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THE DESY POLARIZED γ-RAY BEAM

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(Presented by G. Bologna)

We present some further measurements on the DESY quasi-monochromatic and polarized γ-ray beam from a diamond radiator. Previous results were presented at the Hamburg Conference (1). The internal electron beam of the machine strikes a diamond radiator at an angle θ with respect to the axis [110]. The diamond crystal, 1 mm in thickness, is placed in a goniometer by which it can be rotated around two perpendicular directions, such as to allow for a lattice plane to be oriented in all possible ways. The position of the axis [110] can be determined within 0.1 mrad.

The bremsstrahlung which emerges from the crystal passes through a 0.2 mrad × 0.2 mrad collimator, then is detected by a pair spectrometer and monitored by a quantameter. As it is well known (2), such a bremsstrahlung spectrum shows several peaks, one of which predominate on the others and is strongly linearly polarized.

A typical energy spectrum in shown in the lower part of Fig. 1.

Abscissa gives the fractional energy of the photon with respect to the incoming electron:

$$x = k/E_o$$

The electron energy was fixed at

$$E_o = 4.8 \text{ GeV}.$$

* On visit from Laboratori Nazionali del CNEN, Frascati (Rome), now back at Frascati.

Ordinate gives, i narbitrary units, the bremsstrahlung intensity, a quantity which is proportional to the cross section $d\sigma/dk$ times the photon energy k. The lattice plane $(\bar{1}\,10)$ was placed parallel to the direction of the incoming electron and the angle between this direction and the axis [110] was fixed at

$$\theta = 3.4 \text{ mrad}$$

As already pointed out at Frascati (3), the bremsstrahlung cross section is sensitive to the choice of the atomic form factor. The continuous curve of Fig. 1 is obtained by inserting the atomic form factor computed from the Hartree-Fock-Slater-Dirac (HFSD) wave functions (4). The dashed curve considers a form factor computed from an exponentially screened coulomb field (ESC).

The dots give the experimental data with some statistical errors. They are normalized to the theoretical curve at $x \simeq 0.9$.

The smoothing of the experimental results near the computed peaks is due to the multiple scattering of the electrons in the diamond and to the finite energy resolution of the pair spectrometer ($\Delta k/k = \pm 2\%$). The curves are not corrected for these effects. Computations are in progress.

In the upper part of Fig. 1 the computed values of the linear polarization, in the two field models

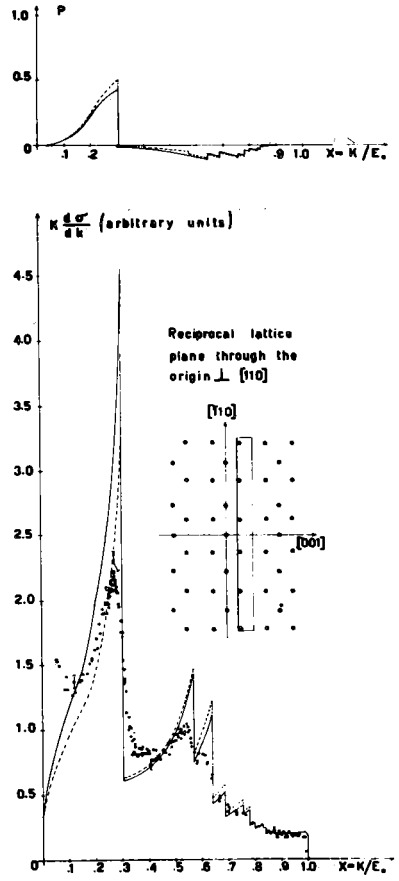

Fig. 1 - Bremsstrahlung intensity k (dσ/dk) and linear polarization P from a diamond crystal, versus fractional photon energy. Electron energy $E_0 = 4.8$ GeV. Angle between primary electron and axis [110]: $\theta = 3.4$ mrad. Continuous curves: HFSD-model. Dashed curves: ESC-model. Points: Experimental results. The errors are statistical.

already mentioned, are given. At the highest peak ($x = 0.30$, or $k = 1.5$ GeV) these polarizations are 43.8 and 50.5 for HFSD and ESC field, respectively.

For the previous spectrum the conventional crystal orientation considered at Frascati (2) was used. The significant part of the permitted kinematical region in momentum space, as represented in the reciprocal lattice plane of the axes [001] and [$\bar{1}$10], is given by the rectangle drawn in Fig. 1, when the photon energy is fixed at the highest peak. One can see that such a peak gets contribution from an entire row of lattice points, a fact this which favours the high amplitude of the peak, but not the polarization. Furthermore, owing to the large value of the electron energy, the angle θ is 3.4 mrad only, which is to be compared with 0.4 mrad for the mean square angle of multiple scattering. As a consequence, the experimental peak is much smaller than the theoretical one.

But now we can also use a different orientation of the diamond by which the calculated value of the polarization and the experimental amplitude of the peak are increased.

With the same electron energy $E_0 = 4.8$ GeV, we fixed

$$\theta = 50 \text{ mrad},$$

and the direction of the incoming electron almost but not exactly parallel to the lattice plane ($\bar{1}$ 10), in such a way that the permitted kinematical region is a rectangle inclined at 1.55° with respect to the axis [110], as shown in Fig. 2. The peak is obtained about in the previous position ($x = 0.33$), and gets contribution from the unique lattice point contained in the rectangle. Thus the amplitude of the first peak in the theoretical spectrum is reduced and the polarization increased with respect to Fig. 1 (see Fig. 2, with the same meaning of the symbols as in Fig. 1). Despite of this, the experimental peak of Fig. 2 is now larger than before, because of the small

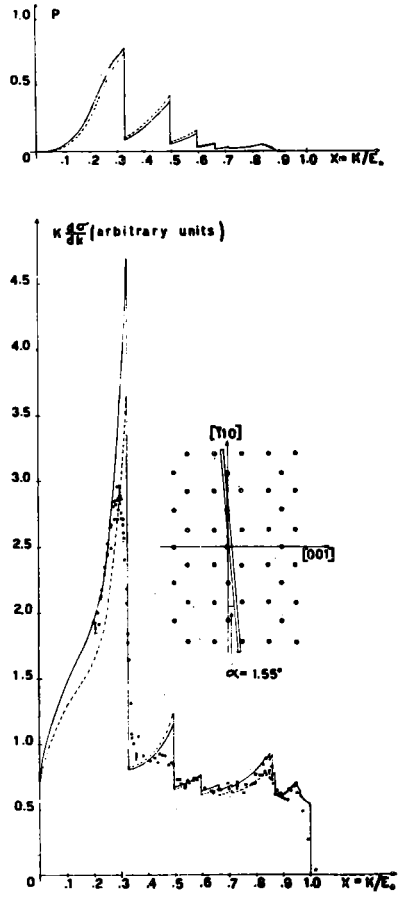

Fig. 2 - The same as Fig. 1, with $\theta = 50$ mrad, and a different orientation (see text).

influence of the multiple scattering on the large angle $\theta = 50$ mrad.

The very important goal made with this orientation is the high value of the calculated linear polarization i.e., 78% at the first peak. This was first pointed out Überall (5).

He suggested a different orientation; for experimental convenience we used the previously mentioned one.

During these measurements the γ-ray beam intensity was 10^{10} eQ/m, but an upper limit of 5×10^{11} e Q/m can be reached.

We thank G. Diambrini for his constant interest and useful collaboration at this work.

REFERENCES

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(3) G. Barbiellini, G. Bologna, G. Diambrini and G. P. Murtas: unpublished.

(4) D. T. Cromer, J. T. Waber: Acta Cryst. *18*, 104 (1965).

(5) H. Überall: Conf. on Photon Interactions in the BeV - Energy Range, Cambridge, 1963, pag. VI. 1.

DISCUSSION

WINICK: What are your plans for measuring the polarization of the peaks you observe?

BOLOGNA: We plan to use a second crystal inside the pair spectrometer, as proposed by G. Barbiellini, G. Bologna, G. Diambrini and G. P. Murtas (Nuovo Cimento *28*, 435, 1963).