# High dynamic range radiation detector

Description:

The chip was designed to be used in cancer treatment facilities, for Quality Assurance as well as for monitoring of the beam during irradiation.

The sensor bases its operation on the integration of the charge generated by the radiation. When the charge surpasses a threshold, a known amount of charge is pumped out from the amplifier. By counting (8-bit counter) how many pumps were generated and the time difference between the first and last pump (also an 8-bit counter), it is possible to calculate the charge generated by the particle, and thus the energy of it.

The chip consists of a matrix of 24x24 pixels, with a pixel size of 200x200 μm, with a fill factor of 80%. It is bonded to a PCB, which is connected via a GECCO board to an FPGA. Using a Qt software developed for the GECCO board, it is possible to configure, control, and read the sensor
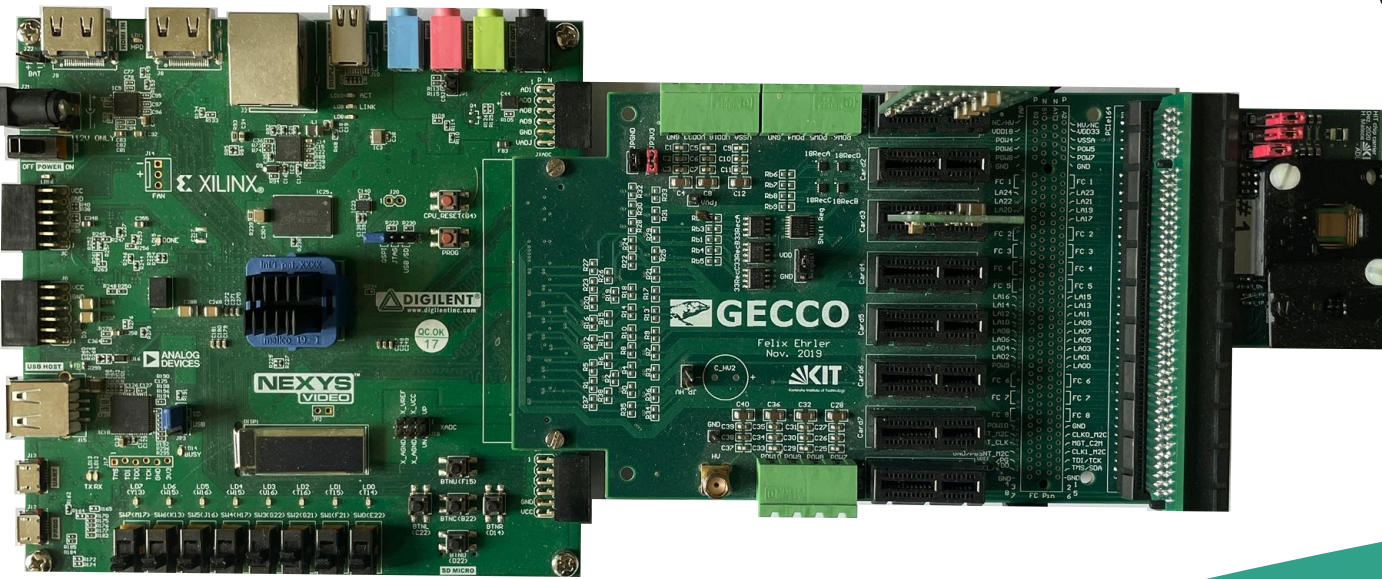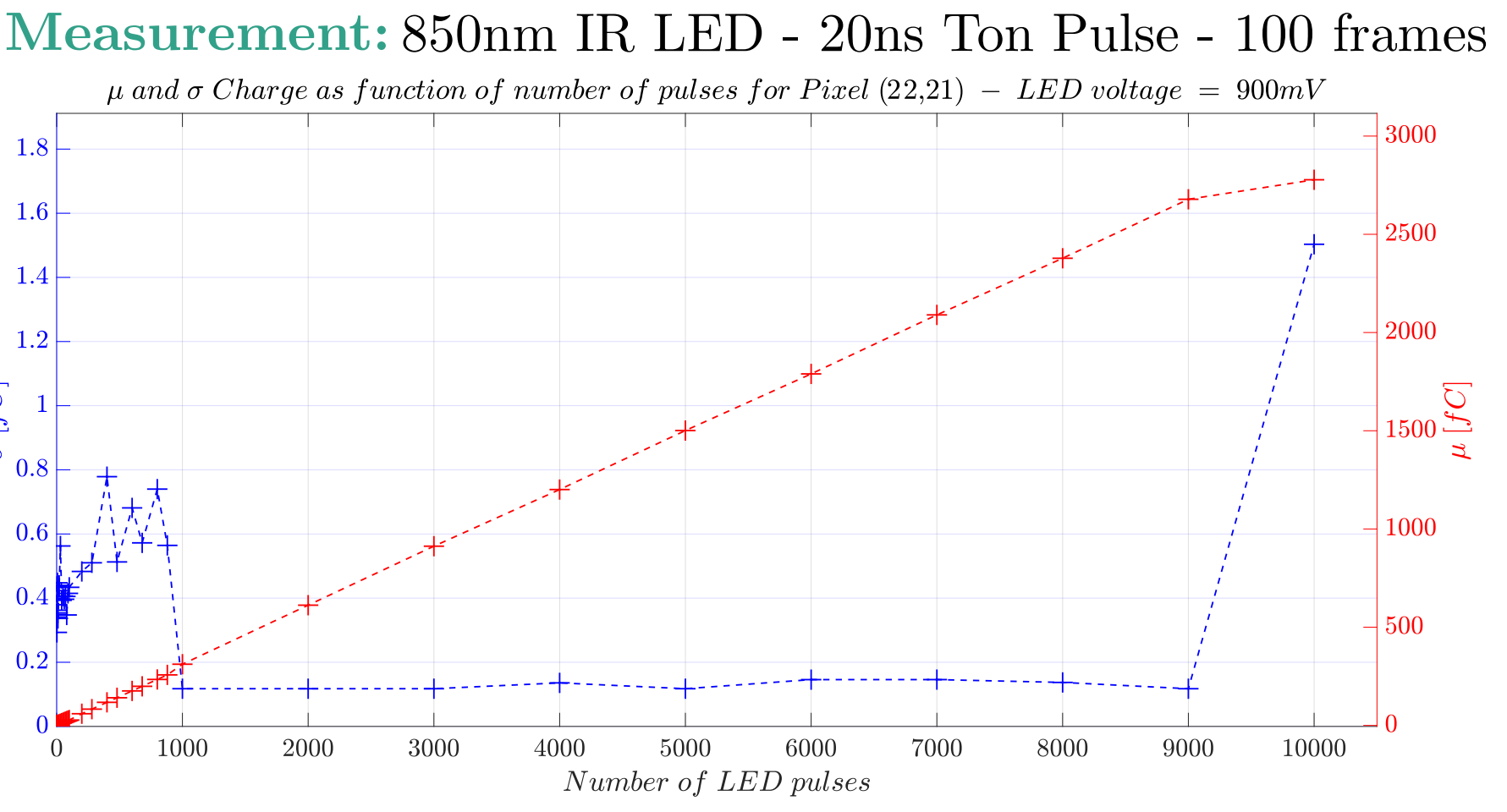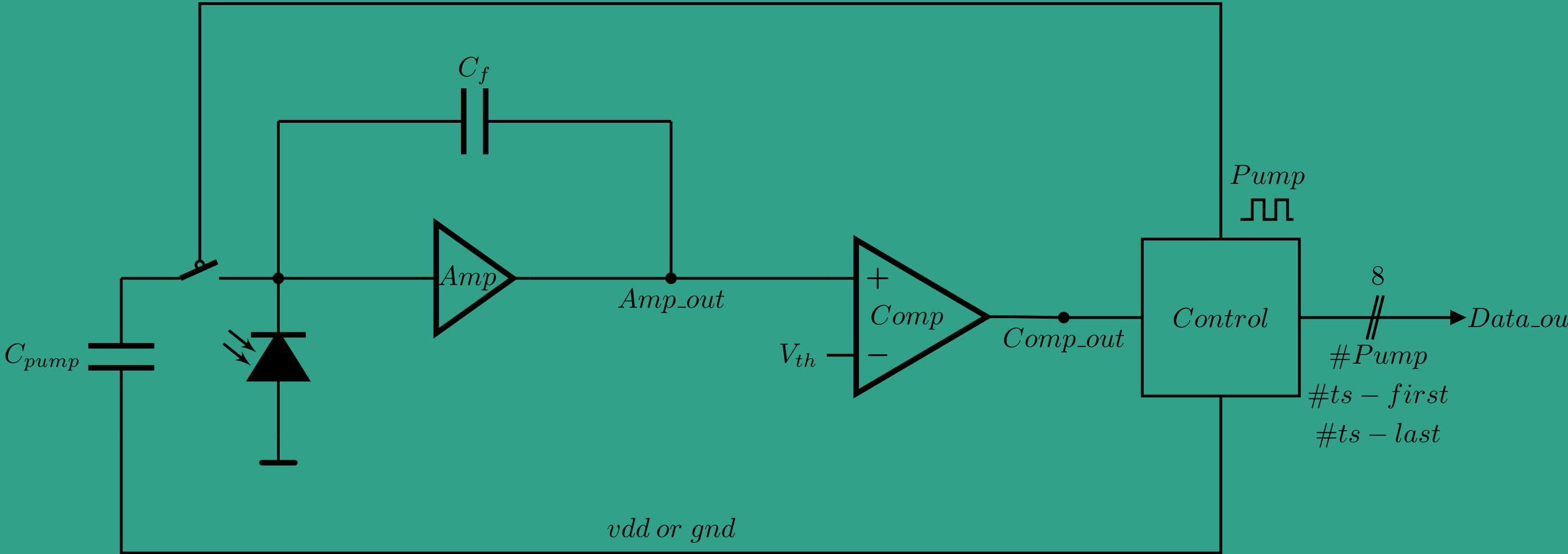
Conclusions:

- The sensor presents a linear response along the whole dynamic range.
- It shows a noise floor of 0.8 fC, equivalent to 5000e-, which decrease to 0.1 fC or 620e- at higher intensities.
- Because the system is based on a discharge pump counter, the integrator will not be saturated, which makes possible to measure particles of high energy.
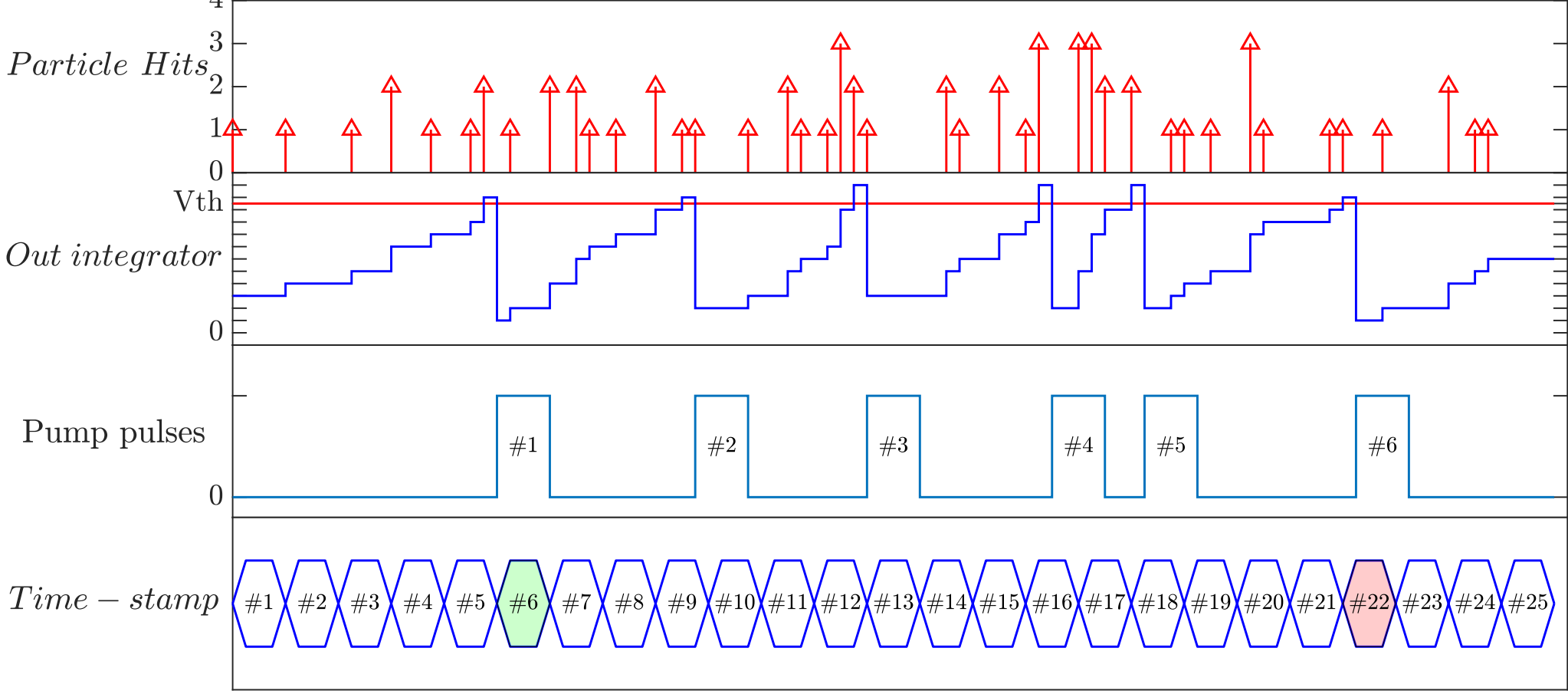
Future improvements plans:
- Different discharge capacitance.
- Different capacitor voltage.
- Bigger counters.
- Bigger matrix size.
- Read while measuring.
- Using other technology to achieve higher fill factor

Measurement: 850nm IR LED - 20ns Ton Pulse - 100 frames

μ and σ Charge as function of number of pulses for Pixel (22,21) − LED voltage = 900mV
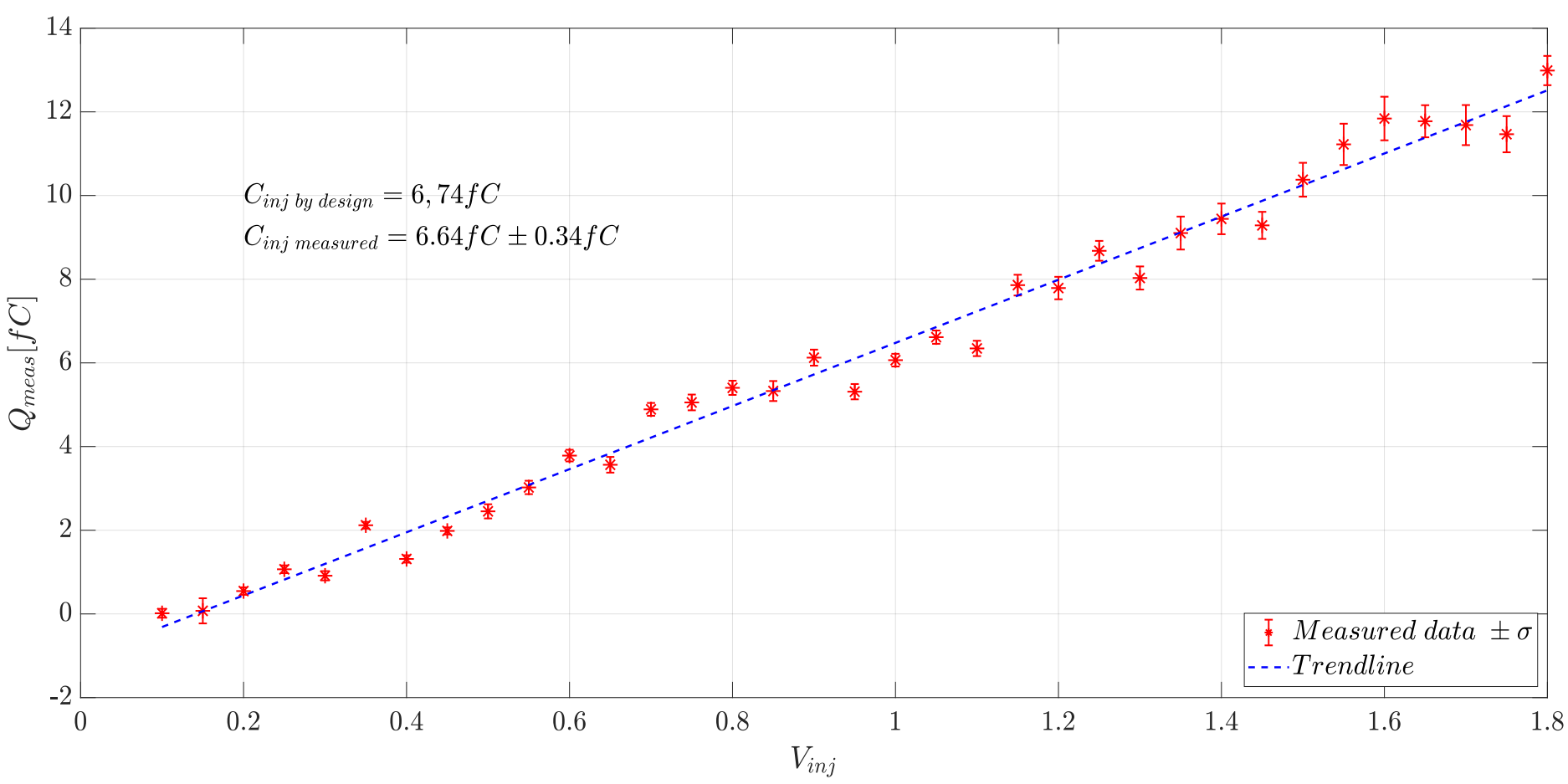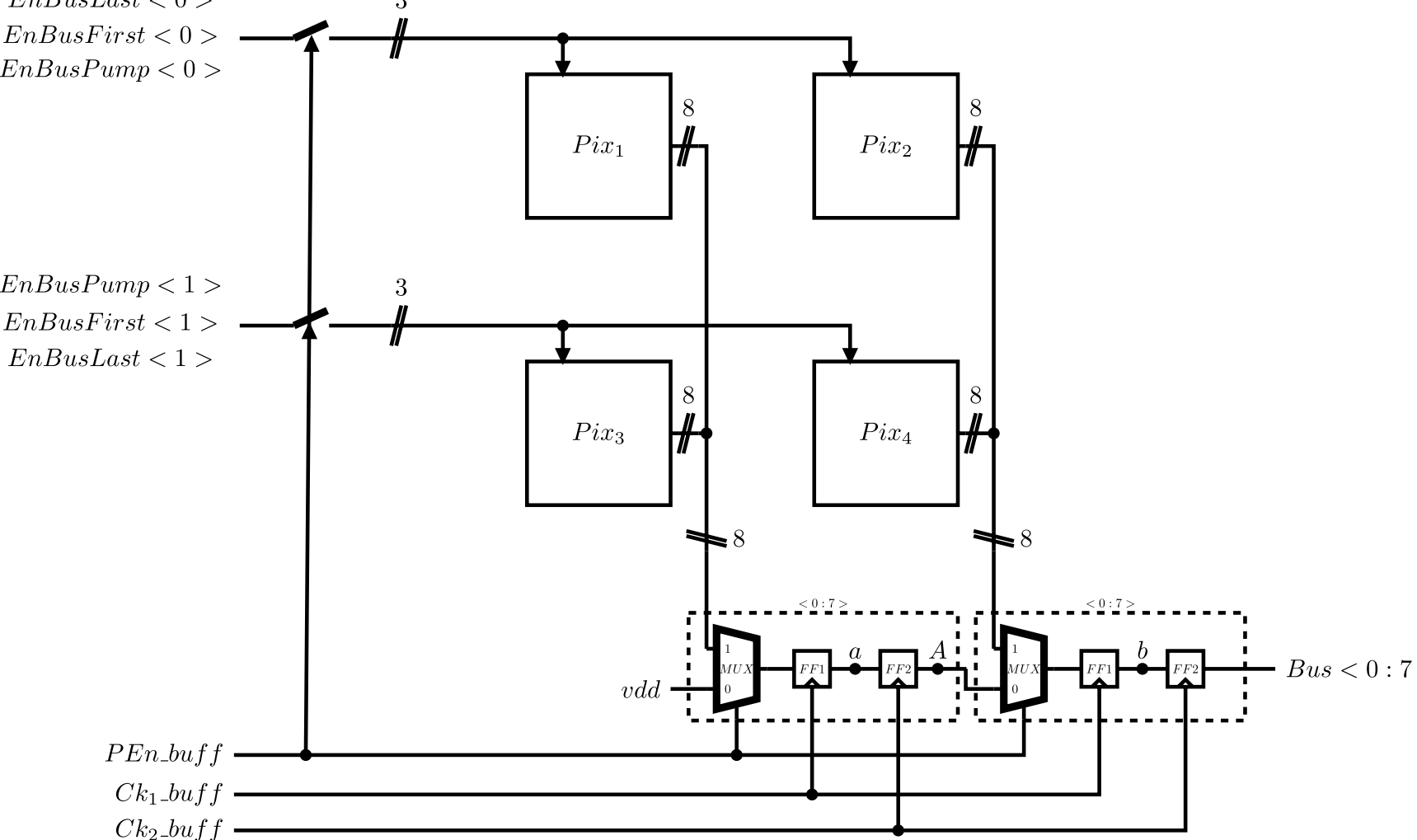

Example of measuremente method

$$Q_{hit} = Q_{pump} \left[(N-1) - (N_{pump\_dark} - 1) \frac{\Delta T_{hit}}{\Delta T_{dark}} \right]$$

Measurement of Pump Capacitor

$C_{inj\ by\ design} = 6,74fC$
$C_{inj\ measured} = 6.64fC \pm 0.34fC$

Matrix topology example

4,8 cm - 24 Pix

4,8 cm - 24 Pix

$200 \times 200\ \mu m^2$