IN CONFIDENCE

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SCIENCE AND TECHNOLOGY FACILITIES COUNCIL

Progress report from UKIDSS

Memorandum by the UKIDSS Consortium Survey Scientist, Prof. S J Warren

1. STFC review

The STFC Programmatic Review dominated events over the report period. UKIDSS provided a submission to the consultation exercise, on 21 March, and a copy is appended to this report.

2. 08A observations progress

Progress in 08A has been affected by relatively poor weather. The schedule lists 74 UKIDSS night. Accounting for 8h on source per night we budgeted for up to 600h on sky over the semester, with the LAS accounting for 2/3 of this time. Previous experience suggests that we might achieve 80% of this figure, accounting for weather.

Progress was reviewed at the end of April. The 74 nights included 45 nights up to the end of April, with a further 29 by mid June, when WFCAM comes off. So by the end of April we hoped for up to 365h on sky, while the actual figure was 220h i.e. only 60% of our goal, which is rather similar to 07B. We have therefore revised our goal to 400h total, broken up by survey into the figures in the first column below (note that the UDS is unobservable this semester). The hours achieved at the end of April are provided in the second column, and the fractional completeness relative to the revised target is provided in the third column:

The table highlights the fact that the LAS is behind relative to the other surveys. Since the LAS accounts for the majority of the time in this semester, this is a serious issue. For this reason we have agreed a revised set of relative weights for the projects, and will monitor progress carefully over the coming weeks.

The idea of executing the LAS in thin cirrus has been raised several times. This possibility will be reconsidered if the relative fractional completion of the LAS continues to be a problem.

Survey	Goal	Complete	Proportion
	h	h	completed
DXS	67	42	0.63
GCS	27	19	0.70
GPS	40	30	0.75
LAS	267	130	0.49

Table 1: Survey progress in 08A to end April

3. Data releases, pipeline and archive

DR3, sans GPS, was released on 6 December 2007, with the GPS element following in January. For the shallow surveys, LAS, GPS, GCS, DR3 is about a factor three larger than DR2.

Visual quality-control checking of DR4 jpeg images is complete except for the LAS. The long-standing issue of channel-bias offsets is now treated, and the results are extremely good. The fraction deprecated at this stage is now impressively small, at the 1 - 2% level. Similarly only a few percent of observations are being deprecated in QC1 (depth, photometric quality, seeing, ellipticity). Duplications, where an MSB was

started but abandoned when the seeing degraded or cloud came in, which are treated in QC2, account for the largest proportion of deprecations. Such losses are inevitable when one is trying to maximise the amount of useful time spent on sky, and we do not see any scope for any saving there.

Some suggestions for improvements to the pipeline and archive were made at the ESO workshop in Dec 2007, in the form of wish-lists, as follows. For the pipeline:

- Quantify the photometric rms as a function of cloud extinction
- Improve sky subtraction in regions of nebulosity
- Include the 1D Sersic profile (and in due course the 2D Sersic profile)

and for the archive:

- Colour postage stamps on demand
- List-driven photometry
- Rephotometer SDSS images for UKIDSS objects undetected in SDSS
- Rephotometer UKIDSS images for a cross-id list object undetected in UKIDSS

Aside from these, we would like the Board to note that from the perspective of UKIDSS, DR4 marks the point where we consider that the implementation, pipeline, and archive procedures are all highly satisfactory.

4. ESO workshop 17-19 Dec 2007

The workshop 'Science from UKIDSS' ran over the three days 17-19 Dec 2007. There were nearly 70 participants. The first day was spent summarising the current status of the data taking, the pipeline and the archive. The high level of detail appeared to have been appreciated by the audience. The remaining two days were devoted to science, with 33 presentations. We learnt of several projects underway within Europe, and valuable discussions took place in the breaks, with new collaborations set up. A number of technical issues arose, listed in the previous section. The workshop appeared to be very popular with participants, and it is hoped to schedule a similar event, perhaps annually, for the next few years. A web page containing copies of the talks may be reached from the UKIDSS from page.

5. Registration

There are now 84 communities registered, of which 54 are non-UK.

6. Publicity

An announcement of the world release of DR1 was made at a press conference at the January 2008 AAS, in Austin Texas. Two press releases on UDS results were made at NAM (see UDS report below).

6. Publications

UKIDSS publications continue to be listed at http://www.ukidss.org/science/science.html. The criteria for inclusion are either that the paper includes results that use UKIDSS data directly, or that the paper is specifically about UKIDSS (e.g. a data release paper). As previously, we refer to papers by the year and by the number recorded on the web page e.g. Chiu et al. (2007:7).

From the end of Sept 07 to the end of Mar 08 the citation count for the survey definition paper, Lawrence et al. (2007:15), increased from 43 to 68. Over the same period the number of UKIDSS papers published increased from 24 to 38. We did not record the exact number of citations from these papers at the end of March, but it would have been just over 400. We could include this figure in future reports if requested.

In our submission to the STFC consultation exercise we noted that the number of publications at this stage in the surveys, i.e. since the date the first survey data was acquired, is very similar to that achieved by both 2MASS (30 publications) and SDSS (42 publications). These surveys now each have over 1000 publications.

7. Progress reports from the Surveys

7.1 LAS report (Jameson)

The Third Data Release (DR3) increased the LAS coverage by a factor of 3, and includes some 900 deg² with YJHK coverage, so the volume of the LAS alone is now larger than that of 2MASS, by a factor 1.5. DR3 is therefore of great interest for searches for rare objects.

A very active search for cool brown dwarfs continues. Some 30 T dwarfs have been discovered, of which 15, of spectral type T2.5 to T7.5, are included in a recently submitted paper by Pinfield et al. The colours show a possible trend to bluer Y-J with decreasing effective temperature, which may be useful in the hunt for Y dwarfs.

There have been further interesting developments in the hunt for Y dwarfs. The paper on the T8.5 dwarf ULAS J0034 (Warren et al., 2007:18) has now been published. Spitzer spectroscopy obtained this year confirms the suggestion from the H-[4.49] colour that the effective temperature is only 600K. Then, this month, Delorme et al. (2008, A&A, 482, 961) published the discovery of a brown dwarf with very similar characteristics to ULAS J0034, discovered in the CFH Legacy Survey. The object was rediscovered by the LAS team in DR3, together with a third very cool brown dwarf, ULAS J1315. The last of these appears to be somewhat cooler than the other two, on the basis of the H-[4.49] colour. Further detailed studies of these three dwarfs, particularly measurement of parallaxes, will be used to test theoretical models over the previously unexplored effective temperature range 550-750K, and to guide the search for even cooler examples.

There has also been substantial activity in the search for cool white dwarfs (WDs). At the Jan 2008 AAS meeting Day-Jones et al described searches using SDSS/UKIDSS for WDs with ultracool dwarf companions. WD ages provide ages for the brown dwarf companions, vital for constraining spectral models. Several such wide binaries are found but need further confirmation. In similar vein,but unpublished, Steele and Burleigh have found more WDs from DR3 with infrared excesses. They tentatively identify one T dwarf companion, 7 WDs with L dwarf companions, 2 with M dwarf companions and 2 that may have dust discs. Further follow up work is needed. Casewell and Jameson have found from DR3 4 candidate Black Dwarfs (very cool WDs with He atmospheres) with Te 2500K. Discovering Black Dwarfs was one of the original goals of the LAS, but we emphasise that these need follow up confirmation. An HST application has been submitted to follow up the brightest of the candidates.

There are at least three active searches for the highest redshift quasars in DR3. As noted in the most recent UKIRT newsletter, within a few weeks of the release Mortlock et al. (2008, in prep) discovered a quasar at z = 6.13, Fig. 1, the highest redshift source found in UKIDSS to date. Follow-up of DR3 is now about 3/4 complete. Accounting for the selection function we predict that DR3 contains 4.5 discoverable high-redshift quasars, whereas so far two have been discovered (the other is the z = 5.86 source presented in Venemans et al (2007:4)), and two other SDSS quasars have been rediscovered (at z = 5.82 and z = 5.93).

7.2 GPS report (Lucas)

Unavailable at the time of submission.



Figure 1: Gemini GMOS-S spectrum of the z = 6.13 quasar ULAS J1319+0950, discovered in January 2008. The spectrum shows the region of Ly α emission. The redshift is established from the detection of the MgII emission line near 2µm with GNIRS on Gemini N.

7.3 GCS report (Hambly)

Observations

As part of continuing UKIDSS operations, GCS observations are progressing well. The status of the ten open cluster / star formation regions (listed below in priority order) in terms of the six (Z,Y,J,H,Kx2) filter coverage as at the end of Semester 07B is:

Target	Area	Completion
	(sq.deg)	fraction
IC-4665	3	84%
Pleiades	79	84%
AlphaPer	50	50%
Praesepe	28	84%
Tau-Auriga	218	15%
Orion	154	10%
Upper Sco	154	21%
Perseus OB2	13	84%
Hyades	291	16%
Coma Ber	79	16%

Table 2: GCS progress

Note that targets with 84% completion have just the second epoch K observations (for proper motion measurement) outstanding (i.e. IC-4665, Pleiades, Praesepe and Perseus OB2), while first epoch K observations are anticipated to be complete for all targets at the end of semester 08A observations.

Survey release update

The last release (DR3; observations up to and including Semester 07A) contains 661 square degrees of GCS areal coverage in one or more filters - survey coverage maps are available at http://surveys.roe.ac.uk/wsa/dr3_gcs.html Individual filter areal coverage (square degrees) in ZYJHK for DR3 is 170, 172, 169, 272, 629 respectively with 131 square degrees being in common to all (these figures assume 10% overlap between adjacent frame sets and have been extracted from the WSA using the simple query SELECT COUNT(*)*0.0518*0.9 AS area FROM gcsMergeLog WHERE zmfid¿0 etc., where 0.0518 is the areal coverage of an individual detector corresponding to a frame set). Coverage in the K band is most advanced to ensure a good time baseline with second epoch K coverage; as noted above, first epoch K band observations are expected to be essentially complete at the end of Semester 08A.

Enhancements at DR3 in the WSA included crossmatch of the GCS with SDSS DR5, which has coverage in Coma Ber and Praesepe. At the time of writing (April 2008) preparations for the next GCS release as part of UKIDSS DR4 are well in hand, with eyeball quality control complete and results communicated to WSA QA support astronomer Mike Read with whom the survey head (Hambly) is advising on the final QC cuts to be applied.

Science update

Interest in the GCS is growing steadily. At the recent ESO Workshop on Science from UKIDSS (Garching, December 2007) a splinter session was held to coordinate science exploitation. Participants included Adamson (JAC), Baker, Burleigh, Casewell, Jameson, Steele (Leicester), Carraro (ESO), Deacon (Nijmegen), Goldman (MPIA), Hodgkin (Cambridge) Lodieu (IAC Tenerife) and Lucas (Hertfordshire) with survey head Hambly chairing. During discussions concerning the various target datasets, immediate interests were declared as follows:

IC-4665: Carraro, Lodieu, Hambly Praesepe: Baker, Casewell, Jameson, Lodieu, Deacon Hyades: Casewell, Jameson Upper Sco: Lodieu Tau-Auriga: Hodgkin Orion: Goldman, Lodieu Perseus OB2: Lodieu, Hodgkin

with work on the other targets on hold pending future data releases.

Specific science results include the following:

Lodieu (IAC, Tenerife) and Deacon (Raboud University, Nijmegen) continue to exploit survey release datasets, at the same time instigating follow-up studies (e.g. Lodieu et al. 2007:17, 2008:2).

Hogan, Caswell and Jameson (Leicester) have worked on the Hyades K-band only data, and in combination with 2MASS data, have discovered the first significant population of brown dwarfs in that cluster. Interestingly, it appears that previous surveys have missed many of these simply because they did not survey the cluster to its tidal radius. This illustrates the power of the GCS in being able to cover the areas required to make complete surveys that take into account dynamical evolution. Results of this study will appear shortly (Hogan et al. 2008, in press).

Caswell and Jameson have also used the combined GCS cluster census to create field L dwarf age calibration curves. This neat piece of science (Jameson et al. 2008:8) uses the GCS cluster sequences of known age and distance to produce absolute K-band / colour relationships with which to compare field L dwarfs, and hence to place strong constraints on the ages of the latter. This is important because the age of field stars is difficult to assess (the best that can be done is to estimate full 3d space motions and compare against the statistical properties of the various kinematic populations), yet it is only with an age that the mass of a brown dwarf candidate can be assigned.

Martin (IAC Tenerife) and Perger (a PhD student at IAC funded by the Constellation Research Training Network led by PI McCaughrean) are working on the GCS Taurus-Auriga star forming region with the main goal of identifying new very low-mass members of the association, and candidate wide companions of known members. Another PhD student Baker (Leicester) is working with the GCS data in Praesepe.

Finally, Lodieu has used the GCS as an extension to the LAS for searches for nearby L/T/Y field brown dwarfs. The GCS filter coverage (ZYJHK) includes that of the LAS (YJHK) and we have been careful to keep the observing strategies and quality control procedures as similar as possible to enable the GCS to be used in this manner - it amounts to a 25% increase in LAS areal coverage. Lodieu has found several very good T (possibly Y) field BD candidates (putatively in the foreground to the more distant GCS targets), and follow-up spectroscopy is being pursued.

7.4 DXS report (Edge)

The DXS has continued to make steady progress over the past 6 months with particular emphasis on the current observing block to make sure that coverage of the Lockman Hole and Elais-N1 fields is improved given their large multiwavelength datasets.

In DR3 there are seven complete fields in J and K, four in SA22, two in Elais-N1 and one each in Lockman Hole and XMM-LSS. There is one field complete in K but not J in Lockman Hole plus two fields in each DXS area that have been started in K but not yet completed. By the end of the current observing block we hope to increase the number of completed fields to twelve.

Work on DXS data has continued at a number of UK institutions. While the number of publications in the past 6 months has not been significant, this is due to a combination of late arrival of supporting datasets from new instruments (e.g. SCUBA-2, FMOS and AMI) and the requirement of the larger statistical studies to obtain a wider area coverage. The DXS WG are well aware of the need to exploit the existing DXS data and I am confident that the number of papers from DXS data will grow dramatically as the dataset reaches completion and the facilities to exploit it finally come on line.

In terms of future multi-wavelength coverage, I am happy to report that it is not all "jam tomorrow". AMI has started survey observations and has already observed the clusters found in the Elais-N1 field at z = 0.9. This is a significant milestone and we are confident that DXS data will be instrumental in the rapid identification of AMI-selected clusters. Also Subaru FMOS is in the process of being commissioned at the moment and it is hoped it will start science operations in the summer. Again DXS data will be key to the target selection for FMOS observations.

In the slightly longer term, Pan-STARRS is very close to full operations and the Medium-Deep fields overlap with the DXS. I gather there is a suggestion within Pan-STARRS for an intermediate, world data release in 2011 which would release the first 18 months of data a year after they are completed. This would be well timed for the end of UKIDSS but has yet to be agreed.

This good news is balanced with the knowledge that both SCUBA-2 and Herschel will not start producing data for at least another 6 months but will require as much DXS coverage as possible when they do.

The work on the currently available data is continuing at a level similar to the last report. Spectroscopic work on the SA22 field is progressing well. The Gemini GMOS cluster follow-up has identified 5 clusters in the range of z = 0.8-0.9 (i.e. similar to that found by Swinbank et al. 2008) with similar cluster properties (see Fig 1). John Stott (LJMU) is working on a paper presenting these identifications. Tom Shanks (Durham) has obtained a substantial amount of VLT VIMOS time to study distant (0.6 < z < 0.9) Luminous Red Galaxies (LRGs) in the current Period and half of the target fields are in the DXS SA22 area and selected from the UKIDSS data. We also have a pending proposal for AAT AAOmega for additional LRG spectroscopy for z > 0.9 targets (PI Michael Brown, Monash).

The SHADES consortium have used the DXS data for the Lockman Hole to make identifications and derive photometric redshifts (Serjeant et al., 2008, arXiv:0712.3613, Clements et al., 2008, arXiv:0803.0475).



Figure 2: The J-K vs K colour-magnitude diagram for one of the DXS-selected clusters in the SA22 field confirmed with Gemini GMOS (Stott et al., in preparation). The red squares are cluster members and the blue circles are spectroscopically confirmed fore- or background galaxies.

DXS data are being exploited in a wide range of institutions and for varied science goals. The following is a brief and inevitably incomplete summary of the status within the UK. In Durham, DXS fields remain the focus for the HiZELs WFCAM Campaign project (PI Smail/Best) and in cluster, LRG and high redshift galaxy selection. In Sussex and Bristol, the combination of SWIRE and DXS data has been the most active area boosted by the arrival in Sussex of Duncan Farrah on an STFC AF. In Hertfordshire, Phil Lucas has been searching for faint L- and T-dwarfs using SWIRE and DXS data with a promisingly small but finite candidate list of six and Matt Jarvis and his PhD student Glen Parish who presented a poster on the number counts and clustering of Distant Red Galaxies at NAM2008.

The observations in this current block are progressing reasonably smoothly but the J-band data are lagging slightly so an adjustment may be made to the seeing to compensate for this.

To conclude, the DXS is having a comparatively modest impact compared to the UDS to date but this will even out as the area covered grows and the supporting datasets come on-stream.

7.5 UDS report (Almaini)

Survey progress

The UDS is already the deepest infrared survey ever conducted over such a large area, and steadily increasing in depth. The only comparable infrared imaging survey is the Ultra-VISTA project, which has yet to begin and is unlikely to supersede the UDS until 2012.

The UKIDSS DR3 was the second major release for the UDS, combining two seasons of data. The depths achieved were K = 21.8, H = 22.0, J = 22.9 (Vega, 5σ within a 2-arcsec aperture) over the full 0.8 sq degree field. The major advance over DR1 was the addition of H-band data, which will be particularly powerful for constraining the space density of galaxies at z > 3. All quality control, stacking and catalogue generation continues to be carried out by the Nottingham UDS team. Improvements in these techniques for DR3 led to stacked data with significantly fewer cosmetic defects and a gain in depth of 0.1 magnitudes compared to previous methods by the removal of large-scale noise. A survey definition paper describing these techniques is currently in preparation (Almaini et al.).



Figure 3: Two-dimensional spectrum of a Lyman-alpha emitting galaxy at z = 6.05 from the UDSz survey, from 5-hours exposure using the FORS2 spectrograph. This represents a look-back time of 12.7 Gyr.

The overall gain in depth from DR1 to DR3 was far less than originally anticipated, due to poor seeing in Nov/Dec 2006 and very unfortunate scheduling (missing the optimal months for this 02-hour field). In contrast, the 2007 season was excellent, and will double the exposure time in all bands for the DR5 release in late 2008.

To ensure rapid progress in the UDS, we urge the board to ensure that the months of September & October are used for UKIDSS observing in future semesters if at all possible.

Progress in related large projects

As mentioned in the previous progress report, very large allocations of telescope time were awarded to the UKIDSS UDS project in 2007. Key among these were a new ESO Large Programme (*UDSz*) to conduct a spectroscopic survey of high-redshift galaxies (235 hours on VLT; PI: Almaini) and a *Spitzer* Legacy proposal (*SpUDS*) to image the field using *IRAC+MIPS* (292 hours; PI: Dunlop). Both projects are proceeding well. All Spitzer data has now been taken and are currently being reduced. A public release is anticipated before the end of 2008. The ESO spectroscopic survey is approximately 20% complete and is anticipated to continue for another 2 years. The data taken so far contain ~ 1000 spectra and are currently being analysed. Early indications suggest a spectroscopic redshift completeness in excess of 80%. Examples are shown, including the dramatic discovery of a Ly α emitting galaxy at z = 6.05. We anticipate the identification of several dozen other galaxies at z > 5 from the completed FORS2 programme.



Figure 4: High-redshift galaxy spectra from UDSz, recently obtained using VLT VIMOS. When complete we anticipate ~ 4000 spectra at z > 1, which will significantly enhance the scientific legacy of the UDS project.

Scientific output and publicity

High-profile scientific results continue to be made by the UDS. Excluding generic UKIDSS and WFCAM papers, there are now 8 published papers based directly on UDS data (3 in 2006, 4 in 2007, and 1 so

far in 2008), with two more recently submitted (Cirasuolo et al., on the galaxy luminosity function out to z = 4, and Ibar et al., on the infrared/radio correlation out to high redshift). We are aware of several groups actively working on UDS data across the ESO and Japanese communities, so we expect this number to rise substantially.

Two press releases were made by the UDS at the UK National Astronomy Meeting in Belfast, one of which was identified by STFC as a highlight of the meeting. The UDS team have also created a web page to help publicise the survey: http://www.nottingham.ac.uk/astronomy/UDS