ANL NOvA Group

R. L. Talaga

September 4, 2012

NOνA Group Activities

- L2 Management & CAM
  - **PVC Design and fabrication (R. Talaga)**
  - **Detector Assembly (D. Ayres, through 2008), replaced by P. Lukens (FNAL)**
    - RT took over as lead ANL physicist, working with Lukens and ANL engineers
- L3 Management
  - Detector Assembly Equipment (V. Guarino), PVC Physical Properties (J. Grudzinski), Instrumentation Controls (A. Zhao)
  - Data Base: Hardware and Offline (J. Paley, manager)
- Near Detector (Surface) Operations (J. Paley, Run Coordinator)
- ***Prototype Detectors*** and ***Assembly Equipment*** **built at Argonne**
  - Full-Size Engineering Prototype, disassembled
  - Full-Height Engineering Prototype, being tested at Fermilab (see later slide)
  - Near Detector (on Surface), in operation at Fermilab

Recent and Future Activities

- Ash River Site: Production, Installation and Commissioning
  - Construction Assembly Equipment was built at ANL and commissioned at Ash River: K. Wood and V. Guarino
    - Wood has been at Ash River for several months this year, leading the installation and assembly efforts.
      - **He was specifically requested by P. Lukens**
- Adhesive tests (May – July)
  - Intense effort led to a new adhesive formulation for block assembly. Details will follow.
- **Data Analysis & Physics: Analysis Groups were formed recently and are gearing up for data.**
  - Neutral Current and Charged Current ν_e Physics co-convener (M. Sanchez)
    - » ν_e appearance detection and nc background rejection
    - » Electron ID: Separate electrons from π^0s (S. Magill; see Poster)
  - Charged Current ν_μ Physics co-convener (J. Paley).
    - » Possibility to measure $\sin^2(2\theta_{23})$, with ~ 2- 3 times more sensitivity than MINOS.
      - MINOS: $\sin^2(2\theta_{23}) = 0.96$ (+/- 0.04)
    - » We may also learn more about θ_{23} from **ν_e appearance probability .**
      - Suppose $\sin^2(2\theta_{23}) = 0.97$ and not 1.00 ($\theta_{23} = 40°$, not 45°)
      - Then $P(\nu_\mu \rightarrow \nu_e)$ and $P(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$ would be **~ 15-20% smaller** [greater if $\theta_{23} = 50°$]
  - Intrinsic beam ν_e determination (Z. Djurcic)
- Executive Committee (J. Paley, M. Sanchez)
- Technical Board (R. Talaga)
- Speaker Committee Chair (M. Goodman)

PVC Extrusions

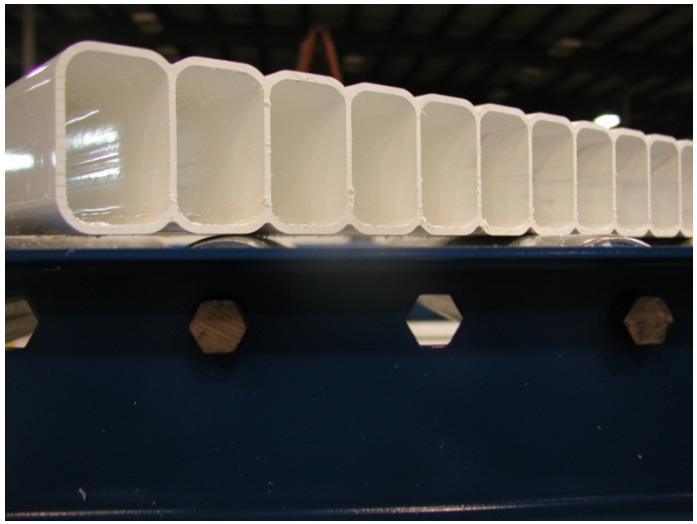
- PVC Formulation
  - High Reflectivity of scintillation light to maximize absorption in WLS fibers
    - PVC resin has anatase TiO2, not used in standard PVC manufacture
    - Anatase has greater reflectivity in the violet than rutile TiO2, which is industry standard
  - Resin must be stable and able to extrude a large complex profile that
    - PVC resin needs the proper stabilizers and lubricants and yet not absorb scintillator light
  - Thorough QC regimen with each lot (typically 250,000 lbs.)
    - Produced twice each month
  - PVC quality has improved markedly (no rejected lots, better extruding stability) this year.
- PVC Extrusion
  - ***Must meet dimensional tolerances***
    - Deviation from flatness across profile < 0.5mm (required for gluing strength)
    - Other dimensions are critical for sealing modules to prevent scintillator leakage
  - ***Must have strength to support 51-foot tall structure filled with liquid scintillator***
    - Detector Mass: 1/3 PVC and 2/3 Scintillator
    - Able to withstand buckling: strong webs, walls and knits are needed.
      - Each extrusion has 77 knits (PVC melt goes around supports and recombines before exiting the die). Each knit is a potential weak point. Strength is tested with hydraulic pressure.
  - Significant improvements in ductility and knit strength made last year.

Extruded PVC

> 11 Million lbs.

NOvA Construction Die

Extruded PVC is pulled through Vacuum Sizing and Water Cooling.

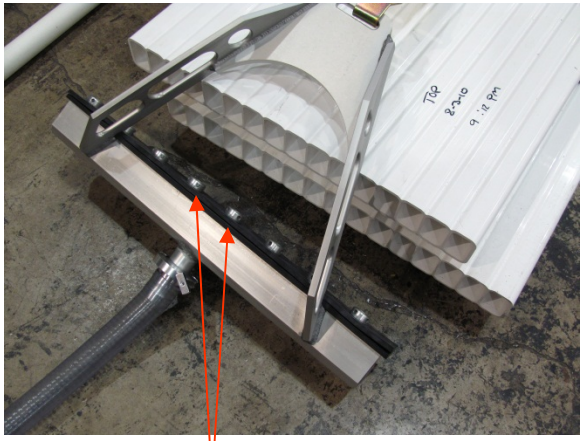


Extruded Profile: 16 cells (77 knits)

Extrusions Shipped to UMN for Module Assembly.

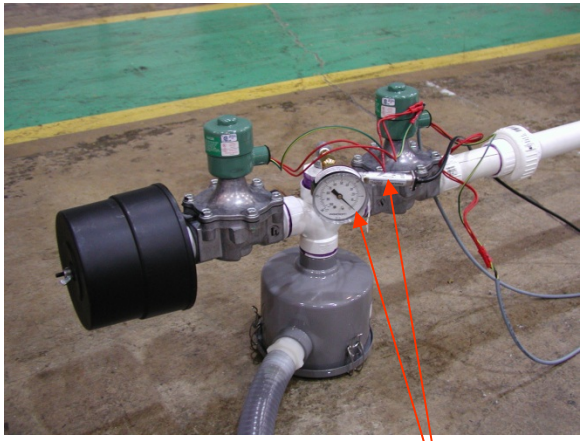
QC Example: Vacuum Tester - Continuity of cell webs (A. Zhao)

Alternate cells under vacuum



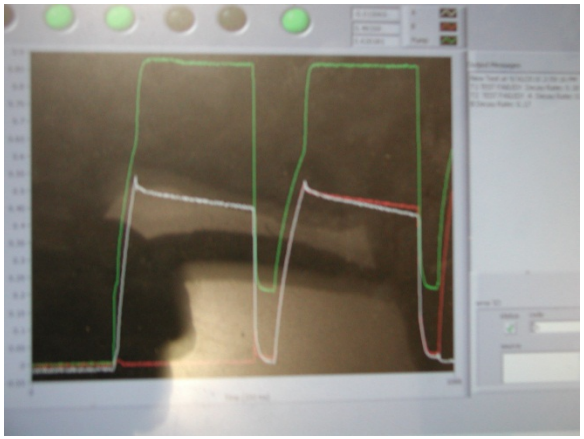
Alternate cells evacuated

Big vacuum pump



Filters, valves and gauges

Pump, valves and gauges under computer control



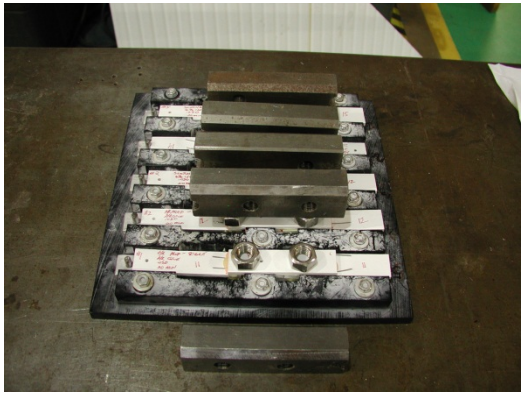
Pressure data (digital values not in photo)

Vacuum test station at Extrutech (PC on table)

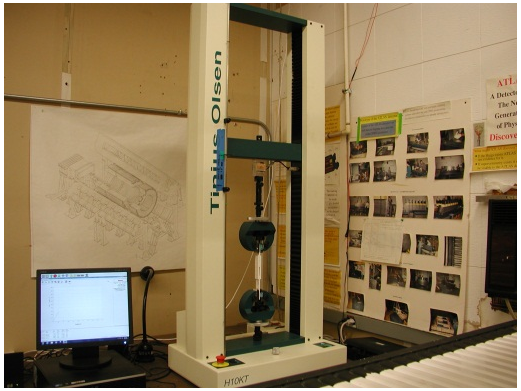
Detector Assembly

- Invented assembly techniques Assembling modules into a detector
  - Devised two critical machines for this purpose
    - Adhesive machine
      - Rotates module upside-down and dispenses 2-part adhesive
    - Vacuum lifter
      - Picks module (on scalloped surface) with vacuum cups
      - Picks steel compression plates and places them on glued module
      - Is able to rotate upside-down in adhesive machine
- Developed "leak tester" to verify that modules are still leak-tight after shipment
  - Fast and accurate method , used just prior to block assembly at Ash River
- Performed adhesive strength tests in the past to select best adhesive: "Devcon 60"
  - Open time > 20 minutes; meets ES&H regulations; bonds well to NOvA PVC
- Earlier this year, we found Devcon 60 is not strong enough for *Construction-grade PVC extrusions*.
  - Significant difference in bond strength when applied to R&D PVC or Construction PVC.
    - PVC Formulation is unchanged, but the extruding speed has doubled.
    - My working hypothesis: construction extrusions are made twice as fast and fewer lubricants are expended in the faster process.
- We have worked with Devcon (adhesive company) to improve bonding strength.
  - Performed lap shear tests with a variety of adhesives, a variety of surface preparations on Construction-grade PVC extrusions.
  - Based on our tests, an improved adhesive designed especially for NOvA was selected in July ago and has been in use for over 1 month at Ash River.

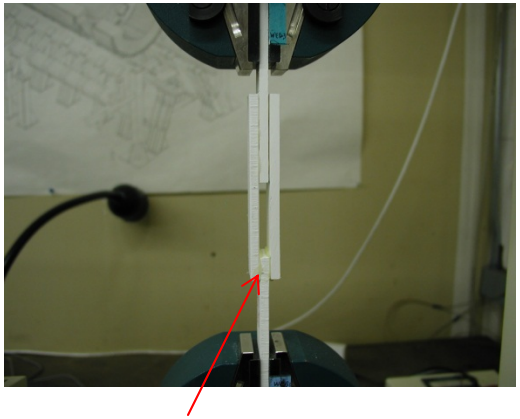
Lap Shear Strength Tests



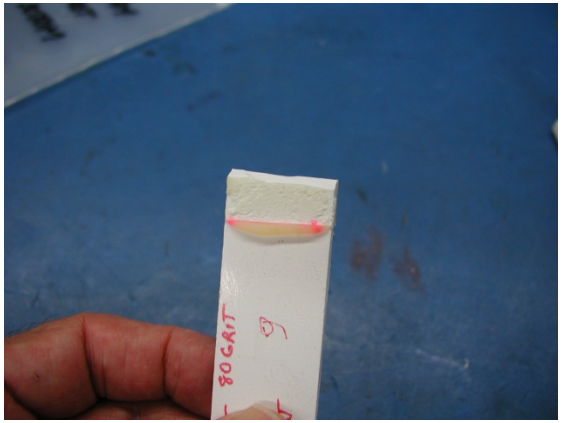
Samples are glued and placed to cure in fixture. Various PVC surface preparations and adhesive formulations tested.



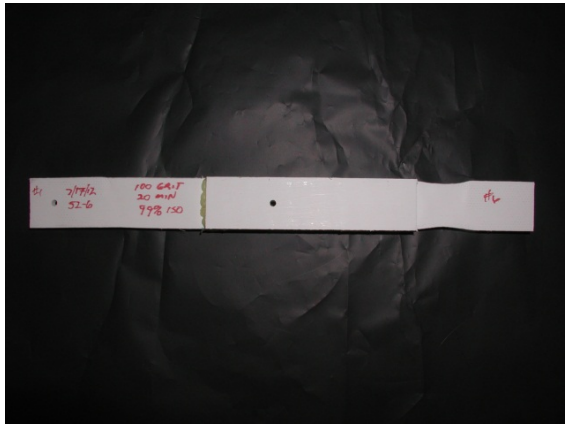
Tensile tester used for PVC QA, adapted for adhesive test.



Bonds being tested are at the bottom of sample.



Good result: Adhesive fails with some adhesion to PVC.



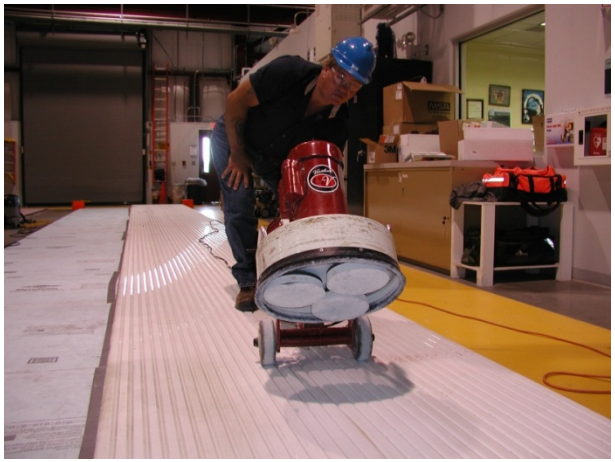
Best result: PVC “necks” with no adhesive failure.

Some of the tested samples.

Result of adhesives tests.

1.“TDR” adhesive formulation is inadequate to bond Construction-grade PVC. There appears to be too much PVC-lubricant on the surface .
2.The formulation was modified with additional acid (and other components). In combination with roughing the PVC surface, adhesive bond is as strong as the PVC.

New: Modules must be sanded (both sides).



After a few days of thinking: prototype flipper was built at ANL

This requires flipping a 1000 pound semi-rigid object.

First Glued Module in NOvA Far Detector at Ash River

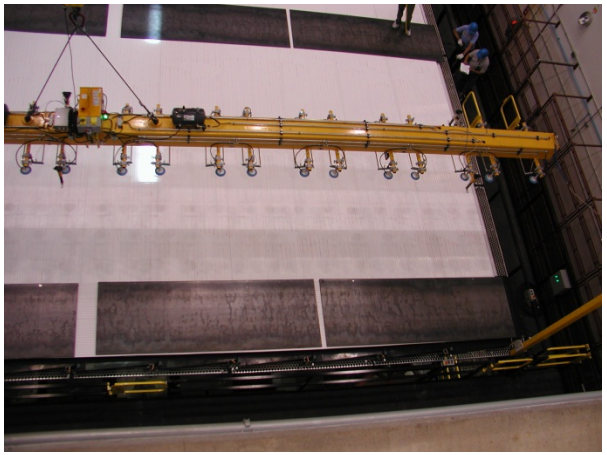
Bottom Layer of V modules on block-pivoter.

First module to be glued (H) and vacuum lifter.

H module is hoisted for gluing in adhesive machine.

Adhesive is applied to bottom of module.

H module is located across layer of V modules.



Steel compression plates placed on top of H module.

One Month Later: Almost Completed and Possibly Installed this Week

Live High-Res Cameras Provide Collaboration with Stroboscopic View of Assembly

Preparing to Install Vertical Modules

Aligning Vertical Module

Full-Height Prototype Detector Assembled at Argonne (Oct. 2011)

Adhesive applied to detector module.

Module placed on detector stack with vacuum lifting device. Steel plates are for compression. Detector is built on its side.

Prototype detector transported to Fermilab's CDF hall and placed on a device to rotate the detector to its operational orientation, standing over 50 feet in height.

NOvA collaboration members visiting assembly hall at ANL, standing on FSAP.

Future work on NOνA

- Complete the PVC Fabrication (end is in sight ~ October 2013)
  - Still requires ***constant*** attention: PVC resin production and PVC extrusion production (RT)
  - Constant QC/QA, including tensile testing at ANL
- Continue Detector Assembly Support
  - Maintain Assembly Equipment at Ash River
  - Measure Strength of new Devcon Adhesive Batches (~ twice per month)
- Develop DAQ Software (J. Paley* and S. Magill)

- Surface Near Detector Analysis
  - Cosmic ray backgrounds
- Far (and Near) Detector Analysis
  - Charged Current ν_μ Physics (J. Paley*, new postdoc)
  - NC and CC ν_e Physics (M. Sanchez*)
  - Electron track identification (S. Magill, S. Phan-Budd, H. Sahoo; RT)
  - Intrinsic beam ν_e determination (Z. Djurcic*)
- Continue NOvA Leadership: Management, Technical Board, Executive Committee and Physics Analysis.

* Younger ANL staff members are taking on large responsibilities and leadership roles

NOvA Collaboration

24 Institutions
110 physicists

…and growing:
28 Institutions
180 physicists