# Detection of Emission Line Galaxies in the Slitless Spectra of HST and CSST (Postprint)

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## Abstract

Slitless spectroscopy onboard space telescopes is a powerful tool to detect emission-line objects such as emission-line galaxies (ELGs) and quasars. In this work, we present a study of ELGs observed with slitless spectroscopy by the Hubble Space Telescope (HST) in a deep field of 44 arcmin2. This is one of the deepest HST fields with a wealth of imaging and spectral data. In particular, previous VLT/MUSE observations have covered this field and identified a large number of ELGs. We reduce the HST spectra using the latest pipeline with a forward modeling algorithm and construct a sample of ELGs. By comparing with the MUSE spectra, we characterize our ELG detection in the HST spectra, including the impact of the line flux, line width, signal-to-noise ratio, etc. We find that the morphological broadening may affect the detection of ELGs, such that more compact sources are easier to be detected in slitless spectra. We discuss its implications to future slitless spectroscopic surveys that will be carried out by the China Space Station Telescope (CSST) and find that the CSST slitless spectroscopy has a capability comparable to that of HST in terms of the detection of emission lines.

## Full Text

## Preamble

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## Abstract

Slitless spectroscopy onboard space telescopes is a powerful tool for detecting emission-line objects such as emission-line galaxies (ELGs) and quasars. In this work, we present a study of ELGs observed with slitless spectroscopy by the Hubble Space Telescope (HST) in a deep field of approximately 44 $\mathrm{arcmin}^2$. This is one of the deepest HST fields with a wealth of imaging and spectral data, particularly as previous VLT/MUSE observations have covered this region and identified a large number of ELGs. We reduce the HST spectra using the latest pipeline with a forward modeling algorithm and construct a sample of ELGs. By comparing with the MUSE spectra, we characterize our ELG detection in the HST spectra, including the impact of line flux, line width, signal-to-noise ratio, and other parameters. We find that morphological broadening may affect the detection of ELGs, such that more compact sources are easier to detect in slitless spectra. We discuss the implications for future slitless spectroscopic surveys that will be carried out by the China Space Station Telescope (CSST) and find that CSST slitless spectroscopy has a capability comparable to that of HST in terms of emission line detection.

**Key words:** techniques: spectroscopic –surveys –methods: data analysis –galaxies: general –galaxies: ISM

## 1. Introduction

Emission line galaxies (ELGs) are valuable tools for studying star formation and exploring galaxy evolution (Kennicutt 1992; Ballinger et al. 1996; Hopkins et al. 2003). For example, Balmer lines are common estimators of the star formation rate (SFR). H$\alpha$ \$ \$6563 is usually the most prominent line in local galaxies, while [O II] $\lambda$\$ $3726, 3729 servesasagoodsubstitutewhenH$ \$ is inaccessible at optical wavelengths for higher-redshift galaxies (Kewley et al. 2004). The combination of different lines reveals various galaxy properties, such as the Balmer decrement for dust extinction corrections (Hao et al. 2011) and the "Baldwin, Phillips & Terlevich" diagram for AGN diagnosis (Baldwin et al. 1981).

Large ELG catalogs from sky surveys make it possible to study cosmic evolution across broader timescales. For example, Comparat et al. (2016) constructed emission line ([O II], H$\beta$, [O III] $\lambda$\$ \$4959,5007) luminosity functions from approximately 35,000 galaxies at $z \leq 1$ and found that the characteristic luminosity and peak number density increase with redshift. The rapid evolution of the Ly$\alpha$ luminosity function at cosmic dawn (z 6) reflects the cosmic reionization history of the universe (Dijkstra et al. 2007; Santos et al. 2016).

To build a large and reliable sample of emission-line galaxies, efficient line identification methods are needed. One such method is slitless spectroscopy, which simultaneously captures the spectra of all sources in its field-of-view (FoV). However, there are several drawbacks. First, slitless spectroscopy works best in sparsely populated fields but is less ideal for crowded fields, as overlaps of different 2D spectra result in contamination among sources (Kümmel et al. 2009). Second, the sky background is also dispersed by the grism or grating, bringing higher noise. Third, for sources with extended morphology, the emission line profiles can become broadened (referred to as morphological broadening hereafter), which results in a lower signal-to-noise ratio (SNR). Currently, two of these disadvantages can be mitigated in space telescope observations, and the excellent point-spread function (PSF) in space minimizes the morphological broadening resulting from atmospheric seeing. Consequently, slitless spectroscopy is currently employed and will continue to be used in many space telescope observations.

During the past few decades, the Hubble Space Telescope (HST) carried out slitless spectroscopic surveys such as PEARS (Straughn et al. 2009; Pirzkal et al. 2013) and 3D-HST (Brammer et al. 2012; Momcheva et al. 2016). More recently, slitless spectroscopy has become more powerful with the James Webb Space Telescope (JWST). On JWST, both NIRISS and NIRCam implement wide-field slitless spectroscopy in the near-IR (Roberts-Borsani et al. 2022; Glazebrook et al. 2023). The resolution of the latter reaches approximately 1600 at 4 m. These instruments work in parallel with slit-spectroscopic observations or simultaneously with multi-band photometry (Sun et al. 2022; Yang et al. 2023; Backhaus et al. 2024; Helton et al. 2024). For example, in Backhaus et al. (2024), the slitless spectroscopy with NIRCam complements the high-z galaxy sample observed with NIRSpec, including 19 galaxies with [O III]/H$\beta$ measurements and 18 H$\alpha$ emitters among 155 galaxies.

Currently, the China Space Station Telescope (CSST) is under development and planned for launch to low Earth orbit (Zhan 2011, 2021). It will feature a 2 m diameter primary mirror with a 1.1° × 1.2° FoV, approximately 300 times larger than that of HST. The larger FoV enables high efficiency in sky surveys across the near-UV, u, g, r, i, z, and y bands. The slitless spectroscopy will include three bands (i.e., GU, GV, and GI), with throughput curves shown in Figure 7 [Figure 7: see original paper] of Zhan (2021). All CCDs will function simultaneously on the focal plane during observations, so the aggregate exposure time depends on the number of CCDs assigned to each band. The slitless spectroscopy (taking up four CCDs for each band), in parallel with photometry (with 18 CCDs total), is planned to cover sky regions totaling 17,500 deg$^2$ and a 400 deg$^2$ ultra-deep field, with spectral resolution \$ $200.Forthe17,500deg\hat{}\{2\}$\$ sky region, the exposure time is planned to be 4 × 150 s per field, and 16 ×

250 s per field for the ultra-deep field. The GI grating can reach a depth of 24.3 mag in the AB system in the ultra-deep field, where magnitude represents the aggregate flux of the grism spectrum. The three gratings carried onboard will provide spectra for tens of millions of sources, enabling CSST to perform effectively for large-area surveys.

In this paper, we reprocess archival HST slitless spectroscopic data in a deep field. We discuss the effect of morphological broadening on emission line identifications and compare them with CSST forecast simulations. The structure of the paper is as follows. In Section 2, we introduce our data from HST and the emission line reference catalog from the MUSE-Wide survey (Urrutia et al. 2019). We also provide brief summaries of data reduction for HST G800L grism spectroscopy using the Grism Redshift and Line Analysis tool (GRIZLI). In Section 3, we generate simulated spectra for CSST observations and fit emission lines in MUSE, ACS/G800L, and CSST/GI spectra. In Section 4, we compare the slitless spectroscopy using ACS/G800L and CSST/GI, and discuss factors that influence their line detection capabilities, particularly the morphological broadening effect. Section 5 summarizes our work.

## 2. Data and Data Reduction

Our data come from the GOODS-South region observed by both HST and the MUSE-Wide Survey. Observations in the GOODS sky regions were initiated in the 2000s for studies of galaxies, AGNs, and cosmology across multiple wavelengths (Treister et al. 2004; Bundy et al. 2005; Ravikumar et al. 2007). The survey includes both North (12h 36m 55s, +62° 14  15 ) and South (03h 32m 30s, −27° 48  20 ) fields, each approximately 160 arcmin$^2$ in size. These are among the deepest observed regions, making them rich pools of multi-wavelength data. Using ACS, both broad and narrow band photometry were performed in these fields. The GOODS HST Treasury Program imaged both fields in the B, V, i, and z bands, allocating 3, 2.5, 2.5, and 5 orbits respectively. Using the narrow band image in F658N, Zhu et al. (2024) have continued discovering new ELG candidates in recent years.

### 2.1. Data Archives

Large slitless spectroscopic surveys like PEARS and 3D-HST were carried out in these fields. Our raw spectroscopic data primarily come from these two programs. PEARS, conducted in Cycle 14, was allocated 200 orbits total for G800L spectroscopic survey and short F606W parallel photometry (Straughn et al. 2009). The grism survey consists of nine ACS fields, including five in GOODS-South and four in GOODS-North. These programs employed a 2D line detection and extraction procedure that identified emission lines in the dispersed light beam images, ultimately detecting 1162 H$\alpha$, [O III], and [O II] emission lines.

The 3D-HST survey aimed to address a series of extragalactic problems, including the mechanisms that quench star formation and the co-evolution of galaxies and their environments. It was allocated 248 orbits of HST time during Cycles 18 and 19 (Brammer et al. 2012). ACS/G800L and WFC3/G141 made the deepest exposures toward regions centered at (03h 32m 30s, −27° 48  00 ). They obtained F814W and F140W direct images for the two grism spectroscopic modes, reaching depths comparable to deep ground-based photometry. The exposure information is provided in Figure 1 [Figure 1: see original paper] and Table 1 .

The observation mode for spectroscopy on HST consists of a pre-image followed by grism exposure. The pre-image serves at least three purposes. First, it provides high-accuracy photometry. Second, during data reduction, we use object positions from the pre-image and the dispersion function to trace 2D spectra for wavelength calibration. Third, the photometry is used for the GRIZLI data reduction process described below.

In this study, we choose to reprocess the spectroscopic data rather than using previously reduced datasets from the 3D-HST archive for several reasons. First, there have been additional observations in these fields since the 3D-HST program completed, including pointings not far away that overlap with the  44 arcmin$^2$ region (such as those in the PEARS survey). This increases the SNR of the spectra to identify fainter sources, as GRIZLI can combine 1D spectra from different position angles (PAs) with unified wavelength calibration. Second, GRIZLI adopts a new data reduction method based on forward modeling (see Section 2.2 for details), which improves spectrum extraction quality, especially for overlapped spectra in densely populated fields. As shown in Figure 2 [Figure 2: see original paper], emission line features in the 3D-HST products are weaker than those in the GRIZLI-reduced data. Consequently, the fitting procedure adopted in Section 3 fails for most 3D-HST sources due to low SNR. Additionally, there are fewer 2D spectra (only 570) for the ELGs identified by MUSE-Wide in the 3D-HST products alone.

We select the MUSE-Wide survey as our reference primarily due to its wavelength range ( 4800-9300 Å), which largely overlaps with the G800L grism on HST ( 5000-11000 Å) and the GI grating on CSST ( 6300-10000 Å, see Section 1). Using VLT, MUSE-Wide represents the largest integrated field spectroscopic survey to date (Bacon et al. 2015). The blind survey program aims to minimize source selection bias. It has a 1 × 1 arcmin$^2$ FoV in wide survey mode and, with a seeing of  0.8 , achieves spatial sampling of 0.2 × 0.2 arcsec$^2$ with adaptive optics assistance. The spectral resolution varies from 1770 at 4800 Å to 3590 at 9300 Å. The one-hour exposure time per unit field makes it deep, reaching an accurate limiting magnitude of I_{AB}   22.28. As a result, we use MUSE-Wide as an atlas for our analysis. The  44 arcmin$^2$ area ensures a sufficiently large sample size. Currently, the public MUSE-Wide data includes 44 fields in the Chandra Deep Field South (Giacconi et al. 2001), containing 1602 ELGs in the archive, almost all with multi-band photometric counterparts in the CANDELS catalog (Guo et al. 2013). In this work, we directly use the redshift information provided by the MUSE team in the emission line catalog.

### 2.2. G800L Data Reduction

Similar to Abramson et al. (2020), we use the GRIZLI pipeline (Wang et al. 2019) to extract spectra for all sources. Initially, we use the MastQuery package to identify all G800L exposures targeting our studied region. Next, we identify all other G800L and photometric exposures overlapping with the footprints of these exposures to ensure that surrounding exposures and all sources at the edge of the FoV are included. We download these from the MAST website. All images are dark-subtracted and flat-fielded. Subsequently, we associate grism exposures with corresponding direct images according to visit, exposure order, and exposure footprints.

Afterward, we run the AstroDrizzle package (Gonzaga et al. 2012) to perform sky background subtraction, astrometric alignment, and image segmentation. Meanwhile, we generate image mosaics, mask bad pixels, and remove cosmic rays (Driz_{CR}) by comparing multiple exposures in the same pointing. In addition, GRIZLI runs the L.A.Cosmic algorithm (Urrutia et al. 2019) to remove cosmic rays in single or double exposures, which is common for fields near the Hubble Ultra-Deep Field (Beckwith et al. 2003). This algorithm detects sharp flux changes between cosmic-ray-contaminated and uncontaminated pixels, then masks the contaminated pixels. The removal process by L.A.Cosmic proves less effective than that by Driz_{CR}, so we exclude pointings with only one or two exposures to avoid fake emission line detections. We then derive a photometric catalog for reference in later steps and create 2D cutouts of dispersed light beams for each position angle.

Next, we perform 1D spectrum extraction. GRIZLI calibrates the spectral wavelength on the 2D cutouts by applying the dispersion function to the center of each photometric source. This process may introduce systematic uncertainties in line identification, which we discuss in Section 4. Additionally, the pipeline determines which spectral orders to extract according to their brightness, considering factors such as SNR, saturated or bad pixels, and spectral resolution. Typically, the first order is extracted because it retains most of the spectral energy.

For sources with nearby contamination, we employ forward modeling. We first sort all sources in densely populated regions by magnitude according to the previously derived photometric catalog. We initially assume each source has a flat continuum by averaging its integrated flux from pre-image photometry. Starting from the brightest sources, we build polynomial continuum models and extract them with contamination removed (using either flat spectra for fainter neighbors or polynomial models for brighter ones). We iterate this refinement repeatedly until we obtain clean 2D spectra.

Finally, spectra from different orders and position angles are combined, resampled, and reduced to 1D. For sparsely populated sources, we adopt the default optimal 1D spectrum extraction method. The spectral resolution is approximately 100. Figure 3 [Figure 3: see original paper] shows the 1D and 2D spectra of an object, together with its photometric information.

## 3. Results

In this section, we first describe our emission line identification process in the MUSE-Wide spectra. We use the archived MUSE-Wide redshifts as preliminary redshifts to fit emission lines, since its resolution and depth surpass those of ACS/G800L and CSST/GI spectroscopy. With the fitted emission line and continuum models from MUSE-Wide data, we generate simulated CSST grism exposures using the Python package Sls_{{{1d}}_{{Spec}}}. We then repeat the line identification process on the ACS/G800L and simulated CSST spectra.

We select emission line samples from the ACS/G800L archived data by cross-matching all extracted G800L sources with the MUSE-Wide ELG catalog, which contains 1602 sources with multi-band photometric counterparts from Guo et al. (2013). Each source typically exhibits different sizes across various bands. We require that selected G800L sources fall within the median Kron radii of their MUSE counterparts, yielding 885 spectra as MUSE counterparts. Additionally, as mentioned in Section 2, some G800L exposures in parts of the 44 arcmin$^2$ region still contain unremoved cosmic rays. Through visual inspection of their 2D spectra and nearby sky regions, we retain 766 spectra from sources with cosmic rays properly removed. Using the archived redshifts from MUSE, we determine the wavelengths of emission lines.

Next, we perform spectral line fitting using the Python package "Specutils" (Earl et al. 2023). We consider only strong emission lines between 6300 Å and 9300 Å (in the observed frame): [O II], H$\beta$, [O III], H$\alpha$ (and [N II] $\lambda$\$ \$6548,6583, if comparably strong). In this wavelength range, G800L achieves high throughput of approximately 20% to 40%, making emission lines more likely to be detected.

We fit all 1602 MUSE spectra to build intrinsic spectrum models for CSST sources. We use a polynomial to fit the continuum, masking possible emission line wavelength regions. For the continuum-subtracted spectrum of each source, we fit all emission lines simultaneously using the Levenberg-Marquardt algorithm (Marquardt 1963). For strong emission lines with centers between 6300 and 9300 Å, we assign each a 1D Gaussian profile initially. Using the redshift z_M measured by MUSE, we take $\lambda$_{rest} × (1 + z_M) as the initial wavelength center, the flux peak as the initial amplitude guess, and adopt an initial $\sigma$ parameter of 2 Å for line width.

For emission lines identified by MUSE, we require SNR $> 5$, defined as the SNR in the $2\sigma$ wavelength region on both sides of the line. Due to the low spectral sampling rate of ACS/G800L spectroscopy, the fitting procedure frequently fails if we adopt narrower line widths (e.g., the FWHM). For the [O III] doublet (similar to [N II]), we use the SNR of the stronger line or the de-blended stronger component. If H$\alpha$ is identified, we fit it together with [N II] to include the [N

II] flux in the simulated spectra. We find that almost all selected emission lines match well with the catalog published on the MUSE website.

We use these modeled intrinsic spectra to generate simulated CSST GI spectra with the Python package Sls_{{{1d}}*{{Spec}}}. The fitting model consists of a polynomial continuum and multiple emission lines ranging from 6300 to 9300 Å (see the dashed and colored lines in the upper panel of Figure 4 [Figure 4: see original paper]). Instrumental broadening in MUSE spectra may slightly reshape the line profile, but since the spectral resolutions of both HST and CSST are significantly lower than that of MUSE, the few Å broadening in MUSE spectra is negligible. We do not use the original MUSE spectra for two reasons. First, we assume a smooth profile for the spectra by nature, and noise in the observed MUSE spectra may impact the quality of the simulated CSST spectra. Second, the current version of Sls*{{{1d}}_{{Spec}}} requires a full spectral energy distribution in the UV, optical, and near-IR bands, so we extrapolate the continuum to the wavelength limit. We select the "GI" grating for its wavelength coverage and first-order beam, which captures most of the dispersed spectral energy.

We inherit the default PSF, readout noise, dark field, pixel size, and sky background. For a fair comparison, we adopt the exposure time and number of exposures from the G800L observations, which are roughly equal to the CSST deep field plan (i.e., 250 × 16 s). We do not generate CSST/GI spectra for MUSE ELGs without G800L detections, as in real CSST/GI observations there would also be undetected sources due to non-detection in photometry or positioning at CCD edges. For simplicity, we adopt a Sérsic index of n = 1, a position angle of PA = 45°, and an axis ratio of q = 1 for galaxies in our simulations. We take 0.4 times the median Kron radii (i.e., the first moment radius of ACS photometry in optical bands) as the intrinsic effective radius of each source. Sls_{{{1d}}_{{Spec}}} adds the PSF of GI spectroscopy (FWHM 0.39 ), which surpasses that of ACS photometry.

We disperse the spectral energy according to these parameters both spectrally and spatially. After adding the simulated sky background, Poisson noise, instrumental noise, etc., we derive the simulated 2D spectra. For each beam order and wavelength, Sls_{{{1d}}_{{Spec}}} increases the aperture radius spatially until the sum reaches 90% of the total flux. We sum the flux within the aperture radius and reduce the spectra to 1D. The 1D spectra of four sources are shown in the lower panels of subfigures in Figure 4 [Figure 4: see original paper].

Similar to the MUSE spectral fitting procedure, we perform line fitting for the G800L and simulated CSST data. We determine the initial amplitude and wavelength center in the same way as before. Considering their lower resolution compared to MUSE, we adopt initial $\sigma$ values of 80 Å and 40 Å for G800L and CSST/GI, respectively. Due to the lower resolution, emission lines become broadened and difficult to distinguish from the continuum. Consequently, we require $\sigma < 150$ Å for ACS/G800L and $\sigma < 75$ Å for CSST/GI. We require SNR $> 5$ for both slitless spectroscopic datasets. H$\beta$ and [O III] are usually blended in G800L spectra due to lower resolution, and we can only decompose them with spectral line fitting in some cases. Thus, H$\beta$ or [O III] identified in G800L spectra may include flux from both lines. H$\alpha$ is close to the [N II] doublets on both sides and is usually much stronger, so we treat H$\alpha$ together with the two [N II] doublets as a single line in both G800L and CSST/GI spectra. All lines identified by MUSE and G800L or GI are listed in Table 2 .

## 4. Discussion

In this section, we first compare line detection between ACS/G800L spectra and simulated CSST/GI spectra. We then discuss the morphological broadening effect on spectral line profiles (the $\sigma$ parameter). While previous simulations have explored this broadening effect (Wen et al. 2024), we find that various factors during data reduction lower the obtained SNR, such as cosmic rays and overlapping spectra. Hence, it is helpful to illustrate this effect using actual HST data.

### 4.1. CSST Detection Efficiency

We compare the detection efficiency between observed HST spectroscopy and simulated CSST spectroscopy given the same exposure time. HST observations share many similarities with CSST: both operate in low Earth orbit with similar aperture diameters ( 2 m), meaning they have similar susceptibility to cosmic rays. As shown in Table 2, G800L identified 33 lines with SNR > 5, whereas the simulated CSST observations identified only 22. At first glance, HST G800L appears to perform better, but several factors may influence slitless spectroscopy efficiency.

First, as mentioned above, masked cosmic rays and bad pixels shorten the actual effective exposure time. Considering this, the SNR of emission lines from CSST/GI would decrease accordingly. Second, spectral resolution and pixel scale affect performance. Due to G800L’ s lower resolution, some blended lines are mistaken as single lines, introducing systematic uncertainties. For example, in Figure 4(a), the identified [O III] line actually includes both H$\beta$ and [O III] flux, leading to overestimated SNR. For CSST/GI spectra, while the current Sls_{{{1d}}_{{Spec}}} adopts resolution $ $200, the CCD sampling is about 10 Å per pixel. The SNR of CSST detection could be enhanced if we adjust the CCD sampling size (e.g., through pixel binning).

Third, the source radius used in 2D spectrum generation affects the line profile. In this work, we directly adopt the first moment radius from multi-band photometry as the effective radius (see Section 3), and Sls_{{{1d}}*{{Spec}}} distributes spectral energy according to the Sérsic profile. In reality, for more extended sources (e.g., mergers, a rare case), the gas clouds generating emission lines may be located farther from the central region (Arroyo-Polonio et al. 2023). Thus, part of the emission line flux might not be included in the 1D spectrum extraction. More importantly, the spatial distribution of gas clouds results in a* *broadened line profile (see Section 4.2) and correspondingly more included noise. Many high-flux emission lines from low-z galaxies (which typically have more extended 2D profiles) thus vanish into the continuum. Examining the ELGs in Table 2, we find that most sources with* $r\{\mathrm{Kron}\} > 1$ exhibit compact emission line regions in MUSE observations (e.g., see Figure 7(b), where 75% of line flux concentrates within a central region of 0.5 radius). Considering the smaller PSF in space, observed emission line regions will be even more compact. Hence, our simulation likely overestimates the morphological broadening effect in GI spectra. In Table 2, ACS/G800L and CSST/GI spectroscopy show similar performance in detecting ELGs with r_{Kron} ≤ 1 , with CSST/GI even making two additional detections. Consequently, we attribute most of the performance difference to this factor.

Finally, in this work we know the source redshifts beforehand from MUSE-Wide DR1. In real observations, lower resolution and shorter wavelength coverage mean fewer emission lines can be confirmed, leading to uncertainties in redshift estimation. Consequently, even when line signals are detected, their identification becomes more difficult. This factor favors CSST/GI, which has higher resolution ($ 200)*.Forinstance, wecandistinguishbetweenH* $ and [O III] if both have sufficiently high SNR and the source is compact (see the upper two panels in Figure 5 Figure 5: see original paper).

### 4.2. Morphological Broadening

We first describe the morphological broadening effect. When a resolved 2D object is dispersed, photons received in one pixel may originate from different parts of the source (which map to different pixels in photometry). Photons away from the source center will be “blueshifted” or “redshifted” to other wavelengths during calibration. As a result, emission lines in slitless spectroscopy are broadened depending on the source’ s 2D size.

Here we use the pixel size to represent the PSF of the grating observation, i.e., 0.074 for the current CSST/GI design. In Figure 5, if the source is point-like (with intrinsic angular size r_e ≤ 0.074 ), instrumental broadening dominates and the line profile hardly changes. If r_e increases, the SNR quickly drops along with the broadened line profile. When r_e increases to 1 , morphological broadening becomes significant, making line fitting less accurate and causing non-monotonic growth in the curve shown in the right panel. In the left panel, when the object size is equivalent to the CSST PSF size, we can see two components of the [O III] doublet. When it reaches 0.2 , [O III] appears as a single line. At 0.5 , [O III] is even blended with H$\beta$. This morphological effect also adds to uncertainties in wavelength calibration when the flux center deviates from the geometric center of the source.

Regarding real observations, we find that ACS/G800L favors more compact sources given the same redshift range. We again use MUSE data for comparison. Morphological broadening has minimal impact on MUSE observations since the entire galaxy is divided into hundreds of subsets to generate data cubes, with each subset having its own wavelength calibration. This implies that, given the same exposure depth, slitless spectroscopy may be more likely to miss lower-redshift sources, which are typically more extended, compared to unbiased integral-field spectroscopy. Powered by star-forming activity, H II regions usually exist broadly across ELGs (Sánchez et al. 2012; López-Hernández et al. 2013), so we select ELGs in the redshift range 0–0.42 with H$\alpha$ detection. Their Kron radius distribution is shown in the histogram in Figure 6 [Figure 6: see original paper]. The mean Kron radii are  2.2  for MUSE and  1.8  for ACS/G800L.

Additionally, we find that for extended sources with G800L detections, the [O III] line region is usually more compact than the continuum emission region (see Figure 7). Previous integral-field observations have also discovered a hot, ionized gaseous component in the central regions of some galaxies (Kehrig et al. 2016; Ilha et al. 2024), possibly produced by active galactic nucleus winds. This compactness alleviates the morphological broadening effect on [O III] line detection.

## 5. Summary

In this work, we reduced ACS/G800L slitless spectroscopic data using the latest GRIZLI pipeline, which applies forward modeling to extract overlapped spectra. Our data come from HST observations covering the  44 arcmin$^2$ MUSE-Wide region in the GOODS-South field. After continuum subtraction, we fitted emission lines ([O II], H$\beta$, [O III], H$\alpha$, and [N II]) in MUSE spectra using Gaussian models. We then used these fitted MUSE spectrum models to generate simulated CSST/GI spectra and fitted the G800L and simulated CSST spectra using the same method.

We identified 33 emission lines with SNR $> 5$ in the G800L observations and 22 in the simulated CSST/GI spectra. Comparing the two sets, we find that CSST has capability comparable to HST for emission line detection. Furthermore, the emission line region morphology from MUSE-Wide suggests that CSST/GI might achieve even better performance in real observations. Higher spectral resolution and larger FoV further enhance the efficiency of CSST grism spectroscopy for sky surveys.

The ELG detection capability of slitless spectroscopy aboard space telescopes may be compromised by various factors, including cosmic rays, spectral resolution, and morphological broadening. We briefly analyzed how source morphology influences line detection and profiles using G800L and simulated GI spectroscopy, finding that sources with more compact emission line regions are favored. This work provides a forecast for slitless spectroscopy and ELG identification in future CSST observations.

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