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Comparing Topologies of the Einstein Telescope: Advancing Sky Localization and Detector Calibration in Third-Generation Gravitational Wave Detectors

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Third-generation gravitational wave detectors like the Einstein Telescope and Cosmic Explorer will have better sensitivity than current ones. The triangular setup is proposed to have three detectors forming an equilateral triangle. Although whether the Einstein Telescope should follow an L-shape or triangular topology has arisen from time to time. Choosing between them is crucial for finalizing its design. This study compares how these setups affect finding where in the sky the gravitational waves come from. The L-shape will have 90-degree angles. We consider the performance of the Einstein Telescope in the network of two Cosmic Explorer detectors. The results show that the ET with triangular topology has better sky localization accuracy compared to the ET as an L-shape detector. The triangular setup has an extra advantage: it can create a "null stream" regardless of where the waves come from. This feature makes it stand out and can help calibrate the detectors better. We have used the residual signal to nullify the stream, and the results show that if the ET can detect a large number (> 100) of loud events more frequently, or within a time span when the detector response function remains the same, it can be used to calibrate the detector with good precision (<0.5% error in calibration parameter).

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