JWST NIRSpec IFU data Reduction and Analysis

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GA-NIFS: JWST/NIRSpec IFU observations of HFLS3 reveal a dense galaxy group at $z \sim 6.3$

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ABSTRACT

Massive, starbursting galaxies in the early Universe represent some of the most extreme objects in the study of galaxy evolution. One such source is HFLS3 ($z \sim 6.34$), which was originally identified as an extreme starburst galaxy with mild gravitational magnification ($\mu \sim 2.2$). Here, we present new observations of HFLS3 with the JWST/NIRSpec IFU in both low (PRISM/CLEAR; $R \sim 100$) and high spectral resolution (G395H/290LP; $R \sim 2700$), with high spatial resolution ($\sim 0.1''$) and sensitivity. Thanks to the combination of the NIRSpec data and a new lensing model with accurate spectroscopic redshifts, we find that the $3'' \times 3''$ field is crowded, with a lensed arc (C, $z = 6.3425 \pm 0.0002$), two galaxies to the south (S1 and S2, $z = 6.3592 \pm 0.0001$), two galaxies to the west (W1, $z = 6.3550 \pm 0.0001$; W2, $z = 6.3628 \pm 0.0001$), and two low-redshift interlopers (G1, $z = 3.4806 \pm 0.0001$; G2, $z = 2.00 \pm 0.01$). We present spectral fits and morpho-kinematic maps for each bright emission line (e.g., [OIII]λ5007, Hα, [NII]λ6584) from the R2700 data for all sources except G2 (whose spectral lines fall outside the observed wavelengths of the R2700 data). From a line ratio analysis, the galaxies in component C are likely powered by star formation, while we cannot rule out or confirm the presence of AGN in the other high-redshift sources. We perform gravitational lens modelling, finding evidence for a two-source composition of the lensed central object and a comparable magnification factor ($\mu = 2.1 - 2.4$) to previous work. The projected distances and velocity offsets of each galaxy suggest that they will merge within the next ~ 1 Gyr. Finally, we examine the dust extinction-corrected SFR$_{\mathrm{H}\alpha}$ of each $z > 6$ source, finding that the total star formation ($510 \pm 140\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$, magnification-corrected) is distributed across the six $z \sim 6.34 - 6.36$ objects over a region of diameter ~ 11 kpc. Altogether, this suggests that HFLS3 is not a single starburst galaxy, but instead is a merging system of star-forming galaxies in the Epoch of Reionisation.

Key words. galaxies: high-redshift, galaxies: star formation, galaxies: kinematics and dynamics, gravitational lensing: strong

Introduction

Extreme high redshift (z~ 6.34) galaxy

Discovered on 18 April 2013 - Far-infrared using Herschel Space Telescope

Starburst galaxy (3,000 solar masses) of stars a year

Earlier studies: found no overdensity at large scale

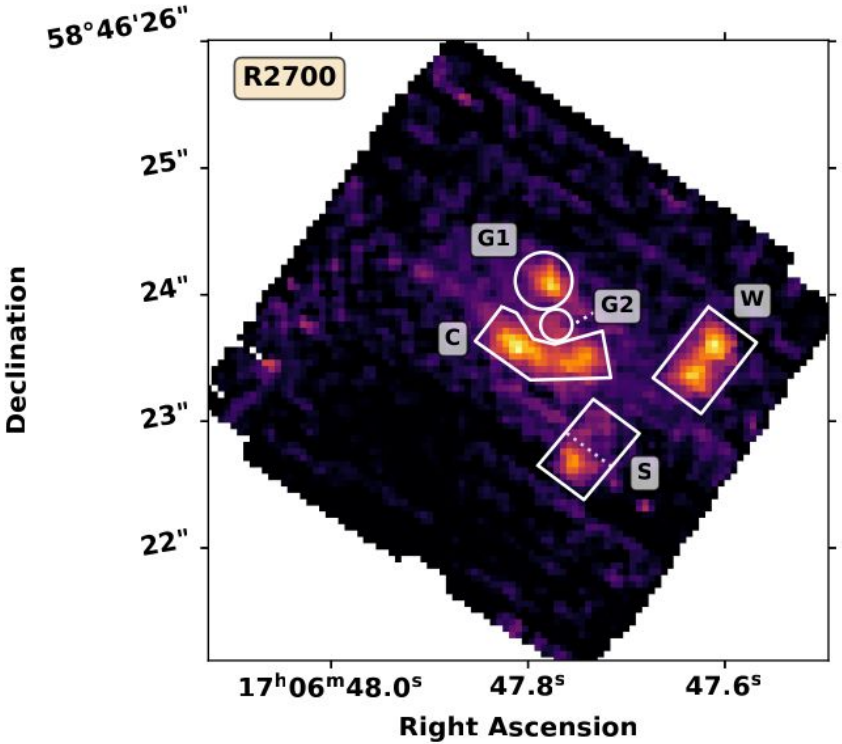
Follow up by JWST/NIRSpec IFU

J170647.8+584623 or HFLS3

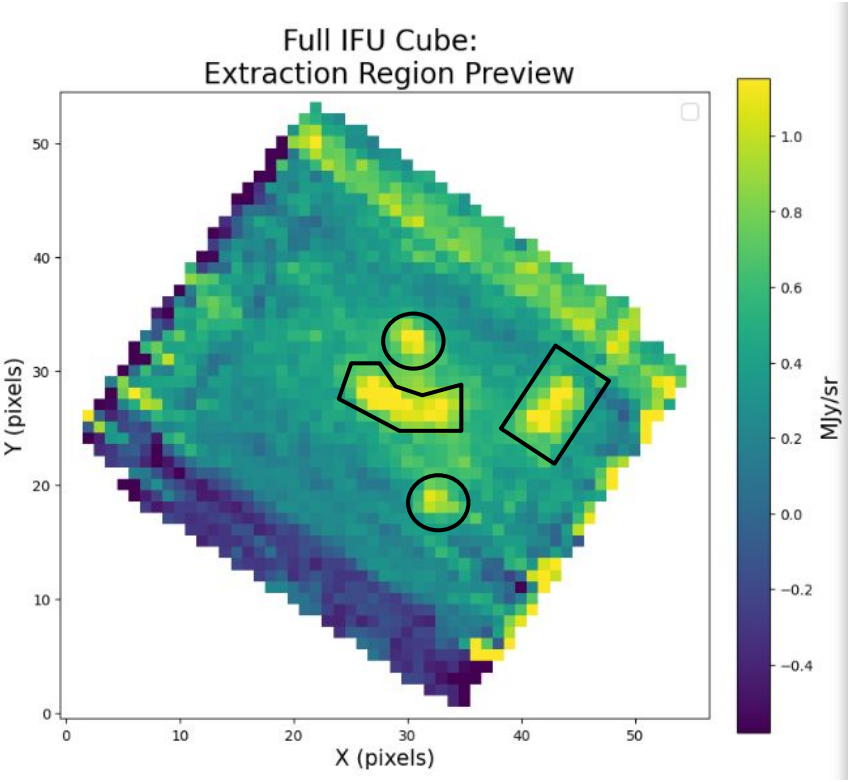
Data Used

HFLS3 observation: JWST/NIRSpec IFU
Disperser/filter combinations G395H/290LP (R2700);
PRISM/CLEAR, (R100)
1 September 2022 PID 1264 PI: L. Colina

Reduction

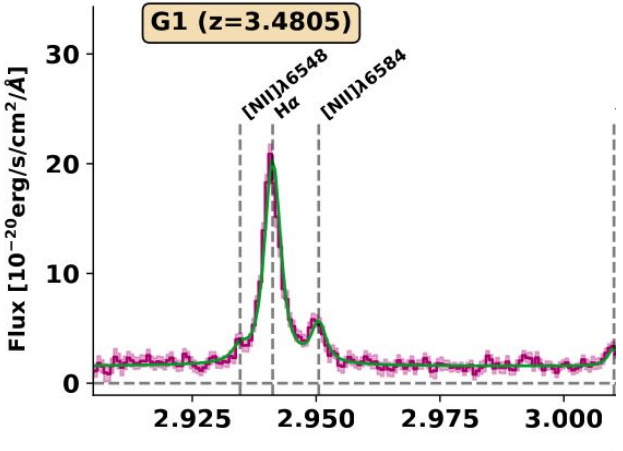


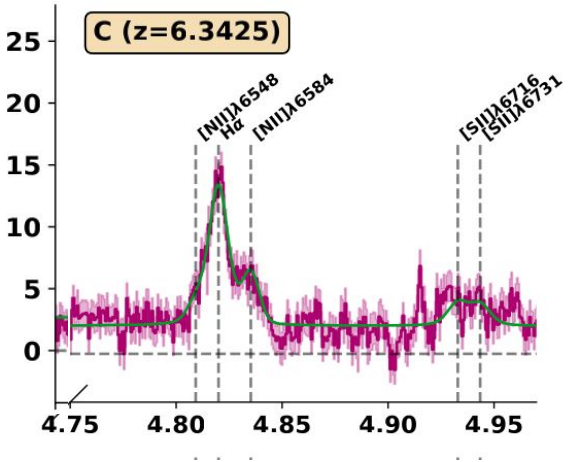
Integrated emission of the HFLS3 redshifted Hα for z ~ 6.34 for the R2700 cube (λobs = 4.79954 − 4.84467 μm)

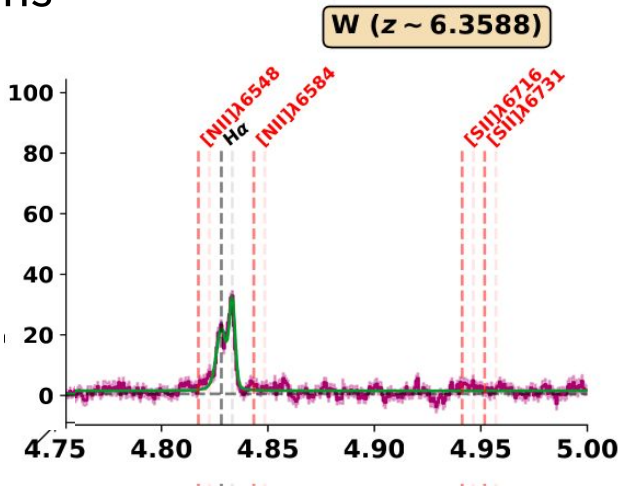


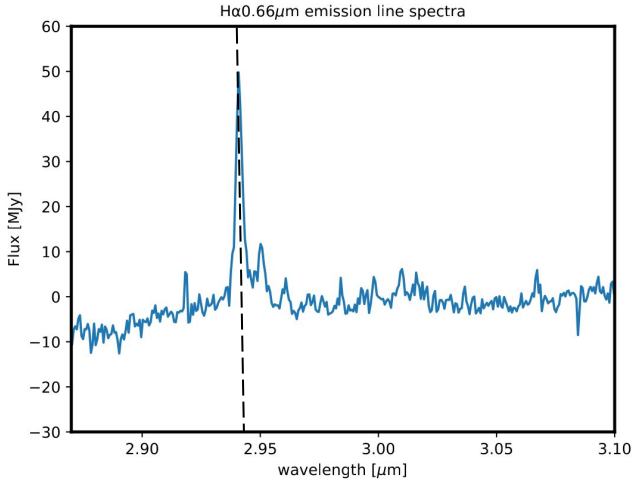
G1, z ~ 3.481; G2, z ~ 2.01
C1 and C2; z ~ 6.342
S1 and S2, z ~ 6.359
W1, z ~ 6.355; W2, z ~ 6.363

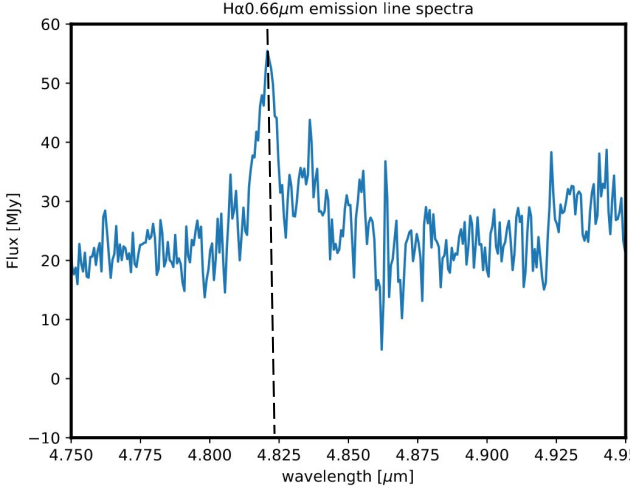
Hα Emission in different regions

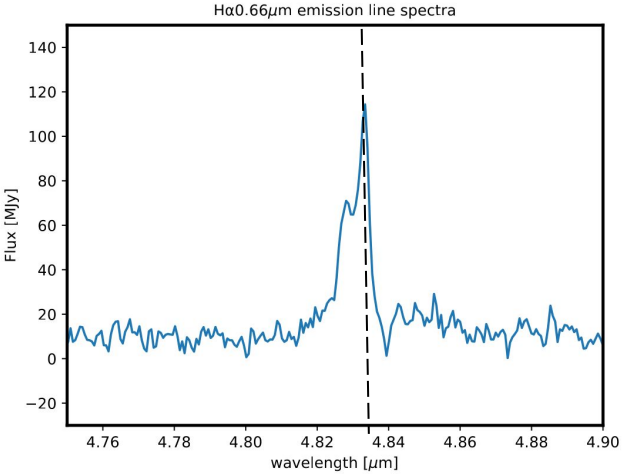




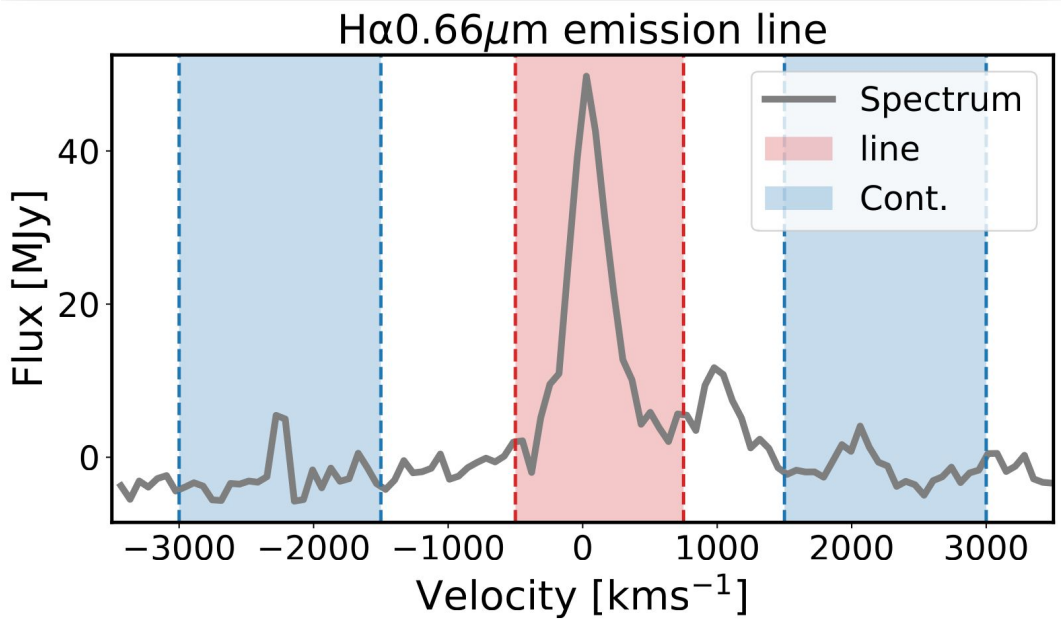


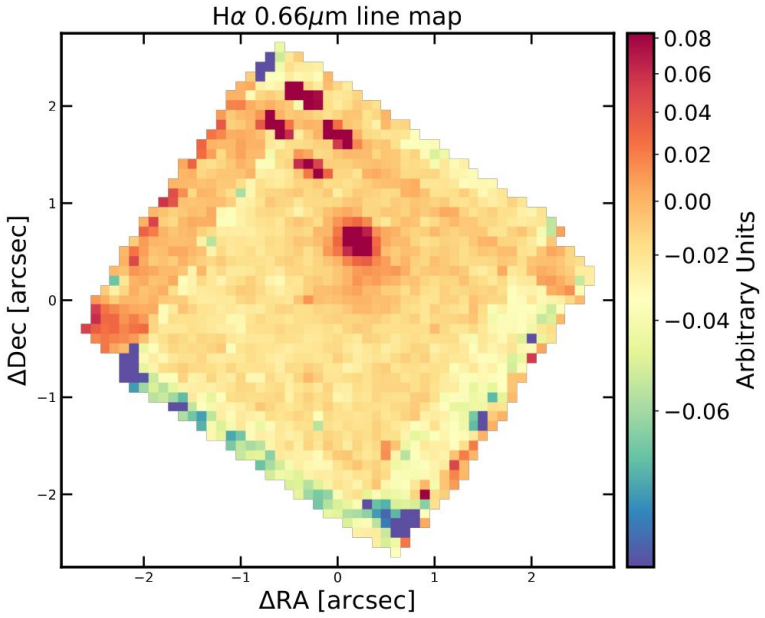






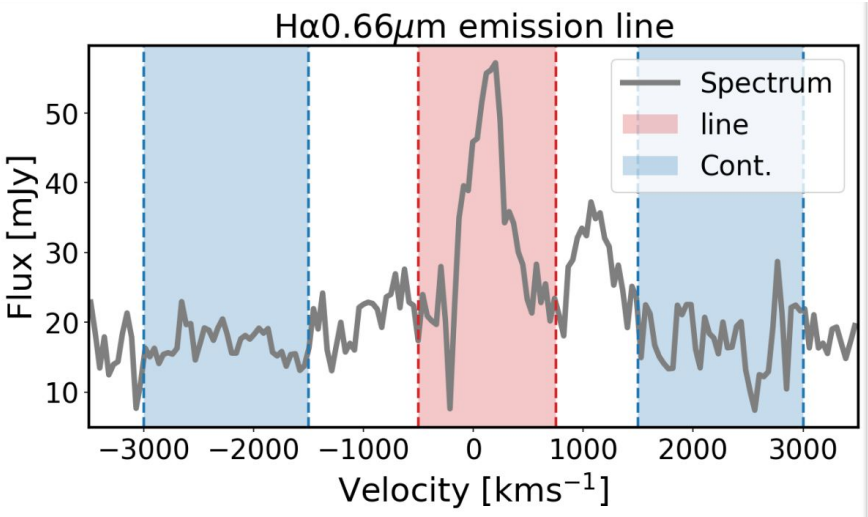
Emission line maps

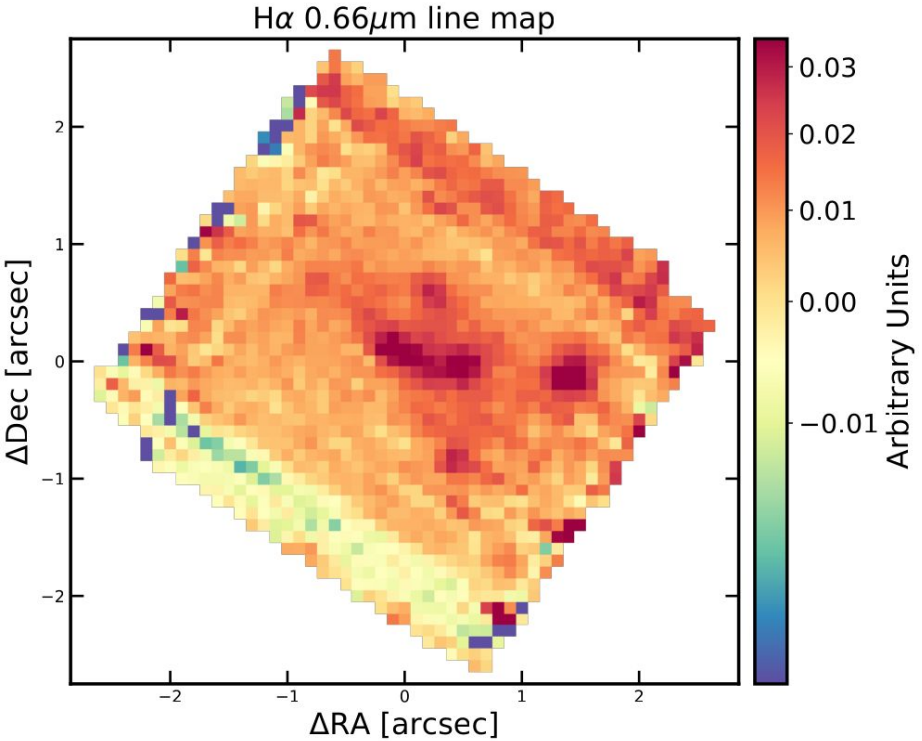




At redshift ~ 3.4805

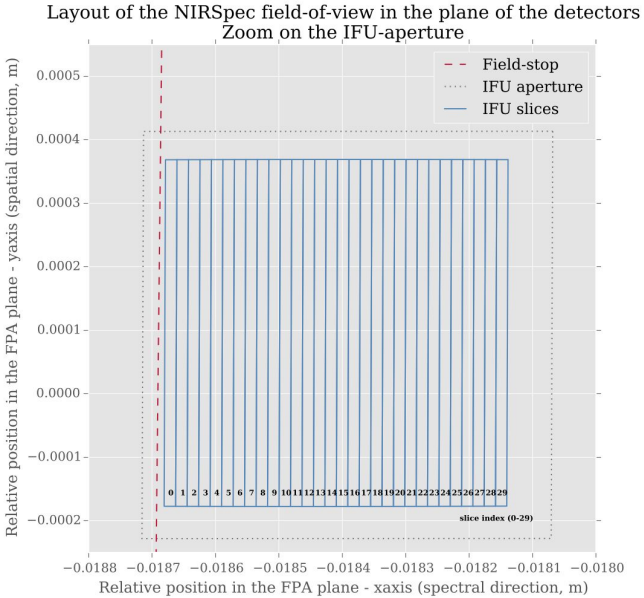
Emission line maps

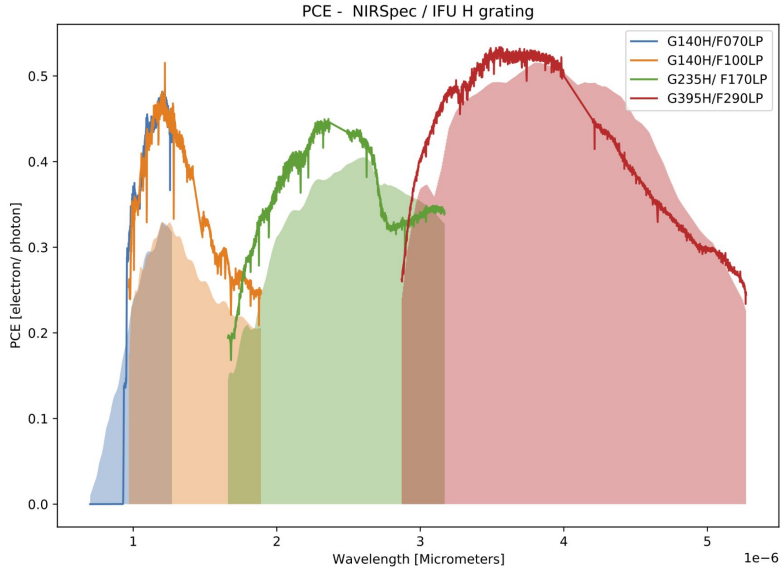




At redshift ~ 6.3425

Thank You:)


Layout of the NIRSpec field-of-view in the plane of the detectors
Zoom on the IFU-aperture
Field-stop
IFU aperture
IFU slices
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
slice index (0-29)
Relative position in the FPA plane - yaxis (spatial direction, m)
Relative position in the FPA plane - xaxis (spectral direction, m)
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
−0.0001
−0.0002
−0.0188 −0.0187 −0.0186 −0.0185 −0.0184 −0.0183 −0.0182 −0.0181 −0.0180


PCE - NIRSpec / IFU H grating
G140H/F070LP
G140H/F100LP
G235H/ F170LP
G395H/F290LP
PCE [electron/ photon]
Wavelength [Micrometers]
1e−6
0.5
0.4
0.3
0.2
0.1
0.0
1
2
3
4
5