



Figure 2: Left panel: Energy dependence of the dipolar amplitude measured above 4 EeV. Right panel: Reconstructed dipole directions in different energy bins and corresponding 68% C.L. uncertainty, in Galactic coordinates. The dots indicate the positions of 2MRS galaxies within 100 Mpc.

from the sources up to Earth, being a difficult task because of our still uncertain knowledge about cosmic ray composition and Galactic and extragalactic magnetic fields. Nevertheless, by using a detailed large scale structure matter density field [21] derived from the *CosmicFlows-2* catalog of peculiar velocities [22], an estimation of the magnitude, direction and energy dependence of the dipolar anisotropy as a function of energy was obtained by performing a combined fit of the dipole components and cosmic ray composition [23].

Allowing for the presence of a quadrupole, the reconstructed dipolar and quadrupolar components of the flux for all energy bins were obtained as in [9] and reported in Table 2. The five independent quadrupolar components are not significant in any of the energy bins.

3.2 Angular Power Spectrum

The angular distribution $\Phi(\mathbf{n})$ of cosmic rays observed by an experiment in some direction \mathbf{n} can be decomposed by separating the dominant monopole contribution from the anisotropic one, $\Delta(\mathbf{n})$, as

$$\Phi(\mathbf{n}) = \frac{N}{4\pi f_1} W(\mathbf{n}) [1 + \Delta(\mathbf{n})], \quad (3)$$

where $W(\mathbf{n})$ is the relative coverage of the observatory, $f_1 = \int d\mathbf{n} W(\mathbf{n})/4\pi$ the fraction of the sky effectively covered by the observatory and N the total number of observed cosmic rays. Unfortunately, due to the partial sky coverage of the observatory, the estimation of the individual $a_{\ell m}$ coefficients of the spherical harmonic expansion of $\Delta(\mathbf{n})$, and its angular power spectrum $C_\ell = \sum_{m=-\ell}^{\ell} |a_{\ell m}|^2 / (2\ell + 1)$, cannot be carried out with relevant resolution as soon as $\ell_{max} > 2$. However, one can make additional assumptions² about the *ensemble-averaged* expectation values of the multipole components [24] and it is possible to recover the angular power spectrum coefficients. In this situation, the pseudo-power spectrum $\tilde{C}_\ell = \sum_{m=-\ell}^{\ell} |\tilde{a}_{\ell m}|^2 / (2\ell + 1)$ (which is directly measurable, obtained from $\tilde{a}_{\ell m} = \int d\mathbf{n} W(\mathbf{n}) \Delta(\mathbf{n}) Y_{\ell m}(\mathbf{n})$) is related to the real power spectrum through

$$\tilde{C}_\ell = \sum_{\ell'} M_{\ell\ell'} C_{\ell'}. \quad (4)$$

²For a more detailed discussion about these assumptions see [25].