Testing of the new VIPIC chip for X-photon counting applications

Intern: Pietro Peronio [1]
Supervisor: Grzegorz W. Deptuch [2]

[1] Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy

[2] Particle Physics Division ASIC Development group, Fermilab, Illinois, USA

September 24th, 2014

Summary

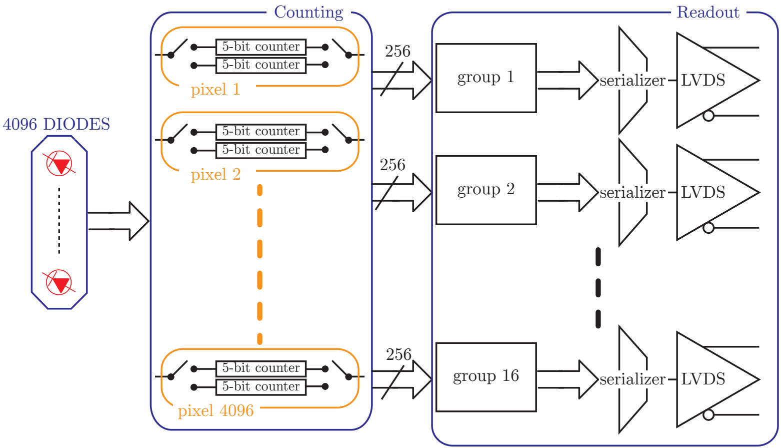
Training program

The intern will be involved in the testing process of a new kind of readout circuit (VIPIC chip) designed in a novel 3D-IC technology by the Fermilab Application Specific Integrated Circuit (ASIC) Development group

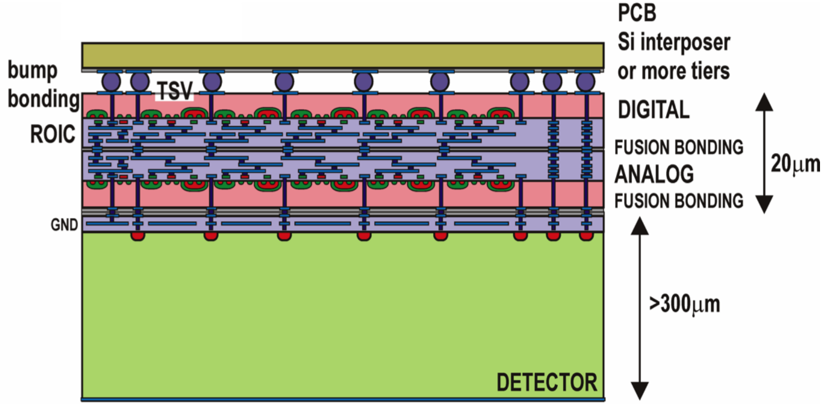
Tasks

- The intern will learn the structure and the working principle of the new Vertically Integrated Photon Imaging Chip (VIPIC)
- The intern will develop Matlab code in order to do in depth analyses of the data acquired with the VIPIC chip at the Argonne National Laboratory (ANL) Synchrotron
- By means of the analyses the intern will infere if the chip is working correctly and so will help the ASIC group in its improvement
- After the basic analyses the intern will collaborate with ANL researchers in order to perform the X-Ray Photon Correlation Spectroscopy (XPCS) using the acquired data

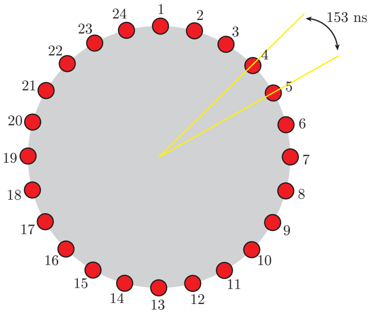
VIPIC basic block scheme

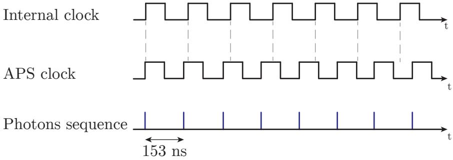


VIPIC 3D structure



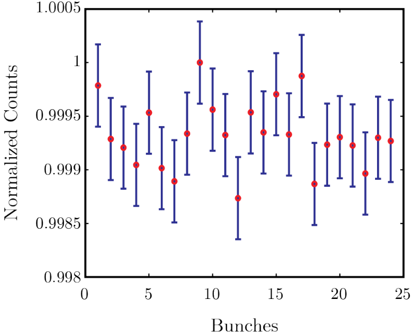
Working principle

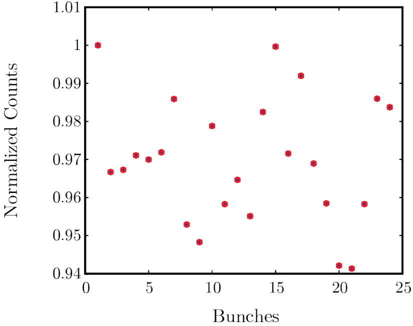




Electrons and photons are sorted in 24 bunches. In order to correctly sort them it is mandatory to have a correct triggering mechanism

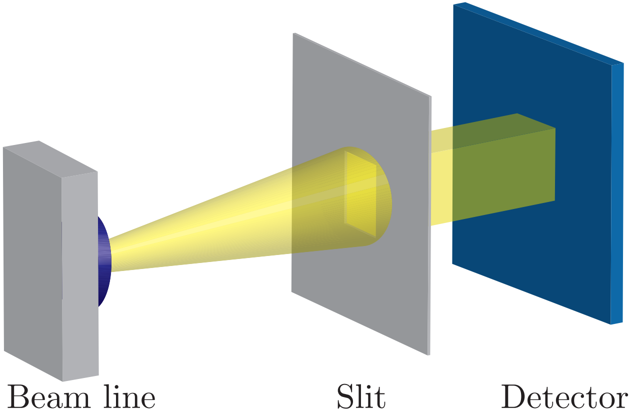
Module 24 analysis



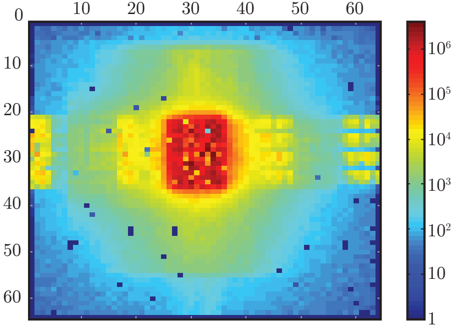


Using the APS clock photons are correctly sorted in the bunches

Direct beam operating condition



Matrix counts



Remark

Moving further from the center of the slit the light intensity is decreasing whereas some pixel on both left and right borders seems to slightly increase their counts

Debug of the reset mechanism

Each pixel is connected to a counter
Counters are reset after being readout
During the analysis it was found that some counters have a value bigger than one. **This is not consistent with physics**

Cause

Only counters that have been readout are forced to reset whereas the other ones keep on counting. This is a problem if the number of hits per frame is too high. **By means of this analysis a new reset mechanism will be designed in other to avoid that problem**.

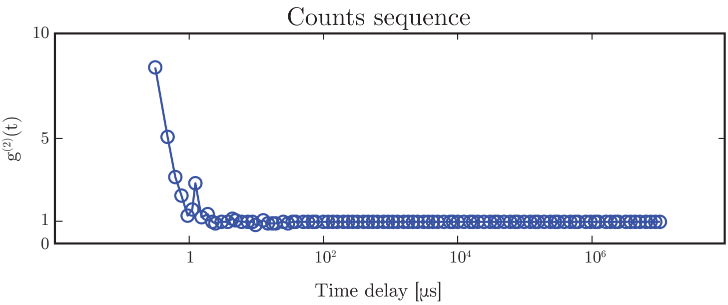
Autocorrelation software

Matlab code provided by ANL's researchers

$$g^{(2)}(p_i, \tau) = \frac{< I(p_i, t) \cdot I(p_i, t + \tau) >_t}{< I(p_i, t) >_t^2}$$

Implemented algorhitm is based on a logarithmic sampling of time delays followed by a time average in order to reduce the dispersion of $g^{(2)}$ function for higher delays due to the lack of samples

Autocorrelation – Direct beam

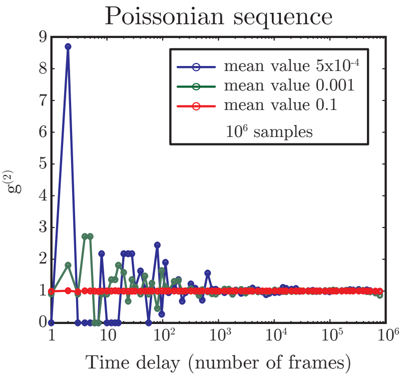


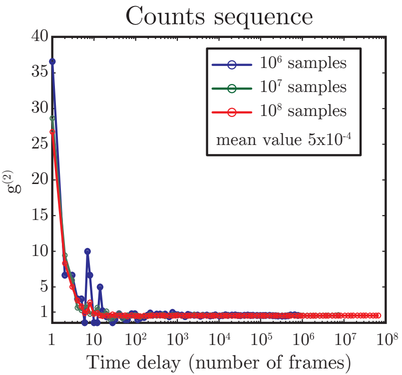
Autocorrelation of a poissonian sequence

$$g^{(2)}(p_i, m) = \begin{cases} 1 & \text{if m>0} \\ 1 + \frac{1}{\mu} & \text{if m=0} \end{cases}$$

where μ is the mean value of the sequence

Direct beam



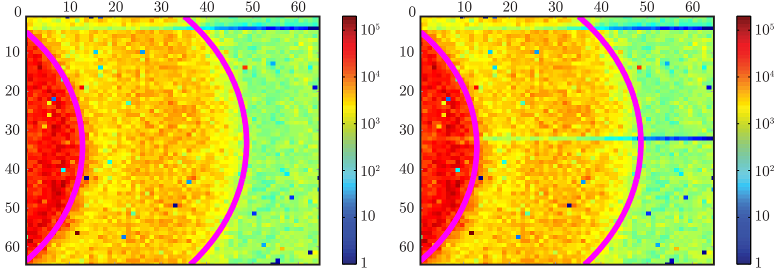


Conclusions

The bouncing at short time delays seems to be due to the finite length of the counts sequence

Colloid data

Data collected illuminating a colloid sample and collecting photons coming from it.
During the analysis it was found that some data have a wrong header



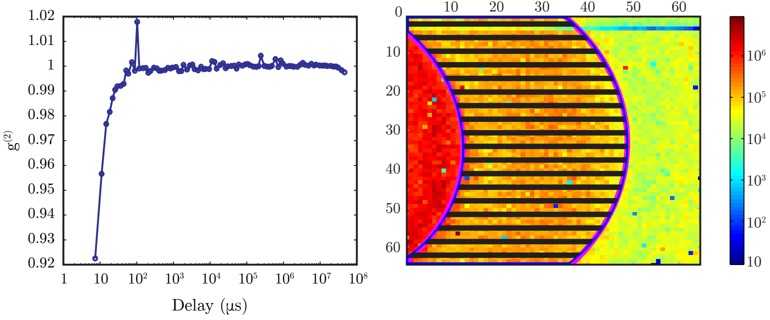
(a) (b)

Conclusions

The problem is related only to a specific readout group. Only the header seems to be corrupted

$g^{(2)}$ – Central anular ring

$g^{(2)}$ was calculated and averaged on an area with quite uniform illumination. The shape is still poissonian increasing the number of frames.



(a)

(b)

Conclusions

$g^{(2)}$ needs to be averaged on a smaller area in order not to change statistics

Next steps

- The autocorrelation analyses will be done on all the files acquired at ANL
- These analyses will help the designers team to debug errors
- A new VIPIC chip meant to be connected to a 1 million pixels matrix will be designed