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The development of the multichannel recording system for short-time processes investigations on SR beams with the application of solid-state detectors

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Abstract

The structure of the new version of the recording system for investigations of short-time processes on SR beams is developed and its construction is launched.

In addition, the schemes of experiments with the improved time resolution and with the enhanced time of medium compression for ultradisperse diamonds yield investigations are suggested.

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1. Introduction

The application of intense synchrotron radiation (SR) beams is the basis of a number of perspective high-time resolution methods of shock-wave and detonation processes investigations [1]—first of all, shadow radiography and small-angle X-ray scattering (SAXS) methods.

In order to provide the conduction of such investigations and for study of real experiment recording conditions, and also to check the correctness of a number of technical solutions, the 12-channel CAMAC-prototype of the recording system was previously developed [2]. The prototype was tested both in various experimental conditions (shadow radiography, SAXS) and with different detector types. The effective noise reduction was provided by combination of analog shaping filters and digital correlated double sampling algorithm. The measured electric noise of the system (rms) was equivalent from 1.5 of

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10 keV X-ray quanta (dynamic range of 70, SAXS) to 15 quanta (dynamic range of 2000, shadow radiography); the maximum duration of the recorded process was 4 ms (4 MHz recording rate).

Though the achieved parameters met the experimental demands, a number of drawbacks, such as the complexity of sensitivity attenuation and the limited possibility of the number of channels growth were revealed. Moreover, in the case of microstrip detector application to simultaneous shadow image and SAXS observations, an interference in the recording channels of the latter occurred. All these made the development of the new improved version of the system necessary.

2. The system under development

A new short-time processes recording system is also a CAMAC-prototype differing from the previous version by wider functional possibilities, new signal processing algorithms and larger capability of increase of number of channels.

The developed system includes the detector block placed in the radiation-isolated (experimental) hatch and the modules deposited in a CAMAC-crate: a number of special-purpose 12-channel analog-to-digital converters (ADCs), a synchronization unit, a fast electromagnetic shutter control unit and a block of "floated" voltage source.

The detector block (designed individually for a given detector) contains a detector and a number of low-noise pre-amplifiers set into the connectors of the block cross-board. The signals from the detector sensitive elements pass to the amplifiers and then—via coaxial cables—to the special-purpose ADC modules. In order to provide voltage supply of the pre-amplifiers and the bias voltage for the detector, the block of special-purpose "floated" voltage sources is used.

A cardinal new element of the system under development is a 12-channel ADC module. The structure of a single channel of this module is shown in Fig. 1A. Each channel includes an input programmable-gain amplifier (PGA0) (with the switchable gain and capability of signal inversion), a correlated double sampling circuit (CDS0), a shaping filter SHAPER and an ADC itself.

The latter ones are represented by the chips of 3-channel 16-bit video-ADCs AD9826. The operating speed of these chips is high enough to provide 8 MHz signal recording that makes the conduction of the experiments in 2-bunch operation mode of VEPP-3 possible. The video-ADC input circuits contain built-in CDS and PGA. In combination with PGA0 amplifiers, this provides 60-fold sensitivity tuning range of each channel—and combined with CDS0 circuits—the effective reduction of low-frequency noise of detector (and pre-amplifier drifts) and slow-time constants.

The CDS0 circuits also perform "time gate" function letting only short signal pulses through and cutting off the high-frequency noise component in the pauses between.

The distinctive feature of the new recording channels is the application of shaping filters (low-pass filters) with the rectangle-approximating impulse response. Such a filter, built on a basis of active delay line, provides effective integration of short pulses but (in contrast to conventional integrator) does not require precise time synchronization. These shaping filters are supposed to suppress both some detector specific noise components [2] and element-to-element capacitive interference.

Constructively the 12-channel ADC module is supposed to be embodied in a 2 M CAMAC-module, enabling placing more than 100 recording channels in a single CAMAC-crate, if needed. Synchronization of the operation of all ADCs is supposed to be provided by a common synchronization unit and start of recording by the electromagnetic shutter control unit (simultaneously starting the blasting machine to initiate detonation).

3. Possible configurations of experiment

It is expected that wide functional and metrological possibilities of the new system will significantly improve the quality of shock-wave and detonation (including non-stationary) processes recording and, when using multi-spectrozonal