Carpet-2 limits on the isotropic diffuse gamma-ray flux between 100 TeV and 1 PeV

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Carpet-2 EAS array

Muon Detector:
175 plastic scintillation counters, 175 m²
$E_\mu \geq 1$ GeV

6 remote stations: 18 liquid scintillation counters (9 m²) each

“Carpet”: 400 liquid scintillation counters (200 m²)
The Carpet array (400 counters, 200 m²)
1st stage of the Muon Detector, 175 m², 175 plastic scintillation counters
Data set (1999 – 2011): EAS trigger + MD trigger

MD: 175 plastic scintillation counters → 5 units (35 counters each)

MD trigger: $\geq 2$ or more MD units ($\geq 2$ muons)

→ this trigger is much more effective for showers from primary protons/nuclei, than for showers from primary gammas
Trigger efficiency as a function of primary energy for air showers induced by photons and protons primaries.
Experimental data, 1999 – 2011, $T_{\text{live}} = 3390$ days (9.28 y)

EAS selection conditions:

1) shower axes well within the Carpet ($\approx 160 \text{ m}^2$)
2) zenith angles $\theta \leq 40^\circ$
3) $N_{\text{ch}}$ in the Carpet $\geq 10^4$
4) the number of fired counters in the Carpet $\geq 300$.

\[
N_{\text{ch}} \geq 10^5
\]
\[
\Delta r \leq 0.35 \text{ m}
\]
\[
\sigma(N_{\text{ch}})/N_{\text{ch}} \leq 0.1
\]

angular resolution $\sim 1^\circ$

$\sim 10^5$ such showers for 3390 days of array operation

Energy release measurements in MD are used for the estimations of the number of muons $n_\mu$
\( n_\mu - N_{ch} \) distribution: experiment and simulation gammas (CORSIKA + array response)

\( n_\mu \) – the number of muons in MD, \( N_{ch} \) – shower size

The line indicates the selection criteria for the showers from primary gamma-rays (there are no events below separating line).
Upper limits on the flux of diffuse gamma rays

\[ I_\gamma = \frac{N_{90}}{S \cdot \Omega \cdot T \cdot \varepsilon_1 \cdot \varepsilon_2} \]

there are no events below separating line
\[ \rightarrow N_{90} = 2.3 \]

\[ S \cdot \Omega \cdot T = 6.2 \cdot 10^{14} \text{ cm}^2 \text{ sr s} \]

\( \varepsilon_1 \) - trigger and reconstruction efficiency
\( \varepsilon_2 \) - selection efficiency for \( \gamma \)-showers
\[ \varepsilon_2 = \frac{N_{\text{tot}}(\geq E)}{N_{\text{select}}(\geq E)} \]
Upper limits on the flux of diffuse gamma rays
Prospects: “Carpet-3” EAS array

- Carpet-3 EAS array
- ~24 additional shower detectors (9 m² each)
- Muon detector: 410 m² (410 plastic scintillation counters): planned to operate since 2019
- 5 such shower detectors (with 9 plastic scintillation counters) are already installed above MD
Carpet-3 sensitivity to the flux of diffuse cosmic gamma rays

O. Kalashev, S. Troitsky, 2014
Conclusions

1) The Carpet-3 air shower array is under construction at the Baksan Neutrino Observatory by step-by-step upgrade and extension. The aim is to study diffuse gamma-ray background at energy above 100 TeV.

2) Two underground tunnels are filled with scintillation counters of total continuous area of 410 m². The detectors are totally equipped with electronics. Full-scale operation of 410 m² MD was planned to be started at the end of 2018.

3) 5 additional shower detectors are already installed above the MD. Every such detector contains 9 scintillation counters of 1 m² area each.

4) 19 additional shower detectors (9 m² each) should be installed during 2019 -2020.

5) After final accomplishment of this array it can be competitive in its class and will have a chance to get the world-best limit on the flux of gamma rays of cosmic origin. This will allow one to solve the problem of origin of high-energy astrophysical neutrinos detected by IceCube.