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The miniBETA spectrometer for the determination of weak magnetism and the Fierz interference term

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Precision correlation measurements in nuclear beta decay searching for new types of weak interactions, have now reached precisions of the order of 1 % and better [Sev2013, Nav2013]. At this level of precision Standard Model higher-order effects in the vector and axial-vector weak currents should be taken into account. The most significant of these is the so-called weak magnetism originating from the hadronic structure of the nucleons and affecting the values of correlation coefficients typically at the level of 0.1 % to 0.5 % [Hol74]. Whereas the weak magnetism form factor can, due to the Conserved Vector Current hypothesis, often be obtained from electromagnetic properties, this is not the case for transitions between non-analog states.

Recent comparisons [Cir2013, Nav2013] of limits for scalar and/or tensor type weak interactions from precision experiments in beta decay with results from direct searches at the Large Hadron Collider showed that both approaches are compatible in sensitivity for the currently available data sets. However, it was also shown that for low energy experiments to remain competitive also with the 14 TeV phase of the LHC, precisions of the order of 0.1 % for the Fierz interference term [Jac57] should be reached. For higher precisions such experiments could even outperform the LHC.

We have developed a new, compact beta spectrometer, miniBETA, for precision beta spectrum shape measurements. As the weak magnetism contribution to the beta spectrum is proportional to the beta-particle energy E, whereas the contribution from the Fierz interference term is proportional to 1/E, both topics discussed above can be addressed with this spectrometer, provided that beta decays with appropriate endpoint energies are selected. The miniBETA spectrometer combines two multiwire drift chambers [Loj2009] for beta particle tracking, with plastic scintillators providing the trigger but also the beta particle energy. In addition, this energy can also be obtained from the curvature of the beta particle trajectories in a magnetic field. The construction of the miniBETA spectrometer was recently finished and commissioning is ongoing. An overview of the technical aspects and physics possibilities of this new beta spectrometer will be presented.

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