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Spatial correlation analysis of seismic noise for STAR X-ray infrastructure design

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The Italian PON MaTeRiA project is focused on the creation of a research infrastructure open to users based on an innovative and evolutionary X-ray source. This source, named STAR (Southern Europe TBS for Applied Research), exploits the Thomson backscattering process of a laser radiation by fast-electron beams (Thomson Back Scattering - TBS).
Its main performances are: X-ray photon flux 109-1010 ph/s, Angular divergence variable between 2 and 10 mrad, X-ray energy continuously variable between 8 keV and 150 keV, Bandwidth ΔE/E variable between 1 and 10%, ps time resolved structure.
In order to achieve this performances, bunches of electrons produced by a photo-injector are accelerated to relativistic velocities by a linear accelerator section. The electron beam, few hundreds of micrometer wide, is driven by magnetic fields to the interaction point along a 15 m transport line where it is focused in a 10 micrometer-wide area. In the same area, the laser beam is focused after being transported along a 12 m structure.
Ground vibrations could greatly affect the collision probability and thus the emittance by deviating the paths of the beams during their travel in the STAR source. Therefore, the study program to measure ground vibrations in the STAR site can be used for site characterization in relation to accelerator design.
The environmental and facility noise may affect the X-ray operation especially if the predominant wavelengths in the microtremor wavefield are much smaller than the size of the linear accelerator. For wavelength much greater, all the accelerator parts move in phase, and therefore also large displacements cannot generate any significant effect. On the other hand, for wavelengths equal or less than half the accelerator size several parts could move in phase opposition and therefore small displacements could affect its proper functioning. Thereafter, it is important to characterize the microtremor wavefield in both frequencies and wavelengths domains.
For this reason, we performed some measurements of seismic noise in order to characterize the environmental noise in the site in which the X-ray accelerator arise. For the characterization of the site, we carried out several passive seismic monitoring experiments at different times of the day and in different weather conditions. We recorded microtremor using an array of broadband 3C seismic sensors arranged along the linear accelerator. For each measurement point, we determined the displacement, velocity and acceleration spectrogram and power spectral density of both horizontal and vertical components. We determined also the microtremor horizontal to vertical spectral ratio as function of azimuth to individuate the main ground vibration direction and detect the existence of site or building resonance frequencies. We applied a rotation matrix to transform the North-South and East-West signal components in transversal and radial components, respect to the direction of the linear accelerator. Subsequently, for each couple of seismic stations we determined the coherence function to analyze the seismic noise spatial correlation. These analyses have allowed us to exhaustively characterize the seismic noise of the study area, from the point of view of the power and space-time variability, both in frequency and wavelength.