Vol. 40 (2009) *ACTA PHYSICA POLONICA B* No 3

GAS SCINTILLATION CHAMBER FOR SUPERHEAVY ELEMENTS DETECTION AT GANIL*

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(Received October 30, 2008; revised version received December 31, 2008)

In the paper we present scintillation-ionization detector (SID) — a new device for support of the superheavy elements (SHE) identification in the standard, complete fusion methods. We highlight problems with background effects in SHE production and their minimization by introducing SID to the detection set-up at GANIL. We also point possible application of this detector in alternative approach for superheavy elements production.

PACS numbers: 25.70.–z, 25.70.Jj, 25.70.Gh, 29.40.Cs

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* Presented at the Zakopane Conference on Nuclear Physics, September 1–7, 2008, Zakopane, Poland.

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1. Introduction

In recent years very intense development in superheavy elements production area is observed. Much effort is made in order to investigate the heaviest yet obtained products and synthesize heavier nuclei. However, along with increasing atomic number (Z), cross-section for SHE production in "hot" and "cold" fusion rapidly decreases and for the heaviest synthesized nuclei is of pico barn order [1,2]. Theoretical calculations for higher Zs predict that for elements from the "island of stability" ($Z \approx 114$) and for elements with $Z > 118$ this value can be even of one order of magnitude lower [3]. Therefore to synthesize new SHE elements in realistic time a very high beam intensities are required and as a result background effects appear.

2. The standard experimental set-up

Experimental set-up for SHE production and detection at GANIL can be treated as a typical one. It is composed of reaction chamber with two large rotating wheels that hold targets and strippers, respectively, two halves of the Wien filter and quadrupoles, a magnetic dipole, a detection chamber with two micro channel plates (MCPs) for time of flight (ToF) measurements and an array of silicon detectors (the BEST) in form of a tunnel closed by the position implantation Si detector [4,5]. At the end of the detection system a veto silicon detector is placed. The role of the veto is to discriminate light charged particles (LCP) that can pass MCPs without producing a pulse, in consequence they can be interpreted as an α-radioactive decay when they are detected by the implantation detector. Unfortunately, because of the thickness of the implantation detector (300 μm) such discrimination system is not very useful.

The identification of SHE in standard method is achieved by investigating spontaneous fission (SF) or/and α-radioactive decay chains of superheavy nuclei. The SHE nuclei and corresponding decay chains are detected in the same position of the silicon implantation detector. Such chains are characterized by half-life time and energy of associated particles (αs or/and SF fragments), therefore we concentrate on two measurements: estimation of half-lives and determination of emitted alphas or fission fragments energy. Both measurements can be biased due to the background. This background, which can be large in case of very high intensity beams, disturbs half-lives measurements because one can get several candidates for the parent nucleus of the detected α-decay chain. Besides, one observes also high intensity of LCPs coming from different types of reactions. Those particles are not registered with 100% efficiency by the MCPs and they can be wrongly interpreted as α-radioactive decay.

3. Scintillation-Ionization Detector as an additional information source

In order to minimize above mentioned background effects we propose to equip the standard detection system with an additional detector (SID) located just before the BEST. SID's construction and associated electronic schematics is presented in Fig. 1. The detector consists of two main parts: photo-tube with focusing mirror (scintillation part) and two planes of proportional counters (PPC, ionization part). Both, scintillation and ionization parts are working in the same gas. SID's principle of operation relies on using gas scintillations and its ionization induced by detected particles, from very light ones (*e.g.* α-particles) to the most massive (superheavy residues). By applying proportional counters, electrons released in the ionization process can be multiplied and after charge amplification seen as pulses even for very light particles. Heavier nuclei force gas scintillations which can be detected by a photo-tube (PT) and can be used to precisely determine the time of evaporation residue (SHE) arrival. Scintillating gas emits light quanta, which are focused by specially profiled mirror and directed to the PT, after electronic amplification we observe it as a pulse with amplitude proportional to energy loss and rise time of the order of nanosecond.

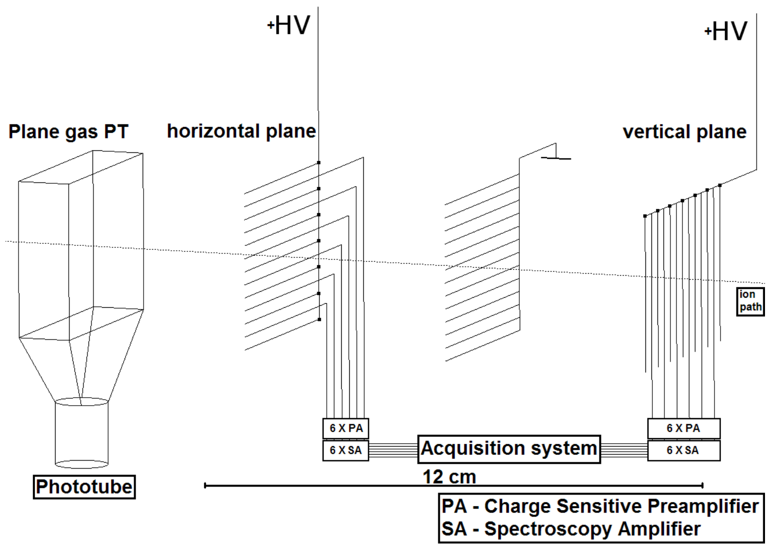

Fig. 1. SID's construction scheme.

In order to test correlation between the light output and generated charge, the simplified prototype of scintillation-ionization counter was build and tested with fission fragments emitted by Cf source. Obtained correlation (see Fig. 2) are showing similar identification possibilities for light and charge output, however, the rise time of the scintillation pulse is about two order of magnitude shorter then the charge one. Such fast scintillation pulse can be also used in the pileup rejection electronics.

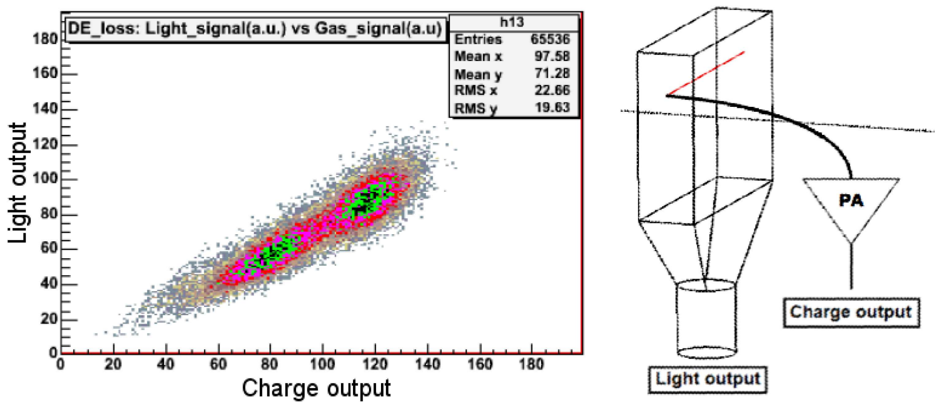

Fig. 2. Light output-charge output correlation.

Each of the PPC consists of 12 wires (horizontal and vertical) connected to positive high voltage (in order to attract free drifting electrons). 6 of them are cathode wires and 6 are the anode-signal wires with higher potential, which gather gas-amplified electric charge and send it to the separate charge sensitive pre-amplifiers. Cathode and signal wires are placed alternately with 5 mm distance. By such approach it is possible to investigate particle's trajectory as well as measure its energy loss. Using tungsten wires with 20 μm diameter yields the total transmission of SID of about 99%. For SID counter we selected the CF_4 gas. Its main advantages are: short drift time, low straggling, large stopping power, relatively strong scintillations and very fast PT pulse rise time ~ 5 ns.

4. Summary and conclusions

Background effects may become an essential problem in the case of high-intensity beams and alternative methods (*e.g.* massive transfer reactions) of SHE production [6,7]. SID detector may significantly reduce such background influence. Scintillation PT pulses are of very short rise time and could be used in ToF measurements as well as in pileup rejection systems. PPC have high efficiency for light charged particles detection thus can strongly reduce LCP background.

It seems that production of SHE in the standard methods is close to their limit of feasibility. Therefore, there is a strong need for testing and developing alternative methods of their production. In such a methods one can expect that significant background appears because SHE nuclei can be produced with broad velocity spectrum what makes the SHE separation from the beam rather difficult.

Our SID chamber was lately used in the complete fusion SHE experiment (E533) at GANIL. The data are presently analyzed.

This work was supported, in part, by the Polish State Committee for Scientific Research (KBN), Grant no. PB 3336/H03/2007/32 and by IN2P3–Poland agreement collaboration no. 08-108.

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