

# Letter of Intent

**To:** EGO Director - EGO Council Chair - Virgo Spokesperson

**Date:** May 9, 2025

**From:** Virgo Pisa Group, Largo B. Pontecorvo 3, 56127 – Pisa. Contact Person (Group PI): Massimiliano Razzano (massimiliano.razzano@pi.infn.it)

**Subject:** Expression of Interest to join VirgoLab

Dear Sir/Madam,

This letter serves as a formal expression of interest by Virgo Pisa Group (hereinafter referred to as "Virgo Pisa", if applicable) 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

Virgo Pisa is one of the founding groups of the Virgo experiment, and since 1980's has been a key player in the development of ground-based gravitational wave (GW) detectors based on large-scale interferometer and in Virgo.

Virgo Pisa is a group involving research and technological staff as well as a large group of younger members, including PhD students, Master and Bachelor students. Members of Virgo Pisa work in the main Universities and Research Institutions in Pisa (INFN Section of Pisa, University of Pisa, Scuola Normale Superiore) and at the nearby University of Siena.

The expertise of our group and its ongoing research activities are highly relevant to the development of GW interferometers under different aspects including operation, commissioning, and upgrades. Part of the group is also involved in data analysis works covering the main classes of GW sources.

A detailed list of activities can be found in the MoA between Virgo Pisa and the Virgo Collaboration (VIR-1156B-23). The list below summarizes the main expertise of the group:

- Development of seismic isolation devices. The group has led the design, construction and integration of the Virgo Superattenuators and is now in charge of the SAT subsystem. Furthermore, the group has an active role in the development of suspensions for the stable recycling cavities in the O5 upgrade in the context of the Advanced Virgo + Phase II (RCS subsystem)
- Development of electronics and control of superattenuators, both for SAT and for the O5 upgrade (chairing the MPS subsystem)
- Maintenance and commissioning tasks related to SAT
- Development of software for data analysis in the context of the Detector Characterization activities, with particular attention to non-linear noise, coherence studies and glitch analysis
- Data analysis of GW sources, including CBCs, burst, pulsars and stochastic background, with applications on astrophysics, cosmology and fundamental physics (e.g. testing GR)

- Multimessenger analysis of GW sources, including GRBs, FRBs, as well as participation in Rapid Response Team activities
- Organization and participation in activities of Education and Public Outreach related to Virgo and GWs.

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 the development and operation of seismic isolation system for GW interferometers, that are connected with the core activities of the VirgoLab projects, in particular:

- **Detector Operations and Maintenance:** the development of seismic isolation systems in the context of O5 upgrade and future post-O5 upgrades. The group has developed the Superattenuators, having had also the responsibility of the suspended bench for injection, the mode cleaner payload and contributing to the development and installation of payloads. The group is now engaged in the development of the Recycling Cavities Suspensions (RCS). We then believe that our ongoing research can contribute to the Detector Upgrades project. Our participation would primarily align with the Mechanics and Vacuum, Sensing and Actuation, Control and Simulations Technical Teams.
- **Detector characterization:** The development of tools for analysis of instrumental data in order to support detector characterization activities. In particular the group has focused its activity on the development of tools to study the coherence among channels and nonlinear noise (e.g. the MOdulated NoisE or BicoheRence EvaluaTiON tools). Furthermore, in the last years the group has pioneered the usage of Machine Learning for noise investigations, including the automatic classification of noise glitches as well as the systematic analysis of auxiliary channels data. These activities can contribute to the Detector Operations and Maintenance project, particularly in the area of detector characterization. Our expertise would be relevant to the Computing & Software Technical Team.
- **Instrumentation, commissioning and noise mitigation:** our group has been active in several areas of noise hunting tasks, with particular attention to the monitoring, diagnostics and maintenance of the SAT subsystems, with the aim of keeping the suspensions working at their best performance. Furthermore, we are also engaged in the study, monitor and mitigation of environmental noise, with particular attention to seismic and magnetic noise. These activities are also connected to a series of activities focused on noise estimation, modeling and simulation. Our research on these topics can contribute to the Detector Commissioning project and align with the Mechanics & Vacuum, Control and Simulations and Infrastructure Technical Teams.
- **Simulations:** our group is deeply engaged in the simulation of mechanical systems and controls for suspensions, a task that has been carried out for SAT and now is in progress for RCS in the context of the O5 upgrade. These tasks include the development of

simulations using various approaches including the Impedance matrix one (used by the Octopus tool) to compute transfer functions, design and optimize controls and mechanical configurations of suspensions. Furthermore, part of the group has gained expertise in the development of detailed simulations of observing scenarios for GW detectors depending on their sensitivity, an activity that is relevant to estimate the scientific results expected from future upgrades of Virgo. Our research on these topics can contribute to the Detector Upgrades project. Our participation would primarily align with the Mechanics and Vacuum, Sensing and Actuation, Control and Simulations, Computing & Software Technical Teams.

- **Low latency and multimessenger:** The group is committed to work to support the Rapid Response Team activities, as well as the low-latency analysis infrastructure, both by contributing to the RRT shifts and in the past years also with the development of low-latency infrastructure and delivery with open data. These activities can contribute to the Detector Operations and Maintenance project, particularly in the area related to low-latency and GW data releases. Our expertise would be relevant to the Computing & Software Technical Team.

### 3. Description of the Proposed Contribution

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

- **Technical Development for upgrades**
  - Contributing to development of seismic isolation systems in the context of O5 upgrade and future post-O5 upgrades. This would primarily align with the Mechanics and Vacuum, Sensing and Actuation, Control and Simulations Technical Teams. This would involve simulation, design, optimization, prototyping, integration and commissioning of new suspensions, including the development of related electronics infrastructure and control software;
  - Contributing to the development of simulation tools and simulations for new seismic isolation systems. This would align with the Mechanics and Vacuum, Sensing and Actuation, Control and Simulations, Computing & Software Technical Teams. This would involve the development of simulations using existing tools (e.g. Octopus), contribute to their development and develop new software tools;
  - Contributing to the development of observing scenarios involving the expected sensitivity of new upgrades. This would align with Computing & Software Technical Teams. This would involve usage of the software developed by the group to compute observing scenario simulations, as well as developing new simulation software.
- **Detector Characterization**
  - Contributing to the study of nonlinear noise using auxiliary channels data. This would align with the Computing & Software Technical Team. This would involve the running of the tools developed by the group (e.g. MONET and BRETON), as well as developing new software tools.

- Contributing to the systematic study and classification of glitches. This would align with the Computing & Software Technical Team. This would involve the using the ML-based tools developed by the group, maintain a list of glitches and develop new tools.
- **Instrumentation Support:**
  - Contributing to monitoring, diagnostics and maintenance of the SAT and RCS suspensions. align with the Mechanics & Vacuum, Control and Simulations and Infrastructure Technical Teams. This would involve a continuous monitoring of suspensions, producing periodic reports and develop software to improve the management of suspensions
  - Contributing to the study of environmental noise. This would align with the Computing & Software Technical Team. This would involve carrying out studies related to seismic and magnetic noise.

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 (approximately x researchers and y engineers with an expected commitment of 8 staff researchers and 5 staff engineers and technicians, with an expected commitment of 6 FTEs. These numbers consider only staff persons, while the group involves also members with temporary contracts, who could contribute to the activity of the VirgoLab if connected to their activity.

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, as we are already doing by supporting 3 people that spend most of their time at EGO and other members that spend at least 1-2 days per week at EGO working on maintenance and commissioning of the suspensions as well as work related to environmental studies

We anticipate the need for

- Travel to EGO;
- Access to clean room and laboratory space for work on the development of suspensions and electronics, a set of activities particularly timely with O5 upgrade;
- Office space, to host group members that spend their time in EGO;
- Computing facilities to access and analyze data.

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 [mention any potential equipment or resources the group might offer, if applicable] 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**

Our primary stakeholders are INFN, University of Pisa, Scuola Normale Superiore and University of Siena.

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 considering the policies and procedures of VirgoLab, including those related to resource allocation and publications, and we understand that the participation to VirgoLab will require to adhere to them. At this stage of preparation of the VirgoLab the group commits to adhere to the policies and procedures that have been stated and communicated to the groups.

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,

Massimiliano Razzano

Department of Physics, University of Pisa & INFN-Pisa

On behalf of Virgo Pisa group

May 9, 2025