SURVEY AND ALIGNMENT STRATEGY FOR COMPTON X-RAY GENERATOR NESTOR

I. Drebot, I. Karnaukhov, A. Mytsykov, A. Zelinsky, NSC KIPT, Kharkov, Ukraine

Abstract

NESTOR facility that is under construction in NSC KIPT (Kharkov, Ukraine) consists of compact 225 MeV electron storage ring, 100 MeV linear accelerator–injector, laser optical system and radiation channel.

To provide effective and cheap survey and alignment system for compact facility is crucial task in order to achieve designed X-ray parameters (X-ray intensity up to 10^{12} phot/s).

In the article the survey and alignment strategy of Compton generator NESTOR is described. The system uses traditional triangulation method and provides the accuracy of technological equipment alignment equal to 100 mkm.

INTRODUCTION

X-ray generator on the base of Compton backscattering is facility consists of an electron accelerator, a storage ring and a laser-optical system with YagNd laser and optical resonator [1]. NSC KIPT Compton X-ray generator NESTOR involves: 225 MeV electron storage ring with circumference of 15.418 m [2], injection channel [3], 100 MeV linear accelerator-injector [1,;laser-optical system [4], X-ray channel, Synchrotron radiation channels.

The number and types of technological equipment of the NESTOR facility are shown in Table 1.

Table 1.

System	Equipment type	N-r
Storage ring	Dipole magnet Quadrupole magnet Multipole magnet RF cavity Electrical inflector Strip-line Beam position monitor	4 20 19 1 1 1 12
Injection channel	Dipole magnet Quadrupole magnet Corrector Beam position monitor Collimator	2 7 5 2 1
Linear accelerator-injector	Electron gun Accelerating section Quadrupole magnet Beam position monitor	1 2 2 1
X-ray channel	X-ray channel Radiation monitor	1 1
SR channel	SR channel Radiation monitor	4 4
Total		91

So, one should align and control position of 91 items of technological equipment with survey methods. The total length of the facility technological lines is of about 70 m.

REQUIREMENTS TO EQUIPMENT ALIGNMENT ACCURACY

Using DeCA code [5] the calculations of RMS value of reference orbit displacement in NESTOR facility storage ring due to element alignment errors were carried out. Results of calculations are shown that acceptable values of electromagnetic element alignment accuracies for the NESTOR facility are the following [6]:

- In transverse x direction is $\Delta x= 1\times10^{-4}$ m,
- In transverse z direction is $\Delta z= 1\times10^{-4}$ m,
- In longitudinal direction is $\Delta s = 3\times10^{-4}$ m,
- Transverse element tilt is Δxz,$= 2\times10^{-4}$ rad,
- Longitudinal element tilt is Δzs, $\Delta sx = 2\times10^{-4}$ rad.

The alignment errors in vertical z direction have the most crucial effect on the value of reference orbit displacement.

The same requirements one can demand for the alignment accuracy of the linear accelerator elements.

ERROR BUDGET

Error budget for any of mentioned above NESTOR facility element involves the following components:

- Accuracy of magnetic (electrical, optical, mechanical) axis of a technological element determination,
- Accuracy of coordinate determination of survey targets for each technological element,
- Accuracy of an element alignment.

On the basis of total value of the alignment error of technological elements for NESTOR facility the error budget for the main components is:

- Accuracy of magnet axis determination – 30-40 μm
- Accuracy of element target coordinate determination – 50-70 μm
- Accuracy of element alignment – 50-70 μm

<u>TOTAL: 77-107 μm</u>

COORDINATE SYSTEM

For survey and alignment procedure at NESTOR facility we developed a survey coordinate net. The coordinate net is formed by 14 horizontal survey targets (Fig. 1).

Wall targets (Fig.1) form 4 storage ring axes *T1-T6, T11-T7, T3-T10, T4-T8*, 2 axes of a linear accelerator *TL1-TL3, T2-T5* and injection axis *TL2-T9*. Projections of each axis at the plane of circulating electron beam are coincided with corresponding axis of NESTOR electron beam passing. Axis *T1-T6* is *X* coordinate of proposed coordinate system and axis *T3-T10* is *Y* coordinate of the system. So, the beginning of the coordinate system *O* is at the reference position of the first bending magnet of the NESTOR facility storage ring and coincides with crossing of *T1-T6* and *T3-T10* axes.

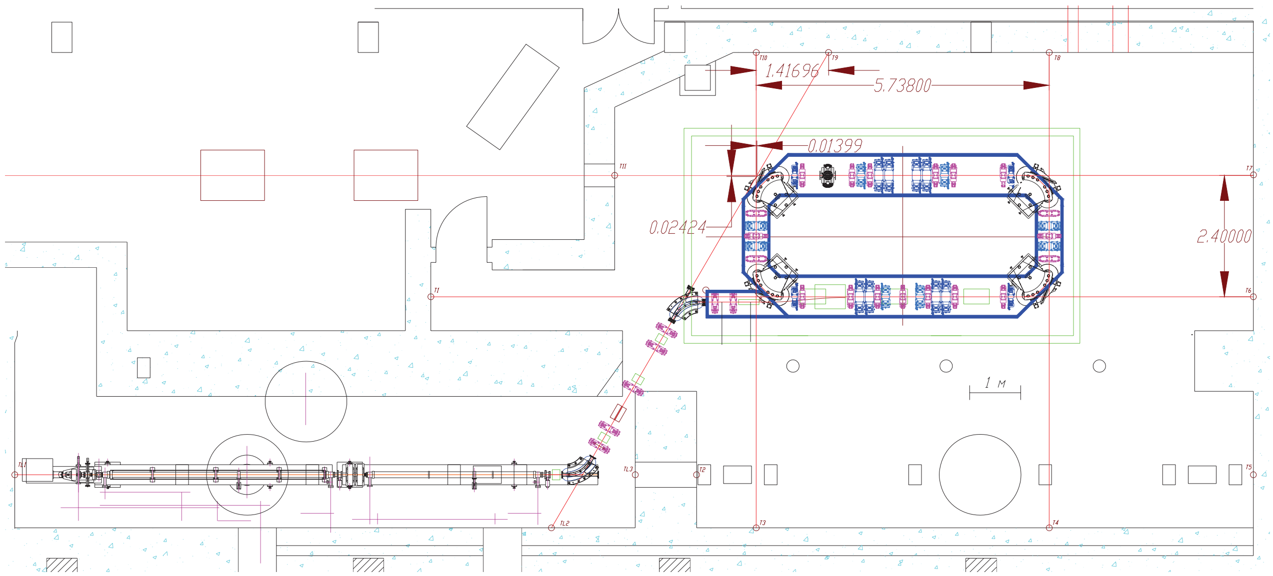

Fig. 1. Layout of the NESTOR facility coordinate net.

Vertical axis *Z* passes trough point *O* in perpendicular direction to the *X-Y* plane. Axes *T11-T7* and *T1-T6* are parallel with distance between equal to 2.4 m. Axes *T4-T8* and *T3-T10* are parallel too with 5.738 m between. So, horizontal coordinate net forms the core of the storage ring. Axis *TL1-TL3* is parallel to the linear accelerator axis and lay in *X-Y* plane of the described coordinate. The axis *TL1-TL3* is parallel to *T1-T6*. Injection axis *TL2-T9* is parallel to injection channel axis and lay in *X-Y* plane under 60° angle with *TL1-TL3* axis. Distance between *T9* and *T10* is 1.41696 m.

So, we can place our measuring device (theodolite) at any intersection of mentioned above axes in single valued way just by orienting device position at corresponding wall targets. In such way we avoid the necessity to develop stationary observation points with deep foundations and precise positioned columns. The designed net forms 6 observation points of high accuracy positioning without additional expenses for design and development of observation column.

SCHEME OF SURVEY MEASUREMENT

To install technological equipment with required accuracy and to provide survey control of equipment positions during facility operation we install survey targets at each technological element. The targets are balls with 19.05 mm diameter mounted at 12.7 mm diameter stem. Accuracy of ball and stem manufacturing are 5 mkm. Ball center displacement off stem centering is ±10 mkm. The target is inserted to the socket manufactured with the same accuracy. The example of the target is shown in Fig. 2. The assembled target is fixed at support that is placed at technological element. All targets, sockets and supports are manufactured in NSC KIPT.

Fig. 2 An example of ball survey target and fixing socket.

In is supposed to use different number of targets for different types of the facility technological elements (see Table 1.). To align dipole magnets one will use 3 targets at them. Quadrupole magnets have 4 targets, multipole magnets have 2 targets, RF cavity have 2 targets, inflector has 2 targets, beam monitors have 1 targets, strip-line has 2 targets, correctors have 1 targets, collimator has 1 target, electron gun has 1 target, accelerating sections have 2 targets and radiation channels have 2 targets at each channel. The ways of targets fixing at each type of technological elements are different too. In Fig. 3 one can see the mounting of the survey target at quadrupole magnets.

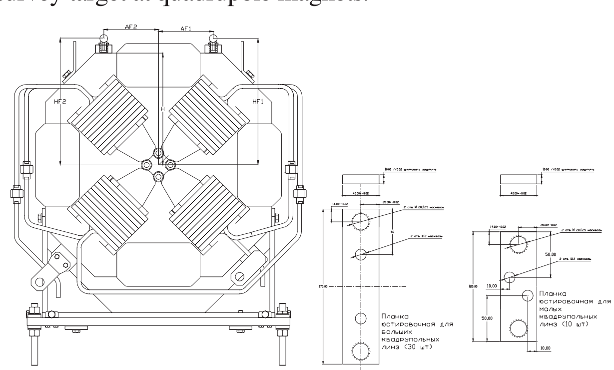

Fig. 3. Mounting of the survey targets at quadrupole magnets.

Wall targets use the same ball targets installed in sockets but mounted in special coordinate table (Fig. 4). The coordinate tables are manufactured in NSC KIPT. The construction of the tables allows adjusting of ball target position in range ± 15 mm in horizontal and vertical planes. The sizes and manufacturing accuracy are the same as for technological element targets mentioned above. After final installation in design position all wall targets are fixed and can not be moved. Their position will be checked during facility operation.

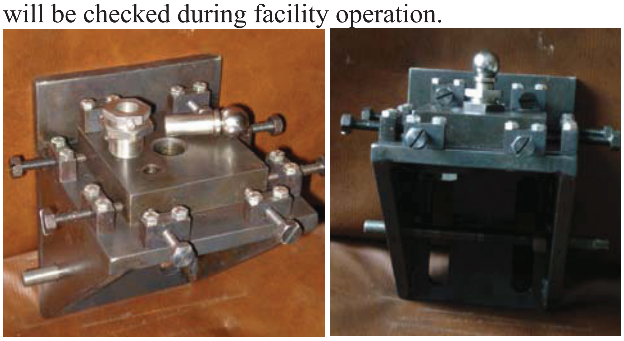

Fig. 4. Wall target at coordinate table.

As were mentioned above, we do not suppose to use deep foundation mark. Stationary observation points will form by mounting theodolites at coordinate tables. These tables are installed at special supports at bending magnets (Fig. 5). The position of the theodiolites are chosen at intersaction of corresponding coordinate axes. So, the accuracy of theodolite positioning is determined by accuracy of a theodolite and by distance to the wall target. For the NESTOR facility a theodolite with angle accuracy of measurements equal to 2'' on character distance 10 m provides positioning accuracy equal to 10 mkm.

Survey and alignment in horizontal plane will be carried out with triangulation method. Alignment in vertical plane will be carried out by leveling. The list of instruments that are going to be used during survey and alignment activity at NESTOR facility is presented in Table 2.

Table 2.

№	Device	Accuracy	Manufacturer
1	Dipole magnet coordinate table support	-	NSC KIPT
2	Dipole magnet coordinate table	5 mkm	NSC KIPT
3	Theodolite 3T2КП	2''	Russia
4	Ball target	10 mkm	NSC KIPT
5	Coordinate table for wall target	10 mkm	NSC KIPT
6	Leveling instrument Leica NA-2	1 mm/rm	Leica, Switzerland
7	Support for Leica NA-2	-	NSC KIPT
8	Laser distance meter LMS100	1 mkm	Germany
9	Equipment for distance measurements	100 mkm	NSC KIPT
10	Optical rule LIR-7, 9	10 mkm	Russia

Fig. 5. View of a theodolite mounting at a NESTOR bending magnet.

CONCLUSIONS

The developed survey and alignment system provides effective and cheap procedure of equipment installation and precise positioning for compact facility of Compton X-ray source NESTOR. The clue features of the system are rejection of development of traditional stationary observation points based at deep foundation columns and development of coordinate net formed with stationary ball wall targets. The system uses traditional triangulation method and provides the accuracy of technological equipment alignment equal to 100 mkm.

REFERENCES

[1] V. Androsov et al. "Status of Kharkov X-ray Generator NESTOR Based on Compton Back Scattering", Proc. of EPAC 2008, 23-27 June, 2008, Genova, Italy, MOPCO47.

[2] P. Gladkikh et al. "Lattice of NSC KIPT Compact Intense X-ray Generator NESTOR", NIM, B79(1993), p.770-772.

[3] P.Gladkikh et al. "Injection System for Kharkov X-ray Source NESTOR", Proc. Of EPAC'2006, 26-30 June, 2006, Edinburgh, Scotland, pp. 2038-2040.

[4] P.Gladkikh et al. "Intense X-Ray Sources Based on Compton Scattering in Laser Electron Storage Rings", Problems of Atomic Science and Technology, 2002, №2, pp. 72-74.

[5] P. Gladkikh, M. Strelkov, A. Zelinsky, "The Application Package DeCA for Calculating Cyclic Accelerators", PAC-93, May, 1993, Washington, USA, pp. 194-196.

[6] V. Ivashchenko et al. "NESTOR reference orbit correction", Proc. Of EPAC'04, 5-9 July, 2004, Lucerne Switzerland, pp. 1431-1433.