On polarization effects of the radio emission from extensive air showers

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Motivation

Polarization characteristics of the radio signals are important in verifying the radio emission mechanisms. The geomagnetic effect seems to be the dominat contribution in the radio emission process [1], while depending on the geometry of the air shower and the position of the observer, the net charge excess of the shower may also contribute significantly [2].

LOPES-pol (40 - 80 MHz)

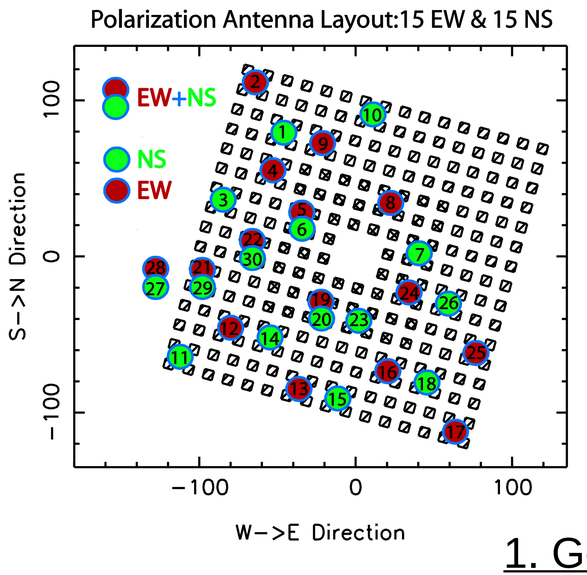
→ Almost 3 yrs operation of dipole antenna configuration

→ Trigger source provided by KASCADE-Grande at KIT

→ Proof-of-Principle → see LOPES talk by F.Schroeder

→ R&D for large scale applications (LOFAR, Auger Observatory)

→ see LOPES-3D poster by D.Huber



Data-sample:

→ 383/710 triggered events

→ $N_\mu > 10^6$, $N_{ch} > 10^{6.6}$

→ $E_p > 10^{17}$eV, $\theta < 55^o$

→ Radio reconstruction in each EW & NS channel (10 EW, 10 NS, 5 dipole)

→ Observable: independent CC-beams

Emission mechanisms

1. Geomagnetic emission

→ deflection of charged particles in the magn. field

→ Lorentz force - 1st order approximation, $|\vec{v}x\vec{B}|$

($\vec{v}$ – direction of shower axis, $\vec{B}$-field direction)

→ Linear polarization, dependence on azimuth & geomag. angle, compared to $|\vec{v}x\vec{B}|$ -amplitude ratio

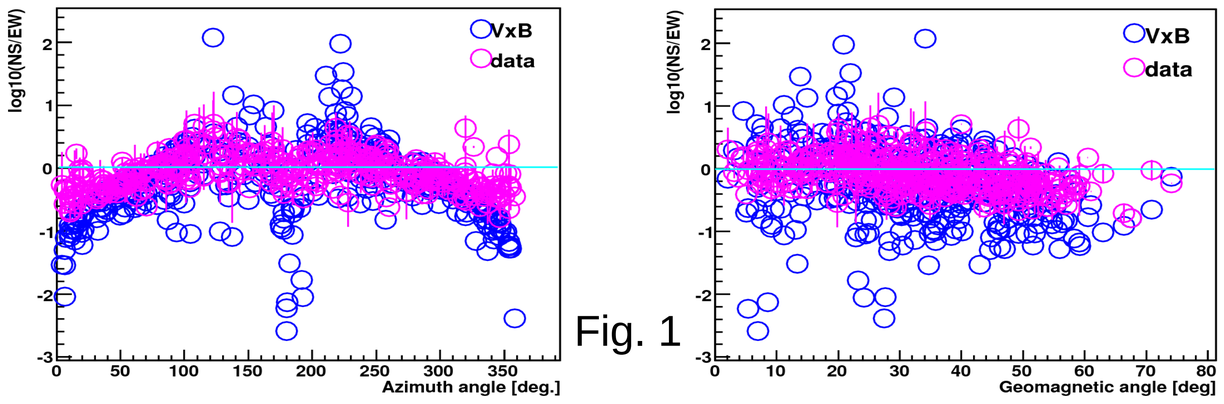


Fig. 1

2. Charge excess

→ variation of negative charge excess lead to emission

→ radial polarization, dependence on polarization angle

→ EW & NS channels rotated to $\Phi_m = \mathrm{atan}(P_{NS}/P_{EW})$

($x' = x\cos(\Phi_m) + y\sin(\Phi_m)$, $y' = -x\sin(\Phi_m) + y\cos(\Phi_m)$)

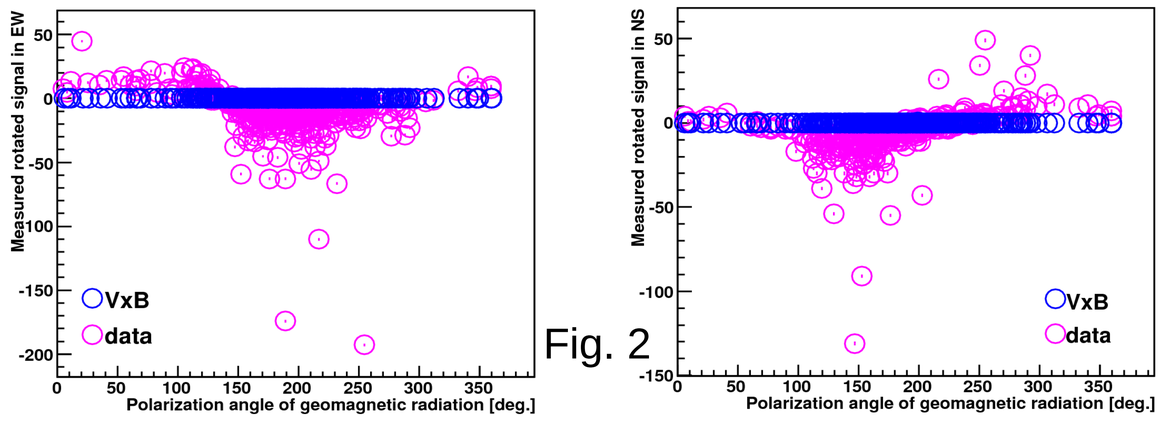


Fig. 2

Discussion

Generally similar features are observed when data are compared with the simplified geomagnetic model (Fig.1). However, in cases of specific geometry, deviations are visible (Fig.1 and Fig.2). Due to the specific LOPES-pol antenna configuration, a mean amplitude for the east-west and north-south polarization component, only is estimated, even valid not for the same observer position. In addition, to distinguish between the emission mechanisms, low signals with high accuracy for the individual polarization components have to be recorded, which is difficult with the simple inverse V-shape antennas and the high noise environment at KIT.

Summary & Outlook

→ Deviations from assumed pure geomagnetic contribution to the radio emission is seen when rotating polarization channels to the expected geomagnetic polarization angle.

→ Full detector simulations are required to verify the theoretical predictions for polarization observations. → see talk by T.Huege

→ Full polarization measurements are needed to validate the emission mechanisms.

References

[1] D. Ardouin et al., ApP 31 (2009)

[2] H. Schoorlemmer, NIMA 662 (2012)

[3] B. Revenu, 32nd ICRC (2011)

[4] D. Fraenkel, Auger GAP notes (2011)

[5] P.G. Isar et al., NIMA 604 (2009)

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