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Beam lines at the TNK SR source

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In the present work the SR beam lines at the TNK are described Two types of SR beam lines are considered: for radiation from strong-field superconducting wigglers in the 0.2–5 Å wavelength range and for radiation from bending magnets, undulators and multipole wigglers in the 5–2000 Å range.

1. Introduction

The TNK facility, designed at the INP, Novosibirsk, is a dedicated synchrotron radiation source and is intended for use in solving submicron technology problems as well as in performing various X-ray structural studies within the 0.2–2000 Å wavelength range.

The magnetic lattice of the storage ring is optimized for obtaining intense photon fluxes of high brightness from both the bending magnets and the special radiation generators – wigglers and undulators.

2. SR beam lines

The general layout of the TNK facility is shown in fig. 1. The main ring comprises six identical mirror-symmetrical cells. One of these cells is shown in fig. 2. In addition to magnets, the initial sections of the SR beam lines and the source points numbered along the path of electron beam can be seen:

(1) centre of the undulator straight section, beam line K1; here an undulator or a multipole wiggler is planned to be installed;
(2) weak field (1/4 of the main field) of the dipole magnet M1;
(3) main field of the dipole magnet M1, beam line K2;
(4) main field of the next magnet M2, beam line K3;
(5) weak field of the dipole magnet M2, beam line K4;
(6) centre of the wiggler straight section where the superconducting wiggler will be installed, beam line K4;
(7) weak field (1/4 of the main field) of the dipole magnet M3;
(8) main field of the magnet M3, beam line K5;
(9) main field of the magnet M4, beam line K6;
(10) weak field of the magnet M4.

There are two types of beam lines: five K14 beam lines (A, B, C, D, E) and five K44 beam lines (A, B, C, D, E) are intended for the superconducting wiggler in the 0.2–5 Å wavelength range and the remaining 29 will be used for radiation from bending magnets and undulators and the multipole wiggler in the 5–2000 Å range. The characteristics of the TNK radiation points are presented in ref. [1]. Beam line K25 is designed to measure the electron beam parameters.

3. Beam lines design

3.1. Hard X-ray beam lines from the superconducting wiggler

Two five-pole superconducting wigglers with a maximum field at the orbit of up to 8 T are planned to be installed in the dispersion-free straight sections [2]. The wiggler vacuum vessel design provides a horizontal opening angle for radiation from the wiggler of 3°. The radiation is split into five beam lines by a radiation absorber installed at the front end. The horizontal angular aperture of each beam line is $2\Delta\theta = 3.6$ mrad.

All the beam lines are identical in design and elements, but differ in length (15 to 35 m) (fig. 3). To protect the ring and beam line components in case of vacuum failure, the ring vacuum and the beam lines are separated by three Be foils, each being 200 μm thick. One more Be foil separates each station from its beam line. The heat is transferred from the Be foils by water-cooled copper rings. The foils are fixed in these rings by diffusion welding in vacuum. The bulk of the radiation is absorbed in the first foil (for source parameters $E = 1.6$ GeV, $I = 0.3$ A and $H_{max} = 8$ T; the temperature difference between the copper ring and the foil centre is 70 °C). It is used only for absorbing the

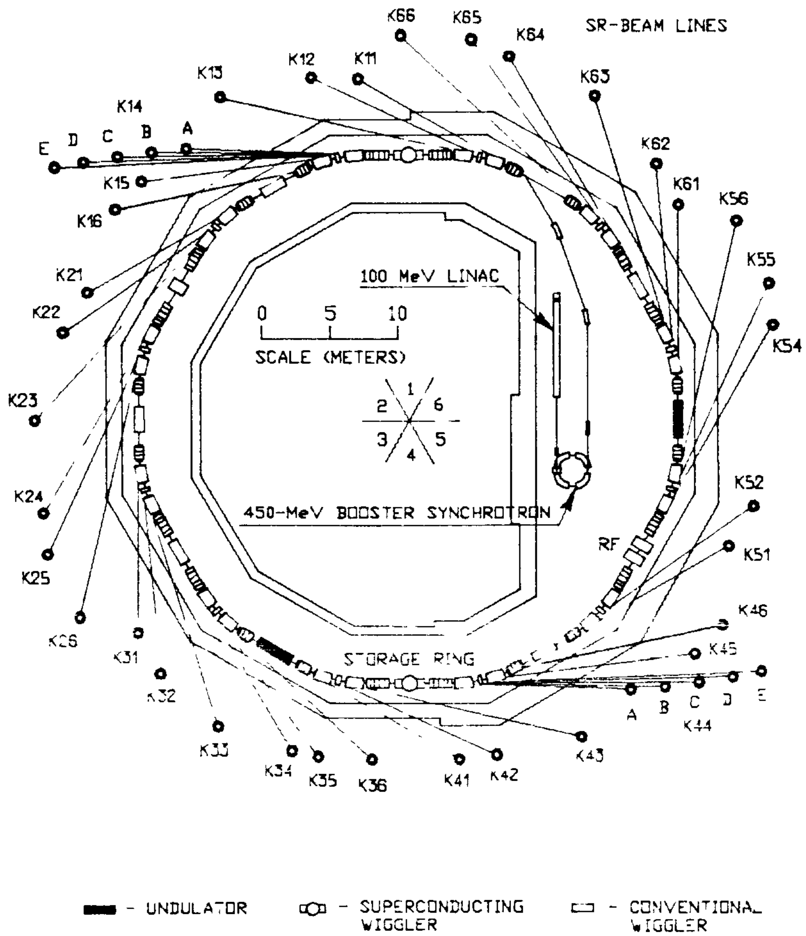

Fig. 1 Layout of the TNK synchrotron radiation source.

long-wavelength radiation and does not provide reliable vacuum protection. The vacuum volumes before and after the first foil are connected to each other by special holes in the copper ring. The power load for the second foil is about 1/3 of that for the first, and the power load for the third foil is about 1/3 of that for the

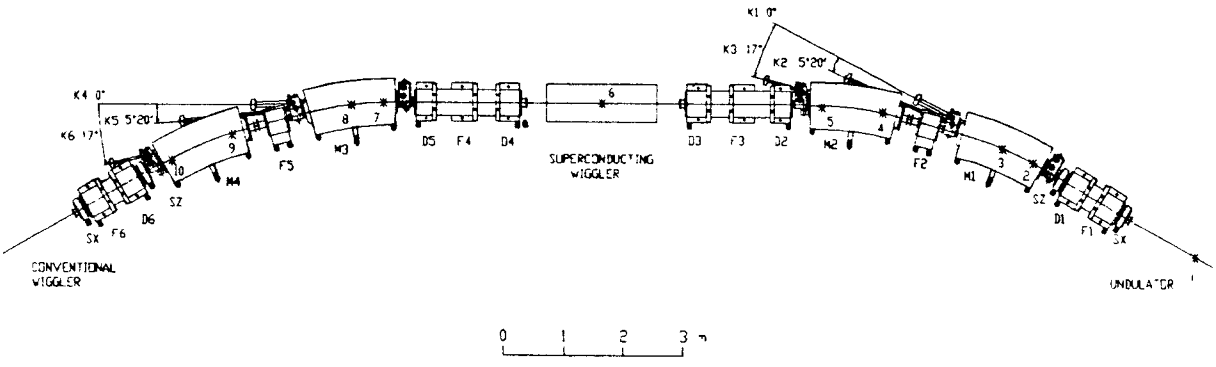

Fig. 2. The cell of the TNK synchrotron radiation source.

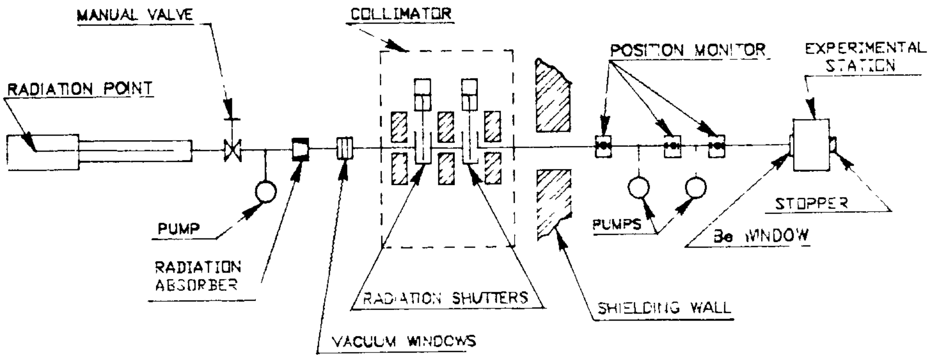

Fig. 3. Schematıc layout of hard X-ray beam lines from the superconducting wiggler.

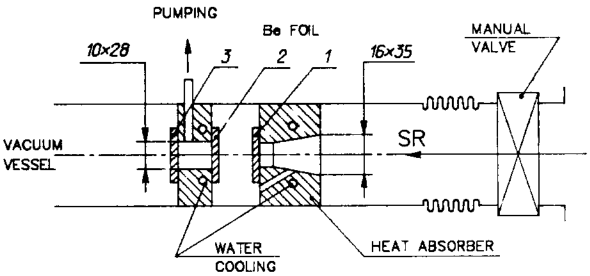

Fig. 4. Schematıc dıagram of the trıple beryllıum window assembly.

second foil. These foils separate the storage ring vacuum from the beam line vacuum, and the volume between them is pumped by an ion pump.

Two W–Cu radiation shutters are used to shield the personnel from bremsstrahlung and showers due to the particle losses ın the ring. In addition, lead collimators are placed near the shutter and a lead absorber is located behind the experimental station. All the collimators and the W–Cu shutters provide the required safety for electron energies of up to 2.5 GeV. Each beam line has a luminophor position monitor for SR-beam matching.

The ıon pumps provıde a pressure in the beam lınes within 10^{-4}–10^{-5} Pa.

3.2. Lithographıc beam lines

For the extraction of soft X-radiatıon 29 beam lines will be mounted. Fig. 5 presents the layout of a bending

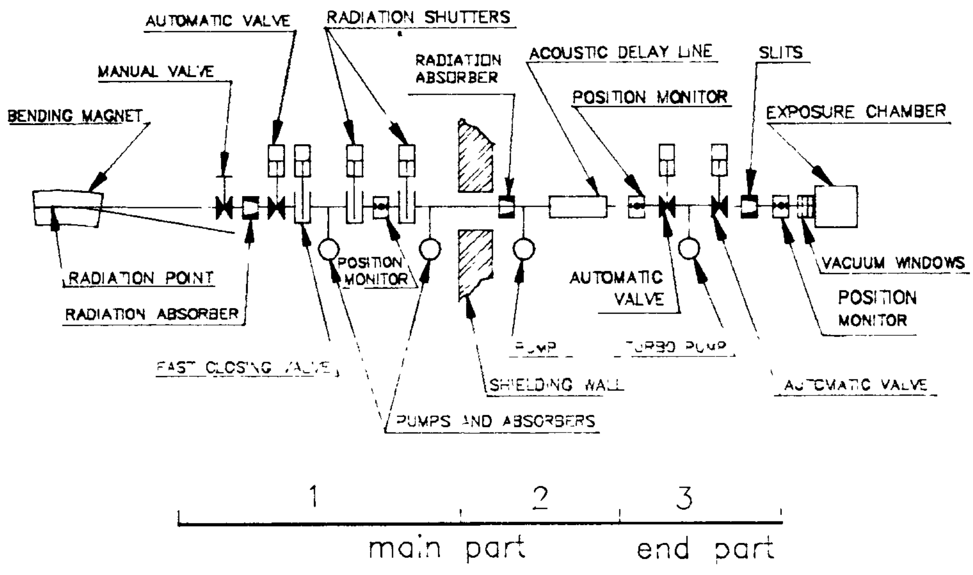

Fig. 5. Schematıc layout of a lıthographic beam lıne.

magnet beam line. The beam line vacuum is common with the storage ring vacuum. The differential pumping provides a pressure at the ring end of 10^{-8} Pa while the pressure at the exposure-chamber end is 10^{-5} Pa. To protect the vacuum inside the ring in case of an emergency, the beam lines are equipped with a manual valve and pneumatic automatic valves with closing times of less than 2 s. Vacuum detection gauges along the beam line trigger the fast valve, which closes in about 15–20 ms. The vacuum acoustic delay line provides a 40–50 ms delay in the propagation with a 10^{-3} Pa pressure at the end of the beam line. The lithographic beam lines with a total length of 15 m can be baked out at 350 °C.

Movable slits are installed before the exposure chamber to obtain beams of the required sizes. These slits make it possible to control the transverse beam sizes in the range 0–30 mm. The propagation of photons along the beam line can be controlled by a set of luminophor position monitors, which can also serve as a fast shutter opened only during the exposure.

The beam lines are separated from the exposure chamber by a vacuum window that consists of a 28 μm thick Be foil, a 8 μm thick kapton foil and a 2 μm thick Si membrane. The space between the kapton foil and the Si membrane is filled with helium at atmospheric pressure. Such a design showed high reliability at the SR beam line of the VEPP-3 storage ring.

Similar to the beam lines from the superconducting wigglers, each beam line for X-ray lithography has two W–Cu radiation shutters in addition to lead collimators, intended for shielding the personnel against bremsstrahlung and shower radiation. These shutters are controlled from the central control desk and are used to shut down the beam lines when the radiation situation at the experimental area becomes dangerous for the personnel (for example, during injection, electron beam ramping, etc.).

All 29 lithographic beam lines have the same front end from the port to the shielding wall. This first part of the beam line includes all the elements for protecting the vacuum inside the storage ring as well the experimenters from the radiation. The maximum horizontal divergence of the photon flux is about 4.2 mrad, which corresponds to a horizontal size of 50 mm after the shielding wall. The design of the beam lines makes it possible to scan the beam in the vertical plane up to an angle of ± 1.6 mrad.

For the commissioning of the ring the outside part of the beam line will have a maximum transverse aperture of 40 mm. In this case an additional radiation absorber will be installed. In the future an increase of the aperture up to 70 mm is expected.

The beam lines were designed at the INP, Novosibirsk, and the Vekshinsky Vacuum Institute, Moscow. Most of the lithographic beam lines have been completed and are now being tested.

References

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