

TECHNICAL NOTE OF RADIATION DOSE AND  
NEUTRON FLUX AT COMET ELECTRONICS

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# Contents

<b>Acknowledgments</b>	<b>2</b>
<b>1 Introduction</b>	<b>5</b>
1.1 Background . . . . .	5
1.2 Electronics involved . . . . .	5
1.3 About this Note . . . . .	6
<b>2 Methodology</b>	<b>7</b>
2.1 Geometry of Simulation . . . . .	7
2.2 Simulation Configuration . . . . .	8
2.2.1 Upstream . . . . .	8
2.2.2 Downstream . . . . .	9
<b>3 CTH</b>	<b>11</b>
3.1 Geometry . . . . .	11
3.2 Radiation Dose . . . . .	12
3.2.1 Radiation Dose Distribution . . . . .	13
3.2.2 Radiation Dose By PID And Their KE Distributions . . . . .	14
3.3 Neutron Flux . . . . .	23
3.3.1 Neutron Flux Distribution . . . . .	23
3.3.2 Neutron KE Distribution . . . . .	25
<b>4 RECBE Boards</b>	<b>27</b>
4.1 Geometry . . . . .	27
4.2 Radiation Dose . . . . .	29
4.2.1 Radiation Dose Distribution . . . . .	29
4.2.2 Radiation Dose By PID And Their KE Distribution . . . . .	31
4.3 Neutron Flux . . . . .	43
4.3.1 Neutron Flux Distribution . . . . .	43
4.3.2 Neutron KE Distribution . . . . .	45

---

<b>5</b>	<b>CyDet Electronics Room</b>	<b>48</b>
5.1	Geometry . . . . .	48
5.2	Shield . . . . .	50
5.2.1	Radiation Dose Distribution . . . . .	51
5.2.2	Radiation Dose By PID And Their KE Distributions . . . . .	53
5.3	InnerBox . . . . .	56
5.4	SimpleBoards . . . . .	59
5.4.1	Radiation Dose Distribution . . . . .	60
5.4.2	Radiation Dose By PID And Their KE Distributions . . . . .	63
<b>6</b>	<b>Electronics Hut</b>	<b>69</b>
6.1	Geometry . . . . .	69
6.2	Radiation Dose . . . . .	70
6.2.1	Radiation Dose Distribution . . . . .	70
6.2.2	Radiation Dose By PID And Their KE Distribution . . . . .	71
6.3	Neutron Flux . . . . .	73
	<b>Final Words</b>	<b>75</b>

# 1

## Introduction

### Contents

---

1.1 Background . . . . .	5
1.2 Electronics involved . . . . .	5
1.3 About this Note . . . . .	6

---

### 1.1 Background

Simulations are conducted using ICEDUST to investigate the radiation dose and neutron flux arriving at certain electronics. This will potentially help with the radiation damage analysis, which therefore aids in the evaluation of necessary protection means for electronics.

### 1.2 Electronics involved

The investigation was focused mainly on the following objects:

1. CTH detectors
2. RECBE boards
3. A box located at the end of CyDet that contains electronics
4. The electronics hut located at the corner of the experiment hall

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The radiation dose and neutron flux for each of these objects are evaluated.

### 1.3 About this Note

This note serves as a reference for future hardware development of COMET Phase-I. Please note that the information provided in this document may lack accuracy because of the relatively short project duration.

All the analysis macro files and analysis results can be found at:

`/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Segment_RECBE`

and

`/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Monitor_RECBE`

Two folders only differ in whether the downstream simulation was ran with segment or monitor type RECBE boards.

It is encouraged to double-check any concerns by re-operating the simulation and analysis then compare with this document.

# 2

## Methodology

### Contents

---

<b>2.1 Geometry of Simulation</b> . . . . .	<b>7</b>
<b>2.2 Simulation Configuration</b> . . . . .	<b>8</b>
2.2.1 Upstream . . . . .	8
2.2.2 Downstream . . . . .	9

---

### 2.1 Geometry of Simulation

The geometry used in the investigation is developed based on *Master* branch of *ICEDUST\_packages* on 16th July 2024. The relevant package is uploaded to:

`https://gitlab.in2p3.fr/lai.gui21/ICEDUST\_packages/-/tree/master20240716`

The main differences are the newly added geometries of the CyDet Electronics Room and the wall of Electronics Hut, as shown in Fig. 2.1.

The details of each geometry and their Hit Container properties will be explained in their corresponding chapters.

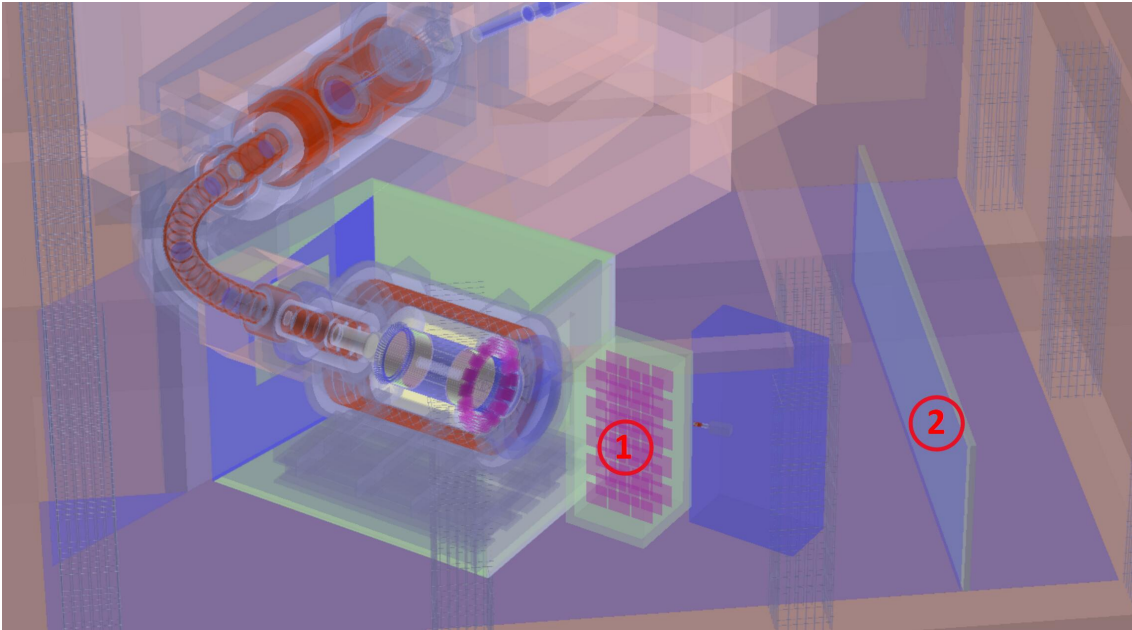


Figure 2.1: Number 1: CyDet Electronics Room, a  $1.5 \times 1.5 \times 3 \text{ m}^3$  Polyethylene box with 10 cm thickness, located at the end of the CyDet; number 2: Electronics Hut wall, a  $10 \times 0.1 \times 2.75 \text{ m}^3$  Polyethylene block located at the end of the experiment hall.

## 2.2 Simulation Configuration

In the investigation, both upstream and downstream simulations are performed using MC6 configurations. The details will be given in the following sections.

Due to the limitation of task processing time (3 hours) on KEKcc, about 30,000 upstream tasks of 5000 POTs were performed. Due to the maximum file size limit (100 GB), the analyser was only able to extract information from about 16,000 files. Therefore, the following analysis will be made based on about  $8e7$  POT events in total (notice: for a 3.2 kW beam of 8 GeV protons, there will be  $2.5e12$  POTs per second).

### 2.2.1 Upstream

Fieldmap: 220304\_COMET\_Phase-I\_Opera\_MTSFineMesh\_15Regions

input file: 20211108\_ProtonBeamHistogram.root

world: Phase-I-Sampling

primary\_mode = RooTrackHist

```
primary_particle = proton
```

```
traj_saveall = False
```

```
traj_hit saveNthPoint = 1
```

```
fake_geantino = False
```

```
init_rootracker = True
```

Notice that when running upstream simulation, in the geometry macro file:

```
/icedust/ICEDUST_packages/SimG4/geometry_macros/ExperimentHall.macro
```

the last line:

```
/control/execute geometry_macros/ElecHut.macro
```

needs to be commented out for a stable upstream simulation (please turn it back on for downstream simulation).

### 2.2.2 Downstream

Fieldmap: 220304\_COMET\_Phase-I\_Opera\_MTSFineMesh\_15Regions

input file: .rootracker files from upstream simulation

world: Phase-I-CyDet

```
primary_mode = rootracker
```

```
rootracker_tree = RooTrackerTree
```

```
rootracker_source = SimG4
```

```
traj_saveall = True
```

```
traj_default_saveNthPoint = 1
```

```
custom_prebeam =
```

```
/generator/kinematics/rooTracker/persistIDs true
```

```
/db/set/trajectoryBoundary .*CDCGasVolume.*
```

Please turn on the last line of *ExperimentHall.macro* (as mentioned above in Upstream section) for downstream simulation.

# 3

## CTH

### Contents

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<b>3.1 Geometry</b> . . . . .	<b>11</b>
<b>3.2 Radiation Dose</b> . . . . .	<b>12</b>
3.2.1 Radiation Dose Distribution . . . . .	13
3.2.2 Radiation Dose By PID And Their KE Distributions . . . . .	14
<b>3.3 Neutron Flux</b> . . . . .	<b>23</b>
3.3.1 Neutron Flux Distribution . . . . .	23
3.3.2 Neutron KE Distribution . . . . .	25

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## 3.1 Geometry

The CTH detectors are located at both ends of CDC, as shown in Fig. 3.1. They are composed of two layers of scintillators, as shown in Fig. 3.2. The inner layer comprises 64 scintillators of size  $368 \times 80 \times 5 \text{ mm}^3$  and mass  $0.150586 \text{ kg}$ , while the outer layer comprises 64 scintillators of  $340 \times 88 \times 10 \text{ mm}^3$  and mass  $0.306082 \text{ kg}$ .

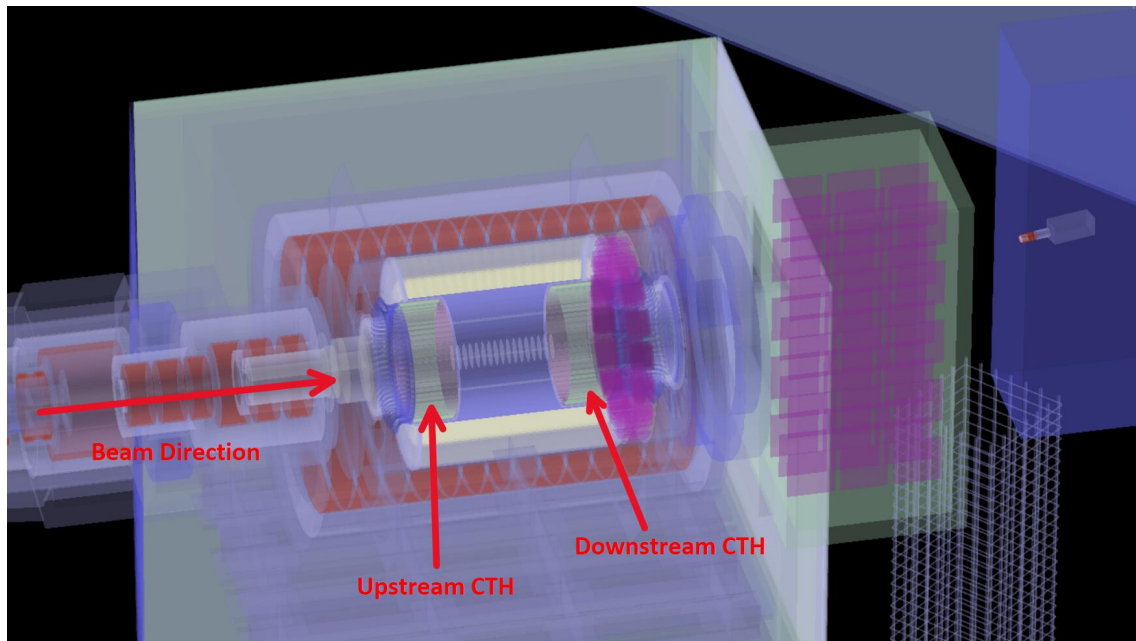


Figure 3.1: CTH detectors can be classified as upstream or downstream based on their location.

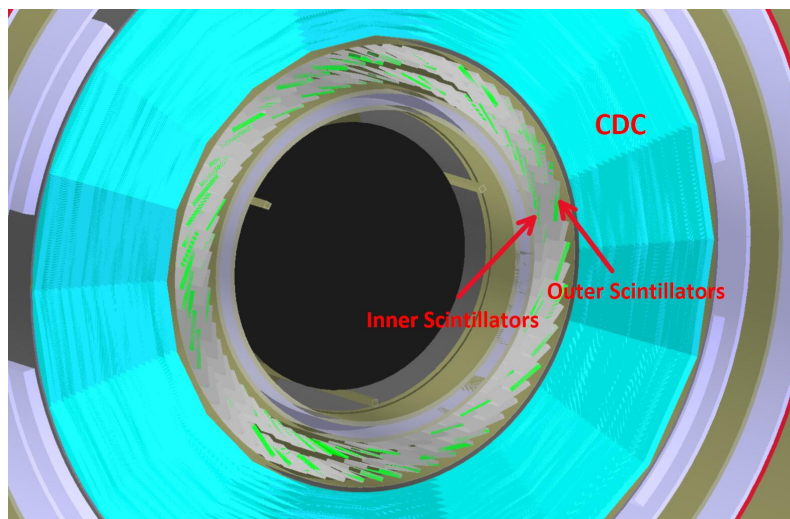


Figure 3.2: CTH detectors have inner and outer layers. Inner layer: 64 scintillators of size  $368 \times 80 \times 5 \text{ mm}^3$  and mass  $0.150586 \text{ kg}$ ; outer layer: 64 scintillators of  $340 \times 88 \times 10 \text{ mm}^3$  and mass  $0.306082 \text{ kg}$ .

## 3.2 Radiation Dose

Over 150 days, the average radiation dose received by scintillators of different parts:

CTH inner upstream:  $15.64 \pm 0.06$  Gy

CTH inner downstream:  $25.7 \pm 0.1$  Gy

CTH outer upstream:  $13.72 \pm 0.04$  Gy

CTH outer downstream:  $23.82 \pm 0.07$  Gy

### 3.2.1 Radiation Dose Distribution

Fig. 3.3, 3.4, 3.5, 3.6 show the distribution of the radiation dose at upstream/downstream inner/outer scintillators respectively, where the phi axis represents the angle on the y-z plane centred at  $(y, z) = (0, 7650)$  (beam direction).

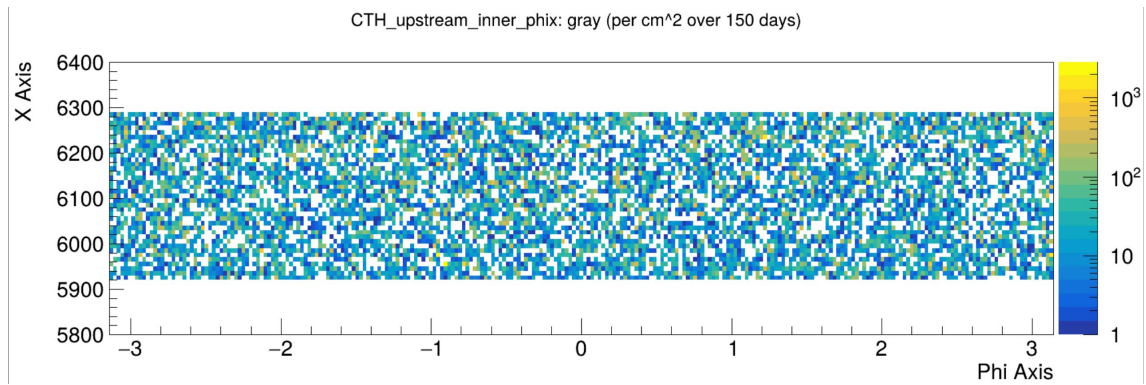


Figure 3.3: Radiation dose per cm<sup>2</sup> over 150 days for CTH upstream inner scintillators on the X-Phi plane.

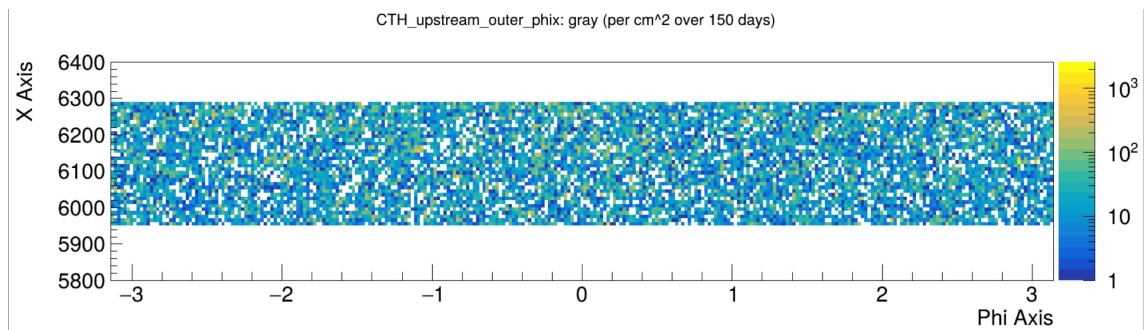


Figure 3.4: Radiation dose per cm<sup>2</sup> over 150 days for CTH upstream outer scintillators on the X-Phi plane.

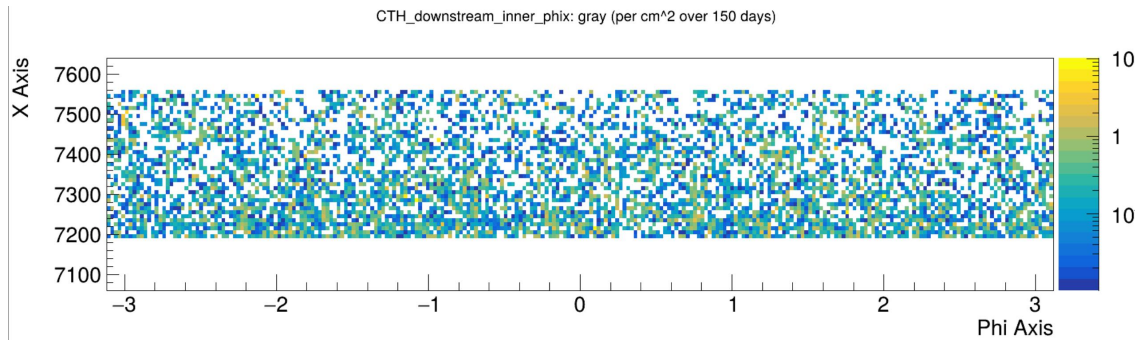


Figure 3.5: Radiation dose per cm<sup>2</sup> over 150 days for CTH downstream inner scintillators on the X-Phi plane.

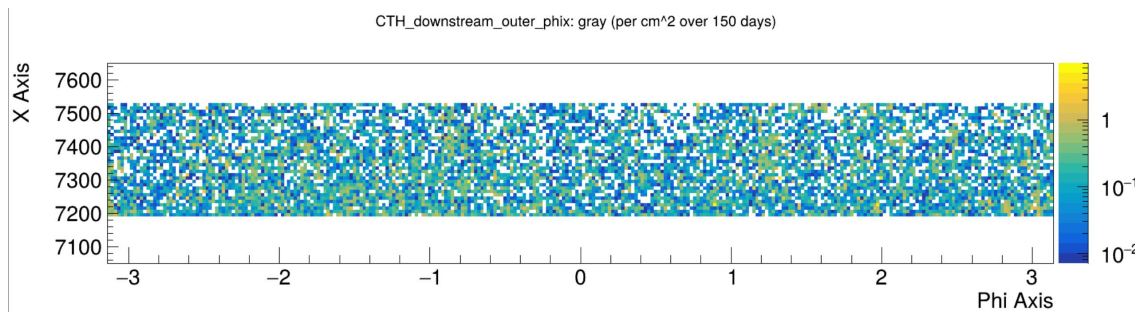


Figure 3.6: Radiation dose per cm<sup>2</sup> over 150 days for CTH downstream outer scintillators on the X-Phi plane.

The radiation dose appears evenly distributed in both x and phi directions for upstream scintillators while being more focused for lower x values for downstream scintillators.

### 3.2.2 Radiation Dose By PID And Their KE Distributions

The accumulated dose for all particles will be shown, however the KE distributions will only be presented for e-, gamma and proton here. For other particles, the histograms can be found on KEKcc at

`/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Segment_RECBE/output_hist_1.root`

**Upstream Inner**

Below are the radiation doses by PID, KE distributions of e-, gamma and proton for upstream inner scintillators.

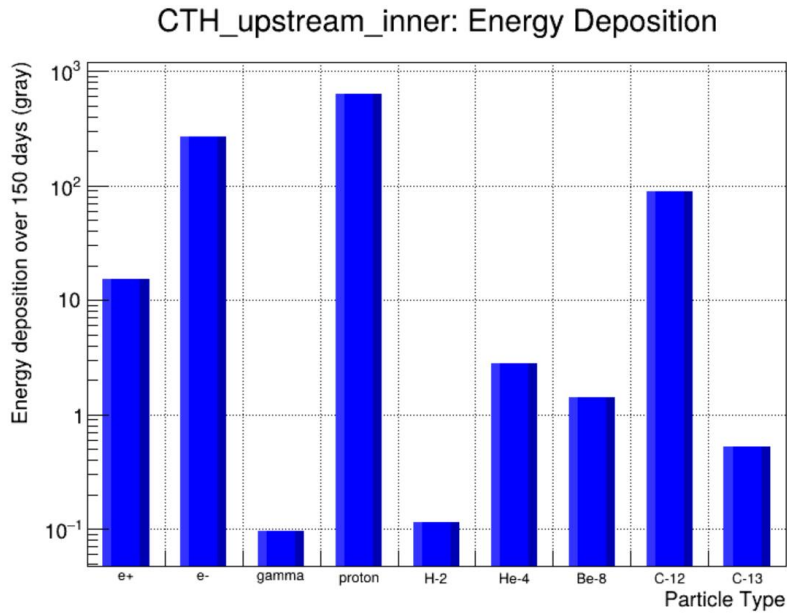


Figure 3.7: Radiation dose of CTH upstream inner scintillators by PID.

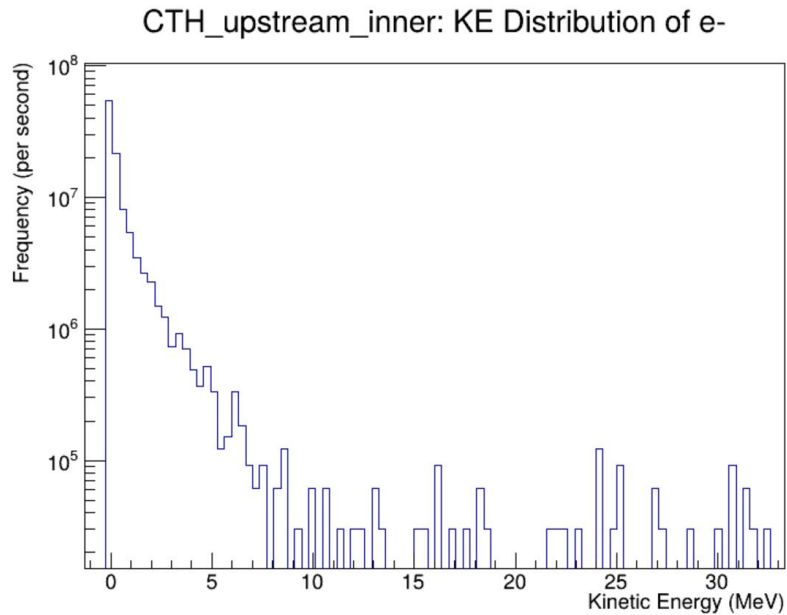


Figure 3.8: KE distribution of e- that CTH upstream inner scintillators encounter.

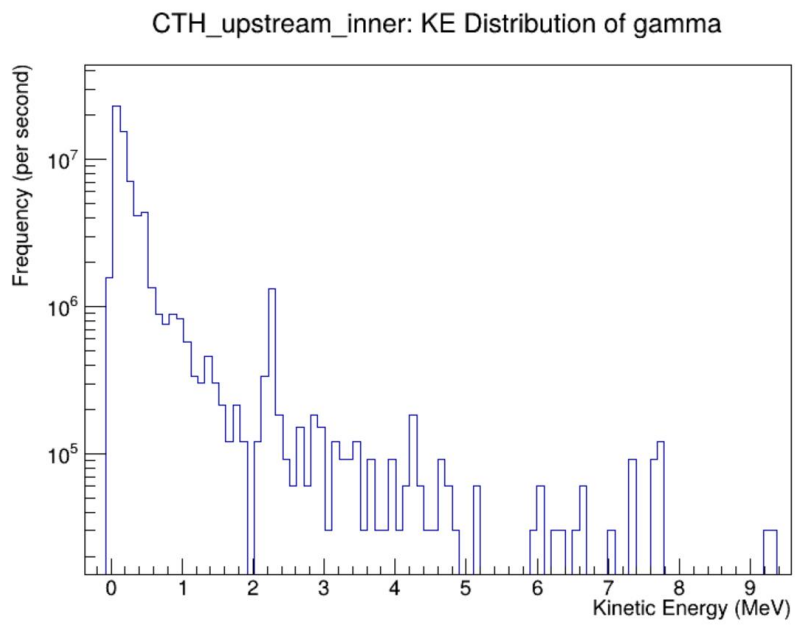


Figure 3.9: KE distribution of gamma that CTH upstream inner scintillators encounter.

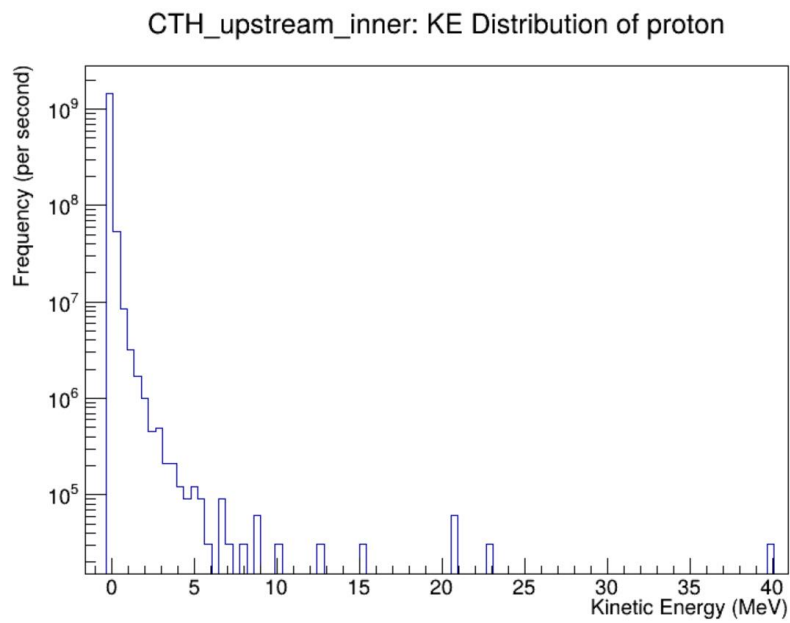


Figure 3.10: KE distribution of proton that CTH upstream inner scintillators encounter.

**Upstream Outer**

Below are the radiation doses by PID, KE distributions of e-, gamma and proton for upstream outer scintillators.

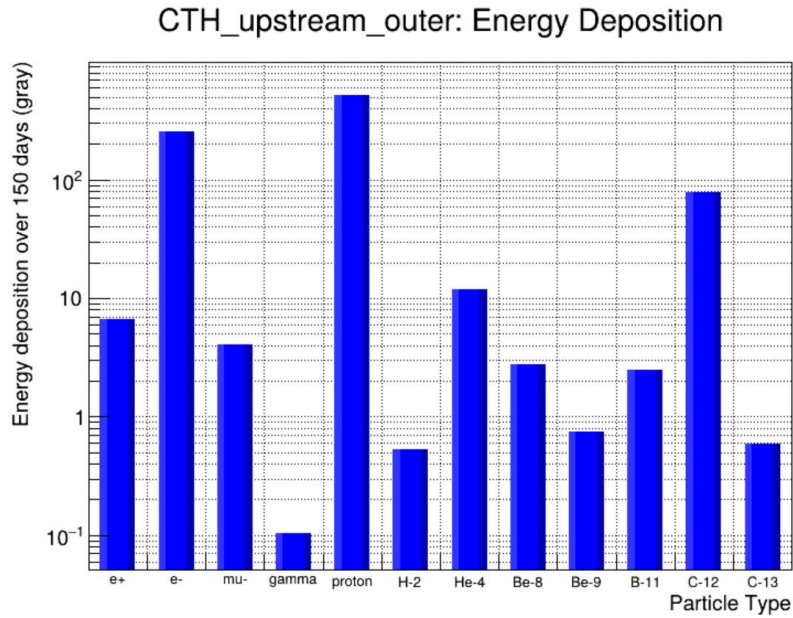


Figure 3.11: Radiation dose of CTH upstream outer scintillators by PID.

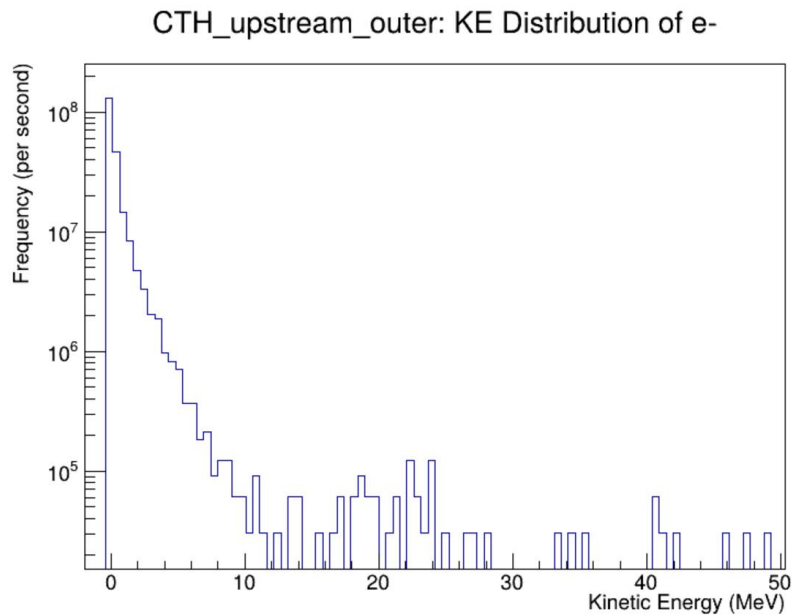


Figure 3.12: KE distribution of e- that CTH upstream outer scintillators encounter.

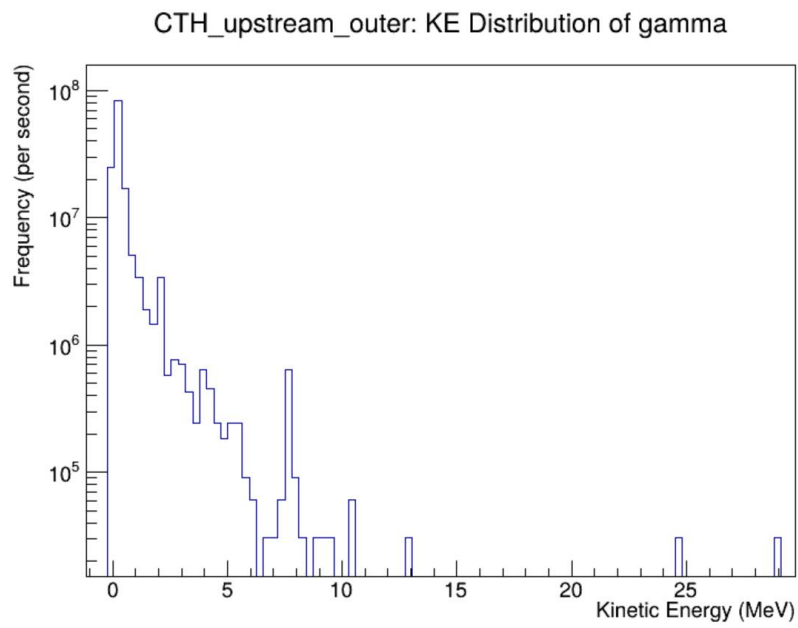


Figure 3.13: KE distribution of gamma that CTH upstream outer scintillators encounter.

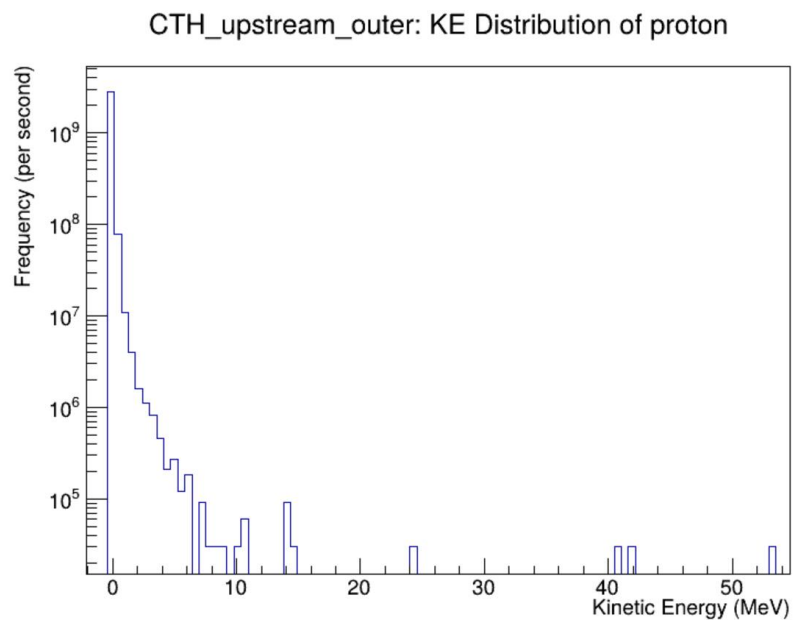


Figure 3.14: KE distribution of proton that CTH upstream outer scintillators encounter.

### Downstream Inner

Below are the radiation doses by PID, KE distributions of e-, gamma and proton for downstream inner scintillators.

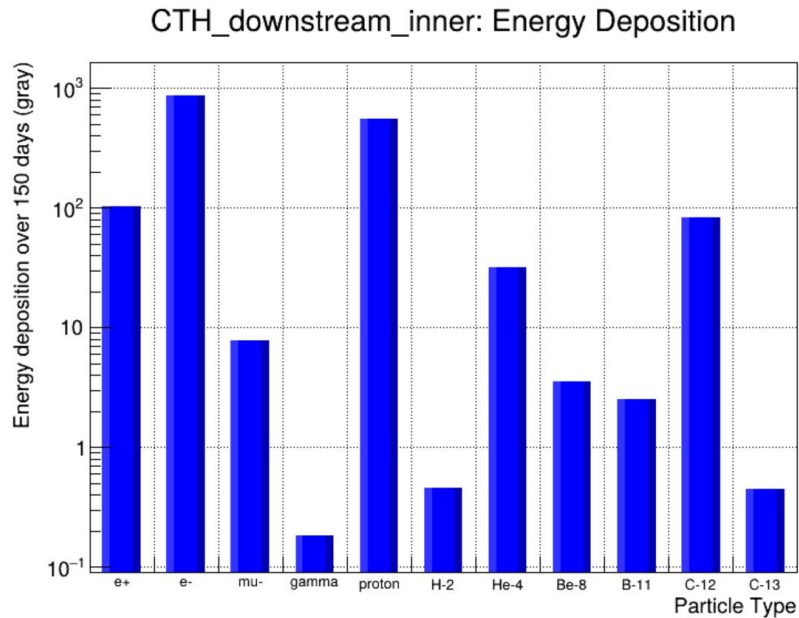


Figure 3.15: Radiation dose of CTH downstream inner scintillators by PID.

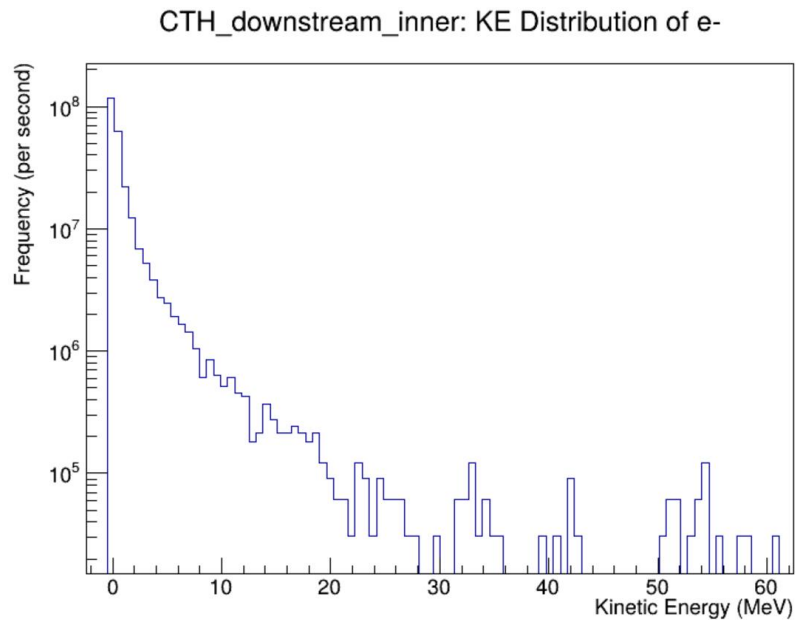


Figure 3.16: KE distribution of e- that CTH downstream inner scintillators encounter.

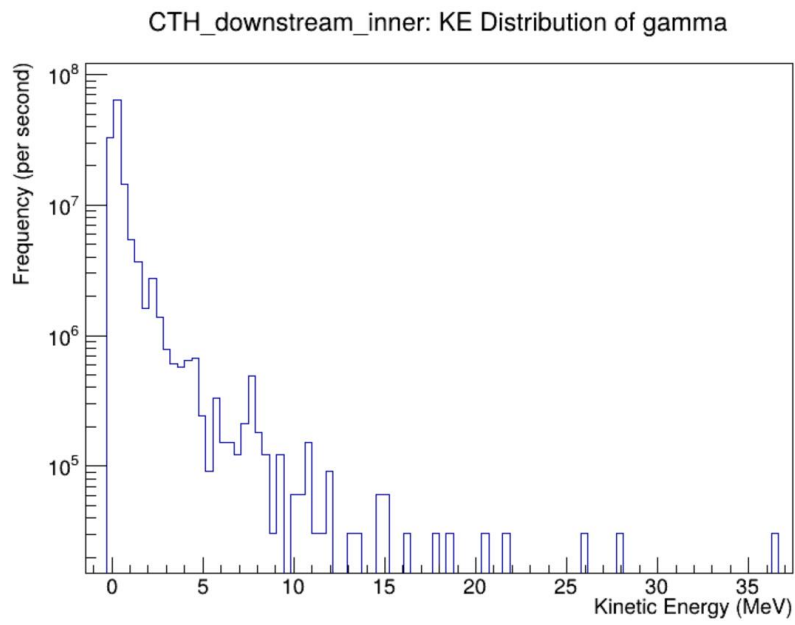


Figure 3.17: KE distribution of gamma that CTH downstream inner scintillators encounter.

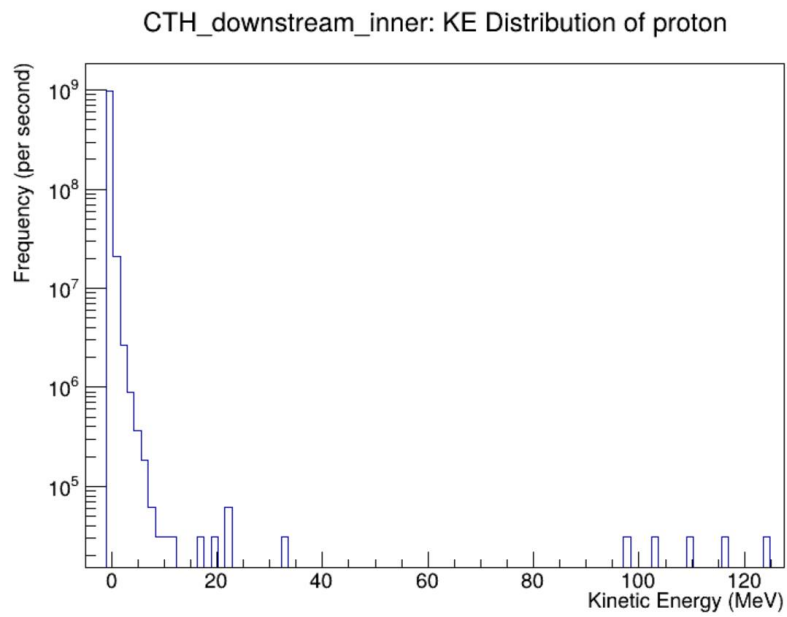


Figure 3.18: KE distribution of proton that CTH downstream inner scintillators encounter.

### Downstream Outer

Below are the radiation doses by PID, KE distributions of e<sup>-</sup>, gamma and proton for downstream outer scintillators.

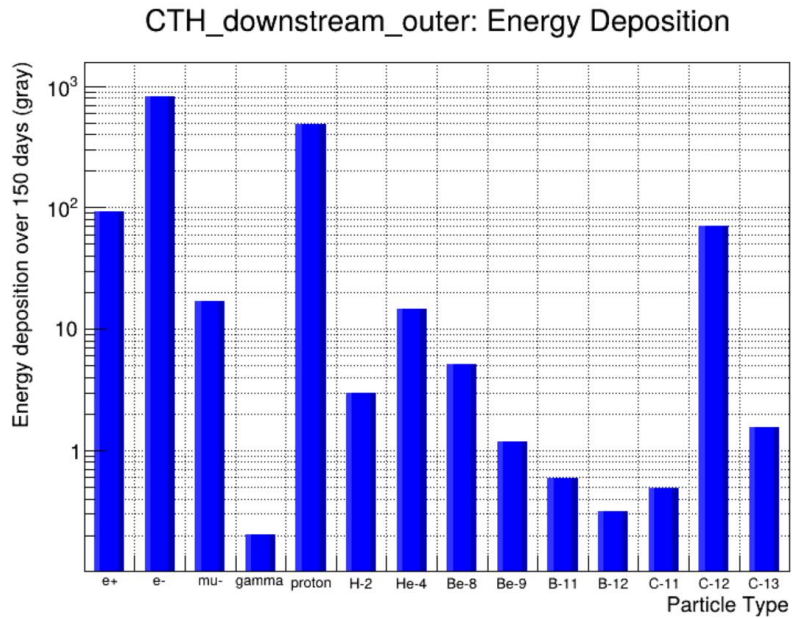


Figure 3.19: Radiation dose of CTH downstream outer scintillators by PID.

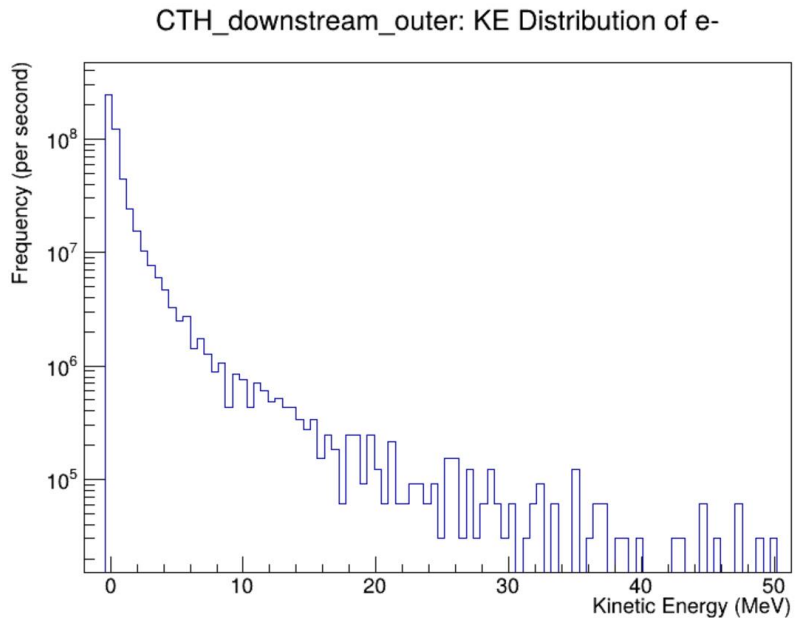


Figure 3.20: KE distribution of e<sup>-</sup> that CTH downstream outer scintillators encounter.

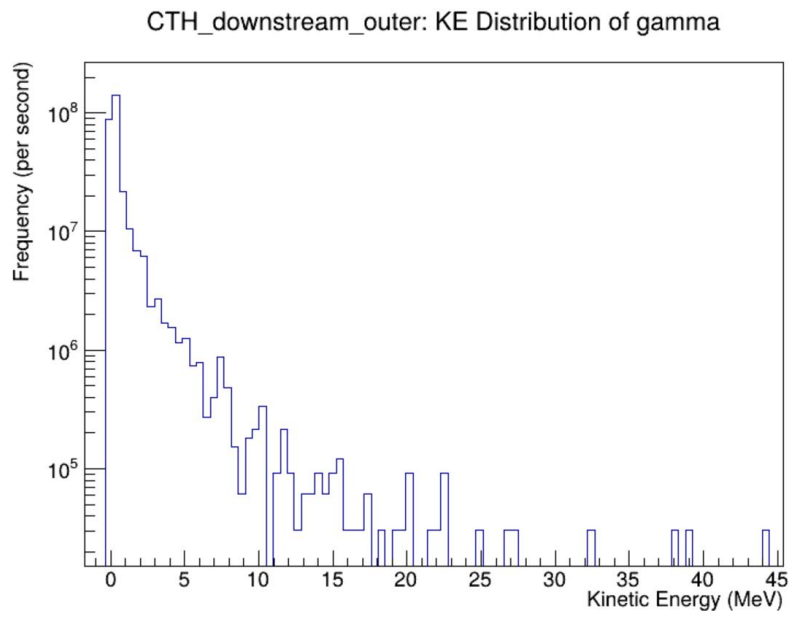


Figure 3.21: KE distribution of gamma that CTH downstream outer scintillators encounter.

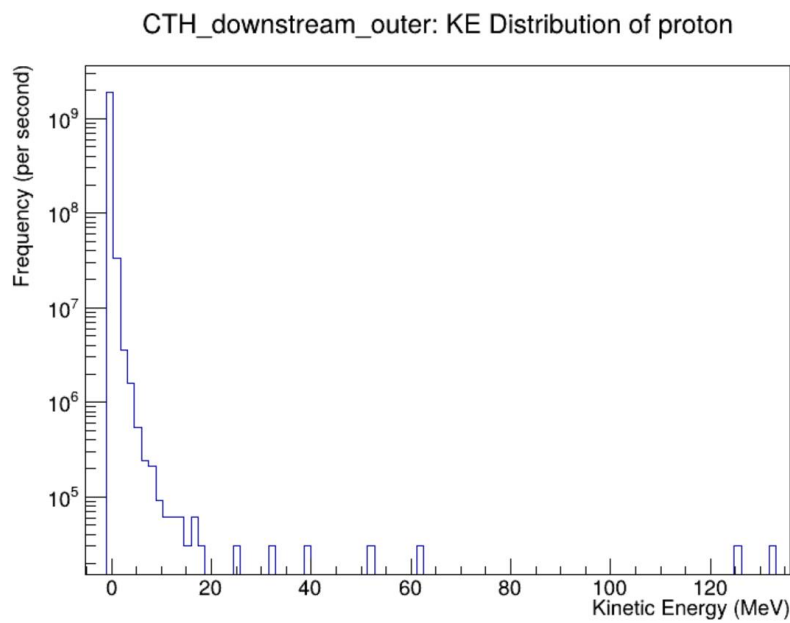


Figure 3.22: KE distribution of proton that CTH downstream outer scintillators encounter.

### 3.3 Neutron Flux

The neutron flux is measured using the monitor type HitContainer named CTHSupport. Over 150 days, the neutron flux at each component is approximately:

Downstream outer:  $6.43\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

Downstream inner:  $6.58\text{e}+11 \pm 4\text{e}+09$  per  $\text{cm}^2$

Upstream outer:  $9.86\text{e}+11 \pm 6\text{e}+09$  per  $\text{cm}^2$

Upstream inner:  $1.266\text{e}+12 \pm 6\text{e}+09$  per  $\text{cm}^2$

#### 3.3.1 Neutron Flux Distribution

The following graph shows the neutron flux distribution for different parts of CTH scintillators. Notice that the x-value range for upstream inner/outer scintillators is the same for better visualisation of the relative position of the CTH Supports. Similar for downstream scintillators. The neutron flux seems evenly distributed in both X and Phi directions.

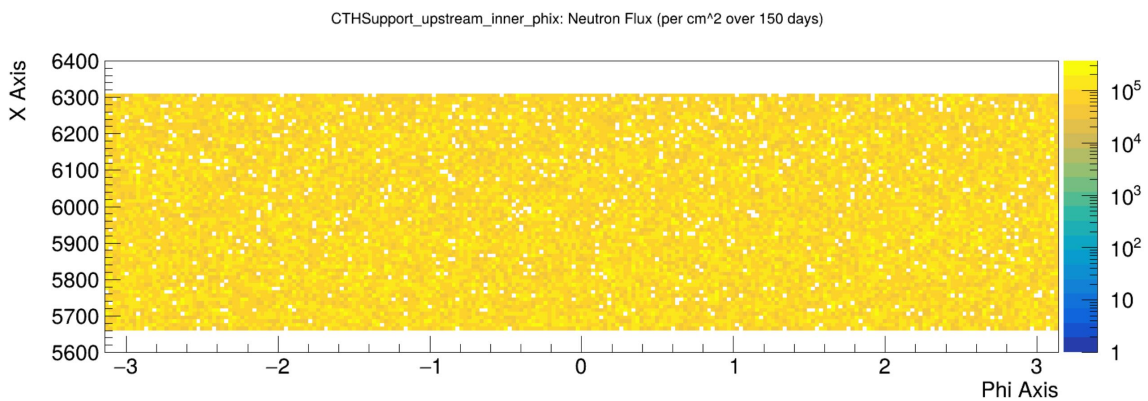


Figure 3.23: Neutron Flux distribution (over 150 days) for CTH upstream inner scintillators.

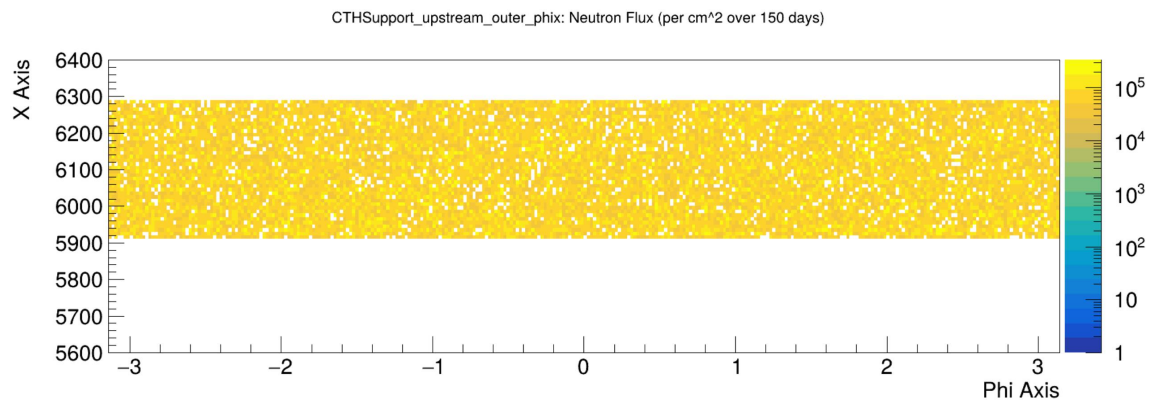


Figure 3.24: Neutron Flux distribution (over 150 days) for CTH upstream outer scintillators.

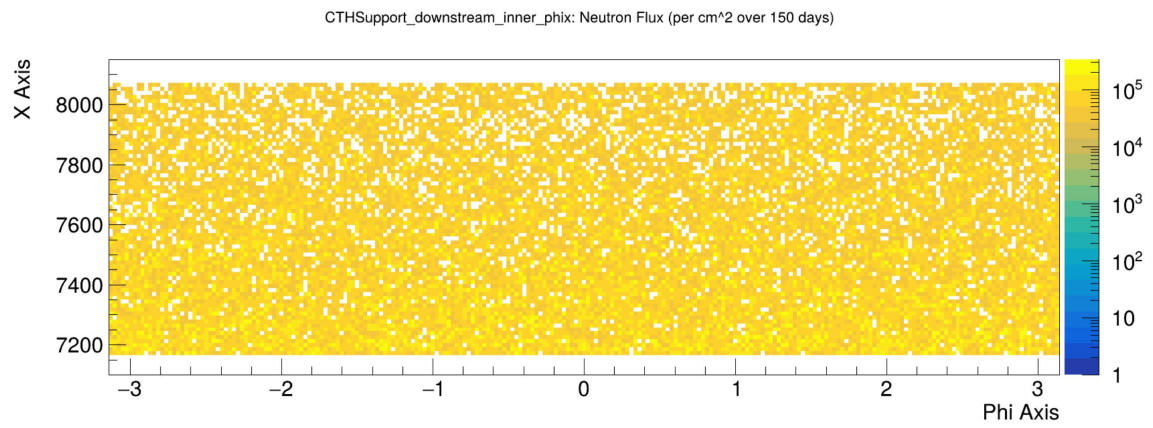


Figure 3.25: Neutron Flux distribution (over 150 days) for CTH downstream inner scintillators.

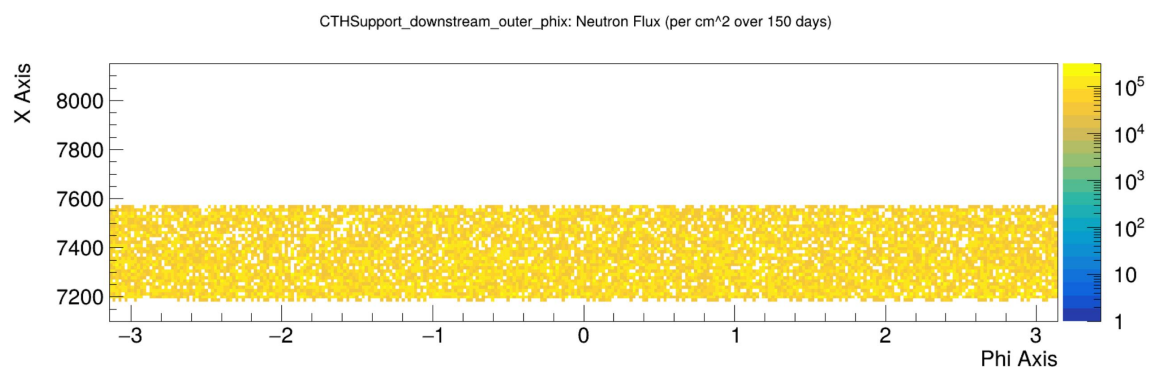


Figure 3.26: Neutron Flux distribution (over 150 days) for CTH downstream outer scintillators.

### 3.3.2 Neutron KE Distribution

Below are the neutron KE distributions (frequency per second) for different parts of CTH scintillators.

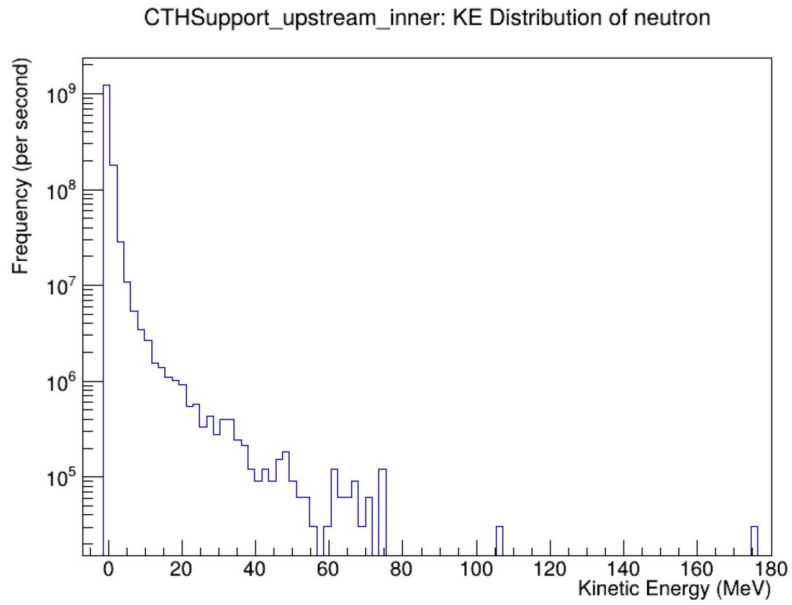


Figure 3.27: Neutron KE distribution for CTH upstream inner scintillators.

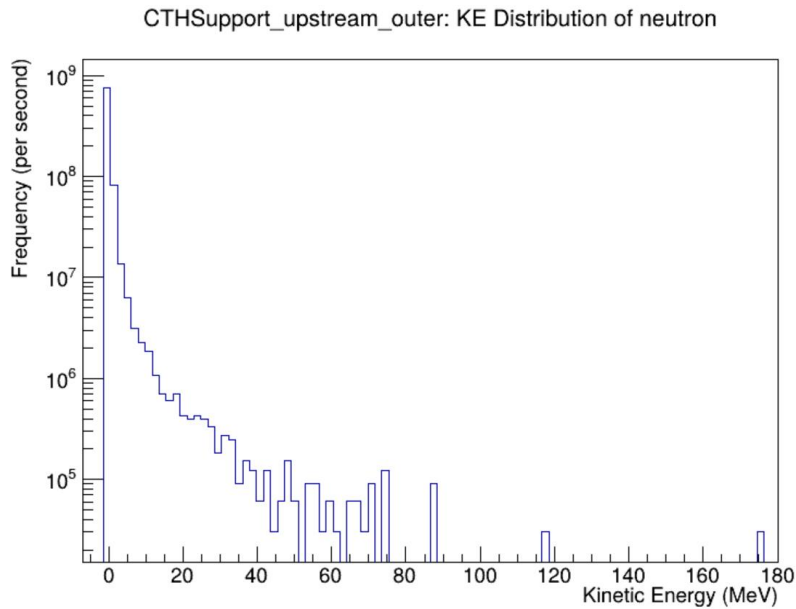


Figure 3.28: Neutron KE distribution for CTH upstream outer scintillators.

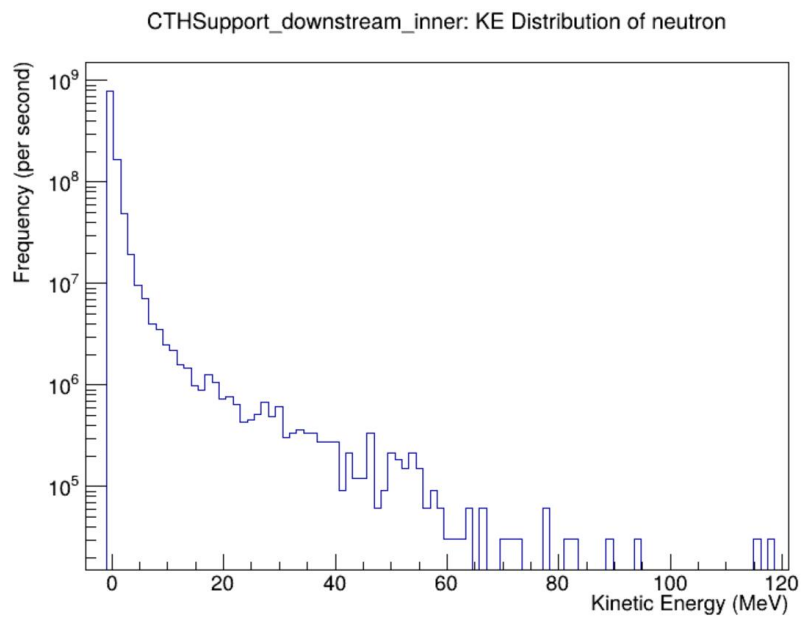


Figure 3.29: Neutron KE distribution for CTH downstream inner scintillators.

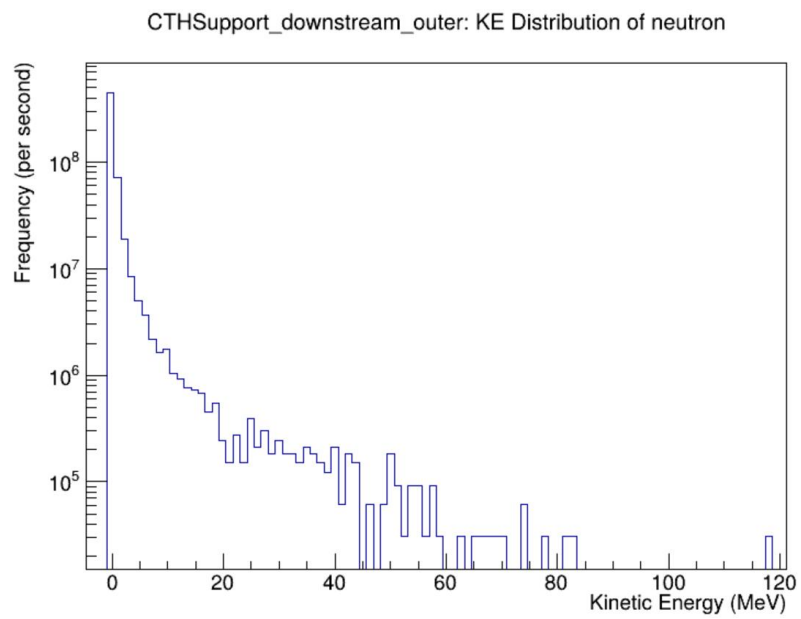


Figure 3.30: Neutron KE distribution for CTH downstream outer scintillators.

# 4

## RECBE Boards

### Contents

---

<b>4.1 Geometry . . . . .</b>	<b>27</b>
<b>4.2 Radiation Dose . . . . .</b>	<b>29</b>
4.2.1 Radiation Dose Distribution . . . . .	29
4.2.2 Radiation Dose By PID And Their KE Distribution . . . . .	31
<b>4.3 Neutron Flux . . . . .</b>	<b>43</b>
4.3.1 Neutron Flux Distribution . . . . .	43
4.3.2 Neutron KE Distribution . . . . .	45

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### 4.1 Geometry

RECBE boards are located right after the CDC, as shown in Fig. ??, forming 6 concentric rings of G10 boards, labelled from 0 to 5, as in Fig, ??. Layers 0 and 1 contain 16 boards each and layers 2 to 5 contain 18. Each board has a dimension of 17x20 cm and a mass of 0.109820 kg.

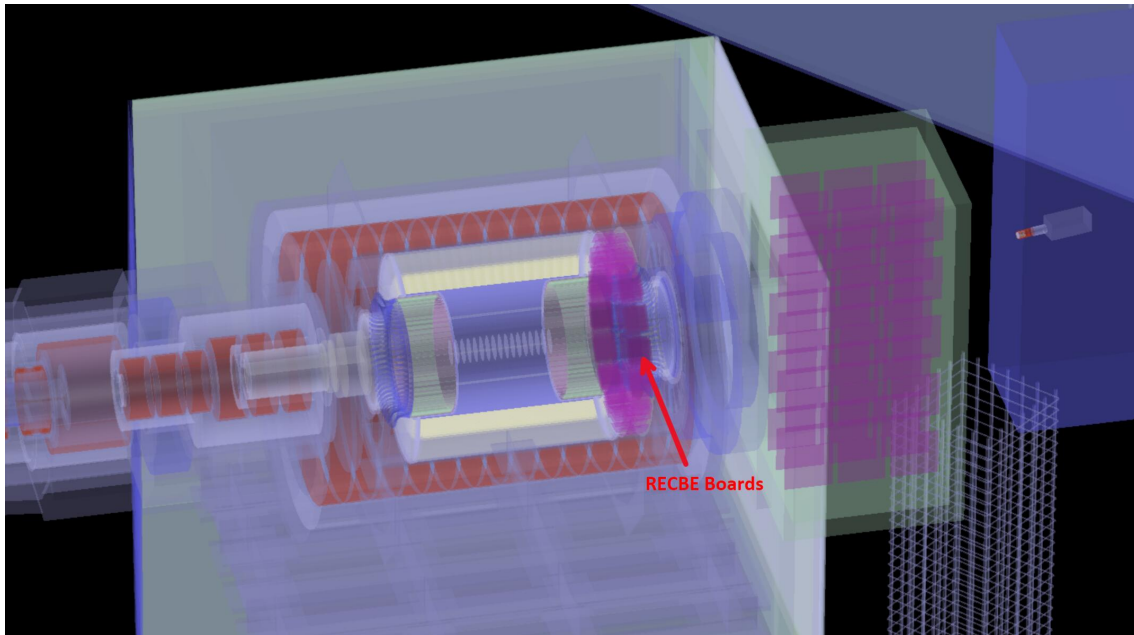


Figure 4.1: RECBE Boards are located after CDC.

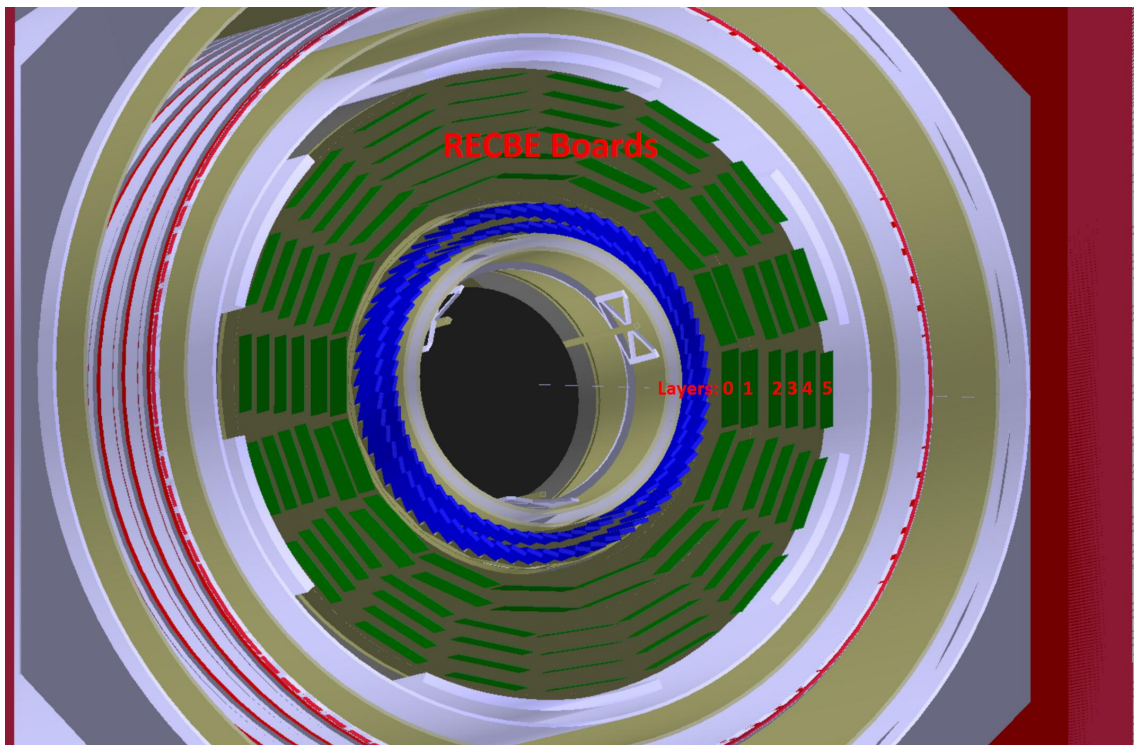


Figure 4.2: RECBE Boards forming 6 concentric rings. Layers 0 and 1 contain 16 boards each and layers 2 to 5 contain 18.

## 4.2 Radiation Dose

Over 150 days, the average radiation dose for each layer is:

RECBE layer 0:  $47.3 \pm 0.6$  Gy

RECBE layer 1:  $37.8 \pm 0.5$  Gy

RECBE layer 2:  $33.8 \pm 0.4$  Gy

RECBE layer 3:  $29.7 \pm 0.4$  Gy

RECBE layer 4:  $25.8 \pm 0.4$  Gy

RECBE layer 5:  $26.3 \pm 0.4$  Gy

Generally the average dose is lower for outer rings

### 4.2.1 Radiation Dose Distribution

Below are the radiation dose distributions for each layer on the X-Phi plane. The energy depositions are relatively evenly distributed in both x and phi directions.

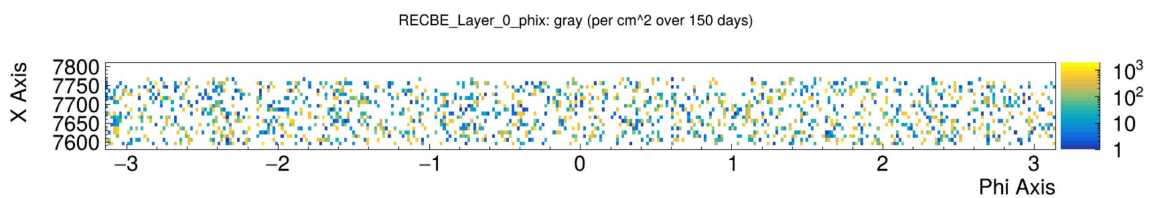


Figure 4.3: Radiation Dose Distribution of RECBE Layer 0 on the X-Phi plane.

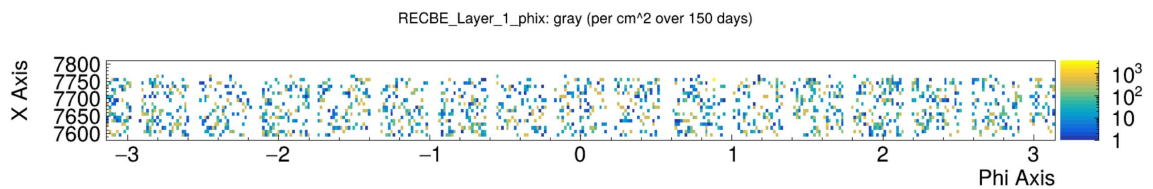


Figure 4.4: Radiation Dose Distribution of RECBE Layer 1 on the X-Phi plane.

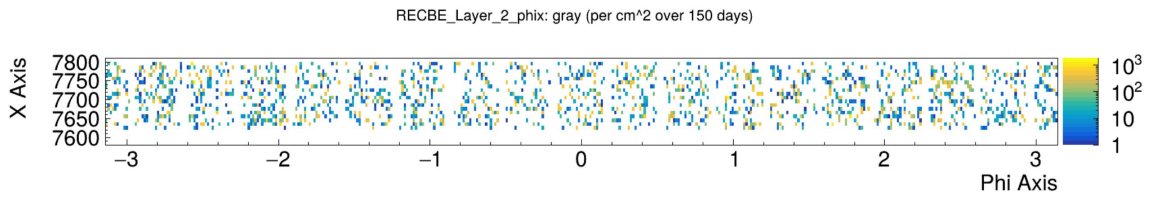


Figure 4.5: Radiation Dose Distribution of RECBE Layer 2 on the X-Phi plane.

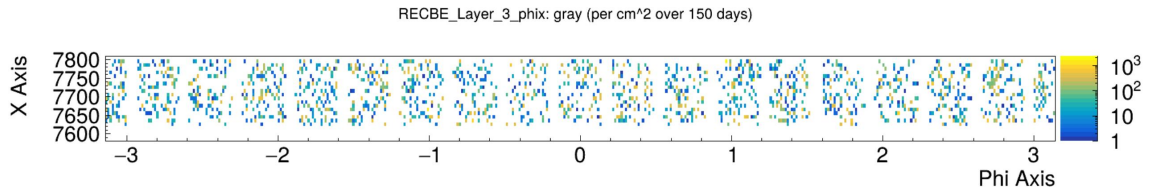


Figure 4.6: Radiation Dose Distribution of RECBE Layer 3 on the X-Phi plane.

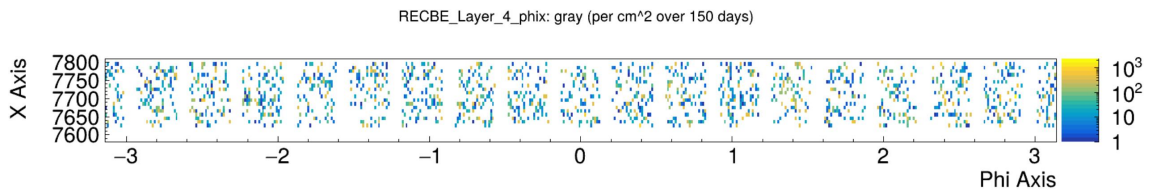


Figure 4.7: Radiation Dose Distribution of RECBE Layer 4 on the X-Phi plane.

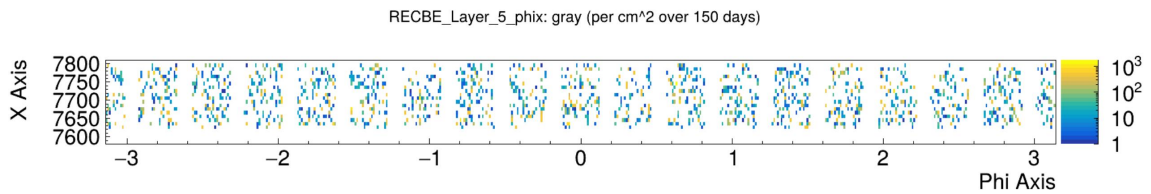


Figure 4.8: Radiation Dose Distribution of RECBE Layer 5 on the X-Phi plane.

## 4.2.2 Radiation Dose By PID And Their KE Distribution

### RECBE Layer 0

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 0.

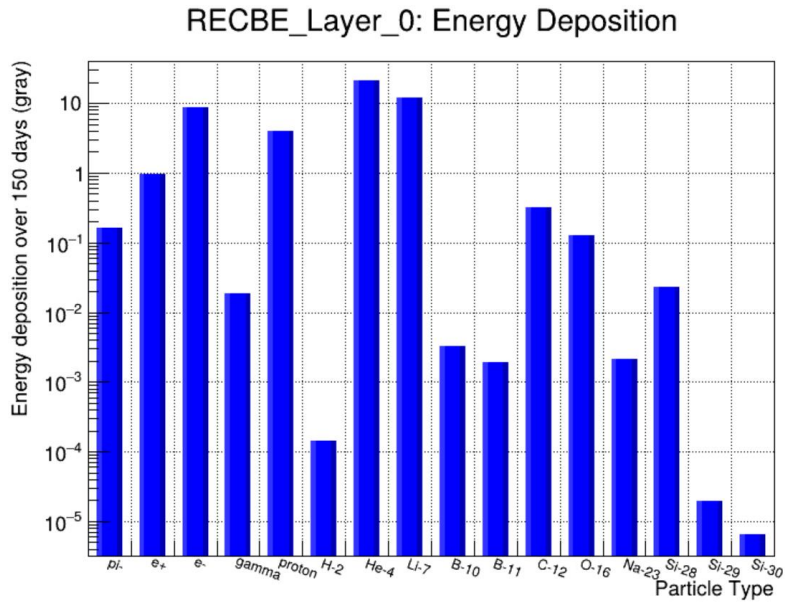


Figure 4.9: RECBE Layer 0 radiation dose by PID.

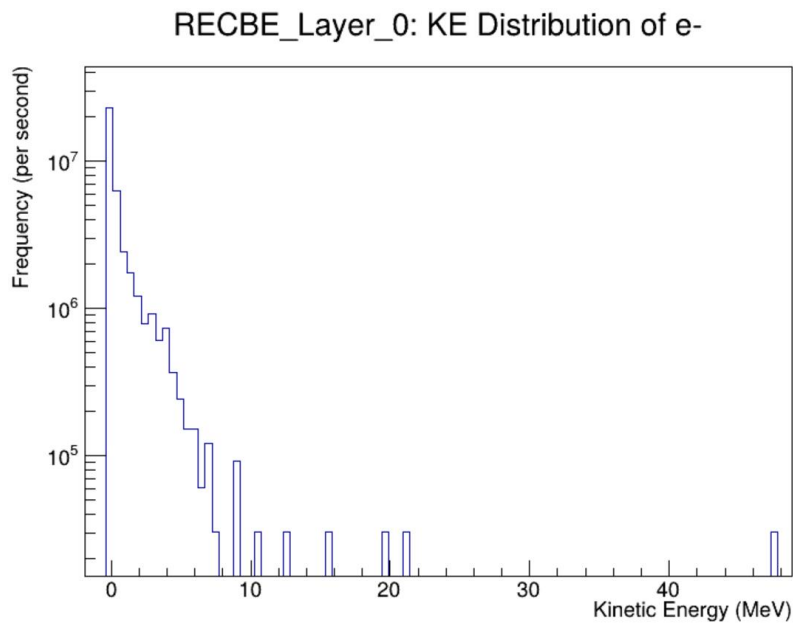


Figure 4.10: RECBE Layer 0 e- KE distribution.

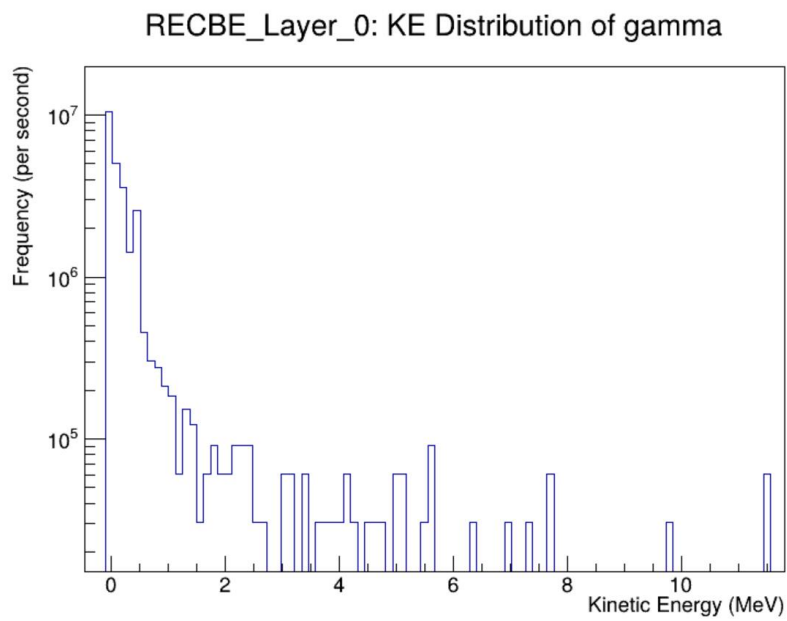


Figure 4.11: RECBE Layer 0 gamma KE distribution.

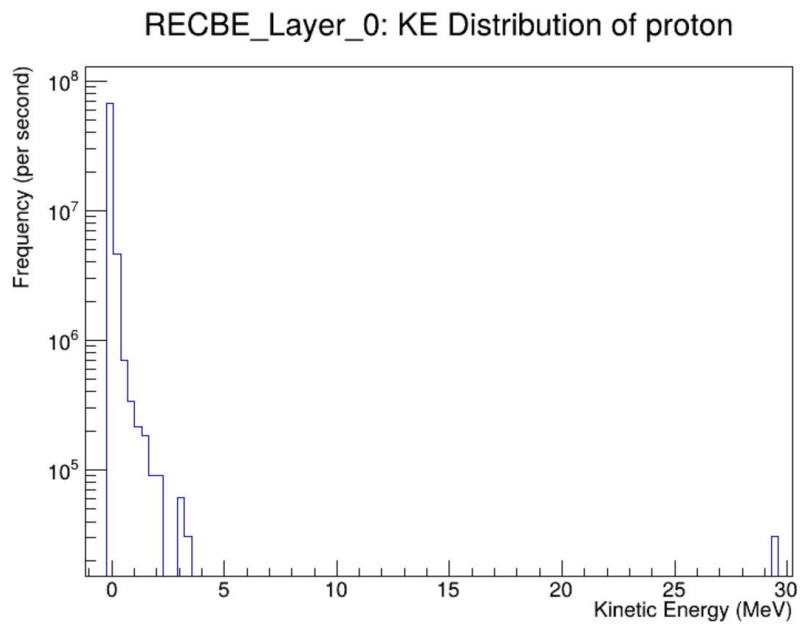


Figure 4.12: RECBE Layer 0 proton KE distribution.

**RECBE Layer 1**

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 1.

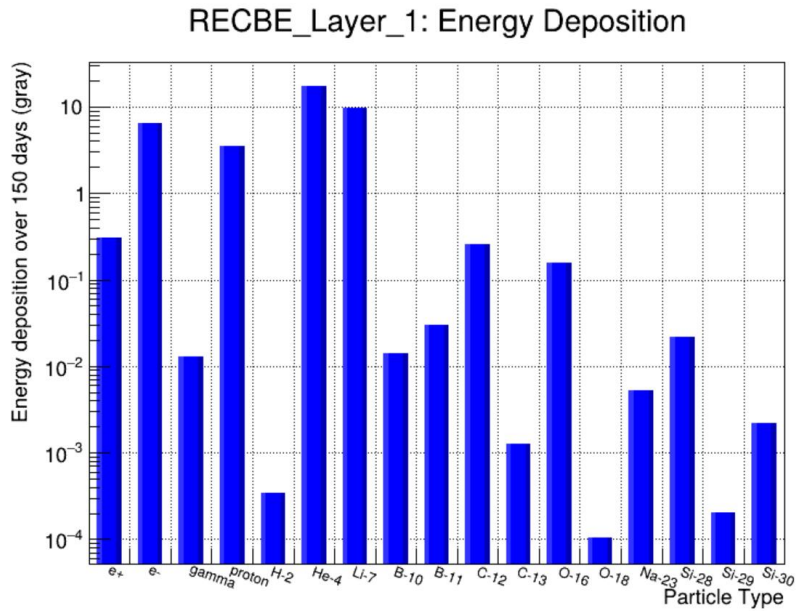


Figure 4.13: RECBE Layer 1 radiation dose by PID.

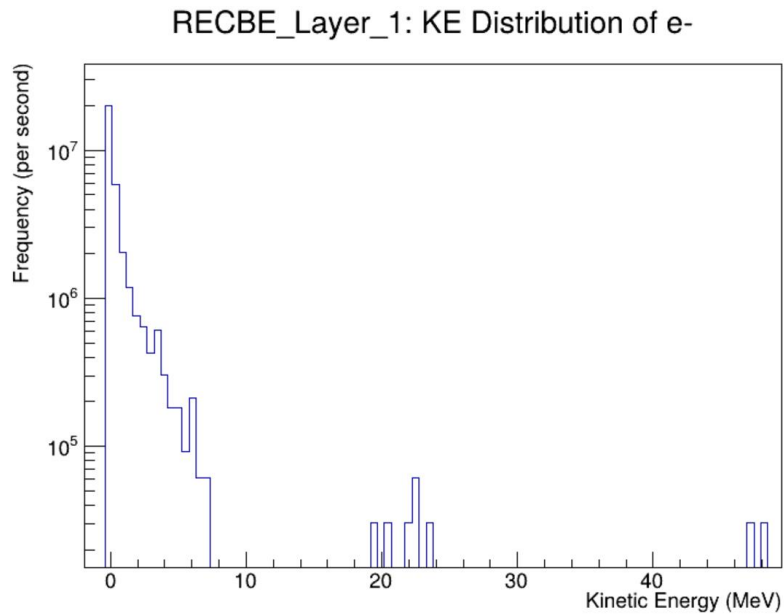


Figure 4.14: RECBE Layer 1 e- KE distribution.

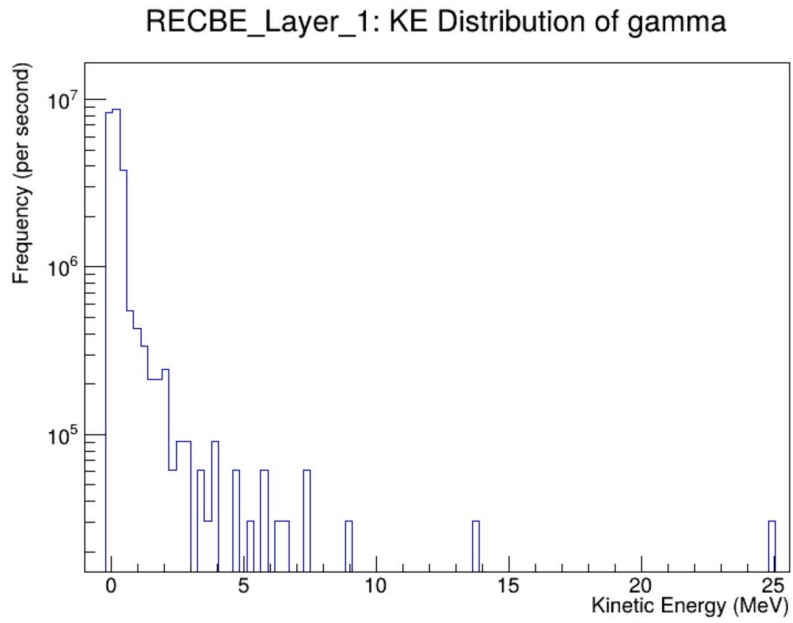


Figure 4.15: RECBE Layer 1 gamma KE distribution.

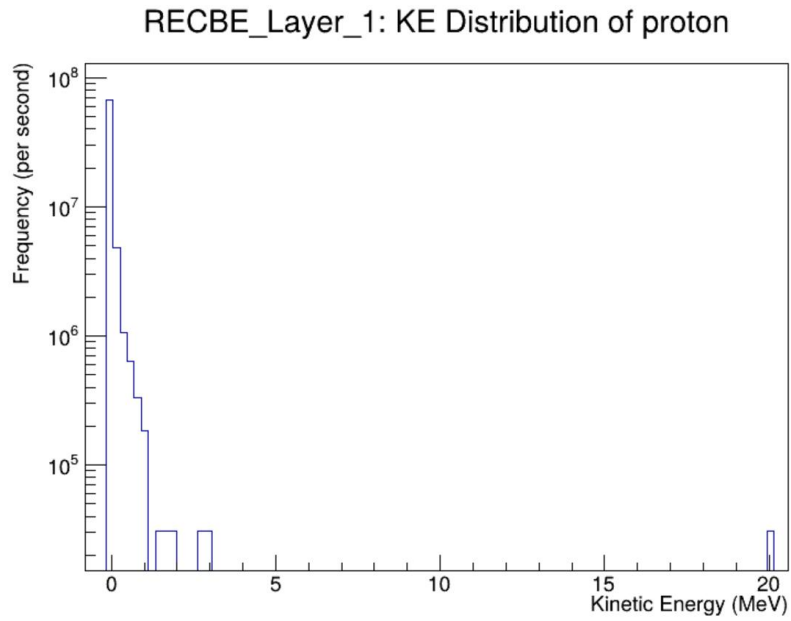


Figure 4.16: RECBE Layer 1 proton KE distribution.

**RECBE Layer 2**

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 2.

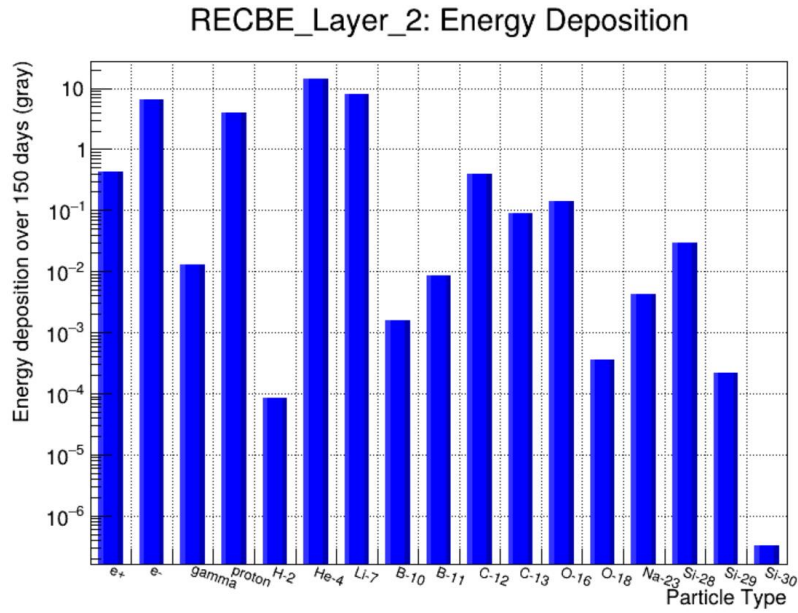


Figure 4.17: RECBE Layer 2 radiation dose by PID.

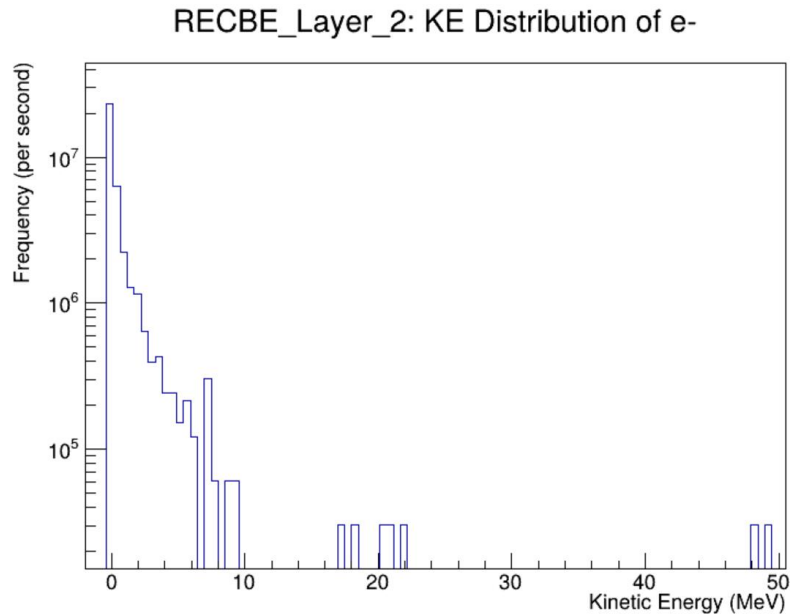


Figure 4.18: RECBE Layer 2 e- KE distribution.

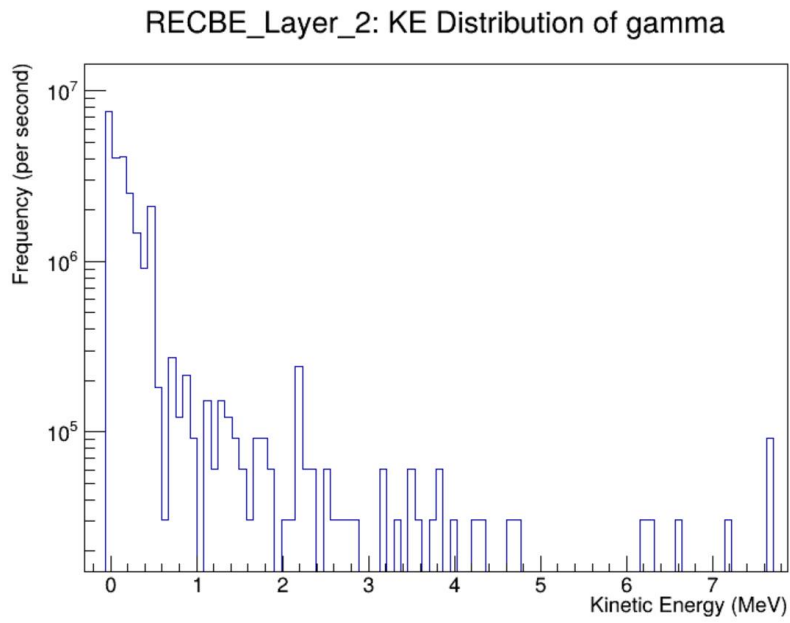


Figure 4.19: RECBE Layer 2 gamma KE distribution.

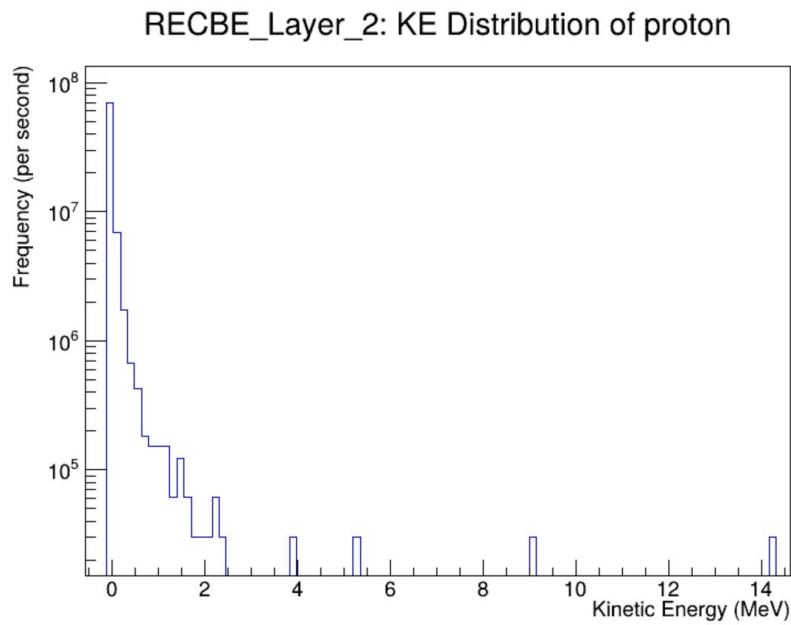


Figure 4.20: RECBE Layer 2 proton KE distribution.

**RECBE Layer 3**

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 3.

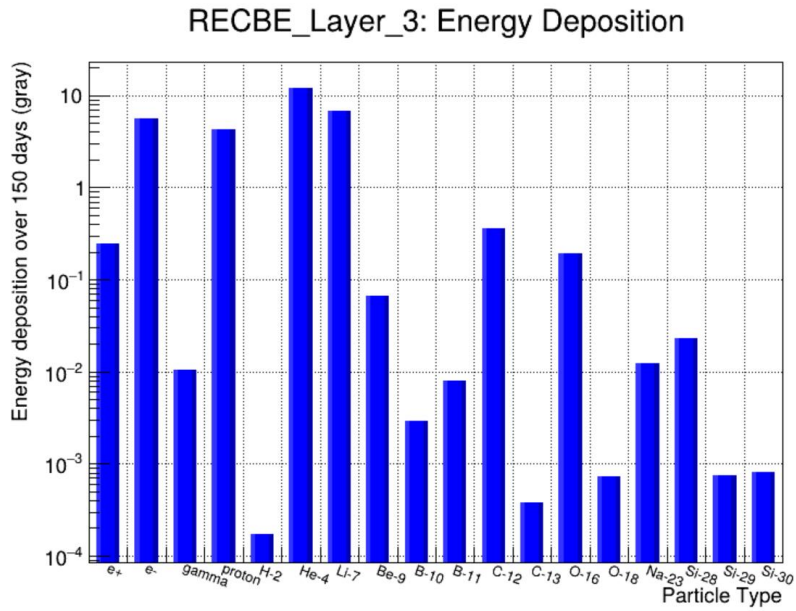


Figure 4.21: RECBE Layer 3 radiation dose by PID.

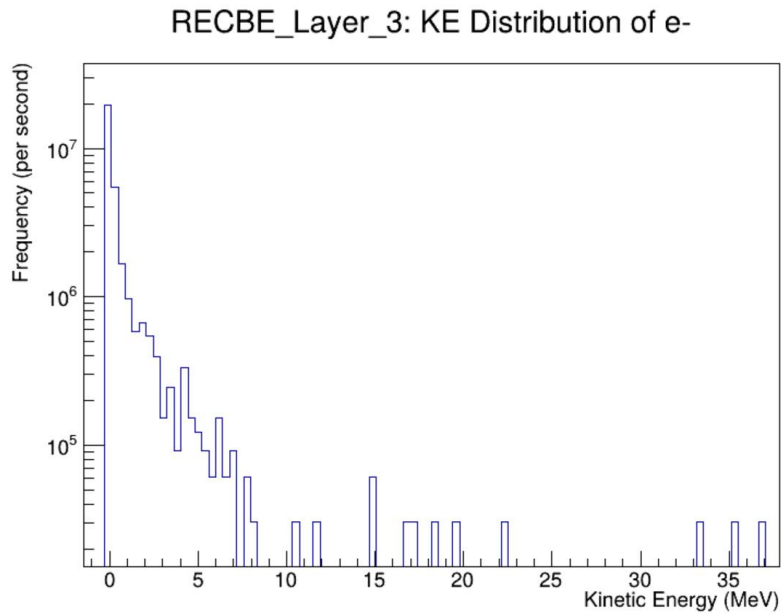


Figure 4.22: RECBE Layer 3 e- KE distribution.

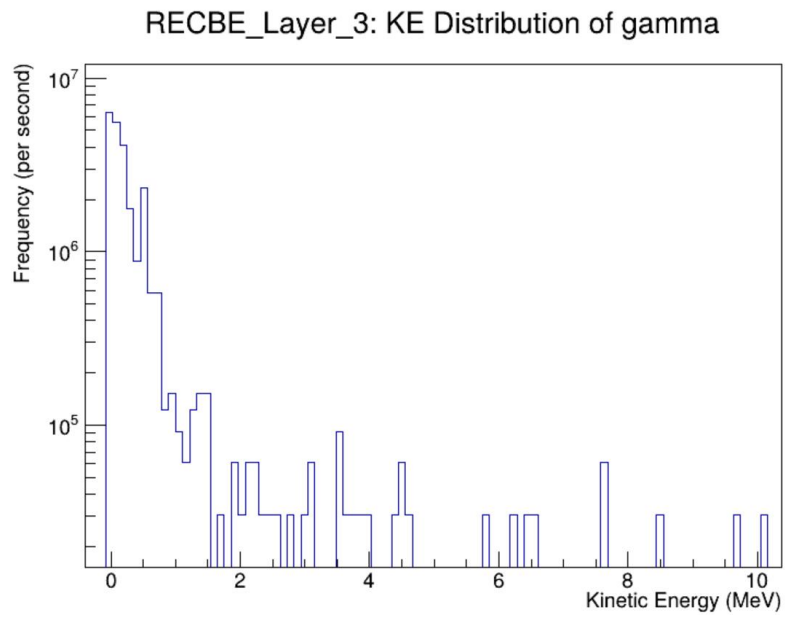


Figure 4.23: RECBE Layer 3 gamma KE distribution.

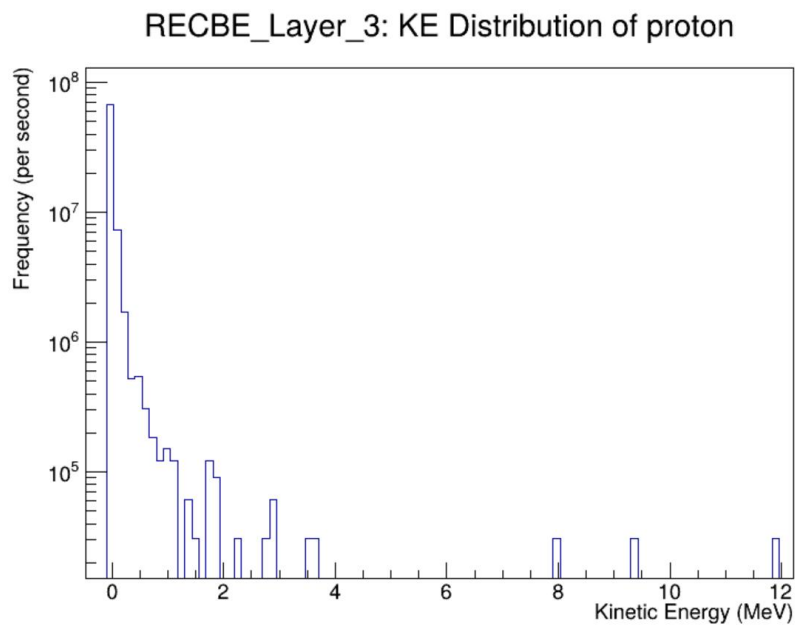


Figure 4.24: RECBE Layer 3 proton KE distribution.

### RECBE Layer 4

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 4.

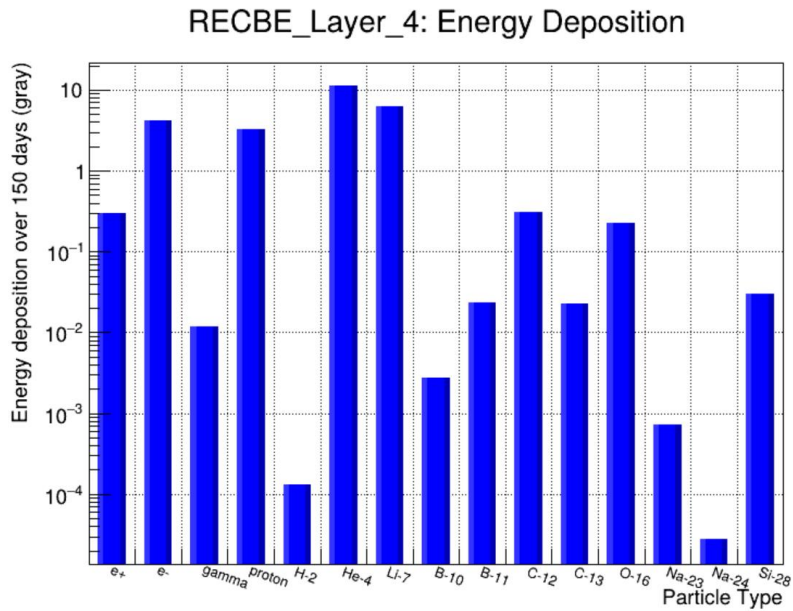


Figure 4.25: RECBE Layer 4 radiation dose by PID.

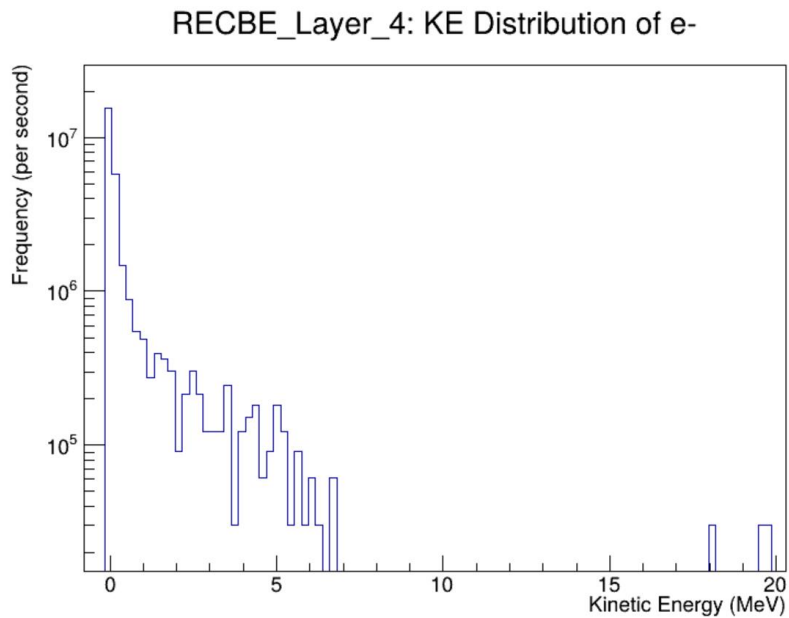


Figure 4.26: RECBE Layer 4 e- KE distribution.

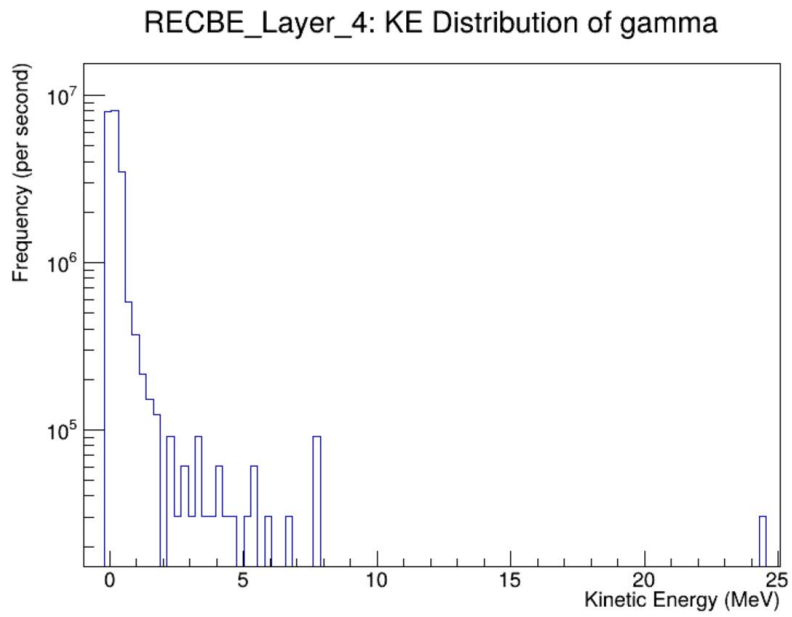


Figure 4.27: RECBE Layer 4 gamma KE distribution.

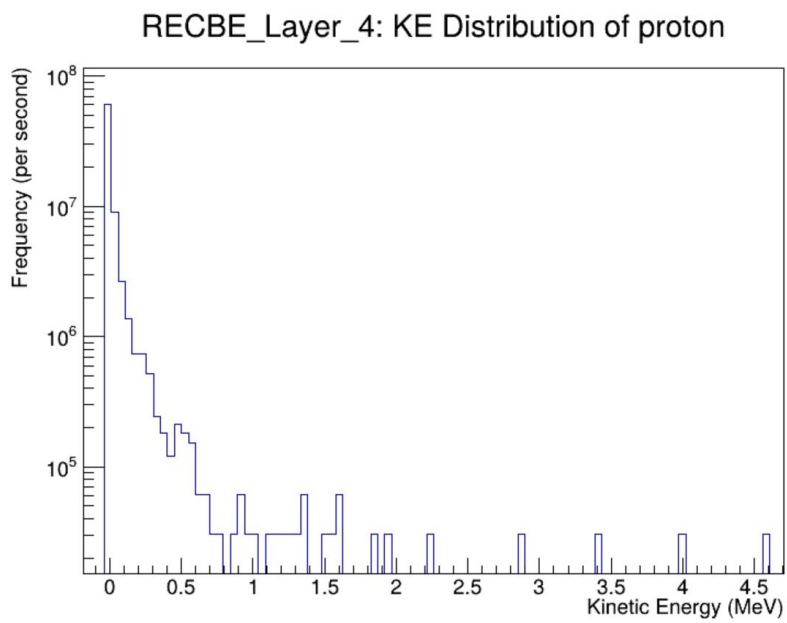


Figure 4.28: RECBE Layer 4 proton KE distribution.

### RECBE Layer 5

Below are the radiation doses by different particle types, and KE distribution of e-, gamma and proton arriving at RECBE Layer 5.

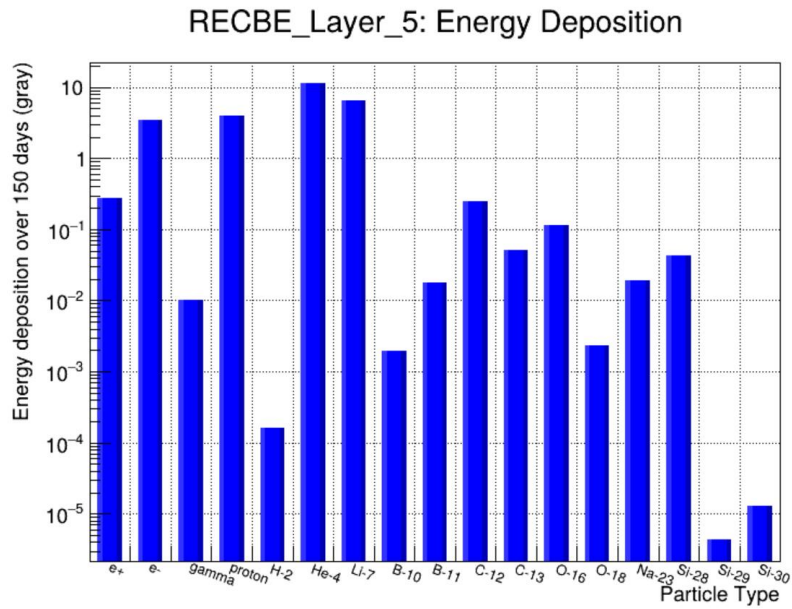


Figure 4.29: RECBE Layer 5 radiation dose by PID.

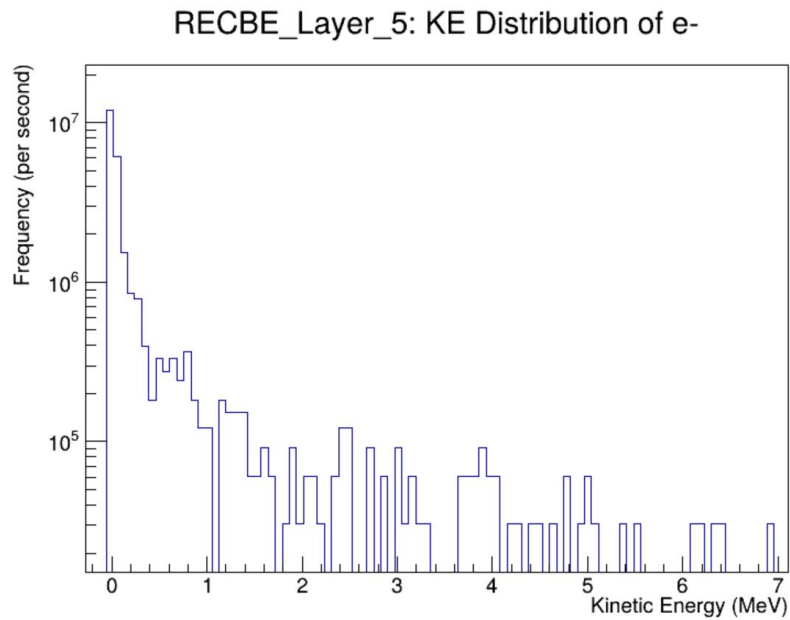


Figure 4.30: RECBE Layer 5 e- KE distribution.

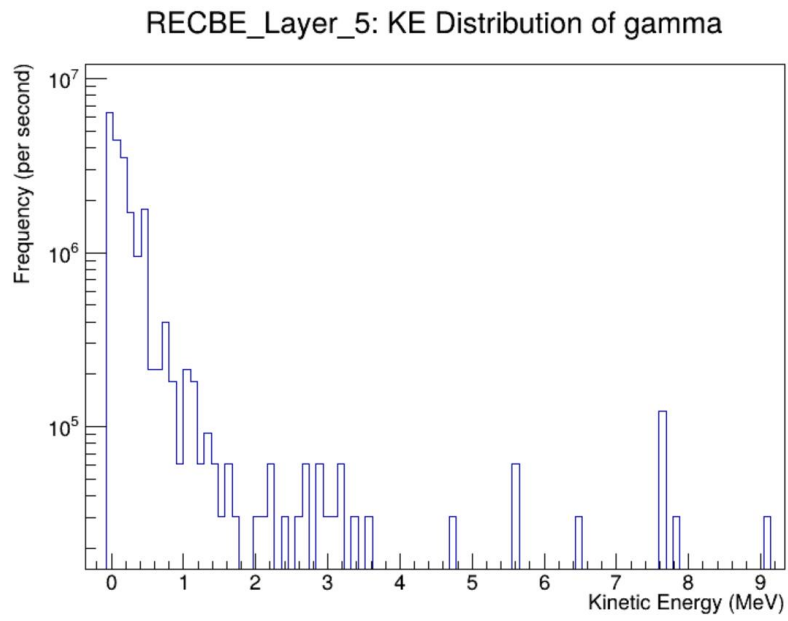


Figure 4.31: RECBE Layer 5 gamma KE distribution.

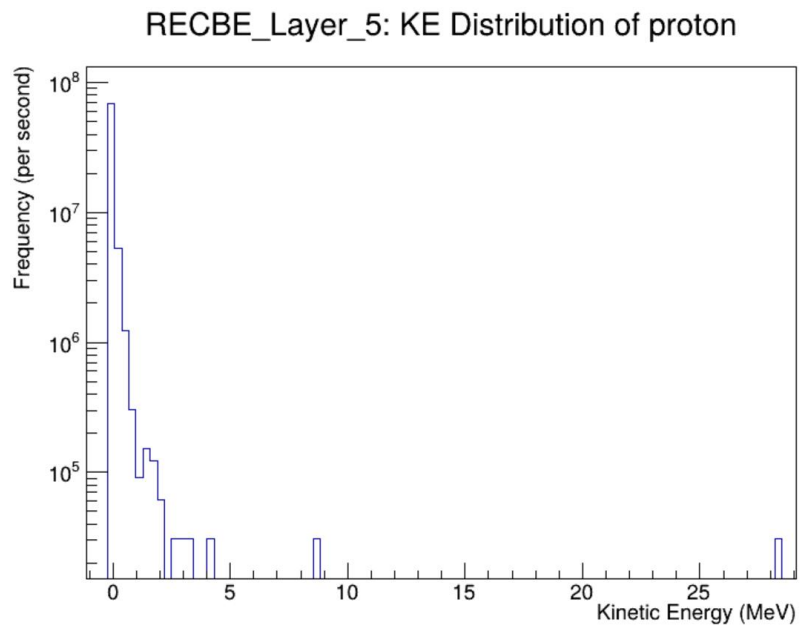


Figure 4.32: RECBE Layer 5 proton KE distribution.

## 4.3 Neutron Flux

Over 150 days, the neutron flux at each layer:

RECBE layer 0:  $4.96\text{e}+11 \pm 6\text{e}+09$  per  $\text{cm}^2$

RECBE layer 1:  $4.78\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

RECBE layer 2:  $4.61\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

RECBE layer 3:  $4.52\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

RECBE layer 4:  $4.55\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

RECBE layer 5:  $4.60\text{e}+11 \pm 5\text{e}+09$  per  $\text{cm}^2$

### 4.3.1 Neutron Flux Distribution

Below are the flux (per  $\text{cm}^2$  over 150 days) distribution of neutrons arriving at each RECBE layer.

Overall the neutrons are evenly distributed in both X and Phi directions.

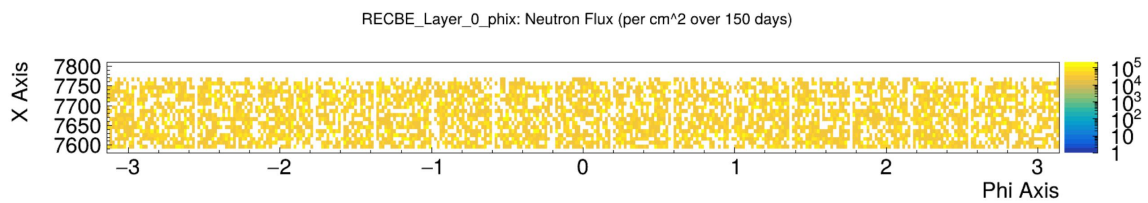


Figure 4.33: RECBE Layer 0 neutron flux distribution.

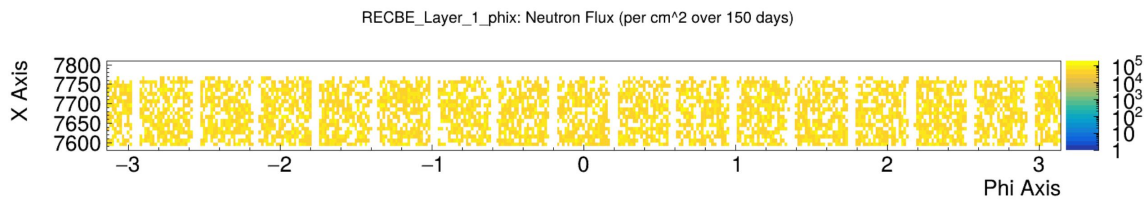


Figure 4.34: RECBE Layer 1 neutron flux distribution.

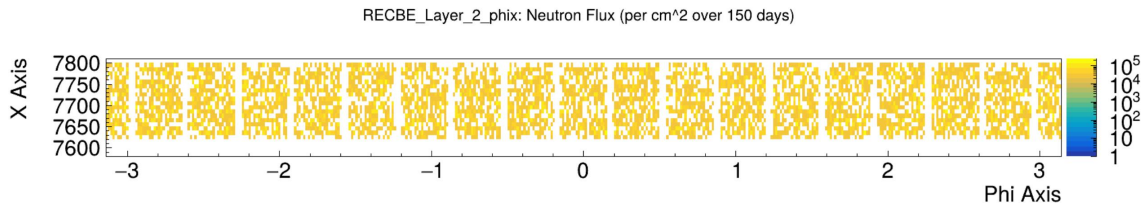


Figure 4.35: RECBE Layer 2 neutron flux distribution.

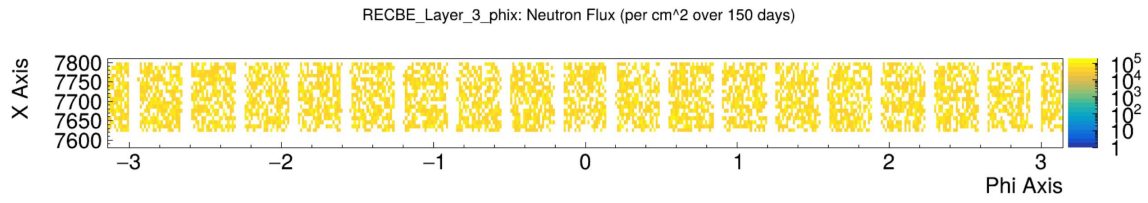


Figure 4.36: RECBE Layer 3 neutron flux distribution.

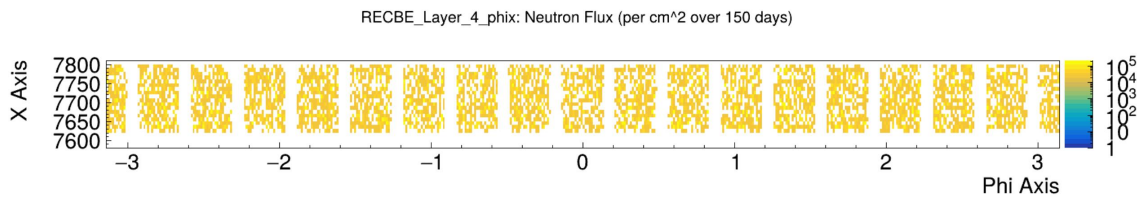


Figure 4.37: RECBE Layer 4 neutron flux distribution.

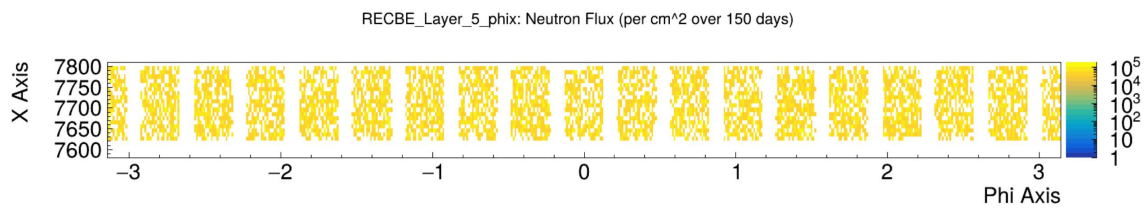


Figure 4.38: RECBE Layer 5 neutron flux distribution.

### 4.3.2 Neutron KE Distribution

Below are the KE distribution of neutrons arriving at each RECBE layer.

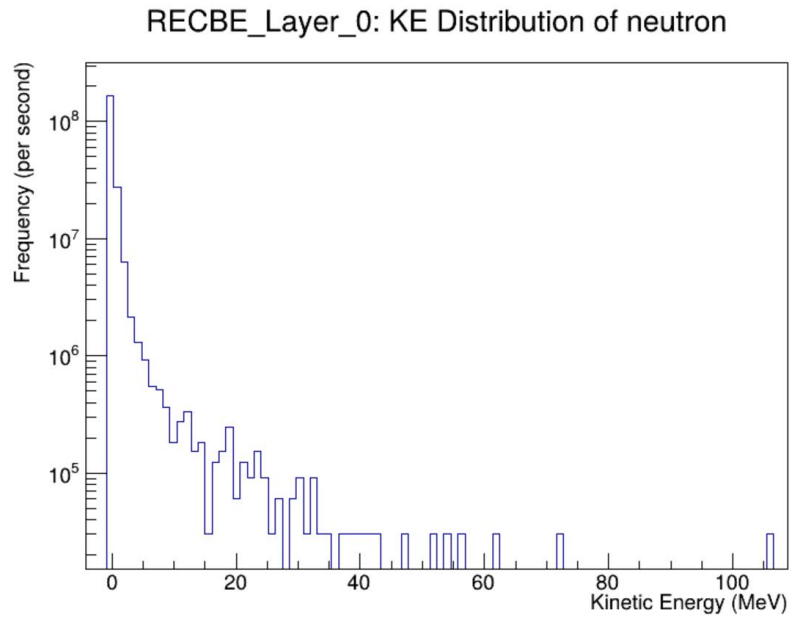


Figure 4.39: RECBE Layer 0 neutron KE distribution.

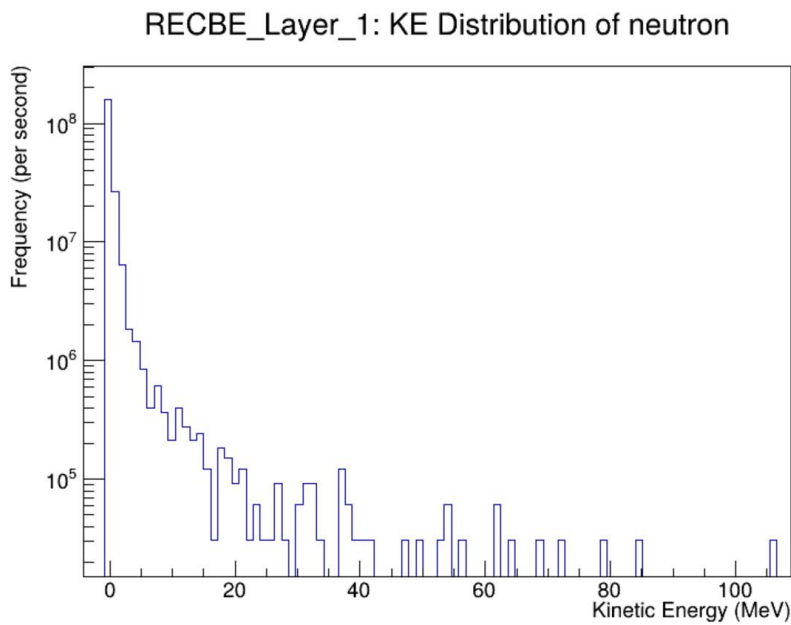


Figure 4.40: RECBE Layer 1 neutron KE distribution.

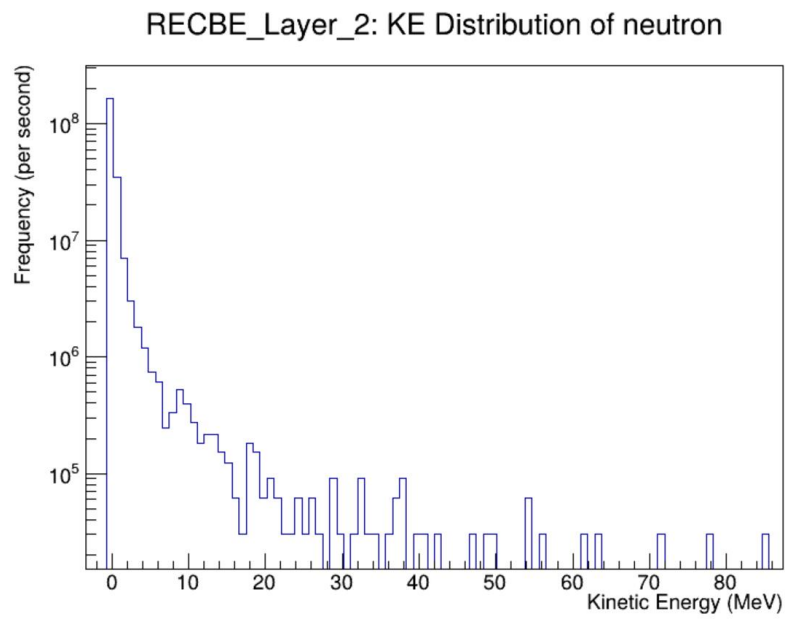


Figure 4.41: RECBE Layer 2 neutron KE distribution.

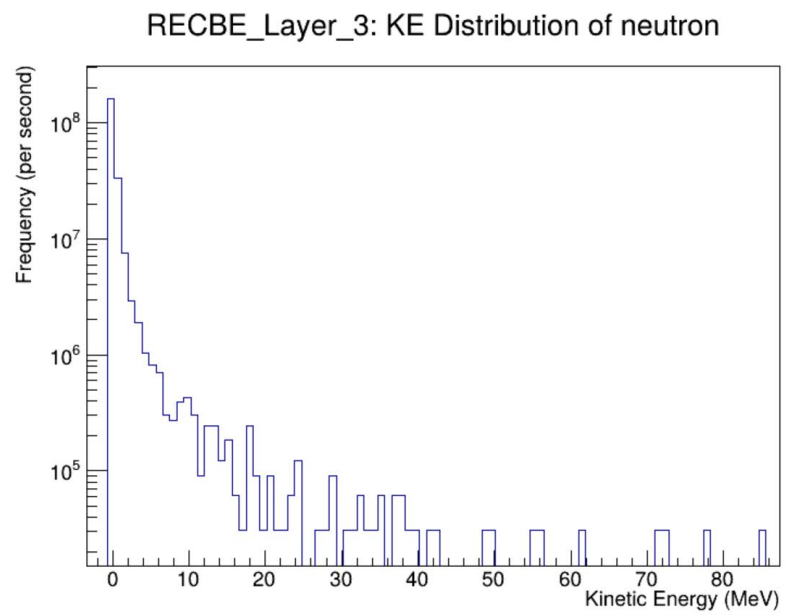


Figure 4.42: RECBE Layer 3 neutron KE distribution.

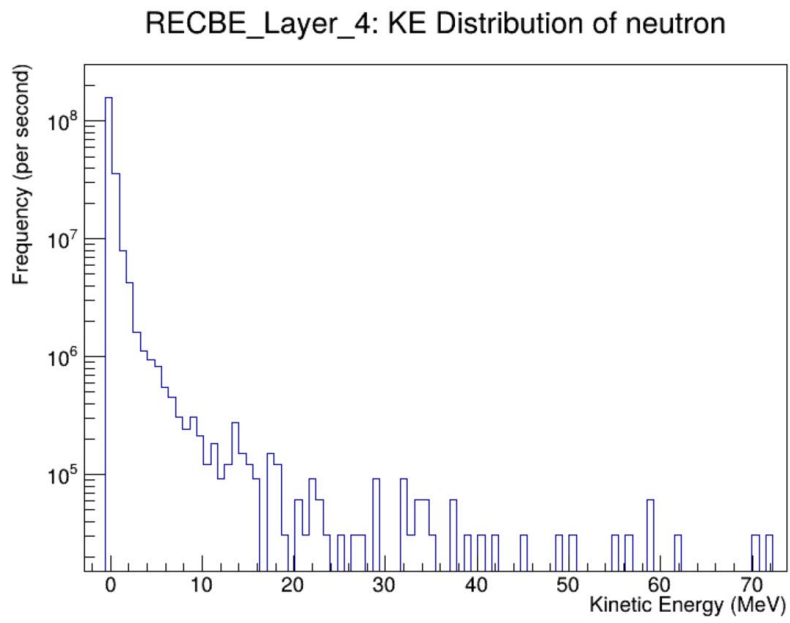


Figure 4.43: RECBE Layer 4 neutron KE distribution.

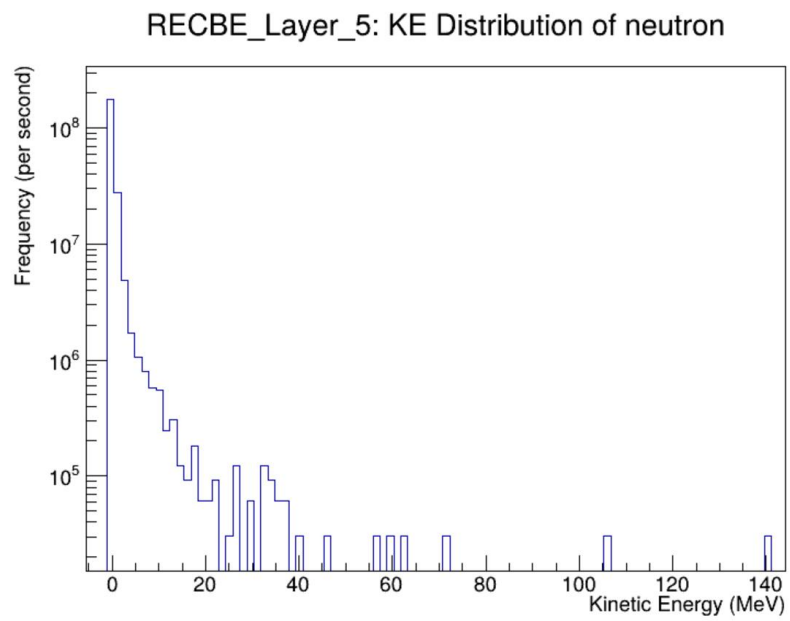


Figure 4.44: RECBE Layer 5 neutron KE distribution.

# 5

## CyDet Electronics Room

### Contents

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<b>5.1 Geometry</b> . . . . .	<b>48</b>
<b>5.2 Shield</b> . . . . .	<b>50</b>
5.2.1 Radiation Dose Distribution . . . . .	51
5.2.2 Radiation Dose By PID And Their KE Distributions . . . . .	53
<b>5.3 InnerBox</b> . . . . .	<b>56</b>
<b>5.4 SimpleBoards</b> . . . . .	<b>59</b>
5.4.1 Radiation Dose Distribution . . . . .	60
5.4.2 Radiation Dose By PID And Their KE Distributions . . . . .	63

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### 5.1 Geometry

The CyDet Electronics Room is located after the detector solenoid, as shown in Fig. 5.1. It is composed of three components:

1. Shield: a  $1.5 \times 1.5 \times 3 \text{ m}^3$  polyethylene box of 0.1 m thick, with a mass of 1901.01 kg;
2. InnerBox: a thin layer of air just inside the Shield;
3. Simple Board: 45 G10 boards with dimension  $40 \times 40 \times 0.32 \text{ cm}^3$  and mass 0.4352 kg distributed inside the Shield.

The SimpleBoards are distributed in three layers, each of three columns and five rows. The layers are labelled as 0, 1 and 2, with Layer 0 to be closest to the beamline, as shown in Fig. 5.2.

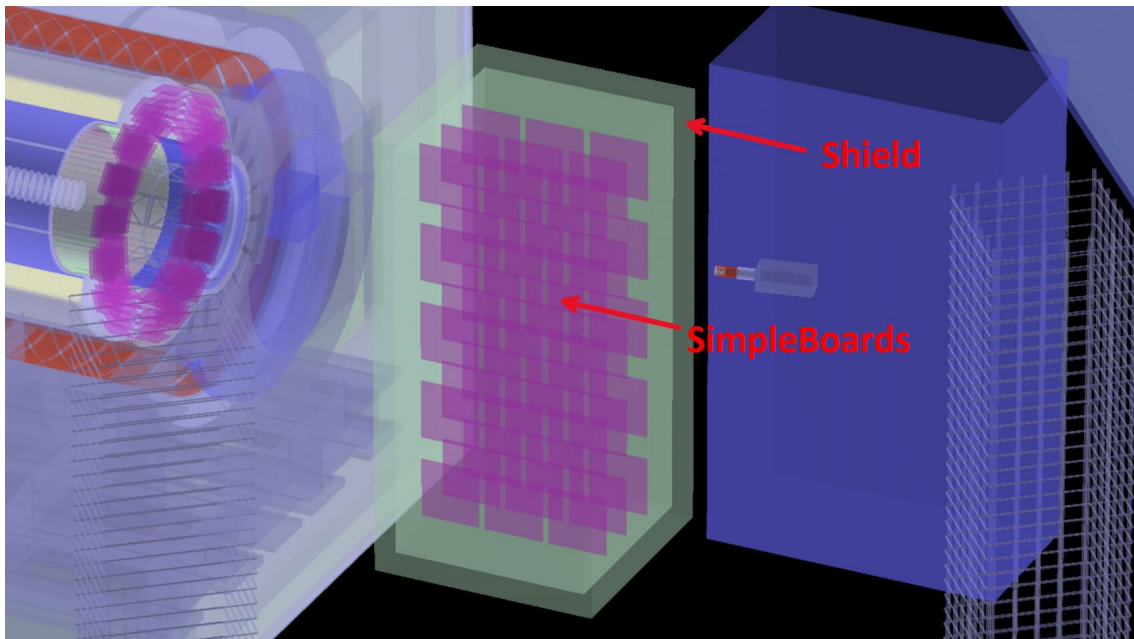


Figure 5.1: CyDet Electronics Room geometry illustration.

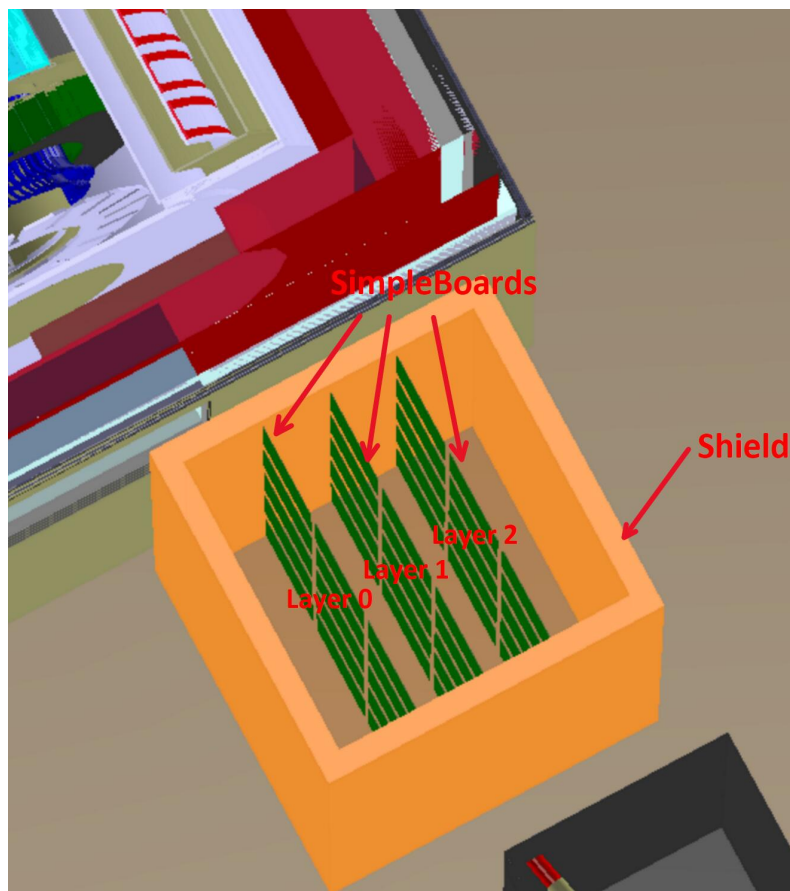


Figure 5.2: CyDet Electronics Room geometry illustration.

## 5.2 Shield

Over 150 days, the radiation dose on the Shield is:

Shield average:  $233.01 \pm 0.06$  Gy

If we split the Shield halfway (at  $y = -750$ ) into upper and lower halves, their radiation doses are:

Upper Shield:  $457.7 \pm 0.1$  Gy Lower Shield:  $8.371 \pm 0.007$  Gy

The Upper Shield receives two orders of magnitude more radiation than the Lower Shield.

### 5.2.1 Radiation Dose Distribution

Below are the Shield radiation dose distributions (per  $\text{cm}^2$ ) over 150 days in three different directions. The part of the Shield closest to the beamline receives the majority of the radiation.

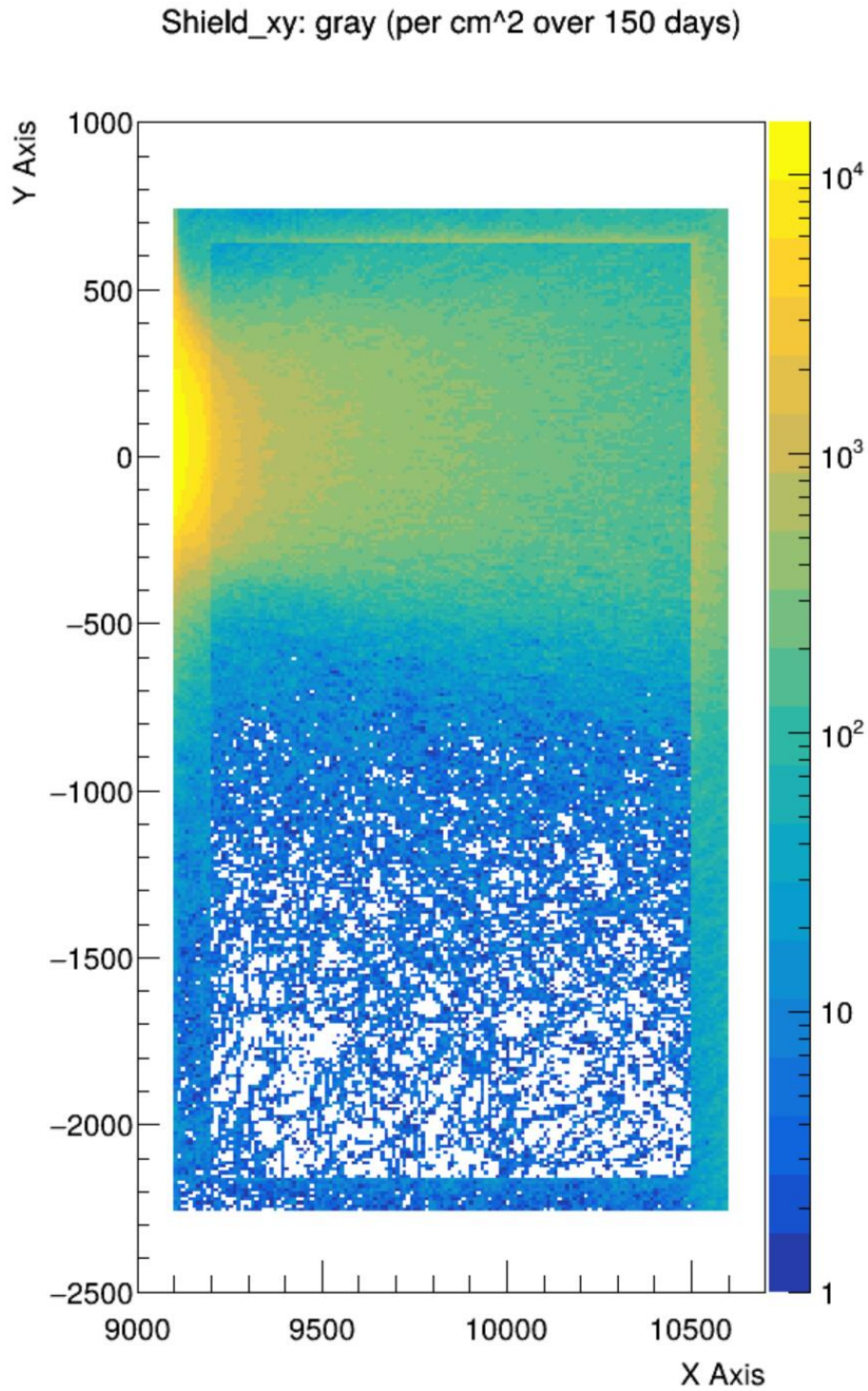


Figure 5.3: Shield radiation dose distribution in the X-Y plane.

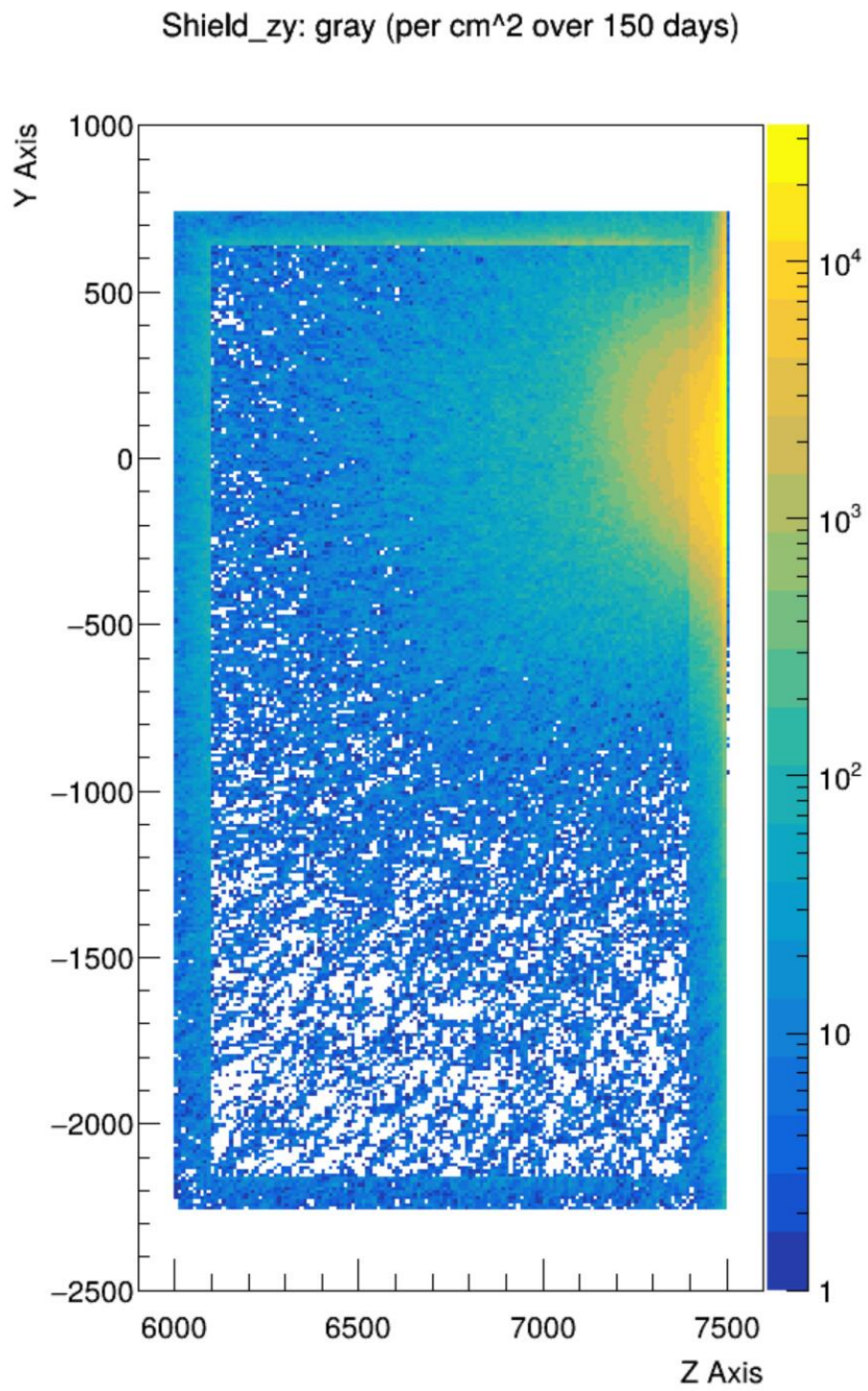


Figure 5.4: Shield radiation dose distribution in the Z-Y plane.

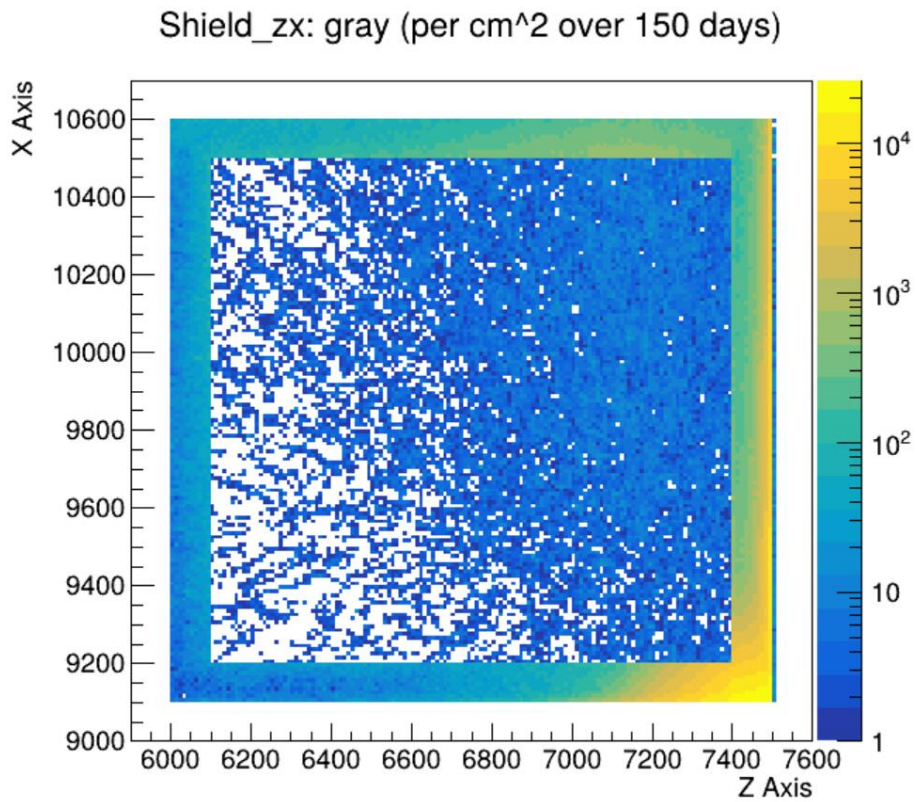


Figure 5.5: Shield radiation dose distribution in the Z-X plane.

### 5.2.2 Radiation Dose By PID And Their KE Distributions

Below are the radiation doses on the Shield from different particle types, as well as the KE distribution of e<sup>-</sup>, gamma and proton that arrive at the Shield.

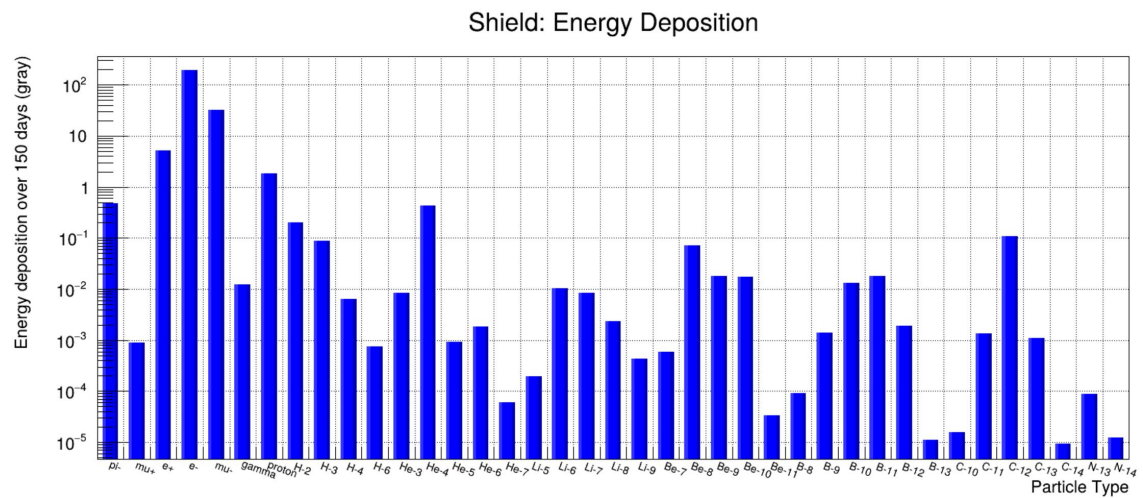


Figure 5.6: Shield radiation dose by PID.

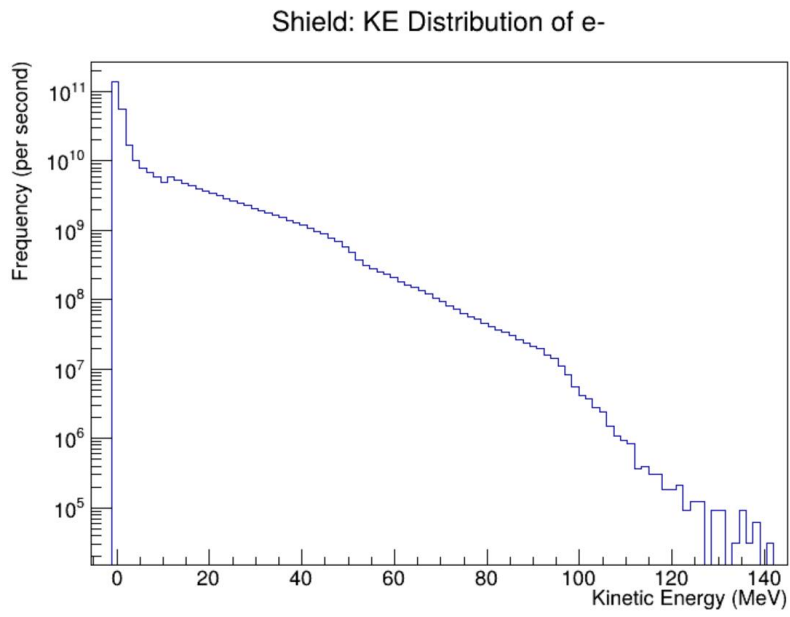


Figure 5.7: Shield e- KE distribution.

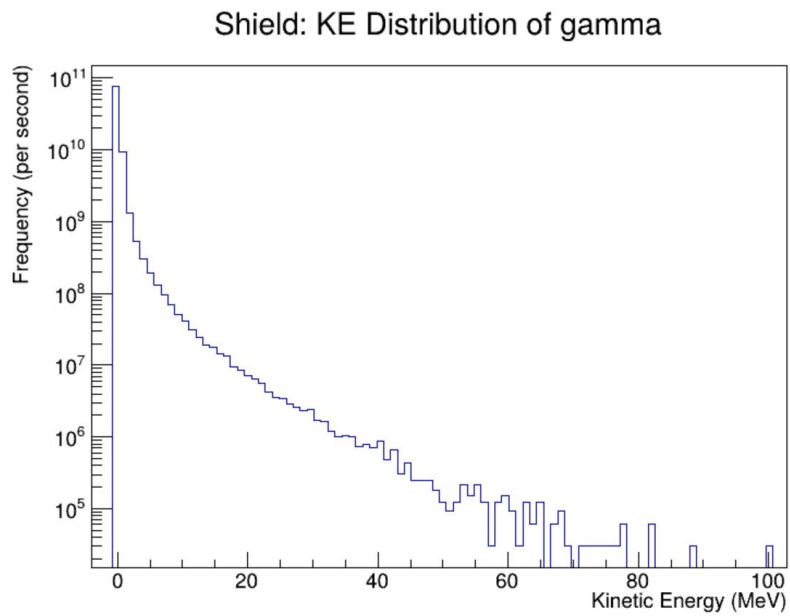


Figure 5.8: Shield gamma KE distribution.

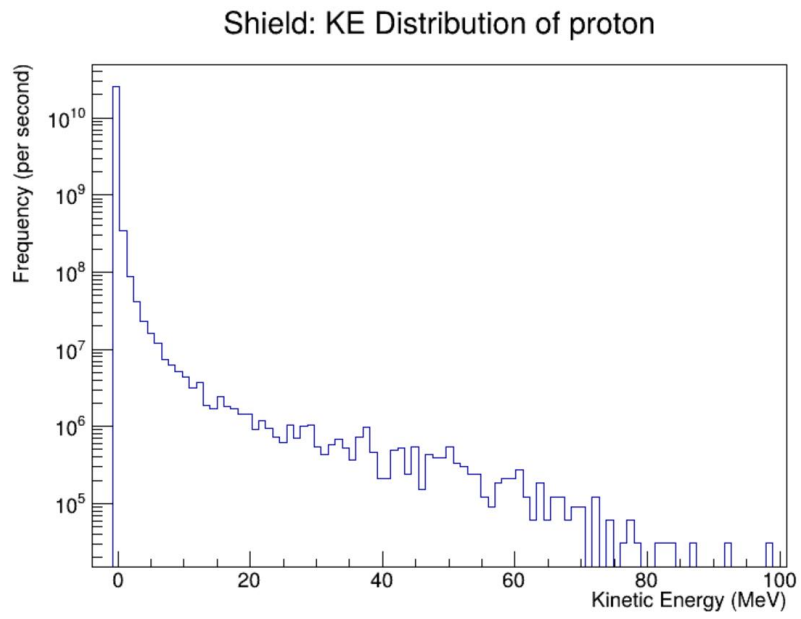


Figure 5.9: Shield proton KE distribution.

### 5.3 InnerBox

Over 150 days, the neutron flux (per  $\text{cm}^2$ ) just inside the Shield is measured by the InnerBox (a monitor type HitContainer) is:  $4.89\text{e}+10 \pm 5\text{e}+08$  per  $\text{cm}^2$

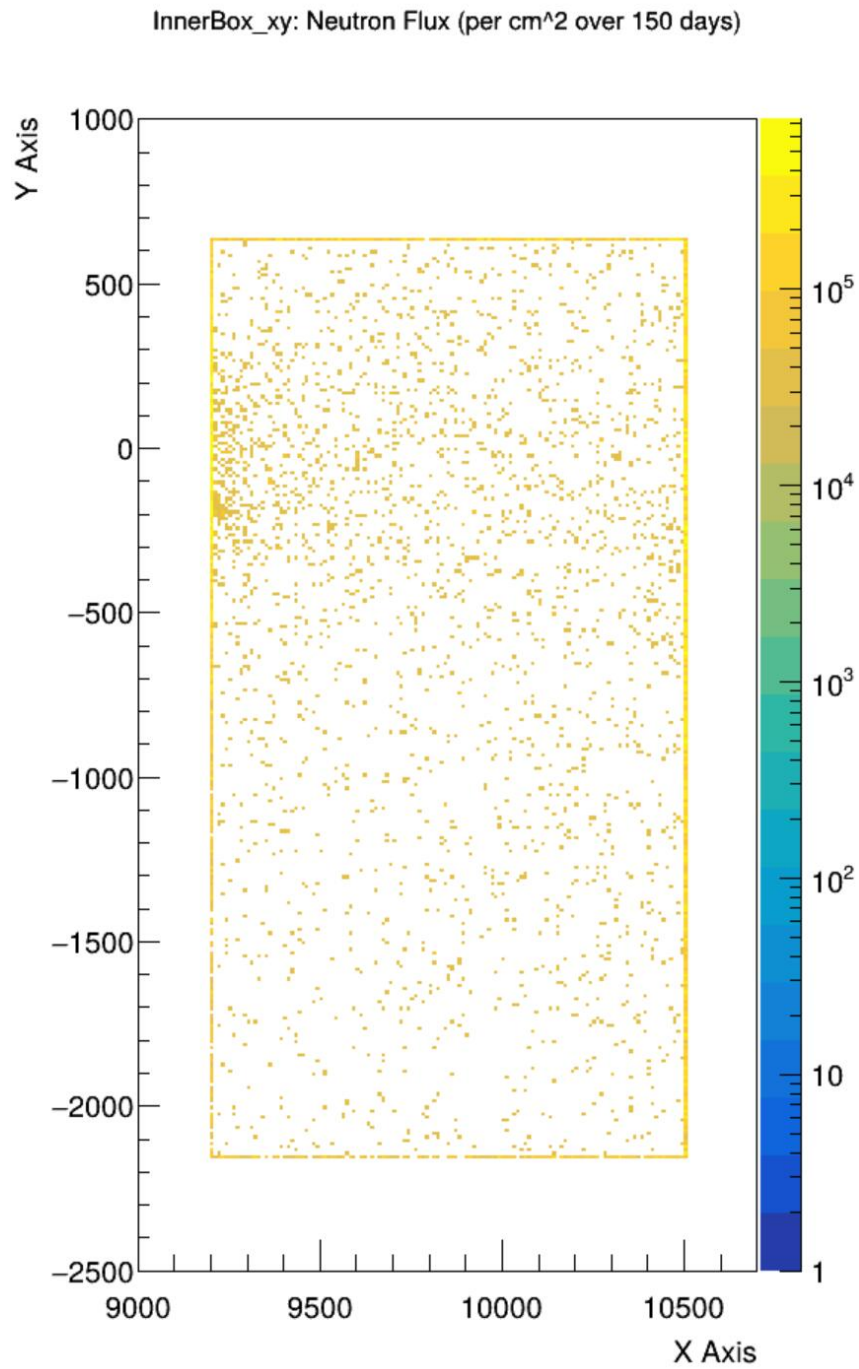


Figure 5.10: InnerBox neutron flux distribution in the X-Y plane.

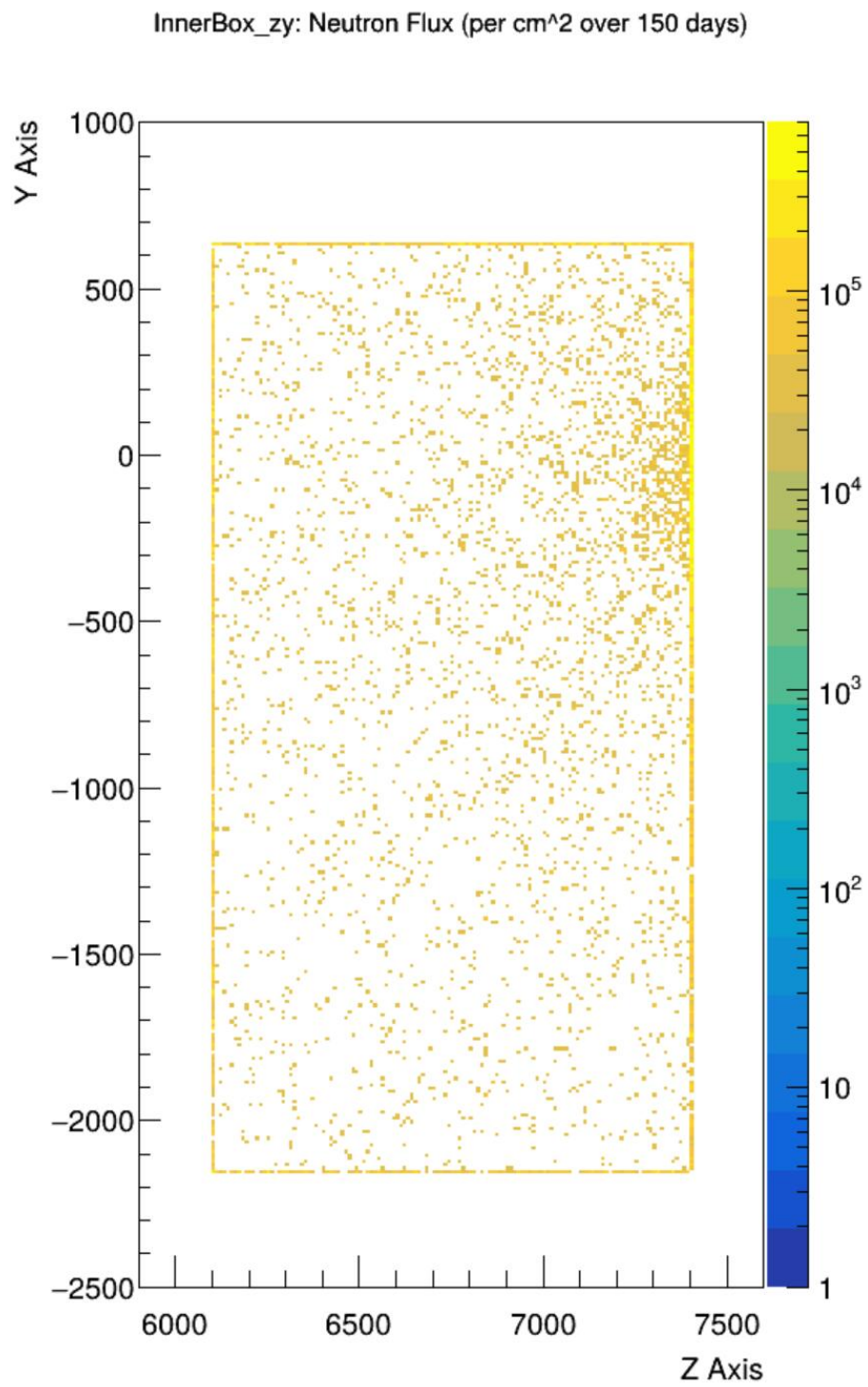


Figure 5.11: InnerBox neutron flux distribution in the Z-Y plane.

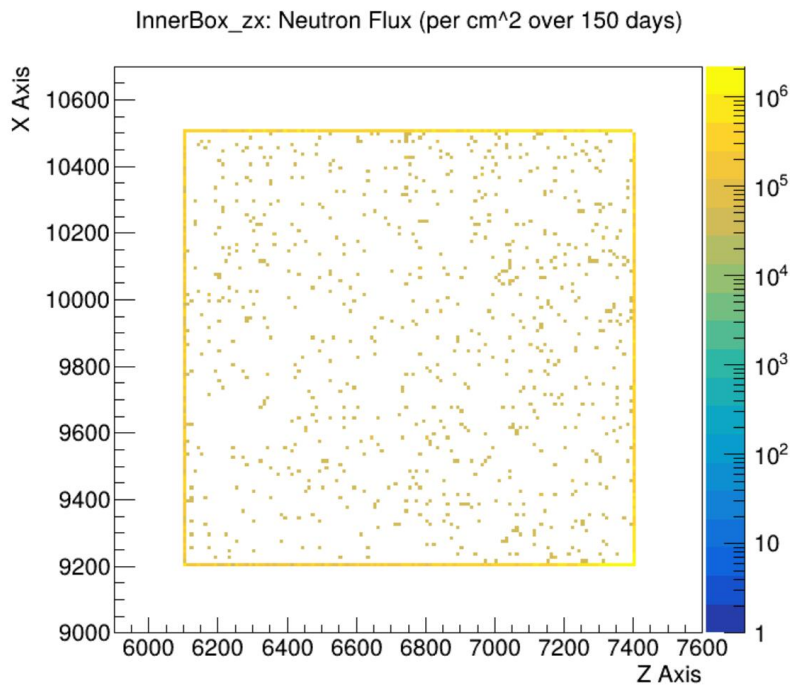


Figure 5.12: InnerBox neutron flux distribution in the Z-X plane.

And the KE distribution of neutrons encountered by InnerBox is below:

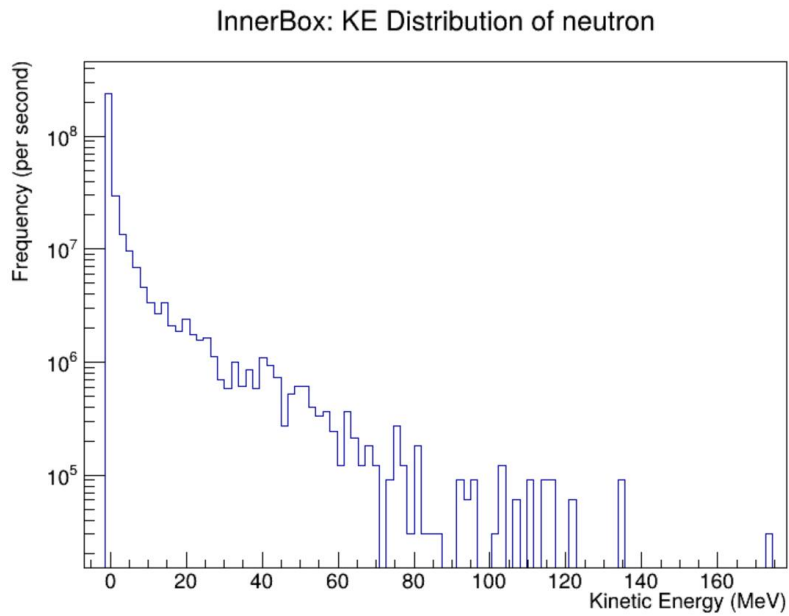


Figure 5.13: InnerBox neutron KE distribution.

## 5.4 SimpleBoards

Over 150 days, the radiation dose at each individual SimpleBoard is listed below in the tables. The relative position of each number corresponds to each SimpleBoard. The SimpleBoards closest to the beamline receive the most radiation, which aligns with the observation of the Shield.

Simple Board Layer 0 (Gy)		
$263 \pm 3$	$446 \pm 5$	$36 \pm 4$
$300 \pm 3$	$519 \pm 5$	$442 \pm 5$
$41.1 \pm 0.9$	$71 \pm 2$	$95 \pm 2$
$16.1 \pm 0.5$	$13.2 \pm 0.4$	$25.9 \pm 0.8$
$8.9 \pm 0.4$	$10.6 \pm 0.4$	$13.8 \pm 0.5$

Table 5.1: Radiation Dose on Simple Board Layer 0 (Gy) over 150 days.

Simple Board Layer 1 (Gy)		
$67 \pm 1$	$143 \pm 2$	$214 \pm 3$
$69 \pm 1$	$130 \pm 2$	$191 \pm 3$
$26.2 \pm 0.6$	$47 \pm 1$	$60 \pm 1$
$10.9 \pm 0.4$	$16.3 \pm 0.5$	$19.2 \pm 0.6$
$5.2 \pm 0.2$	$9.4 \pm 0.4$	$14.0 \pm 0.5$

Table 5.2: Radiation Dose on Simple Board Layer 1 (Gy) over 150 days.

Simple Board Layer 2 (Gy)		
$33.9 \pm 0.8$	$63 \pm 1$	$97 \pm 2$
$30.2 \pm 0.7$	$54 \pm 1$	$81 \pm 1$
$19.9 \pm 0.5$	$33.9 \pm 0.8$	$40.4 \pm 0.9$
$9.8 \pm 0.3$	$17.7 \pm 0.5$	$20.0 \pm 0.6$
$8.4 \pm 0.3$	$8.7 \pm 0.3$	$11.4 \pm 0.4$

Table 5.3: Radiation Dose on Simple Board Layer 2 (Gy) over 150 days.

### 5.4.1 Radiation Dose Distribution

The radiation dose distributions of the three SimpleBoard layers are shown below. The parts closest to the beamline receives the most radiation.

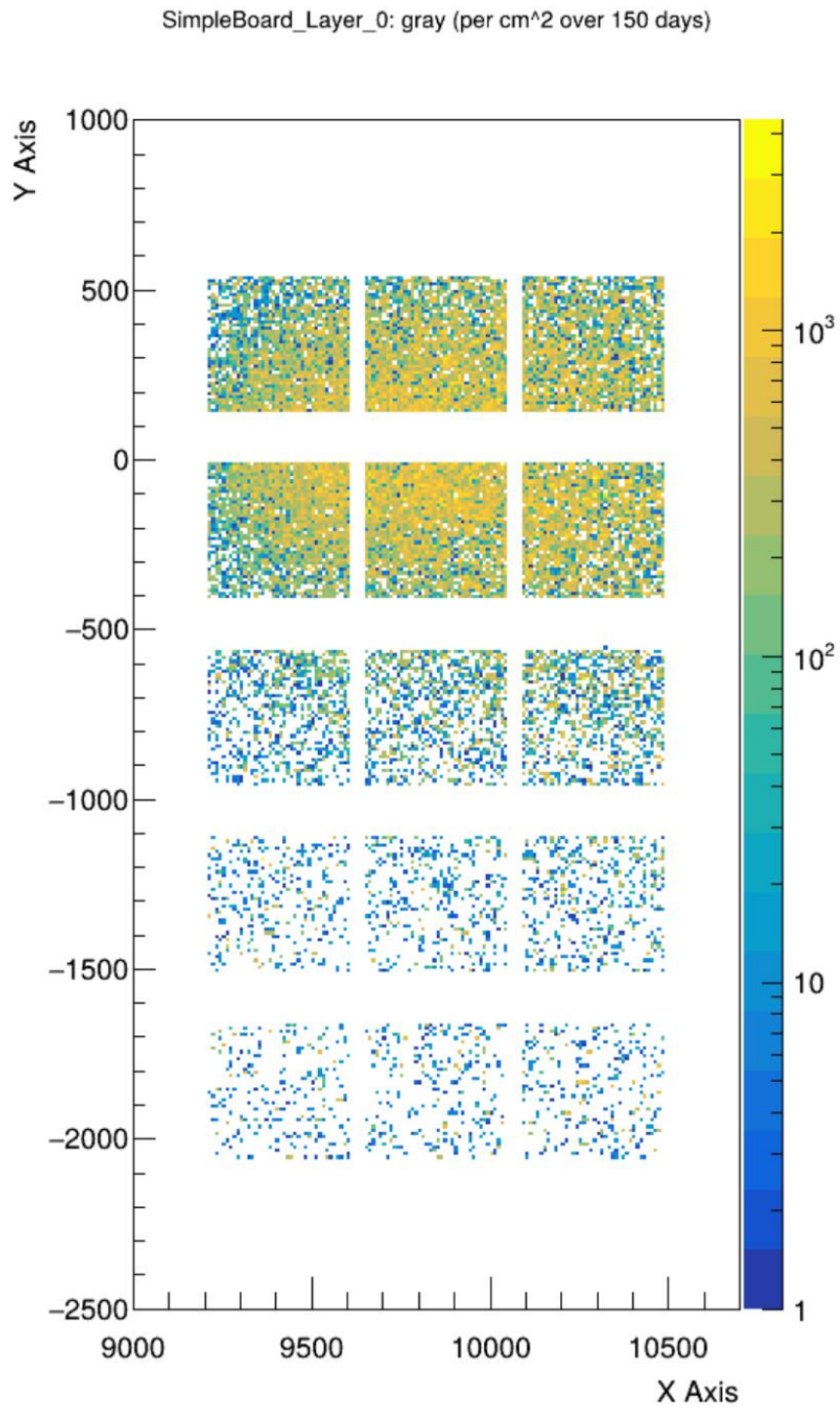


Figure 5.14: Simple Board Layer 0 radiation dose distribution.

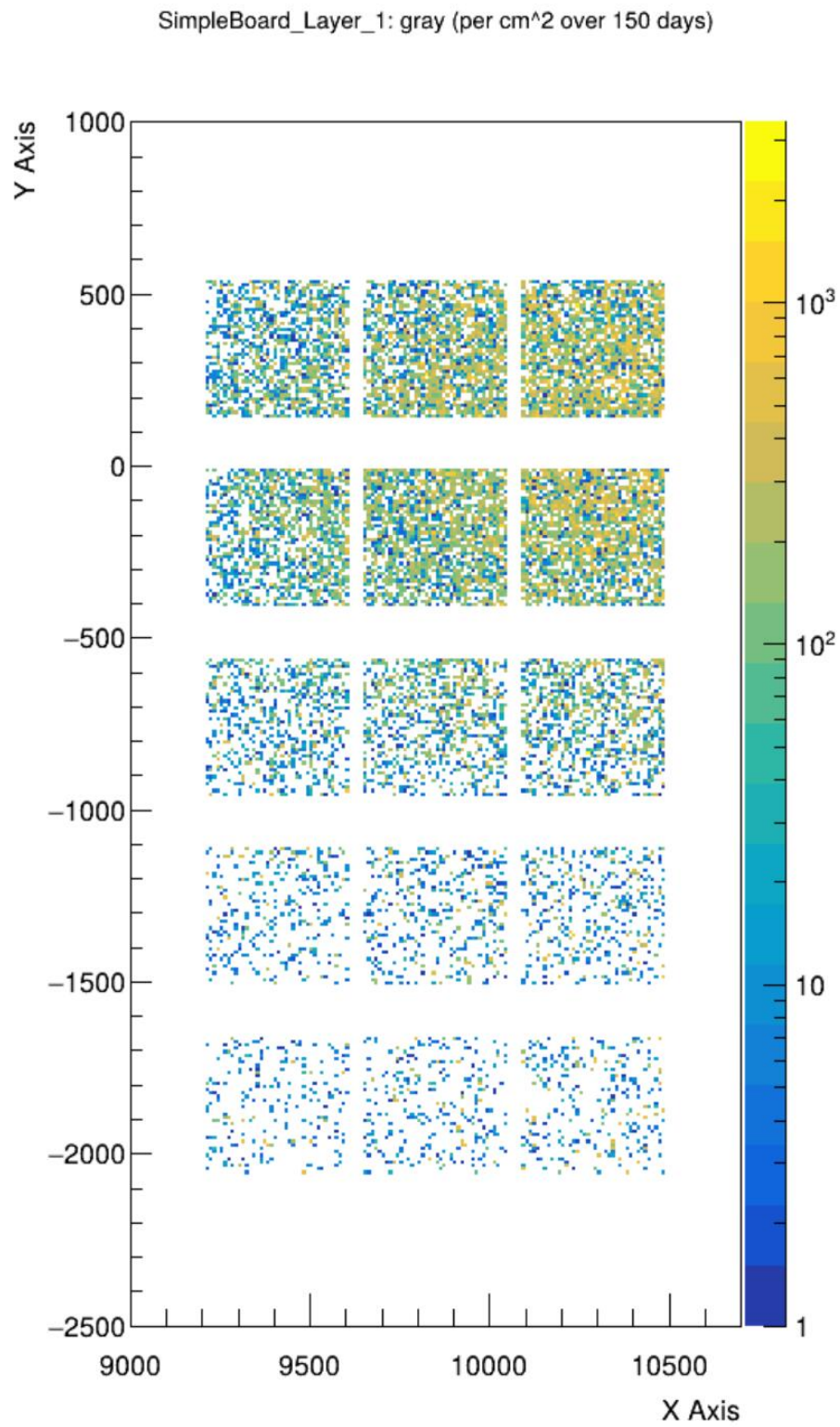


Figure 5.15: Simple Board Layer 1 radiation dose distribution.

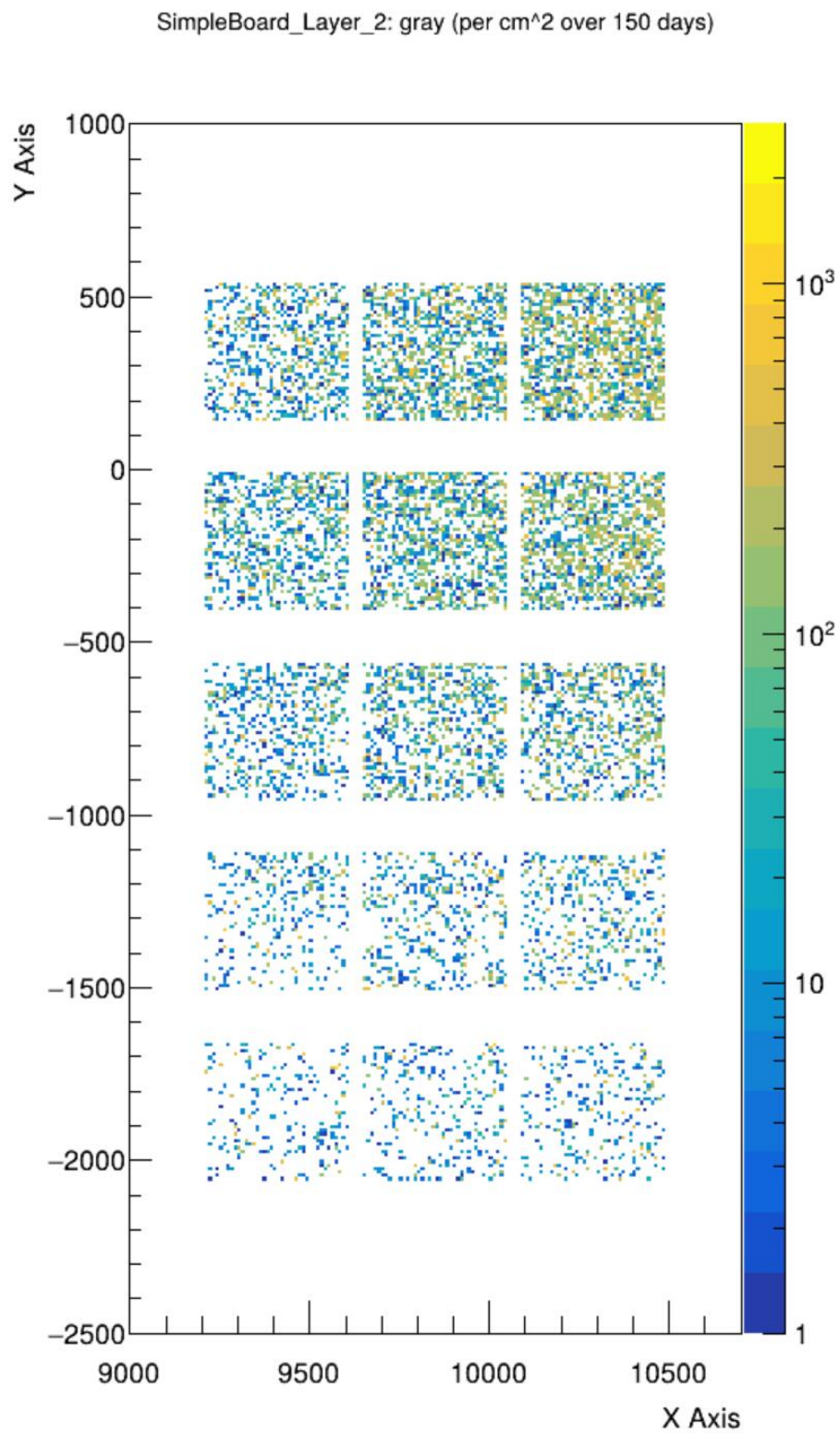


Figure 5.16: Simple Board Layer 2 radiation dose distribution.

### 5.4.2 Radiation Dose By PID And Their KE Distributions

#### Layer 0

The radiation dose by different particle types, and the KE distributions of e-, gamma and proton arriving at SimpleBoard Layer 0 are shown below:

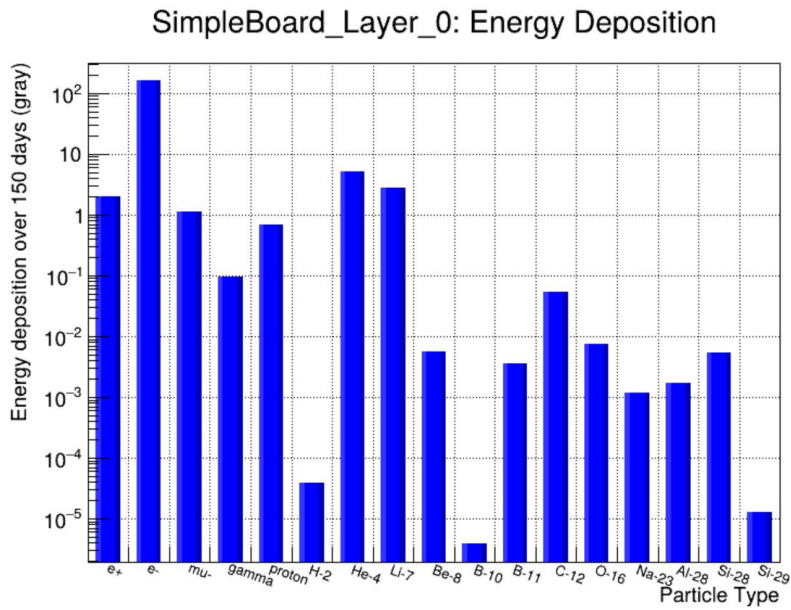


Figure 5.17: Simple Board Layer 0 radiation dose by PID.

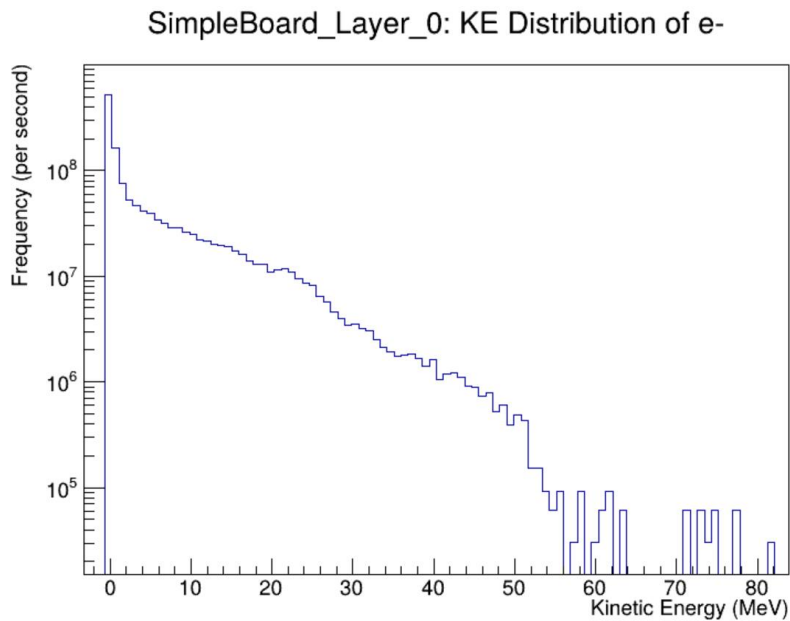


Figure 5.18: Simple Board Layer 0 e- KE distribution.

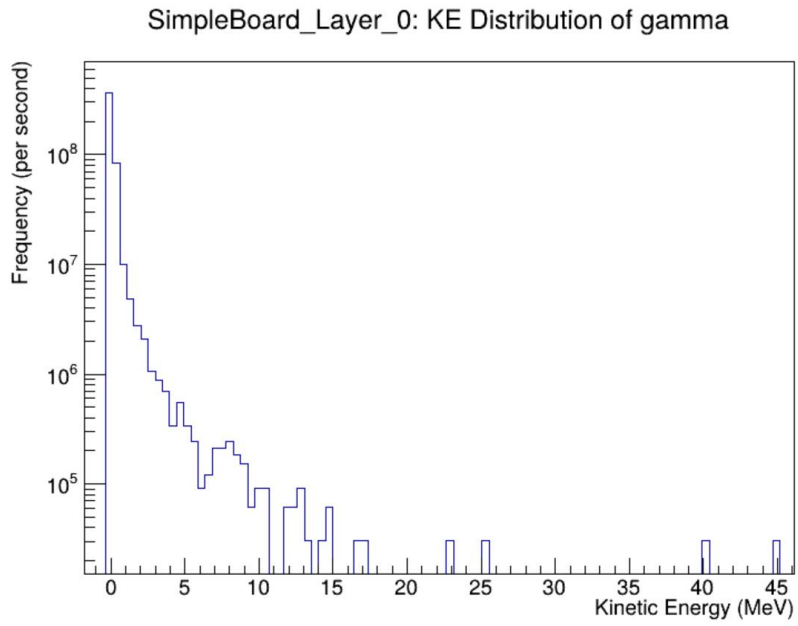


Figure 5.19: Simple Board Layer 0 gamma KE distribution.

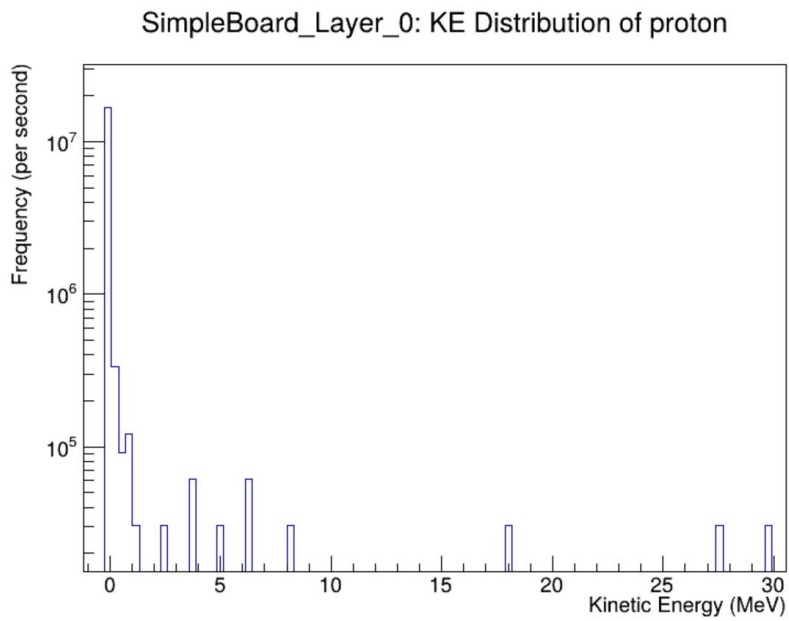


Figure 5.20: Simple Board Layer 0 proton KE distribution.

**Layer 1**

The radiation dose by different particle types, and the KE distributions of e-, gamma and proton arriving at SimpleBoard Layer 1 are shown below:

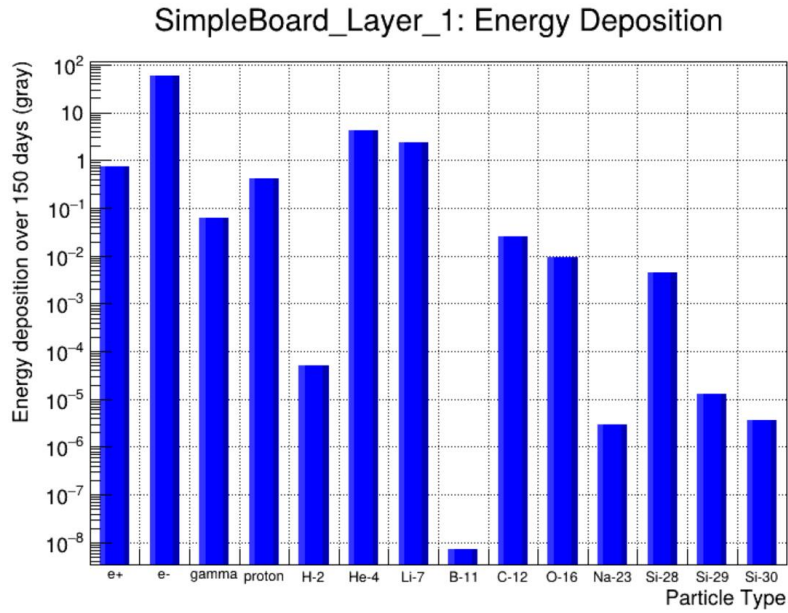


Figure 5.21: Simple Board Layer 1 radiation dose by PID.

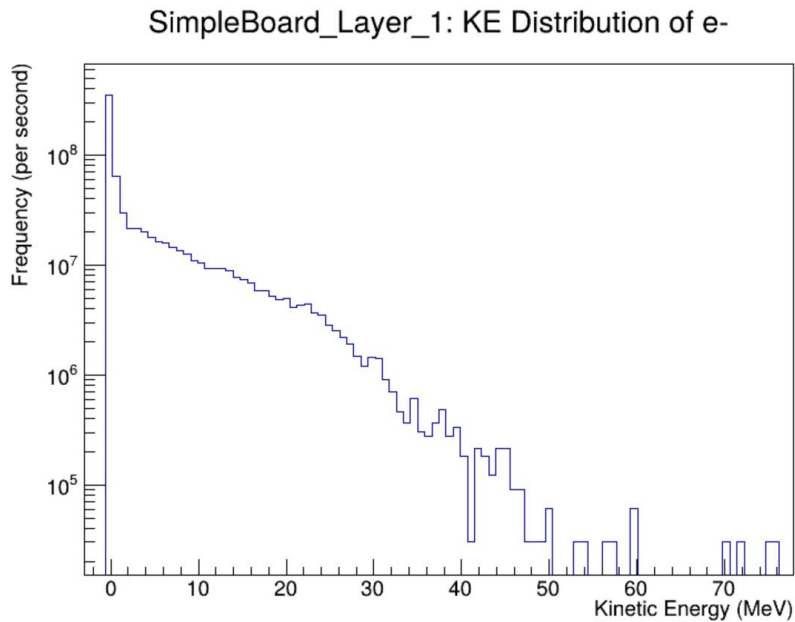


Figure 5.22: Simple Board Layer 1 e- KE distribution.

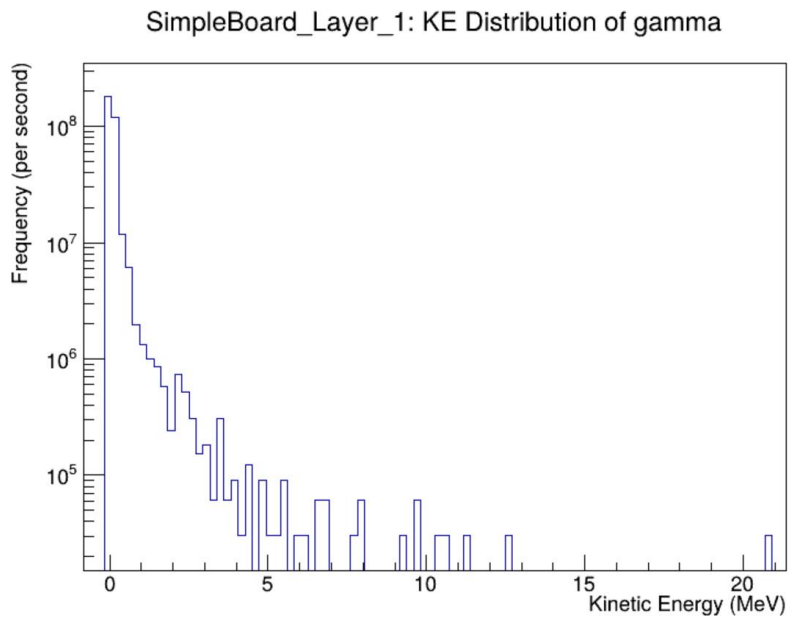


Figure 5.23: Simple Board Layer 1 gamma KE distribution.

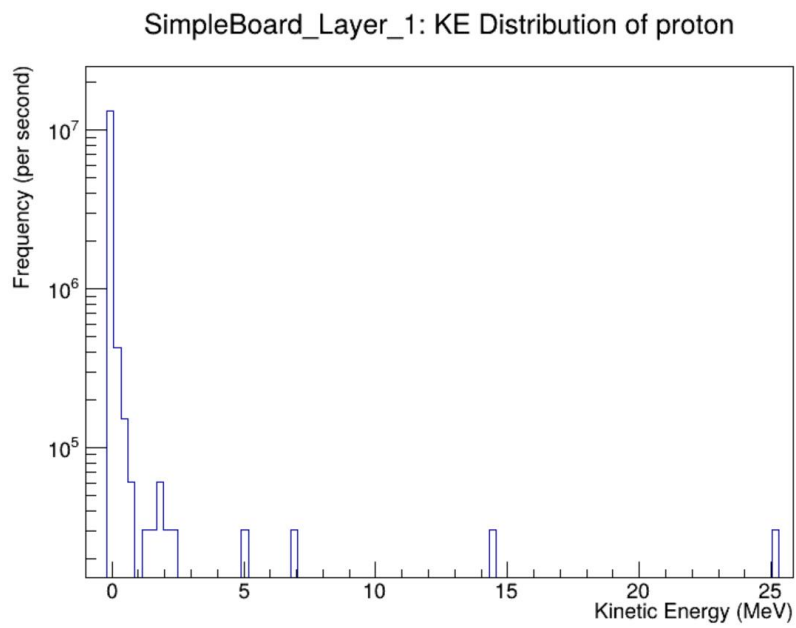


Figure 5.24: Simple Board Layer 1 proton KE distribution.

## Layer 2

The radiation dose by different particle types, and the KE distributions of e<sup>-</sup>, gamma and proton arriving at SimpleBoard Layer 2 are shown below:

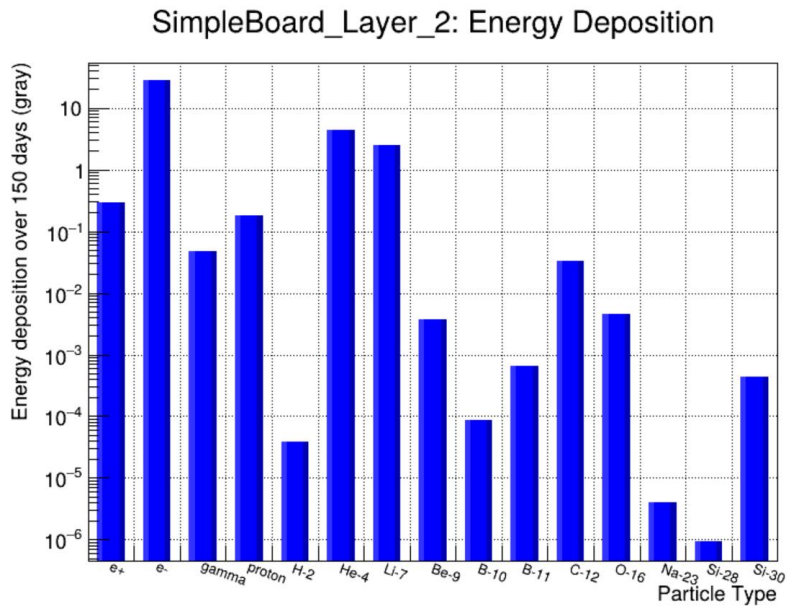


Figure 5.25: Simple Board Layer 2 radiation dose by PID.

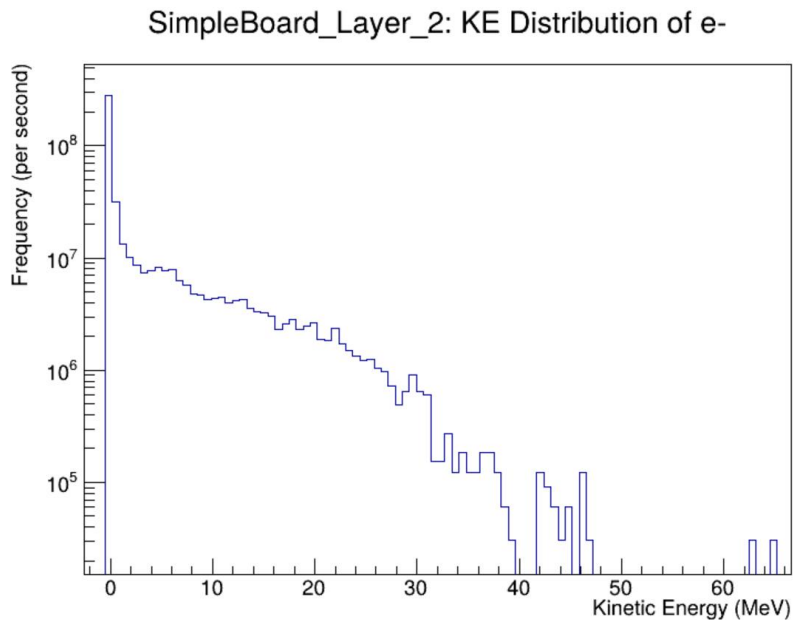


Figure 5.26: Simple Board Layer 2 e<sup>-</sup> KE distribution.

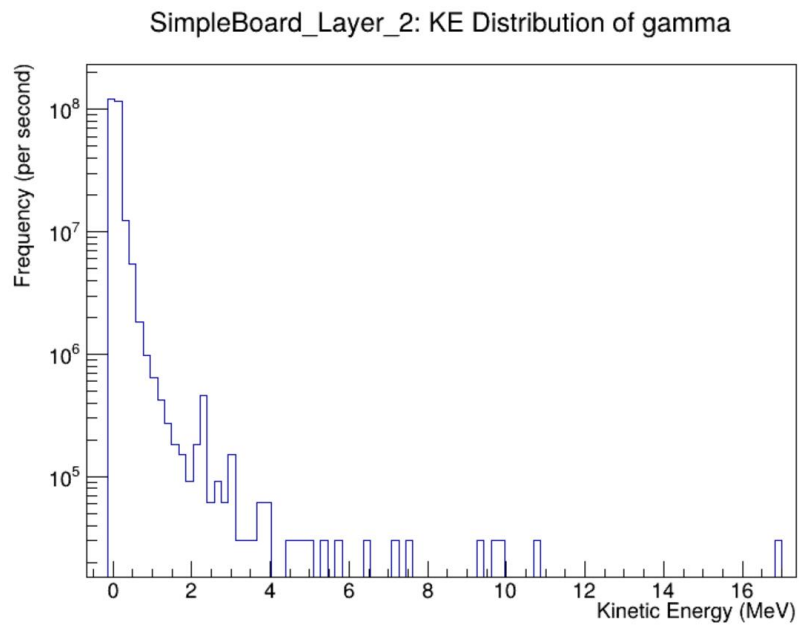


Figure 5.27: Simple Board Layer 2 gamma KE distribution.

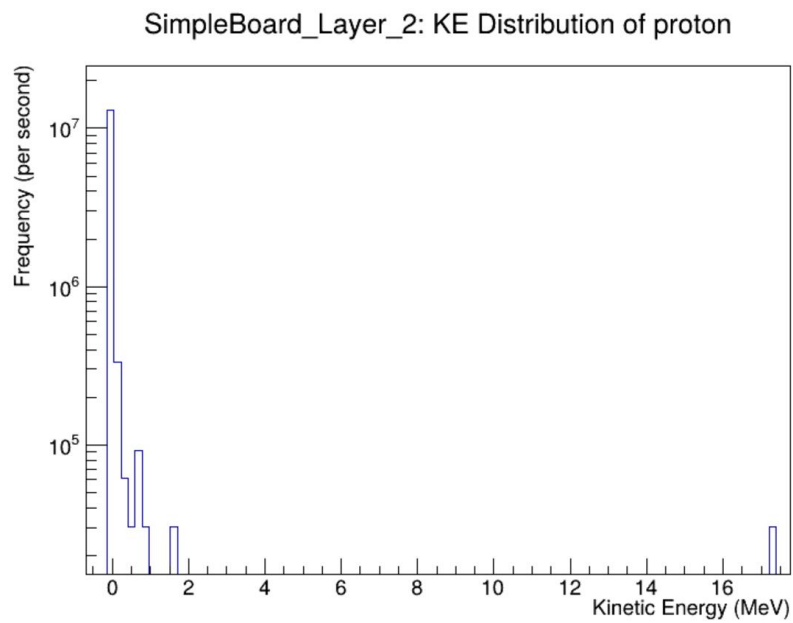


Figure 5.28: Simple Board Layer 2 proton KE distribution.

# 6

## Electronics Hut

### Contents

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<b>6.1 Geometry</b> . . . . .	<b>69</b>
<b>6.2 Radiation Dose</b> . . . . .	<b>70</b>
6.2.1 Radiation Dose Distribution . . . . .	70
6.2.2 Radiation Dose By PID And Their KE Distribution . . . . .	71
<b>6.3 Neutron Flux</b> . . . . .	<b>73</b>

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### 6.1 Geometry

The Electronics Hut is located at the end of the experiment hall. There are two HitContainers placed as the walls of the Hut, as shown in Fig. 6.1 to monitor the radiation and neutron levels:

1. ElecHutMonitor\_0: a  $10 \times 2.75 \times 0.1 \text{ m}^3$  polyethylene board with a mass of 2585 kg.
2. ElecHutMonitor\_1 : a thin layer of air of area  $10 \times 2.75 \text{ m}^2$ , which has the same area as ElecHutMonitor\_1 and is right in front of it.

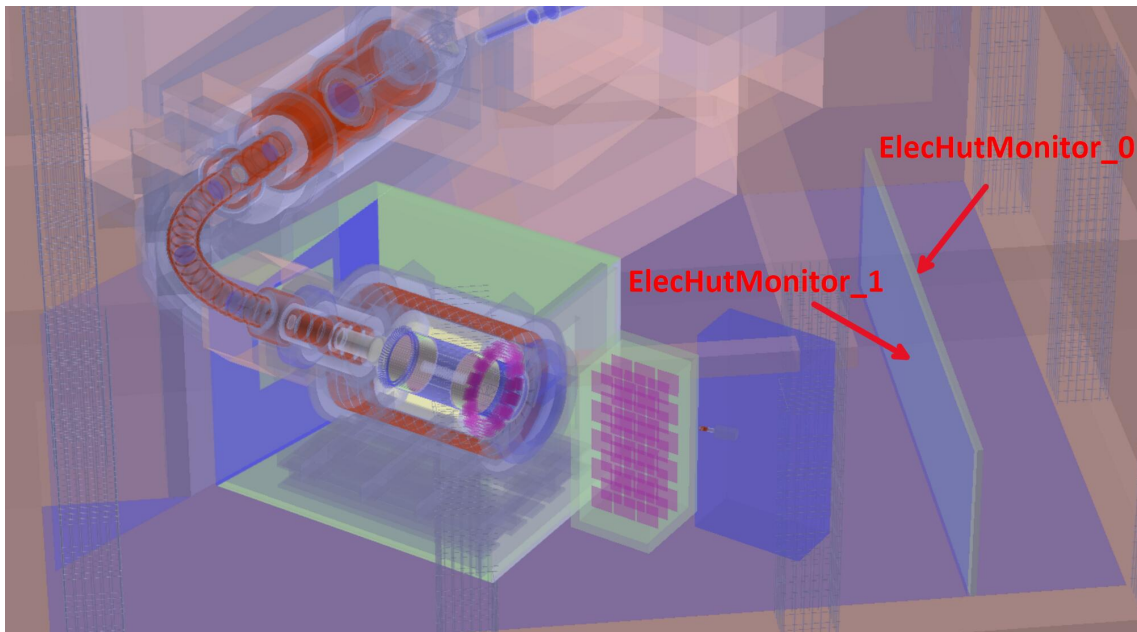


Figure 6.1: Electronics Hut geometry.

## 6.2 Radiation Dose

Over 150 days, the radiation dose of ElecHutMonitor\_0 is:  $3.513 \pm 0.003$  Gy

### 6.2.1 Radiation Dose Distribution

Below are the radiation dose distributions of the ElecHutMonitor\_0 in X-Y and Z-Y planes respectively. The side closer to the beamline receives most of the radiation.

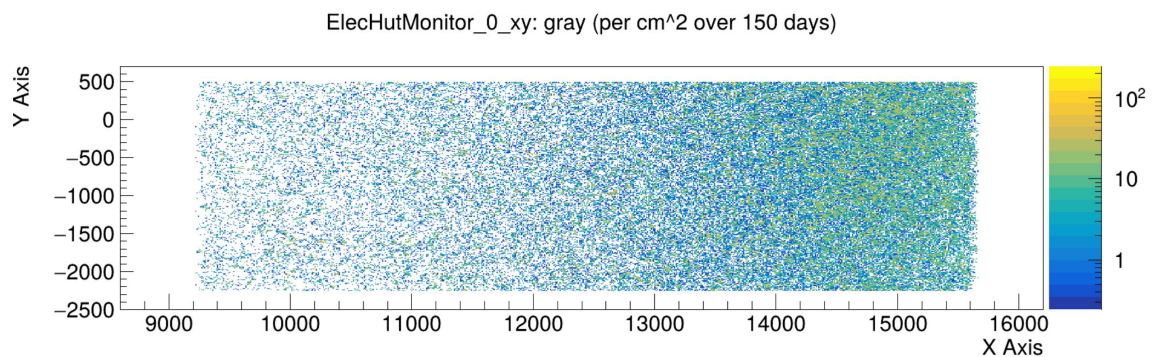


Figure 6.2: Electronics Hut radiation dose distribution in the X-Y plane.

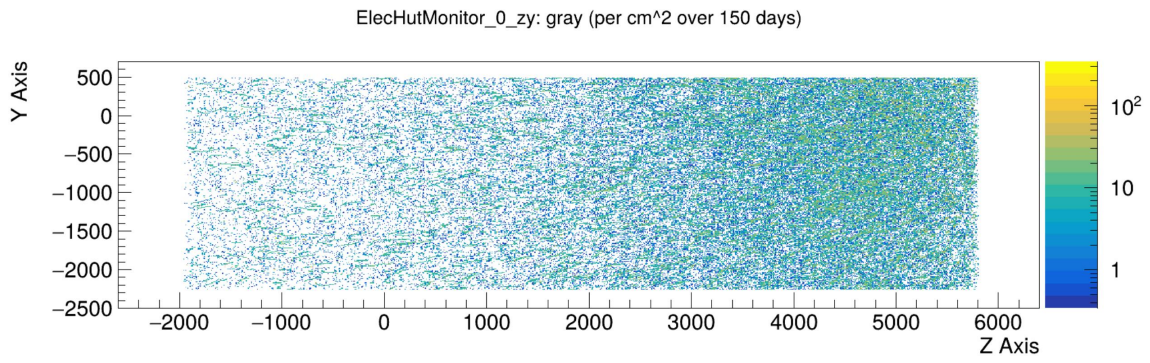


Figure 6.3: Electronics Hut radiation dose distribution in the Z-Y plane.

### 6.2.2 Radiation Dose By PID And Their KE Distribution

The radiation dose by different particle types, and the KE distributions of e-, gamma and proton arriving at ElecHutMonitor\_0 are shown below:

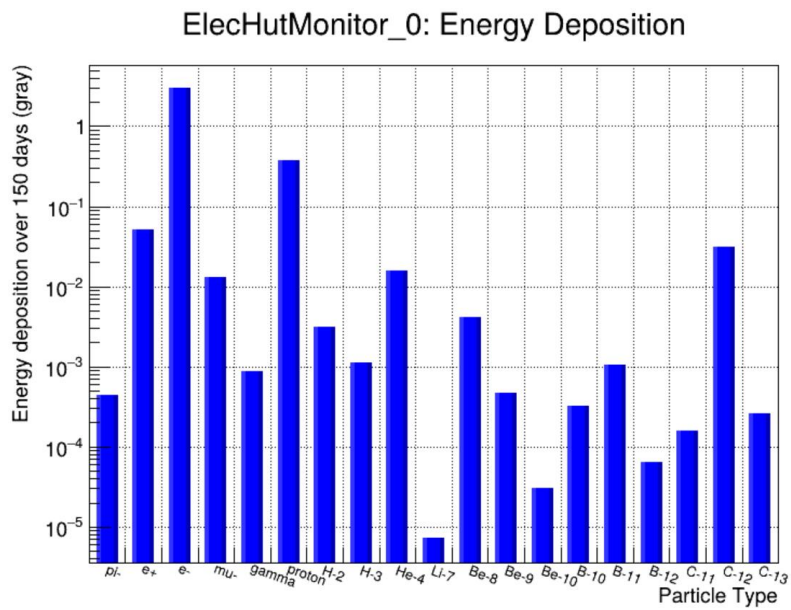


Figure 6.4: Electronics Hut radiation dose by PID.

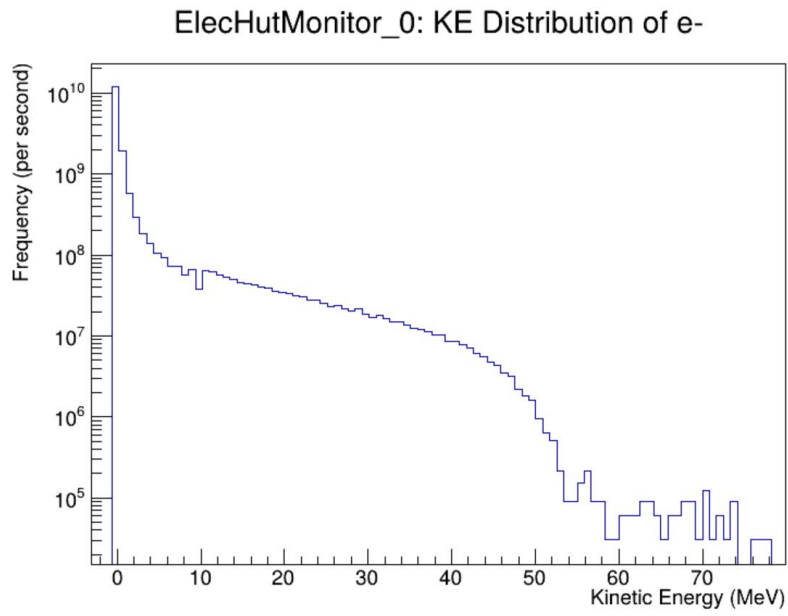


Figure 6.5: Electronics Hut e- KE distribution.

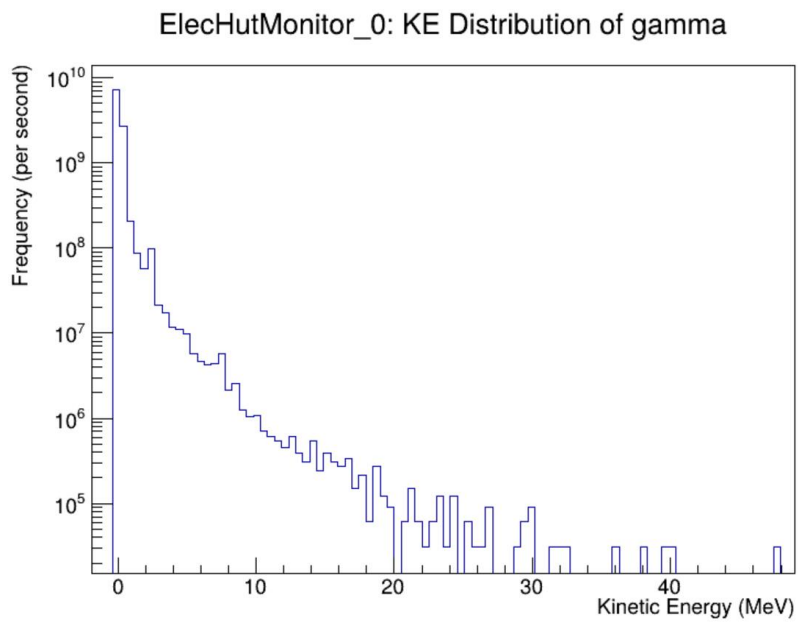


Figure 6.6: Electronics Hut gamma KE distribution.

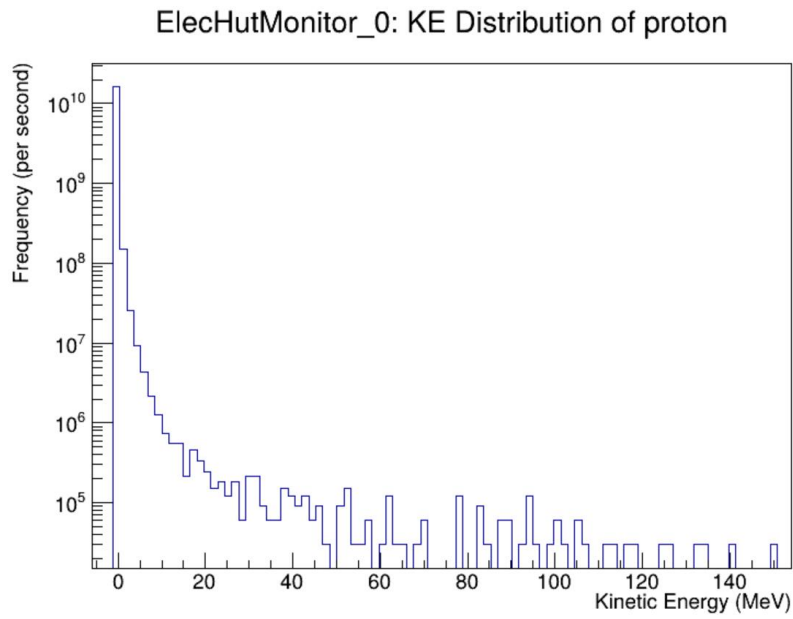


Figure 6.7: Electronics Hut proton KE distribution.

## 6.3 Neutron Flux

Below are the neutron flux distributions of the ElecHutMonitor\_1 in X-Y and Z-Y planes respectively. The side closer to the beamline receives most of the neutrons.

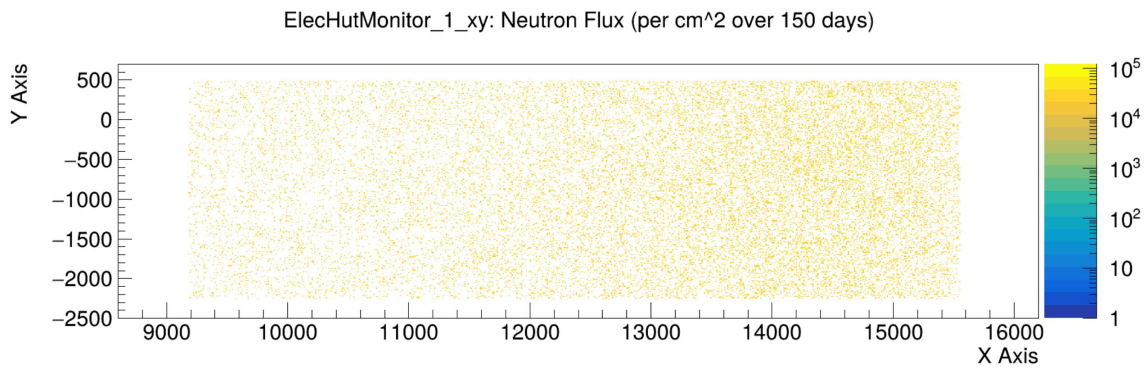


Figure 6.8: Electronics Hut neutron flux distribution in the X-Y plane.

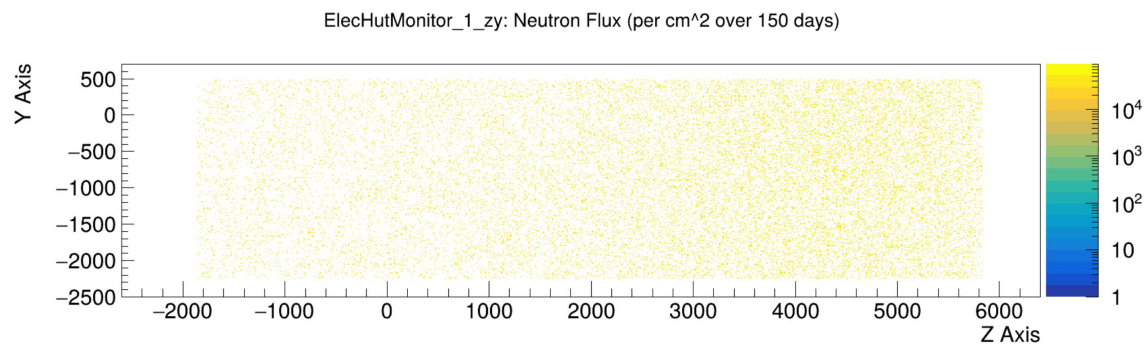


Figure 6.9: Electronics Hut neutron flux distribution in the Z-Y plane.

And the KE distribution of neutrons arriving at ElecHutMonitor\_1 is shown below.

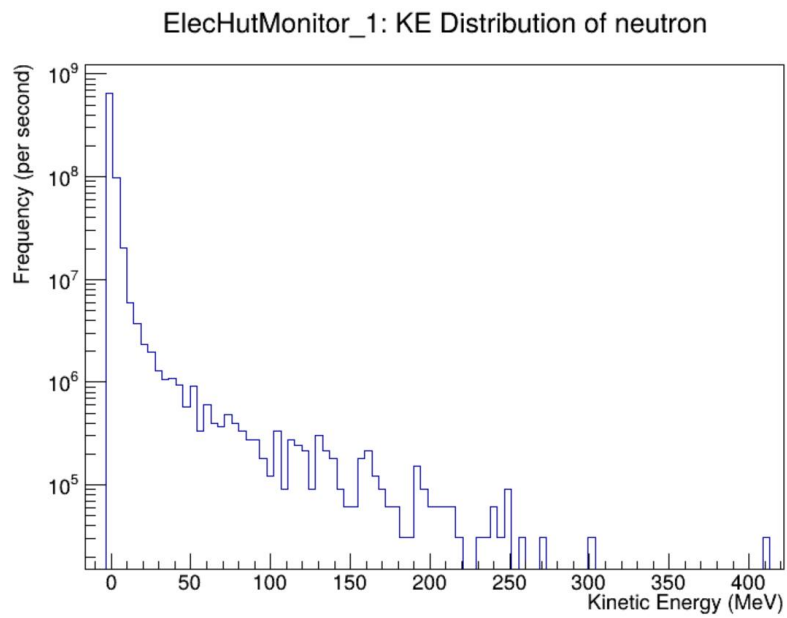


Figure 6.10: Electronics Hut neutron KE distribution.

# Final Words

The radiation dose and neutron flux are concentrated around the beamline. It is therefore recommended to move electronics away from the beamline or to add extra shielding between the beamline and the electronics to prevent severe radiation damage, wherever necessary.

The macro file of making the 2D histograms can be found on KEKcc at:

```
/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Segment_RECBE/draw_plots_1.C
```

The 1D histograms are made using:

```
/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Segment_RECBE/draw_hist_1.C
```

The readings of the overall radiation dose and neutron flux are obtained using:

```
/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Segment_RECBE/myMacro.C
```

(Above are the ones with RECBE type set to be Segment. The corresponding ones for Monitor RECBE can be found in

```
/gpfs/group/had/muon/laigui/script_new/run_0/downstream/Macro/Monitor_RECBE/
```

with the same file name)

I do hope that people reading this note will find it helpful.

