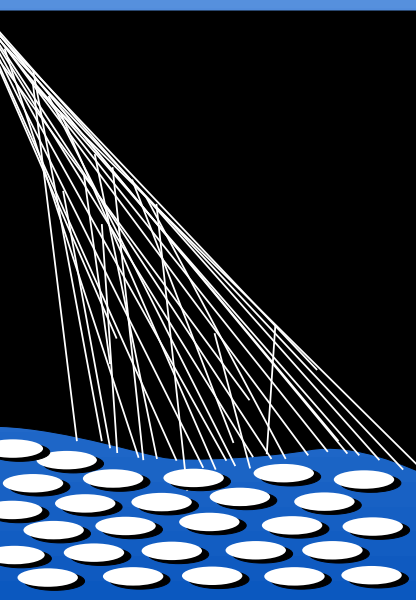


# The core software and simulation activities for data analysis at the Pierre Auger Observatory



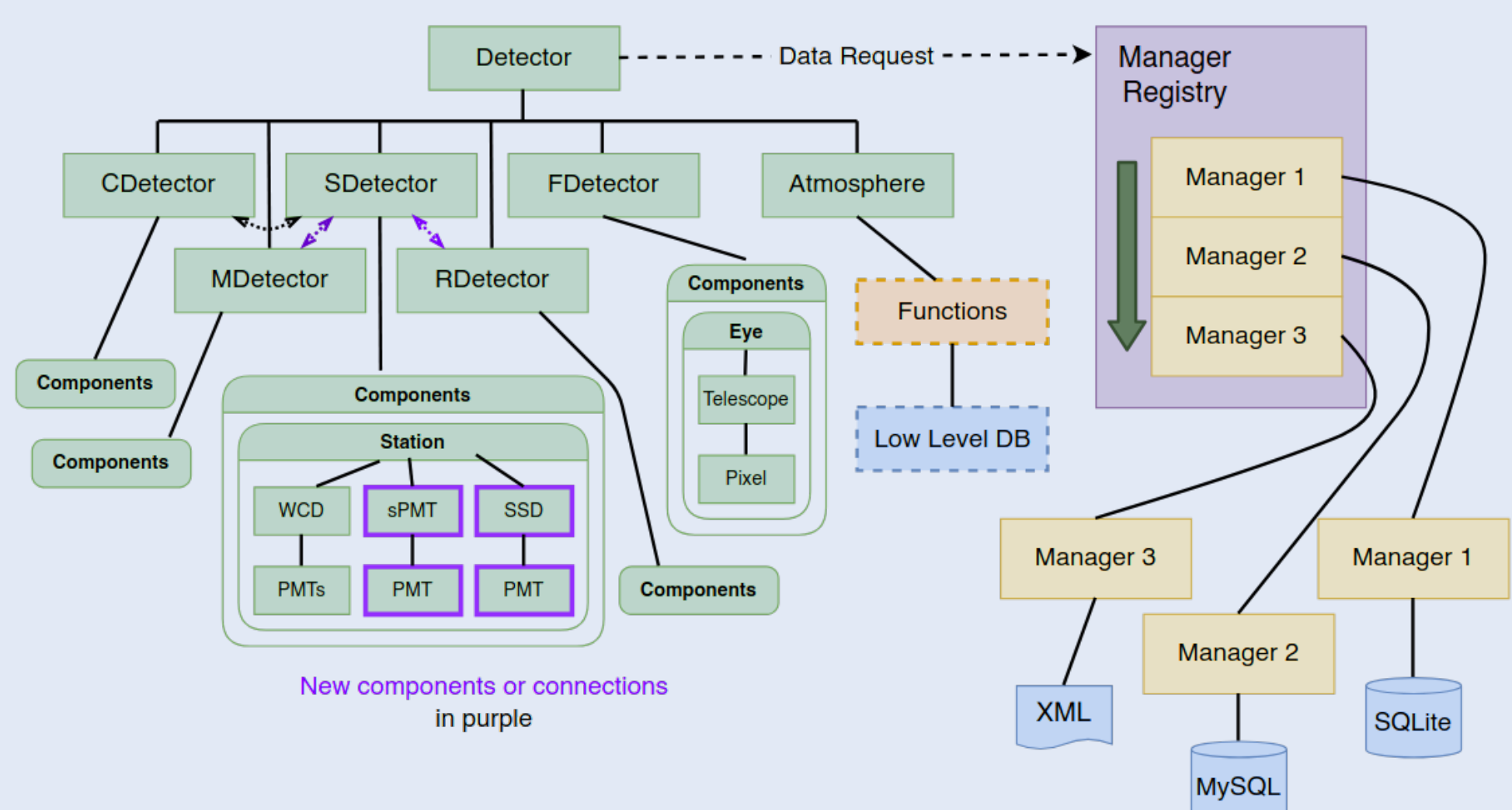
PIERRE  
AUGER  
OBSERVATORY

Eva Santos<sup>1</sup>, for the Pierre Auger Collaboration<sup>2</sup>

<sup>1</sup>FZU - Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic

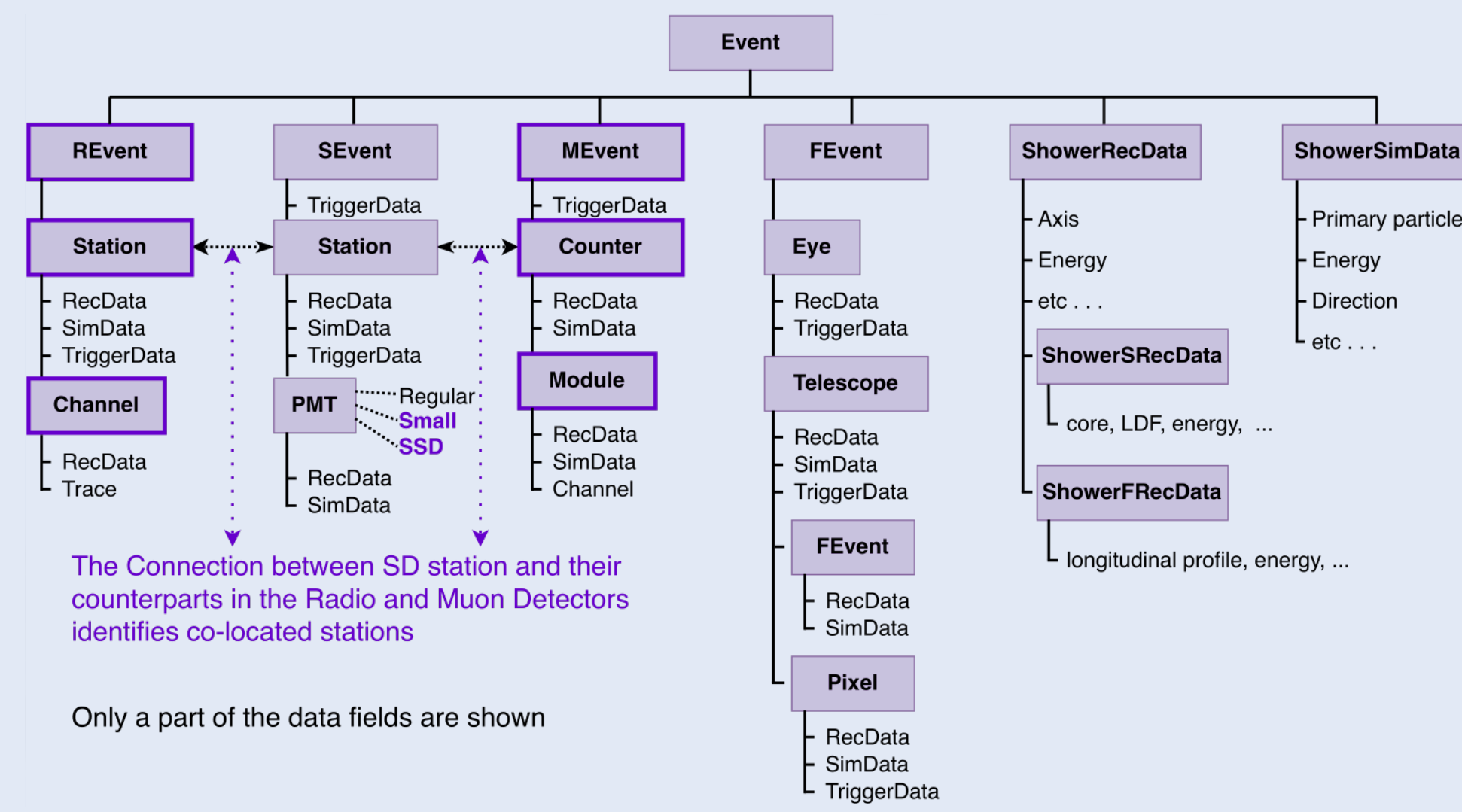
<sup>2</sup>Observatorio Pierre Auger, Av. San Martín Norte 304, 5613 Malargüe, Argentina

## Detector structure



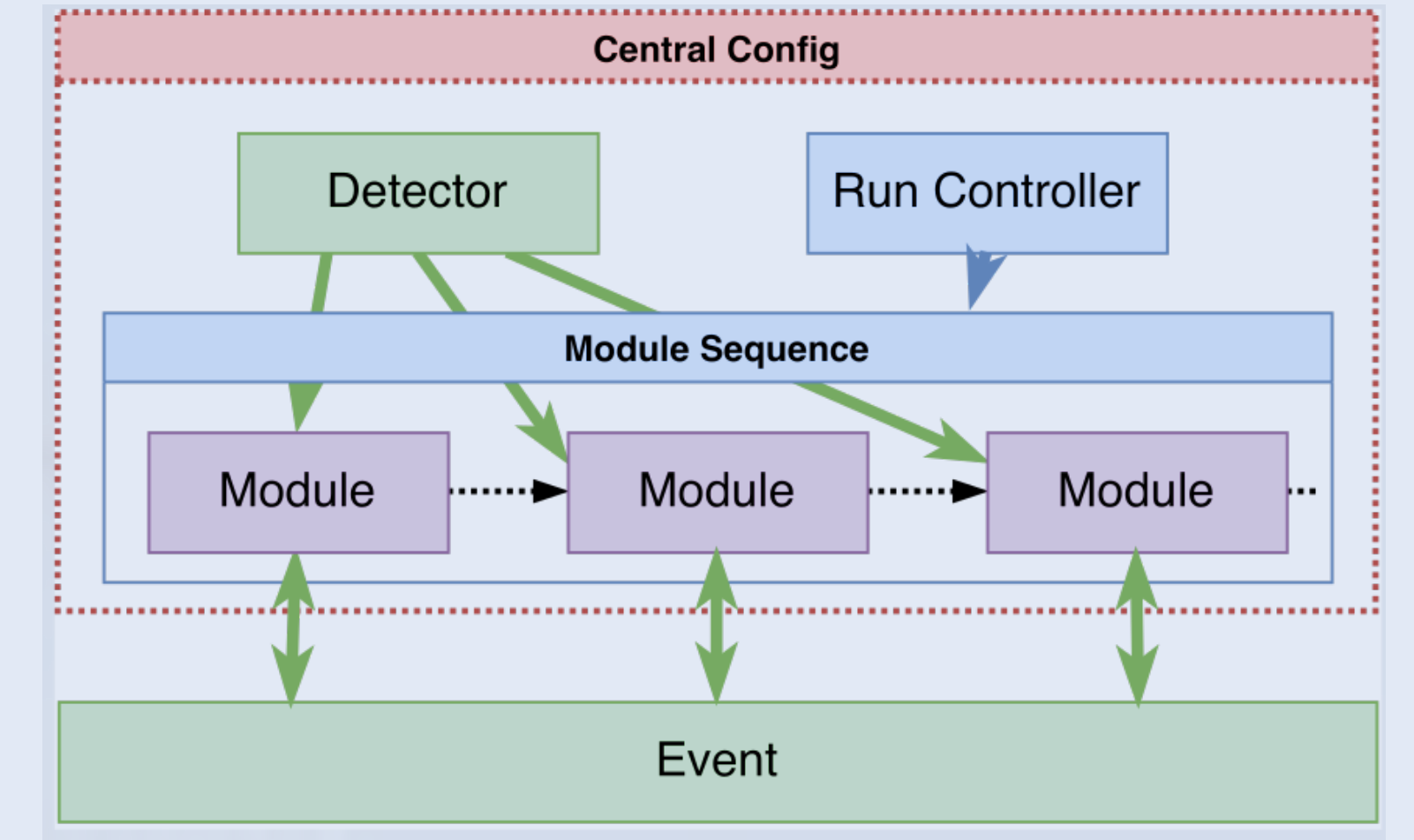
- **Detector structure is slowly changing**
- Structure follows detector hierarchy
- Atmosphere is also part of the detector
- Managers as abstraction for data access
  - Configurable

## Event structure



- Structure parallel to detector
- Mostly write-only
  - Delete only when unavoidable
- **Not all fields shown**

## Control flow



- **Application**
  - Sequence of steps encapsulated as **modules**
- **Run Controller**
  - Configures sequence; Schedules execution
- **Central Config**
  - Detector; Run Controller; modules
- **Detector**
  - Detector is read-only
- **Event**
  - Transports information between modules

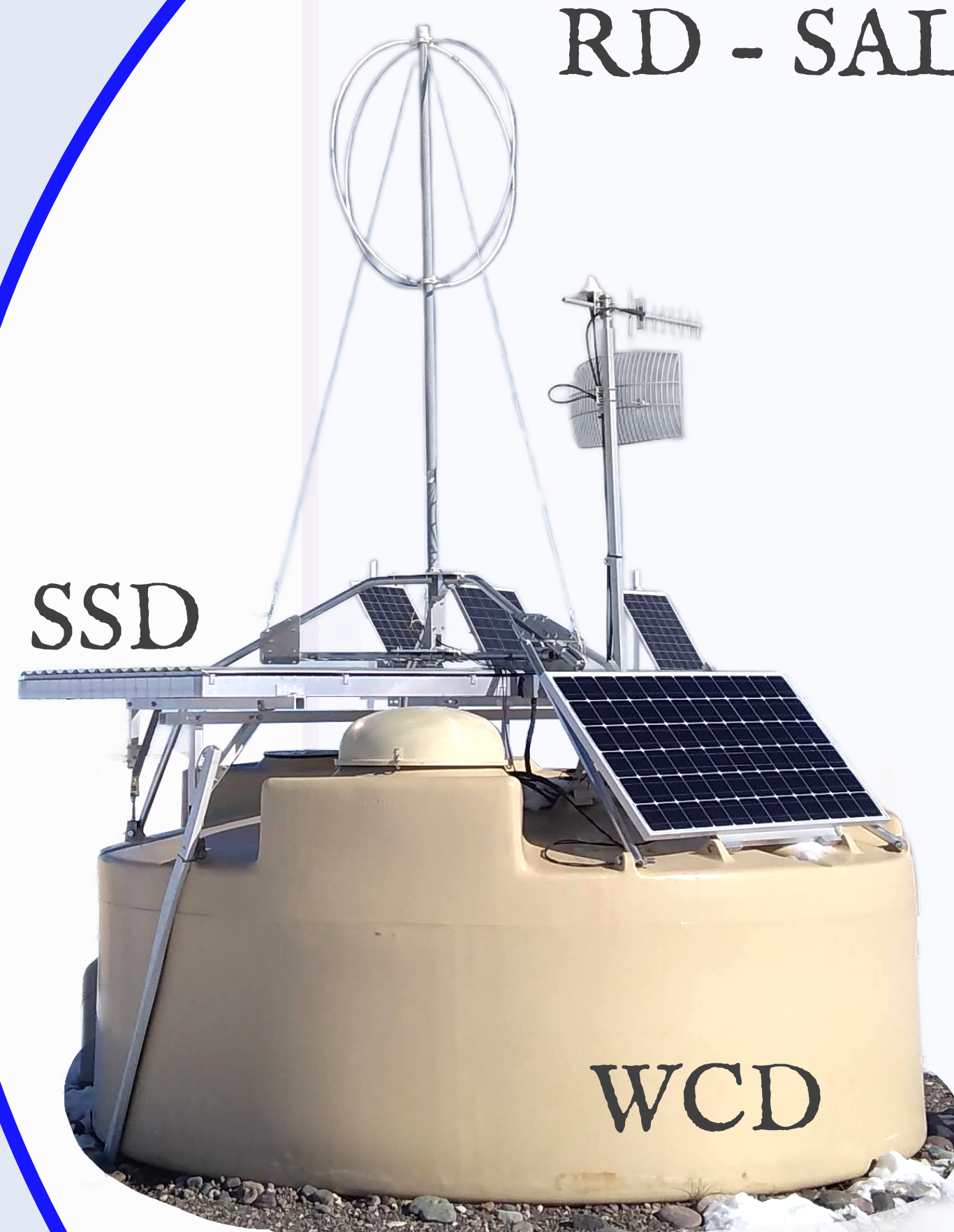
## Lessons learned

### 20 years of Offline experience:

- Clean design and investment in testing infrastructure pay off
- From the beginning consider the need of the end-user
- Choose data formats carefully: event data, detector/slow control, and configuration

## AugerPrime

RD - SALLA antenna



- RD - Radio Detector
- SSD - Surface Scintillator Detector
- UMD - Underground Muon Detector
- UUB - Upgraded Unified Board
- Small PMT

### AugerPrime components implemented in Offline

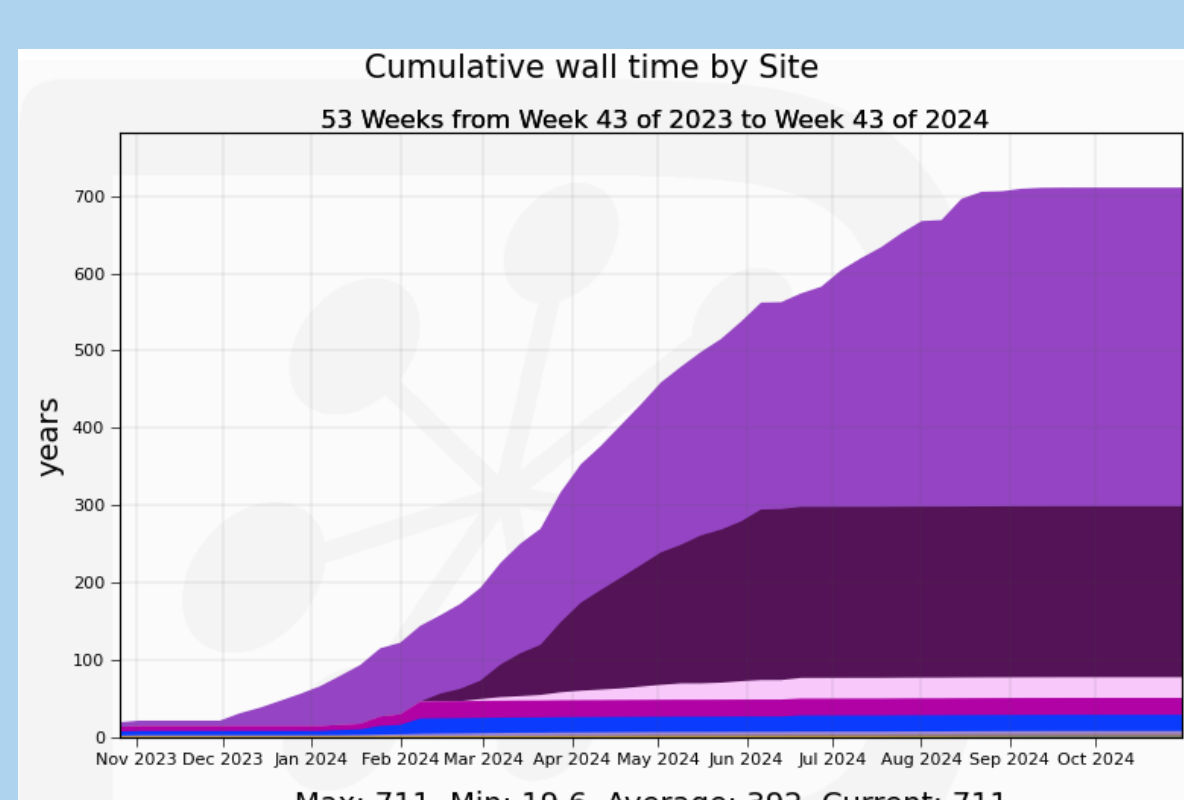
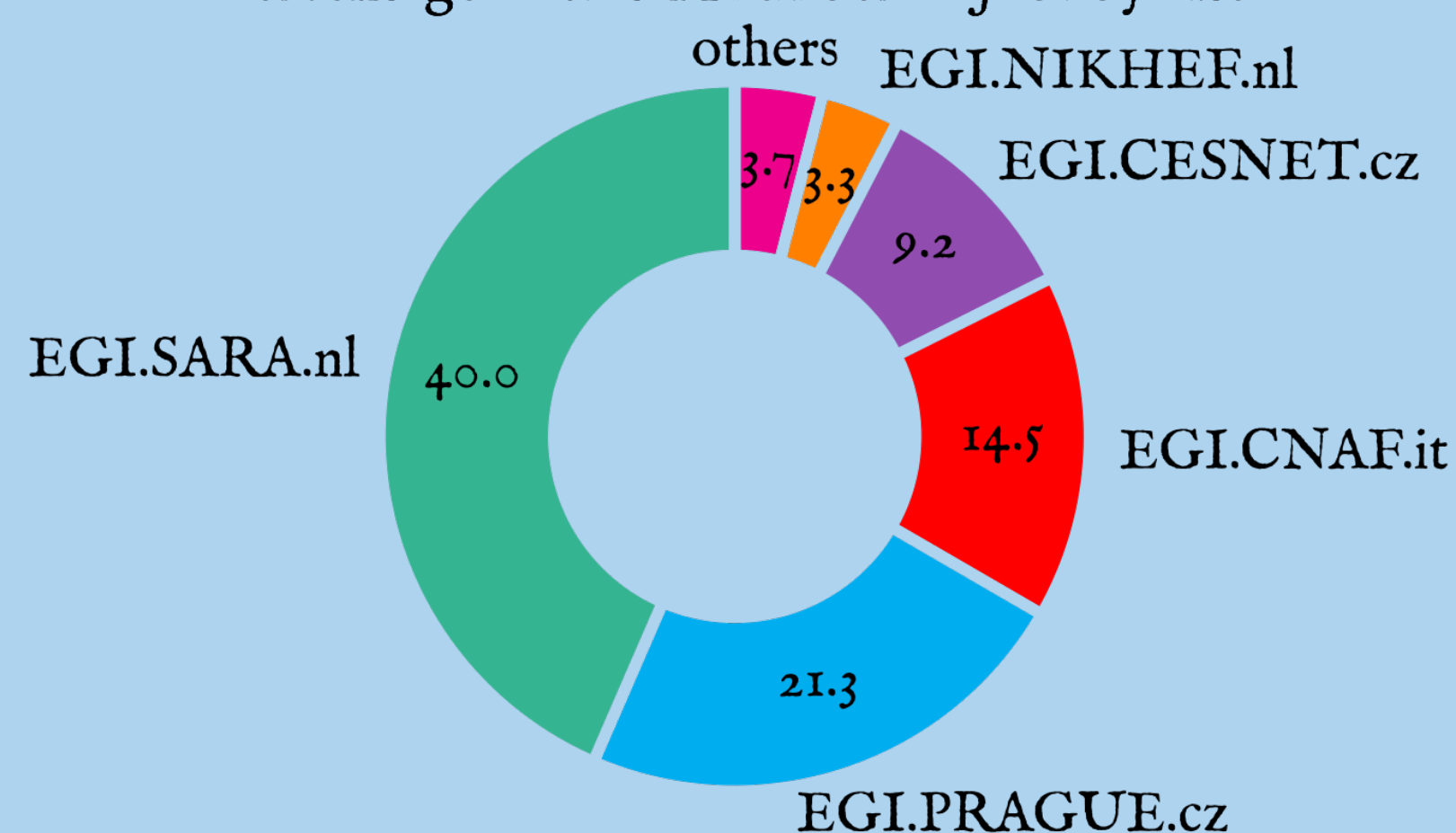
## VO Auger

- **DIRAC Interware**
  - Grid job management
  - File Catalog
- **VOMS server**
- **Registration portal**
- **CVMFS**
  - Software distribution
- **~ 2 PB disk space**
  - 1.7 PB disk occupancy
- **~ 30 members**
- **8 countries**
- **13 sites**

## VO Auger statistics

2024 - Astrophysics VOs

Percentage of Total Number of Jobs by Site

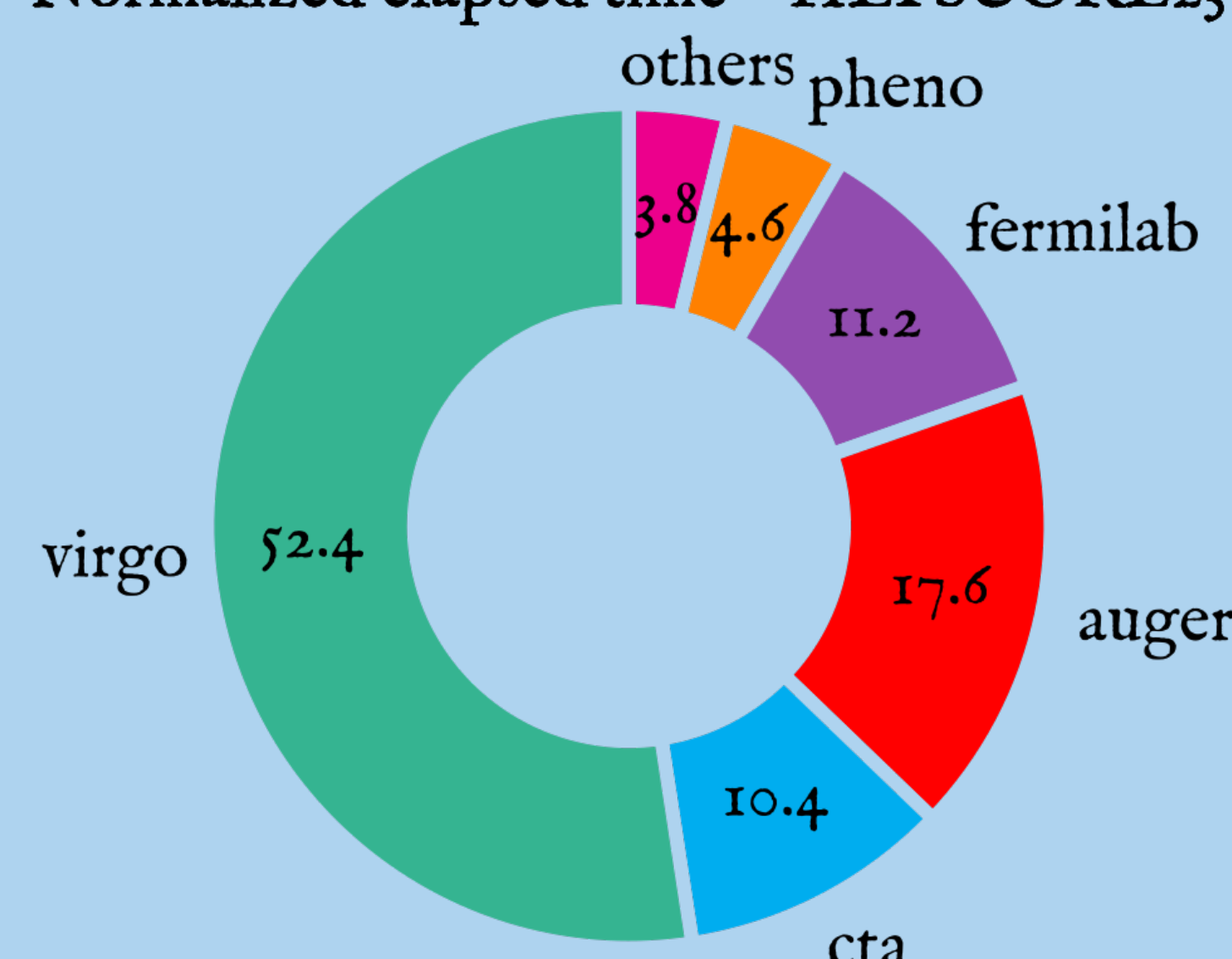


## Astrophysics VOs

2<sup>nd</sup> largest Astroparticle EGI user\*

2024 - Astrophysics VOs

Normalized elapsed time - HEPSCORE<sub>23</sub>



\*Excluding VO LHCb contribution

## Reference libraries

### Shower simulations

- **CORSIKA / CoREAS**
  - $\log_{10}(E/eV) = 14.0 - 20.2$
  - 4 hadronic species: H, He, O, Fe
  - 3 ultra-heavy elements: Te, Pt, U
  - Neutral particles:  $\gamma$ ,  $\nu_e$ ,  $\nu_\tau$
  - EPOS-LHC; Sibyll 2.3d; Sibyll\*; QGSJetII-0.4

### Auger Offline sim & rec

- **CORSIKA / CoREAS as input**
- **Multi-hybrid reconstruction**
- **Different output file formats**
- **Hybrid time-dependent simulations**

## Acknowledgments:

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