A chemical close-up of the Local Group galaxies

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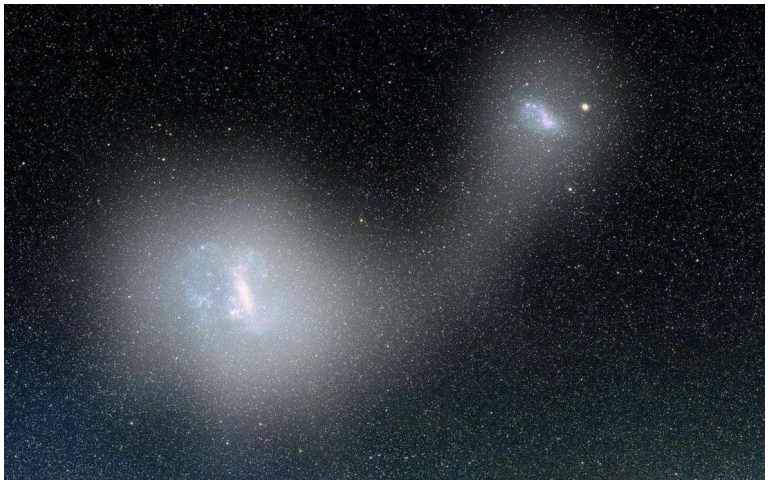
WST – Surveying the Universe in the 2040's and beyond

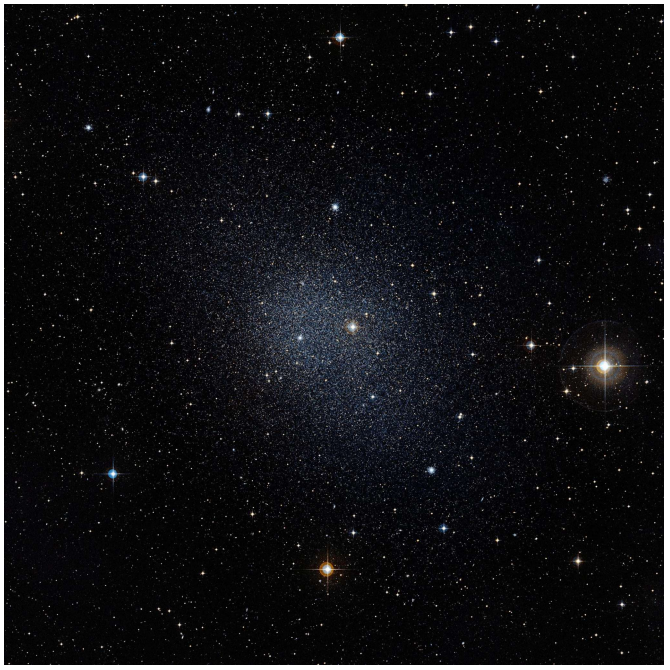


LMC / SMC

- Gas-rich, irregular galaxies
- Wide metallicity and age distributions
- Opportunity to study interacting galaxies

Dwarf Spheroidal galaxies (dSph)

- Metal-poor, gas-poor systems
- Ideal prototypes of the accreted systems that have contributed to form the Milky Way



Ultra Faint Dwarf galaxies (UFD)

- Dark matter dominated stellar systems
- Ideal laboratory to yield of the first zero-metallicity stars

TWO INTERESTING (FOR ME) SCIENCE CASES

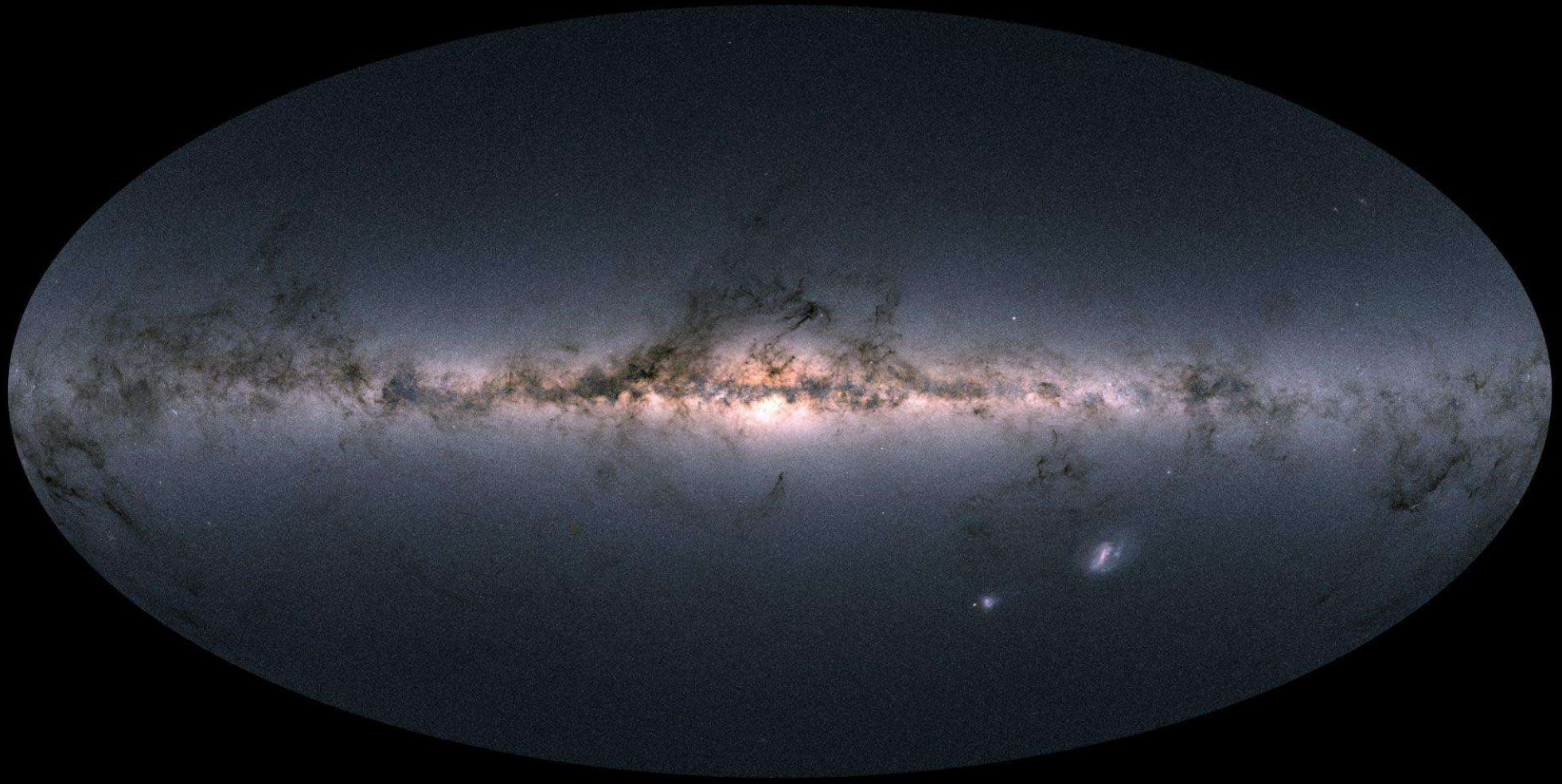
The assembly history
of the Local Group galaxies

The chemical DNA
of the Local Group galaxies

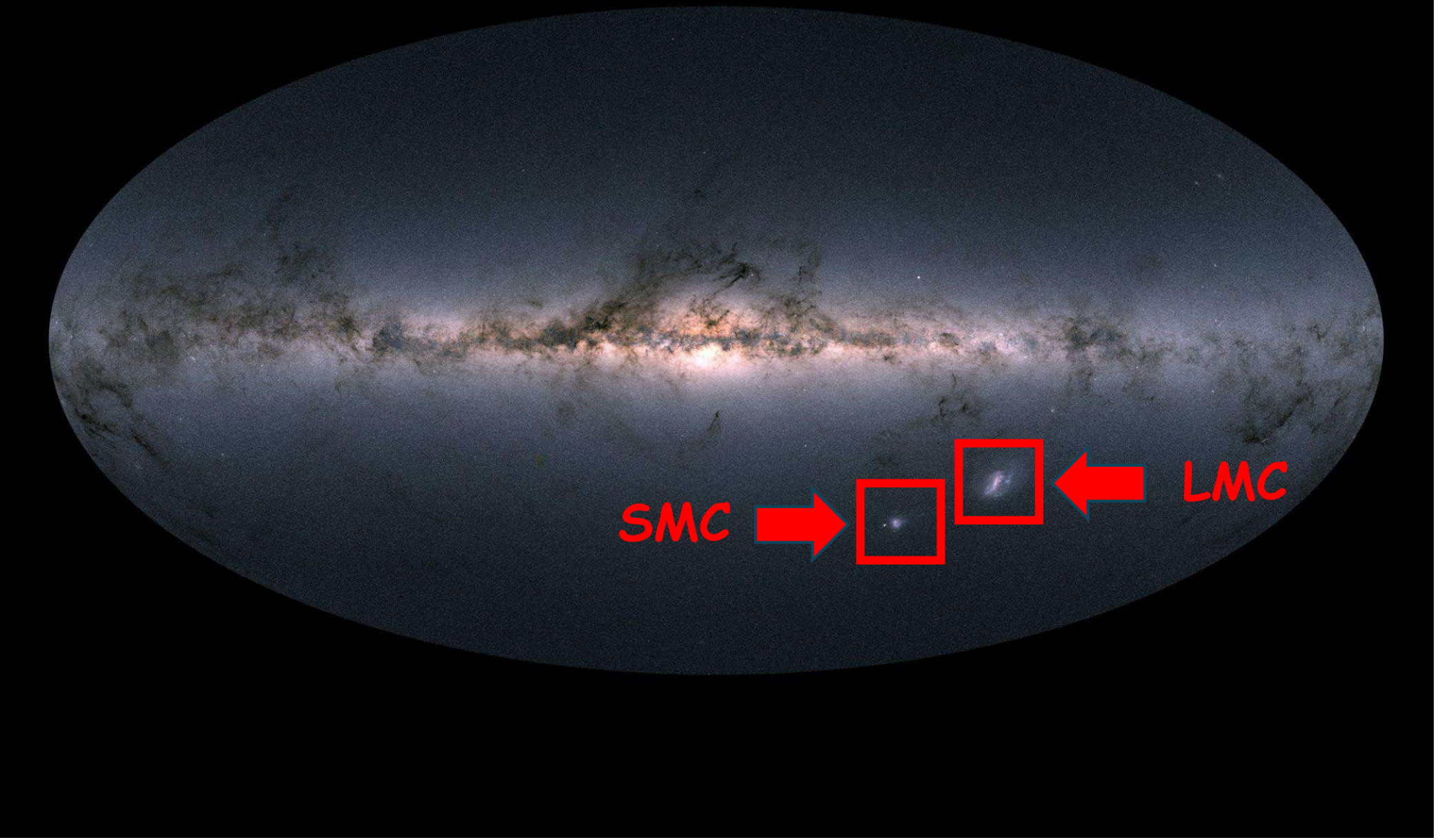
(1) THE ASSEMBLY HISTORY OF THE LOCAL GROUP GALAXIES

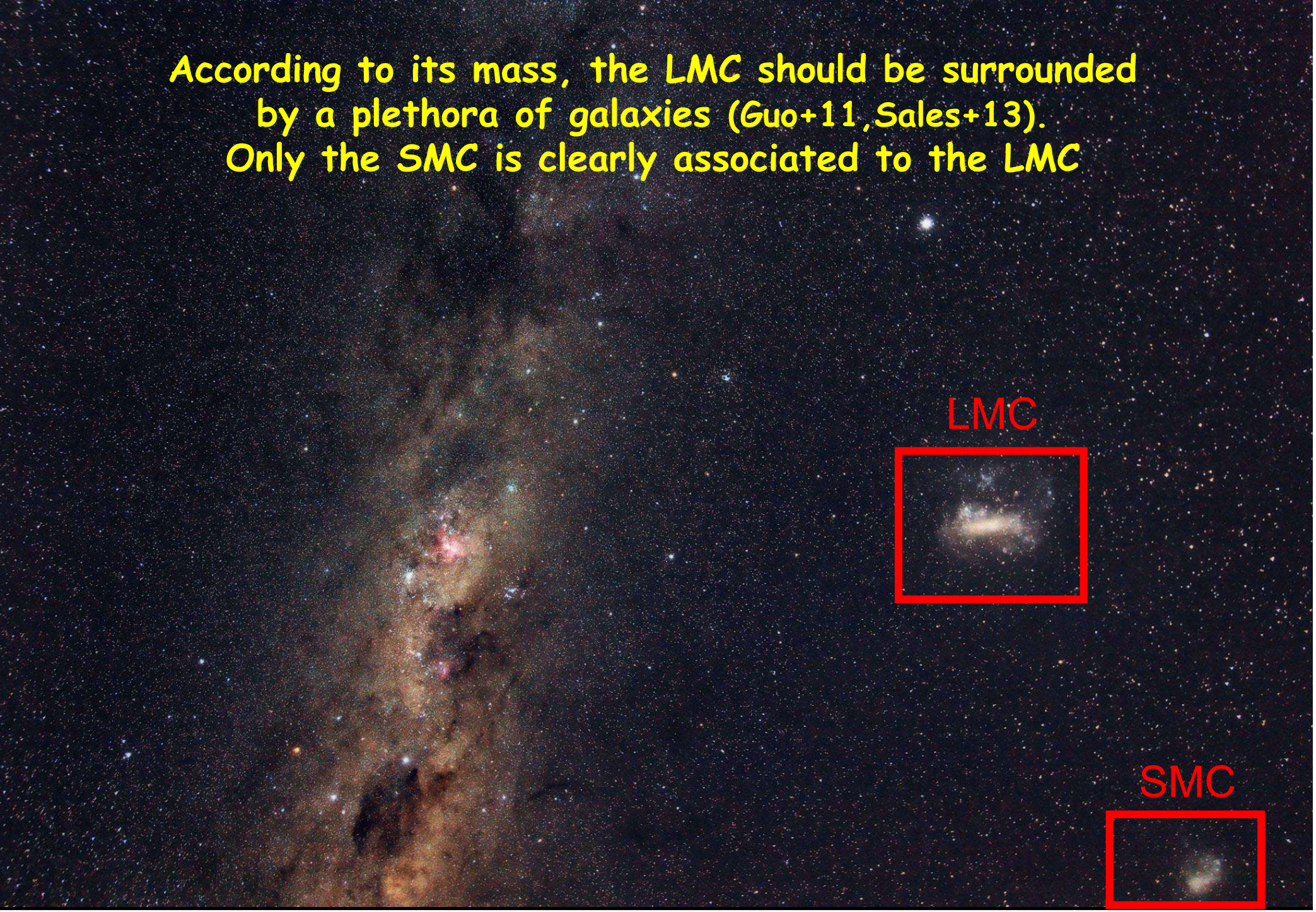

GAIA has revealed the main merger events
occuring in the history of the Milky Way
Gaia-Enceladus … but also
Sequoia, Thamnos, Helmi streams..

The Local Universe : a window into the process of hierchical mass assembly on all scales



In the search of satellites of satellites
LMC and SMC cover the role of the main actors




According to its mass, the LMC should be surrounded
by a plethora of galaxies (Guo+11,Sales+13).
Only the SMC is clearly associated to the LMC
LMC
SMC

Detection of an accreted globular cluster in the LMC using chemical tagging

nature astronomy

LETTERS

https://doi.org/10.1038/s41550-021-01493-y

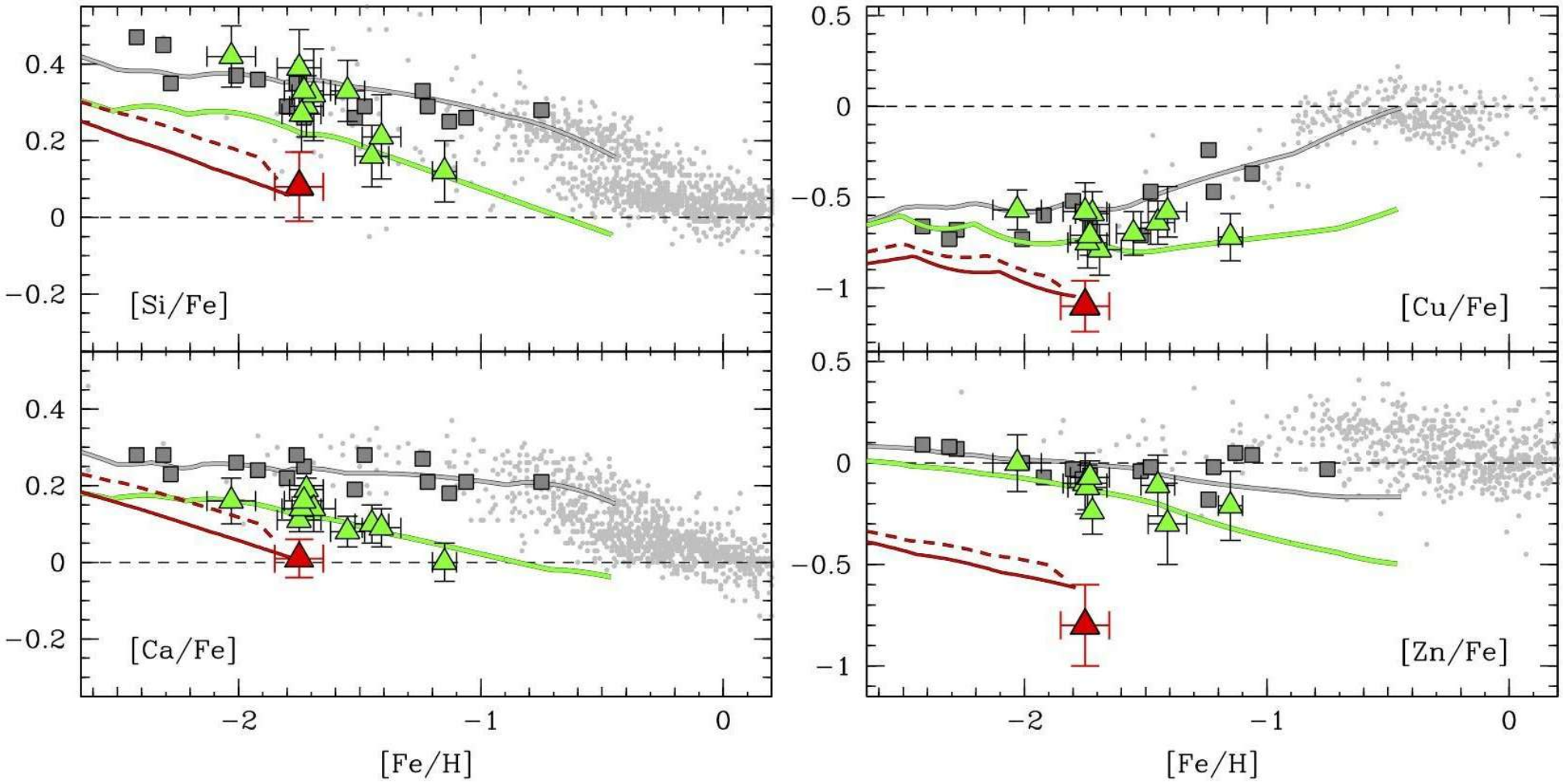
Check for updates

A relic from a past merger event in the Large Magellanic Cloud

A. Mucciarelli[1,2] ✉, D. Massari[2,3], A. Minelli[1,2], D. Romano[2], M. Bellazzini[2], F. R. Ferraro[1,2], F. Matteucci[4,5,6] and L. Origlia[2]

A LMC old globular cluster with an anomalous chemistry: formed in a dissolved LMC satellite with a different star formation history

Mucciarelli+21



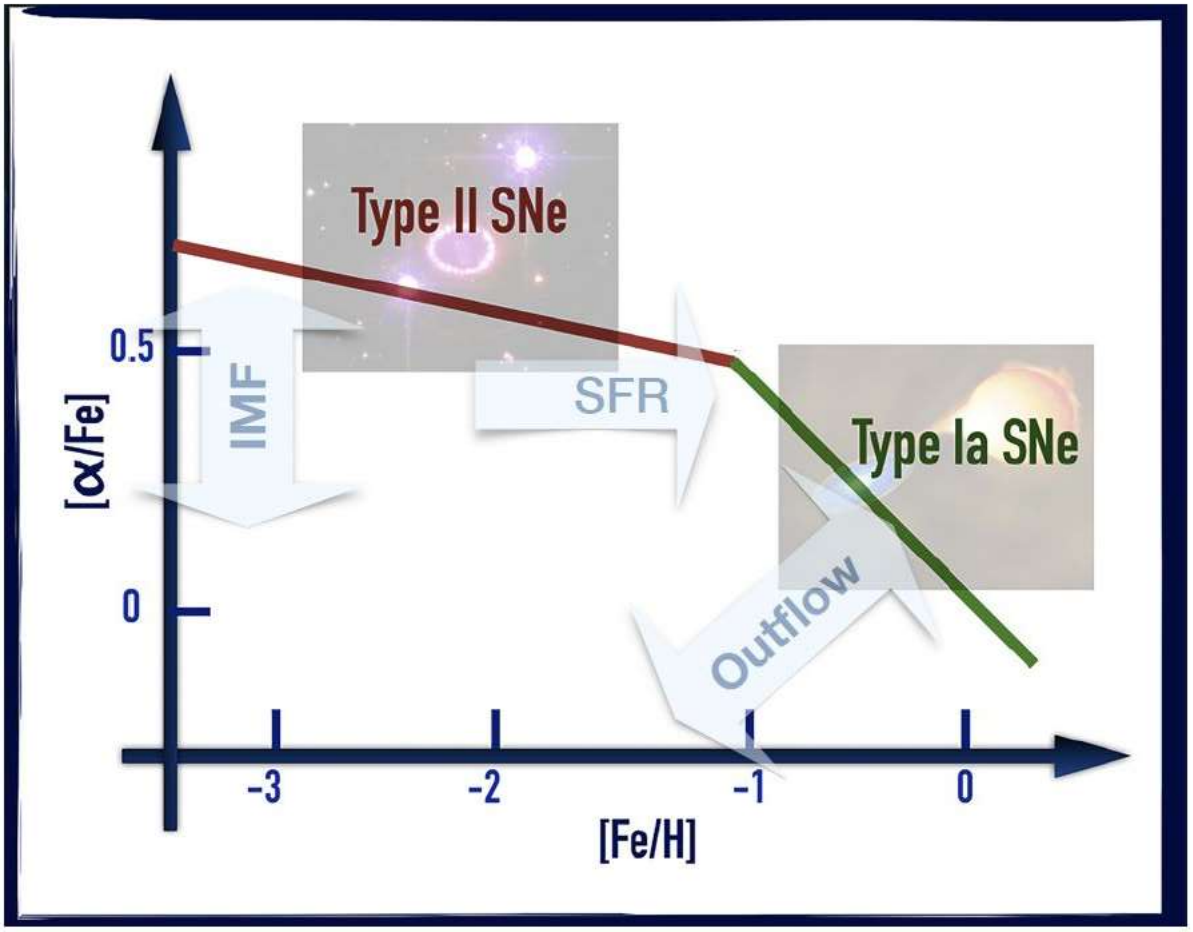
We can reconstruct the assembly history also in other galaxies but we need ….

- **High number statistics** to search for stellar groups with anomalous chemistry with respect to the bulk of stars in the parent galaxy

- **Several elements** to sample different nucleosynthesis paths (chemical tagging)

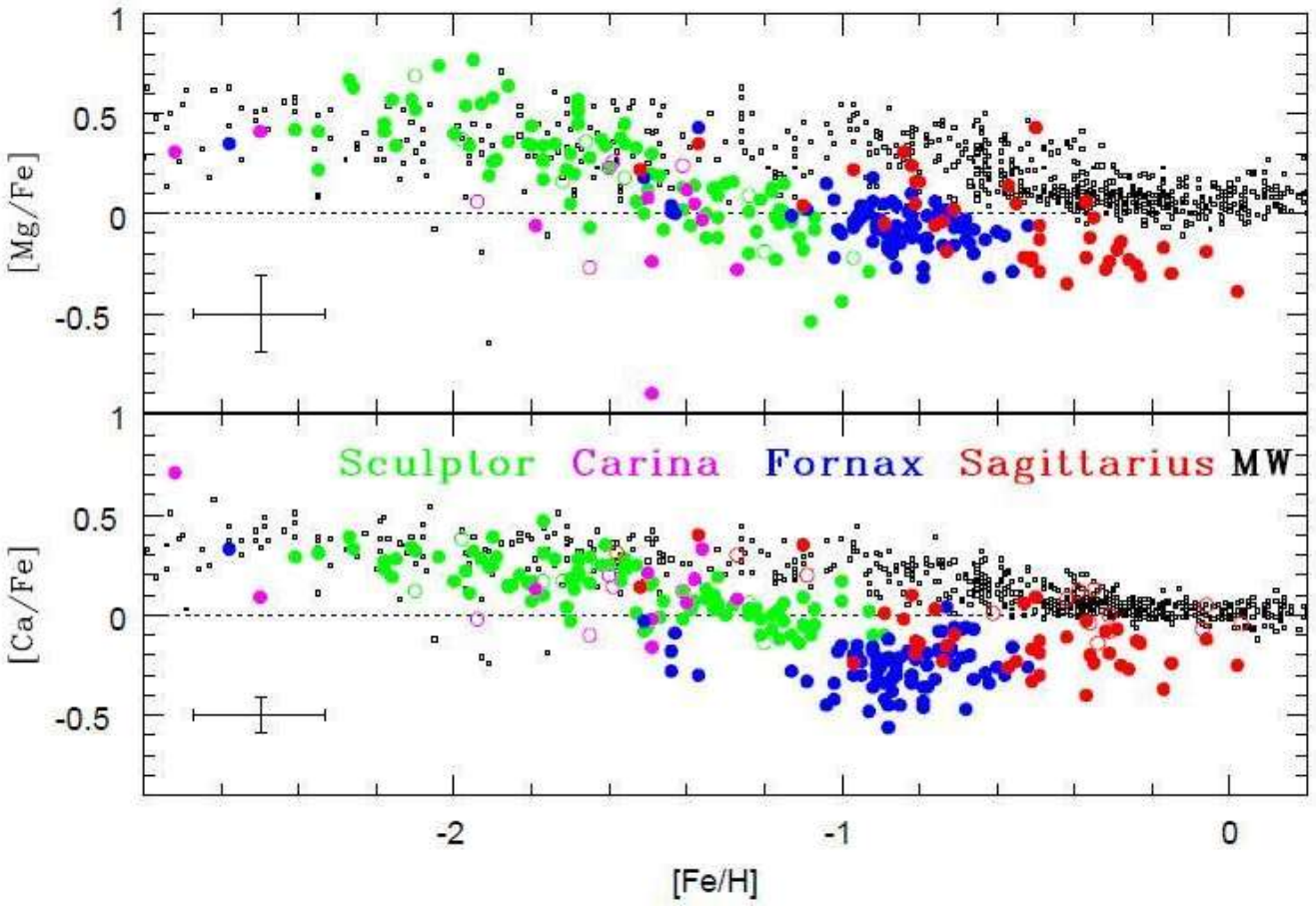
(2) THE CHEMICAL DNA OF THE LOCAL GROUP GALAXIES

[α/Fe] is the classical diagnostic of SFR and IMF …



[α/Fe] is the classical diagnostic of SFR and IMF …

Tolstoy+09



Other chemical elements, less investigated, can provide insights about the SFR and IMF in low-luminosity galaxies

AN EXAMPLE OF A NEW ACTOR ON THE STAGE … ZINC

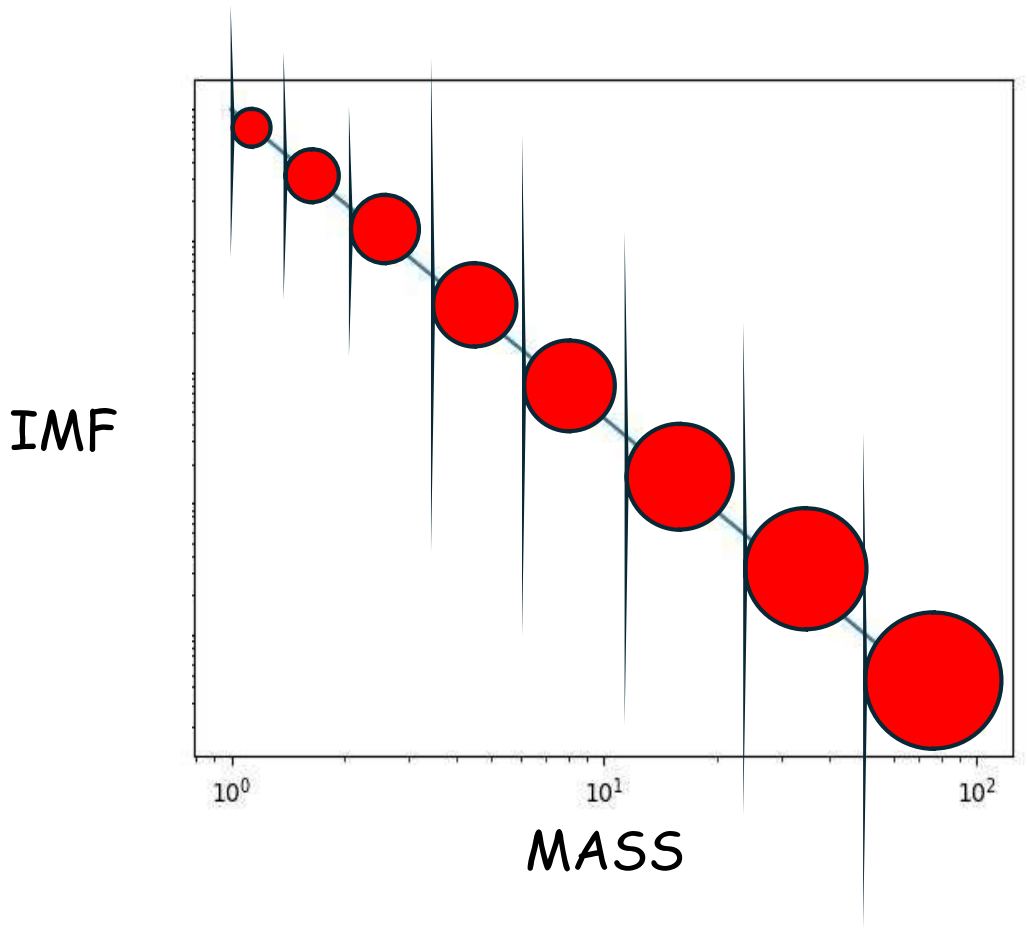
Zinc is produced (for [Fe/H] < -1) almost totally by hypernovae

HYPERNOVAE

- Significantly more energetic than standard CC-SNe
- Associated to stars with initial stellar masses larger than 30-35 Msun (i.e. Kobayashi+06, Nomoto+13)

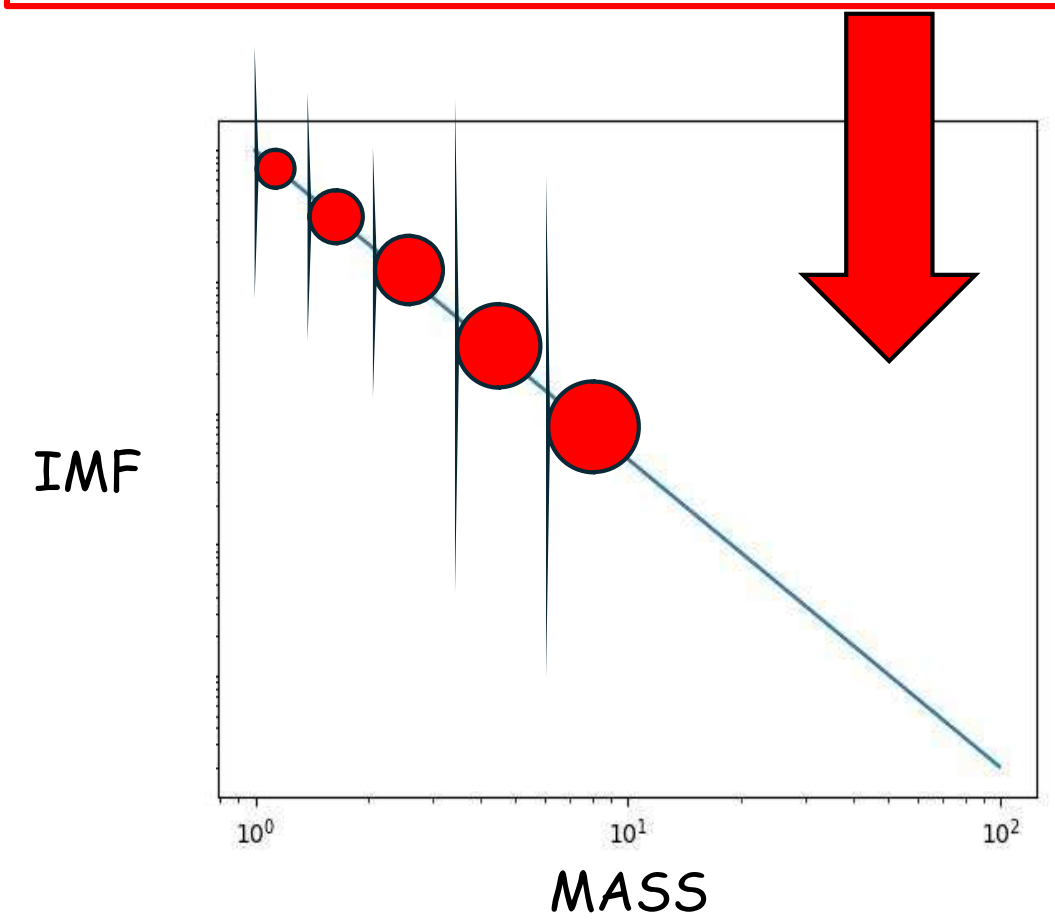
Zinc as an excellent tracer of the contribution of the high mass stars

Small mass galaxies with low star formation rates can have lower upper mass limits for the IMF.



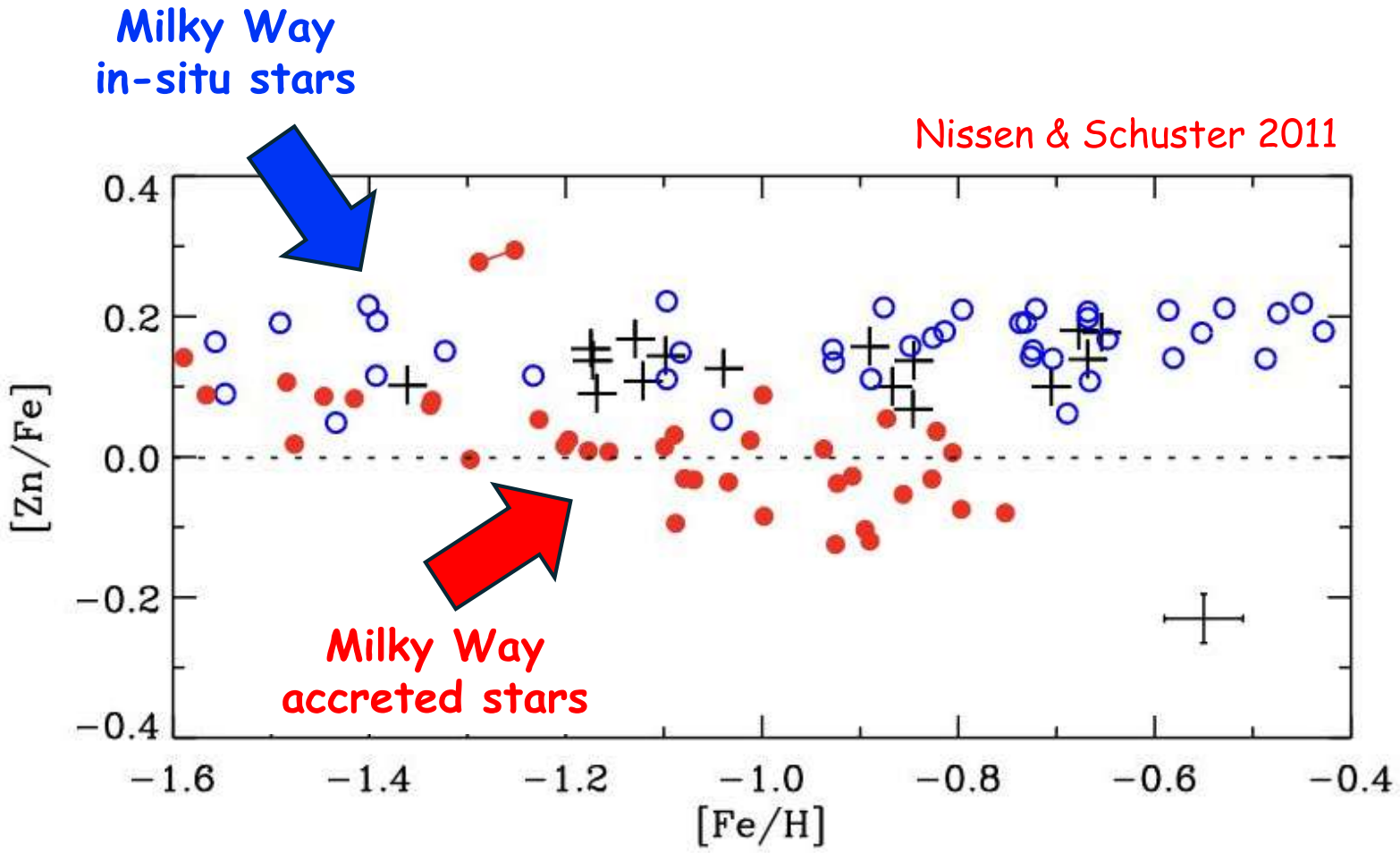
Small mass galaxies with low star formation rates can have lower upper mass limits for the IMF.

The contribution of high-mass stars to the chemical enrichment can be reduced or suppressed
= low [Zn/Fe]



In galaxies with low star formation rates:

- the contribution of hypernovae is reduced or suppressed
- [Zn/Fe] is lower than the Milky Way



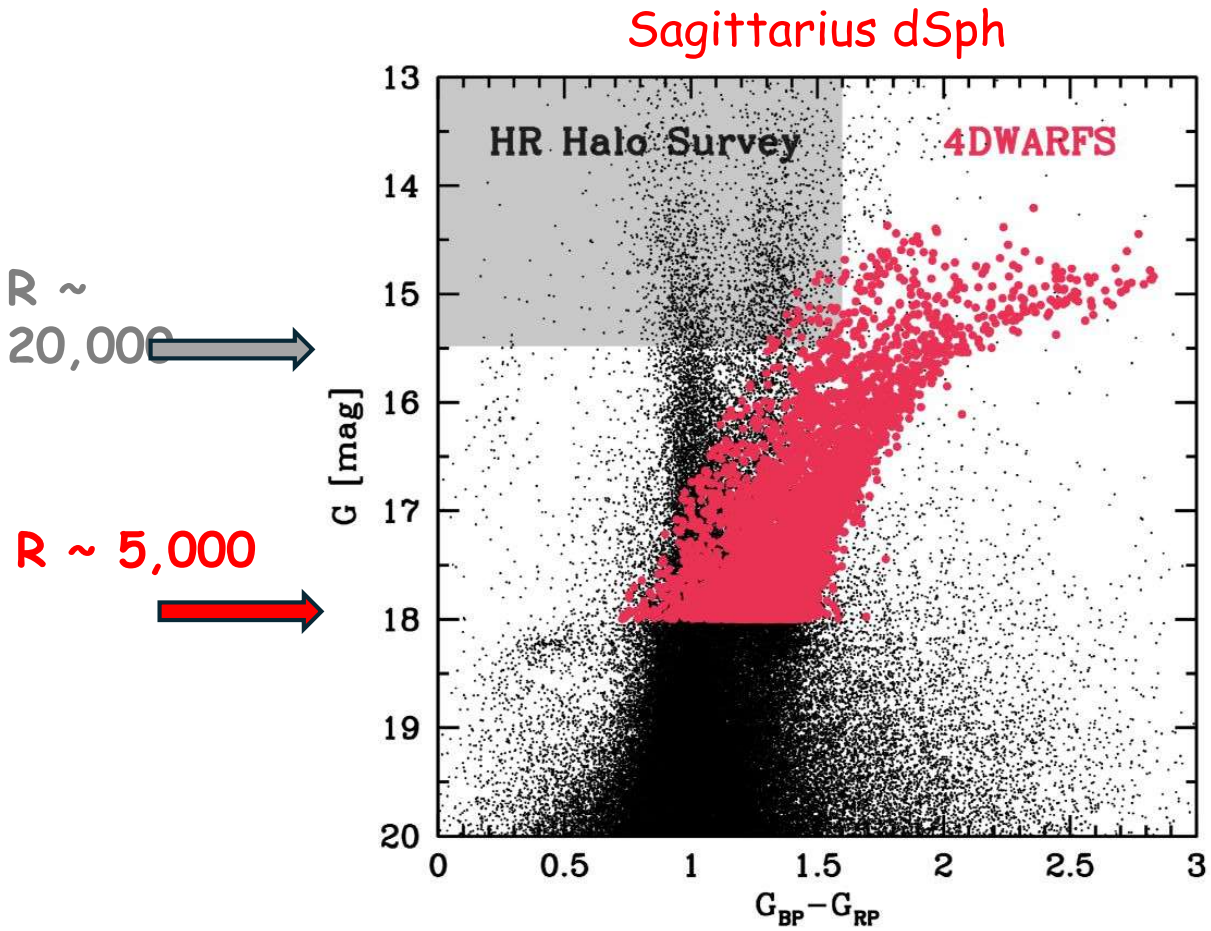
- The main Zinc line is at 4810 A
- No information about most of the dSph and the UFD

To measure Zn abundances in systems characterized by different star formation efficiencies we need

- **Suitable spectral range** (Zn @4810 A)
- **High spectral resolution**
- Capability to reach **faint magnitudes** ($G > 18$) to measure also giant stars in UFDs

NEXT STEPS: 4MOST

- 4DWARFS survey (PI: Skuladottir), targets: Sagittarius, Sculptor, Fornax
- 1001 MCs (PI: Cioni), targets: LMC and SMC



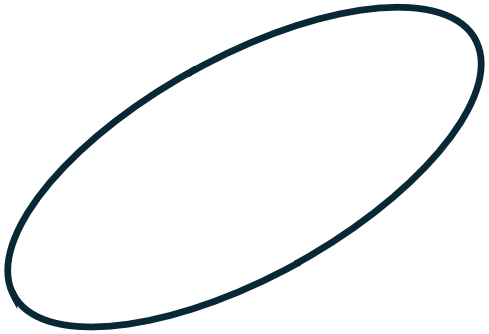
NEXT STEPS:
MOONS

MOONS-GTO: Milky Way satellites (Coordinator: Mucciarelli)

- 30 nights over 5 years (3 target galaxies. LMC, SMC, Sgr)
- I-band (R~9000) and H-band (R~20,000) spectroscopy

LMC

6 nights, ~30,000 stars

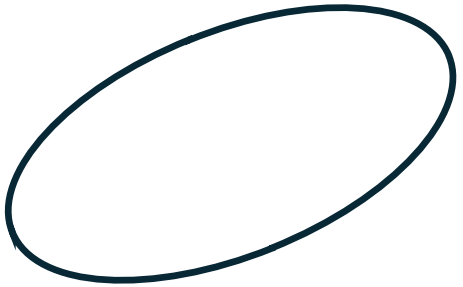


SMC

6 nights, ~25,000 stars

Sgr

6 nights, ~15,000 stars



Conclusions

For several science cases related to small galaxies in the Local group we need

- Large statistics to observe and quantify rare sub-populations
- Large coverage to sample poorly-studied key elements (i.e. Zinc)
- To reach faint magnitudes (17 < G < 22)

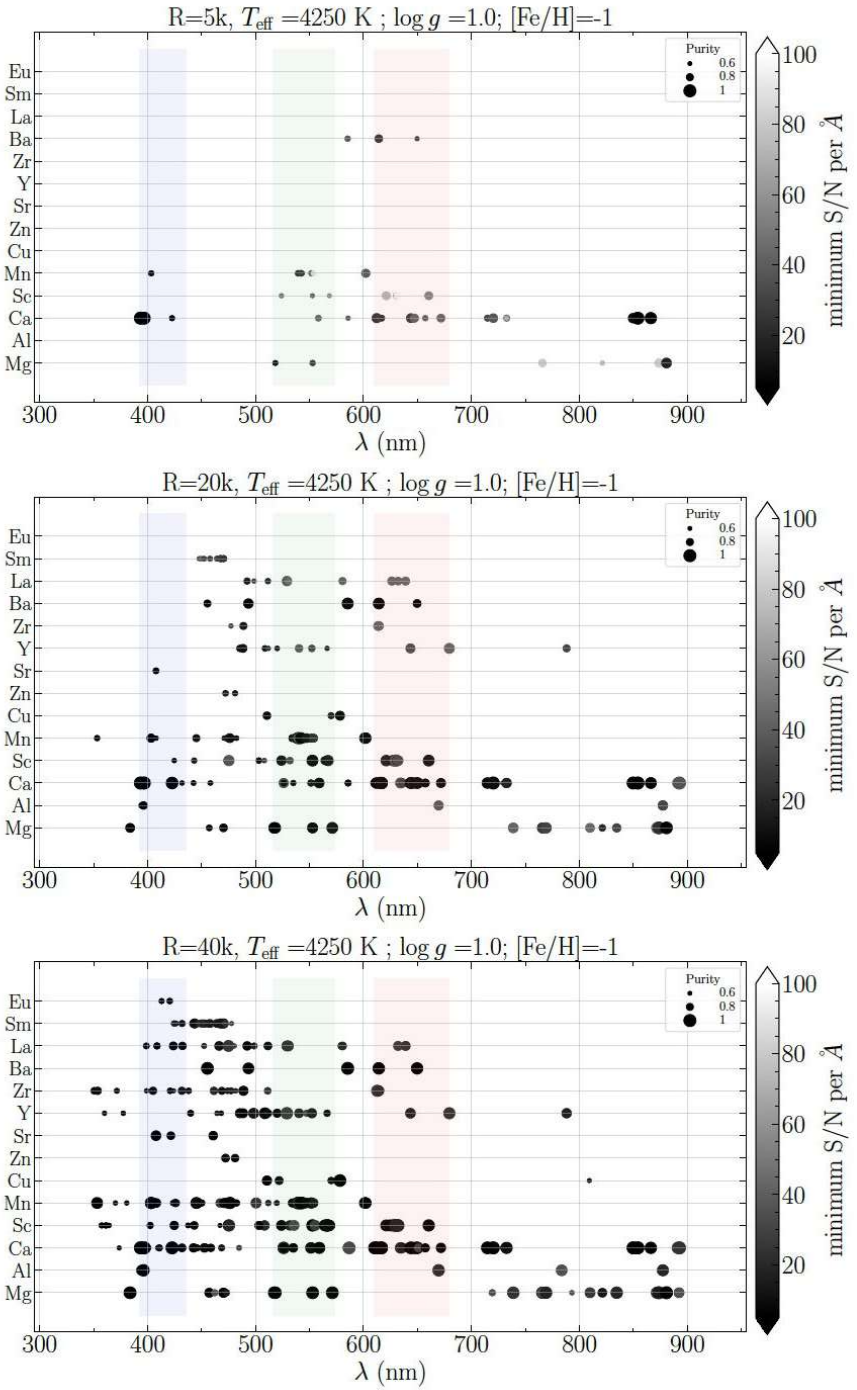
(3) FIRST (VERY METAL-POOR) STARS

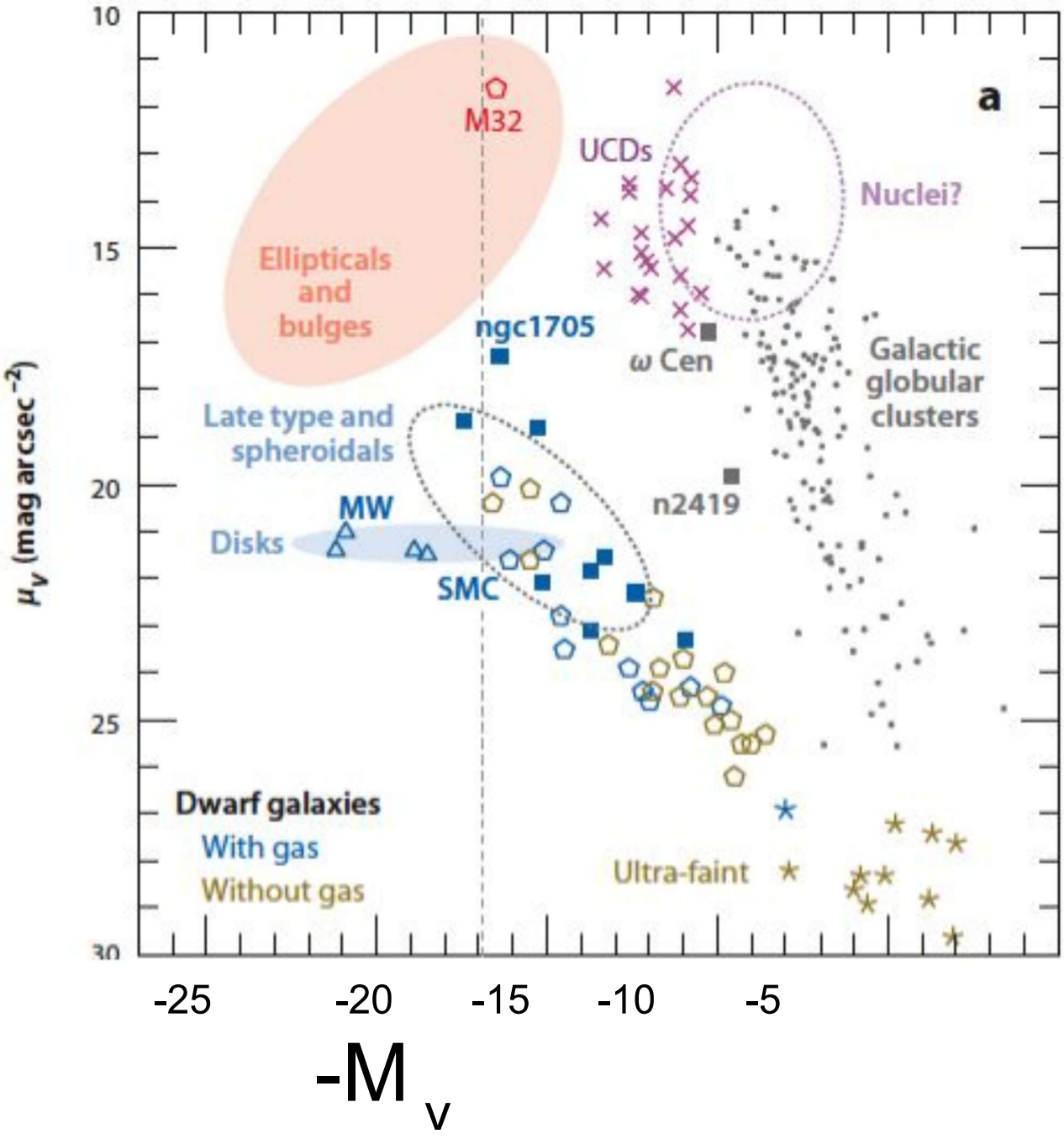
VERY METAL-POOR STARS

- Very rare stars … but they provide information about the first stellar generations in a galaxy

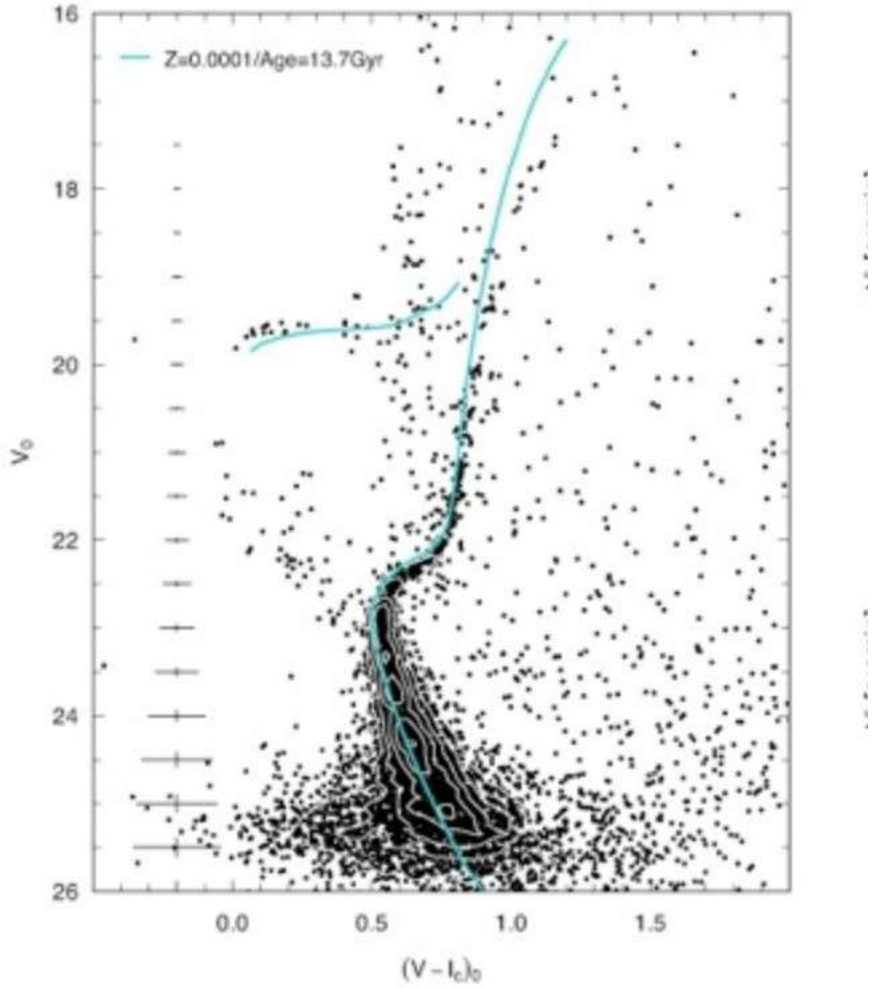
- Only recently, s fe stars with [Fe/H] < -2.0 dex have been discovered in the closest galaxies (LMC, Sculptor, Sgr)

We need a huge statistics also a low resolution in order to identify candidate very metal-poor stars.

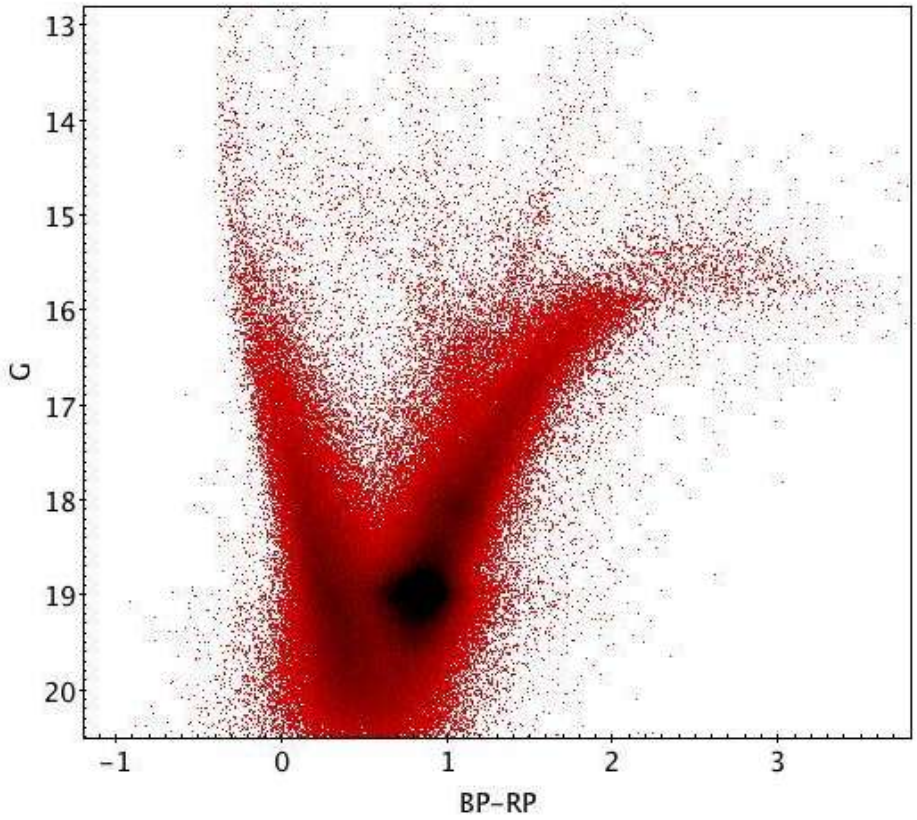

R=5k, $T_{\rm eff}$ =4250 K ; log g =1.0; [Fe/H]=-1
R=20k, $T_{\rm eff}$ =4250 K ; log g =1.0; [Fe/H]=-1
R=40k, $T_{\rm eff}$ =4250 K ; log g =1.0; [Fe/H]=-1
Purity
0.6
0.8
1
Eu
Sm
La
Ba
Zr
Y
Sr
Zn
Cu
Mn
Sc
Ca
Al
Mg
300
400
500
600
700
800
900
λ (nm)
100
80
60
40
20
minimum S/N per $\mathring{A}$


a
M32
UCDs
Nuclei?
Ellipticals
and
bulges
ngc1705
ω Cen
Galactic
globular
clusters
Late type and
spheroidals
n2419
MW
Disks
SMC
Dwarf galaxies
With gas
Without gas
Ultra-faint
10
15
20
25
30
-25
-20
-15
-10
-5
μ_V (mag arcsec^{-2})
$-M_V$

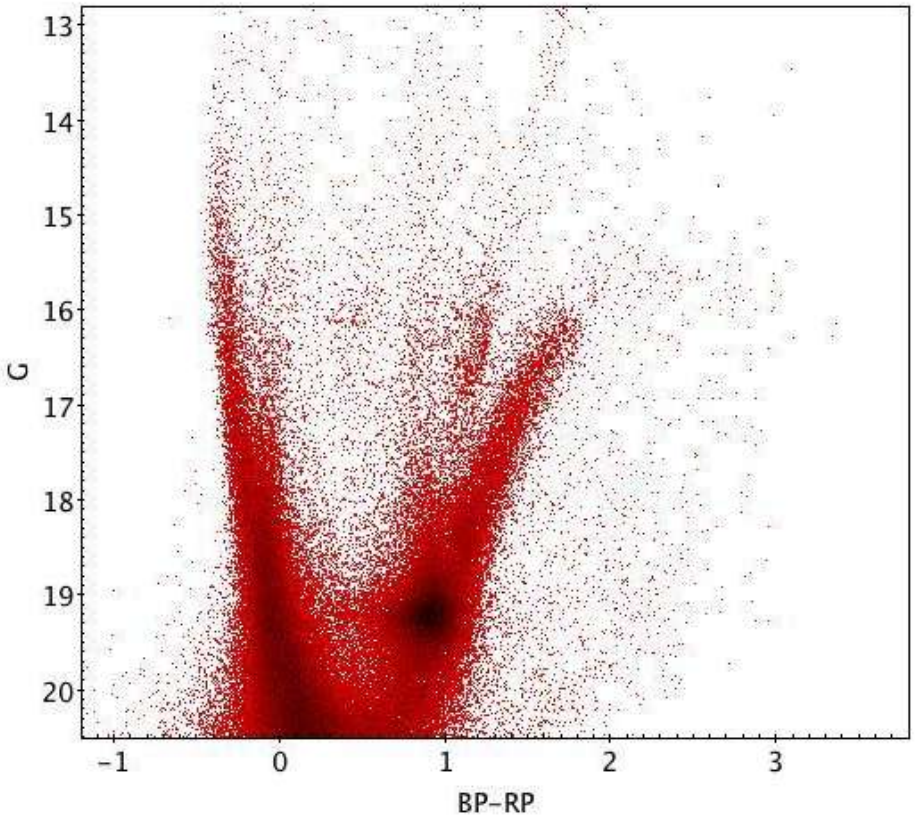
Bootes I UFD



LMC


13
14
15
16
17
18
19
20
G
−1
0
1
2
3
BP−RP

SMC


13
14
15
16
17
18
19
20
G
−1
0
1
2
3
BP−RP

Sagittarius dSph