XXVth Rencontres de Blois

RESULTS OF THE PIERRE AUGER OBSERVATORY

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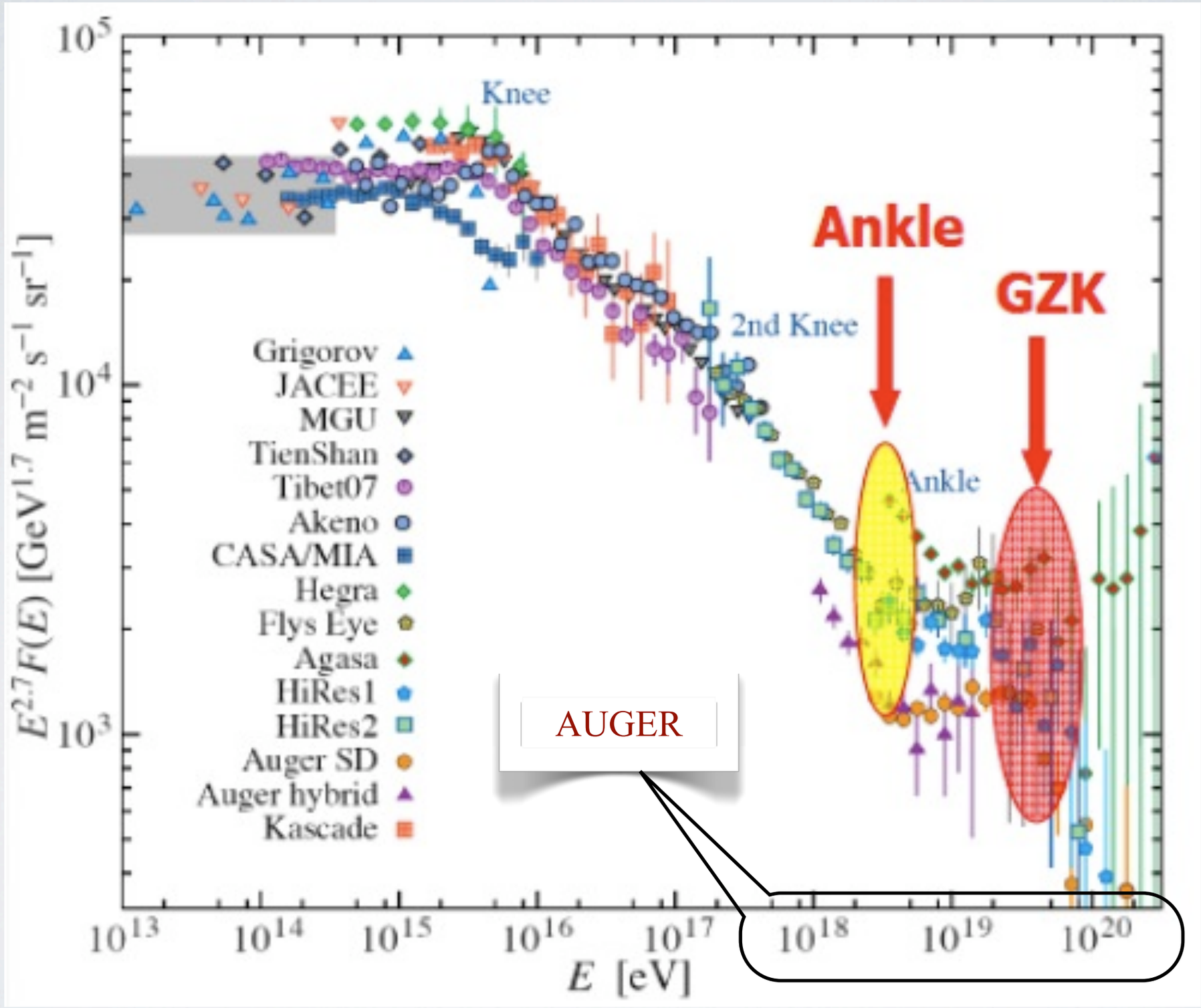
29/05/2013

THE COSMIC RAY SPECTRUM



THE AUGER OBSERVATORY

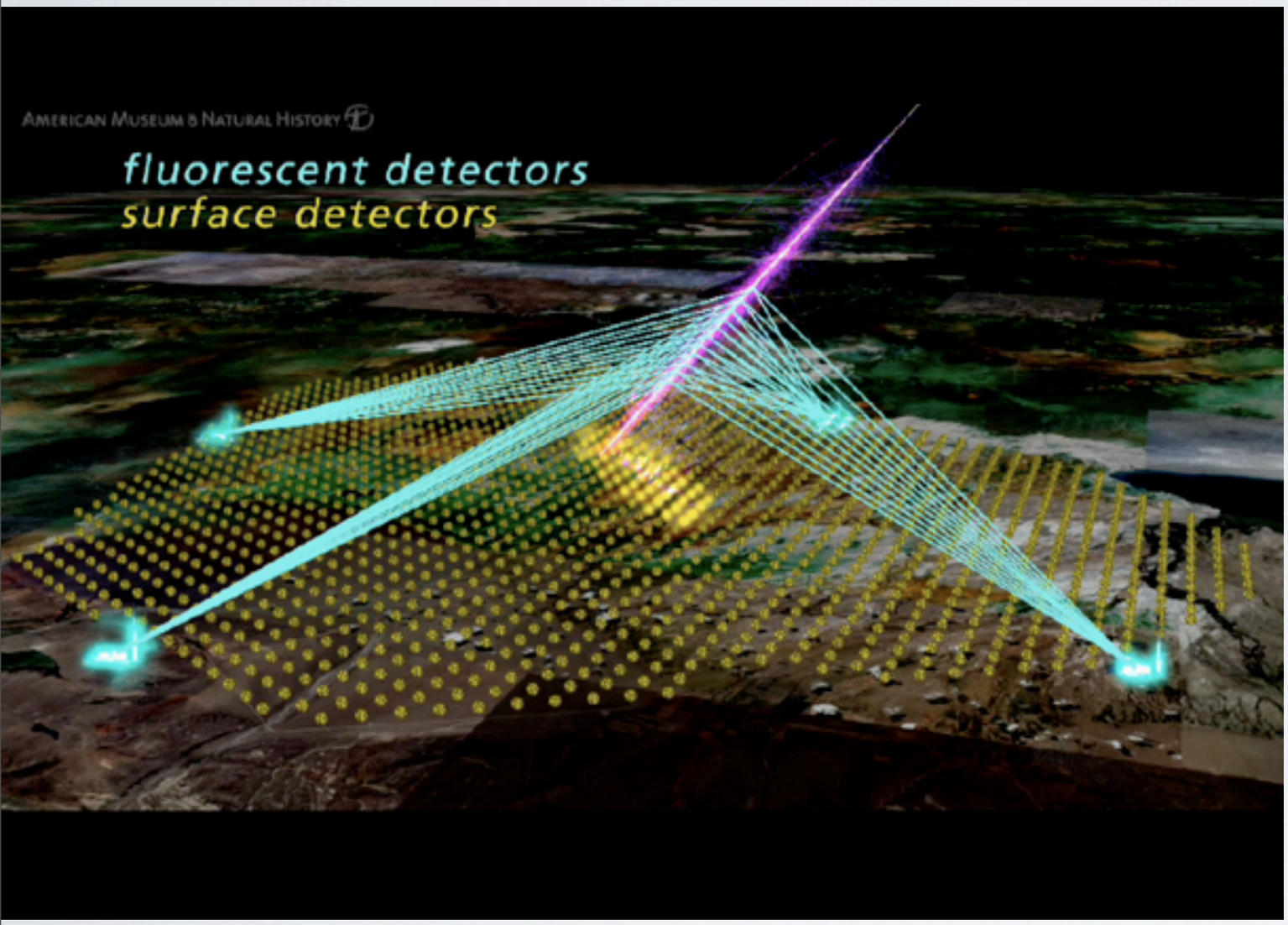
PIERRE AUGER OBSERVATORY

Hybrid detection

In the pampa near Malargüe (Argentine)

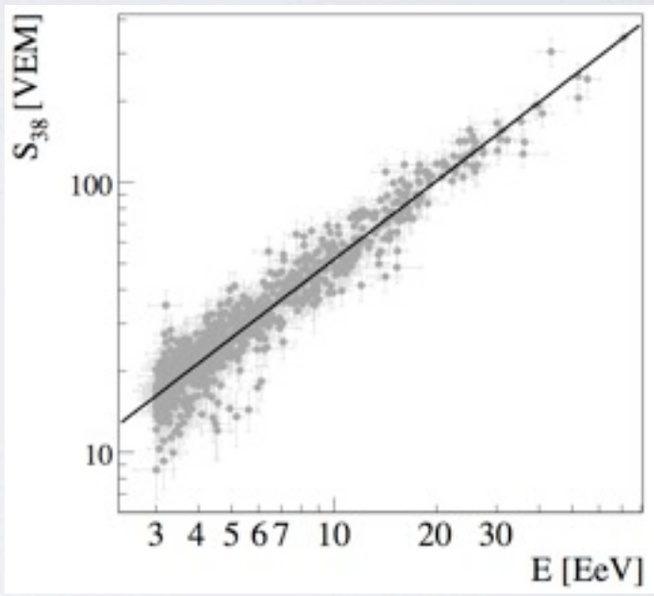
1400m a.s.l. - latitude: 35°

- Complementary EAS detection techniques
  - Lateral profile → Fluorescence detector
  - Longitudinal profile → Surface detector (water Cherenkov)



Accurate measurements

- Cross-calibration for the energy



- Resolutions
  - angular resolution : 1°-2°
  - absolute energy uncertainty : 15%
  - relative energy resolution : 16-12%

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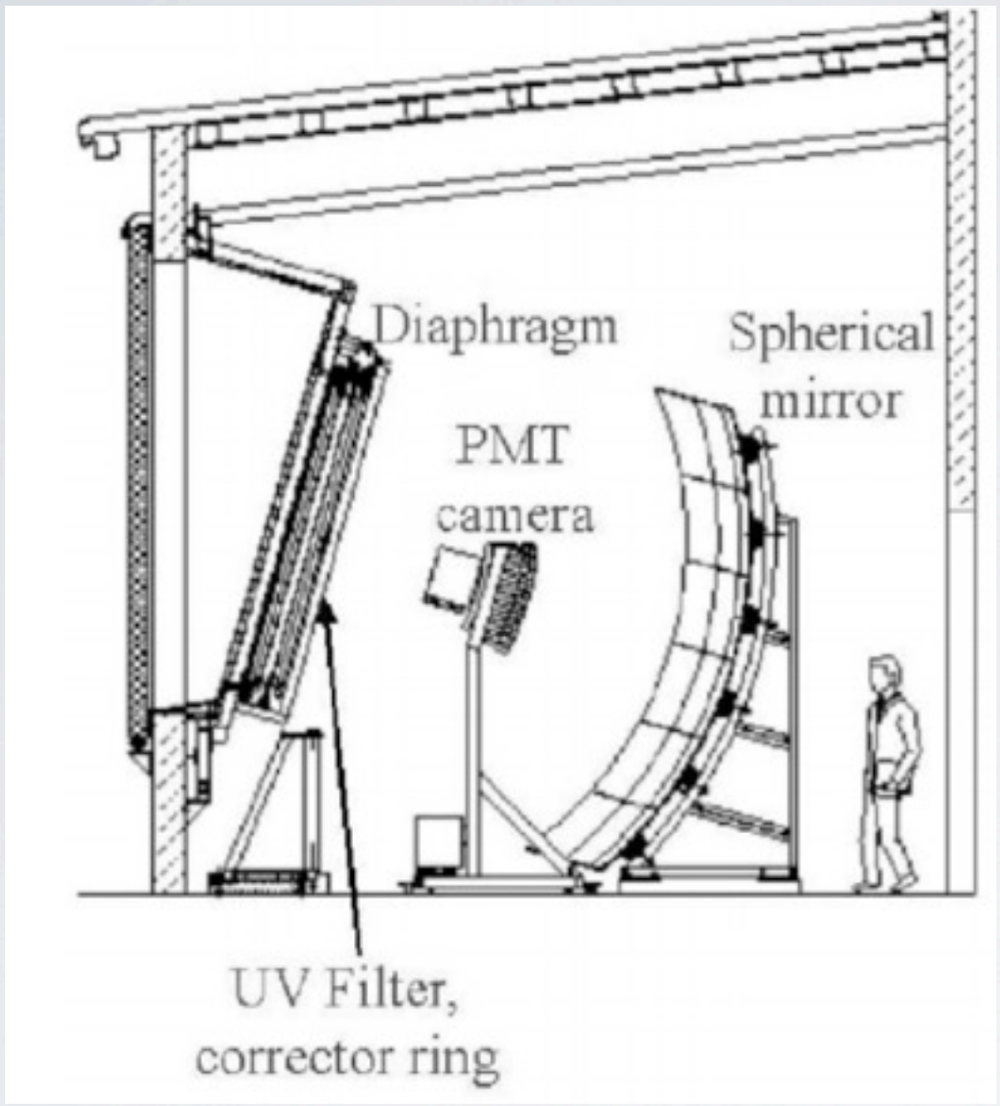


Fluorescence detector

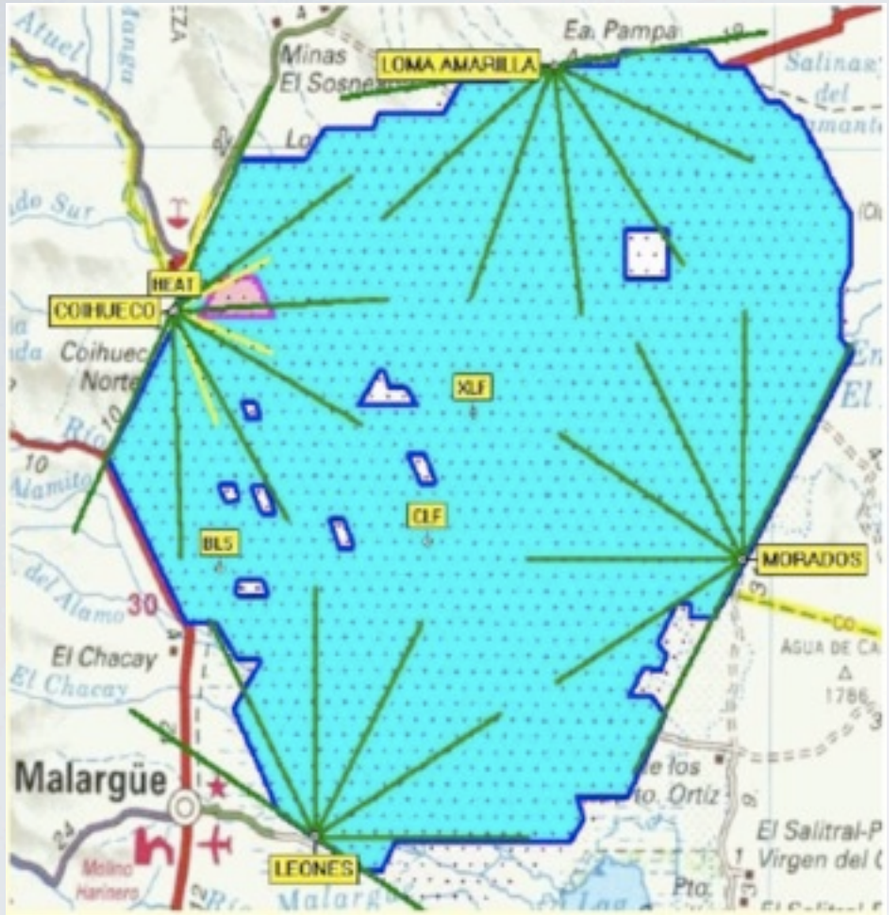
- 4 eyes - 6 telescopes by eye
- Measure the photons generated by the EAS, exciting the N_2 of the air
- Calorimetric measurement of E
  (negligible dependency of hadronic models)
- 10% of duty cycle (clear moonless nights)
- Low energy extension : HEAT
- Requires a monitoring of the atmosphere
  (P, T, aerosol content, clouds)
- For hybrid events E_{sat} = 1 EeV

Selection of events

- Fiducial cuts to have the same acceptance for *p*/*Fe* , FOV(E)
- Quality cuts on the the profile reconstruction
- Atmospheric conditions

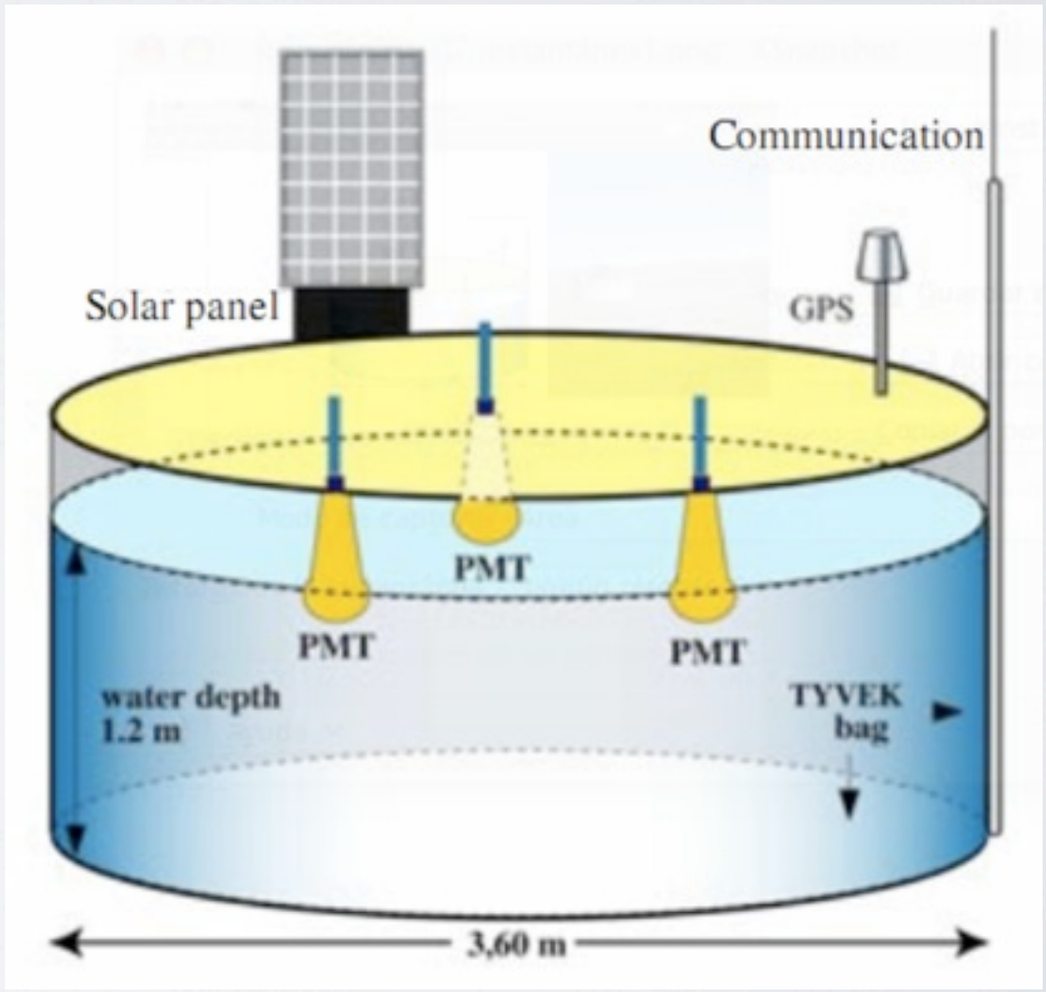
→ exposure determined by MC

THE AUGER OBSERVATORY



Surface detector

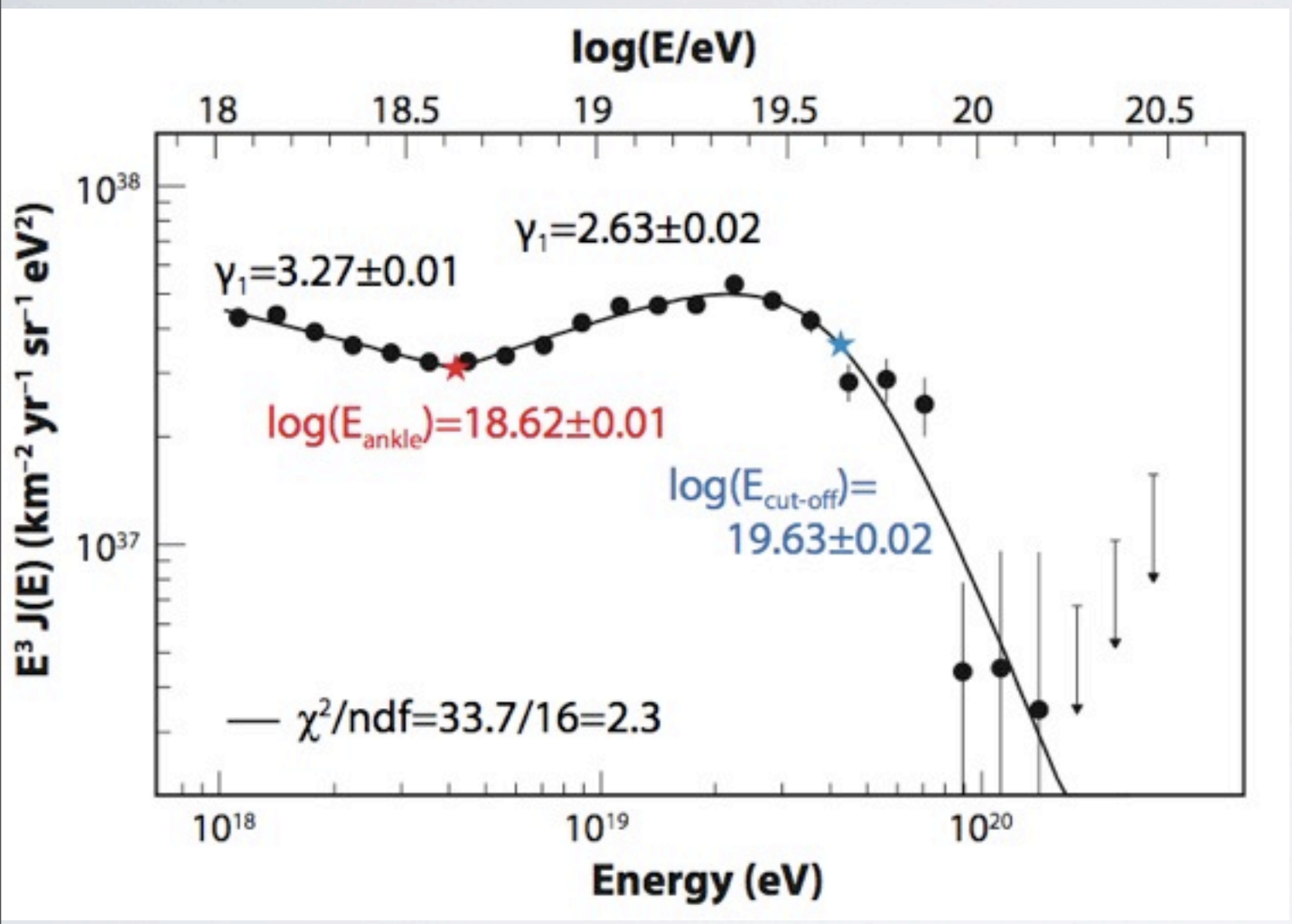
- 1660 surface detectors
- triangular grid (1.5 km)
- covering 3000 km^2
- water Cherenkov tanks
- full efficiency @ E_{sat} = 3 EeV
- low energy extension : infill



Selection of events

- based on the operational tanks configuration
  - → geometrical exposure
- 2 different reconstructions for $\theta < 60°$ & $\theta > 60°$

SPECTRUM



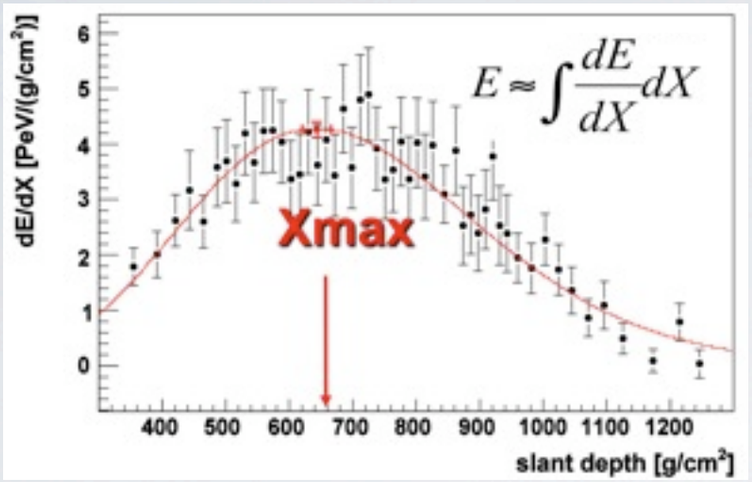
E >∼50 EeV — Flux suppression

- GZK prediction :
  interaction of the CRs on the γ_{CMB}
  - p : pion-production
  - nuclei : photo-dissociation
- E_{max} at the source

E ∼ 4 EeV — The ankle

- Ankle model
  Transition from Gal to X-Gal
- Dip model
  - pure proton component from X-Gal src
  - Pair production in 10^{18} - 4×10^{19} eV

CHEMICAL COMPOSITION

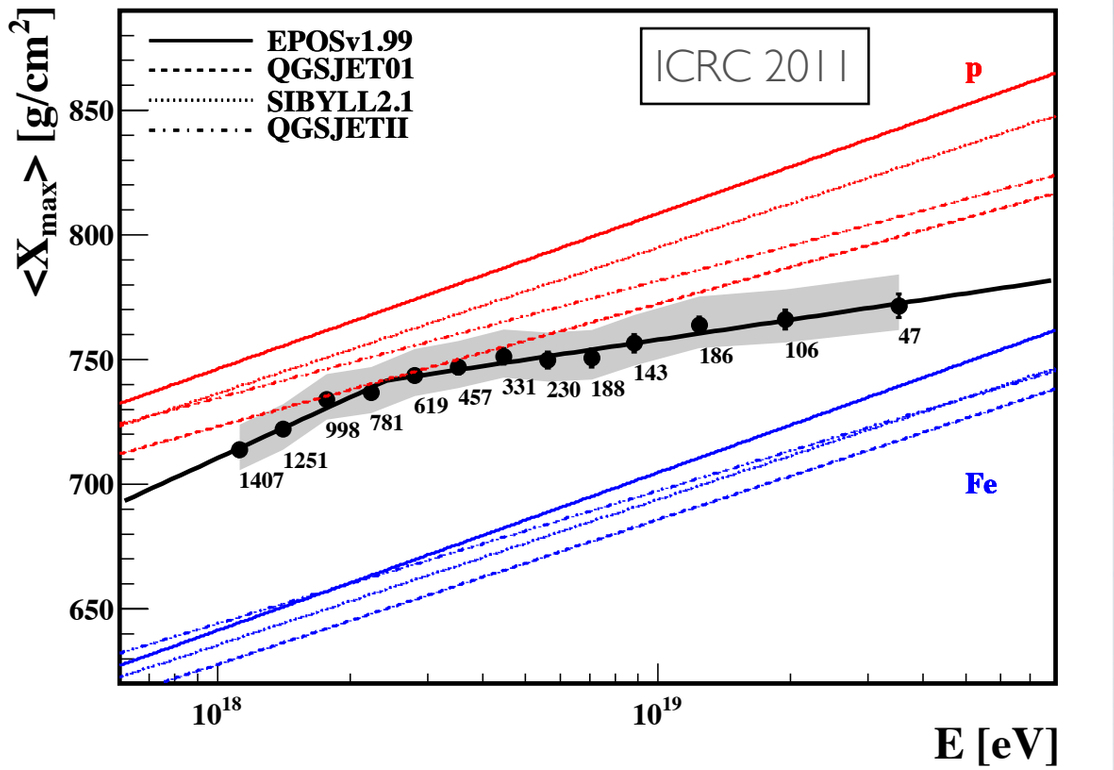


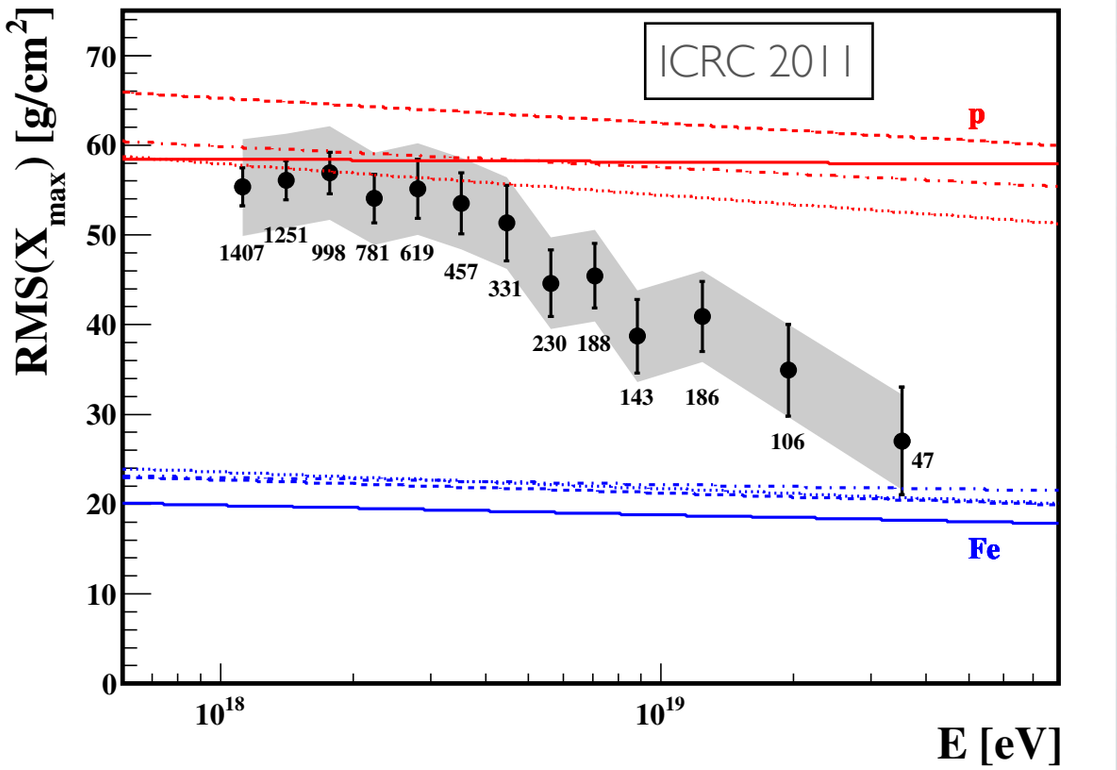
Most straightforward observable to infer composition

mean shower depth maximum : X_{max}

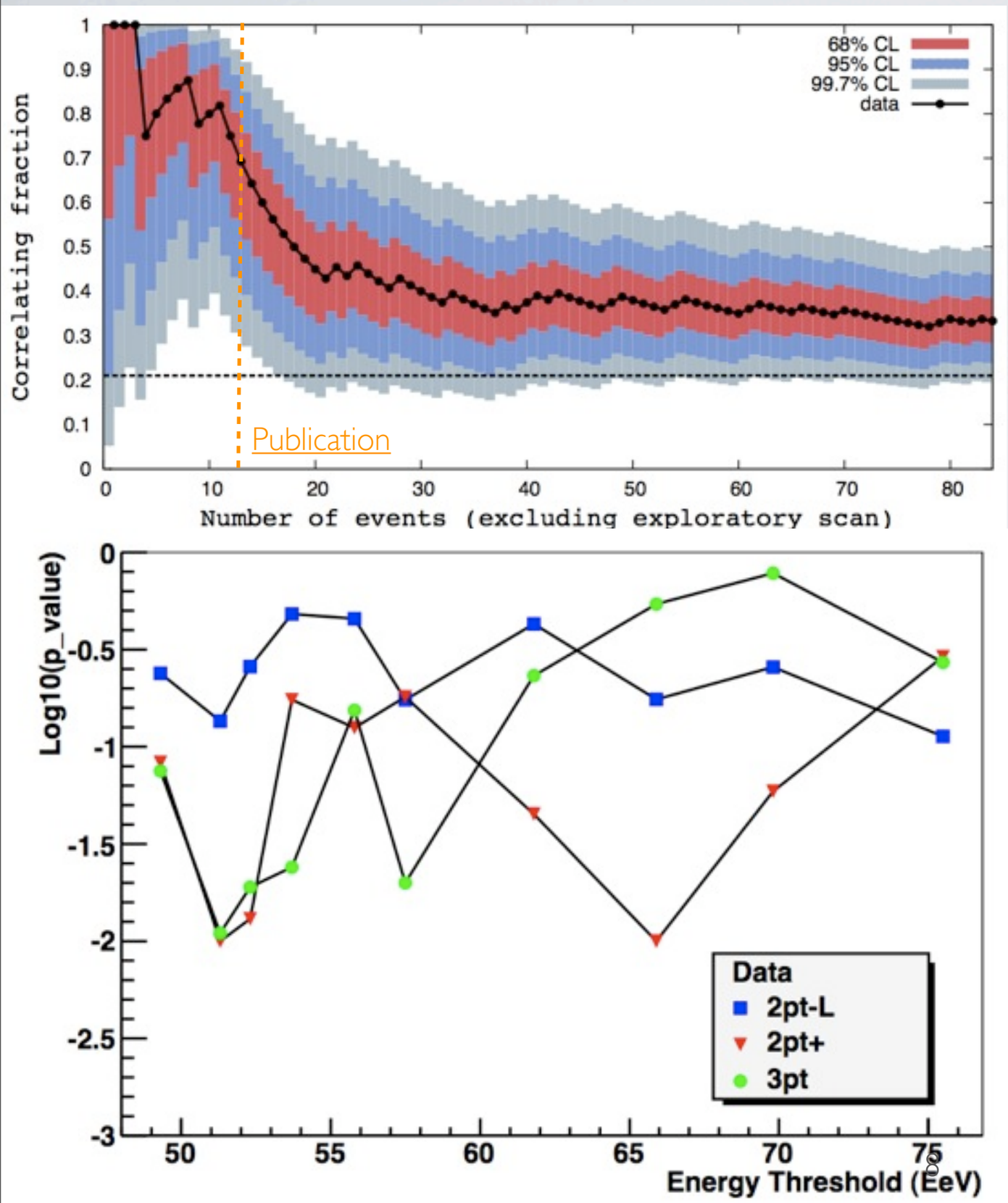
- Direct measurements with FD :
  - X_{max}
  - RMS(X_{max})
- Comparison with MC simulations
- Measurement of the p/air cross-section
- Other observables :
  - Muon production depth (SD) etc

Further details in R. Engel talk on Thursday





ANISOTROPIES : POINT SRC



Correlation with the VC-V catalog

- Publication of the correlation of the 27 highest energy events E > 55 EeV (2007)

the sky is anisotropic at 99% c.l.

- ICRC 2011 : 33% (21% from isotropy)

Without comparison with catalog

- development of methods able to detect the intrinsic anisotropy of a data set
- required to be efficient at low statistics

Min(P_{value}) is @ 52 EeV

ANISOTROPIES : POINT SRC

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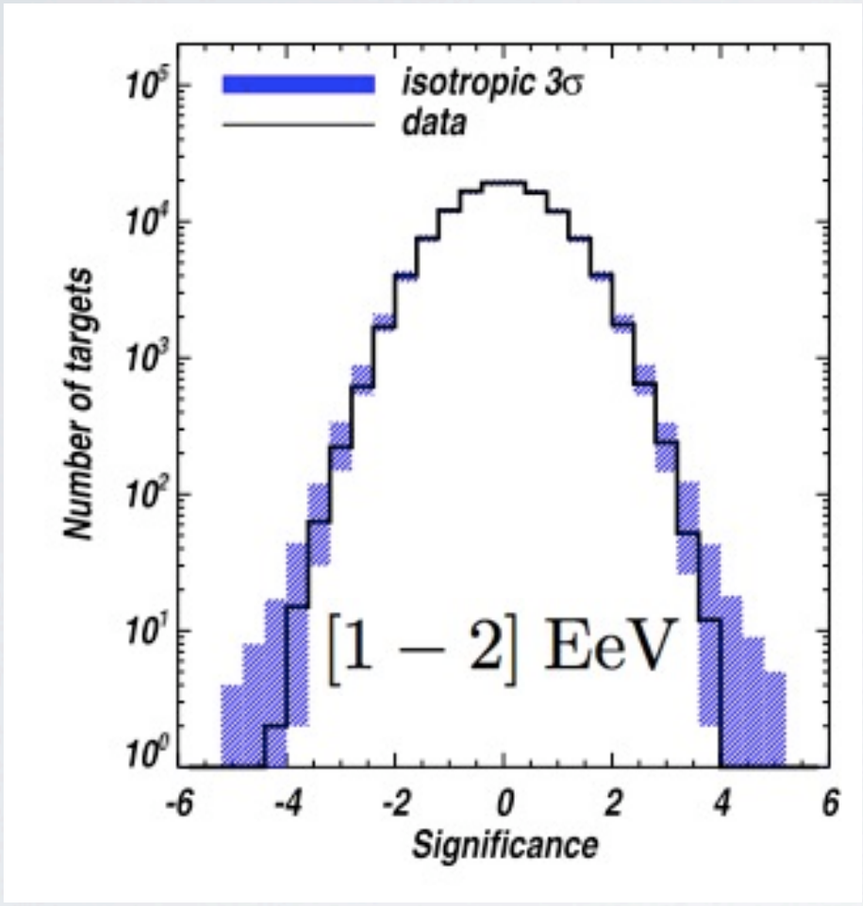
Point sources at low energies

blind search : Li-Ma significance



neutron sources

- (while p iso. by ***B***) , @ 1 EeV : neutron travel 9.2 kpc
- Blind search on the whole sky
- Target search in the direction of bright Galactic γ-ray src form HESS & Fermi (pulsars, PWN, SNR)

no detection → upper limits

- For the Auger sky :

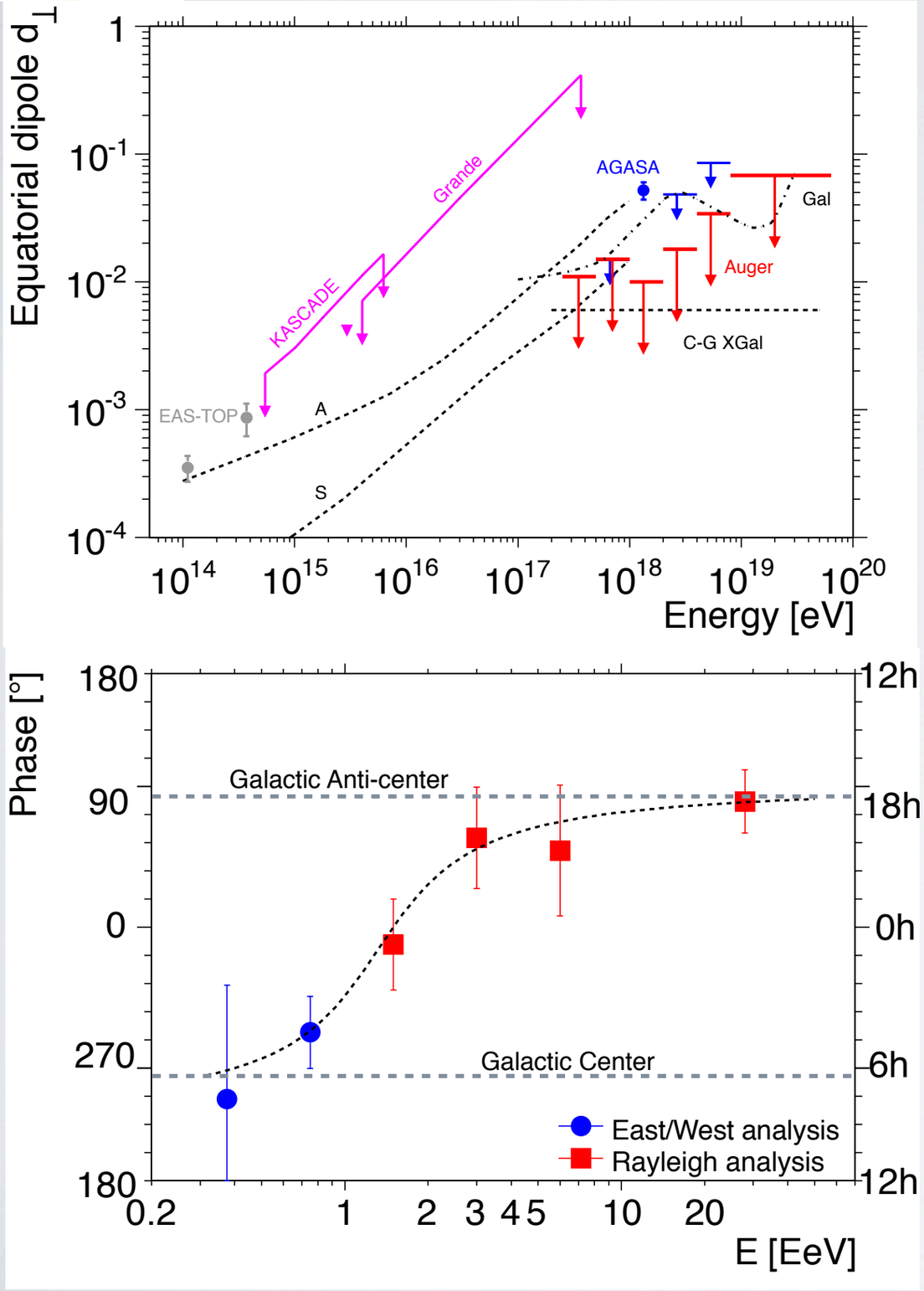
$$\Phi_{sky}(E \geq 1\mathrm{EeV}) \leq 0.065\ \mathrm{km}^{-2}\mathrm{yr}^{-1}$$

- For the Galactic center :

$$\Phi_{GC}(E \geq 1\mathrm{EeV}) \leq 0.01\ \mathrm{km}^{-2}\mathrm{yr}^{-1}$$

ANISOTROPIES : LARGE SCALES

PIERRE AUGER OBSERVATORY



Predictions depends on origin + propagation

- A/S: drift motion due to B_{reg}
- Gal: diffuse motion due to B_{turb}
- Compton-Getting (X-Gal):

Rayleigh analysis

Control the spurious modulations of the event rate (atmospheric effects, exposure variations)

→ no strong anisotropies

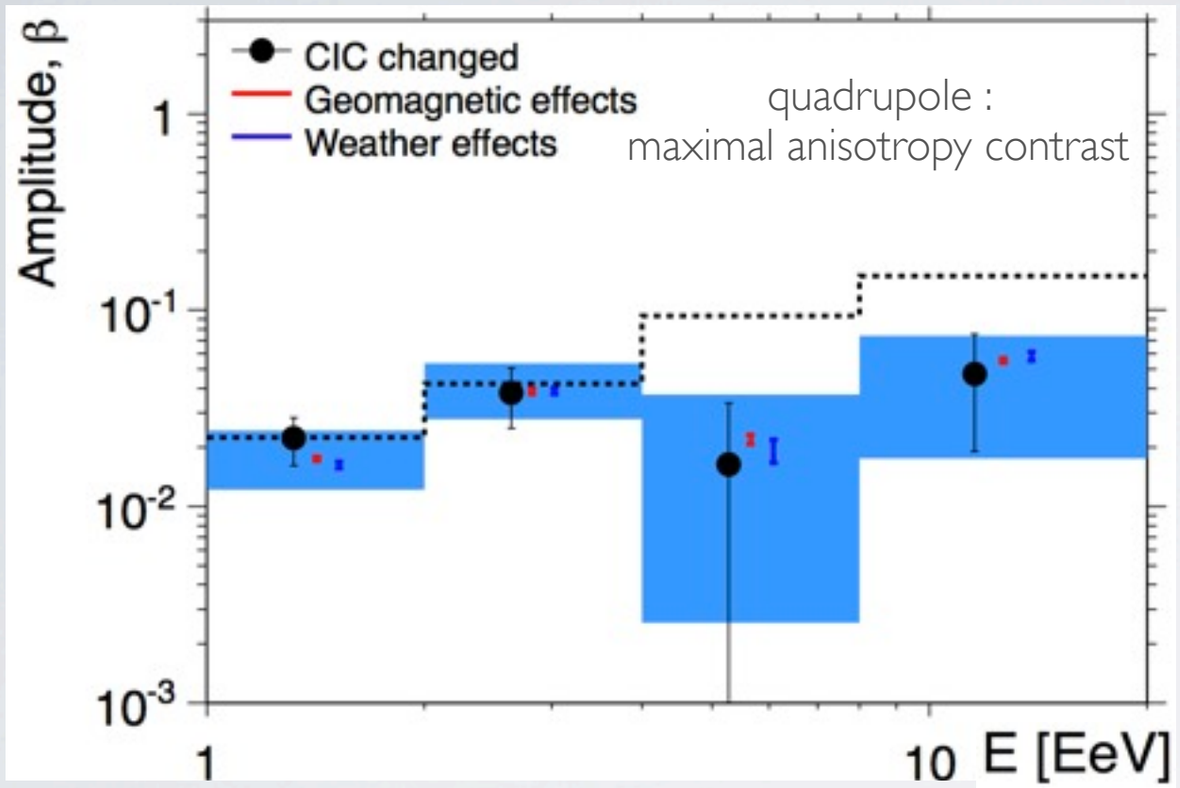
indication of a smooth transition ~ 2 EeV

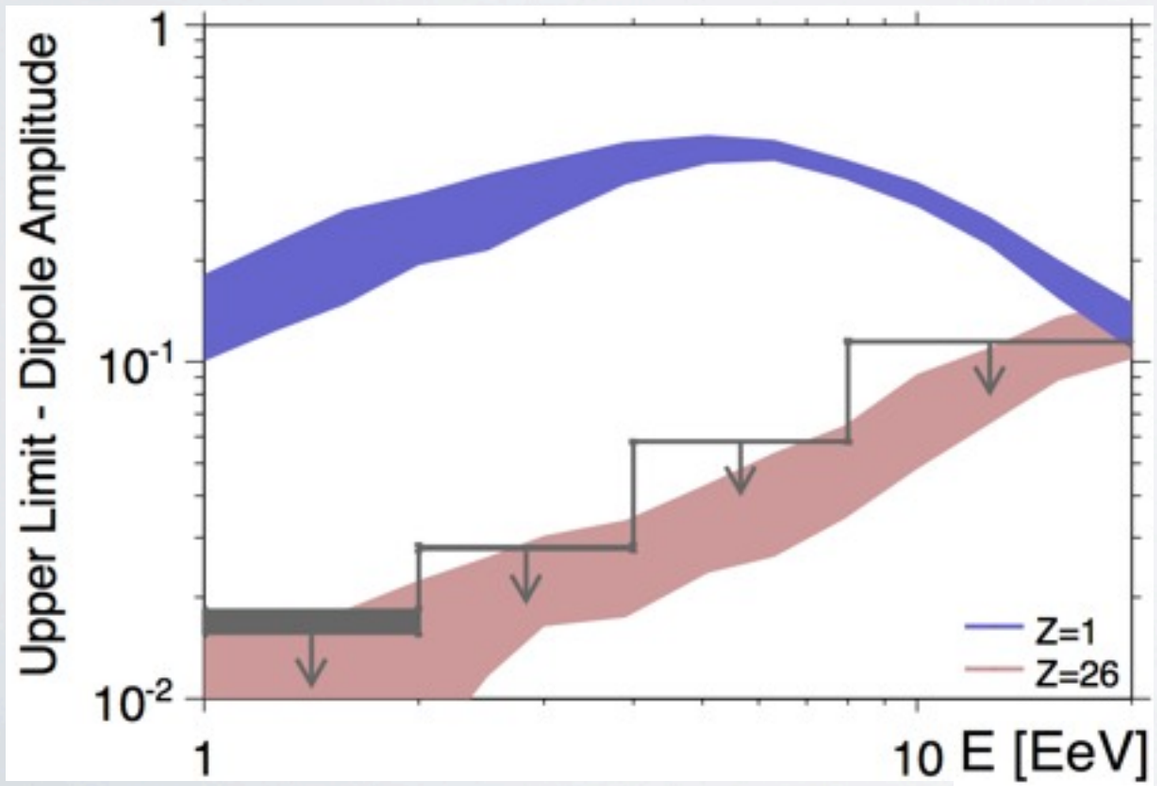
If genuine, phase measurement in independent energy bins is more sensitive than the amplitude

log-likelihood test : $P_{ch} \sim 10^{-3}$

→ Prescription

ANISOTROPIES : LARGE SCALES





3D analysis

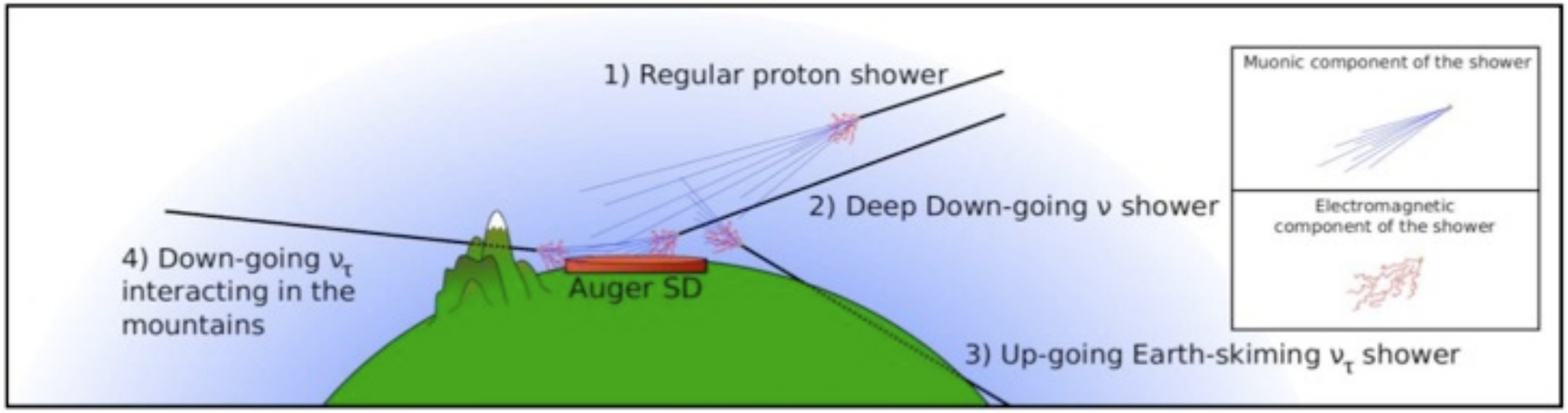
- No full sky coverage
  - → convolution kernel (CMB-like)
- Dipole compatible with Rayleigh analysis
- Quadrupole analysis
  - → compatible with isotropy at 99% CL

upper limits

- Test with a galactic scenario
  - Uniformly distributed sources
  - Isotropic and continuous emission

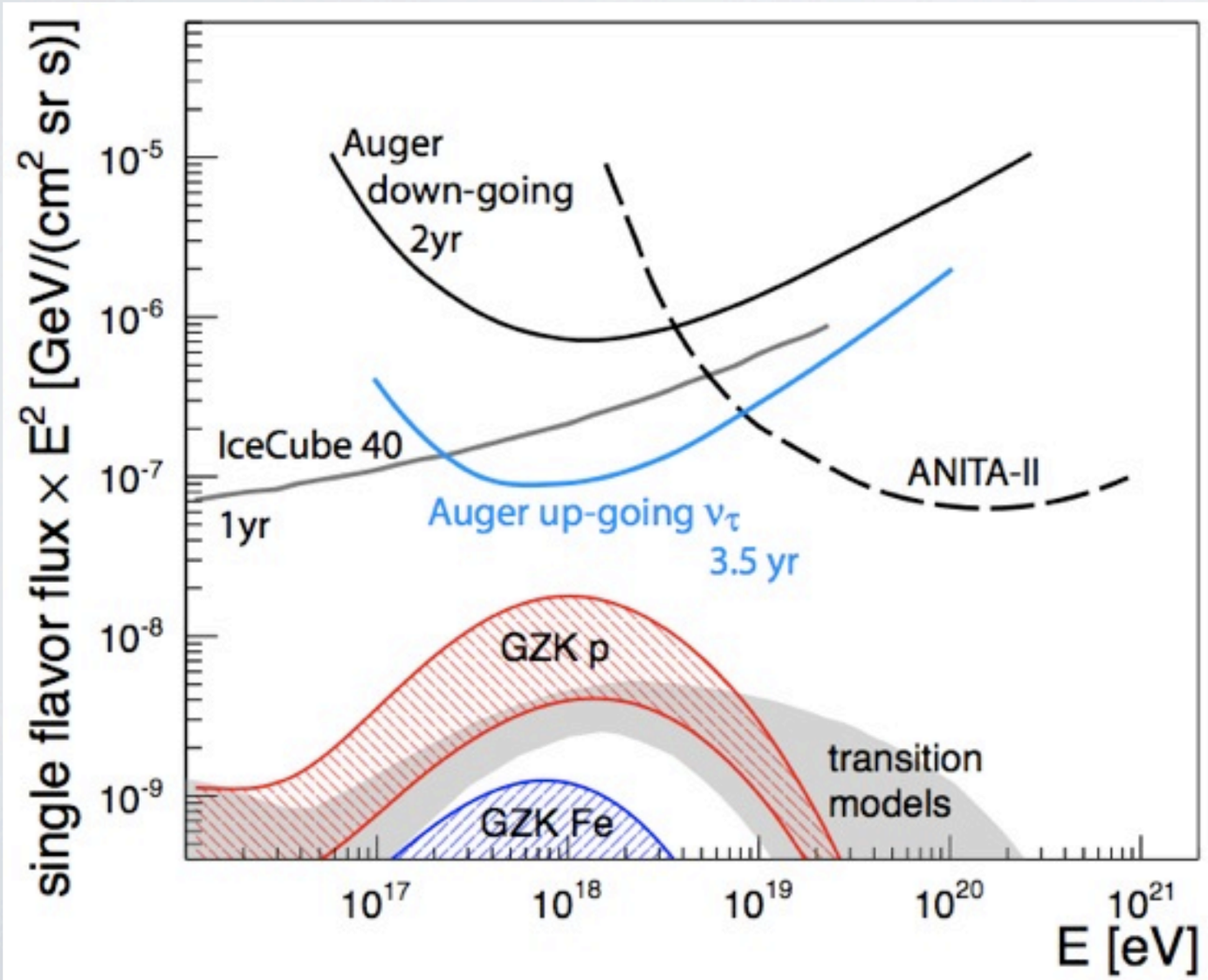
exclusion of the proton scenario

NEUTRINO FLUX



3 sketches of neutrino detection are possible in Auger

Inclined showers



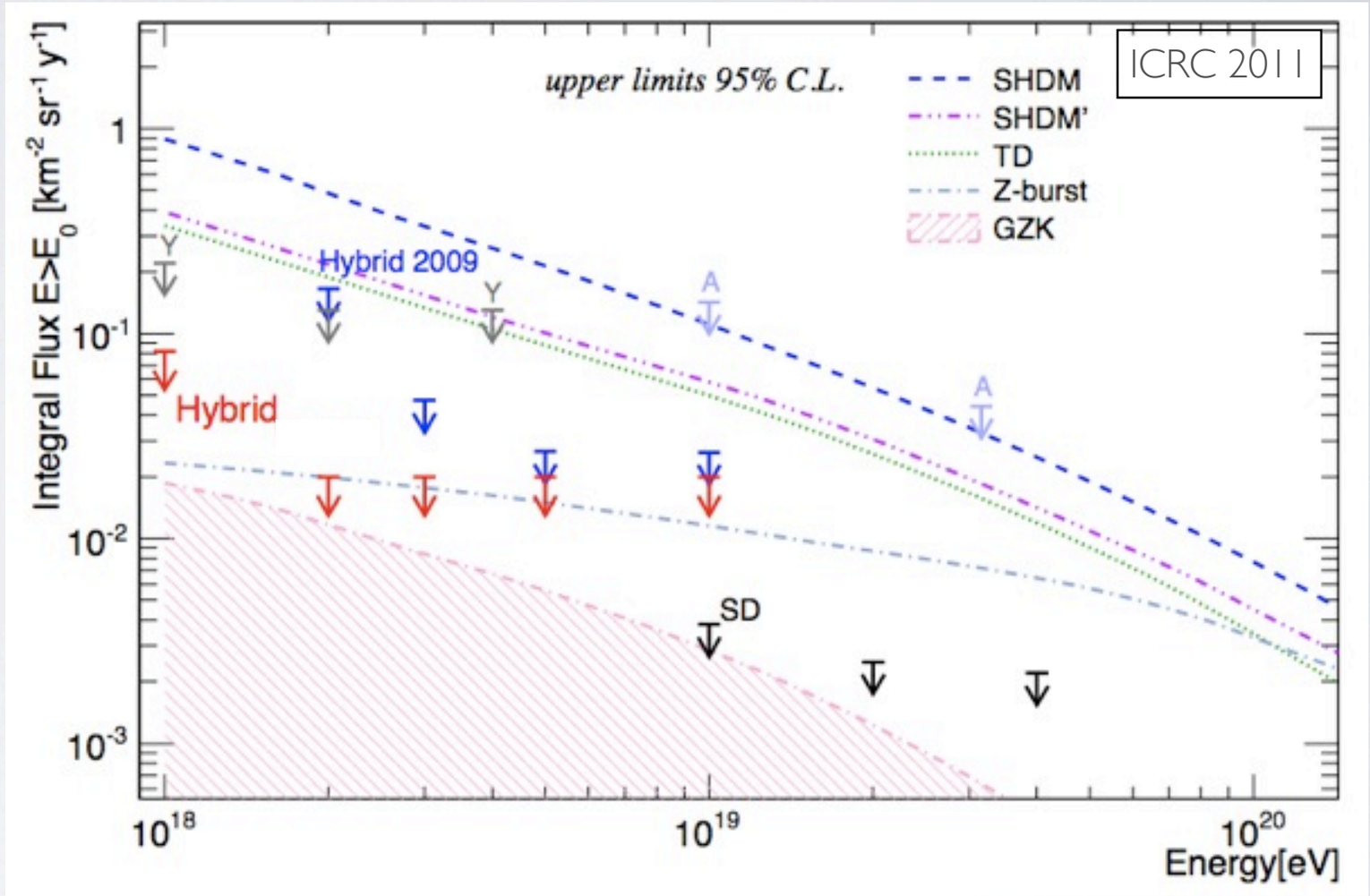
- 2 kinds of events can be detected
  - «down-going» : all flavours
  - «up-going» : ν_τ
- No detection → upper limits
- Comparison with models
- Production by the interaction of CRs (GZK processes)
- Transition models

PHOTON FLUX

Possible candidates for the UHECRs

- Top down models
  - Explanation to trans-GZK CRs
  - Decay of SHDM, Monopoles, Z-burst...
  - Photon fraction ≥ 10%

- Bottom up models
  - Production by the interaction of CRs (GZK processes)
  - Photon fraction ~ 0.1 - 1%



Predictions strongly model-dependent

- Search in the hybrid data set for
  - Large X_{max}
  - Muon-poor EAS

- No detection → upper limits

UPDATES SOON @ ICRC 2013 - RJ

THANK YOU FOR YOUR ATTENTION