LEPTA PROJECT: TOWARDS POSITRONIUM

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Abstract

The project of the Low Energy Positron Toroidal Accumulator (LEPTA) is under development at JINR. The LEPTA facility is a small positron storage ring equipped with the electron coolin system. The project positron energy is of 2 – 10 keV. The main goal of the facility is to generate an intense flux of positronium atoms – the bound state of electron and positron.

Storage ring of LEPTA facility was commissioned in September 2004 and was under development up to now. The positron injector has been constructed in 2005 ÷ 2010, and beam transfer channel – in 2011. By the end of August 2011 experiments on electron and positron injection into the ring have been started. The recent results are presented here.

LEPTA RING DEVELOPMENT

The Low Energy Particle Toroidal Accumulator (LEPTA) is designed for studies of particle beam dynamics in a storage ring with longitudinal magnetic field focusing (so called "stellatron"), application of circulating electron beam to electron cooling of antiprotons and ions in adjoining storage electron cooling of positrons and positronium in-flight generation.

For the first time a circulating electron beam was obtained in the LEPTA ring in September 2004 [1]. First experience of the LEPTA operation demonstrated main advantage of the focusing system with longitudinal magnetic field: long life-time of the circulating beam of low energy electrons. At average pressure in the ring of 10^{-8} Torr the life-time of 4 keV electron beam of about 20 ms was achieved that is by 2 orders of magnitude longer than in usual strong focusing system. However, experiments showed a decrease of the beam life-time at increase of electron energy. So, at the beam energy of 10 keV the life time was not longer than 0.1 ms. The possible reasons of this effect are the magnetic inhomogeneity and resonant behaviors of the focusing system.

Positron Transfer Channel

The channel is aimed to transport positrons extracted from the trap of the injector (see below) and accelerate them up to 10 keV (maximum) in electrostatic field in the gap between the trap and the channel entrance. The designing and manufacturing of the channel elements was completed in 2010(Fig. 1).

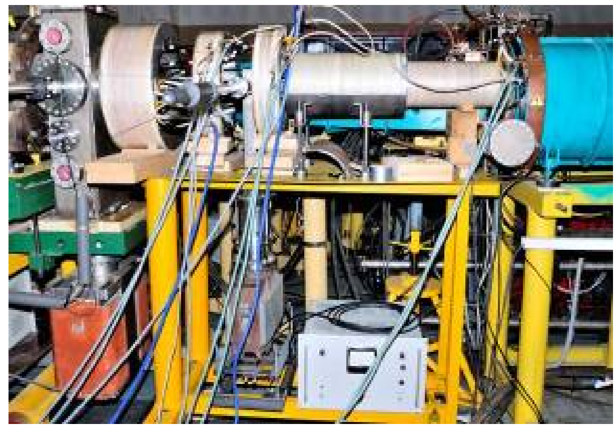

Figure 1. The transfer channel.

Circulating e+ Beam Detector

For fine tuning of the trajectory and control of circulating positron beam aperture probe based on semiconductor gamma detector has been designed (Fig.2). Fabrication of the probe is in progress.

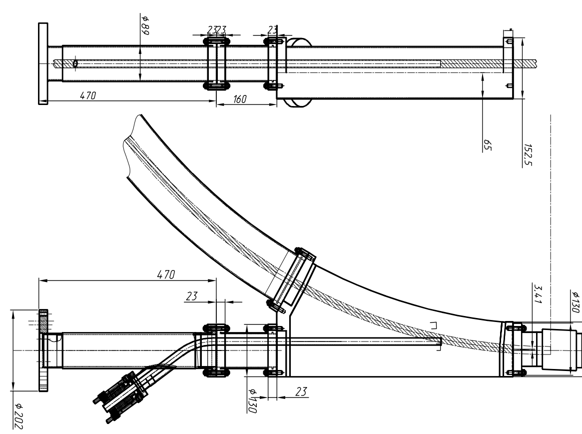

Figure 2. The circulating e^+ beam detector.

THE POSITRON INJECTOR

In summer 2010 the slow positron source and the trap have been assembled. The first attempts of slow positron storage were performed (Fig.3) and stored positrons were extracted to the collector.

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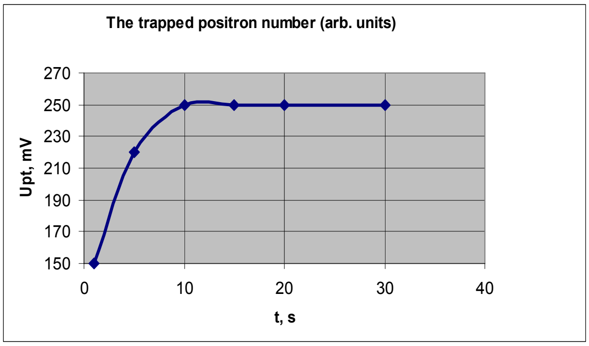

Figure 3: The trapped positron number vs storage time. Rotating wall(RW)=0,5V.

Upt is the amplitude of the signal from the phototube (PT), RW amplitude is equal to 0.5 V.

Manufacturing and assembling of the transfer channel from injector to the ring were completed by the end of July 2011. The test of the channel was performed in August 2011, first with test electron beam and later with positrons. Test electron gun was installed at the entrance of positron trap (Fig.4).

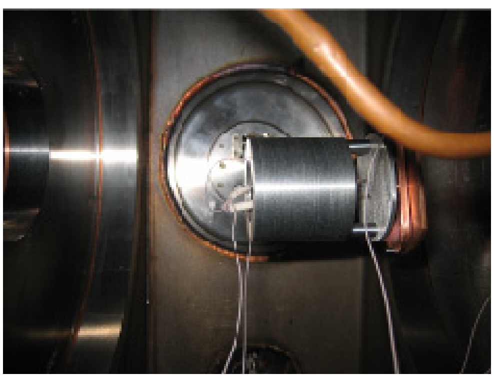

Figure 4. The test electron gun.

The ring was disassembled and luminescent screen was placed inside the kicker chamber. The beam images of electron beams both from the test gun and electron gun of the electron cooling system were obtained on the screen (Fig.5). After that positrons were injected into the ring at facility parameters optimized with electron beam.

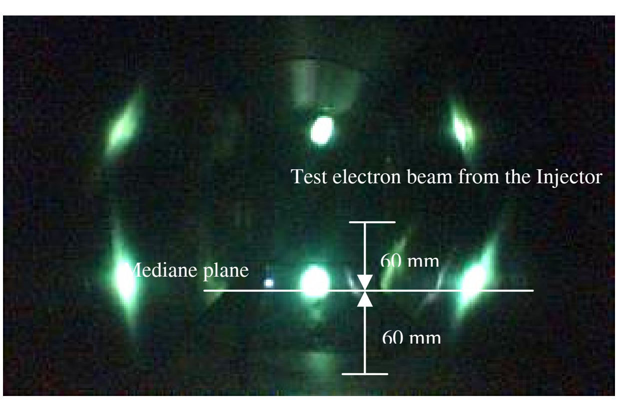

Figure 5. Two beams on luminescence screen.

The registration of positron transportation through the channel and septum section of the ring to the luminescence screen was performed using for e^+ registration a NaI scintillation counter in counting mode.

The vacuum conditions in the accumulation space of the positron trap have been improved by the application of a cryogenic screen that was designed, manufactured, mounted and tested (Fig.6). It has effected in an increase of stored positron life time by three times.

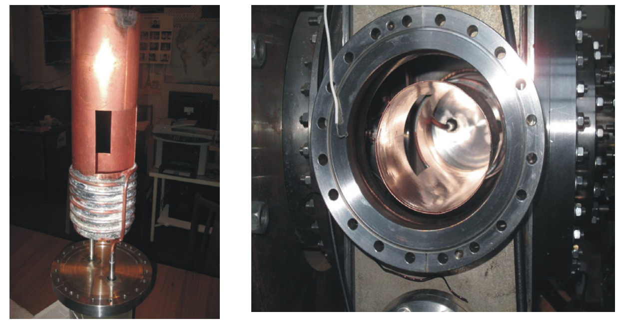

Figure 6. The cryogenic screen.

For magnetic field optimization its measurement and numerical simulations have been produced (Fig.7).

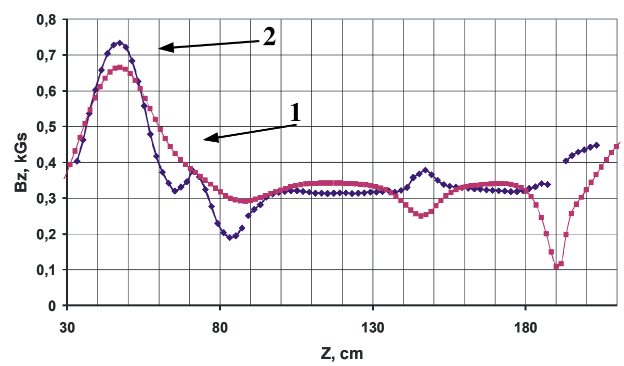

Figure 7. Magnetic field in the transfer channel: 1) B_z(z) at the channel axis (simulation); 2) B_z(z) at r=4 cm (experiment).

During the spring-summer 2012 the experiments on optimization of positron accumulation in the trap and positron injection into the ring have been performed.

We have found in the experiments that quantity of slow positrons rises up by 30% if temperature of neon layer is increased from 6,5 to 7,2 K after the positron source freezing completion.

For tuning of positron trajectory in the ring we have used scintillation counter operated in analog signal mode. The positrons extracted from the trap, passed through the transfer channel and after completion of single turn were shifted to the vacuum chamber wall (Fig.8). Finally, single turn regime of positron extraction/injection has been found and optimized.

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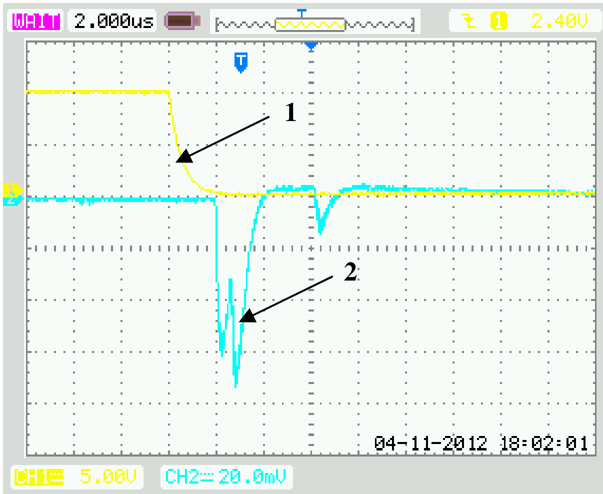

Figure 8. Analog signal from phototube: 1) potential of the trap exit electrode; 2) phototube pulse.

CONCLUDING REMARKS

The development of the LEPTA project is approaching the stage of experiments with circulating positron beam. All main elements of the ring and the injector are ready and have been tested.

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