Budker INP

Upgrade of the detector for imaging of explosions

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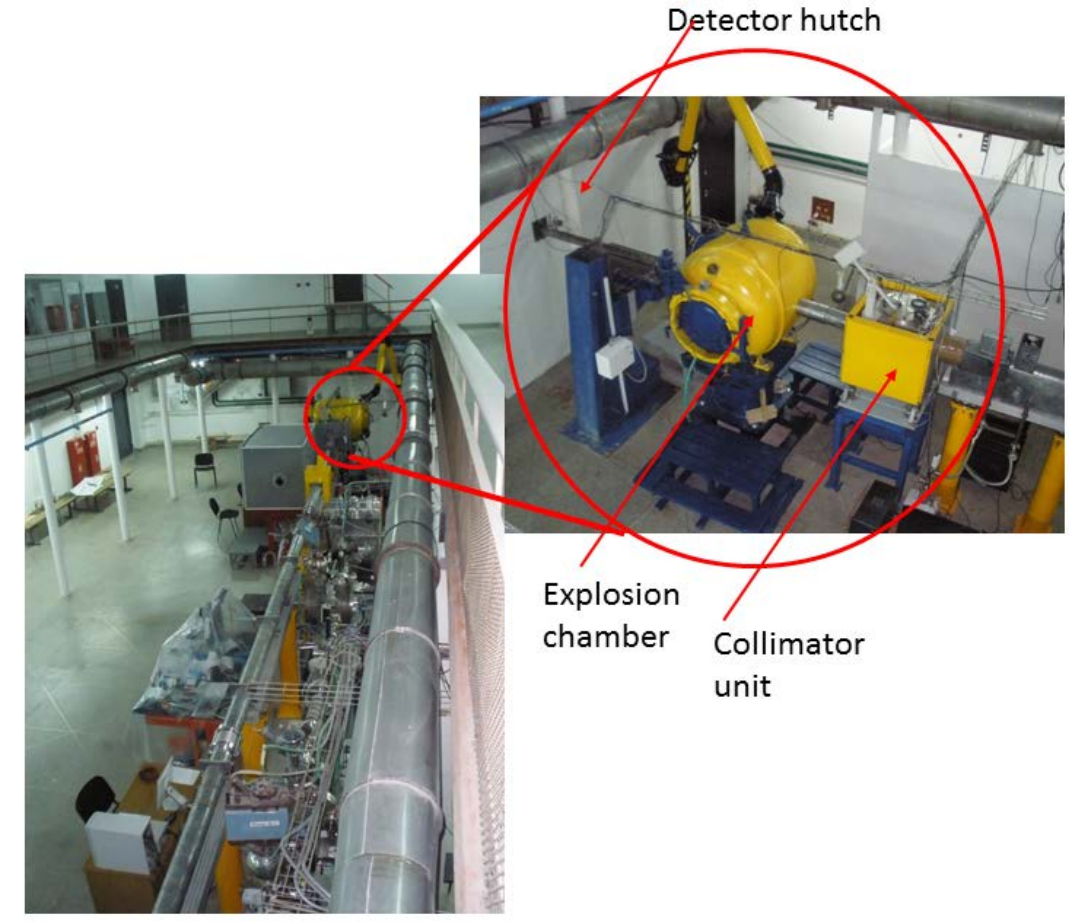
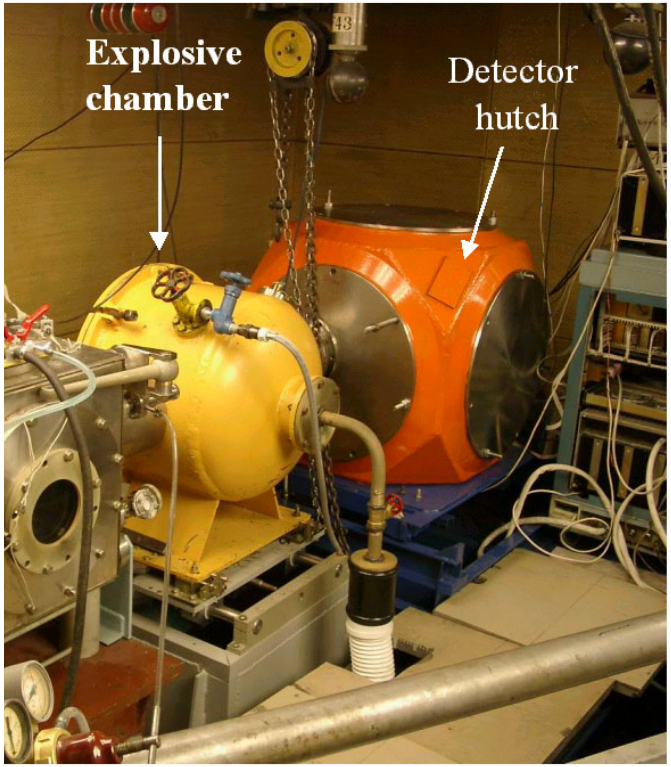
Detector for Imaging of Explosions (DIMEX) is successfully used at beam line 0 at VEPP3 and at beam line 8 at VEPP-4M for more than 15 years.

VEPP-4M, beam line 8



VEPP-3, beam line 0



Main DIMEX parameters:

Spatial resolution ~200 μm FWHM (electron diffusion in gas)
Max. frame rate 2 MHz (front-end ASIC)
Channel pitch – 100 μm, number of channels 512
Number of frames – 32 (front-end ASIC)
Maximum signal ~5000 photons/chan*bunch (space charge in gas, front-end ASIC)
Noise ~2000e (~7 photons, 20 keV)

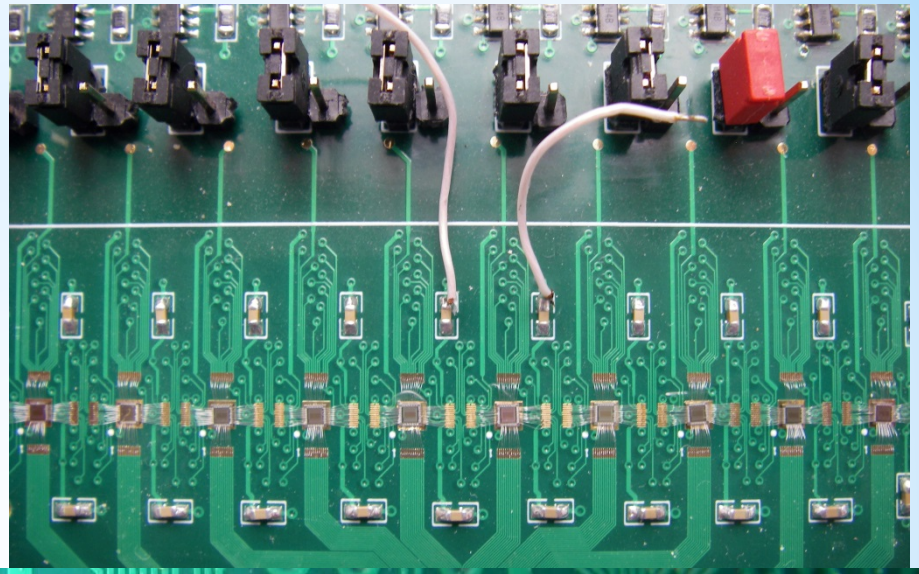
DIMEX-G

Gaseous detector with new front-end ASIC
Max frame rate - 10 MHz
Number of frames – 100
Maximum signal – $2x10^6$ e (~7000 photons, 20 keV)
Noise - <~4000 e

DIMEX-Si

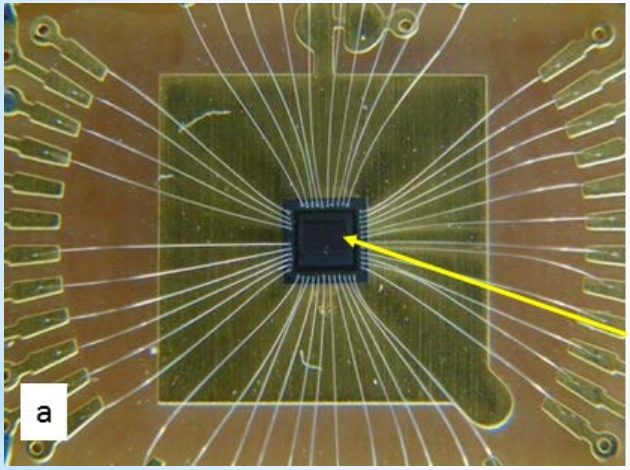
Si micro-strip detector with new front-end ASIC
Max frame rate – 50 MHz
Spatial resolution – 50 μm FWHM
Channel pitch – 50 μm, number of channels – 1024
Maximum signal – 10^6 photons/chan*bunch (20 keV), noise - ~100 photons ($5*10^5$ e)

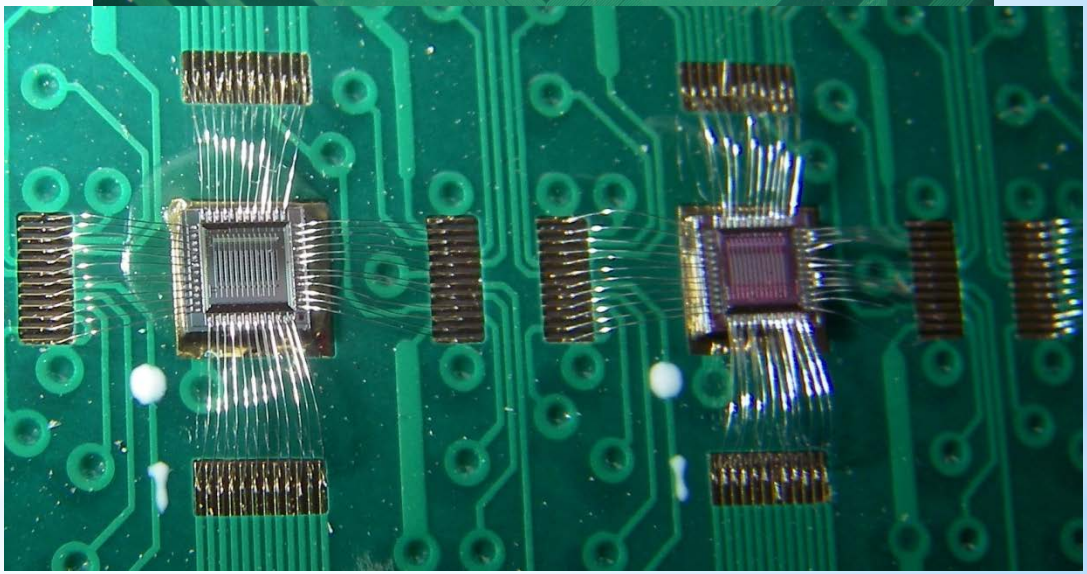
DIMEX-G DMXG12B



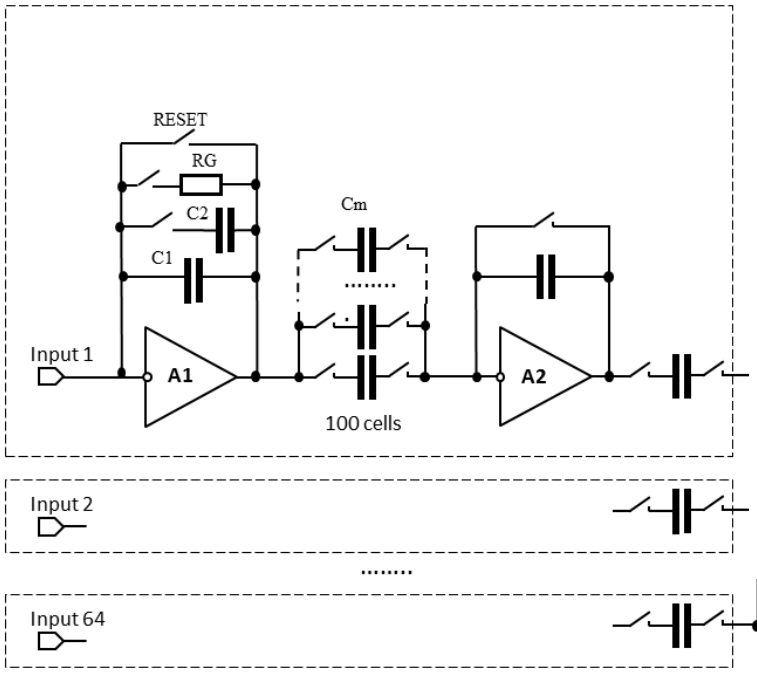
Development of new ASIC based on
180 nm technology
2013-2014 2 iterations of prototypes

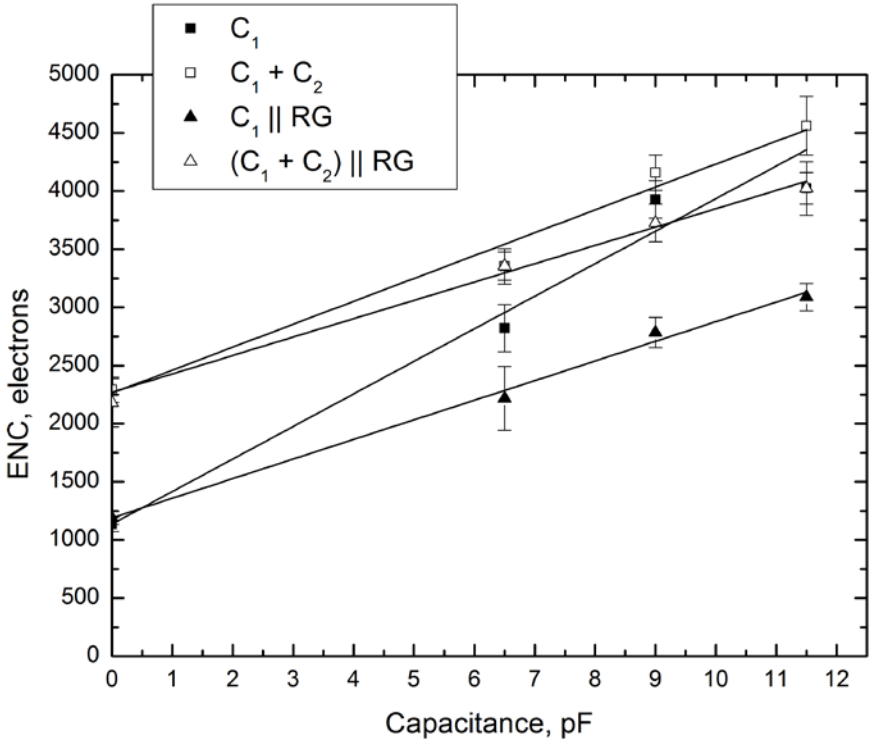
DMXG12A





Block-diagram of the final ASIC





ENC vs capacitance for DMXG12B

DIMEX-G

DMXG64A

64 channels

100 analogue cells
in each channel

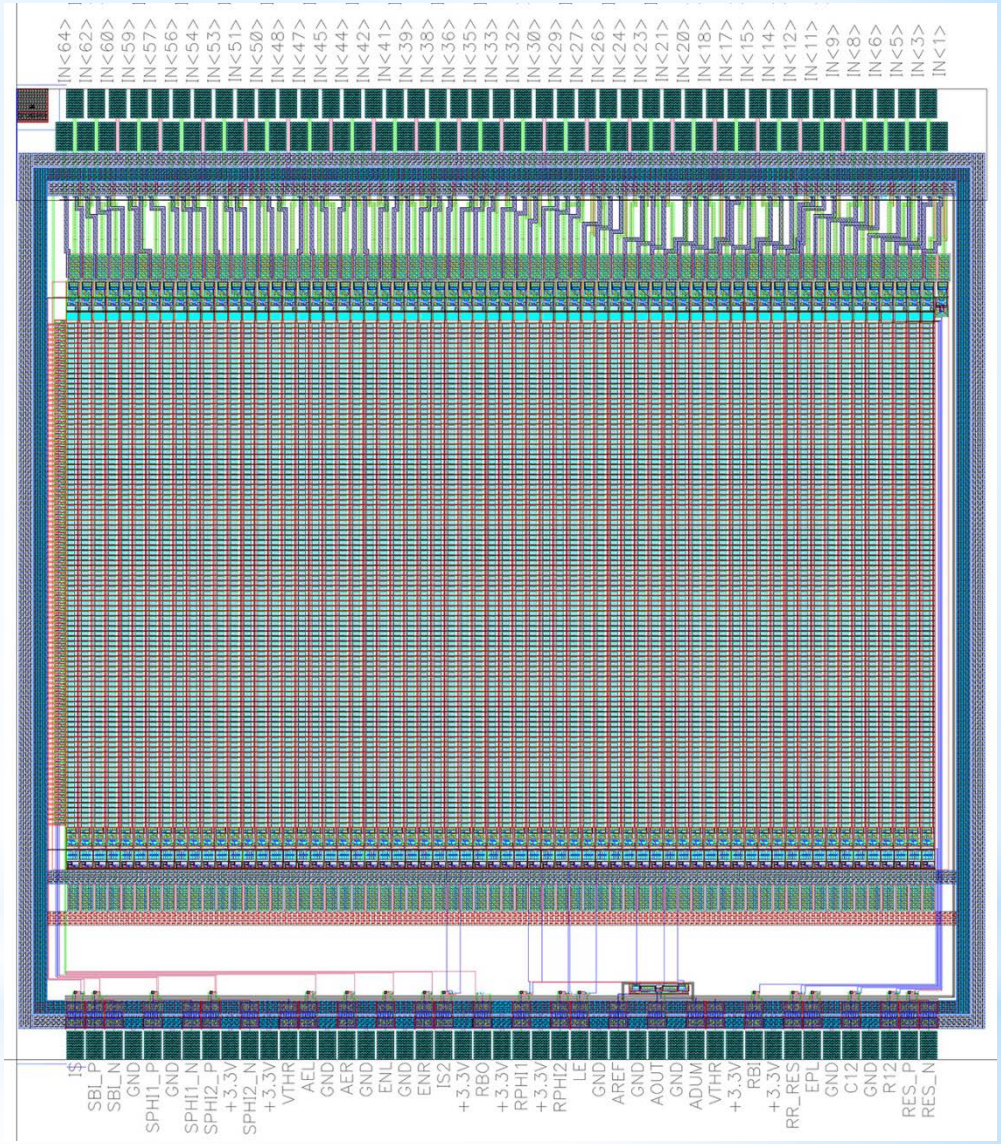
Size ~ 6x6 mm

Input pads pitch ~60 μm

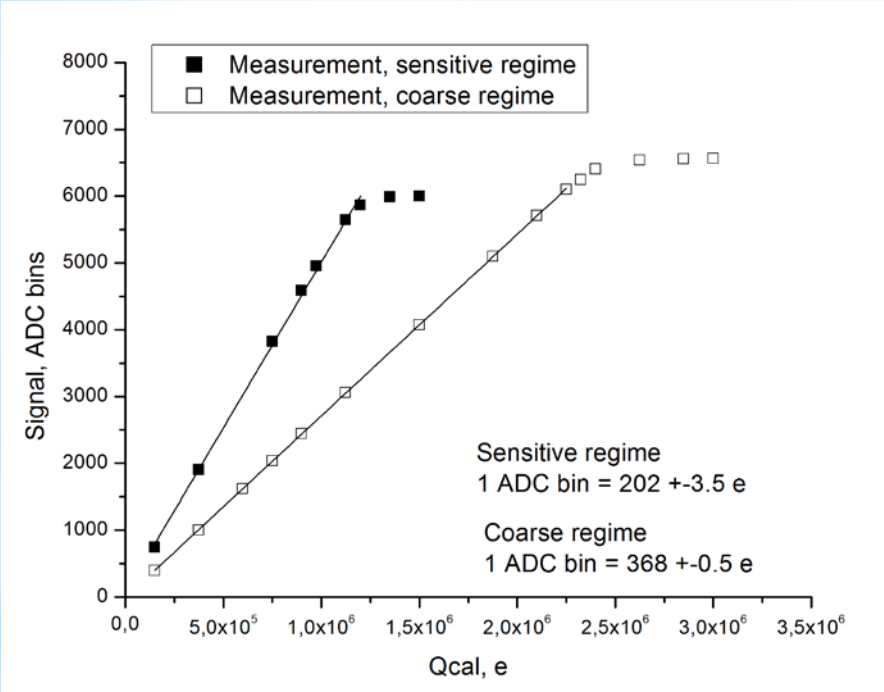
Noise ~ 3000 e

Max. signal ~$2x10^6$ e

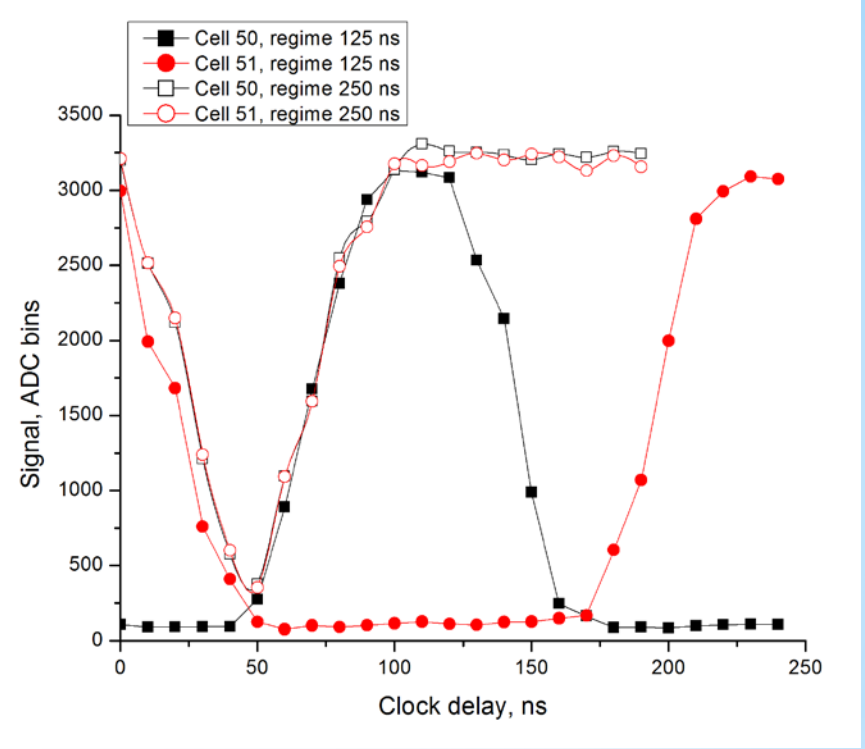
Max. frame rate 10 MHz



DIMEX-G



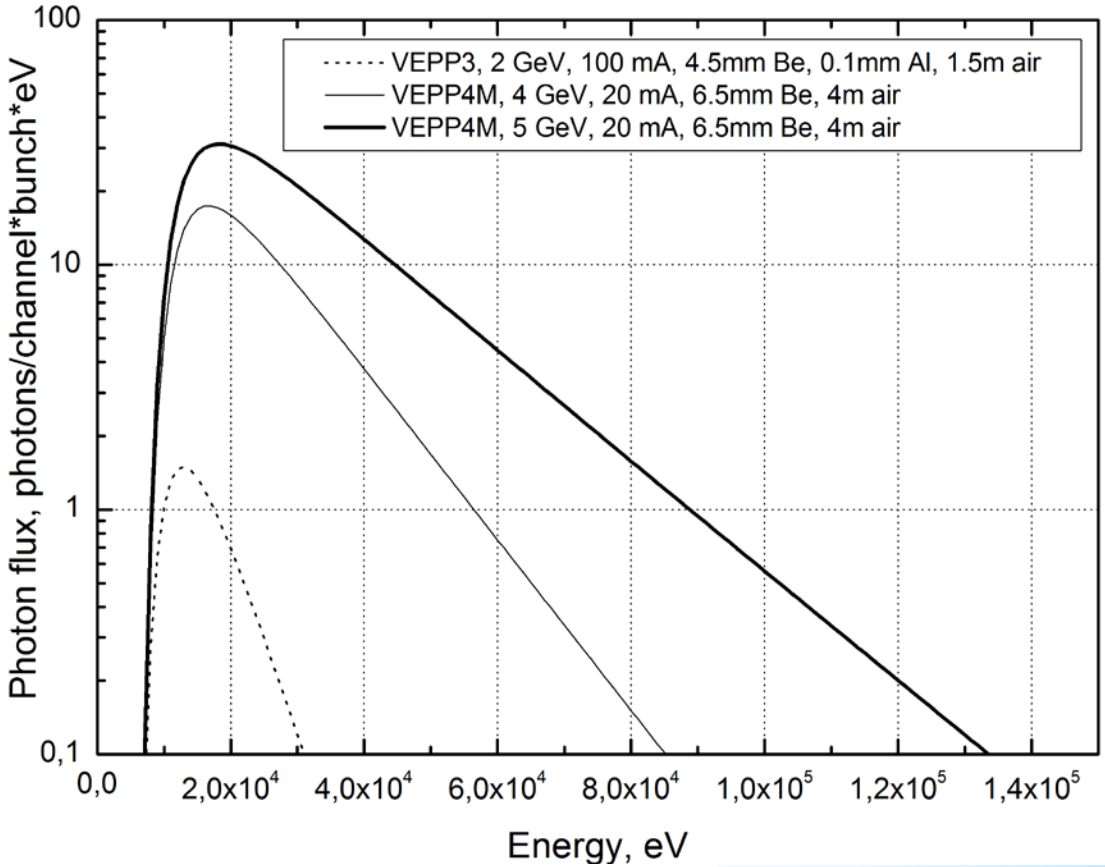
Signal from DMXG64A vs input charge



Signal from DMXG64A vs delay between detector clock and bunch passing moment

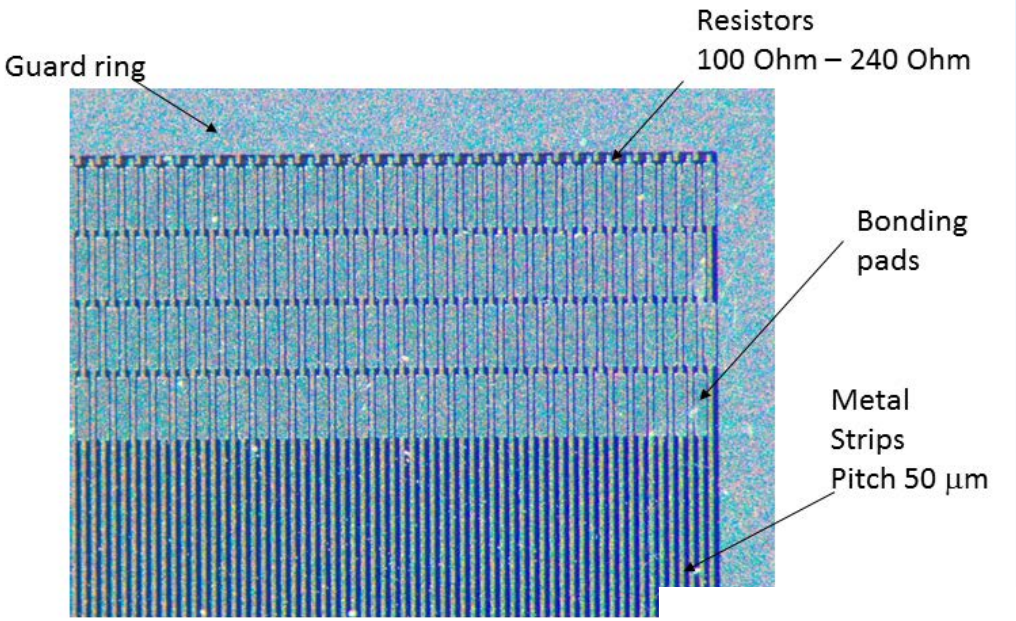
DIMEX-Si

SR spectra from 7-pole wiggler in comparison with VEPP-3 beam line 0



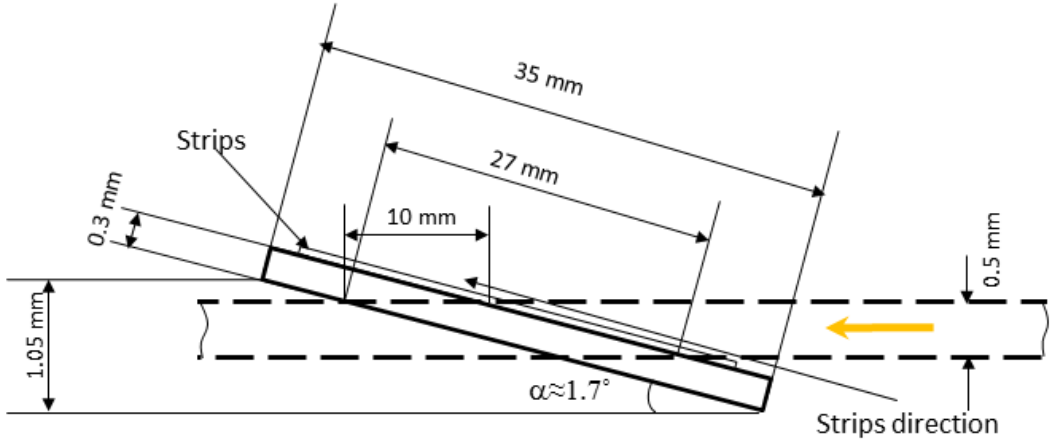
Conditions	no detector	0.3 mm Si	10 mm Si
VEPP-3, total flux (ph/bunch*chan)	1.7×10^4	8.9×10^3	1.7×10^4
VEPP-3, average energy (keV)	16.6	13.4	16.5
VEPP-4M, 4GeV, total flux (ph/bunch*chan)	3.7×10^5	1.0×10^5	3.5×10^5
VEPP-4M, 4GeV, average energy (keV)	25.8	17.4	24.2
VEPP-4M, 5GeV, total flux (ph/bunch*chan)	9.3×10^5	1.9×10^5	8.1×10^5
VEPP-4M, 5GeV, average energy (keV)	33.0	19.3	30.0

DIMEX-Si

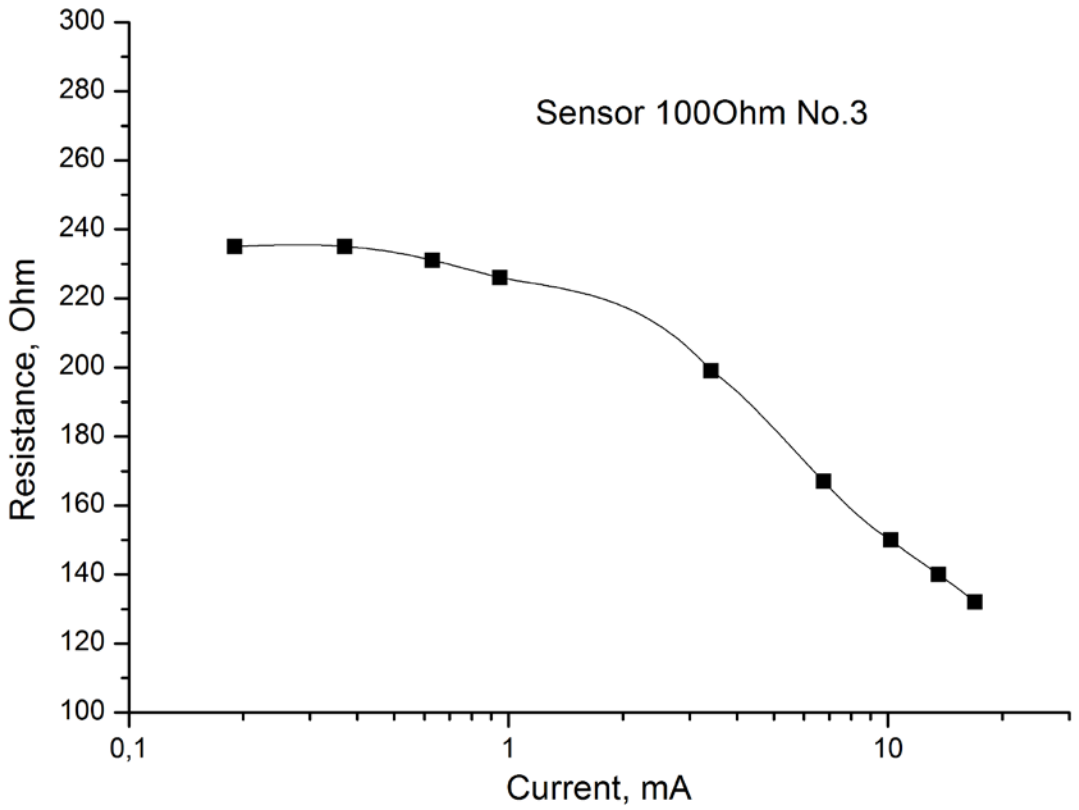


Si microstrip sensors produced by Hamamatsu Photonics
p-on-n technology
DC coupled metal strips
polysilicon resistors between each strip and guard ring
wide guard ring
30 mm long strips
50 μm strip pitch
320 μm sensor thickness

Sensor position in the final detector

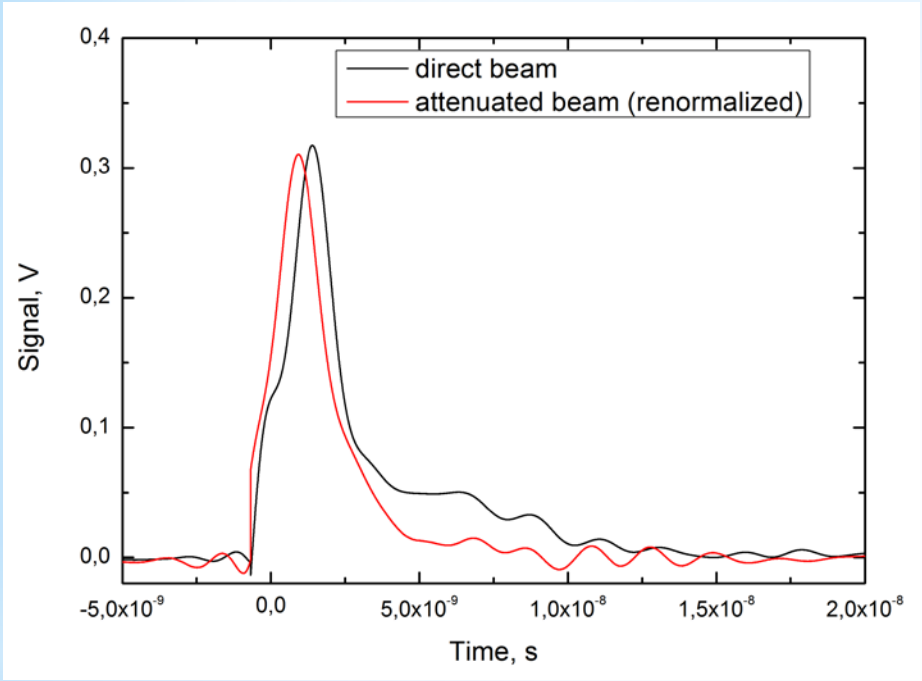


DIMEX-Si

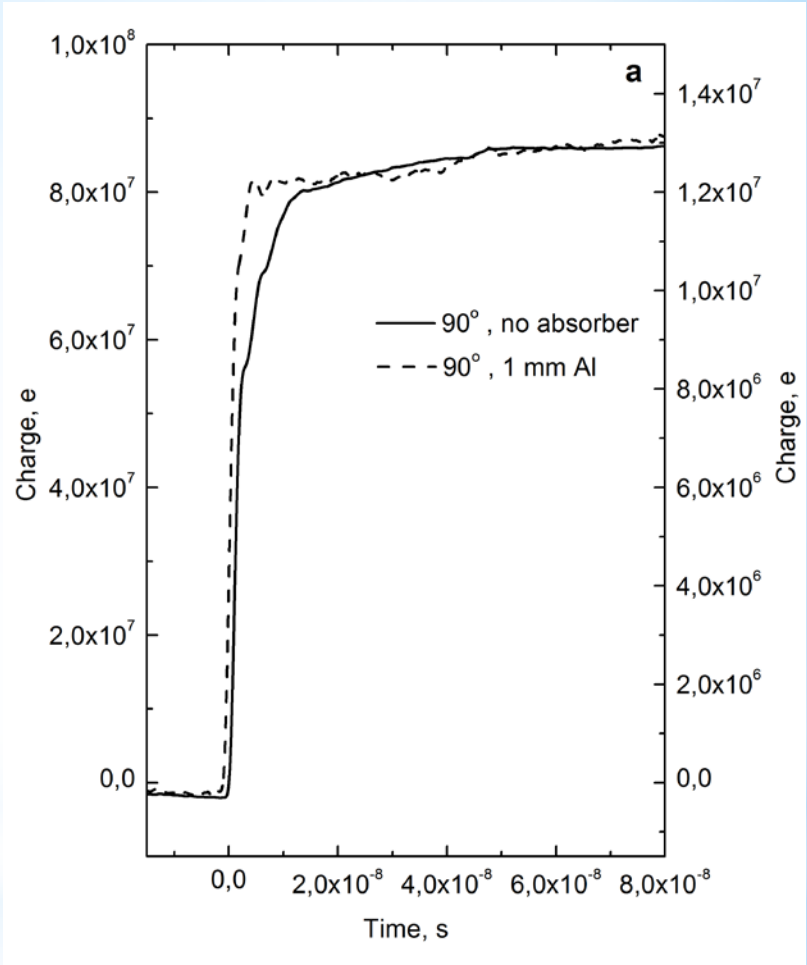


Resistance of the polysilicon resistor as a function of current

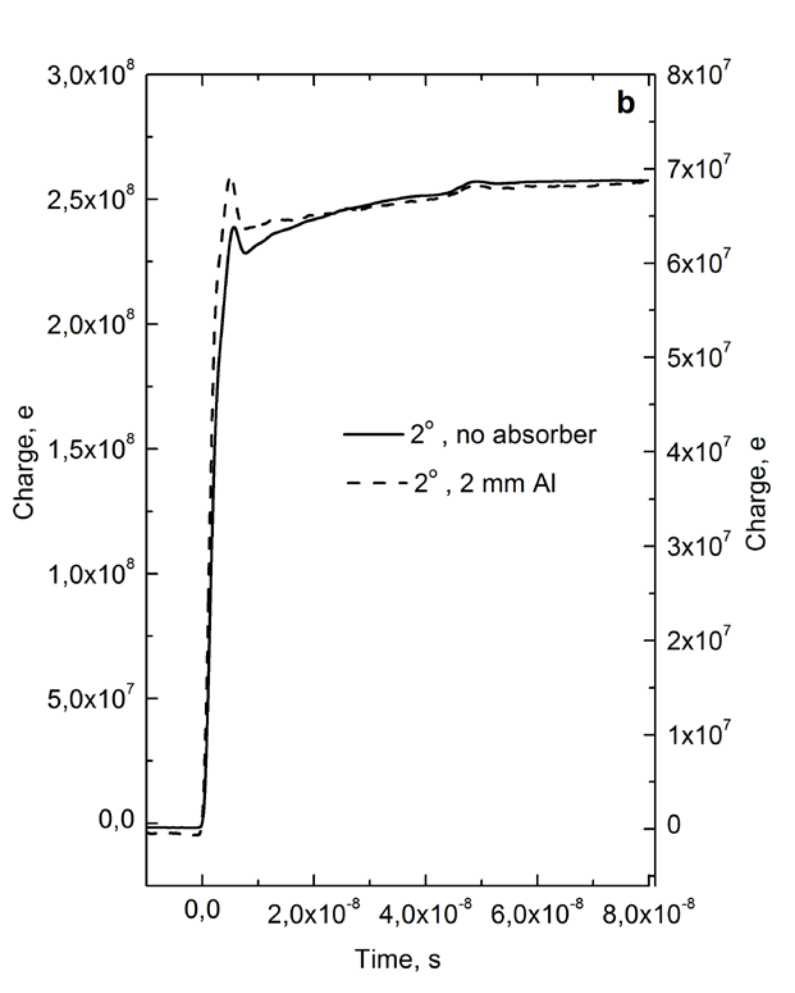
Maximum total photon flux per bunch per channel	8.1×10^5
Average photon energy, keV	30.0
Maximum released charge per bunch per channel	6.75×10^9 e $\approx 1.1 \times 10^{-9}$ C
Peak current per bunch per channel (current pulse duration 1 ns)	1.1 A
Average current per channel with open fast shutter (300 ns between bunches)	3.7 mA



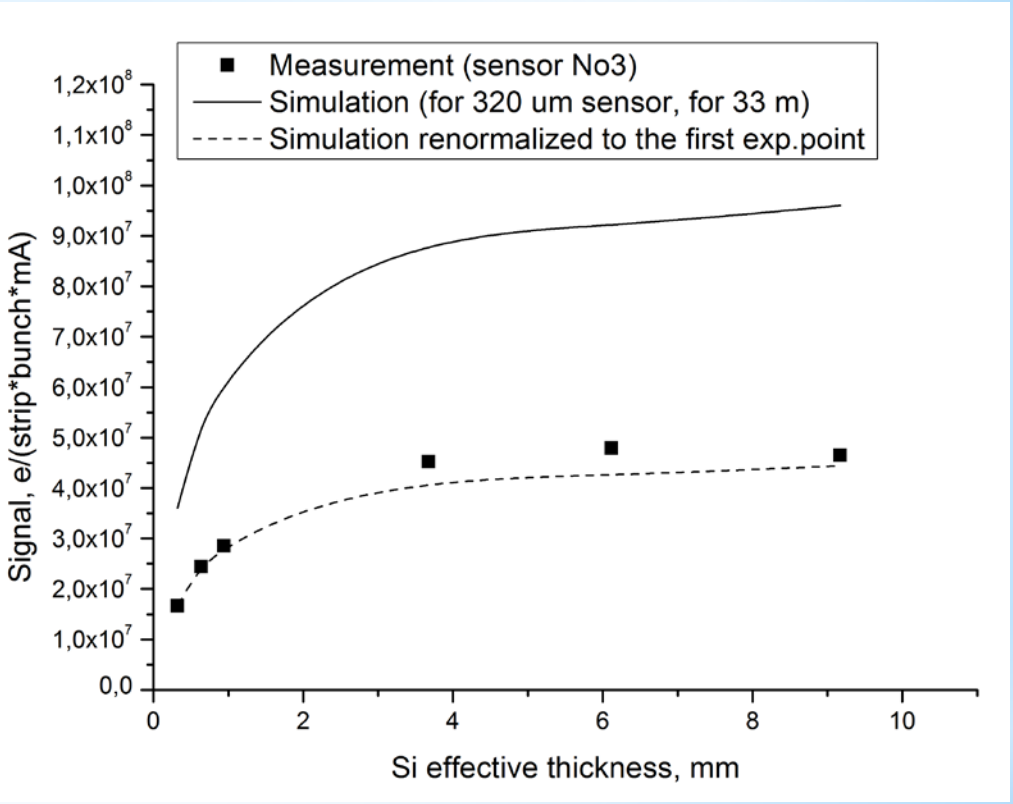
Voltage pulse at 50 Ohm load from one strip, induced by SR flash from one bunch (sensor at 90^{o} , 43 m from source, 10 mA)



Charge from one strip induced by one SR flash, 33 m from the source, 7 mA



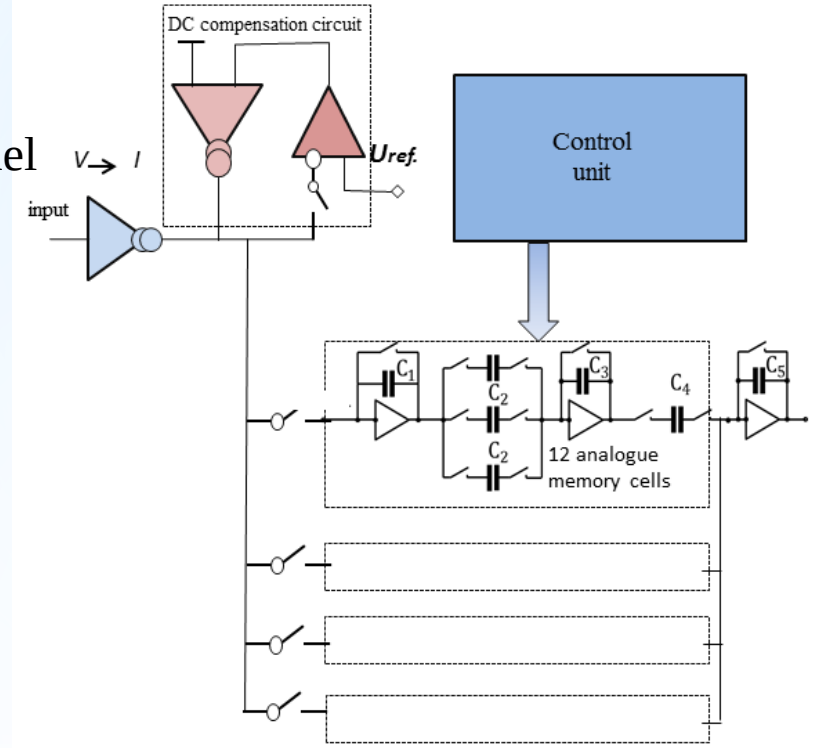
Charge from one strip induced by one SR flash, 33 m from source, 7 mA



Charge from one strip per mA vs Si effective thickness. Measurement and simulation.

DIMEX-Si

Block-diagram of one channel of the ASIC for DIMEX-Si



Prototypes of new ASIC for Si detector were produced in autumn 2015.
At present the detector prototype with Si microstrip sensor and 10 new ASICs (120 channels) is under construction

Conclusions

New ASIC DMXG64A has been developed for the DIMEX-G,
It allows to perform experiments with max. frame rate 10 MHz,
noise at 3000 e and max. signal up to $2x10^6$ e.

Full-size detector with the new chips was assembled and is being tested now.

Si microstrip sensors from Hamamatsu were tested at high intensity SR beam at beam line 8 at VEPP-4M, the sensors demonstrate stable operation with ~10 times higher photon rate than at VEPP-3 beam line 0.

Polysilicon resistors have non-linear behavior and have to be substituted by different technology.

Two kinds of slow components of the signal was found during measurements (~20 ns and ~50 ns) that will make difficult precise measurement of the induced charge within 20 ns, however it is possible within 50 ns.