STATUS OF KHARKOV X-RAY GENERATOR NESTOR BASED ON COMPTON BACK SCATTERING*

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Abstract

The purpose of NESTOR (New Electron STOrage Ring) project is to create intense X-ray generator based on compact storage ring and Compton back scattering in the National Science Centre "Kharkov Institute of Physics and Technology". It allows to carry out investigations in the wide range of fundamental and applied sciences such as physics, biology, medicine and etc. The facility consists of the compact 40-225 MeV storage ring, linear 35-90 MeV electron accelerator as an injector, transportation system, Nd:Yag laser and optical cavity. In addition to hard Compton radiation it is supposed to use 4 soft vacuum ultraviolet radiation channels of natural synchrotron radiation of dipole. The facility is going to be put in operation in the middle of 2009 and the expected X-rays flux will be of about 10^{13} phot/s. In the paper the main facility parameters are presented.

INTRODUCTION

The last few years the sources of the X-rays NESTOR based on a storage ring with low beam energy and Compton scattering of intense laser beam are under design and development in NSC KIPT [1,2]. The paper is devoted to description of the last results on construction of the facility. During the last year a linear accelerator-injector has been put into operation, all electromagnetic elements of the storage ring have been manufactured and installed on the ring, water cooling system and stabilized power supply system have been tested, RF cavity was manufactured in Novosibirsk and delivered to NSC KIPT, the scheme of injection was renovated and new inflector was designed. Vacuum chambers of bending magnets for the ring and injection channels have been manufactured.

MAIN FACILITY PARAMETERS

NESTOR facility project has been described in many details earlier [1-3]. The main task of the project is to develop compact intense X-ray generator on the base of relatively cheap accelerator equipment and up-to-date laser technologies. It is supposed that after experimental stage of operation in accelerator centres, facilities of such type can be installed in many medical and scientific establishments to carry out investigations in the wide range of fundamental and applied sciences. The main parameters of NESTOR X-ray source are presented in the Table 1.

Table 1: The main NESTOR facility parameters

Parameter	Value
Storage ring circumference, *m*	15.418
Electron beam energy range, *MeV*	40-225
Betatron tunes Q_x, Q_z	3.155; 2.082
Amplitude functions β_x, β_z at IP, *m*	0.14; 0.12
Linear momentum compaction factor α_1	0.01-0.078
RF acceptance, %	> 5
RF frequency, *MHz*	700
RF voltage, *MV*	0.3
Harmonics number	36
Number of circulating electron bunches	2; 3; 4; 6; 9; 12; 18; 36
Electron bunch current, *mA*	10
Laser flash energy into optical cavity, *mJ*	1
Collision angle, degrees	10; 150
Scattered photon energy (Nd laser, ε_{las} = 1.16 eV), *keV*	6-900
Spectral brightness, phot/(*s* mm^2 $mrad^2$ 0.1%BW)	5×10^{12}-5×10^{13}

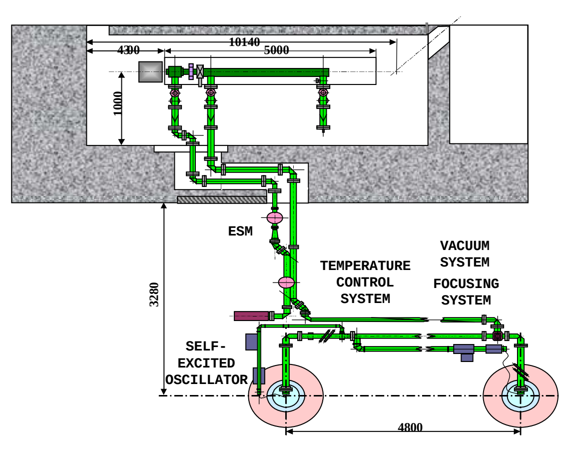

Figure 1. Layout of the NESTOR linear accelerator injector.

LINEAR ACCELERATOR

It is supposed that 60 MeV accelerator section that will be used on the first stage of NESTOR operation as injector will provide the main parameters that are listed in the Table 2.

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Table 2. The main parameters of injector.

Parameter	Value
Electron beam energy, MeV	60
Emittance, m*rad	5×10^{-7}
Energy spread, %	1
Pulse charge, nC	0.5
Pulse duration, ps	10
Repetition rate, MHz	700

The layout of the linear accelerator – injector is shown in Fig. 1. During 2007 year assembling of the linear accelerator was completed and the first test of the facility has been carried out. The results of the tests showed that the linac parameters, which are shown in the Table 2, will be reached in the nearest future. The task for optimization is energy spread of the accelerator. Fig. 2 shows the view of the assembled accelerator.

Figure 2. View of the assembled accelerator of NESTOR facility.

INJECTION SCHEME

In injection scheme of NESTOR facility electron beam is injected through fringe fields of a bending magnet. For the injection purpose the electric inflector on the running wave, as a final beam deflector and power source on the base of SOS diode, will be used. In details the injection scheme and equipment parameters are described in [4]. Parameters of the designed in NSC KIPT electric inflector are shown in the Table 3. The layout of the inflector in injection place is depickted in Fig. 3.

Table 1. The main parameters of the inflector

Impedance, Ω.	50
Deflection angle, ˚	5.44
Pulse voltage, KV	60
Pulse current, KA	1.2
Pulse duration, nsec	50
Time of growth and drop, nsec (no more)	5
Start synchronization, nsec	2
Pulse stability, %	1

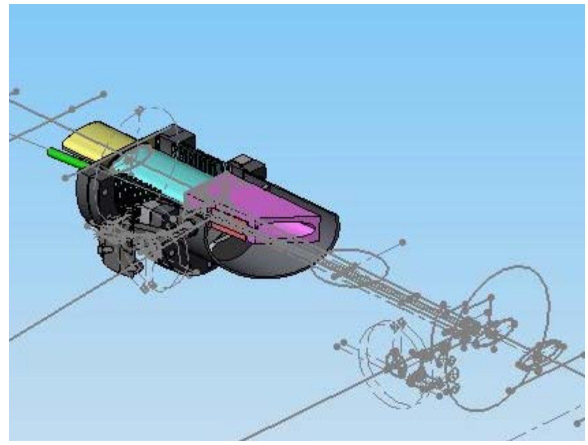

Figure 3. Layout of the electric inflector on the running wave.

Results of calculations showed that using the electric inflector on running wave it is possible to carry out the injection to NESTOR ring through the fringing field of the dipole magnet. In this case, the transportation from Linac to inflector is quite simple. Results of calculations of beam dynamics in the injection section show that with the chosen parameters of injection channel and electric inflector, injection in NESTOR ring will be successful.

RF SYSTEM

The elements of NESTOR facility RF system are under design and development. The main RF system parameters are shown in the Table 4.

Table. 4. The RF-system parameters.

Synchrotron radiation losses, V_s, keV/turn	0.28
Parasitic losses (at the most), V_{par}, keV/turn	0.30
Total energy losses (at the most), V_{tot}, keV/turn	0.58
Synchronous phase, Φ_s, deg	89.93
Beam transferred to the beam, P_b, W	5.8 (17.4)
Cavity shunt impedance, R_{sh}, MΩ	4.5
RF-bucket width, ε_{RF}, %	±4.7
Power dissipated in the cavity, P_0, kW	13.9

When choosing a shape of RF-cavity one have to take into account that while increasing the cavity shunt impedance the required RF-power decreases, the stability of the phase oscillations at the fundamental frequency is degraded because we approach the stability limit (Robinson instability). The compromised settlement would be a re-entrant cavity obtained from a pillbox cavity by incorporating nose cones in axial area and conical slants between a sidewall and front-ends.

Considering multi-bunch operation mode it seems reasonable to use a cavity with minimal HOM impedances in order to decrease the thresholds of coupled-bunch instabilities. The ideal choice would be a HOM-damped cavity. Such a cavity with shunt impedance R_{sh}=4.45 MΩ operating at 700 MHz was developed at BINP (Budker Institute of Nuclear Physics in Novosibirsk) and delivered to NSC KIPT. The view of the manufactured RF cavity and its equipment are shown in Figs. 4, 5.

RF cavity represents a nearly pillbox cavity with a small nose cones and three rectangular waveguide HOM-damping antennas located along the sidewall equidistant from each other. The cavity is provided with a piston tuner. The tuner is ganged and motor-driven via the cavity-tuning loop. Considering the low value of beam-transmitted power as compared with the power dissipated in the cavity walls, cavity detuning induced by changes in beam loading will be negligible, and only detuning arising from the cavity temperature variations has to be compensated. Sample of RF-field in the cavity is taken via the inductively coupled field probe, incorporated into the cavity. The additional port is provisioned for an ion pump.

The cavity is under testing in NSC KIPT.

Figure 4. View of the assembled accelerator of NESTOR RF cavity.

Figure 5. View of NESTOR RF equipment.

WATER COOLING SYSTEM

Water cooling system of NESTOR facility has been manufactured and assembled in 2007-2008. This system is a two circuits system with two main parts, which are heat exchanger and cooling tower (Fig. 6). In the first circuit the circulation of magistral water is provided and through the heat exchanger heat removal from the distilled water of the second circuit is carried out. In the second circuit the distilled water circulates through cooling tubes of electromagnetic elements of the storage ring. Water circulating in the both circuits is provided with two separate water pumps. Temperature and pressure probes check water temperature and pressure in the both circuits and control system can correct pump speeds and water quantity. Each cooling tube in electromagnetic element has on-line water sensor for operation control.

Fig. 7 shows view of the second circuit of the cooling system.

Figure 6. View of NESTOR cooling tower.

Figure 7. View of the second circuit of the NESTOR cooling system.

REFERENCES

[1] E. Bulyak et. al, “Compact X-ray Source Based on Compton Backscattering,” NIM A, 2002, # 487, pp. 241-248.

[2] P.Gladkikh et. al, “Lattice of NSC KIPT Compact Intense X-ray Generator NESTOR,” EPAC-2004, Lucerne, Switzerland. TUPLT134, http://www.JACoW.org.

[3] E.Bulyak et. al,”The operation modes of Kharkov X-ray generator based on Compton scattering NESTOR,” EPAC-2004, Lucerne, Switzerland.TUPLT128; http://www.JACoW.org.

[4] A.Zelinsky et. al, “Injection Scheme of X-rays source NESTOR”, EPAC-2008, Genoa, Italy, THPC078, http://www.JACoW.org.