# Performance of the silicon microstrip detector prototype for ultra-fast imaging with new front-end ASIC

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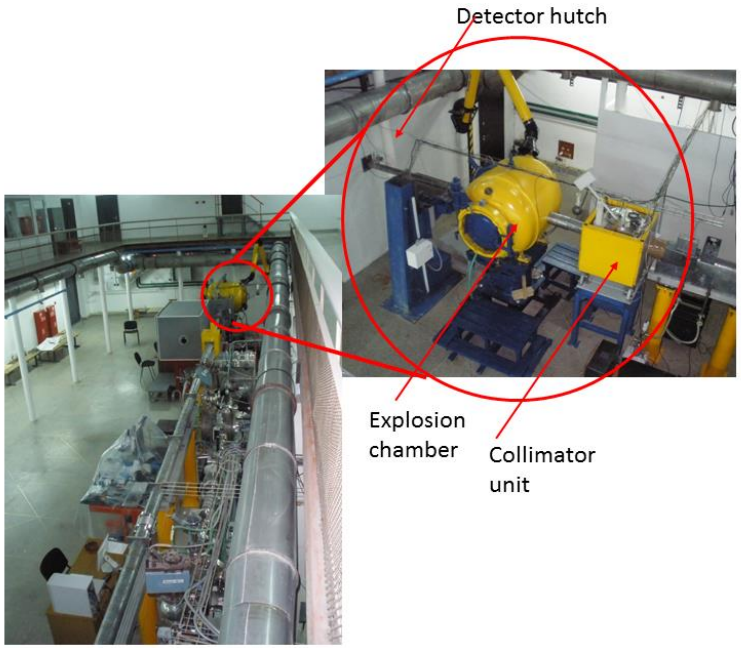
# **Detector for Imaging of Explosions (DIMEX)** is successfully used at beam line 0 at VEPP3 and at beam line 8 at VEPP-4M for more than 15 years

VEPP-4M, beam line 8




VEPP-3, beam line 0

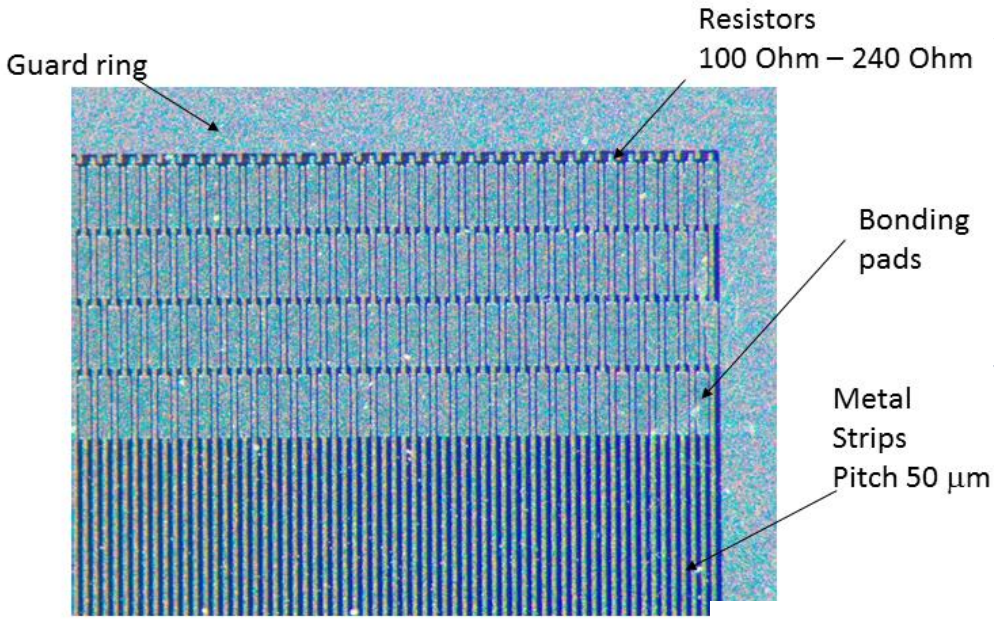
# DIMEX-G

Gaseous 1D detector with new front-end ASIC DMXG64B(A)
Ionization chamber with microstrip readout of electron component
Gas mixture Xe+25%$CO_2$ , 7 atm absolute
Max frame rate - 10 MHz
Number of frames – 100
Maximum signal(electronics) – 2x$10^6$ 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

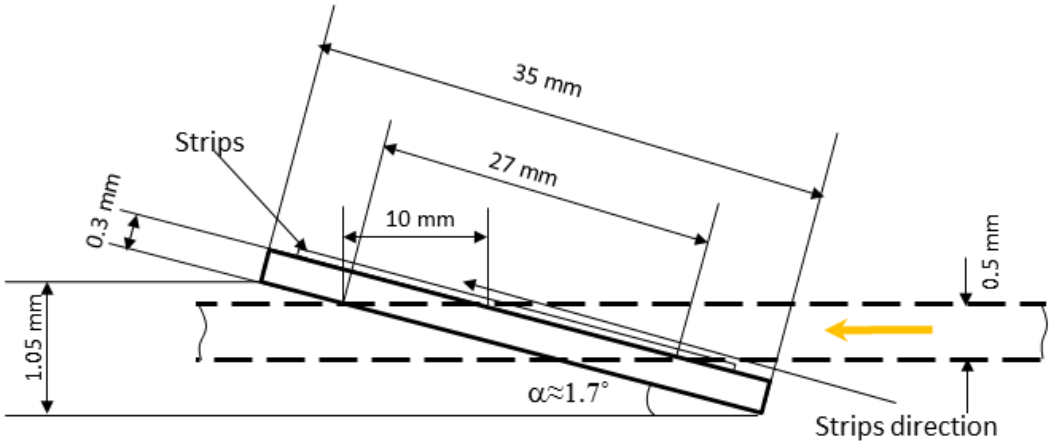
**Maximum detected rate** – limited to ~1000-2000 photons/channel x bunch due to space charge of ions in gas
**Maximum frame rate** – limited due to longitudinal diffusion of electrons and electronics
**Spatial resolution** – limited due to transverse diffusion of electrons

# DIMEX-Si

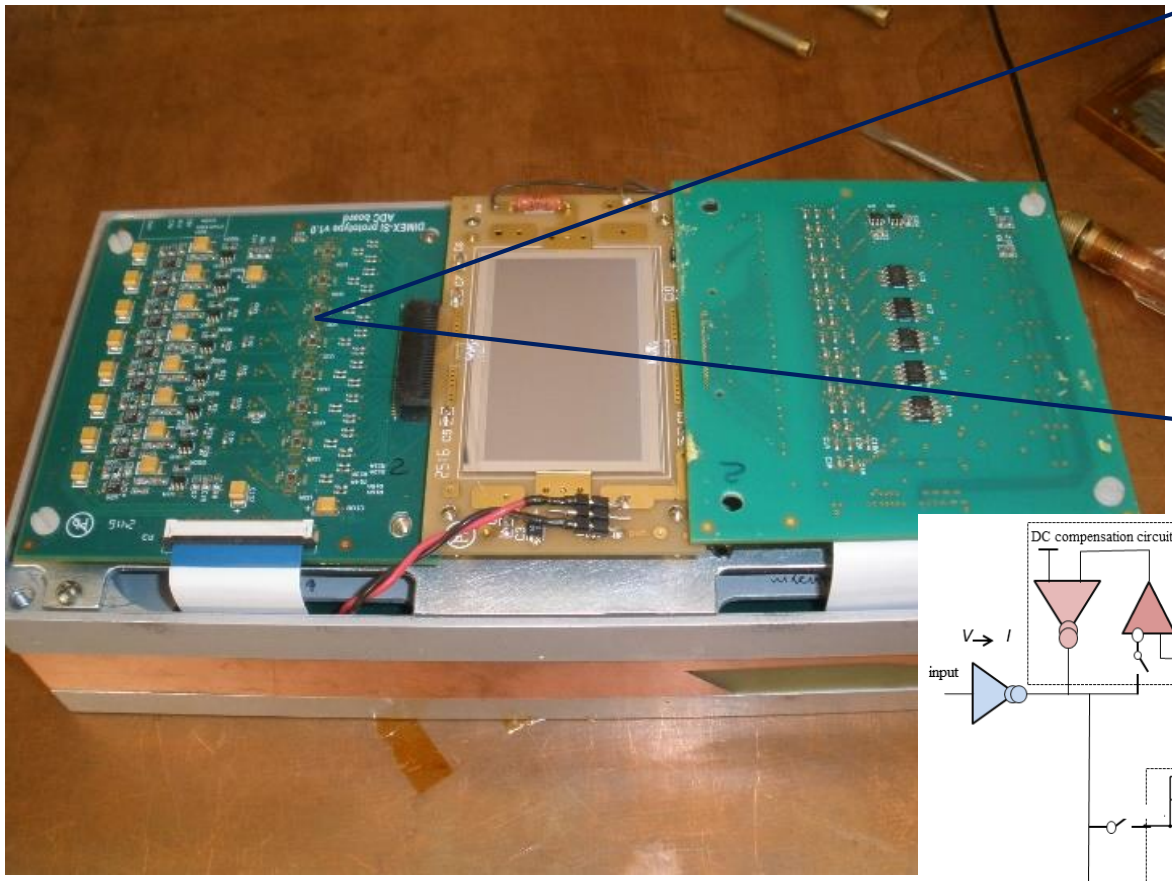


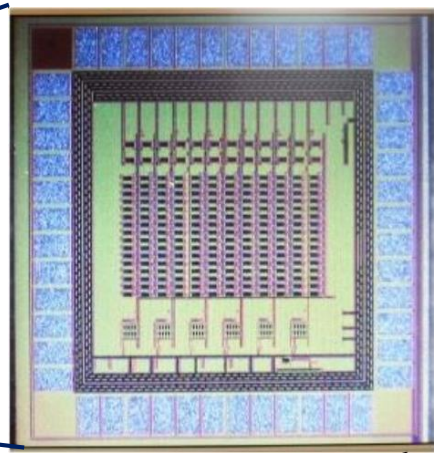

Si microstrip sensors produced by Hamamatsu Photonics
p-in-n technology
DC coupled metal strips
polysilicon resistors between each strip and guard ring
wide guard ring
30 mm long strips
50 μm strip pitch
320 μm sensor thickness

Sensor position in the final detector



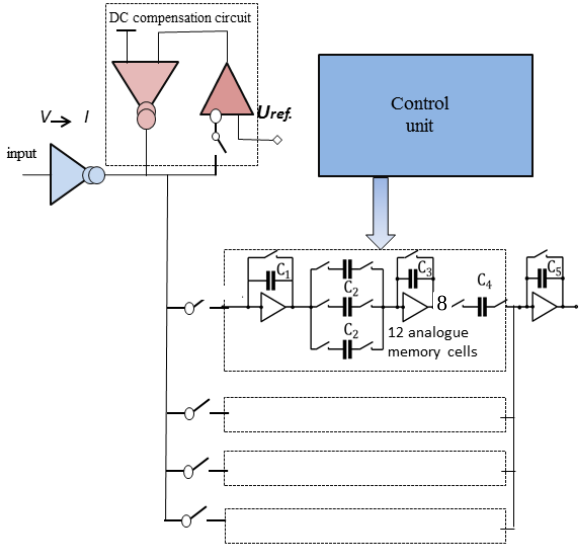
# DIMEX-Si





DMXS6B

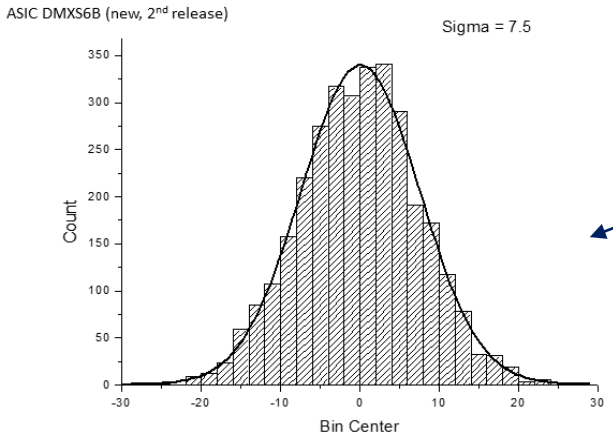
96 channel prototype mounted




Channel structure:

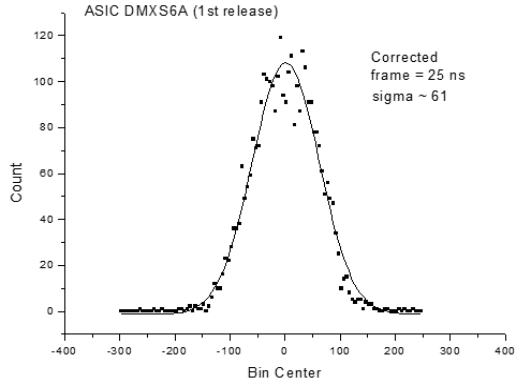
- Input converter voltage -> current
- DC compensation circuit
- Commutator between the input converter and the integrators
- Four integrators with reset
- Analogue memory cells

# First release of DMXS6A ASIC suffered from high noise. This problem was corrected in the second release, the circuit of DC compensation was changed




Distribution of pedestals, corrected for common mode noise for DMXS6B

ASIC DMXS6A (old, 1st release)
Last measurement (2020)




Same for DMXS6A

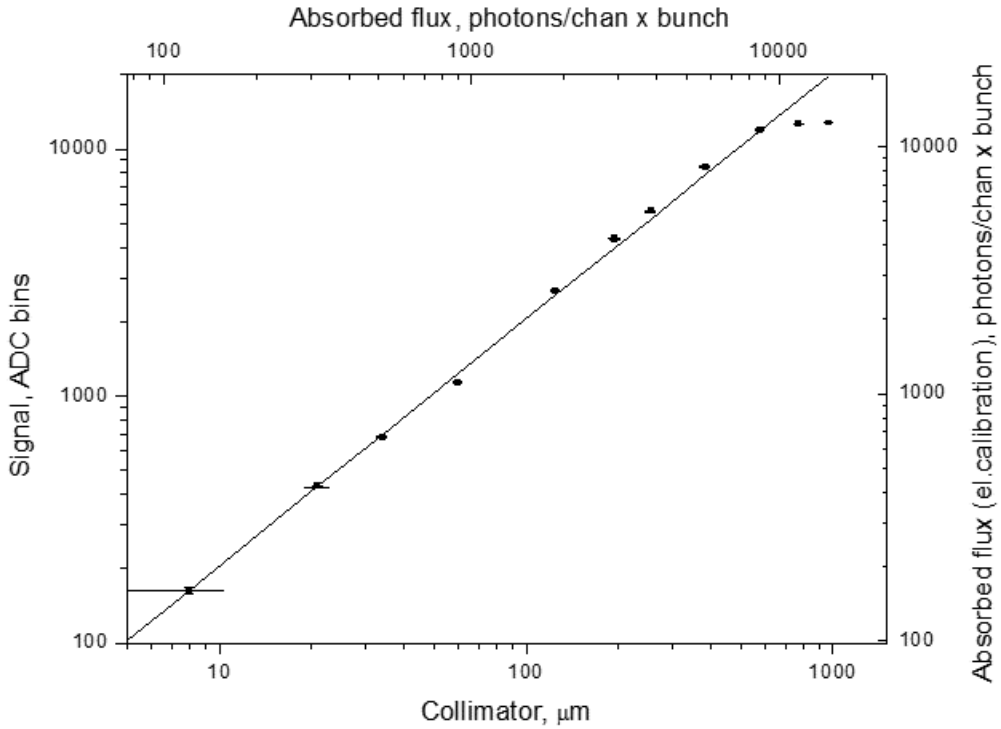
In DMXS6B noise is reduced by a factor of 8, compared to DMXS6A

# Signal from single bunch as a function of the width of SR beam

Signal from single bunches were measured at a different width of the beam (bottom scale).

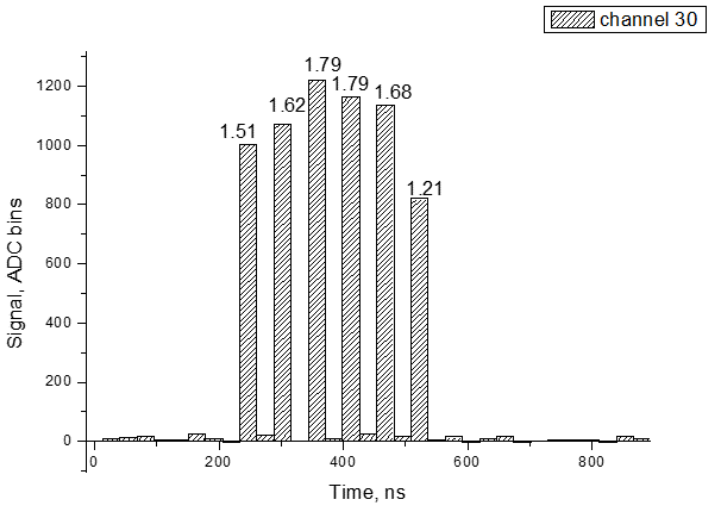
Photon flux absorbed in the detector channel is calculated using measurements from monitoring detector with similar sensor (top scale)

Electronic calibration of ASIC and ADC was also used to calculate absorbed flux in a single detector channel (right scale)

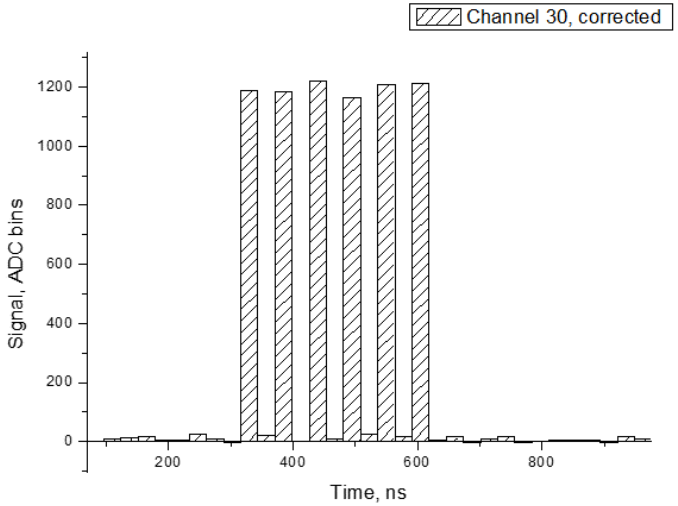



Photon flux was calculated for average photon energy of 26 keV. Maximal flux is ~10000 photons/chan x bunch that is ~8 times higher than the same value for DIMEX-G at VEPP-3. Saturation of the signal occurs due to high current at the input of the ASIC and can be shifted to higher flux by changing the resistive divider at the input.

# Operation in multi-bunch mode with bunches following in ~55 ns
# Detector is operating with frames of 27.5 ns




Raw image from one detector channel
Numbers in the figure are currents of corresponding bunches in mA




Signal from one detector channel as a function of time corrected for different currents of bunches

# DIMEX-Si

## Spatial resolution

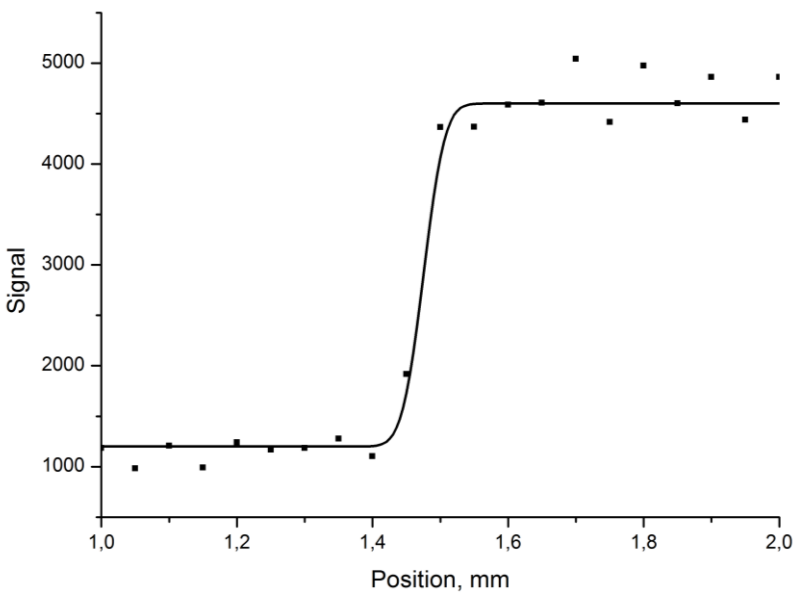
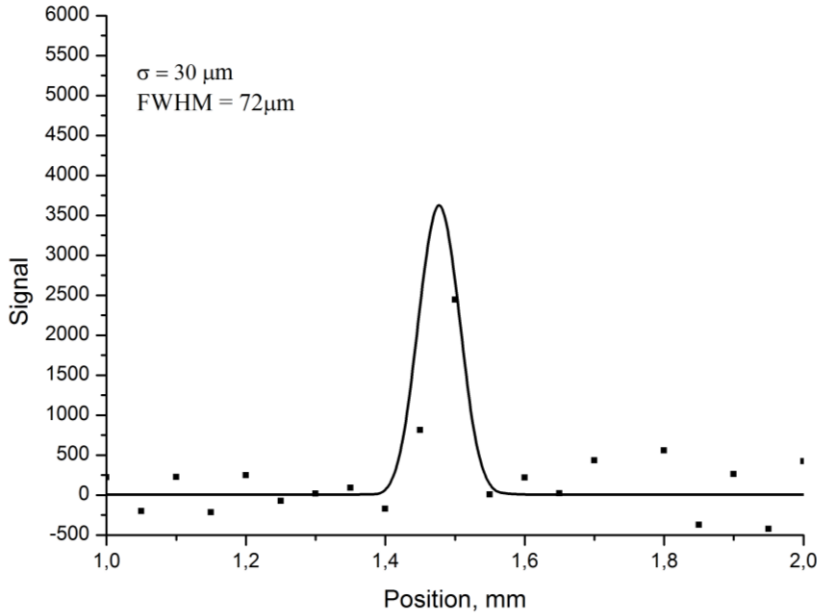



Image of sharp edge (3mm steel) fitted with erf. st.dev. - 30 μm




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

# Summary

- Prototype of the Si detector with 16 DMXS6B ASICs (6 channels and 32 memory cells in each channel) is put in operation and tested at the VEPP-4M;
- DIMEX-Si prototype demonstrated maximum absorbed flux~8 times higher than in DIMEX-G, flux density ~16 times higher, spatial resolution ~3.5 times better (72 μm vs 250 μm) and frame rate 5 times higher (40 MHz vs 8 MHz);
- The problem of high noise is solved in the second release of the front-end ASIC DMXS6B;
- First tests with multi-bunch regime at VEPP-4M showed encouraging results demonstrating that this detector can be successfully used at new SR source SKIF that is under construction in Novosibirsk region