

# PRECISION MEASUREMENT OF SINGLET $\mu p$ CAPTURE IN HYDROGEN

V.A. Andreev<sup>1</sup>, T.I. Banks<sup>3</sup>, B. Besymjannykh<sup>1</sup>, L. Bonner<sup>6</sup>, R.M. Carey<sup>7</sup>, T.A. Case<sup>3</sup>, D. Chitwood<sup>4</sup>, S.M. Clayton<sup>4</sup>, K.M. Crowe<sup>3</sup>, P.T. Debevec<sup>4</sup>, J. Deutsch<sup>6</sup>, P.U. Dick<sup>2</sup>, A. Dijkman<sup>2</sup>, J. Egger<sup>2</sup>, D. Fahrni<sup>2</sup>, A.A. Fetisov<sup>1</sup>, S.J. Freedman<sup>3</sup>, V.A. Ganzha<sup>1</sup>, T. Gorringer<sup>8</sup>, J. Govaerts<sup>6</sup>, F.E. Gray<sup>3</sup>, F.J. Hartmann<sup>5</sup>, D.W. Hertzog<sup>4</sup>, M. Hildebrandt<sup>2</sup>, A. Hofer<sup>2</sup>, V.I. Jatsoura<sup>1</sup>, P. Kammel<sup>4,5</sup>, B. Kiburg<sup>4</sup>, P. Kravtsov<sup>1</sup>, A.G. Krivshich<sup>1</sup>, B. Lauss<sup>3</sup>, E.M. Maev<sup>1</sup>, O.E. Maev<sup>1</sup>, R. McNabb<sup>4</sup>, L. Meier<sup>2</sup>, D. Michotte<sup>6</sup>, F. Mulhauser<sup>2,4</sup>, M. Ojha<sup>8</sup>, C.J.G. Onderwater<sup>4</sup>, C.S. Özben<sup>4</sup>, J. Paley<sup>7</sup>, C. Petitjean<sup>2,5</sup>, G.E. Petrov<sup>1</sup>, C.C. Polly<sup>4</sup>, R. Prieels<sup>6</sup>, G.N. Schapkin<sup>1</sup>, R. Schmidt<sup>2</sup>, G.G. Semenchuk<sup>1</sup>, A. Sharp<sup>4</sup>, M. Soroka<sup>1</sup>, V. Trofimov<sup>1</sup>, A. Vasilyev<sup>1</sup>, A.A. Vorobyov<sup>1</sup>, D. Webber<sup>4</sup>, P. Zolnierczuk<sup>8</sup>

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The MuCap experiment is a high-precision measurement of the rate for the basic electroweak process of muon capture,  $\mu + p \rightarrow n + \nu$ . The proposed measurement of 1% accuracy will determine the least well-known of the nucleon charged current form factors, the induced pseudoscalar  $g_p$ , to 7%.

Several hardware upgrades were made to prepare the detector for the first full physics run. They dramatically improved the performance of the MuCap experiment compared to 2003.

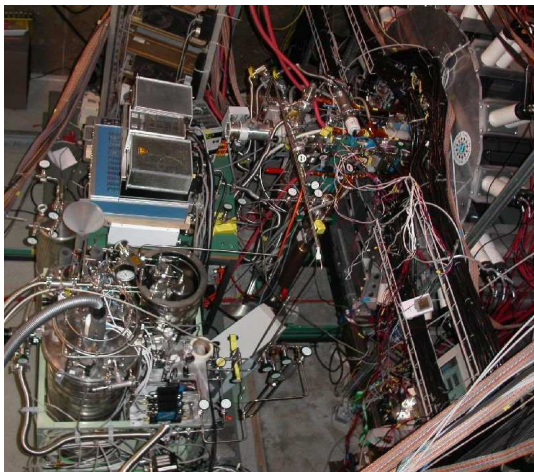


Figure 1: Photo of the MuCap experiment mounted in the  $\pi$ E3 area during the first production run in fall 2004.

**Commissioning of the  $\pi$ E3 beamline.** For efficient stopping the momentum bin of this beamline had to be reduced by a factor two which was achieved by a new tune with a dispersive focus. A customized experimental infrastructure was built including two rail systems (to retract the TPC from the electron detector for gas filling and servicing), additional shielding, and a climatized tent keeping the whole apparatus at low humidity and constant temperature.

**TPC improvements.** In early 2004 all TPC wire planes were carefully inspected, cleaned and reassembled under clean room conditions. During the training procedure, the TPC currents were always kept below 100 nA in order to avoid any degradation of wires. In the laboratory stable operation was reached at 10 bar and 5.6 kV which would allow observation of 5.3 MeV conversion muons from  $pd\mu$  fusion as a measurement of the deuterium depletion in the hydrogen gas. However, due to the reappearance of a hotspot, the TPC was operated in the run only at 5.0 kV. At this voltage the TPC worked for 10 weeks as a perfect muon stop detector. A

new beryllium window was mounted at the muon entrance port. This window, together with a complete redesign of the beam scintillators and of the outer  $\mu$  wire chamber, allowed an increase of the muon stop fraction from 33% to 65%.

**Full electron tracking capability.** During the first half of 2004 the new ePC2 chamber was fully instrumented. This process included construction of additional shielding meshes, the design and construction of new high voltage cards, and the installation of new frame-mounted readout electronics for cathodes and anodes. About 1500 new channels connected to new compressor modules were integrated in the DAQ. Under the new climatized conditions the chamber system performed flawlessly during the experiment.

**Protium production.** The MuCap experiment has to be run in protium, i.e. isotopically pure hydrogen with deuterium levels  $c_d \leq 1$  ppm. A new protium production was started,  $\sim 1500$  STP liters in total, sufficient to load the TPC (400  $\ell$ ) and the new gas circulation system (800  $\ell$ ), and to keep a reserve for samples. The original deuterium content of this production was determined to be  $(1.7 \pm 0.1)$  ppm.

**Gas purity and diagnostics.** The protium gas should contain  $Z > 1$  impurities of less than  $\sim 0.05$  ppm to prevent background from muon capture on impurities. The careful selection of UHV proof materials resulted in a gas purity of about 0.5 ppm. A new continuous gas circulation system operating at 10 bar was developed and built in Gatchina and integrated in the experiment. In contrast to 2003, very low and constant impurity levels were obtained, and the overall amount of impurities decreased to 0.07 ppm.

**Electronics and data acquisition.** We reimplemented the master logic that coordinates the DAQ, and also the trigger for the FADCs, using programmable devices. Notably, a new, powerful FPGA board was constructed for the FADC trigger. All computers were upgraded to newer, faster models. CAMAC ADC modules and an FPGA trigger system were incorporated to monitor the analog signals. The PSI electronics group repaired and tested the TDC400 modules used to digitize the TPC.

**Data collection.** In a first production run with the complete detector about  $2.5 \cdot 10^9$  fully reconstructed  $\mu^-$  events (after selection cuts) were recorded. In addition, some  $\mu^+$  statistics, many beam tests and systematic studies on impurities were performed. The  $\mu^-$  data already doubles the statistics of earlier experiments, and MuCap provides much cleaner conditions for interpretations and systematics. The data are currently being analyzed and a first result on  $g_p$  with improved precision is expected.

