Probing the Origin of the Cosmic Acceleration with the Subaru/FMOS Cosmological Redshift Survey

The FastSound Team

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Abstract

We propose the first large-scale cosmological redshift survey of the $z > 1$ Universe using the newly commissioned FMOS wide-field spectrograph in order to test for predicted gravitational departures from General Relativity in the early Universe. Spectroscopic redshifts will be secured using the Hα emission line for 20,000 galaxies with $0.7 < z < 1.6$ over 30 deg^2 by the target selection method that we have already established in pre-existing fields from FMOS commissioning data. A precise measurement of the two dimensional clustering of galaxies both along and across the line-of-sight will allow us to measure the gravitational growth rate of large-scale structure at $z > 1$, when the universe is still decelerating, at an accuracy sufficient to discriminate the popular scenarios (dark energy or modified gravity) for the origin of cosmic acceleration. Such a discovery would offer a significant breakthrough shedding light on the most fundamental problem in modern physics. To carry out this critical test we ask for 120 SSP nights of Subaru time over 2 years.

1 Scientific Background

1.1 The Dark Energy Problem and Galaxy Redshift Surveys

The most significant mystery concerning our current picture of the Universe is the accelerating nature of the cosmic expansion. This is well-described by the 'ΛCDM' model which supplements dark matter with a repulsive cosmological constant. However this has severe conceptual problems, in that while it is consistent with all current observations (see Frieman et al. 2008, ARA&A, 46, 385 for a recent review) it is an entirely empirical model without a fundamental physical basis. The natural interpretation of Λ as representing the zero-point energy of the vacuum fails by 122 orders of magnitude and an extreme fine-tuning is required for it to appear now in the long history of the universe. This has motivated numerous ideas for new physics of 'dark energy' or 'modified gravity' to explain the large scale cosmic dynamics of spacetime (e.g., Caldwell & Kamionkowski 2009, Ann. Rev. Nucl. Part. Sci. 59, 397 for theoretical reviews.)

Large scale redshift surveys of galaxies are now widely recognized as one of the most powerful approaches to tackle this important and difficult problem. This is because they are able to simultaneously measure the effects of dark energy fields (which modify the expansion) and modifications of gravity (which also affect the growth of structures in the Universe). Low redshift surveys such as 2dFGRS and SDSS have delivered a wealth of cosmological results this way but the results remain consistent with ΛCDM and have, frustratingly, not provided new clues to the underlying physics.

The new instrument, FMOS, at the Subaru Telescope, has the potential to make a significant breakthrough in our understanding of the accelerating Universe by undertaking the first systematic cosmological redshift survey at $z > 1$, probing the early epoch of the Universe for the first time, due to the combination of the near-infrared JH wavelength coverage (including Hα emission lines at $z \sim 1$), 400 fibers in a large field of view ($30'$ diameter) and the large photon-collecting power of the Subaru Telescope. The bright Hα emission line from the extensive star-formation of this epoch is visible to $z = 1.6$ and allows a rapid survey to be performed. In 120 nights on Subaru Telescope our proposed survey will measure ~20,000 redshifts over 30 deg^2 of sky. This will enable the first precise measurement of the applicability of General Relativity to the growth of large-scale structure at $z > 1$ using the 'redshift space distortion' technique, providing a fundamental comparison between dark energy and modified gravity. These 120 nights will also set the ground-work for the observational study of cosmology via redshift surveys in the Japanese community and enable future larger surveys with an improved FMOS (or with the future PFS instrument) that will improve cosmological constraints many-fold.

The call for SSP requires either of the following criteria should be satisfied:
Category A: Observations with use of an instrument having capability for large surveys, and scientific results as well as data itself are highly useful for Japanese and world astronomers. Strategic and systematic time allocation can surpass individual program allocations in terms of depth and wideness of the observations. We note that FMOS is currently the only instrument in the world capable of such a large $z > 1$ cosmological redshift survey. It is an instrument specifically designed for such large and wide surveys. Such redshift surveys have historically had a large worldwide impact not only for cosmology but also as general spectroscopic catalogs for many science topics, but large strategic allocations are required to carry them out.
Category B: Systematic and long observations with a unique instrument are necessary to achieve important and clear science(s) beyond individual programs. The FMOS instrument coupled with the light gathering power of Subaru telescope is truly unique to perform a large redshift survey having a clear science target of cosmology, but to utilize this on such a scale is beyond individual P.I. programs. The next few years provides an exciting window of opportunity for FMOS to explore the cosmology of the early Universe for the first time, however competing instruments are being built so now is the time to start such a strategic program.

We call this project FastSound; "FAST" is a Japanese acronym of "FMOS Ankoku Sekai Tansa（暗黒世界探査）" meaning "FMOS Dark Universe Survey", and "SOUND" is an English acronym of "Subaru Observation Understanding Nature of Dark energy".

1.2 Redshift Space Distortion of Galaxy Clustering

The core idea behind our proposal is to measure the two dimensional clustering of galaxies both across and along the line-of-sight. Because this is measured in 'redshift space' an anisotropic statistical distortion arises in galaxy clustering due to the peculiar velocity of galaxies falling in to larger structures. This distortion allows us to measure the infall rate, and the comparison with the mass fluctuations then provides a constraining test of the theory of gravity (e.g. the review by Hamilton 1998, in "The Evolving Universe" ed. D. Hamilton, Kluwer Academic, p. 185–275, astro-ph/9708102). The quantity that will be measured is the growth rate $f_g \equiv d\ln D/d\ln a$, where D is the growth factor [density fluctuation $\delta(t) \propto D(t)$] and a the scale factor of the universe. This quantity is related to theory as $f_g(z) = \Omega_M(z)^\gamma$ with $\gamma = 0.55$ to high-precision for a ΛCDM model. (Here, Ω_M is the standard matter density parameter of the universe.) In models where the acceleration arises from modification to gravity then this also affects the growth rate of perturbations and γ is in the range $0.4 < \gamma < 0.7$ (Linder E. V., 2005, Phys. Rev. D, 72, 043529), which is measurable by redshifts surveys *as long as a sufficient baseline in redshift is attained*.

However, this distortion has so far only been measured with adequate precision at low redshift ($z <$

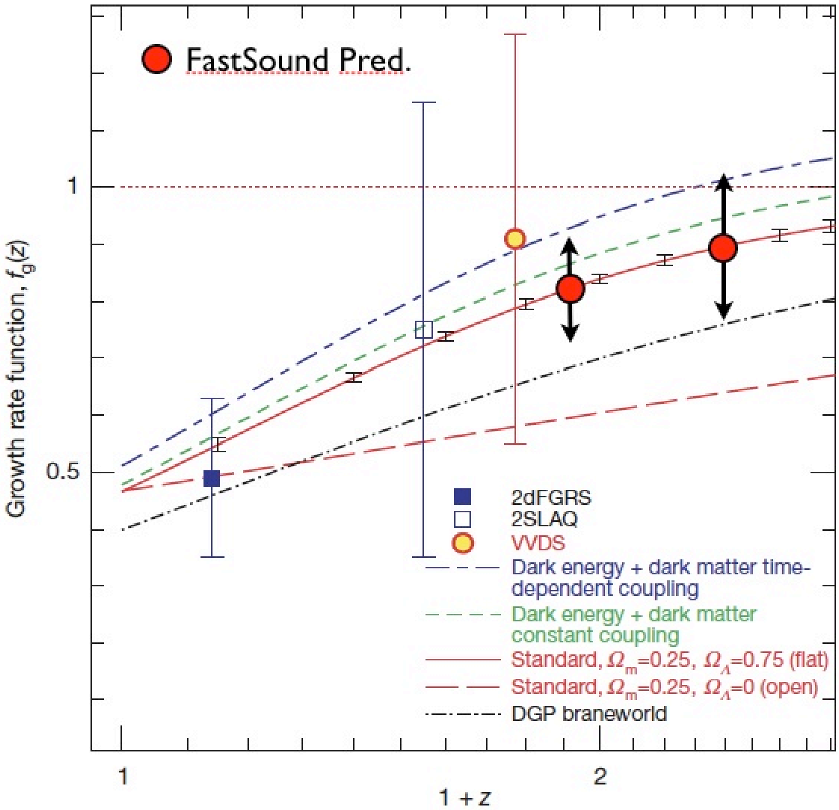

Figure 1: : Expected RSD constraint on the growth rate function by FastSound. This plot is made based on Fig. 2 of Guzzo et al. (2008), by adding FastSound data points with errors estimated by the Fisher matrix analysis of White et al. (2009). Model curves are predictions by the standard ΛCDM cosmology and other various theories for the dark energy problem.

0.2; Figure 1). To secure the growth rate, precision measures are required over the widest possible range in look-back time. So far (Guzzo et al. 2008, Nature, 451, 31) the error bars are too large and do not discriminate between models because galaxy samples are small. Forthcoming optical surveys (WiggleZ, VVDS and BOSS) will increase the precision at redshifts $\langle z \rangle \sim 0.5$—0.7, but to probe the $z > 1$ Universe efficiently requires a wide-field near-IR spectrograph due to the redshifting of strong spectral features out of the optical bandpass. At high redshifts, the Universe becomes more like a Einstein-de Sitter model, and dark energy ceases to be important. It is this change in the Universe that we wish to observe, and we can only do this using measurements before and after the onset of acceleration; high redshift measurements are extremely important as they provide a baseline against which the low-redshift effects of Dark Energy can be compared.

2 The Proposed Redshift Survey

2.1 Size of the redshift survey

The anisotropic distortion of galaxy clustering in redshift surveys can be measured by the two-dimension power spectrum in redshift space $P^s(\boldsymbol{k})$ of the galaxy density field. The 'redshift space distortions' (RSD) can can be described as $P^s(\boldsymbol{k}) = (b + f_g \mu_{\boldsymbol{k}}^2)^2 P(k)$ on the large scales in the linear regime, where $P(k)$ is the isotropic matter power-spectrum without RSD, $\mu_{\boldsymbol{k}} = \cos\theta$, θ is the angle between the wave number vector $\boldsymbol{k}$ and the line-of-sight direction, and b is the linear bias parameter of galaxies. This formula tells us that we can measure $b\sigma_8$ and $f_g\sigma_8$ from observed $P^s(\boldsymbol{k})$, where σ_8 is the standard normalization parameter of density fluctuations and $P(k) \propto \sigma_8^2$. Note that we can combine these measurements to constrain the ratio $\beta \equiv f_g/b$, which is often quoted as it removes the dependence on σ_8 from the observations. Given an independent measurement of b or σ_8 we can constrain f_g alone. Precise measurements of $f_g(z)$ or $f_g(z)\sigma_8$ then give us an important test for the gravity on cosmological scales, as mentioned in the previous section. [Measuring $f_g(z)$ rather than $f_g(z)\sigma_8$ does not necessarily aid with model discrimination (Song & Percival 2009: JCAP 10, 004), thus reducing the need of independent measurement of σ_8 or b.]

The error on $f_g(z)\sigma_8$ is determined by the total number of galaxies and the volume covered (see the Fisher matrix analysis of White et al. 2009: MNRAS, 397, 1348). The total number is normally the most important term, as the distortion is scale independent in the linear clustering regime, but if fields are too small cosmic variance and non-linearities will dominate, requiring a survey of at least 10 deg^2 at these redshifts. Our proposed survey is 20,000 galaxies over 30 deg^2, for which the expected fractional error on the parameter $f_g\sigma_8$ is calculated to be $\sim 13\%$ (see the next section for details of target selection, success rate of redshift determination, and exposure times). This is a significant advance on the current VVDS work of Guzzo et al. (2008) at $z \sim 0.7$, as shown in our simulated points of Fig. 1, and will deliver the first $z > 1$ results with the same accuracy as upcoming $z < 1$ optical results.

2.2 Survey implementation and required time

The most efficient approach to covering a large area is to choose tracers of the galaxy density field whose redshift can be secured in the shortest exposure time. At high-redshift one approach is to use emission line galaxies, because an emission line can be detected in a shorter exposure than galaxy continuum light and due to the evolution of galaxy star-formation rates (Hopkins A. M., 2004, ApJ, 615, 209) high-redshift galaxies are much more luminous in bright lines such as Hα. However this line is only accessible in the near-infrared: FMOS can access it in the range $0.7 < z < 1.6$. Importantly the Hα luminosity function and clustering are already well measured from small surveys in this redshift range (e.g. Geach J. E., et al., 2008, MNRAS, 388, 1473). An example of this emission line approach is the WiggleZ redshift survey on the 4m Anglo-Australian survey which is covering 1000 deg^2 and $0.3 < z < 0.9$ using the [OII] tracer and optical spectroscopy of only one hour exposures.

The detailed survey design is constrained by available photometric catalogs for target selection. Color-selection can easily isolate galaxies in the desired redshift intervals but a key problem is selecting from broad-band properties the brightest few percent of line emitters. For the past few years, our team has studied the optimization of target selection for FMOS from optical photometry catalogs, using photo-z estimates of star formation rate and Hα emission flux based on the rich photometric data sets available for Subaru XMM-Newton Deep Field. After investigations of various photometric survey data sets, we have chosen the CFHT Legacy Survey Wide fields as the best input data set at the moment. There are four sub-fields of CFHTLS-W (W1–W4), each of which includes at least 4×4 square degree area. In

Field Name	R.A. (J2000)	Dec. (J2000)	Area
W1	02:18:00	−07:00:00	$8^\circ \times 9^\circ$
W2	08:54:00	−04:15:00	$7^\circ \times 7^\circ$
W3	14:17:54	+54:30:31	$7^\circ \times 7^\circ$
W4	22:13:18	+01:19:00	$4^\circ \times 4^\circ$

Table 1: : The location and area of the four CFHTLS Wide fields.

these fields, deep u, g, r, i, z band photometric data are available. The limiting magnitudes are >24 mag for u, g, r, i-bands and ∼23 mag for the z-band, i.e., more than 2 mag deeper than the SDSS. We have additionally extended the z-band data over 1.5 mags deeper in 17 deg^2 using SuprimeCam.

Using several nights of FMOS GTO observations, we have tested several selection methods based on color-color plots. The emission line sensitivity of the test observations is close to the official sensitivity of FMOS web page ($1.0\times10^{-16}\,\mathrm{erg\,cm^{-2}s^{-1}}$ at $S/N = 5$ for point sources). We then found that a selection based on two color-color diagrams (grz and giz) is the most successful. The selection criteria are $22.0 < g < 23.7$, $z < 22.5$, $0.0 < (r-z)-1.4(g-r) < 0.8$, $0 < g-r < 0.7$, and $(i-z)-0.6(g-i) > -0.35$, to select candidates with a number comparable to the FMOS fibers. The distributions of selected galaxies on the color-color plots are shown in Fig. 2. The redshift 'yield' (defined as the fraction of fibres giving successful redshifts in the correct range) is 30%, this compares favourably with other surveys with a similar strategy (e.g. the WiggleZ yield is 50%, Drinkwater M. J., et al., 2010, MNRAS, 401, 1429) considering the more limited bandpasses of the near-infrared range. Our yield is sufficiently high that we only need to do a single FMOS fibre configuration per pointing and we can then cover the full area at the maximum rate.

The redshift distribution of detected Hα emitters from the pilot observations is shown in Fig. 3. The distribution is divided into the two redshift ranges of $0.7 \lesssim z \lesssim 1.1$ and $1.2 \lesssim z \lesssim 1.6$ by the gap between J and H bands, with roughly equal numbers of galaxies. Some examples of spectra actually taken by the test observations are presented in Fig. 4. To achieve this success rate, we need about 1.5 hr on-source exposure time. For the beam-switch mode, we need another 1.5 hr for sky and 1.2 hr overhead, and hence 4.2 hr in total for one field-of-view (0.2 deg^2). Taking a weather factor of 75% into account, we will need ∼120 nights (8 hr per night on average) to cover the total area of 30 deg^2, yielding 20,000 galaxy spectra. The four CFHTLS Wide fields are almost evenly distributed along right ascension, and we can efficiently observe one or two of these fields during a whole night throughout a year. The locations of the CFHTLS-W fields are given in Table 1.

We request our 120 nights to be allocated over two years, which is the maximum rate allowed by the SSP framework and will allow our survey to be completed before competing new instruments are constructed (see the next section). Having the first results at $z > 1$ will guarantee the high-impact of the scientific return required for an SSP.

2.3 Uniqueness and Competition with Other Projects

There are several ongoing cosmological redshift surveys at $z \gtrsim 0.5$. VLT/VIPERS will get 100,000 redshifts in a survey area of 24 deg^2, in the redshift range of $z \sim$ 0.5–1.1 (median ∼0.7). WiggleZ will get 240,000 redshifts in 1,000 deg^2 in $z \sim$ 0.2–1.0 (median ∼0.6). BOSS will get 1,500,000 redshifts in 10,000 deg^2 with the median redshift of z ∼0.4.

While all these projects are much larger than the proposed survey in the total number of redshifts it

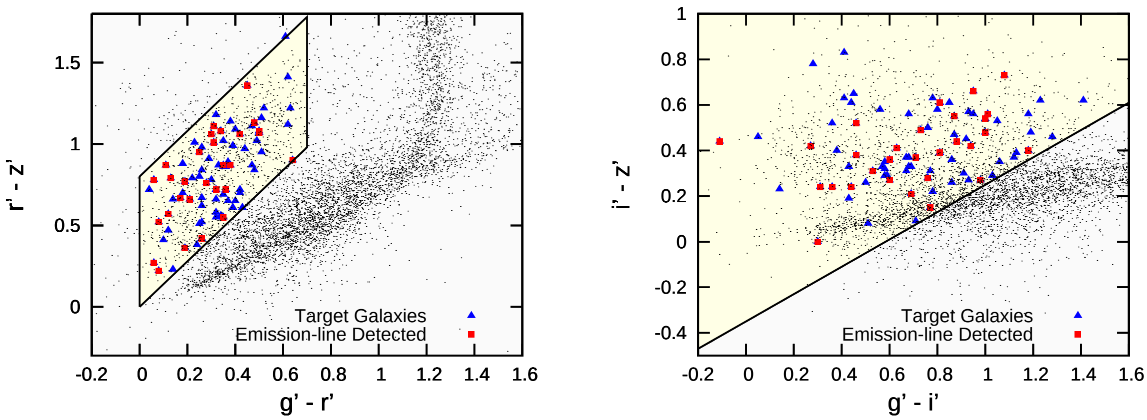

Figure 2: : Color-color selection of target galaxies. Galaxies selected as FMOS targets (see text for the selection criteria) are shown by red squares and blue triangles, where red squares are for galaxies with detected Hα emission. Dots are all CFHTLS galaxies having $g < 23.7$ and $z < 22.5$.

should be noted that these are all optical surveys and very much restricted to $z \ll 1$ for their cosmological measurements. FastSound operates in the $z \gg 1$ regime where the total number of redshifts in all existing surveys is only a few thousand and no survey by itself is large or homogeneous enough to do cosmology. FastSound would surpass all these in only a few months. In terms of size in the total number of redshifts and nights, FastSound is comparable to the very successful DEEP2 optical redshift survey at $\langle z \rangle \sim 0.8$ which measured 50,000 redshifts with 90 Keck nights. DEEP2 is, however, too narrow (four $120' \times 30'$ fields) to do the RSD measurement for cosmology.

In the further future higher-redshift measurements may come from the new HETDEX project which plans to put a massive multi-IFU spectrograph on the Hobby-Eberly telescope. The proposal is for 800,000 redshifts of $1.9 < z < 3.5$ Lyman-α emitters over 400 deg^2 (though the numbers are highly uncertain, perhaps a factor of 2–3, due to the poorly measured properties and luminosity functions of this class of targets). Initial observations for this survey are due to take place in early-2012, and then the survey will accelerate as all 196 spectrographs are constructed and integrated, so mid-2013 is a realistic schedule for the full four-year HETDEX survey to commence. Thus we will be able to deliver the first cosmological result of a redshift survey beyond $z > 1$ if we get 120 nights in two years. It should also be noted that the HETDEX redshift range is much higher than $z \sim 1$, well before the onset of the cosmic acceleration (or appearance of the dark energy in the cosmic energy density budget). Surveys in the critical redshift range of $z \sim$1–2 are highly desired to efficiently reveal the nature of dark energy or modified gravity.

A comparison of all these surveys is given in Figure 5 which shows the accuracy of measuring $f_g\sigma_8$, in comparison with that of FastSound. The low-redshift surveys already completed (2dFGRS, SDSS

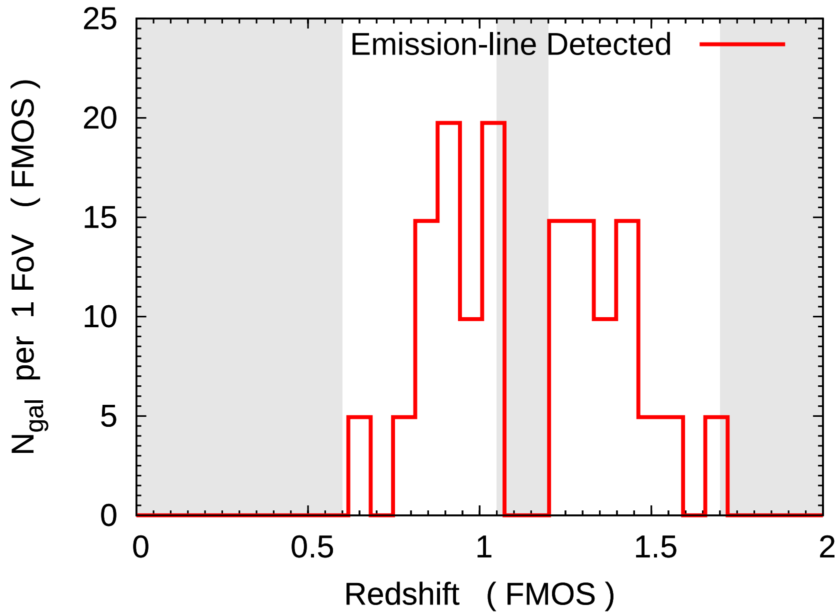

Figure 3: : The redshift distribution of Hα emitting galaxies detected by the test observation of FMOS using the grz-giz selection method described in the text. The white background regions indicate J and H bands. The histogram is made from 15 and 14 galaxies whose Hα emission lines are detected in J and H bands, respectively, out of 82 target galaxies observed by IRS1 in the cross-beam-switch mode. (There are two spectrographs of IRS1 and IRS2 for FMOS, each has 200 fibers.) To match the number expected in the beam-switch mode by IRS1+IRS2, the histogram is multiplied by a factor of 4.

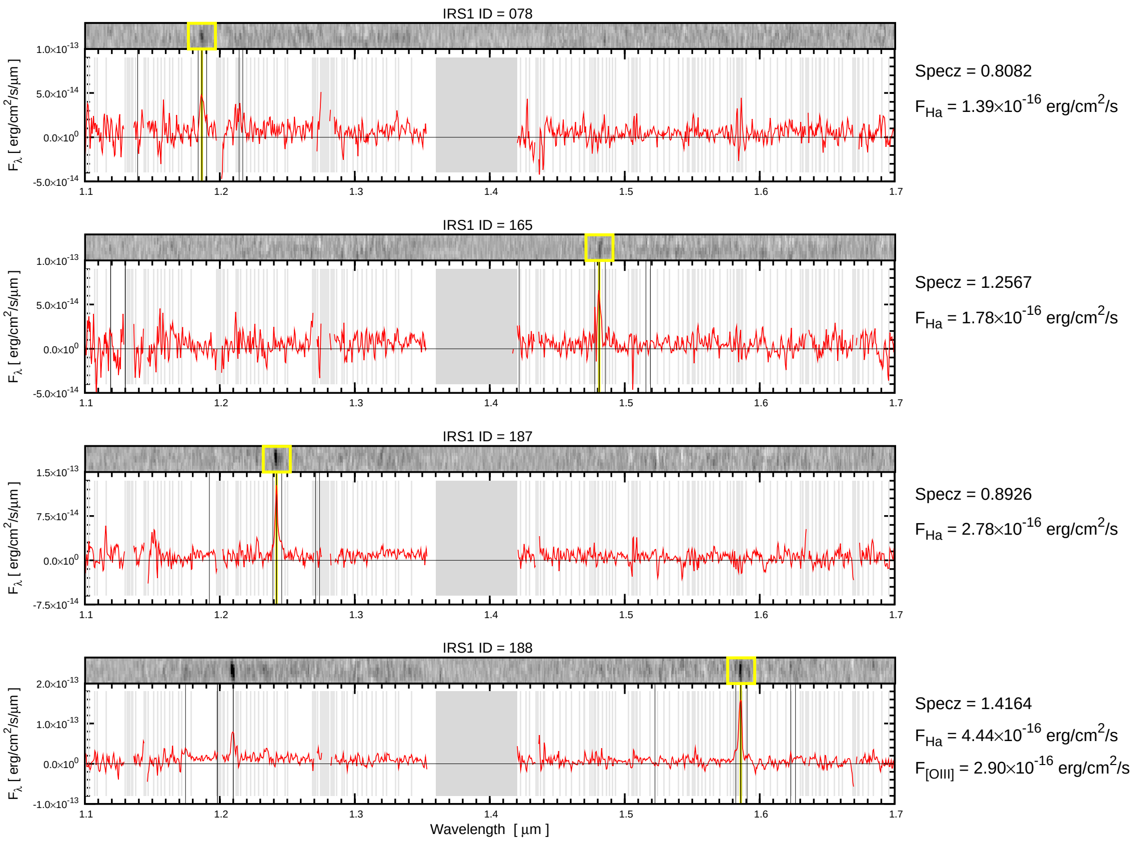

Figure 4: : Examples of galaxy spectra with detected Hα lines taken by FMOS in an engineering run. Hα lines are highlighted by the yellow rectangles. The vertical black lines are representative emission lines found in galaxy spectra.

main, and SDSS LRG) are also shown. The FastSound has a comparable[1] power to 2dFGRS at low redshifts in terms of the accuracy in $f_g\sigma_8$, and probes a truly unique redshift range compared with the ongoing/near-future projects. FastSound will provide the highest redshift measurement of the growth of structure in the Universe for several years.

2.4 Future Possibilities

Cosmological redshift surveys offer many possibilities beyond measurements of RSD. Most notably the Baryon Acoustic Oscillation (BAO) technique has attracted particular attention in recent years. The BAO length scale ($\simeq$ 150 comoving Mpc) is determined by the sound horizon at the time of recombination which itself is set by well-established linear physics in the early Universe. This scale provides us with a standard ruler to precisely measure the expansion history of the universe and hence the equation of state of the dark energy, with small systematic uncertainties. The BAO signatures show up as a bump

[1]The fractional error on f_g for 2dFGRS shown in Fig. 1 is larger than the error on $f_g\sigma_8$ shown in this plot by a factor of about two because it includes the error from an independent measurement of b, required to transform measurements of $b\sigma_8$ and $f_g\sigma_8$ to obtain f_g.

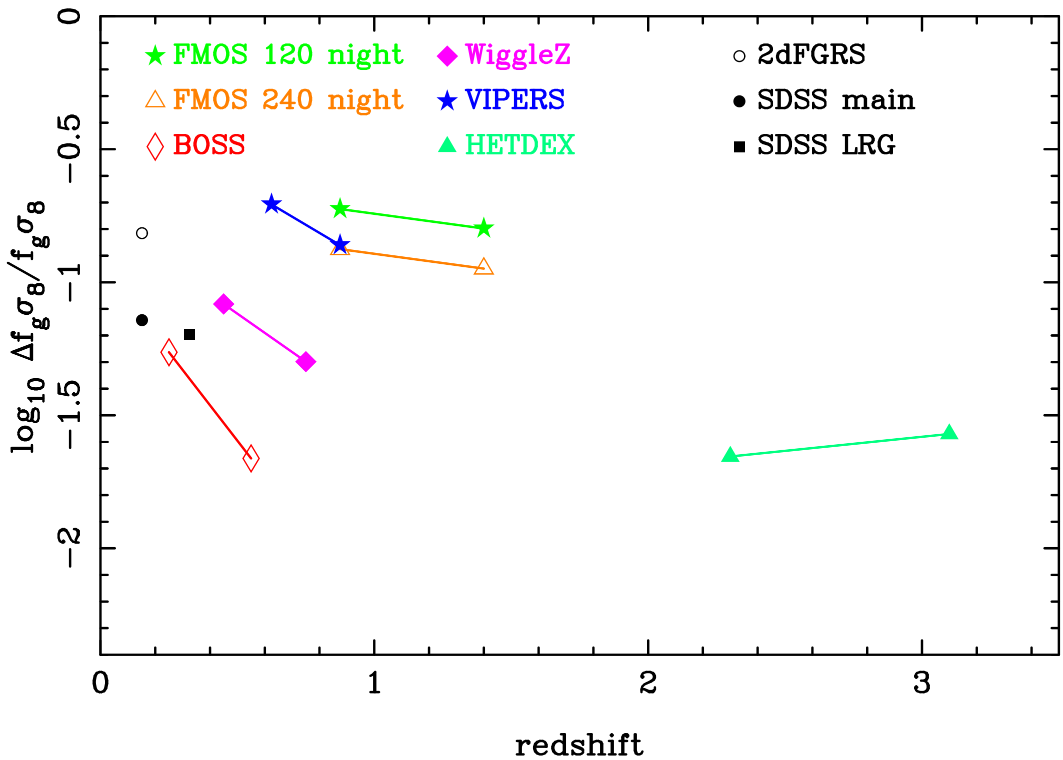

Figure 5: : Comparison of the expected constraining power on the parameter combination $f_g\sigma_8$ by various surveys. The proposed survey is requesting 120 nights for 2 years (green stars). For comparison, an even more ambitious case of 240 nights is also shown.

at a characteristic scale in the galaxy correlation function or as series of wiggles in the power spectrum. At high signal:noise they can be measured in both the angular and radial power spectrum providing powerful independent probes of the angular diameter distance-redshift and Hubble expansion-redshift relations. BAO features have been detected in the 2dGRS and SDSS surveys at low-z and so high-redshift detection is a clear next step, in particular detecting BAO beyond $z > 1$ would be a powerful cosmological probes taking advantage of a long redshift lever arm.

BAO are weak features in the power spectrum and so detecting them requires a large number of galaxy redshifts over a large volume. The required redshift survey would be around 100,000 galaxies and several hundred deg^2, about five times the size of the current proposal. FMOS will be continually refined and improved over the current few years, and new imaging data is continually being collected by new instruments (including Subaru's own HyperSuprimeCam). By carrying out FastSound we will then in two years be in a position to assess the viability of an FMOS $z > 1$ BAO survey. The Subaru community will also need to consider extending the SSP framework to allow for even bigger projects than can fit in to the current limits on nights.

We may also consider future BAO surveys using the proposed Prime Focus Spectrograph (PFS). If this is constructed it will be the most powerful wide-field survey capability in the world taking advantage of the unique 8m prime focus on Subaru telescope. A key point to consider is that whatever instrument is used for a very large future BAO survey, currently the Japanese community does not have experience of leading large cosmological redshift surveys. This is a risk for performing an extremely large program for BAO. We therefore believe that it is crucial to start the first Japanese-led cosmological redshift survey at this timing taking full advantage of the timely opportunity provided by FMOS. It would give the Japanese community a critical learning experience in this field and train young scientists in this area for even larger projects in the future by FMOS and/or PFS.

2.5 Ancillary Science

There are a wide range of possibilities of ancillary and serendipitous science that can be done as a by-product of this project. This is because a small number ($\lesssim 10$) of fibers can be allocated to rare objects (e.g. QSOs, Brown Dwarfs, radio galaxies) having surface number density of a few per FMOS field-of-view. Then, after the survey, we will have a large systematic spectroscopic sample for such rare objects over a large area. We believe that the detailed plan for this should be finalized after we pass the first stage selection and this project becomes open to the Japanese community, in the SSP selection procedure. This would then become a tremendous opportunity for the wider Japanese community to participate by proposing novel users for spare fibres. Below we give a few examples of possibilities for such projects,

2.5.1 Supermassive blackhole growth at z >3.5:

It is important to determine super-massive black hole (SMBH) masses and accretion rate of QSOs at high redshift to understand the history of formation and evolution of SMBHs. At $z > 3$, the reliable SMBH-mass estimator, MgII(0.28μm) emission line (e.g., Shen et al. 2008, ApJ, 680, 169), is redshifted beyond the optical window, and so near-infrared spectroscopy is indispensable. The expected number density of QSOs per FMOS field-of-view is $\sim$4 and $\sim$1 at $z = 3.6 - 4.4$ and $z = 4.6 - 5.1$, respectively (Casey et al. 2008, ApJS, 177, 131), and SMBH masses are derivable in FMOS 1.5–2 hr net on-source exposure time.

2.5.2 QSOs at $z > 6$:

It is very important to discover more $z \sim 6$ QSOs and to investigate the variation of the IGM neutral fraction along many lines of sight to understand the cosmic reionization. Based on the conservative estimate (Willott et al. 2010, AJ, 139, 906), ∼6 QSOs are expected to be found at $z \sim 6$ in 50 deg^2 survey area. QSOs at $z \sim 6$ should be observed as very red $i - z$ sources ($i - z > 2$ mag), and assuming the contamination factor of 10 by brown dwarfs, the expected number of possible $z \sim$6 QSO candidates per FMOS field-of-view would be $\lesssim$1. Their expected J- and H-band magnitudes are ∼21 mag. Once $z \sim 6$ QSO candidates are found in FMOS low-resolution spectra, such interesting objects can be followed up by slit spectroscopy, using Subaru FOCAS and MOIRCS, to confirm as bona-fide $z \sim 6$ QSOs, and to better constrain their redshifts, SMBH masses, and metallicity.

3 Project Management

3.1 Team Members

The FastSound team is currently including the following 19 members.

Japanese Community:
Tomonori Totani (PI, Kyoto University)
Naruhisa Takato (Co-PI, NAOJ/Subaru)
Tomotsugu Goto (IfA, Univ. Hawaii)
Masatoshi Imanishi (NAOJ/Subaru)
Takashi Ishikawa (Kyoto Univ.)
Toshinori Maihara (Kyoto Univ.)
Takahiko Matsubara (Nagoya Univ.)
Masanao Sumiyoshi (Kyoto Univ.)
Ryuichi Takahashi (Hirosaki Univ.)
Naoki Yoshida (Tokyo Univ.)

United Kingdom Community:
Gavin Dalton (Oxford Univ.)
Pedro Ferreira (Oxford Univ.)
Edward Macaulay (Oxford Univ.)
Will Percival (Univ. Portsmouth)
Tom Shanks (Durham Univ.)

International Members:
Chris Blake (Swinburne)
Richard Ellis(Caltech)
Karl Glazebrook (Swinburne)
Lee Spitler (Swinburne)

FastSound has been recognized as one of the key projects by the FMOS team (initially led by T. Maihara who is a Co-I of this proposal, and now led by K. Ohta after retirement of Maihara). Test observations of FMOS for cosmology have been conducted with great deal of assistance from the FMOS team. Because of the regulation of the SSP submission, many of the FMOS team members are now on the other SSP proposal for galaxy science. However, we expect support from the FMOS team once this proposal is accepted. G. Dalton is the PI of FMOS on the UK side. N. Takato, M. Imanishi, and their students will support the observation activity of this project from the Subaru Telescope side.

The survey plan has been developed by members who have extensive experience in planning and carrying out redshift surveys for cosmology and galaxy evolution studies (Dalton, Ellis, Glazebrook, Goto, Shanks, Totani). We have a number of experts about the data analysis and theoretical interpretations of redshift surveys (Blake, Ferreira, Matsubara, Percival), who will contribute to the data analysis for FMOS. Our team includes experts on cosmological numerical simulations (Takahashi and Yoshida), and their simulations will be critical to examine systematic uncertainties in the final results. We have several young postdocs and students who will be crucial for performing observations and data analysis (Ishikawa, Macaulay, Spitler, Sumiyoshi). Imanishi will conduct ancillary science using a small number of fibers for AGN/QSOs.

According to the SSP policy, we will welcome any Japanese colleagues who are interested in this project, after we pass the first selection stage. We especially welcome young students and postdocs who will perform practical observations and data analyses. Such young people will also play active roles in possible larger redshift surveys by FMOS or PFS in the future, building on the experience acquired in this project. Proposals for ancillary science, e.g., a systematic survey of rare objects using a small number of FMOS fibers, will also be welcomed. We will make an announcement for such an opportunity once this proposal passes the first stage of the SSP review process.

3.2 Data Archive Policy

Because this is a mostly single-purpose survey project taking a large amount of telescope time, we request that the data access is limited only to the team members until we publish the redshift catalog and the first scientific results. After that, we will make the redshift catalog open to the world-wide community in a convenient way (i.e. dedicated web pages), so that interested scientists can perform their own analysis to derive constraints on cosmology or get spectral information for any interesting objects.

It is the general Subaru policy that the data become public 1.5 yr after the observation. Because our observation takes a long duration, we request our possession of the unpublished data for 1.5 yr after the end of observation. We propose to divide the project into two stages; 1.5 yr after the first half observation (15 deg^2 data in 60 nights) is completed, we will release the first data together with our first-release papers and a progress report to TAC. Then we will release the full survey data together with the final papers, 1.5 yr after we complete the full 30 deg^2 survey. If there is a significant delay in the survey we will request from the observatory special permission to retain the data access within the team beyond 1.5 yr.

For ancillary science projects, we will include people who are interested in them, so that they can gain access to the data. The timing of publishing their results will be discussed and approved by the team members. We expect to encourage the publication of ancillary science results as soon as possible, unless it includes crucial information about the core cosmological science.