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Implementation of Silicon Detector Arrays in the UHV environment of Storage Rings *)

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The presented work focuses on the implementation of complex and highly granular detector arrays in the UHV environment of a storage ring. The concept to be presented here was borne out when designing the detection system for the upcoming project "EXotic nuclei studied in Light ion induced reactions (EXL)"at the New Experimental Storage Ring (NESR) as a part of the future FAIR facility. By means of kinematically complete measurements in inverse kinematics, EXL provides for studying many physics phenomena in unstable nuclei. The crucial part of EXL is the 2π recoil particle detector ESPA. This detector array will consist of telescope-like segments which, depending on the different angular ranges, house pairs of double-sided silicon strip detectors (DSSDs) for particle tracking and identification, and the subsequent thick Si or Si(Li) detectors and/or CsI scintillator crystals for the spectroscopy and precise full-energy determination of high-energy particles. The innermost DSSDs are common for all the segments and will be arranged in a spherical configuration.

The major technical challenge is to install a large number of detector channels with the correlated front-end electronics, connectors and cables, and possibly cooling circuits at the beam-target interaction region of the NESR where the need of an UHV below the order of 10−10 mb requires low-outgassing and bakeable materials. For the implementation of all detectors in the NESR environment, a new differential pumping concept was envisaged where the storage ring UHV is maintained inside the innermost sphere of DSSDs which is acting as a vacuum barrier to an outer volume, with less stringent constraint in vacuum quality, containing the subsequent layers of detectors and unbakeable and thus outgassing electronic components. Since the vacuum barrier serves at the same time the purpose of an active window it enables the detection of recoil particles varying from protons to alphas down to about 100 keV energy, as required for the measurement at low momentum transfer.

The development, construction and testing of a prototype active vacuum window was carried out at GSI, Darmstadt, with a DSSD sensor of 19×19 mm2 active area. The PCB for the read-out of this detector was designed from aluminum nitride ceramic, chosen for its low outgassing, high thermal conductivity and thermal expansion close to that of silicon. After baking, vacuum separation better than six orders of magnitude was achieved, with the UHV side reaching down to the 10−10 mbar pressure region. The PCB-DSSD system was able to withstand bake-out cycles with unchanged spectroscopic performance. The chosen materials proved to be clean of any UHV disturbing contaminants. Currently, a larger DSSD of 64×64 mm2 active area is built up and tested, which forms already an essential part in the setup for an EXL-type predecessor experiment to be performed at the ESR storage ring at GSI. Details on detector design and performance will be discussed in this presentation.

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Primary author: Dr MUTTERER, Manfred (GSI Darmstadt, Germany)

Co-authors: Mrs GLAZENBORG-KLUTTIG, Annelie (KVI, Groningen, The Netherlands); Dr STREICHER, Branislav (KVI, Groningen, The Netherlands); Dr KOLLMUS, Holger (GSI Darmstadt, Germany); Dr TRÄGER, Michael (GSI Darmstadt, Germany); Mr LINDEMULDER, Michel (KVI, Groningen, The Netherlands); Mr VON SCHMID, Mirco (TUD, Darmstadt, Germany); Prof. KALANTAR-NYESTANAKI, Nasser (KVI, Groningen, The

Netherlands); Prof. EGELHOF, Peter (GSI Darmstadt, Germany); Dr ILIEVA, Stoyanka (GSI Darmstadt, Germany); Prof. KRÖLL, Thorsten (TUD, Darmstadt, Germany)

Presenter: Dr STREICHER, Branislav (KVI, Groningen, The Netherlands)

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