3B2v7.51c GML4.3.1 NIMA : 19537 Prod.Type:COM pp.1–3(col.fig.:1,2,3) ED:VijayaT PAGN: vs SCAN: Mangala

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

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A large tracking detector for low-energy ions

E. Bougamont, P. Bourgeois, A. Drouart, C. Mazur*, L. Nalpas, E.C. Pollacco, M. Riallot

DSM/DAPNIA/SPhN, CEA Saclay, Gif sur Yvette Cedex, 91191 France

Abstract

We present an innovative detector with a large working area (100×400 mm^2) for ion tracking. This device is based on the detection of secondary electron emitted by a thin foil placed at 45° to the direction of the beam. Secondary electrons are accelerated and focused by an electric and a magnetic field toward a low-pressure gaseous chamber. Time and position (X and Y) are measured. The typical resolutions (FWHM) are 300 ps and 1.5 mm, respectively.

PACS: ■; ■; ■

Keywords: Secondary electrons; Low pressure; Gaseous detector; Radioactive beam; Spatial resolution

1. Introduction

The development of radioactive beam facilities, such as Spiral at Caen (France), allows the study of the detailed structure of exotic nuclei and to probe the properties of the nuclear forces far from the "valley of stability". Vamos [1] is a magnetic spectrometer combining a large angular acceptance and a high efficiency. It has been designed to work with complex detection set-up, such as gamma array (Exogam), charged particles array (Must, Indra), located around the target or at the focal plane.

2. Vamos detection

The standard detection at the focal plane (100×400 mm^2) is composed of two drift chambers, an ionization chamber followed by a plastic scintillator. This set-up allows the tracking (scattering angle), the identification (charge, mass) and the energy measurement of incoming ions. To measure low-energy and heavy ions ($Z > 10$, $E < 2$ MeV/nucleon), new techniques are needed. In order to reduce the angular and the energy straggling, windows and non-active area have to be as thin as possible. We have therefore investigated a technique based on the secondary electrons emission induced by ions passing through a thin foil. Microchannels plates are usually used in this field. However, they introduce definitive drawbacks to cover a large working area in terms of mechanics, brittleness and cost. These difficulties have been overcome with the option of a gaseous detector, called Se-D for Secondary electron Detector.

*Corresponding author. Tel.: +33-16-908-3245; fax: +33-16-908-3024.

E-mail address: cmazur@cea.fr (C. Mazur).

0168-9002/$ - see front matter
doi:10.1016/j.nima.2003.10.040

3. Se-D working principle

The Se-D working process is well known [2,3]. The ions pass through a 0.9 μm-thick aluminized Mylar foil (see Figs. 1 and 2). The secondary electrons are accelerated by an electrostatic grid, at 10 keV, and then focused by a longitudinal magnetic field toward the gaseous detector working at low iso-butane pressure (4 Torr). The energy of the electrons is enough to cross the entrance window (aluminized Mylar foil of 0.9 μm supported by a wire-mesh). In the multi-wire counter [3], the amplification occurs over two regimes: the "parallel-plate" region where the field is constant, followed by amplification around the anode wires (10 μm) due to the high-field gradient. The gain of the detector depends on the tension applied to the wires (around 600 V). The position measurements (X and Y) are obtained by analyzing the induced charges distribution on two cathodes, respectively, made up of strips and 50 μm wires. The 128 X-position and 48 Y-position signals are preamplified and shaped by Asics-Gassiplex [4]. The Gassiplex are implanted on a set of boards designed in our laboratory which include spark protection circuits.

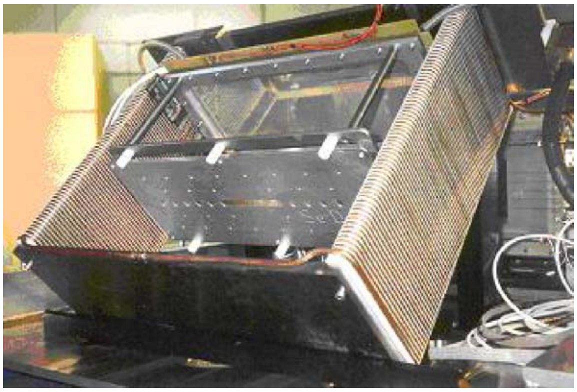

Fig. 1. The picture shows the detector Se-D mounted at the focal plane of Vamos. In the foreground, we see the mask, behind which is the emissive foil, the frame of the accelerating grid, the detector located 20 cm further. The unit is placed in a coil which induces a longitudinal magnetic field in the drift volume. The device is placed at 45° with respect to the incident ions.

4. Beam test results

A full scale detector ($140 \times 420\,\mathrm{mm}^2$ active area) was tested successfully in Vamos. The detection at the focal plane was composed of a Se-D, a drift chamber and a plastic scintillator.

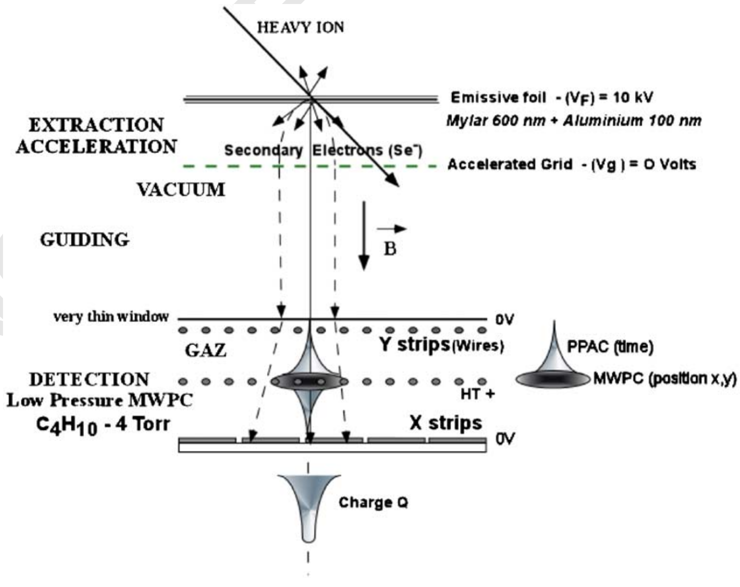

Fig. 2. Working principle of the Se-D.

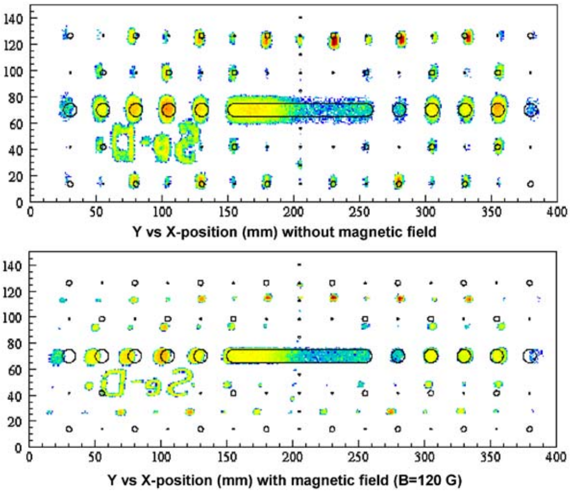

Fig. 3. Images of the mask (colored spots) superimposed to the holes (open circles) without and with magnetic field applied.

Spatial and time resolution measurements were performed with a low-emittance germanium beam (100 μm in diameter) scattered on a tantalum target. We also used a mask with a series of holes of various diameters, mounted in front of the emissive foil, in order to evaluate the deformation induced by the guiding system. In Fig. 3, images of the mask were obtained without and with a magnetic field applied. In the first case, we observe a faithful image of the mask but with a poor resolution. In the second case, at 120 G, the images of the holes are shifted whereas the resolution is highly improved. Vertical focusing and the deformations are clearly seen in the vicinity of the edges due to the heterogeneous field in the drift region. Such effects have to be taken into account in the data analysis.

The spatial resolutions are, respectively, 1.8 and 1.5 mm (FWHM) in the X and Y directions. The time resolution is rather close to that obtained with micro-channels plates (500 ps FWHM). This beam test allows us to validate the R&D performed at Saclay (emissive foil, electric and magnetic guiding device, gaseous detector, electronics, etc.). Final detectors for Vamos will be delivered in summer 2003.

Acknowledgements

We would wish to thank our colleagues of Ganil (France) who carried out studies on the magnet as well as the team of engineers and technicians of Vamos.

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