Contribution ID: **86** Type: **Poster**

Stray light noise from dust particles falling inside Einstein Telescope beam pipes

High sensitivity optical measurements, such as those performed in interferometric Gravitational Waves detectors, are prone to stray light noise. Due to the high-quality optics used in the interferometers, light scattering may be dominated by the residual presence of particles. This can be an issue for the next generation detector Einstein Telescope as well as for the present LIGO and Virgo interferometers. It is therefore crucial to account for all possible light-dust interaction mechanisms and to estimate the noise they can generate.

In our work, we performed a detailed analysis of particulate contamination focusing, as a case study, on the beam pipes of Einstein Telescope. There are two main cases for light scattering by particulate contamination inside the beampipes: particles deposited on the baffles and particles moving in the beam pipe volume under vacuum. Here we report our latest results concerning this latter contribution. First, we determine how the field amplitude and phase fluctuations induced by falling particles crossing the arm cavity beam contribute to the detector's strain noise. Then we perform Monte Carlo simulations to assess the impact of different cleanliness scenarios. Finally we study how installation procedures and general operations on beam-pipes can contribute in terms of dust contamination.

This study allows us to establish upper limits on the number and size of dust particles that can be tolerated detaching from the pipe surface, therefore setting constraints on the cleanliness of environments and installation procedures. Our results refer specifically to Einstein Telescope, but they can be extended easily to other ground-based interferometers.

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Presenter: MOSCATELLO, Andrea

Session Classification: Poster Session

Track Classification: Instrument Science (ISB): Optics