GENERATION AND ACCUMULATION OF LOW ENERGY POSITRONS

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Abstract

The cryogenic source of low energy positrons based on the ^{22}Na isotope has been designed and constructed at JINR. A solid neon as moderator allows to form slow positron beam of the energy of 1,2 eV and width of the spectrum of 1 eV. Afterwards such positrons are accumulated in the Penning-Malmberg trap. Description of the device and experimental results are presented.

THE CRYOGENIC POSITRON SOURCE

Positrons emitted from radioactive source ^{22}Na have a very broad energy spectrum up to 0,5 MeV. To generate monochromatic beam of slow positrons the solid neon as moderator is used [1]. When positron pass trough the moderator the part of the broad energy spectrum are slowed down to thermal speeds. A small longitudinal magnetic field is used for transport of continuous beam of slow positrons (fig.1).

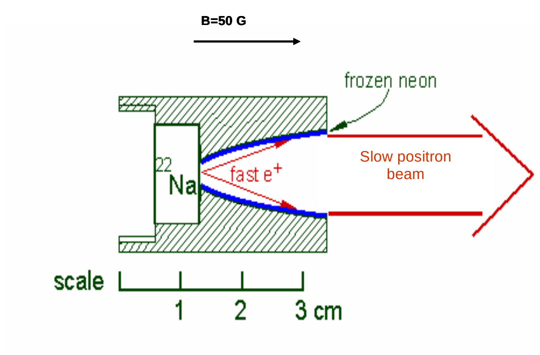

Figure 1: Slow positron getting principle.

The cryogenic source of slow positrons has been developed and made at JINR (fig.2).

For realization of experiments with a cryogenic positron source a stand was constructed. The positron source is located in the vacuum chamber pumped to the pressure 4*10^{-8} Torr.

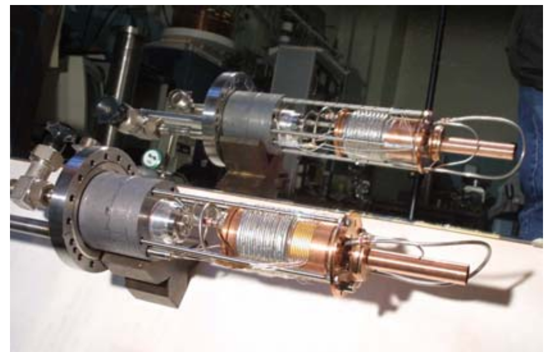

Figure 2: The cryogenic source of slow positrons.

The stand includes neon and liquid helium lines. The slow positron beam flux is detected by a microchannel plate (MCP). During experiments with a test isotope ^{22}Na by activity 100 μCi, the frosting of neon was carried out on a substrate and cone. The dependence of the slow positron output on the thickness of the moderator was investigated (fig,3). Dependence of slow positron spectrum on the thickness of the moderator was measured for the first time (fig.4).

THE POSITRON TRAP

When slow positron beam has been formed, it enters to Penning-Malmberg trap were the positron cloud is accumulated [2]. The Penning-Malmberg trap is a device which uses static electric and magnetic fields to confine charged particles using the principle of buffer gas trapping. The confinement time for particles in Penning-Malmberg traps can easily extend into hours allowing for unprecedented measurement accuracy. Such devices have been used to measure the properties of atoms and fundamental particles to capture antimatter to ascertain reaction rate constants and in the study of fluid dynamics. to inject positron bunch to Low Energy Particle Toroidal Accumulator (LEPTA) [3].

The research of the accumulation process was carried out using electron flux. For this purpose the test electron gun allowing to emit dN/dt = 1*10^{6} electrons per second with energy 50 eV and spectrum width of distribution a few eV was made. These parameters correspond to slow monochromatic positron beam which we expect from a radioactive source at activity 50 mCi.

The total trapped charge as a function of filling time and the loss of the trapped charge for a saturated fill as a function of storage time were investigated (fig.5).

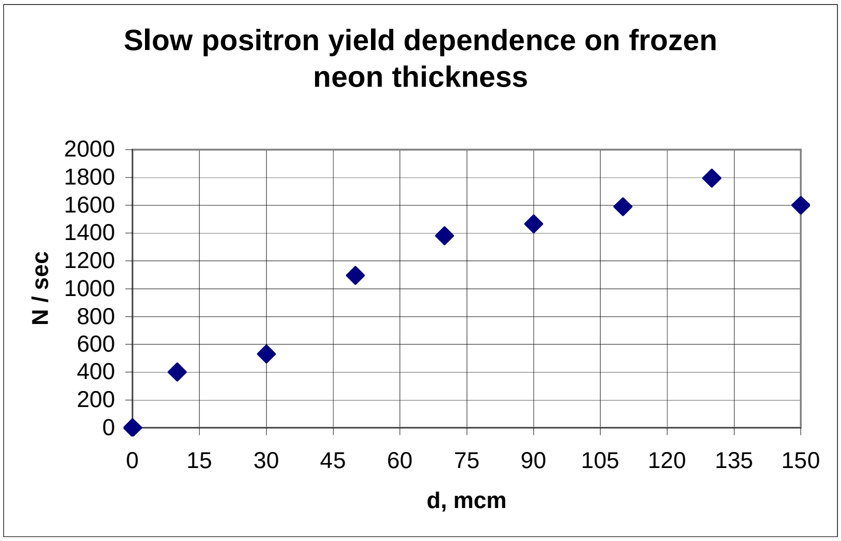

Figure 3: Slow positron yield vs moderator thickness.

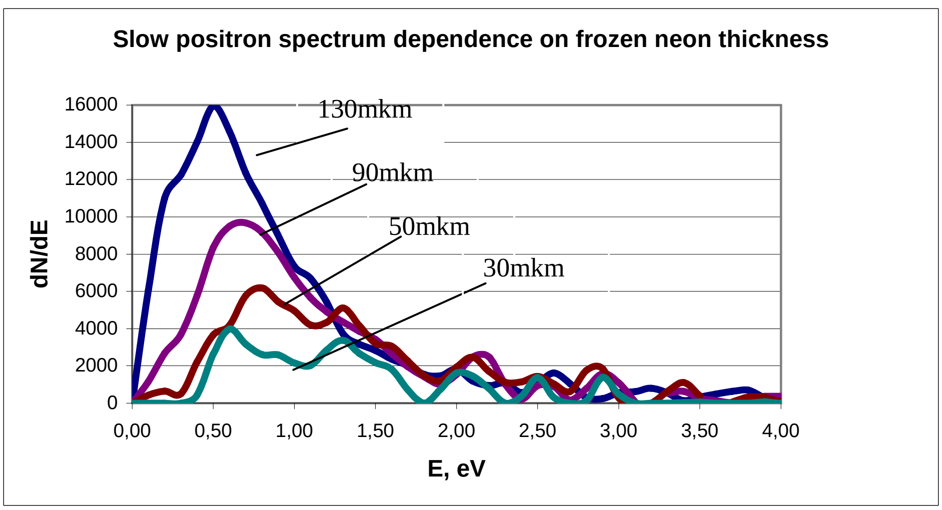

Figure 4: Slow positron spectrum vs moderator thickness.

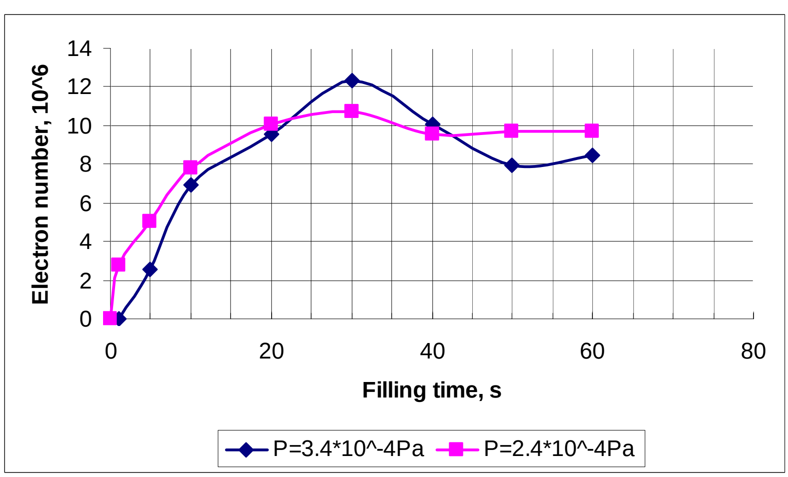

Figure 5: The total trapped charge as a function of filling time.

CONCLUDING REMARK

The continuous slow positron beam at intensity $1.75*10^3$ positrons per second with average energy of 1.2 eV, width of a spectrum 1 eV was received. The achieved moderator efficiency is 0.35 %. The 13% efficiency of accumulation was received. The best efficiency known from literature is around 30% [2].

ACKNOWLEDGMENT

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REFERENCES

[1] A. P. Mills, Jr. and E. M. Gullikson, "Solid Neon Moderator for Producing Slow Positrons". Appl. Phys. Lett. 49, 1121 (1986)

[2] M. Amoretti et al., The ATHENA antihydrogen apparatus, Nucl. Inst.Meth. Phys. Res. A 518 (2004) 679-711

[3] I. Meshkov, LEPTA project: generation and study of positronium in directed fluxes, NIM B 221 (2004) 168-173