Precision Measurement of the Singlet μp Capture Rate via μ^- Lifetime in H_2 Gas

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Nuclear muon capture, $\mu + p \longrightarrow n + \nu_\mu$, is a fundamental electroweak charged-current reaction which can be studied at the low-energy muon beams of Paul Scherrer Institute under ideal conditions. The capture rate is sensitive to the weak form factors of the nucleon, in particular to the induced pseudo-scalar coupling constant g_P. A precise measurement of g_P would rigorously test modern effective field theories of low-energy QCD, which predict g_P with ~2% precision [1]. This goal can be reached by a μ^- lifetime measurement in H_2 gas with an accuracy of 10 ppm or better.

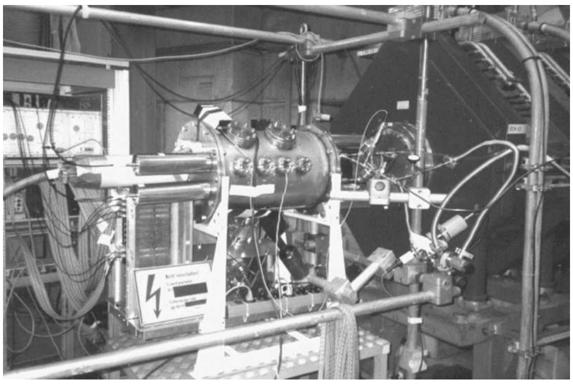

Fig. 1: First setup of the prototype TPC in area μE4

Based on the development of three small test chambers in 1997 [2], a full prototype time projection chamber (TPC) was constructed at Gatchina and shipped to PSI for first tests in the muon beam (fig. 1). The TPC has a sensitive volume x·y·z = $15 \cdot 8 \cdot 30$ cm^3 with a vertical electrical drift field of 2.2 kV/cm. At the beam entrance two x-y MWPC's are placed to localize arriving muons and below the TPC, two large 15x15 cm^2 x-z MWPC's act as external electron detectors. All chambers sit inside a pressure vessel filled with 10 bar of pure hydrogen gas.

In the TPC, the negative charges from tracks of muons and electrons drift towards a MWPC amplification plane of 75 anode wires, where electronic signals are generated for data readout. The idea of using a TPC is to identify unambiguously the tracks of stopping muons and their decay electrons without using global pile-up rejection, thus allowing eventually to reach beam rates up to 50 kHz required for high statistical accuracy.

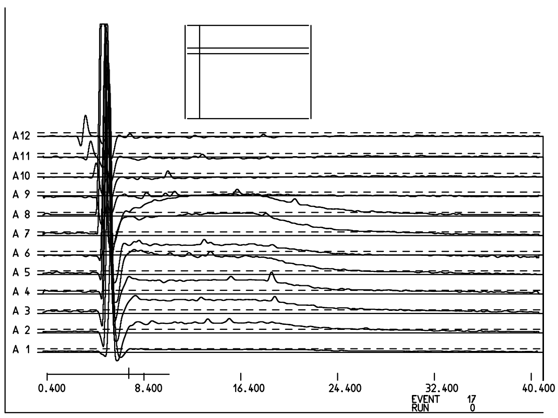

Fig. 2: Sample of a tracked μ-e event in the TPC

Fig. 2 shows a well-tracked event from our first test run in December 98. The muon can be seen passing the entrance wire chambers (bottom cross hairs) and stopping with high dE/dx on anode 8. The decay electron is seen on anodes 9-12 going to the upper left. The negative signals near the electron track are cross talk from the huge muon signals. (The muon signals are shown at low gain compared to the electron signals).

References

[1] V. Bernard *et al.*, Phys. Rev. **D50** (1994) 6899;
H.W. Fearing *et al.*, Phys. Rev. **D56** (1997) 1783
[2] PSI Annual Report 1997 / Annex I, p. 32.