In this poster we show a new attempt to develop a digital positron lifetime spectrometer using external digitizers. We used the digitizers DC211 and DC252 of Acqiris (today Agilent). The software was developed under Qt5/C++. The time mark of the PMT anode pulses is obtained by a constant-fraction routine using cubic splines and a CF-level of 30%. Both PMT’s can act as start- and stop-detector, so that two independent spectra are recorded simultaneously. They can be added without further interpolation when a small channel width is chosen (e.g. 5 ps/ch). The spectrometer is completed by a new coincidence unit which provides leading edge discrimination in both channels to generate the trigger signal. The spectrometer is completed by an external PID controller (Eurotherm) which allows automatic temperature-controlled measurement series. A further unit controls the gas pressure (0…1 bar) in the sample chamber at low temperatures for gas adsorption experiments in porous systems.

Hamamatsu PMTs H-3370 are combined with plastic scintillators. The anode pulses are digitized by Acqiris DC211 or DC252 digitizers. Both PMTs act as start and stop-detector, thus two spectra are collected at the same time.

The coincidence time window must be ≈ 10 times of the expected longest lifetime. Thus, for o-Ps lifetimes one has to use 1…2 µs. An analog system with a 14bit ADC (16384 channels) such as ORTEC 919 has then 60…120 ps/ch. Therefore, short lifetimes such as the p-Ps lifetime of 125 ps cannot be measured any more. The digital system avoids this disadvantage. 5 ps/ch are possible. Then, the spectrum has 2…4×10⁵ channels. Not all analysis software is able to handle this huge amount of data points (LT10 can do).

A self-constructed coincidence unit triggers the digitizer only when PMT1 and PMT2 detect signals above a selected trigger level (8mV…5 V, leading edge discrimination). This way, the data volume generated in the digitizer is drastically reduced. The high-impedance coupling to the PMT signals is done straight at the digitizer input. The coincidence time can be adjusted from 20 ns (defect research) to 2 µs (porosimetry).

The time resolution was measured as a function of the sampling rate. At 4 GS/s it was found to be 197 ps due to the large plastic scintillators in use. Only at 1 GS/s a slight worsening of the resolution is obtained. The resolution of the analog system using the same PMT’s with unchanged high voltage is 226 ps.

Poster is available at http://positron.physik.uni-halle.de
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Photo Gallery
Coincidence Unit
Sampling Rate

5 ps/ch for a 2 µs spectrum