Test of an R^3B Active Target prototype with a beam of ^{58}Ni

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The functionality of a prototype of an Active Target (ACTAR) was tested at the GSI accelerator facility with a beam of ^{58}Ni in April 2014. This detector was designed and constructed for studies of elastic and inelastic scattering of light to heavy nuclei on protons and helium targets. The operating principle and the design of ACTAR are similar to those of the IKAR hydrogen-filled ionization chamber (IC) used at GSI since 1993 in experiments on proton-nucleus scattering in inverse kinematics with beams of light nuclei up to ^{17}C [1, 2, 3].

The main aim of the present test experiment was to prove the possibility of reliable detection of recoiled particles in scattering reactions with a 700 MeV/u ^{58}Ni beam. The ACTAR prototype was constructed with the intention to use it for investigation of inelastic scattering reactions of exotic radioactive nuclei (middle-weight and heavy) on helium. The detector will be later placed inside the CALIFA γ-detector. Another ionization chamber, lager in size, will be built for studying elastic scattering of middle-weight and heavy ions off protons. The anode planes of the ACTAR prototype were designed so that the beam of heavy ions passes across the central anode of 20 mm diameter and possibly the first ring-shaped anode of 40 mm outer diameter. The beam diameter was expected to be smaller than 40 mm. All other anodes around the central anode and the first ring-shaped one were sectioned. The total number of segmented anodes was 66. The signals from all anodes were read out independently by the electronics including preamplifiers, amplifiers and fast 14 bit Flash-ADCs. Along with the information from the ionization chamber, the data from other detectors of the whole set-up were recorded. The beam tracking detectors were placed upstream and downstream of the ACTAR prototype. The IC was surrounded by the γ-detector Crystal Ball (with 162 NaI crystals). The ACTAR chamber was filled with helium-hydrogen (3%) mixture at several gas pressures (2, 5 and 10 bar) for estimation of optimal conditions for registration of recoiled particles with different energy. The energy calibration was performed using a precise pulser and an ^{241}Am α-source. The source was placed on the cathode surface within the chamber. The cathode and the grid of the IC were at –24 kV and –1.2 kV, respectively, provided by new low-noise HV power supplies. The ^{58}Ni beam intensity was ~5 kHz and the total accumulated statistics of elastic scattering events with ^{4}He recoiled particles of 2–15 MeV was about 60000. Figures 1 and 2 show examples of scattering events registered by the ACTAR prototype. The energy resolution in this experiment was estimated to be 20 keV (rms). This value was similar to the one obtained with a pulse generator, demonstrating relatively small influence of the heavy projectiles on the energy resolution of the recoils. One can conclude that reliable registration of recoils in ACTAR with efficiency close to 100% is possible when the energy deposition registered by the anode segments is above 150 keV.

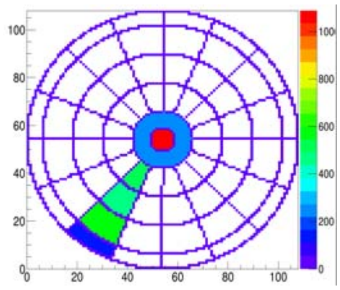

Figure 1: An example of an event registered by the ACTAR prototype. The colour scale represents the energy deposition in keV.

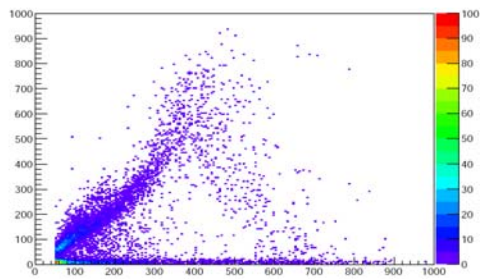

Figure 2: Two-dimensional correlations between the energy depositions of recoil particles registered by neighbouring anode rings along the radius of the ACTAR prototype.

It is also possible to observe pulses from recoils at two central anodes of ACTAR, because fluctuations of the signals produced by the heavy projectiles are relatively small, about 30–40 keV, in agreement with the simulations. This provides a possibility of pile-up rejection and good reconstruction of the total energy deposition of the recoiled particles. The analysis of recoils and γ-rays data is in progress. The experimental data obtained in the test experiment with the ACTAR prototype proved to be of importance for construction of the ionization chambers for the R^3B project. For the first time, the active target of this type was successfully tested with a beam of ions heavier than carbon.

References

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