

Spin manipulation and detection of UCN in the lifetime experiment τ SPECT

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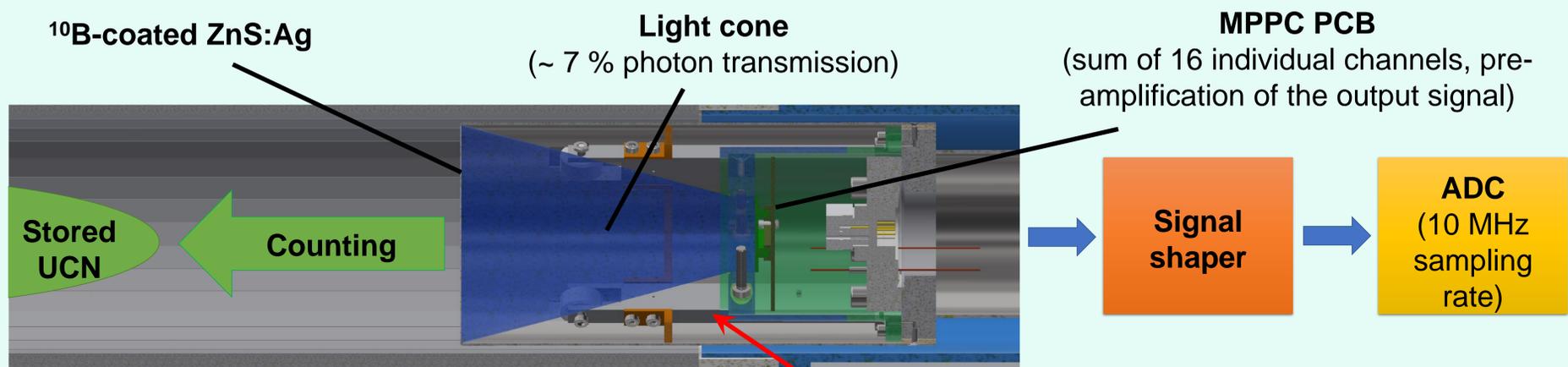
The movable UCN detector

Detection principle

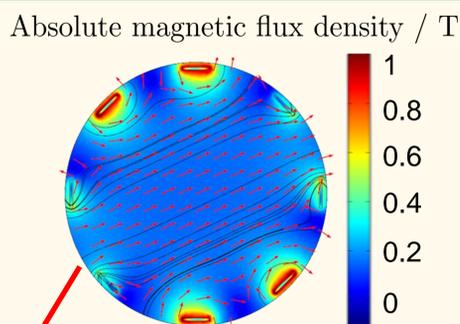
- UCN are absorbed in an 80 nm ^{10}B layer. Charged particles resulting from the neutron capture process $^{10}\text{B} + n \rightarrow ^7\text{Li} + \alpha + 2.31 \text{ MeV}$ are converted to photons in the ZnS:Ag scintillator.
- The photons are detected in a multi pixel photon counter (MPPC) array.
- The detector can be moved into the magnetic trap to count surviving UCN.

DAQ

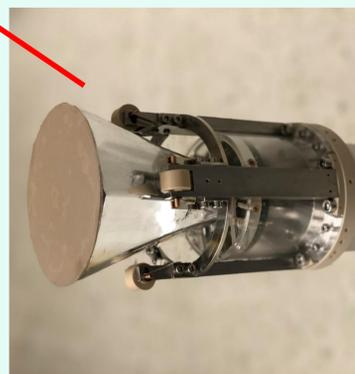
- The shaped signals are digitised by a 14 bit ADC at a sampling rate of 10 MHz.
- The full waveform is stored in binary format.
- Event reconstruction is done offline.
- The typical background rate is 1 - 2 Hz.



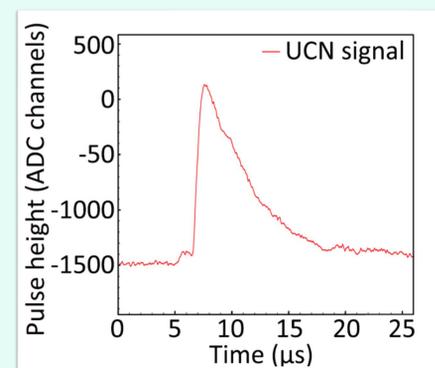
The spin flipper on its PEEK holder



Simulation of the magnetic field inside the spin flipper

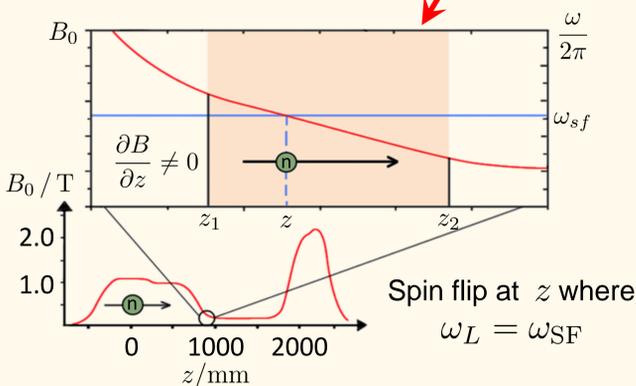


Outer view of the detector.



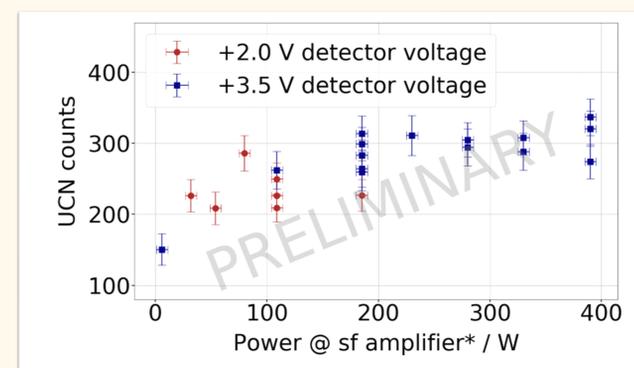
Neutron signal after shaping.

The UCN spin flipper



Detailed view of the spin flipping region.

- RF coil in low pass birdcage design with quadrature excitation
- Resonance frequency at 10.266 MHz (corresponds to $B_0 = 352 \text{ mT}$)
- Pick up coil outside the spin flipper for functionality monitoring
- Tested successfully in τ SPECT with up to 390 W RF power



UCN yield after 50 s storage, normalised to neutron counts in 3-6 s after pulse, depending on RF power.

* Values are taken from amplifier display

- Conversion of high-field-seeking UCN to their low field seeking state is necessary in order to store them magnetically.
- Neutrons precess in magnetic fields at the Larmor frequency ω_L . In τ SPECT the Larmor frequency is position-dependent due to the gradient of the longitudinal magnetic field $B_0(z)$.
- A transverse magnetic field $B_1(z)$ oscillating at ω_L in the centre of the spin flipper is irradiated.
- Spin rotation of 180° when θ (see figure right) changes sign at $B_0 = -\omega/\gamma$

Rotating frame of the neutron:

$$B_{\text{eff}} = \left(B_0(z) + \frac{\omega}{\gamma} \right) \vec{z} + B_1(z) \vec{x}$$

$$\tan \theta = \frac{B_1(z)}{B_0(z) + \frac{\omega}{\gamma}}$$

A.T. Holley et. al., RSI **83**, 073505 (2012)

