000.00	0.00	1,000.00	
Primary Beam line	Vacuum	MSD	design	System	engineer	0.00	0.00	0.00	0.00	
Primary Beam line	Water	Non AD	install	LCW Pipe	welder	2.00	60,000.00	30.00	1,000.00	
Primary Beam line	Water	MSD	procure	LCW Pipe	engineer	2,000.00	32,000.00	0.00	16.00	
Primary Beam line	Water	MSD	procure	LCW pumps	engineer	3.00	60,000.00	0.00	20,000.00	
Primary Beam line	Water	MSD	procure	LCW Heat Exchanger	engineer	2.00	260,000.00	0.00	130,000.00	
Primary Beam line	Safety	Interlocks	design	Safety System interlocks	engineer	0.00	0.00	0.00	0.00	
Primary Beam line	Safety	Interlocks	install	Safety System interlocks	tech	0.00	0.00	0.00	0.00	
Primary Beam line	Operations	Operations	design	review	ops specialist	0.00	0.00	0.00	0.00	
Primary Beam line	Controls	Non AD	install	controls racks	electrician	2.00	120,000.00	30.00	2,000.00	
Primary Beam line	Controls	Controls	procure	Relay Racks	engineer	11.00	5,500.00	0.00	500.00	
Primary Beam line	Controls	Controls	procure	ACNET Crates	engineer	6.00	6,000.00	0.00	1,000.00	
Primary Beam line	Controls	Controls	procure	Control Cards	engineer	40.00	20,000.00	0.00	500.00	
Primary Beam line	Controls	Controls	procure	Front Ends	engineer	4.00	20,000.00	0.00	5,000.00	
Target Hall	Shielding	MSD	procure	Blocks	engineer	1.00	3,418,726.00	0.00	3,418,726.00	
Target Hall	Shielding	MSD	procure	Installation	engineer	1.00	400,000.00	80.00	5,000.00	
Target Hall	Target	MSD	procure	Target Module	engineer	1.00	400,000.00	0.00	400,000.00	
Target Hall	Target	MSD	procure	Module stands	engineer	4.00	80,000.00	0.00	20,000.00	
Target Hall	Target	MSD	procure	Raw Skid	engineer	1.00	50,000.00	0.00	50,000.00	
Target Hall	Horn	MSD	procure	Horn Module	engineer	1.00	500,000.00	0.00	500,000.00	
Target Hall	Horn	MSD	procure	Power Supply	engineer	1.00	1,700,000.00	0.00	1,700,000.00	
Target Hall	Horn	MSD	procure	Raw Skid	engineer	1.00	50,000.00	0.00	50,000.00	
Target Hall	Horn	MSD	procure	Stripline Block	engineer	1.00	200,000.00	0.00	200,000.00	11,683,726.00
Target Hall	Horn	EE	procure	Stripline	engineer	50.00	65,000.00	0.00	1,300.00	
Target Hall	Air Handling	MSD	design	Air Handler	engineer	0.00	0.00	0.00	0.00	
Target Hall	Air Handling	MSD	procure	Air Handler	engineer	1.00	450,000.00	0.00	450,000.00	
Target Hall	Water	MSD	design	LCW	engineer	0.00	0.00	0.00	0.00	
Target Hall	Water	MSD	install	LCW	tech	0.00	0.00	0.00	0.00	
Target Hall	Quadrupoles	MSD	install	install capture quadrupoles	tech	0.00	0.00	0.00	0.00	
Target Hall	Quadrupoles	MSD	procure	Magnets	engineer	2.00	3,000,000.00	0.00	1,500,000.00	

Target Hall	Quadrupoles	EE	procure	Power Supply	engineer	2.00	200,000.00	0.00	100,000.00	
Target Hall	Quadrupoles	EE	install	Power Supply	tech	0.00	0.00	0.00	0.00	
Target Hall	Quadrupoles	MSD	procure	Raw Skid	engineer	3.00	150,000.00	0.00	50,000.00	
Target Hall	Module	MSD	procure	Fixtures	engineer	1.00	50,000.00	0.00	50,000.00	
Target Hall	Module	MSD	procure	Carriage Beams	engineer	3.00	210,000.00	0.00	70,000.00	
Target Hall	Module	MSD	procure	WorkCell Morgue Cameras C	engineer	1.00	760,000.00	0.00	760,000.00	
Secondary Beamline	Magnets	Non AD	install	Magnets	rigging crew	1.00	100,000.00	20.00	5,000.00	
Secondary Beamline	Magnets	Non AD	install	Magnet stands	rigging crew	1.00	150,000.00	30.00	5,000.00	
Secondary Beamline	Magnets	MSD	procure	Magnets	engineer	4.00	6,000,000.00	0.00	1,500,000.00	
Secondary Beamline	Magnets	MSD	procure	Magnets	engineer	11.00	1,320,000.00	0.00	120,000.00	
Secondary Beamline	Magnets	EE	install	Power Supplies	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Cables	Non AD	install	cable trays	Electricians	2.00	120,000.00	30.00	2,000.00	
Secondary Beamline	Cables	Non AD	install	HV Power	Electricians	2.00	120,000.00	30.00	2,000.00	
Secondary Beamline	Cables	Non AD	install	Instrumentation	Electricians	2.00	120,000.00	30.00	2,000.00	
Secondary Beamline	Power Supply	EE	install	supplies	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Power Supply	EE	procure	PEI	PEI	15.00	1,500,000.00	0.00	100,000.00	
Secondary Beamline	Instrumentation	Instrumenation	install	Instrumentation	techs	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	install	Instrumentation	techs	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	procure	BPMs	engineer	13.00	338,000.00	0.00	26,000.00	
Secondary Beamline	Instrumentation	Instrumenation	procure	Toroids	engineer	1.00	78,000.00	0.00	78,000.00	
Secondary Beamline	Instrumentation	Instrumenation	procure	Multiwires	engineer	3.00	312,000.00	0.00	104,000.00	
Secondary Beamline	Instrumentation	Instrumenation	procure	BLMs	engineer	10.00	83,000.00	0.00	8,300.00	
Secondary Beamline	Instrumentation	Instrumenation	design	BPMs	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	design	Toroids	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	design	BBQ	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	design	BLMs	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	design	Multiwires	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Instrumentation	Instrumenation	design	Slit + Scintillating screen	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Vacuum	Non AD	install	vacuum pipe	welder	2.00	24,000.00	20.00	600.00	
Secondary Beamline	Vacuum	MSD	install	Roughing pumps	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Vacuum	MSD	install	Turbo pumps	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Vacuum	MSD	install	Ion Pumps	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Vacuum	MSD	procure	vacuum pipe	engineer	120.00	1,200.00	0.00	10.00	
Secondary Beamline	Vacuum	MSD	procure	Roughing pumps	engineer	2.00	90,000.00	0.00	45,000.00	
Secondary Beamline	Vacuum	MSD	procure	Turbo pumps	engineer	2.00	40,000.00	0.00	20,000.00	
Secondary Beamline	Vacuum	MSD	procure	Ion Pumps	engineer	10.00	50,000.00	0.00	5,000.00	10,651,700.00
Secondary Beamline	Vacuum	MSD	design	System	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Water	MSD	procure	LCW pipe	engineer	500.00	5,000.00	0.00	10.00	
Secondary Beamline	Water	Non AD	install	LCW pipe	welder	2.00	24,000.00	20.00	600.00	
Secondary Beamline	Water	MSD	procure	LCW pumps	engineer	500.00	5,000.00	0.00	10.00	
Secondary Beamline	Water	MSD	install	LCW pumps	techs	0.00	0.00	0.00	0.00	
Secondary Beamline	Safety	Interlocks	design	Safety System interlocks	engineer	0.00	0.00	0.00	0.00	
Secondary Beamline	Safety	Interlocks	install	Safety System interlocks	tech	0.00	0.00	0.00	0.00	
Secondary Beamline	Operations	Operations	design	review	ops specialist	0.00	0.00	0.00	0.00	
Secondary Beamline	Controls	Non AD	install	controls racks	electrician	2.00	120,000.00	30.00	2,000.00	
Secondary Beamline	Controls	Controls	procure	Relay Racks	engineer	11.00	5,500.00	0.00	500.00	
Secondary Beamline	Controls	Controls	procure	ACNET Crates	engineer	6.00	6,000.00	0.00	1,000.00	
Secondary Beamline	Controls	Controls	procure	Control Cards	engineer	40.00	20,000.00	0.00	500.00	
Secondary Beamline	Controls	Controls	procure	Front Ends	engineer	4.00	20,000.00	0.00	5,000.00	
							30,791,426.00			

Appendix 3

nuSTORM Target Station Cost Estimate

23-May-13

Item	*qty*	*qty (ft^3)*	*qty. (lbs)*	*units*	*Cost per unit*	*M&S (unesc)*	*M&S Escalated (x1.3) Per Alan Bross*	*SWF hrs.*	*SWF $ With Overhead*	*Comments*
Target Station Engineering Management & Integration										
Mechanical Engineer								2080		Assume 25% effort over 4 year time period
Electrical Engineer for Control and Electronics								2080		Place Holder; Maybe 33% Over 3 year time period- might be light here
Designer / Drafter								416		Assume 5% effort over 4 year period (Providing images for meetings and reviews)
SubTotal Hours TS WBS Management (base hours)								4576		

Item	*qty*	*qty (ft^3)*	*qty. (lbs)*	*units*	*Cost per unit*	*M&S (unesc)*	*M&S Escalated (x1.3)*	*SWF hrs.*	*SWF $ With Overhead*	*Comments*
Target Station Shield Pile										
Mechanical Engineer								2496		Assume 40% of FTE over 3 years- Includes general TS layout and integration
Designer / Drafter								3744		Assume 60% of FTE over 3 years
Technician Time for Installation Activities								5600		4 man technician crew 35 weeks- to cover installation tasks
Rigging Crew Installation of Shield Pile						$ 400,000	$ 520,000			4 months, 80 days @ $5k/day-WAG
Chase Cover Poly	571	ft^3		ft^3	$ 288.72	$ 164,859.12	$ 214,317			Used to mitigate neutron sky shine per LBNE
Chase Cover Steel	1712.2	ft^3	832129.2	lbs.	$ 2.13	$ 1,772,435.20	$ 2,304,166			Finished steel for air-tight fit
Target and Horn T-Blocks	578	ft^3	280908	lbs.	$ 1.71	$ 480,352.68	$ 624,458			Rough Fabrication CCSS
Filler Steel	153	ft^3	74358	lbs.	$ 2.13	$ 158,382.54	$ 205,897			A36-Finished
Quad T-blocks	150	ft^3	72900	lbs.	$ 1.71	$ 124,659.00	$ 162,057			Rough Fabrication CCSS
Quad 1 Collimator	90	ft^3	43740	lbs.	$ 2.13	$ 93,166.20	$ 121,116			A36
Quad 2 Collimator	104	ft^3	50544	lbs.	$ 2.13	$ 107,658.72	$ 139,956			A36
Duratek Blocks	140			ea	$ 300.00	$ 42,000.00	$ 54,600			
R-Blocks	32	3328		ft^3	$ 22.60	$ 75,212.80	$ 97,777			
Shielding Subtotal Man-hours								11840		
Shielding M&S (Base)						$ 3,418,726.26				
Shielding M&S (Burdened)							$ 4,444,344.13			

Item	*qty*	*qty (ft^3)*	*qty. (lbs)*	*units*	*Cost per unit*	*M&S (unesc)*	*M&S Escalated (x1.3)*	*SWF hrs.*	*SWF $ With Overhead*	*Comments*
Modules										
Mechanical Engineer								3120		Assume 75% of FTE over 2 year- Redesign current modules for 0 beamline pitch
Designer / Drafter								3120		Assume 75% of FTE over 2 years
Technician Time for Module Fabrication								6240		3 techinicians for 1 year
Module Assembly Stands	4			ea	$ 20,000	$ 80,000	104,000.0			
Target	1				$ 400,000	$ 400,000	$ 520,000			

Horn	1				$ 400,000	$ 400,000	$ 520,000			
Stripline Block	1				$ 200,000	$ 200,000	$ 260,000			
Quad 1 Module	1				$ 250,000	$ 250,000	$ 325,000			
Quad 2 Module	1				$ 250,000	$ 250,000	$ 325,000			
Module and Block Handling Fixtures						$ 50,000	$ 65,000			
Carriage Beams	3			ea	$ 70,000	$ 210,000	$ 273,000			Qty. 3: Target, Horn, Quads
Module Subtotal Man-hours								12480		
Module M&S (Base)						$ 1,840,000				
Module M&S (Burdened)							$ 2,392,000			
Item	***qty***	***qty (ft^3)***	***qty. (lbs)***	***units***	***Cost per unit***	***M&S (unesc)***	***M&S Escalated (x1.3)***	***SWF hrs.***	***SWF $ With Overhead***	***Comments***
Target Station Beamline Devices and Support Systems										
Mechanical Engineer								3120		General Engineering for Devices: Assume 50% of FTE over 3 years- Includes integration of beamline devices
Designer / Drafter								3744		Assume 60% of FTE over 3 years
Technician Time for General Assembly Issues not covered specifically in devices (e.g., horns, targets)								4160		2 FTE technicians for 1 year
Horn	1				$500,000	$500,000	$650,000		$ 300,000	NuMI Documented Costs- includes technician assembly time and fabrication oversight
Horn Power Supply	1				$ 1,700,000	1,700,000	$2,210,000			Estimate from Ken Bourkland for LBNE- Includes fully burdened SWF and M&S
Stripline	50			ft	$ 1,300	$ 65,000	$84,500			
Target	1				$300,000	$300,000	$390,000		$ 100,000	NuMI Documented Costs- includes technician assembly time and fabrication oversight
Quads	2				$1,500,000	$3,000,000	$3,900,000			Cost from FRIB
Quad Power Supply	2				$ 100,000	$ 200,000	$260,000			A guess- needs to include cabling, etc.
Cryo						$100,000	$130,000			Guess- Piping from Cryo feed
RAW Skid	5				$50,000	$250,000	$325,000			Qty 5 RAW skids- Target, Horn, Each Quad, Collimators; Rough numbers from Karl Williams
Mechanical Engineer for RAW Skid Layout								1040		Per Karl Williams
TP Air Fan and Chiller						$ 250,000	$325,000	Includes installation per Lee Hammond Email		Need number from Lee Hammond; guess at system cost plus installation
Munters Dehumidifier						$ 125,000	$162,500	Includes installation per Lee Hammond Email		From NuMI, Large Munters at $80k in FY2008; Add $45k to cover escalation and installation
Neutralization Systems and Evaporator						$ 75,000	$97,500	Per Lee Hammond Email		From NuMI, System cost ~$25k in FY2007 dollars, add $25k for installation
Train Cart						$ 40,000	$52,000			
Cameras						$ 20,000	$26,000			
Workcell						$ 500,000	$650,000			
Morgue Doors and Hardware Placeholder						$ 200,000	$260,000			Placeholder for pull-up morgue doors similar to C0

Beamline Devices Subtotal Man-hours								6864			
Beamline Devices M&S (Base)						$	7,325,000				
Module M&S (Burdened)							$	9,522,500			
Cost Summary											
	Man Hours					***Man-Years***	***Cost per Man-Year (Estimate of Burdened Cost per Man-Year)***		***Total SWF (Burdened)***		
Man-Hour Rollup Technician Drafting Category	**27024**					**12.99**	**$**	**250,000**	**$**	**3,248,077**	
Man-Hour Rollup Engineering Category	**13936**					**6.7**	**$**	**325,000**	**$**	**2,177,500**	
SWF $ Burdended for Target and Horn Assy.									**$**	**400,000**	
Un-Escalated M&S									**$**	**12,583,726.26**	
Cost Rollup TPC Escalated M&S plus Burdened Labor = (Excluding Contingency)									**$**	**18,409,303**	

Appendix 4

nuSTORM Racetrack Conventional Quadrupoles

Price stated for each unit																	
Conventional hollow square copper with fiberglass/epoxy insulation in a potted (multi-pancake) mass.																	
	Aperature	T +/-	Fe L	Turns	Cu lin ft	$6/ft	Fe in^3	Fe raw #	Fe $	Mach	Addl parts	T tech hrs	Tech SWF$	EDIA 0.9 T$	T $ M&S	T $ Labor	**Total $**
A	0.3m R	2	0.5m	28	700	$ 4,200	8000	2267	$ 1,813	$ 14,506.50	$ 7,000	804	$ 32,160	$ 28,944	$ 27,520	$ 61,104	**$ 88,624**
B	0.3m R	7.8 max	0.3m	42	900	$ 5,400	14400	4080	$ 3,264	$ 26,111.69	$ 7,000	1,136	$ 45,440	$ 40,896	$ 41,776	$ 86,336	**$ 128,112**
C	0.3m R	11 max	0.8m	32	1100	$ 6,600	26000	7367	$ 5,893	$ 35,359.58	$ 7,000	804	$ 32,160	$ 28,944	$ 54,853	$ 61,104	**$ 115,957**
D	0.5m R	5	1.5m	32	1800	$ 10,800	30000	8500	$ 6,800	$ 40,799.52	$ 7,000	804	$ 32,160	$ 28,944	$ 65,399	$ 61,104	**$ 126,503**
Technicain labor breakout																	
	Pancake hrs	Qty techs	Hrs/ pancake	# pancake	Wind hrs	Mag assy hrs	Qty techs	Assy hrs	Final hrs	Qty techs	Final hrs	T tech hrs		Pancake op	Techs	Hours	**T hours**
A	83	-	83	8	664	40	2.5	100	40	1	40	804		Winding hrs	2.5	10	**25**
B	83	-	83	12	996	40	2.5	100	40	1	40	1136		Insulation	1	10	**10**
C	83	-	83	8	664	40	2.5	100	40	1	40	804		Impregnate	2	20	**40**
D	83	-	83	8	664	40	2.5	100	40	1	40	804		Clean-up	1	8	**8**
E*	40	2.5	100	8	800	80	2.5	200	40	1	40	1040					**83**
A pancake coil is (2) layers * either (7) or (8) turns, thus either (14) or (16) turns per pancake.																	
Tech SWF is estimated at $40/hr. Fully loaded value is ~double.																	
*** High radiation quad assumes hollow square conductor is mineral insulated inside of an outer metal jacket estimated at $35/linear foot.**																	
	Aperature	T +/-	Fe L	Turns	Cu lin ft	$35/ft	Fe in^3	Fe raw #	Fe $	Mach	Addl parts	T tech hrs	Tech SWF$	EDIA 1.4 T$	T $ M&S	T $ Labor	**Total $**
E*	10cm R	1.67	1.0m	28	1100	$ 38,500	6000	1700	$ 1,360	$ 12,239.86	$ 10,000	1,040	$ 41,600	$ 58,240	$ 62,100	$ 99,840	**$ 161,940**
Engineering, Design, Inspection and Administration is historically 90%-140% of tech dollar value (varies by project complexity)																	
EDIA SWF breakout			100%														
	Scientist		2%														
	M Engineer		23%														
	Drafter		25%														
	Proc Eng M		20%														
	Proc Eng W		20%														
	Support/Supervision		10%														
Blue font is calculated field																	

Appendix 5

Euronu Magnetized Iron Neutrino Detector Costing (MIND)

WBS	Description	Unit	Number	Cost/unit (€)	Material Cost (€)	Duration (months)	FTE	FTE months	Comments
2.2.	**Intermediate baseline detector (MIND 100 kton)**								
2.2.1.	**Detector R&D**								
2.2.1.1.	Scintillator R&D	units	1	300000	300000	24	2	48	Develop scintillator geometry and co-extrusion
2.2.1.2.	STL R&D	units	1	200000	200000	24	1	24	Develop STL prototype
2.2.1.3.	Photon detector and electronics R&D	units	1	200000	200000	24	1	24	Testing and characterisation SiPMTs
2.2.2.	**Underground cavern**				0			0	
2.2.2.1.	Geomechanical studies				0	12	3	36	
2.2.2.2.	Cavern construction	volume(m3)	60000	1185	71100000	54		0	Scaled from 13174 m2 of MINOS cavern
2.2.2.3.	Cavern outfitting	length (m)	150		36000000	31		0	Double of MINOS (since double length)
2.2.3.	**Steel plate fabrication**				0			0	
2.2.3.1.	Engineering, design				0	24	3	72	
2.2.3.2.	Steel management				0	60	3	180	
2.2.3.3.	Detector plane prototypes	tonne	188	1750	329000	60		0	Prototype with 5 planes
2.2.3.4.	Steel procurement	tonne	105268	1000	105268000	60		0	€774 per tonne constructed in MINOS
2.2.3.5.	Steel plate assembly	tonne	105268	600	63160800	60		0	60% of steel cost in fabricatin in MINOS
2.2.3.6.	Steel transport	tonne	105268	30	3158040	60		0	3% of steel cost in transport
2.2.3.7.	Steel support structures and handling fixtures	tonne	105268	150	15790200	60		0	15% of steel costs in handling in MINOS
2.2.4.	**Magnet coil**				0			0	
2.2.4.1.	Engineering, design				0	12	1	12	
2.2.4.2.	STL fabrication	length (m)	400	500	200000			0	Price from STL prototype for VLHC
2.2.4.3.	STL cryo plant	Plants	1	500,000	500000			0	1 cryo plant
2.2.4.4.	Power supplies	HV supplies	10	20,000	200000			0	10 power supplies of 10 kA
2.2.5.	**Scintillator detector fabrication**				0			0	
2.2.5.1.	Engineering, design				0	24	3	72	
2.2.5.2.	Scintillator strips	tonne	9209	6000	55254000	60		0	$10/kg extruded scintillator in MINOS (could be as low as $6-7/kg)
2.2.5.3.	WLS fibre	length (km)	25058	1000	25058000	60		0	Kuraray $1/m WLS fibre
2.2.5.4.	Scintillator modules	tonne	9209	600	5525400	60		0	Assembly around 10% cost material (MINOS)
2.2.5.5.	Photon detectors (SiPMTs)	units	4412800	10	44128000	60		0	Projection of cost of €10 per SiPMT
2.2.5.6.	Multiplexing boxes and connectors	units	68950	50	3447500	60		0	Estmate of cost of mechanical box
2.2.5.7.	Calibration systems	units	4412800	1	4412800	60		0	Double cost of MINOS
2.2.5.8.	Assembly and test equipment	units	4	1200000	4800000	60		0	Similar price to MINOS
2.2.5.9.	Factories	units	4	1500000	6000000	60		0	Similar price to MINOS
2.2.5.10.	Scintillator management				0	60	5	300	
2.2.6.	**Electronics, DAQ and database**				0			0	
2.2.6.1.	Front end electronics	units	4412800	5	22064000	60		0	Estimate of price per channel
2.2.6.2.	Data routing and trigger farm	units	4412800	1	4412800	30		0	In MINOS 20% of front-end electronics
2.2.6.3.	Data acquisition and triggering	units	1	250000	250000	24	3	72	Same cost as MINOS (Moore's law helps)
2.2.6.4.	Database				0	24	1	24	
2.2.6.5.	Auxiliary systems	units	1	620,000	620000	60		0	Same as MINOS
2.2.6.6.	Slow controls and monitoring	units	1	1050000	1050000	60		0	Same as MINOS
2.2.6.7.	High Voltage systems	units	68950	3	206850	60		0	Similar to MINOS
2.2.6.8.	Electronics management				0	60	2	120	
2.2.7.	**Detector installation**				0			0	
2.2.7.1.	Management				0	60	2	120	
2.2.7.2.	Lab infrastructure	units	1	1350000	1350000			0	Double of MINOS (since double length)
2.2.7.3.	Plane assembly area	units	1	774000	774000			0	Double of MINOS (since double length)
2.2.7.4.	Installation	units	1	4356000	4356000			0	Double of MINOS (since double length)
2.2.7.5.	Alignment and survey	units	1	318000	318000			0	Double of MINOS (since double length)
2.2.8.	**Project management**				0	84	3	252	
	Total				**480433390**			**1356**	

2.2.	**Intermediate baseline detector (MIND 100 kton)**	**Total Cost (%)**	**Material (%)**	**Material cost (€)**	**Material cost (M€)**	**FTE months**	**Manpower cost per month (€6000)**	**Total cost (€)**
2.2.1.	**Detector R&D**	0.3	0.1	700000	0.7	96	576000	1276000
2.2.2.	**Underground cavern**	22.0	22.3	107100000	107.1	36	216000	107316000
2.2.3.	**Steel plate fabrication**	38.7	39.1	187706040	187.70604	252	1512000	189218040
2.2.4.	**Magnet coil**	0.2	0.2	900000	0.9	12	72000	972000
2.2.5.	**Scintillator detector fabrication**	30.9	30.9	148625700	148.6257	372	2232000	150857700
2.2.6.	**Electronics, DAQ and database**	6.1	6.0	28603650	28.60365	216	1296000	29899650
2.2.7.	**Detector installation**	1.5	1.4	6798000	6.798	120	720000	7518000
2.2.8.	**Project management**	0.3	0.0	0	0	252	1512000	1512000
		100	**100.0**	**480433390**	480.43339	**1356**	**8136000**	**488569390**

Appendix 6

EXTRUDED SCINTILLATOR FOR vSTORM

Requested by Alan Bross
Prepared by Anna Pla-Dalmau
Date: May 17, 2013

IMPORTANT: PROJECT WILL BE BILLED AT ACTUAL COSTS. THIS IS AN ESTIMATE.

Rectangular scintillator bars: 20 mm x 7.5 mm with 1 hole
With white reflective coating (15% TiO2 in polystyrene)
Total amount for detector: 190,000 kg

	Estimated Materials and Services Cost ($)	Estimated Time (hours)	Rate (hours)	Estimated Labor Effort ($)	Total Estimated Cost Materials and Labor ($)
Material - tuning and production					
Die and sizing tooling* - 2 sets	$30,000.00				
Polystyrene pellets* (222,000 Kg @ $2.80 each)	$616,000.00				
Dopants** (5,110 bottles @ $175 each)	$894,250.00				
Titanium dioxide pellets** (5,550 Kg @ $7.50 each)	$41,625.00				
Nitrogen gas (1 year supply)	$15,000.00				
Consumables (1 year supply)	$10,000.00				
Labor - tuning and production***					
Extrusion preparation and operation (2FTE)		6,000	$60.00	$360,000.00	
Extrusion QC (2FTE) - contract?		6,000	$35.00	$210,000.00	
Shipping					
Crates					
Extrusion equipment maintenance	$10,000.00				
Estimated Direct Cost	$1,616,875.00			$570,000.00	**$2,186,875.00**
FNAL Indirect Charges (19.67% M&S)	$318,039.31				**$318,039.31**
FNAL Indirect Charges (71.98% Labor)				$410,286.00	**$410,286.00**
TOTAL Estimated Cost	**$1,934,914.31**			**$980,286.00**	**$2,915,200.31**

*Current price
**Estimated, adjusted price for large quantity
***Estimated 125 kg / h production - 1 line, 1 shift

Appendix 7

KURARAY AMERICA, INC.
2625 Bay Area Blvd., Suite 600
Houston, TX 77059
Phone: 281-283-1739 Fax: 281-283-1722

TO: Alan Bross
Fermi Lab
bross@fnal.gov
(630) 840-4880 (Office)

Date 4/25/2013
Quotation # FNAL-042513

QUOTATION (Valid for 30 Days)

Product Description	Quantity (M)	U Price	Total
Y-11(150)MS, 0.7mmD., BJ	3,100,000	$1.44	$4,464,000.00
Total			

Delivery Schedule TBA

Terms FCA Japan. (Air freight, insurance, tax and all other forwarding charges will be borne by BUYER after you receive your order)

Other Remarks:

Thank you very much for your interest in our products. If you have any question, please do not hesitate to contact me.

Best Regards,

Hui Yao

Hui Yao