# MAGIS-1K: A 1000 m Atom Interferometer Device for Searches in Dark Matter and Gravity Waves

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**This document is responding to the call for input collaboration to the update of the European Strategy for Particle Physics from the MAGIS collaboration.**

Atom interferometry can be used to answer basic science questions in quantum mechanics, dark sector physics, and 'mid-band' gravitational wave detection, due to its exquisite sensitivity to distortion of space-time. It will be able to detect well-motivated ultra-light dark matter candidates several orders of magnitude beyond current bounds.

The Matter-wave Atomic Gradiometer Interferometric Sensor (MAGIS) collaboration seeks to connect two quantum sensors across a long baseline to perform fundamental physics measurements. The phase in each device is compared across this baseline, enabling broad applications for fundamental physics. The science is enabled by the ongoing advances in atomic clocks and atom interferometry.

This scheme will be implemented in the configuration proposed for the MAGIS-100 experiment [1] by taking two atom interferometers and separating them across the baseline of the vertical 100-meter-deep NuMi access shaft at Fermilab. MAGIS-100 will combine the unique physical features of the Fermilab site with the laboratory expertise in vacuum and magnetics fields to give a high level of support to the physics collaboration.

Design, construction, and integration of the main components of MAGIS-100 is expected to take approx. three years. The initial science program will then take an additional three years. It will provide an increase of two orders of magnitude in sensitivity of a dark matter field in the mass region $10^{-15}$ eV and four orders of magnitude increase in sensitivity to B-L coupled new forces over eight orders of magnitude in mass. The experiment will also yield sensitivity to pseudoscalar dark matter. MAGIS-100 is the precursor to a proposed 1000 m baseline experiment which will provide leading sensitivity to gravitational waves in the mid-band frequency range. The project will advance the frontier of quantum sensor technologies and the physics that can be pursued with these technologies, including quantum tests on record-setting macroscopic scales.

To reach its full potential the MAGIS experiment will be extended to the km-scale, to provide sensitivity to physics of the early universe and the dark-sector. The program of R&D for such a device adds to the diversification of the community and experimental techniques for exploring fundamental physics and providing leading sensitivity to gravitational waves in the mid-band frequency range. The project will advance the frontier of quantum sensor technologies ensuring that US and Europe work in partnership to stay at the frontier of the second quantum revolution [2].

Currently there are several efforts within Europe, including the MIGA (France) experiment, the proposed AION (UK) initiative, and the UKs contribution to the MAGIS-100 experiment. There exists substantial benefit for Europe to contribute to the MAGIS programme, and the development of this technology for km scale experiments, and realisation of this experiment on a decadal timescale

**Recommendation:**

**It is important for Europe to collaborate in the new field of quantum sensors for fundamental physics in the search for dark matter across unexplored parameter-space, such as the MAGIS experiment. The opportunity to explore sub-eV territory is not generally accessible through the Higgs portal and the LHC, quantum sensors provide a complimentary effort enabling access to this mass range.**

[1] P. Adamson, et al., "PROPOSAL: P-1101 MAGIS-100", FERMILAB-TM-2700-PPD
[2] Z. Ahmed, et al., "Quantum Sensing for High Energy Physics", https://arxiv.org/abs/1803.11306