Spectroscopic and Imaging Surveys for Cosmology

SISCO

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A Research Results

A.1 Scientific Highlights - 4th year

A.1.1 Summary of New Joint Programmes

The 4th and final year of SISCO has continued the success of previous years both in instigating new joint projects between the SISCO participants and in taking SISCO to a world-leading position in research. Even the continuing delay in commissioning some of the new survey telescopes such as VST and VISTA has not held the network back, although it has delayed some of the more ambitious joint projects. However, the network has shown its resilience in terms of its continued high rate of publication from the analyses of previous and ongoing surveys. The positioning for new surveys in the Southern Hemisphere has continued apace. The ESO Public Surveys Panel has now approved two SISCO surveys as part of its core programme for the VST, the VST ATLAS and the KIDS survey. During 2006 the Survey Management Plans for these have now also been accepted by the ESO OPC. The VST ATLAS will be used for both AAOmega follow-up with AAT 2dF and also by VLT for more detailed follow-up. The VISTA Hemisphere Survey has also been accepted as a core programme for the VISTA NIR telescope. While not a SISCO led project, this survey team includes many SISCO members and is vital for the success of the VST ATLAS. A further joint programme is the VLT VIMOS LBG survey being carried out. The preparation for this survey has been painstaking in terms of the numbers of nights of wide-field imaging carried out on 4-m class telescopes. Thus SISCO continues to have a strongly positive effect in producing better coordination between surveys and also in innovating new survey ideas. These brand new research collaborations are now set to run alongside the smaller scale projects based on the previously existing projects and on new collaborations between individual SISCO participants. Further details of all these joint programmes are included below in the scientific highlights from the various SISCO nodes. Here **(a)**, **(b)** or **(c)** at the end of each highlight refers to the three specific SISCO objectives in Annex I to which the highlight relates (see Section B.1 below for more details).

A.1.2 Durham

Cosmological research at the Durham node consisted of several different topics related to the SISCO network. This list summarizes the main highlights in the period 1/10/05-30/9/06:

- **Analysis of the 2SLAQ LRG Redshift Survey:** The 2SLAQ LRG survey has been completed with redshifts obtained for 11000 LRGs. Under the assumption that galaxies trace the dark matter, we also obtained a low estimate of the matter density and made an estimate of the LRG bias which suggests that LRGs may be created at high redshift and then suffer little dynamical evolution until the present day. **(b) (joint with Edinburgh and Oxford).**
- **Analysis of the 2SLAQ QSO Redshift Survey:** Here we have found little correlation of QSO clustering amplitude with either luminosity or redshift. This may mean that there may be little dependence of QSO luminosity on the host galaxy halo mass. Since there appears to be a strong correlation between black hole mass and halo mass, this means that there may be very little correlation between QSO luminosity and QSO black hole mass. **(b) (joint with Edinburgh and Oxford).**
- **AAOmega LRG ATLAS Pilot Observing Run** A pilot run for a proposal to observe redshifts for 350000 Luminous Red Galaxies in order to detect the baryon acoustic oscillations in the galaxy power spectrum was carried out on the AAT in February-March 2006 in order to test whether this approach to the dark energy equation of state via LRGs is feasible. The pilot programme was highly successful. We measured a strong correlation function amplitude at small scales and we are now applying for AAT observing time. **(b) (joint with Edinburgh and Oxford).**
- **VLT VIMOS LBG Survey:** We have obtained more ESO VLT time for a joint SISCO programme to make a survey of 3000 z=3 galaxies in $z \approx 3.5$ QSO fields. The aim is to study the effect of feedback from the process of galaxy formation on the ISM, as measured by the numbers of Lyman alpha absorption lines in the QSO spectrum. We have so far won 150 hrs of VLT VIMOS time for this project. We have also used the new AAOmega spectrograph to look for fainter QSOs in the same fields to improve our statistics.**(b) (joint with Heidelberg, Groningen, Oxford and Edinburgh).**

- **VST ATLAS:** The ESO OPC has now accepted the Survey Management Plan for the VST ATLAS proposal. This survey will cover 4500deg^2 of sky in the first 3 years VST observations. The survey will complement very well the new AAOmega fibre spectrograph at the AAT and could form the basis for an AAOmega redshift survey of 360000 Luminous Red Galaxies. However the intention is to extend this survey over the whole Southern Sky and make it into the equivalent of the SDSS survey in the Northern Hemisphere. Ultimately we hope that the ATLAS will contain near-infrared JHK photometry from the VISTA telescope as well as *ugriz* optical photometry from VST. **(b) (joint with Edinburgh, Oxford, Naples, ESO).**

A.1.3 Edinburgh

The SISCO related research at Edinburgh has concentrated on environmental properties of galaxies and the search for galaxies of extreme redshift.

- **The variation of the type-dependent galaxy luminosity function with environment:** We have developed a method to calculate overdensities in multicolour surveys, facilitating a direct comparison of the local density contrast measured using galaxy samples that have different redshift error distributions, i.e. for red and blue, or bright and faint galaxies, respectively. We calculate overdensities for three COMBO-17 fields, and identify a region in the Chandra Deep Field South that is underdense by almost a factor 2 compared to the other two fields in the same redshift range ($0.25 \lesssim z \lesssim 0.4$). This can be used for an investigation of the variation of the type-dependent luminosity function with environment: We calculate the luminosity function in this redshift range for red sequence and blue cloud galaxies in each of the fields separately. While the luminosity function of the blue galaxies remains unaffected by different density contrasts, the luminosity function of the red galaxies clearly has a more positive faint-end slope in the CDFS. The underdensity there is thus mainly due to a deficiency of faint red galaxies. This result is in qualitative agreement with the trends seen at $z = 0.1$ in the 2dFGRS. This work is done in collaboration with Dr. Christian Wolf (Oxford). **(b) joint with MPIA and Oxford.)**

- **The evolution of K_s-selected galaxies:** We have selected and analysed the properties of a sample of 2905 $K_s < 21.5$ galaxies in 131 sq.arcmin of the Great Observatories Origins Deep Survey (GOODS) Chandra Deep Field South (CDFS), to obtain further constraints on the evolution of such galaxies with respect to the results already obtained in previous studies. We made use of the public deep multiwavelength imaging from the optical B through the infrared (IR) 4.5 micron bands, in conjunction with available spectroscopic and COMBO17 data in the CDFS, to construct an optimised redshift catalogue for our galaxy sample. We computed the K_s-band LF and determined that its characteristic magnitude has a substantial brightening and a decreasing total density from $z = 0$ to $< z >= 2.5$. We also analysed the colours and number density evolution of galaxies with different stellar masses. Within our sample, and in contrast to what is observed for less massive systems, the vast majority (85-90%) of the most massive ($M > 2.5 \times 10^{11} M_{\odot}$) local galaxies appear to be in place before redshift $z \simeq 1$. Around 65-70% of the total assemble between redshifts $z = 1$ and $z = 3$ and most of them display extremely red colours, suggesting that plausible star formation in these very massive systems should mainly proceed in obscured, short-timescale bursts. The remaining fraction (up to 20%) could be in place at even higher redshifts $z = 3 - 4$, pushing the first epoch of formation of massive galaxies beyond the limits of current near-IR surveys.

A.1.4 Groningen

The SISCO node in Groningen/Leiden has finalised the preparation and analysis of surveys which were one of the main tasks at this node. This can be divided into three parts:

- **Further preparation for the VLT Survey Telescope (VST) and the VISTA surveys:** These include: a) the KIDS (Kilo Degree Survey), a project to map 1500 square degrees of sky in 9 optical and near-infrared bands with the VST and VISTA telescopes and which involves the SISCO nodes in Groningen/Leiden, Edinburgh and Naples, as well as a number of other european institutes; b) VESUVIO (VST/Omegacam Exploration of SUperclusters, Voids and Intermediate Objects): a survey which aims to undertake multi-band, wide-field surveys of nearby supercluster

of galaxies to study the properties of the galaxy population in a wide range of environment; and c) VST16: a deep 16-band survey which will have accurate photometric redshifts for a large number of galaxies.

- **Developing the tools to perform, archive and analyse optical surveys:** Several teams involved in SISCO (Groningen/Leiden and Naples) together with other european institutes have released Astrowise (The Astronomical Wide-Field Imaging System for Europe, Valentijn et al. 2007) to the international community on December 1st 2006. The system was further tested on data coming from different wide-field imagers (WFI, WFC, MDM8K) and the possibility to analyse data coming from new instrument (SUBARU) was added to the system. New analysis tools were added to Astrowise e.g. to detect variable objects and derive luminosity curves, decompose galaxies into several components and compute photometric redshift from multi-band observations like in the case of KIDS. Astrowise will be used to analyse the vast amount of data produced by the VST. It will also be used to archive the data and follow the survey progress. Regarding SISCO objectives, Astrowise matches the three main objectives of SISCO [a, b and c].

- **Analysis of existing surveys:** Ph. Héraudeau, E. Valentijn and two PhD students, Gert Sikkema and Teffie Schneider, have analysed observations obtained with wide field instruments (WFI, WFC and MDM8K) on the ELAIS fields, a region of the 2dFGRS and a part of the Hercules supercluster of galaxies to study the effects of environment on galaxy properties in the frame work of the VESUVIO project. Several papers are in preparation. K. Kuijken (2006) has developed a new implementation of a technique for measuring shear that is based on the shapelets formalism. Results are very promising (e.g. for surveys like KIDS which main goal is to measure the effects of gravitational lensing on galaxy shapes) with attained calibration accuracy better than four percent (1 percent for round PSFs) and PSF ellipticity correction better than a factor of 20.

A.1.5 MPIA, Heidelberg

The SISCO node at the Max-Planck-Institut für Astronomie has been working closely with a variety of SISCO nodes on several projects :

- **Galaxy merging:** Mergers between already-assembled galaxies is predicted to be an important mode of growth for galaxies, even at relatively recent times. We used the COMBO-17 survey to determine the merger rate between massive galaxies at $z \sim 0.6$ for the first time. We used a novel technique to estimate the merger rate which is immune to contamination by projected pairs and uses only imaging data. We found relatively rapid evolution of the massive galaxy merger rate between $z \sim 0.6$ and the present day. Assuming that the major merger timescale is of order the dynamical timescale for close massive galaxy pairs, we tentatively infer that $\sim 50\%$ (70%) of massive galaxies have undergone a major merger since $z = 0.8\,(1)$: major mergers between massive galaxies are a significant driver of galaxy evolution over the last eight billion years. **(a) (joint with Oxford and Edinburgh).**

- **Galaxy clustering and environment:** The accurate photometric redshifts of COMBO-17 together with the large number of galaxies contained in the survey allow to study galaxy clustering at intermediate redshifts. The result is consistent with hierarchical growth of structure between $z \sim 0.6$ and today. From the same data, effects of the environment on the luminosity functions of red and blue galaxies can be investigated. **(a) (joint with Edinburgh and Oxford).**

- **STAGES:** The study of obscured star formation in the COMBO-17 Abell 901/902 supercluster field continued, both through study of obscured star formation in the cluster itself and through study of star formation in the background galaxies. **(b) (joint with Oxford).**

- **SDSS:** The Sloan Digital Sky Survey (SDSS) is a 5-band imaging and spectroscopic survey of 8000 square degrees of the North Galactic Cap. We used the 5th data release of the SDSS to study the distribution of stars in the outer parts of the Milky Way. A number of interesting discoveries were made: the discovery of bifurcation in the Sagittarius stream — an observation which has so far eluded theoretical explanation; the discovery of several streams from disrupting dwarf galaxies; and the discovery of 8 satellite galaxies and a number of globular clusters. **(a)**

A.1.6 Napoli

In the last year, the activities of the SISCO node at INAF-OAC, Napoli have been focussed on three research areas as follows:

- **Preparation of VST/OmegaCam surveys.** The start of operations of the VLT Survey Telescope has been further delayed to mid 2007. As a consequence, during this year it was necessary to revise and update the survey plans. The VESUVIO survey ("VST/OmegaCam Exploration of SUperclusters, Voids and Intermediate Objects", see previous reports) has been embedded in the "Kilo Degree Survey" (KIDS), a joint project of several European Institutes aimed at obtaining medium-deep VST imaging of an area of 1500-2000 square degrees in the Southern sky. The VST-16 survey (a collaboration between the nodes of Heidelberg, Napoli, Edinburgh and other European Institutes, see previous reports) was revised during a meeting held in Napoli. A photometric survey in two wavebands of a 12 square degrees area around the "supercluster" target of VST-16 will start on next spring with the Canada France Hawaii Telescope in collaboration with the node of Heidelberg and with the University of Hawaii.

- **Investigation of the environmental effects of galaxy evolution.** The first phase of Shapley Optical Survey (SOS), the study of 2 $\deg^2$ towards the core of the Shapley supercluster, has been completed. The main result of this work was the discovery of a marked difference between luminous and faint galaxies for what concerns their behaviour in the different supercluster environments.

  Next steps of SOS will be: the extension of the area (to 15 square degrees) to encompass the whole range of supercluster environments, and a spectroscopic survey. Two observing programmes have been proposed at the ESO 2.2m Wide Field Imager, and at AAOmega (the multi-fiber spectrograph at Anglo Australian Telescope, in collaboration with the University of Durham). The comparison of the observed properties of the galaxies in Shapley with the results of semi-analytical simulations has started in collaboration with the node of Edinburgh (E. van Kampen). In the meantime, a study has been carried out on a supercluster at z=0.03 from the Sloan Digital Sky Survey (SDSS). Due to the availability of spectroscopic data, this study allowed to put the first results of SOS on a more robust basis. The new results confirm that while the star formation histories in giant galaxies are primarily determined by major merging events, the star formation history in dwarf galaxies was rather influenced by episodes of ram pressure stripping or galaxy harassment. This work, lead by the SISCO post-doc C. Haines, is currently being extended to the whole spectroscopic catalogue of the Sloan Digital Sky Survey.

- **Wide-field imaging software package.** A software package (provisional name 2DFIT) was developed in collaboration with Reinaldo de Carvalho (INPE, Brazil) and Joao Kohl (National Observatory, Brazil). The package allows a fully automatic two-dimensional analysis to be performed for all the objects (stars and galaxies) in wide-field images. The package will be applied to extract surface photometry parameters for all galaxies (up to a given depth) in the VST surveys.

A.1.7 Oxford

Oxford has continued to have major input into the last few papers to emerge from the 2dF Galaxy Redshift Survey (2dFGRS; Dalton) and the 2dF Quasar Redshift Survey (2dFQSO; Miller). Radio observations linked to the extensions of these surveys have been led by Oxford (Blundell, Rawlings) in collaboration with the Durham node; a low-frequency (240 MHz) GMRT survey now covers a large fraction of the 2SLAQ survey. Our other SISCO activities in the last year include:

- **COMBO-17:** Wolf has worked on further exploitation of the COMBO-17 and GEMS surveys (in close collaboration with the Heidelberg and Edinburgh nodes), and on the preparation of the SISCO-wide VST-16 survey which will make further 'COMBO-17-like' studies of galaxy/AGN evolution and gravitational lensing. He as also worked with the DEEP-2 team comparing the results from large spectroscopic surveys with those from imaging-based photo-z surveys showing agreement.(Wolf et al. 2004). **(b) (joint with Edinburgh, MPIA).**

- **Preparation for VST-16:** Wolf has continued to work on the preparation of the SISCO-wide VST-16 survey which is modelled after COMBO-17 to make sure it is going to be of optimum use for studies of galaxy and AGN evolution and for gravitational lensing applications. **(b) (joint with Durham, Edinburgh, MPIA, Napoli).**

- **UKIDSS:** The UKIDSS surveys are now underway with Dalton & Rawlings (and student van Breukelen) working closely with Durham and Edinburgh colleagues on the generation of cluster catalogues from the first datasets. Oxford have been leading efforts to tie together the evolution of clusters of galaxies (from these near-infrared surveys), with their gas content (via linked SZ surveys) and AGN activity (via radio, X-ray and far-IR surveys). This has involved a close collaboration with Durham (e.g. Edge and Simpson). **(b) (joint with Edinburgh, Durham).**

- **Radio-loud Quasars at $z > 7$:** Oxford's SISCO-supported young researcher (Eugenio Barrio) has been working on a novel survey for the first known radio-loud quasars beyond redshift 7. This programme was motivated partly as a testing ground for surveys possible with UKIDSS, and partly thinking ahead to the time (in five to ten years time) when spectroscopic surveys will be led by radio (rather than optical/near-IR techniques). Due, in part, to illness, Barrio's progress has been very slow this year. (Barrio, Jarvis, Rawlings,). **(b)**.

A.2 Publications related to the SISCO network

The SISCO nodes involved in joint publications and the particular research objective (see Section B.1) are given in squared brackets. SISCO PhD students and postdocs are given in bold print.

A.2.1 Joint Publications

From the 2dF QSO Redshift Survey collaboration

- Fine, S., Croom, S. M., Miller, L., Babic, A., Moore, D., Brewer, B., Sharp, R. G., Boyle, B. J., Shanks, T., Smith, R. J., Outram, P. J., & Loaring, N. S. 2006, MNRAS, 373, 613
  The evolution of host mass and black hole mass in quasi-stellar objects from the 2dF QSO Redshift Survey, [DUR, OXF (a)]

- Croom, S. M., Smith, R. J., Boyle, B. J., Shanks, T., Miller, L., Outram, P. J., & Loaring, N. S. 2006, VizieR Online Data Catalog, 7241, 0
  The 2dF QSO Redshift Survey (Croom+ 2004), [DUR, OXF, (a)]

- **da Ângela, J.**, Outram, P. J., Shanks, T., Boyle, B. J., Croom, S. M., Loaring, N. S., Miller, L., & Smith, R. J. 2005, MNRAS, 360, 1040
  The 2dF QSO Redshift Survey- XV. Correlation analysis of redshift-space distortions, [DUR, OXF, (a)]

- Myers, A. D., Outram, P. J., Shanks, T., Boyle, B. J., Croom, S. M., Loaring, N. S., Miller, L., & Smith, R. J. 2005, MNRAS, 359, 741
  On statistical lensing and the anticorrelation between 2dF QSOs and foreground galaxies, [DUR, OXF, (a)]

- Smith, R. J., Croom, S. M., Boyle, B. J., Shanks, T., Miller, L., & Loaring, N. S. 2005, MNRAS, 359, 57
  The 2dF QSO Redshift Survey - III. The input catalogue, [DUR, OXF, (a)]

- Croom, S. M., Boyle, B. J., Shanks, T., Smith, R. J., Miller, L., Outram, P. J., Loaring, N. S., Hoyle, F., & **da Ângela, J.** 2005, MNRAS, 356, 415
  The 2dF QSO Redshift Survey - XIV. Structure and evolution from the two-point correlation function, [DUR, OXF, (a)]

- Miller, L., Croom, S. M., Boyle, B. J., Loaring, N. S., Smith, R. J., Shanks, T., & Outram, P. 2004, MNRAS, 355, 385
  200-Mpc-sized structure in the 2dF QSO Redshift survey, [DUR, OXF, (a)]

From the 2SLAQ collaboration

- Collister, A., Lahav, O., Blake, C., Cannon, R., Croom, S., Drinkwater, M., Edge, A., Eisenstein, D., Loveday, J., Nichol, R., Pimbblet, K., de Propris, R., Roseboom, I., Ross, N., Schneider, D. P., Shanks, T., & Wake, D. 2007, MNRAS, 375, 68
  MegaZ-LRG: a photometric redshift catalogue of one million SDSS luminous red galaxies, [DUR, OXF, (a)]

- **da Angela, J.**, Shanks, T., Croom, S. M., **Weilbacher, P.**, Brunner, R. J., Couch, W. J., Miller, L., Myers, A. D., Nichol, R. C., Pimbblet, K. A., de Propris, R., Richards, G. T., Ross, N. P., Schneider, D. P., & Wake, D. A. 2006, ArXiv Astrophysics e-prints, arXiv:astro-ph/0612401
  The 2dF-SDSS LRG and QSO Survey: QSO clustering and the L-z degeneracy, [DUR, OXF, (a)]

- Ross, N. P., **da Angela, J.**, Shanks, T., Wake, D. A., Cannon, R. D., Edge, A. C., Nichol, R. C., Outram, P. J., Colless, M., Couch, W. J., Croom, S. M., De Propris, R., Drinkwater, M. J., Eisenstein, D. J., Loveday, J., Pimbblet, K. A., Roseboom, I. G., Schneider, D. P., Sharp, R. G., Strauss, M. A., & **Weilbacher, P. M.** 2006, ArXiv Astrophysics e-prints, arXiv:astro-ph/0612400
  The 2dF-SDSS LRG and QSO Survey: The 2-Point LRG Correlation Function and Redshift-Space Distortions, [DUR, OXF, (a)]

- Sadler, E. M., Cannon, R. D., Mauch, T., Hancock, P. J., Wake, D. A., Ross, N., Croom, S. M., Drinkwater, M. J., Edge, A. C., Eisenstein, D., Hopkins, A. M., Johnston, H., Nichol, R., Pimbblet, K. A., De Propris, R., Roseboom, I. G., Schneider, D. P., & Shanks, T. 2006, ArXiv Astrophysics e-prints, arXiv:astro-ph/0612019
  Radio galaxies in the 2SLAQ Luminous Red Galaxy Survey: I. The evolution of low-power radio galaxies to z˜0.7, [DUR, OXF, (a)]

- Roseboom, I. G., Pimbblet, K. A., Drinkwater, M. J., Cannon, R. D., de Propris, R., Edge, A. C., Eisenstein, D. J., Nichol, R. C., Smail, I., Wake, D. A., Bland-Hawthorn, J., Bridges, T. J., Carson, D., Colless, M., Couch, W. J., Croom, S. M., Driver, S. P., Hewett, P. C., Loveday, J., Ross, N., Schneider, D. P., Shanks, T., Sharp, R. G., & **Weilbacher, P.** 2006, MNRAS, 373, 349
  The 2dF-SDSS LRG and QSO Survey: the star formation histories of luminous red galaxies, [DUR, OXF, (a)]

- Wake, D. A., Nichol, R. C., Eisenstein, D. J., Loveday, J., Edge, A. C., Cannon, R., Smail, I., Schneider, D. P., Scranton, R., Carson, D., Ross, N. P., Brunner, R. J., Colless, M., Couch, W. J., Croom, S. M., Driver, S. P., da Ângela, J., Jester, S., de Propris, R., Drinkwater, M. J., Bland-Hawthorn, J., Pimbblet, K. A., Roseboom, I. G., Shanks, T., Sharp, R. G., & Brinkmann, J. 2006, MNRAS, 372, 537
  The 2df SDSS LRG and QSO survey: evolution of the luminosity function of luminous red galaxies to z = 0.6, [DUR, OXF, (a)]

- Cannon, R., Drinkwater, M., Edge, A., Eisenstein, D., Nichol, R., Outram, P., Pimbblet, K., de Propris, R., Roseboom, I., Wake, D., Allen, P., Bland-Hawthorn, J., Bridges, T., Carson, D., Chiu, K., Colless, M., Couch, W., Croom, S., Driver, S., Fine, S., Hewett, P., Loveday, J., Ross, N., Sadler, E. M., Shanks, T., Sharp, R., Smith, J. A., Stoughton, C., **Weilbacher, P.**, Brunner, R. J., Meiksin, A., & Schneider, D. P. 2006, MNRAS, 372, 425
  The 2dF-SDSS LRG and QSO (2SLAQ) Luminous Red Galaxy Survey, [DUR, OXF, (a)]

From the GEMS collaboration

- Lehmer, B. D., Brandt, W. N., Alexander, D. M., **E. F.**, McIntosh, D. H., Bauer, F. E., Hasinger, G., Mainieri, V., Miyaji, T., Schneider, D. P., & Steffen, A. T. 2007, ApJ, 657, 681
  The X-Ray Evolution of Early-Type Galaxies in the Extended Chandra Deep Field-South, [MPIA, DUR, (b)]

- Heymans, C., **Bell, E. F.**, Rix, H.-W., Barden, M., Borch, A., Caldwell, J. A. R., McIntosh, D. H., Meisenheimer, K., Peng, C. Y., Wolf, C., Beckwith, S. V. W., Häußler, B., Jahnke, K., Jogee, S., Sánchez, S. F., Somerville, R., & Wisotzki, L. 2006, MNRAS, 371, L60

A weak lensing estimate from GEMS of the virial to stellar mass ratio in massive galaxies to z ˜ 0.8, [MPIA, OXF, (b)]

- Barazza, F. D., Jogee, S., Rix, H.-W., Barden, M., **Bell, E. F.**, Caldwell, J. A. R., McIntosh, D. H., Meisenheimer, K., Peng, C. Y., & Wolf, C. 2006, ApJ, 643, 162
  Color, Structure, and Star Formation History of Dwarf Galaxies over the Last ˜3 Gyr with GEMS and SDSS, [MPIA, OXF, (b)]

- **Bell, E. F.**, Naab, T., McIntosh, D. H., Somerville, R. S., Caldwell, J. A. R., Barden, M., Wolf, C., Rix, H.-W., Beckwith, S. V., Borch, A., Häussler, B., Heymans, C., Jahnke, K., Jogee, S., Koposov, S., Meisenheimer, K., Peng, C. Y., Sanchez, S. F., & Wisotzki, L. 2006, ApJ, 640, 241
  Dry Mergers in GEMS: The Dynamical Evolution of Massive Early-Type Galaxies, [MPIA, OXF, (b)]

- Barden, M., Rix, H.-W., Somerville, R. S., **Bell, E. F.**, Häußler, B., Peng, C. Y., Borch, A., Beckwith, S. V. W., Caldwell, J. A. R., Heymans, C., Jahnke, K., Jogee, S., McIntosh, D. H., Meisenheimer, K., Sánchez, S. F., Wisotzki, L., & Wolf, C. 2005, ApJ, 635, 959
  GEMS: The Surface Brightness and Surface Mass Density Evolution of Disk Galaxies, [MPIA, OXF, (b)]

- Heymans, C., Brown, M. L., Barden, M., Caldwell, J., Häußler, B., Jahnke, K., Rix, H.-W., Beckwith, S., **Bell, E. F.**, Borch, A., Jogee, S., McIntosh, D. H., Meisenheimer, K., Peng, C., Sánchez, S., Somerville, R., Taylor, A. N., Wisotzki, L., & Wolf, C. 2005, New Astronomy Review, 49, 392
  Weak lensing studies from space with GEMS [review article], [MPIA, OXF, (b)]

- McIntosh, D. H., **Bell, E. F.**, Rix, H.-W., Wolf, C., Heymans, C., Peng, C. Y., Somerville, R. S., Barden, M., Beckwith, S. V. W., Borch, A., Caldwell, J. A. R., Häußler, B., Jahnke, K., Jogee, S., Meisenheimer, K., Sánchez, S. F., & Wisotzki, L. 2005, ApJ, 632, 191
  The Evolution of Early-Type Red Galaxies with the GEMS Survey: Luminosity-Size and Stellar Mass-Size Relations Since z=1, [MPIA, OXF, (b)]

- Wolf, C., **Bell, E. F.**, McIntosh, D. H., Rix, H.-W., Barden, M., Beckwith, S. V. W., Borch, A., Caldwell, J. A. R., Häussler, B., Heymans, C., Jahnke, K., Jogee, S., Meisenheimer, K., Peng, C. Y., Sánchez, S. F., Somerville, R. S., & Wisotzki, L. 2005, ApJ, 630, 771
  GEMS: Which Galaxies Dominate the $z \approx 0.7$ Ultraviolet Luminosity Density?, [MPIA, OXF, (b)]

From the 2dF Galaxy Redshift Survey collaboration

- Sánchez, A. G., Baugh, C. M., Percival, W. J., Peacock, J. A., Padilla, N. D., Cole, S., Frenk, C. S., & Norberg, P. 2006, MNRAS, 366, 189
  Cosmological parameters from cosmic microwave background measurements and the final 2dF Galaxy Redshift Survey power spectrum, [UEDIN, DUR, (a)]

- Hilton, M., Collins, C., De Propris, R., Baldry, I. K., Baugh, C. M., Bland-Hawthorn, J., Bridges, T., Cannon, R., Cole, S., Colless, M., Couch, W. J., Dalton, G. B., Driver, S. P., Efstathiou, G., Ellis, R. S., Frenk, C. S., Glazebrook, K., Jackson, C. A., Lahav, O., Lewis, I., Lumsden, S., Maddox, S. J., Madgwick, D., Norberg, P., Peacock, J. A., Peterson, B. A., Sutherland, W., & Taylor, K. 2005, MNRAS, 363, 661
  The 2dF Galaxy Redshift Survey: correlation with the ROSAT-ESO flux-limited X-ray galaxy cluster survey, [UEDIN, DUR, OXF (a)]

From the COMBO-17 collaboration

- **Phleps, S.**, Wolf, C., Peacock, J. A., Meisenheimer, K., & van Kampen, E. 2007, AA, 468, 113
  COMBO-17 measurements of the effect of environment on the type-dependent galaxy luminosity function, [UEDIN, MPIA, OXF (b)]

- Zheng, X. Z., **Bell, E. F.**, Papovich, C., Wolf, C., Meisenheimer, K., Rix, H.-W., Rieke, G. H., & Somerville, R. 2007, ApJL, 661, L41
The Dependence of Star Formation on Galaxy Stellar Mass, [UEDIN, MPIA, OXF (b)]

- **Phleps, S.**, Peacock, J. A., Meisenheimer, K., & Wolf, C. 2006, AA, 457, 145
Galaxy clustering from COMBO-17: the halo occupation distribution at $z \gtrsim 0.6$, [UEDIN, MPIA, OXF (b)]

- **Bell, E. F.**, **Phleps, S.**, Somerville, R. S., Wolf, C., Borch, A., & Meisenheimer, K. 2006, ApJ, 652, 270
The Merger Rate of Massive Galaxies, [MPIA, UEDIN, OXF (b)]

- Borch, A., Meisenheimer, K., **Bell, E. F.**, Rix, H.-W., Wolf, C., Dye, S., Kleinheinrich, M., Kovacs, Z., & Wisotzki, L. 2006, AA, 453, 869
The stellar masses of 25 000 galaxies at $0.2 \lesssim z \lesssim 1.0$ *estimated by the COMBO-17 survey*, [MPIA, UEDIN, OXF (b)]

From the CADIS collaboration

- Fuchs, B., **Phleps, S.**, & Meisenheimer, K. 2006, AA, 457, 541
CADIS has seen the Virgo overdensity and parts of the Monoceros and "Orphan" streams in retrospect, [UEDIN, MPIA (a)]

From the VST+OmegaCAM+Lensing collaborations

- Iwert, O., Baade, D., Balestra, A., Baruffolo, A., Bortolussi, A., Christen, F., Cumani, C., Deiries, S., Downing, M., Geimer, C., Hess, G., Hess, J., Kuijken, K., Lizon, J., Muschielok, B., Nicklas, H., Reiss, R., Reyes, J., Silber, A., Thillerup, J., Valentijn, E. 2006,SPIE , 6276, 9 [RUG, ESO (b,c)]
The OmegaCAM 16K x 16K CCD detector system for the ESO VLT Survey Telescope (VST)[RUG, ESO (c)]

- Heymans, C., Van Waerbeke, L., Bacon, D., Berge, J., Bernstein, G., Bertin, E., Bridle, S., Brown, M. L., Clowe, D., Dahle, H., Erben, T., Gray, M., Hetterscheidt, M., Hoekstra, H., Hudelot, P., Jarvis, M., Kuijken, K., Margoniner, V., Massey, R., Mellier, Y., Nakajima, R., Refregier, A., Rhodes, J., Schrabback, T., Wittman, D.,2006, MNRAS, 368,1323
The Shear Testing Programme - I. Weak lensing analysis of simulated ground-based observations[UEDIN, RUG (a,b,c)]

- Massey et al. 2007, MNRAS, 376, 13
The Shear Testing Programme 2: Factors affecting high-precision weak-lensing analyses[UEDIN, RUG (a,b,c)]

From Surveys of Planetary Nebulae

- Merrett, H. R., Merrifield, M. R., Douglas, N. G., Kuijken, K., Romanowsky, A. J., Napolitano, N. R., Arnaboldi, M., Capaccioli, M., Freeman, K. C., Gerhard, O., Coccato, L., Carter, D., Evans, N. W., Wilkinson, M. I., Halliday, C., Bridges, T. J. 2006,MNRAS,369,120
A deep kinematic survey of planetary nebulae in the Andromeda galaxy using the Planetary Nebula Spectrograph[RUG, OAC (a)]

From the ASTROWISE consortium

- Valentijn, E.A., McFarland, J.P., Snigula, J., Begeman, K.G., Boxhoorn, D.R., Rengelink, R., Helmich, E., **Heraudeau, P.**, Verdoes K., Gijs, V., R., Vriend, W., Tempelaar, M.J., Deul, E., Kuijken, K., Capaccioli, Massimo, Silvotti, Roberto, Bender, Ralf, Neeser, Mark, Saglia, Roberto, Bertin, Emmanuel, Mellier, Yannick, 2006, ADASS XVI ASP Conference Series, in press,*'Astro-WISE: Chaining to the Universe'* [RUG, OAC, ESO (a,b,c)]

From the UKIDSS collaboration

- van Breukelen C., Clewley L., Bonfield D. G., Rawlings S., Jarvis M. J., Barr J. M., Foucaud S., Almaini O., Cirasuolo M., Dalton G., Dunlop J. S., Edge A. C., Hirst P., McLure R. J., Page M. J., Sekiguchi K., Simpson C., Smail I., Watson M. G., 2006, MNRAS, 373, L26
Galaxy clusters at $0.6 < z < 1.4$ *in the UKIDSS Ultra Deep Survey Early Data Release* [UEDIN, OXF, DUR (b,c)]

- Simpson C., Almaini O., Cirasuolo M., Dunlop J., Foucaud S., Hirst P., Ivison R., Page M., Rawlings S., Sekiguchi K., Smail I., Watson M., 2006, MNRAS, 373, L21
Extremely red objects in the UKIDSS Ultra Deep Survey Early Data Release [UEDIN, OXF, DUR (b,c)]

- McLure R. J., Cirasuolo M., Dunlop J. S., Sekiguchi K., Almaini O., Foucaud S., Simpson C., Watson M. G., Hirst P., Page M. J., Smail I., 2006, MNRAS, 372, 357
The discovery of a significant sample of massive galaxies at redshifts $5 < z < 6$ *in the UKIDSS Ultra Deep Survey early data release* [UEDIN, DUR (b,c)]

From the SCUBA collaboration

- Coppin K., Chapin E. L., Mortier A. M. J., Scott S. E., Borys C., et al., 2006, MNRAS, 372, 1621
The SCUBA Half-Degree Extragalactic Survey - II. Submillimetre maps, catalogue and number counts [UEDIN, OXF, DUR (b,c)]

- Knudsen K. K., Barnard V. E., van der Werf P. P., Vielva P., Kneib J.-P., Blain A. W., Barreiro R. B., Ivison R. J., Smail I., Peacock J. A., , 2006, MNRAS, 368, 487
An ultradeep submillimetre map: beneath the SCUBA confusion limit with lensing and robust source extraction [UEDIN, DUR (b,c)]

- Mortier, A. M. J. et al. 2005, MNRAS, 363, 563
The SCUBA Half-Degree Extragalactic Survey - I. Survey motivation, design and data processing [UEDIN, OXF, DUR (b,c)]

- Martínez-Sansigre, A., Rawlings, S., Lacy, M., Fadda, D., Marleau, F. R., Simpson, C., Willott, C. J., & Jarvis, M. J. 2005, Nature, 436, 666
The obscuration by dust of most of the growth of supermassive black holes [OXF, DUR (b,c)]

A.2.2 Single Institute Publications

Durham

- Shanks, T. 2007, MNRAS, 376, 173
The effect of lensing on the large-scale cosmic microwave background anisotropy, [DUR, (a)]

- Bielby, R. M., & Shanks, T. 2007, ArXiv Astrophysics e-prints, arXiv:astro-ph/0703470
Anomalous SZ Contribution to 3 Year WMAP Data, [DUR (a)]

- Mountrichas, G., & Shanks, T. 2007, ArXiv Astrophysics e-prints, arXiv:astro-ph/0701870
QSO Lensing Magnification: A Comparison of 2QZ and SDSS Results, [DUR (a)]

- Frith, W. J., Outram, P. J., & Shanks, T. 2006, MNRAS, 373, 759
High-order 2MASS galaxy correlation functions: probing the Gaussianity of the primordial density field, [DUR (a)]

- Frith, W. J., Metcalfe, N., & Shanks, T. 2006, MNRAS, 371, 1601
New H-band galaxy number counts: a large local hole in the galaxy distribution, [DUR (a)]

- Metcalfe, N., Shanks, T., **Weilbacher, P. M.**, McCracken, H. J., Fong, R., & Thompson, D. 2006, MNRAS, 370, 1257
Galaxy number counts - VI. An H-band survey of the Herschel Deep Field, [DUR, (a)]

- Georgantopoulos, I., Georgakakis, A., Akylas, A., Stewart, G. C., Giannakis, O., Shanks, T., & Kitsionas, S. 2006, VizieR Online Data Catalog, 735, 20091
XMM-Newton/2dF survey. IV. (Georgantopoulos+, 2004), [DUR, (a)]

- Frith, W. J., Outram, P. J., & Shanks, T. 2005, MNRAS, 364, 593
The 2-Micron All-Sky Survey galaxy angular power spectrum: probing the galaxy distribution to gigaparsec scales, [DUR (a)]

- Guimarães, A. C. C., Myers, A. D., & Shanks, T. 2005, MNRAS, 362, 657
QSO lensing magnification associated with galaxy groups, [DUR (a)]

Heidelberg

- Zucker, D. B., ... **Bell, E. F.**, et al. 2007, ApJL, 659, L21
Andromeda X, a New Dwarf Spheroidal Satellite of M31: Photometry

- Belokurov, V., ... **Bell, E. F.**, et al. 2007, ApJ, 658, 337
An Orphan in the "Field of Streams"

- Belokurov, V., **Bell, E. F.**, et al. 2007, ApJL, 657, L89
The Hercules-Aquila Cloud

- Belokurov, V., ... **Bell, E. F.**, et al. 2007, ApJ, 654, 897
Cats and Dogs, Hair and a Hero: A Quintet of New Milky Way Companions

- McIntosh, D. H., **Bell, E. F.**, Weinberg, M. D., & Katz, N. 2006, MNRAS, 373, 1321
Nature and completeness of galaxies detected in the Two Micron All Sky Survey

- Zucker, D. B., ... **Bell, E. F.**, et al. 2006, ApJL, 650, L41
A Curious Milky Way Satellite in Ursa Major

- Zheng, X. Z., **Bell, E. F.**, et al. 2006, ApJ, 640, 784
Detecting Faint Galaxies by Stacking at 24 μm

- Le Floc'h, E., ... **Bell, E. F.** et al. 2005, ApJ, 632, 169
Infrared Luminosity Functions from the Chandra Deep Field-South: The Spitzer View on the History of Dusty Star Formation at $0 \lesssim z \lesssim 1$

- Auld, R., de Blok, W. J. G., **Bell, E. F.**, and Davies, J. I. 2006 MNRAS, 366, 1475
Morphology and star formation in nearby low surface brightness galaxies

- Dib, S., Bell, E. F., & Burkert, A., 2006, ApJ, 638, 797
The Supernova Rate-Velocity Dispersion Relation in the Interstellar Medium

Groningen

- de Jong, J. T. A., Widrow, L. M., Cseresnjes, P., Kuijken, K., Crotts, A. P. S., Bergier, A., Baltz, E. A., Gyuk, G., Sackett, P. D., Uglesich, R. R., Sutherland, W. J. 2006,A&A, 446, 855
MACHOs in M 31? Absence of evidence but not evidence of absence

- Grosbøl, P. and **Héraudeau, Ph**, in "Island Universes", 2007, in Island Universes, Astrophysics and Space Science Proceedings, R.S. de Jong (Ed), pp 215-218
Resonances and extent of spiral arms in disk galaxies

- **Héraudeau, Ph., Valentijn, E.** 2005, SF2A-2005,EdP-Sciences, p. 717, Edited by F. Casoli, T. Contini, J.M. Hameury and L. Pagani.
An optical survey of the Elais-S2 field. Data reduction with Astro-Wise[a,b,c]

- Kuijken, K. 2006A&A, 456, 827
Shears from shapelets[b,c]

- Kuijken, K. 2006,astro.ph.,10606
GaaP: PSF- and aperture-matched photometry using shapelets

- Kuijken, K. in "Applications of Gravitational Lensing: Unique Insights into Galaxy Formation and Evolution" 2006
Lensing with KIDS[c]

- Kuijken, K. in "The Virtual Observatory in Action: New Science, New Technology, and Next Generation Facilities", 26th meeting of the IAU, 2006
Large Surveys and the VO

- Verdoes Kleijn, G., Vermeij, R., **Valentijn, E.**, Kuijken, K. 2006,astro.ph.,12469
The Secondary Standards programme for OmegaCAM at the VST [a,b,c]

- Kuijken, K. 2006, IAU General Assembly, Joint Discussion on Virtual Observatory (Prague, Czech Republic, August 14-19)
Large Surveys and the VO [a,b,c]

Edinburgh

- Sereno M., Peacock J. A., 2006, MNRAS, 371, 719
Imprints of deviations from the gravitational inverse-square law on the power spectrum of mass fluctuations

- Brookes M. H., Best P. N., Peacock J. A., 2006, AN, 327, 274
The cosmological evolution of radio galaxies with CENSORS

- Sánchez A. G., Baugh C. M., Percival W. J., Peacock J. A., Padilla N. D., Cole S., Frenk C. S., Norberg P., 2006, MNRAS, 366, 189
Cosmological parameters from cosmic microwave background measurements and the final 2dF Galaxy Redshift Survey power spectrum

- McLure R. J., Jarvis M. J., Targett T. A., Dunlop J. S., Best P. N., , 2006, NewAR, 50, 782
On the evolution of the black-hole:spheroid mass ratio

- Roche N. D., Dunlop J., Caputi K. I., McLure R., Willott C. J., Crampton D., 2006, MNRAS, 370, 74
Deep GMOS spectroscopy of extremely red galaxies in GOODS-South: ellipticals, mergers and red spirals at $1 < z < 2$

- Caputi K. I., Dole H., Lagache G., McLure R. J., Dunlop J. S., Puget J.-L., Le Floc'h E., Pérez-González P. G., 2006, A&A, 454, 143
The role of the LIRG and ULIRG phases in the evolution of K_s*-selected galaxies*

- McLure R. J., Jarvis M. J., Targett T. A., Dunlop J. S., Best P. N., 2006, MNRAS, 368, 1395
On the evolution of the black hole: spheroid mass ratio

- Iono D., Peck A. B., Pope A., Borys C., Scott D., Wilner D. J., Gurwell M., Ho P. T. P., Yun M. S., Matsushita S., Petitpas G. R., Dunlop J. S., Elvis M., Blain A., Le Floc'h E., 2006, ApJ, 640, L1
Interferometric 890 μm Images of High-Redshift Submillimeter Galaxies

- McLure R. J., Jarvis M. J., Targett T. A., Dunlop J. S., Best P. N., 2006, AN, 327, 213
On the evolution of the black-hole/spheroid mass ratio

- Caputi K. I., McLure R. J., Dunlop J. S., Cirasuolo M., **Schael A. M.**, 2006, MNRAS, 366, 609
Further constraints on the evolution of K_s*-selected galaxies in the GOODS/CDFS field*

- Caputi K. I., Dole H., Lagache G., McLure R. J., Puget J.-L., Rieke G. H., Dunlop J. S., Le Floc'h E., Papovich C., Pérez-González P. G., 2006, ApJ, 637, 727
Linking Stellar Mass and Star Formation in Spitzer MIPS 24 μm Galaxies

- Heavens A. F., Kitching T. D., Taylor A. N., 2006, MNRAS, 373, 105
Measuring dark energy properties with 3D cosmic shear

- Sheth R. K., Jimenez R., Panter B., Heavens A. F., 2006, ApJ, 650, L25
Environment and the Cosmic Evolution of Star Formation

- Heymans C., White M., Heavens A., Vale C., van Waerbeke L., 2006, MNRAS, 371, 750
Potential sources of contamination to weak lensing measurements: constraints from N-body simulations

- Bacon D. J., Goldberg D. M., Rowe B. T. P., Taylor A. N., 2006, MNRAS, 365, 414
Weak gravitational flexion

Napoli

- Tresse, L., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A submitted (astro-ph/0609005)
The cosmic star formation rate evolution from z=5 to z=0 from the VIMOS VLT Deep Survey

- Ilbert, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A accepted (astro-ph/0604010)
Galaxy luminosity function per morphological type up to z=1.2

- Ilbert, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A submitted (astro-ph/0603217)
Accurate photometric redshifts for the CFHT Legacy Survey calibrated using the VIMOS VLT Deep Survey

- Cucciati, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A accepted (astro-ph/0603202)
The VIMOS VLT Deep Survey: The build-up of the colour-density relation

- Ilbert, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A submitted (astro-ph/0602329)
Evidence for environment-dependent galaxy Luminosity Function up to z=1.5 in the VIMOS-VLT Deep Survey

- Cucciati, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 458, 423
The VIMOS VLT Deep Survey: the build-up of the colour-density relation

- Ilbert, O., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 457, 841
Accurate photometric redshifts for the CFHT legacy survey calibrated using the VIMOS VLT deep survey

- Gavignaud, I.,..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 457, 79
The VIMOS VLT Deep Survey: the faint type-1 AGN sample

- **Haines, C. P.**, Merluzzi, P., Mercurio, A., Gargiulo, A., Krusanova, N., Busarello, G., La Barbera, F., Capaccioli, M., 2006, MNRAS 371, 55
Shapley Optical Survey - II. The effect of environment on the colour-magnitude relation and galaxy colours

- Zucca, E.,..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 455, 879
The VIMOS VLT Deep Survey. Evolution of the luminosity functions by galaxy type up to z = 1.5 from first epoch data

- Tresse, L., ..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A submitted (astro-ph/0609005)
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The Different Environmental Dependencies of Star Formation for Giant and Dwarf Galaxies

- Ilbert, O.,..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 453, 809
The VIMOS-VLT Deep Survey. Galaxy luminosity function per morphological type up to z = 1.2

- Meneux, B.,..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 452, 387
The VIMOS-VLT Deep Survey. The evolution of galaxy clustering per spectral type to $z \simeq 1.5$

- Mercurio, A., Merluzzi, P., **Haines, C. P.**, Gargiulo, A., Krusanova, N., Busarello, G., Barbera, F. La, Capaccioli, M., Covone, G., 2006, MNRAS 368, 109
Shapley Optical Survey - I. Luminosity functions in the supercluster environment

- Pollo, A.,..., Busarello, G., ..., Merluzzi, P., et al., 2006, A&A 451, 409
The VIMOS-VLT Deep Survey. Luminosity dependence of clustering at $z \simeq 1$

- Soechting, I.; Campusano, L.; **Haines, C.**; Williger, G.; Clowes, R.; Graham, M.; Valls-Gabaud, D., 2006, AAS 2071, 1203
GMOS spectroscopy of galaxies in a z$\sim$ 0.8 structure

Oxford

- Cruz, M. J., Jarvis, M. J., Rawlings, S., & Blundell, K. M. 2007, MNRAS, 375, 1349
*The 6C** sample of steep-spectrum radio sources - II. Redshift distribution and the space density of high-redshift radio galaxies*

- Willott, C. J., Martínez-Sansigre, A., & Rawlings, S. 2007, AJ, 133, 564
Molecular Gas Observations of the Reddened Quasar 3C 318

- Cruz, M. J., Jarvis, M. J., Blundell, K. M., Rawlings, S., Croft, S., Klöckner, H.-R., McLure, R. J., Simpson, C., Targett, T. A., & Willott, C. J. 2006, MNRAS, 373, 1531
*The 6C** sample of steep-spectrum radio sources - I. Radio data, near-infrared imaging and optical spectroscopy*

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Book Review: JENAM 2003. Radio Astronomy from Karl Jansky to Microjansky (Gurvits et al.)

- Martínez-Sansigre, A., Rawlings, S., Garn, T., Green, D. A., Alexander, P., Klöckner, H.-R., & Riley, J. M. 2006, MNRAS, 373, L80
A population of high-redshift type 2 quasars - II. Radio properties

- Simpson, C., Martínez-Sansigre, A., Rawlings, S., Ivison, R., Akiyama, M., Sekiguchi, K., Takata, T., Ueda, Y., & Watson, M. 2006, MNRAS, 372, 741
Radio imaging of the Subaru/XMM-Newton Deep Field - I. The 100-μJy catalogue, optical identifications, and the nature of the faint radio source population

- Martínez-Sansigre, A., Rawlings, S., Lacy, M., Fadda, D., Jarvis, M. J., Marleau, F. R., Simpson, C., & Willott, C. J. 2006, MNRAS, 370, 1479
A population of high-redshift type 2 quasars - I. Selection criteria and optical spectra

- Scott S. E., Dunlop J. S., Serjeant S., 2006, MNRAS, 370, 1057
A combined re-analysis of existing blank-field SCUBA surveys: comparative 850-μm source lists, combined number counts, and evidence for strong clustering of the bright submillimetre galaxy population on arcminute scales

- Vardoulaki, E., Rawlings, S., Hill, G. J., Croft, S., Brand, K., Riley, J., & Willott, C. 2006, Astronomische Nachrichten, 327, 282
The TOOT00 redshift survey of radio sources

- Simpson, C., Rawlings, S., & Martínez-Sansigre, A. 2006, Astronomische Nachrichten, 327, 270
The nature of the faint radio source population from observations of the Subaru/XMM-Newton Deep Field

- Martínez-Sansigre, A., Rawlings, S., Lacy, M., Fadda, D., Marleau, F. R., Simpson, C., Willott, C. J., & Jarvis, M. J. 2006, Astronomische Nachrichten, 327, 266
Most supermassive black hole growth is obscured by dust

A.3 SISCO scientific highlights over 4 years

A.3.1 Durham 4-years

- **Completion and Public Data Release of the 2dF QSO Redshift Survey**. Croom et al. (2004) completed the 2dF QSO Redshift Survey and this catalogue paper is one of the top two most cited MNRAS papers for 2004. From the catalogue, da Angela et al have measured the value of Ω_m and the QSO bias, b, at $z \approx 1.4$, by combining constraints from the evolution and z-space distortion of the QSO clustering. We find values of $\Omega_m = 0.35 \pm 0.16$ and $\beta = \Omega^{0.6}/b = 0.5 \pm 0.14$. We have also fitted models for the real-space QSO correlation function and find that it may exhibit a shoulder feature comparable to that found in the 2dFGRS galaxy correlation function at lower redshifts. **(a) (joint with Oxford).**

  Croom, S. M., Smith, R. J., Boyle, B. J., Shanks, T., Miller, L., Outram, P. J., & Loaring, N. S. 2004, MNRAS, 349, 1397, *The 2dF QSO Redshift Survey - XII. The spectroscopic catalogue and luminosity function*
  da Ângela, J., Outram, P. J., Shanks, T., Boyle, B. J., Croom, S. M., Loaring, N. S., Miller, L., & Smith, R. J. 2005, MNRAS, 360, 1040, *The 2dF QSO Redshift Survey- XV. Correlation analysis of redshift-space distortions*

- **Completion of 2SLAQ LRG and QSO redshift survey**. The 2SLAQ LRG survey has been completed with redshifts obtained for 11000 LRGs and 8000 QSOs. Ross et al (2007) detected a feature in the LRG correlation function at $\approx 1 h^{-1}$Mpc. Under the assumption that galaxies trace the dark matter, we also obtained a low estimate of the matter density and an estimate of LRG bias which is consistent with a 'high peaks' model where the spatial density of LRGs remains approximately unevolved in the range $0 < z < 0.6$. da Angela et al. (2006) used the 2SLAQ QSO survey to show that the clustering of QSOs is approximately independent of QSO luminosity and hence that QSO black-hole mass may also be independent of luminosity. **(b) (joint with Oxford).**

  Ross, N. P., **da Angela, J.**, Shanks, T., Wake, D. A., Cannon, R. D., Edge, A. C., Nichol, R. C., Outram, P. J., Colless, M., Couch, W. J., Croom, S. M., De Propris, R., Drinkwater, M. J., Eisenstein, D. J., Loveday, J., Pimbblet, K. A., Roseboom, I. G., Schneider, D. P., Sharp, R. G., Strauss, M. A., & **Weilbacher, P. M.** 2006, ArXiv Astrophysics e-prints, arXiv:astro-ph/0612400, *The 2dF-SDSS LRG and QSO Survey: The LRG 2-Point Correlation Function and Redshift-Space Distortions*
  da Angela, J., Shanks, T., Croom, S. M., Weilbacher, P., Brunner, R. J., Couch, W. J., Miller, L., Myers, A. D., Nichol, R. C., Pimbblet, K. A., de Propris, R., Richards, G. T., Ross, N. P., Schneider, D. P., & Wake, D. A. 2006, ArXiv Astrophysics e-prints, arXiv:astro-ph/061240, *The 2dF-SDSS LRG and QSO Survey: QSO clustering and the L-z degeneracy*

- **Acceptance of the VST ATLAS proposal**. ESO has now accepted the Survey Management Plan for the VST ATLAS proposal. This survey will cover 4500deg^2 of sky in the first 3 years VST observations. The survey will complement very well the new AAOmega fibre spectrograph at the AAT and is intended to form the basis for a survey of 360000 Luminous Red Galaxies andother redshift surveys. However, the ultimate intention is to extend this survey over the whole Southern Sky and make it into the equivalent of the SDSS survey in the Northern Hemisphere. Ultimately we hope that the ATLAS will contain near-infrared JHK photometry from the VISTA telescope as well as ugriz optical photometry from VST. **(b,c) (joint with Edinburgh, Naples, Oxford).**

A.3.2 Edinburgh 4-years

- **The dependence of the luminosity function on the local density contrast:** Current models of galaxy formation and evolution predict a strong dependence of galaxy properties on the local environment. The galaxy luminosity function is an important tool for investigating and quantifying these effects. Using a sample of approximately 23000 galaxies with multicolor redshifts and SEDs from the COMBO 17 survey (see Wolf et al. 2002), we are investigating the dependence of the luminosity function on the local density contrast. The feasibility of a measurement of galaxy overdensities in a multicolour survey has been tested using a COMBO-17 mock catalogue. We find one of our three fields, the CDFS, to be extremely underdense at $0.25 < z < 0.4$ in respect to the other fields, and the galaxy luminosity function measured in this redshift range to differ significantly. By dividing our sample into subsamples of red sequence and blue cloud galaxies, we can show that the underdensity in the CDFS is mainly due to a deficit of red galaxies. **(b) joint with MPIA and Oxford.)**

  Phleps, S., Wolf, C., Peacock, J. A., Meisenheimer, K., & van Kampen, E. 2007, AA, 468, 113, *COMBO-17 measurements of the effect of environment on the type-dependent galaxy luminosity function*

- **Galaxy Clustering from COMBO 17: The halo occupation distribution at $z = 0.6$:** The formation and evolution of galaxies is driven by the merging history of the dark matter haloes in which they reside, so it is important to measure how galaxies occupy haloes at different redshifts. It is now possible to achieve this by accurate measurements of the shape of galaxy correlation functions at high redshift. Using approximately 10000 galaxy redshifts from the COMBO17 survey, we have measured the projected correlation function at $0.4 < z < 0.8$ for red sequence and blue cloud galaxies. The correlation function of the red galaxies displays clear deviations from a power law at comoving separations around 1 to 3 Mpc , and similar but weaker trends are suggested by the blue data. To interpret these results, we fit the correlation functions with analytical predictions derived from the halo model. This model combines linear clustering of the underlying dark matter with a description of the relation of the galaxies to the dark matter haloes in which they reside (the halo occupation distribution). From the fits, we can infer not only the number of galaxies that occupy a halo of a given mass, but also the linear power-spectrum normalization at zero redshift. The values we find from the data are consistent with the locally-inferred value. This agreement can be regarded as a verification of the hierarchical growth of the halo mass function. **(b) (joint with MPIA, Oxford).**

  Phleps, S., Peacock, J. A., Meisenheimer, K., & Wolf, C. 2006, AA, 457, 145, *Galaxy clustering from COMBO-17: the halo occupation distribution at* $< z >= 0.6$

A.3.3 Groningen 4-years

- **Completion of the work on the European Large Area ISO Survey (ELAIS)**:
  Ph. Héraudeau and his colleagues from Heidelberg, Edinburgh and other institutes have completed their work on the analysis of the ELAIS observations performed with the Infrared Space Observatory (ISO). Number counts at 90 microns confirm and extend at fainter flux the strong evolution detected in the infrared regime (Héraudeau et al. 2004). The final band-merged catalogue (Rowan-Robinson et al. 2004), which compiles observations from optical to radio wavelengths, has been publised and made publicly available. The total catalogue consists of 3762 sources. 23 per cent of the 15μm sources and 75 per cent of the 6.7μm sources are stars. For extragalactic sources observed in three or more infrared bands, colour-colour diagrams are presented and discussed in terms of the contributing infrared populations. Spectral energy distributions (SEDs) are shown for selected sources and compared with cirrus, M82 and Arp220 starburst, and active galactic nuclei (AGN) dust torus models. The high proportion of ultraluminous galaxies detected implies very strong evolution in the star formation rate between z= 0 and 1. There is also a surprisingly large population of luminous (Lir > 11.5), cool (cirrus-type SEDs) galaxies. **(b) (joint with Edinburgh, Oxford, MPIA)**

  Héraudeau, Ph., Oliver S., del Burgo C., Kiss, C., Stickel M., Mueller, T., Rowan-Robinson, M., Efstahthiou, A., Surace C. et al., 2004, MNRAS, 354, 924 *The European Large Area ISO Survey VIII: 90-μm final analysis and number counts*
  Rowan-Robinson, M., Lari, C., Pérez-Fournon, I., Gonzalez-Solares,E.A., La Franca, F., Vaccari, M., Oliver,

S., Gruppioni, C., P.Ciliegi, P.,**Héraudeau, Ph.**, Serjeant, S., Efstathiou, A., Babbedge, T., Matute, I., Pozzi, F., Franceschini, A., Vaisanen, A. et al., 2004 , MNRAS, 351, 1290 *The European Large Area ISO Survey (ELAIS): The Final Band-merged Catalogue*

Several papers have presented the identifications, spectral energy distribution and properties of the ELAIS sources:

- The luminosity function of the 90 microns final sample is presented in Serjeant et al. (2004) and extends the sample size of our previous analysis by about a factor of 4. Our sample extends to z= 1.1. From our optical spectroscopy campaigns of the northern ELAIS 90μm survey (7.4 deg^2 in total, to S(90μm)$>$ 70 mJy), we obtained redshifts for 61 per cent of the sample (151 redshifts) to $B < 21$ identified at 7μm, 15μm, 20 cm or with bright ($B < 18.5$) optical identifications. The luminosity function is in good agreement with our Preliminary Analysis luminosity function in the ELAIS S1 and with the recent IRAS-based prediction of Serjeant and Harrison which requires luminosity evolution of $(1+z)^{3.4+/-1.0}$ for consistency with the source counts. **(b) (joint with MPIA)**

  Serjeant, S., Carraminana, A., Gonzales-Solares, E., **Héraudeau, Ph.** , Mujica, R., Pérez-Fournon, I., Sedgwick, N., Rowan-Robinson, M., Franceschini, A., Babbedge, T., del Burgo, C., Ciliegi, P., Efstathiou, A., La Franca, F., Gruppioni, C., Hughes, D., Lari,C., Oliver, S., Pozzi, F., Stickel, M., Vaccari, M. 2004, MNRAS 355, 813 *The European Large Area ISO Survey X: the 90-μm luminosity function from the Final Analysis sample*

- Pozzi et al. (2003) have studied the optical, near-infrared and radio properties of a complete sample of 43 sources detected at 15 in one of the deeper ELAIS regions. The extragalactic objects in this sample have 15μm flux densities in the range of 0.4-10 mJy, where the source counts start diverging from no evolution models. About 90 per cent of the sources (39 out of 43) have optical counterparts brighter than I= 21 mag. Eight of these 39 sources are stars. Most of the extragalactic objects are normal spiral or starburst galaxies at moderate redshift (zmed$\sim$ 0.2); four objects are active galactic nuclei. Finally, the 15 μm, $H\alpha$ and 1.4-GHz luminosities are used as indicators of star formation rate and show that our galaxies are forming stars at a median rate of ~ 40 $M_\odot$ yr^{-1}. **(b) (joint with MPIA)**

  Pozzi, F., Ciliegi, P., Gruppioni, C., Lari, C., **Héraudeau, Ph.**, Mignoli, M., Zamorani, G., Calabrese, E., Oliver, S., Rowan-Robinson, M., 2003, MNRAS, 343, 1348. *On the nature of the ISO-selected sources in the ELAIS S2 region*

- La Franca et al. (2004) present a multiwavelength catalog (15μm, R-band, K-band, and 1.4 GHz flux) plus spectroscopic identifications for 406 15-μm sources detected in the ELAIS-S1 region over the flux density range 0.5-150 mJy. 332 (82%) sources are optically identified down to R$\sim$23.0. Two main spectroscopic classes dominate the mid-infrared (MIR) extragalactic population: $z < 0.5$ star-forming galaxies [from absorbed to extreme starbursts with MIR luminosities of $10^8 - 10^{11}$ $L_\odot$], which account for $\sim$75% of the sources, and active galactic nuclei which account for $\sim$25% of the sources. We also identified 91 (22%) stellar objects. The counts for starburst galaxies and AGNs down to 0.6 mJy have been derived. A general trend is found in the optical-MIR spectral energy distribution of the galaxies, where the MIR-luminous objects have larger MIR to optical luminosity ratios. **(b) (joint with MPIA)**

  La Franca, F., Gruppioni, C., Matute, I., Pozzi, F., Lari, C., Mignoli, M., Zamorani, G., Alexander, D. M., Cocchia, F., Danese, L., Franceschini, A., **Héraudeau, Ph.**, Kotilainen, J. K., Linden-Vórnle, M. J. D., Oliver, S., Rowan-Robinson, M., Serjeant, S., Spinoglio, L. & Verma, A. 2004, AJ, 127, 3075 *The Nature of the Mid-Infrared Population from Optical Identifications of the ELAIS-S1 Sample*

- In Taylor et al. (2005), we report on a search for the optical counterparts of 175μm selected sources from the Far-Infrared Background (FIRBACK) survey in the European Large Area ISO Survey (ELAIS) N2 field. Applying a likelihood ratio technique to optical catalogues, we found optical identifications for 33 out of 55 FIRBACK sources in this field. We have investigated the nature of this population through a comparison of their observed spectral energy distributions (SEDs) with predictions from radiative transfer models which simulate the emission from both cirrus and starburst components. We find the far-infrared sources to be 80 per cent starburst galaxies with their starburst component at a high optical depth. The N2 FIRBACK population is found to consist of four suspected

ultraluminous infrared galaxies (ULIRGs) with L(FIR)$\sim 10^{12}$L$_\odot$ and star formation rates > 100M$_\odot$ yr^{-1}, a number of luminous infrared galaxies (LIRGs) with moderate star formation rates and L(FIR)$\sim 10^{11}$ L$_\odot$ and a population of low-redshift quiescently star-forming galaxies. **(b) (joint with Edinburgh)**

Taylor, E. L., Mann, R. G., Efstathiou, A. N., Babbedge, T. S. R., Rowan-Robinson, M., Lagache, G., Lawrence, A., Mei, S., Vaccari, M., **Héraudeau, Ph.**, Oliver, S. J., Dennefeld, M., Pérez-Fournon, I., Serjeant, S., Gonzalez-Solares, E., Puget, J.-L., Dole, H. & Lari, C., 2005, MNRAS, 361, 1352

Properties of FIRBACK-ELAIS 175-μm sources in the ELAIS N2 region

- **Main science goals of new cosmological surveys**:
  A lot of energy and time was spent on the definition of the science goals to be reached by future surveys, and their definition in term of observing strategy (area covered, exposure time, choice of filters, seeing and photometric requirements) to ensure their sucess; this triggered a lot of network activities among SISCO participants. Simulations of observations and models (e.g. to get an insight on the attainable accuracy of photometric redshifts) were extensively used. The science goals of the main surveys can be summarized as follows:

- Together with the SISCO nodes of Naples and Edinburgh, as well as a number of other european institutes, Kuijken (Groningen) has set up the Kilo-Degree Survey (KIDS), a project to map $\sim$1500 square degrees of sky with the VLT Survey Telescope (VST). The project has been selected by ESO as one of the core surveys for the VST, and will take some 400 nights of observing time. Science goals of KIDS include mapping the halos of galaxies with gravitational lensing, obtaining useful constraints on the equation of state of the dark energy via lensing and large-scale structure, and searching for very high redshift quasars. [Edinburgh, Naples, RUG (b,c)]

- The VESUVIO (VST/OmegaCAM Exploration of SUperclusters and Intermediate Objects) project was started in June 2004 in a collaborative effort lead by Naples and Groningen and represents 120 nights of the VST. The VESUVIO project aims to undertake multi-band, wide-field surveys of nearby superclusters of galaxies to study the properties of the galaxy population in a wide range of environments. [Naples, RUG (b,c)]

- Groningen is also part of the VST-16 project in collaboration with our SISCO colleagues in Heidelberg and Naples to obtain very deep imaging in some special areas of VESUVIO and derive accurate photometric redshifts for many galaxies. [Edinburgh, Naples, MPIA, RUG (b,c)]

A.3.4 MPIA 4-years

- **Evolution of spheroidal galaxies over the last 8 billion years:** It is well-known that spheroidal galaxies tend to form a well-defined red sequence in colour-luminosity space in the local Universe, characteristic of ancient, aging stellar populations. We used the HST/GEMS survey to extend this finding to $z \sim 0.7$, 6 billion years in the past. We have studied the evolution of the red sequence (thus, by association, the early-type galaxy population) since $z \sim 1$. We detect a factor-of-two increase in the total amount of stellar mass in red-sequence galaxies over the last 8 billon years with high significance (Bell et al. 2004). Importantly, an increase in the stellar mass in red sequence galaxies over the last 8 Gyr is a clear prediction of galaxy formation theories in a hierarchical ΛCDM Universe, and these surveys are the first to securely confirm these predictions. The above paper is in top 0.1% of all 2004 astrophysics papers by citations. **(b) (joint with Oxford).**

  Bell, E. F., Wolf, C., Meisenheimer, K., Rix, H.-W., Borch, A., Dye, S., Kleinheinrich, M., Wisotzki, L., & McIntosh, D. H. 2004, ApJ, 608, 752, *Nearly 5000 Distant Early-Type Galaxies in COMBO-17: A Red Sequence and Its Evolution since $z \sim 1$*

- **Decline of cosmic star formation over the last 8 billion years:** The same sample of $0.65 < z < 0.75$ galaxies has been used to understand the decline in cosmic star formation rate. We investigated in which morphological types of galaxies the star formation occurs. The result is that 50 to 75% of the star formation at $z = 0.7$ takes place in spiral galaxies and (faint) irregular galaxies. No more than 20% of the star formation happens in peculiar or clearly interacting systems, with morphologies suggestive of a galaxy merger. This excludes the hypothesis that the decline

of the cosmic star formation by about a factor of three since $z = 0.7$ can be explained by a declining major merger rate. **a) (joint with Oxford).**

Bell, E. F., Papovich, C., Wolf, C., Le Floc'h, E., Caldwell, J. A. R., Barden, M., Egami, E., McIntosh, D. H., Meisenheimer, K., Pérez-González, P. G., Rieke, G. H., Rieke, M. J., Rigby, J. R., & Rix, H.-W. 2005, ApJ, 625, 23, *Toward an Understanding of the Rapid Decline of the Cosmic Star Formation Rate*

- **Galaxy merging:** Mergers between already-assembled galaxies is predicted to be an important mode of growth for galaxies, even at relatively recent times. We used the GEMS and COMBO-17 survey to determine the merger rate between massive galaxies at $z \sim 0.6$. We probed two different types of mergers — mergers between gas-free elliptical galaxies ('dry mergers') and mergers between all massive galaxies. In both cases, under reasonable assumptions about merger timescale, Bell et al. (2006) found evidence for active merging in the massive galaxy population, with ~ 1 merger per massive galaxy since $z \sim 1$. This paper is in top 0.2% of all 2006 astrophysics papers by citations. **(b) (joint with Edinburgh, Oxford).**

  Bell, E. F., **Phleps, S.**, Somerville, R. S., Wolf, C., Borch, A., & Meisenheimer, K. 2006, ApJ, 652, 270, *The Merger Rate of Massive Galaxies*

- **STAGES:** We have been awarded substantial allocations of Hubble Space Telescope, Spitzer Space Telescope, and GALEX time to explore how environmental processes affect the evolution of dwarf galaxies. Through COMBO-17, we have a very deep (complete down to dwarf galaxy magnitudes $M_r \sim -14$) catalog of cluster members in the Abell 901/902 galaxy supercluster. We received 80 orbits of HST time (Gray, Bell, Wolf, et al) and 41 hours of Spitzer infrared telescope time (Bell, Wolf et al) to explore the morphologies and star formation rates of galaxies in this complex environment. An important bonus is that this is one of the COMBO-17 fields, giving data of a similar quality and area coverage to GEMS for the study of galaxy evolution over the last 6-8 billion years. **(b) (joint with Edinburgh, Oxford).**

  Zheng, X. Z., **Bell, E. F.**, Papovich, C., Wolf, C., Meisenheimer, K., Rix, H.-W., Rieke, G. H., & Somerville, R. 2007, ApJL, 661, L41, *The Dependence of Star Formation on Galaxy Stellar Mass*

A.3.5 Naples 4-years

- **Galaxy Evolution** The work on galaxy evolution consisted in the study of the structure and stellar population in galaxies at different redshifts and the effects of environment on galaxy populations.

  The structure and internal colour gradients of cluster galaxies was studied in the redshift range $z \sim$0.05-0.7 at UV, optical, and NIR wavelengths, either on proprietary data on individual objects (ESO-VLT) or in survey data (~ 200 galaxies in 170 clusters, from the Palomar Abell Cluster Survey). The main new results from the study of structure are: *(a)* the Kormendy relation, relating length scale and surface brightness of early-type galaxies is invariant in the last 6 billion yers of cosmic time; *(b)* the "Photometric Plane", a scaling law relating scale lenght, surface brightness and brightness profile shape of early-type galaxies, does not depend on redshift or wavelength, and is related to the specific entropy of galaxies. This makes it a potentially powerful tool to study probe galaxy evolution; *(c)* the evolution of optical-NIR colour gradients in the last 6 billion years tell us that the disk component of late-type galaxy is at least 2 billion years younger than the bulge. Late type galaxies must therefore have formed by merging of different stellar populations; *(d)* stellar populations are more mixed in galaxies belonging to rich clusters than those in poor clusters, maybe due to the different efficiency of merging processes. **(b)**

  La Barbera, F., Covone, G., Busarello, G., Capaccioli, M., **Haines, C. P.**, Mercurio, A., Merluzzi, P., 2005, MNRAS 358, 1116, *New insights into the structure of early-type galaxies: the Photometric Plane at z∼0.3*

  The effects of environment on galaxy evolution has been mainly investigated in the Shapley Optical Survey, in which a field of 2 suqare degrees centred on the Shapley supercluster was analysed. The main result of this work is that while the star formation histories in giant galaxies are primarily determined by major merging events, the star

formation history in dwarf galaxies was rather influenced by episodes of ram pressure stripping or galaxy harassment. These results are further confirmed by the analysis of the whole SDSS spectroscopic catalogue performed by C. Haines and collaborators. **(b) (joint with Durham).**

Haines, C. P., La Barbera, F., Mercurio, A., Merluzzi, P., Busarello, G., 2006, ApJ 647, 21, *The Different Environmental Dependencies of Star Formation for Giant and Dwarf Galaxies*

- **VST Extragalactic Surveys** The concepts of the two extragalactic surveys that will be carried out with the substantial contribution of the guaranteed time of observations (GTO) of Napoli have been fully developed in the framework of the SISCO Network. From the side of the node of Napoli, the main science goals of both surveys is the study of the effects of the environment on galaxy evolution. For this reason the idea was to explore the area of two superclusters of galaxies at two different redshifts, namely one "local" supercluster (z$\sim$0.07) and one supercluster at intermediate redshift (z$\sim$0.4).

  The start of operations of the VST has been delayed to mid 2007. This prevented us to exploit the first results of the surveys within the SISCO network. At the same time, this delay forced us to keep the survey plans up to date with respect of general framework of ongoing and newly planned extragalactic surveys.

  VESUVIO (VST-Omegacam Exploration of Superclusters,Voids and Intermediate Objects) is a survey planned in collaboration with the node of Groningen. The aim is to image in five wavebands an area of 100 square degrees, mapping the Southern part of the supercluster of Horologium at z=0.07, plus an area of 10 square degrees (Hercules supercluster). The survey requires the use of 40+10 nights of VST observations (provided by Napoli and by the OmegaCam Consortium respectively). In the last year, the VESUVIO survey has been embedded into the KIDS (KIlo Degree Survey) survey, which is a wide-area ($\sim$1500 square degrees) public survey with the participation of several European Institutes (Leiden and Groningen, NL; München, Bonn, D; Edinburgh, GB; Napoli, I, Paris, F). X-ray observations of the Horologium supercluster have already started by the Max-Planck-Institut für Extraterrestrische Physik, Garching (D). **(b) (joint with Groningen).**

  The VST-16 survey was initially conceived by the node of Heidelberg in collaboration with the Universities of München, Bonn and Edinburgh as an extension of the COMBO-17 survey. The node of Napoli joined the project by offering 40 nights of guaranteed time and proposing to add as a further target of the survey a candidate supercluster of galaxies at $z = 0.375$. By means of VST/OmegaCam obervations in 16 wavebands, the survey will deliver accurate photometric redshifts and spectro-phootmetric classification for about one million galaxies up to redshift z$\sim$1.2. **(b) (joint with MPIA and Edinburgh).**

  In the framework of the preparation of the VST surveys, a software package (provisional name 2DFIT) was developed in collaboration with Reinaldo de Carvalho (INPE, Brazil) and Joao Kohl (National Observatory, Brazil). The package allows a fully automatic two-dimensional analysis to be performed for all the objects (stars and galaxies) in wide-field images. The package will be applied to extract surface photometry parameters (including e.g. morphological classification) in the VST surveys.

A.3.6 Oxford 4-years

- **UKIDSS:** The UKIDSS surveys are now underway with Dalton & Rawlings (and student van Breukelen) working closely with Durham and Edinburgh colleagues on the generation of cluster catalogues from the first datasets. Oxford have been leading efforts to tie together the evolution of clusters of galaxies (from these near-infrared surveys), with their gas content (via linked SZ surveys) and AGN activity (via radio, X-ray and far-IR surveys). **(b) (joint with Edinburgh, Durham).**

  van Breukelen C., Clewley L., Bonfield D. G., Rawlings S., Jarvis M. J., Barr J. M., Foucaud S., Almaini O., Cirasuolo M., Dalton G., Dunlop J. S., Edge A. C., Hirst P., McLure R. J., Page M. J., Sekiguchi K., Simpson C., Smail I., Watson M. G., 2006, MNRAS, 373, L26, *Galaxy clusters at* $0.6 < z < 1.4$ *in the UKIDSS Ultra Deep Survey Early Data Release*

- **Radio-loud Quasars at $z > 7$:** Oxford's SISCO-supported young researcher (Eugenio Barrio) has been working on a novel survey for the first known radio-loud quasars beyond redshift 7. This programme was motivated partly as a testing ground for surveys possible with UKIDSS, and partly thinking ahead to the time (in five to ten years time) when spectroscopic surveys will be led by radio (rather than optical/near-IR techniques). **(b) (joint with Durham, Edinburgh)**.

  Simpson C., Almaini O., Cirasuolo M., Dunlop J., Foucaud S., Hirst P., Ivison R., Page M., Rawlings S., Sekiguchi K., Smail I., Watson M., 2006, MNRAS, 373, L21, *Extremely red objects in the UKIDSS Ultra Deep Survey Early Data Release*

Five most significant publications in the 4 years of SISCO

- **da Ângela, J.**, Outram, P. J., Shanks, T., Boyle, B. J., Croom, S. M., Loaring, N. S., Miller, L., & Smith, R. J. 2005, MNRAS, 360, 1040
  The 2dF QSO Redshift Survey- XV. Correlation analysis of redshift-space distortions [DUR, OXF, (a)]
- **Phleps, S.**, Wolf, C., Peacock, J. A., Meisenheimer, K., & van Kampen, E. 2007, AA, 468, 113
  COMBO-17 measurements of the effect of environment on the type-dependent galaxy luminosity function, [UEDIN, MPIA, OXF, (b), (c)]
- **Héraudeau, Ph.**, Oliver S., del Burgo C., Kiss, C., Stickel M., Mueller, T., Rowan-Robinson, M., Efstahthiou, A., Surace C. et al., 2004, MNRAS, 354, 924
  The European Large Area ISO Survey VIII: 90-μm final analysis and number counts [RUG, MPIA, (a)]
- **Bell, E. F.**, Wolf, C., Meisenheimer, K., Rix, H.-W., Borch, A., Dye, S., Kleinheinrich, M., Wisotzki, L., & McIntosh, D. H. 2004, ApJ, 608, 752
  Nearly 5000 Distant Early-Type Galaxies in COMBO-17: A Red Sequence and Its Evolution since $z \sim 1$ [MPIA, OXF, (b), (c)]
- **Haines, C. P.**, La Barbera, F., Mercurio, A., Merluzzi, P., Busarello, G., 2006, ApJ 647, 21
  The Different Environmental Dependencies of Star Formation for Giant and Dwarf Galaxies [OAC, (b)]

B Comparison with the Joint Programme of Work

B.1 Research Objectives

The general research objectives of SISCO as set down in Annex I of the contract are: (i) supporting the European survey astronomy effort at the 6 participating university nodes with four pre-docs and five post-docs (ii) improving the exchange of information between those involved in making the surveys at these institutes in order to strengthen the scientific foundations of the astrophysical virtual observatories of the future and (iii) support the European effort in making astronomical surveys for cosmology and so promote a unified European approach to cosmological surveys, particularly in the Southern Hemisphere. These objectives have essentially been achieved.

These three general objectives were supported by our efficient and early appointment of 5 post-docs and 2 pre-docs at the 6 university nodes of the network. Over the four years we have also had six extremely successful 2-day network meetings with a kick-off meeting at Durham, then meetings at Oxford, Napoli, and Heidelberg, followed by the mid-term review meeting at Groningen on 23-24 Sept. 2004 and then a winter school at Obergurgl, Austria on 12-19 February 2005 and then a 2-day network meeting at Edinburgh on 15-16 September 2005. Finally, on 30 July-4 August, 2006 we had a concluding international 5 day conference, Cosmic Frontiers, to mark the end of the network.

There are three specific research objectives of the network viz.:

(a) Exploitation of existing Cosmological Surveys

(b) Preparation for and then exploitation of Future Cosmological Surveys

(c) Forward look to next generation European Cosmological Surveys

These three specific research objectives as set down in Annex I of the contract have been achieved. Most of the milestones set down for the end of the SISCO network have been achieved. These included:

- Completion of the analysis of the CADIS Survey (Objectives a, b)
- Completion of the preparation for forthcoming 2dF, VST, VISTA and UKIDSS Surveys (Objective b)
- Exploitation started of these forthcoming surveys (Objective b)
- Coherent and unified strategy produced for the future generation of European cosmological surveys (Objective c)
- Completion of the training of eight (now nine) young European researchers (Objectives a,b,c)

Due to the delays to the telescope building programmes of VST and VISTA, the third item above has not been completely achieved, namely the start of exploitation of the VST and VISTA surveys. But, somewhat paradoxically, the delay has meant that the influence of the SISCO network on the design of these surveys has been increased.

There have been some changes in the research method and we list these in Section B.2 below, describing to what extent the objectives are being achieved and noting where details have changed.

B.2 Research Method

B.2.1 2dF Spectroscopic Surveys (Objectives a, b, c)

Exploitation has been proceeding of the extended 2dF spectroscopic survey, 2SLAQ, comprising 11000 Luminous Red Galaxy and 8000 QSO redshifts in the N and S Equatorial regions. These surveys go deeper in both magnitude and redshift than the previous 2dF surveys.

With the 2dF AAOmega instrument, we have had excellent success in winning telescope time to make a pilot survey of Luminous Red Galaxies to push the average redshift from z=0.55 for 2SLAQ to $z \approx 0.7$. We have also been successful in winning time for the AUS proposal to push LRG identifications to yet higher redshifts, $z \approx 0.9$. Using these data we have shown that the photometric redshift route seems a competitive technique in terms of measuring LRG clustering to the largest scales. Thus there are now two routes for LRG redshift surveys such as those that can be made using VST ATLAS and VHS - either samples of < 400000 LRGs using spectroscopic redshifts or samples $10\times$ larger using photo-z.

B.2.2 Near-IR Surveys (Objectives b, c)

Exploitation of the new UKIDSS Large Area Survey (LAS) and Ultra Deep Surveys (UDS) are also proceeding. The LAS data is being used to make NIR galaxy counts at intermediate magnitudes and sldo to find galaxy clusters associated with LRGs in the 2SLAQ redshift survey. The LRG redshifts are also being used to test photometric redshifts obtained by combining UKIDSS near-IR photometry with optical photometry from SDSS. The 2dF QSO surveys are also benefitting from having near-IR photometry available; QSO luminosity functions are being estimated in the K band for the first time, for example. Oxford is leading efforts within UKIDSS to tie together the evolution of clusters of galaxies (from these near-infrared surveys), with their gas content (via linked SZ surveys) and AGN activity (via radio, X-ray and far-IR surveys). There will be close collaboration with Durham.

The VISTA telescope is now due to be commissioned in early 2008 and so work on its NIR surveys will only start at that point.

B.2.3 Imaging Dark Matter via Weak Lensing (Objectives a, b, c)

As reported previosuly, the new lensing survey (KIDS) will be done in the 2dF equatorial and SGP areas. However, the further delay to VST commissioning due to a delay to the mirror support system means that these optical survey will now only begin in 2009.

Exploitation of the new HST ACS imaging of the Chandra Deep Field from the GEMS survey continued and provided vital new insights into weak gravitational lensing by large scale structures.

B.2.4 Narrow-band imaging (Objectives a, b, c)

The COMBO-17 survey is the natural successor to CADIS which is now complete. COMBO-17 uses 17 narrow-, medium- and broad-band filters to produce photometric redshifts. The COMBO-17 redshifts for $z < 0.8$ LRGs in their S11 field have been tested and found to be accurate in the AAOmega LRG pilot project. Preparations for the VST-16 medium band survey are continuing although hindered by the VST delay.

B.2.5 Optical Imaging. (Objectives b, c)

The main activity related to optical imaging is the continuing preparation of the VST imaging surveys, from the study of the observing strategies to the choice of the areas in the sky. Examples of such proposed surveys are KIDS, VST-16, VESUVIO and the VST ATLAS. These are mostly led by SISCO members. Again these are suffering delay because of problems with VST. Otherwise there has been no change to the research methods.

B.2.6 High Redshift Galaxy z-space Distortion (Objectives b, c)

A high-redshift $z \approx 3$ galaxy survey is being made based in fields with bright QSOs to allow studies of the interactions between starforming z=3 galaxies and hydrogen and metal clouds detected in the QSO absorption line spectra. Several observing trips to the KPNO and CTIO 4-metre telescopes and also the INT 2.5-m telescope have been made to provide the imaging material for this survey. Another 60 hours of VLT VIMOS time has been won for this project, making over 170 hours of VLT VIMOS time in total. We have also been successful in winning AAOmega time to detect high redshift QSOs to complement our VLT survey of $z \approx 3$ galaxies.

B.2.7 Variability Surveys - SNIa Searches and Quasar Monitoring (Objectives b, c)

There is no change to the research method here, although the start of the variability survey will be later than expected due to the delay in commissioning VST till 2009.

B.2.8 Mock Surveys via Cosmological N-body and Hydrodynamic Simulations (Objectives a, b, c)

There is no change to the research method in this section. The Millennium N-Body simulation continues to be used to make mock catalogues at higher resolution than previous simulations.

B.2.9 Forward look to next generation European Cosmological Surveys (Objective c)

The conceptual form of the next generation (post-2006) of European cosmological surveys was a major aspect of the discussions at the Cosmic Frontiers conference in July-August 2006. Further workshops are envisaged at Marseille in June 2007 and Grenada in October 2007 to continue these discussions once SISCO has formally ended.

B.3 Work Plan

B.3.1 Breakdown of Tasks

Table 1 was previously updated from the version in Annex I and has been updated again from the 3rd Year Report. The changes mainly reflect the delays to VST and VISTA telescopes and hence their associated surveys. These changes are detailed in the Research Methods discussed above and in previous annual reports. For reference, Table 2 reproduces the timelines for the four SISCO projects as given in the 3rd Year Report. Again, all tasks in these timelines have been

Table 1: Distribution of Tasks between Participants

Task (Objective)		DUR	UEDIN	RUG	MPIA	OAC	OXF
Analysis of Current Surveys **(a)**	2dF QSO	$\surd^*$					$\surd$
	2dF Galaxy	$\surd$	$\surd^*$		$\surd$		$\surd$
	CADIS		$\surd$		$\surd^*$		
	EIS						
	WHT CNOC Lensing			$\surd^*$			
	Cluster Galaxies					$\surd$	
Preparation for Future Surveys **(b)**	2dF-SDSS QSOs	$\surd^*$		$\surd$	$\surd$	$\surd$	$\surd$
	2dF-SDSS LRGs	$\surd$	$\surd^*$	$\surd$		$\surd$	$\surd$
	Photometric Redshifts	$\surd$	$\surd$		$\surd^*$	$\surd$	$\surd$
	Hi-z Cluster Detection		$\surd^*$		$\surd$		$\surd$
	Weak Lensing Shear		$\surd$	$\surd^*$			
	Variability	$\surd^*$	$\surd$	$\surd$			
	z-space Distortion	$\surd^*$	$\surd$				$\surd$
	Numerical simulations	$\surd^*$	$\surd$				$\surd$
Analysis of Future Surveys **(b,c)**	2dF	$\surd^*$	$\surd$	$\surd$	$\surd$	$\surd$	$\surd$
	VST					$\surd$	
	VISTA						
	WFCAM	$\surd$	$\surd^*$	$\surd$	$\surd$	$\surd$	$\surd$

completed, save for the second and fourth lines of Timeline 4, Exploitation of Future Surveys, where VST Optical Imaging and VISTA IR Imaging have been held up by the delays to the VST and VISTA telescopes. Note that Timeline 1 lists VST and VISTA surveys in current and future surveys simply to set the context and there were no SISCO tasks associated with these items. Also note that the preparation for VST and VISTA imaging surveys tasks mentioned in Timeline 3 have been completed.

B.3.2 Schedule and Milestones

As noted above, all end of network milestones have been completed, except for those parts relating to the start of exploitation of the VST and VISTA imaging surveys. This change to this milestone was flagged in the SISCO 3rd Year Report. The training programme for nine network researchers has already been completed. The strategy for future generations of European surveys continues to be formulated after discussions at the end-of-SISCO conference, Cosmic Frontiers in July-August 2006.

B.3.3 Research Effort of the Participants

The updated table summarising the research effort of the participants is given in Table 3. SISCO funding for Jose Cruz da Angela covered 36 months of his PhD at Durham, as foreseen in the last report. Jose obtained his PhD in August 2006.

As noted last year, the Oxford pre-doc, Eugenio Barrio, finished his 36 month contract on 30/9/05 but is continuing to work on his PhD.

The MPIA postdoc, Eric Bell, finished his 40 month postdoc on 31/1/06. A new MPIA SISCO postdoc J de Jong, (Dutch) was appointed for an 8 month period from 1/2/06-20/9/06.

Chris Haines completed his 48 month post-doc at OAC at 30/9/06. He has taken up another 10 month contract at OAC after which he will take up a 3.5 year PDRA position at the University of Birmingham.

Due to the salary of the Groningen post-doc, Philippe Heraudeau, being higher than expected, Groningen's SISCO funding will only pay for 3 months of the final year for Heraudeau taking the total support to 39 months, as previously

Table 2: Timelines

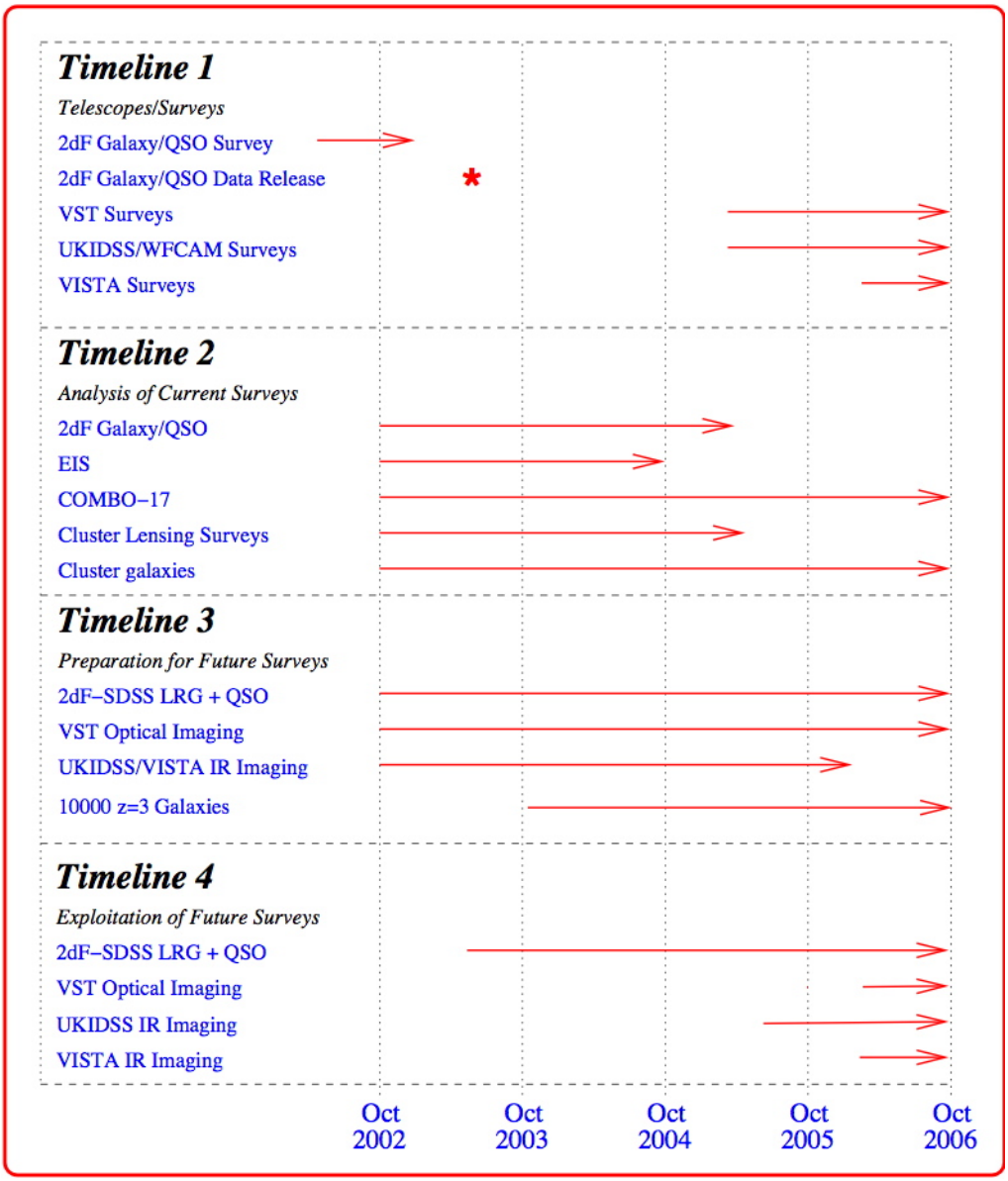

Table 3: Research Effort of the Participants

Participant	Young researchers to be financed by the contract (person-months)	Researchers to be financed from other sources (person-months)	Researchers likely to contribute to the project (number of individuals)
	(a)	(b)	(c)
DUR	65	144	13
UEDIN	58	125	8
RUG	39	58	5
MPIA	48	101	7
OAC	48	82	8
OXF	36	65	7
Totals	294	635	53

notified. However, the final claim of the Groningen node is to support Heraudeau for 6 months in the final year, leading to an overspend at Groningen (see Section B.6 below). This is after taking into account the extra 15k euros transferred to Groningen from the ESO node, 13k euros of which eventually became available to help pay Heraudeau.

The Edinburgh post-doc Steffi Phleps finished her 33 month contract on 30/11/05. The Edinburgh pre-doc Anita Schael has also been funded for a total of 25 months. This has left a small overspend of the SISCO budget at Edinburgh (see Section B.6 below).

(B.1) 4-Year: Research Achievements

Research Objectives and Research Methods
(a) Exploitation of existing cosmological surveys: These objectives were entirely achieved. The 2dF Galaxy and Quasar surveys were fully exploited. The CroNario survey was also completed. The EIS surveys have been published. CADIS was completed. The lensing survey of galaxy clusters was carried out in the form of a QSO lensing survey of galaxy clusters and groups.
(b) Preparation for and then exploitation of future cosmological surveys: A major extension of the 2dF galaxy and QSO surveys was carried out in terms of the 2SLAQ LRG and QSO survey. @SLAQ redshifts have been used to tests photometric redshifts. VLT VIMOS has been used to make a z=3 galaxy survey in QSO fields. Searches for high redshift clusters are being carried out using the UKIDSS NIR surveys. Since the VST and VISTA surveys were delayed by the slower than expected construction of these telescopes this has meant that the exploitation of the variability surveys and the VST and VISTA imaging surveys has also been delayed. However the objective of preparation for these surveys has been very well achieved.
(c) Forward look to next generation European cosmological surveys: This aim has also been well achieved. Paradoxically, the delays to the VST and VISTA programmes has been beneficial in the influence that SISCO has had on the future survey programmes for these telescopes. Therefore the VST surveys like KIDS, VST ATLAS, VST-16 and VESUVIO are all led by SISCO participants. There is also heavy influence on the related VISTA surveys such as the VISTA Hemisphere Survey, the sister NIR survey to the VST ATLAS optical survey. The Cosmic Frontiers conference also provided a useful forum for discussing developments further into the future.
Research Methods The methods used were highly successful, with the only problems arising because of the slower than expected speed of constructing the VST and VISTA telescopes. Even here a basisc start to the research could be made using the SDSS optical and UKIDSS surveys in the NIR as proxies for the VST/VISTA surveys. The spectroscopic surveys went much as planned, including the extension of the 2dF galaxy and QSO redshift surveys, 2SLAQ. Extensive use of mock galaxy and QSO catalogues from N-body simulations were made in interpreting these datasets.
Breakdown of Tasks This went very much as planned. Delays to VST and VISTA meant that the final total collaborative aspects were slightly less than envisaged. Nevertheless the overall aim of integrating the European survey cosmology

effort was realised.
Schedule and milestones The milestones were all achieved with the exception of those relating to the exploitation of VST and VISTA surveys. The delays to the construction of these telescopes were outside the responsibility of SISCO.
Research effort of the particpants The research effort of the particpants was very similar to the original plan. The hiring of post-docs and pre-docs was highly efficient and our 294 months of training has been supplied, almost exactly.

B.4 Organisation and Management

B.4.1 Network Organisation

The network is being organised and managed in much the way described in Annex I. The Network Management Committee has met at each of the 7 network meetings , at the Winter School and at the closing conference, Cosmic Frontiers. in Durham. There have been fewer visits to ESO than planned but more network meetings (see below). The network meetings, email and the SISCO web-page form the main methods of network communications. The SISCO webpage is at http://star-www.dur.ac.uk/cosmology/SISCO/. At the first meeting several working groups were set up, including one on High Redshift Universe, one on the Low Redshift Universe, one on Lensing and one on Theoretical Cosmology. These have links to areas of their own on the SISCO web-page. One of our success stories has been the level of participation in SISCO meetings by the young theory group led by Dr. Eelco van Kampen at the University of Innsbruck in Austria.

B.4.2 Network Meetings

The end-of-SISCO conference was entitled "Cosmic Frontiers" and took place at Durham on 31st July-4th August 2006. Almost 200 participants attended making this one of the biggest cosmology conferences of 2006. These participants included representatives from almost all of the SISCO nodes. Many of the SISCO young researchers made presentations. The invited speakers from outside the SISCO network included Prof L. Cowie (IFA, Hawaii), Prof. D. Eisenstein (Arizona), Prof. R.S. Ellis (Caltech), Dr G. Hinshaw (NASA Goddard), Dr O. Le Fevre (Marseille), Dr G. da Lucia (MPA, Munich), Prof. P.J.E. Peebles (Princeton), Prof. B. Schmidt (Australia National University), Prof. C. Steidel (Caltech), Prof. S.D.M. White (MPA Munich) and many others. Given the amount of preparation needed for this large conference this was the only SISCO network meeting that took place this year. But this large international conference gave us ample opportunity to showcase the work of the SISCO network to current and future generation of researchers in observational cosmology. The conference was a great success and a 400 page proceedings are being published by Astronomical Society of the Pacific.

B.4.3 "Networkings"

We now summarise the networkings in the reporting period (see also Table 4):
DUR - Tom Shanks, Jose Cruz da Angela (SISCO pre-doc), Georgios Mountrichas, Nic Ross and David Wake, attended the Cosmic Frontiers conference in July 2006. Tom Shanks, Alastair Edge attended the Panoramic Surveys meeting and then the UK Infrared Deep Sky Survey meeting at Edinburgh on 10-11 November 2005. T. Shanks attended 'Strings to Cosmic Web' meeting in Groningen 30/11-2/12/05. R. Smith made a collaborative visit to Naples to discuss SOS survey in March, 2006.
UEDIN - Stefanie Phleps (SISCO postdoc), Anita Schael (SISCO pre-doc), P. Best, C. Francis, T. Kitching, E. Rigby, B. Rowe and R. Tojeiro attended the Cosmic Frontiers conference at Durham in July 2006.
RUG - Ph. Heraudeau (SISCO postdoc), GV Klein, JP Mcfarland and E. Valentijn attended the Cosmic Frontiers conference at Durham in July-August 2006. K. Kuijken visited Oxford for the 'Pathway to the SKA' meeting in April 2006.
MPIA - Klaus Meisenheimer, I. Franco, B. Haeussler, K. Knudsen, I. Sakelliou, C. Tapken, attended attended the Cosmic Frontiers conference at Durham in July 2006.
OAC - Chris Haines (SISCO postdoc) visited Groningen to collaborate on VST Astrowise pipeline in November 2005. He also attended the Cosmic Frontiers conference at Durham in July-August 2006.
OXF Eugenio Barrio (Oxford SISCO pre-doc), Lance Miller and Ana Babic attended the Cosmic Frontiers conference at Durham in July-August 2006.

Table 4: Network Visits 2005-06

To / From	DUR	UEDIN	RUG	MPIA	OAC	OXF
DUR	—	(22)	(23)		(24)	
UEDIN	(21)	—				
RUG	(21)		—			(25)
MPIA	(21)			—		
OAC	(21)		(26)		—	
OXF	(21)					—

(21) end of SISCO conference, "Cosmic Frontiers" 31st August - 4 July 2006
(22) Panoramic Surveys meeting+UKIDSS meeting, Edinburgh, 10-11 November 2005
(23) 'Strings to Cosmic Web' meeting in Groningen 30/11-2/12/05
(24) R. Smith collaborative visit to Naples to discuss SOS survey, 3/06
(25) K. Kuijken visit to Oxford for 'Pathway to the SKA' meeting, 4/06
(26) C. Haines visit to Groningen to collaborate on VST Astrowise pipeline, 11/05

(B.2) 4-Year: Overall Organisation and Management

Organisation, co-ordination and management of the network

Network organisation and management was generally straightforward. All scientists-in-charge took their responsibilities seriously and coordination of research and meetings were well-organised at the node level. This generally made the role of the coordinator an easy one.

Due to no fault of the ESO scientist-in-charge L Da Costa, ESO management decided to close down his ESO Imaging Surveys section, at which point da Costa and his team left the ESO node. Since there was no SISCO young researcher employed at ESO, it was decided to redistribute $\approx$ 31k euros of ESO networking funds to other networks, principally $\approx$15k euros to fund an extra year for the SISCO pre-doc Cruz da Angel and $\approx$15k euros to Groningen to go towards the SISCO postdoc, P Heraudeau's, salary which had run into an overspend as noted in the 3rd-year report. Overall, the financial mangement of SISCO at all nodes was sound with even the small final overspends at Durham, Edinburgh and Groningen being mostly balanced by small underspends elsewhere.

Communication strategy

The communication strategy as envisaged in the original contract basically worked. The network meetings were particularly fruitful. These were held at 6 monthly intervals during the first 3 years. Secondments were less successful; young researchers may regard it as disruptive both to their academic and personal lifes to move away from their home node for even a few weeks at a time.

The Winter School held in Obergurgl was a particularly successful exercise in bonding the network together. Meetings and seminars were held in the mornings and evenings with some time for skiing in the afternoons! The knowledge transmitted in the mornings and evenings was matched by the 'ice-breaking' networking of individuals in the afternoons. The winter school presentations are available at `http://astro.uibk.ac.at/sisco/presentations.htm` and also on DVD.

The outstanding end-of-SISCO conference, 'Cosmic Frontiers' also played a vital role in communicating the achievements of the SISCO network to the international community of cosmologists. The conference programme and presentations are available at `http://www.dur.ac.uk/cosmology06/frame.php?go=programme`. The conference papers will also be published by ASP.

Dissemination of network achievements

SISCO personnel at all nodes have been heavily involved in publicising SISCO activities via international conferences. The biggest conferences were all attended by SISCO personnel too numerous to mention: IAU Symposium 235, 'Galaxy Evolution across the Hubble Time', in Prague, August 2006: IAU Symposium 216, 'Maps of the Cosmos' Sydney, July 2003. 'Open Questions in Cosmology' MPE Garching, August 2005 Galaxy and QSO Redshift Surveys, RAS London,

October 2003, Galaxy Formation and Evolution, Kloster Irsee, 4 July 2003. In addition, all the nodes run well-developed public outreach activities and SISCO personnel have played a significant role in these.

List of network meetings, schools, workshops

Kick-Off meeting Durham October 2002; Network meeting Oxford March 2003; Network meeting Napoli September 2003; Network meeting MPIA Heidelberg March 2004; Vesuvio Supercluster meeting Napoli, June 2004; VST meeting, RUG, Groningen, September 2004; Mid-term meeting RUG Groningen September 2004; 2dF+VST meeting, Durham, December, 2004; SISCO Winter School Obergurgl, Austria February 2005; VST-16 meeting Heidelberg July, 2005; Network meeting Edinburgh September 2005; 2dF+VST meeting, Durham, December, 2005; end-of-SISCO Cosmic Frontiers conference August 2006.

Networking activities (e.g. secondments, visits, sample exchanges).

Although the number of secondments is small, there have been a large number of visits (see Table 4 above and Table 5 below).

B.5 Training

B.5.1 Publicising Vacant Positions

N/A

B.5.2 Recruitment of Young Researchers

The recruitment and employment of young researchers has gone as previously forecast at most nodes. The situation is summarised in Table 6 where the first set of 3 person-month columns are those given in Annex I, the second set of 3 person-months column have been updated to take into account recent changes to the Annex I forecast and the final set show how many person-months have been financed so far.

Jose Cruz da Angela's pre-doc 36 month SISCO contract finished at 30/9/06 and he was awarded a PhD in August 2006. Edinburgh's PhD student, Anita Schael contract also finished at 30/9/06 after completeing the first two years of her PhD. Thus the number of pre-doc months at Edinburgh is being increased again from 18 to 25 months (cf 36 months in Annex I). Stefanie Phleps' contract at Edinburgh was extended from 31 months to 33 months (cf 26 months in Annex I) and will end on 30/11/05, as notified at the time of the last report. Otherwise recruitment has progressed as previously planned. The overall number of young researcher person-months is maintained at the 294 figure indicated in Annex I.

B.5.3 Young Researcher Integration

The young researchers were very successfully integrated into the research programme at each node and the regular network meetings have integrated them into a very successful overall research programme. Of course, by the final year of the network, several SISCO young researchers had finished their contracts and left their host node. While there were enough funds to replace some otheres could not be replaced. Even so, the final year there wast still lively and active communication between the nodes culminating in the Cosmic Frontiers conference at Durham in August 2006.

B.5.4 Young Researcher Training

The training of the young researchers so far has mainly been by their full assimilation into the various research programmes at the nodes. All the young researchers have given 10 minute talks at each of the meetings, describing the progress of their work. Several have also attended major international conferences. All the SISCO young researchers were encouraged to participate in secondments and exchanges to other SISCO nodes. The pre-doc young researchers are participating now in the third year training programmes as appropriate at each University.

Table 5: Network Visits 2002-05 (see Table 4 for 2005-06)

To / From	DUR	UEDIN	RUG (Leiden)	MPIA	OAC	ESO	OXF
DUR	-			(6)	(3)		(2)
UEDIN	(1)	-		(5),(6),(8)	(3)		(2)
RUG	(1)		(7)		(3)	(4)	(2)
MPIA	(1)			-	(3)		(2)
OAC	(1)		(7)		-		(2)
ESO	(1)				(3)	-	(2)
OXF	(1)				(3)		-

To / From	DUR	UEDIN	RUG	MPIA (Munich)	OAC	ESO	OXF
DUR	—		(13),(14)	(10),(15)			
UEDIN		—	(14)	(9),(10),(15)			
RUG			—	(10),(11)	(12)		
MPIA			(14)	(15)			
OAC			(13),(14)	(10),(15)	—		
ESO			(14)	(10)		—	
OXF			(14)	(9),(10),(15)			—

To / From	DUR	UEDIN	RUG	MPIA (+Obergurgl)	OAC (+Catania)	ESO	OXF
DUR	—	(20)		(16)		(18)	
UEDIN		—		(16)(19)			
RUG		(20)	—	(16)(19)	(17)		
MPIA		(20)		(16)			
OAC		(20)		(16)(19)	(17)		
ESO		(20)				—	
OXF		(20)		(16)(19)			—

(1) SISCO Network Meeting in Durham
(2) SISCO Network Meeting in Oxford
(3) SISCO Network Meeting in Napoli
(4) ESO Workshop "Large Programmes+Public Surveys", Garching, 19-21 May 2003
(5) Visit to Heidelberg, 9 - 18 May 2003
(6) Meeting "The Formation and Early Evolution of Galaxies" at Irsee, July 2003
(7) Workshop "OmegaCAMs First Surveys", Leiden, 30 Jun - 02 Jul 2003
(8) COMBO17/GEMS meeting in Oxford, 21 - 27 Sept 2003
(9) COMBO17/GEMS meeting in Heidelberg, March 2004
(10) SISCO Network Meeting in Heidelberg, March 2004
(11) Visit to Heidelberg, April 2004
(12) VST survey meeting in Napoli, 22-23 June 2004
(13) VESUVIO Super Cluster meeting, Groningen, 22. Sept. 2004
(14) SISCO Mid-term Review meeting, Groningen, 23.-24. Sept. 2004
(15) VST-16 Kick-off meeting, Munich, 23. Nov. 2004
(16) SISCO Winter School in Obergurgl, Austria, 12-19 February 2005
(17) Catania VESUVIO meeting 12-13 May 2005
(18) ESO Public Surveys, 22-23 June 2005
(19) VST-16 survey meeting in Heidelberg, 22 July 2005
(20) SISCO Network Meeting in Edinburgh, September 2005

Table 6: Recruitment Progress

Participant	Young researchers to be financed by the contract (Annex I) (person-months)			Young researchers to be financed by the contract (Annex I updated) (person-months)			Young researchers financed by the contract so far (person-months)		
	PhD (a)	PDRA (b)	total (a+b)	PhD (a′)	PDRA (b′)	total (a′+b′)	PhD (c)	PDRA (d)	total (c+d)
DUR	24	32	56	36	29	65	36	29	65
UEDIN	36	26	62	25	33	58	25	33	58
RUG	0	45	45	0	39	39	0	39	39
MPIA	0	48	48	0	48	48	0	48	48
OAC	0	48	48	0	48	48	0	48	48
ESO	0	0	0	0	0	0	0	0	0
OXF	36	0	36	36	0	36	36	0	36

B.5.5 Equal opportunities

Advertisements have encouraged women and minority groups to apply.

B.5.6 Multidisciplinarity

There are active links to cosmology theorists, particularly at Durham. The theorists supply us with valuable simulations and models which we use to design surveys and test standard cosmological models.

B.5.7 Connections to Industry

There are potential links to the IT and e-science industry via the techniques that SISCO nodes use to analyse multi-dimensional imaging and spectrocopic astronomical data. There is also connections to high-tech companies such as EIE in Italy that are involved with telescope building and instrument design.

(B.3) 4-year: Training Overview

The young researchers were recruited via adverts on EU websites, our own website and on the European Astronomical Society website. The candidates were all high quality and SISCO. There may have been issues at the UK nodes because the guideline amounts for pay which were followed were rather low compared to continental European equivalents. However, although this may have restricted the number of applicants, it does not seem to have affected their high quality of those appointed.

The above issue of pay meant that Durham could not afford to appoint one postdoc for 4 years. Therefore we decided at an early stage to pay 2 and then as more funds became available a third year for a pre-doc. Edinburgh pursued a similar line. These arrangements worked very well allowing the UK nodes to continue to participate actively in the network longer than would otherwise have been the case.

Young Researcher Integration - 4 year The young researchers were basically integrated into the network by being completely immersed in the research projects at each individual node and in the joint projects between nodes.

Young Researcher Training - 4 year At the Obergurgl Winter School and at the Cosmic Frontiers conference the young reserachers learned from and interacted with some of the most distinguished cosmologists in the world. They published many papers, improving their reporting and writing skills. Most of them gained experience in University teaching at each

nede where this was feasible. Most of the post-docs worked with the pre-docs, including the SISCO pre-docs, enhancing their supervision and project management skills. The young researchers were trained in presentation skills by giving talks at each network meeting. They frequently attended observing runs at telescopes.

Equal Opportunities - 4 year Where there was equality between a male and female candidate for a post, the female candidate was preferred. This situation did not arise. One female pre-doc and Anita Schael and one female post-doc Steffi Phleps were appointed. This number of females that were accepted was broadly in proportion to the numbers that applied.

Multidisciplinarity - 4 year Multi-disciplinary aspects included the interaction of SISCO observers with the Durham and Edinburgh theorists and also their interaction eith instrumentation scientists at Durham, Edinburgh and Naples.

Connections to Industry - 4 year At Naples there was interaction between the postdoc and EIE the company involved in building the VLT Survey telescope and other astronomy instruments.

All of the above training measures were very much in line with what was envisaged in Annex I. Less secondments took place than planned but this was balanced by more frequent network meetings.

SISCO researcher destinations

SISCO has completed the training of 9 Young Researchers including 5 post-docs and 4 pre-docs as follows:

Durham: Peter Weilbacher spent 2.5 years in Durham then was appointed to a research position at AIP Potsdam working to build astronomical software for the new VLT MUSE IFU instrument. Jose Cruz da Angela was funded for a PhD for one year from CAP Portugal and for 3 years by SISCO. Jose was awarded a PhD in September 2006 is now pursuing a career in the City with Morgan Grenfell.
Edinburgh: Steffi Phleps spent two years as a SISCO postdoc and then went on to a postdoc at MPE in Munich. Anita Schael has been funded for 2 years of her PhD and was awarded a PhD in September 2006.
Groningen: Philippe Heraudeau spent 3.3 years as a SISCO postdoc. At the end of his SISCO contract, he was then funded for a further 6 months in Groningen. He was then appointed to a research position at University of Bonn.
MPIA Heidelberg: Eric Bell spent 3.3 years as the SISCO PDRA. He was then appointed to the faculty at MPIA. He was replaced by Jelte de Jong who spent 8 months as the MPIA SISCO PDRA, before moving on to another research contract at MPIA.
Napoli: Chris Haines spent 48 months as the SISCO postdoc at Naples. He then won a further 10 month PDRA contract at Naples and now has been appointed to a further 3.5 year PDRA contract at the University of Birmingham, UK.
Oxford: Eugenio Barrio is now completing his PhD after 3 years as the SISCO pre-doc at Oxford.

The experience and training gained in the SISCO network was invaluable to the pre-docs and post-docs in moving their careers forward. The full exposure they have had to all aspects of European survey astronomy will stand them in good stead throughout their future careers.

B.6 Difficulties

As noted in the 3rd Year Report, the departure of Dr da Costa and his team from the ESO node means that there could be no expenditure at ESO in the final two years and by the start of the final year the ESO networking funds (there was no young researcher at ESO) were already re-distributed to other SISCO nodes.

The only difficulty in the final year was that 3 nodes, Durham, Edinburgh and Groningen overspent their prior allocation of funds. Durham overspent by 14870 euros due to higher than expected networking costs, including additional expenses incurred by the Cosmic Frontiers conference in August 2006. Edinburgh also overspent their allocation by 9238 euros due to higher than expected salary and networking costs. Finally, Groningen overspent by 13187 euros due to higher than expected salary costs. Note that the delivery of months for Groningen had previously been revised in our 3rd Year report to 39 months, down from the 48 months that Heraudeau was actually in post and the 42 months that Groningen are now claiming from SISCO.

The proposal that has been agreed by the SISCO management committee is that the underspends of 22694 euros in total at OAC, MPIA and Oxford be used to offset the total overspend of 37296 euros at Durham, Edinburgh and Groningen. This would mean that each of these nodes would receive 60.8% of their overspends. Unless further funds are now provided by the EU in excess of our initially allocated overall SISCO total, the residual amount of 14602 euros would be paid by other funds at Durham, Edinburgh and Groningen.

(B.4) 4-Year: Connections to Industry

See B5.7 above.

(B.5) 4-Year: Recommendations

The network worked well and the there were good relations between all nodes and also Stephen Davies and his replacement, Renat Bilyalov, our EU officers. The worst parts were the report writing. The present 4th year and Final report could be compressed more leaving less duplication of writing.

It may also be worth thinking about whether total person-months of training is the most efficient way to assess our delivery of the project. Currently it is easy to trade person-months of post-doc into pre-doc but more difficult to trade in the other direction because the latter results in fewer person-months. It may be more flexible if the total delivery was the amount of funding expended on personnel with any change from normal pay rates having to be agreed with the EU officers.

Some way of protecting UK nodes from fluctuations in the euro-pound exchange rate might be considered. Certainly The UK nodes would have appreciated a more generous guideline amount than the one we originally followed in the SISCO proposal. Even without taking into account exchange rates, the UK guideline amount for postdoc salaries in particular was too low.