EFFECTIVE X-RAY BREMSSTRAHLUNG SOURCE
(Is it possible to handle quality of the X-ray bremsstrahlung?)

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Abstract

The efficiency of new nontraditional scheme for generating bremsstrahlung is studied by means of computer simulation. In this scheme the electron beam multiply crosses a thin target due to the presence of special focusing magnetic field [1]. It is showed that one could expect more than two times increasing of the radiation yield power.

1 NEW SCHEME OF EFFECTIVE BREMSSTRAHLUNG SOURCE

The X-ray radiation is widely used in various fields of fundamental and applied studies [2]. The mostly widespread X-ray source is based on the generation of hard electromagnetic radiation by hitting the bremsstrahlung target with the beam of accelerated electrons. Unfortunately, the efficiency of the translation of the electrons energy into the X-ray radiation yield is very low. Hence if the electron beam energy is E_0=1-5 MeV then radiation yield does not exceed 3-8% of the energy of the beam of electrons [3,4].

But analysis shows that the electron energy lost to produce bremsstrahlung is about 3 times more than corresponding radiation yield from the target (Fig. 1). Hence a significant portion of the electromagnetic radiation generated is absorbed in the bremsstrahlung target.

A new nontraditional scheme of the generation of bremsstrahlung is proposed in [1]. This method allows to expect a considerable growth of the photons yield. The scheme is based on the multiple crossing of the thin target by the electron beam. The self-absorption of the generated radiation is not intensive in a thin target. But if the total (summarized) thickness of the multiply crossed target is comparable to the thickness of usual one then the total yield is considerably higher.

The scheme with the multiple crossing of the target by electrons can be developed in various layouts dependently on the parameters of an accelerator and on the way of using bremsstrahlung.

One of the schemes is shown on Fig. 2. Here electrons cross the target, loss a certain part of their energy and then due to the presence of magnetic field they turn back to the target and produce the radiation again.

Accordingly to the estimations presented in [1] the energy yield of the radiation after multiple crossing is 2 - 4 times (in various ranges of the photons energy) more than the one in traditional way.

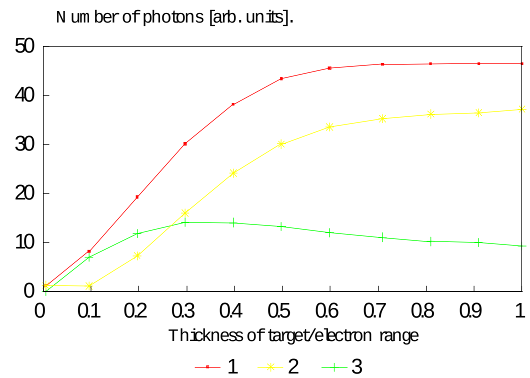

Fig. 1 1- the total number of X-ray photons produced in W-target with depth, 2- the number of X-ray photons absorbed with depth, 3 - the number of surviving X-ray photons.

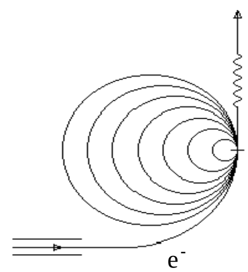

Fig. 2. Efficient X-ray source.

2 METHODS OF THE STUDY. GEANT-SIMULATION

In present work as well as in preceded paper [5] analysis of efficiency of the scheme proposed has been carried out by means of computer simulation. The FORTRAN program using the GEANT 3.15 library routines [6] has been developed to simulate the bremsstrahlung generation.

This program library is designed for simulation of various experiments on nuclear and high energy physics by using the Monte-Carlo technique.

The results of the calculations performed in [5] show that applying the homogeneous magnetic field leads to the rise of the efficiency but at the same time there is a possibility to loose the particles due to the scattering. Therefore it is necessary to use a focusing field.

The results presented were obtained for the axial symmetric magnetic field from conical poles. In the first approximation the fields are

$$B = \frac{B_0 y_0}{\alpha R},$$

$$B_x = -B\frac{xy}{R^2 r},\quad B_y = -B\sqrt{1 - y^2/R^2}\quad B_z = -B\frac{zy}{R^2 r}$$

where: $R = \sqrt{y^2 + (r+\Delta)^2}$, $r = \sqrt{z^2 + x^2}$, and

$$\Delta \cong \frac{y_0}{tg\alpha}\cdot\frac{a}{r} \text{ at } r<a,\quad \Delta \cong \frac{y_0}{tg\alpha} \text{ at } r>a.$$

The target is in the XY plane. The beam passes along the Z axis.

3 DISCUSSION OF THE RESULTS. IT IS POSSIBLE TO HANDLE QUALITY OF X-RAY BREMSSTRAHLUNG?

The efficiencies of the radiation production for the initial electrons energies 5 MeV were calculated. The results are presented on Figs. 3 -7.

Fig. 3 shows that the particles are well focused (different values for the α angle of the conical poles from 10 to 60 degrees were tested).

On Figs. 4-7 one can see that the efficiency of the bremsstrahlung source is really higher than the one in traditional scheme though the configuration used is far from the optimum.

Besides the fact that the X-ray spectrum changes because of the high contribution from the low energy photons is of great importance for various application.

And at last using the optimal focusing gives the possibility to reduce the divergence of the generated X-ray flow because in optimal case the particles return perpendicularly on the target. Hence the new bremsstrahlung source proposed allows to obtain the intensive radiation in narrow angle.

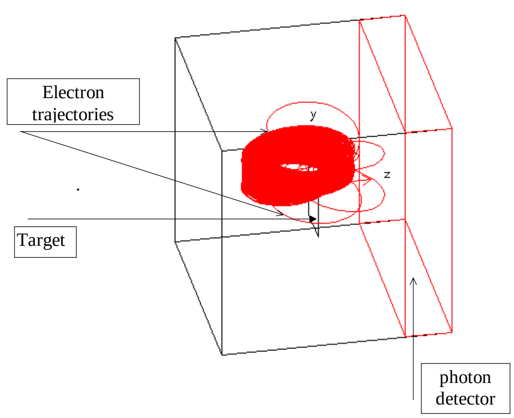

Fig 3. Trajectories of electrons in axial-symmetric magnet field, setup box is 100x100x100 cm^3 (big gap)

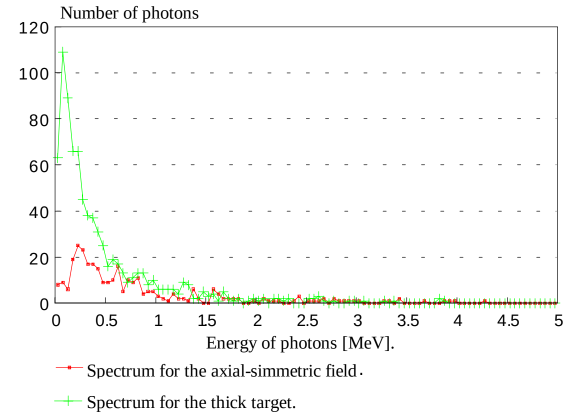

Fig. 4 Spectra for the axial-symmetric magnet field (for the thin target 0.1 free path length) and for the thick target (0.5 free path length). Incident electrons energy 5 MeV, initial electrons number 1000 (big gap).

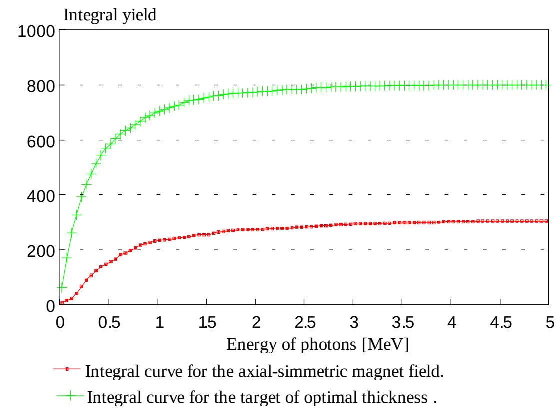

Fig. 5 Integral characteristics for thin target in the axial-symmetric magnet field and for the targets of optimal thickness. Incident electrons energy 5 MeV, initial number of the electrons 1000 (big gap).

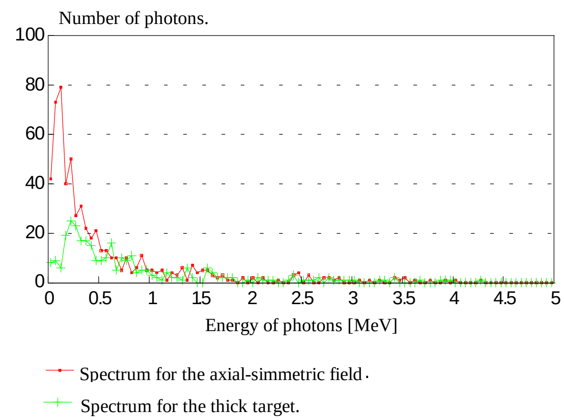

Fig. 6 Spectra for a thin target (of 0.1 free path length) in the axial-symmetric magnet field and for the thick target (0.5 free path length). Incident electrons energy 5 MeV, initial electrons number 1000, setup box is 100x40x100 cm^3 (small gap).

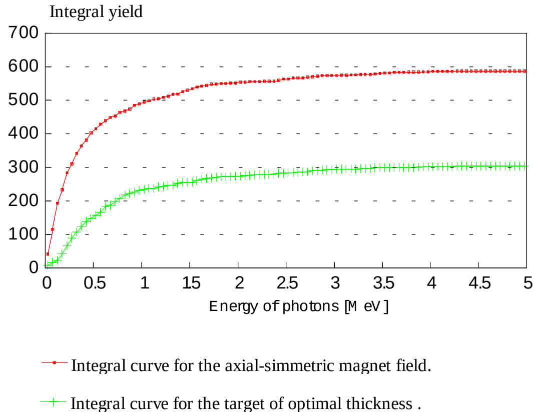

Fig. 7 Integral characteristics for the axial-symmetric magnet field and for the targets of optimal thickness. Incident electrons energy 5 MeV, initial number of the electrons 1000, setup box is 100x40x100 cm^3 (small gap).

4 ACKNOWLEDGMENTS

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