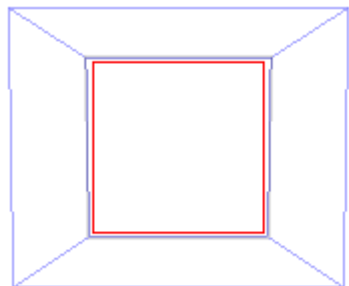
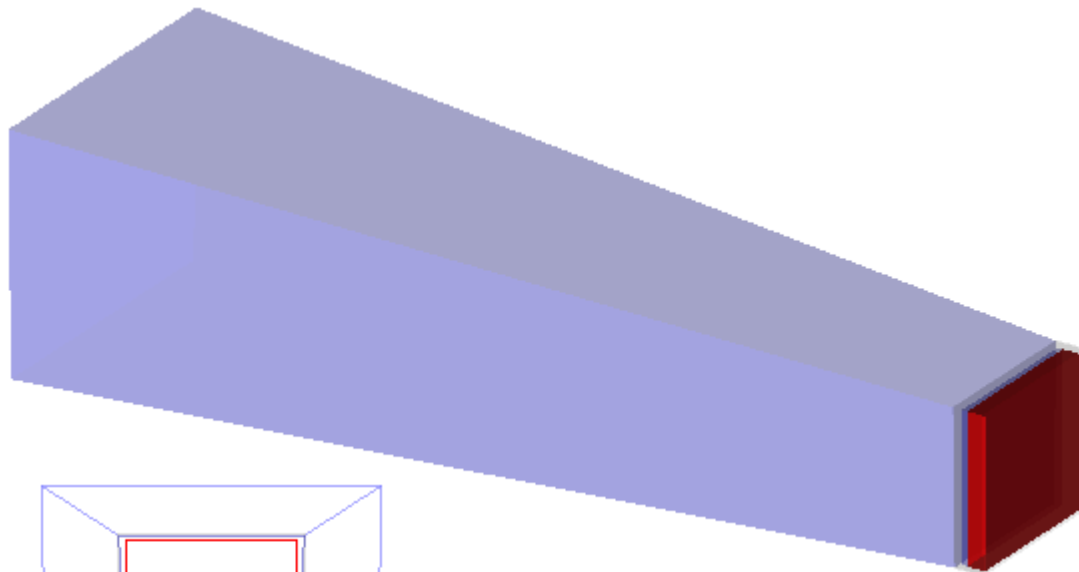
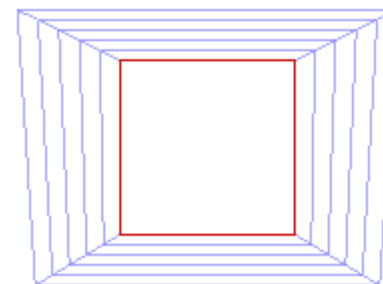
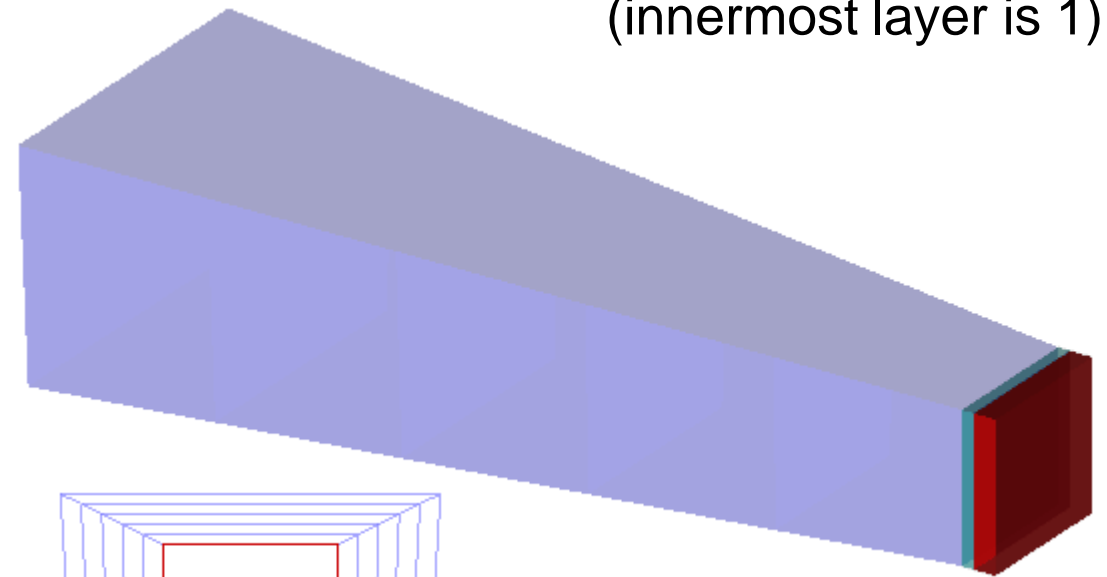


- Generating optical photons (450 nm) at input face of light guides
 - Flat in φ , flat in $\cos(\theta)$
 - Limited to $\theta = 26.7$ degrees
- 0.5 mm air gap or 1.0 mm silicone cookie
- Count photons that reach SiPM face

'b' – BIC
 'g' – GlueX
 '#' – layer number
 (innermost layer is 1)



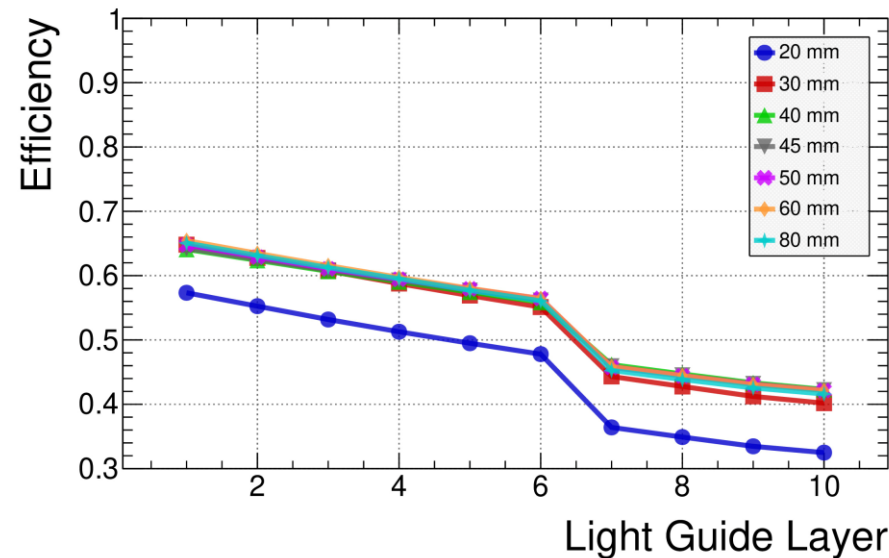
'g6 air'



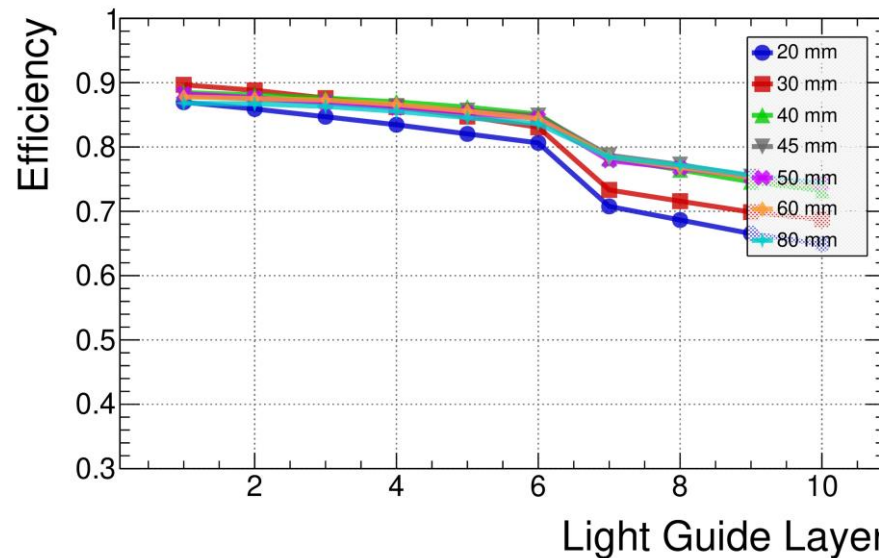
'b6 cookie'

Efficiencies

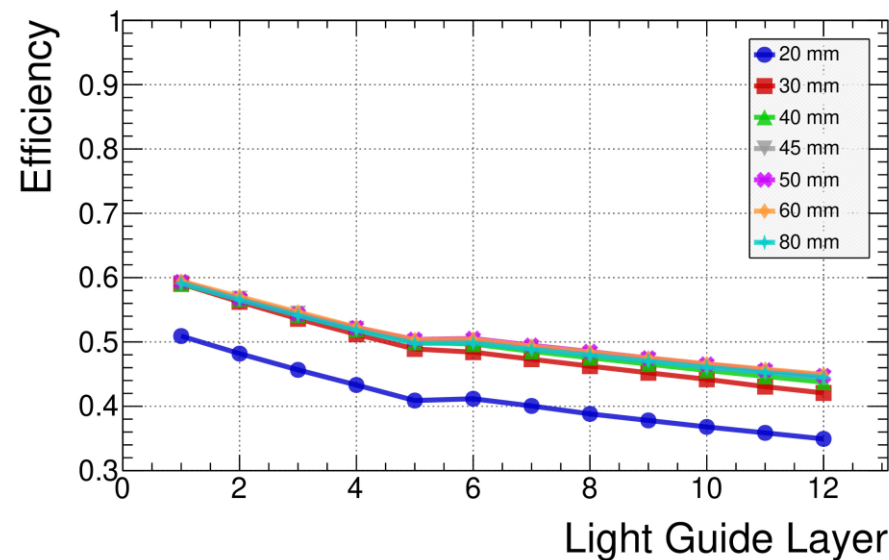
GlueX air S12-GlueX Efficiency vs. Layer



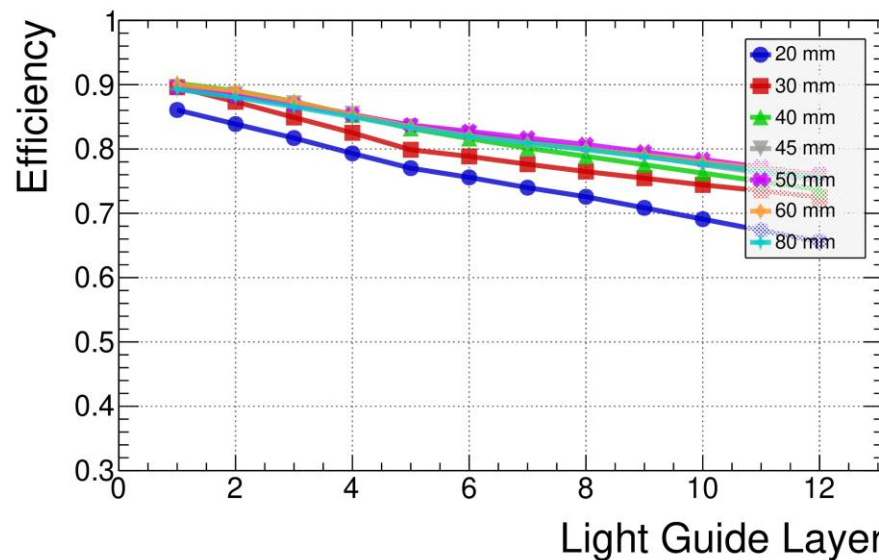
GlueX cookie S12-GlueX Efficiency vs. Layer



BIC air S13-BIC Efficiency vs. Layer



BIC cookie S13-BIC Efficiency vs. Layer

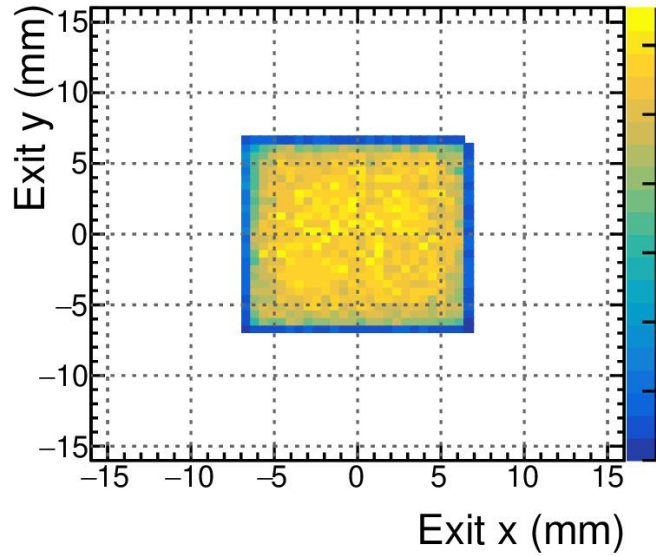


50 mm Efficiencies

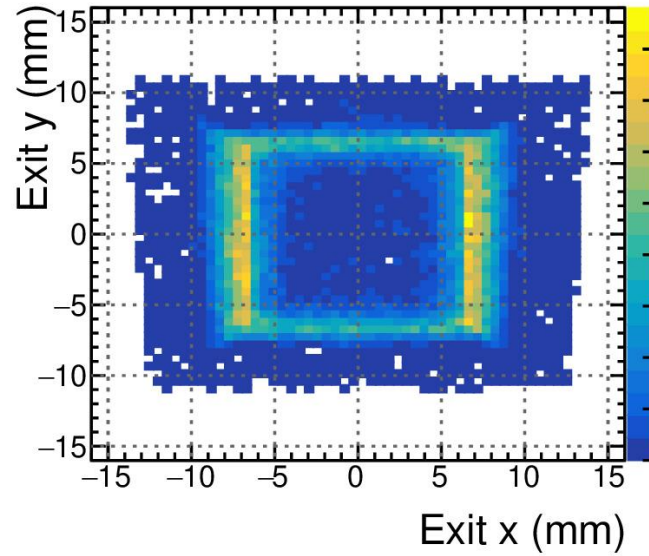
Layer #	GlueX air	GlueX cookie	BIC air	BIC cookie
1	0.647	0.883	0.594	0.896
2	0.629	0.877	0.567	0.883
3	0.611	0.868	0.543	0.869
4	0.594	0.861	0.522	0.853
5	0.579	0.852	0.504	0.837
6	0.564	0.845	0.505	0.827
7	0.457	0.779	0.495	0.817
8	0.444	0.767	0.485	0.807
9	0.431	0.753	0.475	0.795
10	0.421	0.742	0.465	0.784
11	–	–	0.456	0.772
12	–	–	0.448	0.760

Light Mixing – BIC cookie

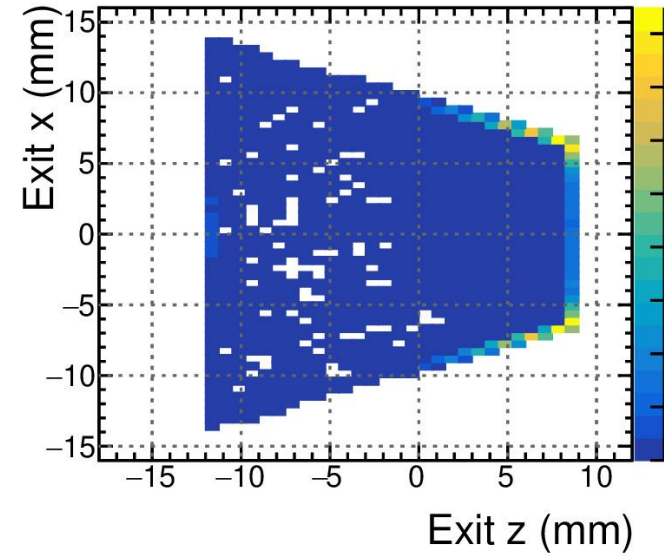
b5 20 mm Exit y vs. x (Success)



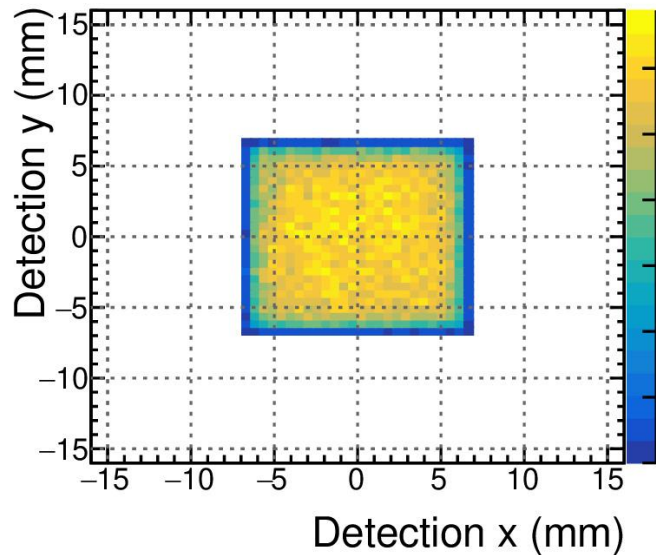
b5 20 mm Exit y vs. x (Failure)



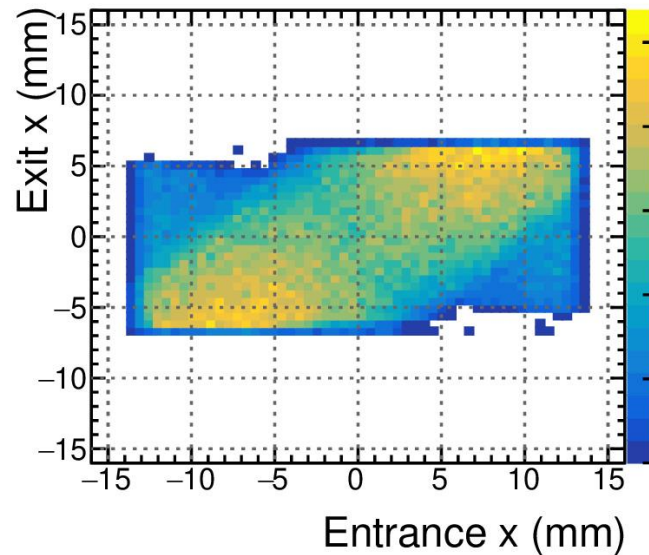
b5 20 mm Exit x vs. z (Failure)



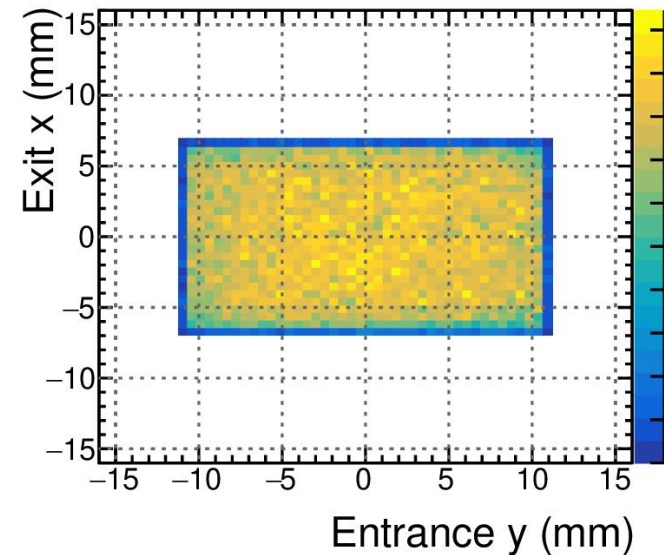
b5 20 mm Detection y vs. x (Success)



b5 20 mm Exit x vs. Entrance x (Success)

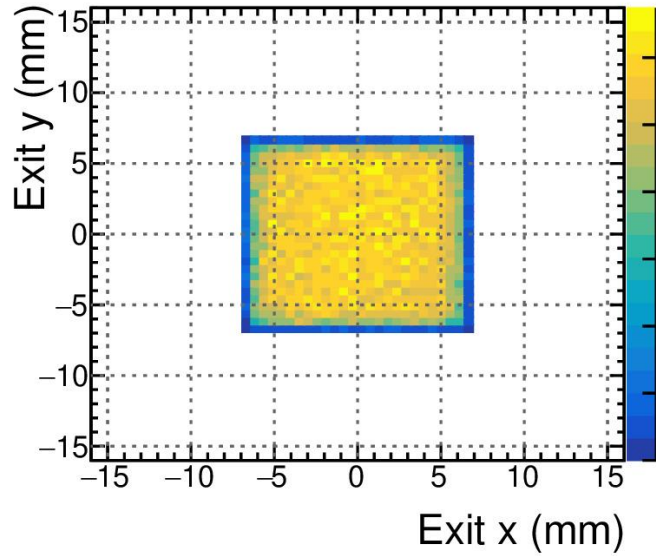


b5 20 mm Exit x vs. Entrance y (Success)

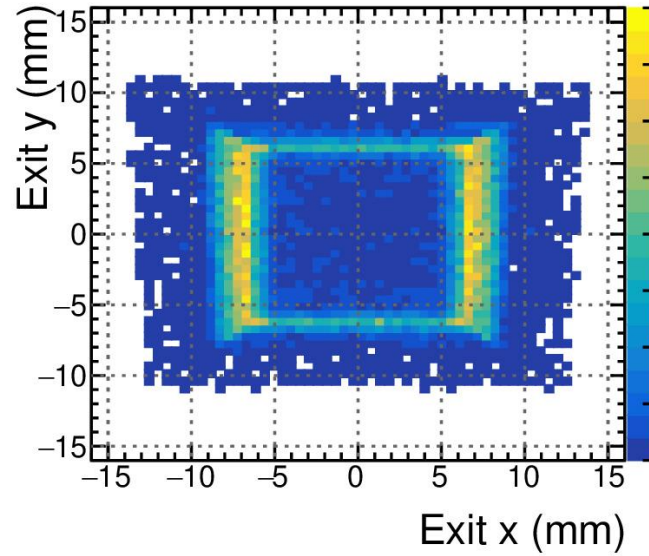


Light Mixing – BIC cookie

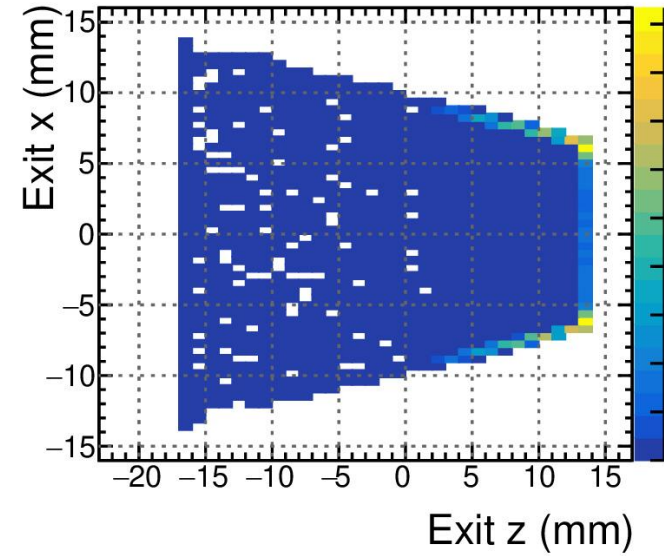
b5 30 mm Exit y vs. x (Success)



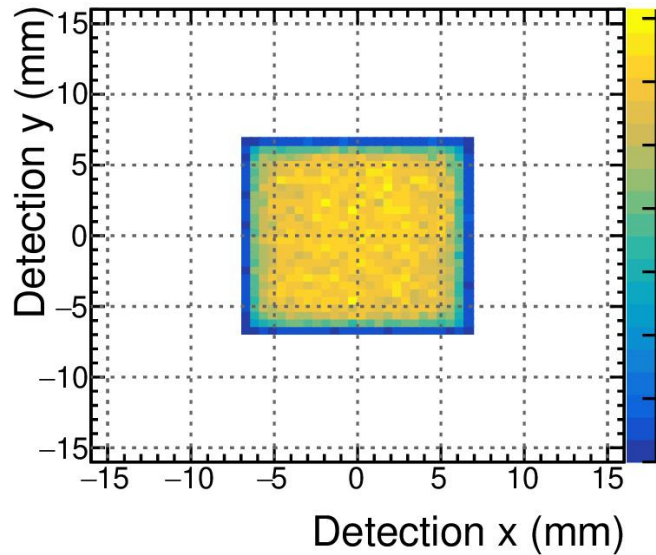
b5 30 mm Exit y vs. x (Failure)



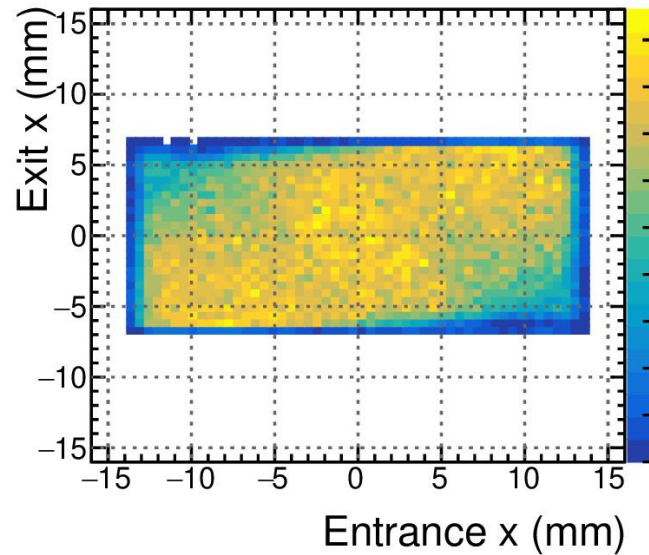
b5 30 mm Exit x vs. z (Failure)



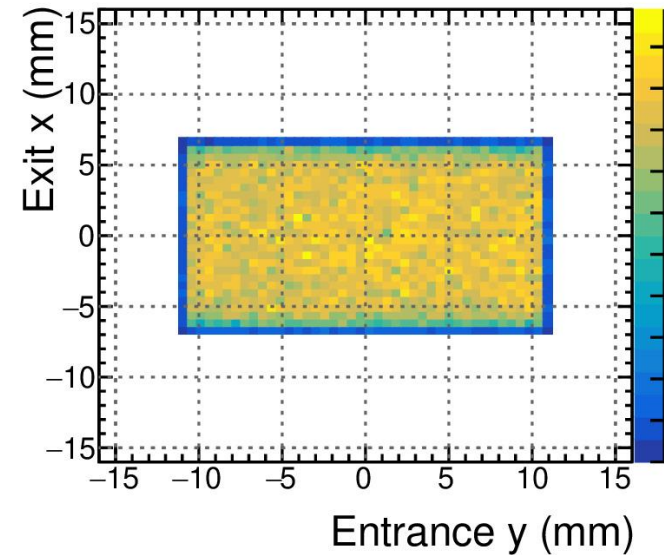
b5 30 mm Detection y vs. x (Success)



b5 30 mm Exit x vs. Entrance x (Success)

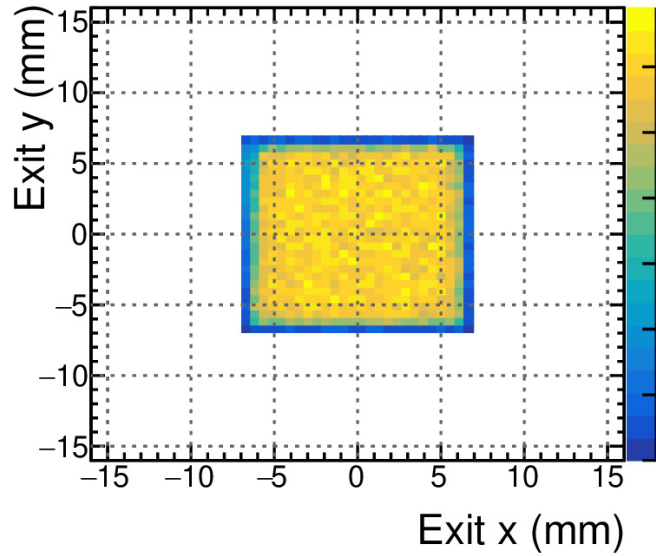


b5 30 mm Exit x vs. Entrance y (Success)

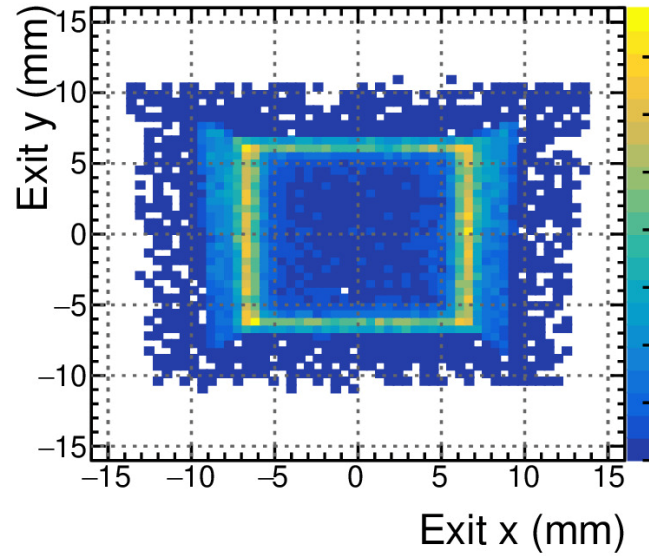


Light Mixing – BIC cookie

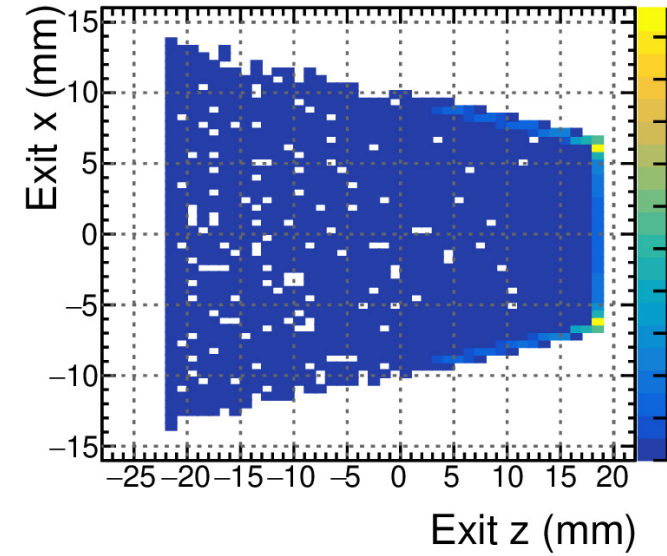
b5 40 mm Exit y vs. x (Success)



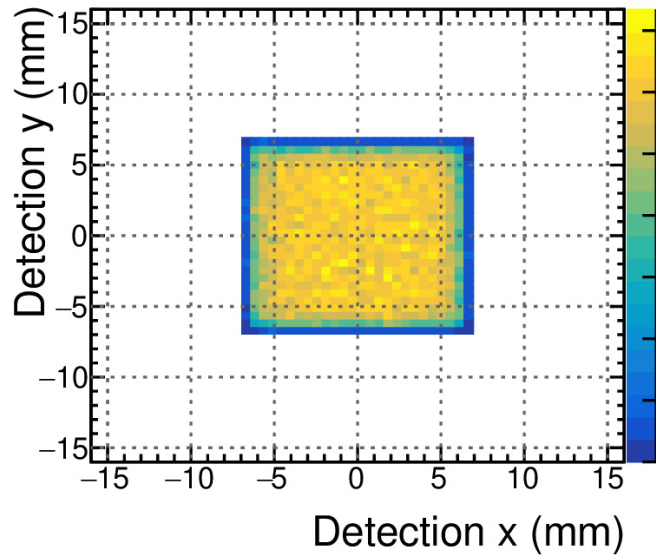
b5 40 mm Exit y vs. x (Failure)



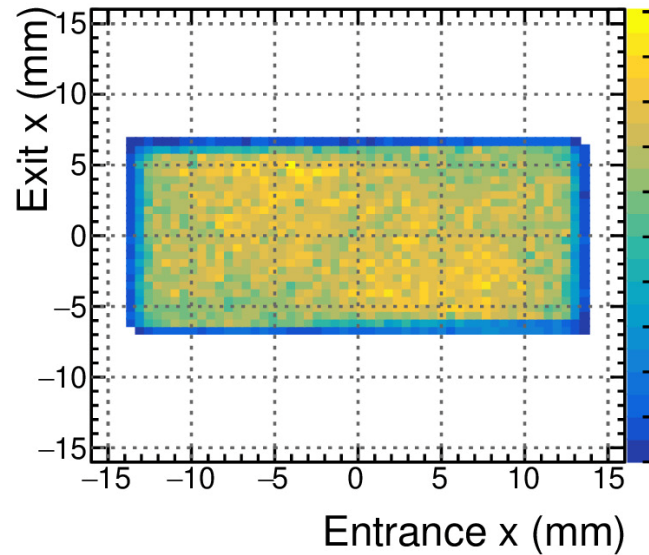
b5 40 mm Exit x vs. z (Failure)



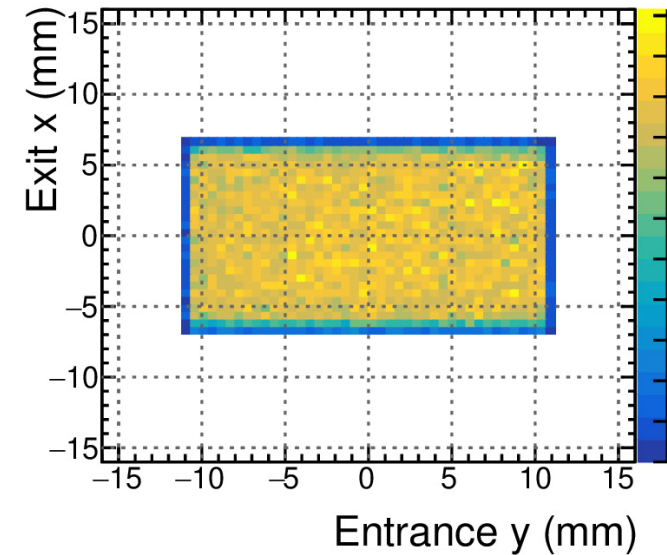
b5 40 mm Detection y vs. x (Success)



b5 40 mm Exit x vs. Entrance x (Success)

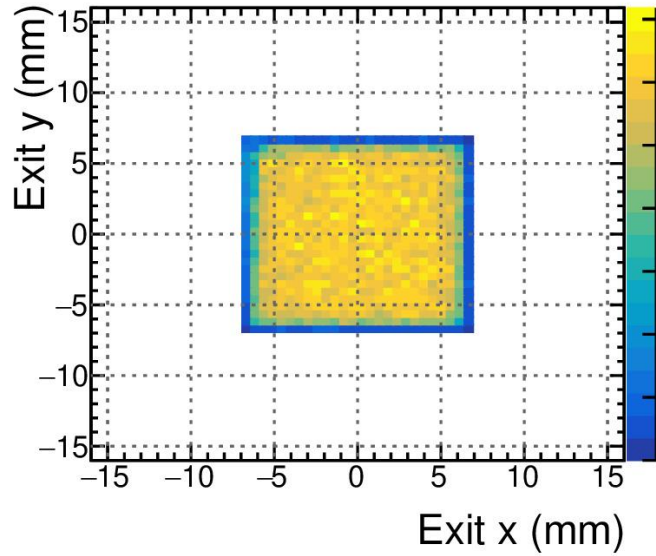


b5 40 mm Exit x vs. Entrance y (Success)

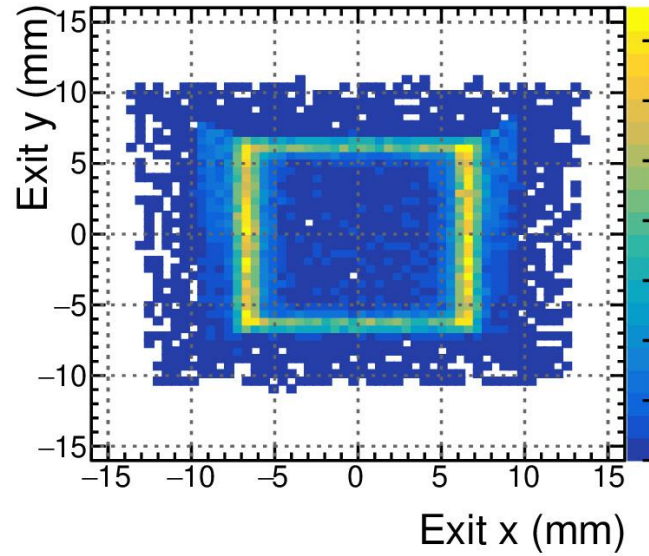


Light Mixing – BIC cookie

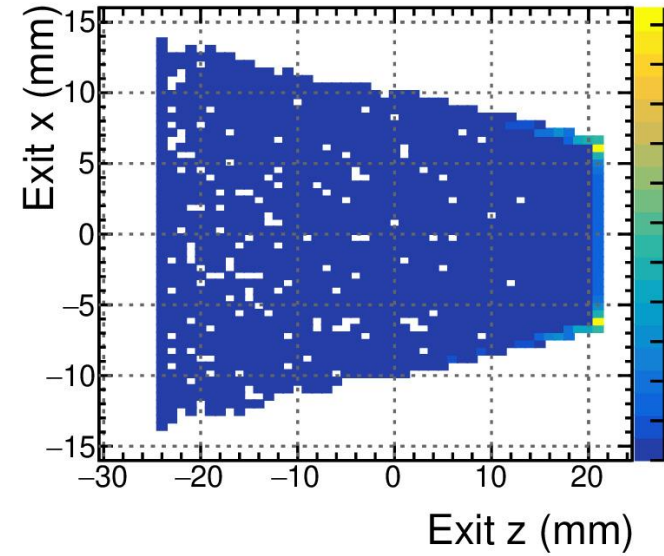
b5 45 mm Exit y vs. x (Success)



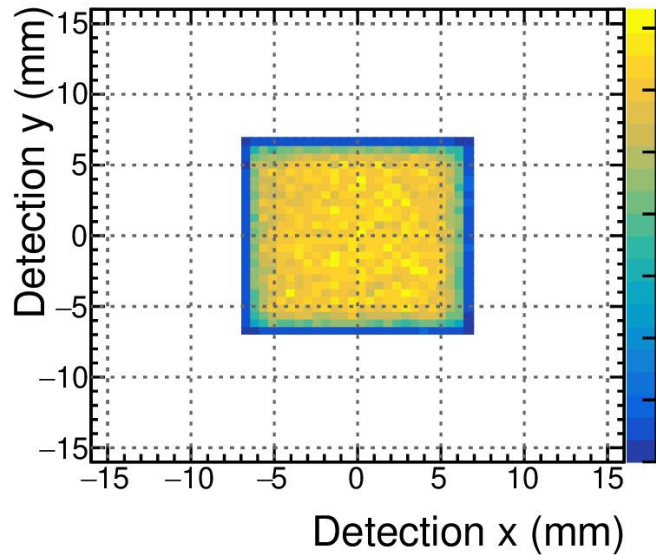
b5 45 mm Exit y vs. x (Failure)



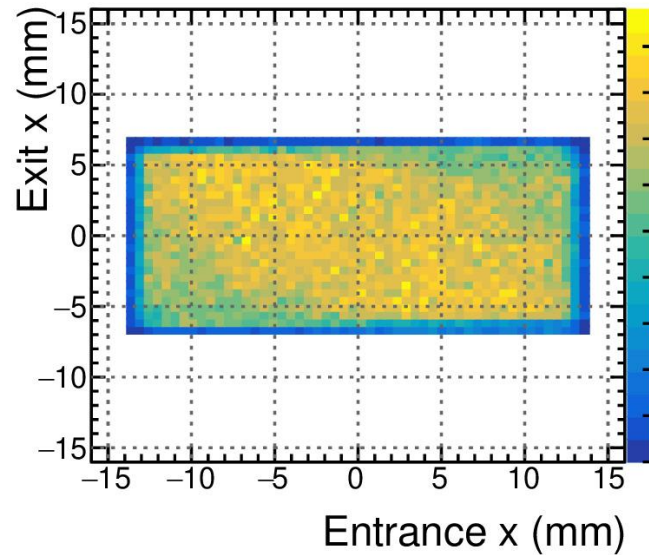
b5 45 mm Exit x vs. z (Failure)



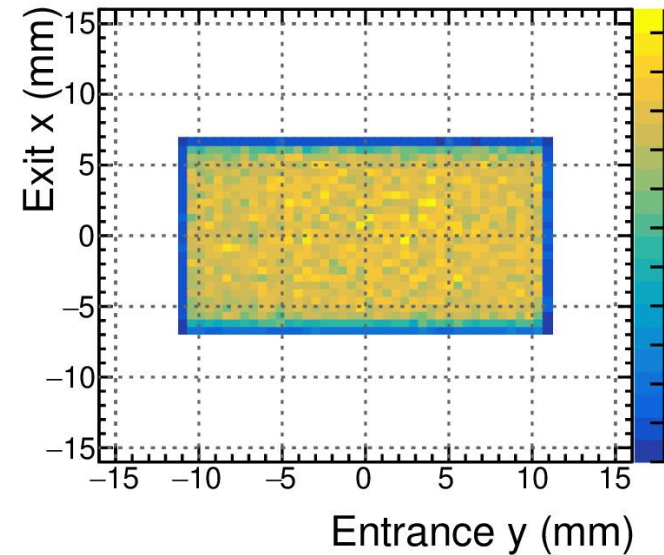
b5 45 mm Detection y vs. x (Success)



b5 45 mm Exit x vs. Entrance x (Success)

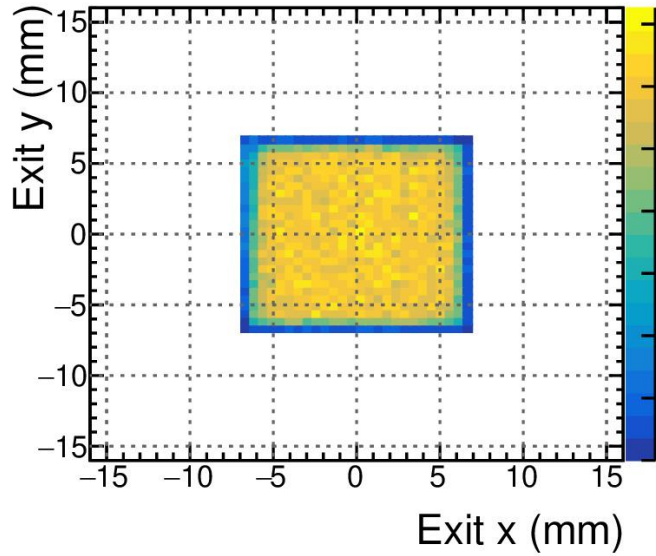


b5 45 mm Exit x vs. Entrance y (Success)

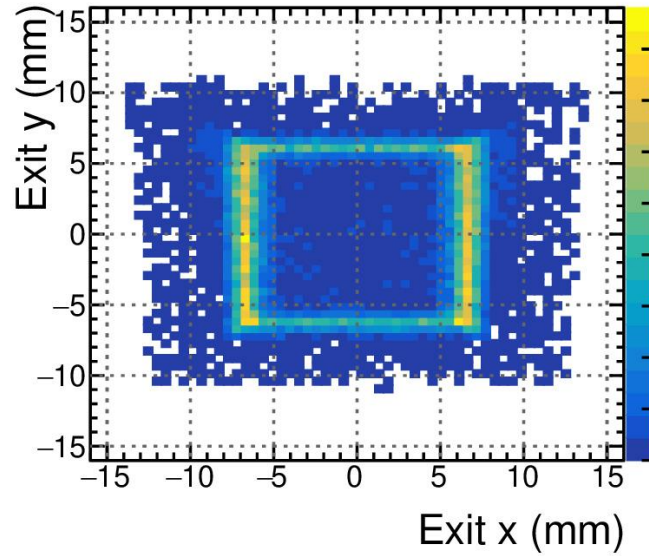


Light Mixing – BIC cookie

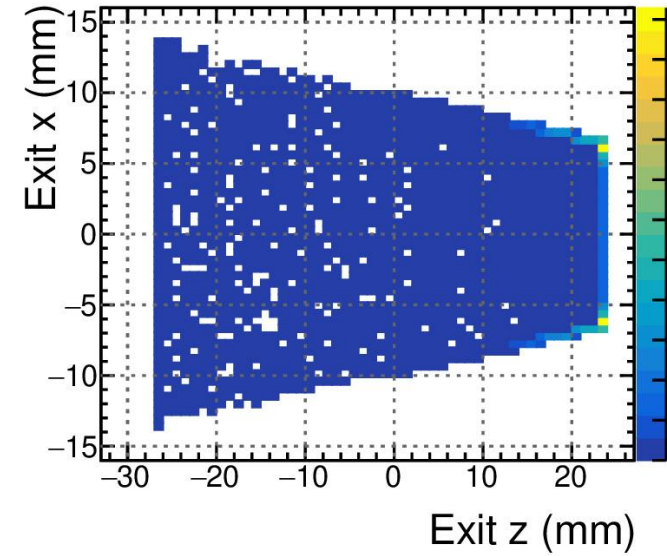
b5 50 mm Exit y vs. x (Success)



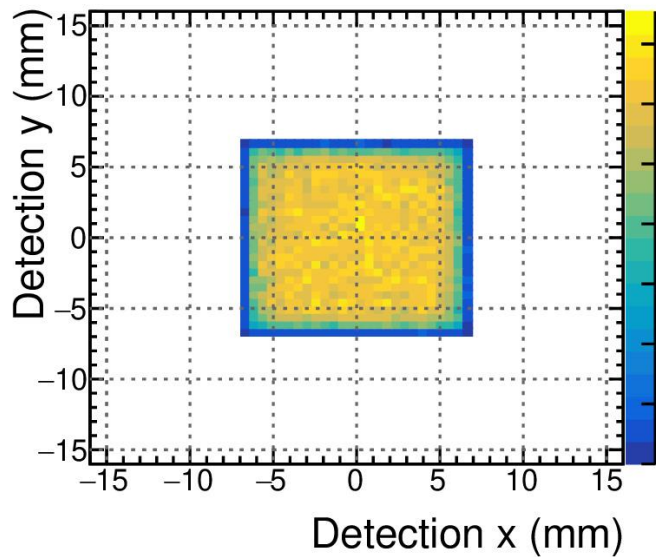
b5 50 mm Exit y vs. x (Failure)



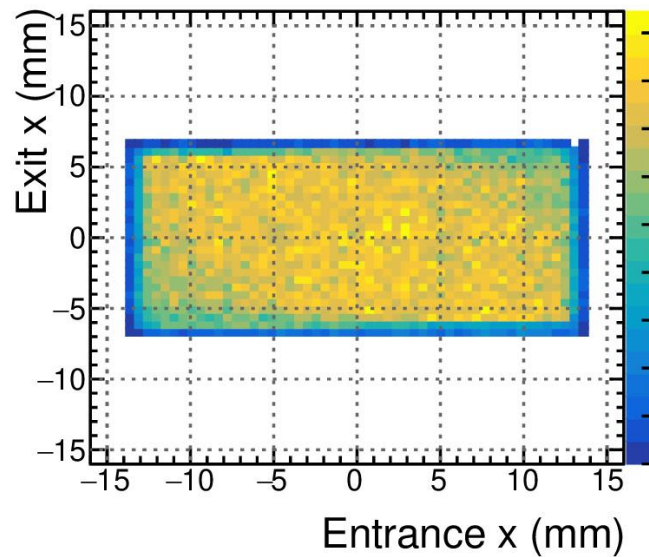
b5 50 mm Exit x vs. z (Failure)



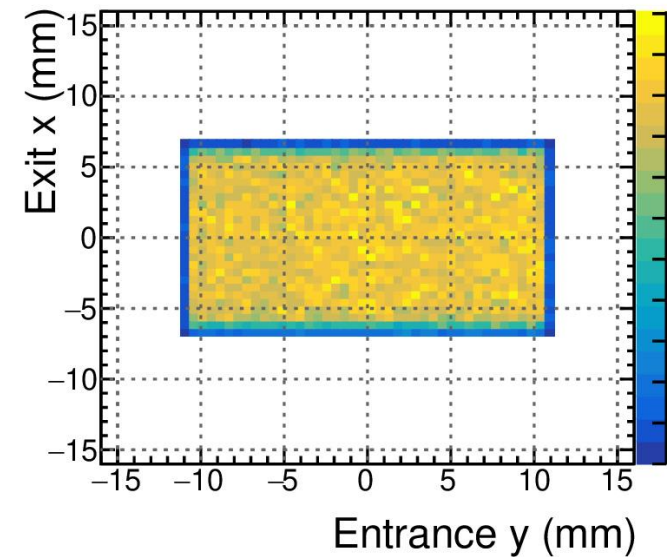
b5 50 mm Detection y vs. x (Success)



b5 50 mm Exit x vs. Entrance x (Success)

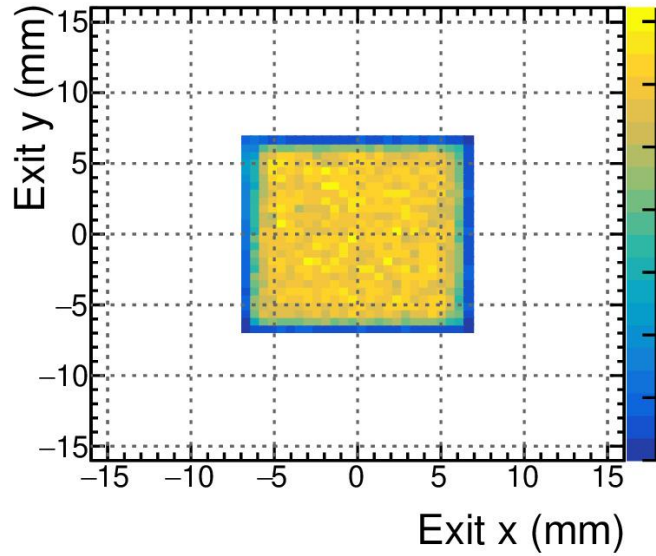


b5 50 mm Exit x vs. Entrance y (Success)

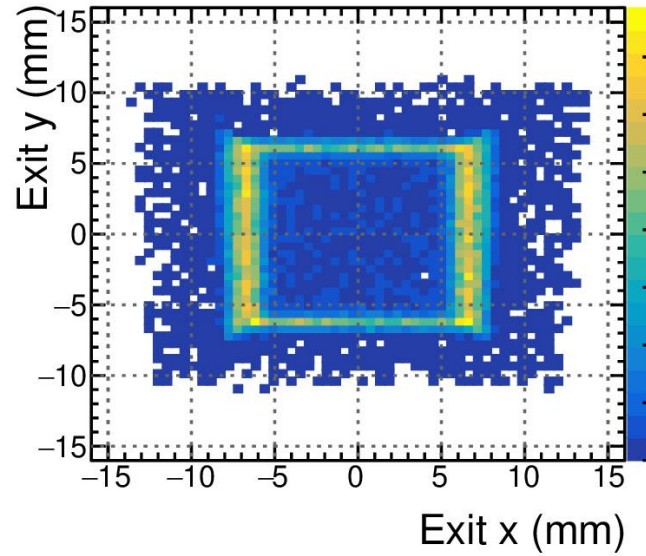


Light Mixing – BIC cookie

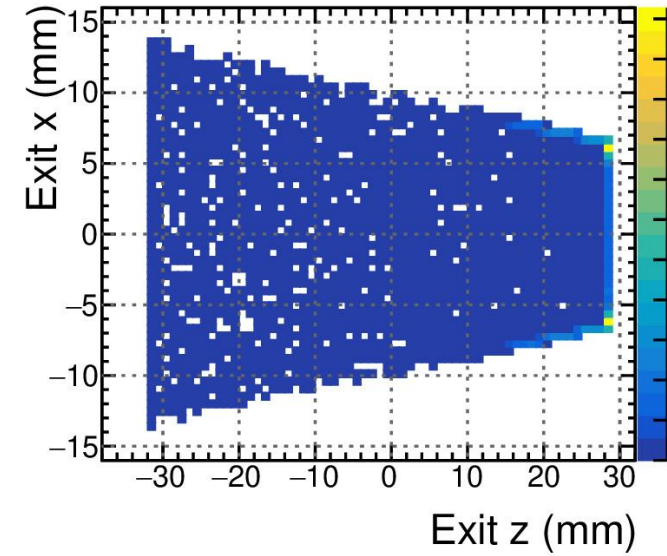
b5 60 mm Exit y vs. x (Success)



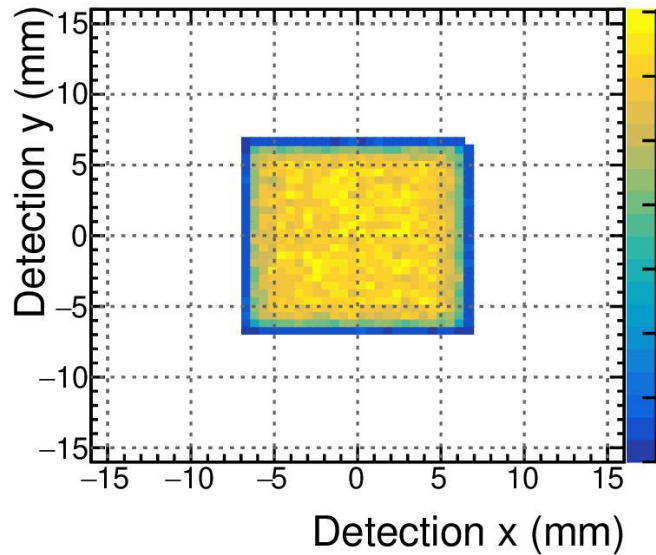
b5 60 mm Exit y vs. x (Failure)



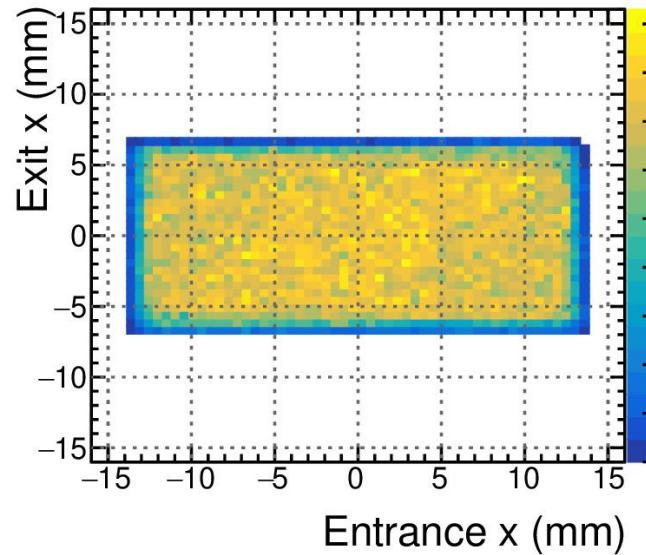
b5 60 mm Exit x vs. z (Failure)



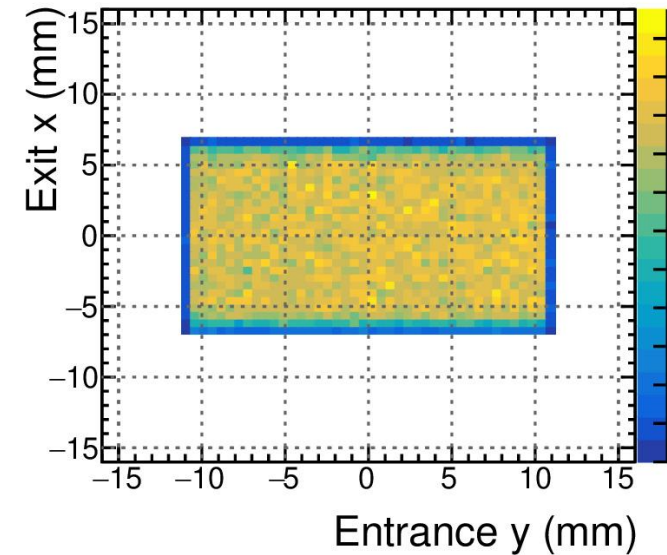
b5 60 mm Detection y vs. x (Success)



b5 60 mm Exit x vs. Entrance x (Success)

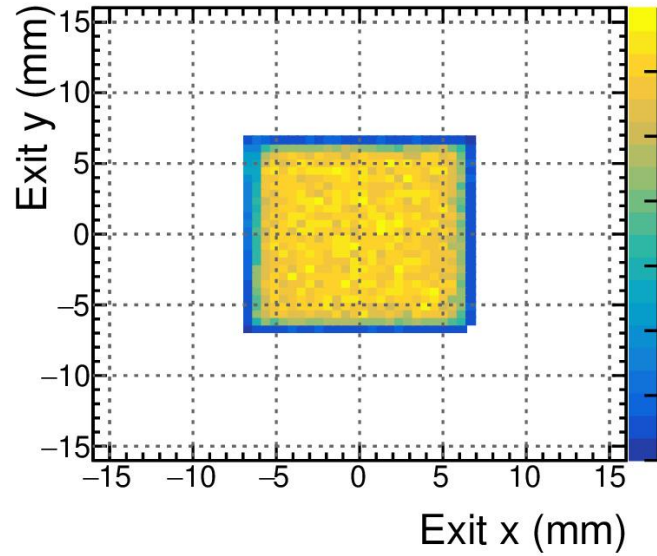


b5 60 mm Exit x vs. Entrance y (Success)

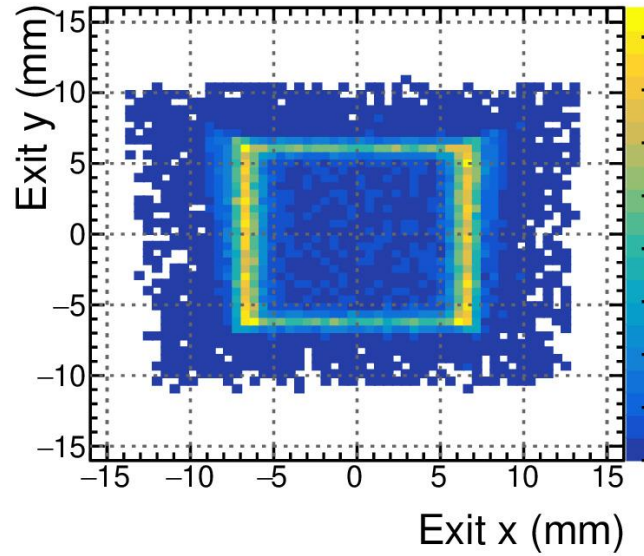


Light Mixing – BIC cookie

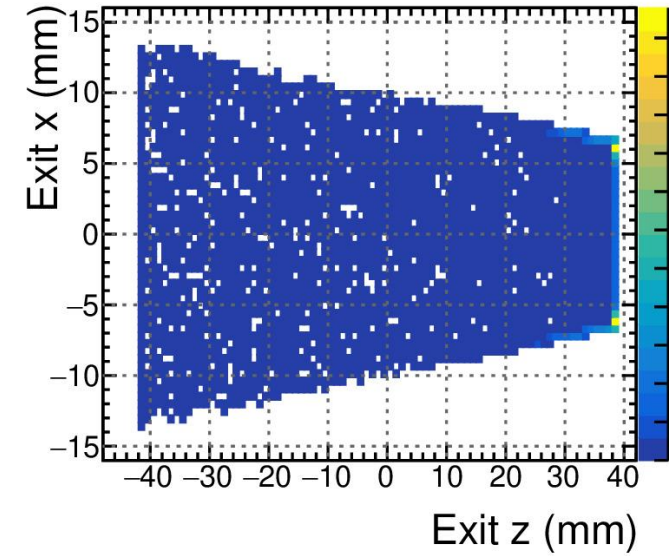
b5 80 mm Exit y vs. x (Success)



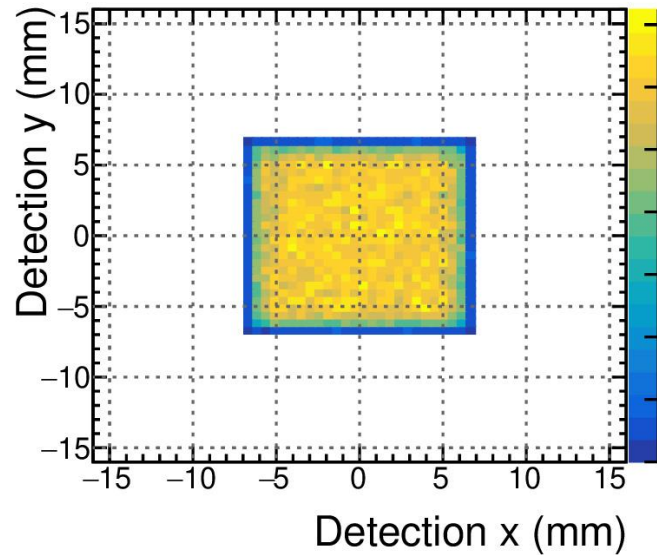
b5 80 mm Exit y vs. x (Failure)



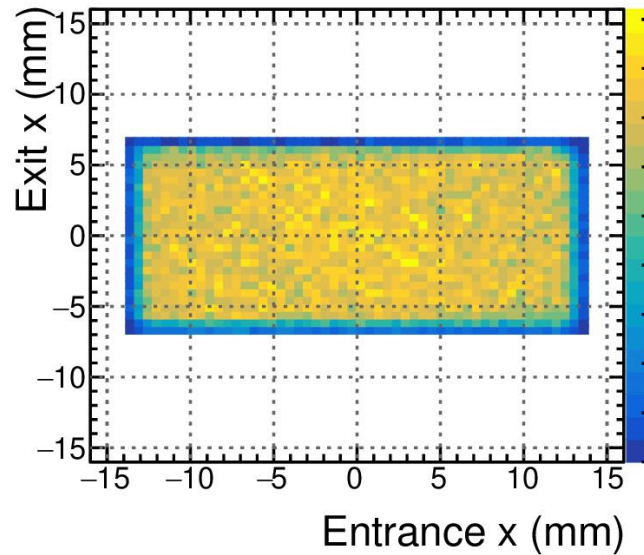
b5 80 mm Exit x vs. z (Failure)



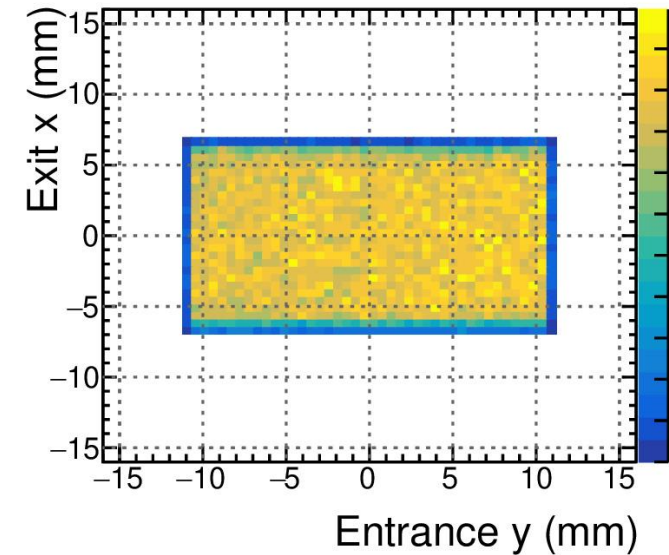
b5 80 mm Detection y vs. x (Success)



b5 80 mm Exit x vs. Entrance x (Success)

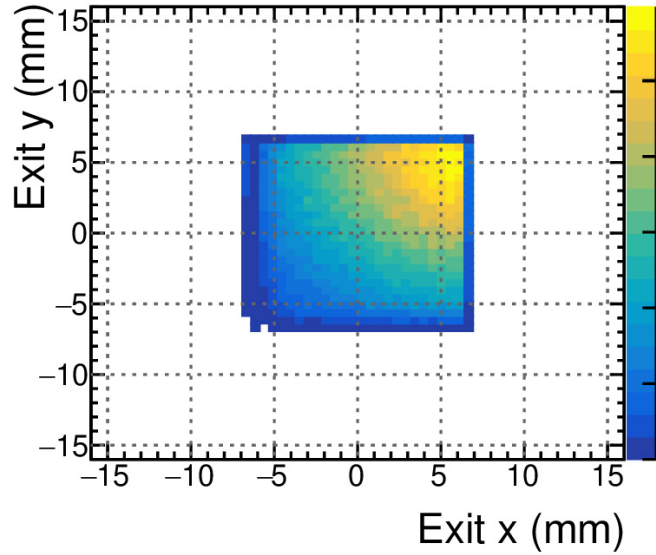


b5 80 mm Exit x vs. Entrance y (Success)

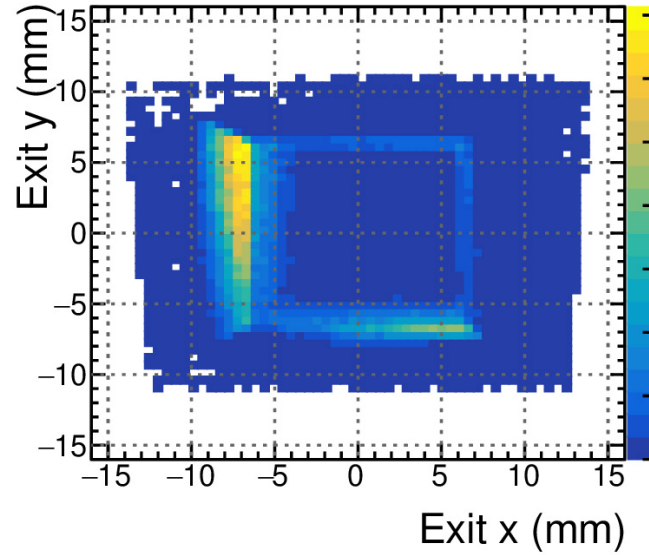


Light Mixing – BIC cookie (single-quadrant source)

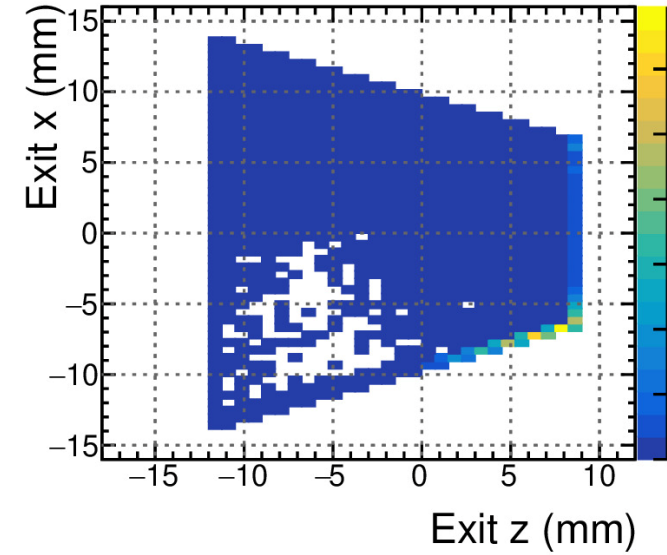
b5 20 mm Exit y vs. x (Success)



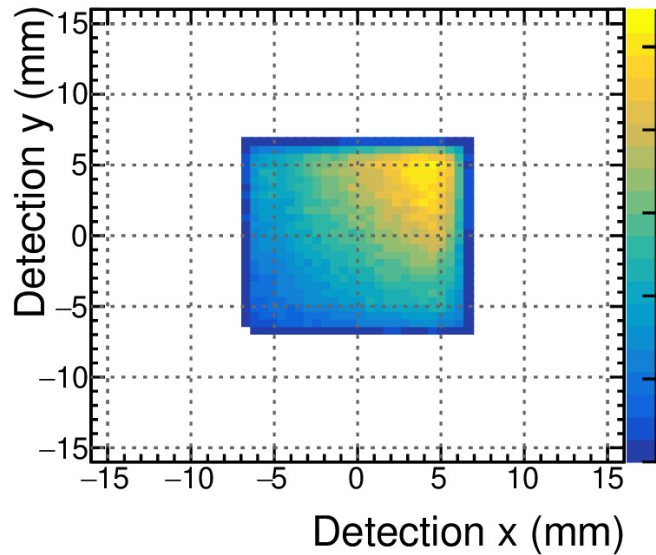
b5 20 mm Exit y vs. x (Failure)



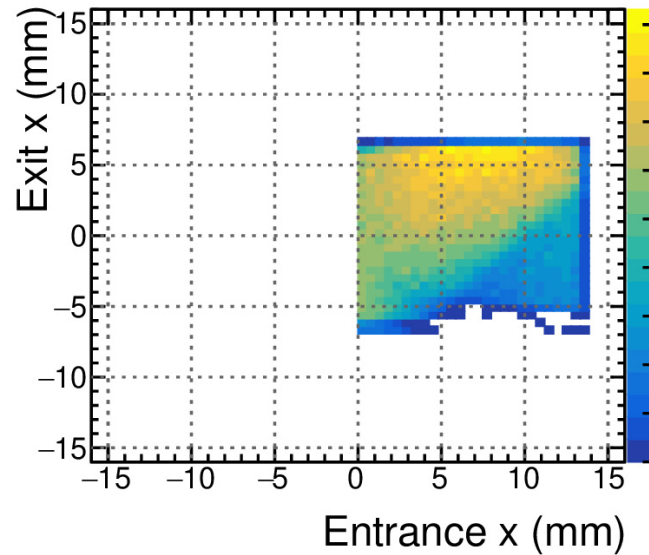
b5 20 mm Exit x vs. z (Failure)



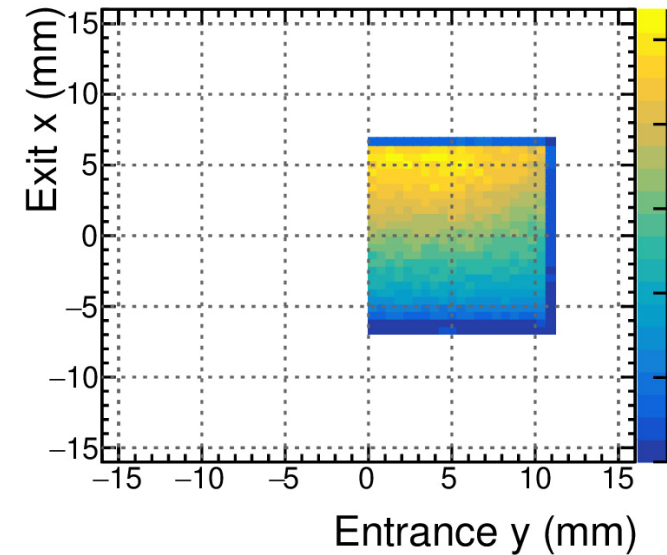
b5 20 mm Detection y vs. x (Success)



b5 20 mm Exit x vs. Entrance x (Success)

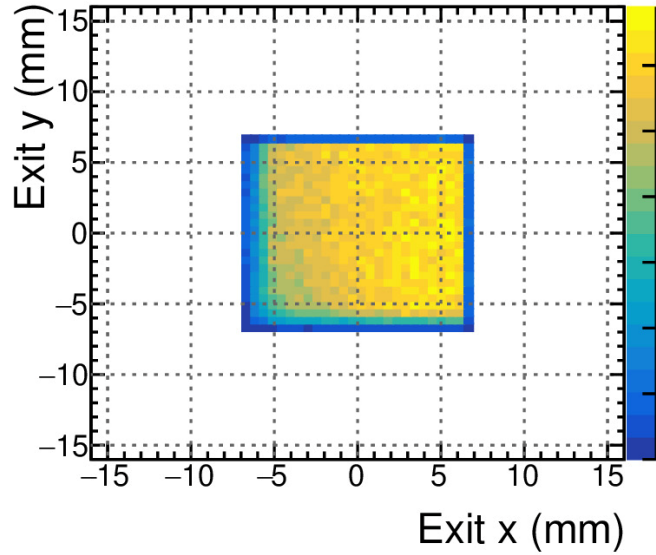


b5 20 mm Exit x vs. Entrance y (Success)

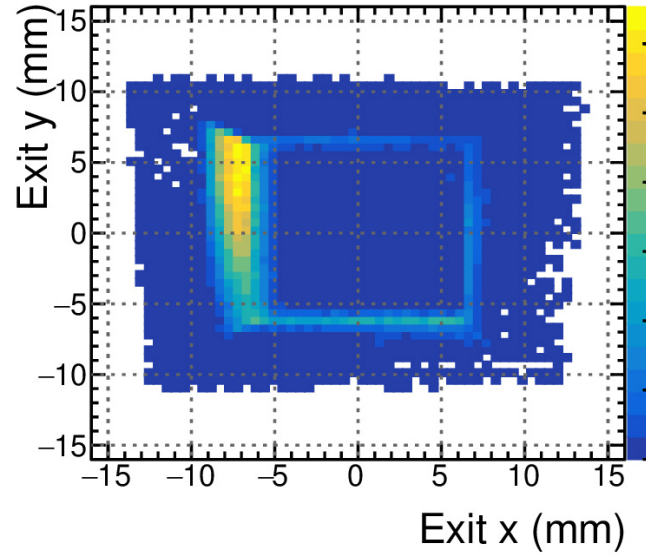


Light Mixing – BIC cookie (single-quadrant source)

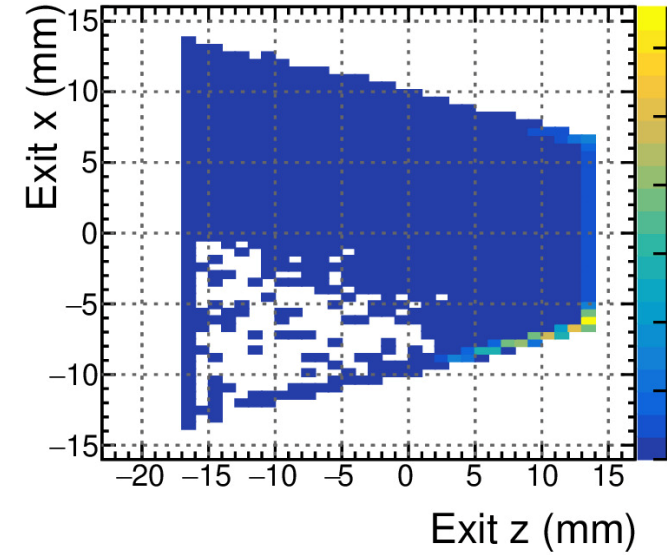
b5 30 mm Exit y vs. x (Success)



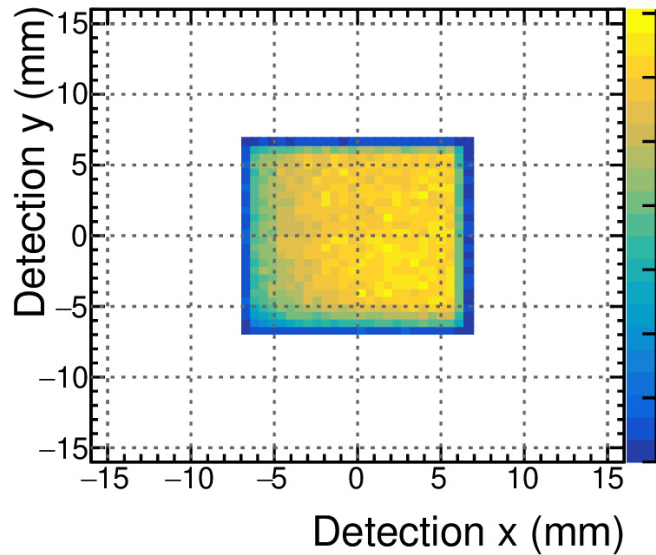
b5 30 mm Exit y vs. x (Failure)



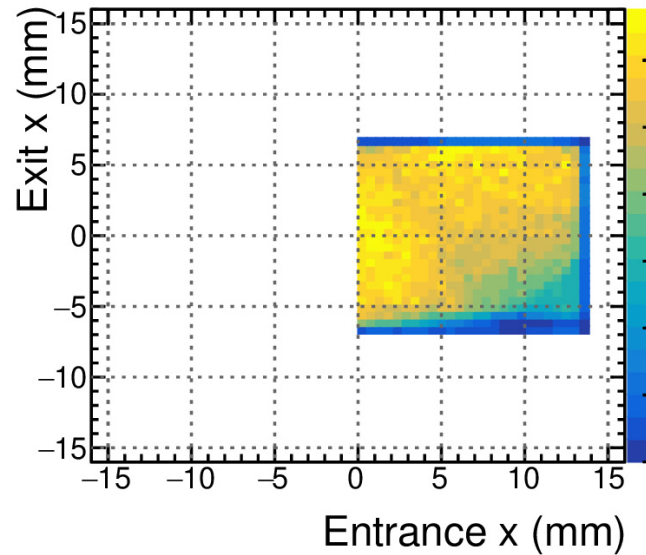
b5 30 mm Exit x vs. z (Failure)



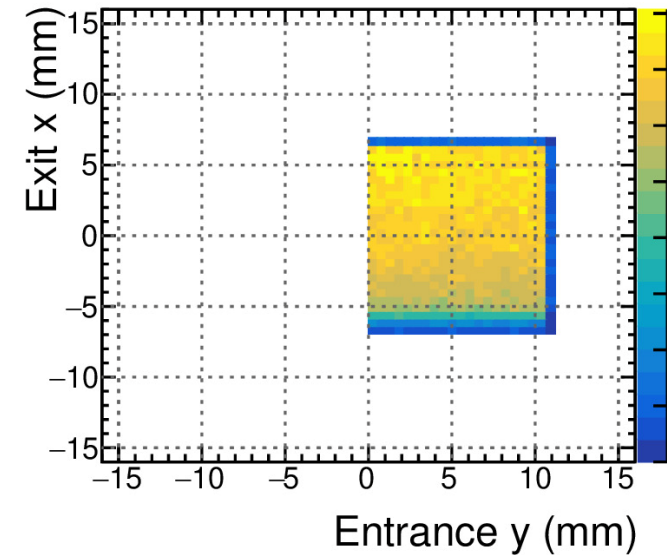
b5 30 mm Detection y vs. x (Success)



b5 30 mm Exit x vs. Entrance x (Success)

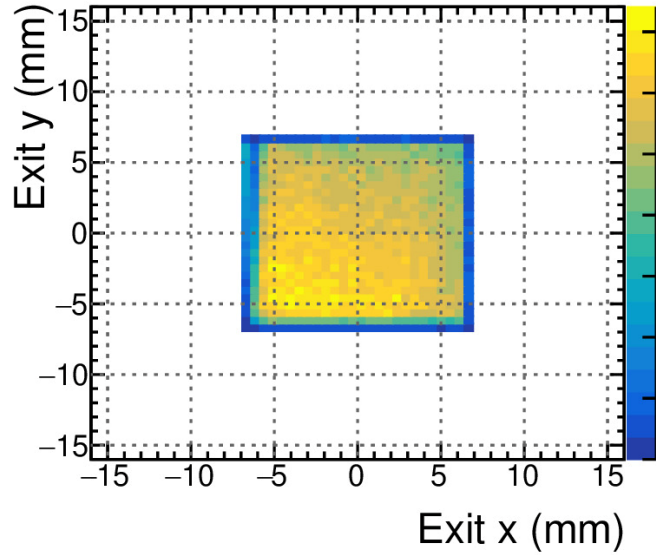


b5 30 mm Exit x vs. Entrance y (Success)

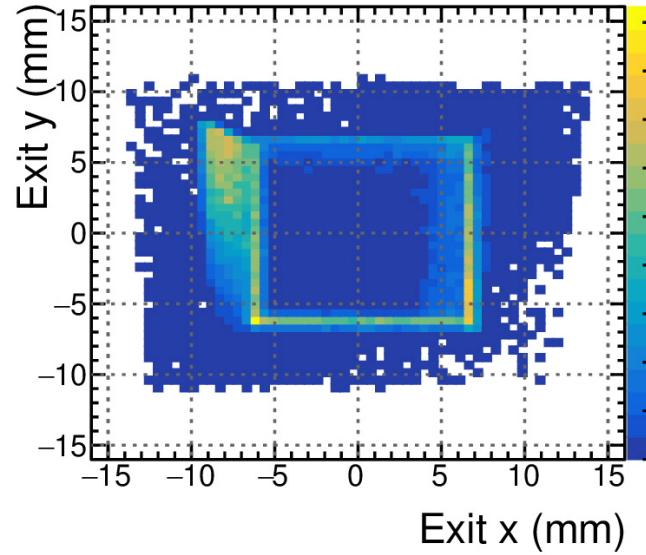


Light Mixing – BIC cookie (single-quadrant source)

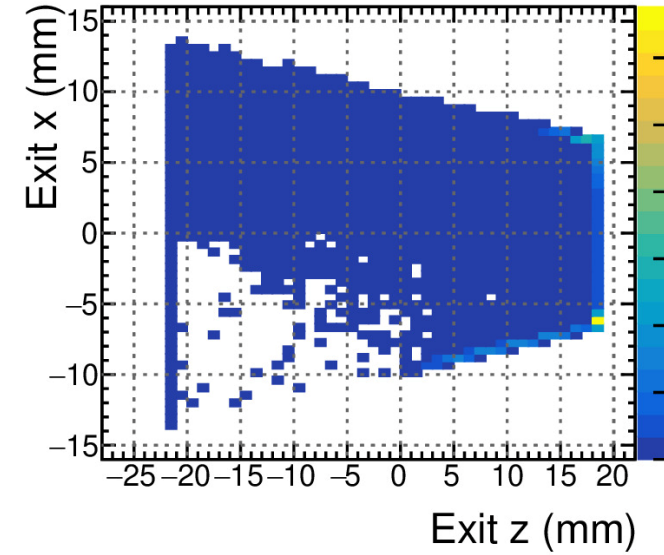
b5 40 mm Exit y vs. x (Success)



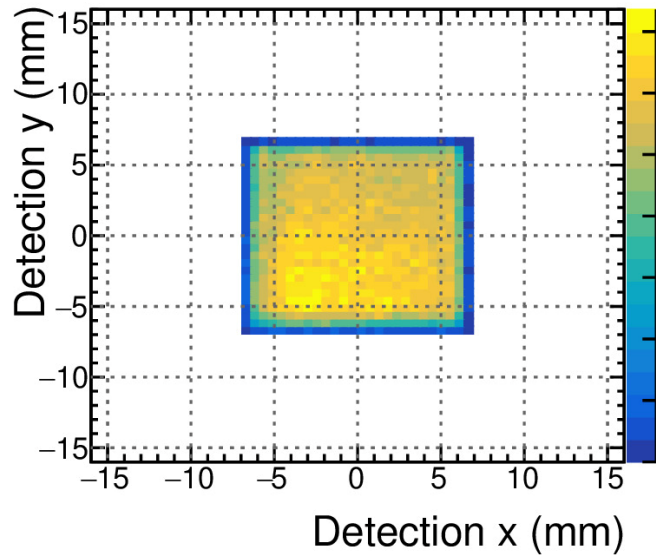
b5 40 mm Exit y vs. x (Failure)



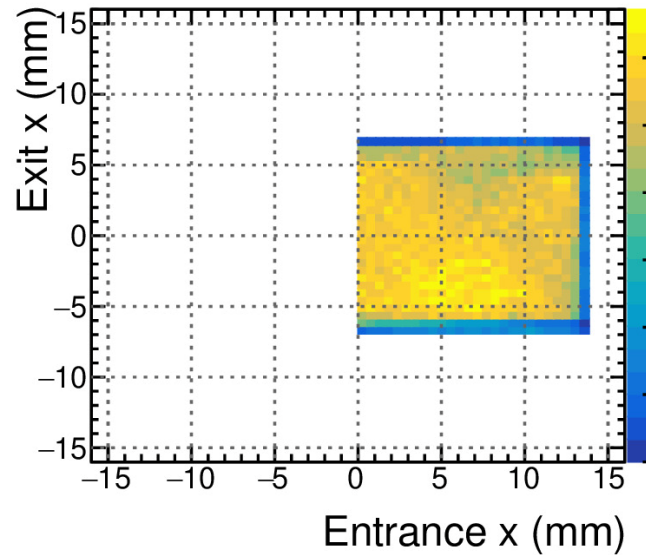
b5 40 mm Exit x vs. z (Failure)



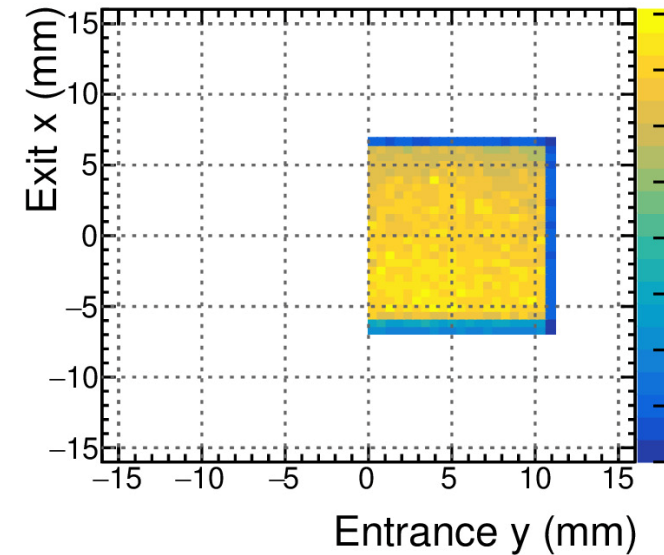
b5 40 mm Detection y vs. x (Success)



b5 40 mm Exit x vs. Entrance x (Success)

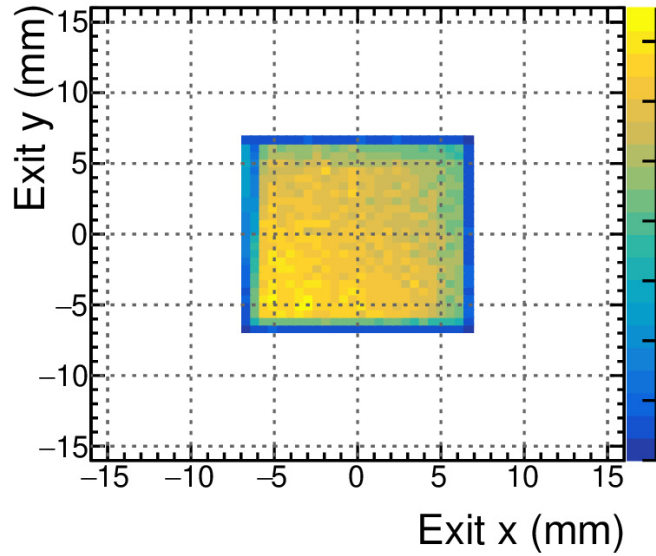


b5 40 mm Exit x vs. Entrance y (Success)

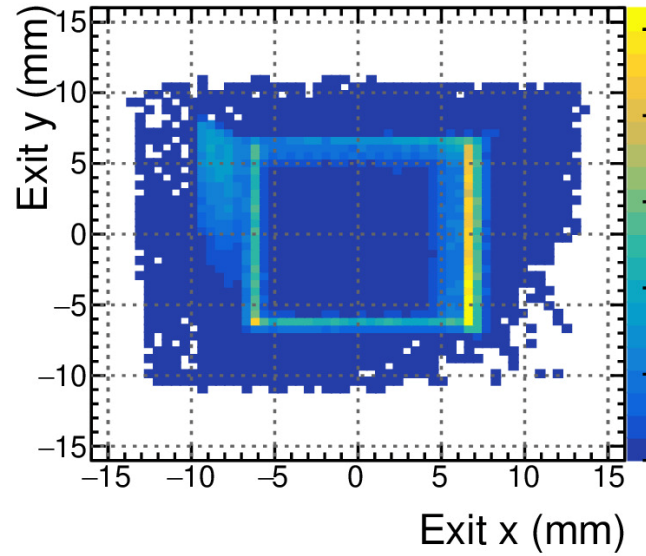


Light Mixing – BIC cookie (single-quadrant source)

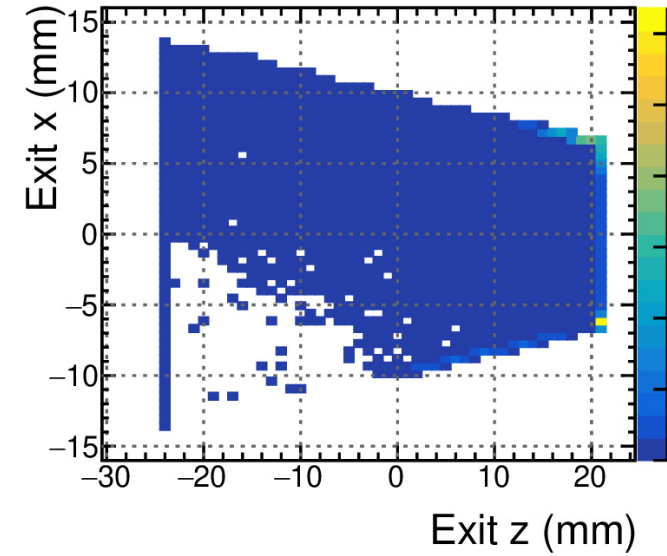
b5 45 mm Exit y vs. x (Success)



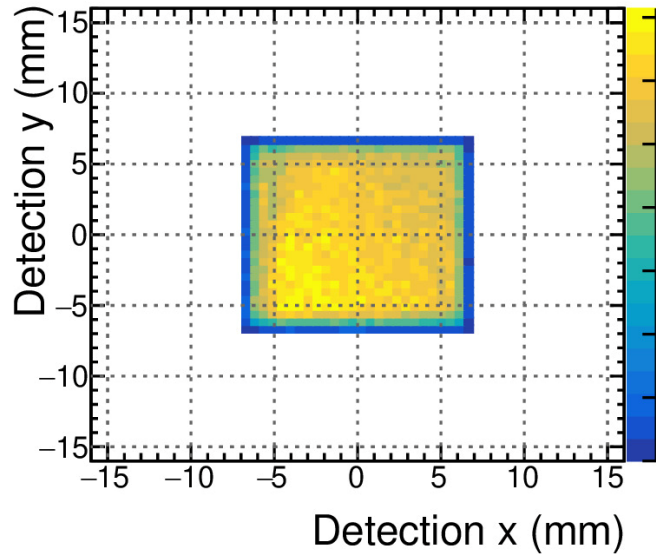
b5 45 mm Exit y vs. x (Failure)



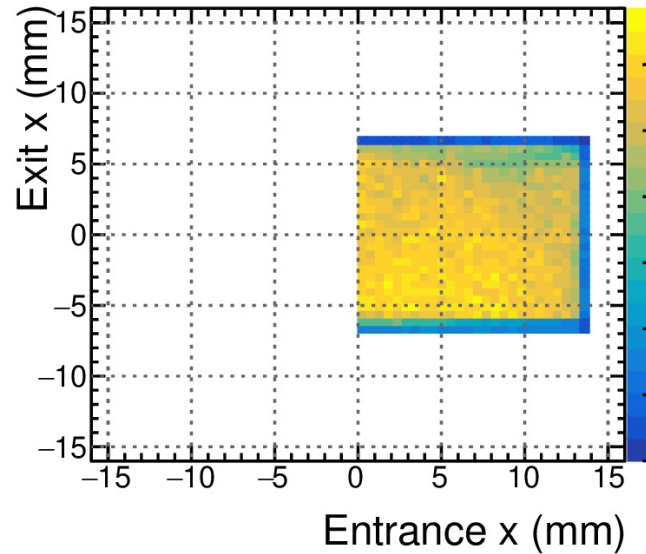
b5 45 mm Exit x vs. z (Failure)



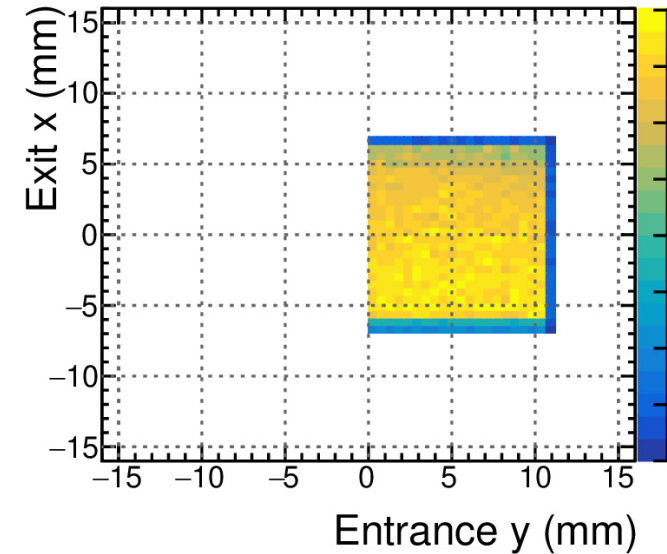
b5 45 mm Detection y vs. x (Success)



b5 45 mm Exit x vs. Entrance x (Success)

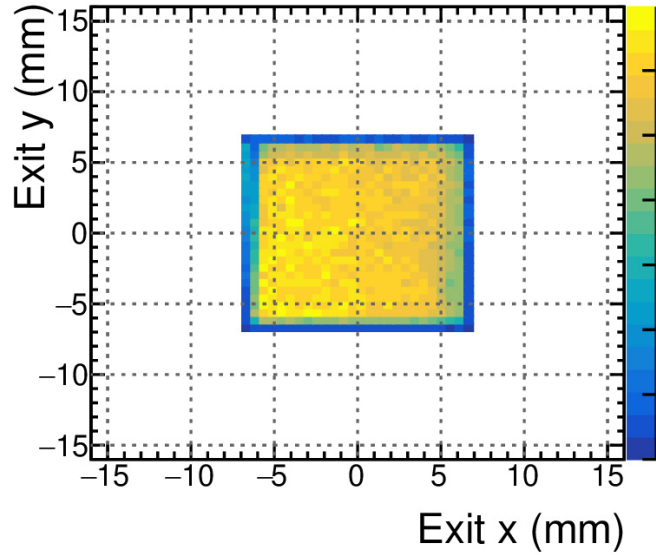


b5 45 mm Exit x vs. Entrance y (Success)

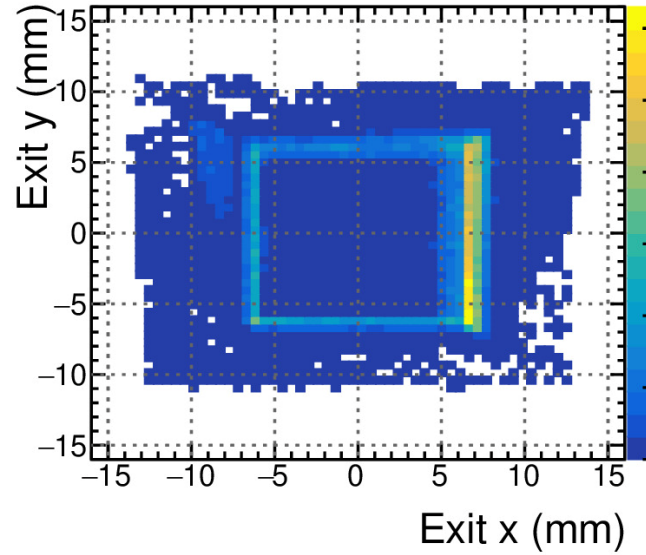


Light Mixing – BIC cookie (single-quadrant source)

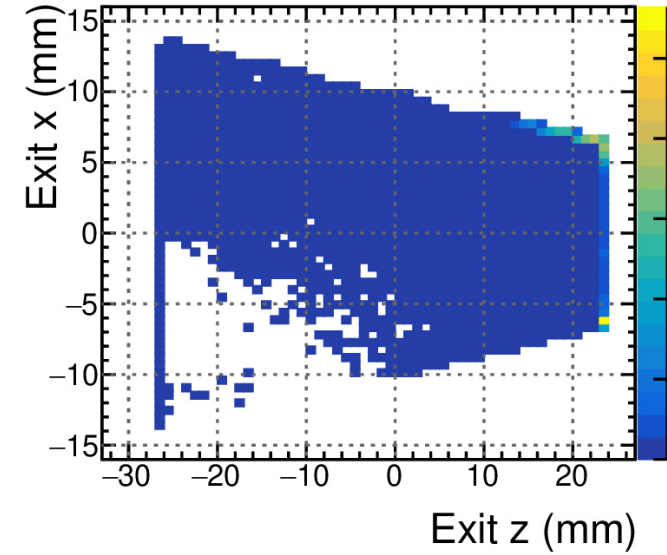
b5 50 mm Exit y vs. x (Success)



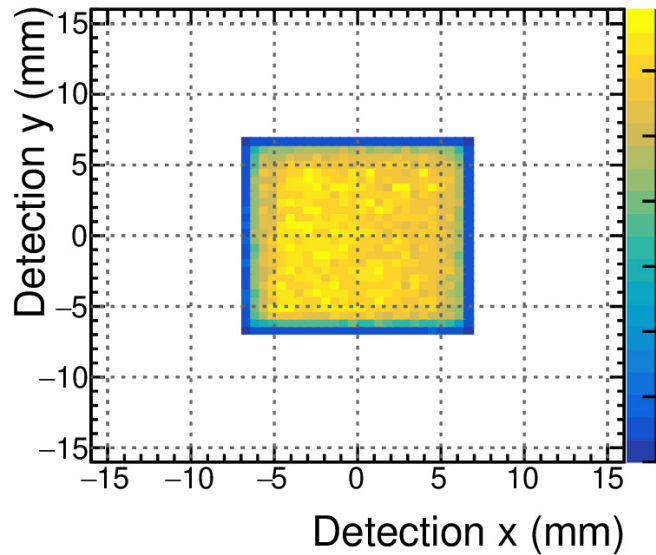
b5 50 mm Exit y vs. x (Failure)



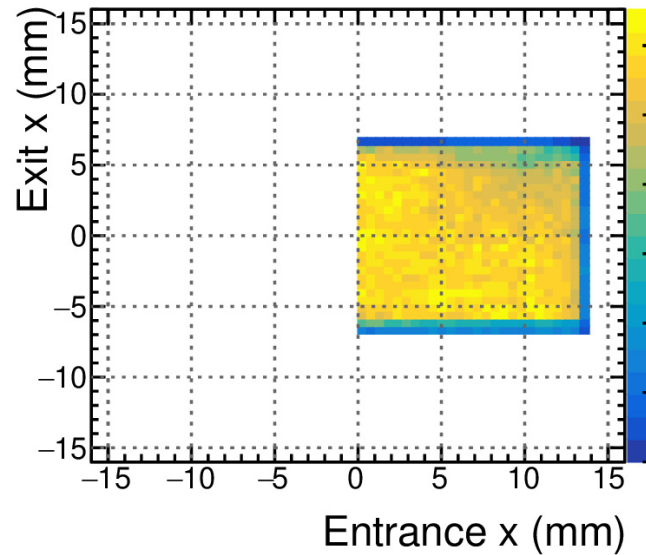
b5 50 mm Exit x vs. z (Failure)



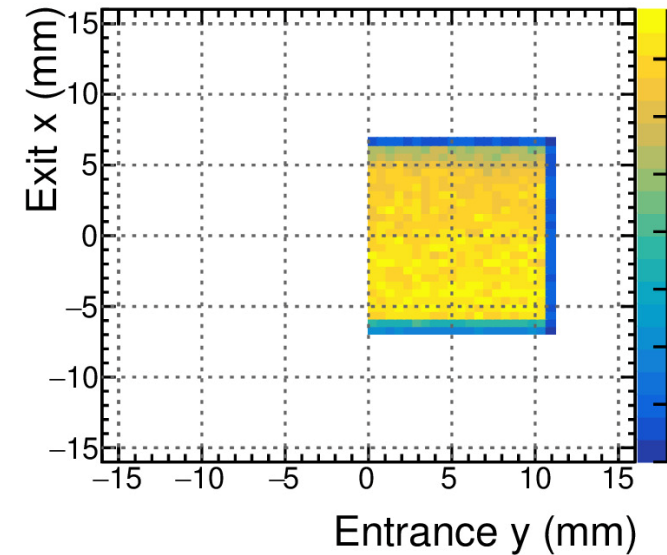
b5 50 mm Detection y vs. x (Success)



b5 50 mm Exit x vs. Entrance x (Success)

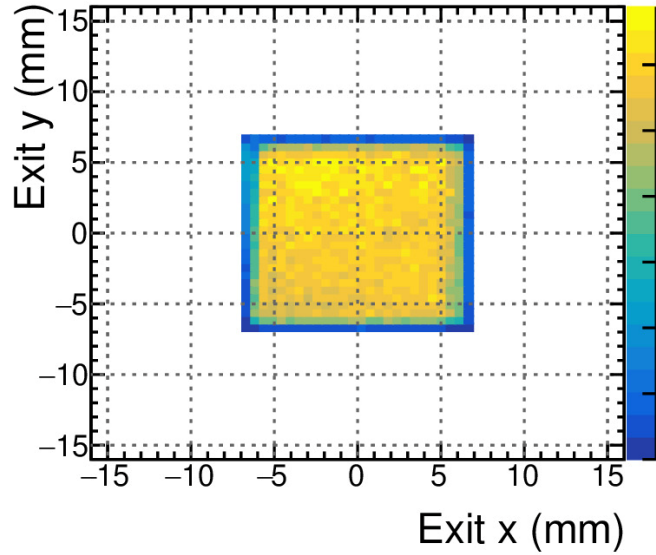


b5 50 mm Exit x vs. Entrance y (Success)

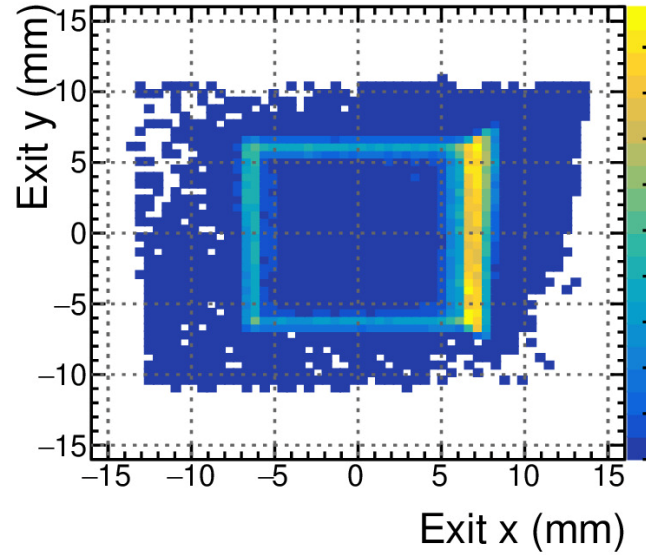


Light Mixing – BIC cookie (single-quadrant source)

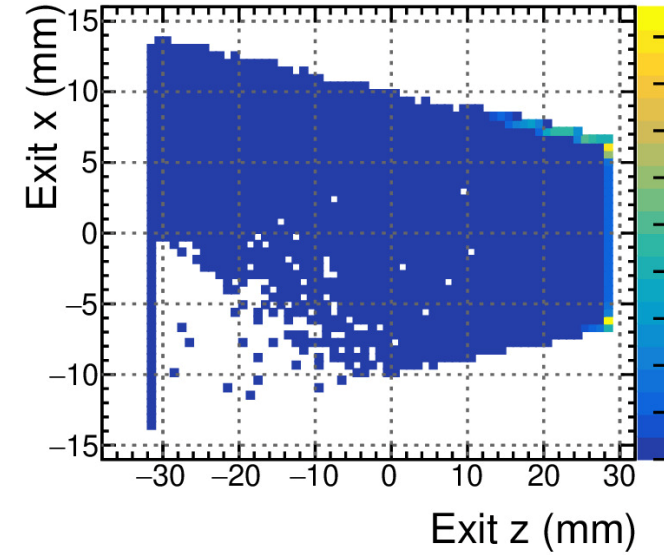
b5 60 mm Exit y vs. x (Success)



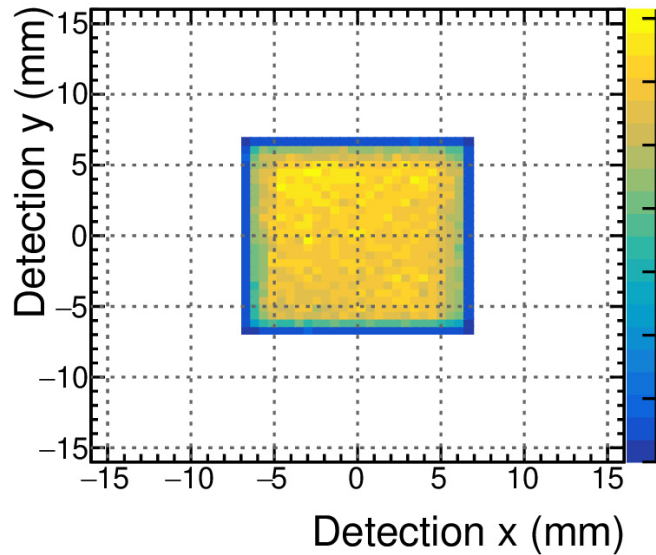
b5 60 mm Exit y vs. x (Failure)



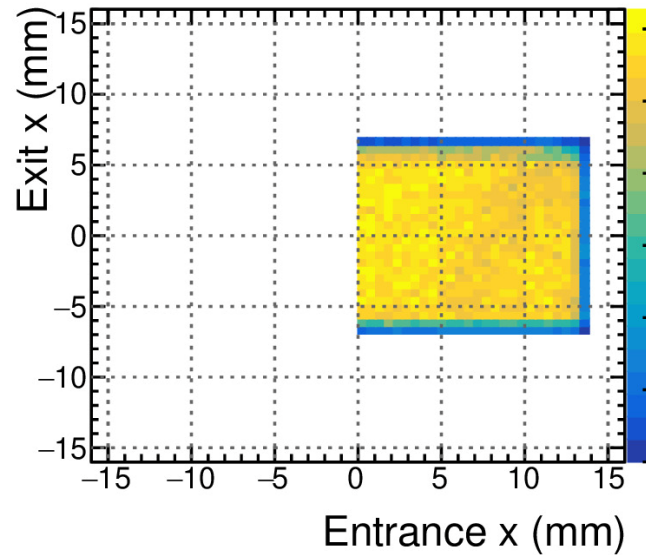
b5 60 mm Exit x vs. z (Failure)



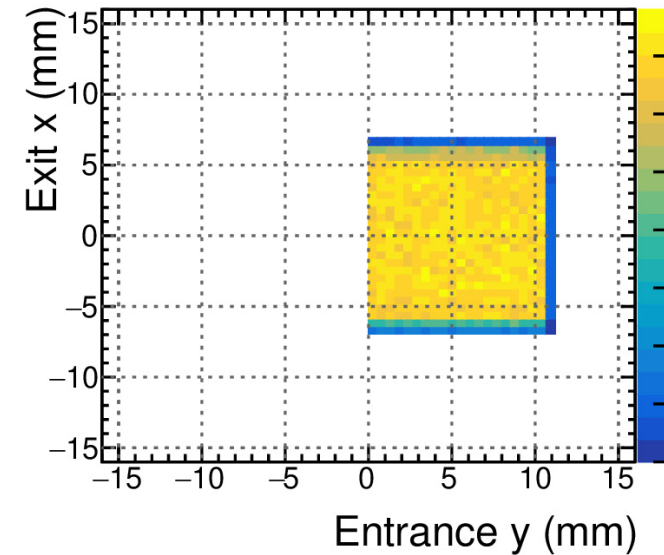
b5 60 mm Detection y vs. x (Success)



b5 60 mm Exit x vs. Entrance x (Success)

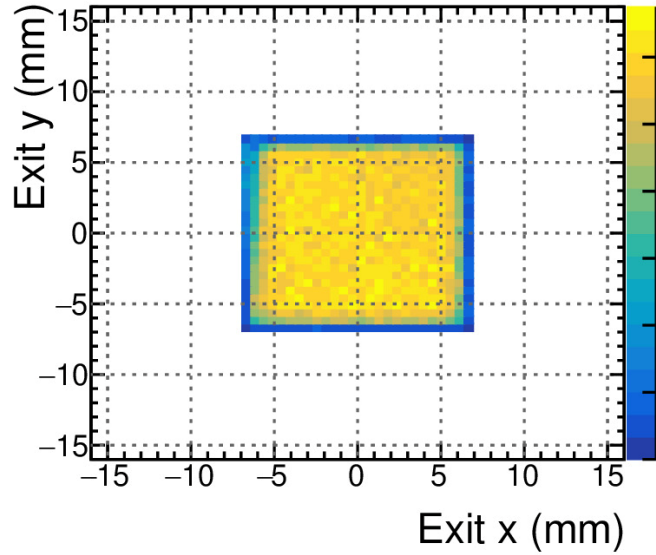


b5 60 mm Exit x vs. Entrance y (Success)

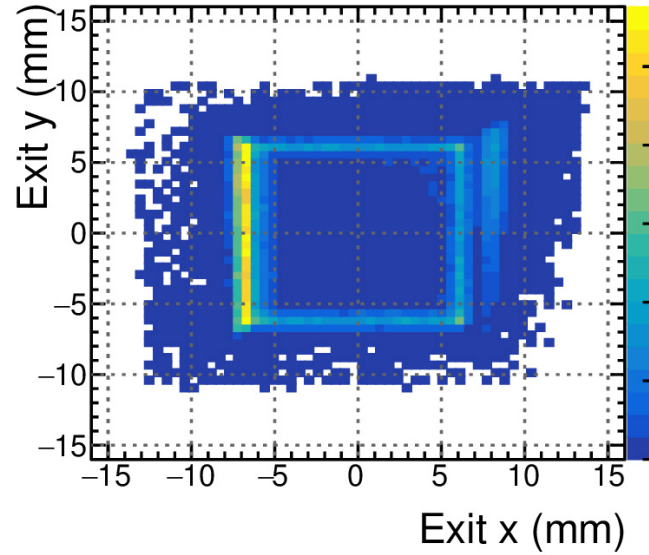


Light Mixing – BIC cookie (single-quadrant source)

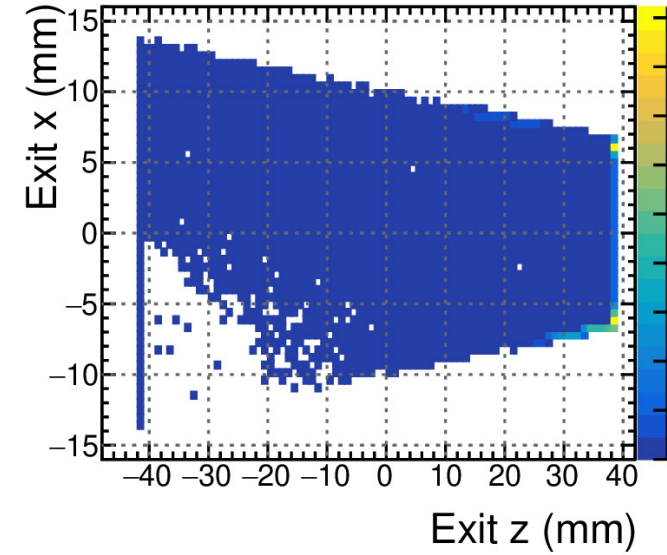
b5 80 mm Exit y vs. x (Success)



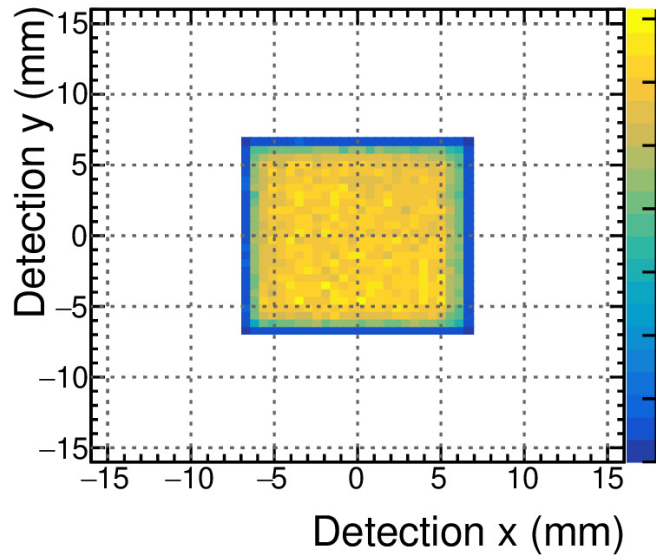
b5 80 mm Exit y vs. x (Failure)



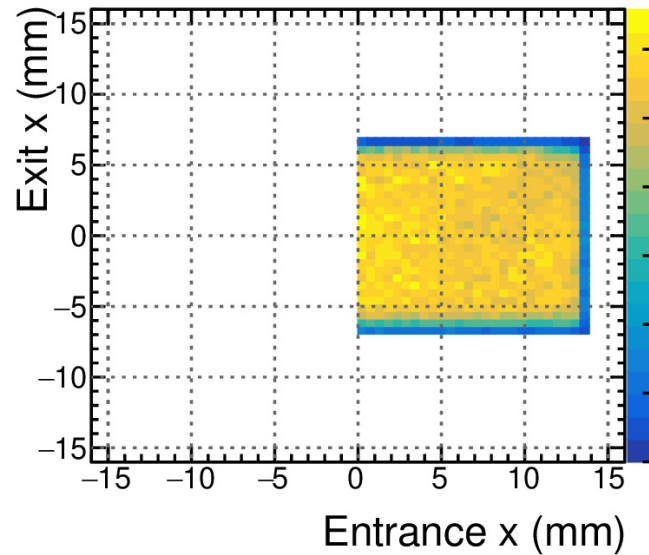
b5 80 mm Exit x vs. z (Failure)



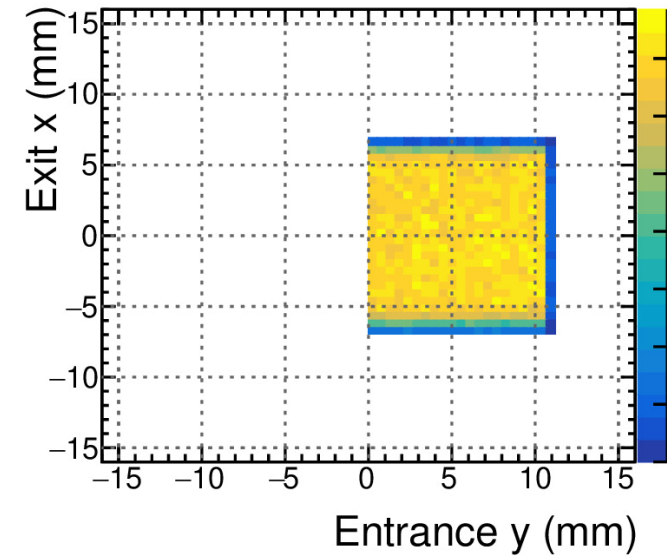
b5 80 mm Detection y vs. x (Success)



b5 80 mm Exit x vs. Entrance x (Success)

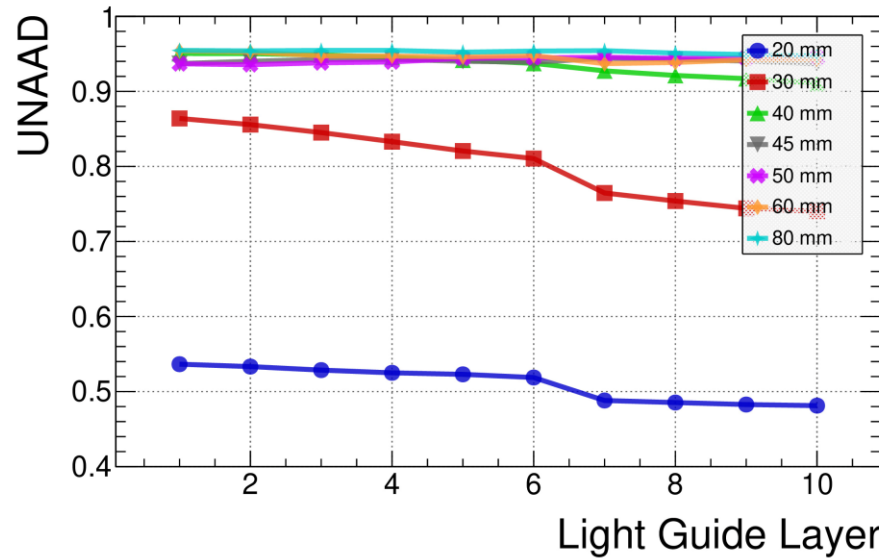


b5 80 mm Exit x vs. Entrance y (Success)

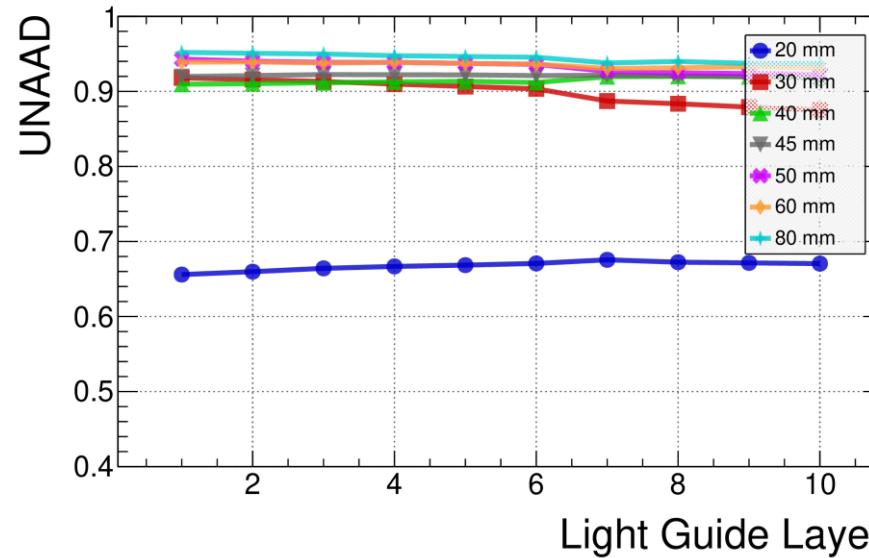


Light Mixing – UNAAD (single-quadrant source)

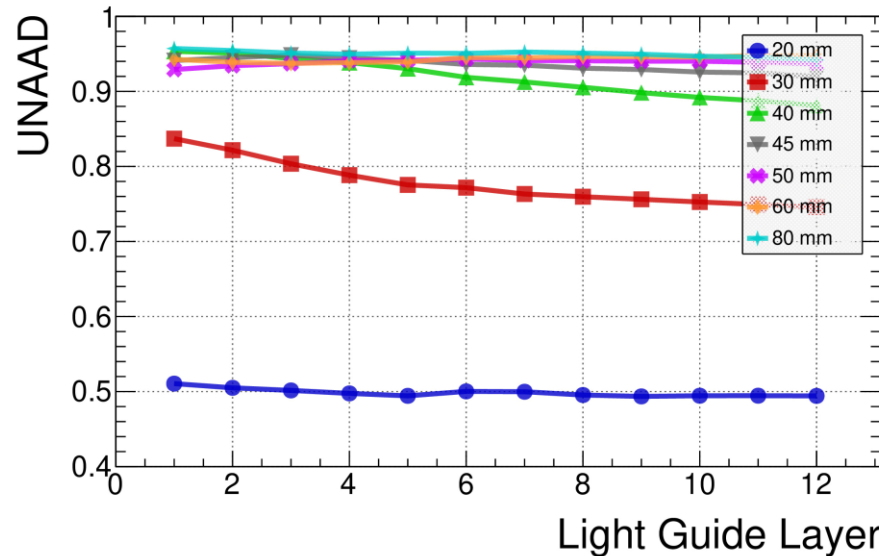
GlueX air S12-GlueX UNAAD vs. Layer



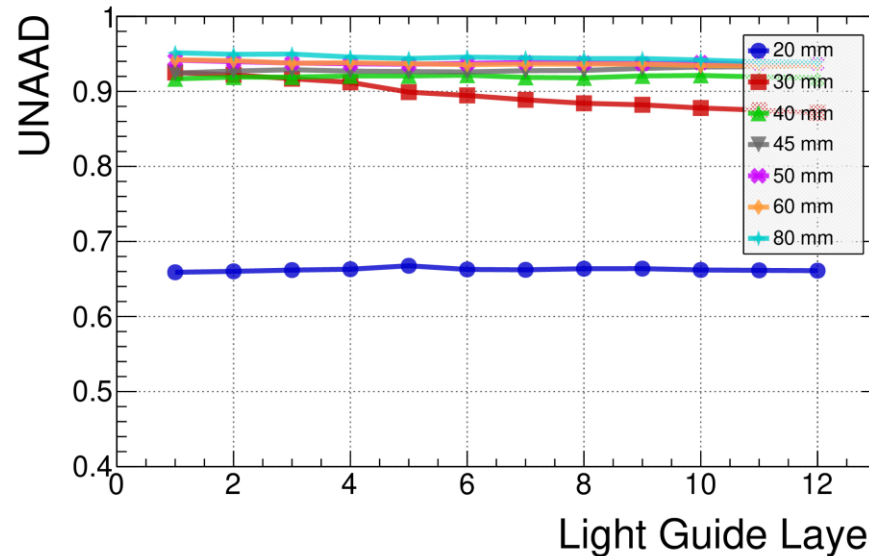
GlueX cookie S12-GlueX UNAAD vs. Layer



BIC air S13-BIC UNAAD vs. Layer

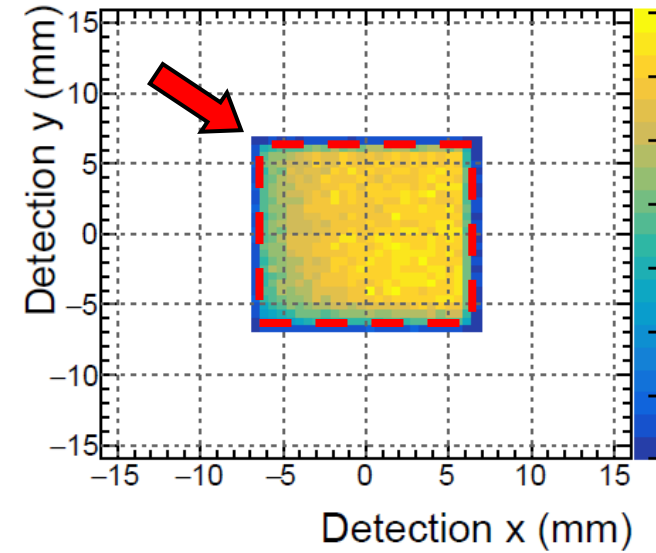


BIC cookie S13-BIC UNAAD vs. Layer



- Normalized Absolute Average Deviation
- Metric for flatness of inner SiPM pixels

b5 30 mm Detection y vs. x (Success)



$$1 - \frac{1}{N \cdot \bar{Y}} \sum_{i=1}^N |Y_i - \bar{Y}|$$

Conclusions

- ~30% more efficient with silicone cookie than with air gap
- Efficiency begins to drop off at 40 mm length for outer layers
- Spatial correlations between input and detected photons are strong below 40 mm length
- 45 – 50 mm appears reasonable for efficiency and light mixing so far
- Ongoing simulations looking at using 6x6 SiPMs and smaller light guides rather than the 13x13 arrays

