LEPTA PROJECT: TOWARDS POSITRONIUM

E. Ahmanova, V. Lokhmatov, I. Meshkov, O. Orlov, V. Pavlov, A. Rudakov,
A.A. Sidorin, S. Yakovenko, JINR, Dubna, Russia
A. Kobets# JINR, Dubna and Institute of Electrophysics and Radiation Technologies,
NAS of Ukraine
M. Eseev JINR, Dubna and M.V. Lomonosov Pomor State University, Russia

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 is 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 injection into the ring of electrons and positrons stored in the trap 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 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 170 ms was achieved that is by several 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 12 ms. The possible reasons of this effect are the magnetic inhomogeneity and resonant behavior of the focusing system.

Diagnostic System Development

Previous PU system was connected to amplifier by using the cable of near 3 meters length. That reduced significantly sensitivity for all system. New amplifier was designed, manufactured and mounted (Fig. 1). It locates directly at connector exits from vacuum chamber. Sensitivity of new system is of 1,1 mV/μA.

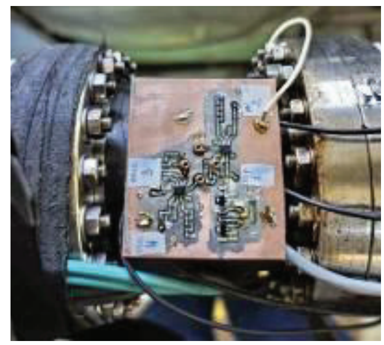

Figure 1: The new PU amplifiers.

For fine tuning of the trajectory and control of circulating positron beam aperture probe based on semiconductor gamma detector has been designed (Fig.2), fabricated, mounted and tested with positrons injected into the ring.

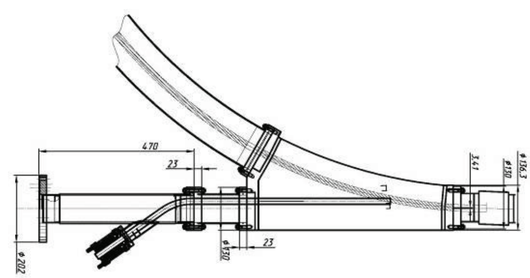

Figure 2: The circulating e^+ beam detector.

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 and stored positrons were extracted to the diagnostic collector.

Vacuum System Development

New vacuum chamber for transport channel was manufactured and mounted to minimize losses during injection. Aperture was increased from 3,2 cm to 6,5 cm.

The vacuum conditions in the accumulation space of the positron trap have been improved by the application of a cryogenic screen (Fig 3). that was designed, manufactured, mounted and tested. It has effected in an increase of stored positron life time by a three times.

#kobets@jinr.ru

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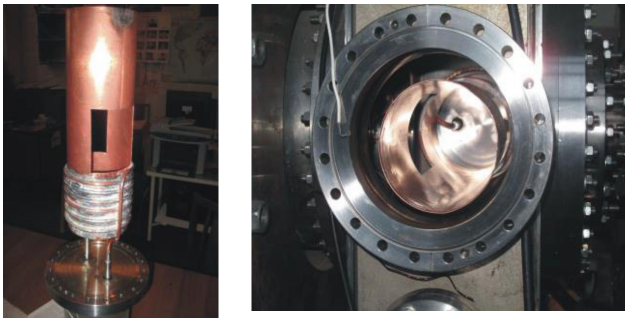

Figure 3: The cryogenic screen.

Decision to mount new cryogenic pump (VCP160 CF-F) (Fig. 4) in place of old ion pump on positron Injector picture) was made after analysis of experimental test of nitrogen screen.

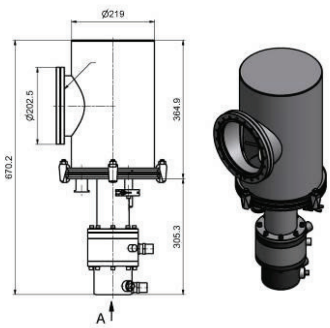

Figure 4: The cryogenic pump.

e^- Injection and Circulation

Circulation of electron beam accumulated and extracted from the trap was received in March 2013. Electron energy was of 4 keV (Fig. 5).

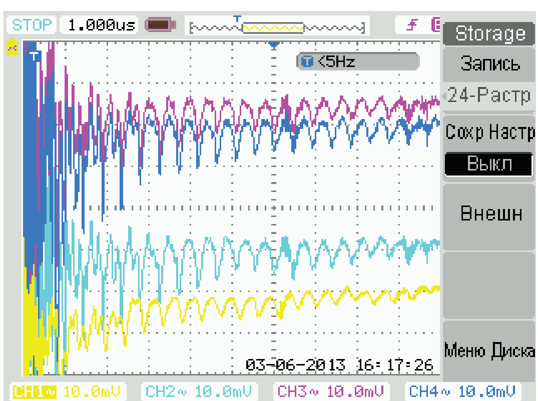

Figure 5: The oscillogram of electron circulation.

e^+ Accumulation and Injection

During the spring-summer 2012 the experiments on optimization of positron accumulation in the trap and positron injection into the ring have been performed. Typical spectrum of slow positrons beam is shown on Figure 6.

We have found in the experiments that quantity of slow positrons rises up by 30% if temperature of neon layer on the source surface is increased from 6.5 to 7.2 K after the positron source freezing completion.

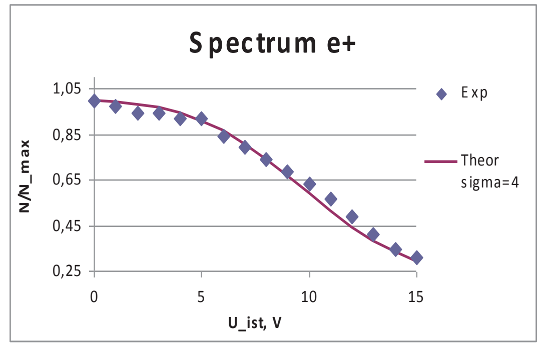

Figure 6: The spectrum of slow positrons.

For tuning of positron trajectory in the ring we have used scintillation counter operated in analog signal mode (Fig. 7). The positrons extracted from the trap, passed through the transfer channel and after completion of single turn were deflected to the vacuum chamber wall. Finally, single turn regime of positron extraction/injection has been found. Photoelectron multiplier tube has been calibrated by etalon 22Na source that allows to measure accumulated e+ beam. Its sensitivity is 10^3 e^+/Volt.

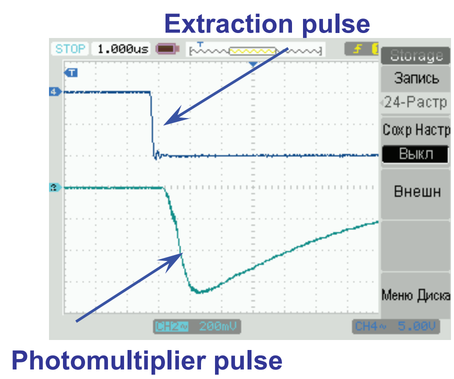

Figure 7: Pulse from photomultiplier tube.

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.

ACKNOWLEDGEMENTS

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