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ФИЗИКА И ТЕХНИКА УСКОРИТЕЛЕЙ

POSITRON INJECTOR FOR LEPTA

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The injector of the low energy positrons for accumulator LEPTA is being assembled at JINR. The key elements of the injector have been tested. The cryogenic source of slow positrons has been tested with a test isotope ^{22}Na of the initial activity of 0.8 MBk. The continuous slow positron beam intensity of $5.8 \cdot 10^3$ s^{-1} with average energy of 1.2 eV and width of a spectrum 1 eV has been obtained. The achieved moderator efficiency is about 1%. The accumulation process in the positron trap was investigated with electron flux. The lifetime of the electrons in the trap, $\tau_{\rm life} \geqslant 80$ s and capture efficiency $\varepsilon \sim 0.4$ have been obtained. The maximum number of the accumulated particle was $N_{\rm exp} = 2 \cdot 10^8$ at the initial flux of $5 \cdot 10^6$ e^-/s.

В ОИЯИ завершается сборка импульсного инжектора позитронов низкой энергии для установки LEPTA. Проведено экспериментальное исследование работы основных узлов инжектора. Исследована работа криогенного источника позитронов с тестовым изотопом ^{22}Na, активностью 0,8 МБк. Получен пучок медленных позитронов интенсивностью $5{,}8 \cdot 10^3$ с$^{-1}$ со средней энергией 1,2 эВ при ширине спектра 1 эВ. Доля замедленных позитронов составила 1% от полного потока. Проведено исследование процесса накопления частиц в ловушке на электронах. В результате оптимизации параметров ловушки достигнуто время жизни накопленных электронов $\tau_{\rm life} \geqslant 80$ с, а эффективность захвата $\varepsilon \sim 0{,}4$, что соответствует наилучшим результатам, полученным в ловушках подобного типа. При этом максимальное число накопленных частиц $N_{\rm exp} = 2 \cdot 10^8$ при первоначальном потоке $5 \cdot 10^6$ e^-/с.

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INTRODUCTION

The Low Energy Particle Toroidal Accumulator (LEPTA) with circulating electrons was commissioned in September 2004 [1]. The main goal of the LEPTA is generation intense flux of the positronium atoms [2]. Preparation of the accumulator for circulating positron beam now is made. One turn injection is used in the accumulator. The pulse duration of the injection has to be shorter than 300 ns. The period of the injection pulses is $10-100$ s. The peculiarity of the accumulator LEPTA is small value of the momentum spread of the circulating positrons — $\Delta p/p < 10^{-3}$. The demand positron intensity per pulse is 10^8.

The low energy positron injector corresponding to the demands of the accumulator LEPTA was developed [3]. The positron injector is based on the radioactive isotope ^{22}Na. The positron trap is used in the antihydrogen atoms creature experiments ATHENA at CERN which is chosen as prototype of the positron injector [4].

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THE CRYOGENIC SOURCE OF SLOW MONOCHROMATIC POSITRONS

The cryogenic source of slow monochromatic positron (CSSMP) is one of the key elements of the injector. The possibility of precise control of the frozen layer thickness of the moderator (neon) was realized for the first time in the original design of the CSSMP [5]. A special stend was assembled with the goal of measuring the parameters of the slow monochromatic positron beam [6]. The dependence of the slow positron yield on moderator thickness has been measured in the experiments (Fig. 1). The yield of slow positrons increases with an increase in the moderator thickness and attains maximum at $\delta = 130$ μm. Further increase of the moderator thickness is followed by a smooth decline in the slow positron yield.

The dependence of the shape of the slow positron spectrum on the frozen layer thickness was measured for the first time for this type of sources (Fig. 2).

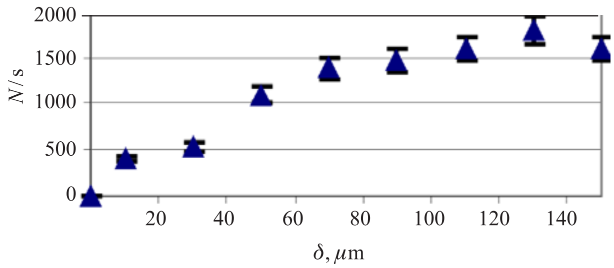

Fig. 1. Counting rate of positrons vs thickness of the frozen moderator layer

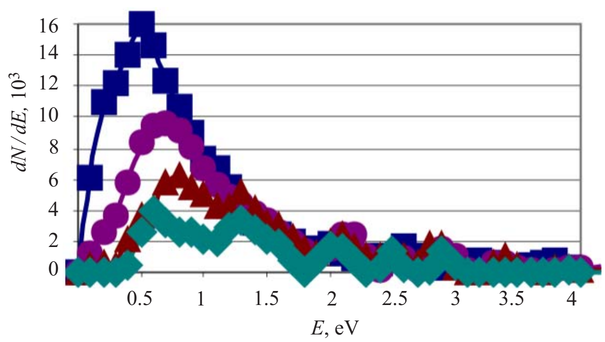

Fig. 2. Positron spectrum at different thicknesses δ of the frozen moderator layer: 30 (♦), 50 (▲), 90 (●), 130 μm (■)

After the moderator thickness was optimized, deceleration efficiency ε is 1%. The spectrum width was 1 eV at the mean positron energy of 1.2 eV.

THE POSITRON TRAP [7]

The research of the accumulation process in the trap was carried out using electron flux. For this purpose the test electron gun allowing one to emit $dN/dt = 5 \cdot 10^6$ electrons per second with energy 50 eV and spectrum width of distribution of a few eV was made (see Fig. 3).

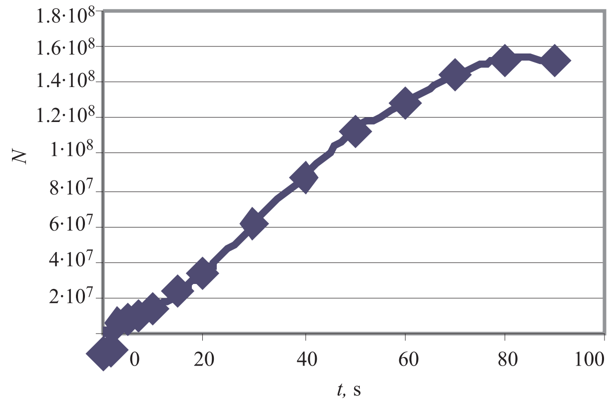

Fig. 3. The dependence $N(t)$ of the accumulated electron number on accumulation time (in the corner of the initial part of the experimental curve one can find the efficiency of capture ε. The value of $N(t)$ at saturation allows us to find lifetime $\tau_{\rm life}$)

The lifetime of the electrons in the trap, $\tau_{\rm life} \geqslant 80$ s and capture efficiency $\varepsilon \sim 0.4$ have been obtained. These values corresponded to the best results got in this type of the traps. The maximum number of the accumulated particle is $N_{\rm exp} = 2 \cdot 10^8$ at the initial flux of $5 \cdot 10^6$ e^-/s.

The method of the fast extraction particle from the trap was developed and experimentally investigated for the first time of extraction less than 500 ns. This time of extraction from the trap allows capture 60% accumulated particles. It provides achievement of design parameters.

CONCLUSION

The results of experimental testing of the main units allow one to provide the design parameters of the injector for accumulator LEPTA. Preparation for injection of the positrons in the accumulator now is carried out. To provide design parameters of the injector the isotope ^{22}Na by activity 25 mCi will be used.

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