# Fast Timing with DSSSD Detectors

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The NuSTAR HISPEC slowed down beams project at FAIR aims to produce rare isotopes with energies of 10 MeV/u and less. The setup requires Time of Flight (ToF) information to determine the ion velocity, energy loss for Z identification and beam tracking for scattering angle reconstruction [1]. A timing resolution of $\Delta$T$\sim$100 ps, position resolution of the order of a mm and energy resolution of $\Delta$E/E$\sim$1% is required [1]. Due to the low beam energy, the number of detectors should be kept to a minimum. Thin Double Sided Silicon Strip Detectors (DSSSD) provide energy loss and position information, while their use as fast timing detectors was not extensively studied. A combination of commercially available DSSSDs and a new 16ch fast pre-amplifier developed at GSI was investigated. The system was cooled to -17°C in order to reduce the detector noise, improving the time resolution.

A 5x5 cm$^2$, 40 $\mu$m DSSSD model W1(DS)-40 9G produced by Micron was glued on a copper frame. The DSSSD has 16$\times$16 x-y strips. They are bonded on one side only. A 16ch low power pre-amplifier based on BGA2712 amplifiers by NXP Semiconductors was attached to the DSSSD [2]. The detector and the pre-amplifier were cooled with a refrigerating machine and a two-stage Peltier cooler. A picture of the detector and the fast pre-amplifier mounted in the cooling frame is shown in Figure 1.

The detector performance was studied with a 48 MeV $^{12}$C beam produced at the Cologne FN-Tandem Accelerator [3], where the DSSSD time resolution was measured relative to a transmission Micro-Channel Plate detector (MCP) [4]. The energy of 48 MeV was sufficient for the $^{12}$C beam to punch through the thin DSSSD.

As mentioned above, the detector was cooled to -17°C. The signal amplitude and rise time varied along the length of the detector strips. The fastest rise times (10% - 90%) of order of 2 ns were measured for the pixels close to the strip readout contact. Such a signal is shown in Figure 2. The RMS noise after the fast pre-amplifier was in the order of 0.3 mV. The signal rise time and noise level indicate that a resolution better than 100 ps can be reached.

For timing measurements, the fast pre-amplifier was connected to a 16ch leading-edge discriminator, while the other side of the DSSSD was read out with a Mesytec MPR-32 charge sensitive pre-amplifier. A CAEN 1290A TDC with 25ps LSB was used to measure the ToF between the MCP and the DSSSD detector. A FWHM$\sim$0.4 ns was obtained for the DSSSD time resolution after subtracting the contribution from the MCP.

The difference between the expected and the measured time resolution was attributed to the variation of the signal rise time along the detector strips and high discriminator thresholds. The latter was due to a technical limitation of the fast discriminator used in the measurement.

Improvement of the cooling system in order to reach lower temperatures, will lead to rise times below 2 ns. The faster rise times and a readout from both sides of the detector strips should lead to resolutions better than 100 ps.

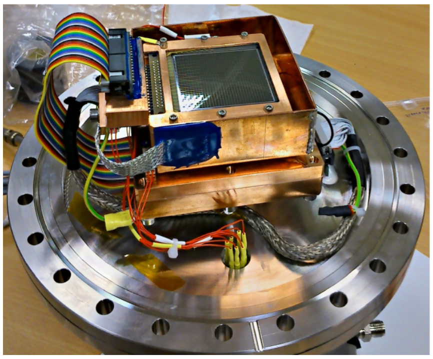

Figure 1: An assembly of the 40 $\mu$m DSSSD and the 16ch pre-amplifier mounted on the cooling frame.

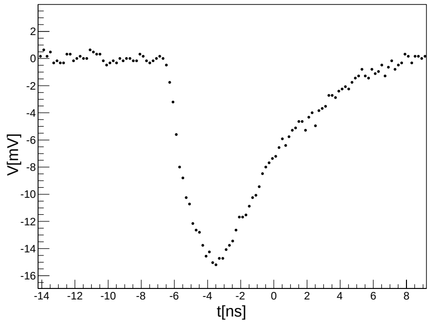


Figure 2: A fast pre-amplifier signal from a pixels close to the strip readout contact.

## References

[1] P. Boutachkov *et al.*, GSI Scientific Rep. (2007) 215.

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[3] M. Pfeiffer *et al.*,"A new Detector Testbed for future FAIR based Slowed Down Beam Setups at the Cologne FN-Tandem Accelerator Facility", GSI Scientific Rep. (2012).

[4] P. Boutachkov *et al.*, GSI Scientific Rep. (2008) 236.

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