Status of the novel CORSIKA 8 air shower simulation framework

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A. Augusto Alves Jr

Presented at 37$^{\text{th}}$ International Cosmic Ray Conference (ICRC 2021)
21 July 2021 – Berlin, Germany

Karlsruhe Institute of Technology

CORSIKA 8

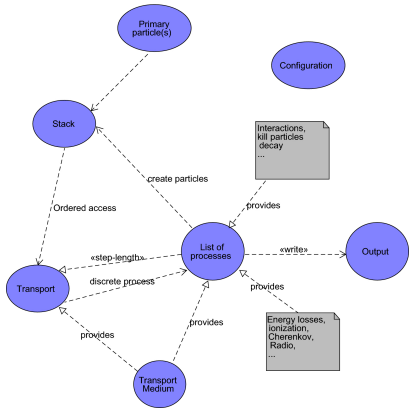
CORSIKA 8 is a new C++ framework for Monte Carlo simulations of extensive particle cascades in air and other media.

- Successor of long-standing FORTRAN-based CORSIKA 7 and aiming to serve the astroparticle physics community over the next decades.
- Designed as a modular and open framework.
- Wider scope in comparison with its predecessor.
- Collaborative, open source and community driven project under GPLv3.

Design

CORSIKA 8 is designed to provide most, if not all, the infrastructure necessary to write concrete physics applications.

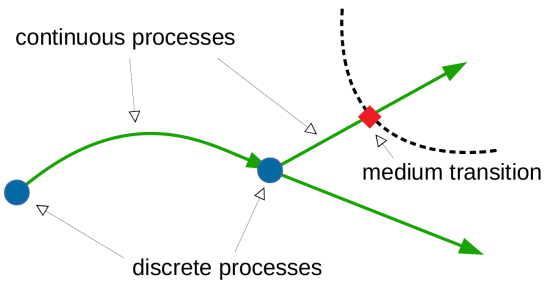
- **Modularity.** All algorithms and physics models as modules.
- **Completeness.** Interfaces for the most, if not all, approaches available to deal with a given problem.
- **Robustness.** Designed for long-term stability. Example: statically typed units to express physics properties, like in `"HEPEnergyType E0 = 10_GeV;"` .
- **Performance:** Efficient implementations, including planned extensive support for modern multithread architectures, like multicore CPUs and GPUs.



Modularity and Physics

Provide flexibility while strictly enforcing physics concepts in code:

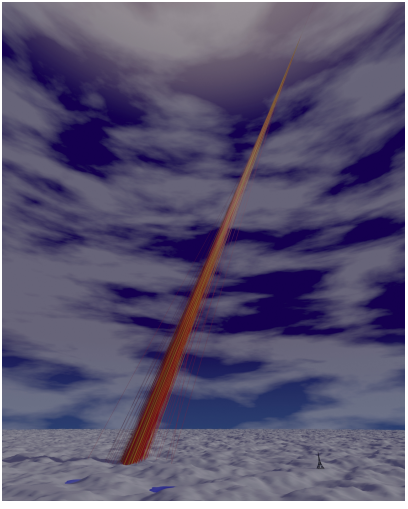
- Process types represented by dedicated classes.
- Physical units defined and checked at compile-time.
- Geometric objects have well defined reference frames.
- Particle properties represented as classes and enumerations to mitigate error prone conditions.



Environment and Geometry

The region of interest, containing an environment potentially filled with different media is described using a custom geometry set of functionality.

- Simple and efficient geometric primitives representing tracks, volumes, shapes etc.
- Each geometry object can be represented with its own physical properties.
- Easing the exchange of atmospheric models: Earth and Mars atmospheric models already available.
- Environment with mixed media can be transparently handled, e.g. air/ice showers.



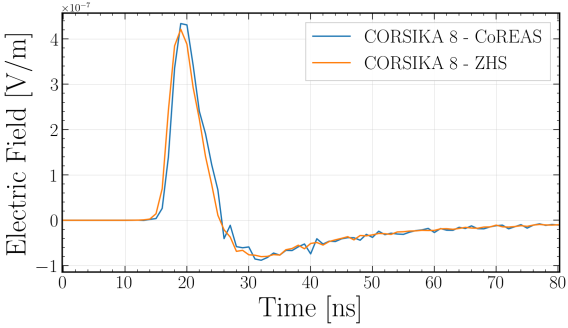
At right Blender (`https://www.blender.org/`) scene representing a shower simulated in CORSIKA 8

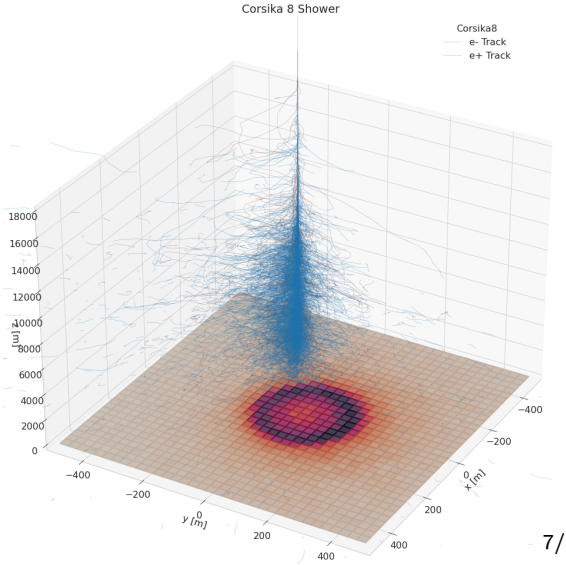
CORSIKA 8 at ICRC2021

Many interesting presentations detailing aspects of CORSIKA 8 at ICRC2021:

- *Simulations of radio emission from air showers with CORSIKA 8*, N. Karastathis - 13/07/2021
- *Hadron cascades in CORSIKA 8*, R. Ulrich - 14/07/2021
- *Electromagnetic Shower Simulation for CORSIKA 8*, Jean-Marco Alameddine 21/07/2021
- *GPU Accelerated optical light propagation in CORSIKA 8*, D. Baack - 16/07/2021.
- *Air shower genealogy for muon production*, M. Reininghaus - 14/07/2021

Examples





- Above, a pulse produced by radio using both algorithms CoREAS and ZHS.
- On the right, the Cherenkov light at ground level simulated using GPU.

Summary and status

CORSIKA 8 framework, a novel high-performance computing platform for simulations of secondary particle cascades in astroparticle physics has been described.

- The framework is written in C++17 and has a modular design.
- Planned support for modern hardware architectures including GPUs and FPGAs.
- Most of the core functionality and many modules already implemented and working (see other presentations at ICRC2021).
- A first pre-release version is available for tests, validation and development at

  `https://gitlab.ikp.kit.edu/AirShowerPhysics/corsika`

- The project is under intense development. It is open source and community driven project, licensed under GPLv3. Everyone is welcome to contribute.