Squeezed light sources at different wavelengths for the Einstein Telescope

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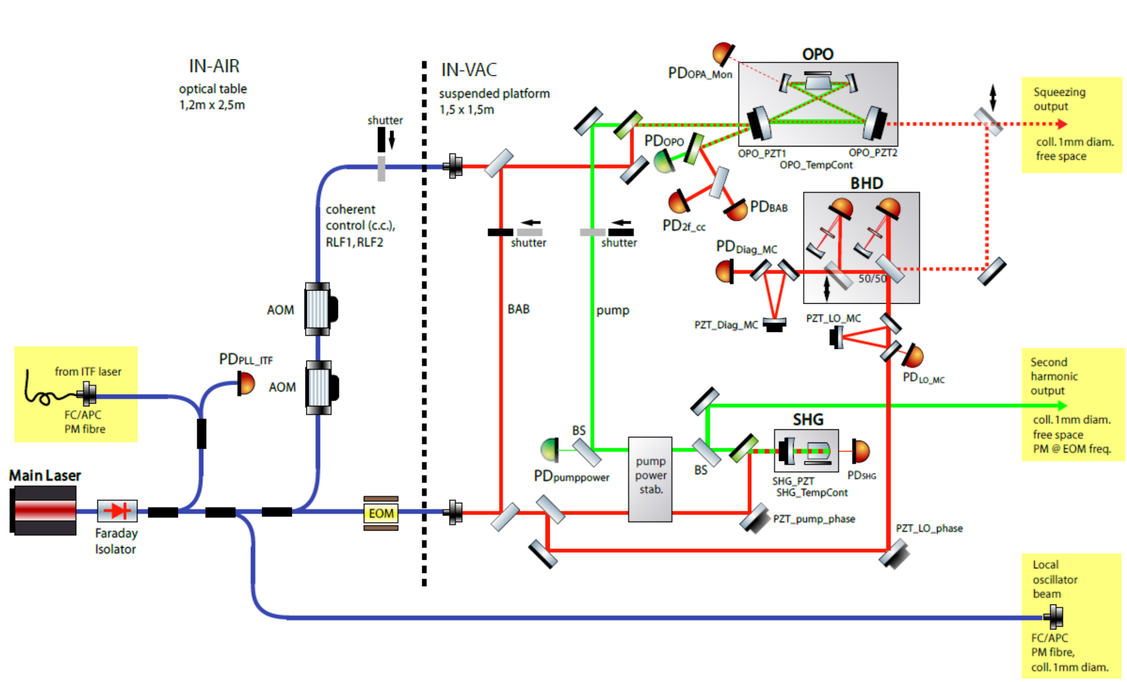
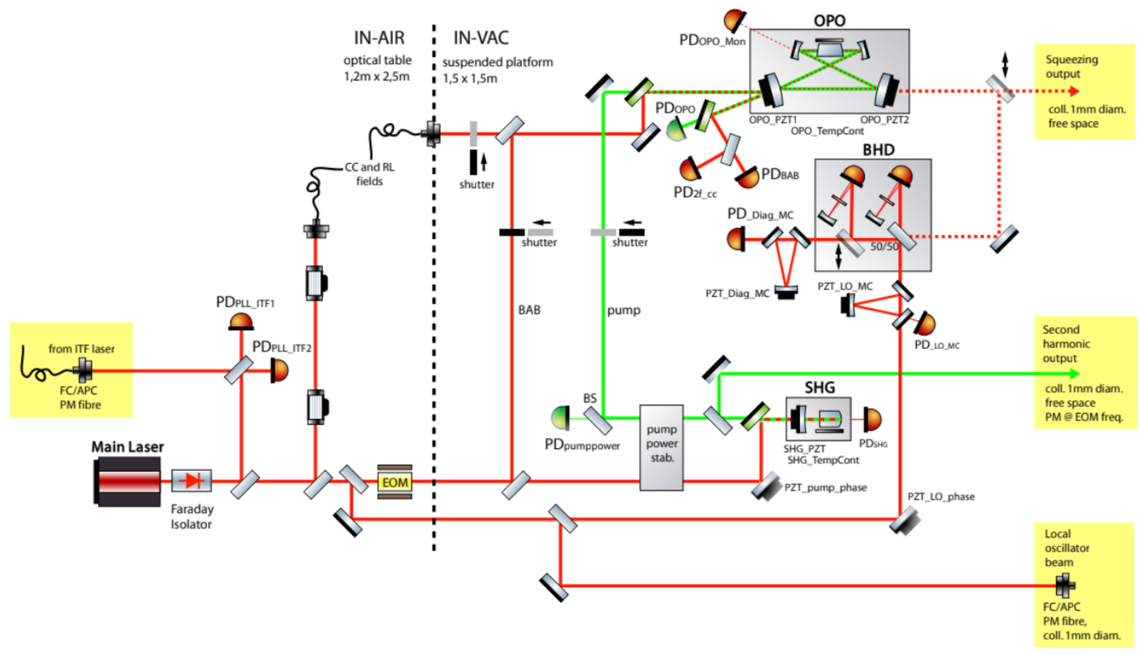
Abstract:

One of the limiting factors for gravitational wave detection sensitivity to date is the coating thermal noise in the lower audio-band. The use of cryogenically cooled crystalline silicon in combination with high-quality silicon-based coatings for the test mass mirrors will allow tackling the thermal noise problem. Therefore, despite the fact that the Einstein Telescope's low-frequency (ET-LF) wavelength is specified as 1550 nm and the high-frequency (ET-HF) one as 1064 nm at room temperature, the Gravitational Wave International Committee recommended the research and development of squeezing sources at a 2 μm wavelength as an alternative wavelength. Here, we present possible approaches for the development of the squeezed light sources for ET at various wavelengths.

ET-LF and ET-HF design concepts:



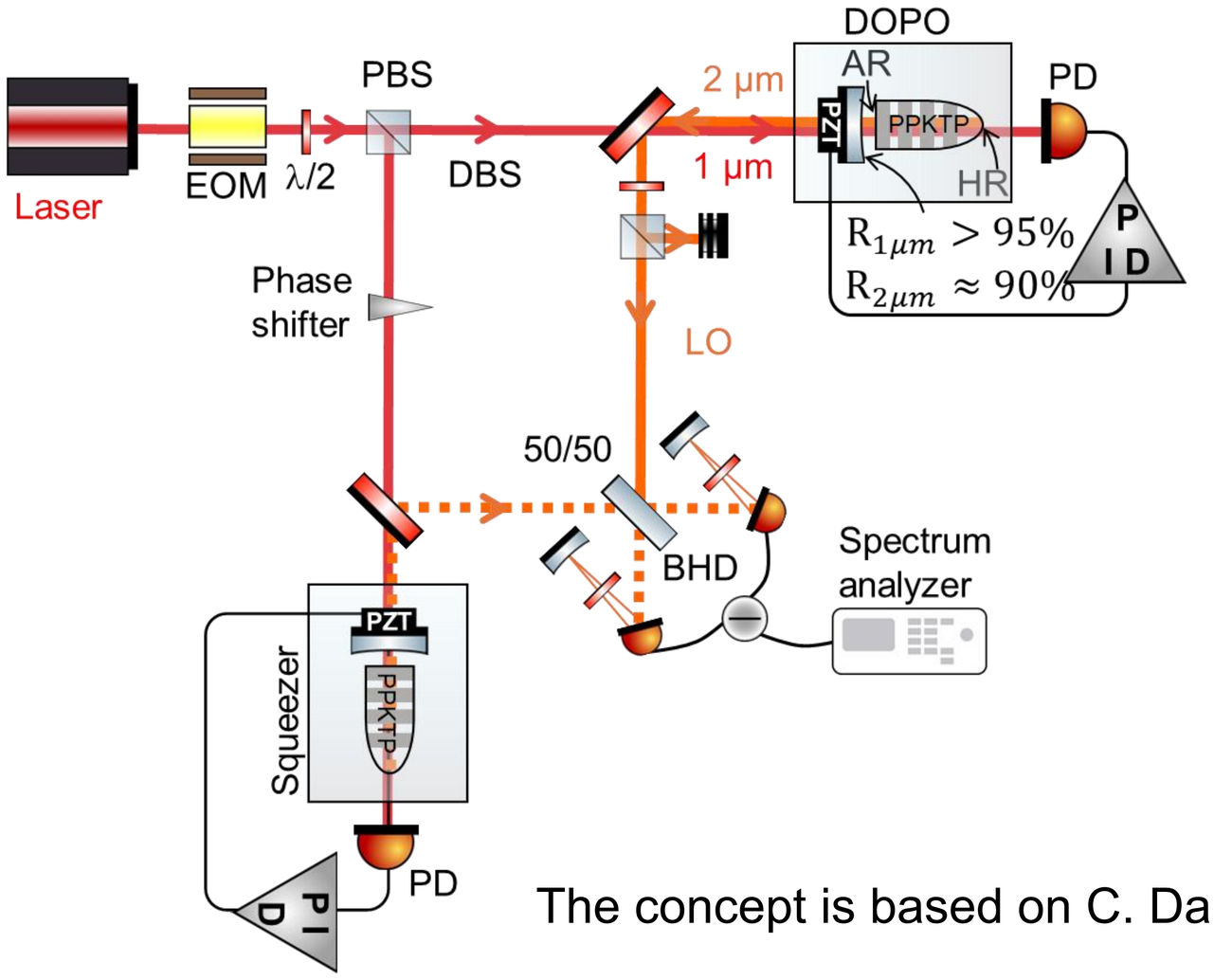
ET-LF scheme
Main laser - 1550 nm fiber-amplified external cavity diode laser;
Nonlinear crystal - Periodically poled KTP (PPKTP).



ET-HF scheme
Main laser - 1064 nm NPRO laser;
Nonlinear crystal - Periodically poled KTP (PPKTP).

Detector Conceptual Design Report (Pre-TDR_Nov_2025) based on F. Meylahn et al. Phys. Rev. Lett. 129, 2022.

Schematics of the proposed squeezer at 2090 nm wavelength:



Candidates for the laser: Ti:Sapphire tuneable laser with noise stabilization at 1045 nm;

Nonlinear crystal: Periodically poled KTP (PPKTP);

Photodetectors for 2090 nm: InGaAs high-sensitivity PIN photodiode with extended range detection.

The concept is based on C. Darsow-Fromm et al. Opt. Lett. 46, 5850-5853, 2021.