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Geant4 Based Simulations for Novel Neutron Detector Development

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The construction of the European Spallation Source ESS AB, which will become the worlds most powerful source of cold and thermal neutrons (meV scale), is about to begin in Lund, Sweden, breaking ground in 2014 and coming online towards the end of the decade. Currently 22 neutron-scattering instruments are planned as the baseline suite at the facility, and a crucial part of each such beam-line will be the detector at which neutrons are detected after undergoing scattering in a given sample under study. Historically, the technological choices for neutron detection at thermal energies have been Helium-3 based, a gas which in recent years has become unavailable for all but the smallest of detectors, due to the effect of a rapidly dwindling worldwide supply at the same time the demand is increasing heavily. This makes novel neutron detectors a critical technology for ESS to develop, and also neutron detection itself presently is a hot topic to a range of disciplines and industrial applications.

Thus, an extensive international R&D programme is currently underway at ESS and in European partner institutes, and worldwide (under the auspices of the International Collaboration for the Development of Neutron Detectors, icnd.org) in order to develop efficient and cost-effective detectors based on alternative isotopes such as Boron-10 based thin-film detectors or Lithium-6 doped scintillators.

In this contribution we present the Geant4-based python/C++ simulation and coding framework, which has been developed and used within the ESS Detector Group and in collaboration with FRM-II, in order to aid in these R&D efforts. We show specific examples of results from investigations of specific proposed detector designs, and discuss the extensions to Geant4 which have been implemented in order to include the (at this energy scale) very significant effects of low-energy phenomena such as coherent scattering (Bragg diffraction) in the polycrystalline support materials of the detector. We also present a custom object oriented output file format with meta-data, GRIFF ("Geant4 Results In Friendly Format"), developed in order to facilitate a faster turn-around time when analysing simulation results by enabling high-level whole-event analysis in addition to the usual benefits of a persistified output format (such as multi-processing and fast re-analysis of the same data).

Whilst these simulations have been implemented specifically for neutron detectors, it has potential for wider applications in neutron scattering, and in other disciplines.

Summary

Primary author: Dr KITTELMANN, Thomas (European Spallation Source ESS AB)

Co-authors: Dr STEFANESCU, Irina (FRM2, Technische Universität München); Dr KANAKI, Kalliopi (European Spallation Source ESS AB); Dr ZEITELHACK, Karl (FRM2, Technische Universität München); BOIN, Mirko (Helmholtz Zentrum Berlin); Dr HALL-WILTON, Richard (European Spallation Source ESS AB)

Presenter: Dr KITTELMANN, Thomas (European Spallation Source ESS AB)

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