

1) Low Energy Particle Toroidal Accumulator (LEPTA).

2) The following experimental works:

2.1. *Particle dynamics in Penning-Malmberg Syrko Trap.*

Student will learn the principle of the position (electron) storage in the trap:

- the trap design and operation regimes;
- methods of particle storage and extraction;
- methods of diagnostics of stored particle bunch parameters.

Student will carry-out experiments aiming measurements of particle storage in the trap regions and particle bunch parameters.

2.2. *Electron cooling system of LEPTA ring.*

Students will learn the principle of electron cooling system operation and carry-out experiments on electron cooling system tuning and optimization.

2.3. *Positron Annihilation Spectroscopy (PAS)*

Student will learn the principle and goals of PAS method and the PAS experimental set up at LEPTA facility. Student will carry-out experiments on PAS of samples of different materials (metals, semiconductors, etc.)

3) Abstract – What Is LEPTA Facility

The project of Low Energy Particle Toroidal Accumulator (**LEPTA**) is dedicated to construction of a small positron storage ring with electron cooling of positrons circulating in the ring. Such a peculiarity of the LEPTA enables it to be a generator of **Positronium (Ps)** atoms, which appear in recombination of positrons with cooling electrons inside the cooling section of the ring. The Ps atoms are generated in form of an intense, up to 10^4 atoms/sec, flux which has very small angular, of order of 1 mrad, and momentum (less than 10^{-3}) spreads.

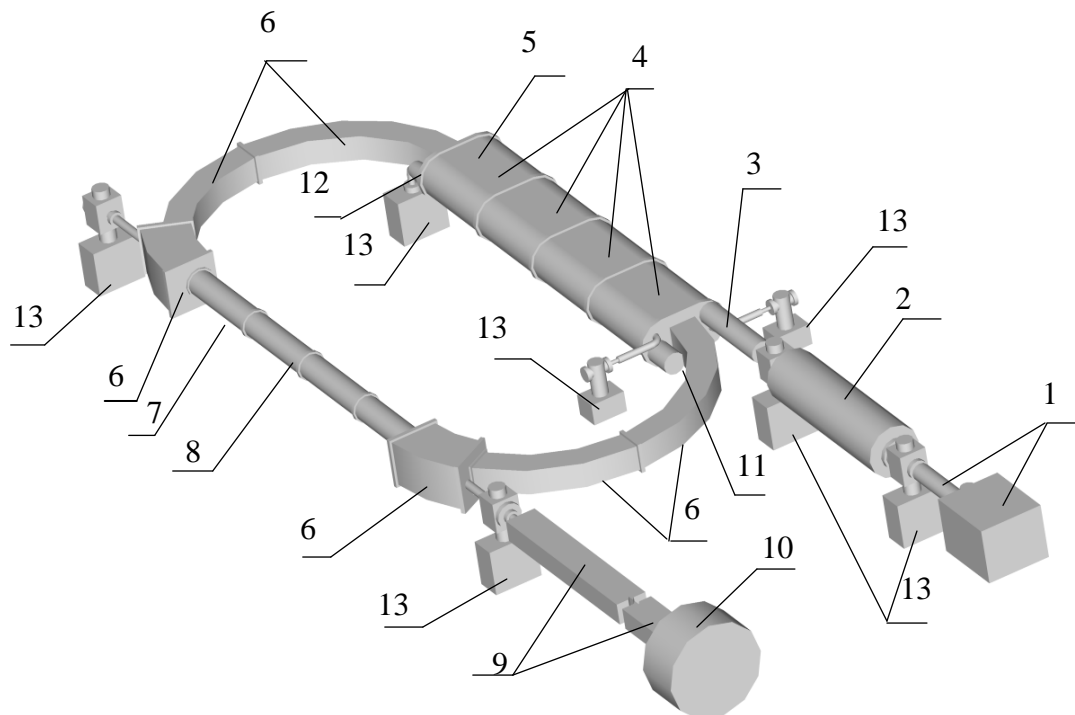


Fig.1. LEPTA Scheme. 1 – positron source, 2 – positron trap, collector, 3 – positron transfer section, 4 – septum solenoids, 5 – kicker (inside septum solenoid), 6 – toroidal solenoids, 7 – solenoid and quadrupole coil, 8 – electron cooling section, straight solenoid, 9 – analyzing magnets, 10 – detector, 11 – electron gun, 12 – collector of the electrons, 13 – vacuum pump.

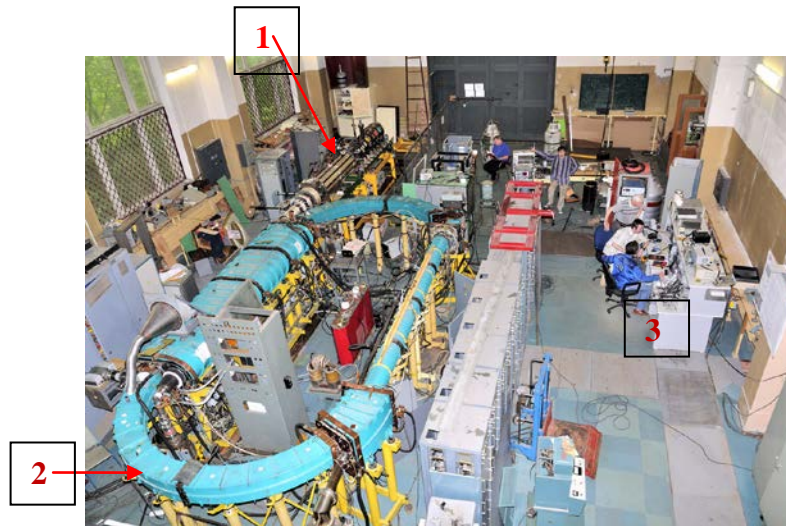


Fig.2. General view of the LEPTA facility
 1 – injector, 2 – storage ring, 3 – control panel

Surko Positron Trap

The geometry of the Surko trap at the LEPTA facility is shown in Fig. 3. The electrode assembly is placed in a cylindrical vacuum chamber, which is located in a solenoid creating the longitudinal magnetic field. The differential vacuum pumps placed at the ends of the chamber are used to evacuate the residual gas, which decreases the lifetime of particles in the trap, and create the pressure gradient of the buffer gas (nitrogen) (Fig. 4). The latter is achieved by creating a special configuration of eight mutually isolated cylindrical electrodes of different lengths and diameters. The buffer gas is injected into the system through a gap in the middle of electrode II and is pumped out through the ends of electrodes I and VIII. As a result, a pressure drop is produced between the trapping regions (sections 1 and 2) and the storage region (section 3). The injected positrons are trapped and cooled due to inelastic collisions with buffer gas molecules. The pressure is chosen in such a way that a positron generated in the source experiences on the average one inelastic collision as it passes through electrode II. Having lost energy in a collision event, the positron is unable to overcome the potential barrier of electrode I and leave the trap. The subsequent inelastic collisions lead to the trapping of positrons in the potential well of section 3. The positron energy at the entrance to the trap and the electrode potentials (Fig. 4) are chosen in such away that the positron energy in the storage region (section 3) is about 1 eV. Further, the positrons spend their energy on the excitation of rotational and vibrational modes of the buffer gas molecules and are cooled to room temperature (≈ 0.026 eV). The storage process continues until equilibrium is established between the supply of positrons from the source, on the one hand, and their annihilation in the residual gas and their diffusion onto the chamber wall, on the other hand. The nitrogen pressure and the trap potentials determine the effective positron energy and substantially affect the storage efficiency. The choice of nitrogen as a buffer gas is explained by the low cross section for positron annihilation in this gas at particle energies typical of our experiment. In order to study the influence of the rotating electric field on the efficiency of particle storage, one of the trap electrodes (electrode IV) is made of four isolated segments. To each segment, a sinusoidal voltage with the same frequency and amplitude is applied, the phase shifts between the segments being 90° . As a result, an electric field rotating in the plane perpendicular to the trap axis is produced.

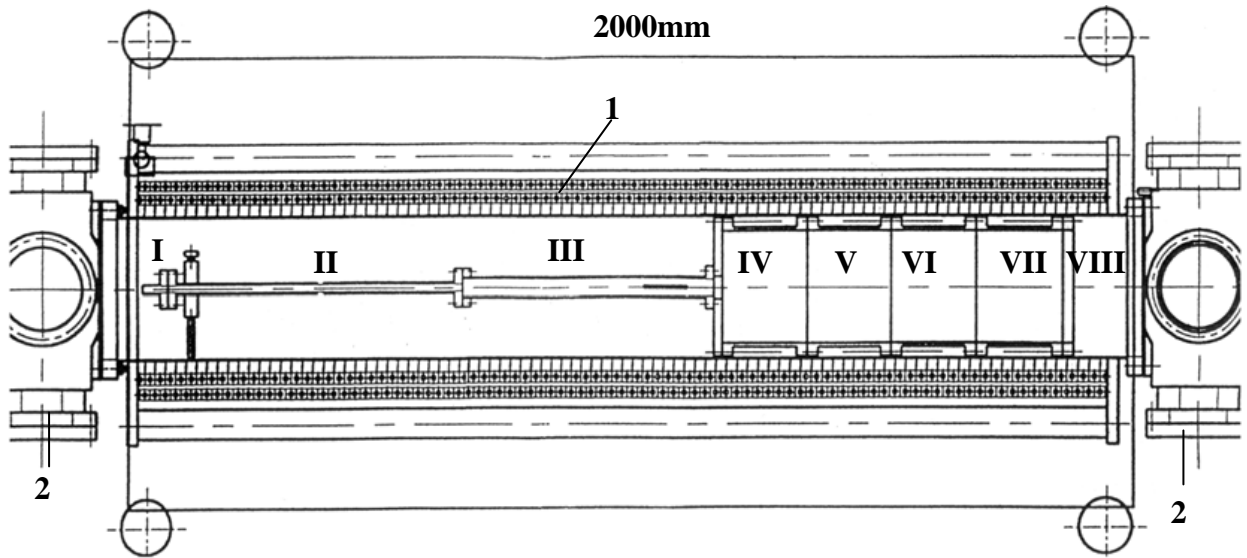


Fig. 3. Schematic of the Surko trap at the LEPTA facility: (I–VIII) electrodes, (1) solenoid, and (2) vacuum posts.

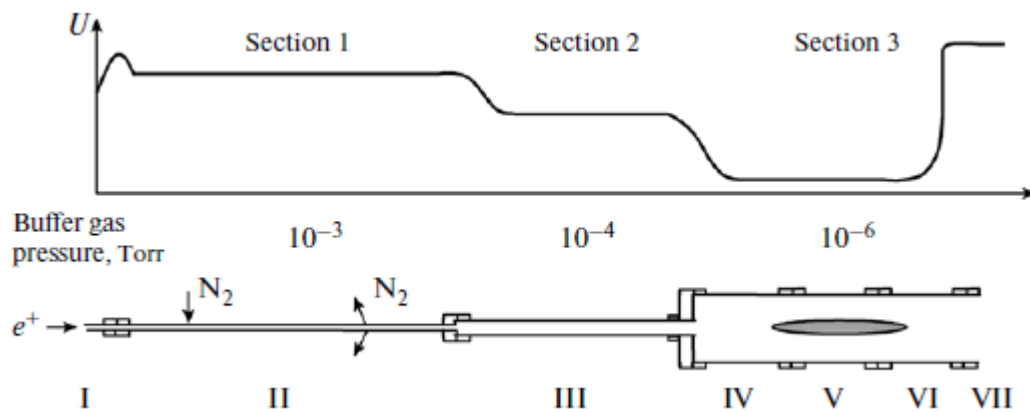


Fig. 4: Assembly drawing of the positron trap (upper picture), potential and pressure distributions along the electrode system.

Positron Source

The first part of preinjector is the positron source placed inside the vacuum chamber. The radioactive isotope ^{22}Na tablet is placed on copper substrate (1) inside a copper cylinder (2). The cylinder ended by the copper cone (3). Solid neon, frozen on the surface of the cone, serves as moderator for flying positrons. First cryogenic heat exchanger (4) inheres on the surface of the cylinder. A liquid helium flowing through the heater cools down cylinder and cone to the temperature less than 5 K. The copper cylinder is located inside of the copper cover (5) used for heat and radiation protection of the internal system. On the outer surface of the cover second cryogenic heat exchanger is disposed (6). The liquid helium has passed through cylinder's heat exchanger leaves system through copper cover's one. On the other side neon falls into the system through second heat exchanger where preliminary cooled. Then it is injected on internal surface of the copper cone by nozzles (7). Such design allows checking thickness of the frozen moderator.

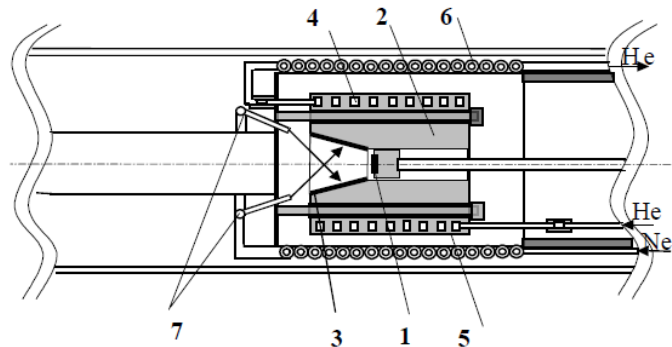


Fig. 5. Positron Source (description in the text)

The work of students includes: experimental measurements of processes to be studied, experimental results and the report preparation.

The results will be presented in form of a report containing: the experimental description, experimental results (description, graphics, etc.), analytics of the results.

4) The student should have a basic knowledge in the field of general physics and electrodynamics own course.

5) Suggested Reading:

1. Eseev, M.K. LEPTA Project: Towards Positronium, Proc. COOL' 2013, <http://accelconf.web.cern.ch/AccelConf/COOL2013/papers/weppo11.pdf>

2. A. Kobets, et. al., Status of the LEPTA Proc. COOL' 2007, <http://accelconf.web.cern.ch/accelconf/cl07/papers/wem1c01.PDF>

6) In the project can work 1 – 3 students simultaneously.

7) The project Manager - Kobets Andrey Gennadievich, the group head, research worker, Laboratory of nuclear problem, Sector of electron cooling, Accelerator Physics, more 30 Scientifics reports, <http://lepta.jinr.ru/>)