WBS 2.3
Wavelength Shifting Fiber

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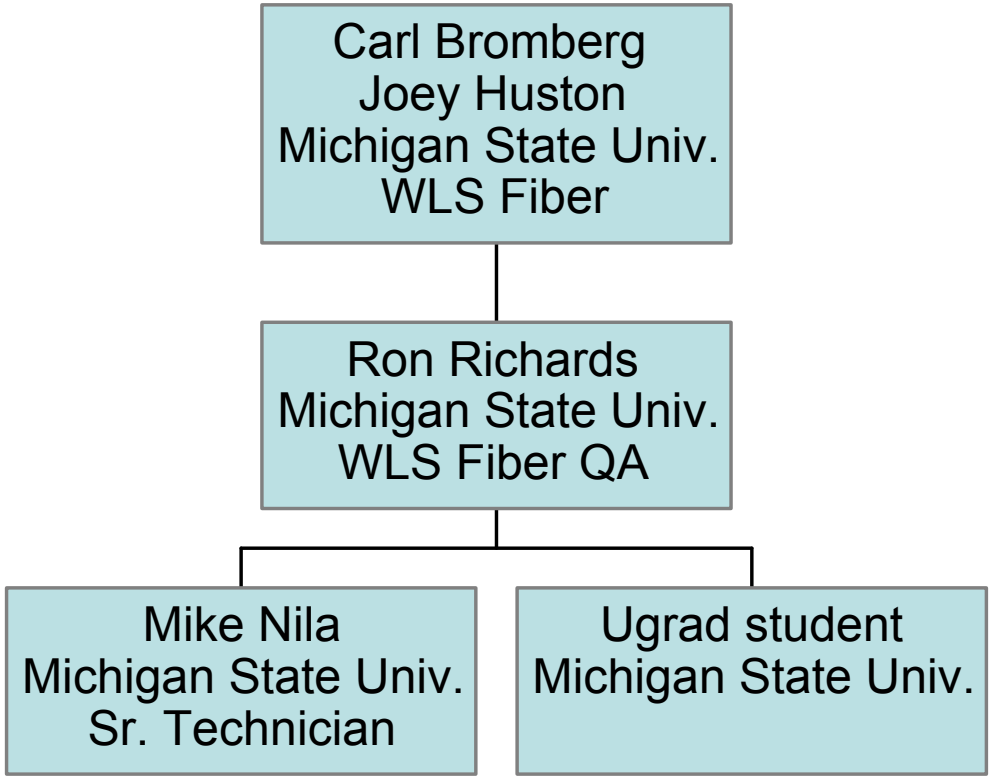
NOνA Signal Generation

- Liquid scintillator in a highly reflective PVC cell
  - ionization generates blue scintillation light
  - liquid is quite transparent to the bluest light
- Wavelength shifting (WLS) fiber loop
  - fiber vendor is Kuraray, Japan -- extensive HEP experience
  - fluorescent dye absorbs blue scintillation and emits green light
  - guides ~15% of emitted light toward the loop ends
- Avalanche photodiode (APD)
  - both ends of the fiber loop land on a single APD pixel
  - APD quantum efficiency >80% for WLS light

WBS 2.3 WLS Fiber QA Organization

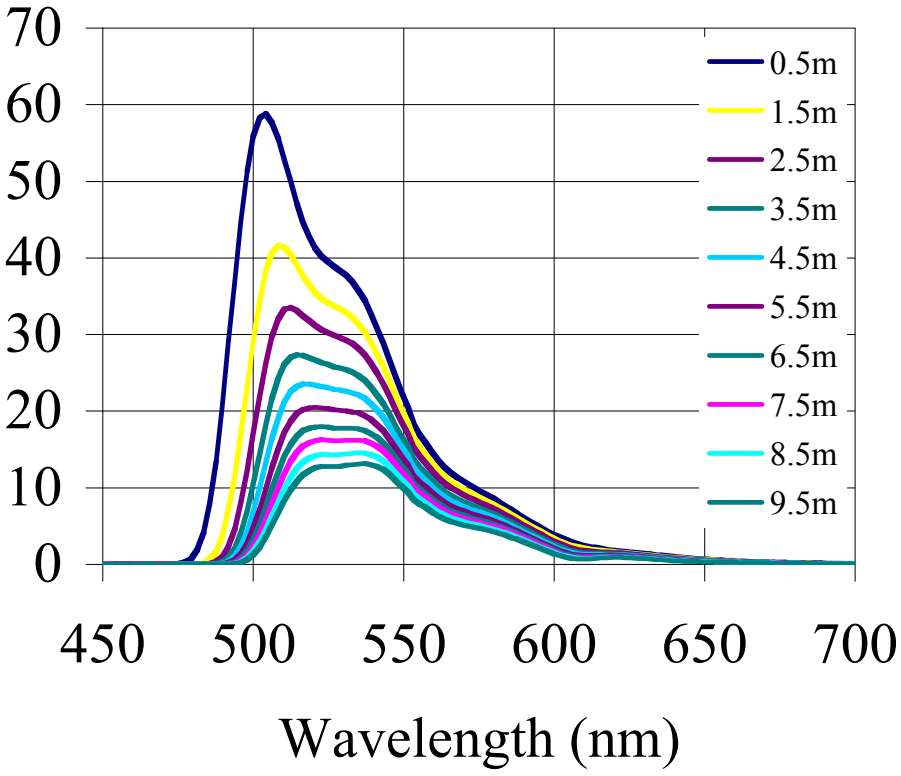


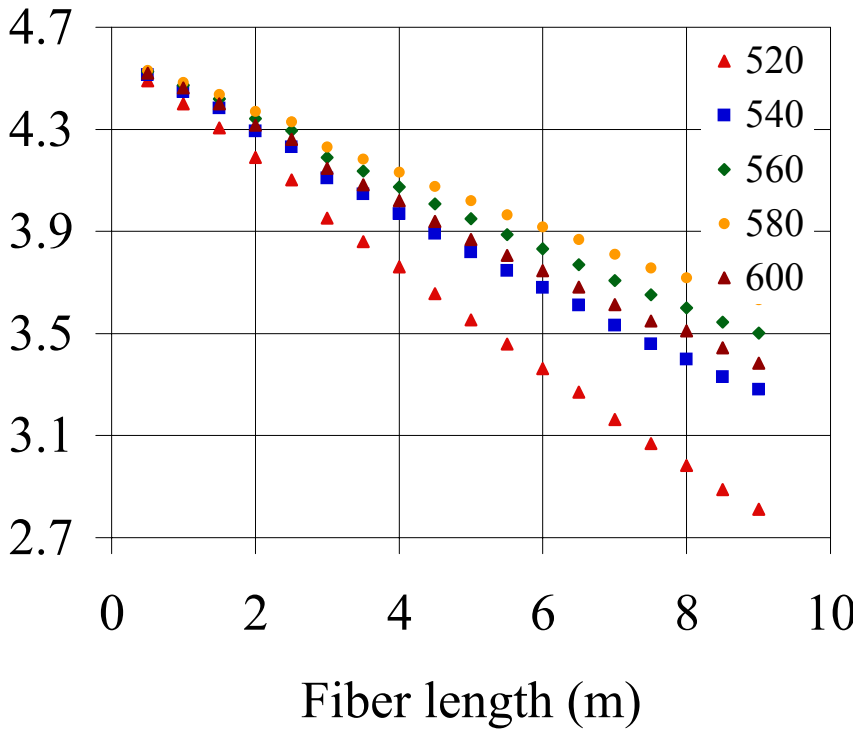
WLS fiber Technical Design

- R&D Institutions: CalTech, UCLA, UT Dallas, MSU
- WLS fiber will be 0.7 mm diameter, S-type (flexible)
  - Baseline fiber gave ~30 p.e. for muons at the far end of cell
  - Fibers damaged if bend diameter is 40 • fiber diameter.
    NOνA bend diameter of ~60 mm is 85 • fiber diameter
- Converging on WLS dye (K27) concentration
  - Tested 10 diameter-dye content combinations, $\geq$ 300 ppm is best
  - Attenuation length *fluctuations* (σ~12%) clouded the results
  - Our measurements agree in detail with Kuraray QC
- Quality Assurance testing plan based on our R&D results
- Tests show fibers will survive in liquid scintillator
  - Claddings are insoluble in pseudocumene
  - No changes to fiber in heated 50% pseudocumene scintillator
  - NOνA scintillator is only 5.5% pseudocumene

R&D example

- Scan LED over fiber, use spectrometer to analyze light output





- Other tests
  - Absolute light output in NOvA cells with photodiodes and APD
  - Attenuation length and light output variations between fibers

Requirements & Quality Assurance

- NOνA WLS Fiber Requirements are reflected in Kuraray's detailed proposal, based on their MINOS experience.
- Fiber delivered monthly to Michigan State University over a 4 year period, ~ 4500 km/year, 120 spools/month
- QA performed at MSU with fiber storage in a location TBA (likely MSU), until needed.
  - Automated scanning device is being constructed.
  - Scan first 30 m of every spool to obtain spectrographic data
  - Data analyzed in real time with databases updated daily
  - Tasks: Receive, prepare, scan, repack, store (dark,dry), ship

Cost: WBS 2.3

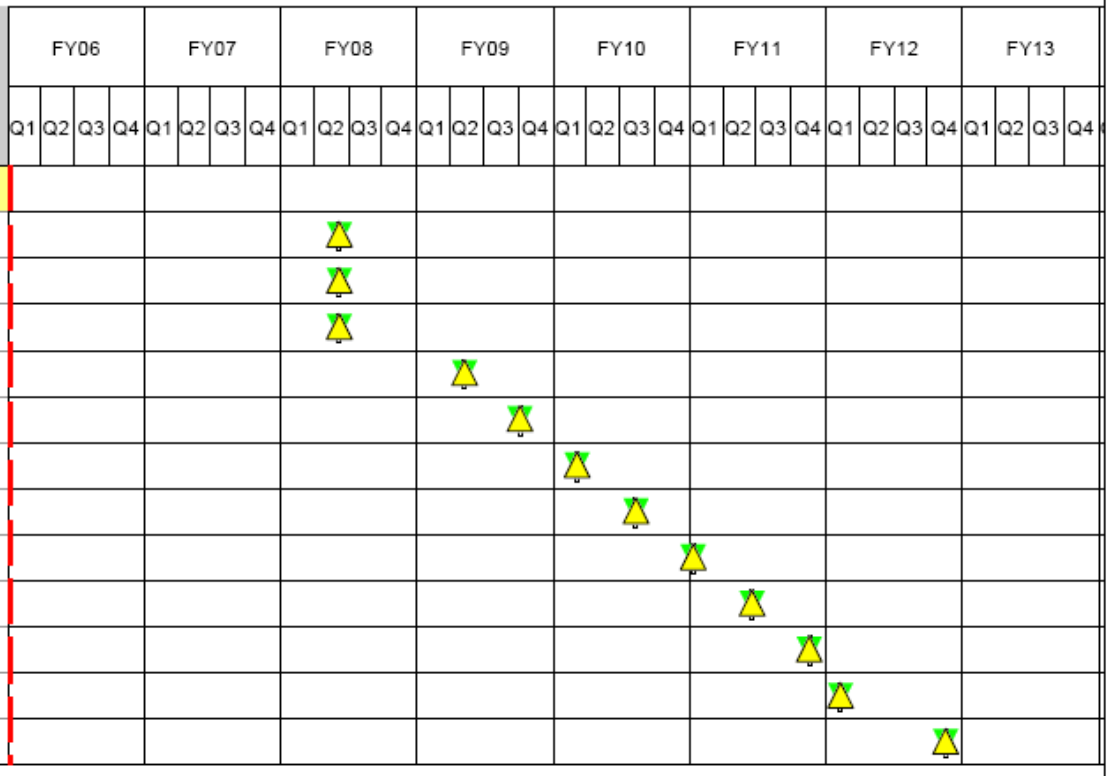
WBS x.3 WLS Fiber	Estimated Cost (AY $M)	Contingency Estimate (AY $M)	Contingency (%)	Total Cost (AY $M)
Construction w indirects				
M&S	12.3	3.4	28%	15.8
Labor[1]	1.2	0.1	10%	1.4
Construction total:	**13.6**	**3.6**	**26%**	**17.1**
R&D				
M&S	0.1	0.0	0%	0.1
Labor[1]	0.1	0.0	0%	0.1
R&D total:	**0.2**	**0.0**	**0%**	**0.2**

[1] Labor costs presented here include all project labor from Fermilab, other DOE facilities, and Universities.

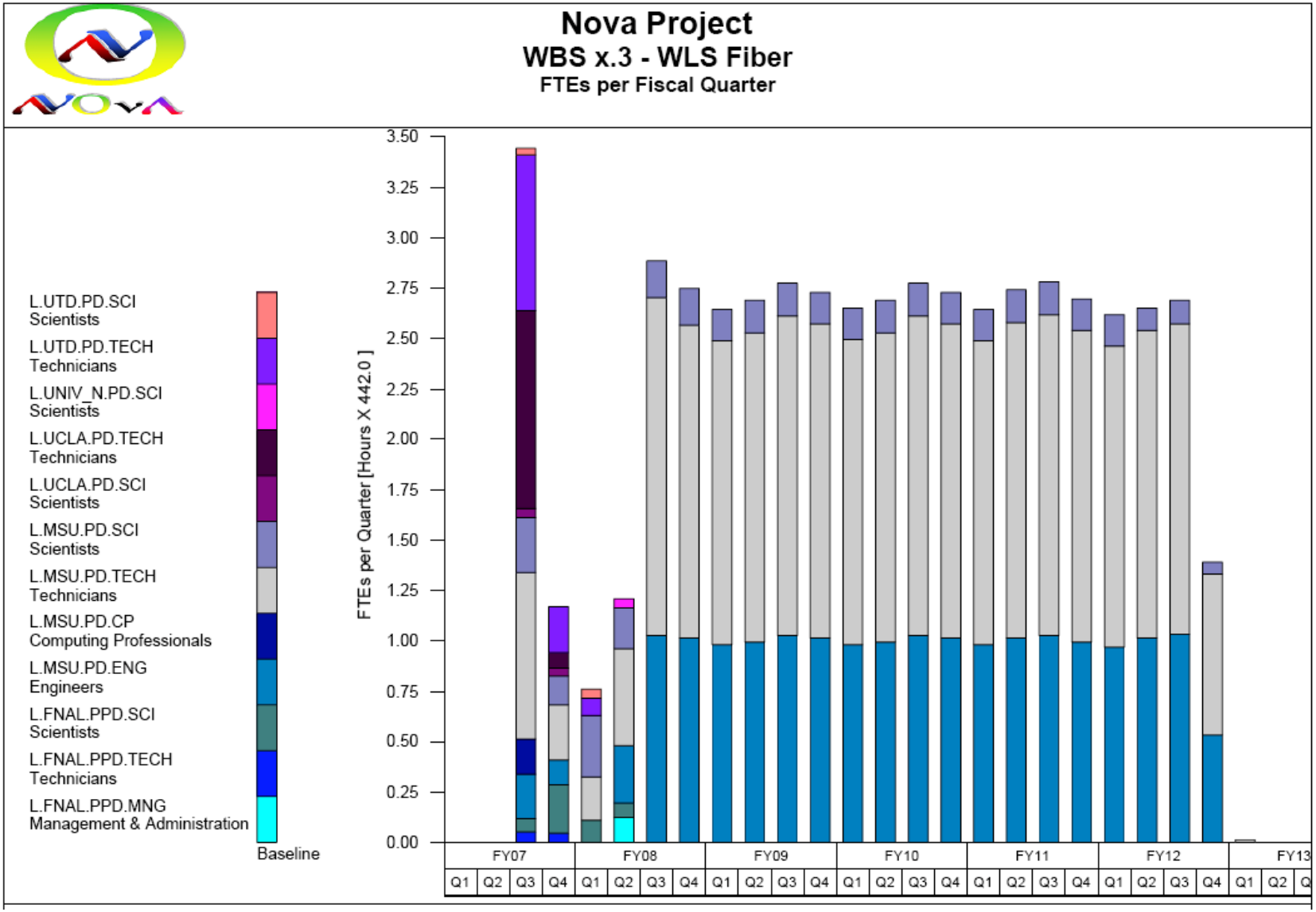
Schedule: WBS 2.3

Nova Project
WBS x.3- Nova_Milestones_WLS_Fiber
Milestone Gantt Chart

Activity ID	Milestone Description	Date
2.3 -- Wave-Length-Shifting Fiber		
2.3.1.1.5	Release purchase orders-near detector	05Mar08
2.3.1.2.5	Release purchase orders-far detector	05Mar08
2.3.2.2.2	WLS fiber production begins	06Mar08
2.3.2.2.3	WLS fiber production for superblock 1 completed	03Feb09
2.3.2.2.4	WLS fiber production for superblock 2 completed	02Jul09
2.3.2.2.5	WLS fiber production for superblock 3 completed	02Dec09
2.3.2.2.6	WLS fiber production for superblock 4 completed	10May10
2.3.2.2.7	WLS fiber production for superblock 5 completed	08Oct10
2.3.2.2.8	WLS fiber production for superblock 6 completed	14Mar11
2.3.2.2.9	WLS fiber production for superblock 7 completed	16Aug11
2.3.2.2.10	WLS fiber production for superblock 8 completed	08Nov11
2.3.2.2.11	All WLS fiber production completed	16Aug12



Manpower


Nova Project
WBS x.3 - WLS Fiber
FTEs per Fiscal Quarter
L.UTD.PD.SCI Scientists
L.UTD.PD.TECH Technicians
L.UNIV_N.PD.SCI Scientists
L.UCLA.PD.TECH Technicians
L.UCLA.PD.SCI Scientists
L.MSU.PD.SCI Scientists
L.MSU.PD.TECH Technicians
L.MSU.PD.CP Computing Professionals
L.MSU.PD.ENG Engineers
L.FNAL.PPD.SCI Scientists
L.FNAL.PPD.TECH Technicians
L.FNAL.PPD.MNG Management & Administration
Baseline
FTEs per Quarter [Hours X 442.0]
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
FY07
FY08
FY09
FY10
FY11
FY12
FY13
Q1 Q2 Q3 Q4

Summary

- Technical Design
  - WLS fiber diameter is 0.7 mm
  - R&D on dye concentration complete by the end of 2007
  - QA plan evolved from WLS fiber R&D
- Costs: fiber ($11.34M), QA 4 years ($1.0M)
- Schedule
  - Specify fiber for Integration Prototype ND in Q1 FY08
  - Specify fiber for Near & Far Detector in Q3 FY08
  - Fiber multiyear contract placed in Q4 FY08
  - QA tunes up with IPND fiber in FY08
  - Full production speed FY09-12
- No CD-3a items in this WBS