

Evaluation of the thesis of Daniel Tureček

I was very pleased to see the work of Daniel Tureček presented in this thesis. The first publication covers the fundamental effort to turn a new readout-ASIC into an full data acquisition system. What is not necessarily evident either from the publication nor from the thesis is the scope and impact of the developed readout hardware and DAC software. The Timepix3 is a very powerful, yet very complicated readout ASIC. The benefits of the reduction of the complexity of operation on the accessibility of the detector system should not be underestimated. It automatizes and streamlines an enormous amount of data processing and enables online data visualization and verification, without which many measurements would not be possible to be performed with the same ease in a reliable manner. Also not immediately evident, but still of significant impact in the ease of use is, among other features, the extension of the ToA timestamp from 410us to 26s, the inclusion of external triggering and the possibility to synchronize several readout systems. The proposed method for time-walk correction is an excellent improvement and replacement of the previously used method based on the injection of electronic test-pulses, which are susceptible to gain inhomogeneities across the pixel matrix.

The application publications demonstrate impressively the versatility of the detector system based on the developed readout and data acquisition software. By using the time and energy information provided by the Timepix3, a significant improvement in Signal-to-Background-Ratio in small animal SPECT could be achieved. The enhancement of the temperature stability of the detector system, for sure, played a vital role in the successful suppression of fluorescence and Compton scattered photons and the largely improved spectral fidelity of the detector system. A significant improvement could also be demonstrated for PET imaging, where the timestamp was used to both recompute the spectrum of the detected photons and the detection of coincident signals, leading to an impressive background rejection. Finally the last two articles of the thesis on Compton imaging show the feasibility of extremely compact and high resolution Compton cameras, which are of high interest for medical imaging, nuclear decommissioning and beam monitoring in hadron-therapy. The high potential of single photon processing technology in medical imaging is clearly demonstrated in the publications. It will be very interesting to see the future translation from prototype stage into clinical application.

It would be very interesting to hear Daniel Tureček's opinion on the impact of the next generation readout-ASICs, such as the Timepix4 on the improvement in instrumentation in particular in PET and Compton imaging.

Furthermore I would like to discuss the impact of source distance on the achievable improvement of spatial resolution using deconvolution filters obtained by simulation like the one mentioned on page 65.

Also interesting would be a comment on the absence of the fluorescence escape peak in figure 4.13.

I would conclude that the presented thesis of Daniel Tureček is an excellent example of the impact of new instrumentation technology on science in general and in this case on medical medical imaging in particular. In my opinion he has well earned the right to defend and receive a doctorate.

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