Project Status

John Cooper
Project Manager

NOvA Scope

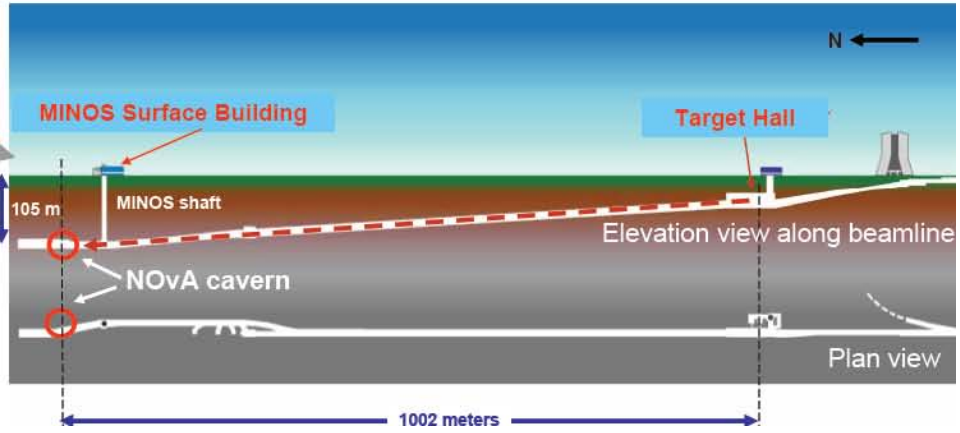
Key Performance Parameters (KPP)	NOvA Threshold KPP	NOvA Objective KPP
Proton Beam Power	Capable of 700 kW to NUMI Target	
Near Detector Mass	0.2 kt	
Long Baseline Distance	810 km	
Detector Angle Off-Axis	14.6 mr	
Far Detector Mass	14 kt	18 kt

» Above from December 22, 2010 revised PEP

- Proton Beam Power is “capable” of 700 kilowatts, not commissioned
  - We reconfigure the existing Fermilab accelerator complex to increase the proton intensity (beam power) by a factor of two.
- Two Detectors
  - **Near Detector** at Fermilab to measure the electron neutrino content of the muon neutrino beam just after production,
  - **Far Detector** at Ash River, Minnesota near the Canadian border to look for extra electron neutrinos appearing after a 810 kilometer trip north
    - This required a new building at Ash River now **done** via a Cooperative Agreement between DOE and the University of Minnesota
    - Far Detector mass can be as large as 18 kilotons if we can afford it within the TPC and CD-4 date.
  - Detectors must see neutrino events to meet threshold KPP

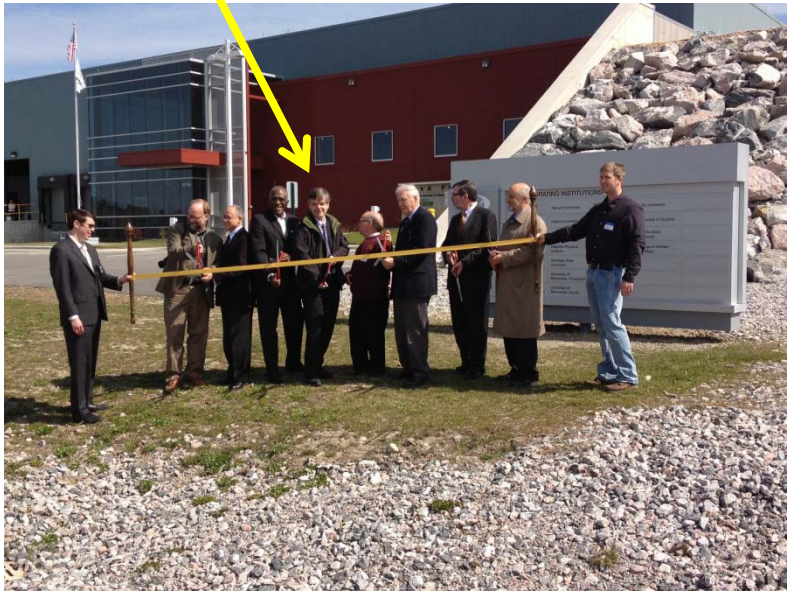
Accelerator & NuMI Upgrades

- **NOvA adds items to an extensive existing accelerator infrastructure**
  - Fermilab is the lead institution here
- **Existing Main Injector & Recycler**
  - Dotted yellow circle in picture
  - Previous ~ $250 M project completed in 1999 for the Tevatron Collider (the other circle in the picture)
  - NOvA:
    - Cycle time reduced by using the Recycler as proton storage ring and by using more RF stations in the Main Injector
    - Faster cycling gives more protons/second
- **Existing NuMI Beamline**
  - Dotted red arrow in picture
  - Previous ~ $175 M project completed in 2004
    - This includes an underground tunnel at Fermilab with space for Near Detectors 300 feet below the surface
  - NOvA:
    - New target, move focusing horn, …
- **NOvA Result:**
  - Increase beam power from 400 to 700 kW
  - More protons to make more neutrinos

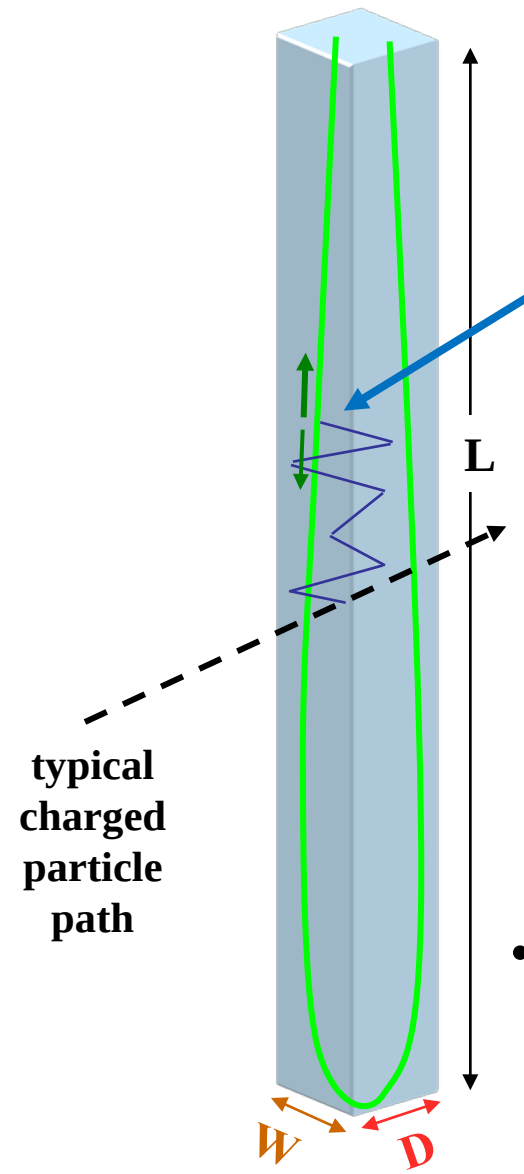


NOvA building

- Building at Ash River, Minnesota for a 18 kt Far Detector
- This is complete.
- Dedication was April 27,2012

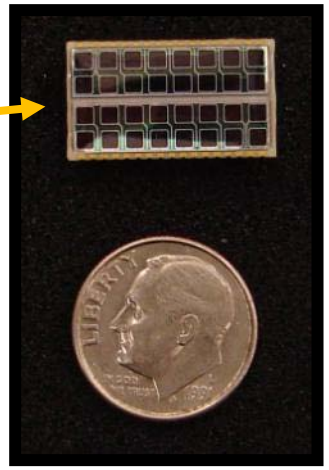


Reminder: NOvA Basic Detector Element



- Liquid scintillator in a highly reflective PVC plastic cell
  - Passage of charged particle through scintillator creates light
  - Light bounces off reflective PVC walls until captured in a thin wavelength-shifting fiber
    - Typically light hits fiber within 50 cm of particle path, ~ 8 reflections
  - The fiber is U-shaped and both ends terminate in one pixel of a 32-pixel avalanche photodiode (APD)
- Simple construction, just repeat 356,352 times
  - Cells are 15 m long, so they just fit in a 53 ft semi-trailer truck

Prototype Near Detector with ~ 16,000 cells is operating at Fermilab



Technical Status as of May 1, 2012

(I will cover all aspects, but 5 additional speakers will have details on 4 WBS items)

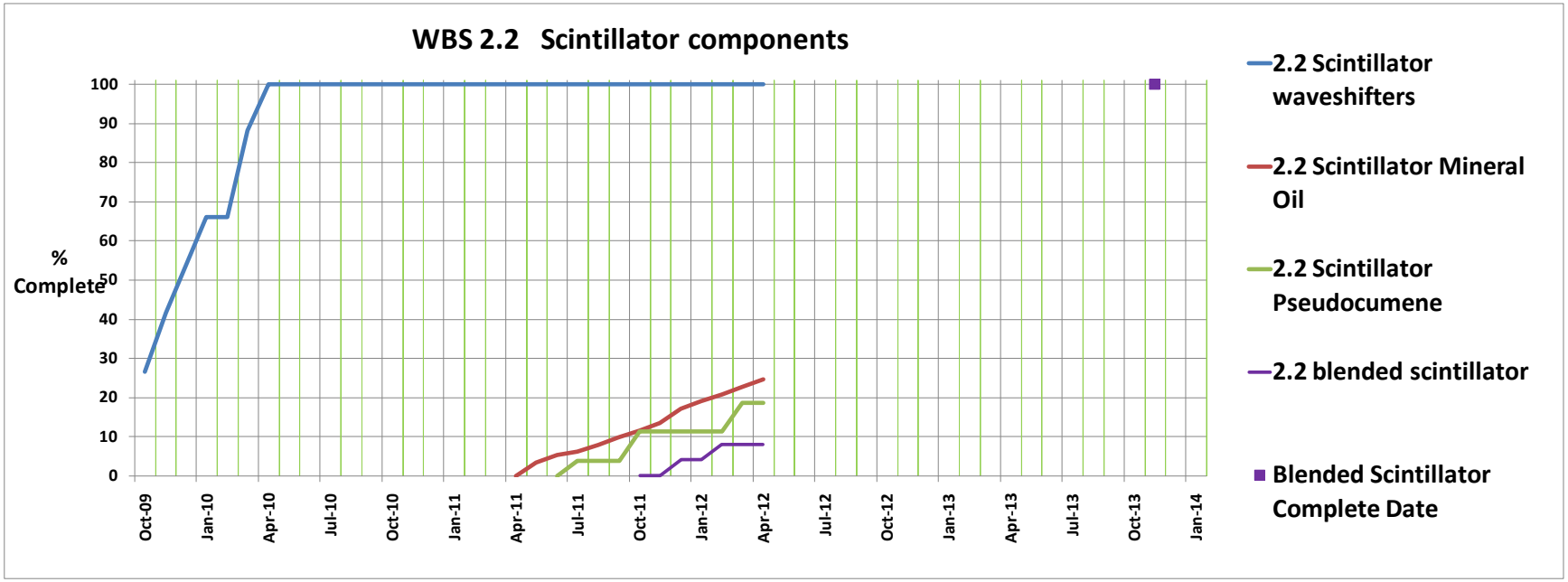
- WBS 2.0 Accelerator and NuMI Upgrades (Paul Derwent)
  - Shutdown has started and will finish in 12 months.
- WBS 2.1 Site and Buildings
  - Ash River Building is done.
- WBS 2.2 Scintillator
- WBS 2.3 Waveshifting Fiber
- WBS 2.4 PVC Extrusions
- WBS 2.5 PVC Modules (Ken Heller)
- WBS 2.6 Electronics & 2.7 Data Acquisition (Leon Mualem)
- WBS 2.9 Far Detector Assembly (Pat Lukens) and Outfitting (Rick Tesarek)
- WBS 2.8 Near Detector Cavern and Detector

WBS 2.2 Scintillator

- We need 2.8 M gallons of scintillator
  - 2.65 M gallons of mineral oil, delivered by railcar from Louisiana
  - 155,000 gallons of pseudocumene, delivered by ISO tankcar from China
  - Waveshifters (we own enough for the full experiment)
- We do Fluor blends (pseudocumene + waveshifters) then mix that in a separate tank with mineral oil to make scintillator at Wolf Lake, Indiana
  - 5% Fluor Mix: waveshifter powders into 300 gallons of pseudocumene to start
  - Then add into 6,000 gallon tank of pseudocumene
  - Then add into 120,000 gallon tank of mineral oil & blend with pulsed Nitrogen
  - 5 % pseudocumene + 95% mineral oil

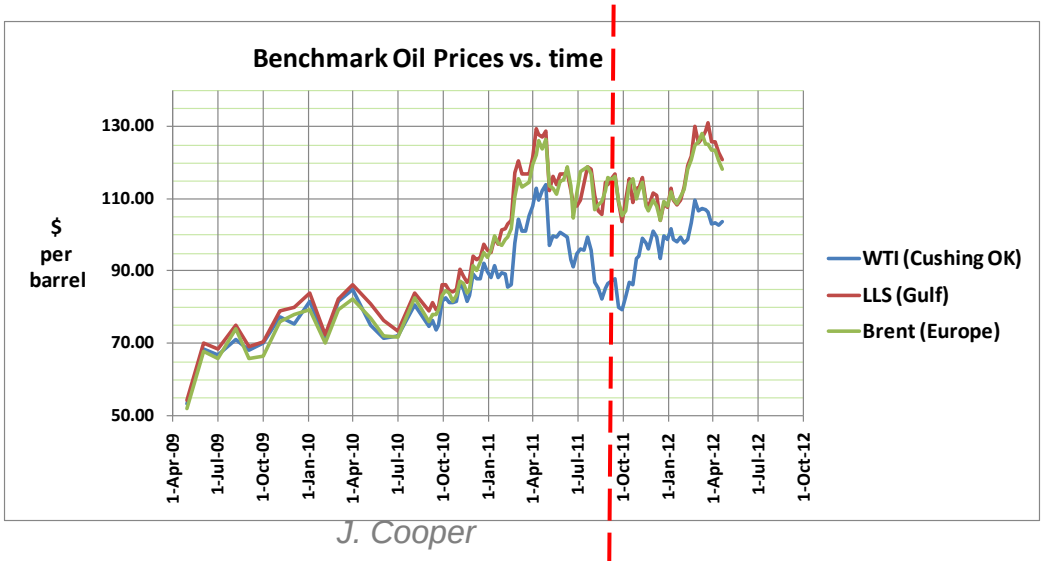
WBS 2.2 Scintillator

- We blended the first 115,564 gallons of scintillator in December
  - Production Readiness Review, Dec 22, 2011 (link from website, right-hand column)
  - Our two scintillator storage tanks at Wolf Lake are now full
    - **Both meet the NOvA specifications for light transmission & for light output,** with samples from top and bottom of each 120,000 gallon tank
  - We have 3 pseudocumene tankers set aside at Lockport, IL as a buffer
  - We have a 500,000 gallon mineral oil buffer tank in Riverdale IL, now nearly full
  - Waiting for shipments to Ash River before we can proceed



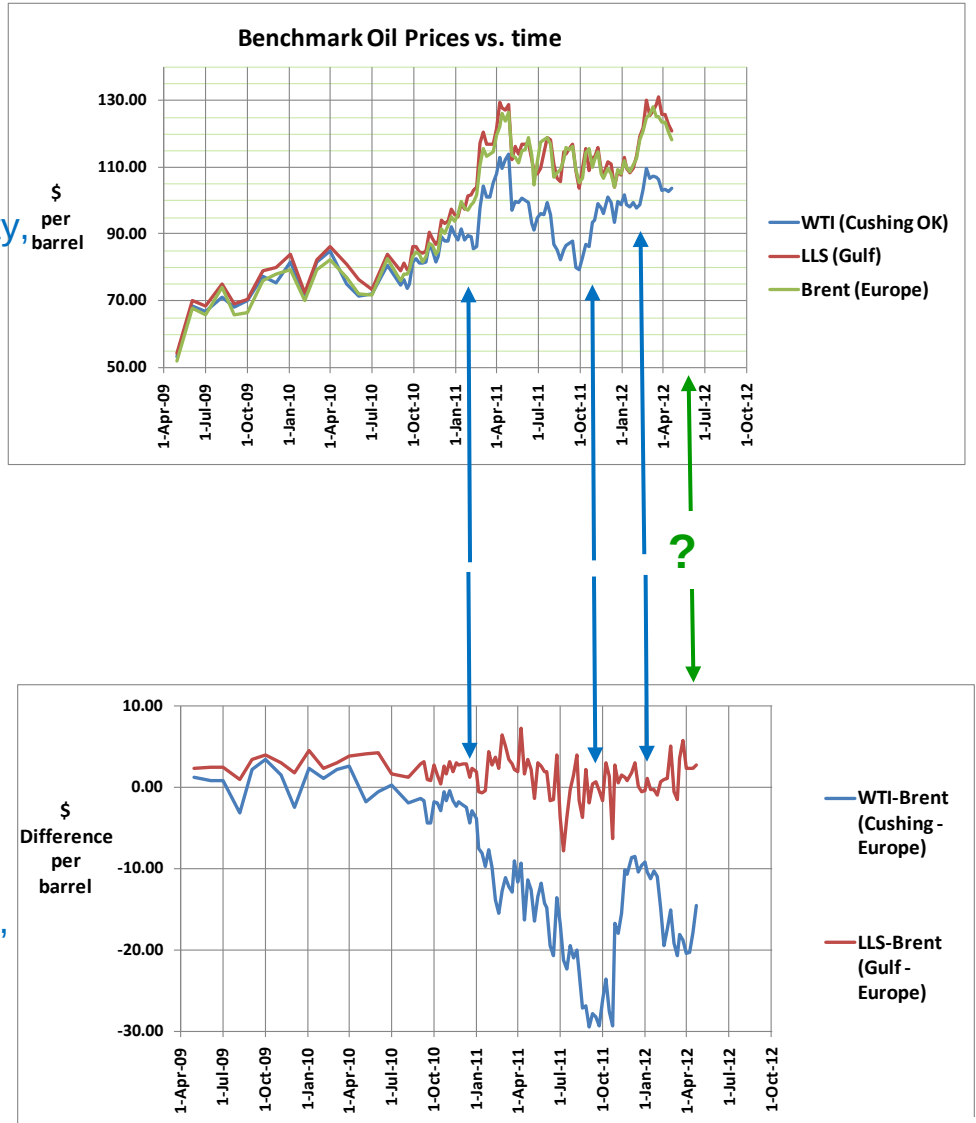
Scintillator prices and Crude Oil

- NOvA Mineral Oil had a fixed price as long as Crude Oil was in the range $60 to $110 per barrel (West Texas Intermediate [WTI] benchmark agreed)
  - Sept 2011 (dashed red line): NOvA Mineral Oil vendor said he could not stay in business at that price (losing ~ $ 1.17 per gallon).
  - Vendor's raw material source is Lake Charles, LA.
  - Vendor asked the index to be changed to Brent (European) or Louisiana Light Sweet (LSS) Crude Index instead of West Texas Intermediate, since that index was already > $110 / barrel and WTI was not
  - Instead we agreed to index off of the raw material Lubrication Oil (next page) and ignore the price of Crude
- What has happened to these benchmarks?
  - WTI = Brent = LLS since at least 1987
  - **Something changed in Jan/Feb 2011 (next slide)**



Crude Oil: Why split Brent vs. WTI?

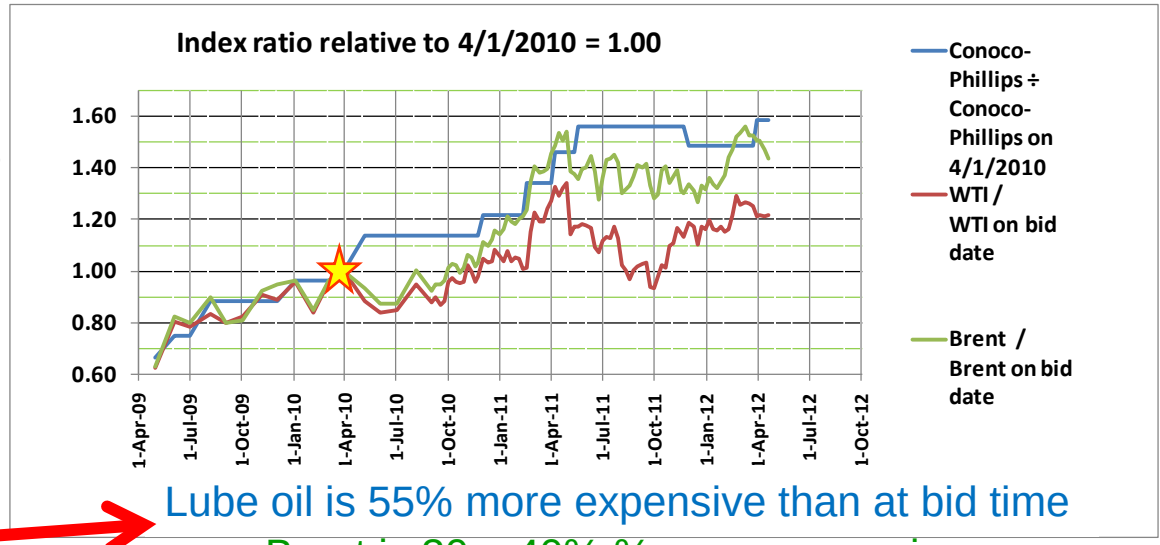
- Feb 2011
  - Libya stops 1.65 Mb/day production, Brent up
  - Keystone pipeline to Cushing OK (extension from Nebraska) adds 155,000 b/day input, storage soars to 85% of 44 Mb storage capacity, WTI price drops. "Full" = supply high.
- Nov 2011
  - Libya back up to 0.5 Mb/day, no Brent effect
  - Seaway pipeline reversal announced (Cushing to Gulf Coast). 150,000 b/day. WTI price up.
- Jan 2012
  - President blocks Keystone XL (1.3 Mb/day), no effect on WTI
- Feb 2012
  - Seaway reversal delay: April to June 2012, WTI drops again
- Mar 2012
  - President green lights XL from Cushing to Gulf, no effect on WTI, too far off in time?
  - Libya back to 1.0 Mb/day, offset by Soudan
- June 2012
  - Seaway reversal should have an effect?



The WTI- Brent difference partially reflects transportation costs from Cushing, OK to the Gulf

and, WHY is Lube Oil so expensive?

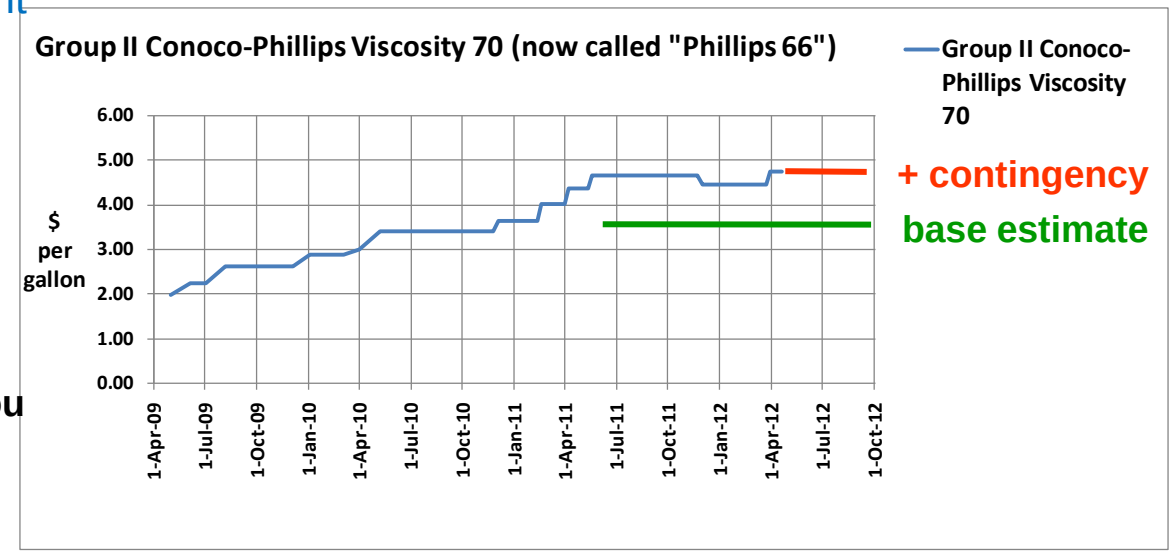
- NOvA has tracked the Conoco-Phillips Group II Viscosity 70 lubrication oil with years of data
  - Lube followed WTI Crude, typically with a lag of several months both up and down.
  - Since Brent separated from WTI, no longer the case.
- Now Lube Oil is overpriced relative to WTI and even relative to Brent
  - History indicates we might expect ultimate price movement in our favor.
  - Particularly if WTI can get to the Gulf Coast again?
- **Meanwhile, we have the current price just covered in our base + contingency.**
- **Point of last 3 slides: To convince you that we are watching this cost & will until we own all the mineral oil we need.**



Lube oil is 55% more expensive than at bid time

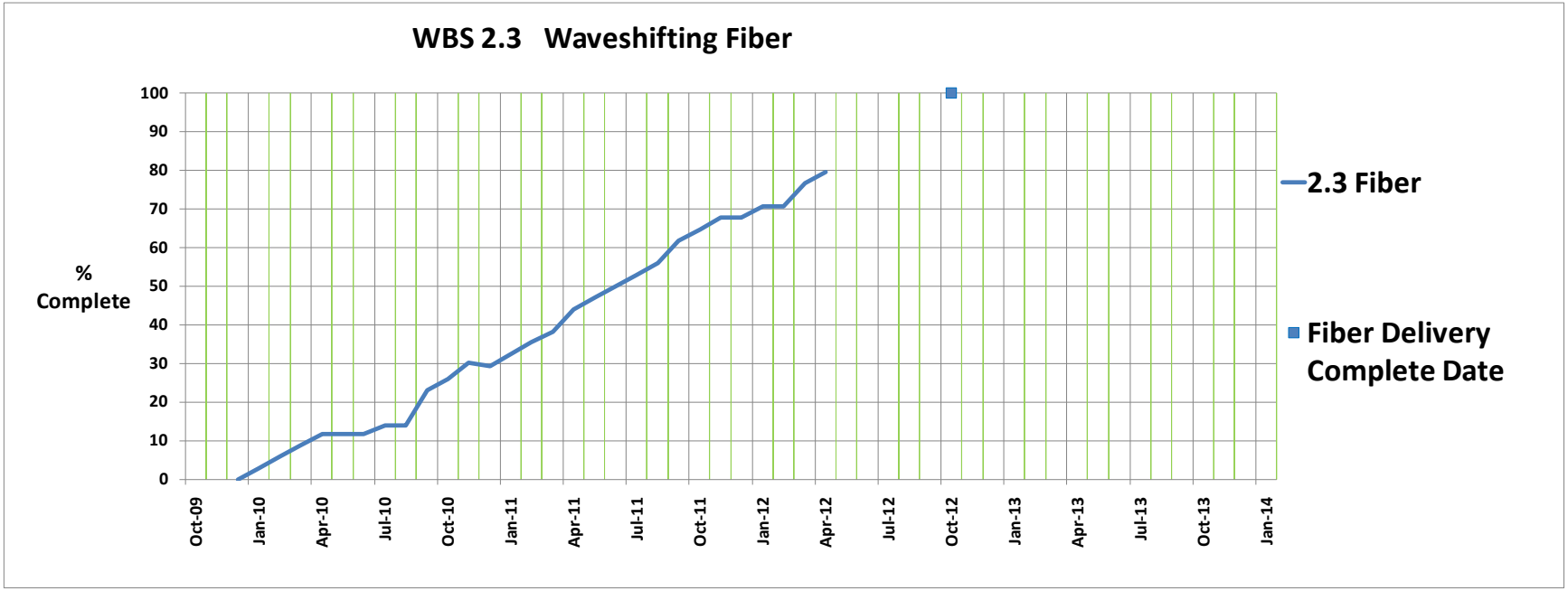
Brent is 30 – 40% % more expensive

WTI is 0 - 20% more expensive



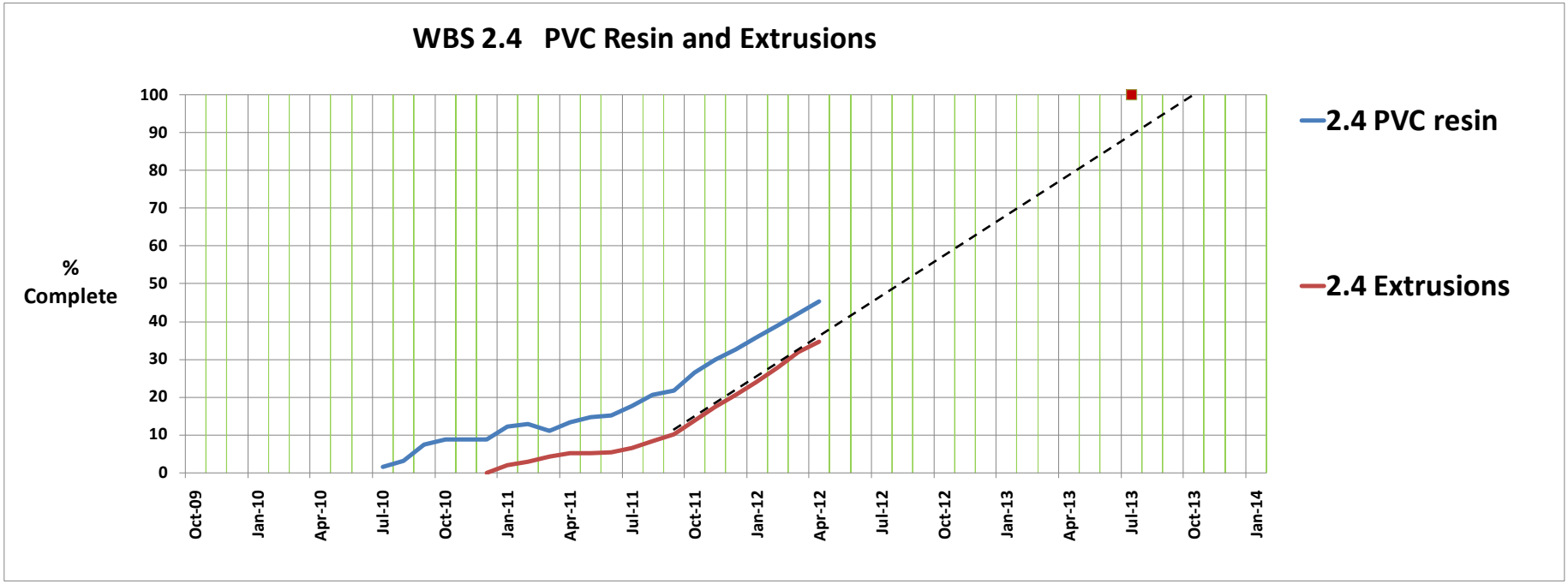
WBS 2.3 Fiber

- We need 12,183 km of wavelength shifting fiber
- **We have 9,690 km of fiber or 80% of the total needed.**
  - Still on schedule to complete as planned.
- Price is variable since we pay in Yen and the $/Yen ratio has not been in our favor since the 12 M$ Kuraray P.O. was put in place.
  - Was $ 0.98 per meter when 95 Y/$, recently 83 Yen/$ means $1.12 per meter
- We still need to know the waste rate in the Minneapolis module factory to see if we need to buy more fiber than in the current purchase order.
  - Need to exercise our option in by July 2012 (before they stop production)



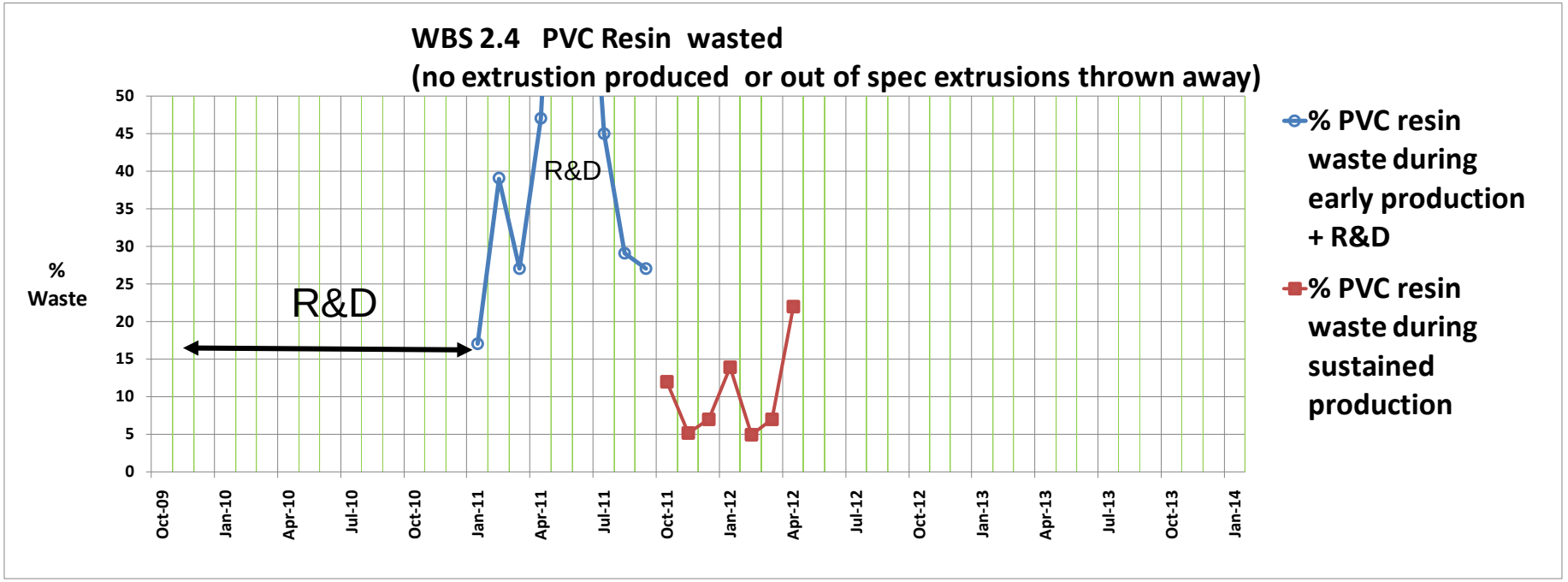
WBS 2.4 PVC Extrusions

- We have 7,734 good extrusions in hand of the 22,272 required
- **So we have 35% of the total needed.**
- 6 x 24 operations continue at the extruding vendor
- Continuing at this rate implies may finish ~ 3-4 months later than planned
  - Still evaluating production rate, searching for work-arounds if more rate is needed.
  - Also thinking about protective measures to keep production going (extra die inserts)



PVC scrap rate

- Our schedule assumes 6% scrap & that's about what we have seen since production started in October 2011.
  - This does not include 2% due to 6" QA samples at end of each 51' extrusion
  - 1 bad week in April.
- Have saved about 1/8th of the 6% "waste" for the Near Detector
  - Only a couple of parameters out of spec & OK for less vertically challenged detector



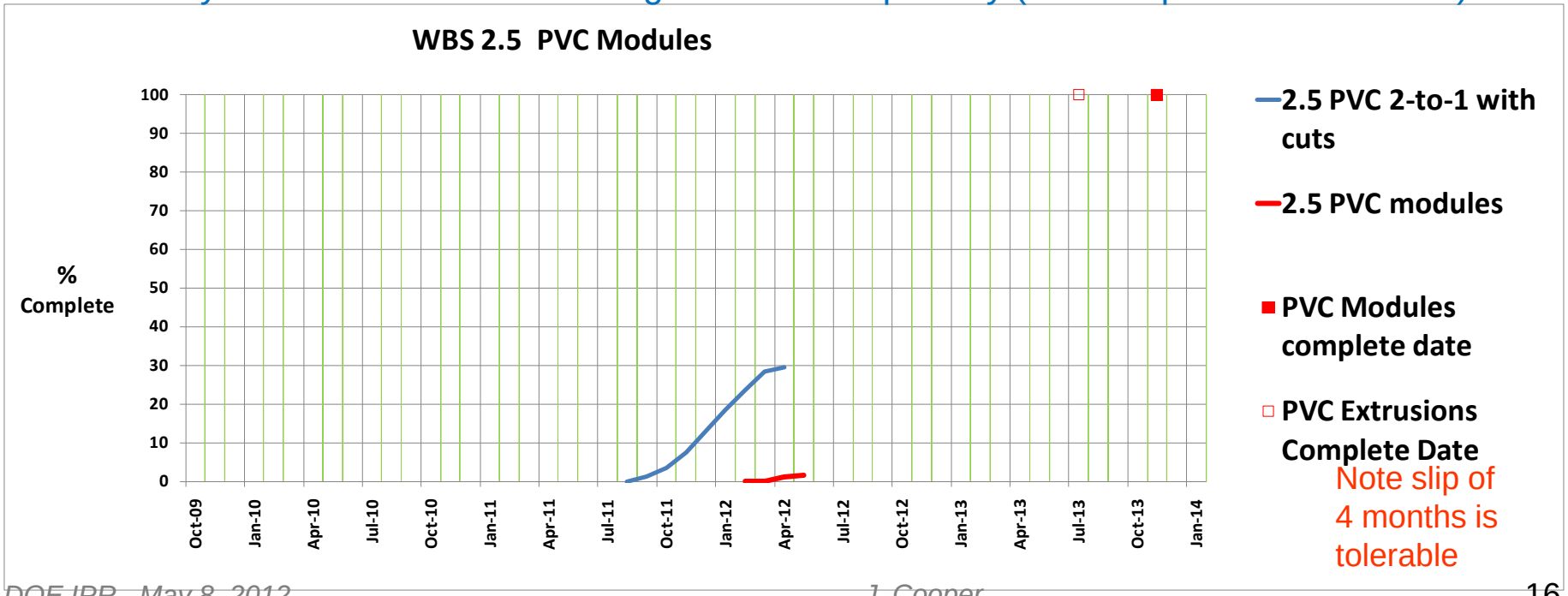
PVC prices

- Extruding costs are a fixed price contract with Extrutech in Manitowoc, WI
  - About $1.00 / pound of good extrusion
  - Occasional disputes on whether bad extrusions are due to Extrutech problems or PVC resin problems, e.g. that bad week in April.
    - To mitigate disputes, we find boxes of PVC resin that extrude well and set them aside.
    - If a problem arises with the extrusions, we can quickly go back to a box that worked well before. This often leads to a die purge (~1/week) or even a die cleaning (~1/month).

- PVC resin costs were originally a fixed price contract with PolyOne in Pasadena, TX
  - About $1.06 / pound of resin powder, indexed to Chemical Data PVC prices
  - But 15% of our PVC is TiO_2 and TiO_2 prices have been climbing since the recession start to factor of 2 higher than when PolyOne bid.
  - We have agreed to pay the difference on this component.
  - PolyOne has been working diligently to provide consistently good powder (a challenge with our unique formula) so that Extrutech extruding is not impacted by the powder input.
    - They have accepted for refund a total of 463,000 pounds of powder in addition.

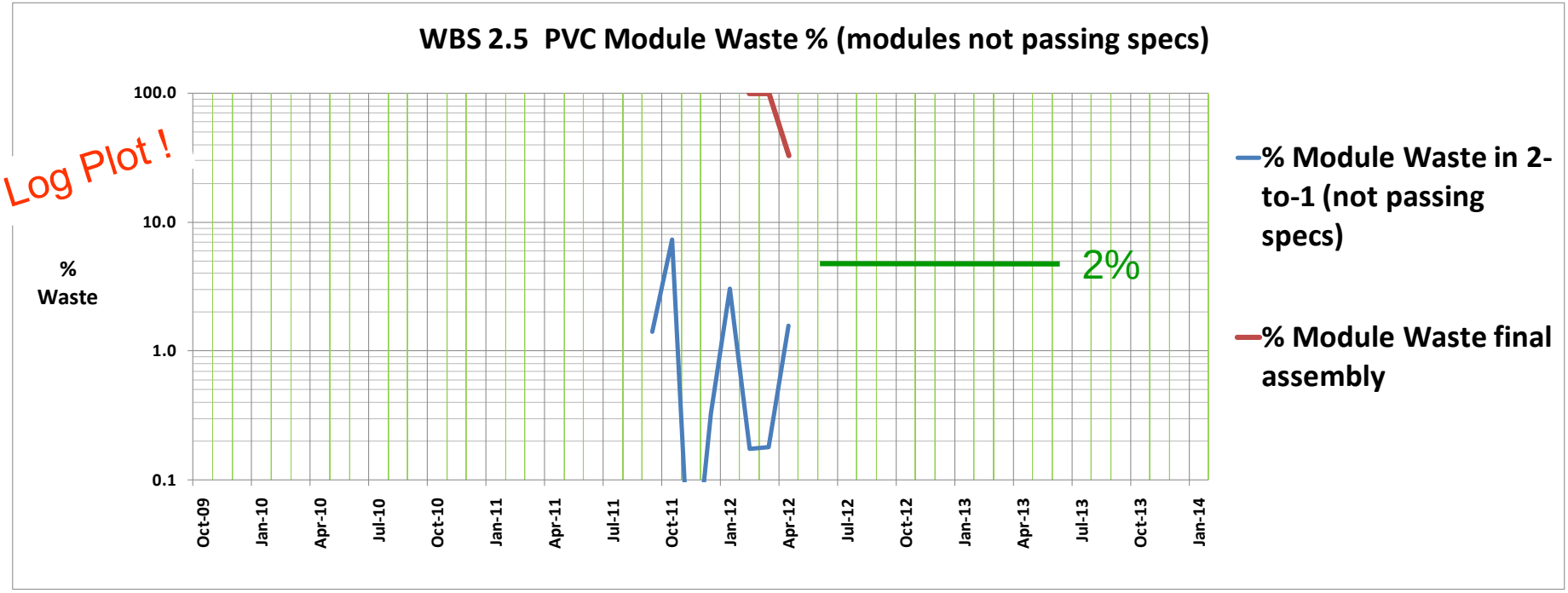
WBS 2.5 PVC Modules

- Module assembly at Minnesota has been divided into two parts:
  - 2–to–1 assembly of 2 extrusions into one module + cut to length
  - Final assembly with fiber, endcap, manifold, & all seals + pressure test
    - Not all the final assembly parts were available until recently, so our work-around was to do it in 2 steps
- **3,295 2-to-1s are done out of 11,136 needed. We have 30%.**
  - Moved effort to final assembly in April, so slope of curve changed.
- **166 good final assembly modules are done out of 11,136 needed (1.5%)**
  - Steady state rate needs to be 24 good modules per day (123 in April = ¼ rate so far)



PVC Module scrap rate

- Our schedule assumes 2% scrap from all sources and we have a long ways to go. ~ 30% scrap in April.
  - Ken Heller will have data on weekly progress in April & May
  - Scrap counts vary since some modules fail in one month and get fixed in a following month.
- As with PVC extrusions, we save scrap as raw material for the Near Detector

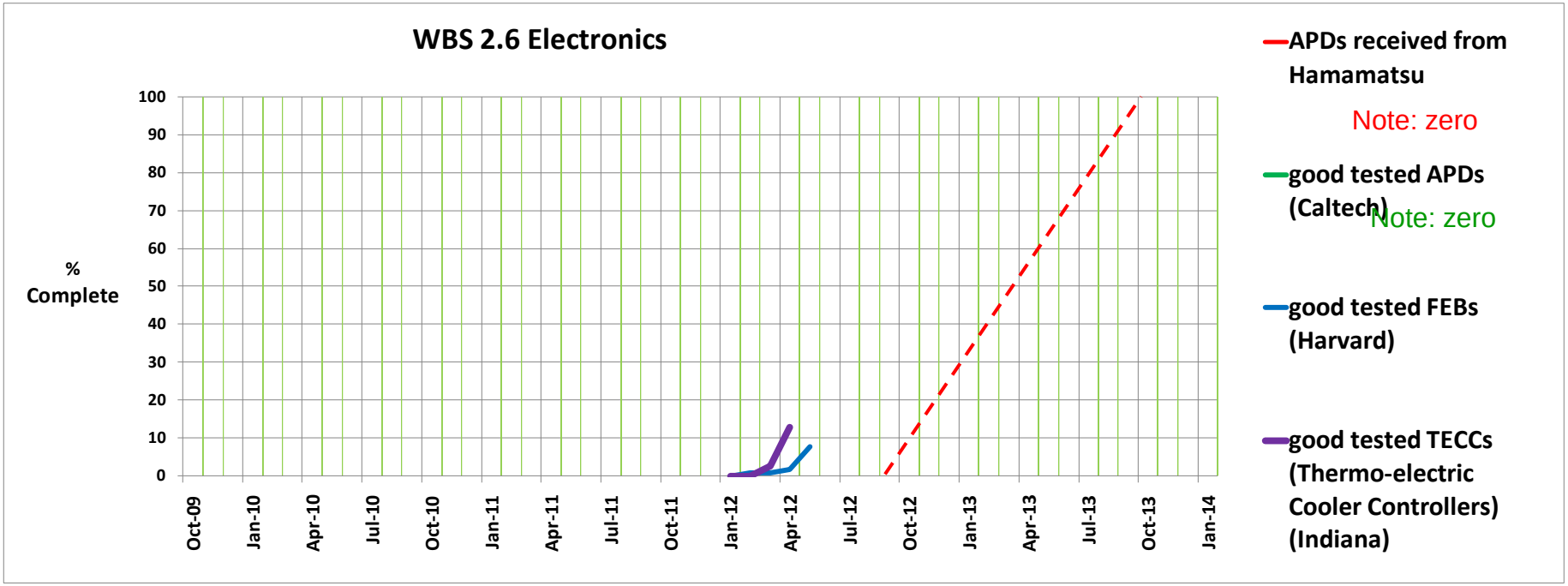


WBS 2.6 Electronics

- APD status for Near Detector
  - Air leaks into -15 ºC area next to APD,…, condensation & ice = **Dead APDs**
- Solution: Fix leaks & coat APDs so they don't die (belt & suspenders)
  - Reviewed by an outside Expert Committee last October
- After 3 tries on fixing leaks in Nov, Dec, Jan, went to our back-up plan:
  - A new Flow–through dry air system is in place on the prototype Near Detector
    - Design has 32 in series, with a flow meter at the end to adjust / limit the flow in the 0.1 – 1.0 SCFH range & a humidity monitor at the end.
  - 11 new APDs with new mounting boxes operating cold since April 23, 2012
    - 3 with Silicone, 8 with Parylene coating, all with passivated APD silicon.
- **Full APD delivery (12,000) on hold until we demonstrate successful cold operation on the prototype Near Detector**
  - Plan: Operate on Near Detector for 2 months with ~200 Silicone and ~240 Parylene coated devices
    - Leon Mualem will have more details on the cooling tests of coated APDs
  - Evaluate performance of Silicone and of Parylene, then choose one coating
  - Following choice (July), tell Hamamatsu to proceed, they start deliveries in ~2 months, finish in ~ 12 months.

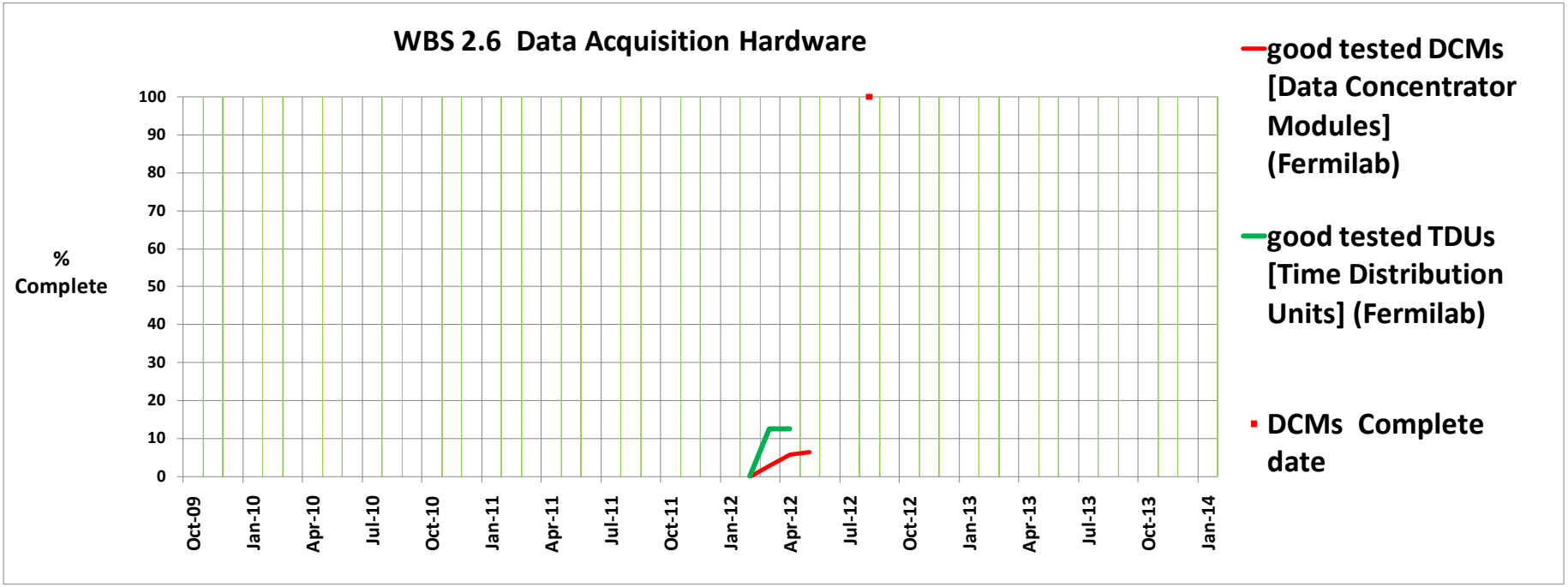
WBS 2.6 Electronics

- Front End Boards (FEBs) (Harvard) , need 11,136
  - **1st 100 stuffed boards were tested in February,** 86 OK
  - Held a Production Readiness Review in early March, then authorized to start building and testing all boards.
  - Now testing the first 2700
- Thermo-electric Cooler Controllers (Indiana), need 11,136
  - Now testing the first 3300



WBS 2.7 Data Acquisition

- Data Concentrator Modules (DCMs), need ~ 200
  - 5 Pre-Production DCMs tested at FCC test stand, a few patches added.
  - Now have 11 final boards completely tested
- Timing Distribution Units (TDUs)
  - 2 Types, Master (2 required at Ash River) & Slave (30 required at Ash River)
  - Have them all, 4 are completely tested
  - 2 Masters operating at Ash River for about a month now

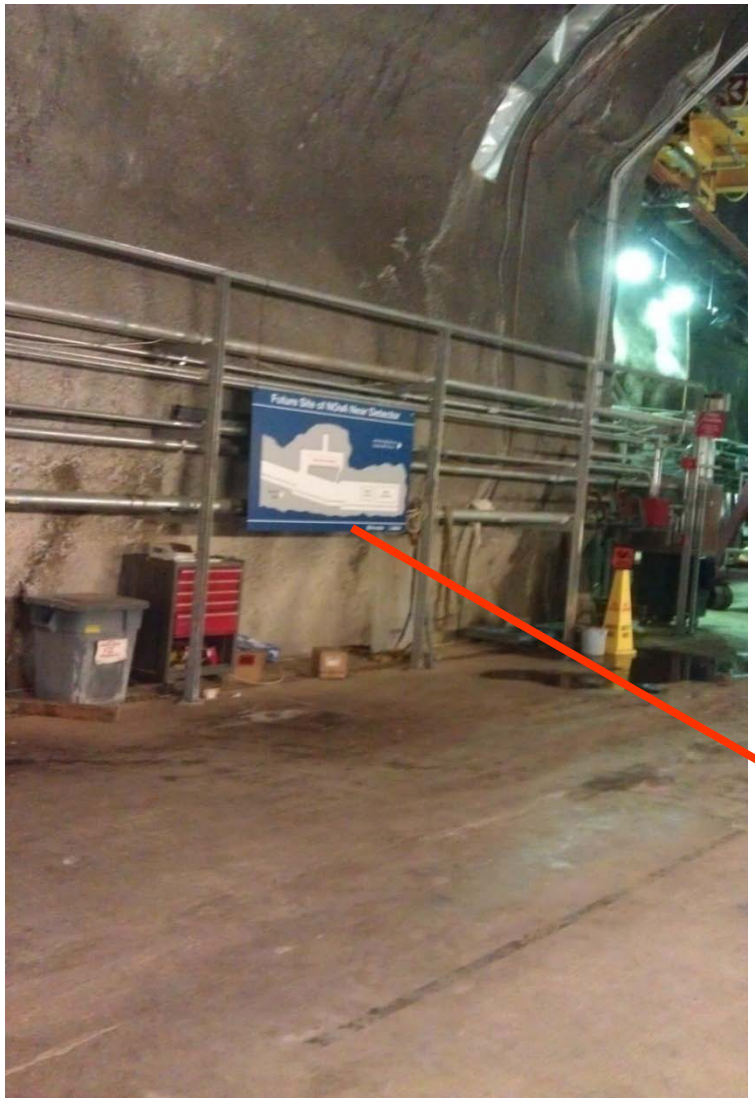


WBS 2.9 Assembly at Ash River & Detector Outfitting

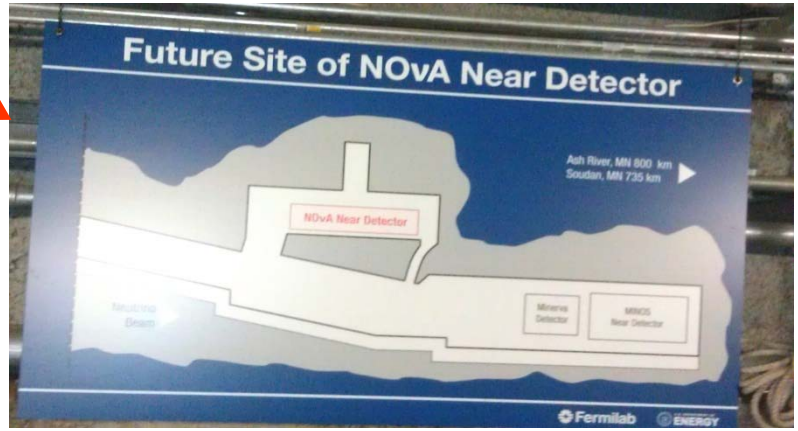
- The tools for assembly are in place and being reviewed for full operation by our ES&H Review Committee (see Lukens talk)
  - QA testers for fibers and PVC module pressure seals
  - Vacuum Lifting fixtures & Adhesive Machine
  - Block Pivoter
  - Real PVC Modules are at Ash River for first assembly trials
  - No graph yet, but we are close to starting this final step
- Outfitting, lots of progress
  - Divided WBS 2.6, 2.7, and 2.9 tasks so Tesarek runs this part (see Tesarek talk)
  - List of items we call “outfitting”:
    - Scintillator distribution system & filling of the detector with Scintillator
    - Cable and Power Supply installation
    - Electronics installation (APDs, Front End Electronics, Data Concentrator Modules, Timing Distribution Units)
    - Cooling system and Dry Air system installation (APD cooling)
    - Installation of Data Acquisition computing
    - An APD clean room
    - A Control Room with links to a Fermilab Control Room to be manned by Collaborators

WBS 2.8 Near Detector & Cavern

View downstream towards MINOS hall



View upstream towards MINOS shaft

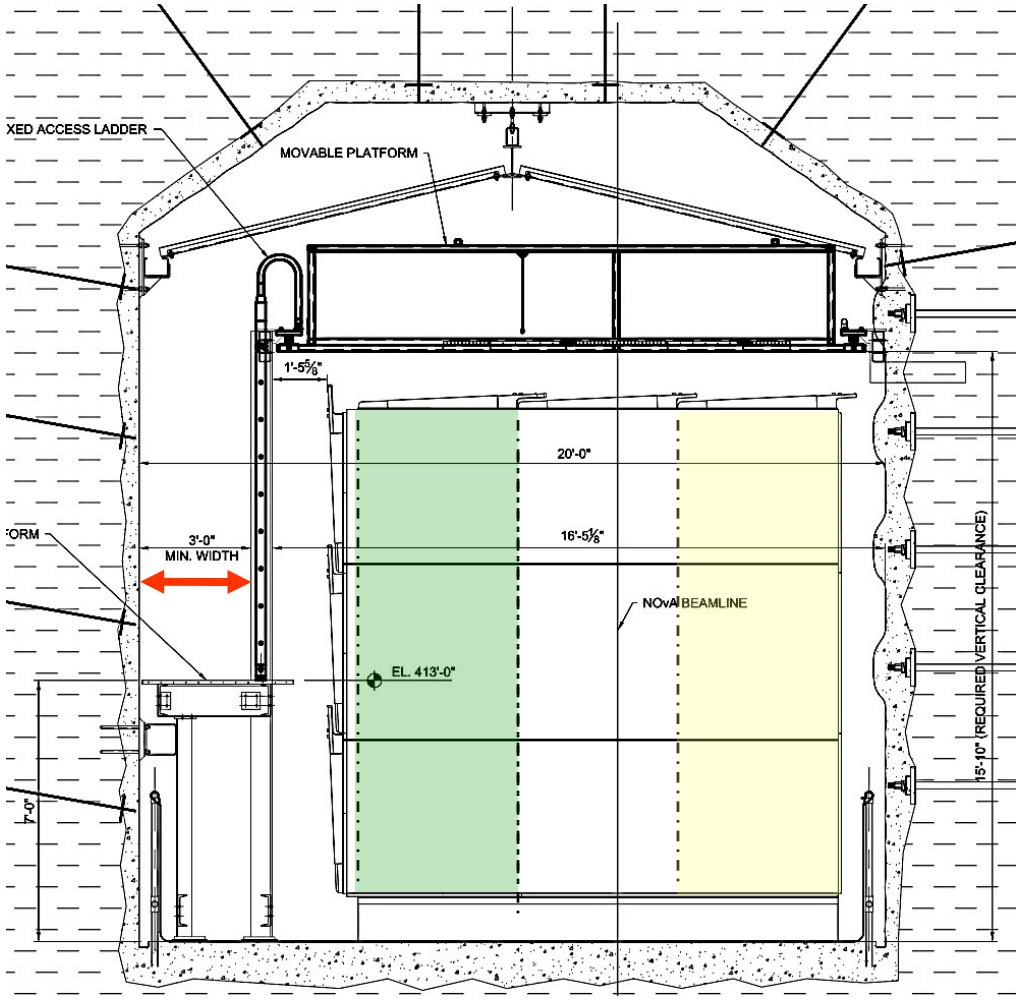


WBS 2.8 Cavern and Hall Schedule

- Request for Proposal out Dec 1 2011 to 13 potential bidders
- 2 bids received Feb 29 2012
  - Kiewit Infrastructure Company selected
  - $ 7.8 M, more than our estimate of $ 6.4 M
  - Roadheader construction method, no blasting

- Pre-construction meeting held April 19
- Schedule estimate (Detailed schedule submission from Kiewit ~ May 15)
  - Notice to proceed to start site preparation,
    sent to Kiewit yesterday May 7, 2012.
  - Equipment mobilization, June 2012
  - Tunnel excavation, July 2012 – Oct 2012
  - Hall outfitting, Nov 2012 - Apr 2013
  - Finish equipment demobilization, Apr 2013
- Fermilab Facilities & Engineering Services Section, Fermilab ES&H Section to oversee construction
  - Experience with NuMI is NOT forgotten
    - High expectations with Kiewit

New plan: 3x3 modules in the Cavern



- Collaboration requested 3x3 vs original plan of 2x3
  - Better event containment and better ability to evaluate systematics of neutrino production in NuMI beam.
  - Better ν_eCC efficiency, fewer NC with lost π^0

Detector	Energy	ν_e CC	NC	ν_μ CC	Fraction of NC with Lost π^0
ND 2x3 60	1-2 GeV	76.2±1.2%	82.1±2.2%	45.0±0.6%	11.9±2.9%
	2-3 GeV	79±1.2%	81.5±4%	35.4±0.5%	10.0±2.7%
ND 3x3 98	1-2 GeV	93.1±0.8%	93.1±2%	63.9±0.7%	6.8±3.4%
	2-3 GeV	93.1±0.8%	88.8±3.6%	51.5±0.8%	5.0±3.0%

- Project managed to fit 3x3 in existing cavern designed for 2x3
  - Hinged on ES&H approval of a 36” wide catwalk on the west side

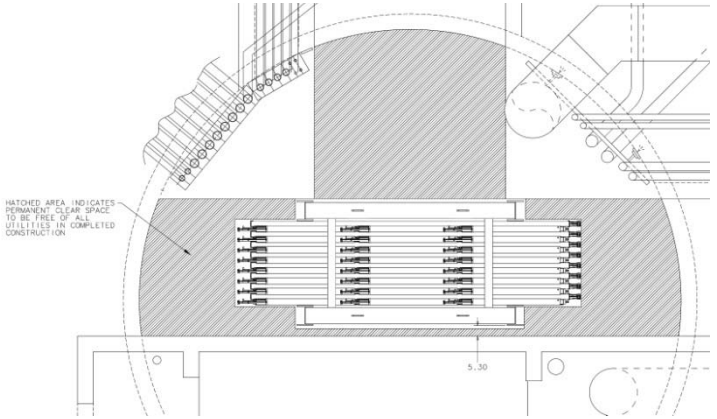
Complication: transport of 3x3 block over highways from ANL

- Risk to structure
- Plan to build on site in CDF east bay,
  move ANL prototype adhesive machine to Fermilab

November 2011

April 2012, decommissioning in progress,
Items removed in yellow area

WBS 2.8 Near Detector Design Tasks



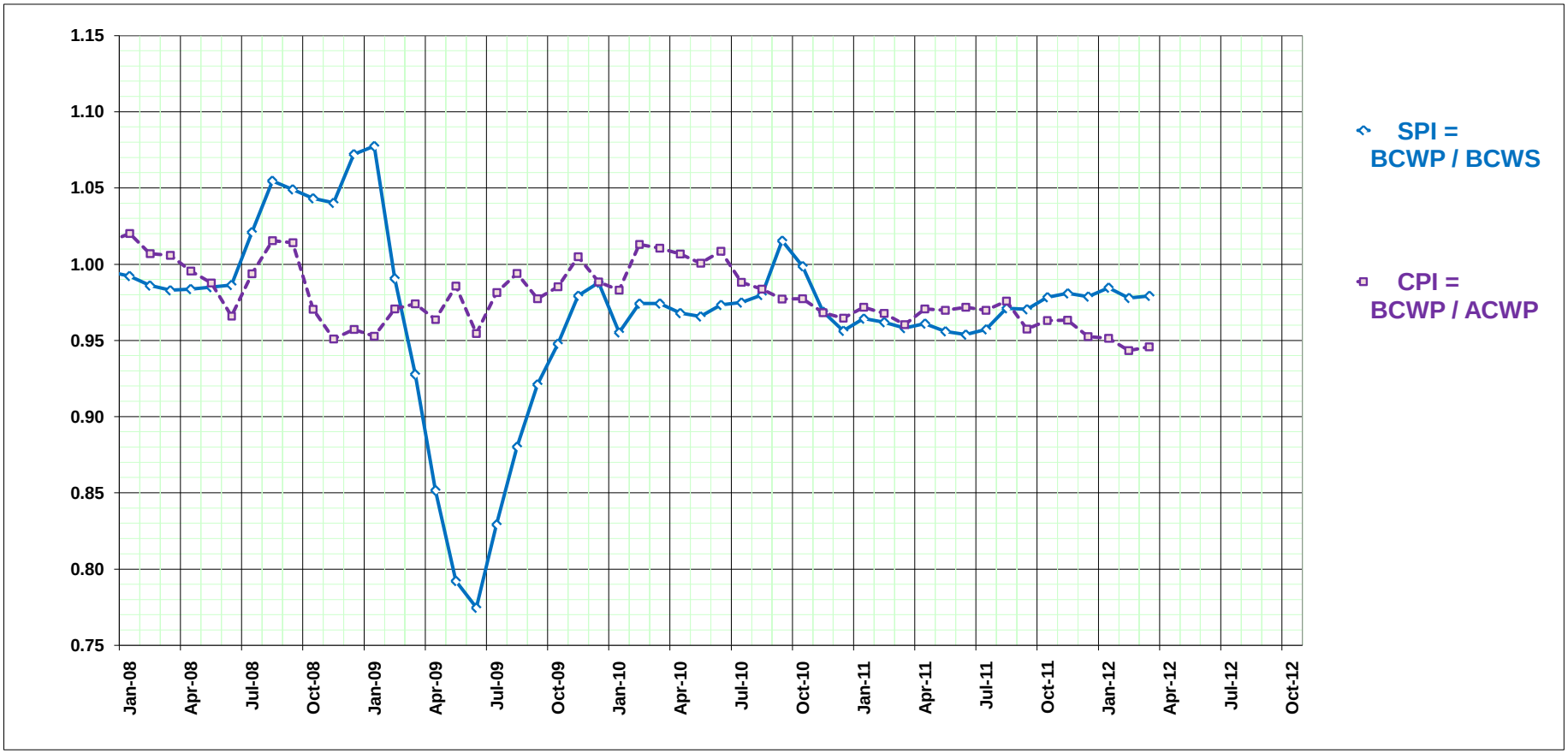
- This is still a Planning Package
  - Plan 16 plane blocks so they can get down the MINOS shaft
  - Engineering for block transfer through MINOS access tunnel
  - Engineering to positioning block in ND hall
    - South bookend
    - Rail tracks on top of spill containment lining for easy sliding
    - Tie-down/lockup for mechanical stability of thinner block
  - Wider block base frame (pallet), with removable wheels
  - Wider assembly table and new block transportation cradle
  - New muon-catcher support frame and installation procedure
  - New alignment posts (Far Detector-like) for tighter module position control
  - Scintillator filling equipment
    - Double wall Pipe down shaft, spill containment on shaft base
- A long list, but we did these tasks for the prototype Near Detector and now just have to do them again for slightly different circumstances

WBS 2.8 Planning: **Who? What?**

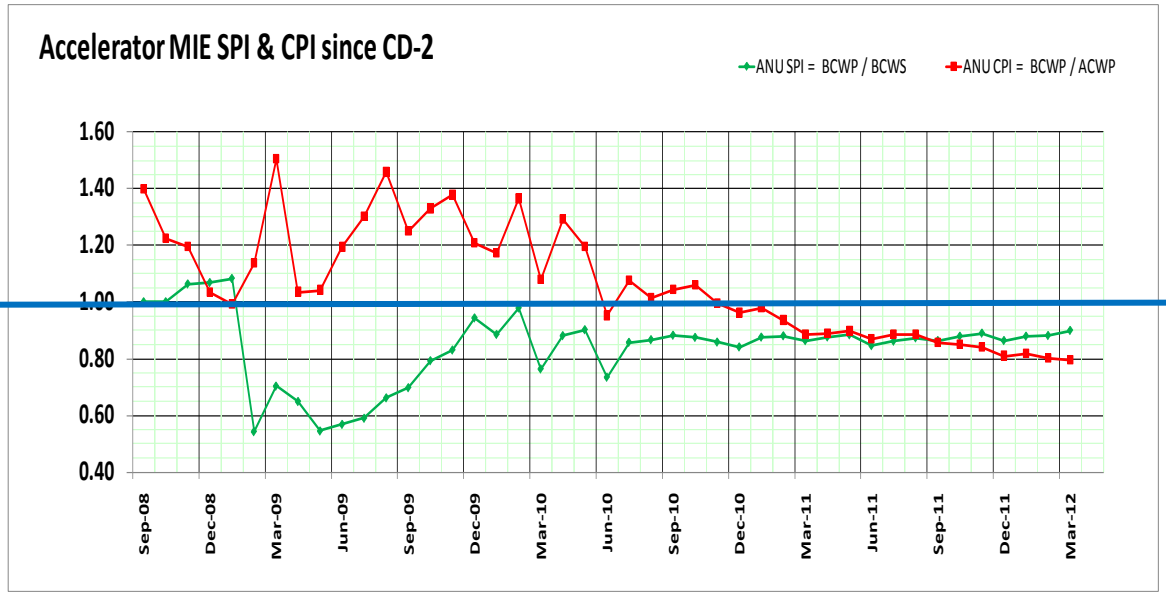
- **New Level 2 Manager (Ting Miao, Fermilab)**
- PPD mechanical engineering NOvA team to continue on ND structure, assembly and installation designs
  - Start as soon as Far Detector blocks are in production
- PPD technicians expected for block assembly and installation
  - Small team of ~ 4-5, similar to the team used at ANL for prototype
- NOvA Collaboration help expected in many areas
  - Module leak test and optical fiber connectivity
  - Block assembly QA/QC, alignment/survey, coordination etc.
- Cavern excavation and hall outfitting drive the schedule
  - We have about a year before the Near Detector installation can begin
  - Experience with prototype Near Detector indicates we can fit all this in during the remaining 1+ year to CD-4 in November 2014
    - Still, exploring interleaving of tasks with Kiewit construction
- **WHAT MATERIAL?** Plan to use out of spec extrusions and out of spec modules from Far Detector production as source of PVC (50 ft cut into 3 x 13 ft)
  - Have ~ 150 (extrusion + modules) now = 78% of Near Detector

EVMS Reporting Overview

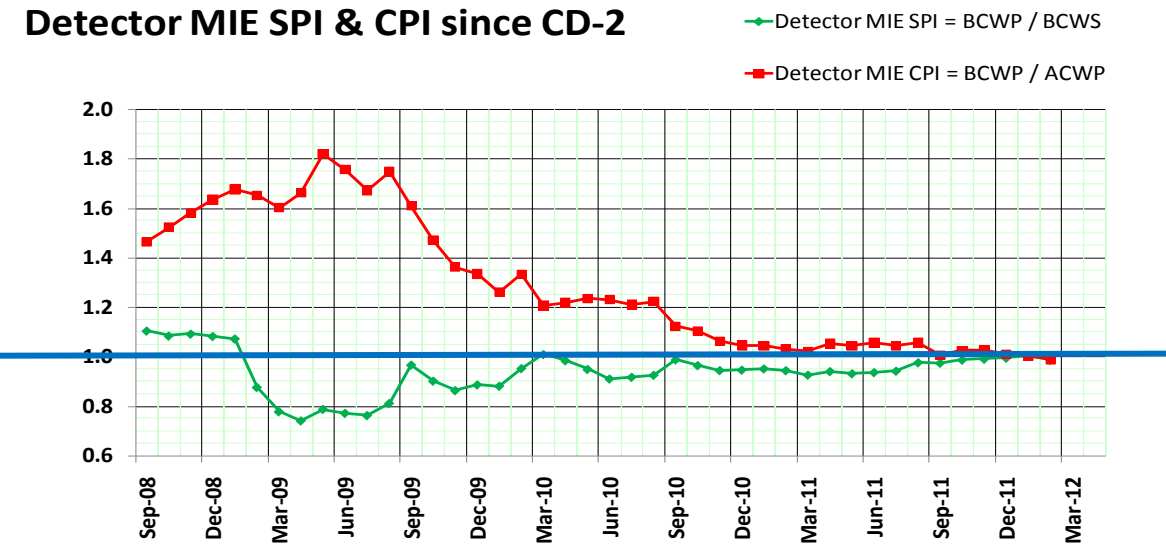
- Data now available through **March 2012**
  - SPI = **0.979**, compare to 0.978 in Feb, 0.985 in Jan, 0.979 in Dec, 0.981
  - CPI = **0.946,** compare to 0.943 in Feb, 0.951 in Jan, 0.952 in Dec, 0.963



SPI & CPI for Active Work



- Accelerator work shows long slide down to CPI = 0.8
  - 20% of slide is due to RF technical problems
  - Additional labor overrun in CR487
  - For 4 months of shutdown effort, added ~15% to base, reducing Management Reserve based on experience to date
  - Accelerator portion is 15% of remaining cost.



- Detector relatively constant near CPI = SPI = 1.0
  - Detector portion is 85% of remaining cost

Bottoms up Cost Estimate

- We have gone back through our Basis of Estimate documents and reviewed each one
  - The status is shown below
  - LEFT is at the last IPR in Aug 2011, RIGHT is today's status

May 2012

Cnt %		BOE Status - 5/8/2012	Total
62%		a) Tasks are complete, no change necessary	279
13%		b) Not changed, tasks will complete by end of CY12, and ETC forecast keeps track of anticipated contingency use	59
23%		c) Reviewed, no changes required	102
1%		d) Updated, CR completed	4
1%		e) New activity, new BOE, CR completed	5
		Grand Total	449

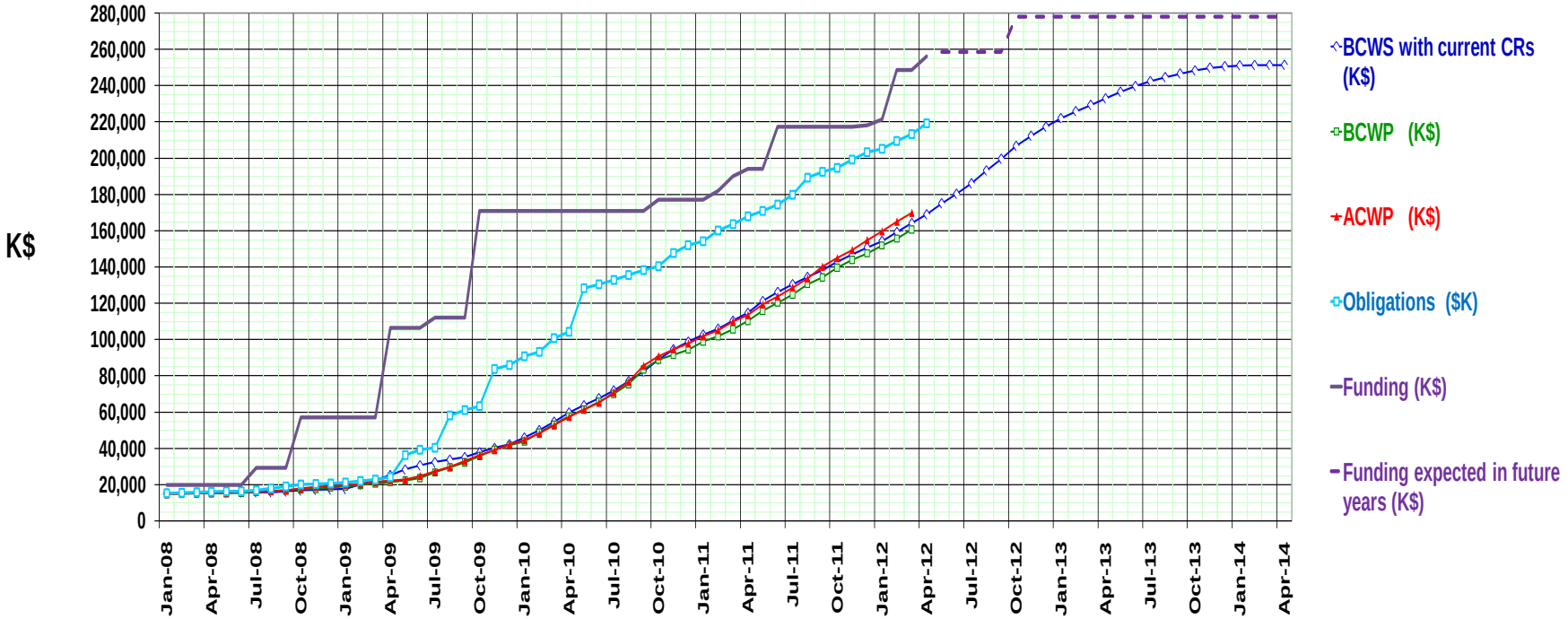
August 2011

%		Status of BoEs	Total
50%		a) Tasks are complete, no change necessary	218
8%		b) Not changed, tasks will complete by end of CY11, and ETC forecast keeps track of anticipated contingency use	36
33%		c) Reviewed, no changes required	145
7%		d) Updated, CR completed	31
2%		e) New activity, new BOE, CR completed	8
0%		f) Reviewed, BOE updated but has a small cost change, no CR done	1
0%		h) Reviewed and updated BOE, no CR completed yet	1
		Grand Total	440

Updated 39 of 222 at last IPR (18%),
Updated only 9 of 170 this time (5%)

EVMS Reporting Overview

- Basic data in BCWS, BCWP, ACWP, **Funding** & **Obligations** through Mar 2012
  - BCWS = Budgeted cost of work Scheduled
  - BCWP = Budgeted cost of work Performed
  - ACWP = Actual cost of work Performed
- Project is 64.0 % complete (BCWP/BAC = 160.8 M$ / 251.4 M$)
  - BAC = Budget at Completion (using EAC, get 62.1 %)
- Project is 87.2 % obligated as of May 1 (Obligations/BAC = 219.3 / 251.4)
  - EAC = Estimate at Completion (using EAC, get 84.7 %)



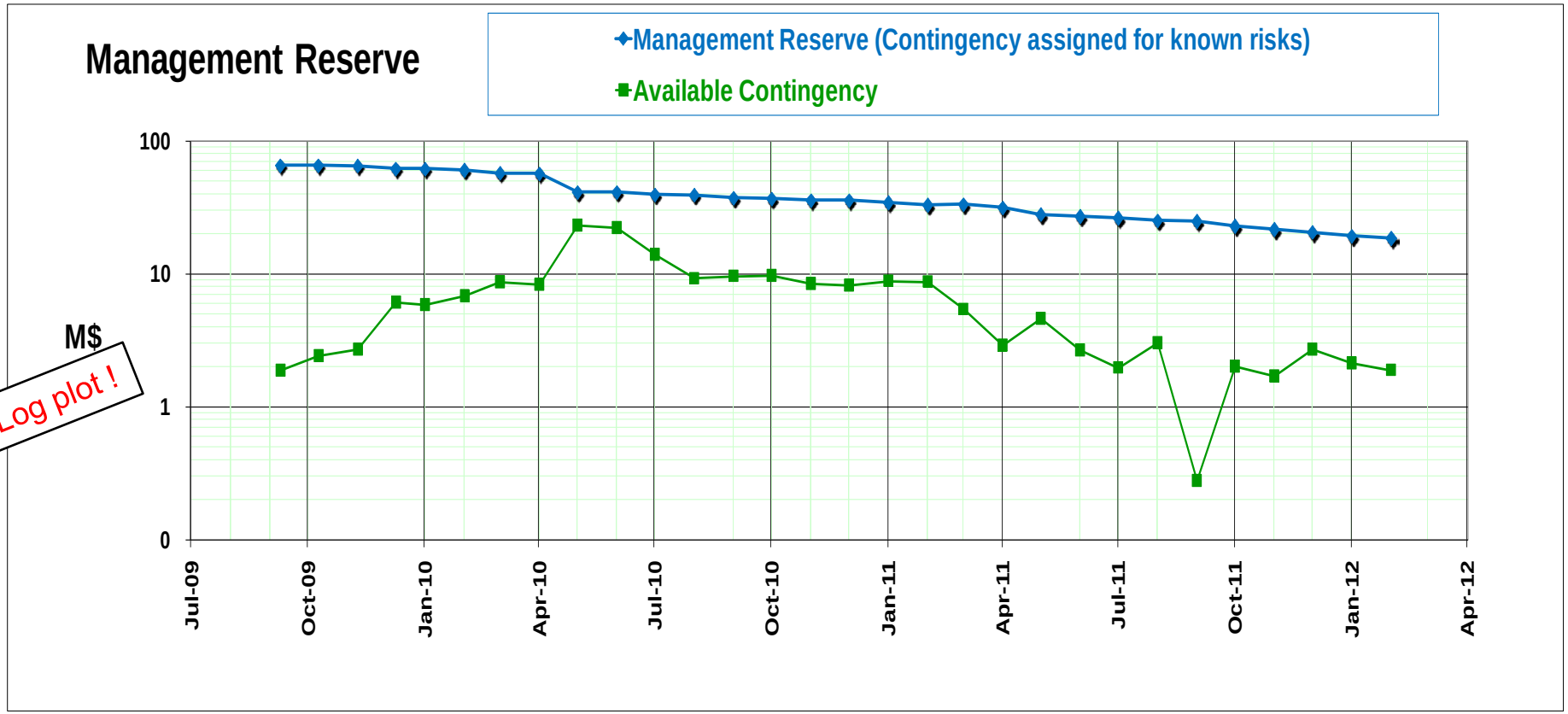
AY$ by Level 2 with MIE/OPC split

	WBS	Items	NOvA Costs to Date ($M) as of 31-Mar-2012	NOvA 's Cost Estimate AY $M (for April 1, 2012 to project end) Estimated Cost (with indirects) M&S	Labor[1]	Total	Mgmt Reserve Estimate M&S	Labor[1]	Total	Contingency % M&S	Labor[1]	Total	Total Cost
TEC	2.0	Accelerator & NuMI Upgrades	$ 25.3	$ 2.1	$ 10.2	$ 12.3	$ 1.2	$ 2.1	$ 3.3	57%	20%	26%	$ 40.9
	2.1	Far Detector Site and Building	$ 5.8	$ 0.1	$ 0.0	$ 0.1	$ 0.0	$ 0.0	$ 0.0	3%	19%	5%	$ 5.9
	2.2	Liquid Scintillator	$ 8.7	$ 13.4	$ 0.2	$ 13.7	$ 3.3	$ 0.1	$ 3.4	24%	42%	25%	$ 25.7
	2.3	Wave-Length-Shifting Fiber	$ 10.4	$ 2.3	$ 0.2	$ 2.5	$ 0.1	$ 0.0	$ 0.1	5%	11%	5%	$ 13.1
	2.4	PVC Extrusions	$ 15.0	$ 14.9	$ 0.6	$ 15.5	$ 0.9	$ 0.1	$ 1.0	6%	21%	7%	$ 31.5
	2.5	PVC Modules	$ 8.1	$ 3.9	$ 6.5	$ 10.4	$ 0.3	$ 1.0	$ 1.3	9%	15%	13%	$ 19.9
	2.6	Electronics Production	$ 4.6	$ 6.1	$ 1.1	$ 7.2	$ 0.4	$ 0.3	$ 0.8	7%	28%	11%	$ 12.5
	2.7	Data Acquisition System	$ 3.1	$ 0.9	$ 0.6	$ 1.6	$ 0.2	$ 0.2	$ 0.4	22%	33%	26%	$ 5.1
	2.8	Near Detector Assembly	$ 2.5	$ 4.8	$ 0.4	$ 5.2	$ 1.0	$ 0.1	$ 1.1	20%	38%	22%	$ 8.8
	2.9	Far Detector Assembly	$ 9.7	$ 7.0	$ 8.2	$ 15.2	$ 1.4	$ 3.9	$ 5.3	20%	48%	35%	$ 30.3
	2.10	Project Management	$ 6.5	$ 0.2	$ 3.9	$ 4.0	$ 0.0	$ -	$ 0.0	25%	0%	1%	$ 10.5
		Subtotal Construction	**$ 99.8**	**$ 55.6**	**$ 32.0**	**$ 87.7**	**$ 8.9**	**$ 7.9**	**$ 16.8**	**16%**	**25%**	**19%**	**$ 204.2**
OPC		**R&D - Accelerator**	$ 6.6	$ -	$ 0.0	$ 0.0	$ -	$ 0.0	$ 0.0	0%	20%	20%	$ 6.6
		R&D - Detector	$ 28.1	$ -	$ -	$ -	$ -	$ -	$ -	0%	0%	0%	$ 28.1
		Cooperative Agreement	$ 34.9	$ -	$ -	$ -	$ -	$ -	$ -	0%	0%	0%	$ 34.9
		Operating	$ 0.6	$ 0.0	$ 1.2	$ 1.2	$ 0.0	$ 0.2	$ 0.2	42%	15%	16%	$ 2.0
		Total OPC:	**$ 70.2**	**$ 0.0**	**$ 1.2**	**$ 1.2**	**$ 0.0**	**$ 0.2**	**$ 0.2**	**42%**	**15%**	**16%**	**$ 71.7**
		Available Contingency							**$ 2.163**				**$ 2.2**
		TPC:	**$ 170.0**	**$ 55.7**	**$ 33.2**	**$ 88.9**	**$ 8.9**	**$ 8.1**	**$ 19.1**	**16%**	**24%**	**22%**	**$ 278.000**

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

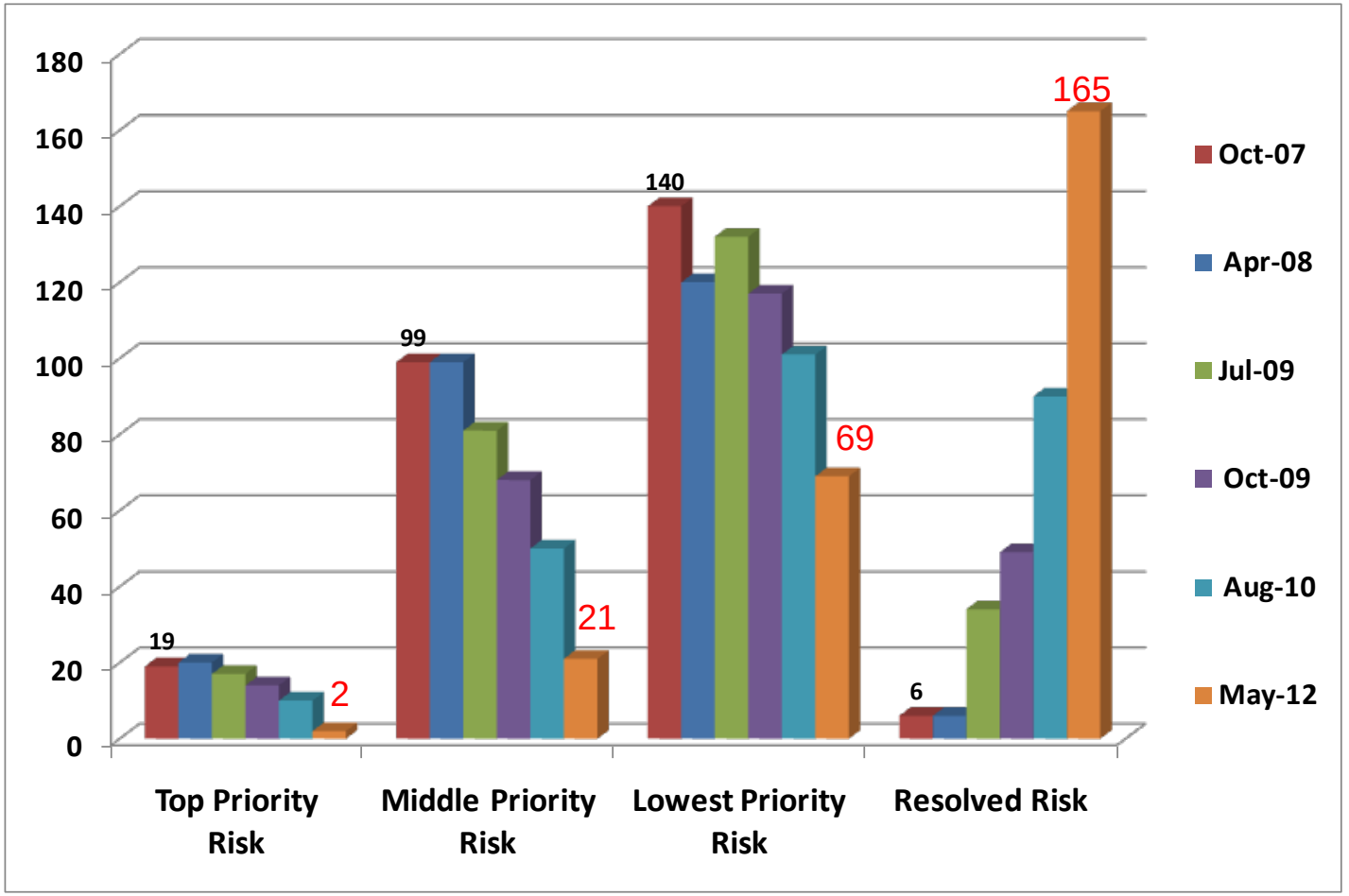
Contingency Status, Mar 2012

- **Total Contingency is 19.1 M$** (Feb= 20.5, Jan= 21.4, Dec= 23.3)
  - 22.2 % Contingency on remaining work (Estimated Cost is 88.9 M$)
  - 42.7 % on remaining Obligations (EAC-Obligations to date).
    - Obligations are ~ 43 M$ ahead of Costs
- **Available Contingency = $ 2.163 M$** (Feb= 1.889, Jan= 2.124, Dec= 2.71)
  - Management Reserve or Assigned Contingency is assigned according to estimate of remaining risks



Status of Risks

- ~250 Risks identified, 165 have been resolved (66%)
- Here is a graph of Risks vs. time
  - This is a series of snapshots from our Access database of Risks.



Score based on impact & probability matrix. See Risk Plan

Top ten risks (Sorted by tolerance, then by score, April 2012)

Activity	Risk	Score	Tolerance	Event	Owner	Cause	Consequence	Details
2.9.4 - Block Assembly and Installation	185	0.66	Top Priority	Adhesive failure causes structural failure	Lukens	Shear and peel stresses in plane adhesive bonds exceeds adhesive strength	Structural failure of blocks during or after filling. Adhesive supporting horizontal modules from vertical modules fails. Possibility of large liquid scintillator spill. Detector installation would be stopped until a solution was found.	See NOVA-doc-500 (NOvA Risk Form) for details.
2.0.3 - NuMI Upgrades	39	0.35	Top Priority	Insufficient manpower, takes longer	Derwent	Operational issues require people and/or higher priority projects.	Takes longer to complete work.	See NOvA Risk Form in NOvA-Doc-1446.
2.0 - ANU Construction	92	0.28	Middle Priority	Work can not be accomplished as planned	Derwent	Lack of needed AD & FNAL resources to accomplish the work	Work to get TD/PPD manpower to help and contract help - takes longer as those people need to be trained/overseen and thus costs more	See NOvA Risk Form in NOvA-Doc-1446.
2.2.1.5 - Mineral Oil Production and Delivery	506	0.27	Middle Priority	Mineral oil cost more than base cost	Mufson	Due to fluctuations of the price of crude oil and the following indices diesel fuel, producer price index and the base oil cost as published in the Lube report.	Mineral oil procurment requires the use of contingency money	To account for fluctuations over time we use independant scaling index to accompany the quotes. The quotes give us the base cost and the indices help determine the contingency(see NOvA-doc-681) A CR was issued to assign 30% contingency to theses procurements.
2.2.5.3 - Far Detector Scintillator Transport	170	0.25	Middle Priority	scintillator deliveries must be halted	Mufson	schedule delays in detector construction; mounting blocks halted	transportation of scitnillator to Ash River must be halted since there is no storage infrastructure at Ash River	build possibility of delays in transporting scintillator to Ash River into contract with trucking company. some contingnecy to cover some cost overruns due to this issue.
2.9.1.4.11 - Test block pivoter	126	0.23	Middle Priority	unanticipated problems encountered in pivoter test	Lukens	design issues, component quality, assembly difficulties	schedule delay, cost increase in order to fix the problem.	Will have extensive design reviews. This assembly is to detect problems before it is shipped to Ash River so it can be corrected by FNAL experts who designed it. Some contingency on this task to cover issues. There is also ample schedule float to cover most issues. We now have experience with the prototype and are using the experience to mitigate problems in finial pivoter.
2.9.4.3 - Block Assembly and Alignment	130	0.21	Middle Priority	block assembly takes longer than planned	Lukens	The ten minutes per module handling time that is currently planned is found to be overly optimistic.	Might need to have more elaborate equipment, might need more people working longer hours.	Present estimate is based on crane speeds and MINOS detector assembly experience. Time and motion studies are planned to measure the handling time per module. This on the critical path. Some contingency to cover the costs of this. We are now using compresion plates which will require additional time.
2.0.1.1.1.14 - Installation	8	0.20	Middle Priority	Takes longer than expected	Derwent	Unforeseen circumstances in tunnel, overlap of activities in same area, radiation levels higher than expected	Installation shutdown is longer/costs more/requires more people	See NOvA Risk Form in NOvA-Doc-1964.
2.0 - ANU Construction	99	0.20	Middle Priority	Installation takes longer than expected	Derwent	Unforeseen circumstances in tunnel, overlap of activities in same area,	ilstallation shutdown is longer/costs more/requires more people	See NOvA Risk Form in NOvA-Doc-1964.
2.6.1.2 - APD Arrays	193	0.20	Middle Priority	Delivery lags schedule	Mualem	Vendor performance	delays installation	Begin sole sourced delivery early

Risk and Contingency

	WBS	Items	NOvA Costs to Date ($M) as of 31-Mar-2012	NOvA 's Cost Estimate AY $M (for April 1, 2012 to project end)									
				Estimated Cost (with indirects)			Mgmt Reserve Estimate			Contingency %			Total
				M&S	Labor[1]	Total	M&S	Labor[1]	Total	M&S	Labor[1]	Total	Cost
TEC	2.0	Accelerator & NuMI Upgrades	$ 25.3	$ 2.1	$ 10.2	$ 12.3	$ 1.2	$ 2.1	$ 3.3	57%	20%	26%	$ 40.9
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		R&D - Detector	$ 28.1	$ -	$ -	$ -	$ -	$ -	$ -	0%	0%	0%	$ 28.1
		Cooperative Agreement	$ 34.9	$ -	$ -	$ -	$ -	$ -	$ -	0%	0%	0%	$ 34.9
		Operating	$ 0.6	$ 0.0	$ 1.2	$ 1.2	$ 0.0	$ 0.2	$ 0.2	42%	15%	16%	$ 2.0
		Total OPC:	**$ 70.2**	**$ 0.0**	**$ 1.2**	**$ 1.2**	**$ 0.0**	**$ 0.2**	**$ 0.2**	**42%**	**15%**	**16%**	**$ 71.7**
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		TPC:	**$ 170.0**	**$ 55.7**	**$ 33.2**	**$ 88.9**	**$ 8.9**	**$ 8.1**	**$ 19.1**	**16%**	**24%**	**22%**	**$ 278.000**

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

Contingency Use Plan

- Link from Review webpage

NOvA Contingency Use Plan (updated version for May 2012 IPR)

(Sorted by expected decision date, Project Manager's estimate)

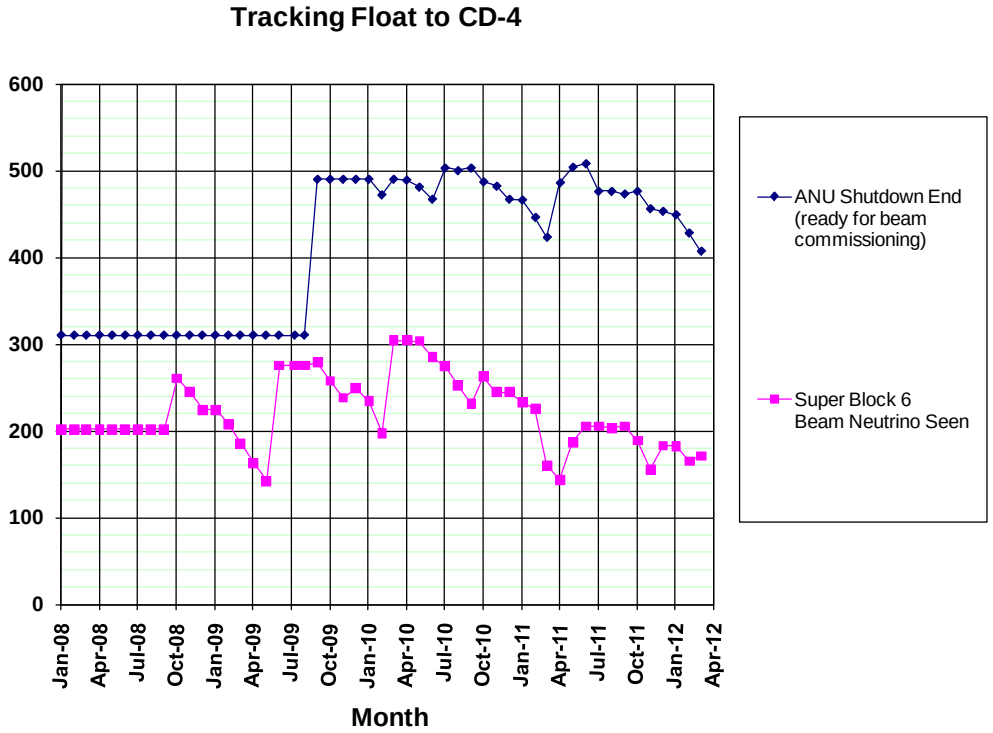
Item Description	Current Cost Estimate (K$) (does not include contingency)	Current Decision Date Estimate	Comments (blue comments are new for this IPR)
Build a new Near Detector with identical thick plastic as Far Detector	1,000	already decided before last IPR in August 2011, cost still being assessed	Size & cost depends on size of cavern on next line. Size now known to be 3 x 3 modules. Basic parts exist as rejects from Ash River module failures. Some additional assembly costs ~ 300 K$, 1/4 of Far blocks, but 6 of them (Now perhaps only 5-6 blocks since more mass)
Design to increase transverse size of Near Detector Cavern	300	Not needed, 1/1/2012	
RFP for larger Near Detector Cavern once design in hand	500	rejected, 1/1/2012	not needed
Add 2nd Near Cavern to RFP as an option	-	Done, 12/1/2011	would be a duplicate of 1st cavern
Recover Far Detector 30th block (then close to 15 kt)	5,000	1-Aug-12	All $ for 30th block now removed from schedule. Price is calculated from MIE Detector total / 29 blocks. Decision Date stems from need to buy Kururay fiber in Summer 2012. Early decisison date implies the most likely decision is to reject this item. Fiber cost for 1 block is about 500K$, so don't have to bite it all off, but if we buy the fiber and don't build the block...
Add additional 6" of Barite shielding over Far Detector	500	1-Aug-12	Need input from a fully instrumented protoype Near Detector. Will get this data from new APDs running on the prototype Near Detector this summer.
Exercise Option for 2nd Near Cavern	3,500	1-Oct-12	Cheaper than the 1st cavern, no mobilization overheads, cost dominated by excavation. This price is unchanged but is now the sum of the excavation and outfitting bid from the selected Cavern contractor.
Build a 2nd Near Detector for short baseline oscillations	500	1-Oct-12	Proponents opt for cheapest option: to re-use the prototype Near Detector, then only installation costs.
Build SciNOvA front end for Near Detector	150 - 2500	1-Oct-12	Proponents will pursue NSF funding in early Fall 2012 except for installation costs (estimated at 150 K$)
Build a testbeam module of the NOvA detector	500	1-Apr-13	Proponents are doing simulations on the required size. 1x 1 module or 2 x 2? Probably only 3 or 4 blocks long. Basic parts exist as rejects from Ash River module failures. Assembly must follow assembly of KPP Near Detector, therefore decide when Near Detector is done.
Build additional Far Detector mass, up to 3 additional kt (10,000 K$ per kt)	10,000	rejected, 4/1/2012	I can't imagine doing any more than recovering the 30th block

Prospects for Contingency Use Plan

- At the moment, I don't see how we can do any of the scope changes listed in the plan
  - **We need to make sure the KPPs can be satisfied:**
  - Scintillator: price of mineral oil is on the edge
  - Fiber: may need more for PVC module factory waste
  - PVC: will need more for PVC resin waste during R&D and production
  - Minnesota Factory Labor: need to see production rate
  - Ash River Labor: need to see production rate
- We are becoming trapped by time constraints for any scope changes:
  - Lack of available contingency at the time of decisions
    - Most are in August – October 2012, this year
    - Not clear that we will know the cost of steady state operations in the Minnesota Module Factory or at Ash River on this time scale.
  - Trapped on the other side by the lack of time to execute scope changes prior to CD-4 if we decide to do them later than the dates in the plan.
- Will know more in six months…..

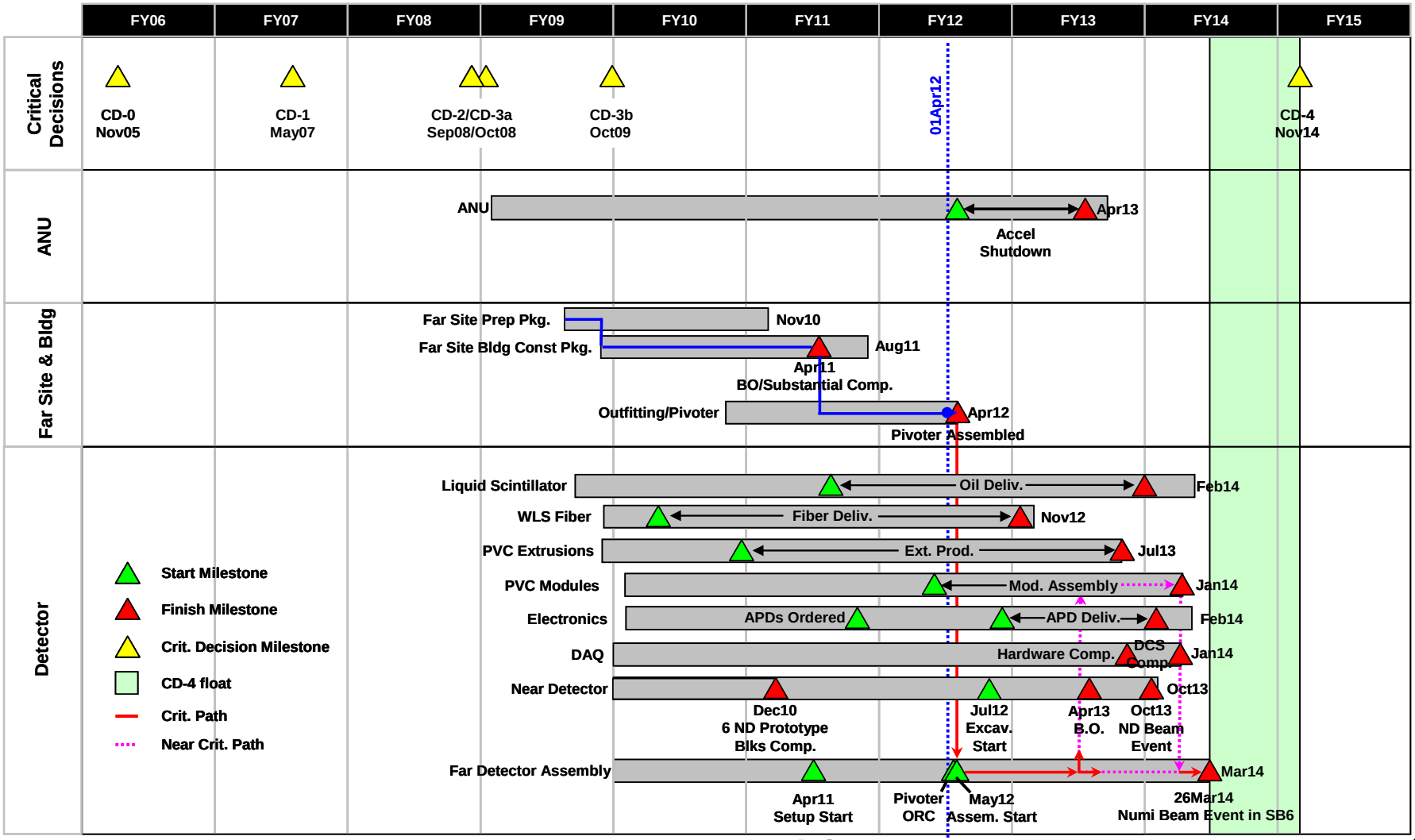
Milestones: What about CD-4 ?

- **ANU lost 21 days of float in March -- Now at 401 days**
  - Kicker and RF schedules drive this float, lost 2 weeks on front for Accelerator cool-down period since high intensity operations continued to end of run.
- **The Detector gained 6 days of float in March -- Now at 171 days**
  - We tried to compensate for 17 days lost in February by adding a 5th workday every week for Ash River assembly of 8 more blocks in March (already did this for blocks 4 through 11 in Feb) but ran into a new problem of too few PVC modules available from the Minnesota Factory to do the faster rate.
    - So the Factory becomes the critical path at about block #14
    - Our assigned Ash River Assembly contingency was always set by the cost of perhaps adding overtime or a 3rd shift. We have now put overtime in the schedule & reduced the contingency by the 10% extra cost
    - This does not mean we "know" the assembly schedule better, but shows that we can compensate using our plan.
    - We won't know the required labor at Minnesota or at Ash River until we get to steady production.
    - **Clearly the critical path can move quickly between the Factory and Ash River**



Schedule Critical Path

- Here is the “schedule on a page”
  - The Detector portion has many parts moving in parallel, has “buffers” between parts
  - Note critical path splits between PVC Modules and Ash River Assembly in mid-FY13



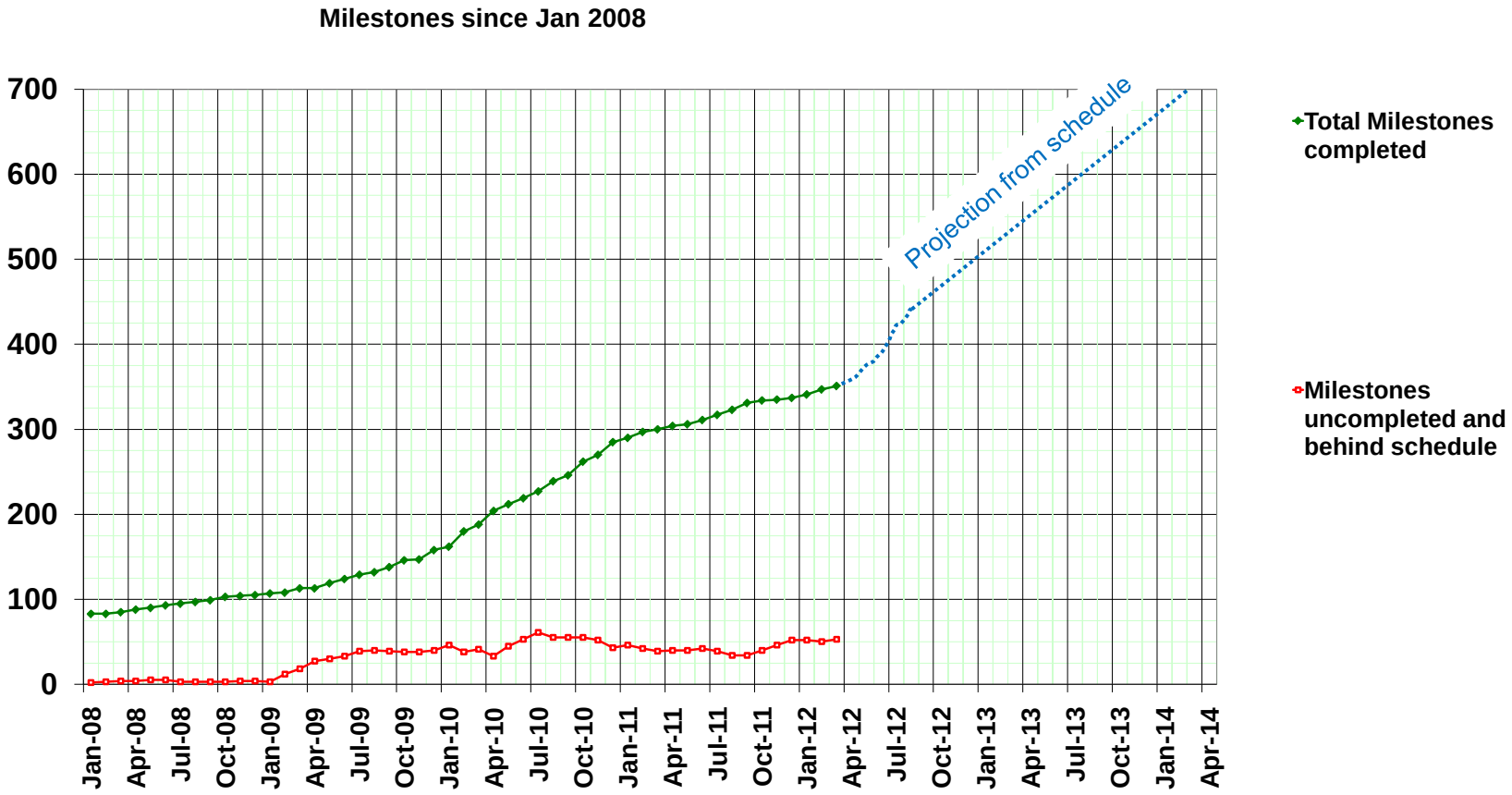
Schedule Contingency

- As of April 1, 2012, we show completion of the project on March 26, 2014
  - That's 498 workdays from April 1
- The float to CD-4 is 171 workdays.
- So the schedule contingency is 171/498 or 34%

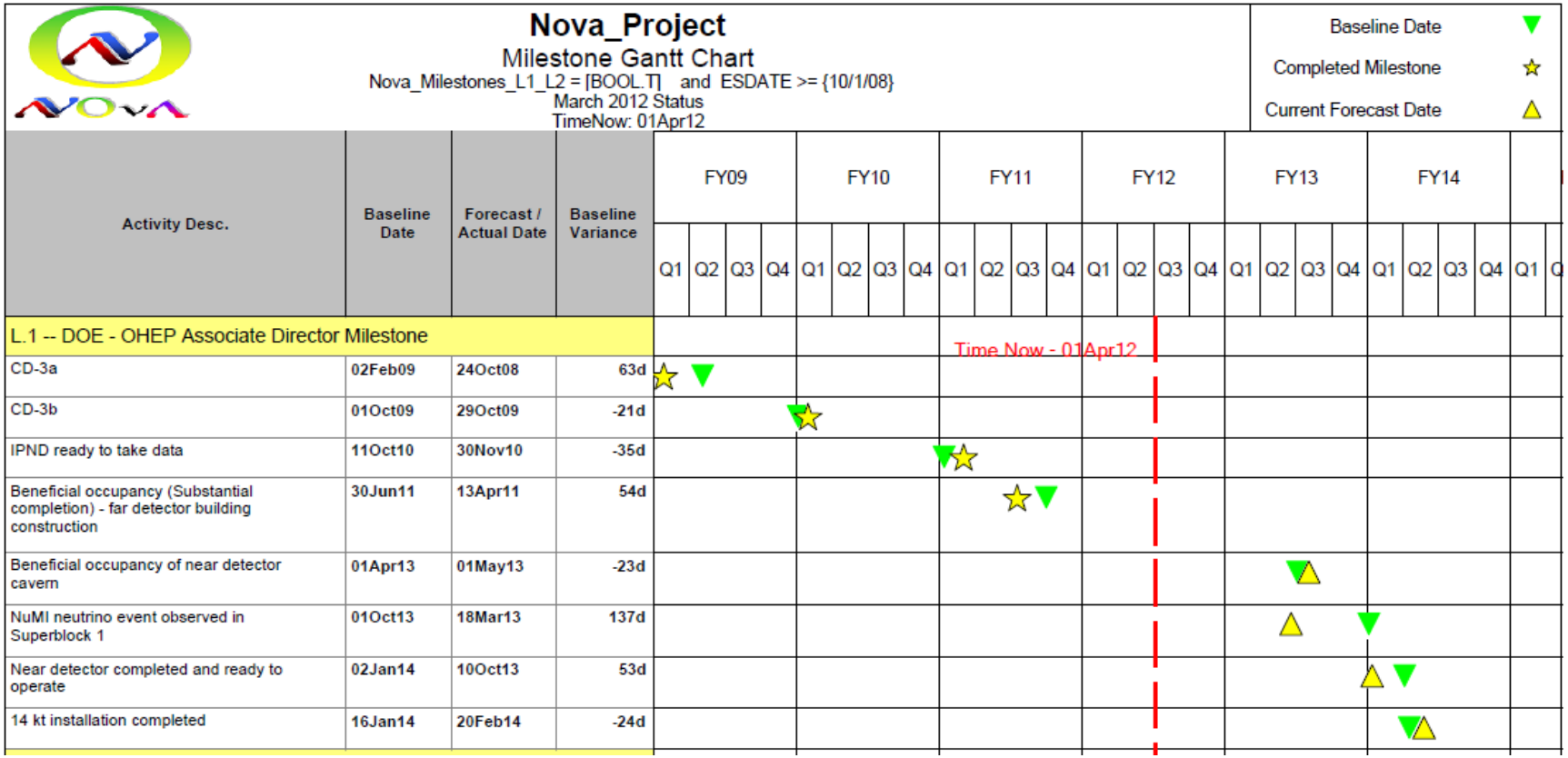
- Similar calculation by months:
  - 24 months to complete project (April 1, 2012 to March 26, 2014)
  - Float is 8 months (March 26, 2014 to November 26, 2014)
  - 8/24 = 33%

Analysis of all milestones

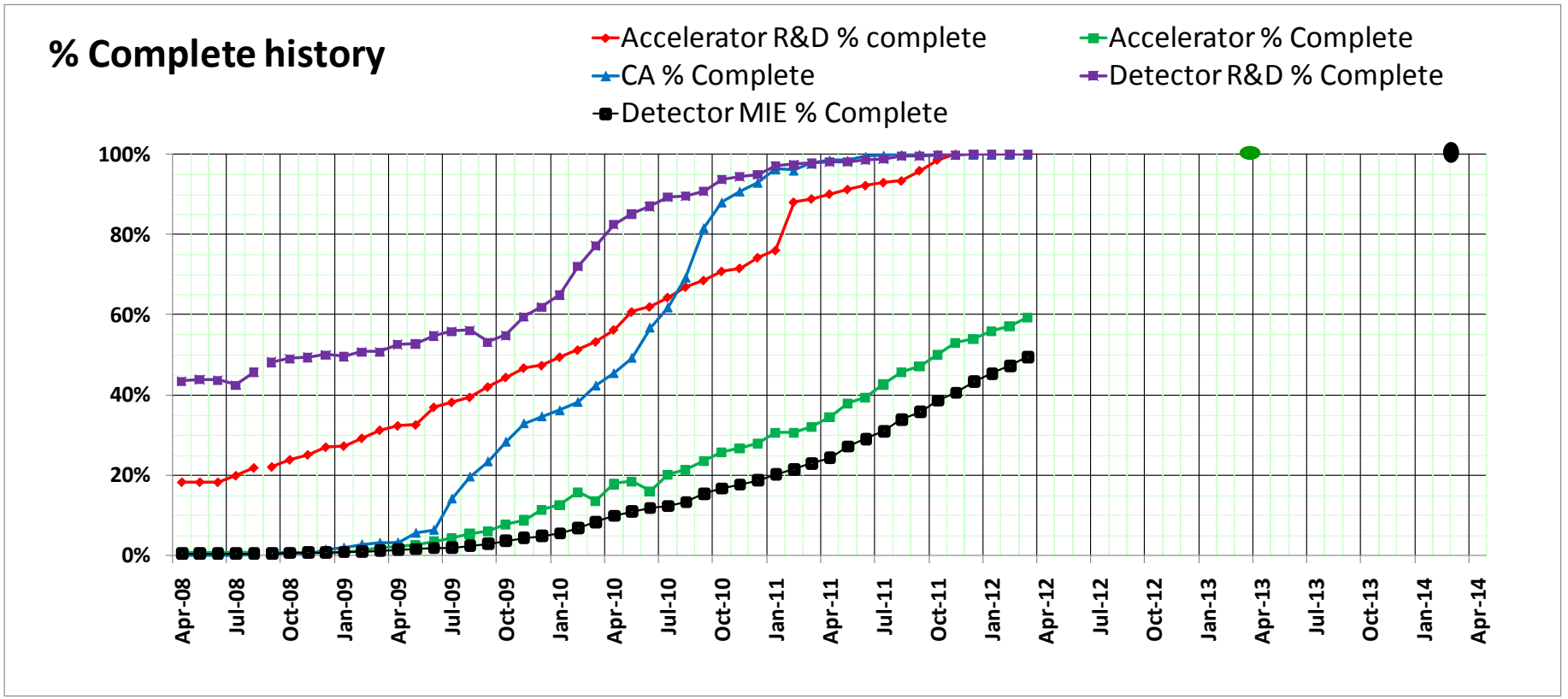
- **351 of 694 now complete**
  - 4 completed in March
  - Total of 500 milestones at last IPR, since added 194 for outfitting at Ash River
- **Behind on 53,** ~ steady state ~ 50, but different milestones each month



Milestones held by DOE - OHEP



% Complete history for the **5** Main parts of the Project



- Building & Detector R&D & ANU R&D are all done
- ANU at 59.4%, to be complete by ~ April 2013
- Detector at 49.5%, to be complete by ~ March 2014

Status of Recommendations from the August, 2011 IPR

Recommendation	NOvA Response
1. The NOvA Project should insure that the development of the installation schedule includes contingency planning if ceramic beam tubes are delayed	**Closed.** This is included in our installation planning by scheduling these tasks as late as possible. From the 22 Nov 2011 PMG, we are confident that we now have enough tubes in hand for all of the various fallback scenarios we have envisioned.
2. Conduct an APD review by October 31,2011, with international experts, to ensure fallback plans and planned testing are thorough and complete. Speed up delivery of an initial lot of coated devices in order to verify the solution	**Closed.** Expert Review (by P. Denes & R. Rusack) was conducted on October 14, 2011. A report from the reviewers was received on October 24. Attempted to speed up delivery of coated devices but Hamamatsu had problems and devices were late.

Status of Recommendations from the August, 2011 IPR

Recommendation	NOvA Response
3. Update the QA plan and organization across the Project by December 2011 to prepare for full-scale production, assembly and outfitting.	**Closed.** The QA plan was updated on November 23, 2011. Following the updated plan, the Project Manager charged 2 members of Project Controls with a series of QA audits at institutions & vendors involved with NOvA Project work. Audits have been done at: 1) Michigan State (waveshifting fibers) 2) Fermilab (PVC resin testing) 3) ANL (PVC extrusion testing) 4) Extrutech (PVC extrusions) 5) U of Minnesota (PVC modules, 3 audits) 6) Wolf Lake Inc. (scintillator blending) 7) U of Virginia (power supplies) 8) Harvard Univ (FEBs) 9) Indiana Univ (scint testing, scint fill machines, electronics) Audit recommendations and statuses are tracked in our database (link from website)

BACKUP SLIDES

CPR1 Mar 2012

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

CONTRACTOR						CONTRACT		PROGRAM			REPORT PERIOD		
NAME						NAME		NAME			FROM 01-Mar-2012		
Fermi National Accelerator Laboratory								NOvA project			TO 31-Mar-2012		
PERFORMANCE DATA													
CTC-FndSrc	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
CTC[2]			ACTUAL					ACTUAL					
Results...	BUDGETED COST		COST	VARIANCE		BUDGETED COST		COST	VARIANCE			LATEST	
	WORK	WORK	WORK			WORK	WORK	WORK				REVISED	
ITEM	SCHEDULED	PERFORMED	PERFORMED	SCHEDULE	COST	SCHEDULED	PERFORMED	PERFORMED	SCHEDULE	COST	BUDGETED	ESTIMATE	VARIANCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
DA DOE-ACEL MIE													
2.0 ANU Construction													
Fully burdened AY$k	759	1,069	1,509	309	(440)	22,423	20,164	25,349	(2,259)	(5,185)	33,953	37,646	(3,693)
CTC-FndSrcTotals:	759	1,069	1,509	309	(440)	22,423	20,164	25,349	(2,259)	(5,185)	33,953	37,646	(3,693)
DC DOE-CA													
2.1 Site and Building													
Fully burdened AY$k	0	0	0	0	0	35,060	35,060	34,872	0	188	35,060	34,872	188
CTC-FndSrcTotals:	0	0	0	0	0	35,060	35,060	34,872	0	188	35,060	34,872	188
DD DOE-ACEL R&D													
1.0 ANU R&D													
Fully burdened AY$k	0	0	1	0	(1)	7,025	7,022	6,611	(2)	412	7,025	6,613	412
CTC-FndSrcTotals:	0	0	1	0	(1)	7,025	7,022	6,611	(2)	412	7,025	6,613	412
DE DOE-DET MIE													
2.1 Site and Building													
Fully burdened AY$k	0	73	107	73	(34)	6,928	6,919	5,783	(8)	1,136	6,992	5,857	1,135
2.10 Project Management - Nova Project - Construction													
Fully burdened AY$k	207	207	183	0	24	7,609	7,609	6,458	0	1,152	11,652	10,501	1,152
2.2 Liquid Scintillator													
Fully burdened AY$k	463	301	149	(161)	152	7,899	8,564	8,704	665	(140)	22,246	22,380	(134)
2.3 WLS Fiber													
Fully burdened AY$k	404	791	387	387	404	9,280	10,075	10,443	795	(368)	12,606	12,958	(352)
2.4 PVC Extrusions													
Fully burdened AY$k	1,204	1,003	1,025	(201)	(22)	13,878	15,007	14,960	1,130	48	30,695	30,465	230
2.5 PVC Modules													
Fully burdened AY$k	244	210	138	(34)	72	9,840	9,563	8,115	(278)	1,448	19,974	18,531	1,443
2.6 Electronics													
Fully burdened AY$k	739	250	330	(489)	(80)	6,654	5,178	4,583	(1,475)	595	12,299	11,744	555
2.7 DAQ													
Fully burdened AY$k	264	98	249	(166)	(151)	3,123	2,355	3,126	(768)	(771)	3,962	4,718	(757)
2.8 Near Detector Assembly													
Fully burdened AY$k	278	521	145	243	376	1,944	1,847	2,534	(97)	(687)	7,234	7,686	(452)
2.9 Far Detector Assembly													
Fully burdened AY$k	336	434	632	98	(198)	8,247	7,116	9,709	(1,130)	(2,593)	22,206	24,935	(2,729)
CTC-FndSrcTotals:	4,138	3,888	3,345	(250)	543	75,401	74,234	74,415	(1,167)	(181)	149,865	149,775	89

CPR1 Mar 2012 continued

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

CONTRACTOR	CONTRACT	PROGRAM	REPORT PERIOD
NAME	NAME	NAME	FROM 01-Mar-2012
Fermi National Accelerator Laboratory		NOvA project	TO 31-Mar-2012

PERFORMANCE DATA

CTC-FndSrc	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
CTC[2]			ACTUAL					ACTUAL					
Results...	BUDGETED COST		COST	VARIANCE		BUDGETED COST		COST	VARIANCE			LATEST	
	WORK	WORK	WORK			WORK	WORK	WORK				REVISED	
ITEM	SCHEDULED	PERFORMED	PERFORMED	SCHEDULE	COST	SCHEDULED	PERFORMED	PERFORMED	SCHEDULE	COST	BUDGETED	ESTIMATE	VARIANCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
DO DOE-ACEL OPS													
1.0 ANU R&D													
Fully burdened AY$k	0	60	31	60	29	390	410	599	20	(189)	1,642	1,827	(184)
CTC-FndSrcTotals:	0	60	31	60	29	390	410	599	20	(189)	1,642	1,827	(184)
DR DOE-POST CD-1 DET R&D													
1.1 Site and Building R&D													
Fully burdened AY$k	0	0	0	0	0	3,630	3,630	3,168	0	462	3,630	3,168	462
1.2 Liquid Scintillator R&D													
Fully burdened AY$k	0	0	0	0	0	297	297	389	0	(92)	297	389	(92)
1.3 WLS Fiber R&D													
Fully burdened AY$k	0	0	0	0	0	341	341	375	0	(34)	341	375	(34)
1.4 PVC Extrusion R&D													
Fully burdened AY$k	0	0	0	0	0	1,369	1,369	2,084	0	(715)	1,369	2,084	(715)
1.5 PVC Module R&D													
Fully burdened AY$k	0	0	0	0	0	2,260	2,260	2,421	0	(160)	2,260	2,421	(160)
1.6 Electronics R&D													
Fully burdened AY$k	0	0	0	0	0	2,028	2,028	2,600	0	(572)	2,028	2,600	(572)
1.7 DAQ R&D													
Fully burdened AY$k	0	0	0	0	0	1,635	1,635	2,822	0	(1,186)	1,635	2,822	(1,186)
1.8 Detector Assembly R&D													
Fully burdened AY$k	0	0	0	0	0	3,123	3,123	4,929	0	(1,806)	3,123	4,929	(1,806)
1.9 Project Management R&D													
Fully burdened AY$k	0	0	0	0	0	383	383	559	0	(176)	383	559	(176)
CTC-FndSrcTotals:	0	0	0	0	0	15,067	15,067	19,347	0	(4,280)	15,067	19,347	(4,280)
DY DOE CD-0 TO CD-1 R&D													
1.9 Project Management R&D													
Fully burdened AY$k	0	0	0	0	0	8,801	8,801	8,801	0	0	8,801	8,801	0
CTC-FndSrcTotals:	0	0	0	0	0	8,801	8,801	8,801	0	0	8,801	8,801	0
Undist. Budget											0	0	0
Sub Total	4,898	5,016	4,887	118	129	164,166	160,757	169,993	(3,409)	(9,236)	251,412	258,881	(7,469)
Management Resrv.											26,588		
Total	4,898	5,016	4,887	118	129	164,166	160,757	169,993	(3,409)	(9,236)	278,000		

~ 67% ANU, 33% Det MIE ~50% ANU, 50% Det R&D