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Physics and Electronics Simulations of the Large Pixel Detector at EuXFEL

A. Joy[1], M. French[2], M. Hart[2], P. Seller[2], M. Wing[1]

1. Department of Physics and Astronomy, UCL, Gower Street, London, WC1E 6BT

2. Rutherford Appleton Laboratory, Harwell Oxford, Didcot, OX11 0QX

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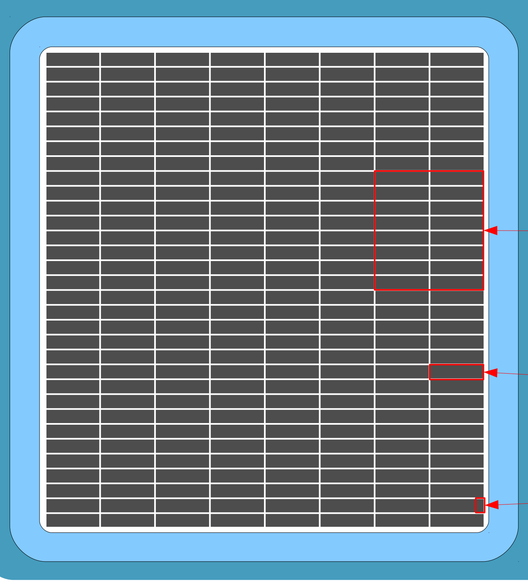
HORUS_LPD is a software tool written in Interactive Data Language (IDL) that simulates the physics and electronics response of the Large Pixel Detector (LPD), a 1 Megapixel X-Ray camera under development at Rutherford Appleton Laboratory (RAL) for use at the European X-Ray Free Electron Laser (XFEL).

From an array describing the photons incident on the detector, HORUS_LPD generates the complete picture that will be delivered to the user.

The program was developed from HORUS, the tool built to simulate LPD's sister detector AGIPD.

The Large Pixel Detector



The full LPD will consist of 16 super-modules in a 4x4 grid, each with a Front End Module (FEM). Currently 4 super-modules are complete, making a quadrant detector that will be used for testing.

Each super-module consists of 16 modules in an 8x2 grid, the FEM receives timing signals from the C&C system, controls the modules, receives data from the ASICs, processes the data and outputs to the train builder.

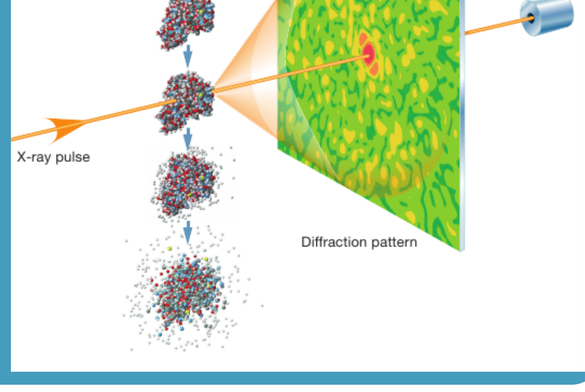
Each module has 8 ASIC chips in a line bonded to a single silicon strip. The spacings between every module, whether on the same super-module or not, is always 2mm.

Each ASIC connects to a 32x16 pixel grid, and for each pixel stores three signals at three gain values for up to 512 pulses per bunch train. Each pixel is a 500x500x500nm cube.

Experimental Layout

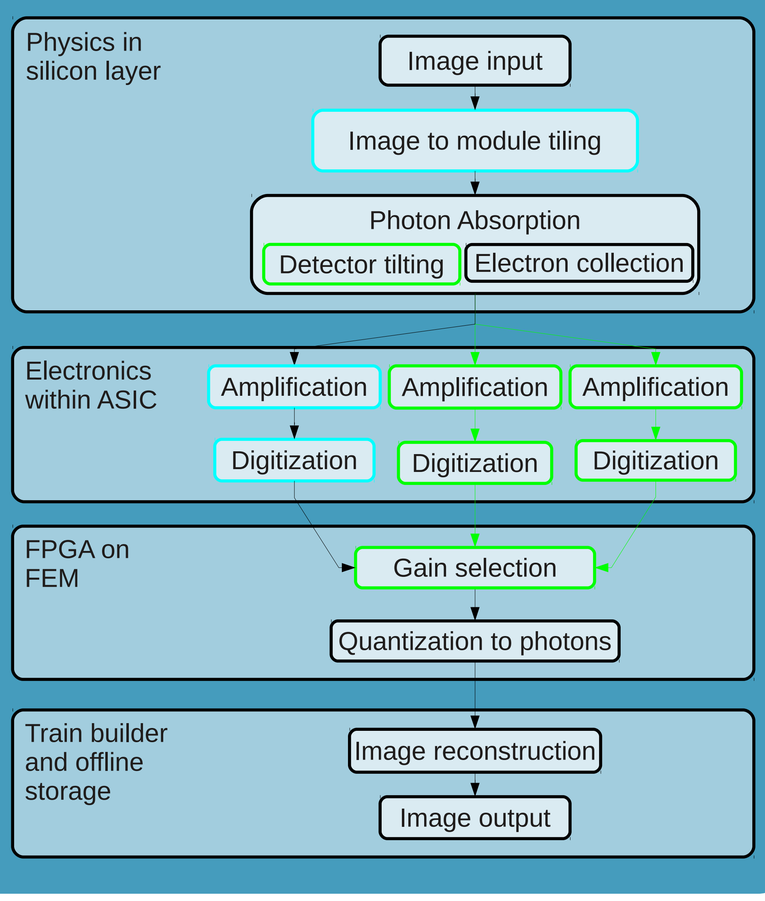
The European X-Ray Free Electron Laser is currently under construction at DESY in Hamburg. The facility will produce high brilliance X-Ray laser light down to 0.05nm wavelength for producing diffraction images of small structures.

LPD has three different gain values for the charge it collects and the ability to set the capacitors in the amplifier of each pixel to either 5pF or 50pF, this gives it both single photon sensitivity and a maximum signal of 1.2GeV per pixel, or 100,000 photons at its nominal operating energy of 12keV. All results presented below were made at 12.4keV.



The HORUS_LPD simulation of LPD

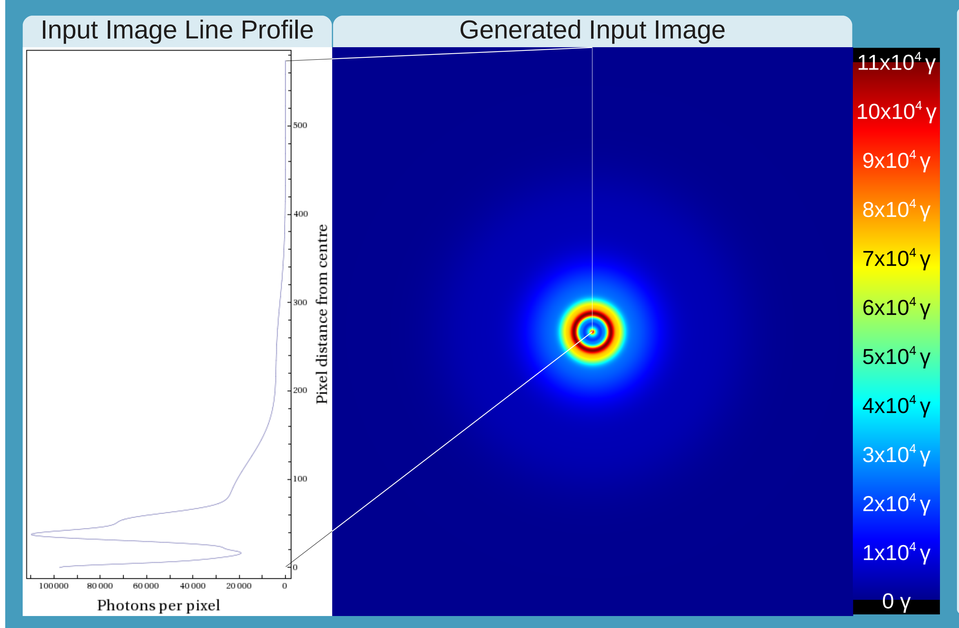
The flowchart to the side shows the steps that build up the simulation of LPD in HORUS_LPD, labels the steps that have been modified or added compared to HORUS and indicates where each process corresponds to on the real detector.



HORUS code modified in HORUS_LPD

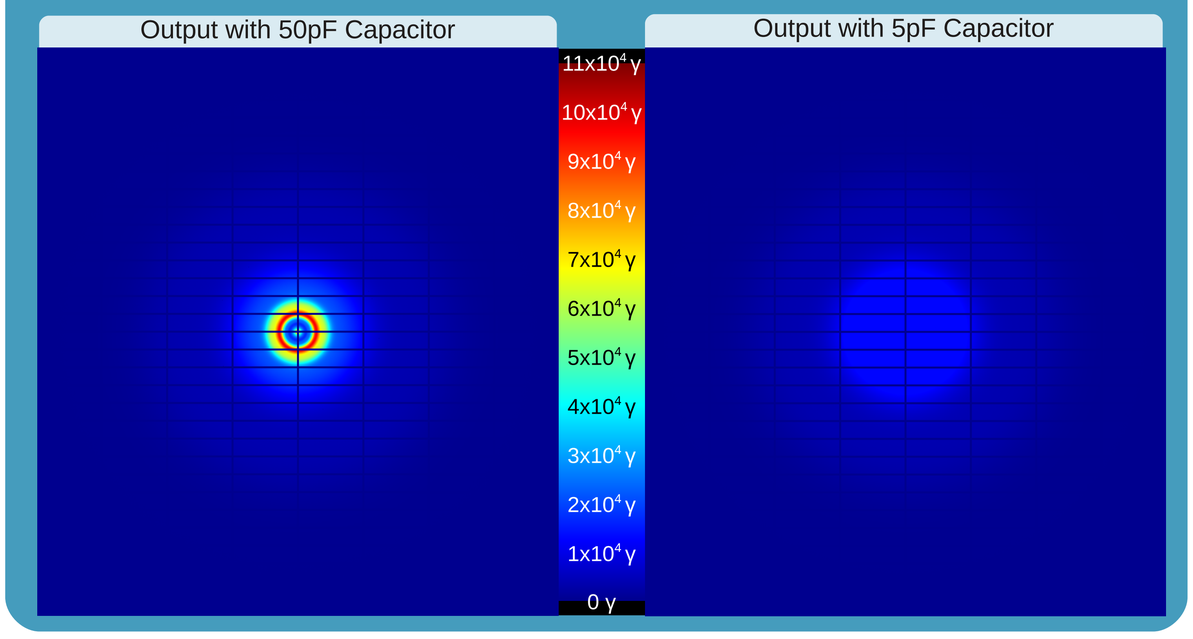
New code added in HORUS_LPD

Input Generation and Output

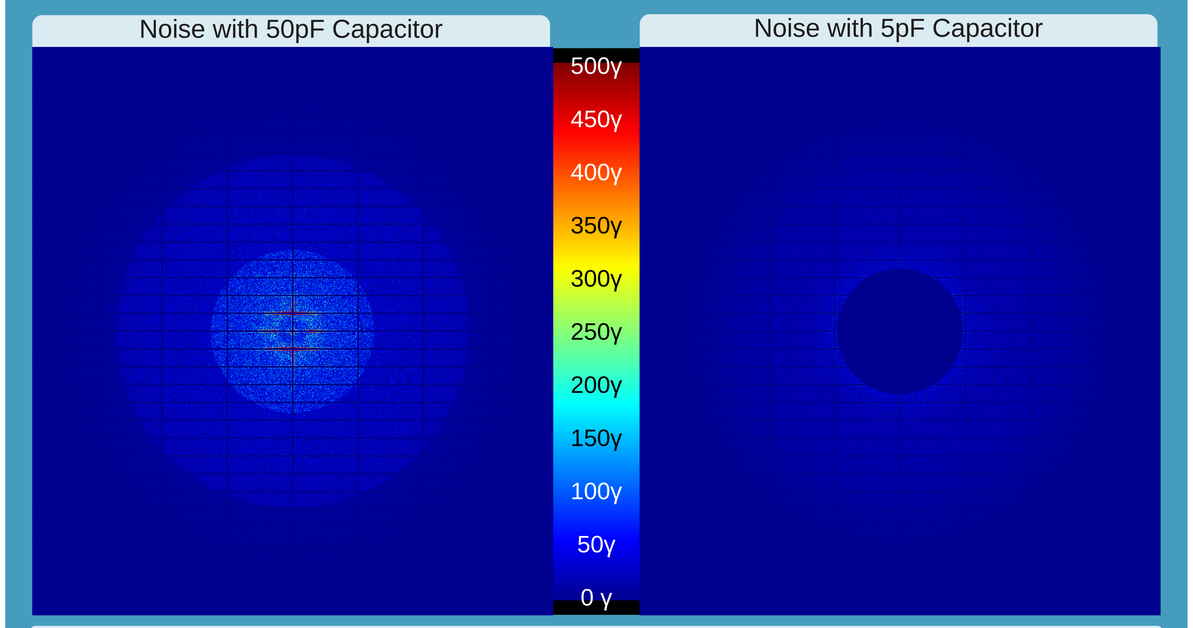


The graph on the left shows the intensity line profile of the input image to the radius from the centre. Where this corresponds to is indicated on the input image.

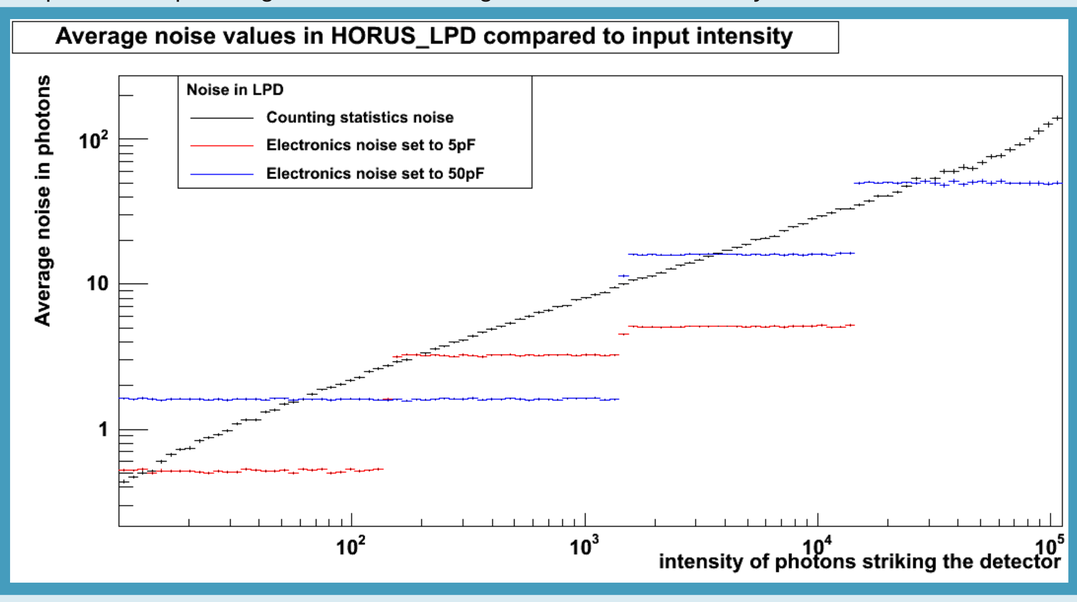
Below are the output images delivered to the user when set to 50pF or 5pF (each pixel can be set independently on the detector).



Noise on the Output



The images above are the noise on the output image, the amplitude of the difference between the input and output images after accounting for detector inefficiency.



The histogram above shows noise due to counting statistics, noise due to electronics when set to 5pF and noise due to electronics when set to 50pF across the dynamic range of the detector.

Future Plans

A Geant4 model of LPD is currently under development, which will be used to model radiation dosage levels and the rate of fluorescence in the materials used to make the modules.
A total replacement for HORUS_LPD, written in C++ and integrated into the XFEL suite package at EuXFEL is in the planning stages. This would model all three detectors at XFEL.

a.joy@ucl.ac.uk
Marcus.french@stfc.ac.uk
Paul.seller@stfc.ac.uk
mw@hep.ucl.ac.uk