Available online at www.sciencedirect.com
SCIENCE DIRECT®
Nuclear Instruments and Methods in Physics Research A 543 (2005) 58–64
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

X-ray generator based on Compton scattering

V. Androsov[a], A. Agafonov[b], J.I.M. Botman[c], E. Bulyak[a], I. Drebot[a], P. Gladkikh[a], V. Grevtsev[a], V. Ivashchenko[a], I. Karnaukhov[a], V. Lapshin[a], A. Lebedev, V. Markov[a], N. Mocheshnikov[a], A. Mytsykov[a], F. Peev[a], A. Ryezayev[a], A. Shcherbakov[a], V. Skomorokhov[a], V. Skyrda[a], R. Tatchyn[d], Y. Telegin[a], V. Trotsenko[a], A. Zelinsky[a,*]

[a]*National Science Center, ''Kharkov Institute of Physics and Technology'', 61108 Academicheskaya St. 1, Kharkov, Ukraine*
[b]*Lebedev Physical Institute, Moscow, Russia*
[c]*Eindhoven University of Technology, Netherlands*
[d]*SSRL, SLAC, USA*

Available online 23 February 2005

Abstract

Nowadays, the sources of the X-rays based on a storage ring with low beam energy and Compton scattering of intense laser beam are under development in several laboratories.

In the paper the state-of-art in development and construction of cooperative project of a Kharkov advanced X-ray source NESTOR based on electron storage ring with beam energy 43–225 MeV and Nd:YAG laser are described. The layout of the facility is presented and latest results are described. The designed lattice includes 4 dipole magnets with combined focusing functions, 20 quadrupole magnets and 19 sextupoles with correcting components of magnetic field. At present, a set of quadrupole magnet is under manufacture and bending magnet reconstruction is going on. The main parameters of developed vacuum system providing residual gas pressure in the storage ring vacuum chamber up to 10^{-9} Torr are presented. The basic parameters of the X-ray source laser and injection systems are presented.

The facility is going to be in operation from the middle of 2006 and generated X-ray flux is expected to be of about 10^{13} phot/s.

PACS: 41.85.Lc; 85.25.Ly; 07.55.Db

Keywords: Compton scattering; Magnetic field; Storage ring; Laser

*Corresponding author. Tel.: +380 572 356 966; fax: +380 572 351 688.
E-mail address: zelinsky@kipt.kharkov.ua (A. Zelinsky).

0168-9002/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.nima.2005.01.114

1. Introduction

One of the most promising methods producing the short-pulse X-rays is Compton scattering (CS) of an intense laser flash on a relativistic electron beam. Radiation produced with CS has several advantages. They are the easy wavelength tunability, the spectrum and spatial distributions, and ad extremum a capability to produce the X-rays using electron beams with relatively low energy that decreases the cost of a facility essentially.

The progress of the NESTOR (New Electron STOrage Ring) X-ray generator based on CS of an intense laser beam on electron beam with low energy circulating in a storage ring has been regularly reported [1–4] since its very first proposal in 1998 [5]. But in reality the project entered the construction phase after the SfP NATO Grant #977982 award in early 2003.

At present, a full-scale definition of the magnetic system design specification was completed and design projects of vacuum and laser systems are under development. Results of beam dynamics investigations and main technological systems design have been completed with the production of a technical design report.

2. X-ray parameters of NESTOR

Luminosity and brightness are the main characteristics of any light source. Table 1 shows luminosity and spectral brightness of NESTOR source in the main operation modes [6].

3. Main NESTOR facility parameters

Based on the strategy of maximum X-ray intensity with feasible parameters of technological systems the main NESTOR facility parameters were worked out (Table 2).

4. NESTOR allocation and lattice

NESTOR X-ray source is constructed on the base of N-100 electron storage ring and is located in a building of 300 MeV linear accelerator complex. Such a decision makes the total cost of the project much cheaper for the reasons of using existing infrastructure and absence of building construction costs. Layout of the NESTOR facility is presented in Fig. 1. For new equipment allocation an old radiation shelter has been broken down and a new one will be built. Old accelerator sections and N-100 storage rings were dismounted and new accelerator sections, injection channel and magnetic system of the storage ring along with a laser system will be assembled as shown in the figure.

Table 2
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 (deg)	10; 150
Scattered photon energy (Nd laser, $\varepsilon_{las} = 1.16$ eV) (keV)	6–900

Table 1
NESTOR X-ray parameters

	Angiography	Biology	Hard X-ray
X-ray energy (keV)	33	5–16	900
X-ray luminosity (phot/mm^2 s)	10^{15}	4×10^{13}	4×10^{14}–4×10^{15}
Spectral brightness (phot/s mm^2 mrad^2 0.1% BW)	5×10^{12}	2×10^{11}	5×10^{12}–5×10^{13}