Deliverable D10.4

WP10 – JRA04 – Innovative solutions for nuclear physics detectors
Task2

Report describing the concept and proof-of-principle for a detection system for high-resolution measurement of fast neutrons

Concepts for the detection of fast neutrons have been investigated in detail focussing on two alternative solutions, one based on a converter plus charged particle detection with RPCs (Resistive Plate Chambers), and one based on a fully active detector composed of individual plastic scintillator bars. After several prototype tests and extensive simulations, the decision has been made, that the large-volume active target with high granularity is the best option. The final detector concept foresees a 250x250x300cm^3 volume of plastic scintillator material, which is composed of 300 individual bars of the size 250x5x5cm^3, each read out on both sides with photo-multipliers. This concept results in a very high efficiency close to unity for one-neutron detection and in particular, also very high efficiency for multi-neutron events, e.g., in the order of 60% for four-neutron events. This includes already the efficiency for a proper recognition of the 4-neutron event. The time resolution of the scintillator bars including readout has been proven in prototype tests to reach around 100 ps. A detailed report on the simulation studies has been delivered as milestone MS119. A prototype consisting of 150 modules has been tested using mono-energetic neutrons produced in d(p,2p)n reactions using deuteron beams in the energy range from 200 to 1200 MeV (Milestone MS120). The data have been evaluated and compared in detail to the simulations. Very good agreement has been found validating the detector concept. In 2014, 5 planes of the detector with a total thickness of 50 cm have been tested successfully at GSI under heavy-ion beam conditions. In summary, one can say that the detector concept has been proven and that the performance of the full system can be expected to reach all required design values as verified with the simulation.

During the last part of the ENSAR funding period, possible extensions and improvements of the detection concept for future upgrades have been followed up. This research and development studies have been performed in collaboration with the R3B tracking working group from TU Darmstadt. Different readout systems have been tested for the operation of scintillating fibres. Both, alternatives for light readout as well as for the associated electronics have been tested. As a result, we see the readout of scintillating fibres with multi-pixel photon counters (MPPC) as a realistic option. In combination with a mixed readout on both ends, an economic solution for the readout of a huge number of fibres seems possible. An upgrade of NeuLAND by adding relatively thin planes based on fibres for tracking will be considered in the future.