Diffuse Galactic γ-ray and ν fluxes at very high energy and the Galactic/extragalactic Cosmic Ray transition

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The study of the diffuse gamma ray and neutrino fluxes is an important tool to investigate the cosmic ray properties in all the Galaxy since their spectra and angular distributions encode the energy and space distribution of the parent CRs.

We will discuss here how measurements at energy > 100 TeV in different regions of the sky could provide important information on two major questions concerning cosmic ray origin and propagation:

1) Have cosmic rays the same spectral shape in all the Galaxy ?

2) At which energy the extragalactic component becomes dominant?

The first question is addressed by c**omparing the recent Tibet-ASγ data on diffuse gamma rays above 100 TeV with the expectation of our model**, under different assumption on the spectral and spatial distribution of CRs in the Galaxy, in particular we discuss the hypothesis of a **hardening of the CR spectra approaching the Galactic center,** proposed by some authors**.** This hardening would produce an enhancement of the VHE gamma ray flux in the direction of the galactic center region, and a depletion of the flux in the opposite direction.

The result of our study is that the Tibet data are closer to predictions that include a CR hardening, however it is difficult to draw firm conclusions, because of: (1) the large uncertainties of the CR composition at the knee, in particular the proton fraction; (2) the limited angular region studied; (3) the large error bars of the Tibet data. More precise measurements in a broader range of Galactic longitudes are necessary to solve the question.

The second topics concerns the identification of the **transition energy at which the contribution of extragalactic cosmic rays becomes dominant** from a study of the energy dependence of the angular distributions of gamma rays and neutrinos.
Several models predict that the transition occurs at the “ankle”, while others affirm that the transition occurs at lower energy, at the “second knee” at $\sim 10^{17}$ eV.

Extragalactic CRs are likely to have a constant space density, and this will be reflected in the angular distribution of the diffuse emissions of gamma rays and neutrinos. **The Galactic and extragalactic CR components could then be identified with a sufficiently precise measurement of the longitudinal distribution of the diffuse flux.** This study requires the extension of gamma ray and neutrinos measurement at 10 PeV at least, to investigate the second knee energy region.

Observations of the diffuse fluxes can determine the CR space distributions only inside the volume of the Galaxy. A measurement of the CR density at a distance of 50-60 Kpc from the Galactic center could in principle be obtained measuring the gamma and neutrino fluxes at very high energy from the Small and Large Magellanic clouds. The observation that the density of CR of energy above 10^{17} eV inside the clouds is equal to the local one would constitute a robust demonstration of the extragalactic origin of the particles. This measurements would require detectors of higher sensitivity than those are available today, but could be a goal for future studies.