Probing the chemical composition of the young stellar populations in the solar neighborhood

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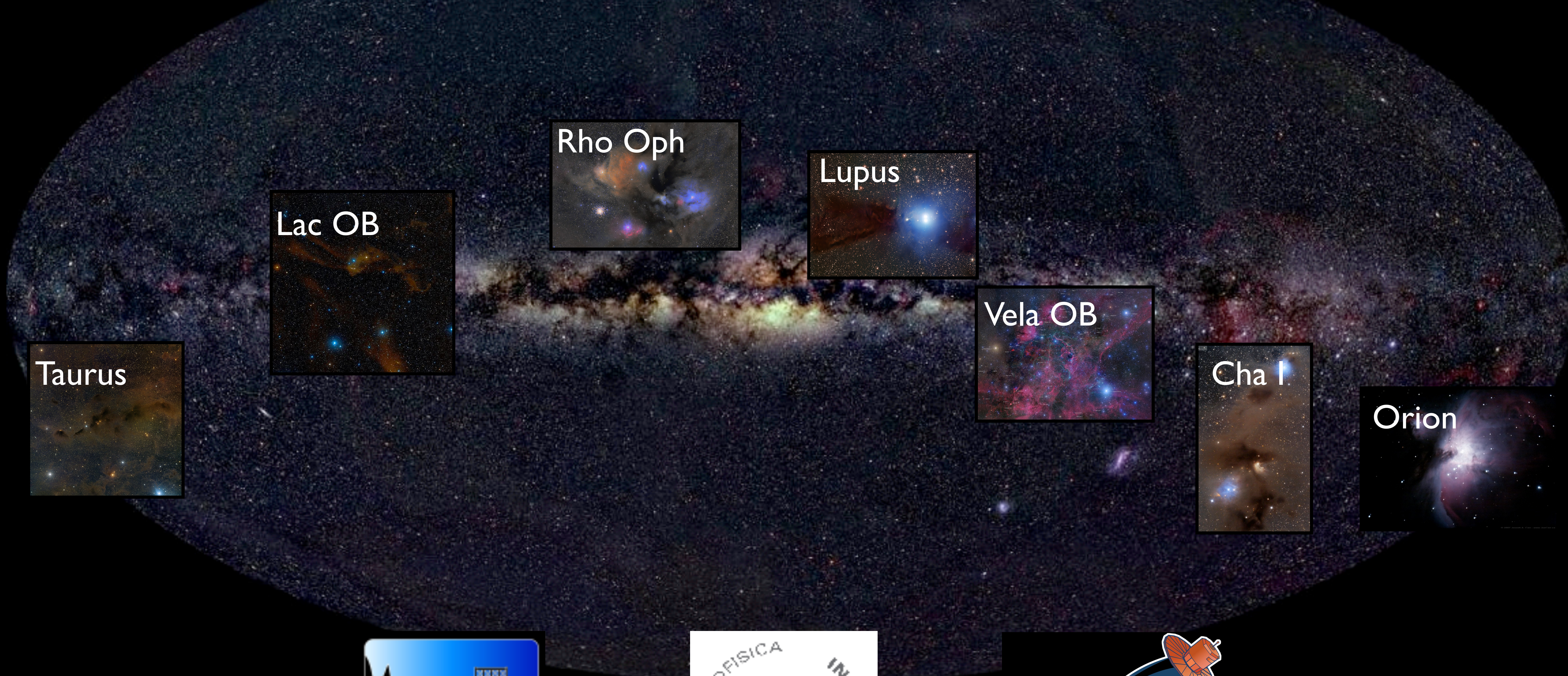


Why metallicity of young populations?

Latest products of the Milky Way → Chemical evolution of our Galaxy

No time to move and disperse through the Galaxy → Key objects to trace the actual chemical pattern of the thin disk

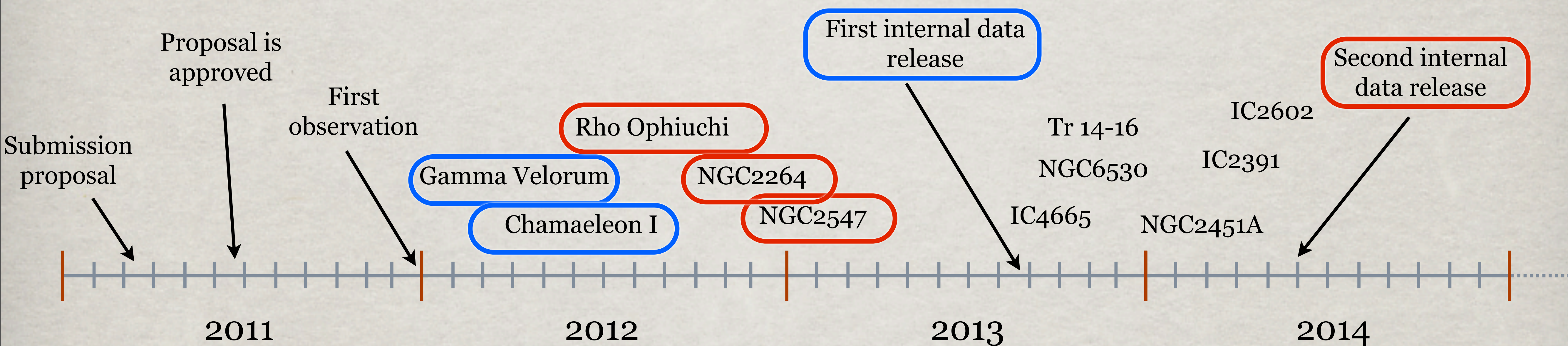
Nature of the local star formation events

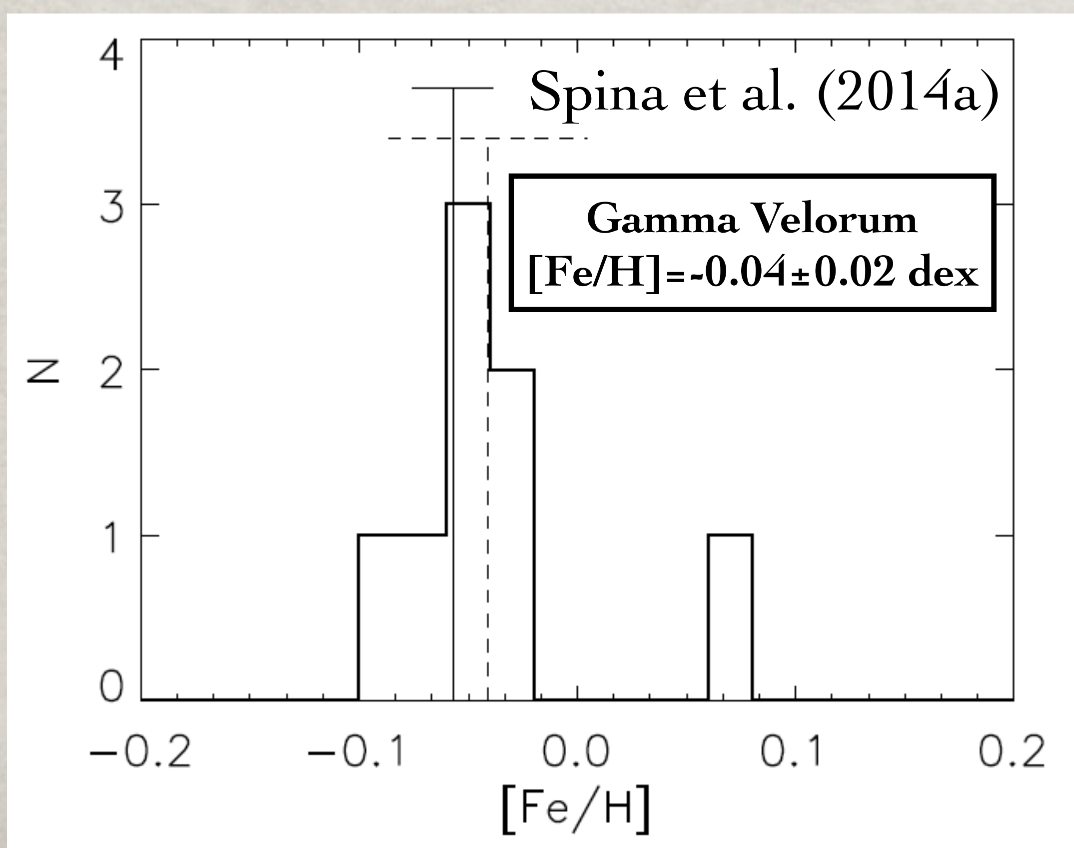
Connection with planet formation:
Disk photo-evaporation efficiency depends on metallicity (e.g., Ercolano & Clarke 2009)
Surveys have shown that gas giant planets are more frequently found around metal-rich stars (e.g., Santos et al. 2004)

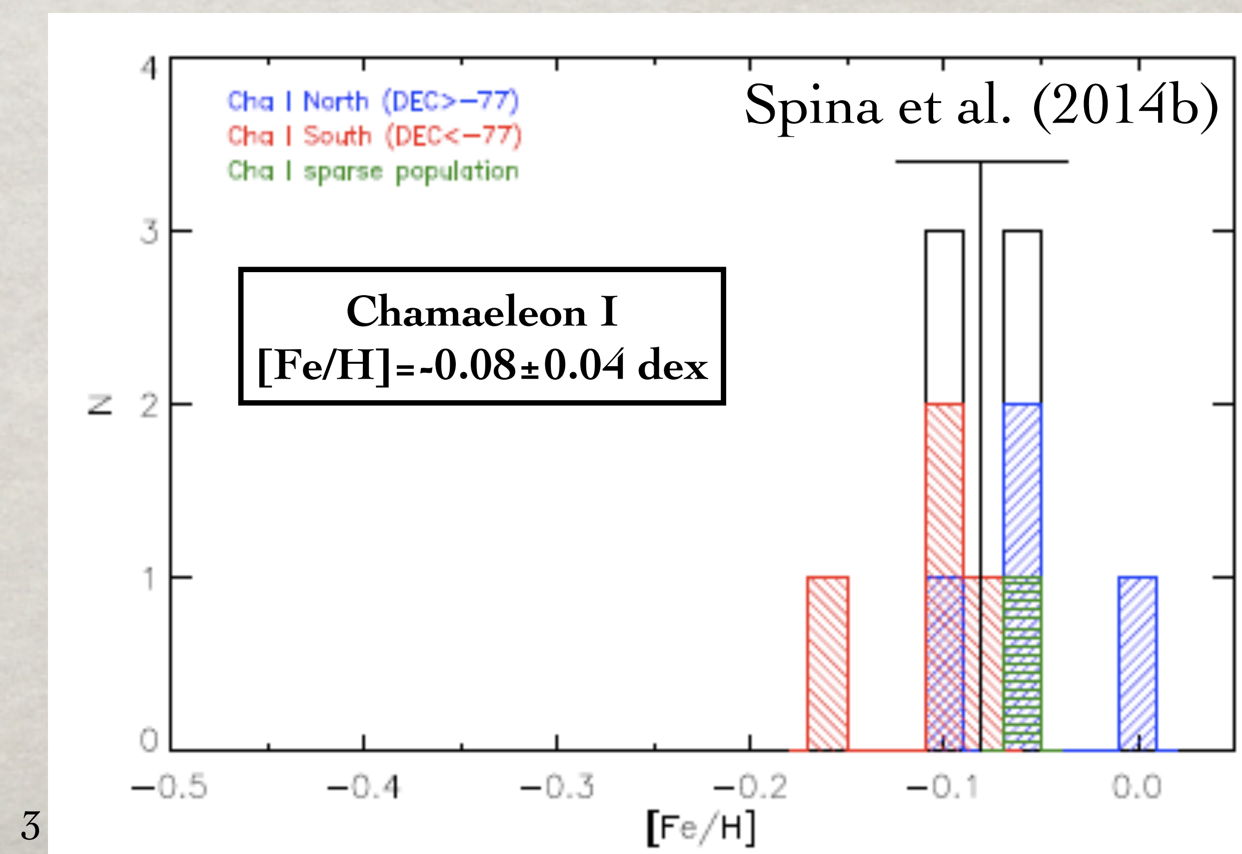
Abundances help to trace back the common origin of different sub-groups in a given association and to reveal the presence of enrichment caused by nearby supernovae
iron-peak elements: V, Cr, Mn, Fe, Co, Ni
α-elements: Si, Mg, Ti, Ca

The strength of the Gaia-ESO Survey

Homogeneous & reproducible analysis → Homogeneous comparisons of different stellar populations





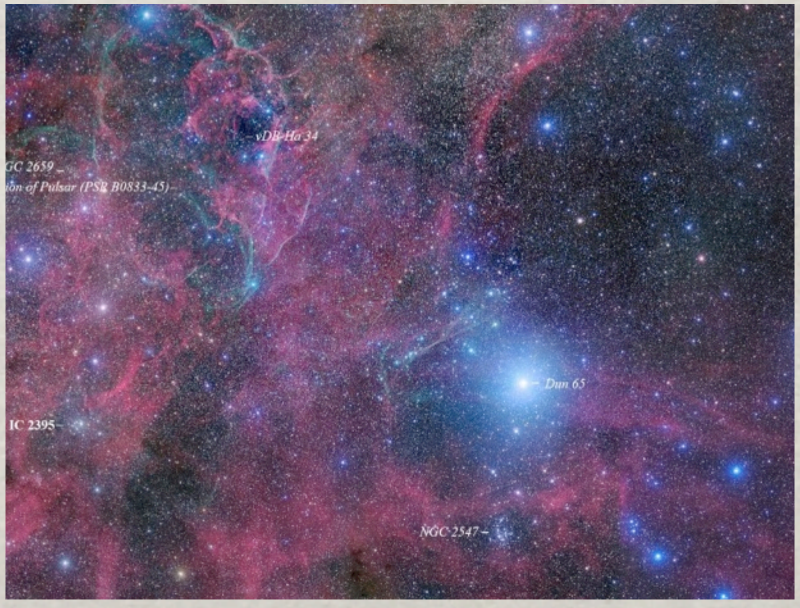


Today's clusters

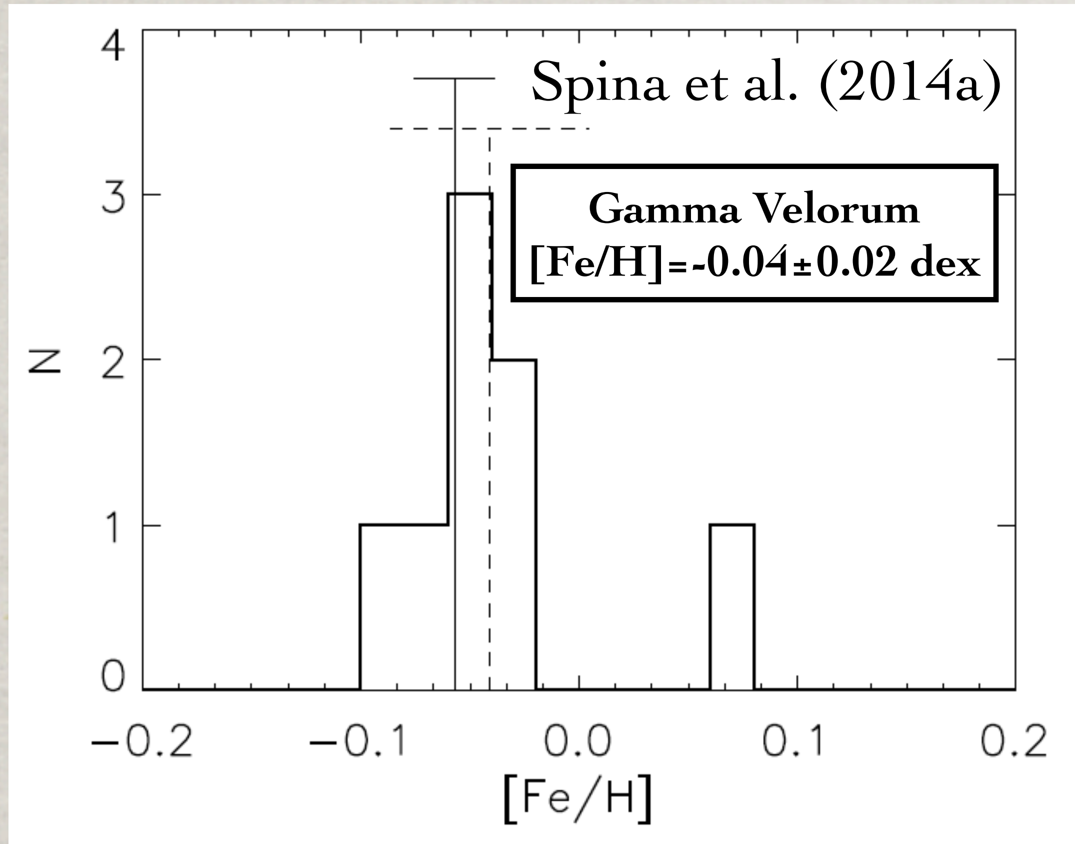
Rho Ophiuchi (23 UVES targets)
l,b= 353.22, -16.533
d = 120 pc (Loinard et al. 2008)
age = 3 Myr (Erickson et al. 2011)
• one of the closest SFRs
• prototype of triggered star formation

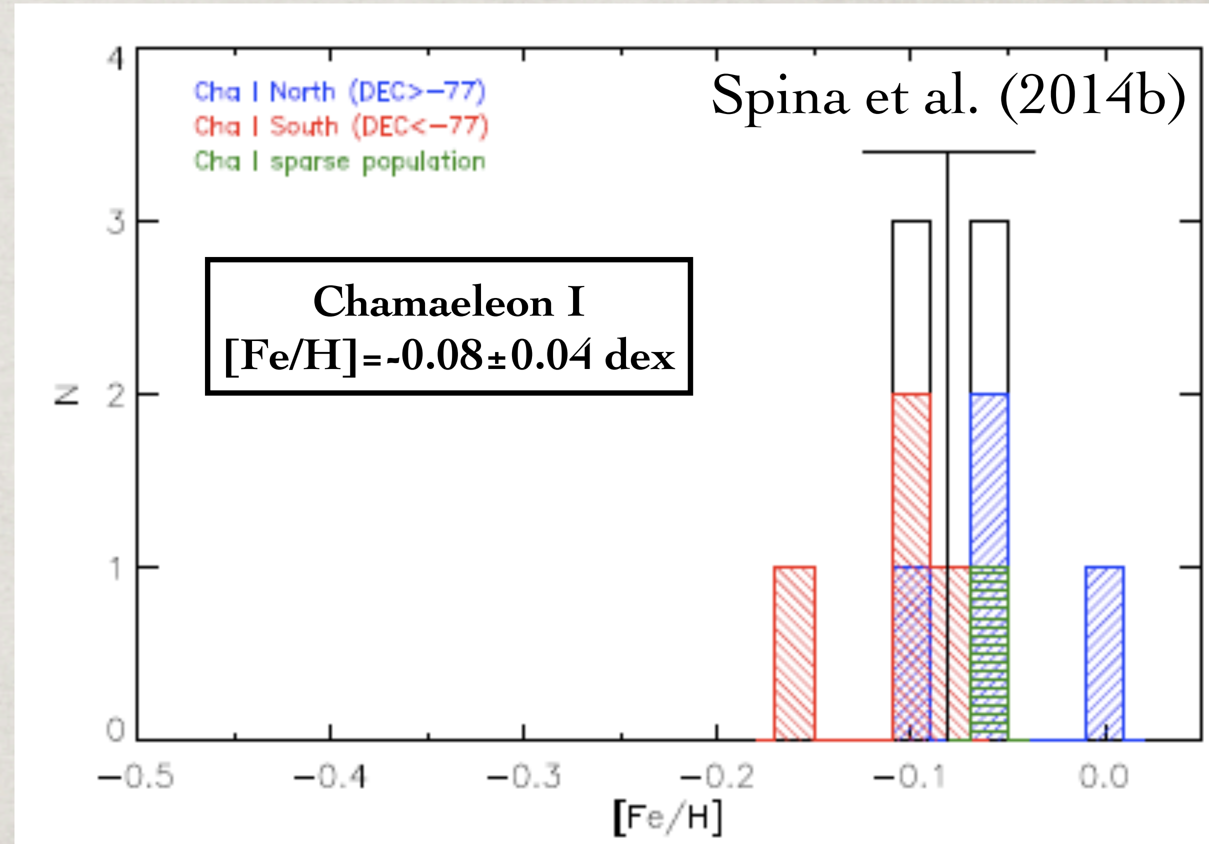
NGC 2264 (118 UVES targets)
l,b=202.95, +02.20
d = 760 pc (Sung et al. 2007)
age = 3 Myr (Sung et al. 2004)
• relatively far (Rgal~9 kpc)
• composite and rich cluster that also contains several early-type stars (07-B9)
• unknown metallicity

NGC 2547 (26 UVES targets)
l, b = 264.47, -8.60
d = 360-400 pc (Naylor & Jeffries 2006)
age = 35 Myr (Jeffries & Oliveira 2005)
•it lies in the Vela OB association, within the Gum Nebula and close to Gamma Velorum
•two kinematic pop. (Sacco et al., in prep.)
•unknown metallicity

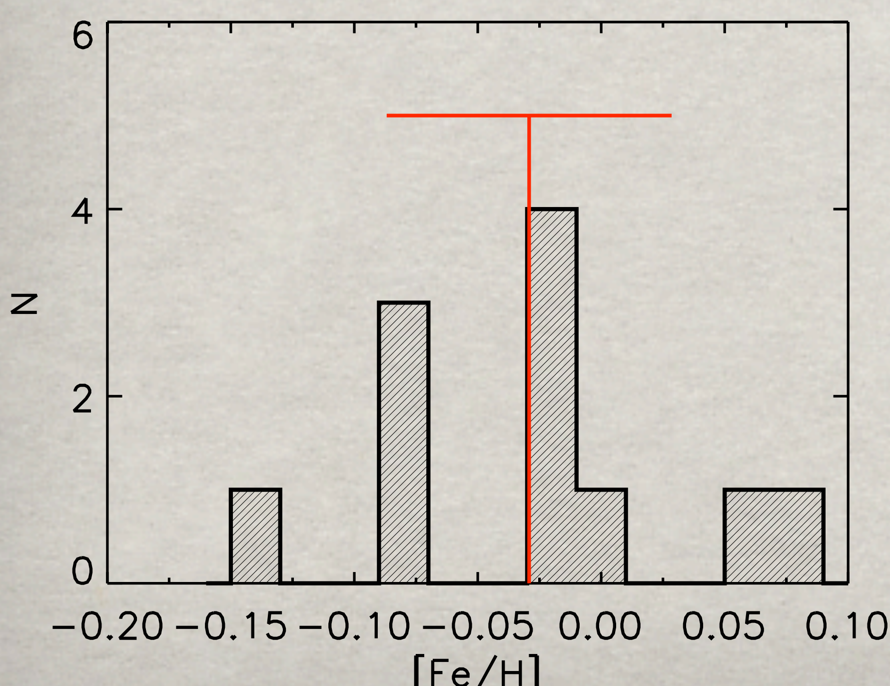


Iron abundance distributions

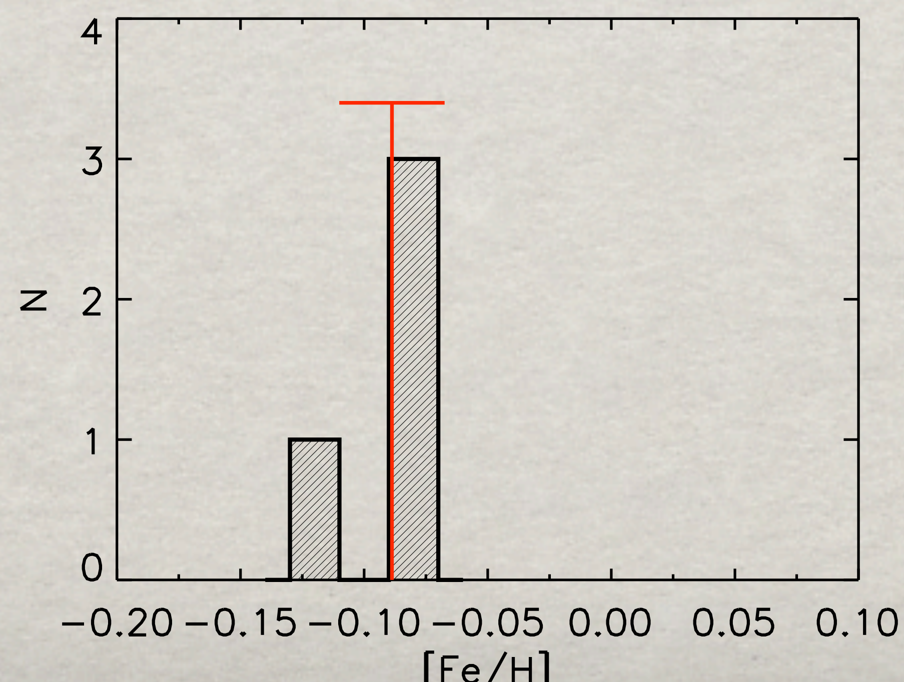




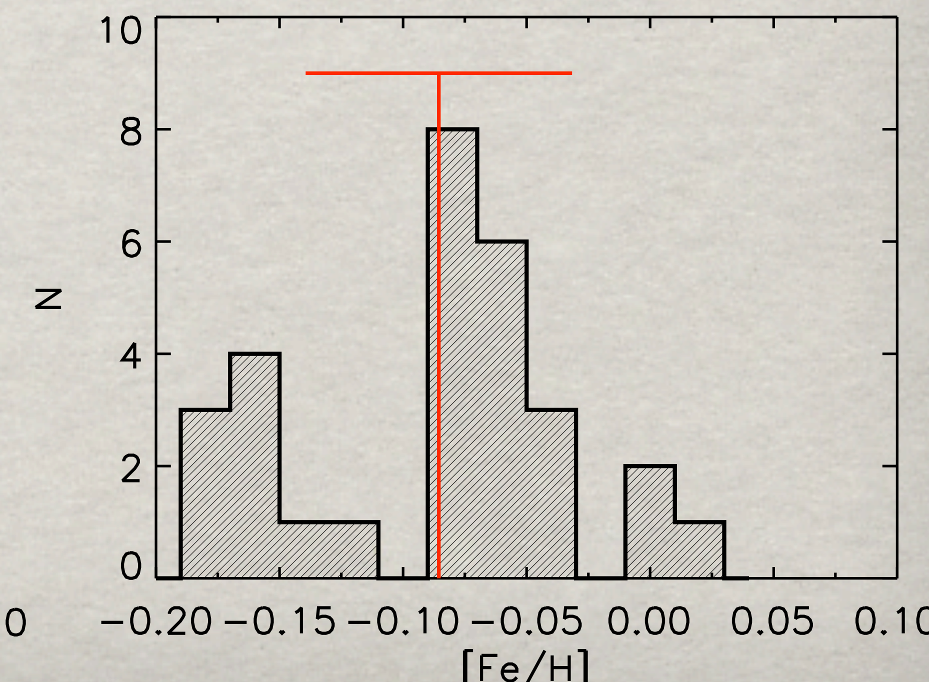
NGC 2547
[Fe/H]=-0.03±0.06 dex



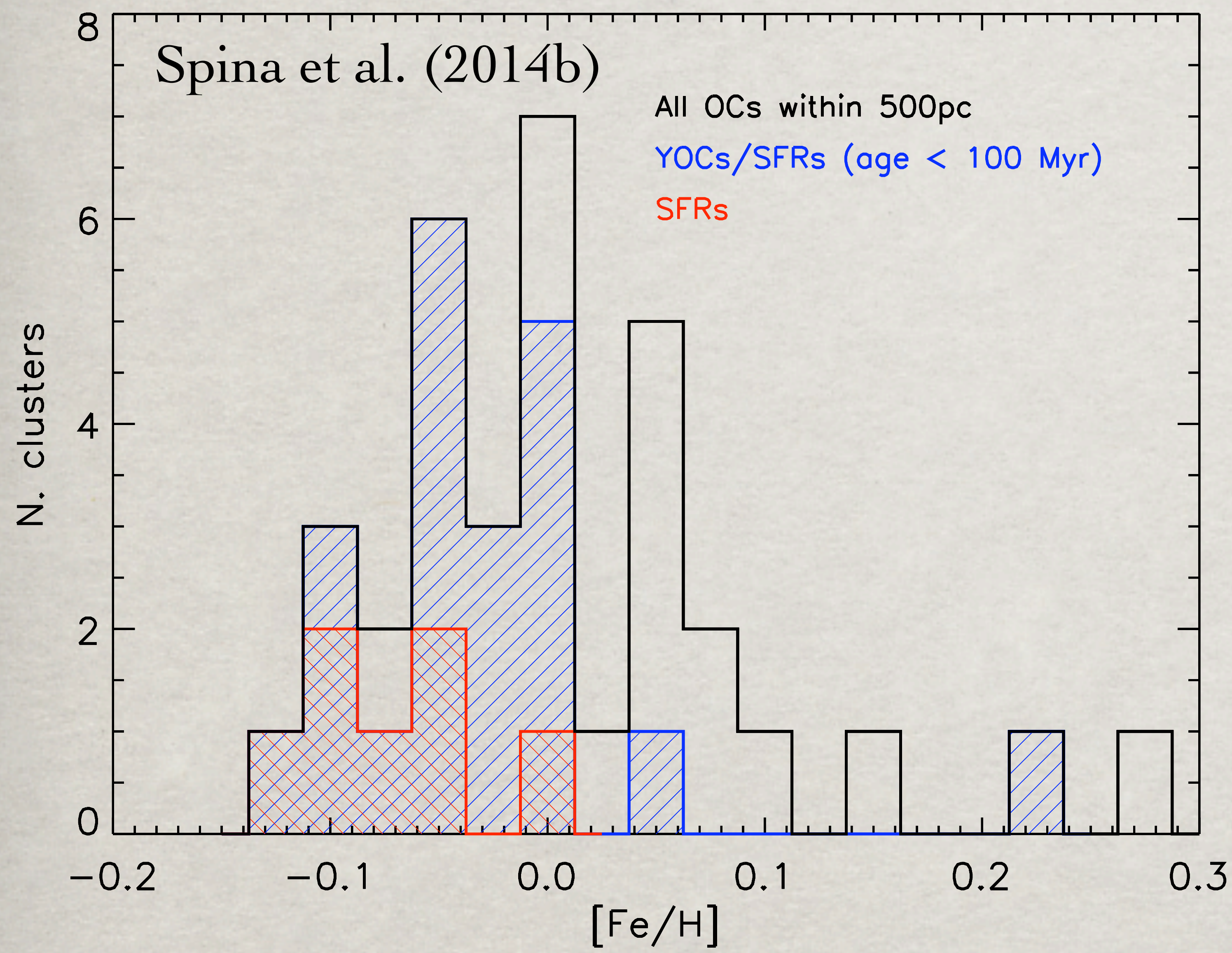
Rho Ophiuchi
[Fe/H]=-0.09±0.02 dex



NGC 2264
[Fe/H]=-0.09±0.05 dex



Metallicity in nearby young populations



- Nearby clusters cover a range in [Fe/H] from -0.12 to +0.27 dex

- The youngest clusters are restricted to the low metallicity values (with one exception)

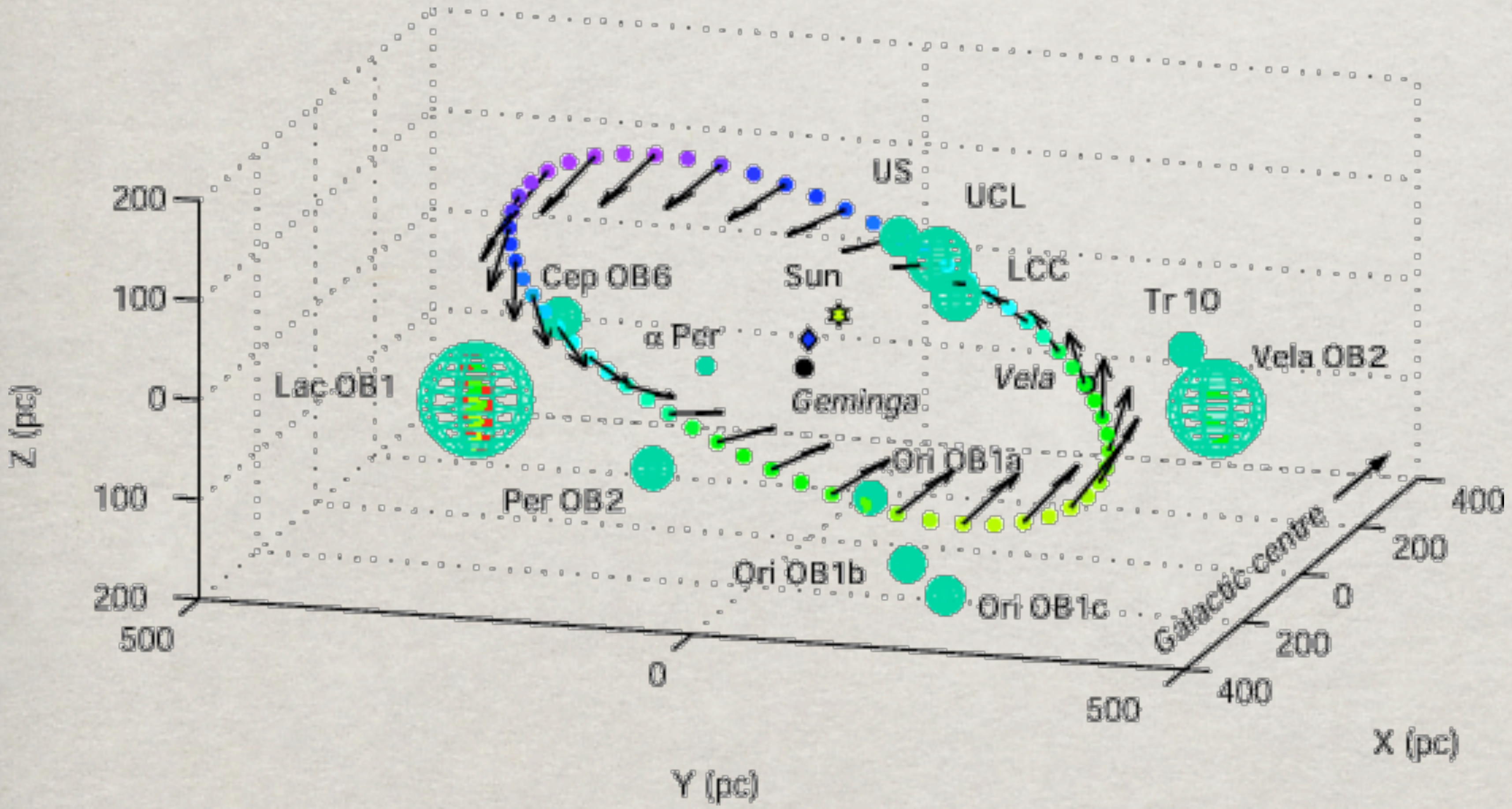
- No metal-rich SFRs seem to exist! ...genetic vs statistical?

The present chemical pattern of the ISM in the solar neighborhood seems to be poorer of metals than the Sun itself!

...is there a possible reason for that?

The Gould Belt

- A structure clearly visible in the sky as a large ring of O-,B-type stars (Poppel 1997).
- Hipparcos: 60-66% of the young massive stars within 600 pc belong to the GB (Torres et al. 2000).
- Most of the molecular clouds within 1Kpc are related to the GB (e.g., Dame et al 2001).
- Young (30-80 Myr) lithium-rich low-mass stars trace the “Gould Disk” (Guillout et al. (1998).

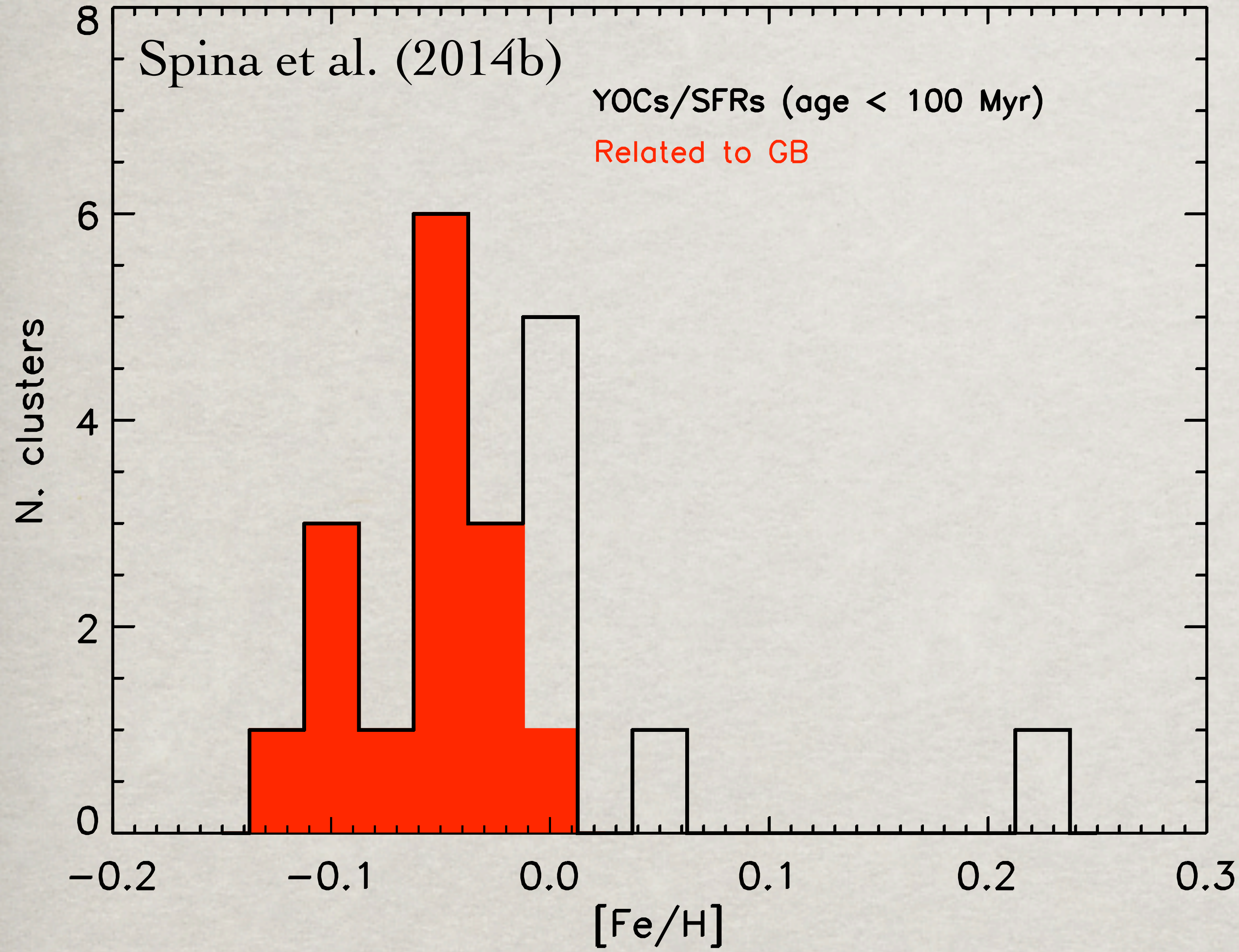


Perrot & Grenier (2003)
- Major semi-axis: 354 pc
- Minor semi-axis: 232 pc
- Thickness: 60 pc
- Inclination: 60 deg
- D(center): 104 pc

The GB Origin

It formed between 20 and 90 Myr ago.
Its origin is still uncertain:
a) expansion from the Cassiopeia-Taurus center (Blaauw 1991, Poppel 1997)
b) oblique impact of a high-velocity HI cloud on the Galactic disk (Comeron & Torra 1992)
c) feedback effects of supernova explosions on the interstellar medium (Bally 2008)

The Gould Belt scenario



Evidence:
It contains most nearby YOCs/SFRs with metallicity determinations (Poppel 1997; Elias et al. 2009).
Sub-solar metallicity.
Metal-rich clusters are not associated with GB.

Scenario:
The observed metallicity may reflect the initial abundance of the Giant Molecular Cloud complex that gave birth to the GB.

Caveats:
- A small number of metallicity determinations
- Estimates are not homogeneous
- Small differences in [Fe/H].
- Cluster relation with the GB can be highly uncertain.

...additional data are required!

Metallicity anomalies and planet evolution

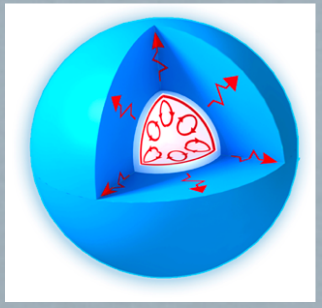
Planet engulfment

Inward migration of planets → Some part of the planetary material may fall into the central star suddenly after the planet formation phase → The circumstellar rocky material that is mixed in the stellar convective envelope can cause an overall metallicity enhancement (Laughlin & Adams 1997)

Where can you observe it?

Thin convective layer →

~~Massive stars $M>3M_\odot$~~



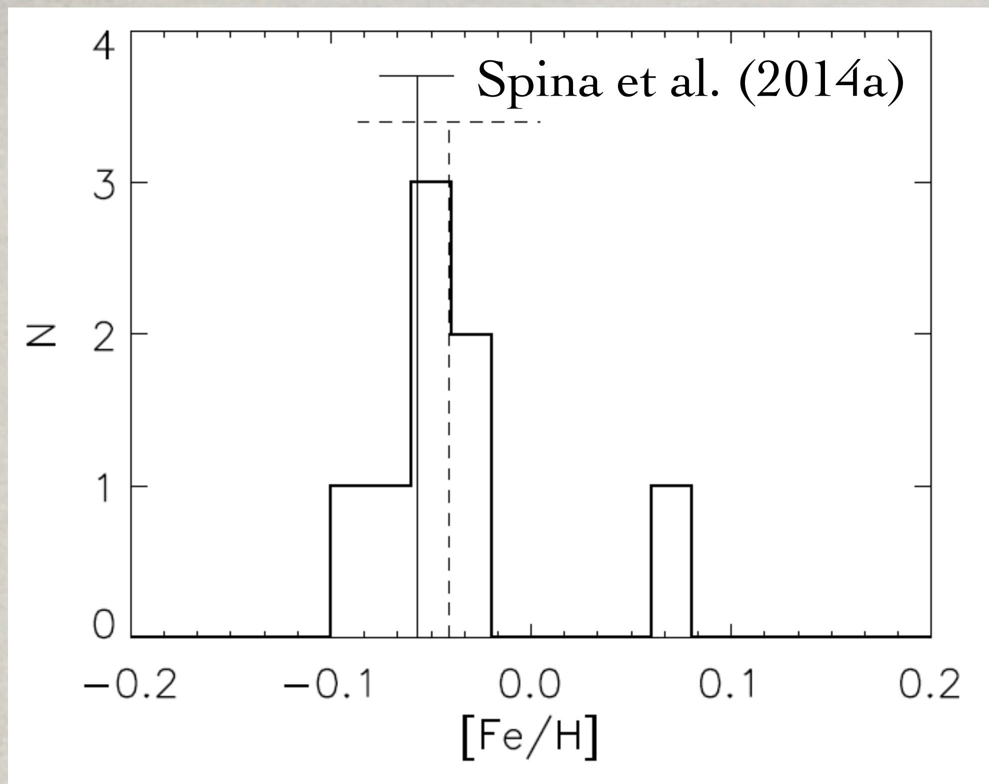
~~Low mass stars $M<1M_\odot$~~

Intermediate mass stars $1<M/M_\odot<3$

When can you observe it?

Not too early (t<10Myr) → Young pre-main-sequence stars stars have a thick convective envelope

Not too late (t>100Myr) → Mixing mechanisms quench the over-abundance (Theado & Vauclair 2012)



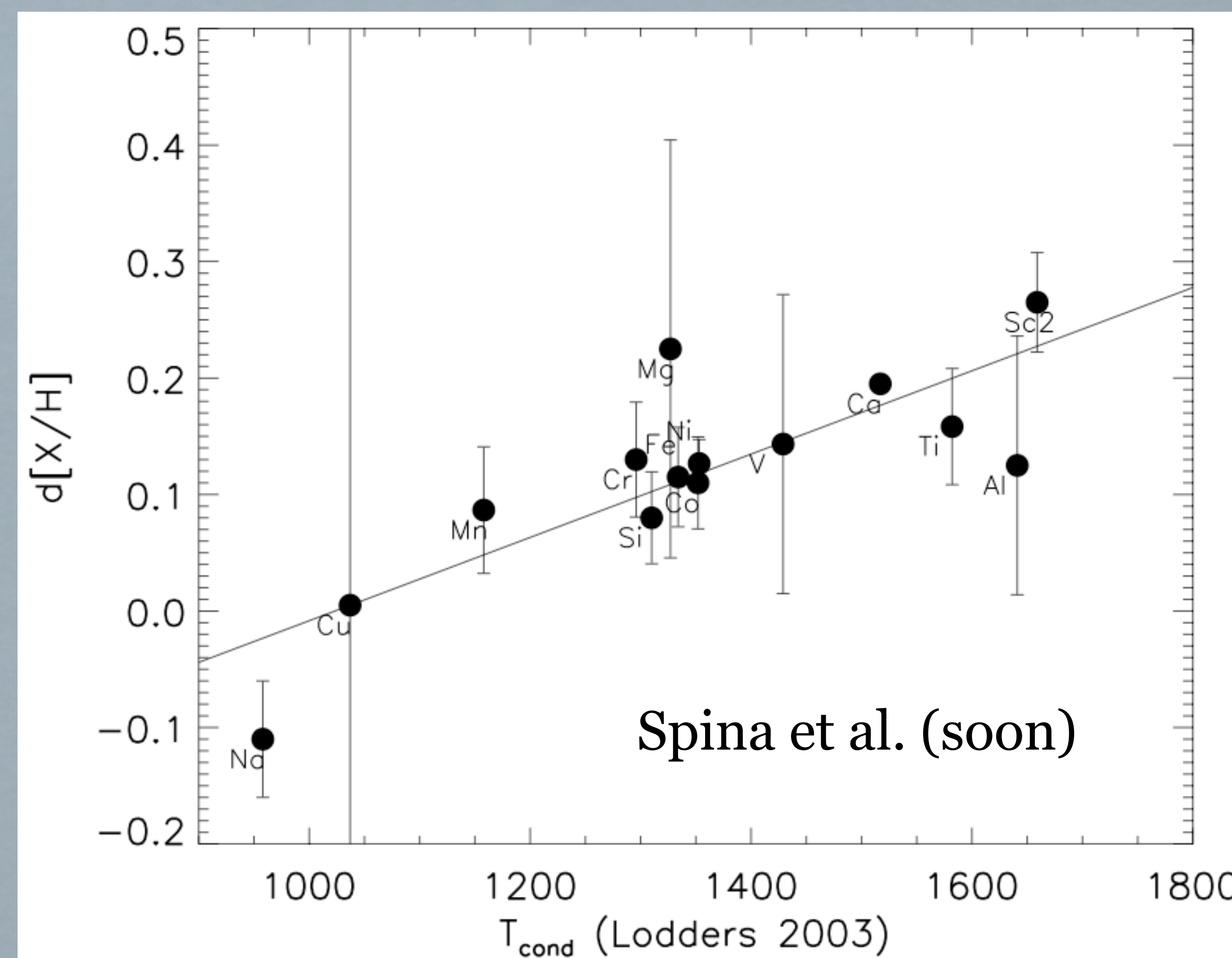
Evidence:
One star (1.3 M⊙;15Myr) is +0.07 dex richer of iron respect to the cluster average (~2σ).

<u>Is it due to planet engulfment?</u>
60 M⊕ of rocky material can produce an enhancement Δ[Fe/H]~0.07 dex (Spina et al. 2014a).

The perfect comparison: two stars of the same cluster!!!

Refractory elements are more abundant than volatiles.
Slope: 0.36 x 10^3 dex K^{-1}

First signature of rocky accretion!



Conclusions & Future Perspectives

We established the metal content of 3 SFRs and 2 YOCs observed by the Gaia-ESO Survey:
1) homogeneous estimates
2) slightly sub-solar metallicity

Most YOCs/SFRs share a similar metal content → The result of a common origin? ...additional data needed.

The Gaia-ESO Survey will provide additional homogeneous abundances

Gaia will provide precise parallaxes and proper motions

→ Confirm the metal poor nature and the association with the GB.

Unexpected topics can be addressed with a homogeneous set of data.

Thank you & stay tuned!