"Mosaic": a new start (sCVD) detector for nuclear fragmentation measurements

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Introduction

Nuclear fragmentation cross-sections are of high interest both for radiation therapy and space research. The aim of measurements is to benchmark different Monte Carlo codes with new data sets. The main observable is the double-differential cross-section for charged fragments and neutrons. The number of produced fragments is measured as a function of emission angle relative to the beam and their kinetic energy. Different experimental setups were used for such measurements at GSI in cave A and also in cave C during last years. Information on energy loss of charged fragments, their time-of-flight between target and detection place in combination with magnetic field and/or pulse shape technique is used to perform identification of fragments both in charge and mass.

Mosaic detector

In order to perform time-of-flight measurements mentioned above for big angles (> 30°) relative to the beam in reasonable time the primary beam intensity has to be increased up to 10^7 or even 10^8 pps. It requires a start detector with excellent performance properties [1]. The start detector positioned in front of the target is counting number of primary beam particles, starting or stopping all time-of-flight measurements and providing a fast trigger signal for the data acquisition system. The "mosaic" detection system (CIVIDEC) consisting of an array of 3 x 3 sCVD diamonds (Element6) was proposed as a new start detector for future nuclear fragmentation experiments.

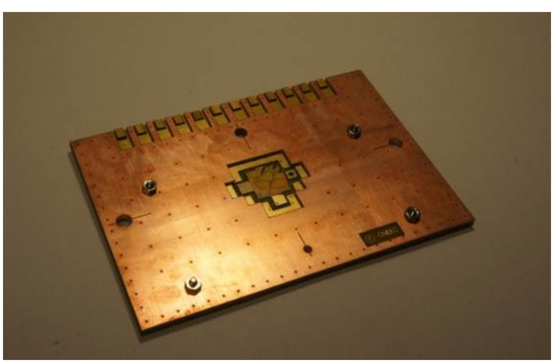

Figure 1: mosaic-detector for the n_ToF-collaboration.

The diamond has an excellent time resolution (tens of ps), works stably in very high rates (factor of 100 or higher than plastic scintillator) and is much more radiation resistant then other detectors. The size of one diamond is 4,5 x 4,5 mm^2 x 300 µm with an active area of 4,0 x 4,0 mm^2 (about 80 % of the total area). The total area of the "mosaic" detector is 13,5 x 13,5 mm^2 (a typical size of the beam spot on target is between 5–10 mm FWHM). Three printed circuit boards make a mechanical support for diamonds and interface signals from diamonds to further signal processing.

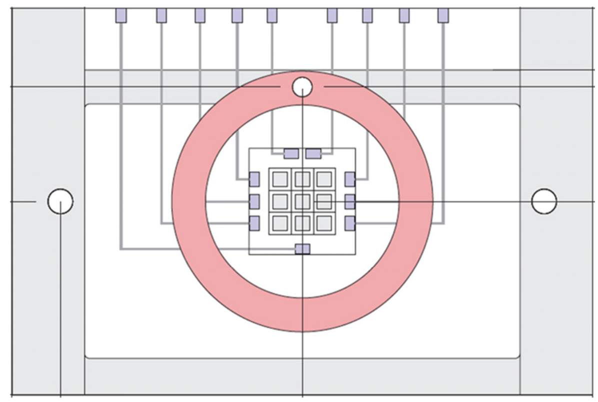

Figure 2: scheme of mechanical layout.

Special preamplifiers for diamond detectors were developed in order to apply the "mosaic" detection system in beams from proton up to uranium in an kinetic energy range from 100 – 1000 MeV/u. For example, in the case of proton and oxygen beam at 500 MeV/u a charge of 3.2 and 350 µC is collected. After passing 40 dB amplifier (f = 100) the output signal has a level of 4 and 200 mV. This corresponds to a signal-to-background ratio of 1.6 and 62.5. Therefore in the case of protons a fast charge amplifier has to be used (4 mV/fC) to get signal-to-background ration of 21.3. The time resolution for protons and oxygen beam at 500 MeV/u is 150 and 10 ps. The energy information provided by sCVD diamonds is used to identify primary beam particles in charge.

Outlook

The "mosaic" detection system is one part of a new experimental setup developed in order to perform future measurements on nuclear fragmentation at GSI and worldwide. A combination of two "mosaic" detectors (positioned on the beam axis upstream and downstream relative to target) offers a possibility to build a high precision start-veto system providing direct information on total reaction cross section and beam-on-target position during measurement. The project is financed by BMBF.

References

[1] R. Pleskac, "Mosaic Detector: Experiments for Therapy and Space Research", 1st ADAMAS Workshop, GSI Darmstadt, December 2012, http://www-adamas.gsi.de.