# Double-beta decay of $^{96}Zr$ – nuclear physics meets geology

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Double-beta (ββ) decay measurements are a class of nuclear studies with the objective of detecting the neutrinoless (0νββ) decay variants. Detection of a 0νββ decay would prove the neutrino to be massive and to be its own anti-particle (i.e., a Majorana particle).

$^{96}Zr$ is of particular interest as a double-beta decay candidate. A geochemical measurement of its ββ decay half-life was previously performed by measuring an isotopic anomaly of the $^{96}Mo$ daughter in ancient zircons. This measurement yielded a half-life of $0.94(32)x10^{19}$ yr [1]. More recently, the NEMO collaboration measured the half-life by a direct count rate measurement to be $2.4(3)x10^{19}$ yr [2], twice as long as the geochemical measurement.

We aim to study this discrepancy through a series of experiments combining nuclear physics and geochemical techniques. We are measuring the mass independent fractionation of $^{96}Mo$ due to the ββ decay of $^{96}Zr \rightarrow ^{96}Mo$ in 1.8 Gyr zircons. The zirconium silicates, which have remained a closed system over their lifetimes, are especially suitable for this investigation due to their high zirconium content and the low natural molybdenum abundance. This makes it possible to detect the small amount of accumulated decay product. We are performing these measurements using improved chemical preparation techniques and isotopic analysis using the Thermo Scientific Neptune MC-ICP-MS.

These measurements are being performed in conjunction with beta decay Q-value measurements at the TRIUMF TITAN experiment, a high precision mass measurement penning trap for atomic and nuclear science. The Q-value measurements aim to study a possible second decay route, a highly forbidden single-beta decay of $^{96}Zr \rightarrow ^{96}Nb$, which then immediately decays to $^{96}Mo$. Combined, these measurements will remove a long-standing discrepancy of the two independent $^{96}Zr$ ββ decay half-life measurements.

[1] Wieser & De Laeter (2001), *Phys. Rev. C* **64**, 024308. [2] NEMO-3 Collaboration (2010) *Nucl. Phys. A* **847**, 168-179.