Discrepancy in the Neutron Lifetime

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The lifetime of the neutron is an important quantity used in many areas of physics. For example, it is needed to calculate the rate of nucleosynthesis after the Big Bang and constrain fundamental parameters of the Standard Model. However, precision measurements of the neutron lifetime differ by about 8 seconds.

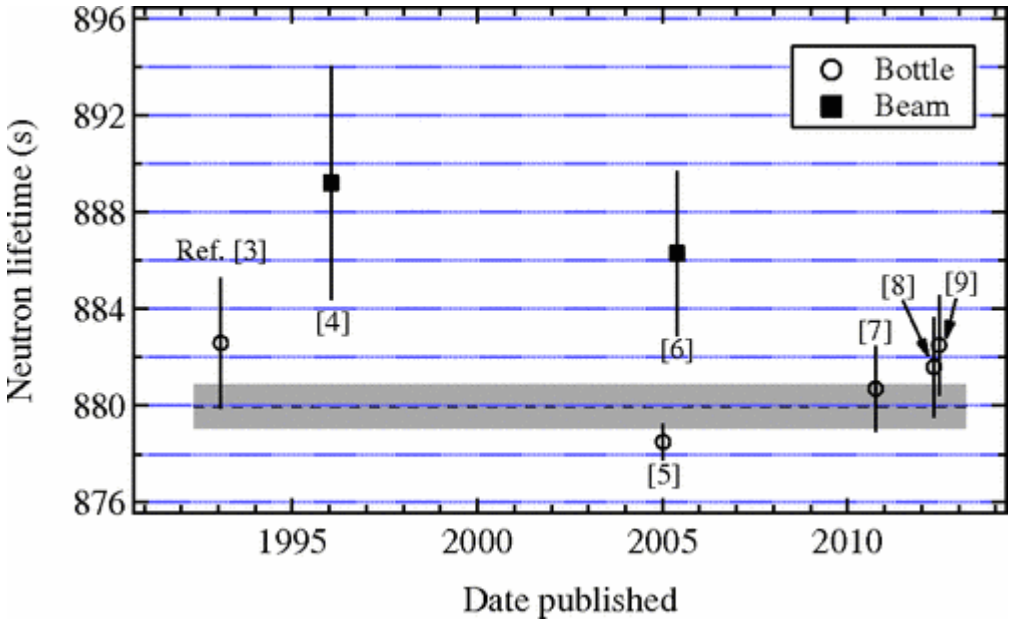
Current values

$\tau_{pdg} = 880.2 \pm 1.0s$

$\tau_{beam} = 888.0 \pm 2.1s$

$\tau_{bottle} = 879.6 \pm 0.8s$

$\tau_{beam} - \tau_{bottle} = 8.4 \pm 2.2s$



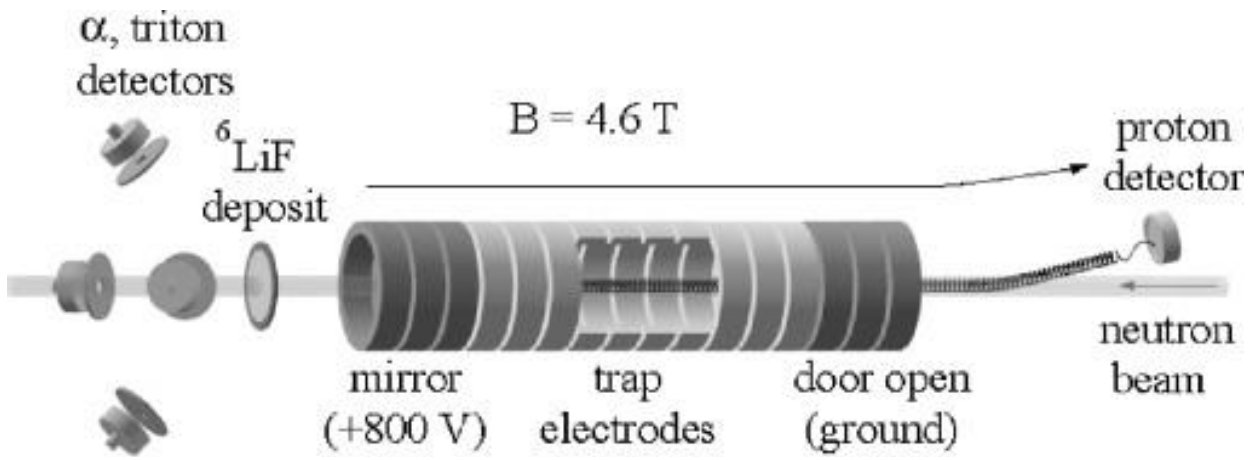
A. T. Yue *et. al.*, Phys. Rev. Lett. **111**, 222501 (2013)

Beam Method

Performed at NIST Center for Neutron Research

Method based on differential equation:

$$\frac{dN}{dt} = -N/\tau_n$$



J.S. Nico *et. al.*, Phys. Rev. C **71**, 055502 (2005)

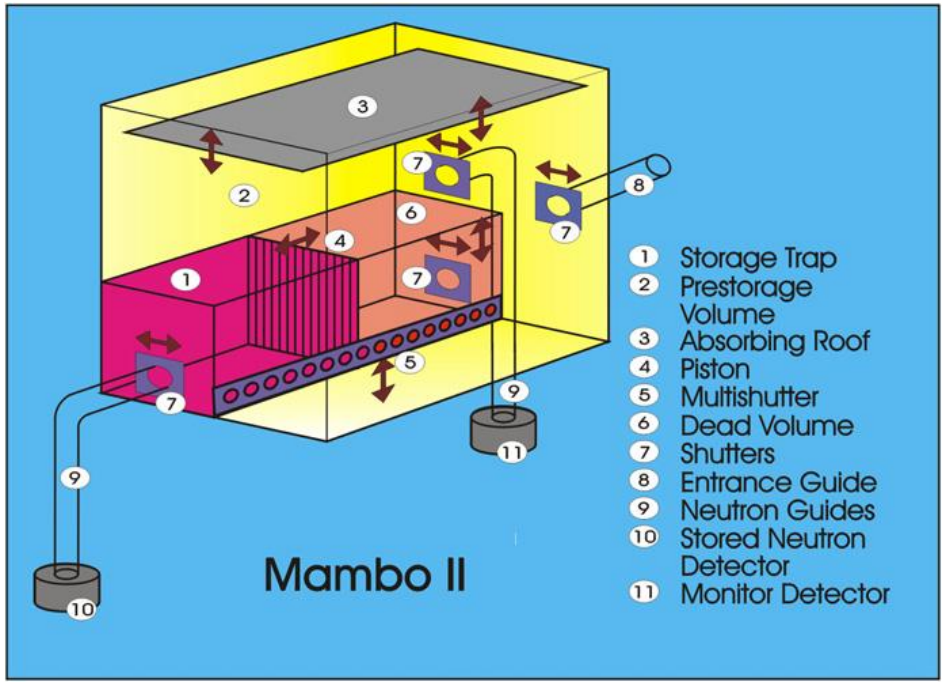
Bottle Method (Mambo II)

Performed in Grenoble, France

Makes use of neutron energy density measurements:

$$n(E,t) = n_0(E)\exp(-\mu_{st}t)$$

$$\mu_{st} = \mu_n + \mu_{loss}$$



A. Pichlmaier *et. al.*, Phys. Lett. B **693**, 221-226 (2010)

Summary

- Two independent methods for measuring the lifetime of the neutron.
- Methods differ by 3.8σ.
- Current discrepancy attributed to unresolved systematic errors.

$$\tau_{beam} - \tau_{bottle} = 8.4 \pm 2.2s$$

Beam Method Uncertainties (extra)

- Main Systematic Uncertainties
  - 2.5 s contribution due to ^{6}Li(n,t)^{4}He reaction (cross section, areal density)
  - 1.0 s contribution due to detector solid angles
- Main Statistical Uncertainties
  - 1.0 s contribution due to proton counting statistics

$\tau_{beam} = 886.3 \pm 3.4s$

J.S. Nico *et. al.*, Phys. Rev. C **71**, 055502 (2005)

Bottle Method Uncertainties (extra)

- Main Systematic Uncertainties
  - 0.7 s contribution due to measurement of volume of trap
    - Used to determine μ_{loss}
  - 0.5 s contribution due to uncertainty in emptying time

$\tau_{bottle} = 880.7 \pm 1.8s$

A. Pichlmaier *et. al.*, Phys. Lett. B **693**, 221-226 (2010)