A NEW INJECTOR FOR POLARIZED ELECTRONS AT ELSA

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A pulsed 50 kV inverted gun of polarized electrons, optimized for a reliable operation for future experiments at the stretcher ring ELSA, was set into operation. Due to operation in space charge limitation a current of 100 mA in a rectangular $1\mu s$ long electron puls is produced. Using a Be-InGaAs/Be-AlGaAs superlattice photocathode P = 80 % and QE = 0.2 % could be obtained. The performance of the gun, the transfer line and the results of first measurements are described in the following report.

1 Introduction

Soon experiments with circularly polarized photons (produced by Bremsstrahlung of longitudinally polarized electrons) will start at the electron stretcher ELSA in Bonn[1]. To fullfill the demands of the experiments a new pulsed source of polarized electrons was developed. In order to enhance the overall efficiency it operates with a newly installed pulsed injector linac which requires an injection energy of 50 keV, a pulse length of $1\mu s$ and a repetition rate of 50 Hz. The performance of the new injection system will be presented in the following paragraphs.

2 The 50 kV Gun

A pulsed 50 kV inverted gun of polarized electrons was set into operation. A cross section of the gun is shown in fig.1. This setup allows for heat cleaning and activation of the photocathodes inside the chamber. By changing the cathode-anode distance the perveance of the gun is set to the desired value, allowing a space charge limited operation over a wide range of currents (see fig.2).

The total preasure in the gun is about 1×10^{-11}mbar, with partial pressures of the major poissoning gases (carbon dioxide and water vapor[2]) below 1×10^{-13}mbar. To improve the gun vacuum and consequently the lifetime of the photocathodes heat cleaning and activation of the photocathodes are carried out in a load-lock-system[3]; which allows in addition to change crystalls without breaking the vacuum of the gun.

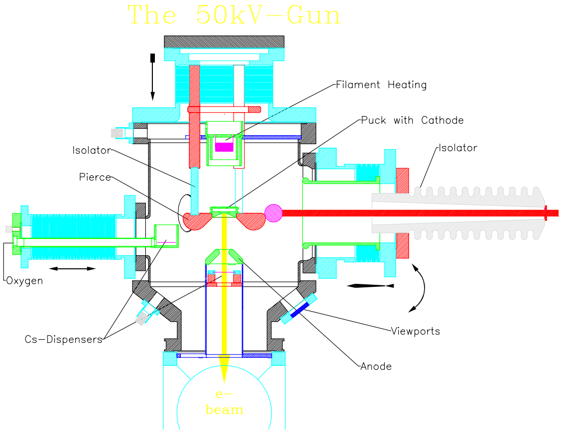

Figure 1. Setup of the 50 kV gun.

2.1 *The Lasersystem*

The light source is based on a tunable (700-900 nm) free running flashlamp-pumped 50 Hz Ti-Sapphire laser. The laser pulses (pulslength 10 μs), which show the well known spiking phenoma typical for this sort of lasers, are chopped to 1 μs (20 mJ energy/puls) by a pockels cell and a *Glan-Thomson*-prisma and fed via a 85 m long optical multimode fibre to the source. Before eluminating the photocathodes the laserpuls has to pass a second pockels cell to get circulary polarized laser light.
A cw beam of polarized electrons of low intensity (typ. 100 pA), which is needed for the measurement of the beam polarization, is produced using a continuos wave tunable (700-900 nm) Ti-Sapphire laser. This laser is pumped by an argon vapor laser and can be fed into the fibre as well.

2.2 *Transfer Line*

In order to compensate for beam blow up caused by space charge solenoids and quadrupols were installed in the transfer line (see fig.3). To optimize the position of these magnets the space charge dominated beam transport was simulated by numerical integration of the paraxial differential equation for elliptical beams. It turned out that a current of 100 mA can be transfered to the linac without considerable beam losses (see fig.4).
In order to decouple the ultrahigh vacuum of the gun from higher pressures

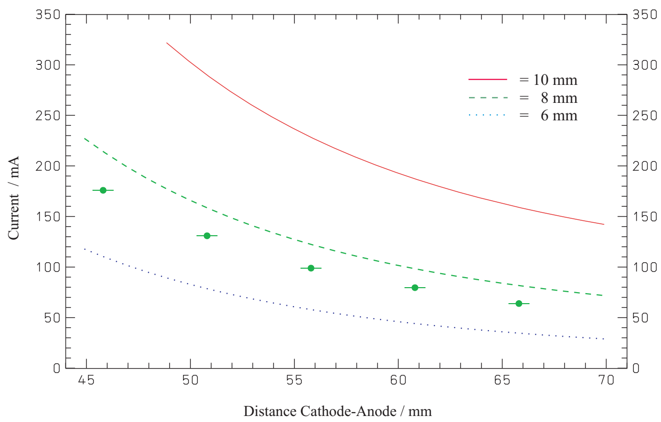

Figure 2. Simulated and observed space charge limitation. The simulation, represented by the lines, were carried out using the EGUN-code[4].

downstream in the injector ($P = 10^{-7}$mbar), the transfer line is equipped with ion getter, NEG and turbo molecular pumps. Two 90° magnetic bends provide for additional isolation (see fig.3). The polarization of the beam is changed from longitudinal to transverse by means of an electrostatic toroidal bending condensor.
To allow a precise measurement of the beam position, profile and intensity several monitor stations (wire scanners, cromox screens, faraday cup) are installed in the beamline. To measure the polarization of the polarized electron beam a polarimeter, based on Mott-scattering of polarized electrons from thin gold foils, was built up.

2.3 First measurements

Maximum currents of up to 180 mA could be obtained from a 8 mm diameter Be-InGaAs/Be-AlGaAs superlattice photocathode[5]. Electron emission could be varied from 60 mA to 180 mA (see. fig.2) by changing the cathode-anode-distance. A rectangular pulsstructure was obtained in all cases. The observed space charge limitation differ significantly from the calculated one which may be attributed to the different emission properties of a (cold) photocathode and a (hot) thermionic cathode, which is not implemented in the EGUN code so far.

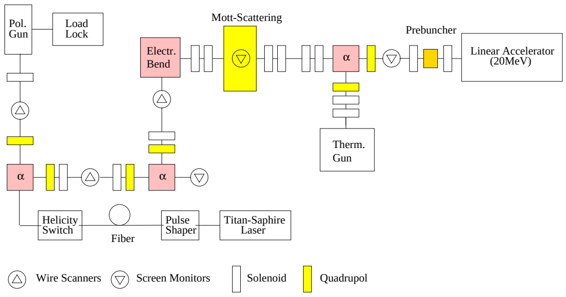

Figure 3. Setup of the transferline from the source to the linac.

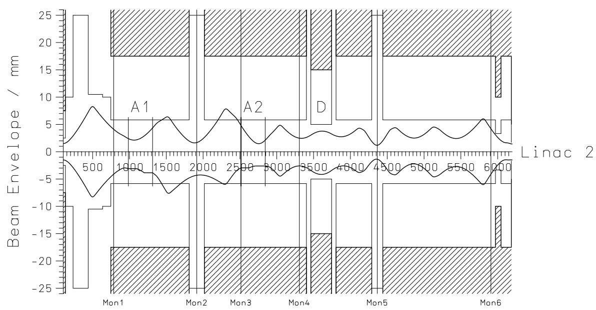

Figure 4. Simulation of the space charge dominated beam transport from the source to the linac. The horizontal and vertical extension of the beam is presented by the shaped solid lines. The position of the α-magnets (A1, A2), the bending condensor (D) and the monitor stations (Mon1-Mon6) are indicated. The hatched area represents the bounds of the geometrical aperture of the beamline.

In fig.5 the wavelength dependance of polarization and quantum efficiency, obtained from Mott-scattering off thin gold foils, is presented. A maximum polarization of P = 80 % is achived at 830 nm, using a Be-InGaAs/Be-AlGaAs superlattice photocathode. The corresponding quantum efficiency was 0.2 %. The dark lifetime of the photocathode was found to be greater than 3000 h. After one week of operation no significant degradiation of the photocathode could be determinated by measuring the time dependent quantum efficiency using a wavelength of 830 nm. At 633 nm slightly higher values were observed. By carefully optimizing the focusing strengths of the beamline from the gun to the linac, a transmission close to 100 % was reached for 100 mA.

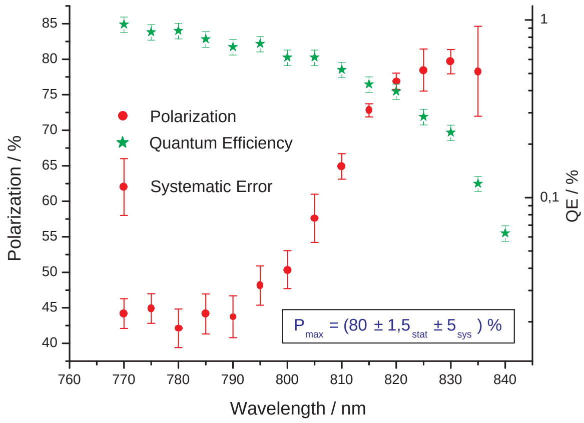

Figure 5. Polarization and quantum efficiency versus wavelength, obtained from Mott-scattering off thin gold foils. The error bars represent only the statistical error. A systematic error of 5 %, caused by an insufficient knowledge of the effective Sherman function, has to be taken into consideration for all data points.

Polarized electrons could be successfully accelerated to higher energies by means of an improved closed orbit correction and additional corrections for depolarizing resonances using fast tune jumps quadrupoles. We observed a polarization of $P \approx 72\%$ up to energies of 2 GeV, which decreases to $P \approx 65\%$ at 2.55 GeV and drops to 30 % at 3.2 GeV. An external current of 3 nA could be delivered to the GDH-Tagger target.

2.4 Conclusions

A 50 kV source of polarized electrons was successfully set into operation. A polarization of P = 80 %, QE = 0.2 % and a current of 100 mA were obtained. First operation experiences showed a reliable operation of the source and indicate a high source availability close to 100%. Polarized electrons were successfully accelerated to higher energies. The demands of GDH-experiment[1] could already be fullfilled for the complete energie range of ELSA.

References

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