The SAGA Survey for Dwarf Satellites around Milky Way Analog Galaxies

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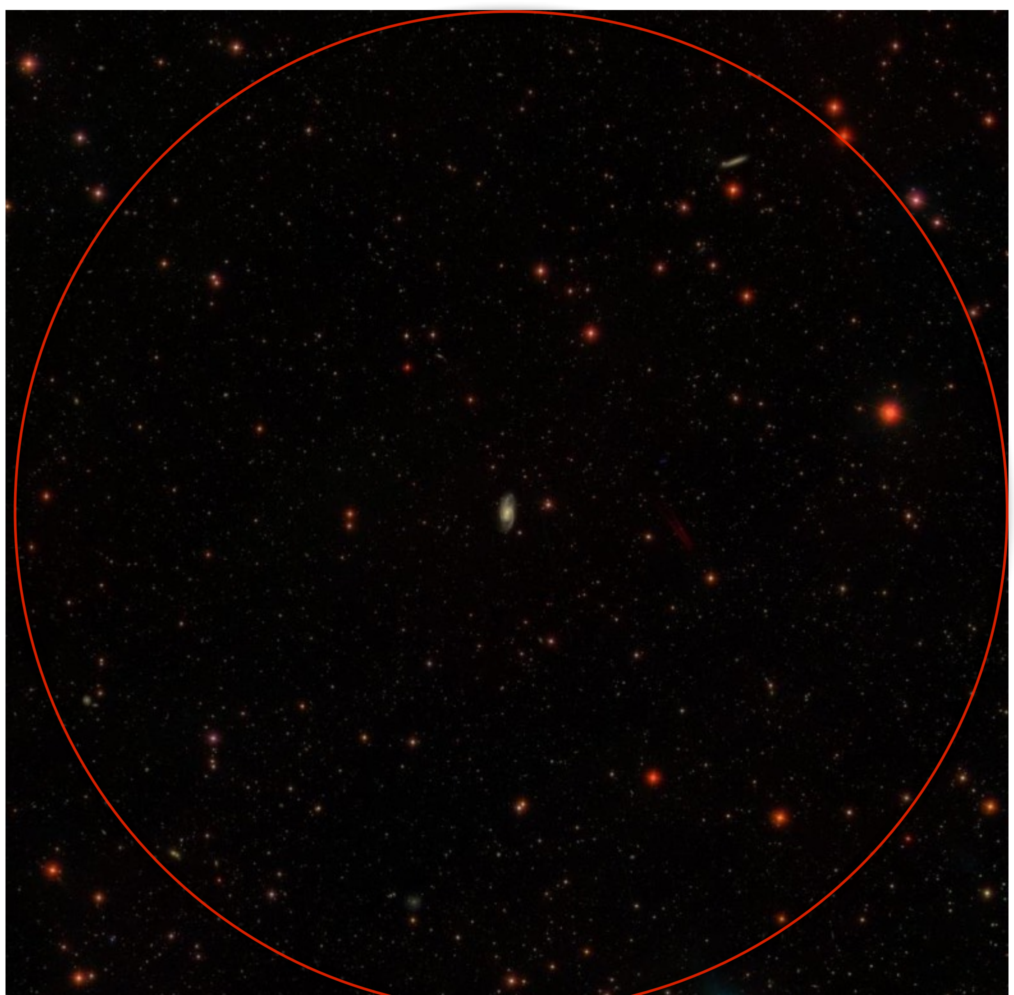
1 degree field



SAGA: Satellites Around Galactic Analogs, is a survey for spectroscopic redshifts of dwarf satellites around ~100 galaxies similar in mass to the Milky Way, mostly NGC-like galaxies at D ~ 25-35 Mpc.

SAGA Paper I: M. Geha et al 2017: fields of 8 central galaxies
Paper II: Y-Y. Mao et al 2021: 35 centrals
Paper III: Y.-Y. Mao et al 2024: 101 centrals, 378 satellites
Paper IV: M. Geha et al 2024: satellite SFR distributions

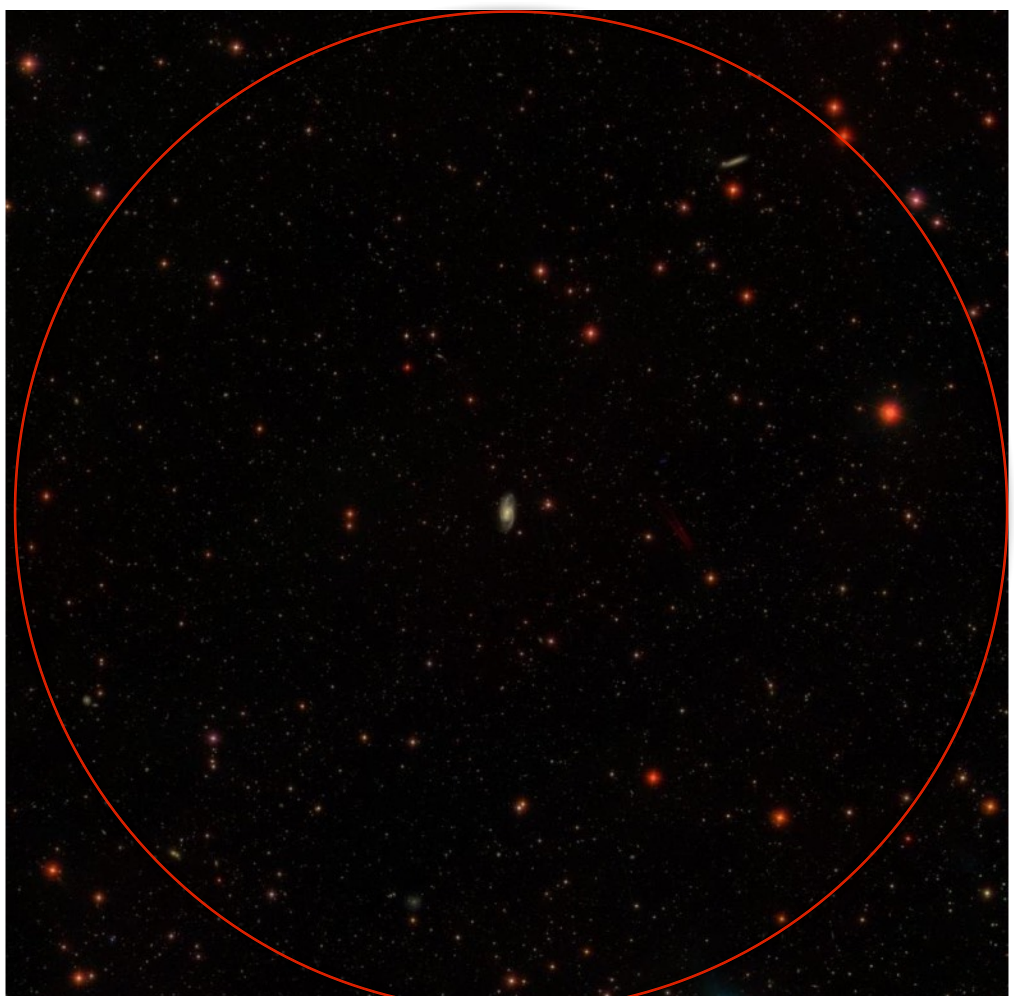
SAGA's goal is to find dwarf satellites around nearby galaxies of similar mass to the Milky Way and confirm them with spectroscopy.

We select central galaxies close in mass to the Milky Way, and D ~ 25-35 Mpc, basically NGC galaxies, R_vir ~ 250 kpc ~ 30 arcmin.

Imaging from SDSS/Legacy Surveys/DES and color cuts to exclude many background objects and stars.

Take spectra of ~200-300 objects per field, with MMT/Hectospec or AAT/AAOmega multi-fiber spectra, finding 0-12 dwarf satellites per field.

1 degree field



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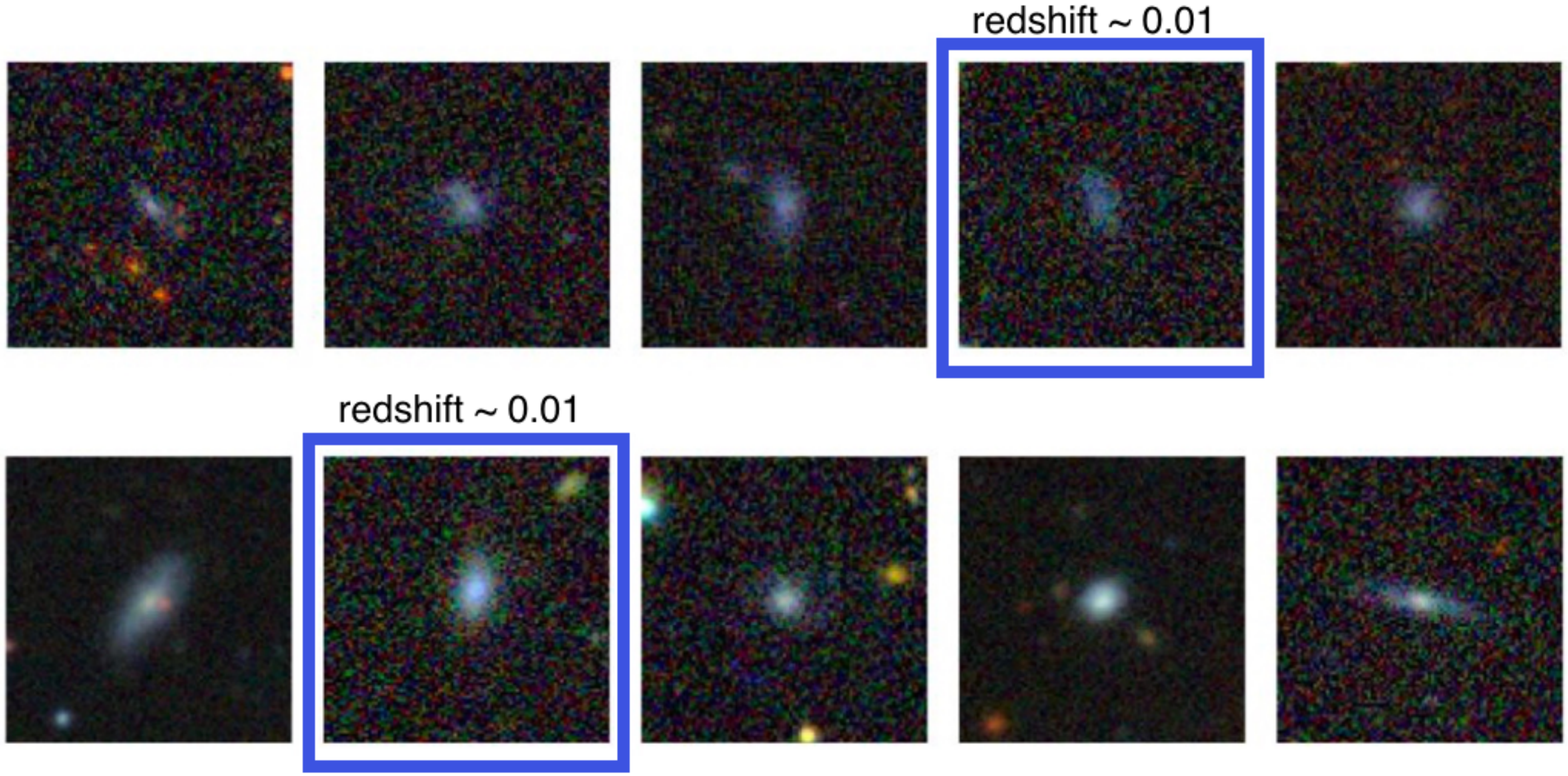
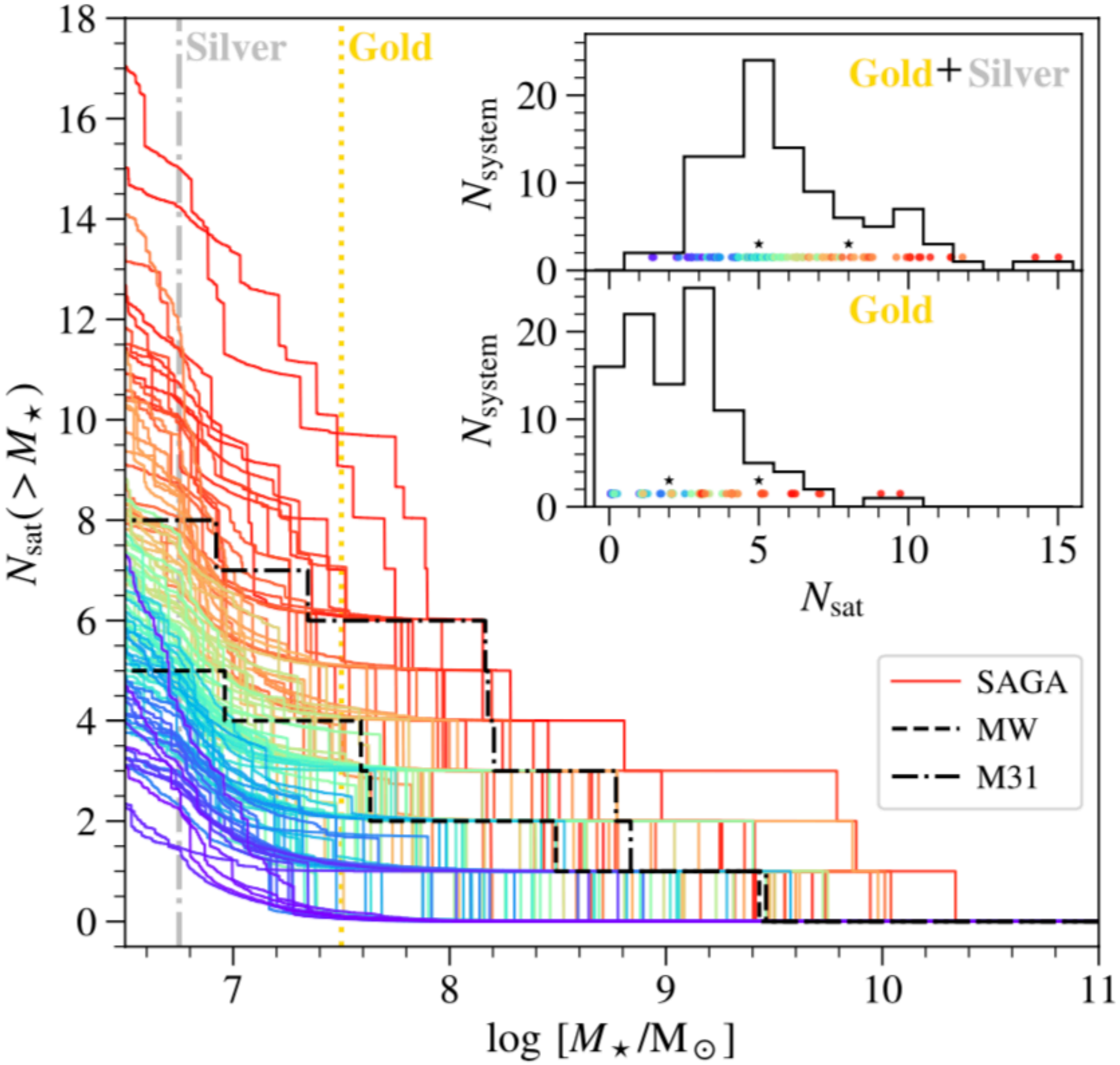
The need for wide field spectroscopic surveys

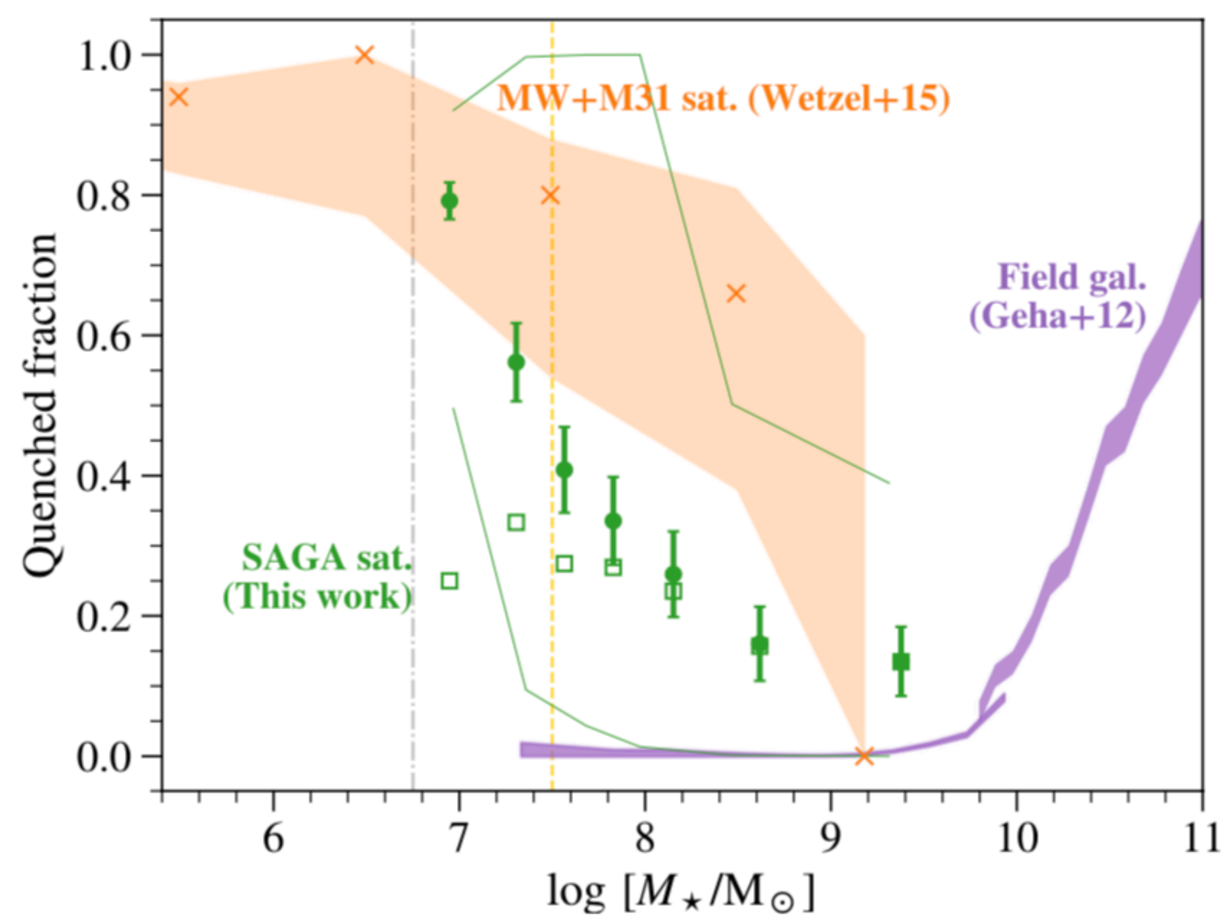


SAGA searches for dwarf satellites in ~ 1 deg diameter fields around galaxies of Milky Way mass, at 25-35 Mpc distance. Some stars and background galaxies can be screened out by shape and color, but many z ~ 0.1-0.5 galaxies appear similar to the z ~ 0.008 dwarf galaxies we seek.
We take hundreds of spectra with MMT/Hectospec and AAT/AAOmega per field, finding ~ 0-11 satellites per field.
Survey limit r=21; similar to Leo A ~ 3e6 Msun, ~5 mag fainter than the SMC.
Complementary to imaging surveys around very nearby galaxies (eg HSC; Carlsten et al 2019).

We find 0 - 12 satellites per host, similar to MW and M31, but with a large variance, and about 75% of the satellites are starforming, unlike the MW and M31 satellite systems.

SAGA Dwarf Satellite Mass Functions



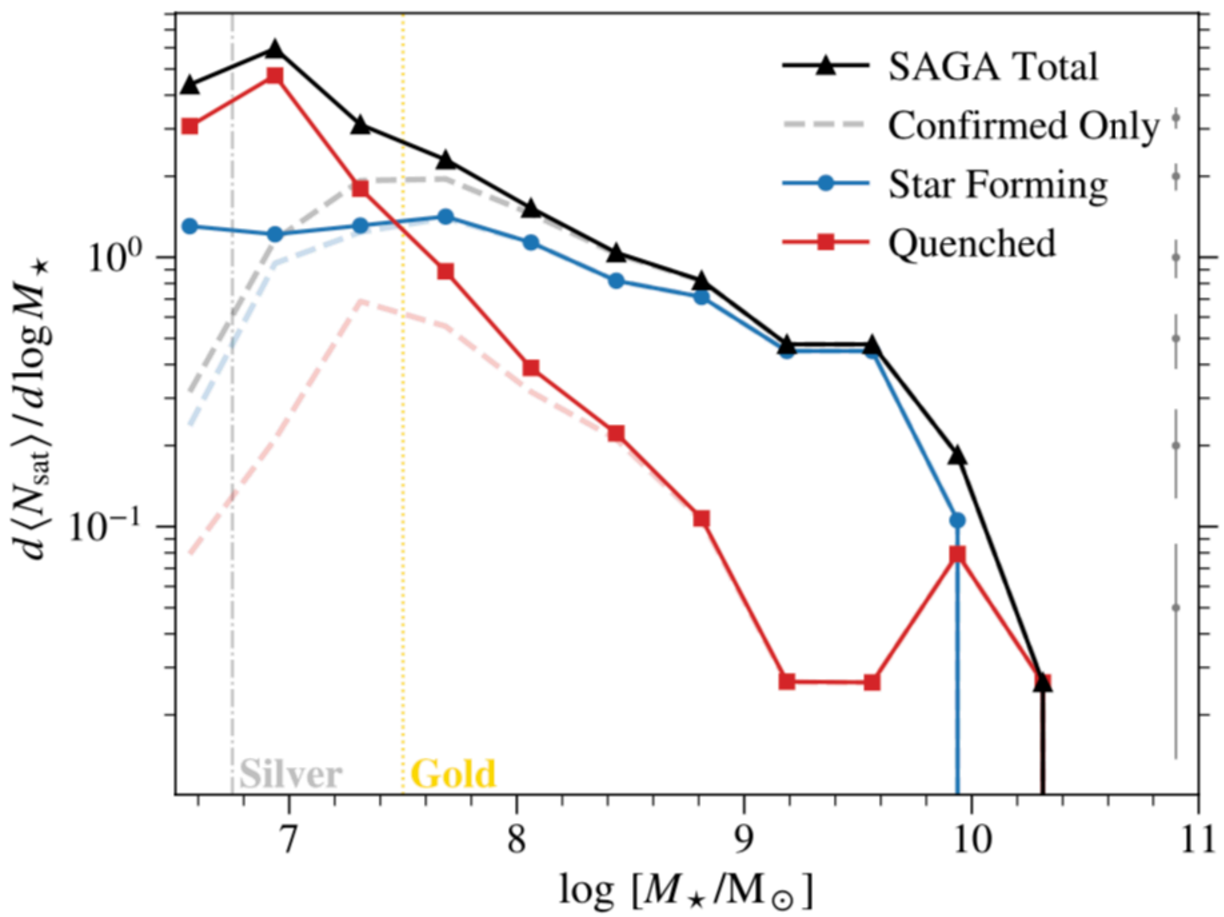


SAGA paper 3, Mao et al 2024

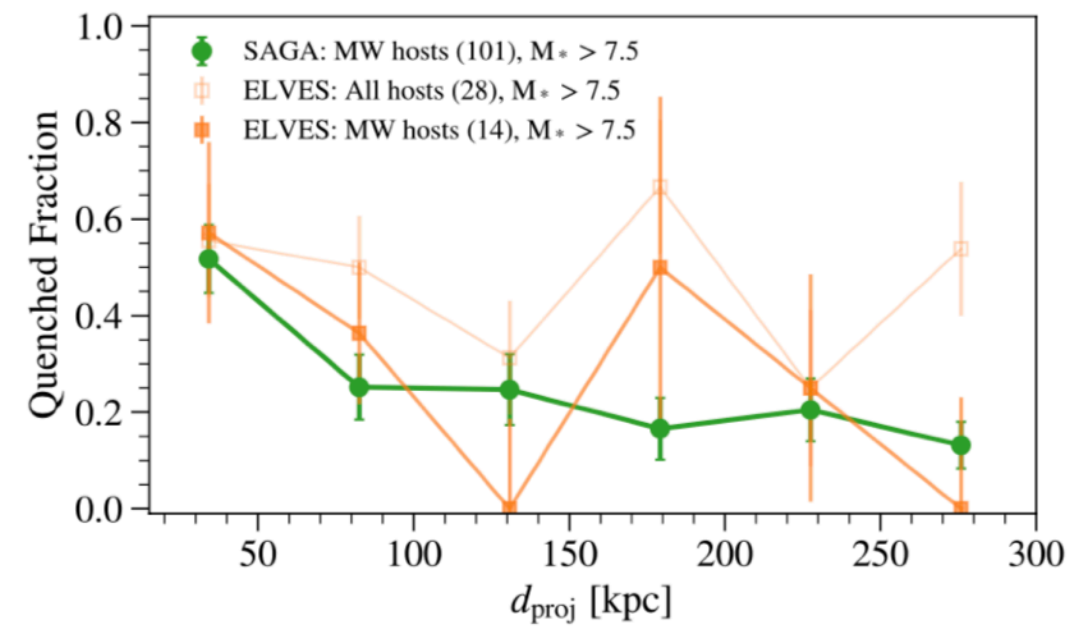
SAGA has completed surveys around 101 host galaxies similar in mass to the Milky Way, to M_V < -12. We find 0 to 12 satellites per central inside R_vir; the MW has 5 and M31 has 8, to the same luminosity.

BUT: there is a large variance per central, and most dwarfs we find are star-forming, while the MW and M31 each have just 2 star-forming dwarfs. Not a failure to find quenched satellites, but an excess of star-forming satellites. Suggests that there is strong variation in recent accretion, and that satellites don’t quench quickly on infall to an MW-like halo.

Most SAGA dwarfs are star-forming!

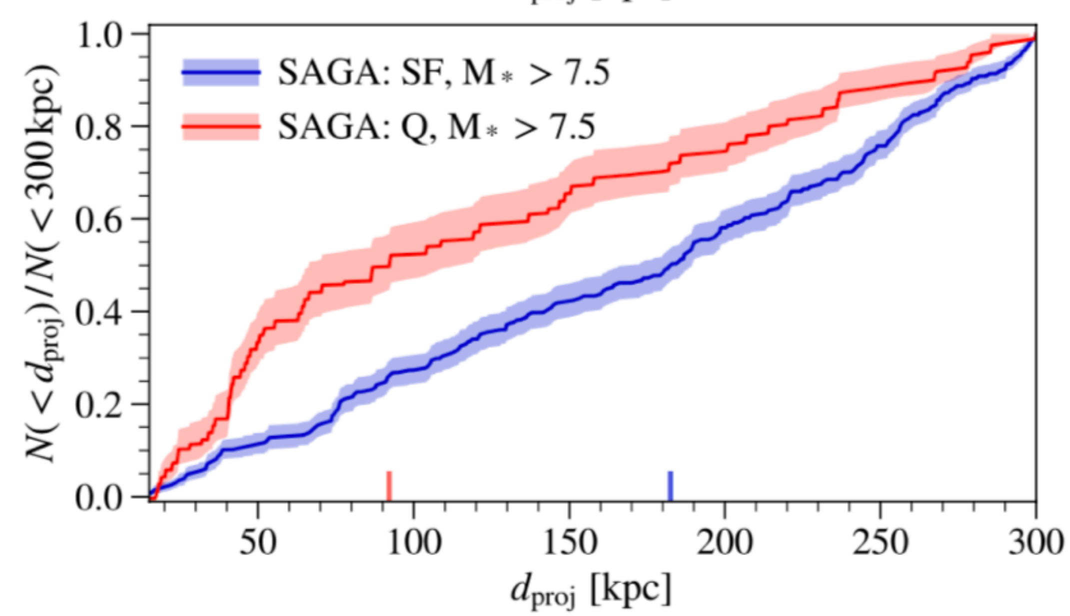


SAGA paper 3 sample: ~75% star-forming (strong dependence on Msat). We do get redshifts for quiescent galaxies; this is not purely a selection effect. Star-forming dwarfs inside R_vir are more common than in the Local Group.
Probably many long-quiescent dwarfs have faded below our surface brightness limit.



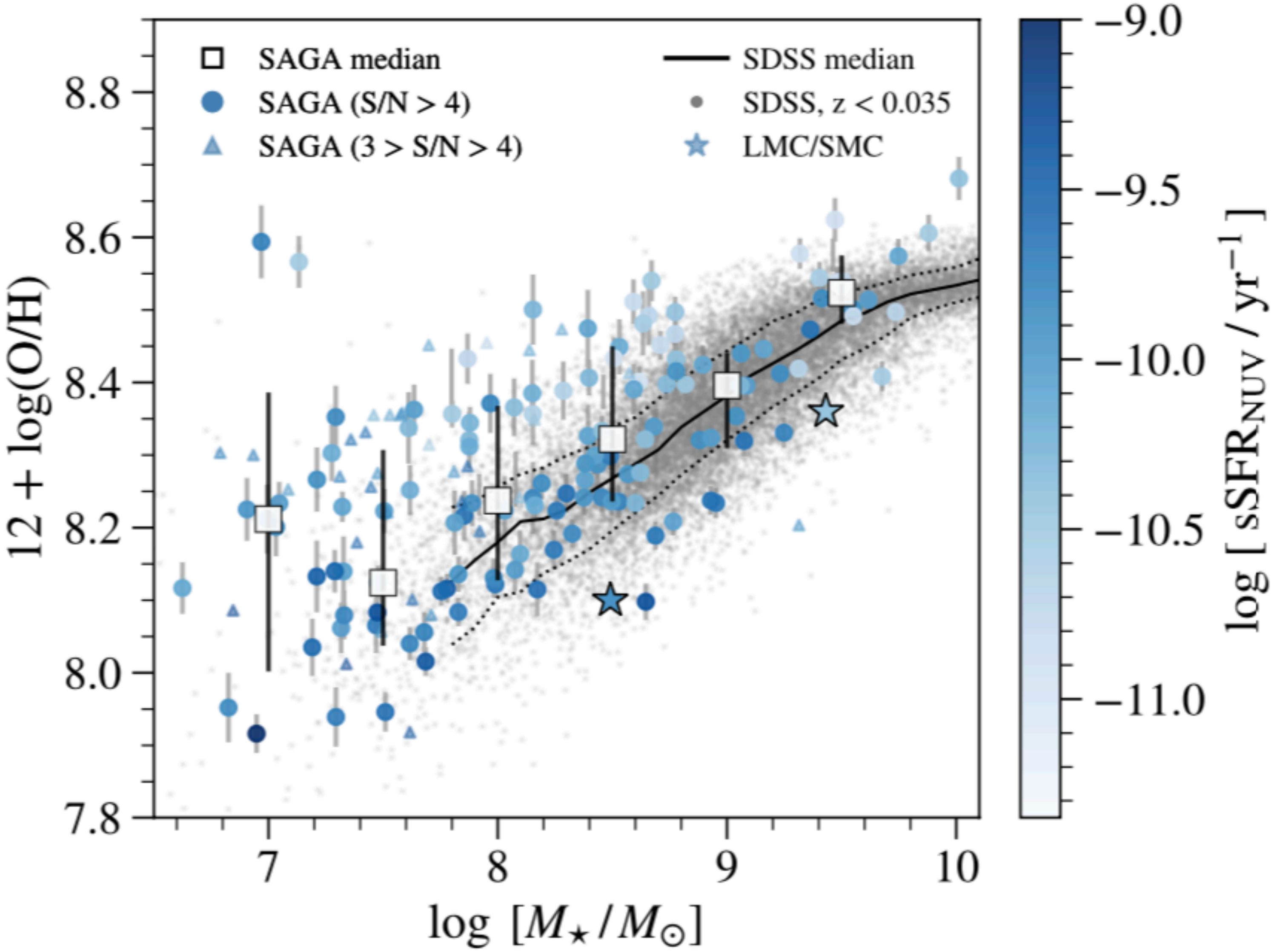
We find that SFR in SF satellites is not strongly dependent on radius to host, but that the quenched satellites are concentrated to lower host-centric radius, especially for higher-mass satellites.

Presumably this is host halo quenching the satellite. The quenched fraction in field low-mass galaxies is near 0.



SAGA paper 4, Geha et al 2024

SAGA dwarfs have a metallicity excess over field, large at low masses



SAGA dwarf satellite gas-phase mass-metallicity relation, from [N II]/Ha.

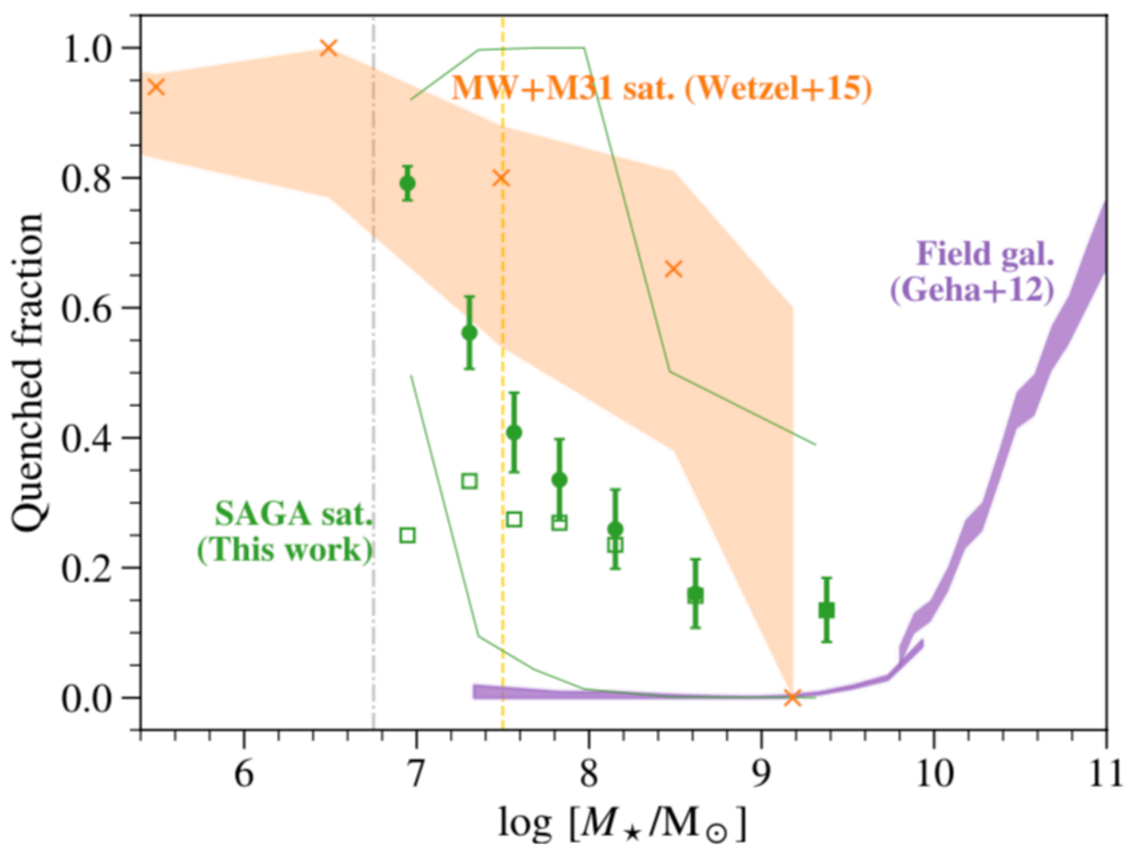
Metallicity offset vs field galaxies: ~ 0.1 dex could be systematic in the calibration, much of the offset is real.

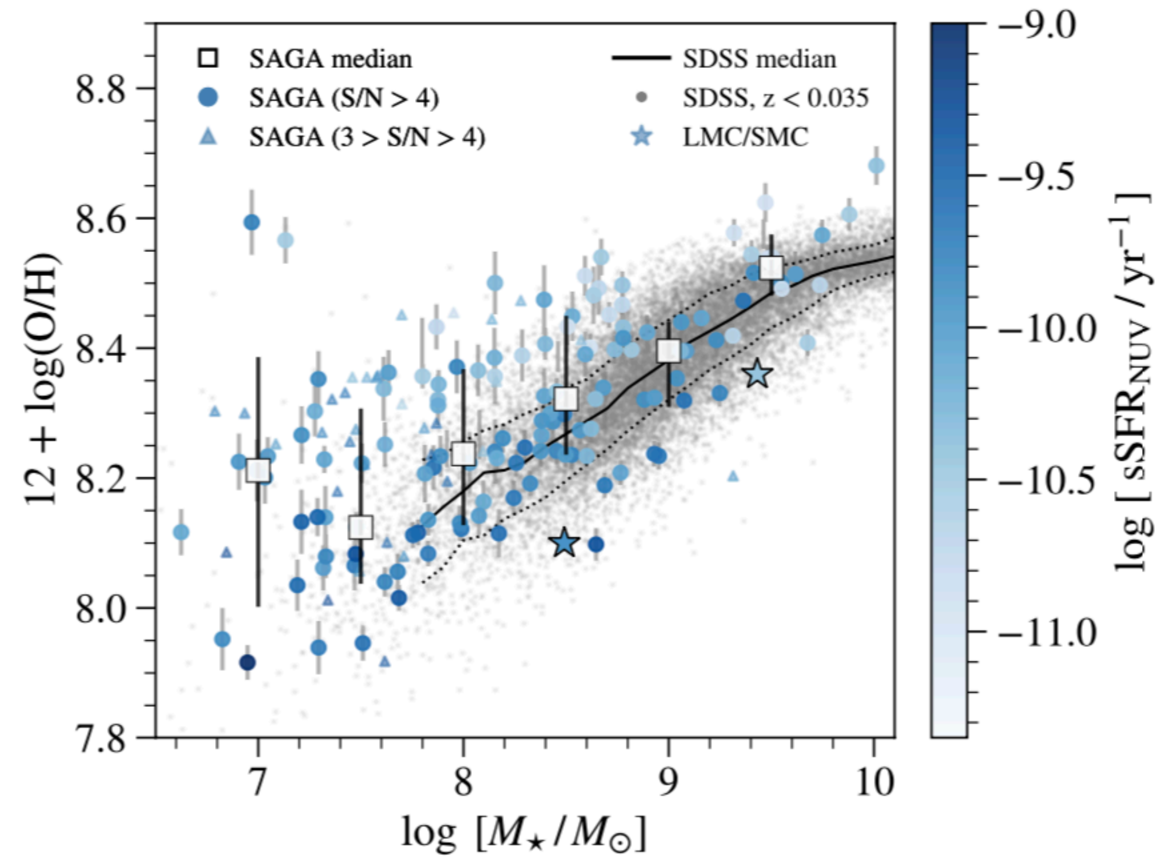
Strong indications of a metallicity excess at low satellite masses.

Metallicity excesses are much too large to be explained by mass stripping. Rather, these suggest cutoff of gas accretion and then enrichment (toward a closed-box model).

SAGA paper 4, Geha et al 2024

SAGA Dwarf Satellite Properties - Slow Quenching?





Summary:
- SAGA finds several dwarf satellites per Milky Way analog, with a large variance (0-12).
- Many are star-forming, unlike in the MW and M31.
- Persistence of star formation and metallicity excess suggest that the parent has started to cut off gas accretion, but the decline of SF is slow.

Spectra are a powerful tool to understand dwarf satellites and their evolution.
We now have 101 completed fields, reaching the original ambitious [crazy] goal of 100!
SAGA Papers 3, 4, 5 recently published.