A Look into Far Detector Photon Rates

Caroline Zhang

Calibration Consortium Meeting

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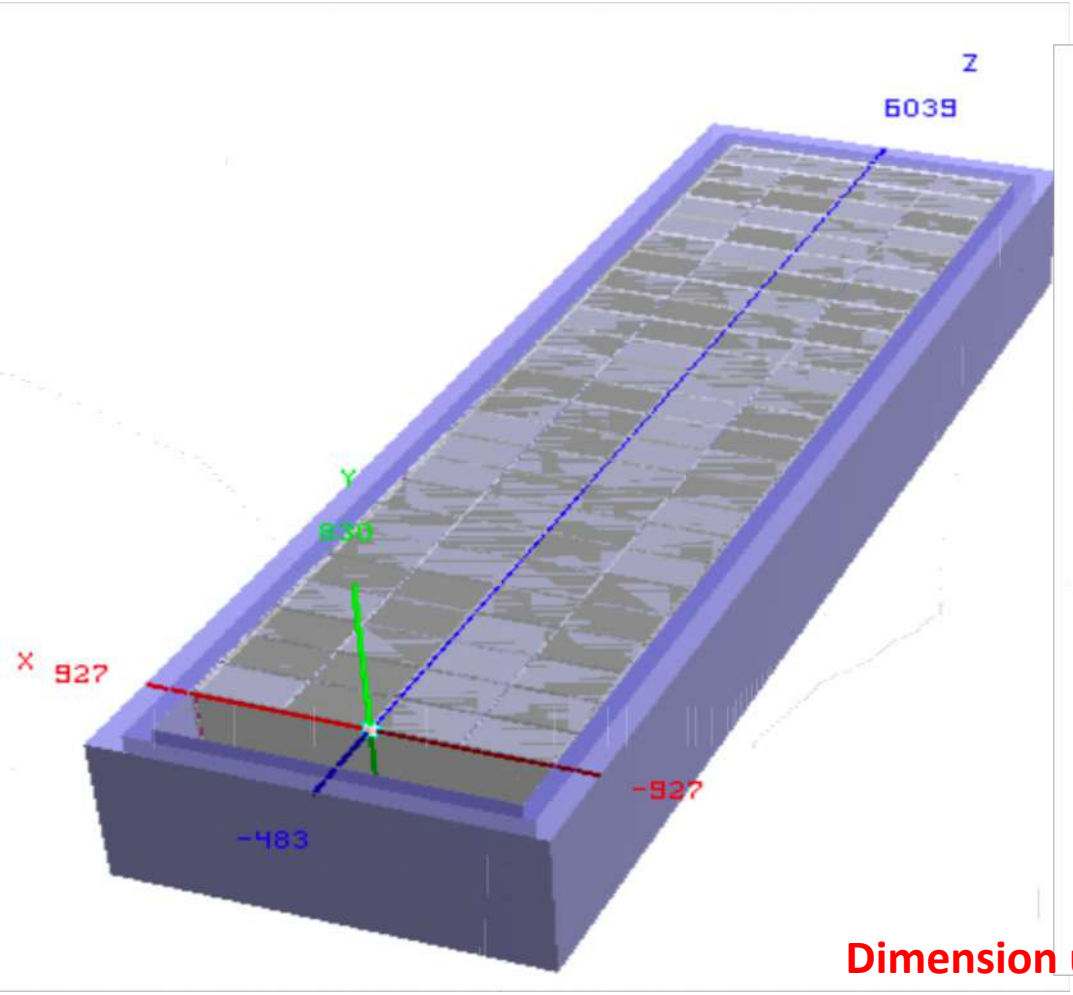
UNIVERSITY of HAWAI'I MĀNOA

Content

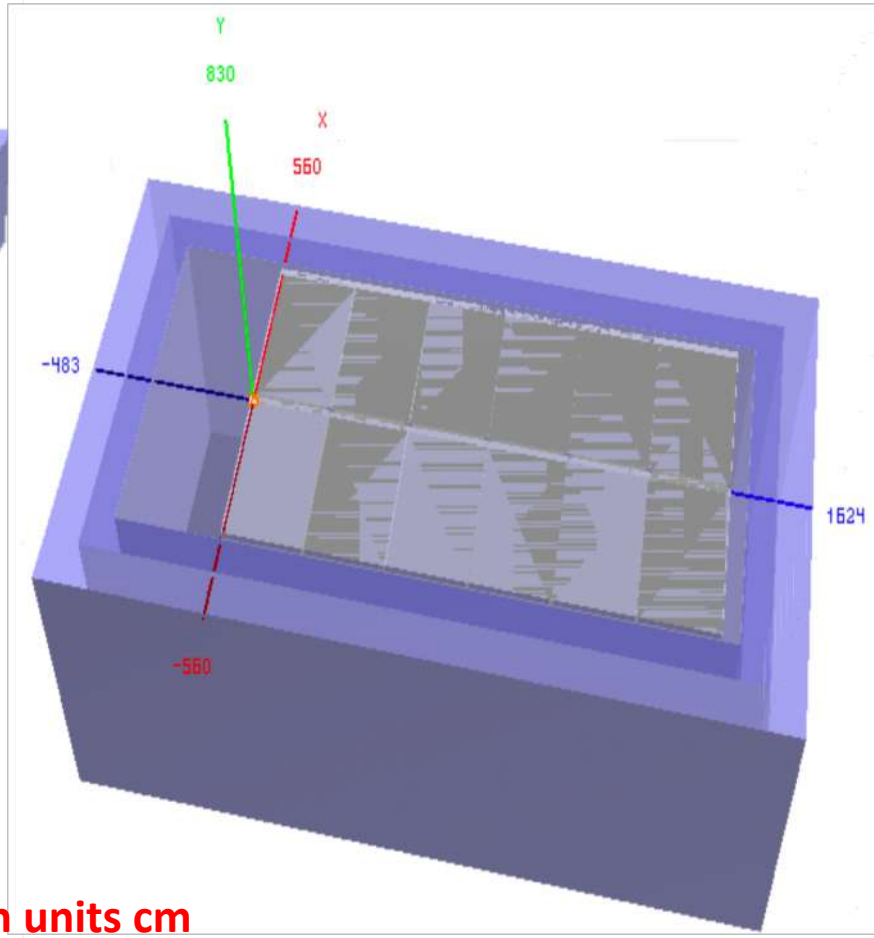
- Motivation
  - Estimate the effect of Ar scintillation light on photo-electric targets in order to understand the suitability of electron calibration using photo-electric effect
- DUNE Geometries
- PD Area Calculation
- Monte Carlo Sample Analysis
- Results
- Questions and Feedback

DUNE Geometries and Coordinates

- Entire FD



- 1x2x6



Dimension units cm

Workspace Definition in Geometry GDML Files

```
if ( ! defined $workspace )
{
    $workspace = 0;
    if ( ! defined $protoDune )
    {
        $protoDune = 0;
        print "\t\tCreating full geometry.\n";
    }
    elsif ( $protoDune == 1 )
    {
        print "\t\tCreating rough version of protoDUNE.\n";
    }
}
elsif ( $workspace == 1)
{
    print "\t\tCreating smaller (1x2x2-APA) workspace geometry.\n";
}
elsif ( $workspace == 2)
{
    print "\t\tCreating 1x2x6-APA geometry.\n";
}
```

```
if($workspace==1){
    $nAPAWide          =    1;
    $nAPALong          =    2;
}
elsif($workspace==2){
    $nAPAWide          =    1;
    $nAPALong          =    6;
}

$nAPAs                 =    $nAPAWide*$nAPAHigh*$nAPALong;
```

```
# dune10kt ~45 deg UV wires version
if($UVAngle45Option==1){
    $UAngle                =    45.7;
    $VAngle                =    44.3;
}

$nAPAWide                  =       3;
$nAPAHigh                  =       2;
$nAPALong                  =      25;

if($protoDune==1){
    $nAPAWide              =       2;
    $nAPAHigh              =       1;
    $nAPALong              =       3;
}
```

Definitions of 1x2x6 Geometry in the GDML Files

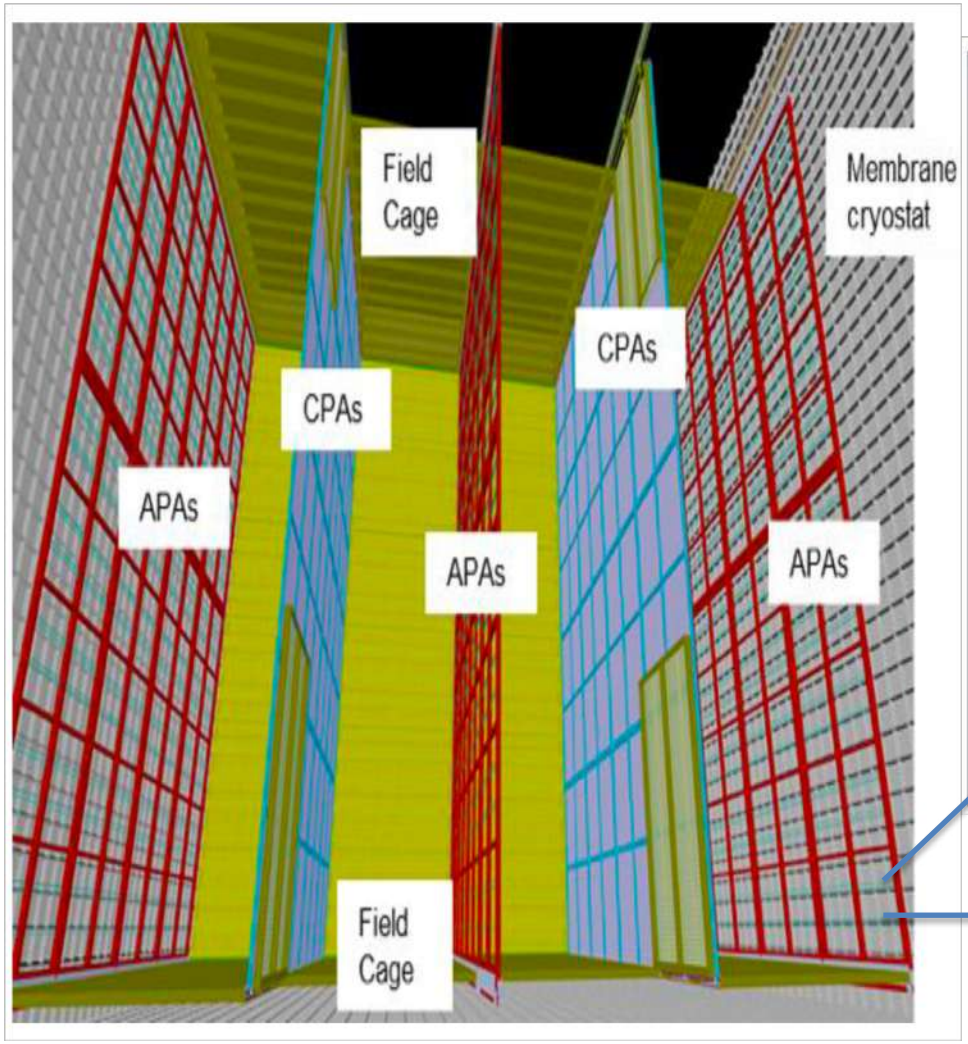
Photon Bars on APA

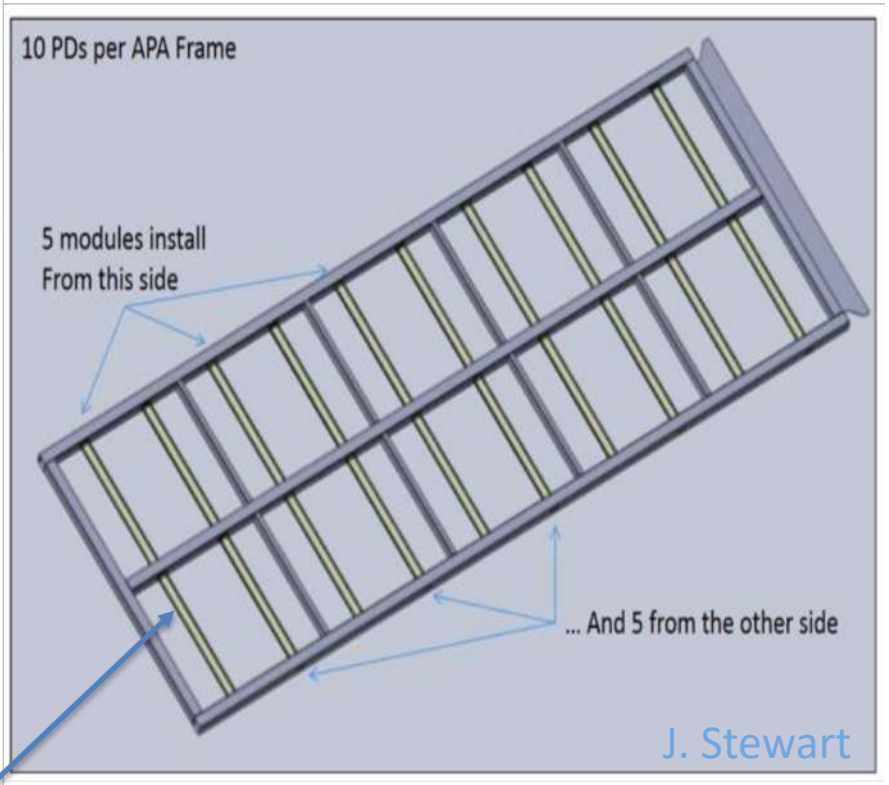
```
for($i=0 ; $i<$nAPAs ; $i++){
for($p=0 ; $p<10 ; $p++){
print CRYO <<EOF;
    <volume name="volOpDetSensitive_$i\-$p">
      <materialref ref="Acrylic"/>
      <solidref ref="LightPaddle"/>
    </volume>
EOF
}
}
```

```
<volume name="volOpDetSensitive_0-0">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-1">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-2">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-3">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-4">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-5">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-6">
  <materialref ref="Acrylic"/>
  <solidref ref="LightPaddle"/>
</volume>
<volume name="volOpDetSensitive_0-7">
  <materialref ref="Acrylic"/>
```

- Each APA has 10 Photon Bars and
  - there are 1x2x6=12 APAs
  - meaning 120 Photon bars

Photon Bars on APA





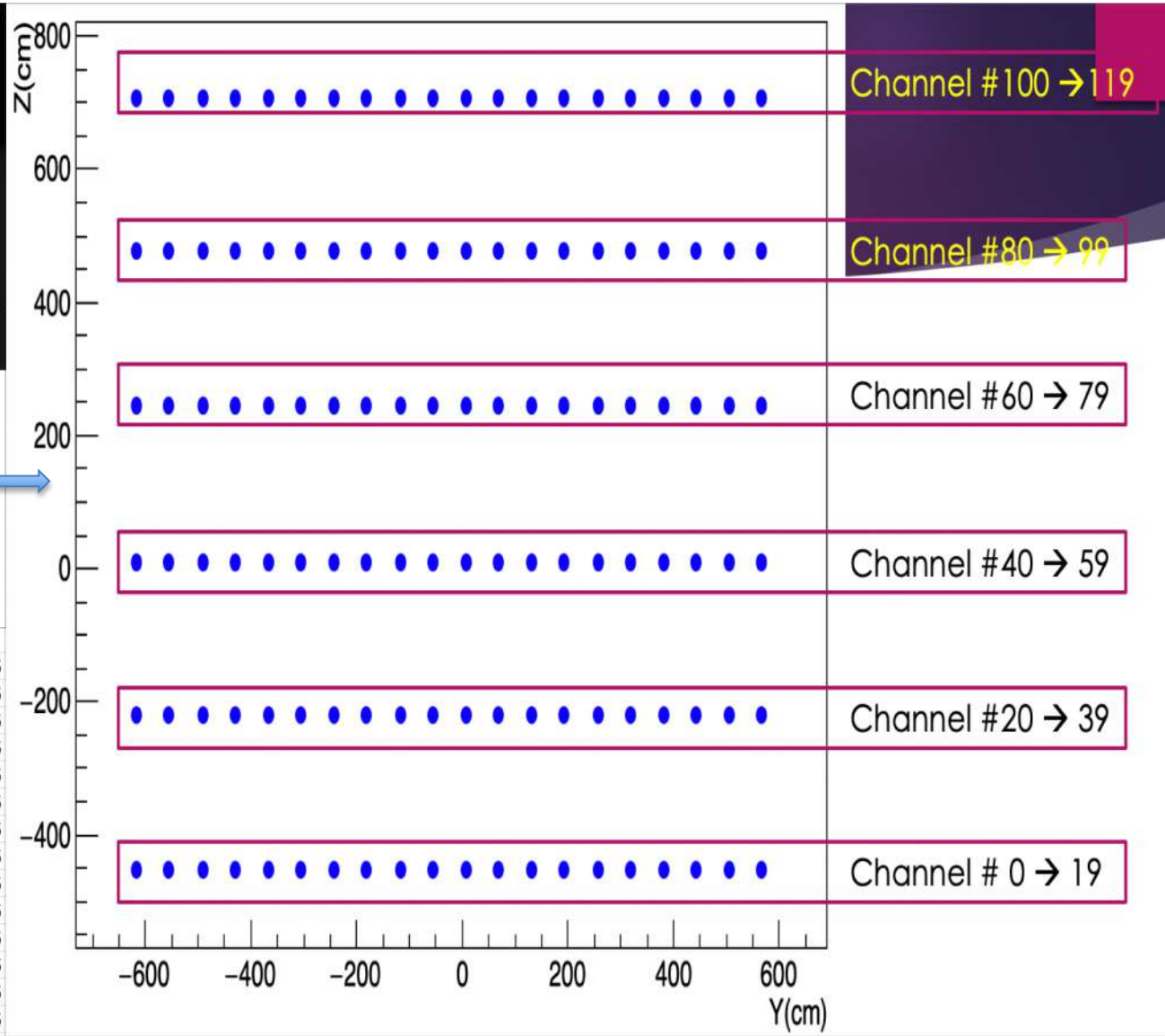
PD bars

Mapping Channel locations

```
<volumeref ref="volOpDetSensitive_5-0"/>
<position name="posPaddle-0-TPC-12-1-2" unit="cm"
  x="0"
  y="10.4283552631578"
  z="9.805"/>
<rotationref ref="rIdentity"/>
</physvol>
<physvol>
<volumeref ref="volOpDetSensitive_5-1"/>
<position name="posPaddle-1-TPC-12-1-2" unit="cm"
  x="0"
  y="72.7850657894736"
  z="9.805"/>
<rotationref ref="rPlus180AboutY"/>
</physvol>
<physvol>
<volumeref ref="volOpDetSensitive_5-2"/>
<position name="posPaddle-2-TPC-12-1-2" unit="cm"
  x="0"
  y="135.141776315789"
  z="9.805"/>
```

.gdml → .txt/chart

APA #	PD Bar #	Channel #	X(cm)	Y(cm)	Z(cm)
0	0	0	0	-613.13875	-454.975
0	1	1	0	-550.78204	-454.975
0	2	2	0	-488.42533	-454.975
0	3	3	0	-426.06862	-454.975
0	4	4	0	-363.71191	-454.975
0	5	5	0	-301.3552	-454.975
0	6	6	0	-238.99849	-454.975
0	7	7	0	-176.64178	-454.975
0	8	8	0	-114.28507	-454.975
0	9	9	0	-51.928355	-454.975
1	0	10	0	10.4283553	-454.975
1	1	11	0	72.7850658	-454.975
1	2	12	0	135.141776	-454.975
1	3	13	0	197.498487	-454.975

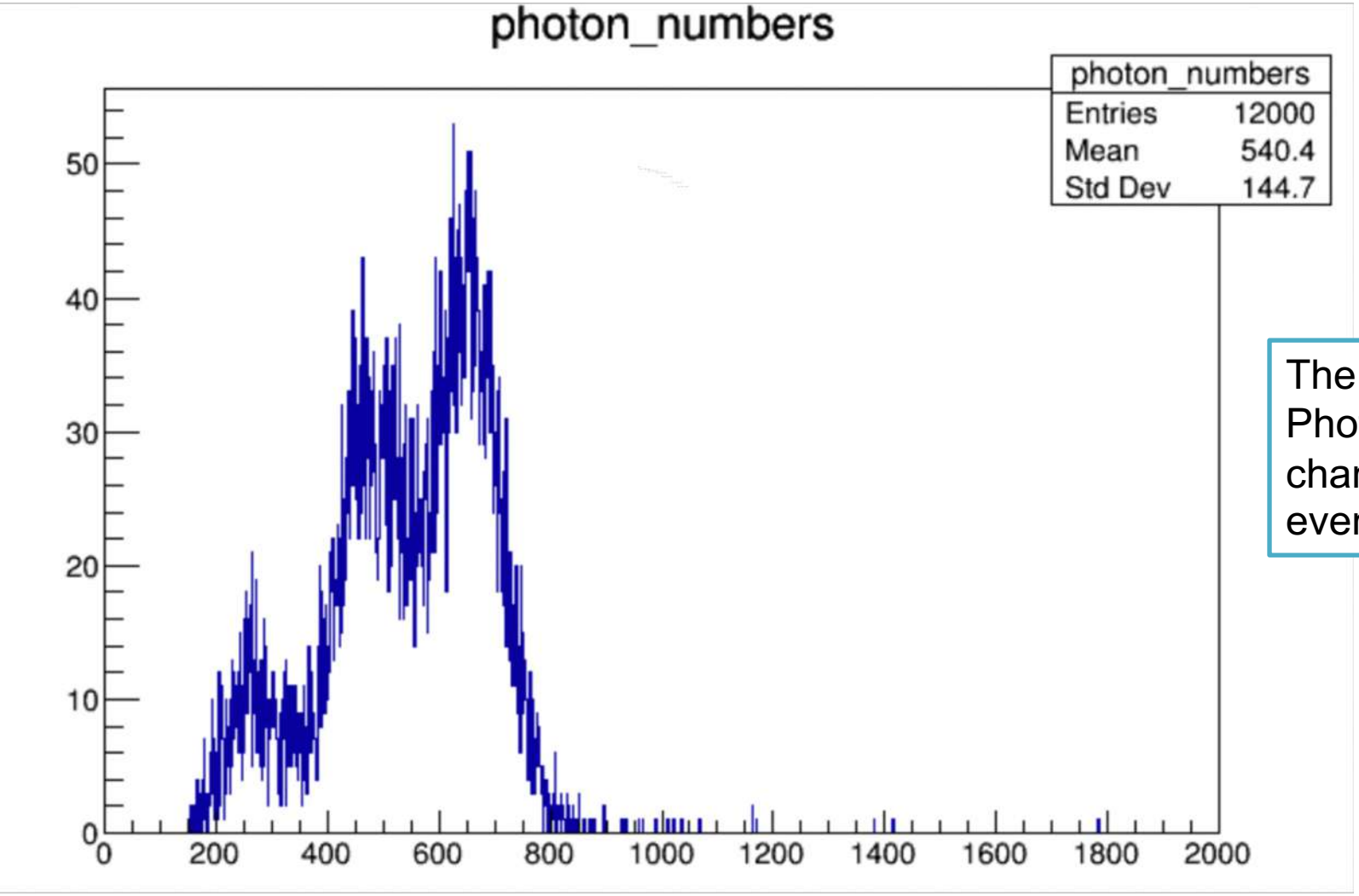


Current PD Simulation only has1x2x6 Analyzed all the 100 events I have

```
OpDet XXXXX98 had 399 photons.
OpDet XXXXX99 had 206 photons.
OpDet XXXXX100 had 230 photons.
OpDet XXXXX101 had 349 photons.
OpDet XXXXX102 had 410 photons.
OpDet XXXXX103 had 534 photons.
OpDet XXXXX104 had 410 photons.
OpDet XXXXX105 had 531 photons.
OpDet XXXXX106 had 508 photons.
OpDet XXXXX107 had 503 photons.
OpDet XXXXX108 had 452 photons.
OpDet XXXXX109 had 526 photons.
OpDet XXXXX110 had 481 photons.
OpDet XXXXX111 had 621 photons.
OpDet XXXXX112 had 464 photons.
OpDet XXXXX113 had 575 photons.
OpDet XXXXX114 had 481 photons.
OpDet XXXXX115 had 501 photons.
OpDet XXXXX116 had 411 photons.
OpDet XXXXX117 had 436 photons.
OpDet XXXXX118 had 309 photons.
OpDet XXXXX119 had 208 photons.
```

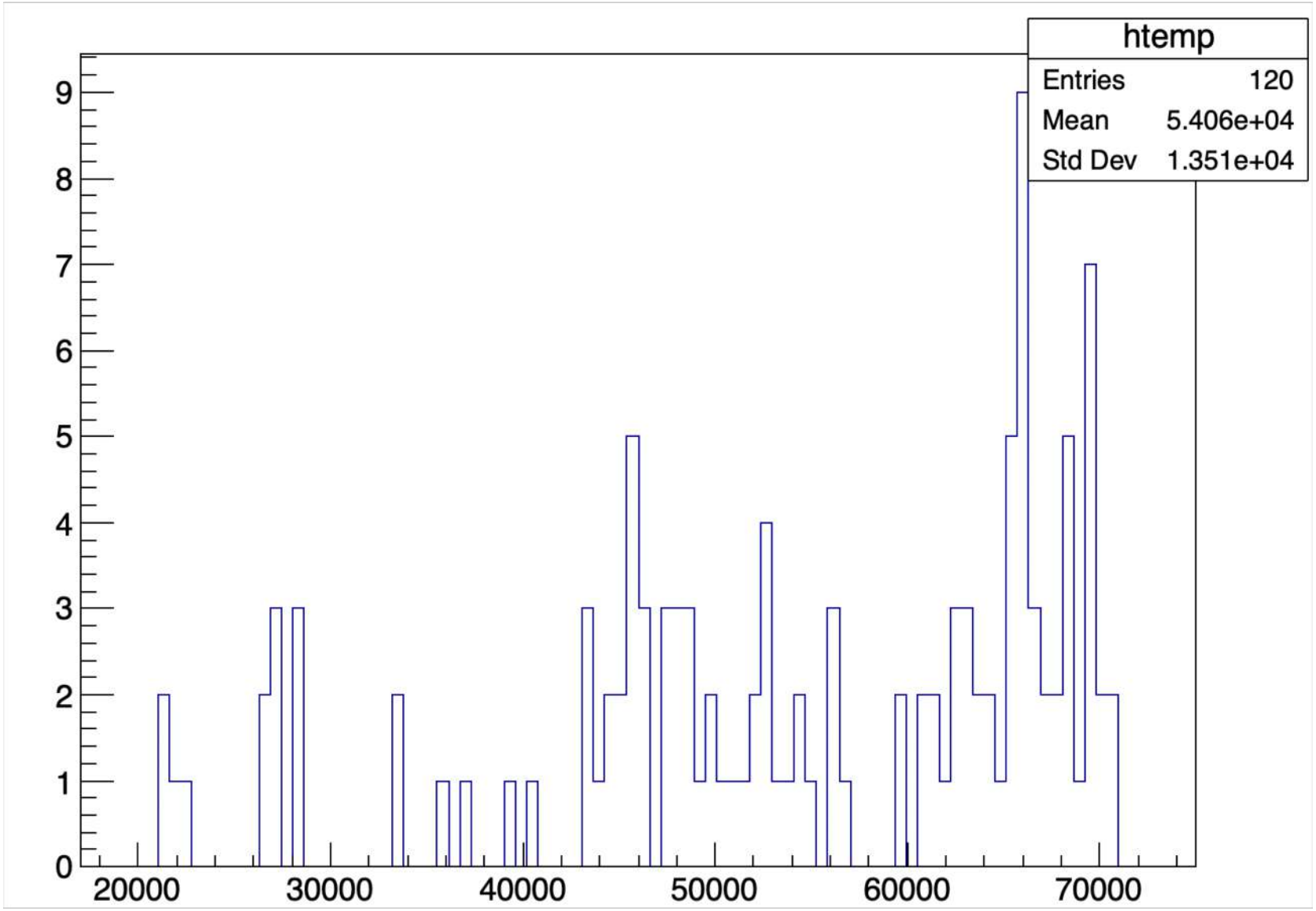
```
#readlines.C#     output24.txt  output44.txt  output64.txt  output84.txt
#voltage.txt#     output25.txt  output45.txt  output65.txt  output85.txt
1001stchannel.C   output26.txt  output46.txt  output66.txt  output86.txt
count_photons.C   output27.txt  output47.txt  output67.txt  output87.txt
count_photons.C~  output28.txt  output48.txt  output68.txt  output88.txt
output1.txt       output29.txt  output49.txt  output69.txt  output89.txt
output10.txt      output3.txt   output5.txt   output7.txt   output9.txt
output100.txt     output30.txt  output50.txt  output70.txt  output90.txt
output11.txt      output31.txt  output51.txt  output71.txt  output91.txt
output12.txt      output32.txt  output52.txt  output72.txt  output92.txt
output13.txt      output33.txt  output53.txt  output73.txt  output93.txt
output14.txt      output34.txt  output54.txt  output74.txt  output94.txt
output15.txt      output35.txt  output55.txt  output75.txt  output95.txt
output16.txt      output36.txt  output56.txt  output76.txt  output96.txt
output17.txt      output37.txt  output57.txt  output77.txt  output97.txt
output18.txt      output38.txt  output58.txt  output78.txt  output98.txt
output19.txt      output39.txt  output59.txt  output79.txt  output99.txt
output2.txt       output4.txt   output6.txt   output8.txt   readlines.C
output20.txt      output40.txt  output60.txt  output80.txt  readlines.C~
output21.txt      output41.txt  output61.txt  output81.txt  voltage.txt
output22.txt      output42.txt  output62.txt  output82.txt
output23.txt      output43.txt  output63.txt  output83.txt
```

Photon Counts of 100 events x 120 channels/event



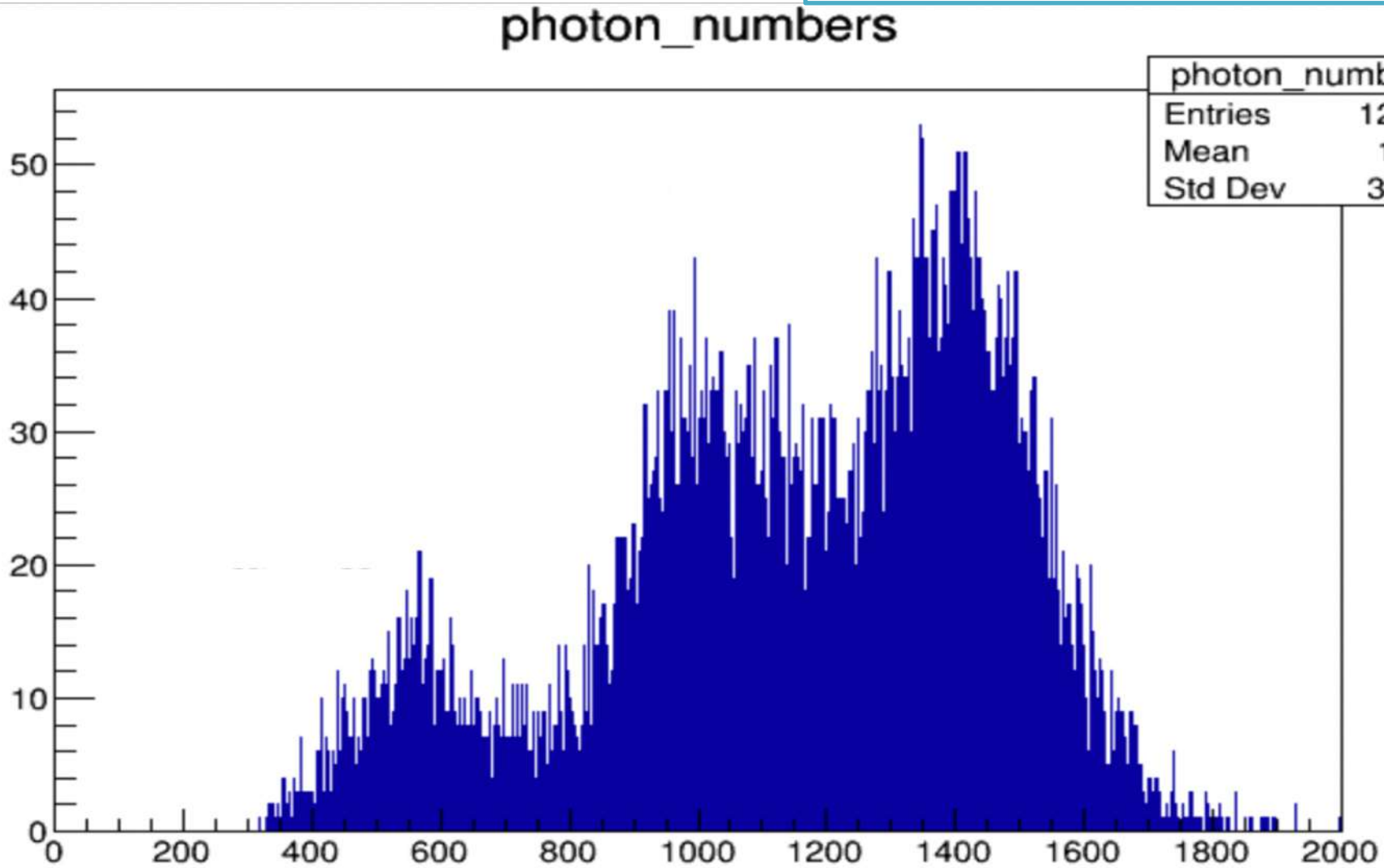
The mean of Photon Hits per channel per event is 540.4

Sum 100 events for each channel (120 total)



Photons counts with Attenuation Effect Removed

The average attenuation is 0.4642



Calculate PD bar area from the gdml file

```
##########################################################
#####################  Paddle Dimensions ##################

$APAFrameZSide_y = 4*$inch;
$APAFrameYSide_z = 4*$inch;
$LightPaddle_x          =   0.476;
$LightPaddle_y          =   4*$inch;
$LightPaddle_z          =   $APAFrame_z - 2*$APAFrameYSide_z;
$nLightPaddlesPerAPA    =   10;   # 10, or 20 for double coverage (for now)
$PaddleYInterval        =   (2*$APAphys_y+$APAGap_y-$LightPaddle_y-2*$APAFrameZSide_y)
                           /(2*$nLightPaddlesPerAPA-1);
$FrameToPaddleSpace     =   ($PaddleYInterval-$APAGap_y)/2;

$SiPM_z                 =   0;

                        $APAFrame_z  = 231.59 - 2*(2*$G10thickness+$WrapCover);
$inch = 2.54;           $G10thickness = $inch/8;
                        $WrapCover    = $inch/16;
```

meaning:

- Paddle_y = 4x2.54 = 10.16 cm
- APAFrame_z = 230.0025 cm
- Paddle_z = 230.0025 – 2x4x2.54
  - =209.6825cm
- Paddle_Area= Paddle y x z =

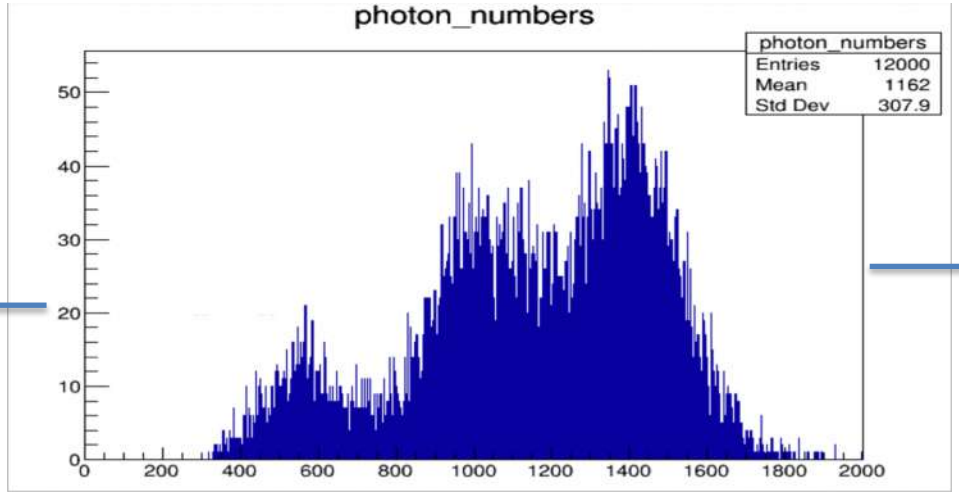
2130.3742 cm^2

Photon Rate Calculation

The length of the time window per event :

4.492 ms

```
T0:                [ -2246000 ]
T1:                [  2246000. ] # ending time in ns
```

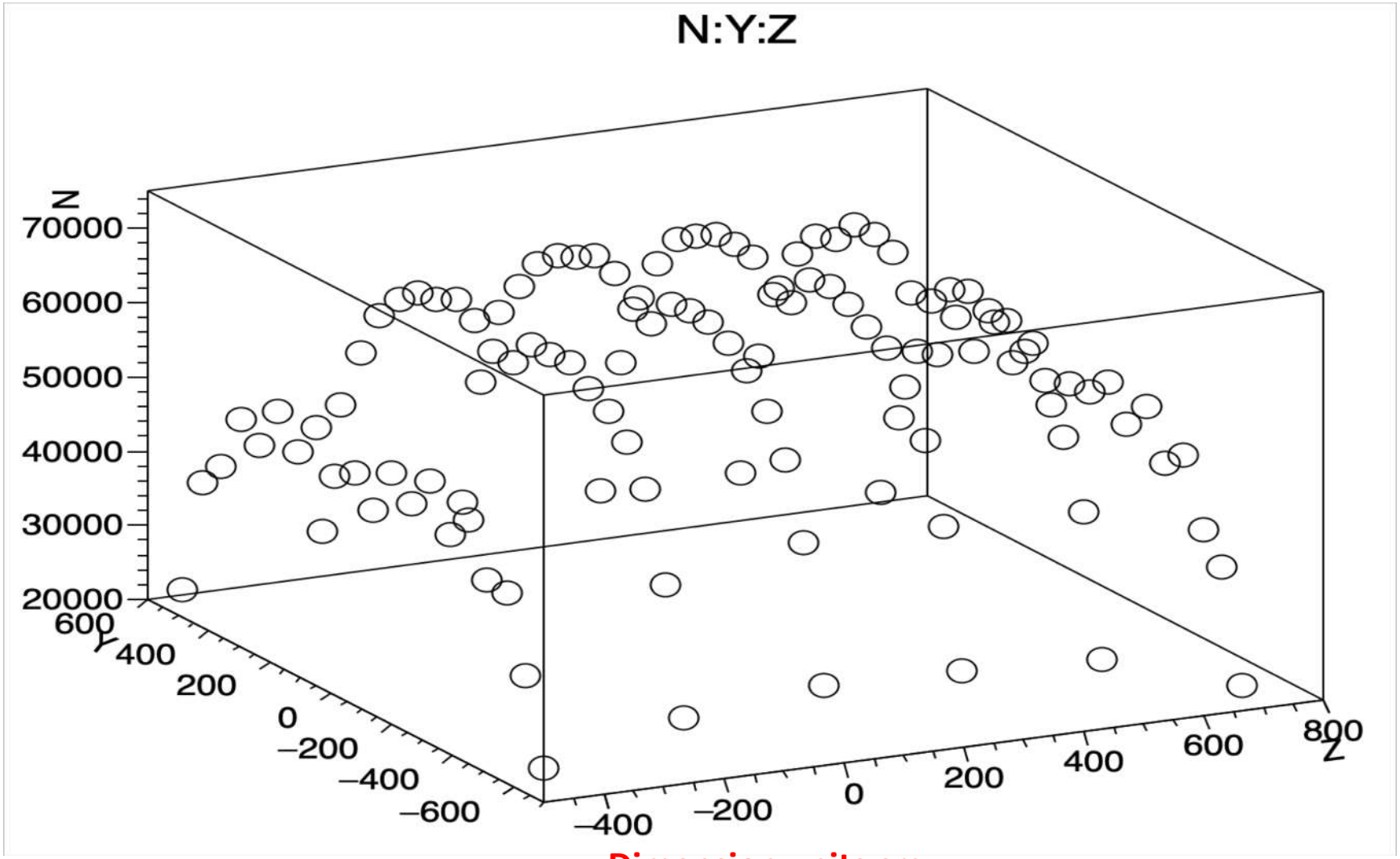


Mean: 1162
Maximum: 2000
Center of the 3rd peak :1400

N_photons	Area (cm^2)	Time window Length(ms)	Per Area(cm^2) Per event time window	Per Area (cm^2) Per ms
2000	2130.3742	4.492	0.938802207	0.208994258
1400			0.657161545	0.146295981
1162			0.545444082	0.121425664

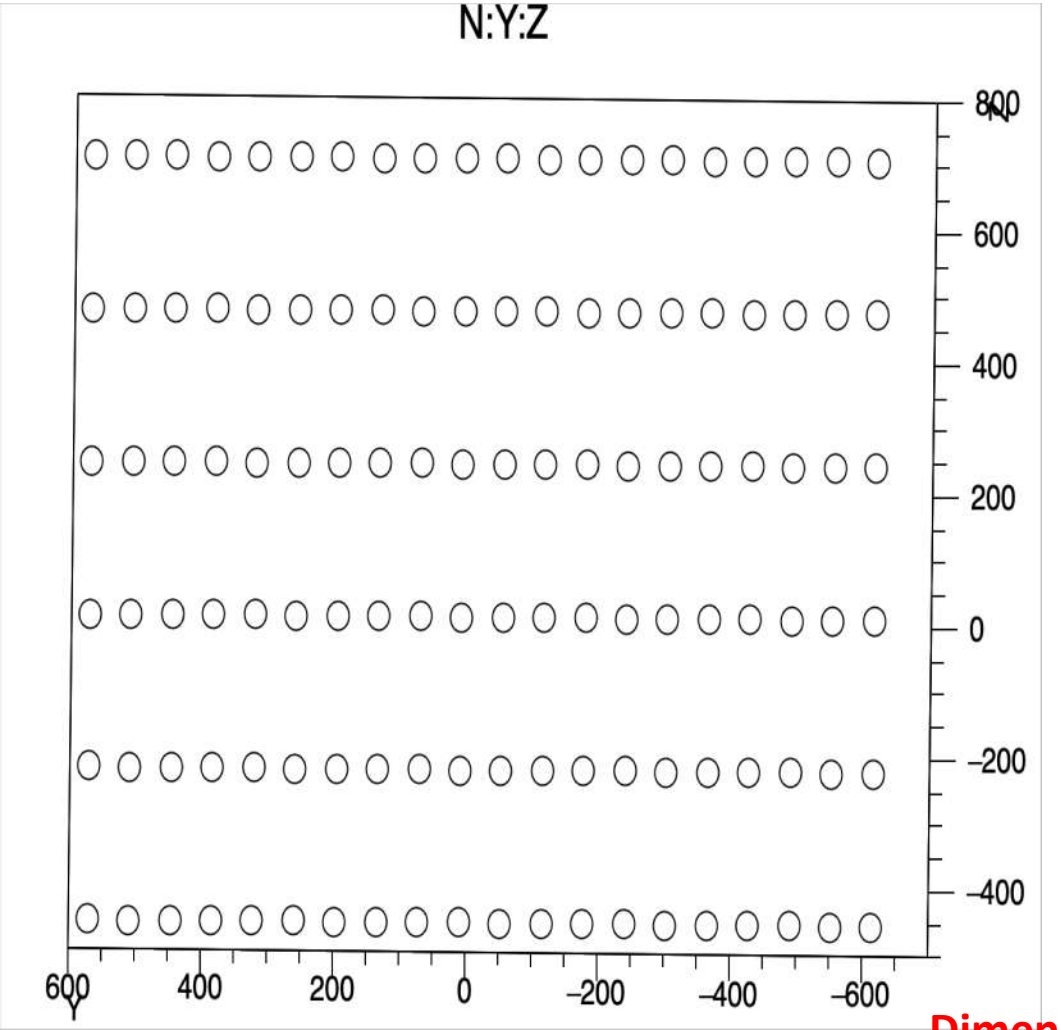
The average photon rates is therefore 0.146 photons per cm^2 per ms

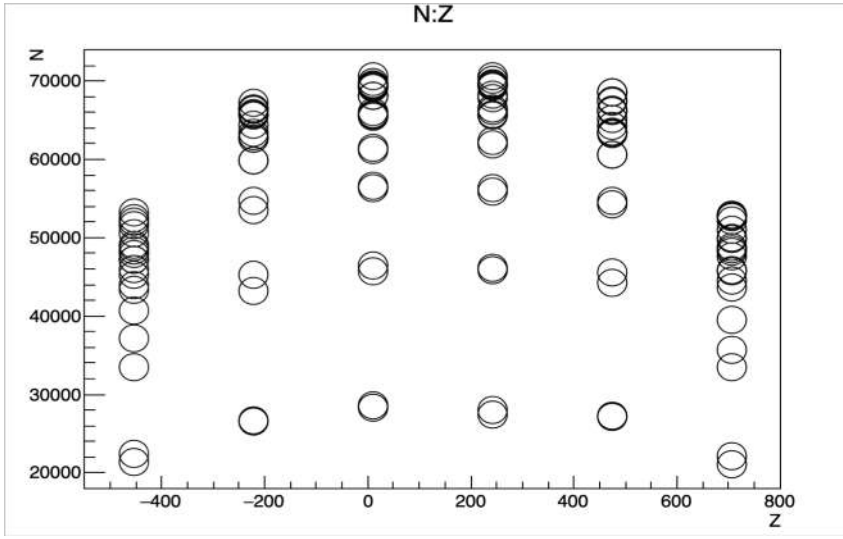
Photon Counts (N) across the entire APA Plate

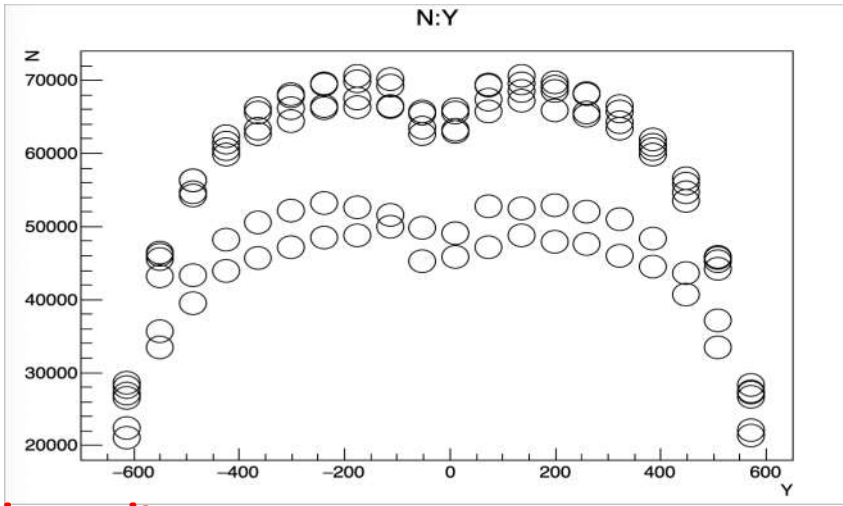


Dimension units cm

Distribution of Photon Rates across Y/Z of APA Plate







Dimension units cm

Next Step

- Think about optimization for electron source metal location and area

Any Ideas and Questions?

References

- Sample location

dune/data/users/ahimmel/2019-02-07-gallery

Mahalos