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PANDA—A novel instrument for non-destructive sample analysis

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ABSTRACT

An instrument known as PANDA (Particles And Non-Destructive Analysis) for non-destructive sample analysis has been designed and built at the Finnish Radiation and Nuclear Safety Authority (STUK). In PANDA the measurement techniques and instruments designed for the basic research are applied to the analysis of environmental samples. PANDA has two vacuum chambers, one for loading samples and the other for measurements. In the measurement chamber there are two individual measurement positions. Currently the first one hosts an HPGe gamma detector and a position-sensitive alpha detector. The second measurement position is intended for precise characterization of found particles. PANDA's data are recorded in event mode and events are timestamped. In the present article the technical design of PANDA is presented in detail. In addition, its performance using depleted uranium particles and an air filter is demonstrated.

1. Introduction

Sample measurements in environmental surveillance and nuclear safeguards are typically done using single detectors along with multichannel analyzers [1]. Using this approach a single measurement seldom gives all the information needed for the complete characterization of a sample. Therefore, a feasibility study was carried out to introduce state-of-the-art techniques used in basic research to the measurement of environmental and other samples [2]. In practice this means the introduction of a double sided silicon strip detector (DSSSD), an event-mode data acquisition system and alpha–gamma coincidence technique to the analysis process of samples.

The feasibility study was carried out in the summer 2007. Based on the encouraging results, an instrument called PANDA (Particles And Non-Destructive Analysis) was designed and constructed. In the present article we describe the technical design of PANDA and demonstrate its operation using depleted uranium particles and an air filter.

2. PANDA

PANDA is not only a new instrument for measurements of radioactive samples but it is also a platform where novel detectors and ideas can be studied. PANDA has two measurement positions. Currently the first measurement position, meant for the screening of large samples, is operational.

2.1. Mechanical design

PANDA consists of two vacuum chambers (Fig. 1). These chambers are named the loading chamber, for loading and chancing the samples, and the measurement chamber. These two chambers are customized and built from 6 mm thick stainless steel and assembled on top of an aluminium pedestal. The chambers are connected to each other with a manually operated vacuum gate valve (Series 12.1, DN 160, VAT, Switzerland).

The samples are transported from the loading chamber to the measurement chamber using a linear feedthrough (Linear PowerProbe, UHV Design, UK). The feedthrough is equipped with a digital scale telling the position of the sample inside the system with an accuracy of 10 μm. Various types of sample holders can be mounted on the tip of this linear feedthrough.

The measurement chamber has two measurement positions both of which have four openings, one on the top, others on the bottom, the right and the left side of the chamber.

Two scroll pumps (Scrollvac SC 15 D, Oerlikon Leybold Vacuum GmbH, Germany) and one turbomolecular pump (Turbovac 361, Oerlikon Leybold Vacuum GmbH, Germany) are used to create a high vacuum, see Fig. 2. One of the scroll pumps is connected to the loading chamber and is only used when changing a sample. The other scroll pump and the turbomolecular pump form the main pumping unit of the system. These pumps are connected to the measurement chamber.

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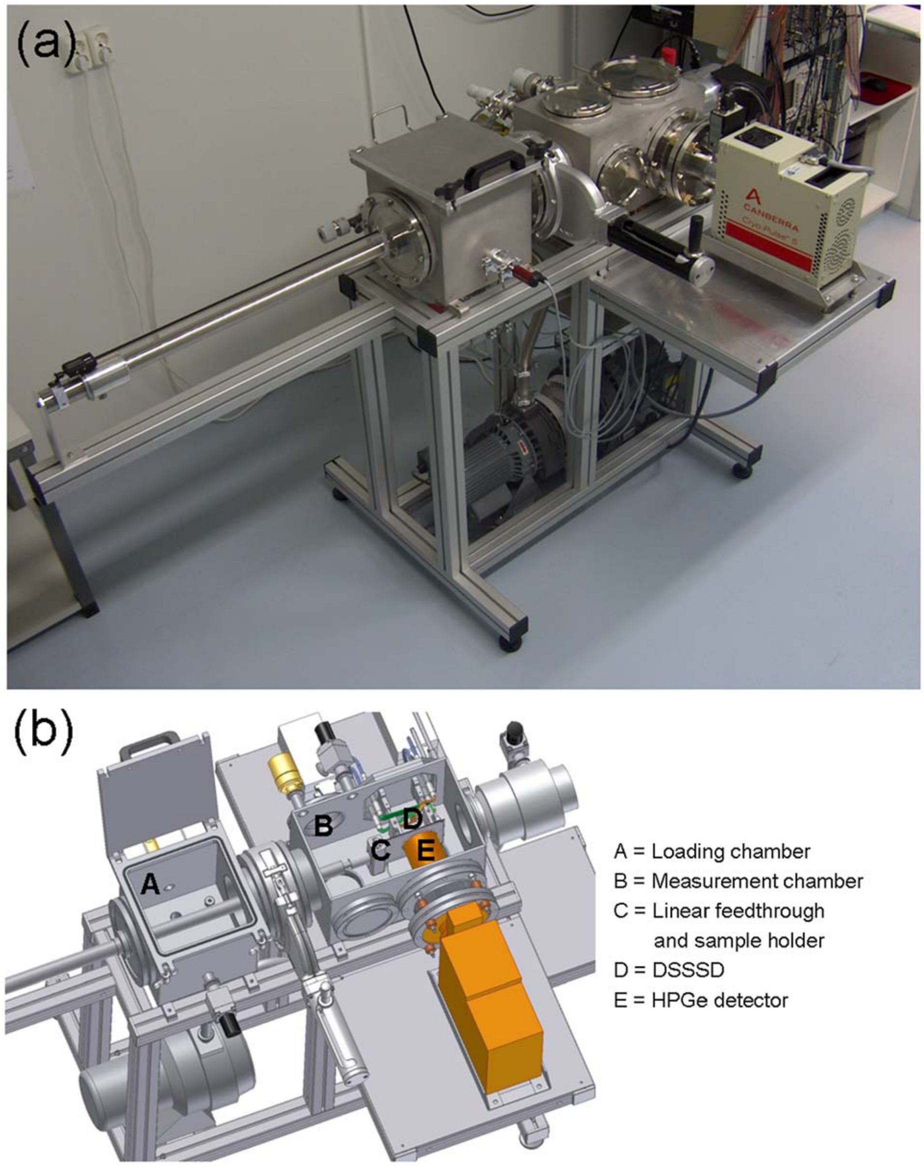

Fig. 1. (a) Photograph of PANDA's vacuum chambers and the equipment attached. (b) A technical drawing of PANDA where the top plate of the measuring chamber is removed.

The pressure inside the chambers is monitored with a DualGauge measuring system (Pfeiffer Vacuum GmbH, Germany). It contains a TPG 262 control unit and two gauges, a model PKR 251 full range gauge and a model TPR 280 Pirani gauge. The full range gauge is connected to the measurement chamber and the Pirani gauge to the loading chamber. The Pirani is only needed during the pump down and the venting of the loading chamber. Typical pressure during the measurements is around 5×10^{-7} mbar.

In addition to the gate valve, PANDA's vacuum system consists of six valves (Fig. 2). The valves are from the Pfeiffer Vacuum GmbH, Germany, and their models are AVC 025 angle valve, EVN 116 gas dosing and shut-off valve and EVD 010 H rough gas dosing valve. All valves are manually actuated. The pumping of the vacuum for the loading chamber can be done using two separate lines or by combining these two. One line has a delicate EVN 116 gas dosing valve and is used when the vacuum has to be created very slowly. The other line has an AVC 025 angle valve, which is more robust and has larger conductance. The venting valve for the loading chamber is an EVN 116 gas dosing valve. This way the venting can also be controlled very precisely. Delicate pumping and venting possibilities are important considering powder and other sensitive samples.

The vacuum chambers are connected on the bottom side using a bellows and an EVD 010 H rough gas dosing valve. This connection can be used to equalize the pressure difference between the two chambers. A second EVD 010 H valve is used as a venting valve for the measurement chamber. The valve between the scroll pump and the turbomolecular pump connected to the measurement chamber is an AVC 025 angle valve. This pumping configuration means that the measurement chamber can always be kept at high vacuum, i.e., the silicon detectors need not be de-biased when changing the samples. In addition, the risk to contaminate the detectors is reduced.

2.2. Detectors

The current measurement setup consists of a High-Purity Germanium (HPGe) detector and a Double Sided Silicon Strip