New gas target system for ^{83}Rb production

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Introduction

Short-lived isomer ^{83m}Kr ($T_{½}$ = 1.83 h) is an ideal calibration source in several low-energy experiments like or KATRIN (determining the neutrino rest mass, monitoring high voltage stability and investigation of the main spectrometer properties) or XENON (detection of the dark matter).
The isomer ^{83m}Kr is formed by decay of ^{83}Rb ($T_{½}$ = 86.2 d) that can be produced predominantly via the reaction ^{84}Kr(p,2n)^{83}Rb by irradiation of ^{nat}Kr (57 % abundance of ^{84}Kr).
The design and construction of the new gas target for effective production of radionuclide ^{83}Rb as well as target processing will be shortly described.

Material and Methods

For the target design, we selected the following criteria: minimizing activation of target components; efficient cooling system allowing higher beam currents; easy handling; high life-time of the target chamber (low impact of the irradiation and radionuclide separation process on the target chamber surface and ^{83}Rb recovery).

The target consists of three parts:

1. Water cooled aluminium (alloy EN 6082) mechanical interface for easy connection of the target to the beam line. It also serves as a beam collimator (diameter 9 mm).
2. Holder of He-cooled foils (vacuum separation foil – Havar 0.025 mm, target body window – Ti 0.1 mm).
3. Aluminium (alloy EN 6082) water cooled target body with 150mm long cone-shaped target chamber of the volume 27.1 ml. Internal surface of the chamber is nickel-coated.

FIGURE 1. Gas target for ^{83}Rb production

The target filled with natural Kr of purity 0.9999 and absolute pressure 13 bar was irradiated on the external beam of the isochronous cyclotron U-120M of the NPI AS CR. The proton beam energy was set so that it is decreased after degradation in the separation foils to 25.6 MeV. Beam energy loss in the natural Kr gas filling is 9.6 MeV. The target was tested up to 25 μA beam current.
After irradiation, the target is left for a week to let the short-lived activation products to decay. Then, ^{83}Rb is washed out from the target walls by two portions of freshly prepared de-ionized water, target is rinsed by high-purity ethanol and dried. The two portions of ^{83}Rb aqueous solution are then connected and activity and radionuclidic purity of the product is determined via γ-spectrometry (HPGe detector). Large-distance sample-detector measurements of the target prior and after the separation are used in order to determine recovery of ^{83}Rb.

Results and Conclusion

The new gas target for routine production of ^{83}Rb was successfully designed, tested and implemented for regular ^{83}Rb production. Six-hour irradiation with 15 μA proton beam resulted repeatedly in ca 300 MBq of ^{83}Rb (EOB). Besides ^{83}Rb, we identified in the separated product also ^{84}Rb ($T_{½}$ = 32.82 d) at levels ca 31 % of the ^{83}Rb activity (EOB) and ^{86}Rb ($T_{½}$ = 18.631 d) at levels ca 8 % of the ^{83}Rb activity (EOB). Both radionuclidic impurities do not disturb the use of ^{83}Rb, since none of them emanates any radioactive krypton isotope. Moreover, their relative content decreases in time. Rubidium isotopes are recovered from the target almost quantitatively (98–99 %).

References

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