Method of "active" correlations: status and development

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Introduction

The During the recent years, at the FLNR (JINR) a successful cycle of experiments has been accomplished on the synthesis of the superheavy elements with Z=112-118 with ^{48}Ca beam [1]. From the viewpoint of the detection of rare decays and background suppression, this success was achieved due to the application of a new radical technique – the method of active correlations [2]. The method employs search in a real-time mode for a pointer to a probable energy-time-position correlation like recoil-alpha for switching the beam off. In the case of detection in the same detector strip an additional alpha-decay event, of "beam OFF" time interval is prolonged automatically.

Reasonable scenarios of developing the method are considered. Statistical model of PIPS detector operating in a real-time mode is considered too. The correction parameter for estimation of random correlation probability is calculated basing on the LDSC approach [3].

The Dubna Gas Filled Recoil Separator

For the synthesis and study of heavy nuclides, the complete fusion reactions of target nuclei with bombarding projectiles are used. The resulting excited compound nuclei (CN) can deexcite by evaporation of some neutrons, while retaining the total number of protons. Recoil separators are widely used to transport EVRs from the target to the detection system, while simultaneously suppressing the background products of other reaction, incident beam of ions, and scattered target nuclei. A distinctive feature of gas-filled separators [4] is the fact that atoms recoiling from the target with the broad distribution of high charge states interact with the gas such that both average charge and dispersion are reduced. The decrease of average charge of EVRs results in their larger rigidity in the magnetic field in comparison with the background ions. Thus, EVRs can be rapidly separated in flight from unwanted reaction products and collected at detection system.

Real-Time Algorithm for Radical suppression of the Beam Associated Background Products

The simple but new idea of the algorithm is aimed at searching in real-time mode of time-energy-position recoil-alpha links, using the discrete representation of the resistive layer of the position sensitive PIPS detector separately for signals like "recoil" and "alpha-particle". So, the real PIPS detector is represented in the PC's RAM in the form of two matrixes, one for the recoils (static) and one for alpha-particles (dynamic). Those elements are filled by values of elapsed times of the given events. The second index number of the matrix element is defined from the vertical position, whereas the first index is in fact strip number (1…12). In each case of "alpha-particle" detection, a comparison with "recoil"-matrix is made, involving neighboring elements (+/-3). If the minimum time is less or equal to the setting time, the system turns on the beam chopper which deflects the heavy ion beam in the injection line of the cyclotron for a 1-5 min. The next step of the PC code ignores the vertical position of the forthcoming alpha-particle during the beam-off interval. If such a decay takes place in the same strip that generated the pause, the duration of the beam-off interval is prolonged up to 10-30 min.

Application in Heavy-Ion-Induced Nuclear Reactions

Before application in the long-term experiments, the algorithm and technique described above have been tested in $^{48}Ca + {}^{206}Pb \rightarrow {}^{252}No+2n$ nuclear reaction tests.

During the last 8 years the mentioned method was successfully applied in the HI induced nuclear reactions:

$^{238}U + {}^{48}Ca \rightarrow 112^{286-x} + xn;$
$^{242,244}Pu + {}^{48}Ca \rightarrow 114^{290,292-x} + xn;$
$^{245,248}Cm + {}^{48}Ca \rightarrow 116^{293,296-x}+xn;$
$^{243}Am + {}^{48}Ca \rightarrow 115^{291-3,4}+3,4n ;$
$^{237}N\ p + {}^{48}Ca \rightarrow 113^{282}+3n;$
$^{249}Cf + {}^{48}Ca \rightarrow 118^{294}+3n.$

References

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