Experiments on imaging of fast dynamic processes (explosions, combustion) with a synchrotron radiation beam are performed in the Budker INP at the VEPP-3 storage ring for more than 15 years. The DIMEX (Detector for Imaging of Explosions) based on gas technology is used for this purpose. DIMEX allows to measure photon flux up to ~2000 photons/channel x bunch/channel area is 0.140.5 mm², average photons energy ~20 keV, with spatial resolution of ~0.2 mm and frame rate of 10 MHz. In order to improve all detector parameters, namely, maximum measured photon flux up to 10⁶ photons/channel x bunch, spatial resolution down to 50 µm and maximum frame rate up to 50 MHz, a new development was started based on Si microstrip technology. A new beam line with 100 times higher flux and higher x-ray energy is constructed for this purpose at the VEPP-4M storage ring.

Schematic view of the experimental set-up is shown in Fig.1. The SR beam is provided by a 4-pole wiggler with 7 poles having 2 T field and the first and the last poles having 1.2 T field. The beam passes through the collimator block forming a flat narrow beam, the explosion chamber that can withstand an explosion of 210 g of trinitrotoluene (TNT) and then passes to the detector hutch.

The VEPP-4M storage ring operates at present with electron beam energy up to 4.5 GeV and beam current up to 20 mA (in two bunches). In future the energy will be increased to 5 GeV and the beam current will be increased to 20 mA in each bunch. The bunches can be grouped in trains of 4-5 bunches with 20 ns time gaps. Calculated energy spectrum at the entrance of the detector in comparison with the spectrum in the VEPP-3 beam line is shown in Fig.3.

Si microstrip detector with a thin sensor aligned at a small angle with respect to the beam plane and with the strips parallel to the beam direction can provide the required improvement of the parameters. The limitation of maximum rate in the gaseous detector is determined by ion space charge that affects the drift of electrons. Mobilities of electrons and holes in silicon are not so different as those of electrons and ions in gas and have much higher values. Thus, space charge effects in silicon start at much higher rates than in high pressure Xe. Charge collection time in 0.3 mm thick Si sensor about 100 times shorter than in 1 mm thick high pressure Xe layer, therefore time resolution of Si detector will be much better. Finally, the spatial resolution of gaseous detector is determined by electron diffusions that is much higher than in Si.

A dedicated ASIC was developed for this detector that allows to measure the signal at the resistor at each strip with 20 ns duty cycle. The block diagram of one channel of this ASIC is shown in Fig.5. It contains voltage to current converter at the input that transfer voltage pulse at the input resistor to the current pulse at the output, DC compensation circuit, commutator to four integrators with reset circuit and analog memory. In order to provide the fastest operation, the integrators are switched to the output of the voltage to current converter by turns one at a time, because the reset circuit of the feedback capacitor can not discharge it within 20 ns. The prototype ASIC was manufactured with 6 channels, each containing 4x4 analogue memory cells. The prototype, based on Si micro-strip sensor with 400 Ohm resistors between the strips and the guard ring and 16 DIMEXA ASICs, was assembled and put into operation (see Fig.6). It consists of the board for the sensor with 48 strips bonded to the connectors from each side. The sensor board is connected to two front-end boards each containing 8 DIMEXA chips. Output signal from each chip is digitized by 14-bit 3 Mps ADC and then the digital data are transferred to the memory at the motherboard. The data are readout to a computer through 1 Gb Ethernet connection. The motherboard provides the trigger signal and all control sequences that allow proper operation of the ASICs and ADCs.

Several p-on-n 300 µm thick sensors with DC-coupled metal strips of 50 µm pitch and with polysilicon resistors in the range of 100 Ohm to 1000 Ohm introduced between each strip and the guard ring were manufactured for us by the Hamamatsu Photonics company. The sensors are 55x35 mm² in size and contain 1024 30 mm long strips each.