Topic number: 2

Simulation of Penning-Malmberg-Surko trap through numerical Monte Carlo simulation

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In recent years, investigation of low energy positron (e^+) interaction has become possible by application of positron traps that cool the beam to low energies and allow good beam energy resolution. Main characteristics of the trap are trapping efficiency, outgoing beam energy resolution, and divergence. In order to help optimize some of these characteristics, we analyzed several trap configurations, using a Monte Carlo code, and investigated the effect of several trap parameters, such as geometry, axial electric potential, buffer gas composition and pressure profile, and trapping time.

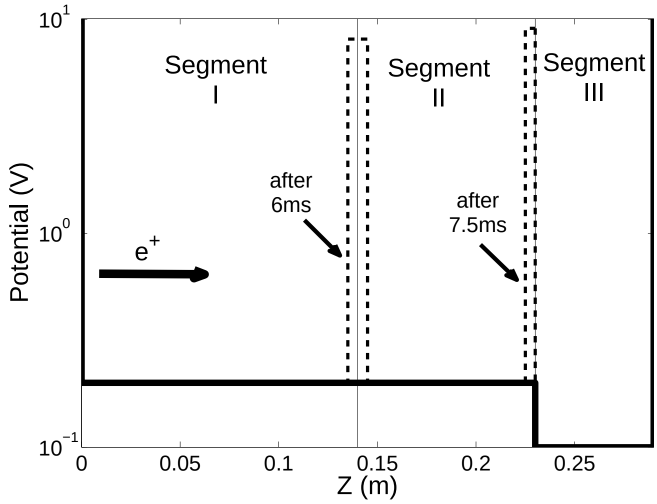

Fig. 1: Dynamic trap model with time dependent potential profile representing the apparatus presented in [1]. Duration of different operating stages is set to $T_{load} = 6\,ms$ and $T_{cool} = 1.5\,ms$.

In respect to the axial potential profile, we have analyzed three different models of positron traps. The static model represents a realistic three stage potential well configuration [2]. The dynamic model is implemented in a way to represent the trap described in [1] as closely as possible, including the time dependent potential profile. The third model is a trap with semi-permeable potential barriers, representing an ideal case of raising the barrier after each individual particle has passed.

The buffer gas used in all models is a mixture of N_2 and CF_4. Our code supports continuously varying gas pressure and composition along the axis of the trap cylinder. The conditions were set to closely resemble the conditions inside of an existing apparatus [1]. We used comprehensive cross sections sets for e^+ - N_2 [3,6] and e^+ - CF_4 [4,5] interactions including loss processes (Ps formation and direct annihilation) which are essential in determining the trap efficiency. The results show good agreement with the reported characteristics of existing traps and we suggest several modifications that should improve their operation.

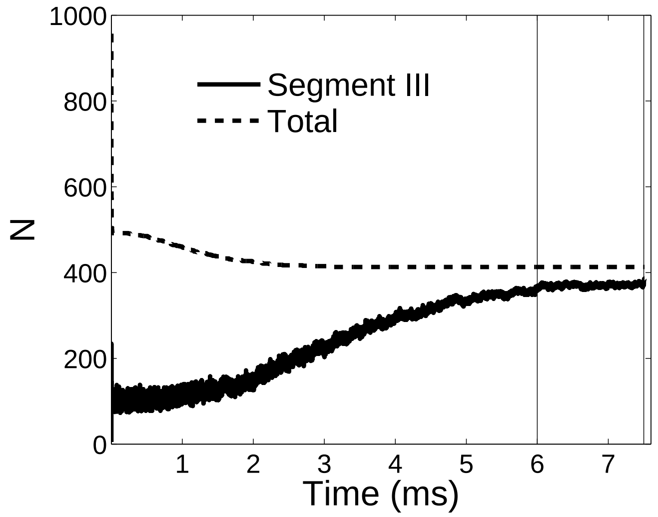

Fig. 2: Number of particles in the third segment of the dynamic trap model during the operation of the trap. Vertical lines represent time marks for different operating stages.

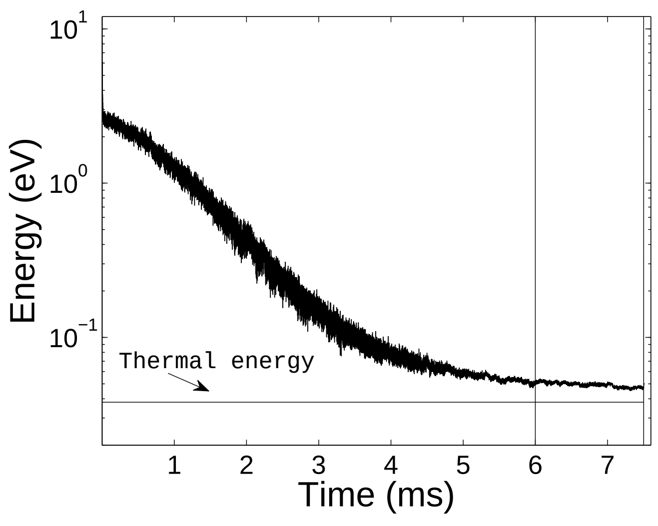

Fig. 3: Mean energy of the particles in the third segment of the dynamic trap model. Vertical lines represent time marks for different operating stages.

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