### Letter of Intent

To: EGO Director - EGO Council Chair - Virgo Spokesperson

Date: [Insert Date]

**From:** European Gravitational Observatory group. Maddalena Mantovani maddalena.mantovani@ego-gw.it

Subject: Expression of Interest to join VirgoLab

Dear Sir/Madam,

This letter serves as a formal expression of interest by European Gravitational Observatory group (hereinafter referred to as "EGO 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

EGO group is specialized in optics, electronics, control, simulation, environmental noise, vacuum, mechanics, survey engineering and computing. Our expertise and ongoing research activities are highly relevant to the operation, commissioning, and potential upgrades of gravitational wave interferometers.

We believe that our participation in VirgoLab would 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:

## • Control (Technology-focused):

Involved in the control of the Virgo detector for a long time. Currently coordinating the ISC subsystem for Advanced Virgo phase I and phase II. The main activities at the moment are the commissioning during the O4 run and the maintenance of the ISC sub-system. Moreover the group is strongly involved in the design of the control strategy for the upgrade of Stable Cavities. This implies simulation work for the longitudinal and angular opto-mechanical system, in order to reach the best performance for Advanced Virgo phase II. Our participation would contribute to the Detector upgrade and commissioning and primarily align to the Control & Simulations Technical Team.

• Suspension design (Technology-focused):

Involved in the commissioning and in the design of the Virgo suspension for a long time. Currently participating in the RCS working group for AdV+ Phase2. Design and simulation of the suspensions for stable recycling cavities. Our participation would contribute to the Detector upgrade and commissioning and primarily align to the Control & Simulations Technical Team.

## • Optics (Technology-focused):

The group has long-standing involvement in the Injection (INJ) and Pre-Stabilized Laser (PSL) subsystems of Virgo and is currently coordinating the INJ subsystem. This role includes the commissioning and maintenance activities for the O4 run, as well as the design of the upgraded system for Advanced Virgo Phase II. The group has also been deeply involved in the development, installation, and commissioning of the new ALS subsystem. It is currently responsible for coordinating ALS operations during O4 (maintenance and commissioning) and the design evolution for the subsystem to be compatible with the Stable Cavities configuration. In the Thermal Compensation System (TCS), the group has made significant contributions, notably in the design, construction, and installation of the CHRoCC device for Advanced Virgo Phase I. It is also coordinating the TCS.08 CHRoCC deliverable for Phase II. The team has developed expertise in high-power and vacuum-compatible optical components, such as those installed on the injection. Moreover, it has experience in low-loss optical elements like the Faraday Isolators used in the Detection (DET) and Squeezing (SQZ) subsystems. With strong expertise in the functioning of the interferometer-particularly in optics-related parts the group serves as local experts for PSL, TCS, PCal, and DET. Our participation would contribute to the Detector upgrade and commissioning and primarily align with the Optics Technical Team.

## • Environmental Noise (Fundamental Physics/Instrumentation-focused):

The group, since the initial Virgo phase, deals with the study and measurement of the environmental noises present on site, generated by the auxiliary devices of the interferometer (ITF), the site infrastructures, or by external sources.

The main objective is to evaluate the impact of environmental noises on the interferometer, design specific measurement systems and measurement campaigns, model the coupling mechanisms between the noises and the interferometer, and develop effective solutions for its mitigation. To this end, the group owns and operates specialized equipment for environmental noise measurements and investigations. Additionally the group provides scientific support for evaluating the impact of external facilities (e.g. wind farms, quarries, sports plants) with the purpose of preserving the site noise levels. Moreover, the group is actively involved in the interferometer upgrade phases - by coordinating the IME subsystem for AdV+ phase II - and is in charge of the noise hunting activities during commissioning. Our participation would contribute to the Detector Characterization and Commissioning and primarily align with the Vacuum & Mechanics and Infrastructure Technical Team.

# • Vacuum and Mechanics (Technology-focused):

Knowledge of ultra-high vacuum (UHV) techniques and extensive experience of the systems currently in use at Virgo. Operation, maintenance, and monitoring of vacuum and cryogenic systems. Mechanical design (and realization) capabilities in support of the Collaboration groups. On-site support for cleanroom operations and contribution to the contamination control task. Coordination of the upgrades to the vacuum system (VAC).

Our participation would contribute to the Detector upgrade and commissioning and primarily align with the Vacuum & Mechanic Technical Team.

## • Infrastructure activities (Technology-focused):

Maintenance and new projects for the buildings of the EGO site and urbanization works for both the experimental buildings and premises dedicated to the personnel offices, the collective spaces and the technical systems. Our participation would contribute to the Detector upgrade and primarily align Infrastructure Technical Teams.

## • Survey Engineering and Alignments (Technology-focused):

Survey engineering activities for the initial definition, the materialization and the upgrades and maintenance over-time of the Virgo Reference System points network. VRS network is essential in the Lab for each subsequent activity of alignment of the scientific equipment (vacuum towers and vacuum tubes, suspensions, optical benches, etc.) and the monitoring of their position over-time, including the activity for the displacement of the scientific equipment related to new optical layouts of the interferometer. The monitoring over-time of the position of the tunnels due to the land subsidence is another important specialized survey engineering activity for the vacuum tube re-alignment procedures. Our participation would primarily align Infrastructure Technical Teams.

## • Computing (Technology-focused):

Development and tuning of Information Technology platforms, Operating Systems and software tools used by the Detector subsystems like detector control, online computing , data acquisition, distribution and access, for a long time.

In particular we offer competence on linux clustering monitoring and tuning, network filesystems, HTCondor-based computing, Identity Management, MySQL databases, web/php/python applications development, data transfer tools, security policies.

Our participation would primarily align with the Computing & Software Technical Team.

## • Electronics (Technology-focused):

Design, implementation and development of custom-tailored electronic solutions for interferometer systems and research activities. They include design, development, fabrication, test, and integration of

- a dedicated DC Power Generation and Distribution system that allows using only low-noise, DC power in sensitive areas of the experiment

- low-noise DC, audio, and RF front-end and processing electronics units

- mixed-signal, multi-actuator control electronics equipment

Our participation would contribute to the Detector upgrade and commissioning and primarily align to the Control & Simulation and Sensing & Actuation Technical Teams.

In addition we have gained proficiency in electromagnetic compatibility and immunity concerning multiple distributed system installations and commissioning, identifying and suggesting possible standards to be adopted to minimize side effects.

## • Operations (Technology-focused):

The team was established about 20 years ago, and since then it has constantly provided the Operator service, both during the commissioning phases and during the scientific observation phases. Provides an operator on duty, and on-call service based on the needs advanced by the Commissioning Coordinator or the Run Coordinator. During observing runs, 3 shifts/day (7:00-15:00, 15:00-23:00 and 23:00-07:00), 7 days/week). The service also takes care of preparing the shift schedule of the operators, organizing the updating of the operators and the training of the new ones. The Operator in shift takes care of maintaining the ITF in the required state, provides support to researchers both in the Control Room and remotely, performs routine operations (relock, calibrations, etc.) and basic troubleshooting (recovery for software crashes, earthquakes, etc.) and, in case of more complex problems, contacts the proper on-call persons and assists them remotely when required. The team also deals with the implementation of software tools necessary for the Operator's work and for Operation/Commissioning, in particular the DMS (Detector Monitoring System https://dms.virgo-gw.eu/, the Operation.wirgo-gw.eu/itfem/), graphical user interfaces for monitoring and control.

Over the years, the team has acquired particular experience on special movements (optical tables, mechanical suspensions, mirrors), support during interventions inside the towers, assembly and wiring of high vacuum components, in-vacuum cabling. It also manages the cabling laboratory.

## • Mechanical simulations tool "Octopus" (Simulations-focused):

Development and optimization of the Octopus software tool to model complex mechanical systems. This simulation tool is able to provide the essential design and commissioning support.

### 3. Description of the Proposed Contribution

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

#### • Technical Development:

Contributing to the design, development, and testing of thermal actuators, such as CHRoCC, Faraday Isolators, Phase noise subtraction system, within the Detector Upgrades project and the Optics & Light sources Technical Team. This would involve opto-mechanical design, prototyping and testing in the Optics Lab facility.

Design of vacuum systems; testing of new materials for compatibility with ultra-high vacuum applications. Design (and realization) of mechanical parts for the experimental setup. Contribution to multidisciplinary projects, such as the realization of "in-vacuum static charge neutralizer" and methods for controlling particulate contamination.

Design of low noise solution for sources mitigation and new facilities, linked with the Detector Upgrades project.

#### • Instrumentation Support:

Contributing to the monitoring and mitigation of Control noise within the Detector Commissioning project and relevant Technical Teams (Control & Simulation Technical Teams). This could involve the implementation of subtraction techniques, controller improvements and improved sensing configuration. Moreover the group effort is focused on reaching and maintaining the optimal working point to ensure the best opto-mechanical configuration for the detector for data taking. Contributing to the suspension control in order to ensure low noise and robust control within the Detector Commissioning project and the Control & Simulation Technical Teams.

Contributing to the characterization, monitoring, identification and mitigation of noise sources in the detector environment and in the site external environment; measurement of couplings of ambient noise with the interferometer within the Detector Commissioning project and the relevant technical teams (Vacuum & Mechanics, Infrastructure, Sensing & Actuation and Control & Simulation TT).

Contributing to the evaluation of the impact of noisy facilities and plants in the surrounding area of the site, with the aim of preserving acceptable noise levels, within the Detector Commissioning and Upgrade project and the Infrastructure Technical Team.

Contributing to the Injection system by ensuring the delivery of a stable and clean laser beam to the detector, through activities including optical simulations, component design and production, installation, commissioning, and maintenance. Efforts focus on improving input optics to reduce noise, enhance high-power handling capabilities, and increase overall stability and reliability, within the Detector Commissioning project and the Optics Technical Teams.

Contributing to ALS, to ensure the robustness of the lock acquisition process through the stabilization of the interferometer by keeping the arm cavities out of resonance during the lock acquisition of the central interferometer, within the Detector Commissioning project and the Optics Technical Teams.

Monitoring and operation of the Virgo vacuum system, ensuring the required vacuum levels and a high duty cycle, including the management of cryogenic apparatuses. Operation of the mechanical workshop to ensure timely interventions during maintenance and upgrade activities. Support for cleanroom operations, including the development of systems and procedures aimed at controlling contamination of the experimental components, within the Detector Commissioning project and the Vacuum & Mechanics Technical Teams.

Provide the Operator Service both during the commissioning phases and during the scientific observation phases. Maintenance and improvement of software tools necessary for the Operator's work and useful also for Operation/Commissioning (DMS, ITFEM, graphical user interfaces for monitoring and control, etc).

## • Survey Engineering:

Contributing to definition and design of the reference system network and the alignment strategy for future GW projects (i.e. Einstein Telescope).

## • Computing and Software:

Designing, installing and operating at Cascina the Linux computing clusters and associated storage for the Interferometer Control, on-line processing and characterization and on-line analysis. Developing and operating the tools for bulk data transfer to external computing centers. Developing and maintaining the Virgo web/php/python applications dedicated to Interferometer data monitoring and browsing. Managing the Virgo members' identities and access control. Contributing to the definition of the security policies for Virgo systems.

We are also open to contributing to other areas based on the evolving needs of VirgoLab and the expertise within our group. We are keen to engage 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 25 researchers/engineers and with an expected commitment 19,44 SVAC, moreover it will involve 19 technicians.

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 understand that Member Labs are in charge of maintaining and operating the equipment they provide, and we are prepared to discuss the provision of them as part of a 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

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 the VirgoLab and contributing to its continued success.

Sincerely,

Maddalena Mantovani On behalf of the EGO group

[Date]