International Workshop on future research program with the high power Cyclotron of SPES-LNL

Contribution ID: **6** Type: **not specified**

Production at SPES of a 94Nb radioactive source for studying the quenching of the weak interaction axial-vector coupling constant

The present proposal aims at the production of a solid state 94Nb beta-emitting radioactive source via the proton irradiation of a $94ZrO_2$ thin film (~200 μg/〖cm〗^{2} areal density) evaporated onto a multilayer graphene (MLG) sheet, via 94Zr(p,n)94Nb reaction at 35 MeV incident energy. The source will be exposed to an array of silicon drift detectors (SDD) in order to study the shapes of the beta decay spectrum.
94Nb is an odd-odd nucleus with ground state spin-parity J^π (GS)=6^+. It decays by β^- emission, with an half-life $T_{(1/2)}=2.03\,10^4$ y, to the J^π (E^x=1573.7 keV)=4^+ excited state of 94Mo. This non-unique transition generates a spectrum with an endpoint set at 471.5 keV. No measurement of this spectrum has been performed so far, although this decay is suggested as one of the best cases to probe sensitivity of the axial-vector coupling constant g_A of the weak interaction to the nuclear medium, with major consequences in present and future search of neutrinoless double beta decay. A measurement of this spectrum is therefore highly desirable.
Since no commercial sources of 94Nb is available, the custom production in a laboratory facility is mandatory. The sizable cross section for the (p,n) reaction (~30 mb at E_p=35 MeV) and the very high intensity for the proton beam of the LNL SPES facility offer a unique possibility to build by irradiation of $94ZrO_2$ targets a thin 94Nb source, thus less affected by self-absorption. Assuming an areal density of about 200 μg/cm^2 and a beam current of about 300 μA, the resulting activity will grow as about 6 Bq/day pointing to about 20 Bq after three days of irradiation.
Challenging aspects connected with the removal of heat generated by the beam target interaction are considered. Indeed, an efficient heat dissipation is guaranteed by the high thermal conductivity of the MLG backing sheet.
Another issue is connected to the target isotopes different from the 94Zr. Although the $94ZrO_2$ target is based on isotopically enriched material, the 94Zr content is about 85-90% for affordable costs of the raw material. An insight on this problem shows that the main challenge comes from 91Nb, which decays by electron capture with an half-life $T_{(1/2)}=6.80\,10^2$ y, thus potentially generating a 91Nb activity comparable to the 94Nb one. Nevertheless, the decay products from 91Nb are Auger electrons with 2.02 keV and 13.4 keV, the latter of which may be visible just above the detector threshold (about 10 keV).
In conclusion, a promising technique to produce for the first time a 94Nb radioactive source is at reach, using the very intense proton beam from LNL SPES facility. For the study of the sensitivity of the axial-vector coupling constant gA of the weak interaction to the nuclear medium, which requires the measurement of the beta decay full spectrum with high energy resolution and very low systematic uncertainties, a source activity of more than 20 Bq would be ideal, which in turn means three days irradiation time.

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Session Classification: Fourth Session: Nuclear Physics