VEPP-5 POSITRON SOURCE SIMULATIONS

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1 INTRODUCTION

Positron yield of a conventional positron source is obtained based on positron statistic after conversion target, provided with GEANT[1] runs, and tracing of positrons in a matching device and first accelerator section, placed in solenoid. This work is connected with positron source design for injector of VEPP–5 complex of electron-positron factories in Novosibirsk [2, 3]. Numerical simulations allows to extend and specify estimations of positron yield obtained by semi-analytical treatment[4] of the problem. Sample analysis is done for matching device with adiabatically decreasing magnetic field, primary electron bunch of $300\ MeV$, $2\sigma_z = 6\ mm$, radius of beam spot at conversion target is $1mm$. $3m$ first accelerator section is placed in solenoid with focusing magnetic field of a $0.5\,T$. Iris radius of accelerating cavities is $12\,mm$, operating frequency is $2856\ MHz$, accelerating ratio is $25\ MeV/m$. Positron bunches are accelerated in linac upto energy $510\ MeV$ and injected into storage ring which energy acceptance is $\pm 3\%$.

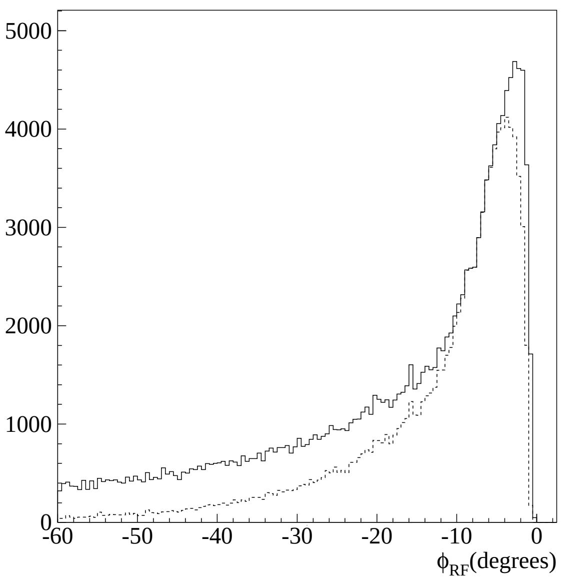

Figure 1: *The positron bunch profile and profile for positrons with $5 \div 25\ MeV$ initial energies (dashed).*

2 BEAM PROFILE

Positron bunch profiles, which are presented in Fig.1 and Fig.2, are results of tracing through out matching device and

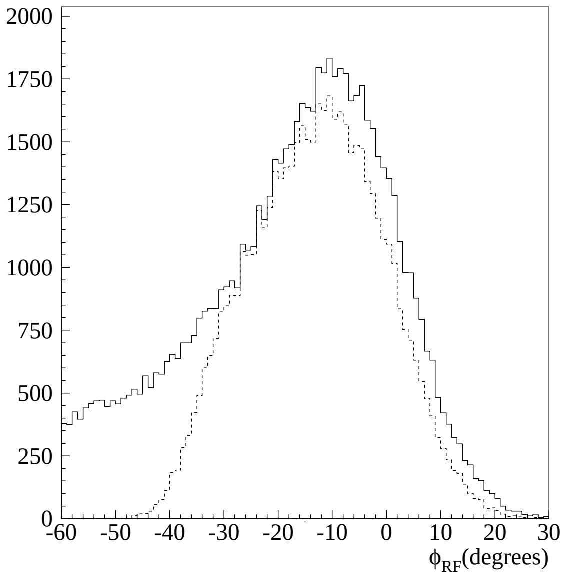

Figure 2: *The positron bunch profile for initial longitudinal distribution with $2\sigma_z = 6\ mm$ ($\sim 20°$) and profile for positrons with $77 \div 97\ MeV$ after first section. (dashed).*

first positron accelerator section. Starting parameters for each positrons are taken from statistic provided by GEANT simulations of electromagnetic showers in tungsten target of 2.5 radiation length. Radial distribution of incident electron bunch also taken into account. Lengthening is measured in units of RF-phase of accelerating field ($10°$ corresponds to $\sim\ 3\ mm$), a reference particle moves straight ahead with a speed of light. ϕ^0_{RF} is a phase of accelerating field (cosine dependence for traveling wave is assumed) at a moment when this particle enter accelerating section. Profiles in both figures are obtained for $\phi^0_{RF} = 20°$. Fig.1 illustrates a lengthening of the positron bunch for δ–function initial longitudinal distribution. Fig.2 presents results for Gaussian initial longitudinal distribution.

3 OUTPUT POSITRON YIELD

The distribution over output RF-phases and energies at the exit of the first section are shown in Fig.3. This distribution has a maximum at central part with RF-phase between $-40°$ and $-10°$, density decreases to periphery. Lines of equal positron density per one incident electron are drawn for magnitudes $4 \cdot 10^{-5}$ (outmost), $9 \cdot 10^{-5}$, $14 \cdot 10^{-5}$ $MeV \cdot degree$.

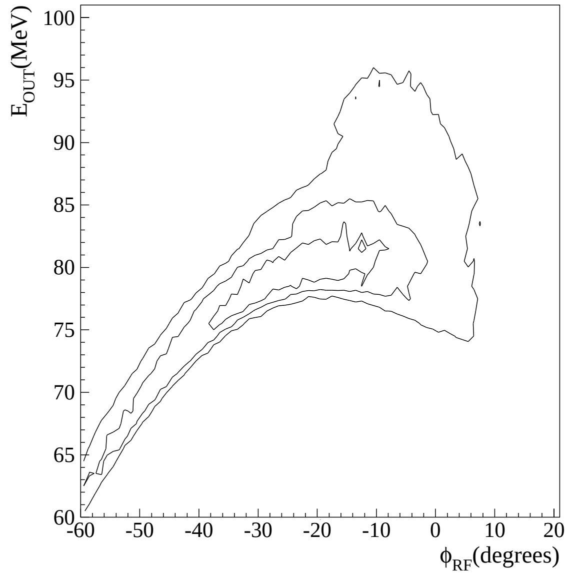

Figure 3: *The lines of equal positron density after first section for $\phi^0_{RF} = 20^\circ$*

To compute positron yield with $\pm 3\%$ energy spread requirement at the end of the linac have to be taken into account. A reasonable restrictions may be obtained in assumption that during further acceleration sections center of bunch is always at the maximum of accelerating field. In this case relation

$$\triangle E = \triangle E_1 + 2AL\sin^2(\varphi_b/4)$$

determine the region of RF-phase bunch length φ_b and energy deviation after first section $\triangle E_1$, for which at the linac exit energy deviation less then $\triangle E$. A is accelerating rate, L is a length of acceleration.

Positron yield now may be calculated for fixed pair φ_b and $\triangle E_1$ in any region of distribution over output RF-phases and energies. Parameters, where maximum yield values are reached, may be found. A table 1 shows that for different output RF-phase bands maximum yield values with correspondent $\triangle E_1$ varies slowly.

Variation of ϕ^0_{RF} leads to the different output positron density distributions. Nevertheless table 1 show the small difference.

Table 1: *Maximum positron yields for output RF-phase slices.*

φ^0_{RF}	-35° -10°	-30° -5°	-25° 0°	-20° 5°	-15° 10°
15°	2.9%	3.5%	3.7%	3.6%	3.3%
20°	3.0%	3.5%	3.7%	3.6%	3.3%
25°	3.2%	3.5%	3.7%	3.6%	3.2%

4 'BACKTRACE' DISTRIBUTION

In Fig.4 distribution over initial E and Θ is presented for positrons which pass matching device, accelerator section and satisfy to final energy spread requirement. Positron density has maximum in and decreases to periphery. Dashed curve is maximum angle for particles started from axis, discussed in [4]

$$\Theta^0_{max} = \frac{e\sqrt{B_0 B_s}a}{2P}$$

. Almost all positrons are below this curve.

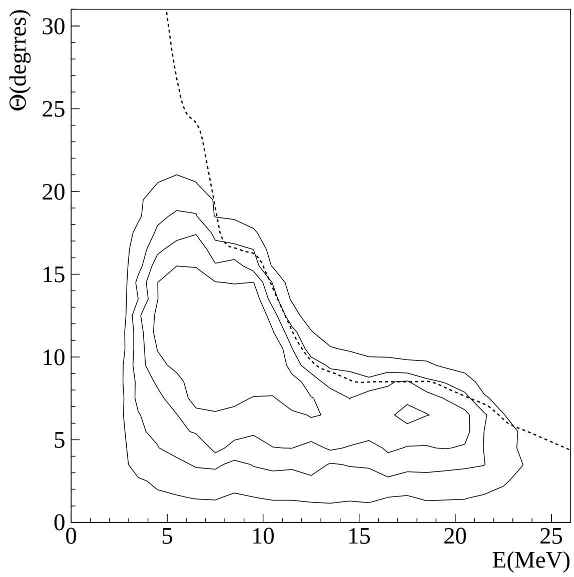

Figure 4: *Lines of equal positron density for positrons which contribute in output yield mapped back on their initial E and Θ.*

5 SUMMARY

The results of numerical simulations over GEANT statistics for various parameters of the matching device and converter target thickness of 2.5 radiation presented in table 2.

Table 2: *Positron yield for different lengths and maximum magnetic field strength of the AD matching device. Field of solenoid $0.5\,T$.*

Adiabatic device field length	2—0.5 T	3.5—0.5 T	5—0.5 T
15 cm	2.9%	4.4%	5.7%
30 cm	2.5%	3.7%	4.6%

The computation results shows that short field length of the matching device and the high maximum field strength are desirable to obtain high positron yield.

6 REFERENCES

[1] GEANT—Detector Description and simulation Tool. CERN, Geneva 1993.

[2] *N.S.Dikansky et al.*, Status of VEPP–5 Complex, *Proceedings of EPAC-94*.

[3] *A.V.Novokhatski et al.*, Electron-Positron Preinjector Complex at Novosibirsk, *Proceedings of SOURCES'94*, Schwerin, Germany, October 1994.

[4] *A.A.Kulakov, P.V.Martyshkin* VEPP–5 Positron Source Simulations. *Submitted to EPAC'96*.