The Archimedes' prototype at SAR-GRAV laboratory

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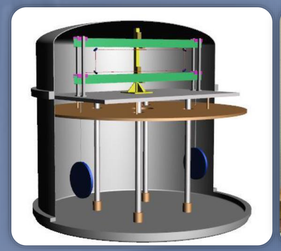
The Archimedes' prototype is a high sensitivity balance and can be used as a tiltmeter. Nowadays, it is installed at the SAR-GRAV laboratory in Sardinia. The laboratory is settled at the Sos-Enattos (Lula, Nuoro), a former mine located in a region characterized by low seismic noise. The tiltmeter is a beam balance with an interferometric optical readout and it reaches a sub-picoradiant sensitivity in the frequency region between 2 and 20 Hz and therefore, the Archimedes prototype has the best sensitivity in the world. The result was obtained by a direct measurement of the ground tilt.

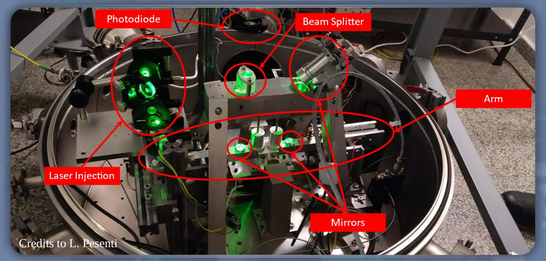
The Archimedes experiment goal is the measurement of the interaction between vacuum fluctuations with gravity by weighting a Casimir multi-cavity while changing the reflectivity of its layers. A change in the reflectivity corresponds into a variation of the internal vacuum state energy.



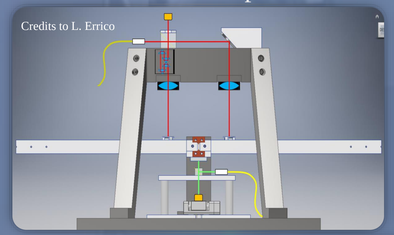
Archimedes is located at **Sar-Grav Laboratory** characterized by:

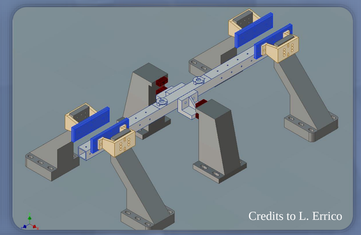
- **Low Seismic Noise:** Absence of active tectonics involving Sardinia, no significant earthquakes.
- **Low Anthropogenic Noise:** Noise related to human activities is very low since the inner NE Sardinia region is one of the less populated area in Europe.
- **Site Characterization:** Environmental noise monitored with different kind of sensors both on surface and underground.
- **Support Available:** In terms of logistics and manpower, mechanics and masonry services for both surface and underground work.

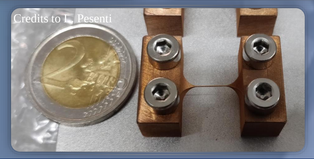
The Archimedes' prototype reads finely the ground tilts using a Michelson interferometer mounted on a balance arm.



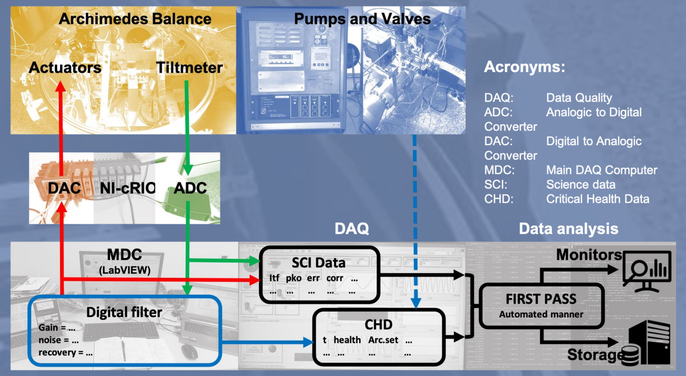
The Archimedes' Prototype **mechanics** consists in a 50 cm long arm with low momentum of inertia suspended through thin flexible joints (100 μm x 500 μm). Depending on the center of mass positioning, its resonance frequency is around 20-30 mHz. At the ends of the arm, there are two actuators needed to keep the arm in balance.



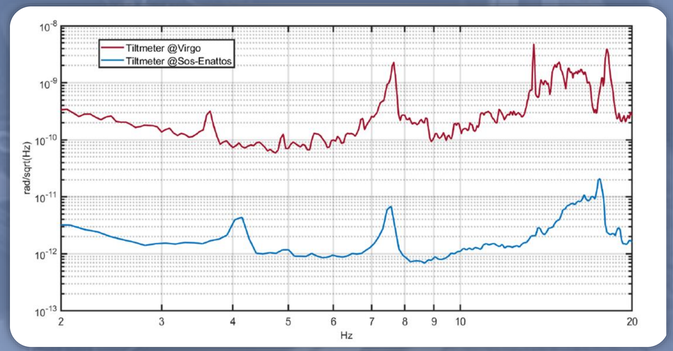




The **data flow** of the experiment is shown below.



The Archimedes' prototype was used as a **tiltmeter** at Virgo while reached the sensitivity of the sub-picoradiant in the frequency region between 2 and 20 Hz at Sos-Enattos.



E. Calloni et al, **High-bandwidth beam balance for vacuum-weight experiment and Newtonian noise subtraction**, Eur.Phys.J.Plus 136 (2021) 3, 335, https://doi.org/10.1140/epjp/s13360-021-01214-4
A. Allocca et al, **Picoradiant tiltmeter and direct ground tilt measurements at the Sos Enattos site,** Eur. Phys. J. Plus (2021) 136:1069, https://doi.org/10.1140/epjp/s13360-021-01993-w