High resolution vertical inertial sensor

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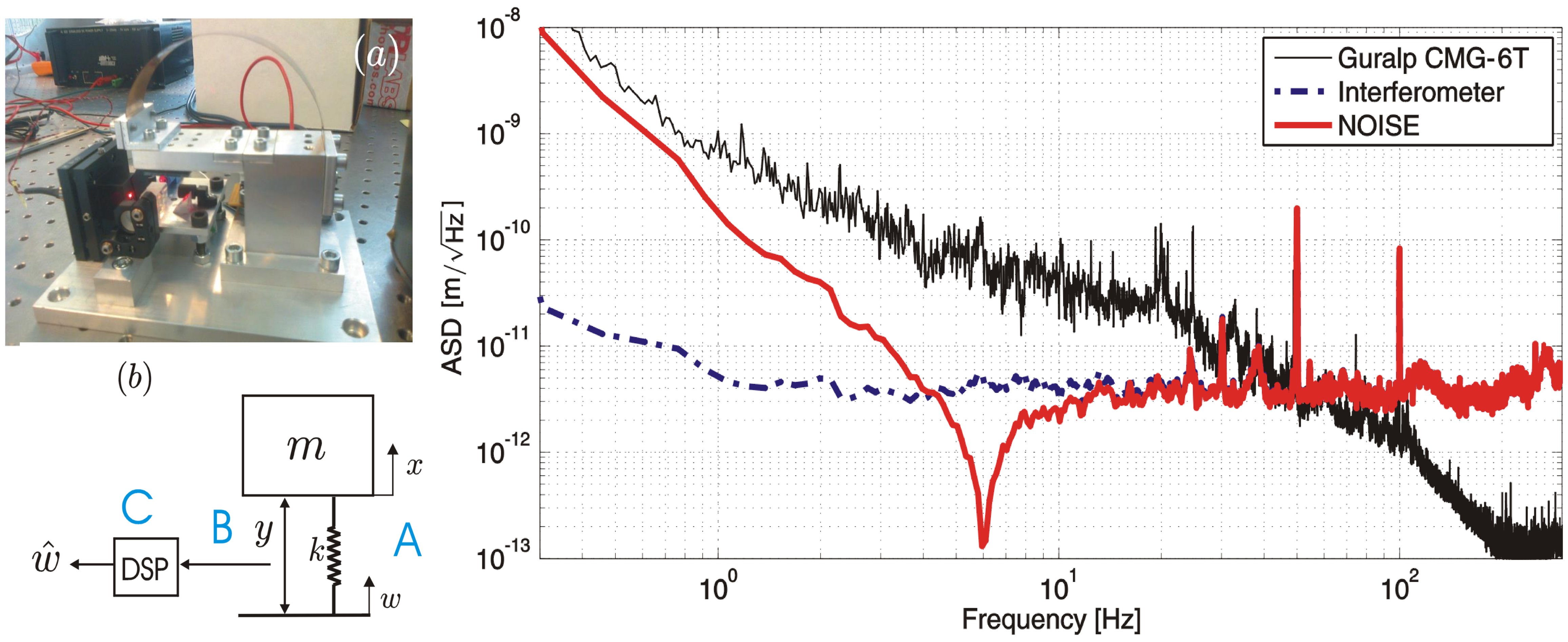
Abstract

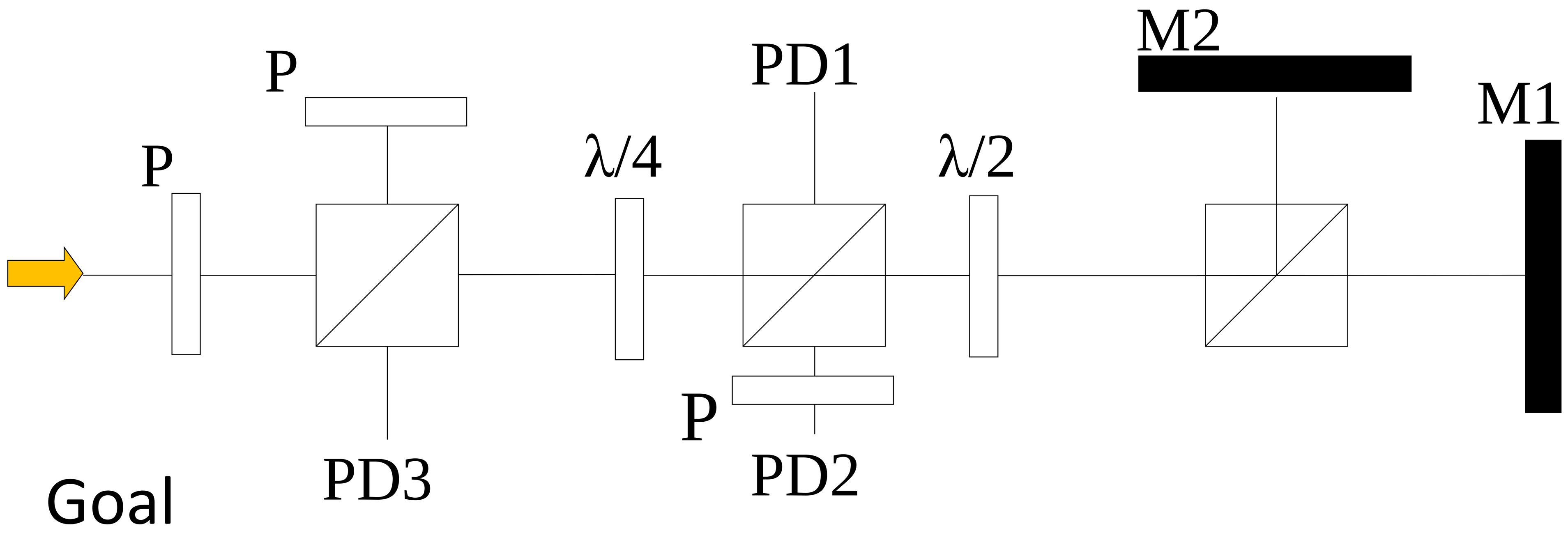
100 years ago, gravitational wave was predicted by Albert Einstein in his theory of general relativity. Today, gravitational wave have been detected by the LIGO (Laser Interferometer Gravitational-Wave Observatory). The LIGO is aimed to detect and study astrophysical GWs, with the promise of creating a brand new branch in physics and astrophysics[1]. The breakthrough discovery successes after a century because it is not an easy task. The Advanced LIGO detector needs to minimize the coupling of the laser noise and the GW signal. In fact, the test mass displacement due to a GW is $dx \leq 10^{-19}$ m/ Hz-1/2 at 10 Hz and $dx \leq 10^{-20}$ m/ Hz-1/2 at 100 Hz[2]. Consequently, the measurement is easily disturbed by ambient noise, especially ground noise. In order to detect a GW, the LIGO has to be isolated properly. This task is accomplished thanks to a high resolution vertical inertial sensor. Here we propose a new model of inertial sensor that can potentially be integrated in the new version of the LIGO.

Non-magnetic Optical Inertial Sensor (NOSE)



Picture (a) and schematic (b) of the prototype of the interferometric inertial sensor NOISE. (A) single degree of freedom oscillator, (B) interferometric sensor and (C) acquisition processing unit. (c) resolution of NOSE compared to that of a Guralp,

New model of interferometric inertial sensor[3]



Goal

- Reduce the different sources of noise (mechanical electronics, laser,…)
- Sub-Hz resolution
- Integration of the sensor in a STS-1

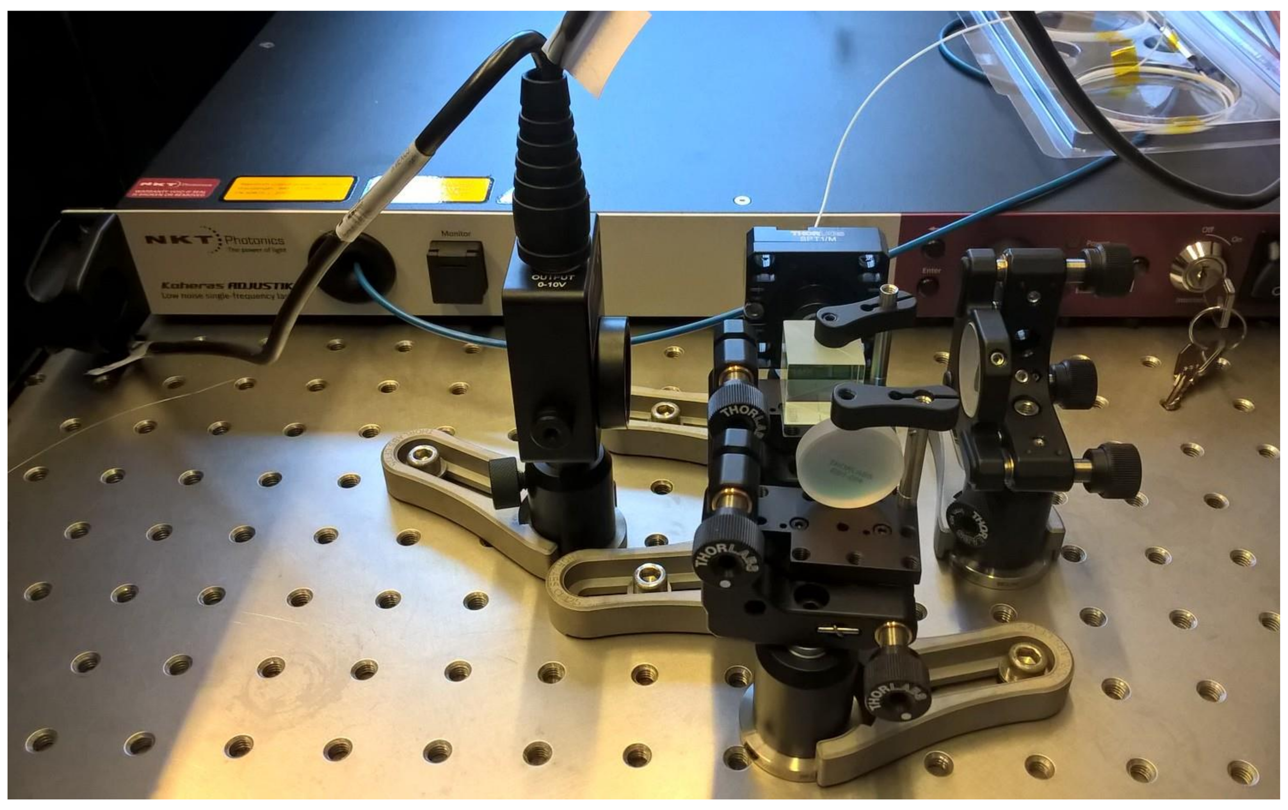
Noise budgeting

In order to identify the various sources of noise, which are the factors limiting the sensor resolution, we are going to block the inertial mass and record the following signals:

• Cable unplugged from the recorder. This will provide the ADC noise.
•The photodiode is connected, but the laser switched off. The photodiode will be determined.
•The laser source is turn on.

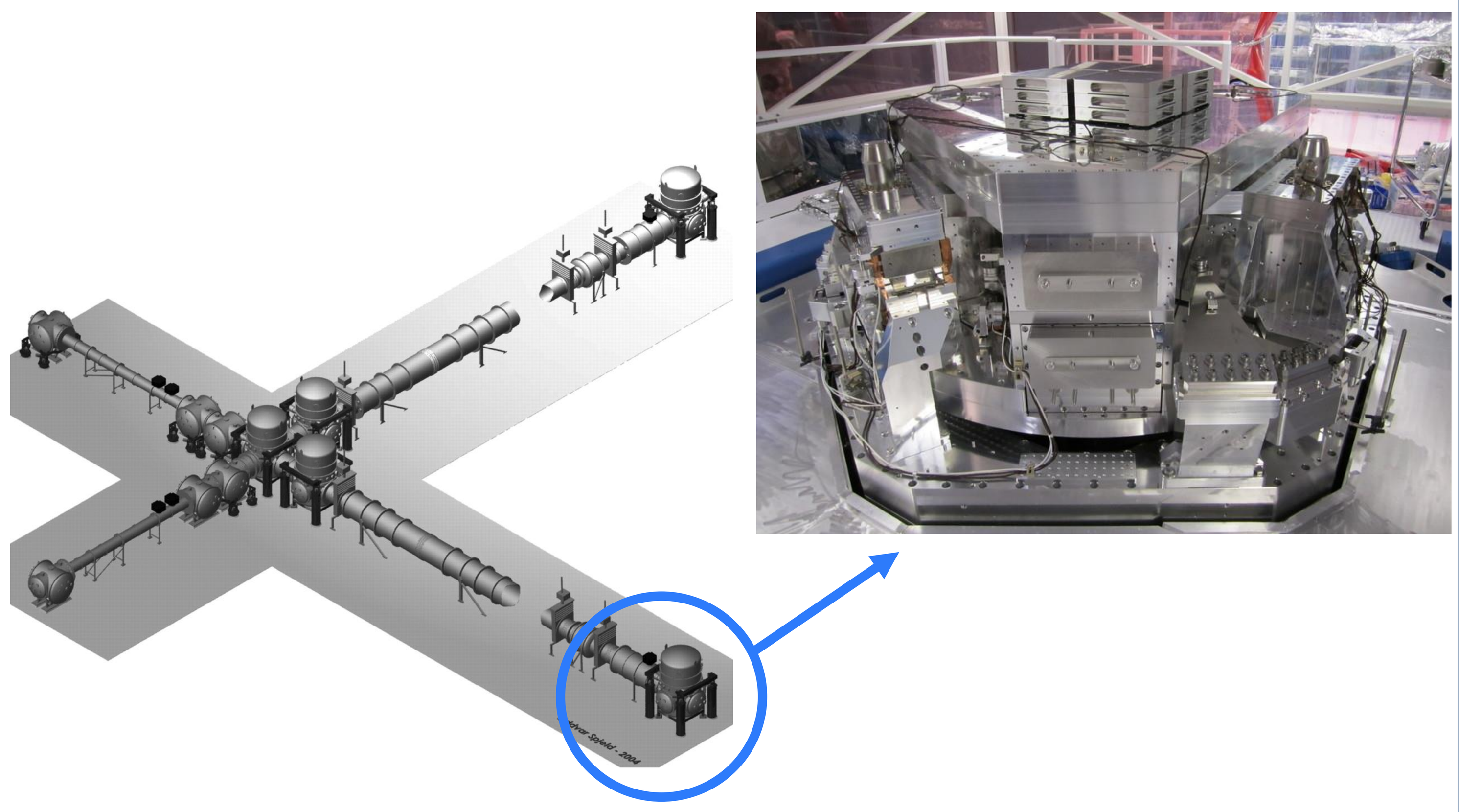
The measurements are then compared to the theoretical predictions to validate the model iimplemented.

Improvement of the electronical and optical components

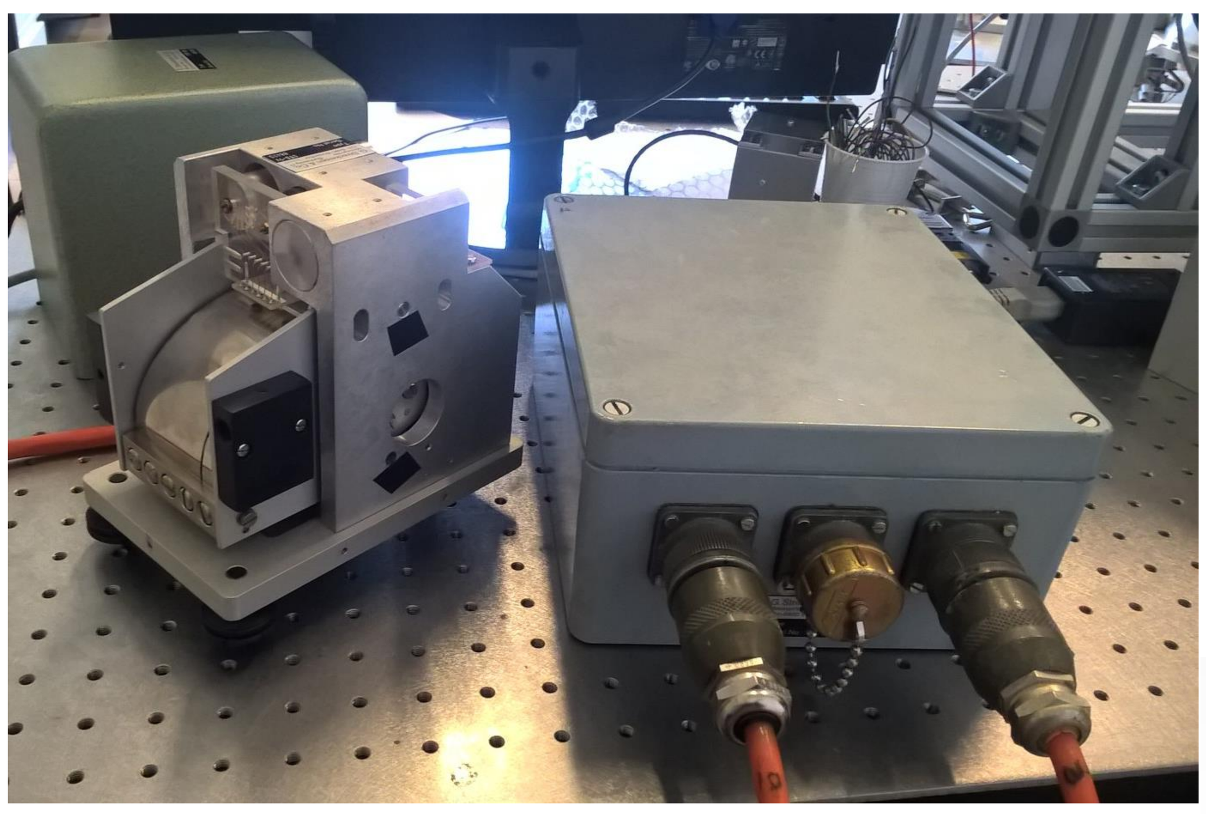


- Laser source Koheras Adjustik X15: low noise
- Adaptated low noise Photoiodes
- dSpace with a high Sampling frequency: reduction of the ADC noise,

LIGO large vacuum chambers[4,5]



Improvement of the mechanics



Observatoire royal de Belgique

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