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The synchrotron radiation beamline 8-b at VEPP-4 collider for SAXS, WAXS and micro tomography investigation of fast processes at extreme condition of high temperature and pressure with nanosecond time resolution

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Abstract

The main purpose of the beamline design – realization of experiments using explosive charges up to 200 grams of TNT equivalent. To achieve this goal is necessary to use a of hard range of photons in the region of 30-60 keV. Additional requirement - the development of a powerful explosion chamber, and very fast one coordinate detector DIMEX. The fist detonation experiments was made with explosive 40 mm diameter. Test WAXS experiments was made and time resolution of 73 ps was received. SAXS/WAXS experiments was made at accelerators complex VEPP-3/VEPP-4.

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Keywords: synchrotron radiation, SAXS, WAXS, detonation, shock wave, nanodiamond, high pressure, high temperature, time resolved, nanosecond, picosecond, TNT, BTF, RDX

Introduction

The 8-b beamline uses radiation of 7-pole wiggler (five main poles with the field of 1.3 T and the two side, with

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half the field), is aimed for the study of fast processes taking place in the detonation wave and under the shock wave impact. The main purpose of the beamline design – realization of experiments using explosive charges up to 200 grams of TNT equivalent. To achieve this goal it is necessary to use a hard range of photons in the region of 30-60 keV. Additional requirements - the development of a powerful explosion chamber, and very fast one coordinate detector DIMEX (Aulchenko, 2010).

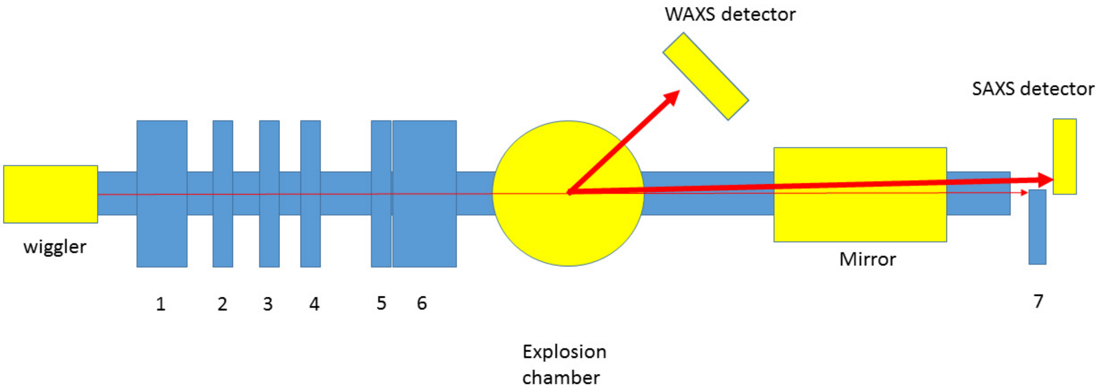

Fig. 1. The scheme of The synchrotron radiation beamline 8-b at VEPP-4 collider for SAXS, WAXS and micro tomography investigation of fast processes at extreme condition of high temperature and pressure with nanosecond time resolution. 1 – X-ray optics unit, 2 – CCD beam position monitor, 3 – position sensitive ionization chamber, 4 - horizontal slit, 5 – fast acting shutter, 6 – Kratky collimator, 7 – beam stop.

Another goal of this project was to obtain high temporal resolution -an exposure time of 0.1 ns with a 600 ns interval and a number of shots of 32 was attained at the station for research on shock-wave processes.

Beamline consists of the following main elements: 1 – X-ray optics unit, 2 – CCD beam position monitor, 3 – position sensitive ionization chamber, 4 - horizontal slit, 5 – fast acting shutter, 6 – Kratky collimator, 7 – beam stop.

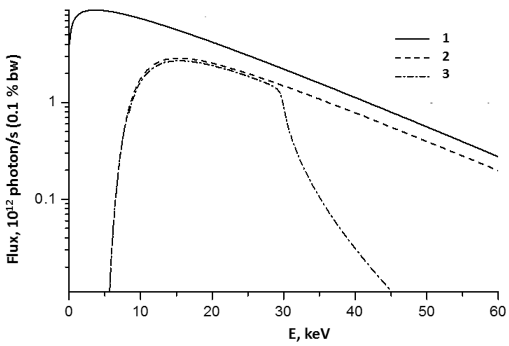

Fig. 2. Spectrum of SR (20 mA, 4 GeV electron energy, the main pole wiggler field 1.3 T, the critical energy of 13.8 keV): (1) from the source, (2) after the Be-foil, (3) after the mirror with nickel plating (angle 2 mrad).

1. Wiggler

The source of synchrotron radiation for the beamline is the seven-pole wiggler, where two side poles have approximately half the field, and five main poles are in the region of maximum field of 1.3 Tesla.

The emission spectrum of the wiggler for the field 1.3 T, energy of the electrons is equal to 4 GeV, and the current drive of 20 mA, is shown in Fig. 2 for the horizontal angle 1 mrad (by integral vertical angle). Also it shows the spectrum after Be foils of front end (total thickness of 12 mm), and after the mirror (nickel plated angled 2 mrad beam SR).