



Canadian Association  
of Physicists

Association canadienne  
des physiciens et physiciennes

Contribution ID: 76 Type: Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)

## High-Precision Study of the Superaligned Fermi Beta Emitter $^{62}\text{Ga}$

Thursday 11 June 2020 15:40 (15 minutes)

High-precision measurements of the  $ft$  values for superallowed Fermi beta decays between  $0^+$  isobaric analogue states have provided invaluable probes of the Standard Model description of the electroweak interaction. Theoretical corrections must be applied to the experimentally determined  $ft$  values obtained from precise measurements of the half-lives, branching ratios, and  $Q$  values of the decays. Of particular interest is the isospin symmetry-breaking correction,  $\delta_C$ , which is nuclear-structure-model dependent; several theoretical approaches can and have been used to calculate these corrections with varying results. In the most recent survey of superallowed Fermi  $\beta$  emitters [1] the selection of a particular  $\delta_C$  model depended significantly on four of the least precisely determined corrected- $ft$  values:  $^{22}\text{Mg}$ ,  $^{38}\text{Ca}$ ,  $^{62}\text{Ga}$ , and  $^{74}\text{Rb}$  for the well-measured cases.

Recently, updated calculations of the universal “inner” electroweak radiative correction,  $\Delta_R^V$ , have been performed [2-4]. This value is used in combination with the corrected superallowed  $\mathcal{F}t$  values to extract such quantities as  $G_V$ , the vector coupling constant, and  $|V_{ud}|$ , the most precisely determined element of the CKM quark mixing matrix. With the updated value of  $\Delta_R^V$ , the first row of the CKM quark mixing matrix now disagrees with unitarity at the  $2\text{-}4\sigma$  level, prompting an increased interest in re-investigating the model-dependent nuclear structure corrections, especially those which can be directly constrained experimentally.

We have performed a high-statistics experiment for the superallowed Fermi  $\beta^+$  emitter  $^{62}\text{Ga}$  at the Isotope Separator and Accelerator (ISAC) radioactive ion beam facility at TRIUMF using the high-efficiency Gamma-Ray Infrastructure for Fundamental Investigations of Nuclei (GRIFFIN) spectrometer. The high coincidence efficiency of the GRIFFIN spectrometer allowed for a significant expansion of the level scheme, more than doubling the known  $\gamma$ -ray transitions in the daughter nucleus,  $^{62}\text{Zn}$ . This allowed a new measurement of the superallowed branching ratio with a precision of  $\pm 0.0012\%$ ,  $\sim 6$  times more precise than previously achieved [5]. Gamma-ray intensities were measured down to the 1 ppm level, effectively solving the Pandemonium problem [6] for  $^{62}\text{Ga}$ . For one particularly important cascade, sufficient statistics were obtained to perform a  $\gamma - \gamma$  angular correlation measurement. This allowed the previously-conflicting spin-assignments for the 2.34 MeV excited state in  $^{62}\text{Zn}$  [7,8] to be resolved and firmly established this state to have  $J^\pi = 0^+$ . The assignment of the spin of this state has important implications for the isospin symmetry breaking correction,  $\delta_{C1}$ . Final results from this analysis will be presented.

[1] J.C. Hardy and I.S. Towner, Phys. Rev. C 91, 025501 (2015).

[2] C. Seng, M. Gorchtein, H.H. Patel, and M.J. Ramsey-Musolf, Phys. Rev. Lett. 121, 241804 (2018).

[3] C. Seng, M. Gorchtein, and M.J. Ramsey-Musolf, Phys. Rev. D 100, 013001 (2019).

[4] A. Czarnecki, W.J. Marciano, and A. Sirlin, Phys. Rev. D 100, 073008 (2019).

[5] P. Finlay et al., Phys. Rev. C 78, 025502 (2008).

[6] J.C. Hardy, L.C. Carraz, B. Jonson, and P.G. Hansen, Phys. Lett. B 71, 307 (1977).

[7] M. Albers et al., Nucl. Phys. A 847, 180 (2010).

[8] K.G. Leach et al., Phys. Rev. C 88, 031306 (2013).

**Author:** MACLEAN, A.D. (Department of Physics, University of Guelph, Guelph, Ontario)

**Co-authors:** Dr LAFFOLEY, Alex (Department of Physics, University of Guelph, Guelph, Ontario); Dr SVENSON, Carl (Department of Physics, University of Guelph, Guelph, ON); Dr BALL, Gordon (Physical Sciences Division, TRIUMF, Vancouver, BC); ANDREOIU, Corina (Physical Sciences Division, TRIUMF, Vancouver, BC); Prof. LESLIE, James (Queens University); Mr BABU, Aditya (TRIUMF); Prof. BENDER, Peter (University of Massachusetts); BILDSTEIN, V. (University of Guelph); Dr BHATTACHARJEE, Soumendu (TRIUMF); Mr BIDAMAN, Harris (Department of Physics, University of Guelph, Guelph, ON); BURBADGE, Christina; BOWRY, M.. (Physical Sciences Division, TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia); CROSS, David; Ms VARELA DIAZ, Alejandra (Department of Physics, University of Guelph, Guelph, ON); Dr DILLMAN, Iris (Physical Sciences Division, TRIUMF, Vancouver, BC and Department of Physics, University of Victoria, Victoria, BC); DUNLOP, Michelle (University of Guelph); Mr DUNLOP, Ryan (Department of Physics, University of Guelph, Guelph, ON); EVITTS, Lee (TRIUMF); FINLAY, Paul (Katholieke Universiteit Leuven (BE)); Dr GARNSWORTHY, Adam (Physical Sciences Division, TRIUMF, Vancouver, BC); Mr GRIFFIN, C (TRIUMF); Dr HACKMAN, Greg (Physical Sciences Division, TRIUMF, Vancouver, BC); HALLAM, S. (TRIUMF); Dr HENDERSON, Jack (TRIUMF); ILYUSHKIN, Sergey; Mr JIGMEDDORJ, Badamsambuu (Department of Physics, University of Guelph, Guelph, ON); KASANDA, Eva (University of Guelph); LEACH, Kyle (Colorado School of Mines); Ms LUBNA, R.S. (TRIUMF); Mr MCAFEE, J (TRIUMF); MOUKADDAM, Mohamad (TRIUMF); NATZKE, C. (Colorado School of Mines); OLAIZOLA, B. (Physical Sciences Division, TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia); Ms PAXMAN, C. (TRIUMF, University of Surrey); PORE, Jennifer (Lawrence Berkeley National Laboratory); PORZIO, Carlotta (Università degli Studi di Milano, TRIUMF); RADICH, Allison (University of Guelph); RAND, Evan (Canadian Nuclear Laboratories); RUOTSALAINEN, P. (TRIUMF); Mr SAITO, Yukiya (Physical Sciences Division, TRIUMF, Vancouver, BC and Department of Physics, University of British Columbia, Vancouver, BC); Dr SMITH, Jenna (Department of Physics, Reed College, Portland, Oregon); Dr SMALLCOMBE, James (University of Liverpool); Mr TURKO, Joey (Department of Physics, University of Guelph, Guelph, ON); Mr WILLIAMS, J. (TRIUMF); YATES, Daniel Aaron (TRIUMF (CA)); Mrs ZIDAR, Tammy (Department of Physics, University of Guelph, Guelph, ON)

**Presenter:** MACLEAN, A.D. (Department of Physics, University of Guelph, Guelph, Ontario)

**Session Classification:** R-DNP-1 : Best student competition

**Track Classification:** Nuclear Physics / Physique nucléaire (DNP-DPN)