NOνA Project Status

John Cooper & Ron Ray

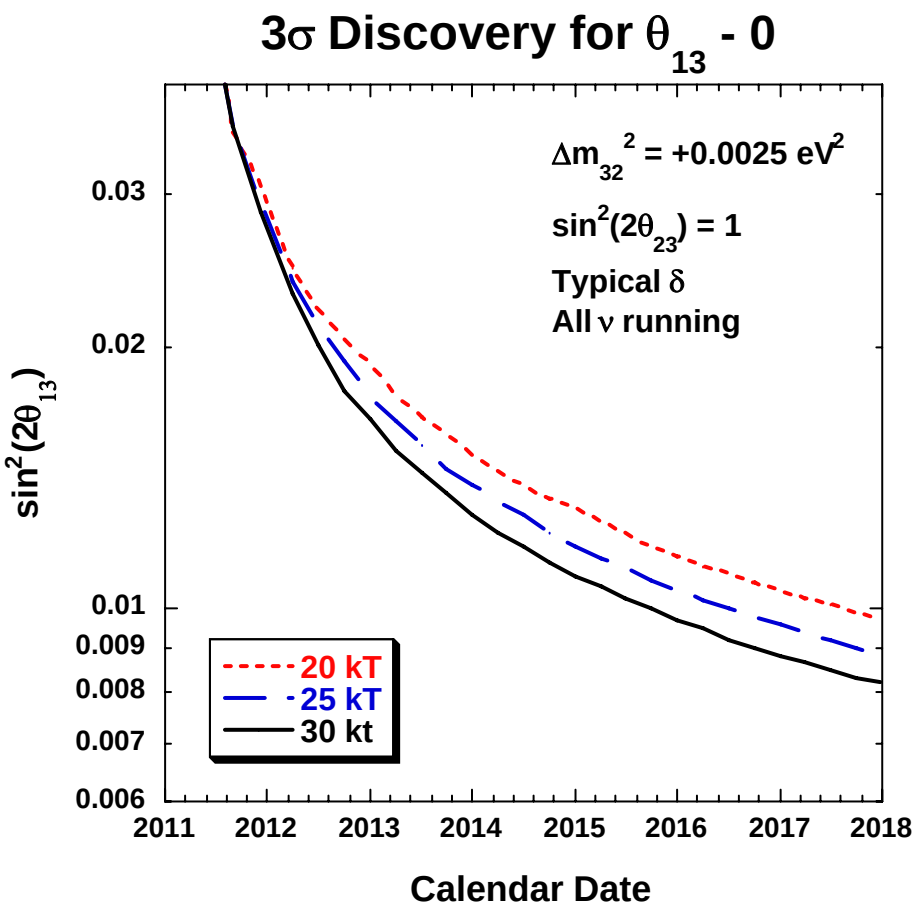
March 15, 2006

Interactions with Mike Procario

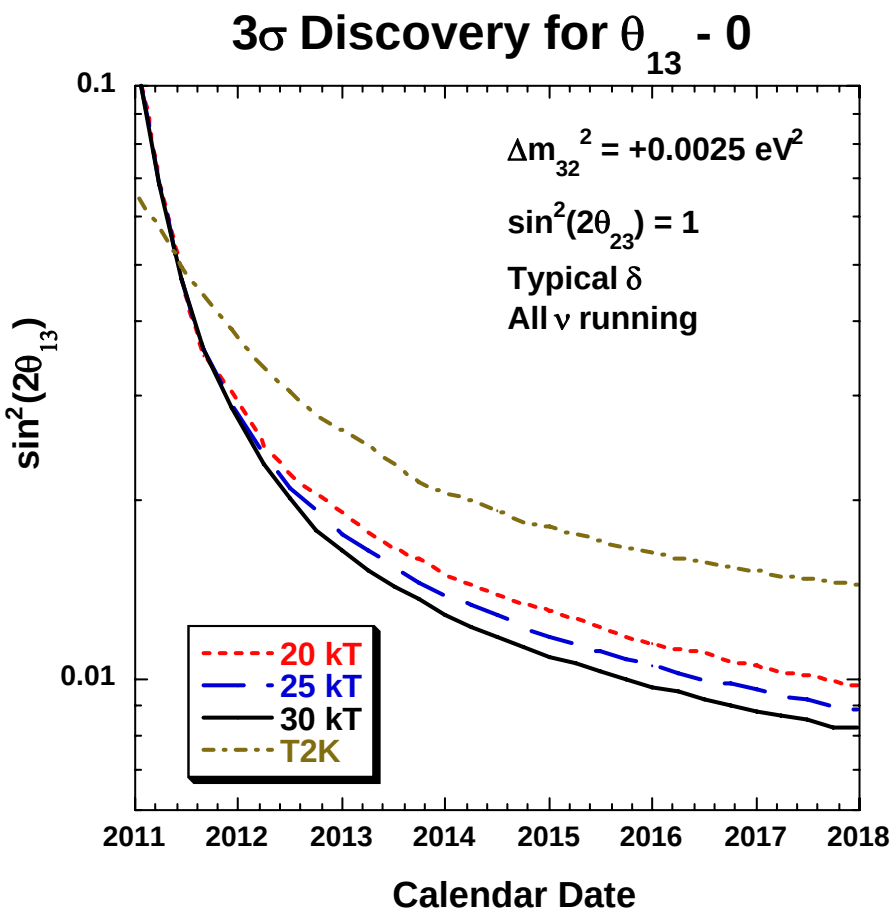
- Solicitation for bids on Cooperative Agreement
  - U of Minn worried any letter from them might screw up the bid process
  - Mike says OK if they send us a Letter of Intent saying they would be interested in
    - Acquiring the land (probably option)
    - Acquiring rights of access
    - Being RGU if selected
  - Marvin is working on such an LoI
  - And our CDR should say “we expect at least one bidder”

Mont, Robin, Pier

- They talked together on March 8
  - Robin expecting increase, but not that much
  - Would like a number closer to $ 200 M
  - Pier would like to see science impact for 20, 25, 30
- Conclusion: descope to 25 kt
  - But we will do 6 years vs. 5, so science stays constant
  - Will discuss a Scope Range in CDR and CD-1
    - i.e, if low end of cost range, then more mass for base estimate
    - If high end of range, then less mass
    - My guess to Robin is 22 – 29 kt for a 25 kt base estimate



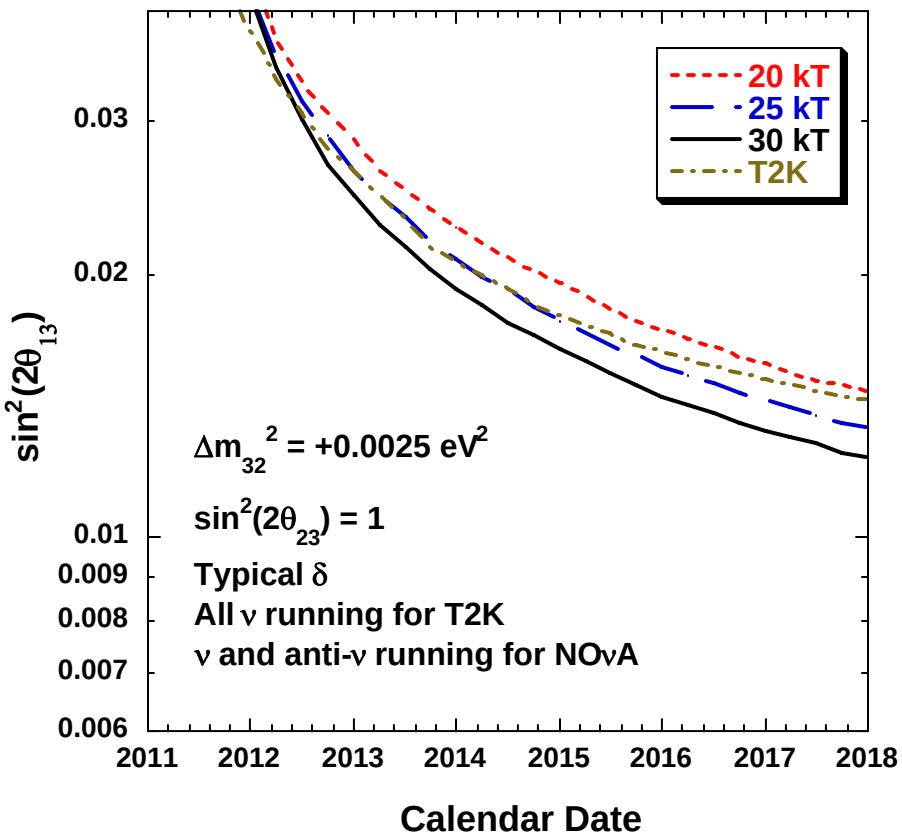
All ν running,
6.5 10^{20} pot/yr



Same, but add T2K using their planned proton intensity turn-on.

The T2K collaboration is pushing for a faster turn-on

3σ Discovery for θ_{13} - 0



Same, but now with equal amounts of ν and anti-n running for NOνA.

This is our preferred mode because it provides more uniform sensitivity and information on mass ordering and the CP phase.

Robin / Mont on 3/9

- Reasons for Cost increase

- Mont suggests 3 bins:
  - Amount due to crude oil
  - Amount due to design changes
  - Amount do to maturity of estimate

- Sent following to Robin on 3/10

Overview of the NOvA Cost Increase

- March 2005 NOvA proposal, base estimate = $ 109.8 M
  - This estimate was in "FY04$", but in fact some of the cost estimates were based on information from mid-calendar 2003.
  - Base includes indirects but no contingency and no R&D.

- March 2006 CD-1 Preliminary Director's Review, base estimate = $ 171.1 M
  - This estimate was in FY06$ (~ 2 years later) and is largely based on real vendor quotes for the cost drivers.
  - Again, base including indirects but no contingency and no R&D

- These slides give an overview of what changed.
  - ~ $ 12 M of the cost increase is due to the price of crude oil which has doubled since our proposal estimate
    - This would have been $ 31.6 M if we had not taken steps to reduce this cost
  - ~ $ 25 M of the cost increase is due to changes in the design
  - ~ $ 25 M of the cost increase is due to a maturing estimate
    - » (includes escalation 2003 → 2006)

- We stick to the base cost estimate in this overview since the contingency estimate has also changed from the proposal
  - 50% → 38% since we now have real quotes in hand for most of the M&S costs.

Overview of the NOvA Cost Increase

- The Far Detector Site & Building is up from $ 18.6 M (proposal) to $ 35.8 M (today)
  - ~ $ 10 M is due to design changes for the added overburden and south end wall required to shield the detector from the photon component of cosmic rays.
  - ~ $ 3 M is due to design changes to the building
    - » Foam Fire Suppression system @ $ 2 M
    - » Cast in place concrete walls for better containment (vs. shotcrete in proposal)
    - » 25 ton crane (vs. 5 ton in proposal)
    - » Elevator
    - » More loading dock area for the 1900 incoming truckloads of detector materials
    - » Catwalks around the detector, chilled water piping,
  - ~ $ 2.5 M is due to design changes for the access road
    - Ash River access is 3.3 miles long, not 1.0 miles as assumed in the proposal
  - ~$ 1.5 M for Site Logistics (call this one maturity of estimate)
    - realized we have to do upkeep on the building during the detector assembly phase as part of the project

Overview of the NOvA Cost Increase

- Liquid Scintillator cost is up
  from $ 24.1M (proposal) to $ 33.2 M (today)
  - ~ $ 3.5 M was an error in the proposal cost estimate now corrected.
  - The rest (~ $ 5.6M) is <u>all</u> due to the price of crude oil which doubled since our proposal.
  - The increase from crude oil would have been <u>much</u> larger,
    an additional $19.6 M ,
    had we not taken steps to reduce this cost
    (see next page on Scintillator details)

Liquid Scintillator Details

- Liquid Scintillator is a blend of mineral oil (solvent), pseudocumene (scintillant), and wave-shifting compounds
  - Mineral Oil:
    - Different grades, different costs
      - **USP** - food grade (Most expensive), **NF** - indirect food use, **Technical Grade** – used in animal feed (Least expensive)
    - MiniBooNE used NF grade, scintillator vendors Bicron and Eljen use NF grade
    - NOνA uses Technical Grade to save money and because it's "good enough" for our application
    - Our proposal used a quote of $1.80/gallon for "Parol" Technical grade from a leading lubrication oil vendor named Penreco.
      - At that time we were explicitly told by Penreco that mineral oil was not coupled to crude oil and was driven only by market forces. We have since discovered that this is not true.
      - The price of this same Penreco "Parol" mineral oil today is ~ $4.70 / gallon in bulk quantities.
      - Because of the cost increases, we have gone to the next lower grade, known as the "*Consol*" grade at Penreco
        - » we have TWO firm quotes from two different vendors of ~ $2.93/gal.
    - **This change to a cheaper mineral oil saved ~$10M (base cost).**
  - Pseudocumene:
    - The proposal had an 11% fraction of pseudocumene @ $1.79/ kg
    - **We have since reduced the fraction to 5.5% to save $ 2.4 M, even thought the price is now $2.31/kg**
    - We only lost ~ 20% of the light output and this is still enough light for the experiment
  - Waveshifters:
    - The reduction in pseudocumene goes hand in hand with a reduction in waveshifters (PPO, bis-MSB)
    - **We saved $ 5.6 M by reducing the quantity of these components**
  - In addition we have actually reduced the amount of scintillator by 2 kilotons from the proposal value (and added more PVC for a stronger structure)
    - **This saved $ 1.6 M**

Overview of the NOvA Cost Increase

- Wavelength Shifting Fiber cost is up
  from $ 13.4 M (proposal) to $ 22.5 M (today)
  - We know this cost is <u>not</u> linked to crude oil.
  - We don't understand this cost increase and have arranged a trip to Japan to talk with senior management at Kuraray about their cost increase.
    - A Kuraray estimate was used in the proposal,
      a Kuraray quote is used today.

Overview of the NOvA Cost Increase

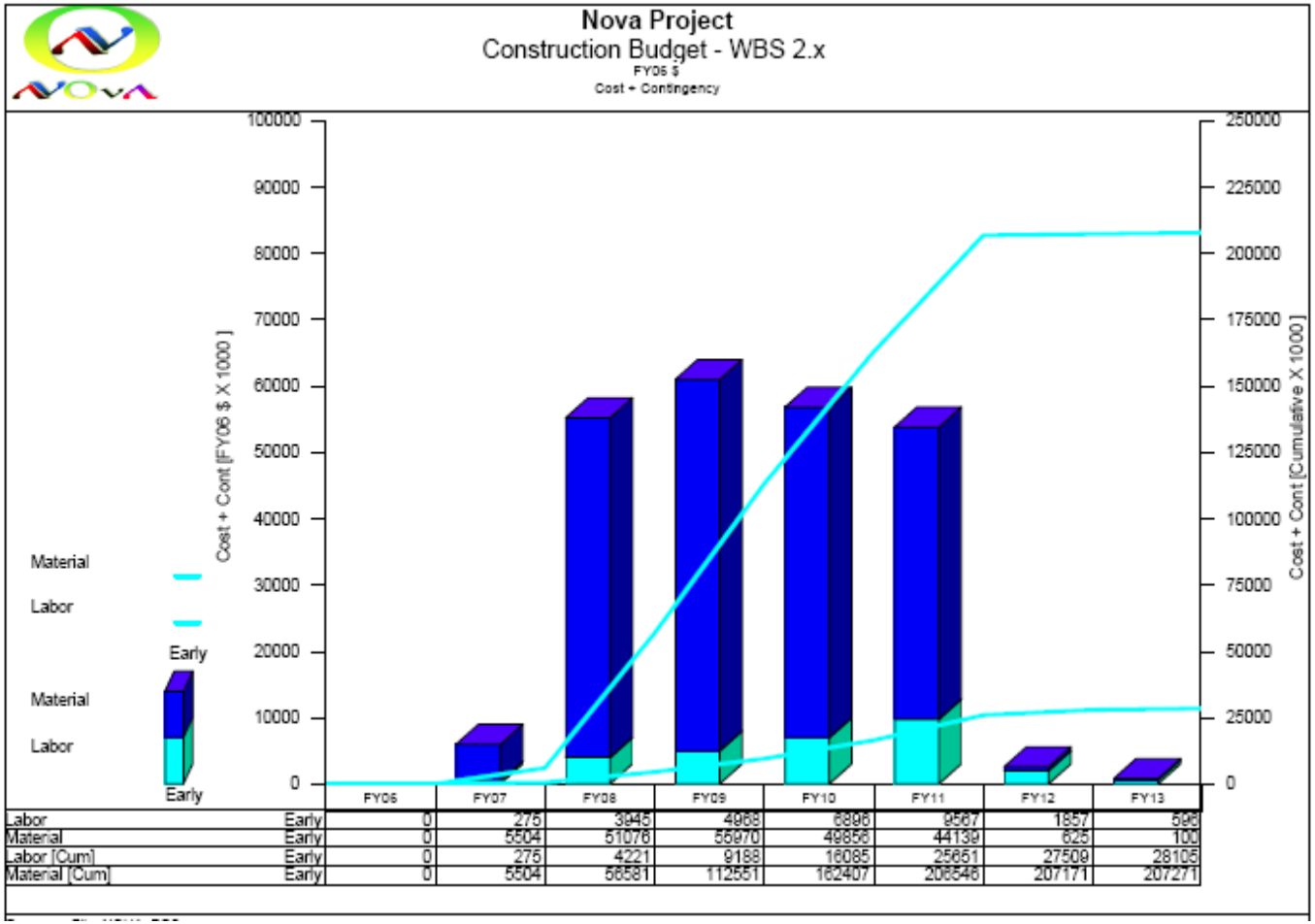
- The PVC extrusion Cost is up
  from $ 18.9 M (proposal) to $ 36.2 M (today)
  - This is partially due to an increased amount of PVC in our design
    - The walls of the vertical PVC cells are now 50% thicker for structural safety.
      - The horizontal PVC cells are still the same thickness as in the proposal
    - We now have 25% more PVC in our current design (cost increase of $ 4.4 M)
    - This means we need two separate PVC dies, not just one as in the proposal (cost increase of $ 1.4 M)
  - This is partially due to a more mature estimate
    - The cost of the PVC die and preproduction work was only $ 0.16 M in the proposal
    - It is now ~ $ 1.4 M for the original horizontal die and preproduction work
  - The rest (~ $11.8 M) is due to the increased price of PVC.
    - PVC prices were estimated in 2004 at $ 1.08 /lb, now the quote is $ 1.74 /lb
      - Up $ 0.35 / lb (~ $ 6.3 M) due to the cost of crude oil and natural gas
      - Up $ 0.31 / lb (~ $ 5.6 M) -- call it maturity of estimate, real quotes vs. phone contacts

Overview of the NOvA Cost Increase

- Factory production of extrusion modules is up from $ 4.8 M (proposal) to $ 8.6 M (today)
  - All maturity of estimate
- Electronics is up from $ 9.5 M (proposal) to $ 17.5 M (today)
  - The largest part is the Hamamatsu APD estimate which is up from $ 4.3 M to $ 8.4 M
    - This is a design change for us in the pixel aspect ratio, same pixel area.
    - We hope our current R&D with Hamamatsu will fix this cost to a lower number. Hamamatsu can't quote a number yet.
- Data Acquisition costs are ~ stable.
- Assembly costs are up from $ 9.5 M to $ 13.3 M
  - All maturity of estimate
- Shipping costs (scintillator and PVC) are changed
  - Proposal had $ 5.8 M with module factories on the East and West coasts
  - Now the module factories are in the Midwest near the extruder vendors.
  - Net is a cost <u>reduction</u> of ~ $ 3 M in spite of increased costs in diesel fuel.
  - Call it maturity of estimate
- Project Management Costs are ~ stable.

Mike, March 13

- Funding Profile for budget retreat
  - Gave him the 30 kt version, includes contingency
  - Reaction: probably can't get that much in 08 …..



		FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
Labor	Early	0	275	3945	4968	6896	9567	1857	596
Material	Early	0	5504	51076	55970	49856	44139	625	100
Labor [Cum]	Early	0	275	4221	9188	16085	25651	27509	28105
Material [Cum]	Early	0	5504	56581	112551	162407	206546	207171	207271

Where are we?

- Close to having all the R&D in Open Plan
  - Instructions for milestones at May 15 and Aug 1
  - Narrow choices, finish R&D by CD-2
    - Except for long term aging studies
    - And the ultimate goal: Integration Prototype Near Detector in 2007
- Have parameter sheet for 25 kt Construction
- Hope to have 25 kt version by Monday
  - Will start tasks at same times
  - Will end when each part hits 25 instead of 30
  - Expecting TEC ~ $ 218 M……
    - But have to see details

Status of Conceptual Design Report

3/14/2006

Chapter		Author	1st draft (# pages)	2nd draft (after comments)	Final (incl descope)
i	Title Page		1	1	1
ii	Author List			0	0
iii	Preface		1	1	1
iv	Table of Contents		yes	5	
1	Executive Summary	John	1	1	1
2	NOvA Scientific Requirements	Gary/John	14	15	
3	Overview of the NOva Design	John	29	29	
4	Alternative Designs Considered	John	14	15	
5	Optimization and Risk Analysis	John	19	18	
6	WBS Dictionary for the Construction Project	Ron	9	8	
7	Site Description	John	2	13	
8	Conventional Facilities	John	5	5	
9	Scintillator	Ron/John	8	12	
10	Wavelength Shifting Fiber	Ron	6	6	
11	PVC Extrusions	John	0	10	
12	PVC Modules	Ron	6	7	
13	Photodetector & Electronics	Ron	11	10	
14	Data Acquisition System	Ron	5	5	
15	Near Detector	Ron	6	6	
15	Far Detector Assembly	Ron	14	10	
17	ES&H Overview	John	x	2	2
18	Quality Assurance Overview	John	x	1	1
19	Risk Analysis Overview	John	x	2	2
20	Safeguards and Security	John		2	2
21	Stakeholder Input	John	x		3
22	Life Cycle Costs	John			
23	Cost Range, Scope Range, Schedule Range	John	x		
A1	WBS dictionary for R&D	Harry	x	11	11
A2	MPCA letter	John	x	1	1
		SUM	151	196	25

Exec Summary

1. Executive Summary

1.1 Introduction

Fermi National Accelerator Laboratory and the NOνA Collaboration composed of 142 scientists and engineers from 28 Universities and Laboratories around the world have collaborated to create this conceptual design for a new detector to study neutrino oscillations using the existing Department of Energy investment in the NuMI neutrino beam at Fermilab.

1.2 Project Components

The NOνA Project consists of three main elements:

1. A new building on a site near the US-Canadian border in Ash River, Minnesota to house the NOνA detector. This site is 810 kilometers from Fermilab. The building is 22.5 meters wide by 196 meters long and is sunk 14 meters below the existing grade into granite rock at the site. The excavated granite is used to cover the detector with a 3 meter thick overburden as a cosmic ray shield.
2. A 25 kiloton neutrino detector composed of ~ 643,000 cells of extruded PVC plastic in a cellular structure. Each cell is 3.9 centimeters wide by 6.0 centimeters deep and is 15.7 meters long. The cells are filled with a total of 6.8 million gallons of liquid scintillator. The liquid scintillator comprises 73% of the total mass, making this a totally active tracking calorimeter detector designed for identification of electron neutrino (ν_e) interactions. The detector is read out via 22,000 kilometers of 0.8 millimeter diameter optical wave-shifting fiber into approximately 20,000 avalanche photodiodes with associated electronics.
3. A small 200 ton detector on the Fermilab site to measure the inherent beam backgrounds.

Exec Summary

1.3 Use of Existing Facilities

The existing Fermilab NuMI beam transport, target, focusing horns, vacuum decay pipe, and absorber will be used to provide the neutrino beam for NOνA. The NuMI beam is used in a new way by placing the NOνA detector at an angle ~ 15 milliradians off the beam axis to obtain a muon neutrino (ν_μ) beam sharply peaked at 2 GeV in energy. The small 200 ton detector will be placed in the existing NuMI underground tunnel at a depth 105 meters below grade.

1.4 Capabilities

In a six year run with 6.5 x 10^{20} protons per year delivered by the Fermilab Main Injector to the NuMI target, NOνA would measure the probability for muon neutrino to electron neutrino oscillations ($\nu_\mu \rightarrow \nu_e$) down to a value ten times smaller than the existing experimental limit.

The existence of neutrino oscillations means that neutrinos have mass. In a six year run equally split between neutrino and anti-neutrino beams, NOνA can resolve the neutrino mass ordering for a significant portion of the available parameter space for these oscillations. This capability is a unique aspect of NOνA not duplicated by any other formally proposed experiment.

1.5 Cost & Schedule

The Total Estimated Cost of the NOνA Project is in the range $ xxx M - $ yyy M. The Total Project Cost is in the range $ XXX M - $ YYY M. The Scope Range of the NOνA Project is a Far Detector of mass in the range 22 – 29 kilotons. A schedule range of N to M years is proposed for the construction project.