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THE NOVOSIBIRSK FOURTH-GENERATION LIGHT SOURCE SKIF DEVELOPMENT STATUS

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Abstract

SKIF (Russian acronym for Siberian Circular Photon Source) – fourth-generation light source under construction in Novosibirsk. Natural emittance (at zero beam current and absent betatron coupling) of the SKIF is 72 pm at 3 GeV beam energy and 476 m circumference. Only two families of sextupoles provide horizontal and vertical dynamic apertures of 12 mm and 3.5 mm, respectively, and energy acceptance more than 5%. The flexibility of the lattice allows the beta functions to be changed in center of straight sections in a wide range from 0.5 m to 16 m, which opens up additional experimental possibilities for users. The paper presents status of development the SKIF project.

THE ACCELERATION COMPLEX

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Photon Source "SKIF" is a cutting-edge fourth-generation synchrotron radiation (SR) facility currently under construction in the science city of Koltsovo, Novosibirsk Oblast. The SKIF accelerator complex consists of a 200 MeV linear electron accelerator, an intermediate booster synchrotron, and a 3 GeV storage ring with a 476-meter circumference (Fig. 1). The storage ring is designed to achieve a "natural" horizontal emittance of 72.7 pm (without insertion devices, at zero beam current, and with no betatron oscillation coupling) [1].

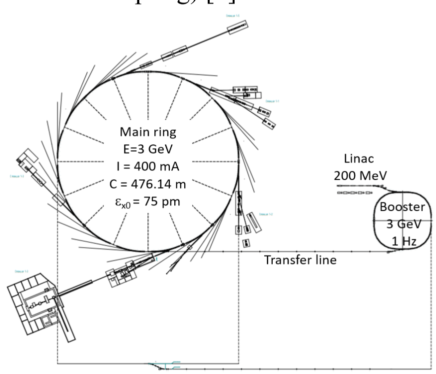

Figure 1: Scheme of acceleration complex SKIF.

THE LINAC 200 MeV

The Budker Institute of Nuclear Physics (BINP SB RAS) has developed a 3 GHz, 50 MW high-frequency klystron (Fig. 2).

Figure 2: Klystron produced by BINP.

At the SKIF injection complex, a grid-controlled thermionic RF gun was implemented. Its functionality and ability to achieve the required parameters were confirmed through experiments measuring the beam's key characteristics after formation and acceleration in the RF gun. In December 2023, the linear accelerator was launched. All declared specifications were confirmed [2,3]. The image of the beam on the streak camera at the end of the linac is shown in the Fig. 3.

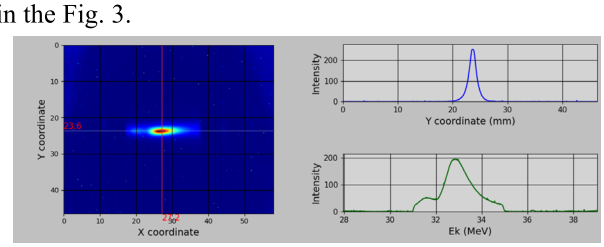

Figure 3: Image of the beam on streak camera at end of the linac.

THE BOOSTER

The booster synchrotron represents (Fig. 4) a critical acceleration stage in the SKIF facility's injection chain, bridging the gap between the 200 MeV linear accelerator and the 3 GeV storage ring. This sophisticated machine has been meticulously designed to fulfil several essential functions, including efficient beam acceleration, emittance control, and stable beam transfer to the main storage ring.

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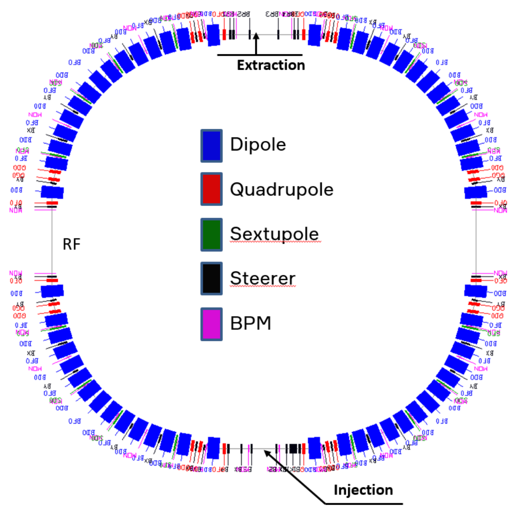

Figure 4: Booster magnet system scheme.

The machine employs a modified FODO lattice configuration comprising 28 periodic cells organized into four superperiods. This carefully optimized structure features combined-function magnets that simultaneously provide bending, strong focusing, and chromaticity correction. The lattice achieves excellent beam dynamics characteristics, with maximum horizontal and vertical β-functions of 9 m and 25.7 m respectively.

THE MAIN RING

The magnetic lattice of the SKIF light source is based on a modified Minimum Theoretical Emittance (mTME) [4] cell (Fig. 5), incorporating several key innovations to achieve low emittance, improved beam dynamics, and enhanced SR performance. First, horizontal shifting of focusing quadrupoles created a reverse bend that improves dispersion matching and enables emittance control and adjusting the horizontal damping partition number J_x. Second, careful optimization of magnet strengths and positions enhanced dynamic aperture while maintaining low emittance and manageable chromaticity.

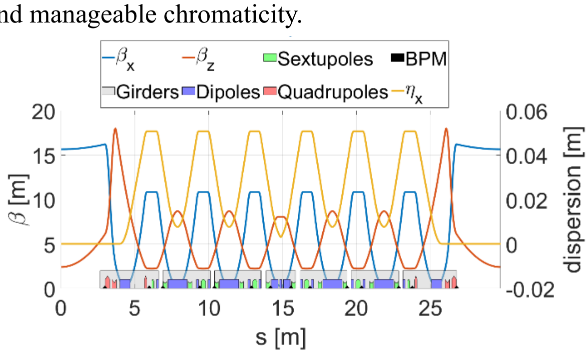

Figure 5: Optical functions of SKIF super period (1=16th of the ring), beginning and ending at the center of the straight section.

Chromatic correction is achieved through a combination of two sextupole families, with their positions optimized for dynamic aperture. The parameters of the main ring are shown in Table 1.

Table 1: The Main Ring Parameters

Parameter	Value
Circumference	476.14 m
α	$0.76\cdot10^{-4}$
Emittance	73 pm
Energy spread	$1.03\cdot10^{-3}$
Energy loss	536 keV
Betatron tune (x/y)	50.806 / 18.84
Natural chromaticity (x/y)	-149 / -55
Harmonic number	567
RF frequency	357 MHz
Dumping partition number (x/y/s)	1.94 / 1 /1.06
Dumping time (x/y/s)	9.2/17.7/16.7 ms

At the moment, the assembly of the main ring girders is underway (Fig. 6). The commissioning of the main storage ring is planned for December 2025.


Figure 6: Girders of main ring.

CONCLUSION

At the moment, the SKIF project is at the final stage of its implementation. The linear accelerator and booster synchrotron have been successfully commissioned. The magnet elements are being exhibited on the girders and prepared for installation in the storage tunnel.

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