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Impact of Atmosphere fluctuations on Absorption Muon Tomography opacity estimates.

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Muography is an imaging technique based on the differential absorption of a flux of incident particles, muons, by the target being studied. Muons are elementary particles that have the property to pass through standard rocks in a straight line to the first order, up to several kilometers away, and whose relative absorption allows to generate images by contrast densitometry, like a standard clinical X-ray. This technique infers the density of an object by tracking the number of muons received by a detector, before and after traversing a structure. The amount of density met by a muon on its path minimizes its survival probability in a predictable manner, hence diminising the average flux received by a detector. The incident direction (defined by the zenital angle) of the detected muons is reconstructed by means of a detector composed of a 3 scintillators panels, allowing to produce 2-D (or 3-D) density images.

To evaluate the degree of absorption caused by the density of structures, there are two key components: (1) the input flux (open-sky flux) which is infered theoretically, and (2) the output flux, measured by a detector. However, due to the diversity of possible observation conditions (altitude, longitude, latitude, solar winds, weather conditions, geomagnetic field...) of the open-sky flux, it is challenging to estimate it properly. The goal of this study is to improve the current way in which this estimate is done and apply it to the imaging of an industrial structure.

Two approaches are generally possible to estimate the open-sky flux. The first is based on semi-empiric models (Tang, Shukla, Gaisser ,etc...). The parameters of these formulae are calibrated using data sets. Analytical or empirical correction factors could be used to extrapolate these values to the desired survey elevation (z) and take into account the atmospheric conditions influence on muon production. The second approach makes use of CORSIKA, a Monte Carlo driven Nuclei-Hadron interaction model used for cosmic shower simulation. It has been used to simulate the influence of atmospheric conditions on the production and buffering of muons, as well as the effect of the geomagnetic field and the detector elevation. Both of these approaches have to overcome issues with extreme zenital angles.

Inter-comparision of analytical models, CORSIKA fluxes, and laboratory measurements are used as a means to validate our CORSIKA numerical experiment. Then, we analyzed the geodesic effects on the muon flux in terms of energetic composition with varying magnetic field, altitude and density distribution of the atmosphere. As a result, we have used our theoretical CORSIKA fluxes on an industrial application. We have studied the impact of the input flux in the opacity (quantity of matter crossed along a trajectory) estimate. First numerical results suggest that opacity estimate is strongly influenced in the 70 to 90° zenith angle region especially for low opacity targets.