Modular RICH Detector Simulation – Fresnel Lens Calibration

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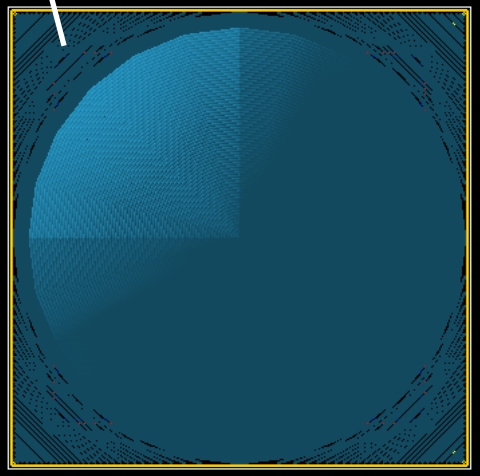
This Week

- Flip Fresnel lens polarity by rotating its mother volume, i.e. lens holder (see next slide)
- Adjust Fresnel lens profile
  - Shperical Fresnel lens
  - Flatten the corner
- Adjust the distance between Fresnel lens and sensor plane
- Change aerogel refractive index to 1.03

Fresnel Lens Polarity

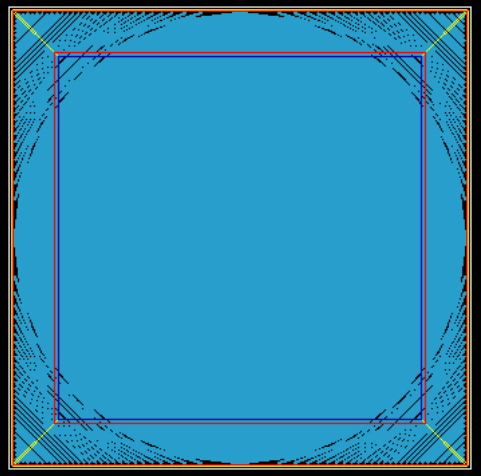
Front view

Flat corners



Pattern shows at the Front view

Back



The lens is smooth
when look from the back

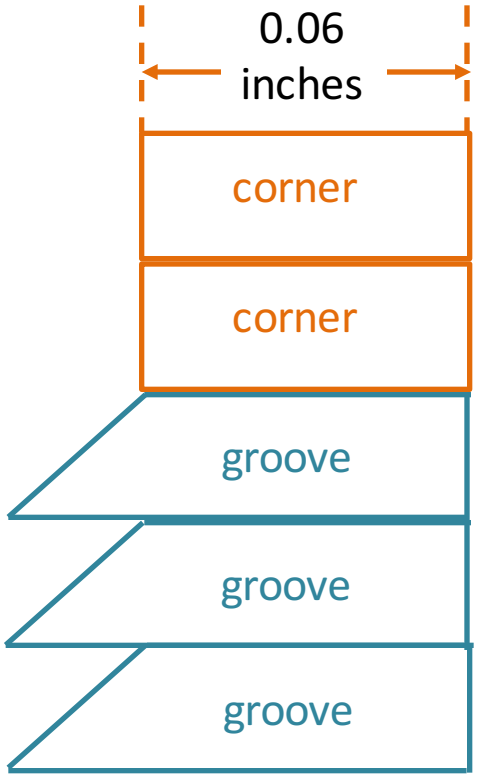
Fresnel Lens Profile

- Spherical Fresnel Lens
  - Set array Aspher=0, then
  - $curvature = \frac{1}{(n-1)\times focal\ length} \approx 0.0287\ mm^{-1}$

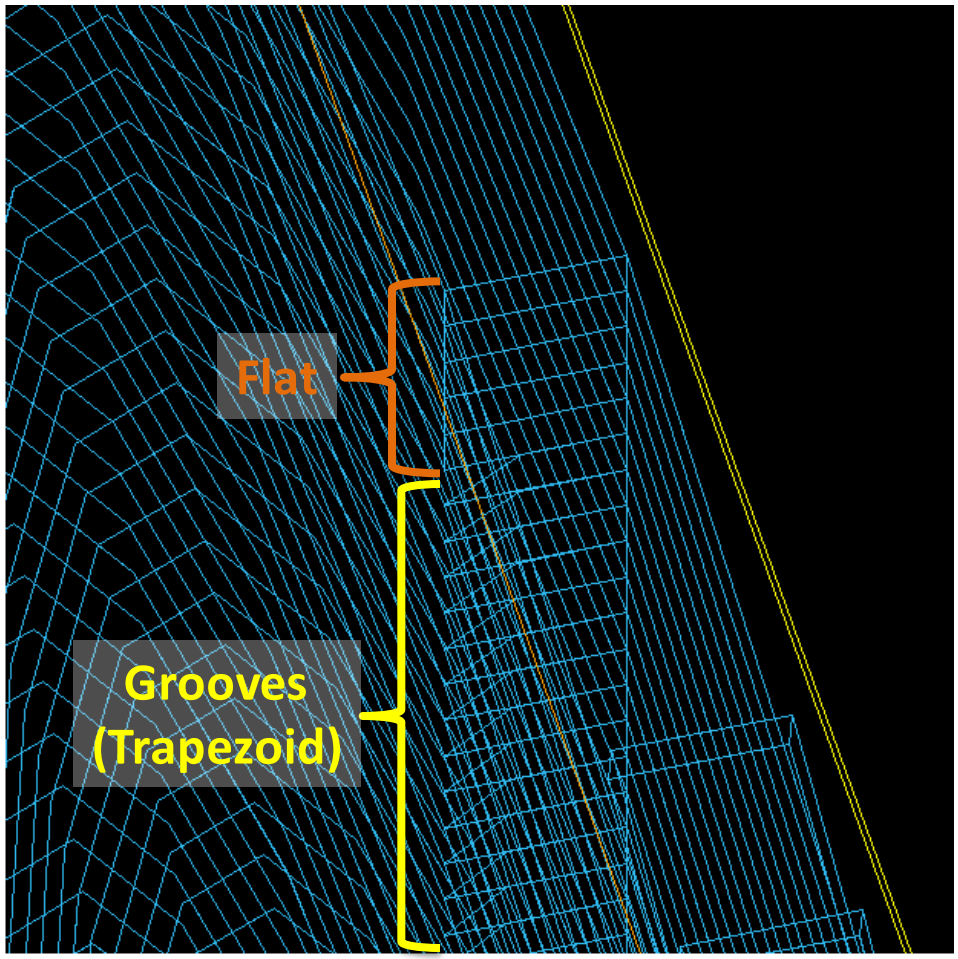
    (Edmund Optics stock# 32-683)

  $\rightarrow dZ = \frac{curvature}{2} \times r_{outer}^2 - \frac{curvature}{2} \times r_{inner}^2$
- Flatten the corner of Fresnel Lens (see next slide)

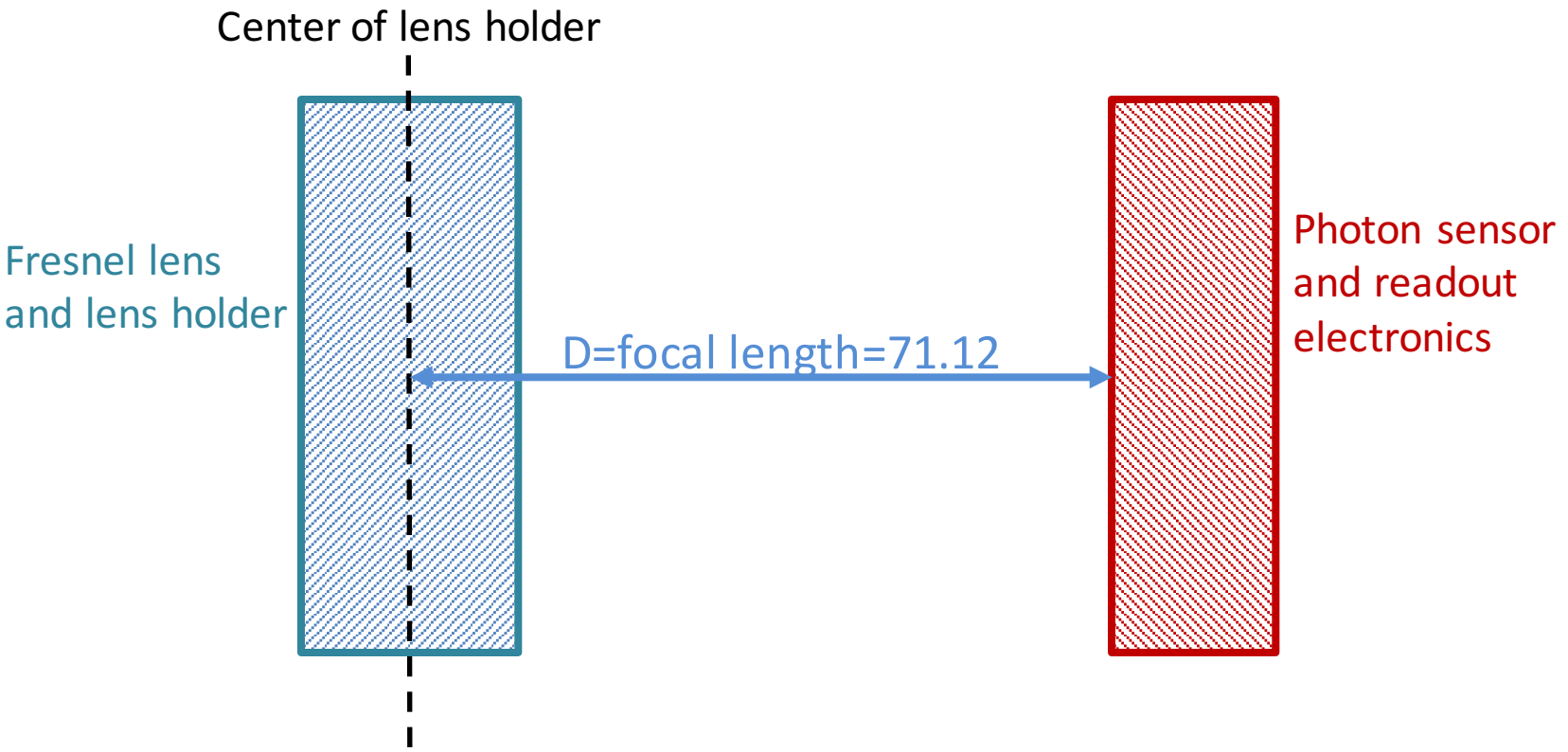
Flatten the Corner of Fresnel Lens



On the lens we got, corners are thinner then the optical effective area (the grooves)



Position of Sensor Plane



Detector Setup

Focus

- Aerogel
  - 3 cm thick
  - Refractive index = 1.03
- Fresnel Lens
  - Spherical (see slide 4)
  - Distance between center of the lens holder & sensor plane = 71.12 mm
  - Flat corner
    - Eff. diameter = 4in = 10.16cm

Out of Focus

- Aerogel
  - 3 cm thick
  - Refractive index = 1.03
- Fresnel Lens
  - Aspherical (defined by Hubert)
  - Distance between center of the lens holder & sensor plane =72mm
  - Flat corner
    - Eff. diameter = 4in = 10.16cm

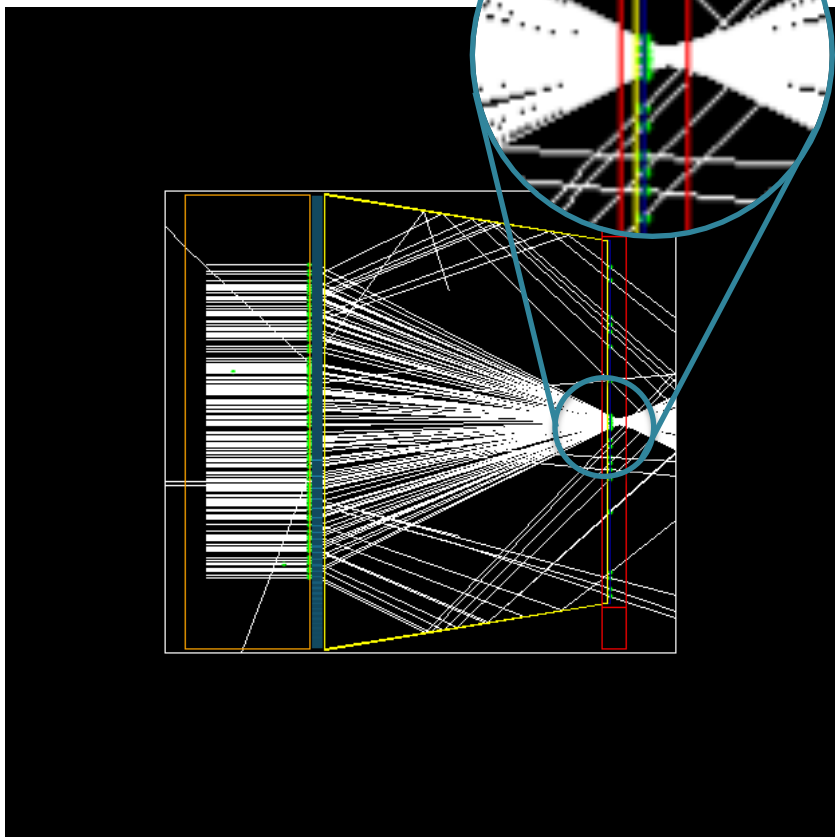
Simulation 1: 2eV Photons

- 200 optical photons with 2eV momentum
- Launching position
  - Move parallel to z axis
  - at the same z position (inside aerogel. detector holder blocks photons)
  - at random xy positions: $\sqrt{y^2 + x^2} \leq 4cm$, within effective area

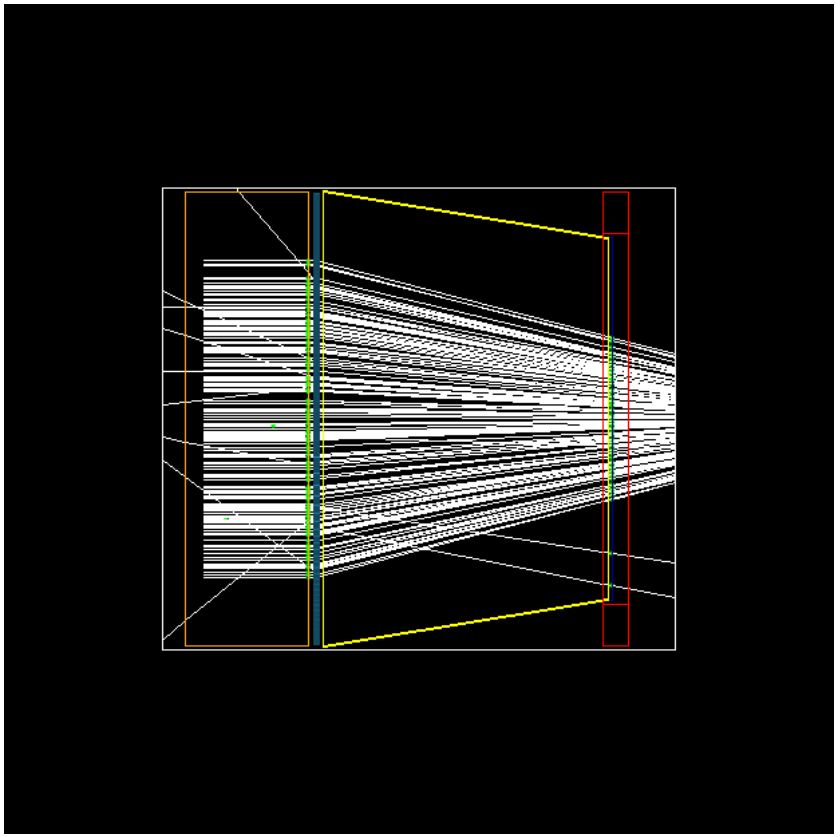
Focal Plane (Simulation 1)

Still a bit out of focus

Focus

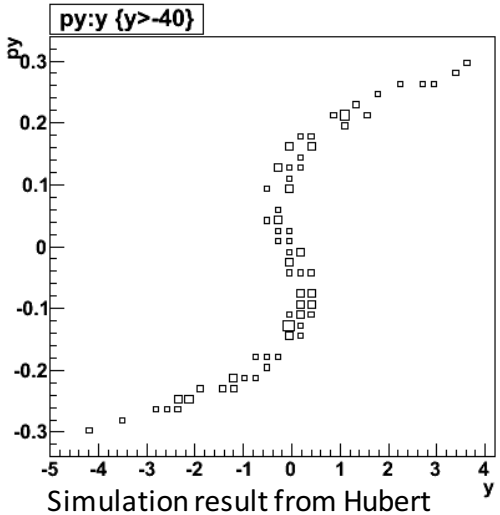


Out of Focus



Simulation 2: 10,000 Photons

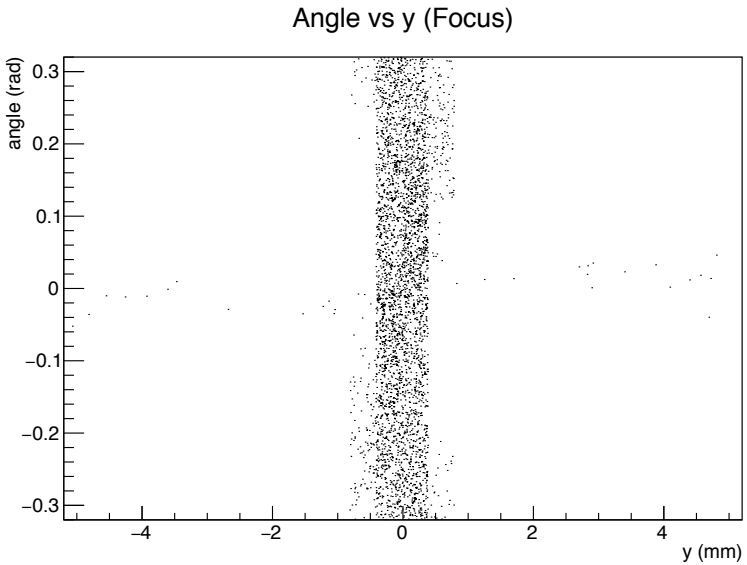
- To compare Huburt's plot
- Simulation Setup:
  - 10000 optical photons
  - Momentum = 3 eV
  - Launching position
    - Move parallel to z axis
    - at the same z position (inside aerogel. detector holder blocks photons)
    - at random xy positions: $\sqrt{y^2 + x^2} \leq 4cm$



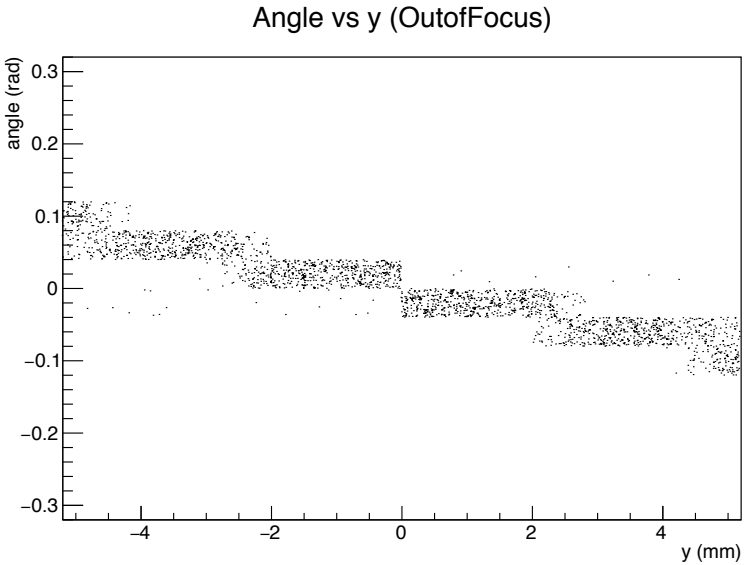
Simulation result from Hubert
http://p25ext.lanl.gov/~hubert/eic_rich/modular/agel_sim.html

Angle vs y (Simulation 2)

Focus

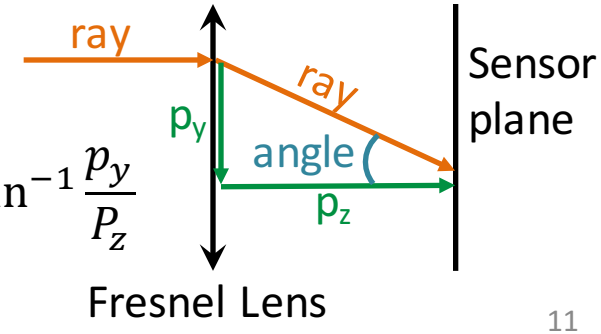


Out of Focus



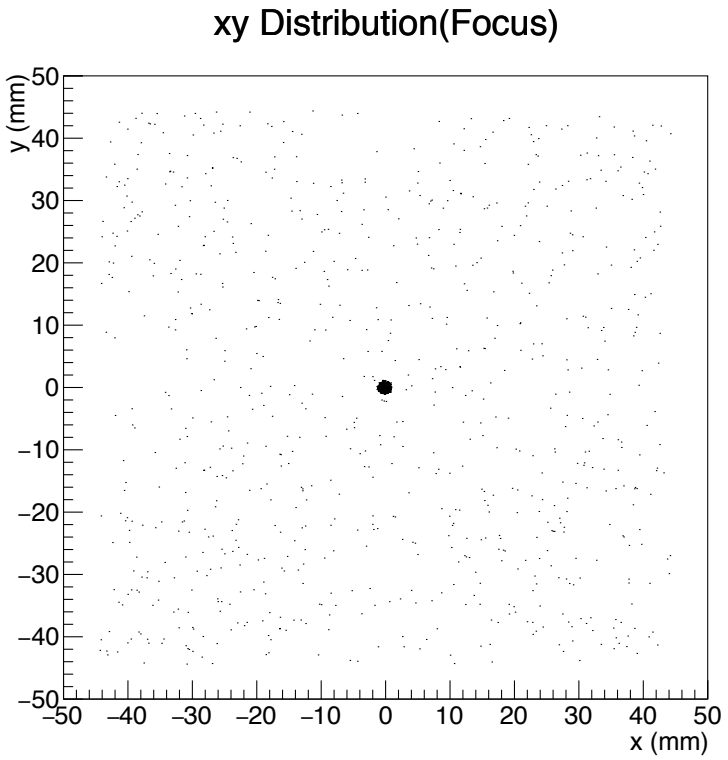
- Photon hits are more centralized in the focus setting (see also slide 12-14)
- See full range plots on back up slide

$$angle = \tan^{-1}\frac{p_y}{P_z}$$

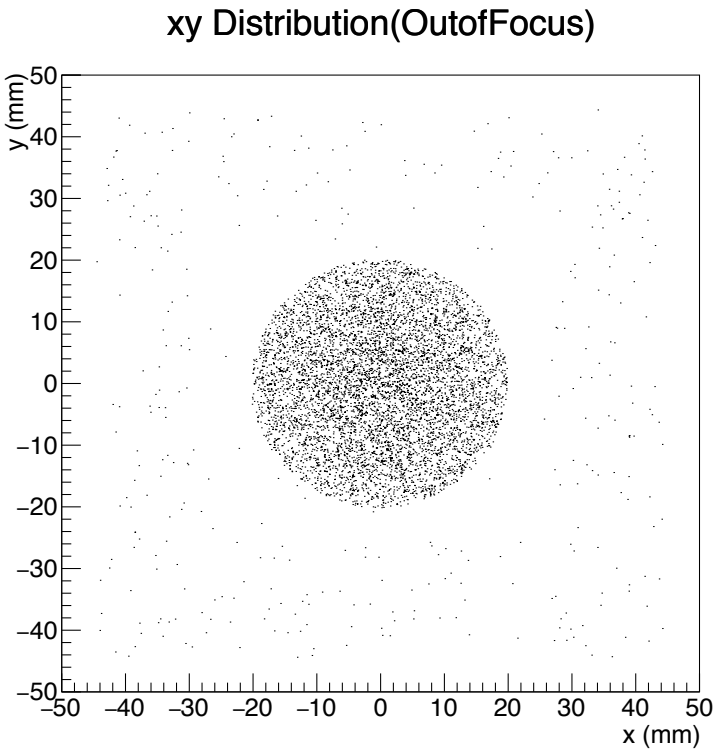


xy Distribution on Sensor Plane (Simulation 2)

Focus



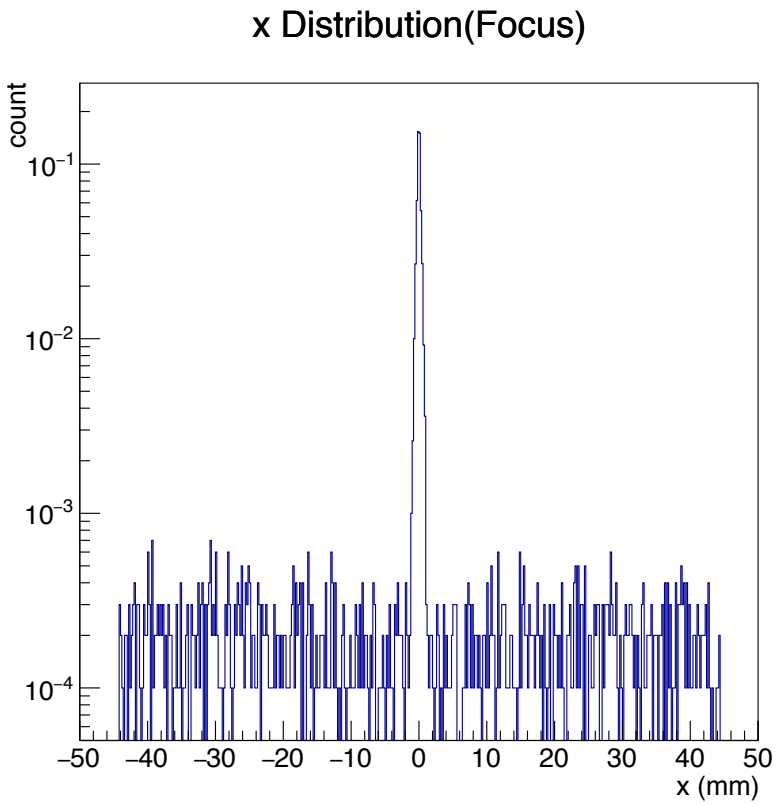
Out of Focus



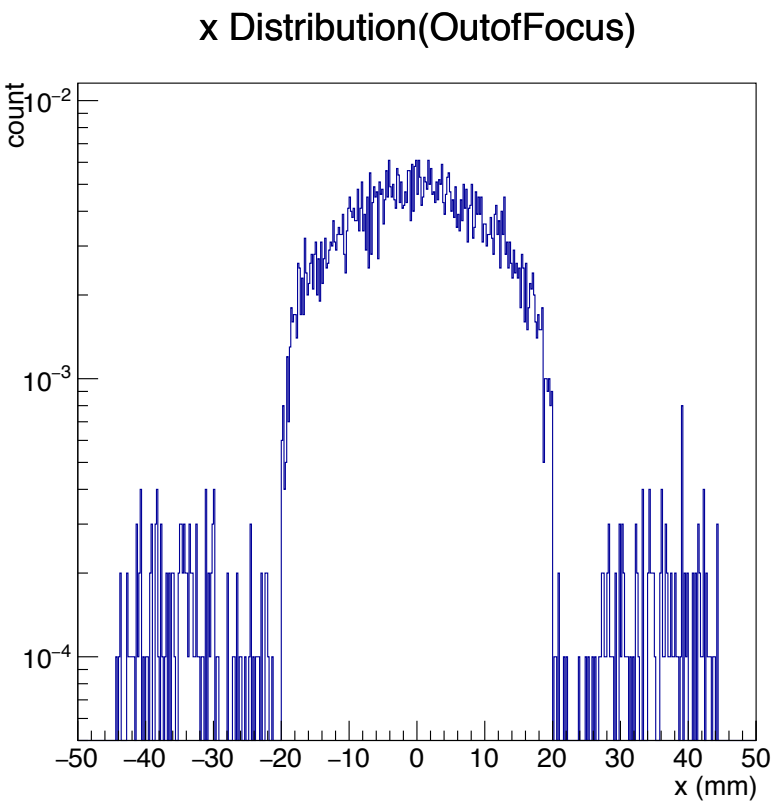
- Hit distribution is denser in the “focus” detector setting (see also slide 13 and 14)

x Distribution on Sensor Plane (Simulation 2)

Focus



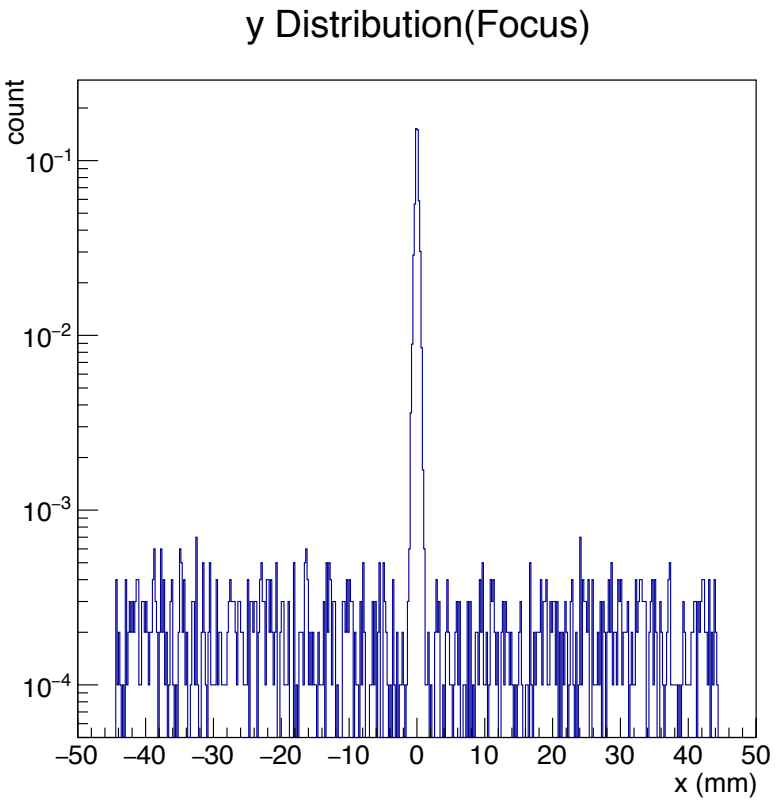
Out of Focus



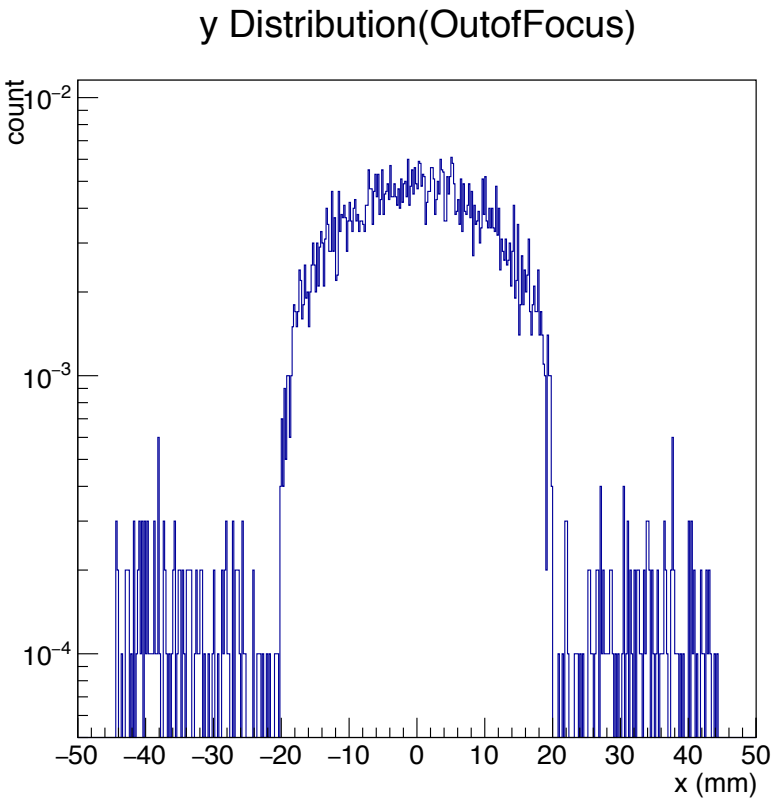
Normalized by total number of events

y Distribution on Sensor Plane (Simulation 2)

Focus



Out of Focus



Normalized by total number of events

Simulation 3: 10,000 mu-

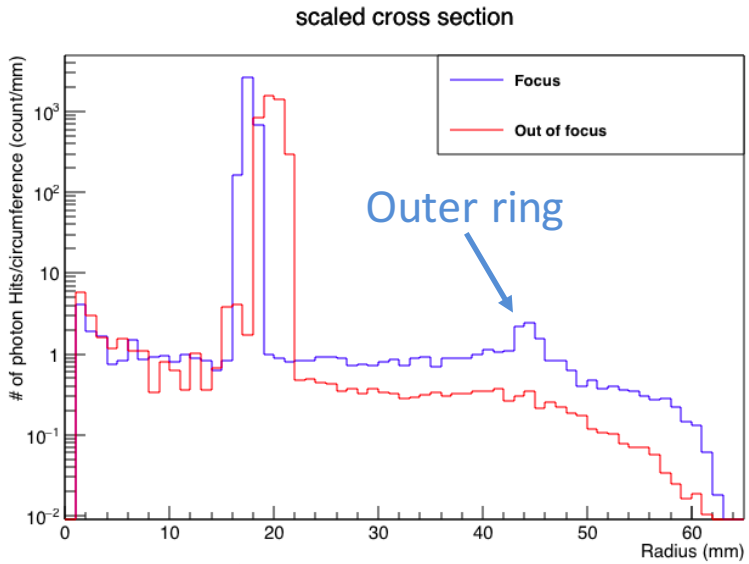
- Study Cherenkov photon hit cross-section
- Simulation Setup
  - 10,000 mu-
  - Momentum = 9GeV
  - Launching position
    - shoot at the origin of the hall
    - Toward the center of the xy plane of the detector

Analysis Setting (Simulation 3)

- Basic Cut
  - Photon only
  - Hit on photon sensor or readout
  - $p_z>0$
- Additional Cut
  - Mother pid= Muon-
  - Emitted inside aerogel
- Cross Section : # of photons vs ring radius
- **Scale Cross Section**:
  "# of photons / ring circumference" vs ring radius

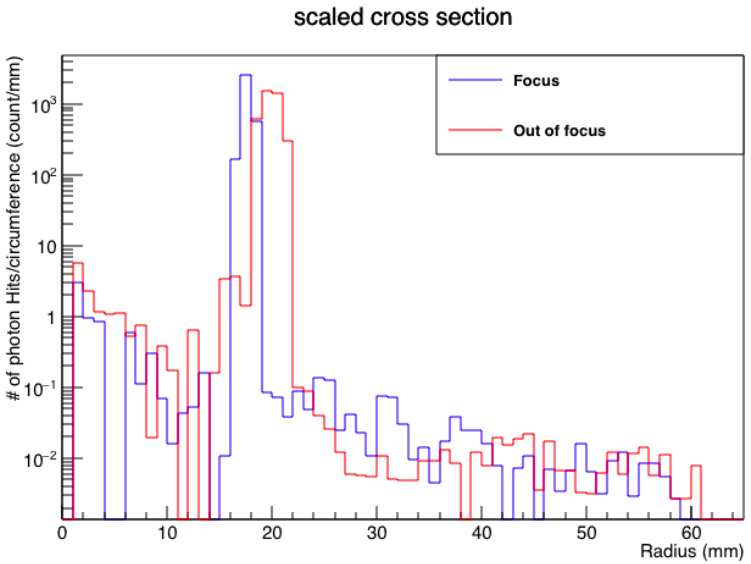
Scale Cross Section (Simulation 3)

Basic Cuts



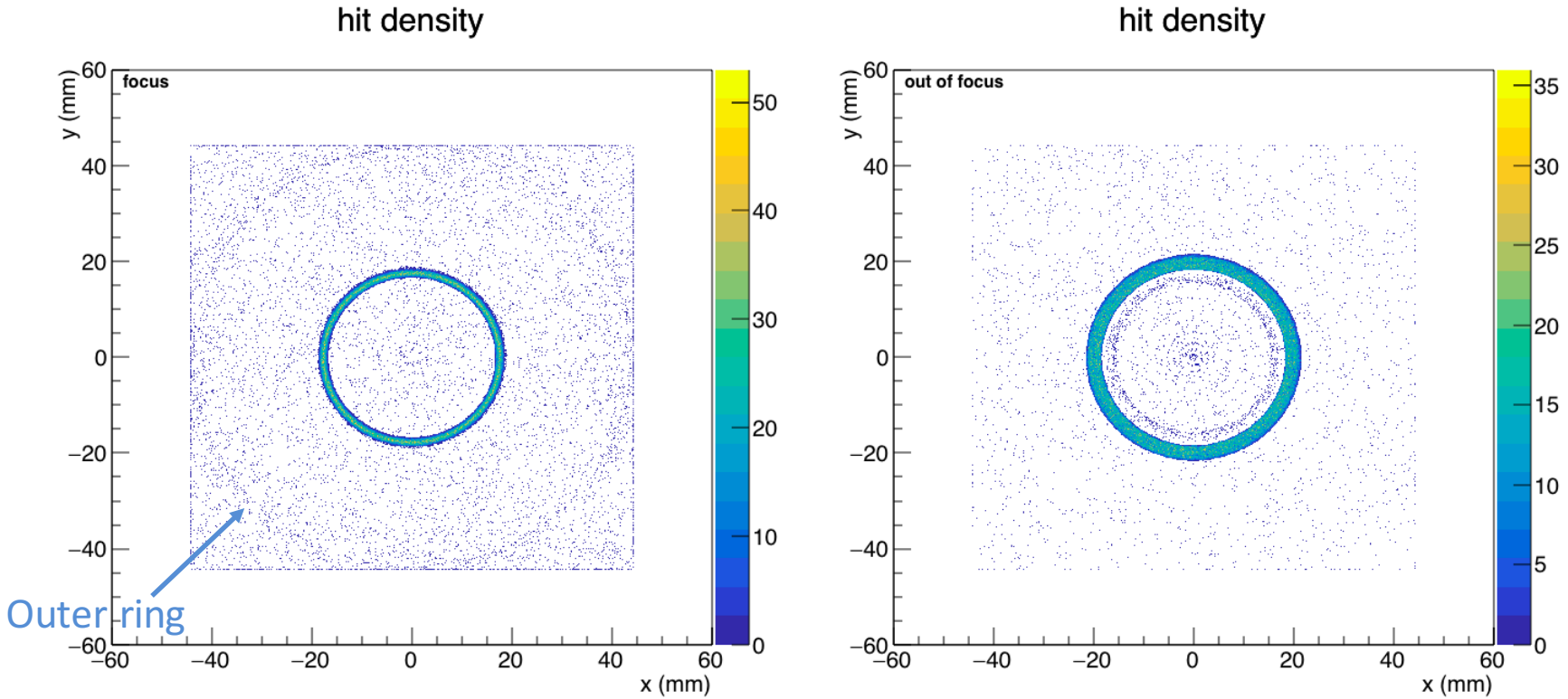
- Stronger background outside the ring in the Focus setting (see next slide)
- Peak shifted to the left
  → smaller ring radius
- Cross section of inner ring is much lower (>100 times) than ring in both setting

Basic & Additional Cuts



- background are comparable inside and outside the ring, in both setting (see slide 24)
- Peak shifted to the left
  → smaller ring radius
- Cross section of inner ring is much lower (>100 times) than ring in both setting

Photon Hit Density
Basic Cut only (Simulation 3)



In “focus” detector setting

- Stronger background outside the ring
- Pattern shown on the background outside the ring
- Thinner/sharper ring (need a quantity ring radius deviation study)

Summary

- In the (more) focus setting
  - Sharper ring
  - Higher level of background outside the ring
  - But blurrier inner/extra rings.
  - Cross section of inner rings are much lower than the outer ring (signal)

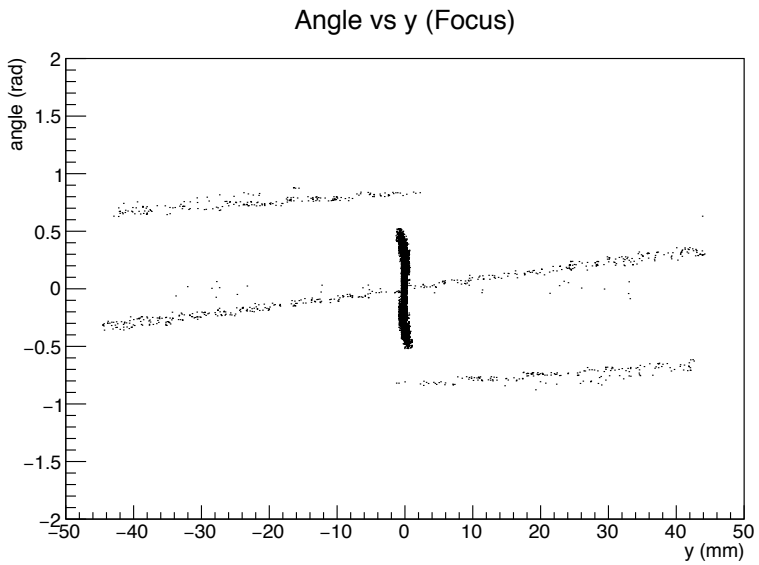
Next

- Fresnel lens profile
  - Groove width
  - Number of grooves
- Ring resolution

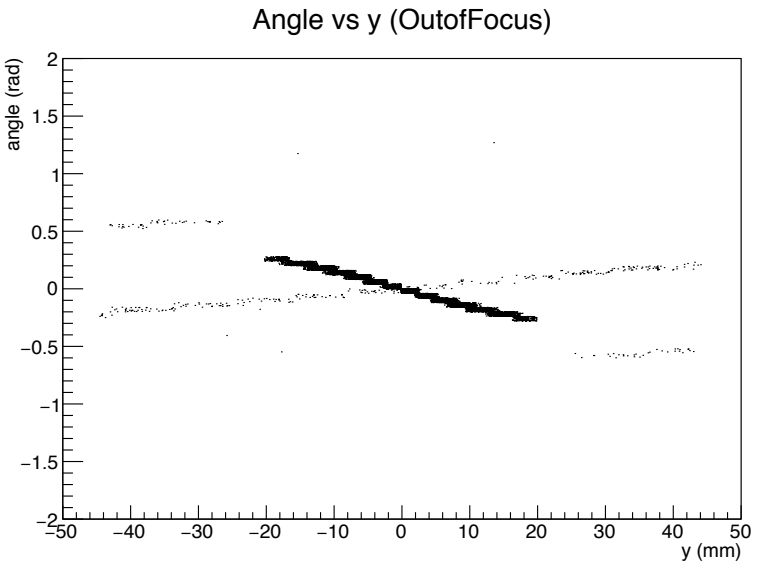
Back Up

Photon Momentum vs y-position at sensor plane (Simulation 2)

Focus

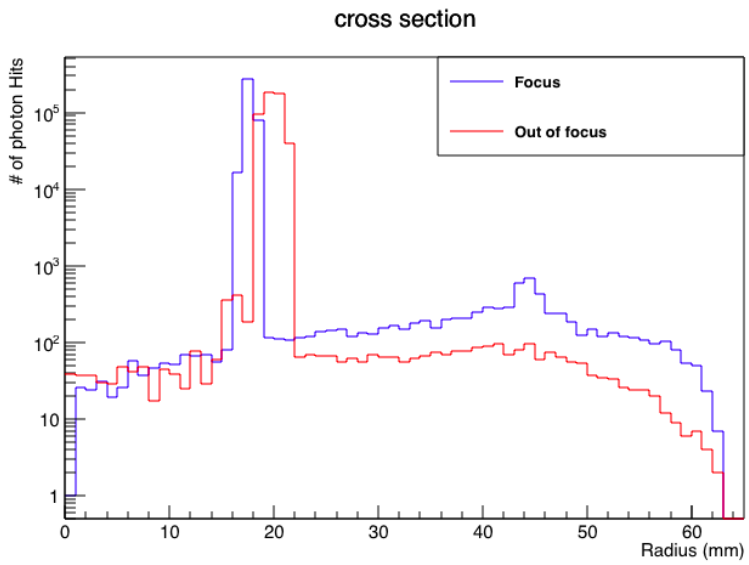


Out of Focus

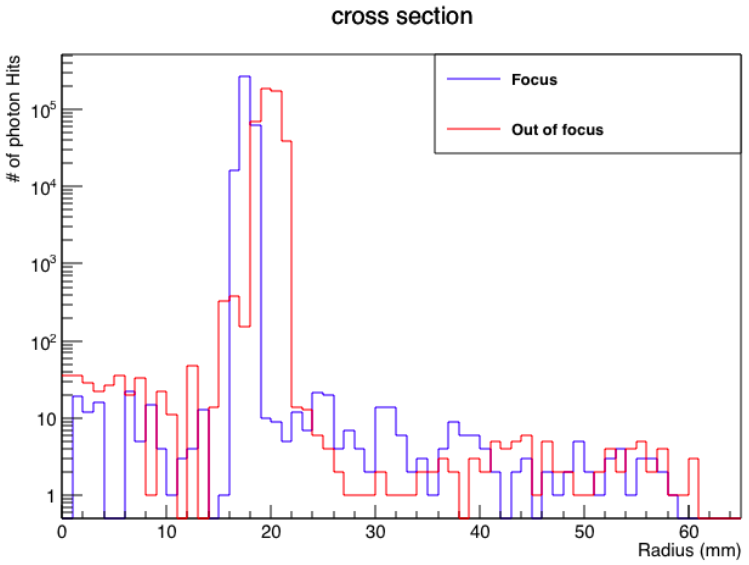


Cross Section (Simulation 3)

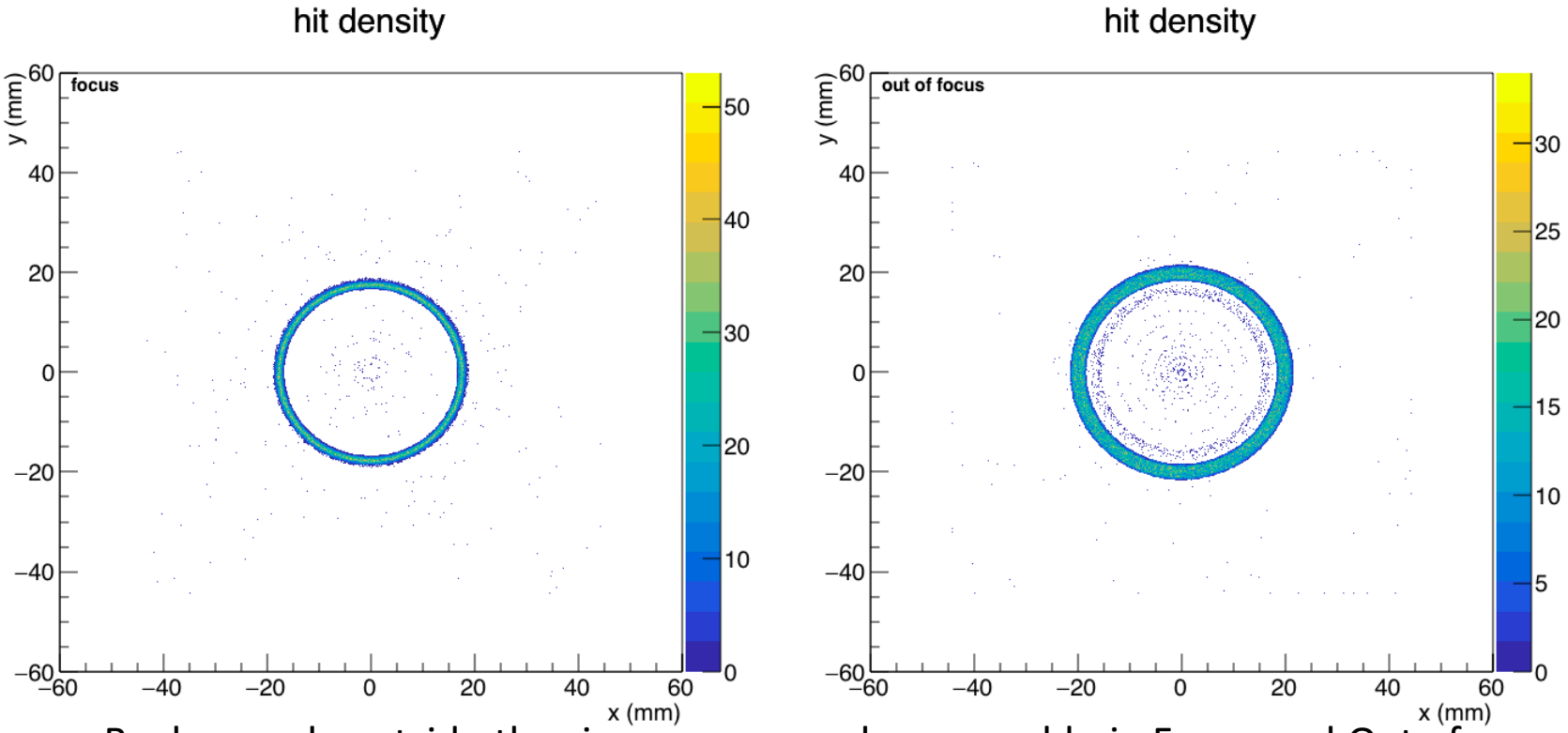
w/ Basic Cuts



w/ Additional Cuts



Photon Hit Density w/ Basic & Additional Cut (Simulation 3)



- Backgrounds outside the ring are rare and comparable in Focus and Out of Focus setting
- Inner rings are clear if Additional cut is applied