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SINDRUM II

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Abstract. In the year 2000 SINDRUM II took final data in a search for μe conversion on gold. A short description of the experiment and some preliminary results are presented.

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1. Introduction

The conversion $\mu \to e$ of a μ^- bound in a muonic atom is a sensitive test of charged lepton flavour conservation [1]. In the past decade in a series of searches with the SINDRUM II spectrometer limits on the conversion rates on medium and heavy nuclei have improved significantly. This program was finished in the year 2000 with a measurement on gold. See [1] for a general discussion of μe conversion experiments and the SINDRUM II gold run in particular. Here I will discuss some more details.

2. The SINDRUM II spectrometer

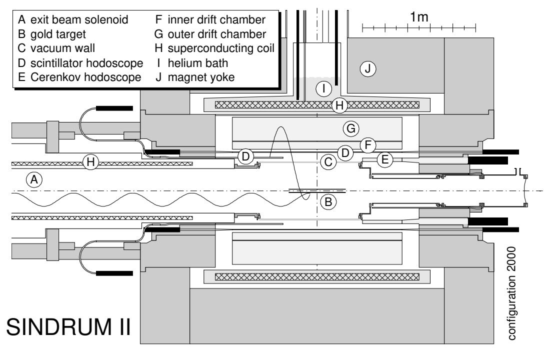

Figure 1. The SINDRUM II spectrometer

Figure 1 shows a vertical cross section through the spectrometer in the configuration used in the year 2000. Typical trajectories of a beam μ^- and a hypothetical conversion electron are indicated.

3. $\pi - \mu$ separation

Radiative π^- capture followed by $\gamma \to e^+e^-$ produces electrons with energies in the region of interest with a probability of $O(10^{-5})$ (see also section 5 below). Such prompt beam related background can be suppressed by beam pulsing, a beam veto counter, or beam purity. For heavy muonic atoms with lifetimes below 100 ns the first two methods lead to large inefficiencies. Here pions are removed with the help of an 8 mm thick CH_2 degrader at the entrance of a 9 m long solenoid which is coupled directly to the spectrometer (see figure 1 and [1]). At 50 MeV/c π^- stop in the degrader and μ^- go through (see figure 2). The tails in the calculated distributions

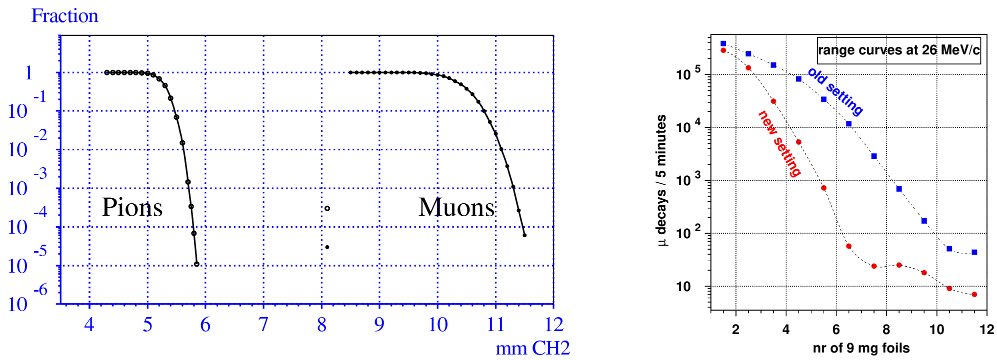

Figure 2. Left: CH_2 crossing probability calculated for 50 MeV/c π^- and μ^- v.s. thickness. Right: experimental μ^- crossing probabilities before and after optimisation. The latter were monitored through their decay electrons. The beam momentum was reduced for better μ^- identification.

result from range straggling. In practice the range distributions depend mainly on the momentum distribution of the beam. By carefully adjusting the fields in the various beam elements the required steeply falling range distribution was obtained.

4. Number of μ stops

Target stops were monitored by observing muonic X-rays with a Ge(Li) detector

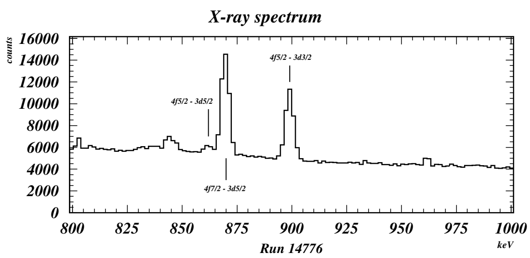

Figure 3. X-ray spectrum accumulated during three hours of μe data taking.

positioned outside the spectrometer coil (see figure 3). Detector efficiency and acceptance were calibrated with radioactive sources. The number of μ^- stopping in the gold target during μe data taking determined this way was $4.3 \pm 0.2 \times 10^{13}$.

5. Momentum spectra

Figure 4 shows momentum spectra observed with the spectrometer for various settings of the beamline. Events were selected with trajectories originating in the target and

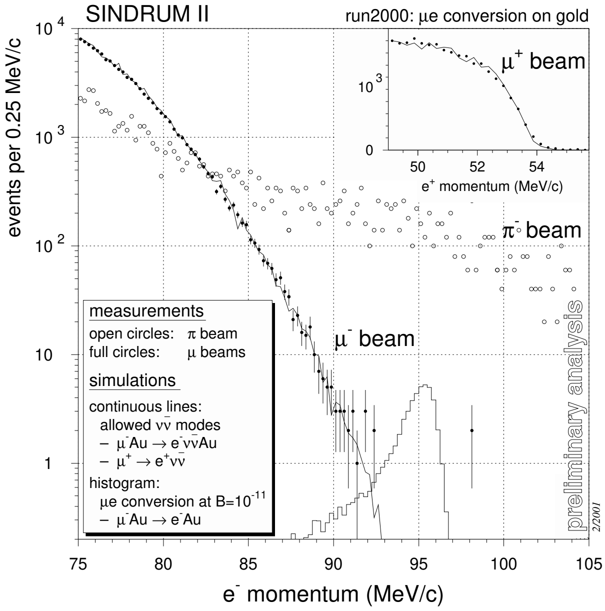

Figure 4. Momentum distributions for three different beam momenta and polarities: (i) 53 MeV/c negative optimized for μ^- stops, (ii) 63 MeV/c negative optimized for π^- stops, (iii) 48 MeV/c positive optimized for μ^+ stops. The 63 MeV/c data were normalized to correct for the different measuring times. The μ^+ data were taken at scaled spectrometer field.

cosmic background was suppressed as discussed in [1]. The main spectrum taken at 53 MeV/c shows the steeply falling distribution expected from muon decay in orbit μ^-Au$\rightarrow$ $e^-\nu\overline{\nu}$Au. Two events are observed at higher momenta just outside the region of interest. The agreement between measured and simulated spectra for μ^+ decay gives confidence in the momentum calibration.

6. Single-event sensitivity

The total efficiency for observing a μe conversion event including the geometrical acceptance and the efficiencies of the detector, the trigger for readout and the event reconstruction and selection amounts to $7 \pm 1\%$. This corresponds to a single-event sensitivity of $3.3 \pm 0.3 \times 10^{-13}$, i.e. almost two orders of magnitude below the best previous result on a heavy target [2]. We expect to produce the corresponding 90% c.l. upper limit on the branching ratio before the end of 2002.

References

[1] van der Schaaf A 2003 Muon Physics *Proc. Nufact'02 (London)*
[2] Kaulard J *et al* SINDRUM II Collaboration 1998 *Phys. Lett.* B **422** 334–38