

Tunnel configurations and seismic isolation optimization in underground gravitational wave detectors

Gravitational wave detectors like the Einstein Telescope (ET) will be built a few hundred meters underground to reduce both seismic and Newtonian noise. Underground facilities must be designed to take full advantage of the shielding properties of the rock mass to maximize the detector's performance. A major issue with the ET design are the corner points, where caverns need to be excavated in stable and low permeability rock. This paper proposes a new topology that moves the top stages of the seismic attenuation chains and the recombination of the beams of the Michelson interferometers in separate excavations far from the beam-line and equipment induced noise while the test mass mirrors remain in the main tunnels. Distributing the seismic attenuation chain components over multiple tunnel levels allows the use of arbitrarily long seismic attenuation chains that relegate the seismic noise at frequencies completely outside the low-frequency noise budget, thus keeping the door open for future Newtonian noise suppression methods. Separating the input-output and recombination optics of different detectors into separate caverns drastically improves the observatory detection efficiency and allows staged commissioning. The proposed scheme eliminates structural and instrumentation crowding while the reduced sizes of excavations require fewer support measures.

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