Kinetic Energy of the pμ Atom

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The recent progress achieved in the production and use of very-low-energy μ^- has found a first experimental application in the measurement of the pμ kinetic energy at pressures around 1 mbar. By using frictional cooling [1] and detector triggered muon trapping [2] in a high solenoidal magnetic field, efficient μ^- stopping in a 1 cm diameter, 20 cm long gas volume could be obtained. After pμ formation and deexcitation to the 1s ground state the pμ atoms travel along almost straight-line trajectories to the walls of the target. By using gold coated cylindrical target walls the diffusion time to the walls is measured as the time difference between muon stopping time (obtained from a separate measurement in a H_2 + 4 % Xe target) and the time of transfer to gold (obtained from the detection of the emitted μAu x rays) [3].

Preliminary data analysis of the measurements done at 1 mbar and 4mbar H_2 resulted in transfer time spectra (shown in Fig. 1 for 1 mbar) that were fitted to an arbitrarily selected set of discrete pμ energies with variable intensities. The response-time functions associated with each of these energies (shown in Fig. 1) are calculated by taking into account the effect of the pμ emission angle, the diameter of the pμ source (muon stopping volume) and the measured stopping time distribution. A good independent determination of the main energy components is obtained showing the potential of the method to provide "differential" energy spectra.

The resulting intensities, given in table 1, reveal the existence of substantial high-energy tails which was unexpected to be present at such low pressures. Together with the clear increase in average kinetic energy with pressure they indicate that the acceleration mechanism resulting from Coulomb deexcitation is stronger than predicted by theory [4].

Another important clue is provided by these measurements in connection with the pμ(2s) state which is expected to remain long-lived when formed at sufficiently low energy. The present results give the first evidence for the existence of a fraction of long lived pμ(2s) atoms (estimated to be about 25 % at 1 mbar [5]), which is sufficiently high to allow an optimum realization of the planned 2s–2p laser-spectroscopy experiment.

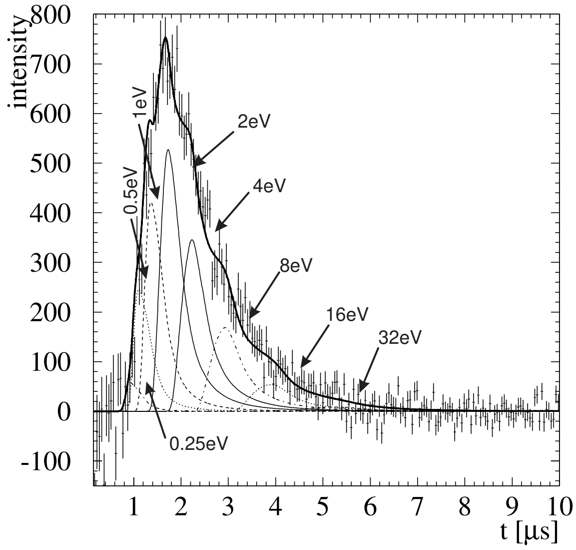

Fig. 1: Transfer-time distribution obtained at 1 mbar fitted with a superposition of time functions (lines) associated with arbitrarily selected discrete pμ energies $E = 1\,\text{eV} \cdot 2^n$ with $-2 < n < 5$. The data are preliminary.

References

[1] H. Daniel et al., PSI Nuclear and Particle Physics Newsletter 1993, p. 71.
[2] H. Daniel et al., PSI Nuclear and Particle Physics Newsletter 1994, p. 42.
[3] F.J. Hartmann et al., to be published in Hyperfine Interactions.
[4] L. Bracci et al., Nuovo Cim. **43A** (1978) 9.
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E(eV)	0.25	0.5	1	2	4	8	16	32	64
1 mbar	5(3)	13(2)	20(2)	22(1)	22(2)	12(2)	5(2)	1(1)	
4 mbar	8(6)	6(4)	13(3)	19(3)	23(2)	16(2)	8(2)	5(2)	2(1)

Table 1: Relative strength (in %) of the pμ energy lines obtained from fitting data at 1 and 4 mbar, respectively