Stellar populations of tidal streams in the local Universe

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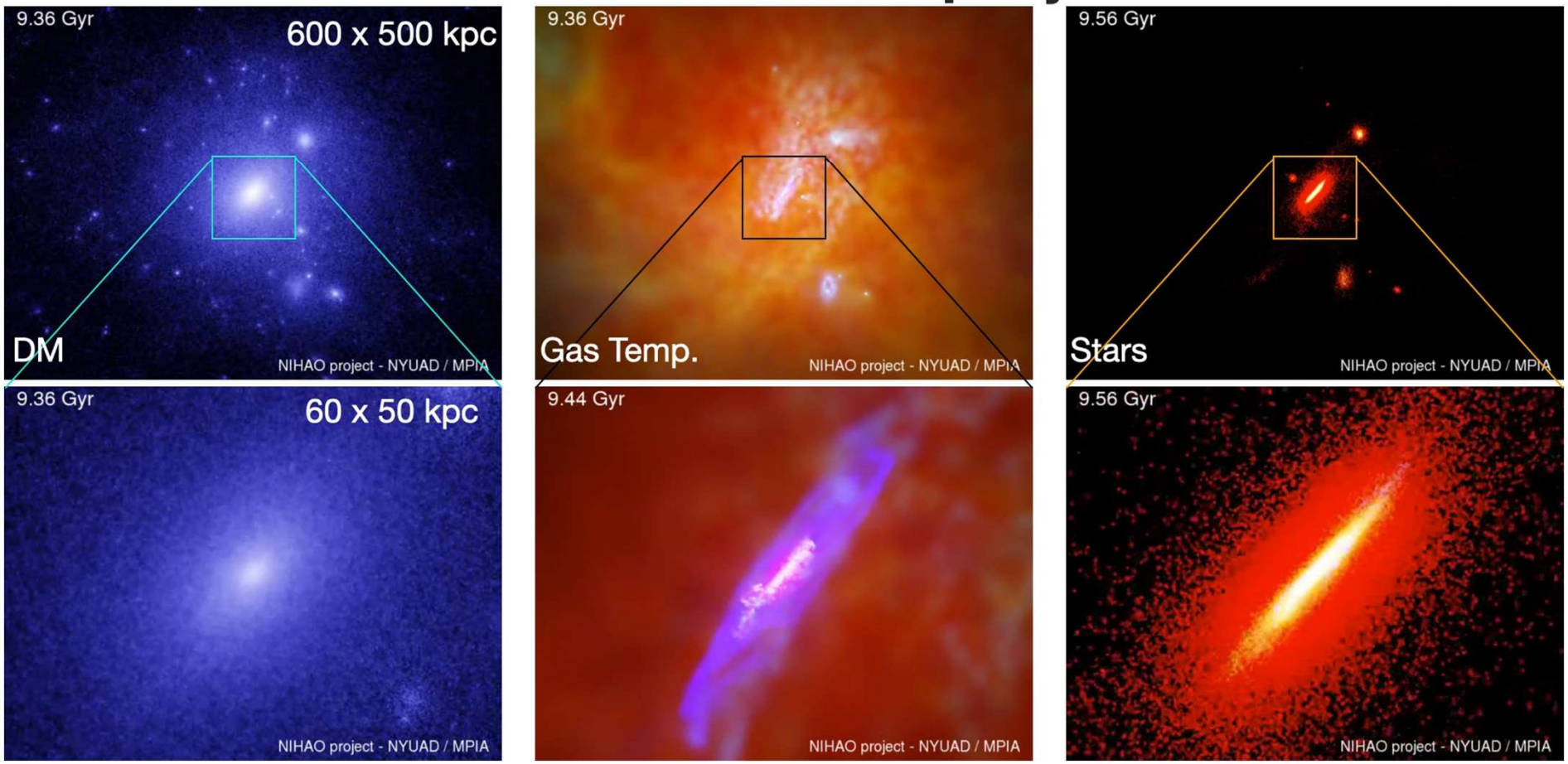
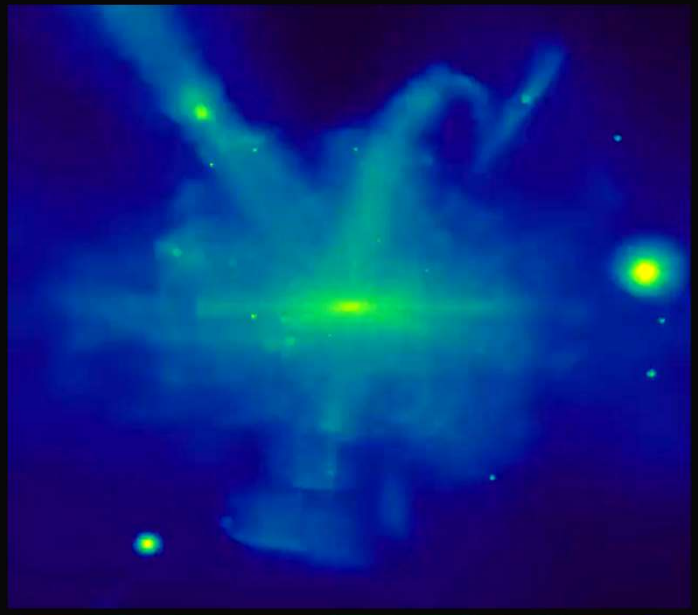
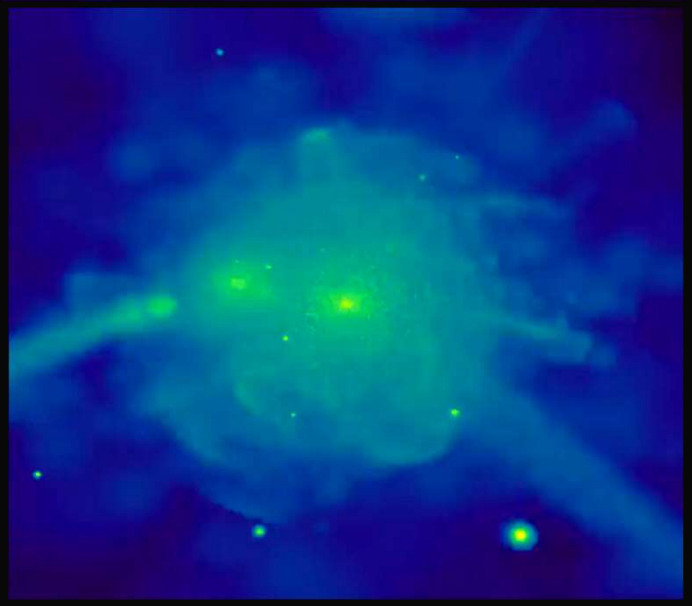
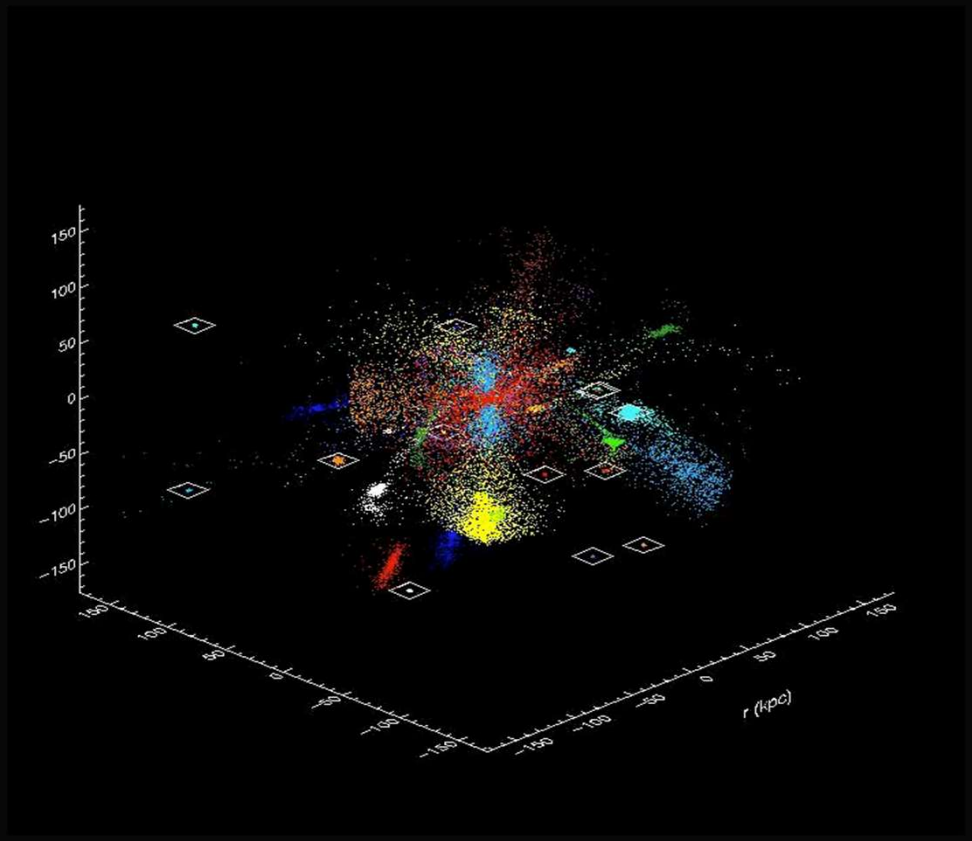
Formation of a simulated MW analogue in the NIHAO-UHD project Buck+2019, Buck+2020



GALACTIC ARCHAEOLOGY



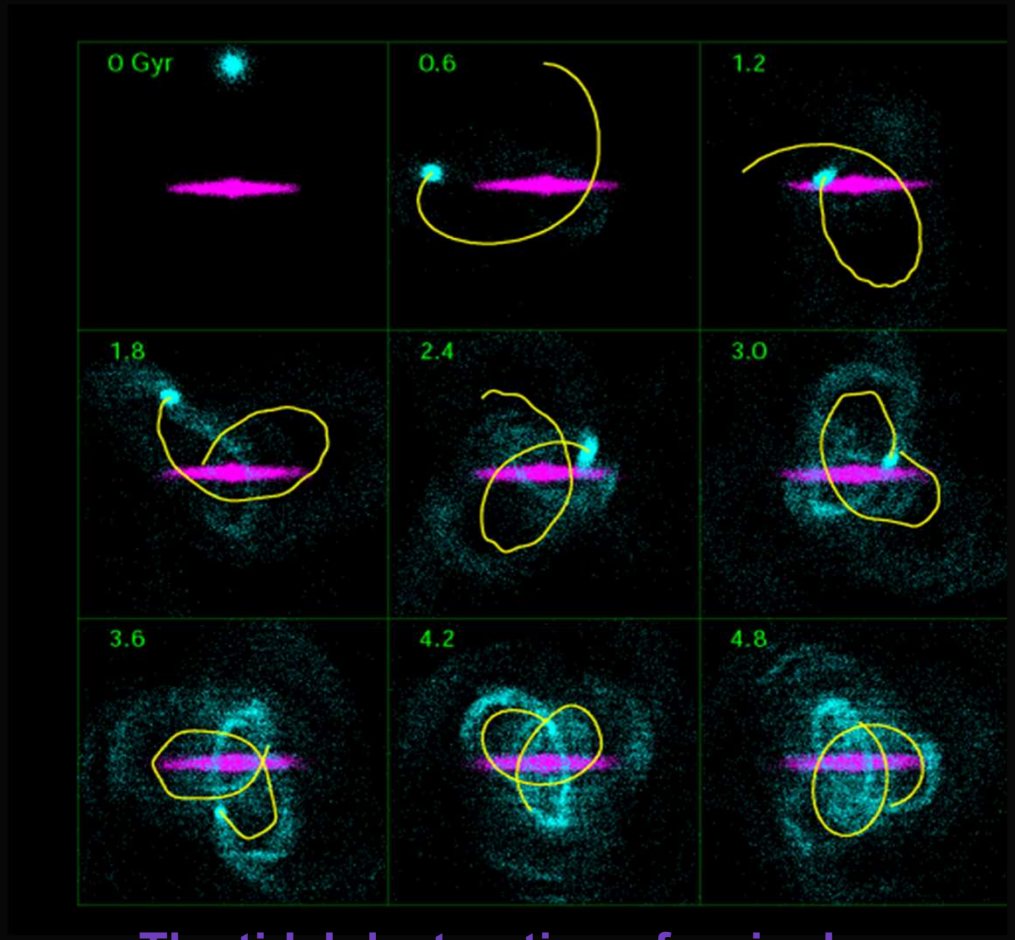




The fossils from the accretion of hundreds of dwarf galaxies should be still detectable in halos of nearby spiral galaxias.

Bullock & Johnston 2005

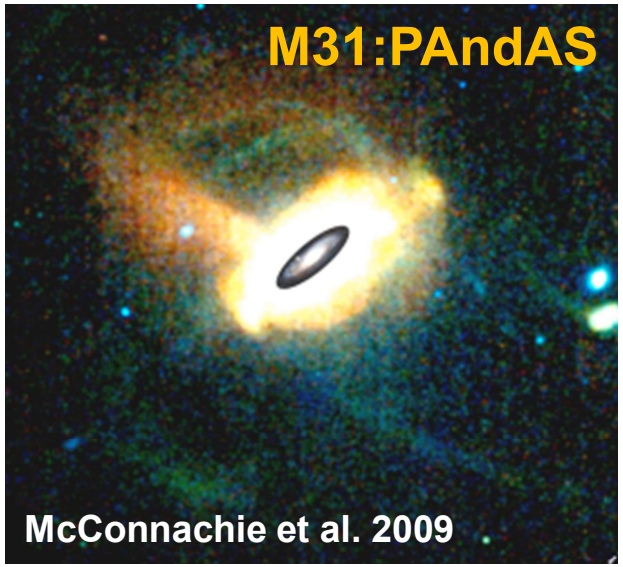
A Field Guide for Tidal Stream Hunting

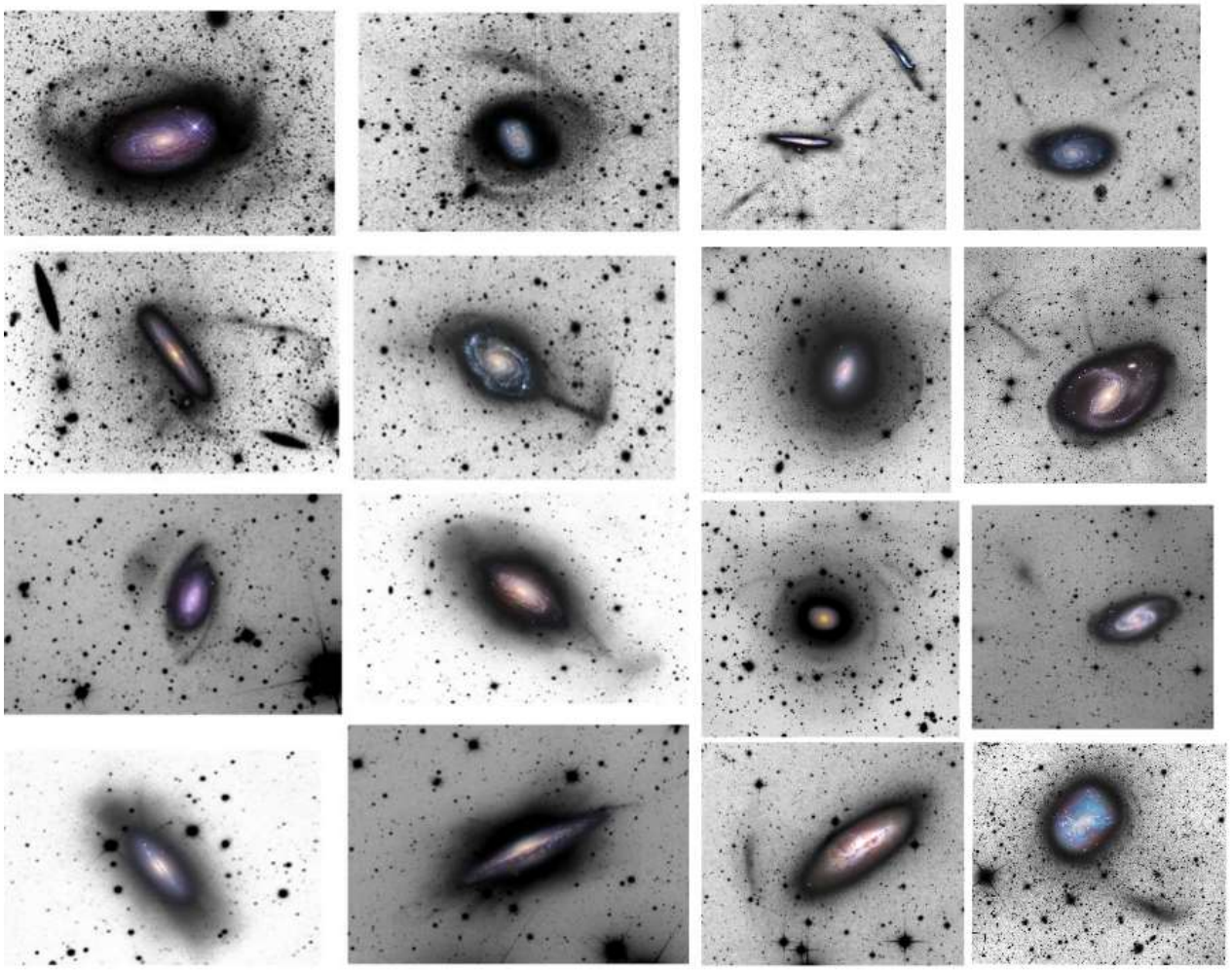


The tidal destruction of a single satellite in the halo of a spiral galaxy is enough to produce a giant and complex debris in a few Gyrs, with typical merger ratio 1:50 -1:100

- Streams are really faint stuff: few brighter than 28 mag/arcsec^2; typical SB~ 30 mag/arcsec^2
- All MW-like galaxies should show tidal debris in their outskirts if you go deep enough
- How many disruption events still exist as recognizable tidal streams around nearby spiral galaxies? At what rate are new stellar streams being formed in the local Universe? Is the abundance of streams in the Local Group typical or exceptional in the context of cosmological models?

Stellar Tidal Stream Survey



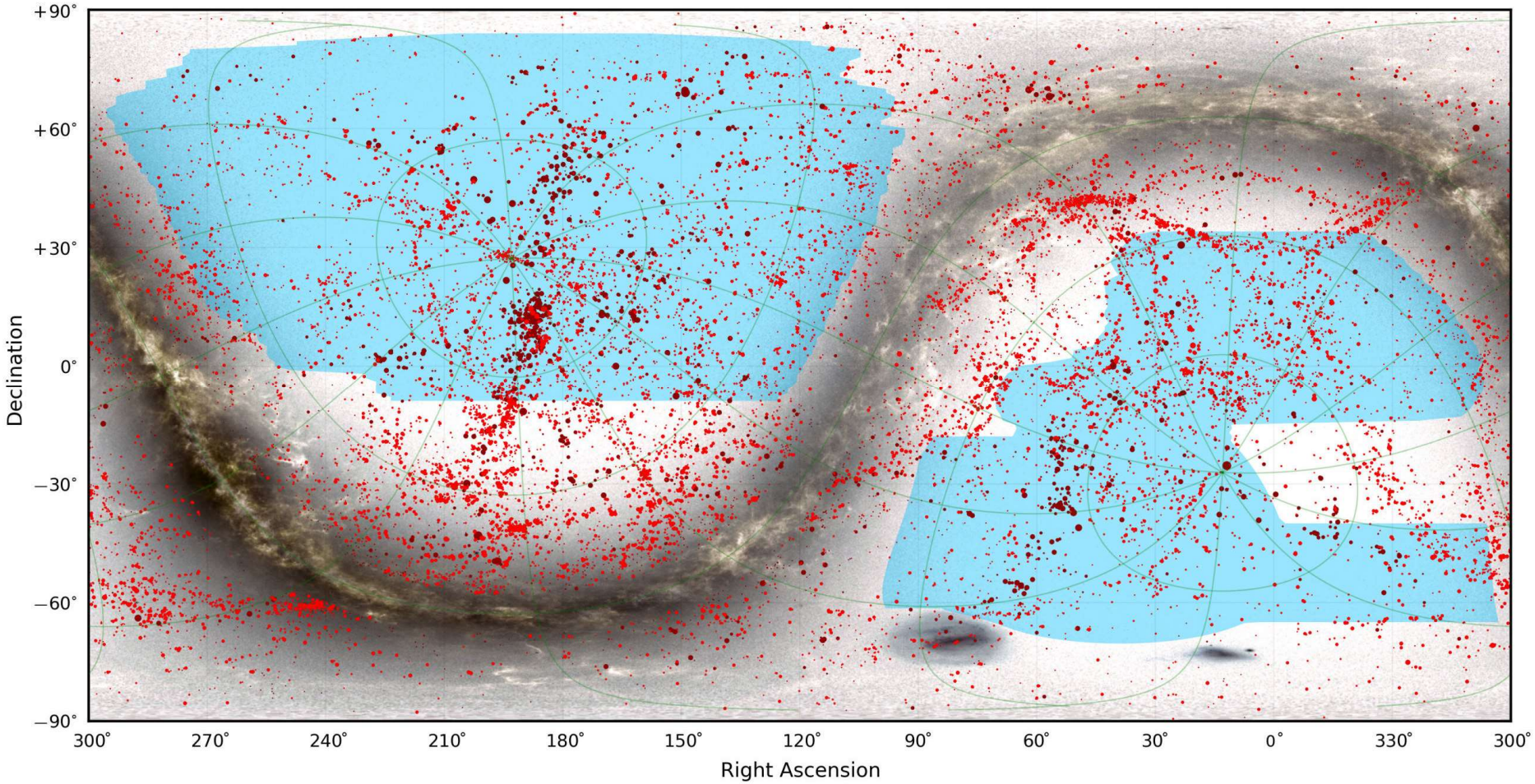


Streams detected as diffuse light structures around nearby spirals beyond the LG with a luminance filter (no colors) and amateur telescopes (0.10-0.50m)

2005: 3 stellar known streams
2018: 30-40 stellar streams

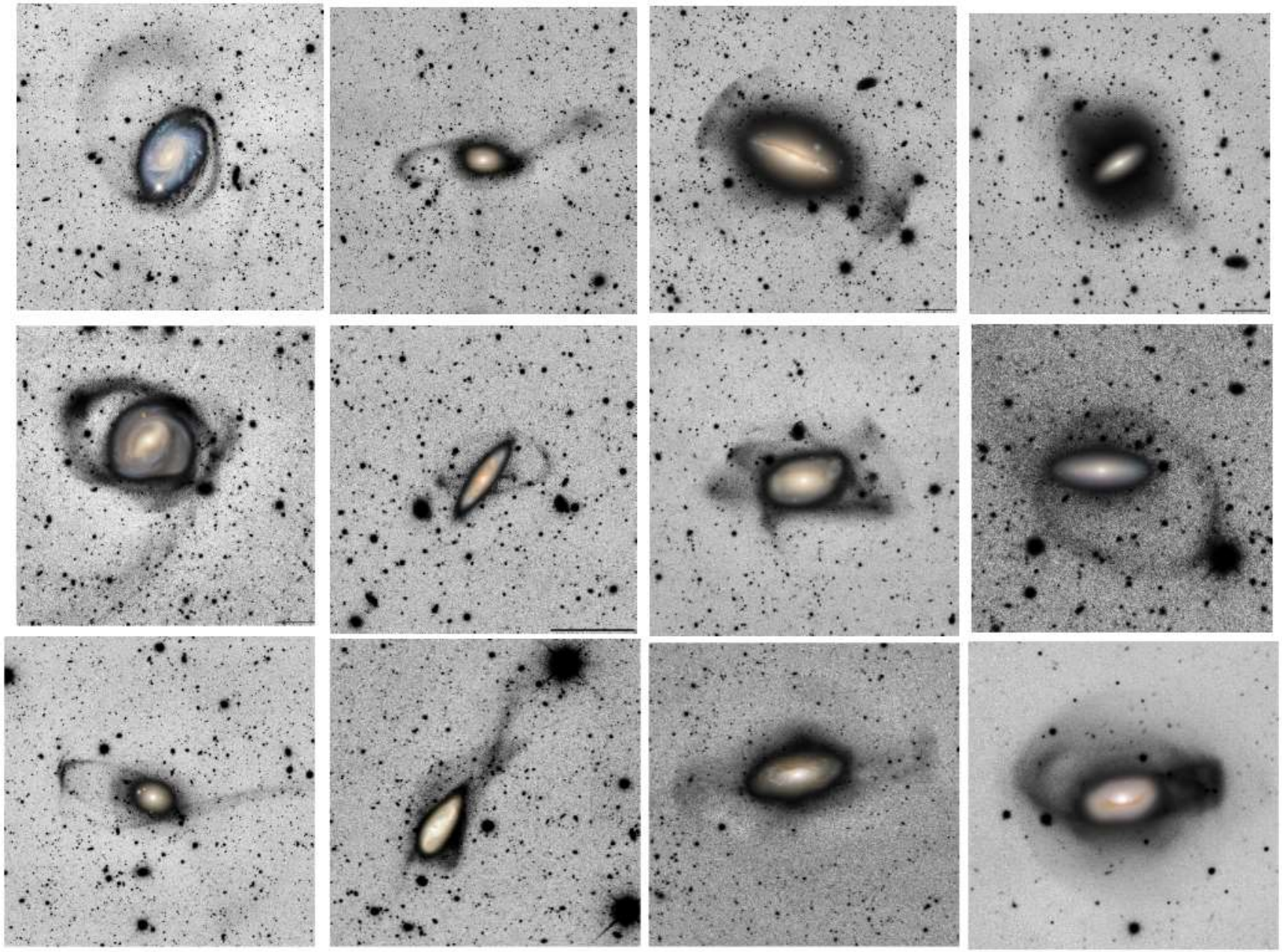
Martinez-Delgado et al. 2008, 2010 ,2012, 2015, 2021

Stellar Streams in the DESI Legacy imaging surveys



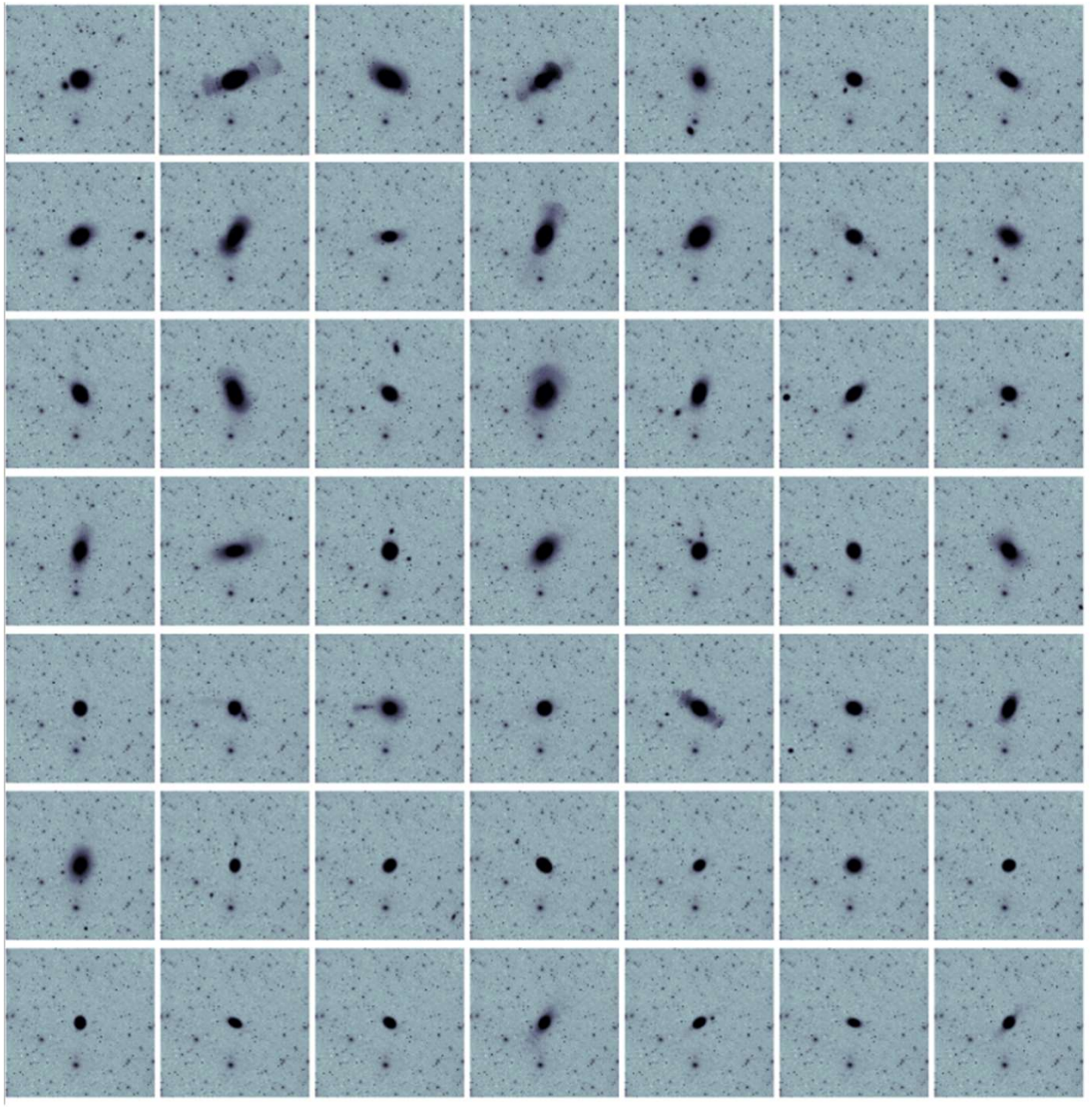
A sample of 3200 Milky Way-like galaxies (with z<0.02) with deep imaging (~29 magn/arcsec^2) available in the DESI Imaging survey

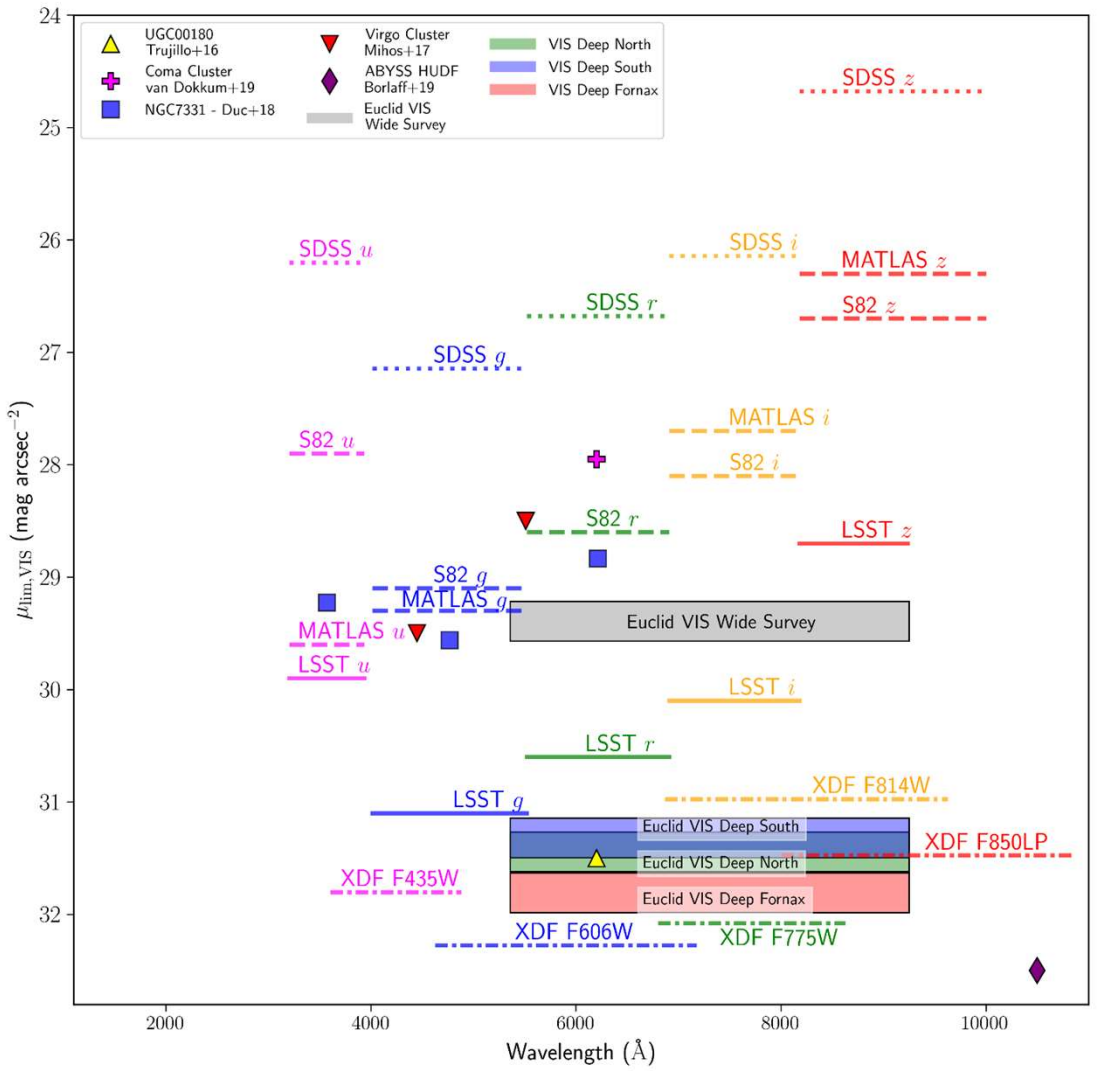
Martínez-Delgado et al. 2021 (arXiv: 2104.06071)

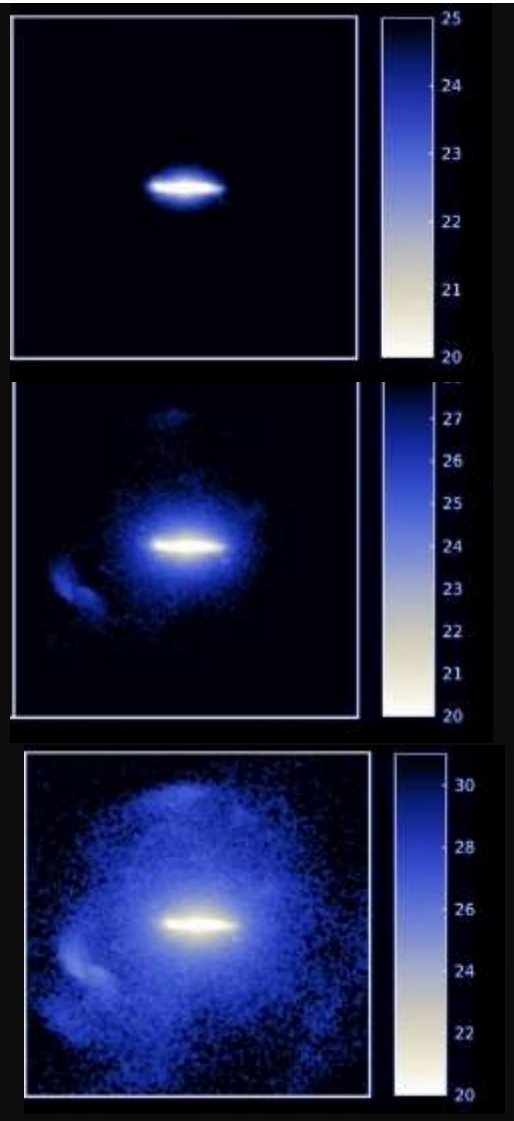


Martinez-Delgado et al. 2021;arXiv:2104.06071

A first sample of ~ 400 stellar tidal streams with broad-band photometry (g,r,z) and morphological types







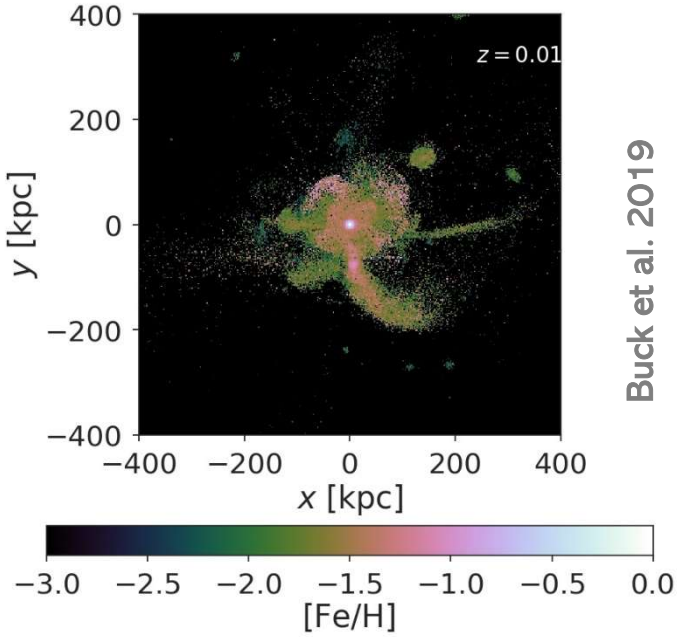
Borlaff et al. 2021

High Latitude Surveys (HLS) and Targered Surveys (TS) will provide observations of tidal streams from our sample in four near-infrared bands (Y, J, H, F184)

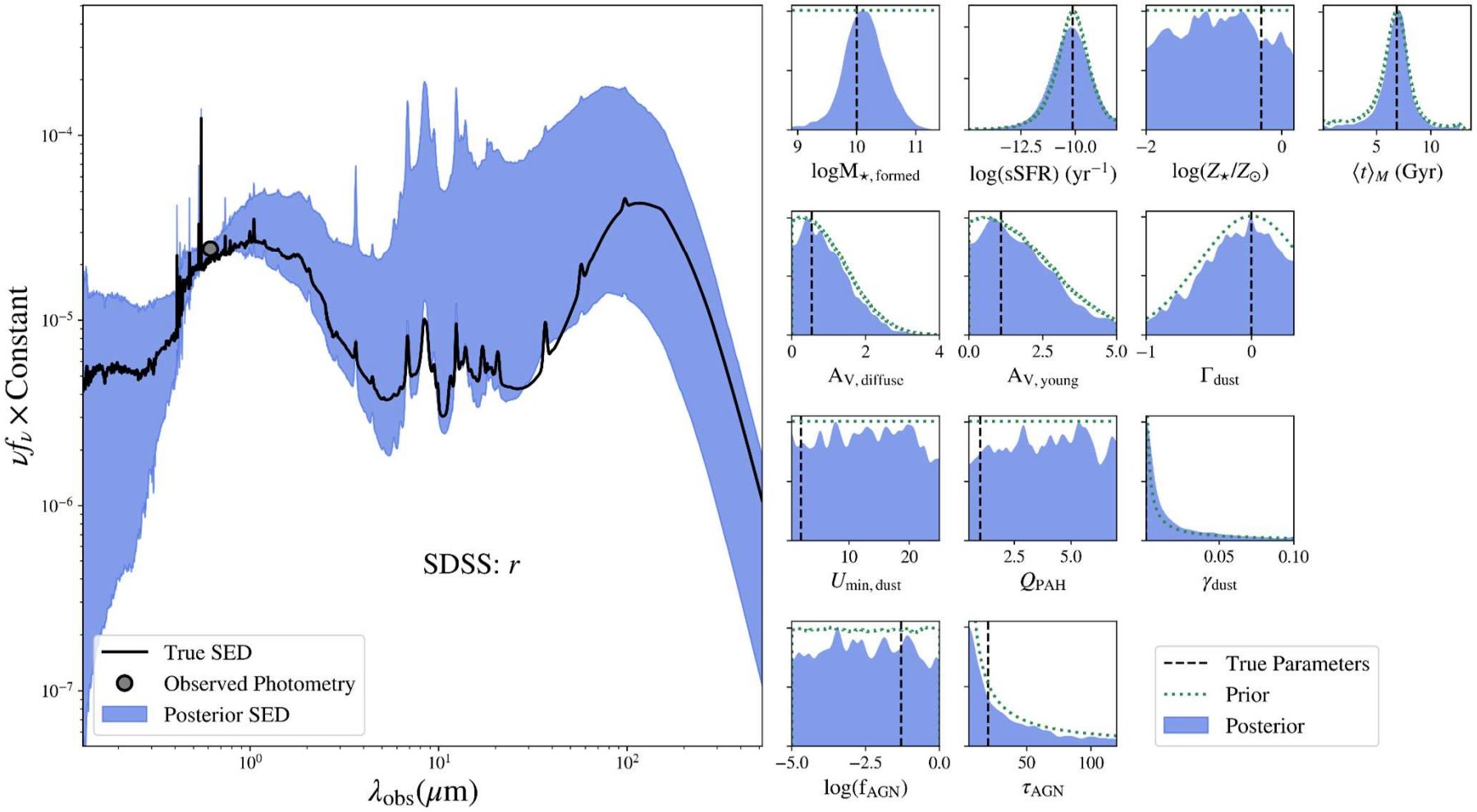
What can we constrain in extra-galactic stellar streams with Roman Telescope observations?

- **What is the mass spectrum of recent accretion events that contribute to the stellar halos of Milky Way-like galaxies?**

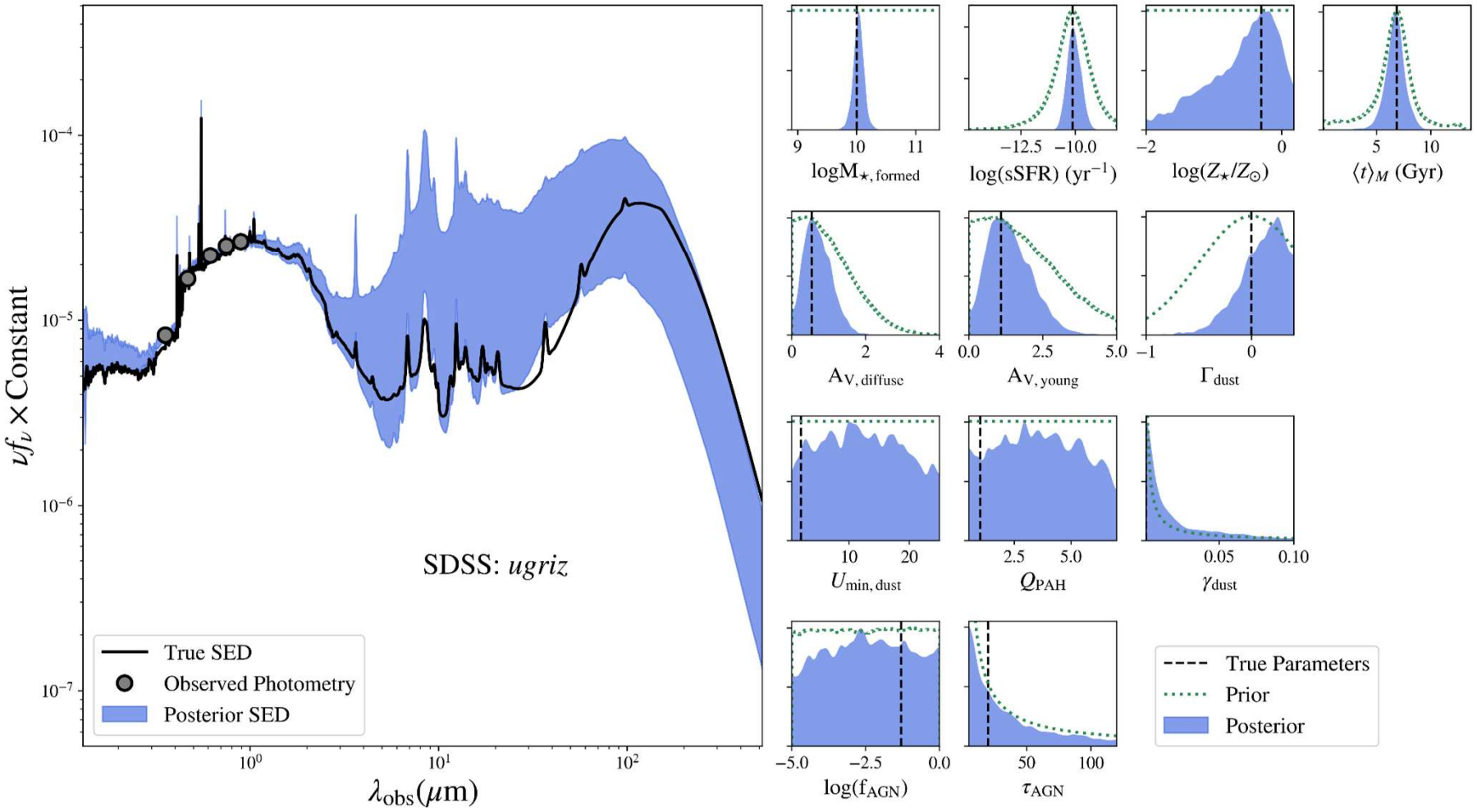
- **Is it possible to constrain the fraction of halo stars attributable to distinct tidal structures?**



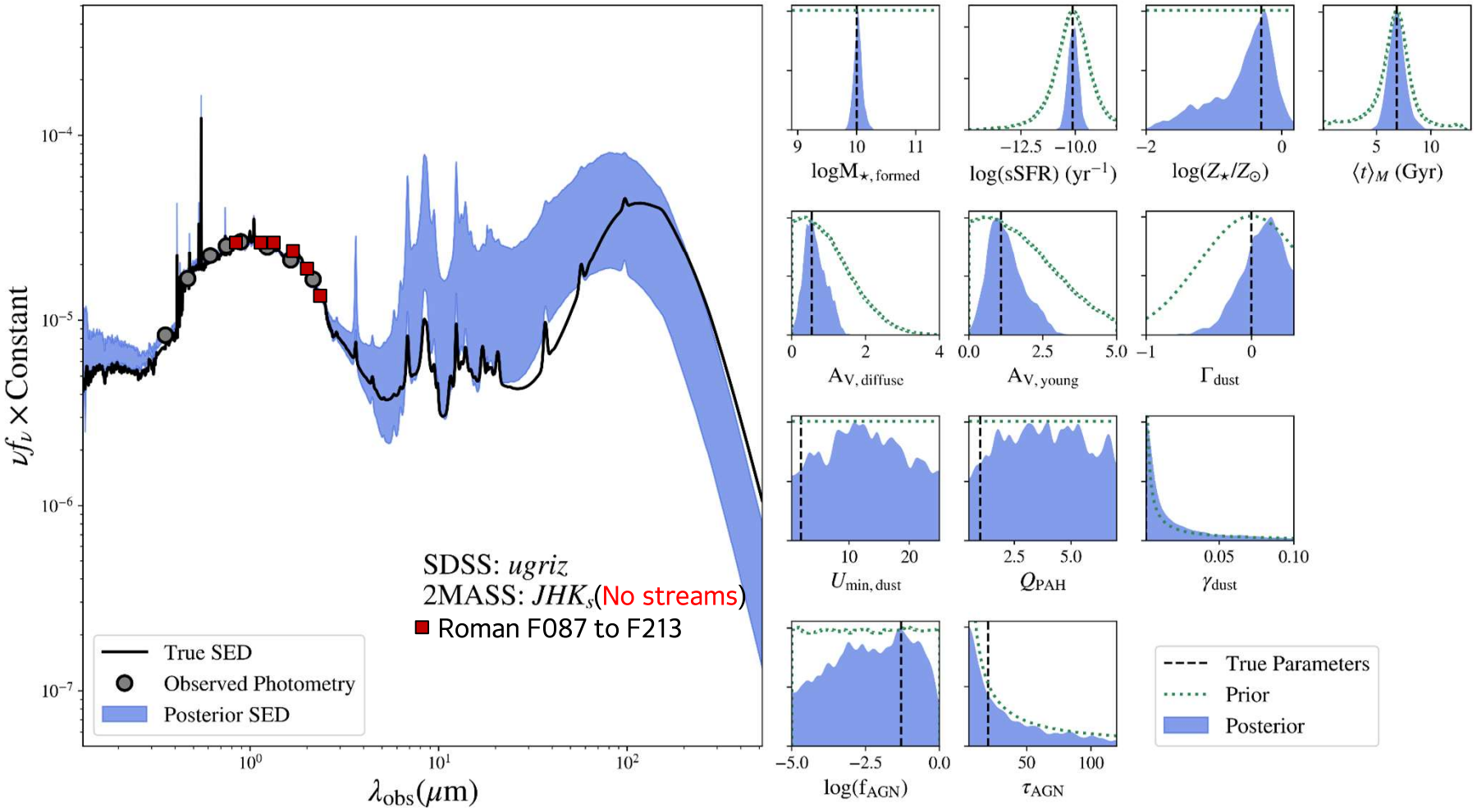
Spectroscopy of extragalactic streams (>26 mag/arcsec^2) is not feasible yet, so tentative contraints on their stellar masses and stellar population (e.g. metallicity) can only obtained by SED fitting combining our optical data with new near-infrared photometry in the Roman bands.



Stellar Stream Survey: one-band SED fitting

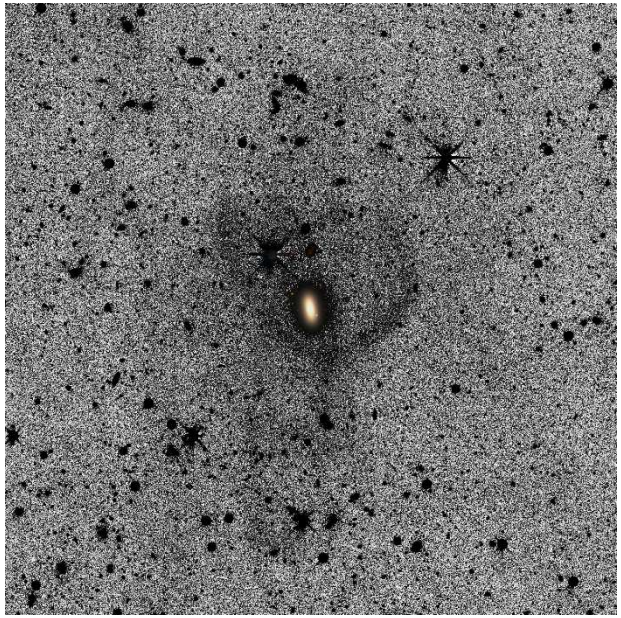


DESI Imaging Legacy Surveys: three-band SED fitting (g,r,z)



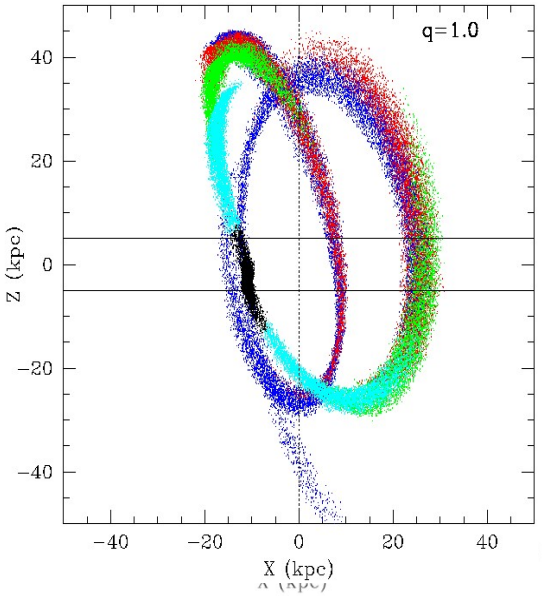
DESI Imaging Legacy Surveys + Roman: six-band SED fitting (g,r,z)

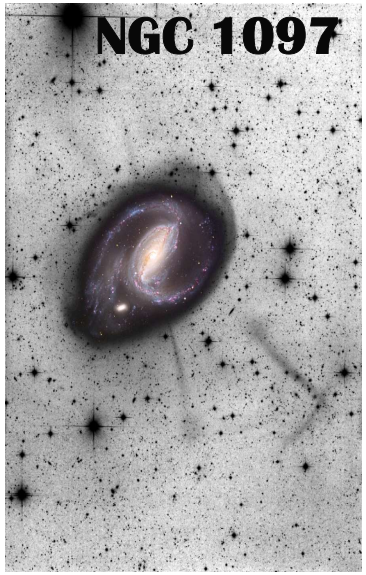
Stellar population gradients in tidal streams

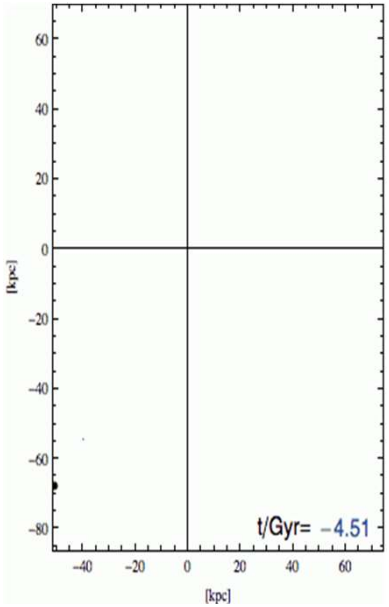


Stellar streams are excellent laboratories to explore the effect of the orbit and the tidal interaction on the SFH of the progenitor satellites. (e.g. though comparison with N-body simulations)

Kinematic information of LSB stream pieces (26-27 magn/arcsec^2) is not available: **only sky-projected path of the stream available.**







Amorisco, Martínez-Delgado et al. 2015

Enhanced star formation in a dwarf by tidal interaction

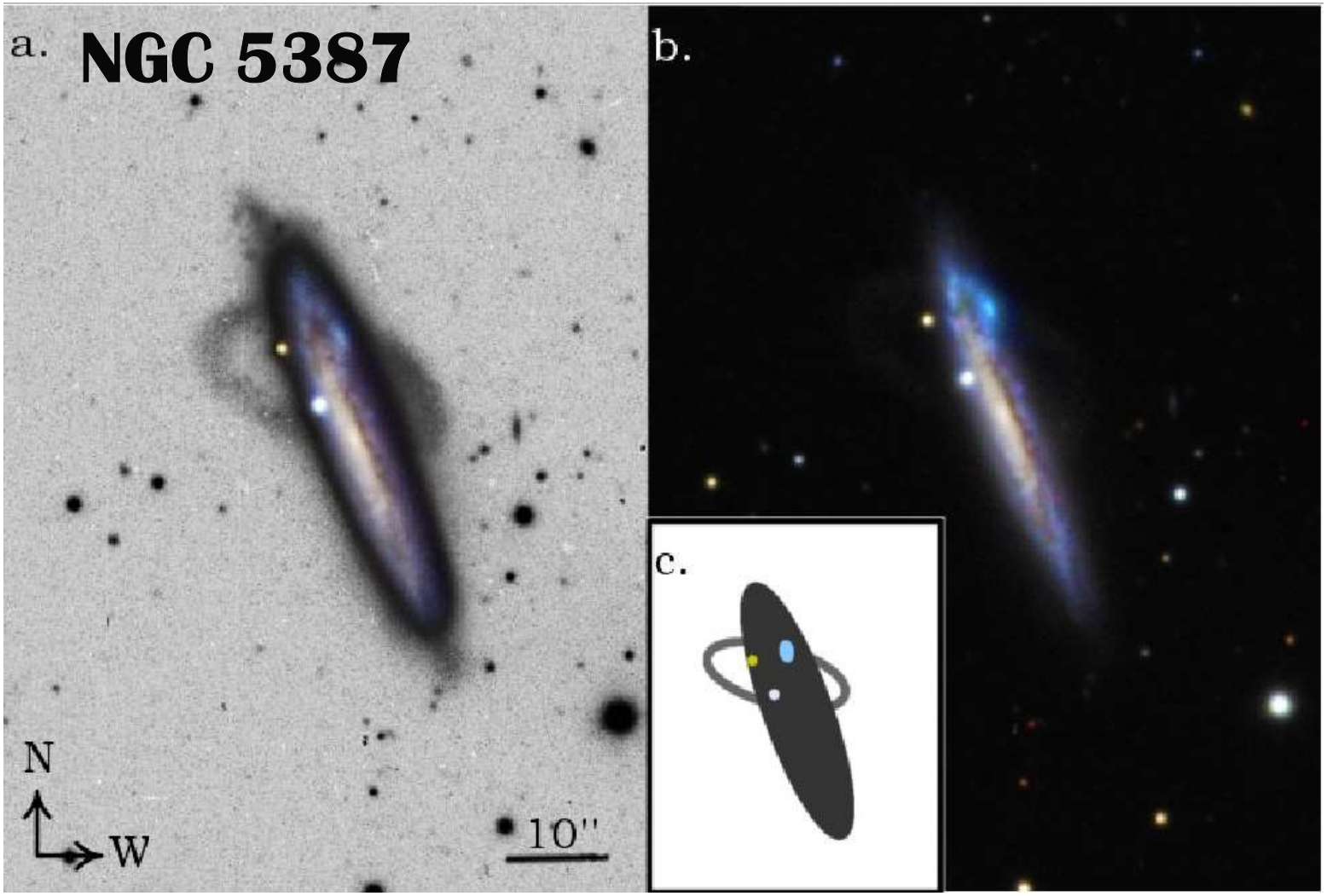
Can a stellar stream enduced star formation when it crosses the disk of its host? The case of the NGC 5387 stream.

Beaton, Martínez-Delgado et al. 2014

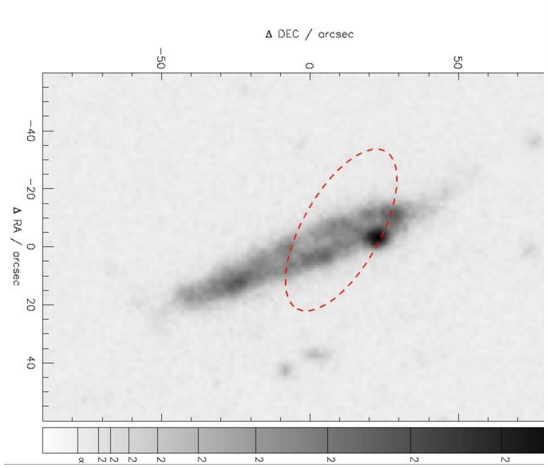
Can a dwarf progenitor of a stellar stream undergoing a period of enhanced SF due to the tidal interaction with its host?

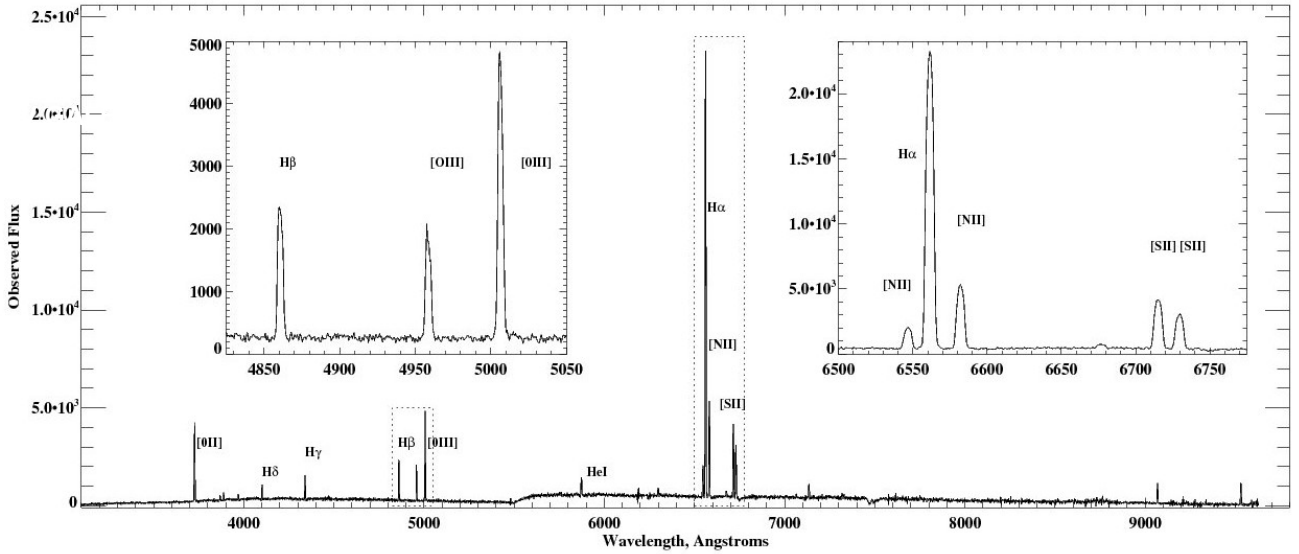
Martínez-Delgado et al. 2021

Induced star formation in the disk by a stellar tidal stream?



A "normal" spiral galaxy ($M=1.8\times10^{11}$ M_o; $M_{HI}/M_*=0.53$)), smaller than the MW at 70 Mpc with a "great circle" stellar tidal stream (m1:m2= 1:50; $M_*=6\times10^8$ M_o)





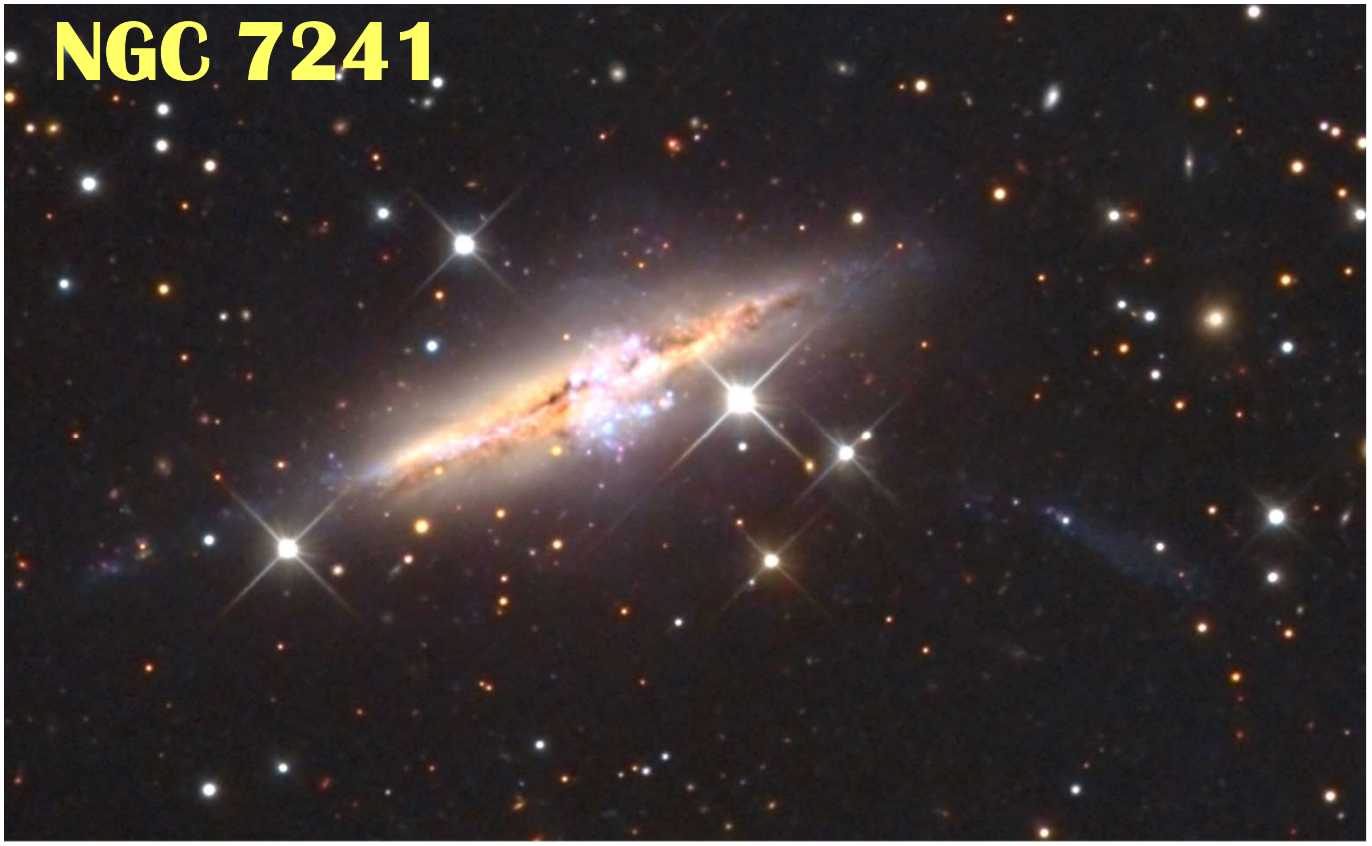
SPECTROSCOPIC PROPERTIES OF THE NGC 5387 SYSTEM

Property	NGC 5387 Total	Blue Overdensity $E(B-V)-0.03$	Blue Overdensity $E(B-V)-0.35$
v_{los}	5226 km ± 3 kms^{-1}	5331 ± 2 kms^{-1}	5331 ± 2 kms^{-1}
M_*	3×10^{10} $M_\odot$ (1)		2×10^{7} $M_\odot$
$12+\log(O/H)$	9.05 (2)	8.04	8.03
Age	...	8 Myr	8 Myr
$L(H\alpha)$	...	9.97×10^{40} ergs s^{-1}	2.24×10^{41} ergs s^{-1}
SFR $L(H\alpha)$	0.22 $M_\odot$ yr^{-1} (3)	0.53 $M_\odot$ yr^{-1}	1.19 $M_\odot$ yr^{-1}
L(FUV)	...	3.0×10^{26} ergs s^{-1}	1.95×10^{28} ergs s^{-1}
SFR L(FUV)	...	0.04 $M_\odot$ yr^{-1}	2.72 $M_\odot$ yr^{-1}
N_{LyC}	...	7.83×10^{52} photons	1.35×10^{53} photons

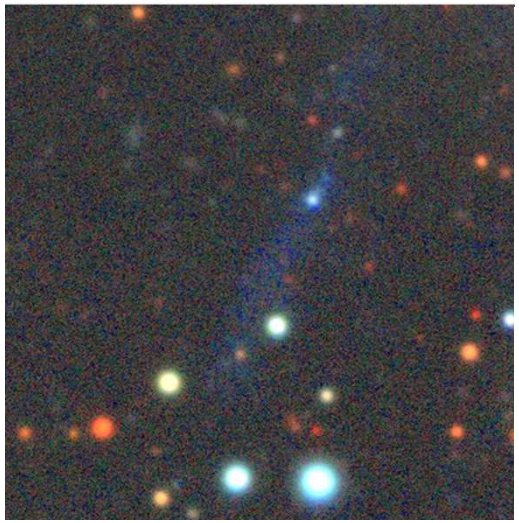
References: (1) Kauffmann et al. (2003), (2) Tremonti et al. (2004), (3) Brinchmann et al. (2004) for the central region only

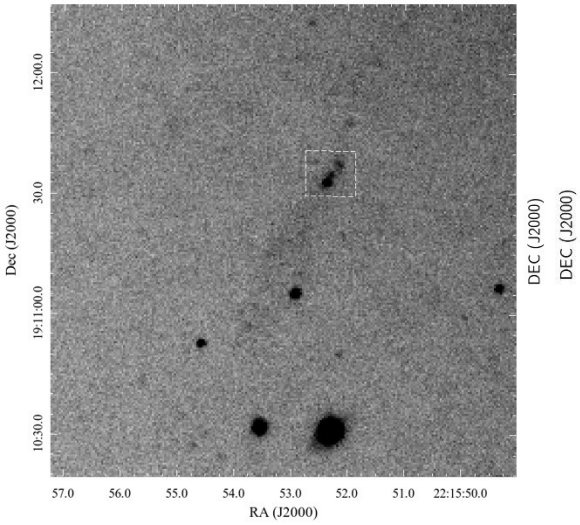
Blue blob properties: young stellar population (10 Myr), metal poor and forming star at enhanced rate (1-3 M_o year $^{-1}$) for its stellar mass (2 10^7 M_o; *Starburst 99 model*).

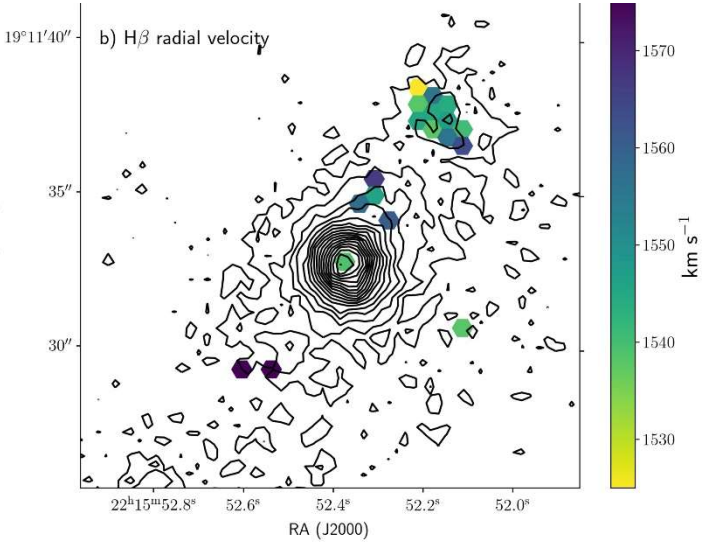
L(Hα) is equivalent to 54 x 30 Doradus (LMC) regions!



A blue stream in NGC 7241: evidence of induced star formation in the progenitor of a stream from MOS spectroscopy with MEGARA@GTC 10.4m







Martinez-Delgado et al. 2021; Leaman et al. 2015

CONCLUSIONS

Diffuse light detection of streams in nearby spiral galaxies by means of optical deep imaging (SB_{limit} ~28.5-29 magn/arcsec$^{2)}$ This Sb_{limit} only allows to detect the most massive streams in the 15-20% of galaxies, but still in agreement with preliminary ΛCDM preditions.

The Roman Telescope infrared photometry will provide important insights on the stellar masses, stellar populations and possible episodes of enhanced star formation in the stream progenitors (e.g. related to their orbits or their tidal interaction with the hosts).

Our study will complement and expand on resolved stellar population studies of these minor merger events in the Local Group. We also plan to compare our observations to the predictions of cosmological models of galactic halo formation