

ERRE

10th Recontres du Vietnam VHEPU Quy Nhon August 7, 2014

WITH THE Pierre Auger Observatory

Carla Bleve* for the Pierre Auger Collaboration *Bergische Universität Wuppertal, Università del Salento & INFN Lecce

Outlook

- The Pierre Auger Observatory: designed to detect charged UHECRs, is sensitive to photons from 10¹⁷ eV to highest energies (~10²¹eV)
- Hybrid and SD mode

•

• Largest exposure currently available:

 \rightarrow will reach ~ 10⁵ km² sr yr by 2023 (SD)

• UHE photons: diffuse searches

→ with hybrid data: $10^{18} - 10^{19} \text{ eV}$ → with the surface detector data:> 10^{19} eV with possible extension to lower energies(E > $10^{18.5} \text{ eV}$)Search for steady point sources $10^{17.3} - 10^{18.5} \text{ eV}$

The questions

- \rightarrow UHE astronomy?
- → CR spectrum cutoff from GZK or E_{max} at sources?

→ Test of fundamental Physics (LIV)

UHE photons



Observatory

 \rightarrow No alternative to EAS detection at ground

How to recognize a photon EAS



Diffuse flux 1: Search with Auger hybrid data

Observables for photon identification



FD

Maximum of the longitudinal profile Xmax

→ deeper Xmax

SD

Measure difference in normalisation and shape of LDF:

$$S_b = \sum_i S_i \left(\frac{R_i}{1000}\right)^4$$

Signal in the i-th station Distance to the Shower axis

→ smaller signal, steeper LDF

Define photon candidates



Candidate cut at the median of

MC photon distribution

- → Trained on MC simulations of protons and photons
- → E dependent exposure for photons: from detailed simulations of observational conditions

Diffuse flux 2: Search with Auger SD data

Identifying photons with SD only

 \rightarrow Use observables related to Xmax and muon content:



→ Photon energy reconstructed using the signal at 1000 m scale different from 'usual' Auger one [~ half decade higher]



Define photon candidate for SD analysis



Results on diffuse searches

Upper limits on diffuse fluxes of photons



- → Top-down models highly disfavoured
- \rightarrow Approaching the most optimistic predictions of cosmogenic photon fluxes

Cosmogenic photons and the future



To higher sensitivity

If no photons, UL from:





Cosmogenic photons and the future (2)



Search for point sources

Search for point sources



- \rightarrow Idea: find fluxes of photons in a **blind directional search**
- → Needs large statistics: go to low energies Hybrid data, 10^{17.3}-10^{18.5} eV Horizon: ~ hundreds Mpc (Milky Way, Local Group of galaxies)
- → Aim: look for steady sources of photons (possible sources of galactic EeV Crs)
- → Method: build a sample of data with reduced background level, search for excess flux in any direction

Event observables



Multi Variate Analysis



Building the data sample with reduced background

Background map built with the scrambling technique





Directional optimisation of β_{cut} to maximise the expected sensitivity

Sky map



95% CL directional ULs on the photon flux

ApJ, 789, 160 (2014)



 \rightarrow Targeted searches in progress

Auger searches for UHE photons



FUTURE:

- → Enhanced sensitivity with new analysis, upgraded detector, accumulated exposure
- \rightarrow If discovery: source pointing, GZK messengers
- → If no discovery: constraints on astrophysics scenarios (source parameters, composition, ...)



Backup

Details of directional search

Zech method to determine the
number of signal events
$$n_s$$
 at a
95% confidence level
 $P(\leq n_b^\beta | n_b^\beta + n_s) = \alpha_{\rm CL} \cdot P(\leq n_b^\beta | n_b^\beta)$
(1-CL)

Optimisation of the "photon-like" event selection:

$$\min\left(\frac{n_s(\beta_{\rm cut})}{\varepsilon_{\gamma}^{\beta}(\beta_{\rm cut})}\right) \quad \text{with } \beta_{\rm cut} \in [-1, 1]$$