

**Memorandum of Agreement  
between the Virgo collaboration  
and the LMA group  
for the participation to Advanced Virgo**

**April, 2015**

The purpose of this agreement is to describe the participation of the LMA group to the Virgo collaboration. The period covered by this Memorandum is two years from the approval date of the VSC.

1. CNRS and INFN signed an agreement concerning the realization of an antenna, VIRGO, for the detection of gravitational waves on 27 June 1994 in Pisa. VIRGO consists of a three kilometer Fabry-Perot interferometric antenna aimed at the detection of gravitational waves in the frequency range 10-10000 Hz. The construction, exploitation and data analysis of the VIRGO antenna is under the responsibility of the Virgo collaboration, which has been defined in its present form in December 2001. The VIRGO collaboration is represented by its Spokesperson. The operation of the VIRGO antenna is supervised by the EGO Council.
2. This document defines the responsibilities of LMA in the construction and development of Advanced Virgo; they are listed here below.

The LMA group is responsible for providing and characterizing the main mirrors and to provide the coatings for the optical components of the injection and detection benches (INJ and DET subsystems) and to manage the optical simulation effort, with the MIR and OSD subsystem managers being members of the LMA.

**Advanced Virgo (AdV)**

- Subsystem: Mirrors
  - Substrates  
LMA is responsible for providing the polished substrates for all the AdV large mirrors. These include components and spare parts for the 3 km cavities mirrors, the beam-splitter, the recycling mirrors, the input mode-cleaner, the suspended optics for the thermal compensation system.
  - Coating  
LMA is in charge of the realisation of all the coatings on the F-P cavities mirrors, the compensation plates, the pick-off plates, the beam splitters, the power recycling mirrors, the input and output benches optics, the input mode cleaner optics. LMA puts in place all the tools required for the mirror cleaning, coating (including corrective coating, if required), annealing, manipulation and transport.
  - Metrology  
LMA is responsible for the upgrade of all the mirror metrology tools required for AdV. LMA will perform the substrate and mirror characterization measurements (absorption, diffusion, point defect detection, reflectivity, transmission, wave front distortion and mechanical loss) and will provide a report for each large mirror.
- Subsystem: Optical Simulation and Design
  - Simulation  
LMA plays an important role in the OSD subsystem since it hosts the subsystem manager and simulation codes are developed in-house to define mirror specifications, estimate the performance of the interferometer from real mirror maps and at the end ease the commissioning by helping to understand the interferometer behaviour.
  - Commissioning  
Simulations will be essential to understand the interferometer and validate solutions to improve the detector. The OSD subsystem will include the optical characterisation work done on site.
- Subsystem: Infrastructures
  - Clean air  
LMA is not responsible for the realization of the cleanroom system at the Virgo site. Nevertheless

the laboratory participates to the design of this sub-system as consultant. LMA expertise in manipulating optics in clean environment is essential to the success of Advanced Virgo.

- Subsystem: AdV-squeez
  - Frequency independent squeezing  
Simulation and optimization of the optical losses encountered by the squeezed light during the injection into the interferometer. Production of low loss coating for the most critical optical components of the squeezed light generator.
  - Filter Cavities  
Simulation of realistic losses in filter cavities with state of the art mirrors and investigation on the limit imposed by the current technology on total loss budget of such cavities.

Remarks:

- 1) the group will provide adequate support for the proper operation and maintenance of the devices under its responsibility;
- 2) LMA is also providing a continuous improvements efforts on the mechanical loss performances of coatings, on the uniformity of the coating thickness across the surface and on the deposition processes with the development of an in-situ optical metrology of coatings during deposition.

3. The current LMA group contributions to Virgo working groups are the following:

- Management of the Mirror subsystem for Advanced Virgo
- Management of the interferometer Optical Simulation and Design subsystem
- Participation into the vacuum system design (clean air)

5. The current LMA group composition is:

| Name               | FTE  | Author | Student | Main activities and FTE   |
|--------------------|------|--------|---------|---|
| Balzarini Laurent  | 40%  | No     | No      | Mirrors Coatings  |
| Cagnoli Gianpietro | 40%  | Yes    | No      | (20%) Group leader<br>(20%) Coatings developments   |
| David Bertrand     | 20%  | No     | No      | Mirror Coatings   |
| Degallaix Jérôme   | 70%  | Yes    | No      | (10%) OSD management<br>(30%) Optical simulation development<br>(20%) Mirrors Metrology<br>(10%) AdV-squeez |
| Dolique Vincent    | 40%  | Yes    | No      | Mirrors Coatings and developments   |
| Flaminio Raffaele  | 40%  | Yes    | No      | (20%) Coatings developments<br>(20%) AdV-squeez   |
| Forest Danièle     | 40%  | No     | No      | Mirrors Metrology   |
| Granata Massimo    | 50%  | Yes    | No      | (20%) Coatings characterization<br>(30%) R&D Materials  |
| Hofman David       | 100% | Yes    | Yes     | R&D on Coating Processes  |
| Lagrange Bernard   | 50%  | No     | No      | (25%) Coatings developments<br>(25%) Mirrors Metrology  |
| Michel Christophe  | 50%  | Yes    | No      | (40%) Coatings developments<br>(10%) Clean Air  |
| Pignard Renée      | 10%  | No     | No      | Direction of LMA  |
| Pinard Laurent     | 50%  | Yes    | No      | (40%) Coatings developments and Metrology<br>(10%) Mirrors subsystem management                             |
| Sassolas Benoit    | 40%  | Yes    | No      | Coatings developments and Metrology   |
| Straniero Nicolas  | 100% | Yes    | Yes     | (40%) Mirrors Metrology<br>(60%) Optical Simulation   |
| Teillon Julien     | 50%  | No     | No      | Mirrors Coatings  |

Remarks:

- For a person who just joined the collaboration, the date in the author column is the date when the

person will be added in the author list. This date is one year after the joining of the collaboration (except for student where there is no delay)

The LMA group leader will inform the collaboration of any change in the group composition and of any new thesis proposed.

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Virgo collaboration Spokesperson

  
LMA group Leader

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01/04/2015  
Date

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01/04/2015  
Date