

A 2×32-format hybrid matrix high-speed XUV-detector

V.V. Zabrodskii¹, S.V. Bobashev¹, A.V. Nikolaev¹, A.G. Alekseev², P.N. Aruev¹, E.V. Sherstnev¹

¹ Ioffe Institute, 26 Polytekhnicheskaja St., St-Petersburg, 194021, Russia

² NRC "Kurchatov Institute", Akademika Kurchatova pl., Moscow, 123182, Russia

sildet@mail.ioffe.ru

The importance of high-temperature plasma direct ultrafast visualization system development is due to the need to study the behavior of the impurity in the scrape layer and radiation loss profile dynamics during the development of magnetohydrodynamic instabilities, having a time span of μs . Absorption of VUV, soft x-ray XUV, and HXR spectra [1] in optical window materials does not allow direct visualization of fast processes in plasma without the use of detectors placed just inside the tokamak. A 2×32-format hybrid matrix high-speed XUV-detector for high-speed detection of high-temperature plasma radiation profile is presented ($E=1 \dots 10^4$ eV). The detector includes silicon SPD XUV photodiodes, preamplifier, system of data digitizing and transmission from a tokamak with a frame for 2 μs and continuous recording up to 4 seconds. The experience of using the previous 16×16-format hybrid matrix XUV detector model in tokamaks T-11M and Globus-M is taken into account when developing [2,3].

1. ISO 21348 Definitions of Solar Irradiance Spectral Categories

2. "Investigation of the plasma jet penetration into the plasma on the Globus-M tokamak" A.D. Sladkomedova, A.N. Voronin, A.G. Alekseev, V.K. Gusev, G.S. Kurskiev, Yu.V. Petrov, N.V. Sakharov, S.Yu. Tolstyakov and V.V. Zabrodsky, [Physica Scripta](#), [Volume 93](#), [Number 10](#), 2018

3. "Tomography diagnostic of plasma radiated power on the spherical tokamak Globus-M" A.D. Sladkomedova, A.G. Alekseev, N.N. Bakharev, V.K. Gusev, N.A. Khromov, G.S. Kurskiev, V.B. Minaev, M.I. Patrov, Y.V. Petrov, N.V. Sakharov, P.B. Shchegolev, V.V. Solokha, A.Y. Telnova, S.Y. Tolstyakov, V.V. Zabrodsky, 2018, [Rev. Sci. Instrum.](#), v.89, 8

The results of using the previous 16×16-format hybrid matrix XUV detector model in tokamak T-11M

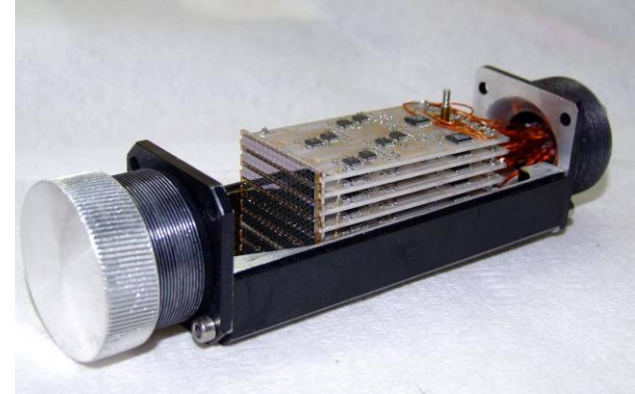
Fast 16x16 hybrid matrix array based on SPD photodiodes is implemented for direct 2D plasma imaging with the frame rate up to 1Mfps [1]

- optimum compromise between the response uniformity and the radiation hardness, the read-out cycle frequency (frame rate) and the spatial resolution (pixel No)
- vacuum compatibility, limited number of vacuum feedthroughs, ability to withstand thermal baking at 150-200°
- the frame rate up to 10^6 s^{-1}
- the total matrix array front size is $31 \times 31 \text{ mm}$ with ~25% filling factor (single element size $0.88 \times 1.22 \text{ mm}$) (fig.2)

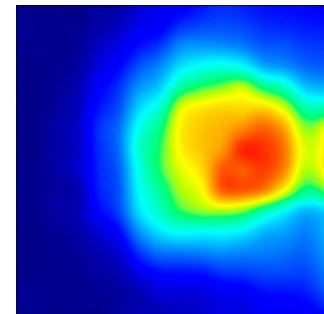
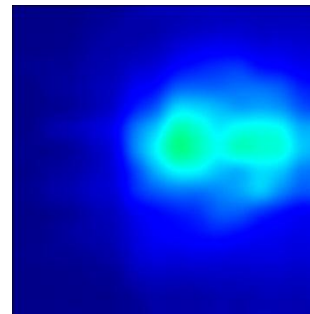
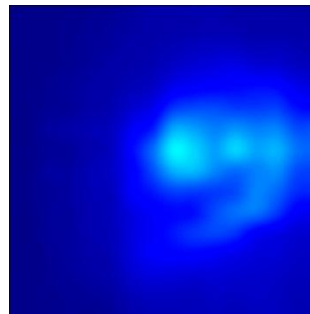
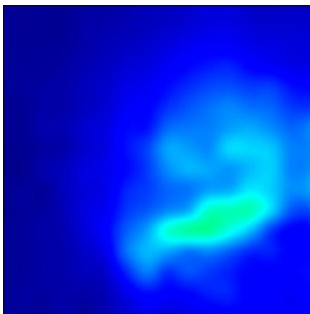
The external data acquisition system (DAS) External Each ADC channel has a 64 MB on-board memory limiting the acquired period to 3.2 s at 1.25 Mfps frame rate. A common TCP/IP Ethernet protocol is used for the data transmission to main PC operating as a DAS control console, data preview and storage computer.

Post-acquisition processing includes the following stages:

1. Calculation and subtraction of the offset levels ("black level" balance).
2. Recovery of the signals of two broken photodiodes (interpolation).
3. Image smoothing by interpolation to 160×160 pixels.
4. Transformation into the AVI -files and into a specific file format for the combined data visualization software.



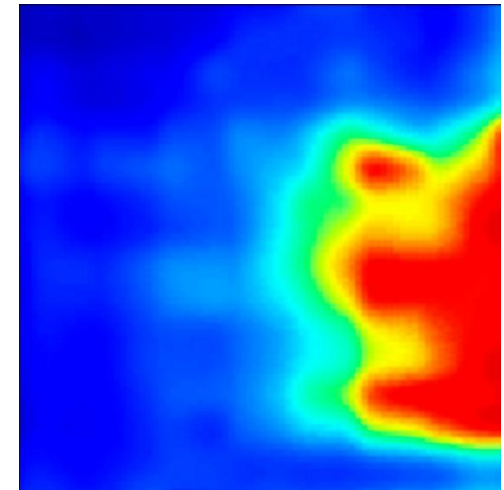
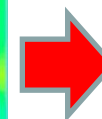
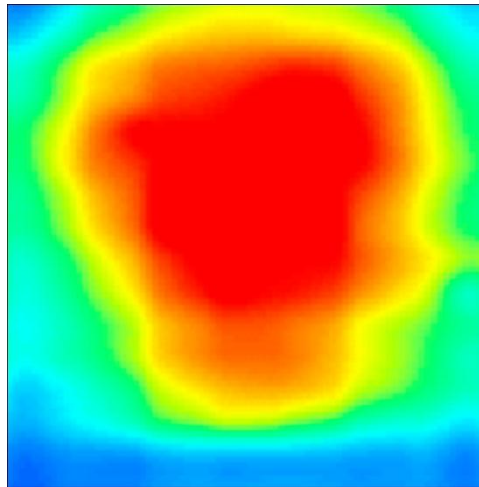
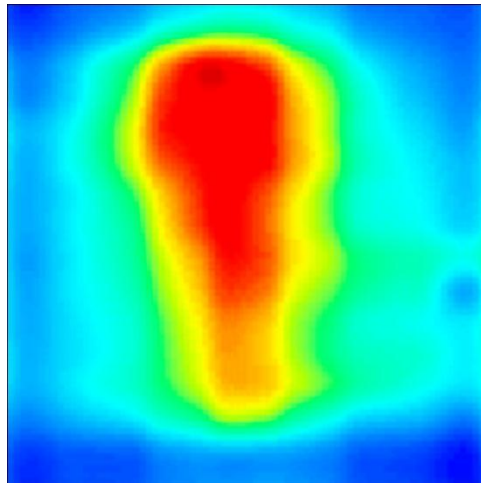
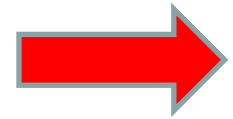
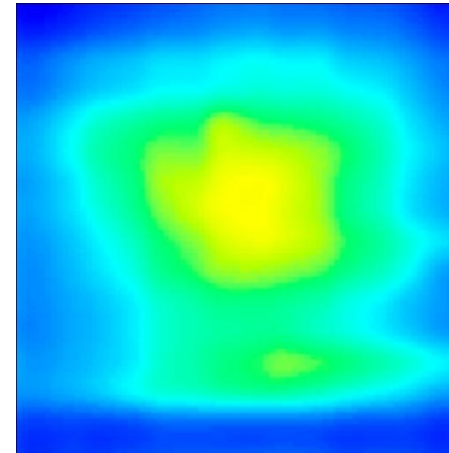
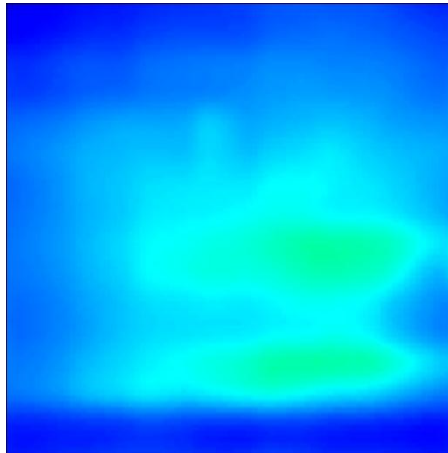
**16×16-format hybrid matrix (38x38x155 mm)
(vacuum part)**



Fast direct 2D plasma visualization in tokamak (T-11M)

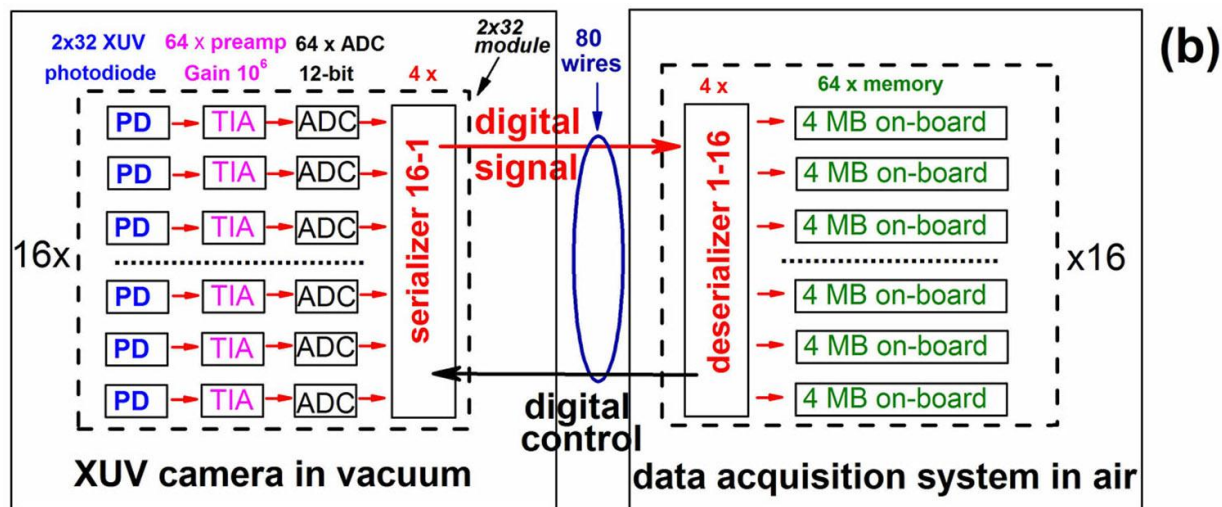
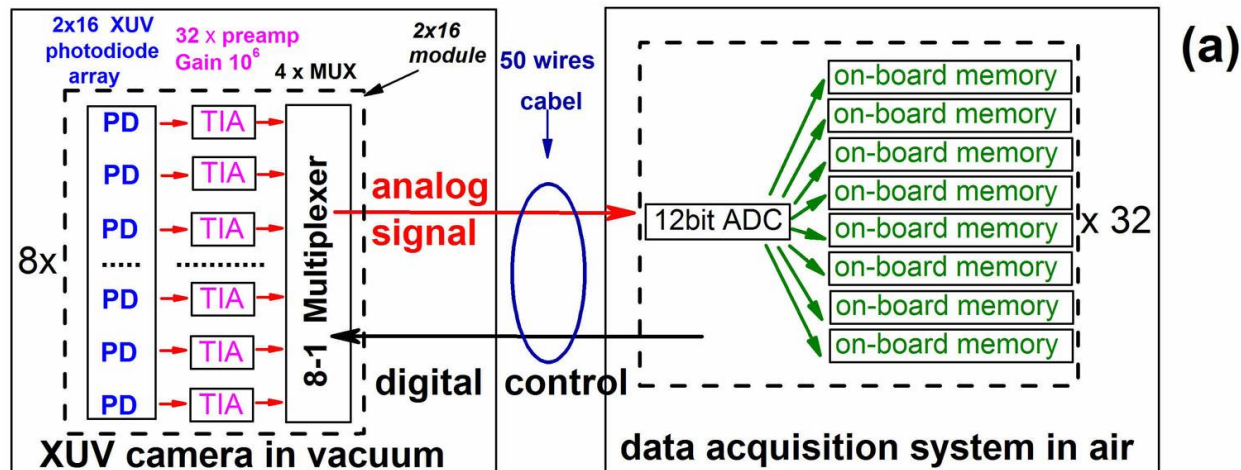
The results of using the previous 16×16-format hybrid matrix XUV detector model in tokamak Globus-M [1]

Dynamic of plasma: generation, stabilization and collapse

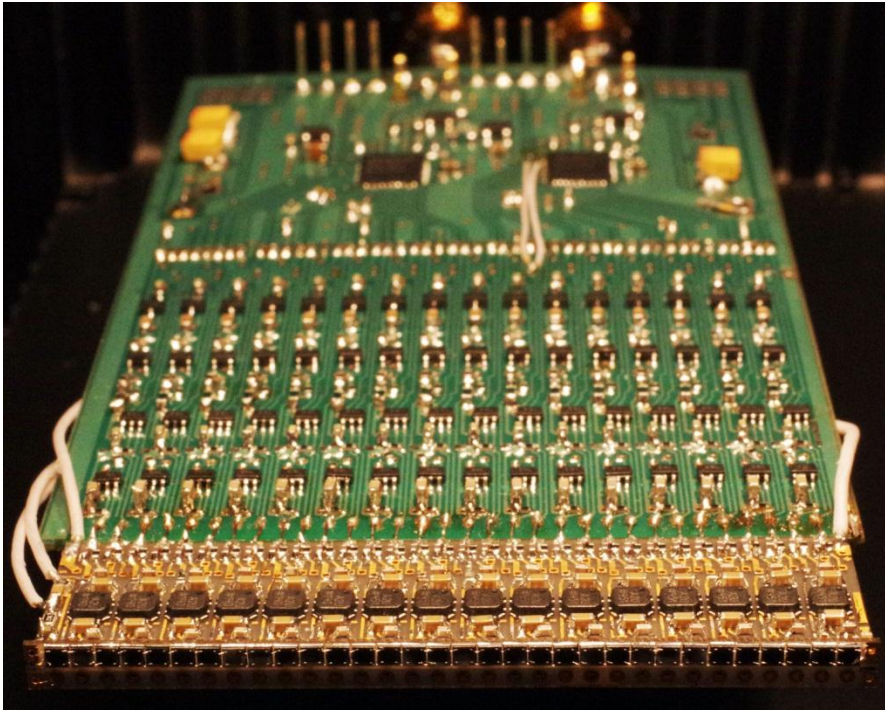


1. "Tomography diagnostic of plasma radiated power on the spherical tokamak Globus-M" A.D. Sladkomedova, A.G. Alekseev, N.N. Bakharev, V.K. Gusev, N.A. Khromov, G.S. Kurskiev, V.B. Minaev, M.I. Patrov, Y.V. Petrov, N.V. Sakharov, P.B. Shchegolev, V.V. Solokha, A.Y. Telnova, S.Y. Tolstyakov, V.V. Zabrodsky, 2018, Rev. Sci. Instrum., v.89, 8

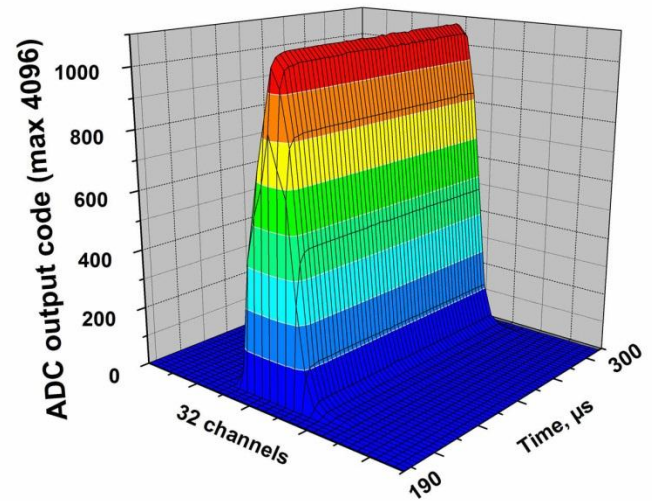
The block diagrams of the implemented 16×16-format hybrid matrix and the perspective 32×32-format hybrid matrix in order increase the resolution



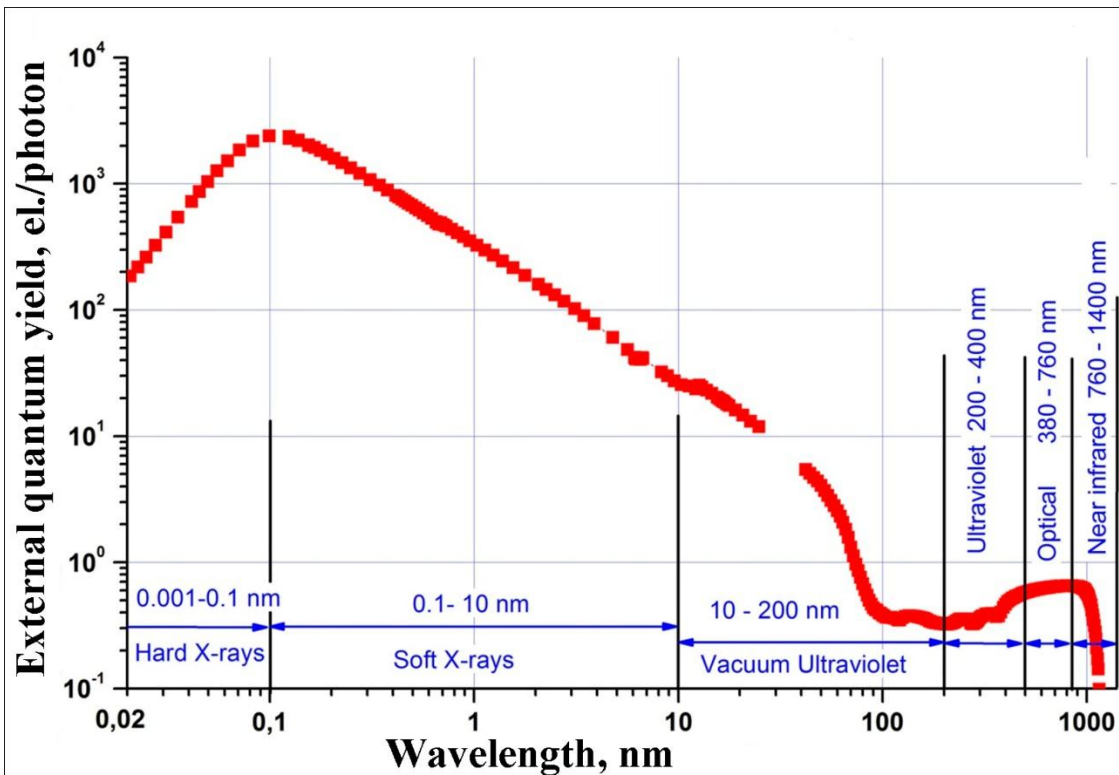
The 1×32 module prototype of the perspective 32×32-format hybrid matrix



The first time and dynamic range tests (620 nm LED pulse) of the 1×32 module prototype



The results of SPD XUV photodiodes [1] absolute sensitivity calibration in a 1 - 60 000 eV quantum energy range in PTB (Berlin) and **calibration certificate's** →



**Calibrated SPD XUV photodiode
10x10 mm active area**



1. "Characterization of spatial homogeneity of sensitivity and radiation resistance of semiconductor detectors in the soft X-ray range" P.N. Aruev, Yu.M. Kolokolnikov, N.V. Kovalenko, A.A. Legkodymov, V.V. Lyakh, A.D. Nikolenko, V.F. Pindyurin, V.L. Sukhanov, V.V. Zabrodsky Nucl. Instrum. Meth. Phys. Res. A **603**, 58 (2009)

P.N. Aruev acknowledges support from RFBR grant 16-29-13009-ofi-m..