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Azimuthal distribution of photoelectrons for an LHC beam screen prototype in a magnetic field

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1. Introduction

This note describes a study fulfilled within the frame of the collaboration between CERN and the Budker Institute of Nuclear Physics (Novosibirsk, Russia). This work continued the studies described in Refs. [1] and [2]. In Ref. [1], the reflection of photons and the azimuthal distribution of photoelectrons in a cylindrical beam pipe were studied. Reference [2] describes the measurements of the photoelectron current as a function of the magnetic field, the angle between the sample surface and the magnetic field with the normal photon incident angle. The present study joins these two studies into one: the reflection of photons and the azimuthal distribution of photoelectrons in a LHC beam screen prototype in a magnetic field were studied.

2. Sample preparation and set-up

A section of the LHC beam screen, 34 cm in length, was cut into four strips: two rounded and two flat ones. The strips were installed into a previously used set-up [1] for photoelectron distribution measurements which was modified accordingly. A magnet with a magnetic field of up to 0.3 T was installed along the whole length of the vacuum chamber with the strips. The layout of the installation is shown in Figure **1**.

3. Experiment

The beam energy was E_p = 220 MeV, which corresponds to the critical energy of the photons E_c = 20 eV. The photon beam was collimated to 2 mm horizontally and 15 mm vertically. The photon flux was typically $1.7 \cdot 10^{13}$ photon/(sec·mA).

The measurements were done for a bias voltage from 0 to 290 V and with the magnetic field values B=0 T, 0.05 T, 0.1 T, 0.2 T and 0.3 T.

The rounded strip no. 1 (without welding) was irradiated by direct photons (see Figure 1). Strips no. 2 and 4 were perpendicular to magnetic field. The rounded strip no. 3 was opposite to strip no. 1.

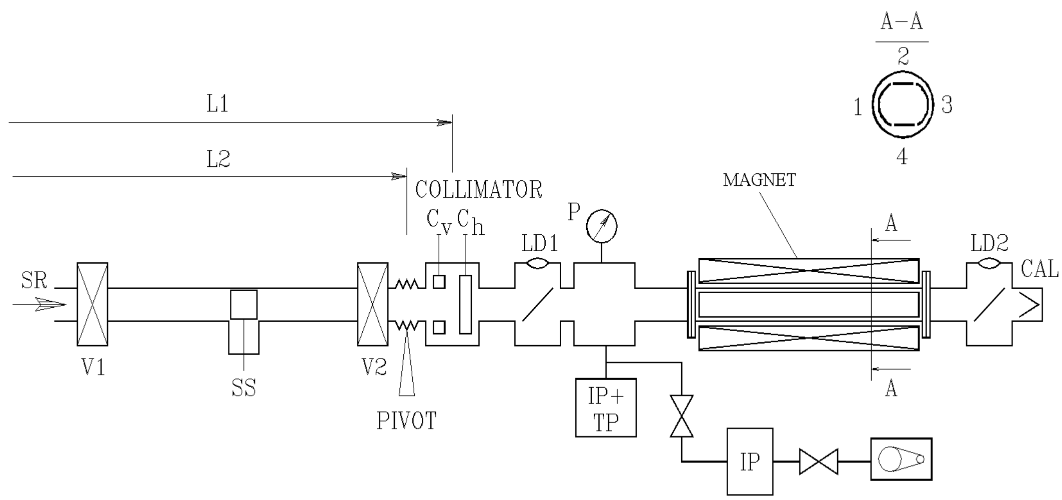

Figure 1. Set-up for measurements of the azimuthal photoelectron distribution in magnetic field and of the photon reflectivity

The main results are presented in Figs. 2 and 3.

The dependence of the photocurrent on bias potential without magnetic field is presented in Figure 2. There is a dependence on bias for the photocurrent of strips 2 and 4 at a potential of less than about 10 V. In contrast to this behaviour, the photocurrents of strips 1 and 3 are still not fully saturated at a potential of 200–300 V.

The reflectivity was measured by the photocurrent only: R = 67 %. The calorimeter has not sufficient sensitivity for a power measurement at such a low photon energy.

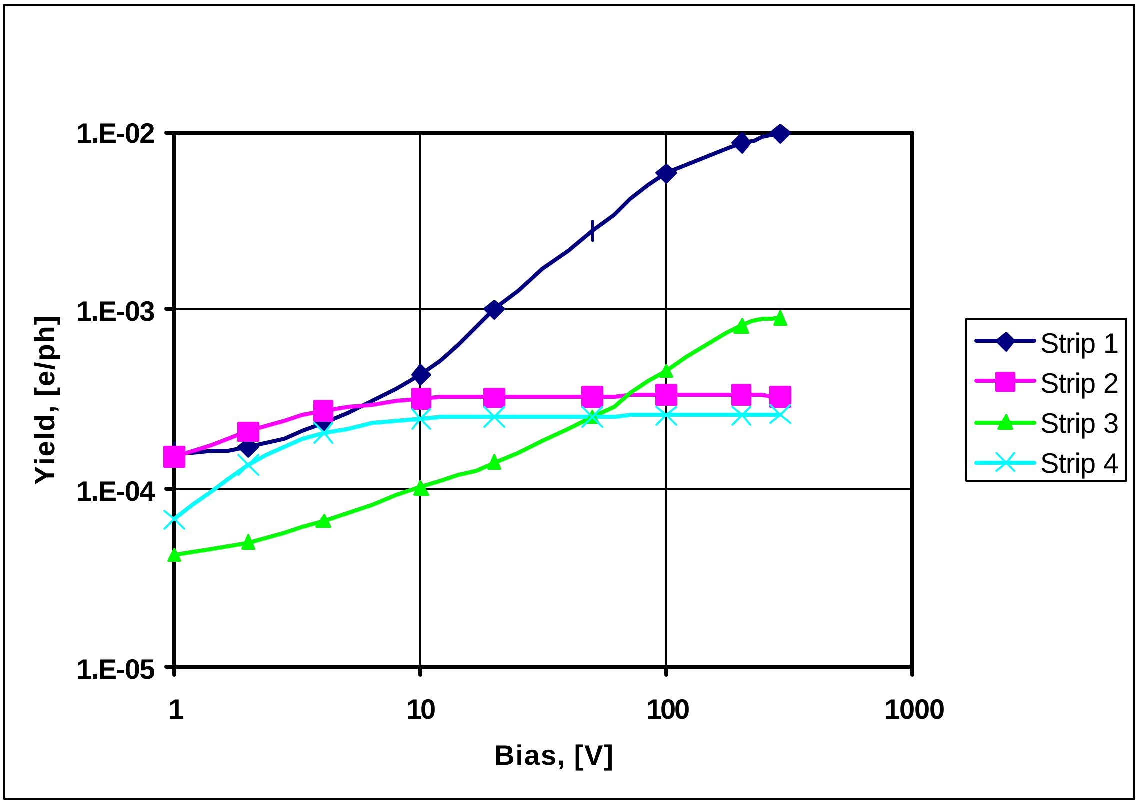

Figure 2. Experiment with B = 0

It is interesting to note that the measurements can be expressed by the following relation:

$$\sum_{i=1}^{4} I_i + I_{cal}^{ref} = I_{cal}^{str},$$

here I_i is the photocurrent from *i*-th strip, I_{cal}^{ref} is the photocurrent from the calorimeter for the reflected photon flux and I_{cal}^{str} the photocurrent from the calorimeter in the straight through position. This relation suggests that the sum of the diffused reflection and of the forward-scattered photons is a constant, assuming that the photoyield of Cu and for stainless steel are about the same.

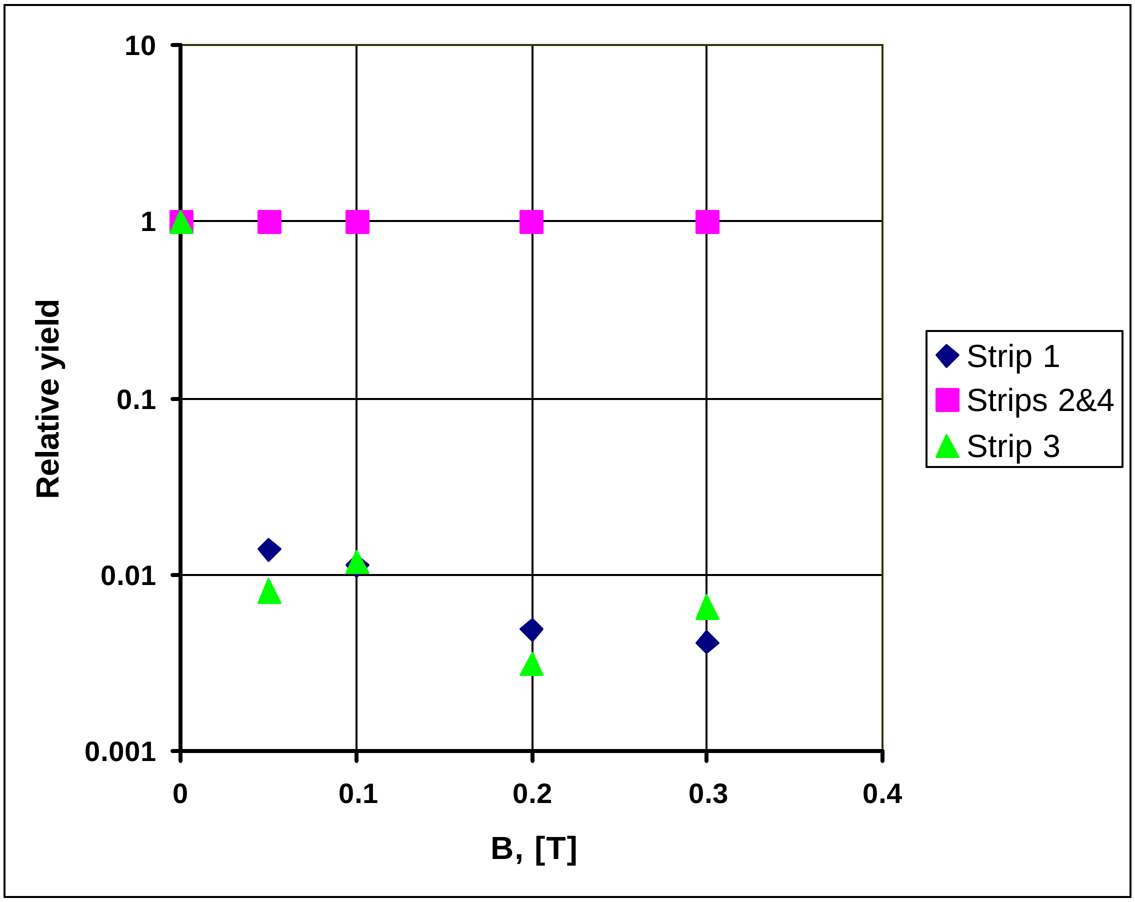

Figure 3. Dependence on the magnetic field

Figure 3 presents the dependence on the magnetic field. All the data are presented in the form of a relative yield, $R_i = I_i^B / I_i^{B=0}$. One can see that the photoelectron current on strips 1 and 3 is indeed strongly suppressed by the magnetic field by more than two orders of magnitude. In contrast to this, the signals from strips 2 and 4 are not affected by the magnetic field.

References

1. V.V. Anashin, O.B. Malyshev, N.V. Fedorov, V.P. Nazmov, B.G. Goldenberg and O. Gröbner. Reflection of photons and azimuthal distribution of photoelectrons in a cylindrical beam pipe. LHC Vacuum Technical Note 98-17, July 1998

2. V.V. Anashin, R. V. Dostovalov, A.A. Krasnov, O.B. Malyshev and E.E. Pyata. Photoelectron current in magnetic field. Vacuum Technical Note 99-03, April 1999.