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A digital positron lifetime spectrometer

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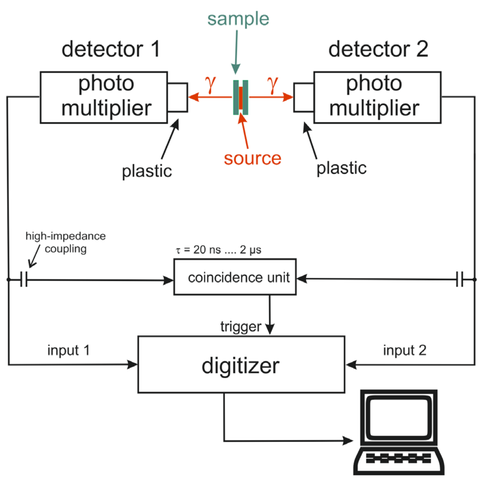
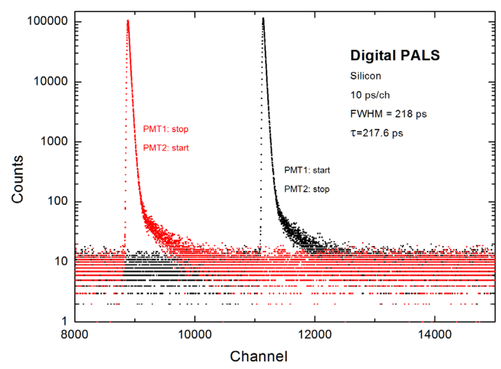
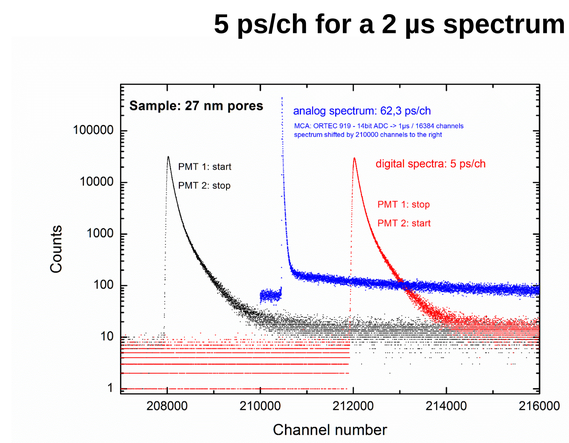
In this poster we show a new attempt to develop a digital positron lifetime spectrometer using external digitizers. We used the digitizers DC211 and DC252 of Acqiris (today Agilent). The software was developed under Qt5/C++. The time mark of the PMT anode pulses is obtained by a constant-fraction routine using cubical 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.





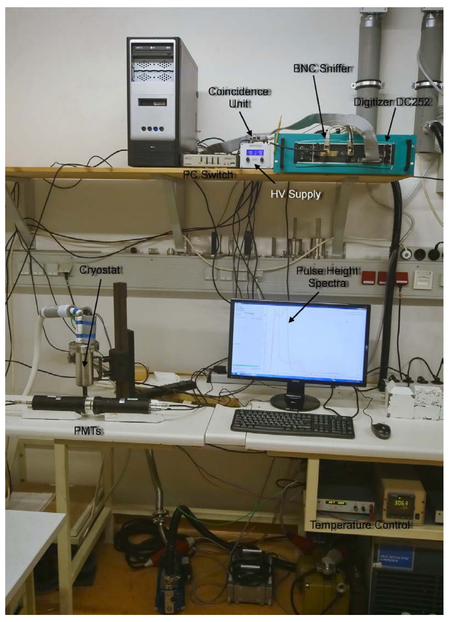
Hamamatsu PMTs H-3370 are combined with plastic scintillators. The anode pulses are digitized by Aqciris DC211 or DC252 digitizers. Both PMTs act as start and stop detector, thus two spectra are collected at the same time.

5 ps/ch for a 2 µs spectrum



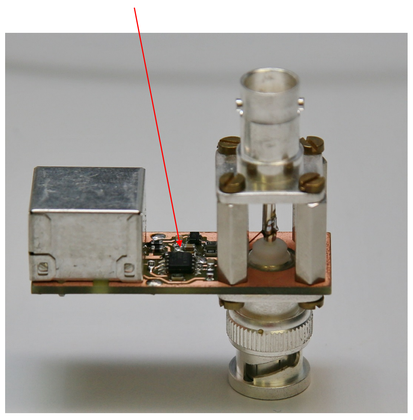
The coincidence time window must be ≈ 10 times of the expected longest lifetime. Thus, for o-Ps lifetimes one has to use 1…2 µs. An analog system with a 14bit ADC (16384 channels) such as ORTEC 919 has then 60…120 ps/ch. Therefore, short lifetimes such as the p-Ps lifetime of 125 ps cannot be measured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

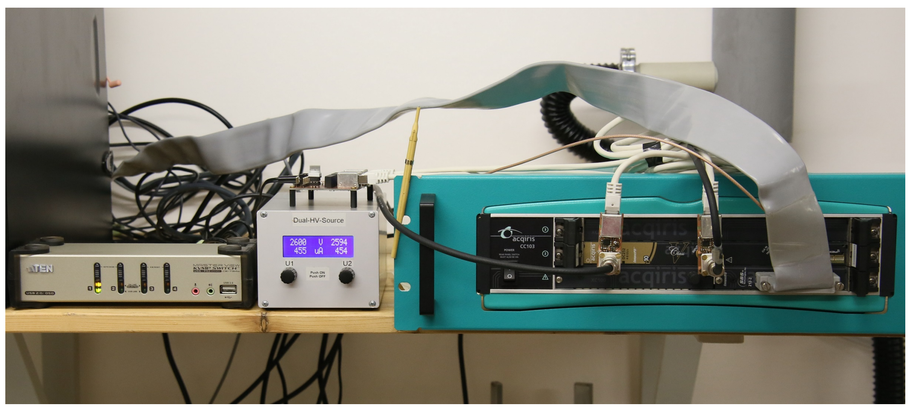
Photo Gallery



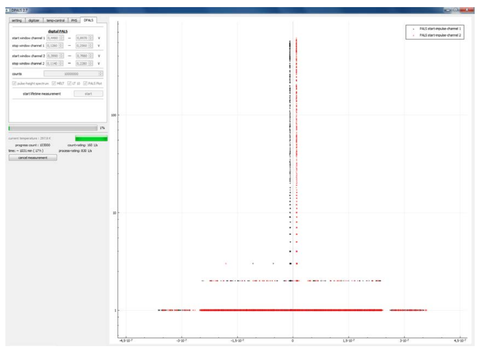
The completed spectrometer with cryostat, vacuum system and temperature control unit.

No signal splitter is used for the coincidence unit to avoid the 3dB signal loss. Instead, the signal is obtained by a capacitive high-impedance "sniffer" unit. An analog amplifier circuit is visible which elongates and amplifies the signal for further processing.





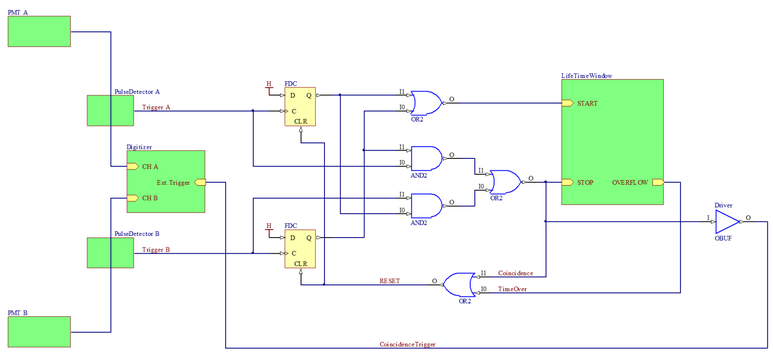
The unit in the left is a PC switch which allows the operation of all PCs of 4 digital spectrometers by only one keyboard and a single monitor. In the middle, a self-constructed high-voltage box displays the voltage and the divider current of both PMT's. On top of it, a full-functioning test version of the coincidence unit is visible. In the right, one can see the digitizer with two "sniffer" units at both inputs and the PCI bridge cable to the PC.

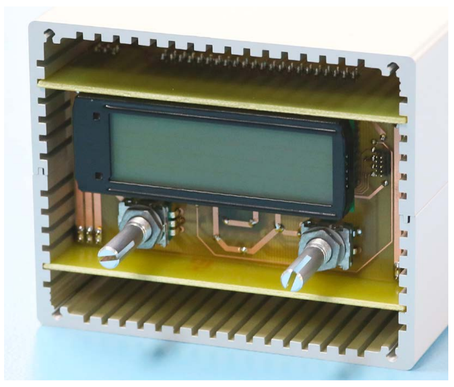


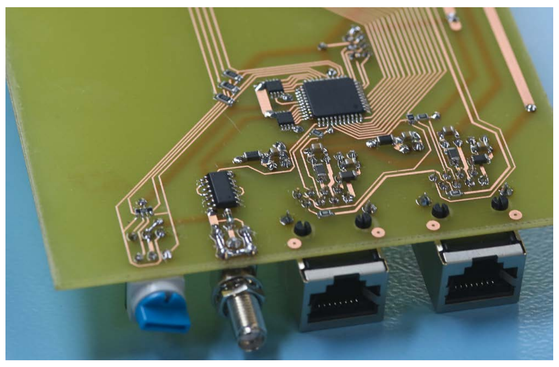
A screenshot of the control program is shown. Two Si spectra are visible in a linear plot. The program, written in Qt5/C++, controls also sample temperature and gas pressure in the sample chamber.

Coincidence Unit

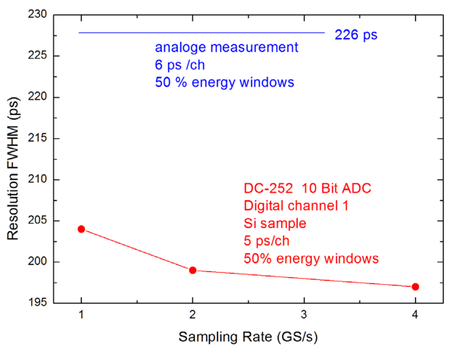
A self-constructed coincidence unit triggers the digitizer only when PMT1 <u>and</u> PMT2 detect signals above a selected trigger level (8mV…5V, leading edge discrimination). This way, the data volume generated in the digitizer is drastically reduced. The high-impedance coupling to the PMT signals is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







Sampling Rate



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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