Contribution ID: **10** Type: **oral**

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Saturday 13 September 2025 13:30 (20 minutes)

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The discrepancy in neutron lifetime measurements between storage experiments with ultracold neutrons and beam experiments with cold neutrons has persisted as a significant puzzle in particle physics. Storage experiments typically involve trapping neutrons and observing their decay over time, while beam experiments measure the decay products, such as electrons and protons, as neutrons pass through the decay volume. Interestingly, the average lifetimes obtained from these two methods differ by nearly 10 seconds, despite reduced statistical and systematic errors.
A promising yet controversial explanation for this discrepancy involves the bound beta decay of the neutron into a hydrogen atom and a anti-neutrino. Traditional theoretical estimates suggested a branching ratio of approximately $\sim 10^{-6}$, which seemed too small to account for the observed differences. However, recent theoretical developments propose a significantly larger branching ratio of $\sim 10^{-2}$, potentially bridging the gap between the two experimental findings.
In this presentation, I will explore the implications of these new theoretical predictions and present my own calculations, which question their validity. By critically evaluating these findings, I aim to shed light on whether bound beta decay could indeed resolve the neutron lifetime puzzle or if alternative explanations need to be considered.

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Session Classification: Systematic Effects, Physics beyond the Standard Model