ESCAPE OSSR onboarding

"ConCORDIA Containers" tech report

# Context

The KM3NeT Collaboration is currently building 2 large volume Cherenkov neutrino detectors in the Mediterranean sea. The KM3NeT-ARCA telescope will be located 100 km off-shore Sicily and will study the astrophysics of high-energy neutrinos. KM3NeT-ORCA, 40 km off-shore Toulon, France, will study neutrino oscillation phenomena with atmospheric neutrinos. In these detectors, particles are observed by catching their Cherenkov radiation with a 3-D array of PMTs placed at large depths. The majority of events are induced by muons produced by cosmic ray air-showers reaching large depths. Neutrinos are usually selected by searching for upward-going particles, using the whole Earth as a shield against the cosmic ray muons.

# The Cherenkov Telescope Array (CTA) is the next generation ground-based observatory for gamma-ray astronomy at very-high energies. With more than 100 telescopes located in the northern and southern hemispheres, CTA will be the world’s largest and most sensitive high-energy gamma-ray observatory. This type of telescope focuses the Cherenkov light emitted from air showers, initiated by very-high-energy gamma rays and cosmic rays, onto the camera plane. Then, a fast camera digitizes the longitudinal development of the air shower, recording its spatial, temporal, and calorimetric information. The properties of the primary very-high-energy particle initiating the air shower can then be inferred from those images

# The characterization of both instruments heavily rely on determining the response of their corresponding hardware to different signals by means of Monte Carlo simulations. Common to both instruments stands the CORSIKA package, a program for detailed simulation of extensive air showers initiated by high energy cosmic ray particles.

# The ConCORDIA project

**ConCORDIA** (**Con**tainers for **COR**SIKA on **DI**R**A**C) is a project developed within the scopes of the ESCAPE WP3 and represents one of the main subject of the FG5. Its goal is to provide the possibility of simulating cosmic ray air-showers with CORSIKA using the DIRAC GRID middleware for the job management. It has been developed by (in alphabetical order)

C. Bozza (INFN and University of Salerno) – KM3NeT Collaboration

J.L. Contreras (Universidad Complutense de Madrid) – CTA Observatory

L.A. Fusco (CNRS-CPPM, currently at University of Salerno) - KM3NeT Collaboration

G. Hughes – CTA Observatory

D. Nieto Castaño (Universidad Complutense de Madrid) – CTA Observatory

B. Spisso (INFN-Napoli) - KM3NeT Collaboration

M.S. Stellacci (University of Salerno) - KM3NeT Collaboration

A. Tsaregorodtsev (CNRS-CPPM) - DIRAC

D. Zito (INFN- LNS) - KM3NeT Collaboration

and with a duly cooperation between the KM3NeT and the CTAO participants to FG5.

It has two main consituents: a CORSIKA Containers library; a DIRAC Web App for CORSIKA.

# The CORSIKA Containers library

A Java GUI has been developed to produce CORSIKA v7.7100 docker and singularity containers based on an *Alpine OS* linux distribution. Together with the GUI, also a *bash* script is provided to create the same containers (or any additional new container the user might need). A library of pre-built images has been created following some of the main possible required compilation options for CORSIKA

## Developments

The development of the CONCORDIA project began with the creation of a Java GUI and a bash script interface for the creation of docker and singularity containers. Once this has been completed a set of containers has been released: these covered some of the possible configurations that could be useful in the simulation of extended air showers for detectors on the surface of the Earth or under-sea. Then, specifically for the CTA scopes, those images were tailored to mirror the same exact CORSIKA configuration used by the CTA Consortium for the most up-to-date massive Monte Carlo production by the time of the start of CONCORDIA (the so-called Production 4).

In order to allow the processing of Monte Carlo simulations using these containers on GRID computing resources, a series of scripts have been prepared that allow the submission of jobs on the EGI resources using the DIRAC system. *For the CTAO the production is run on the CTA-specific DIRAC instance.*

The GUI for the generation of the containers has been eventually included in DIRAC together with a job launcher interface. Both will be made part of the DIRAC WebGUI in a specific DIRAC release to come.

## Requirements and software dependencies

*Singularity* or *docker* are required to build and run the containers.

For what concerns the ESAP integration, the current setup for ESAP required singularity containers. However, users deploying their own version of the ESAP and DIRAC instance can easily change this.

## Workflow integration and Input/Output Data

The ConCORDIA containers library can be the first step of a DIRAC processing chain. The GUI for container creation is indeed also implemented in a DIRAC WebApp that will be made available in a future DIRAC release. Scripts for the DIRAC job submission are provided within the container library. The same containers can also be used, standalone, on any computing centre where singularity is available.

With a correctly installed and configured ESAP it will be possible to launch ConCORDIA containers via the ESAP. The ESAP worker needs to be deployed on a system with a correctly configured DIRAC client. Instructions can be found on the ESAP documentation page, [here](https://git.astron.nl/astron-sdc/esap-api-gateway/-/wikis/ESAP-API-gateway-Overview). The user is required to create a correctly formatted json steering file and the location of a ConCORDIA singularity image.

A set of tests have been implemented to provide a benchmark of the perfomance of the container execution and of different options in the processing. In particular, the “IceCube” option for the generation of neutrinos in atmospheric cosmic rays interactions could be tested providing an estimation of the (significant) gain that can be obtained for most primary energies.

## User’s story

From the KM3NeT and CTAO communities, the containers can be used as first step of the Monte Carlo simulation chain. Containers are indeed a staple for the current data and Monte Carlo processing in the collaboration and these containers (or others, created with the tools developed in this project) are used to simulated in a reliable and reproducible way results across different computing centres. The users can retrieve the containers or create new ones, according to their necessities. GRID jobs can be launched using the DIRAC interface.

## On-boarding

Containers are stored at **TO BE ADDED**

and can be retrieved **TO BE DESCRIBED**.

The accompanying scripts for the creation of the containers are also available at

**TO BE ADDED**

The Java GUI **TO BE ADDED**

The implementation in the DIRAC Web App is described in a DIRAC release **TO BE ADDED**