Kurchatov Synchrotron Radiation Source status report

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A brief description of the Kurchatov Synchrotron Radiation Source is given. Commissioning of the injection complex is presented. Installation of the big storage ring is almost finished and high-vacuum conditions are fulfilled in half of the ring. Active proposals for investigations are described. © *1995 American Institute of Physics.*

I. INTRODUCTION

The construction of the Kurchatov Synchrotron Radiation Source (KSRS) at the Russian Research Center "Kurchatov Institute" (RRC KI) is coming to its end. The facility includes an electron linac with energy 80–100 MeV, a booster storage ring with electron energy 450 MeV, and a big storage ring with electron energy 2.5 GeV. The main parameters of the storage rings are presented in Table I. The linac, both storage rings, and the corresponding electron transfer lines had been constructed by the Institute of Nuclear Physics (INP) of the Siberian Division of the Russian Academy of Science.[1,2] Installation and commissioning of the facility are fulfilled by joint efforts of INP and RRC KI. The building housing dedicated to the synchrotron-radiation source consists of two parts: an experimental hall of 2700 m^2 (Figs. 1 and 2) where all accelerators, rf systems, and experimental stations are located, and the technological part, where all engineering systems are located.

II. COMMISSIONING OF THE KSRS INJECTION COMPLEX

A linac structure had been chosen according to Ref. 3. Designed linac parameters are the following: energy 80–100 MeV, energy spread 1%, pulse current 200 mA, pulse duration 15 ns, transverse emitted 0.1 mrad cm, repetition frequency 1 pulse/s. The accelerator structure is a fulfilled DAW type with the following parameters: wave type TM-02, shunt impedance 92 MΩ/m, frequency 2795.7 MHz, quality 27 000, characteristic impedance 3.4 kΩ/m, length 6.1 m. The linac has no buncher and a continuous electron beam with an energy of 40 keV and a duration of 15 ns is injected by a diode electron gun to the accelerating structure. The input hole has a high transparent grid. There exist vertical and horizontal correctors and focusing solenoid lenses. The linac rf power supply consists of a klystron generator connected to accelerating structure by means of a 90×45 mm^2 rectangle waveguide. Klystron parameters are the following: pulse power up to 18 MW, repetition frequency up to 100 Hz, pulse duration 8 mcs, jitters on the top 0.4%, front duration 2 mcs. By now we get a power of 8 MW. At a power level of 6.5 MW the linac gives an electron beam with an energy of 70 MeV. The electron current reaches 300 mA with an energy spread of 15%.

By now the linac and the little storage ring are operational and we already have 102 mA and 450 MeV of stored electron current in the little ring. The construction of the VUV experimental hall inside the big storage ring is nearly finished and in the near future we will begin establishing VUV experimental stations. The big ring magnet system and vacuum chamber had been mounted and now after baking we have 5×10^{-10} Torr in a half of the ring. Two big accelerating cavities and an rf system have been installed, too. We hope that the first SR beam from the big ring will be at the end of 1994.

Now we have 20 experimental groups with active proposals. Fourteen institutions (Table II) take part in these proposals.

III. LITTLE RING BEAM LINES

Beam line D'1.1: Commissioning of nondestructive ionization SR beam monitor (IGNP RRC KI). Such a monitor was primarily developed for registration of accelerated beams' two-dimensional cross sections. The image of the beam cross section is formed on the screen of an image converter tube, recorded by a TV camera, processed and represented on a computer.

Beam line D'3.1 (straight section between D'2 and D'3 bending magnets). The application of edge radiation from bending magnets of the storage ring to electron-beam diagnostics will be performed (KSRS RRC KI). The long-wave radiation generated by two adjacent magnets gives an interference ring pattern which is dependent upon emittance of the storage ring.

Beam line D'3.3: Ultra-high-vacuum VUV spectrometer with high luminosity (KSRS RRC KI). It has a horizontal

TABLE I. Main parameters of Kurchatov Synchrotron Radiation Source.

Parameter	Big ring	Little ring
Energy (GeV)	2.5	0.45
Current (mA)		
single bunch mode	100	100
multibunch mode	300	...
Orbit circumference (m)	124.13	8.7
Number of dipoles	24	4
Bending magnets, ϵ_c (keV)	1.75, 7.1	0.21
Horizontal emittance E_x (nm rad)	76	880
No. of beamlines from bending magnets	24	8
Lifetime (h)	10	4
Bunch length (cm)	4.4	59.8
Number of possible undulators	5	...
Number of possible wiglers	4	...

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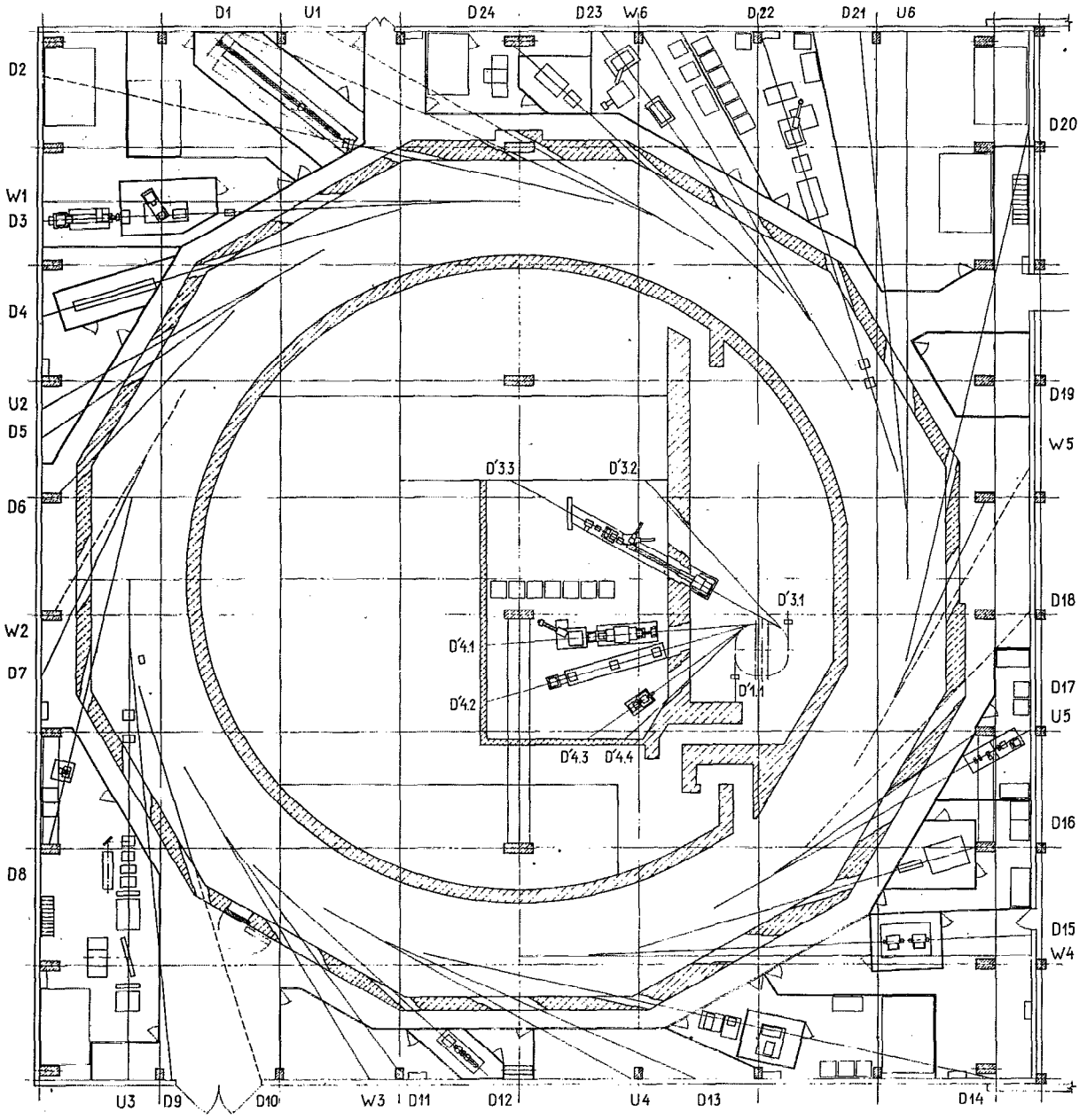


FIG. 1. Kurchatov Synchrotron Radiation Source. Existing hall with beam lines and experimental stations. Little ring: D′—dipole magnets. Big ring: D—dipole magnets, W—wiggler possible beam lines, U—undulator possible beam lines.

acceptance angle of 65 mrad. The energy band of the spectrometer is 4–40 eV, with a resolution of 0.2 Å and a sample temperature range of 4–500 K. There exists quick Auger analysis. High-temperature superconductors, wide-band-gap dielectric, and crystal phosphorous are some examples for investigation.

Beam line D′4.1: Ultra-high-vacuum photoemission spectrometer for thin-film (up to 5 Å) investigation (ISSSP RRC KI). The spectrometer is comprised of a research chamber, a sample preparation chamber, an ion-plasma sputtering unit, and a cryostat. The base pressure amounts to about 10^{-11} Torr; the sample temperature can be from 2 K up to 1000 °C. The spectrometer has built in units for ion-beam sample cleaning and for the Auger, LEED, ELS, and luminescence spectroscopy techniques.

Beamline D′4.2: Universal VUV spectrometer for an energy band of 3–200 eV (KSRS RRC KI). Electron structure of clusters, thin films and multilayer structures are examples for investigation.

Beam line D′4.3: VUV spectroscopy station (LMSU). This is for studying the optical characteristics of anisotropic crystal (e.g., of the scaly ones), of low-dimensional solids (thin films and threadlike crystals, such as porous silicon), and relaxation dynamics of electron excitation in objects of this kind. The station is based on a normal-incidence vertical

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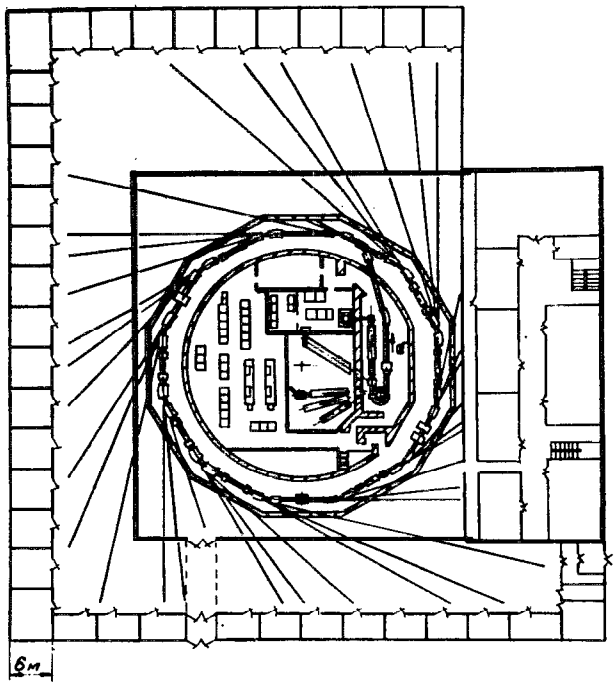


FIG. 2. Future development of Kurchatov Synchrotron Radiation Source.

dispersion monochromator (4–40 eV) with resolution up to 0.1 eV and vacuum 10^{-9} Torr.

III. BIG RING BEAM LINES

Beam line D2. This facility is for investigation of biological objects by means of high-speed small-angle x-ray diffractometry—"diffraction cinematography" (ITEB RAS, ICB RAS). Muscle contraction and excitation propagation along a nerve are examples of investigation.

Beam line D3. Two stations can operate one after another. (1) The ALMAZ facility for x-ray structure analysis and spectroscopy at high pressures (ISSSP RRC KI, VIHP RAS). H_2 and D_2 cryocrystals, high-temperature superconductors, and electron configuration of ions in metals are examples for studying. (2) A small angle-diffractometer in energy dispersive mode (ITEB RAS, ICB RAS). Investigation of biological objects, namely living muscle, will be performed.

Beam line D4. Multipurpose diffractometer (ISSSP RRC KI). An x-ray refraction tomograph with a single-crystal interferometer having an angular resolution of the order of 1 in. will give opportunity to obtain images of biological objects. This is one example.

Beam line D8. XUV spectroscopy (KSRS, LMSU). This is for development and investigation of highly efficient crystal phosphorous for different applications.

Beam line U3 (straight section, parasitic regime with SR) (KSRS RRC KI, INR RAS). The intermediate photon energy (about 100 MeV) nuclear photodisintegration low-background correlation experiment and the tagged polarized photon nuclear electromagnetic interaction experiment using polarized targets and beams are in the investigation program.

Beam line D11. The EXAFS station (5–40 keV) is conceived as a general purpose one (KSRS RRC KI, LMSU).

Beam line D13: X-ray scanner for deep lithography. The LIGA technique will be used (KSRS RRC KI, IMM).

Beam line D14. Three stations can operate one after another.

TABLE II. User list.

No.	Acronym	User	Site
1	KSRS RRC KI	Kurchatov Synchrotron Radiation Source Russian Research Center "Kurchatov Institute" (RRC KI)	Moscow
2	ISSSP RRC KI	Institute of Superconductivity and Solid State Physics RRC KI	Moscow
3	IGNP RRC KI	Institute of General and Nuclear Physics RRC KI	Moscow
4	IIT	Institute of Information Technologies RRC KI	Moscow
5	ICB RAS	Institute of Cell Biology Russian Academy of Science (RAS)	Pushchino
6	ITEB RAS	Institute of Theoretical and Experimental Biology RAS	Pushchino
7	IC RAS	Institute for Crystallography RAS	Moscow
8	INR RAS	Institute of Nuclear Research RAS	Moscow
9	VIHP RAS	Vereshchagin Institute of High Pressure RAS	Moscow
10	MEPU	Moscow Engineering Physics University	Moscow
11	LMSU	Lomonosov Moscow State University	Moscow
12	IMM	Institute of Microtechnology at Mainz	Mainz, Germany
13	IP CzAS	Institute of Physics Czech Academy of Science	Prague, Czech Republic
14	ISSPS	Institute of Solid State Physics and Semiconductors	Minsk, Belarus

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(1) An x-ray photoelectron-diffraction spectrometer (KSRS RRC KI, IC RAS) is intended to test the perfection of single-crystal surface-bound layers using the x-ray standing-wave method.

(2) X-ray emission line chemical shift spectrometer (KSRS RRC KI, IP CzAS). Systematic measurements of elements from Ca ($Z=20$) practically to the end of the periodic table is possible. The technique of chemical compound unambiguous identification using sum total 8–10 x-ray emission line shifts will be worked out.

(3) Elements of these two stations can be used in double Bragg-reflection diffractometry structural state research (KSRS RRC KI, MEPU).

Beam line D15. Two stations can operate one after another.

(1) Beam diagnostic station (KSRS RRC KI). (SR critical wavelength, SR time structure, SR source linear and angular size).

(2) SR Mössbauer experimental station. Collective nuclear state excitation, polarized gamma-ray optic, magnetic structure investigation, and gamma-ray interferometry can be fulfilled on that station.

Beam line D16. The x-ray topography station (IC RAS). Different topography methods are available, including non-dispersion plane-wave topography, dispersion quasi-plane-wave topography, triple-crystal plane-wave topography with angular resolution of x-ray images, by using the analyzer crystal. The flexible optical scheme makes it possible to use this station also for diffractometry measurements with high angular resolution.

Beam line U5. This is the same as on beam line D′3.1.

Beam line D22. This is the same as on beam line D′4.1.

Beam line D23. This is an ultra-high-vacuum three-crystal diffractometer (IIT RRC KI) with asymptotic Bragg diffraction mode for investigation of clean atomic surfaces. There exists the possibility to deposit adsorbates on the sample.

Beam line D24. The station of multicrystal x-ray spectrometer (IC RAS). The station provides the possibility of the production of the perfect plane wave, suppression of the high-order harmonics, energy scanning, two-dimensional x-ray beam collimation, long-term stabilization of the crystal position, and high precision on crystal adjustment and rotation. It is intended for the analysis of the structures of the surfaces, thin surface layers, interfaces, and bulks of single crystals by using modern x-ray-diffraction methods.

[1] V. V. Anashin, Nucl. Instrum. Methods A **282**, 369 (1989).
[2] A. N. Artemiev, Nucl. Instrum. Methods A **308**, 61 (1991).
[3] M. M. Karliner, Proceedings of the EPAC, Rome, 1988 (unpublished), p. 602.

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