A Narrow-Band Hα survey of massive distant clusters

We propose to observe massive galaxy clusters homogeneously selected through the thermal Sunyaev-Zel'dovich effect with the Atacama Cosmology Telescope (Hilton et al. 2021, ApJS, 253, 3) and with spectroscopic redshifts such that the Hα line coincides with the wavelengths of the NB1066 and NB118 filters, i.e., z = 0.62 and z = 0.81. This Science Verification program will serve as a benchmark for a 2024A 2-night approved program, allowing us to determine the optimal observing strategy for it. The program includes 17 and 7 clusters with spectroscopic redshifts where Hα falls within the FWHM of each filter, respectively. In order to isolate the Hα flux we will also perform observations in the *J* band.

The largest existing Hα survey in clusters is that of Stroe et al. (2017, MNRAS, 465, 2916), who observed 19 clusters over z=0.15-0.30, and found indications that mergers trigger star formation due to interactions between gas-rich galaxies (which are more common in 'young', i.e. dynamically-disturbed, clusters) as well as ICM shocks. However they could not draw robust conclusions due to the limited number of clusters and the complicated cluster sample definition. Our proposal remedies both aspects: accompanied by a lower-redshift DECam survey we will target, over the next few semesters, 66 clusters covering z=0.47-0.81 with a well-defined selection function. Our program will offer a unique view of the evolution of AGN activity and star formation in massive galaxy clusters. The NEWFIRM science verification program is critical for the success of this program.

Observing strategy

We aim to reach a specific star formation rate (sSFR = SFR/M*) limit of 10^{-11} yr^{-1}, corresponding to the typical threshold used to separate star-forming and quiescent galaxies. In order to derive the corresponding Hα flux we assume the Kennicutt (1998, ARA&A, 36, 189) relation, and we aim at a 3σ detection significance at the threshold sSFR. Scaling from the exposure time and depth of the NB1066 observations by Harish et al. (2020, ApJ, 892, 30) implies a narrow-band exposure time of 41 minutes per cluster. Assuming a standard 50% overhead for NIR observations, we require 62 minutes per cluster with NB1066. Similar considerations for the z = 0.81 clusters lead us to request 156 min per cluster, including overheads, with the NB118 filter.

We also scale the NEWFIRM *J* band observations of Ly et al. (2011. ApJ, 726, 109) needed to determine the Hα continuum emission. In order to be able to confidently (i.e., at 3σ) isolate galaxies with significant Hα line emission using the criteria of Harish et al. (2020), we require 19 minutes of exposure per cluster in the *J* band. With an assumed 50% overhead, this results in a total observing time of 29 minutes per cluster.

For this SV run we propose to observe three low-z and one high-z targets visible during January, as listed in the Table. We request a total of 3x62 + 156 + 4x29 = 458 min or 7.6 hours.

Our proposed targets are all observable during the second halves of the nights of Jan 22-25:

Name	**RA**	**Dec**	**NB Filter**
ACT-CL J1038.7+0236	10:38:46.0	+02:36:51	NB1066
ACT-CL J1104.5+1110	11:04:32.8	+11:10:51	NB1066
ACT-CL J1110.3+0143	11:10:22.9	+01:43:40	NB1066
ACT-CL J0952.7+1850	09:52:47.4	+18:50:42	NB118