EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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APPLICATION FOR OBSERVING TIME LARGE PROGRAMME PERIOD: **71A**

To be submitted only to: proposal@eso.org
Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of COIs and the agreement to act according to the ESO policy and regulations, should observing time be granted

1. Title Panel: **A–1**

The Great Observatories Origins Deep Survey: ESO Public Observations of the SIRTF Legacy/HST Treasury/Chandra Deep Field South

2. Abstract / Total Time Requested

TotalAmountOfTime: 125h TotalNumberOfSemesters: 3

This proposal represents the continuation with VIMOS of the ESO campaign to secure essential ground-based data for the Great Observatories Origins Deep Survey (GOODS). Through ESO, the European astronomy is playing a major role in this public survey program, with raw and reduced data products to be rapidly released to the community. GOODS combines observations with three NASA Great Observatories (*HST*, *SIRTF*, and *Chandra*), ESA's *XMM–Newton* and ground–based telescopes to carry out an intensive study of galaxy evolution and cosmology. GOODS is designed to measure the evolution of stellar mass content and star formation activity in galaxies from $z \sim 5$ to $z \sim 0.5$; to map the emergence of the Hubble Sequence; to take a census of energetics from massive central black holes in galaxies and study their role in galaxy evolution; and to secure a large sample of SNe Ia at $1.2 < z < 1.8$ to confirm or rule out the accelerated cosmic expansion. **This specific program with VIMOS will provide low-resolution spectra for redshift determination for all ~ 6000 objects in the 160 arcmin^2 area of the GOODS field in the Southern hemisphere, down to mag=25.** This public data set will allow the ESO community to start cutting–edge research with GOODS data alone, as well as to most efficiently plan for further follow–up studies with the VLT.

3.

Run	Telescope	Instrument	Time	Month	Moon	Seeing	Sky Trans.	Obs.Mode
A	UT3	VIMOS	1h	aug	d	$\leq 0.8''$	CLR	s
B	UT3	VIMOS	10h	sep	d	$\leq 0.8''$	CLR	s
C	UT3	VIMOS	10h	sep	d	$\leq 0.8''$	CLR	s

4. Principal Investigator: **C. Cesarsky** (ESO, ESO, ccesarsk@eso.org)

CoI(s): J. Bergeron (IAP, F), S. Cristiani (INAF, I), L. da Costa (ESO, ESO), E. Daddi (ESO, ESO), M. Dickinson (STScI, USA), D. Elbaz (CEA, F), S. Ettori (ESO, ESO), R. Fosbury (ST-ECF, ESA), M. Giavalisco (STScI, USA), R. Hook (ST-ECF, ESO), H. Kuntschner (ST-ECF, ESO), B. Leibundgut (ESO, ESO), M. Nonino (INAF, I), A. Renzini (ESO, ESO), P. Rosati (ESO, ESO)

5. Description of the proposed programme

A) Scientific Rationale: The first part of this section replicates the basic information on the GOODS project, as from the GOODS Large Programme proposal submitted for P70, approved by OPC, and and currently being carried out. Updates, whre needed, are in *italic*. The P70 proposal had illustrated the integrated strategy for a complete, low-resolution spectroscopic follow-up first with FORS2 (in P70) and then with VIMOS (in P71 and following periods). VIMOS is now being offered, and the current proposal describes the GOODS strategy with this instrument. **Quotation from P70 proposal begins here**.

GOODS in Context: The Great Observatories Origins Deep Survey (GOODS) is a public, multi–facility project that aims to answer some of the most profound questions in cosmology: How did galaxies form and assemble their stellar mass? When was the morphological differentiation of galaxies established and how did the Hubble Sequence form? How did AGN form and evolve, and what role do they play in galaxy evolution? How much do galaxies and AGN contribute to the extragalactic background light? Is the expansion of the universe dominated by a cosmological constant?

A project of this scope requires large and coordinated efforts from many facilities, pushed to their limits, to collect a database of sufficient quality and size for the task at hand. It also requires that the data be readily available to the worldwide community for independent analysis, verification, and follow–up. To accomplish this, NASA proposed a new concept for large–scale investigations: the Legacy/Treasury programs. These are defined as (1) large, coherent science investigations, not reproducible by any reasonable number or combination of smaller General Observer programs; (2) programs whose archived scientific data are of general and lasting importance to the broad community; and (3) programs for which all raw and pipeline–processed data **must enter the public domain immediately**, enabling timely and effective opportunities for follow–on observations and archival research.

Among the approved Legacy/Treasury projects, GOODS (http://www.stsci.edu/science/goods) is a deep, high latitude survey to study cosmology and galaxy evolution. The program targets two carefully selected fields, the Hubble Deep Field North (HDF–N) and the Chandra Deep Field South (CDF–S), with the three NASA Great Observatories (*HST*, *SIRTF* and *Chandra*), ESA's *XMM–Newton*, and a wide variety of ground–based facilities (see Table 1). The area common to all the observing programs is 320 arcmin^2, equally divided between the N and S fields. For an overview of GOODS, see Dickinson et al. (astro-ph/0204213) and Renzini et al. (astro-ph/0204214).

European collaboration was established in all major components of GOODS since its inception, including the *SIRTF* Legacy Program (P.I. M. Dickinson; 647 hours of observing time), and the *HST* Treasury Program (P.I. M. Giavalisco; 398 orbits). Given the public nature of the survey and the importance of wide community involvement, European participation at large was also stimulated through an Open Letter, emphasizing the importance of coverage from the observatories at La Silla and Paranal for Legacy programs with substantial involvement from the ESO community (http://http.hq.eso.org/observing/misc/20000824.sirtf.html).

Ground–based observations are an integral part of GOODS. The Legacy project was allocated multi–year blocks of NOAO time for deep optical and infrared imaging, including critical U–band imaging, which cannot be done with ACS. ESO allocated 298h of near–IR imaging of the CDF–S with ISAAC in P68-70-72, and 40h of optical imaging with WFI to reach deeper flux limits compared to the EIS data on the same field (see Table 1). With this proposal, we seek to secure one of the most important parts of the whole project, namely spectroscopic observations for redshift identification in the CDF–S.

Science with GOODS: Each segment of the GOODS project aims at major scientific goals. Here we review some of these, with emphasis on the data from the CDF–S.

• *SIRTF*/IRAC data from 3.6 to 8.0μm will sample the rest–frame near–IR light (e.g., K–band at $z \sim 3$) of $\sim L^*$ galaxies out to $z \sim 5$, providing the best measure of stellar mass to reconstruct the mass assembly history of galaxies from $z \sim 5$ to $z \sim 0.5$. *SIRTF* CDF–S observations are planned for Aug 2003 – Feb 2004.

• 24μm *SIRTF*/MIPS data will detect dust–obscured star forming galaxies and AGN with a 6$''$ FWHM beam, locating them to $\sim 1''$ accuracy and enabling the identification of optical/near-IR/X-ray/radio counterparts. ISOCAM 15 μm surveys studied obscured star formation at $z \sim 1$; GOODS 24 μm data will extend this work to $z \approx 2.5$ by probing the rest–frame 7.7 μm PAH emission from relatively "ordinary" starburst galaxies.

• *HST*/ACS *is now imaging* the GOODS field in the F435W (B), F606W (V), F775W (i), and F850LP (z) bands with "near–HDF" sensitivity. The observations (see Fig. 2) are phased in 5 epochs (with the CDF–S in the period Aug 2002 – Feb 2003) to allow detection of type Ia supernovae at $1.2 < z < 1.8$ to test the transition from decelerated to accelerated expansion predicted in "dark energy" cosmological models. Deep, high–resolution imaging will trace the emergence of the Hubble Sequence, gather a census of Lyman break galaxies (LBGs) out to $z \approx 6.5$ (i.e. approaching the reionization epoch), and provide a rich resource for studying the cosmic mass distribution via weak gravitational lensing. *At the time of submitting this proposal complete data for the first three epochs have been successfully completed, and the reduced data for the first epoch have been publicly released.*

• Deep JHK_s imaging with ISAAC over the GOODS/CDF–S bridges the wavelength gap between ACS and *SIRTF*, providing optical rest–frame photometry for high redshift galaxies. Data for about 1/3 of the field have

5. Description of the proposed programme (continued)

already been taken in P68 and have been made immediately publicly available from the ESO/GOODS URL (www.eso.org/science/goods). The preliminary (V0.5) version of the coadded and reduced frames have *been released in March 2002*. These include JK_s data for part of the field from another program (PI E. Giallongo), whose PI kindly waived his proprietary rights.

Besides the above data taken explicitly for the GOODS project, other complementary data on the two GOODS fields are publicly available or are now being collected. These include:

• The deepest *Chandra* (1–2 Msec) and *XMM–Newton* (225–500 ksec) X–ray observations. Using these X-ray data, the sample of SIRTF 24 μm-selected sources will be "sorted" among starburst galaxies and AGN, enabling a census of energetic output from both types of objects, and a determination of the relative abundance of type 2 (obscured) vs. type 1 (unobscured) AGN at the "quasar epoch" ($z \sim 2$–3).
• Far-UV (135-180 nm) and Near-UV (180-300 nm) imaging of the GOODS fields will be secured by GALEX, to be launched by NASA in *February 2003*.
• Radio observations, including data from the VLA and new CDF–S observations from the ATCA.
• The *SIRTF*/SWIRE Legacy Project. While shallower than GOODS, it includes a much larger (7.2 deg^2) field around the CDF–S, with ESO supporting optical imaging from WFI (PI A. Franceschini).
• The COMBO-17 project, having imaged a $30' \times 30'$ region around CDF–S through 17 broad and intermediate-band filters, will observe this area with *HST*/ACS through F606W and F850LP as a Large Program (*GEMS*, PIs K. Meisenheimer & H.-W. Rix).

From this list it is clear that GOODS offers an absolutely unique combination of area, depth, angular resolution and wavelength coverage for studying the distant universe. GOODS is arguably the most ambitious, complete and coherent attempt to understand fundamental cosmology and galaxy formation and evolution for many years to come. The GOODS data base will set the ground for a variety of follow–up programs from future facilities such as NGST and ALMA.
Clearly, imaging alone is not sufficient to reach GOODS scientific goals. Spectroscopy is essential to get reliable redshifts, which provide the time coordinate needed to delineate the evolution of galaxy masses, morphologies, and star formation. It will also calibrate the photometric redshifts that can be derived from the 13–band imaging data at 0.36–8μm. Spectroscopy will measure physical diagnostics for galaxies in the GOODS field (e.g., emission line strengths and ratios to trace star formation, AGN activity, ionization, and chemical abundance; absorption lines and break amplitudes that reflect stellar population ages). Precise redshifts are also indispensable to properly plan for future follow–up at higher dispersion, e.g., to study galaxy kinematics or detailed spectral line properties.
Among southern hemisphere observatories, ESO has unparalleled spectroscopic multiplex. It is therefore proposed that ESO will lead the southern campaign with an effort proportional to the unique capabilities of its VLT. In the same spirit as the multiwavelength GOODS imaging programs, we aim to collect and disseminate a public data resource of low resolution spectra for *all* the objects in the GOODS/CDF–S field which can feasibly be observed. As demonstrated below, this can be achieved with a rather modest investment of VLT time. Given the size of the GOODS/CDF–S field, the field of view of the VLT multiobject spectrographs, and the number of feasible targets, we argue that this campaign is most efficiently done as a single project, as opposed to a set of several smaller projects each selecting targets according to different criteria. For a project of the scientific importance of GOODS, we argue that **completeness** and **uniformity** of the low–resolution spectroscopic database is mandatory.
The ESO/GOODS spectroscopic program is a complete, magnitude–limited survey, observing all galaxies for which VLT optical spectroscopy is likely to yield useful data (*i.e. redshifts*). The program will make full use of the VLT instrument capabilities (FORS2 and VIMOS), matching targets to instrument and disperser combinations in order to maximize the effectiveness of the observations. The magnitude limits and selection bandpasses depend to some degree on the instrumental setup being used. *The aim is to reach mag = 25 with adequate S/N, with this limiting magnitude being in the B band for objects observed with the VIMOS LR-Blue grism, in the V band for those observed in the LR-Red grism, and in the z band for the objects being now observed with FORS2.* This is not only a practical limit, however, but is also well matched to the scientific aims of the GOODS program. The ACS i-band imaging will sample rest–frame optical (B–band) light out to $z = 1.2$, where $i_{AB} = 25$ reaches 1.5 to 2 magnitudes past L^*_B. This is also the practical limit for high–quality, quantitative morphological measurements from the ACS images (cf. Abraham et al. 1996). Similarly, $i_{AB} = 25$ is ~ 1 mag fainter than the measured L^*_{UV} for $z = 3$ LBGs, and 0.5 mag fainter than that at $z = 4$ (Steidel et al. 1999). These are the limits to which GOODS/*SIRTF* IRAC data will robustly measure rest–frame near–IR light, and hence constrain the stellar mass. The proposed ESO spectroscopy will therefore target galaxies to luminosities where the *HST* and *SIRTF* data will be most valuable.
Certainly, low-resolution spectroscopy alone will not answer all the scientific questions that will arise by studying the GOODS database. Spectroscopy at higher resolution than that proposed here will be necessary to derive dynamical masses for high redshift galaxies (from rotation curves of spirals and velocity dispersion of spheroids), chemical compositions of passively evolving and star-forming galaxies, detailed stellar population indices, etc.

5. Description of the proposed programme (continued)

However, such projects are sufficiently diverse and self–contained that they may be carried out more effectively with dedicated follow–up programs. As a public survey, GOODS will concentrate on low–resolution spectroscopy for the purpose of redshift identification. These data, together with the multiwavelength imaging from ground– and space–based observatories, will then promote both archival research and dedicated programs of follow–up observations. ESO will make every effort to promote effective coordination among those teams from the community that aim to submit such proposals, and hence a more efficient use of the VLT.
End of quote from P70 proposal.

B) Immediate Objective:
Two spectrographs are needed to carry out the GOODS observing program, namely 1) VIMOS, the workhorse instrument due to its uniquely large multiplexing power, which will be used every time that extreme red sensitivity is not key to the success of the observations; and 2) the newly refurbished FORS2, when its unique sensitivity at red wavelengths is required. While the observing time has already been allocated on FORS2 in P70, and the observations are under way (data can already be retrived from www.eso.org/science/goods/products.html#spectroscopy, see also Fig. 3 &4, here we provide a description of the overall observing program with both instruments, as currently envisaged.
To the limits of VIMOS spectroscopic capability (say, $V_{\rm AB} = 25$), there are $\sim$ 6000 objects over the 160 arcmin^2 of the GOODS field, or $\sim$ 37 arcmin^{-2}. This is $\sim 10\times$ higher than the surface density of VIMOS slits ($\sim 800/224 = 3.6$ arcmin^{-2}). Hence, more than 10 masks per pointing are necessary to ensure virtual completeness in the spectroscopic survey. Moreover, the VIMOS field of view ($16' \times 18'$, with a cross gap of $2'$ between the quadrants) is such that only 50% of it can overlap with the $10' \times 16'$ GOODS field. So, up to 400 objects at a time could be observed. We calculate that $\sim$ 24 VIMOS *masks, 6 for each of 4 pointings* are necessary to ensure $\sim$ 90% completeness in the spectroscopic coverage of $\sim$ 6000 targets in the GOODS field, with the extra bonus of longer–than–average integration times on sources located in 45% of the field (Renzini et al. 2002, astro-ph/0204214). With an average integration time of 4h per pointing, and $\sim$ 30% overhead, this makes a total of 125h, or $\sim$ 13 nights.
As mentioned above, there are three possible instrument/disperser combinations to carry out the GOODS low-resolution spectroscopic survey: VIMOS/LR-Blue, VIMOS/LR-Red, and FORS2, and in order to maximize the efficiency of the survey a strategy is needed to identify the setup of choice for each target. Figure 1 shows the total instrument+telescope throughput for these three options, and Table 2 summarizes the situation. It shows that $\sim$ 60% of the objects are best observed with VIMOS/LR-Red, $\sim$ 30% with VIMOS/LR-Blue, and $\sim$ 10% with FORS2. The P70 GOODS proposal was focused on the FORS2 observations dedicated to objects best observed with this instrument, i.e. those with $(R-I)_{\rm AB} > 1$ and $I_{\rm AB} < 25$. In practice, for the observations being carried out in P70 it was decided to use the superior GOODS/ACS data already publicly available, hence the actual selection has been $(i-z)_{\rm AB} > 0.6$ and $z_{\rm AB} < 24.5$ with $\sim$ 450 galaxies fulfilling this criterion. Also for the GOODS/VIMOS spectroscopic observations the targets will be selected from the GOODS/ACS catalogs.
For the observation with VIMOS a simple color criterion would not ensure the best target-to-setup assignement, and a more refined, two step strategy will be applied. Step 1: On the basis of photometric redshifts (from GOODS publicly available $UBVizJHK$ data) the λ-range in which the key spectral features are expected will be identified, and following Table 2 $\sim 2/3$ of the objects will be observed first with VIMOS red and $\sim 1/3$ with VIMOS blue, primarily in P71+P72. Step 2: Objects which fail to yield redshifts in P70-72 will be re-observed in P74 with the complementary grism. No observations are planned for P73. It is also planned to reach down to $B < 25$ for objects observed with the blue grism and to $V < 25$ for those with the red grism.

C) Telescope Justification: Spectroscopy of so many objects down to the stated limiting magnitudes requires VLT+VIMOS.

D) Observing Mode Justification (visitor or service): Service mode is preferable, given that the S/N of faint object spectra will critically depend on the seeing. However, visitor mode will also be acceptable.

5. Attachments (Figures)

Table 1: GOODS Observations and Complementary Data Sets.

Wavelength	Facility	Sensitivity (S/N=5)
0.36μm	KPNO+CTIO 4m	AB = 27.3 (U)
0.4-0.9μm	*HST*/ACS	AB = 27.9, 28.2, 27.5, 27.4[a] ($BViz$)
1.2-2.2μm	VLT, KPNO 4m	AB = 25.2, 24.7, 24.4 (JHK_s)
3.6-8.0μm	*SIRTF*/IRAC	AB = 24.5, 24.5, 23.8, 23.7 (0.6–1.2 μJy)[b]
24μm	*SIRTF*/MIPS	20-80 μJy[c]
Type	**Facility**	**Notes**
Spectroscopy	VLT, Gemini, Keck	Various PIs; GOODS programs & collabs.
X-ray	*Chandra*, *XMM*	Public *Chandra* data and *XMM* GTO progs.
70, 160μm	*SIRTF*/MIPS	*SIRTF* GTO program; SWIRE Legacy program
Sub-mm	SCUBA, SEST	Various PI programs
Radio	VLA, ATCA	Various PIs; CDF–S observs. in progress

[a] For 0.5 arcsec diameter aperture
[b] For "handbook" IRAC PSF; 3.6 and 4.5μm performance may be better
[c] Uncertain sensitivity; depends on instrument performance and source confusion

Table 2: Most Effective Instrument Setups vs Redshift

Redshift	Fraction	Key Features	Instrument/grism
$z < 0.5$	24%	[OII], Hβ, [OIII], (Hα), CaII H&K	VIMOS blue
$0.5 < z < 1.3$	56%	[OII], Hβ, CaII H&K	VIMOS red/FORS2
$1.3 < z < 2.3$	12%	[OII], CaII H&K; CIV, AlII	FORS2/FORS1-UV(?)[a]
$2.3 < z < 3.5$	6%	Lyα, SiII, CII, CIV, OI, SiIV	VIMOS blue
$z > 3.5$	1%	Lyα, SiII, CII, CIV, OI, SiIV	VIMOS red/FORS2

This table shows for the various redshift intervals the fraction of galaxies in a $R = 25$ limited sample (from photometric redshifts), the features most useful for redshift determination, and the most appropriate instrument/grism combination for detecting such features.
[a] In this range the lack of a near-IR spectrograph and of a UV-optimized spectrograph will limit somewhat the capability of measuring the redshift of intrinsically red and blue galaxies, respectively.

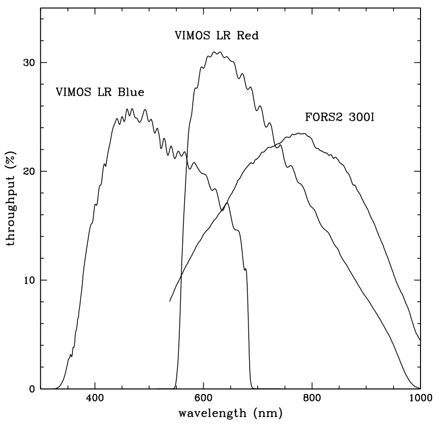

Fig. 1 - The VIMOS and FORS2 throughput for the grisms adopded for the GOODS survey.

5. Attachments (Figures)

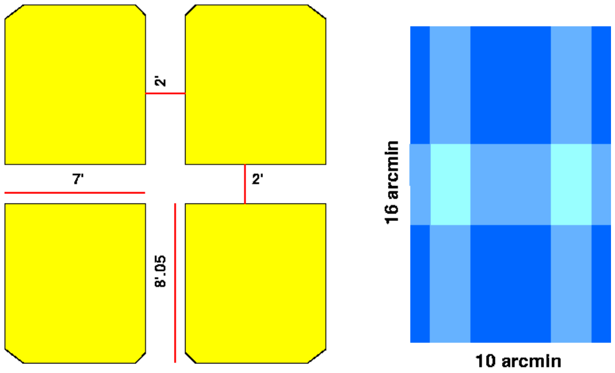

Fig. 2 - The VIMOS field of View and its 4-pointing imprint over the GOODS field.

Left: The geometry of the VIMOS field of view, for either imaging or multiobject spectroscopy. *Right:* The CDFS/GOODS $10' \times 16'$ field, in the same scale as the VIMOS FoV. The VIMOS 4-pointing imprinting on the GOODS field is rendered with different shadings. Dark areas: areas common to all 4 VIMOS basic pointings (A set of subfields). Shaded areas: areas common to 2 VIMOS pointings (B set of subfields). Lightly shaded areas: areas covered by only one VIMOS pointing (C set of subfields). Subfields A will be covered by all the 24 planned masks, subfields B by 12 masks, and subfields C by 6 masks only. Correspondingly, spectra will be obtained for $\sim 100\%$ of targets down to mag~ 25 in area A, for $\sim 85\%$ in area B, and for $\lesssim 60\%$ in area C. The actual efficiency may be somewhat reduced in area B when using the blue grism, as for each pointing there will relatively few objects to observe, i.e. ~ 3 times the maximum number of slits.

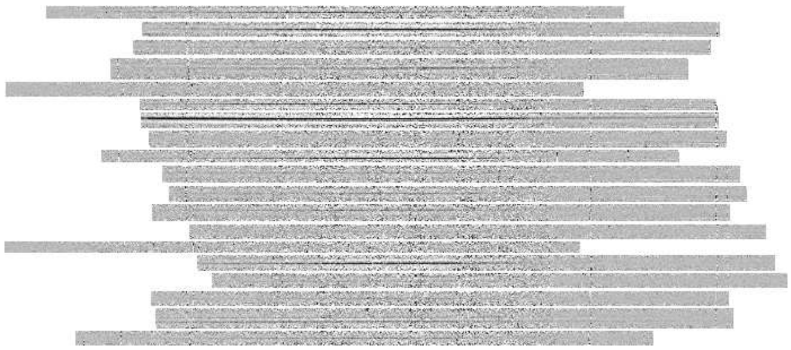

Fig. 3 - A sample of GOODS/FORS2 spectra.

These spectra have been obtained during the October 2002 run of the GOODS program with FORS2, and have been retrived from the ESO public archive. The sky-subtracted spectra shown here come from only one of the two FORS2 CCDs.

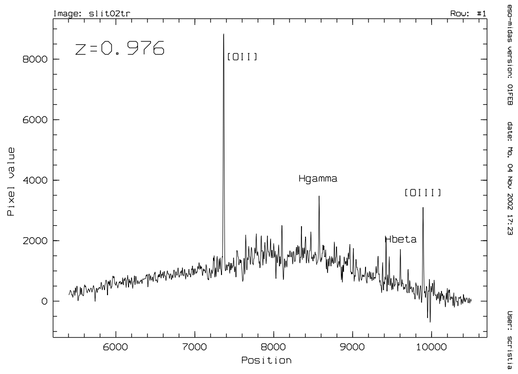

Fig. 4 - An example of an extracted emission line galaxy at a redshift of one.

6. Experience of the applicants with telescopes, instruments and data reduction

Many of the proposers have extensive experience with deep multiobject spectroscopy of faint targets with the VLT and other facilities, and are well versed in the reduction of these sorts of data. Moreover, many have lead or contributed to major surveys with rapid public data releases, such as the HDF and EIS programs.

7. Resources available to the team, such as: computing facilities, research assistants, etc.

ESO shall take responsibility for the whole data taking, reduction, and prompt dissemination world–wide, both in the spirit of Legacy/Treasury Programs and as a firm commitment to its own community. The list of targets, maps, etc. will be posted on the ESO/GOODS web well in advance of the observations. The immediate public release of the raw data will be made using the standard resources of the ESO archive. For the processing and prompt dissemination of the spectroscopic data, a dedicated team is being established including – besides the proposers – a suitable number of scientists from the ESO community. This opportunity will also be widely advertised through the web and The Messenger, and it is ESO commitment to achieve the widest possible involvement of the community in the data production process. Data products will include reduced, coadded, calibrated and extracted spectra. The Team will be committed to exploit VIMOS/FORS pipeline tools, experiencing an in-house scientific validation of such tools and provide feedback to the pipeline producers. Besides working as an early testbed for pipelines, the GOODS project is already offering to the AVO project data to start built "bottom-up" Virtual Observatory tools using top quality data in wide demand. Funding will be requested from the EC for Fellowships associated with the exploitation of GOODS data.

8. Special remarks

Two other major European programs are underway on the CDF-S field and are submitting VIMOS proposals: the follow-up of XMM X-ray sources and optically selected AGNs (PI J. Bergeron) and the VIMOS follow-up of the COMBO17/GEMS project (PI M. Barden). To avoid overlap with GOODS, the PIs of these two projects have decided to refrain from submitting a proposal for VIMOS low-resolution spectroscopy, and will concentrate on intermediate- and high-resolution spectroscopy, expecting sufficient low-resolution data will be made publicly available from GOODS. GOODS is a community-service project, and it is very important that the community is widely involved. ESO resources will be used to attract young scientists to ESO to participate in the preparation of the observations and data reduction efforts. Information for and from the community is organized through the Web, as well as through focused ESO workshops, the first one on "The Mass of Galaxies at Low and High Redshift," was held in the fall of 2001. A second such workshop is now planned for 2003 on "Multiwavelength Mapping of Galaxy Formation & Evolution".

9. Justification of requested observing time and lunar phase

Lunar Phase Justification: For the deep optical spectroscopy of the faint galaxies in the field dark time is mandatory.

Time Justification: The telescope time is set by two requirements: completeness down to the limiting magnitude, and adequate S/N. The target sample consists of ~ 6000 galaxies down to B (or V)=25. The layout of the VIMOS FoV is shown in Fig. 2: a minimum of 4 VIMOS pointings is necessary to ensure that all parts of the GOODS field are covered by at least one of the pointings. The chosen pattern consist of 4 VIMOS pointings in which in turn each of the 4 outer corners of the VIMOS FoV coincides with each of the 4 GOODS field corners. For each pointing, the central cross gaps of VIMOS separate 4 sub-fields over GOODS, for a total coverage of 112 arcmin^2. Hence, for each pointing, the fraction of the VIMOS low resolution multiplex expendable on GOODS is 112/224 (50%,), i.e., with an *effective multiplex* $0.5 \times 800 = 400$. These 4 pointings imprint on the GOODS field a set of subfields, with some being common to all 4 pointings (set A, 45% of GOODS), some only to 2 pointings (set B, also 45% of GOODS), and 2 subfields are covered by only one pointing (set C, 10% of GOODS). This is also shown in Fig. 2. For a set of 6 masks for each of the 4 pointings, all targets in A subfields can be observed at least once, and some twice, i.e. for a total 8h integration; we estimate that $\sim 85\%$ of all targets in B subfields can be observed once, while only $\lesssim 60\%$ of targets in subfields C could be observed. Hence, with a total of $6 \times 4 = 24$ sets of masks one can ensure $\sim 90\%$ completeness over the whole field. In any case, priority in slit assignement will be given to observe objects with $z_{\rm phot} \gtrsim 0.5$, including LBGs, EROs, AGN candidates, and few objects with special characteristics.
The current exposure VIMOS time calculator has been used under default assumptions (i.e., new moon, 1.2 airmass, $0''.8$ seeing, $1''$ slit, point sources) using elliptical, Sb, and starburst galaxy templates redshifted to $z > 1$. For both $B = 25$ objects with the LR-Blue grism and $V = 25$ objects with the LR-Red grism one reaches S/N$>$ 10 per resolution element (3-4 pixels). The overhead is 17m per observation (from VIMOS web). To reach 4h integration per mask 4 OBs, 1h each, are necessary, hence the overhead is 68m per mask. The total telescope time is therefore $24 \times (240 + 68)$ min = 7392 min = 123h, or ~ 13 nights. For the pre-imaging, 4 exposures 15m each are necessary, or 22m including 7m overhead, for a total of 68m, i.e. ~ 1h. **NB: for the targets lying inside the VIMOS FoV but outside the GOODS field the same selection criteria as for the GOODS field will be followed. ACS COMBO17/GEMS data are publicly available, and the COMBO17/GEMS team will provide the astrometric catalogs for mask preparation.**

Calibration Request: We need wavelength calibration for each science frame.

10. Applicant's publications related to the subject of this application during the past two years

Cristiani, S., Appenzeller, I., Arnouts, S., et al. 2000, A&A, 359, 489: "The first VLT FORS1 spectra of Lyman-break candidates in the HDF-S and AXAF Deep Field."

Daddi, E., Cimatti, A., & Renzini, A., 2000, A&A, 362, L45: "EROs and the formation epoch of field ellipticals."

Elbaz, D., Cesarsky, C., Fadda, D, et al. 1999, A&A, 351, L37: "Source counts from the 15 μm ISOCAM Deep Surveys."

Ferguson, H.C., Dickinson, M., Williams, R., 2000, ARA&A, 38, 667: "The Hubble Deep Fields."

Genzel, R., & Casarsky, C. J., 2000, ARA&A, 38, 761: "Extragalactic Results from the Infrared Space Observatory."

Giacconi, R., Rosati, P., Tozzi, P., et al. 2001, ApJ, 551, 624: "First Results from the X-ray and Optical Survey of the Chandra Deep Field South."

Giavalisco, M., & Dickinson, M., 2001, ApJ, 550, 177: "Clustering Segregation with UV Luminosity in Lyman-Break Galaxies at $z \sim 3$ and its Implication."

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11. List of targets proposed in this programme

Run	Target/Field	α	δ	Eq.	Mag.	Diam.	Additional info	Reference star
A	CDF-S	03 32 28	-27 48 30	J2000				
B	CDF-S	03 32 28	-27 48 30	J2000				
C	CDF-S	03 32 28	-27 48 30	J2000				

12. Scheduling requirements

13. Instrument configuration

Telescope	Instrument	Run ID	Parameter	Value or list
UT3	VIMOS	A	PRE-IMG	R
UT3	VIMOS	B	MOS-grisms	LR-Red
UT3	VIMOS	C	MOS-grisms	LR-Blue