Measurement of the decay scheme of ^{142}Cs

Project: Phd level
Supervisor: P Jones
Start date: Immediately

Project Aim / Scope:
A South African led experiment has been approved for the ISOLDE facility at CERN for nuclear structure studies. The measurement aims to measure precisely the decay of an extremely important nucleus - ^{142}Cs of which further comprehension has far-reaching implications from its production at radioactive ion-beam facilities (such as the South African Isotope Facility (SAIF) [1]), nuclear structure, and even the anomalous production of antineutrinos in nuclear reactors. Through these studies, a new understanding of these processes and the underlying associated physics associated will be achieved. Specialised detectors, sensitive to the high energy gamma rays expected, will be employed. These detectors are currently being used at iThemba LABS as part of the ALBA [2] project and will be incorporated into the measurements. Prior to the experiment being scheduled, data are available for immediate analysis for both training, thesis work and for publication of new results.

Abstract:
For a long time various experiments related to the yield of fission products have been indicating a singularity occurring at ^{142}Cs. These measurements suggest a renormalisation of the gamma-ray intensities in the decay scheme. A salient feature of this decay is the very low logft of 5.6 for the first-forbidden $0^- \rightarrow 0^+$ β transition to the ground state of the ^{142}Ba daughter. After renormalisation, it would become even lower, which seems unrealistic. However, a recent measurement with a total absorption spectrometer revealed a β-feeding pattern in disagreement with the decay scheme evaluated in Nuclear Data, though it does not solve the yield problem.
The decay of ^{142}Cs is an important roleplayer in the field of reactor antineutrino anomalies [3] and the link to nuclear structure. Calculations of the antineutrino spectra from ^{235}U up to 4 MeV includes ^{142}Cs as one of the strongest contributors, and more recently the largest contribution at 6-7 MeV [4]. Moreover, it was recently shown that the understanding of first-forbidden transitions is crucial to the full understanding of the antineutrino spectra [5, 6]

A more recent measurement of the γ sum spectra using the Modular Total Absorption Spectrometer (MTAS) [7] confirmed the correction of a large discontinuity of the ^{92}Rb yield observed at IRIS by renormalisation of the γ-ray intensities listed in ENSDF [8]. The same MTAS paper moved the β feeding away from low-lying 142Ba levels and indicated a larger feeding near 1.5 MeV and above 3.5 MeV than reported in ENSDF.

Relevant References:

[1] https://tlabs.ac.za/wp-content/uploads/pdf/articles/saif.pdf
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[6] L. Hayen, et al., Phys. Rev. C 100, 054323 (2019)
[7] B.C. Rasco, et al., Phys. Rev. Lett. 117, 092501 (2016)
[8] G. Lhersonneau et al., Phys. Rev. C 74, 017308 (2006)