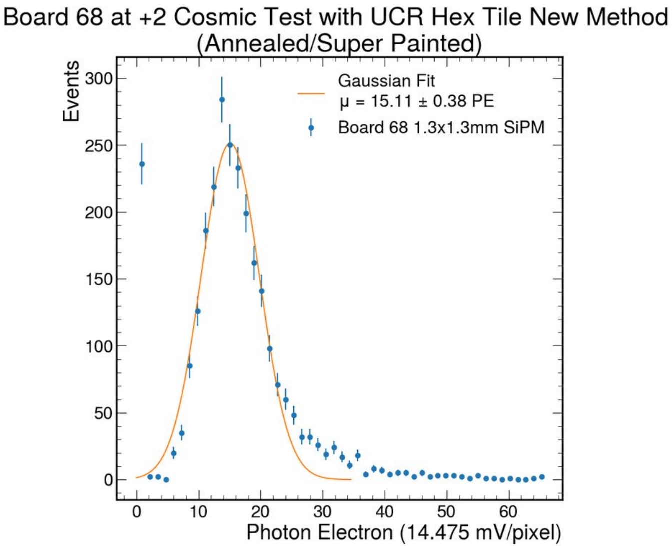
SiPM-on-tile Light Yield Studies

Miguel Rodriguez



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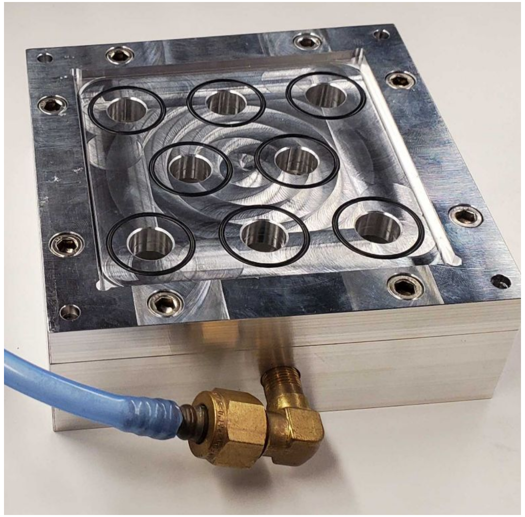
CALIFORNIA EIC CONSORTIUM

Outline

1) Update on painting and its impact on light yield
2) Update on Crazing and annealing and impact on light yield
3) Other comparative studies

How we manufacture the cells at UCR

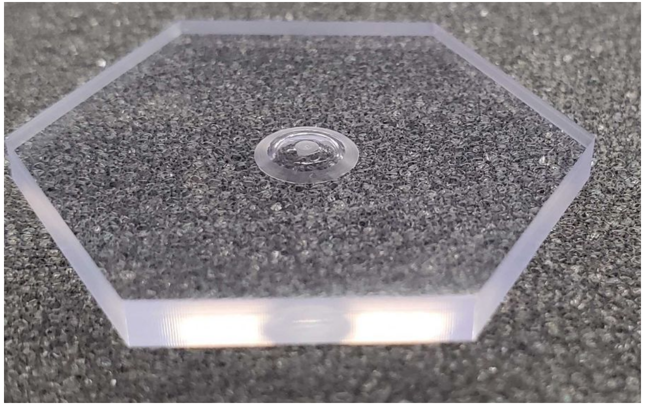
From EJ 212 raw material (square 10x10 cm2), we get ~8 small cells.
These are milled while in a custom vacuum chuck.

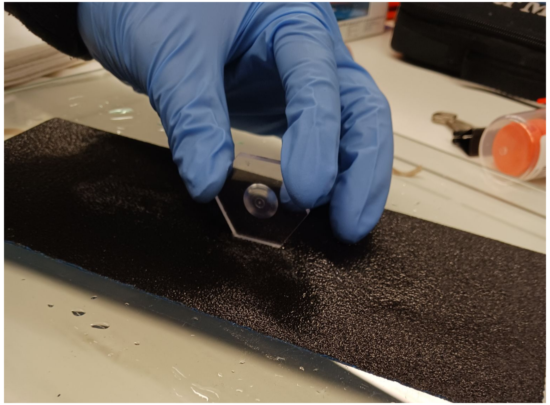


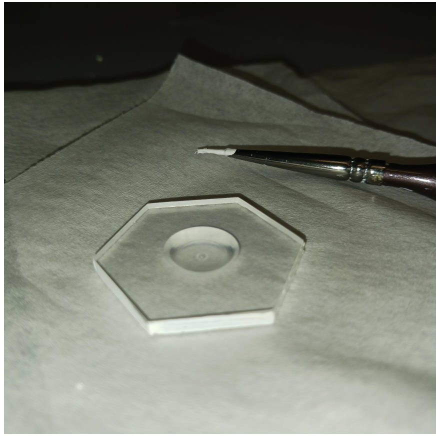
Polishing & Painting

Edges & dimple are hand polished,

Edges painted with Saint-Gobain BC-621 paint







Update #1: painting and its impact on light yield

For this we tested before and after applying more paint for two type of cells as a cross-check: FNAL made (injected molded) and UCR made (machined)

Scintillators and painting

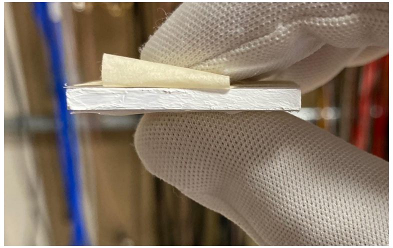
Scintillators were originally painted just enough so that the surface appeared completely white.

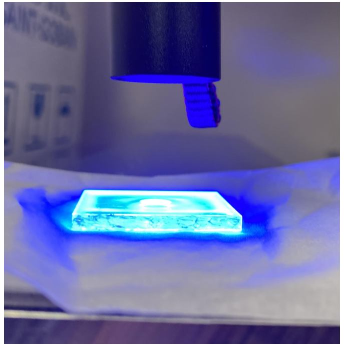
Scintillators did not meet our light yield expectations.

Too much light appears to escape when painted normally

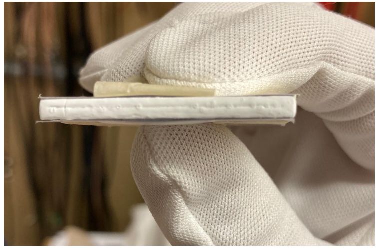
Scintillators were then painted even more with 3 layers until they were super painted.

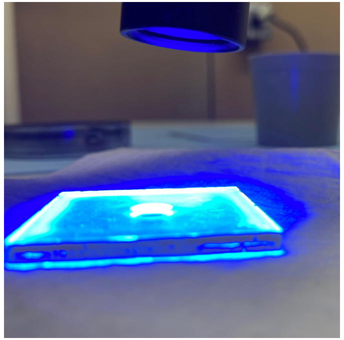
Normal painted





Super painted



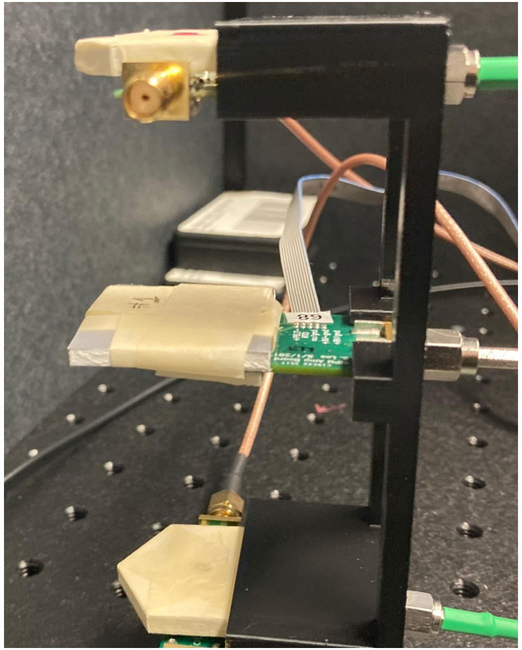


Cosmic Ray Setup

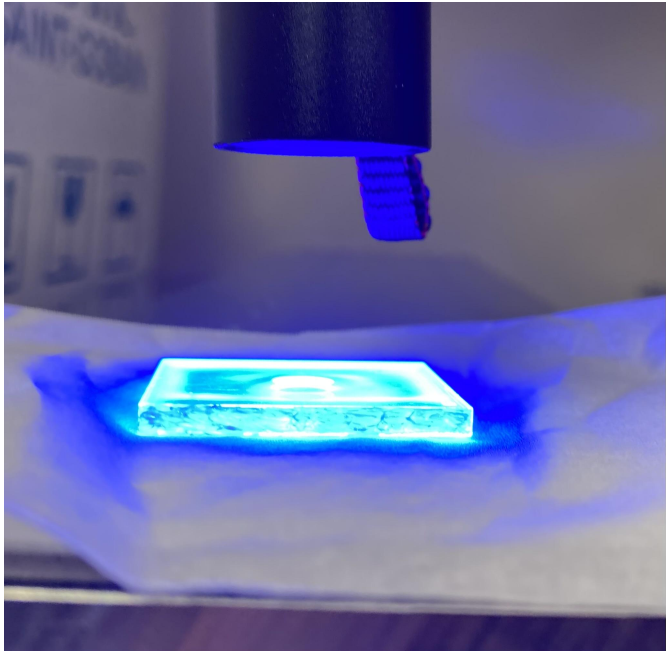
Three fold coincidence, SiPM on tile

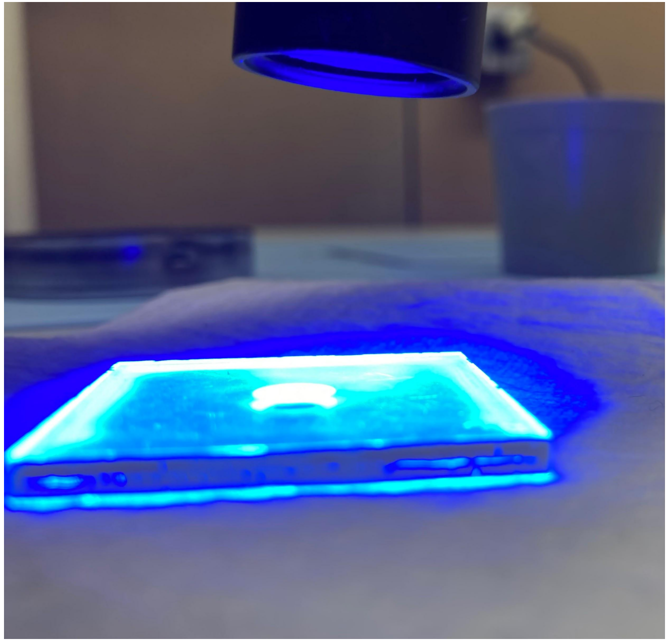
Full-waveform digitizer readout with DRS4 board.

14160-1315PS SiPM operated at +2V

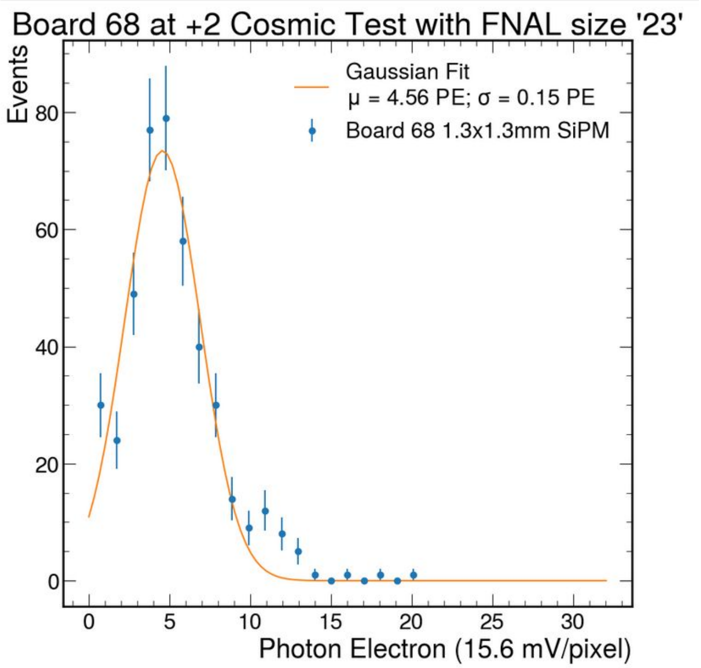


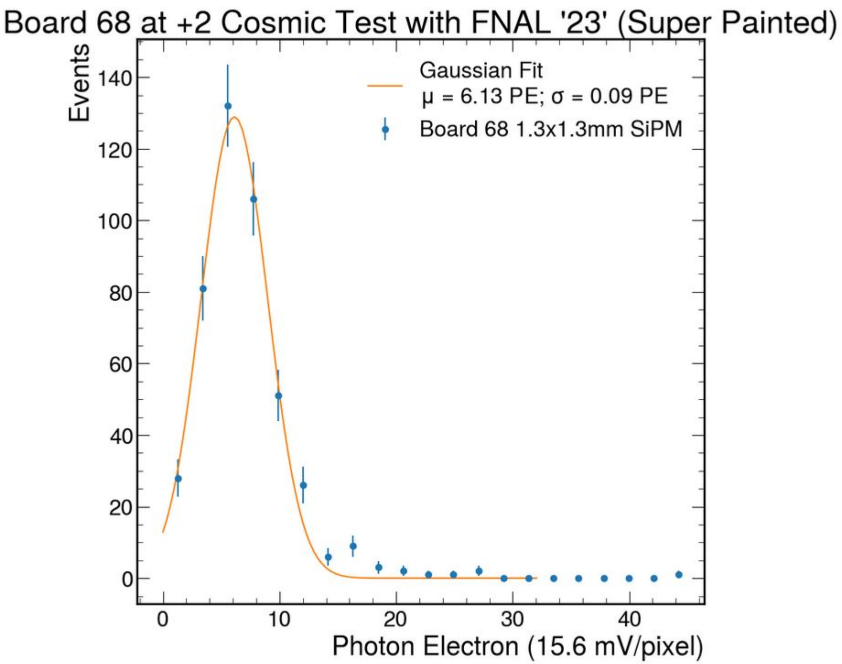
Normal Paint vs Super Paint (FNAL Square Tile)





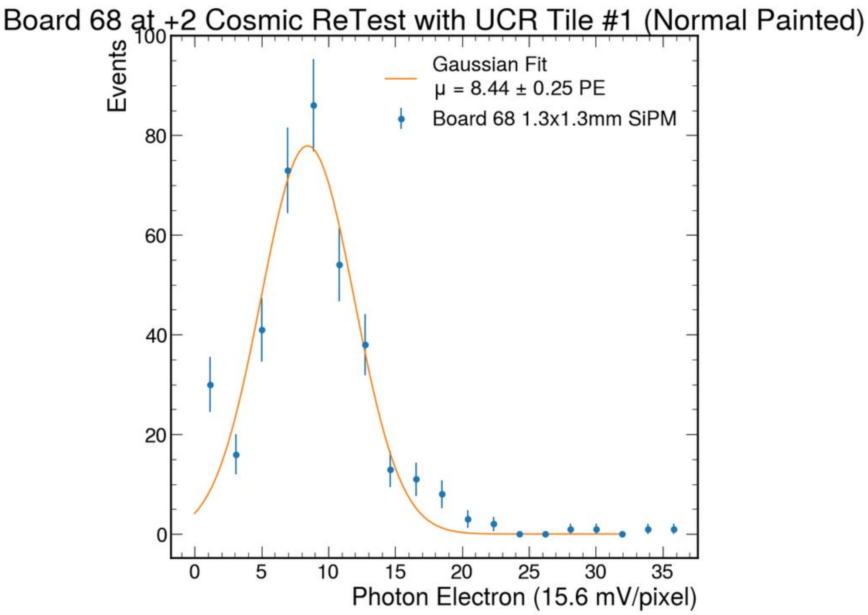
Normal Paint vs Super Paint (FNAL Square Tile)

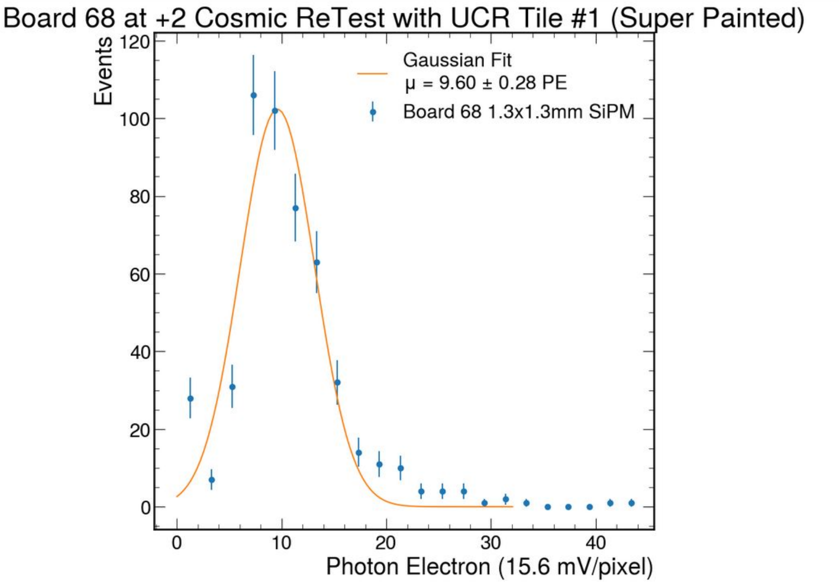




These results show that paint can have a significant improvement in the light yield.

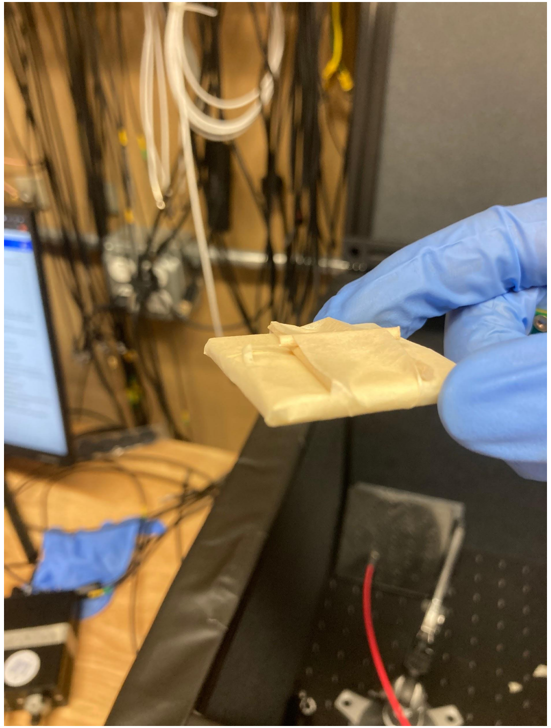
Normal Paint vs Super Paint (UCR Square Tile)

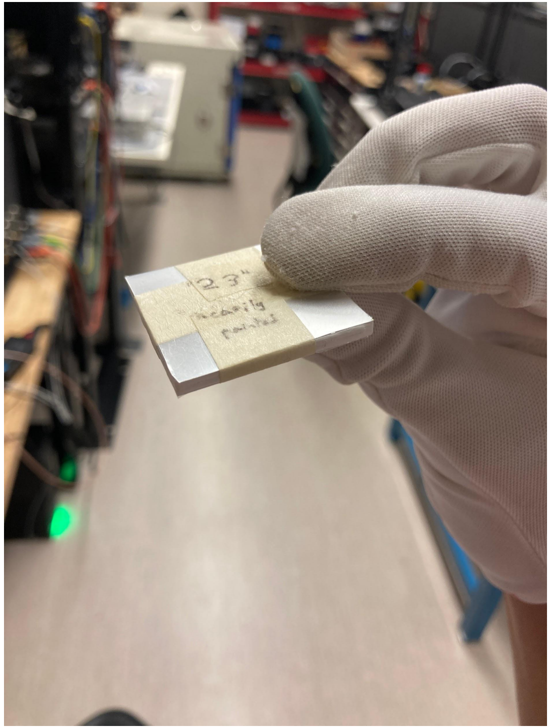




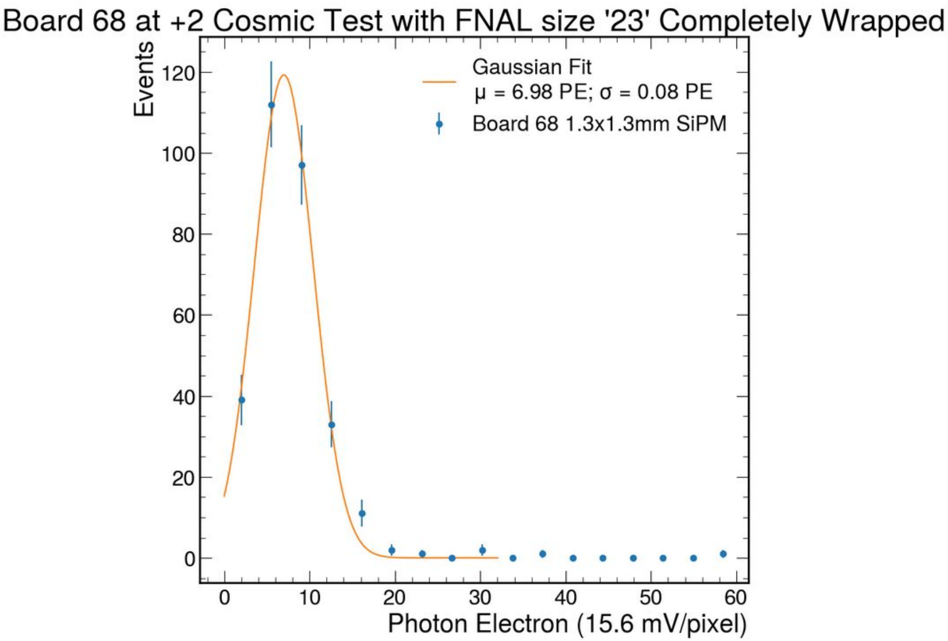
These results show that paint can have a significant improvement in the light yield.

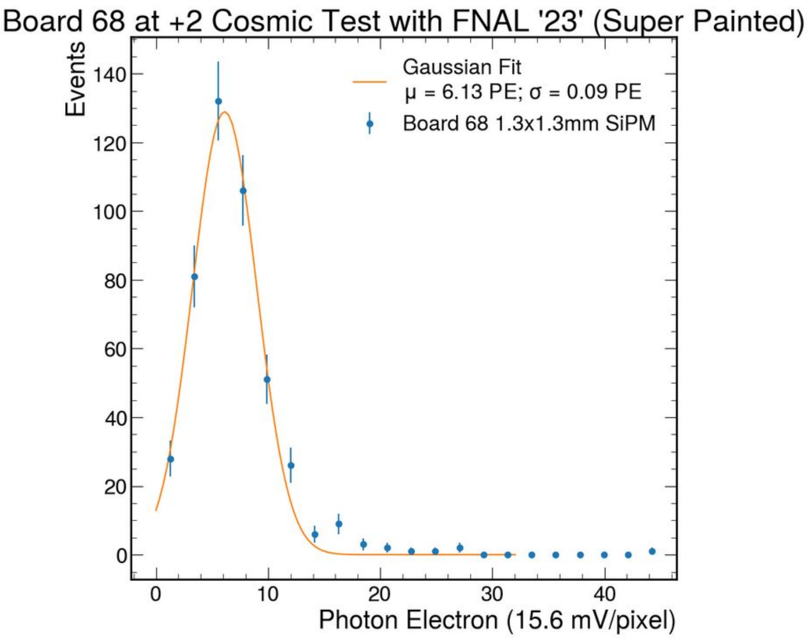
ESR Wrapped Completely(No paint) vs Super Painted (ESR on top and bottom)





ESR Wrapped Completely vs Super Painted (ESR on top and bottom)





These results show that paint a scintillator well can create results close to a cell that was completely wrapped in foil.

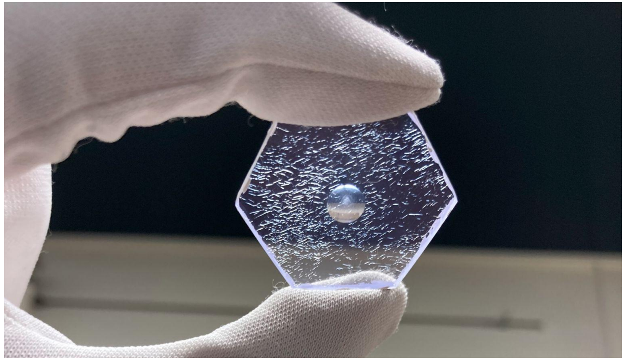
Update #2 . Crazing and annealing and its impact on light yield

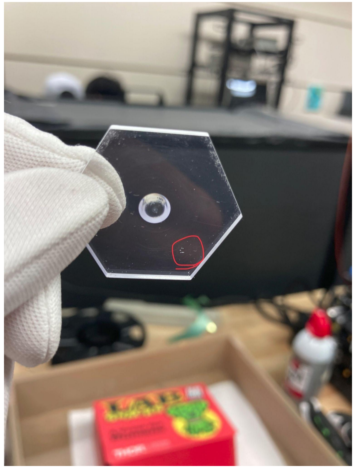
Scintillators with Crazing

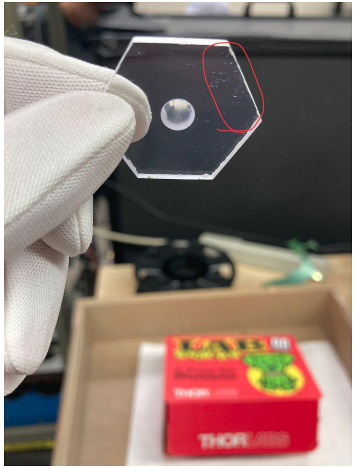
Crazing is internal damage in scintillators.

Can be very dramatic or almost unnoticeable but will spread and grow overtime

Possible solutions to solve this could be to place them in the oven to be annealed.







New Method vs Old Method of Manufacturing Scintillators

Our new method of milling scintillators involves using soapy water instead of any other damaging solution. (likely culprit for creating crazing)

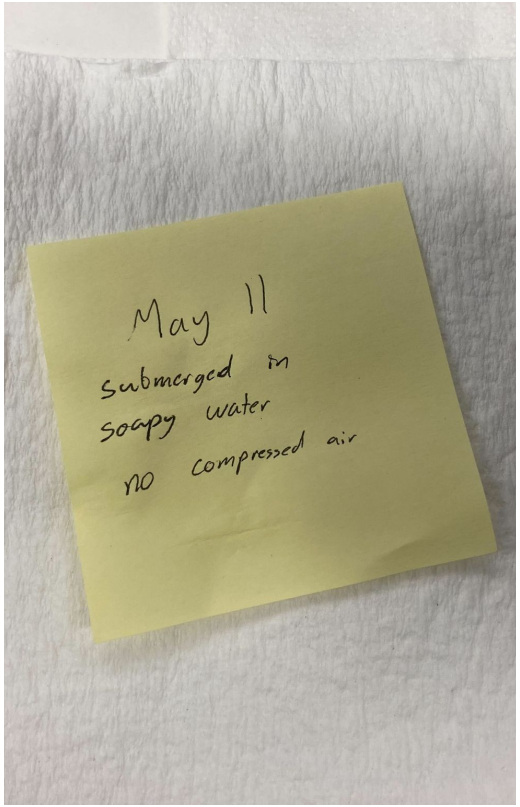
Any excess plastic that was seen on the scintillator is no longer being scraped off. (another possible culprit for crazing)

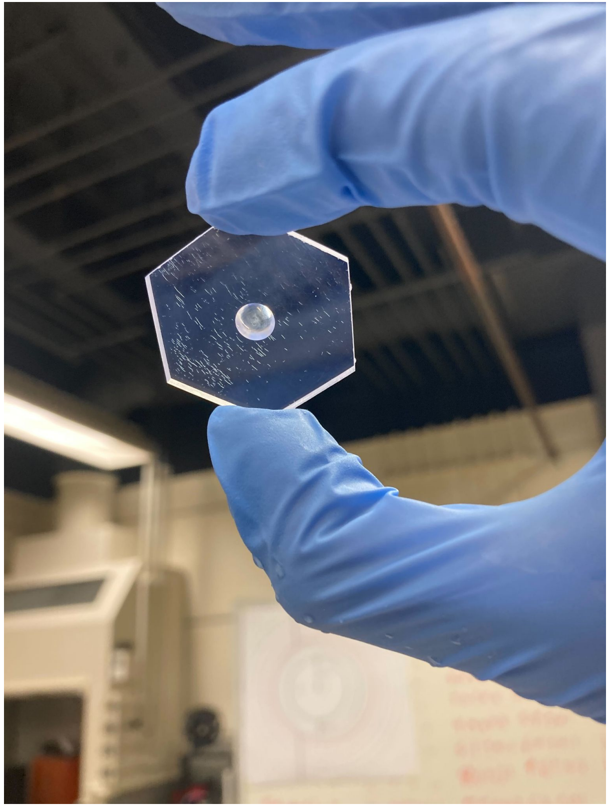
And a lower speed is being used during cutting. (to reduce stress)

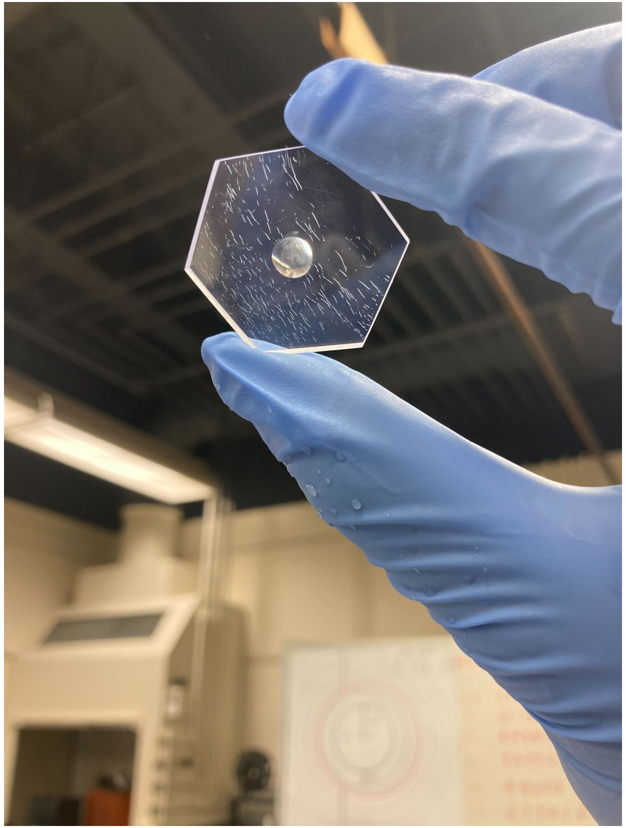
Old Method

New Method

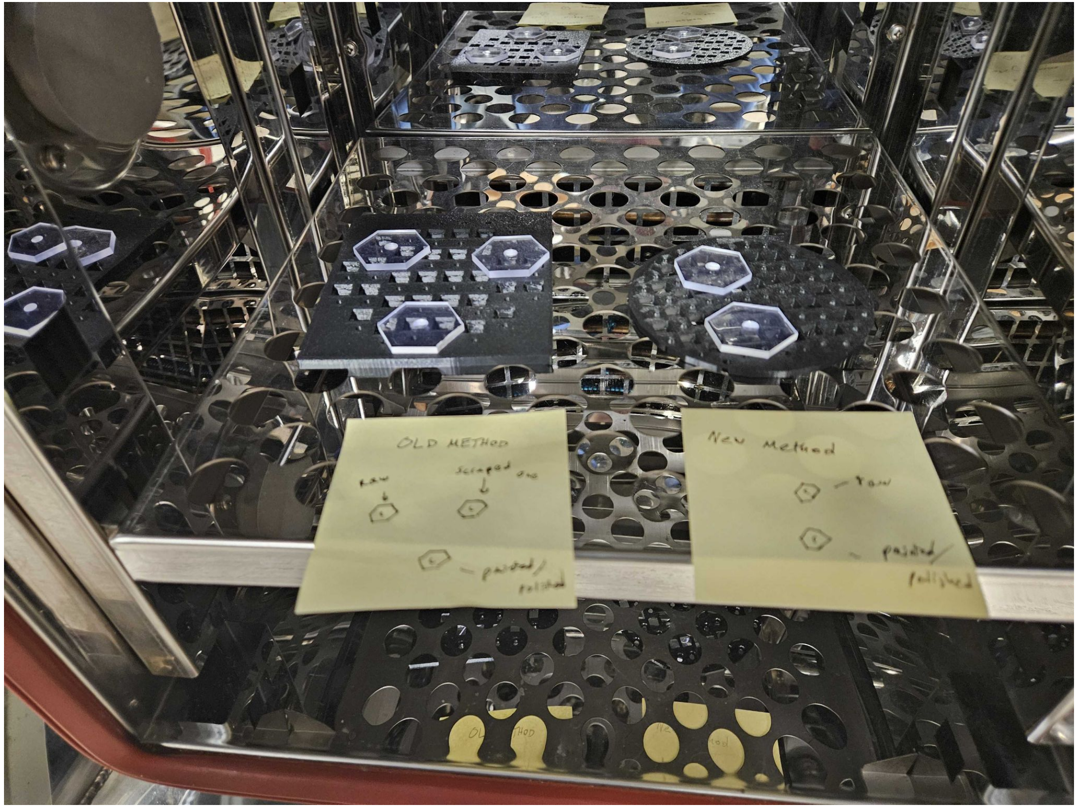
Batch made with new method (submerged in water for cooling, no compressed air) still shows crazing after ~1 month

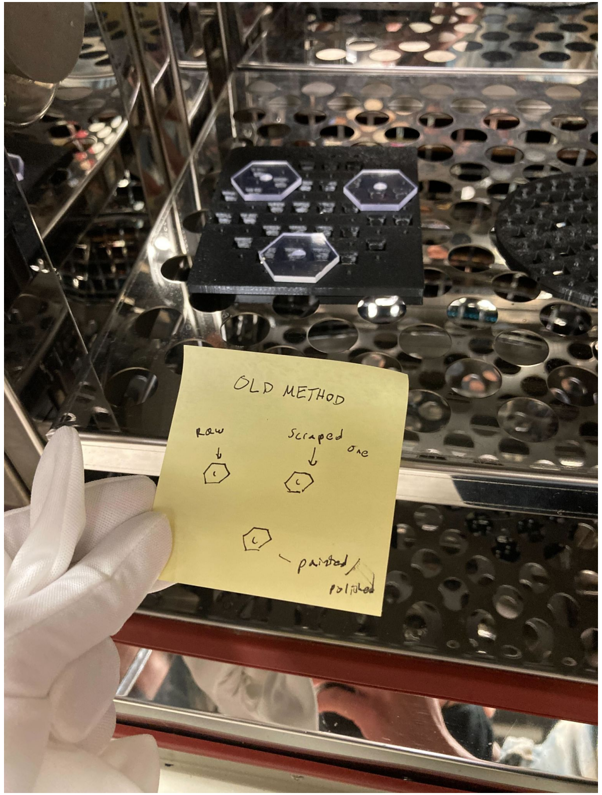






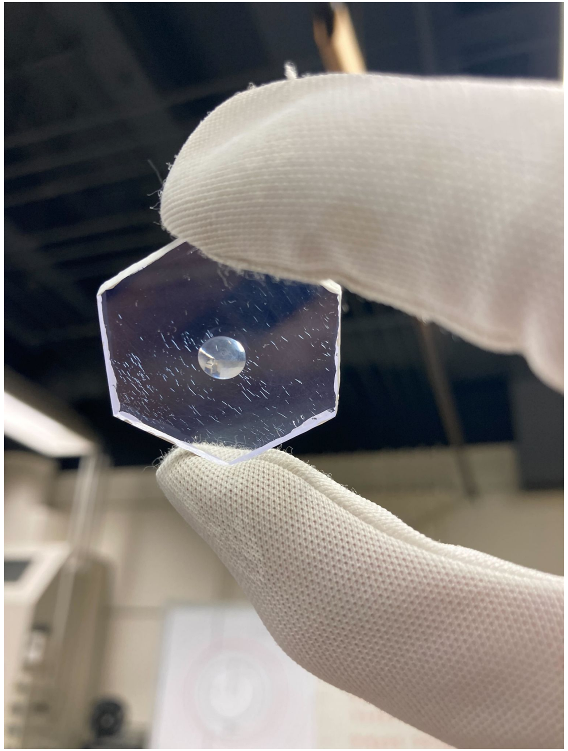
We used our climate chamber to anneal them

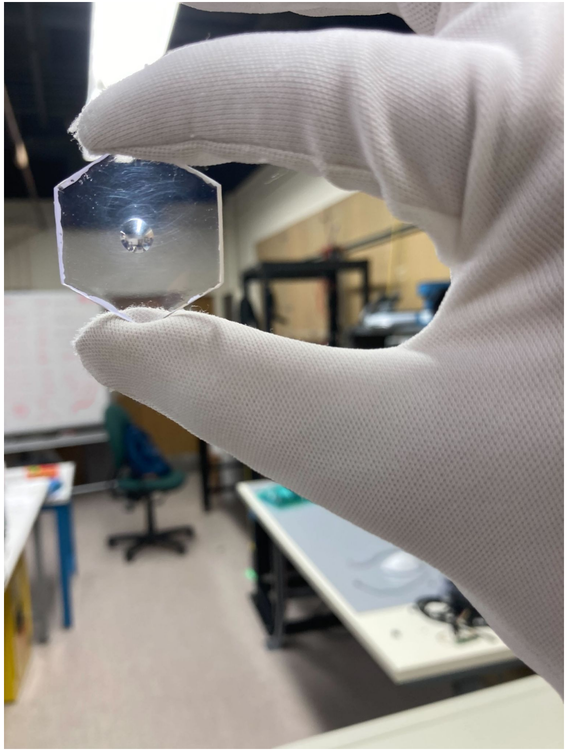




We tried various times and temperatures until we found something successful (80C, 4hr)

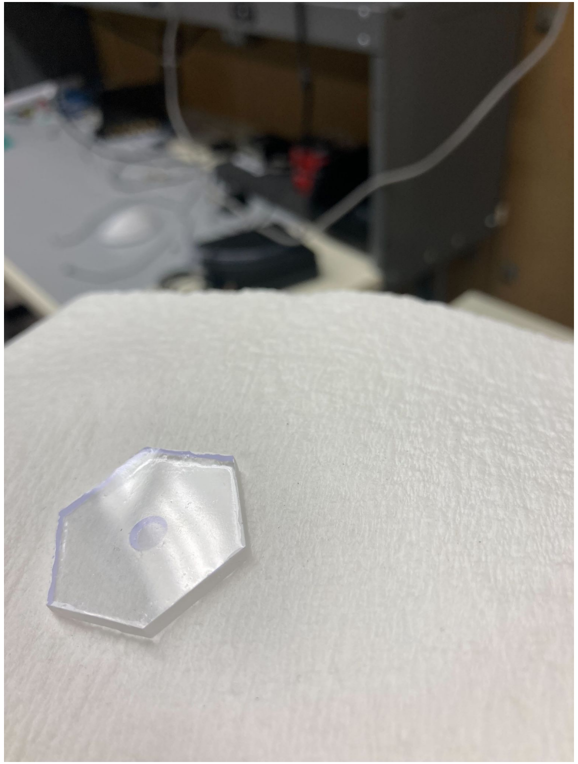
Before and after annealing (4 hr @ 80C)

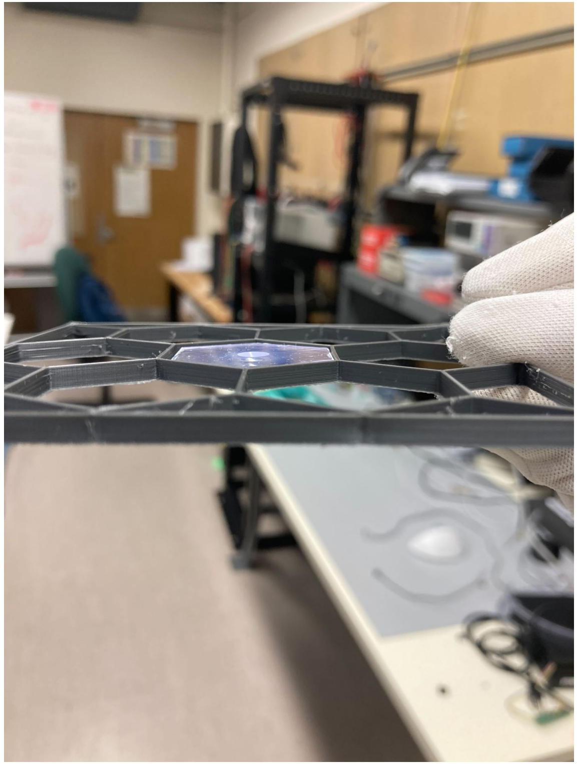




Crazing goes away with annealing, for the most part

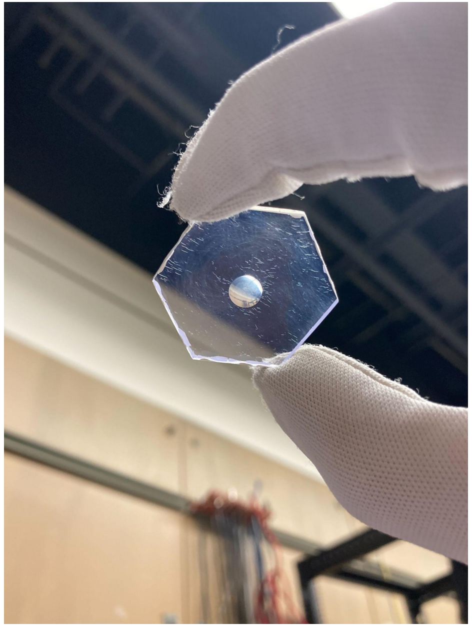
No noticeable warping or texture in the scintillator with the annealing (4 hours, 80 C)

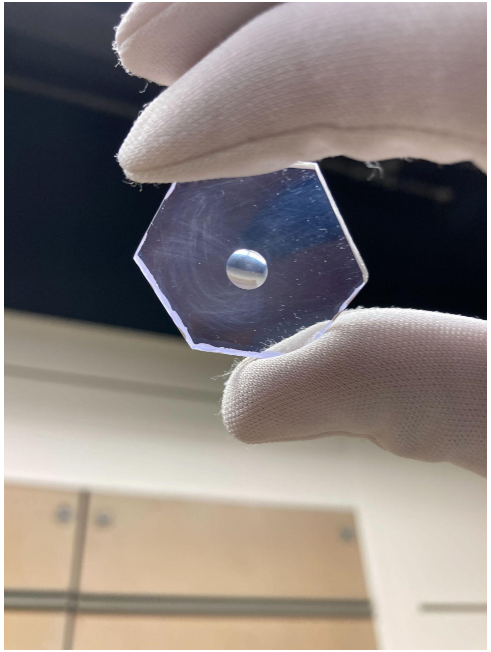




New-method scintillator before and after annealing

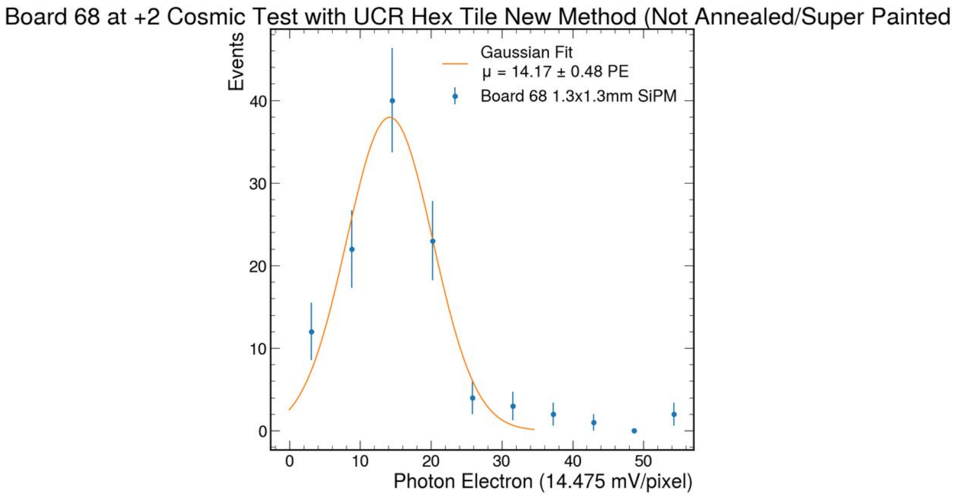
Before Annealing

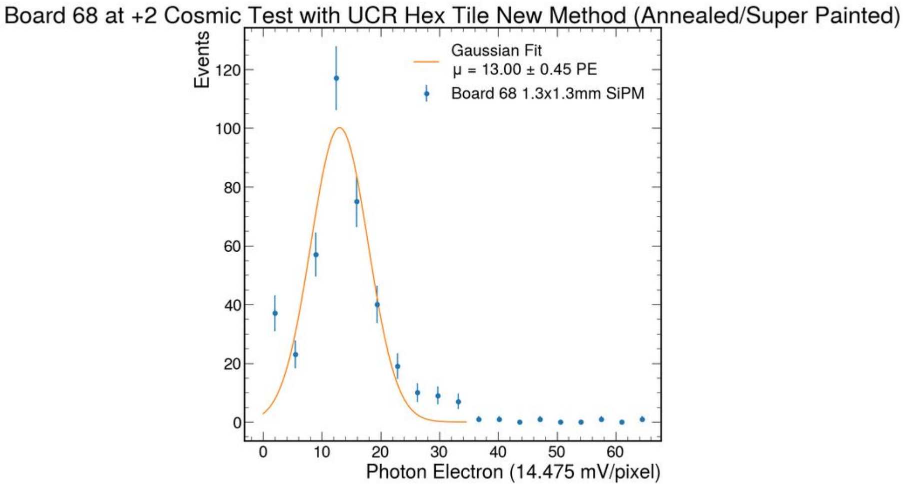




After Annealing

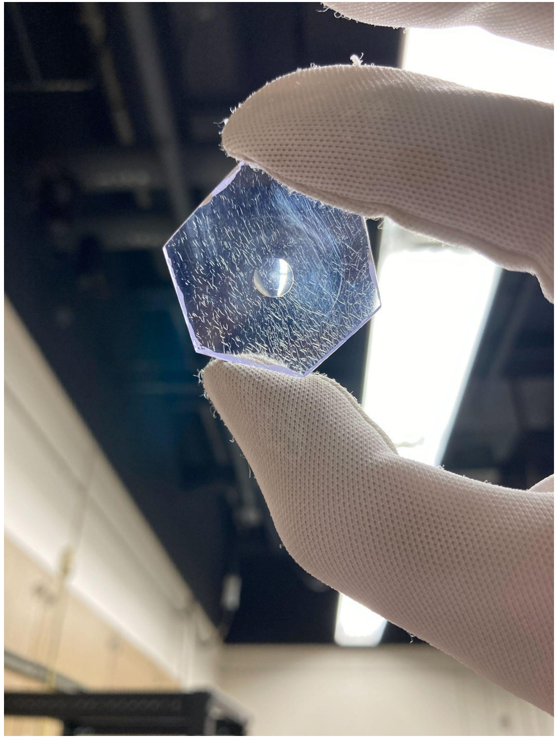
New-method scintillator before and after annealing

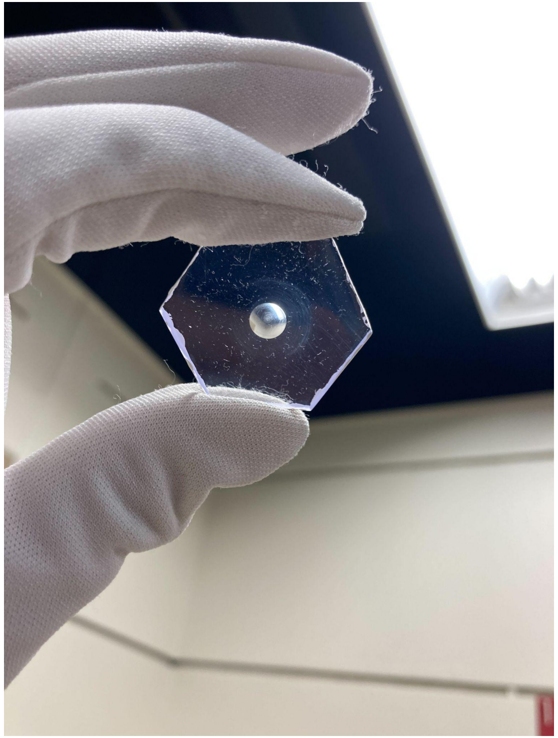




These results show that annealing a scintillator does not make a significant improvement nor worsen the amount light yield.

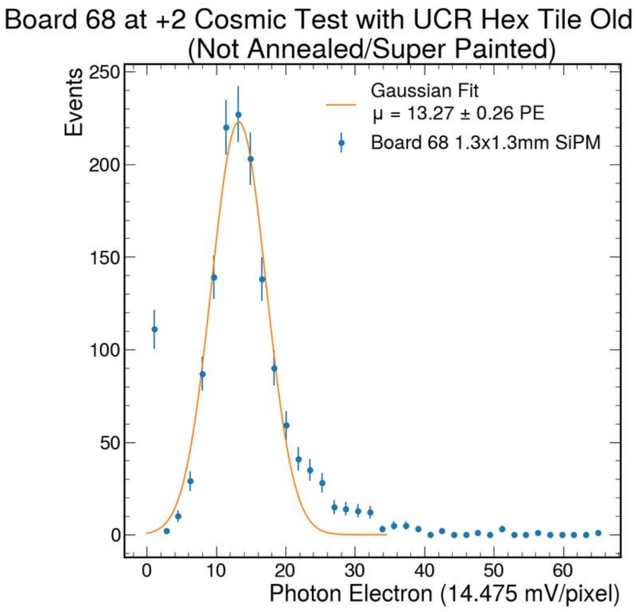
Old Method Scintillator before and after annealing

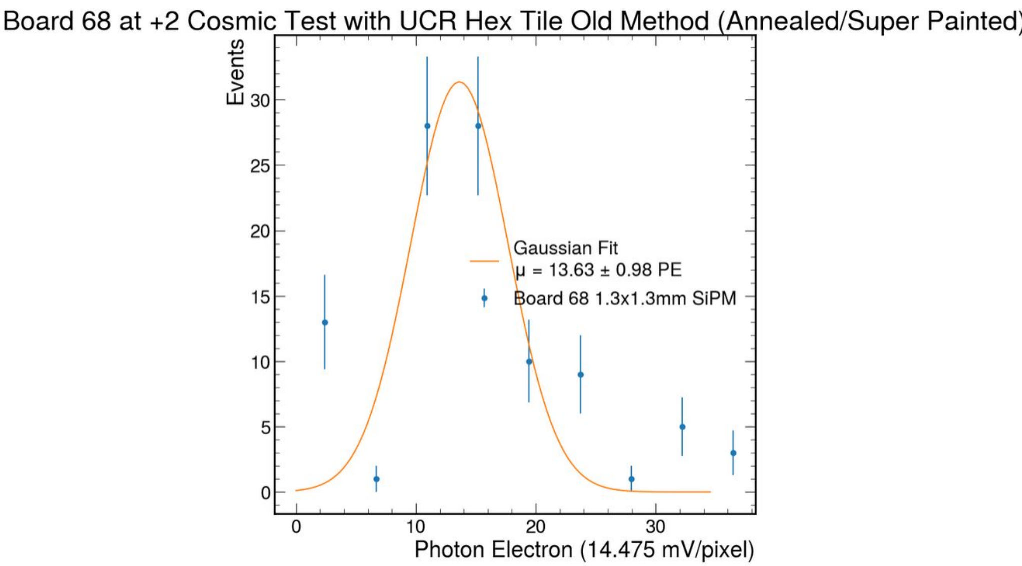




This one was a success, crazing gone

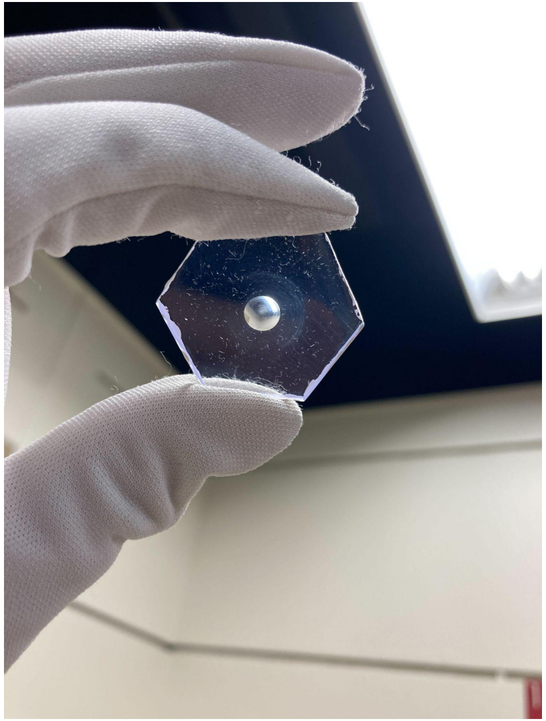
Old Method Scintillator before and after annealing

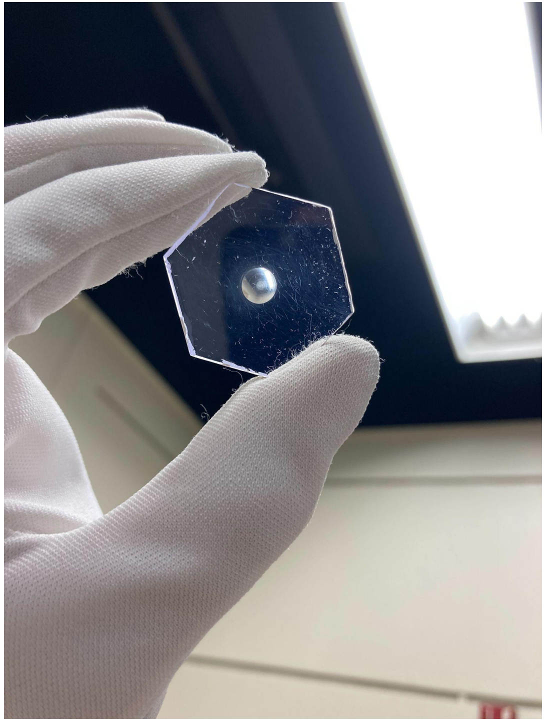




These results show that crazing may not significantly worsen light yield.

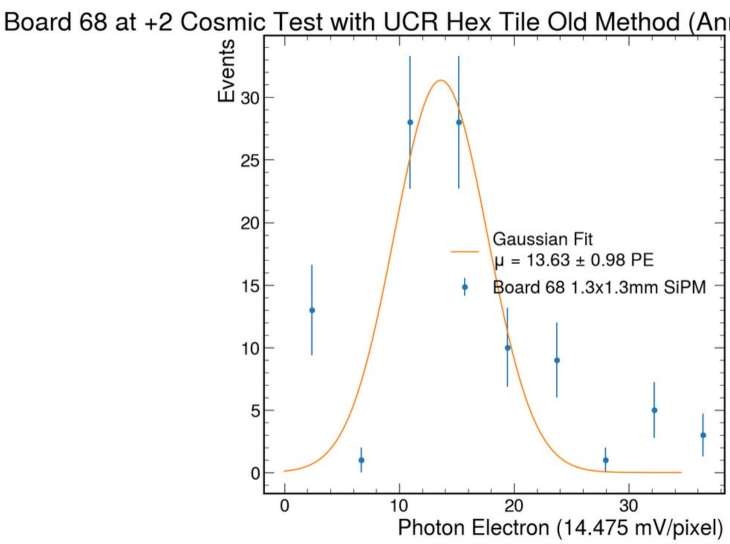
After annealing (no crazing) vs After annealing (some crazing)

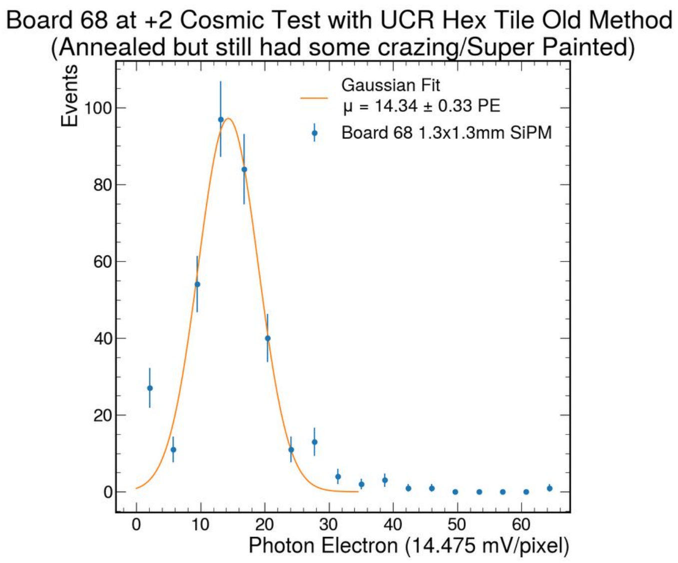




This was not totally successful, some crazing visible by eye

After annealing (no crazing) vs After annealing (some crazing)



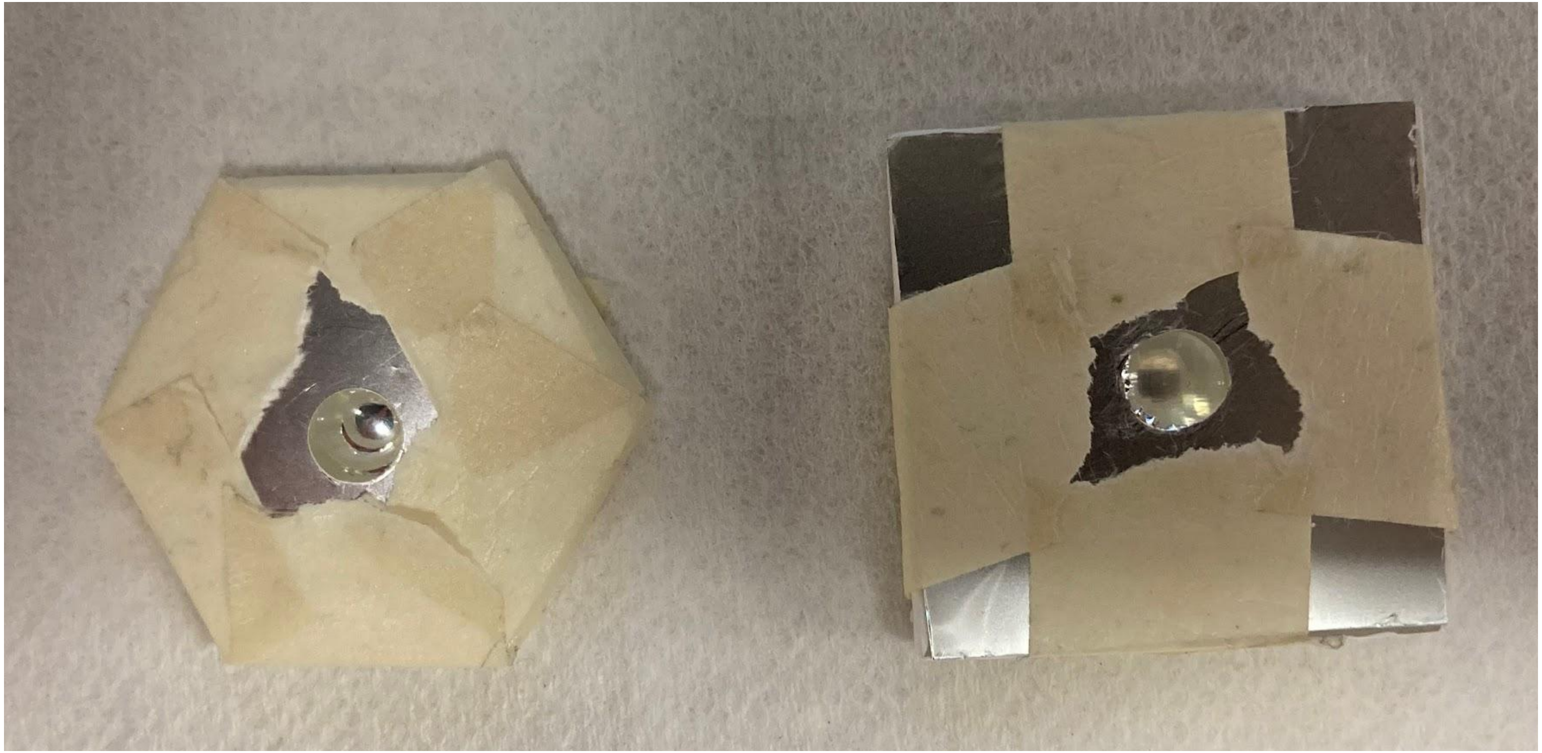


This result shows that tiles that were annealed but did not have their crazing fully removed were still producing similar light yield.

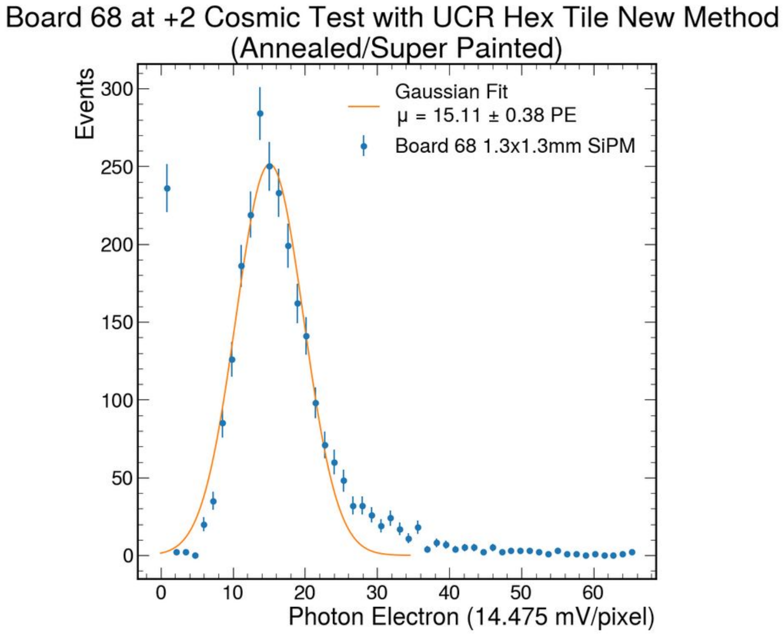
Update on Other comparative studies

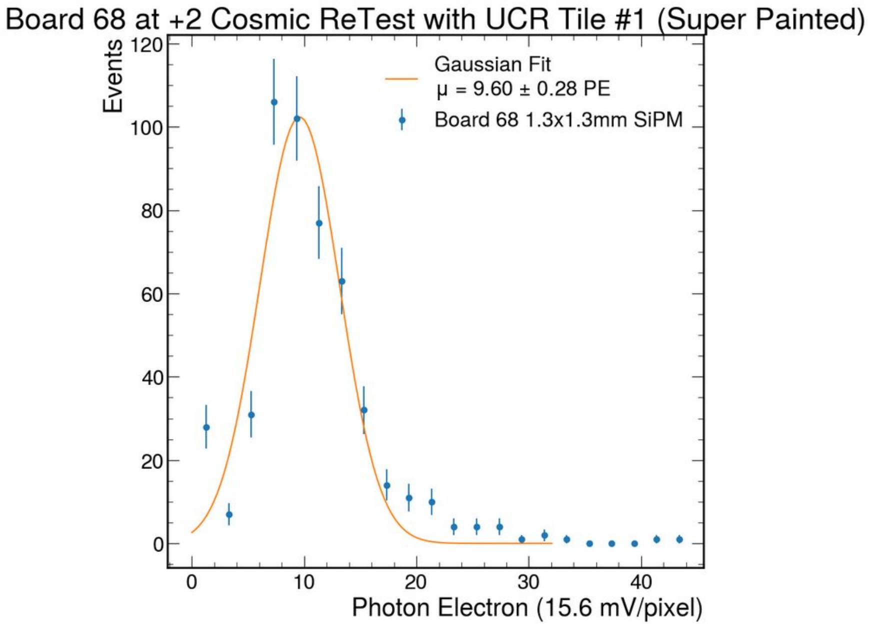
For this we compared different shapes (hexagons vs squares) and different type of cells (FNAL injected molded vs EJ-212 machined at UCR)

Hexagons Vs Squares (UCR Manufactured)



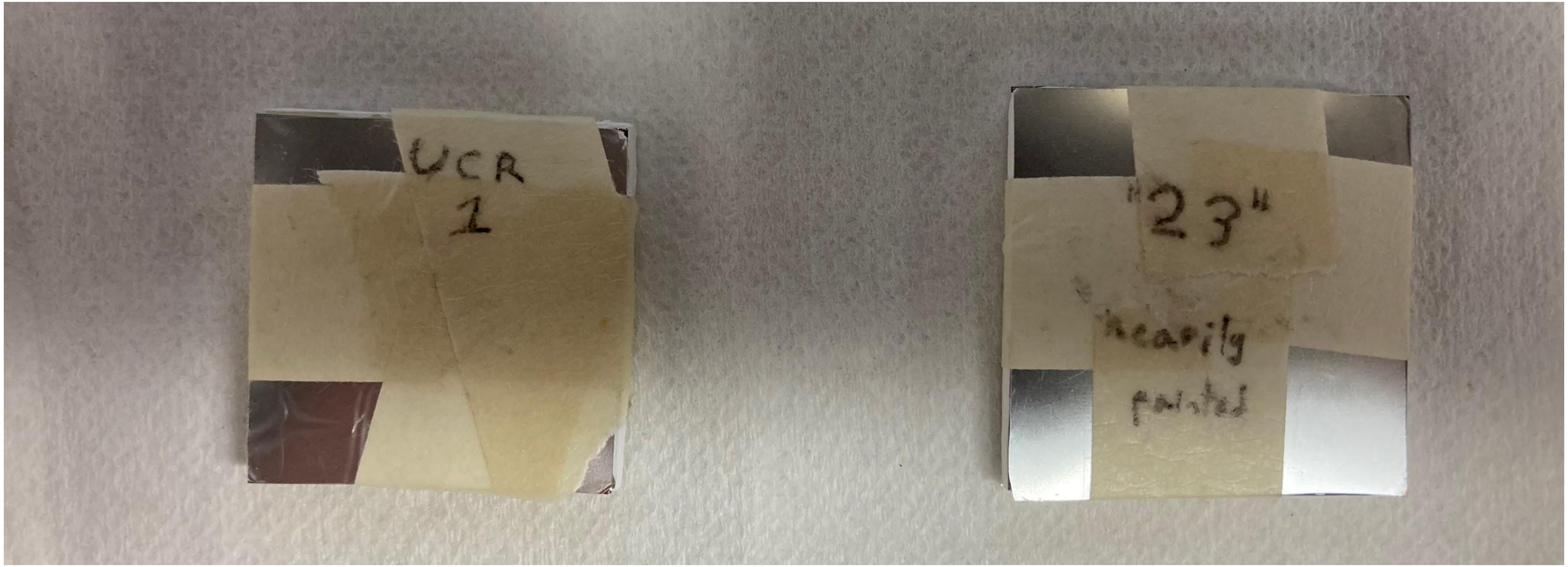
Hexagons Vs Squares (UCR Manufactured)





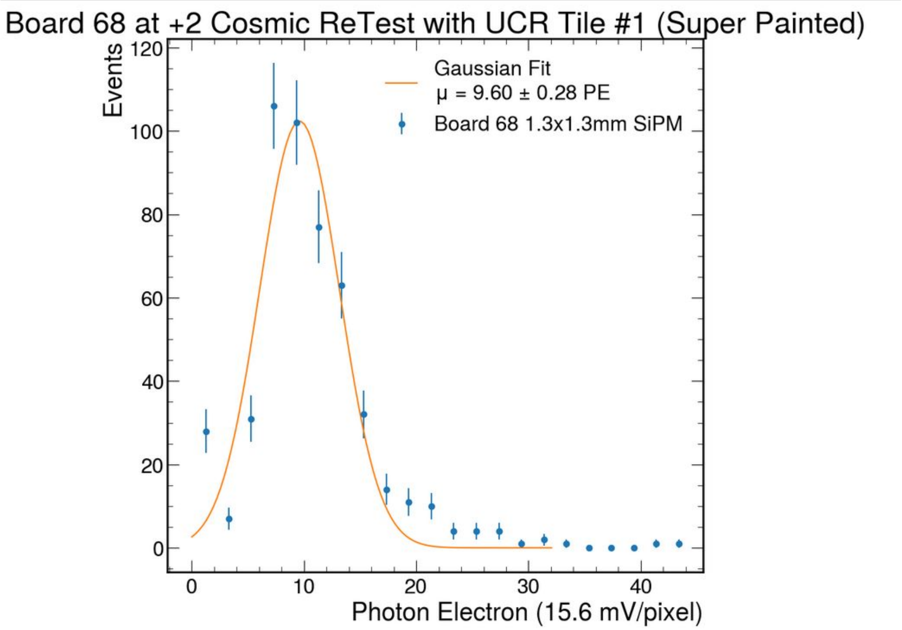
These results show that hexagons create greater light yield
(Distance to center is smaller in hexagons)

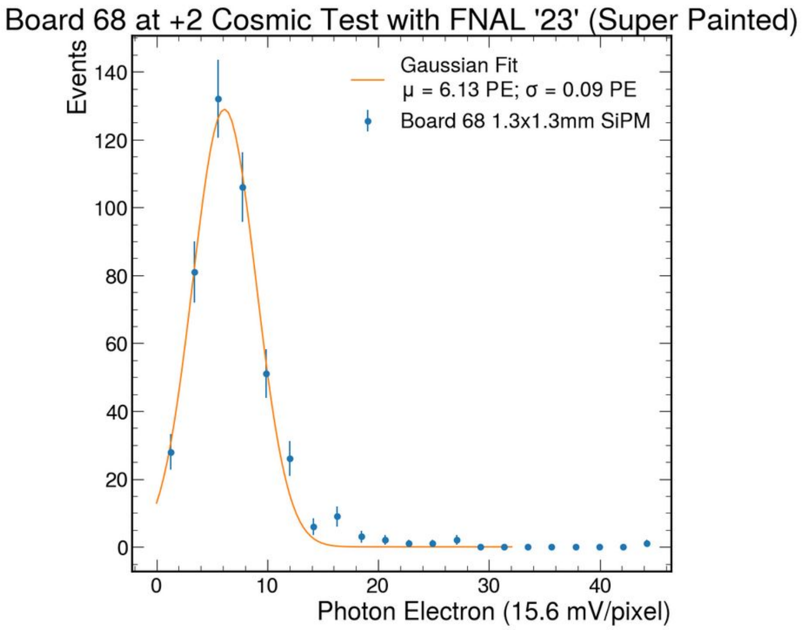
UCR Manufactured vs FNAL injected molded



Same size and treatment

UCR Manufactured vs FNAL injected molded

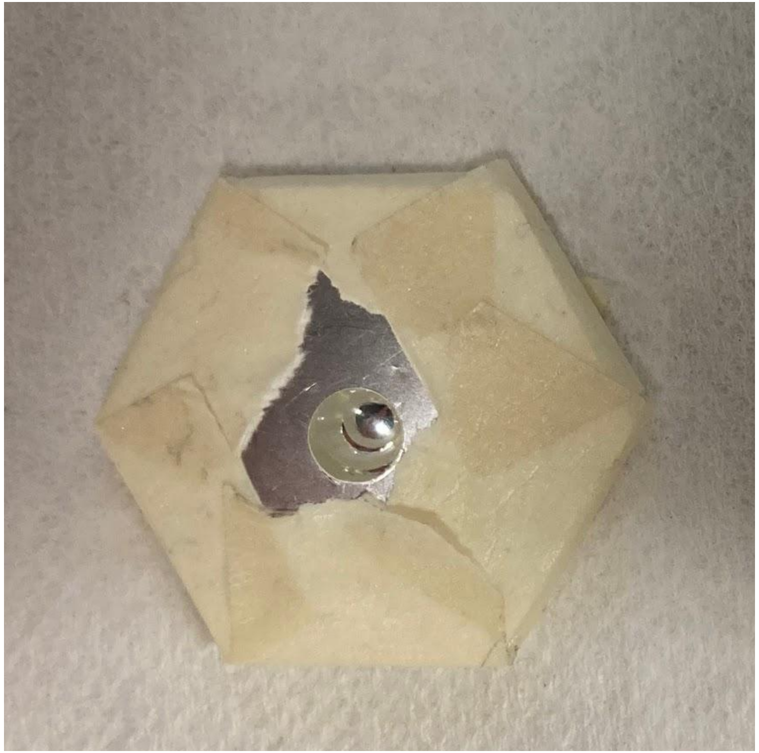


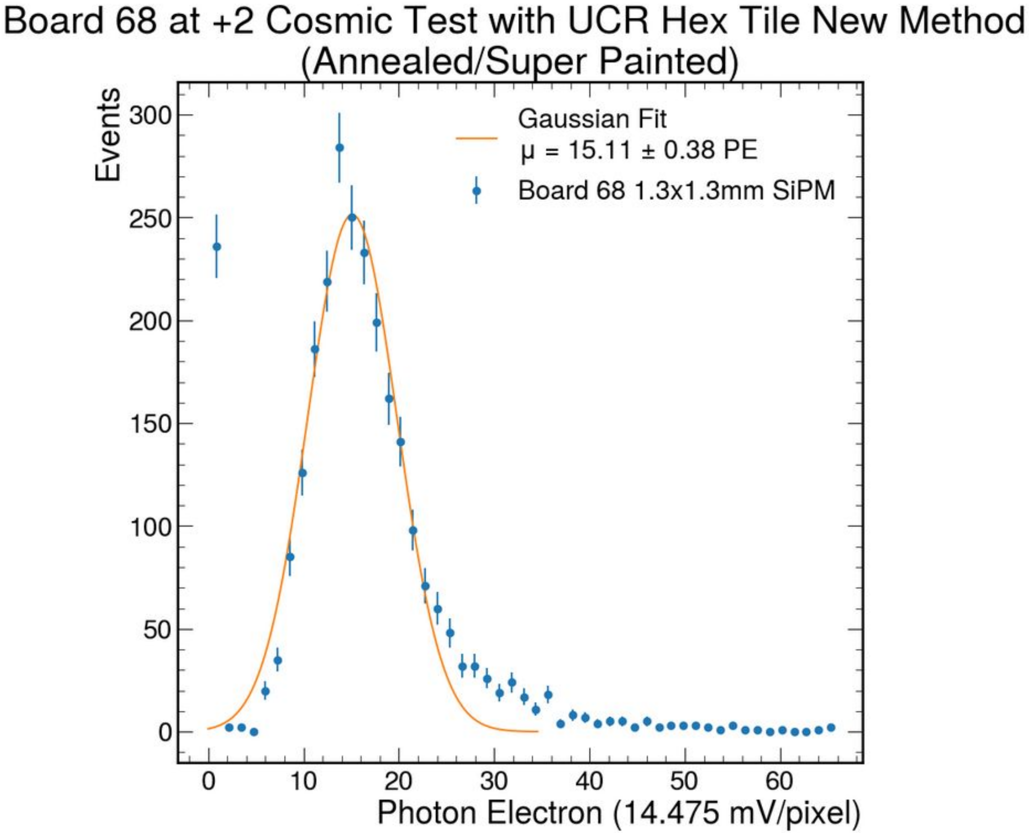


These results show that our scintillator tiles made in UCR create better light yield than the scintillator tiles produced by injection plastic molding machines in Fermilab.

Bottom line

Fittest design currently yields 15.1+/ 0.4 photons at 2V





Summary

- We found we were applying not enough paint. Adding more layers improves light yield by, reaching similar light yield wrt to fully ESR-wrapped cell.
- We found issues with our machining process, which we rectified.
- We found that scintillator crazing can be fixed with annealing at 80C for 4hr
- We found that crazing does not seem to have significant impact in light yield
- We found that hexagons yield more light than squares
- We found that machined EJ-212 yield more light than injected molded cells
- Fittest design currently yields 15.1+/ 0.4 photoelectrons at 2V