Memorandum of Agreement between the Virgo collaboration and the Valencia Virgo group for the participation to Virgo

The purpose of this agreement is to describe the participation of the Valencia group to the Virgo collaboration. The period covered by this Memorandum is from **July 2016 to June 2017**.

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. The members of the Valencia Virgo group are experts in relativistic astrophysics, applied mathematics, theoretical physics, computing, data analysis and signal processing. They have many years experience in numerical simulations of astrophysical sources of gravitational radiation. Using numerical relativity simulations members of the group have generated waveform templates for isolated rotating neutron stars, binary neutron stars, rotational supernovae core collapse, collapsars (long GRBs), and accreting black holes. The group is currently involved in data analysis with Total-Variation (TV) techniques for gravitational wave denoising and waveform reconstruction. TV algorithms, originally developed in the context of image processing, do not need any a priori information about the signals. Members of the group participate in an ongoing collaboration with researchers from both Virgo and LIGO in the topic of detector characterization, and have signed a MoU to apply identification and classification methods for noise transients (glitches) in advanced gravitational wave detectors (VIR-0402A-15). Members of the group have broad interest in parameter estimation. The group has local computing power in Valencia on SGI and Fujitsu clusters that can be used to analyse Virgo data.

3. The Valencia group proposes the following contributions to Virgo:
    - Data analysis:
        - Apply TV (Rudin-Osher-Fatemi) algorithms to denoise the actual Virgo data.
        - Combine TV algorithms with spectrograms and other common (Bayesian) data analysis techniques to improve the chances of detection in low SNR scenarios.
        - Incorporation of information about sources into TV algorithms through the use of signal dictionaries from numerical relativity waveform catalogues and known glitches, and through the implementation of machine learning algorithms to improve the purely denoising results.

- Detector characterization:
  - Apply Wavelet Detection Filter (WDF) + Machine Learning algorithms for an automatic prompt characterization of instrumental and environmental noise transients (glitches) in upcoming science runs of advanced detectors (initiated in VIR-0402A-15 for ER6 and ER7 aLIGO data).
  - Develop TV + dictionary learning algorithms for identification and classification of glitches in upcoming science runs. Comparison with PCAT, LALInferenceBurst and WDF+ML algorithms.

- Generation of waveform templates:
  - Apply numerical relativity techniques to build gravitational wave templates for various astrophysical systems, namely black hole-forming core collapses (collapsars as progenitors of long GRBs) and compact binaries (neutron stars, boson stars, Proca stars and hairy black holes; elucidate if observed signals, e.g. GW150914, are consistent with alternative scenarios). This effort will produce new codes to be embedded in the Virgo library analysis.

- Parameter estimation:
  - Contribute to the development of parameter estimation methods for gravitational waveform signals from simulated data and real data.

4. The Valencia Virgo group will contribute with new software to the Virgo libraries and will maintain it; it will provide adequate support for the proper operation and maintenance of the devices and tools under its responsibility and for the participation to the collaboration activities. The Valencia group will explore the possibility to contribute significantly to the computing effort of Virgo and LSC devoted to the gravitational wave data analysis.

5. The current Valencia Virgo group composition is (in alphabetical order):

Name	**FTE**	**Author**	**Student/Postdoc**	**Main activities and FTE**
Pablo Cerdá-Durán	50% (U)	Yes	Yes	DA (10%), TG (20%) PE (20%)
Isabel Cordero-Carrión	50% (U)	Yes	No	DA (20%), TG (10%) PE (20%)
José Antonio Font	50% (U)	Yes	No	DA (10%), DC (10%) TG (20%), PE (10%)
José María Ibáñez	20% (U)	No	No	DA (10%), TG (10%)
Antonio Marquina	40% (U)	Yes	No	DA (30%), PE (10%)
Nicolás Sanchis-Gual	40%	Yes	Yes	TG (30%), PE (10%)
Alejandro Torres-Forné	80%	Yes	Yes	DA (30%), DC (30%) TG (10%), PE (10%)

Remarks:

- It is understood that for a person who just joined the collaboration, the date in the author column is one year after the joining of the collaboration (except for students and postdocs where there is no delay).
- In the activity section the leading activity and the FTE are specified for each of the four main categories: Data Analysis (DA), Detector Characterization (DC), Template Generation (TG), and Parameter Estimation (PE).
- The label (U) means: teaching duties. In that case, the FTE is computed on the research time.

The Valencia Virgo group leader will promptly inform the collaboration of any change in the group composition and of any thesis proposed.

6. Since Spain is not contributing to EGO, the final integration of the Valencia Virgo group as a regular group into the Virgo collaboration is subject to the approval of the EGO Council who may negotiate agreement(s) with the relevant Spanish institutions.

Approved:

Fulvio Ricci
Virgo collaboration Spokesperson

June 8th, 2016
Date

José Antonio Font Roda
Valencia Virgo group Leader

June 9th, 2016
Date