2019/04/11:
ProtoProto Source Simulations

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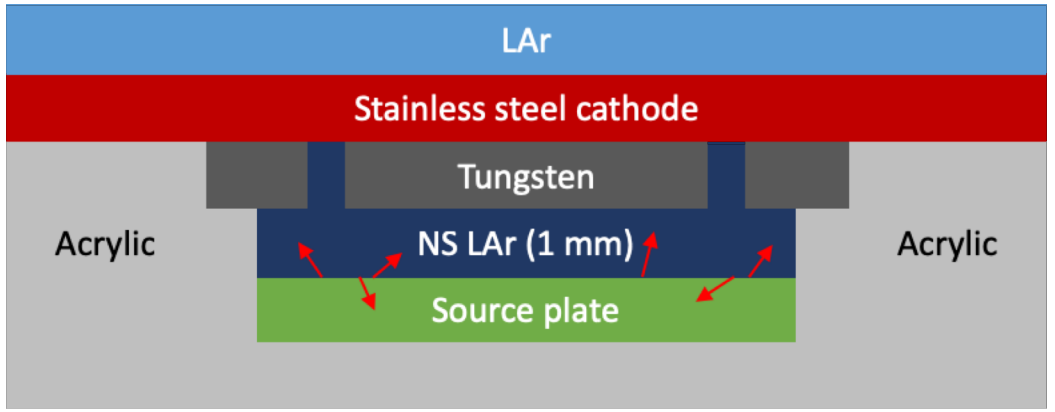
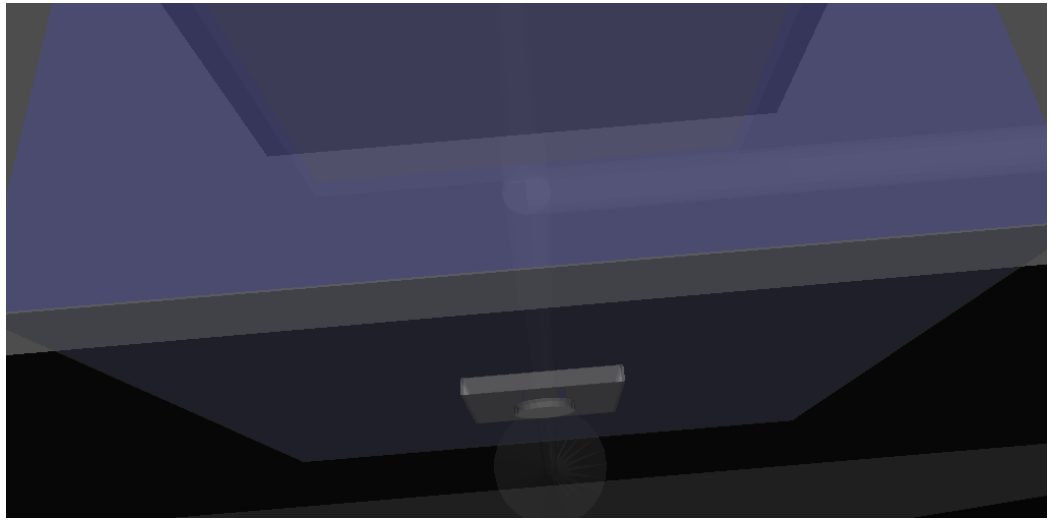
Overview

- Summary of previous MC results
- Study of current collimator design
- Proposal of new collimator design
- S1S2 simulations with event rates
- Background study

Previous Collimator Geometry

- Source plate: 20mm diameter disc
- Steel cathode: 0.5mm thick
- Tungsten collimator: 53 x 53 x 5.6mm plate
  - Lead time for purchase is about 1 week
- Primaries: 60 keV isotropic gammas emitted uniformly at top surface of disc



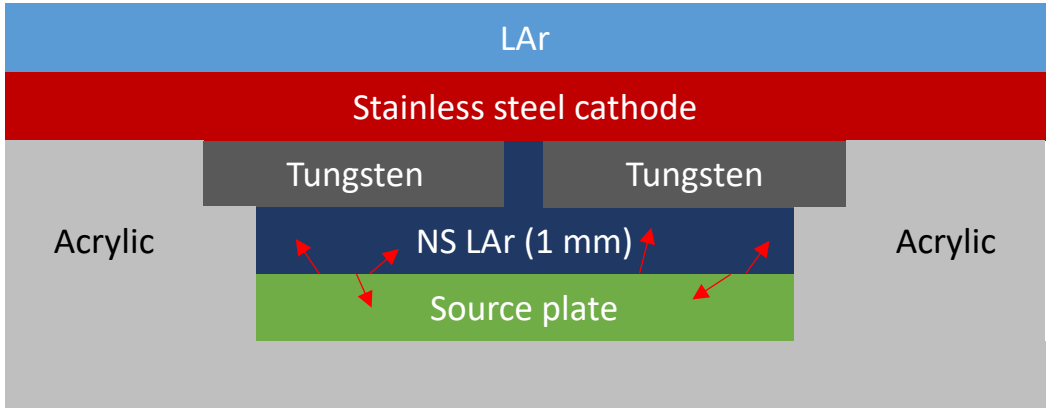


Effects of Scattering

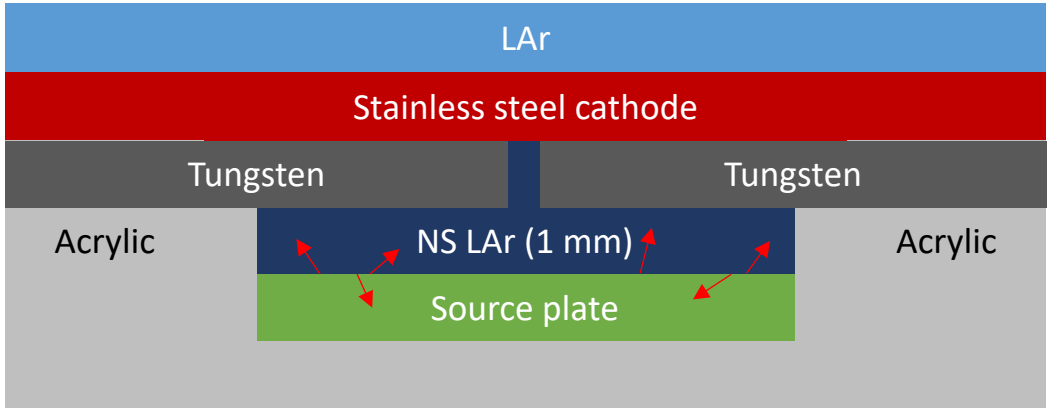
- Compton scattering in the acrylic or in the outer LAr bath allow gamma to reach TPC around tungsten plate
- To examine this effect, two geometries were explored with one hole of variable size in center of collimator
  1. 53 x 53 x 5.6mm tungsten plate
  2. 5.6mm sheet across full bottom of TPC

Effects of Scattering: Geometries

53 x 53 x 5.6mm tungsten plate



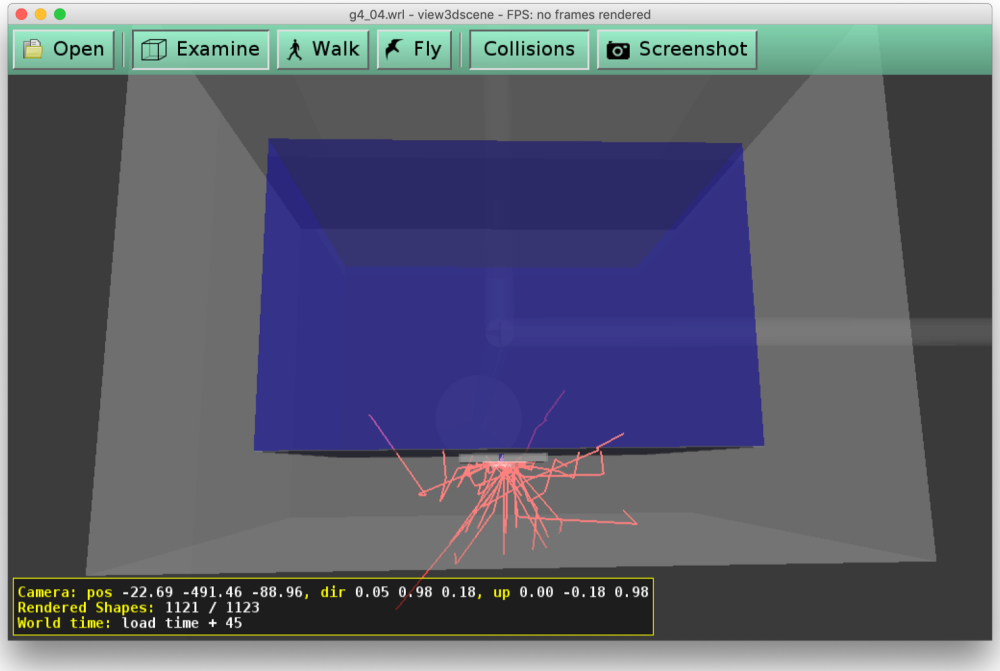
5.6mm thick tungsten sheet covering full bottom of TPC



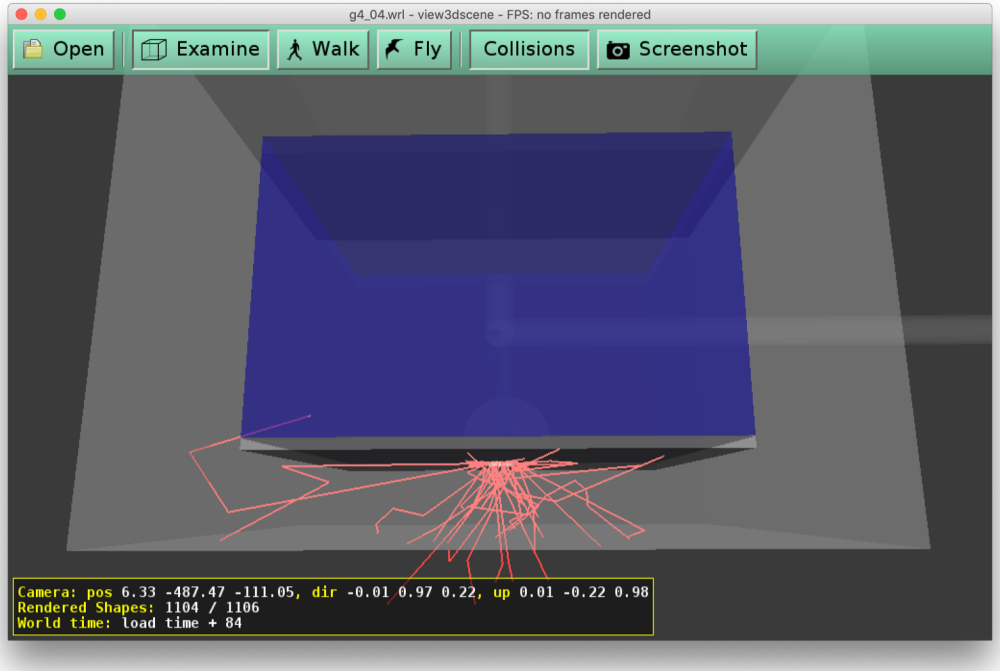
*(500 random events shown for each)

Effects of Scattering: Visualization

53 x 53 x 5.6mm tungsten plate

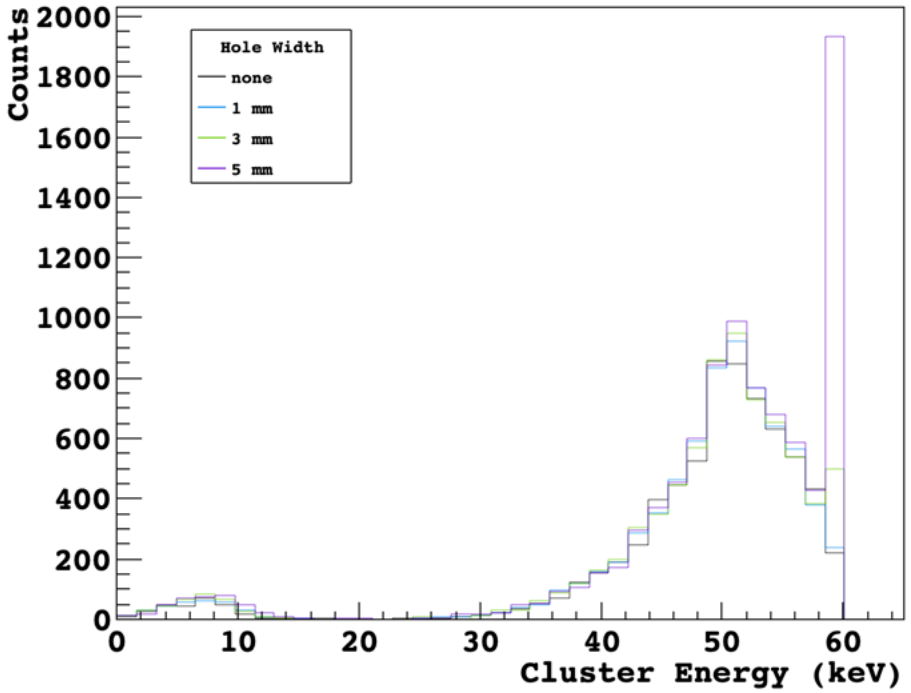


5.6mm thick tungsten sheet covering full bottom of TPC

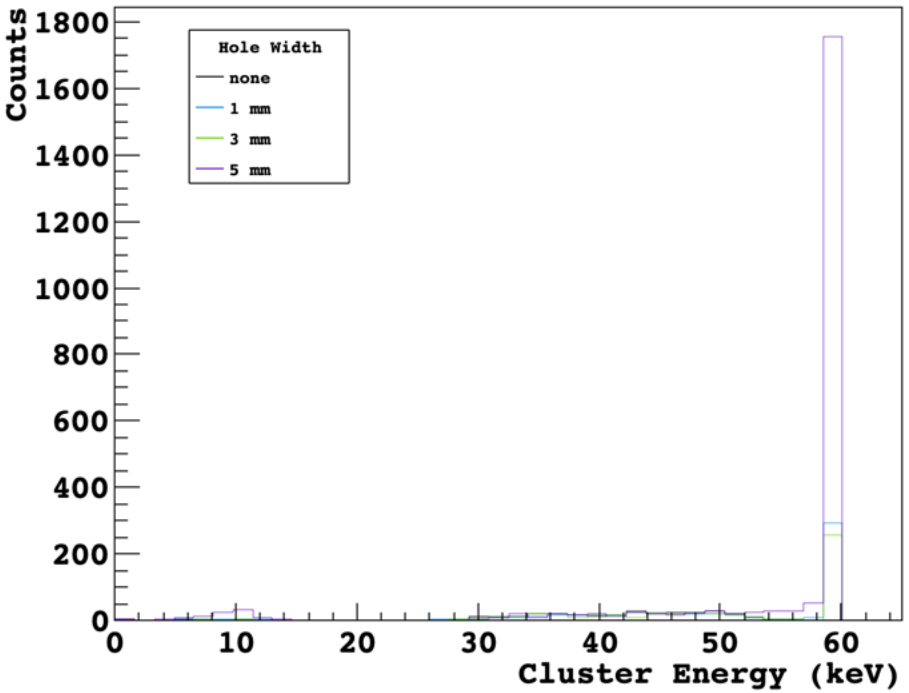


Cluster Energy

53 x 53 x 5.6mm tungsten plate

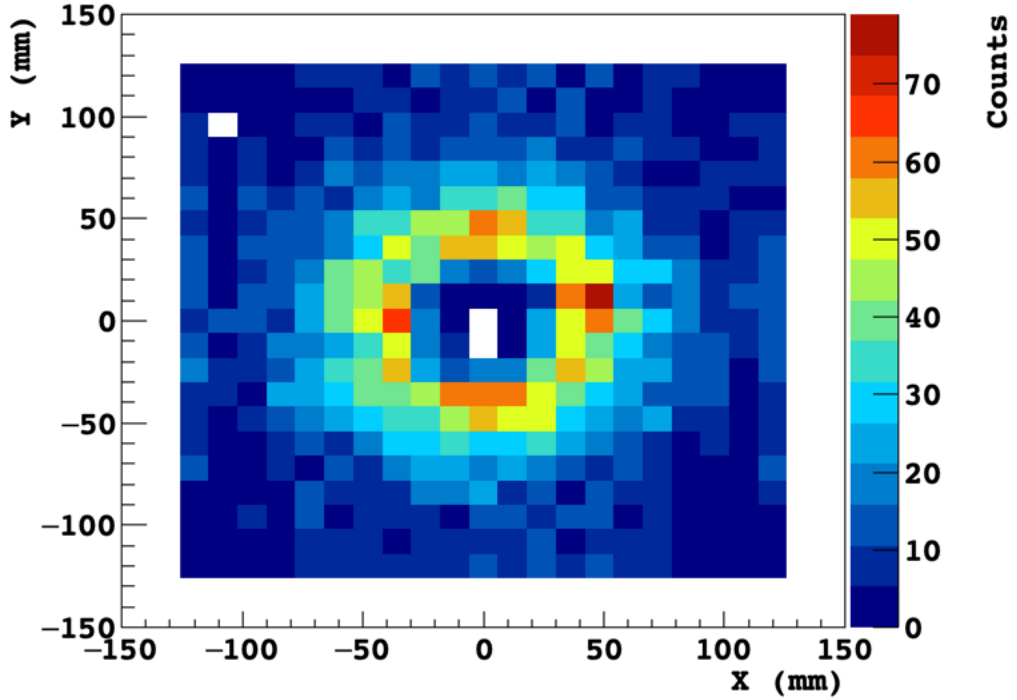


5.6mm thick tungsten sheet covering full bottom of TPC

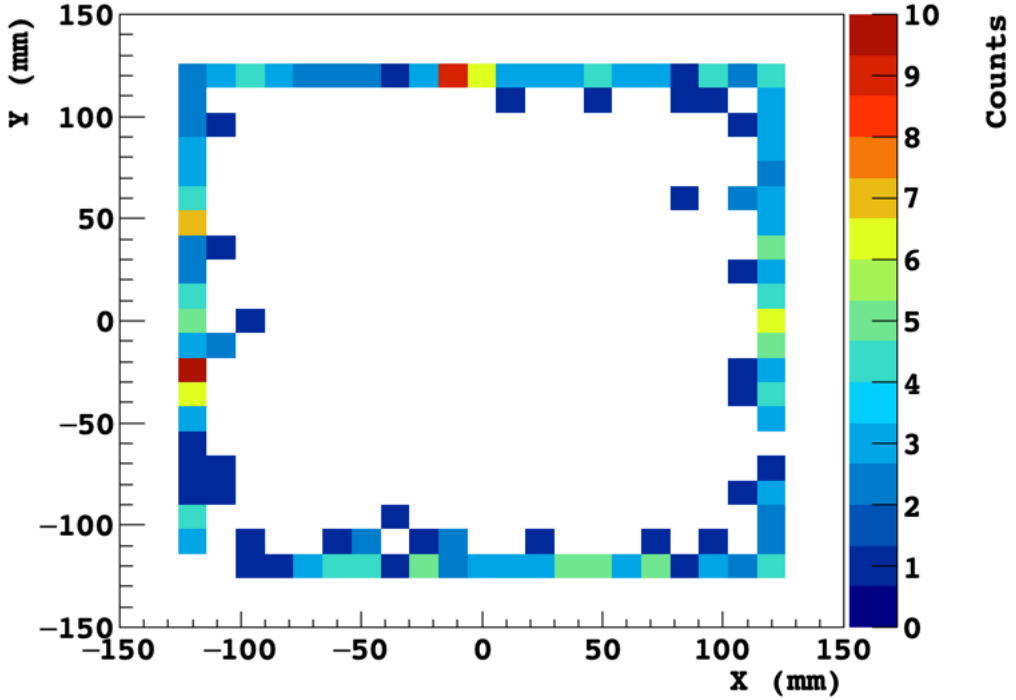


MC with No Hole in Collimator: Cluster XY

53 x 53 x 5.6mm tungsten plate

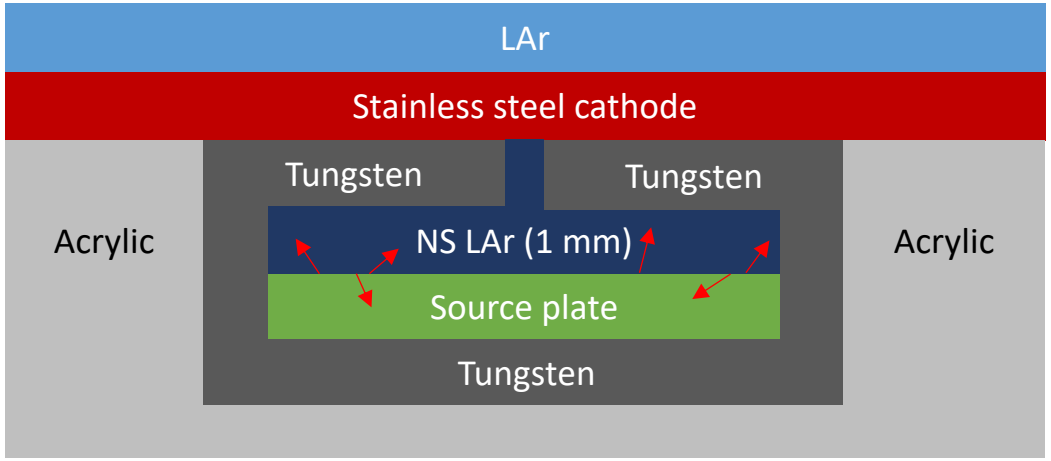


5.6mm thick tungsten sheet covering full bottom of TPC



New Proposed Geometry

- As shown by the MC with no hole in the collimator plate, events are located in the region of interest for old geometry
- Tungsten plate covering entire bottom of TPC not feasible
- Instead, source plate can be encapsulated by tungsten (or steel)



Simulations with Single Hole

- For source plate encapsulated by 5mm tungsten with 1 hole in center of collimator:

Hole Diameter	Frac. w/ cluster in TPC	Event Rate (40kBq source)	Cluster Radial RMS
No hole	0 / 1e7 = 0%	0 Hz	---
1mm	27 / 1e7 = (2.7 ± 0.5)e-4%	(0.037 ± 0.007) Hz	not enough statistics
2mm	468 / 1e7 = (4.7 ± 0.2)e-3%	(0.59 ± 0.03) Hz	(4.8 ± 0.2) mm
3mm	1962 / 1e7 = (1.96 ± 0.04)e-2%	(2.53 ± 0.06) Hz	(5.7 ± 0.1) mm
4mm	5700 / 1e7 = (5.70 ± 0.08)e-2%	(7.2 ± 0.1) Hz	(6.40 ± 0.06) mm
5mm	12411 / 1e7 = (0.124 ± 0.001)%	(15.7 ± 0.2) Hz	(6.91 ± 0.04) mm

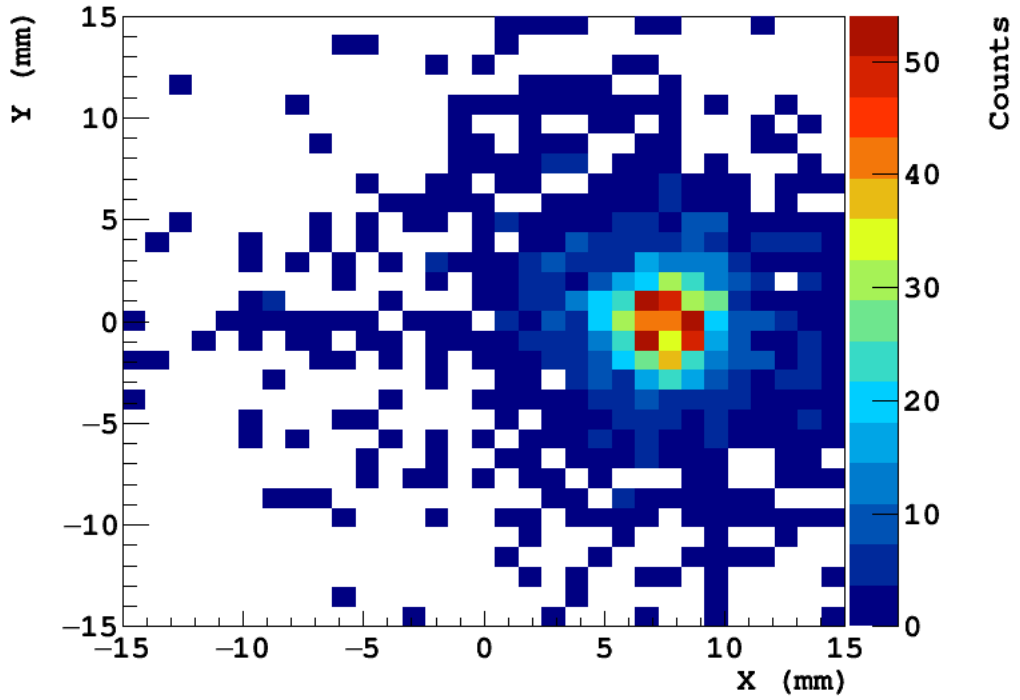
(note that the RMS is in terms of radius and hole size is in terms of diameter)

Resolving Two Holes in Collimator

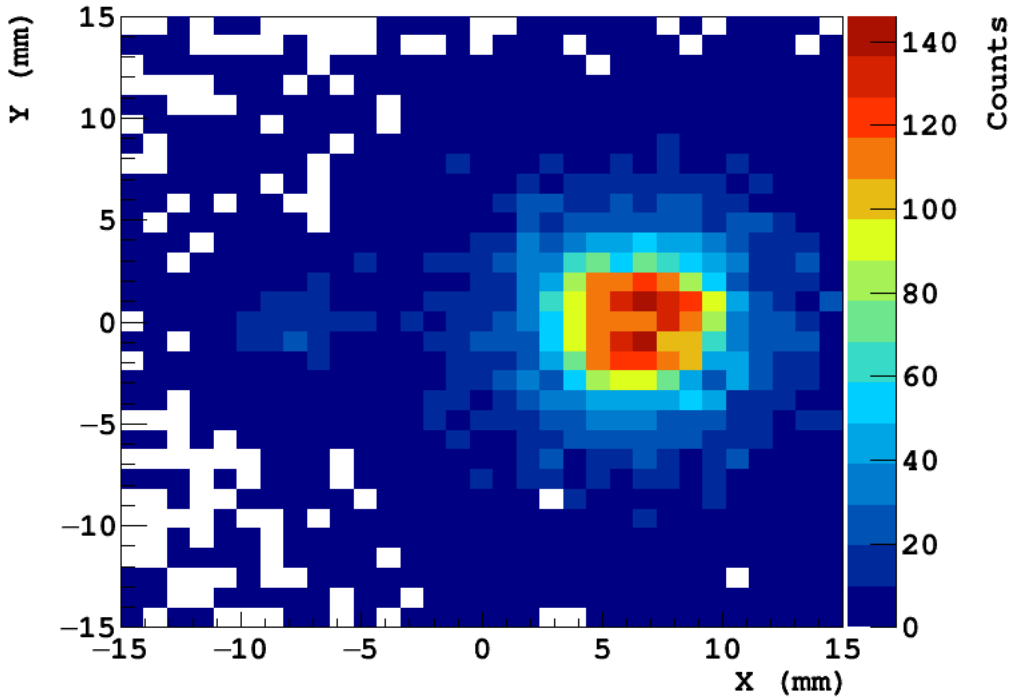
- Two simulations performed to see if two holes in collimator is feasible
  1. 3mm diameter hole centered @ (x,y) = (7.5,0)mm and 1mm hole @ (-8.5,0)mm
  2. 5mm hole @ (6.5,0)mm and 2mm hole @ (-8.0,0)mm

True MC Cluster XY

1 & 3 mm holes



2 & 5 mm holes



Conclusions

- Cluster true position spreads overlap so it will be difficult to resolve multiple holes in the collimator
  - This resolution will only be made worse by reconstruction
- Our proposal is to use a single hole with diameter of 5mm centered on the source plate
  - (15.7 ± 0.2) Hz event rate for 40kBq source

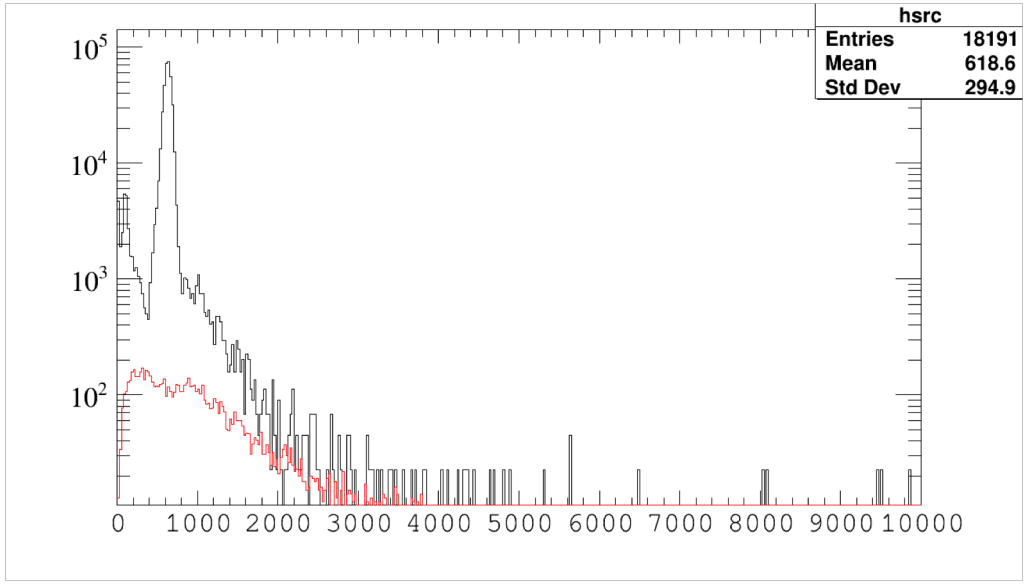
Backup Slides

Background Rate Estimation

- Given data, can scale S1 but unclear how to properly scale event rate
  - Run is 53 minutes, histogram appears to be missing low energy events

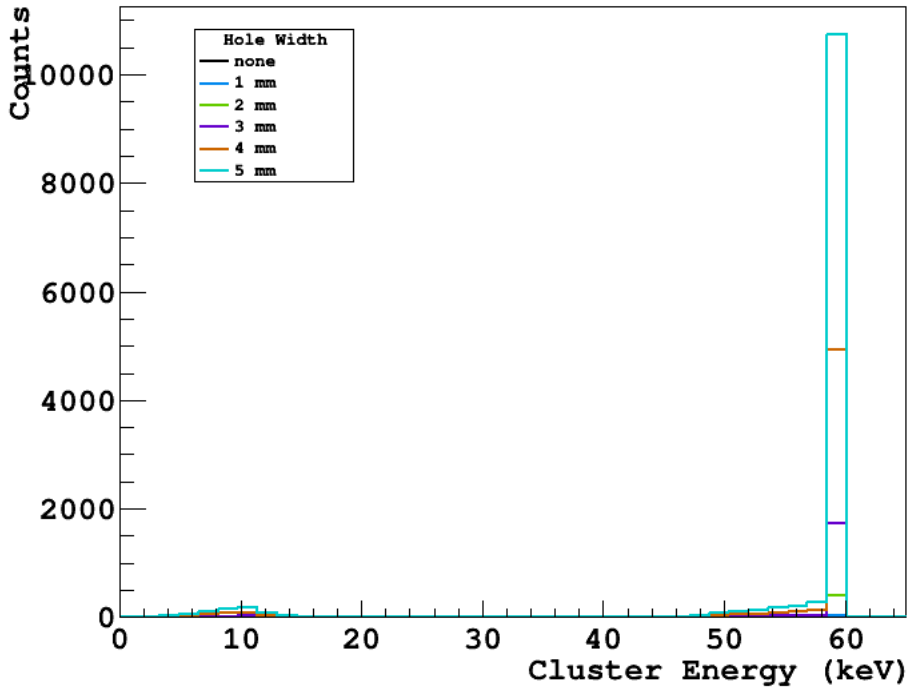
? ?

$$\text{Bg\_Proto} = (\text{scale factor for relative detector sizes}) \times (\text{Bg\_ReD})$$

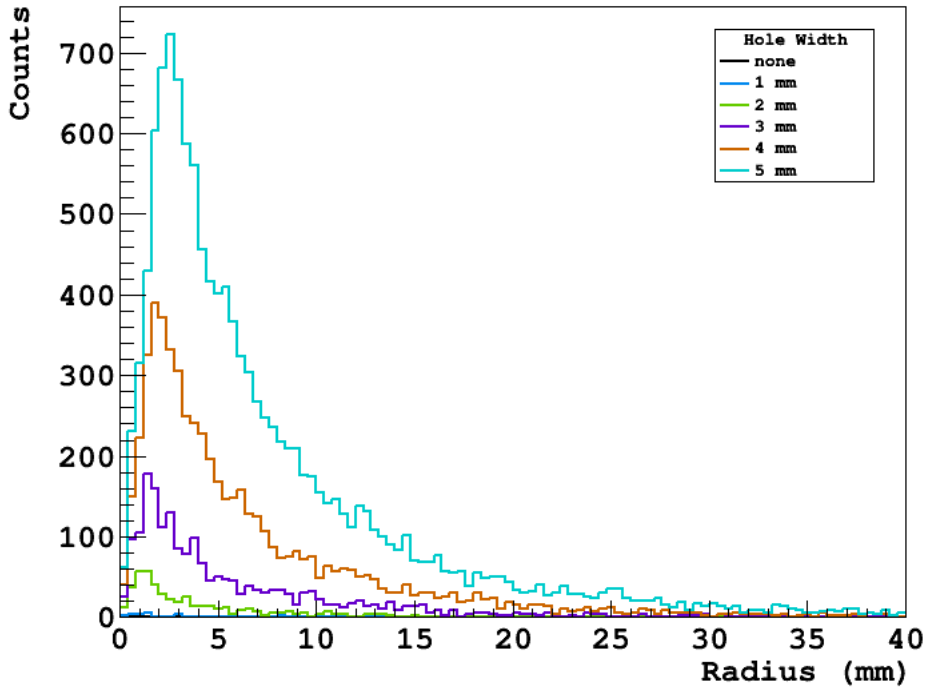


New Collimator Geometry (one hole)

Cluster True Energy

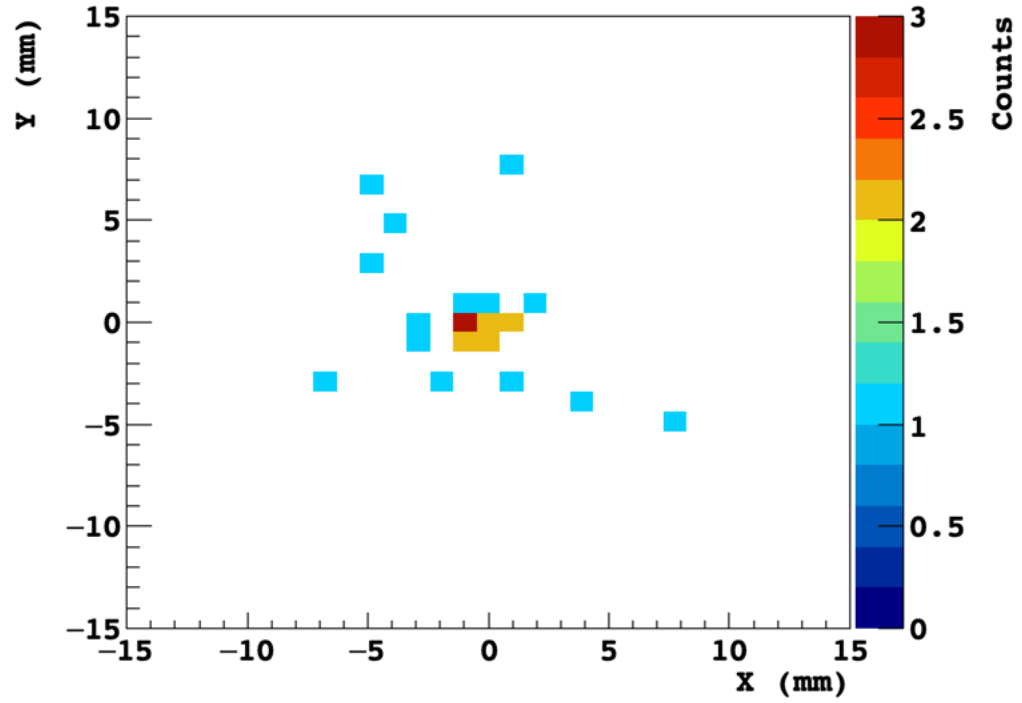


Cluster Radius

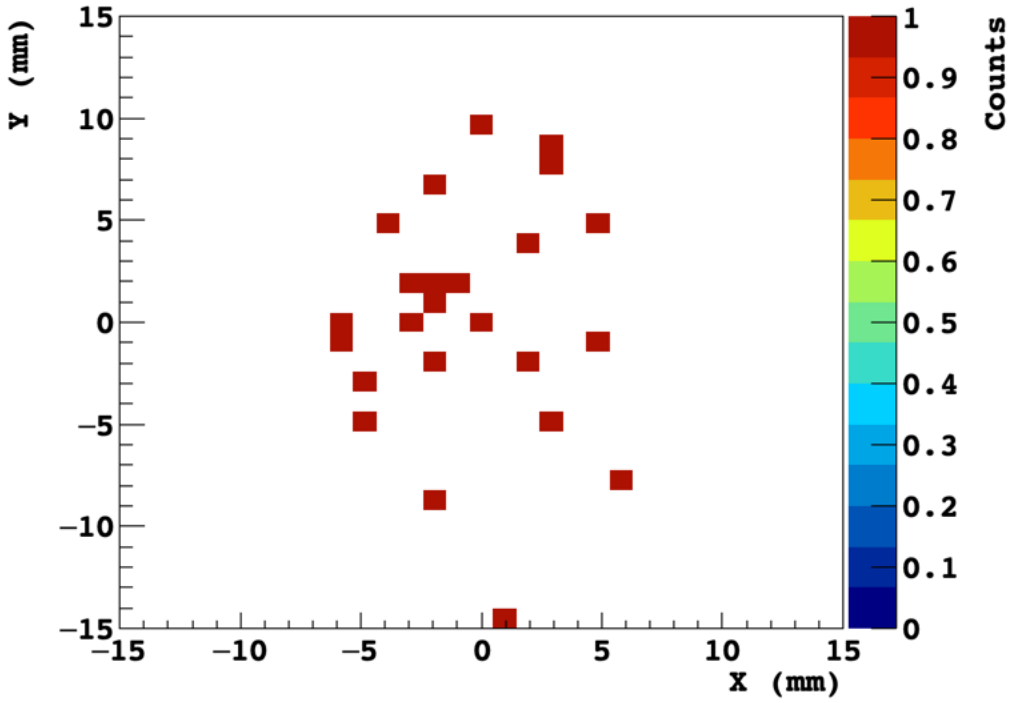


d=1mm Hole

Cluster XY

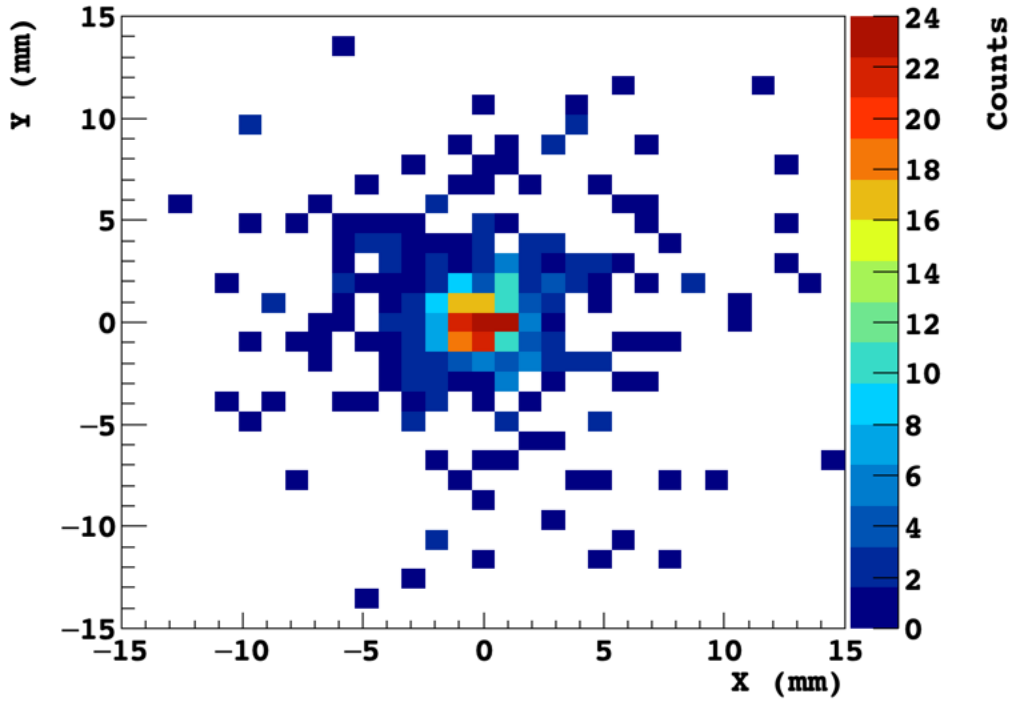


Barycenter XY

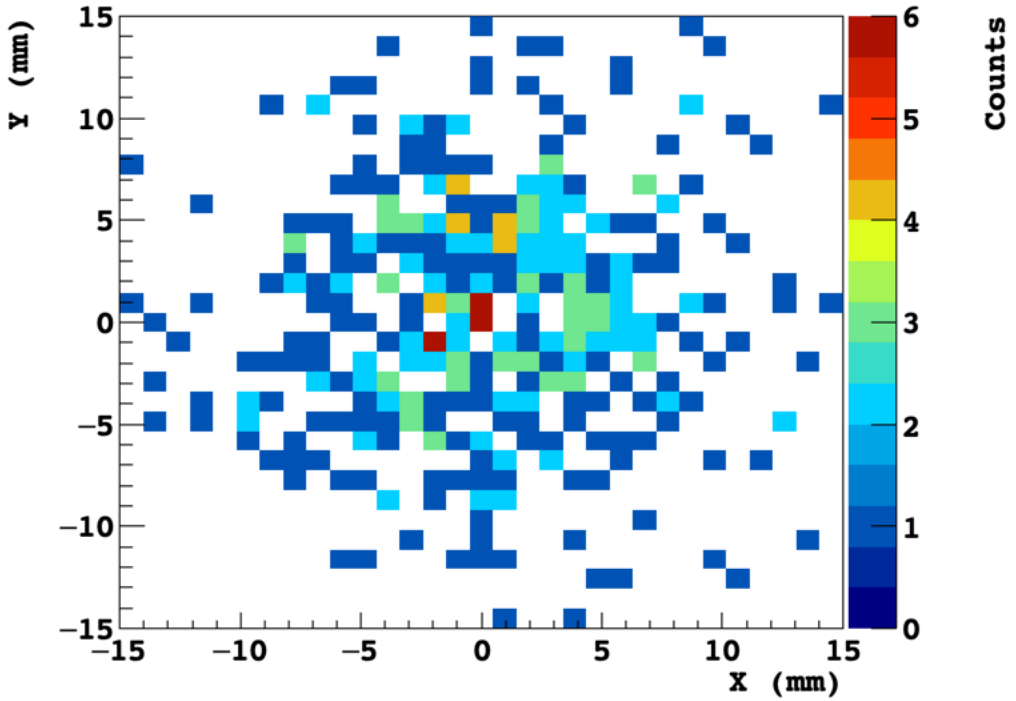


d=2mm Hole

Cluster XY

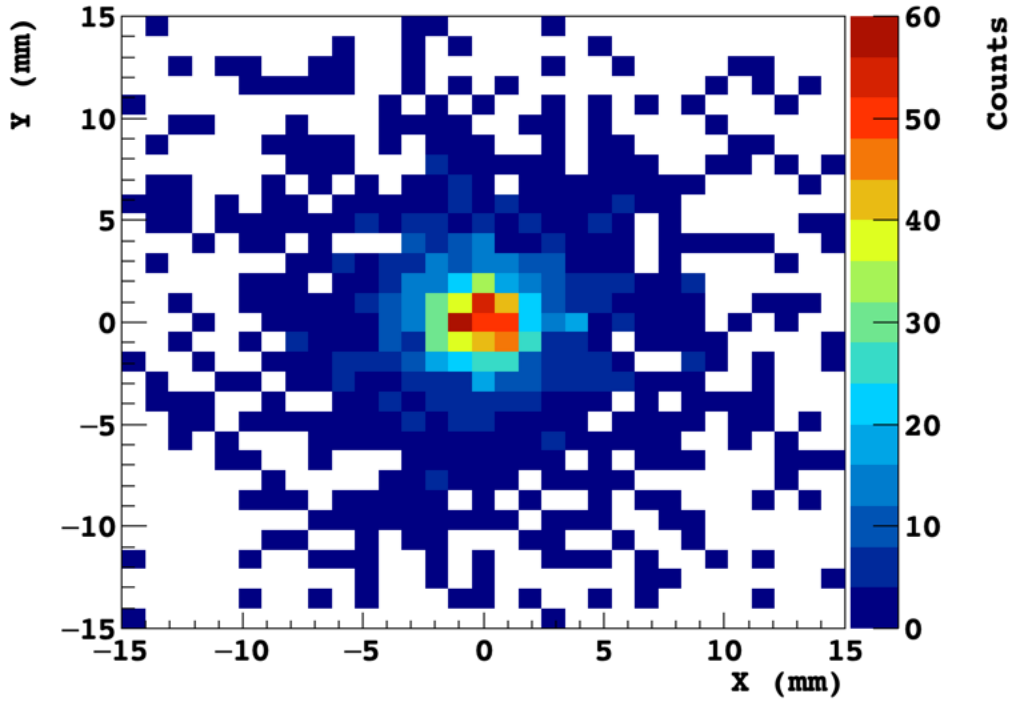


Barycenter XY

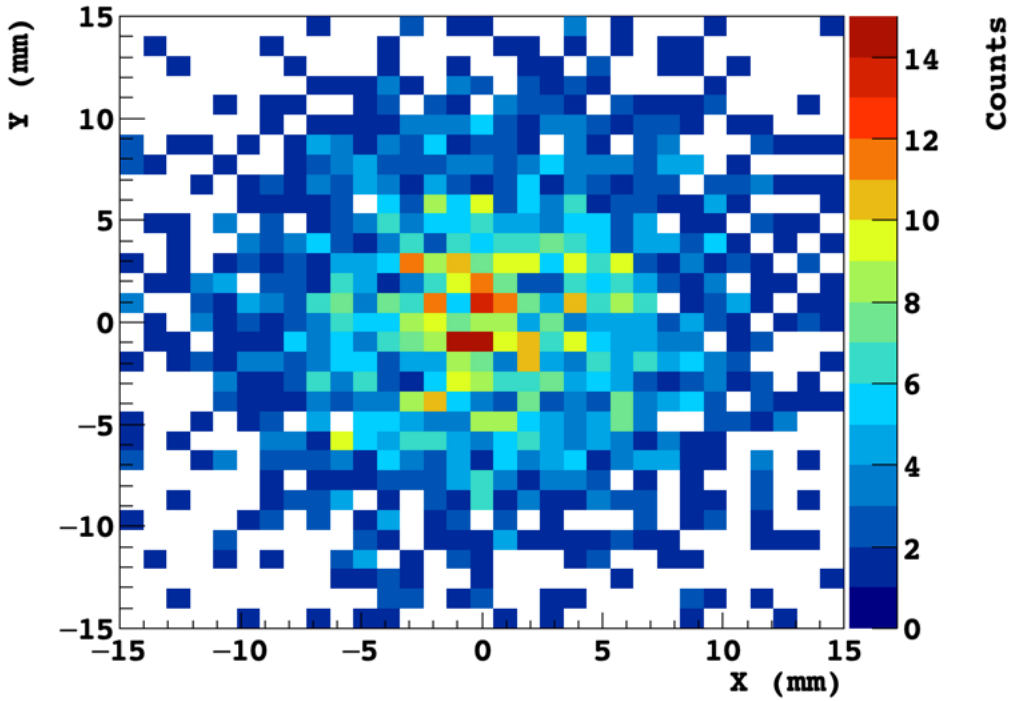


d=3mm Hole

Cluster XY

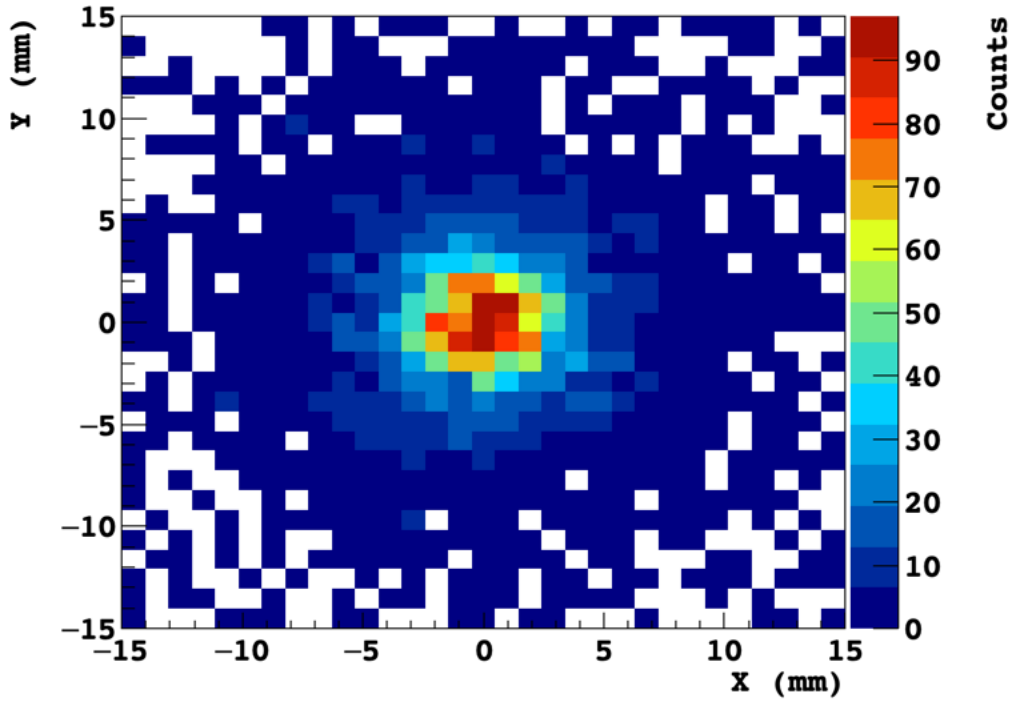


Barycenter XY

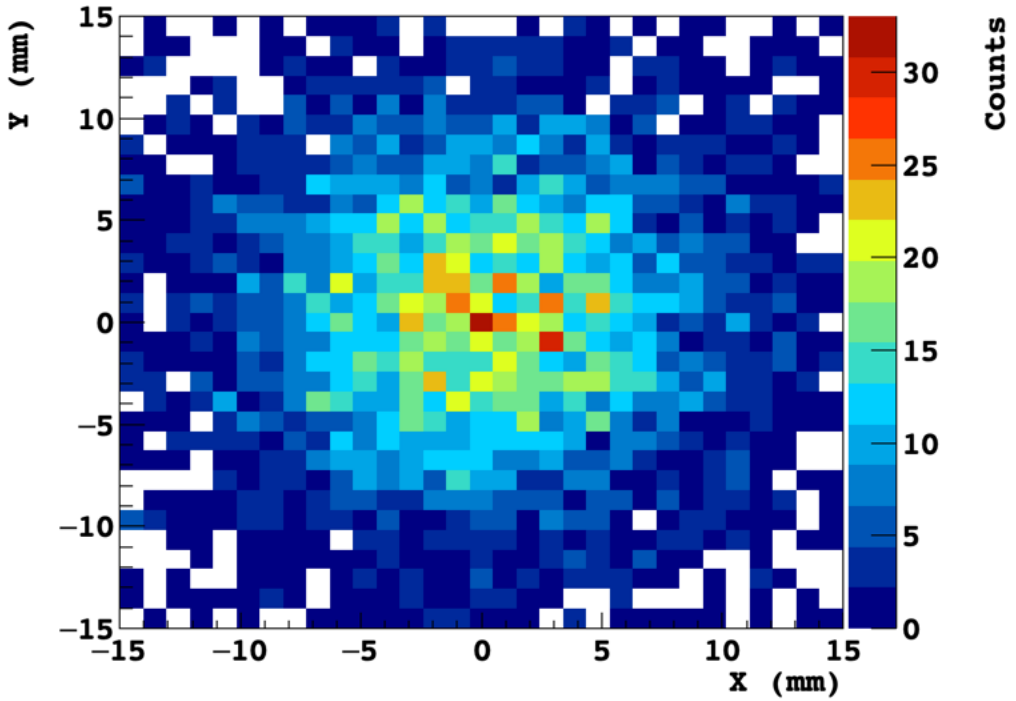


d=4mm Hole

Cluster XY

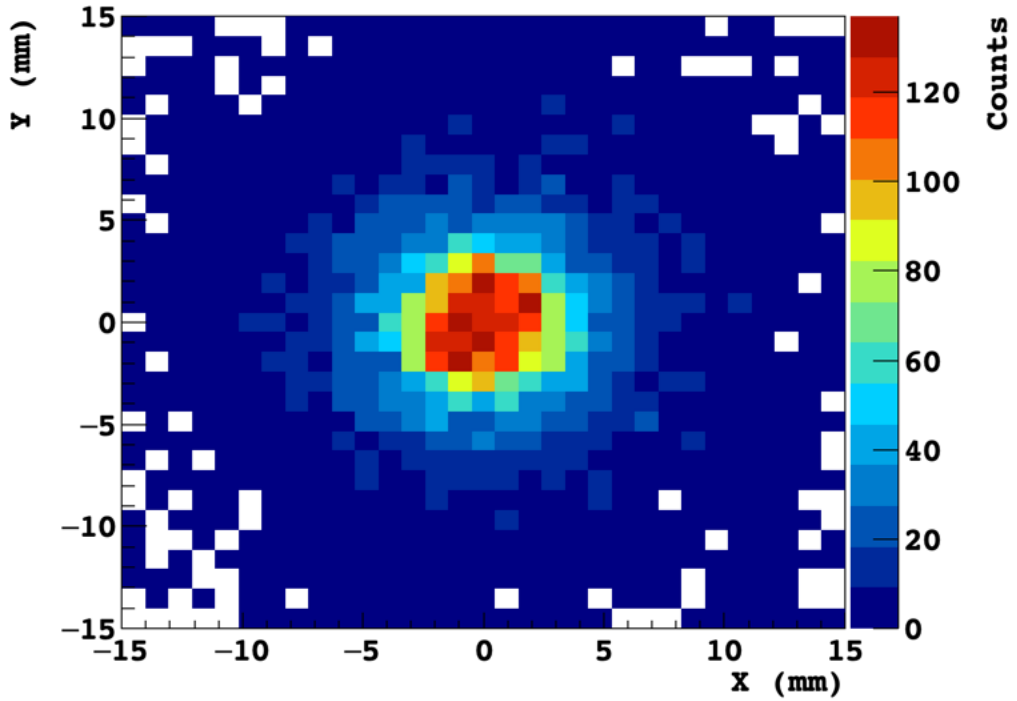


Barycenter XY

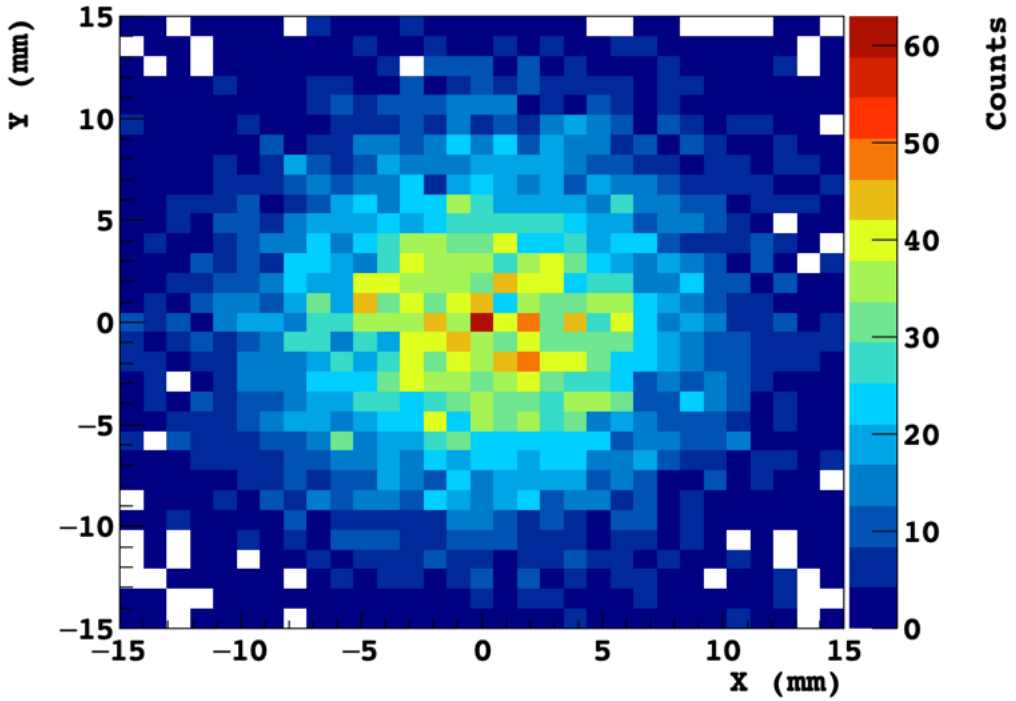


d=5mm Hole

Cluster XY

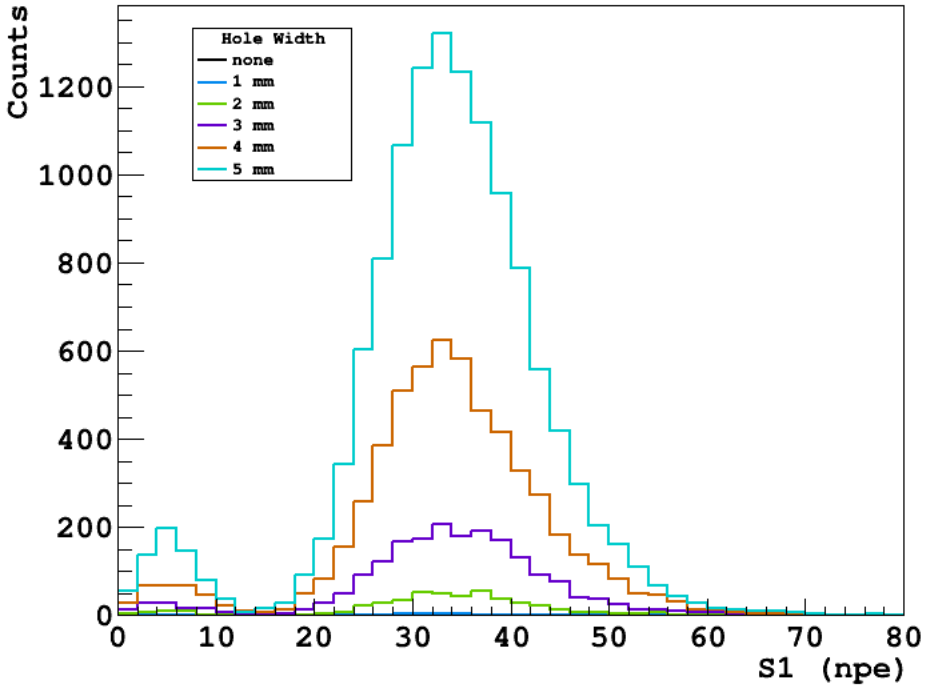


Barycenter XY

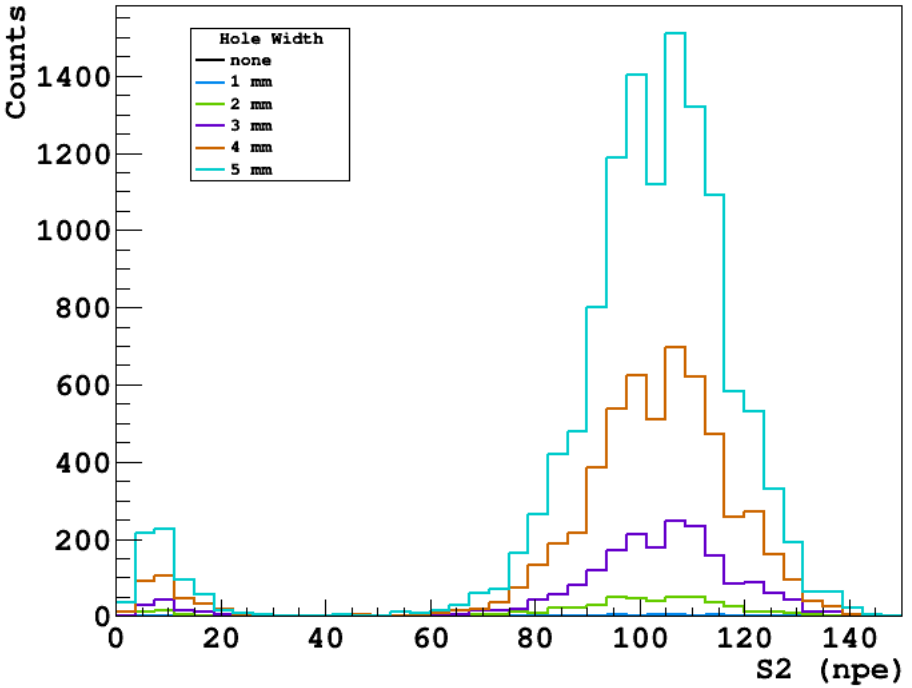


New Collimator Geometry (one hole)

Total S1

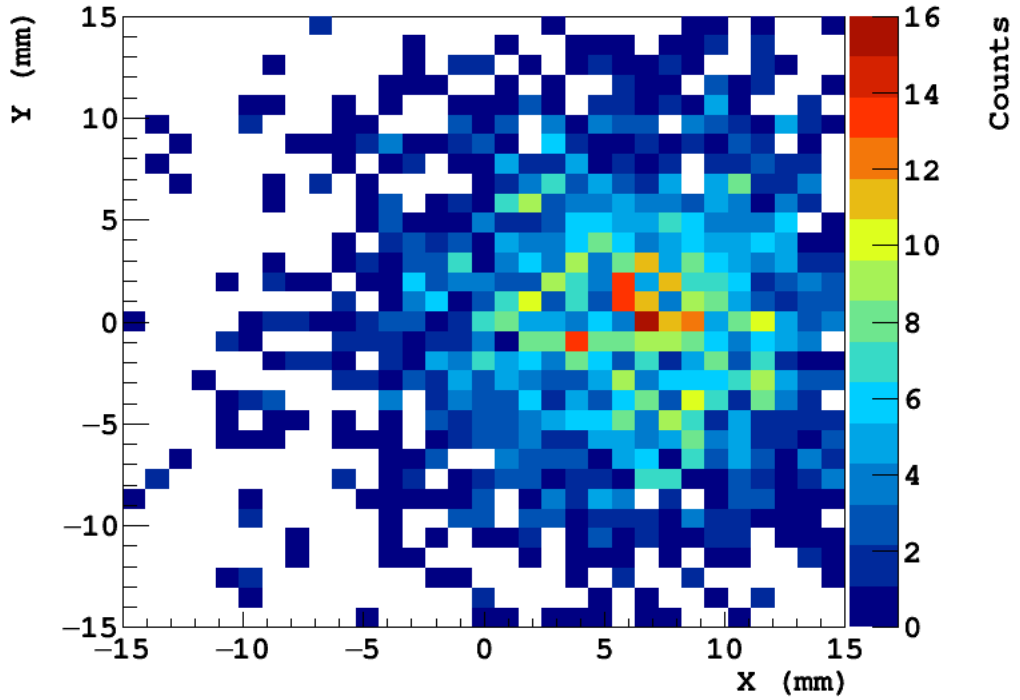


Total S2



XY Reconstruction Using Charge Barycenter

1 & 3 mm holes



2 & 5 mm holes