2019/03/14: Optimization of ProtoProto Plate Source

Michael Poehlmann

Passage of Particles Through Materials

- First examined the percentage of gammas/alphas that passed through tungsten and steel
- Generators
  - Isotropic: uniform hemisphere
    - Longer average path length through material
  - Beam: perpendicular to material surface
    - Shorter average path length through material

Passage of Gammas Through Materials

Tungsten Thickness (mm)	# Pass Through Tungsten (beam)	# Pass Through Tungsten (isotropic)
1	6909 / 5e6 = 0.13%	774 / 5e6 = 0.015%
2	3 / 5e6 = 6e-05%	1 / 5e6 = 2e-05%
3	0 / 5e6 = 0%	0 / 5e6 = 0%

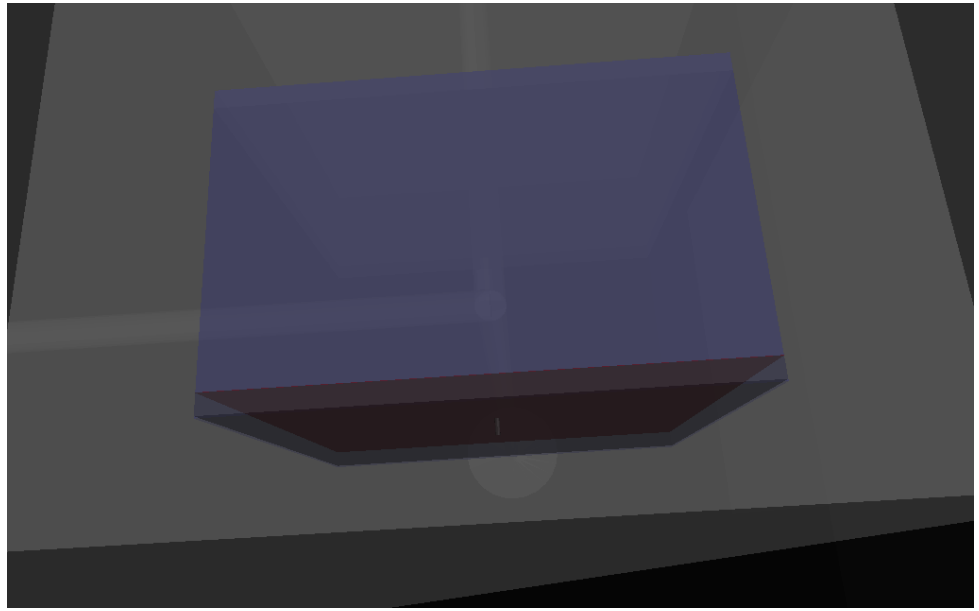
Steel Thickness (mm)	# Pass Through Steel (beam)	# Pass Through Steel (isotropic)
0.1	461967 / 5e5 = 92.3%	394753 / 5e5 = 78.9%
0.3	392781 / 5e5 = 78.5%	279626 / 5e5 = 55.9%
0.5	333024 / 5e5 = 66.6%	205462 / 5e5 = 41.0%
0.7	281815 / 5e5 = 56.3%	155245 / 5e5 = 31.0%
1.0	219467 / 5e5 = 43.8%	103403 / 5e5 = 20.6%

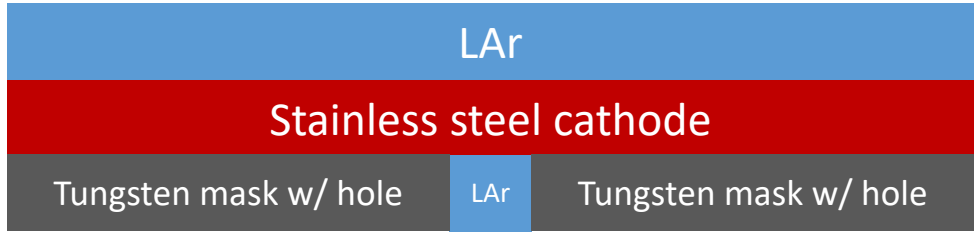
Passage of Gammas Through Materials

- As expected, fewer primaries pass through when using isotropic distribution in all cases
- Thinner steel lowers the probability of scattering leading to a more collimated beam
- Practically all off-hole gammas killed by at least 3mm thick steel
- With 0.5mm of SS or less, >40% of gammas that are within the tungsten hole will pass through to LAr

Simulation Parameters

- Geometry
  - Tungsten mask (begins 1mm above bottom acrylic) with hole in center
  - Stainless steel cathode directly above tungsten
- Primary:
  - 60 keV gammas uniformly generated from 0.5x0.5 cm^2 square centered on hole at bottom surface of tungsten
  - Hemispheric momentum distribution to account for isotropic nature of emission
- Objective: majority of clusters should have radius < 5 mm





* Radius is xy distance from hole center, calculated for events w/ single cluster in TPC

Cluster Spread in TPC: Steel Cathode Thickness

Cathode Thickness (mm)	Mask Thickness (mm)	Hole Width (mm)	Radial RMS (mm)	Events w/ Single Cluster in TPC
0.2	5	1	5.09 ± 0.14	614 / 12.5e6 = 4.91e-03%
0.5	5	1	4.98 ± 0.15	503 / 12.5e6 = 4.02e-03%
0.7	5	1	5.14 ± 0.17	431 / 12.5e6 = 3.45e-03%
1.0	5	1	5.57 ± 0.21	332 / 12.5e6 = 2.66e-03%

Cathode Thickness (mm)	Mask Thickness (mm)	Hole Width (mm)	Radial RMS (mm)	Events w/ Single Cluster in TPC
0.2	5	2	5.526 ± 0.039	10131 / 12.5e6 = 8.10e-02%
0.5	5	2	5.729 ± 0.046	7853 / 12.5e6 = 6.28e-02%
0.7	5	2	5.870 ± 0.051	6573 / 12.5e6 = 5.26e-02%
1.0	5	2	6.076 ± 0.060	5097 / 12.5e6 = 4.08e-02%

Cluster Spread in TPC: Tungsten Mask Thickness

Cathode Thickness (mm)	Mask Thickness (mm)	Hole Width (mm)	Radial RMS (mm)	Events w/ Single Cluster in TPC
0.5	1	1	9.469 ± 0.044	23290 / 12.5e6 = 1.86e-01%
0.5	2	1	6.311 ± 0.067	4465 / 12.5e6 = 3.57e-02%
0.5	3	1	5.365 ± 0.091	1732 / 12.5e6 = 1.39e-02%
0.5	5	1	4.98 ± 0.15	503 / 12.5e6 = 4.02e-03%
0.5	7	1	3.59 ± 0.17	205 / 12.5e6 = 1.64e-03%
0.5	10	1	2.48 ± 0.18	87 / 12.5e6 = 6.96e-04%

Cluster Spread in TPC: Hole Diameter

Cathode Thickness (mm)	Mask Thickness (mm)	Hole Width (mm)	Radial RMS (mm)	Events w/ Single Cluster in TPC
0.5	5	0.5	1.51 ± 0.19	31 / 12.5e6 = 2.48e-04%
0.5	5	1	4.98 ± 0.15	503 / 12.5e6 = 4.02e-03%
0.5	5	2	5.729 ± 0.046	7853 / 12.5e6 = 6.28e-02%
0.5	5	3	6.095 ± 0.034	37949 / 12.5e6 = 3.04e-01%

0.5 accounts for hemisphere generator
y BR = 35.9% for 60keV gammas
Area ratio = (0.25 cm^2) / (pi cm^2) = 0.07959

Source Activity

- Plate source = 40k Bq for diam=20mm disk
- Calculated expected event rate for one hole over plate source

$$\text{Rate} = 0.5 \times (\text{activity}) \times (\gamma\ \text{BR}) \times (\text{frac evts w/cluster}) \times \left(\frac{\text{area of MC generator}}{\text{area of source plate}} \right)$$

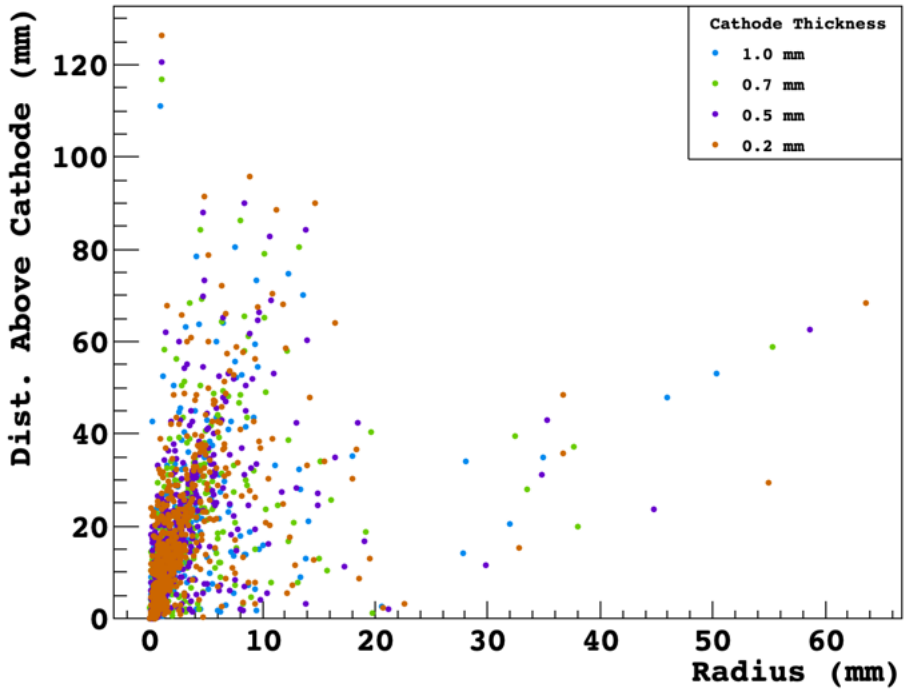
$$\text{Event rate (Hz)} = 571.4 \times (\text{frac evts w/cluster})$$

Cathode Thickness (mm)	Mask Thickness (mm)	Hole Width (mm)	Radial RMS (mm)	Events w/ Single Cluster in TPC	Event rate	Time for 1000 Events
0.2	5	1	5.09 ± 0.14	614 / 12.5e6 = 4.91e-03%	2.82e-2 Hz	9.85 hrs
0.5	7	1	3.59 ± 0.17	205 / 12.5e6 = 1.64e-03%	9.41e-3 Hz	29.5 hrs
0.5	10	1	2.48 ± 0.18	87 / 12.5e6 = 6.96e-04%	4.00e-3 Hz	69.4 hrs
0.5	5	0.5	1.51 ± 0.19	31 / 12.5e6 = 2.48e-04%	1.42e-3 Hz	195 hrs

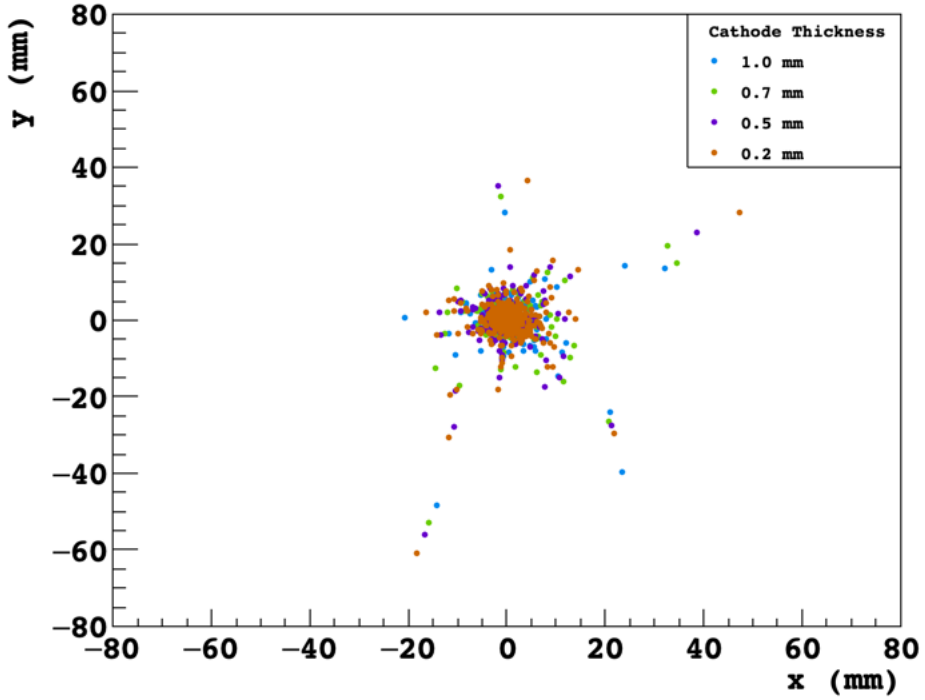
Backup Slides

Mask thickness = 5 mm
Hole diameter = 2 mm

Z vs. R

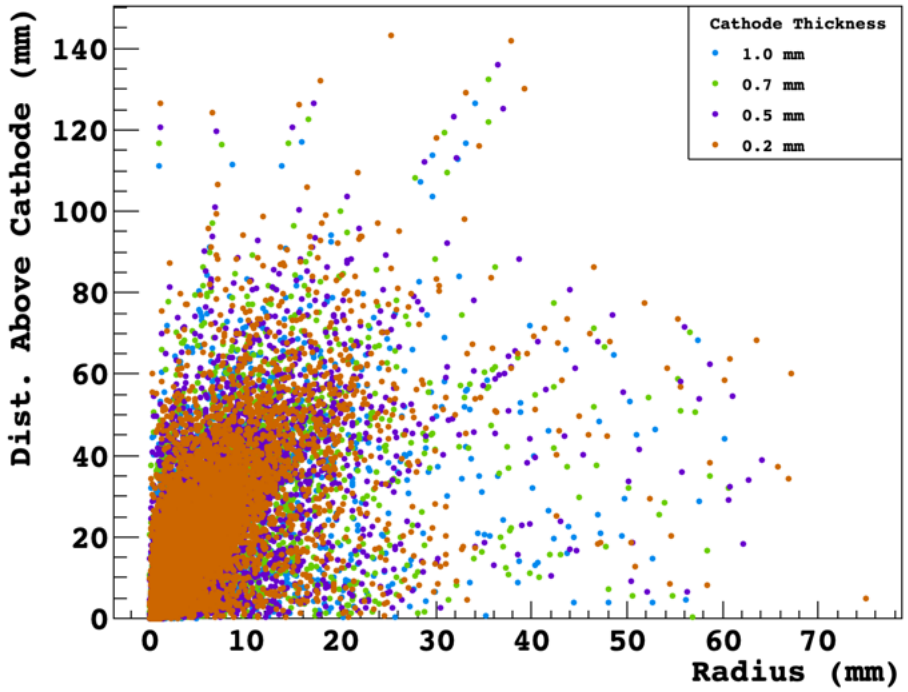


Y vs. X

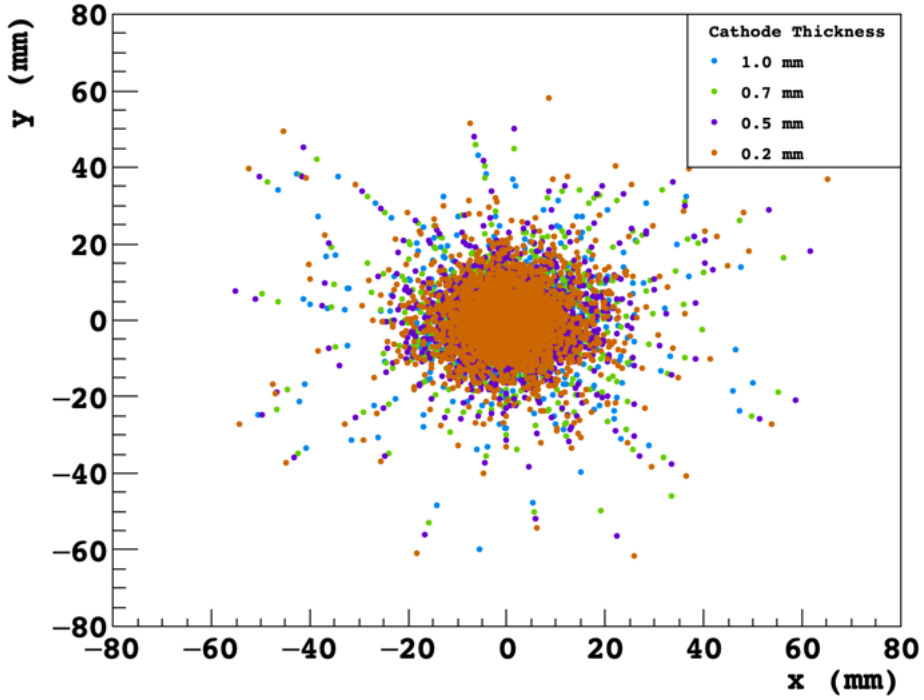


Mask thickness = 5 mm
Hole diameter = 1 mm

Z vs. R

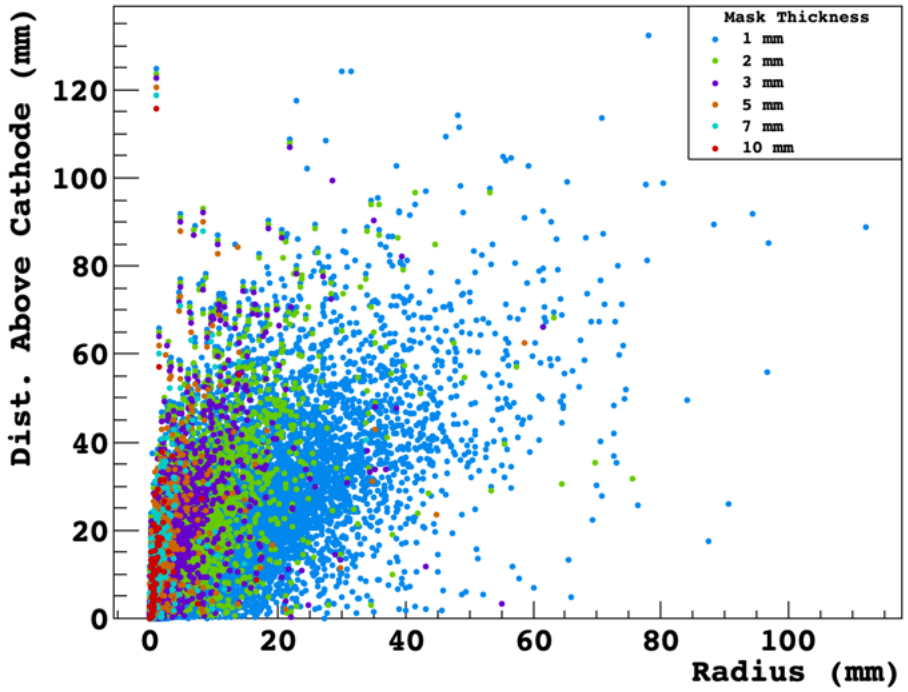


Y vs. X

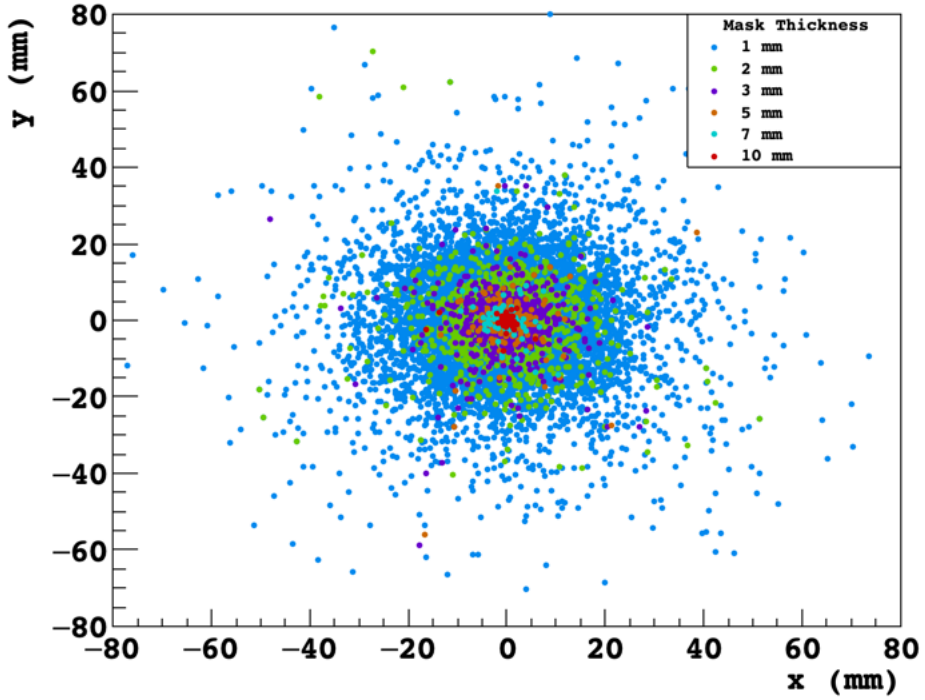


Cathode thickness = 0.5 mm
Hole diameter = 1 mm

Z vs. R

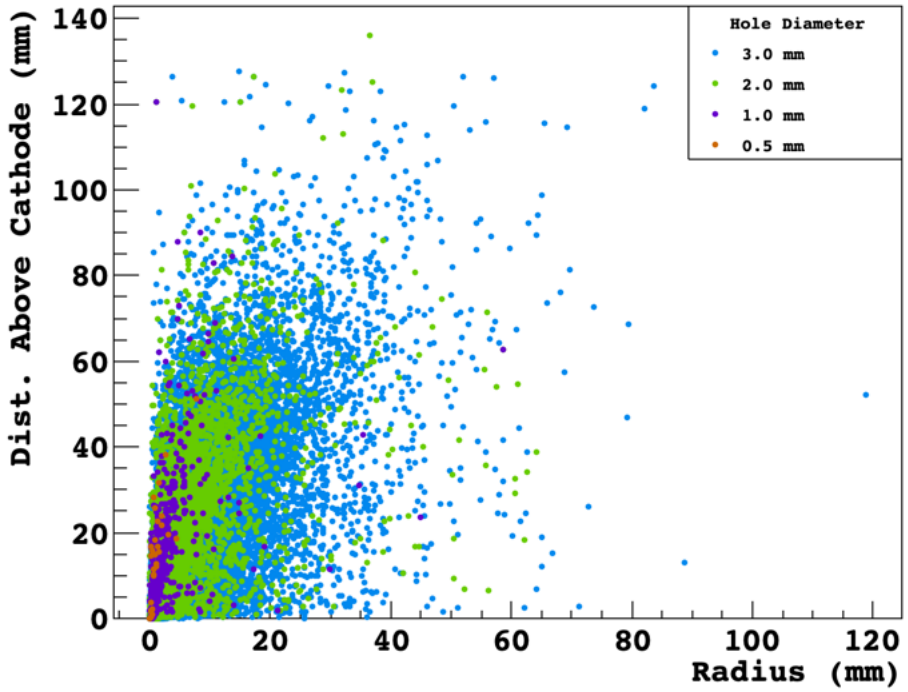


X vs. Y

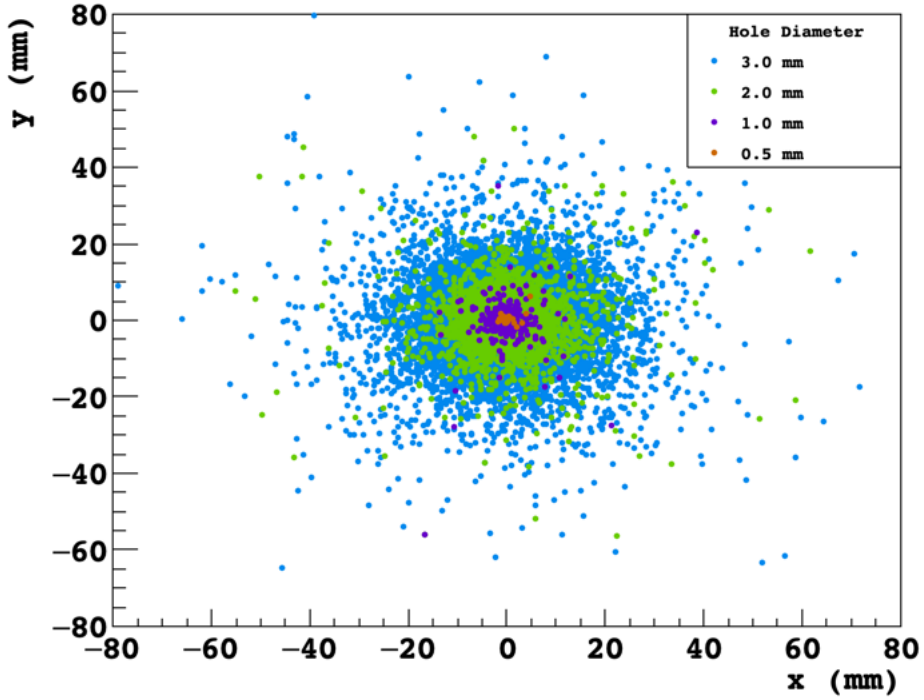


Cathode thickness = 0.5 mm
Mask thickness = 5 mm

Z vs. R

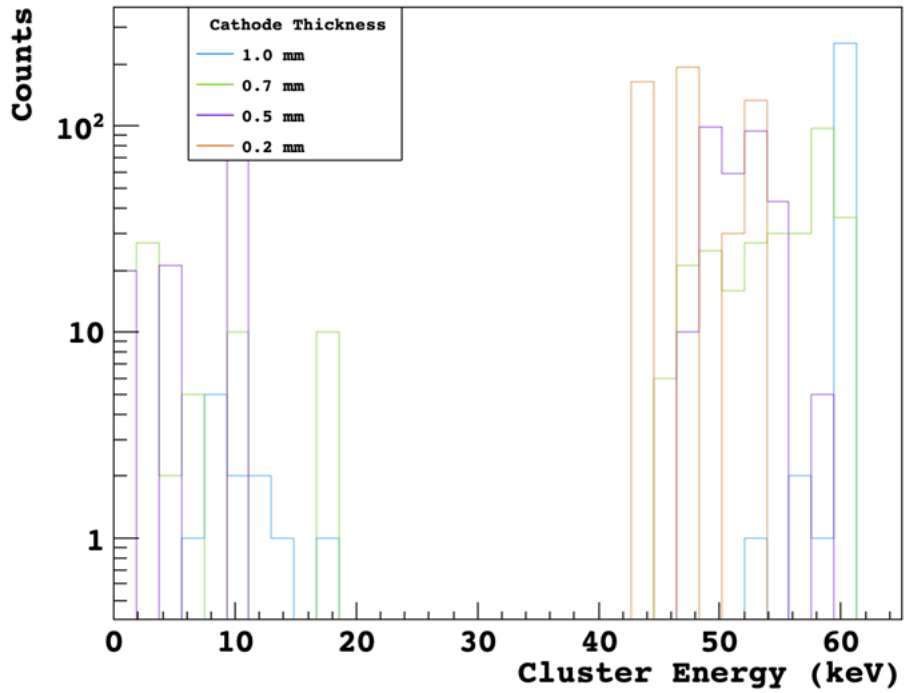


Y vs. X

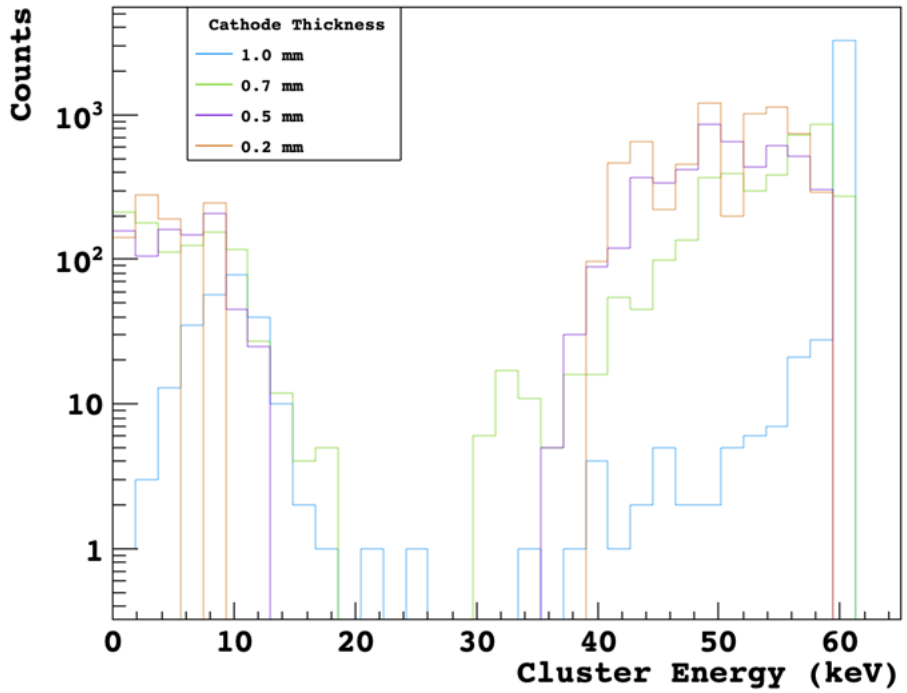


Cluster Energy

Mask thickness = 5 mm
Hole diameter = 2 mm

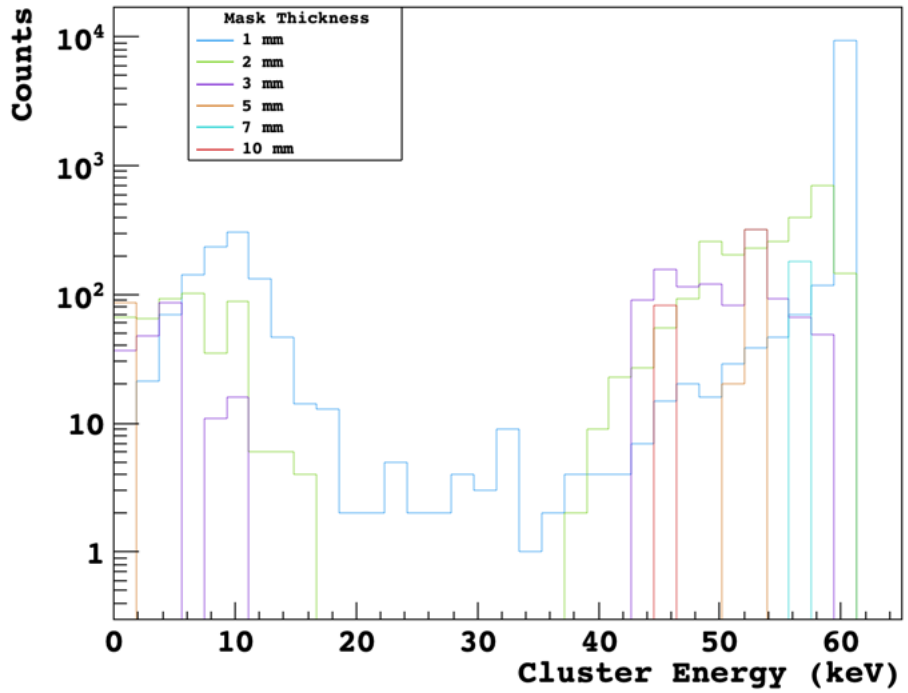


Mask thickness = 5 mm
Hole diameter = 1 mm



Cluster Energy

Cathode thickness = 0.5 mm
Hole diameter = 1 mm



Cathode thickness = 0.5 mm
Mask thickness = 5 mm