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Preparation for the signal search in the VIRGO data

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Abstract

The construction of the gravitational antenna Virgo is now started. By the end of the century, this detector will perform a permanent survey of the sky producing thus a huge amount of data. The expected signal search will gain a lot from a well prepared online system associated to efficient software tools. We present these tools with the online system.

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1. Introduction

The VIRGO experiment[1,2] aims at the detection of gravitational wave signals by measuring the phase difference between the laser beams propagating through a large suspended Michelson interferometer. Its incident light power is enhanced with a power recycling mirror and its 3km armlength is magnified using Fabry Perot cavities.

In the first part of this article, we recall briefly the characteristics of the most probable gravitational signals. Their expected amplitude and time structure determine the specifications of the control and data acquisition systems which will be set up for the experiment. In the second part, we underline the key role of a detailed numerical simulation presently used to understand the behavior of the various optical components, to optimize the feedback control system and to prepare the final data analysis.

2. Gravitational sources

The most likely sources of Gravitational waves expected in the frequency band (10Hz to 10 kHz) accessible to VIRGO can be classified in two categories presenting specific requirements on the control and data acquisition systems:

- Periodic sources like asymmetrical pulsars produce rather weak signals. Being stable over time, their integration provides however nice cross checks. As a consequence, one has to register permanently the time dependance of the measurements performed around the detector as well as the status of the associated controls. Given the long duration of the observations, the offline system has to cope with a large amount of data.

- Burst sources like coalescences of binary systems of neutron stars or black holes will produce rather rare and short observations within the initially limited sensitivity of the experiment. The discrimination of such events against the various instrumental backgrounds requires a detailed analysis of all available parameters over the limited event duration.

3. The detector control

The various active components of the interferometer (laser, mirrors) are kept within a given set of tolerances by a local control system processing locally the data measured on local captors (accelerometers, imaging systems). During standart operations these components have to be perfectly aligned, the Fabry Perots and the recycling cavity on resonance and the interferometer locked on its dark fringe. A global feedback system, driven by a set of appropriate photodiodes, keeps the mirrors in position. Controls are synchronized on a global timing system which provides clocking signals all over the site. The system flexibility and performances are optimized with digital controls and fiber optic transmissions.

4. The data acquisition

Most of our data are produced on three sites: the central one and those of the two Fabry Perot end mirrors. Data are first read out locally, in parallel on each site and at the maximum frequency allowed by the bandwith of the interferometer. They are concentrated at the same speed on the central site. In background with this fast read out, but with a related synchronisation, the detector environment, i.e., the temperature, pressure, speed of wind, acoustic, seismic and electromagnetic noises are recorded by a slow control system. On the central site, the collected data are structured in *Frames*, i.e. blocks of structured informations which incorporate all the timed measurements and control status collected around the detector over a few seconds.

Controls and data acquisition are programmed along the client/server scheme. The servers are the real time process which directly control the hardware and the client are the users interfaces which run on workstations. All the servers are coordinated by a single Supervisor task.

5. The online processing

Once the Frames are build, they are archived on tape at a 1 MBytes/s rate, producing a safe and unaltered but rather difficult to manage amount of data. Another data stream is produced by the online processing system which runs permanently quality checks and selects the frames according to a search algorithm.

As a pulsar search requires a permanent recording of a limited number of parameters whereas a burst search requires only the rare recording of a great number of parameters over a short time , we process the preselected data flow accordingly: a fast search algorithm identifies burst candidates and initiates the registration of all necessary data. In the absence of burst candidate, the registered information is compressed to the minimum compatible with a pulsar search. The compressed data stream is send to a storage system acting as a data server.

6. The simulation

A numerical simulation program gives us the capability to understand the detailed behavior of the detector. Very usefull at the design and commissioning stages, it becomes a major tool for the data analysis as it allows for the prediction of the interferometer response to various sollicitations. Today we have developed a simulation program called SIESTA[4]. It describes the behavior of the interferometer as function of time. It can generate the metric perturbations induced by a pulsar or by a binary coalescence. It computes the mirror positions accounting for the seismic and thermal noises as well as for the effect of the suspensions. It propagates the laser beam through the interferometer and simulates the observed signals. It produces the same frames as the VIRGO online system. SIESTA is still under development but it provides already hints for the detector design.

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References

1. Virgo collaboration, Proposal for the construction of a large interferometric detector of gravitational waves, revised version January 1990.
2. Virgo collaboration, Final Conceptual Design (FCD), Avril 1992
3. R. Flaminio L. Massonnet, B. Mours, S. Tissot, D. Verkindt, M. Yvert *Fast trigger algorithms for binary coalescences* To be published in AstroParticles Physics
4. Mours B., Wingerter-Seez I., Proc. of the sixth Marcel Grossmann Meeting on General Relativity, Kyoto, June 1991, ed. Humitaka S. and Nakamura T., p.1576 (1992).