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Design and parameterisation of a pinhole camera and selection of the X-ray source energy for the GEM based X-ray fluorescence imaging system

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The basic principle of an X-ray imaging system based on a large area 10cm x 10cm GEM (Gas Electron Multiplier) detector equipped with 2-dimensional readout and its application to mapping of pigment distributions in historical paintings using X-ray fluorescence technique has been already demonstrated in our previous works. The key components of the developed system are: X-ray tube, adjustable pinhole camera to project the fluorescence radiation on the GEM detector, custom-designed front-end integrated circuits, FPGA based data acquisition system, and software. The system is fully functional and recently new features have been added to make in more versatile. In this paper we report on further studies and optimisation of the system performance with particular focus on the pinhole camera design and the X-ray energy used for excitation of fluorescence radiation.

For selecting the geometry of the pinhole camera one has to consider a fundamental trade-off between the spatial resolution and the yield of radiation projected on the detector, which translates directly into the measurement time required to obtain images of satisfactory quality. A new pinhole design with adjustable height and exchangeable pinhole plates (with different hole diameters) has been implemented. The experimental results on the spatial resolution for different pinhole camera configurations will be presented and compared with analytical predictions. Furthermore, possible improvements of the X-ray projection set-up by implementation of a multi-hole camera will be discussed and the measurement results obtained for such a set-up will be presented.

The effects of the energy of exciting radiation on the imaging performance will be discussed and comparison of images obtained with different X-ray tubes, with molybdenum and copper anodes, will be presented. Further possible improvements of sensitivity of the imaging system by combining images obtained for different energies of exciting X-ray primary beam and different energy windows optimised for detecting specific elements will be presented.

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