ON COMPUTER MODELLING OF PRIMARY TRANSDUCERS IN ELECTRON RADIATION DIAGNOSTICS*

S.P.Karasyov, S.V.Maryokhin, V.L.Uvarov
Kharkov Institute of Physics & Technology, 310108, Kharkov, Ukraine
I.I.TsvetkovMendeleyev Institute of Metrology, 198005, St.-Petersburg, Russia

Abstract

Determination of transformation coefficient of primary measuring transducers of ionizing radiation is one of complicated problems in metrology as well as estimation of systematic error of measurement. As a possible approach for its solution authors suggested a method of computer modelling of radiation-transducer interaction processes [1]. Electron radiation is described through its spacial and energetic characteristics, transducer is set by means of its real geometrical parameters and elemental content. Elaborated in CERN code GEANT for modelling high-energy radiation-detector interaction seems to be very promising within such approach. Report contents the results of GEANT based analysis of two Faraday cup type transducers for electron energy range 1...50, MeV. The transducers belong to State Measurement Standard of Russia GET 72-90.

1 FC-1 TRANSDUCER

For improvement of the calculation technique the Faraday cup FC-1 being the State Primary Measurement Standard of unit of electrons stream in a range of their energy E=5...50,MeV and having a known error of reproduction of this unit was chosen. The configuration of its sensing volume (electron beam absorber) is outlined in Figure 1. It represents a solid of revolution consisting of entry graphite collimator **1,** aluminum conic absorber 2 and lead screen **3** in a back part.

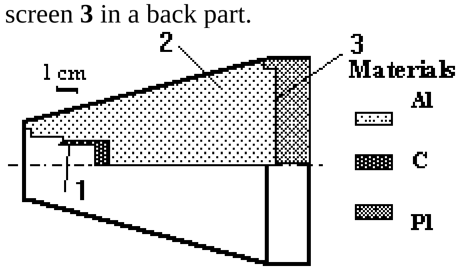

Figure 1: Sketch of the FC-1 absorber

In calculation it was supposed that the stream of accelerated electrons is axially symmetric relatively absorber axis and evenly distributed within the limits of cylinder surface of 1cm in diameter. In a Fig.2[a] the results of calculation for allocation of electron stream along absorber length for their initial energy 5 and 50, MeV are given. In the latter case the saltus of electron stream in the screen due to electron-positron pair generation in the lead by bremsstrahlung photons is seen as well as a leakage of a part of electrons from sensing volume. The appropriate allocation of positrons (for E=50 MeV) is given in a Fig.2[b].

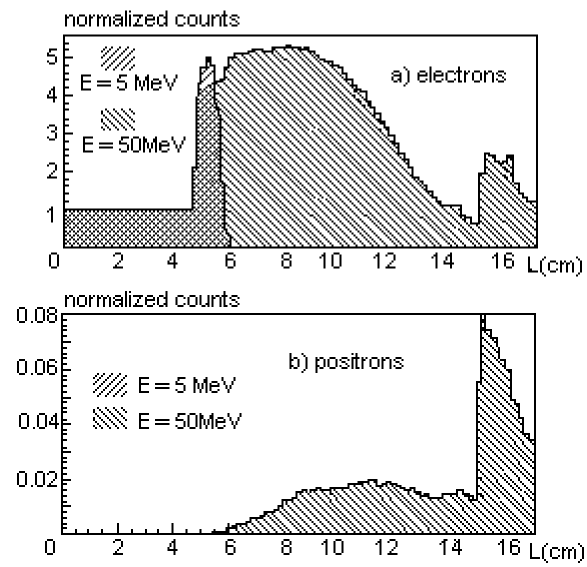

Figure 2: Allocation of electron and positron flow along the absorber

In Fig.3 the allocation of breamsstrahlung photons flow within transducer for E=5 and 50 MeV is represented. In the latter case the saltus of the dependence on aluminium-lead boundary also is seen.

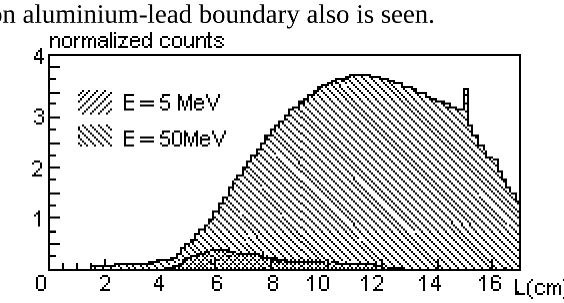

Figure 3: Allocation of photon flow

The analysis of Fig.2 and 3 shows that more and more noticeable part of a charge and energy of absorbed beam abandons boundary of the sensing volume. The allocation of absorbed energy of the beam along the absorber is given in Fig.4, and in Fig.5[a,b] - relative charge **Q** (5[a]) and energy leakage (5[b]) of a beam from the absorber as a function of initial energy of electrons **E**. Data thus

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obtained allow to determine a systematic error for measurements of a charge and energy of an electron beam using FC-1.

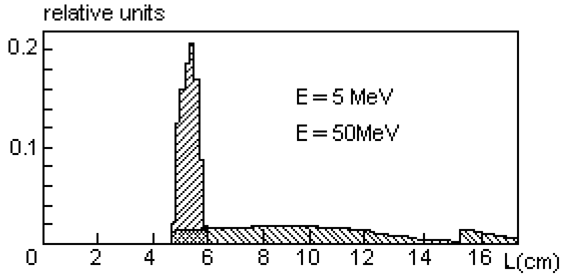

Figure 4: Allocation of absorbed energy

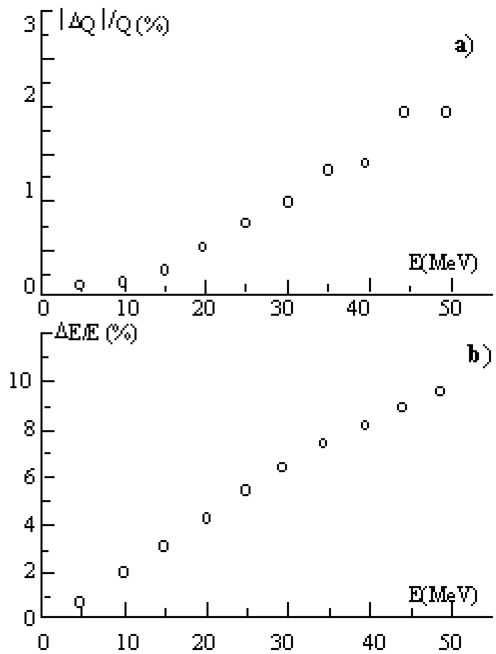

Figure 5: Charge and energy leakage for FC-1 transducer

2 FC-REB TRANSDUCER

For determination of fluence of electrons there is a Faraday cup of FC-REB type in content of the Measurement Standard GET 72-90 (Fig.6).

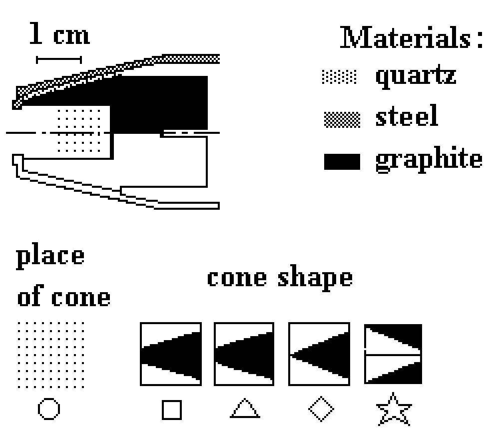

Figure 6: Sketch of the FC-REB transducer

It originally was designed for measurements of the geometrical characteristics of electron radiation having energy of electrons up to 5 MeV.

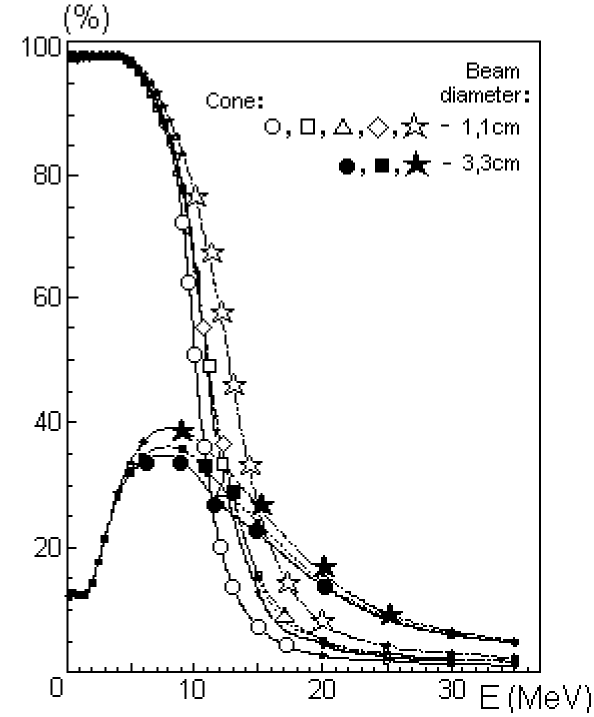

Figure 7: Charge collection coefficient for FC-REB transducer

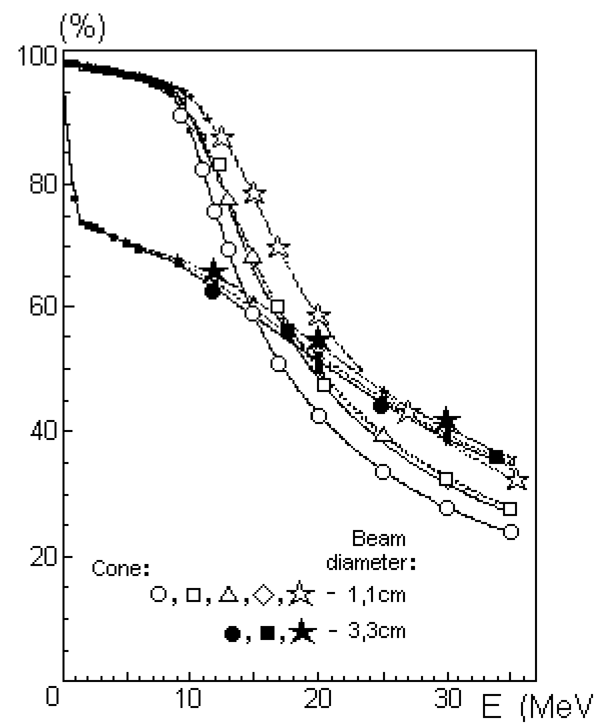

Figure 8: Energy collection coefficient for FC-REB transducer

We execute the computer analysis of metrological characteristics of the FC-REB transducer in a range of energy value 100keV-35MeV for two possible situation of transducer application

-the transversal size of a beam does not exceed a diameter 1.1cm of the entry window of FC-REB (on the graphs appropriate points are designated by outlines of geometrical figures);

--the transversal size of a beam is equal to a maximum diameter 3.3cm of the transducer (outlines of points are solid in this case).

Besides for a research of influence of the form of sensing volume surface on coefficient of beam charge collection there was investigated 5 variants of geometry of this surface represented at the bottom of Fig.6 together with outlines of points appropriated to them on the graphs.

In Fig.7 the dependences of charge collection coefficient on the value E for two above named cases and in Fig.8 similar dependences for beam power loss in the transducer are given. It is visible that the geometry of an internal transducer surface of a type “an inverted cone” ensures amaximum of charge and energy collection of an electron beam.

SUMMARY

The obtained outcomes show a possibility of determination with the help of code GEANT the charge and energy losses in processes of beam-transducer interaction. That, in turn, allows to receive evaluations of a systematic errors in carrying out of appropriate measurements and to optimize the transducer configuration as well.

REFERENCES

[1] S.P.Karasyov, V.L.Uvarov, I.I.Tsvetkov. “System of metrological ensuring for radiation technologies using electron & bremsstrahlung radiation”, VANT, Series:Nucl. Phys. Invest., in.2,3(29,30) 1997, p.54.