High Precision Measurement of Singlet μp Capture by μ^+/μ^- Lifetime Measurements in H_2 Gas

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Nuclear muon capture on the proton

$$\mu + p \longrightarrow n + \nu_\mu \qquad (1)$$

is a fundamental electroweak charged-current reaction which can be studied at PSI under ideal conditions. Its rate is sensitive to the weak form factors of the nucleon, in particular to the induced pseudoscalar coupling constant g_P. Its accurate measurement would provide a rigorous test of modern effective field theories of low energy QCD, which predict g_P with a precision of 1-3 % [1].

However, experiments have not yet come close to the required accuracy, because of two main reasons: it is difficult to determine the absolute detection efficiency for the neutrons in reaction (1) with sufficient precision; the formation of mesic $p\mu p$ molecules and the subsequent transitions between molecular states lead to considerable uncertainties in the interpretation of experimental results.

In our new experiment [2] we have proposed an approach avoiding these problems by using the lifetime method in low density hydrogen gas. The singlet capture rate is extracted from the difference of μ^+ and μ^- lifetimes by

$$\Lambda_C^{F=0} = \frac{1}{\tau_{\mu^-}} - \frac{1}{\tau_{\mu^+}} \, . \qquad (2)$$

A new time projection chamber (TPC) is developed which can independently detect and track the incoming muons (μ^+/μ^-) stopping in ultra-pure hydrogen gas, and the positrons/electrons emerging from μ-decays.

During 1997, this detection method was successfully tested in Gatchina with the prototype setup shown in Fig. 1. A hydrogen vessel (d = 20 cm, pressure 10 bar) houses two multiwire proportional chambers on top and bottom, that identify and localize tracks of minimum ionizing electrons from a ^{90}Sr β-source. In between, a small TPC (sensitive area 5x5 cm^2) is mounted defining a homogeneous electrical field of $\sim$ 2 keV/cm. The negative charges drift towards the cathode grid-anode planes at right with velocity $\sim$ 0.7 cm/μs and create avalanches on the anode wires. Typical gas gains of 10^4 and clean electronic signals were obtained.

At present, the design and construction of the proposed full size TPC with dimensions 16x12x30 cm^3 is under way as well as the electronics and data processing system. First tests with beam are planned in 1998.

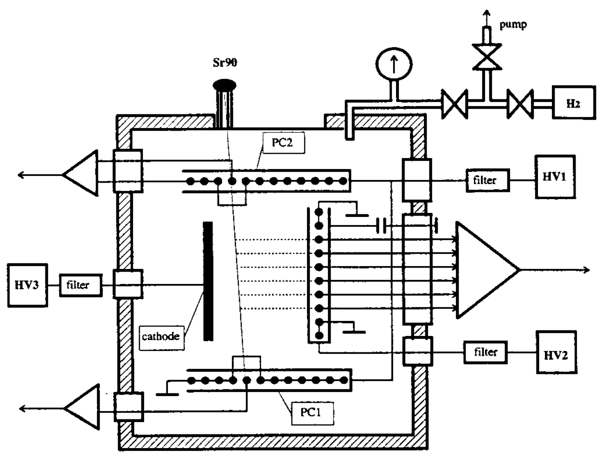

Fig. 1: The prototype TPC chamber at Gatchina.

References

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[2] D.V. Balin *et al.*, PSI Proposal R-97-05.1 (1996) and Progress Report (1997)