Self-Triggering Readout System for the Neutron Lifetime Experiment PENeLOPE

Basic Principles of PENeLOPE
- lossless storage of Ultra-Cold Neutrons (UCN) in magneto-gravitational trap
- neutron lifetime derived from neutron and proton counting
- new and unique approach with separate systematics
- blind analysis
- experimental goal: measurement of the neutron lifetime with a precision of 0.1 s

Proton Detection
- charged decay particles guided along magnetic field lines to detector
- high voltage helps protons to overcome magnetic mirror effect
- extraction efficiency of 69% for protons and 37% for electrons feasible

Requirements on the detector
- single proton counting
- energy from neutron decay max. 750 eV
- the whole detector setup including electronics on -30 kV electrostatic potential
- 0.6 T magnetic field due to operation close to superconducting coils
- operation at 77 Kelvin
- 10⁻⁸ mbar in storage volume
- 0.23 m² cross-sectional area has to be covered
- Charge-sensitive (CS) preamplifier
- Shaping: CR differentiator and RC integrator
- 12-bit ADC (AD7450) with \( f_{\text{sample}} = 1 \text{ MHz} \)

- “Real-time” pedestal calculation: Averaging over \( N_{\text{avg}} \) samples
- Calculating sigma noise over \( N_{\text{avg}} \) samples: Calculating quadratic deviation from mean value
- Signal Detection: If \( n_s \) consecutive samples > pedestal + \( x_f \cdot \sigma \)

Switched Enabling Protocol (SEP)
- time-division multiplexing transport layer protocol
- developed for star like optical network topology
- up to 256 slaves
- supports data transmission, slow control (IPBus) and synchronous message with determined latency

<table>
<thead>
<tr>
<th>Transmission Time [( \mu s )]</th>
<th>Efficiency [%]</th>
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<tbody>
<tr>
<td>25000</td>
<td>99.93</td>
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<td>10000</td>
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<td>500</td>
<td>96.90</td>
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<td>86.20</td>
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