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## Project summary:

## Time-of-Flight PET with SiPM sensors on monolithic scintillation crystals

(project ran from 2006 to 2011)

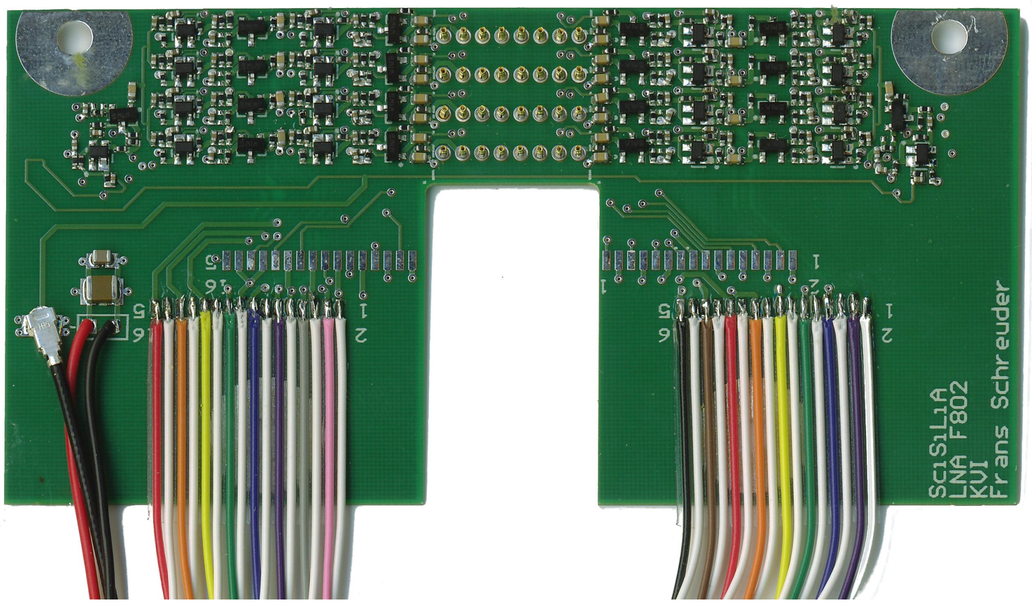
A standard PET detector consists of a pixellated scintillation crystal (pixels about 4x4x25 mm3) read out by a set of photosensors (most often photomultiplier tubes, PMT). Each photosensor covers many scintillation pixels and the scintillation light from each pixel is distributed over a number of neighbouring PMTs. Anger logic analysing the distribution of the PMT signals allows to identify the scintillation pixel in which the 511 keV positron annihilation photon interacted. Thus a position sensitive detector, essential for imaging, is obtained.

An alternative, and in some sense inverse, approach is the monolithic scintillation detector: a relatively large scintillation crystal (typically a few cm on each side) is coupled to an array of photosensors. Now the light distribution across the photosensors can be used to determine the interaction position in the scintillator and imaging can be performed. Excellent detector spatial resolution across the surface of the crystal can be obtained. Very importantly, the depth-of-interaction in the crystal can also be determined, resulting in PET images that suffer less from the parallax error than standard detector configurations.

In the SciSiLiA project (novel SCIntillators with SIlicon LIght sensor Arrays for next generation positron emission tomography detectors), the concept of the monolithic PET detector was investigated using state-of-the-art materials and technology. This project was a collaboration between the University of Groningen, the University of Delft, Philips and had the two PET centres in the Netherlands (at the University Medical Centre Groningen and at the VU Medical Center in Amsterdam) as partners.
Epxeriments were performed using $LaBr_3$:Ce and LYSO:Ce scintillation crystals in combination with Silicon Photomultipliers. Great attention was paid to optimizing spatial and timing resolution. The following main results were obtained:

- world-record coincidence time resolution for 511 keV photons and scintillation detectors: 95 ps for small $LaBr_3$:Ce detectors coupled to SiPM sensors
- demonstration of the software-wise correction of time walk related to the 3D interaction position in the monolithic crystal
- excellent spatial resolution in the determination of the 3D interaction position in the monolithic crystal

A poster with a summary of the main results can be downloaded from:
http://www.rug.nl/staff/p.g.dendooven/Dendooven_SciSiLiA_2012.pdf




16-channel low-noise amplifier developed at KVI-CART for reading out a 4x4 SiPM array (Hamamatsu MPPC S11064-050p(X1)).The 16 SiPM sensor outputs are split after the first amplification stage. One branch, the ’energy signals’, is used to determine the amount of scintillation light detected by each SiPM sensor. Each channel of the other branch is sent to a second amplification stage after which the 16 channels are combined into an analogue sum to form the ’timing signal’ of the monolithic crystal detector. In the electronic design it was ensured that the electrical path lengths are the same for the 16 signals that are used to generate the timing signal.