



INDIANA UNIVERSITY

# Comp Graph Module for protoDUNE-HD PDS



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ProtoDUNE PDS Sim/Reco meeting

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# Updates (I)

- ❖ Last presentation: <https://indico.fnal.gov/event/64956/>
- ❖ Size of training set: ~1,900,000  ~3,600,000
- ❖ Evaluation set: ~90,000  ~170,000

```
1 make directory output_2048b_10000e0-mod/  
2 Processing 21233 files...  
3 Dataset loaded, dataset length: 1892711  
4 Train the network with epoch: 10000 batch: 2048.  
5 Loading ProtoDUNEHD t0 net...  
6 Model: "protodunehd_model"
```



```
1 Processing 40042 files...  
2 Dataset loaded, dataset length: 3578007  
3 Train the network with epoch: 10000 batch: 8192.  
4 Loading ProtoDUNEHD t0 net...  
5 Model: "protodunehd_model"
```

```
1 Processing 1000 files...  
2 Dataset loaded, dataset length: 89305  
3 Evaluating network performance...  
4 Loading ProtoDUNEHD t0 net...  
5 Model: "protodunehd_model"
```

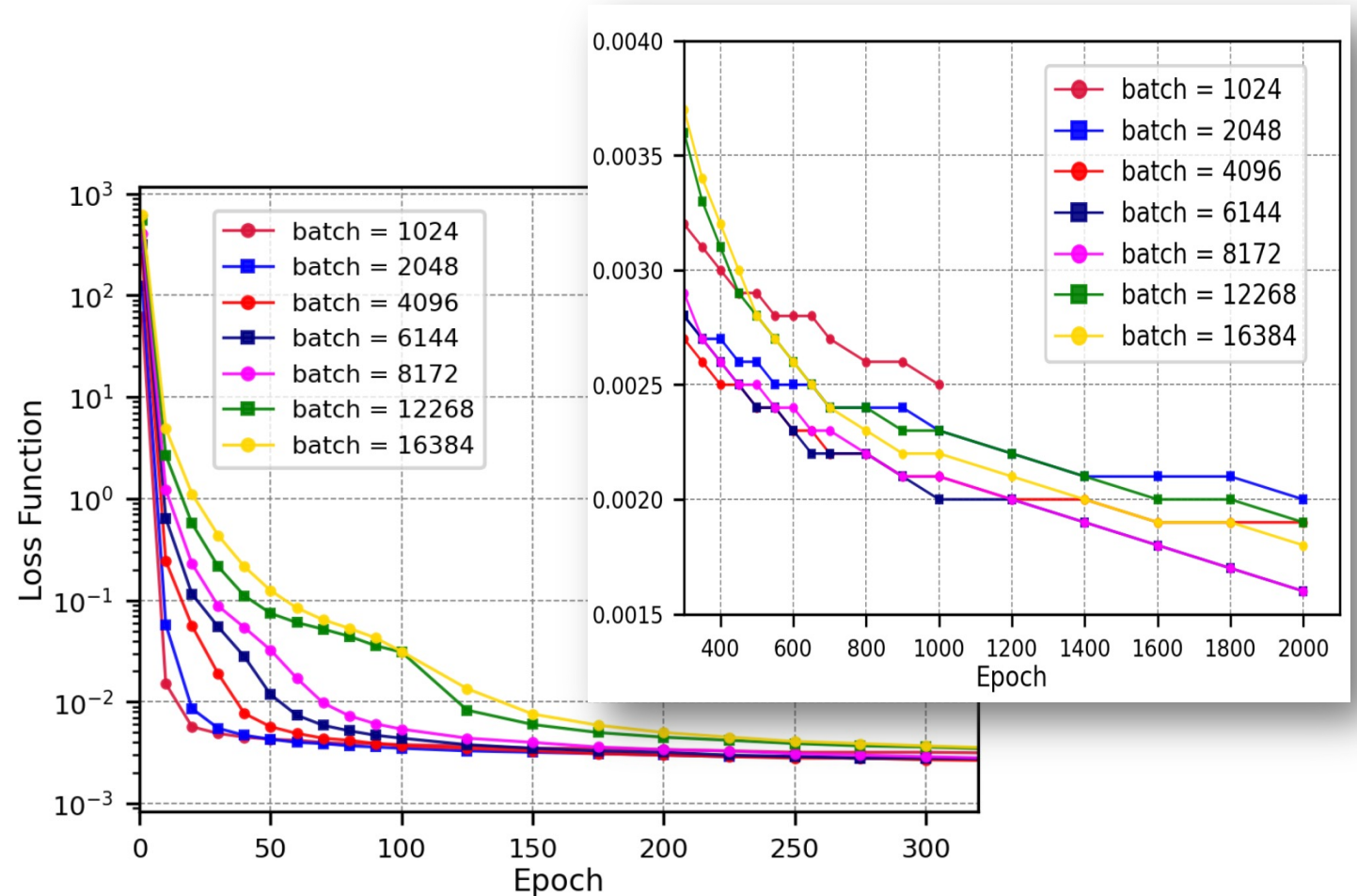
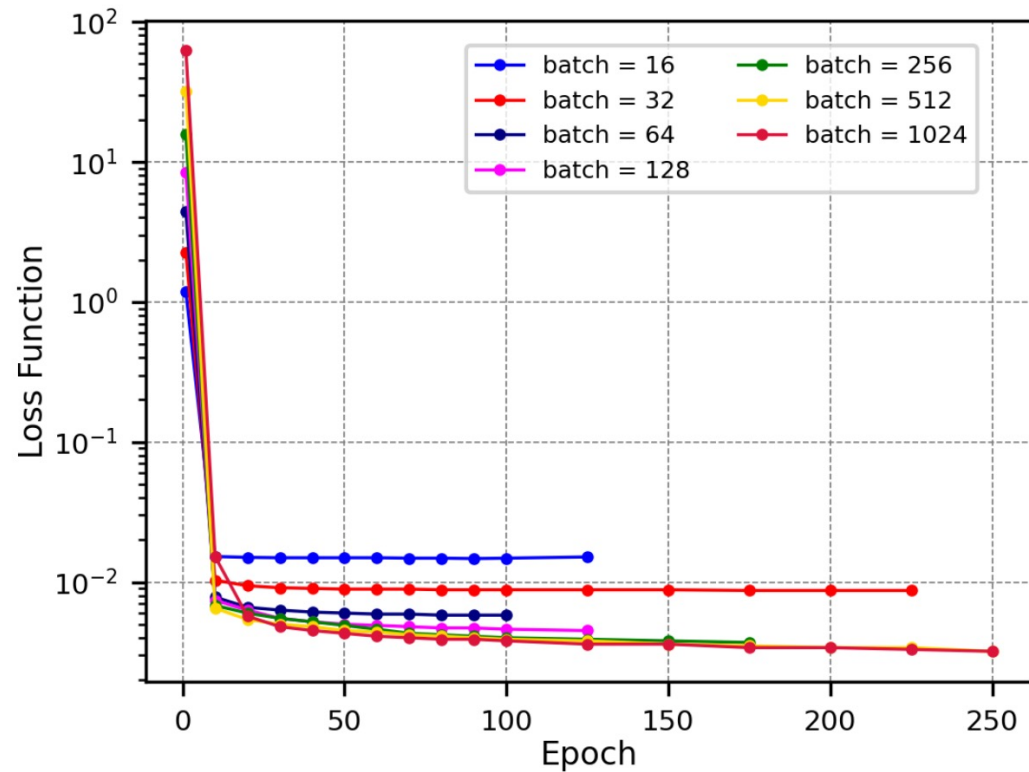


```
1 Processing 1947 files...  
2 Dataset loaded, dataset length: 174103  
3 Evaluating network performance...  
4 Loading ProtoDUNEHD t0 net...  
5 Model: "protodunehd_model"
```

# Updates (II)

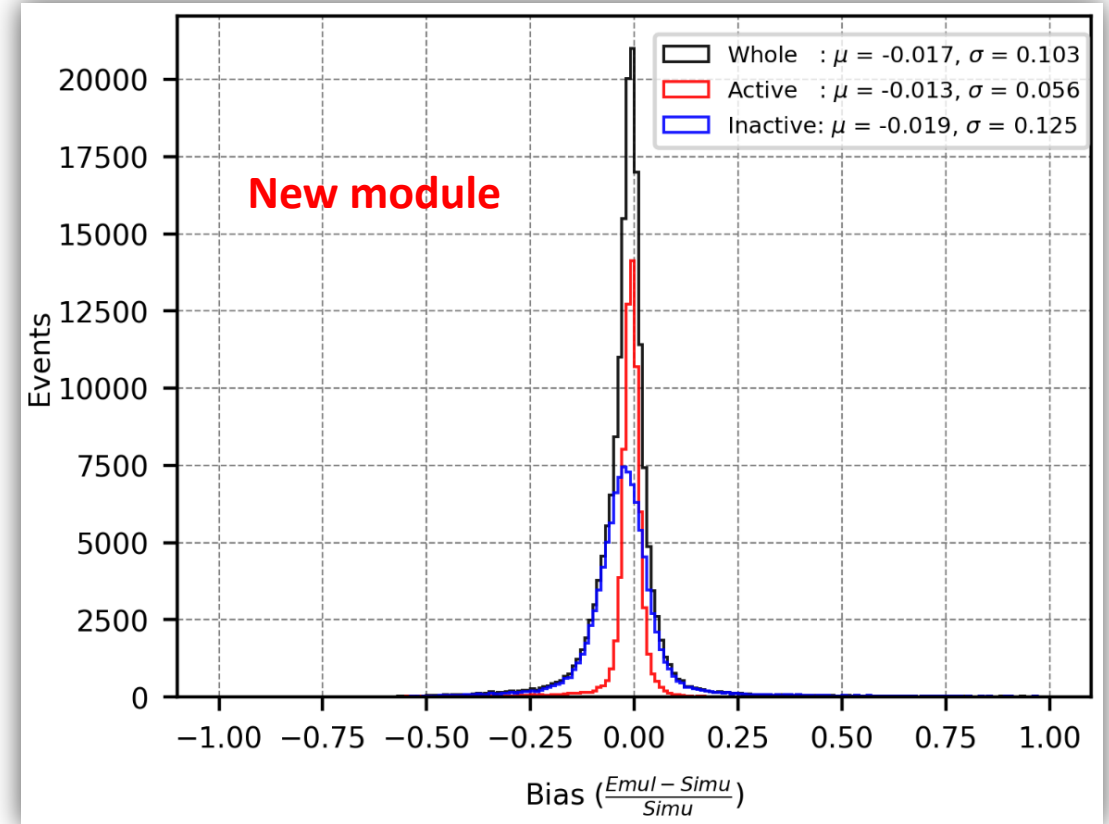
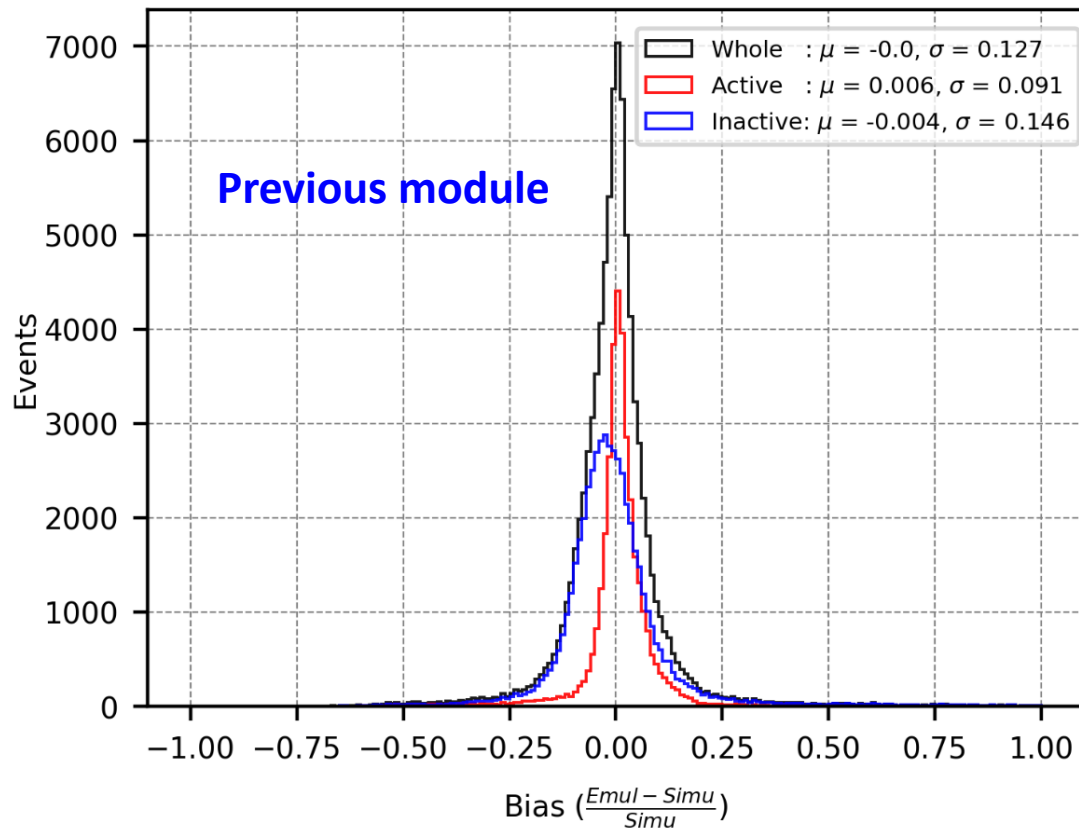
❖ Tests with different batch sizes are made: 16, 32, 64, 128, 256, 512, 1024, 2048(*last train*), 6144, 8172, 12268, 16384

❖ Choice of new training (this presentation): 8,172



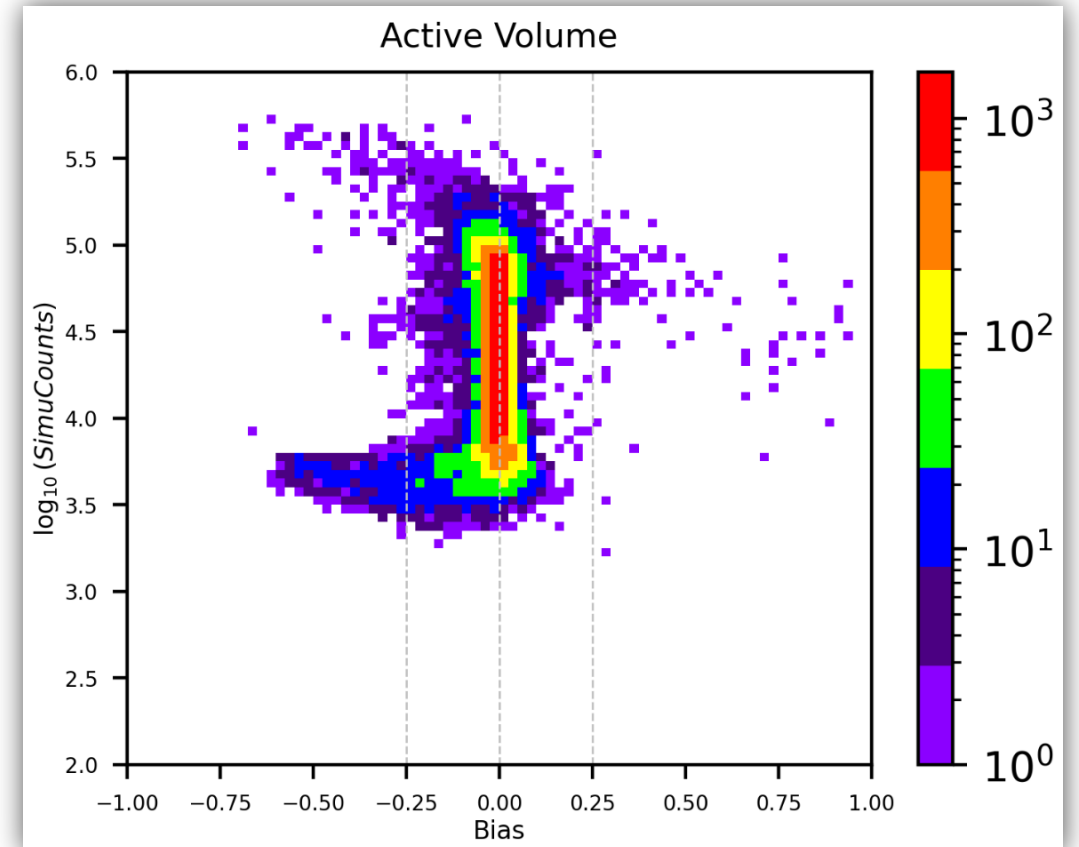
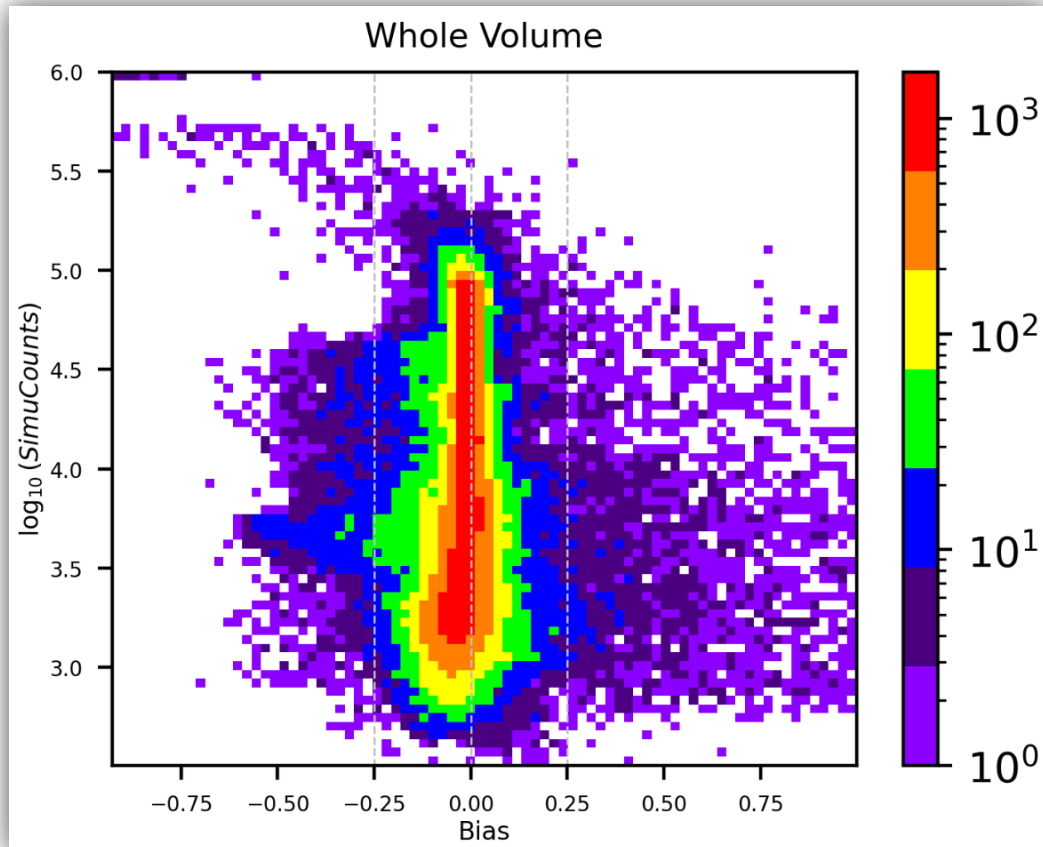
# Comparison:

- ❖ Performances for whole, active and inactive volumes ALL apparently improved



# Performance of New Module:

- ❖ Whole volume: moderate events with high bias values (mainly contributed by inactive volume)
- ❖ Active volume: well constrained around  $bias = 0$  in general



# Active Volume (I):

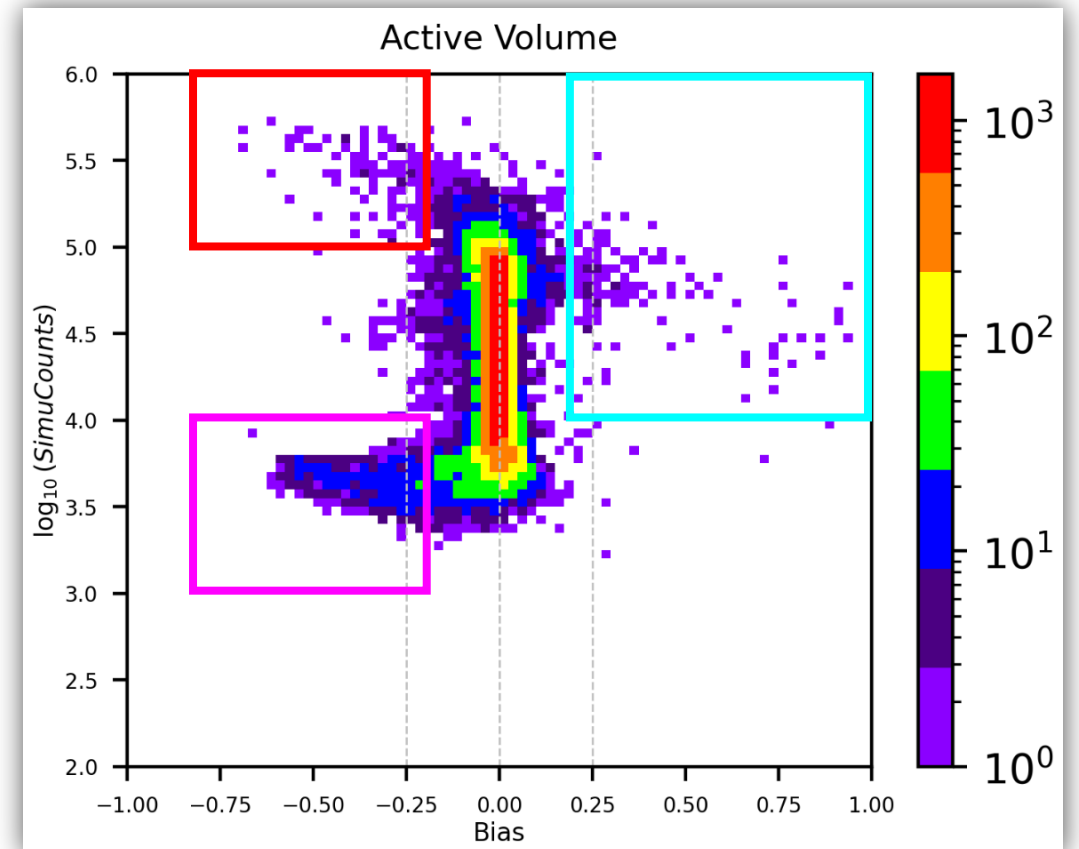
❖ Statistics for active volume:

Total Events	$ bias  \leq 1$	$ bias  \leq 0.1$
68,414	68,412(99.98%)	65,790(96.15%)

❖ **Red:**  $bias \in [-0.8, -0.2]$  &  $simu \in [10^5, 10^6]$   
111 (0.16%)

❖ **Magenta:**  $bias \in [-0.8, -0.2]$  &  $simu \in [10^3, 10^4]$   
907 (1.33%)

❖ **Cyan:**  $bias \in [0.2, 1.0]$  &  $simu \in [10^4, 10^6]$   
130 (0.19%)

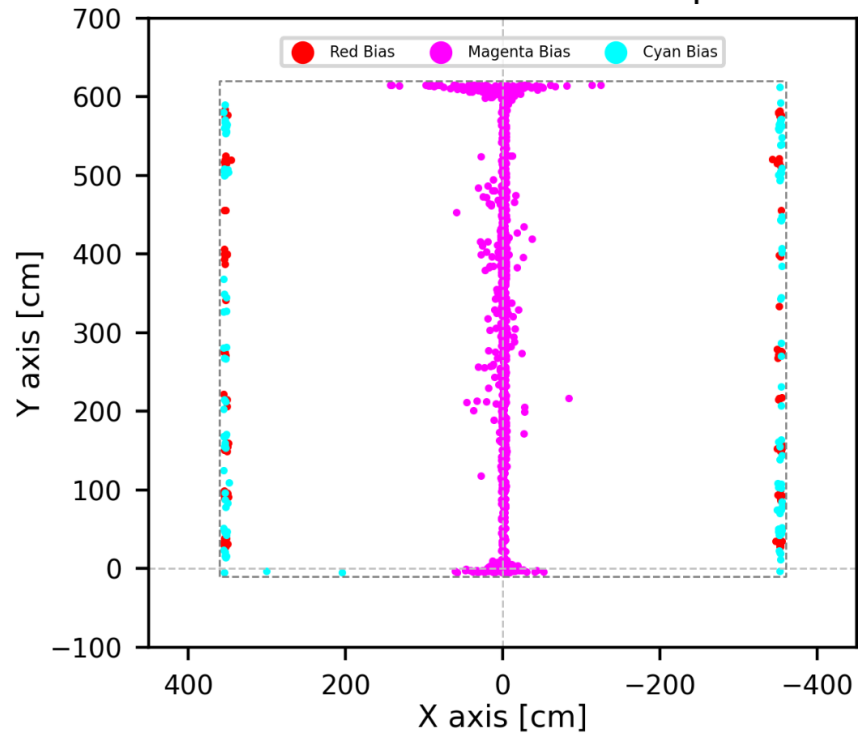




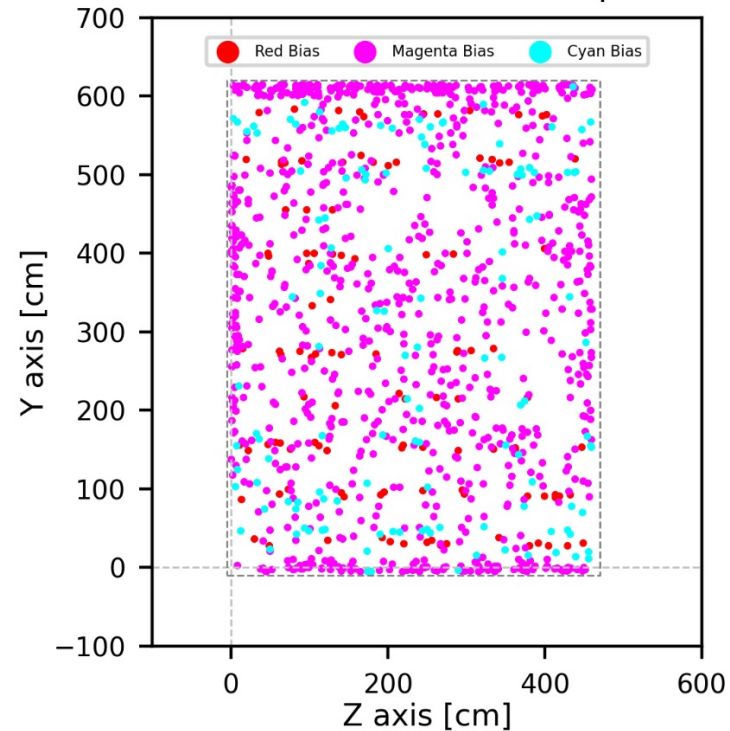
# Active Volume (II):

- ❖ Red & Cyan: close to X-Arapuca
- ❖ Magenta: close to CPA, top & bottom field cage

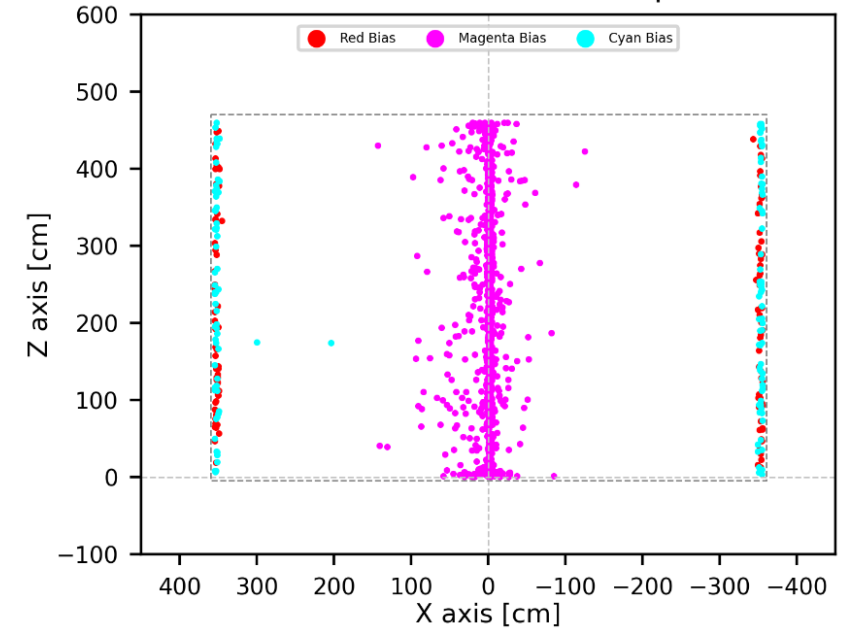
Events distribution in Y-X plane



Events distribution in Y-Z plane



Events distribution in Z-X plane



# Active Volume (III):

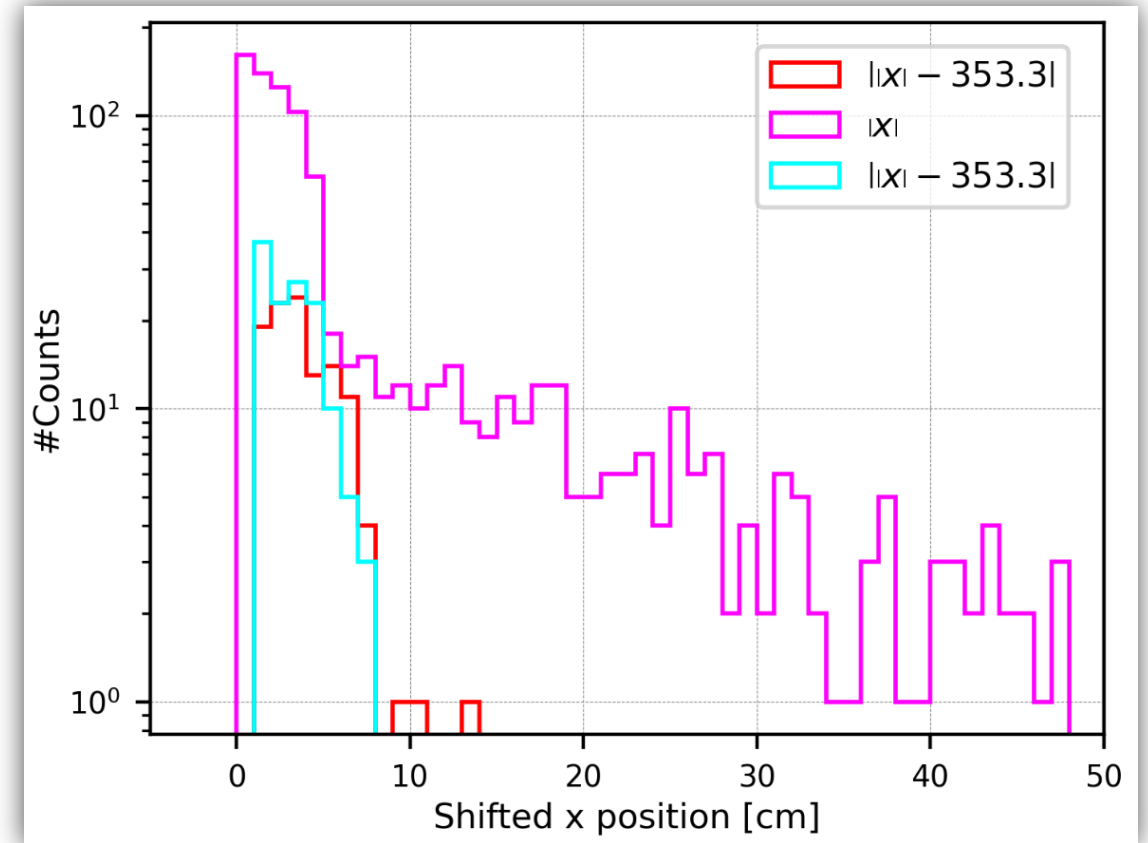
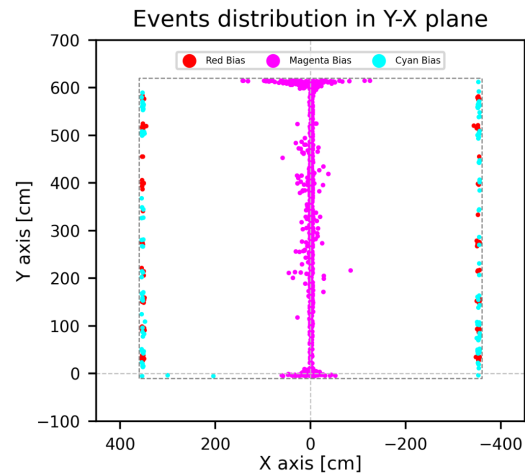
- ❖ Red and Cyan:

  - Almost all events within 10cm to X-Arapuca

- ❖ Magenta:

  - The majority within 10cm to CPA

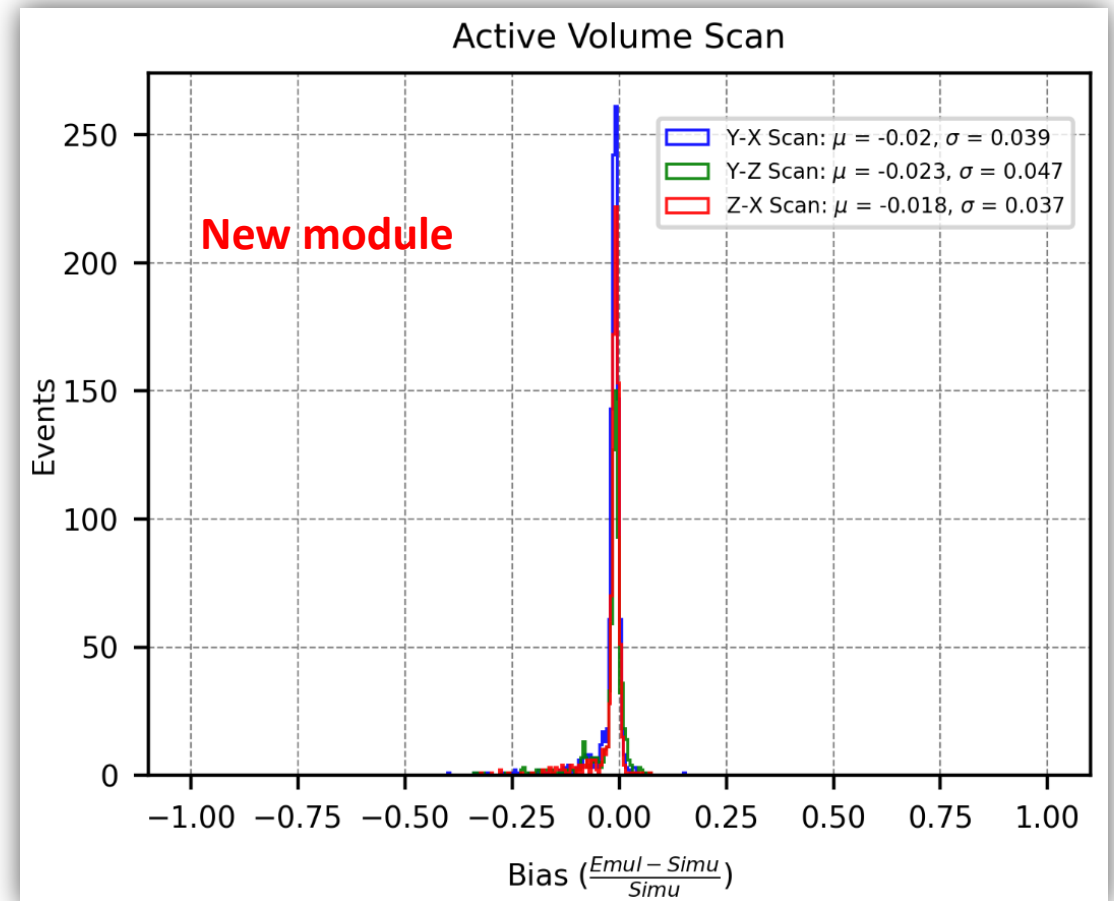
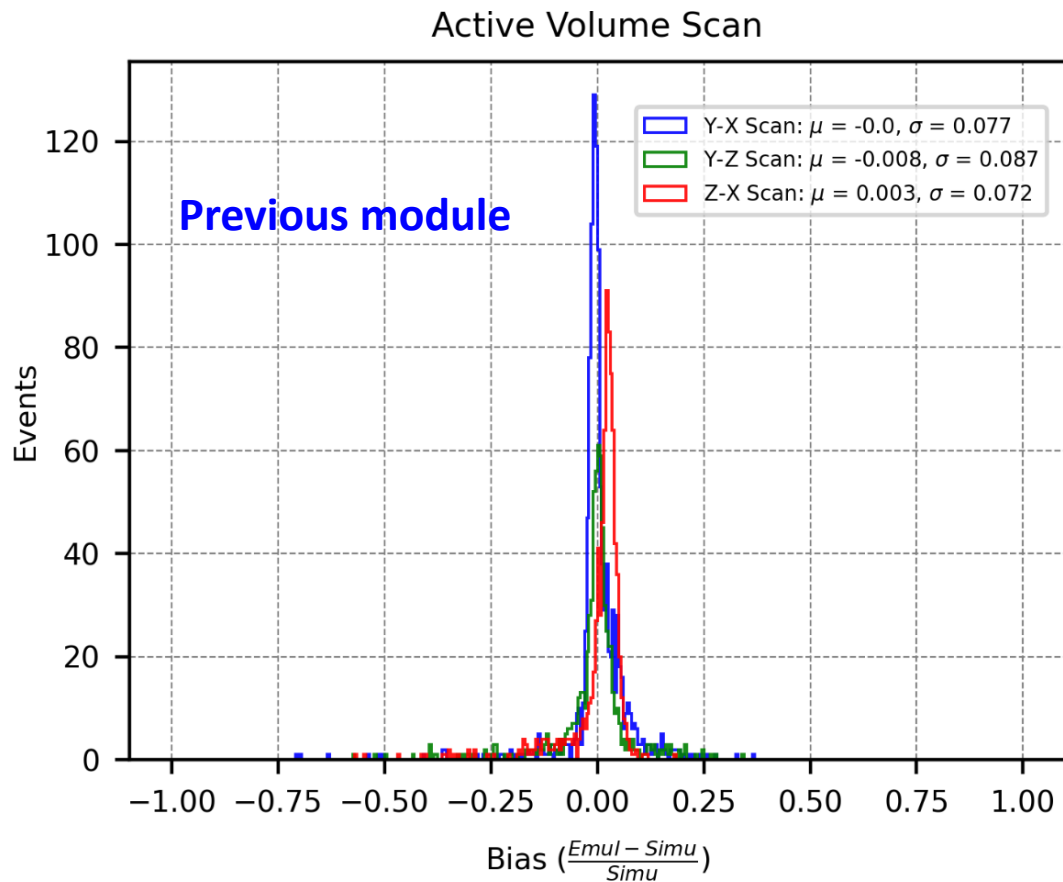
- ❖ Thicknesses of X-Arapuca and CPA NOT considered





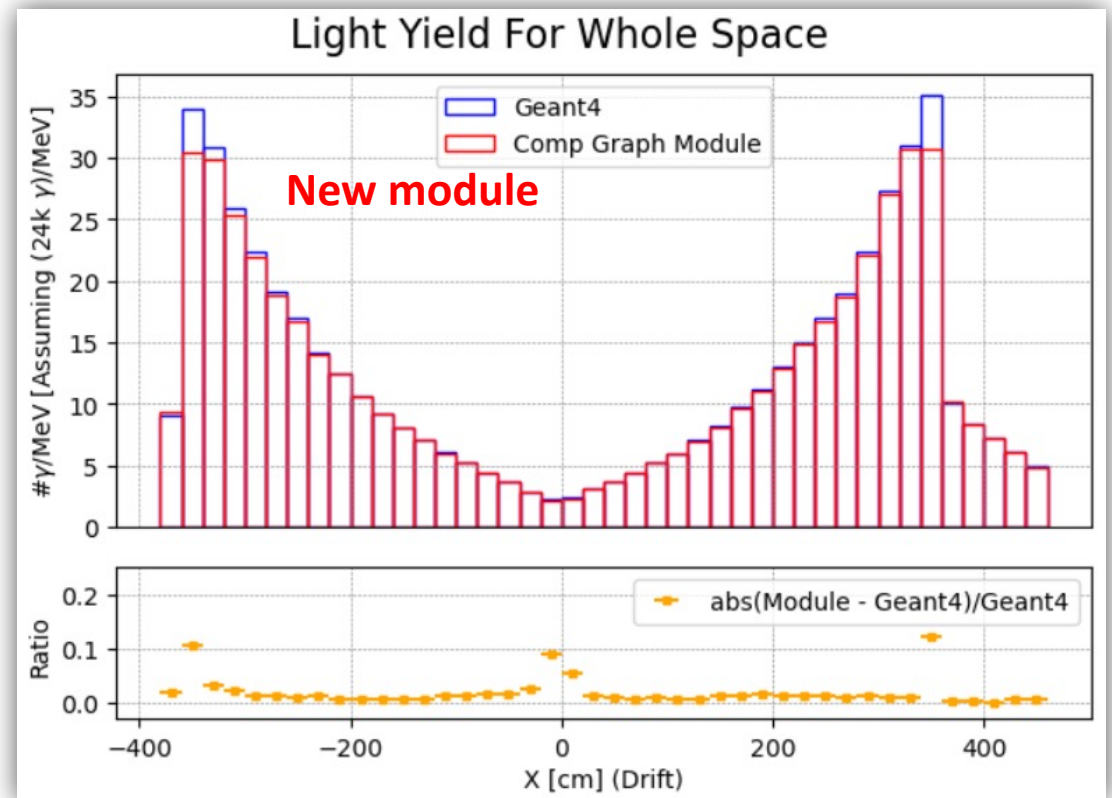
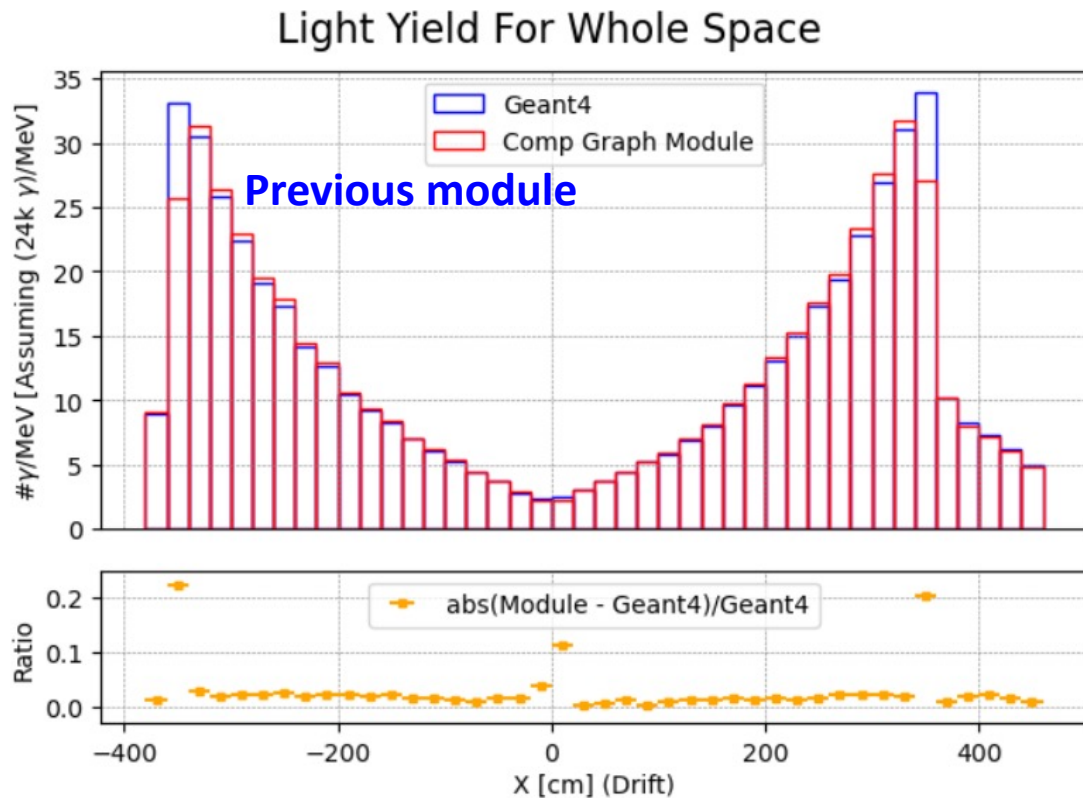
# Track-like Evaluation:

- ❖ All 3-direction scans apparently improved
- ❖ Z-X space scan: Bias of distribution corrected



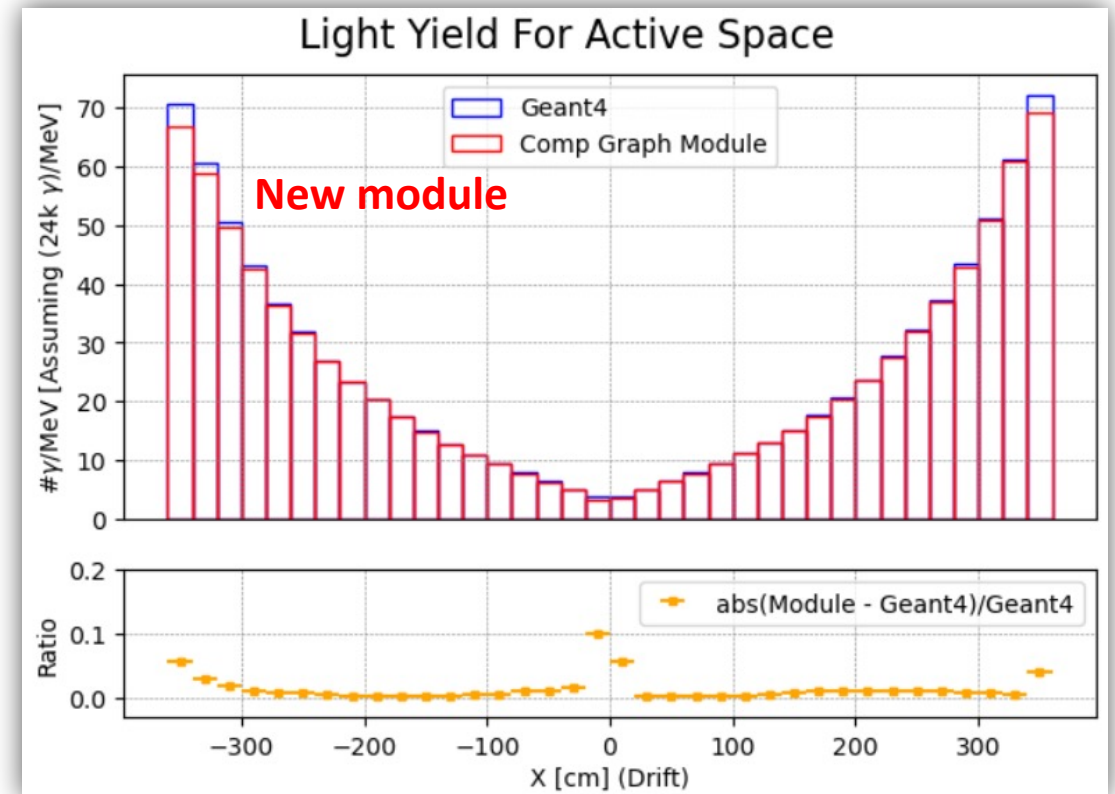
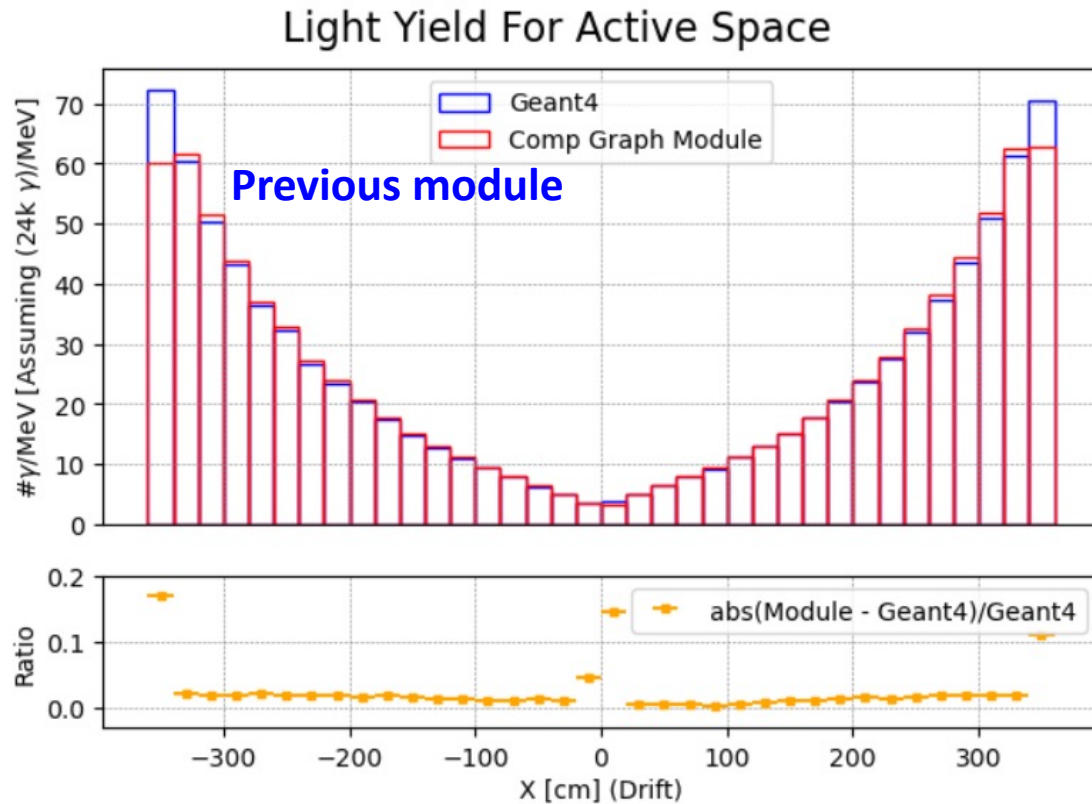
# Photon Map: Whole Space

- ❖ Most regions slightly improved
- ❖ Regions close to APA or CPA apparently improved



# Photon Map: Active Volume

- ❖ Most regions slightly improved
- ❖ Regions close to APA or CPA apparently improved

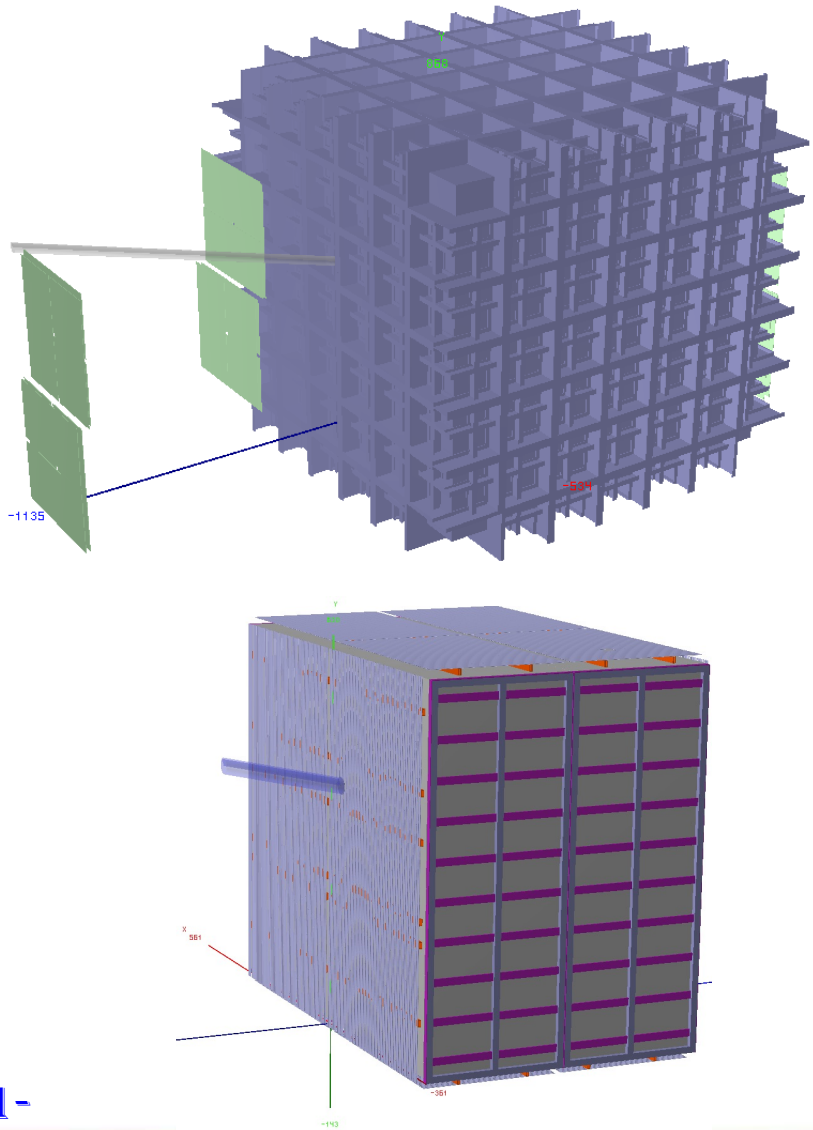


# Conclusion

- ❖ Training based on doubled training set & updated hyper parameter made
- ❖ Performances of module apparently improved: point-like & track-like evaluations
- ❖ Module NOT sensitive to regions very close to X-Arapuca ( $< 10cm$ ) or CPA ( $< 10cm$ )
- ❖ Further steps:
  1. Possibly improve performance further (modify loss function, network structure, etc)
  2. Upload to LArSoft, make it collaboration-wide available

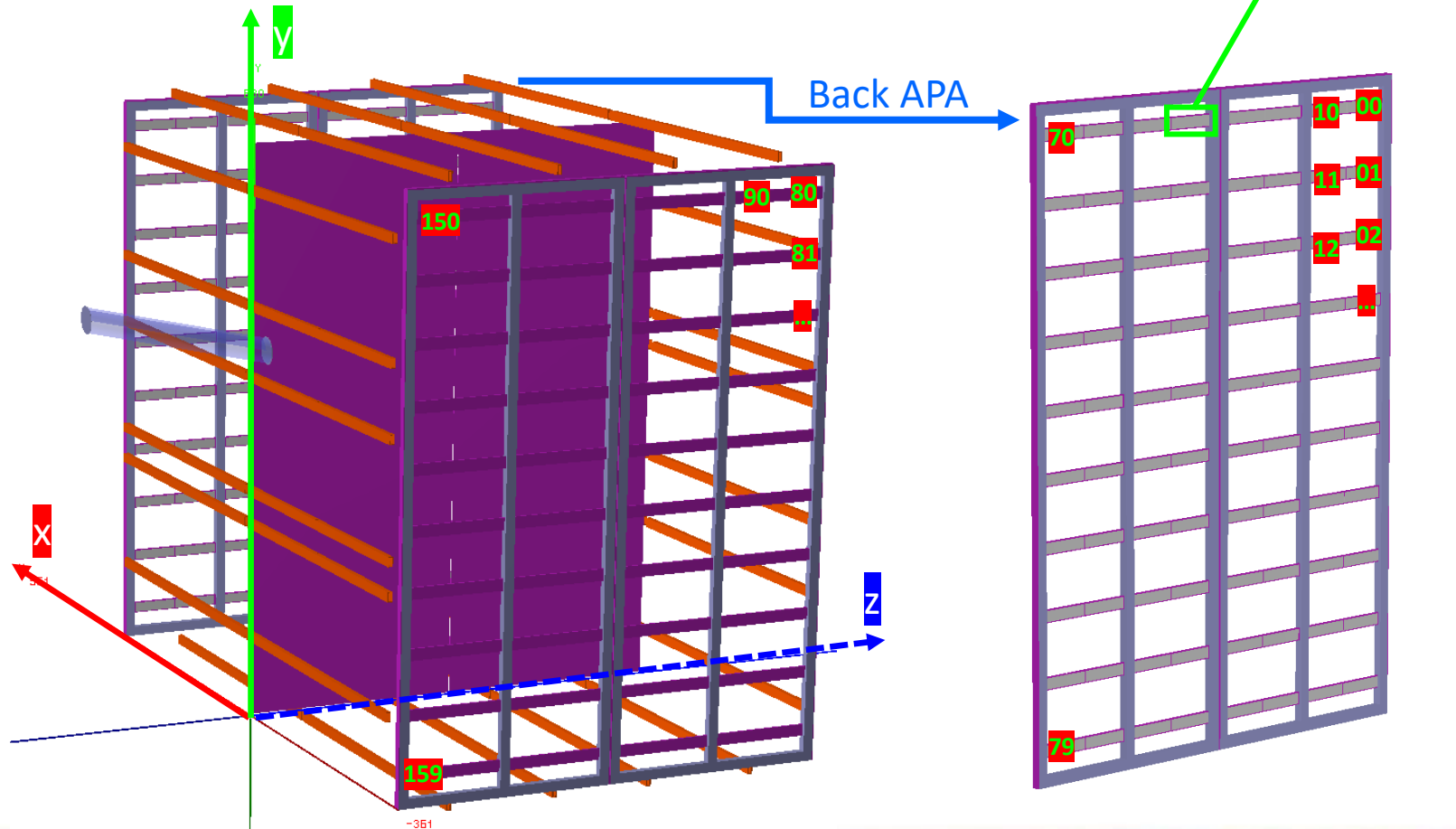
# Backups

# protoDUNE-HD Geometry Review



❖ [protodunehd\\_v6\\_refactored\\_nowires.gdml](#)

❖ 160 optical channels; All X-Arapuca bars; 48cm×10cm





# Optical Channel Labels (I):

❖ APA and Field cage border:  $x \in [-360, 360]cm$ ,  $y \in [-10, 620]cm$ ,  $z \in [-5, 470]cm$

Cryo Boundaries

Xmin: -391.52 Xmax: 463.52 Ymin: -65.1706 Ymax: 725.069 Zmin: -193.854 Zmax: 661.186

Optical Channels positions: 160

0	356.246	578.909	427.071	10	356.246	578.909	377.921	20	356.246	578.909	316.671	30	356.246	578.909	267.521
1	356.246	518.159	427.071	11	356.246	518.159	377.921	21	356.246	518.159	316.671	31	356.246	518.159	267.521
2	356.246	457.409	427.071	12	356.246	457.409	377.921	22	356.246	457.409	316.671	32	356.246	457.409	267.521
3	356.246	396.659	427.071	13	356.246	396.659	377.921	23	356.246	396.659	316.671	33	356.246	396.659	267.521
4	356.246	335.909	427.071	14	356.246	335.909	377.921	24	356.246	335.909	316.671	34	356.246	335.909	267.521
5	356.246	275.159	427.071	15	356.246	275.159	377.921	25	356.246	275.159	316.671	35	356.246	275.159	267.521
6	356.246	214.41	427.071	16	356.246	214.41	377.921	26	356.246	214.41	316.671	36	356.246	214.41	267.521
7	356.246	153.66	427.071	17	356.246	153.66	377.921	27	356.246	153.66	316.671	37	356.246	153.66	267.521
8	356.246	92.9099	427.071	18	356.246	92.9099	377.921	28	356.246	92.9099	316.671	38	356.246	92.9099	267.521
9	356.246	32.16	427.071	19	356.246	32.16	377.921	29	356.246	32.16	316.671	39	356.246	32.16	267.521

40	356.246	578.909	195.011	50	356.246	578.909	145.861	60	356.246	578.909	84.6112	70	356.246	578.909	35.4612
41	356.246	518.159	195.011	51	356.246	518.159	145.861	61	356.246	518.159	84.6112	71	356.246	518.159	35.4612
42	356.246	457.409	195.011	52	356.246	457.409	145.861	62	356.246	457.409	84.6112	72	356.246	457.409	35.4612
43	356.246	396.659	195.011	53	356.246	396.659	145.861	63	356.246	396.659	84.6112	73	356.246	396.659	35.4612
44	356.246	335.909	195.011	54	356.246	335.909	145.861	64	356.246	335.909	84.6112	74	356.246	335.909	35.4612
45	356.246	275.159	195.011	55	356.246	275.159	145.861	65	356.246	275.159	84.6112	75	356.246	275.159	35.4612
46	356.246	214.41	195.011	56	356.246	214.41	145.861	66	356.246	214.41	84.6112	76	356.246	214.41	35.4612
47	356.246	153.66	195.011	57	356.246	153.66	145.861	67	356.246	153.66	84.6112	77	356.246	153.66	35.4612
48	356.246	92.9099	195.011	58	356.246	92.9099	145.861	68	356.246	92.9099	84.6112	78	356.246	92.9099	35.4612
49	356.246	32.16	195.011	59	356.246	32.16	145.861	69	356.246	32.16	84.6112	79	356.246	32.16	35.4612



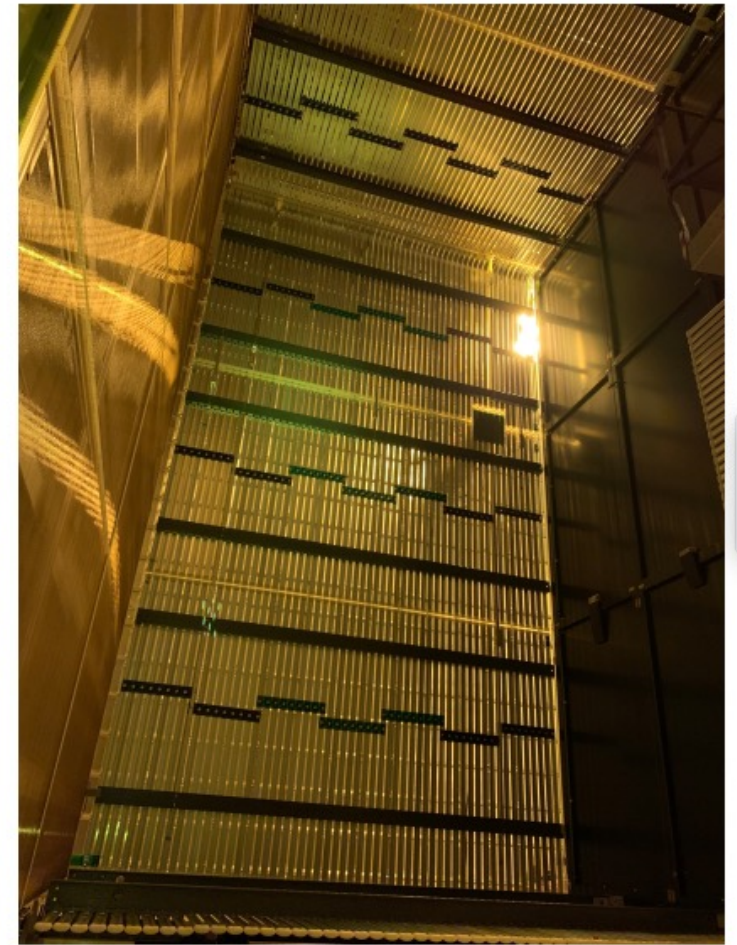
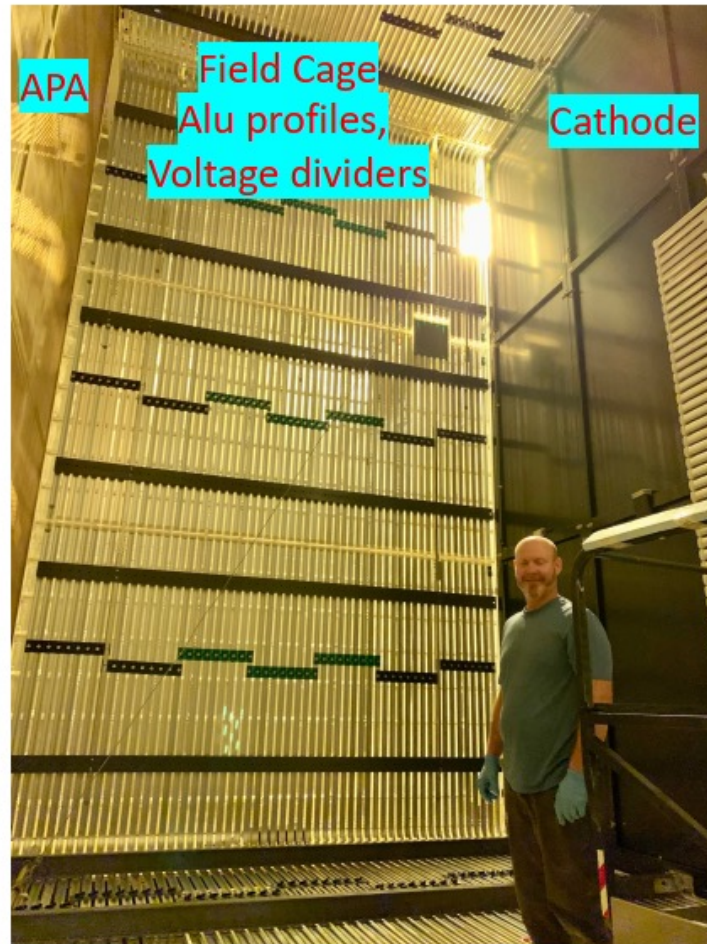
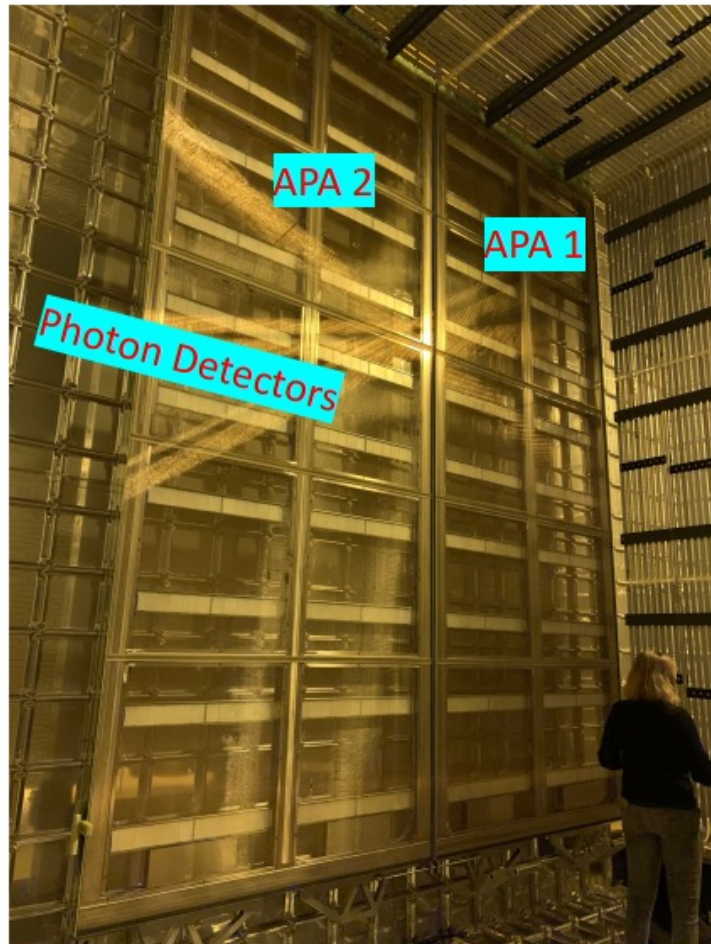
# Optical Channel Labels (II):

80	-356.446	578.909	427.071	90	-356.446	578.909	377.921	100	-356.446	578.909	316.671	110	-356.446	578.909	267.521
81	-356.446	518.159	427.071	91	-356.446	518.159	377.921	101	-356.446	518.159	316.671	111	-356.446	518.159	267.521
82	-356.446	457.409	427.071	92	-356.446	457.409	377.921	102	-356.446	457.409	316.671	112	-356.446	457.409	267.521
83	-356.446	396.659	427.071	93	-356.446	396.659	377.921	103	-356.446	396.659	316.671	113	-356.446	396.659	267.521
84	-356.446	335.909	427.071	94	-356.446	335.909	377.921	104	-356.446	335.909	316.671	114	-356.446	335.909	267.521
85	-356.446	275.159	427.071	95	-356.446	275.159	377.921	105	-356.446	275.159	316.671	115	-356.446	275.159	267.521
86	-356.446	214.41	427.071	96	-356.446	214.41	377.921	106	-356.446	214.41	316.671	116	-356.446	214.41	267.521
87	-356.446	153.66	427.071	97	-356.446	153.66	377.921	107	-356.446	153.66	316.671	117	-356.446	153.66	267.521
88	-356.446	92.9099	427.071	98	-356.446	92.9099	377.921	108	-356.446	92.9099	316.671	118	-356.446	92.9099	267.521
89	-356.446	32.16	427.071	99	-356.446	32.16	377.921	109	-356.446	32.16	316.671	119	-356.446	32.16	267.521

120	-356.446	578.909	195.011	130	-356.446	578.909	145.861	140	-356.446	578.909	84.6112	150	-356.446	578.909	35.4612
121	-356.446	518.159	195.011	131	-356.446	518.159	145.861	141	-356.446	518.159	84.6112	151	-356.446	518.159	35.4612
122	-356.446	457.409	195.011	132	-356.446	457.409	145.861	142	-356.446	457.409	84.6112	152	-356.446	457.409	35.4612
123	-356.446	396.659	195.011	133	-356.446	396.659	145.861	143	-356.446	396.659	84.6112	153	-356.446	396.659	35.4612
124	-356.446	335.909	195.011	134	-356.446	335.909	145.861	144	-356.446	335.909	84.6112	154	-356.446	335.909	35.4612
125	-356.446	275.159	195.011	135	-356.446	275.159	145.861	145	-356.446	275.159	84.6112	155	-356.446	275.159	35.4612
126	-356.446	214.41	195.011	136	-356.446	214.41	145.861	146	-356.446	214.41	84.6112	156	-356.446	214.41	35.4612
127	-356.446	153.66	195.011	137	-356.446	153.66	145.861	147	-356.446	153.66	84.6112	157	-356.446	153.66	35.4612
128	-356.446	92.9099	195.011	138	-356.446	92.9099	145.861	148	-356.446	92.9099	84.6112	158	-356.446	92.9099	35.4612
129	-356.446	32.16	195.011	139	-356.446	32.16	145.861	149	-356.446	32.16	84.6112	159	-356.446	32.16	35.4612



# X-Arapucas in APA:



X