NOvA Response to Questions

June 5, 2007

Q1 a & b: What is the detector efficiency independent of fiducial cut? What % of events are quasi-elastics? Mark Messier

- NOvA reconstruction does not use a fixed fiducial volume cut but rather attempts to determine if the event is contained based on energy deposition near the edge of the detector. Hence, we typically quote a total efficiency rather than an efficiency after containment requirements.
- The selection criteria which maximizes FOM at 43.5 yields:
  - ε = 27% including containment cut / 31% after containment cut
  - These efficiencies include an energy window cut, which retains 61% of the signal events. For events inside the energy window, the reconstruction is 52% efficient
  - Typical background rejection factor of 1000:3
  - The final sample of selected signal events is composed of:
    - 50% quasi-elastic
    - 38% resonant production
    - 12% deep inelastic scattering

Q 1C: How has the physics case changed since the PAC approved NOνA?

Maybe compare at CD-1, now (18 kton), and now (14 kton) the following parameters: performance; assumed pots. Gary Feldman

Time	Mass (kT)	PoT (10^{20})[1]	Δm^2 (eV^2)	Performance[2]
Proposal 03/2005	30	39[3]	0.0025	0.036 to 0.040[4]
CD-1/P5 03-04/2006	25	60	0.0025	0.037
			0.0030	0.024
Now 06/2007	18	36	0.0027	0.043
		60		0.030
	14	36		0.051
		60		0.036

1. 3 years each of neutrino and antineutrino runs.
2. $\sin^2(2\theta_{13})$ for the 95% limit on the sign of Δm^2 for the best δ.
3. There was also the possibility of a proton driver discussed.
4. Bin in which the value fell (different presentation).

Question #2 Ron Ray

2. Is there a risk register that can be shared?

Yes. It is NOνA-doc-1323 and it is viewable by the Review Team.

It is an excel file that is difficult to display because it contains so much information. The risk registry currently contains 22 moderate and high risks.

See Ron's Management breakout talk for details - NOνA-doc-1442

Ultimately we plan to utilize Welcome Risk to track our risks and generate the risk registry. Welcome Risk links directly into the WBS. We are just not there yet.

No.	WBS	Docdb Number	Date Submitted	Submitter	Date Last Revised	Revised By	Risk Severity	Risk Description	Risk Retired Mark"X" for yes and date
1	2.9.4	500	12/4/05	D. Ayres	8/31/06	D. Ayres	High	Horizontal extrusions at the end of a 32-plane block are supported by the vertical extrusions on only one side. FEA calculations indicate a problem for the horizontal modules near the bottom of the detector where the vertical modules experience maximum swelling when filled with liquid scintillator. The shear stress on the adhesive for these horizontal modules is comparable to the shear strength of the adhesives we have tested. This does not provide adequate safety factor.	
2	2.9.4	812	4/6/06	D. Ayres	8/31/06	D. Ayres	High	Static electrical charge could build up during the filling of extrusion modules with liquid scintillator. This could result in high voltage electrical discharges that have the potential to ignite a mixture of scintillator vapor and air inside the modules. Static electrical charge can also build up during the transfer of liquid scintillator from ISO-tanker trucks to the far detector scintillator supply system, although standard industrial mitigation strategies are expected to be effective for this case.	
3	2.9.4	813	4/6/06	D. Ayres	8/14/06	D. Ayres	High	"Creep" of the PVC plastic in the extrusion modules after filling with liquid scintillator could result in significant distortions of the shapes of the extrusions that make up far detector blocks. Such distortions could lead to large-scale structural failure and/or liquid scintillator leaks, which could occur many months or even years after a block is filled.	
4	2.1	1094	8/16/06	J. Cooper	8/31/06	J. Cooper	High	New simulations of cosmic ray backgrounds in the NOnA detector indicate that the overburden thickness can be reduced by a factor of 1.5 - 2.3 from the original estimates in the CDR. Such a thinner overburden might be supported by different construction techniques and lead to a lower cost for the Far Detector Hall. The risk in this case is a cost risk in that too much money may be allocated to the overburden construction and lead to a smaller detector with reduced scientific capability. However, there is a counter technical risk with a thinner overburden in that the simulation might not be completely correct. The experiment might therefore see a larger background than the simulation indicates.	
5	2.8	1095	8/16/06	J. Cooper	8/31/06	J. Cooper	Moderate	The MINOS access tunnel is not parallel to the neutrino beam at the position of the near detector and instead is at an angle of 11.15 degrees. Such a large horizontal angle may cause problems in the Near Detector with containment of neutrino events. Large beam angles can also cause electron identification differences between the Near Detector and the Far Detector since Near Detector at an angle to the beam effectively has a wider cell size and a larger radiation length per plane sampling size.	X 5/3/07
								Five kicker systems will have to be installed in the Recycler Ring (RR). The ceramic vacuum chamber for all	

Question #3 Ken Heller

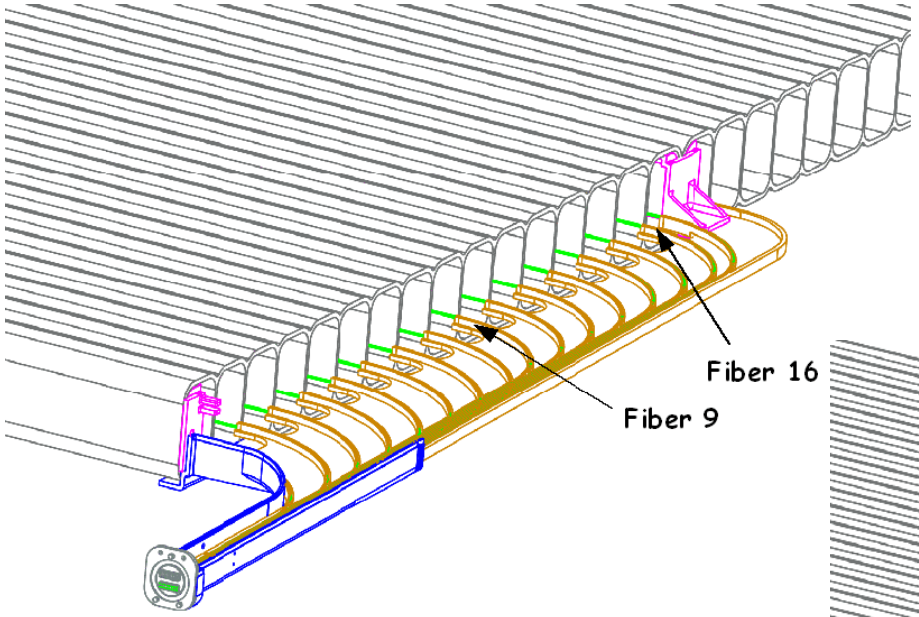
Discuss conceivable interim pressure tests of the integrity of the bottom seal of the PVC Modules before attaching the manifold.

The bottom seal is put on after the fiber is in all the cells.

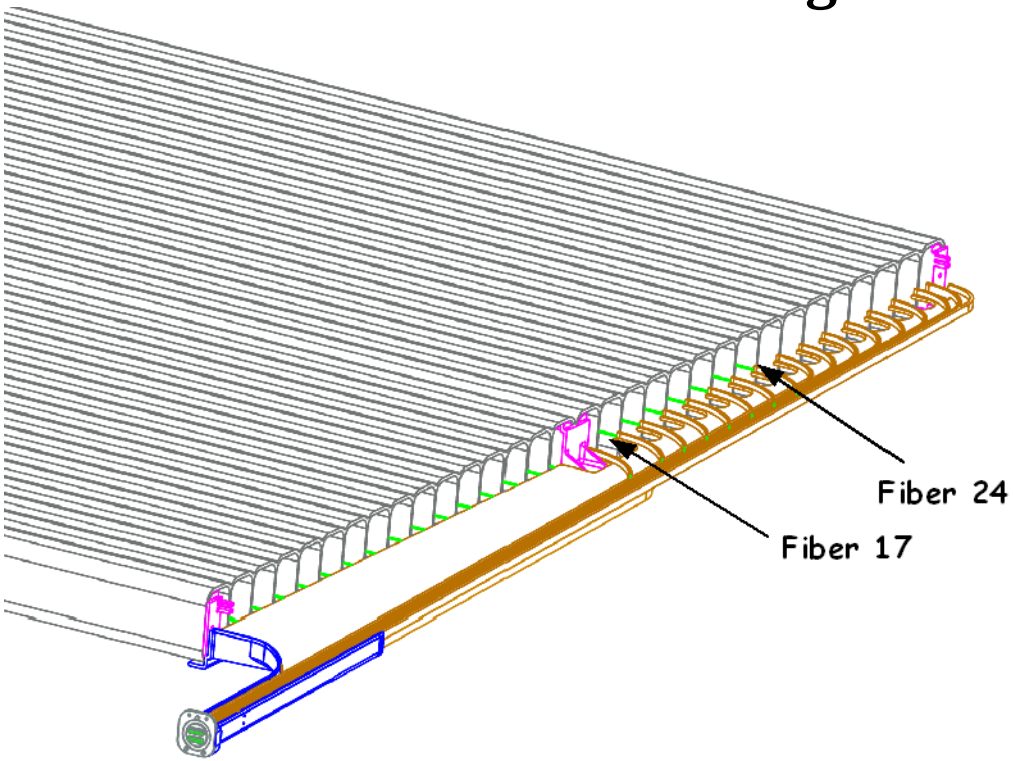
Fiber output into vacuum fixture

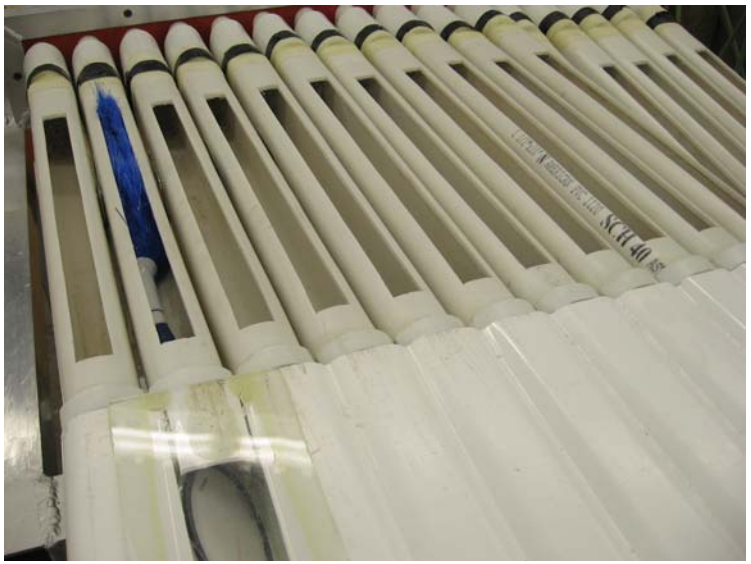
Fiber input by stringing machine

Fiber is pulled through each cell by the vacuum on the other end of the cell



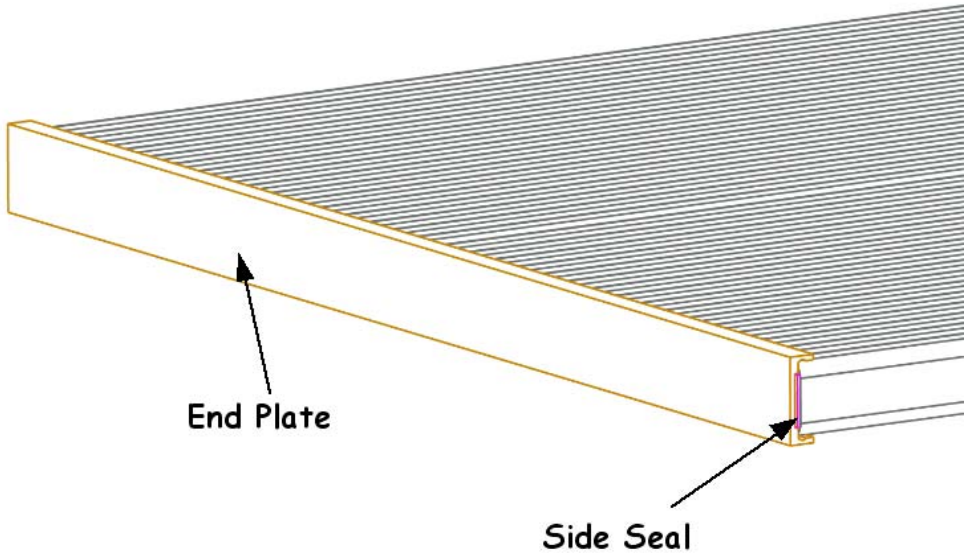
After 8 fibers are strung, they are threaded through the manifold raceway while 8 more fibers are strung.



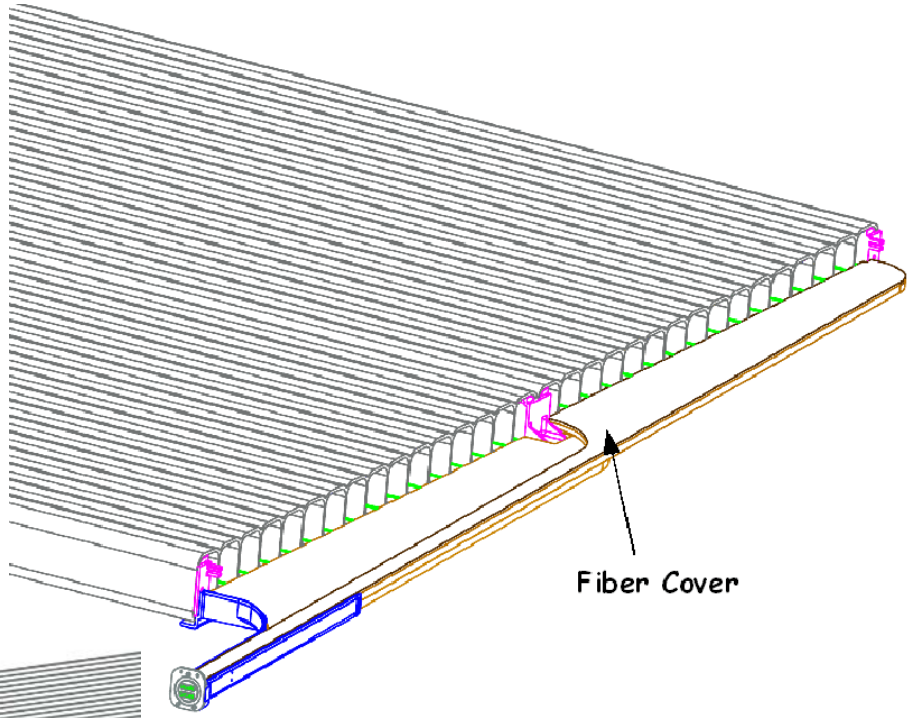


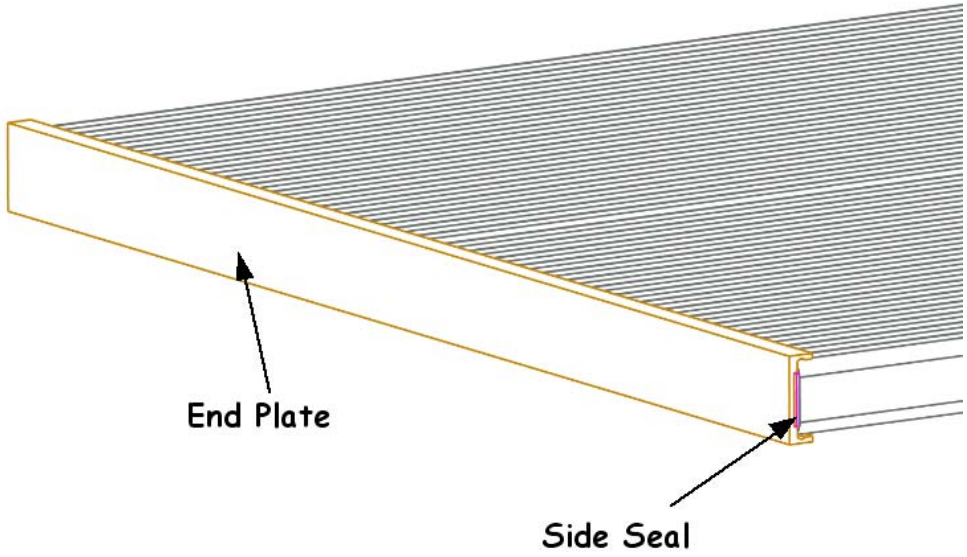
Vacuum fixture with one cell being strung

Bottom is sealed after all the cells are strung and the vacuum fixture is removed.

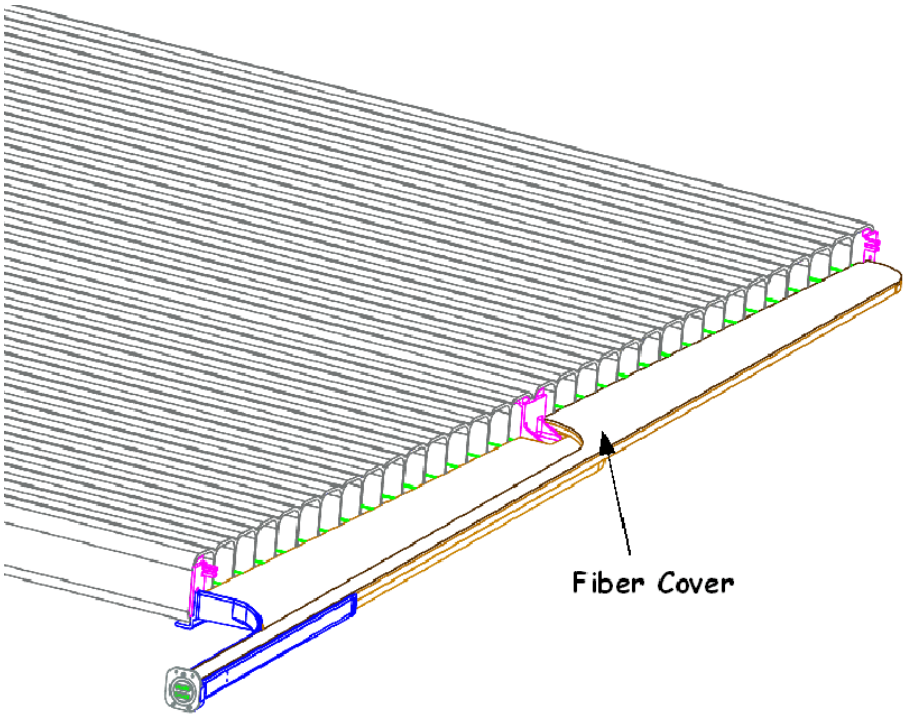


At the time the bottom is sealed, the top end has most of the manifold already constructed.





To test the seal of the bottom, it is necessary to seal the top. We do this by completing the manifold and sealing it.



One could to build a large fixture that fits over the partially constructed manifold and clamps on the scalloped sides of the extrusion. After waiting overnight for the glue to cure, one could then pressurize the extrusion to test the bottom seal.

Difficulties

- **A completely leak tight soft seal on the scalloped surface is difficult.**
- **This adds another significant step in the process and increases the assembly cost.**
- **If one does detect a leak after testing for 12 hours it is probably the fixture clamp.**

Question 4

- It looks like there are some CD-3a "buys" of Electronics/DAQ components before prototyping and testing. Is this correct? What are the risks?
  - No, all will be prototyped and tested before the "buy", APDs and ADCs are already tested and met acceptance criteria for NOvA. Final flexible ASIC will be tested before purchase.

Question #5 Dave Ayres

For near and far detectors are the design reviews or other peer reviews planned? **Yes**

- See Dave Pushka's talk, "Design Review Process," NOVA-doc-2078, examples, slide 4
  - FD structure, scintillator filling, glue machine, block pivoter table
  - In addition, Project Management will hold an external engineering review on the structural design (after CD-2)
- See schedule of detector assembly group internal reviews in NOVA-doc-1014
  - Six WBS 1.8 reviews completed and 4 more scheduled in 2007
    - Block pivoter (in progress)
    - IPND assembly facility operational readiness (December 5)
    - FD mechanical systems and tooling (August 21)
    - Design of full scale assembly prototype (August 7)
    - Design of full-height prototype (September 11)
  - Seven WBS 2.8 reviews planned (and in Open Plan) in 2009-2010
  - Twelve WBS 2.9 reviews planned (and in Open Plan) in 2007-2010

Question #6 Steve Dixon

Q: Please compare the building costs at CD-1 and now and address changes and cost impacts.

A: Total at CD-1: $46.8m

Total at CD-2/3a: $57.8

Significant Cost Increases Include:

- Electrical utility upgrade: from $266k to 900k
- Cranes: 1 @ $319k to 4 @$909k
- HVAC: $430k to $2,600k (+ associated electrical)
- Fire Protection: $1,238k to $2,678k
- Barite: $0k to $1,253k
- UMN PM support: $0k to $3,158k (4.5% of construction)

(note: costs in FY07 burdened dollars)

From DOE CD-1 Review

WBS x.1 Site & Building	Estimated Cost (FY06 $M)	Contingency Estimate (FY06 $M)	Contingency (%)	Total Cost (FY06 $M)
Construction w indirects				
M&S	28.8	6.6	23%	35.4
Labor[1]	1.1	0.4	33%	1.5
Construction total:	**29.9**	**6.9**	**23%**	**36.9**
PED				
M&S	7.9	1.7	22%	9.6
Labor[1]	0.3	0.1	26%	0.4
PED total:	**8.2**	**1.8**	**22%**	**10.0**
R&D				
M&S	0.73	0.12	17%	0.85
Labor[1]	0.25	0.06	25%	0.31
R&D total:	**0.98**	**0.19**	**19%**	**1.16**

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

Cost Drivers

17% - Access Road/Site Work  x 4,800 = 96,000 cy

13% - Excavation and Backfill  x 8,100 = 162,000 cy

23% - Structural Steel  920 tons

22% - Concrete  x 1,910 = 15,260 cy

10% - Mechanical  2,900,000 cubic feet

7% - Electrical  1.2 megawatts

From Director's CD-2/3a

WBS x.1 Site & Building	Estimated Cost (AY $M)	Contingency Estimate (AY $M)	Contingency (%)	Total Cost (AY $M)
Construction w indirects				
M&S	0.0	0.0	0%	0.0
Labor[1]	1.9	0.5	24%	2.4
Construction total:	**1.9**	**0.5**	**24%**	**2.4**
Cooperative Agreement				
M&S	46.9	9.3	20%	56.2
Labor[1]	0.0	0.0	0%	0.0
CA total:	**46.9**	**9.3**	**20%**	**56.2**
R&D				
M&S	0.1	0.2	155%	0.3
Labor[1]	0.3	0.1	23%	0.4
R&D total:	**0.4**	**0.3**	**59%**	**0.7**

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

Question 7 John Cooper

- Talk about how you "see" management of the CA activities working. That is how the NOvA Project Manager and the Level 2 Manager control or influence these activities.
- See John Cooper's breakout talk on the CA in the Management breakout
- Summary:
  - The CA is not yet in place, requires procurement package from DOE OHEP to Chicago Office and subsequent negotiations
  - Expect one feature to be the requirement of an MOU between Fermilab NOvA Project Office and U. of Minnesota
    - Marvin Marshak (U of Minn CA PI) and I have agreed that a principle of consensus will be used on major decisions so that both parties are satisfied.
      - 1st try at this appears to have worked for selection of "Project Management firm"
    - Monthly reporting, narrative and financial status, will be part of MOU
    - Expect reality to be that both parties will have to work hard at keeping each other in the loop on the more day-to-day decisions. E.g. weekly status meetings to include NOvA L2.
  - In addition I am continually promised by DOE OHEP that funds will not go to the University if the Project is not satisfied with progress
    - 2-edged sword since stopping funds will bring progress to a complete halt, but this "remedy" would exist.
    - I am not satisfied if my Level 2 Manager is not satisfied.

Question 8 Nancy Grossman

8. Discuss what experiments have been conducted or are planned for the Main Injector to investigate questions that need to be answered to deliver 700 kW. Some suggestions were made at the SNuMI Director's Review. (addressed in ANU breakout the am)

- MI has run with intensities around 4.6E13 which is 94% of our design intensity for NOvA (11 batches) with negligible issues.
- Run with intensities around 4.0E13 (82% of NOvA) to the NUMI target with no significant losses down the beamline and will run higher intensities to NuMI soon.
- Will study transient beam loading effects at transition by measuring the bunch length across the batches.
- Will commission/monitor MI transverse dampers during slip stacking very soon.
- Have measured the instability growth rates as a function of intensity and bunch length, and will repeat it with slip-stacked beam.
- Work has been ongoing in commissioning and monitoring the MI-8 collimators.
- Electron cloud studies have been done with the 11-batch beam and are consistent with previous measurements and this work will continue (measurements & simulations)
- Continuing investigation of the MI-10 damper / kicker interactions and thus whether NOvA needs a bumper system.

2nd set of Questions, #1 Ron Ray

Oil prices aren't based solely on crude prices; rather a combination of crude and the availability of refiners. Note that we actually have crude price per barrel less than or equal to what it was a year ago; however, the price of gasoline per gallon is now a dollar higher (i.e. the price of refining has gone up by 4X). Need to revise your estimates as the gap between the cost of crude correlated to cost of gasoline is still changing. I would assume that you can correlate the cost of gasoline to that of mineral oil as they both come from the same distillation and refinement process.

Gasoline is not relevant. It's connection to crude oil is different than the connection of mineral oil to crude. We have quotes from suppliers who have indexed the cost of their mineral oil to a specific base oil and we have archival data on the price of this base oil going back ten years. A ten year time span adequately averages over crude oil price movements as well as refinery issues and anything else that might impact the price of mineral oil. (Refinery issues do occur, they are thoroughly discussed in industry newsletters and we monitor them). We have correlated the cost of the base oil to the price of crude and use this in our model. SEE NEXT PAGE

2nd Set, Question 2 Carl Bromberg

The production of fiber involves a "preform" of a polystyrene core loaded with fluorescent dye and concentric cylinders (2) of cladding each with a thickness of 3% of the overall diameter. The preform is heated and drawn down to the fiber diameter. A single preform produces 3 spools of *continuous* fiber. The continuous nature of the fiber on a spool is essential for the efficient loading of fiber into the modules by a semi-automated machine.

Problems associated with a preform will be identified by QA testing of each spool. Similar measurements on fiber samples taken between each spool are provided by Kuraray, along with their average and standard deviation as shown in the figure below. Any discrepancies between the Kuraray QC data and our QA measurements obtained on the first 30 m of each spool, would be investigated immediately.

		Length	Attenuation Length [cm]						
Type	Thk[mm]	[m]	1st	2nd	3rd	n	Ave	σ	σ / Ave
Y-11(150)MSJ	0.70	1,000	388	386	424	3	399	9	2.4%
		1,000							
		1,000							
		1,000							

Initially, and occasionally thereafter, we will chop up 1000 m of fiber from an occasional spool to verify that the variations within a spool are similar to those found between spools from the same preform and less than that found between spools from different performs or shipments of fiber.

Experience has shown that the variations in the fiber within a spool are small. During fiber production, The fiber diameter, a critical parameter in maintaining the nominal attenuation length of the fiber, is monitored and recorded by Kuraray >100 times per meter of fiber length as part of their drawing process control. This data is provided to NOvA for each spool as well as a summary, including the mean diameter, the standard deviation, and the number of excursions larger than 4% from the mean diameter, as shown in the table below. The number of these excursions is typically a few per 1000m of fiber. An excursion of 4% might degrade the light output of this fiber, however, the signal would remain at a useful level. In the first few shipments we will verify that the Kuraray diameter data is reliable, as was found in the recent detector construction for Minos.

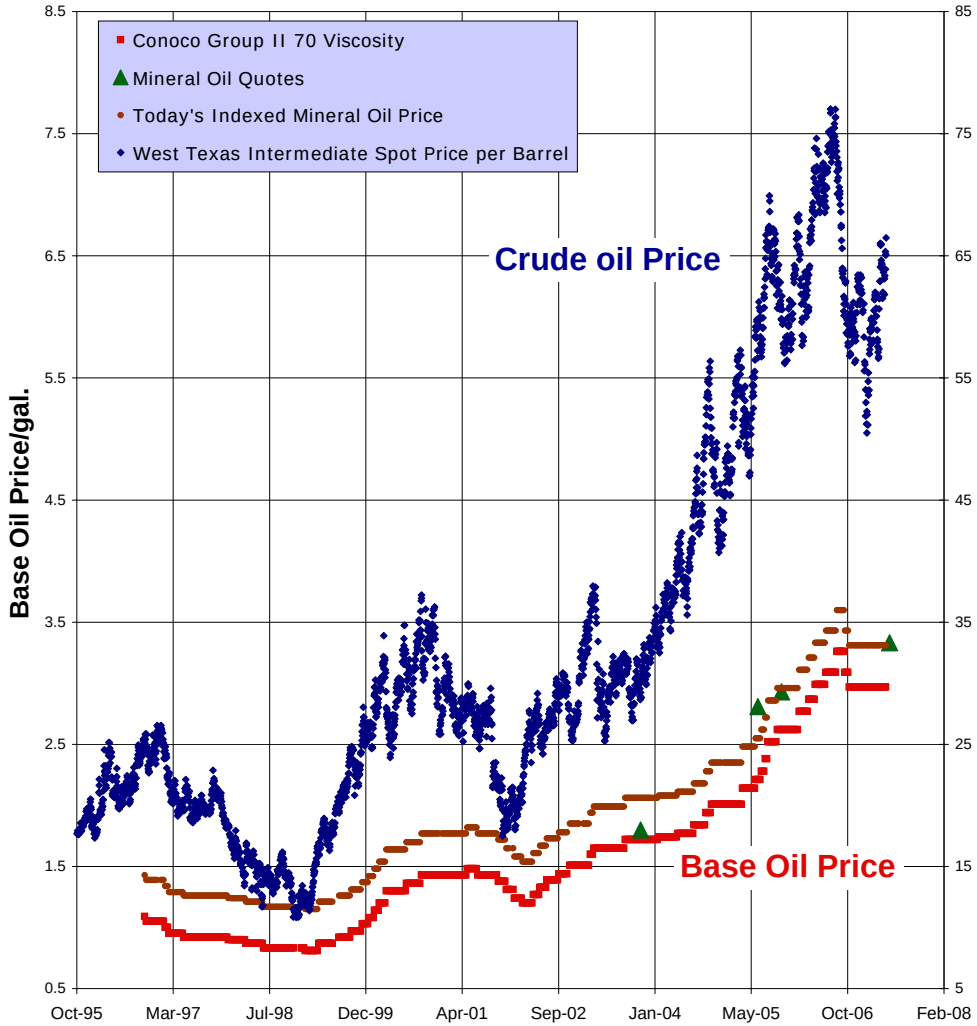
		Length	Diameter[_m]				ea%
Type	Thk[mm]	[m]	n	Ave	σ	σ / Ave	Over
Y-11(150)MSJ	0.70	1,000	290,911	699.9	2.0	0.28%	7
		1,000					
		1,000	284,887	699.9	2.0	0.28%	5
		1,000					

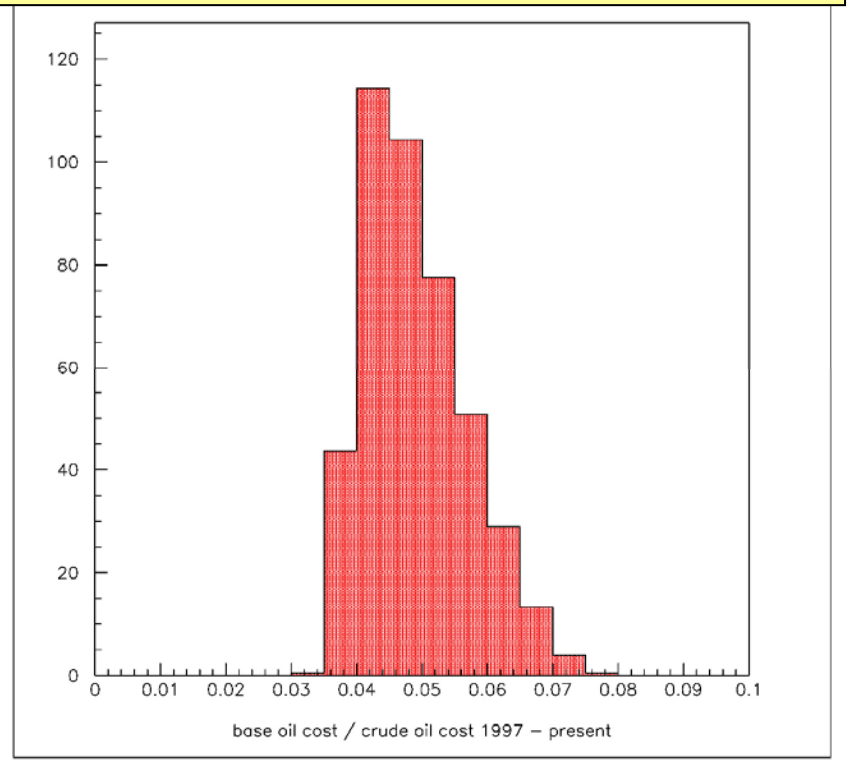
It is impractical and unnecessary to remove sections of fiber that are down by even 30% from the mean light output. During a module construction QA procedure, the normal variations in the light output from each fiber will be measured, and a calibration constant determined that would normalize its signal. Even the rare module containing a completely dead fiber (for whatever reason) would almost certainly be installed, as it would have a negligible effect on the physics capabilities of that section of detector.

2nd set Question 3 (PVC QC/QA) Rich Talaga

- Issue: "Should have heavy QA up front…then back off if error rate is low"
- Response: This is our plan.
  - Refer to breakout talk by C. Grozis.
  - Detailed in TDR chapter 12.3.3 (QA and QC)
  - Done as soon as extrusion is produced at the vendor: for example
    - **Careful and Detailed** visual inspection of every extrusion
      - Examine junctions of webs with exterior walls
    - Thickness measurements
      - 15 web measurements, 34 wall measurements per extrusion
    - Flatness measurements
    - Extruding is a continuous process; anomalies tend to get worse over time
      - » Problems can be anticipated before they cause a structural issue and corrective action will be taken

Ratio of base oil price to crude oil. There is not a 1-1 relationship, but rather a distribution. So for a given crude oil price there has historically been a range of base oil prices. This distribution is what we use in our simulation.





2nd set of Questions, # 4 John Cooper

- PM spoke of a limiting the size of the detector to meet the $260M target but did not discuss the risk associated with this decision. Is it really as simple as a matter of scalability?
- Risks
  - We don't change the size of the detector until we know that the details of the cost and schedule are correct. Expecting help from this review.
  - DOE might conclude that a lengthened time scale for data collection is a fatal flaw. Lehman has asked what minimum is acceptable so he will know for his review.
- Simple scalability is a first order answer.
  - One must compute the fixed costs, one time costs
    - I did this part without benefit of a "correct cost & schedule" as above.
  - Then the detector scales to second order
    - But to get it right you have to understand the quantities discount quotes for smaller quantities.
    - We have not done this yet since the data are only 48 hours old.

2nd set of Questions, #5 Ron Ray

- CD-2/3a reviews require risk evaluation – it was severely lacking throughout the discussion.

- See answer to Question #2 above.

2nd set, Question 6

Dave Ayres

- PVC expansion gaps – since most creep will happen at the bottom where the greatest weight is, is it a problem that the gap at the bottom will close before the top (or, probably, touch as soon as it's built)?

- No (based on detailed FEA analysis of both swelling and buckling effects)
- Superblock swelling will not close expansion gaps until ~20 years after filling

2nd set, Question 7

Dave Ayres

- Q6: Will the vertical lifter ever be used again once it is installed as a bookend?

- No, it remains in place until after the detector is drained at the end of the experiment

2nd set of questions, #8 John Cooper

- Statement was made that “detailed engineering will proceed in parallel with prototype work”…….but, CD-3a is supposed to have an actual design with specs to approve construction.
- Statement was made for a project L2 NOT seeking a CD-3a.
- Yes, we understand that CD-3a requires design with specs.
  - We believe we have such for the CD-3a items listed.
  - Please tell us if you don’t agree

2nd set of questions, #9 John Cooper

- Where can I see the BOE for the budget roll-up

- This is on the review website
  - Cost & Schedule tasks refer to BOEs
  - BOEs are on the NOvA docdb database
  - See Harry Ferguson's Management breakout talk.