# Detector Geometries

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## 1 Different Geometries

There are four major geomitries we will be checking, seen in Figures 1a-1d. The two big variables are whether or not the silicon detectors are in a 45°/135°. and whether the beam counter is inside or outside the chamber.

## 2 Specifications

Throughout this document I use the term valid to mean

- Muon entered beam counter (MuSC)
- Muon did not enter entrance veto (MuSCA)
- Muon did not enter downstream scintillator (MuVeto)

The specifics of the beam and target are

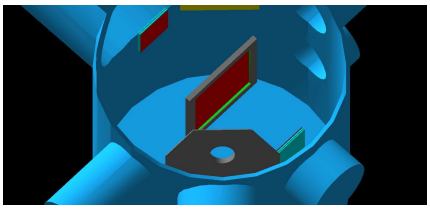
- Target Material: Aluminum
- Target Thickness: 50 $\mu$m
- Beam Momentum: 28.5 MeV/c

## 3 Scattered Muons

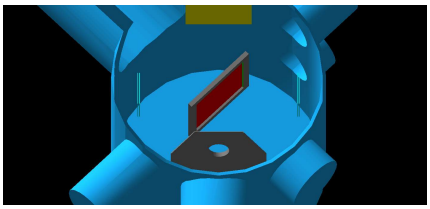
The primary motivation for the different geometries is the effect of muons scattering into the silicon detectors. The numbers can be seen in Table 1.

| Orientation | Processed | Valid | Stopped | Scattered | Scattered/Valid |
|---|---|---|---|---|---|
| 135° Beam Right | $11 \times 10^6$ | 10,530,474 | 1,628,797 | 63 | $3.87 \times 10^{-5}$ |
| 45° Beam Left | $11 \times 10^6$ | 10,530,474 | 1,628,797 | 9176 | $563. \times 10^{-5}$ |
| 90° Beam Right | $14.8 \times 10^6$ | 13,997,538 | 2,498,510 | 128 | $0.914 \times 10^{-5}$ |
| 90° Beam Left | $14.8 \times 10^6$ | 13,997,538 | 2,498,510 | 172 | $1.23 \times 10^{-5}$ |

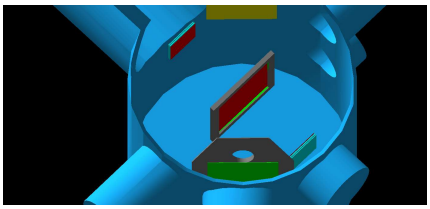
Table 1



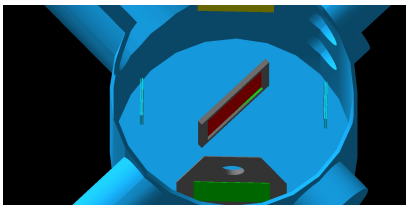
(a) The beam counter is outside the chamber. The beam left silicon detectors are are at a 45° angle to the beam direction, and the beam right silicon detectors are at 135°.



(b) The beam counter is outside of the chamber, with the beam left and beam right silicon detectors both at 90° to the beam direction.



(c) The beam counter is now inside the chamber, and the silicon detectors are back in the 45°/135° orientation.



(d) The beam counter is inside the chamber, and the silicon detector orientation is 90°/90°.

Figure 1: The different chamber geometries. For now we'll mainly stick to the top two (with the beam counter, MuSC, outside the chamber).

# 4 Proton Energy

The proton energy deposited in the silicon detectors changes based on the orientation, and it can be see in Figure 2. Additionally, we hope to measure the full energy of protons produced in the target. Since this isn't necessarily possible, we at least want to maximize the fraction of the proton energy we measure. Seen in Figure 2 is also the fraction of the energy measured in the silicone detectors as a function of the energy of the initial proton.

We can also take a look at the proton transfer functions in Figure 3.

# 5 Electrons After Decay

Decay in orbit electrons will also be a source of noise. So we can look at those in Figure 4.

# 6 Source Code

The cource code has been uploaded to Nam's github, and has several options available in the input/parameters.txt file. The lengths/thicknesses are apparent (ending in T or L). The useful options are

- Deg90: True to orient the silicon detectors at 90° to the beam axis. False for the 45○/135○ orientation.

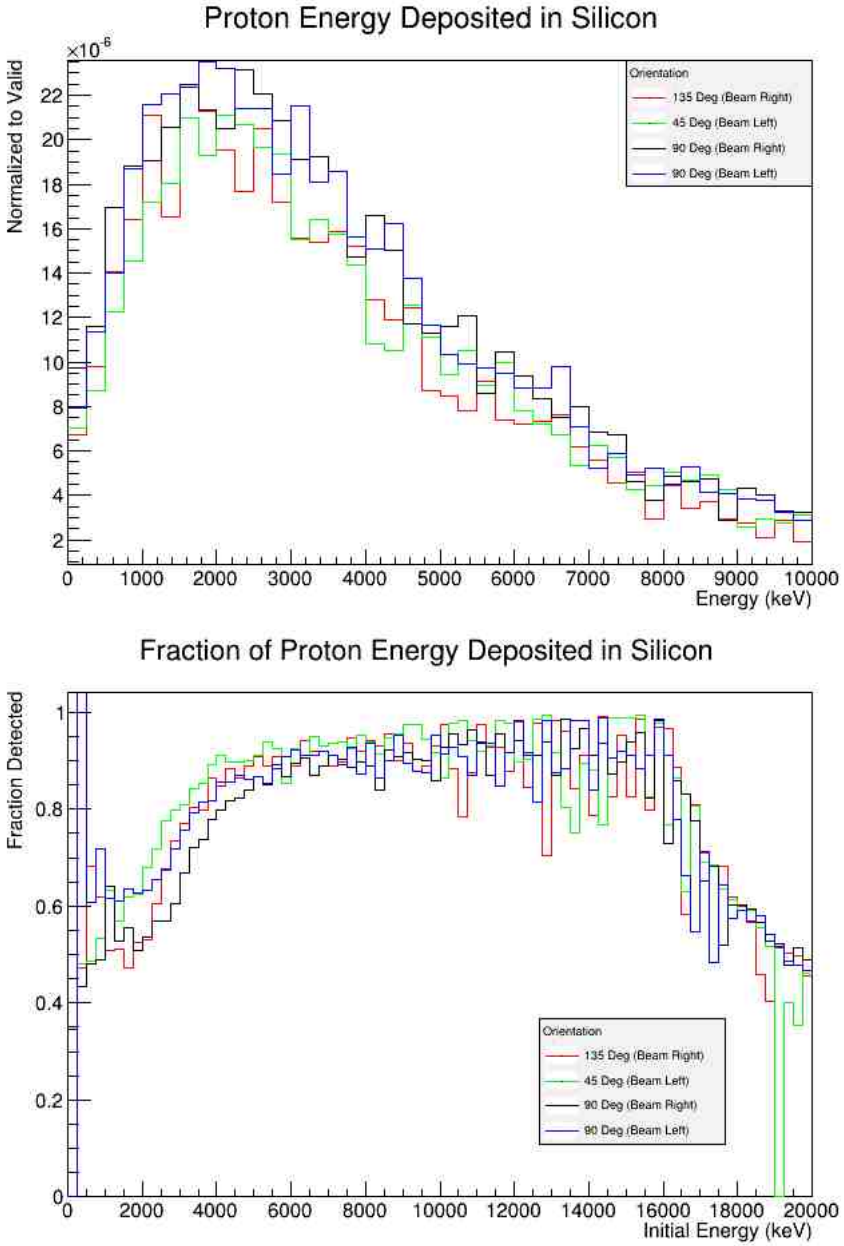



Figure 2: The energy deposited by the protons in the silicon detectors (top) is peaked a little above 2 MeV. The energy fraction (bottom) measured drops off at high initial energy (punch-through) and low intial energy (large fraction of energy deposited in target). There finicky behavior at low energies is a result of protons often not escaping the target at low initial energies. Additionally, it seems that we do not see a whole lot of punch through until 15-16 MeV, as opposed to the 10 MeV we've been assuming so far.

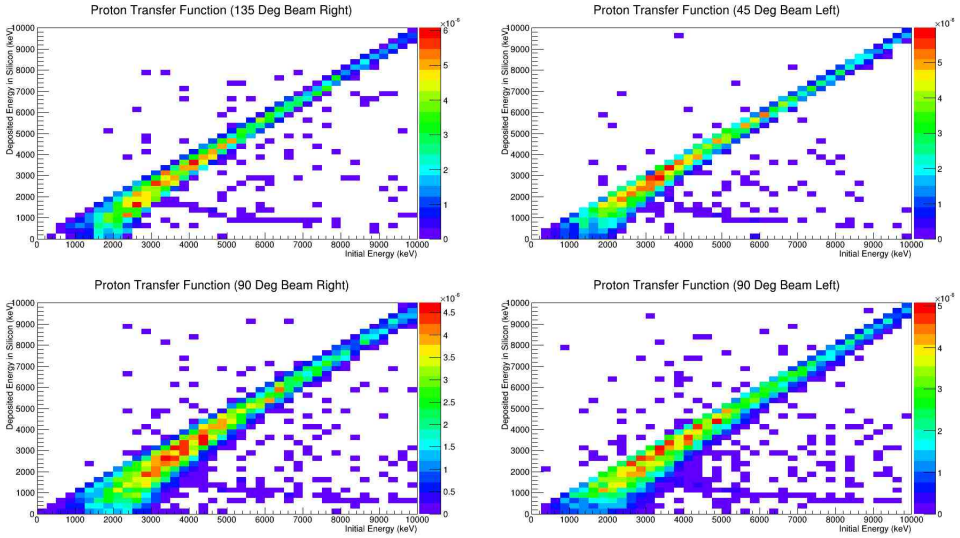



Figure 3: Due to the way we count energy, in that once a proton enters the silicon detectors we consider *all* energy deposited in those detectors as coming from the proton, we have some strange outliers. Otherwise these are in good agreement with 2.

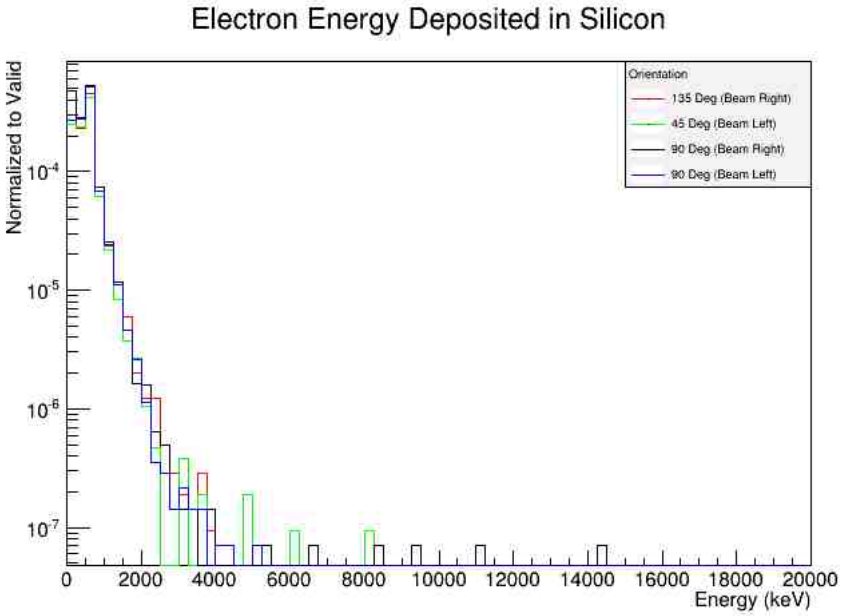



Figure 4: The electron energies deposited in the detector arms after a decay in orbit occurs in the target. All four orientations are shown.

- Target.XX: Material to use for the target. True/False for aluminum (XX=Al), silicon (XX=Si), and titanium (XX=Ti). If multiple are true, then the first that is true in that order is used.
- Muon: True to use muons beam.
- Electron: True to use electron beam. Only checked if Muon is false.
- Turtle: True to use turtle data in input/turtle.root. False to use Gaussian parameters set earlier in parameters.txt.
- MuSCOutside: True to have the beam counter outside the chamber, false to have it inside.
- ProtInTarg: Use a histogram of muon stopping locations in the target (input/MuStopDistribution.root) to generate protons in the target.
- Save.Hits: True to save vector of TTrackerHits. If not going to be used, can be set to False to reduce file size.
- Save.DR: True to save the DetectorResponse vectors. Used in creating pseudo-data and other analysis.