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Monte Carlo simulations for the Pierre Auger Observatory using the VO auger grid resources

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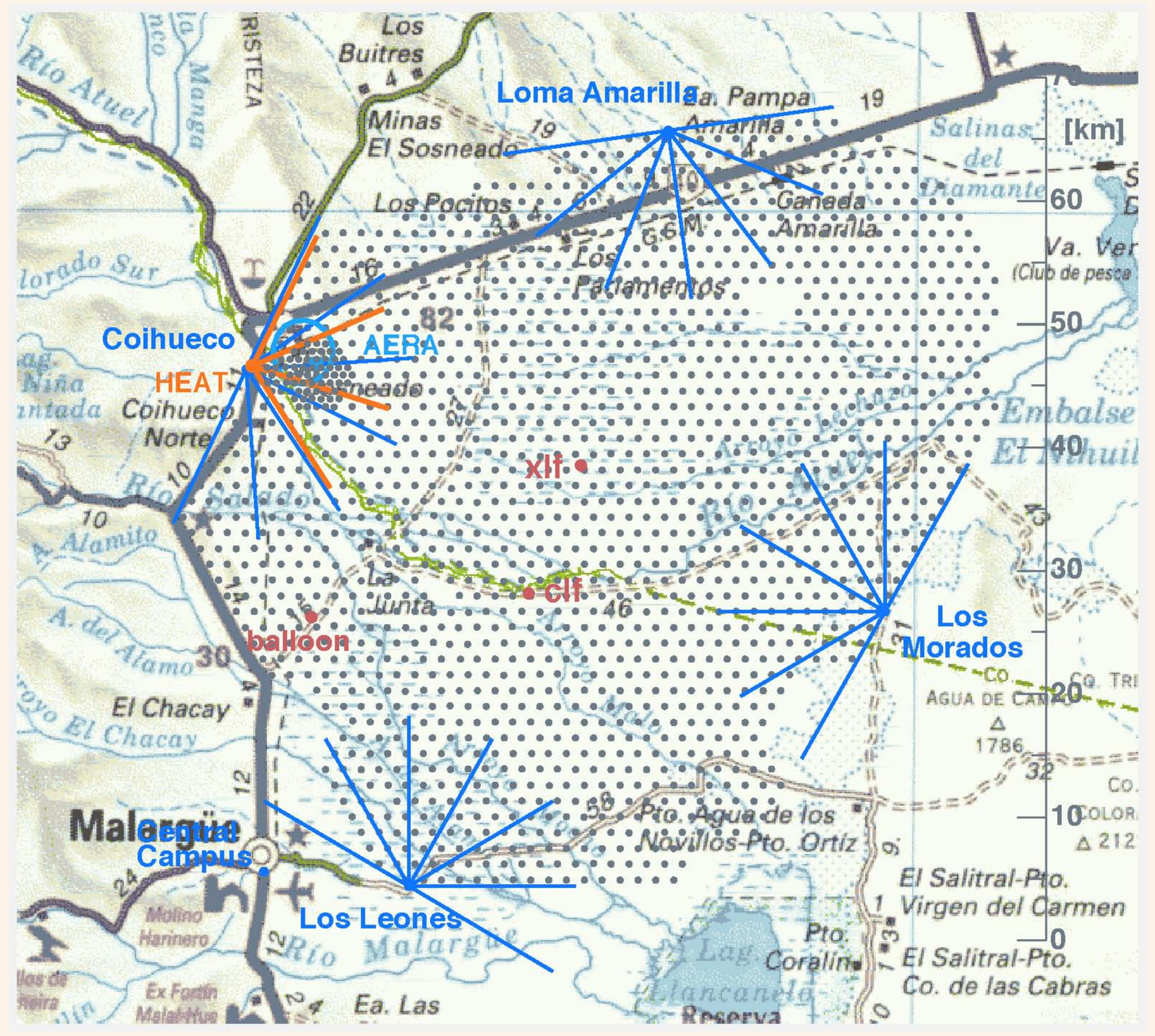
PIERRE AUGER OBSERVATORY

1. Pierre Auger Observatory

Largest cosmic ray detector in the world

More than 1500 events with $E > 10^{19.5}$ eV!



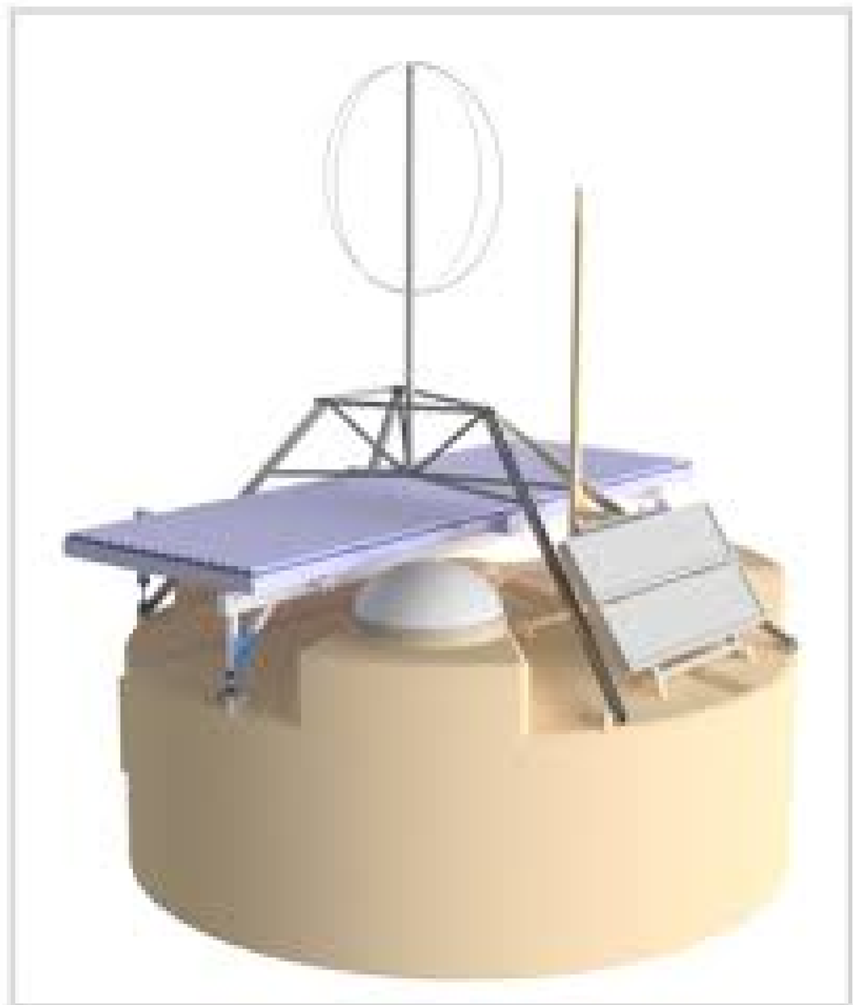
Pierre Auger Observatory schematic sketch.

- $E > 10^{16}$ eV
- Surface Detector (SD)
  - 3000 km^2
  - 1660 water-Cherenkov detectors
- Fluorescence Detector (FD)
  - 4 sites
  - 27 fluorescence telescopes

2. AugerPrime

Enhanced measurements at the highest energies

- Surface Scintillator Detector
- Radio Detector
- Underground Muon Detector
- SD extended dynamic range
- SD Electronics Upgrade
- FD extended duty cycle



AugerPrime surface detector station.

New simulation libraries needed!

3. Auger Monte Carlo libraries

Multipurpose simulation libraries

CORSIKA

- $\sim$ 700 k files
  - $\lg(E/\mathrm{eV}) = 15.0 - 20.2$
  - 5 species (γ, H, He, O, Fe)
  - 3 hadronic interaction models
  - 10^{-6} thinning

Auger Offline

- $>$ 1 M files
- CORSIKA as input
  - $5 - 30\times$ resamplings
- Hybrid reconstruction
- SD reconstruction

And also hybrid time dependent simulations

4. VO auger

Established in 2006 by the Czech group

Cooperation with CESNET

- 32 members
- 11 countries
- 23 sites
  - 1.3 M files
  - 210 TB disk space

1.4 PB storage capacity!

cesnet metacentrum

- Provides and maintains central resources
- Registration portal
- VOMS server

DIRAC THE INTERWARE

- Job management
- File Catalog

5. VO auger - 2020 Yearly statistics*

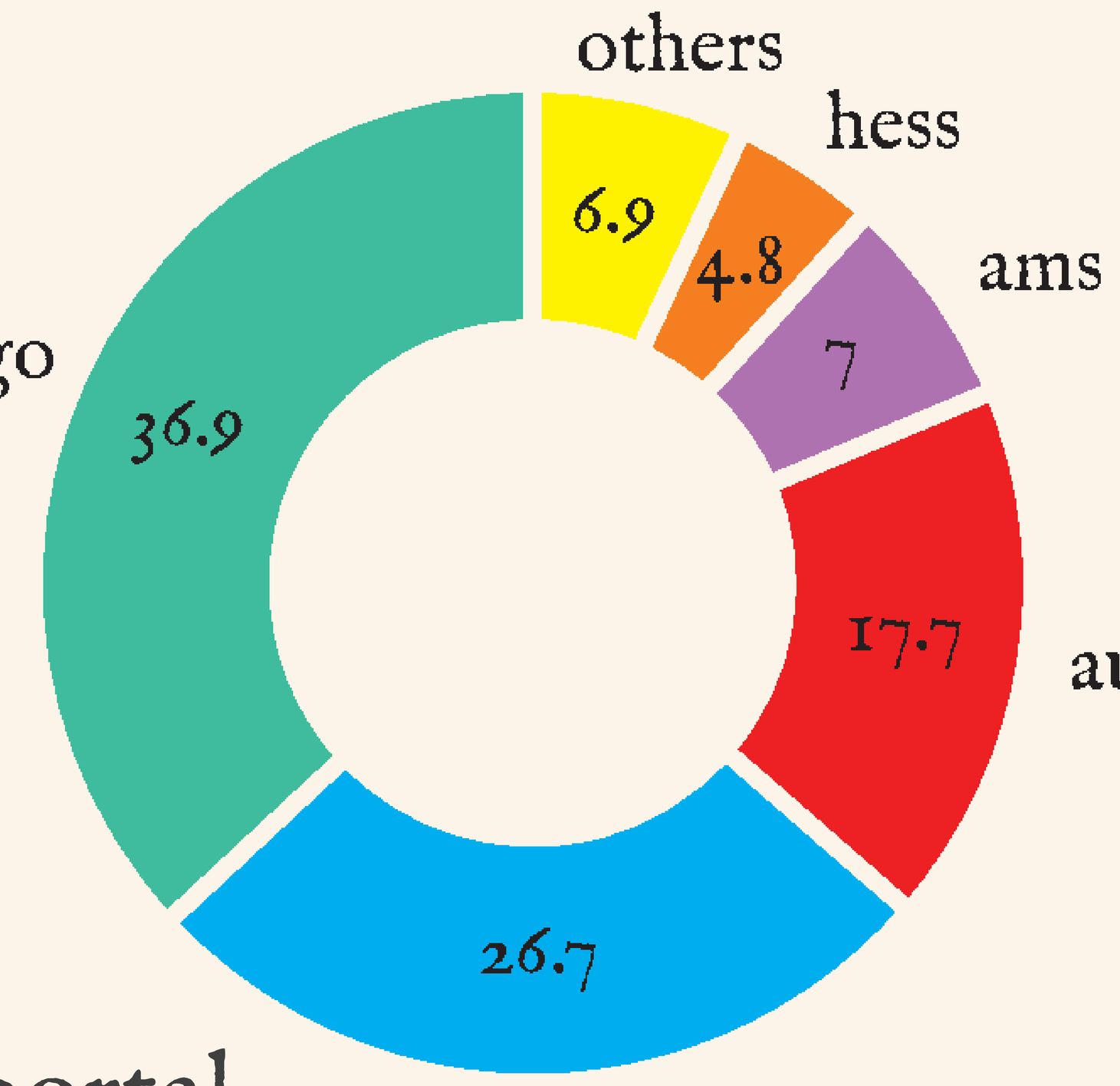
Usage comparable with other astrophysics VOs

Single-core jobs

- $\sim$ 100000 jobs
  - 5 Regions
  - 6 Sites
- 60 million CPU hours
- Year average
  - 562 cores
- $>$ 200 TB

2020 - Astrophysics VOs

Relative elapsed time



*From the EGI accounting portal

6. Production framework

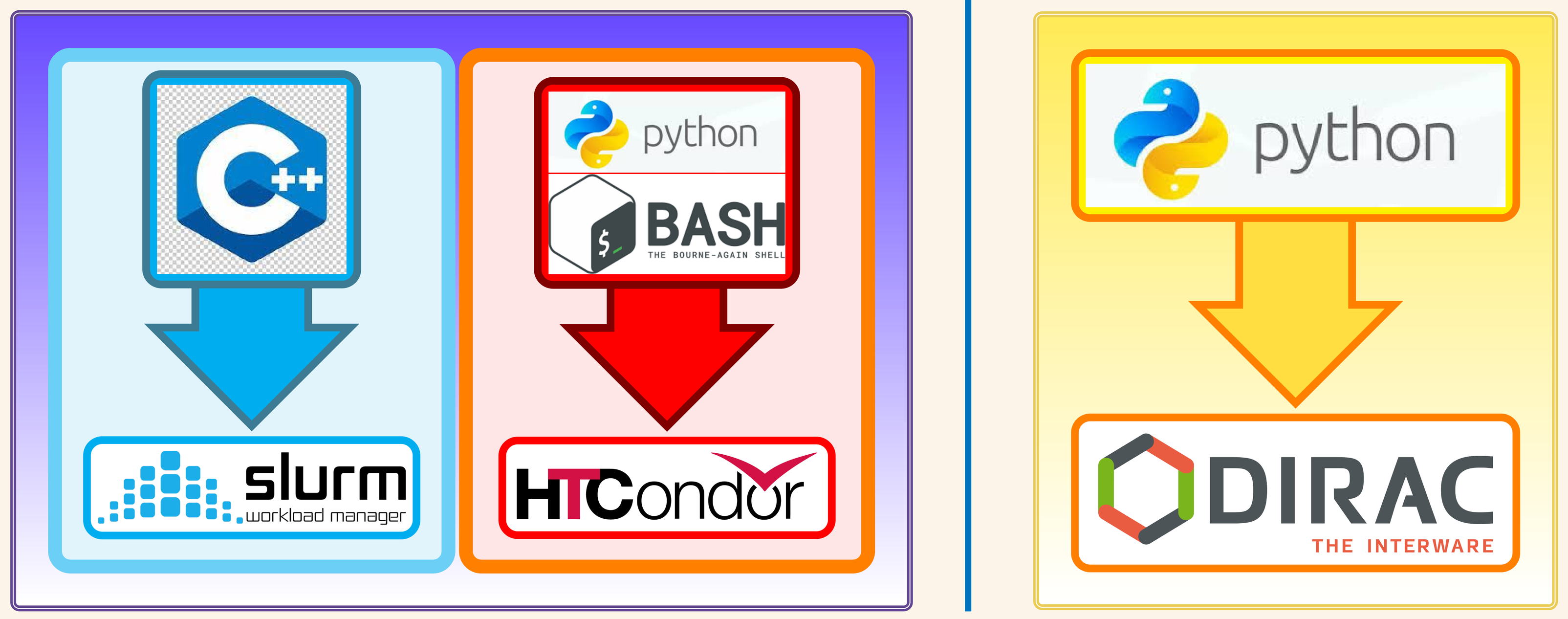
Local clusters and grid

Farm

- Productions:
  - CORSIKA & Offline
- Job submission:

Grid

- Productions:
  - CORSIKA
- Job submission:

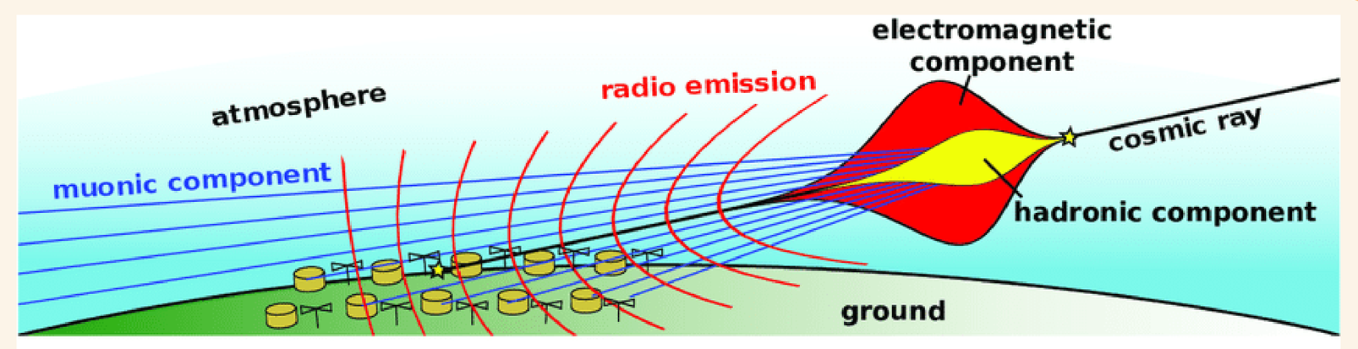


- DIRAC server: FRANCE GRILLES https://dirac.france-grilles.fr/DIRAC/

CernVM-FS — CVMFS for software distribution

iRODS IN2P3 — iRODS - preferred data access

7. In the pipeline...



- Multi-messenger studies
  - Neutrino simulation libraries
- Hadronic studies; muons
  - Inclined air shower libraries
- AugerPrime
  - Upgrade existing libraries

- Many radio simulations
  - Computationally expensive

MPI needed!

8. References:

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9. Acknowledgments:

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