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Construction and timing system of the EPOS beam system

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ABSTRACT

The Forschungszentrum Dresden-Rossendorf provides an intense pulsed 40 MeV electron beam with high brilliance and low emittance (ELBE). The pulse has a length of 1–10 ps and a repetition time of 77 ns, or in slow mode 616 ns. The EPOS system (ELBE Positron Source) generates by pair production on a tungsten converter and a tungsten moderator an intense pulsed beam of mono-energetic positrons. To transport the positrons to the laboratory (12 m) we constructed a magnetic beam guidance system with a longitudinal magnetic field of 75 G. In the laboratory outside the cave, the positron beam is chopped and bunched according to the time structure, because the very sharp bunch structure of the electron pulses is broadened for the positron beam due to transport and moderation.

1. Introduction

In the last years, the investigation of crystal lattice defects and open-volume cavities of nanometres scale has become more important. With the EPOS system it is possible to determine materials with different methods, positron lifetime spectroscopy, age–momentum correlation and Doppler broadening spectroscopy can be used [2]. Another advantage of the EPOS system is the fact that the measurements are very fast. With the multidetector system we expect a detection rate of approximately 6.2×10^5 counts/s. Due to the fact that we have the alternative of two repetition-times, fast and slow lifetimes can be measured. We will look at some parts of the beam in more detail.

2. Einzel lens

At the beginning of the positron lens (see Fig. 1), a mesh grid made of stainless steel with an open area of 89% is located. The first tube has a length of 170 mm, the others 50 mm each. The length of the tubes is 10 mm. The moderator has a potential of +2000 V. The mesh grid of the first and the third part of the Einzel lens have earth potential. Thus, the positrons obtain the transport energy. On the second electrode, −675 V are applied. So the focal length is 1.1 m. On this point, the magnetic field is beginning. On the focus, the diameter of the positron beam is 0.8 mm. Due to the gyration on the magnetic field, expansion of the positron beam is avoided. Because the converter chamber and the tubes material is aluminium, the whole construction is build at a flange of stainless steel, so that electrical feed-through's can be used. The second tube is mounted on the electric connection, so further electric isolation is not necessary. The first electrode is made of a thin cylinder with a wall thickness of 0.025 mm. The slight wall thickness is essential because the heat input should be not so high by the electron beam.

3. Chopper

As the very sharp bunch structure is broadened on the way to the laboratory we use a chopper which is described in [1]. The aim is that the positron beam has a time slot of 2 ns with a repetition time of 77 ns. Before the beam arrives at the chopper, an aperture limits the diameter of the positron beam. The main component consists of an aperture, which is used in optical instruments.

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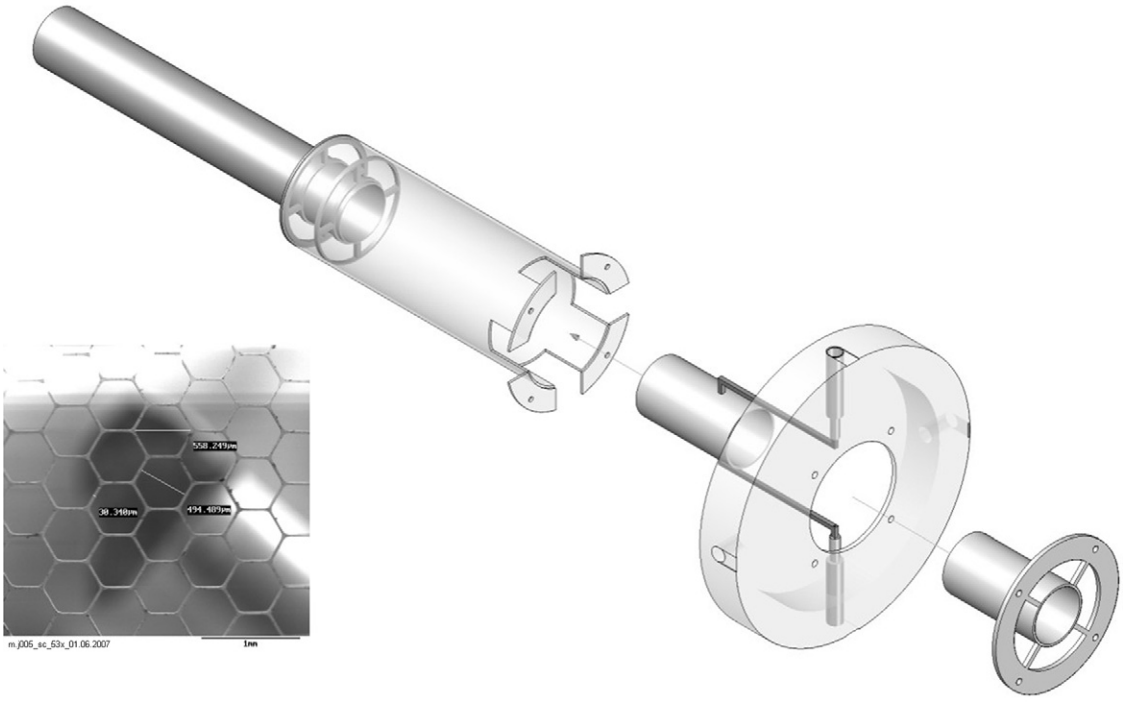

Fig. 1. Exploded view of the Einzel lens, and a SEM view of the mesh grid.

In z-direction, a magnetic field of 75 G is applied. If between two plates an electric field is applied in x-direction, the positrons obtain a transversal energy in that direction. Therefore, the radius of gyration is larger and the positrons cannot pass the plates of the chopper. The pairs of electrodes with an antipodal electric field are spaced at intervals of one length of gyration (126.3 mm), so that the transversal energy is compensated when the positrons drop out of the chopper. A draft of the chopper is shown in Fig. 2. The plates of the chopper and the rotary feedthrough are installed on a double-sided bored flange. By means of a thread rod with a left-hand and right-hand thread, the aperture can be changed. In a range of 2 ns the chopper will open the way for the positrons because the voltage is lower than 100 V. Otherwise (Fig. 3), the positrons will be more deflected and annihilate in the aperture material. As signal for the electrodes we use a damped oscillation with a frequency of 130 MHz, superposed with a direct voltage (Fig. 4). The oscillation will be stimulated at regular intervals with the signal from the ELBE system.

4. Construction and magnetic guidance field

The floor of the concrete channel between the cave 111b and the positron laboratory is 2.2 m lower than the electron beam axis

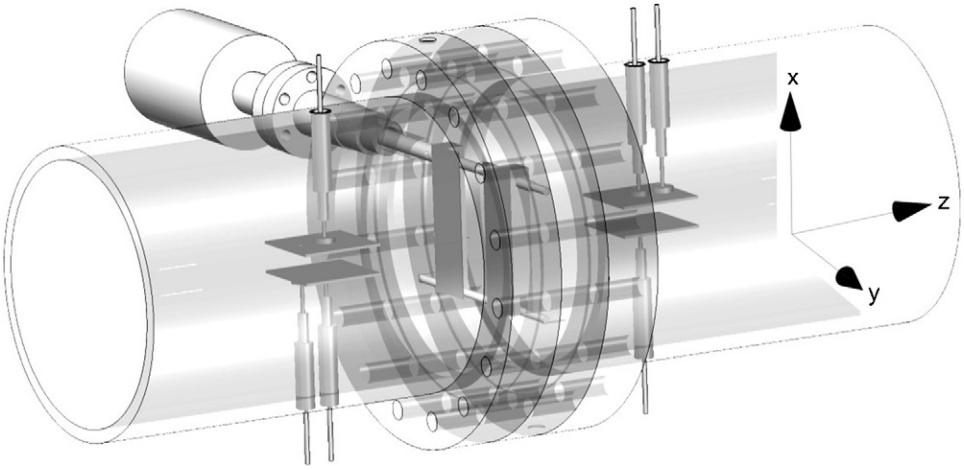

Fig. 2. Draft of the chopper.