hpDIRC Study

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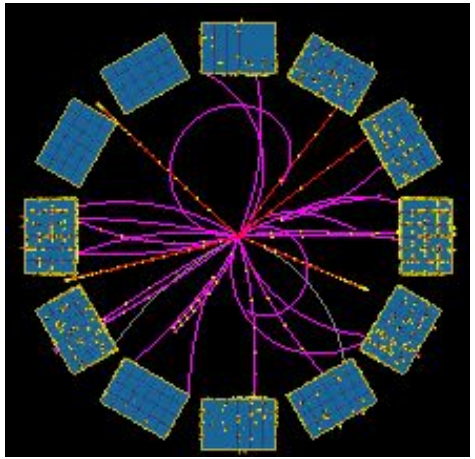
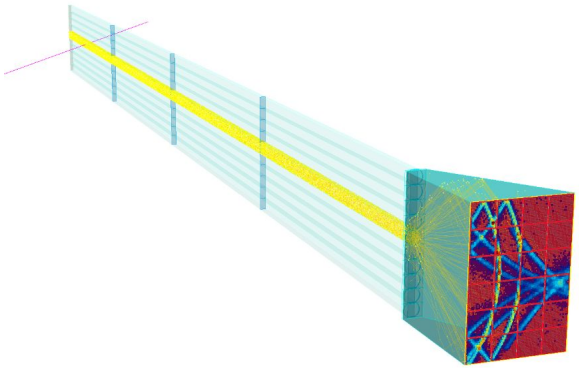
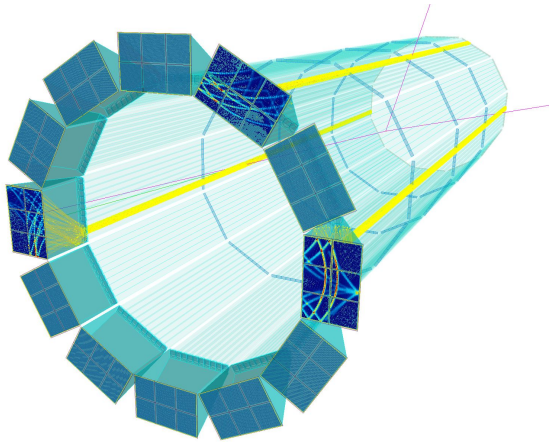
Graduate Student, CUA





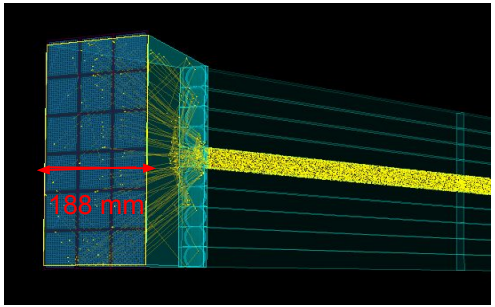


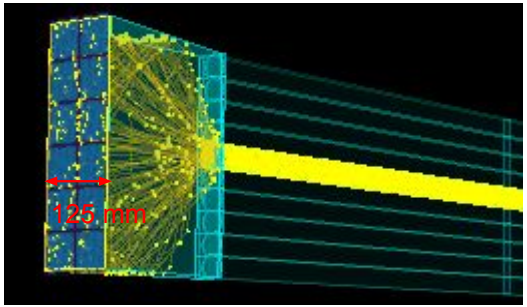
Annual DIRC Meeting, June 2026

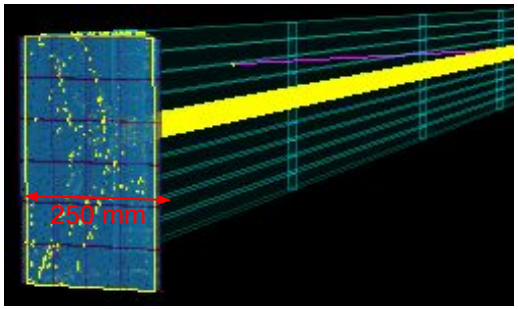
Prism height study

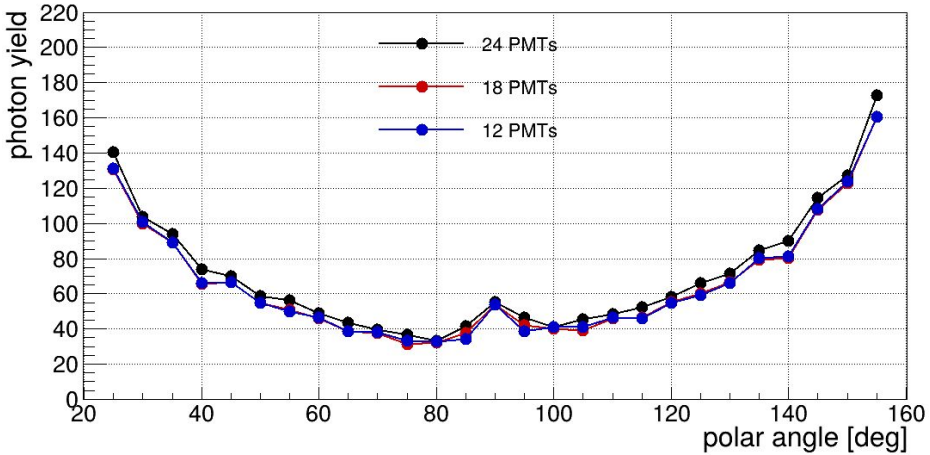
- The prism backplane was reduced from **250.83 mm** to **188.13 mm to 125.42 mm**.
- The opening angle was reduced from **33.7°** to **24.75° to 14.1°** .
- The reduced prism height accommodates **3 columns (or 2 columns) and 6 rows of MCP-PMTs**.
- The track is directed to hit the middle bar.
- The magnetic field is turned on.
- PDF was generated using **45,000 events**.

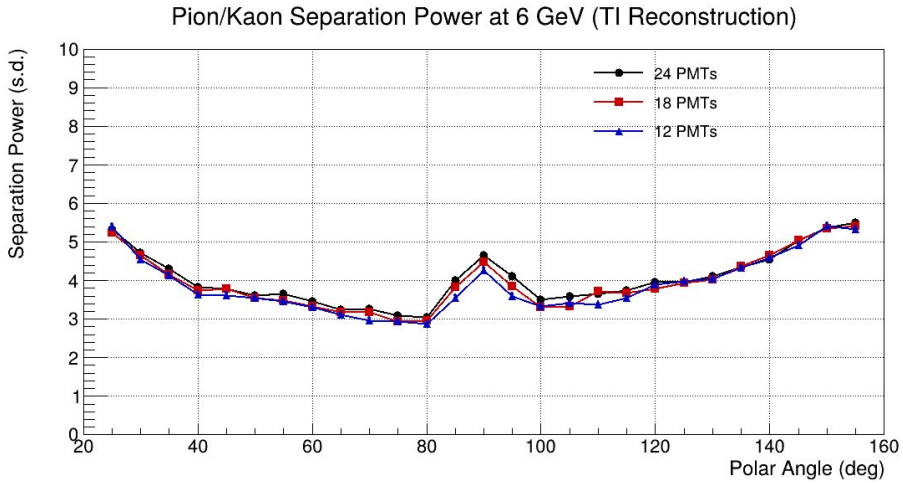
Prism height study



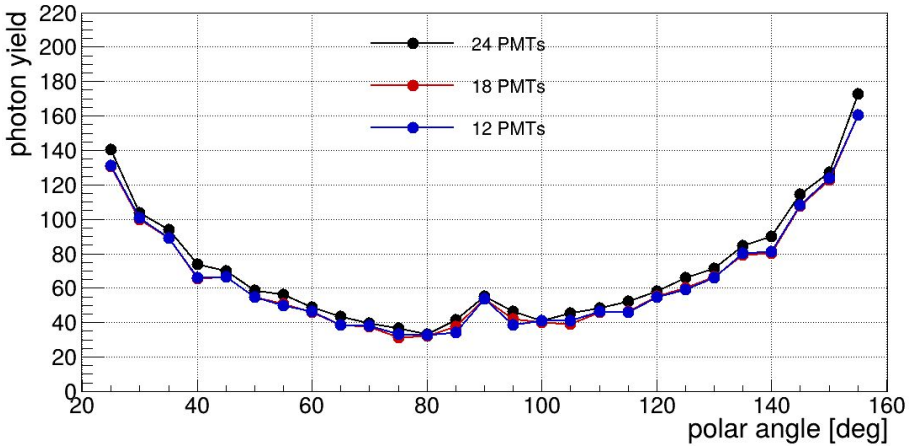


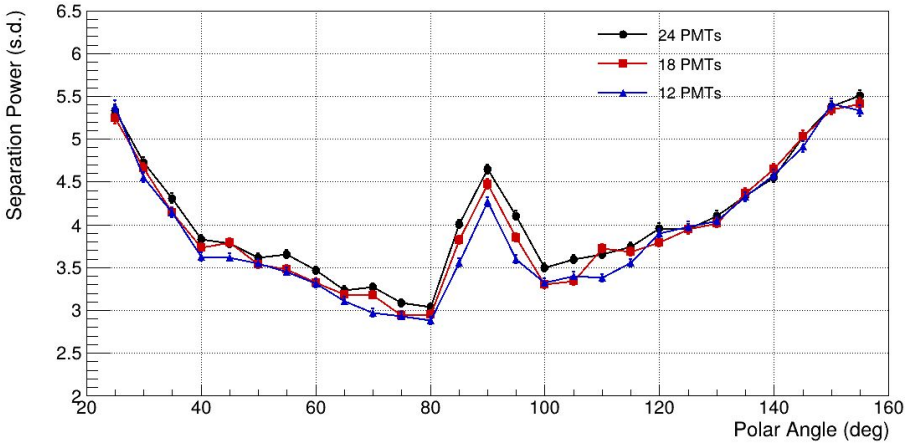




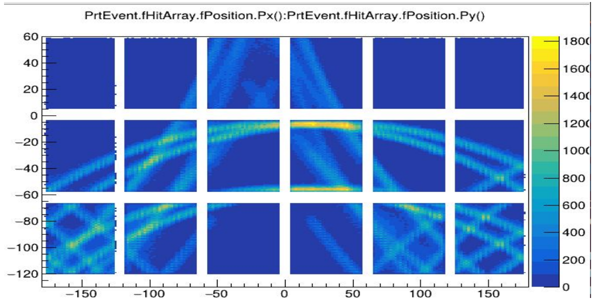


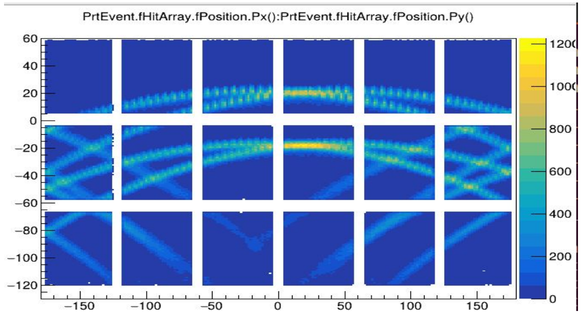
Prism height study

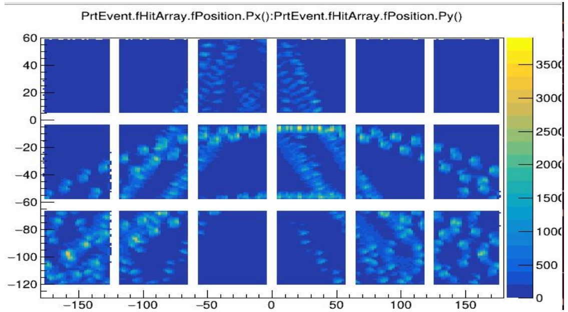




- A reduction in the detector plane height enables the use of a smaller prism and decreases the required number of sensors.
- The reduction in the number of sensors has minimal impact on overall performance.



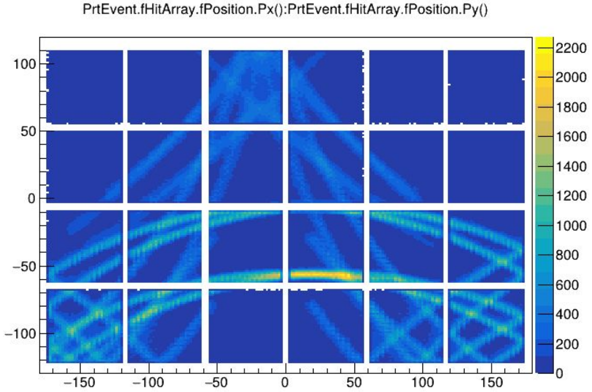


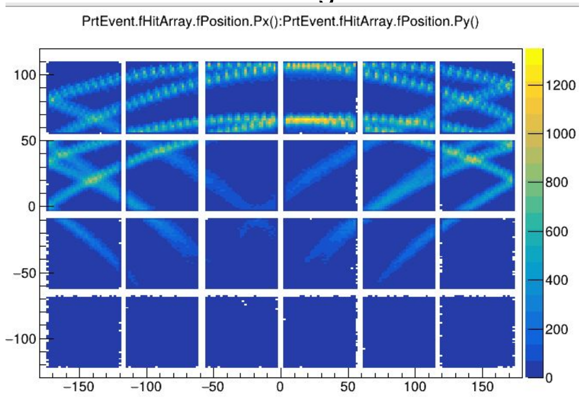


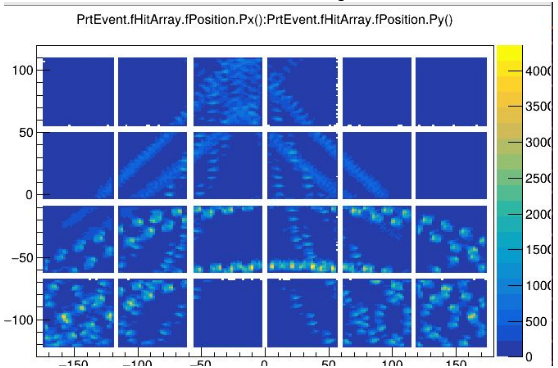
30 deg.

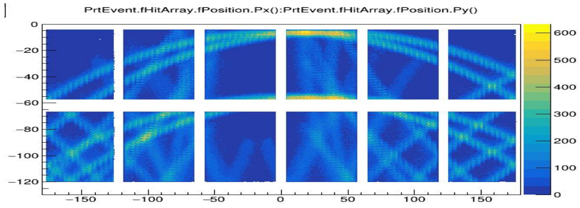
90 deg.

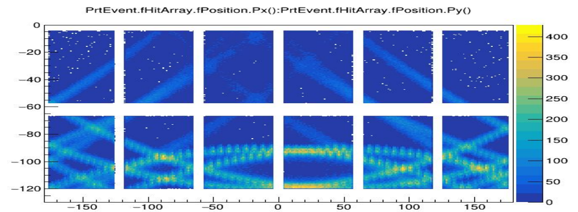
150 deg.

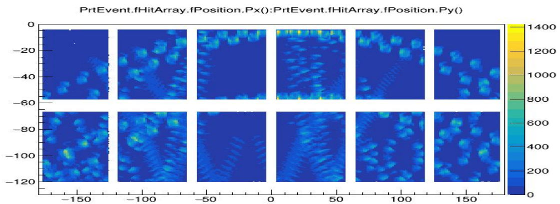


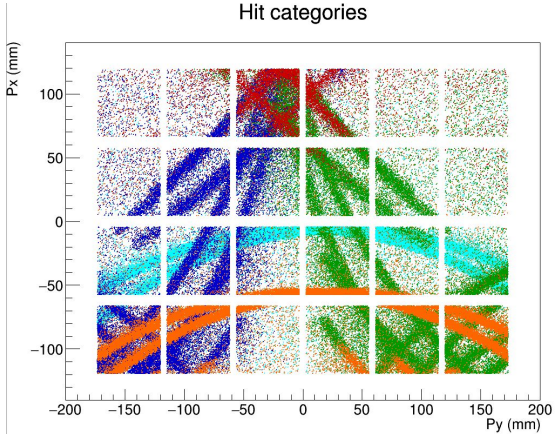


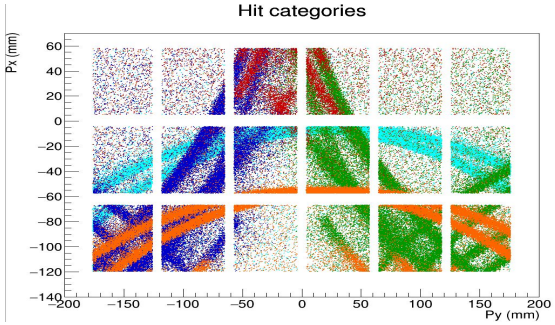


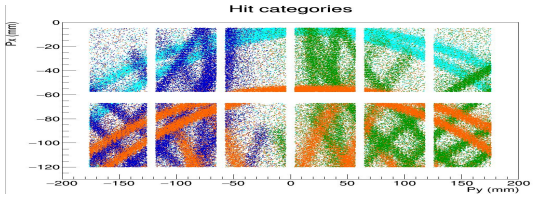




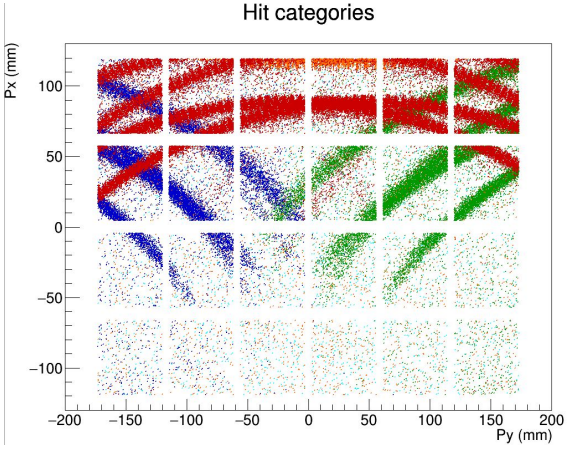


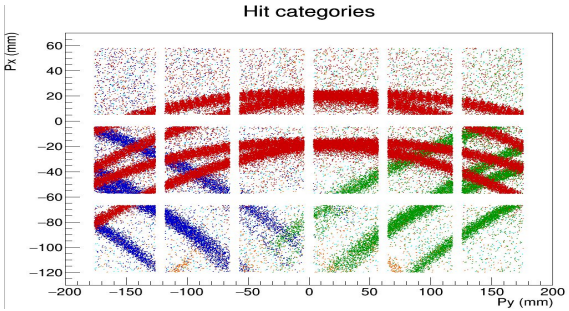


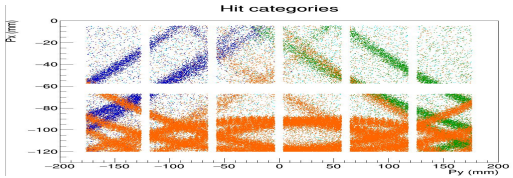




30 deg.

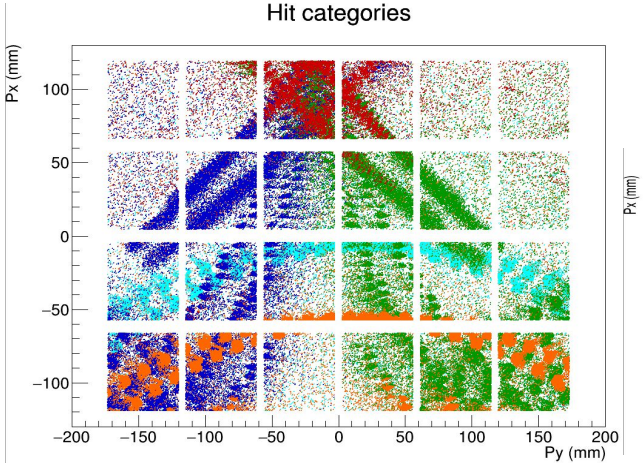


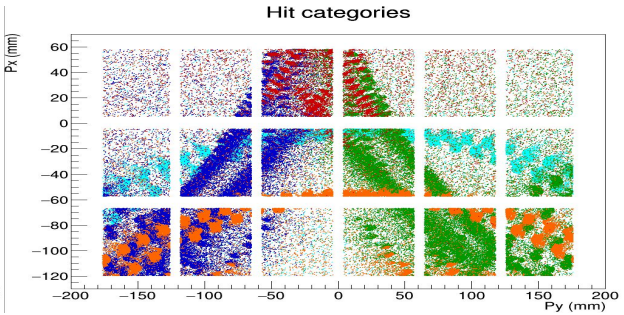


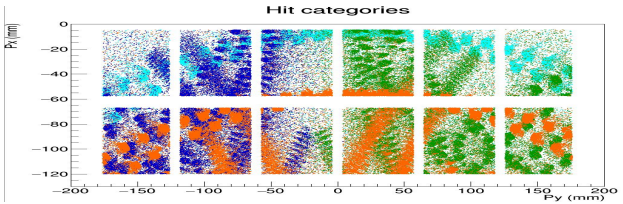


90 deg.

Polar angle = 30 deg. ,hpDIRC. Reflection Type: Cyan - Direct, Blue/Green - Side, Orange - Bottom, Red - Top





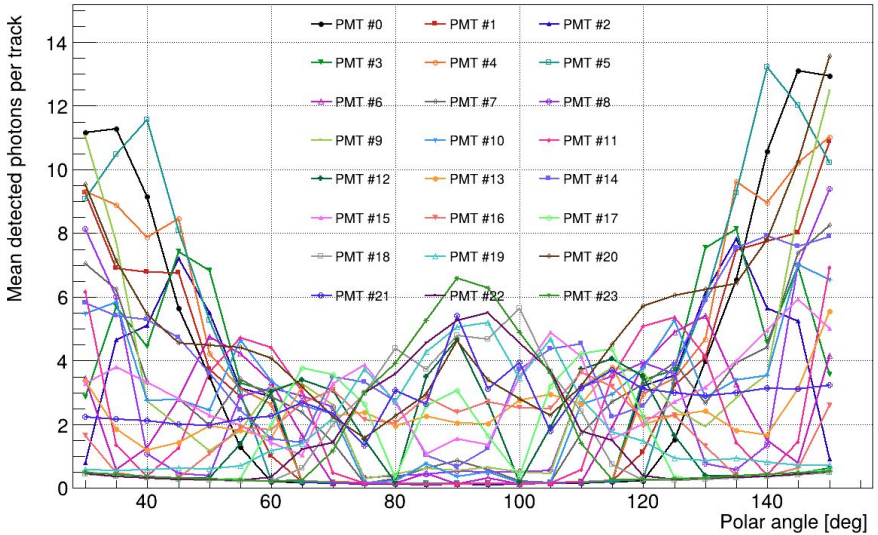


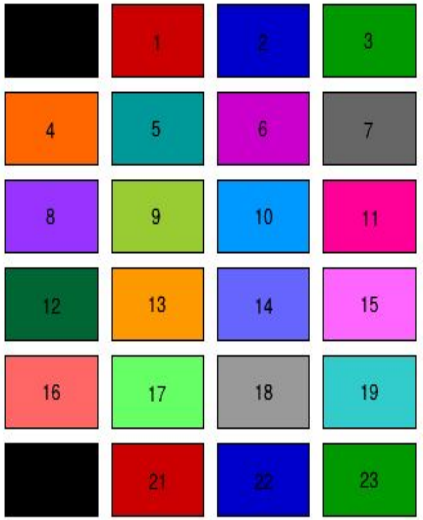
150 deg.

Polar angle = 30 deg. ,hpDIRC. Reflection Type: Cyan - Direct, Blue/Green - Side, Orange - Bottom, Red - Top

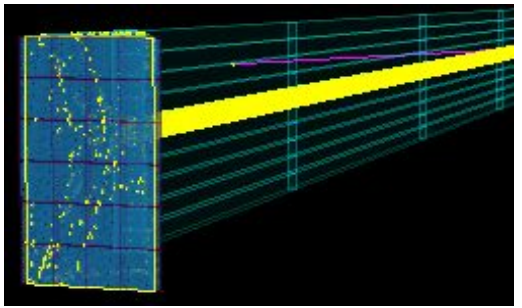
Pmt Occupancy

Mean detected photons per track per pmt (hpDIRC)

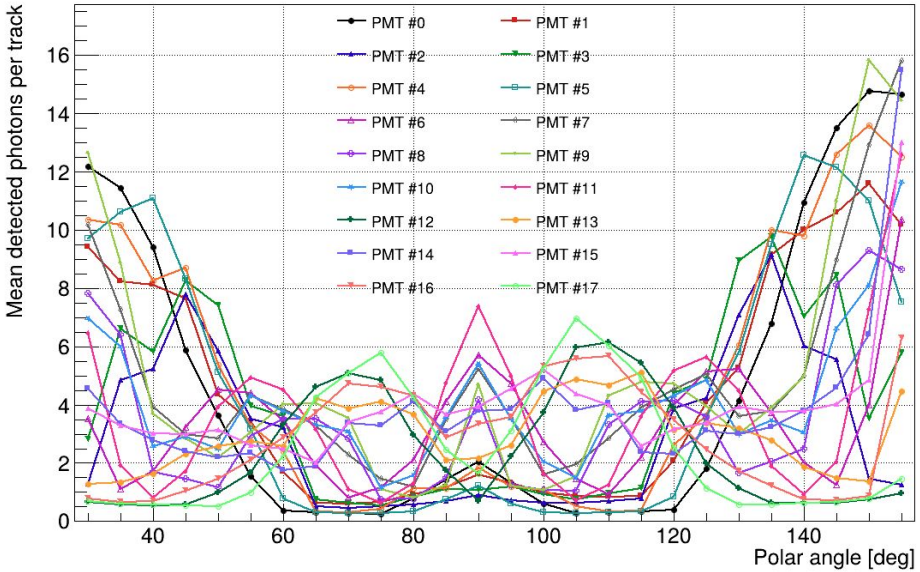


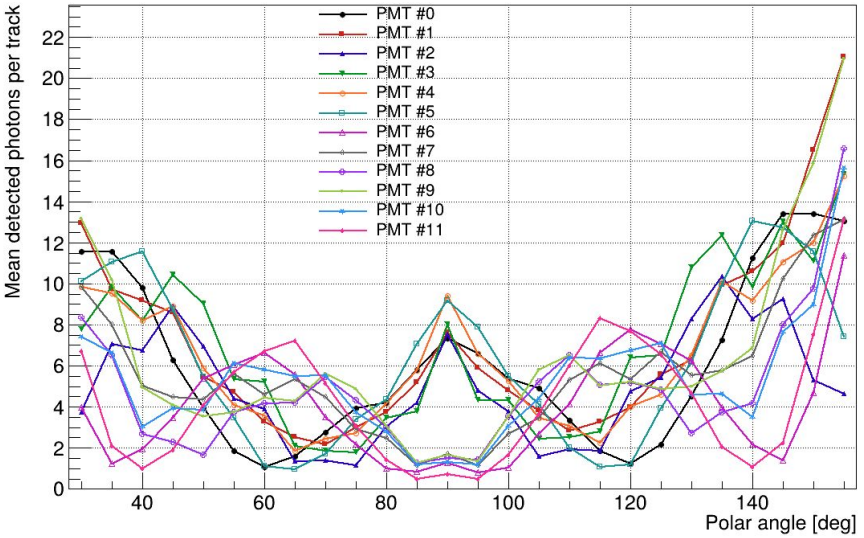


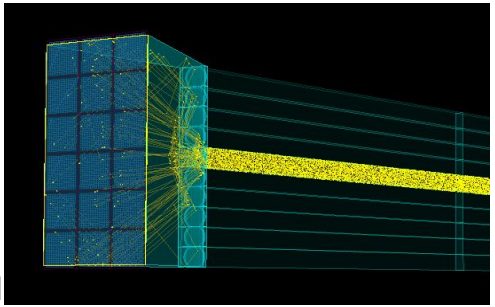
hpDIRC Geometry, Sensor: Mcp_Pmt
Phi angle is not zero, Magnetic field on
Track hitting in the middle bar, Events = 50k

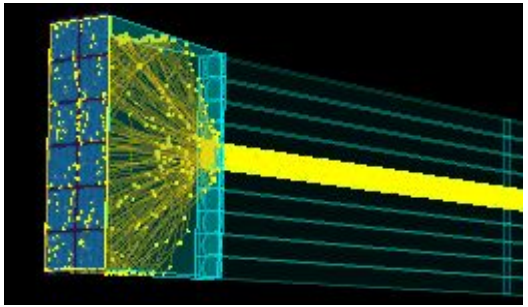


Mean detected photons per track per pmt (hpDIRC)

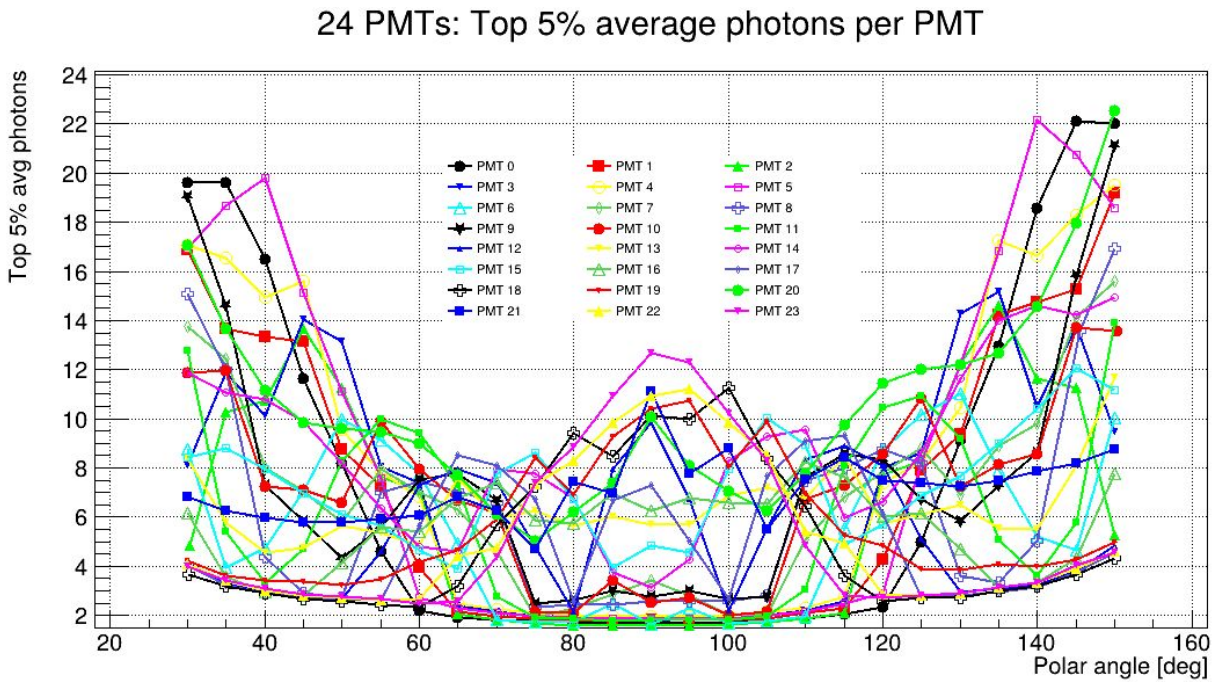


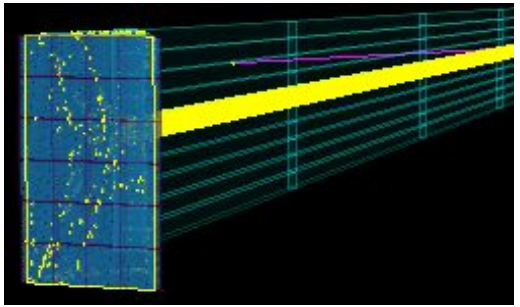






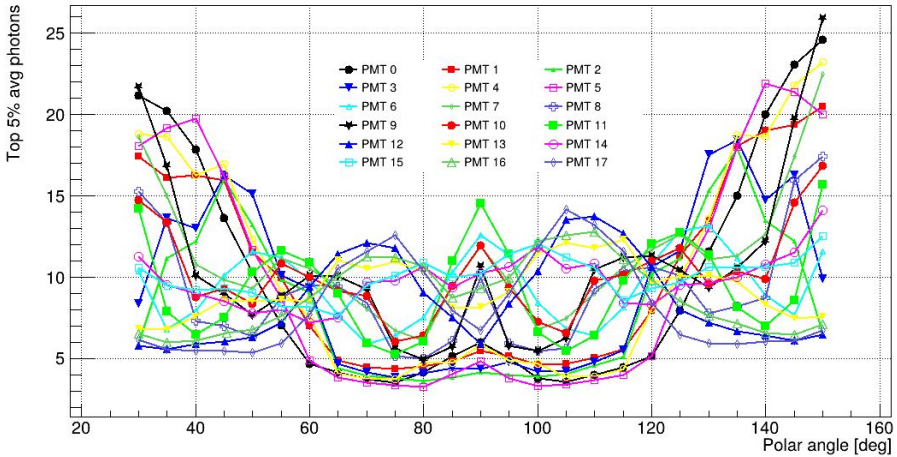
Max. detected photons per pmt (hpDIRC)

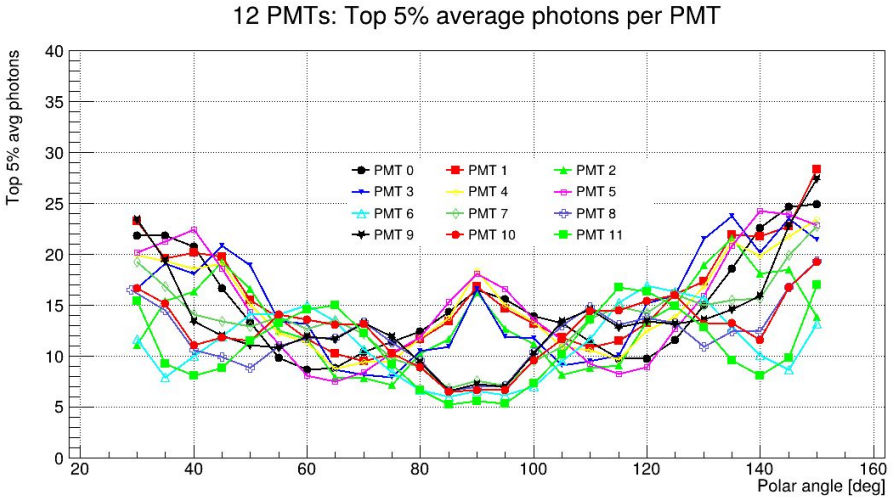


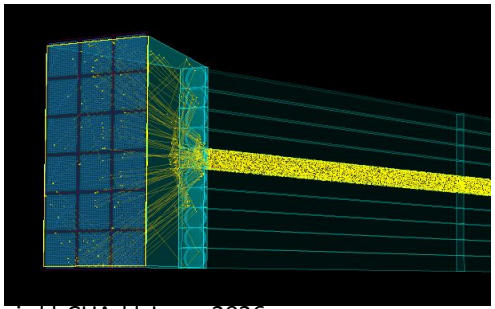


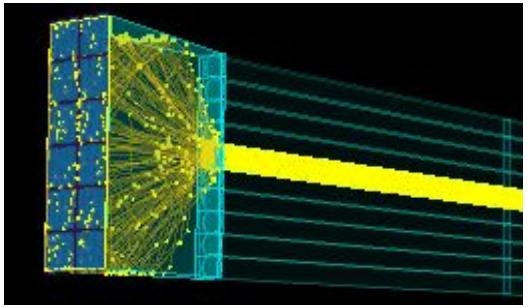
Events = 50k ,hpDIRC Geometry, Sensor: Mcp_Pmt, Phi angle is not zero
Magnetic field on, Track hitting in the middle bar

Max. detected photons per pmt (hpDIRC)









Sensor Coverage Study

1. tracks hitting middle of the bar #5
2. 3-layer spherical lens with sapphire, r=[62,36]
3. 4x6 layout; 3 x 6 + 5 layout, 4 x 5 layout, 16x16 pixels MCP-PMTs with HIQ400, CE=95%;100 ps time precision

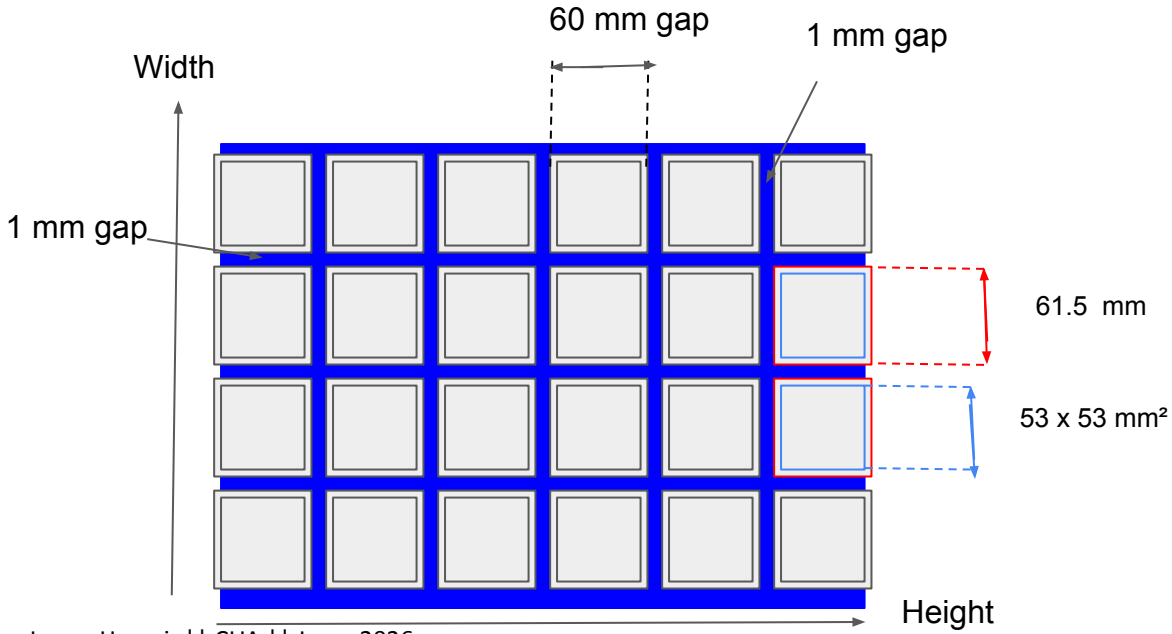
   Layout description: width = 61.5 mm, height = 60 mm, gap between pmts = 1 mm.

4. TI with 45k PDF for each particle type. PDF generated with corresponding bar shape.
5. Prism Opening angle = 33.8 deg

6 x 4 arrangement of Mcp_Pmt

6x4 Sensor arrangement

- Total area = 6x4x61.5x60 mm²
  = 88,560 mm²
- Active area = 6x4x53x53 mm²
  = 67416 mm²



Prism Opening angle = 33.8 deg
Prism width = 250.83 mm
Prism height = 351.35 mm

For 6 x 4 pmts:

Width = 249 mm (inside the plane)

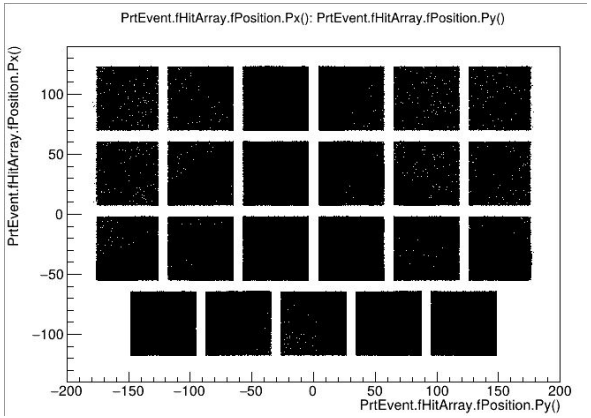
Height = 365 mm

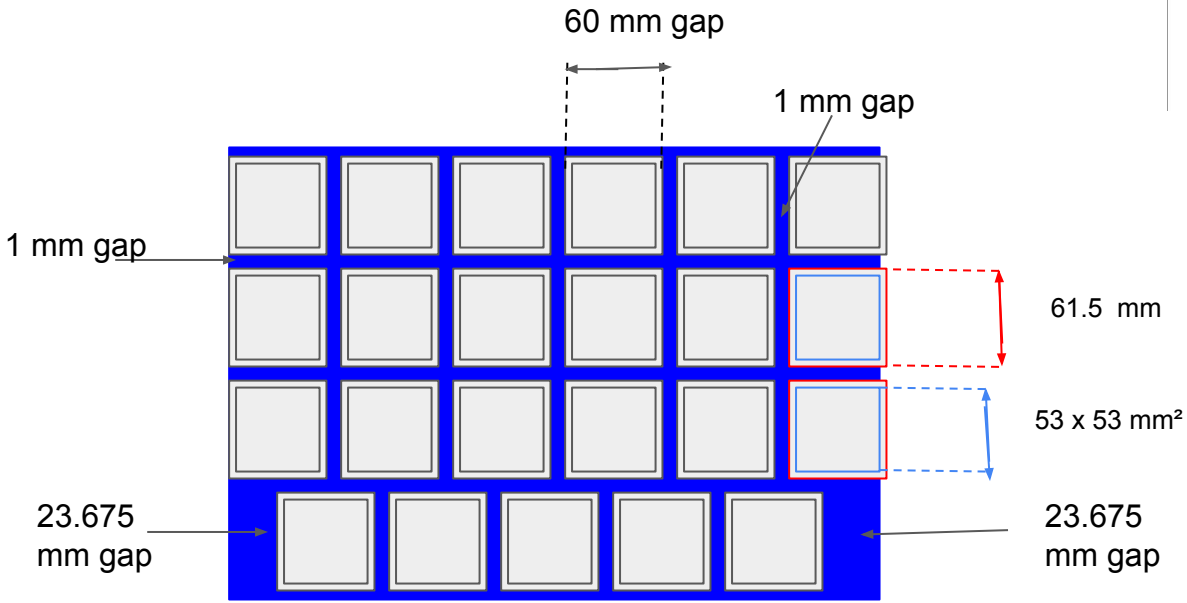
Stick out = 6.825 mm (along height)

1 pmt removed from one column

6x3 + (5 x 1) Sensor arrangement

- Total area = 6x3x61.5x60 + (5 x 1 x 61.5 x 60) mm²
  = 84870 mm²
- Active area = (6x 3 x53x53) mm² + (5 x 53 x 53)
  = 64607 mm²





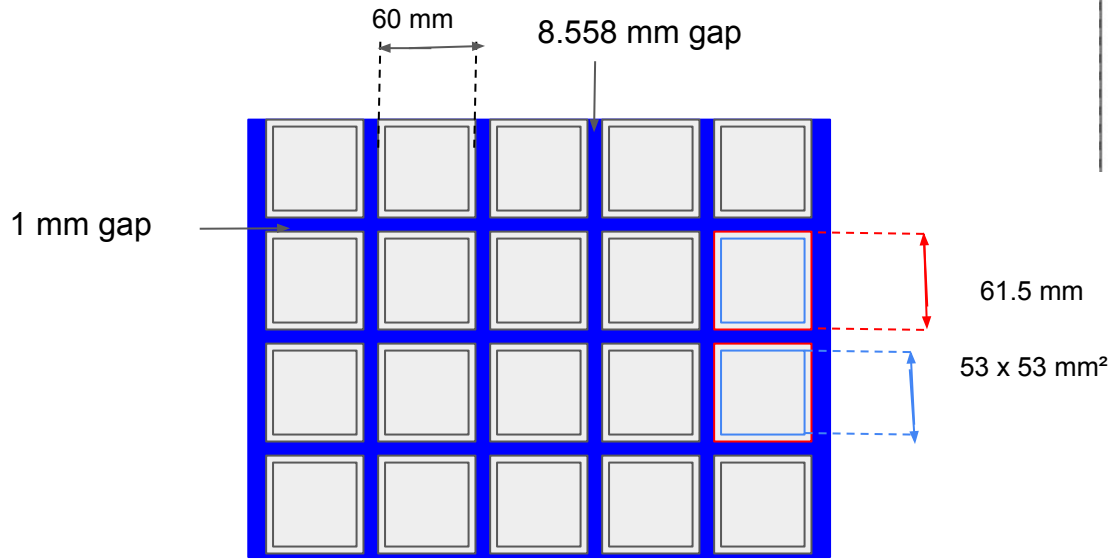
5 x 4 Symmetrical Spread Layout of Mcp_Pmt

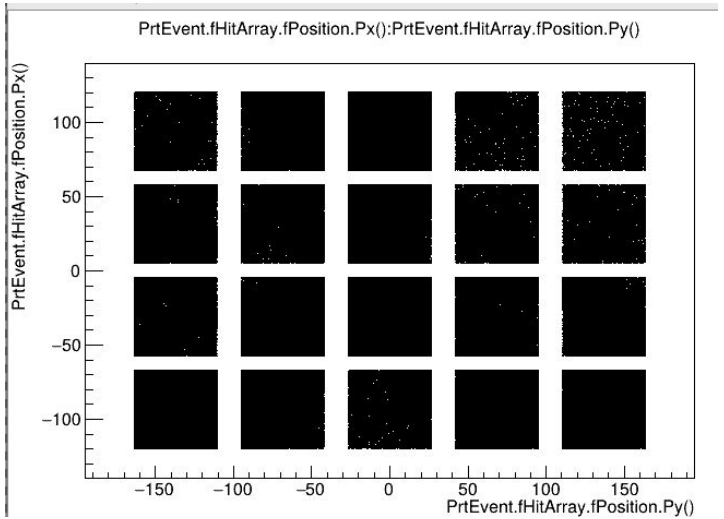
5x4 Sensor arrangement

- Total area = 5x4x61.5x60 mm²
  = 73,800 mm²
- Active area = 5x4x53x53 mm²
  = 56180 mm²

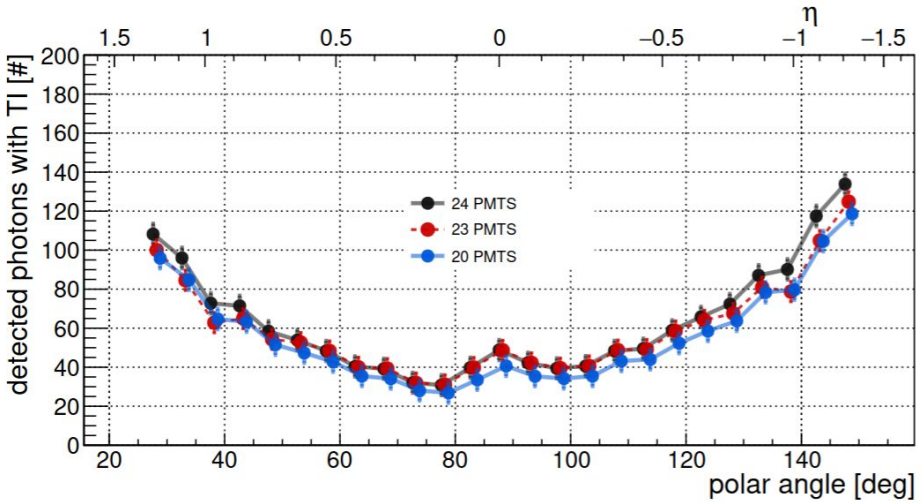
Mcp_pmt = 61.5 x 60 mm²

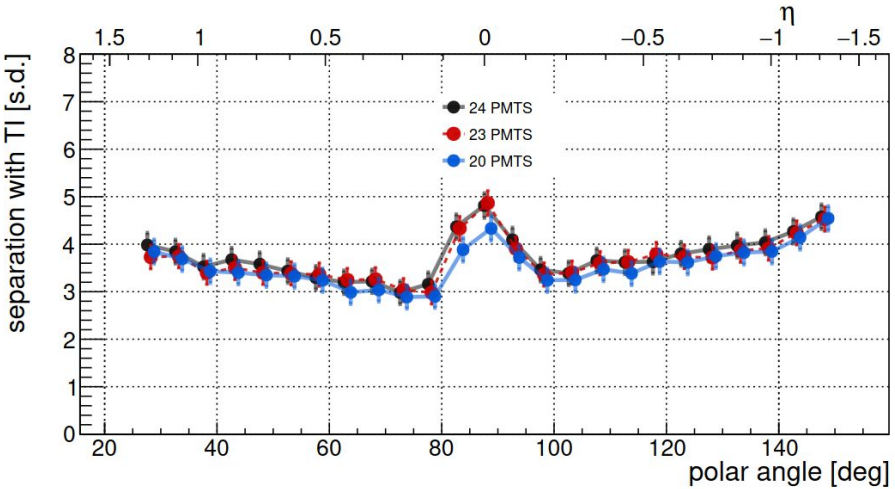
gap x = 1 , gapy = 8.55833



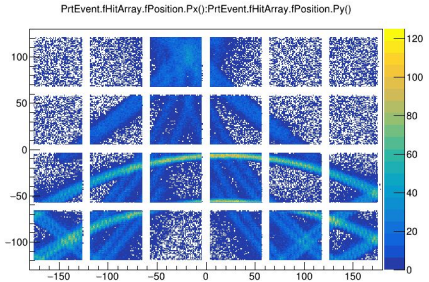


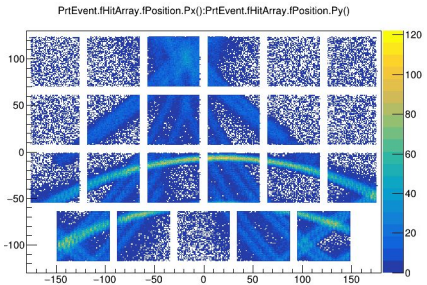
Performance Plot

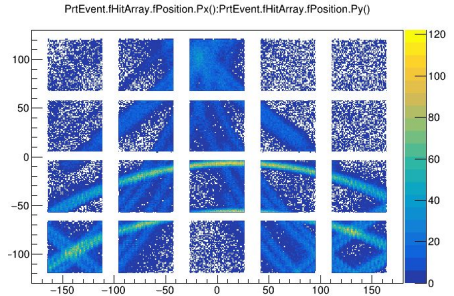




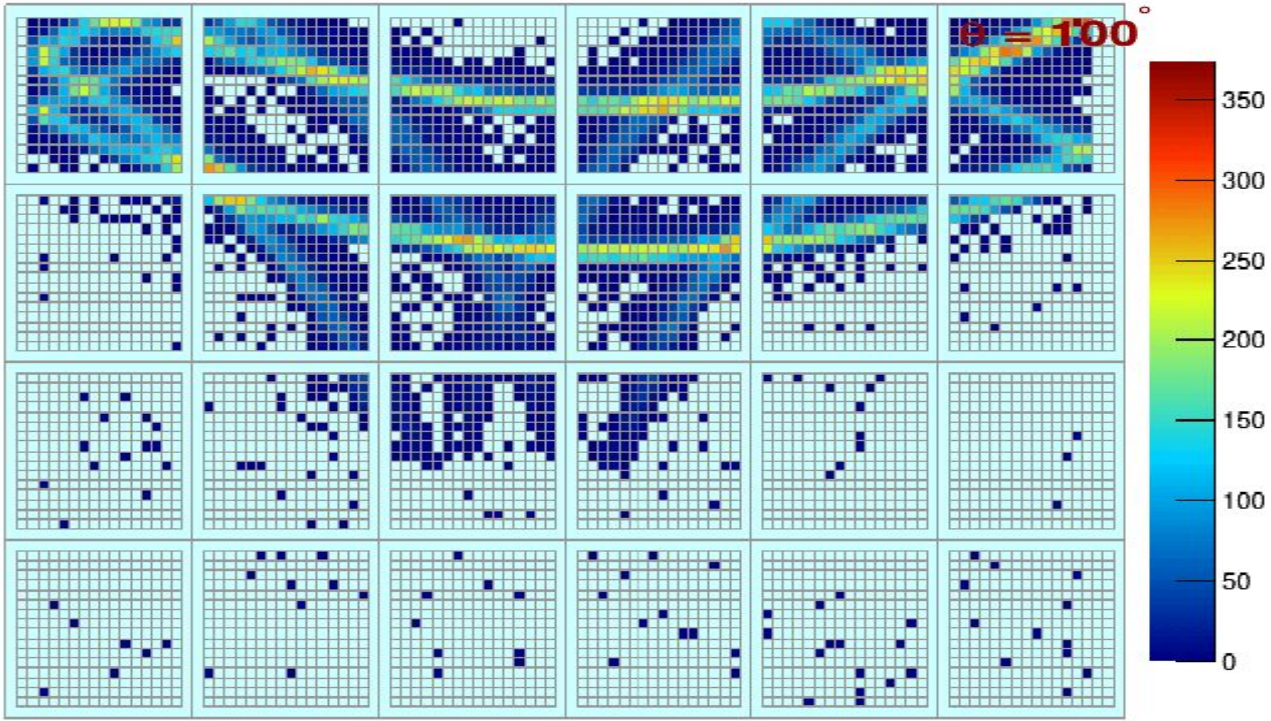
- Impact on PID performance in agreement with expectations.



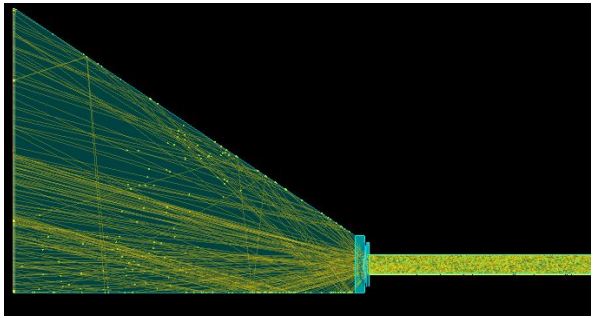




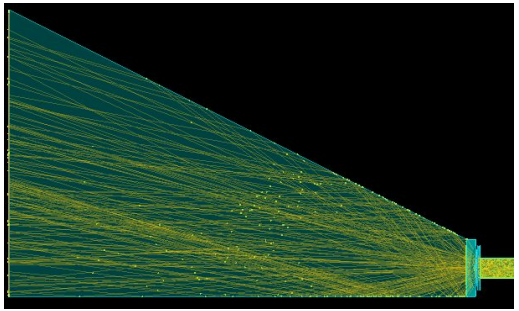
Hit Pattern 6x4 sensor coverage



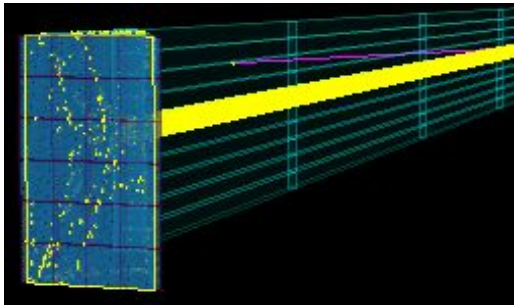
Prism depth Study



300 mm prism depth

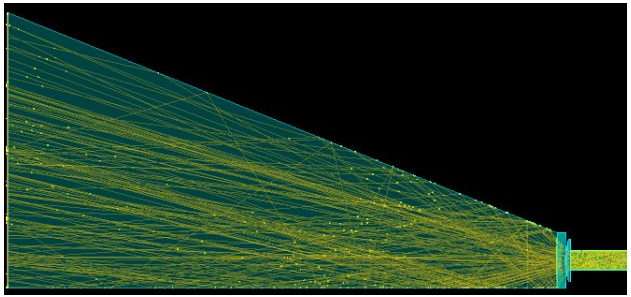


400 mm prism depth

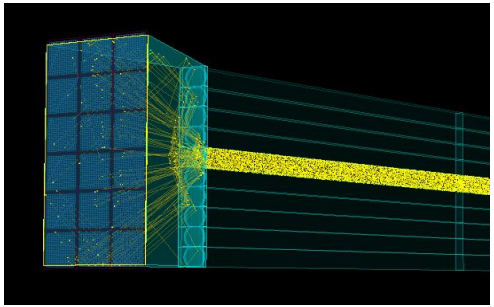


24 pmts

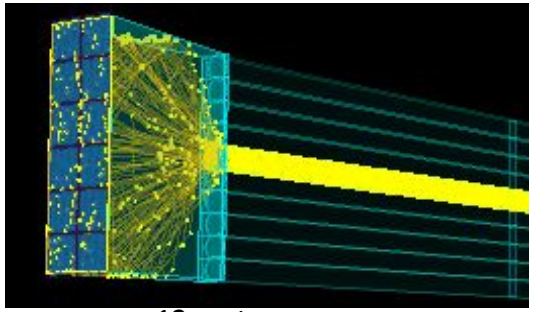
Event display



500 mm prism depth

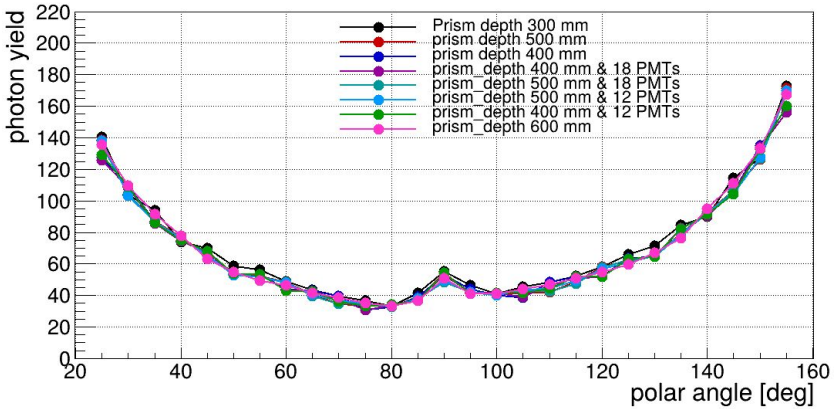


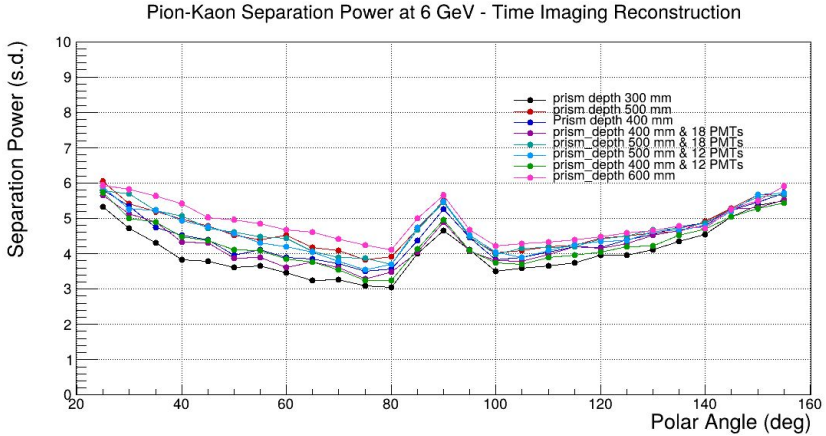
18 pmts



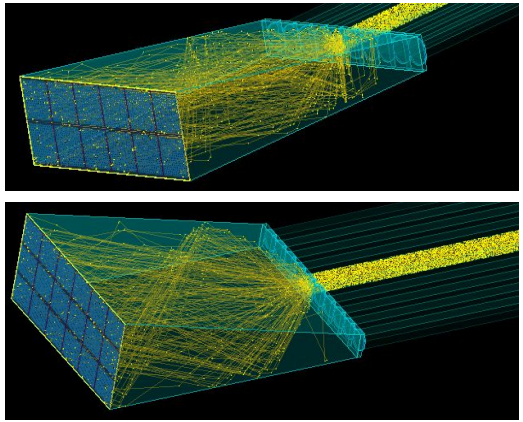
12 pmts

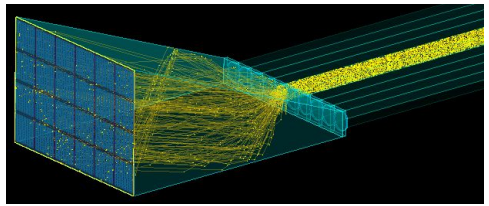
Performance for Different Prism Depths (hpDIRC, 24, 18, 12 PMTs)



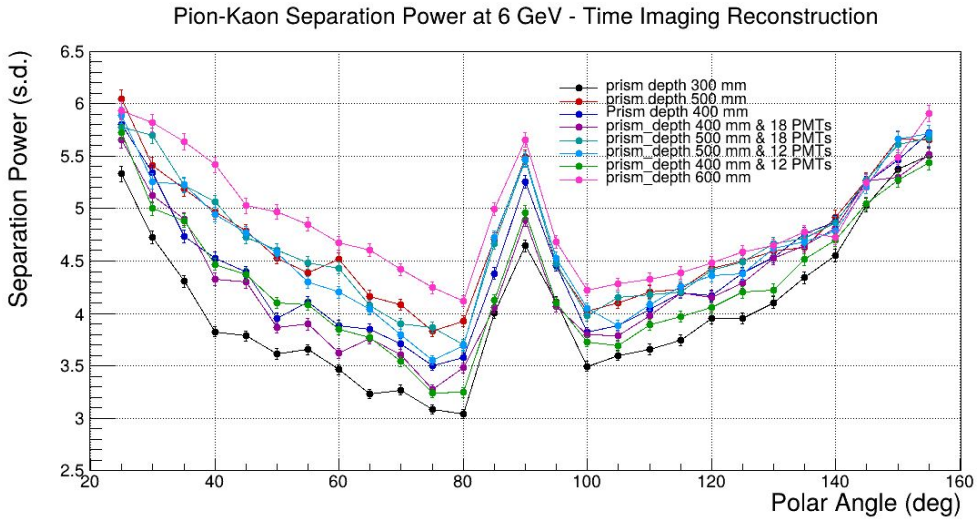


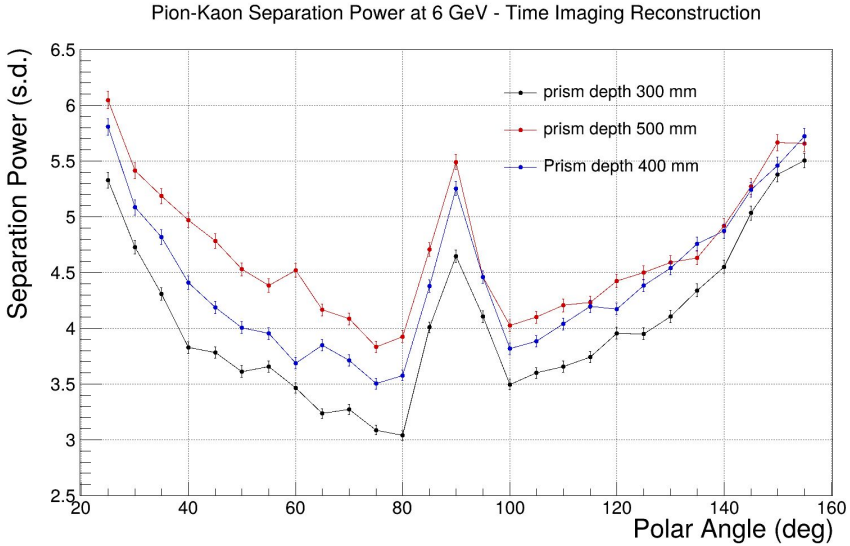
Prism depth = 500 mm, r1 = 75 mm, r2 = 50 mm
Prism depth = 300 mm, r1 = 62 mm, r2 = 36 mm
Prism depth = 400 mm, r1 =70 mm, r2 = 45 mm
Prism depth = 600 mm, r1 = 70 mm, r2 = 50 mm
Opening angle = 33.7 deg.(24 pmts), 24.75 deg. (18 pmts), 14.1 deg (12 pmts)
Magnetic field on
Hitting in the middle bar
Pdf = 45k
Sensor = Mcp Pmt (CE = 95%)
(Time imaging reconstruction)



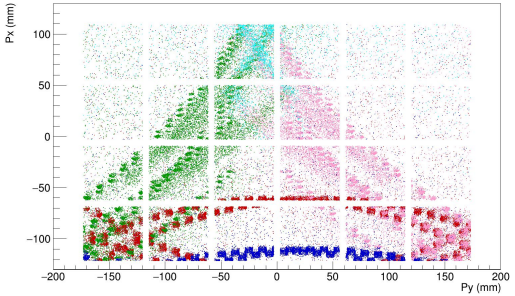


Performance for Different Prism Depths (hpDIRC, 24, 18, 12 PMTs)



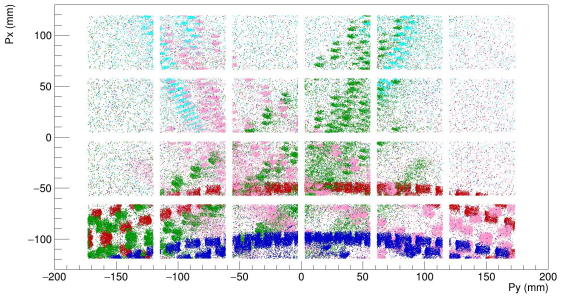


- Increasing the prism depth leads to improved performance.
- Reducing the number of sensors, and consequently the height of the detector plane, does not have a significant impact on performance.

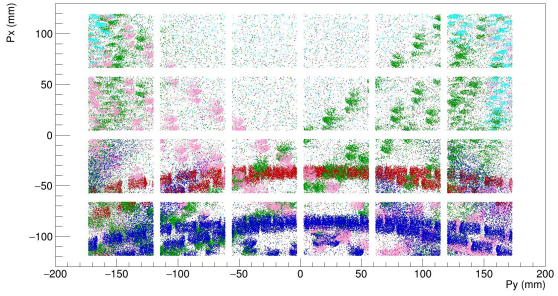


300 mm prism depth

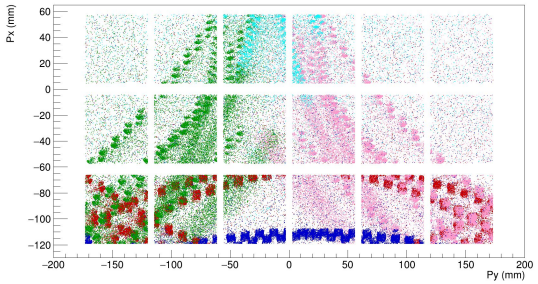
Polar ang = 140 deg.

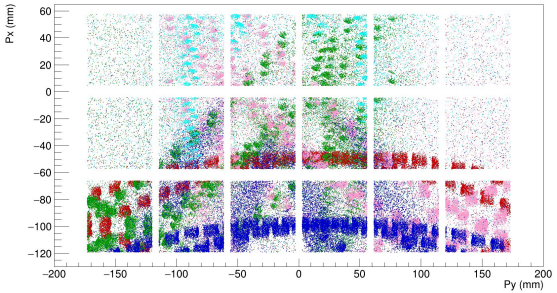


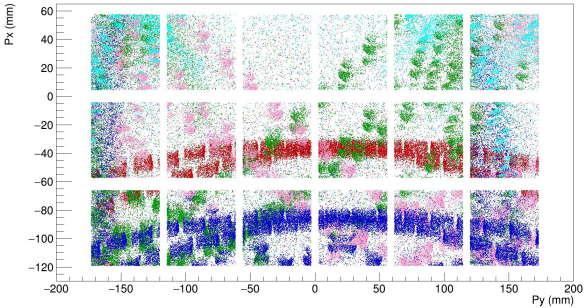
400 mm prism depth

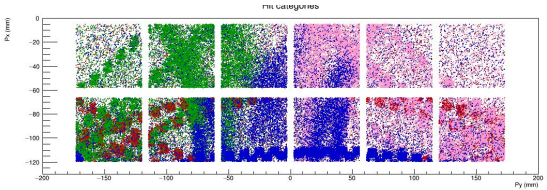


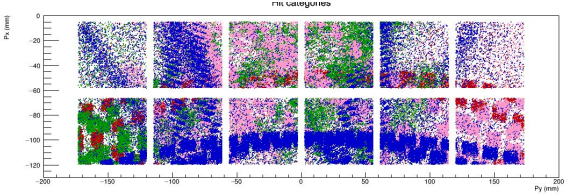
500 mm prism depth

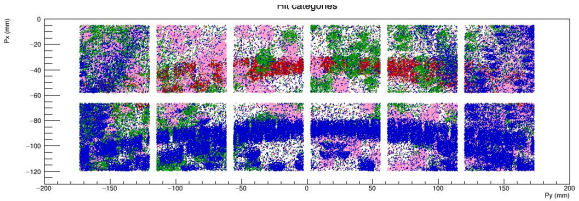




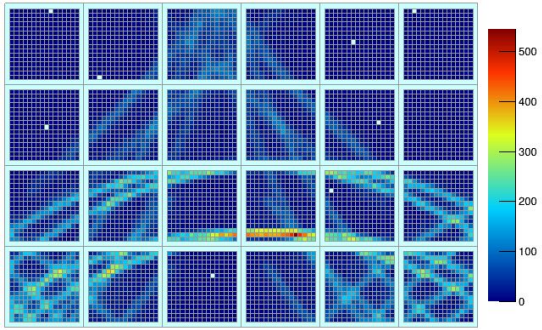


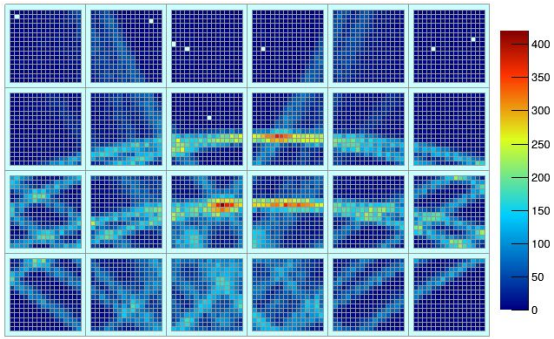


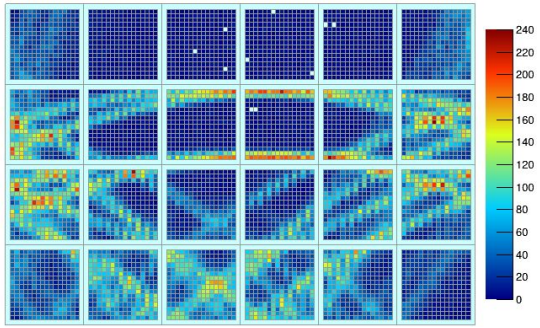




Last reflection inside Prism, Direct = Red, left side = Green, Right side = Pink, Bottom = Blue, Top =Cyan



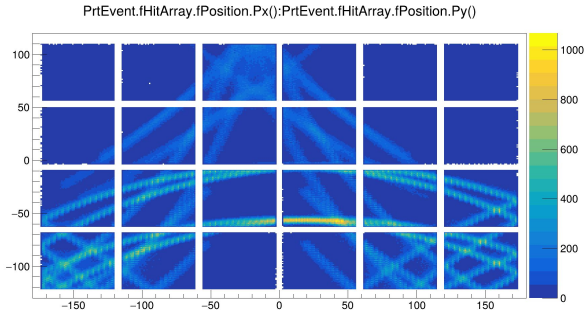


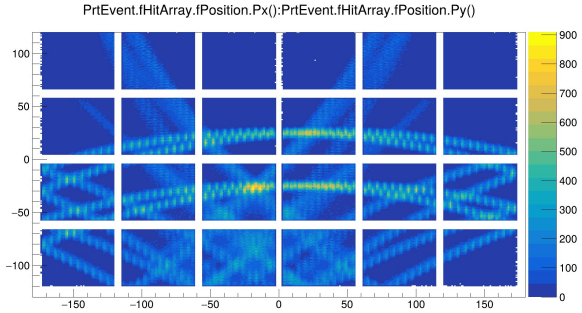


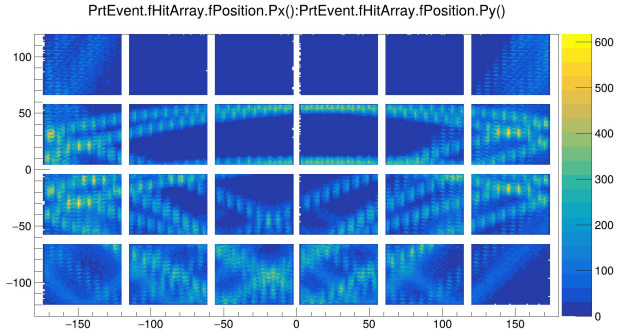
30 deg. pol. angle, 300 mm prism

400 mm prism

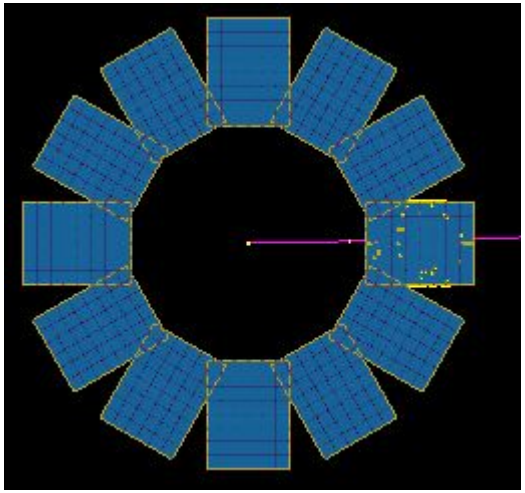
500 mm prism

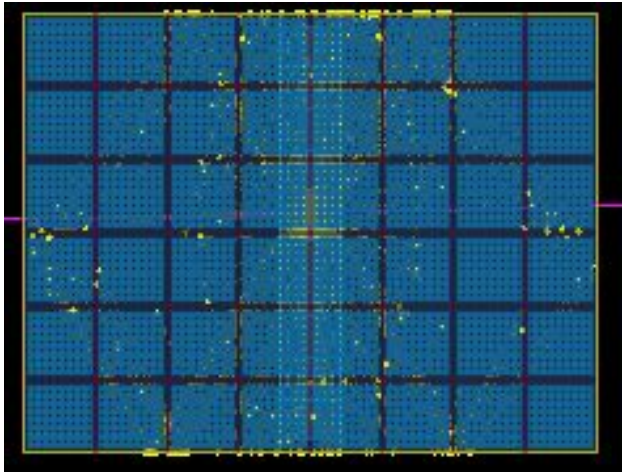


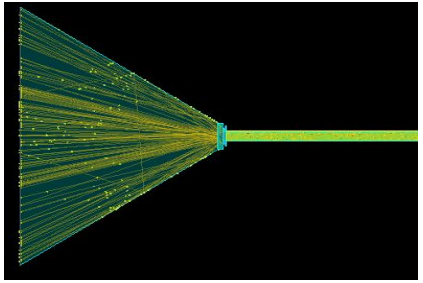


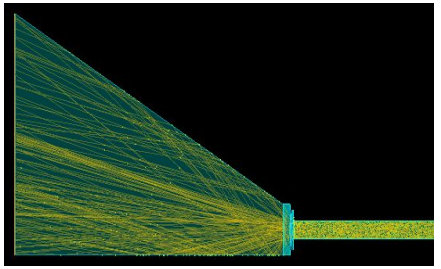


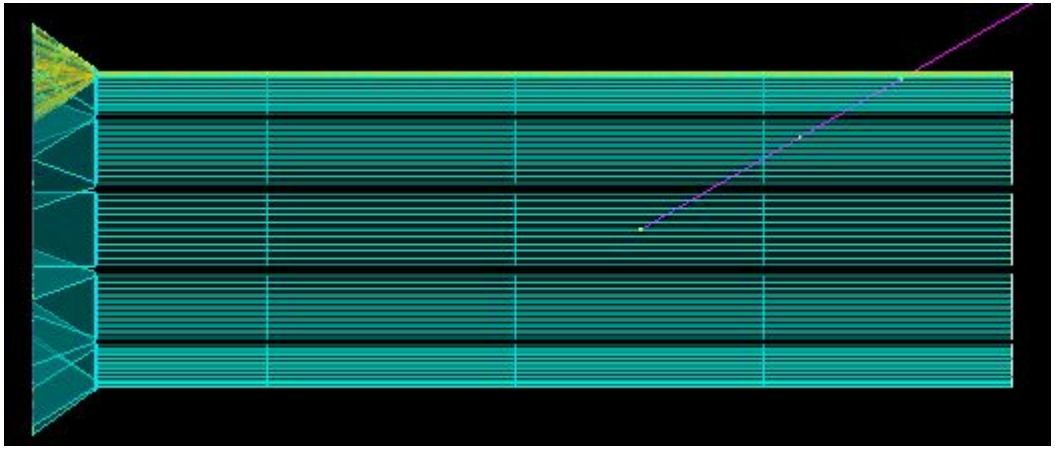
Prism design study











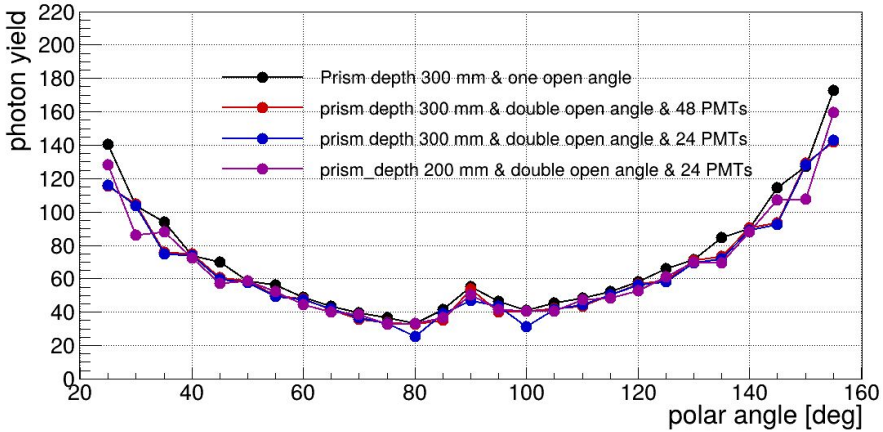
Prism height = 374 mm
Open angle = 17.8 deg. (24 PMTS) & 33.7 deg. (48 PMTs)
Prism length/depth fPrizm[1]=300 mm
Prism narrow side fPrizm[3]= 50 mm
Prism backplane width fPrizm[2] =487 mm
MCP total size (single PMT)= 60 x 61.5 x 1

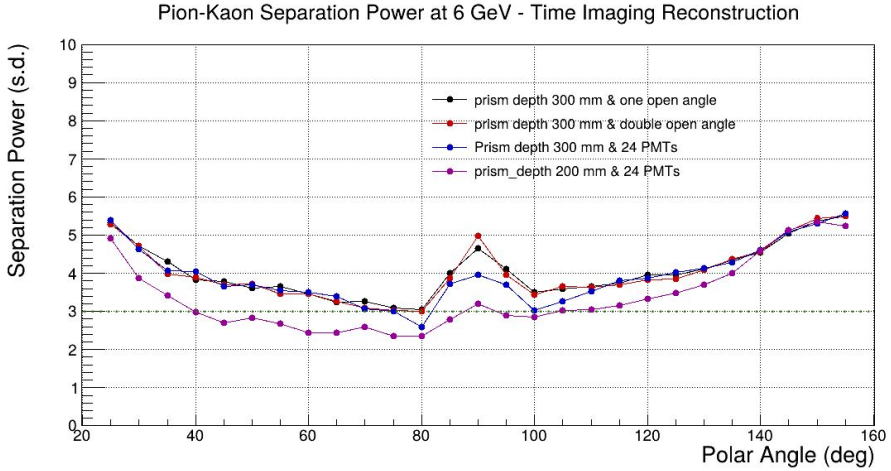
MCP active size (single PMT)= 53 x 53

Used PMT (48) plane size= usedX = 487 mm, usedY = 374 mm

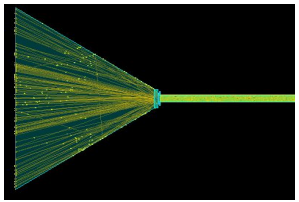
Used PMT (24) plane size = usedX = 243, Y = 374 mm

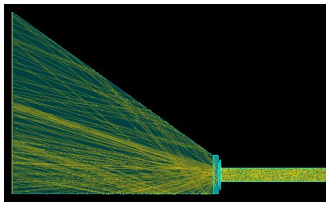
Performance Plots for Different Prism Designs

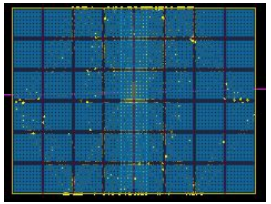




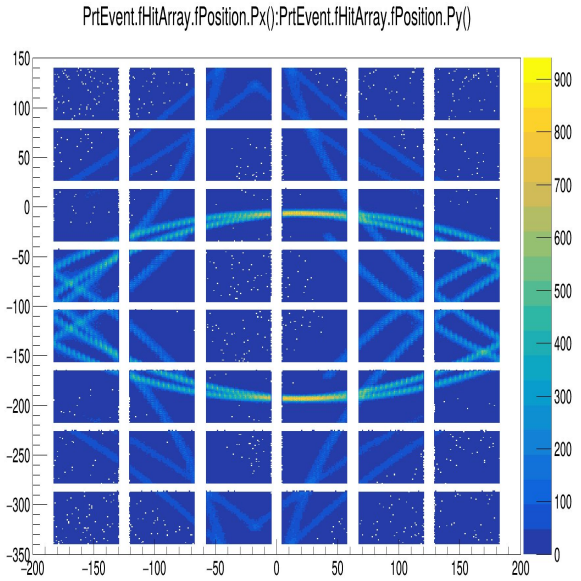
For 300 mm prism depth, r1=62 mm, r2 = 36 mm
200 mm prism depth, r1 = 75 mm, r2 = 33 mm
Pdf = 45k
B-field on



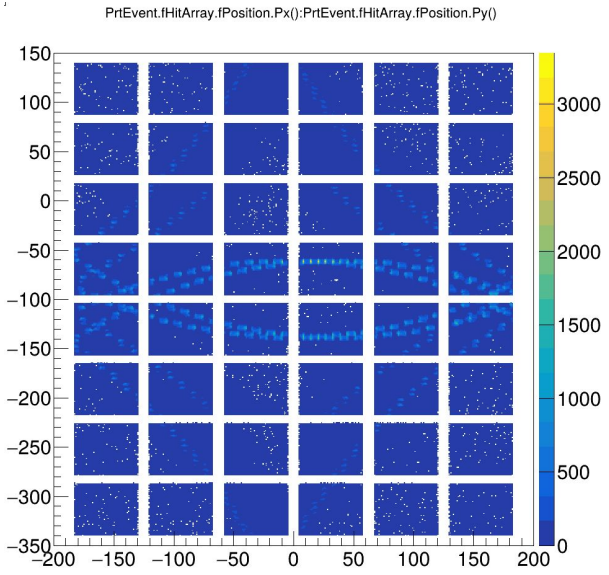




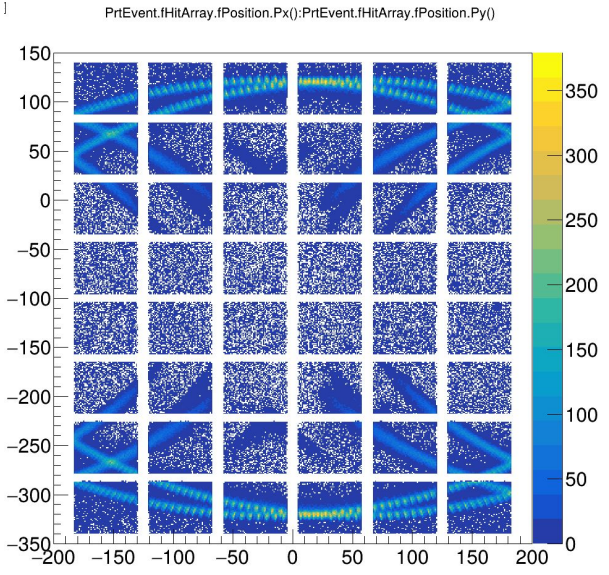
- The alternative prism design does not provide any significant improvement in performance.



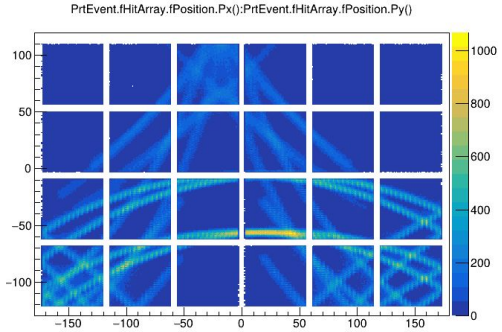
polar ang = 30 deg

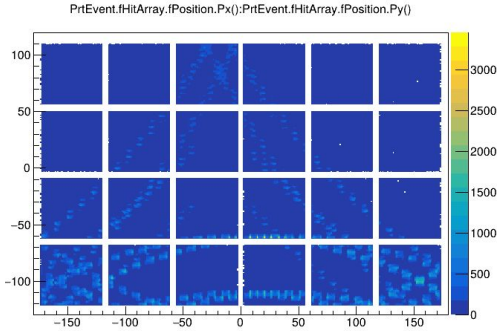


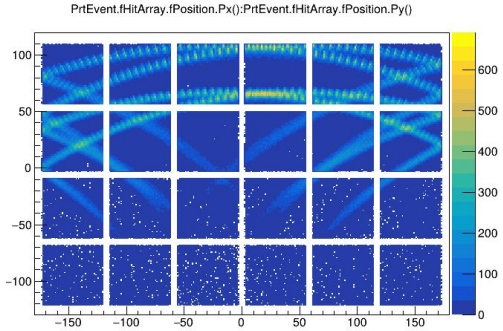
polar ang = 140 deg

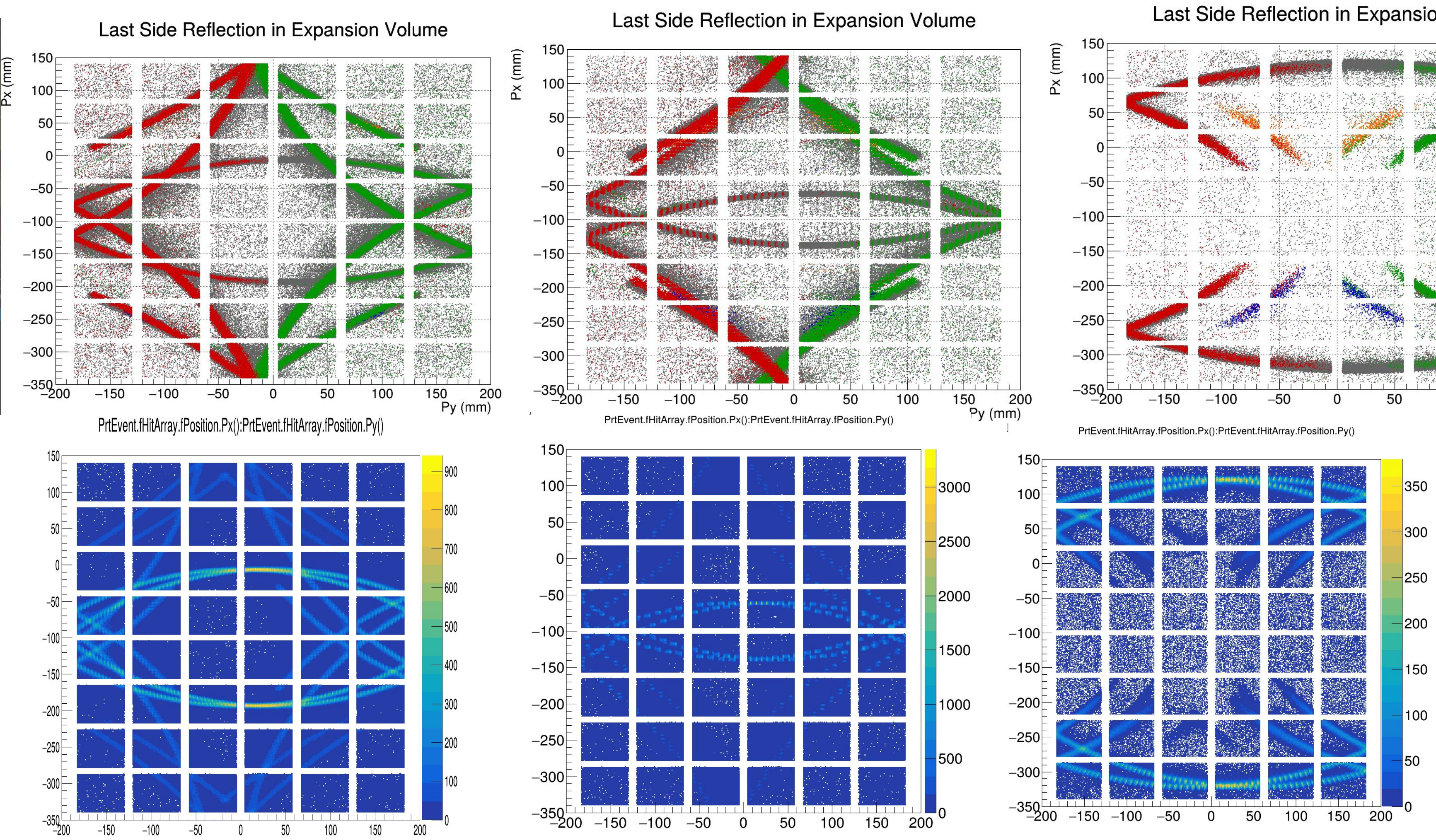


polar ang =90 deg

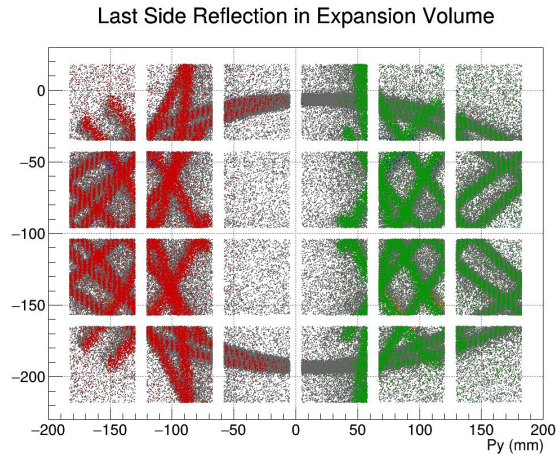




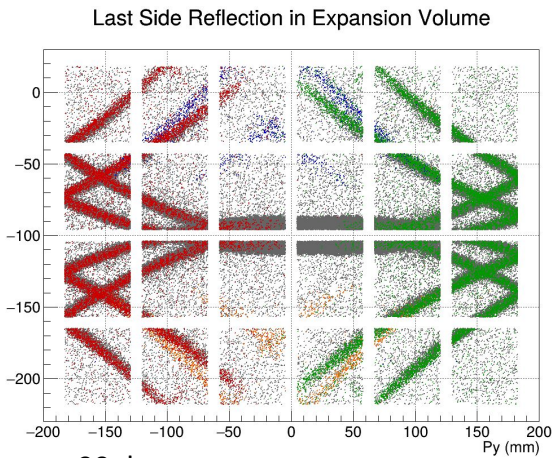




Gray = direct
Blue = top
Orange = bottom
Green = left
Red = right
Double open ang & 48 PMTs & 300 mm prism depth

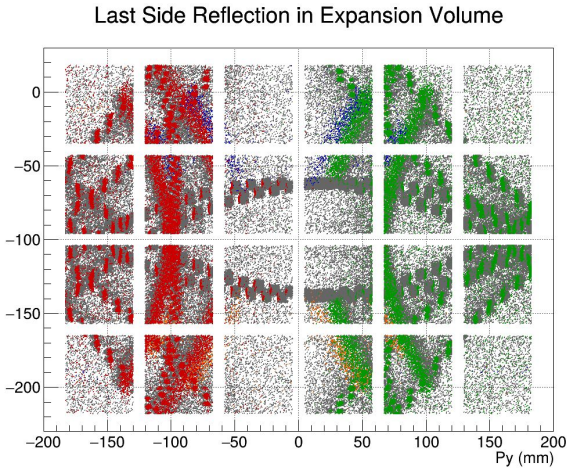


30 deg.

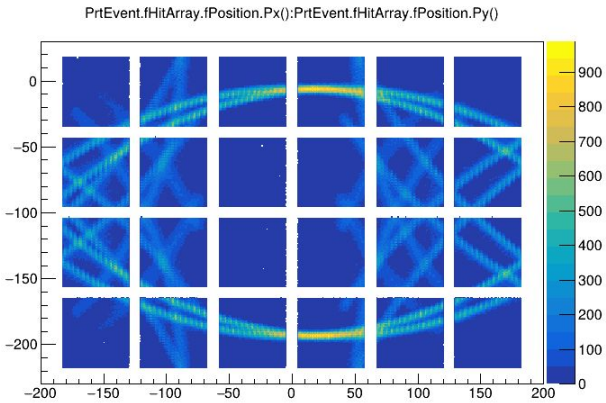


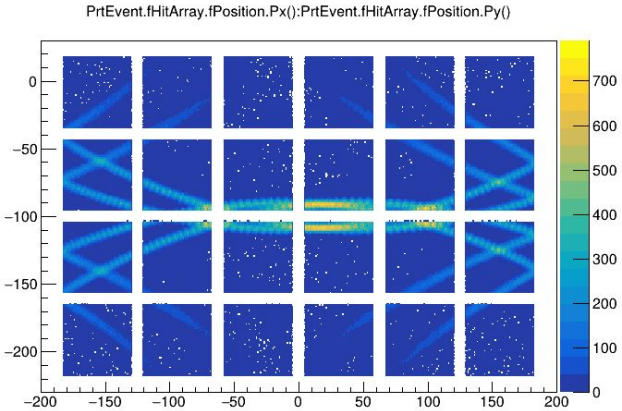
90 deg.

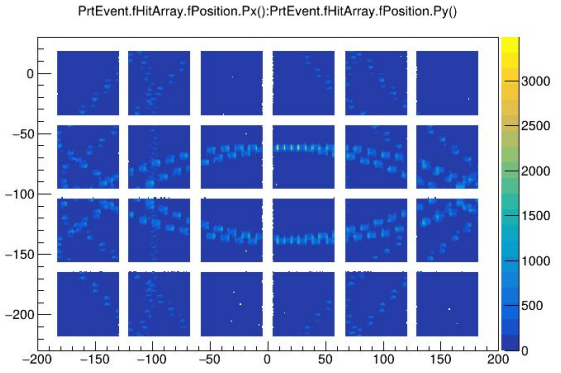
Gray = direct, Blue = top, Orange = bottom, Green = left, Red = right



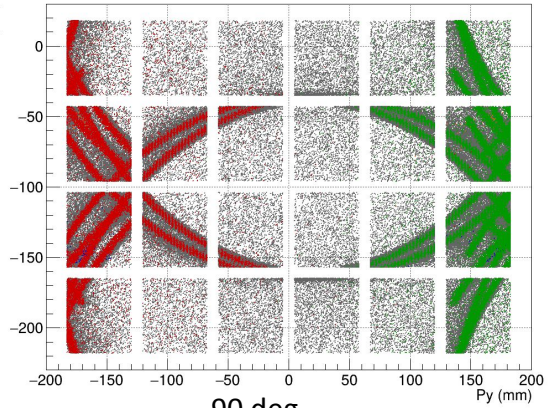
140 deg.



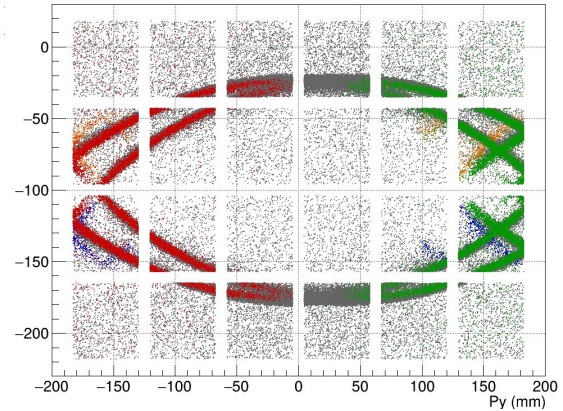




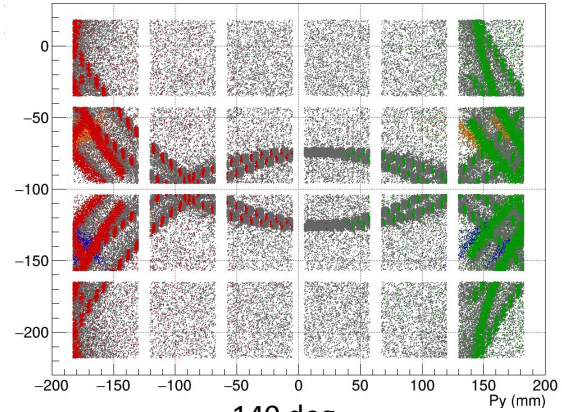
Double open angle & 24 PMTS & 300 mm prism depth



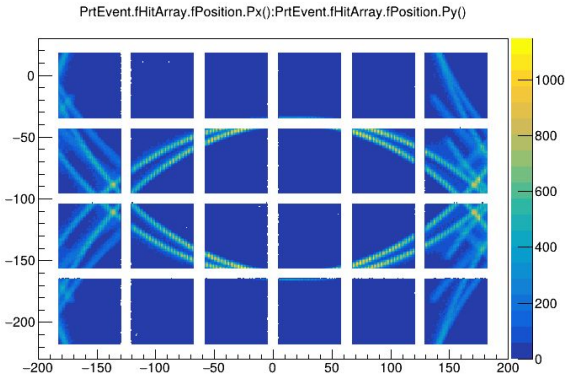
90 deg.

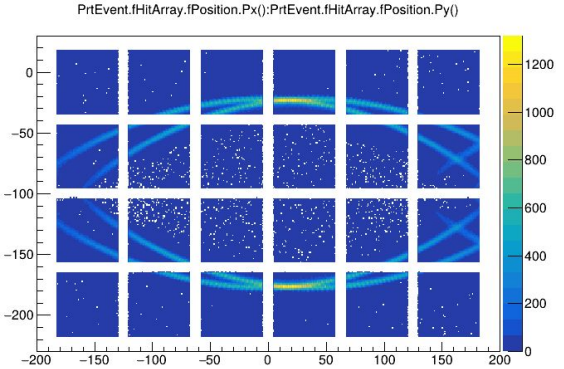


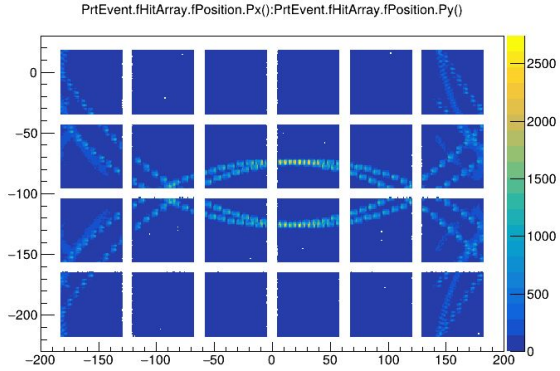
90 deg.



140 deg.





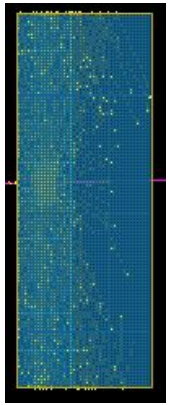


Gray = direct, Blue = top, Orange = bottom, Green = left, Red = right

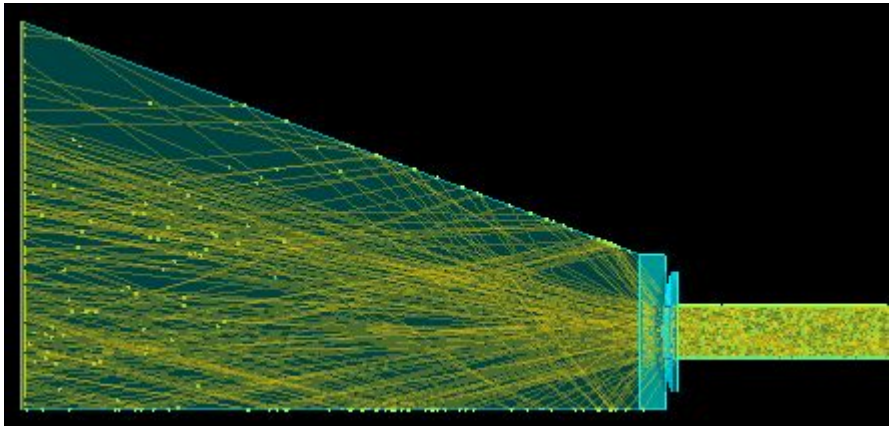
Double open angle & 24 PMTS & 200 mm prism depth

Shorter Prism & smaller pixel

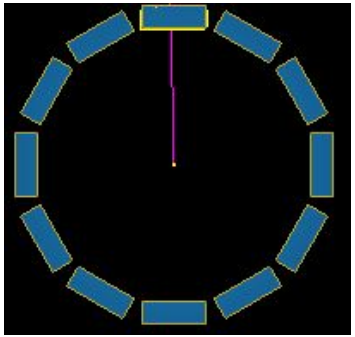
Shorter Prism & smaller pixel

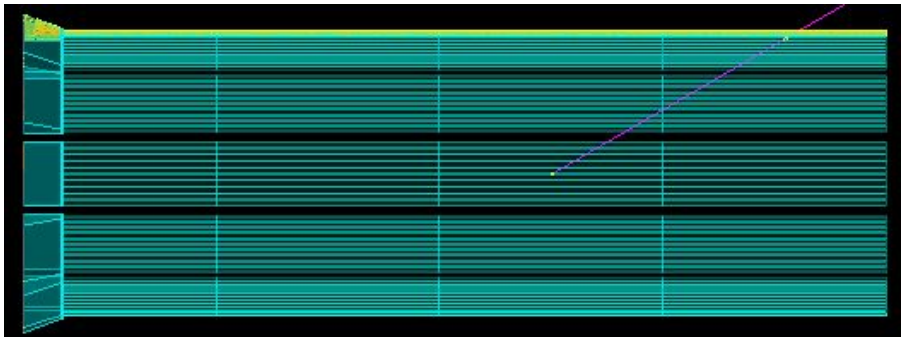


Front View of full pixelated sensors



200 mm Prism Depth





Event display

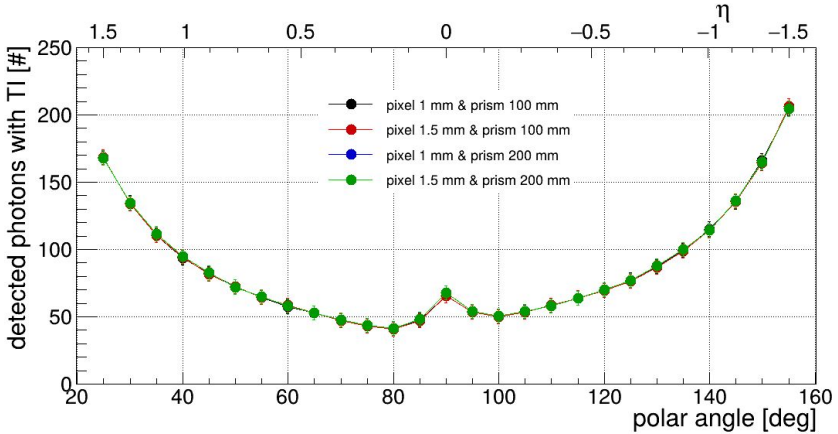
1×3 layouts; 32×32 pixel HRPPD (Incom) corresponds to a fully pixelated sensor

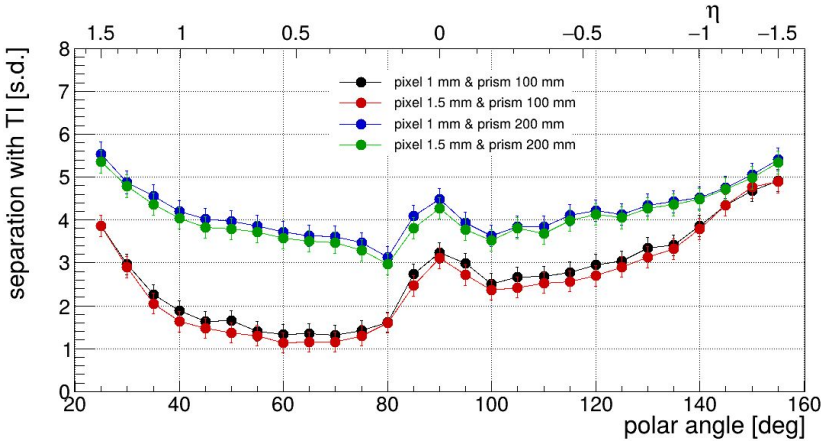
CE=95%; 100 ps time precision
B_field on

TI with 20k PDF for 3 mm pixel
TI with 45k PDF for 1.5 mm pixel
TI with 75k PDF for 1 mm pixel

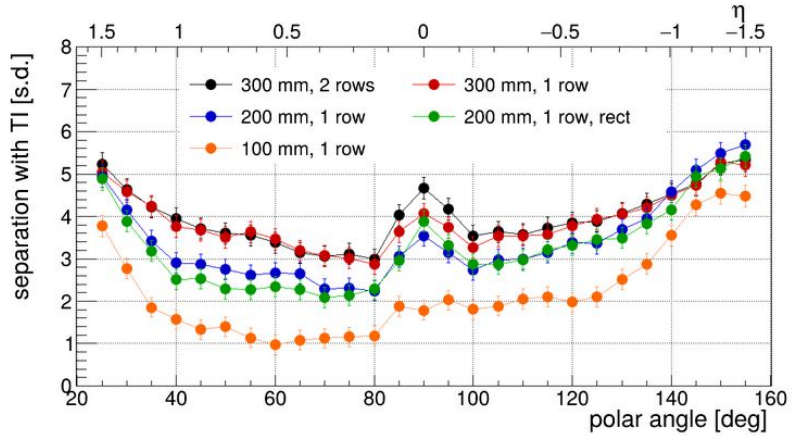
Prism plane same as one row of HRPPD
CE = 95%
Full pixelated plane
For 200 mm Prism depth, (r1. r2) = 75, 33
100 mm prism, (r1, r2) = 108, 27

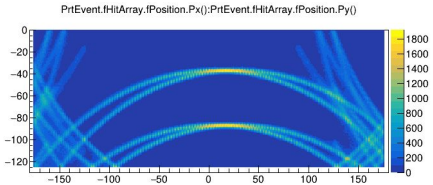
Shorter Prism & smaller pixel

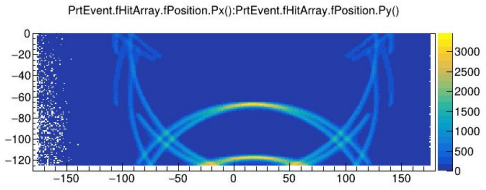




Roman's result: pixel size 3 mm, 20k PDF
Imran's result: pixel size 1 mm, 75k PDF
Pixel size 1.5 mm, 45k PDF
Tracking resolution: 0.5 mrad
Timeres: 100 ps

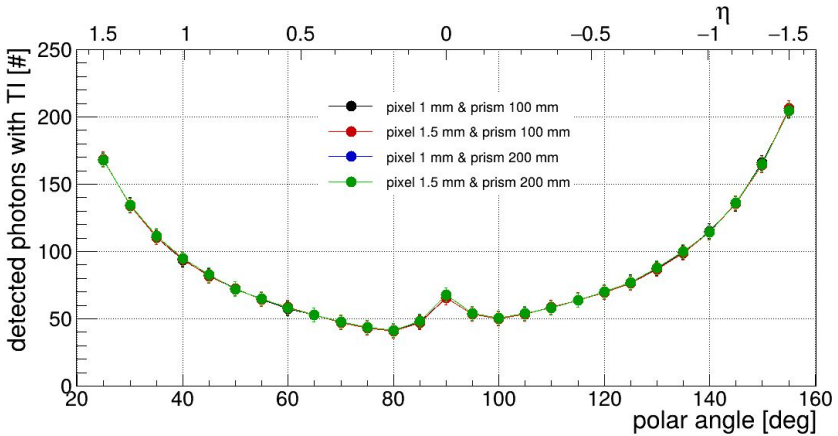


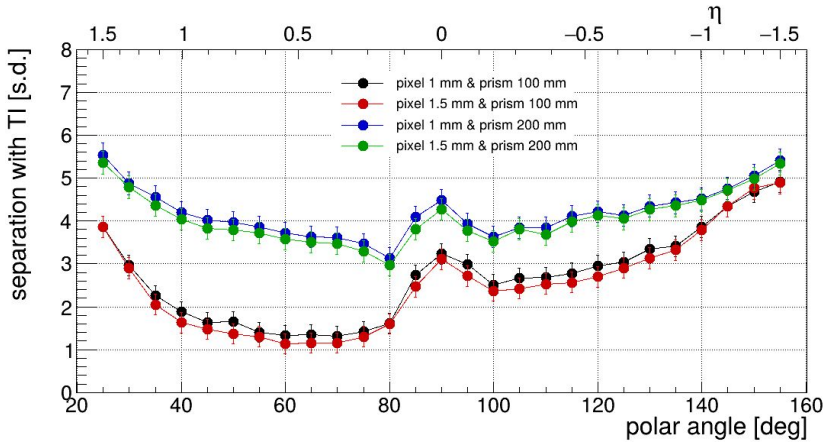




200 mm Prism 30 deg. Pol. ang. 100 mm Prism

Shorter Prism & smaller pixel

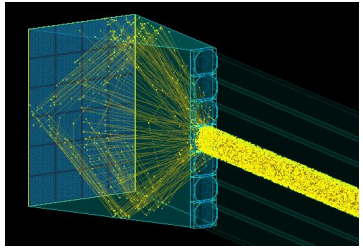




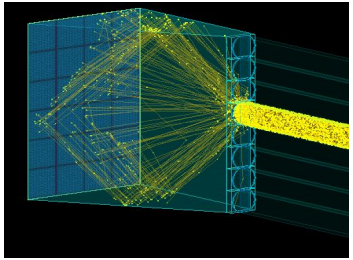
- For a prism depth of 200 mm, pixel size has a significant impact on PID performance.
- However, for prism depths smaller than 200 mm, reducing the pixel size provides only limited improvement in PID performance.

Different number of bars in a barbox

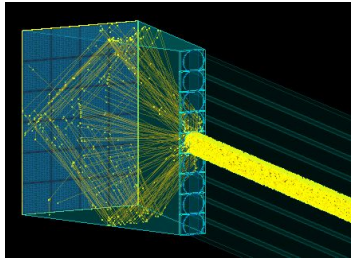
Event Display of different number of bars in a barbox



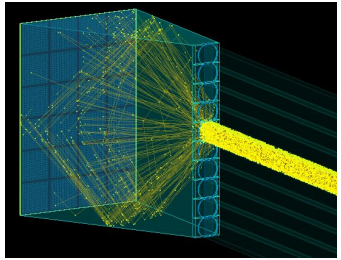
7 bars



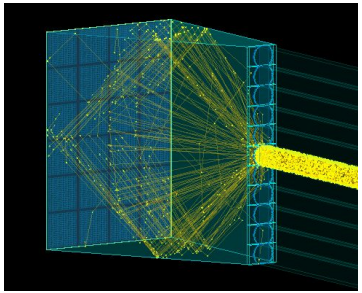
8 bars



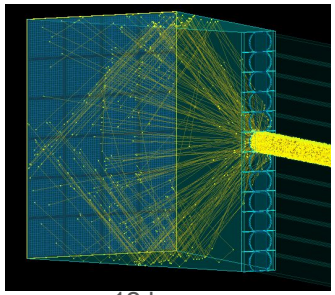
9 bars



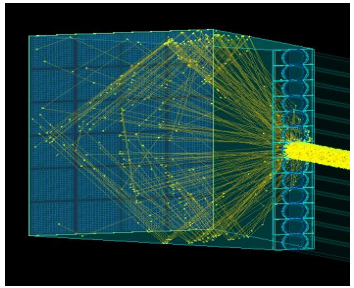
10 bars



11 bars



12 bars

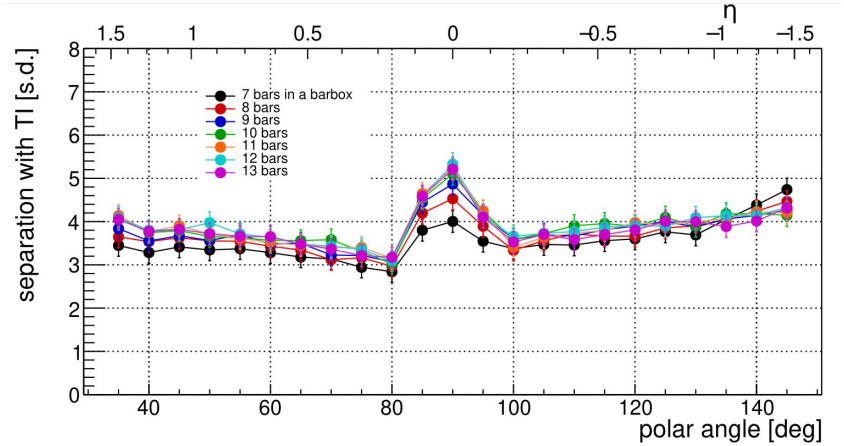


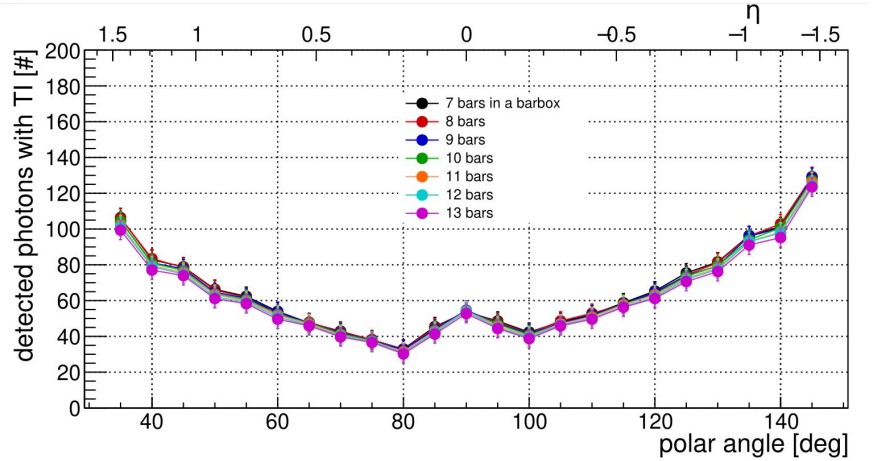
13 bars

Bar Width and len thickness in different configurations

Number of bars	Bar Width(mm)	Barbox Width(mm)	Radius (mm)	Lens Thickness (mm)
7	49.0357	351.35	770.5	17.6295
8	42.7375	351.35	770.5	14.7688
9	37.8389	351.35	770.5	12.97
10	34.92	351.35	770.5	11.7488
11	30.7136	351.35	770.5	10.8761
12	28.0417	351.35	770.5	10.2284
13	25.7808	351.35	770.5	9.7336

Time Imaging reco performance plots for different bars set up in barbox

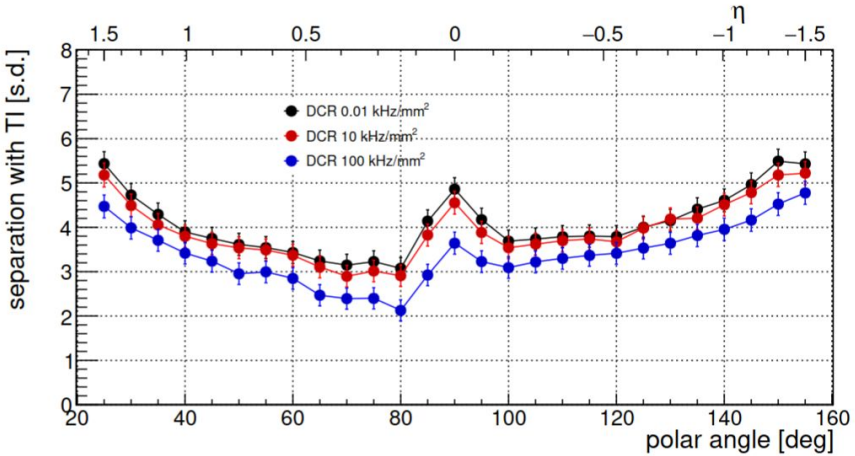


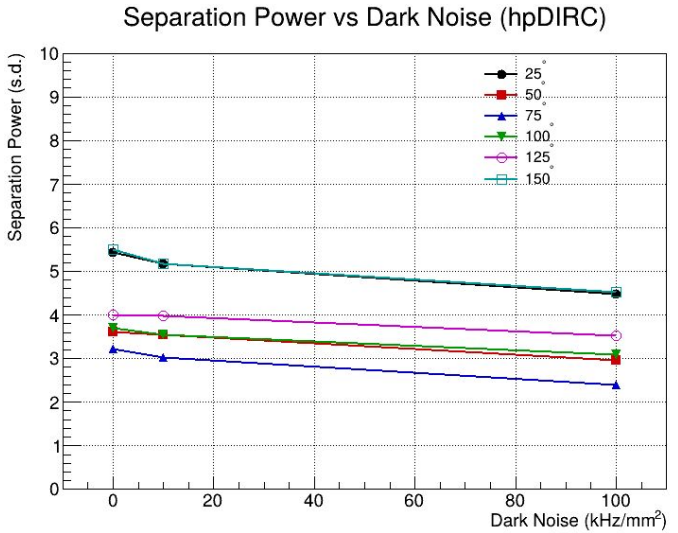


- No significant difference in PID performance is observed when the number of bars in a barbox varied from 7 to 13.

hpDIRC Performance under Varying Dark Count Rates

hpDIRC Performance under Varying Dark Count Rates





- Dark Count Rate (DCR) expected to have significant impact on detector performance.
- Performance degradation due to DCR not dramatic!

hpDIRC, Sensor: **HRPPD** (QE =0.95)
Events = 50000, Pdf = 45k, Time res =100ps
Tracking res = 0.5 mrad, Magnetic field = 1.7 T

BackUp

Processing /work/eic3/users/ihossain/pmt_occupancy/plot_mean_detected_photons_12pmts.C...

angle=30 deg tracks=50000 mean_detected_photons_per_track=105.402

angle=35 deg tracks=50000 mean_detected_photons_per_track=93.4282

angle=40 deg tracks=50000 mean_detected_photons_per_track=72.3129

angle=45 deg tracks=50000 mean_detected_photons_per_track=71.8673

angle=50 deg tracks=50000 mean_detected_photons_per_track=59.5717

angle=55 deg tracks=50000 mean_detected_photons_per_track=54.7431

angle=60 deg tracks=50000 mean_detected_photons_per_track=50.4082

angle=65 deg tracks=50000 mean_detected_photons_per_track=42.42

angle=70 deg tracks=50000 mean_detected_photons_per_track=42.1063

angle=75 deg tracks=50000 mean_detected_photons_per_track=36.9686

angle=80 deg tracks=50000 mean_detected_photons_per_track=36.6697

angle=85 deg tracks=50000 mean_detected_photons_per_track=37.9863

angle=90 deg tracks=50000 mean_detected_photons_per_track=57.1132

angle=95 deg tracks=50000 mean_detected_photons_per_track=42.3755

ngle=100 deg tracks=50000 mean_detected_photons_per_track=44.4785

angle=105 deg tracks=50000 mean_detected_photons_per_track=45.5572

angle=110 deg tracks=50000 mean_detected_photons_per_track=50.6136

angle=115 deg tracks=50000 mean_detected_photons_per_track=50.591

angle=120 deg tracks=50000 mean_detected_photons_per_track=59.5712

angle=125 deg tracks=50000 mean_detected_photons_per_track=65.2384

angle=130 deg tracks=50000 mean_detected_photons_per_track=71.2547

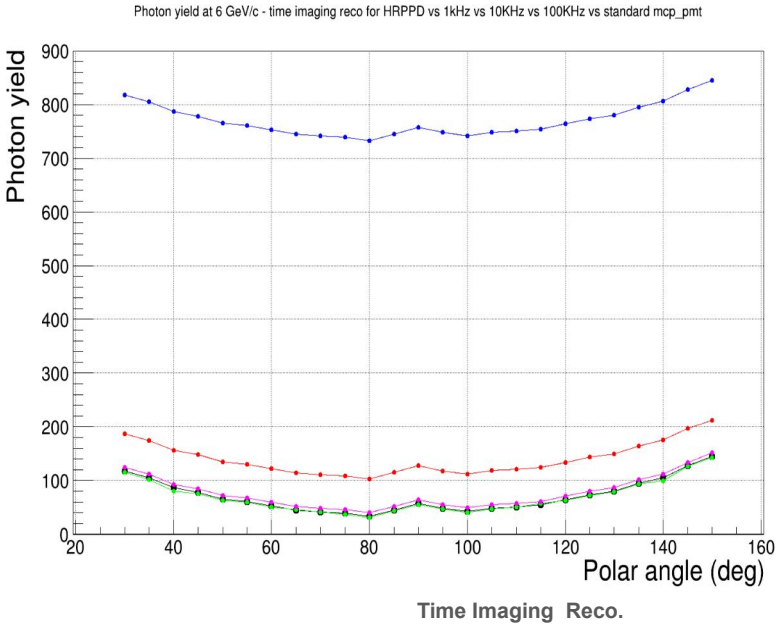
angle=135 deg tracks=50000 mean_detected_photons_per_track=85.7748

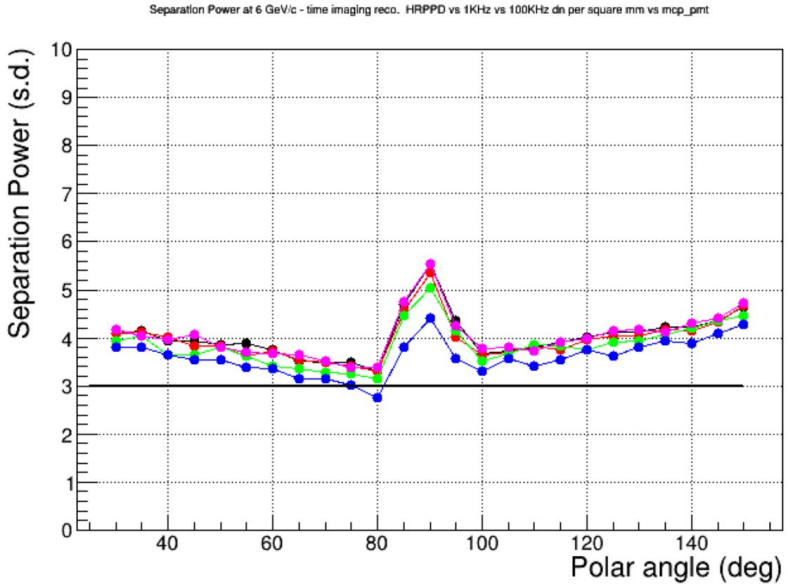
angle=140 deg tracks=50000 mean_detected_photons_per_track=86.3981

angle=145 deg tracks=50000 mean_detected_photons_per_track=113.497

angle=150 deg tracks=50000 mean_detected_photons_per_track=128.976

DN impact on performance with time-based reco different pixel size for mcp_pmt and HRPPD





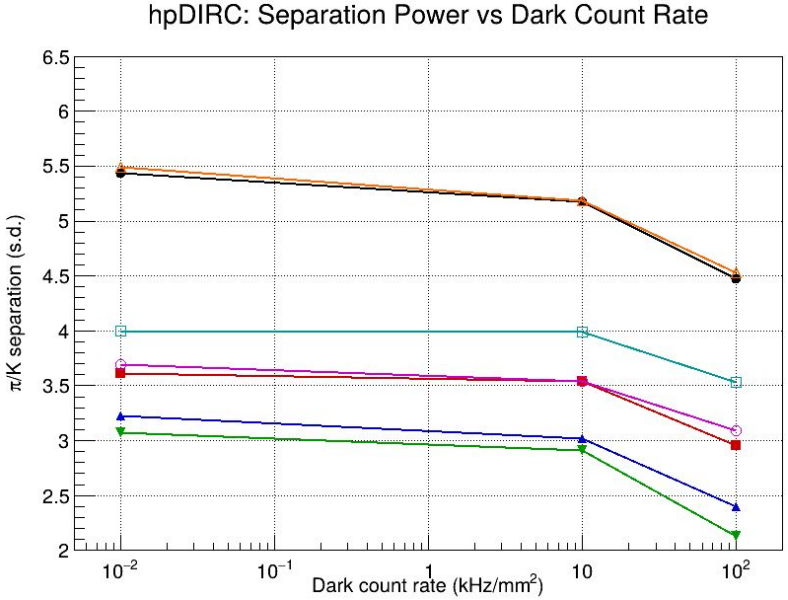
Photon Yield is visibly higher for higher DN rates because in time imaging reco there are no cuts applied..

For MCP_PMT, pixel size (16 x 16) = 3.3 x 3.3 mm^2 , active area = 53 x 53
For HRPPD, pixel size (40x40)= 2.7 x 2.7 mm^2, active area = 108 x 108

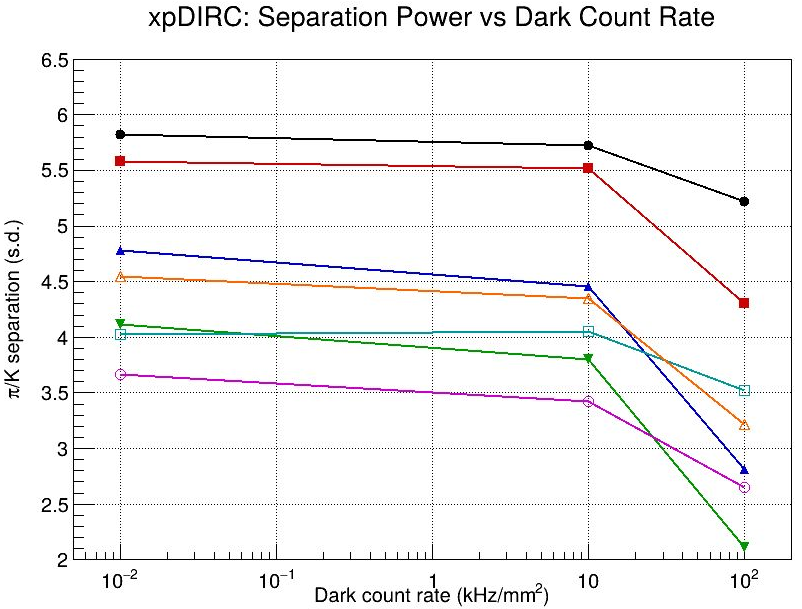
HRPPD (0.01KHz per square mm && 116.64 KHz/pmt)
1KHz DN per square mm
10KHz DN per square mm
100KHz DN per square mm
Standard mcp_pmt (0.01KHz per square mm && 28.09 KHz/pmt)

xpDIRC Performance: SiPM Dark Count Rates

- Dark Count Rate (DCR) expected to have significant impact on detector performance.
- Performance degradation due to DCR not dramatic! (but more pronounced in the plate-based xpDIRC geometry compared to the bar-based hpDIRC)



Different Colors represents polar angle in degree:
- 25
- 50
- 75
- 80
- 100
- 125
- 150

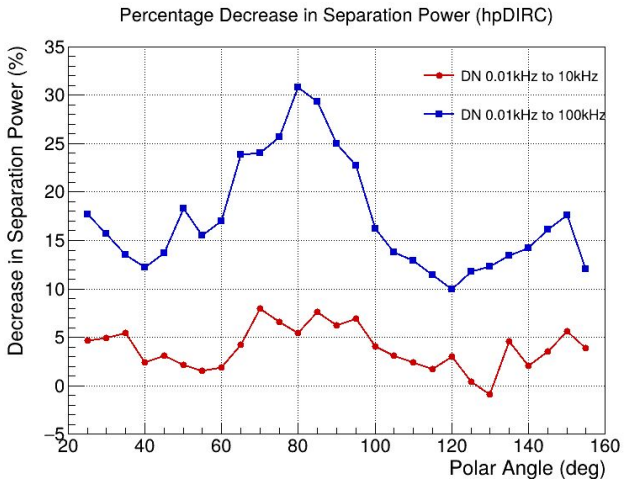


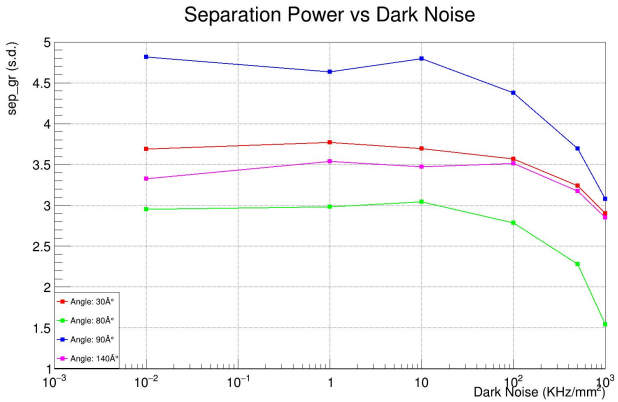
Detailed performance values for Time imaging reco (HRPPD pixel 3.37 mm and Mcp_pmt pixel 3.3mm)

	Dark noise(mm^2)	80°	90°	110°	125°	145°
Time imaging	1KHz	41	66	59	82	139
(pixel size around 3.3)	10KHz	104	129	122	145	202
Photon yield	100KHz	734	758	752	775	832
	HRPPD (0.01KHz)	34	59	52	75	132
	Mcp_Pmt (0.01KHz)	32	55	52	74	130
Sep.	10KHz	3.15	5.02	3.54	3.79	4.26
Power	100KHz	2.52	4.18	3.26	3.63	3.98
	HRPPD (0.01KHz)	3.18	5.19	3.64	3.96	4.36
	Mcp_Pmt (0.01KHz)	3.14	5.03	3.86	3.90	4.35

Average Sep power shift from pixel size 2.7 mm to 3.3 mm= 0.164 s.d.

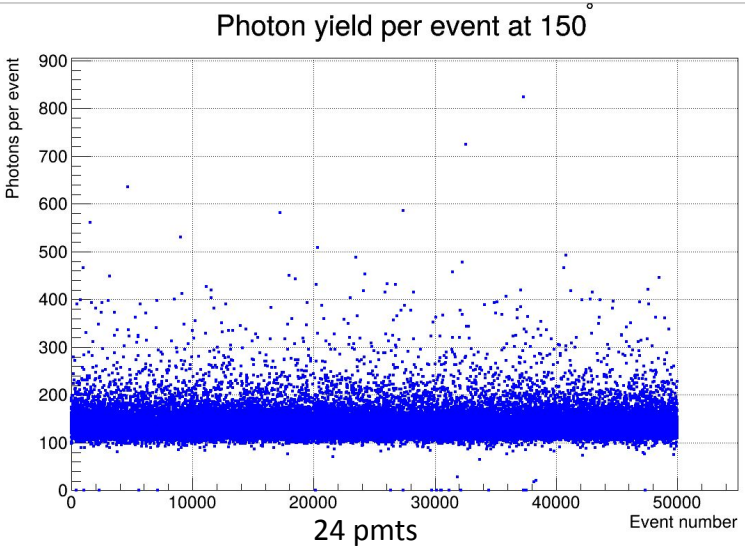
DCR impact on hpDIRC



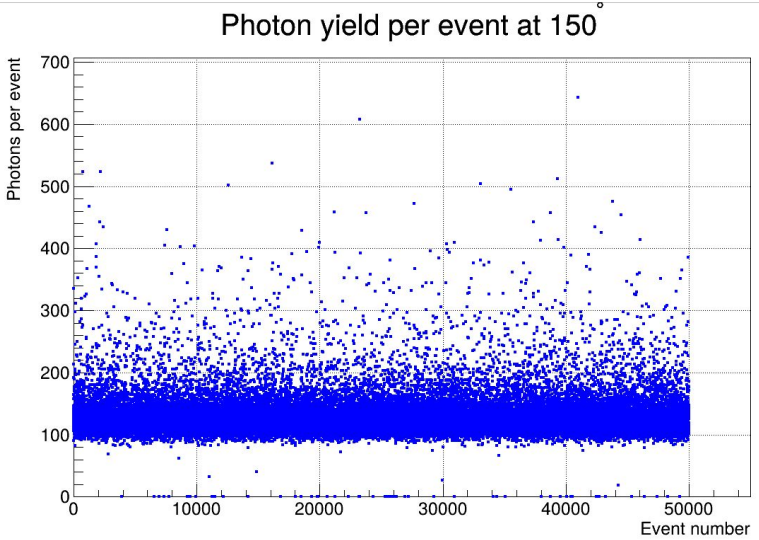


Percentage decrease in separation power (hpDIRC)

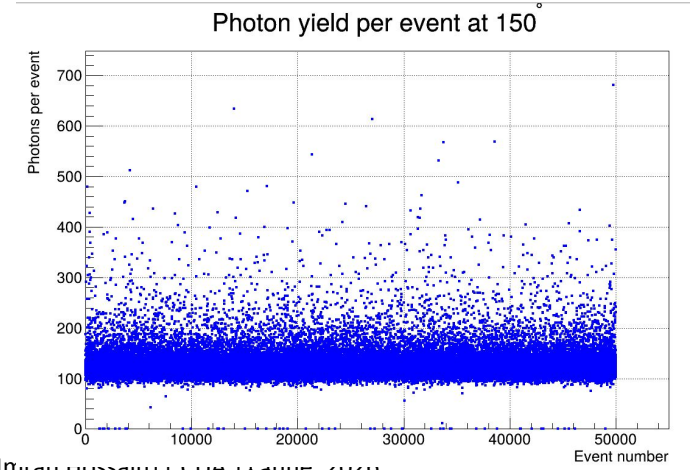
Angle(deg)	0.01→10 kHz (%)	0.01→100 kHz (%)	
25	4.68	17.73	
30	4.96	15.67	
35	5.45	13.56	
40	2.45	12.23	
45	3.09	13.70	
50	2.14	18.28	
55	1.53	15.48	
60	1.86	17.02	
65	4.21	23.87	
70	7.94	24.01	
75	6.57	25.65	
80	5.41	30.83	
85	7.62	29.36	hpDIRC
90	6.27	25.02	
95	6.94	22.71	
100	4.04	16.19	
105	3.07	13.78	
110	2.38	12.94	
115	1.72	11.43	
120	3.03	9.93	
125	0.44	11.75	
130	-0.87	12.31	
135	4.59	13.47	
140	2.09	14.22	
145	3.56	16.12	
150	5.62	17.59	
155	3.91	12.07	



24 pmts

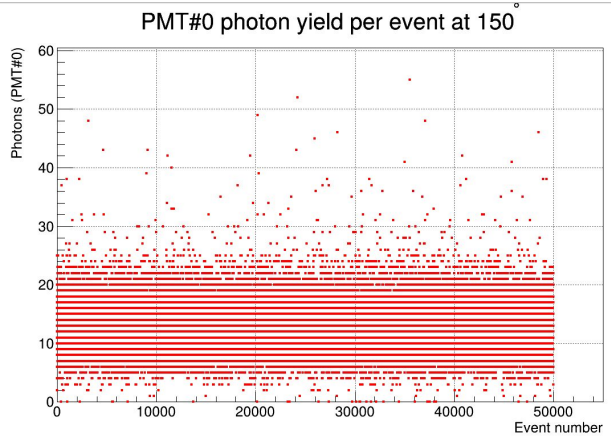


18 pmts

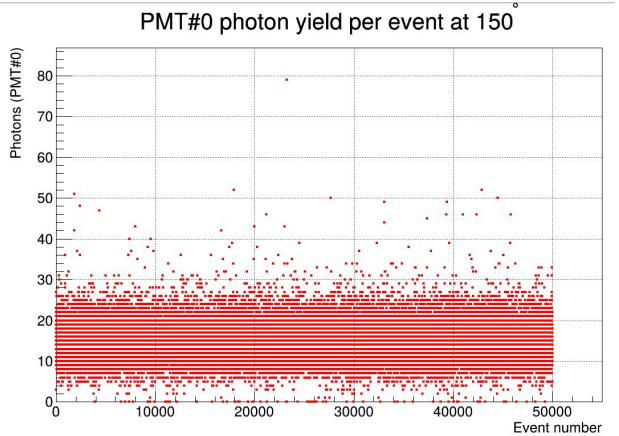


12 pmts

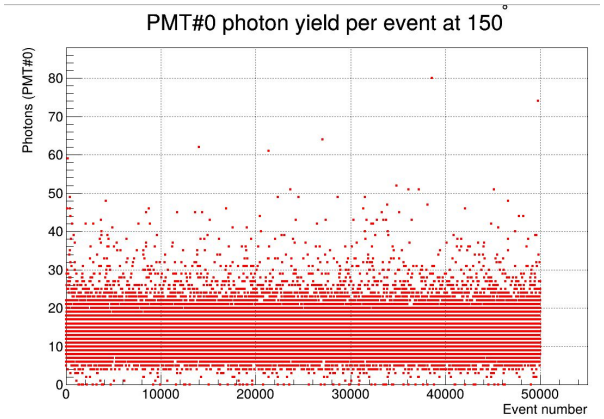
All Detected photons per event



24 pmts



18 pmts



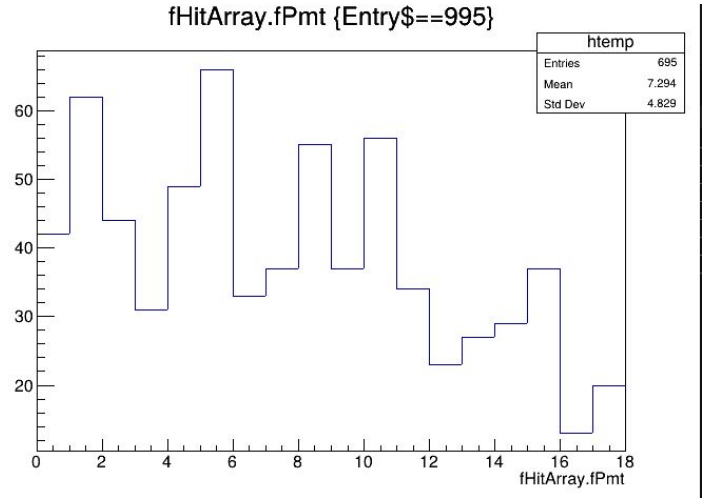
12 pmts

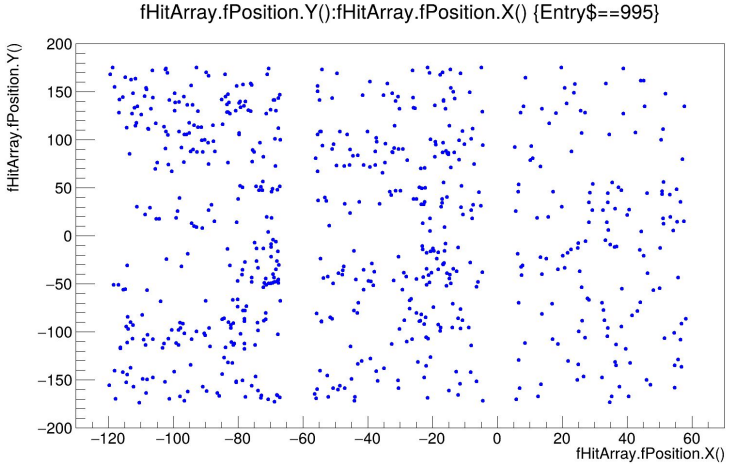
All Detected photons per event ,polar angle = 150 deg. , PMT#0

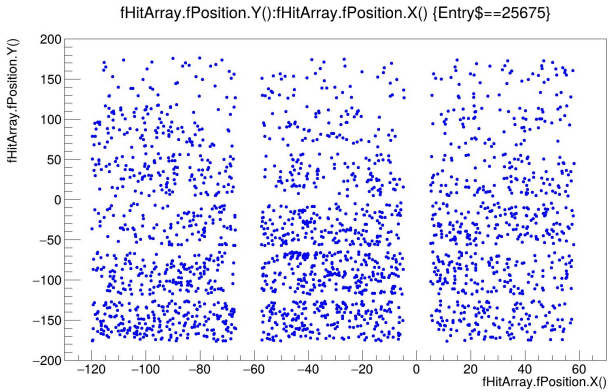
```
*    Row   *    Entry$ * Length$(f *
************************************
*     995 *      995 *      695 *
*    3585 *     3585 *      523 *
*    7129 *     7129 *      784 *
*    7148 *     7148 *      521 *
*    7966 *     7966 *      522 *
*   22000 *    22000 *      528 *
*   25675 *    25675 *     2272 *
*   31959 *    31959 *      515 *
************************************
```

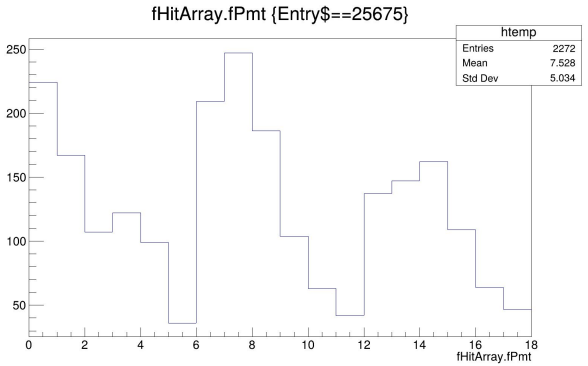
==> 8 selected entries

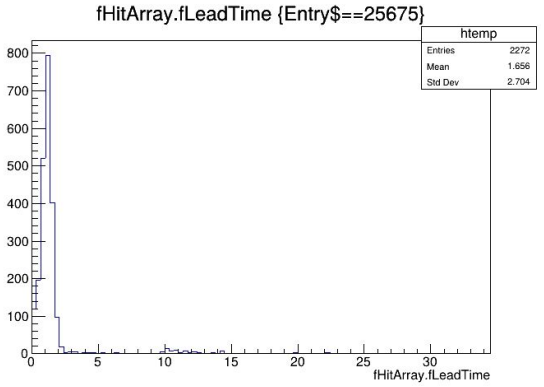
18 pmts, hpdirc
Polar angle= 145 deg.



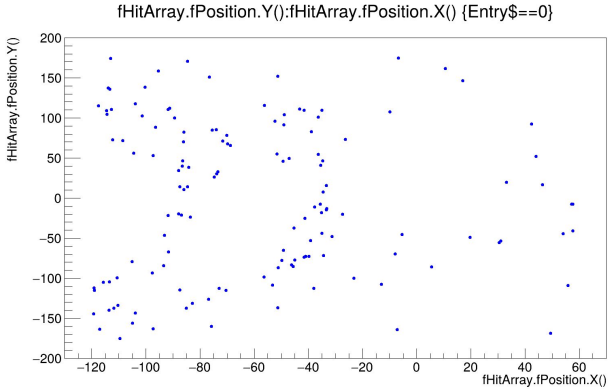


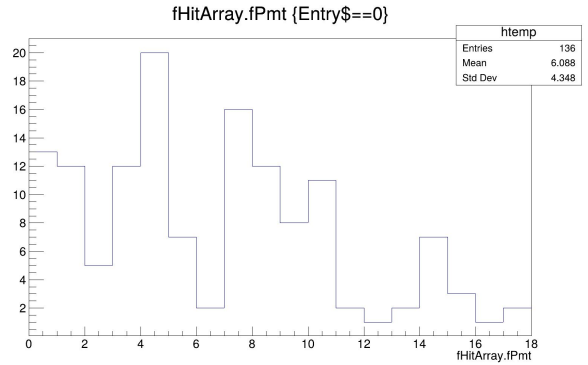


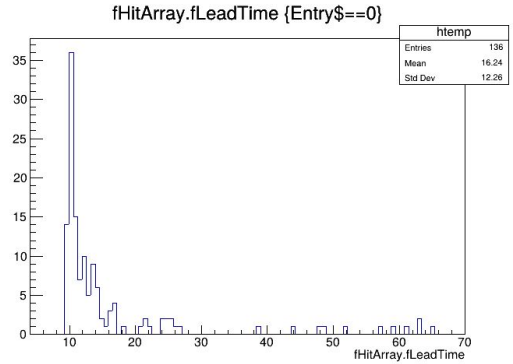




Abnormal event = 25675

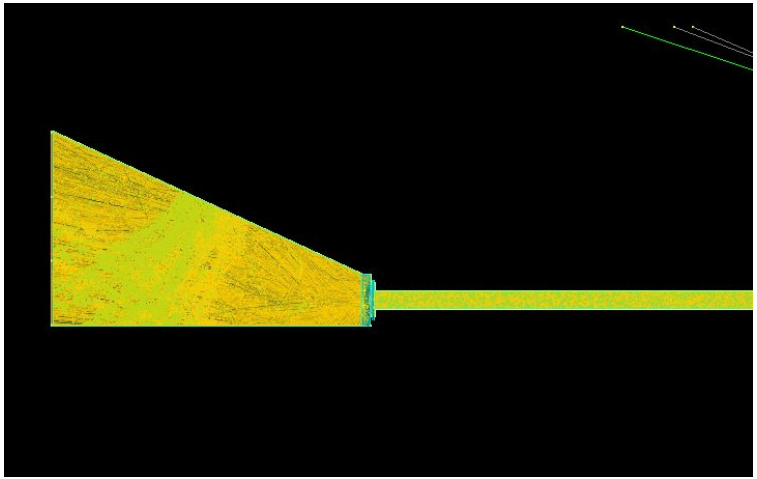


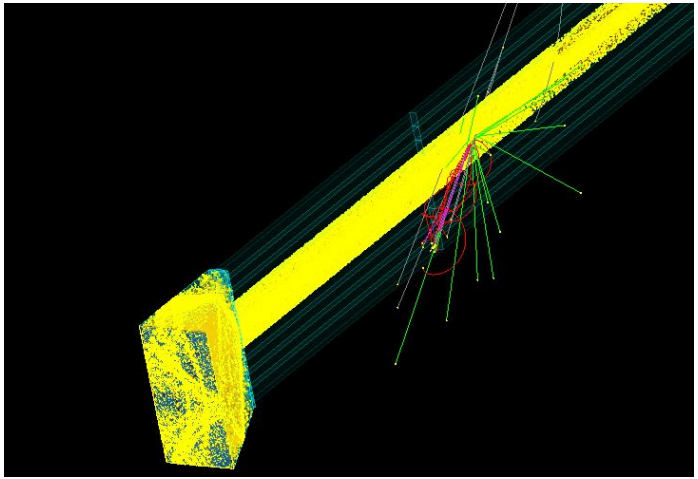




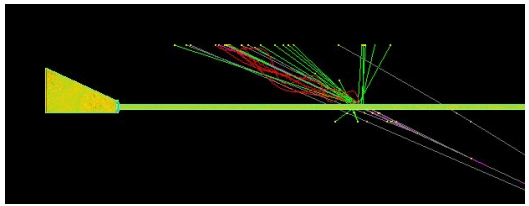
Normal event = 0

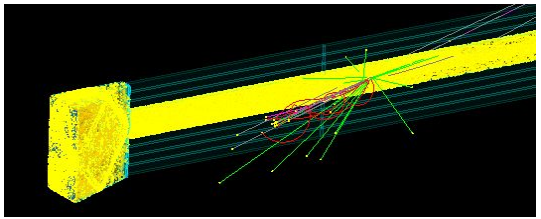
- I check 30 deg. to 120 deg. Polar angle and did not get any events greater than 500 photons
- I run 155 deg. Polar angle without multiple scattering and bremsstrahlung, did not find any event greater than 210 photons

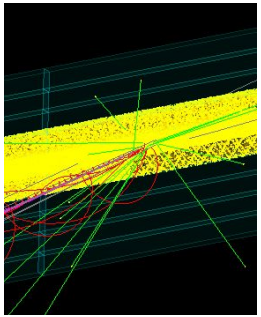


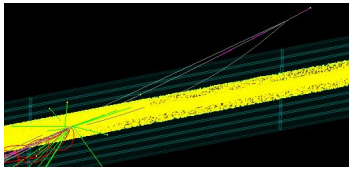


Detected photon= 503







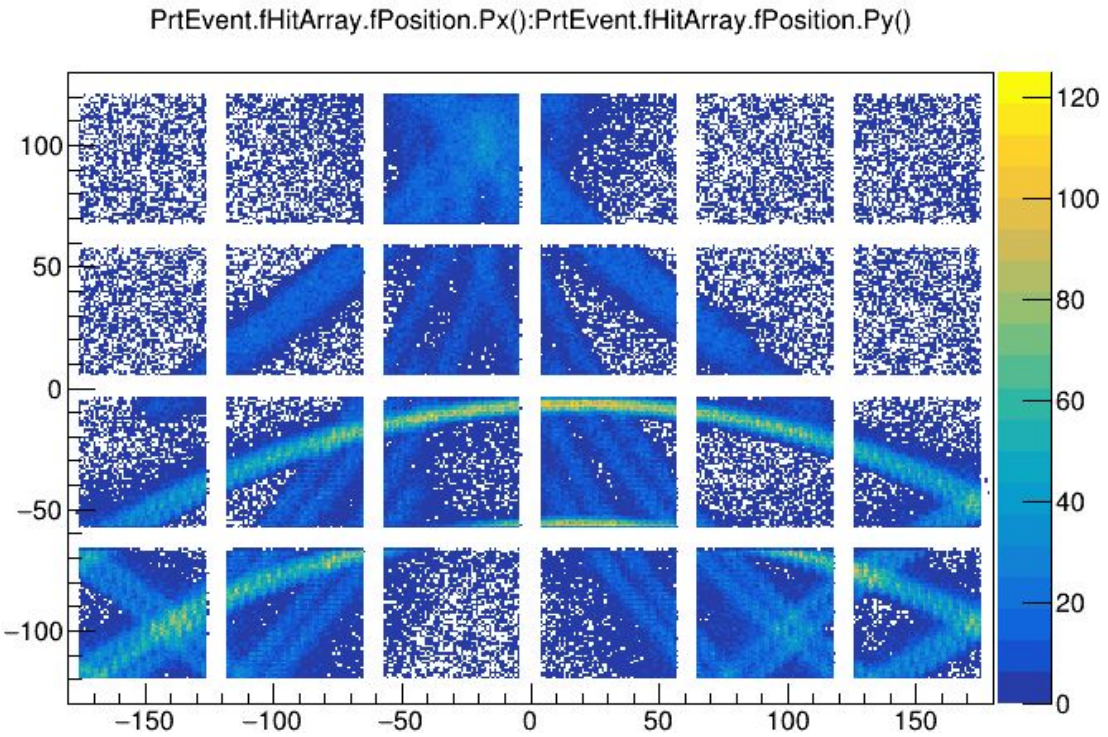


Sensor Coverage

24 pmts
Total photons detected across all 24 PMTs:
630,620 photons

Number of Photons per track = 126.124

(sum of all PMTs:
59574 (**pmt 0**) + 49803 (**pmt 1**) + 4614 (**pmt 2**) + 16399 (**pmt 3**) + 50421(**pmt 4**) + 48070(**pmt 5**) + 19933 (**pmt 6**) + 37924(**pmt 7**) + 39393 (**pmt 8**) + 58916 (**pmt 9**) + 30376(**pmt 10**) + 32403(**pmt 11**) + 3408 (**pmt 12**) + 27654 (**pmt 13**) + 21907(**pmt 14**) + 24022(**pmt 15**) + 13395 (**pmt 16**) + 2744 (**pmt 17**) + 2723 (**pmt 18**) + 3753 (**pmt 19**) + 60334 (**pmt 20**) + 16941(**pmt 21**) + 2793(**pmt 22**) + 3120(**pmt 23**))

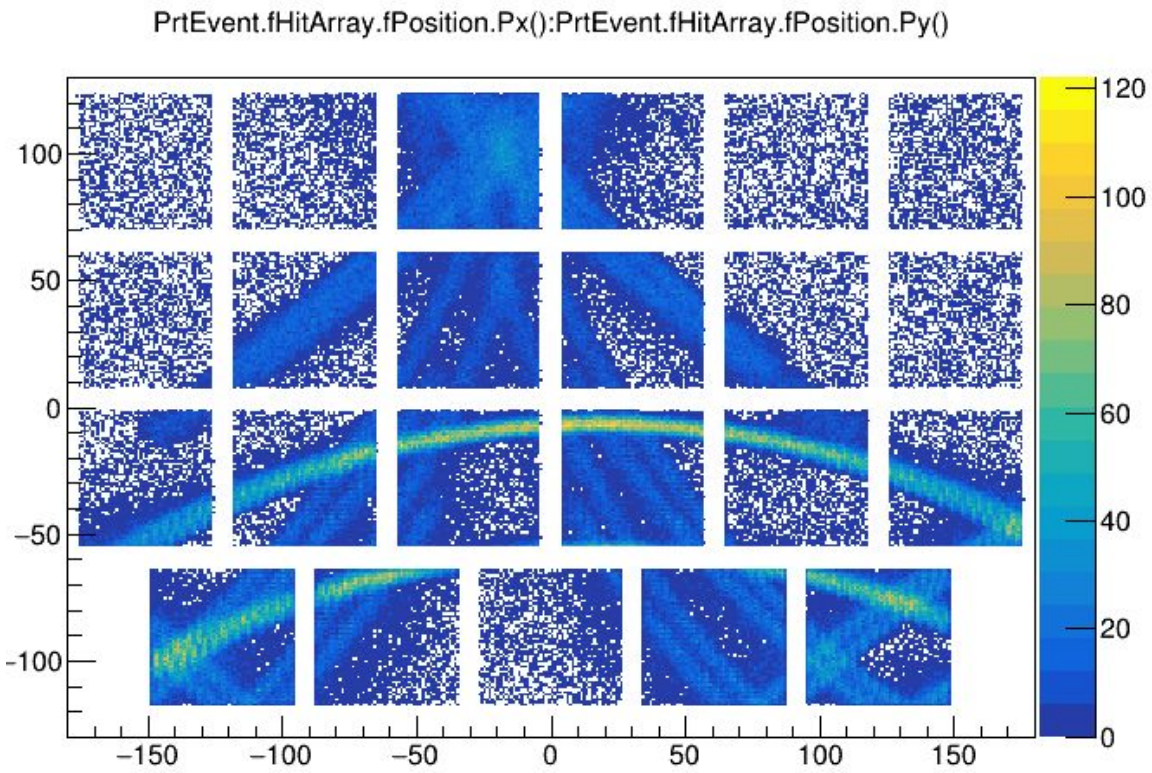


23 pmts

Total photons detected across all 23 PMTs:
582,202 photons

Number of photons per track = 116.44

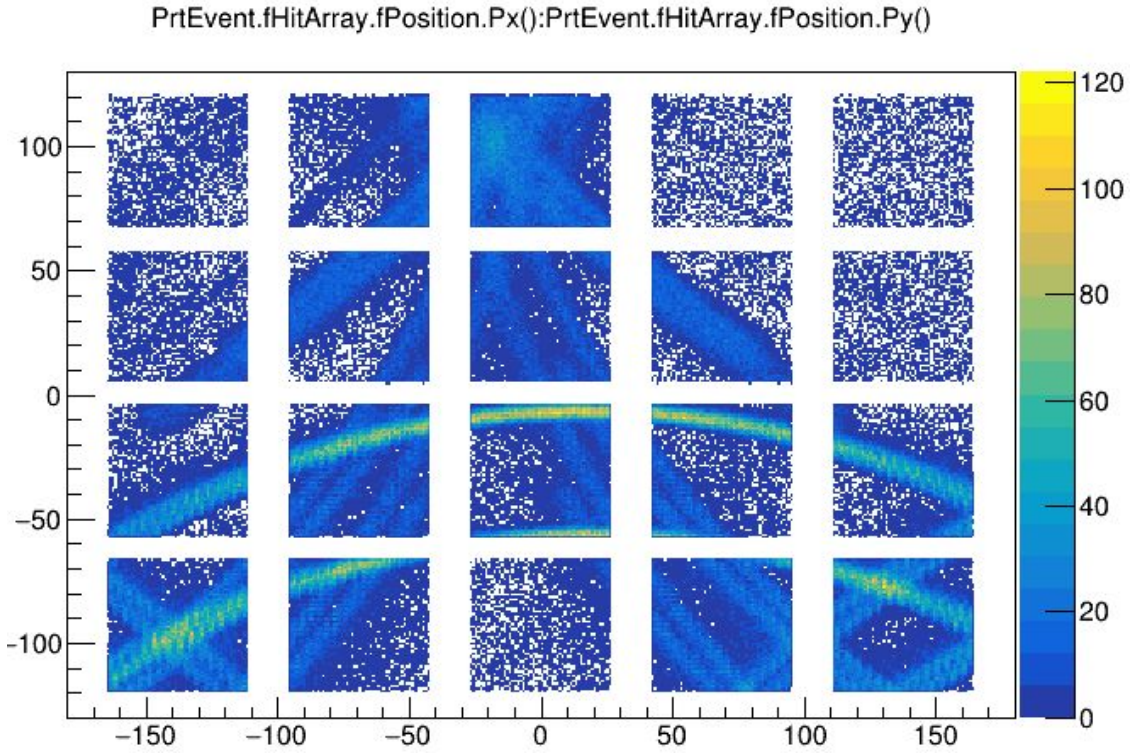
(Sum of all PMTs:
62370 + 24957 + 4523 + 30783 + 59192 + 19922 + 37343 + 39328 + 58390 + 30120 + 31990 + 3348 + 27928 + 22054 + 24154 + 13388 + 2676 + 2546 + 3795 + 60738 + 16820 + 2846 + 2991)



5 x4 evenly distributed
Total photons detected: 555,780

Number of Photons per track =111.156

64248**(pmt 0)** + 33657**(pmt 1)** + 4998 **(pmt 2)**+ 36564**(pmt 3)** + 56887**(pmt 4)** + 25960**(pmt 5)** + 47131**(pmt 6)** + 48101**(pmt 7)** + 37345**(pmt 8)** + 30987**(pmt 9)** + 10173**(pmt 10)** + 24397 **(pmt 11)**+ 22100 **(pmt 12)**+ 24733**(pmt 13)** + 3777**(pmt 14)** + 4828 **(pmt 15)**+ 16701 **(pmt 16)**+ 56064 **(pmt 17)**+ 3628 **(pmt 18)**+ 3501 **(pmt 19)**+ 0 **(pmt 20)**+ 0 **(pmt 21)**+ 0 **(pmt 22)**+ 0**(pmt 23)**



Pmts	Pmt (0)	Pmt (1)	Pmt (2)	Pmt (3)	Pmt (4)	Pmt (5)	Pmt (6)	Pmt (7)	Pmt (8)	Pmt (9)	Pmt (10)	Pmt (11)
24 pmts	59574	49803	4614	16399	50421	48070	19933	37924	39393	58916	30376	32403
23 pmts	62370	24957	4523	30783	59192	19922	37343	39328	58390	30120	31990	3348
20 pmts	64248	33657	4998	36564	56887	25960	47131	48101	37345	30987	10173	24397

	Pmt (12)	Pmt (13)	Pmt (14)	Pmt (15)	Pmt (16)	Pmt (17)	Pmt (18)	Pmt (19)	Pmt (20)	Pmt (21)	Pmt (22)	Pmt (23)	Total Counts
24 pmts	3408	27654	21907	24022	13395	2744	2723	3753	60334	16941	2793	3120	**630,620**
23 pmts	27928	22054	24154	13388	2676	2546	2546	60738	16820	2846	2991	0	**582,202**
20 pmts	22100	24733	3777	4828	16701	56064	3628	3501	0	0	0	0	**555,780**

30 deg pol angle

Photon loss: (30 deg polar angle)

For 23 pmts, (23 pmts photon count / 24 pmts photon count) = 582,202 / 630,620 = 0.923

Loss in percentage = (1- 0.923) x 100 = 7.7 %

For 20 pmts, 555,780 / 630620 = 0.8813

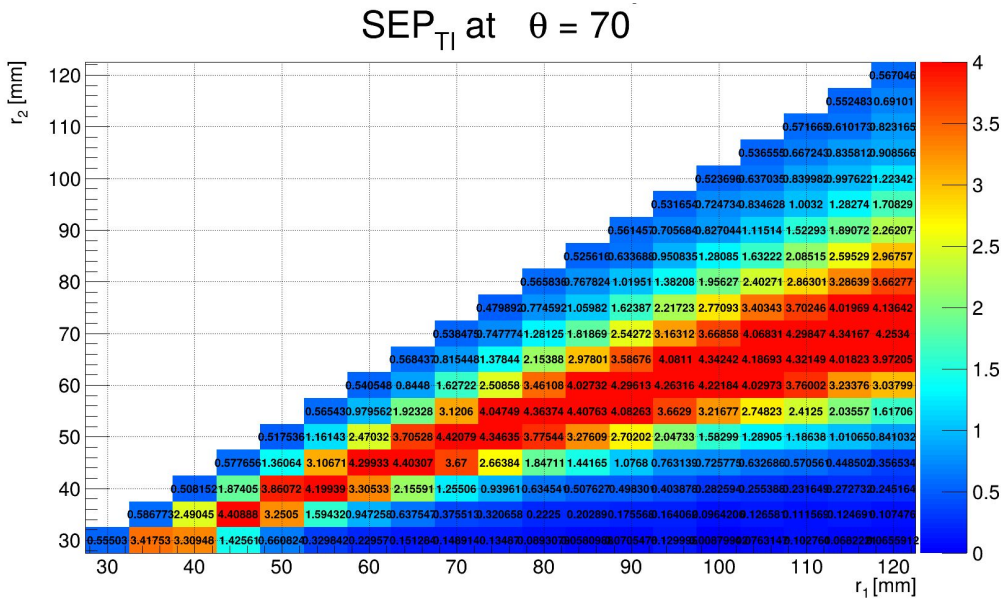
Loss in percentage = (1 - 0.8813) x 100 = 11.87%

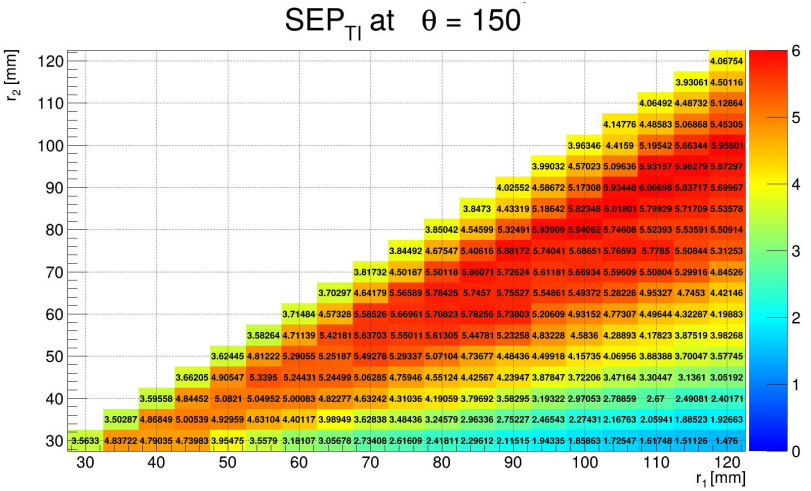
In reconstruction at 30 deg. Polar angle the photon yield, for 24 pmts = 108.65

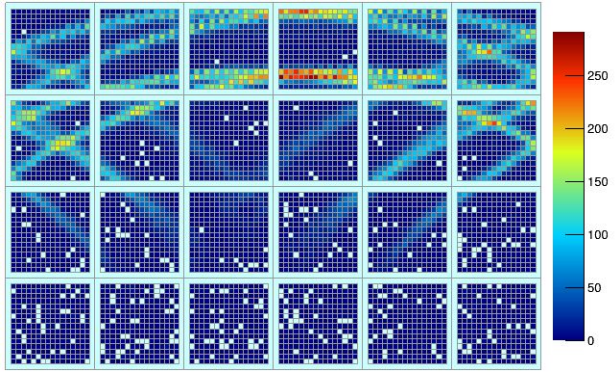
Now, validate this result by calculation, for 23 pmts = 108.65 x 0.923 = 100.28

For 20 pmts = 108.65 x 0.8813 =95.753

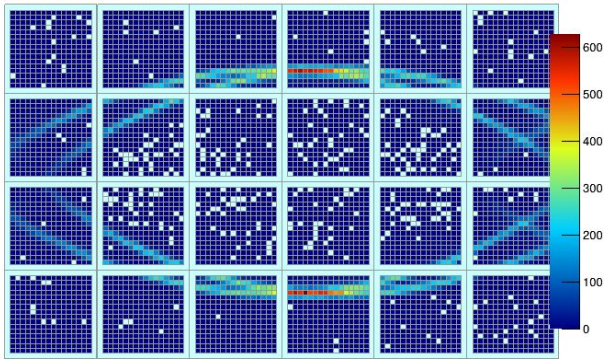
Radii scan for 600 mm prism depth with ev 0 , 24 pmts



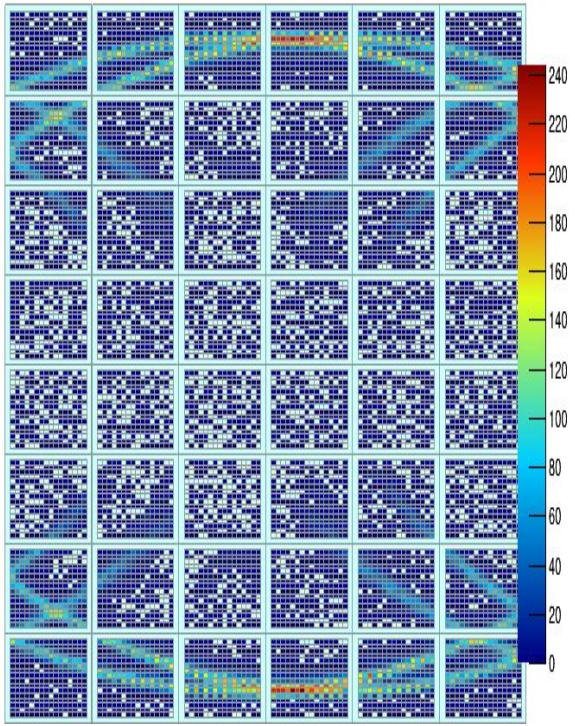




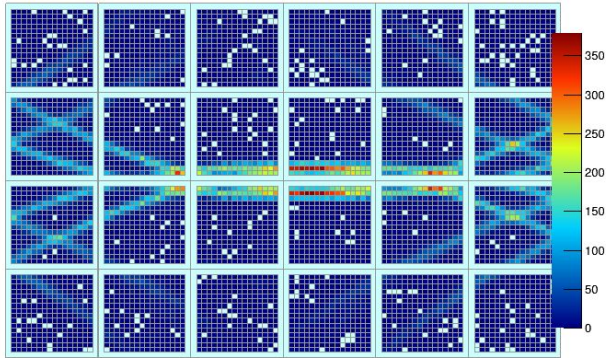
hpDIRC



24 PMTs + double open ang Prism (depth 200 mm) + bars



48 PMTs + double open ang Prism (depth 300 mm) + bars

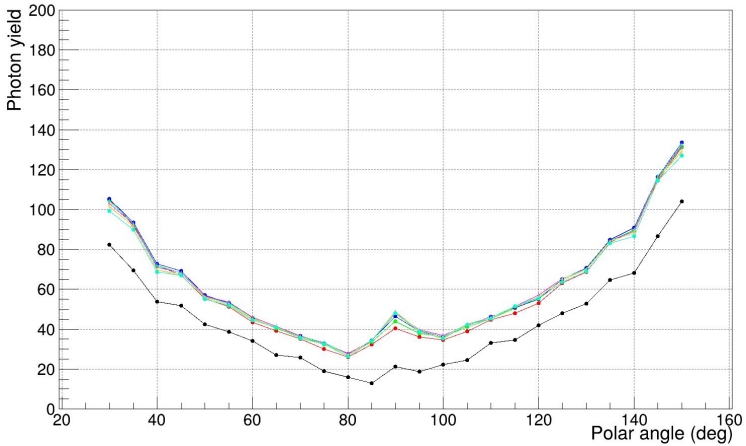


24 PMTs + double open ang Prism (depth 300 mm) + bars

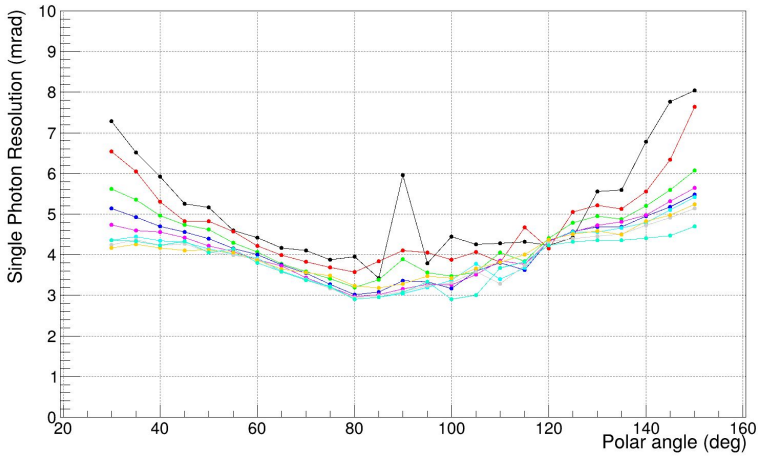
Polar angle = 90 deg.

Geometric reco performance plots (Pion-Kaon) for different bars set up in barbox

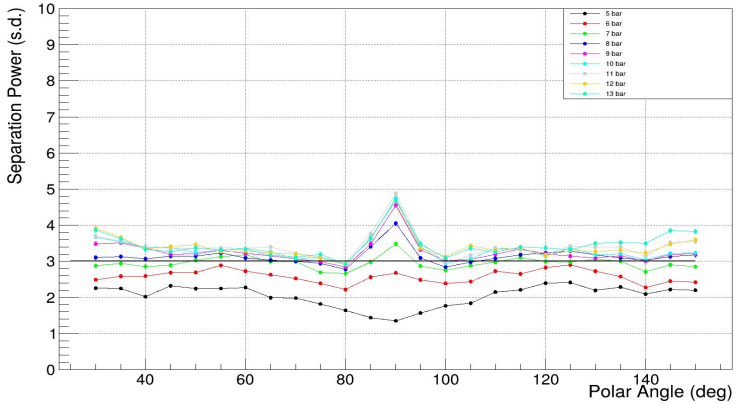
Photon yield at 6 GeV/c - geometric reco.



SPR at 6 GeV/c - geometric reco.

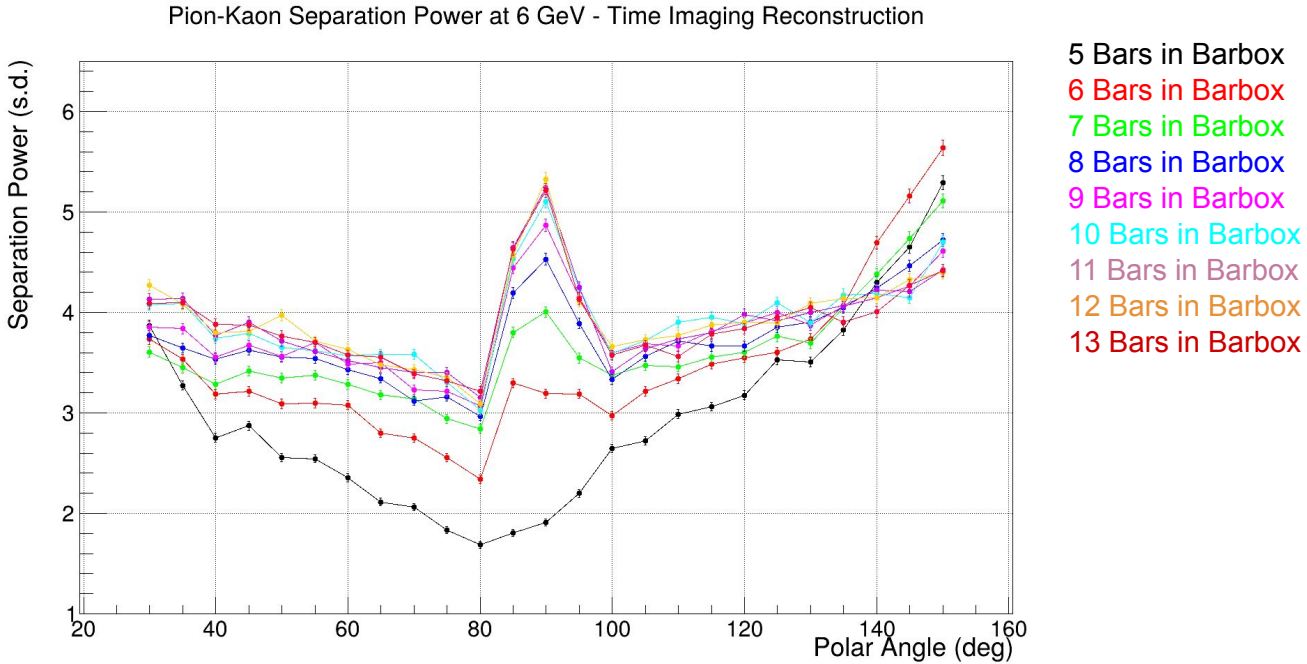


Separation Power at 6 GeV/c - Geometric Reconstruction

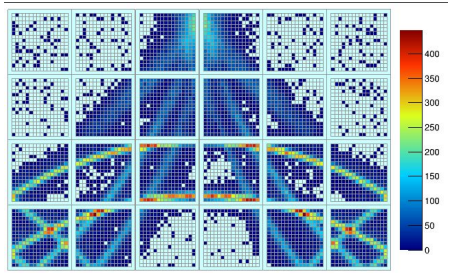


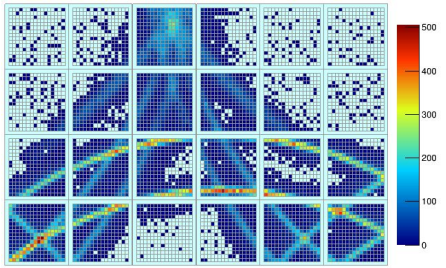
5 bars in a barbox
6 bars in a barbox
7 bars in a barbox
8 bars in a barbox
9 bars in a barbox
10 bars in a barbox
11 bars in a barbox
12 bars in a barbox
13 bars in a barbox

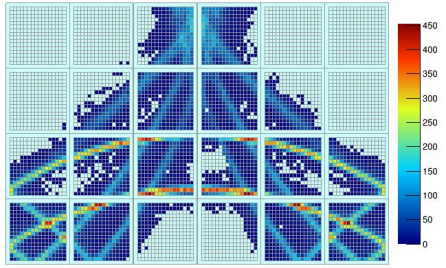
Time Imaging reco. performance plots for different bars set up in barbox

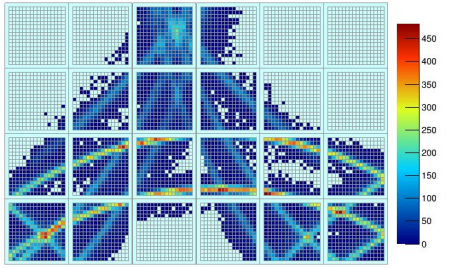


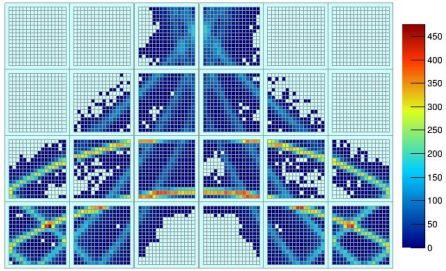
Hit pattern for a 30-degree polar angle in different bars of a barbox

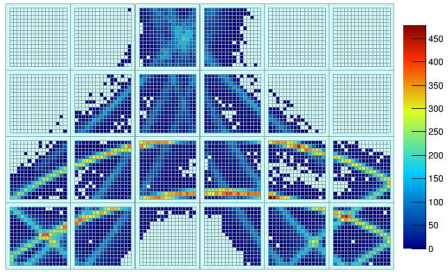

7 bars

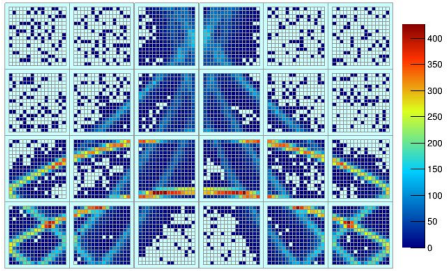

8 bars

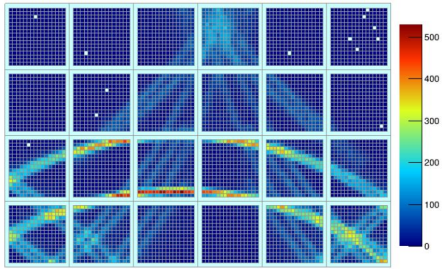

9 bars

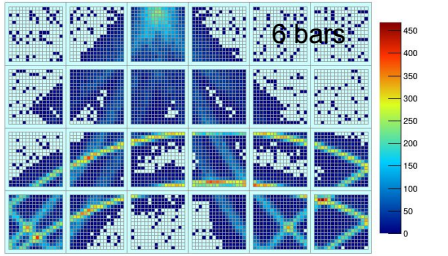

10 bars


11 bars

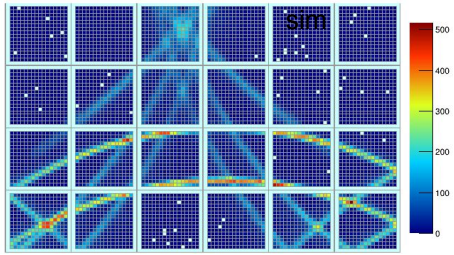

12 bars

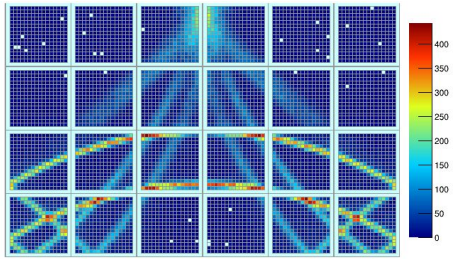

13 bars


5 bars

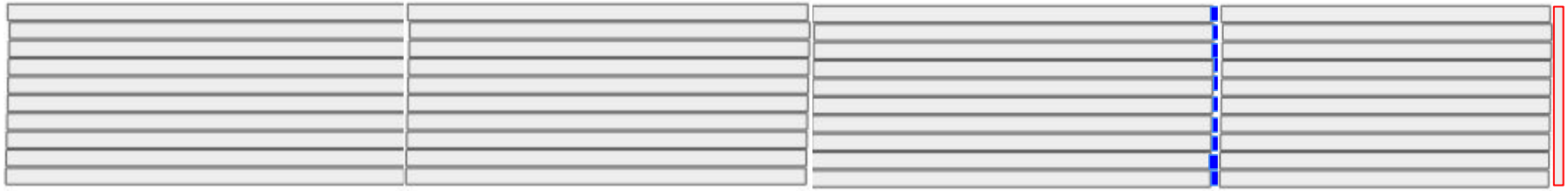


10 bars sim

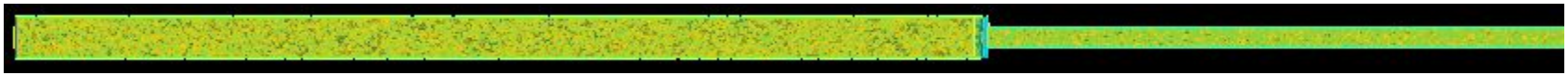


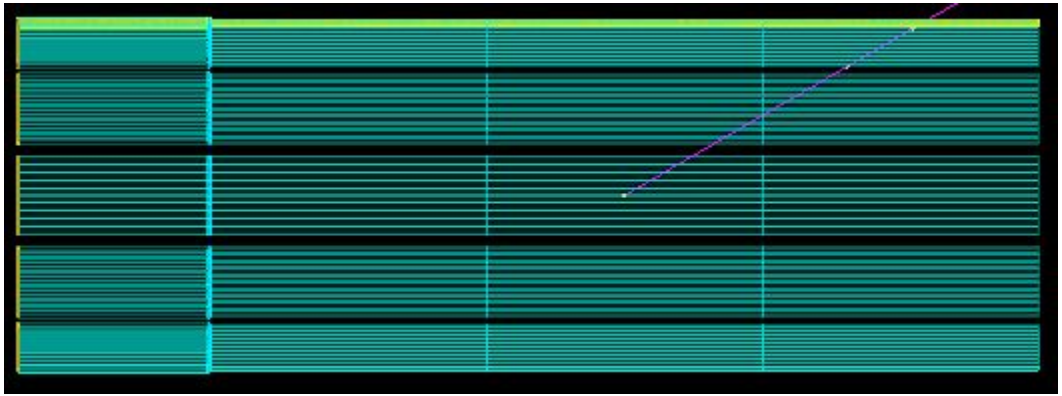


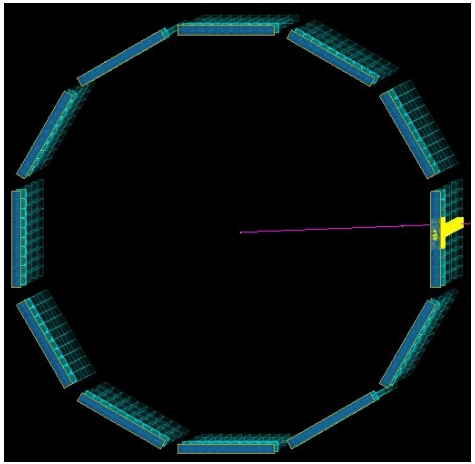
7 bars sim

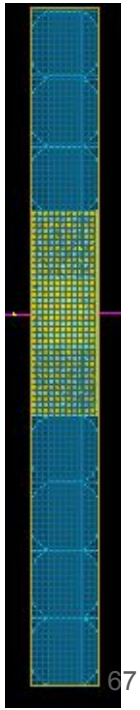


Bars = 17.5 x 35 x 1225 mm^3 Bars = 17.5 x 35 x 1225 mm^3 Bars = 17.5 x 35 x 1225 Lens= 35 x 35 x 12 =l 3 radiators = 35 x 35 x 840 mm^3

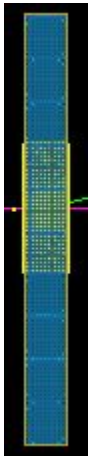


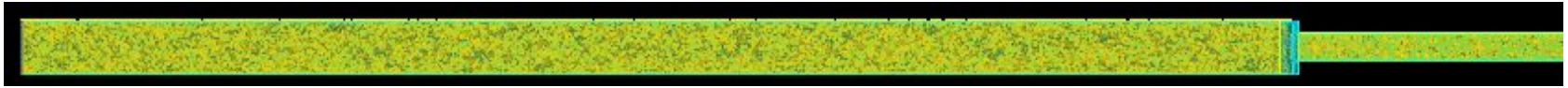






hpDIRC without EV





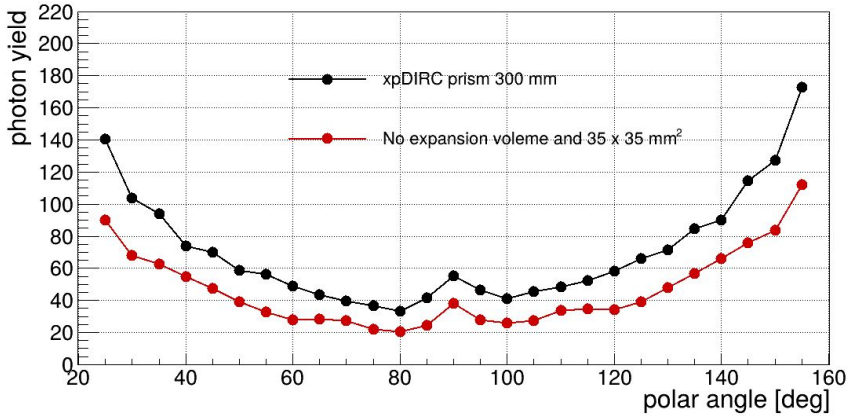
Bars = 17.25 x 35 x 1225 mm^3

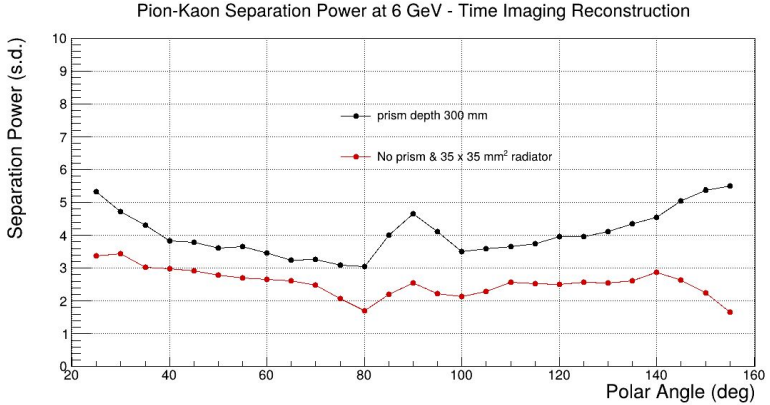
Lens= 35 x 35 x 12 =l 3

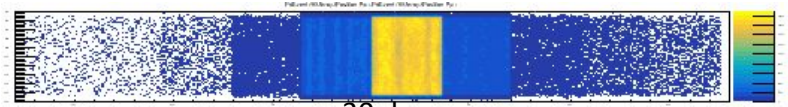
radiators = 35 x 35 x 840 mm^3

Radii scan, r1 = 70, r2 = 55

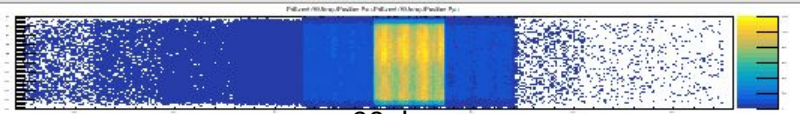
hpDIRC without EV



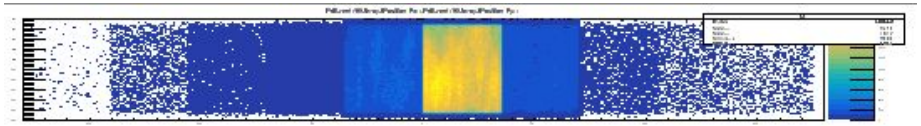




30 deg



90 deg



140 deg