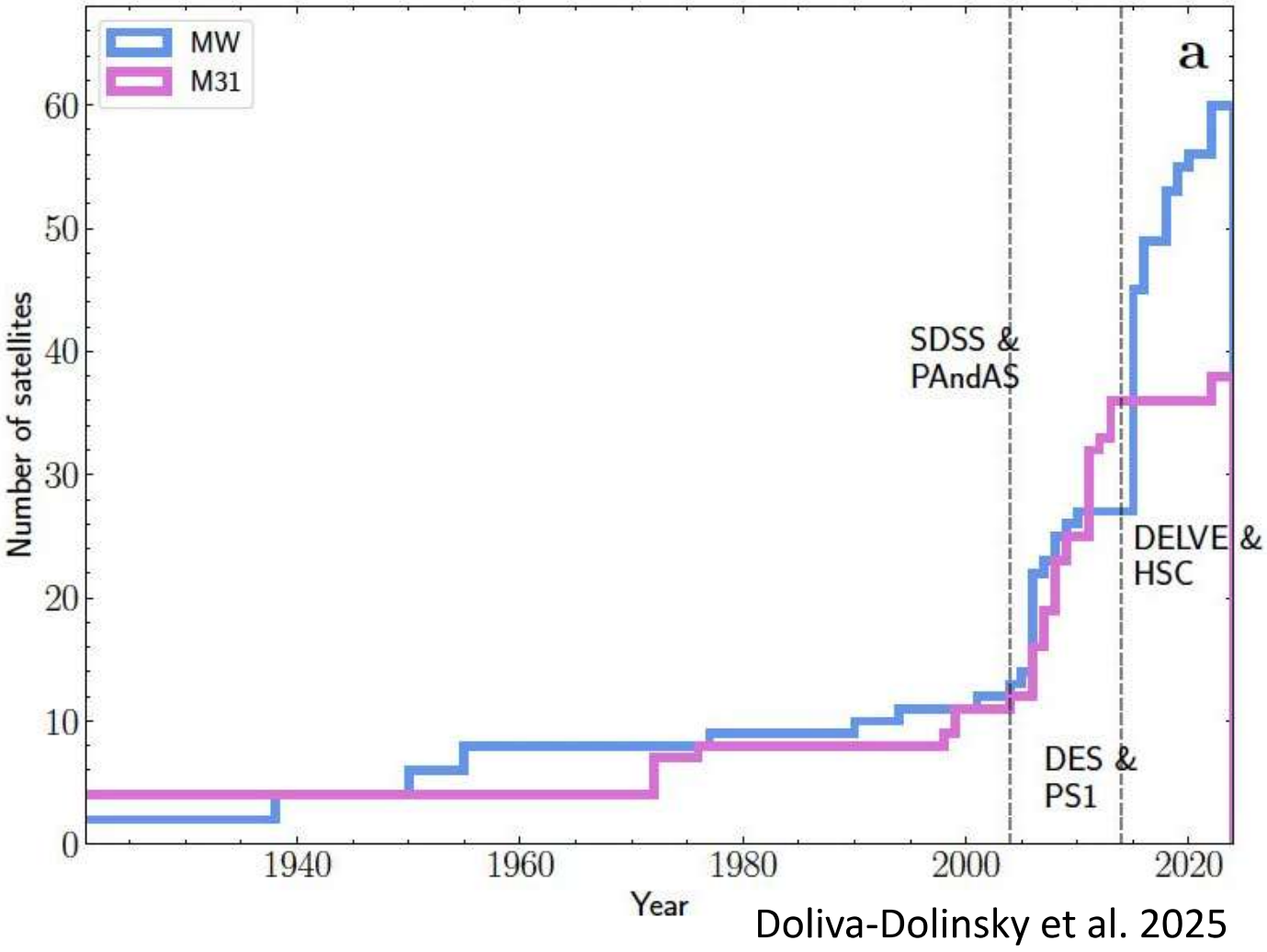
Unveiling the Secrets of Ultra-Faint Dwarf Galaxies w WST

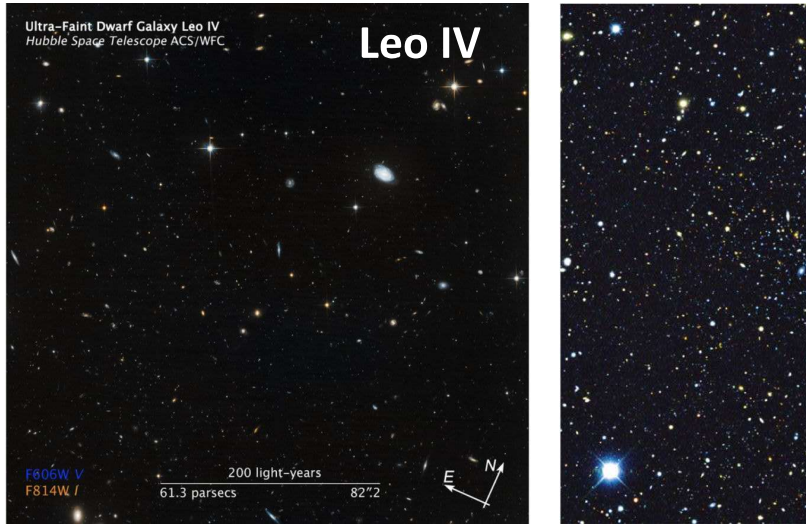
Massimiliano Gatto (INAF – Osservatorio Astronomico di Capodimonte)

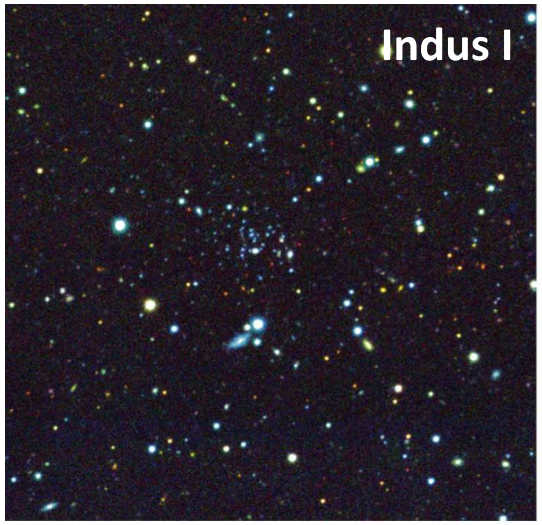
The Ultra-Faint Dwarf Galaxies



Doliva-Dolinsky et al. 2025

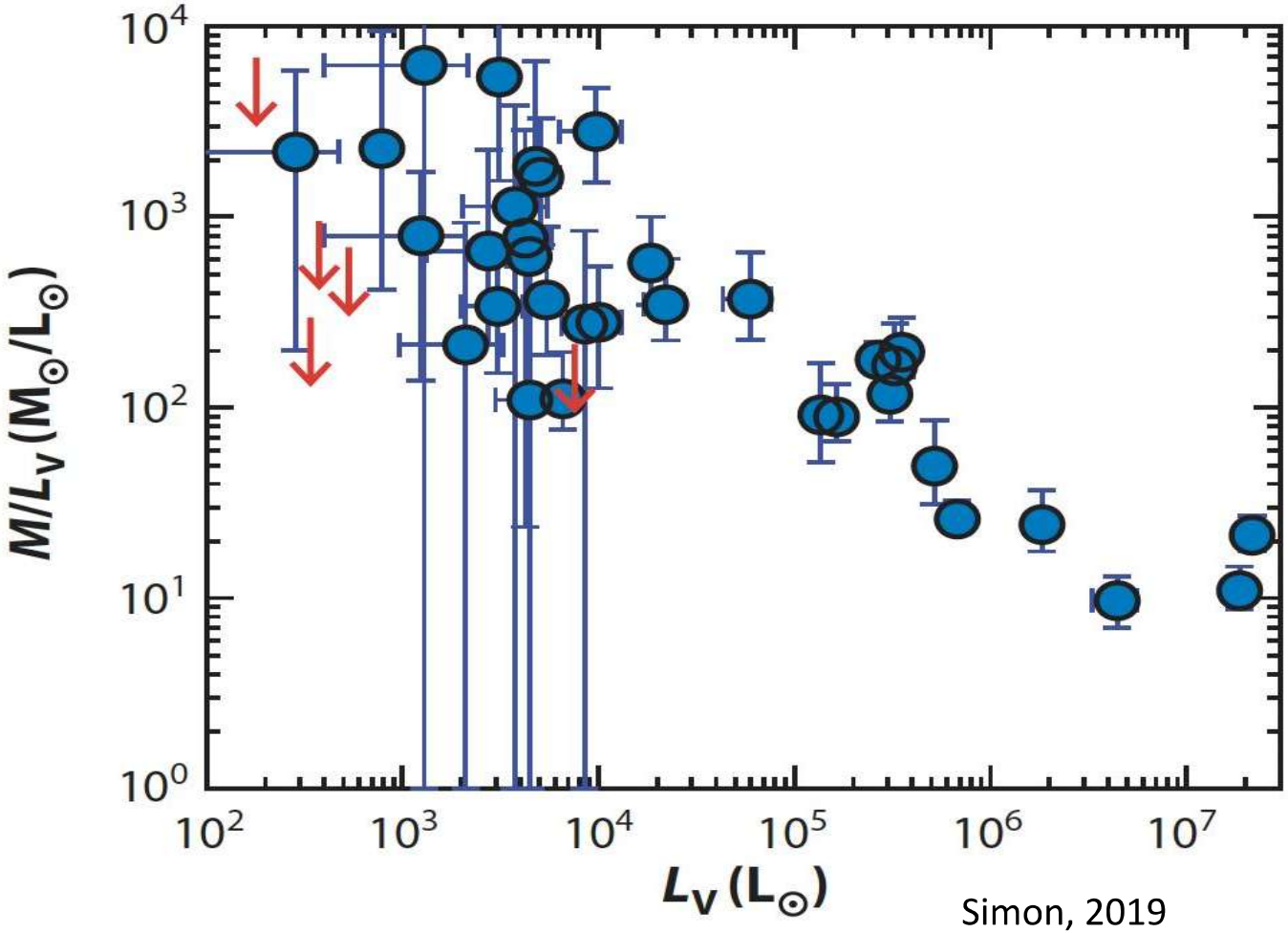
ULTRA-FAINT DWARF GALAXI





The UFDs as cosmic probes

The most dark matter–dominated systems known



Simon, 2019

- Nature of the Dark Ma
- Core - Cuspy problem

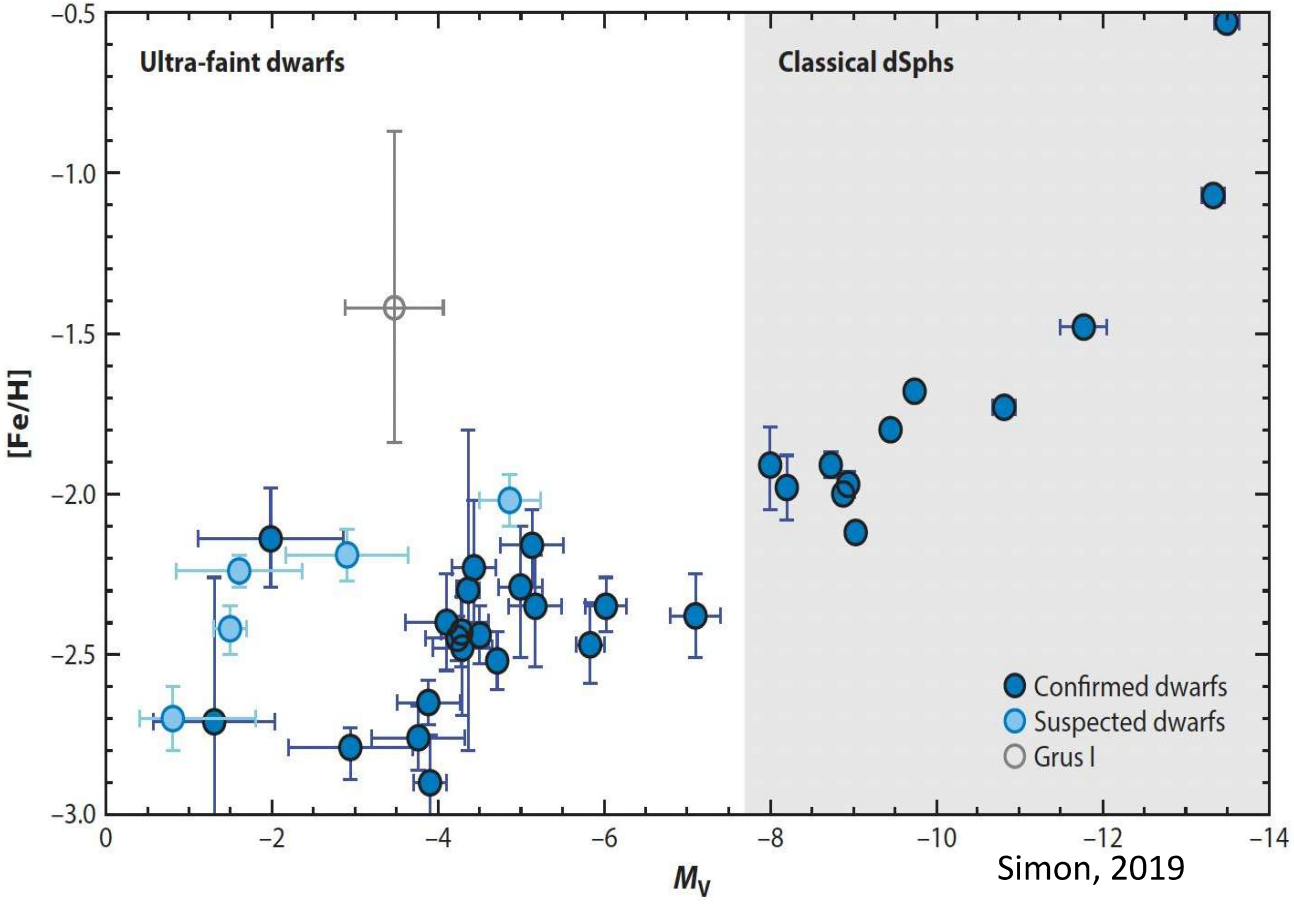
Velocity dispersions of about 3-8 k
(Simon, 2019)

CAVEATS:

- Few Bright Stars
- Outliers
- Binaries

The UFDs as proxy of early chemical evolut

The most metal-poor galaxies known



Simon, 2019

- Nucleosynthesis
- Population III

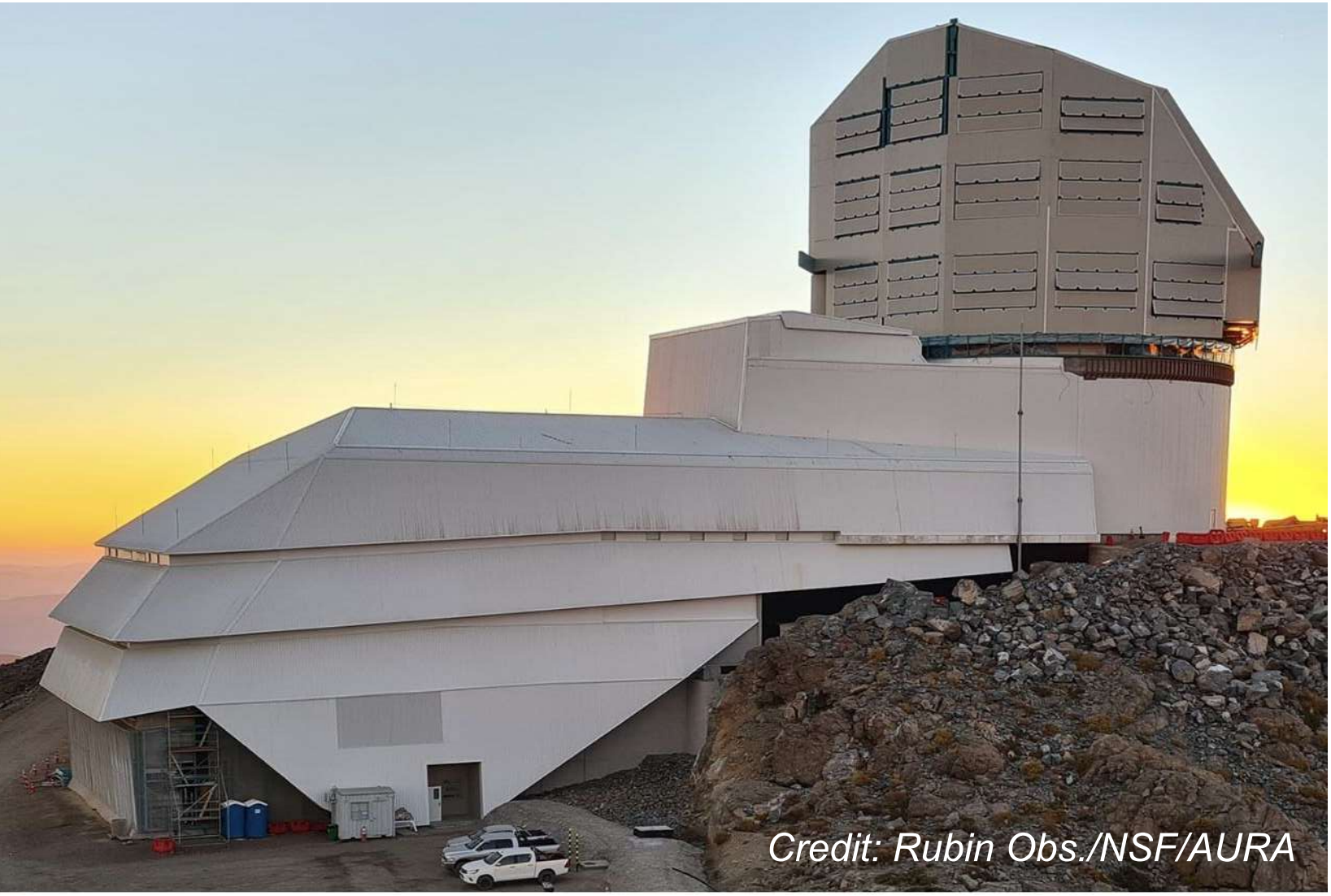
Nearly half of known MW UFDs lack metallicity information

CAVEATS:

- Few Bright Stars
- Heterogenous sample
- Lack of chemical abundan

The UFDs in the next decade

Vera Rubin Observatory - LSST

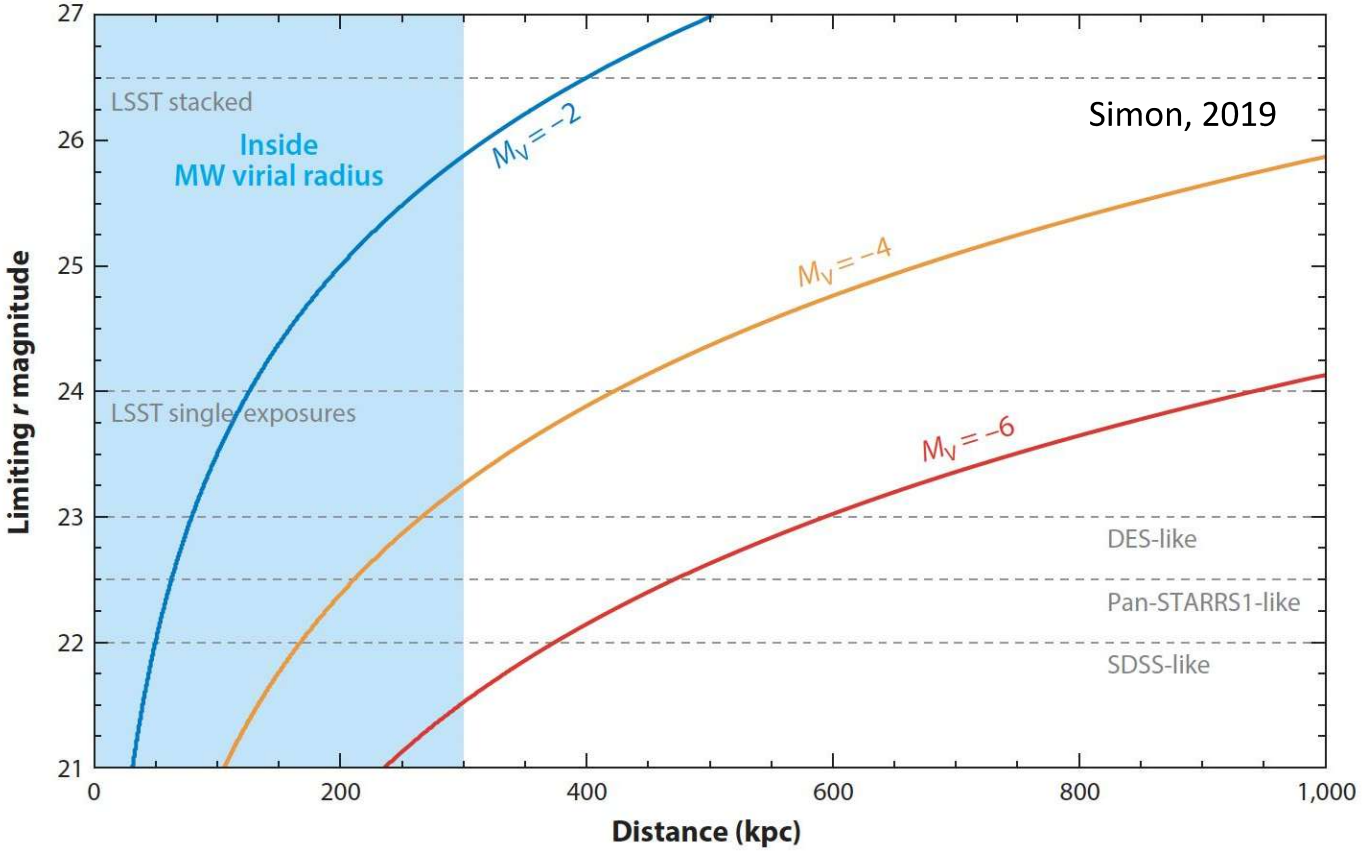


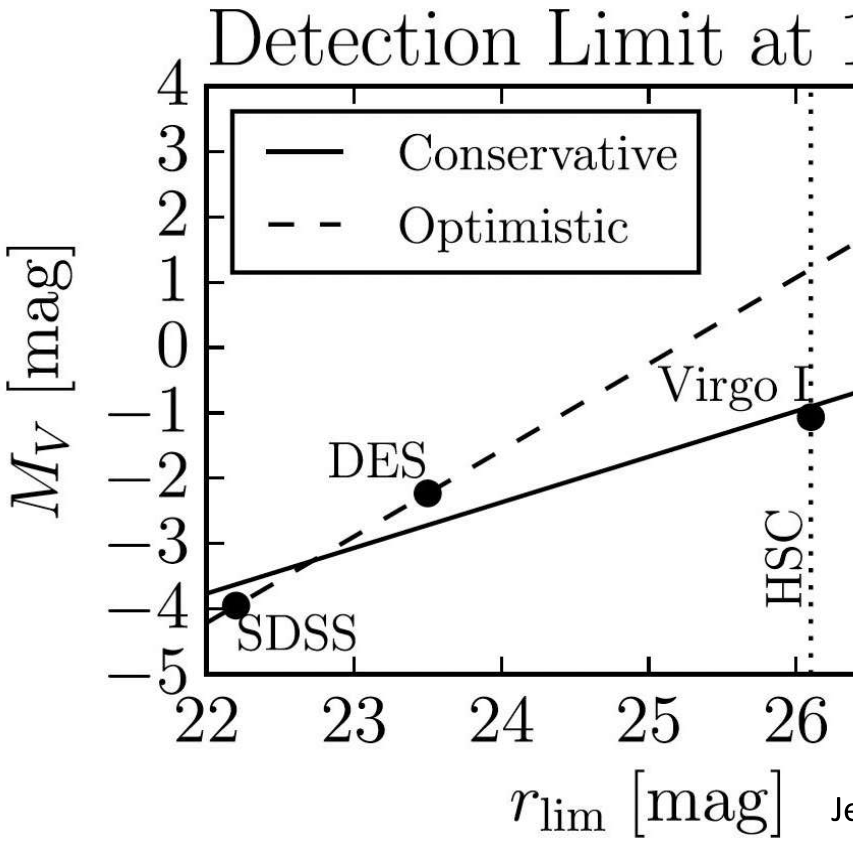
- Six filters (ugrizy)
- Repeated images.
- 9.6 deg2 field of vi

- r ~ 24.5 with a sing
- r ~ 27.5 after 10 ye

LSST will resolve
sequence turnoff st
300 kpc

The UFDs in the next decade with the LSST

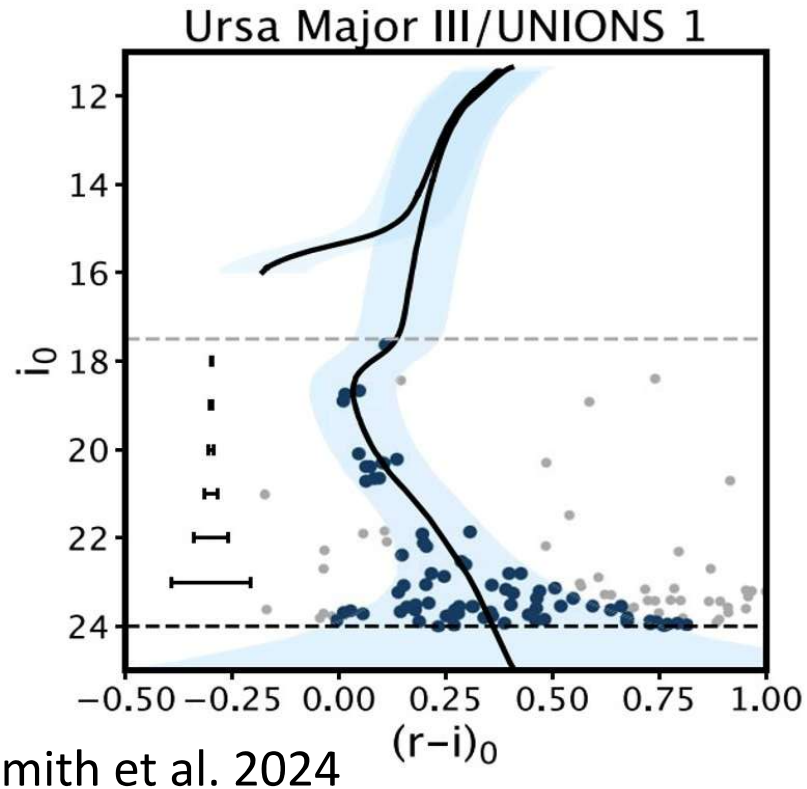




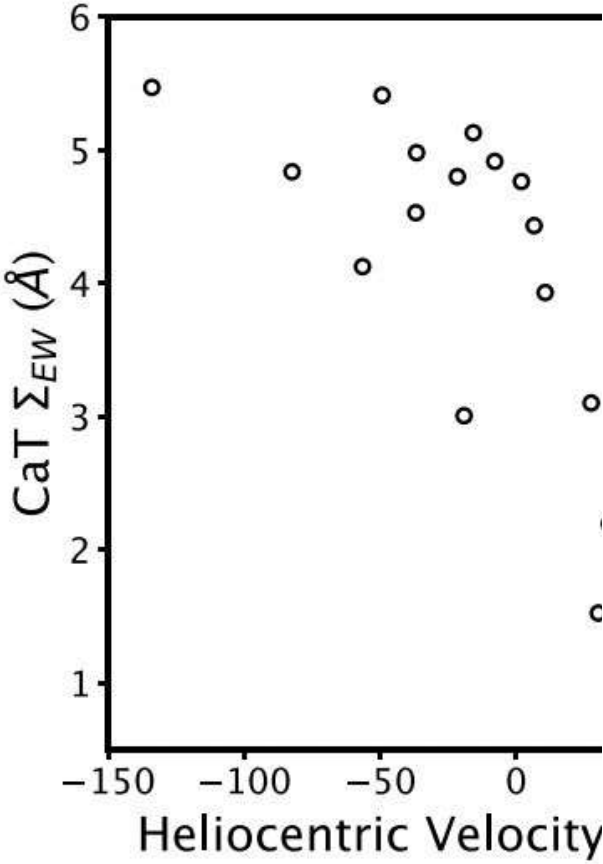
$M_* < 100\ M_\odot$

Ursa Major III/UNIONS 1

- Spectroscopically confirmed with Keck II/DEIMOS
- Absolute Magnitude of M_V = + 2.2 mag
- Stellar Mass of $M_* = 16\ M_\odot$
- Darkest UFD ever discovered
- Heliocentric distance ≈ 10 kpc



Smith et al. 2024

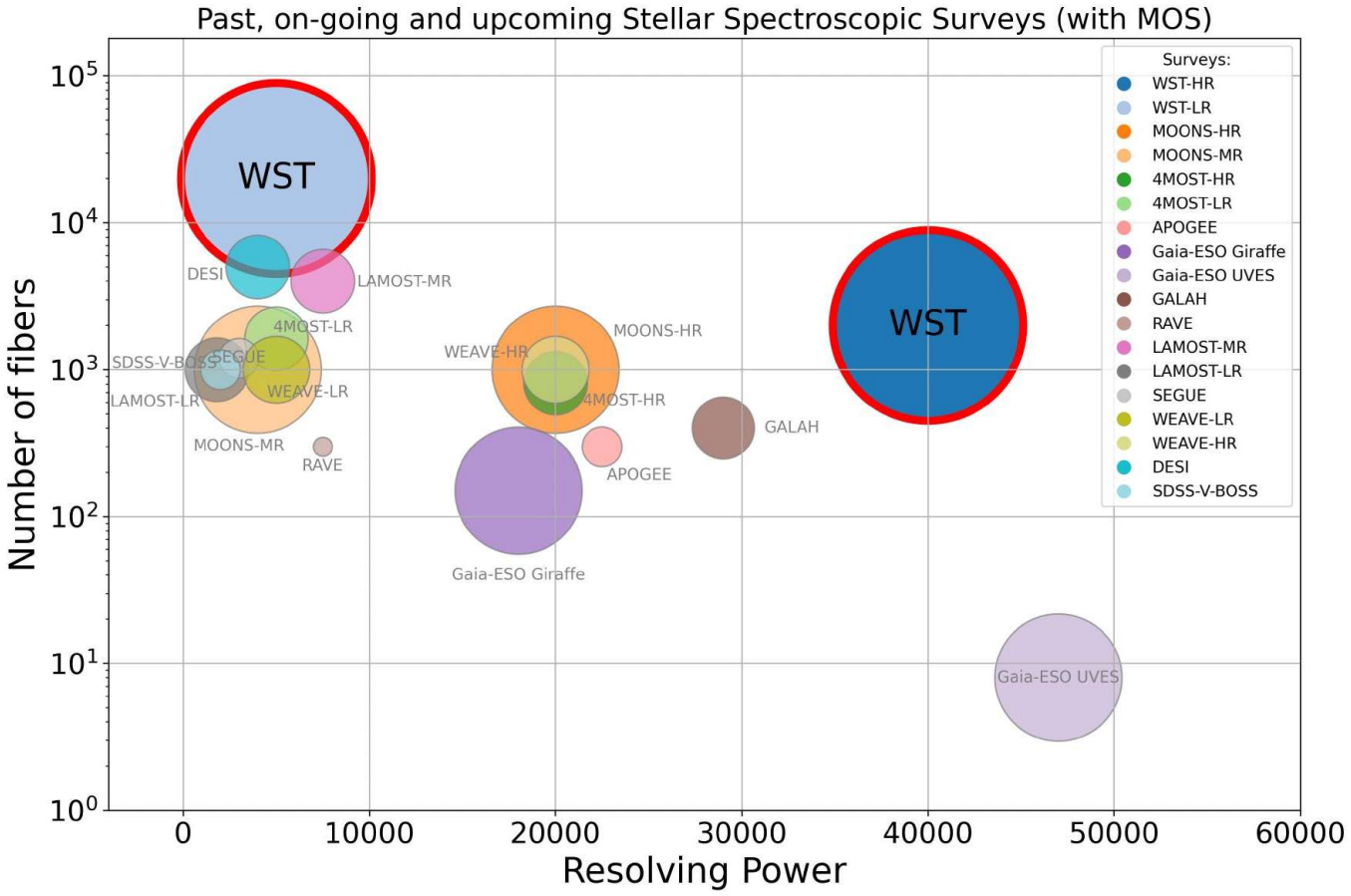


Expected hundreds of UFDs similar to UM

(e.g., Tollerud+2008, Hargis+2014, Jethwa+2018, Newton+2018, Sim

Important implications for the minimum halo threshold able to trigger the formation of st

The Wide-Field Spectroscopic Telescope



Facility/Instrument	First light	Aperture (M1 in m)	Field of View (sq. deg)	Etendue	Multiplexing	Wavelength coverage (µm)
TMT/WFOS	2030+	30	0.007	4.9	80	0.30-1.0
VLT/FLAMES-GIRAFFE	2002	8.2	0.14	7.4	132	0.37-0.95
VLT/MOONS	2024	8.2	0.14	7.4	1000	0.65-1.8
						3 windows
ELT/MOSAIC	2030+	39	0.009	10.7	200	0.39-1.80
					100	windows
WHT/WEAVE	2022	4	3.14	39.5	1000	0.37-1.00
						3 windows
GMT/MANIFEST	2030+	25.4	0,09	45.5	250	0.35-0.95
VISTA/4MOST	2024	4	4.2	52.8	1600	0.37-0.95
					800	3 windows
Subaru/PFS	2024	8.2	1.25	65.9	2400	0.38-1.26
Mayall/DESI	2019	4	7.1	89.2	5000	0.36-0.98
MSE-QM	2030+	11.25	1.5	149	20000	0.36-1.8
						0.36-0.95
						3 windows
MUST	2030+	6.5	5	166	10000	0.36-1.0
MegaMapper	2030+	6.5	7.1	235	20000	0.36-0.98
WST	2030+	12	3.1	350	20000	0.37-0.97
					2000	windows

The WST White paper

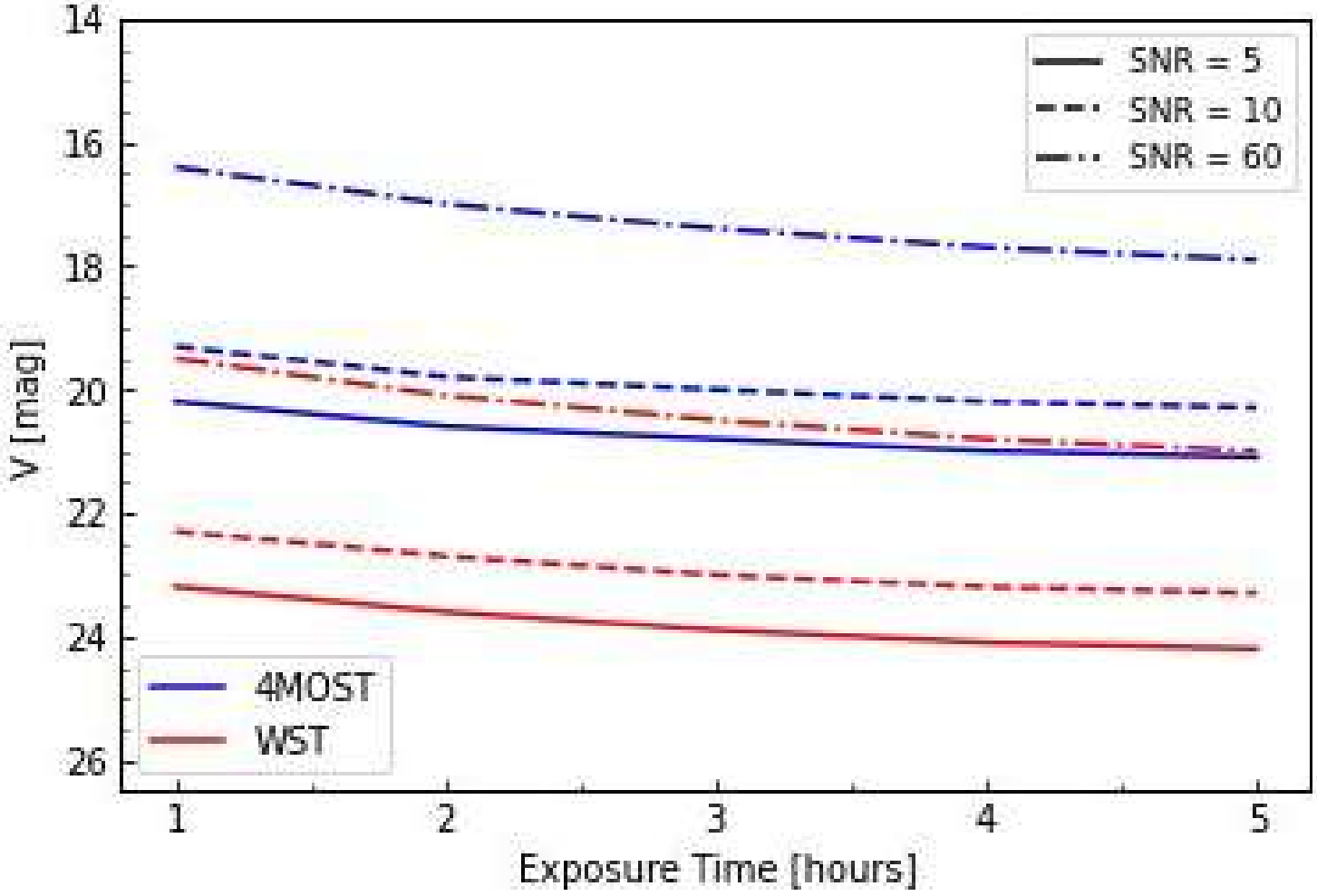
WST Capabilities

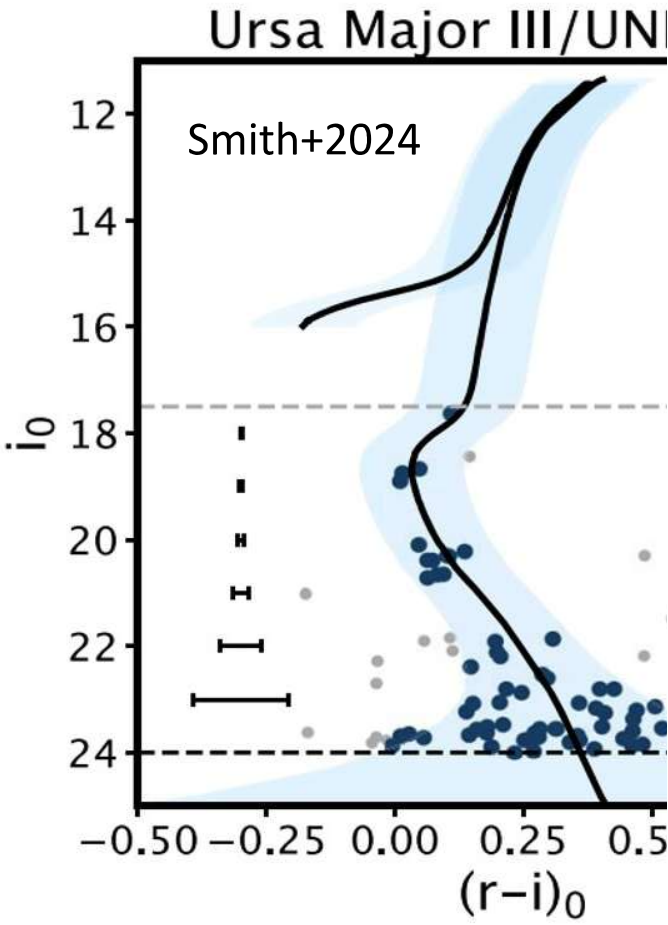
- M_V = + 2.2 mag
- No post main-sequer

https://github.com/RolandBacon/pyetc

LOW RESOLUTION MOS

Main sequence star; Dark; Seeing = 0.8”; Airmass = 1.0”





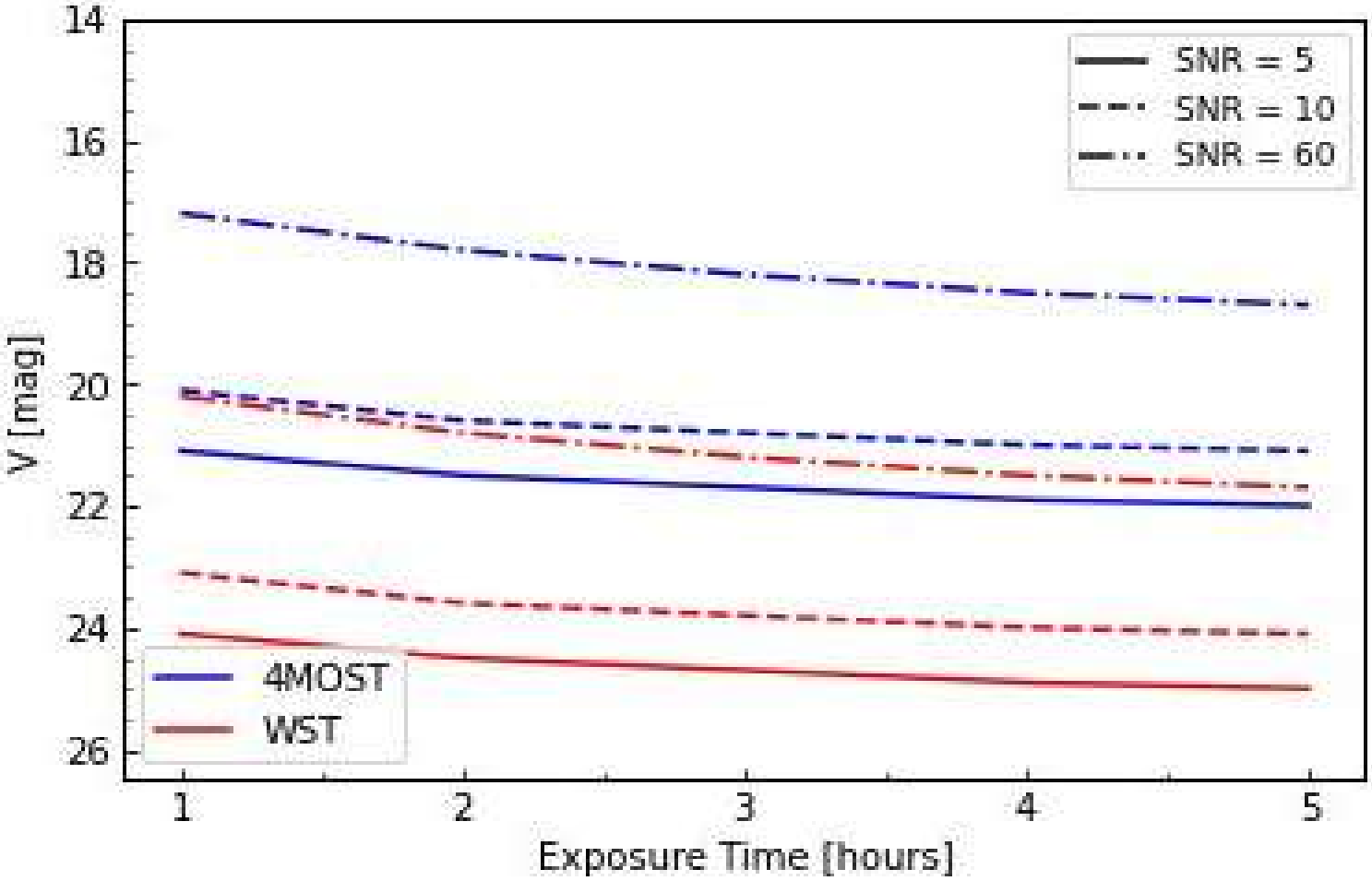
- ❖ Radial Velocities and [Fe/H] u
- ❖ Velocity Dispersion up to 80 -
- ❖ Chemical abundances (Ca-Mg

WST Capabilities

https://github.com/RolandBacon/pyetc

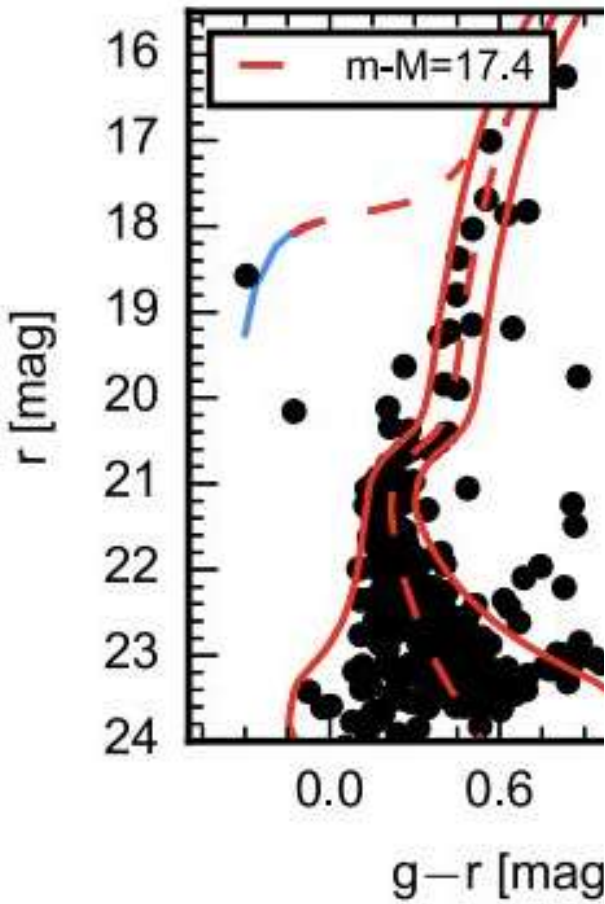
LOW RESOLUTION MOS

Red giant branch star; Dark; Seeing = 0.8”; Airmass = 1.0”



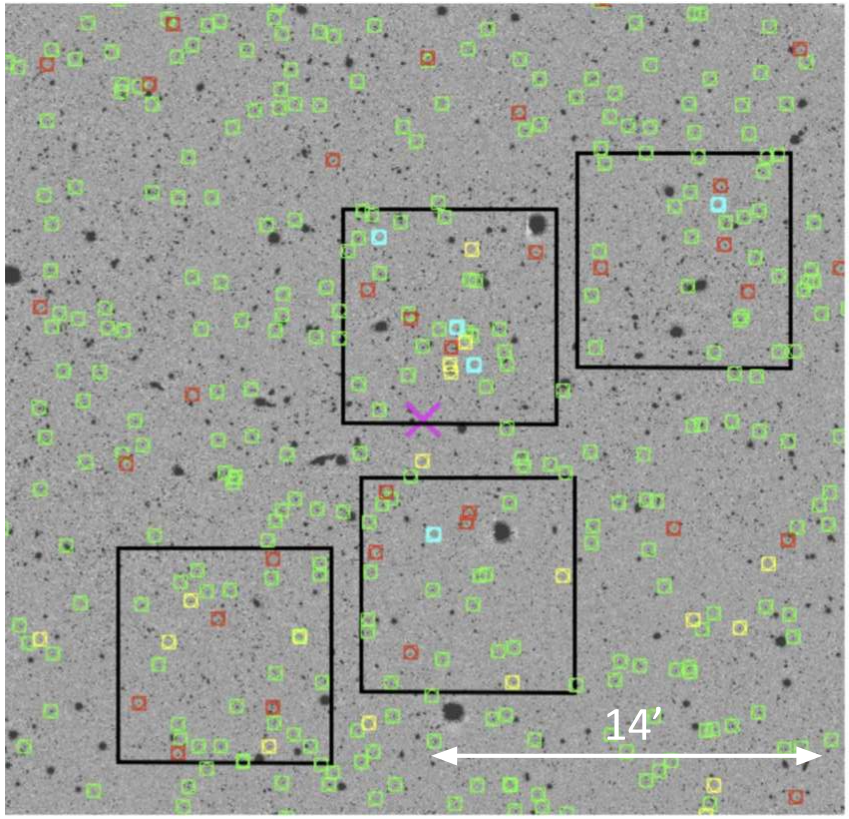
- M_V = - 2.7 mag
- Few RGB Stars

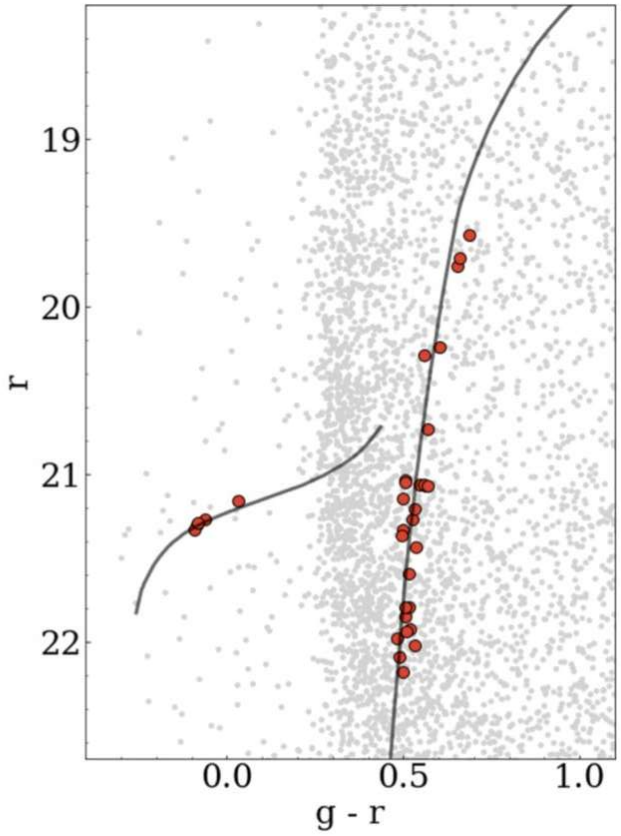
Reticulum



- Radial Velocities and [Fe/H] up t
- Velocity Dispersion up to 300 kp
- Chemical abundances (Ca-Mg-N
- High Resolution up to ≈ 80 kpc

WST Capabilities





Sextans II

- 150 kpc MSTO at r ≅ 24
- M_V = -3.9 mag
- r_h ≅ 200 pc → 5 arcmin

FORS2@VLT Follo

- 13 hours
- 32 stars down to r ≅ 2
- Sampled only up to R =
- Outskirts unexplored

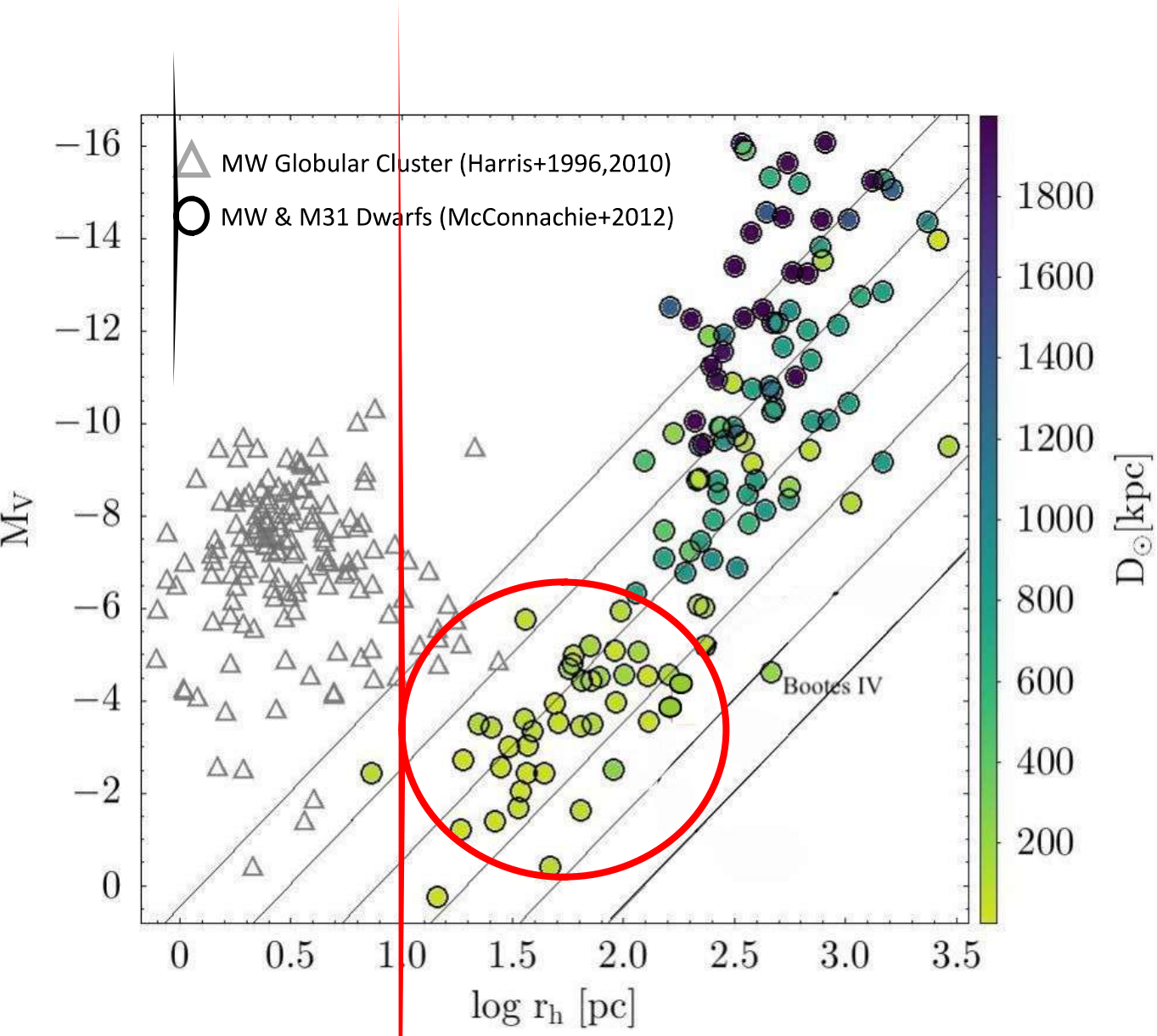
WST

- 1 hour → RV and [Fe/H] for all stars down to ≅ MSTO
- 1 single pointing → Complete catalog of spectroscopic confirm
- Possibilities to unveil tidal streams
- Probing the presence of metallicity gradients

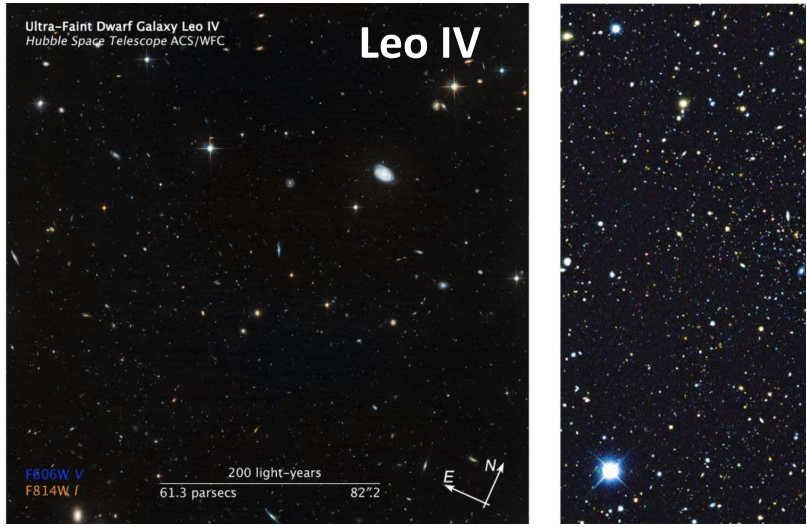
Summary

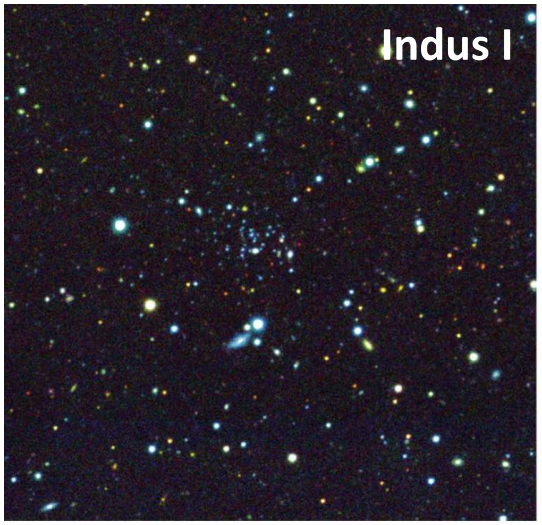
- ✔ Spectroscopic counterpart of the LSST
- ✔ Constrain dark matter content in UFDs
- ✔ Orbital properties of Milky Way Satellites
- ✔ Determine the metallicity distribution functions
- ✔ Chemical abundances of a significant fraction of stars
- ✔ Unveil tidal structures in UFDs
- ✔ Quantify the fraction of stripped stars as a function of galactocentric radius

The Ultra-Faint Dwarf Galaxies



ULTRA-FAINT DWARF GALAXI



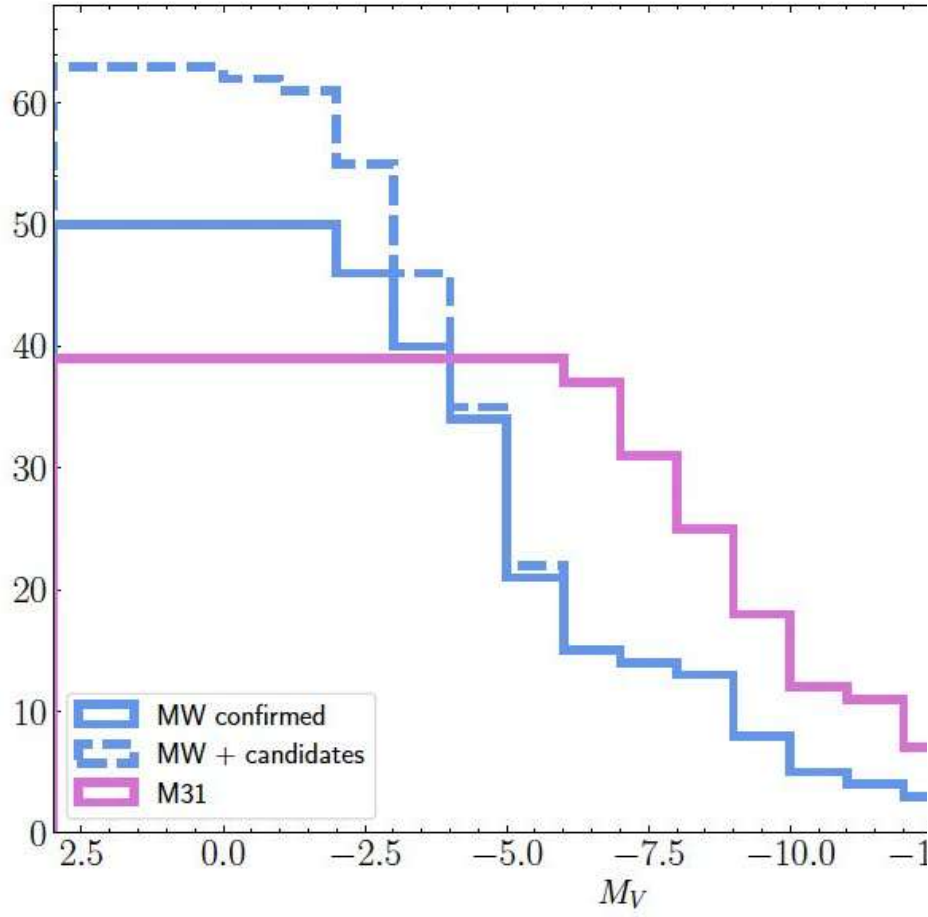


Confirming a UFD is challenging especially at faint magnitudes

Metallicity Spread

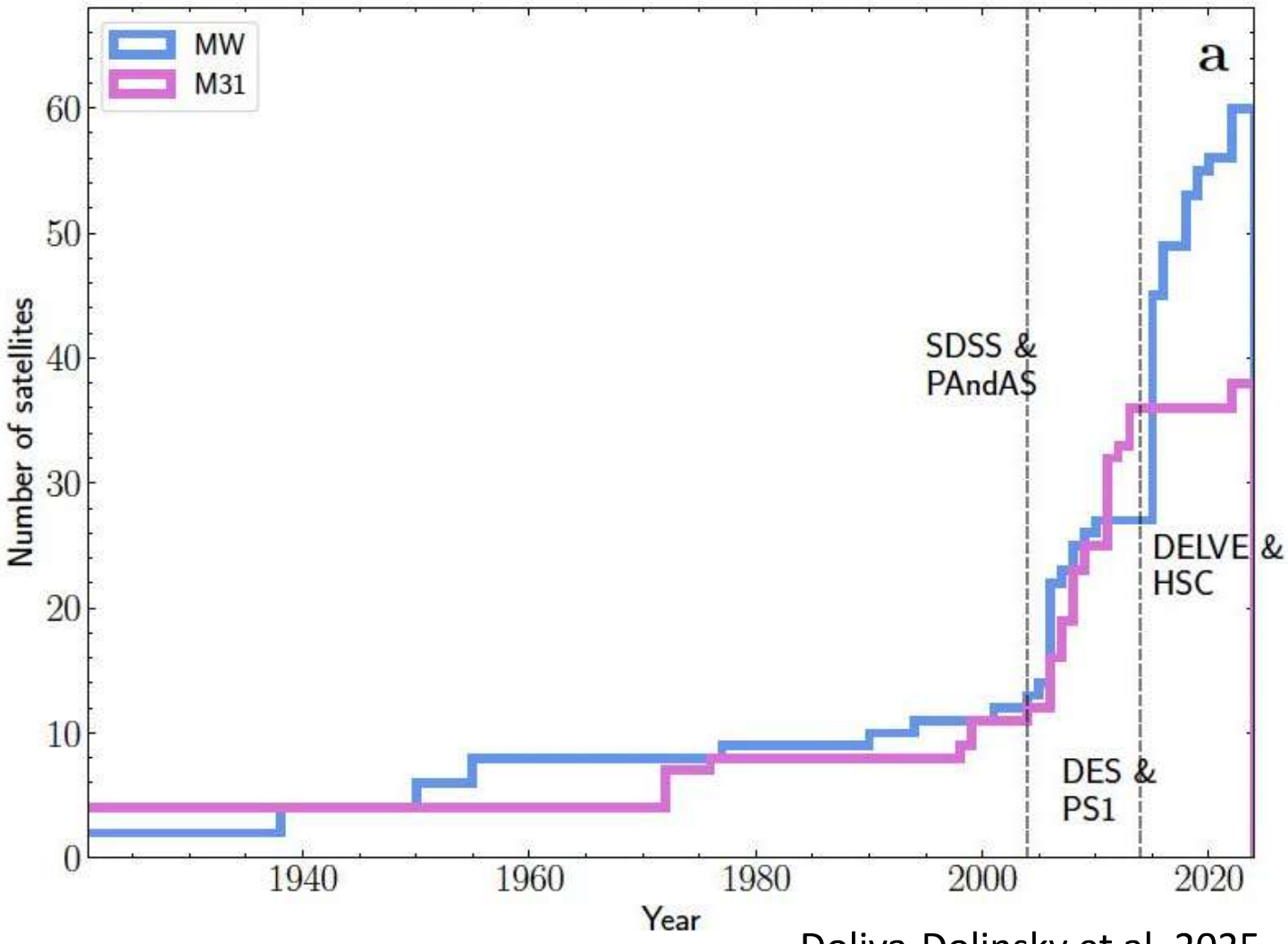
Presence of Dark Matter

SPECTROSCOPIC FOLLOW-UP



Doliva-Dolins

The census of Milky Way satellites



Doliva-Dolinsky et al. 2025

- About 60 MW sa
  (confirmed + candi
- The advent of the
  era enables to sam
  faint-end of the
  Luminosity Functio