ELECTRODES FORM OPTIMIZATION OF RF DEFLECTING SYSTEM WOBBLER FOR FAIR PROJECT

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Abstract

The new method for high energy density states in matter investigation, which based on irradiation of combined target by hollow high energy heavy ion beam was proposed in the Institute for theoretical and experimental physics (ITEP). The target consists of a sample of matter at the center and a hollow shell around it [1]. The experiment of high energy density states generation will be carry on at FAIR project. The RF deflecting system (Wobbler) for hollow high energy heavy ion U_{238}^{28+} beam with kinetic energy W_k = 1 GeV/n formation is developing at ITEP [2].

The current results of electrodes form optimization for RF deflecting system (Wobbler) which is developing at ITEP for FAIR project are shown in this paper.

INTRODUCTION

The electrodes form of RF deflecting system influence to homogeneity heavy ions U_{238}^{28+} beam with kinetic energy W_k = 1 GeV/n deflection was investigated. The deflecting system developed for ITEP TWAC project was taken as basis [3]. The length of deflecting cell could be defined by $D = \beta\lambda / 2$, where D – cell`s length, $\beta$ – relative speed of particles, $\lambda$ – wavelength of RF electromagnetic field. According to that, for particles with kinetic energy $W_k$ = 1 GeV/n and resonant frequency $f_0$ = 352 MHz the cell`s length should equal to D = 373 mm.

RESULTS

The model of one deflecting cell for FAIR project is presented on Fig. 1. In order to increase self quality factor of the deflecting cavity the area of the electrodes stems was increased [4] as well as electrodes deflecting plates form was also changed (compared to cavity developed for ITEP TWAC project).

The method of electrodes form optimization was the same as it described in [5]. During electrodes form optimization the width of plate (EW parameter) as well as height (EH parameter) of edges were varied.

According to electrodes form optimization it was found that particles deflection homogeneity not better than 1.9% at EH = 6 mm; at EH = 10 mm and 12 mm deflection homogeneity was equal to 1.1% and 1% correspondently. The particles deflection homogeneity equaled to 0.9% was achieved at EH = 8 mm and EW = 130 mm (see Fig. 2). The cavity`s self quality factor was also increased to Q_0 = 20000 which on 30% greater than Q_0-factor of the deflecting cavity for ITEP TWAC project.

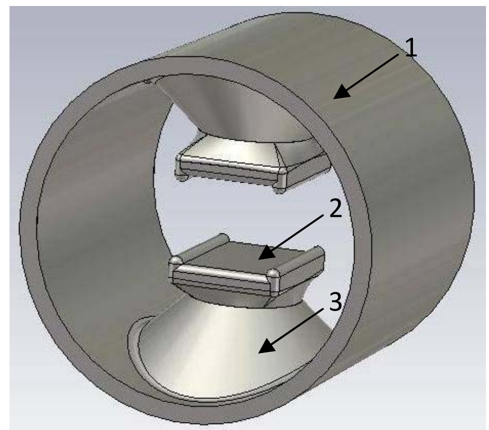

Figure 1. The model of one deflecting cell, where 1 – cavity`s shell; 2 – electrode; 3 – electrode`s stem.

The maximum intensity of the electric field on electrodes surface (E_{max}) is located on plates edges and greater than the maximum electric field intensity at axis (E_0) up to E_{max} / E_0 ≈3.7 times. The typical electric field distribution on the electrodes surface is presented on Fig. 3. In order to reduce the maximum electric field intensity on the electrodes surface the electrodes edges was rounded (see Fig. 4) [6]. From Fig. 4 one can see that E_{max} / E_0 has a sharp increasing up to ≈ 4.4 at rounding radius El_R = 5 mm. The following increasing of El_R parameter leads to decreasing E_{max} / E_0 as well as worsening a particles homogeneity deflection (see Fig. 5). The cavity`s self quality factor Q_0 vs. El_R is presented on Fig. 6.

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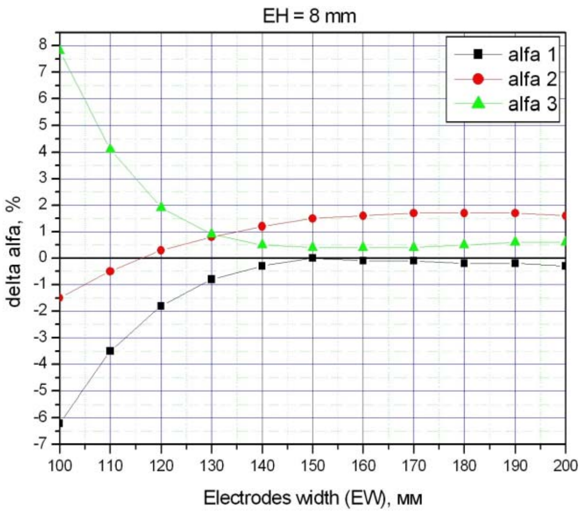

Figure 2. The dependence of deflecting homogeneity on electrodes geometrical sizes. (the angle number corresponds to [5]).

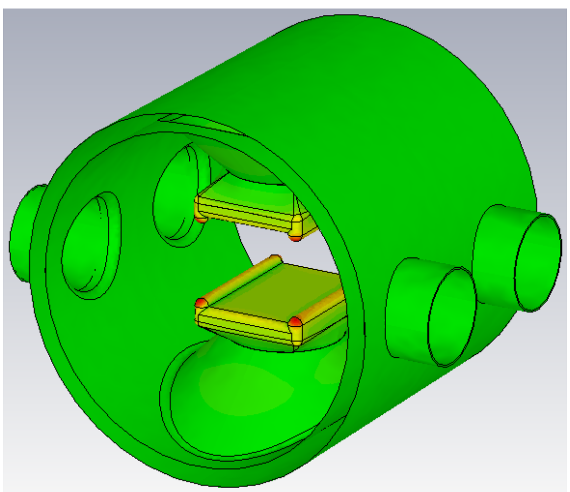

Figure 3. The electric field intensity on electrodes surface.

According to results presented on Fig. 2, 4-6 the following parameters of the deflecting cavity were chosen: the cell length D – 373 mm; the cell diameter – 368 mm; the width of deflecting electrodes EW – 130 mm; the height of electrodes edges EH – 8 mm; the rounding radius of electrodes edges El_R – 15 mm. The particles deflection homogeneity at this parameters of the cavity is equaled to $\delta\alpha$ = 1.1%, the self quality factor Q_0 = 20700 and E_{max} / E_0 = 3.1.

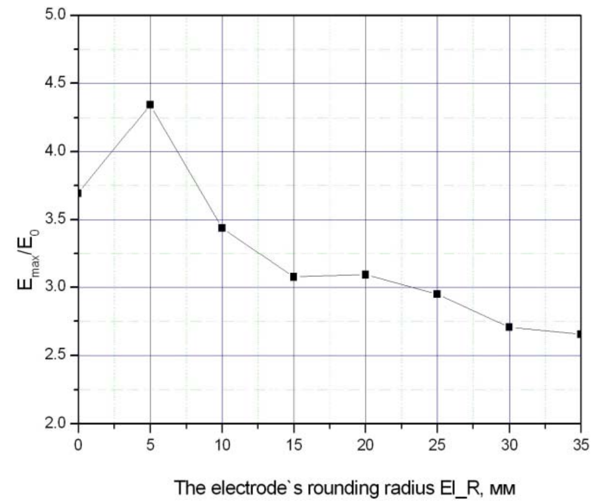

Figure 4. The dependence of E_{max} / E_0 on electrode`s rounding radius.

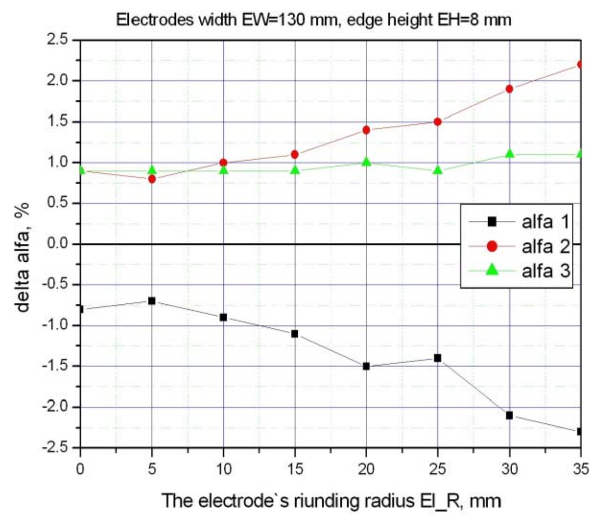

Figure 5. The dependence of deflecting homogeneity on electrode`s rounding radius El_R.

According to particle dynamics simulation the maximum intensity of the deflecting electric field at the axis should equal to E_0 = 10 MV/m, the cavity should be feeding by RF power P = 403 kW/cell. The maximum intensity of the electric field on the electrodes surface in this case will be lower than 31 MV/m. It equals to ≈ 1.6 $E_{кл}$, where $E_{кл}$ – intensity of the electric field by Kilpatrick criteria and equals to $E_{кл}$ ≈ 19 MV/m [7] at frequency f_0 = 352 MHz.

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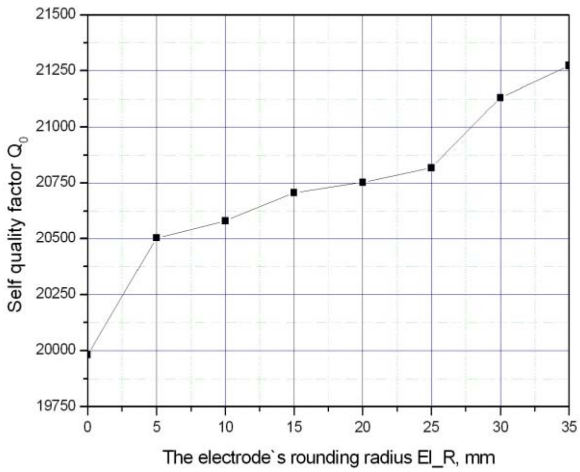

Figure 6. The dependence of self quality factor Q_0 on electrode`s rounding radius El_R.

CONCLUSION

The electrodes form optimization of the deflecting cavity for FAIR project LAPLAS experiment was carried out. The new form of deflecting electrodes which provide the particles deflection homogeneity not worse than 1.1% was found. Also this electrodes form increases the self quality factor up to 20700 as well as decreases the intensity of the electric field on electrodes surface to $E_{max} / E_0 = 3.1$.

REFERENCE

[1] Prospects of heavy ion fusion in cylindrical geometry, Basko M.M., Churazov M.D., Aksenov A.G., Laser and Particle Beams, 20, 2002;
[2] S. Minaev, et al., Nucl. Instr. and Meth. A (2010);
[3] Introduction of radio-frequency power into the cell of a former of a high-energy beam heavy ion beam , A.L. Sitnikov, V.G. Kuz'michev, A.A. Golubev, A.M. Kozodaev, Yu.B. Stasevich, T.V. Kulevoi, S.A. Minaev, YFEN, 2011, vol 2, № 4, pp. 355–358;
[4] Private communication with Dr. V.V. Paramonov, Institute for Nuclear Research RAS, Troitsk, Moscow, Russia;
[5] Formation of a quasi-hollow beam of high-energy heavy ions using a multicell resonance RF deflector, S. A. Minaev, A.L. Sitnikov, A.A. Golubev, T.V. Kulevoy, Technical Physics, 2012, Vol. 57, No. 9, pp. 1251–1256.;
[6] Private communication with Dr. A.A. Kolomiets, Institute for Theoretical and Experimental Physics, Moscow, Russia;
[7] Issledovanie vozmozhnosti sozdaniya nachal`noi chasti uskoritelya (NCHU) nepreryvnogo rezhima na energiu 5 MeV, report, V.A. Teplyakov;

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