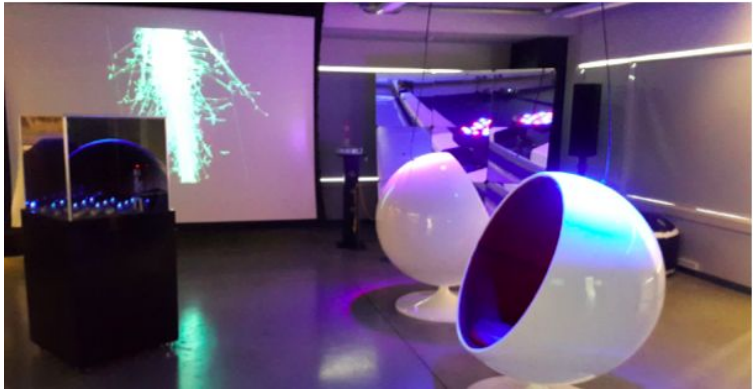
Development of an international Masterclass with the public data of the Pierre Auger Observatory

Raul Sarmento for the Pierre Auger Collaboration

raul@lip.pt

12th Cosmic Ray International Seminar
CRIS 2022
Naples, Italy, September 16, 2022

Pierre Auger Observatory
outreach



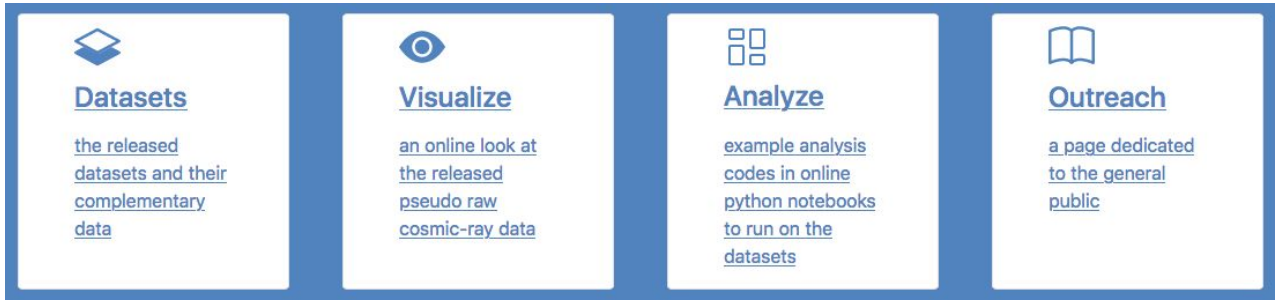
- Visitor's centre at Malargue
- Science Fair
- Outreach webpage
- Social networks

https://labdpr.cab.cnea.gov.ar/ED/

Auger Open Data

opendata.auger.org

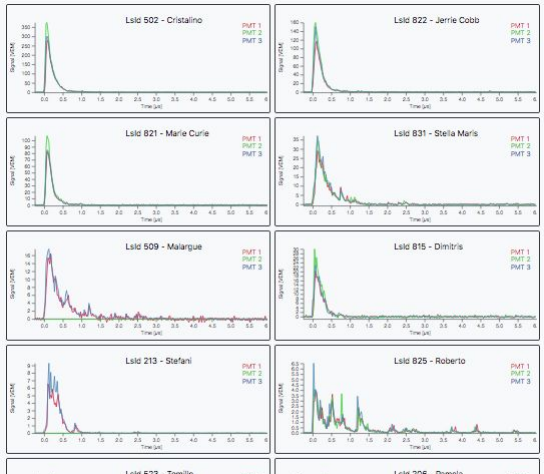
- 2021 public release of 10% of the observatory data
- Standard SD, hybrid, weather and space-weather data
- + Several educational, analysis and visualization tools
- Stay tuned for upcoming releases

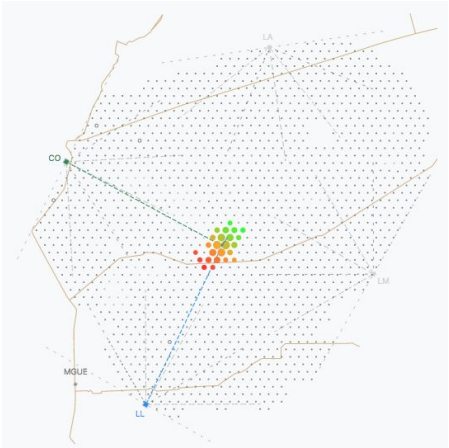


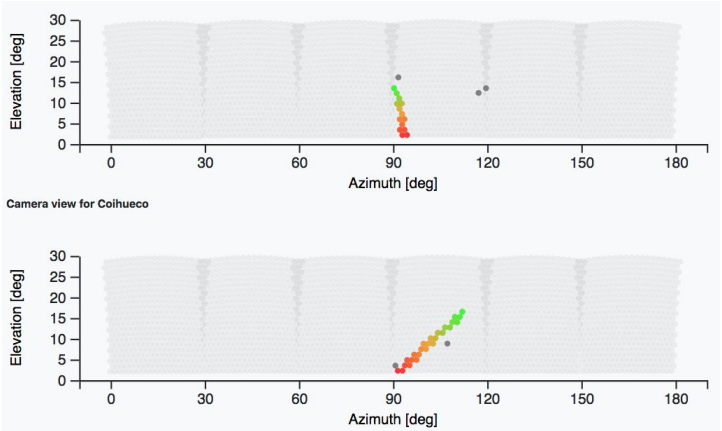
Auger Open Data

opendata.auger.org

- Shower events: 22731 (SD) + 3156 (hybrid)
- Pseudo-raw and reconstructed data in JSON format
- Example event: highest energy multi-eye event



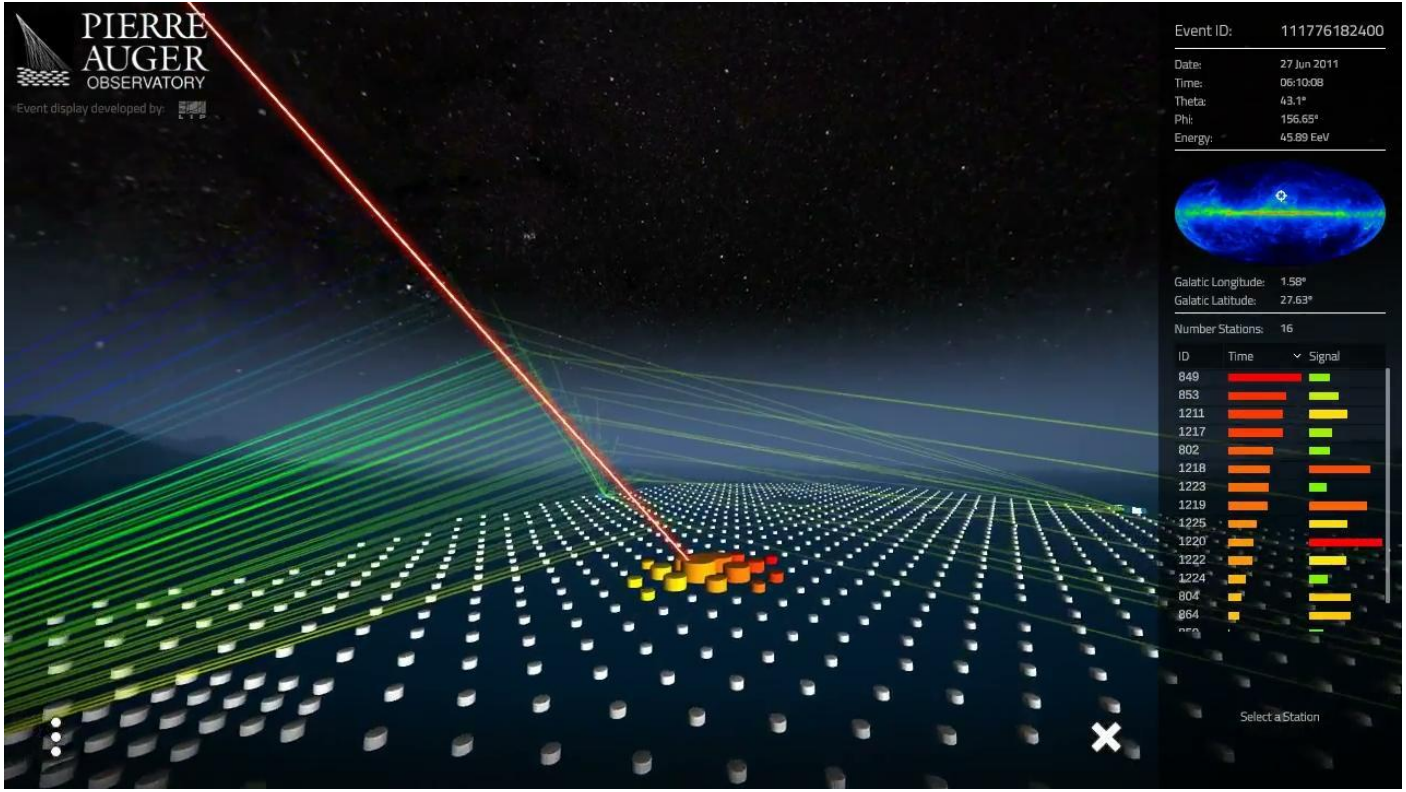




Auger Open Data

opendata.auger.org

- 3D display made with *Unity*



Auger Open Data
opendata.auger.org

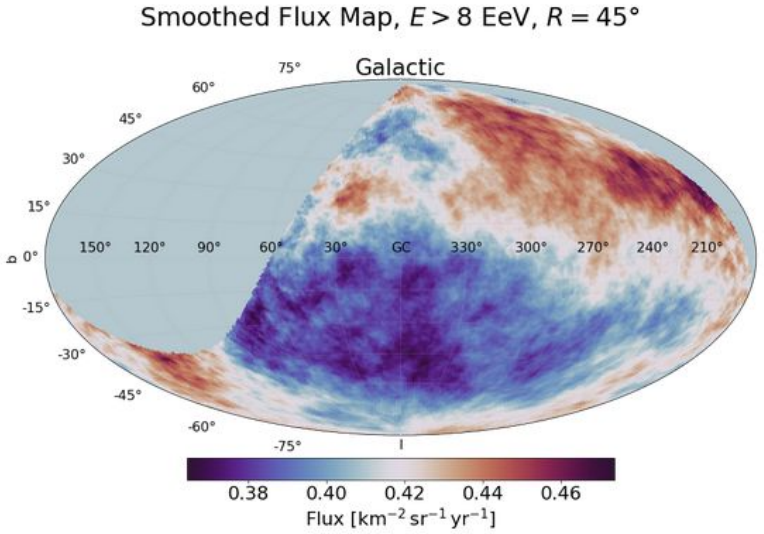
- Analysis notebooks based on *python*, run on *kaggle*

Large-scale anisotropy

Notebook Data Logs Comments (0)

In [10]:

```
#LiMa significance map
def LiMaMap(nside, Non, Noff, alpha):
    Non_log_term = (1. + alpha)*Non / (alpha*(Non + Noff))
    Noff_log_term = (1. + alpha)*Noff / (Non + Noff)

    sig2_ov_2 = np.zeros_like(Non)
    ind = np.where((Non > 0) & (alpha > 0))# ensures non negative log terms induced by smoothing
    sig2_ov_2[ind] += Non[ind]*np.log(Non_log_term[ind])
    ind = np.where(Noff > 0)# ensures non negative log terms induced by smoothing
    sig2_ov_2[ind] += Noff[ind]*np.log(Noff_log_term[ind])

    return np.sign(Non-alpha*Noff)*np.sqrt(np.abs(2*sig2_ov_2))

# Parameters of the maps
Emin = 8 # EeV
galCoord = True
nside = 64
radius_deg = 45 # top-hat radius in degrees

# Exposure map
exposure_map = LoadExposureMap(totalExposure, nside, galCoord)
exposure_map_smoothed = LoadSmoothedMap(exposure_map, radius_deg, nside)

# Count map
dataset = LoadShapedData(galCoord, Emin) # data above 8 EeV
count_map = LoadCountMap(dataset, nside)
count_map_smoothed = LoadSmoothedMap(count_map, radius_deg, nside)

# Flux-map
flux_map = count_map_smoothed / exposure_map_smoothed
ra, dec = Get_ra_dec(nside, galCoord)
dec_max = np.radians(24) # degrees corresponding to a 60° maximum zenith angle
flux_map[np.where(dec > dec_max)] = np.mean(flux_map[np.where(dec <= dec_max)]) #uniform above m
aximum dec
```



International Masterclasses
particle physics

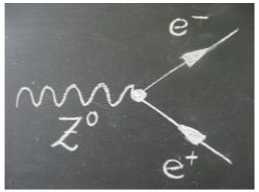
http://physicsmasterclasses.org

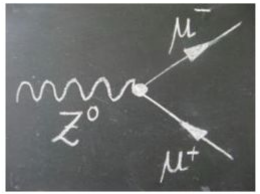
- Activity inspired in the IPPOG model
- For high-school students worldwide
- “Scientists for one day with the hands on particles”

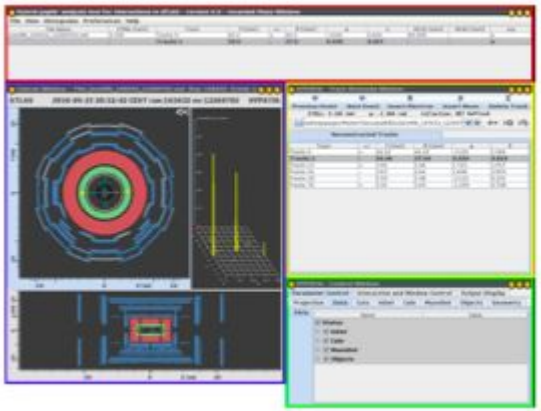
International Masterclasses
particle physics

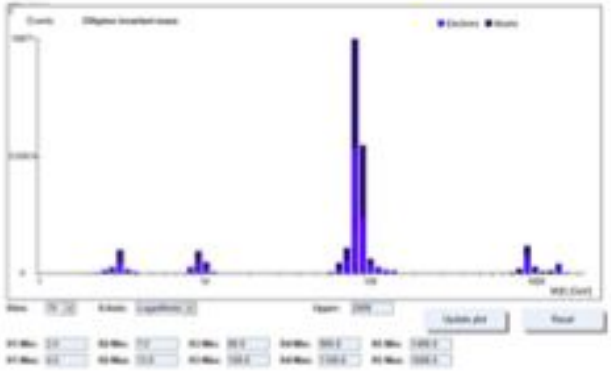
http://physicsmasterclasses.org

- Agenda for the day:
  - Morning: introductory talks
  - Afternoon: experimental activity + videoconference









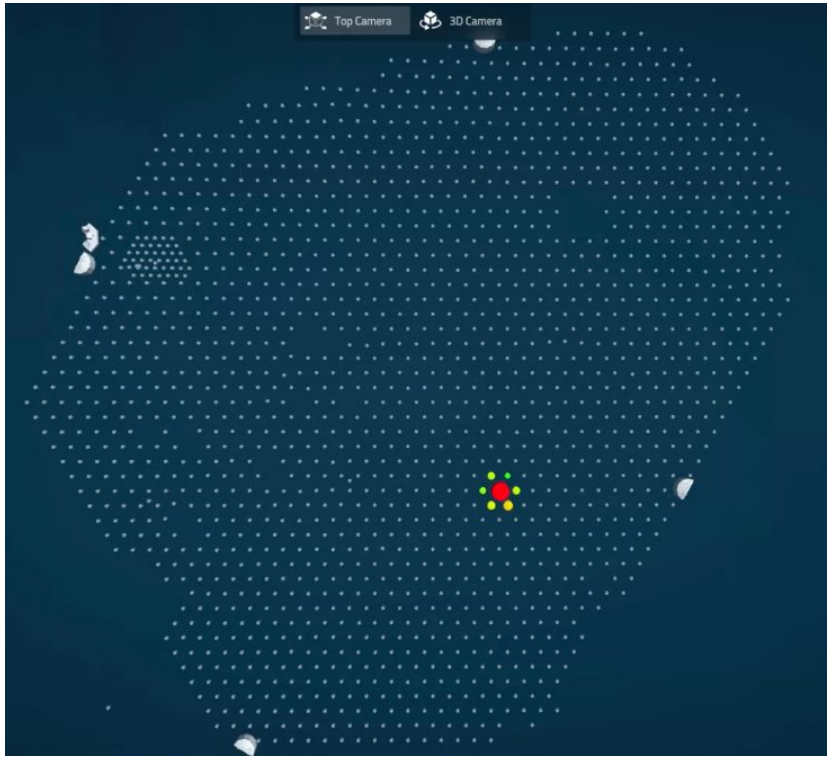
Auger Masterclass
concept

- 3D display interface
  - event reconstruction: arrival direction + energy
  - event selection

- Python notebooks
  - smoothed, exposure-corrected sky map with reconstructed arrival directions of selected events

Auger Masterclass
experimental activity

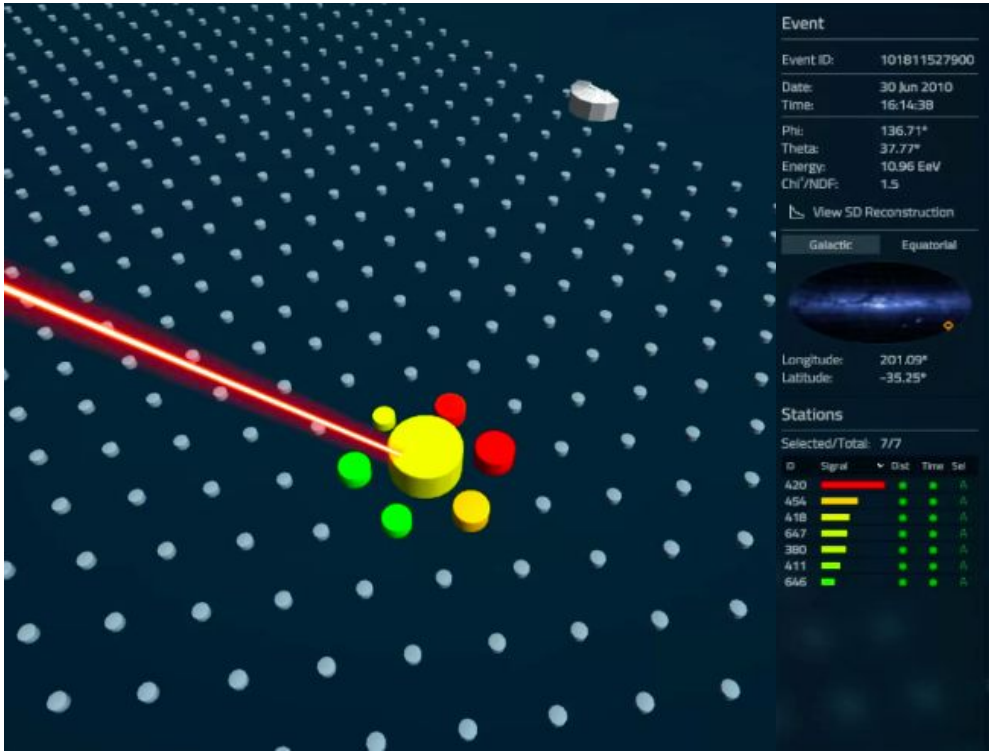
Starting point



SD stations time and signal only

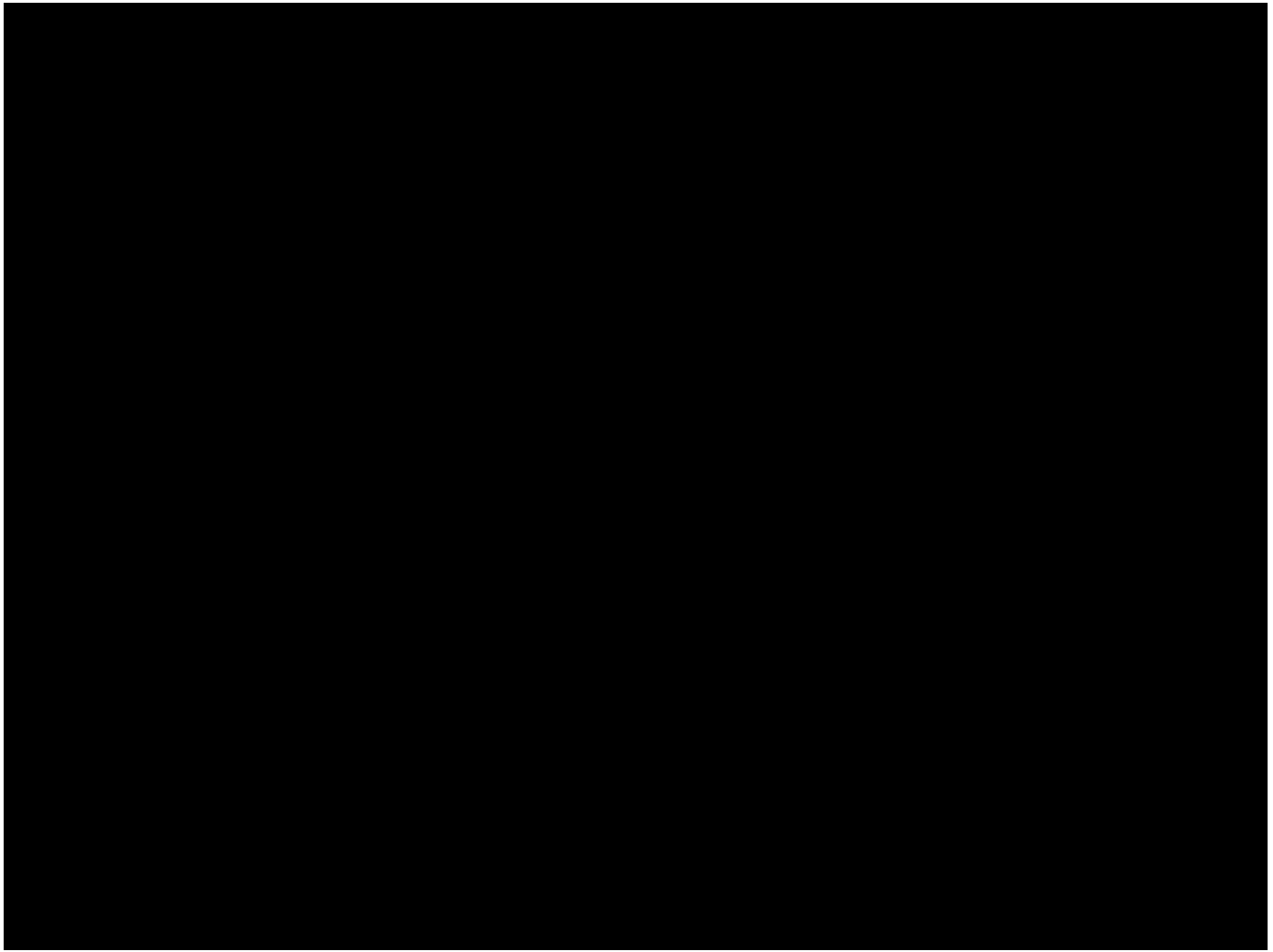
Auger Masterclass
experimental activity

Reconstructed event



energy

arrival direction



Auger Masterclass
first international event

- 9th of May, 2022
- 80 high-school students
- 6 cities of Portugal and Italy

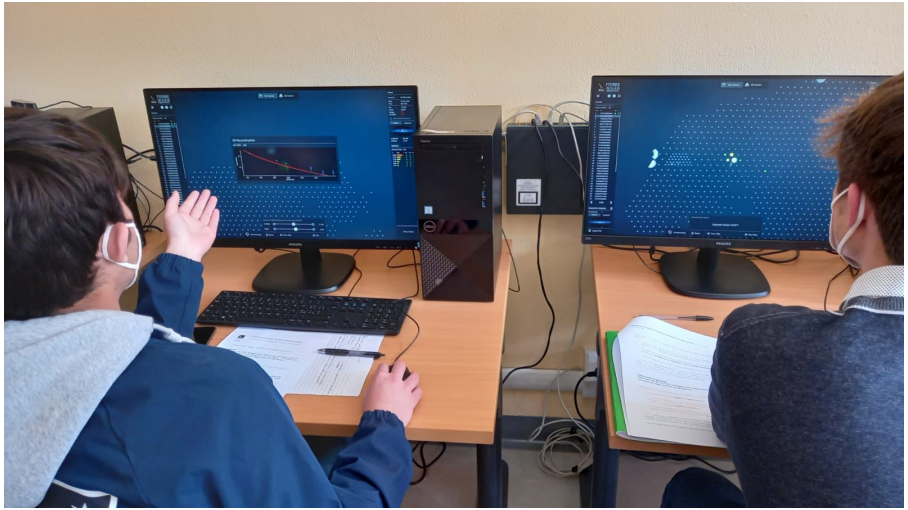
Auger Masterclass
first international event in Braga

introductory lecture + detector demonstrations

Auger Masterclass

first international event in Lecce, L'Aquila

data analysis



Auger Masterclass
first international event in Lisbon, Coimbra

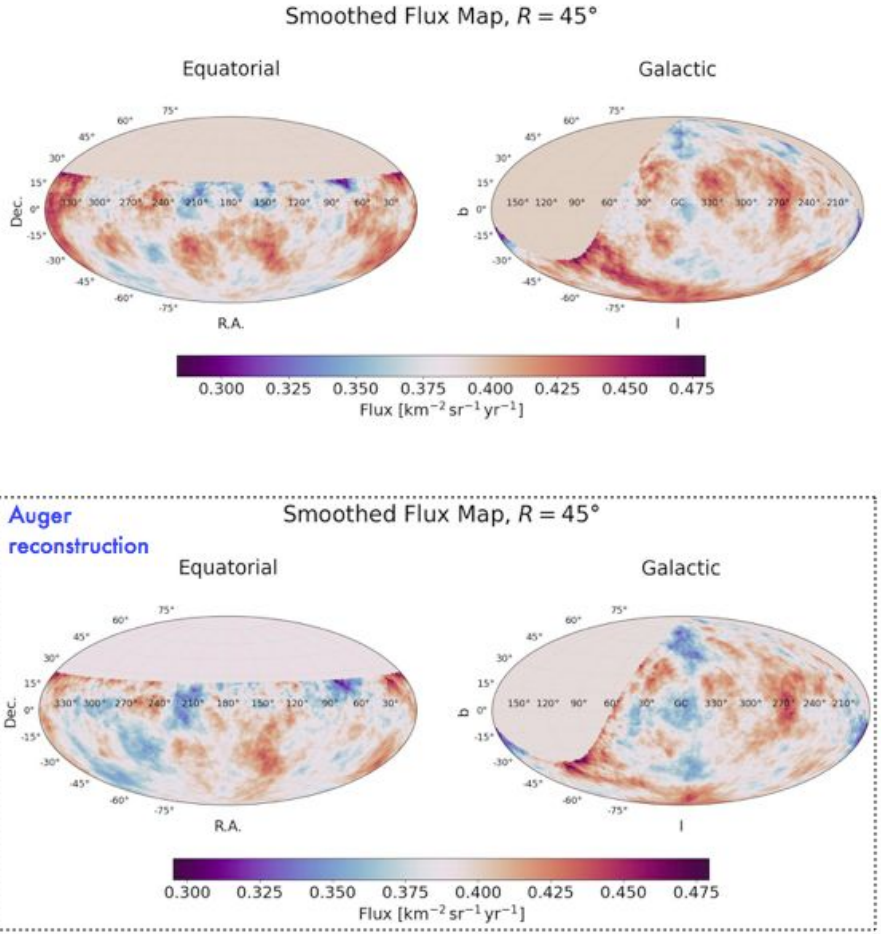
setting the video conference for discussing the results with peers

Auger Masterclass
first international event in Naples

final quiz + group photo

Auger Masterclass
students performance

- 667 reconstructed events that matched the selection criteria
- By eye, same pattern as Auger's
- Scalable to the full statistics available



Summary
outlook

- Successful development and test of an international masterclass with the public data of the Pierre Auger Observatory
- Formal proposal for implementation
- Hopefully, starting worldwide soon!

Thanks for the attention!

Questions?

You may contact me at:

raul@lip.pt

Acknowledgements

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

LIP

PIERRE AUGER OBSERVATORY