WST and the variable sky

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IAC - ULL

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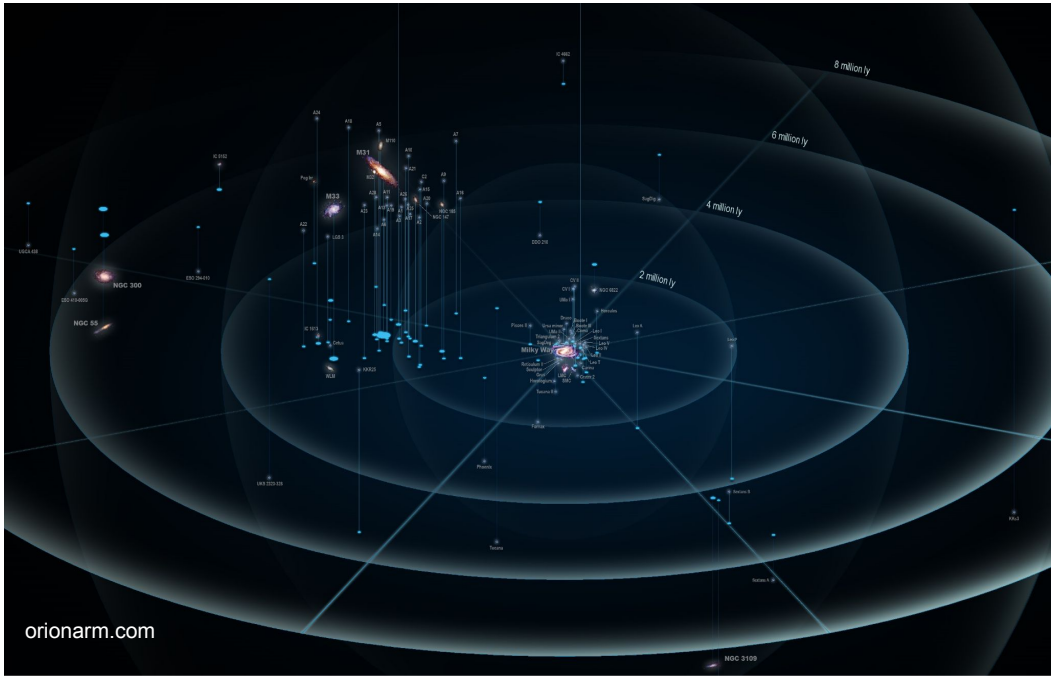
Galaxy evolution unravelled by resolved stars



- MW, M31
  → disc, halo, bulge
- Dwarf galaxies
  → satellites systems, isolated
- Magellanic Clouds
  → peculiar, massive, interacting
- Globular clusters
  → LMC, SMC, Fornax, M31

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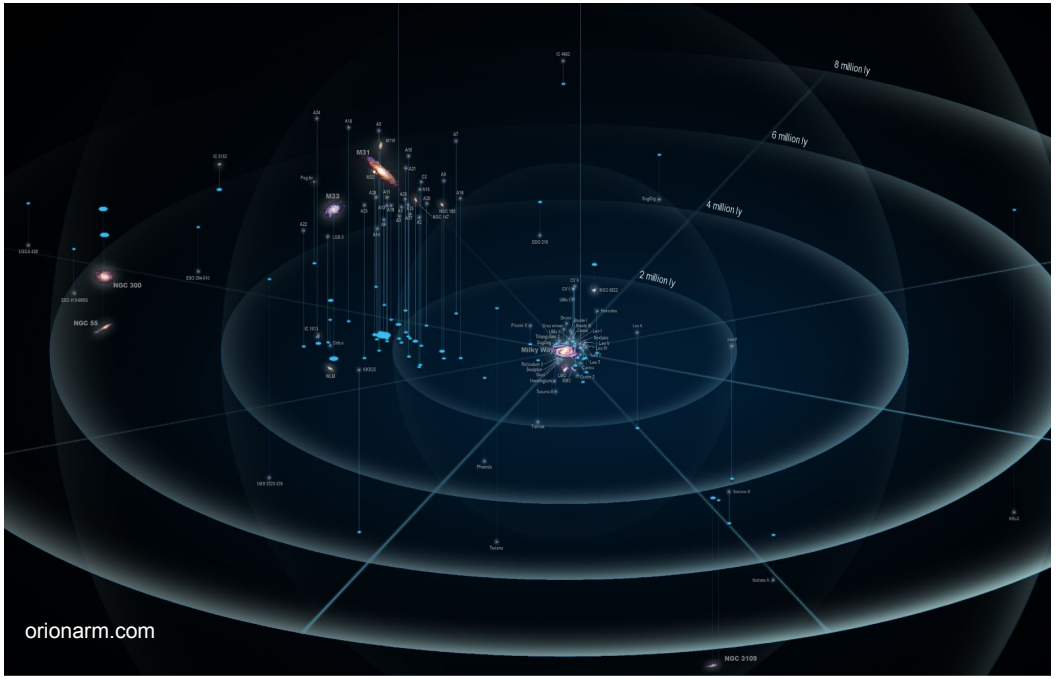

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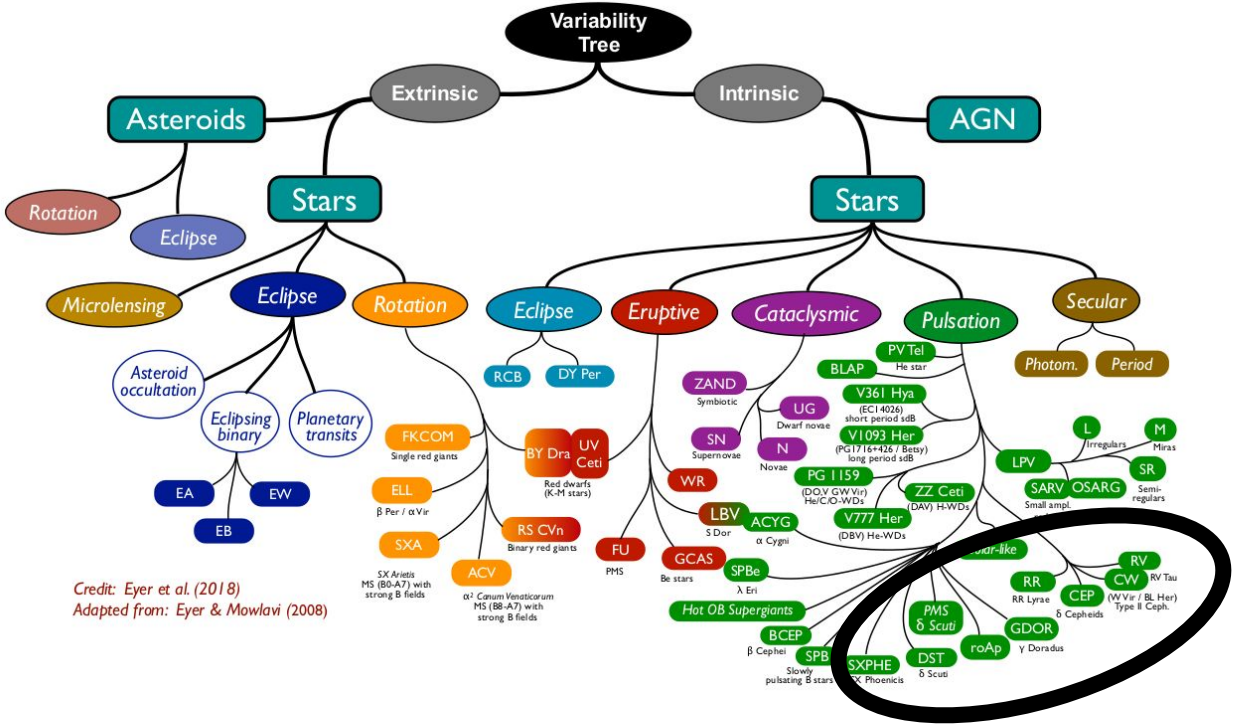
Photometry
Spectroscopy
Kinematics
Dynamics
Asteroseismology

The variability tree



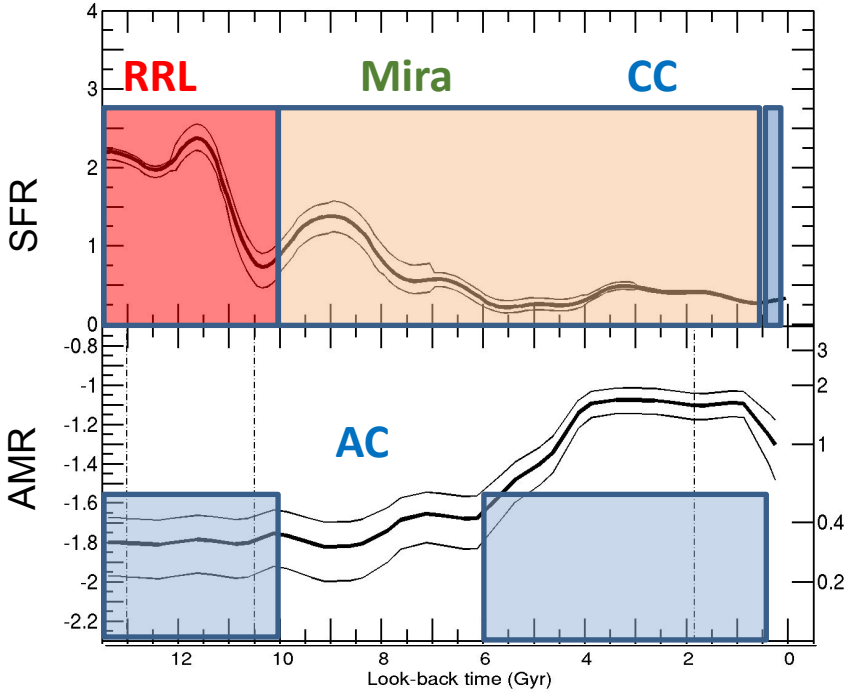
WST White Paper 2024

The importance of variable stars

Stellar evolution

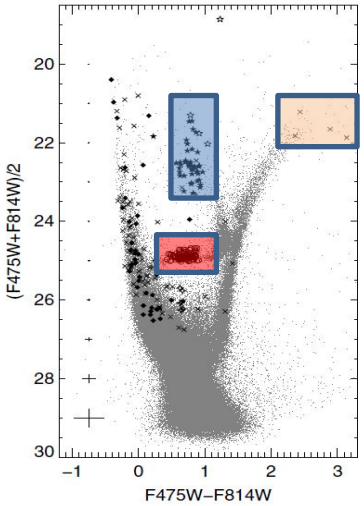
- ★ Convection
- ★ Mixing length
- ★ Stellar atmosphere
- ★ Stellar Masses
- ★ Stellar ages
- ★ Mass loss
- ★ Fast evolutionary phases
- ★ …

The importance of variable stars



Galaxy evolution

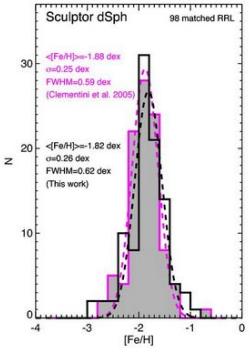
- Stellar population tracers



IC1613, Bernard+2010

The importance of variable stars

photometric metallicities



Martínez-Vàzquez+16 (PLI)

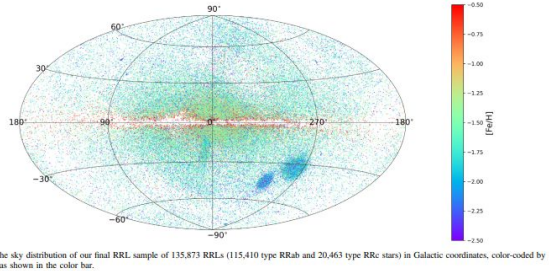
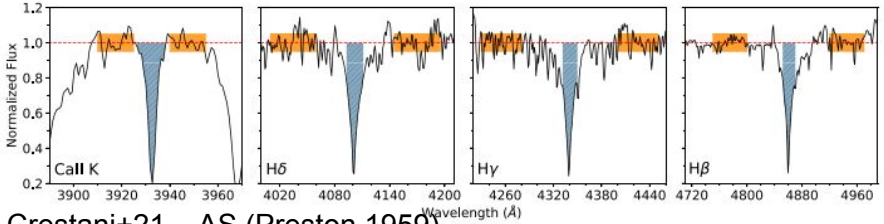


Figure 5. The sky distribution of our final RRL sample of 135,873 RRLs (115,410 type RRab and 20,463 type RRc stars) in Galactic coordinates, color-coded by metallicity, as shown in the color bar.

Li+23 (Fourier)

Low-resolution spectroscopy

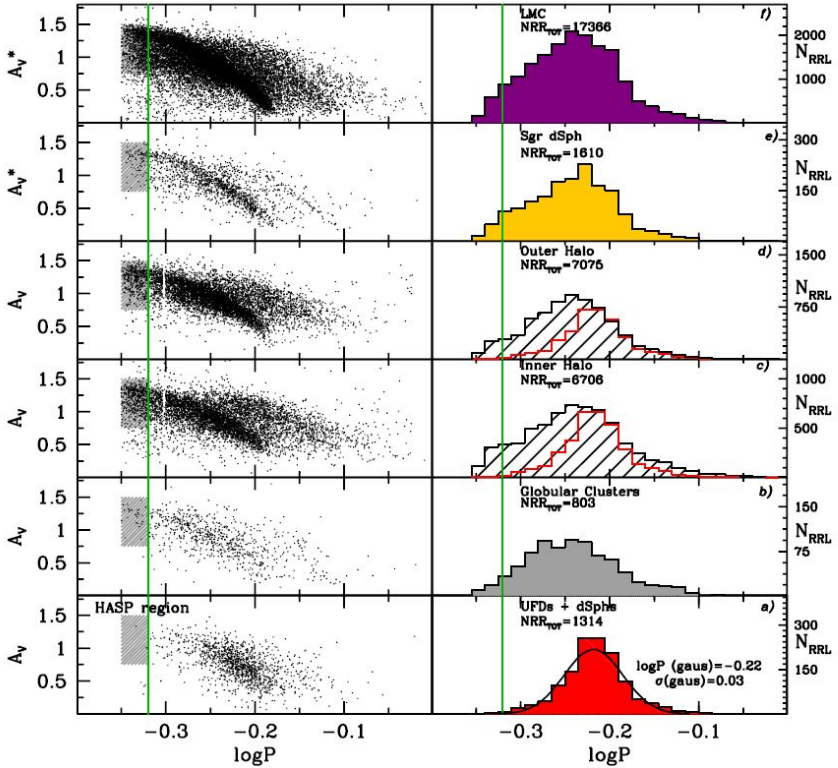


Crestani+21 ΔS (Preston 1959)

Galaxy evolution

- Stellar population tracers
- Chemical evolution

The importance of variable stars

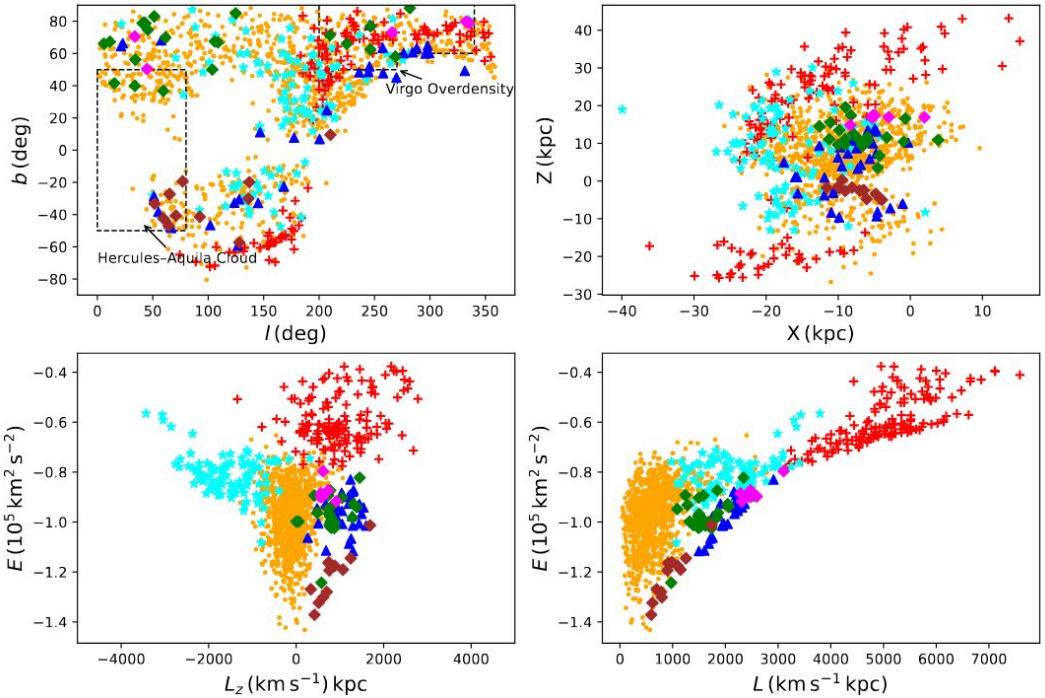


Fiorentino+15

Galaxy evolution

- Stellar population tracers
- Chemical evolution
- Building blocks

The importance of variable stars

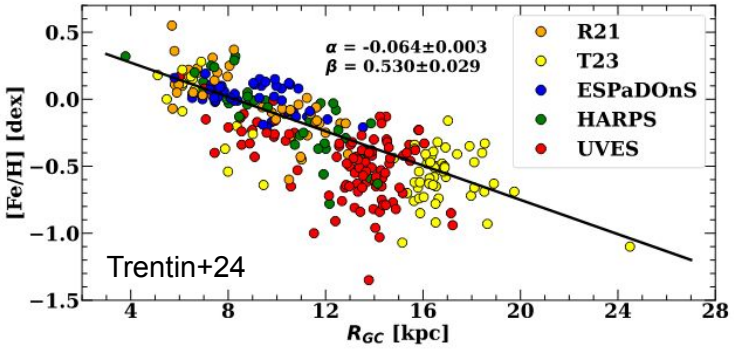


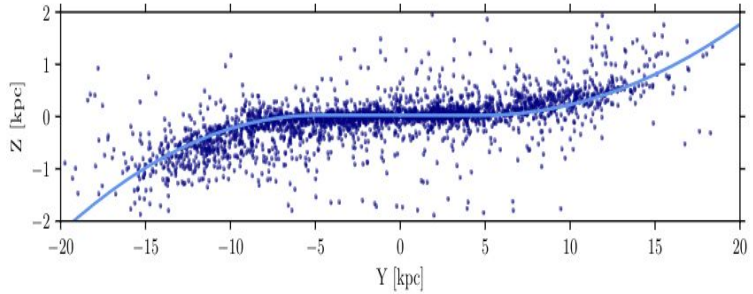
Galaxy evolution

- Stellar population tracers
- Chemical evolution
- Building blocks
- Mass assembly history

Wang+22

The importance of variable stars



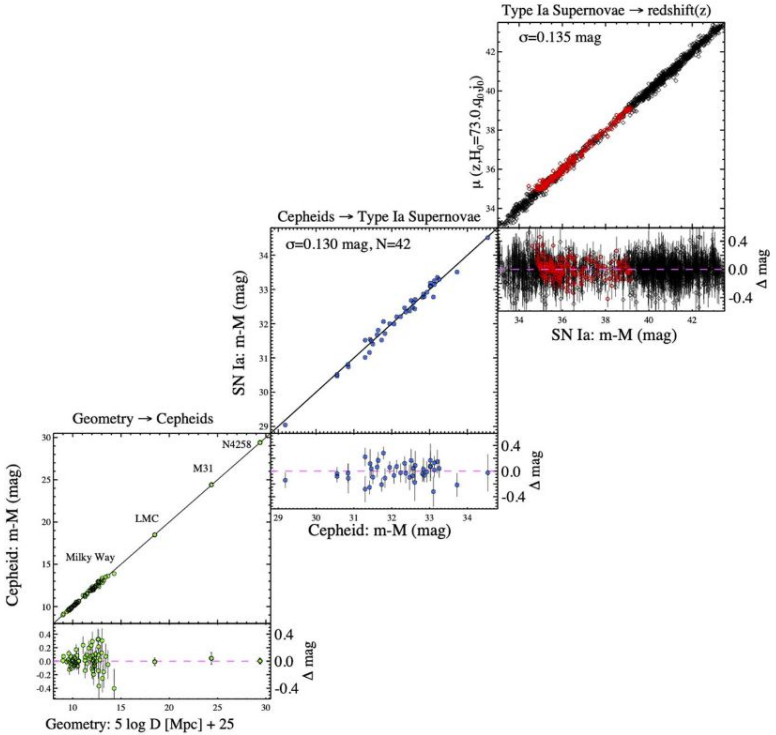


Lemasle+22

Galaxy evolution

- Stellar population tracers
- Chemical evolution
- Building blocks
- Mass assembly history
- MW structure and evolution

The importance of variable stars

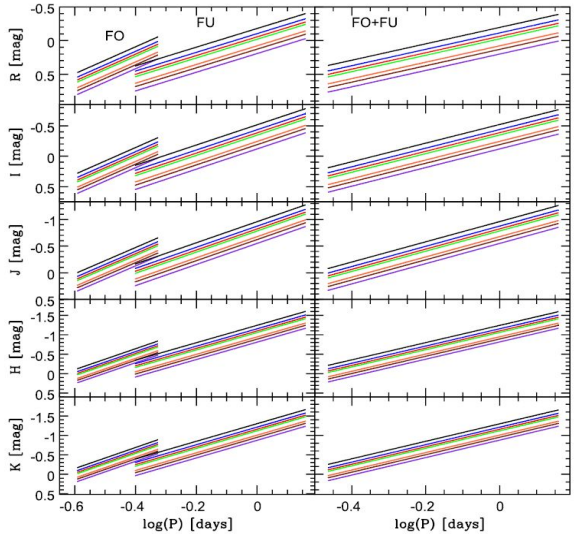


Riess+24

Galaxy evolution

- Stellar population tracers
- Chemical evolution
- Mass assembly history
- Stellar streams
- MW structure and evolution
- **Distance indicators**

The importance of variable stars

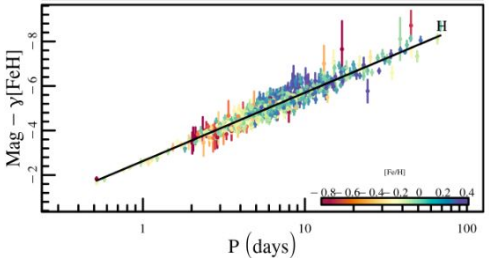


Marconi+15

Galaxy evolution

- Stellar population tracers
- Chemical evolution
- Mass assembly history
- Stellar streams
- MW structure and evolution
- **Distance indicators**

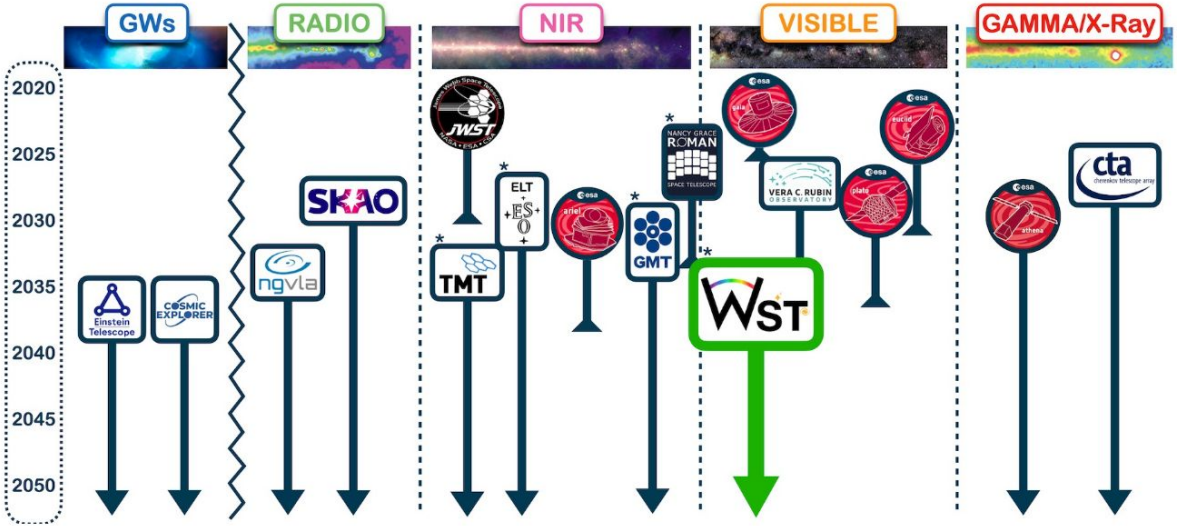
$$W_* = \alpha + \beta \cdot \log P_* + \gamma \cdot [Fe/H]$$



Trentin+24

Before WST…

- ✓ Gaia DR4, DR5
- ✓ Rubin/LSST
- ✓ Roman



WST White Paper 2024

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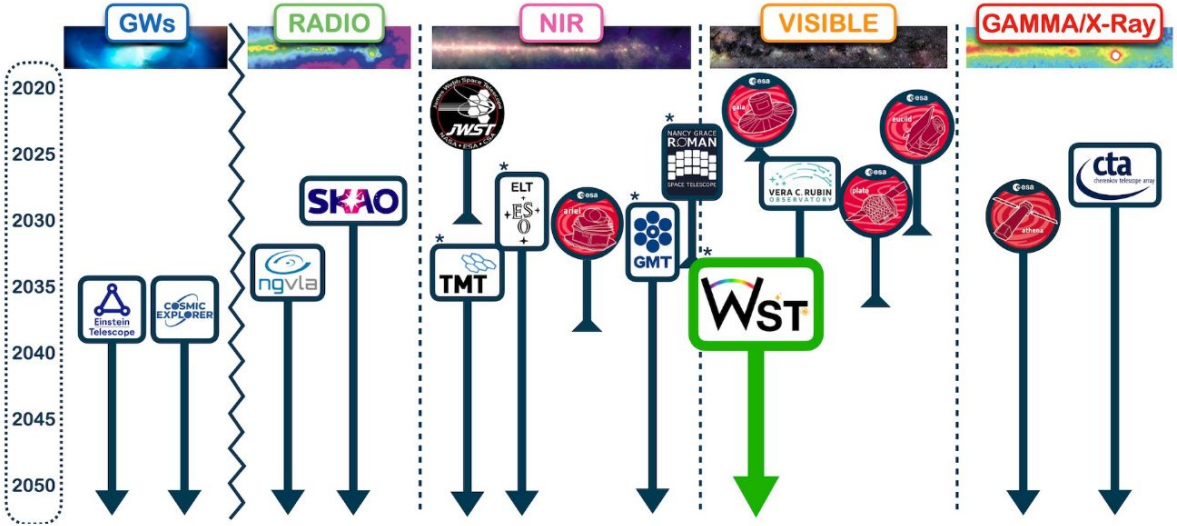
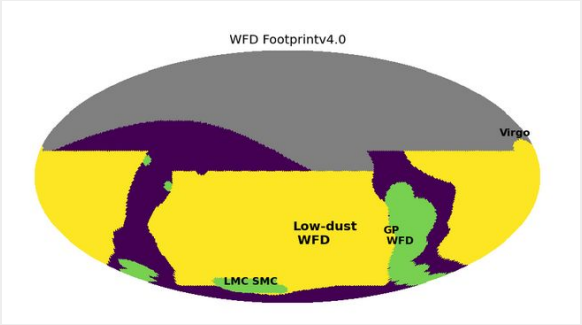


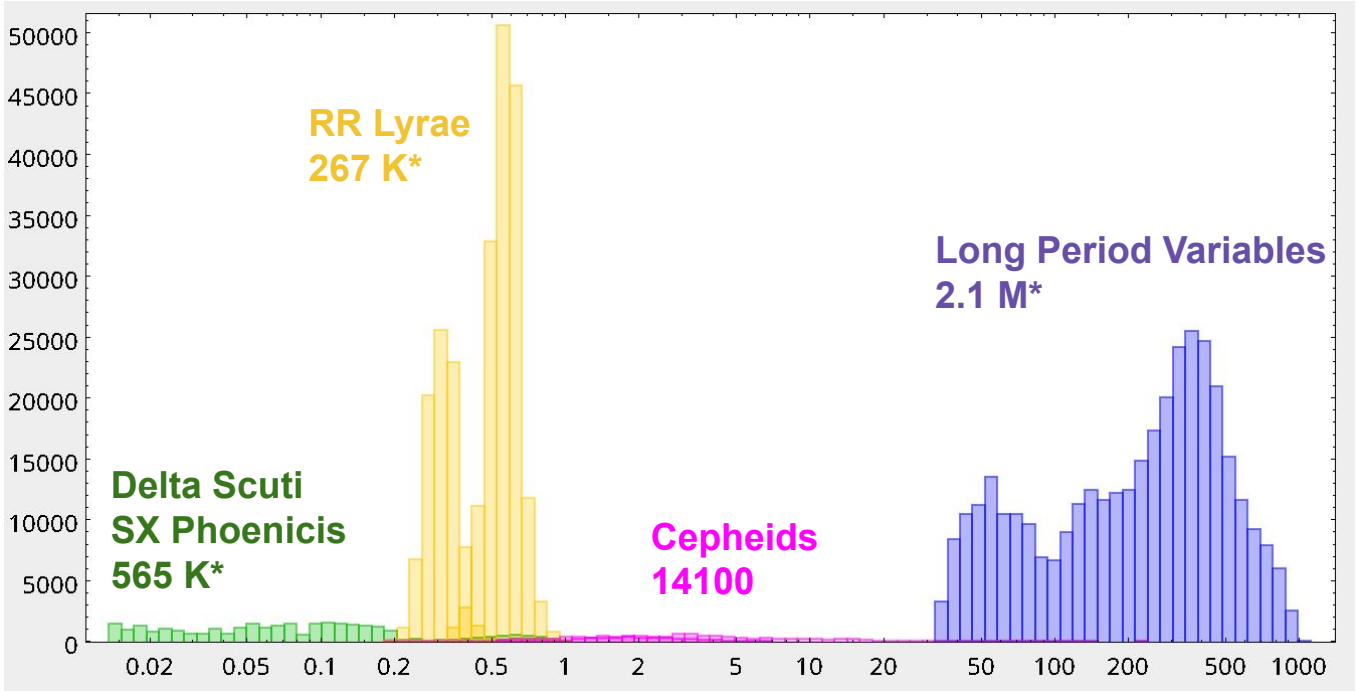
WST White Paper 2024



r ~ 24.5 mag (single epoch)

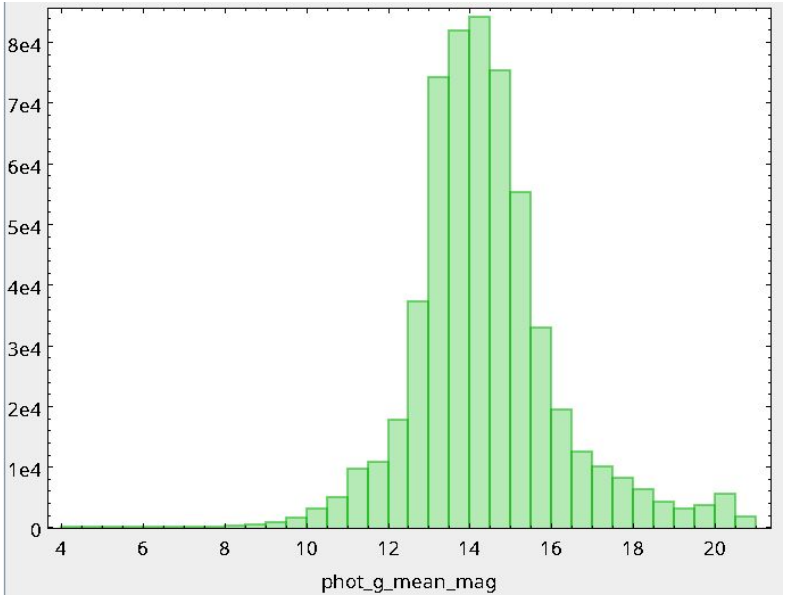
➜ RRL to ~ 500 kpc
➜ brightest Cepheids to 20 Mpc

Gaia variables

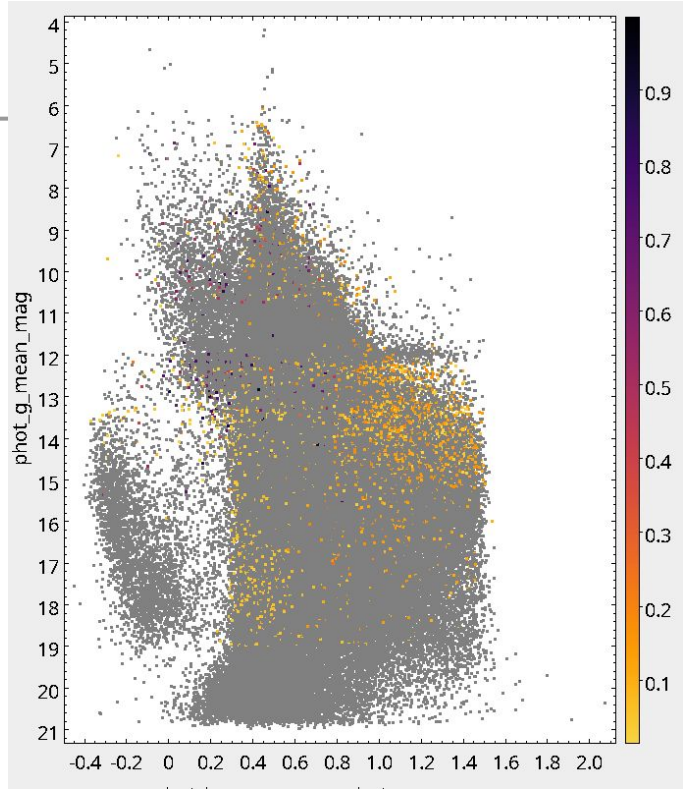


DEC < 20 deg

Short Period Variables



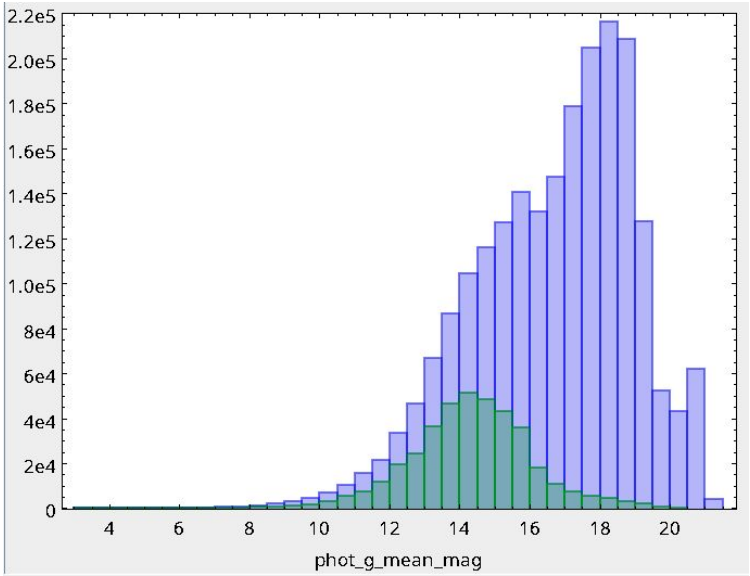
Relatively hot stars
MS - SGB stars
M_V ~ 2-3
Radial and non radial modes



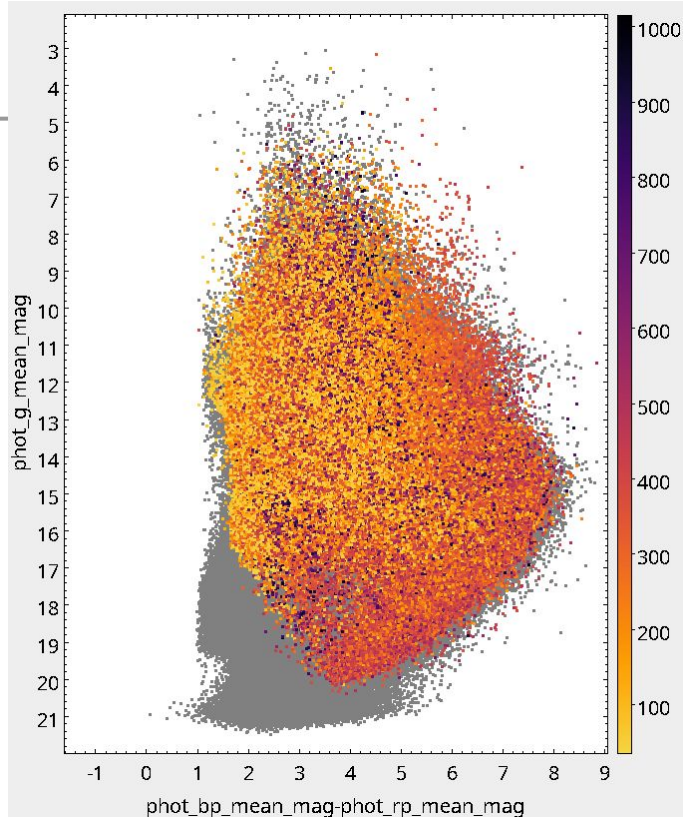
➜ stellar interiors
➜ rotation
➜ transition between a convective to radiative core

Huge amount in Rubin/LSST

Long Period Variables



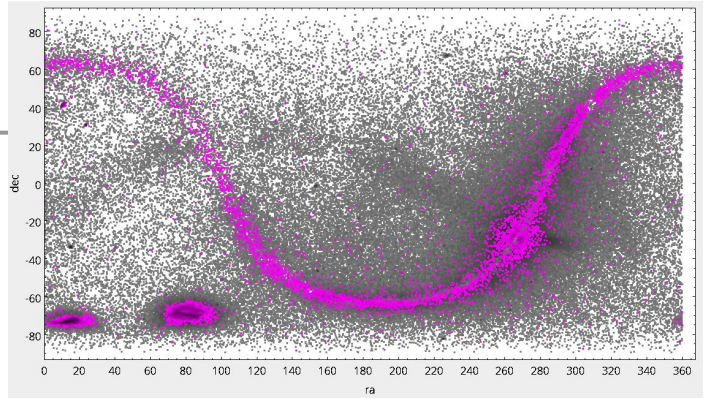
Cool stars
RGB - AGB stars
M_V ~ -4,-7



➜ intermediate-age population
➜ mass loss
➜ convection, thermal pulses

All galaxies within 1 Mpc with Rubin/LSST

4MOST

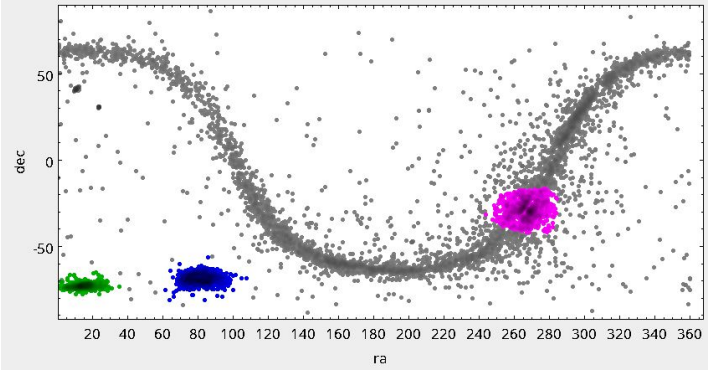


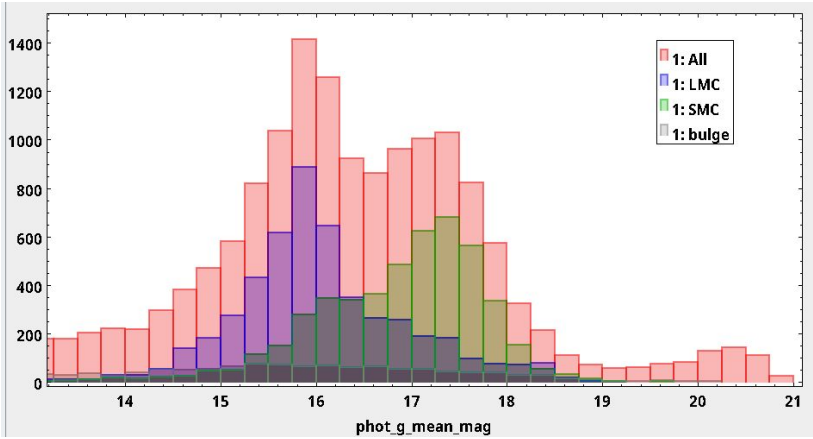
Galactic consortium surveys (HR and LR; The Messenger 175)
- **Halo**
- **Bulge+disc** (4MIDABLE; HR G<15.5 ~4x10^6 stars + deep fields: 800 Cepheids 13.5 < G < 15.5)
- **Magellanic Clouds** (1001MC; 36,000 RRL LR; 10000 Cepheids)

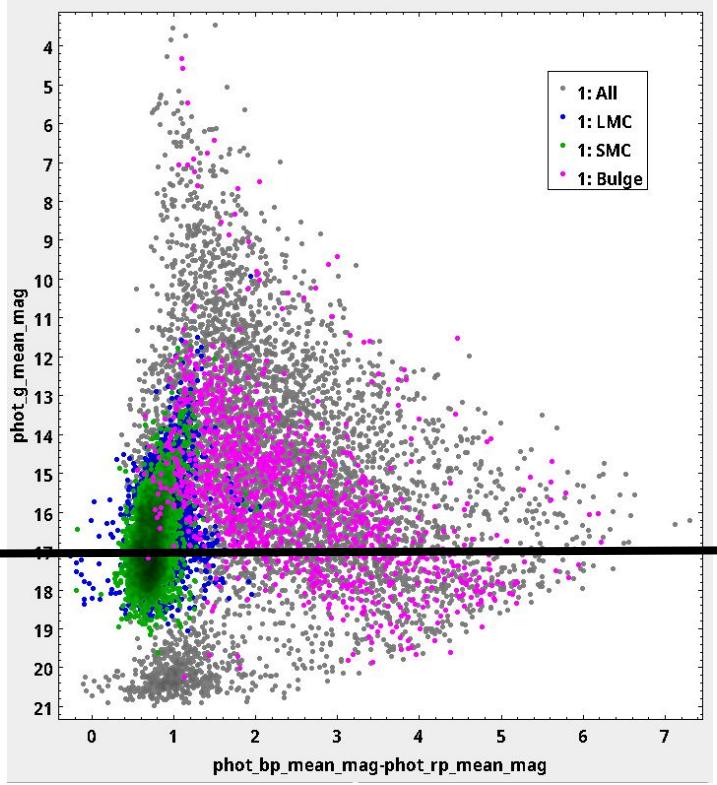
Community surveys (The Messenger 190)
Gaia RRLyrae Survey (4GRoundS), ~100,000 RRL stars expected

Survey of dwarf galaxies and their stellar streams: Small but fundamental (4DWARFS), 140,000 stars expected

Classical Cepheids

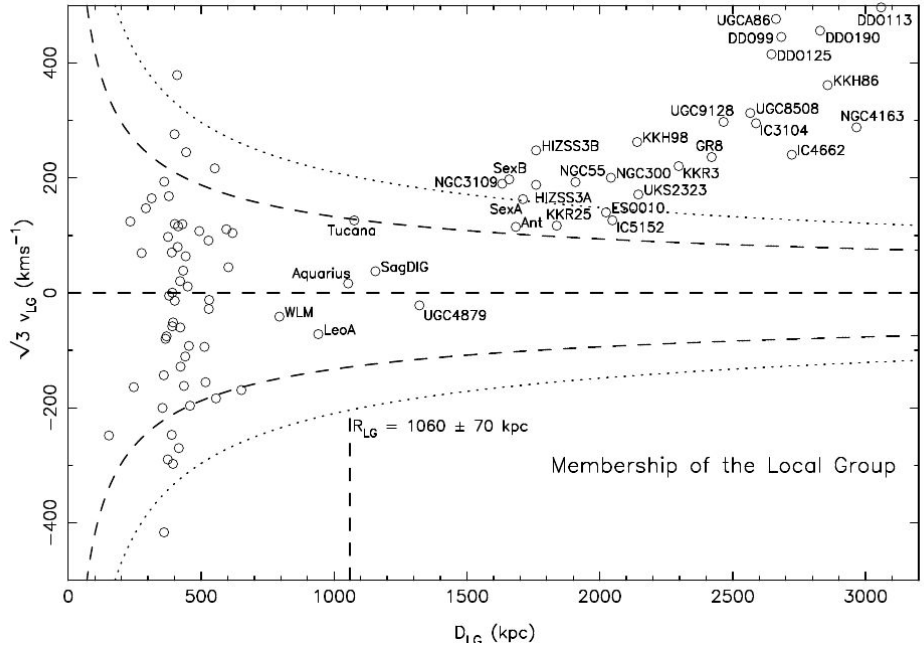






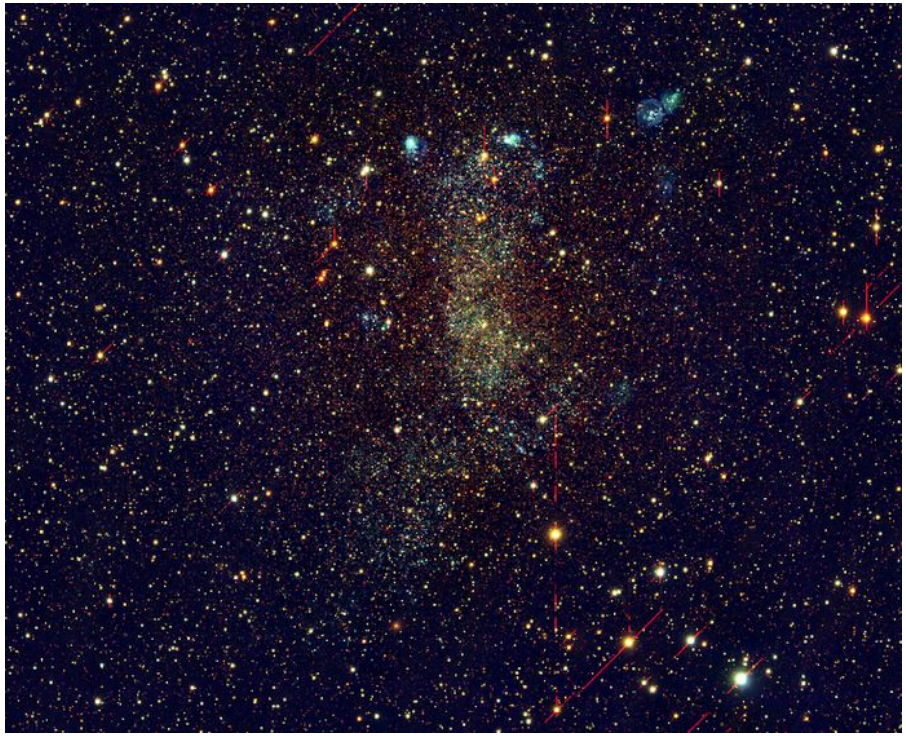
4most 4 hrHR limit

Cepheids: moving out

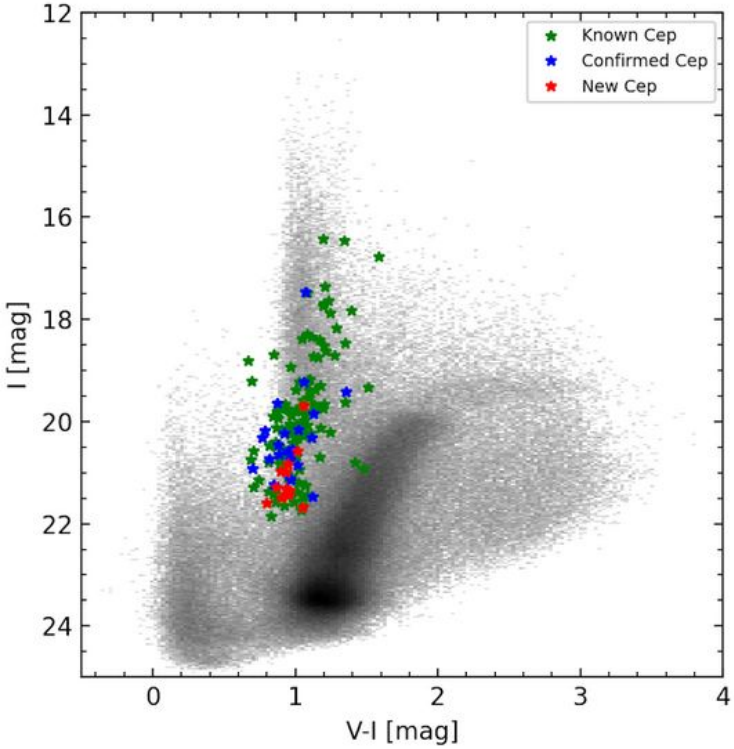


McConnachie 2012

Outside the Local Group: NGC 6822



2x2 sq. deg



Tantalo, MM in prep.

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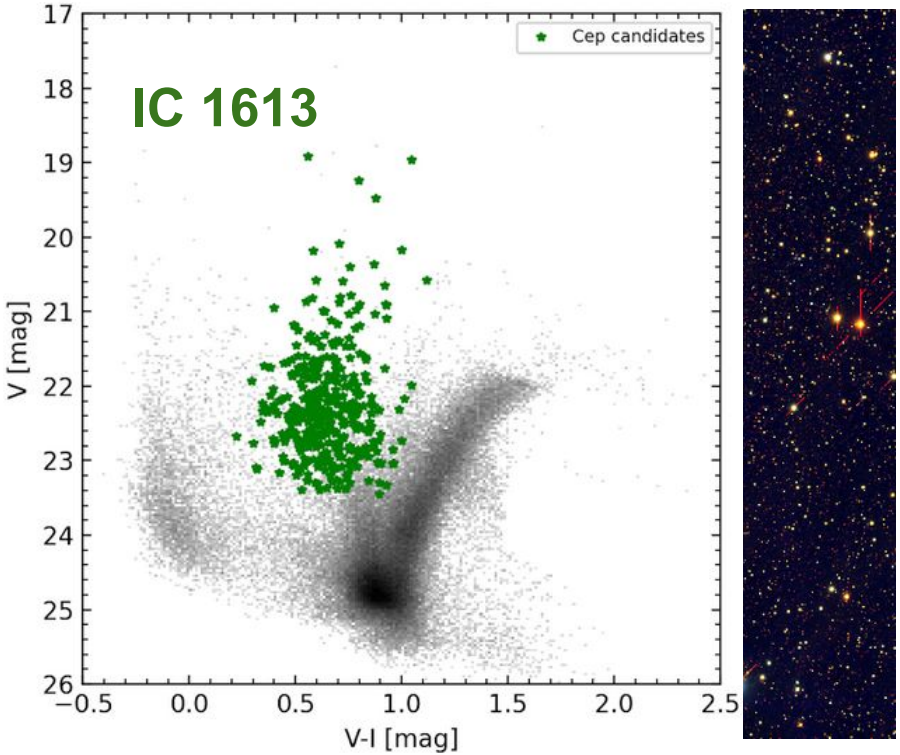

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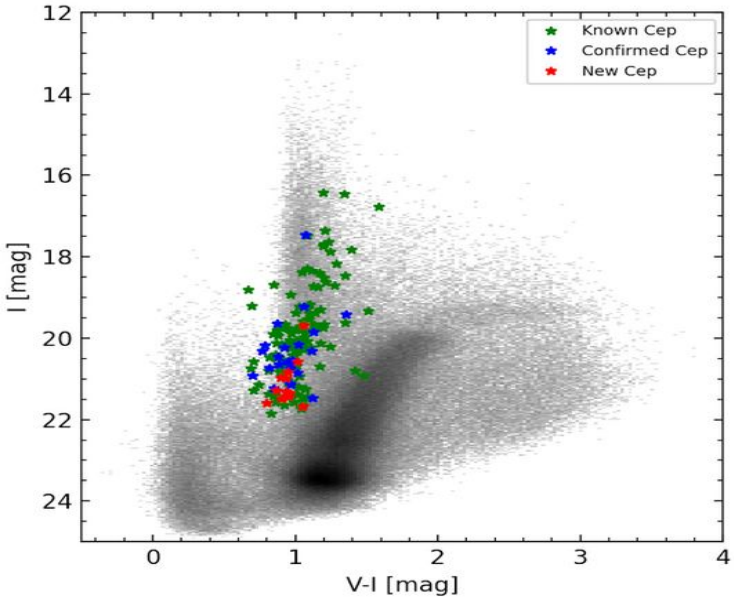
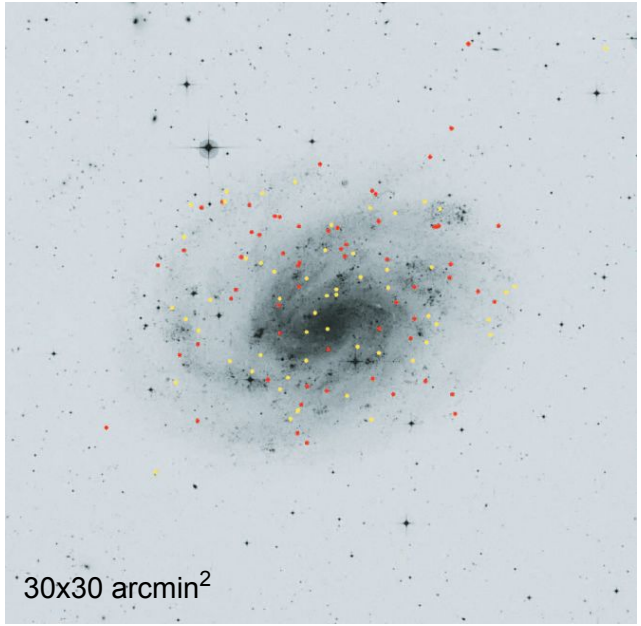
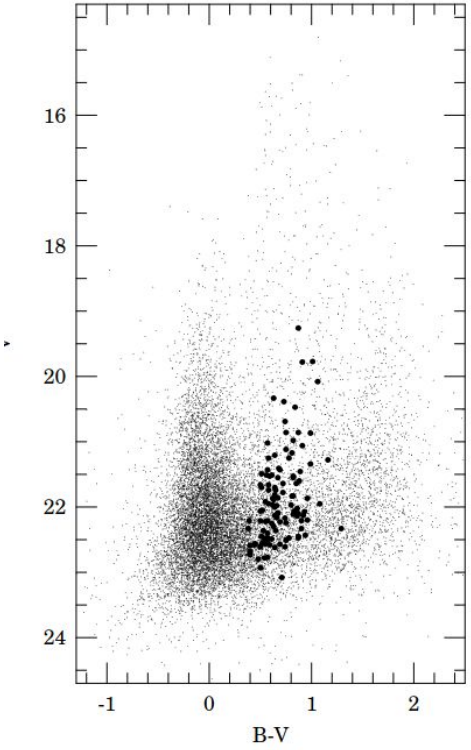


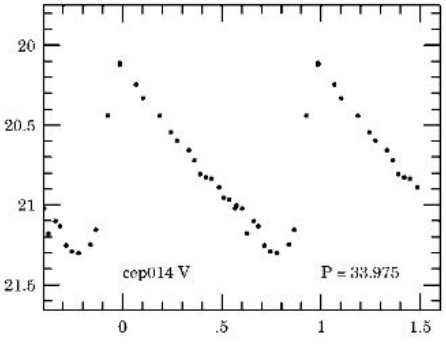
PLZ at low metallicity

Tantalo, MM in prep.

Outside the Local Group: NGC 300







Pietrzynski+02

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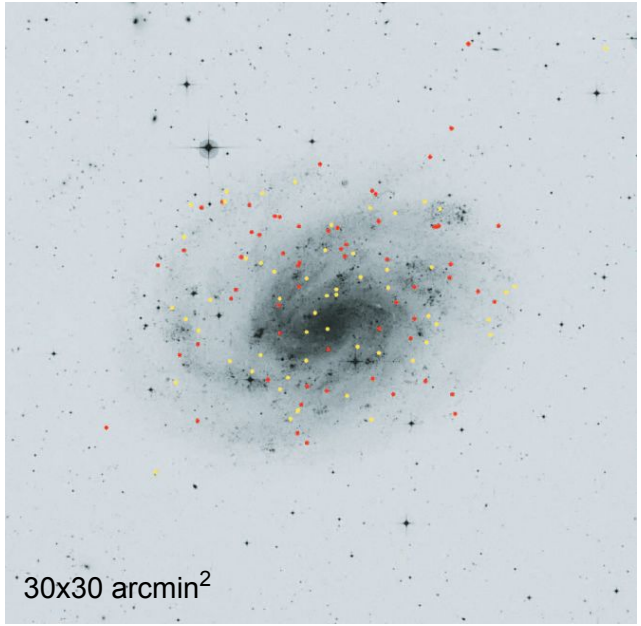
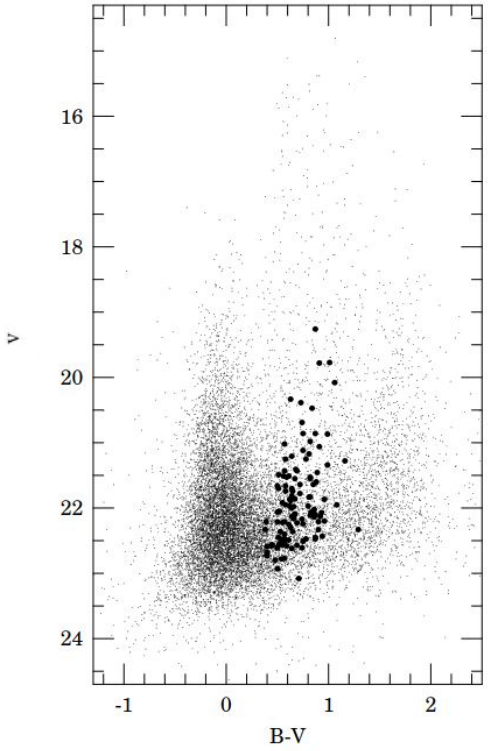
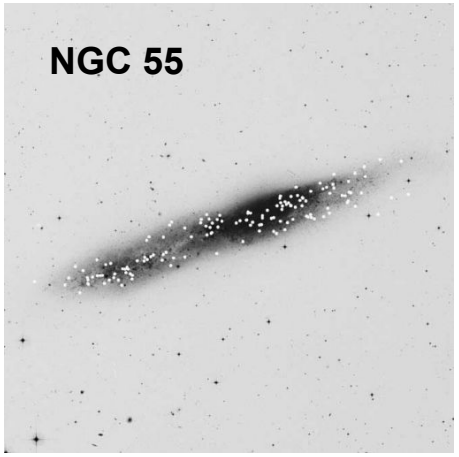
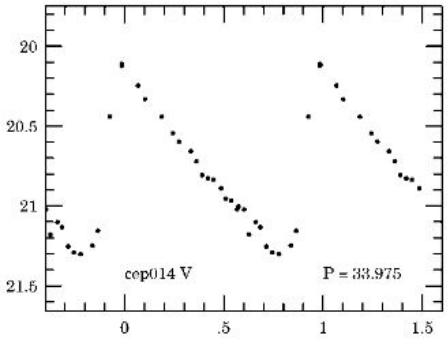


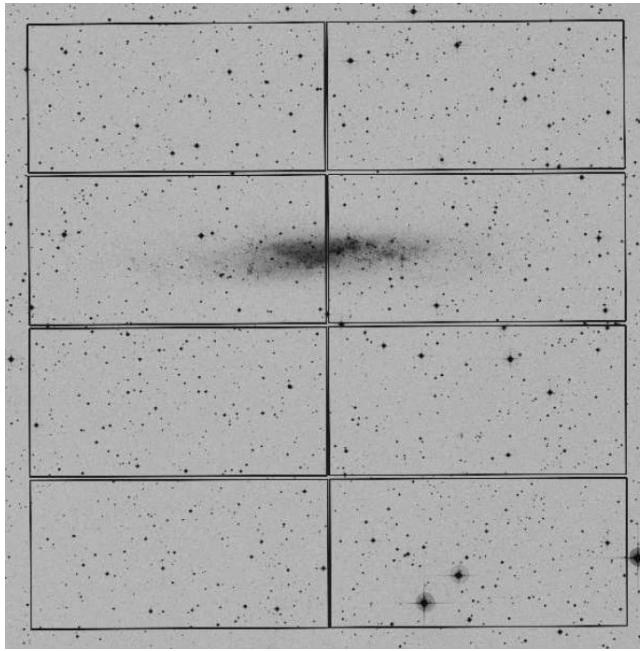


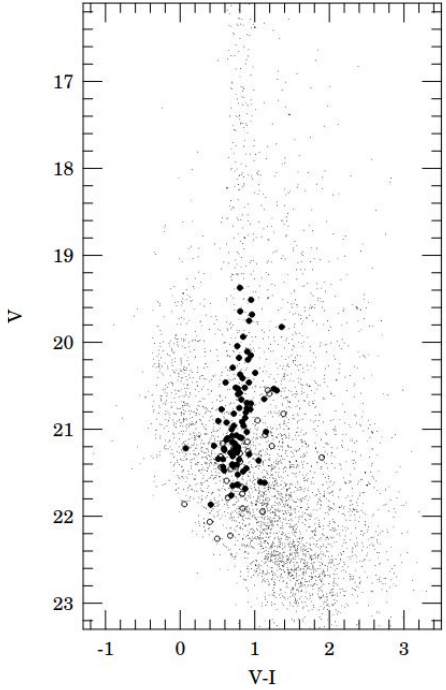


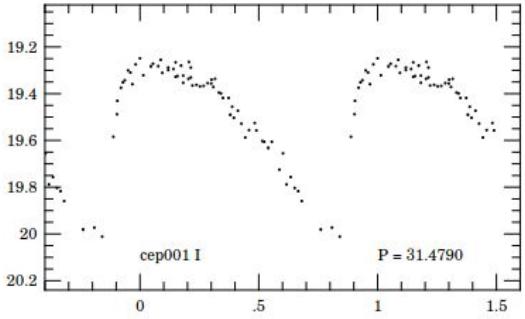


Pietrzynski+02

Outside the Local Group: NGC 3109







Probing star formation in different environments and other low-mass groups

Pietrzynski+06

On the observing strategy

Intrinsically small populations

- Anomalous Cepheids, Type II Cepheid, Ultra Faint Dwarfs, … Would require few fibers, possibly increasing the complexity ➜ limited time cost to derive **complete and homogeneous** samples and characterize a class and derive global conclusion

On the observing strategy

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Supernovae

- WST will be extremely efficient in characterizing the host galaxy a posteriori
- less efficient to allocate targets in real time. ➜ **Leave few fibers for Target of Opportunity**?

On the observing strategy

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Binary stars

- Is the velocity dispersion (hence the dark matter estimate) in dwarf galaxies artificially increased by wide binary stars? ➜ **Would benefit from repeated observations**

Distant RR Lyrae

RR Lyrae are difficult spectroscopic targets:
- relatively bright: M_V ~ 0.6 mag
- relatively short period: 0.25 < P < 1
- large T_{eff} and Log g variation

➜ cannot use long exposure times (> 1800s)
➜ cannot easily stack spectra

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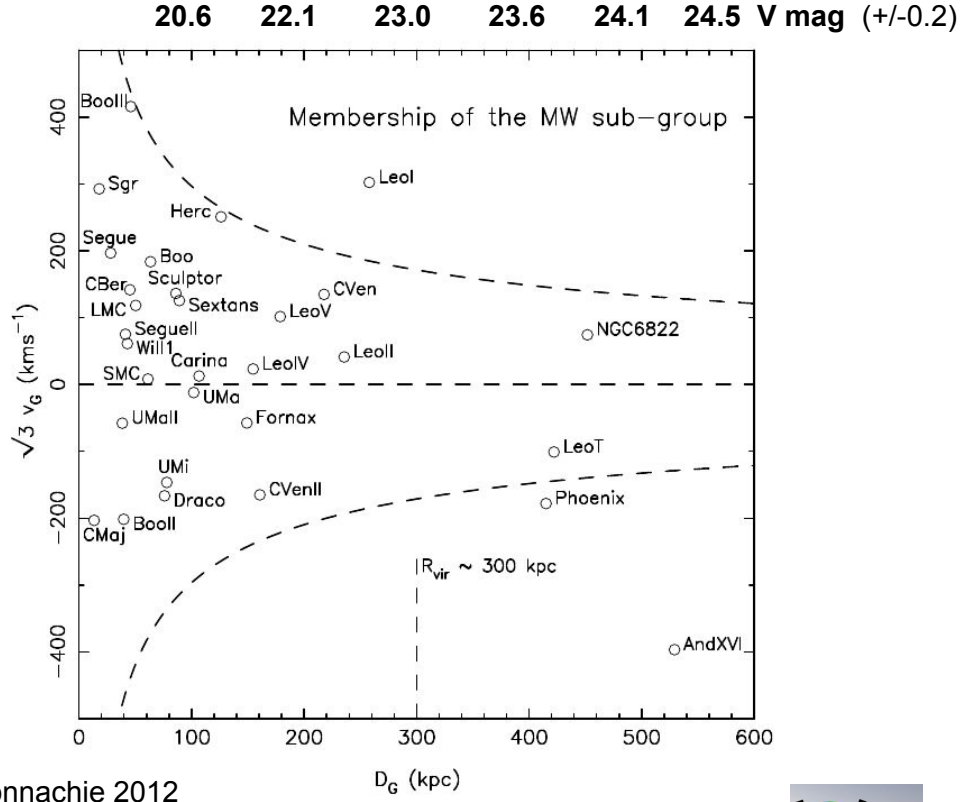
An HR spectroscopic follow-up of faint RRL discovered by Rubin/LSST (V > 20 mag) is complicated

➜ radial velocities of distant substructures + ΔS



McConnachie 2012

Conclusions

- WST will be an incredibly complex machine:
  Build on other projects experience and expertise

- Flexibility
  →ToO
  →redundancy of targets

- Repeatability/monitoring