Procurement Plan for the NOνA
Cost Drivers

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1.0 Introduction

The procurement requirements for NOνA are relatively unique. Approximately 70% of the total project cost is tied up in 5 WBS items. One of these items is the Far Detector Hall that will be handled through the Cooperative Agreement and will not be considered here. The remaining 4 items comprise approximately 50% of the total project cost. These items are:

- Liquid scintillator
- Wavelength shifting fiber
- PVC extrusions
- Avalanche photo diodes (APDs)

Each of these items has unique requirements and will be discussed separately.

1.1 General Philosophy

The culmination of NOνA's R&D program is the construction of the NOνA Integration Prototype Near Detector (IPND). Small quantities of all of the pieces needed for the full detector must come together in order to build this working prototype. Our philosophy for the cost drivers listed above has been to send out bid packages asking for quotes on the quantities required for the IPND along with quotes on a *unilateral option* for the full quantities required for the entire NOνA project. *The primary reason for the unilateral option is to allow NOνA to obtain real price quotes on real quantities of the cost drivers.* These actual quotes lend accuracy and credibility to NOνA's cost estimate and were exceptionally well received during the DOE CD-1 Review. Fermilab can choose to exercise the unilateral option or re-bid the item, depending on the circumstances at the time. The option is entirely DOE's and the goal is to follow the path that saves us the most money.

Vendors are sometimes reluctant to bid on items that will not be delivered for several years and when they do, they often inflate the price to cover worst-case price volatility. This is a particularly difficult problem for NOνA as two of the cost drivers are directly coupled to the highly volatile price of crude oil. It has become standard business practice to use *fixed price contacts with economic price adjustment* (*Federal Acquisition Regulation – Section 16.203-2*). Adjustments to the contract price can be made based on cost indices of labor or materials in cases where instability of market conditions over an extended period is anticipated. The most common example of this is the use of the Producer Price Index (PPI) to account for inflation. From the Department of Labor's Bureau of Labor Statistics document *Escalation Guide for Contracting Parties;* "Business firms in search of effective methods of coping with inflation often employ price adjustment (escalation) clauses in long-term sales and purchase contracts." Using an index is an effective method to protect both the buyer and the seller. In addition, by

understanding how vendors link their prices to volatile commodities, buyers can perform a more accurate contingency analysis for the contracted items. The NOνA IPND RFPs are key to understanding these links. NOνA has treated the price of crude oil as a contingency risk in a full Monte Carlo analysis using the projections of the DOE's Energy Information Administration combined with historical information. This analysis has been applied to items that are linked to the price of crude oil.

The guidelines from the Escalation Guide relevant for NOνA are listed below. These items would all be addressed in the contracts that Fermilab establishes with the various vendors.

- Establish the base price subject to escalation.
- Select an appropriate index or indexes.
- Clearly identify the selected index and cite an appropriate source.
- State the frequency of price adjustment.
- Provide for missing or discontinued data.
- Define the mechanics of price adjustment.

Fermilab frequently makes use of *master contracts* to purchase goods over a number of years. A Master Contract is a phased procurement that specifies a minimum and a maximum purchase of goods per year. The DOE refers to such arrangements as *Multi-Year Contracting* (*Federal Acquisition Regulation – Section 17.1*). Economic price adjustment clauses are frequently included in such contracts (*Federal Acquisition Regulation – Section 17.109*). NOνA plans to use multi-year contracting with economic price adjustment clauses to allow us to purchase more materials when the price is low and fewer when the price is high. This is similar to master contracts that Fermilab has executed in the past for the purchase of ethane gas for CDF.

There is less risk associated with a procurement that is spread over multiple vendors and NOνA will attempt to do this when possible and practical. There are a number of items for which there is only one known vendor. In these cases, NOνA will procure the required items as early in the project as possible in order to mitigate some of the risk associated with sole sources.

2.0 Liquid Scintillator (WBS 2.2)

NOνA requires approximately 4.3 million gallons of liquid scintillator delivered over a 3-year period. Fermilab sent an RFQ to the two known vendors of liquid scintillator. Neither vendor could supply the quantity required by NOνA for the full detector or even for the Integration Prototype Near Detector. NOνA must therefore procure the components individually and blend them together.

The liquid scintillator for NOνA is comprised primarily of mineral oil with 5.5% by weight of pseudocumene and small amounts of wavelength shifting powders. The components are listed below in Table 2.1. Each of the components comprises a different set of issues and challenges.

Component	Purpose	% by mass	Gallons	Total Mass (kg)
Mineral oil	Solvent	94.3	4,072,844	13,132,557
Pseudocumene	Scintillant	5.5	237,044	765,314
PPO	Waveshifter	0.12	-	16,698
bis-MSB	Waveshifter	1.7×10^{-3}	-	237
Total			**4,309,888**	**13,914,806**

Table 2.1 Composition of the NOνA liquid scintillator.

2.1 Mineral Oil

NOνA requires approximately 4.1 million gallons of mineral oil delivered over a 3-year period beginning in FY10.

2.1.1 Statement of Work

Fermilab issued an RFP for mineral oil in November of 2005. The RFP requested quotes for a base quantity of 9040 gallons for the IPND, to be delivered in 2007. In the same RFP we also requested bids on a unilateral option for the full quantity required for the NOνA Project, to be delivered between September 2009 and December 2011. An index for scaling the price in future years was also requested. The specifications for the mineral oil are shown in Table 2.2.

2.1.2 Cost Estimate

The estimated cost and contingency for 4,072,844 gallons of mineral oil, produced to NOνA specifications, is shown in Table 2.3. The cost of the mineral oil and the delivery are broken out separately.

Density	API gravity at 60 F between 31.0 and 34.0 (specific gravity between 0.855-0.870) measured via ASTM D 4052 or ASTM D 1298
Viscosity	< 11 cSt at 40° C - measured via ASTM D 445. This oil will be supplied with a kinematic viscosity graph in the range 20° C to 100° C
Color	: >= +29 Saybolt Color units - measured via ASTM D 156.
Water content	< 30 ppm
Antioxidants	< 15 ppm

Table 2.2 Specifications for mineral oil.

	Unit Cost	Full Volume Cost	Contingency	Total
Mineral oil	$2.96/gallon	$12,055,618	$3,375,573 (28%)	$15,431,191
Shipping	$0.18/gallon	$733,112	$190,609 (26%)	$923,721
Total		$13,659,814	$3,809,087 (28%)	**$16,354,912**

Table 2.3 Estimated cost and contingency for mineral oil.

The cost estimate is based on an actual quote, in response to the unilateral option for the full quantity of mineral oil included in the RFP. The contingency has been determined by a Monte Carlo calculation that linked price movements in crude oil to the scaling index provided by the vendors in response to the RFP. Details of the Monte Carlo calculation are provided in NOνA-doc-681 which is attached as Appendix A.

2.1.3 Funding Constraints

Mineral oil is one of NOνA's cost drivers and is loaded into our Deltek Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. Based on our current working funding profile and our matching assembly schedule, the mineral oil will be a 3-year procurement with mineral oil being purchased and scintillator being blended in FY10, FY11 and FY12.
If the funding profile were stretched this procurement could also be stretched accordingly.

2.1.4 Contract Type

The contract for mineral oil will be a *fixed price contact with economic price adjustment.* This is the preferred type of contract because the price of mineral oil is linked to the price of crude oil, which has been extremely volatile for several years. Allowing for economic price adjustment based on an index protects both the buyer and seller and allows the seller to submit the best possible bid without the need for padding to cover possible upward price swings.

The mineral oil RPF required that the bids for the unilateral option include a price adjustment index. The two vendors who responded to the RFP used identical indices. The Group II, viscosity 70, paraffinic base oil price quoted in the industry standard *Lube Report* (http://www.lubereport.com) is used to index the mineral oil. The Lube Report is published weekly. Every penny per gallon *increase or decrease* in the posted price of the base oil results in a penny per gallon *increase or decrease* in the cost of mineral oil. The historical data in Figure 2.1 shows that the base oil price is correlated with the price of crude oil. The cost of delivering the mineral oil by rail to Fermilab has been broken out separately. The delivery cost is indexed to the Burlington Northern Santa Fe (BNSF) diesel fuel surcharge. The fuel surcharge is percentage-based and depends directly on the price of diesel fuel that is also dependent on the price of crude.

Because of the potential volatility of crude oil, NOνA would like to retain some flexibility to buy as much mineral oil as possible when the price is low and buy less when the price is high. We would like to execute a *master contract* with the eventual mineral oil vendor that allows us to vary the amount of mineral oil we buy between a pre-determined minimum and maximum volume each year, depending on the price.

The master contract for mineral oil would also specify the price adjustment frequency based on movement of the indices. Mineral oil will be delivered at a rate of approximately 125,000 gallons per month over a period of 36 months. A 60 – 90 day price lock period, corresponding to 250,000 – 375,000 gallons, seems appropriate. Periods shorter than 60 – 90 days become an administrative headache and longer periods expose both the buyer and seller to unwanted risk. The Lube Report would be selected as the source of the base oil index and the ICIS Base Oil Report from Reed Business Information Ltd. would be identified as a backup source. The BNSF diesel fuel surcharge table, available online, will be used to index deliveries.

2.1.5 Identification of Suppliers

There are many domestic sources of mineral oil. The original RFP in Appendix I was sent to 11 vendors. There are no sole source or *Buy American Act* concerns.

2.1.6 Evaluation Methodology

We do not necessarily accept the low bid but evaluate the bids to determine the *best value* to Fermilab. For all of our large procurements, we follow the model of assembling a review board consisting of Project Management and L2 and L3 managers to evaluate all received bids based on a point system that has been determined in advance. For the RFP that was issued for mineral oil for the IPND, the criteria in Table 2.4 were used. A very similar formula would be used for evaluation of future mineral oil bids.

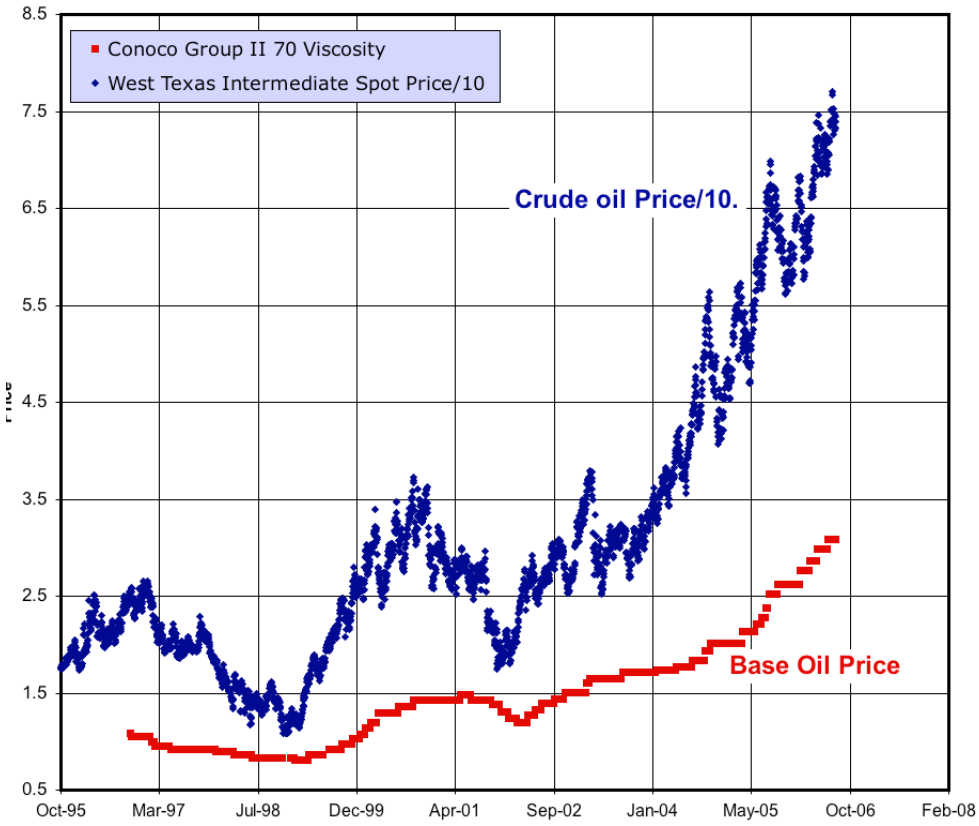

Figure 2.1 Historical data showing the connection between the group II, viscosity 70, paraffinic base oil price and crude oil.

Criteria	Maximum Points
1. Documentation of QA plans	4
2. Manufacturing plan	6
3. Manufacturing facilities	8
4. Previous performance	8
5. Schedule	5
6. Packaging and shipping plan	2
7. Cost and breakdown	10
Maximum Possible Points	**43**

Table 2.4 Criteria used for evaluating mineral oil bids for the IPND.

2.2 Pseudocumene

NOνA requires 237,044 gallons of pseudocumene delivered over a 3-year period, corresponding to about 1 ISO tank delivery every month or 1 rail car every 3 months. Deliveries are to begin in FY2010 but a 6 month lead time is required for the supplier to secure rail cars or ISO tanks.

2.2.1 Statement of Work

Fermilab issued an RFP for pseudocumene in December of 2005. The RFP requested quotes for a base quantity of 980 gallons for the IPND, to be delivered in 2007. In the same RFP we also requested bids on a unilateral option for the full quantity to be delivered between September 2009 and December 2011. An index for scaling the price in future years was also requested. The specifications for the pseudocumene are shown in Table 2.5. These specifications are typical for pseudocumene and do not require any special effort on the part of the vendor.

Purity	98% or greater
Specific Gravity	Between 0.875 and 0.882 at 60° F, measured via ASTM D 4052 or ASTM D 1298
Pt-Co Color	20 color units or greater, measured via ASTM D 1500
Total Sulfur Content	2.0 ppm or less

Table 2.5 Specifications for pseudocumene.

Only one vendor responded formally to the RFP. A second vendor was willing to provide a 90-day quote. One vendor is domestic and the second vendor is in China. The unit cost of pseudocumene from the two vendors is similar, as is the product quality. However, shipping charges from China nearly double the price of delivered pseudocumene. We are currently pursuing another domestic vendor that we have recently become aware of, though the ultimate source of the pseudocumene is the same as the first domestic supplier.

The domestic supplier of pseudocumene has been unwilling to quote prices beyond 90 days. We know little about the manufacturing process for pseudocumene aside from the fact that it is from the C9 distillation process, so it is ultimately linked to crude oil in some way. We have no historical pricing data for pseudocumene, but the price appears to be more stable than mineral oil. It is likely that our pseudocumene order will consist of a series of 90-day price locks though we would prefer to lock-in the price for longer periods of time. We are trying to set up a meeting with the domestic vendor to discuss some of these issues.

There are ES&H issues associated with pseudocumene that also have to be taken into account from the earliest stages of planning and procurement. Pseudocumene has a flash point that is between diesel fuel and regular gasoline. It is a benzene derivative that must be kept out of the water supply. This has implications for how the pseudocumene is delivered and how it is stored.

2.2.2 Cost Estimate

The estimated cost and contingency for 237,444 gallons of pseudocumene, produced to NOνA specifications, is shown in Table 2.6. The cost includes delivery.

	Unit Cost	Full Quantity Cost	Contingency	Total
Pseudocumene	$1.05/lb	$1,771,591	$885,796 (50%)	$2,657,387

Table 2.6 Estimated cost and contingency for pseudocumene.

The cost estimate is based on a 90-day quote from our domestic source. We assign a large contingency to the pseudocumene because a 90-day quote is not considered by us to be as solid as a response to an RFP. In addition, we do not have historical pricing information on pseudocumene and we have not been provided with a scaling index.

2.2.3 Funding Constraints

Liquid scintillator and its components are cost drivers for NOνA. The cost of pseudocumene is loaded into our Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. Based on our current working funding profile and our matching assembly schedule, the pseudocumene will be a 3-year procurement with pseudocumene being purchased and scintillator being blended in FY10, FY11 and FY12. If the funding profile were stretched this procurement could also be stretched accordingly.

2.2.4 Contract Type

Based on what we know now, the contract for pseudocumene would be a standard fixed price contract. If, prior to purchase, we were to find an appropriate scaling index for pseudocumene we would consider a fixed price contract with economic price adjustment, similar to the mineral oil contract.

2.2.5 Identification of Suppliers

There are few sources for large quantities of pseudocumene. RFPs were sent to about a dozen potential suppliers of pseudocumene, but only two suppliers responded One of the respondents was domestic, the other was from China. The base cost of the pseudocumene was approximately the same from both sources but the cost of delivery from China nearly doubled the price. This will likely be a sole source purchase from the domestic supplier. If a problem develops with the domestic supplier we can always

procure pseudocumene from the Chinese vendor and pay the higher cost. The Chinese supplier has an office in California, so they are not difficult to communicate with.

2.2.6 Evaluation Methodology

Because there is only one vendor in the US, we are purchasing significant quantities of the pseudocumene and subjecting it to an intensive evaluation process. We have also purchased pseudocumene from the other known supplier in China. The pseudocumene from the two suppliers are very similar and they both perform to expectations. We will use pseudocumene from both suppliers on an even larger scale for the IPND to verify performance.

2.3 Waveshifting Powders

Two waveshifting powders are required for the liquid scintillator. They are commonly known as PPO and bis-MSB. NOνA requires approximately 16,700 kg of PPO and about 237 kg of bis-MSB.

2.3.1 Statement of Work

Fermilab issued an RFP for the waveshifting powders in December of 2005. The RFP requested quotes for the base quantities needed for the IPND, to be delivered in 2007. In the same RFP we also requested bids on a unilateral option for the full quantities required for the NOνA Project, to be delivered between September 2009 and December 2011. An index for scaling the price in future years was also requested. The required specifications are shown in Table 2.7. These specifications are standard for these materials and do not require any special effort on the part of the vendor.

	PPO	**Bis-MSB**
Melting Point	71-73° C	179-181° C
Purity of Material	> 99.6%	> 99.6%
Background	< 30 counts/min	< 30 counts/min
Transmittance in Toluene	> 85% at 370 nm	>90% at 420 nm
IR Spectrum	Conform with standard	Conform with standard

Table 2.7 Specifications for waveshifting powders.

The RFP was sent to 3 vendors. One was a chemical company known to make the materials and the other two were the vendors that produce mixed scintillator containing the waveshifting powders. Only the chemical company responded and it turns out that the two scintillator producers buy the waveshifting powders from this same chemical company.

2.3.2 Cost Estimate

The estimated cost and contingency for 16,700 kg of PPO and 237 kg of bis-MSB, is shown in Table 2.8. The cost includes delivery.

	Unit Cost	Full Quantity Cost	Contingency	Total
PPO	$189/kg	$3,155,922	$788,980 (25%)	$3,944,902
Bis-MSB	$1160/kg	$274,920	$68,370 (25%)	$343,659
Total		$3,692,000	$923,000	**$4,288,552**

Table 2.8 Estimated cost and contingency for waveshifting powders.

2.3.3 Funding Constraints

Liquid scintillator and its components are cost drivers for NOνA. The cost of the waveshifting powders is loaded into our Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. The PPO and bis-MSB are both delivered over a period of 3 years. The bis-MSB could presumably be delivered faster but it takes 3 years to manufacture the full quantity of PPO. This fits within our funding profile and is consistent with the procurement of the other liquid scintillator components. If the funding profile were stretched this procurement could also be stretched accordingly.

2.3.4 Contract Type

The contract for waveshifting powders will be a *fixed price contact with economic price adjustment.* Several years will be required to produce the PPO for the NOνA project, so a price indexing formula has been proposed by the vendor. The adjustment would be based on the Producer Price Index (PPI) and a market basket of representative chemical costs. The market basket includes ethanol, methanol and toluene. 50% of the adjustment would depend on the PPI and 50% on the market basket of chemicals. The adjustment based on the market basket would be determined by averaging the percentage changes in the three chemicals. Figures for the PPI are available from the Bureau of Labor Statistics. Chemical prices are available from the Chemical Marketing Reporter, the leading chemical industry publication. The adjustments will be made annually.

2.3.5 Identification of Suppliers

There is only one known vendor in the US for these chemicals. This vendor is well known to Fermilab and we have purchased smaller quantities of these waveshifting powders and others from this vendor in the past. Because this will be a sole source procurement we would like to get the order placed early in the project.

2.3.6 Evaluation Methodology

Because there is only one vendor in the US, we are purchasing significant quantities of the waveshifting powders and subjecting them to an intensive evaluation process. In addition, the MINOS collaboration used these same waveshifting powders (and others) from this vendor and has extensive experience with their product and their company. The experience has all been positive, so we have no reservations about this vendor.

3.0 Wavelength Shifting Fiber

NOνA requires approximately 18,000 km of wavelength shifting (WLS) optical fiber delivered over a 4-year period beginning in FY08.

3.1 Statement of Work

Fermilab issued an RFP for wavelength shifting fiber in December of 2005. The RFP requested quotes for a base quantity of 25 km of 0.8 mm diameter WLS for the IPND, to be delivered in 2007. In the same RFP we also requested bids on a unilateral option for the full quantity to be delivered over a 4-year period beginning in 2008. An index for scaling the price in future years was also requested.

3.2 Cost Estimate

The estimated cost and contingency for 18,000 km of WLS fiber, produced to NOνA specifications, is shown in Table 3.1

	Unit Cost	Full Quantity Cost	Contingency	Total
WLS Fiber	$0.75/m	$13,500,000	$3,780,000 (28%)	$17,280,000

Table 3.1 Estimated cost and contingency for WLS fiber.

The cost estimate is based on an actual quote from Kuraray. The contingency has been determined by a Monte Carlo calculation that uses the historical relationship between the dollar and the yen to account for the uncertainty due to currency fluctuations. Details of the Monte Carlo calculation are provided in NOνA-doc-681.

3.2.1 Duty

Plastic wavelength shifting fiber is not currently duty free. The duty charge through US Customs is approximately 5-8% and constitutes a considerable expense for a procurement of this size. Because of the potential cost savings, we will be working on this issue over the next year.

3.3 Funding Constraints

WLS fiber is one of NOνA's cost drivers and is loaded into our Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. Based on our current working funding profile, our matching assembly schedule and Kuraray's manufacturing capability, the fiber will be a

4-year procurement with fiber being produced in FY08, FY09, FY10 and FY11. If the funding profile were stretched this procurement could also be stretched accordingly.

3.4 Contract Type

The contract for the wavelength shifting fiber will be a *fixed price contact with economic price adjustment.* This is the preferred type of contract because the vendor is foreign and the price of fiber can fluctuate up or down with the value of the yen. Allowing for economic price adjustment based on an index protects both the buyer and seller and allows the seller to submit the best possible bid without the need for padding to cover possible upward price swings.

The master contract for WLS fiber would specify the price adjustment mechanism. Kuraray has given us a quote that is valid for a yen-to-dollar ratio between 110 and 120. If the ratio moves outside this range the price would be adjusted for subsequent shipments.

3.5 Identification of Suppliers

An RFP was issued to the two known vendors who produce WLS fiber but we received only one response. The unresponsive vendor told us they could not meet the specifications. NOνA has offered to work with this vendor to try and improve their process and allow them to meet the specifications, but thus far the vendor has shown no interest.

The responsive bid came from Kuraray, a Japanese company that is well known to Fermilab and the high-energy physics community. The Buy American Act and currency fluctuation concerns therefore come into play. The bid was for a base amount for the Integration Prototype Near Detector and there was a unilateral option that can be exercised by Fermilab for the full 18,000 km. The full 18,000 km quantity is significantly larger than any other known order for WLS fiber. The vendor will require 4 years to produce the full quantity. For these reasons it would be highly desirable to have a second vendor, but none exists. Because this is a sole source we will start the procurement as early in the project as possible.

3.6 Evaluation Methodology

Because there is only one viable vendor in the world, we have purchased significant quantities of the WLS fiber and subjected it to an intensive evaluation process. We have visited their production facility in Japan, tested their fiber for light output, dimensional tolerance, chemical resistance and mechanical strength. In addition, the MINOS collaboration used Kuraray WLS fiber and has extensive experience with their product and their company. CDF, D0 and many other HEP experiments have all had experience

with Kuraray over the years. The experience has all been positive, so we have no reservations about this vendor.

4.0 PVC Extrusions

NOνA requires about 5.9 kt of rigid PVC extrusions delivered over a period of 3 years. The PVC required by NOνA is not the typical off-the-shelf variety but must contain a large percentage of titanium dioxide (TiO_2) to provide highly reflective surfaces. Typically, PVC is acquired through a single procurement with the extruder and the extruder subcontracts with a PVC resin vendor. These procurements were separated in the R&D phase because the price of PVC resin depends on crude oil as well as natural gas, while the extrusion of the resin is mostly labor and NOνA wants to explicitly understand its exposure to fluctuations of volatile energy prices. Additionally, NOνA is still experimenting with the formula for the PVC resin, so dealing directly with the resin vendors is more straightforward. For the procurement of the 5.3 kt, we would prefer to issue a single contract to the extruder and let the extruder acquire the PVC resin that we specify, but this depends on the ultimate results of NOνA's R&D program that is not yet completed.

4.1 Statement of Work

Fermilab issued an RFP for PVC resin in April of 2006. The RFP requested quotes for a base quantity of 35,000 lbs. of resin for the IPND and various mechanical prototypes. In the same RFP we also requested bids on a unilateral option for the full quantity to be delivered over a 2-year period beginning in 2009. An index for scaling the price in future years was also requested. The formula for the NOνA resin mix has changed since the RFP was issued. We will go out for bids again when we are ready to procure the resin for the Project.

An RFP for extruding the PVC was issued by Fermilab in July of 2005. The RFP also included the tooling and die costs. The RFP requested quotes for extruding 16-cell extrusions from the 35,000 lbs. of resin formulated for the IPND as well as a unilateral option for extruding the full quantity needed for the NOνA Project. The cost of extruding the resin is largely labor so there is no scaling index.

4.2 Cost Estimate

The estimated cost and contingency for 5.9 kilotons of PVC, including delivery, is shown in Table 4.1. The cost estimate is based on responses to the RFIs described in section 4.1. The resin RFI was for a slightly different resin formula, but the cost drivers do not change significantly from one formula to another. The uncertainty that results from not yet knowing the final mix is reflected in the contingency. The contingency has been determined by a Monte Carlo calculation that linked price movements in crude oil and natural gas to the scaling index provided by the vendors in response to the RFP. Details of the Monte Carlo calculation are provided in NOνA-doc-681 (Appendix A). The contingency for the extruded PVC includes a contingency on shipping that has been

determined by a Monte Carlo calculation that linked price movements in crude oil to the diesel fuel. Note that when NOνA-doc-681 was written we had only obtained cost information on PVC through a *Request For Information* (RFI), a less formal communication path between Fermilab and the PVC suppliers. Since that time we have issued an RFP and received better costing information on PVC and have reduced the contingency on PVC relative to what is quoted in NOnA-doc-681.

	Unit Cost	Full Quantity Cost	Contingency	Total
PVC Resin	$0.984/lb	$12,883,825	$3,736,309 (29%)	$16,620,134
PVC Extrusion	$15.70/meter	$7,849,498	$2,747,324 (35%)	$10,596,822
Transportation	$800/truck	$416,800	$62,520 (15%)	$479,320
Total		**$20,234,211**	**$6,794,339**	**$27,696,276**

Table 4.1 Estimated cost and contingency for PVC extrusions.

4.3 Funding Constraints

PVC extrusions are a cost driver for NOνA. The cost of the extrusions has been loaded into our Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. Based on our current working funding profile, our matching assembly schedule and the time required to extrude all of the resin, the PVC will be a 4-year procurement with extrusions being in produced in FY09 – FY12. If the funding profile were stretched this procurement could also be stretched accordingly.

4.4 Contract Type

The contract for PVC extrusions will be a *fixed price contact with economic price adjustment.* This is the preferred type of contract because the price of PVC resin can fluctuate up or down with the price of crude oil and natural gas. Allowing for economic price adjustment based on an index protects both the buyer and seller and allows the seller to submit the best possible bid without the need for padding to cover possible upward price swings.

The master contract for the PVC extrusions will likely be placed with the extruder for both the resin and the extrusion of the resin. The price adjustment mechanism and the frequency of adjustment will be described in the master contract. An annual adjustment seems appropriate from our end but this will have to be negotiated with the vendor.

4.5 Identification of Suppliers

There are many extrusion facilities and many suppliers of PVC resin in the US. Identifying vendors and suppliers will not be difficult. There are no sole source or Buy American Act concerns.

4.6 Evaluation Methodology

We do not necessarily accept the low bid but evaluate the bids to determine the *best value* to Fermilab. For all of our large procurements we follow the model of assembling a review board consisting of Project Management and L2 and L3 managers to evaluate all received bids based on a point system that has been determined in advance. For the RFP that was issued for PVC resin for the IPND the criteria in Table 4.2 were used. A very similar formula would be used for evaluation of future bids.

Criteria	Maximum Points
1. Documentation of QA plans	10
2. Manufacturing plan	6
3. Manufacturing facilities	8
4. Previous performance	10
5. Delivery Schedule	10
6. Packaging and shipping plan	4
7. Cost and breakdown	10
8. Alternative ingredients	10
Maximum Possible Points	**68**

Table 4.2 Criteria used for evaluating PVC resin bids.

5.0 Avalanche Photo Diodes

NOνA requires approximately 17,000 Avalanche Photo Diode (APDs) chip arrays. Each APD chip is an array of 32 pixels, one pixel for each NOνA extrusion cell. NOνA is currently engaged in R&D with Hamamatsu to repackage their commercial APD array to explicitly suit NOνA's requirements. Hamamatsu, a Japanese company that is well known to Fermilab, is the only vendor in the world known to make such devices. This will be a sole-source foreign procurement.

5.1 Statement of Work

Fermilab issued an RFI to Hamamatsu for APDs in November of 2005. The RFI requested unit prices for 32 channel APDs with the same performance specifications as Hamamatsu's standard APD arrays, but repackaged into a flip-chip design. Hamamatsu will also bump-bond the APD arrays to circuit boards that they will supply.

5.2 Cost Estimate

Hamamatsu was unable to respond to the RFI described in section 5.1 because there were unresolved engineering and technical issues with regard to the repackaged APDs. Hamamatsu did supply us with an anticipated cost range, but with no guarantee that the cost might not be more (or less). We have used the top end of the cost range for our cost and schedule and have assigned a contingency to the APDs that appropriately captures the current uncertainty. The estimated cost and contingency for 17,000 APDs is shown in Table 5.1

	Cost Range	Unit Cost	Full Quantity Cost	Contingency	Total
APDs	$220-$260/chip	$260/chip	$4,420,000	$2,431,000 (55%)	$6,851,000

Table 5.1 Estimated cost and contingency for APDs.

The contingency has been determined by a Monte Carlo calculation that uses the historical relationship between the dollar and the yen to account for the uncertainty due to currency fluctuations, though most of the contingency results from the current base price uncertainty. Details of the Monte Carlo calculation are provided in NOνA-doc-681.

5.2.1 Duty

The avalanche photodiodes have been determined to be duty free.

5.3 Funding Constraints

The APDs have been loaded into our Open Plan ™ cost and schedule. We have been given a working funding profile and have made a first pass at making our obligation profile match. Based on our current working funding profile, our matching assembly schedule and Hamamatsu's manufacturing capability, the APDs will be a 3-year procurement with APDs being produced in FY08, FY09 and FY10. If the funding profile were stretched this procurement could also be stretched accordingly, however we strongly prefer an early start with Hamamatsu because of the risk associated with a sole source.

5.4 Contract Type

The contract for APDs will be a *fixed price contact with economic price adjustment.* This is the preferred type of contract because the vendor is foreign and the price of APDs can fluctuate up or down with the value of the yen. Allowing for economic price adjustment based on an index protects both the buyer and seller and allows the seller to submit the best possible bid without the need for padding to cover possible upward price swings.

5.5 Identification of Suppliers

Fermilab announced this project in the Federal Business Opportunity Registry. No additional suppliers of pixilated APDs were identified. This leaves us with Hamamatsu, a Japanese company that is well known to Fermilab and the high-energy physics community, as the only known source. Because this is a sole source we will start the procurement as early in the project as possible.

5.6 Evaluation Methodology

There is only one viable vendor in the world for this procurement and we are working closely with them to make sure we get a product that performs according to our specifications. We have visited their production facility in Japan, tested prototype devices and communicate on a regular basis. The HEP community has considerable experience with Hamamatsu over the years and the company has always delivered quality products. We are confident that they will deliver a product that meets our needs.

6.0 Cavern Excavation for the Near Detector

NOνA requires a Near Detector within a few kilometers of the NuMI target in order to understand and normalize backgrounds that will be seen in the Far Detector. The Near Detector is most useful if it is oriented 14 mr offaxis, similar to the Far Detector. Some excavation of the MINOS cavern is required in order to accommodate a Near Detector

that is rotated to the correct angle while still allowing personnel and equipment to pass through the tunnel. NOνA has elected to excavate a new cavern adjacent to the existing MINOS cavern that will allow for the Near detector to be placed in the required orientation without blocking any of the existing tunnel.

The Near Detector Cavern is not a cost driver for NOνA but is included here because of past concerns with regard to underground excavations.

6.1 Statement of Work

The existing cavern design is still at the conceptual phase. An outside engineering firm with relevant underground experience will be hired to design the new cavern. A construction firm with relevant underground construction experience will be hired to execute the design and additional contracts will be required for final outfitting of the cavern.

6.2 Cost Estimate

We currently have only a conceptual design. Our cost estimate for the excavation is based on recent studies for the ILC by Lemley International for small-scale tunnel excavations. The unit cost for projects of similar scope is $1850 per cubic yard. We require an excavation of approximately 735 cy. Our current cost estimate includes 100% contingency to cover the uncertainty associated with designs that are only at the conceptual stage as well as the uncertainties associated with underground excavations. We will have a better estimate of the cost after engineering and design of the cavern is complete.

6.3 Funding Constraints

The Near Detector Cavern excavation has been loaded into our Open Plan ™ cost and schedule. There are no funding constraints.

6.4 Contract Type

The cavern excavation will be done as a standard construction project. An engineering firm will be hired to do the design and a construction firm will be hired to do the excavation. Separate RFPs will be issued for the design, construction and outfitting. The bids will be evaluated based on a predetermined formula designed to guarantee the best value and performance to the government.

6.5 Identification of Suppliers

While there are many design and construction firms, we are specifically looking for firms with experience with underground tunnels and caverns. While this narrows the field

considerably, there are still many to choose from. Previous experience from NuMI is useful here. There are no sole source or Buy America Act issues.

6.6 Evaluation Methodology

We do not necessarily accept the low bid but evaluate the bids to determine the *best value* to Fermilab and the US Government. For all of our large procurements we follow the model of assembling a review board consisting of Project Management and L2 and L3 managers to evaluate all received bids based on a point system that has been determined in advance.

7.0 Summary

Procurement	**Total Cost Including Contingency**	**Comments**
Mineral Oil	$16,354,912	Price tied to crude oil. Must index.
Pseudocumene	$2,657,387	Only 1 known domestic source. Also a source in China.
Waveshifting Powders	$4,288,552	Only 1 known supplier in US. Sole source procurement.
WLS Fiber	$17,280,000	Only viable supplier is in Japan. Sole source foreign procurement. Price subject to currency fluctuations. Currently not duty free.
PVC Extrusions	$27,696,276	Price of PVC resin tied to energy costs. Must index.
APDs	$6,851,000	Manufacturer in Japan. Sole source foreign procurement. Price subject to currency fluctuations. Duty free.
Near Detector Cavern	<$2,000,000	Only a conceptual design currently exists. Not a cost driver, but watched carefully because of previous NuMI experience.

Appendix A

Contingency and Risk in NOνA

R. Ray
March 6, 2006

For most of the items in the NOνA WBS we assign a simple flat-rate contingency based on the NOνA contingency rules [1]. There are a handful of items that receive special attention because they have a high cost risk associated with them. For these items, an additional risk-based contingency is assigned. Items that are closely linked to the cost of crude oil, which has doubled in price since the NOνA proposal, are identified as having a high cost risk. Additionally, items from foreign vendors are identified as having high cost risks because of the potential for unfavorable currency fluctuations. Following the guidance in *DOE order 413.3*, we use a Monte Carlo to statistically add together the flat-rate contingency and the risk-based contingency for high cost risk items.

Crude Oil

The price of mineral oil, used in NOνA's liquid scintillator, is closely tied to the price of crude oil. Petroleum and natural gas are both used in the various stages of PVC resin production, used to produce PVC extrusions for NOνA. Increases in the cost of crude oil also impact all phases of transportation and delivery.

The Energy Information Administration (EIA) is an independent agency within the U.S. Department of Energy (DOE) that develops surveys, collects energy data, and analyzes and models energy issues. Each year they publish a short-term energy outlook that includes the best information available on the likely range of crude oil prices several years into the future. Their most recent survey [2] summarizes the near-term outlook in the following way: "Prices for crude oil, petroleum products, and natural gas are projected to remain high through 2006 before starting to weaken in 2007. For example, the price of West Texas Intermediate (WTI) crude oil, which averaged $56 per barrel in 2005, is projected to average $63 per barrel in 2006 and $60 in 2007." In addition, the EIA provides a model with 95% C.L. bands for the price of crude oil, shown in Figure 1.

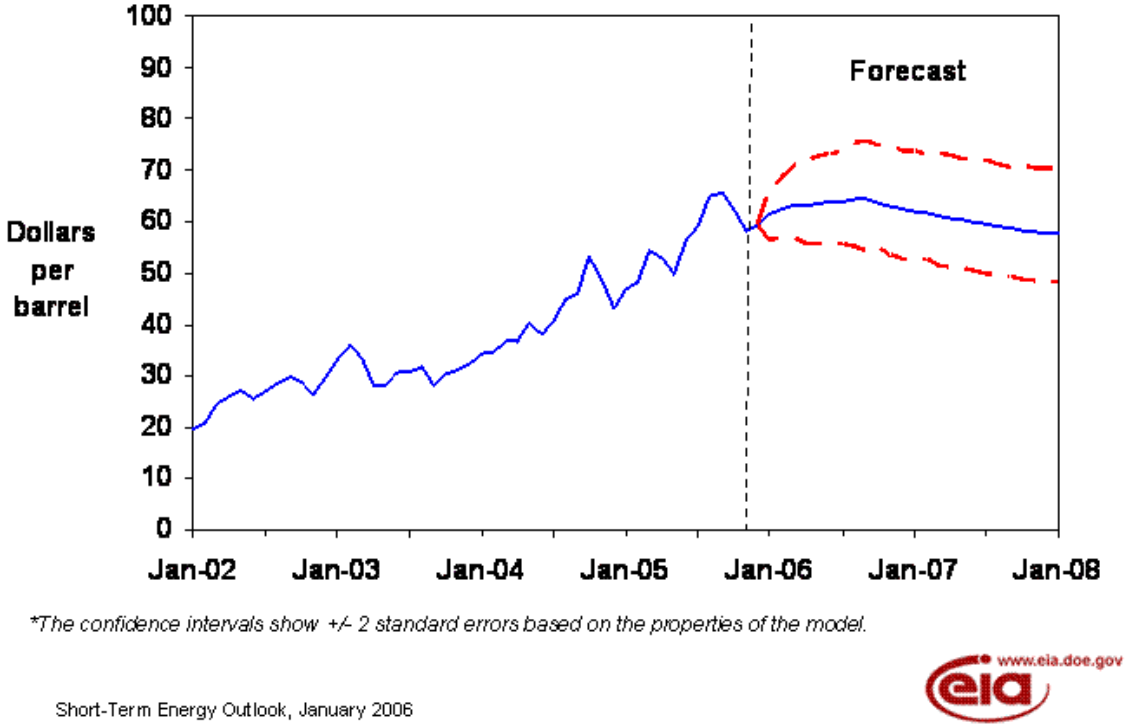

Figure 1. Model for short-term crude oil costs from the Energy Information Agency within the DOE. The model includes a base estimate and 95% C.L. bands (red dashed lines).

The EIA model attempts to estimate supply and demand, regional production, the cost of extracting oil from the ground in various regions and the relative production split between OPEC and non-OPEC nations. However, world events are known to also impact the cost of crude oil and they are not accounted for in the EIA model. In Figure 2 we show the historical cost of crude oil going back over 60 years. Data exists going back over the past 100 years. This plot does reflect the impact of world events as well as all other effects over time. The red line is the cost of crude normalized to 2005 dollars. The cost of crude oil peaked at $97.50/barrel (in 2005 dollars) in December 1979 and remains above $70/barrel for approximately 3 years, about 5% of the 60-year plot duration.

The EIA model from Figure 1 is used to construct a Gaussian price distribution for crude oil. The Gaussian peaks at $60/barrel, the projected cost in January 2008. The 95% C.L. band in January 2008 passes through $70/barrel corresponding to a Gaussian with a standard deviation of $5.10. In addition, a high-side tail is added based on the historical distribution of crude oil in Figure 2. The tail extends out to $100/barrel and comprises 5% of the total area, consistent with the historical data. There is no low side added to the model. The resulting distribution is shown in Figure 3.

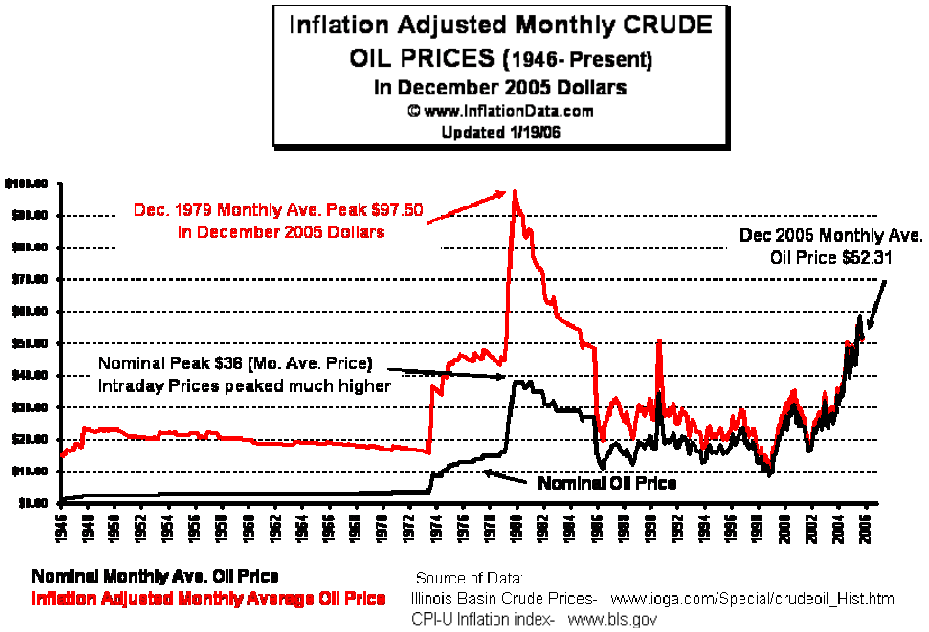

Figure 2. Historical crude oil price going back 60 years. The red curve represents the price of crude normalized to 2005 dollars.

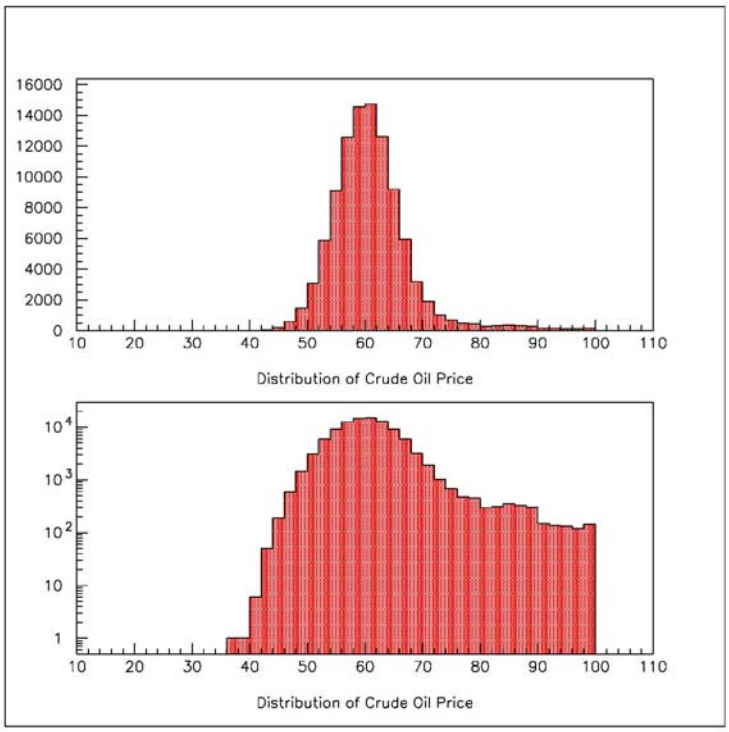

Figure 3. Price distribution for crude oil based on the EIA model in Figure 1. A high-side tail has been added based on the historical data in Figure 2. The tail beyond $70 corresponds to 5% of the total area, consistent with the historical data. The top and bottom plots are the same data. The top plot is linear and the bottom plot uses a log scale.

Natural Gas

The EIA also models near-term prices for natural gas. From the EIA Short Term Energy Outlook, they summarize the near term outlook for natural gas as "Henry Hub natural gas prices, which averaged \$9.00 per 1000 ft^3 in 2005, are projected to average \$9.80 in 2006 and \$8.84 in 2007." Cost projections are driven by anticipated demand and weather projections. The EIA natural gas forecasting model is shown in Figure 4 along with 95% C.L. bands. The EIA model from Figure 4 is used to construct a Gaussian price distribution for crude oil, shown in Figure 5. The Gaussian peaks at \$9.80/1000 ft^3, the projected cost in January 2008. The 95% C.L. band in January 2008 passes through \$14.25/1000 ft^3, corresponding to a Gaussian with a standard deviation of \$2.27.

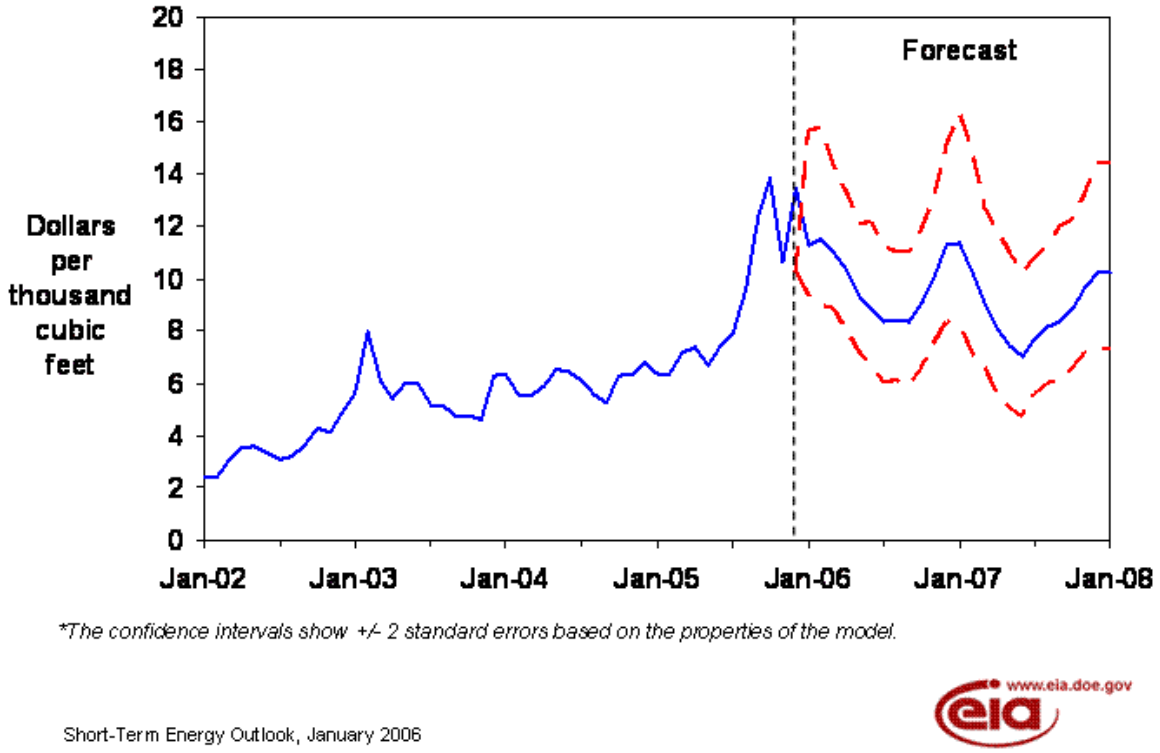

Figure 4. Model for short-term natural gas costs from the Energy Information Agency within the DOE. The model includes a base estimate and 95% C.L. bands (red dashed lines).

Mineral Oil

Mineral oil is refined from the heavy "base oils" left behind after the lighter crude components have been distilled off to make gasoline, diesel, jet fuel, etc. The price of base oils is tabulated weekly in a trade journal known as the *Lube Report* [3]. Based on bids we have received from mineral oil venders we know that our mineral oil is linked to *Group II Paraffinic Base Oil – viscosity 70*. For every penny change, up or down, in the cost per gallon of the base oil, the cost of mineral oil will go up or down by a penny. The *Lube Report* has archives going back to 1997. This data is plotted in Figure 6 along with the spot price of West Texas crude. The price of crude has been divided by a factor of 10 to make the data easier to compare. It is clear from the plot that the price of the base oil

follows the general trend in crude oil prices. When the base oil price data is divided by the crude oil price data, the distribution in Figure 7 results.

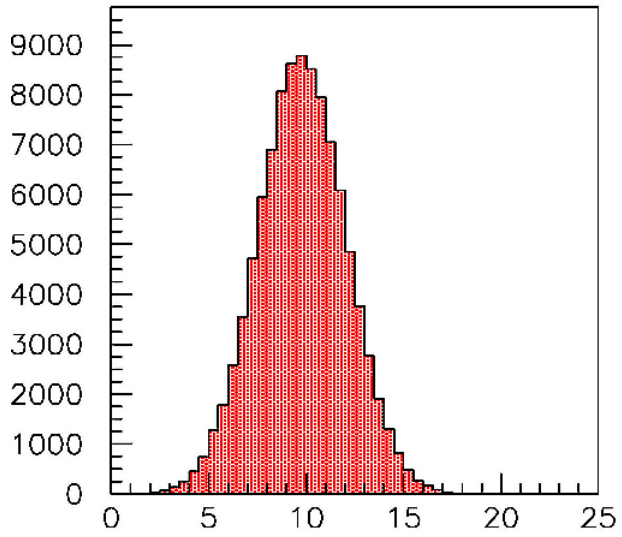

Figure 5. Price distribution for natural gas based on the EIA model in Figure 4. The Gaussian peaks at \$9.80/1000 ft^3 with a standard deviation of \$2.27.

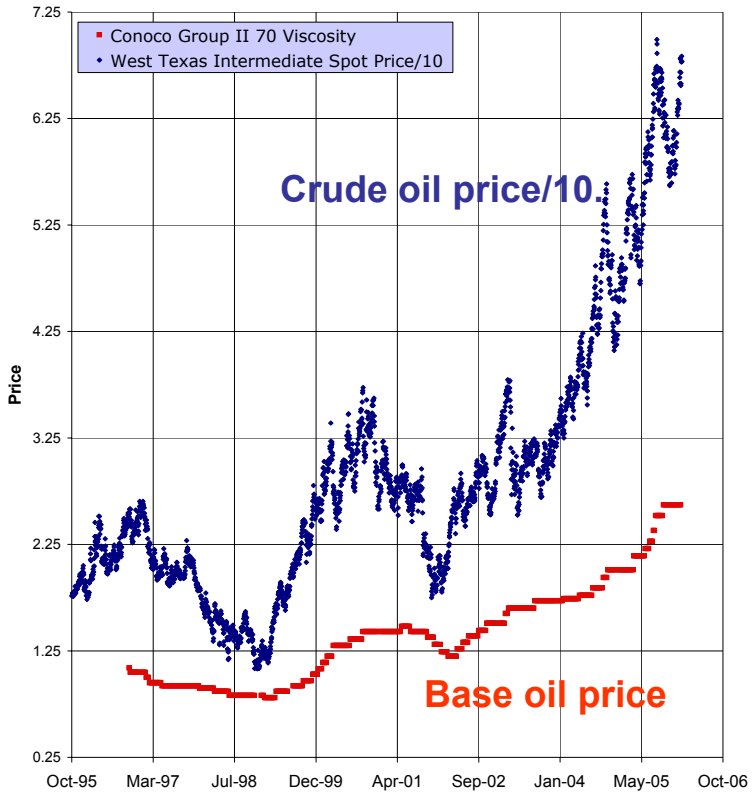

Figure 6. Historical data for the cost of a barrel of crude oil and the cost per gallon of Group II- viscosity 70 base oil. The price of crude has been divided by a factor of 10 to facilitate comparison.

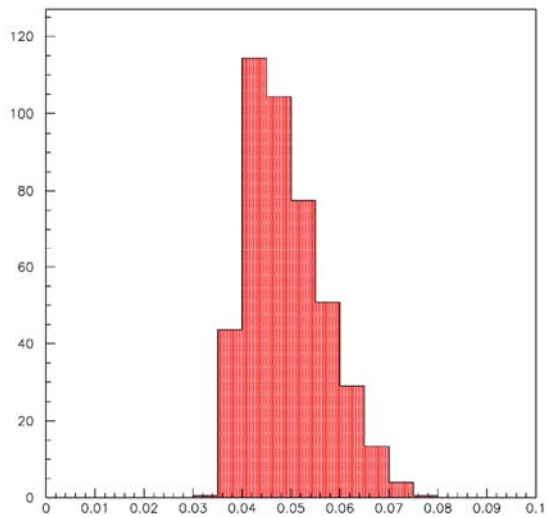

Figure 7. Distribution of the ratio of base oil price to the price of crude oil using the data in Figure 6.

We have firm quotes from multiple venders for the full quantity of mineral oil required for the NOνA Far Detector. Based on the NOνA contingency rules, we assign a flat-rate contingency of 15% to the base cost of $2.93/gallon. In order to statistically combine the flat-rate contingency with a risk-based contingency related to crude oil, cost distributions are required. In Figure 8 a single-sided Gaussian distribution is shown, peaked at $2.93/gallon. 95% of the area is contained between $2.93 and $3.37 representing the base cost and base cost + 15% contingency, respectively.

To determine the overall contingency, the following procedure is followed:

1) Randomly pick a mineral oil cost from the distribution in Figure 8.
2) Randomly pick a crude oil price from the distribution in Figure 3.
3) Use the deviation of the selected crude oil price from $60 to determine the deviation in the cost of the base oil using a randomly selected value from the distribution in Figure 7. Add this cost (which could be negative) to the mineral oil cost selected in 1) above.
4) Repeat 100,000 times.

The resulting distribution for the total mineral oil cost is shown in Figure 9 along with the probability distribution plot. From the probability distribution we have a 95% probability that the total cost of mineral oil (Base + contingency) will be less than $3.74/gal for a base price of $2.93/gal. This corresponds to an overall contingency of 28%.

PVC Resin

The cost of PVC resin depends on the cost of both crude oil and natural gas. PVC resin is 57% chlorine by weight. The rest is hydrogen and carbon, which are derived from natural gas and petroleum. Most PVC is made from ethylene. Ethylene is made by cracking

ethane in a reactor at about 800°C. Ethane is extracted during the refining of natural gas. Fossil fuels are used to power the ethane reactor.

A resin producer's rule of thumb can be found in industry trade journals stating that a \$1/1000 ft^3 increase in the price of natural gas adds about 2¢/lb. to the price of PVC [4]. Historical data for PVC resin, natural gas and crude oil is presented on a log plot in Figure 10. During the recent run-up in natural gas prices after Hurricane Katrina the resin producer's rule of thumb approximately holds.

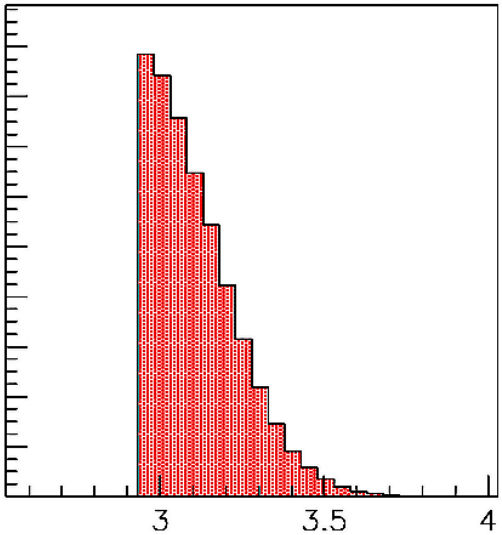

Figure 8. Price distribution for mineral oil represented by a single-sided Gaussian peaked at the base quote of \$2.93/gallon. 95% of the area is below \$3.37/gallon corresponding to the base cost + 15% contingency.

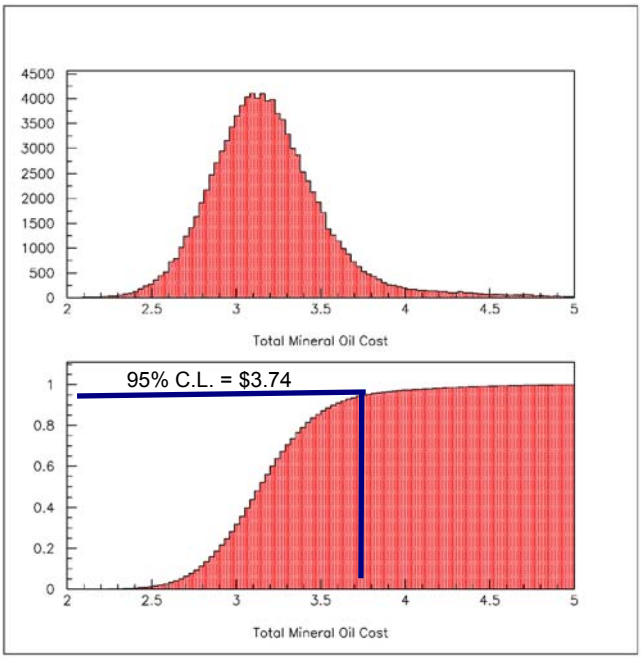

Figure 9. Distribution for the total cost, base + contingency, of the mineral oil for NOνA (top) and the resulting probability distribution (bottom). The probability distribution indicates a total cost of less than \$3.74/gallon at the 95% C.L.

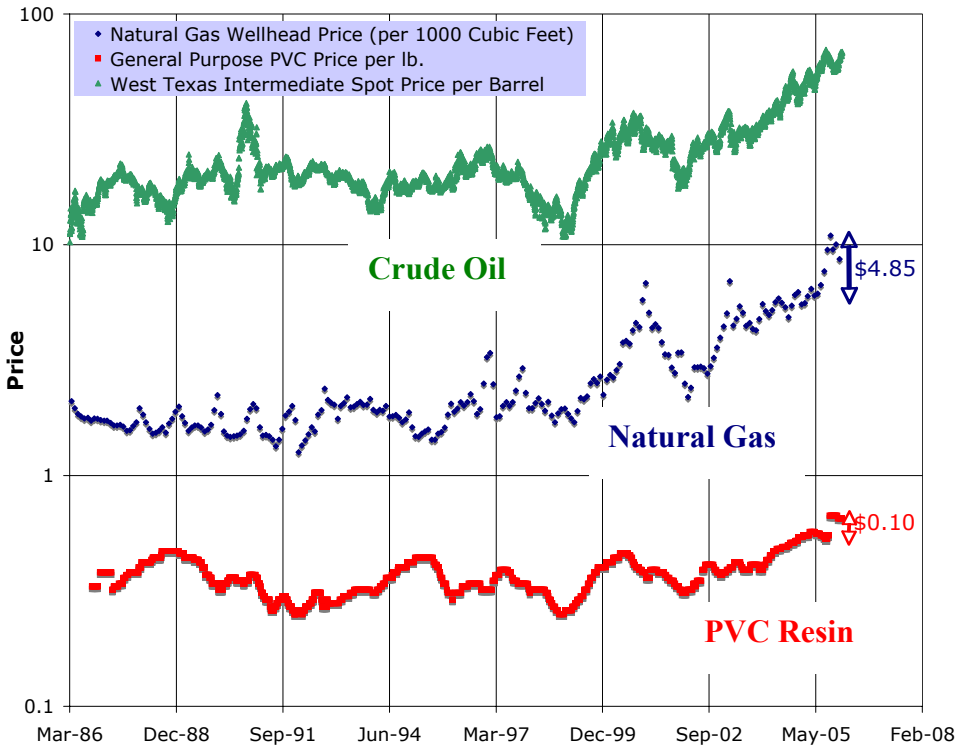

Figure 10. Log plot showing the historical price data for PVC resin, natural gas and crude oil.

Using the resin producer's rule of thumb, the PVC resin price in Figure 10 is corrected for the cost of natural gas. The corrected PVC resin distribution is divided by the crude oil distribution. The resulting distribution is shown in Figure 11.

Unlike the case for mineral oil, we do not have firm quotes for the PVC resin. We do have responses from 3 vendors to a less formal *Request For Information*. We use the middle quote of $0.89/lb for resin mix that includes a 15% concentration, by weight, of TiO_2. The price of TiO_2 has been relatively steady and has no known dependence on crude oil. The price of TiO_2, extracted from trade journals, is about $1.00/lb, so it contributes about $0.15/lb to the cost of the resin mix. This leaves $0.74/lb for the cost of the PVC component of the resin mix.

Based on the NOνA contingency rules, we assign a flat-rate contingency of 40% because of the lower quality of information combined with the fact that we don't yet know the final composition of the PVC resin. For the TiO2 we assign a flat-rate contingency of 30%. In order to statistically combine the flat-rate contingency pieces with the risk-based contingency related to crude oil and natural gas, cost distributions are required. Figure 12 shows a single-sided Gaussian distribution, peaked at $0.74/lb. 95% of the area is contained between $0.74 and $1.04 representing the base cost and base cost + 40%

contingency, respectively. Similarly, the price distribution for TiO2, with a flat-rate contingency of 30% , is shown in Figure 13.

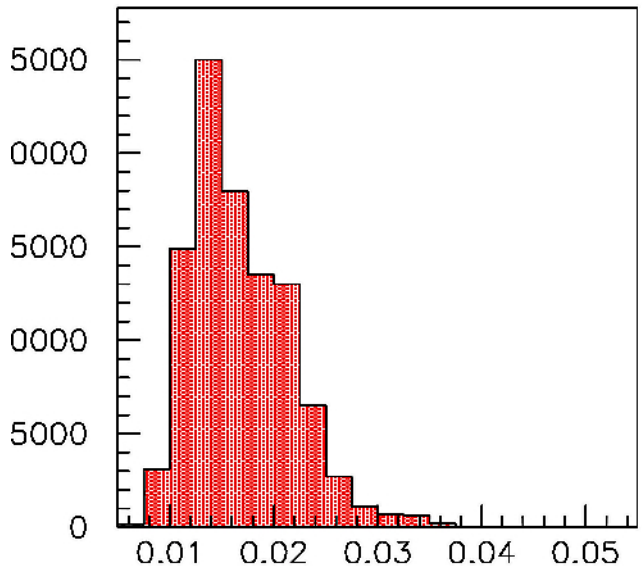

Figure 11. Distribution of the ratio of PVC resin price, corrected for the price of natural gas, to the price of crude oil using the data in Figure 10.

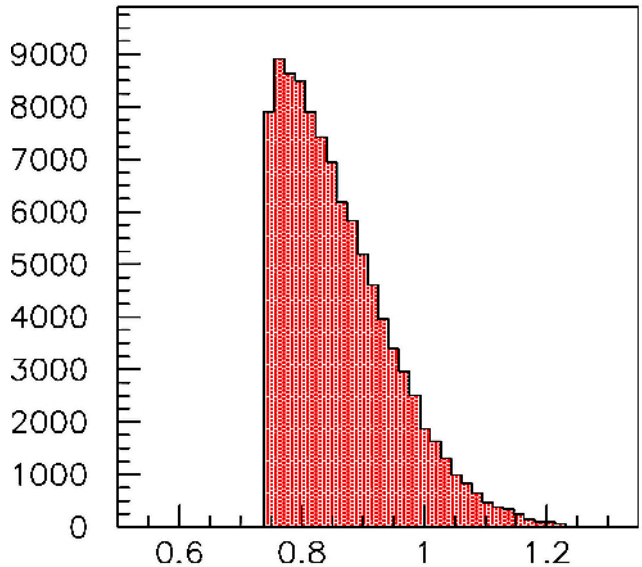

Figure 12. Price distribution for PVC resin represented by a single-sided Gaussian peaked at the base quote of $0.74/lb. 95% of the area is below $1.04/lb corresponding to the base cost + 40% contingency.

To determine the overall contingency, the following procedure is followed:

1) Randomly pick a PVC cost from the distribution in Figure 12.
2) Randomly pick a price for natural gas from the distribution in Figure 5.

3) Use the deviation of the selected natural gas price from $9.80 to determine a correction to the price of PVC using the resin producer's rule of thumb. Add this cost (which could be negative) to the cost of PVC selected in 1).
4) Randomly pick a crude oil price from the distribution in Figure 3.
5) Use the deviation of the selected crude oil price from $60 to determine the deviation in the cost of PVC using the distribution in Figure 11. Add this cost (which could be negative) to the PVC cost in 3) above.
6) Randomly pick a price for TiO2 from the distribution in Figure 13. Add this to the PVC cost in 5) above.
7) Repeat 100,000 times.

The resulting probability distribution for the total cost of the PVC resin mix is shown in Figure 14. From the probability distribution we have a 95% probability that the total cost of the PVC resin mix (Base + contingency) will be less than $1.30/lb (including the TiO2) for a base price of $0.89/lb. This corresponds to an overall contingency of 46%.

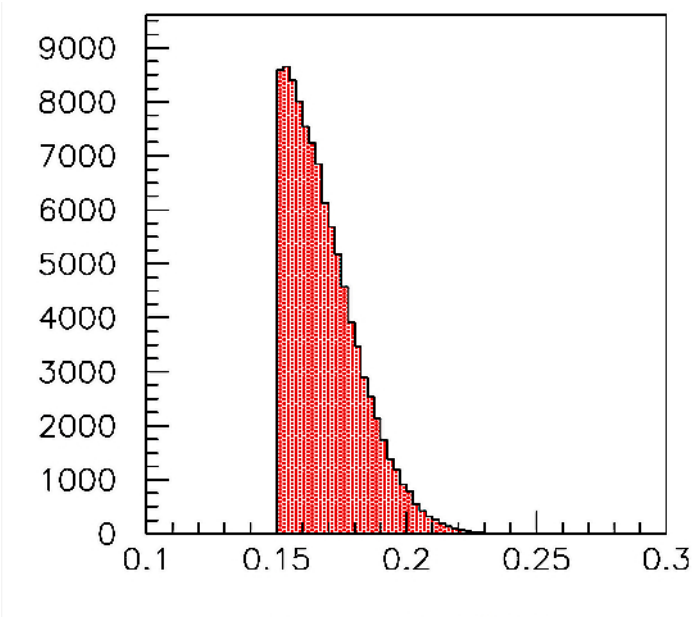

Figure 13. Price distribution for TiO_2 represented by a single-sided Gaussian peaked at the base price of $0.15/lb. 95% of the area is below $0.195/lb corresponding to the base cost + 30% contingency.

WLS Fiber

The cost of fiber is not dominated by raw materials or transportation and there is no known connection to crude oil. However, there is a risk associated with currency fluctuations since the likely vendor is in Japan. The historical relationship between the yen and the dollar is shown in Figure 15 and the one-dimensional distribution extracted from projecting the historical data from Figure 15 onto the vertical axis is shown in Figure 16.

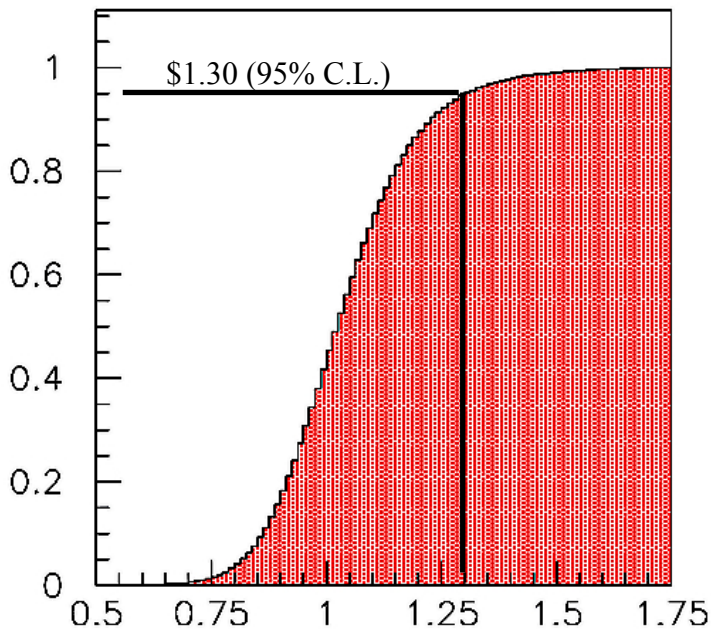

Figure 14. Probability distribution for the total cost, base + contingency, of the PVC resin mix for NOνA. The probability distribution indicates a total cost of less than $1.30/lb at the 95% C.L.

We have a firm quote for WLS fiber, in response to an RFP, for $0.86/meter FOB Fermilab. This assumes an exchange rate of 115 yen per dollar. The transportation costs are small, so we do not break them out separately. Based on the NOνA contingency rules we assign a flat-rate contingency of 15%. We construct a probability distribution for the cost of the WLS fiber, similar to that which was done for the mineral oil and PVC resin. The single-sided Gaussian is shown in Figure 17 with a mean of $0.86/meter. 95% of the area is contained between $0.86 and $0.99 representing the base cost and base cost + 15% contingency, respectively. The costs are converted to yen in the Figure.

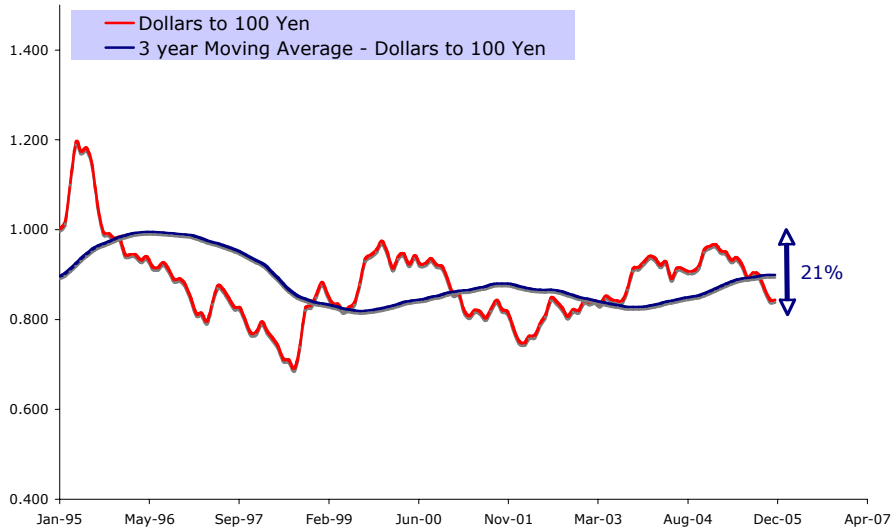

Figure 15. Historical ratio of US dollars per hundred yen.

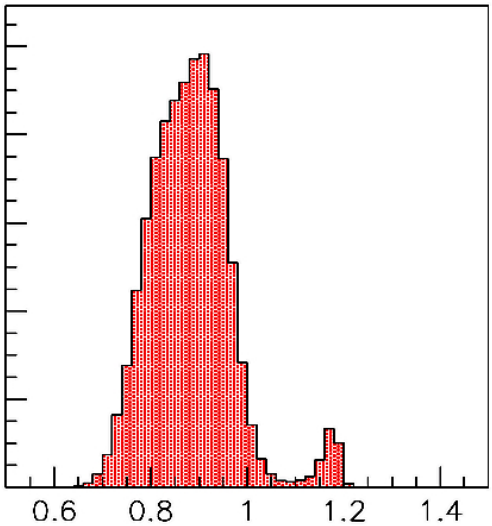

Figure 16. One-dimensional distribution of US dollars per hundred yen from historical data in Figure 15.

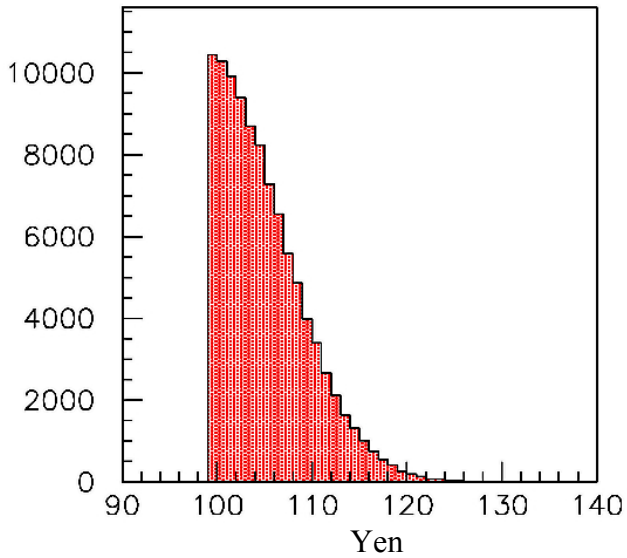

Figure 17. Price distribution for WLS fiber in yen represented by a single-sided Gaussian peaked at the base quote of $0.86/meter (assuming 115 yen per dollar). 95% of the area is below $0.99/meter corresponding to the base cost + 15% contingency.

To determine the overall contingency, the following procedure is followed:

1) Randomly pick a fiber cost in yen from the distribution in Figure 17.
2) Randomly pick a conversion rate from yen to dollars from Figure 16 and convert the fiber cost in yen from 1) to dollars.
3) Repeat 100,000 times.

The resulting probability distribution for the total cost of the WLS fiber is shown in Figure 18. From the probability distribution we have a 95% probability that the total cost of the fiber (Base + contingency) will be less than $1.10/meter for a base price of $0.86/meter. This corresponds to an overall contingency of 28%.

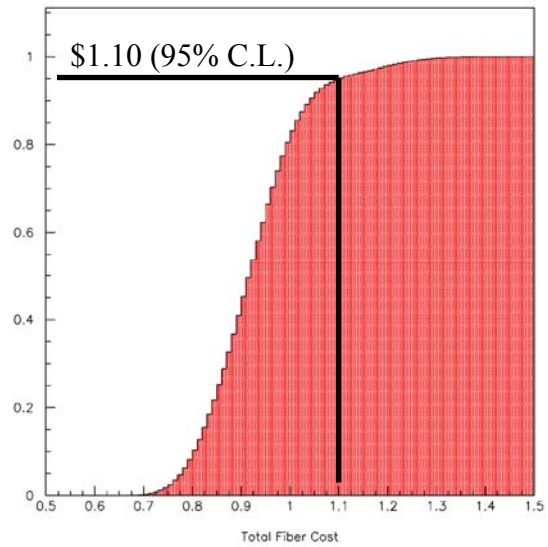

Figure 18. Probability distribution for the total cost, base + contingency, of the WLS fibers for NOνA. The probability distribution indicates a total cost of less than $1.10/meter at the 95% C.L.

APDs

The NOνA APDs are a custom part from Hamamatsu. The APDs are based on an existing design but are being repackaged in a format more suitable for NOνA's application. The APDs present a cost risk because of the potential for unfavorable currency fluctuations.

Hamamatsu has provided us with a best guess cost range of $220 to $260 per APD chip. Based on this we use the high-end price of $260 and assign a flat-rate contingency of 50%. The price distribution for APDs is shown in Figure 19. Performing an analysis similar to that for the WLS fiber, the probability distribution in Figure 20 results showing a total cost of less than $410/APD chip at the 95% C.L. for a base cost of $260 and an overall contingency of 58%.

Transportation Costs

There are a number of significant shipping costs in the NOνA project. These include delivery of mineral oil to Fermilab from Lake Charles Louisiana, shipping of mixed scintillator from Fermilab to the Far Detector Hall in Ash River, shipping of extrusions from the vendors to the module factories and shipping of completed modules from the factories to Ash River. Transportation costs typically have a fuel surcharge associated with them. Diesel fuel surcharge tables can be found on the web. They are simple

lookup tables that correspond directly to the cost of diesel fuel. For railcar shipping of mineral oil to Fermilab we have used the BNSF surcharge table that we were referred to by our mineral oil vender. There is also a standard diesel surcharge table for truck deliveries that differs from the table from railcar deliveries, as one might expect.

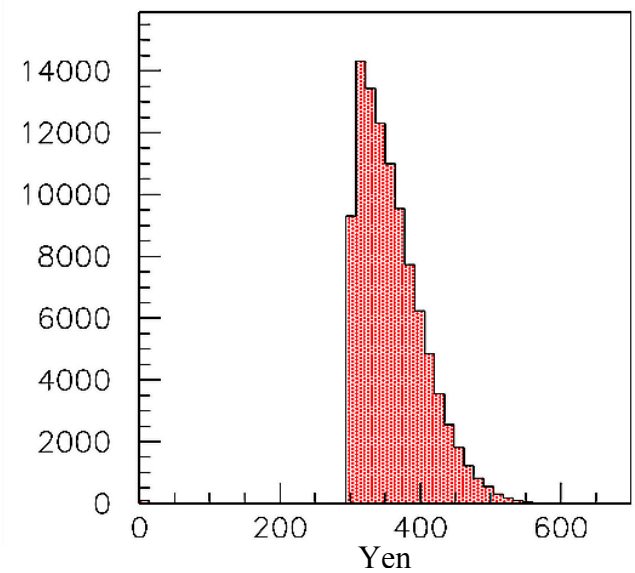

Figure 19. Price distribution for APDs in units of 100 yen represented by a single-sided Gaussian peaked at the base quote of $260/chip (assuming 115 yen per dollar). 95% of the area is below $3.90/chip corresponding to the base cost + 50% contingency.

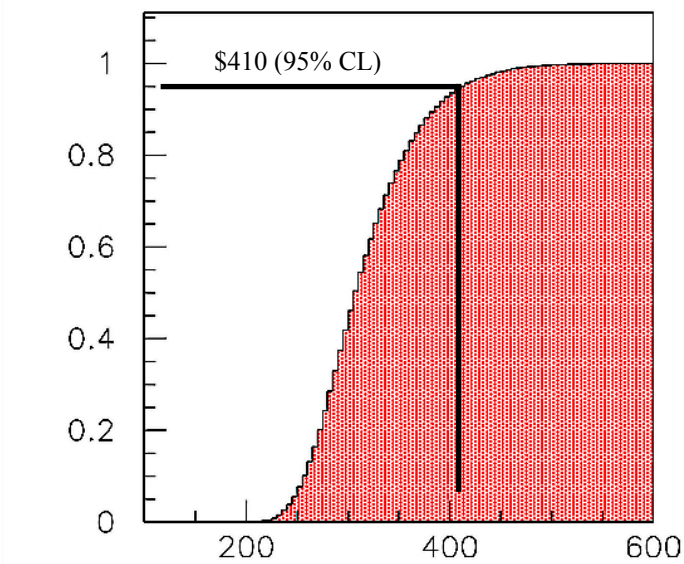

Figure 20. Probability distribution for the total cost, base + contingency, of the APDs for NOνA. The probability distribution indicates a total cost of less than $410/APD chip at the 95% C.L.

The cost of diesel fuel is obviously linked to the price of crude oil, as shown in the historical data that appears in Figure 21. When the diesel price data is divided by the crude oil price data, the distribution in Figure 22 results. Figure 22 is used to perform a contingency analysis similar to those described earlier.

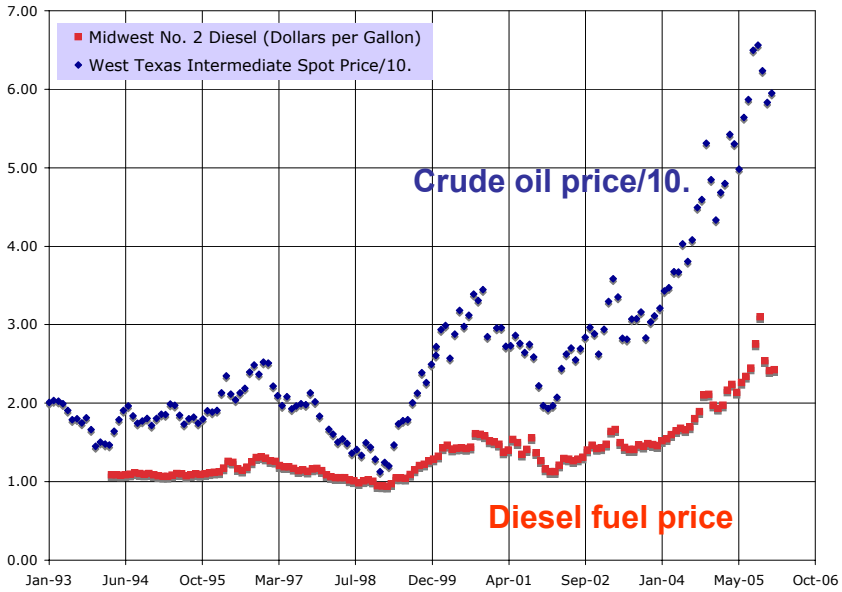

Figure 21. Historical data for the price of crude oil and diesel fuel. The crude oil price has been divided by a factor of 10 to facilitate comparison with the price of diesel fuel.

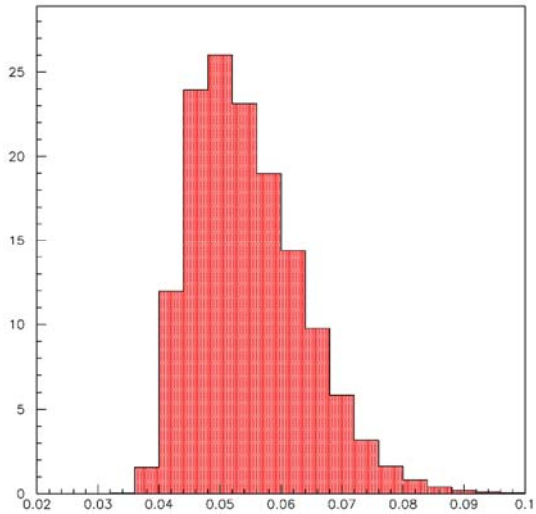

Figure 22. Distribution of the ratio of the price of diesel fuel to the price of crude oil from Figure 19.

Summary

A summary of the major contingency items in NOνA appears in Table 1. This includes items that have only a flat-rate contingency because they have no additional cost risk associated with them.

	Overall Contingency	Comments
Pseudocumene	50%	1 quote from China. 1 quote from US source, but only good for 90 days. No indexing.
Mineral Oil	28%	15% + dependence on crude. Monte Carlo. Transportation not included.
Mineral Oil Delivery	26%	15% + dependence on diesel/crude. Monte Carlo.
Trucking Scintillator	29%	25% + dependence on diesel/crude. Monte Carlo.
Waveshifters	25%	Firm quote, single source.
WLS Fiber	28%	15% + currency fluctuation. Monte Carlo.
PVC Resin	46%	40% for PVC, 30% for TiO_2 + dependence on natural gas + dependence on crude. Monte Carlo.
Extrusions	35%	Mostly labor and tooling. Two firm quotes but design not final.
APDs	58%	Design not final. 50% + currency fluctuation. Monte Carlo.
Building and Site	22%	DOE Cost Estimating Guide for conventional construction

Table 1. Summary of major contingency items in NOνA. The pseudocumene, waveshifters and extrusion process have only flat-rate contingencies associated with them. The others have additional risk-based contingencies that are statistically combined with their flat-rate contingency using a Monte Carlo as described in the text.

References

[1] "Contingency Analysis Rules for NOνA," NOνA-doc-616.
[2] http://www.eia.doe.gov/emeu/steo/pub/contents.html
[3] http://www.lubereport.com/
[4] http://www.plasticstechnology.com/articles/200511price.html