



# PVC Module Production (2.5)

**Ken Heller**

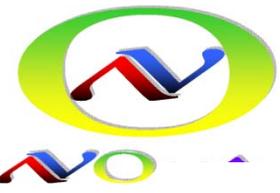
**University of Minnesota**

**May 8, 2012**

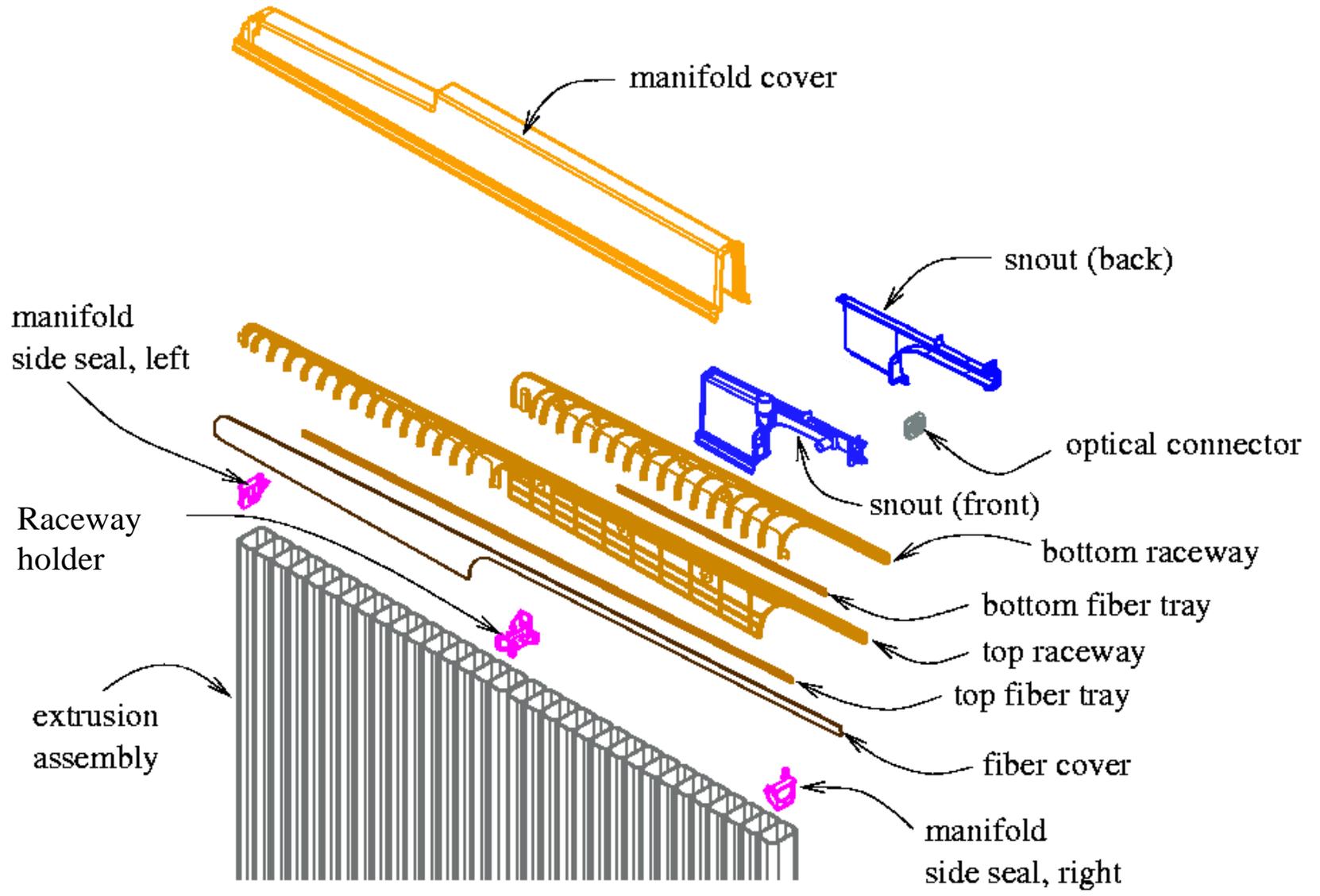
**Minerba Betancourt, Jianming Bian, Tom Chase,  
Dan Cronin-Hennessy, Ben DeYoung, James Geddes, Chris Kluge,  
Susan Lein, Tina Lorsung, Jarek Nowak, Greg Pawloski, Jim Parker,  
Nathaniel Pearson, Ron Poling, Nick Raddatz, Dominick Rocco,  
Kanika Sachdev, Alex Smith, Brian Sherwood, Dick Wildberger,  
Robyn Woolands, Jan Zirnstein**

**Technician**  
**Accounting**  
**Engineer**  
**Physicist**

**+ 170 undergraduates**



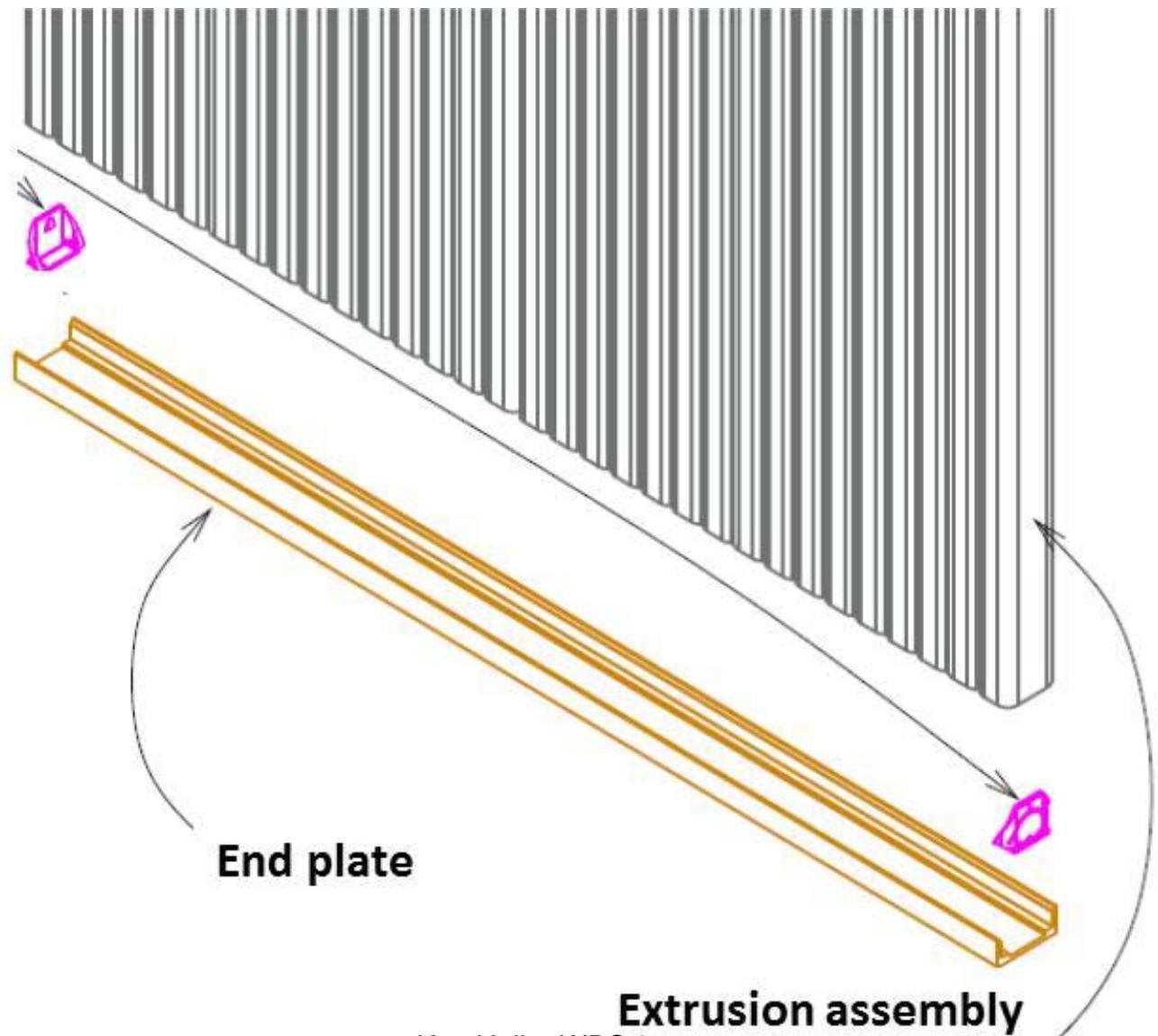
# Manifold Parts





# End Seal Parts

Side seals



End plate

Extrusion assembly



# Module Production Status

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- All machines & QA – **operating.**
- All molds & dies – **completed and in production.**
- Parts – **flowing in.**
- QA, process, & inventory software – **operating**
- Asynchronous 2 to 1 operation – **in production**
- Module production – **ramping up**
- Module shipping – **4 planes (48 modules) to Ash River on schedule**
- Factory floor – **filling up**

**Slow ramp-up for approximately 1 month 95 good modules produced**

**Initial process adjustments to minimize**

- **Fiber damage**
- **Optical connector leaks**
- **Outer seal leaks**
- **Visual inspection flaws**

# Module Factory Stable 2 to 1 Production



**Factory and annex are full**

**Peak 2 to 1 production rate 38/day (average needed 27/day)**

**3272 complete 2 to 1 (8.5 blocks = 29% of far detector)**

**Failure rates overall**

**Flatness – 0.7%**

**End Cut – 0.6%**

**Failure rates April**

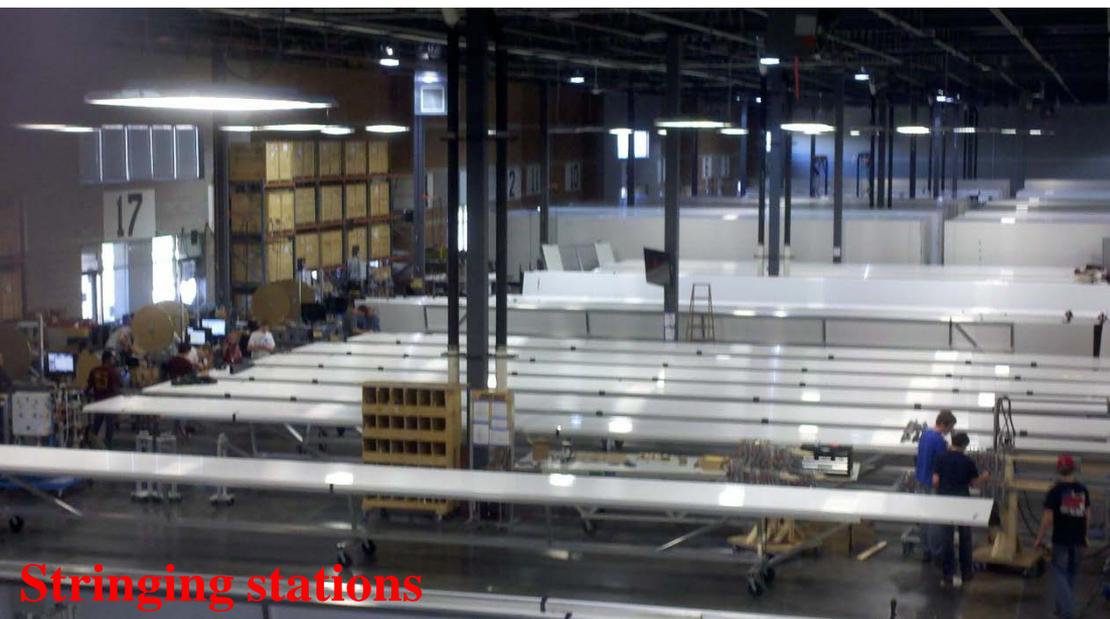
**Flatness – 0% (125 done)**

**End Cut – 1.6 % (125 done)**

**Slowing 2 to 1 production to put effort into module production**

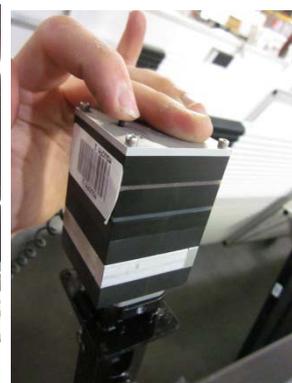
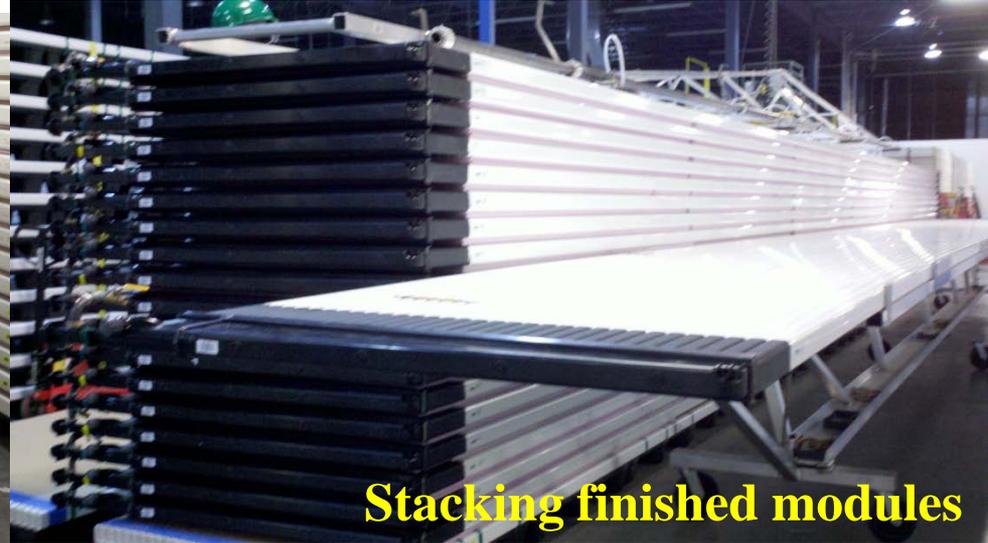
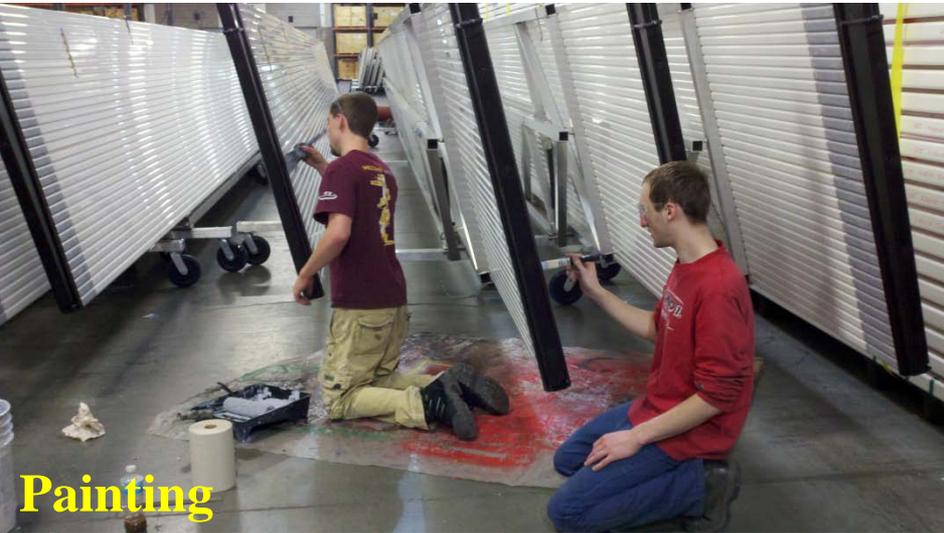


# Scenes from the Factory Floor





# Scenes from Production – Final Stages





# Scenes from Production



**Pressure testing**



**Fly cutting**



**Sealing endplate**



**Open fiber testing**

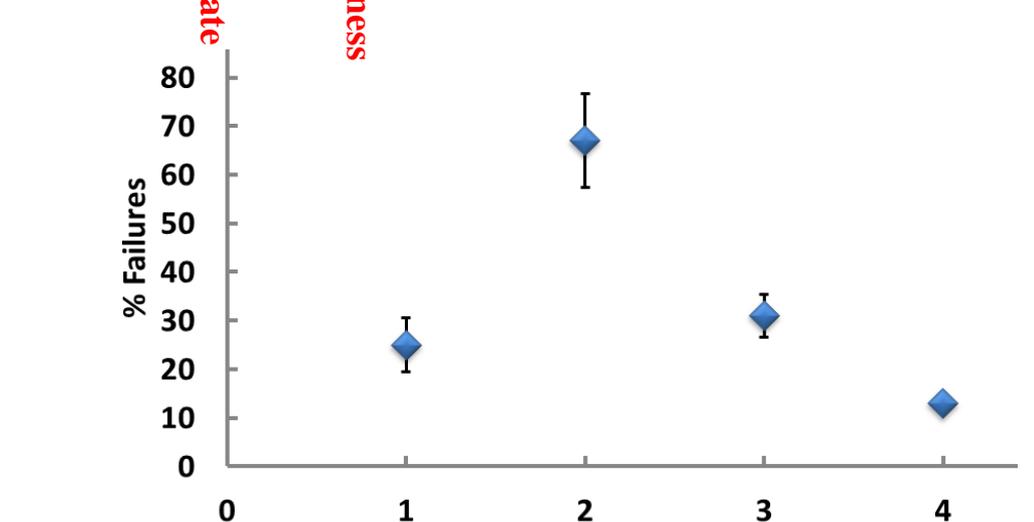
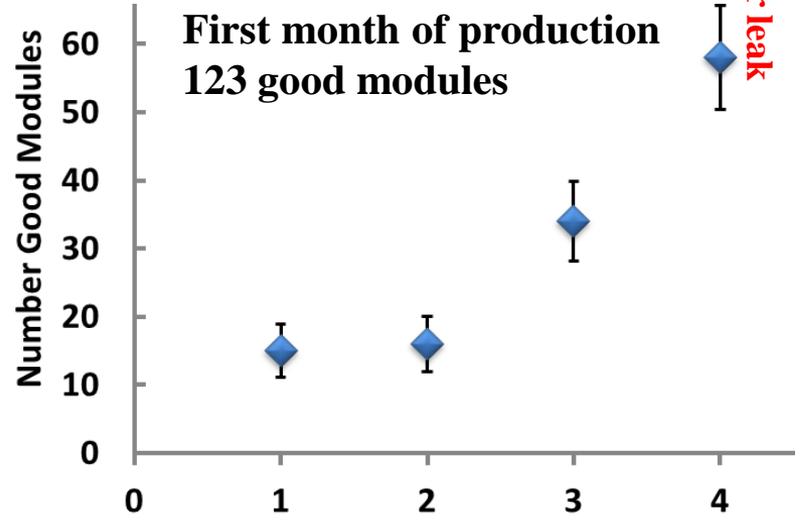
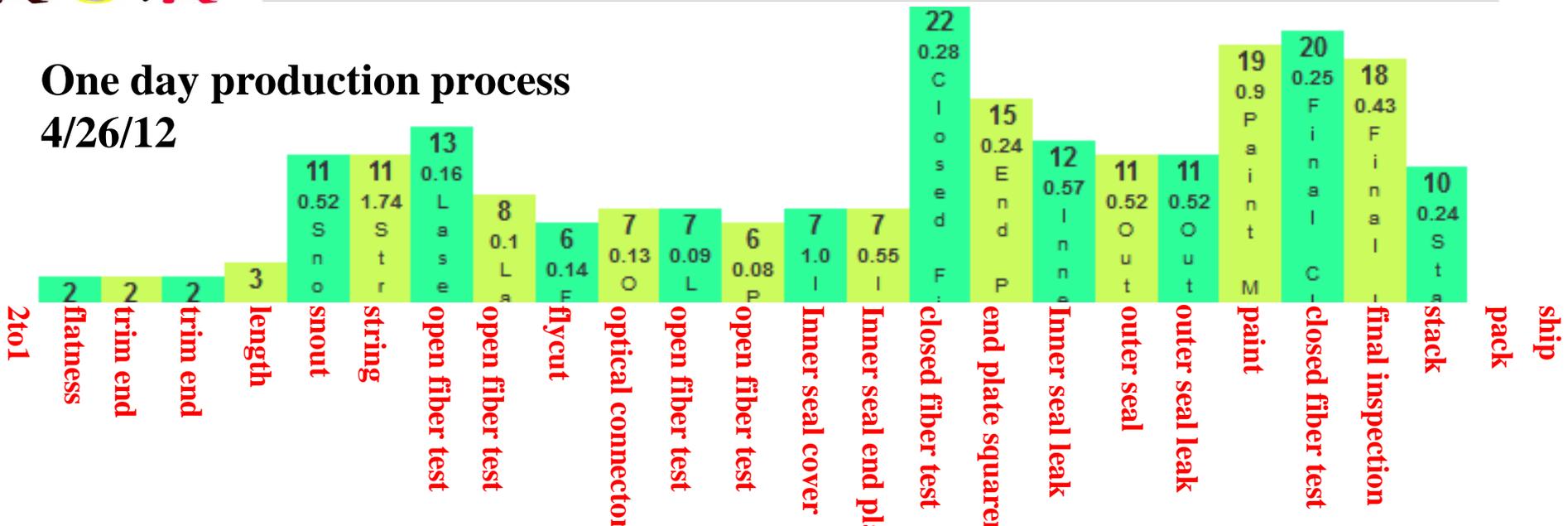


**Stringing**



# Production Snap Shot

## One day production process 4/26/12







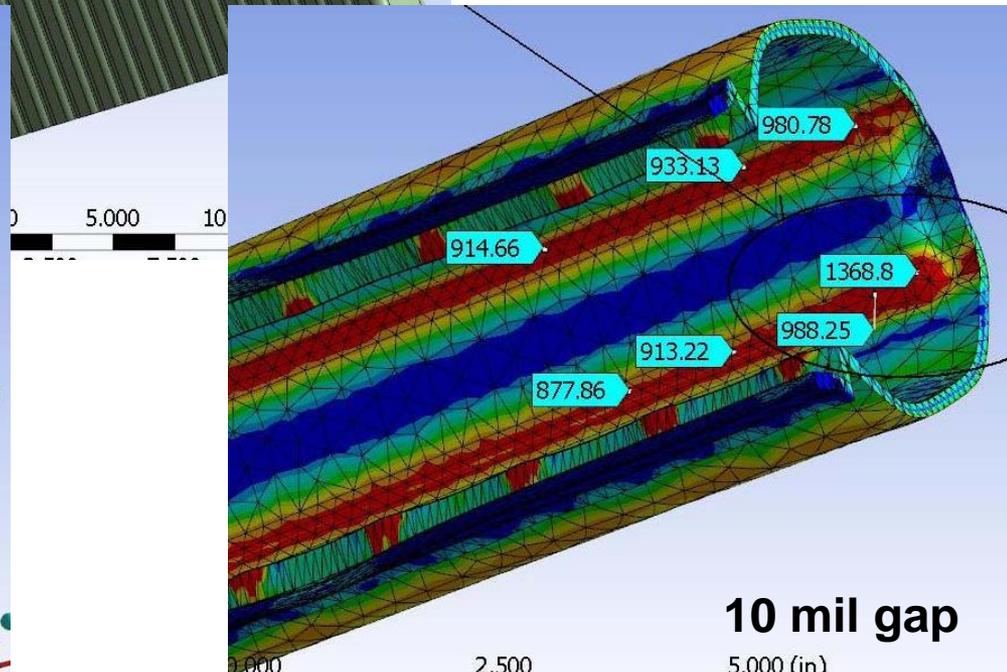
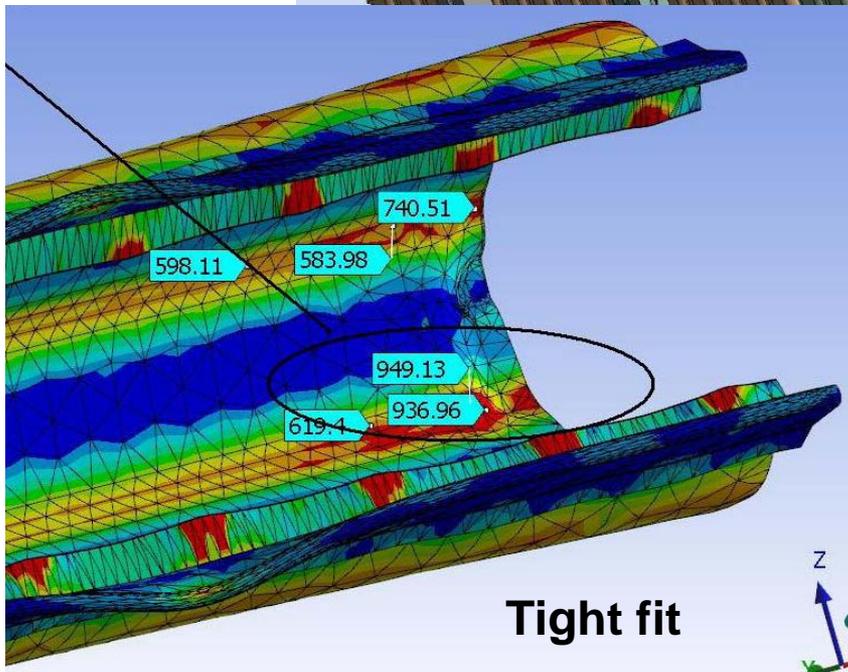
# New Tooling – Cover Clamp

## Ang Lee Analysis

Measured material strength between 6400 & 5100 psi.

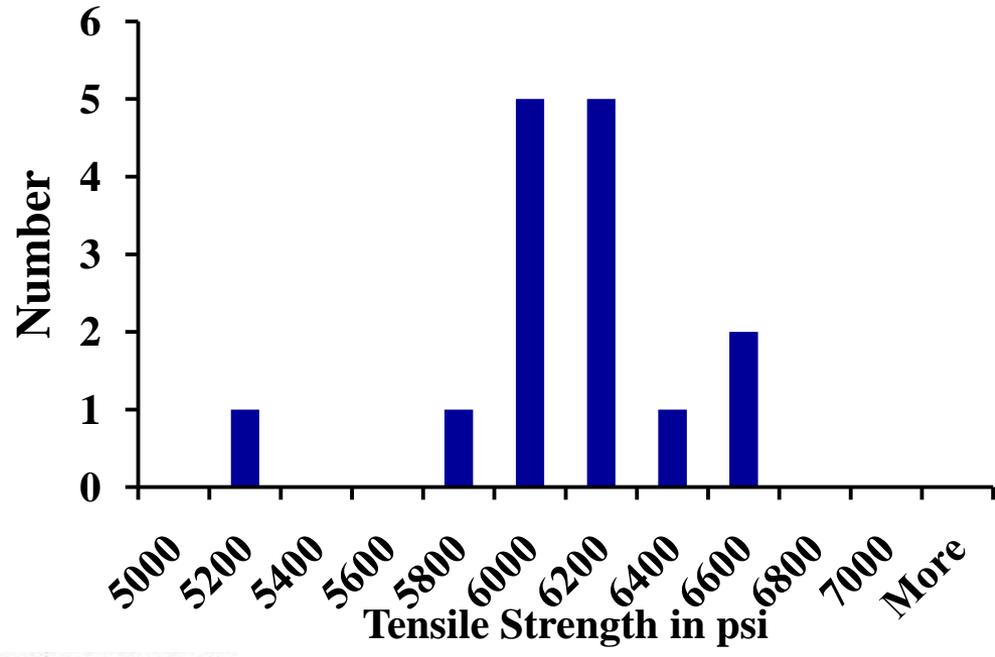
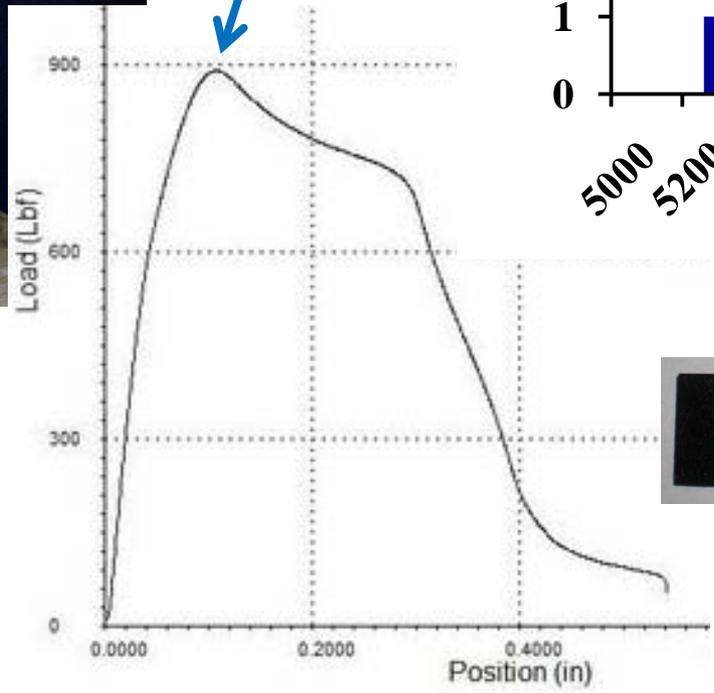


New cover and clamp design - max stress between 1000 & 1400 psi.





# Manifold Cover Strength Tests





# Manifold Cover Ultrasound Scans

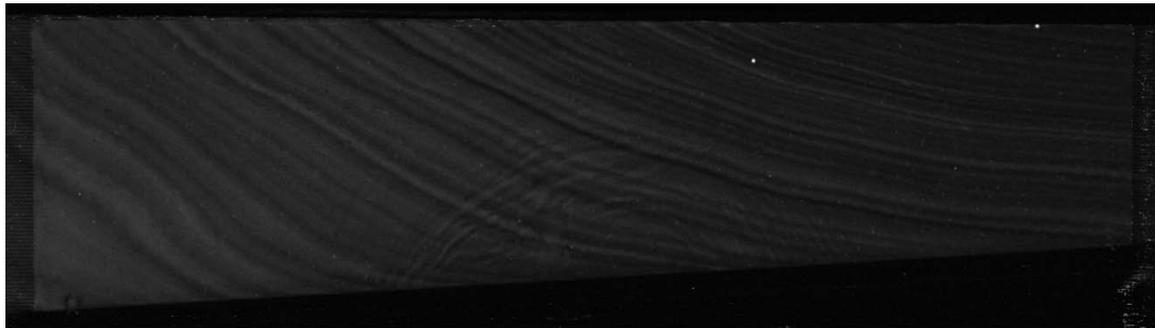


## Production

### Section 1



### Section 2





# Cover Tensile Strength

Sample	Section	Direction	Max PSI
1	1	S	6448
2	1	S	5998
3	1 – 2	L	5984
4	5	L	5697
5	5	S	5963
6	2	L	5937
7	6	L	5117
8	7	S	6141
9	7	L	6105
10	7	S	6196
11	3	L	6056



**Sample size: 1" x 5/32"**

**Pulling rate 0.15 inches/minute**

**Data rate 10 measurements/sec**

**No significant strength difference among sections**

**Visual inspection of cross-sections shows no difference**



# Vigilance is the Price of NOvA



<http://www.animal-photos.org/photo/2673.html>

**2 QA audits by Fermilab project staff**

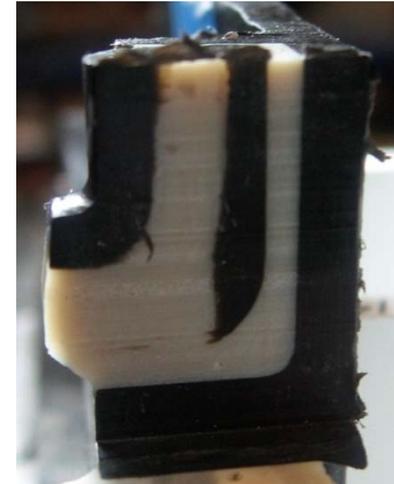
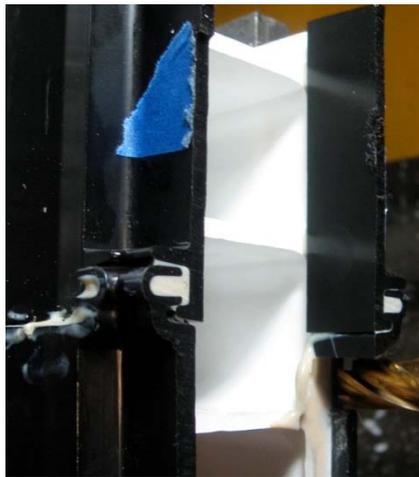
## **It's all about QA/QC**

- **Parts inspected when received**
- **2 to 1**
  - **Flatness**
  - **Length**
  - **Squareness**
  - **Glue strength**
- **Fiber**
  - **Continuous as strung**
  - **Open ended after stringing**
  - **After fly cutting**
  - **After sealing**
- **Fly cut dimensions**
- **Optical connector leak check**
- **Inner seal leak check**
- **Outer seal leak check**
- **Final visual inspection**
- **Glue strength**

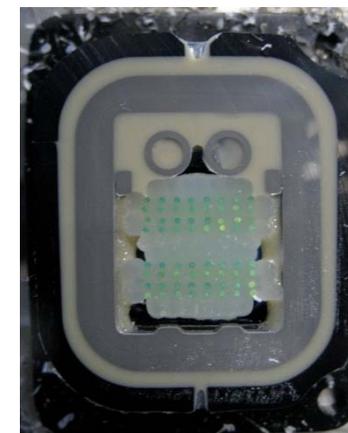
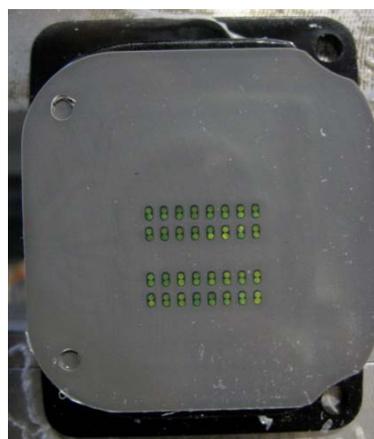


# Cross section cuts to check glue flow

## Snout Joints Cross-section cut every 0.05"

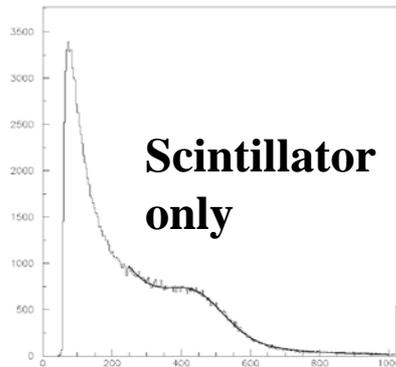
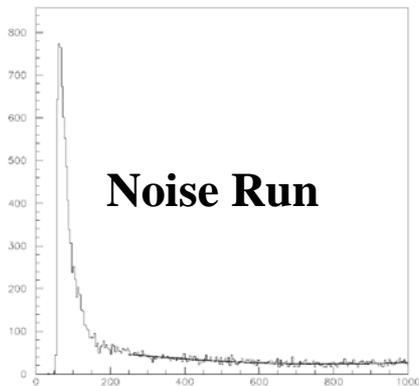


## Optical connector Cross-section cut every 0.015"

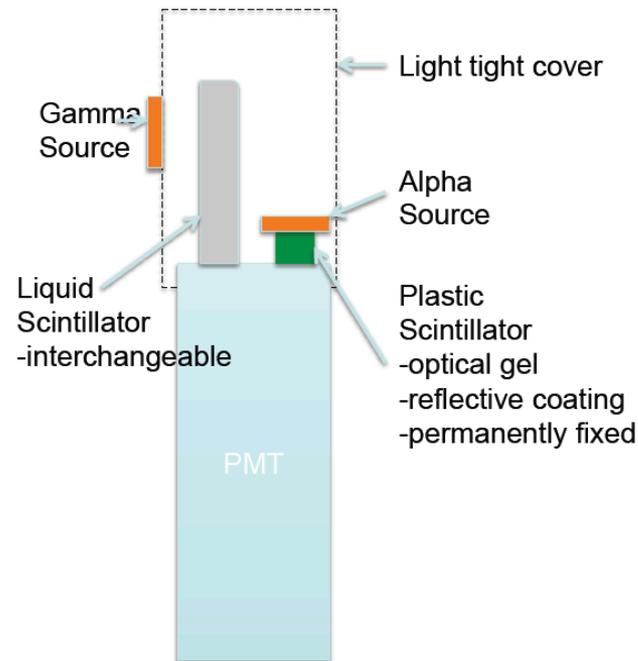
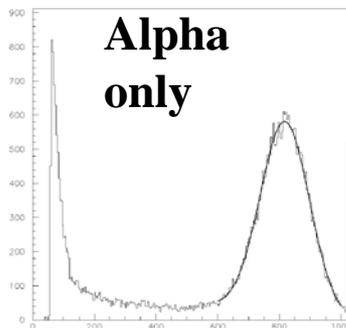
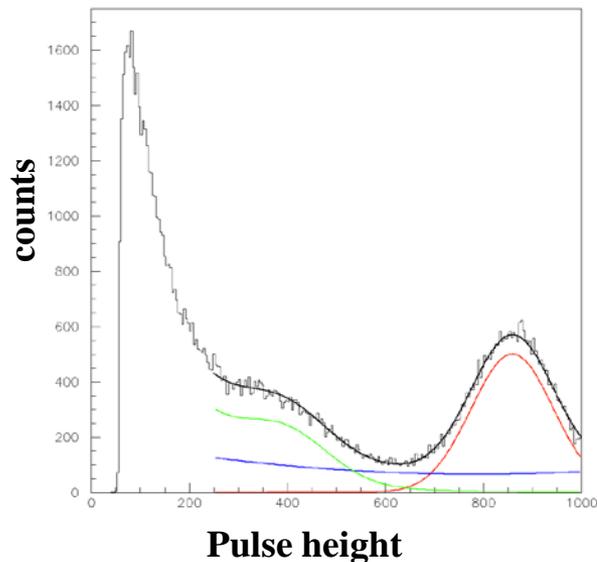




# Scintillator Interaction Testing



**Test all glue types  
and all parts**



**Ratio of Compton to alpha to take out  
phototube variation**



# Risks and Mitigation

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**Parts do not meet specifications**

**Have manufacturer pay attention to their QC and remake parts. Adequate parts are buffered so should not cost production time. Add weekend production if necessary.**

**Utility rates increase for factory**

**Project contingency held to cover up to a doubling of utility rates.**

**Extrusion delivery interrupted**

**Factory already has over 6 months of stored extrusions so should not cost production time if extrusion factory can make up the deliveries later.**

**Unable to ship completed modules**

**Factory stores several months of completed modules so should not cost production time if shipments can resume.**

**Module production interrupted**

**Factory stores several months of completed modules so detector assembly can continue. Weekend production can make up the time.**



# Looking Ahead



- Get to ~ 2% module failure rate (now at 13%)**
- Ramp up to 27 modules/day (now at 13)– end of May**
- Maintain quality**
- Integrate 2to1 production**
- Summer means fewer students (~70) working full time**

