Enrichment of heavy elements in the Sextans dwarf Spheroidal Galaxy

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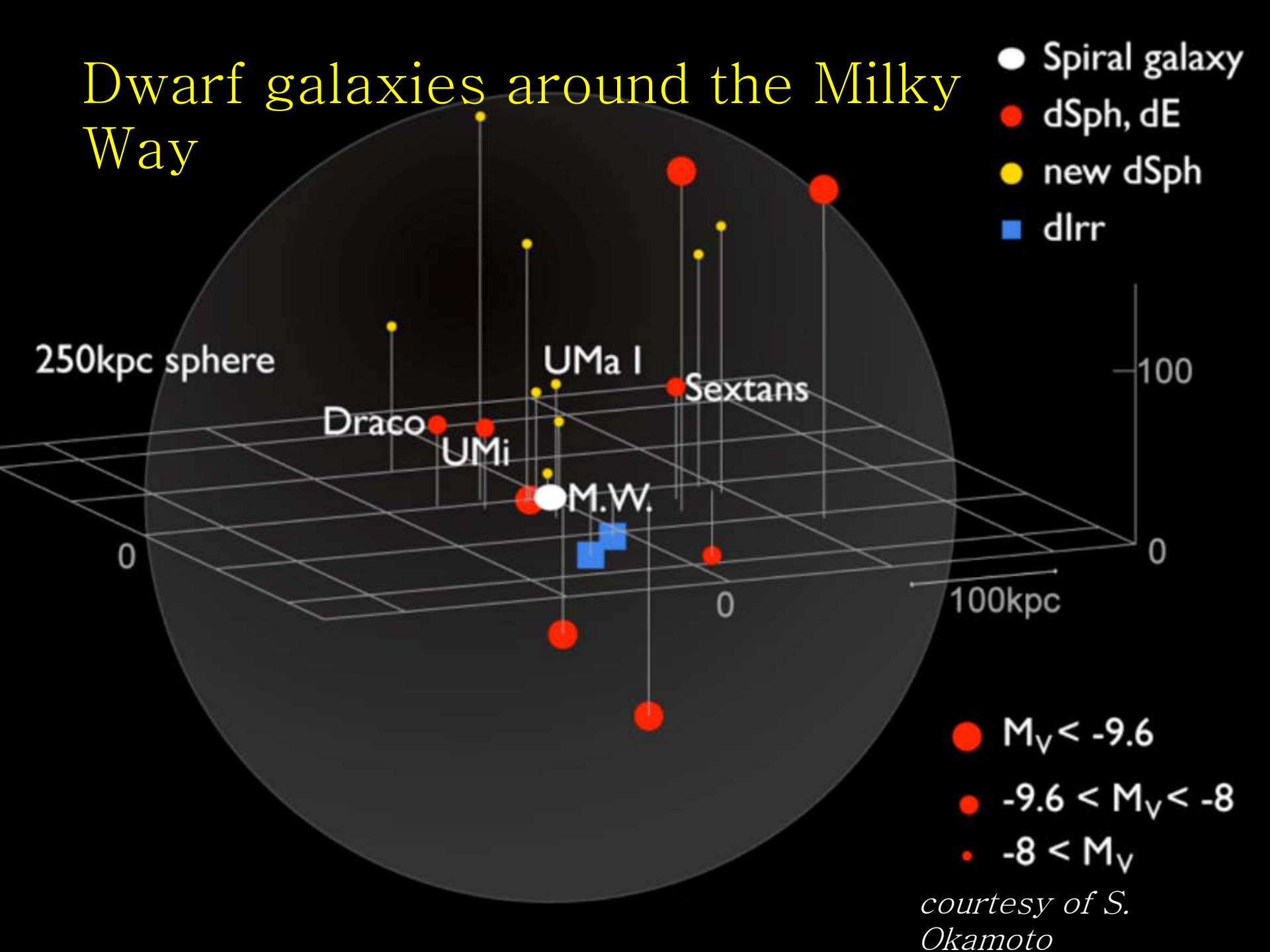
Dwarf galaxies around the Milky Way



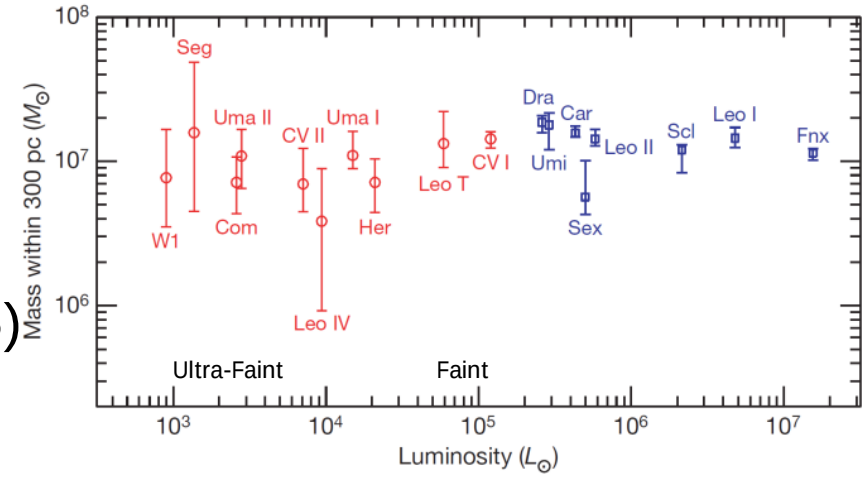
courtesy of S. Okamoto

Dwarf Galaxy and Our Galaxy

- Small stellar mass and Low luminosity
  - Mass : $M \fallingdotseq 10^7 M_{sun}$
    - Dark Matter dominant.
  - Absolute magnitude :

    $M_V > -17$ (MW : $M_V \sim -20.5$)
    - Luminosity;

      Faint, Ultra-Faint

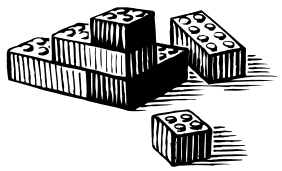


Strigari et al. 2008

- <u>Remnants of Building blocks of Our Galaxy ?</u>

Galaxy formation, Dark matter, Chemical evolution, etc.

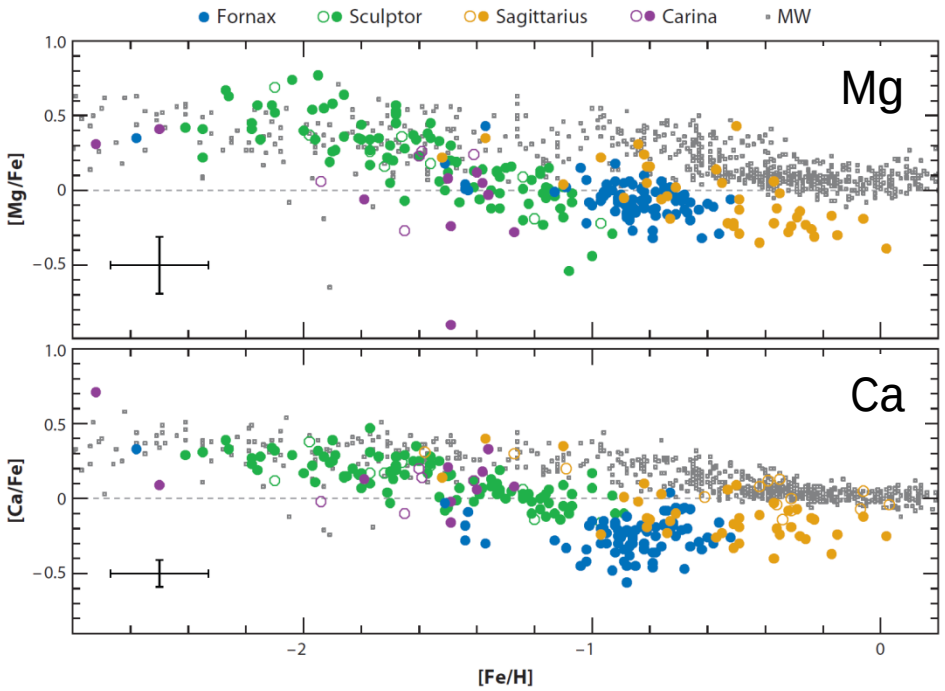
Cf. talked by A. Frebel, A. McWilliam, N. Prantzos, Y. Ishimaru



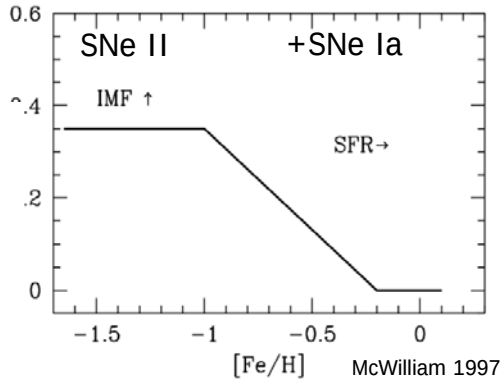
Abundance studies for individual stars in dwarf galaxies

Tolstoy et al. (2009, ARAA)

- Low α trend
  - Large contributions of Type Ia SNe at low metallicity?
- Chemical abundance trend of “luminous” (“metal-rich”) dwarf spheroidal galaxies is different from MW halo.



How is the very low metallicity range ?



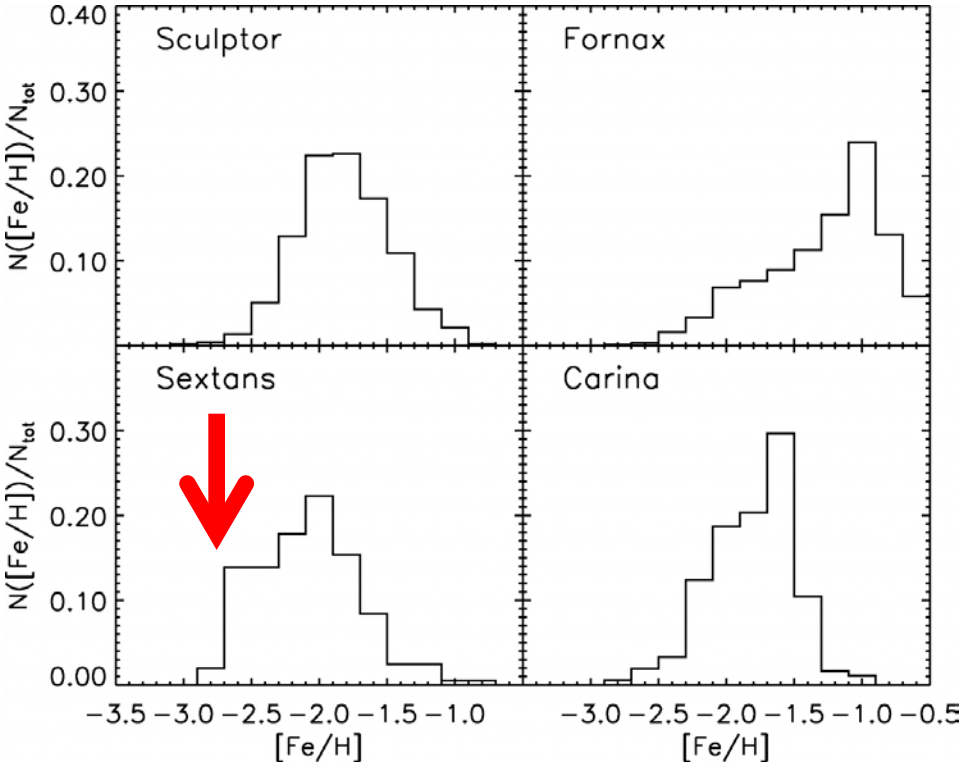
McWilliam 1997

EMP stars in faint dwarf galaxies

(**E**xtremely **M**etal-**P**oor)

(**D**warf **A**bundance and **R**adial-velocity **T**eam)

- DART program by VLT/FLAMES
- Existence of EMP stars in Faint dwarf galaxies.



Helmi et al. (2006)

High dispersion spectroscopy, to determine chemical abundances of EMP stars in Sextans.

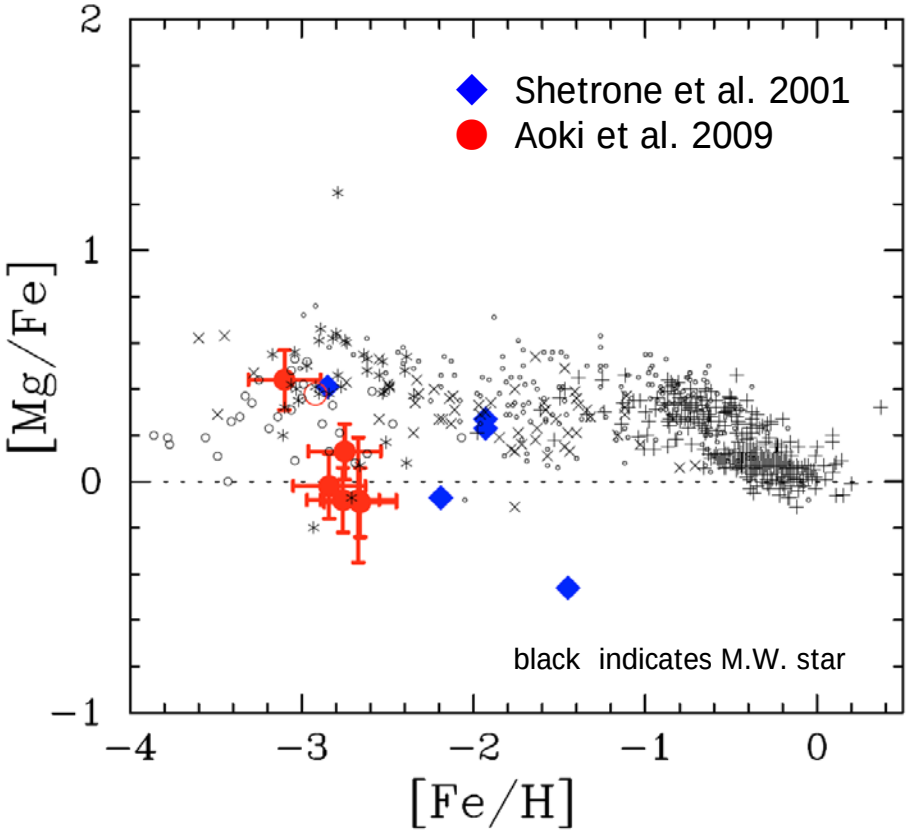
Chemical abundance analysis of Sextans stars with Subaru/HDS

- High resolution follow-up for candidate EMP stars discovered with VLT/FLAMES
  (Helmi et al. 2006)

- Subaru/HDS observations (P.I.: N. Arimoto)
  - Jan. 2007 + May 2005
  - R=40,000
  - λ 4400-7200 A
  - S/N ~ 17-46 @5180A
  - Exp. time 60-390 min

Mg abundance of EMP stars in dwarf galaxy Sextans.

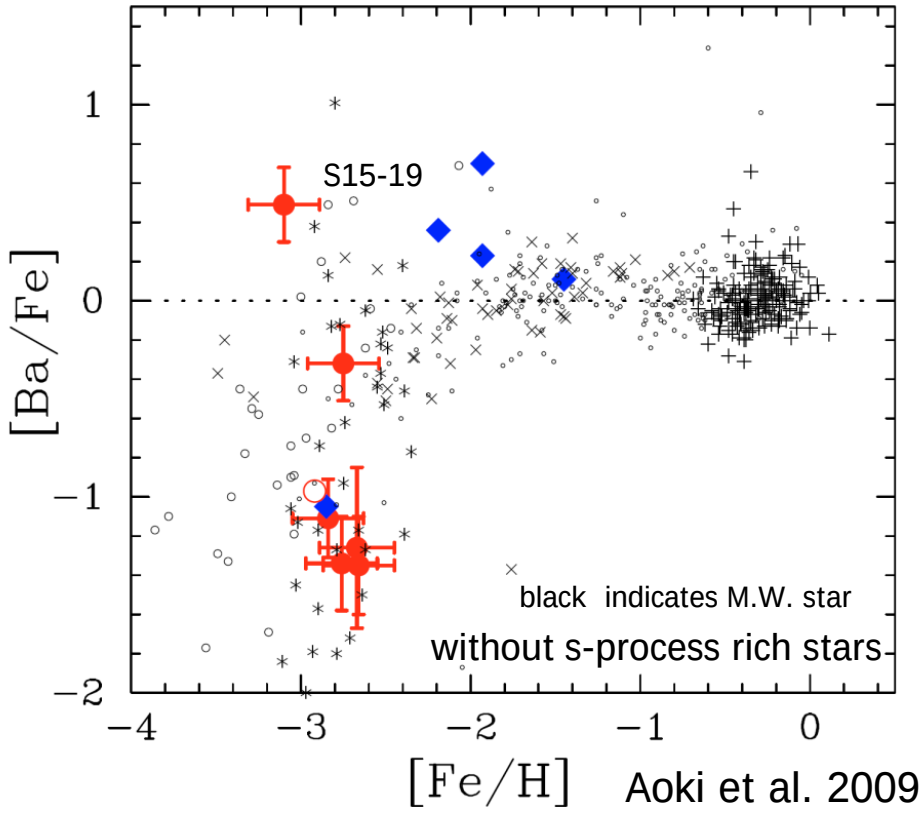
- Confirm the low metallicity
- Most stars show low Mg/Fe ratios.
- Different from MW halo stars
  - The contributions of Type Ia SNe in [Fe/H] < -2.5 ?
  - Small contribution of very massive stars ? (different IMF)



Aoki et al. 2009

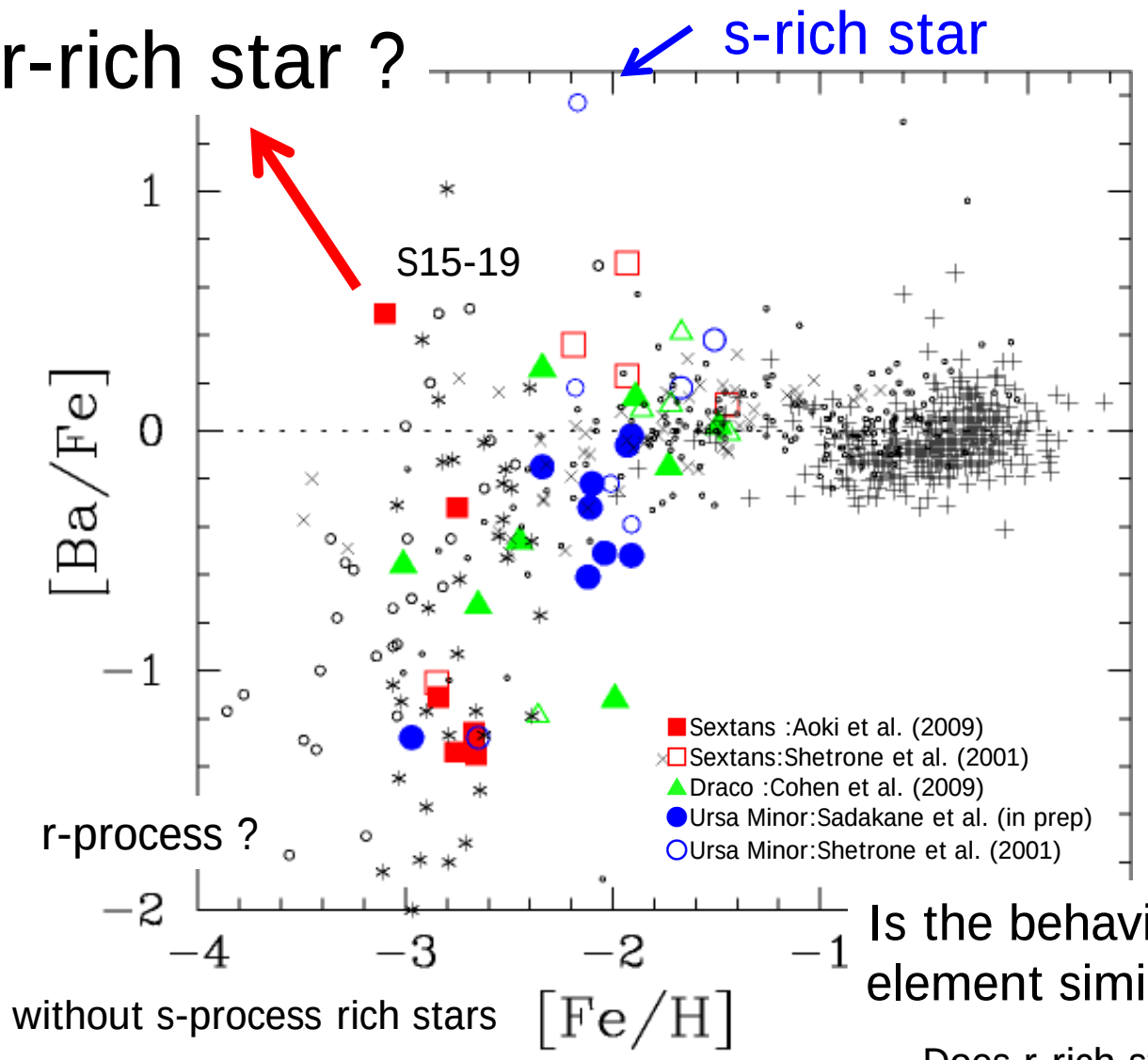
Neutron-capture elements in dwarf galaxy Sextans

- Under-abundant in five EMP stars.
- Two EMP stars show large and moderate excess of Ba.
- Ba in Sextans shows large scatter as in MW halo.



Aoki et al. 2009

neutron-capture elements in EMP stars in faint dwarf galaxies



- Field halo EMP stars show large dispersion in the abundances of neutron-capture elements.
  → Reflects spatial inhomogeneity of the chemical composition of interstellar gas in the early Galaxy.
- r-process enhanced stars will reflect the pure r-process.

Is the behavior of neutron-capture element similar to that of Our Galaxy ?

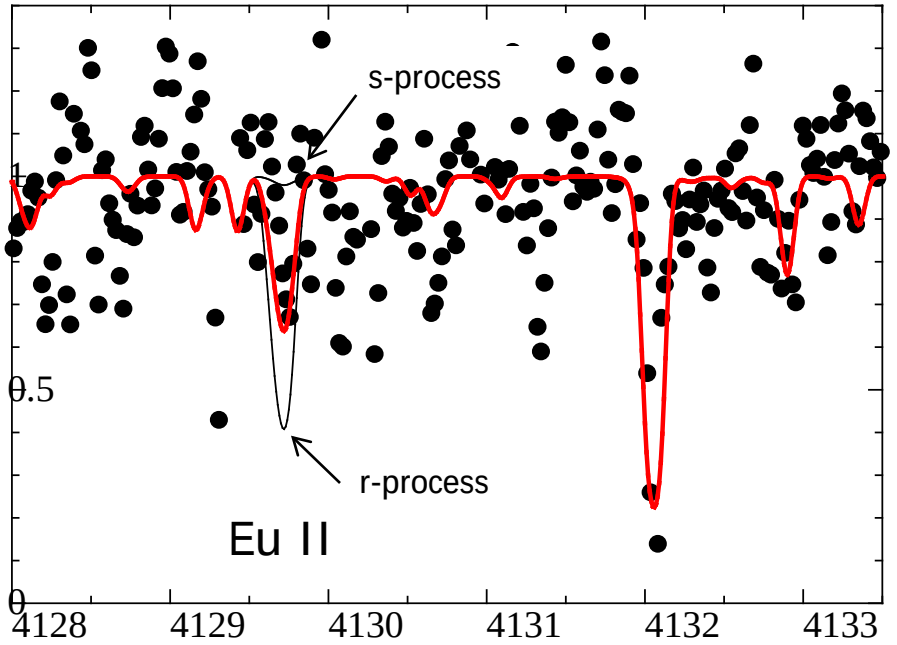
Does r-rich star exist also in dwarf galaxy?

High resolution spectroscopy of the Ba-rich EMP star S15-19 with Subaru/HDS

- V=17.5
- $T_{\rm eff}$: 4600K, logg: 1.2, [Fe/H]=-3.1
- Obs. Date : 2010 Feb. 9
- R=40,000, λ 3760 ~ 5490 A
  - 4400 ~ 7200 A (previous obs.)
- Exp. time 8h
- S/N = 25 @ 4500 A

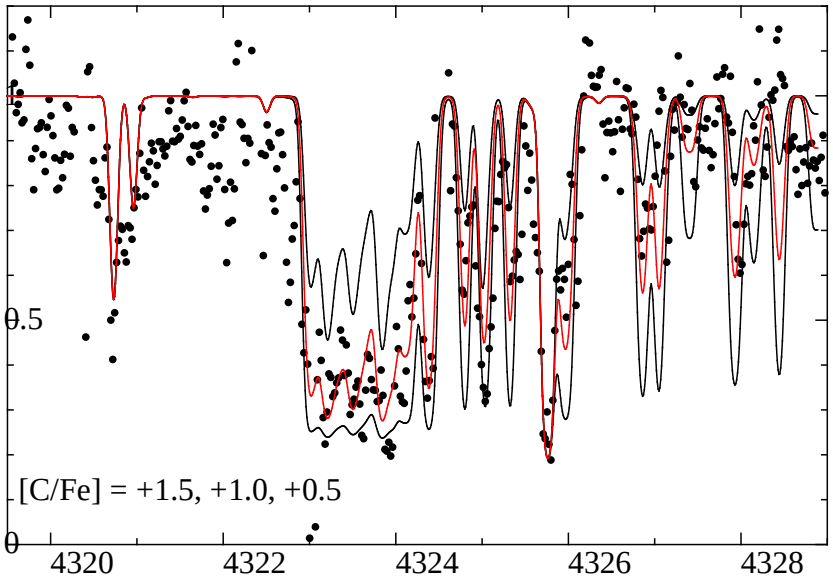
Ba and Eu abundance of S15-19

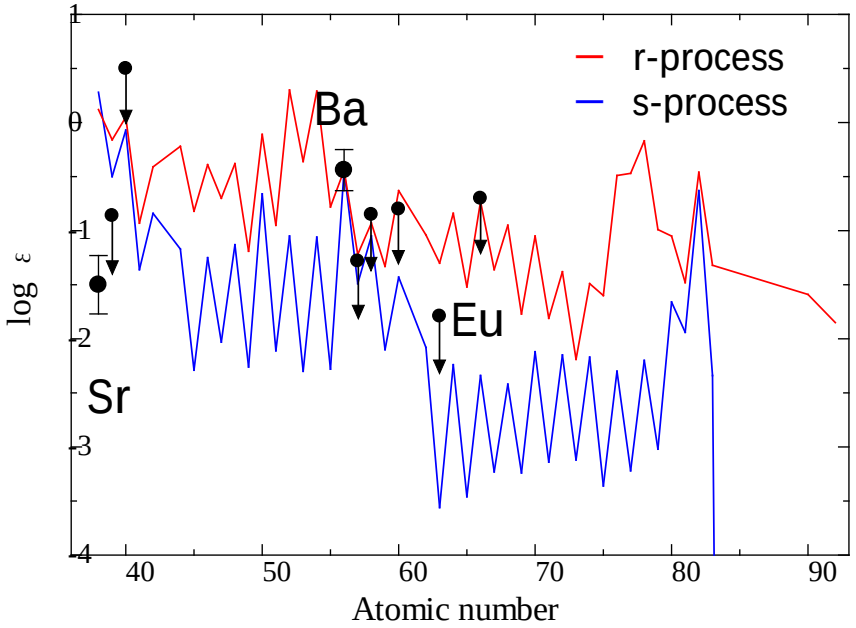
- Confirm [Fe/H] = -3.1 and Ba-rich ([Ba/Fe]～+0.4) abundance.
- But no detection Eu II line.
  - [Eu/Fe] < +0.8
- [Ba/Eu] > -0.4
  - In case of r-process [Ba/Eu] = -1



This result indicates that Ba of this star is not synthesized by r-process only.

Abundance pattern of S15-19





- Carbon-rich ([C/Fe] = +1.0)
- Low Sr/Ba

This result shows that the abundance of this star is reflecting **s-process in low metallicity**.

S15-19 is not r-process enhanced star

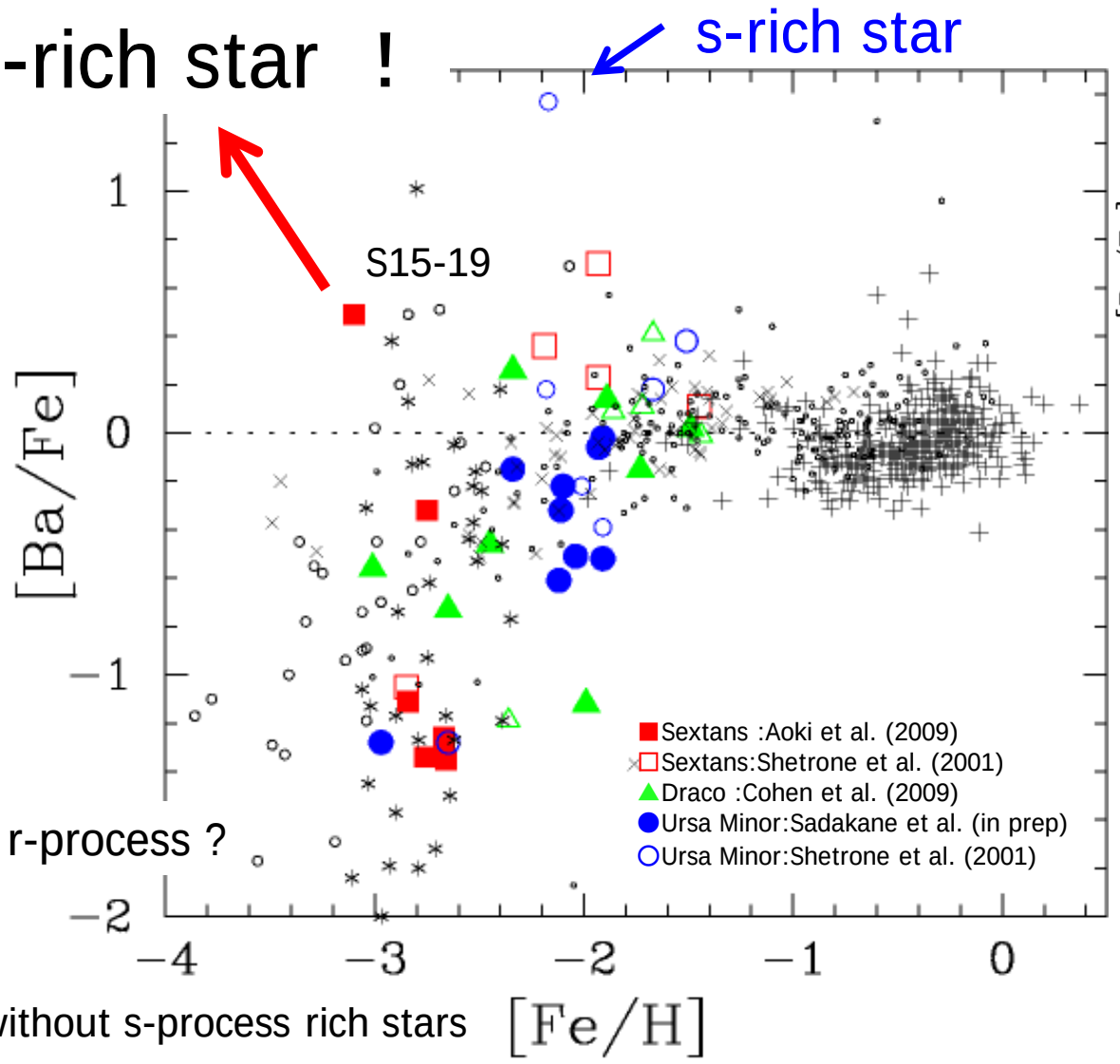
- The result shows that the abundance of this star is reflecting s-process in low metallicity.
- Variation of radial velocity is found.

  226.05±0.11 km/s (2005) → 223.5±0.6 (2010)

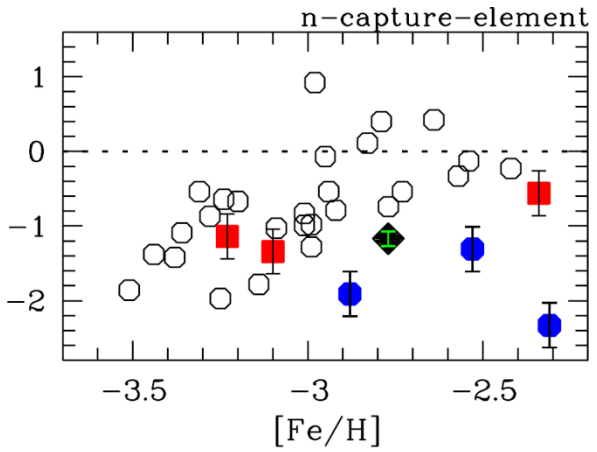
  → binary system
- S15-19 probably belongs to binary system and is affected by an AGB star.
  - High Ba is the result of the mass transfer from AGB star.

neutron-capture elements in EMP stars in faint dwarf galaxies

s-rich star !



Ultra-Faint Dwarf galaxies



Frebel et al. 2010

No r-process enhanced EMP star is found in Dwarf galaxies and Ultra-Faint Dwarf galaxies, yet.

Summary

- We derived the abundance of neutron-capture elements in EMP stars in the Sextans dwarf galaxy.
- No r-process enhanced ([Eu/Fe] > +1) EMP star is found in dwarf galaxies yet.
- However, we need more sample to derive definitely conclusion.