SPECTRUM 1k – An Integrated Circuit for Precise Energy Measurement

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We present a 960 channel Integrated Circuit (IC) (see Figure 1) designed in CMOS 40nm process dedicated to biomedical imaging [1, 2], that is a continuation of our previous works [3, 4]. Each IC's pixel is equipped with a 6-bit Analog to Digital converter (ADC) responsible for converting Charge Sensitive Amplifier's (CSA) output pulses. The ADC conversion is started upon triggering signal provided by the Discriminator (DISCR) working with a reference energy set by the Threshold Setting block (THSET). The whole conversion and further converted data assignment to the 1 out of the 64 12-bit based counters Memory (MEM) cells is realized by the in-pixel synthesized logic. Working with the 200 MHz system clock, the single ADC conversion, its data classification, and in-pixel memory writing takes about 110 ns what taking into account pixel pitch of 75 µm results in about 1.6 Gcps/mm^2. Thanks to the in-pixel memory it is feasible to collect the information regarding the incoming photons energy spectrum. The IC is under measurements, i.e. the whole chip functionality has been verified successfully and the exemplary transfer function of the 960 ADCs is shown in the Figure 2.

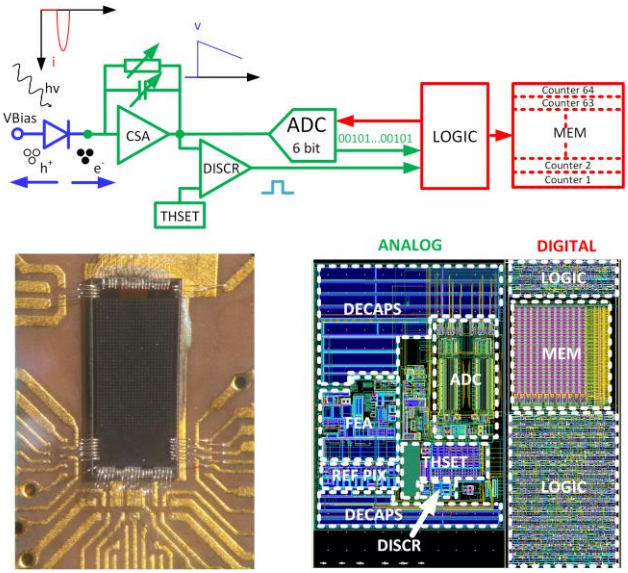

Figure. 1. Recording channels' schematic idea, photo of the wire-bonded chip and masks view of a particular pixel.

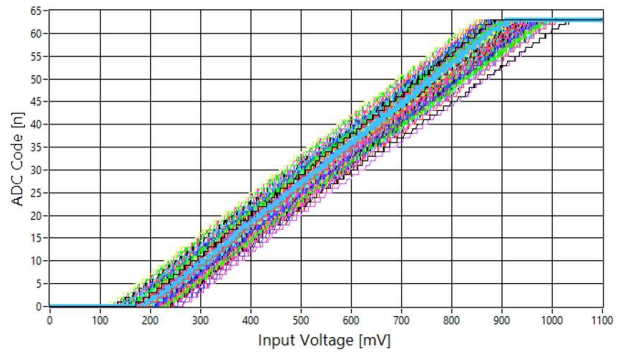

Figure. 2. Measurement results of the 960 ADCs.

[1] E. H. M. Heijne, "How chips pave the road to the Higgs particle and the attoworld beyond," ISSCC Dig. Tech. Papers, (2014), 22– 28.
[2] B. Dierickx et al., "X-ray photon counting and two-color X-ray imaging using indirect detection," Sensors, 16 (2016).
[3] P. Kmon et al., "Spectrum1k — integrated circuit for medical imaging designed in CMOS 40 nm", JINST, (2022).
[4] R. Kleczek et al., "Single Photon-Counting Pixel Readout Chip Operating up to 1.2 Gcps/mm^2 for Digital X-Ray Imaging Systems", IEEE JSSC, 53 (2018).

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