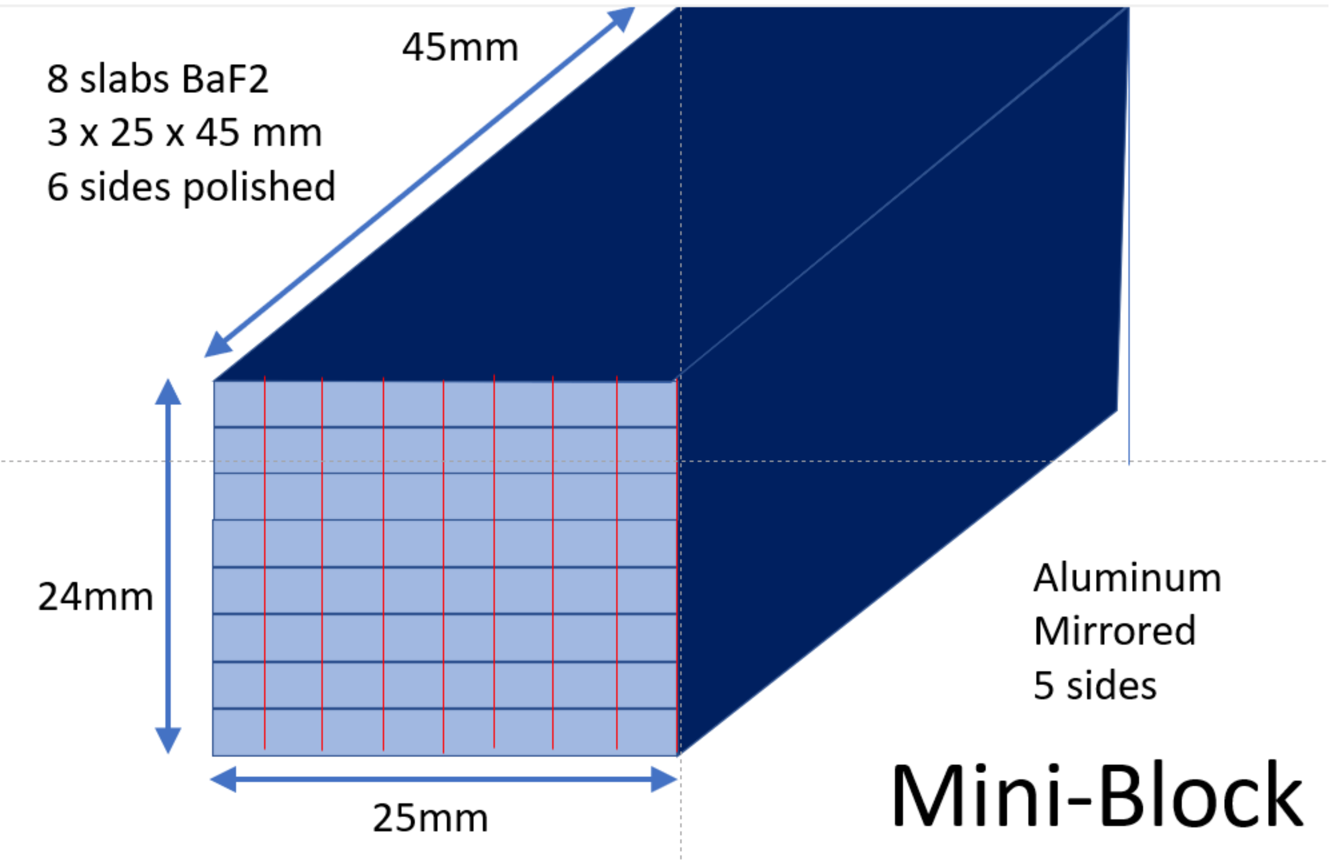
Specular Infinity Mirror Optics Model Validation Python/GitHub/Google Colab

Bill Worstell

PicoRad Imaging

10/10/2023



Isomorphism: There is a 1-to-1 map from a ray starting at a point within the miniblock then reflecting off mirrors (or by total internal reflection) -> a virtual ray traveling in a straight line through a double layer of 2D virtual lattices

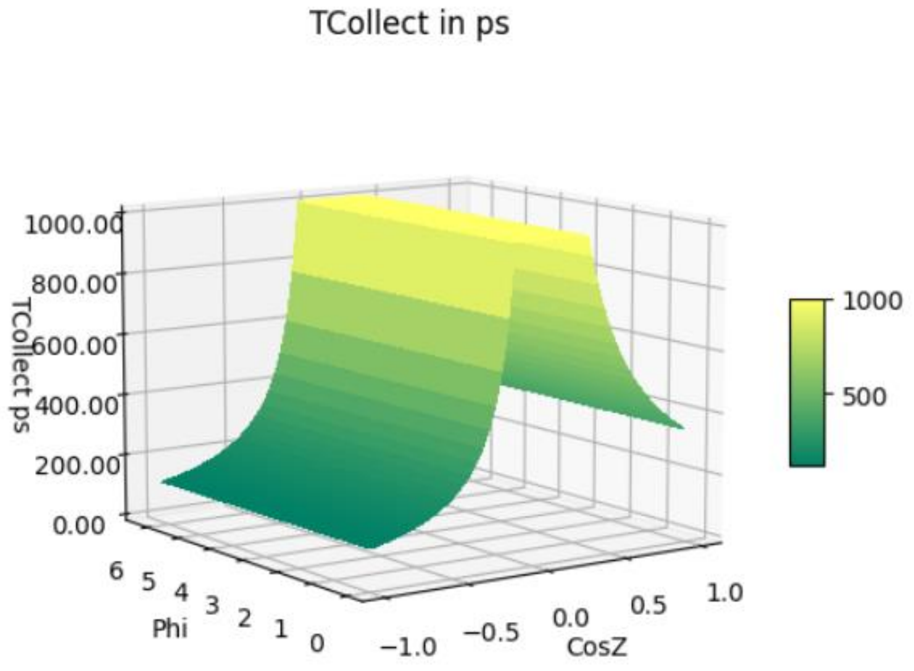
X-reflection: [vx,vy,vz] -> [-vx, vy, vz]
Y-reflection: [vx,vy,vz] -> [vx,-vy, vz]
Z-reflection: [vx,vy,vz] -> [vx, vy,-vz]

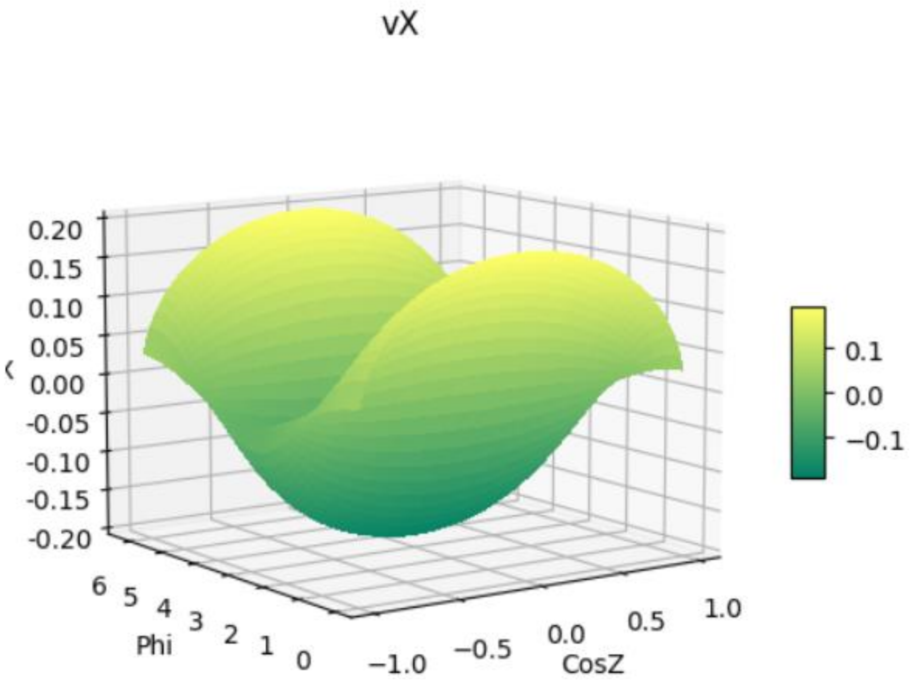
[x,y,z,t,Θ,Φ]|[dX,DX,dy,DY,dz,DZ,nx,ny,ηx,ηy]-> detected [X,Y, T] and multiple reflection survival probability

2-D Infinite Mirror at each pixel, and for Miniblock

SimpleOpticsPhotons.ipynb

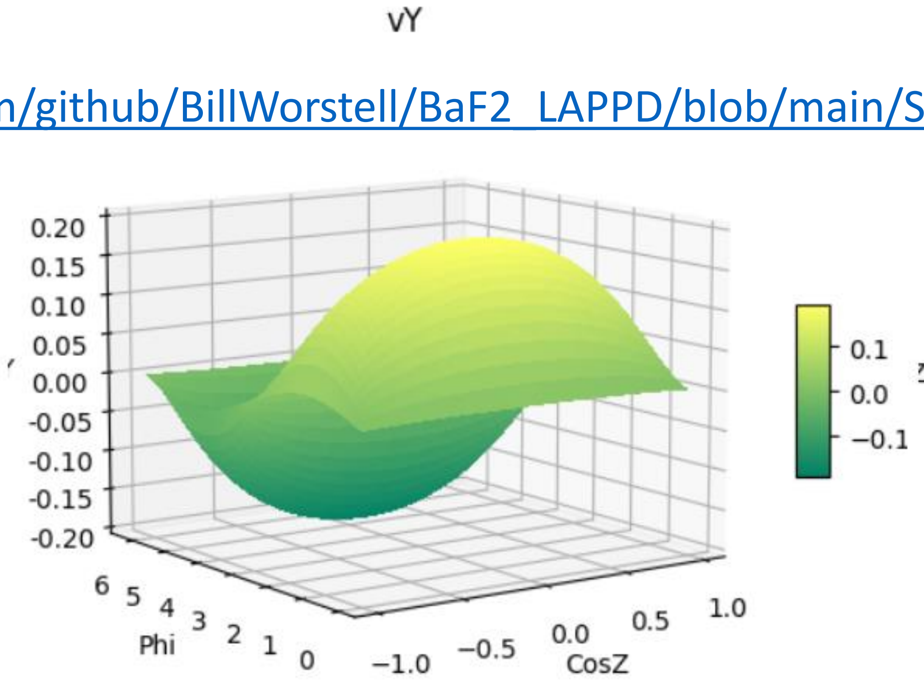
[Θ,Φ ,n] -> [vX,vY,vZ]

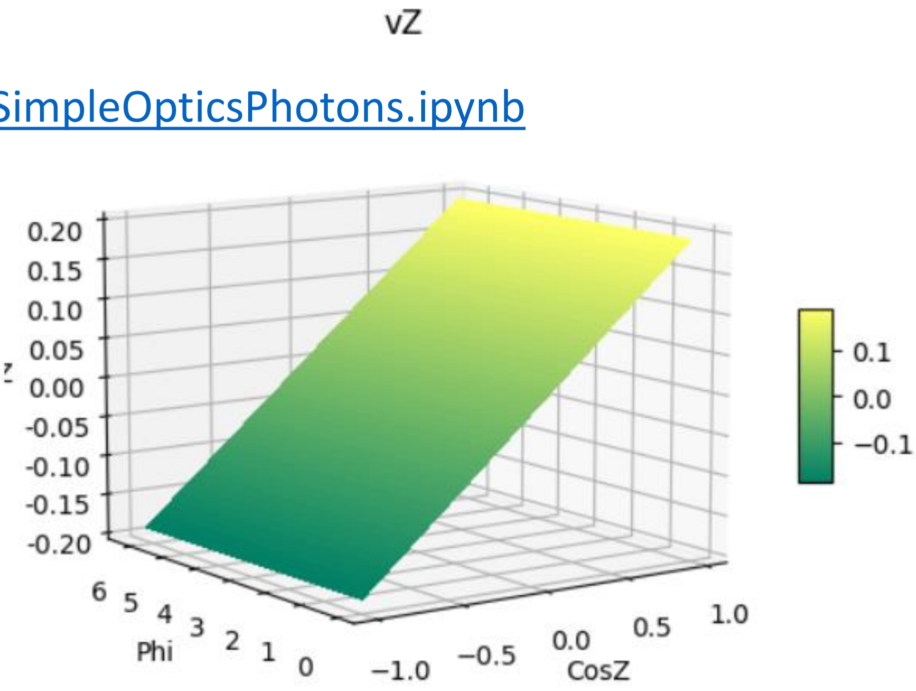




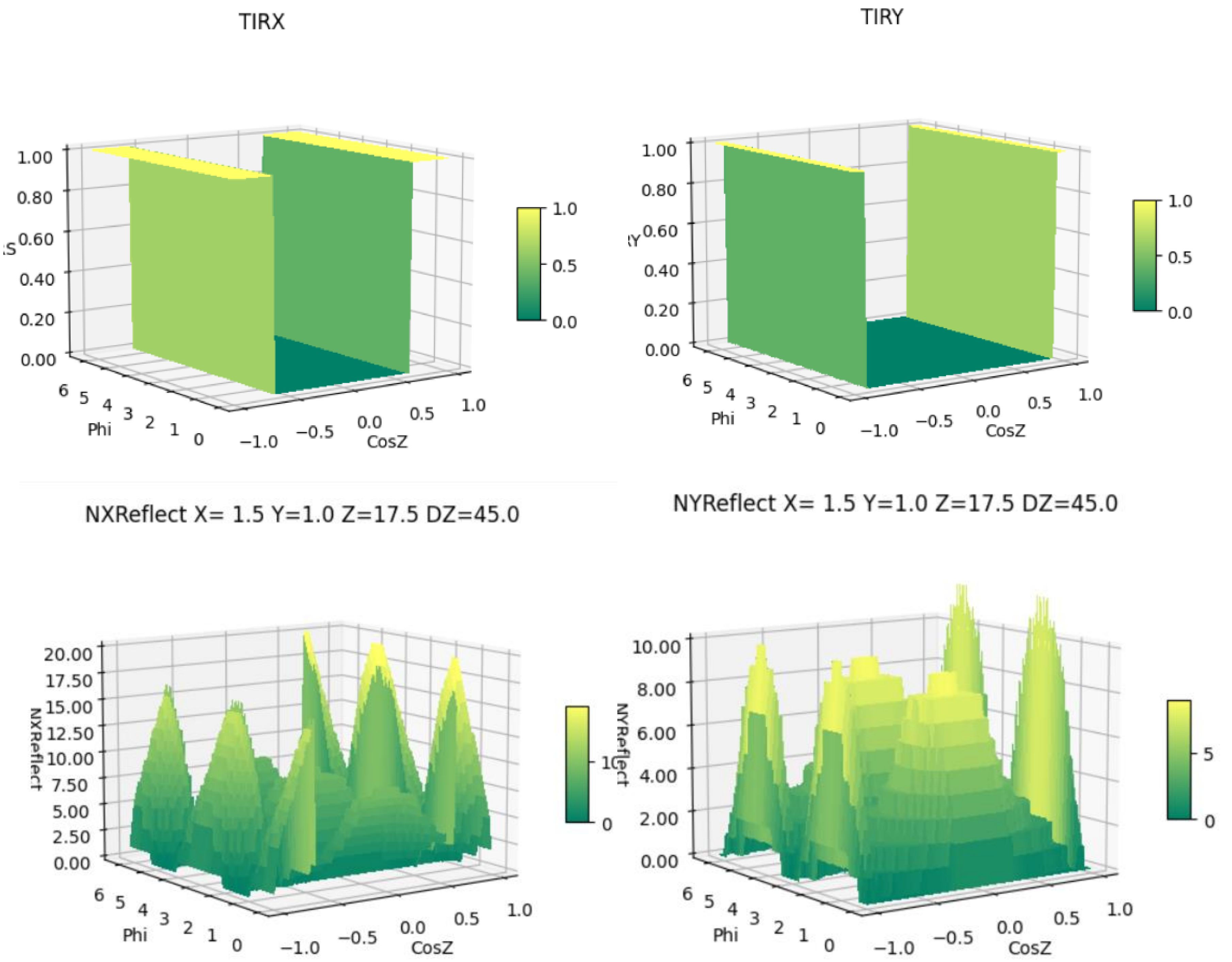
https://colab.research.google.com/github/BillWorstell/BaF2_LAPPD/blob/main/SimpleOpticsPhotons.ipynb

[z,t,vZ]|[DZ] -> [T]



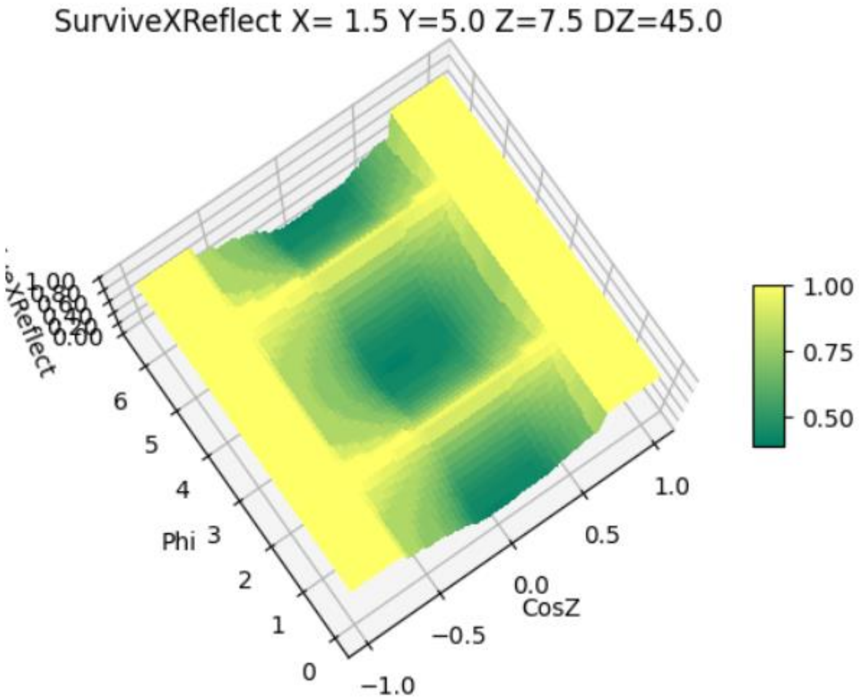


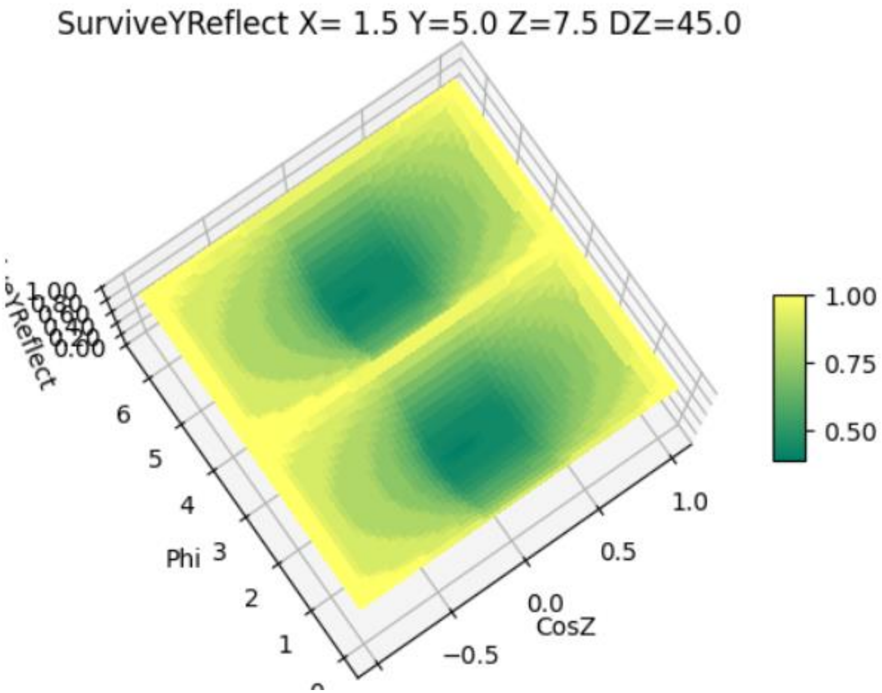
```
# Index of refraction for
optical barriers
#  (Air and LIOB=Laser
Induced Optical Barrier)
IndexX=1.0
IndexY=1.40
# Index of refraction for
fast and slow component
IndexFastBaF2=1.55
IndexSlowBaF2=1.50
# Reflectivity of mirrored
surfaces
ReflectX=0.90
ReflectY=0.90
ReflectZ=0.90

#Constant Geometry
Parameters
DZ = 45. #mm
DetectNX = 8
dX = 3.0  #mm
DX = DetectNX * dX
DetectNY = 12;
dY = 2.0; #mm
DY = DetectNY  * dY
```



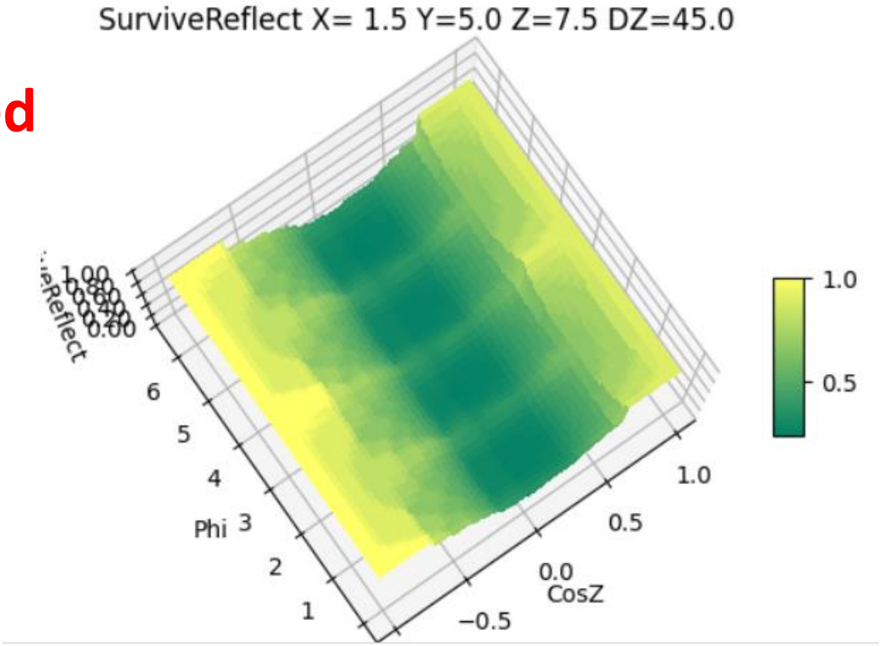
SimpleOpticsPhotons.ipynb

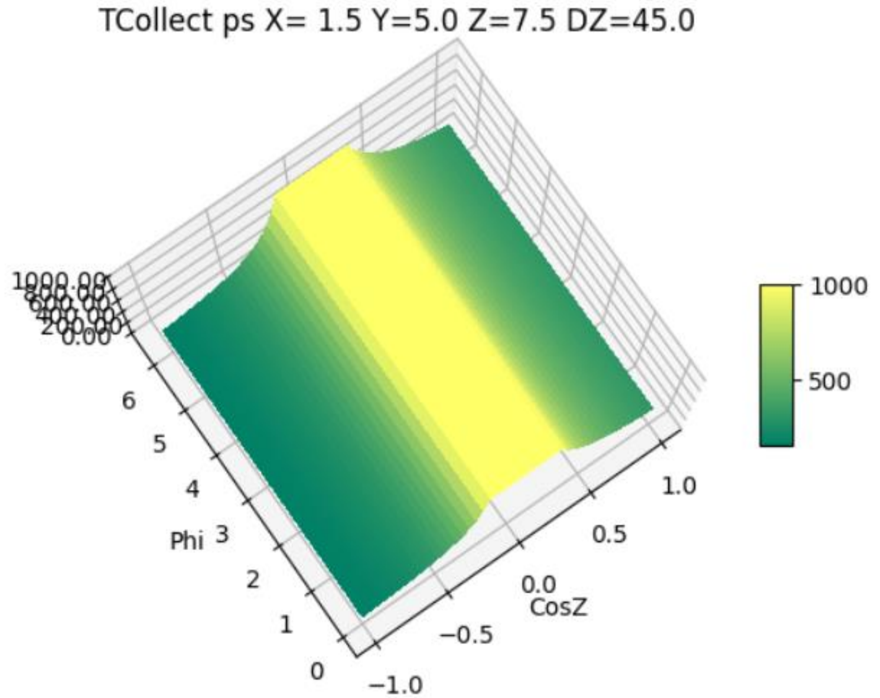
[x,y,z,t,Θ,Φ]|
[dX,DX,dy,DY,dz,DZ,
nx,ny,ηx,ηy] ->
collected T and
multiple reflection
survival probability





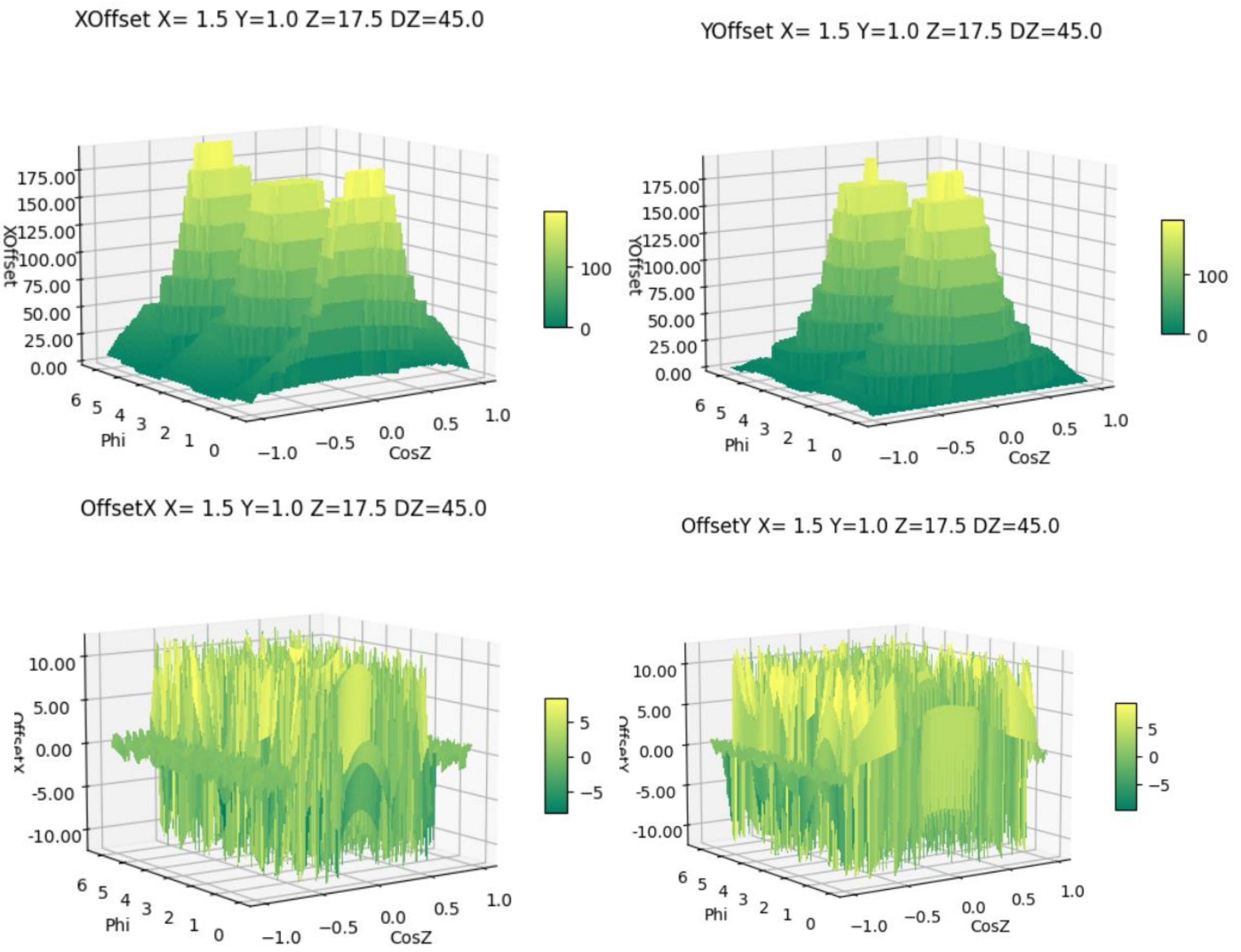
TCollect to be later convolved with emission time distribution and detector timing jitter distribution when randomly sampling (fast parallel in PyTorch)





SimpleOpticsPhotons.ipynb

[x,y,z,t,Θ,Φ] | [dX,DX,dy,DY,dz, DZ,nx,ny,ηx,ηy]-> detected [X,Y]



Find detection point in virtual detector within a reflected virtual unit cell, then map back onto real detection point within a real unit cell

Size of unit cell depends on total internal reflect or not

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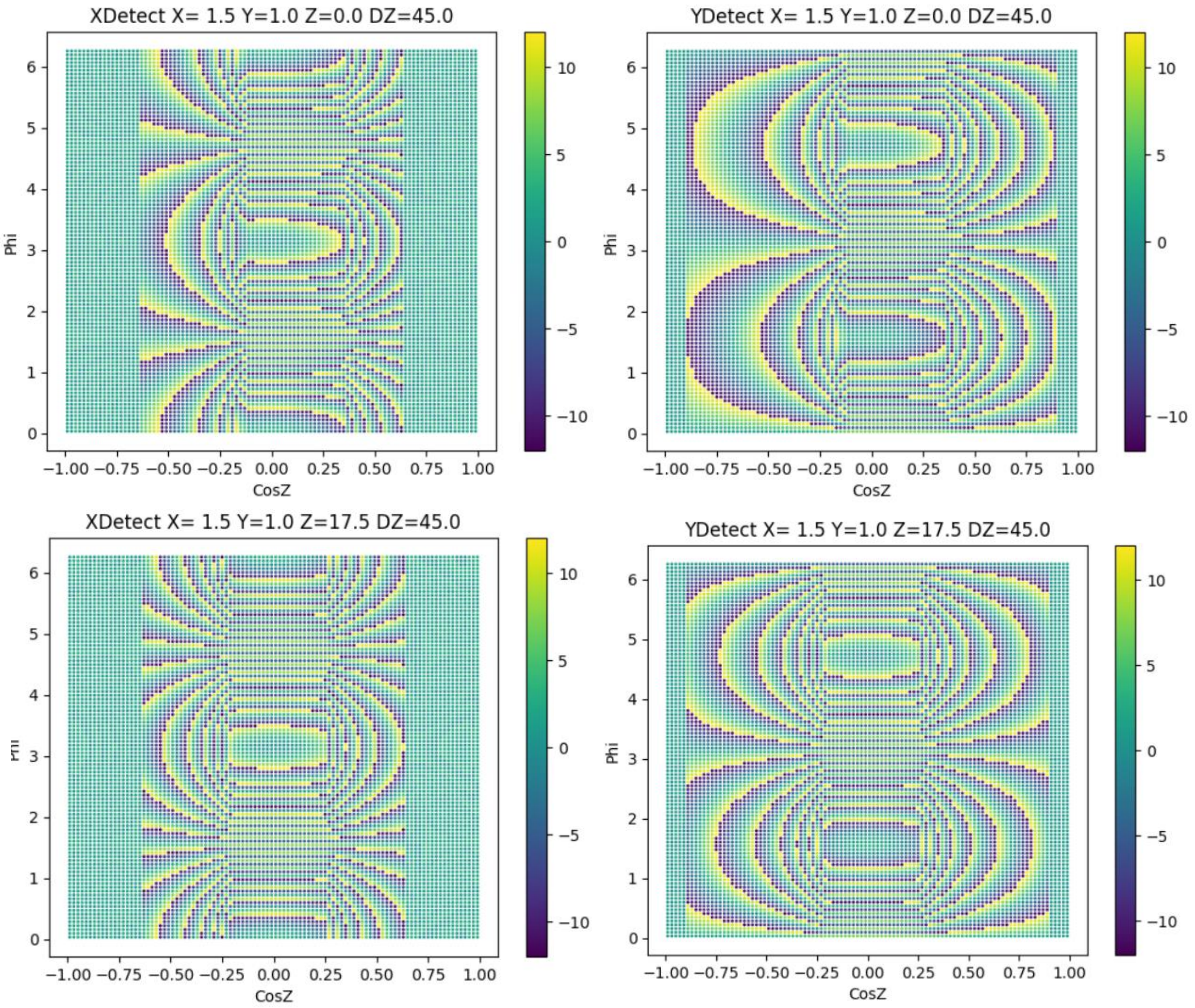

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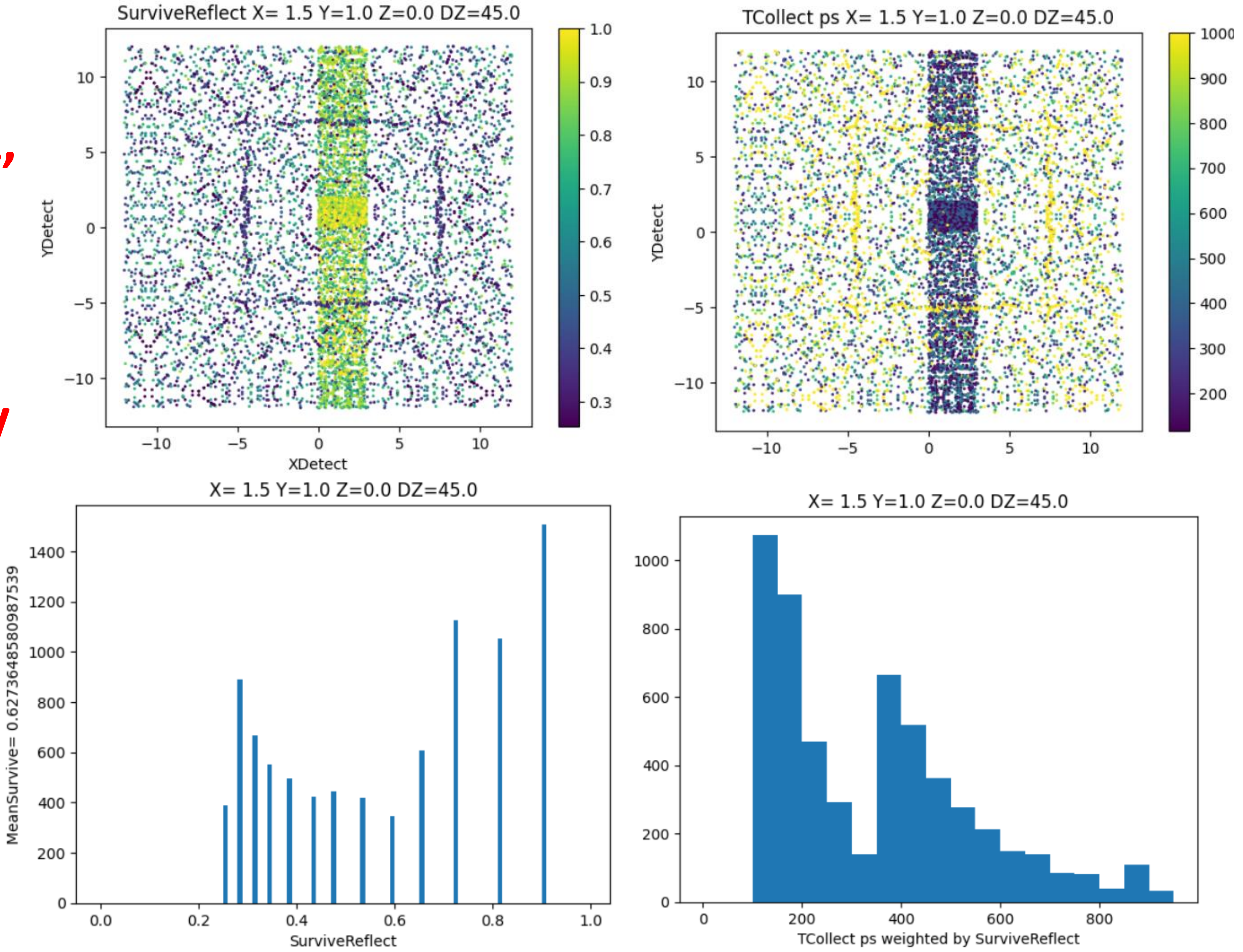
[X,Y] distribution
encodes [x,y]

T distribution
encodes t and Z



Z Scan:

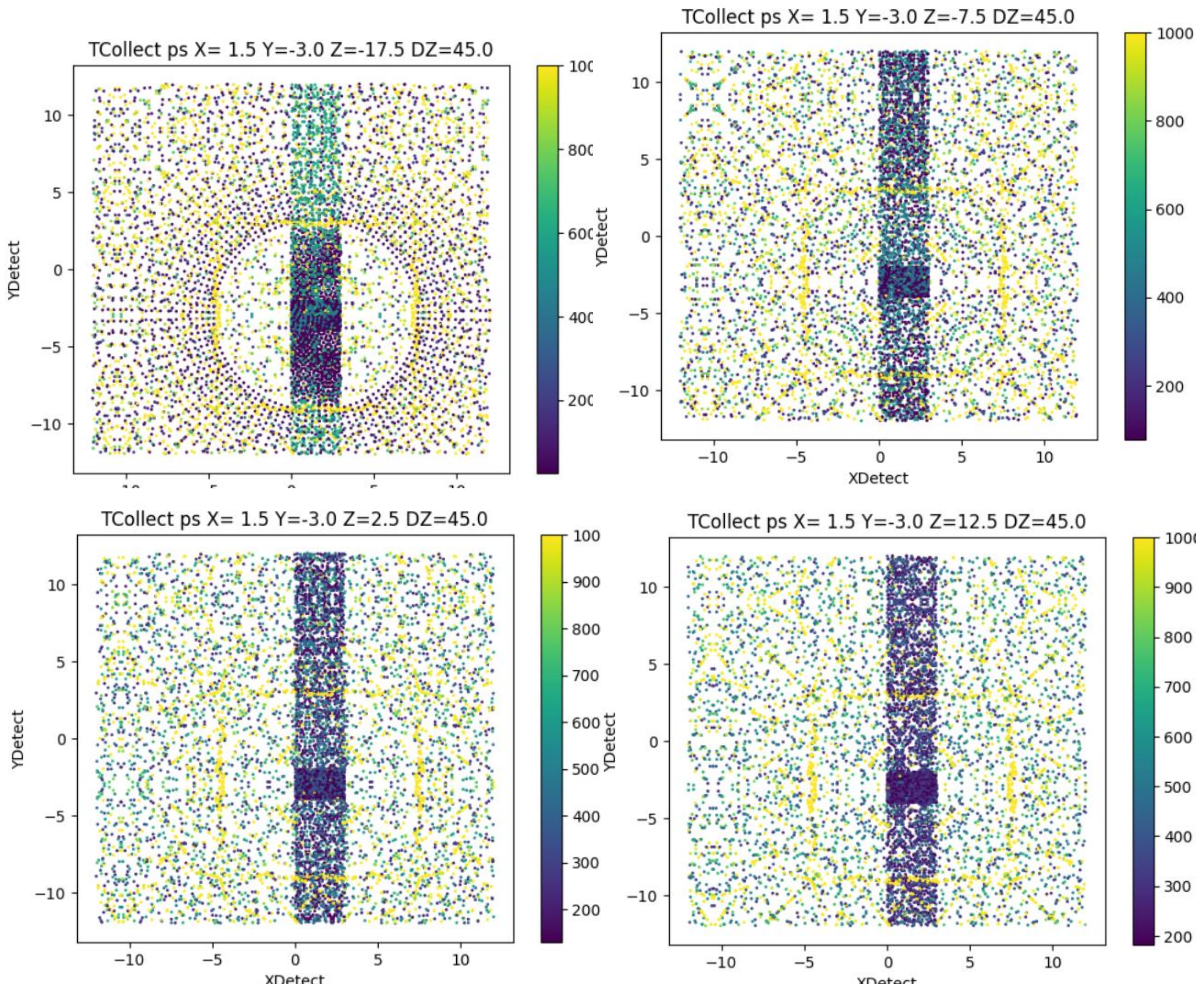
X=1.5

Y=3.0

Z=[-12.5, -7.5, 2.5, 12.5]

[X,Y] distribution encodes [x,y]

[X,Y] distribution independent of Z except very near low-Z end near photodetectors (fewest events)



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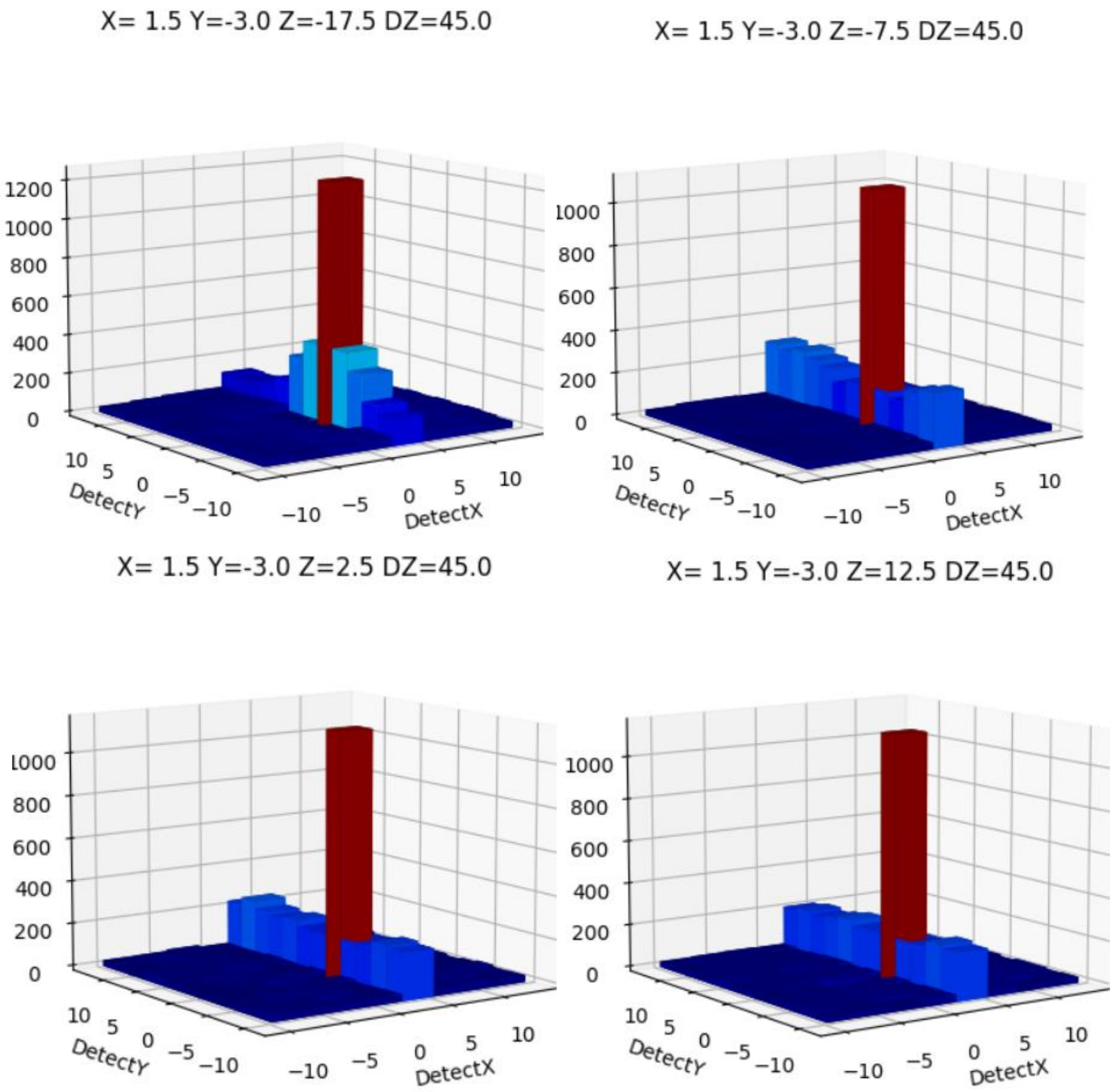

z Scan:
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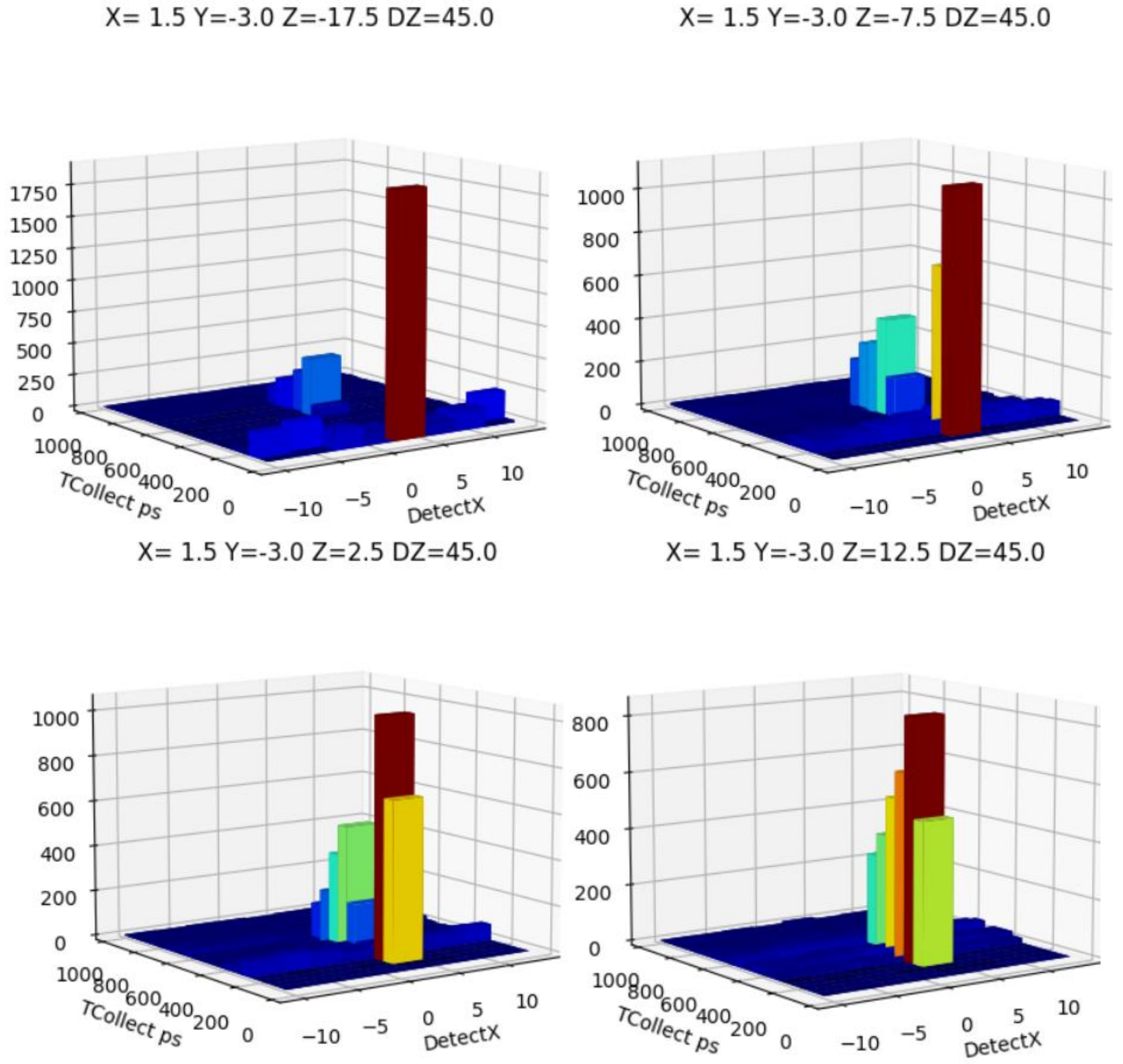
[T] distribution encodes [z,t]

[T] distribution at peak [X,Y] shows two peaks which move as a function of z, where the lower peak + z encodes t, while the separation between the peaks encodes z



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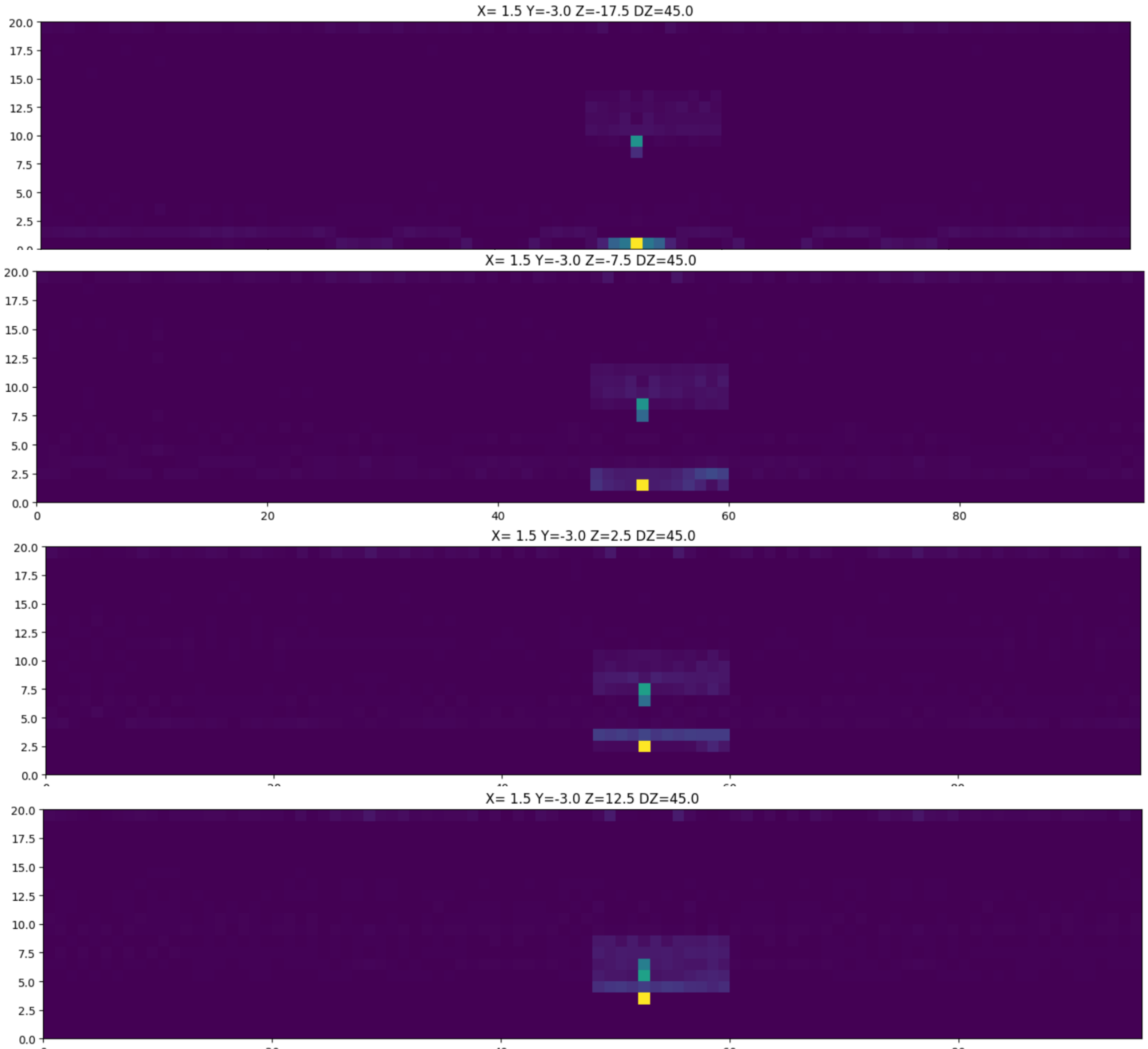


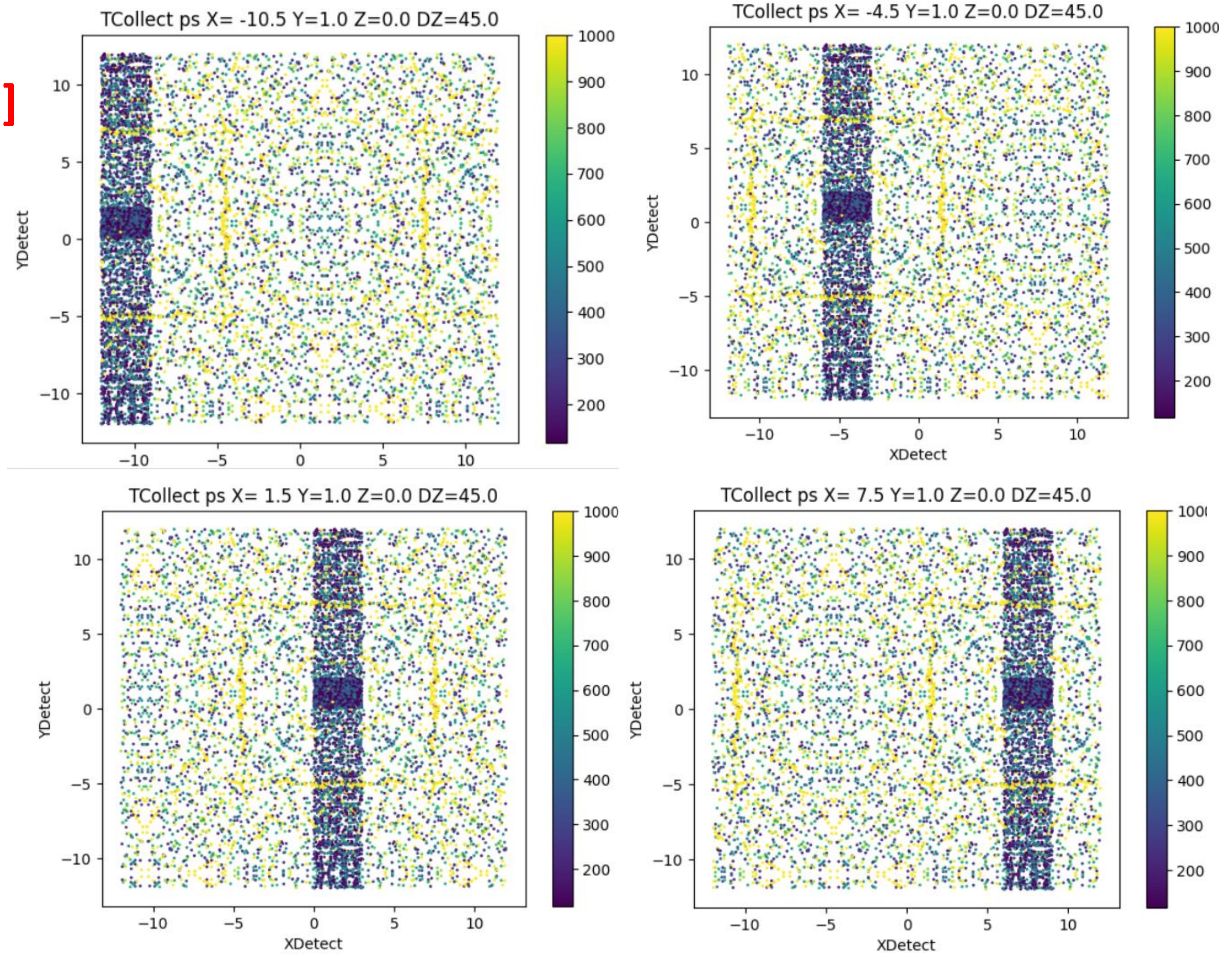
x Scan:

x=[-10.5, -4.5, 1.5, 7.5]

y=3.0

z =0.

[X,Y] distribution encodes [x,y]



[X,Y] distribution similar in Y but shifted in X according to x

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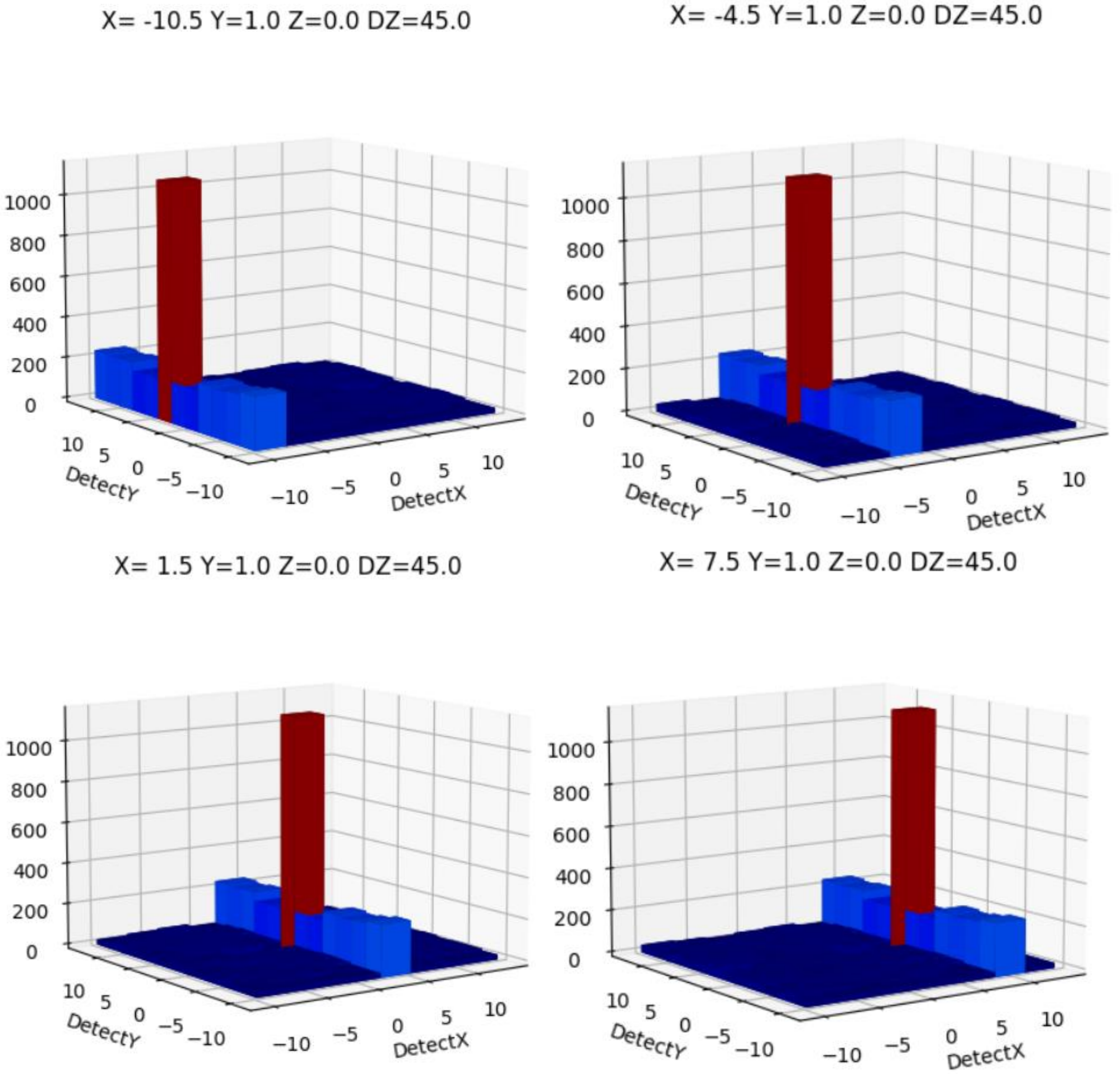

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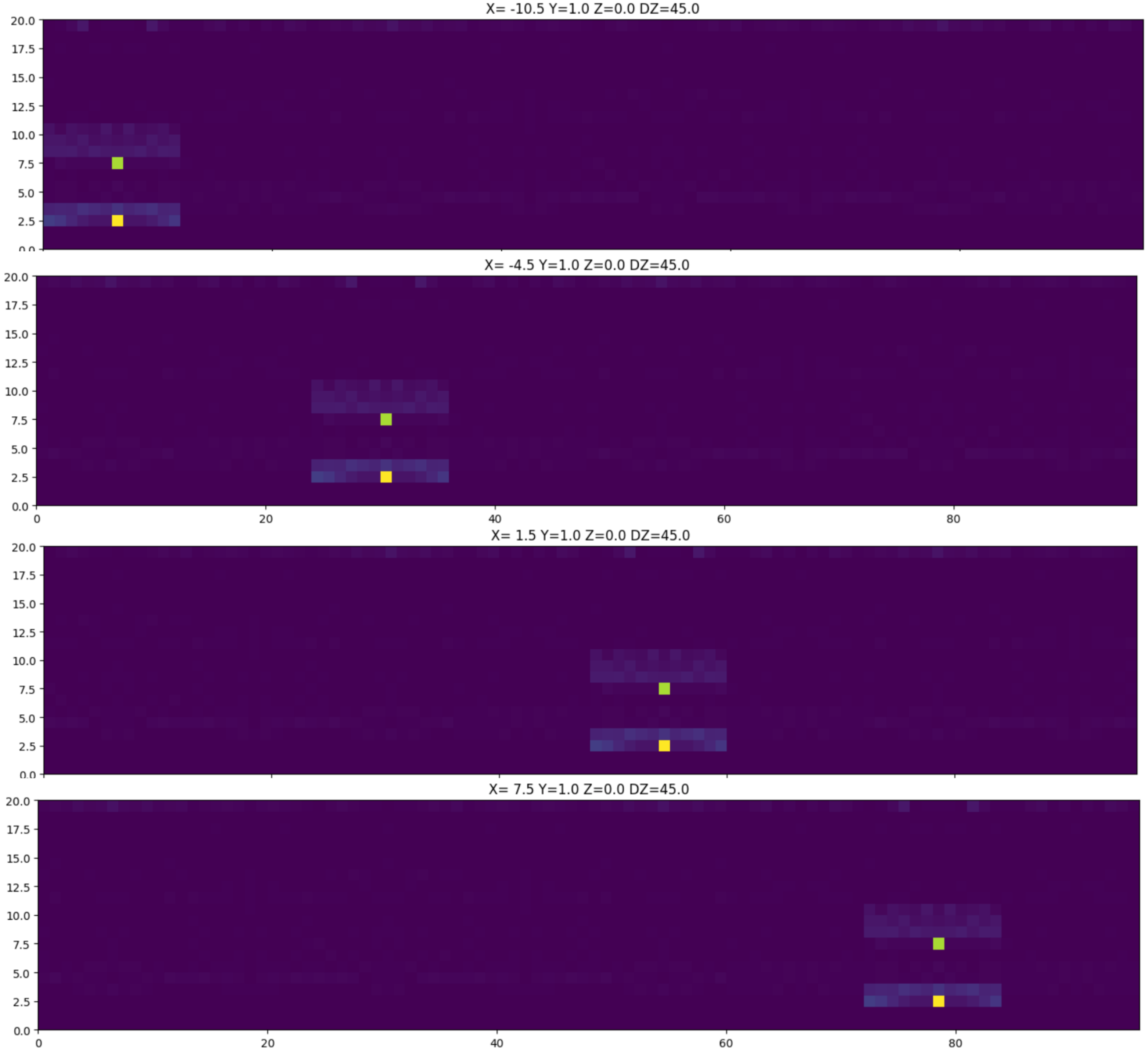


y Scan:

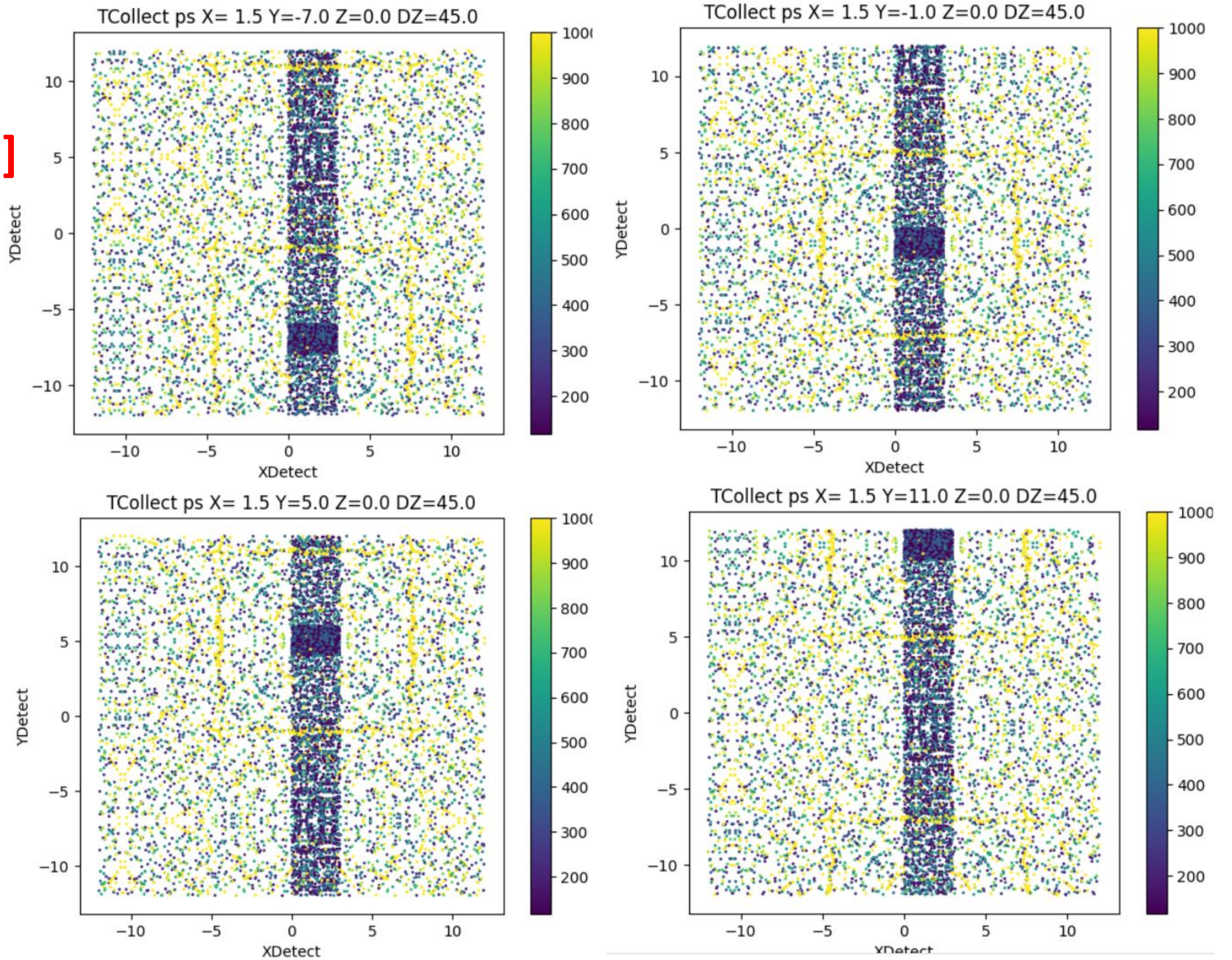
x=1.5

y =[-7.0, -1.0, 5.0, 11.0]

z =0.

[X,Y] distribution encodes [x,y]

[X,Y] distribution similar in X but shifted in Y according to y



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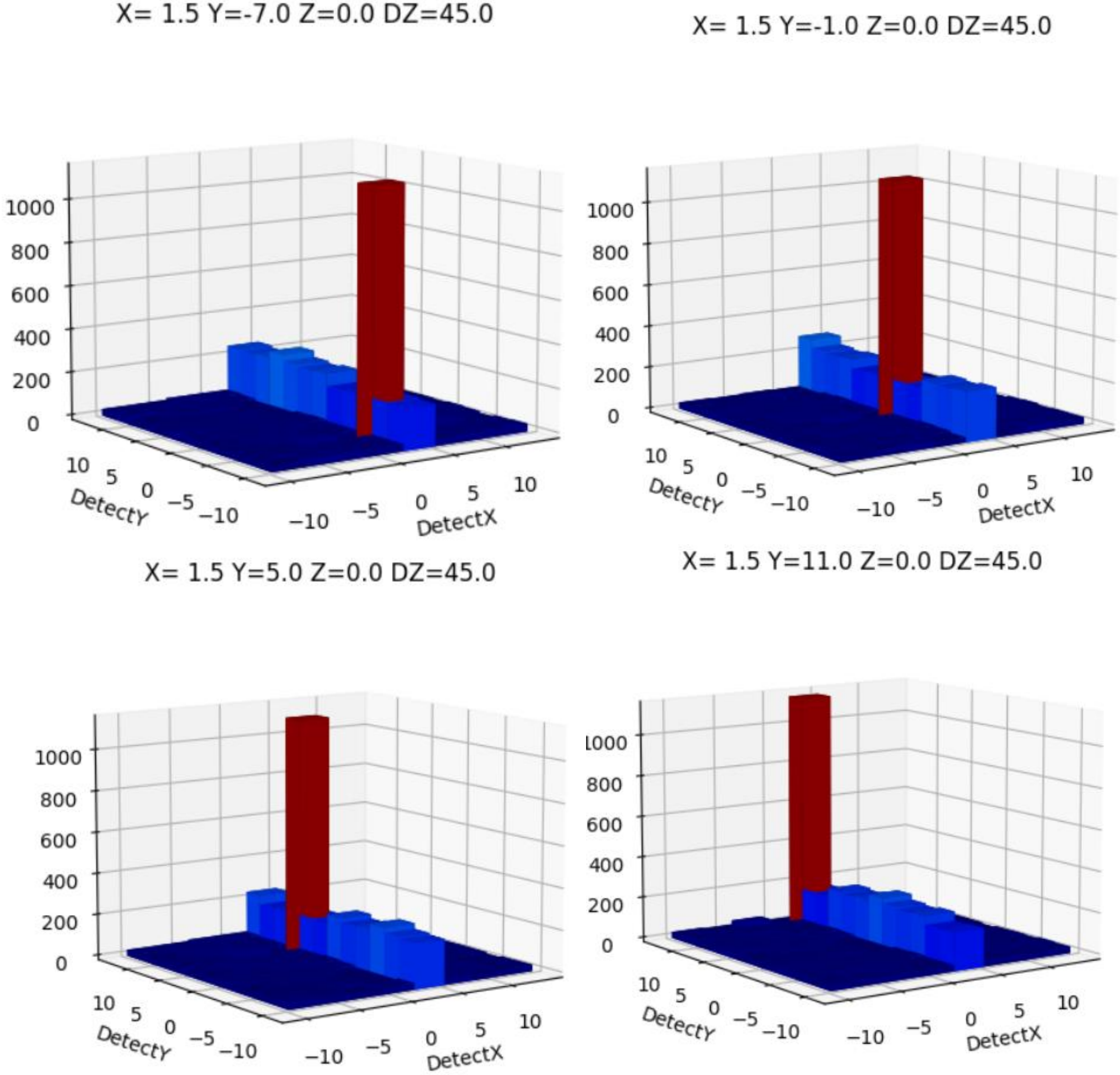

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