THE DETECTION SYSTEM OF THE DUBNA GAS-FILLED RECOIL SEPARATOR*

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The Dubna Gas-filled Recoil Separator, operated at the U400 cyclotron at the Flerov Laboratory of Nuclear Reactions, is one of the most efficient existing separator systems used to separate heavy products of the complete fusion nuclear reactions. The system of detecting the compound nuclei $\alpha-$decay sequences and spontaneous fission events, data processing, readout and accumulation is described. The present system was successfully applied in our experiments aimed at the synthesis of superheavy elements with $Z = 116$ and $Z = 114$.

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1. Introduction

In our experiment on the synthesis of $Z = 116$ nuclei in the reaction ^{248}Cm+^{48}Ca [1] the bombardment energy of Ca ions was 240 MeV and the average beam intensity on the target was 0.7 pμA. The evaporation residues (EVRs) recoiling from the target were separated in flight from beam particles, scattered nuclei and transfer reaction products in the separator's dipole magnet, filled with hydrogen at a pressure of about 1 Torr. The dipole is followed by two quadrupole lenses for focusing the EVRs on the focal plane of the separator. The transmission efficiency of the separator for Z=116 nuclei was estimated to be about 35%.

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2. Detector and measurement system

The separated EVRs passed through a time-of-flight (TOF) measurement system composed of two multiwire proportional chambers [2,3] placed in pentane at a pressure of about 1.5 Torr and were finally implanted in the detector module installed in the focal plane of the separator (Fig. 1). The TOF information is used to discriminate the particle that passed through the separator from $\alpha-$particles or spontaneous fission (SF) of implanted EVRs. START and STOP chambers are mounted 65 mm from each other and have a sensitive area of about 140×60 mm^2. The focal-plane silicon detector has twelve 40 mm-high×10 mm-wide strips with vertical position sensitivity [4].

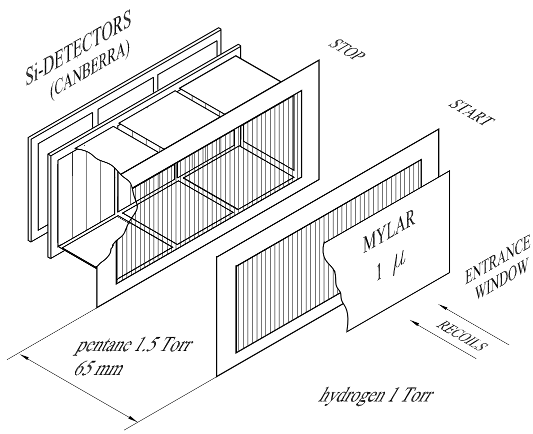
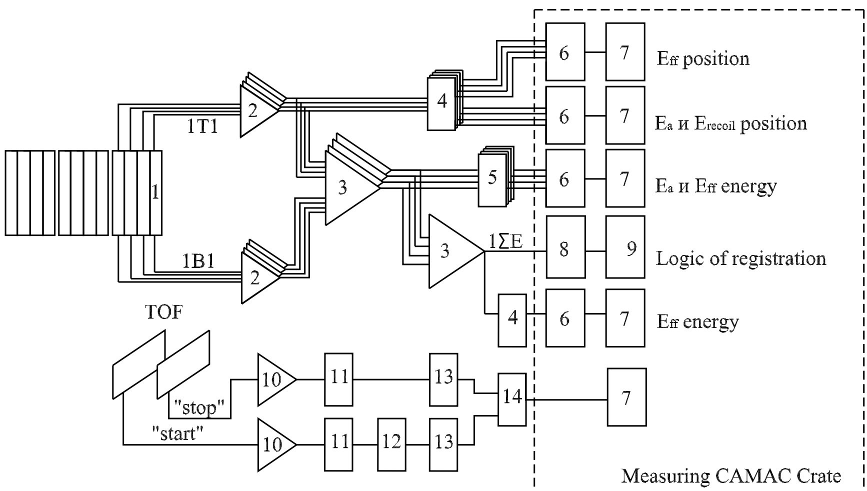


Fig. 1. Schematic view of the detecting module.

The detector is used to measure energies of EVRs, sequential $\alpha-$decays and spontaneous fission events. Their vertical position is determined from comparison of the charge signals measured at the top and the bottom of each strip. This detector is surrounded by eight 40×40 mm^2 side detectors without position sensitivity. Thus, detection efficiency for $\alpha-$decays of implanted nuclei is increased up to 87% of 4π. A set of three similar Si detectors was mounted behind the detector array and operated in "veto" mode in order to eliminate signals from low-ionizing light particles, which could pass through the focal-plane detector (300 μm) without being detected in the TOF system.

The detection system was tested by detecting the recoil nuclei and SF and $\alpha-$decays of the known isotopes of No produced in the reactions $^{204,206-208}$Pb(^{48}Ca, xn) [5]. The energy resolution for $\alpha-$particles absorbed in the focal-plane detector was about 40 keV in the beginning of irradiation. For measuring the sum signals of $\alpha-$particles escaping the focal- plane detector at different angles and registered by side detectors, the energy resolution was $\sim$ 190 keV. The FWHM position resolutions of the signals of correlated decays of nuclei implanted in the detectors were 0.8 mm for EVR$-\alpha$ and 0.5 mm for EVR-SF signals.

To improve background conditions for detecting long-time decay sequences the beam was switched off after a recoil signal was detected with parameters of implantation energy and TOF expected for $Z = 116$ EVRs, followed by an $\alpha-$like signal with the expected energy in the same coordinate position [6]. A schematic view of the measurement equipment is shown in Fig. 2.



1 - position-sensitive strips of Si detector.
2 - charge-sensitive preamplifier micro Catsa.
3 - sum-invert-amplifier SU-206K.
4 - amplifier SU-4K [7].
5 - amplifier ORTEC575.
6 - analog multiplexer AM-206K [8].
7 - ADC PA-24K [9].
8 - analog discriminator of energies.
9 - logical block KL-202 (to control all ADCs).
10 - charge-sensitive preamplifier PA-201.
11 - timing filter amplifier Polon 1501.
12 - nanosecond delay Polon 1506.
13 - constant fraction discriminator.
14 - T/A converter Polon 1701A.

Fig. 2. Block diagram of the measuring electronics (only one detector circuit is shown completely).

To determine the event time, the 16-bit counters KC-011 are used [10]. All the data are digitized and organized in events by CAMAC electronics. Specially designed crate controllers [11,12] are used to transfer the data from the CAMAC crate to the buffer memory module [13] and to the memory of the PC AT/586.

3. Results

The presented system of detecting, measurement and storage of experimental data, operated at the Dubna Gas-filled Recoil Separator FLNR JINR, was successfully applied in the experiments aimed at the synthesis of superheavy nuclei with $Z = 114$, 116 in the complete fusion reactions ^{244}Pu+^{48}Ca [14] and ^{248}Cm+^{48}Ca [1], respectively. During four months of continuous bombardment of ^{248}Cm targets, we observed three similar decay sequences that can be assigned to the implantation and decay of the isotope of element 116 with mass number 292. All the decay chains of consecutive $\alpha-$decays that follow the decay of the mother nucleus agree well with the decay chains of ^{288}114, previously observed in the ^{244}Pu+^{48}Ca reaction [14]. With the aim of preparing a further experiment on the synthesis of the new element 118, the present detecting and measurement system is being modernized.

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