Test of the conserved vector current hypothesis in the beta-decay of ^{14}C

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In 1957, Feynman and Gell-Mann proposed the conserved vector current (CVC) hypothesis.[1] In the classic case of the mass-12 isospin triplet (B-C-N), CVC relates the width of the electromagnetic transition ($^{12}C^* \rightarrow {}^{12}C$) to the shape factors of the beta decay spectra ($^{12}B \rightarrow {}^{12}C$) and ($^{12}N \rightarrow {}^{12}C$). The shape factor represents a deviation of the beta spectrum from the simple allowed shape by the additional factor $S(E) = 1 + aE$, where E is the total electron energy Several experiments have measured a in the mass-12 system, but the agreement with CVC is weak at best.[2]

The mass-14 isospin triplet (C-N-O) represents another viable system for testing CVC (Fig. 1).

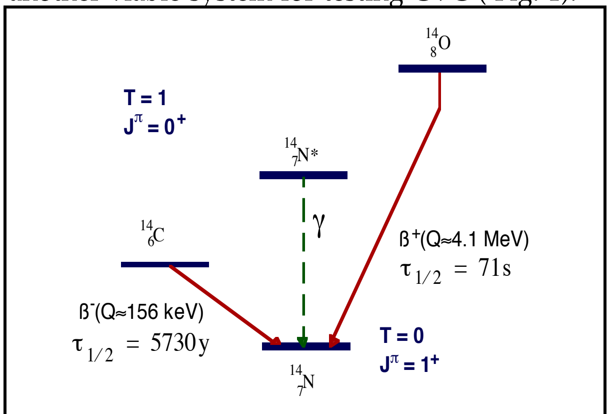

Fig. 1. Mass-14 isospin triplet.

We have performed a measurement of the beta decay spectrum of $^{14}C \rightarrow {}^{14}N$ ($Q \approx 156$ keV) toward this end. The apparatus used for this measurement consists of a superconducting solenoid and Si(Li) solid state detector.[3] The magnetic field transports the electrons in helical orbits (r < 3mm) to the Si(Li) detector without the possibility of scattering on material collimators. The detector response function was determined by measurement of internal conversion spectra from ^{139}Ce and ^{109}Cd. The ^{14}C data consists of four separate runs with a total of about 7×10^9 total decays accumulated over a period of 515 livetime hours. The data is fitted from 65 to 250 keV. The results are quoted for this energy interval, but the shape factor was observed to be independent of the chosen interval. In Fig. 2 we show the fit from run 1 which yielded a = -39.1±0.4(stat.)%/MeV for the shape factor. Including the results from the other three data

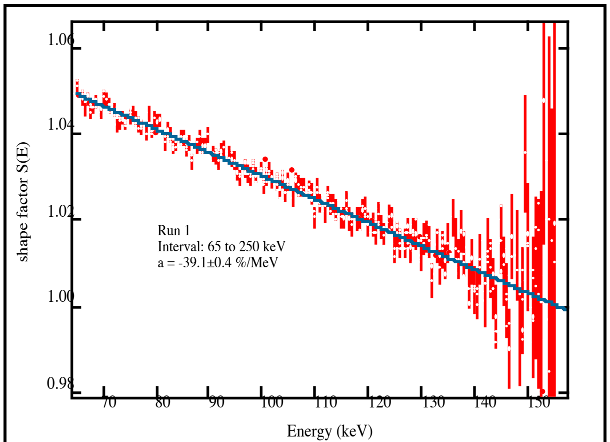

Fig. 2. Residuals of fit to 14C spectrum. The straight line represents the linear shape factor of -39.1%/MeV.

sets and we have a = -39.2± 0.2(stat.)±0.6(sys.) %/MeV. This represents the most precise determination of the shape factor in ^{14}C and appears to be in good agreement with the value predicted by CVC of -38.0±1.2%/MeV,[2] where the error reflects the uncertainty in the radiative width of $^{14}C \rightarrow {}^{14}N^*$.

Footnotes and References

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