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Residual Nuclide Analysis in a Beamline of a 100-MeV Proton Linac

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1. Introduction

Korea multi-purpose accelerator complex (KOMAC) has been operating with 20 MeV and 100 MeV beam lines, starting in 2013 and provided a proton beam for various fields, including research, medical and industrial applications. The proton beam is generated in the ion source and accelerated to 3 MeV in the RFQ. Through DTL20 and DTL100, proton beam is accelerated up to 100 MeV and curved to target room by using the bending magnets. HPGe detector (High purity germanium detector) is widely used for radiation measurements and enables analysis of radionuclide by measuring the gamma ray energy spectrum detected with the associated software (Genie2000) [1]. In addition, it is easy to detect radiation in a particular location by adjusting the direction of detector window therefore it is suitable for measuring radiation near the bending magnet at the end of the linac. In this experiment, the gamma ray energy spectrum near the bending magnet of 100 MeV beamline was measured by using the HPGe detector. Based on the measured gamma ray spectrum, the associated nuclides were analyzed.

2. Experiment and Results

The HPGe detector is placed 120 cm away from the bending magnet at the 100 MeV beamline and the energy calibration was performed prior to the experiment by using the ^{60}Co of radioactive standard source. Figure.1 shows a set of detector near the bending magnet for radiation measurement.

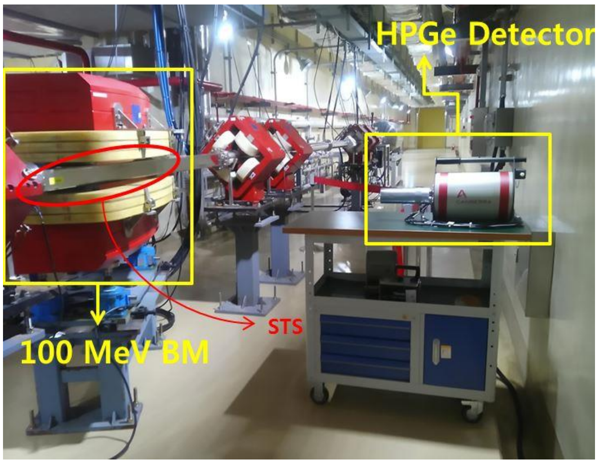

Fig. 1. Set of HPGe detector and equipment near the bending magnet of 100-MeV beamline.

The live time was set to 300 s during the calibration.

Figure.2 shows the energy spectrum obtained by the software (Genie2000) of the HPGe detector. As a result of the analysis of the energy spectrum, several isotopes such as ^{51}Cr, ^{57}Co, ^{58}Co, ^{54}Mn, ^{56}Mn, and ^{40}K were identified. A peak at around 511 keV is considered as positron annihilation peak and a peak at 1461 keV is from ^{40}K, which is a natural radioactive isotope. In addition, the energy peaks of ^{60}Co (1173.2 keV, 1223.5 keV) were excluded from the analysis because it is used for the standard source of energy calibration [2].

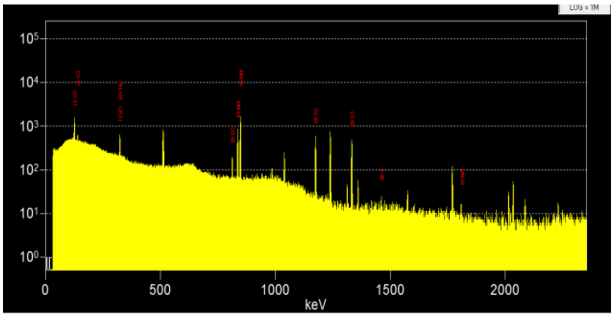

Fig. 2. Measured Energy spectrum by HPGe detector.

Because the spectrum contains several peaks which are not identified by default database in the Genie2000, MCNP simulation was carried out. In the simulation, the target material was stainless steel because it is material used for the beamline pipe. As a result, the ^{48}V and ^{56}Co were additionally found. Comparison of the isotopes found by the simulation with the experimental results from HPGe measurements is summarized in Table 1. In Table 1, the stable nuclides and short half-life radionuclides were excluded. The results show reasonable agreement between the simulation and the measurement, which supports the fact that the isotopes were generated by the beam loss at the beam pipe. The radionuclides found in the above two methods were checked on the energy spectrum, as shown in Fig. 3 [3].

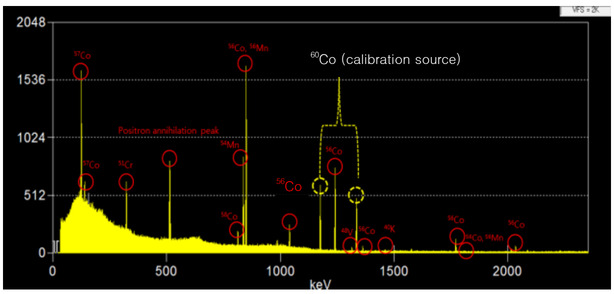

Fig. 3. Peak search results of spectrum

Table 1. Summary of radionuclide

No.	Energy [keV]	HPGe detector	MCNP	Remark
1	121.57	^{57}Co	^{57}Co	
2	136.1	^{57}Co	^{57}Co	
3	319.88	^{51}Cr	^{51}Cr	
4	510.87			Positron annihilation peak
5	810.81	^{58}Co	^{58}Co	
6	834.89	^{54}Mn	^{54}Mn	
7	846.82	^{56}Mn	^{56}Mn, ^{56}Co	
8	1038		^{56}Co	
9	1238.25		^{56}Co	
10	1312.06		^{48}V	
11	1360.25		^{56}Co	
12	1461.18	^{40}K		Natural radioactivity nuclide
13	1771.48		^{56}Co	
14	1811.11		^{56}Mn, ^{56}Co	
15	2035.02		^{56}Co	

3. Conclusion

HPGe detector was used to measure the gamma ray spectrum near the end of 100-MeV proton linac at KOMAC to analyze the residual radionuclides in the beamline and several isotopes were identified.

Measurement results were compared with the MCNP simulation with a proton beam on stainless steel target and shows reasonable agreement. From the measurement and the simulation results, we may conclude that the isotopes were generated by the proton beam loss in the stainless steel beam pipe.

Acknowledgements

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REFERENCES

[1] Radiation Detection and Measurement, 2nd, Glenn F. Knoll, Professor of Nuclear Engineering The University of Michigan Ann Arbor, Michigan
[2] Gamma Ray Spectrometry, Nafaa Reguihui, 2006
[3] National Nuclear Data Center (www.nndc.bnl.gov)