# Growth of Massive Galaxies in the Early Universe Revealed by Subaru's FMOS

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We are catching a glimpse of the universe, over nine billion years ago, when massive galaxies are creating new stars at remarkable rates, by using the Fiber Multi-Object Spectrograph (FMOS) on the Subaru telescope [1].

FMOS can observe the emission line Hα redshifted into near IR window from galaxies at $z \sim 1$–2. H$\alpha$ is one of the most well-calibrated indicators of star formation and has been widely used in studies of low-redshift galaxies. Therefore the use of H$\alpha$ enables us to compare with other studies consistently over cosmic time. Over the last few years, a tight correlation between stellar mass ($M_*$) and star formation rate (SFR) has been reported by many authors at different redshifts, namely called "star forming main sequence". It has become one of most intriguing subjects in galaxy evolution.

We observed 755 BzK-selected star forming galaxies at $1.4 \lesssim z \lesssim 1.7$ in the COSMOS field using the *H*- and *J*-long gratings (Fig. 1) through the "Intensive Program" (PI: J. Silverman) and the UH-time (PI: D. Sanders). In order to estimate the intrinsic SFR, it is necessary to correct H$\alpha$ luminosities for dust extinction. One can estimate the extinction toward nebular emissions $E_{\rm neb}(B\text{–}V)$ from the Balmer decrement (H$\alpha$/H$\beta$). Since our data do not permit an detection of H$\beta$ for most individual galaxies, we co-added 89 spectra with both quality H$\alpha$ detection and the *J*-long coverage in three bins of reddening $E_{\rm star}(B\text{–}V)$ and measure the average ratio of H$\alpha$/H$\beta$. Comparing the stellar and nebular extinction, we found average relation $E_{\rm neb}(B\text{–}V) \sim 1.2\,E_{\rm star}(B\text{–}V)$ for our sample, which indicates that the two extinctions are more similar to each other relative to the canonical relation. This possibly implies a more uniform dust distribution as compared with the local galaxies.

Based on our result, we derived SFRs based on the dust-corrected H$\alpha$ luminosities for 271 galaxies with an H$\alpha$ detection. Figure 2 shows a comparison of SFR and $M_*$ illustrative of a main sequence that evolves with redshift. With cosmic time, the sequence declines with little change of its slope. Our result at $z \sim 1.6$ also shows a tight correlation between these two quantities and lies in between the sequences at $z \sim 1$ and $\sim 2$ with a consistent slope and normalization, which is ~20 times higher as compared with the local galaxies.

This study establishes a main sequence based on a large sample in the high-redshift universe using the spectroscopic Hα emission lines. We refer the reader to our published paper [2] for more details.

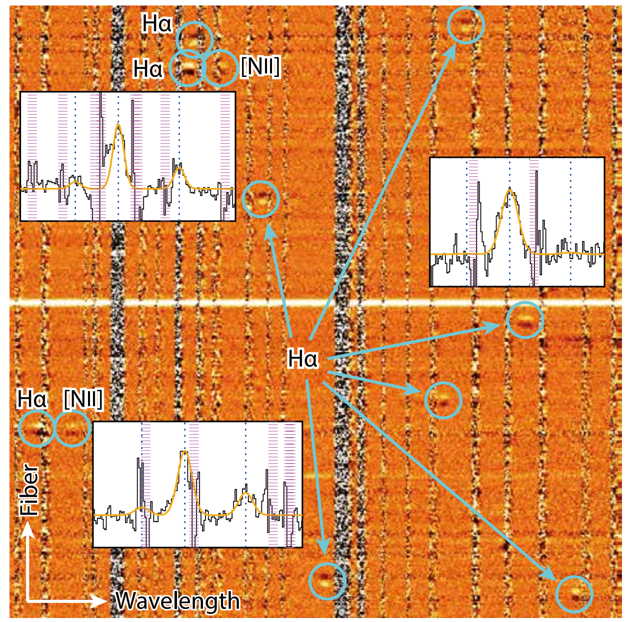


**Figure 1**: A part of a spectral image in the *H*-long band. The horizontal axis refers to the wavelength direction while the vertical axis indicates individual spectra observed through each fiber. Circles indicate the detection of emission lines and the inset boxes show the intensity of the emission lines.

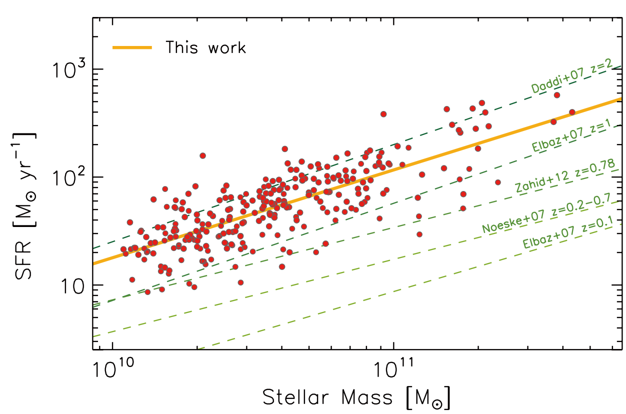


**Figure 2**: $M_*$ vs. SFR. The main sequences at different redshfts are also shown by the dashed lines.

## References

[1] Subaru web release (2013/12/5).
[2] Kashino, D., et al.: 2013, *ApJ*, **777**, L8.