Pierre Auger Observatory

The group

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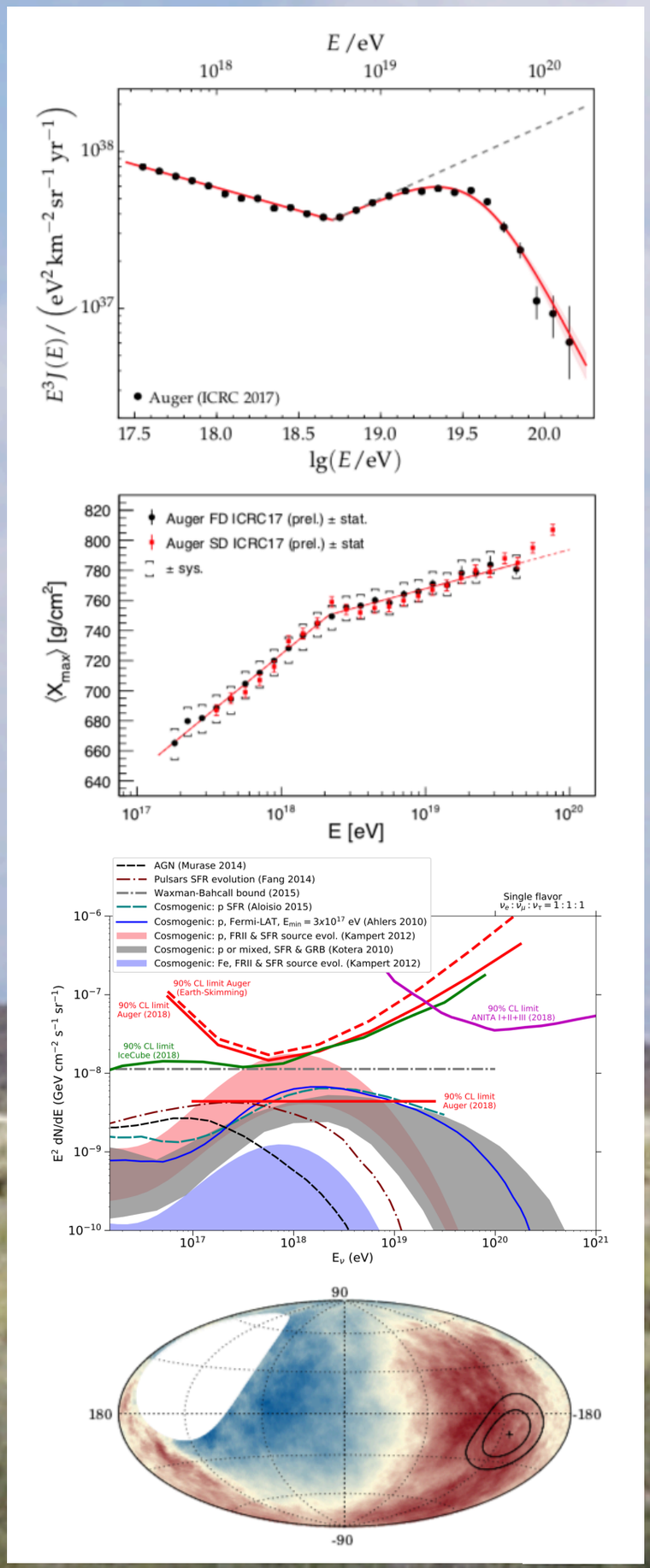
PIERRE AUGER OBSERVATORY



The main activities in Torino

Energy spectrum and spectral features

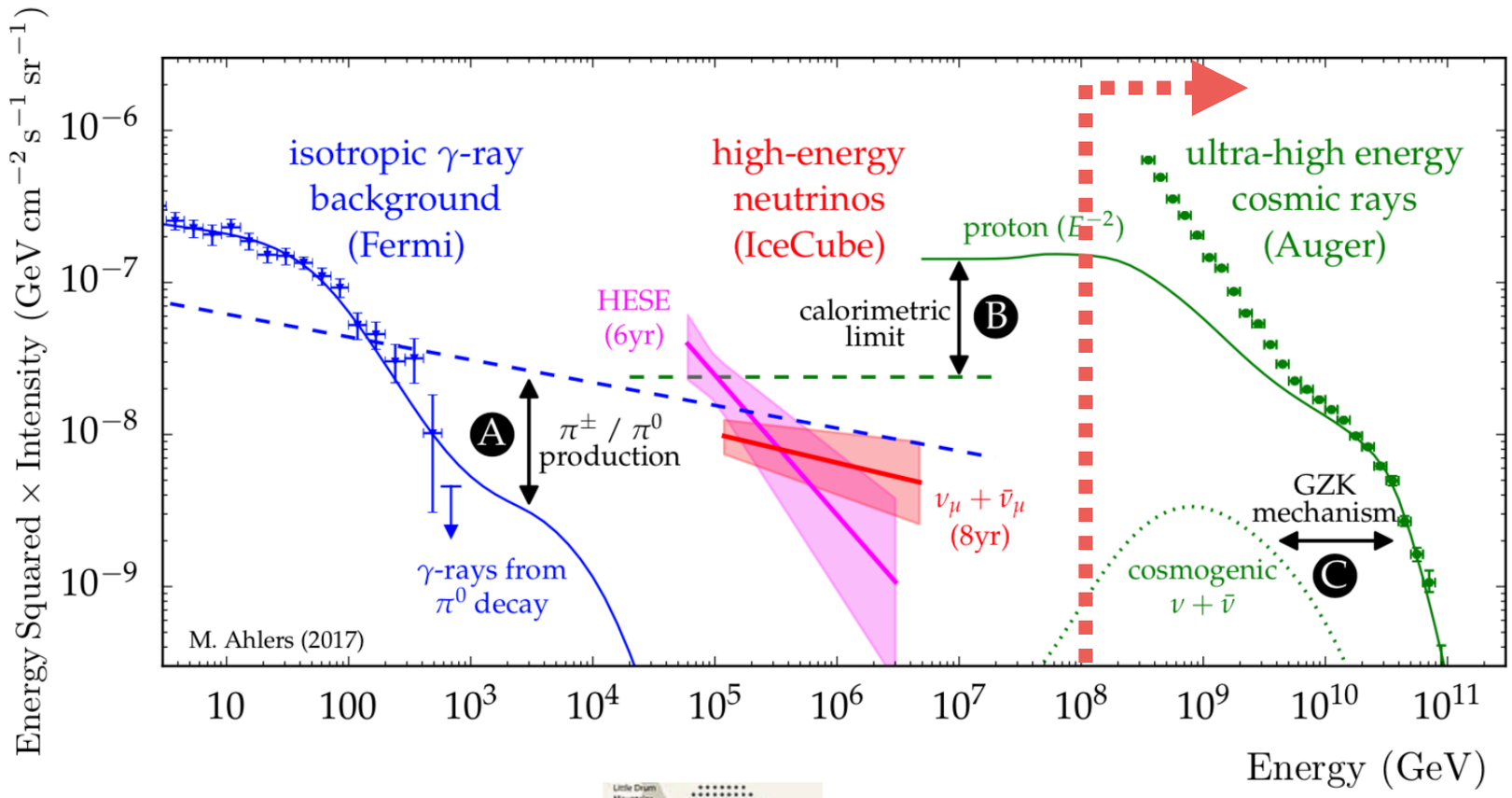
From spectrum+composition to source modelling

Anisotropy searches

Cosmo-geophysics

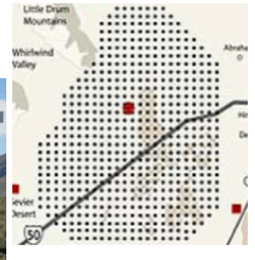
AugerPrime upgrade

Auger in the multi-messenger era

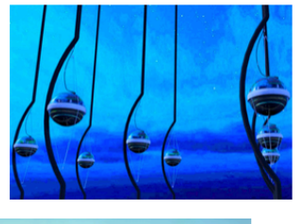


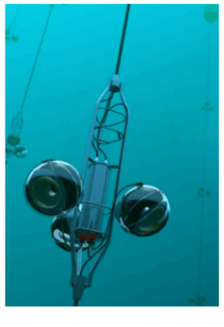
Collaboration, working groups and common papers with

Telescope Array
UHECR spectrum, composition, full sky search for anisotropy



Telescope Array, IceCube, Antares
search for coincidences among CRs and neutrinos

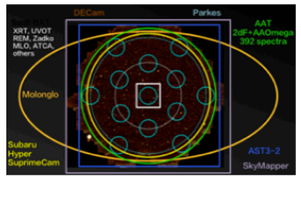




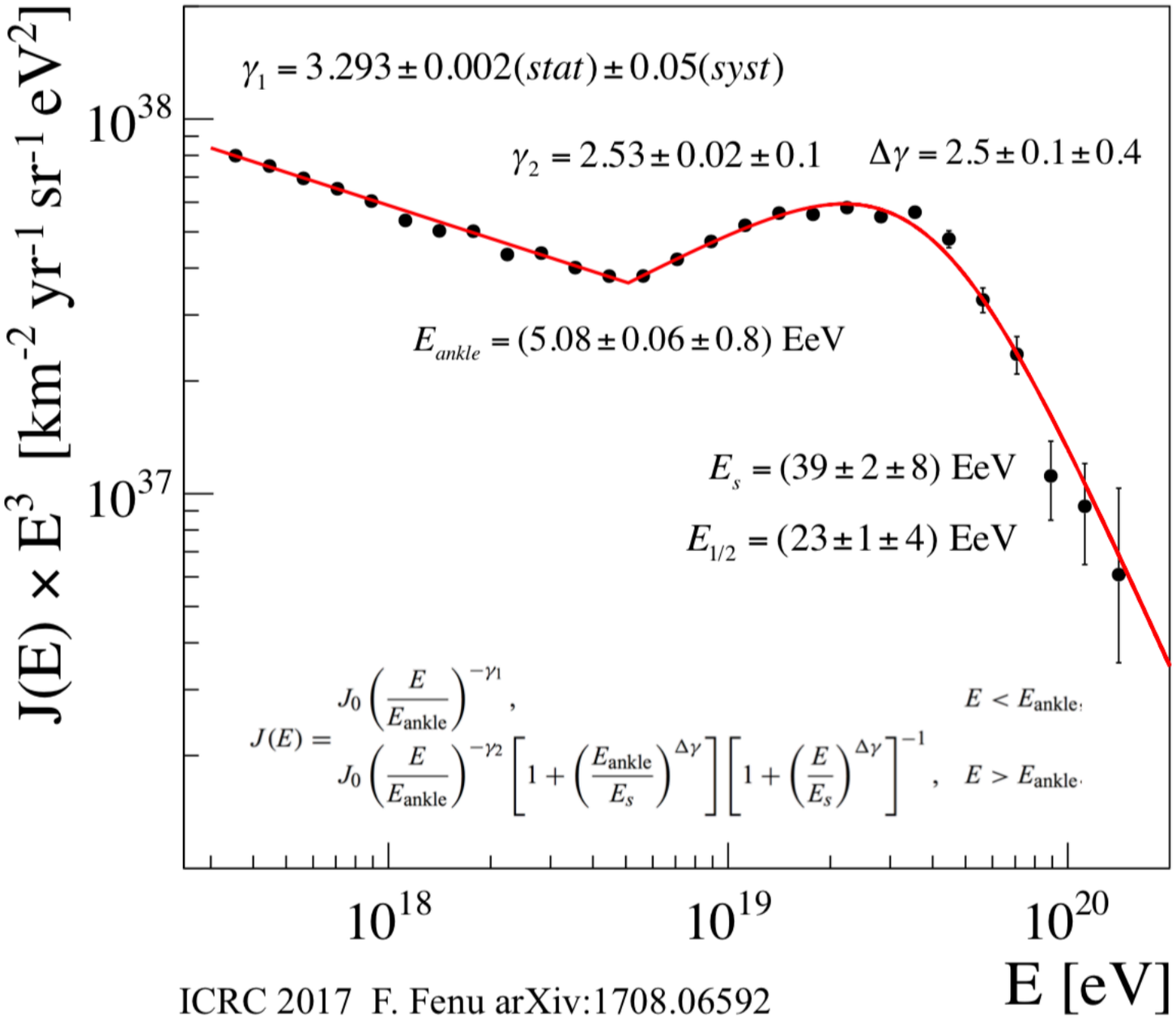
AMON (Astrophysical Multimessenger Observatory Network)
transients and their counterparts

Virgo and LIGO
neutrino follow-up of Gravitational Wave events

DWF (Deeper, Wider and Faster)
>30 collaborations multi-wavelength correlation with fast transients



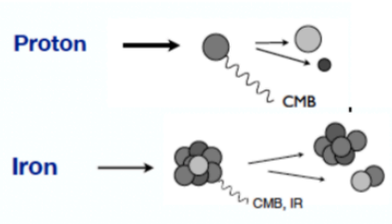
The energy spectrum and its features



ICRC 2017 F. Fenu arXiv:1708.06592

What is the origin of the flux suppression?

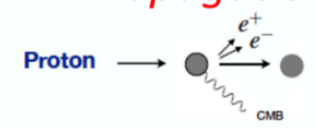
- *Propagation effect?*
  "Greisen-Zatsepin-Kuzmin"



- *Maximum injection energy?*

What is the origin of the ankle?

- *Propagation effect?*



- *Transition effect?*
- *Interactions in the source environment?*

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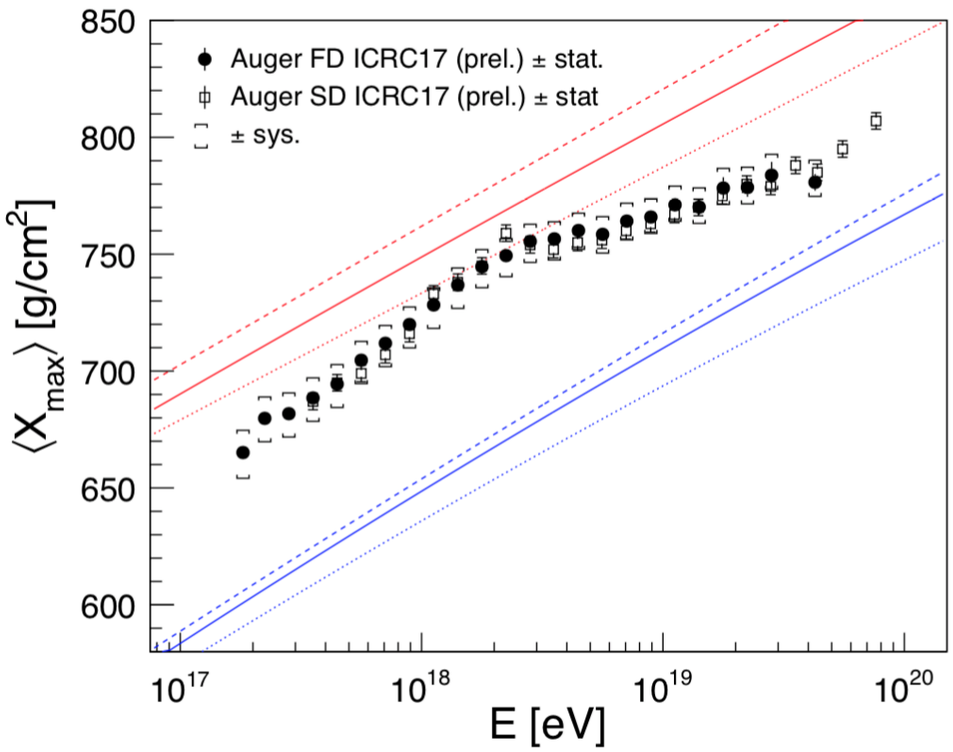
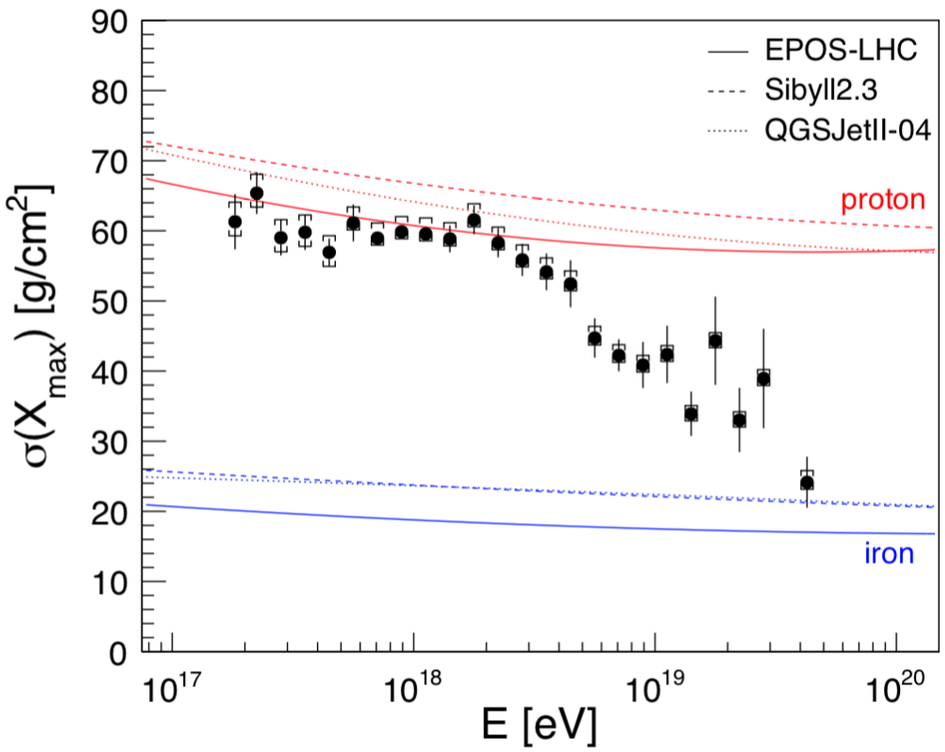
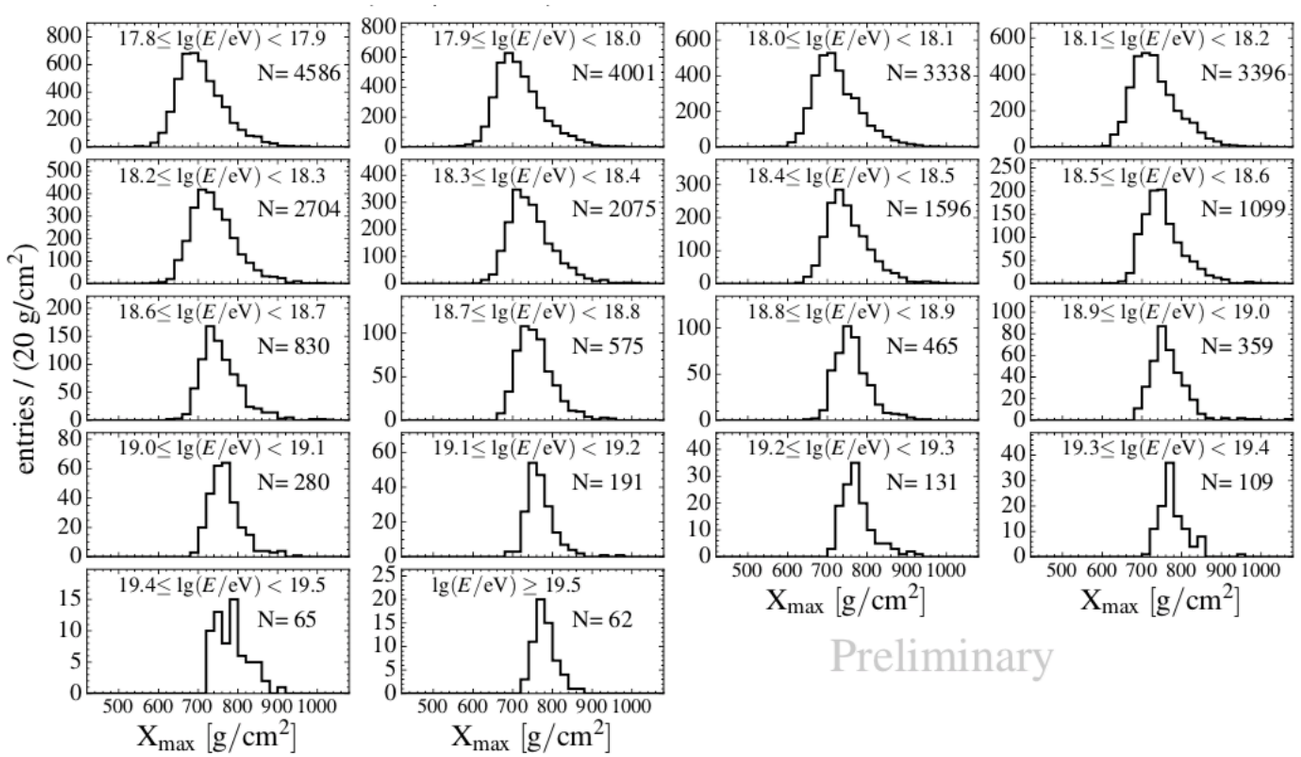
Francesco

The UHECRs composition







Preliminary

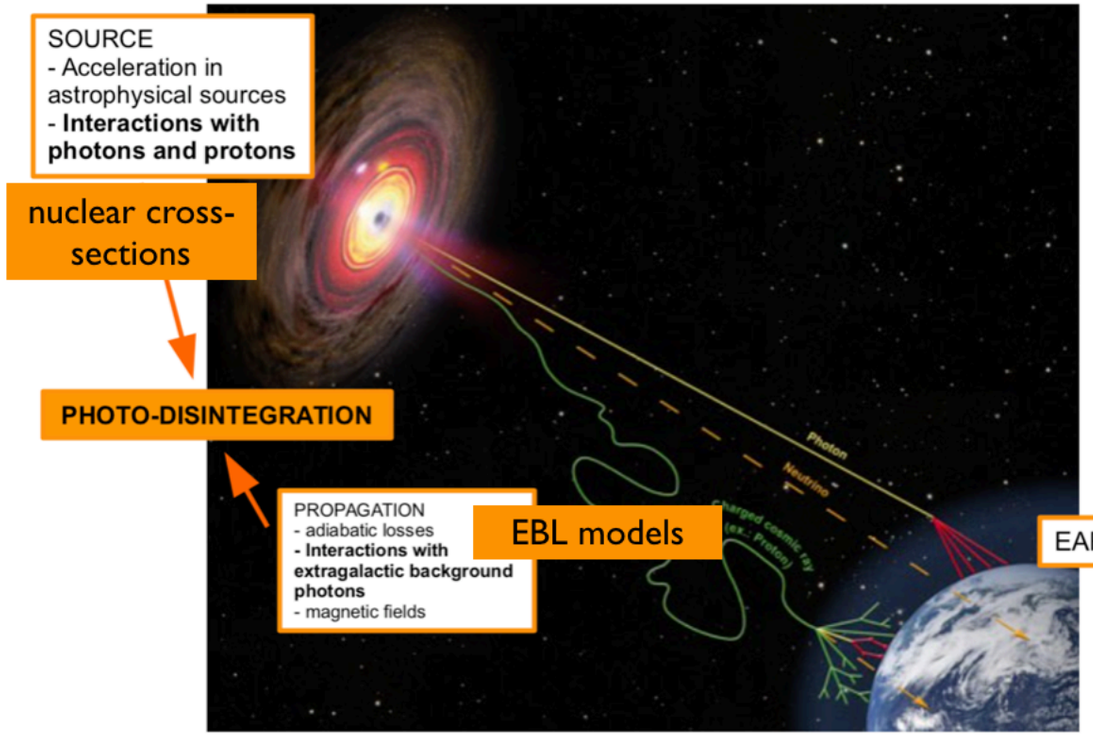
The combined fit

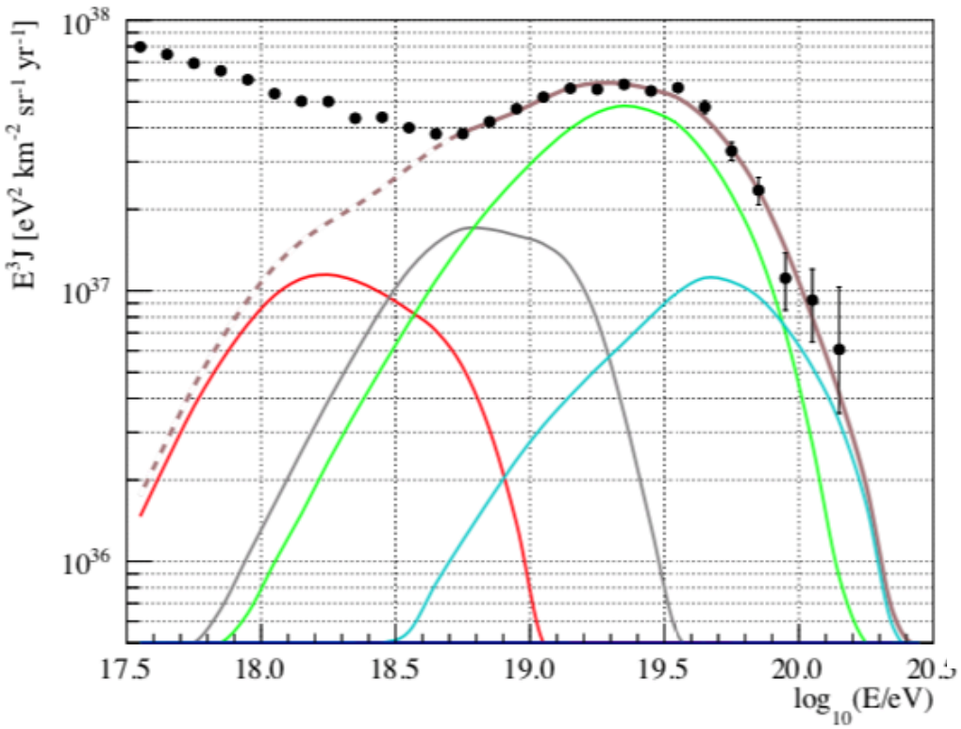
Eleonora

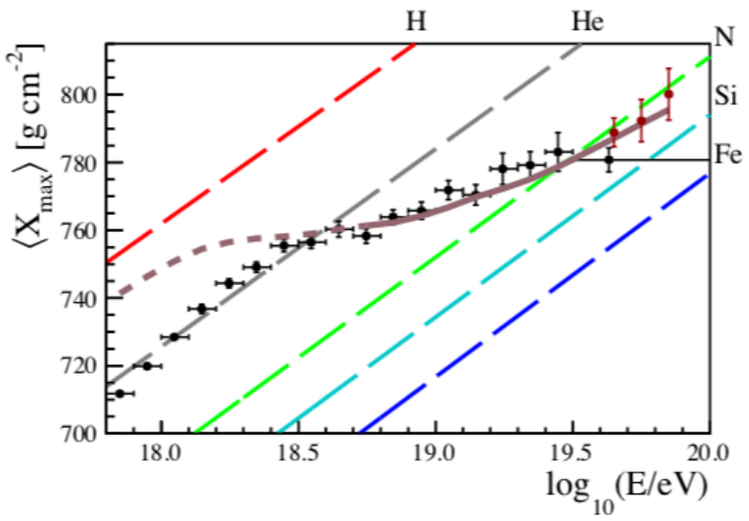
MOTIVATION: study astrophysical models able to describe energy spectrum and composition of UHECRs measured in Auger

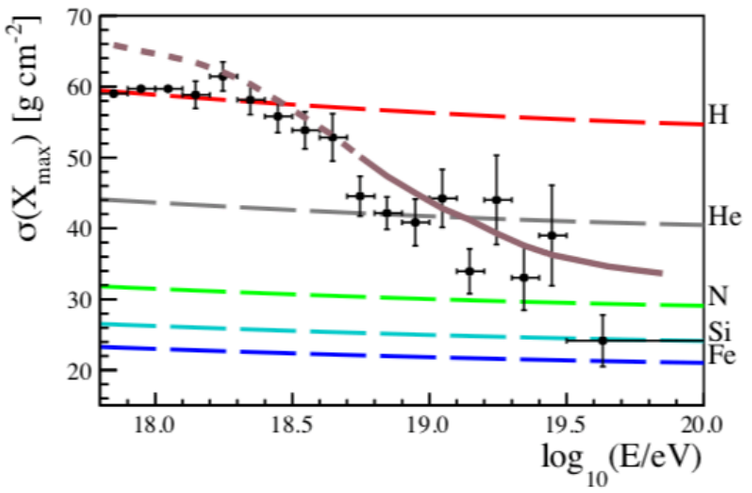
$E^{-\gamma}$ injection spectrum

Rigidity dependent cutoff at source $E_{max}=\mathbf{R_{cut}}Z$
injected representative **mass fractions**
Source over density
Source evolution with z: $(1+z)^{\mathbf{m}}$
Magnetic fields







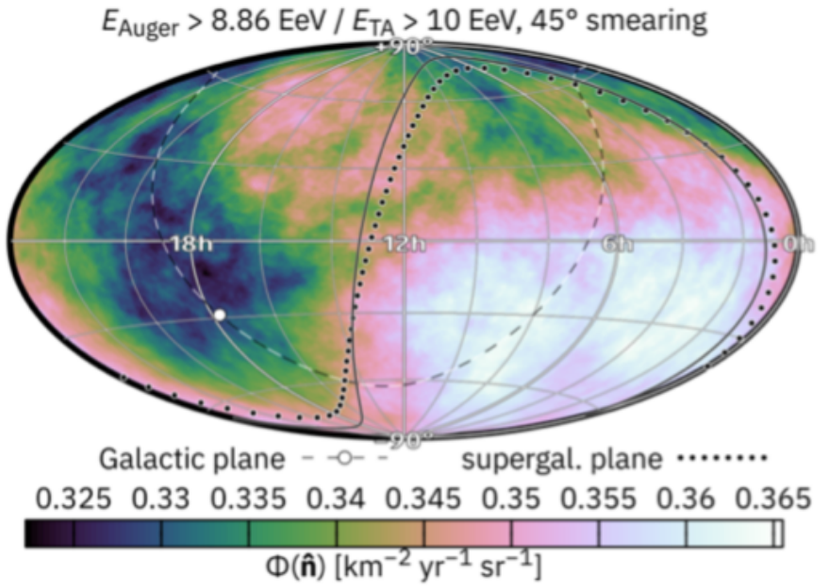


Anisotropy searches : Auger+TA

Armando

MOTIVATION:

- UHECRs interact with background photons : propagation lengths < tens Mpc
- the Universe is not homogeneous at these scales : look for the source distribution
- magnetic deflections ~ 3Z (E/100 EeV)$^{-1}$ deg can distort the picture

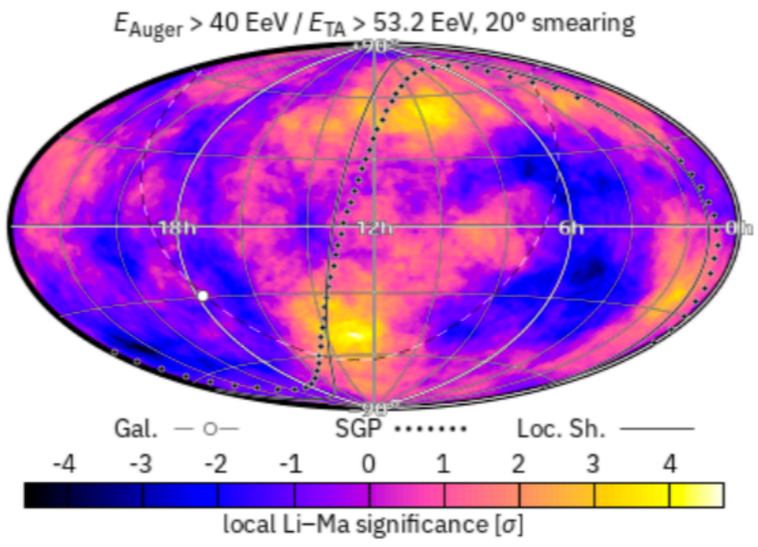


Full sky: analysis is unbiased regardless of higher multipoles

dipolar moment seen by Auger alone confirmed

hints for existence of a quadrupole (more data needed)

cosmic rays above 8 EeV are extragalactic



Blind search for medium scale anisotropies

- 20^0 window

“warm spot” in the Auger FOV σ~4.7 local significance

“hot spot” in the TA FOV σ~4.2 local significance

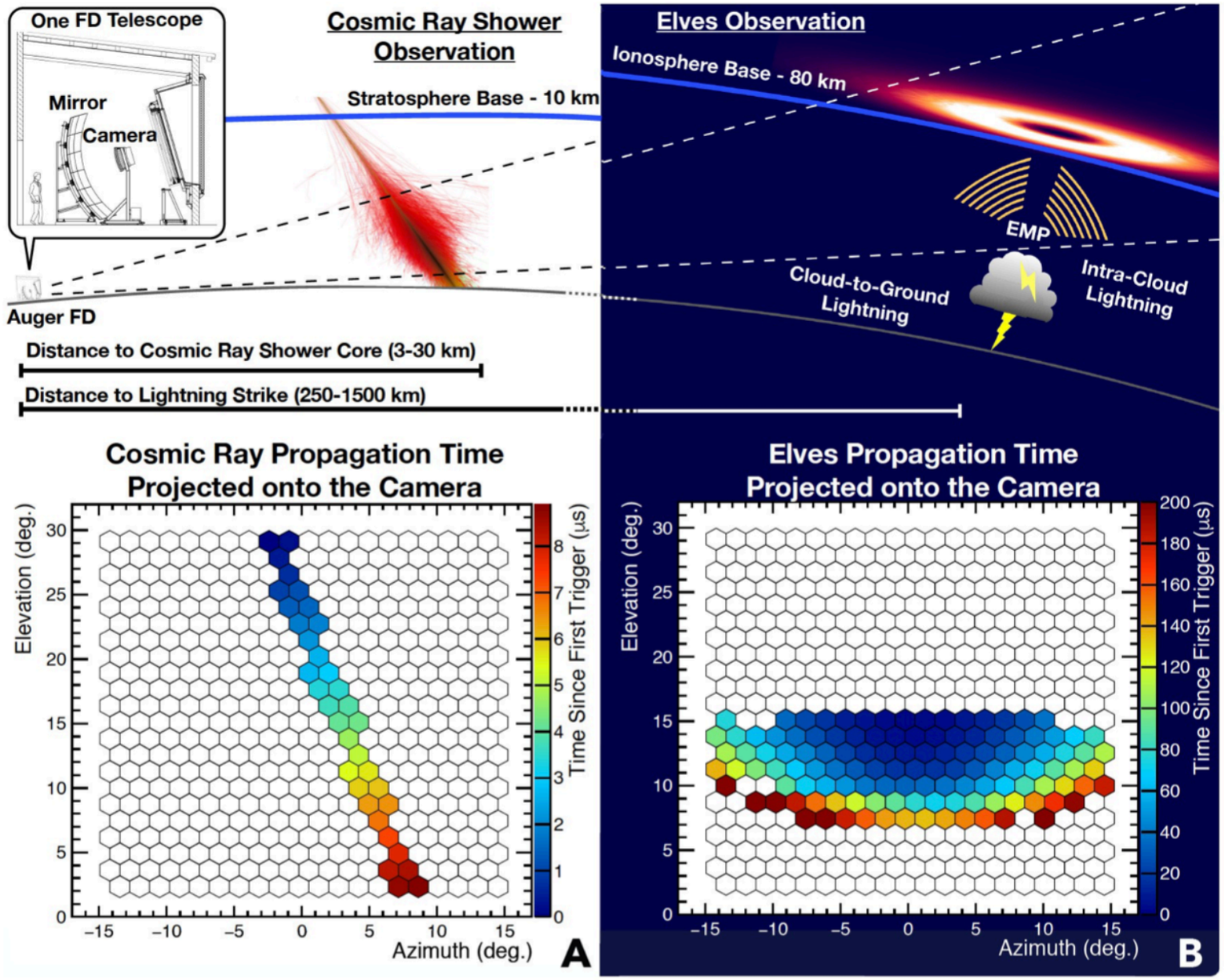
Elves

Roberto

Emission of **L**ight and **V**ery Low Frequency perturbations due to **E**lectromagnetic Pulse **S**ources

MOTIVATION: deeper understanding of mechanisms that govern the production of the most intense lightning and **improvement of current models**

- **observational footprint ~3 · 10^6 km^2** (portions of the Pacific and Atlantic Ocean, Chile, Andes and Northern Argentina)
- first and only ground-based facility that measures elves with year-round operation with full horizon coverage, controlled photon counting, and 100 ns resolution.



- possible correlation studies with e.g. the RELAMPAGO ground-based lightning detection campaign, the GLM instrument aboard the GOES-6 satellite, the Mini-EUSO cosmic-ray detector aboard the space station

AugerPrime - the Upgrade

Next foreseen goals

- understand the origin of the flux suppression
- measure the composition shower by shower
- improve the multi-messenger studies
- explore hadronic interactions above 100 TeV

Extend operations to 2025, increasing the statistics

Improve the sensitivity to the composition at UHE : disentagle the EM and μ components

Surface Scintillator Detectors (SSD)

New Upgraded Electronics

Small PMT (SPMT)

AugerPrime - the Upgrade

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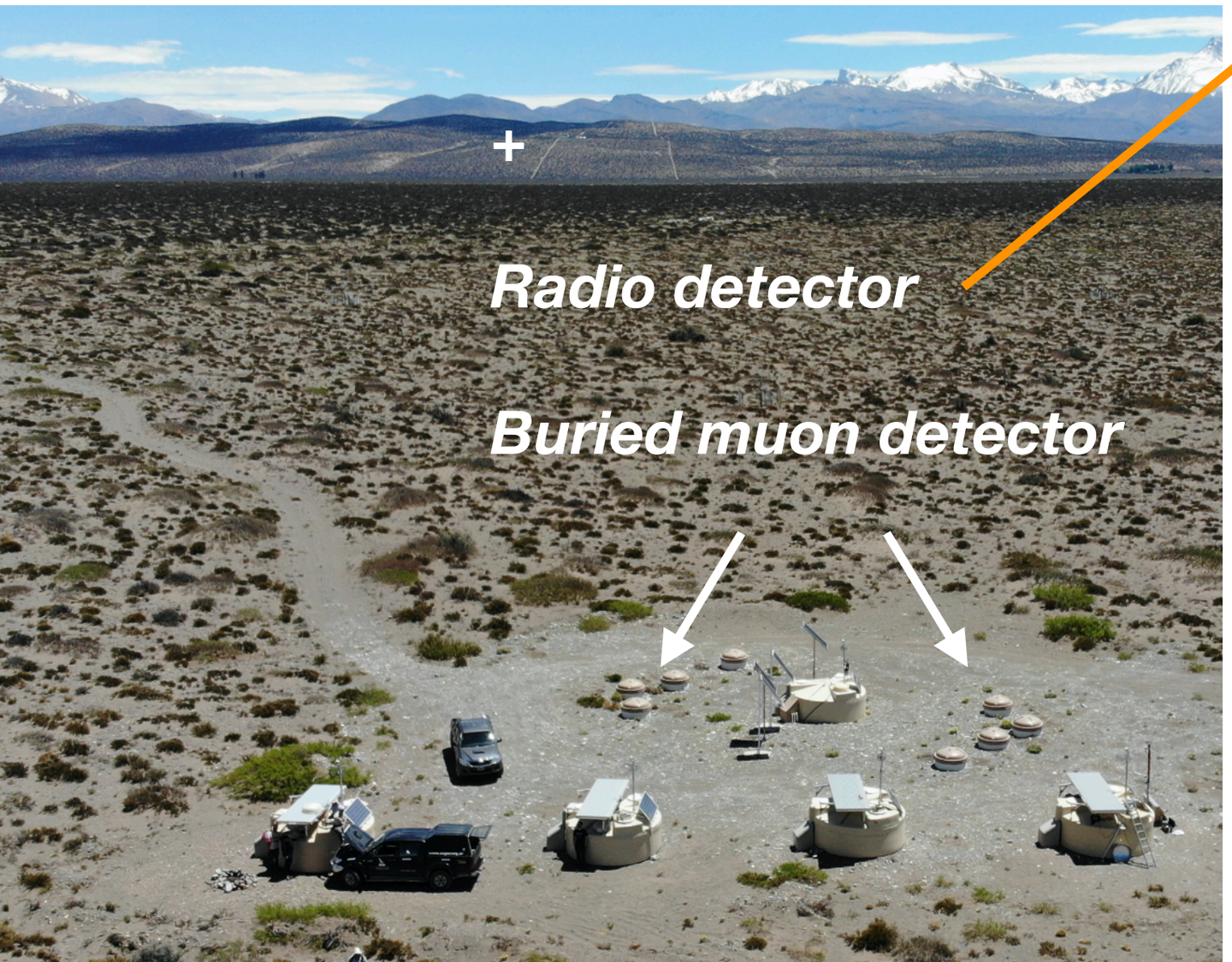
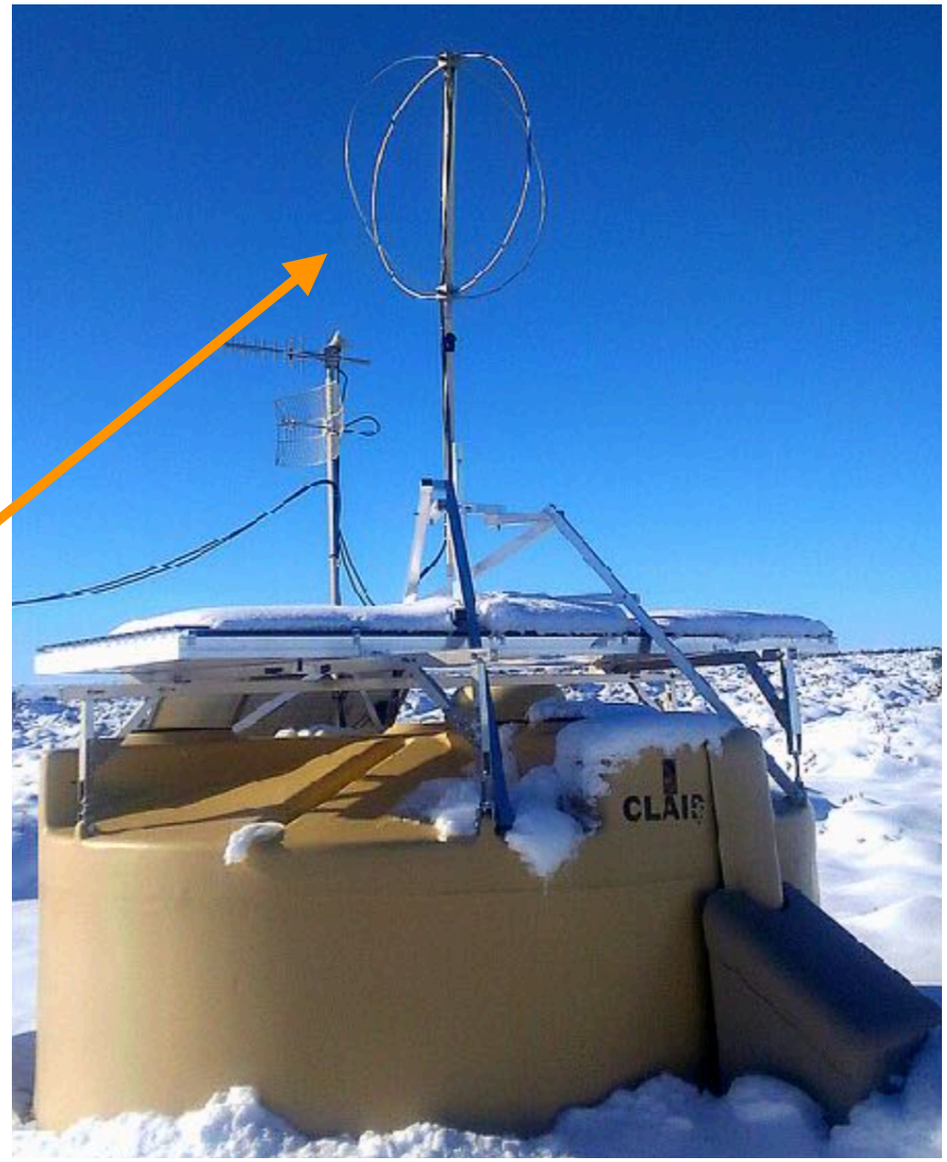


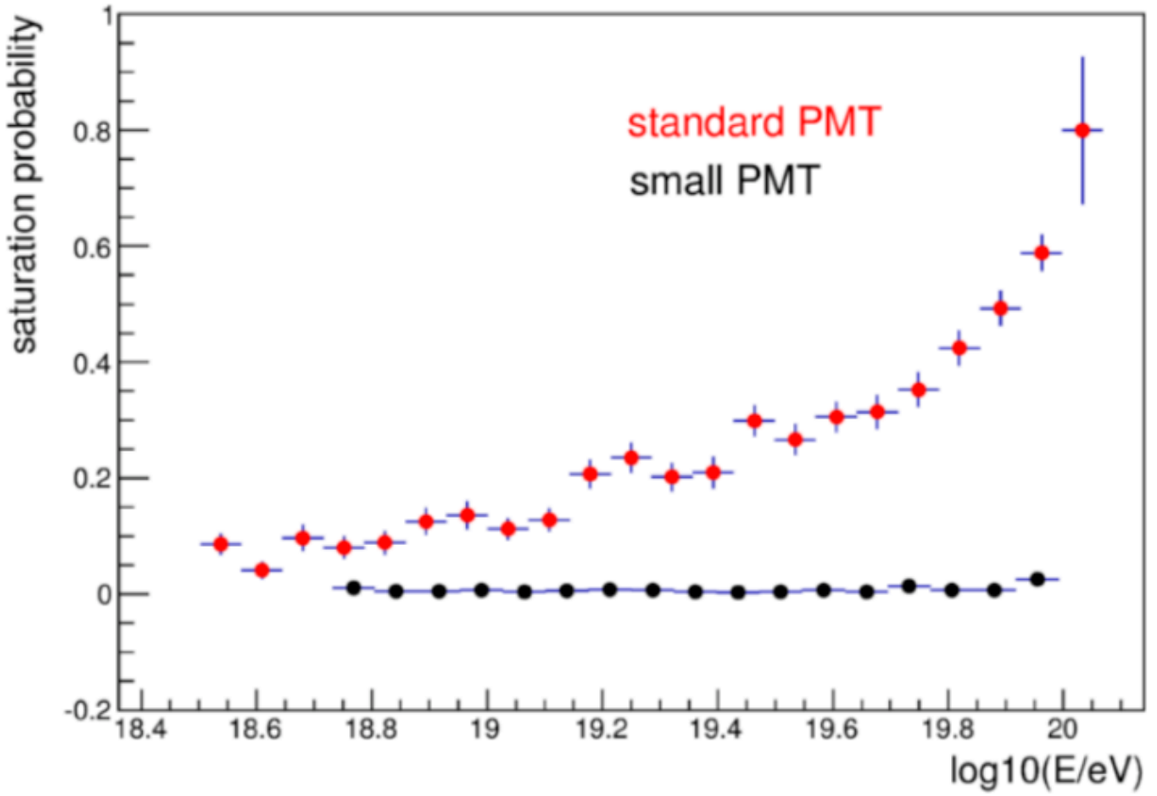


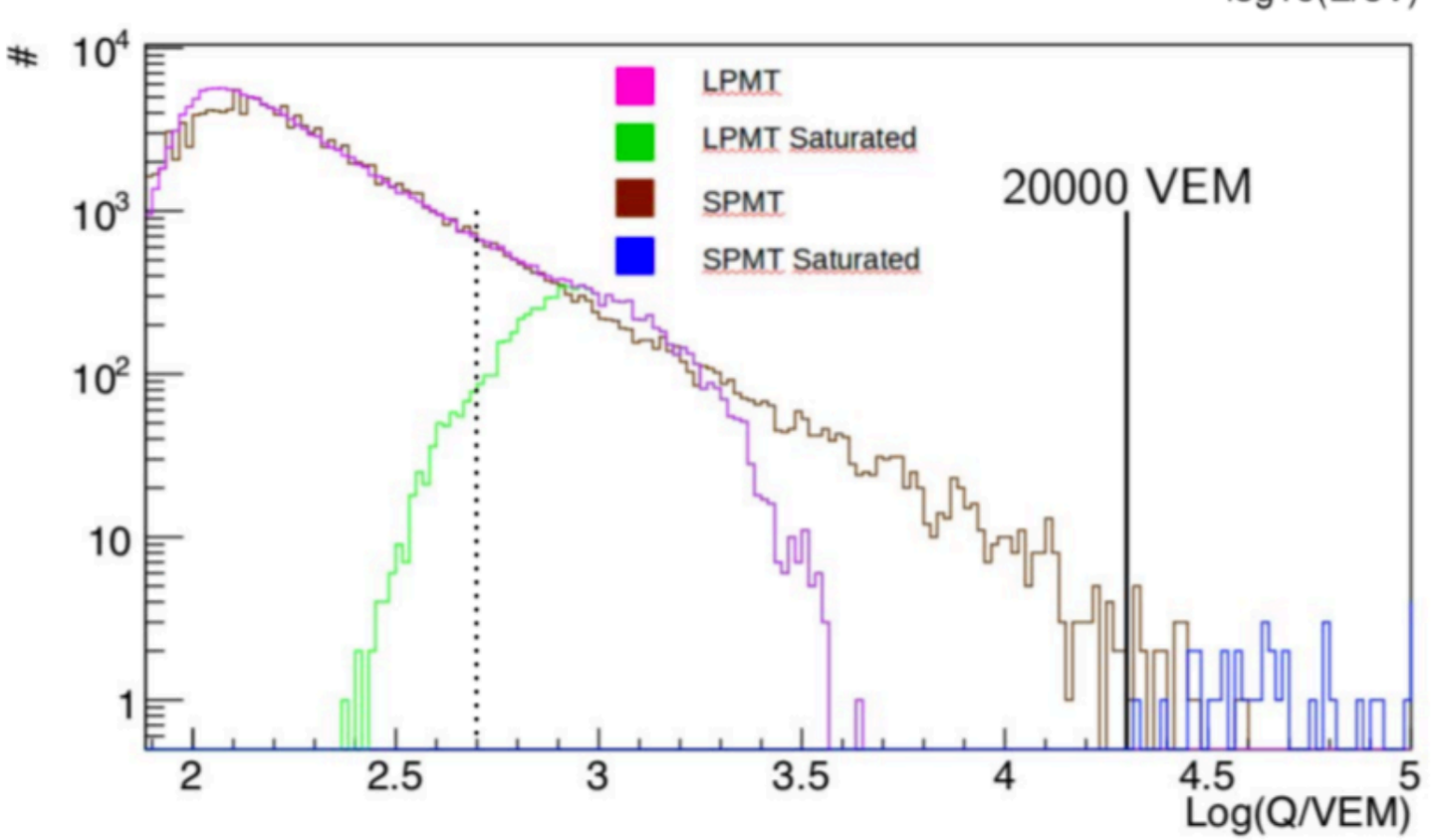
AugerPrime - SPMT

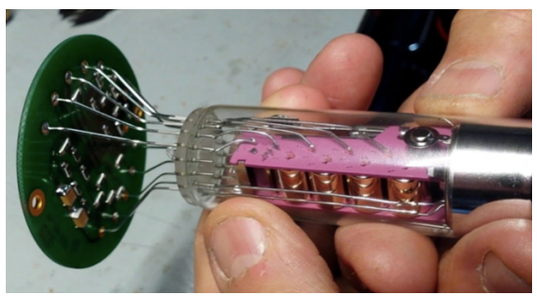
Extending the dynamic range

Extra small PMT in the WCD (1" ∅)

- x32 dynamic range : **~20000 VEM**
- **P(≥1 saturated SD) ~0** at all energies
- signals measured **as close as 250 m** from the core
- easy installation (no mechanical modification of SD tanks)
- dedicated input in the UUB
- comparable dynamic range in WCD and in SSD







Marco, Francesco, Alessio

AugerPrime - the Upgrade

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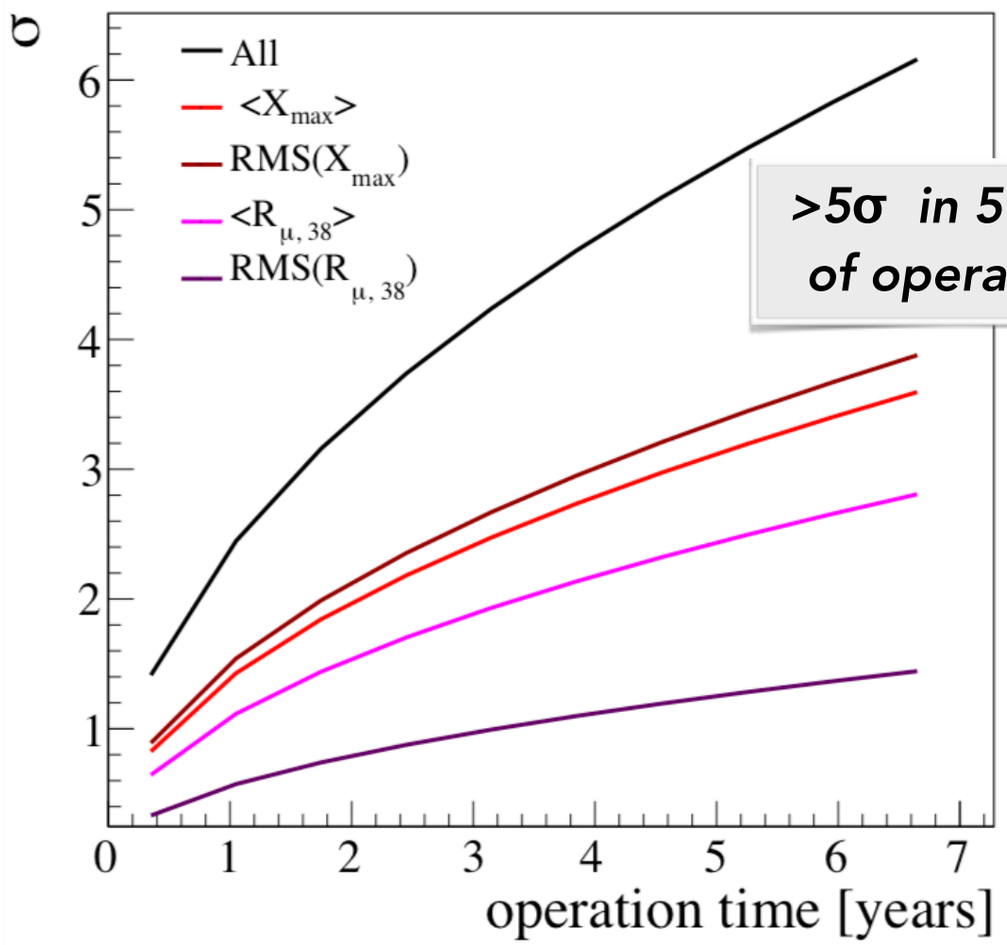

Figure 8. Significance of distinguishing scenarios 1p and 1 (with and without at least 10% protons respectively) as a function of the operation time of AugerPrime.

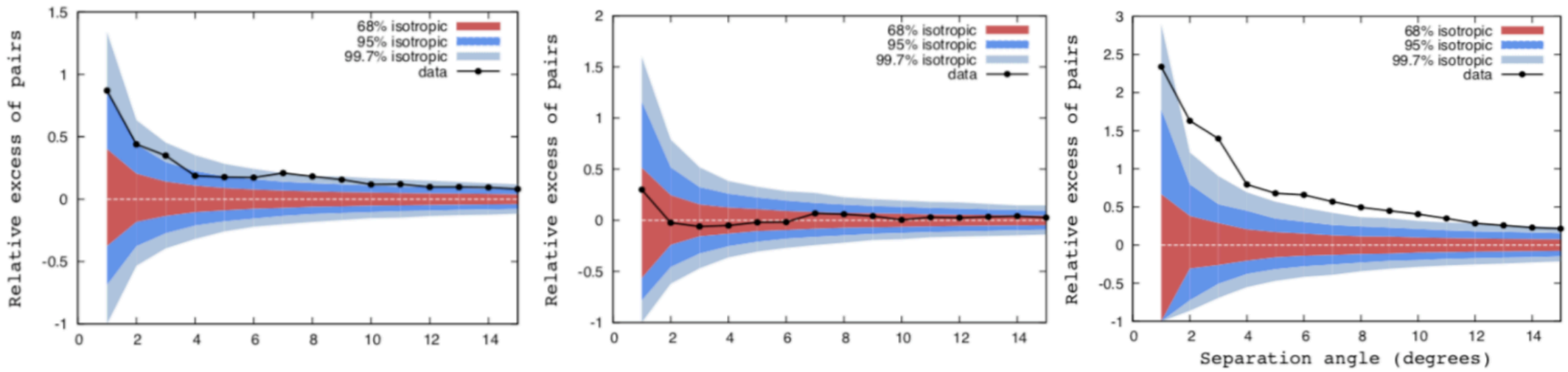

Figure 9. Angular correlation of Auger data modified according to scenario 1 and 1p with the AGNs of the "70 Months Swift-BAT catalog" (see text for details). The relative excesses of pairs of events as a function of their angular separation is shown for the complete data set (left), the selection deprived of light elements (center) and the proton-enriched one (right panel).