



PVC Module Production (2.5)

Ken Heller

University of Minnesota

May 8, 2012

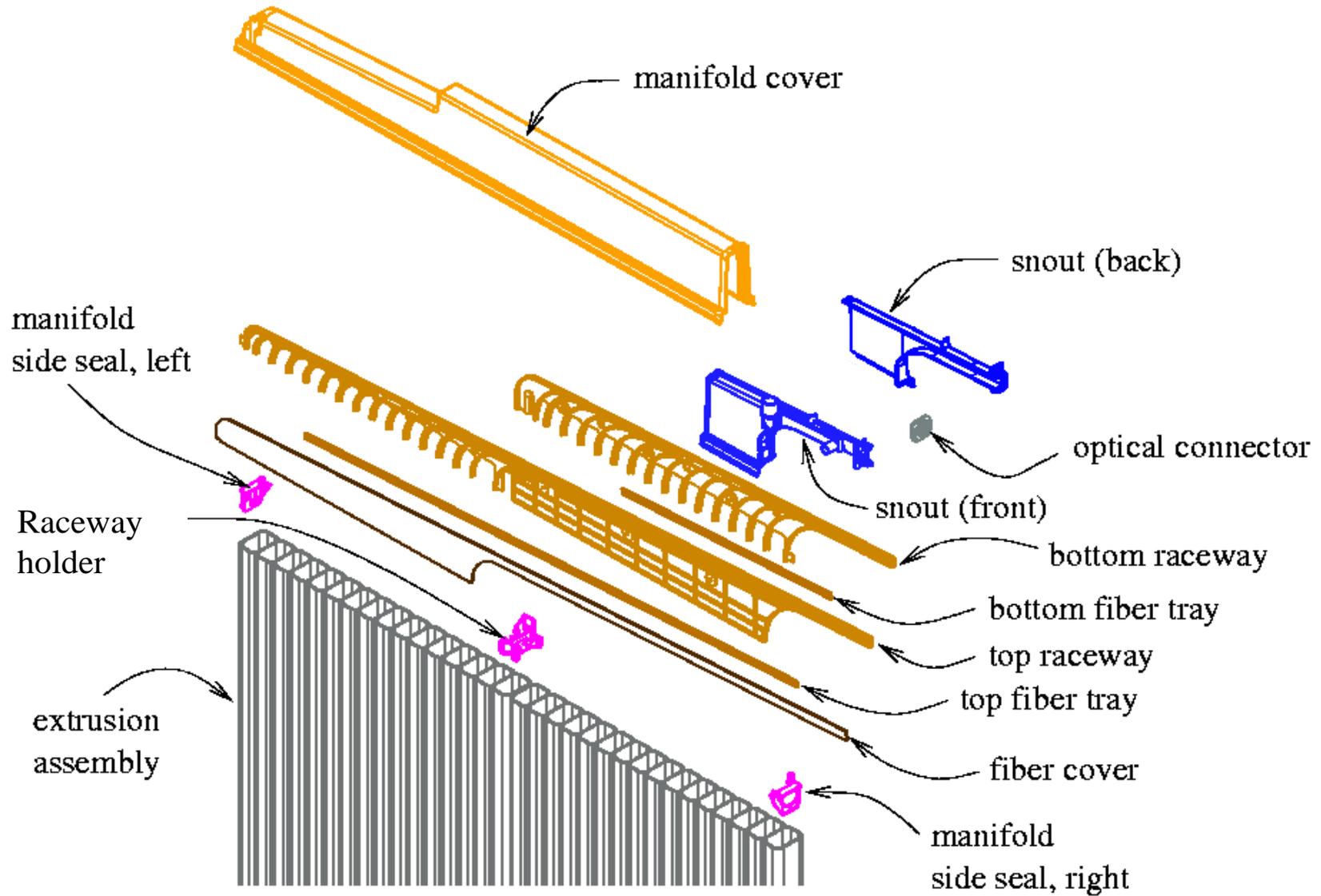
**Minerba Betancourt, Jianming Bian, Tom Chase,
Dan Cronin-Hennessy, Ben DeYoung, James Geddes, Chris Kluge,
Susan Lein, Tina Lorsung, Jarek Nowak, Greg Pawloski, Jim Parker,
Nathaniel Pearson, Ron Poling, Nick Raddatz, Dominick Rocco,
Kanika Sachdev, Alex Smith, Brian Sherwood, Dick Wildberger,
Robyn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

Technician
Accounting
Engineer
Physicist

+ 170 undergraduates



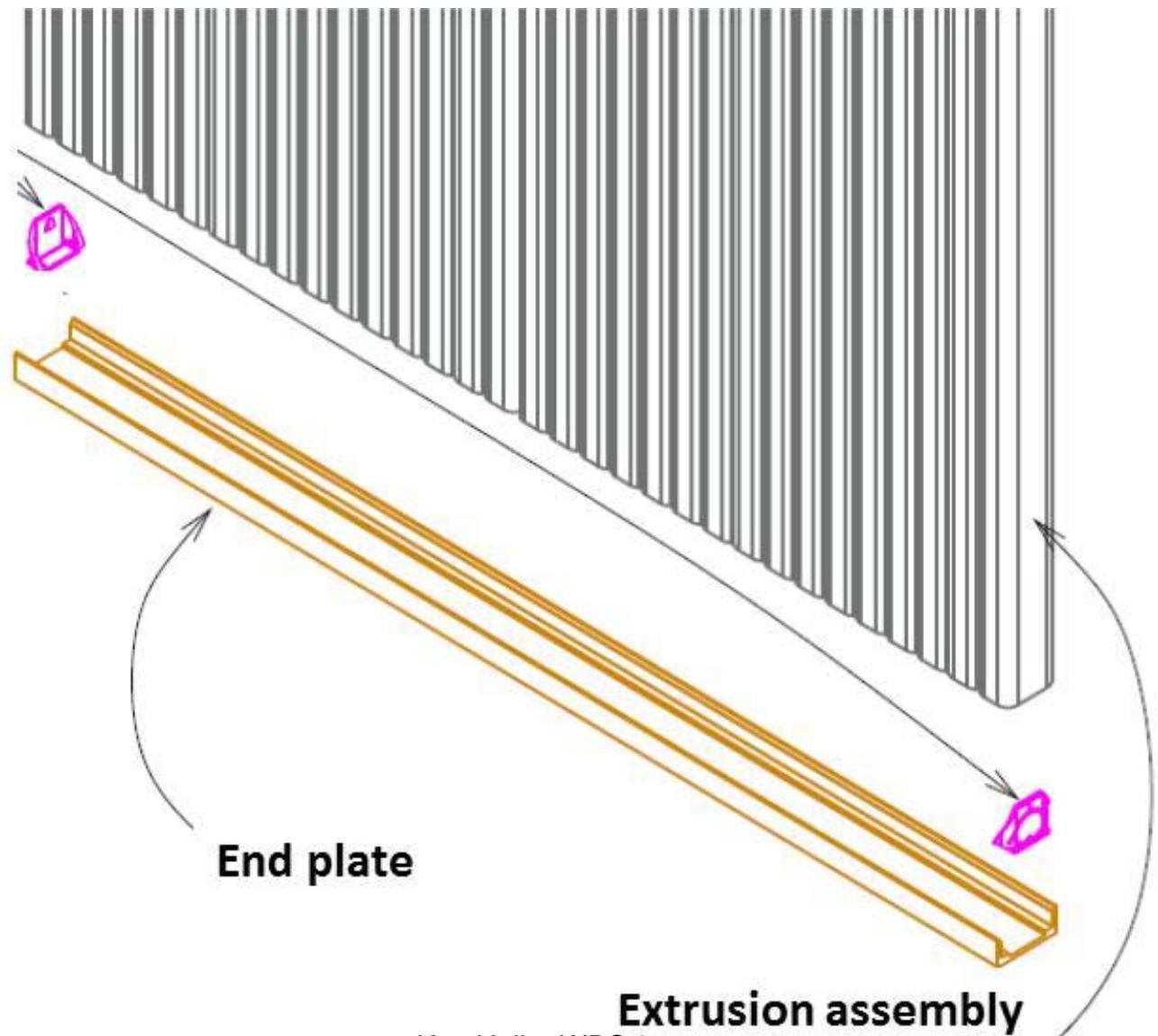
Manifold Parts





End Seal Parts

Side seals



End plate

Extrusion assembly



Module Production Status

- 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)

3263 complete 2 to 1 (8.5 blocks = 29% of far detector)

Failure rates overall

Flatness – 0.7%

End Cut – 0.6%

Failure rates April 1 – April 19

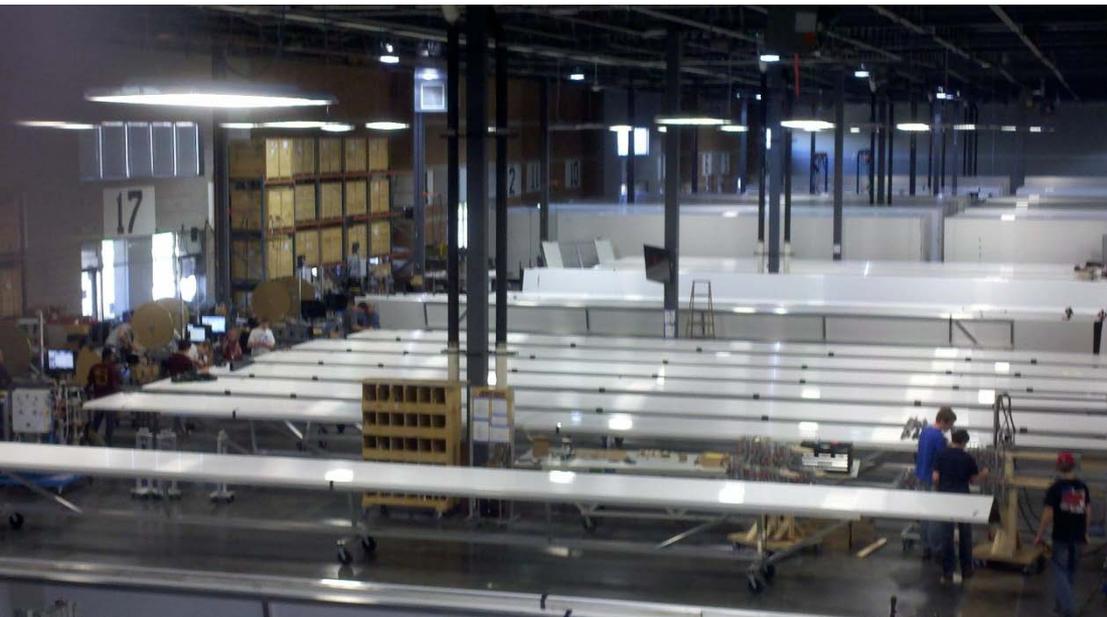
Flatness – 0% (118 done)

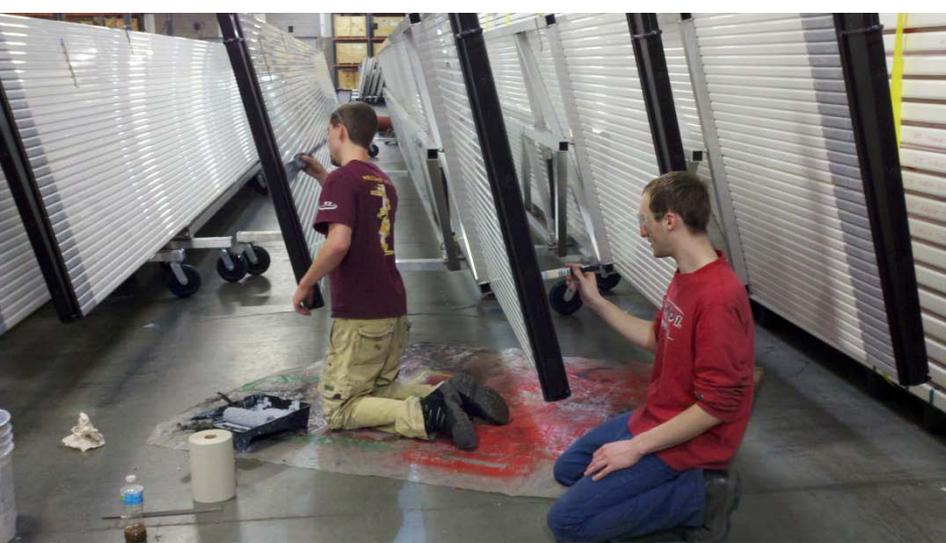
End Cut – 2% (118 done)

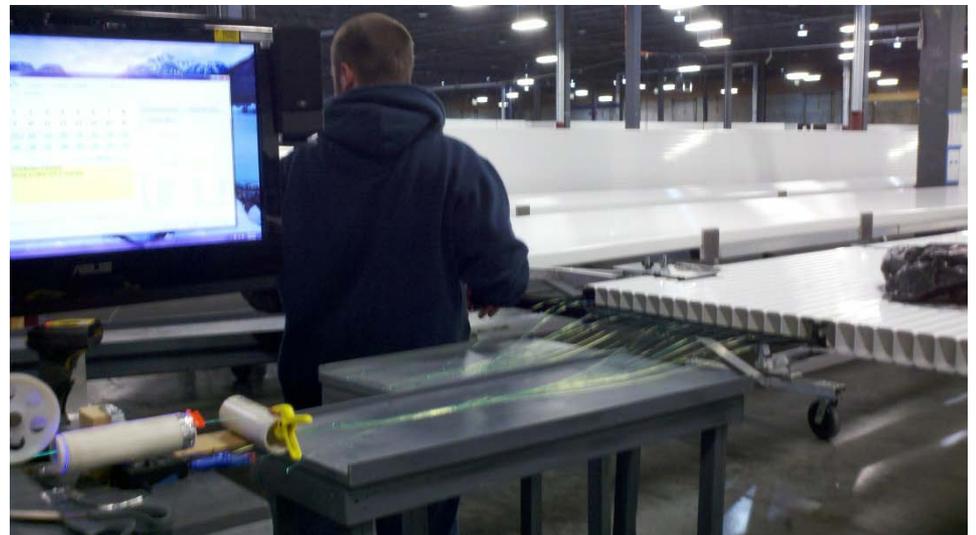
Slowing 2 to 1 production to put effort into module production



Scenes from the Factory



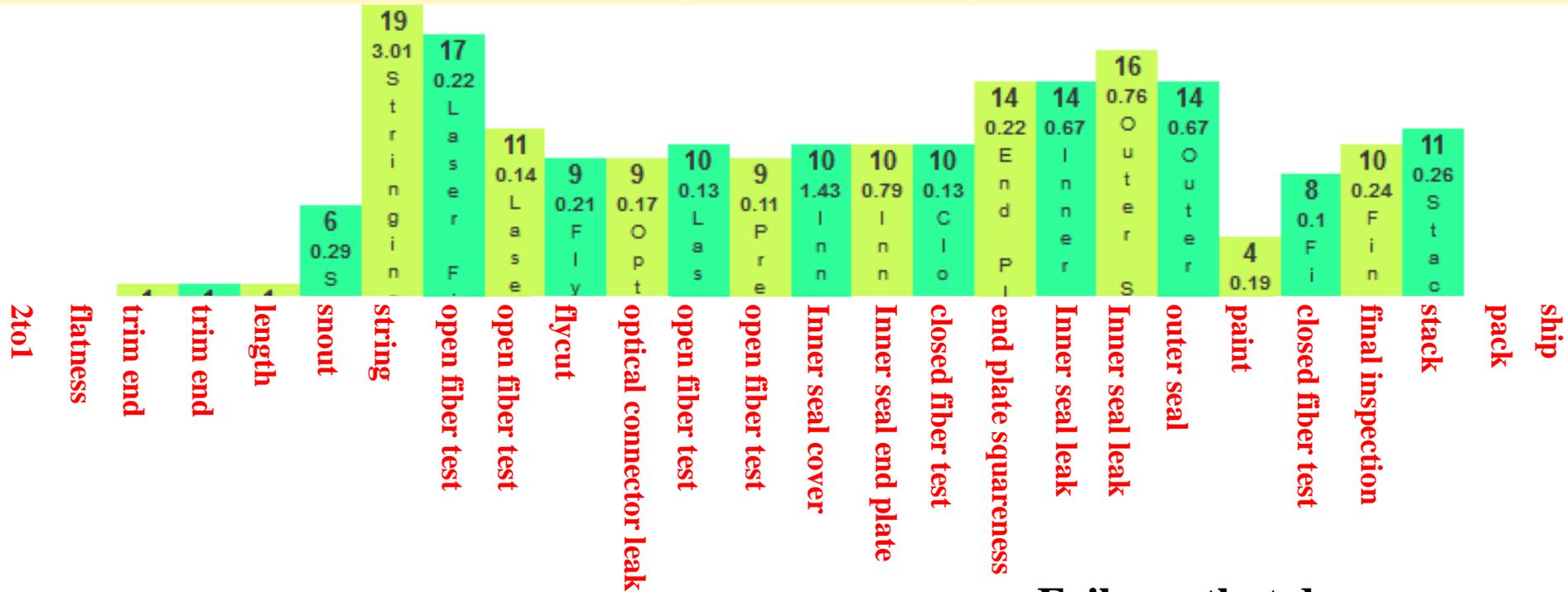






One Day Production Snap Shot

Today 2012-04-20 (9.8)



108 modules handled on 4/20 with 10 failures (9%)

Failures that day
 Fiber: 6
 Outer seal: 2
 Final inspection: 2

Module Parts



Plastic Part	Parts received (module units)	Last week
Manifold Cover	388	
End Plate	3372	3040
Top Raceway	343	
Bottom Raceway	536	
Top Fiber Tray	7394	1512
Generic Fiber Tray	2570	
Bottom Fiber Tray	4464	
Raceway Cover	3422	
Raceway Support	3919	
Snout Front	3300	
Snout Back	3300	
Manifold Side Seal	3919	
End Plate Side Seal	3920	
Optical Connector	12544	completed
Fiber Ring	12891	
External Center Seal	12500	



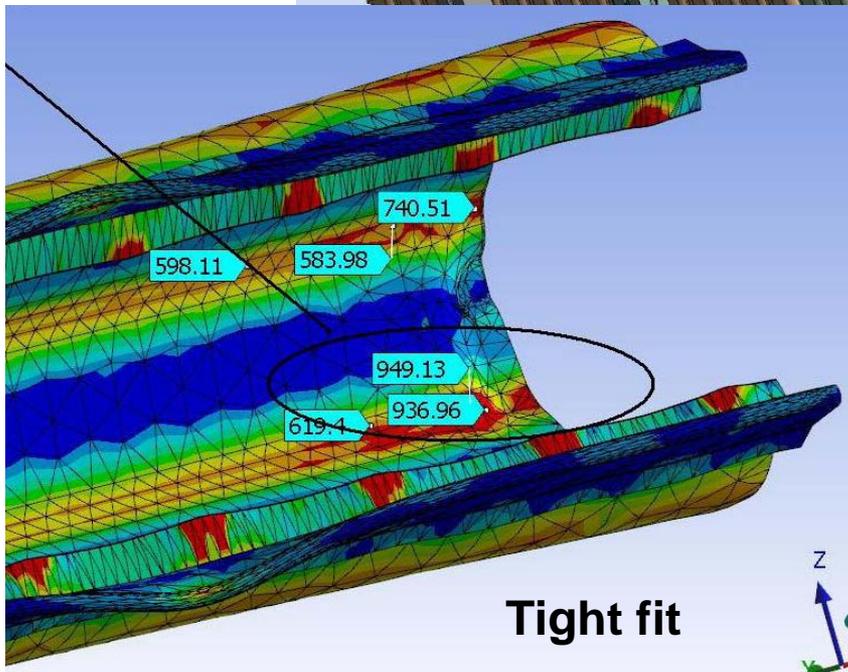
New Tooling – Cover Clamp

Ang Lee Analysis

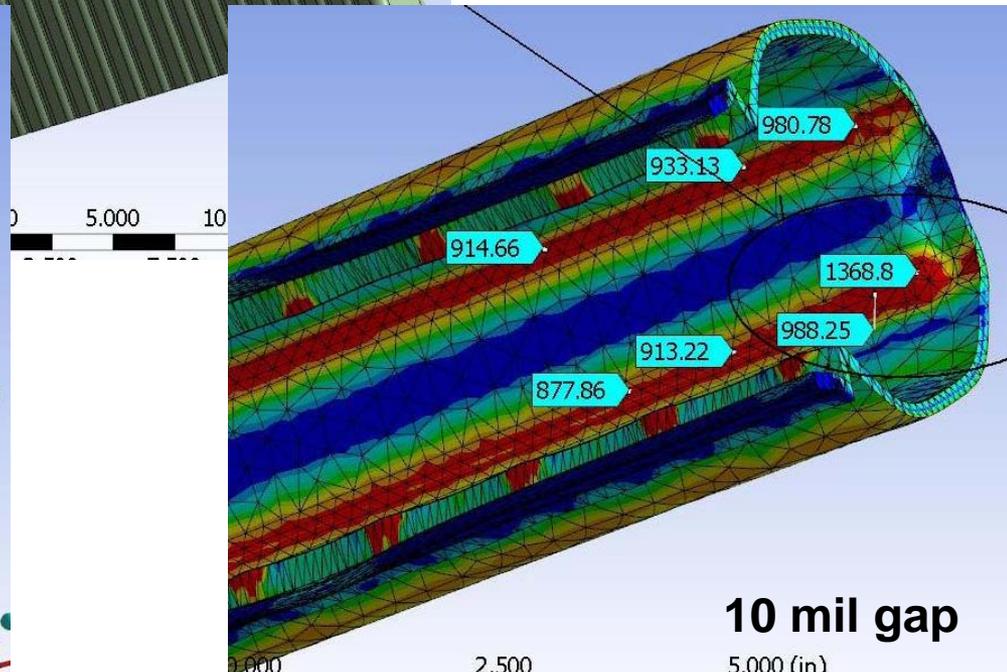
Measured material strength between 6400 & 5100 psi.



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



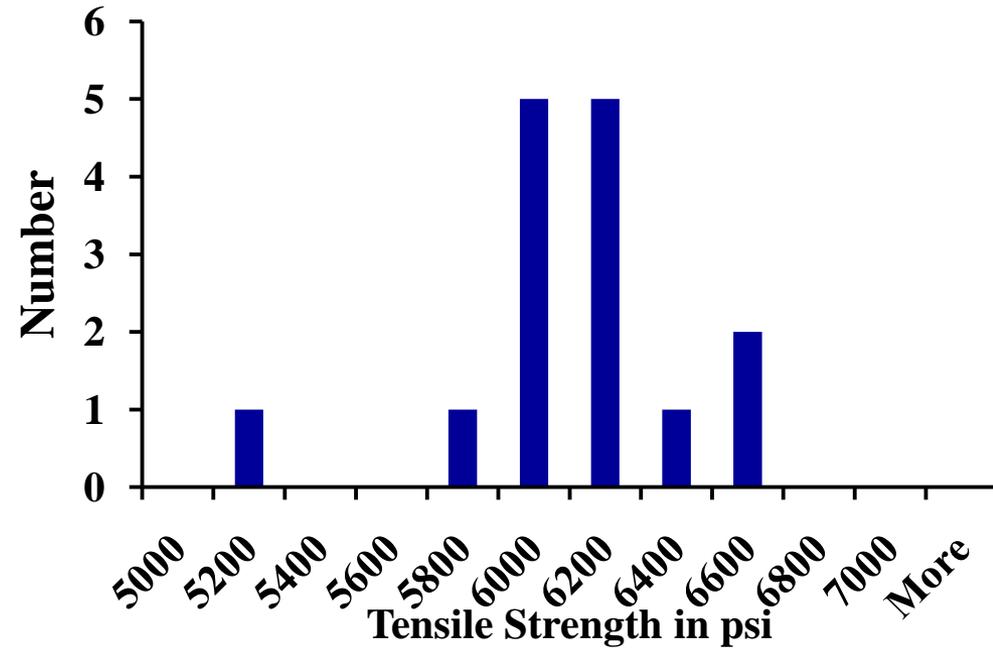
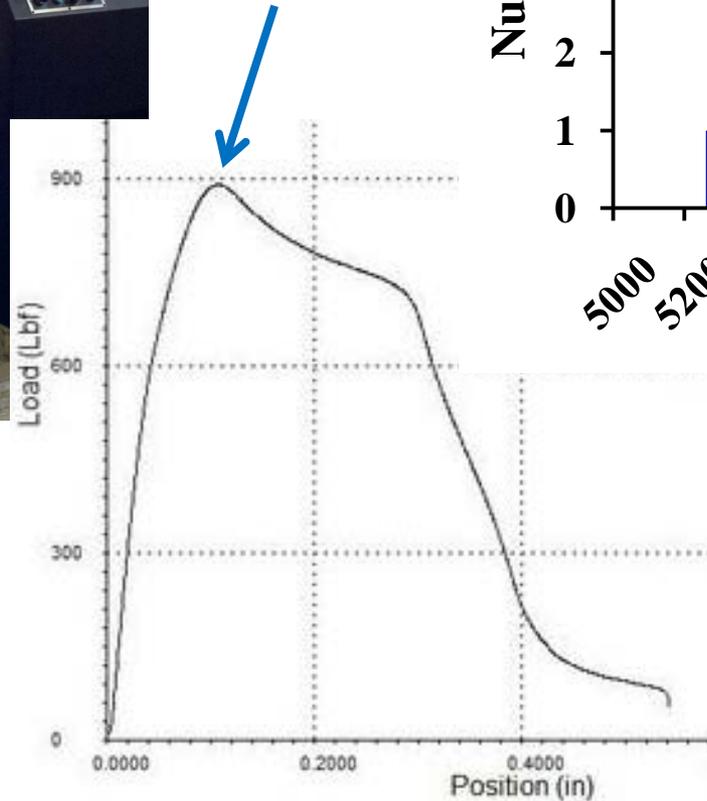
Tight fit



10 mil gap



Manifold Cover Strength Tests





Manifold Cover Ultrasound Scans

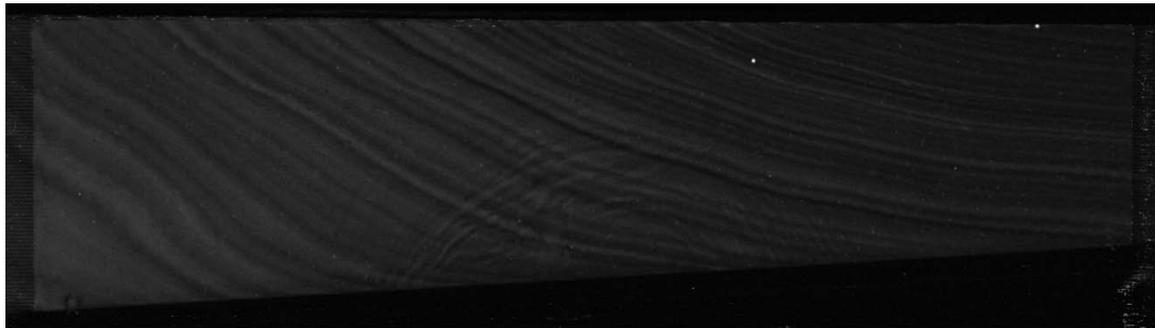


Production

Section 1



Section 2

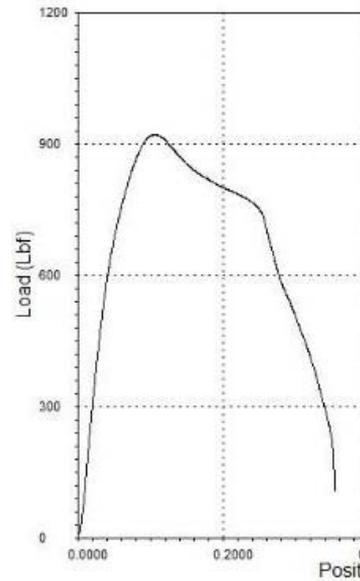




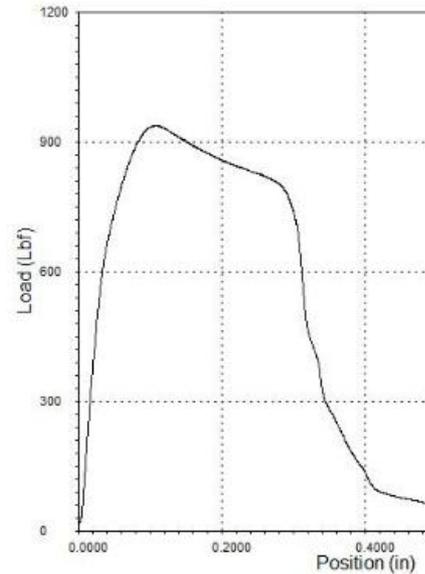
Manifold Cover Strength Tests



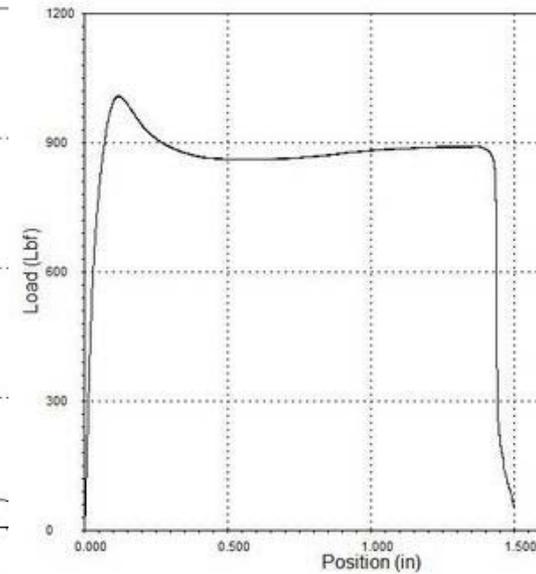
Section 3



Section 2



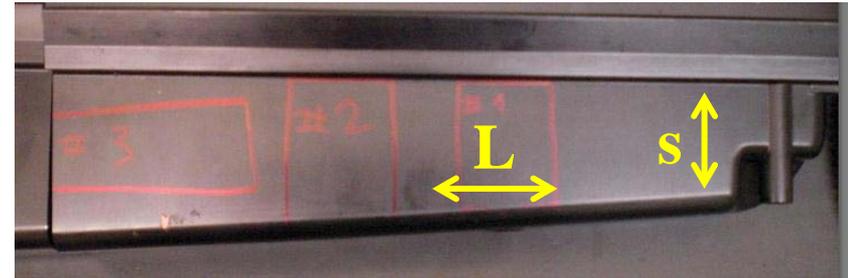
Section 1





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>

It's all about QA/QC

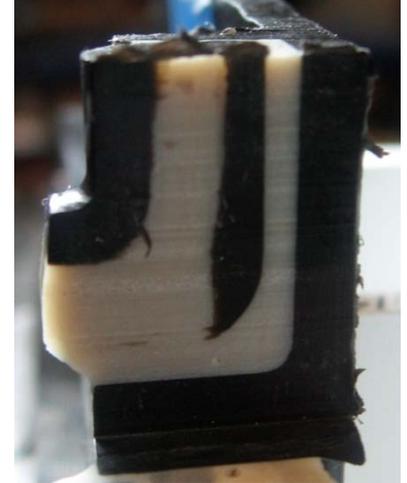
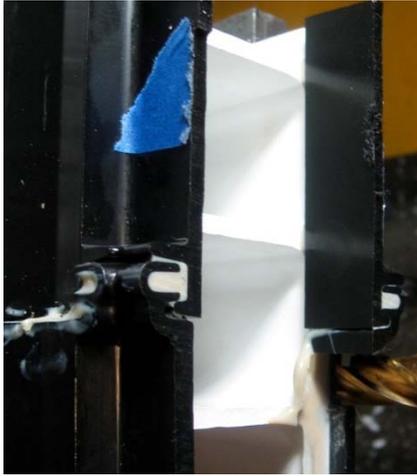
- Parts inspected when received
- 2 to 1
 - Flatness
 - Length
 - Squareness
 - Glue strength
- Fiber
 - Continuous as strung
 - Open ended after stringing
 - After fly cutting
 - After sealing
- Fly cut dimensions
- Optical connector leak check
- Inner seal leak check
- Outer seal leak check
- Final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

2 QA audits by Fermilab project

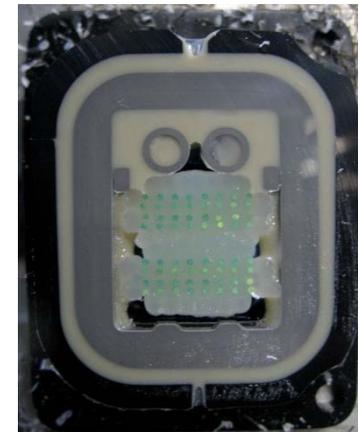
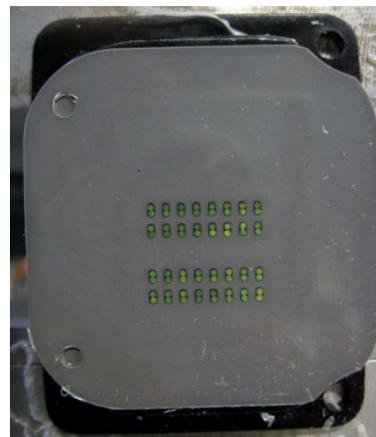


Cross section cuts to check glue flow

Snout Joints Cross-section cut every 0.05"

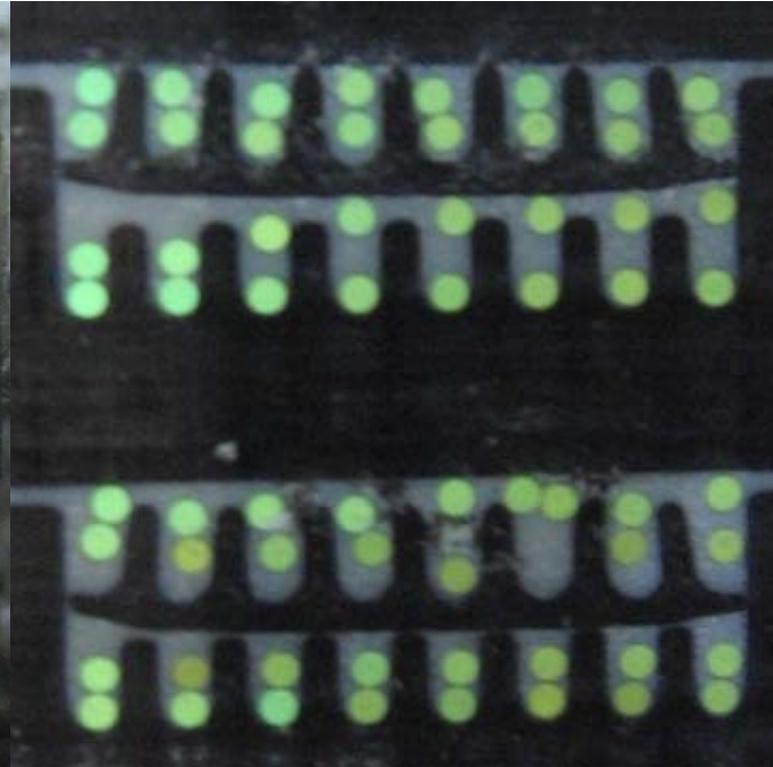
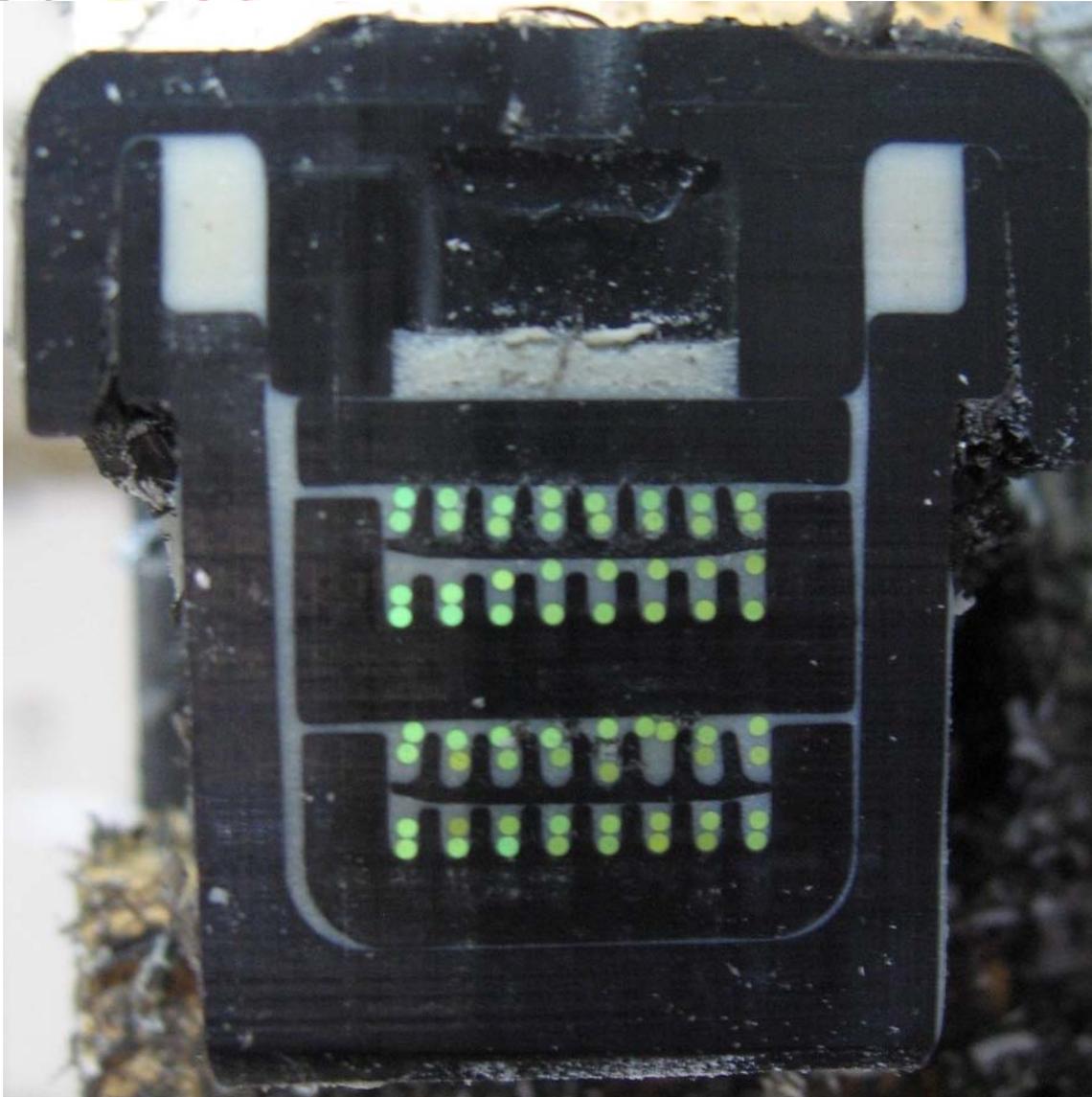


Optical connector Cross-section cut every 0.015"





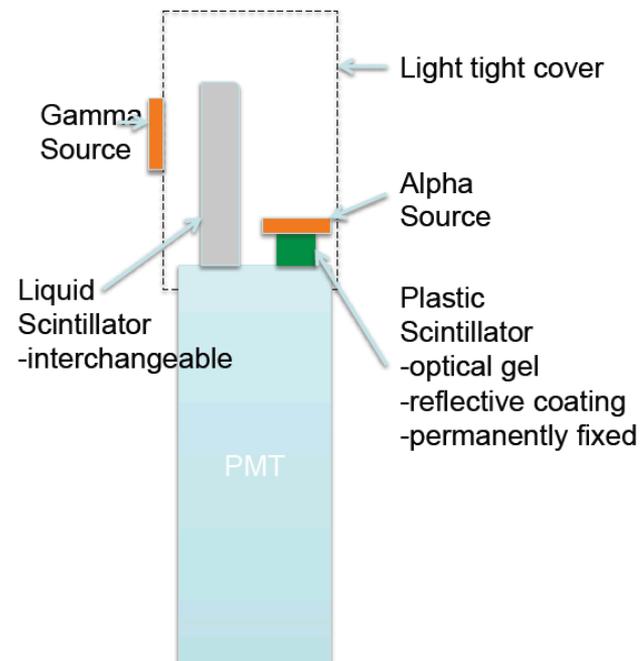
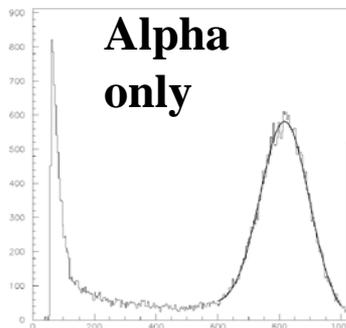
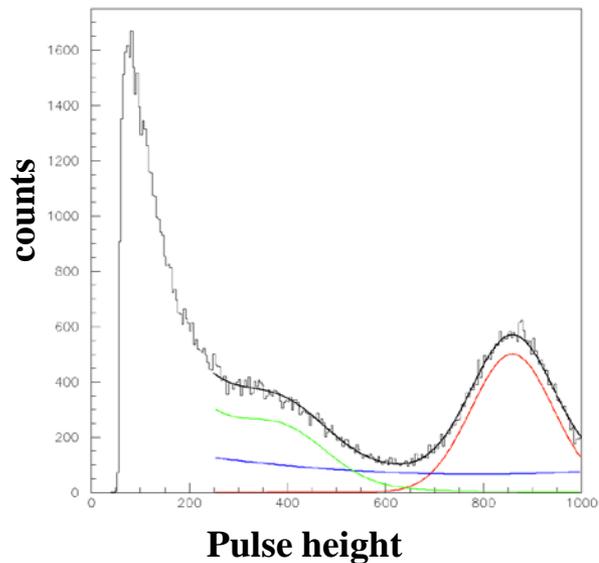
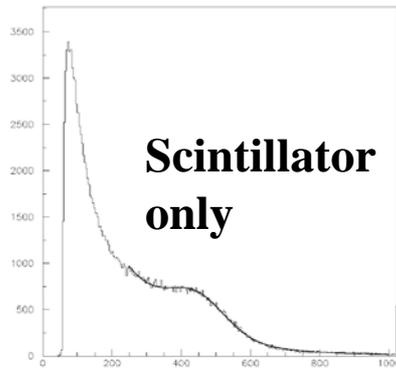
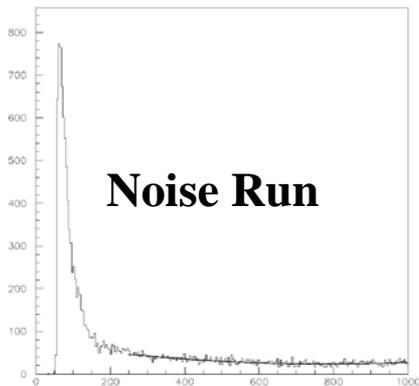
Cross Section Cuts to Check Glue Flow



**Fiber Hermetic
Seal in Snout**



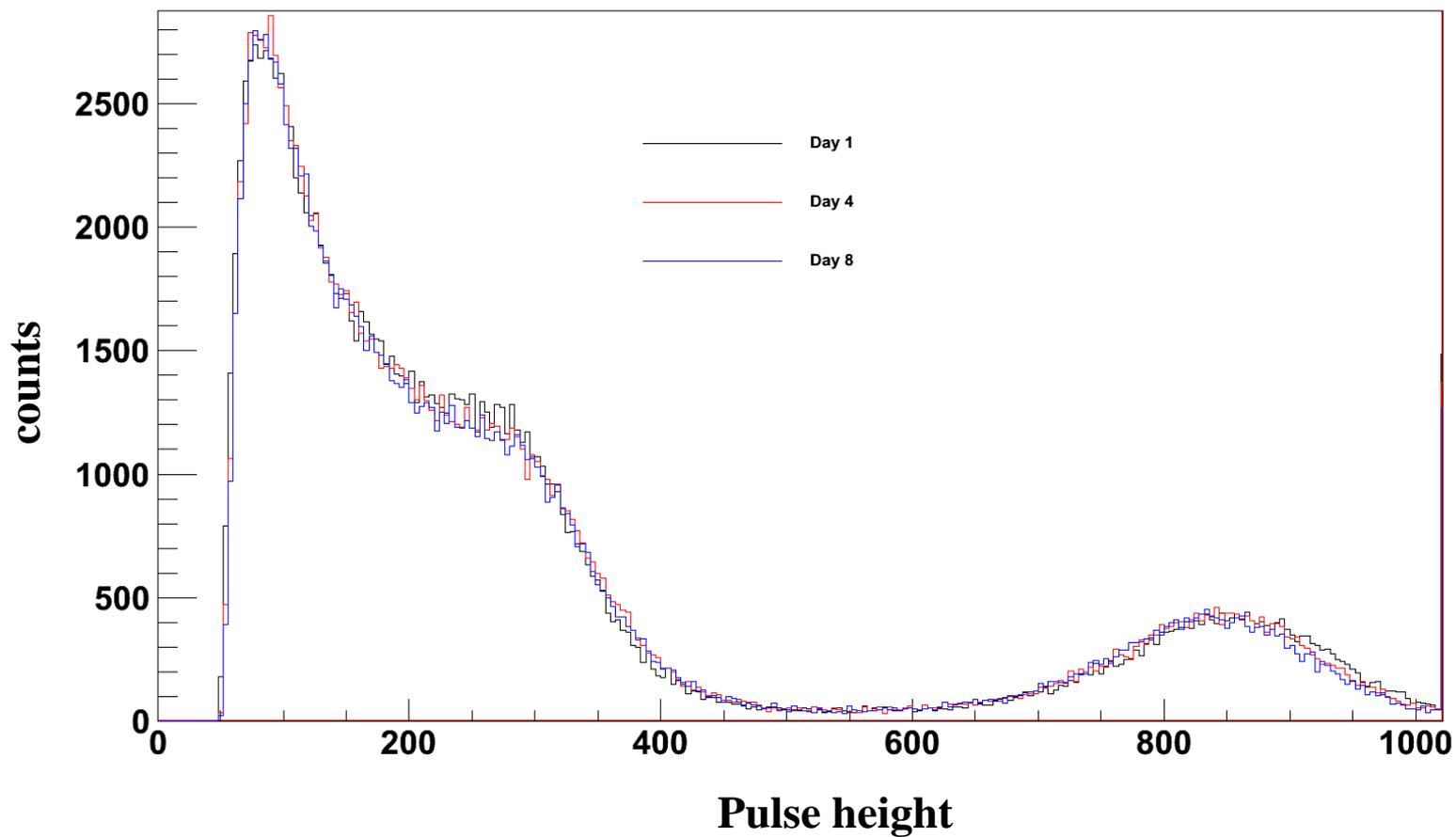
Scintillator Interaction Testing



Ratio of Compton to alpha to take out phototube variation



Side Seals – day 1, 4, 8





Looking Ahead



Get to ~ 2% module failure rate

Ramp up to module production rate – end of May

Maintain quality

Continue 2to1 production

Summer means fewer students (~70)

but working full time