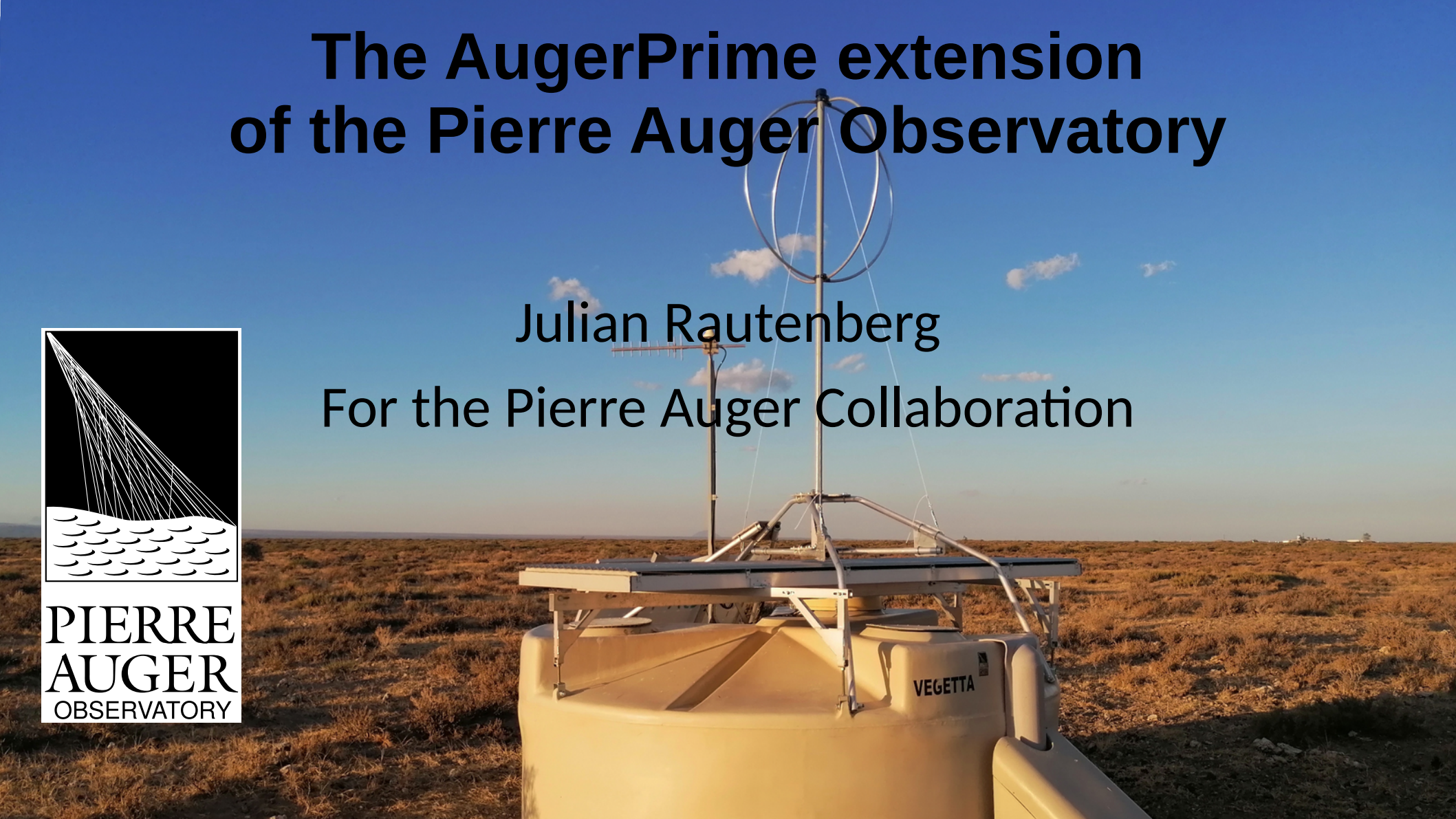
The AugerPrime extension of the Pierre Auger Observatory

Julian Rautenberg

For the Pierre Auger Collaboration

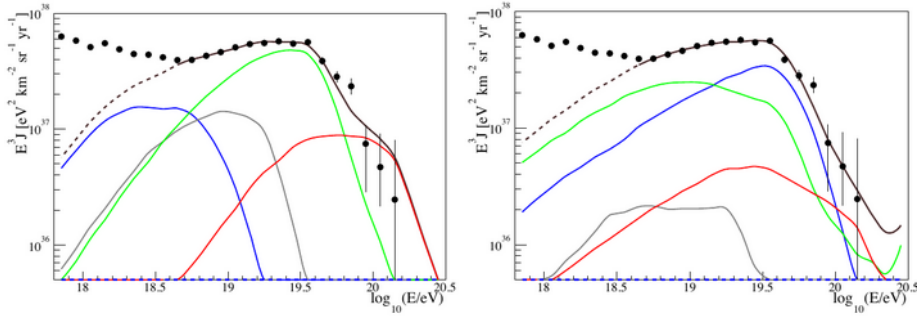


AugerPrime – Science Case

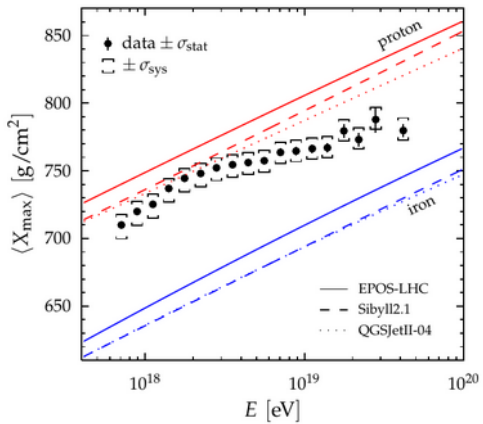
Design Report: arxiv 1604.03637

1. Mass composition and origin of flux suppression

2. Cosmic Rays Astronomy only at highest energies and with protons



3. Hadronic interaction in extensive air shower development



Requirement of event-by-event composition sensitivity

Event-by-Event Composition Sensitivity

- Fluorescence Detector with X_{max} sensitivity,
  but only ~15% duty cycle
- How to increase sensitivity with particles?

- Review process with different proposals:
  - underground muon detector
  - below WCD RPC Detector
  - segmented tank
  - scintillator on top

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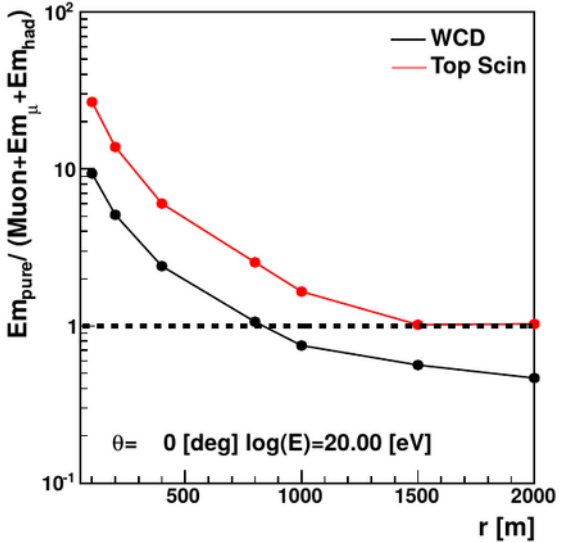
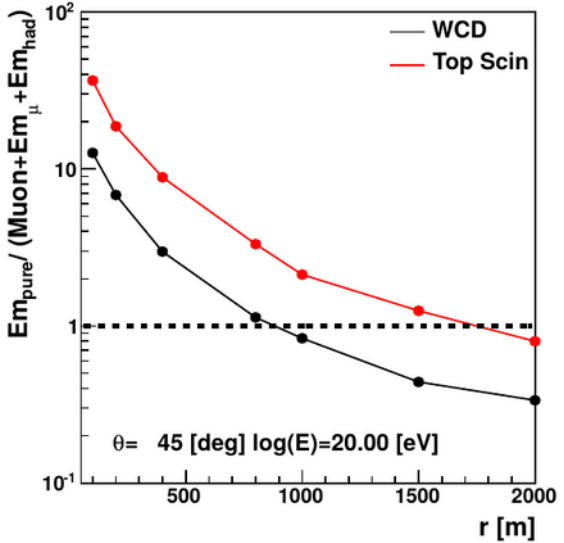
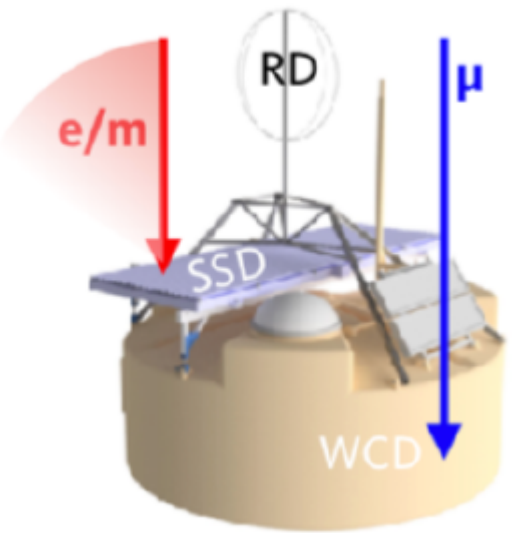




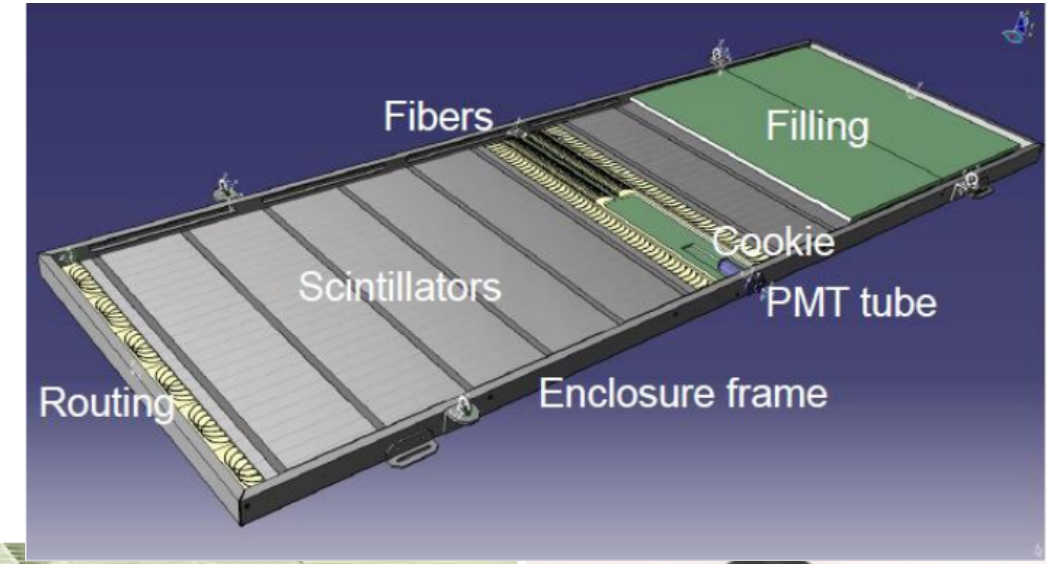


- **scintillator on top**

Increase dynamic range to 20000 MIPs

Design Report: arxiv 1604.03637

Scintillator Surface Detector

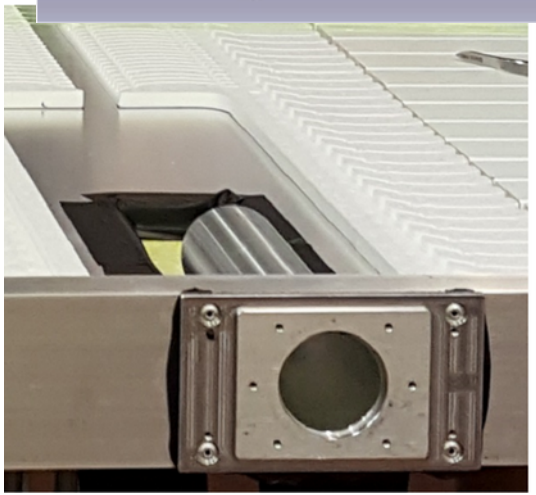


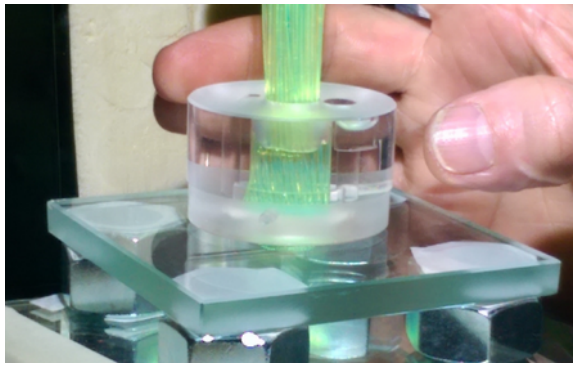
24 scintillating bars, 5 cm x 160 cm x 1 cm

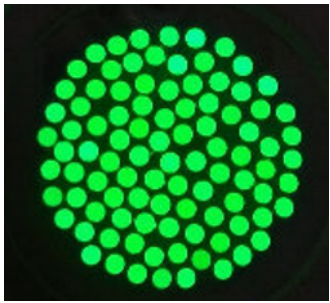
Wavelengthshifting fibre collected in “cookie”

Hamamatsu R9420 PMT + ISEG Base

Aluminium casing + sun-shadow roof





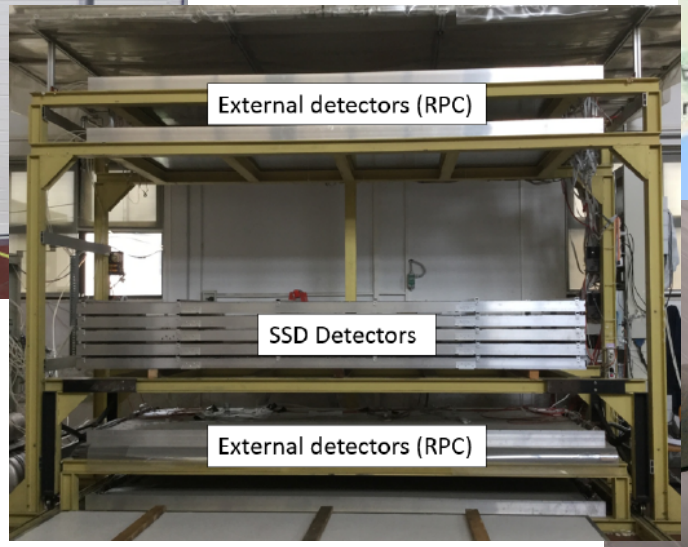


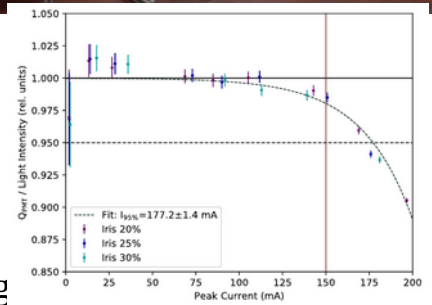
Scintillator Surface Detector

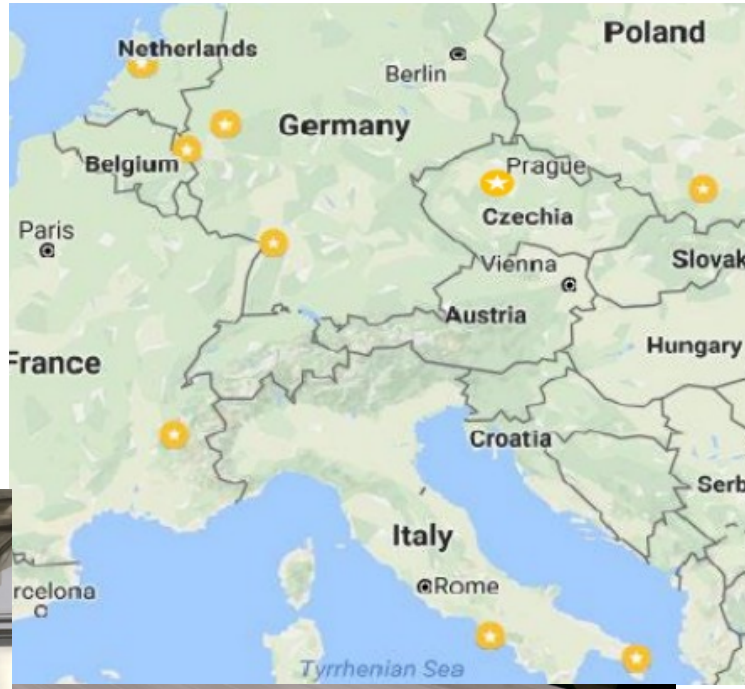
Collaborative production & testing of 1500 SSD

Production sites: Karlsruhe, Lecce, Krakow, Nijmegen, Grenoble, Aachen

PMT-Testing sites: Wuppertal, Naples







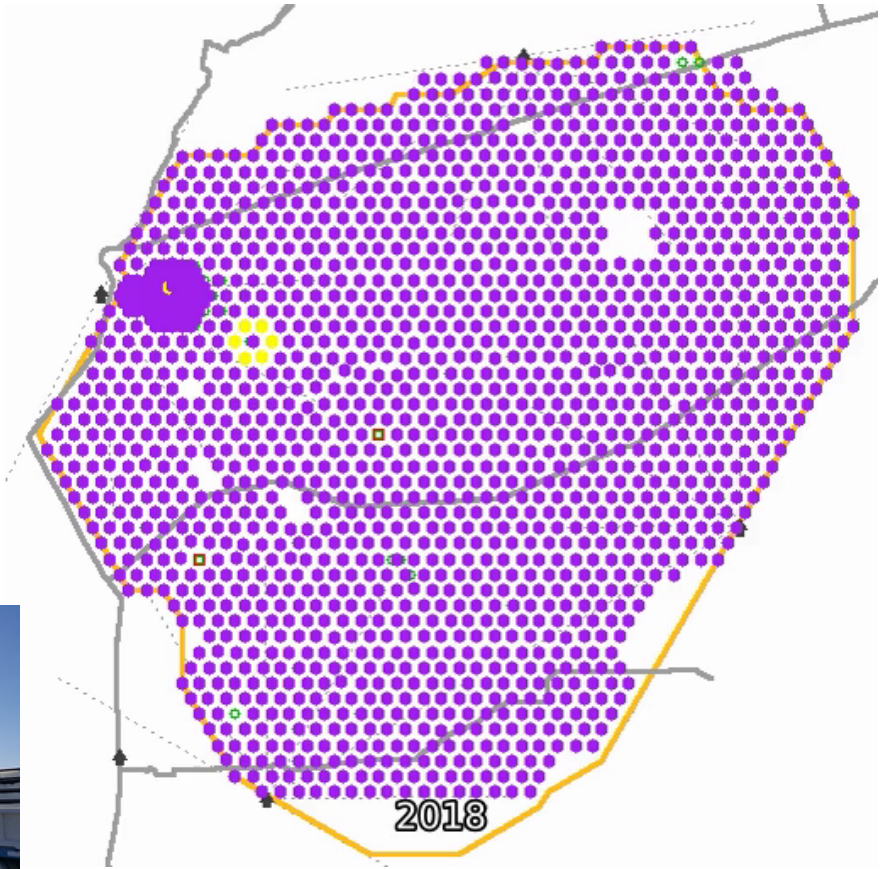
Upgrade of Electronics

- Upgrade Unified Board (UUB) to combine 3 previous PCBs
- Increase in digitization: 6 x 40MHz, 10 bit => 10 x 120 MHz, 12 bit
- Digital port for external ADC externsion (RD,UMD)
- Increased logics: Xilinx Zynq-7020 All Programmable SoC
  (Artix-7 FPGA + associated Cortex A9 Dual 333 MHz ARM co-processor)
- Board production A4F
  (formerly SITAEL)
- Extensive testing @ Prague
- Extension of dynamic range by adding a small PMT
  - Hamamatsu R8619,
  - passive base
  - CAEN A7501 HV supply
  - all tested in Naples

AugerPrime Surface Detector Electronics
P. Abdul Halim et al. (Pierre Auger Collaboration),
JINST 18 (2023) P10016

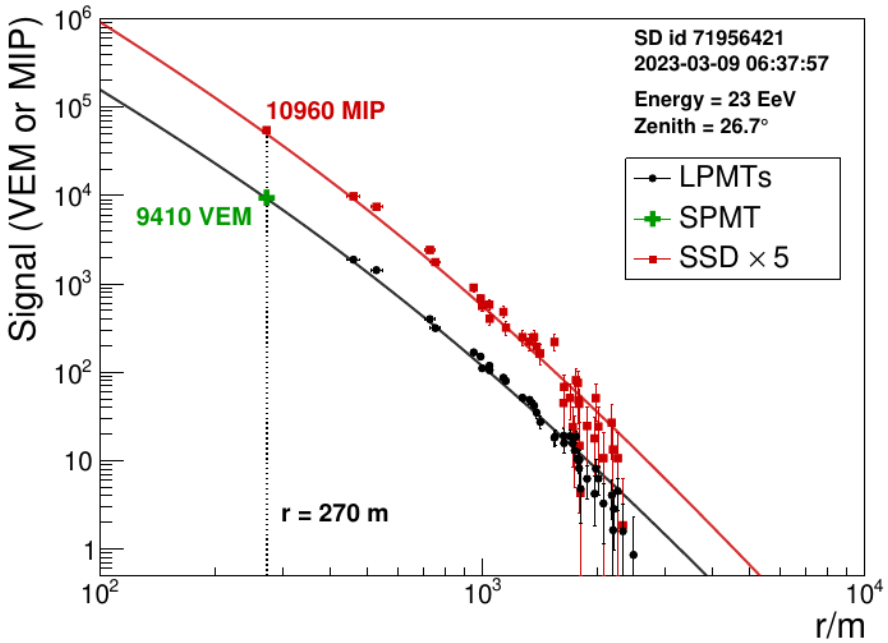
Deployment SSD / UUB

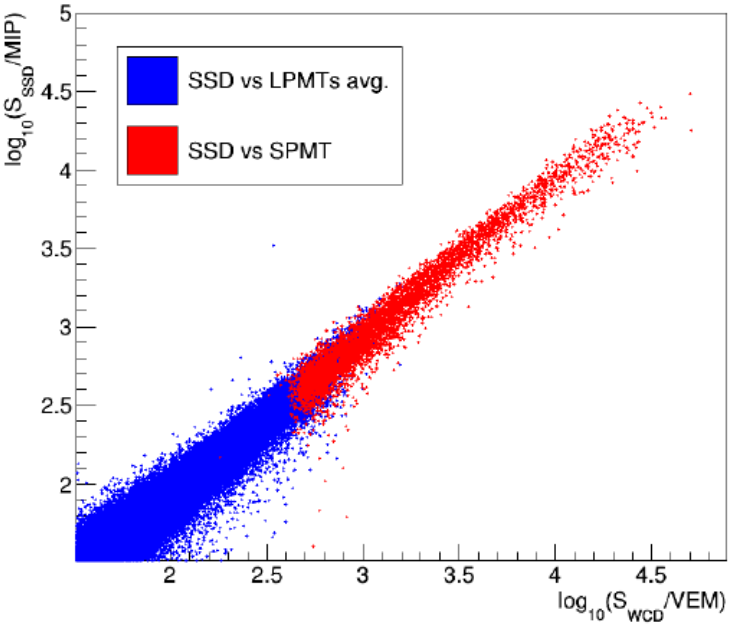
Time-lapse 01/09/2018 to 22/03/2023
purple : WCD sending T2
yellow : with SSD
orange : pre-production array
red : with UUB



Performance SSD/WCD

- Good agreement of SSD and large/small PMT of WCD
- No saturation down to 250m
- PoS(ICRC2023)34





Underground Muon Detector

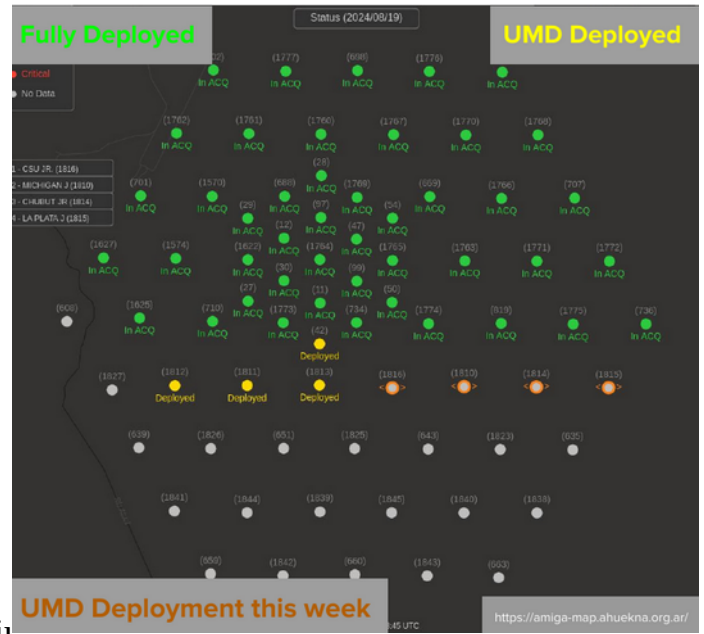
3x 10 m^2 scinntillator per station

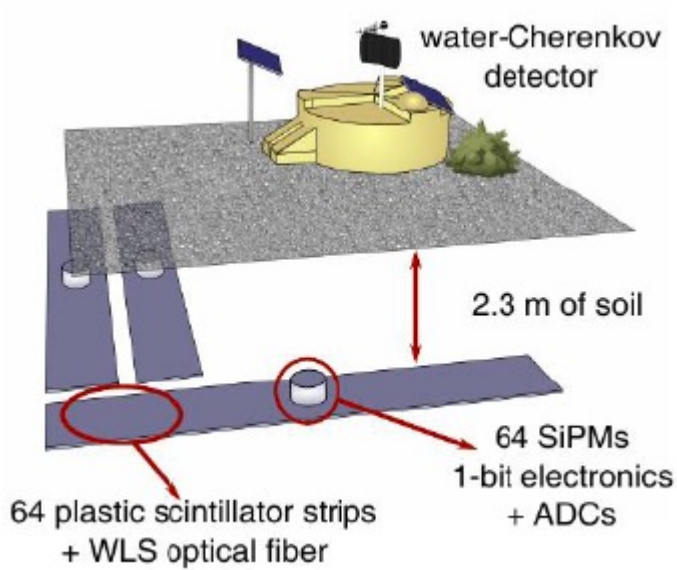
Each module “counting” muons in 64 strips

Deployement on the 750m + 433m grid, 23 km^2

Connected to digital port of UUB

49 Stations installed

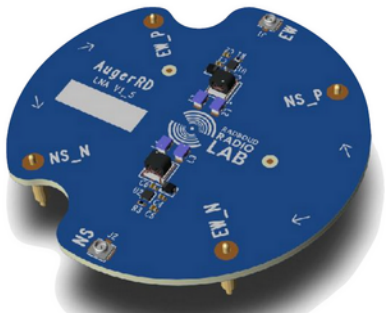


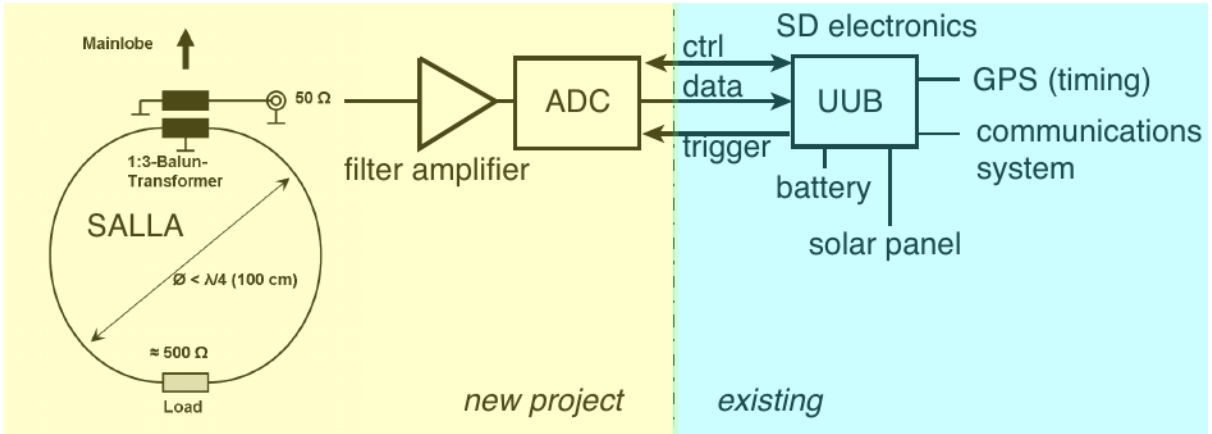


Radio

SALLA Antenna based on development for AERA
2012 JINST 7 P10011 20

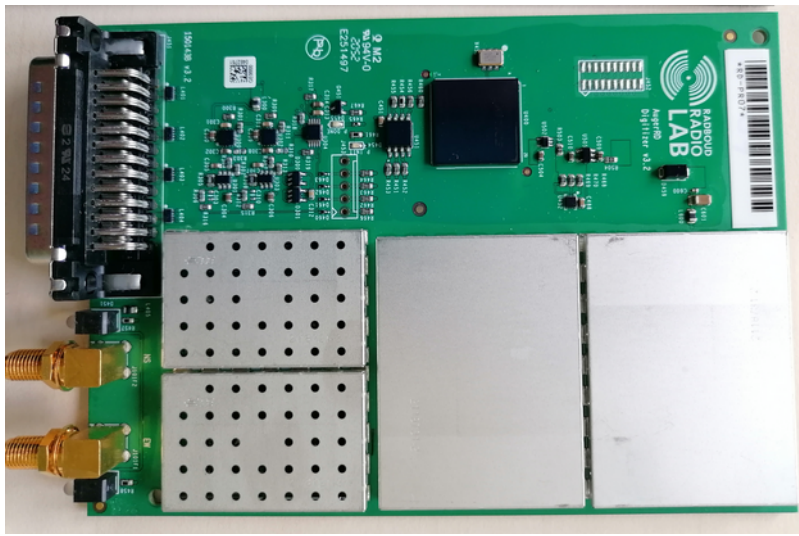
LNA with 18.2 dB gain
in 30 – 80 MHz, 0.2 W





Front-end electronic board, 2.4 W
Filter-amplifier and 2x 250 MHz 12 bit ADC
Connected to digital port of UUB

Mechanical structure to mount on SD-clams



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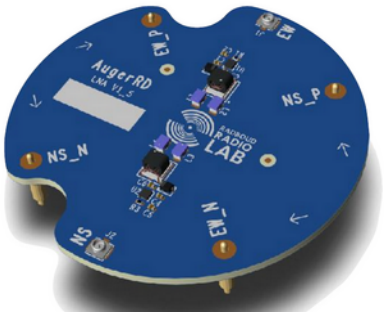

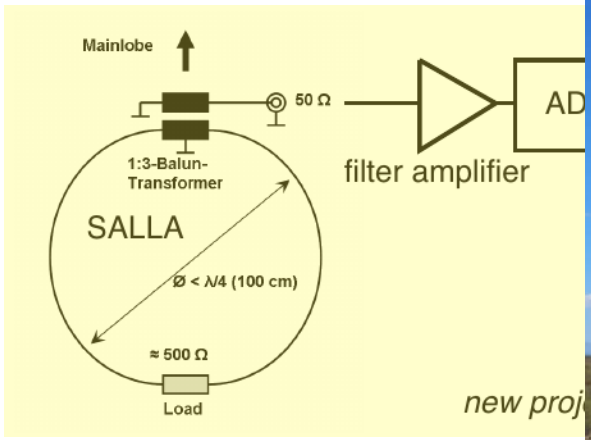

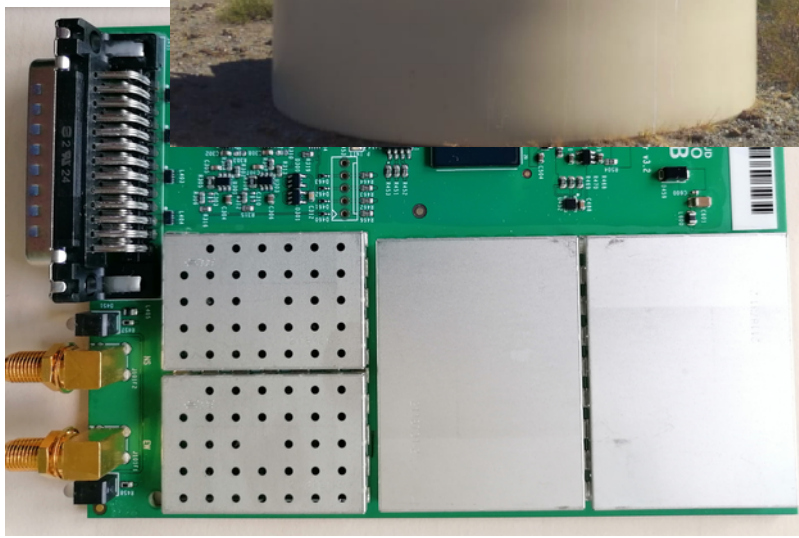

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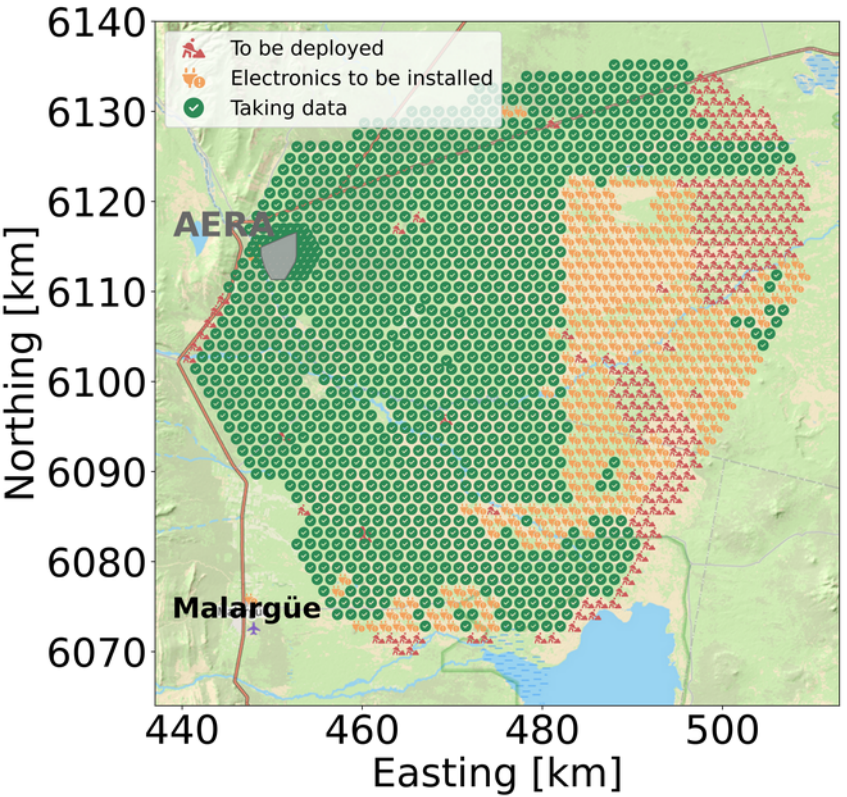
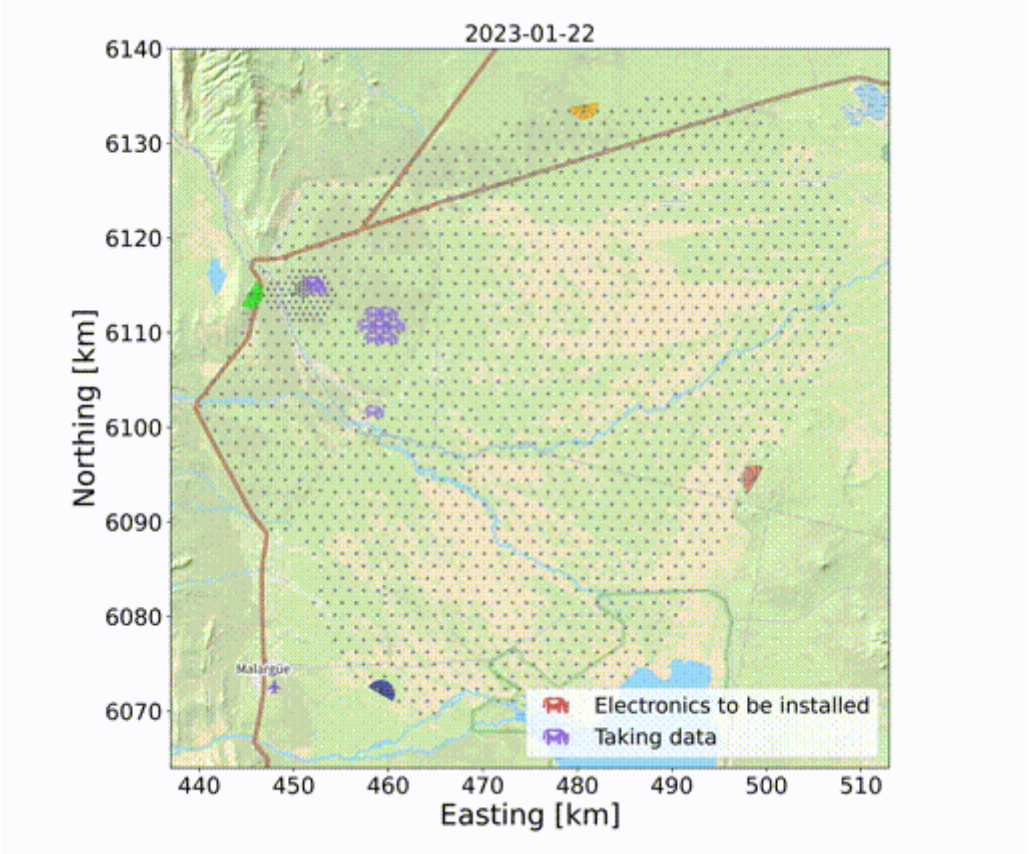
Radio Deployment



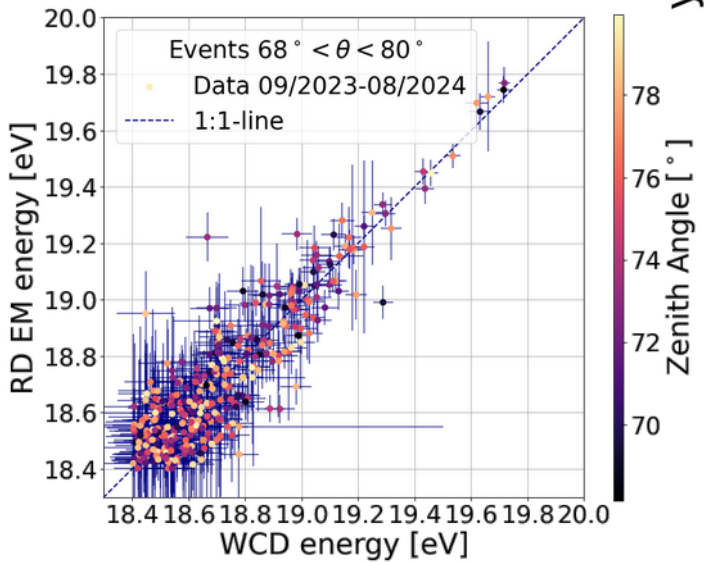


Radio first results

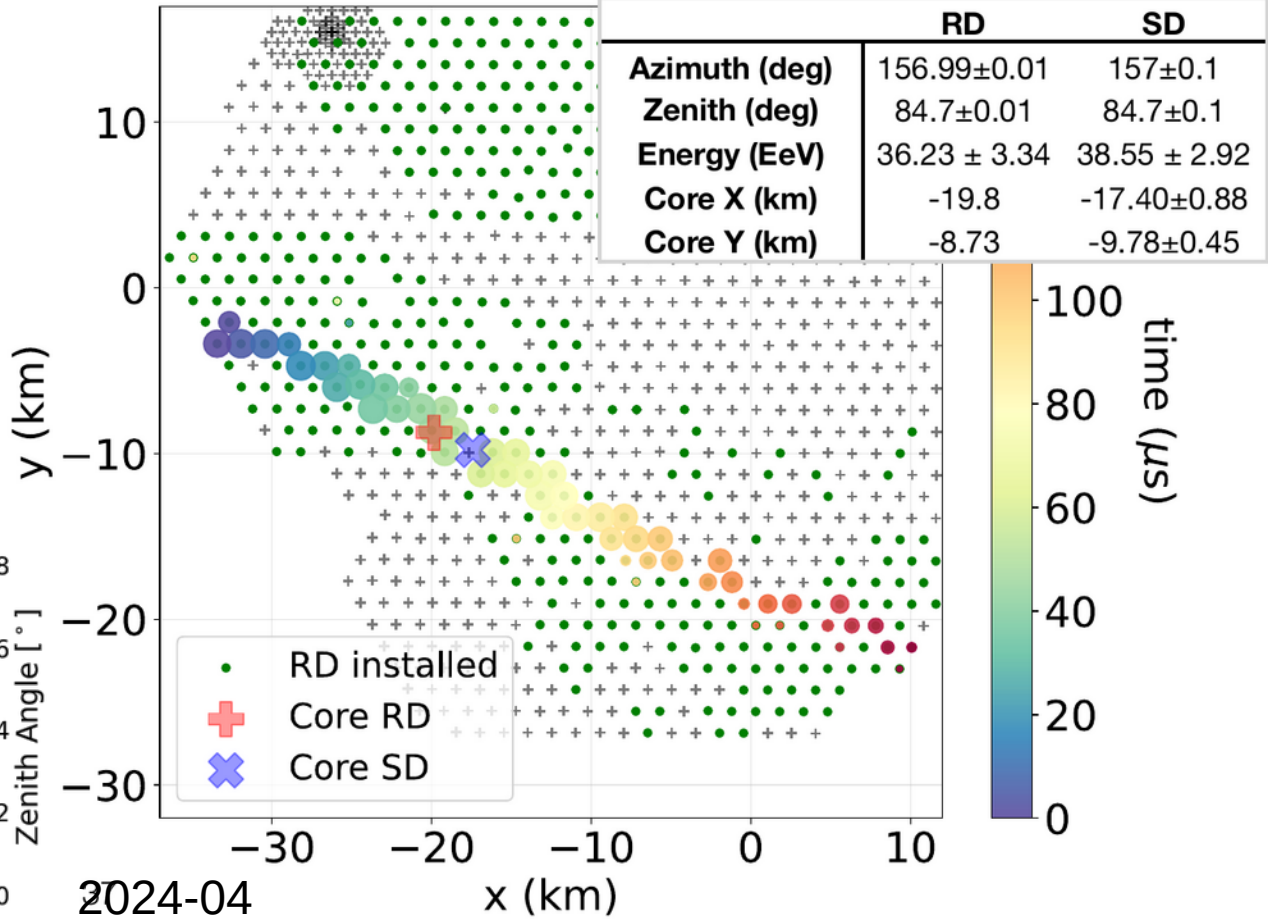
Largest Radio CR detector (deployment ready 2024-10)

First promising data

Full reconstruction working
Good agreement with SD



	RD	SD
Azimuth (deg)	156.99±0.01	157±0.1
Zenith (deg)	84.7±0.01	84.7±0.1
Energy (EeV)	36.23 ± 3.34	38.55 ± 2.92
Core X (km)	-19.8	-17.40±0.88
Core Y (km)	-8.73	-9.78±0.45



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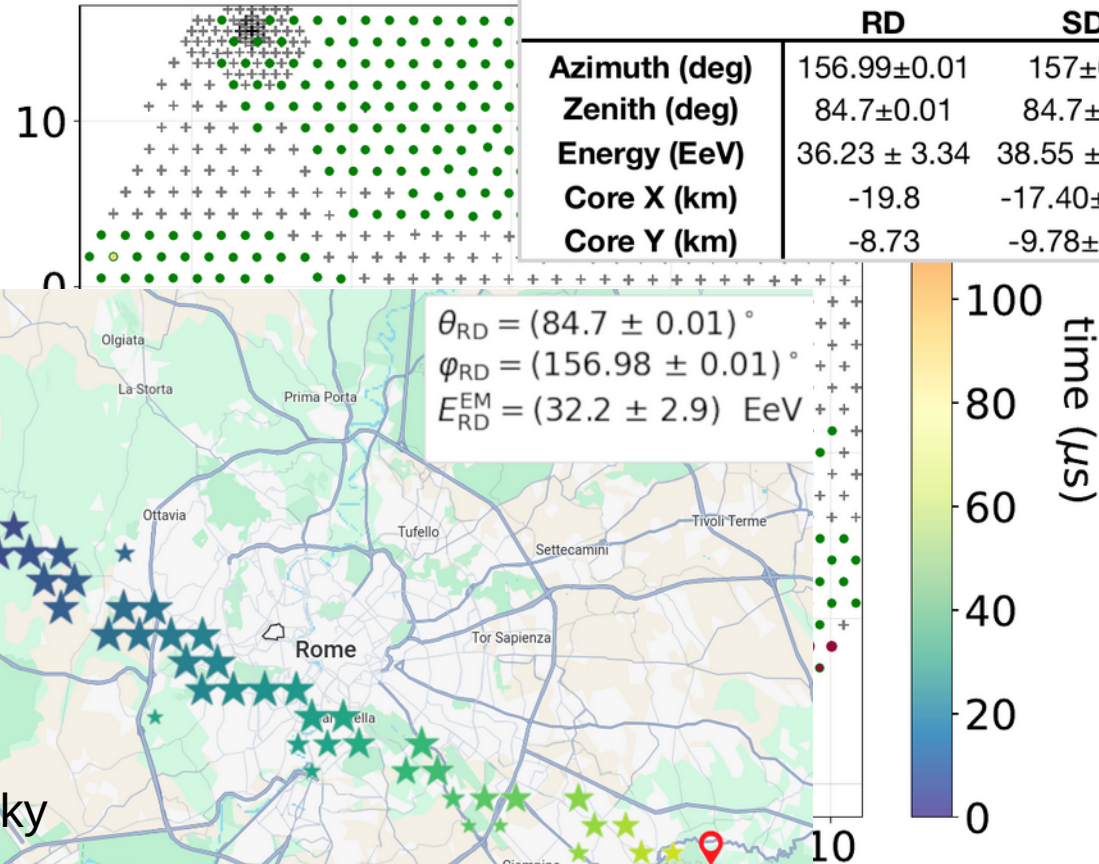

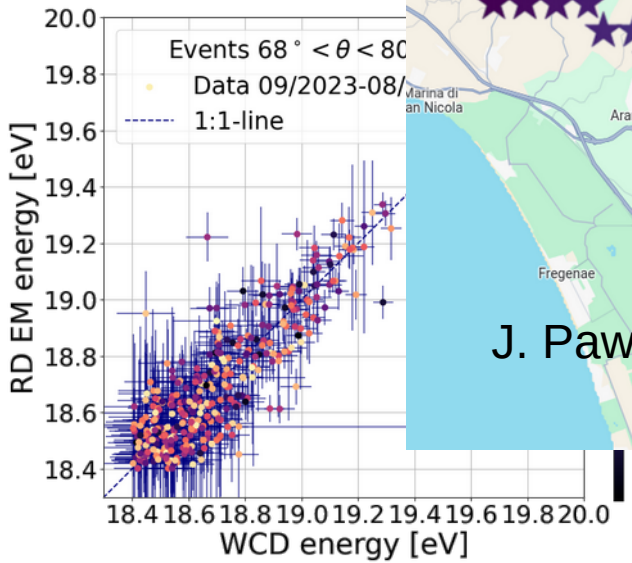

Summary

AugerPrime extension is almost ready deployed

- Surface Szintillator Detector (SSD)
- upgraded Electronics (UUB)
- Radio Detector
- dynamic range extension (small PMT)
- Underground Muon Detector sub-array (UMD)

First data promising, complete integration ongoing

Getting ready for Auger Phase 2