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First report on the inventory of radionuclides in 1.4 GeV proton irradiated thick Lead-Bismuth Eutectic (LBE) target

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In the planning of the EURISOL (European Isotope Separation On-Line) facility at CERN, the use of liquid Hg or Lead Bismuth Eutectic (LBE) was proposed as proton to neutron converter. The study on the impact of high energy protons (˜1-1.5 GeV) on the liquid Hg has already been carried out; however, handling of tons of liquid Hg has some practical difficulty, which may be overcome using LBE target. Hence, it is important to have a detailed knowledge on the production of radioisotopes in the LBE targets induced by the impact of high energy (1.4 GeV) protons. A target prototype phase, the so-called LIEBE (Liquid lEad Bismuth eutectic loop target for EURISOL) project with participation of CEA, CERN, IPUL, PSI, SCK-CEN and SINP is ongoing and foresees the operation of a direct LBE target at ISOLDE in 2015. In this framework, we have started a systematic program to investigate the impact of the target thickness on the production of radioisotopes, and more particularly addressing the highly radiotoxic Po and At known to occur through secondary particle reaction channels. Eight cylindrical LBE targets having a fixed diameter of 6 mm with varying lengths from 1 to 8 mm weighing between 0.43 and 2.83 g were irradiated by 1-3 pulse of 1.4 GeV protons using the rabbit irradiation facility at CERN-ISOLDE. The intensity of the proton beam was 3.18×1012 protons/pulse for 1 and 2 mm length target and 3.22×1013 protons/pulse for the rest. We have analyzed two samples (2mm and 8mm) till date.

The impact of 1.4 GeV protons produced radionuclides of mainly 4th, 5th and 6thperiod elements of the Periodic Table. Most of the radioisotopes identified in sample length 2 mm are also present in sample length 8 mm. Additionally some more radioisotope production is seen in sample length 8 mm. The radioisotopes identified in both the samples ranged from 7Be (53.12 d) to 207Po (5.8 h). The list of produced radionuclides includes 206,207Po, 203-207Bi, 200,201,203Pb and other elements. The total number of radioisotopes identified in sample length 2 and 8 mm are 54 and 103 respectively. Apart from this, there are some radionuclides in both the samples which could not be confirmed due to overlap of photo-peaks and similar half life for different radionuclides. The modes of production of the radionuclides are mainly fission, electron capture decay of the fission products, fragmentation, spallation, etc. Also, typical reactions can be found in thick targets like 209Bi(p, pi-xn)210-xPo or 206Pb(alpha,xn)210-xPo. The highest activity observed in sample length 2 was for 172Lu (6.70 d) (˜610 Bq) and in 8 mm for 205Bi (15.31 d) (˜2800 Bq) at End Of Beam (EOB) in the experimental condition. It has been difficult to calculate the activity of short lived radionuclides, because of high Compton background in the initial spectra.

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