T 80: Cosmic Rays IV

Time: Thursday 16:00–18:35 Location: Te

Group Report T 80.1 Thu 16:00 Te

Status of the CORSIKA 8 Project — •Ralf Ulrich for the CORSIKA 8-Collaboration — Institute for Astroparticle Physics, KIT

It is the goal of the CORSIKA 8 project to create a novel framework for astroparticle physics to simulate and describe high-energy particle cascades in matter. While solidly founded on the legacy of the fortran version of CORSIKA, this new framework will provide high flexibility, modularity, and is opening new opportunities for research in the intersection of astroparticle-, astro-, particle-, nuclear-physics – and beyond. The CORSIKA 8 framework is implemented as a modern C++ high-performance computing code, with the main goal to provide best achievable physics performance. The recent progress of the CORSIKA 8 framework is described, the current capabilities are presented, and the roadmap to a first production release is outlined.

T 80.2 Thu 16:20 Te

Random number generation in massivelly parallel platforms for CORSIKA8 — •Antonio Augusto Alves Junior, Anton Poctarev, and Ralf Ulrich — IAP - KIT, Karlsruhe, Germany

Advances of the generation of high quality random numbers in CORSIKA8, which is being developed in modern C++17 and is designed to run on multi-thread modern processors and accelerators, are discussed.

The aspects associated with the generation of high quality random numbers on massively parallel platforms, like multi-core CPUs and GPUs, are reviewed in depth, with particular emphasis on the deployment of counter-based engines.

Detailed performance measurements for the available counter-based algorithms are provided, as well as detailed comparisons with conventional designs. Finally, the design choices and integration into CORSIKA 8 are presented, together with some cascade simulation examples.

T 80.3 Thu 16:35 Te

Radio emission simulations using CORSIKA 8 — •Nikos Karastathis[1], Remy Prechelt[2], and Tim Huege[1,3] for the CORSIKA 8-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Department of Physics and Astronomy, University of Hawaii-Manoa, Hawaii, USA — [3]Astrophysical Institute, Vrije Universiteit Brussel, Brussels, Belgium

For years, CORSIKA has served the scientific community as one of the leading simulation tools for air showers. Simulations of the radio emission from air showers are made possible within this context using the CoREAS extension. Given that the current code rests upon the monolithic structure of FORTRAN77, a complete reimplementation of CORSIKA 8 that is based on a modular and more flexible C++ design is an ongoing project. Part of this effort is to include radio-emission calculations as an integral part of the program.

In this talk, I will present the current state of the software design and how a reimplementation of CoREAS fits into CORSIKA 8 by taking advantage of its features. This design makes radio calculations more general, giving the freedom to choose different formalisms for the radio-emission calculations, such as the Endpoint or ZHS formalisms, and in the future accommodating more complex interaction media. Our first radio simulations using CORSIKA 8 will be presented.

T 80.4 Thu 16:50 Te

Millicharged Particles in Cosmic Ray Air Showers — Anatoli Fedynitch[1], Ralf Ulrich[2], Tanguy Pierog[2], Max Reininghaus[2], Antonio Augusto Alves Jr[2], and •Maria Pokrandt[2] for the CORSIKA 8-Collaboration — [1]Tokyo University, ICRR — [2]Institut for Astroparticle Physics, KIT

Despite its widely appreciated success, there are open questions in the Standard Model (SM) such as potential dark matter particles, the neutrino masses or the anomalous magnetic moment of the muon. Some theories extending the SM suggest the existence of millicharged particles (MCPs) with just a fraction of an electron charge. Such particles are experimentally poorly constraint in the quite interesting mass range from about 1 to 100GeV. Cosmic air showers abundantly produce particles of such energies and are therefore an interesting opportunity to look for the existence of MCPs. In this work, MCPs in the GeV regime are implemented in the powerful air shower simulation tool MCEq (Matrix Cascade Equations) and first results are derived from the resulting simulations. The goal is to obtain competitive exclusion limits for MCPs in that particular mass range.

T 80.5 Thu 17:05 Te

EAS genealogy for muon production — Tanguy Pierog[1], •Maximilian Reininghaus[1,2], and Ralf Ulrich[1] — [1]Institut für Astroteilchenphysik, KIT, Karlsruhe — [2]Instituto de Tecnologías en Detección y Astropartículas (CNEA, CONICET, UNSAM), Buenos Aires

Measurements of the muon content of extensive air showers at the highest energies show large discrepancies compared to simulations. This so-called muon puzzle is commonly attributed to a lack of understanding of the hadronic interactions in the shower development. Furthermore, measurements of the fluctuations of muon numbers suggest that the discrepancy is likely a cumulative effect of interactions of all energies in the cascade.

With the newly developed "history" extension of the air shower simulation code CORSIKA 8 we are able to relate interactions happening at any intermediate stage in the cascade to the final-state muons. With this technique we study "muon-number weighted" particle distributions of hadronic interactions in order to quantify the relevance of different phase space regions for muon production.

T 80.6 Thu 17:20 Te

Prediction of cosmic ray signatures on Earth from nearby supernova explosions — •Jonathan Heil — Ruhr-University Bochum, Germany

Supernova remnants are among the most promising candidates for the production of a large component of the cosmic-ray flux at Earth. However, even more than 100 years after the detection of cosmic rays, the exact contribution to the luminosity of cosmic rays from SNRs is could not be fully quantified yet. In this contribution, we present a simulation performed with the CRPropa transport framework, in which particles are propagated from sources in the Galaxy to Earth for different source parameters like luminosity, activity time and position. The goal is to map the influence of nearby supernova remnants on the diffusive cosmic ray flux and to extend the simulated cosmic ray energy range to low energies. In this talk, the simulation setup will be presented together with first results.

T 80.7 Thu 17:35 Te

Recent developments for the high-energy lepton and photon propagator PROPOSAL — •Jean-Marco Alameddine[1], Jan Soedingrekso[1], Alexander Sandrock[2], and Maximilian Sackel[1] — [1]TU Dortmund University — [2]National Research Nuclear University MEPhI

The precise simulation of high-energy particles is a major task for many analyses in astroparticle physics. PROPOSAL is a Monte Carlo software, usable in both C++ and python, providing an easy to use and customizable environment to simulate high-energy muons, taus, electrons, positrons and photons. Its functionalities allow finding an adequate trade-off between simulation precision and performance.

In this talk, the recent developments of PROPOSAL are presented, including the implementation of electron, positron and photon propagation as well as a major code restructuring towards a more modular software. This provides the possibility to extract individual components of the propagation routine of PROPOSAL to be used in external frameworks or analyses. One application example is the air shower simulation framework CORSIKA 8, where it will be possible to use PROPOSAL as an electromagnetic interaction model.

T 80.8 Thu 17:50 Te

Distributed simulation of extensive air showers with Geant4 — Kai-Thomas Brinkmann, Hans-Georg Zaunick, and •Daniel Treffenstädt — Justus-Liebig-Universität Gießen

This talk presents an approach to simulating extensive air showers caused by ultra high energy cosmic radiation in earths atmosphere with Geant4. The scope is to simulate the interaction of extensive air showers with an array of plastic scintillator detectors distributed in a loose formation within an area of few square kilometers. The main area of interest thereby is to determine the signature of a shower event specific to the timing of individual detecor events with respect to each other. This simulation however requires a high level of precision and tracking of all individual particles produced in the shower, which causes a high CPU runtime impact. An approach to reduce the total runtime of each simulation by distributing the simulation on a large number of calculation nodes is investigated.

T 80.9 Thu 18:05 Te

The air shower arrays at the South Pole — •Agnieszka Leszczyńska, Mark Weyrauch, and Fiona Ellwanger for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

The IceTop air-shower array, detecting cosmic rays in the PeV–EeV energy range, will be enhanced with scintillation detectors and radio antennas. Due to their better sensitivity to the electromagnetic component of the air showers, those will, together with the IceTop Cherenkov tanks, help to improve the measurement of the cosmic ray mass and energy. A denser sampling of the area will lower the energy threshold to cover the knee region of the cosmic ray spectrum. A similar array is planned to be also deployed within the surface footprint of the next generation of the IceCube experiment, IceCube-Gen2. A larger exposure of the IceCube-Gen2 surface array will allow for studying higher energy cosmic-rays and, at the same time, will serve as an additional veto of the atmospheric background for the down-going astrophysical neutrinos. Recent simulation results as well as the prospects for these new surface arrays will be discussed.

T 80.10 Thu 18:20 Te

Cosmic muon induced neutron measurement with the MINIDEX experiment — •Xiang Liu, Iris Abt, Bela Majorovits, Oliver Schulz, Christopher Gooch, Anton Empl, and Raphael Kneissl for the GeDet-Collaboration — Max Planck Institute for Physics, Föhringer Ring 6, Munich D-80805, Germany

Cosmic-ray muon induced neutrons are an important source of background in low-background experiments searching for rare phenomena, like neutrinoless double beta decay or dark matter. These neutrons can generate radioactive isotopes in the shielding materials or in the detector itself, creating background which can not be easily removed by a cosmic muon veto, due to the time delay. The Muon-Induced Neutron Indirect Detection EXperiment, MINIDEX, running in the shallow undergound laboratory at the University of Tuebingen, measures the production of muon-induced neutrons in a variety of high-Z materials. Recently, the experiment has been upgraded to measure the neutron production not only from through-going muons but also from stopped muons. The design of the experiment and the upgrade are presented as well as selected results.