

GW Counterpart Search of CAL Gamma-Ray Events associated with S190408an

GW candidate T0: 2019/04/08 18:18:02.288180
CAL zenith at T0: RA= 352.907 deg, DEC= 8.350 deg
HXM zenith at T0: RA= 344.377 deg, DEC= 13.827 deg

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January 22, 2020

1 LVC GCN Notice

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TITLE:          GCN/LVC NOTICE  
NOTICE_DATE:    Mon 08 Apr 19 20:21:45 UT  
NOTICE_TYPE:    LVC Initial Skymap  
TRIGGER_NUM:    S190408an  
TRIGGER_DATE:   18581 TJD;    98 DOY;    2019/04/08 (yyyy/mm/dd)  
TRIGGER_TIME:   65882.288180 SOD {18:18:02.288180} UT  
SEQUENCE_NUM:   2  
GROUP_TYPE:     1 = CBC  
SEARCH_TYPE:    1 = AllSky  
PIPELINE_TYPE:  4 = GSTLAL  
FAR:            2.811e-18 [Hz] (one per 4117051101094.8 days) (one per 11279592057.79 years)  
PROB_NS:        0.00 [range is 0.0-1.0]  
PROB_REMNANT:   0.12 [range is 0.0-1.0]  
PROB_BNS:       0.00 [range is 0.0-1.0]  
PROB_NSBH:      0.00 [range is 0.0-1.0]  
PROB_BBH:       1.00 [range is 0.0-1.0]  
PROB_MassGap:   0.00 [range is 0.0-1.0]  
PROB_TERRES:    0.00 [range is 0.0-1.0]  
TRIGGER_ID:     0x10  
MISC:           0x2898607  
SKYMAP_FITS_URL: https://gracedb.ligo.org/api/superevents/S190408an/files/bayestar.fits.gz  
EVENTPAGE_URL:  https://gracedb.ligo.org/superevents/S190408an/view/  
COMMENTS:      LVC Super Initial Skymap -- a location probability map.  
COMMENTS:      This event is an OpenAlert.  
COMMENTS:      LIGO-Hanford Observatory contributed to this candidate event.  
COMMENTS:      LIGO-Livingston Observatory contributed to this candidate event.  
COMMENTS:      VIRGO Observatory contributed to this candidate event.
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2 Run Mode & Observation Range

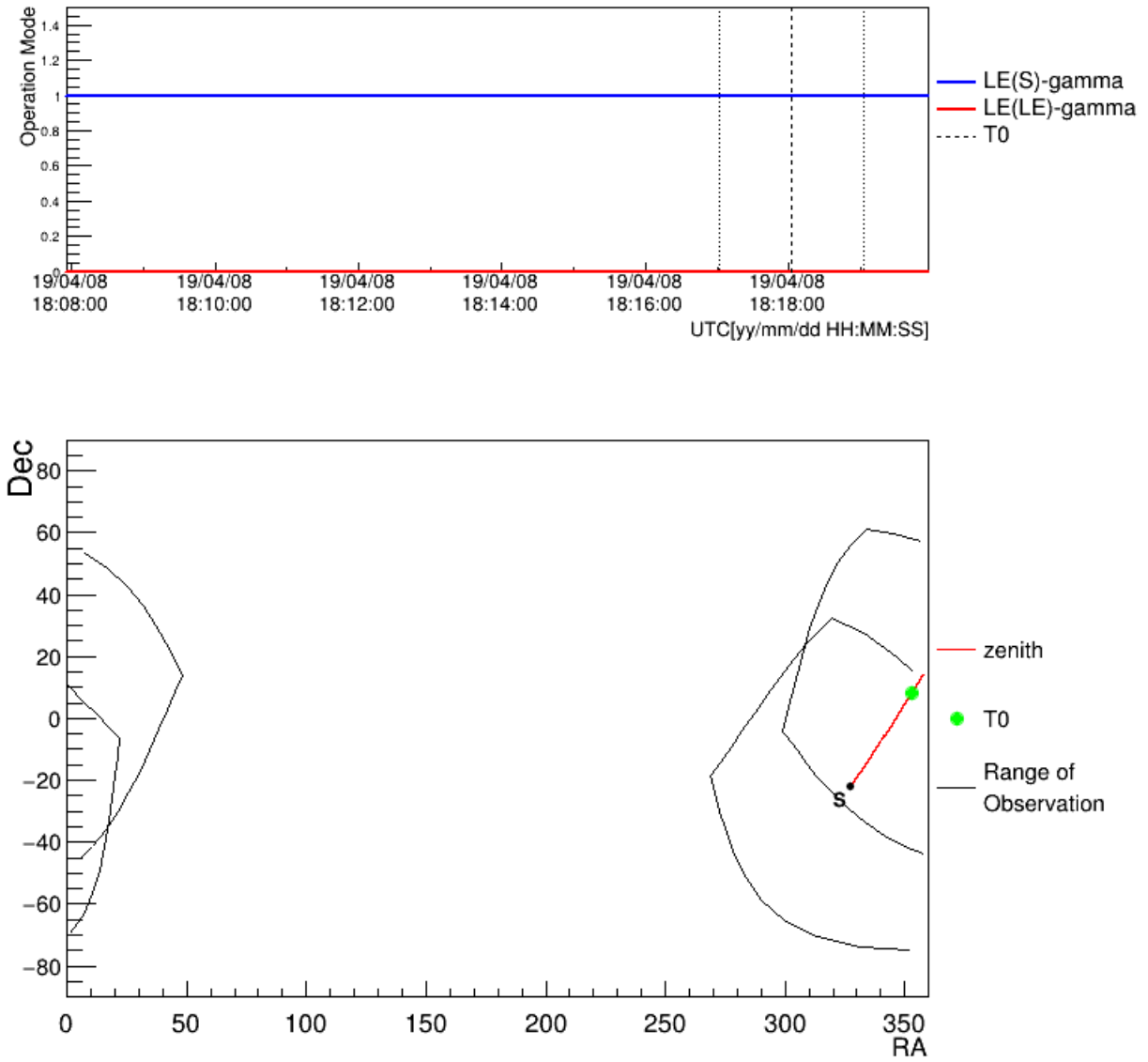


Figure 1: CAL Observation Mode

3 Event Search Result

3.1 Analysis Condition

Energy Range: 1 ~ 10 GeV

Run Mode : LE Gamma Run Mode

3.2 Event Search

There is/are events

Table 1: Candidate Event table

fileID	MDCTime [s]	Time - T_0 [s]	EventID	UTCTime [s]	Energy [GeV]	R.A. [deg.]	Dec [deg.]	FOV ¹	NProb ²	SProb ³
19040818	1238782138	-547.023	27563	1554746935.264781	1.68	318.28	-67.99	Fixed	8.60e-23	0.000e+00
19040818	1238782139	-546.378	27589	1554746935.909937	1.50	340.26	-68.00	Monthly	1.71e-22	0.000e+00
19040818	1238782157	-528.241	28320	1554746954.047359	1.12	290.38	-34.96	Fixed	3.86e-06	2.200e-05
19040818	1238782195	-490.529	29832	1554746991.759328	1.05	296.87	-42.67	Monthly	1.41e-09	0.000e+00
19040818	1238782206	-479.460	30277	1554747002.828359	3.35	20.06	-20.80	Monthly	4.41e-19	0.000e+00
19040818	1238782349	-335.982	35795	1554747146.306062	3.66	329.85	-55.60	Fixed	2.97e-23	0.000e+00
19040818	1238782465	-220.442	40207	1554747261.846500	1.69	307.68	-31.07	Fixed	4.01e-09	0.000e+00
19040818	1238782471	-213.702	40462	1554747268.586344	1.22	312.07	-44.27	Fixed	2.17e-19	0.000e+00
19040818	1238782513	-172.091	42082	1554747310.197250	1.10	314.85	-39.50	Fixed	1.68e-19	0.000e+00
19040818	1238782520	-165.199	42321	1554747317.089141	4.20	27.76	-12.52	Monthly	1.64e-17	0.000e+00
19040818	1238782540	-144.777	43100	1554747337.510797	0.72	337.21	-51.19	Fixed	3.50e-23	0.000e+00
19040818	1238782586	-98.652	44895	1554747383.636453	1.46	315.61	-25.18	Fixed	1.46e-10	0.000e+00
19040818	1238782619	-65.841	46170	1554747416.446938	1.10	296.79	-18.11	Fixed	2.22e-12	0.000e+00
19040818	1238782681	-4.487	48615	1554747477.800906	1.96	324.02	-30.93	Fixed	2.06e-17	0.000e+00
19040818	1238782730	44.924	50621	1554747527.212078	1.52	328.04	-30.02	Fixed	9.34e-18	0.000e+00
19040818	1238782758	73.047	51802	1554747555.335641	1.92	26.82	38.79	Clear	1.26e-19	0.000e+00

1. FOV is the blocking status for each event. Fixed and Moving mean that the direction of the gamma-ray candidate were blocked by fixed structures and moving structures, respectively. Clear means there is no obstruction to the gamma-ray candidate direction. Monthly means the direction overlaps with Monthly structure map.
2. NProb is the normalized probability in the gamma-ray candidate direction pixel. The probability was normalized at the highest probability in the LVC probability.
3. SProb is the survival probability when the gamma-ray candidate pixel is included. After sorting the LVC probability of each pixel to the descending order, we calculated the cumulative probability (CProb) with increasing pixel. SProb is 1 - CProb.

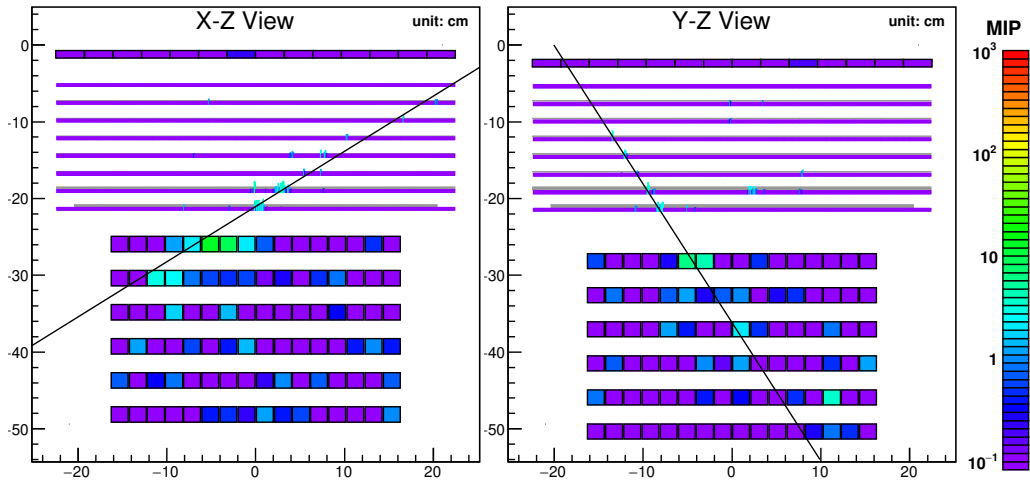


Figure 2: Event Display of Candidate 27563

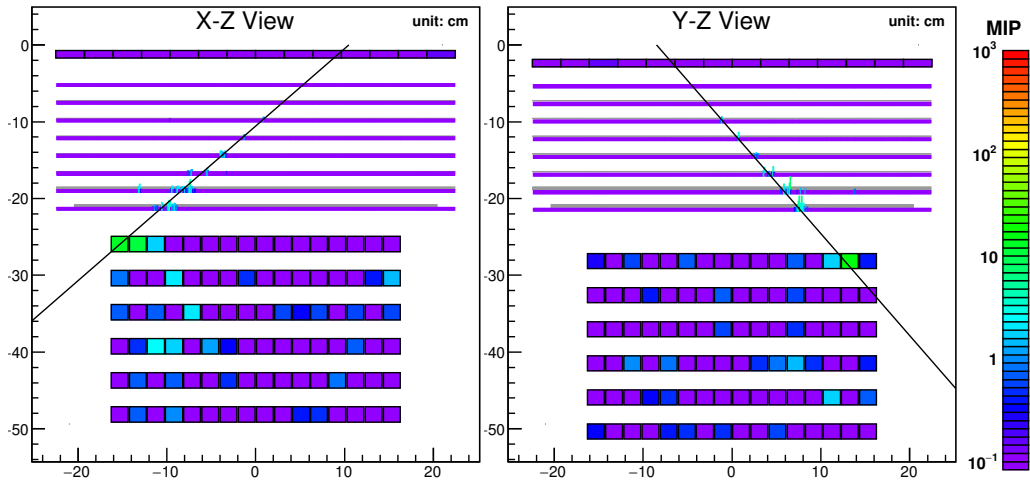


Figure 3: Event Display of Candidate 27589

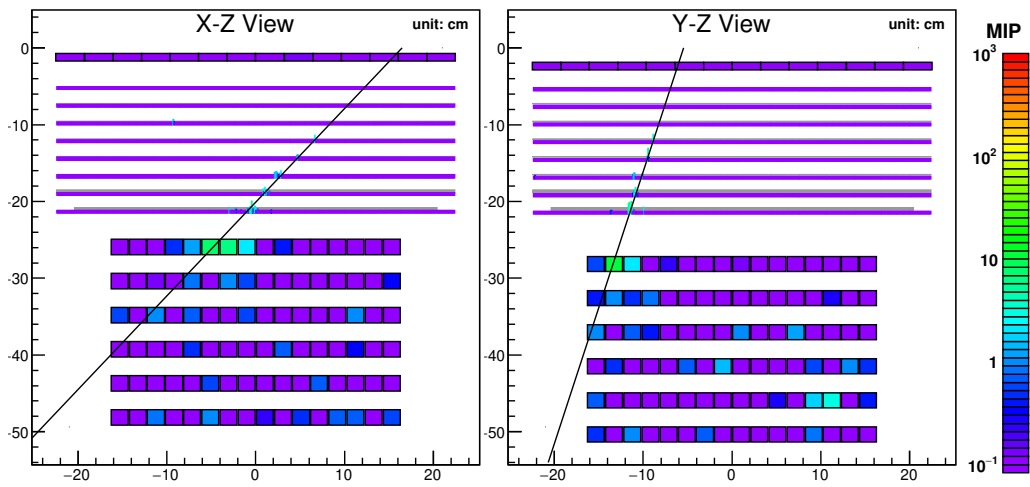


Figure 4: Event Display of Candidate 28320

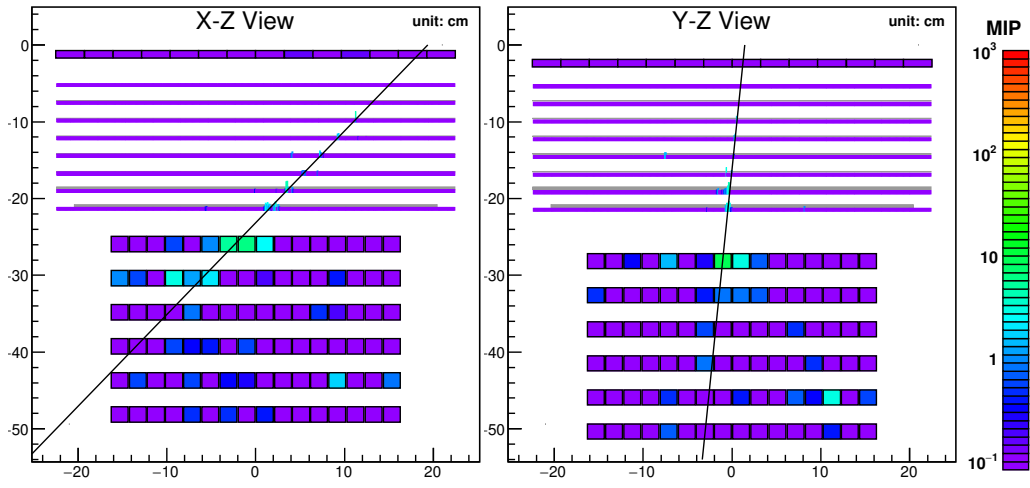


Figure 5: Event Display of Candidate 29832

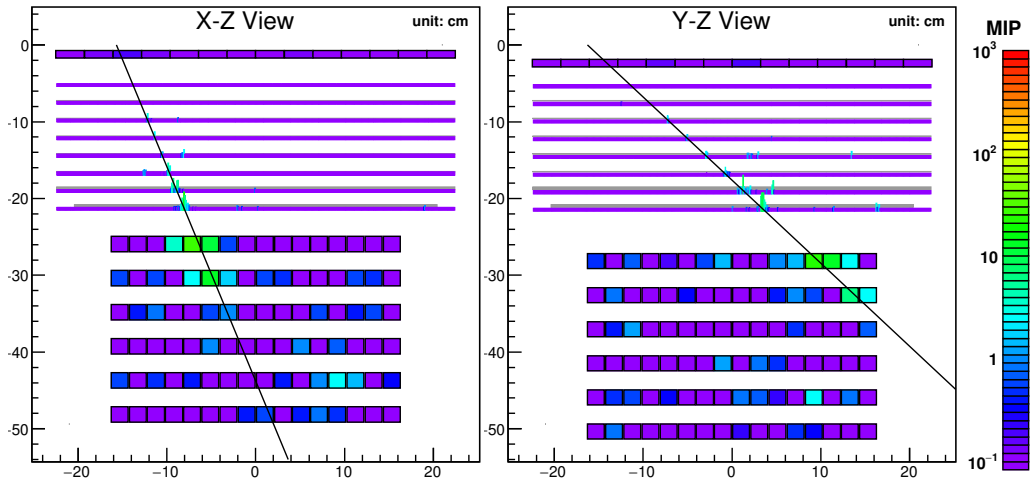


Figure 6: Event Display of Candidate 30277

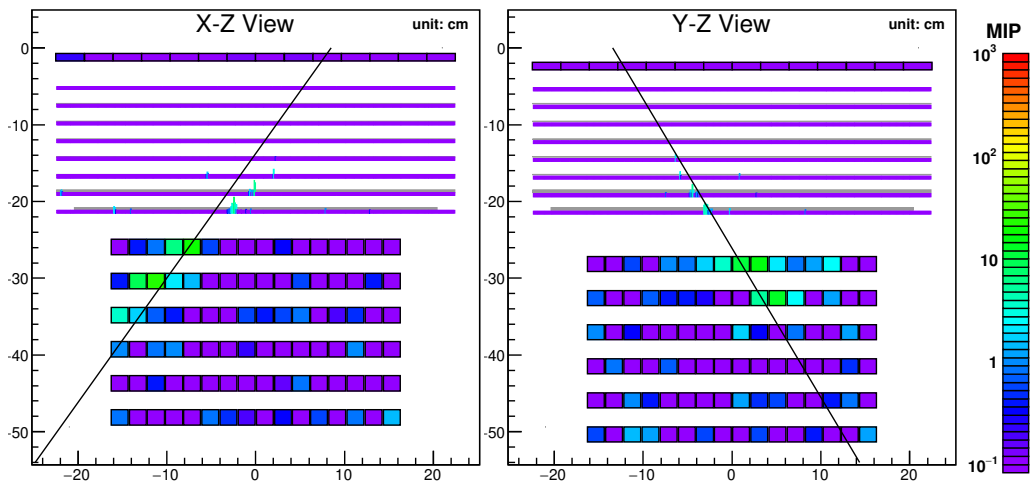


Figure 7: Event Display of Candidate 35795

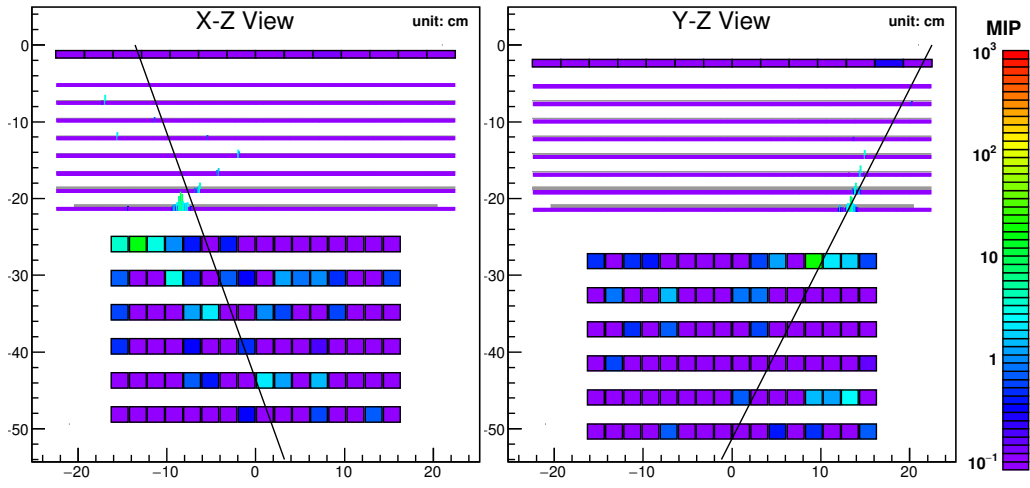


Figure 8: Event Display of Candidate 40207

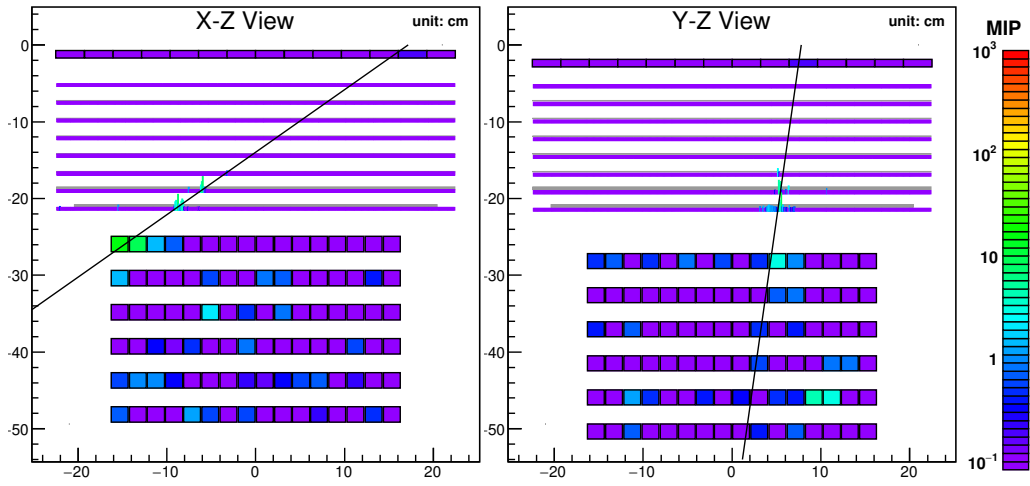


Figure 9: Event Display of Candidate 40462

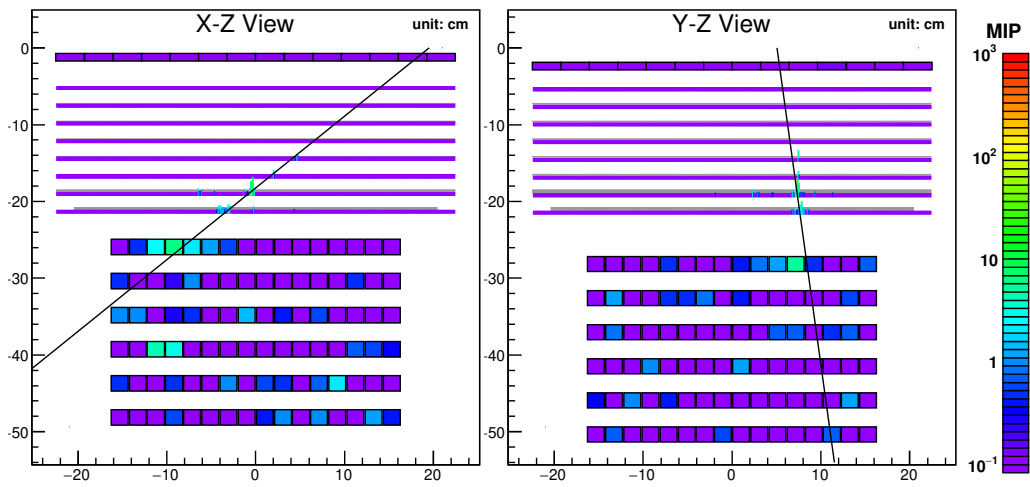


Figure 10: Event Display of Candidate 42082

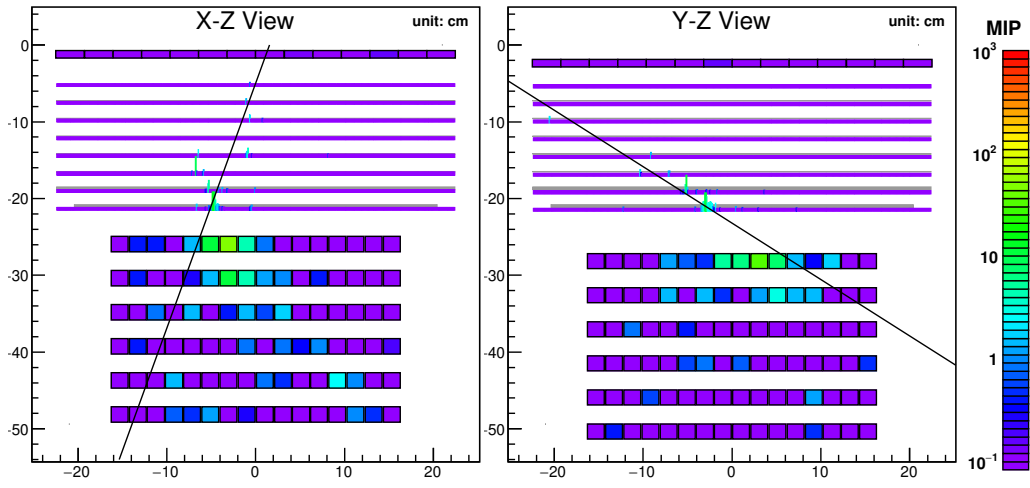


Figure 11: Event Display of Candidate 42321

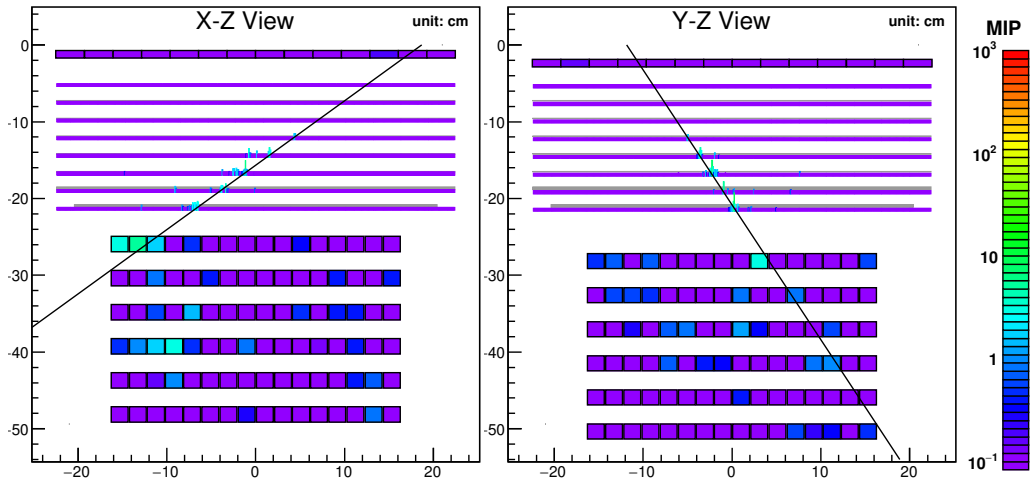


Figure 12: Event Display of Candidate 43100

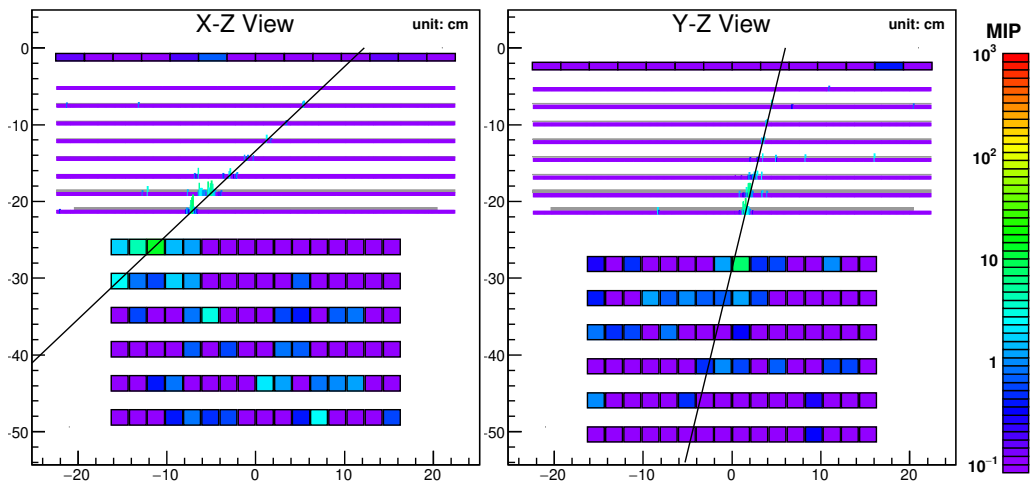


Figure 13: Event Display of Candidate 44895

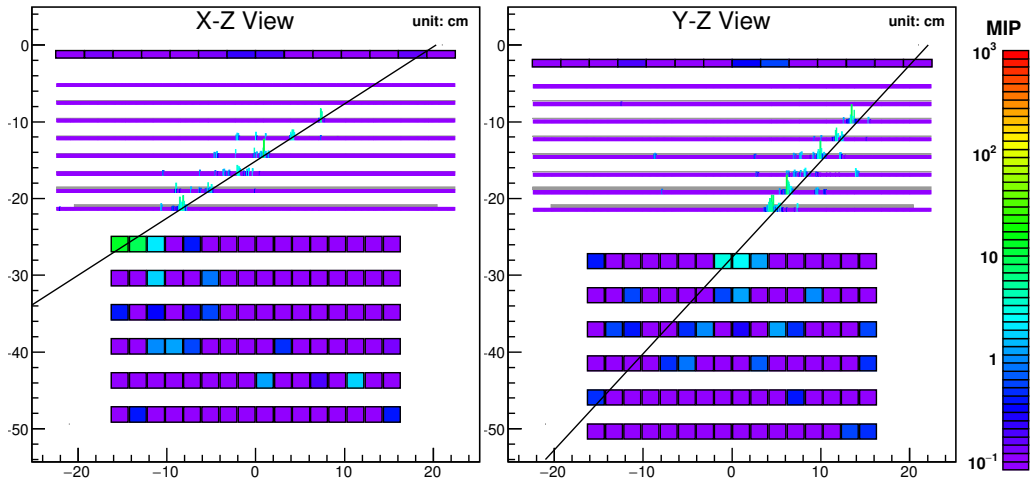


Figure 14: Event Display of Candidate 46170

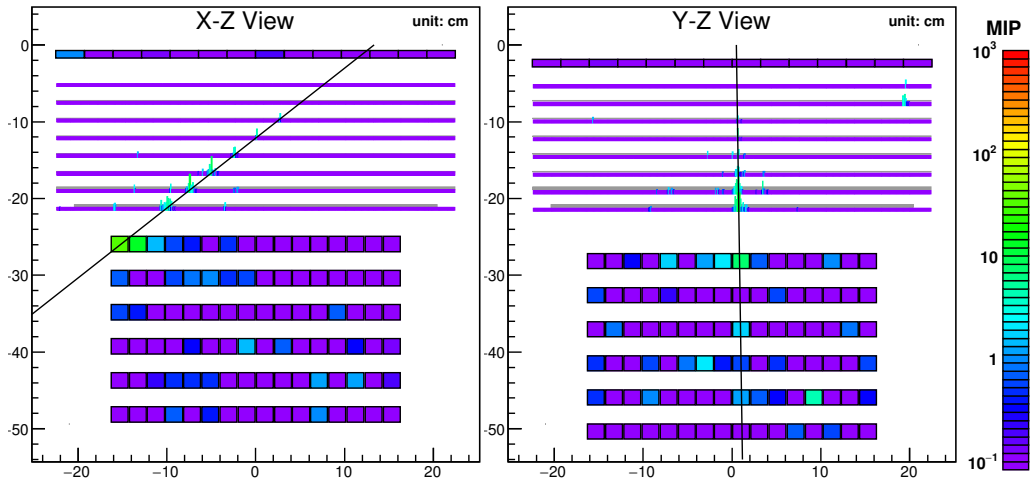


Figure 15: Event Display of Candidate 48615

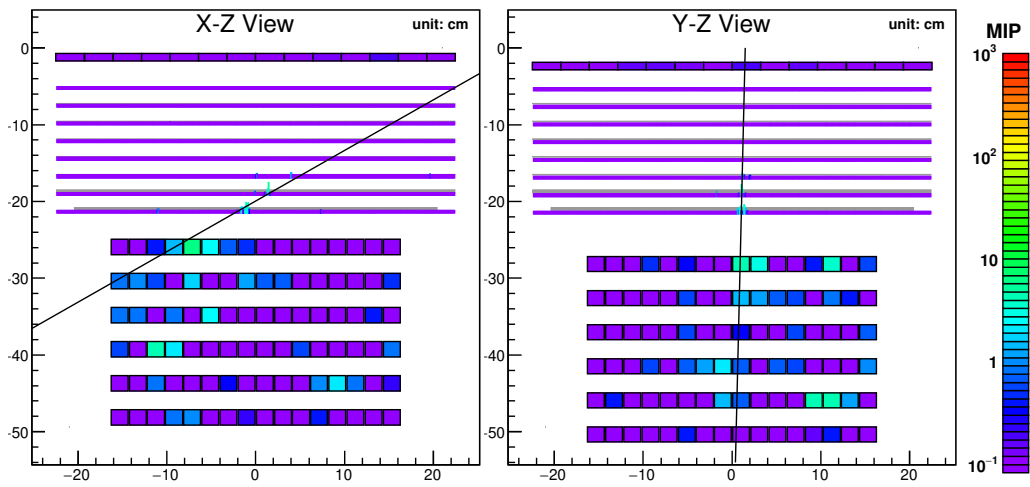


Figure 16: Event Display of Candidate 50621

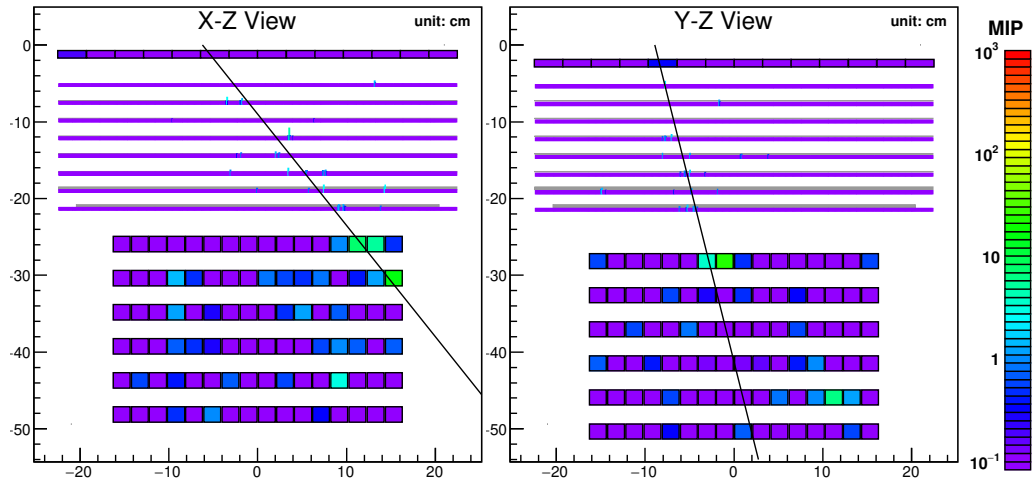


Figure 17: Event Display of Candidate 51802

4 Integrated Exposure & 90% CL Upper limit w/ LIGO/Virgo probability

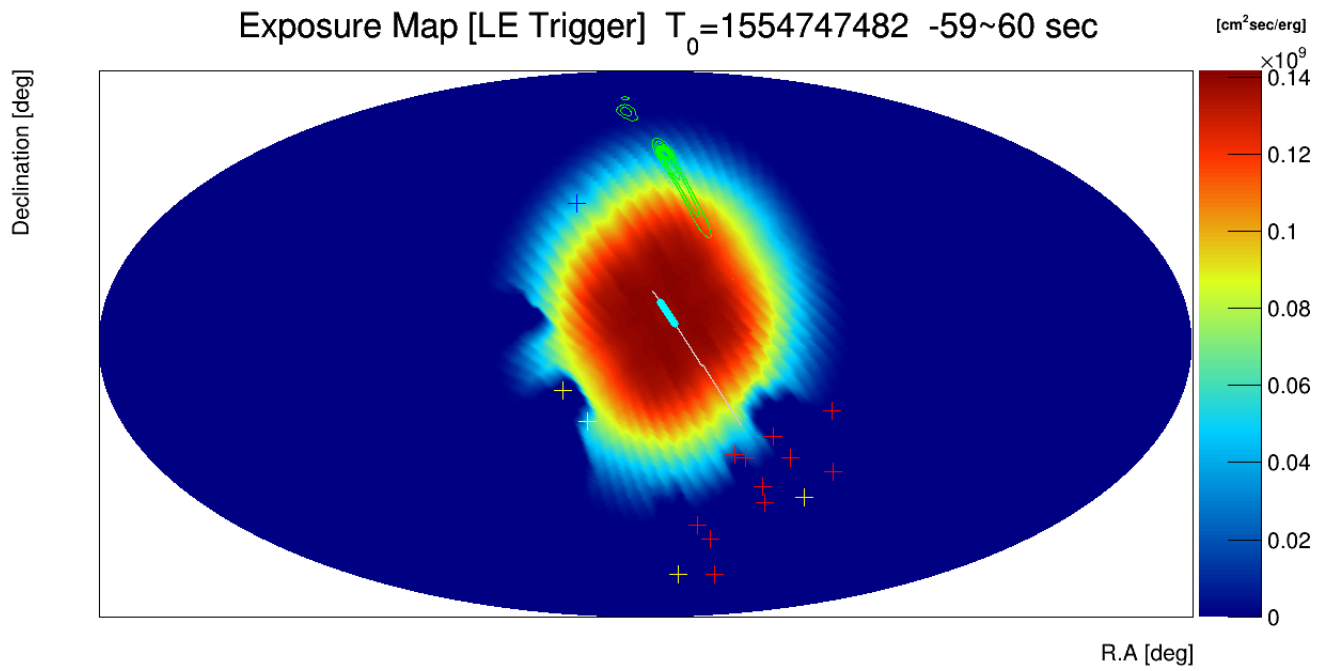


Figure 18: Integrated Exposure Map

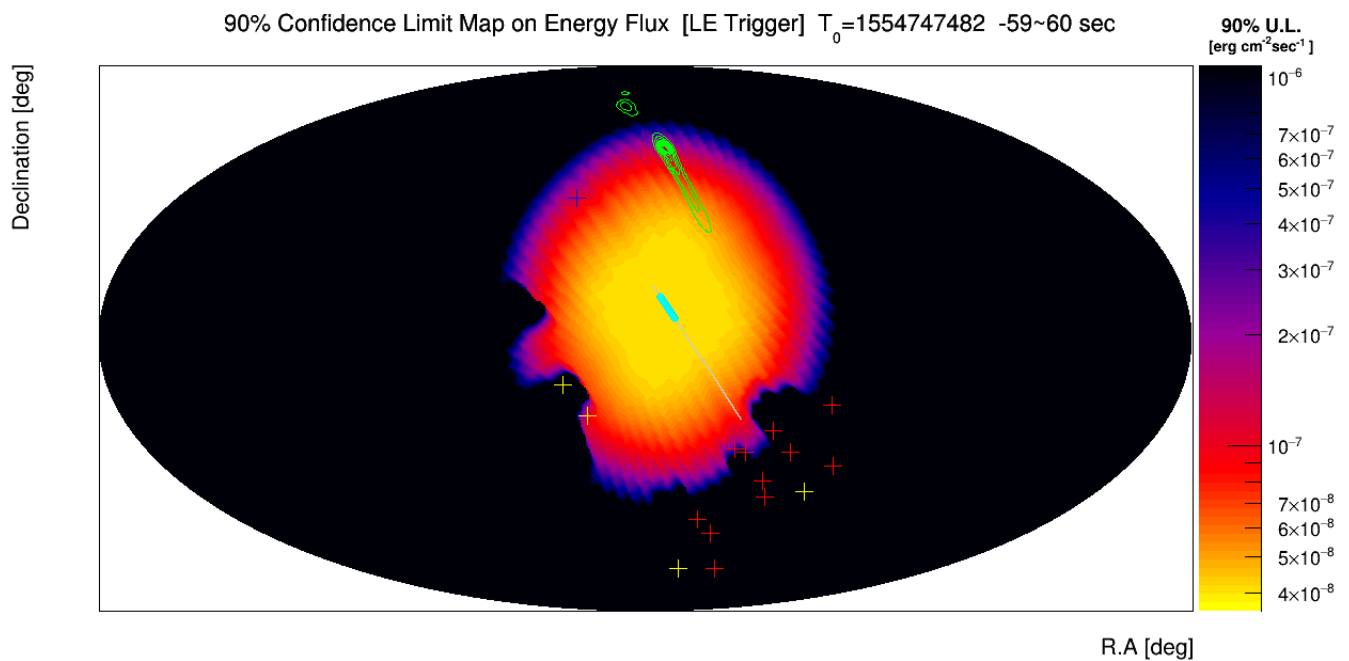


Figure 19: Confidence Limit on Energy Flux

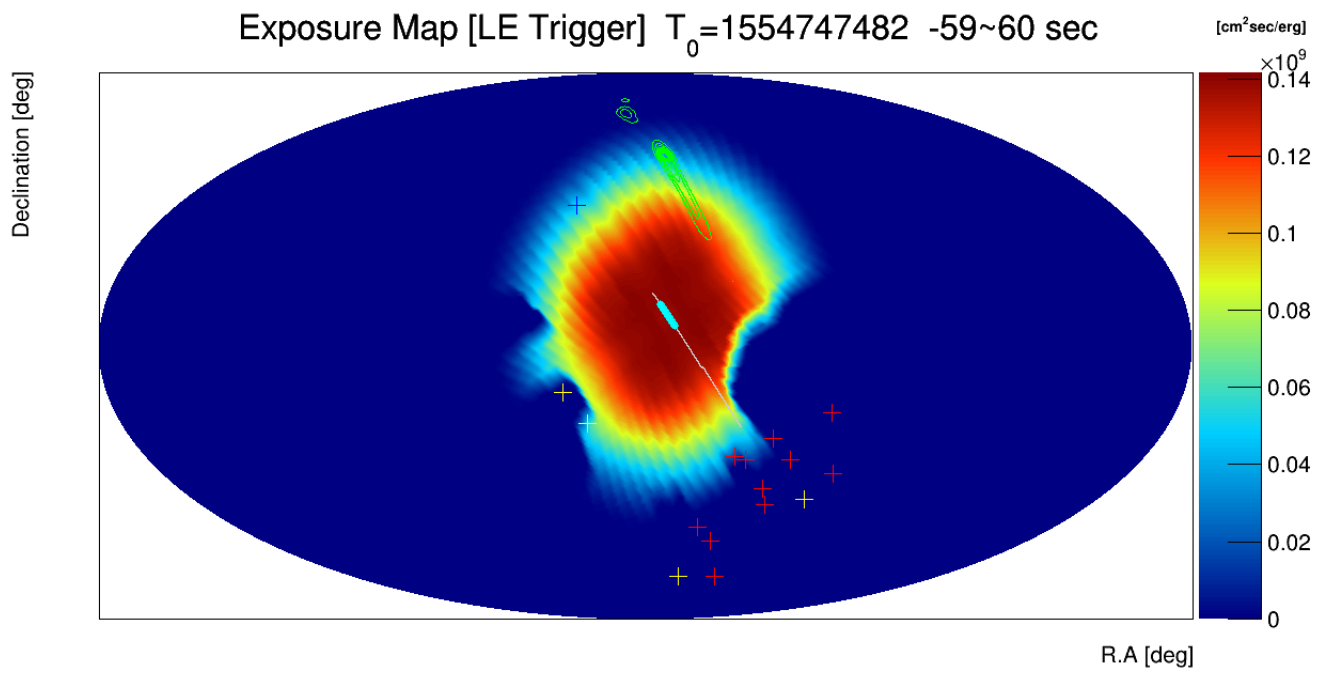


Figure 20: Integrated Exposure Map w/ FOV Moving Structure Cut

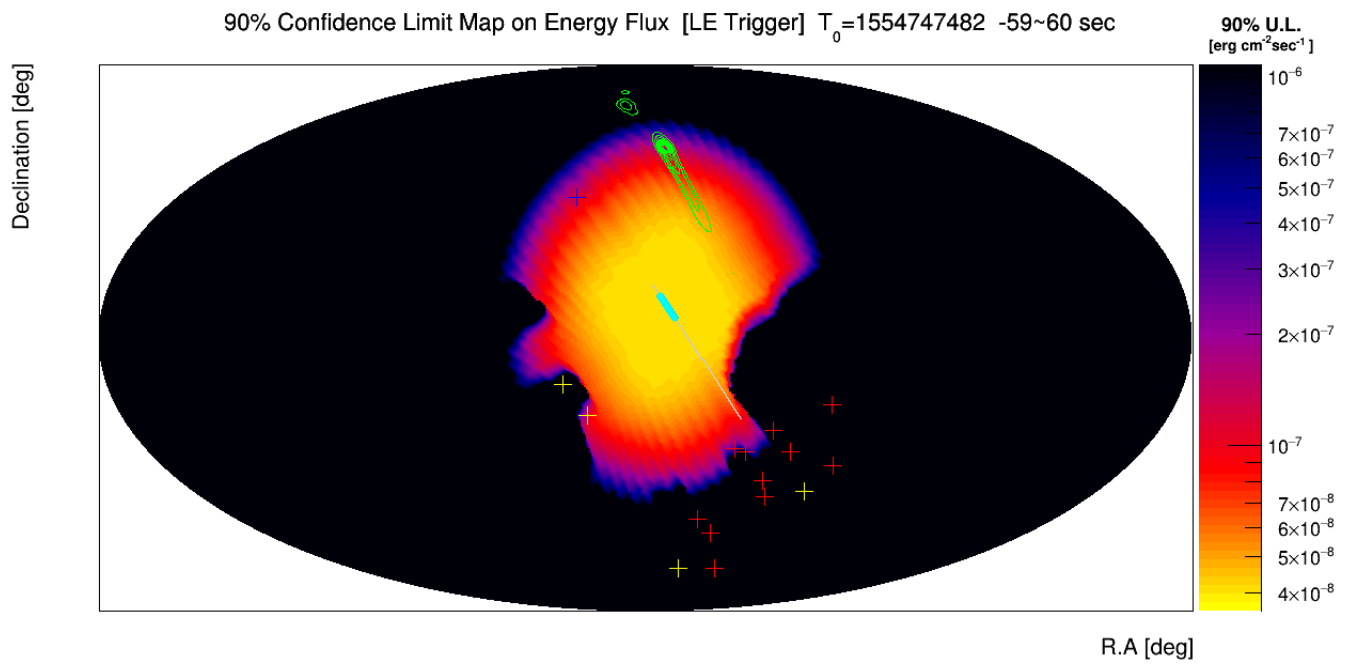


Figure 21: Confidence Limit on Energy Flux w/ FOV Moving Structure Cut

5 Exposure & 90% CL Upper limit compare with enclosed probability

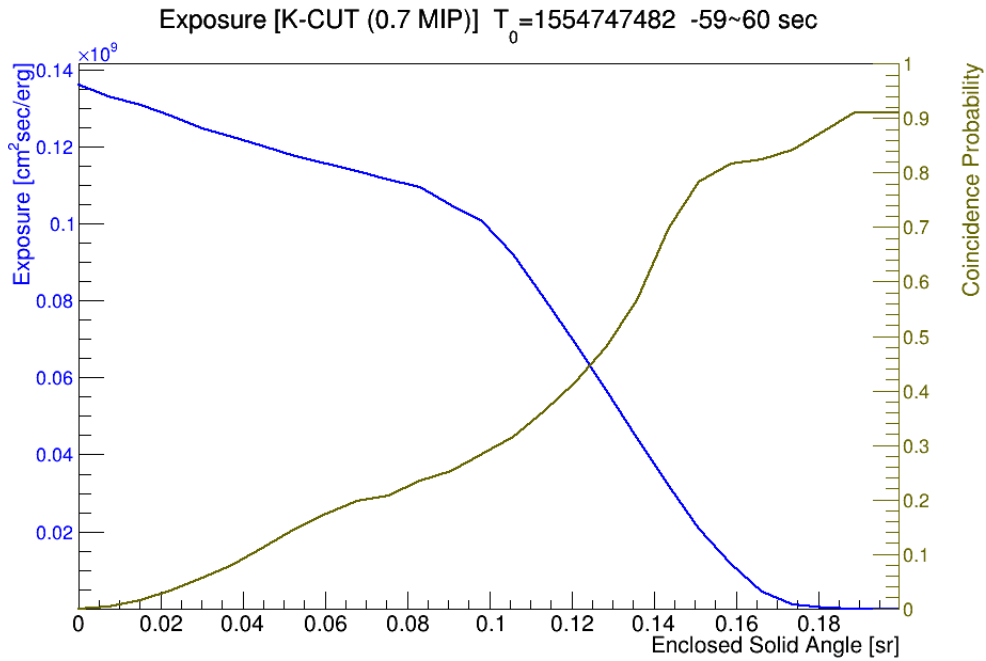


Figure 22: Exposure & enclosed probability

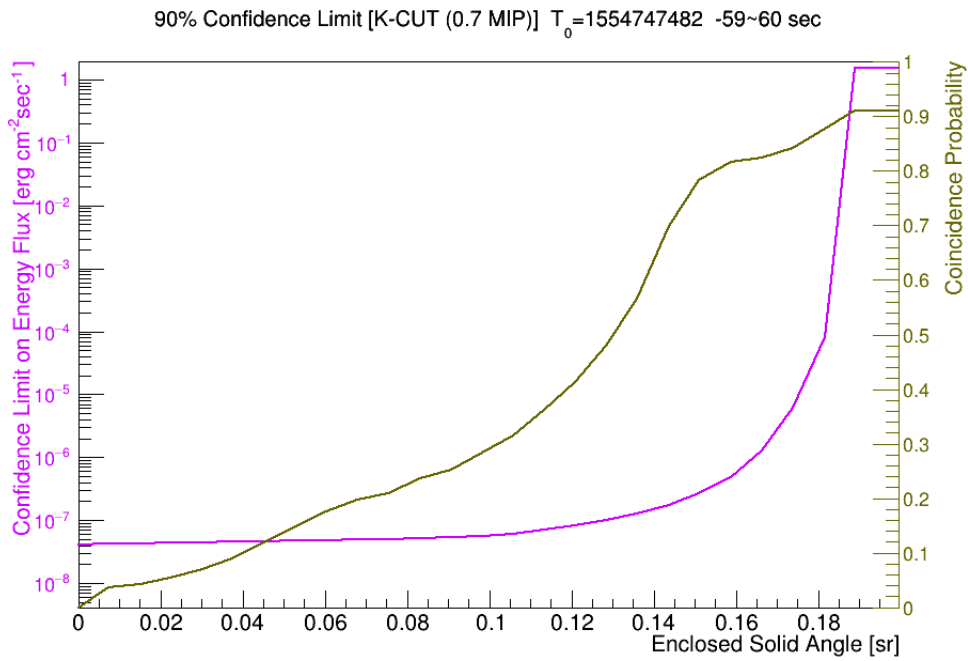


Figure 23: Limit on Energy Flux & enclosed probability

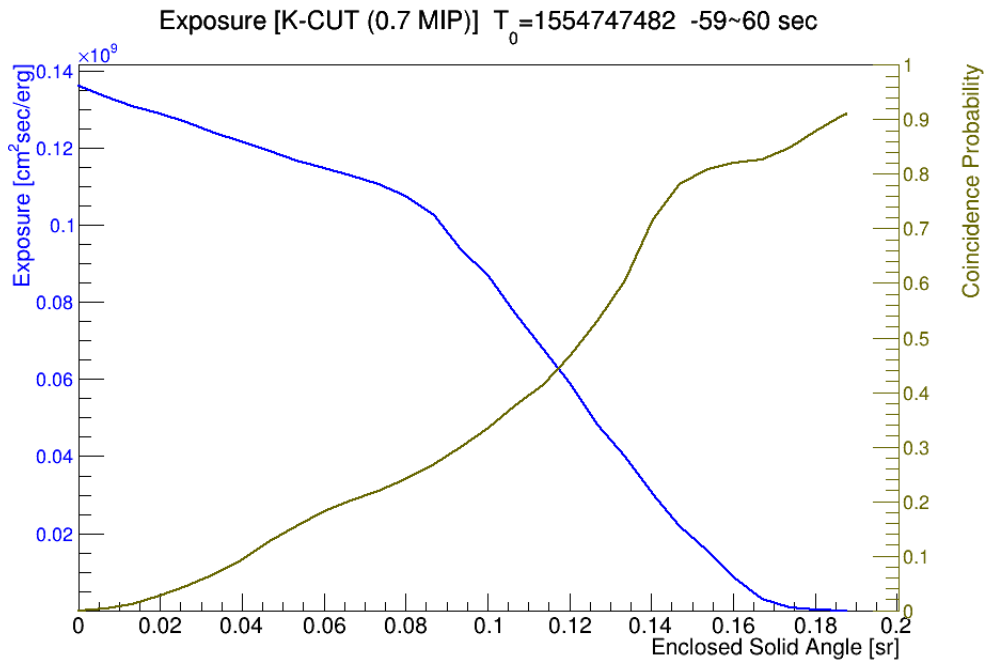


Figure 24: Exposure & enclosed probability w/ FOV Moving Structure Cut

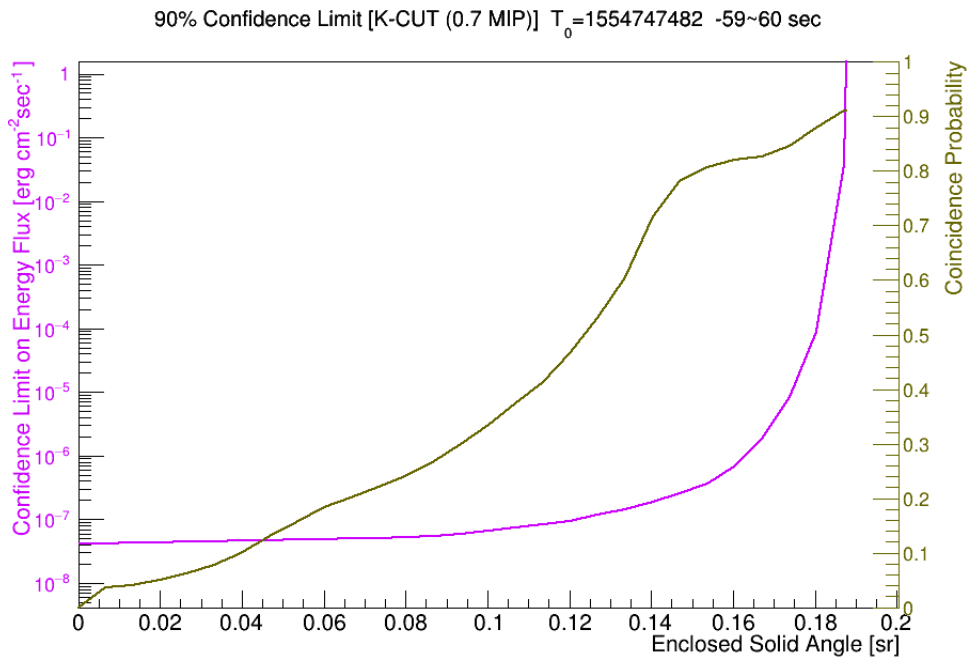


Figure 25: Limit on Energy Flux & enclosed probability w/ FOV Moving Structure Cut

Table 2: Exposure & Limit table with Probability

Probability	Solid Angle [sr]	Exposure [cm ² s erg ⁻¹]	Limit [erg cm ⁻² s ⁻¹]	Instrumental BG [counts]	Diffuse [counts]
0	0.000e+00	1.360e+08	4.130e-08	2.944e-08	3.698e-07
5	2.876e-02	1.255e+08	4.476e-08	8.148e-04	1.256e-02
10	4.260e-02	1.213e+08	4.633e-08	1.184e-03	1.921e-02
15	5.433e-02	1.170e+08	4.801e-08	1.487e-03	2.444e-02
20	7.011e-02	1.130e+08	4.970e-08	1.881e-03	3.110e-02
25	9.057e-02	1.048e+08	5.359e-08	2.367e-03	4.049e-02
30	1.036e-01	9.485e+07	5.924e-08	2.652e-03	4.627e-02
35	1.119e-01	8.293e+07	6.774e-08	2.812e-03	5.072e-02
40	1.196e-01	7.159e+07	7.847e-08	2.941e-03	5.540e-02
45	1.253e-01	6.171e+07	9.105e-08	3.024e-03	5.775e-02
50	1.307e-01	5.271e+07	1.066e-07	3.091e-03	5.952e-02
55	1.349e-01	4.538e+07	1.238e-07	3.136e-03	6.080e-02
60	1.384e-01	4.012e+07	1.400e-07	3.168e-03	6.181e-02
65	1.410e-01	3.641e+07	1.543e-07	3.190e-03	6.259e-02
70	1.438e-01	3.169e+07	1.773e-07	3.210e-03	6.347e-02
75	1.472e-01	2.661e+07	2.111e-07	3.232e-03	6.459e-02
80	1.532e-01	1.873e+07	3.000e-07	3.261e-03	6.665e-02
85	1.757e-01	6.037e+05	9.307e-06	3.297e-03	7.128e-02
90	1.850e-01	2.967e+04	1.893e-04	3.297e-03	7.133e-02

Table 3: Exposure & Limit table with Probability w/ FOV Moving Structure Cut

Probability	Solid Angle [sr]	Exposure [cm ² s erg ⁻¹]	Limit [erg cm ⁻² s ⁻¹]	Instrumental BG [counts]	Diffuse [counts]
0	0.000e+00	1.360e+08	4.130e-08	2.946e-08	3.698e-07
5	2.876e-02	1.255e+08	4.476e-08	8.155e-04	1.256e-02
10	4.191e-02	1.213e+08	4.633e-08	1.167e-03	1.886e-02
15	5.247e-02	1.169e+08	4.806e-08	1.439e-03	2.368e-02
20	6.658e-02	1.128e+08	4.981e-08	1.791e-03	2.982e-02
25	8.371e-02	1.043e+08	5.388e-08	2.198e-03	3.827e-02
30	9.393e-02	9.360e+07	6.002e-08	2.421e-03	4.299e-02
35	1.026e-01	8.286e+07	6.780e-08	2.588e-03	4.759e-02
40	1.118e-01	7.101e+07	7.912e-08	2.740e-03	5.244e-02
45	1.180e-01	6.171e+07	9.105e-08	2.830e-03	5.487e-02
50	1.243e-01	5.271e+07	1.066e-07	2.909e-03	5.677e-02
55	1.293e-01	4.538e+07	1.238e-07	2.962e-03	5.816e-02
60	1.333e-01	4.012e+07	1.400e-07	2.998e-03	5.923e-02
65	1.359e-01	3.641e+07	1.543e-07	3.020e-03	6.001e-02
70	1.390e-01	3.169e+07	1.773e-07	3.043e-03	6.095e-02
75	1.429e-01	2.661e+07	2.111e-07	3.068e-03	6.208e-02
80	1.509e-01	1.855e+07	3.029e-07	3.106e-03	6.434e-02
85	1.745e-01	6.037e+05	9.307e-06	3.143e-03	6.889e-02
90	1.837e-01	2.967e+04	1.893e-04	3.144e-03	6.894e-02