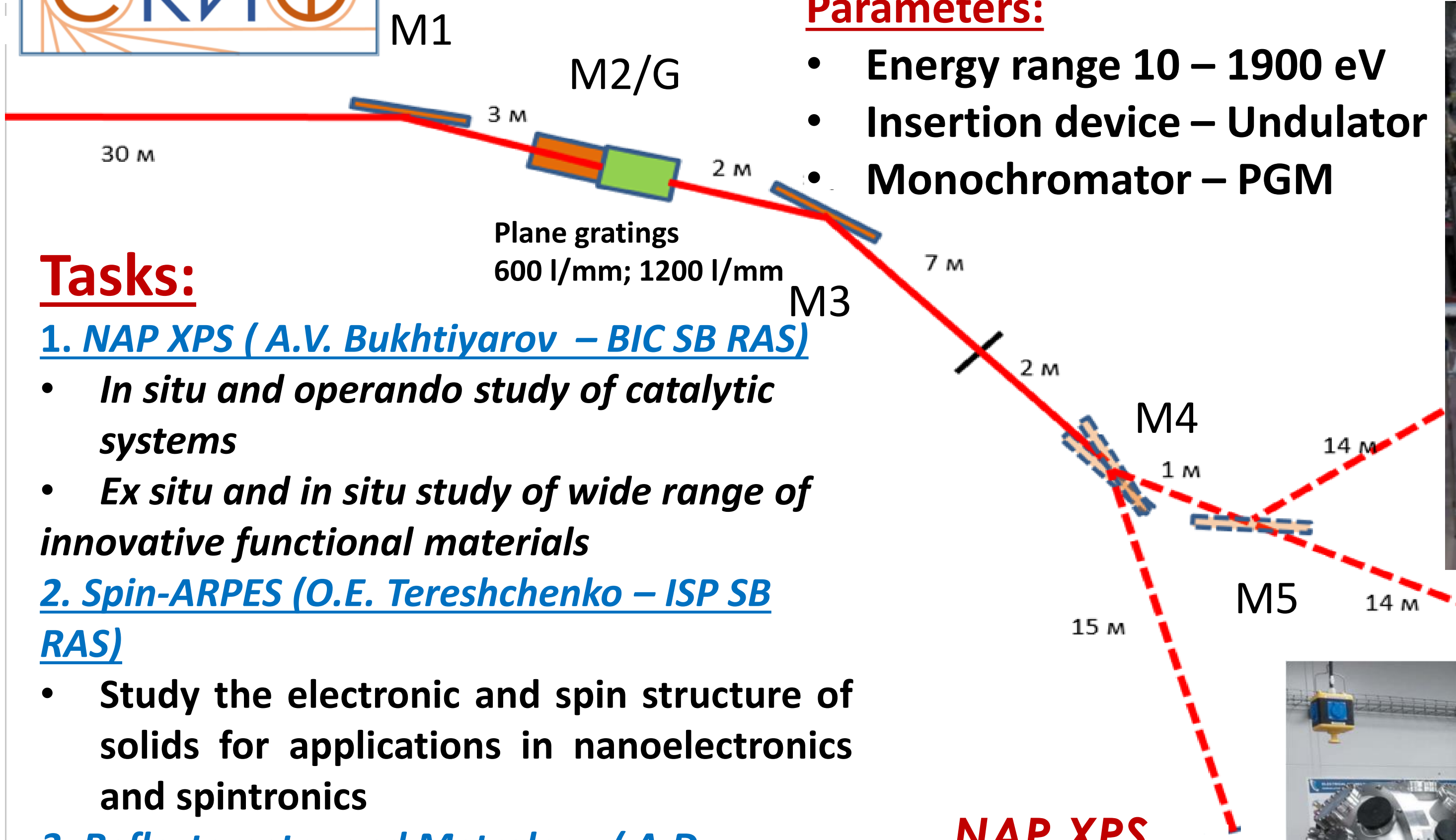
Project of the optical scheme for the soft X-ray & VUV beamline at SKIF synchrotron facility

The "electronic structure" is modern beamline for methods using the VUV and soft X-rays (10–2000 eV) on the 3 GeV ring at the SKIF synchrotron facility. The collimated PGM scheme based on a modified SX-700 monochromator is used. During monochromatization and transportation from the frontend to the sample, the SR beam passes through five reflective elements, including a plane deflecting mirror and a plane diffraction grating. The remaining three mirrors have a curved shape, and two of them are interchangeable in order to change the beam path for transportation to one of the end-stations. To reduce the contribution of high diffraction orders, it is planned to additionally use a four-mirror high orders suppression system.

“Electronic Structure” beamline 1-6



Parameters:

- Energy range 10 – 1900 eV
- Insertion device – Undulator
- Monochromator – PGM

Tasks:

1. NAP XPS (A.V. Bukhtiyarov – BIC SB RAS)

- *In situ and operando study of catalytic systems*
- *Ex situ and in situ study of wide range of innovative functional materials*

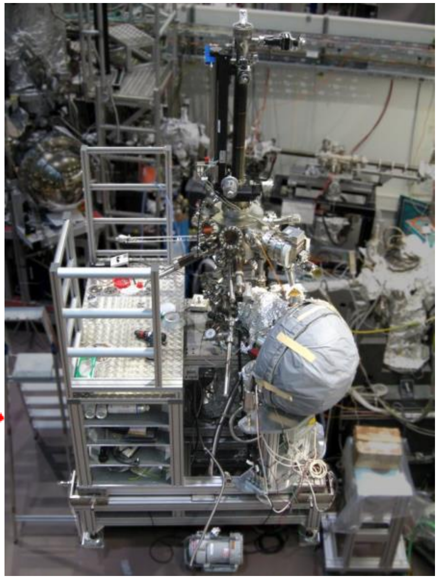
2. Spin-ARPES (O.E. Tereshchenko – ISP SB RAS)

- Study the electronic and spin structure of solids for applications in nanoelectronics and spintronics

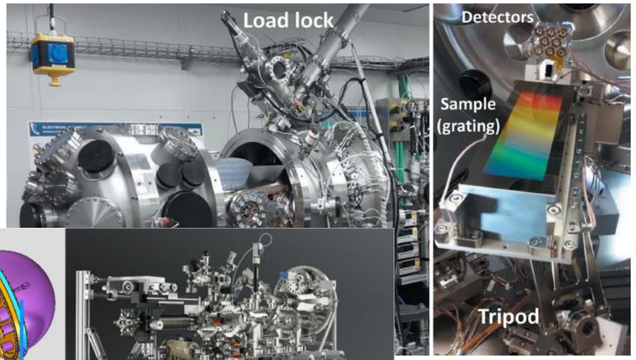
3. Reflectometry and Metrology (A.D. Nikolenko – Budker INP SB RAS)

- certification of spectral optical elements, focusing elements and X-ray detectors
- reference detector method for absolute calibration of the spectral sensitivity of various kinds of X-ray radiation receivers in the VUV and Soft X-Rays ranges

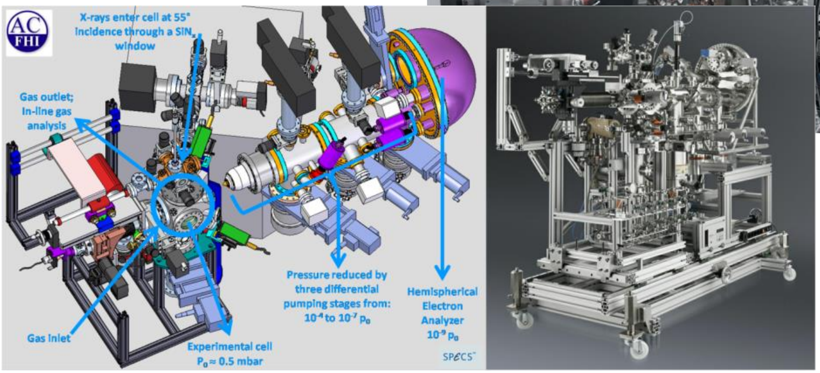
Spin-ARPES



Reflectometer

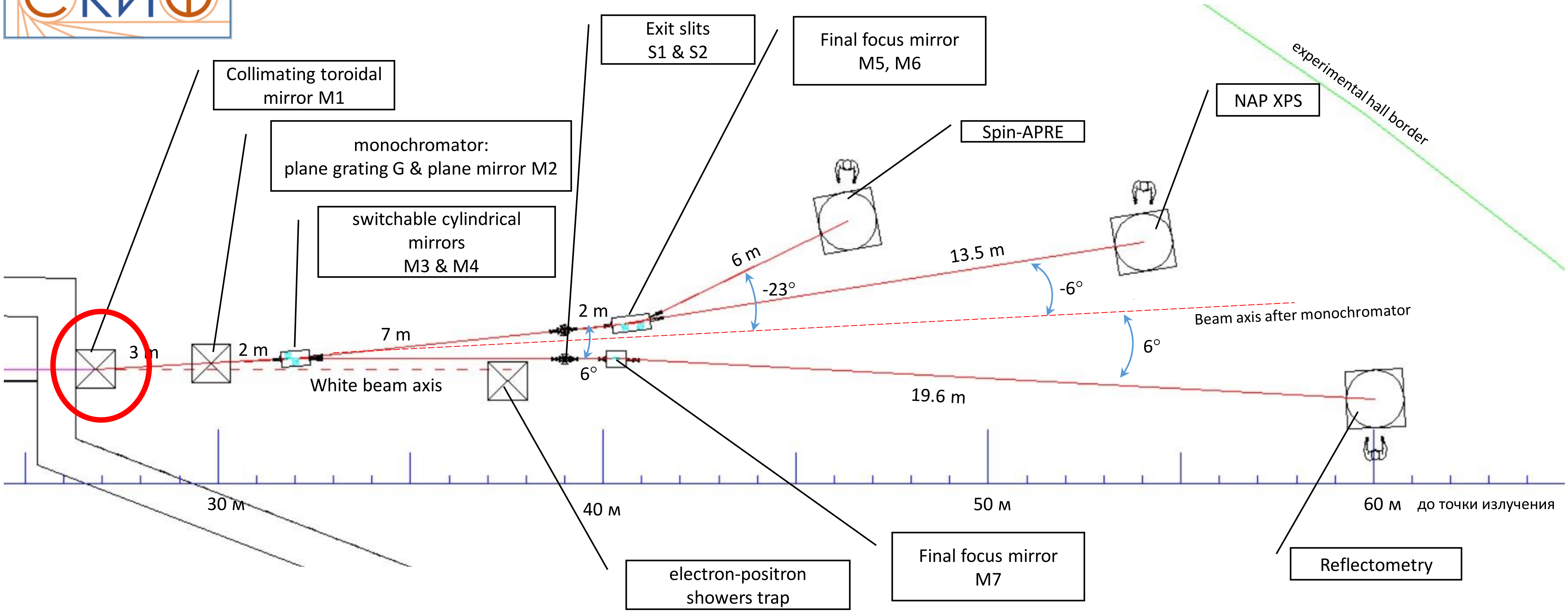


NAP XPS



СКИФ

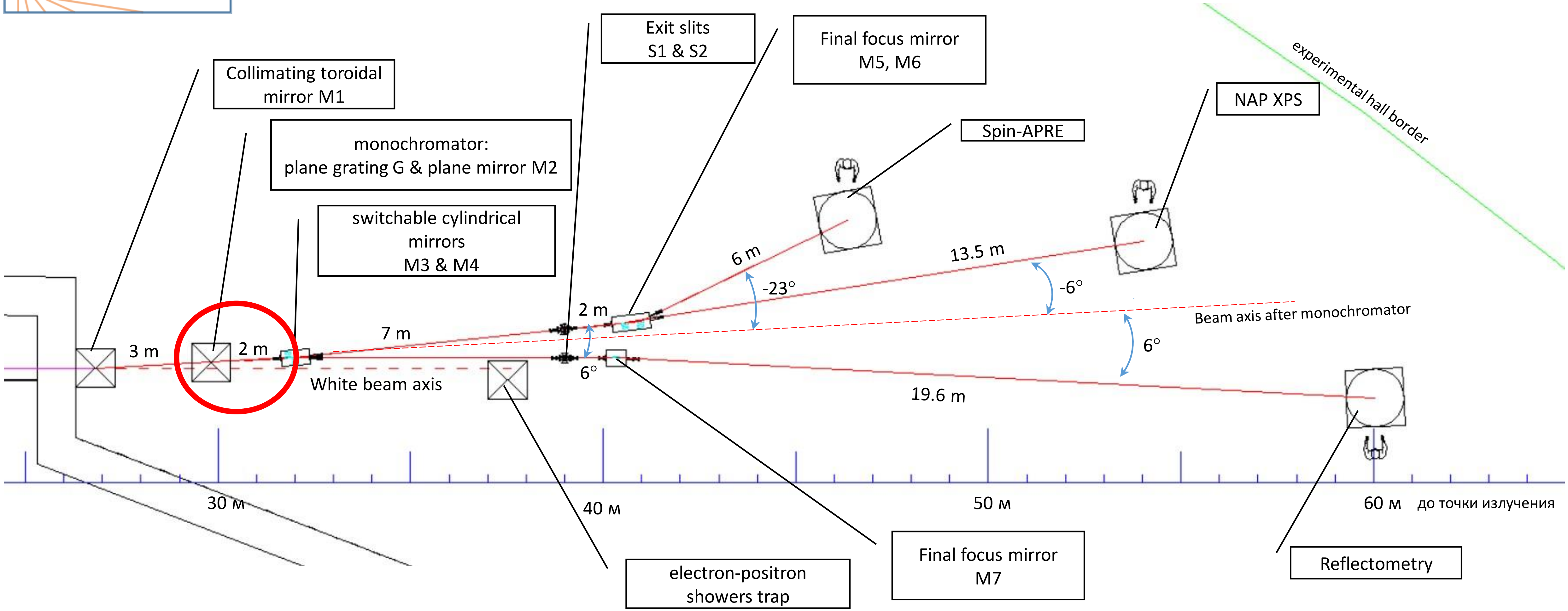
Layout of beamline: Mirror M1



A collimating toroidal mirror. Installed immediately after the drive biosecurity wall (27 m from the radiation point). Focuses the beam horizontally on the slit (the distance from the mirror to the slit is 12 m). In the vertical direction it turns a diverging beam into a parallel beam for the collimated PG monochromator. The size of the working area of the mirror is 10 mm X 350 mm, therefore, the aperture of the captured beam is 6 X 10 mm2 (width X height)

BL 1-6 “Electronic Structure”

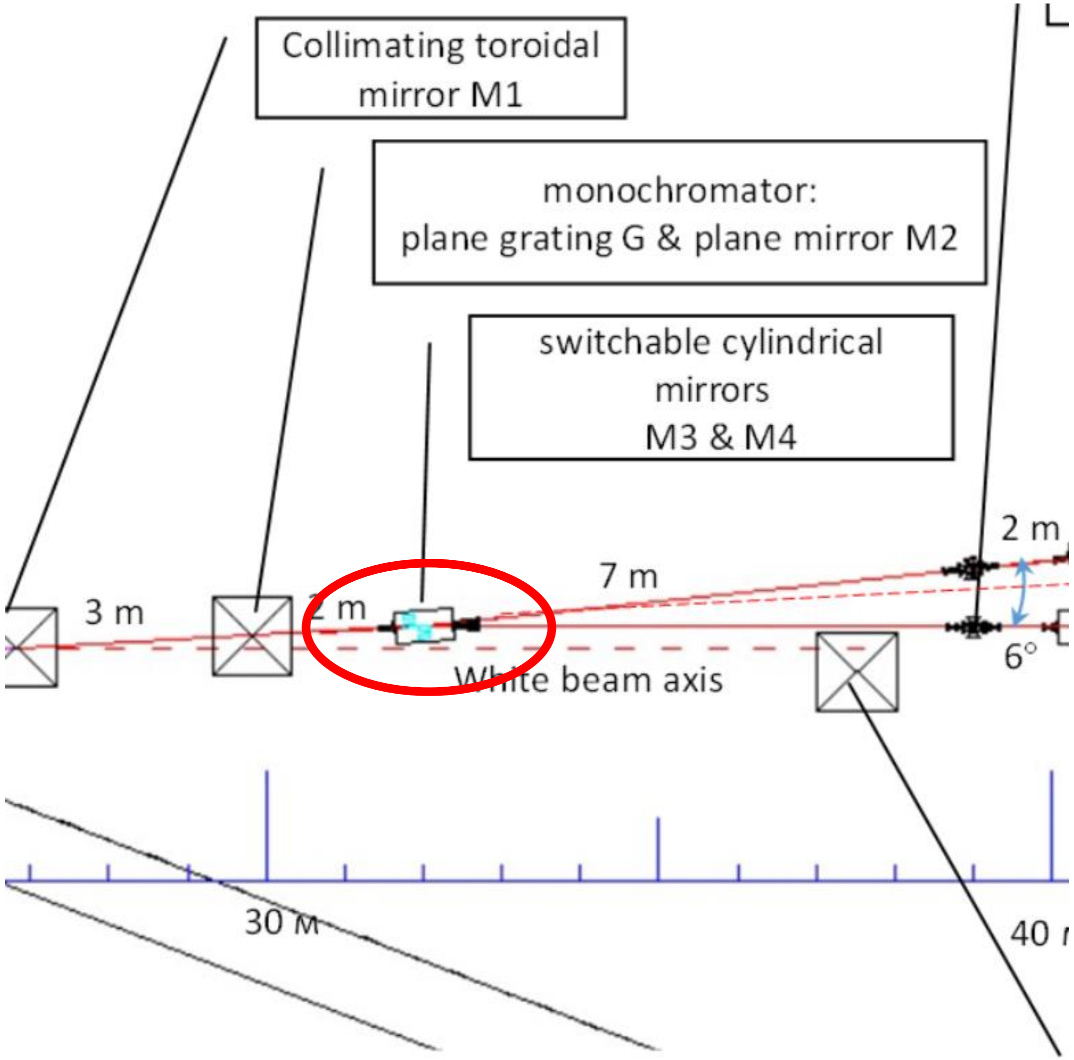
Layout of beamline: Monochromator



We use the so-called “collimated plane grating monochromator” optical scheme (cPGM). This ccheme is based on the classic scheme of the SX-700 monochromator developed at the BESSY. The difference from the classical scheme is the presence of a collimating mirror M1 that turns a diverging beam to the parallel beam.

BL 1-6 “Electronic Structure”

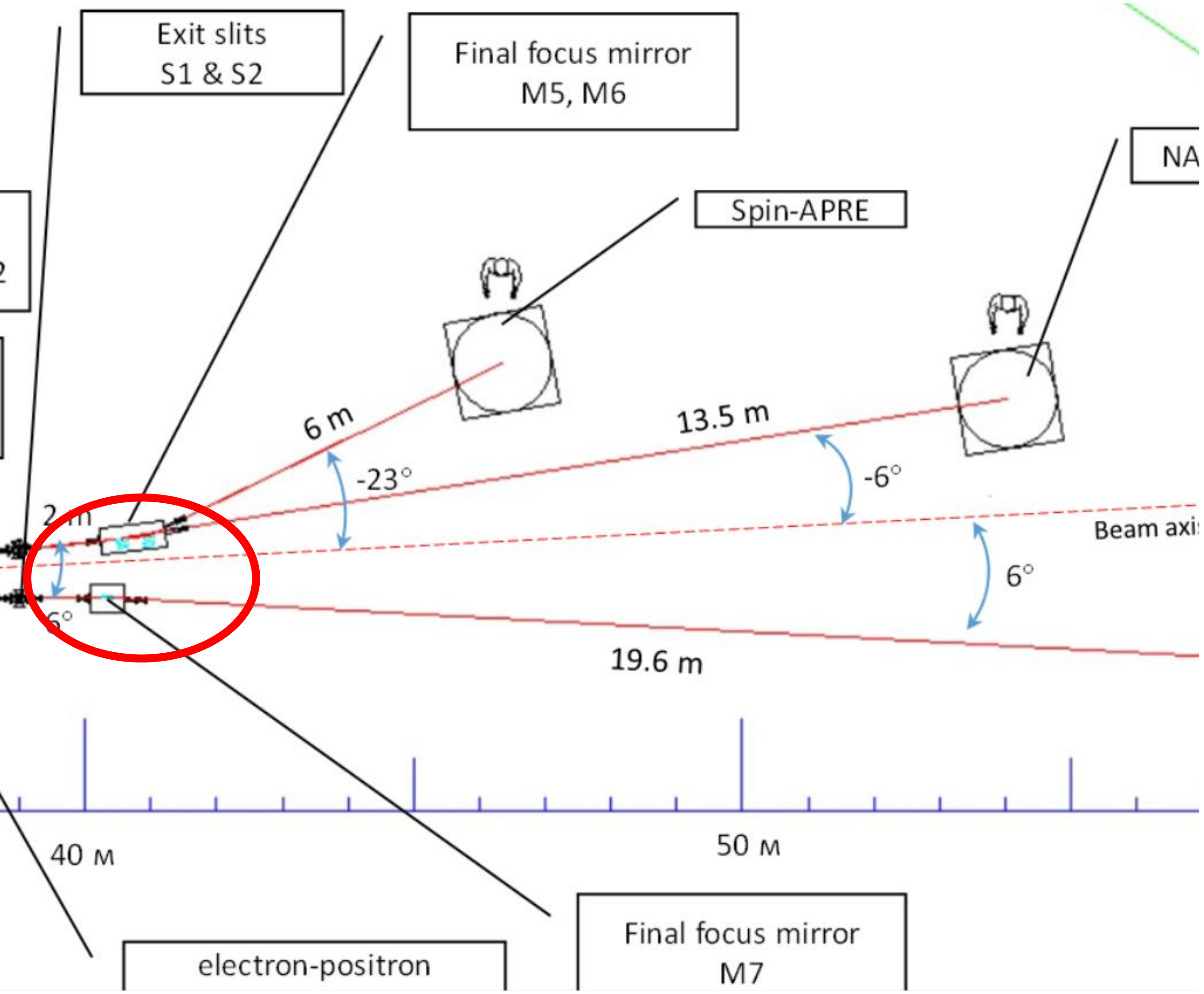
Layout of beamline: Mirror M3 & M4



Two identical cylindrical mirrors focus the beam after the grating onto the exit slits of the monochromator S1 or S2 (distance 7 m). Mirrors are introduced into the beam alternately, installed at angles of +1.5° and –1.5°, deflect the beam by an angle of ± 3° for in order to direct the beam to one of the three stations: "Metrology", Spin-ARPES or NAP XPS.

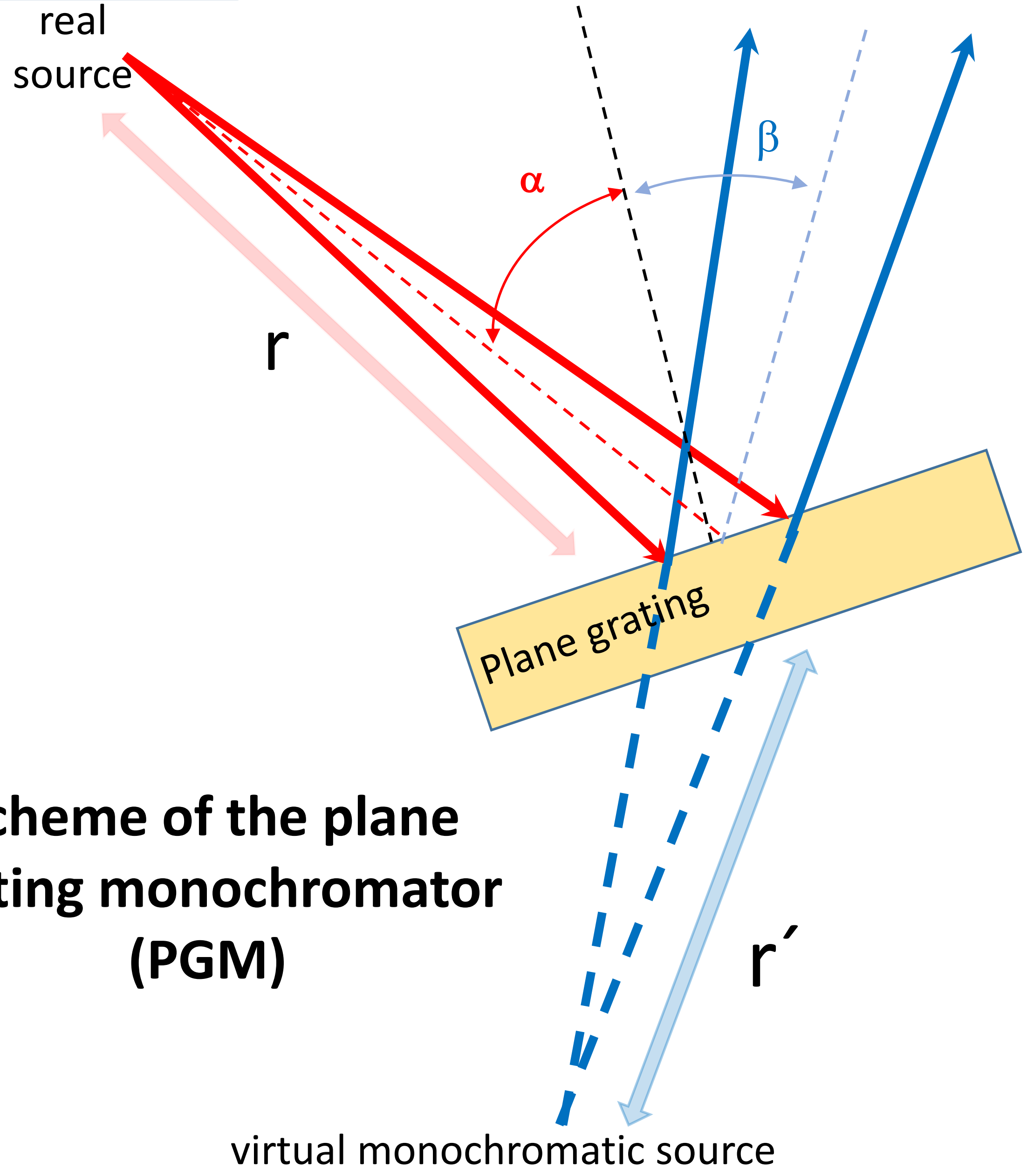
R = 0.366 m,
Optical size 120x40 mm.

Layout of beamline 1-6: Mirror M5, M6, M7



Toroidal mirrors of the final focus. Replaceable optical element. One of the three mirrors of the final focus is introduced into the beam, which are installed to the beam at angles of + 1.5�, -1.5°, + 10 °, providing beam turn at the angles of + 3 °, -3 ° and + 20 ° and focuses the beam in both coordinates at distances of 19.6 m, 13.5 m and 6 m, respectively. Mirrors M5 and M6 are installed one after another at a distance of 500 mm from each other in the same volume, mirror M7 - in its own volume on the lower branch of the beamline.

cPGM Monochromator



Scheme of the plane grating monochromator (PGM)

As is known, in the case of beam diffraction from a point source, a plane diffraction grating is a defocusing element, and the distance to the virtual monochromatic source r´ obeys the rule

$$r' = -r \cdot \frac{cos^2\beta}{cos^2\alpha}$$

$$c_{ff} = \cos\beta / \cos\alpha$$

where r is the distance to the real source, α and β are the angles of incidence on the grating and diffraction, respectively. The cff ratio is called "fix-focus constant."

If the cff value remains constant during scanning over the spectrum, the distance to the virtual monochromatic radiation source remains unchanged, and the monochromatized radiation can be focused by a stationary optical element with unchanged parameters. The cff value is selected based on considerations of a compromise between the reflection coefficients and the intensity of high orders. For the SX-700* type monochromator, cff = 2.25 is selected.

* Cinthia Piamonteze at. al. J. Synchrotron Rad. (2012). 19, 661–674

cPGM Monochromator

In the proposed optical scheme, the distance to a real source, due to the use of a collimating mirror, actually becomes infinite and the value of the constant cff loses its meaning as a rule of constant focusing. However, this constant is conveniently used to control the suppression of high orders: for cff = 2.25, high orders are suppressed much worse than for cff = 1.4.

However, in the second case, the reflection decreases significantly and, since one has to work in a region closer to the zero order, the background illumination increases significantly. Thus, the selection of the cff value remains a convenient tool for choosing the operating mode of the monochromator.