NOνA PVC Extrusions and Detector Assembly

Richard Talaga

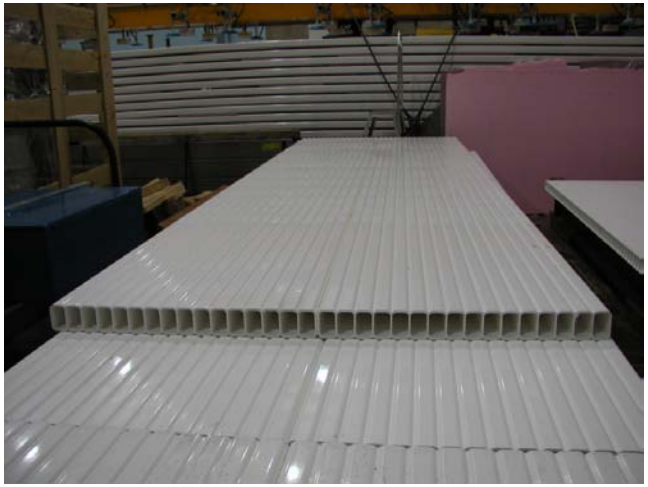
ANL-HEP

ANL and NOvA

- ANL has been an integral member of NOvA from the beginning, before detector technology was selected
  - RPC, solid scintillator, PVC-filled with liquid scintillator, shipping container modules
  - D. Ayres (ret), G. Drake, M. Goodman, J. Grudzinski, V. Guarino, R. Talaga
- **ANL group became the core of PVC detector design for NOvA Project**
  - **Dave Ayres: L2 manager for assembly and installation of near and far detectors**
    - Vic Guarino: L3 manager for detector assembly equipment
  - **Richard Talaga: L2 manager for PVC development and production**
    - Jim Grudzinski: L3 manager for PVC Physical Properties and Quality Control
  - Members of executive committee, technical board, etc.
  - ANL was selected as the site to:
    - Build prototype assembly equipment
    - Develop detector assembly methods
    - Develop procedures and safety approval
      - Adhesive vapors, vacuum lifters
- After Dave Ayres retired, Pat Lukens (FNAL) replaced Dave as L2 manager
  - ANL remained the site for prototype development
  - R. Talaga replaced D. Ayres as physicist in charge of detector development work at ANL

1. PVC Extrusions

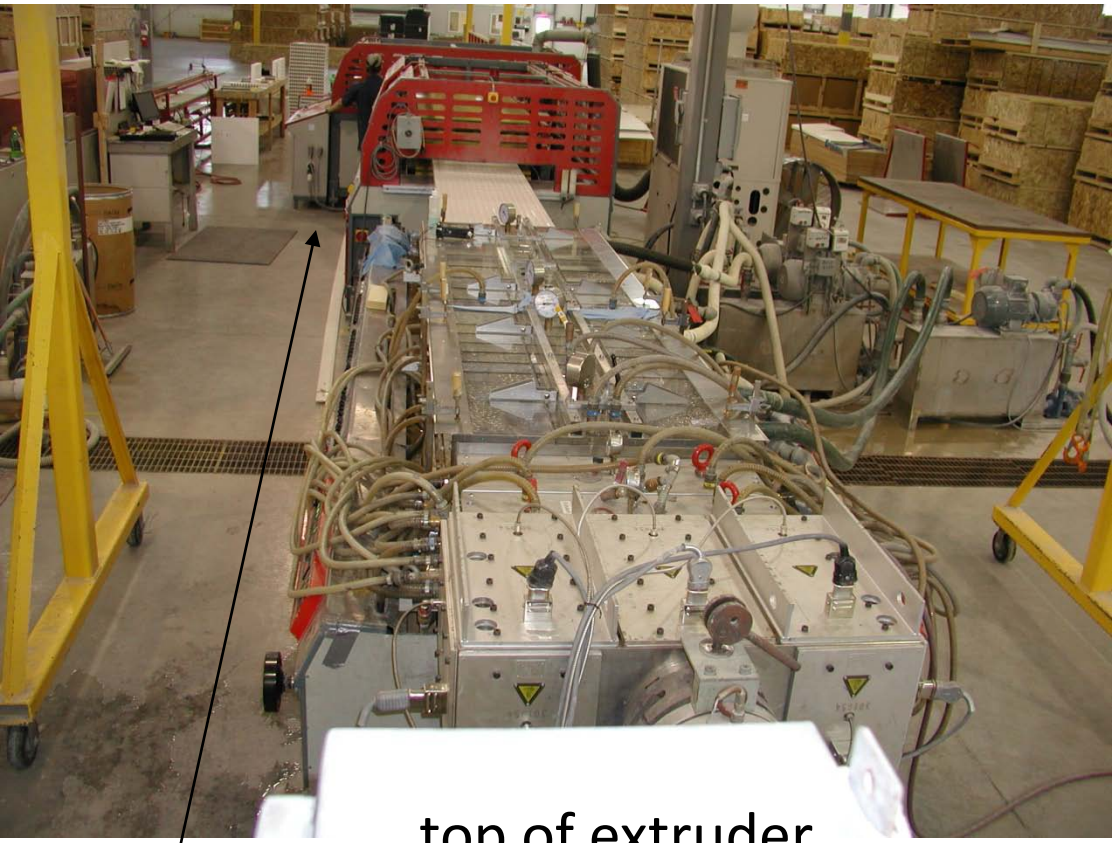
- **Basic Elements of NOvA Detectors**
- **Two** extrusions are combined to make one detector module
- Extrusions must have:
  - High reflectivity for scintillation light to reach WLS optical readout fibers
  - Mechanical strength to support themselves and the liquid scintillator within
  - Exceptional dimensional tolerance
    - to be sealed properly
    - to be assembled with good glue bonding, flatness must be 0.5 mm across the profile



PVC Extrusions and ANL

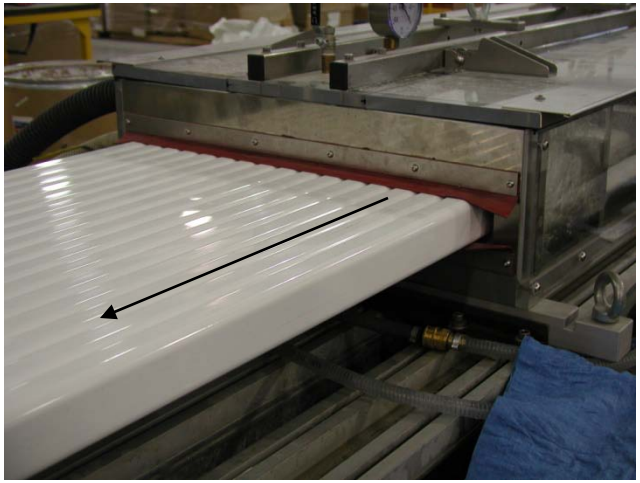
- L2 Manager and CAM of $26M PVC sub-project: R. Talaga
- R&D 2006 – 2010, Construction 2010 - 2013
- ANL participants: Engineers and Physicists
  - J. Grudzinski (L3 manager), **R. Fischer**, V. Guarino, **A. Zhao**, K Wood; R. Talaga,
  - **S. Phan-Budd** (database organization and plots)
- PVC Task: Two sub-tasks, each roughly $10M (~$1/lb)
  - Develop and produce custom N-27 PVC resin
    - Must exhibit high degree of reflectivity & be suitable for extruding
  - Extrude N-27 resin into 16-cell panels
    - Two 51-ft panels combined to make one 32-cell module (UMN)
    - Strict dimensional tolerances: height, flatness, wall thickness, etc.
- Extensive QC procedures, developed by PVC group
  - Headed by Jim Grudzinski (ANL-NE) with help from Allen Zhao (ANL-HEP)
    - Designed and built specialized QC instruments
    - Researched and purchased commercial instruments
- Detailed analysis of PVC strength throughout construction period
  - R. Fischer (ANL-NE)
    - Plastics expert (engineer)

Extrusion Line Production



top of extruder

extruding direction

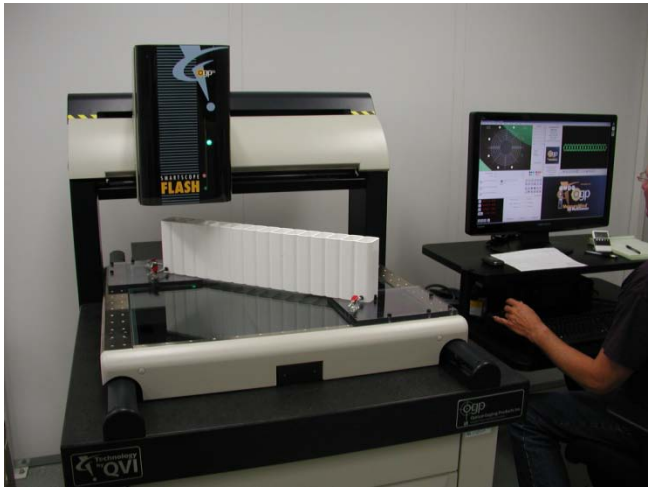


exiting cooling tank

entering the puller

PVC **Quality Control Instruments**

- Dimensions: Optical Metrology Machine
  - Flatness, Thickness and Shape
  - Hundreds of measurements per extrusion
  - **Jim Grudzinski** establish geometrical definitions and documented "as-built" dimensions and tolerances



- Reflectivity: Spectrophotometer
  - Measures reflectivity across scintillation spectrum
    - MC computes relative light output of module based on reflectivities (**Sarah Phan-Budd**)

Not Shown (custom-made instruments):

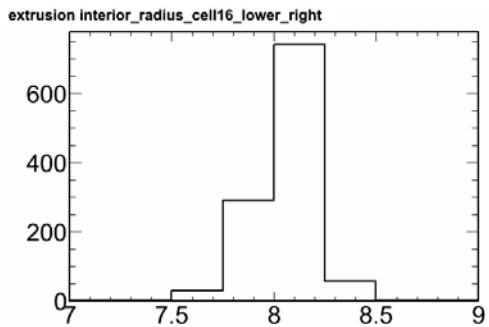
- Vacuum tester: **Allen Zhao**
- Impact tester: **Jim Grudzinski**

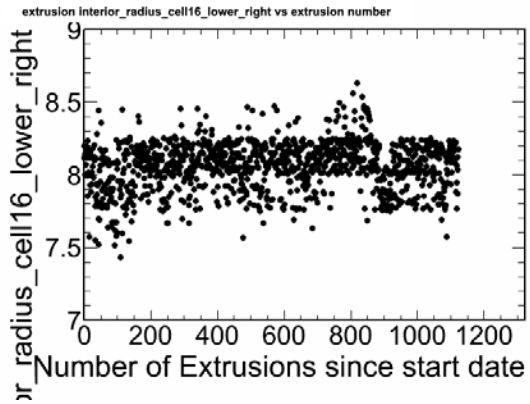
- All data entered into NOvA Hardware DB
  - **Sarah Phan-Budd, Jon Paley**

PVC Hardware DB Plots

- Plots are automatically generated every day for a variety of PVC measurements
  - A sample of the measurements in the hardware DB
- http://www.hep.anl.gov/sbudd/Extrusion_data.html
- Each quantity is plotted as a function of time, and histogramed
  - For the past week, past month month, and for all FD extrusions
  - Example on left is the interior radius of cell 16, measured in the lower left corner

Full Length





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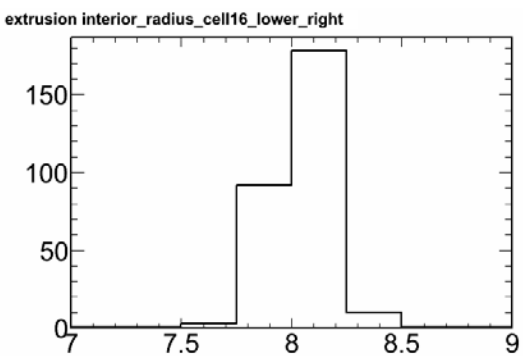
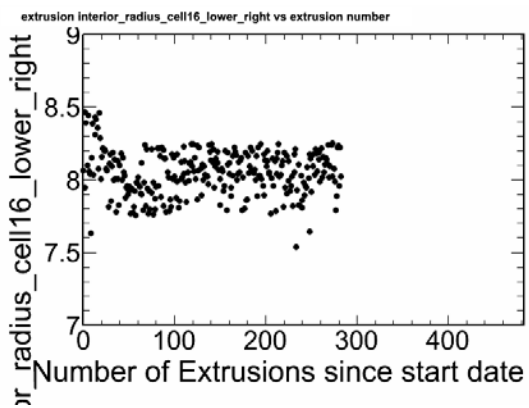




Developed by S. Phan-Budd

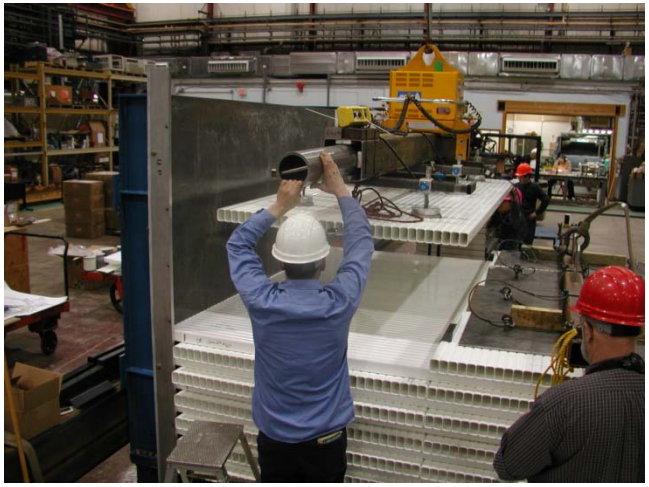
2. Detector Assembly

- Richard Talaga
  - Physicist in charge of Assembly work at ANL
    - Coordination, Planning & Safety Documentation
    - SOWs (and helped prepare change requests)
- Sarah Phan-Budd
  - In charge of leak-testing NDOS modules using UMN test device
    - Safety documentation and operations
- Zelimir Djurcic
  - Developing, with Allen Zhao, the ANL Pressure Leak Tester
    - To be used at Ash River to check possible module leaks due to transportation
- Vic Guarino
  - L3 Manager: Detector Assembly Equipment
    - From start of Project
  - Detector Installation, Assembly and Integration Engineer: ~2/3 FTE, starting January 2011
    - Spans several tasks: PVC extrusions, detector modules and detector assembly
  - **Critical member of overall NOvA engineering team**
- Ken Wood
  - Built detector prototypes (FSAP, IPND)
  - NOvA adhesive dispenser, vacuum lifters, NDOS
  - Innovative contributions to assembly procedures
  - Next: Full-Height Engineering Prototype (FHEP), in July-August
    - **Final prototype before assembly of 400,000-lb blocks at Ash River**

Detector Assembly at ANL Snapshots

- Full Scale Assembly Prototype

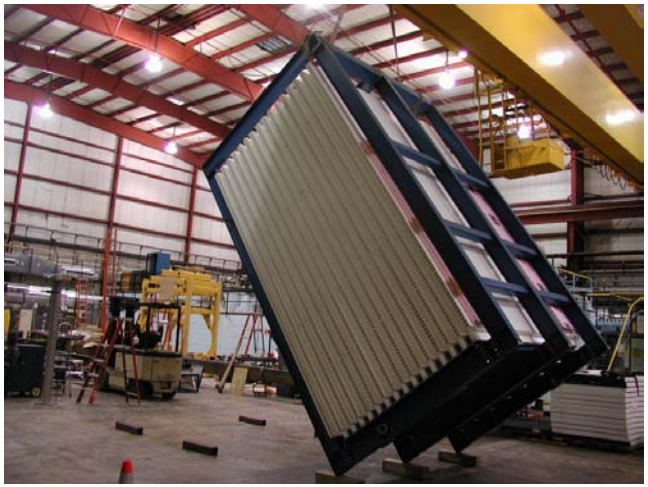
- Near Detector Engineering Prototype



Detector Assembly at ANL

Full Size Prototype

Leak testing Modules for Near Detector on Surface (NDOS)

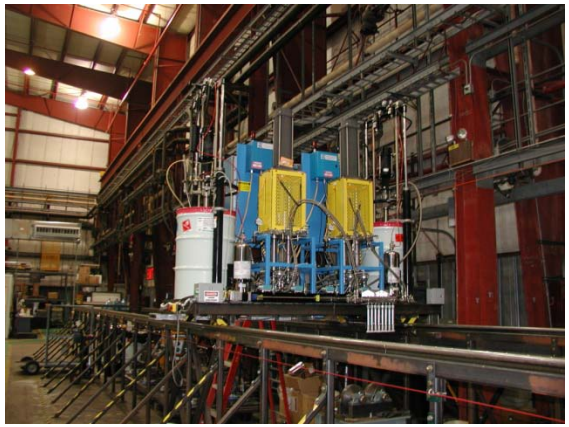


Rotating Engineering Prototype

Moving NDOS Block outside for Shipment to FNAL

Assembly Equipment for Ash River

Based on Prototypes Developed at ANL



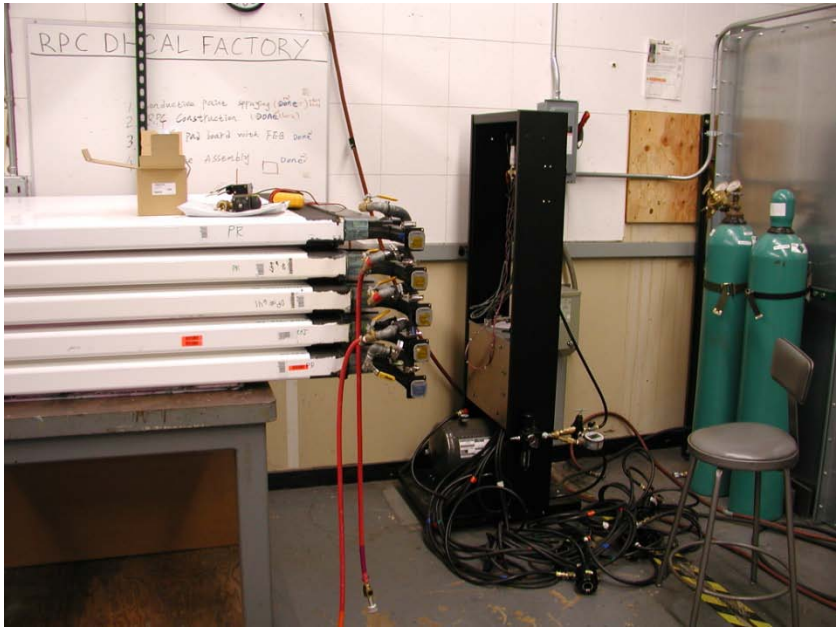
Prototype Adhesive Machine

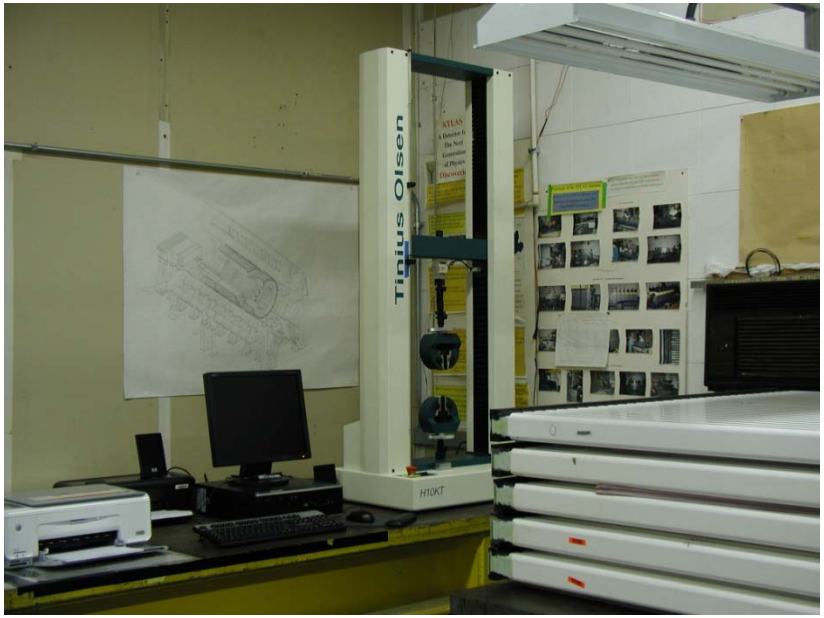
Adhesive Dispensers for Ash River

Ash River Vacuum Lifters , Fabricated at ANL

Evolution Samples of Prototypes

Assembly QC Equipment





Leak Test Prototype with four channels, scalable to 24 channels for use at Ash River.

Tensile Machine tests glue strength of various samples as part of adhesive RFP. Primary purpose is to test PVC tensile properties for duration of production.

Detector Assembly: Current Activities

- Three production Vacuum Lifters (and prototypes)
- Adhesive machine at ANL and Ash River
- Flexane machine : FHEP at ANL, then transported to Ash River
- Construction Methodology; Procedures
- Adhesive evaluations for RFP
- Adhesive thickness
  - Constraints on accuracy of joined extrusions
- Leak tester prototype and for Ash River
- Full Height Engineering Prototype (July-August)
- Prior Prototypes
  - Full Size Assembly Prototype
  - Near Detector on the Surface (Integration Prototype)
- Technicians installing adhesive machine at Ash River
- **Assembly Engineering and Integration**

Conclusion

- PVC Extrusions
  - Developed PVC compound with strength and high reflectivity
  - Produced extrusions for FSAP and NDOS
  - Produced > 1,000 51-foot extrusions for Far Detector
- Detector Assembly
  - Making Prototype Detectors
    - Made NDOS
    - Will make underground Near Detector
  - Developing Equipment for Ash River
  - Developing Installation Procedures for Ash River
- ANL is a critical core constituent of the NOvA Project