INTEGRATED MEASURING SENSOR FOR ELECTRON RADIATION PARAMETERS

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INTRODUCTION

One of the most actual problems of the metrology is obtaining of information about several parameters measured with the help of one sensor. With the reference to the metrology of the electron radiation on the industrial accelerators such parameters can be particle flux (mean current of the beam), energy flow (power) and energy of electrons (average value). For solution of these problems the authors of the report designed the combined charge-calorimetric sensor (CCS) on the base of elaborated in VNIIM Faraday cup (FC) FC-1 from the State Measurement Standard of Russia GET 72-90 content. With the help of the soft ware package GEANT the computer model for radiation-sensor interaction was constructed, that allowed to receive quantitative data on leakages from the sensing volume of a charge and radiation energy. The measuring channel for the mentioned parameters of electron radiation in energy range 5...50 MeV was built. The experimental investigation of the channel on the specially built bench and accelerator LU-10 KIPT has been carried out.

1. COMPUTER SIMULATION

One of the main and most complicated problems in the metrology of the electron radiation is the calculation of the conversion coefficient of the primary sensor and estimation of the systematic errors of the measurements. As the possible approach to the solution of this problem it was offered by the authors to use a method of computer simulation of the interaction between the radiation characterized by the given characteristics with the converter. The latter is described by means of a set of the geometrical sizes and element structure. In such formulation it seems rather perspective the application of the code GEANT, elaborated in CERN for research of electromagnetic interaction of high-energy radiation with matter.

For improvement of the calculation technique FC-1 having known metrological characteristics has been chosen [1]. It represents a body of revolution with an input sleeve **2** of graphite, conical absorber **1** of aluminium and screen **3** of lead in a back part of the sensing volume.

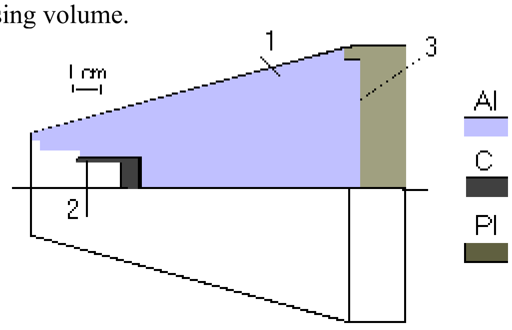

Fig. 1 The configuration of the FC-1 sensing volume

It was assumed in calculations that the electron flux is uniformly distributed within the cylinder of 1 cm diameter. The outcome of the calculations of stopped electrons and positrons distribution per unit length of the sensing volume for initial energy of the electrons 5 and 50 MeV is shown on Fig.2. The jump of the electron concentration in a screen border in the latter case one can explain by electron-positron pair generation in the lead by braking photons born in the aluminium by primary electrons. The offset of a part of electrons of this parentage from the sensing volume is seen also.

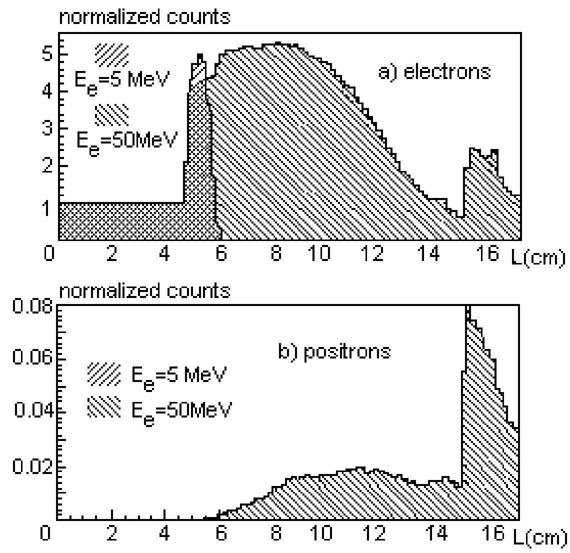

Fig.2.Distribution of electrons (a) and positrons (b) along the absorber

The distribution of braking photons per unit length of the absorber is submitted on a Fig.3. The distribution of an absorbed radiation energy along absorber for E_0=5 and 50 MeV is shown on the Fig.4, and general relative losses of the charge and energy of accelerated electrons in the sensing volume are presented on a Fig.5. The analyses of the latters demonstrates that at E_0>10 MeV the more and more noticeable part of the charge and energy escapes from the absorber.

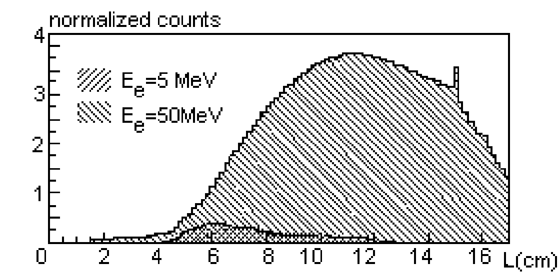

Fig.3.Distribution of photons in the absorber

2. MEASURING CHANNEL

The geometrical characteristics and structure of the CCS sensor are adduced on the Fig.6. It consists of casing 1 executed from stainless steel with a thick forward wall (for absorption of a background radiation) and pipe socket **3** on the back side for connection of vacuum pump.

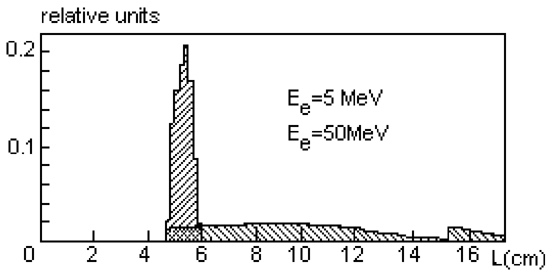

Fig.4.Distribution of absorbed energy along FC-1.

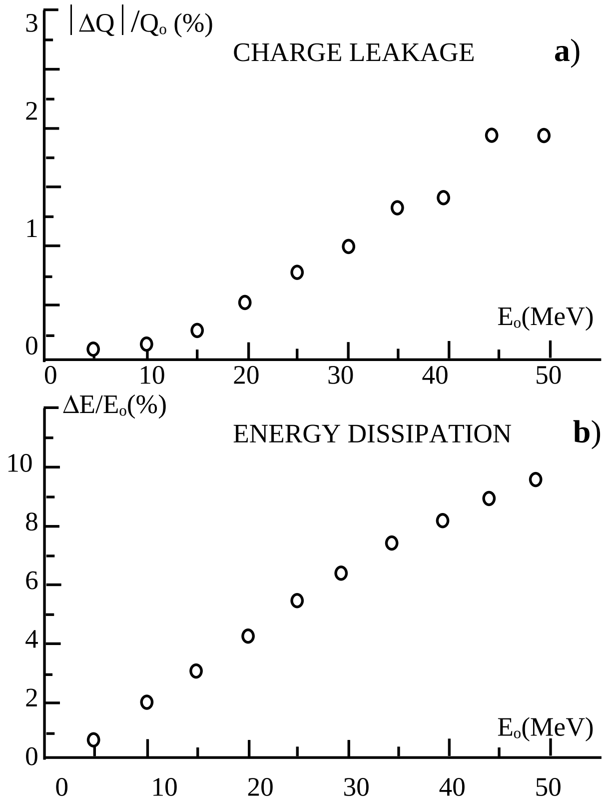

Fig.5.Dependence of relative beam charge (a) and energy (b) loses of electrons energy E.

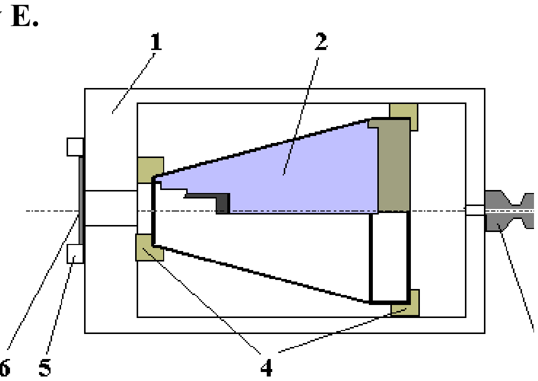

Fig.6.The FC-structure.

The absorber **2** is fixed in the casing through two isolating rings **4** (polystyrene). The input collimator a dia of 40 mms is closed by titanium foil **6** through flange **5**. The thermistor is placed in the back of the absorber through isolating cover for galvanic isolation of tracts for measurement of a charge and absorbed energy of the electron radiation.

The measuring channel on the basis of CCS is shown on a Fig.7. It consists of two separated measuring tracts (charge and energy).

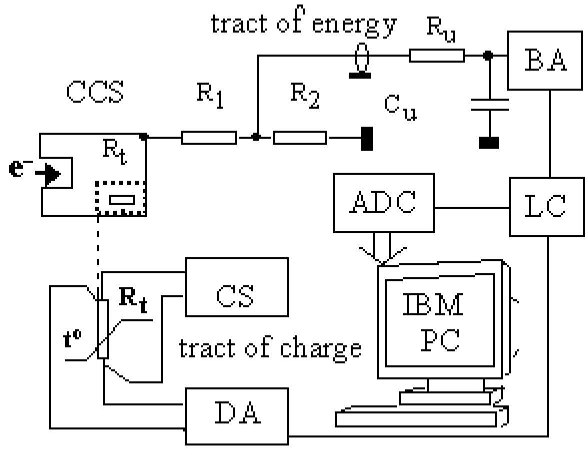

Fig.7.The scheme of CCS measuring channel.

The tract of charge involves a precise ohmic divisor R_1, R_2, located directly on CCS and having appropriate electronic set up. The tract of absorbed energy includes built-in thermistor R_t as the primary sensor supplied by the stabilized current source CS. The error of the temperature measurement in range 0...100°C does not exceed ± 0.2°C.

CONCLUSION

At fulfillment of CCS metrology investigation were applied a method of direct measurements in radiation field of the LU-10 linac [3], and also a method of indirect measurements of the thermal characteristics of the CCS with the help of special designed test stand.

As a result of executed activity the measuring channel on the basic of charge-calorimetryc sensor of electron radiation was designed that provides the measurement of physical quantities of the following nomenclature and range of values

- beam flux density, s^{-1} - - $10^{12}...10^{15}$
- beam flux density , $m^{-2}\cdot s^{-1}$ - $10^{15}...10^{18}$
- beam power, W - $10^{2}...10^{4}$
- absorbed energy of electron radiation, J - $10^{3}...10^{5}$
- energy of electrons (average value), MeV - 5...50

with the metrological characteristics

- absolute error of the electron flux and density measurement (at a confidence coefficient P=0.95) - not exceed 2%
- absolute error of electron beam power and absorbed energy measurement (P=0.95) - not exceed 4%
- absolute error of electron energy measurement - not exceed 5%
- time of one measurement - not exceed 200 s

The measuring channel was certificate as in VNIIM as a working standard [2].

REFERENCES

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2. S.P.Karasyov, V.L.Uvarov, I.I.Tsvetkov. System of methrological ensuring for radiation technologies using & bremsstrahlung radiation. // VANT, series: Nucl. Phys. Invest., in. 2,3 (29.30) 1997, p.54.