Paper Evaluation and Summary

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Paper: Nico et al. (Measurement of neutron lifetime using beam method)

- What is the main finding of this paper and why is it important?
  The mean neutron lifetime was found to be $\tau_n = 886.3 \pm 1.2(\text{stat}) \pm 3.2(\text{sys})s$ and therefore is the most precise measurement utilizing the in beam method. It still disagrees with the magnetic trap method. The systematic uncertainties are dominated by the neutron counting, could be reduced by new techniques in the feature down to $2s$.

- Describe at a high level the basic technique used. Try a series of "steps" here if necessary, if there is a sequence to be followed (like a recipe).

  1. Generate cold neutrons, guide into the proton trap
  2. Start the trapping cycle:
     – Trapping: trap protons produced by neutron decay for $10ms$.
     – Counting: Door gets grounded and a ramped potential "flushes" out the produced protons which are guided to the silicon detector (enabled for $21\mu s$).
     – Clearing: ramp potential gets maintained for another $33\mu s$ to clear the trap from all charged particles
  3. Measure resulting protons with silicon surface barrier detector (must be aligned precisely with proton beam).

- Choose an interesting technical aspect of the experiment and describe its relation and importance to the measurement.
  The alignment of the proton detector to measure the proton beam is quite sophisticated to avoid loss of counts due to exceeding the active area of the silicon. To do so, optical measurements were performed first to get a "rough" alignment. Furthermore, an electron beam from a ^{210}Pb-^{210}Bi-^{210}Po source was used to monitor the the beam position on the detector. Last, the same procedure was performed with decay protons. All measurements agreed, according to the paper, better than $1mm$.

- Pick one systematic uncertainty issue that you find interesting and describe its importance and the author's method of addressing it.
  The largest contributing systematic uncertainty is the loss of neutrons (less neutrons give a shorter life time). Neutrons get lost by three different mechanisms:

1. Time variation of the neutron fluence rate $I(v)$ (dependence on variations of the brightness of the source) and the transmission functions for all involved materials of the trap and the guide tubes.
2. Neutron absorption correction for the absorption in the Li deposit.
3. Neutron loss due to scattering in the silicon wafer. This uncertainty was addressed by measuring the count rate for stacking layers of blank silicon wafers.

- Fascinating aspect:
  The experiment is described much more sophisticated than the Pattie et al. paper. The method also necessitates the application of much more systematic corrections to the data then the magnetic trap method.