Simulation of EXL Silicon Particle Array Response*

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The silicon target-recoil detector - EXL Silicon Particle Array (ESPA)- is designed to detect charged particles and light ions in experiments measuring elastic and inelastic scattering, charge-exchange and transfer reactions, quasi-free scattering. The EXL project objective is to study the structure of exotic nuclei in light-ion scattering experiments in inverse kinematics at the NESR storage ring. The ESPA will be a part of the setup which also includes gamma-ray and slow-neutron detectors, forward detectors for fast ejectiles and an in-ring heavy-ion spectrometer.

The ESPA surrounds the internal gas-jet target and is divided into 6 regions: D, C, B, A, E', E [1]. It consists of arrays of thin double-sided silicon strip detectors (DSSD) and thick lithium drifted silicon detectors (Si(Li)). Regions D and C (tracking section, $10° < \theta < 75°$) include two layers of thin DSSDs, regions B and A (non-tracking section, $75° < \theta < 89°$) - only one layer.

A simulation program was developed for modelling the ESPA response to the tracks of particles in the regions D, C, B, A using the Geant4 framework (Figure 1). The common framework of the program makes it possible to add silicon detectors from other regions (E', E) in the same way and to include an interface to external event generators.

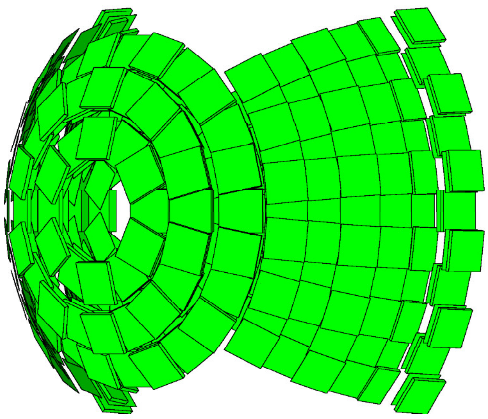

Figure 1: Part of ESPA geometry (regions A, B, C and D)in Geant4.

Geometry parameters are not "hard-coded" inside the program code. The set of basic geometry parameters, material properties and parameters that control the initialization stage, geometry building and the run of the program are read in from ASCII files and stored in a multimap container. All necessary internal geometry parameters are derived from the basic set. This structure permits to change input to any database.

The program is very flexible and permits to make different changes in geometry building and run conditions without recompilation. Setup geometry may be built without thick silicon detectors and without some regions. There is also possibility to build geometry without the first layers of thin DSSDs in the regions D and C. There are options for primary vertex displacement and smearing using the Gaussian distributions. The simulation program writes event headers and hits to the binary file. There is possibility to write output to the ROOT file.

The simulation output file is read in by the digitization program. All hits which belong to the same silicon detector are grouped and energy deposits are summed. For thin DSSDs local coordinates of the primary particle entry point are corrected taking into account the strip pitch. Obtained values of energy losses and time-of-flight are folded with resolutions taken from the known test results.

The simulation and digitization programs are designed to simulate events for investigation of angular and energy resolution and particle identification. The aim is to optimize the detector geometry. In particular, it was shown that for expected value of vertex spread (σ = 0.5 mm) the increase of strip pitch to 0.5 mm does not worsen considerably the angular resolution in the non-tracking section (Figure 2). Obtained angular resolution (about 0.06°) meets the physics requirements [1]. For the tracking section the angular resolution depends very crucially on the thickness of the first DSSD layers and particle energy because of the multiple Coulomb scattering. Detailed investigation demands use of external event generators for the reactions of interest.

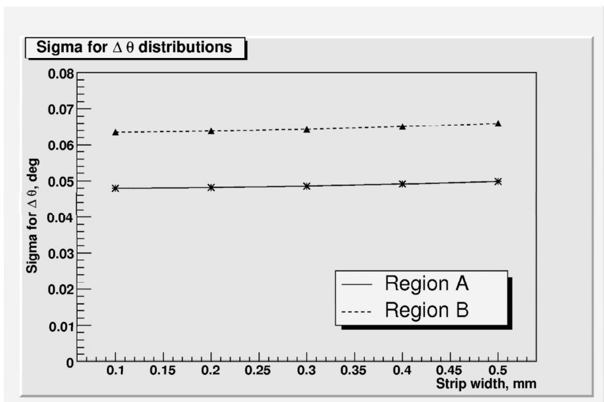

Figure 2: Angular resolution in regions A and B as function of silicon strip width for expected vertex spread.

References

[1] EXL Technical Proposal. http://www-linux.gsi.de/~wwwnusta/tech_report/05-exl.pdf

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† http://ns.ph.liv.ac.uk/~mc/EXL/ns-instrum-exl.html