Positron burst detecting array system based on SiPM and DRS4

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The timing resolution of positron lifetime detector is usually based on BaF_2 scintillator and quartz window fast PMT [1]. The limitation of this design lies in BaF_2's low fast component light output and low stopping power, as well as PMT's limited quantum efficiency and time jitter. Therefore, the timing resolution of traditional positron annihilation lifetime measuring system is difficult to be further improved.

In the work, we proposed a new positron annihilation lifetime spectrum measuring method. The spatially arranged positron burst detecting system is based on state of the art LYSO crystal and silicon photomultiplier (SiPM) array, readout by multichannel fast waveform digitizing chip DRS4[2], to obtain high sensitivity and better timing resolution at the same time. Current system has 32 detector modules. Each module is composed by 64 3mm × 3mm × 5mm LYSO crystals coupling to 64-channel 3mm × 3mm SiPMs array. All timing signals from a detector are digitalized by two 32-channel high speed sampling board based on DRS4 chip, and then implemented digital timing by PC, instead of traditional leading edge or constant fraction discriminator circuit. With buncher signal used as starting trigger and each channel's timing signal as stopping signal, the time spread distribution would be the lifetime spectrum of positron.

The single channel detector performance was investigated and optimized by improvement of LYSO scintillation light collection, SiPM readout and temperature stability. Preliminary results showed that the double 511keV coincidence timing resolution of two single channel detectors achieved 84 ps, measured by placing a Na^{22} source in the middle. Module level and system level studies are being carried out.

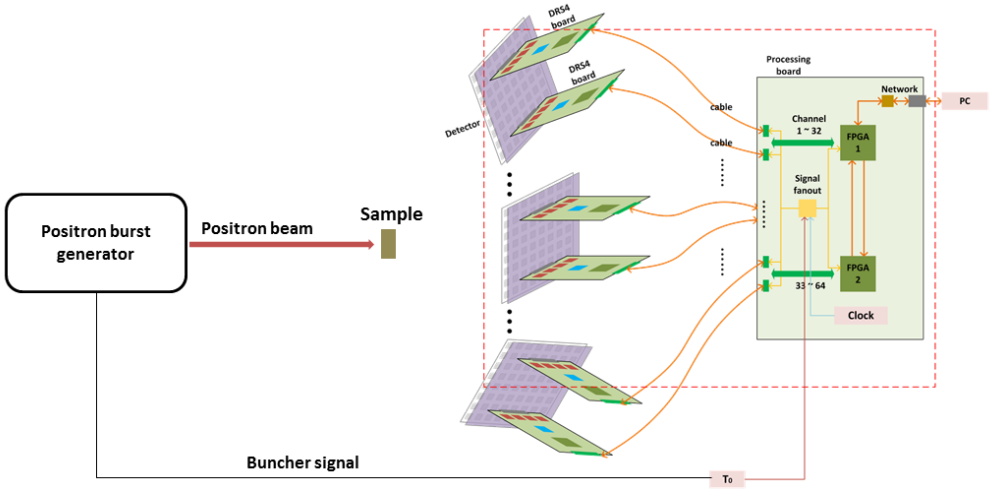

Figure 1 *Schematic of the positron burst detecting array system*

References

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