Virgo Progress Report
To the STAC and EGO Council

VIR-046A-08
May 29, 2008

Abstract

This report describes the Virgo activities and progress since November 2007 until May 2008 period. It starts by a status overview and collaboration news, and is followed by five sections describing briefly the detector evolution and commissioning, data analysis, Advanced Virgo and outreach activities. Virgo organization issues are also briefly discussed. Detailed information can be found in the reports prepared by the coordinators.

Summary

Table of documents produced for the STAC meeting of June 11-12, 2008

EGO-STC-117-2008	Full report of R&D projects	Virgo Collaboration
EGO-STC-116-2008	Evaluation of R&D approved projects and new proposals	Losurdo
EGO-STC-115-2008	Status of R&D projects	Colas
EGO-STC-114-2008	Status of fellowships	Colas
EGO-STC-113-2008	Preliminary report on incident et North end tower	Colas
EGO-STC-112-2008 VIR-042A-08	Progress report on Advanced Virgo	Losurdo
EGO-STC-111-2008 VIR-044A-08	Progress report on Virgo+	Punturo
EGO-STC-110-2008 VIR-043A-08	Progress report on Commissioning	Tournefier
EGO-STC-109-2008 VIR-039A-08	Progress report on DA	Vicere
EGO-STC-108-2008 VIR-046A-08	Virgo progress report to the STAC and EGO Council (June 2008)	Fidecaro

1 Overview

1.1 Recent activities

During the period covered by this report (November 2007-May 2008) a conspicuous commissioning work took place, interleaved with detector upgrades. Work was organized on the basis of two shifts, one starting at 8 am and the other ending at 11 pm. The detail of the work can be found in the commissioning and detector reports (see Table of produced documents, EGO-STC-110-2008, EGO-STC-111-2008).

1.2 Viewport breaking (EGO-STC-113-2008)

This commissioning activity, that was planned to be concluded with a ten days commissioning run, was abruptly interrupted by the breaking of a 15 cm diameter viewport while the North End tower was being evacuated after an intervention on the mirror. The current understanding of this incident, that could have had serious consequences, can be found in the corresponding section of the detector report and in a dedicated document (EGO-STC-113-2008). Needless to say that this represents a major source of worry and an adequate response is being formulated by a working group that will meet external experts on June 4. First actions are:

- cleaning of the NE tower base down to the main tube vacuum valve
- a study of the behaviour of the NE tower under venting cycles
- a examination of the broken window by specialists
- a review of installed viewports on the various towers with visual and polarized light inspection
- coating of the best End mirror available (Herasil bulk)

Since the needed components were already on site the shutdown operations foreseen to start on June 3 could be anticipated. As of today, although **there is an additional load of work and there will be a need for additional resources**, the potential for a timely restart in the Virgo+ is intact thanks to the availability of polished mirrors and in spite of the long time needed for the coating operations.

1.3 Detector upgrades and commissioning results (EGO-STC-110-2008, EGO-STC-111-2008)

Before the incident very significant results were achieved, making Virgo the most sensitive gravitational wave detector in the band 10-40 Hz, where several sources are predicted to emit waves having significant amplitude.

1.3.1 Control noise

The first main commissioning topic was the reduction of the control noise that represented a limit to sensitivity to signals below 50 Hz. This was achieved by improving the sensing and filtering strategy for the longitudinal and angular degrees of freedom. Mirror actuation noise was further reduced improving the force allocation on mirror and marionetta. The progress has been very significant: the control noise is no more a limit in reaching the nominal Virgo sensitivity at low frequency.

1.3.2 Thermal compensation

The light absorption in the Fabry-Perot cavities input mirrors is currently limiting the intensity of the circulating beams. As second commissioning topic a Thermal Compensation System (TCS) was installed to correct distortions of the light wavefront by heating in a non uniform way the mirrors. The system could be shortly tested on the West Input Mirror, because only one compensating laser was available before the forced shutdown. Very

encouraging results were obtained both on its effectiveness and on the lack additional noise introduced.

1.3.3 Environmental noise

Finally the systematic search for noise sources that are able to couple to the dark fringe signal initiated at the end of VSR1 was continued. Target of these studies were sound and infrasound, seismic and machine induced vibrations, magnetic coupling.

Further work to mitigate sound and vibration effects was done on all external benches, where optical elements are not isolated as the interferometer optics is. A main actor was found to be the scattered or diffused light reentering some of the beams used by the interferometer. The same diffused light appeared to play a crucial role in the very strong coupling of the dark fringe signal with vibrations of the Brewster window closing the link to the detection tower. This was cured with the replacement of that window with a cryogenic trap for residual impurities. Additional work took place in the Laser Laboratory where input beam jitter was reduced.

Magnetic coupling was systematically studied and steps to cure it were taken by reducing the strength of the magnets and also by correcting their orientation to reduce coupling to external fields. This implied ungluing and gluing again the magnets on the mirrors, a delicate operation that was developed on purpose. The reduction of magnet strength has an effect of the reference mass eddy currents, a dissipative effect that is a serious candidate for limiting the sensitivity at low frequency. The NE tower incident happened right after the magnets were replaced so the opportunity to observe a further noise reduction is delayed.

1.3.4 Automation

The reliability of the interferometer and its capability to return in Science Mode automatically have greatly improved thanks to the increased robustness of the control system. Several nights of good quality data have been recorded and are available on mass storage making the detector ready for astrowatch mode.

1.3.5 Results

To summarize, Fig. 1 shows the progress in sensitivity since the beginning of commissioning the step between the last two curves being what was achieved since October 2007. Fig. 2 shows a comparison of the Virgo and LIGO sensitivity, where the work at low frequency can be appreciated. Finally Fig. 3 shows the horizon for binary neutron star inspiral events at the end of VSR1 and at the beginning of May. With the increase in circulating light and a continuing search for environmental sources of noise it is expect to improve significantly this figure.

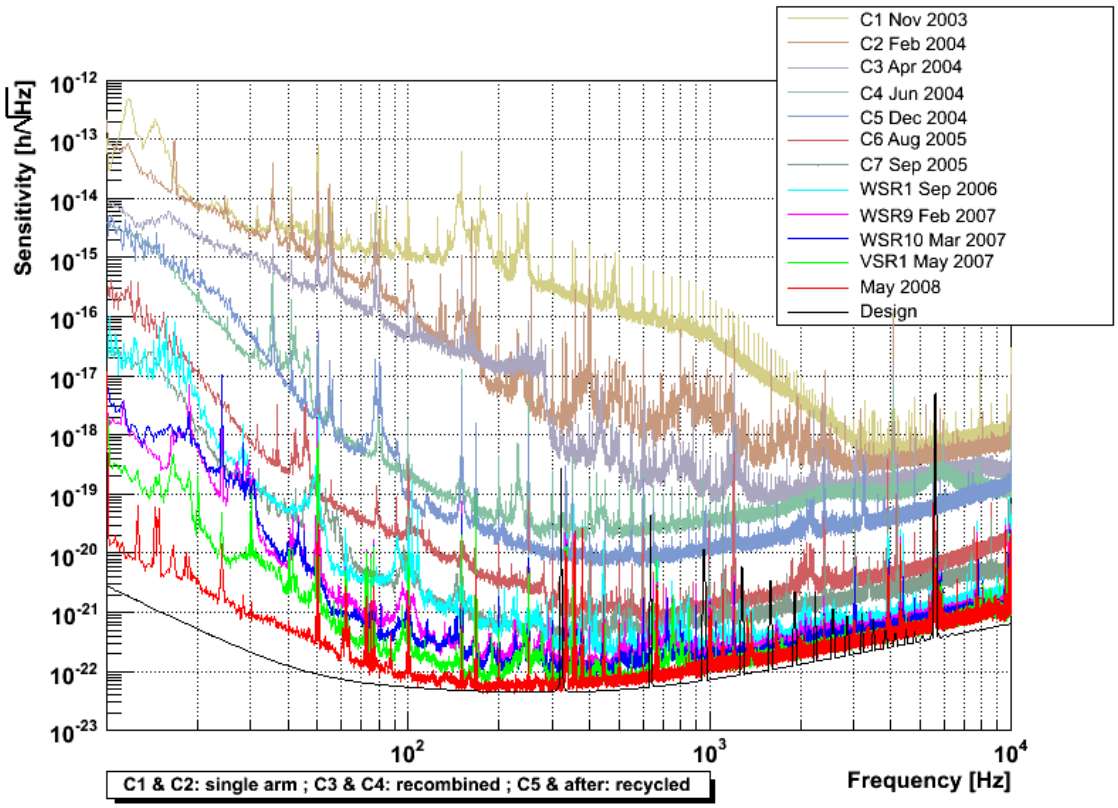

Figure 1. History of the Virgo sensitivity since the very beginning. Particularly noticeable is the progress in the low frequency band. The reduction of the number and size of structures comes from a series of interventions while overall reduction of level comes from the improvements in the control system, from sensing to correction signals and actuation.

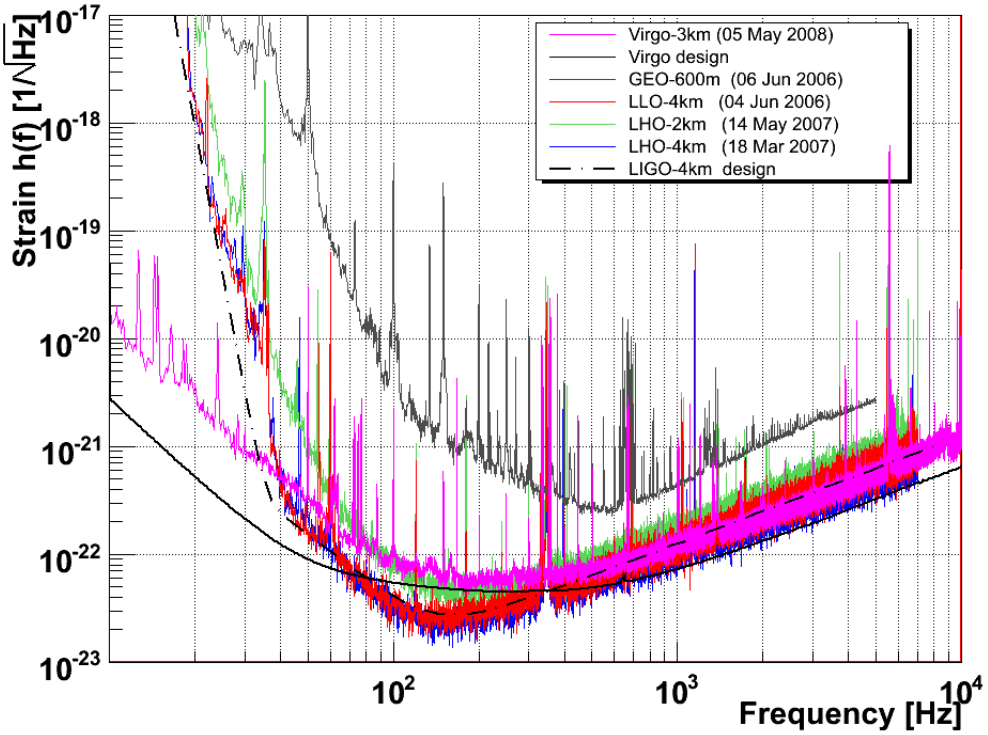

Figure 2. Comparison of the achieved Virgo sensitivity with the LIGO and GEO detectors. The LIGO detectors have a length of 4 km and a Finesse of 150. GEO is a folded Michelson interferometer with 600 m long arms.

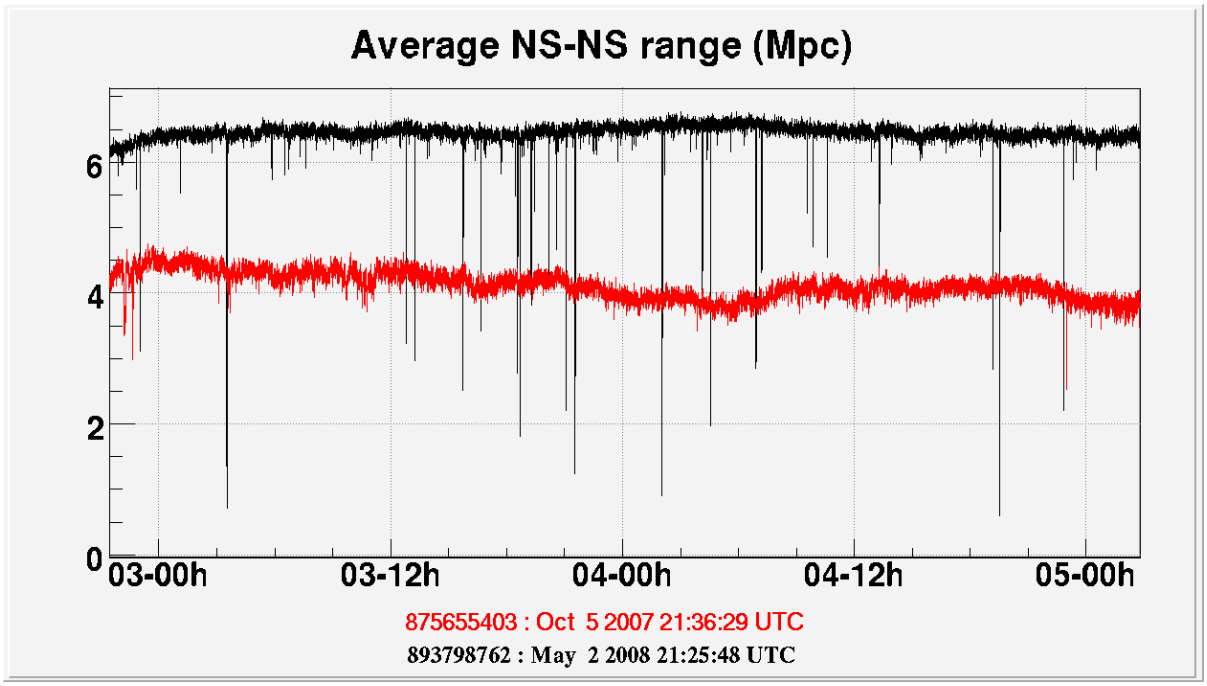

Figure 3. Horizon for the detection of binary neutron star inspiral events averaged onorientation. An increase of 50% has been achieved. The medium term stability has improved. Spikes have been traced back to the West Input mirror, whose magnets were changed. This is planned to be cured in the current shutdown.

2 Virgo+ upgrade (EGO-STC-111-2008)

2.1 Activities in parallel with commissioning

The scientific requirement of having the longest possible periods of data taking with all the world network interferometers dictated the steps that could be made in improving the Virgo interferometer as Virgo+. An intense construction work of the following elements took place this semester, in preparation of the shutdown period.

2.1.1 Thermal compensation

As mentioned in the detector and commissioning section the Thermal compensation system was installed and partially tested with success. Once the second compensation laser will be available the system will be ready for tests once the interferometer becomes again operational.

A phase camera was developed and is ready to be tested for use in the Thermal Compensation System.

2.1.2 Laser amplifier

Concerning the power increase of the light source the new 50 W laser amplifier was successfully tested in Nice as well as its pre mode cleaner. It was brought on site and now brought on site for integration as described in more detail in the detector/V+ document.

2.1.3 IMC mirror

A new payload for the Input Mode Cleaner has been built and is now being assembled in the clean rooms on site. This will allow to debug the injection system together with the mode cleaner while working on the main interferometer.

2.1.4 Control electronics upgrade

The complexity of the suspension control and the general necessity to increase the real time computing power to control the interferometer have led to several developments that will be introduced in Virgo+. On the digital side new DSP as well as timing boards have been developed while new coil drivers designed to control mirrors with weaker magnets are being produced.

2.1.5 Environmental noise mitigation

Additional isolation of the laser laboratory from acoustic noise will be achieved by displacing the related electronics in an Electronics Extension room with acoustic insulation nearby. On the same line a plan to locate the detection photodiodes in vacuum on the suspended detection bench is going on.

2.2 Monolithic suspensions

The installation of a monolithic suspension during Virgo+ is one of our goals. It provides a significant scientific opportunity by increasing the sensitivity in particular at low frequency. In addition the Advanced Virgo design foresees the monolithic suspension solution. Virgo+ is in fact the unique place to test the monolithic suspension and to explore the level of noise at low frequency before Advanced Detectors are built.

During this spring the development of silica fiber suspension has made very substantial progress. A solution avoiding to bring a flame in the proximity of a mirror has been successfully tested and has now been used to suspend a dummy mirror on the Cascina site. This solution, that requires an appropriate shaping of the future Suprasil (low mechanic dissipation) mirrors, might be compatible with the use of steel wires. The latter remains a backup option should unexpected difficulties arise.

.

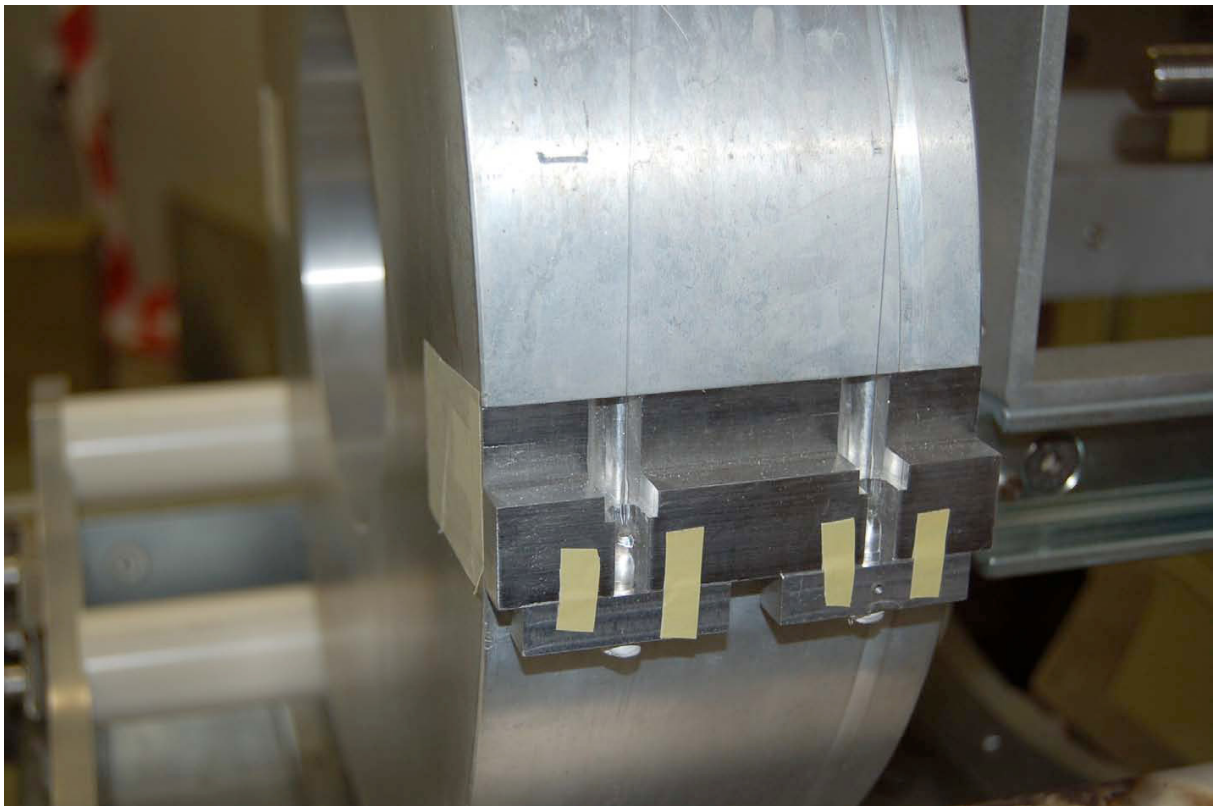

Figure 4. Dummy mass suspended by silica fibers produced in Cascina.

2.3 Virgo+ sensitivity

The commissioning activity included a reduction of the strength of the mirror magnets. In spite of this change by modifying the electronics and the locking strategy locking the control system is still performing correctly. This could not be tested on the full interferometer (the NE mirror was still with strong magnets), but it is felt that having all mirrors with smaller magnets will indeed allow to reach the thermal noise limit with steel wires. This would be the effective clearance toward the usefulness of silica fibers.

The evolution can be seen on Figure 5, where the current option is in blue, the intermediate solution with steel wires in red and the silica fiber solution is in green. Table 1 summarizes the impact on the different kind of sources.

Table 1. Comparison of the effect of the payload improvement for different type of signals. The CW Crab search requires the Monolithic suspension to make a significant step, the Coalescing Binary search benefit more progressively from the payload change, although the monolithic suspension provide a big step, while the high frequency burst search is basically not affected by the type of payload

Payload solution	Crab (60Hz)	BNS range	BBH range	Burst; 1kHz
Virgo design	$7.7\ 10^{-23}$	13 Mpc	63 Mpc	$7.5\ 10^{-23}$
V+ Current mirrors, no E.C.	$5.6\ 10^{-23}$	15 Mpc	76 Mpc	$5.1\ 10^{-23}$
V+ Steel Wires; new mirrors	$4.6\ 10^{-23}$	21 Mpc	109 Mpc	$5.0\ 10^{-23}$
V+ Mon Suspension	$1.4\ 10^{-23}$	49 Mpc	250 Mpc	$5.0\ 10^{-23}$

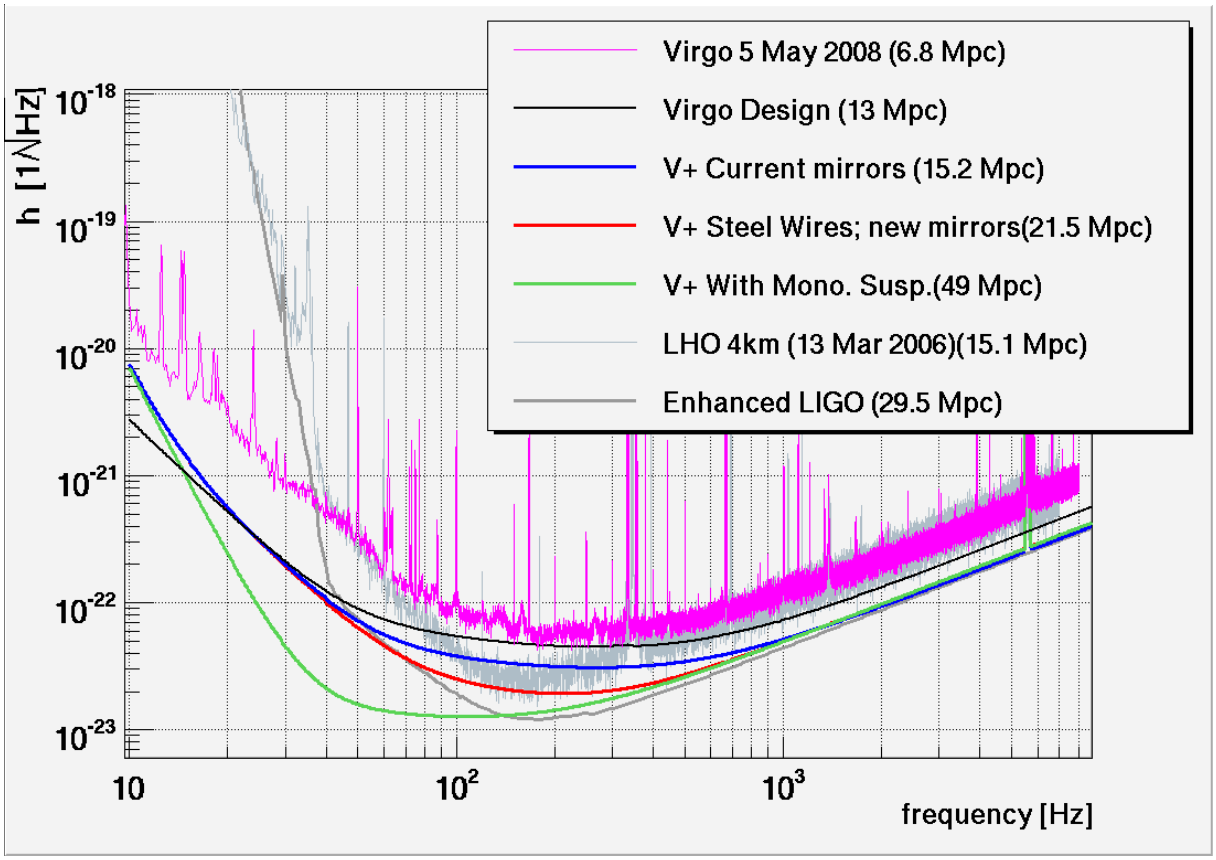

Figure 5. Different options for the Virgo+ mirror/payload choices. The V+ current mirror curve assumes that we can mitigate the possible effect of the Eddy current by means of caps on the magnet or by replacing the magnets. All the Virgo+ curves assume the new Thermal noise model ("Penn model"). The steel wires suspension curves assume a conservative number for the mirror internal noise). Some technical noise based on an evaluation of the actuator noise have been added to the Virgo+ sensitivity. It should be underlined that these technical noises which are limiting the sensitivity at very low frequency are by definition not absolute noises. Their level may vary depending on many parameters like the exact configuration of the control system and therefore, their exact prediction is difficult.

The NE incident, requiring the immediate replacement of an End mirror leaves little choice but confirming the option of a Finesse 50 inteferometer with Herasil mirrors and steel wires. The second Virgo Science Run (VSR2) will then start with the existing mirrors and reference mass. Unless major troubles in commissioning occur the start of VSR2 could occur earlier than mid-2009. This will give enough time to accumulate data and prepare a change of the mirror payload during the LIGO S6 run.

It is important to remark that **the success of the monolithic suspension relies on the presence of a few key people that all work on a non permanent base**. This is a critical situation that may jeopardize the whole low frequency effort of Virgo.

We finally remind that up to the start of VSR2 and S6, the detector improvements and commissioning activities have the priority over data taking for data analysis or "astrowatch".

3 Advanced Virgo(EGO-STC-112-2008)

After a slow start due to the priority on Virgo commissioning, the Advanced Virgo activity ramped up. The details can be found in the Advanced Virgo report (EGO-STC-112-2008) and

in the reports on R&D activity (EGO-STC-117-2008, EGO-STC-116-2008, EGO-STC-115-2008).

3.1 Milestones

In the Advanced Virgo report the following information should be highlighted. Some important milestones have been set:
Oct 08: AdV workshop to review:
- the **optics design**
- the **length sensing and control scheme**
- the **vacuum needs** (size of the central links, residual pressure requirements)
- the **Thermal Compensation scheme**

Nov 08: Updated AdV design and the updated Project Execution Plan and Cost Plan
Jan 09: Place the order for the mirror substrates (if funding is approved)
Spring 09: AdV workshop to:
- review the optics and LSC design;
- decide BS,PR,SR mirrors geometry and cavity mirrors Radius of Curvatures
- decide on the needed infrastructure modifications.

Fall 09: new AdV workshop to finalize the design.

3.2 Economic resources

The first expenses for Advanced Virgo are expected to be made in 2009. We will continue the Advanced Virgo preparatory work and will provide a more detailed budget ***for the 2008 EGO council meetings, during which we expect to get the approval of our first expenditures.***
It should be noticed that a start of the Advanced Virgo construction after 2009 would automatically delay it compared to Advanced LIGO which is now approved and that has received spending authorization.

Given the R&D funds constraints, a list of priorities among the R&D projects has been proposed (see R&D report). **We ask the STAC to review and hopefully endorse it.**

3.3 Human resources

During the last months, also thanks to the confidence acquired with the achievements of the last phase of commissioning activities and with the approval of the ET Design Study, people are shifting their interest toward the realization of AdV. While Virgo+ is an important step toward Advanced Virgo and must be a success, the Virgo Collaboration will make every effort to allocate enough manpower to the AdV design, though **new resources will have to be acquired** to be able to start the Advanced detector era simultaneously with the LIGO interferometers**.**

3.4 STAC Milestones

About the milestones defined by the STAC at the Nov 07 meeting:
1. a preliminary design of the AdvVirgo detector with a detailed plan for each subsystem: as described in the previous pages, the subsystem manager have been appointed at the end of april/beginning of may and have started the design and planning work. A detailed plan for each subsystem will be presented in the next months.
2. a detailed plan for the whole system with simulations of the subsystem interplay and a detailed installation and commissioning plan.

The subsystem managers started to work on the planning of each subsystem. The subsystem interplay and the construction and installation plan will be better defined in the next months. A preliminary discussion on the commissioning plan will also start, mostly dedicated to defining the main commissioning phases and milestones (i.e. start with or without signal recycling), while a detailed commissioning planning has to be considered a longer term milestone.

4 Data analysis status (EGO-STC-109-2008)

While a detailed description of the activities can be found in the Data Analysis coordinator report (EGO-STC-109-2008) it is worth highlighting a few aspects that show the vitality and the concerns for this activity. Answers to specific questions of the STAC are reported at the end of this section.

4.1 Calibration

With the improvement of sensitivity at low frequency much attention has been devoted to the calibration in the band 10-50 Hz, where a precise knowledge of the transfer function from the correction signals to the mirror position is essential. Measurements of mechanical transfer functions, that include both mirror and marionette actuation have been performed. Radiation pressure was also used to apply a known force to a mirror. In the frequency band of interest the two methods are consistent at the 5 percent level. Differences at high frequency due to differences in the details of actuation are present.

One aspect of the calibration of the network of interferometers has been identified and addressed, namely the timing calibration.

4.2 Data Quality

The analysis groups working on transient events (Bursts and coalescing binaries) have been working together on data quality flags and vetoes tuned to their searches. This is an essential and critical step to be made before any systematic analysis of the data can begin. Several dozen of Data Quality flags has been made available and new glitch finder tools are running on auxiliary and environmental channels.

For the study of continuous sources (periodic sources and stochastic background) the data cleaning has to follow different criteria acting either in the time domain (data segments to be removed) or in the frequency domain (identification and follow up of peaks in the frequency spectrum).

4.3 Burst Group

4.3.1 Analysis of C7 data

A first paper concerning the joint analysis of one day of C7 data in coincidence with resonant bar detectors, mainly with a methodological purpose, was already submitted in 2007, has undergone extensive modifications to answer referees concerns and was recently resubmitted.
A second paper concerning a search in coincidence with the gamma ray burst GRB050915a has been submitted after completion of the review process at the end of 2007.
A third one is an “all-sky” search in the frequency band [150Hz, 2kHz] with astrophysical interpretation of the search results (upper limits) in particular in the context of recently predicted supernova signals and recent black hole –black hole merger waveforms

4.3.2 VSR1 data quality and vetoes studies

A new glitch finder tool (the Kleine-Welle pipeline developed in the LSC) is available for

use. This tool has fast execution time and it is expected to be of help in identifying critical auxiliary channels and understanding the origins of the VSR1 outlier events distribution

4.3.3 Gravitational burst searches in the VSR1 / S5 data

There are two all-sky searches mainly carried on by Virgo people. One is using the EGC pipeline, focusing on the [300 - 5000] Hz bandwidth where Virgo and LIGO detectors had similar sensitivity during VSR1 and S5. The analysis is designed to take fully exploit the Virgo contribution to the network with two fold coincidences. The other is based on coherent WaveBurst focusing on the high frequency [2 -- 6] kHz.
Concerning the searches triggered by external astrophysical signals, we are participating to the combined study of coincidences with gamma ray bursts (GRB). Two GRBs, namely GRB070520b and GRB070729, have been identified for a first joint study (all the interferometers were in science mode around these GRB events). The main effort is currently put on GRB070729.

4.4 CBC

The group considers including Virgo data in the triggered search around some of the GRBs that occurred during VSR1/S5. This work has not started yet, but is expected to gear up from July 2008, with the start of a post-doc position in the Annecy group. The other DA post-doc position assigned to the CB group – the one in Urbino – is expected to be filled in summer and be operative next fall.

4.4.1 Data quality and vetoes

This activity is in common with the Burst group and is in constant progress toward the compilation of the full quality flag and veto list.

4.4.2 Follow-ups

Loud events are subject to follow up that requires dedicated tools. Further work is still needed, especially for automation.

4.4.3 Tests for h(t) validation

Some work is also going on in the CB group to validate the new (v2) h(t) for VSR1, which is in the process of being produced. Some checks on CB triggers and CB hardware injections are being done to assess the quality of the new h(t).

4.5 Periodic source analysis

4.5.1 VSR1 blind analysis

The work to analyse the first half of VSR1, applying a new, more robust cleaning of the peak maps, has continued. The explored parameter space is: all-sky, frequency in [20,1100]Hz, minimum spin-down decay time 20kyr.
The incoherent step of the analysis (based on the Hough transform) has been done on the grid, submitting ~6500 jobs each covering a variable frequency band between 5Hz (at the low frequency end) and 0.1 Hz (at the high frequency end) so that the duration of each job is similar.
First order candidates have been produced, setting a threshold of 3.8 on the critical ratio of the hough maps and their analysis is underway.

4.5.2 Search for known pulsars

Frequency bands can now be extracted from the Short Fourier Transform Data Base (SFDB) data to construct a cleaned time data subsampled sequence. The next step, consisting of a spectral matched filter, is being developed.

The procedure to setup upper limits, using software injected signals, is also being developed.

4.6 Stochastic Background (SBGW)

The activity of the group is totally dedicated to the collaboration between Virgo and the LSC.

4.6.1 VSR1 data analysis and GRID

The search for an isotropic stochastic background is currently in progress on the Caltech cluster. A complete analysis with an artificial time shift has been performed, and the results will be presented at the next LSC/Virgo meeting in June.
Concerning the Virgo side, the possibility of using the GRID is confirmed. The data analysis software has been ported to the GRID environment. A limited number of modifications has been introduced in the SB/NAP library in order to do that, mainly introducing the possibility of directly and transparently access the data published in the GRID catalog.

4.6.2 Non Gaussian backgrounds

There is an activity in the Nice group aimed at the study of non Gaussian stochastic background, in the context of astrophysically motivated models. The main investigator in this activity is Tania Regimbau, that will be helped in the near future by a dedicated postdoc.
This subject is currently discussed in the LSC/Virgo group, and there is the concrete possibility that a dedicated data analysis pipeline will be implemented. If this will be the case, it will be very natural to apply it not only to the VSR1/S5 data but also to the full S5 dataset.

4.7 Data services and tools

A significant activity on data servicing and related tools has taken place, offering now an essential support to the data analysis groups.

Replication of VSR1-LIGO data was completed only in March 2008, several points having been ironed out. While this activity is going to be limited until the first quarter of 2009 further tests will be done to ensure a smooth operation for VSR2.

Raw and reduced Virgo data distribution to the computers centers is now a responsibility of the EGO Computing Department. Data on the computing centers can now be accessed remotely by the groups, two different solutions being implemented in Bologna and Lyon. In addition, some groups are able to access the data over the GRID, although a unified approach isn't available yet.

The Virgo Bookkeeping Database, online at the address http://vdb.virgo.infn.it, is now routinely used by the Burst and CBC groups to store information about the data location, the definition of run segments, as well as tables of status conditions and vetoes.
The database stores now both Virgo and LIGO tables and a newly formed Data Quality group is in fact active since a few months in defining and filling the tables of Virgo veto and quality information. Contact persons in LIGO provide the guidance to upload similar information about LIGO data.

4.8 Offline computing in Bologna and Lyon

We recall that the off line computing for Virgo is performed mainly in the two computing centers of INFN and IN2P3, located in Bologna and Lyon. Some of the groups also access GRID resources at Tier 2 sites.

4.8.1 Resources used to date at INFN Tier1-Bologna

Status of the storage

At present in Bologna the Virgo collaboration has available 108 Terabytes, of which 101 TB are dedicated to data and 7 TB to processed data and user space.
Of the assigned space, 94 TB are used, and 14 TB are available.

CPU utilization

As of May 2008 Virgo has used at CNAF 3450 kSI2k.day, mainly for CW searches.

4.8.2 Resources used to date at CCIN2p3 - Lyon

Storage:

128 TB used in HPSS for all data taking periods since 2001
2TB of disk has been recently added to the existing 300 GB to allow the h(t) VSR reprocessing.

CPU:

Use of the CPUs since 2008 January 1st: 21820 kSI2000.day. Our request for 2008 is 420'000 kS2000.day. Virgo consumption represents for the moment 3.5% of the total CPU consumed by all the other experiments performing data analysis in 2008.

4.8.3 Year 2008 computing cost estimates

The computing costs forecast computed in April 2008, on the basis of requests placed at Bologna and Lyon in 2007, can be summarized as follows:

CC-IN2P3 (unit costs: 0.533E/ KSI2K.day, 0.633E/GB disk, 0.15E/GB tape)

CPU: 120000 KSI2K.days	→ 64 k€
Disk storage: new 60TB Xrootd cache	→ 38 kE
Tape storage: 50TB more in HPSS	→ 7.5 kE
Virgo/User space : 5TB	→ 7 k€

CNAF (unit costs set equal to those of CC-IN2P3)

CPU 100000 KSI2K.days	→ ~51k€
Disk storage: new 30TB on the farm + new 10TB for users	→ ~35k€
Tape storage: 200TB in Castor	→ ~30k€

The total cost of the computing is therefore estimated at 240k€, and starts to be dominated by the computing, no more just by the storage. This is a good sign since it shows the progress of the analysis activity.

However the figures for CPU utilization appear outdated; the latest 2008 forecast for the use of CPU resources, quoted in the Data Analysis report are

Burst: 250'000 kSI2k.day
CW: 100'000 kSI2k.day
CBC: 1'000 kSI2k.day
SBGW: 0 (not running at the CC)

for **a total of about 350'000 kSI2k.day which is 60% higher than computed in April 2008.**
It is to be remarked that the CW request is believed to be a minimum needed, while the main increase is due to the Burst group forecast, partially compensated by a review of the CBC

forecast towards smaller figures. The time consuming analysis are being reviewed and the Burst group is tuning the analysis parameters to reduce the computing costs.

The extra computing energy of 130'000 kSI2k.day would correspond to an extra cost of 70k€, for **a total cost of the offline computing of 310k€ in 2008**.

4.8.4 Comparison with LSC resources

The LSC has available about 6'000 nodes full time, not including the new 5'000 nodes cluster in Hannover. The total computing energy available to LSC is of about 6'000'000 kSI2k.day, roughly twenty times the 2008 Virgo forecast.
If we consider the relative size of LSC and Virgo, and estimate at 5 to 1 the ratio of people actually running searches in the respective collaboration, we see that the Virgo forecast of computing energy / researcher is still short by at least a factor 4 with respect to the LSC one.

4.8.5 Year 2009 trends and preliminary estimates

The preliminary computing estimates for 2009 by the different search groups are the following
Burst: 500'000 kSI2k.day
CW: 300'000 kSI2k.day
CBC: 200'000 kSI2k.day
while the SBGW group plans not to use the resources at the CCs.

This gives a total of 1'000'000 kSI2k.day which should be taken with great care since numbers could still vary by small factors. Particularly the CW might turn to be an underestimate.

Such an energy roughly correspond to the computing power delivered by a 1'000 nodes computing center, to be compared to the 11'000+ nodes available in 2009 to the LSC.
We believe that these figures are therefore realistic and probably underestimating the real needs, when considering a prudent 5 to 1 ratio of researchers active in analysis.

At the 2008 costs, the CPU alone would therefore cost about 500 k€, to which one may expect to add O(100 k€) for storage and user disks.

4.9 Answers to November 2007 STAC recommendations

The answers to the last STAC recommendations are presented here, summarizing most of what has been described in the Data Analysis section and in the corresponding report.
Quoting the November 2007 STAC report (EGO-PRE-STAC-94)

1. The Data Analysis activities are proceeding very well. The team is well organized, the methods and plans are clearly stated. **The STAC considers that the collaboration should avoid concentrating on data processing only and should be more active in data analysis and interpretation if it wishes to play a leading role in this field. The STAC thinks that such a role is an essential part of the Virgo success. Of course the collaboration is undermanned compared to the LSC and cannot compete with it in quantitative way but leadership is not about quantity but quality.**

The Virgo components of the search groups have undertaken several initiatives in order to have a visible impact on the LSC-Virgo collaboration, by means also of *flagship* searches:

- a coherent high frequency (above 1-2kHz) search for burst events has been proposed, implementing modifications to the LSC algorithm “Coherent Wave Burst” which have

enabled it to run efficiently over a wider frequency band. The first analysis tests are encouraging and the LSC-Virgo collaboration is considering to extend the application of the modified method to the analysis of data prior to the start of the data sharing agreement, with an obvious impact on the publication plans.

- An all-sky search for burst events based on a Virgo algorithm (EGC), targeting the intermediate and high frequency range (300Hz - 5 kHz), has been proposed as an original contribution to the analysis of coincident VSR1 - S5 data. The method is based on the coincidence of pairs of detectors, which allows to optimize the sky coverage and is expected to lead to an increase of detection efficiency up to 50% if compared with a search requiring coincidence among all detectors; preliminary results are encouraging. The method requires a large computing power, which motivates an increase of our requests for computing budget, that we have tried to justify in the burst search section of this report.
- The development of data quality (DQ) and veto information for Virgo data is being carried out by Virgo people. New DQ are regularly developed and released for the use by the search groups.
- The Virgo Data Base system has been proposed by Virgo as the solution to the complex bookkeeping problem represented by the many detector and veto conditions on the different instruments, and is being considered as a possible reference tool.
- In the CBC group, the searches around GRB for which Virgo has a favorable orientation will be led by Virgo folks.
- The CBC group made also an effort to contribute to coherent searches, and to techniques exploiting higher harmonics content in the signal; these may not lead to a leadership in the short term but should keep the group up to date with promising developments.
- The Virgo CW group is pursuing a strategy for targeting low frequency pulsars, leveraging on the better Virgo sensitivity, and the calibration team has supported this initiative by a large effort to provide accurate data down to 10Hz.
- In parallel, the CW group keeps developing original methods for noise removal and for targeting pulsars in the frequency – spin down parameter space more efficiently than with conventional methods. These techniques are likely to become reference techniques for LSC-Virgo.
- The SB group is investigating the detection prospects of non-Gaussian stochastic background, as resulting from astrophysical sources. This could lead to the development of a pipeline, which could be applied to the entire S5 data and not only the portion coincident with VSR1.

It is to be underlined again that acquiring and keeping a leadership in some search has a price in terms of computing costs. In order to carry out a credible search, to win a consensus about its sensitivity and correctness in front of the LSC colleagues, it is necessary to invest a computing power consistent with what the LSC is investing.

One reasonable criterion is to spend a similar amount in computing for each FTE in data analysis; our requests for 2008 and 2009 aim precisely at this objective, which would procure an equal status to Virgo DA scientists in the LSC-Virgo collaboration.

For this reason, **we are asking the STAC to review the computing requests and endorse them.**

5 Outreach

5.1 Newspaper and magazines

After the several articles triggered by the First Virgo Science Run, the rate of appearance on the press has somewhat slowed down.
An extended article on Virgo appeared on Locus, a local quarterly cultural review. The march 2008 issue "Pisa: I luoghi della ricerca", included also an interview to Adalberto Giazotto (http://locus.felicieditore.it/).
A short article on the status and perspectives of GW research has been published on the last issue of "Aspera this Month", the newsletter of Aspera, the network of the agencies funding astroparticle physics research.
http://www.aspera-eu.org/
http://www.aspera-eu.org/index.php?option=com_content&task=blogcategory&id=47&Itemid=97
Additional contribution to ASPERA initiatives are planned with the help of the APC group.

5.2 Site visits

As usual, during the school year, most of the Saturday mornings have been devoted to receive one or two school classes.
On March 4 there was an informal, but not less important, visit by the mayor of Cascina, accompanied by several members of the local administration.
On March 8, in the framework of the XXVIII Settimana della Cultura Scientifica, the third "Open door day at EGO" was held; several EGO and Virgo members devoted the full morning to assist and guide the visitors.

5.3 Exhibitions

Our participation to the Ludoteca Scientifica (http://www.ludotecascientifica.it/index.htm) was successful, thanks to the traditional initiative to assemble "100 € interferometers" to be donated to the participant schools.

5.4 LIGO/Virgo

The LSC is also involved in an intense outreach program and contacts have started to find synergies also in these activities.

6 Collaboration organization

6.1 New groups

The Padova-Trento has joined Virgo. These are physicists that were working on the AURIGA resonant bar and who are bringing to Virgo their expertise in data analysis and detector characterization. They have been able to start very rapidly contributing to the data analysis of burst events, in collaboration with the LSC.

The APC group from Paris was formed by a few Virgo members coming from existing groups. The location of the group within the University of Paris 7 as well as the general interest of the Laboratory should permit to establish closer links between Virgo and other scientific communities, one of the aims being multimessenger observations.

Finally contacts with Polish scientists already well known in the field have lead to a proposal for participation of the POLGRAW group in Virgo. This was approved by the collaboration and is waiting the definition of the participation by the EGO Council.

Without counting the EGO contribution, that is in the process of being defined, this makes a total of 17 groups and 4 countries.

6.2 Remote participation

A significant effort was undertaken to improve the participation of people to the collaboration meetings. Phone conferences have been working rather well, in particular for the meetings located in Cascina. There technical support for sound quality is available, and meeting participants have learned to upload their presentation so that remote participants can follow the presentation. However sometimes sound is poor, which discourages participation. A common effort with LSC was undertaken to improve the situation addressing sound and video issues, either with commercial software or with some software developed for the scientific community (EVO for High Energy Physics). The goal is to fully involve people off the sites (either European or US) offering comfortable audio and video channels, increase participation (and contribution) and reduce travel somewhat. This imply asking for audio equipment that meets some standard and diffusing the culture of organized meetings. A small contribution to the development might be required while phone and phone conference expenses for meetings should drastically diminish.

In this effort the role of EGO staff on site is essential to guarantee a high quality service.

6.3 External collaboration

The close collaboration with the LSC is on-going, with especially the joint data analysis working group. Exchanges on technical topics continue (coating, thermal compensation, charging…). We had joint collaboration meetings in March and in June in Orsay. the next meeting is a Data Analysis meeting end of October.

All effort will be done to have maximum overlap between the data taking periods of LIGO and Virgo starting from 2009 onwards.

The definition of the procedure to assess a detection is progressing with the setup of a joint LSC-Virgo committee. The announcement procedure has been submitted to the funding institutions for comments and eventually approval.

7 Manpower Statistics

This section gives a summary of the Virgo Manpower. This is a compilation of the 2007 Memorandum of Agreement between the groups and the collaboration. This detailed information is available in the Virgo codifier (https://pub3.ego-gw.it/codifier/). The MoAs, and therefore the following tables are covering the period October 1 2007 to September 30th 2008. The data include the Polish POLGRAW group, who has a primary commitment in Data Analysis and more specifically in the Periodic Sources group.

Table 1. Manpower distribution

Group	Persons	FTP	Student	Authors	FTE	V	V+	AdV	DA	Other
Annecy	18	11	0	12	14.8	3.2	8.2	0.3	3.3	0

Artemis	14	5	2	12	10.2	1.4	2.8	3	3	0
Firenze	10	6	2	10	9.4	1.9	1.7	3.8	2	0.8
Genoa	8	0	1	3	2.8	0.5	0.8	1.5	0	0
LMA/ESPCI	12	0	1	8	4.6	0.4	2.5	1.7	0.1	0
Napoli	15	1	4	10	7.9	2.1	0.1	3.1	2.6	2.2
NIKHEF	7	0	1	4	4	0.6	1.6	0	1.9	0
Orsay	7	5	0	8	6	0.7	0	1.6	3.7	0
Padova-Trento	4	0	0	4	2	0.2	0	0	1.8	0
Perugia	10	2	2	9	3.5	0.5	1	1.1	1	3.4
Pisa	24	6	7	22	14.7	2.6	2.5	4.2	5.4	4.6
POLGRAW	8	0	0	7	4.1	0.4	0	0	3.7	0
Roma I	16	7	2	9	12.1	1.1	2.8	3.1	5.1	0
Roma II	10	0	2	8	6.8	0	2.8	2.2	1.8	0
Total	**163**	**43**	**24**	**126**	**102.9**	**15.6**	**26.8**	**25.6**	**35.4**	**11**
EGO	32	25	0	21	28.1	18.1	6.2	1.9	1.9	
Total	**195**	**68**	**24**	**147**	**131**	**33.7**	**33**	**27.5**	**37.3**	**11**

Remarks:

- FTP is the number of person (including the one with teaching duties) who are working full time on Virgo, excluding the students (who usually are 100% on Virgo).
- The V column quotes the FTE spend on the current Virgo detectors (commissioning activities, services activities,…)
- The V+ column quotes the FTE working of the preparation of the Virgo+ upgrades.
- The AdV column quotes the FTE working on the preparation of the Advanced Virgo, (baseline and possibles options)
- DA is for data analysis
- The column "other" includes activities that are not part of the Virgo/V+ or Advanced program (like the cryogenic activities), but are listed as Virgo contribution in the institution list. These activities are not included in the total FTE which is just the sum of the V, V+, AdV and DA columns.

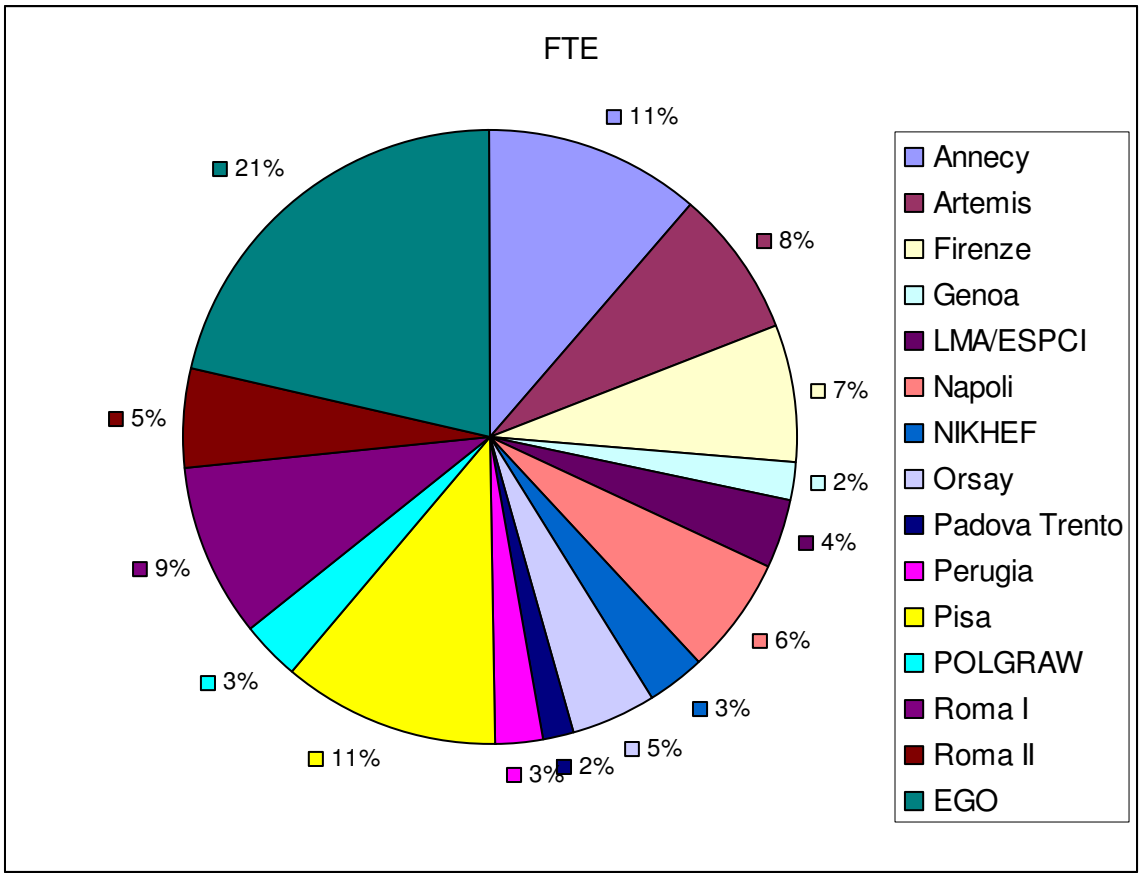

Figure 1 Graphical representation of the FTE contribution to the Virgo Collaboration.

Data Analysis is an area that needs to be strengthened. Quantitatively the participation of the POLGRAW group brings a net increase to the manpower dedicated to that subject. Qualitatively Virgo has several groups with a long tradition in GW data analysis and now Padua Trento is also fully efficient. With proper support they will increase significantly the contribution of Virgo to the common data analysis effort. It is noted explicitly that the data analysis groups are ready to use additional manpower if resources become available.

The following table gives the breakdown of the contributions to the different data analysis working groups. Notice that some persons who are working on the data analysis are sometimes contributing to different analysis groups or are working on other hardware activities.

Table 2. Manpower distribution in Data Analysis tasks

Topic	# of persons	FTE
Coalescing Binaries	12	5.8
Bursts	19	11.2
Periodic	19	8.7
Stochastic	5	2.4
Noise, Data transfer, support	19	7.2

8 Conclusive remarks

Excellent results have been obtained in the sensitivity curve and a remarkable stability has demonstrated, during VSR1 and afterwards. This makes Virgo and EGO confident to be able to undertake the next necessary steps toward detection and study of gravitational waves, from the scientific and technical point of view. These results have been achieved under the spokespersonship of Benoit Mours. The organization has also been more formalized, a necessary step to ensure a long life to this scientific enterprise.

The collaboration agreement with the Ligo Scientific Collaboration, also reached by Benoit Mours, is an opportunity to further increase performances. The unavoidable comparison shows that there is an unbalance between Virgo and LSC in the area of Data Analysis. This is a stimulus to search for better and more efficient ways to analyze data, that is an advantage for the quality of the scientific results produced.

However the current simple numerical unbalance between Virgo and the LSC indicates a critical area, both in terms of number of persons involved and of computing means. The way computing resources are allocated has drastically changed with the charging policy of the national Computing Centers. The available computing resources are barely sufficient to ensure the presence of Virgo in the joint data analysis tasks.

The upgrade toward Advanced Virgo is a necessary step from the scientific point of view. The collaboration is confident to be able to meet the challenge of reaching the Advanced Virgo sensitivity. The process has started with the intermediate step Virgo+ but it apparent that a long term perspective must be given. This is not only to secure financial resources but also to attract and further motivate the people that will have to produce scientific results in five years from now.