The effect of ground motion on the SKIF beam orbit

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Introduction

The Resource Sharing Centre «The Siberian Circular Photon Source» ("SKIF") is a fourth-generation synchrotron radiation (SR) source currently under construction in Novosibirsk. "SKIF" will require unprecedented orbit stability because the effect of seismic noise might become a relevant source of brightness loss, several studies have been conducted to characterize the actual ground motion in the area of the construction site of the "SKIF". This work summarizes the observations made on the "SKIF" area and uses this data to estimates of the impact of vibrations on the closed orbit at the radiation output points.

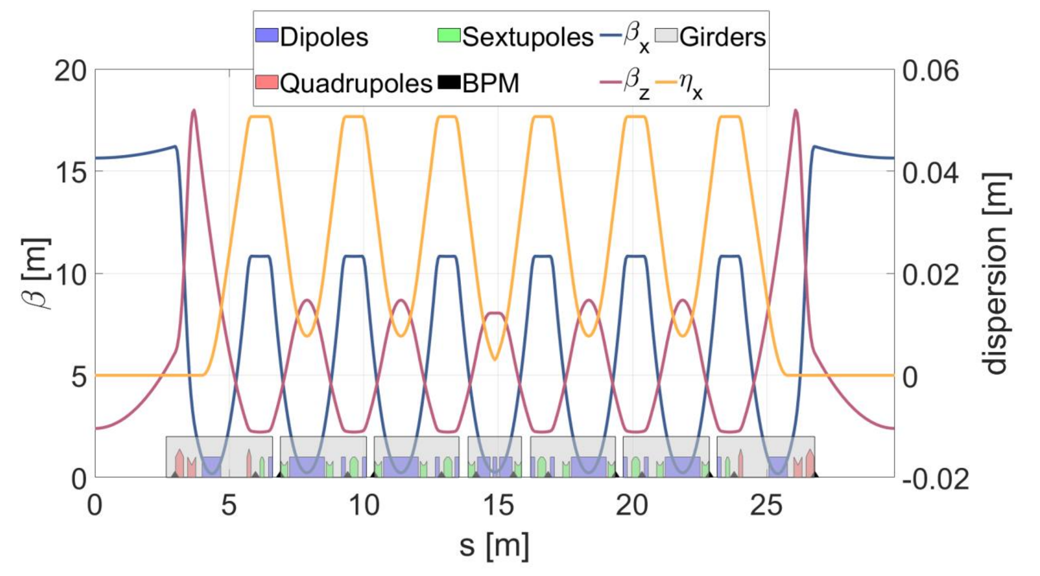


Figure 1: Optical functions for one super-period of the SKIF storage ring lattice.

Objectives

For emittance coupling between vertical and horizontal:

$\varepsilon_y/\varepsilon_x = 10\%$

Stability requirements: $\Delta\sigma = 0.1 \times \sigma \rightarrow$

$\Delta\sigma_x < 3.37\ \mu m$
$\Delta\sigma_y < 0.42\ \mu m$

Slab design

Storage ring lattice design

$\Delta x(\Delta y) = x_{ground} * K_{slab} * K_{girders} * f_{damping} * K_{str} * f_{FOFB} < 0.1\ \sigma_x(\sigma_y)$

Ground vibration

Girder design

≈ 1.1

FOFB

Ground vibration measurements

Table 1. Classification of seismic events on the SKIF site.

	per day	f, Hz	t, sec.	PGD, μm	RMS, nm
earthquakes	0.3	5–20	15–200	3–9	500
industrial explosions	1.6	5–20	15–25	1–3	500
railway	100	3–8	200	1–3	100–300
auto transport	2500	5–30	10–30	≤1	60–200
industrial segment	-	20–50	-	-	-
noise (day/night)	-	2–100	-	0.15/0.02	35/5

Slab vs ground measurements

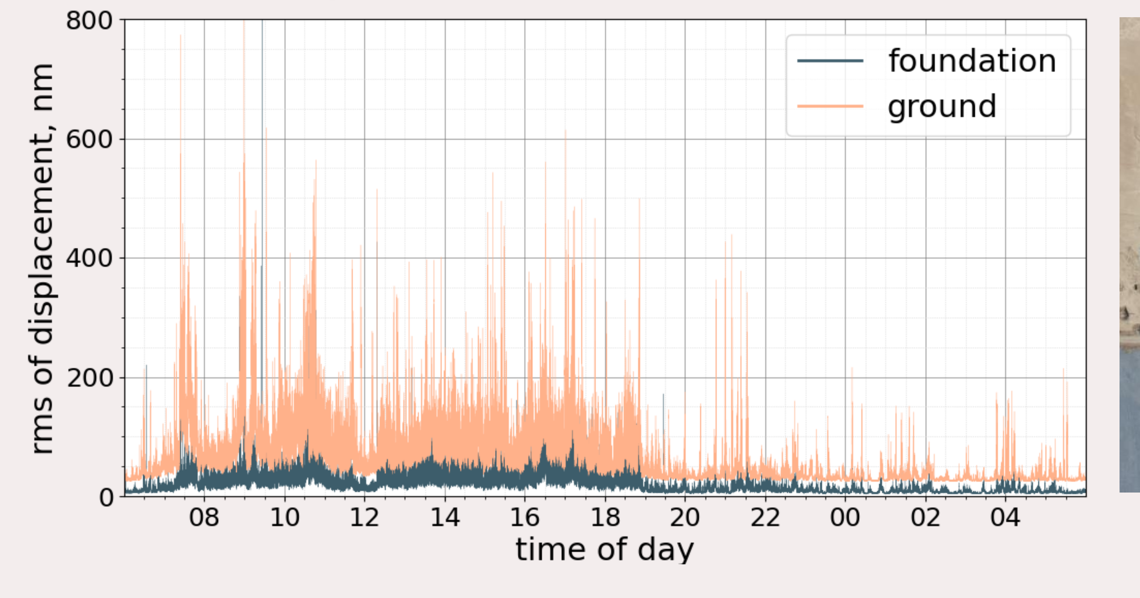
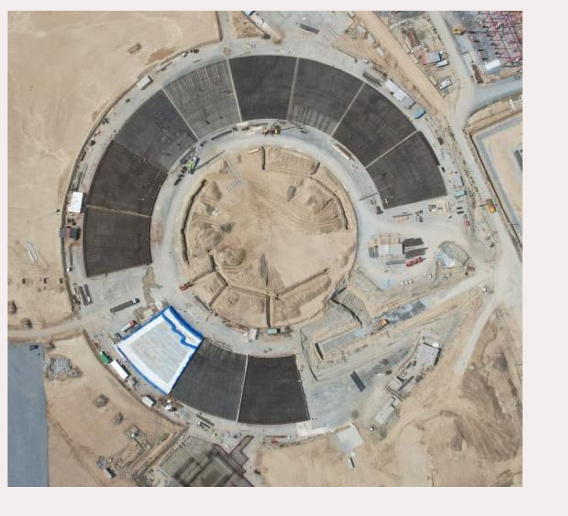


Figure 2: Results of measurements depending on time of day



Slab of the storage ring

Storage ring lattice design

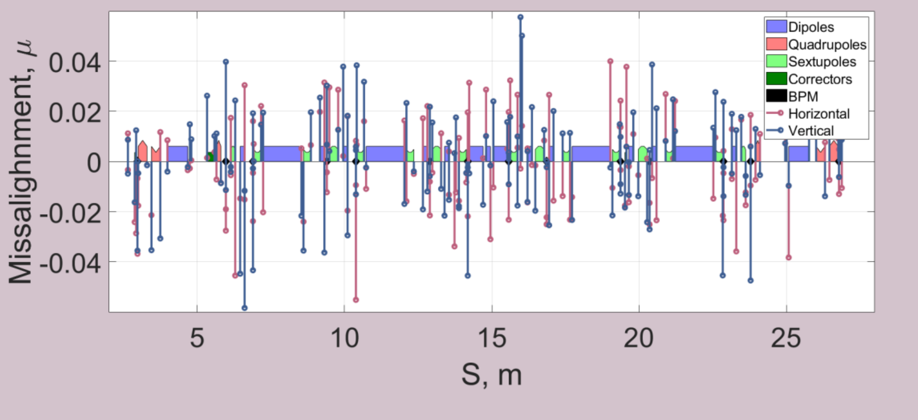


Figure 3: Distribution of misalignments along the ring.

Table 2. Transmission factors for dipoles, quadrupoles and sextupoles at an rms magnet displacement of 100 nm

	M_{dip}	M_{quad}	M_{sext}	M_{Σ}
x	12	113	4.2×10^{-4}	113
y	28	45	2.2×10^{-4}	55

Fast orbit feedback

All fast correctors horizontal and vertical. Correction for two BPM around insertion devices.

Three-dimensional model of fast two-coordinate corrector with a vacuum chamber.

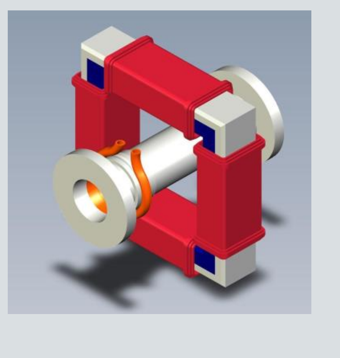


Table 3. Fast corrector requirements

Number of correctors	48
Maximum field	±10 Гс
Maximum winding current	2.8 A
Effective length	10 см
Overall length with windings	12 см
Maximum frequency	1000 Гц

Misalignment distribution was Gaussian with σ = 100 nm and a cut at 3σ.

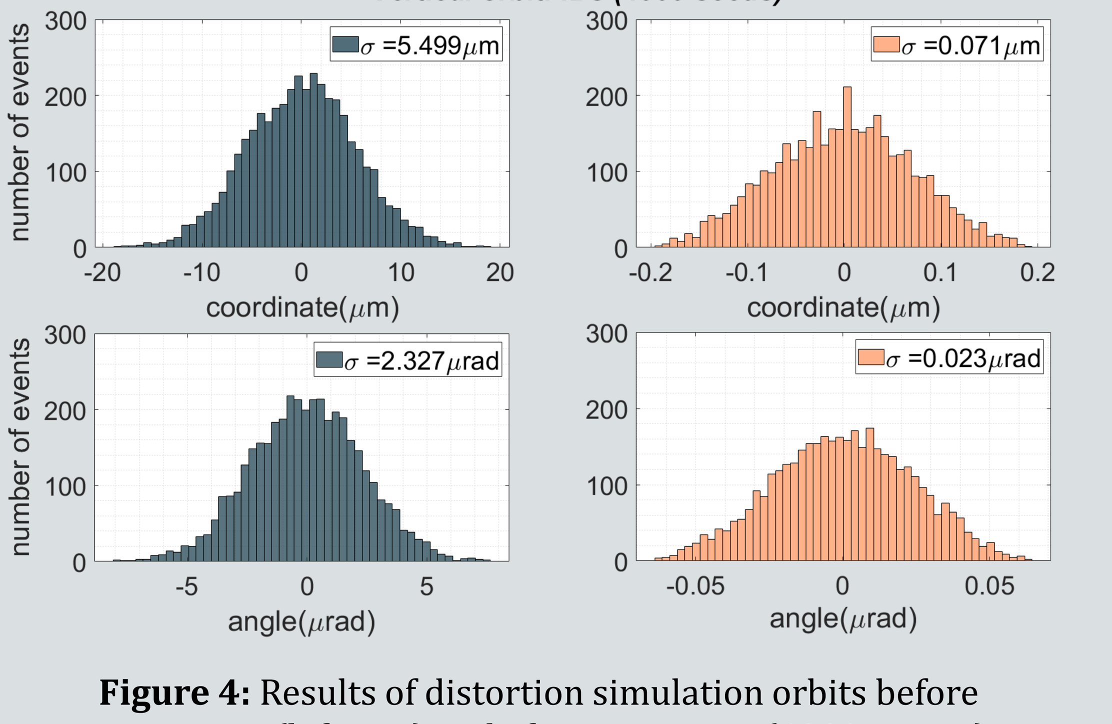


Figure 4: Results of distortion simulation orbits before correction (left row) and after correction (4000 events)

Conclusion

An analysis of the influence of seismic vibrations was carried out based on measurement data by two independent organizations at the SKIF Center for Collective Use. Numerical modeling has shown that the measured level of seismic vibrations at the accelerator site can have a significant impact on the deviation of the closed orbit of the electron beam, exceeding the requirements of SR users for beam stability. To maintain beam stability, the location of the correctors of the fast feedback system is considered, their parameters are estimated, and a magnet design is proposed.

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