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# The Double-Energy Double-Velocity fission spectrometer VERDI

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The particle spectrometer VElocity foR Direct particle Identification (VERDI) allows measurements of fission fragment (FF) mass distributions with a resolution from 1 to 2 mass units, by means of the detection of two fragment velocities and two fragment energies. VERDI consists of two arms with up to 32 Passivated Implanted Planar Silicon (PIPS) detectors and a Micro Channel plate (MCP) each. The MCPs provide the start signal used to trigger the time-of-flight (ToF) measurement, and the Si detectors are used both for energy detection and for providing the stop signal. The main challenge to achieving accurate fragment velocities is the so-called plasma delay time (PDT) phenomena in the PIPS detectors.

In this talk, we will first present the results of a dedicated experimental campaign at the LOHENGRIN fragment-recoil spectrometer, designed to determine the PDT characteristics of PIPS detectors. The PDT effect was systematically investigated as a function of mass and energy, using a dedicated time-of-flight setup. In addition, the pulse height defect (PHD) was determined, simultaneously. The studies were conducted for five PIPS detectors, with kinetic energies and mass numbers ranging from 20 to 110 MeV and 85 to 149, respectively. Using digital signal processing, an excellent timing resolution was achieved, reaching as low as 60 ps (one $\sigma$) for the heavy ions. We will present the complete set of PDT and PHD data for all detectors used in the experiment campaign, and we will discuss the mass- and energy-dependent trends of the PDT and PHD. Furthermore, the inter-detector comparison of the PDT and PHD data will be presented. We will conclude on the plasma delay studies by presenting the newly developed two-dimensional parameterisation of the PDT.

In the second part of the talk, we will shed light on the recent progress of the spectrometer at JRC Geel. The challenges and achievements in the re-operation and upgrade of VERDI will be highlighted. This includes the characterization of the performance of the PIPS detectors mounted on a new flange employing new preamplifiers. Moreover, we will present the upgrade of both MCPs of VERDI, including the installation of a new position-sensitive MCP. The results of the position-sensitivity analysis and the optimal operation of the MCP will be discussed. Another aspect is the use of a new DAQ framework, called Acquisition and Broadcast of Collected Data (ABCD). ABCD has been coupled to new digitizer cards with superior sampling frequency and number of bits, to assure optimal energy and TOF resolutions. All these successful developments facilitate new fission experiments with VERDI, that will be performed in 2024.

**Auteur principal:** GOMEZ L., Ana M. (Uppsala University)

**Orateur:** GOMEZ L., Ana M. (Uppsala University)

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