Development of large area diamond detectors for time-of-flight measurements of heavy ions

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A few experiments have been carried out in order to assess the Time-of-Flight (ToF) performances of radiation detectors based on diamond material.

In early 2014, two diamond devices of 0.3 and 0.6 mm thickness, respectively were irradiated at JINR (Dubna, Russia) using an ^{40}Ar beam at 40.5 MeV/u. Amplification of the induced signal was performed by broadband preamplifiers (DBA-IV) [1]. In this case, the sensors, mounted a couple of cm away from each other, showed a resolution of σ_{tof} ~ 80 ps per detector pair.

In August 2014, another experiment was performed with the FRS at GSI. This time, large-area radiation detectors based on two 20x20x0.3 mm^3 polycrystalline CVD diamonds have been developed. Electrodes were fabricated in house in a 16-strips geometry by depositing on both sides of the diamond samples Cr/Au layers of 50/100 nm thickness, respectively. Each device was then mounted on a board (Fig. 1) which has an integrated amplification stage [2] and is able to provide LVDS signals as output. The novelties of this experiment were: the use of integrated electronics, a distance between the diamond detectors of more than 30 m, and experimental conditions similar to those expected at the Super-FRS [3].

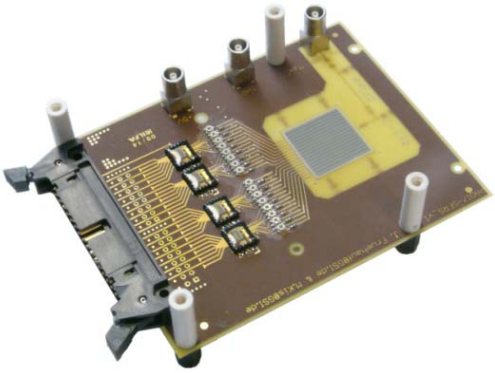

Figure 1: Diamond detector and its integrated electronics.

In this experiment at GSI, the diamond detectors have been irradiated with a ^{197}Au beam at 1 GeV/u. ToF measurements were performed in two ways: i) placing the detectors only 2 cm apart (S4 case) and ii) placing them more than 30 m apart (S2-S4 case).

As for the S4 case, first the effect of the threshold and bias voltage on the ToF resolution of the sensors was studied. It was observed that the best performances could be achieved with a voltage of -200 V. In this case, σ_{tof} =39.8 ps has been found between two strips of the front and back diamond detector. This value has shown also no dependence on the beam rate in the range of 1 – 10 kHz. For the S2-S4 case with 30 m flight path, the diamond sensors showed a resolution of σ_{tof} =52.7 ps. Taking advantage of the Time Projections Chambers (TPCs) [4] mounted along the beam line, a position correction was applied which led to an excellent resolution of σ_{tof} =45.7 ps (Fig. 2). No dependence on the beam rate over the range 10 – 80 kHz was found.

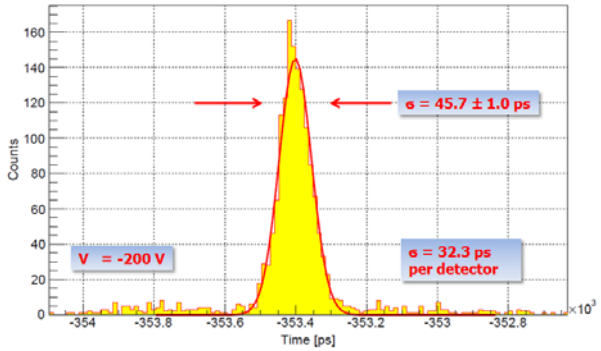

Figure 2: Diamond ToF resolution (S2-S4 case).

The new developed diamond detectors have shown excellent timing properties making this material an attractive solution for the next generation of experiments foreseen at the FRS and Super-FRS. It has to be mentioned that the ToF resolution of the diamond detectors can be further improved once a correction for the deposited energy will be done.

References

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