Neutron beta decay study with the spectrometer *a*SPECT

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Free neutrons decay into a proton, an electron and an antineutrino. This is a weak interaction process described by the *V-A* theory within the Standard Model. Within this theory, the neutron beta decay is parametrized by several correlation coefficients [1] related to one single parameter, the weak coupling constants ratio $\lambda = \frac{g_A}{g_V}$. Beyond the Standard Model, the weak interaction is described by additional parameters that modify the expression of the correlation coefficients. Precise measurements of these coefficients allow to test the Standard Model theory (e.g. unitarity test of the CKM matrix [2-4]) and to derive limits for new physics [5,6].

Within this scientific scope, the experiment *a*SPECT [7] aims to measure the angular correlation coefficient *a* defined by the distribution of the momenta of electron and antineutrino. The spectrometer *a*SPECT was designed to improve the accuracy of the coefficient to 0.3% (previous experiments reached 5% accuracy). As it is difficult to detect the antineutrino, the value of the coefficient *a* is inferred from a precise measurement of the proton recoil energy spectrum [8,9]: the shape of the energy spectrum is related to the value of the coefficient (Fig. 1).

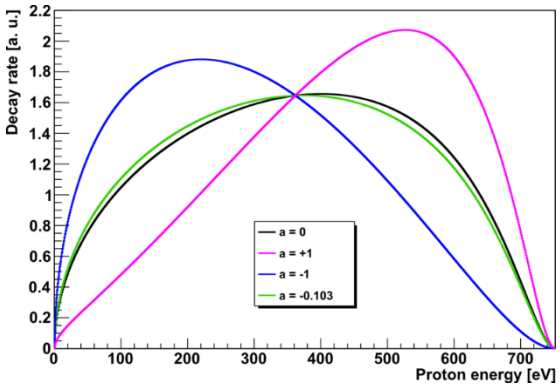

Figure 1: Proton recoil energy spectrum calculated for different value of the coefficient *a*. Decay protons can have a maximum energy of 751.4 eV.

In order to obtain this energy spectrum, the spectrometer *a*SPECT (Fig. 2) measures the integrated proton energy spectrum using a collimation by a magnetic field and selection by a retardation electrostatic potential. Protons with sufficient energy overcome the potential barrier

and are focused and accelerated by a potential of -15 kV onto a silicon drift detector (SDD). The proton count rate is extracted for the different barrier potential voltages (between 0 V and 780 V).

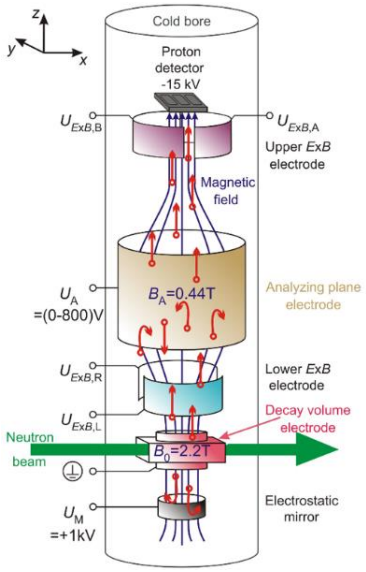

Figure 2: Sketch of the spectrometer *a*SPECT. Protons (red arrows) from the neutron decay are guided by the magnetic field lines (blue) through an electrode system.

In 2013, data acquisition for a 1% measurement of the correlation coefficient *a* was performed at the reactor of the Institut Laue-Langevin. Dedicated measurements and simulations were conducted to determine systematic effects (e.g. the background [10]). The data analysis is ongoing and preliminary results are presented here.

[1] J.D. Jackson *et al.*, *Possible tests of time reversal invariance in beta decay*, Phys. Rev. 106 (1957) 517

[2] N. Severijns, M. Beck, O. Naviliat-Cuncic, *Test of the standard electroweak model in beta decay*, Rev. Mod. Phys., 78, 993 (2006)

[3] H. Abele *et al.*, *The neutron. Its properties and basic interactions*, Part. Nucl. Phys. 60, 1-81 (2008)

[4] H. Abele *et al.*, *Is the unitarity of the quark-mixing CKM matrix violated in neutron beta-decay?*, Phys. Rev. Lett. Vol. 88, 21 (2002)

[5] V. Gapanov, *Possible contribution of an intermediate-leptoquark-boson mechanism to free-neutron beta decay*, Phys. At. Nucl. Vol. 63, No. 7, 1274-1279 (2000)

[6] D. Dubbers and M.G. Schmidt, *The neutron and its role in cosmology and particle physics*, Rev. Mod. Phys. 83, 1111 (2011)

[7] O. Zimmer, J. Byrne, M.G.D. van der Grinten, W. Heil, F. Glück, *aSPECT – a new spectrometer for the measurement of the angular correlation coefficient a in neutron beta decay*, Nucl. Instr. Meth. A 440, 548 (2000)

[8] F. Glück *et al.*, *The neutron decay retardation spectrometer aSPECT: electromagnetic design and systematics effects*, Eur. Phys. J. A. 23, 105 (2005)

[9] S. Baeßler *et al.*, *First measurement with the neutron decay spectrometer aSPECT*, Eur. Phys. J. A. 38, 17 (2008)

[10] Romain Maisonobe, PhD thesis, *Measurement of the angular correlation coefficient a between electron and antineutrino in neutron beta-decay with the spectrometer aSPECT*, Université de Grenoble (2014)