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Electron spectrometer for "in-beam" spectroscopy

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Abstract

A spectrometer that uses a set of silicon detectors and a combination of two magnetic fields for separation and for transportation of electrons from the target position to the silicon detectors has been constructed at the University of Lodz for "in-beam" studies of internal conversion electrons. The separation of electrons from positrons is achieved in a simplified mini-orange set-up. The transportation field is produced by a set of permanent magnets arranged in a form of coaxial rings. The background from delta electrons and gamma rays is highly reduced. The spectrometer was designed to be coupled to OSIRIS-II, the array of gamma-ray detectors at the Warsaw Heavy Ion Laboratory. The performance of the spectrometer is illustrated by examples of spectra obtained from the conversion electron spectrometer and also the OSIRIS-II array, which were recorded in- and off- beam.
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1. Introduction

Internal conversion electron (ICE) spectroscopy plays an important role as a tool for "in-beam" spectroscopy of products from heavy-ion induced nuclear reactions. Measurements of ICE spectra, combined with gamma-ray studies, allow the determination of transition multipolarities. The emission of ICEs may be a dominant process for low-energy transitions, especially in high-Z nuclides, however, it is the only possibility for $0^+ \to 0^+$ de-excitations.

High efficiency at registering electrons in a wide energy range with good energy resolution is required for an electron spectrometer, employed for "in-beam" measurements. What is more, the background, which originates from delta electrons, positrons and photons emitted by the target towards the detectors, should be kept low. According to convention, electron spectrometers, used "in-beam", fall mainly in to two categories:

(i) devices with a magnetic field which is transverse to the flat trajectories of electrons (e.g. mini-orange spectrometers) [1–4],
(ii) devices with longitudinal magnetic fields (long magnetic lenses) in which electrons, while moving toward the detector, follow helical trajectories, e.g., spectrometers with an homogeneous magnetic field [1,4,5].

Nowadays, electron spectra are measured with silicon detectors, and the magnetic field plays an auxiliary role.

Spectrometers of both types have been successfully used in "in-beam" experiments [1,6,7]. However, they show some deficiencies. Devices of the first type allow the rejection of positrons and delta electrons and reduce the gamma-ray background, but they have too high electron-energy selectivity that may often be a negative feature. In the case of solenoid spectrometers, electrons are accepted

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in a wide energy range, although it is necessary to use a baffle between the target and the detector or a potential barrier produced by a special electrode [5] in order to eliminate delta electrons. Such a baffle or a potential barrier does not eliminate high energy positrons [5]. The gamma-ray background, which is rather low due to the large target-to-detector distance, can be additionally reduced if a lead block is placed in between.

The constructional solution that we have chosen combines advantages of both types of spectrometers as we use magnetic fields in the two different layouts. Such a solution makes it possible to register electrons in a wide energy range and at the same time to reduce both delta electrons and positrons and also the gamma-ray background essentially. The mechanical construction of the new ICE spectrometer allows us to couple it with the multidetector gamma-ray spectrometer OSIRIS-II at the Heavy Ion Laboratory of Warsaw University.

In the studies of nuclear transition multipolarities in electron–gamma coincidence measurements one needs to use the electron spectrometer with the features described above as well as to use a highly efficient gamma-ray spectrometer. This can be achieved by placing HPGe detectors as close as possible to the target secured inside the

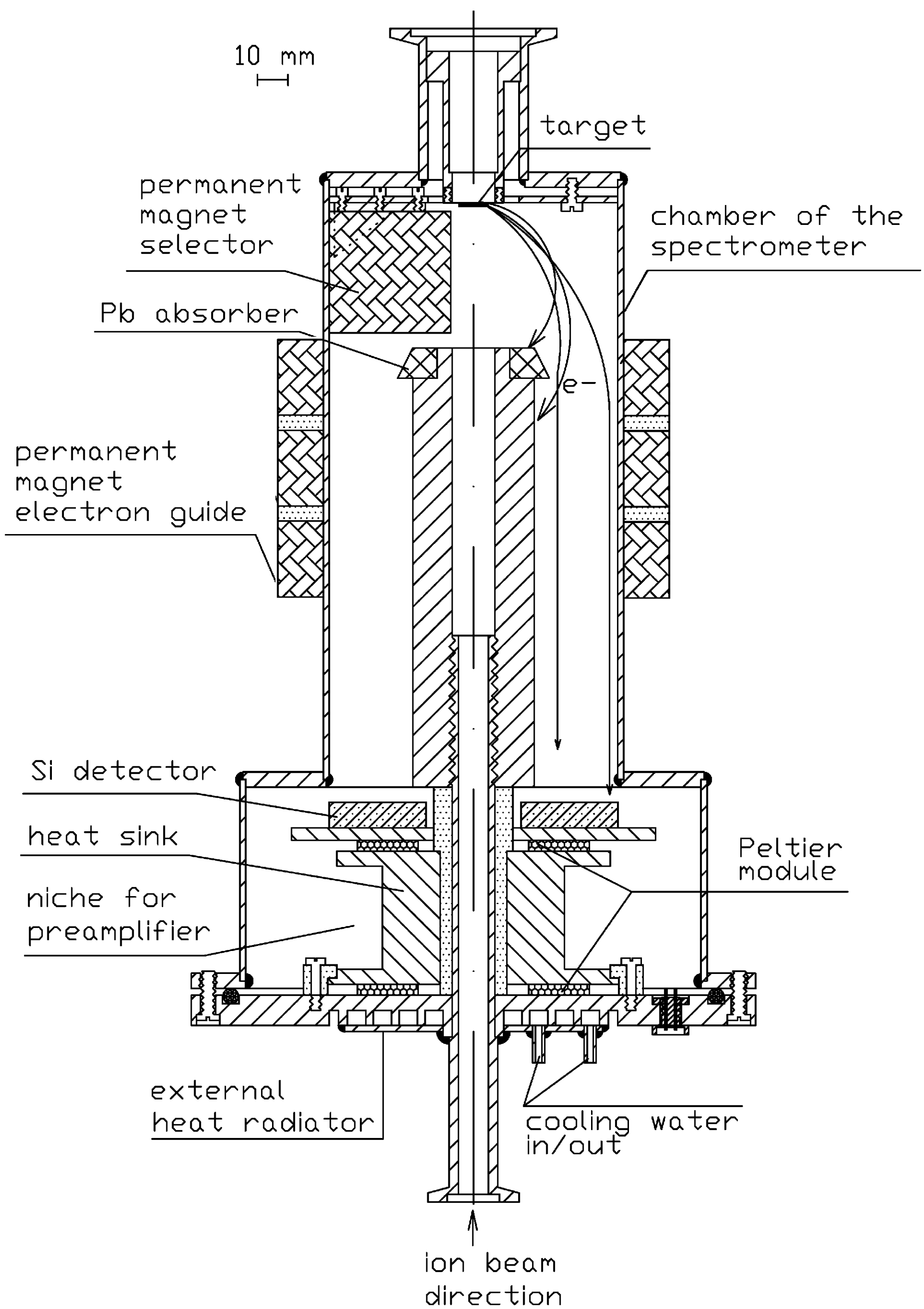

Fig. 1. A schematic view of the spectrometer. The three magnet rings are positioned in the geometry used in the experiment discussed in this article, but can be moved, depending on the experimental requirements.

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