



# Generative Artificial Intelligence for Air Shower Simulation

Project status and outlook

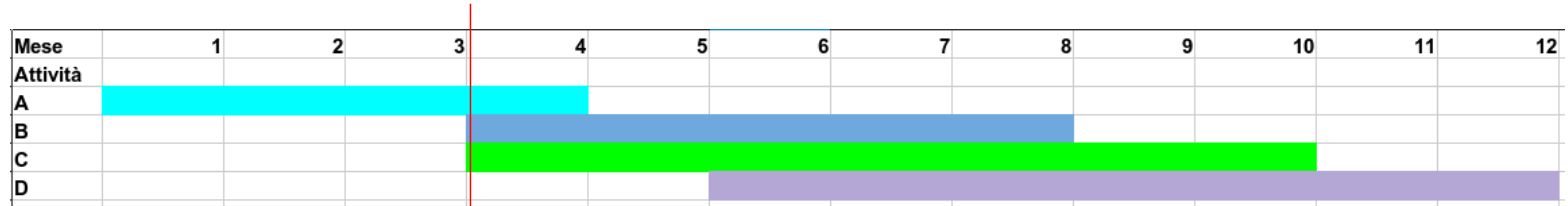
Cristiano Bozza @UNISA

**Goal of GAIAS2:** Demonstrate and develop the use of generative techniques (GAN) for the production of simulations of cascades from cosmic rays in the atmosphere

## Activities:

- A) Definition of the benchmark simulations for cosmic ray interactions
- B) Comparison among benchmark simulations with CORSIKA 7 and CORSIKA 8
- C) Definition of the extensive air shower model for the neural network
- D) Test of extensive air shower generation by GAN and comparison with benchmark simulations

## Timeline



## Resources:

- 1) Staff for 8 personnel units: ~157 k€
- ~~2) Request to purchase NVIDIA A100: 285 k€~~

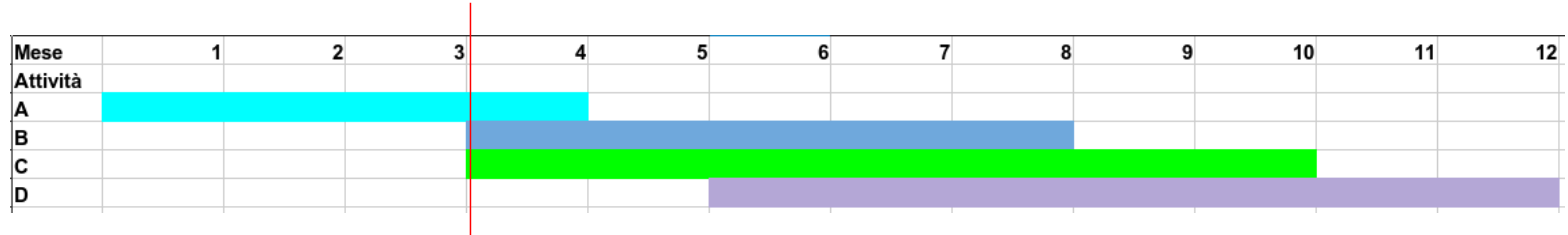
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We will be using 5 × A40 of the computing cluster at the Department of Physics of UNISA

Request: 1 node from LEONARDO Booster with 4 × A100 (50%)

Scientific goals are unchanged

## Project status (Q1)



### Time

Total time elapsed: **25%**

### Activities

A): 75%

B), C) ready to start

D) Starting in February 2025

### Accounted costs

Up to 30/11/2024: 37,7 k€ = **24.1%**

## Indicators and Deliverables

I1: Creation of the technical/scientific specifications (qualitative parameter) for the simulation of secondary particle showers from high-energy cosmic interactions

– **Report ( [hypertext](#) )**

I2: Creation of benchmarks for at least 2 different software (quantitative parameter) and for 10 different types of cosmic rays (protons of various energies)

– **Report ( [hypertext](#) )**

I3: Creation of specifications for GANs (qualitative parameter)

– **Report ( [hypertext](#) )**

I4: Acceleration of computations with GANs by at least 50% compared to traditional simulation with CORSIKA 7/8 (quantitative parameter).

– **Paper submission**

## Official site

<https://gaias2-icsc.github.io/home>  
(will be moved to the ICSC GitHub)

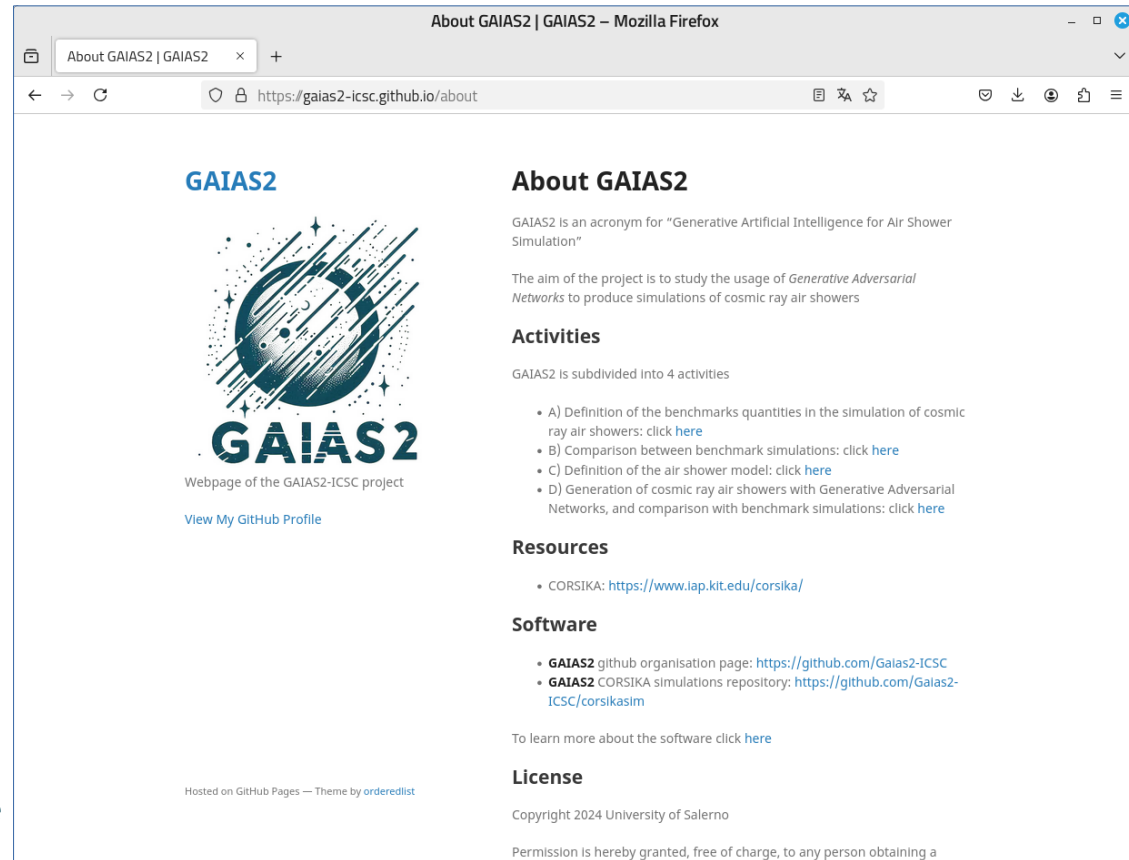
All code and results are published

Deliverables for I1, I2, I3 will be published on the site

MIT Licence

Connections

GAIAS2 reuses CORSIKA containers developed for the ConCORDIA initiative in ESCAPE (H2020)




The screenshot shows a web browser window displaying the 'About GAIAS2' page. The page features the GAIAS2 logo, which is a stylized globe with streaks of light. Below the logo, it says 'Webpage of the GAIAS2-ICSC project' and 'View My GitHub Profile'. The main content area is titled 'About GAIAS2' and explains that GAIAS2 is an acronym for 'Generative Artificial Intelligence for Air Shower Simulation'. It states the project's aim is to study the usage of Generative Adversarial Networks to produce simulations of cosmic ray air showers. Under 'Activities', it lists four sub-projects: A) Definition of benchmarks, B) Comparison of benchmark simulations, C) Definition of the air shower model, and D) Generation of cosmic ray air showers with GANs and comparison with benchmarks. The 'Resources' section lists CORSIKA. The 'Software' section lists the GAIAS2 GitHub organization and the CORSIKA repository. The footer includes copyright information for the University of Salerno and a license statement.

About GAIAS2 | GAIAS2 – Mozilla Firefox

https://gaias2-icsc.github.io/about

## GAIAS2



Webpage of the GAIAS2-ICSC project

[View My GitHub Profile](#)

### About GAIAS2

GAIAS2 is an acronym for “Generative Artificial Intelligence for Air Shower Simulation”

The aim of the project is to study the usage of *Generative Adversarial Networks* to produce simulations of cosmic ray air showers

### Activities

GAIAS2 is subdivided into 4 activities

- A) Definition of the benchmarks quantities in the simulation of cosmic ray air showers: click [here](#)
- B) Comparison between benchmark simulations: click [here](#)
- C) Definition of the air shower model: click [here](#)
- D) Generation of cosmic ray air showers with Generative Adversarial Networks, and comparison with benchmark simulations: click [here](#)

### Resources

- CORSIKA: <https://www.lap.kit.edu/corsika/>

### Software

- GAIAS2 github organisation page: <https://github.com/Gaias2-ICSC>
- GAIAS2 CORSIKA simulations repository: <https://github.com/Gaias2-ICSC/corsikasim>

To learn more about the software click [here](#)

### License

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## Work status

Technical-scientific specifications close to complete publication (I)

CORSIKA7 / CORSIKA8 simulations ready to run on 400 cores (DipFisica UNISA)

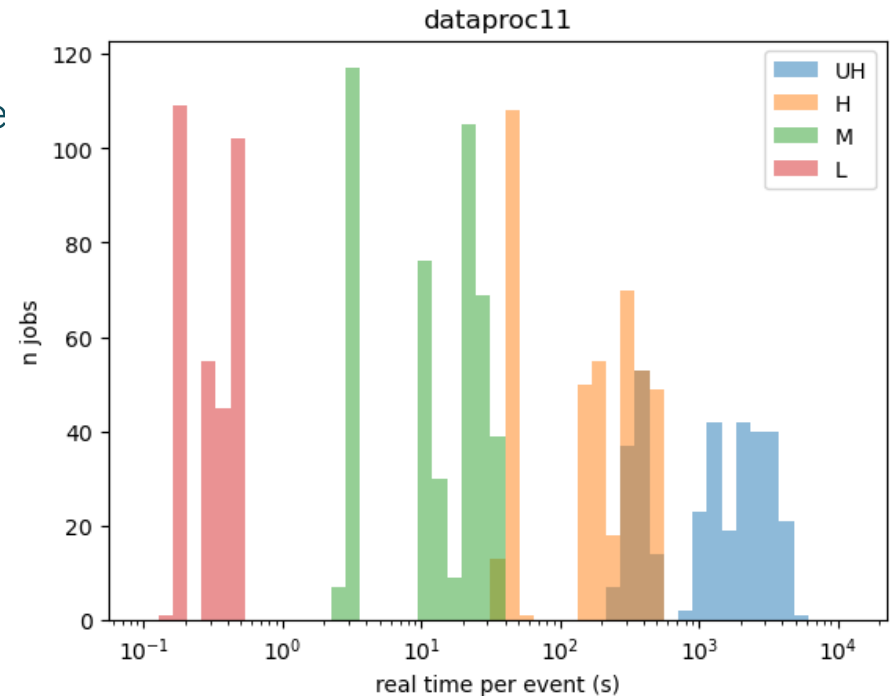
Primaries and energies defined  
Preliminary productions (2M events / category):

L: 1 - 100 TeV

M: 100 TeV - 10 PeV

H: 10 PeV - 100 PeV

UH: 100 PeV - 1 EeV



## Outlook

Already from preliminary production, we see hints of opportunities for the generation of events with GAN

We expect dramatic improvements for high-energy events, in particular with respect to simulations based on the EPOS interaction model

## Risks and criticalities

As of today we do not see any

