PENeLOPE and AbEx

Towards a precise neutron lifetime measurement

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Neutron lifetime measurement

$$n \rightarrow p + e^- + \bar{\upsilon}_e$$

Current PDG value : $\tau_n = 885.7 \pm 0.8$ s

Latest measurement : $\tau_n = 878.5 \pm 0.8$ s !!

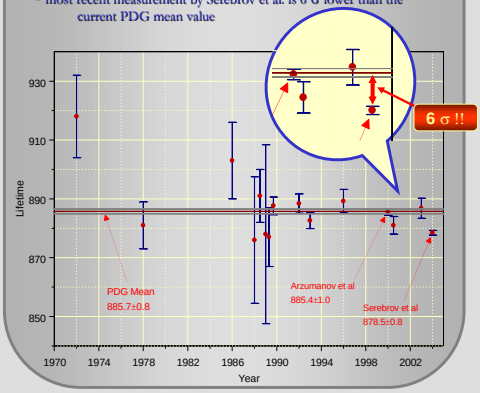
A. Serebrov et al, Phys. Lett. B, Vol. 605, 1-2, 2005, p. 72-78.

Method:

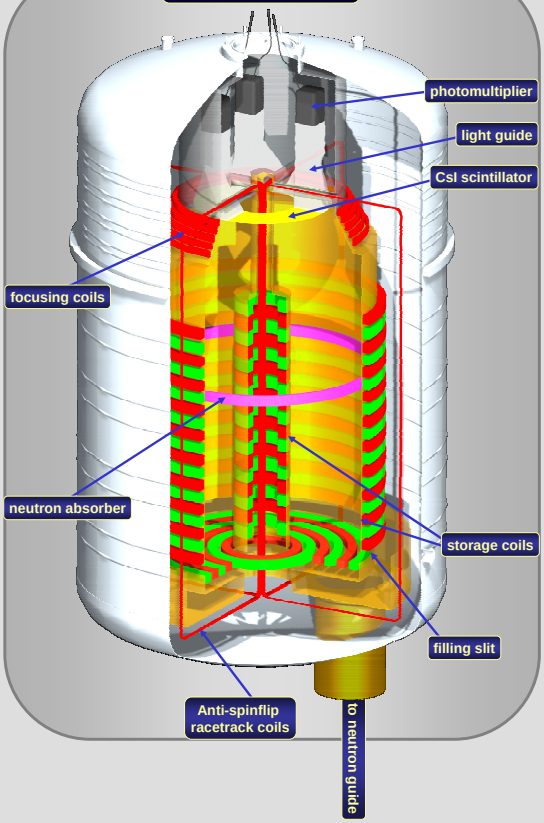
Magnetic and gravitational storage
Real-time proton extraction and detection
with CsI scintillator, APD/PM
Monitoring of depolarization
Goal: accuracy better than 0.1 s

Motivation

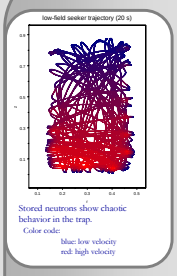
- τ_n vital for testing the unitarity of the CKM matrix
- τ_n influences the primordial helium abundance
- most recent measurement by Serebrov et al. is 6 σ lower than the current PDG mean value

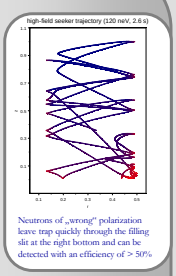


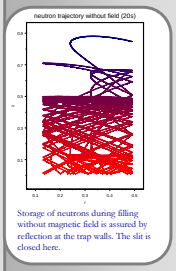
PENeLOPE

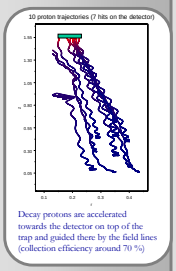


MC simulations









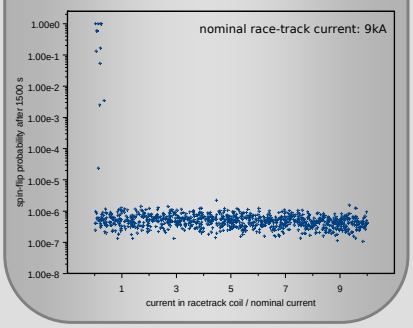
Further results:

- to minimize proton losses: $p < 10^{-7}$ mbar
- $\rho(v,t) = \rho(v)$
- spectrum cleaning => effective absorber scheme necessary => see AbEx
- coil ramping leads to UCN "heating" of 20-40 neV

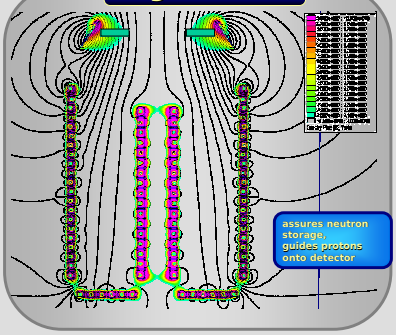
Neutron spin tracking

- field topology => zero-field regions
  => danger of spin-flip and UCN loss
- racetrack coils => no zero-field regions
- nevertheless: investigations of still existing low field regions necessary
- MC integration of Bloch equation

$$\frac{d\mathbf{S}}{dt} = [\omega \times \mathbf{S}]$$

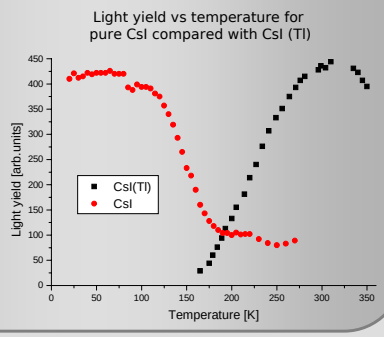


Magnetic field



Proton detection

proton source tunable up to 30 keV built at E18 to investigate optimum detection scheme

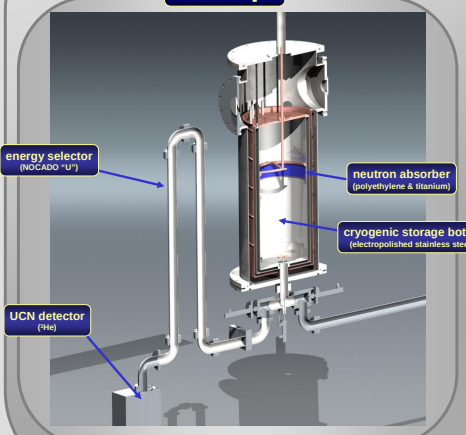


R. Picker *et al.*, J. Res. Natl. Inst. Stand. Technol. **110**, 357-360 (2005)

AbEx (Absorber Experiment)

Goal: characterization of different absorber materials for use in PENeLOPE down to liquid helium temperatures

Concept



Realisation

Preliminary results

temperature	≈ 293 K	≈ 80 K	≈ 5 K
storage time of bottle	≈ 150 s	≈ 200 s	≈ 250 s
storage time with PE	≈ 6 s	≈ 6 s	-
storage time with Ti	≈ 6 s	≈ 6 s	≈ 6 s

preliminary !!

⇒absorber geometry seems very effective and eliminates marginaly trapped UCN to < 10^{-4} in 100 s with either absorber
⇒no significant temperature dependence of Ti down to 5 K
⇒low temperatures could not be reached with PE, because of insufficient heat coupling of absorber, also no significant temp. dep. down to 80 K
⇒detailed analysis still ongoing!