



# NOvA Project Status

March 29, 2007

John Cooper

NOvA Project Manager

## Outline:

Progress since PAC approval (reviews, DOE hoops)

Technical Progress

Next Steps (More reviews & DOE hoops)



# Scientific Reviews, **Approvals**,

## **DOE Reviews, Funding “Actions”**

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- 4/05: This PAC recommends Stage I approval for NOvA (30 kt, 5 yr)
  - 4/05: **The Director approves NOvA**
  - Most of 2005: NuSAG and EPP2010 talks, questions, answers
  - 11/28/05 **Ray Orbach approved DOE CD-0 (Mission Need) for “EvA”**
- 
- 2/06: **EvA in the President’s FY07 budget for \$ 10.3 M**
  - 2/06 NuSAG result
    - **“The U.S. should conduct the NOvA experiment at Fermilab.”**
  - 2/06 Director’s Review for CD-1 (Cost, schedule, scope ranges)
  - 4/4-6/06 DOE Lehman Review for CD-1 (25 kt, 6 yr)
    - **“CD-1 Approval is recommended upon receipt of final documentation.”**
  - 5/06 EPP2010: Internationally coordinated neutrino program
  - During 2006: P5 talks, questions, answers
  - 10/06: P5 result:
    - **“Proceed with the 20 kt scale NOvA Experiment”** (\$200M implied) (20 kt, 7.5 yr)
      - Provides information for the next step on the road to measuring CP violation, e.g. conventional beams vs. neutrino factory
- 
- 11/06: **HEPAP approves the P5 Report**
  - **2/07: NOvA (no longer EvA) in President’s FY08 budget for \$ 36 M,**



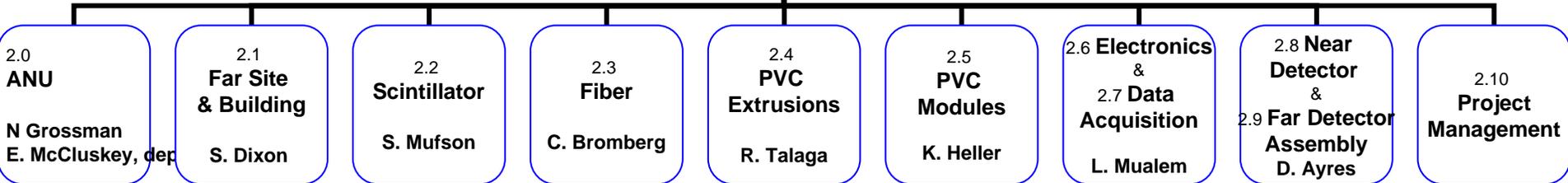
# Moving along in parallel was an Accelerator story with quickly changing names:

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- March, 2005:
  - NOvA proposal included using the Recycler to get NuMI to ~ 600 KW
- Summer, 2006: P5 probing
  - The laboratory gets more serious about NuMI at 700 KW and 1.2 MW
  - The P5 reduction to 20 kt was tangled with the potential increase to 1.2 MW
- Fall, 2006: Laboratory organized the SNuMI Plan
  - 700 KW Phase I, then 1.2 MW Phase II
- November, 2006: Director's Review of SNuMI
  - Concludes 700KW should be a “campaign” called Proton Plan 2
    - Modeled after the successful Proton Plan 1 campaign
  - 1.2 MW is then a separate plan / likely full fledged project, the SNuMI Project
- **December 20, 2006:**
  - **OMB asks DOE to combine Proton Plan 2 with NOvA**
  - **Suggests a \$ 240 M TPC combined total including all R&D after CD-1**
  - **Some quick footsteps to correct OMB / DOE perceptions of costs with R&D resulted in the \$ 260 M TPC cap in the President's FY08 Budget**
- January, 2007 Accelerator & NuMI Upgrades (ANU) now in NOvA

# NEW Project Organizational Breakdown Structure

J. Cooper, Project Manager  
R. Ray, Deputy Project Manager  
N. Grossman, Associate Project Manager



## Project Office List:

Dave Pushka, Mechanical Project Engineer  
John Oliver, Electronics Project Engineer  
Anna Pla-Dalmau, Project Chemist  
Suzanne Pasek, Project Financial Officer  
Bill Freeman, Project Scheduler  
Ken Doman, ANU schedule  
Harry Ferguson, Assistant Project Scheduler  
Keith Schuh, ES&H, EA, pSAD  
Mike Andrews, ES&H for Accelerator side  
Alan Wehmann, websites & document databases  
Nancy Grossman, QA oversight  
Elaine McCluskey, Configuration Control oversight  
Jon Paley, databases  
Sarah McCook, administrative support

**“Full Fledged Project”**

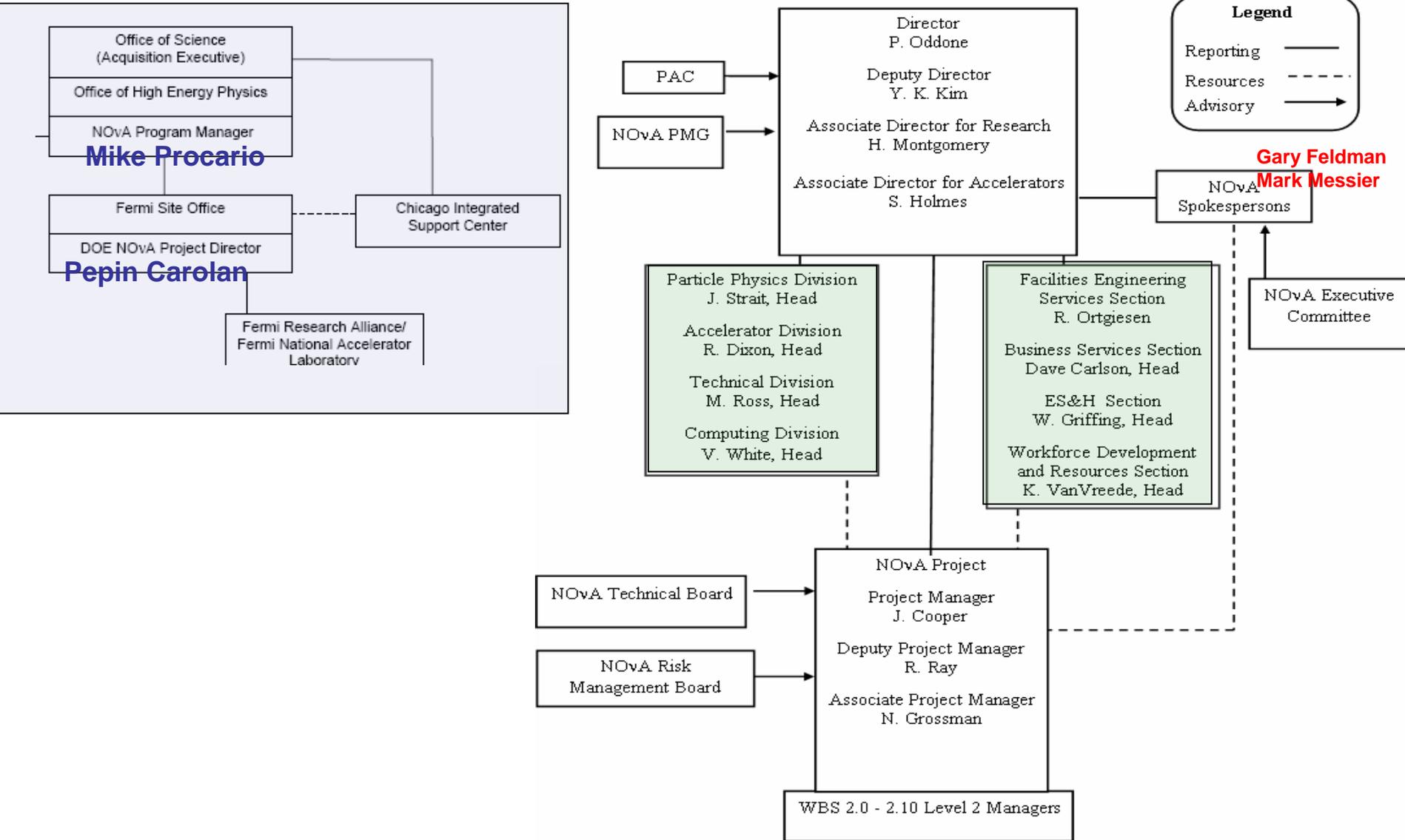
2.0.1 **Recycler**  
Upgrades

2.0.2 **Main  
Injector**  
Upgrades

2.0.3 **NuMI**  
Upgrades



# Getting help from the DOE & the whole laboratory





# Dealing with the funding total

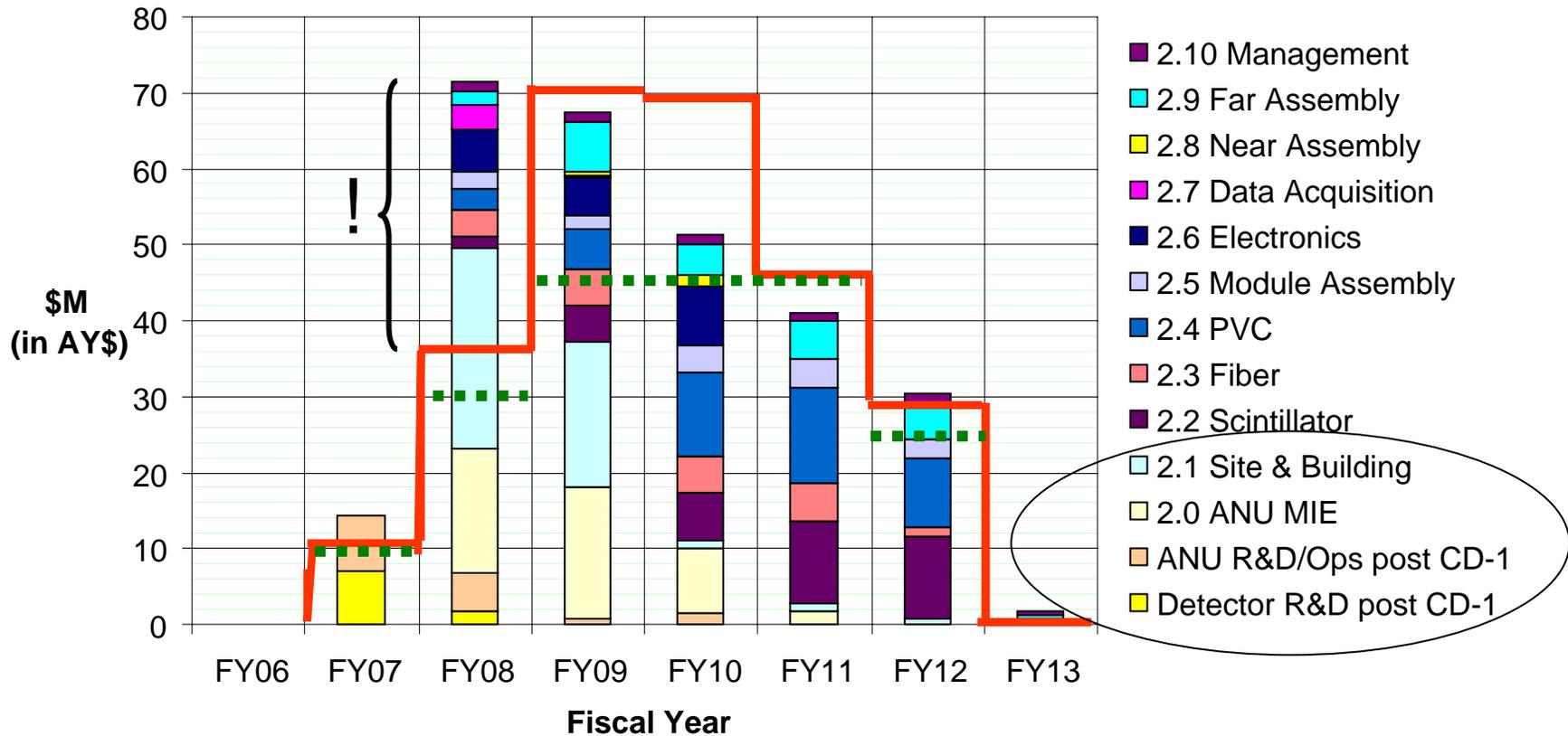
- **Our best TPC estimate is \$ 277 M, not \$ 260 M**
  - ANU: \$ 44.3 M + \$ 14.3 M R&D/Operating (58.6, not 40)
  - Detector \$ 209.8 M + \$ 9.0 M R&D (218.8, not 200)  
(includes building)
- The ANU part of the project has a rather fixed scope
- The only handle we have (other than good management saving contingency along the way) is detector mass,
  - THEN the \$ 17 M implies a reduction in mass of ~ 2.3 kt
  - **THAT IS, we currently estimate we can build ~ 18 kt**
    - 16 – 20 kt is the estimated scope range  
for an estimated CD-1 cost range of \$ 244 – 293 M
      - Cost range depends on contingency analysis (e.g. price of crude oil)  
High price, high end of range, low end of kt scope for fixed \$260M



# Full funding profile from DOE:

**\$ 260 M now, \$ 200 M last August**

- FY07–12: 10, 36, 70, 69, 46, 28 M\$ = 260 total
- And our combined estimate (277 total) looks like:



**Clearly, major work to move items downstream one year.**

**Crude estimate: Shortfall in FY08 implies 6 - 12 month delay, looking at options.**



# Value Engineering in progress to

shift costs, reduce costs, recover mass

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- Several items in the “few M \$” class:
  - Shorter Building
    - No longer logical to build a 25 kt building
    - Reducing to 20 kt
  - Cheaper overburden on building
    - Barite (not granite) for electromagnetic cosmics, simulations say thin is OK
  - Optimize PVC / scintillator / Fiber for light output
    - Plan to use 0.7 mm diameter fiber instead of 0.8 mm
  - Reducing the R&D
    - Integration Prototype (IPND) and the Near Detector
      - We planned to build two nearly identical \$ 5M objects, one early , one late
      - Now plan to build an Integration Prototype of 4 modules (2/3 of original plan)
      - Now plan to build a Near Detector of 6 modules (and re-use 3 from IPND here)
    - Buy APDs on construction project but use first few hundred initially on the IPND then move to the final Near Detector later
- But, scintillator blending now ~ \$0.90 / gallon vs. \$0.10 at CD-1, and other costs are likely to rise as we add more details



# Technical Progress

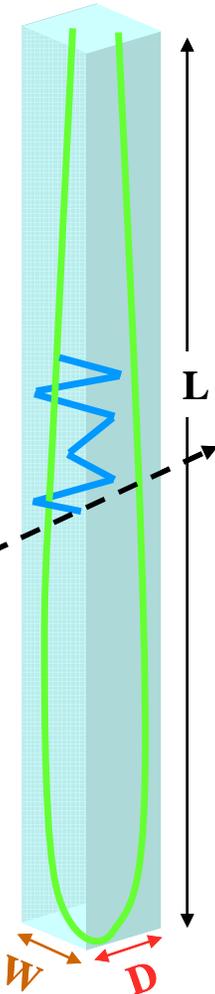


# Recall the NOvA Detector design

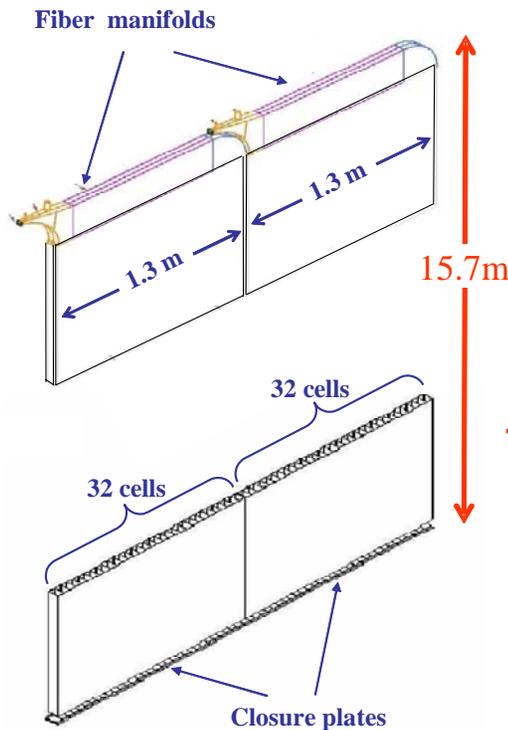
- Liquid scintillator in 3.9 cm (W) x 6.6 cm (D) cells

To 1 APD pixel

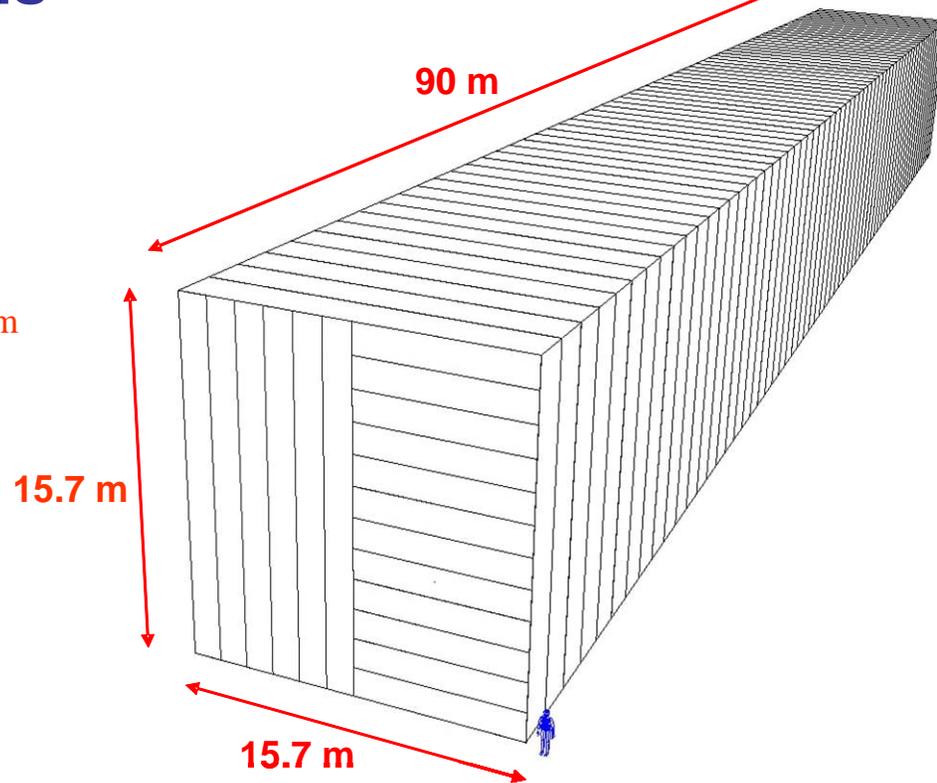
one cell



Two 32-cell PVC extrusions



~14,000 extrusions in 1178 planes of 12



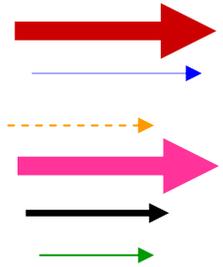


# More Value Engineering.

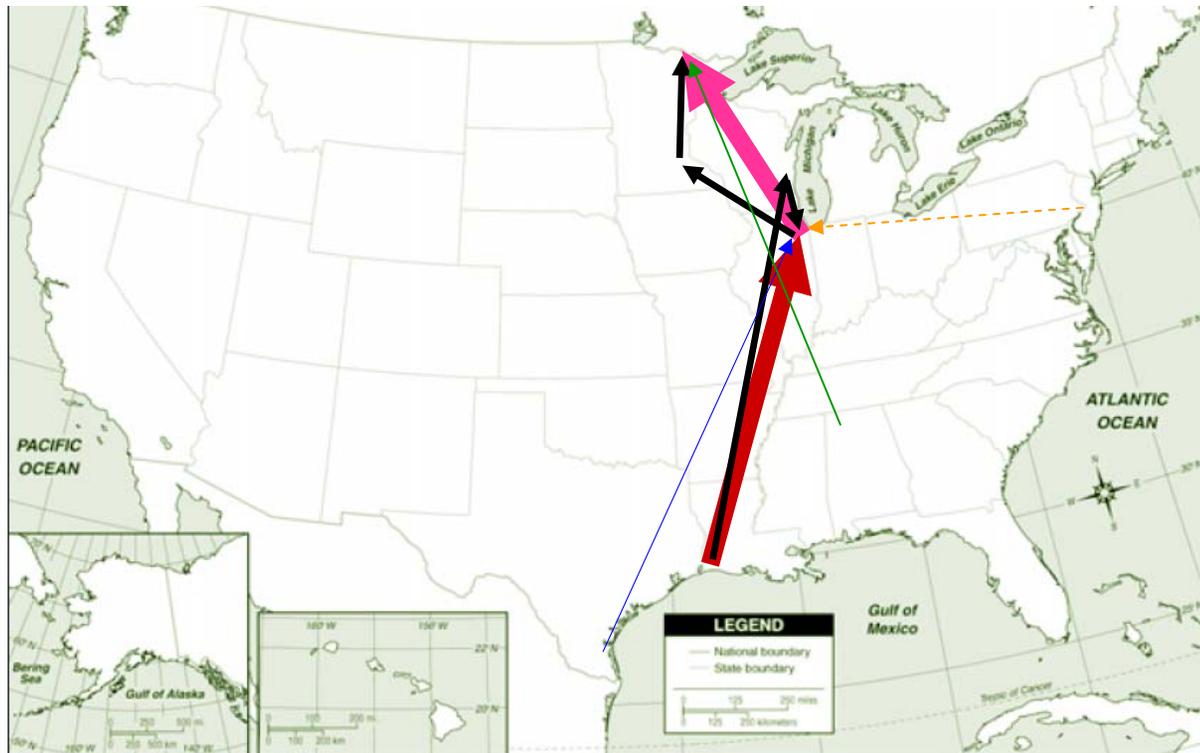
## NOVA moves 20 kt from the Gulf to northern Minnesota

- In the style of Charles Joseph Minard, 1861

- Mineral oil comes from the LA / TX border 14 kt
- Pseudocumene comes from Corpus Christi, TX 0.75 kt
- Waveshifters come from Bensalem, PA 17 t
- Scintillator gets mixed in Chicago
- Extrusions come from Manitowoc, WI, but PVC resin comes from LA 5 kt
- Barite comes from Cartersville, GA 1.5 kt



- Deviations from N-S routes cost money in transportation

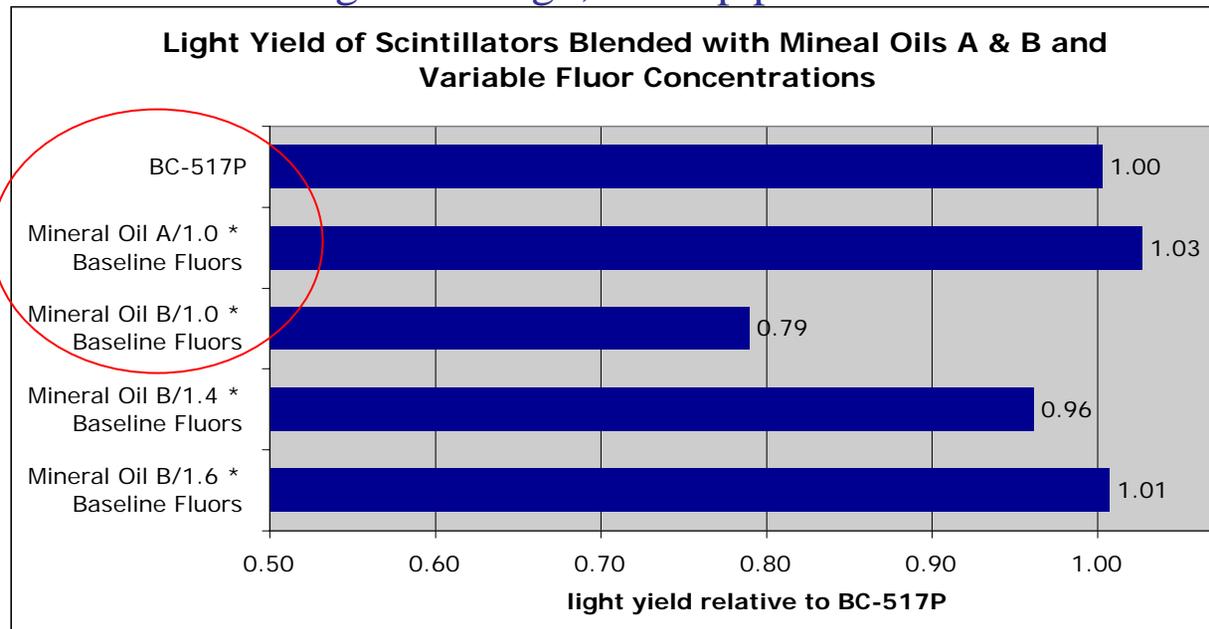


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# Scintillator

- **We need 3.9 million gallons of scintillator**
  - Our baseline is 94.5% mineral oil + 5.5% pseudocumene + 1000 ppm waveshifters
  - Mixture is made semi-conductive for safety with 3 ppm Stadis-425
- **We have bids for all the components** (Bicron and Eljen declined to bid)
  - We have two viable vendors for White Technical Grade Mineral Oil
    - The price scales with: Group II Viscosity 70 Lube Oil & we know how this tracks crude oil
  - We believe we can blend the scintillator components with ~ 1% tolerances
    - First try on the 6,000 gallon scale this summer
  - We have budgetary quotes for “toll” blending in Chicago, backup plan is at Fermilab
- **Using QA devices**
  - Lovibond Tintometer for attenuation lengths <12m
  - Indiana Univ. device for light output using an alpha source
- **We would like to have the option to use both mineral oils A & B in the Figure.**
  - Implies must have 21% extra light

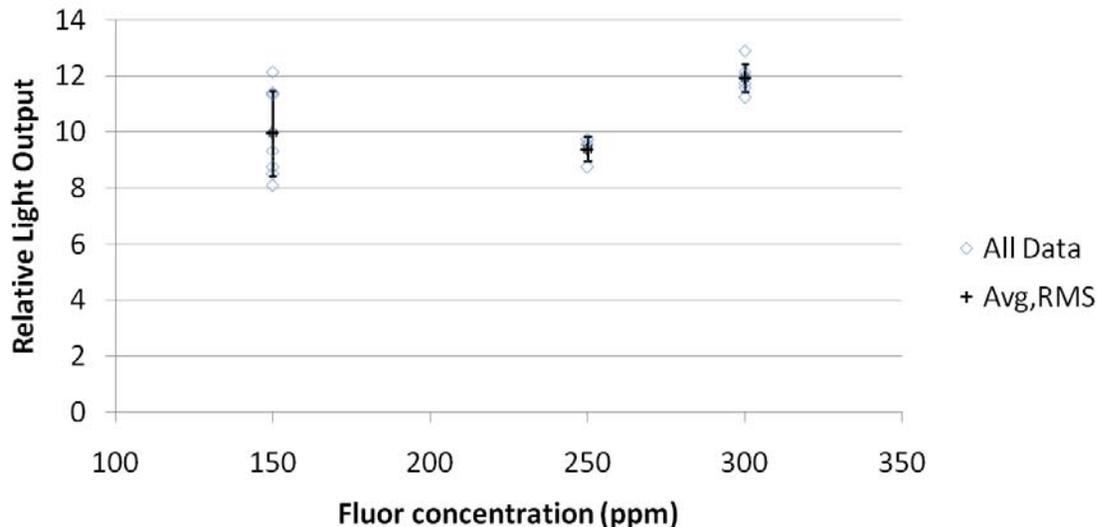




# Waveshifting Fiber

- **We need 17,000 km of fiber (+ some spare)**
  - We have a quote from Kuraray
- **We plan to QA the fiber at Michigan State**
- **We have enough light to decrease the fiber diameter to 0.7 mm**
  - But with an increased ( $>$  usual 3% of diameter) coating of the inner acrylic cladding based on advice that the cladding can develop holes if it gets too thin
- **The concentration of K27 waveshifter is still undetermined**
  - Our 250 ppm sample is flawed (Kuraray agrees)
  - Ordered additional samples at 100, 200, 300, 400, 500, 750 ppm due May 1

Far End Light output (1670cm) vs. Fluor concentration

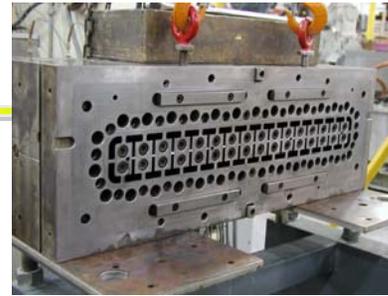




# PVC Extrusions

\$ 175 K

16 cell die

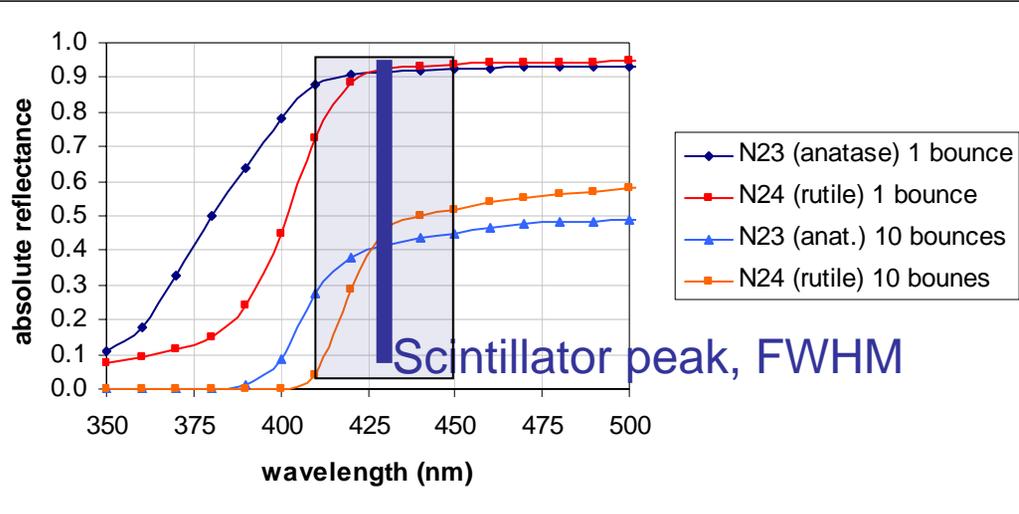


R&D Integration Prototype parts



J. Cooper

- We need 5.4 kt of extruded PVC
  - Loaded with TiO<sub>2</sub>

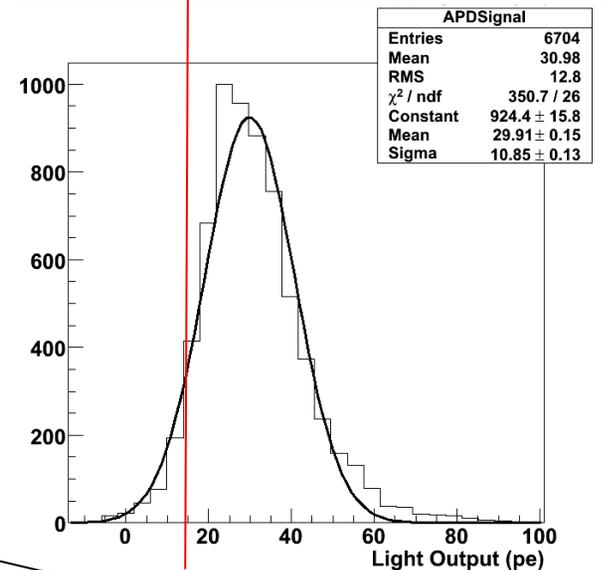
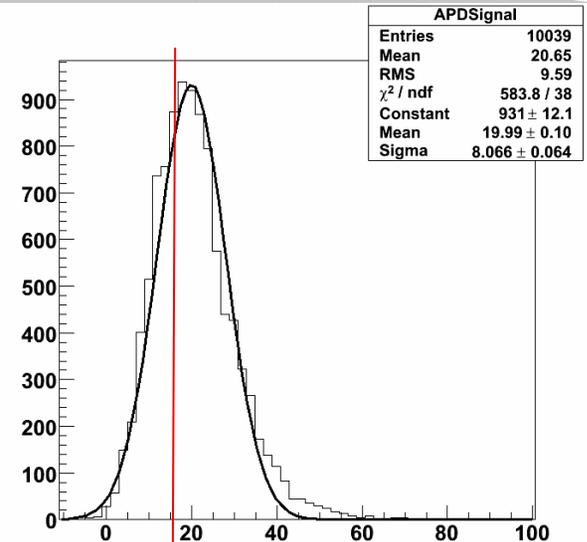


- Anatase picks up ~ 15% more light from low tail , integrated over all paths
- We have extruded both types
  - 35,000 pounds of rutile (~1,000 meters)
- Doing QA on reflectivity, web thickness, overall width and thickness
- Testing structural properties



# One issue crosses all NOvA cell components

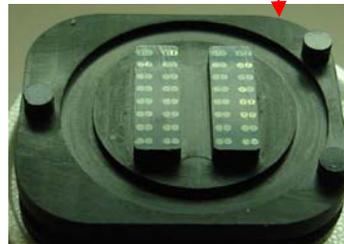
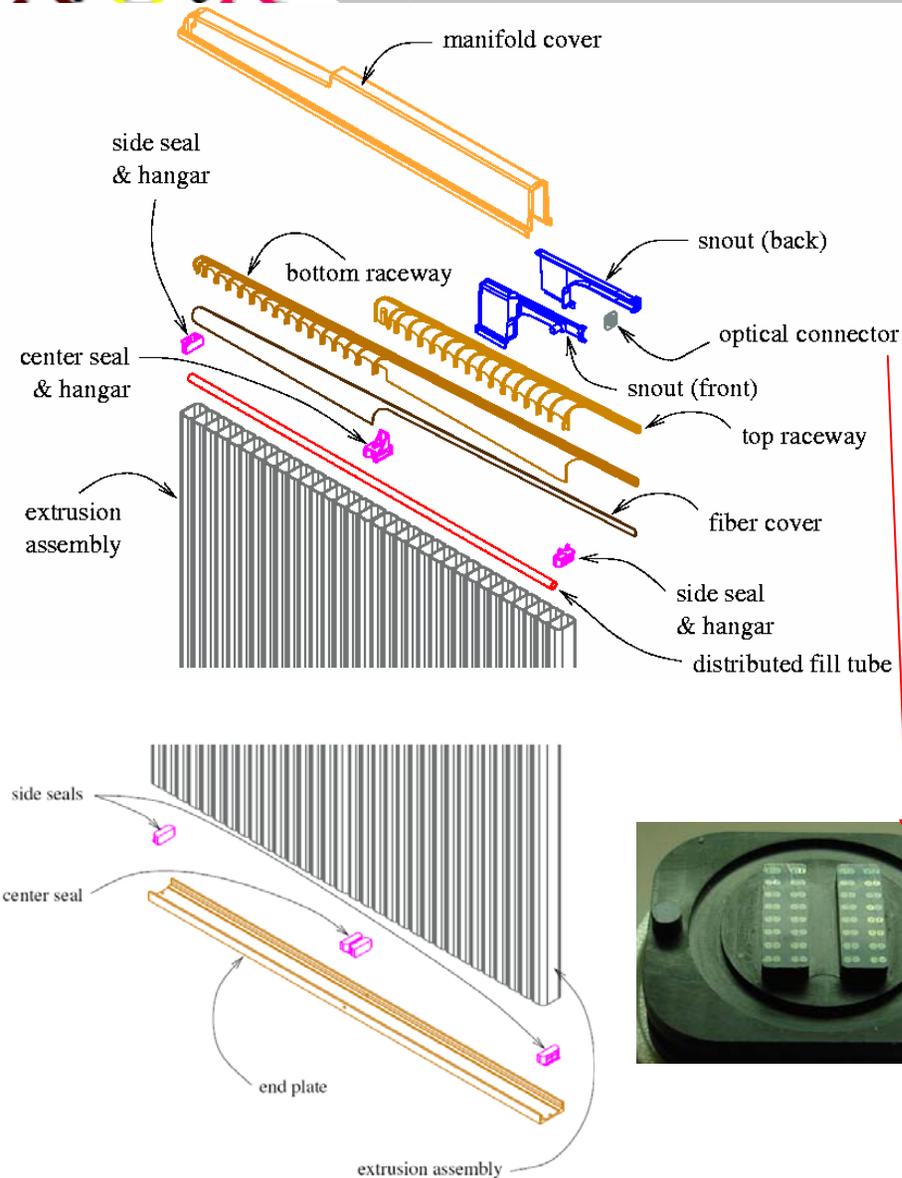
- In November we changed from 0.8 mm fiber (200 ppm) and rutile PVC to 0.7 mm fiber (250 ppm **the bad one**) and anatase PVC, expecting to just preserve the CDR light 20 p.e. output from the far end of a cell
  - But observed 30 p.e. with same APD ! (see figures)
  - No obvious errors found
- Now trying to get a handle on statistical variations in cells, PVC, fiber, fiber position, scintillator, ...
  - 12 cells any day now
  - 32 cells next as new electronics becomes available
- **We want to accommodate fluctuations in the basic components, e.g.**
  - Scintillator: 20% range from different mineral oils
  - Fiber: 10% variation batch to batch, 10% within batch seen by MINOS
  - PVC: 12% range in light via reflectivity seen by us
  - Readout: 10% variations expected
  - **And still be above our design 15 p.e. threshold with 20 p.e. at the far end of a 15.7 meter long cell**



15 p.e.



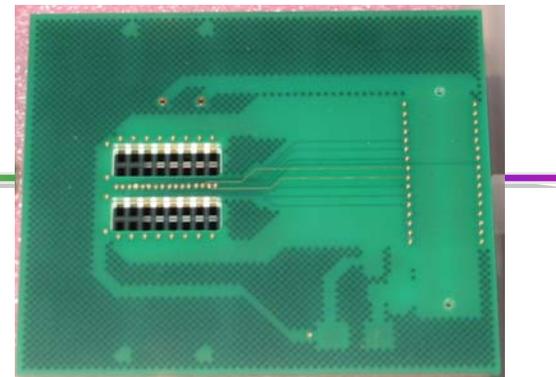
# PVC Modules



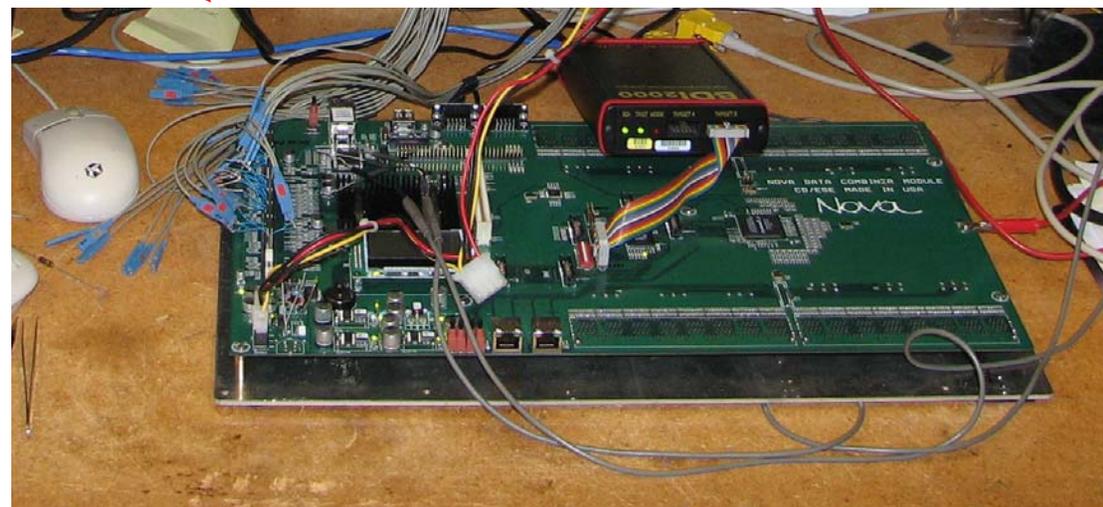
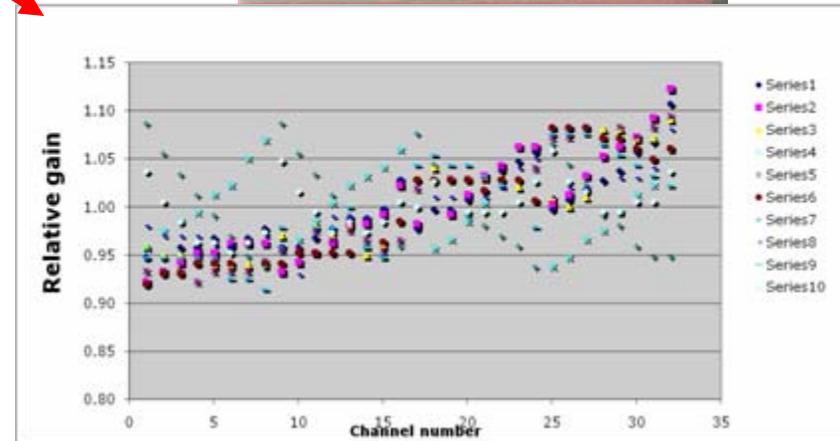
- **We need to make 14,136 modules**
- Two Factories must produce ~ 30 modules per day
- At Fermilab, check PVC for structural properties, glue two 16 cell objects together to make the basic 32 cell unit
  - Agreement with laboratory (Strait & Montgomery) that we can use the deep enclosure at WideBand Lab
  - MINERvA should be done by the time we appear
- At Minnesota, string fiber, add end plate and fiber manifold, check fiber continuity and leak check the assemblies.
  - Parts design complete
    - Injection molding yet to come
  - Have fiber stringing machine
  - Extensive time & motion studies completed



# Electronics & DAQ



- APD Carrier Board & Thermoelectric cooler circuit in hand
- We have 10 “NOvA” APDs from Hamamatsu
  - Range of gains is +/-10% with RMS of 4%
- We have prototype #2 of the Front End Board under test
  - Will do one more design pass on the ASIC amplifier
    - Switchable 4x less multiplexing to handle higher Near Detector rates
- We have a prototype Data Concentrator Module under test
- We have a water cooling system design
- We have a low voltage distribution system design
- We have ~ 60% of the effort identified for DAQ software
  - Looking within the collaboration for additional help







# Far Detector Assembly

- **The basic structure is 38 blocks of 31 planes with a bookend at each end**
  - Each plane of 12 extrusions assembled with a Methyl Methacrylate based adhesive
- Extensive finite element analyses of the structure have been completed
- Tests to compare FEA to simple real structures underway
  - Strength of PVC webs
  - Adhesive shear, peel
  - Swelling of blocks under pressure
- Integration Prototype trial assembly
  - No fiber / manifold / end plates yet
- We believe we have a structure with an appropriate safety factor of  $\sim 5$  for all stages of assembly and filling with kt of scintillator
- Filling infrastructure designed



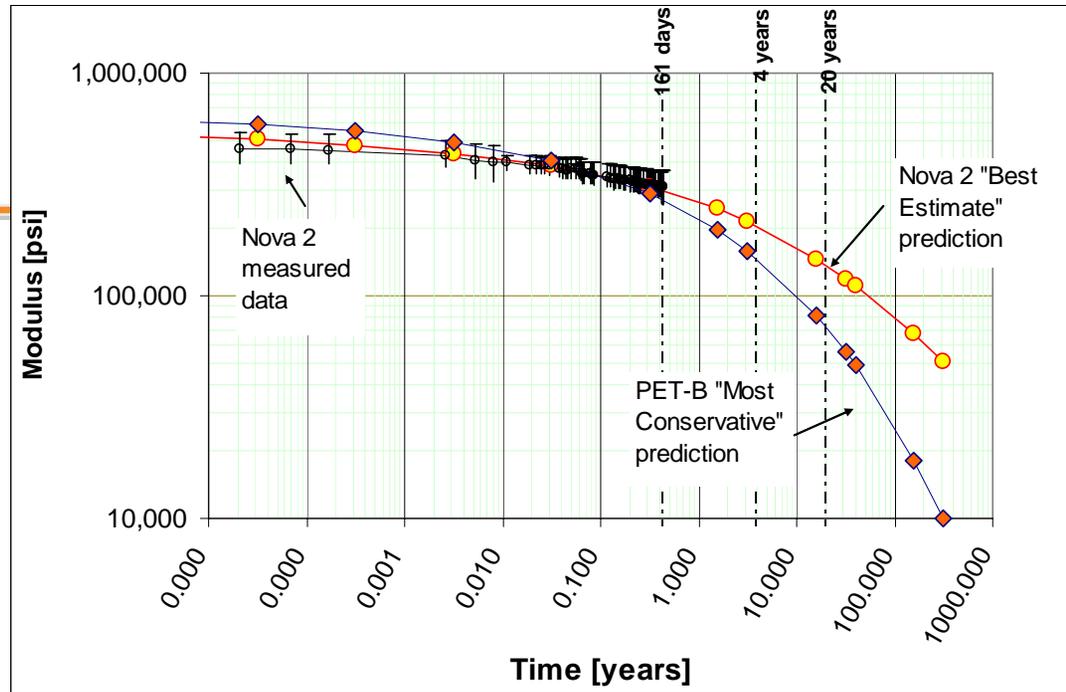
11 plane test



# Far Detector Assembly

- PVC creep**

- Consultant estimates from frequency analysis at elevated temperatures
- Real time tests underway
- Design good at 4 years with most pessimistic value (then 2<sup>nd</sup> bookend)
- Stable with bookends at 20 years with most pessimistic value

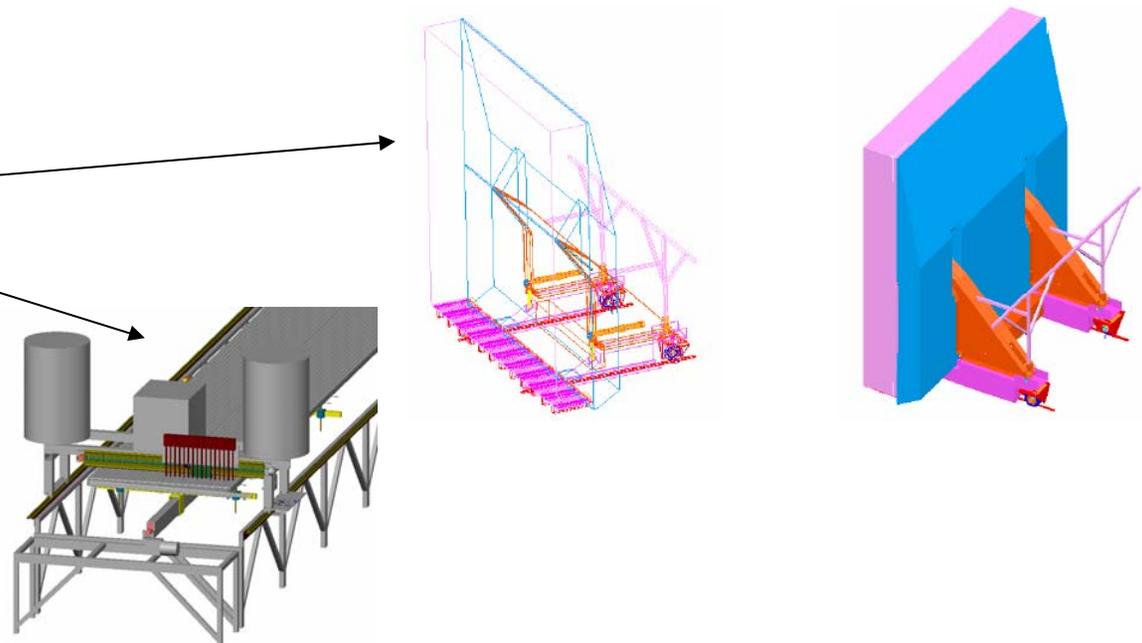


- 125 ton block raiser final design started**

- Glue machine design started**

- Conceptual Time & Motion**

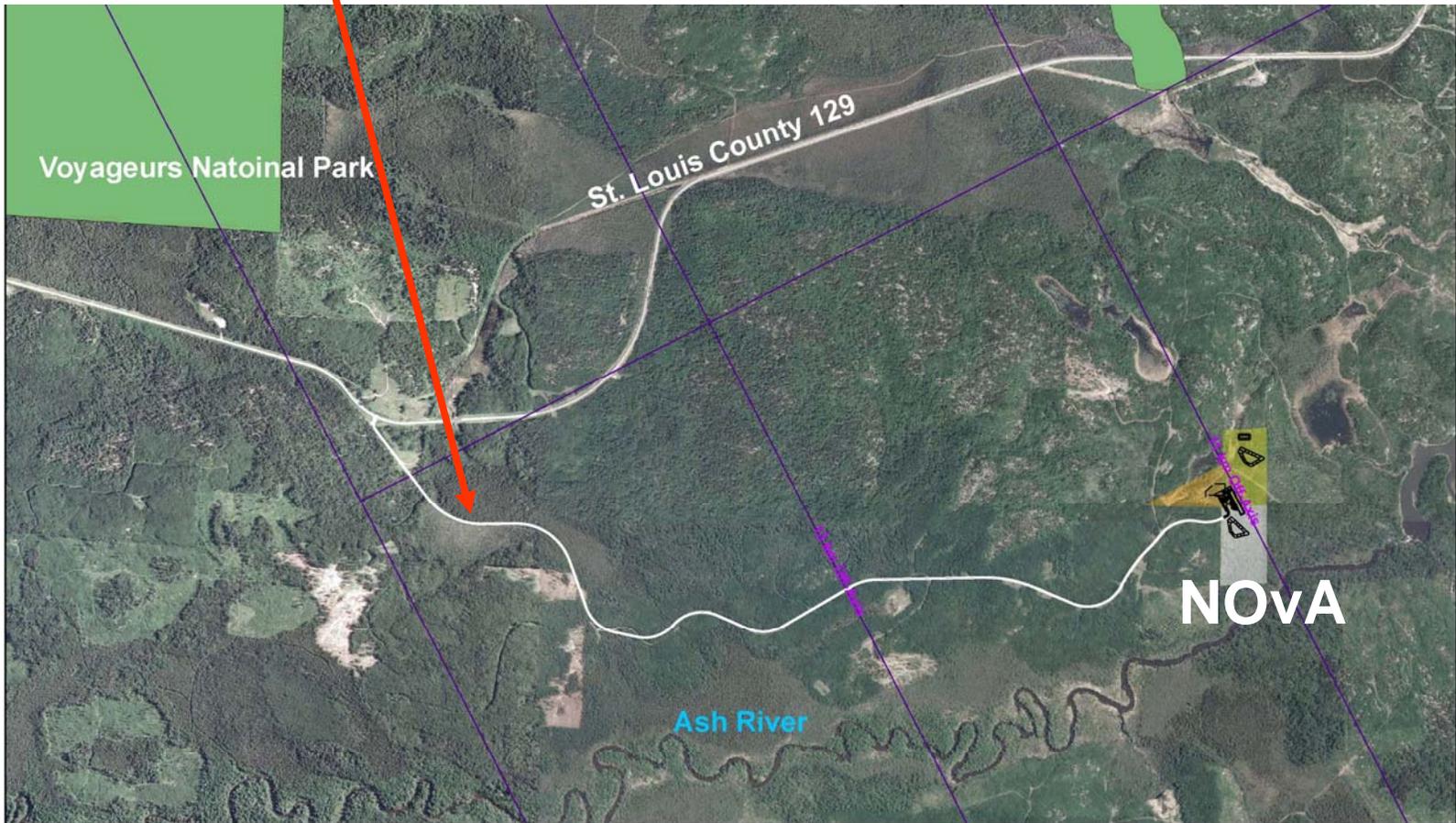
- Full trial coming this summer





# Ash River Site

- The 3.6 mile access road is fully designed:
  - roadbed, utility corridor, curves straightened, borings done all along the route
  - Will need wetlands permit, but for existing logging road

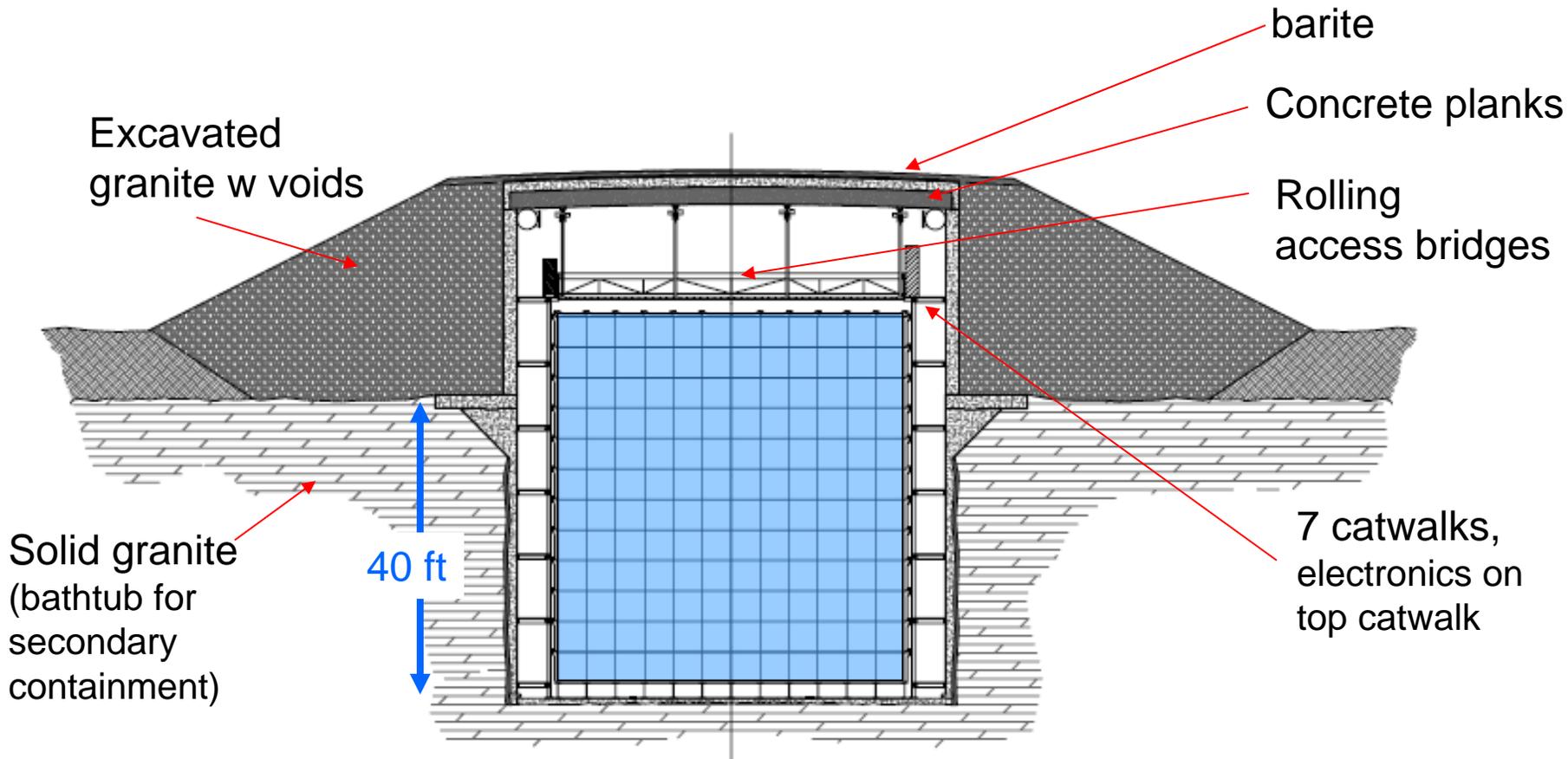




# Site and Building

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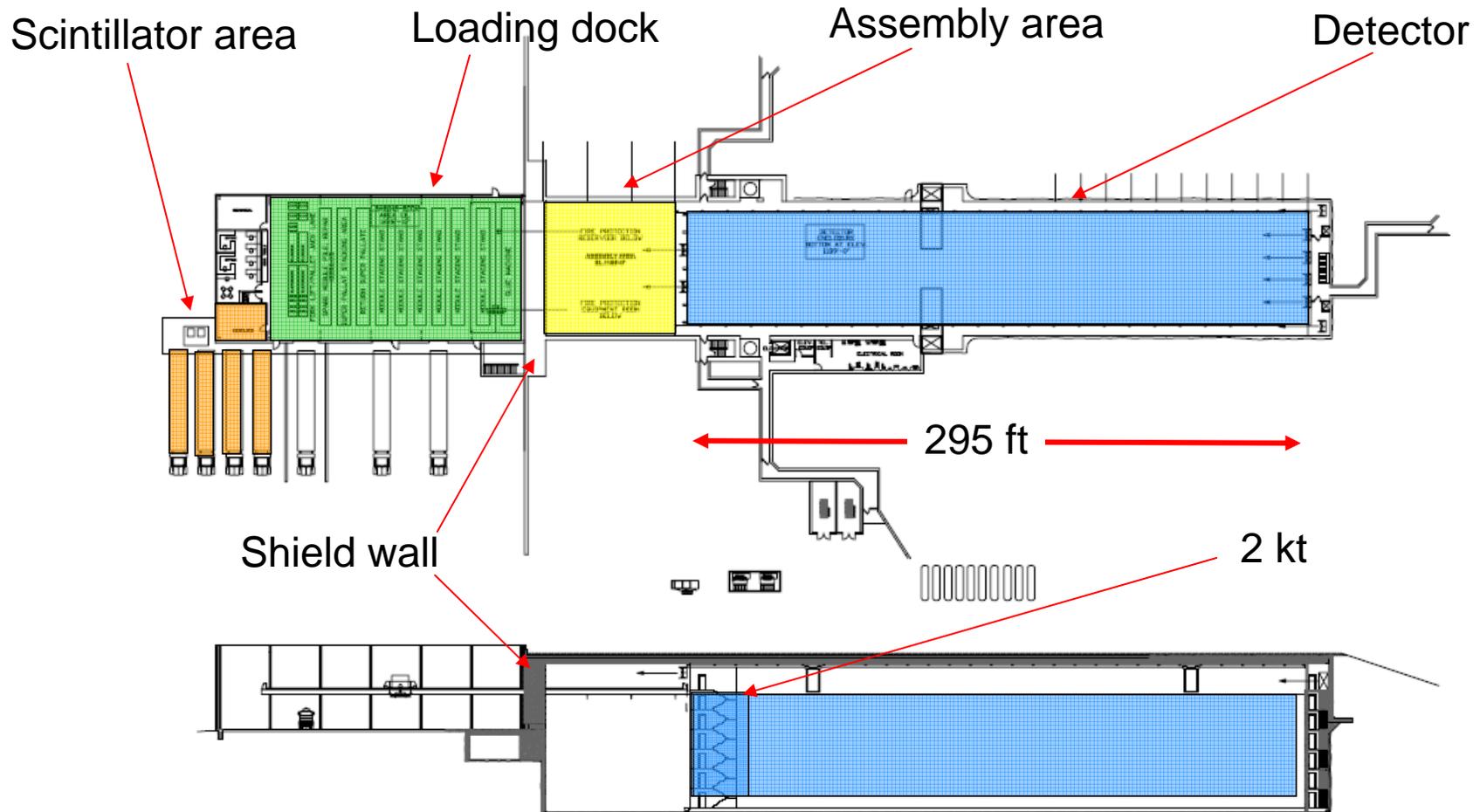
- As seen by the neutrino beam
- Want “30% design” by June
  - Fermilab in house design
  - Independent cost estimates from one Illinois firm and one Minnesota firm





# Site and Building

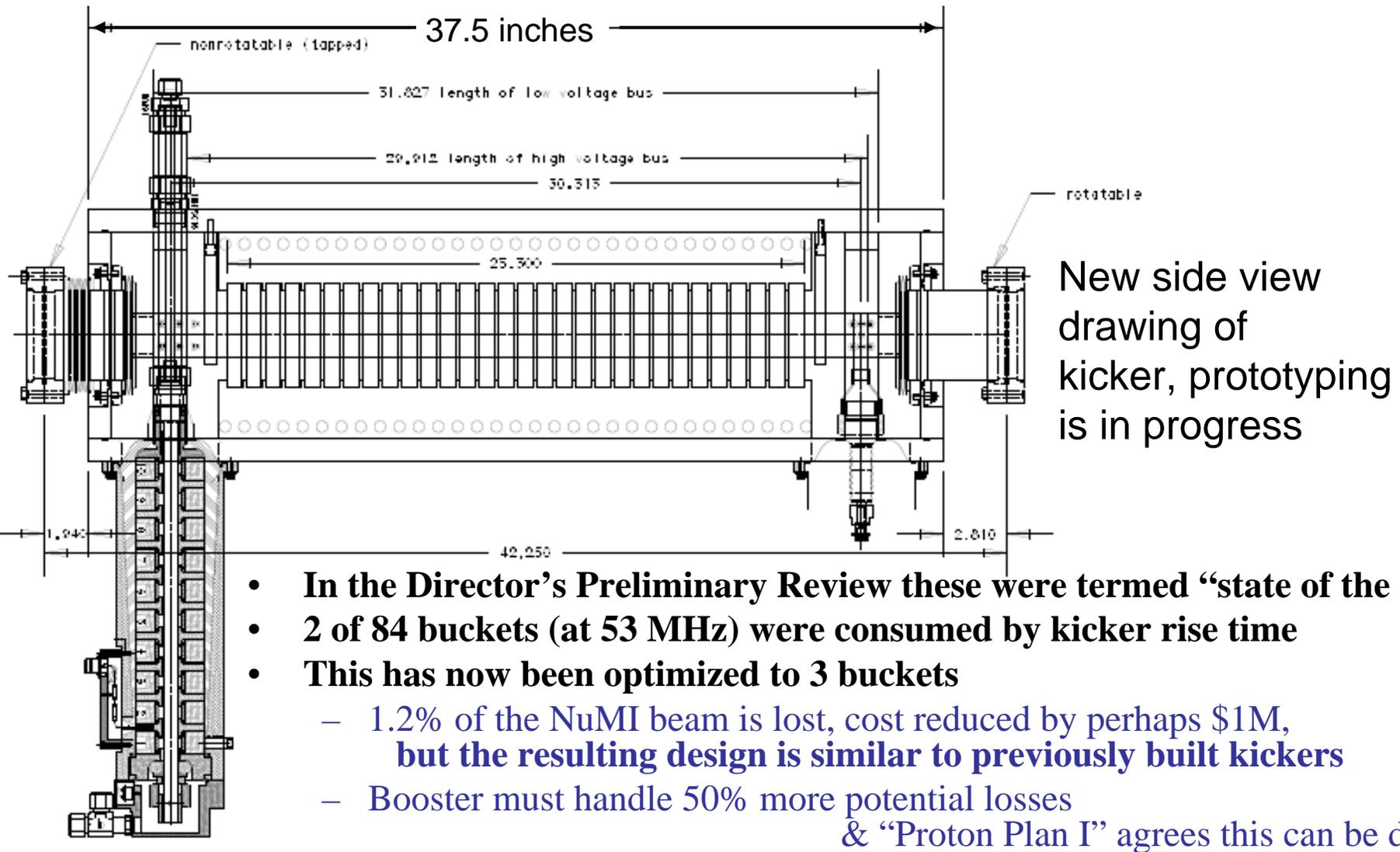
- Plan view & Longitudinal cross section





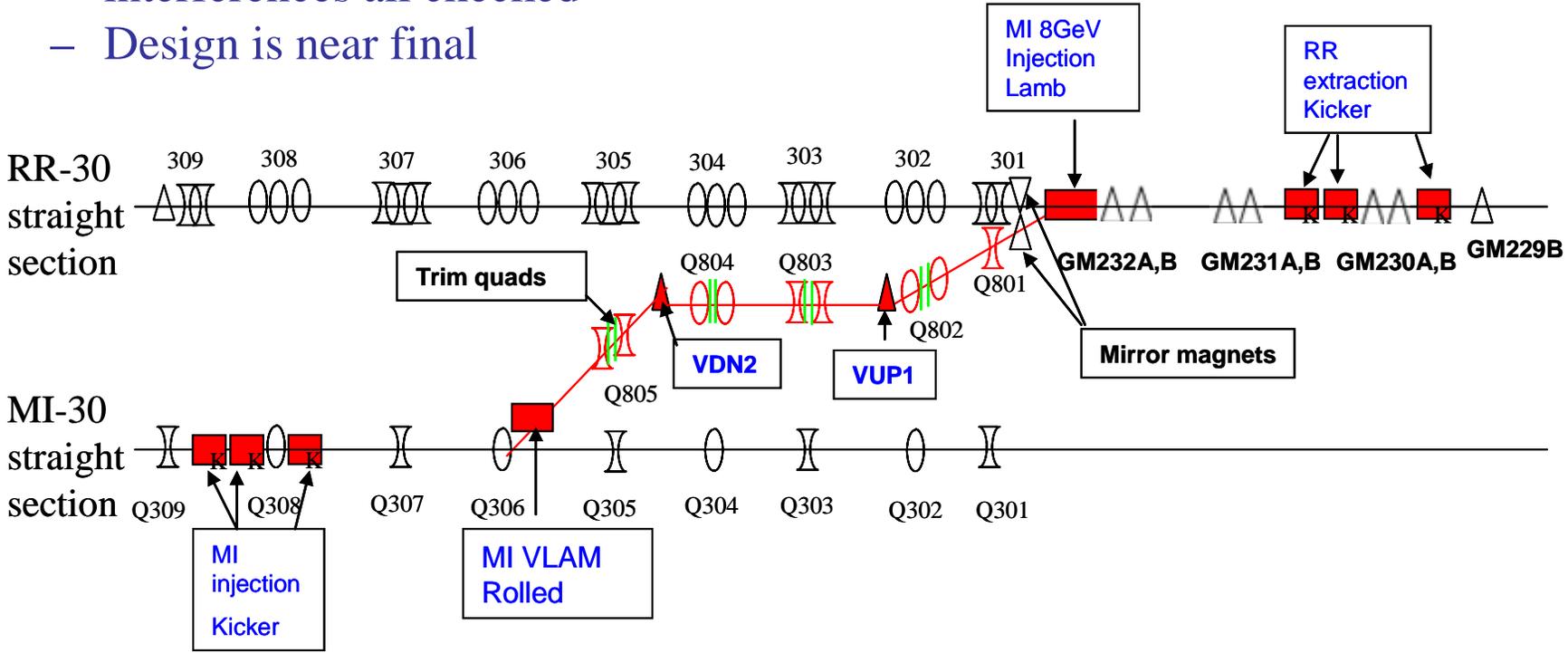
# Accelerator & NuMI Upgrades

- The largest ANU cost is for kickers, ~ 40% of the project



# Accelerator & NuMI Upgrades

- Recent Work: update of extraction line design, Recycler to Main Injector
  - Lattice match, trajectories, magnet apertures, quad strengths, magnet interferences all checked
  - Design is near final



Cartoon of extraction line, including RR and MI 30 straight section



# Next Steps

(mostly bureaucratic)



# CD-1 Review last April, what about a CD-1 sign-off?

- DOE documents required
  - Acquisition Strategy (signed by Procario, Lehman, )
  - Preliminary Project Execution Plan (signed by Carolan, Livengood)
- NOvA documents required (all are done)
  - NOvA Conceptual Design Report
    - Detector CDR from CD-1 Review
    - Separate CDR for Accelerator & NuMI Upgrade
  - Preliminary Hazard Analysis
    - Detector HA from CD-1 review (signed by Cooper, Heflin, Carolan)
    - Accelerator and NuMI Upgrades HA (signed by Cooper, Anderson, Carolan)
  - Risk Management Plan
    - Risk Registry and current list of risks
      - Have 11 for Detector, 3 for ANU in place
      - NOvA Risk Management Board has met multiple times and it is on the record
- ~ ready for ESAAB
  - Energy Systems Acquisition Advisory Board
  - Pepin Carolan hoping for meeting in (early?) April
  - Ray Orbach would then sign if convinced all is in order



# Cooperative Agreement Story

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- **Cooperative Agreement is a grant to construct the Ash River building**
  - Competition path pursued April – November, 2006
  - Unsolicited Proposal from Univ. of Minnesota, Nov 2006
  - Merit review by DOE
  - DNFA (Determination of Non-Competitive Financial Assistance) required
    - Requires Ray Orbach's signature
    - May therefore get linked to his CD-1 sign-off discussed on previous page
- **If it all goes ahead without a hitch:**
  - Start official negotiations ~ May 1, DOE Chicago legal/procurement involved
  - First funding could appear in July to cover 4 months in FY07 / early 08.
  - Final building design would be the first priority  
(turning dirt requires even more DOE reviews and sign-offs)
- **This would be an FY07 start**
  - Report went to congress with this HEP portion intact.
  - Now only objections from congress could derail funding
  - But both sides have to get through the negotiating phase



# Environmental Assessment

- **Project draft #2 to DOE NEPA team by April 6?**
  - Draft depends on a **Minnesota Environmental Assessment Worksheet (EAW)**
  - White House Council on Environmental Quality requires cooperation with local and state agencies to reduce duplication
- **The EAW requires a Responsible Government Unit (RGU) as submitter.**
  - Marvin Marshak met with U of Minn VPs and Counsel on March 12
  - U of Minn would agree to be the RGU with 3 stipulations
    - Must check with St. Louis County that U of Minn as RGU is OK
      - This probably takes a voting action of the County Board of Commissioners
    - Must get a “letter of reliance” from S E H (Fermilab Environmental consulting firm)
    - Must see Cooperative Agreement in discussion before going to Board of Regents
      - Regents do not act on 1<sup>st</sup> reading, 2<sup>nd</sup> reading would be June 8 earliest
  - Then have to submit to Minn. Environmental Quality Board by June 25 to get published by July 2 and **start 30 day public comment clock**
- **Implication is that the Federal EA can't be sent out until June**
  - Still, would mean we are OK for DOE CD-2 review in July
  - Barely OK for CD-2 sign-off in late September



# Other Documents for next step, all exist in draft form

- Project Management Plan
  - Including how we interact with the Cooperative Agreement
- Configuration Management Plan
- Risk Management Plan
- Earned Value Management System
- Quality Assurance Plan
- Procurement Plan
- Preliminary Safety Analysis Document
- Security Vulnerability Assessment Report
- High Performance Sustainable Building considerations documented
- Monthly reporting in place
- **Technical Design Report (~ 600 pages)**
- **Full Cost & Schedule in Open Plan (~ 5000 lines)**
  - Revisions in progress, cost must match DOE funding profile



# Next Step: CD-2 / 3a Reviews

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- Dates Scheduled
  - Director’s Review: June 4 - 6
  - DOE Review: week of July 16
    - External Independent Review combined?
  - Still allows a sign-off by DOE ~ October 1
- CD-2 sets the project baseline, CD-3a authorizes funds
  - CD-2 requires a “preliminary” (~ 30%) design
    - Lets us spend FY07 funds on final design, an FY07 start
  - CD-3a requires a “final” design
    - Lets us turn dirt and spend the \$ 36 M in FY08
- What we want for a CD-3a list
  - Build access road, excavate hole, some concrete work -- all on the Cooperative Agreement
  - ANU parts procurements
  - Start phased fiber, scintillator waveshifter, and APD procurements



# Summary

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- All the parts of this interlocking puzzle have to come together to initiate the project



- So far all hands are pulling together to make it happen
  - DOE, Fermilab, NOvA Collaboration, NOvA Project