

Letter of Intent

To: EGO Director - EGO Council Chair - Virgo Spokesperson

Date: 10/05/2025

From: Roma Tor Vergata group | Tor Vergata University of Rome - Physics Department, Via della Ricerca Scientifica, 1 – 00133 Roma | Viviana Fafone, viviana.fafone@roma2.infn.it.

Subject: Expression of Interest to join VirgoLab

Dear Sir/Madam,

This letter serves as a formal expression of interest by Roma Tor Vergata group to join the VirgoLab, as described in VIR-1025B-24. We understand that VirgoLab operates, commissions, and upgrades the Virgo interferometer, and we are willing to contribute to its mission and to the achievement of its goals.

1. Introduction

The Roma Tor Vergata group is mostly composed of researchers from the Physics Department of the Tor Vergata University of Rome and the INFN Roma Tor Vergata division, with contributions from the local Department of Industrial Engineering, the Department of Industrial, Electronics and Mechanical Engineering of the Roma Tre University and the INAF Institute of Space Astrophysics and Planetology. The group's competencies cover Instrument Science (advanced optical coatings, optics, wavefront sensing and control, interferometer simulations and commissioning), Observational Science (multimessenger astrophysics) and Operations (detector characterization). Our expertise and ongoing research activities are highly relevant to the operation, commissioning, and potential upgrades of gravitational wave interferometers.

We are aware that important aspects of the VirgoLab organization still need to be fully defined and clarified, and we understand that this letter does not imply any formal commitment.

Nevertheless, we believe that our participation in VirgoLab has the potential to be mutually beneficial, allowing us to contribute our knowledge and resources to the advancement of gravitational wave science in Europe and beyond, while also providing our members with valuable experience and opportunities within a leading international collaboration.

This letter outlines our main areas of interest and potential contributions to VirgoLab.

2. Scientific / Technological Case or Context of Opportunity

Our group has a strong background in:

- **Adaptive Optics (Technology-focused):** design, development, and implementation of the adaptive optics system aimed at maintaining optimal interferometer performance in the presence of optical distortions. We have achieved significant advancements in the sensing and control of wavefront aberrations in ground-based interferometric detectors. Our group has coordinated the TCS subsystem for the Virgo+, Advanced Virgo, and Advanced Virgo+ projects. The group's activities include both experimental work and

numerical modeling and simulation. We believe that our ongoing research can contribute to the Detector Upgrades and Commissioning projects. Our participation would primarily align with the Optics & Light sources Technical Team.

- **Optics (Technology-focused):** development of advanced optical coatings aimed at reducing thermal noise. This includes the exploration of novel materials through comprehensive mechanical, optical, morphological, and structural characterization, supported by detailed modeling and simulation. We believe that our ongoing research can contribute to the Detector Upgrades project. Our participation would primarily align with the Optics & Light sources Technical Team.
- **Detector characterization:** identification and monitoring of scattered light sources; development and acceleration of adaptive algorithms for scattered light noise subtraction; development of technical environmental noises mitigation algorithms and their application to interferometer data. We believe that our ongoing research can contribute to the Operations & Maintenance project.
- **Interferometer simulations and commissioning:** our group has played a key role in the commissioning of the interferometer, with a particular focus on defining and optimizing its working point. In close collaboration with the ISC team, we have contributed both to the development of control strategies through simulations and to their implementation and fine-tuning with the aim of improving the detector's stability and sensitivity. We believe that our ongoing research can contribute to the Commissioning project.

3. Description of the Proposed Contribution

Our proposed involvement in VirgoLab would encompass the following potential contributions:

- **Technical Development:**
 - Design, testing and implementation of the Thermal Compensation System, within the Detector Upgrades project. This includes the development of advanced sensors and actuators to detect and correct optical aberrations.
 - Contributing to the design and development of next-generation mirror coatings for gravitational wave interferometers, within the Detector Upgrades project. This includes modeling thermal noise and dissipation mechanisms, investigating novel materials with improved optical and mechanical properties to reduce thermal noise, as well as developing advanced facilities for their thorough optical and mechanical characterization.
- **Detector characterization:** Research and development of data analysis methods for noise identification/mitigation; improve monitors of known data quality features in the interferometer; development, testing and maintenance of an automated pipeline for scattering sources identification and monitoring; development, testing and application of algorithms for scattering subtraction, with the goal of improving parameter estimation of the astrophysical sources.
- **Instrumentation Support:**

- Contributing to the tuning of optical simulations to model and predict the behavior of the interferometer in presence of optical distortions, within the Detector Commissioning project and relevant Technical Teams (Control & Simulation Technical Team).
- Contributing to interferometer sensitivity studies (PyGWINC), within the Detector Upgrades project.
- Contributing to the tuning of the interferometer's working point by operating the Thermal Compensation System during the commissioning phase, within the Detector Commissioning project. This process includes measuring aberrations, identifying the figure of merit to assess their impact on the interferometer's operation, and implementing compensation strategies to mitigate them.
- Contributing to the monitoring and mitigation of displacement noise induced by thermal actuators within the Detector Commissioning project. This may involve developing numerical models and simulations, designing monitoring systems, and implementing noise reduction strategies.

We are also open to considering contributing to other areas based on the evolving needs of VirgoLab and the expertise within our group. We are open to engaging with the existing VirgoLab Technical Teams and Projects to identify areas where our skills and resources can be most effectively utilized.

4. Costs, Calendar and Resources

Initially, our contribution would primarily involve the effort of our existing personnel with a total of 17 researchers with an expected commitment of about 8.5 FTE.

We understand that the successful accomplishment of VirgoLab tasks, particularly the timely installation and commissioning of the O5 upgrade, will demand strong and continual presence at EGO site. Our group commits to support that effort as much as reasonably possible.

We anticipate the need for travel to EGO, access to interferometer data, use of EGO infrastructure and laboratory facilities, and, if necessary, support from on-site technical staff.

We understand that Member Labs are in charge of maintaining and operating the equipment they provide, and we are prepared to discuss the provision of components of the Thermal Compensation System, including sensing and actuation hardware as part of a future Memorandum of Agreement (MoA).

We are aware that financial resources are allocated by EGO Council, national funding agencies, or research organizations. We will explore potential funding opportunities through our institution and national agencies to support our involvement in VirgoLab.

We are prepared to work towards the establishment of a MoA with EGO should our application be successful.

5. Stakeholders and Requirements

Our primary stakeholders are Tor Vergata University of Rome, INFN, Roma Tre University.

We understand that as a contributing group, our main requirements would be to have effective communication channels within VirgoLab, opportunities for our members to actively participate in relevant projects and technical teams, and recognition for our contributions to the scientific and technical advancements of Virgo.

We are committed to adhering to the policies and procedures of VirgoLab, including those related to resource allocation and publications.

We are ready to discuss our potential participation further and provide any additional information that may be required. We look forward to the possibility of joining VirgoLab and contributing to its continued success.

Sincerely,

A handwritten signature in dark ink, appearing to read "Viviana Fafone". The signature is fluid and cursive, with the first name "Viviana" and the last name "Fafone" clearly distinguishable.

Prof. Viviana Fafone

on behalf of the Roma Tor Vergata group

10/05/2025