



15827 - First-time direct imaging of newborn stars within a galactic outflow

Cycle: 27, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) NGC-6810-W	ACS/SBC	2	24-Jul-2019 14:02:00.0	yes
02	(2) NGC-6810-E	ACS/SBC	2	24-Jul-2019 14:02:00.0	yes

4 Total Orbits Used

ABSTRACT

Recent models predict that star formation can occur directly within galactic outflows, either in active or star-forming galaxies. Tentative observational evidence of such phenomenon has been recently found in an AGN and in a few MaNGA galaxies based on the observed excitation of the ionized gas in the outflow. However, we are still missing a direct detection of the continuum emission from the newborn stars. Thanks to the

unprecedented capabilities of MUSE at VLT, we have found tentative spectroscopic evidence of star formation occurring within the outflow in the nearby star-forming galaxy NGC 6810. We propose to image NGC 6810 in the FUV band with HST ACS/SBC to detect, for the first time, the direct emission from young OB stars in the outflow providing direct and conclusive evidence of this new star formation mode.

OBSERVING DESCRIPTION

We want to observe both sides of the outflow in NGC 6810 (see Fig. 1) with HST ACS/SBC in imaging mode in the F140LP filter, by making two separate exposures, one on the western side of the outflow and the other on the eastern side (as shown in Fig. 1b). At the redshift of NGC 6810 ($z = 0.00677$) the Ly α emission line is observed at a wavelength of 1223.5 Angstrom, outside the spectral range of the F140LP filter.

From VLT/MUSE data we measure an H α extinction-corrected flux for the outflowing gas (i.e. only from the Gaussian component associated to the outflow in our fits; see e.g. Fig. 1f) varying from $\sim 10^{-15}$ erg s $^{-1}$ cm $^{-2}$ arcsec $^{-2}$ in the inner regions down to $\sim 2.5 \times 10^{-17}$ erg s $^{-1}$ cm $^{-2}$ arcsec $^{-2}$ in the outer regions at $\sim 20''$. We can then estimate the expected FUV continuum emission from the young stars giving rise to such ionized gas line emission, by employing the SFR tracers from Kennicutt & Evans (2012), i.e. $\log \text{SFR} = \log L(\text{H}\alpha) - 43.55$ and $\log \text{SFR} = \log L(\text{FUV}) - 41.27$, giving $\log L(\text{FUV}) = \log L(\text{H}\alpha) + 2.08$. This gives a FUV flux in νF_ν , which corresponds to a monochromatic flux at 1500 Angstrom, after having applied dust extinction (derived from H α /H β line ratio of the outflow component), of $F_\lambda \sim 10^{-17}$ erg s $^{-1}$ cm $^{-2}$ Angstrom $^{-1}$ arcsec $^{-2}$ and $F_\lambda \sim 10^{-18}$ erg s $^{-1}$ cm $^{-2}$ Angstrom $^{-1}$ arcsec $^{-2}$ in the inner and in the outer regions of the outflow, respectively. A map of the expected observed FUV flux from the outflow is displayed in Fig. 1i, obtained from our MUSE H α and extinction maps with the procedure just described (the map represents the expected observed FUV emission from the outflow only, not also from the disk, having considered only the outflow spectral component in the H α line profiles for our calculation).

We employed the ACS imaging Exposure Time Calculator (ETC) to calculate the needed exposure time to request for SBC F140LP filter. We set a Bruzual Synthetic Stellar Spectra B1 V spectral shape of the continuum. We adopted an extinction $E(B-V) = 0.2$, average extinction in the outflow from VLT/MUSE data. We set average Earth shine and air glow and the zodiacal light value corresponding to the coordinates of NGC 6810. The estimated orbital visibility of the target, as given by the Astronomer's Proposal Tools (APT), is about 56 minutes per orbit. With the FUV fluxes estimated above we reach, in about 5400 s = 90 min (i.e. within two orbits), a S/N going from ~ 21 in the inner regions down to ~ 5 in the outer ones at $\sim 20''$ from the center, having considered an aperture of 0.5 arcsec diameter (containing about 80% of the PSF encircled energy, and corresponding to a box size of 15x15 pixel). The addition of the overheads, i.e. guide star acquisition (6 min for first-orbit acquisition, 4 min for reacquisition in subsequent orbits), instrument overheads (1.7 min for first exposure, 0.9 min for subsequent identical exposures), does not exceed two orbits (112 min).

Since we aim to carry out two observations, covering each of the two sides of the bipolar outflow of NGC 6810, as shown in Fig. 1b, we ask for a

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total of 4 orbits.

The actual observable time emerging from the Orbit Planner run in Phase 2 results to be higher than the one conservatively considered above for Phase 1, i.e. 6022 s instead of 5400 s in 2 orbits. Anyway, the S/N does not increase much and is consistent with that estimated above.

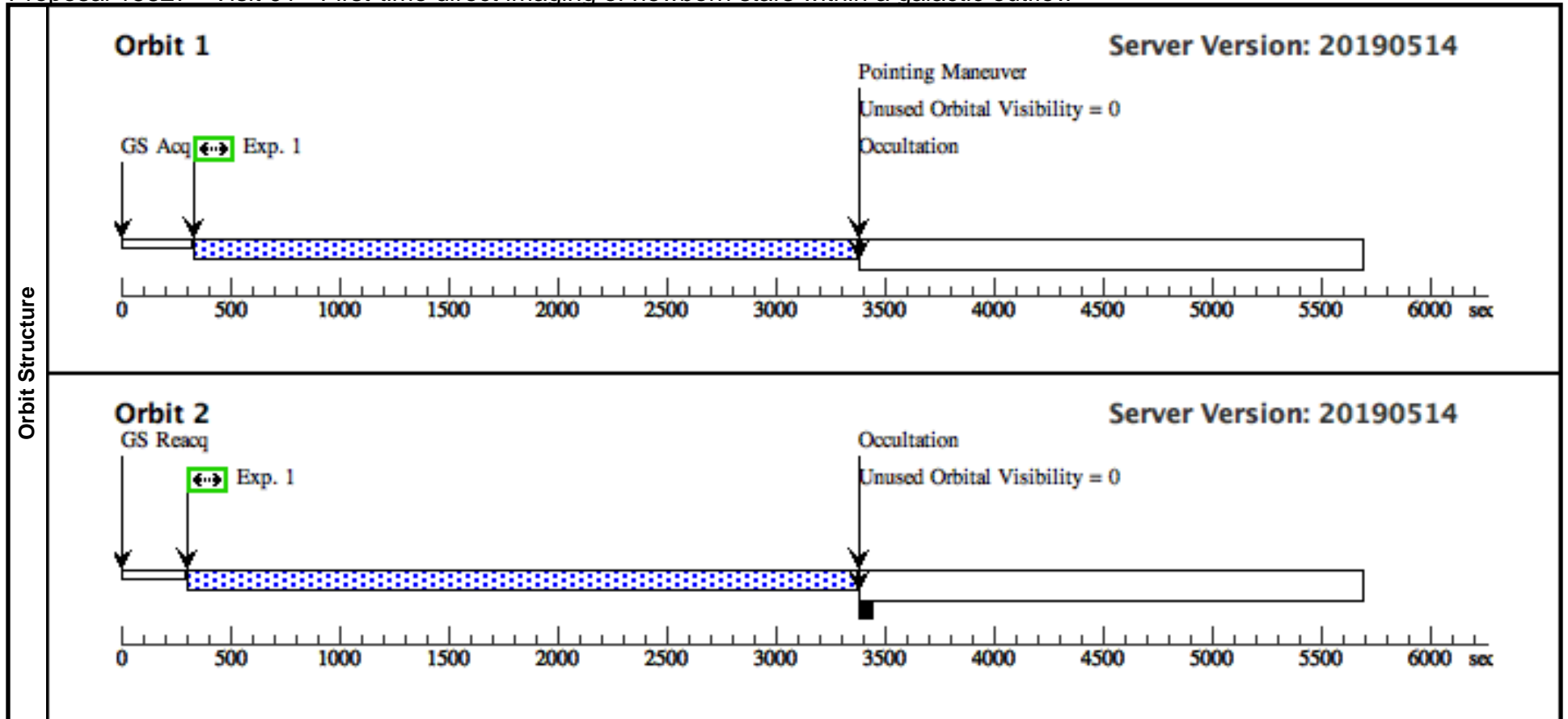
We performed a check for bright sources in the FOV of ACS/SBC, by making use of the ACS imaging Exposure Time Calculator (ETC). The brightest source in the FOV is the galaxy itself. We thus considered the emission from its central region, having a FUV AB magnitude from Galex RCS of 25.1 per arcsec² and an extinction $E(B-V) \sim 0.65$ measured from VLT/MUSE optical data. This results in $\sim 2.5 \times 10^{-4}$ counts/s/pixel, which is well below the screening limit of 50 counts/s/pixel reported in the Instrument Handbook for ACS/SBC. We exclude for our science goal the possibility of having the issue of red leak, which consists in photons from NUV and optical bands contaminating ACS/SBC observations thereby falsely boosting the FUV count rate. In fact the target of our observations is the emission from hot OB newborn stars in the outflow and observations of such stellar types are basically unaffected by red leak, which instead affects solar- and redder-type stars. Our VLT/MUSE observations show in fact no indication of optical continuum emission associated with the outflow, thus excluding the presence of sensible emission from solar- or redder-type stars, which might cause read leak. Red leak might affect the galaxy disk in principle, but this is not a problem for our goal since our interest resides in the outflow. We would simply need to subtract the underlying disk emission (modelled through an isophotal profile) to isolate the intrinsic FUV emission from young OB stars in the outflow.

If HST will end up going in Reduced Gyro Mode (RGM) our target will still be in HST field of regard, having coordinates RA=295.892703 and Dec=-58.655590 (and in the Solar Avoidance Zone as it already is in 3 gyro-mode). The increase of target acquisition time by 2 minutes (180 s) will reduce the Actual Duration of each of our subexposures within a single orbit from ~ 3000 s to ~ 2820 s, which is still a bit higher than the time estimated in phase 1 based on the S/N needed for our science goal. We then conclude that the RGM will not impact significantly on our science case.

Proposal 15827 - Visit 01 - First-time direct imaging of newborn stars within a galactic outflow

Wed Jul 24 18:02:01 GMT 2019

Visit	Proposal 15827, Visit 01 Diagnostic Status: No Diagnostics Scientific Instruments: ACS/SBC Special Requirements: PCS MODE FINE									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(1)	Pattern Type=ACS-SBC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.472 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=44.4 Angle Between Sides= Center Pattern=false					(1)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	NGC-6810-W	RA: 19 43 32.2795 (295.8844979d) Dec: -58 39 18.10 (-58.65503d) Equinox: J2000	Redshift: 0.00677	V=11.22 FUV AB mag = 25.1 arcsec ⁻² ; E(B-V)~0.65	Reference Frame: ICRS				
	<i>Comments: The V-magnitude reported above is the magnitude of the galaxy NGC 6810 from SIMBAD. The FUV AB magnitude reported above is the magnitude per arcsec² of the central, brightest region of the galaxy (being also the brightest source within at least 2x2 arcmin²), measured from Galax RCS; the extinction of this central region is E(B-V)~0.65 measured from VLT/MUSE optical data. Employing the ACS imaging ETC, this results in ~2.5x10⁻⁴ counts/s/pixel, which is well below the screening limit of 50 counts/s/pixel reported in the Instrument Handbook for ACS/SBC.</i> Category=EXT-MEDIUM Description=[BIPOLAR OUTFLOW, WIND] Extended=YES									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	West (ACS.im.13 71292)	(1) NGC-6810-W	ACS/SBC, ACCUM, SBC-FIX	F140LP			Pattern 1, Exps 1-1 in Visit 01 (1)	2700 Secs (6022 Secs) [=>2975.0 Secs (Pattern 1)] [=>3047.0 Secs (Pattern 2)]	[1] [2]



Proposal 15827 - Visit 02 - First-time direct imaging of newborn stars within a galactic outflow

Wed Jul 24 18:02:01 GMT 2019

Visit	Proposal 15827, Visit 02 Diagnostic Status: No Diagnostics Scientific Instruments: ACS/SBC Special Requirements: PCS MODE FINE										
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures		
		(1)	Pattern Type=ACS-SBC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.472 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=44.4 Angle Between Sides= Center Pattern=false							(1)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous					
	(2)	NGC-6810-E	RA: 19 43 36.2149 (295.9008954d) Dec: -58 39 21.20 (-58.65589d) Equinox: J2000	Redshift: 0.00677	V=11.22 FUV AB mag = 25.1 arcsec ⁻² ; E(B-V)~0.65	Reference Frame: ICRS					
	<i>Comments: The V-magnitude reported above is the magnitude of the galaxy NGC 6810 from SIMBAD. The FUV AB magnitude reported above is the magnitude per arcsec² of the central, brightest region of the galaxy (being also the brightest source within at least 2x2 arcmin²), measured from Galax RCS; the extinction of this central region is E(B-V)~0.65 measured from VLT/MUSE optical data. Employing the ACS imaging ETC, this results in ~2.5x10⁻⁴ counts/s/pixel, which is well below the screening limit of 50 counts/s/pixel reported in the Instrument Handbook for ACS/SBC.</i> Category=EXT-MEDIUM Description=[BIPOLAR OUTFLOW, WIND] Extended=YES										
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]		Orbit
	1	East (ACS.im.13 71292)	(2) NGC-6810-E	ACS/SBC, ACCUM, SBC-FIX	F140LP			Pattern 1, Exps 1-1 in Visit 02 (1)	2700 Secs (6022 Secs)		
									[=>2975.0 Secs (Pattern 1)]	[1]	
									[=>3047.0 Secs (Pattern 2)]	[2]	

