Assembly Group Report

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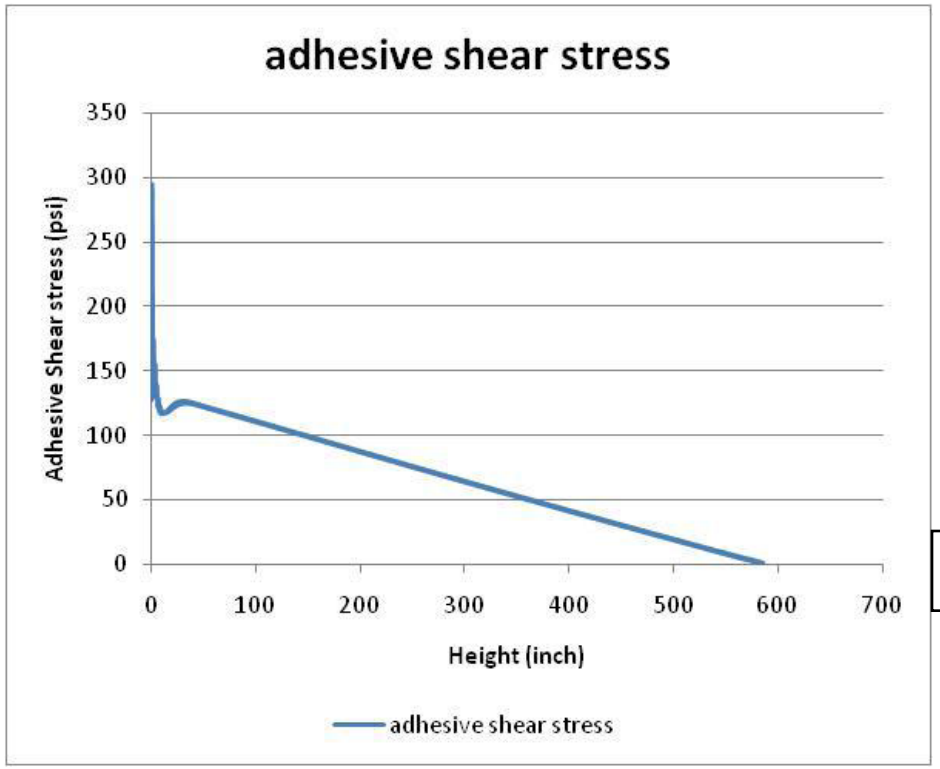
Detector Assembly

- Assembly of the Nova Far Detector began Aug. 2012
  - Three blocks have been assembled and installed.
  - Installation of the fourth is scheduled for week of 19 Nov.
  - Each assembly has improved from the previous one
    - Crew gains experience
    - More efficient methods are developed.
    - Off-loading surface preparation from the assembly factory.
- Startup was delayed by adhesive concerns
  - Solutions were identified and implemented

Adhesive Strength Requirement



From Nova #5726

- Predicted maximum stress in the adhesive is 125 psi
- Predicted peel force is 9 lb./in.
- We established a 500 psi standard, based on desiring a safety factor of 4 in this stress.

Adhesive Strength

	Zero Open Time			20 Minute Open Time		
Glue Line Thickness	**0.012”**	**0.030”**	**0.060”**	**0.012”**	**0.030”**	**0.060”**
Shear Stress (psi)	1132.3	1008.6	792.9	842.6	508.5	294.3
Shear Stress Std-Dev.	131.6	309.7	47.1	137.5	124.0	87.8
Peel (lbs/in)	99.12	125.1	122.9	87.1	64.8	84.1
Peel Std-Dev.	14.3	15.8	21.7	17.2	23.2	22.4

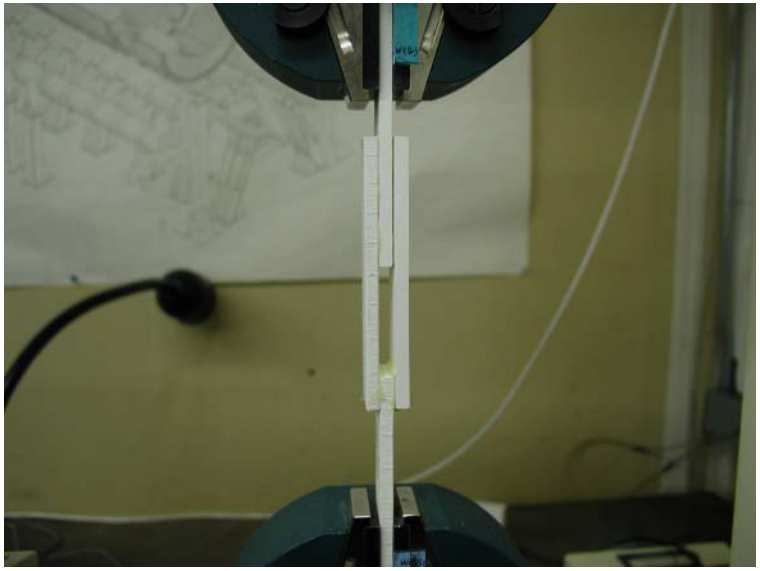
From Nova #1944

- Plastic Welder 60 from ITW Devcon was developed for Nova
- Strength tests on prototype Nova PVC established our assembly specifications
  - No more than 20 minutes open time
  - Flatness to within 0.75 mm

Adhesive Strength Concerns

- Strength test performed in May, 2012 by ITW Devcon and ANL showed poor strength when our intended adhesive was used on production PVC.
  - Prototype parts gave stronger joints.
- This problem was addressed on two fronts
  - Modified Plastic Welder formula from ITW Devcon
    - Minor, no cost change
  - PVC surface treatments were studied for improved bonding
    - Abrading the surface with sandpaper

Tests with New Adhesive



Shear sample under tension

1000 psi shear strength seen

Peel samples

100 pounds/inch seen

- Safety factor in shear is ~8, ~10 or more in peel.
- All glued surfaces will be scuffed with sandpaper
  - Considered to be very conservative, since stress declines with height.

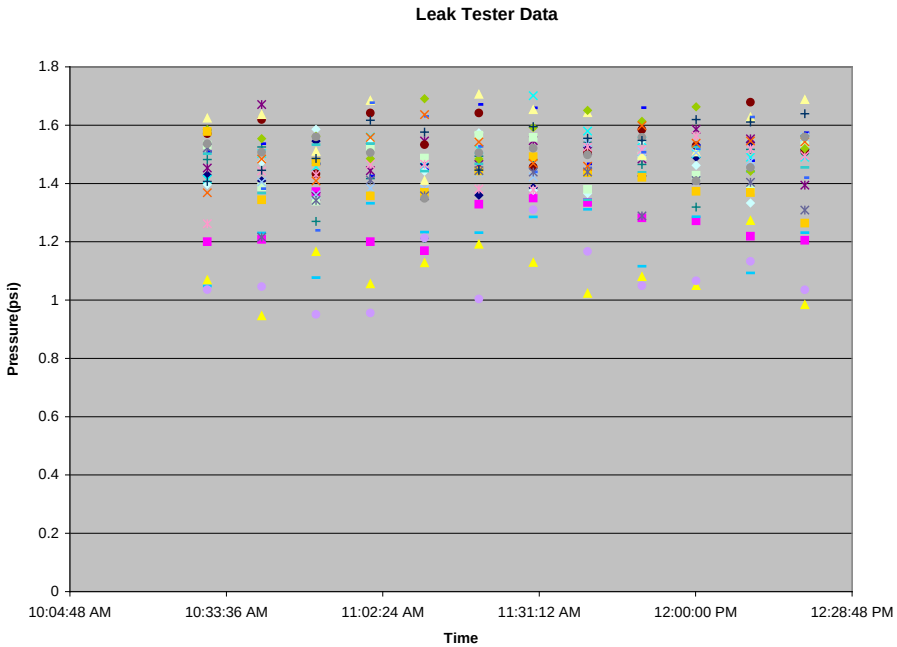
Adhesive Aging

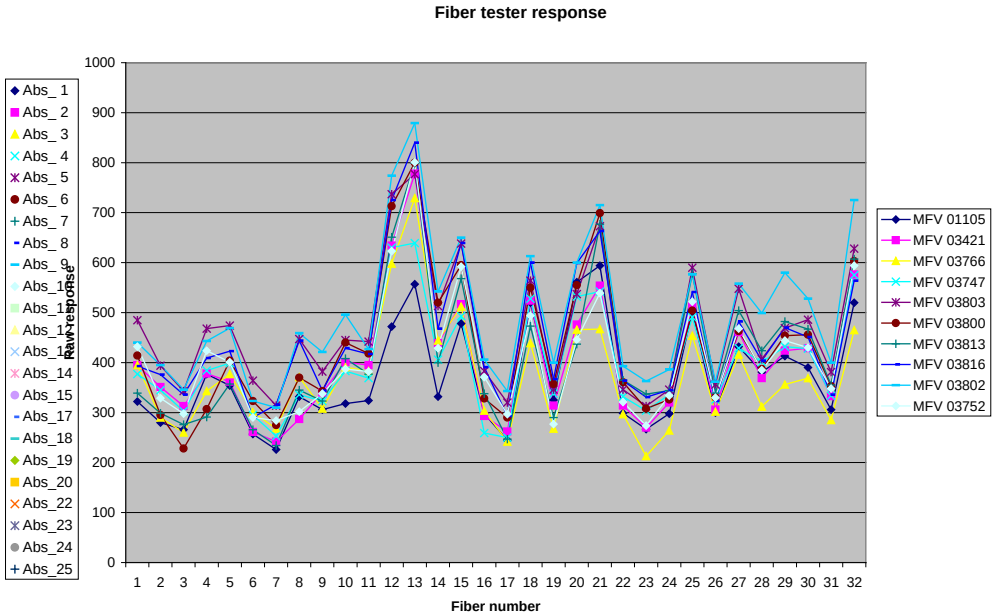
- Obviously, no direct aging tests are possible with Plastic Welder 60 and Nova 27 PVC.
- From the Devcon, No loss of strength from
  - Plastic Welder/PVC bonds immersed in scintillator
  - Plastic Welder immersed in hot salt water for one year.
- There is a long history of using this product.
  - "Aside from these two quantitative studies we have the historical knowledge that similar chemistry - methacrylate - to the PW and PW 60 has been utilized for end use applications such as bonding FRP stringers to hulls within the marine industry…..Again, the life expectancy of such joints is many years. As such, given the more static and environmentally controlled nature of your application, I am very confident that the adhesive joints will have an extensive life span…." M. Faino, Devcon

Module Surface Preparation

- Blocks are built with scuffing for all glued surfaces.
- For first 6 layers, leak and optical fiber tests were repeated after scuffing
  - No failures were found
- Current technique is a floor sander, 80 grit sandpaper.
- Probably ~40 minutes per module to sand
  - Requires crane to move, people to flip, space to work
- Not compatible with the Ash River assembly schedule.

Quality Checks Before Assembly





- A leak test is performed to test for shipping damage
- Pressurize, wait 2 hours
- Any observed decline is retested
  - No bad modules have been found

- Optical continuity is checked for each module
- Broken fibers show no response
- These tests only confirm that shipping has not caused problems
  - More sensitive tests are performed at the factory.

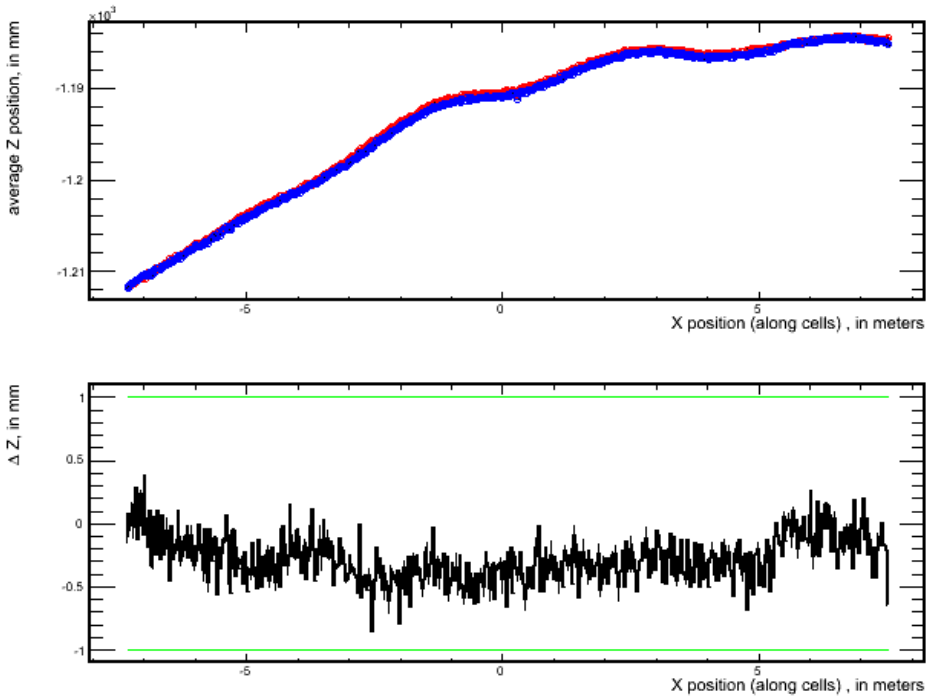
Assembling a Block

Module being positioned

- The technique was developed at ANL
- Two multilayer “dry stack” exercises at Ash River

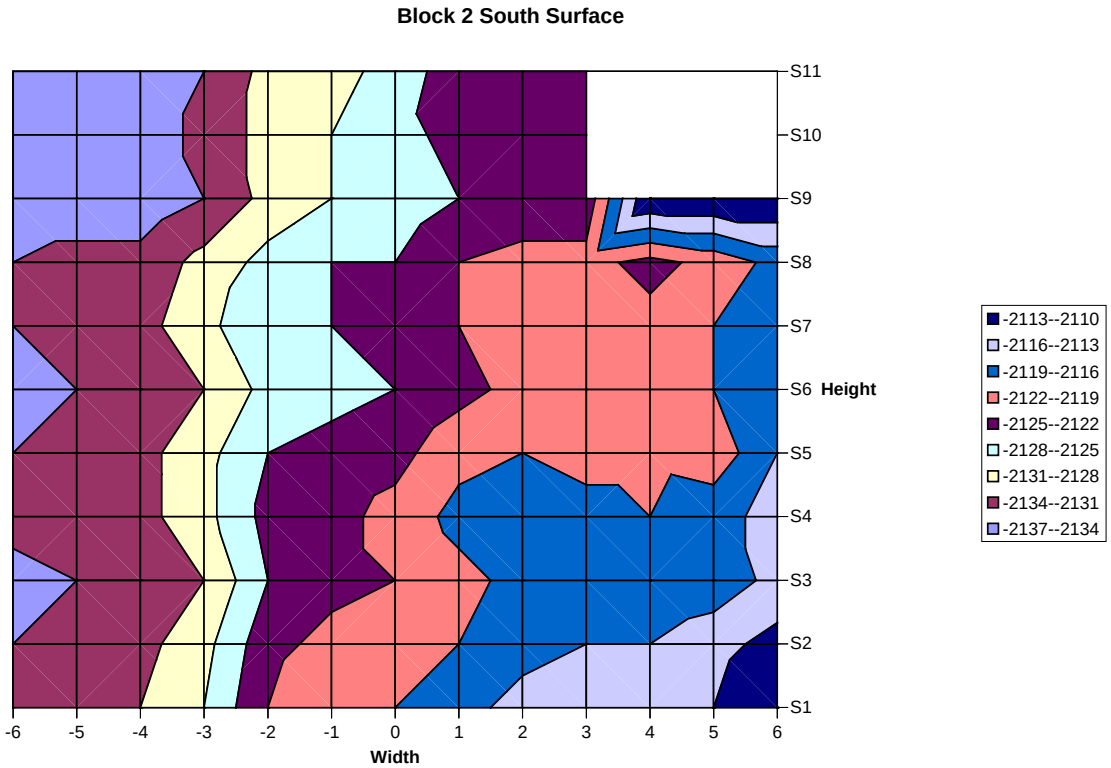
Layer Quality

- After assembly, each layer is measured.
- Scanner data is analyzed by examining the relative heights of adjacent modules
  - Typical flatness check from Layer 14, Block 0.
- Laser scanner gives a height of channel 0 (blue) for one module, channel 31 (red) for the adjacent one.
  - We look at the difference
  - Green lines are ±1 mm



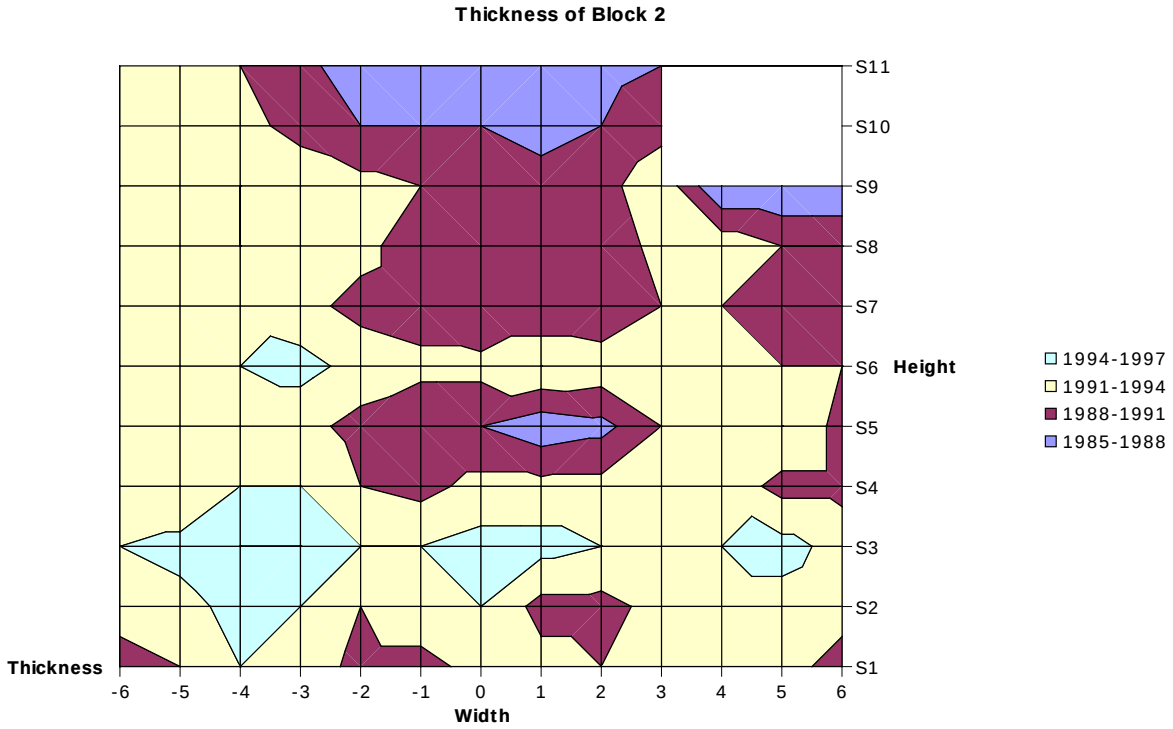
- No problems have been seen with layer flatness
  - We're within our flatness specification

Block Shape



- Scanner data shows the shape of the block front face
  - Each band is a 3 mm range
  - 27 mm full range – the table top accounts for 16 mm

Block Thickness



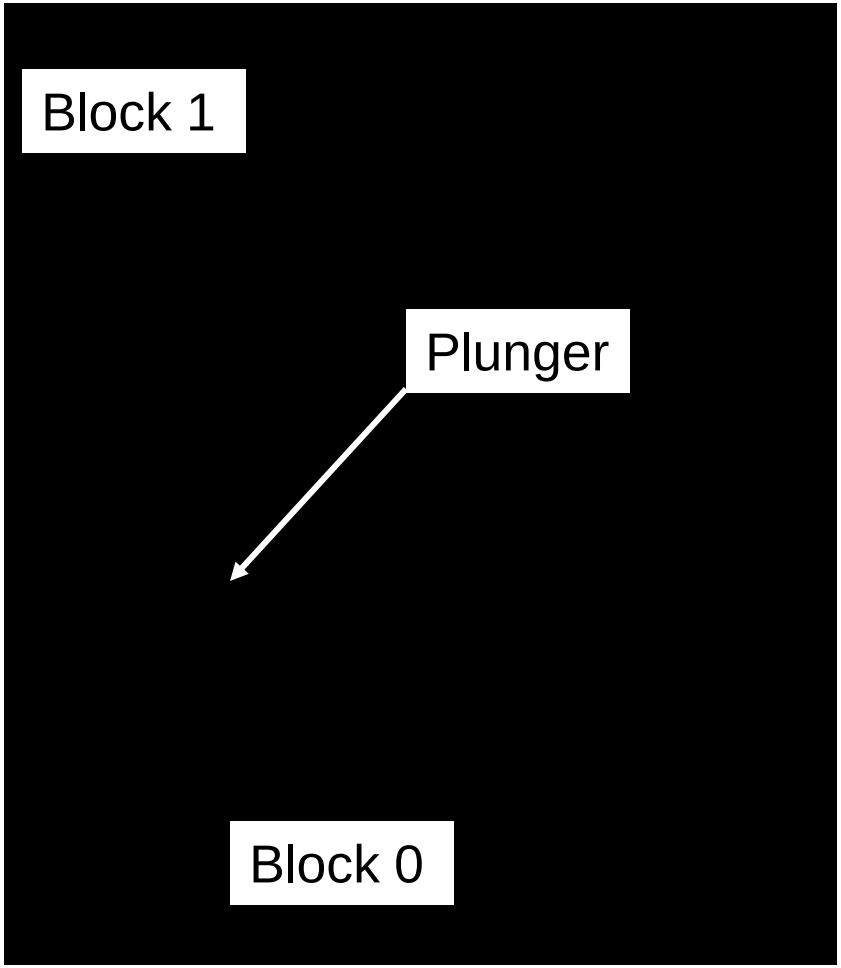
- The difference between Layers 0 and 30 give block thickness
  - Each band is a 3 mm range
  - Table contour tracks through the stack or 32 layers
  - ±6 mm thickness variation

Block Installation

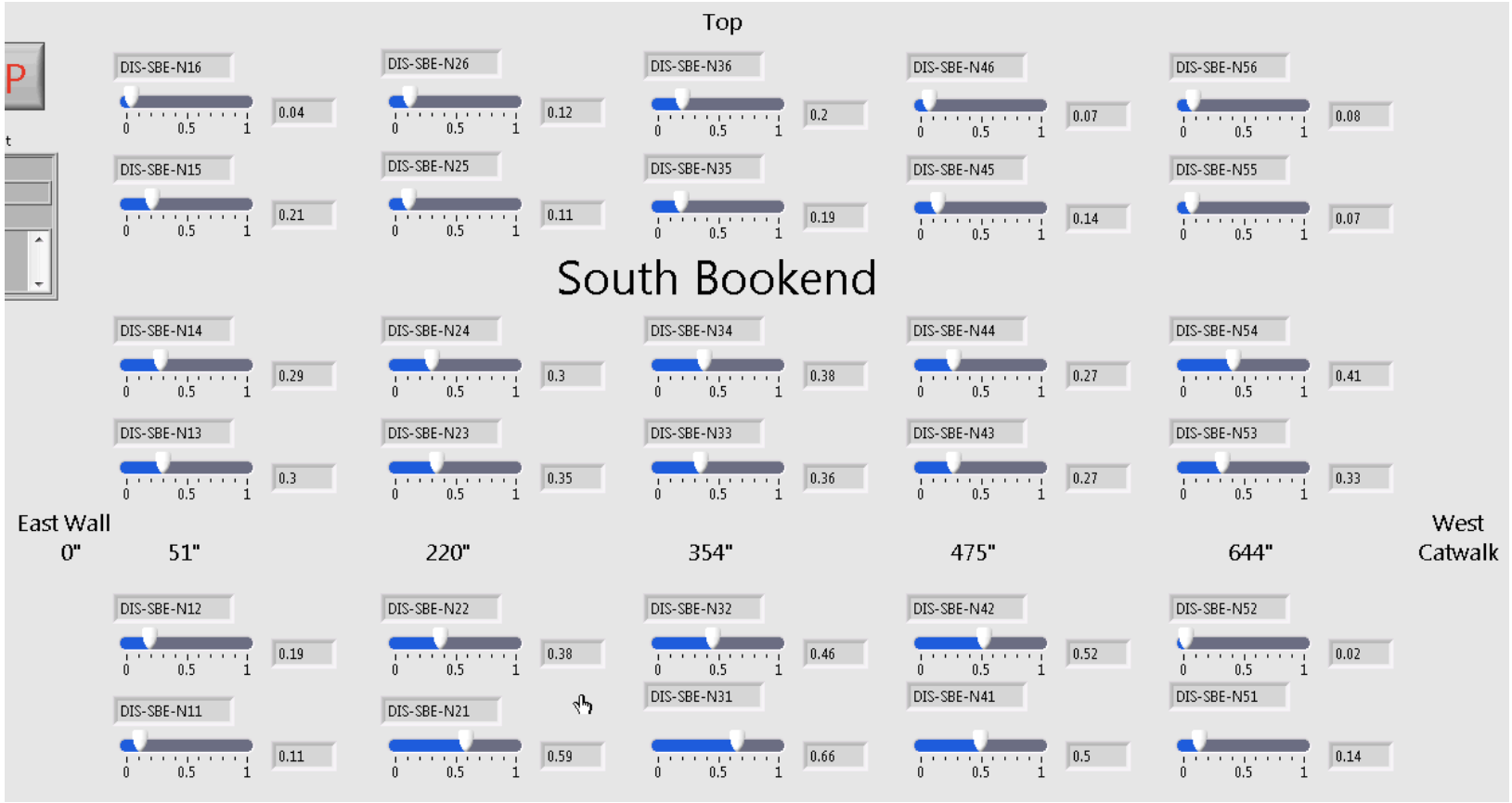
- Block 0 went in on 10 Sep. with the whole world watching
  - Slowed, due to the drive being set for too low an operating pressure
  - A few components were changed, controls reprogrammed for the second block

Position Sensors

- Each block's position with respect to neighbors is measured with a plunger.
- These are used to monitor proximity in installation
- Long term motion will be monitored



Proximity to the Bookend

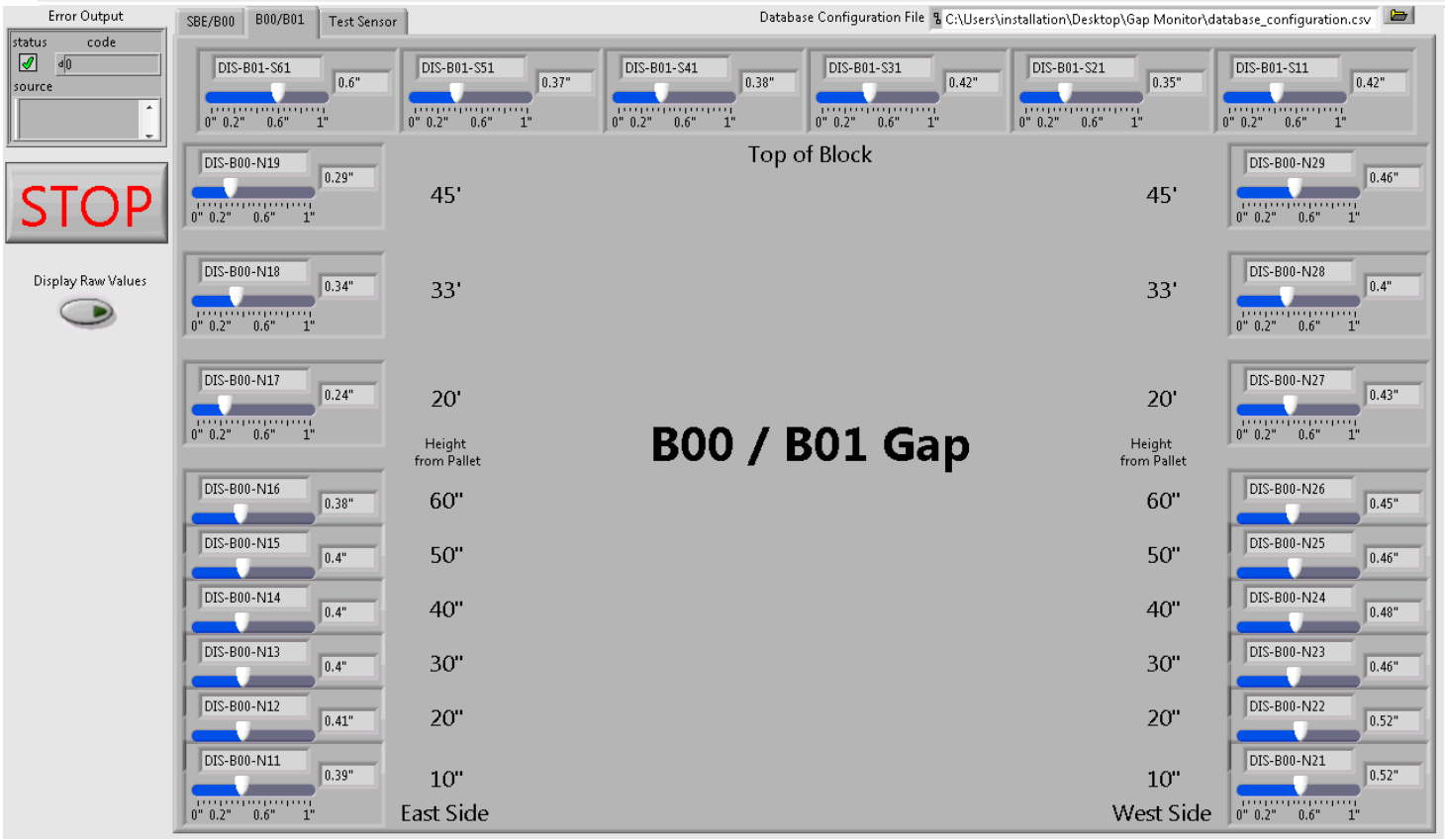


- Sensors show Block is hard to the bookend on the corners
  - Bowing in the middle.

Block 1 Installation

- Installation of Block 1 was our first block-block gap
- Requirements
  - Touching the adjacent block at the top
  - 0.25 inch gap to the neighbor
  - 1 inch tilt to the south
- Accomplished with
  - 0.25 inch PVC shim at the top, 4’ x 52’
  - Adjustable stops on the pallets at the bottom
  - Pallet design has nominal tilt

Block 1 Sensor Screen Shot

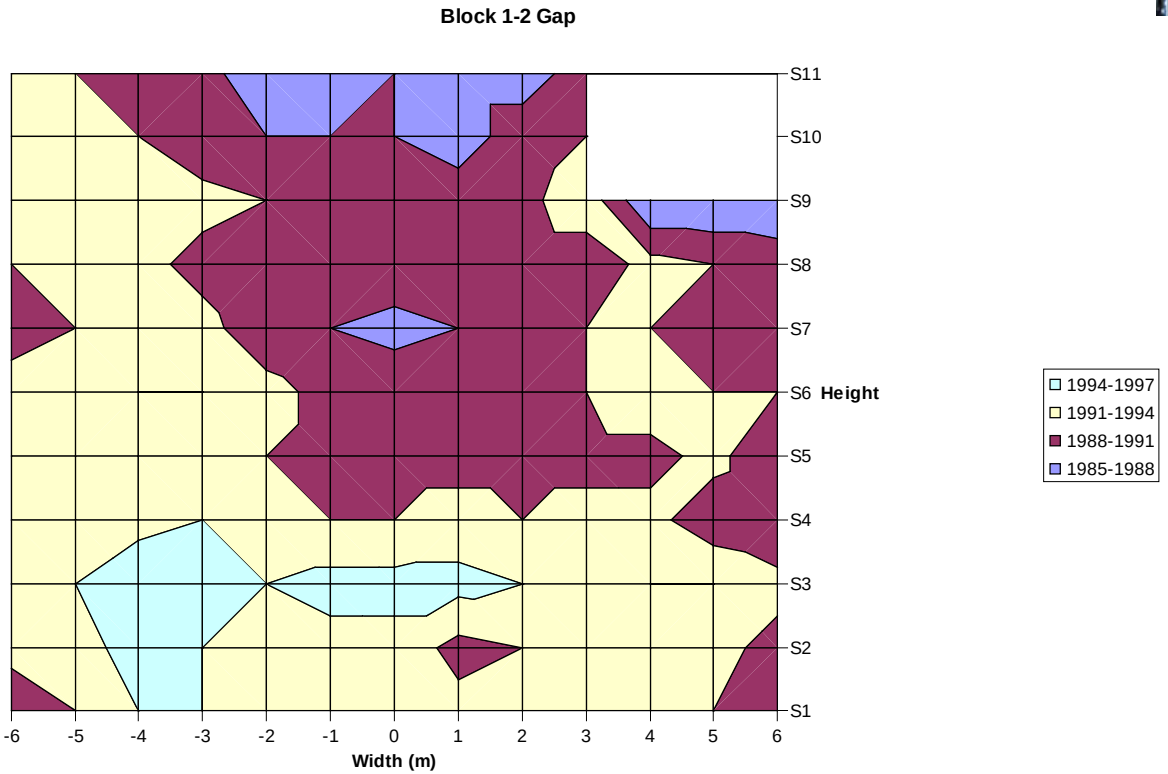


- Generally, our gap is slightly large
  - Pallet adjustments will be pulled in slightly next time
  - Tilt measured to be 1 3/8 inch - satisfactory

Block 2 and Beyond

- Block 2 was installed on 25 Oct.
  - A three week turnaround
- Slight excess in Blocks 0-1 gap was corrected
  - Blocks 1-2 gap is slightly narrower at the bottom
- Block 3 may go slower
  - Factory will prepare fewer modules – shifting from module sanding to extrusion sanding
  - Anticipated installation for the week of Thanksgiving.
- Block 4 will be facing the holidays
  - Staff reduction will be small though, still two shifts

Nesting of Blocks

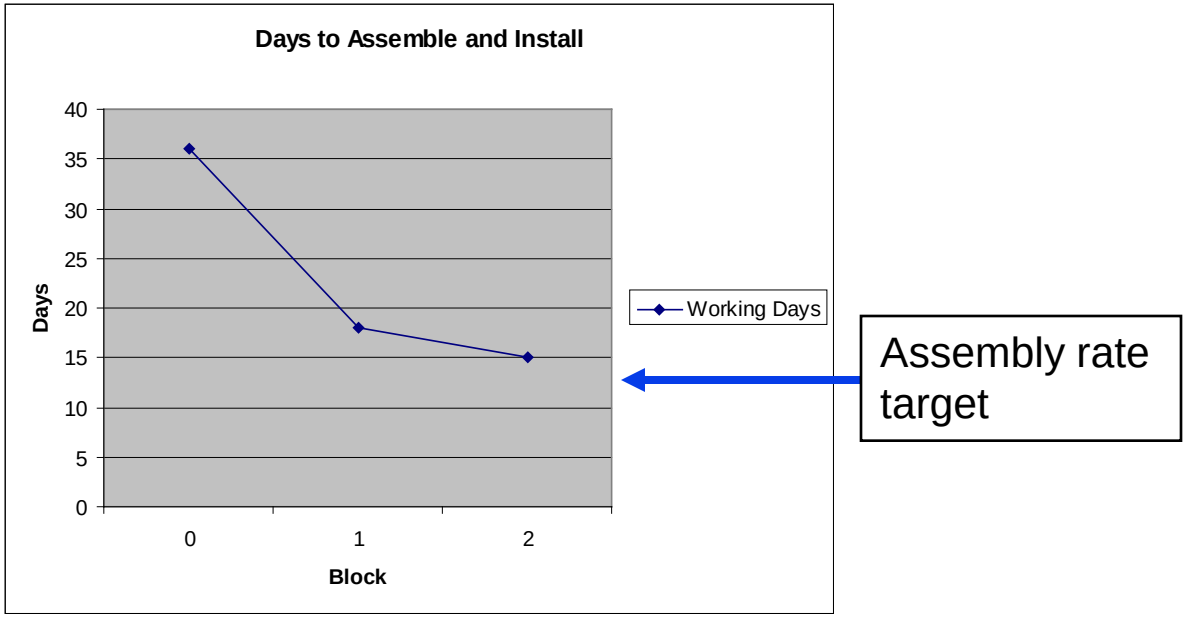


- Difference between Block 2 Layer 0 and Block 1 Layer 30
  - Shapes are strongly correlated – “Pringle affect”

Assembly History

- Block 0 assembly began as soon as our first batch of modified Plastic Welder 60 arrived
  - Assembly took 6 weeks
- Block 1 assembly required 3 weeks and a day
  - Crew was practiced. A rhythm was established between sanding and stacking.
- Block 2 assembly required 2 weeks and 2 days
  - Most modules were scuffed in Minneapolis
- Block 3 is in progress
  - More scuffing at Ash River, 14 layers done in 6 days

Assembly Conclusions



- Assembly of the Far Detector is in progress
  - The crew has settled into a routine.
- Assembly rate of 3 weeks/block has been achieved
  - 2.5 weeks/block is the goal.
- At this point, we're in operations, and we'll continue to look for improvements in efficiency.