Supplemental material for manuscript "Confinement of Positrons Exceeding One Second in a Supported Magnetic Dipole Trap"

J. Horn-Stanja,* S. Nißl, U. Hergenhahn, T. Sunn Pedersen, H. Saitoh, E. V. Stenson,
M. Dickmann, C. Hugenschmidt, M. Singer, M. R. Stoneking, and J. R. Danielson
(Dated: September 11, 2018)

ELECTRODE SETTINGS FOR LOSSLESS INJECTION

The electrode settings of the supported dipole trap used for the two lossless injection conditions discussed in the main text are given in Tab. I.

condition	$\lvert V_{ExB} \rvert$ / V	V_{mag} / V	V_{Seg1} / V	V_{Top1} / V	V_{Top2} / V
A	220	8	22	14	0
B	220	0	22	14	14

TABLE I. (Supplementary material) Two different electrode settings used to inject a 6-eV positron beam into the supported magnetic dipole trap with an injection efficiency close to 100%.

TIMING DIAGRAM FOR CONFINEMENT MEASUREMENTS

The timing diagram of an injection-hold-dump cycle used for the confinement measurements discussed in the main text is shown in Fig. 1.

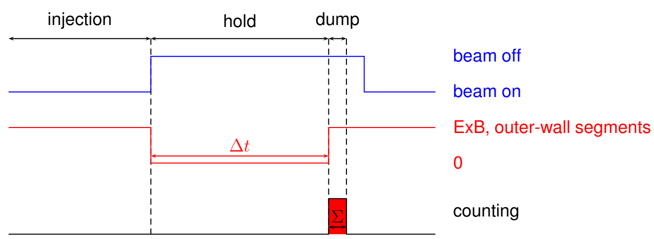

FIG. 1. (Supplementary material) Injection-hold-dump sequence for the measurement of the confinement time. The injected positrons are held for a time Δt before being dumped due to the gating of the E×B and other trap electrodes. Only the signal caused by the dump is used to determine the confinement time.

During the injection phase the positron beam is injected continuously. Due to the perturbing effect of the E×B plate biases most of the positrons leave the trap after one toroidal transit ($\sim 20\,\mu$s). The effective injection time is thus $20\,\mu$s. The dump and thus counting interval was set to 3 ms.

DATA RECONSTRUCTION

The confinement data was stored either in a preprocessed way during the experiment, as raw data or both. For the experiments described here, the preprocessing algorithm immediately converted the detector traces into binned traces assuming no pile-up events (on-line data). This was used for all data sets of condition A and some of condition B. In contrast, data reconstruction from the raw data took pile-up events into account (off-line data). From the single traces cycle failures or outliers could be identified and the data could be corrected accordingly. This was applied to some data sets of condition B. The fitting routine was then applied to the corrected pure or merged data sets from on-line and off-line data.

COLLISIONS OF POSITRONS WITH NEUTRALS

Literature data on the collisions of positrons with neutrals such as threshold energies, cross sections and annihilation rates are compiled in Tab. II.

species	E_e / eV	E_i / eV	E_{Ps} / eV	σ_{tot} / Å^2	σ_{vib} / Å^2	λ / 1/s	references
H	10.2	13.6	6.8	0.63	-	$6 \cdot 10^{-5}$	[1, 2]
H_2	11.19	15.58	8.78	0.84	0.03	$1.1 \cdot 10^{-4}$	[1–5]
H_2O	6.9, 7.2	12.6	5.8	9.8	0.16		[5–7]
N_2	8.42, 8.56	15.6	8.8	3.55	0.003	$2.3 \cdot 10^{-4}$	[2, 3, 5, 8, 9]

TABLE II. (Supplementary material) First electronic excitation energies, ionisation potentials, thresholds for Positronium formation, total and vibrational cross sections at 6 eV and the direct annihilation rates for some typical residual species.

MAGNETIC FIELD LINES

The magnetic field lines of the permanent magnet intersect the E×B electrodes only if they extend to equatorial distances above ∼ 7.1 cm. This is illustrated in Fig. 2.

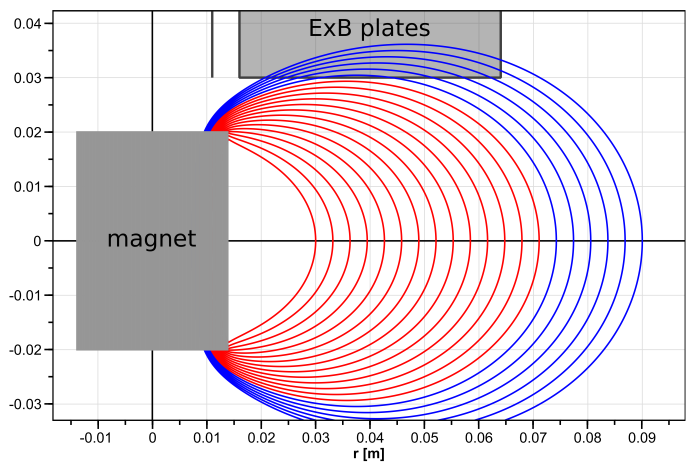

FIG. 2. (Supplementary material) Magnetic field lines of the permanent magnet in the dipole trap. Red field lines do only intersect the magnet surface but none of the other trap electrodes. Blue field lines intersect the magnet surface and the E×B electrodes.

* juliane.stanja@ipp.mpg.de

[1] S. Zhou, H. Li, W. E. Kauppila, C. K. Kwan, and T. S. Stein, Phys. Rev. A **55**, 361 (1997).
[2] C. M. Surko, G. F. Gribakin, and S. J. Buckman, J. Phys. B: At. Mol. Opt. Phys. **38**, R57 (2005).
[3] K. R. Hoffman, M. S. Dababneh, Y.-F. Hsieh, W. E. Kauppila, V. Pol, J. H. Smart, and T. S. Stein, Phys. Rev. A **25**, 1393 (1982).
[4] J. P. Sullivan, S. J. Gilbert, J. P. Marler, L. D. Barnes, S. J. Buckman, and C. M. Surko, Nucl. Instr. and Meth. in Phys. Res. B **192**, 3 (2002).
[5] "NIST Chemistry WebBook," `http://webbook.nist.gov`, accessed: 13.11.2017.
[6] A. Zecca, D. Sanyal, M. Chakrabarti, and M. J. Brunger, J. Phys. B: At. Mol. Opt. Phys. **39**, 1597 (2006).
[7] T. Nishimura and F. A. Gianturco, Eur. Phys. J. D **33**, 221 (2005).
[8] G. Karwasz, D. Pliszka, A. Zecca, and R. Brusa, J. Phys. B: At. Mol. Opt. Phys. **38**, 1 (2005).
[9] F. A. Gianturco and T. Mukherjee, Phys. Rev. A **55**, 1044 (1997).