

Comp Graph Module for Full-size FDHD

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FD1 (FDHD) Geometry Review

❖ Full-scale FD1 geometry: [dune10kt_v6_refactored.gdml](#)

❖ # of optical channel: 6,000 in total

❖ APA planes:

$$x = 727.102, 0, 727.002\text{cm}$$

❖ 150 ($3 \times 2 \times 25$) APAs, 40 opchs / APA

❖ Boundaries:

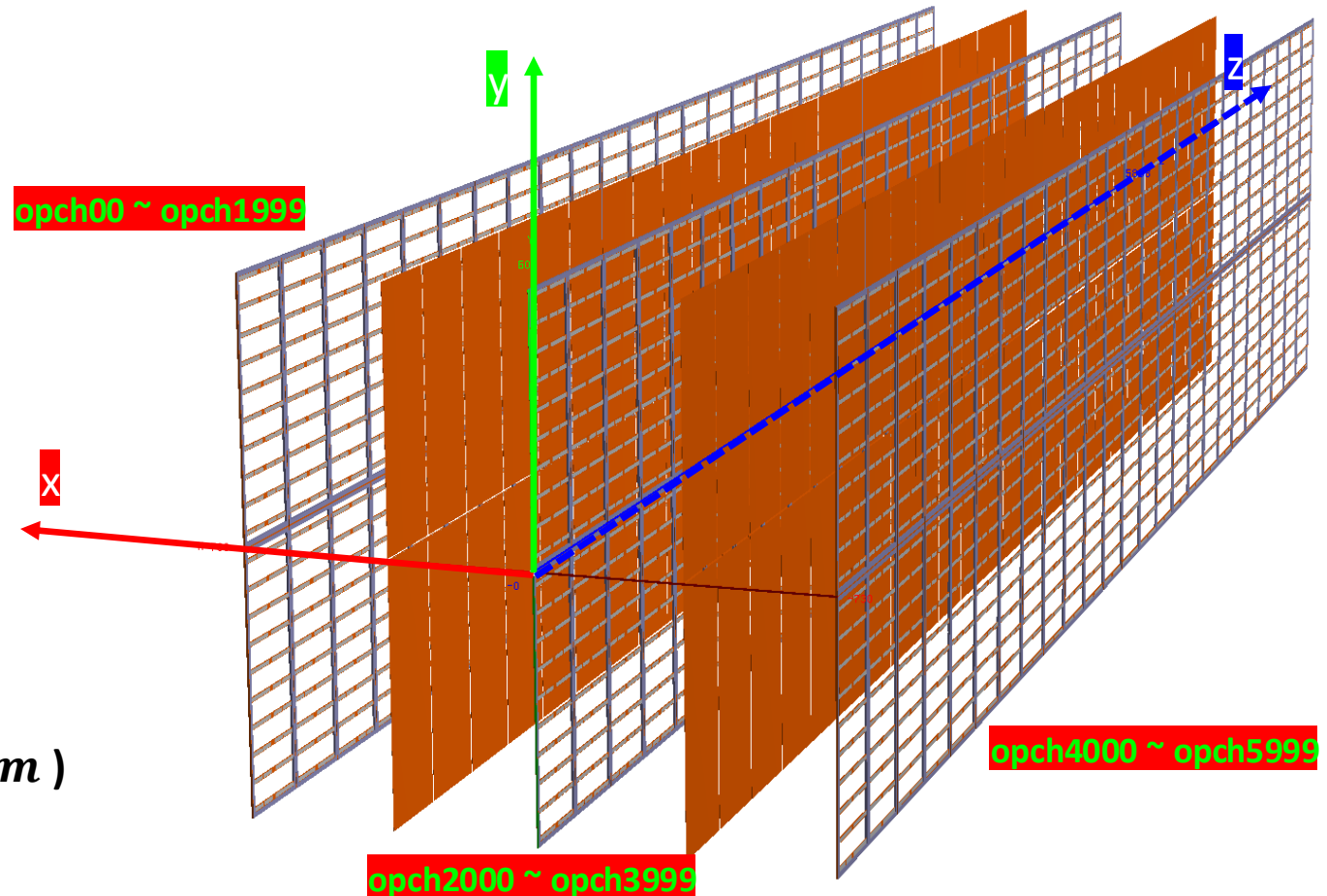
Xmin: -747.298cm; Xmax: 747.298cm

Ymin: -658.099cm; Ymax: 699.599cm

Zmin: -302.946cm; Zmax: 5858.94cm

❖ Symmetric layout of chambers:

Consider one chamber at first (Ex: $x = 727\text{cm}$)



Training Sample Generation:

- ❖ Based on Geant4 (full optical simulation)
- ❖ Size of training sample: 435,296
- ❖ Uniformly distributed in whole space
- ❖ Event relocation:

Chamber B:

$$x'_B = 727.102 - x_B; y'_B = y_B; z'_B = z_B$$

Keep opchs of APA2 and convert to of APA1

(Ex: *opch3000* → *opch00*; *opch2000* → *opch1000*)

Chamber C:

$$x'_C = 727.102 + x_C; y'_C = y_C; z'_C = z_C$$

Keep opch of APA2 and convert to that of APA1

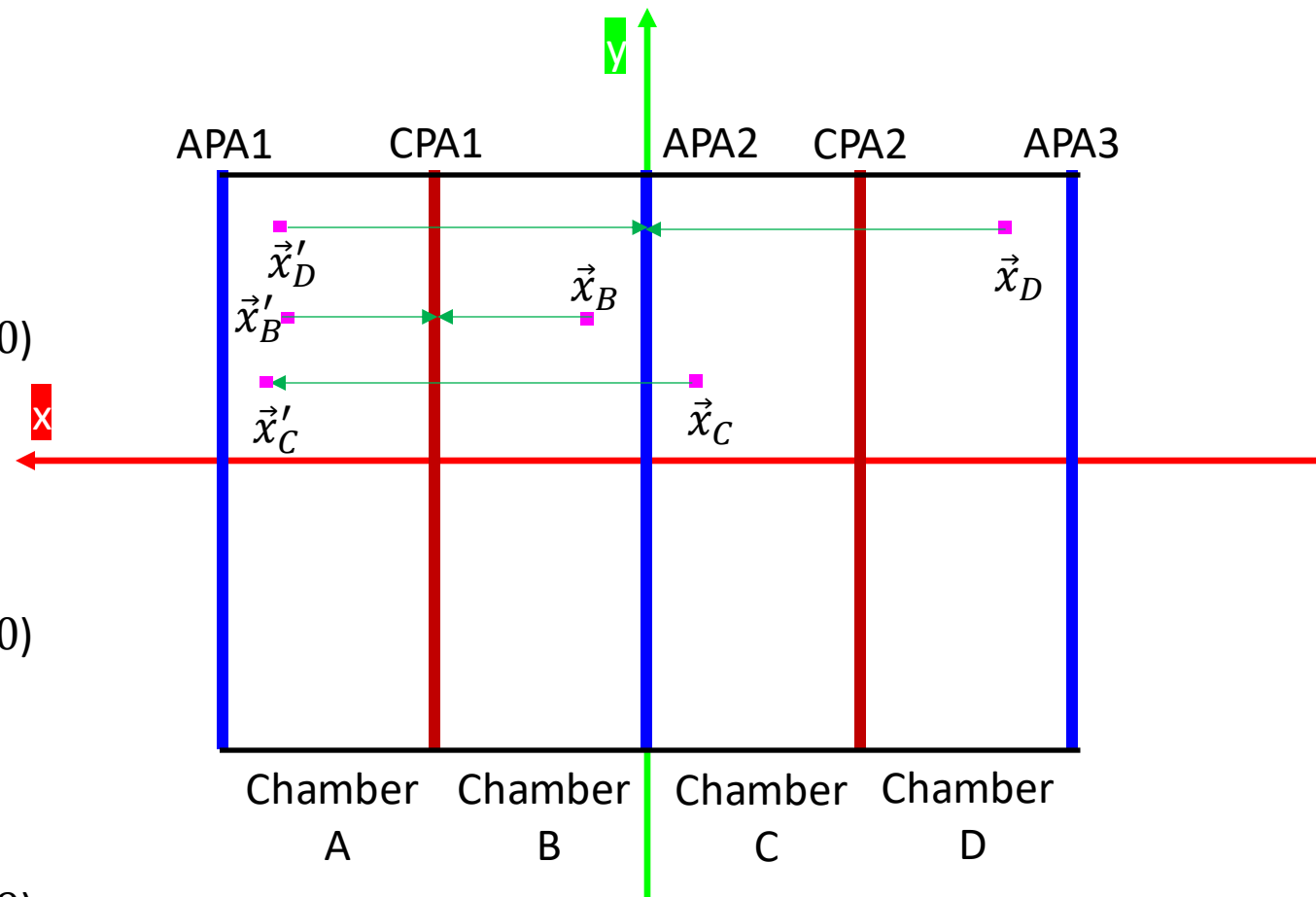
(Ex: *opch3000* → *opch00*; *opch2000* → *opch1000*)

Chamber D:

$$x'_D = -x_D; y'_D = y_D; z'_D = z_D$$

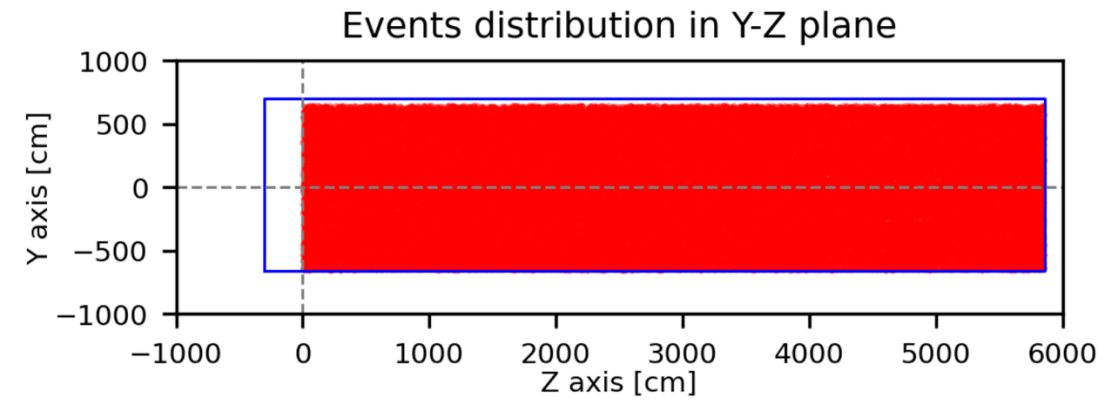
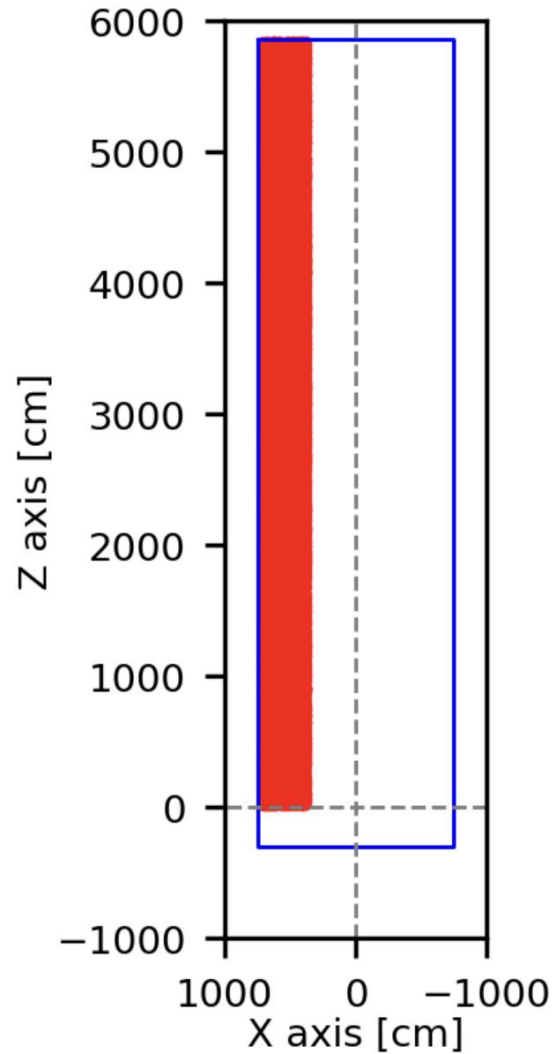
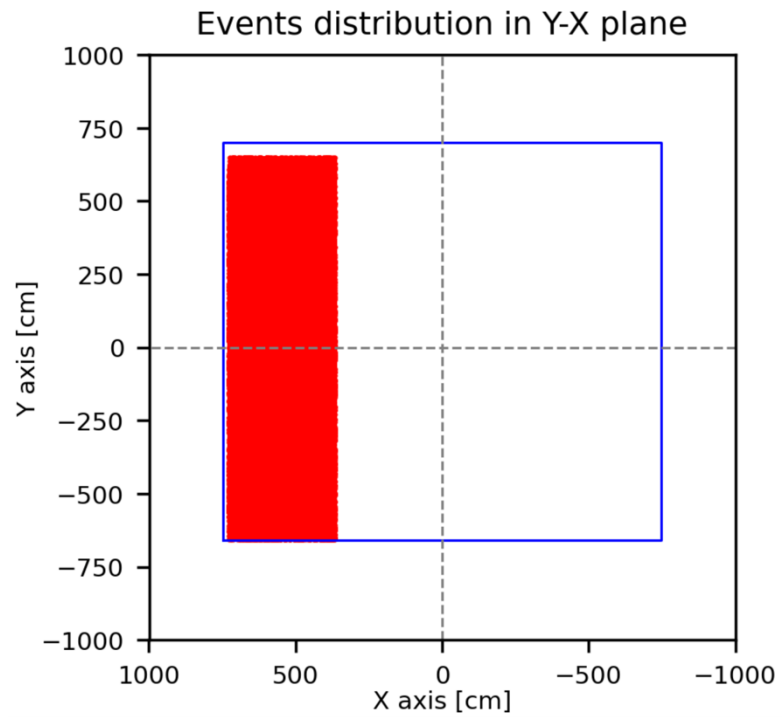
Keep opch of APA3 and convert to that of APA1

(Ex: *opch4000* → *opch00*; *opch5999* → *opch1999*)



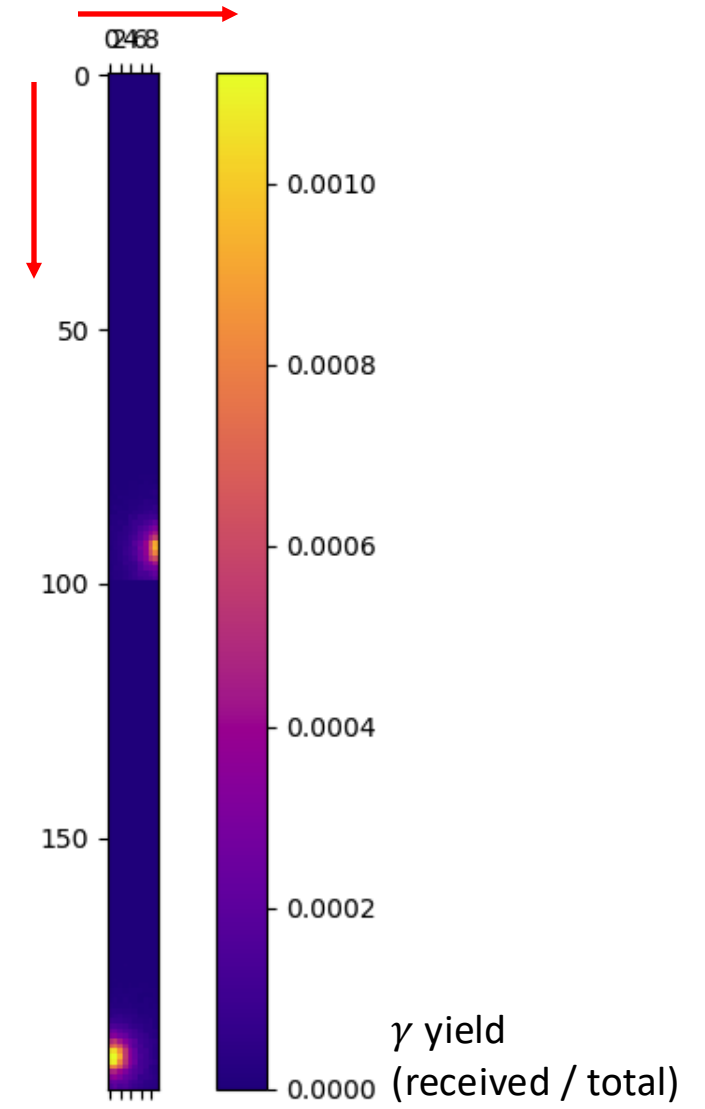
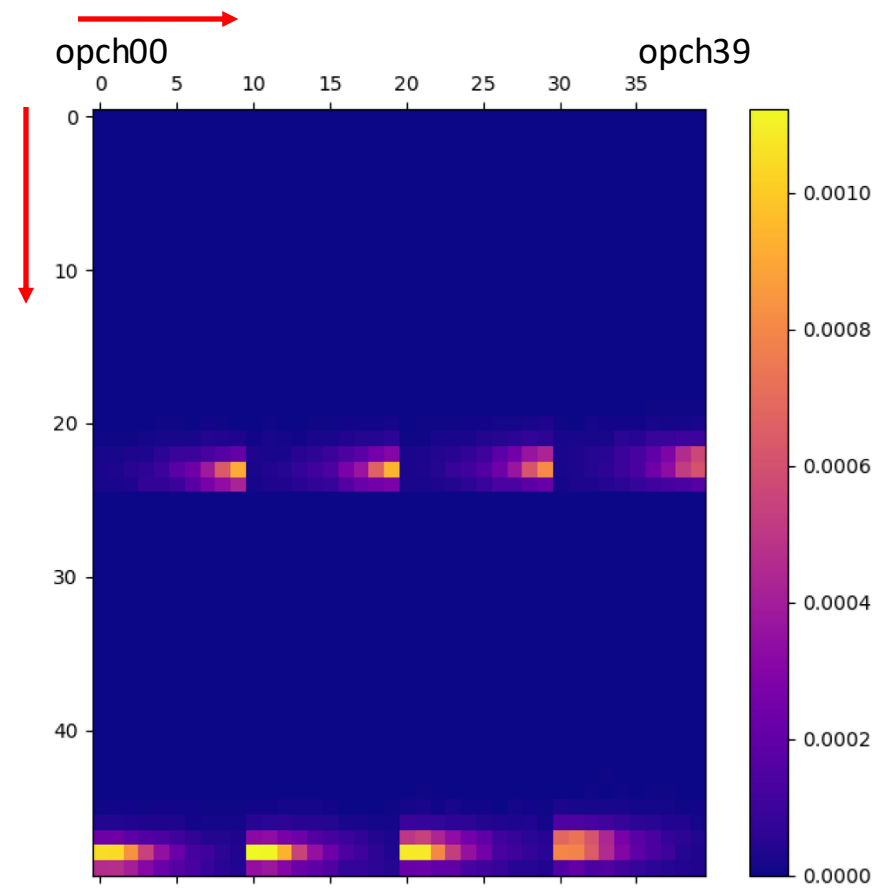
Effect of Relocation:

❖ Blue: border of cryostat



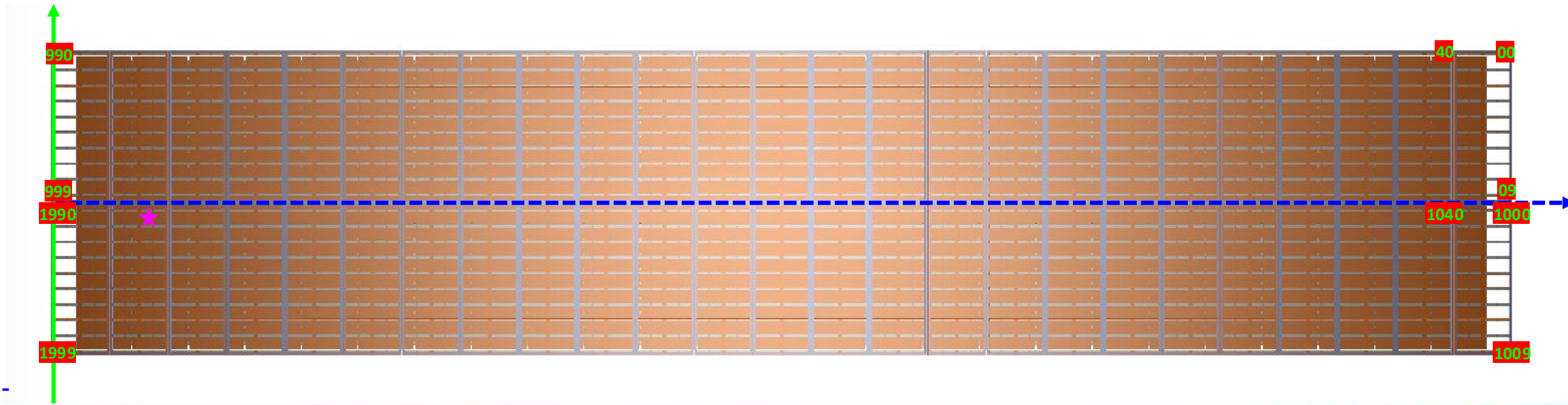
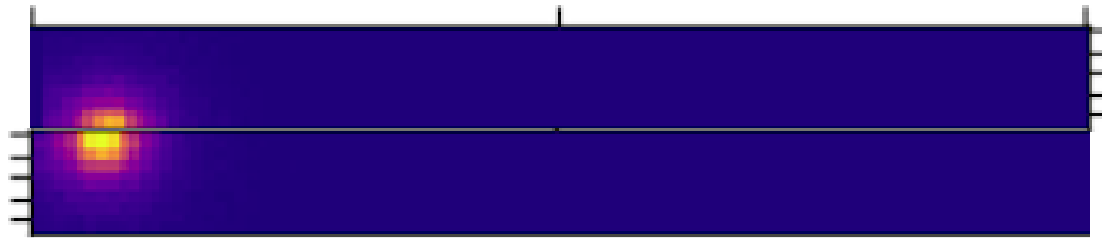
Event Example (I)

❖ Photon emission vertex (★): (534.833, -53.176, 377.926)
[close to opch1930 & 1931]



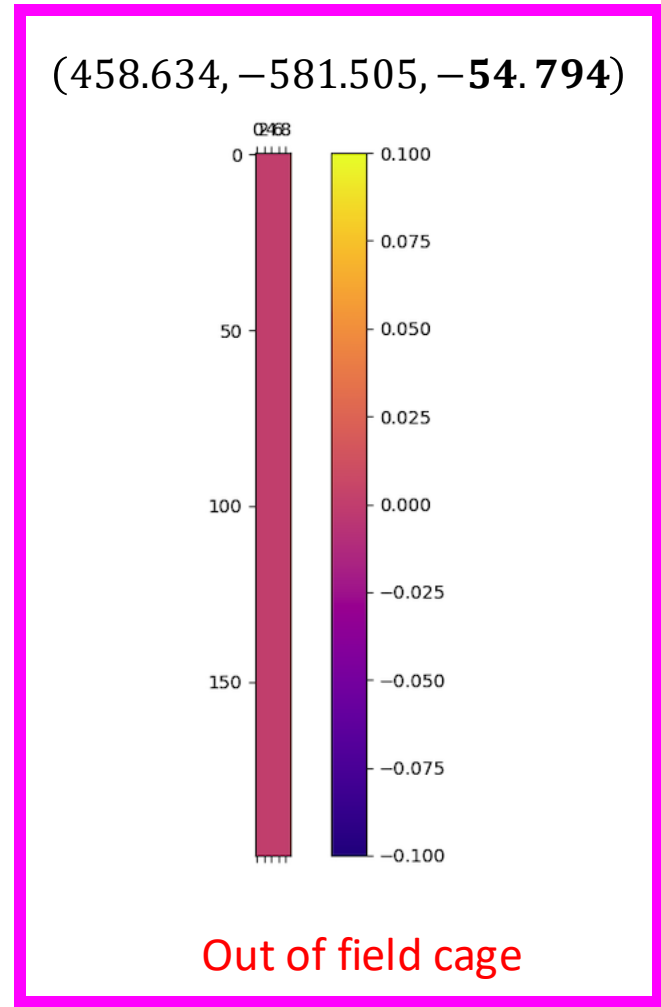
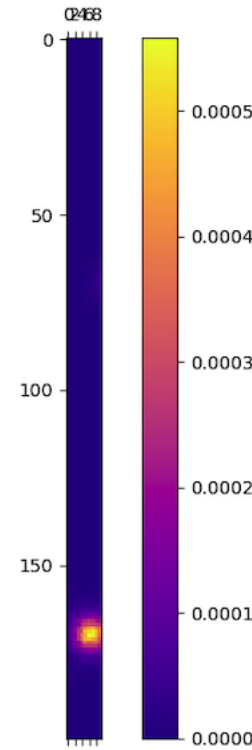
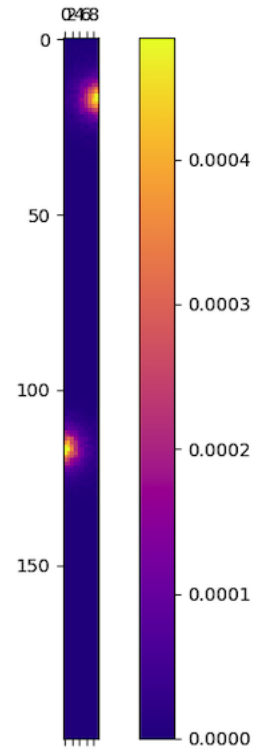
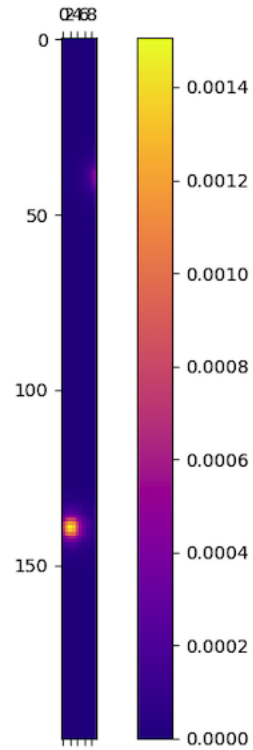
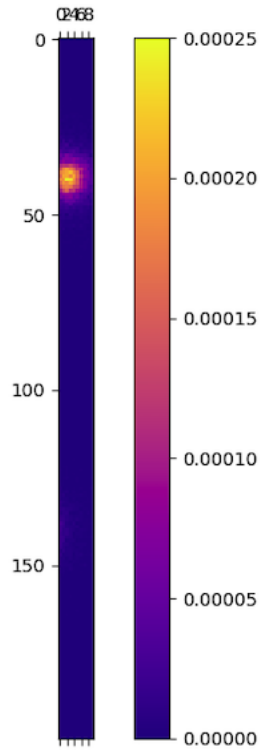
Event Example (II)

- ❖ Photon emission vertex (★): (534.833, -53.176, 377.926)
[close to opch1930 & 1931]
- ❖ Responses of opchs: quite localized



Event Example (III)

❖ More examples:



Cryo Boundaries

Xmin: -747.298 Xmax: 747.298 Ymin: -658.099 Ymax: 699.599 Zmin: -302.946 Zmax: 5858.94

Neural Network

❖ Very preliminary

❖ Network complexity

FDHD: 2,000 opchs

Total params: 1,022,138
Trainable params: 1,021,132
Non-trainable params: 1,006

PDHD: 160 opchs

Total params: 340,280
Trainable params: 337,360
Non-trainable params: 2,920

❖ Hyper-parameters:

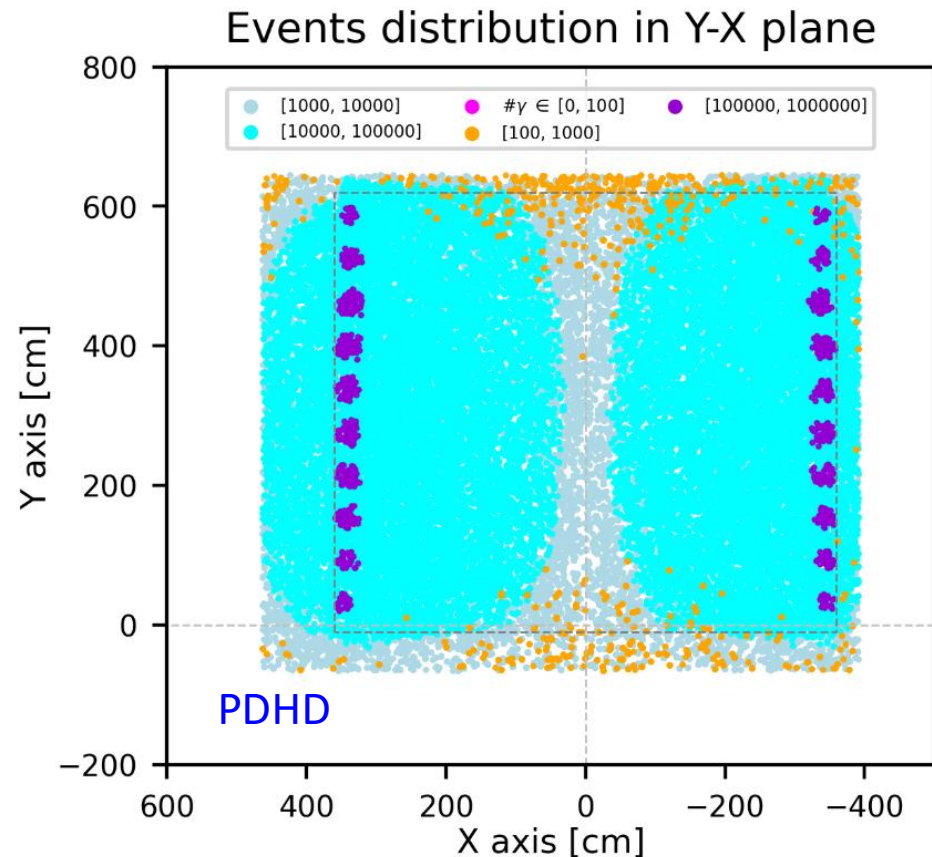
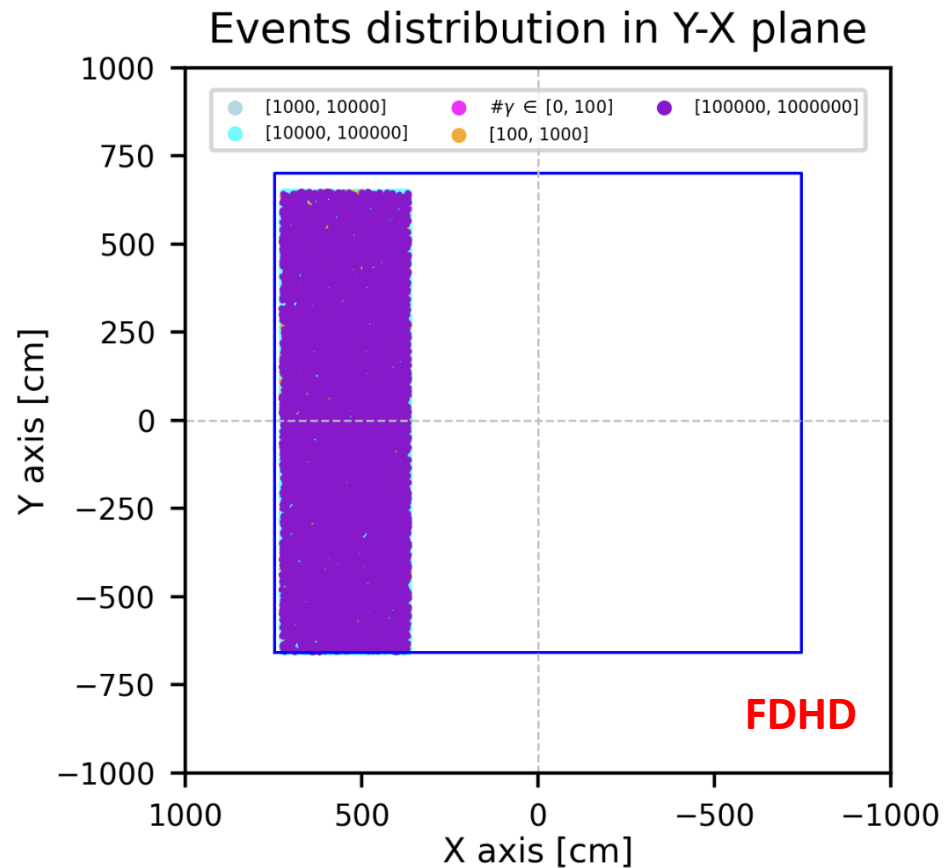
```
(tf_env) train_2 > python3 gnn_Muve/gnn.py -i ../dataSet/train_4976Files -o output_2048b_10000e -t 0 -b 2048 -e 10000 -n 4976 -d 2000 --train > train_2048b_2000Files.txt &
```

```
def model_fdhdv6_dune10kt(dim_pdr):  
    pos_x      = Input(shape=(1,), name='pos_x')  
    pos_y      = Input(shape=(1,), name='pos_y')  
    pos_z      = Input(shape=(1,), name='pos_z')  
    input_layer = [pos_x, pos_y, pos_z]  
  
    feat_int = Dense(1)(pos_x)  
    feat_int = BatchNormalization(momentum=0.9)(feat_int)  
    feat_int = ReLU()(feat_int)  
  
    ...  
  
    feat_cov = Dense(480)(feat_cov)  
    feat_cov = BatchNormalization(momentum=0.9)(feat_cov)  
    feat_cov = ReLU()(feat_cov)  
  
    pdr      = Dense(dim_pdr, activation='sigmoid', name='vis_full')  
(feat_cov)  
    model    = Model(inputs=input_layer, outputs=pdr,  
name='fdhdv6_dune10kt_model')  
  
    model.summary()  
    return model
```

Network snippets

Evaluation: Compare with PDHD

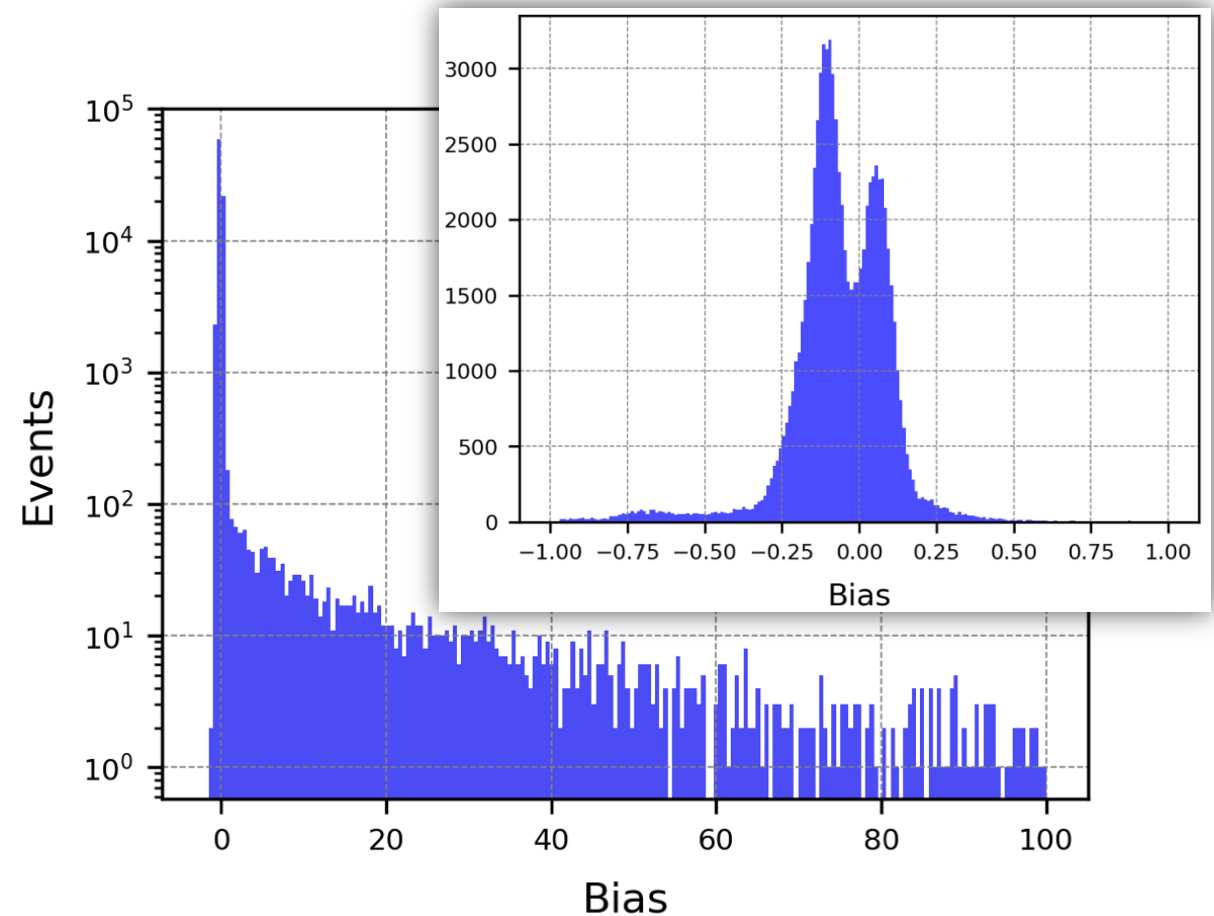
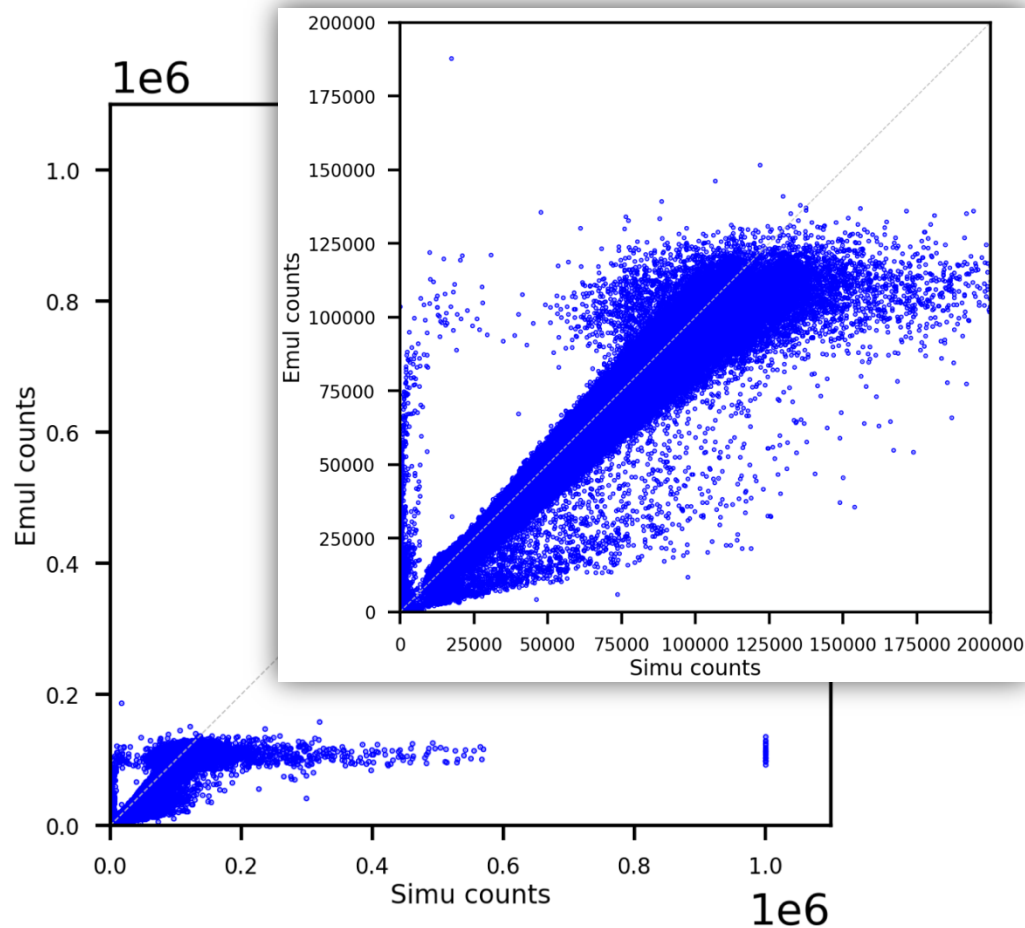
- ❖ Events based on “simu” (Geant4 prediction; NOT comp graph module prediction)
- ❖ Events with γ yield $> 10^5$ (total γ emission / event: 10^6): FDHD: $\sim 14\%$, PDHD: $\sim 1\%$
- ❖ Very weird behavior of FDHD dataset



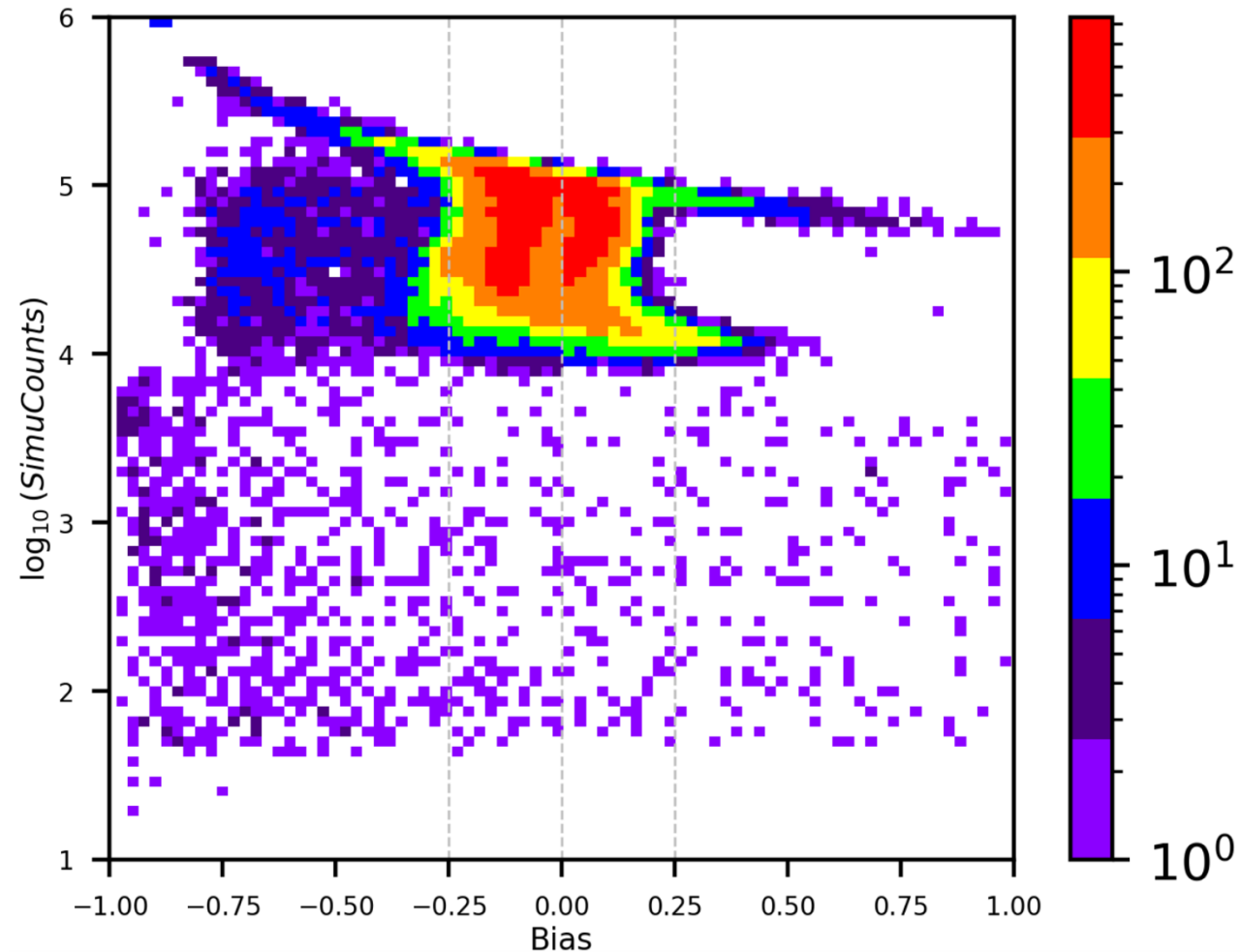
Evaluation: Bias Distribution (I)

- ❖ Based on evaluation set: # = 84,730
- ❖ Emul: prediction of Comp Graph Module; Simu: Geant4

$$\text{Bias} \equiv \frac{\text{Emul} - \text{Simu}}{\text{Simu}}$$



Evaluation: Bias Distribution (II)



Summary:

- ❖ Training samples for full-size FD1 well generated
- ❖ Relocation method applied, regarding to symmetry of chambers
- ❖ Simple neural network developed
- ❖ Preliminary module trained & simple evaluation applied

- ❖ Further steps:
 1. Generate more training samples (constrain emission within one chamber)
 2. Improve network (new loss function, new structure)
 3. Test different hyperparameters

Backups

FD1 (FDHD) Geometry Review

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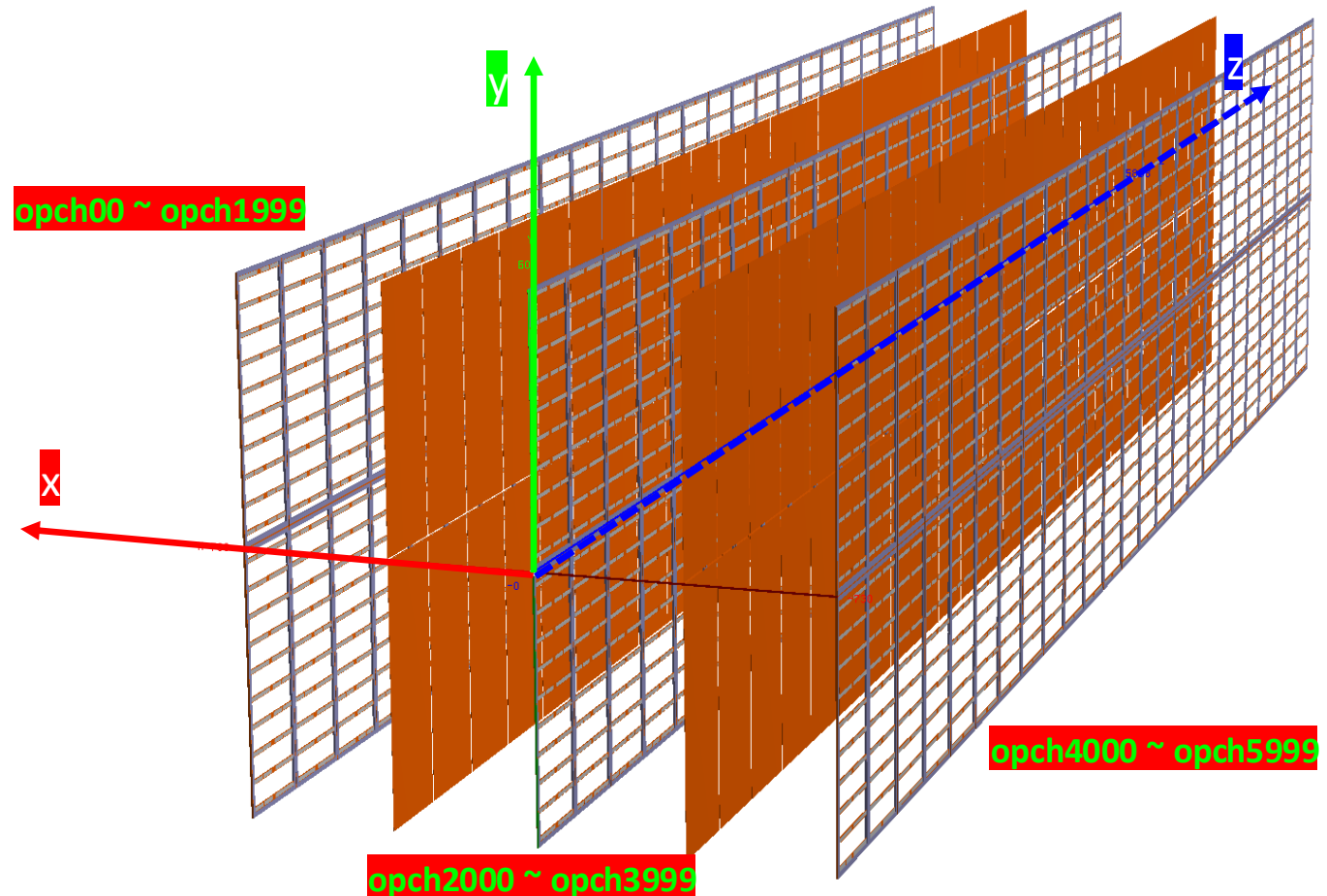
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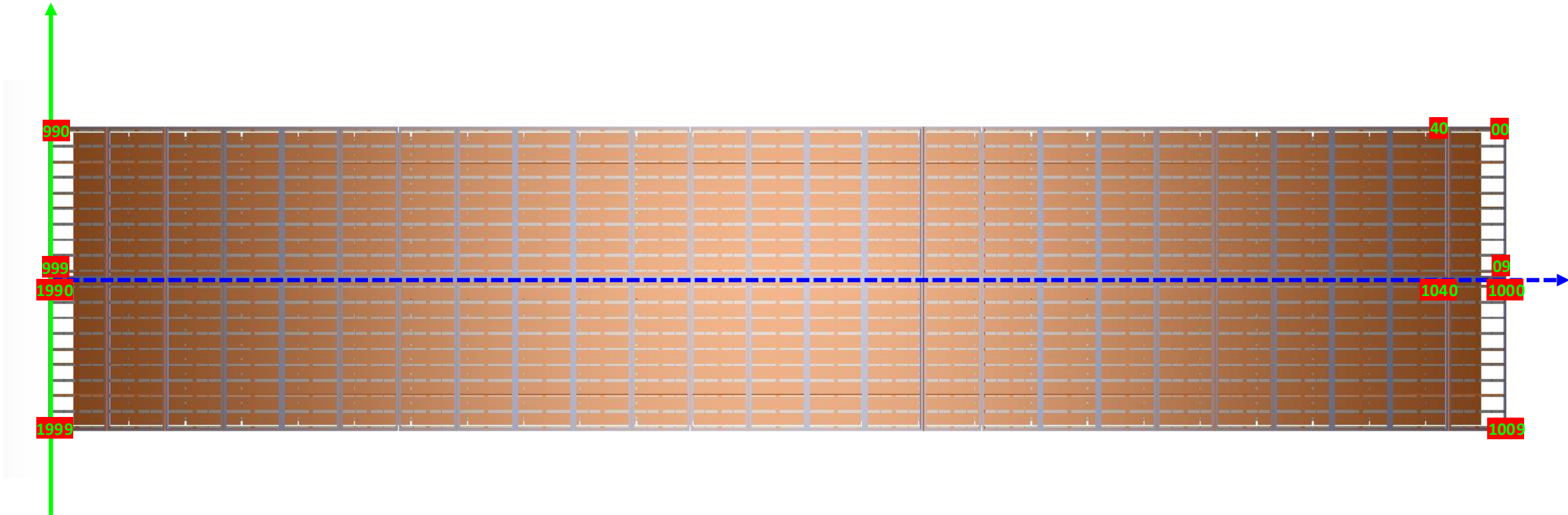
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❖ XXX



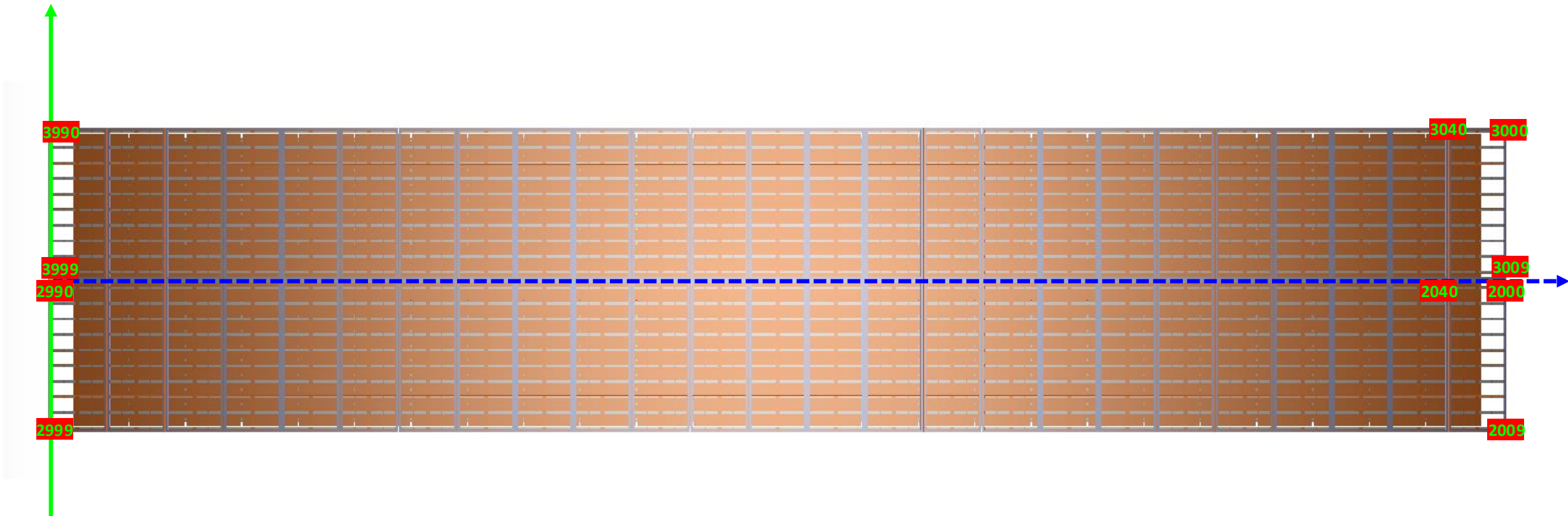
Optical Channel Labels (I):

❖ APA plane $x = 727.102\text{cm}$



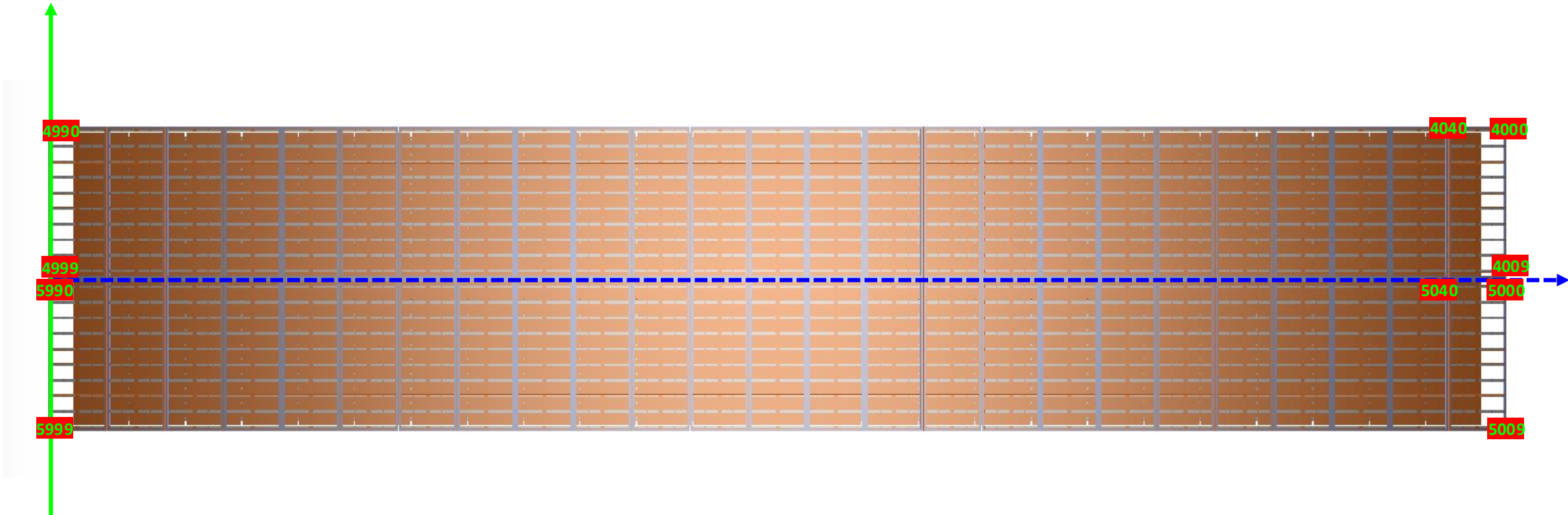
Optical Channel Labels (II):

❖ APA plane $x = -0.05, 0.05\text{cm}$



Optical Channel Labels (III):

❖ APA plane $x = -727.002cm$



X