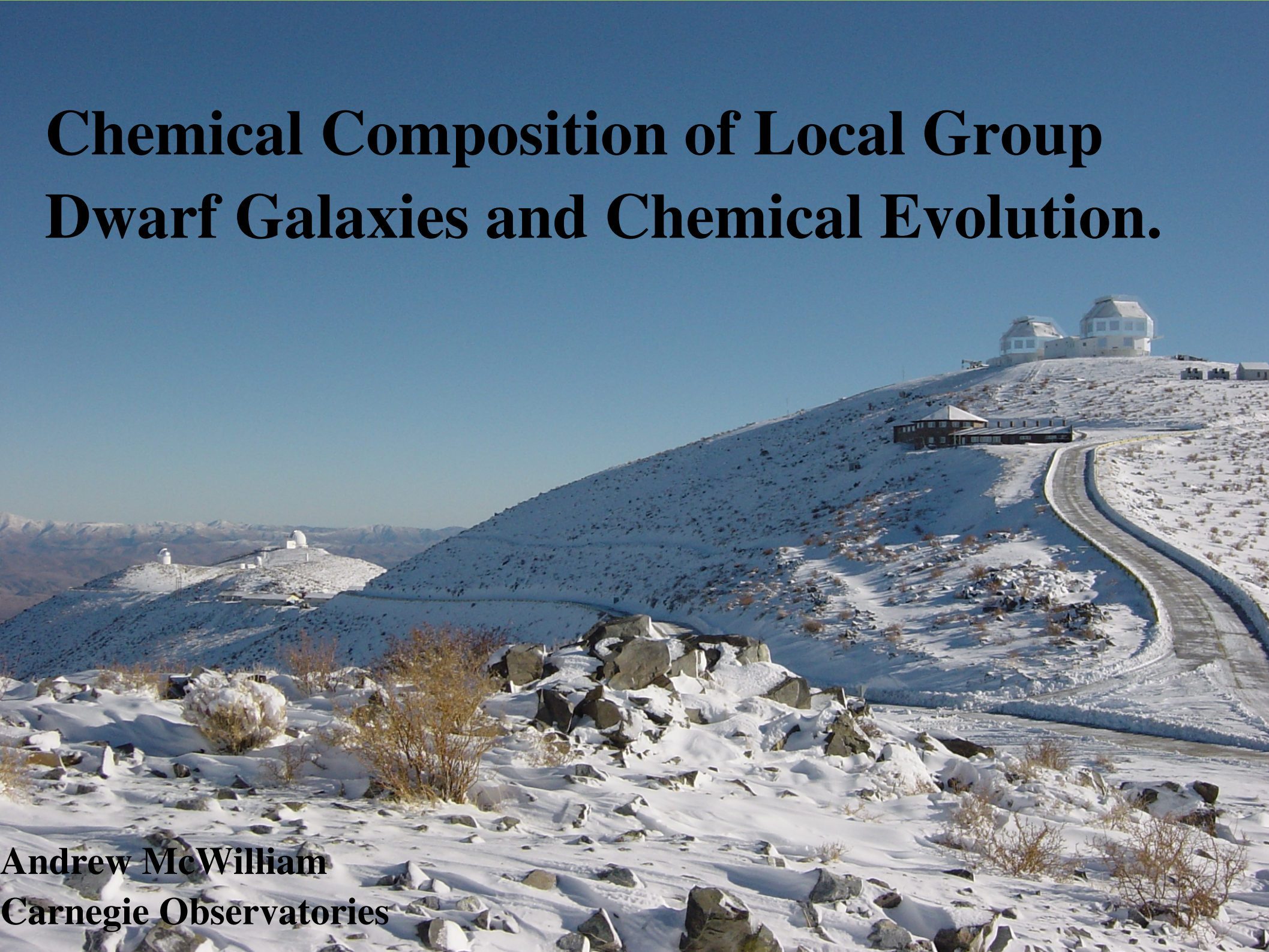
Chemical Composition of Local Group Dwarf Galaxies and Chemical Evolution.



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Summary:

1. Clarification of McWilliam et al. 2013: SNIa time delay not responsible for the low [O/Fe] ratios in Sagittarius dwarf galaxy; but, the SNIa time delay still occurs and may explain [Eu/Fe] in Sgr.

2. [O/Fe] deficiencies in Sgr could easily be due to IMF truncation, or a steep slope, say due to IGIMF.

3. Other dwarf galaxies (LMC, Fornax, IC1613), show similar [Eu/O] and/or [Eu/Mg] ratios, suggesting a common origin for their [O/Fe] deficiencies.

4. New data and additional Eu II lines confirm earlier results for Sgr.

5. The very useful Neutron-Capture Plot

1. Clarification:

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CHEMISTRY OF THE SAGITTARIUS DWARF GALAXY: A TOP-LIGHT INITIAL MASS FUNCTION, OUTFLOWS, AND THE *R*-PROCESS

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ABSTRACT

From chemical abundance analysis of stars in the Sagittarius dwarf spheroidal galaxy (Sgr), we conclude that the α-element deficiencies cannot be due to the Type Ia supernova (SN Ia) time-delay scenario of Tinsley. Instead, the evidence points to low [α/Fe] ratios resulting from an initial mass function (IMF) deficient in the highest mass

SNIa time-delay **not** responsible for low [O/Fe] in Sgr dSph (relative to the trend in the MW disks).

- can still have SNIa
- can still have a SNIa time delay

Review: Matteucci & Brocato (1990) predictions (cf Tinsley 1979)

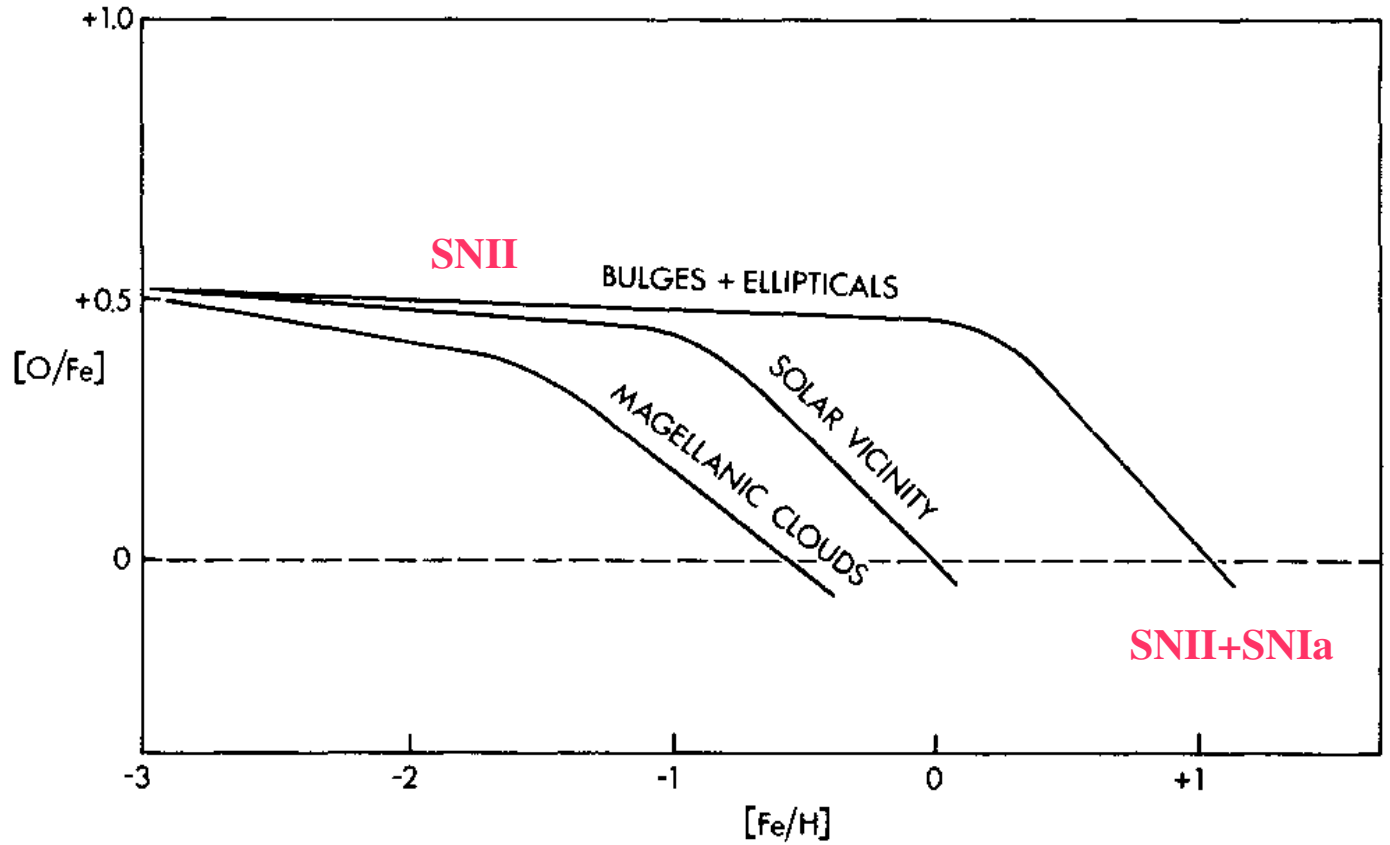


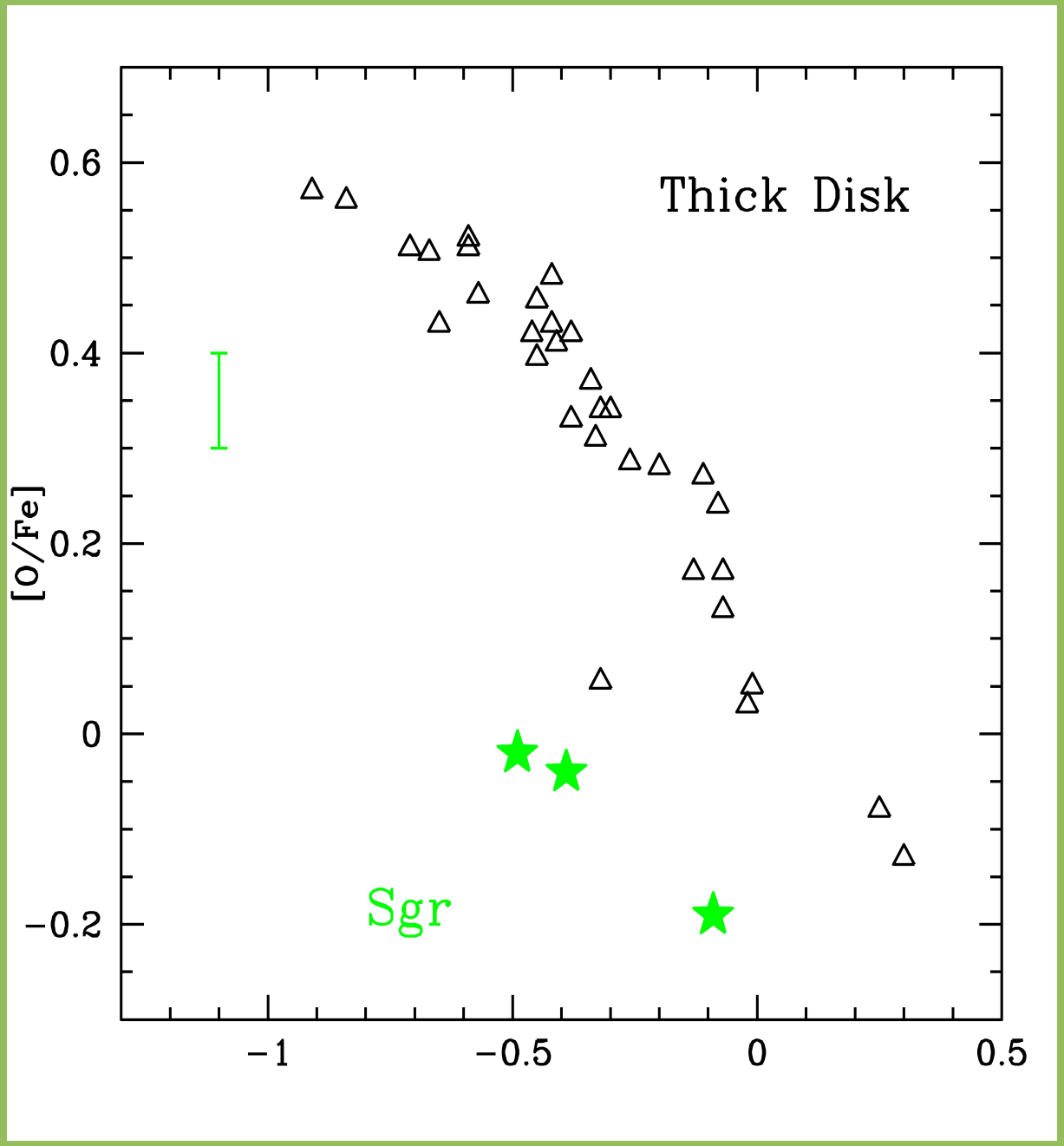
FIG. 4.—A sketch of the predicted [O/Fe] vs. [Fe/H] relations in different systems as a consequence of their different [Fe/H]-*t* relations.

SNIa time-delay

Star-formation rate determines [Fe/H] of the knee

dwarf galaxies ⟶ lower specific SFR

[O/Fe] in Sagittarius dwarf galaxy



Not surprising: low alphas known in dwarf galaxies since Shetrone et al 2002; Venn et al. 2003.

Looks like SNIa time delay, but...

Eu behaves like an alpha-element in the Solar neighborhood

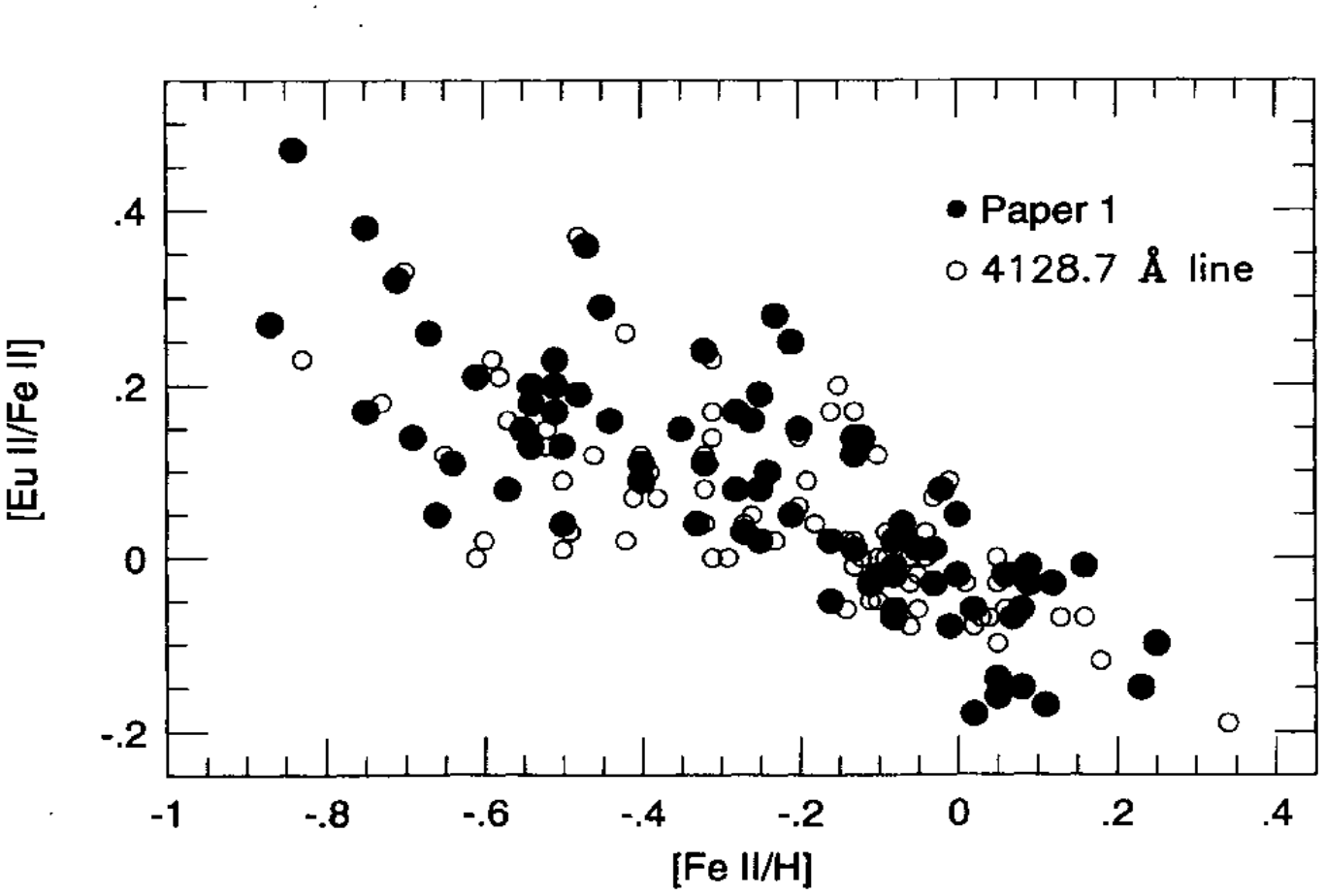


FIG. 5.—*Top panel*: [Fe II/H] from Paper I compared to that from the 4128.7 Å line. *Bottom panel*: [Eu II/Fe II] vs. [Fe II/H] with Fe II as indicated.

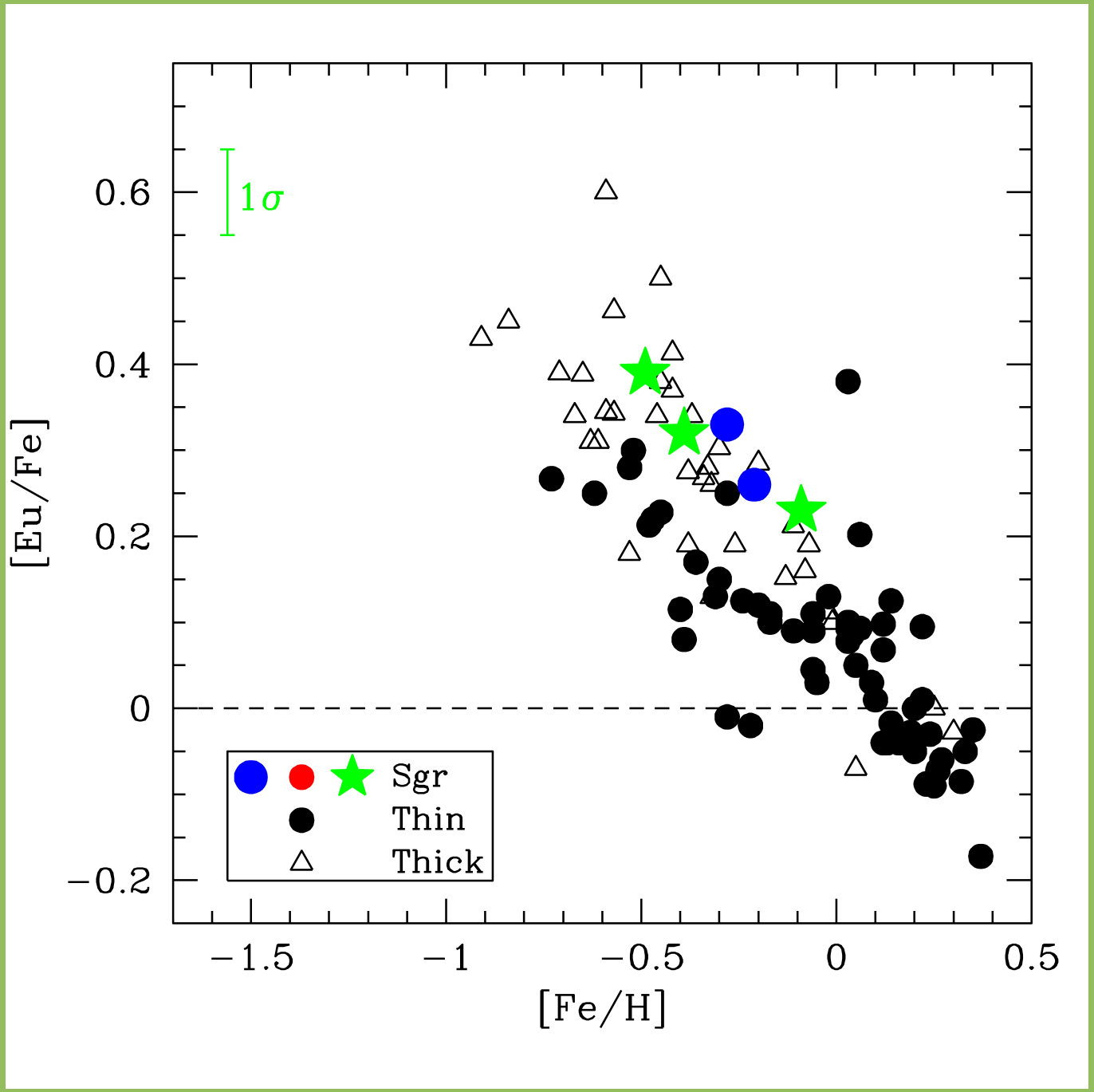
Eu is ~95% r-process

Suggests a SNII origin

(merging NS or low-mass core collapse SN)

Woolf & Lambert (1995)
(but see McWilliam & Rich 1994)

[Eu/Fe] in the Sagittarius dwarf galaxy: same as Thick Disk!

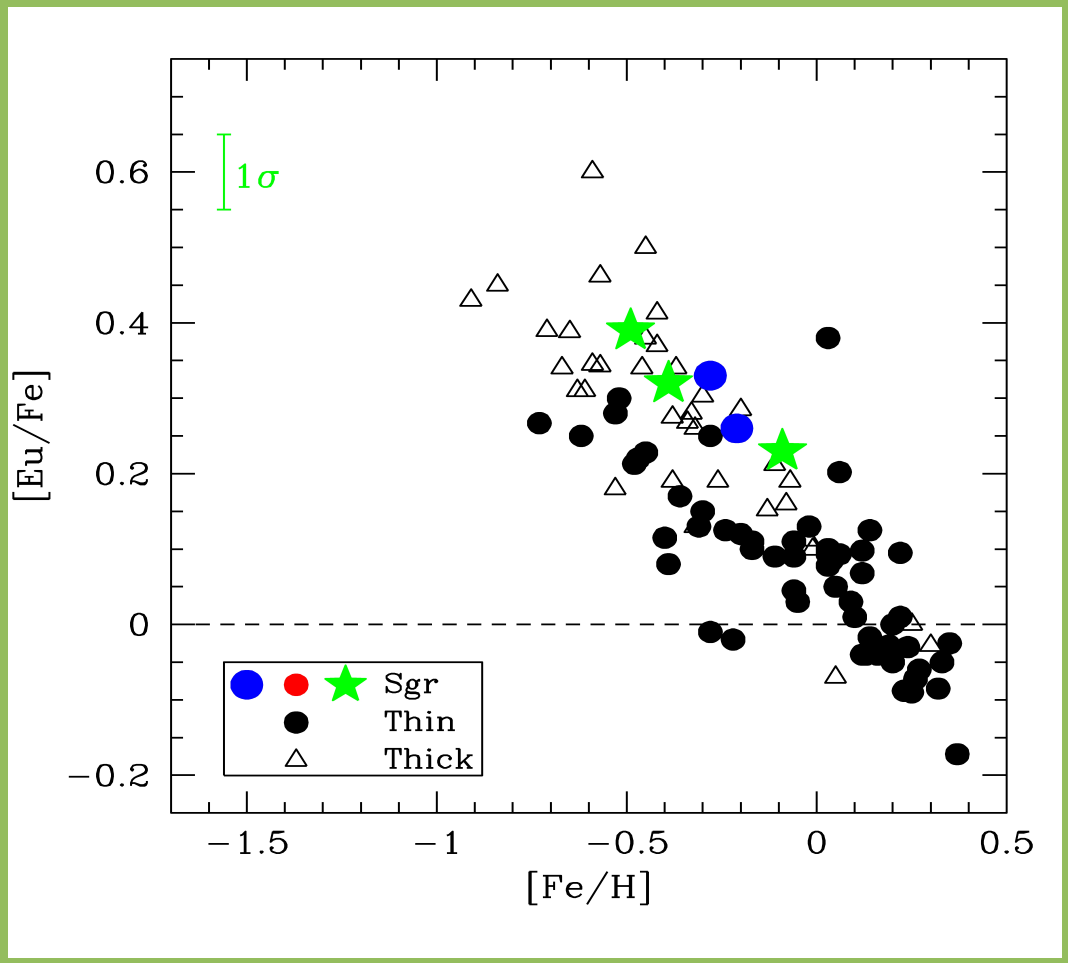


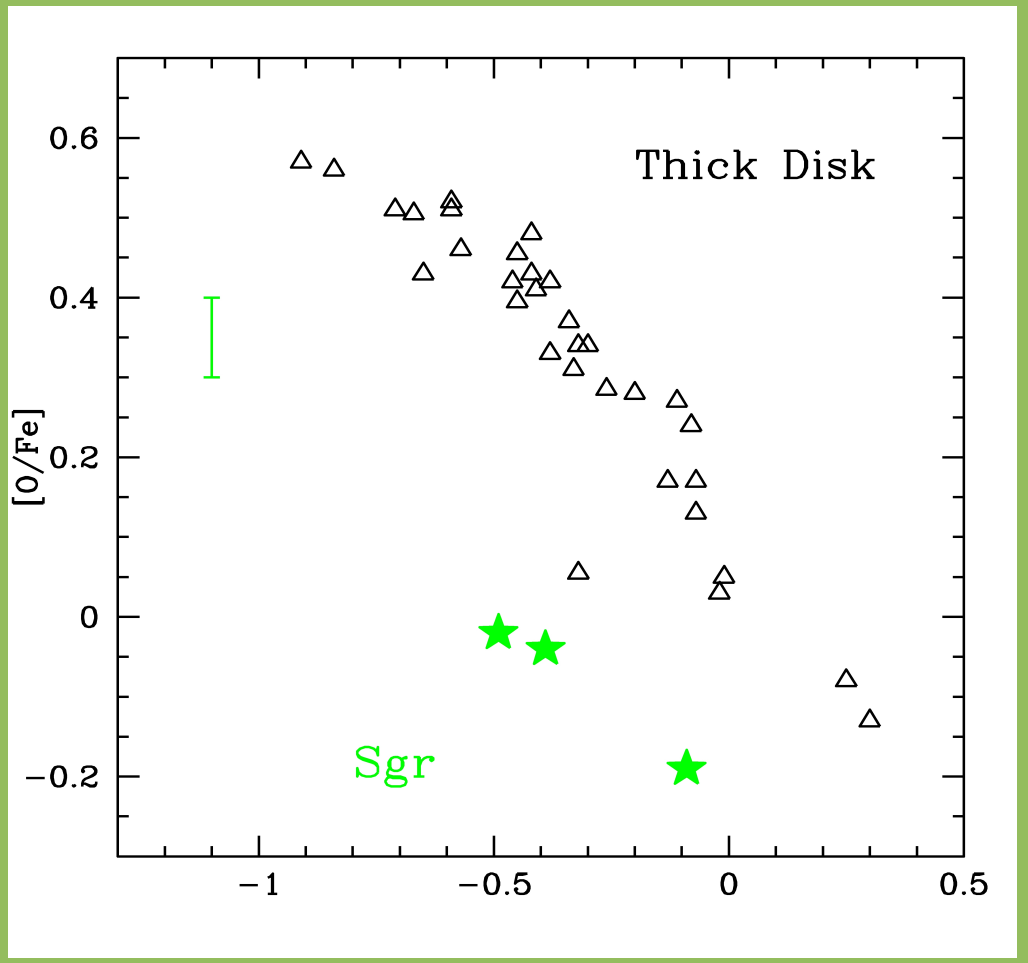
No Eu deficiency in Sgr!

Sgr SFR = MW?

Europium

Oxygen





No deficiency

0.4 dex deficiency

How can this be?

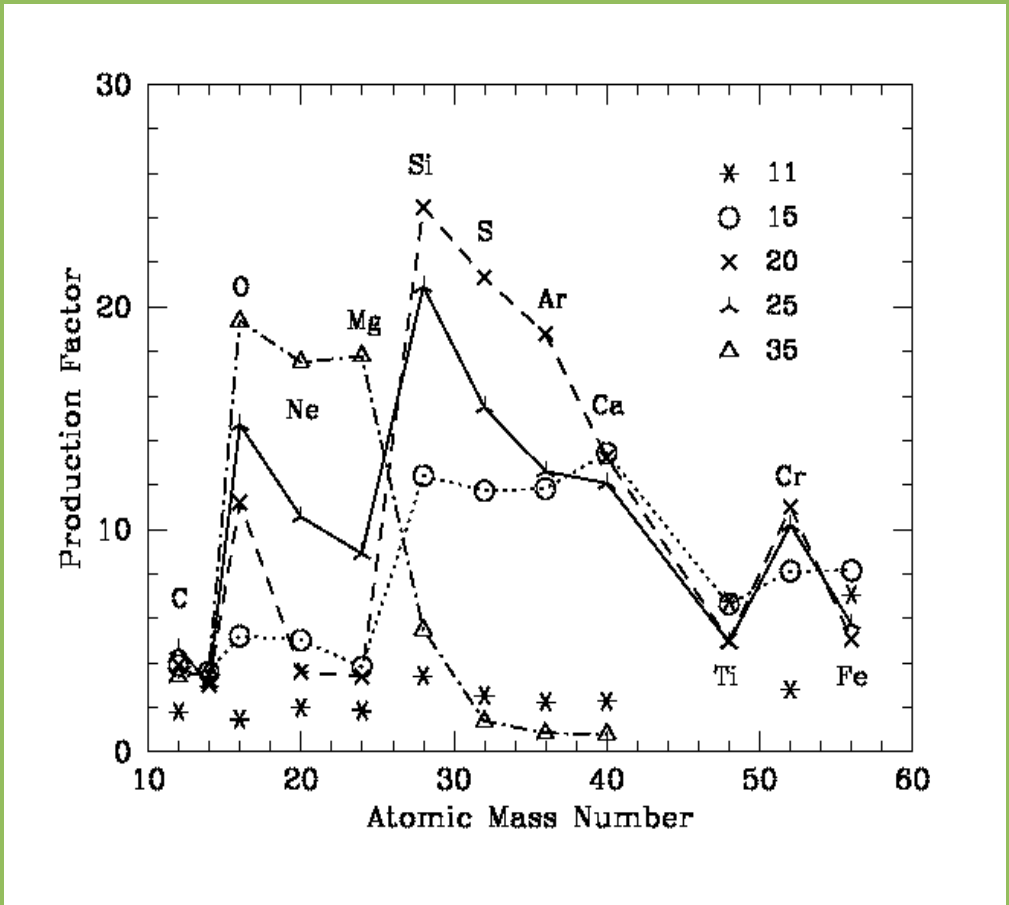
Need two mechanisms to explain Eu and O trends:

* **[Eu/Fe] trend may be due to SNIa Fe**
* **[O/Fe] deficiency due to truncated or steep IMF (or IGIMF) (fewer very massive SNII)**

⟶ predict less deficiency for Si,Ca than O,Mg

IGIMF (Integrated Galaxy Initial Mass Function):
steeper, and truncated, IMF due to paucity of gas in dwarf galaxies (Weider & Kroupa 2003)

Oxygen, Magnesium produced by the most massive SNII



Woosley & Weaver 1995

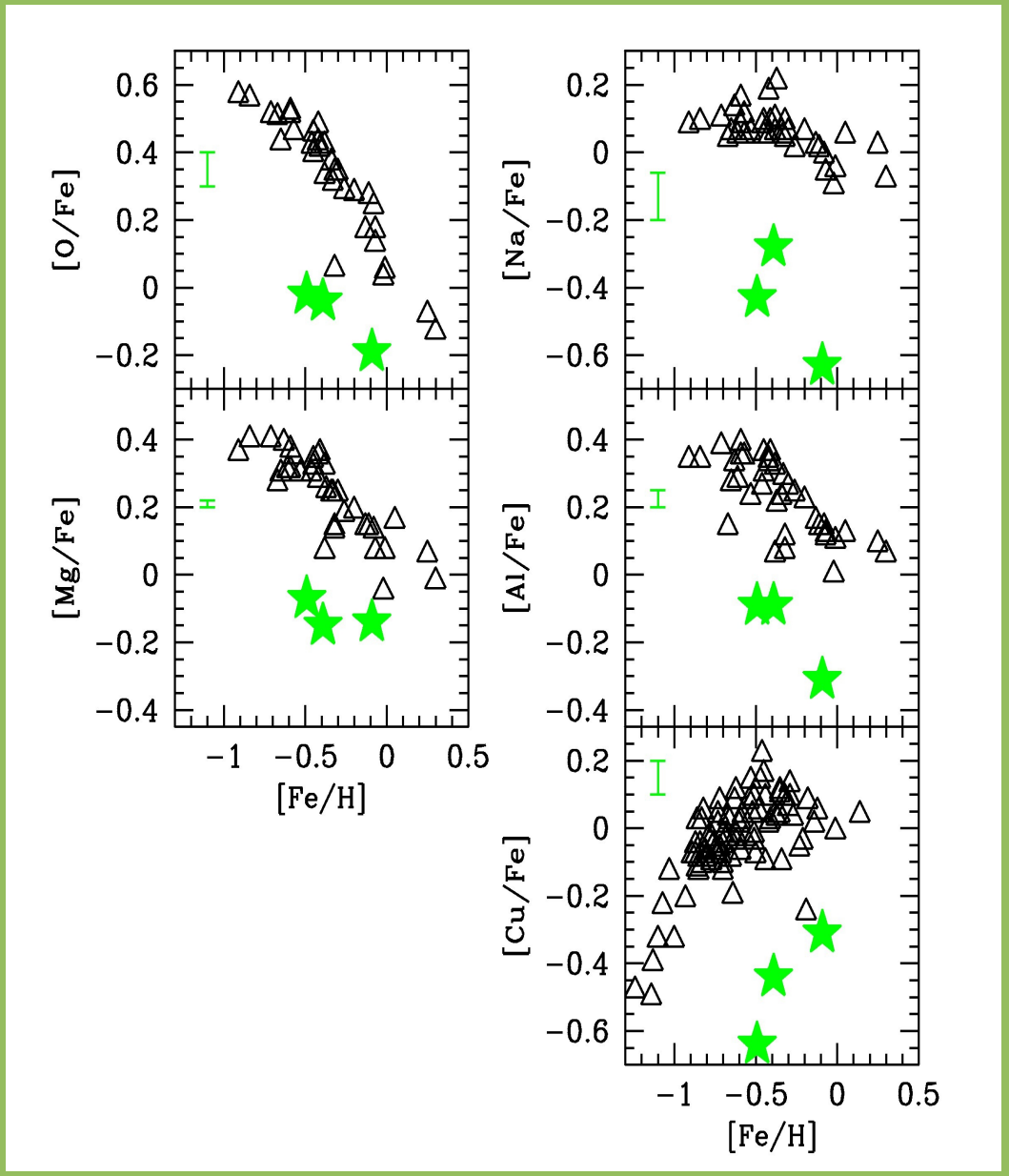
O,Mg ≥ 25 Msun
Si,Ca 15-25 Msun

An IMF truncation, or steep slope, will reduce O,Mg more than Si,Ca.

Hydrostatic Elements in Sgr

(Limongi)

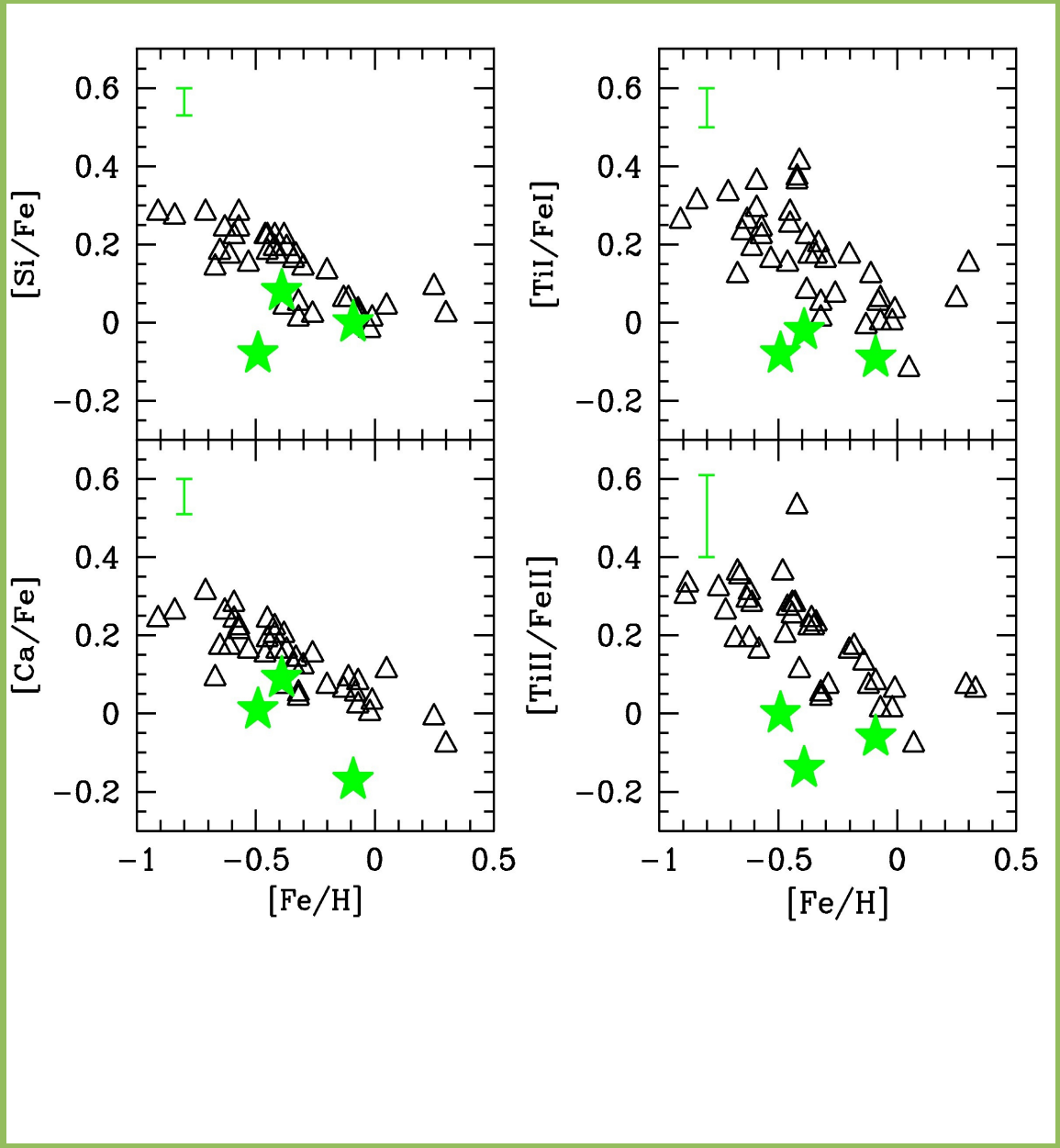
0.43+/-0.04 dex deficiency



(cf thick disk Bensby et al. 2005)

Note Thick Disk [Cu/Fe]!

Explosive Alpha Elements in Sgr

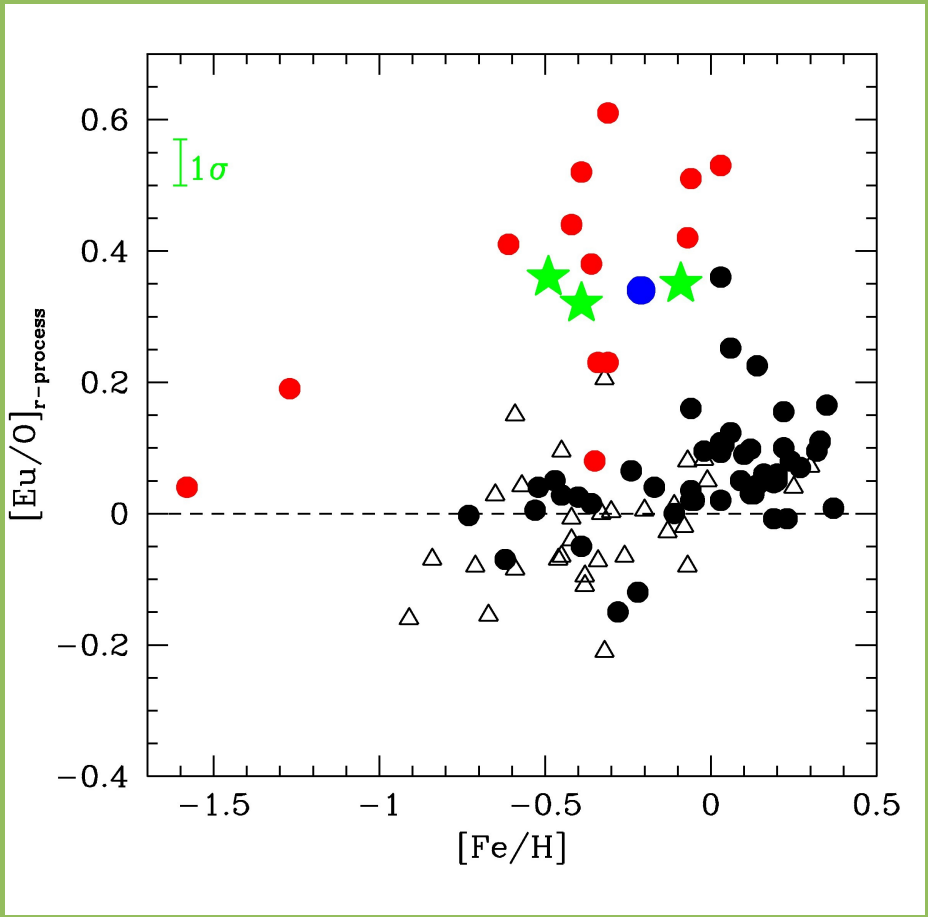


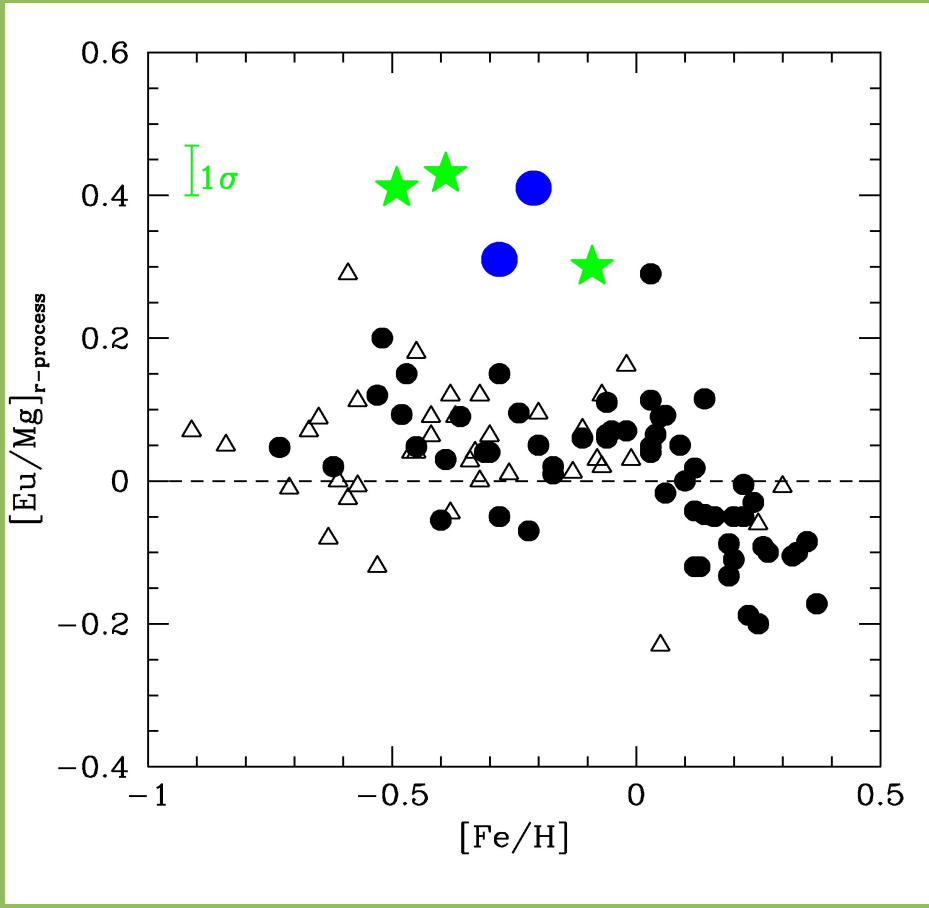
0.17+/-0.03 dex deficiency

Consistent with steeper IMF

(cf Bensby et al. 2005)

A signature of alpha-element deficiencies due to IMF is high [Eu/O] and [Eu/Mg] (also high [explosive/hydrostatic] ratios).





Seen in other dwarf galaxies, namely: LMC, Fornax, IC1613

⟶ look for this signature in other LG dwarf galaxies

A constraint on the site of the r-process? (cf Vincenzo's talk)

low [O/Fe] and normal [Eu/Fe] in Sgr suggests that the r-process SNII have little overlap with O, Mg SNII.

Can we find galaxies with steeper IGIMFs or truncated at lower masses (stronger [hydrostatic/explosive] signatures) with indications of Eu depletion?

⟶ Further constrain r-process site

Potential Systematic problem:

These results depend on the Eu II line at 6645A. A systematic error from that line could change these conclusions. Most dwarf galaxy abundance studies rely only on this line,! (low S/N and low resolution make it difficult to use other lines.)

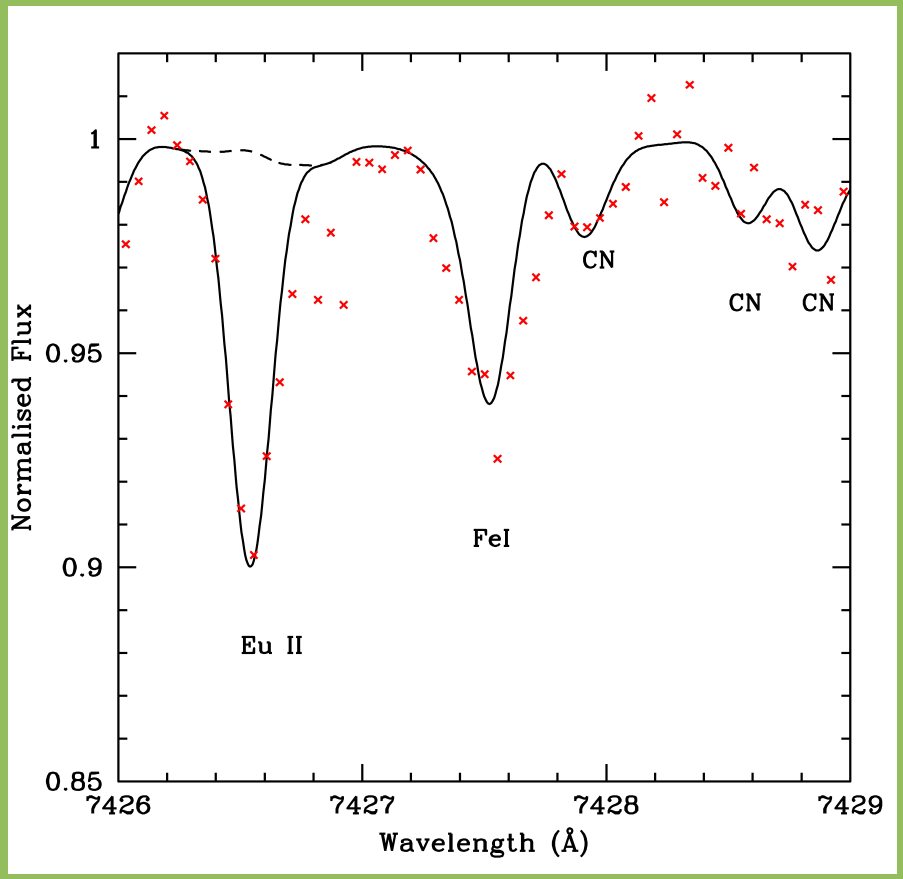
Solution: better data, more stars

New data, more Eu II lines: 10 new Sgr stars, R=48,000, S/N >100 per pixel, using Magellan Echelle (MIKE)

Analysis for half of one RGB star: sgr42146527, Teff = 4050K
[Fe/H] = -0.50

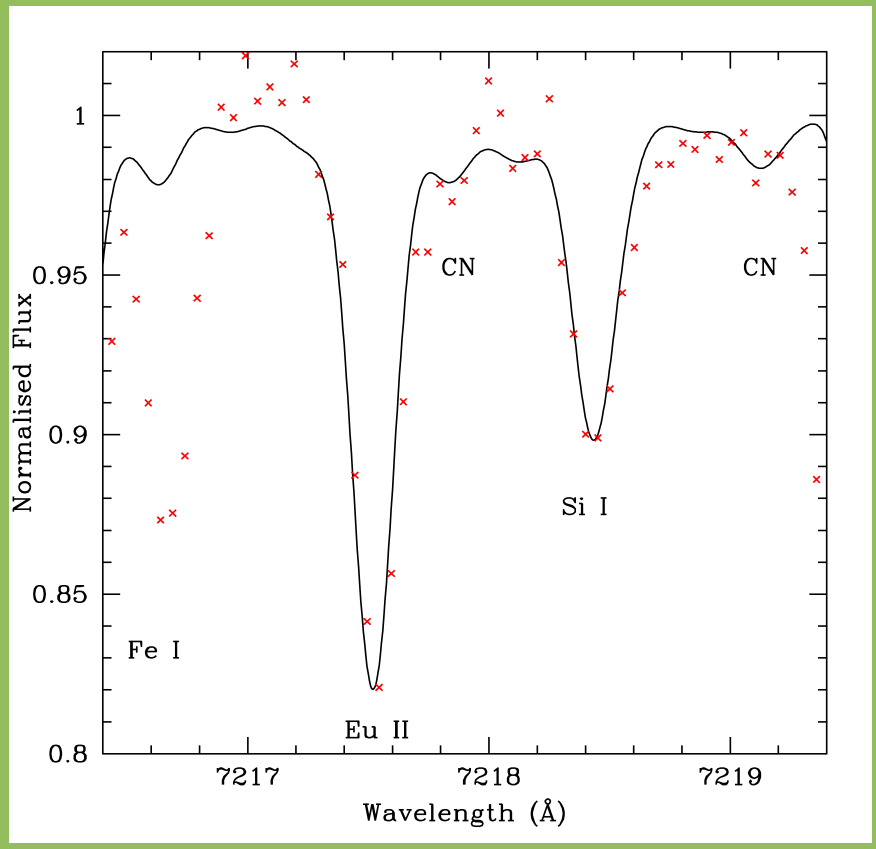
Eu II lines at 6645, 7217 and 7426A [Eu/FeII]=+0.36 dex
[O I] 6300A line [O/FeII]=-0.01 dex [Eu/O] = +0.37 dex

New Eu II lines



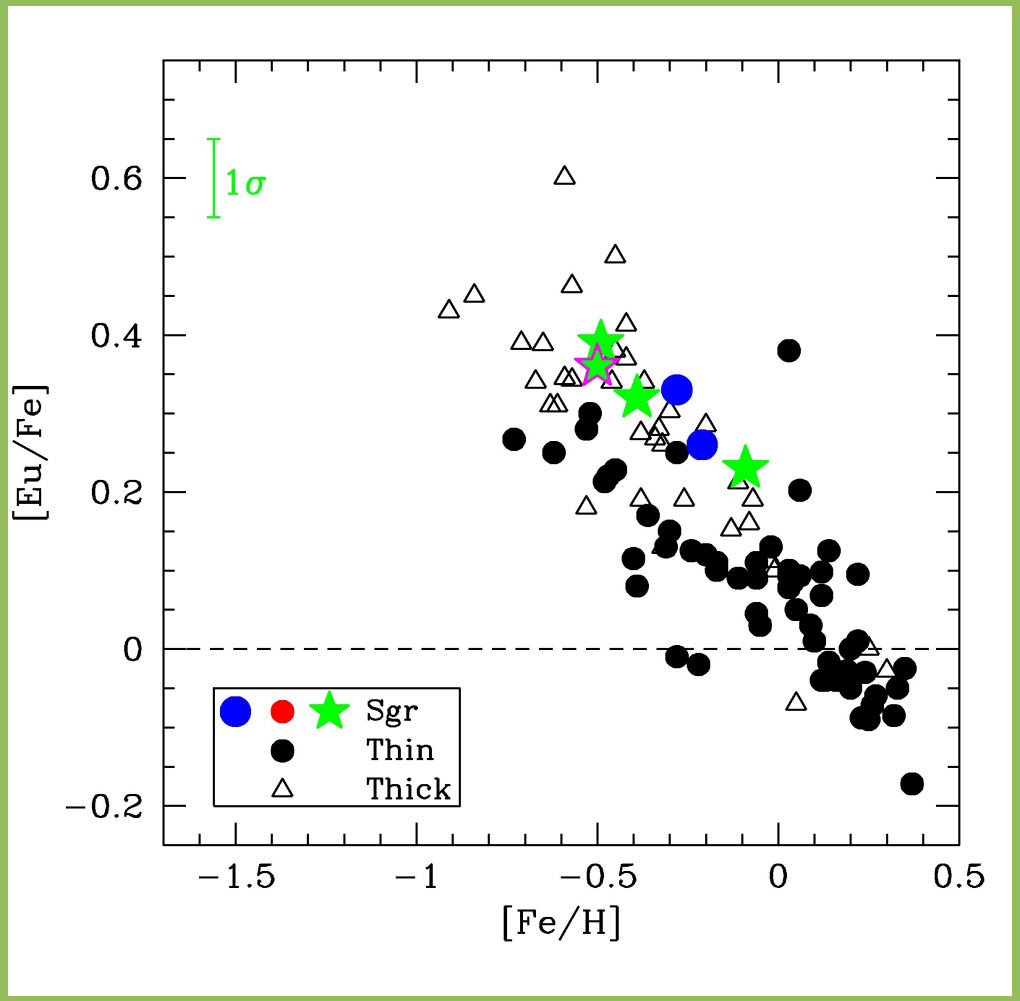
Eu II 7426A

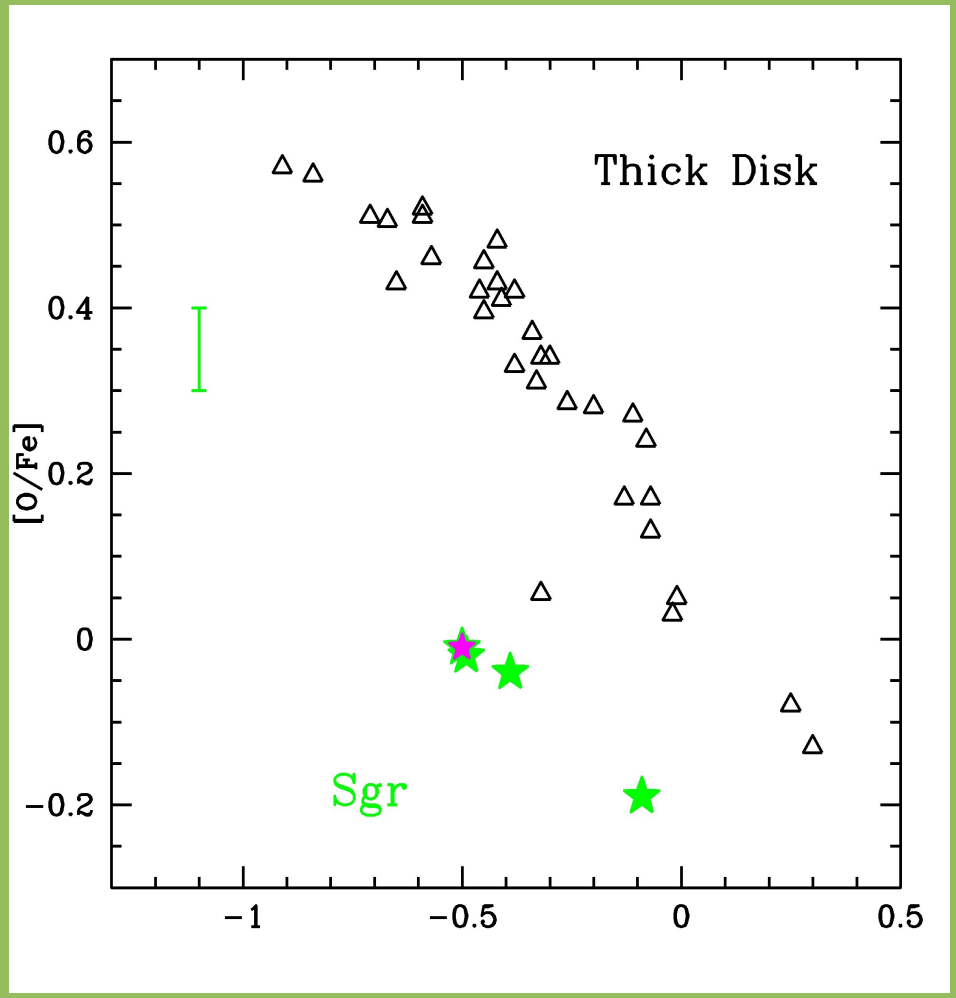
Eu II 7217



Internal scatter from 3 lines 0.02 dex

Our new results confirm previous findings





Conclusions:

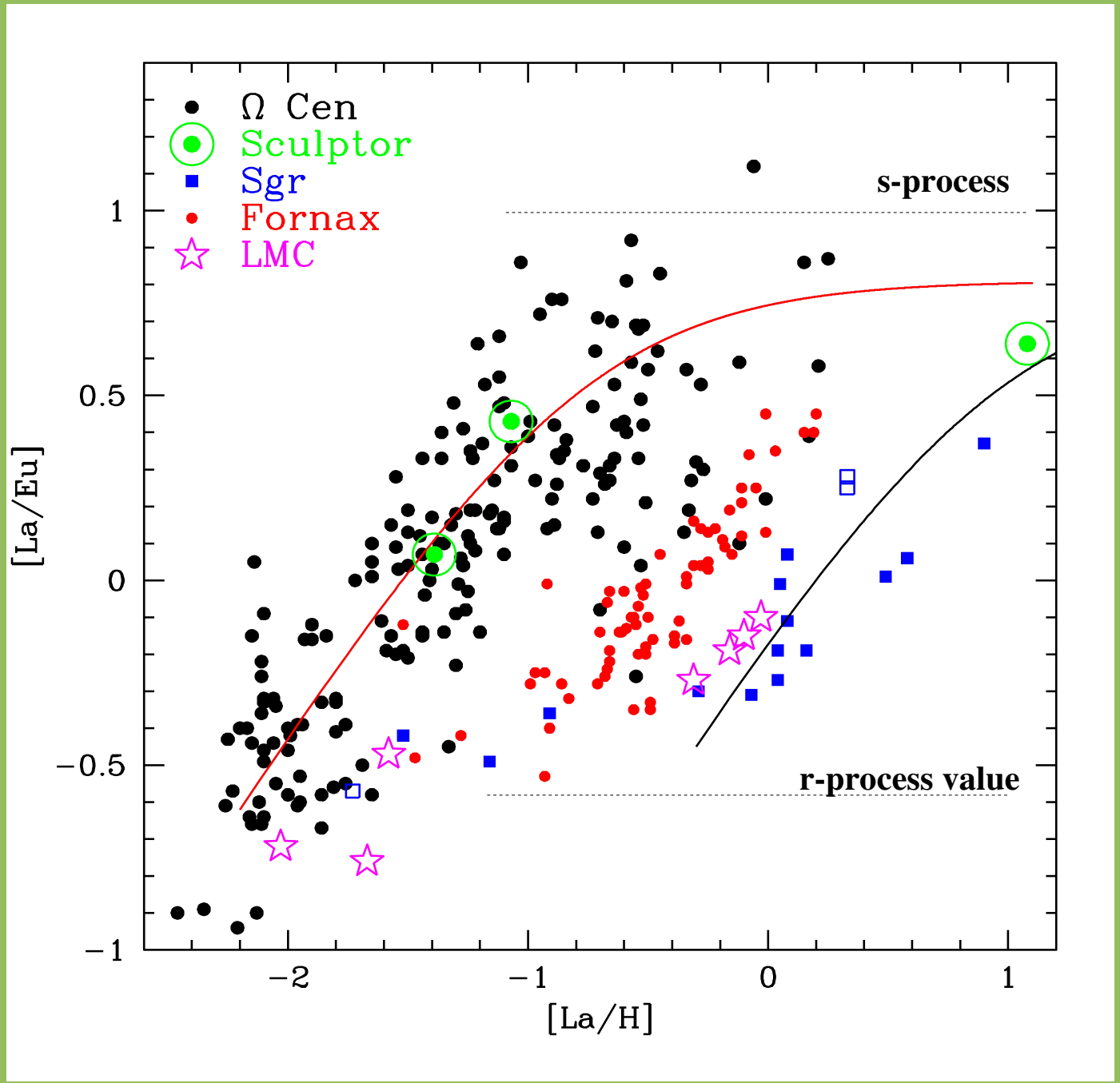
1. Confirmed O deficiencies in Sgr are in conflict with Eu abundances.

2. O is likely reduced due to reduced numbers of massive SNII in Sgr, by IMF truncation or steep slope (e.g. expected of the IGIMF).

3. Eu/O signature seen in other dwarf galaxies, suggesting that they, too, show low [O/Fe] due to a paucity of massive SNII.

4. The r-process site is associated with lower-mass SNII than the bulk of the oxygen producers.

Introducing the Neutron-Capture Plot



locii are 100% s-process dilution curves

break at main s-process

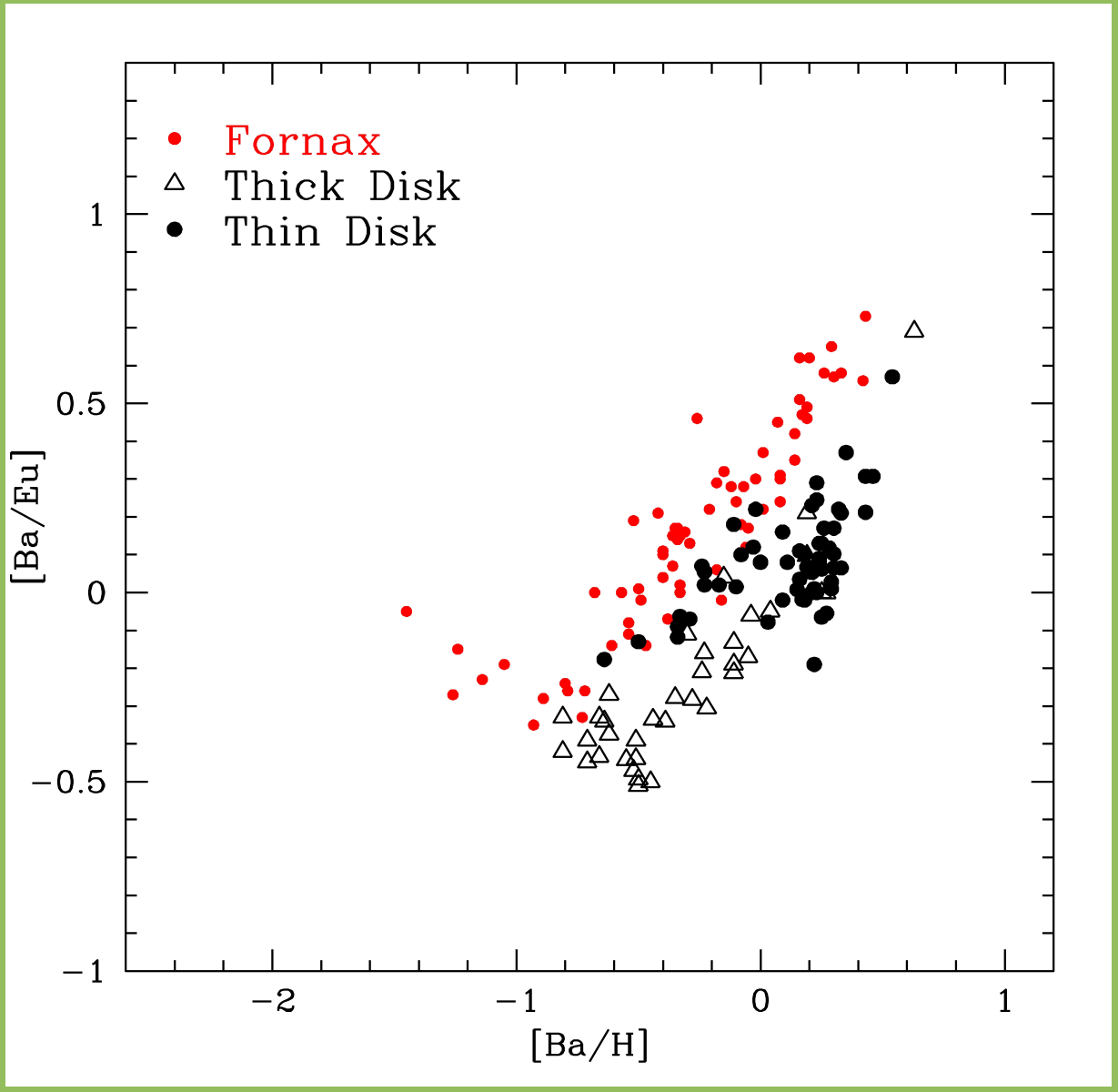
main s- time delay?

weak s-process visible

LMC GCs show common chemical origin?

Chemical tagging?

MW Thin and Thick Disks show similar s-process dilution curve



(Ba proxy for La)

The Neutron-Capture plot shows:

Two phase neutron-capture element enrichment (r- and s-)

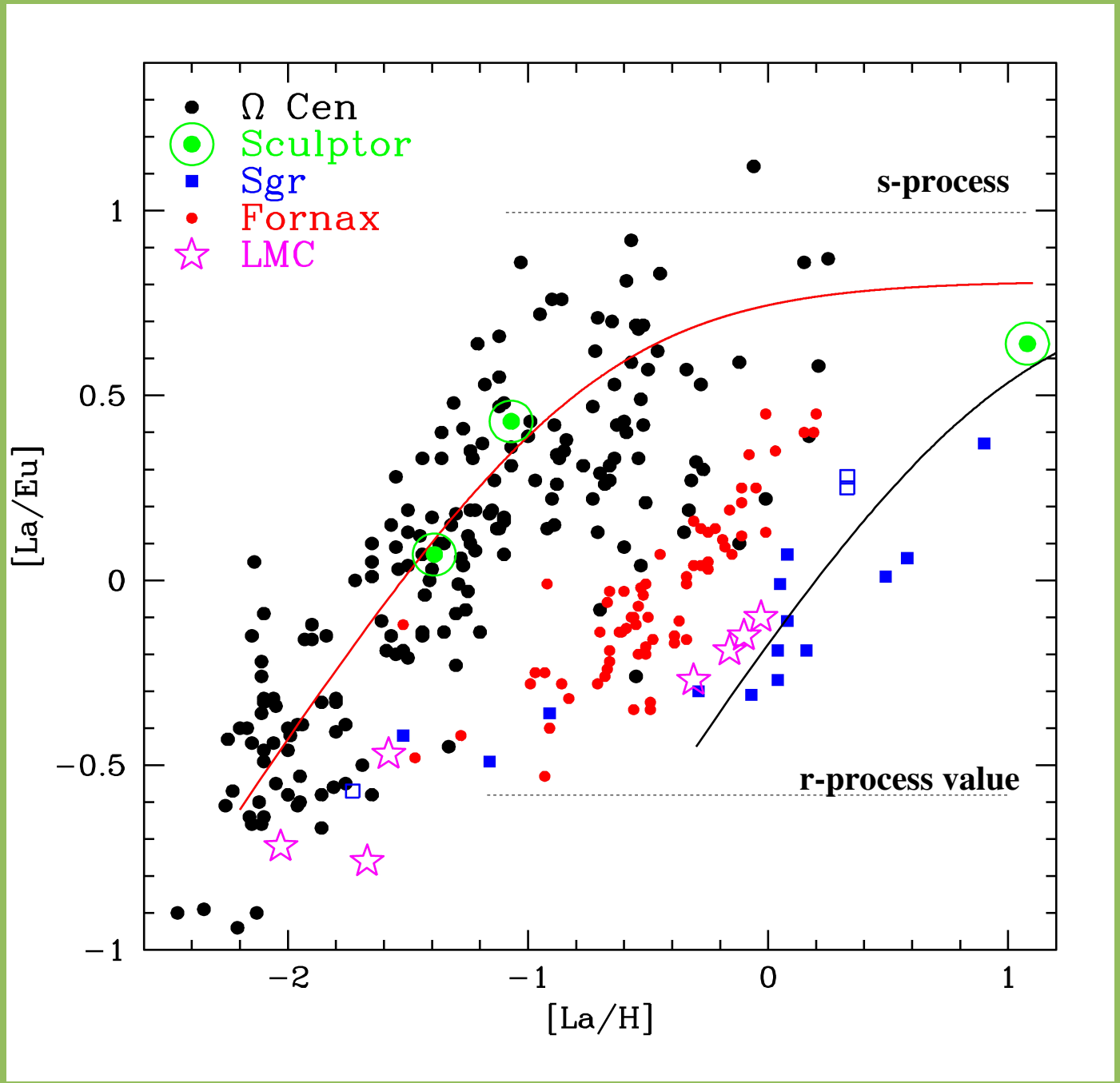
Dilution by nearly pure s-process

Suggests a time delay

Evidence of the weak s-process from massive stars

Useful for chemical tagging

Introducing the Neutron-Capture Plot



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