Background study with collimators

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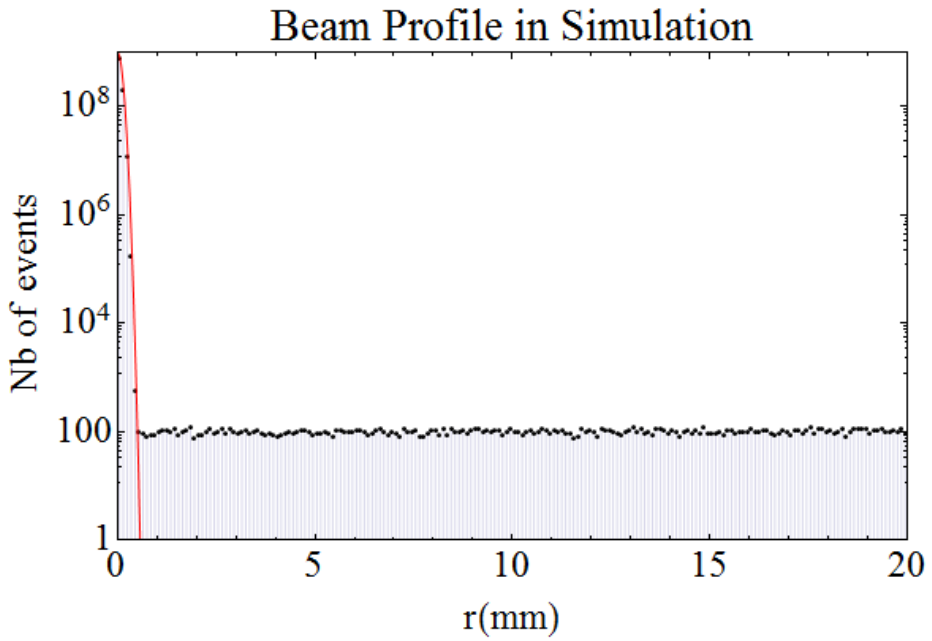
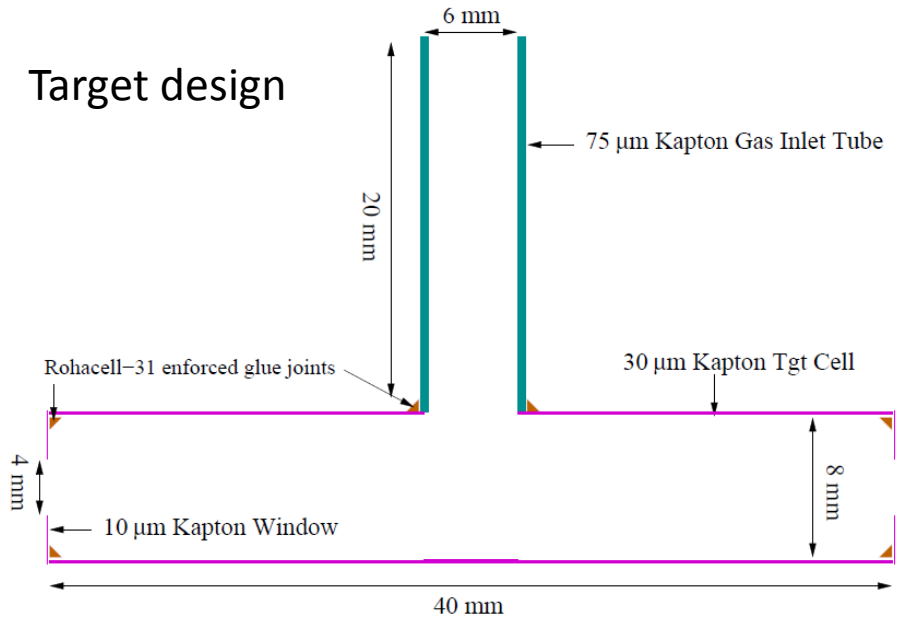
Beam profile and target cell

- Beam halo
  - Beam : Halo = 10^7
  - Halo range: 20 mm
  - Halo energy: the same as the beam energy (1.1 GeV)



Target design

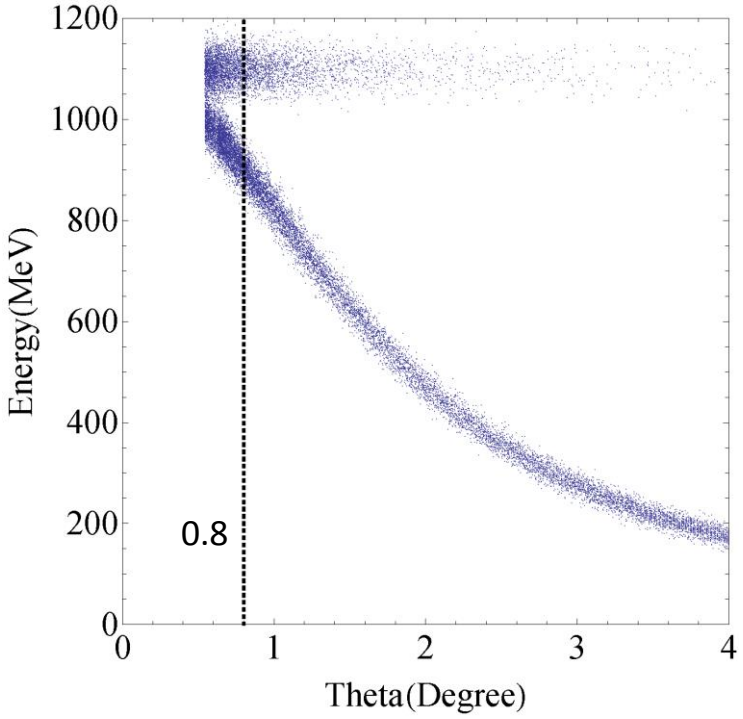


- Target
  - Made of Kapton
  - 8 mm in diameter, the materials are in the range of halo

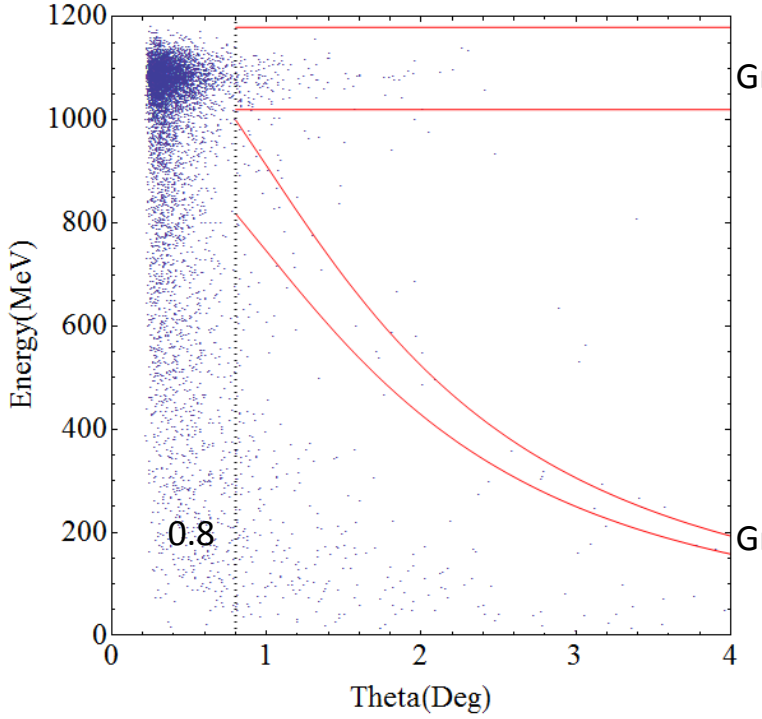
Background

- Halo has the same energy as the beam. Energy resolution 2.6 %/$\sqrt{E}$ included
- If applying the graphical cut as shown in the right plot, the background level is about 14 % for ep and about 2 % for Møller

Hydrogen gas only



Target cell only

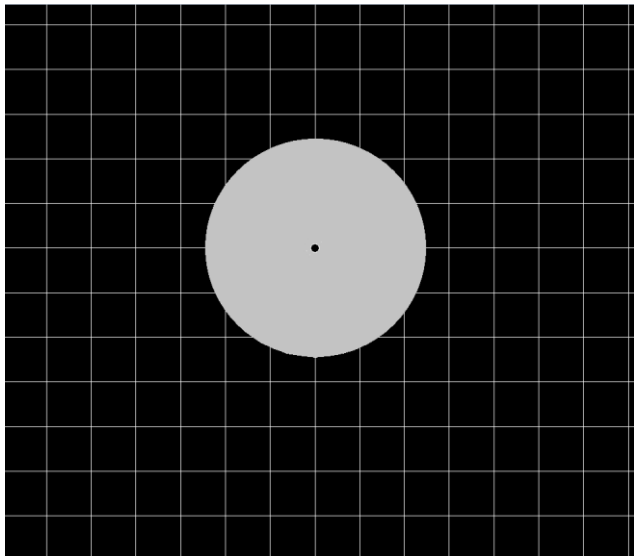


Graphical cut for ep events

Graphical cut for Møller events

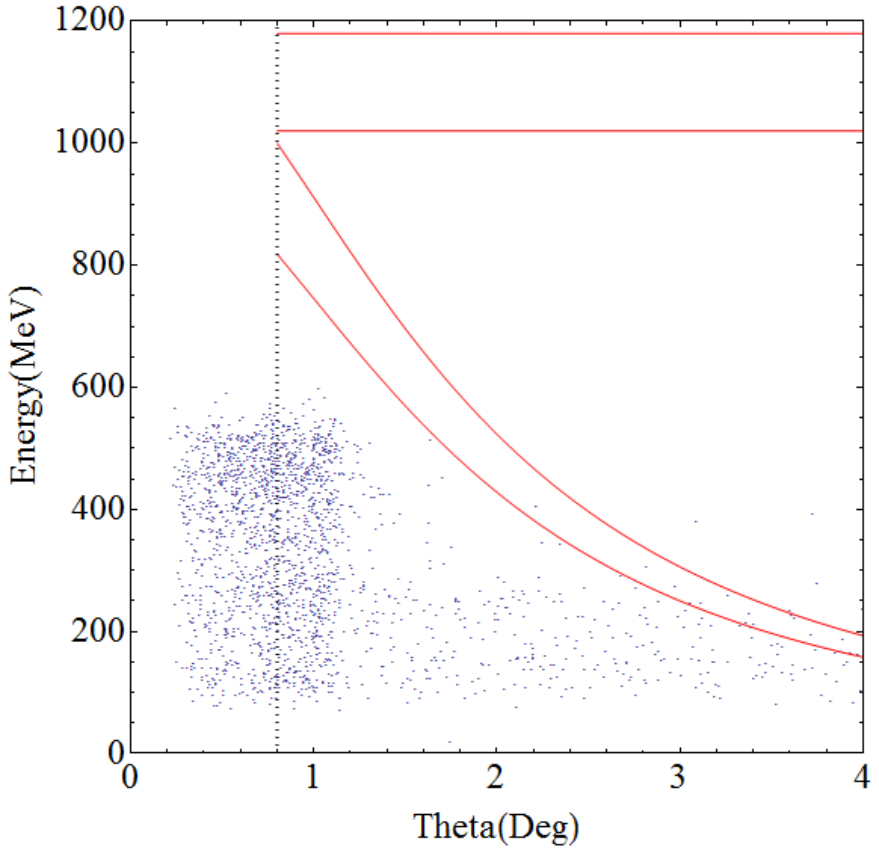
A larger collimator

- Tungsten, tube-like collimator at upstream of the target
  - Inner radius 2 mm, outer radius 50 mm
  - Length 20 cm
- Background is significantly reduced
  - < 0.1 % for ep, about 0.8 % for Møller



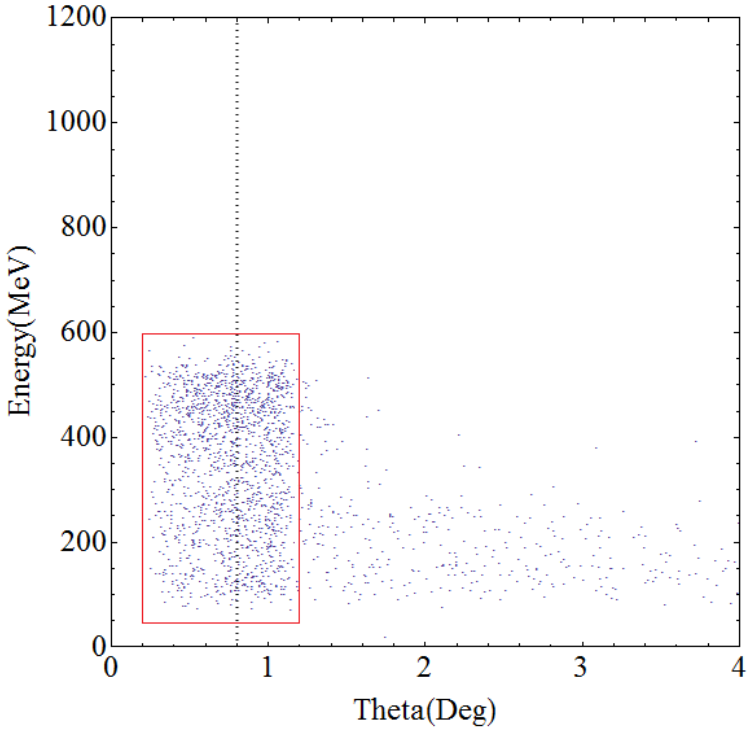
Front view

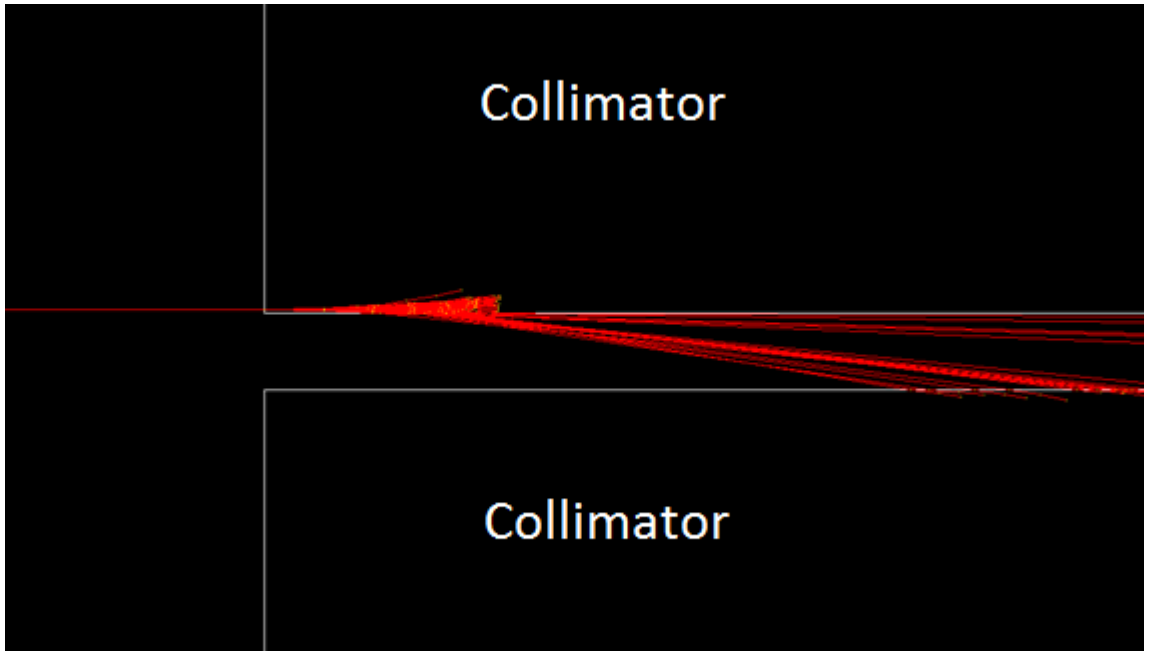
Large collimator + target cell



Background from collimator

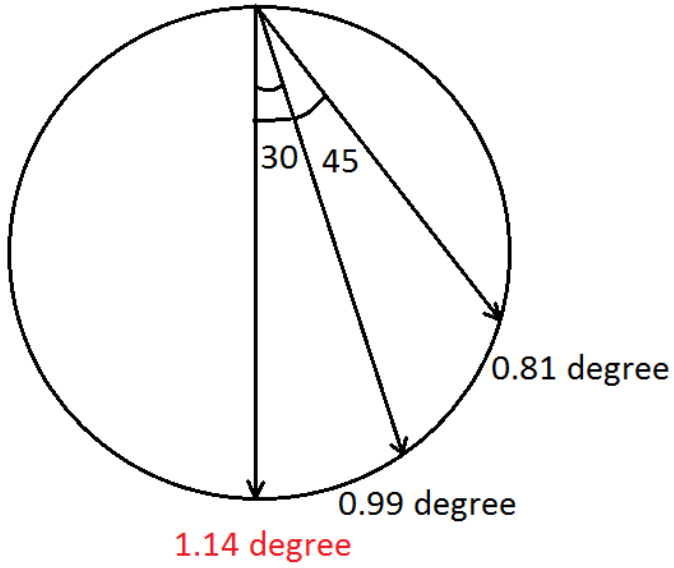
- Most of the high energy events (> 200 Mev) are located in the left bottom corner
- It is caused by “leakage” at the edge of the center hole
- The leaked particles with small angles will pass through the collimator

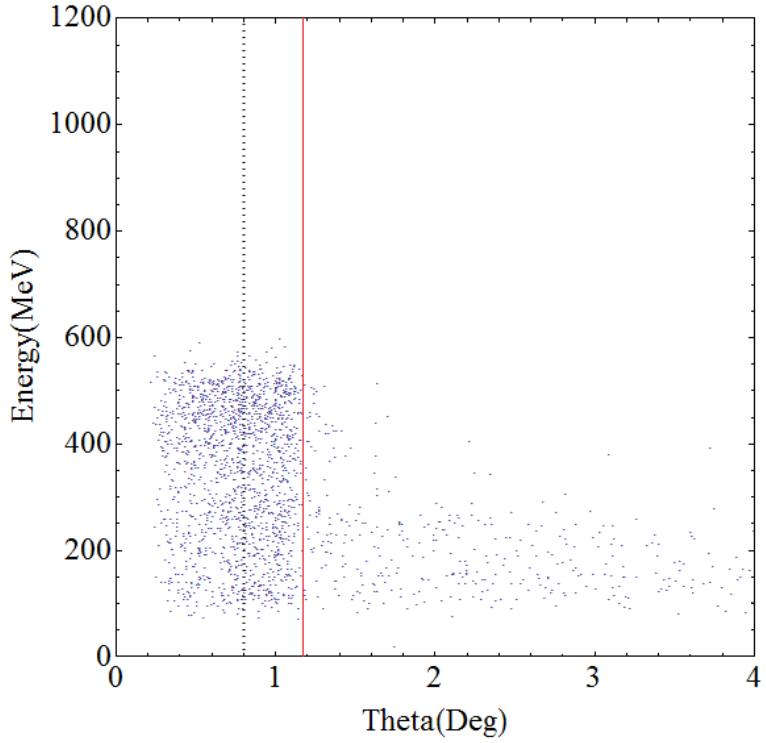




Background from collimator

- High energy leakage is very likely to happen at the beginning (radiation length is 3 mm for tungsten)
- The opening angle is about 0.57 degree, thus the maximum “leaking” angle is about 2*0.57 = 1.14 degree
- Considering the shift due to resolution and reconstruction, the maximum “leaking” angle is slightly different

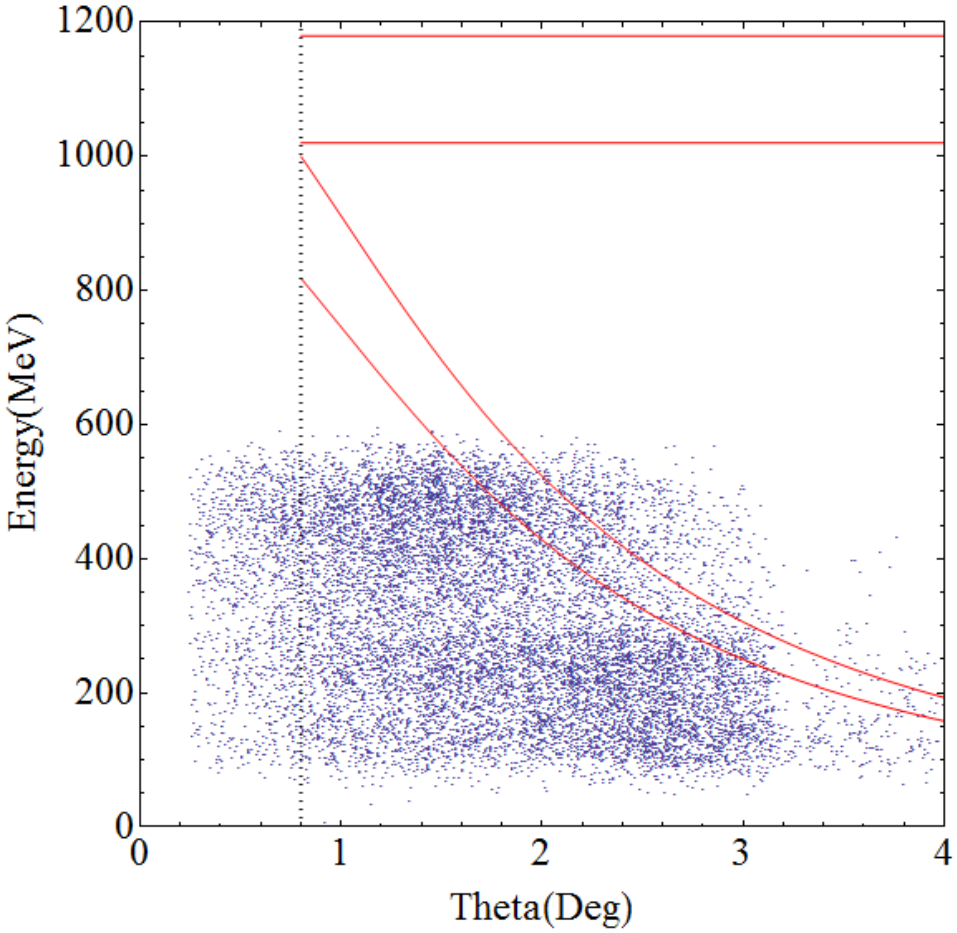




The existing collimator

- 6 mm (diameter) center hole, length is assumed to be 12 cm (> 30 times of radiation length)
- The opening angle is increased from 0.57 degree to about 1.4 degree
- The high energy events distribution is extended to about 3 degree, thus destroys the Møller region

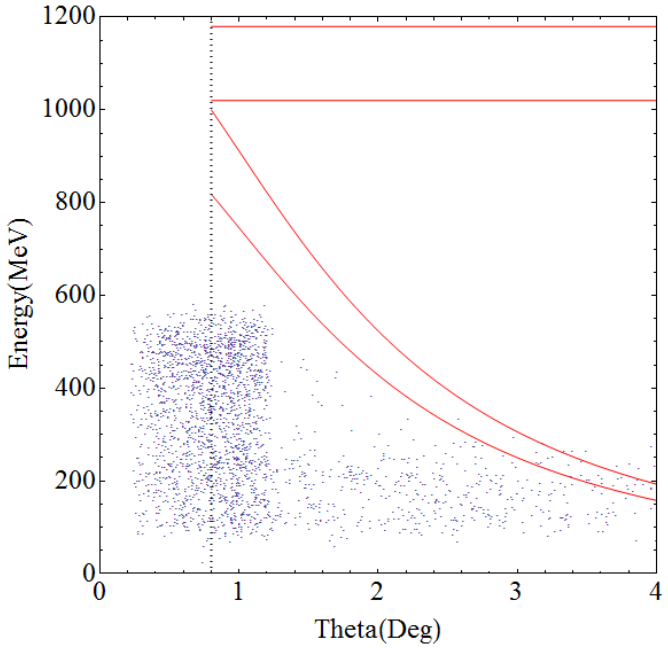
collimator + target cell



Other dimensions for collimators

- Keep the opening angle of 0.57 degree, reduce the outer radius
  - Inner radius: 2 mm, outer radius: 30 mm, Length: 20 cm
- Result is good enough, close to the one with the outer radius of 50 mm

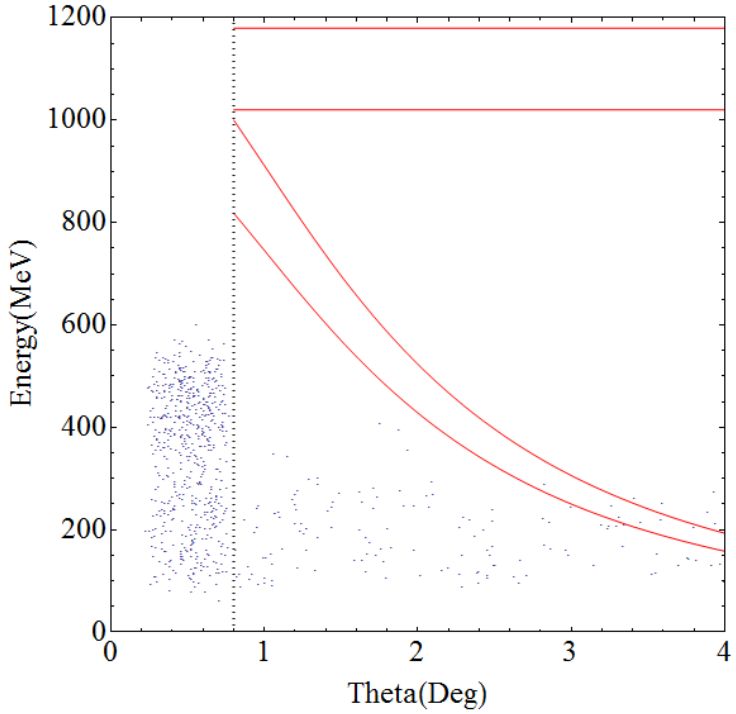
collimator + target cell



Other dimensions for collimators

- Further reduce the opening angle
  - Inner radius: 1.25 mm, outer radius: 30 mm, Length: 20 cm
- Opening angle 0.36 degree, most of the background can be cut by theta > 0.8

collimator + target cell



Summary

- Since our experiment focuses on the very forward angle (> 0.8 degree), the opening angle of the collimator is restricted to be very small

- From simulation, 0.57 degree is good enough, although there will be some leaking events at up to 1.2 degree, they can be cut by a 2D cut of energy and angle.

- The best option would be some collimator with opening angle < 0.4 degree, thus it would not have effect on our data-taking region.
  - But it may introduce practical issues in aligning the beam