# Development of silicon microstrip detector with integrating readout for time-resolved studies in microsecond scale.

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## Abstract

First results from the tests of a new full-size prototype of a silicon microstrip detector with integrating readout for studies of material deformations under pulsed heat load are presented. The prototype includes the silicon microstrip sensor with 1024 30 mm long strips with 50 um pitch, half of which are connected to the inputs of analogue pipeline ASICs APC128. The readout electronics can integrate charge released in the sensor under synchrotron radiation within exposure time from 100 ns to tens microseconds. Spatial resolution measured at an energy of X-rays about 70 keV is close to 100 um (FWHM). Next steps of this development including the change of sensor material to GaAs and usage of the new ASIC DMXG64B for the readout electronics are discussed..

The new synchrotron radiation (SR) scattering station "Plasma" was constructed at VEPP-4M beamline eight for dynamical measurements of deformations of tungsten samples and stresses in them during pulsed heating and cooling after it. Main goal of this experimental program is the study of local stresses in a material of the wall of future tokamak facilities under pulsed plasma load. Basic structure of the experiment is shown in Fig. 1, photos of the beam line 8 and station "Plasma" are shown in Figs.2 and 3.

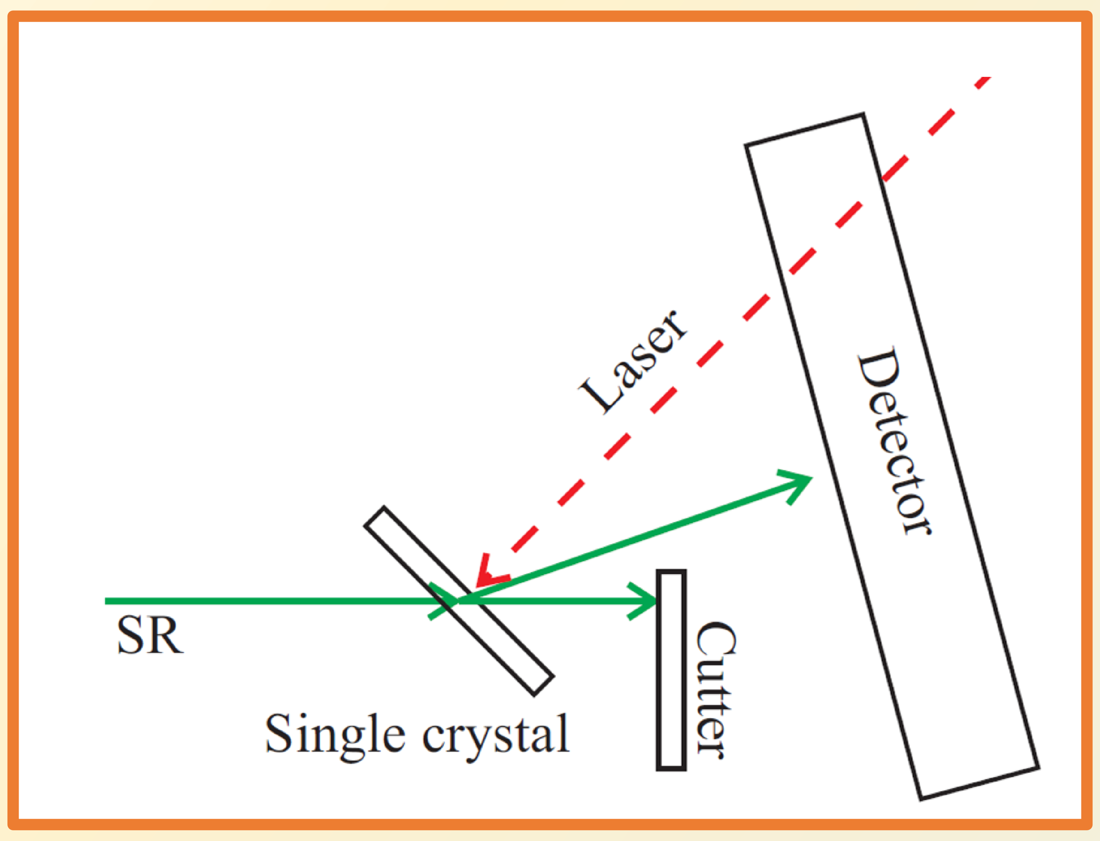


Fig.1. Schematic view of the layout of station "Plasma" for the dynamic diffraction experiments.

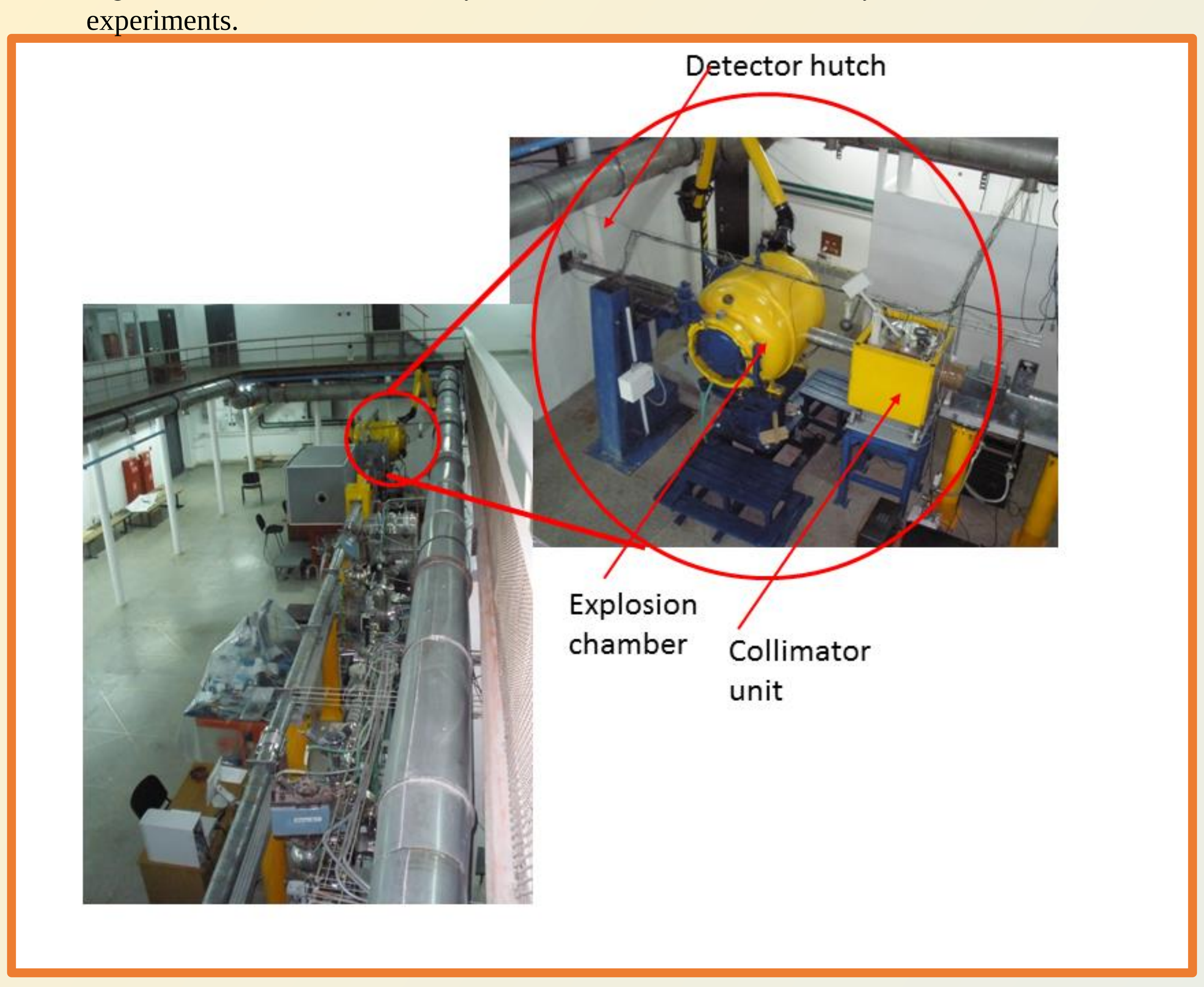


Fig.2. Photo of the beam line 8 at the VEPP-4M storage ring that has three stations, including station for the experiments for imaging of explosions and station "Plasma".

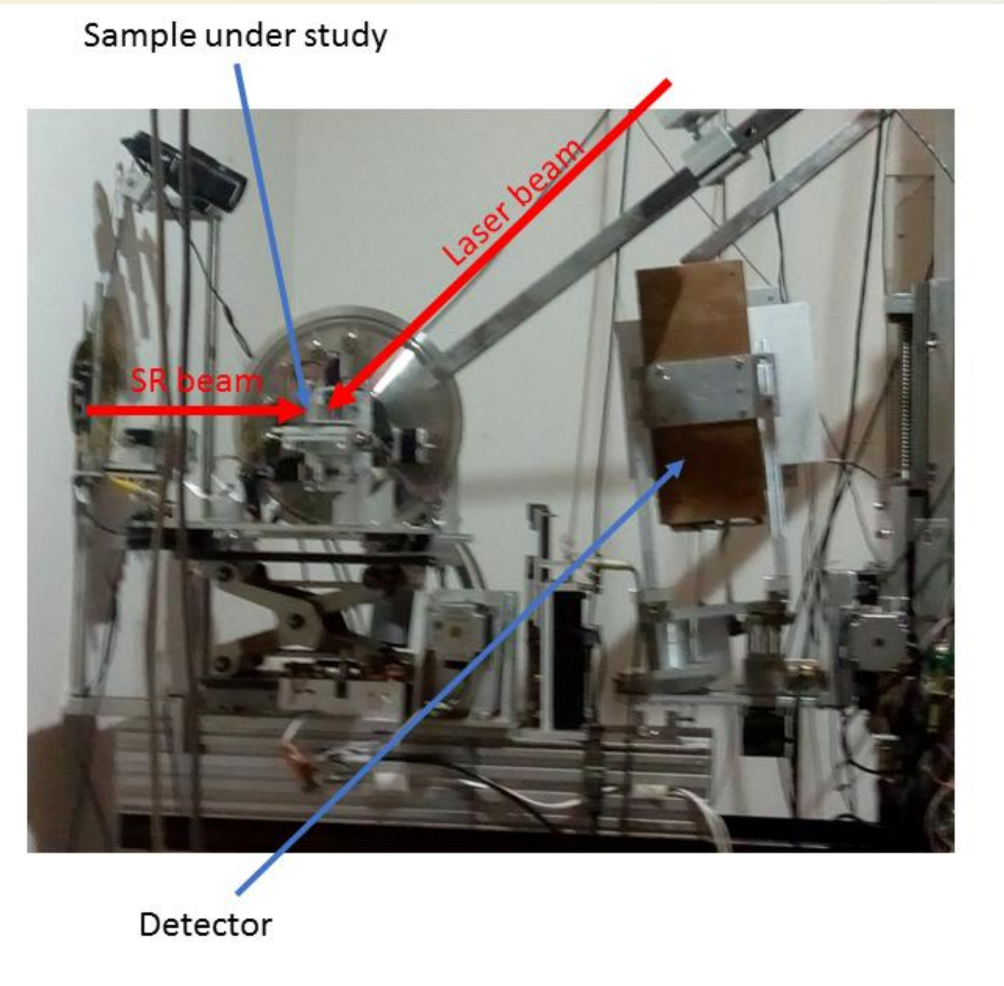


Fig.3. Photo of the station "Plasma" in the detector hutch of the beam line 8.

Polychromatic SR beam from 9-pole 2 Tesla wiggler installed at the VEPP-4M storage ring hit mosaic single-crystal tungsten sample installed at such angle that Laue reflection 110 with photon energy below the tungsten K edge (69.525 keV) fall on the detector. In the first experiments one-dimensional detector DIMEX-G was used to measure the dynamics of the diffraction peak shape.

DIMEX-G (Detector for IMaging of EXplosions, gaseous version) was developed for ultra-fast experiments with exploding samples at a SR beam. The detector has 512 channels at 0.1 mm pitch that can record signal at a frame rate of 10 MHz in 100 frames. DIMEX-G works in integrating mode and allows to register up to 2000 photons/channel/bunch with average energy of 20 keV in linear regime. Detective quantum efficiency at this energy is equal to ~40% and electronic noise is equivalent to about seven 20 keV photons.

DIMEX-G is not well adapted for the measurements of deformations of tungsten samples under pulsed heat load because of relatively low photon flux, 1-10 photons/bunch/channel and high energy of photons (~70 keV). Comparison of spatial resolution of DIMEX-G with the detector based on silicon microstrip sensor is shown in Fig.4. In order to improve signal-to-noise ratio and spatial resolution for 70 keV photons we developed a new detector prototype based on silicon microstrip sensor coupled to the electronics of the old version of DIMEX-G based on APC128 ASIC. The first measurements with small-size prototype demonstrated feasibility of such approach. In this poster the first experimental results from full-size Si detector prototype are presented.

Si sensor for this detector was produced by Hamamatsu Photonics Company. It contains 1024 p-on-n implants with aluminum strips on top. Metal strips are in contact with p-implants. Strip pitch is 50 μm and strip length is 30 mm. The Si sensor is 320 μm thick. Each second strip of the sensor is connected to an input of the APC128 ASIC. The ASIC contains 128 channels, with low-noise integrator and 32 analogue memory cells (Fig.6). The sensor connected to the front-end board with ASICs is put in the detector box and positioned at an angle of 5 degrees with respect to the beam in order to increase quantum efficiency.

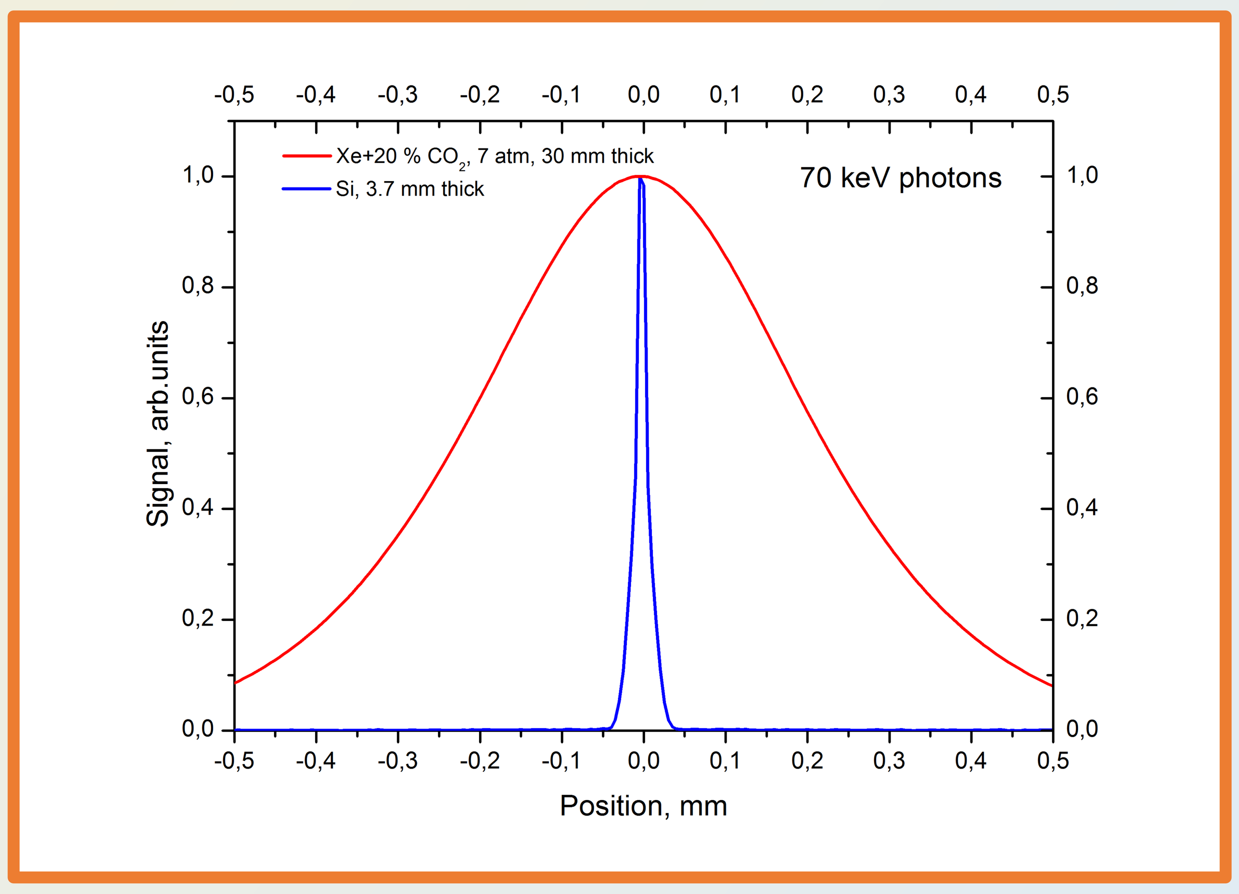


Fig.4. Comparison of Line spread functions of DIMEX-G (red) and Si-plasma prototype (blue) for 70 keV photons (simulation).

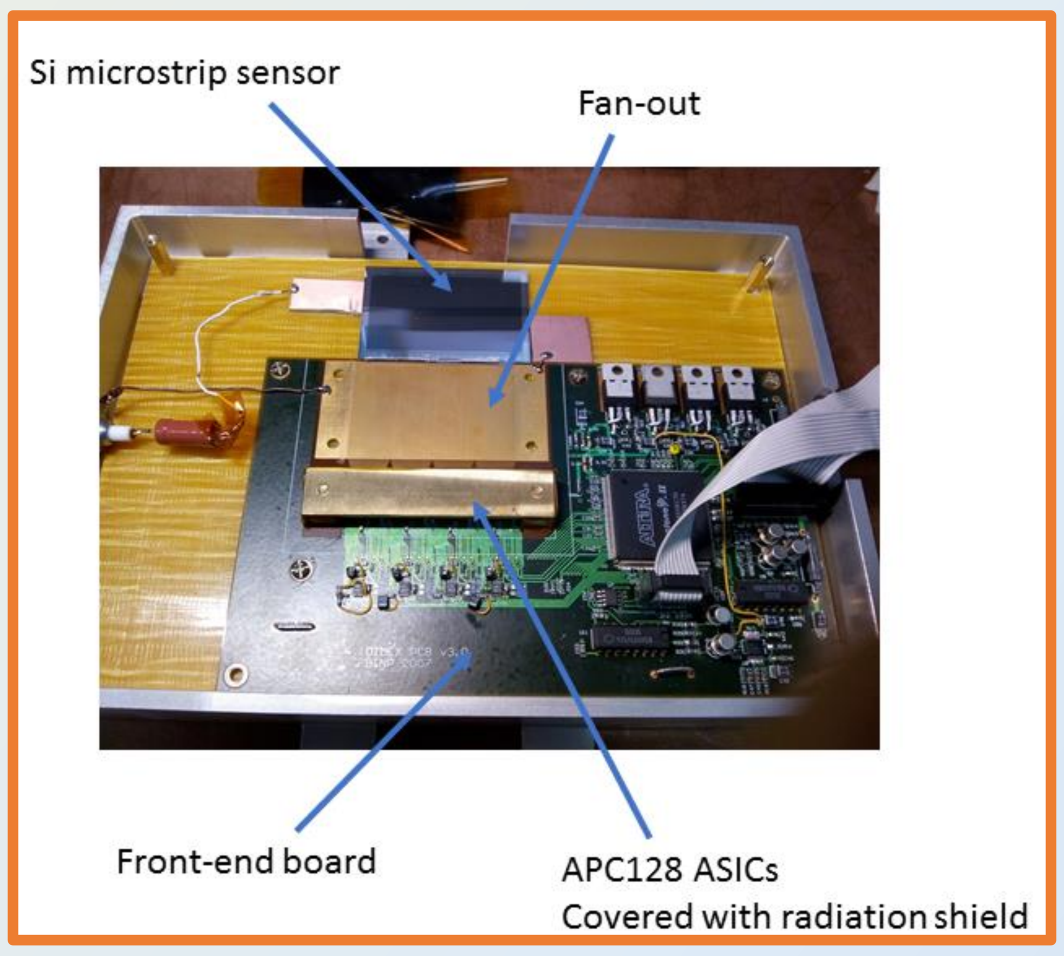


Fig.5. Components and layout of the full-size 512 channel prototype of the Si detector for dynamic diffraction experiments.

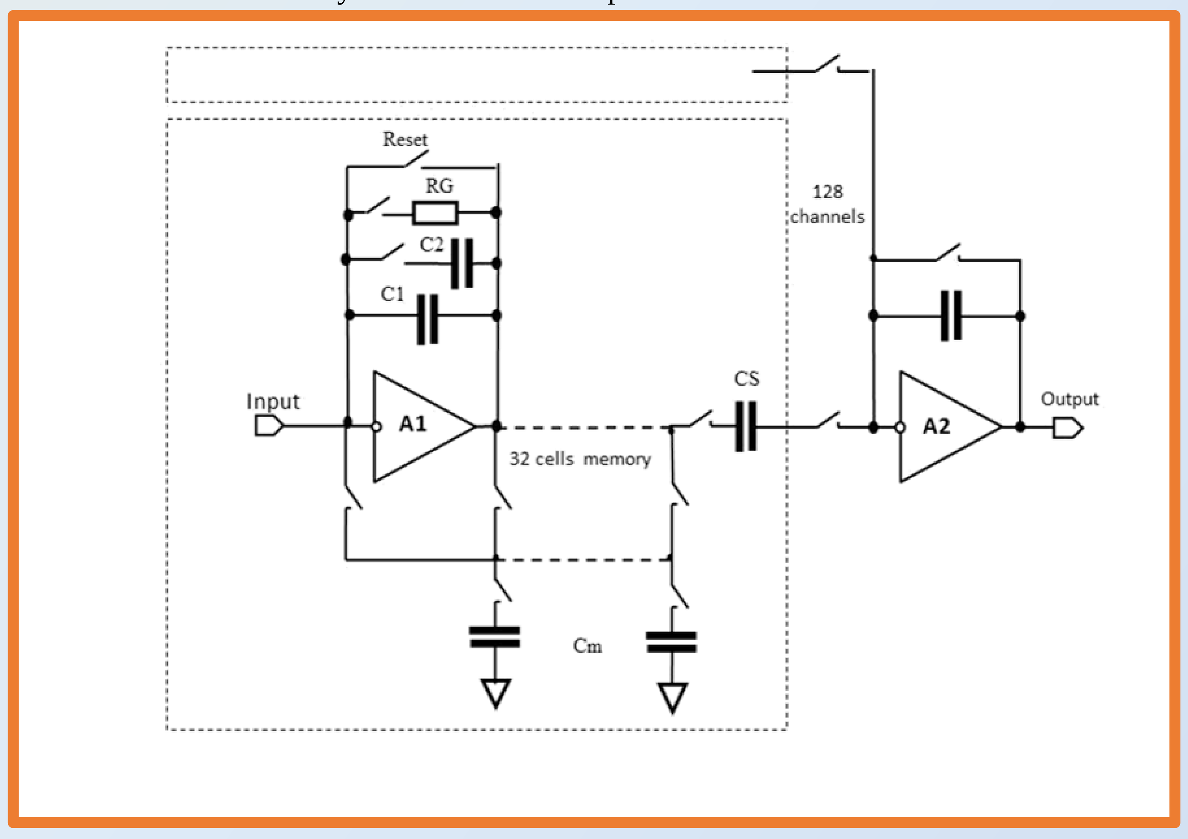


Fig.6. Block-diagram of one channel of the APC128 ASIC.

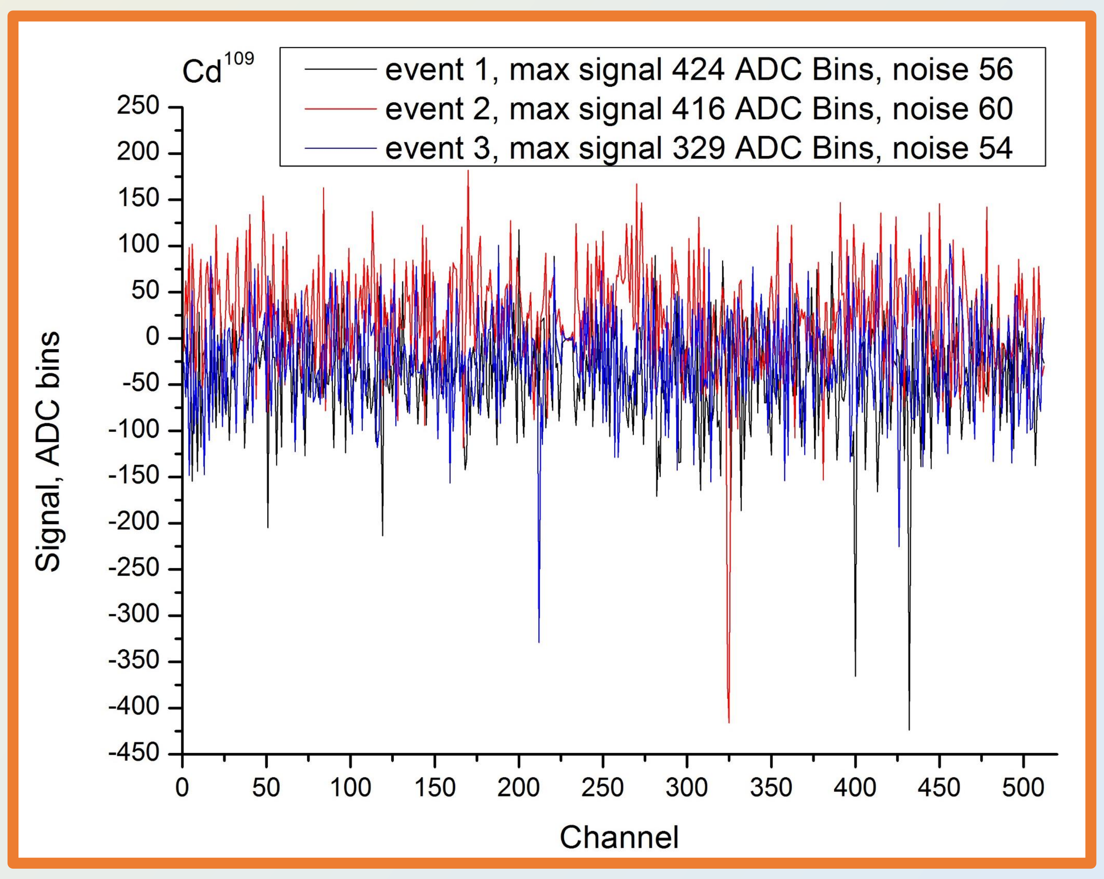


Fig.7. Signals from individual photons(negative) of $^{109}$Cd radioactive source (87 keV).

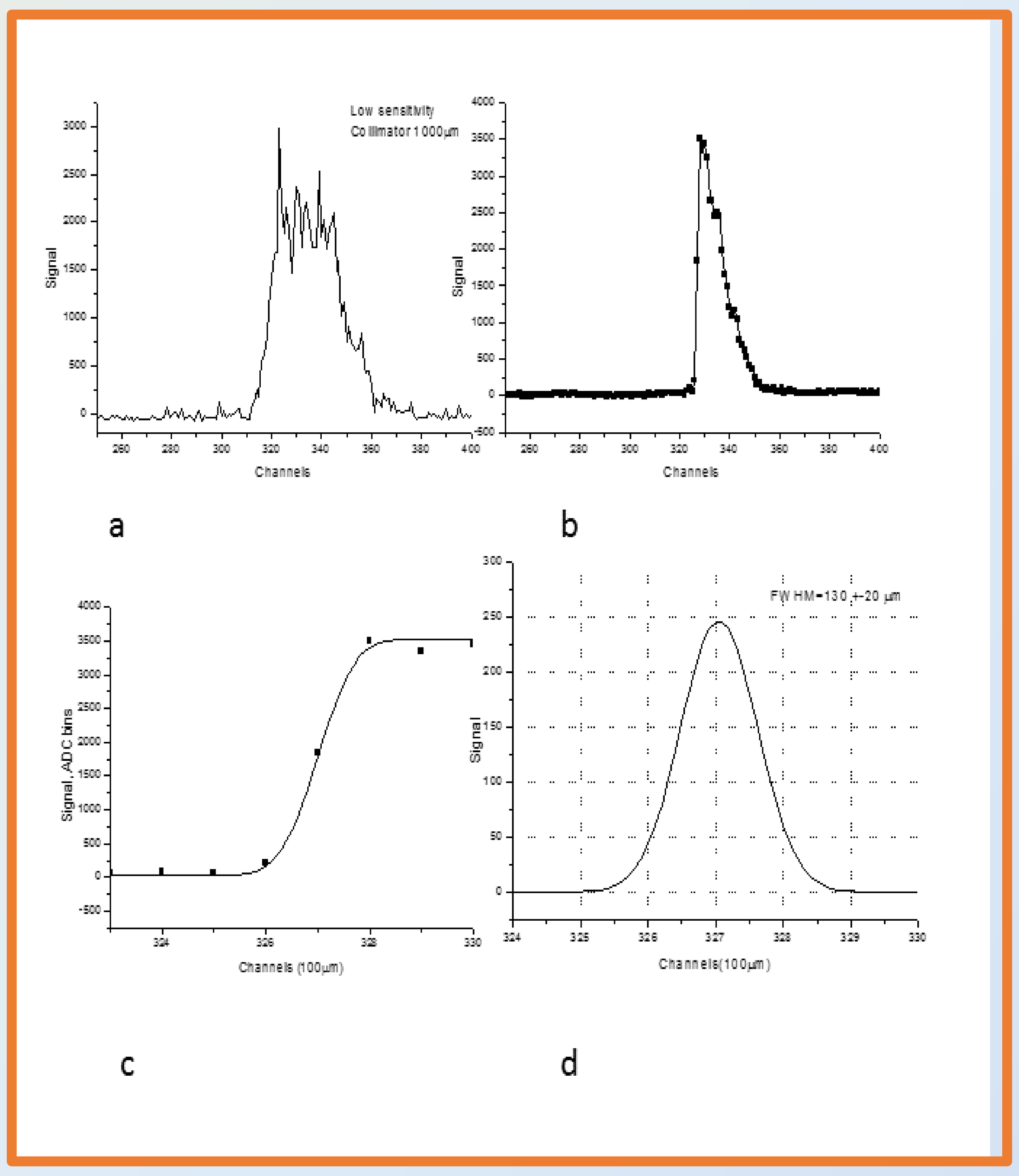


Fig.8. Measurement of spatial resolution. a. Image of Laue reflection from W crystal with wide primary beam (1mm); b. Part of the image is closed with 3mm lead screen with sharp edge; c. Magnified view of the edge image with fit function; d. Derivative of the fit – line spread function, FWHM = 130 +-20 μm

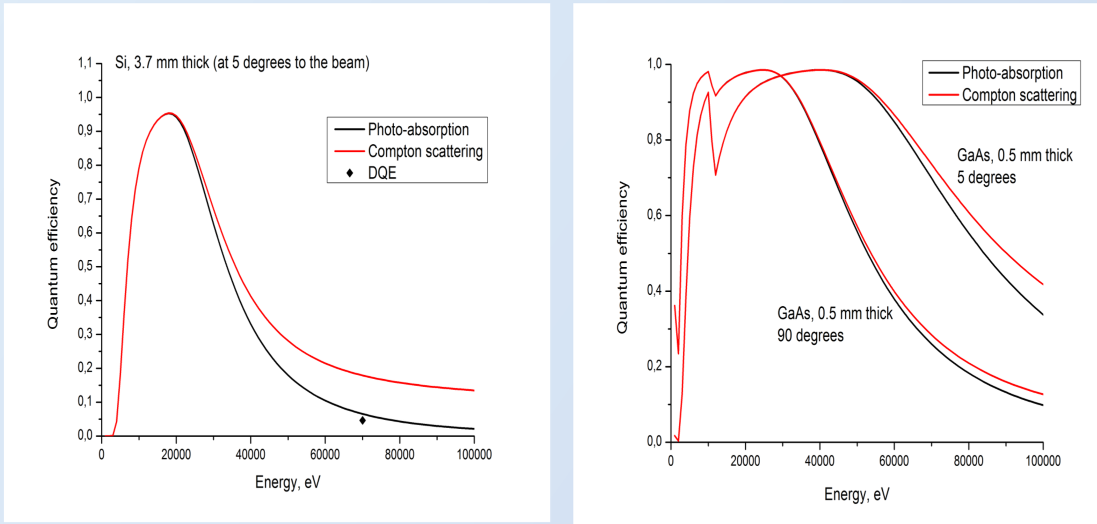

Fig.8. Comparison of quantum efficiency of Si detector (left) with GaAs (right). In case of 0.5 mm GaAs inclined at 5 degrees with respect to the beam, QE is increased by more than a factor of 10 at 70 keV compared to Si detector.

**Summary:**

Si microstrip detector can significantly improve the quality of data measured in time –resolved experiments aimed to study deformations and relaxation of a tungsten sample under pulsed heating. As a next step we consider development of full-size detector with 50 um channel pitch (all strips will be bonded to the ASICs) with custom ASIC DMXG64B. However it is clear that with GaAs the efficiency of the detector can be drastically increased and we are going to build the next detector based on microstrip GaAs sensor produced in Tomsk State University.

**Acknowledgements:**

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