Budker INP

Detectors for fast time-resolved studies at SSRC, status and future

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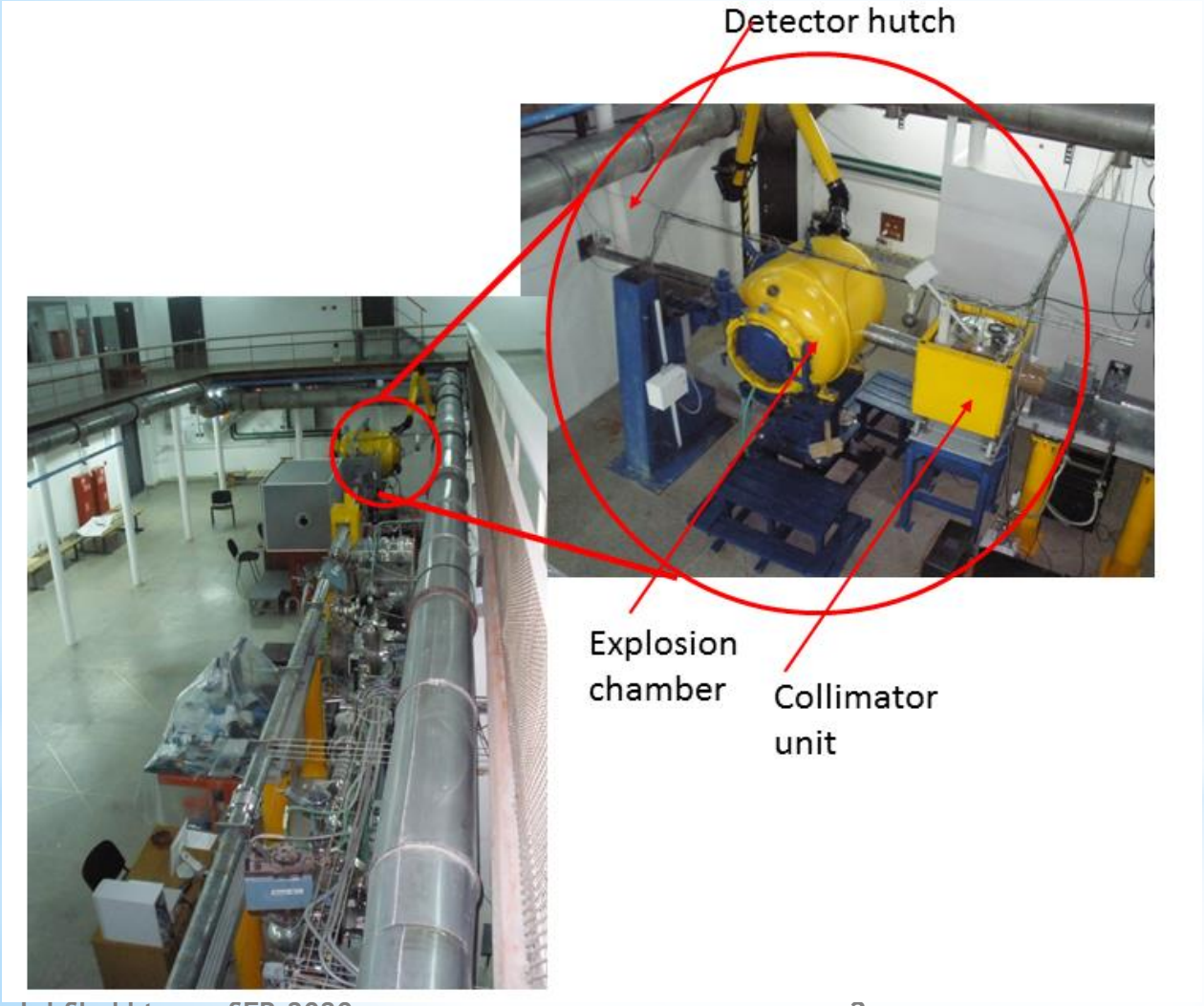
Detector for Imaging of Explosions (DIMEX) is successfully used at beam line 0 at VEPP3 and at beam line 8 at VEPP-4M for more than 15 years.

VEPP-4M, beam line 8

VEPP-3, beam line 0



DIMEX-G

Gaseous 1D detector with new front-end ASIC DMXG64B(A)
Max frame rate - 10 MHz
Number of frames – 100
Maximum signal(electronics) – $2x10^6$ e (~3500 photons, 20 keV)
Noise - <~4000 e ~ 7 photons 20 keV (GEM attenuation)
Channel pitch – 100 μm
Number of channels - 512
Spatial resolution – 250 μm (FWHM, for 20 keV photons)
DQE ~ 40% (for 20 keV photons)
Maximum detected photon rate - ~1200 photons/chan x bunch (20 keV photons)

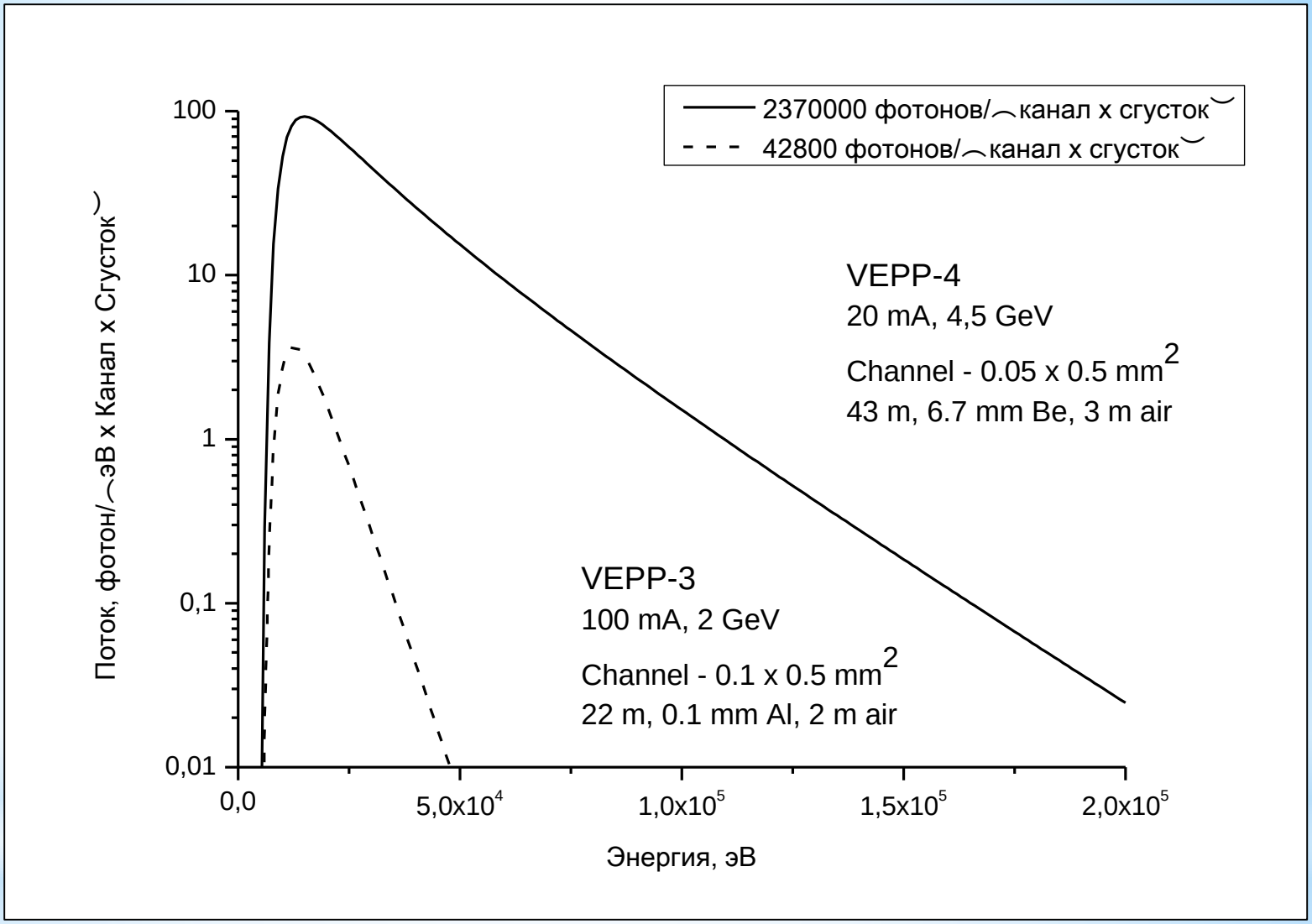
Main limitations of DIMEX-G

Maximum detected rate – limited to ~1000-2000 photons/channel x bunch due to space charge of ions in gas

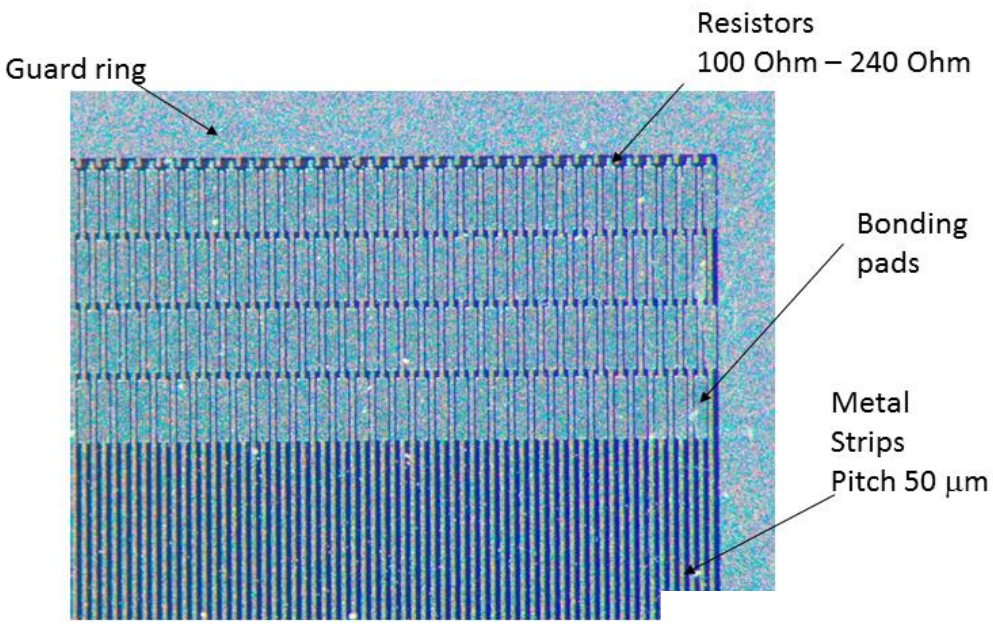
Maximum frame rate – limited due to longitudinal diffusion of electrons and electronics

Spatial resolution – limited due to transverse diffusion of electrons

DIMEX-G

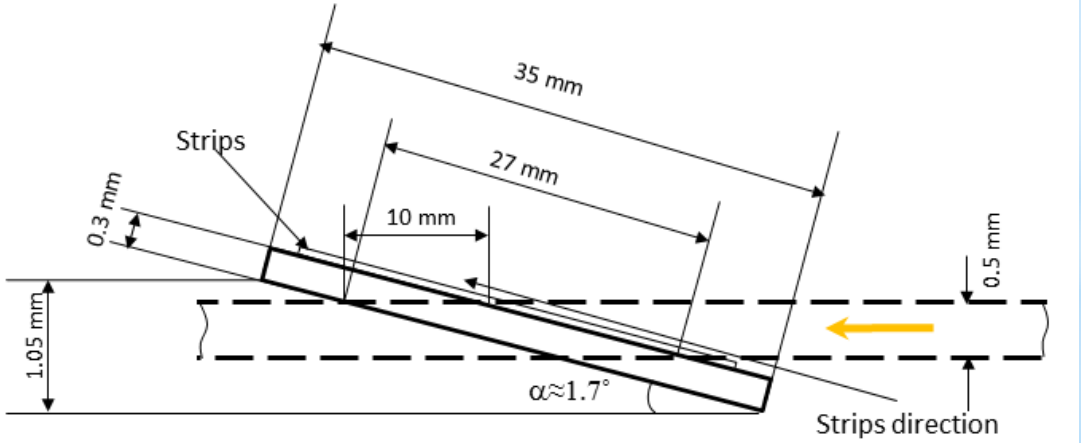

2370000 фотонов/⌒канал х сгусток⌣
42800 фотонов/⌒канал х сгусток⌣
Поток, фотон/⌒эВ х Канал х Сгусток⌣
100
10
1
0,1
0,01
0,0
5,0x10^4
1,0x10^5
1,5x10^5
2,0x10^5
Энергия, эВ
VEPP-4
20 mA, 4,5 GeV
Channel - 0.05 x 0.5 mm^2
43 m, 6.7 mm Be, 3 m air
VEPP-3
100 mA, 2 GeV
Channel - 0.1 x 0.5 mm^2
22 m, 0.1 mm Al, 2 m air

DIMEX-Si

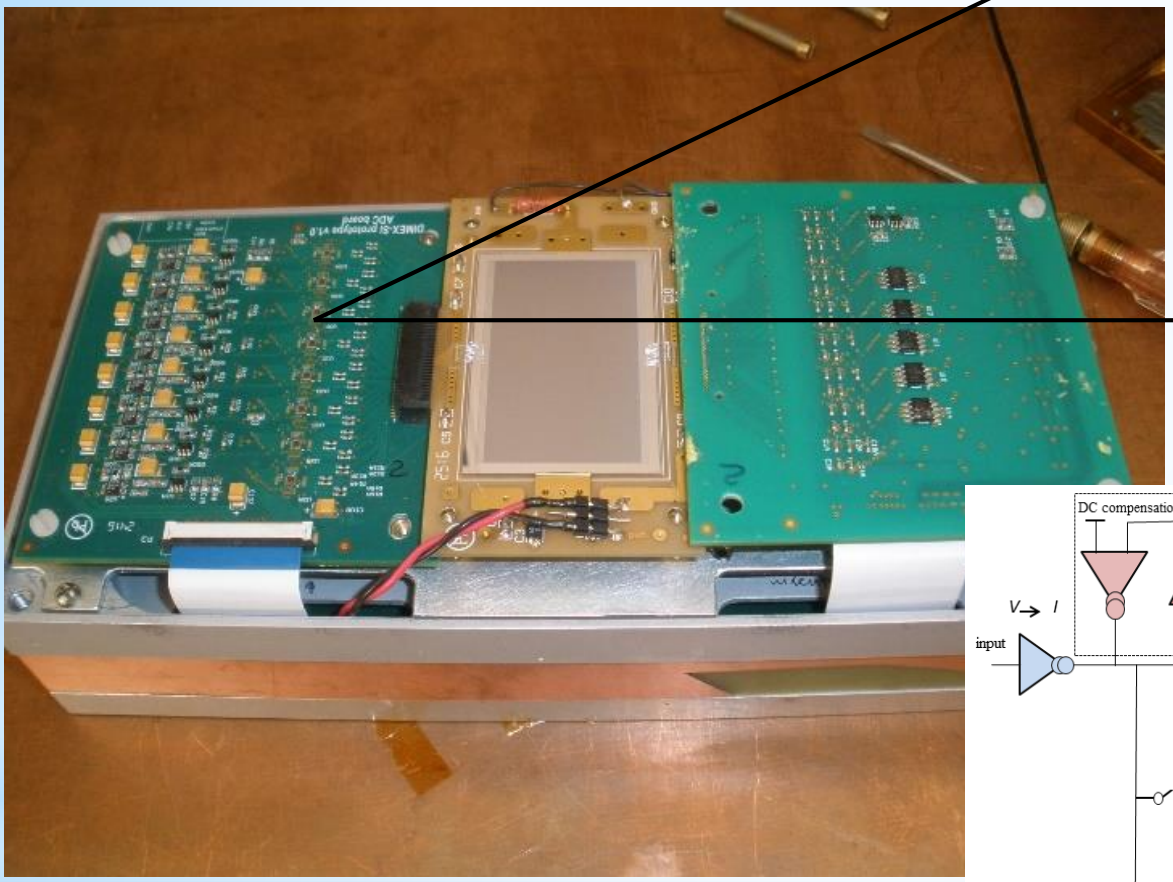


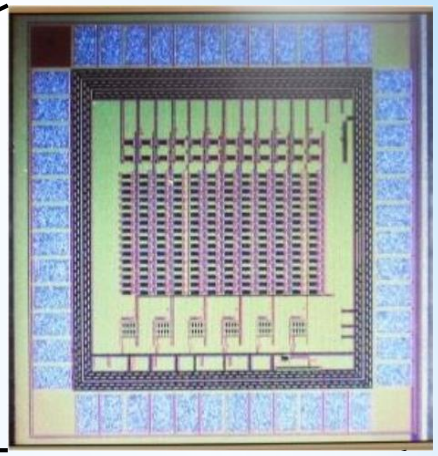
Si microstrip sensors produced by Hamamatsu Photonics
p-in-n technology
DC coupled metal strips
polysilicon resistors between each strip and guard ring
wide guard ring
30 mm long strips
50 μm strip pitch
320 μm sensor thickness

Sensor position in the final detector



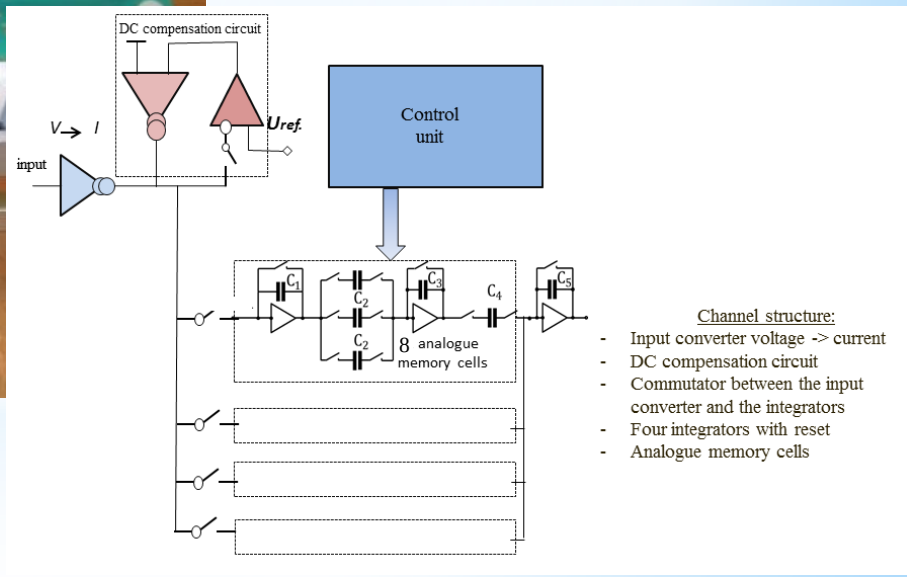
DIMEX-Si





DMXS6A

96 channel prototype mounted

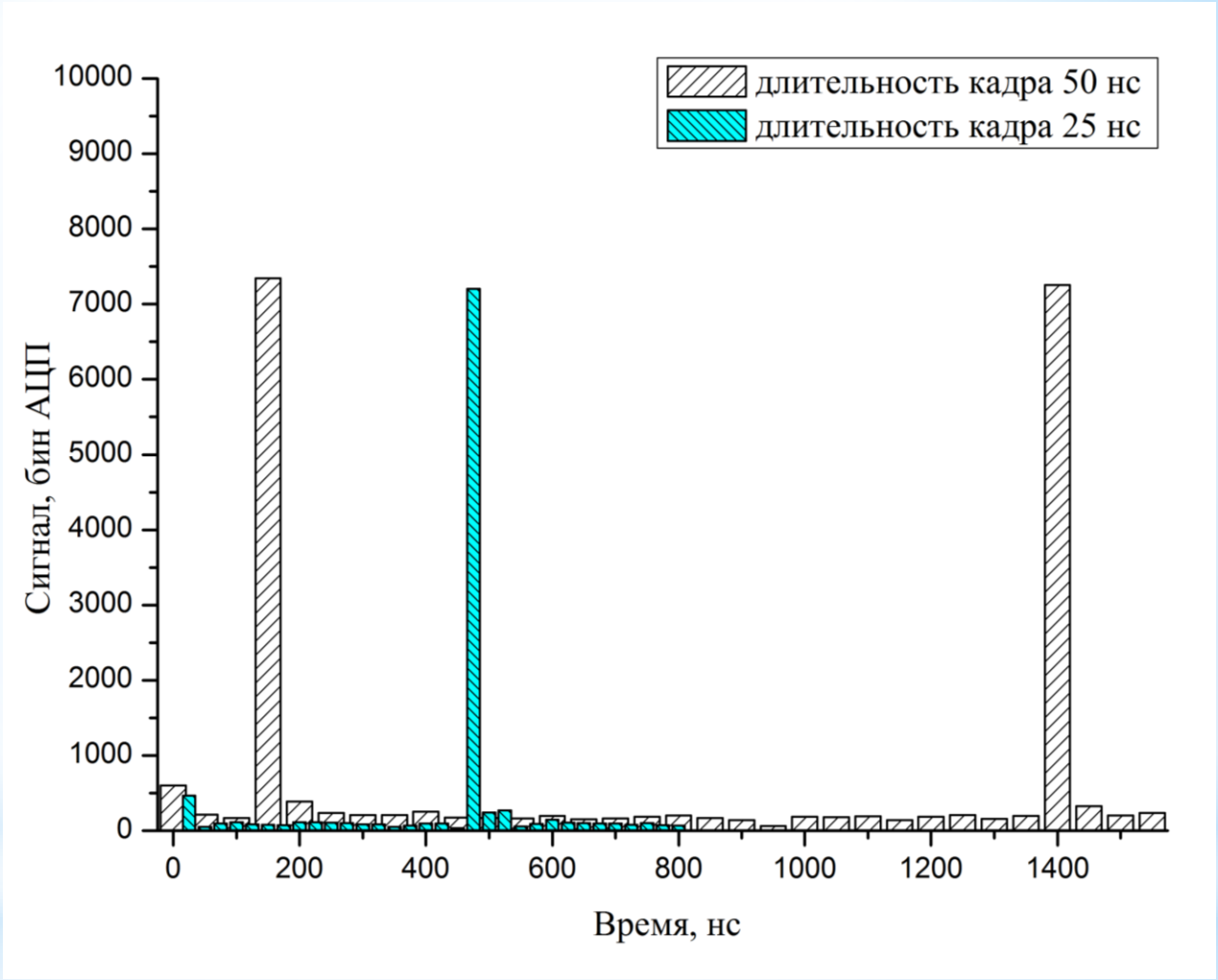


Channel structure:

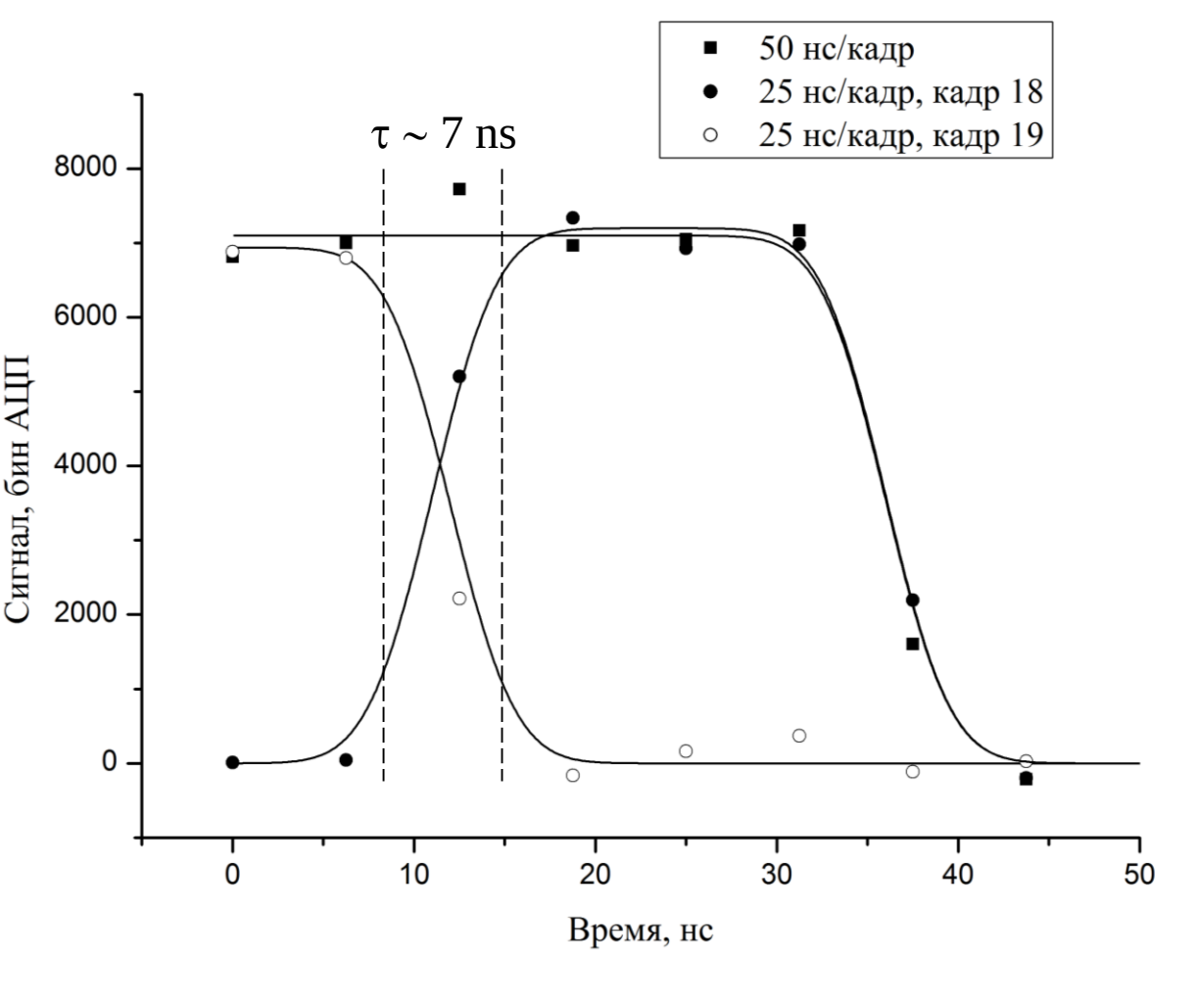
- Input converter voltage -> current
- DC compensation circuit
- Commutator between the input converter and the integrators
- Four integrators with reset
- Analogue memory cells

DIMEX-Si

VEPP-4M
1 bunch



Signal as a function of time in one channel



Signal as a function of time shift between bunch crossing and detector clock

Spatial resolution

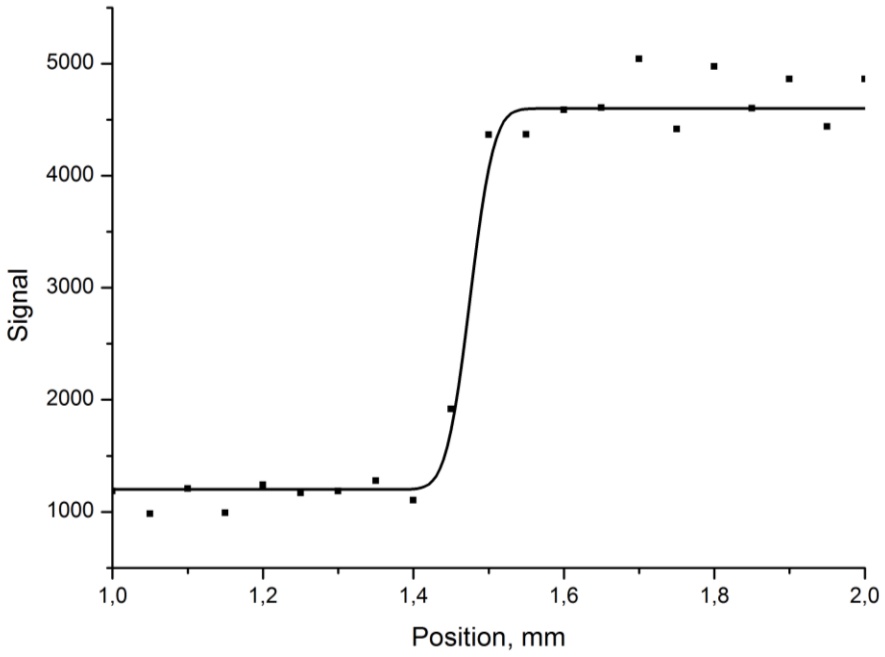
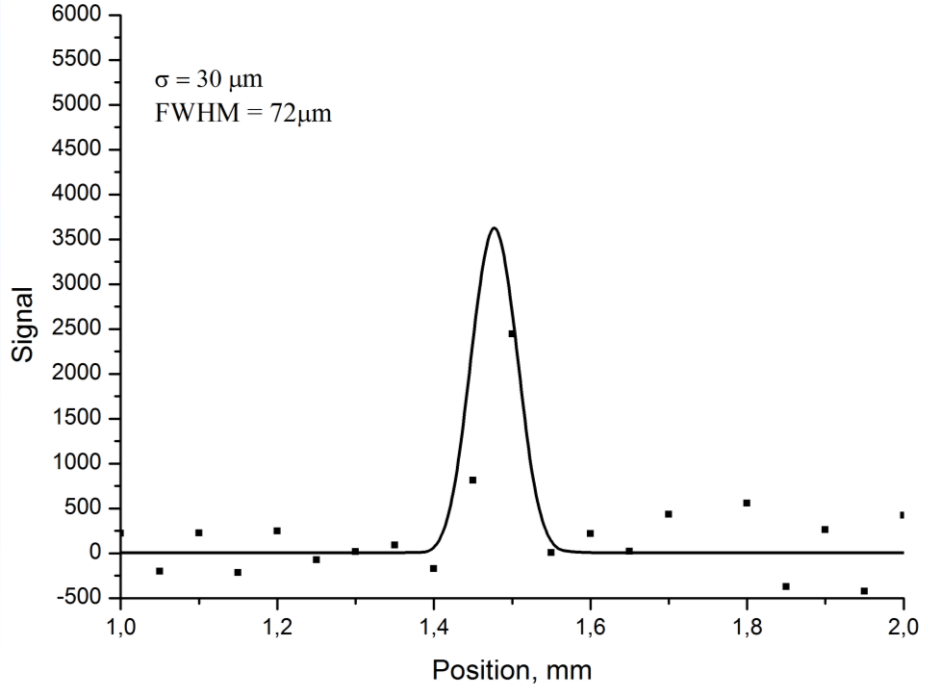
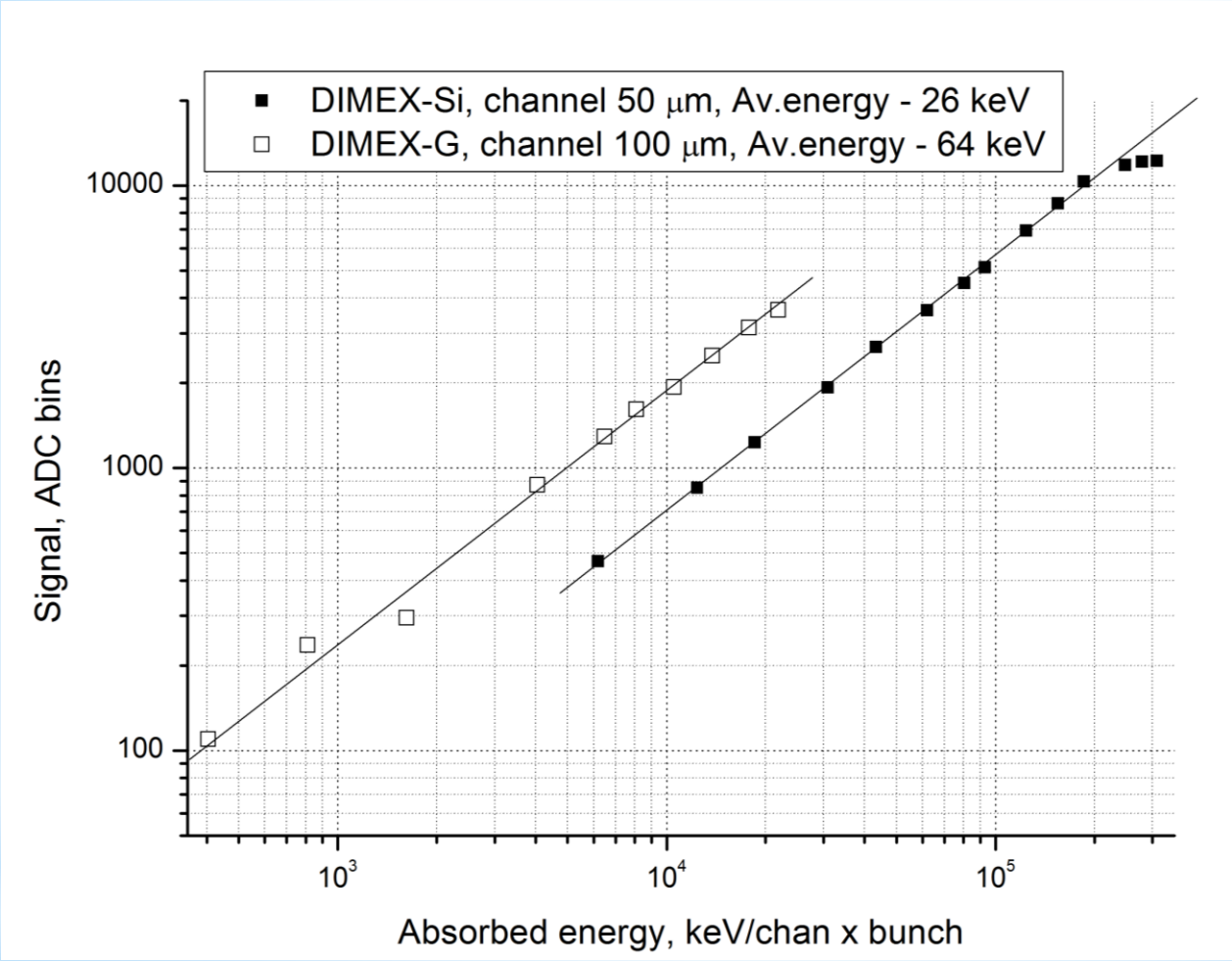


Image of sharp edge (3mm steel) fitted with erf. St.dev. - 30 μm



Derivative of the fit and exp. Data FWHM ~ 72 μm.

DIMEX-Si



Signal as a function of absorbed power for the prototype of DIMEX-Si and DIMEX-G
Maximum absorbed power density for DIMEX-SI is 20 times higher than for DIMEX-G

Summary

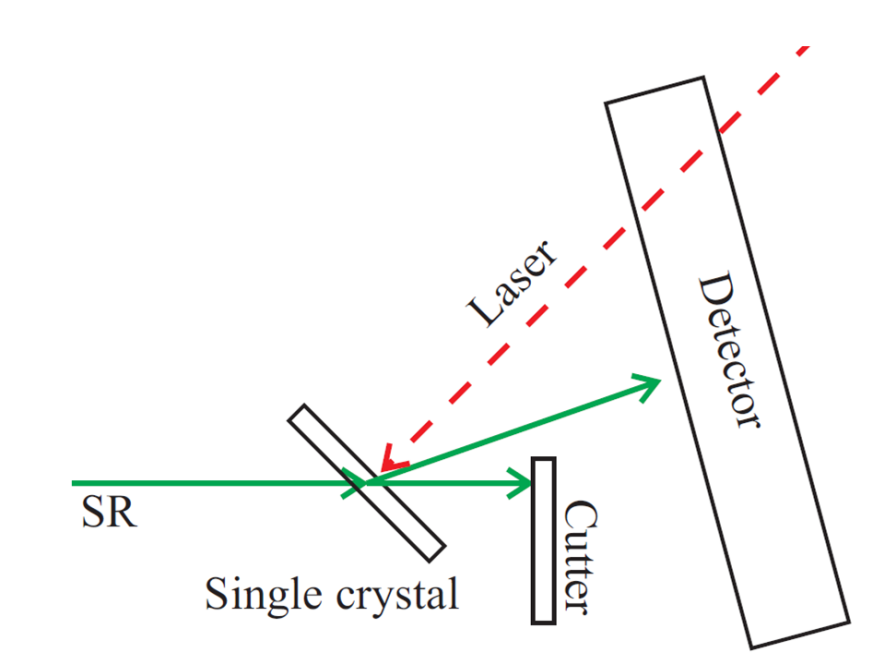
- Prototype of the Si detector with 16 DMXS6A ASICs (6 channels and 32 memory cells in each channel) is put in operation and tested at the VEPP-3 and VEPP-4M.

- DIMEX-Si prototype demonstrated maximum absorbed power density ~20 times higher than in DIMEX-G, spatial resolution ~3.5 times better (72 μm vs 250 μm), time resolution ~7 times better (7 ns vs 50 ns) and frame rate 5 times higher (40 MHz vs 8 MHz)

- Main problem of the DIMEX-Si prototype is noise of the DMXS6A ASIC that is going to be solved in the next version of the chip

- First attempts with multi-bunch regime in VEPP-4M showed that new synchronization scheme is necessary between the detector and the experimental set-up

New silicon micro-strip detector with integrating readout for dynamic experiments for studies of material deformations under pulsed heating “Si-Plasma”



Schematic of the experiment

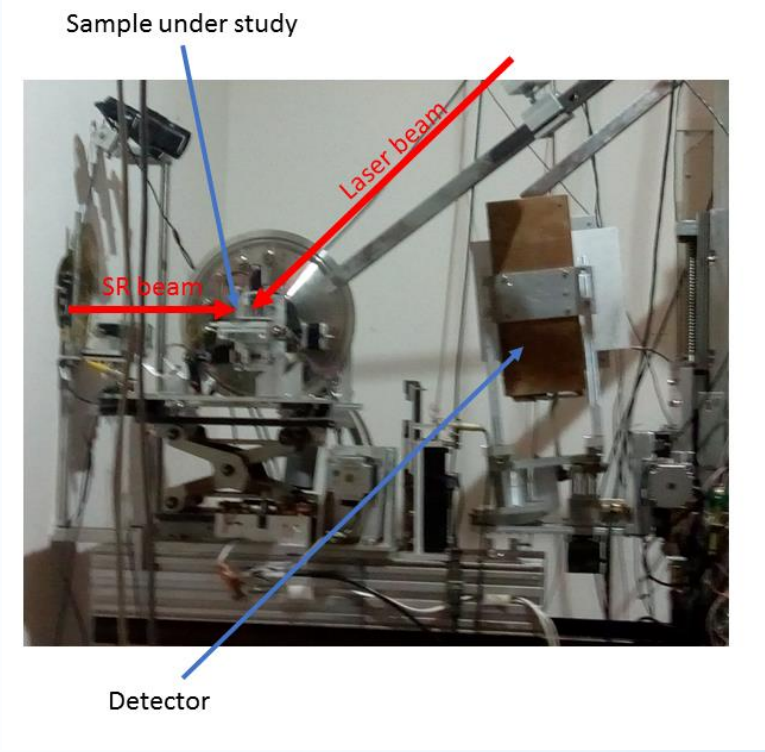
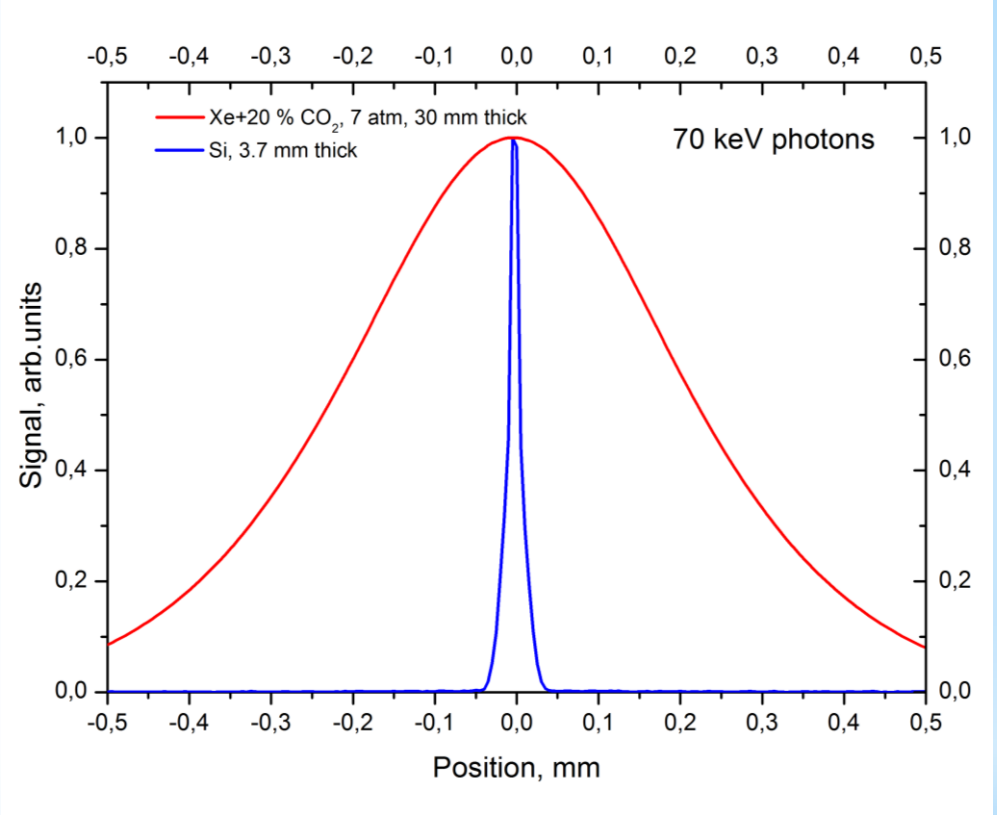


Photo of the station “Plasma”

Si-plasma

In the first experiments one-dimensional detector DIMEX-G was used to measure the dynamics of the diffraction peak shape.

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 (line spread function) of 3.7 mm thick silicon (320 um sensor inclined at 5 degrees) and DIMEX-G (simulation)

Si-plasma

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

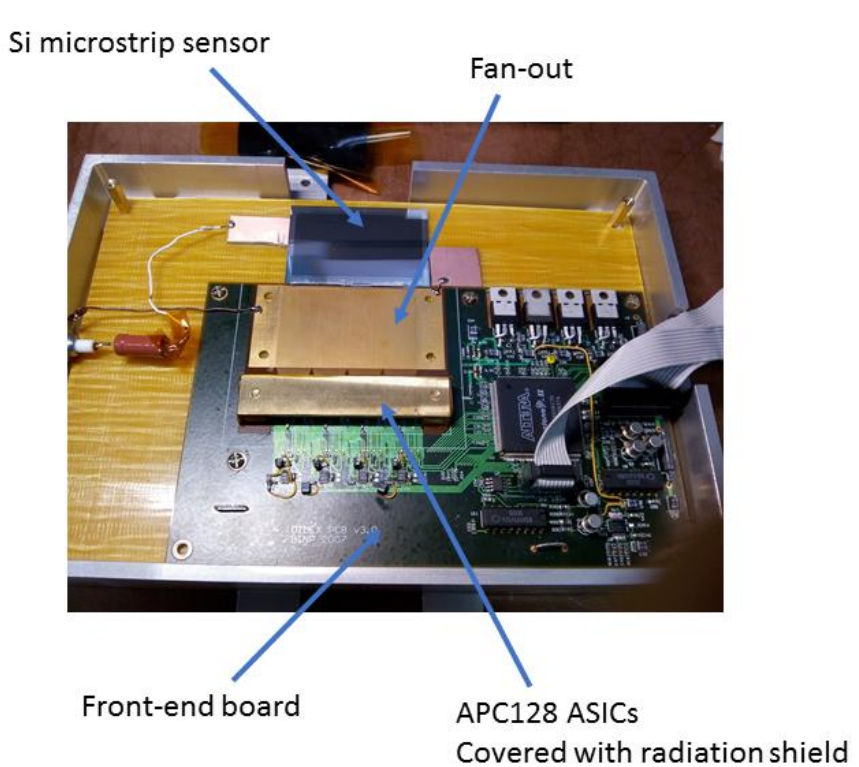
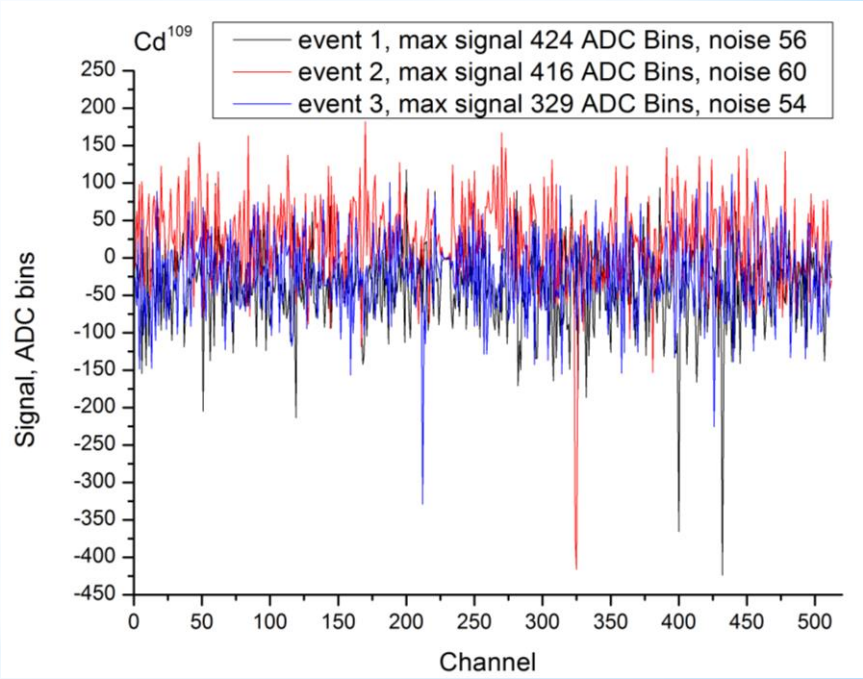


Photo of the prototype during mounting



Signals from 88 keV photons from ^{109}Cd radioactive source (negative)

Si-plasma

Main parameters of new prototype:

Channel pitch - 0.1 mm

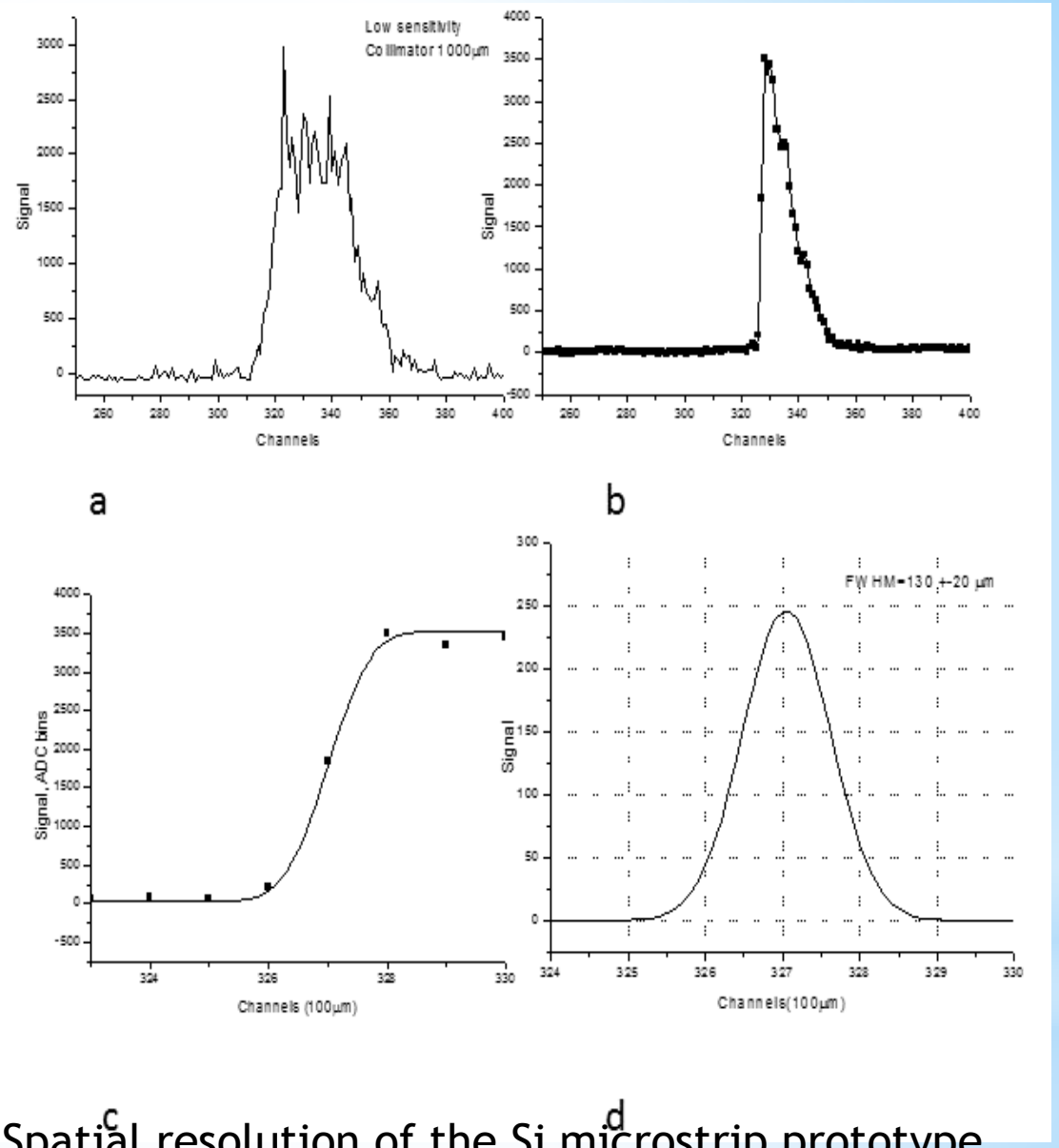
Spatial resolution - 130 μm (FWHM) for 70 keV photons

Maximum registered signal - ~200 70 keV photons

Number of channels – 512

Max. frame rate – 2 MHz

Frame exposure – 0.5 – 100 μs



Spatial resolution of the Si microstrip prototype 130 +- 20 μm

Next steps

- Full-size Si microstrip detector with DMXG64B ASIC with 50 μm pitch
- GaAs microstrip prototype (increase of DQE by 5-10 times)
- GaAs full-size microstrip detector with DMXG64B ASIC with 50 μm pitch