Abundance structure of the Galactic disk

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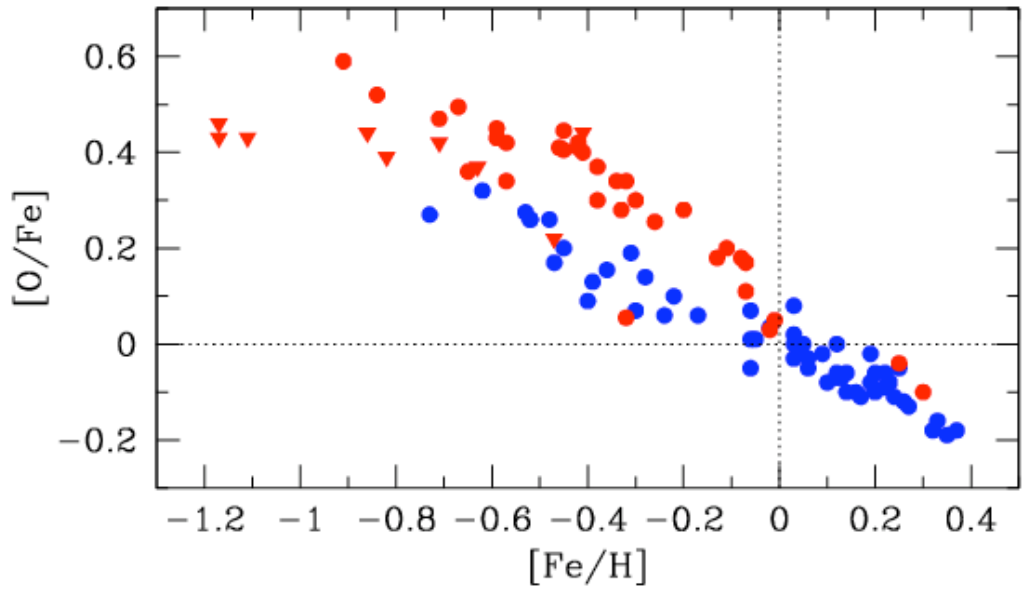
S. Feltzing, JD13 at IAU General Assembly in Prague 2006

Abundance structure of the Galactic disk



Thin disk
Thick disk

Kinematically distinct samples show distinctly different trends for many elements, e.g. oxygen and alpha-elements but also elements like Ba and Al

Nissen et al. 2002 A&A 390 235
Bensby et al. 2004 A&A 415 155
Bensby et al. 2005 A&A 433 185

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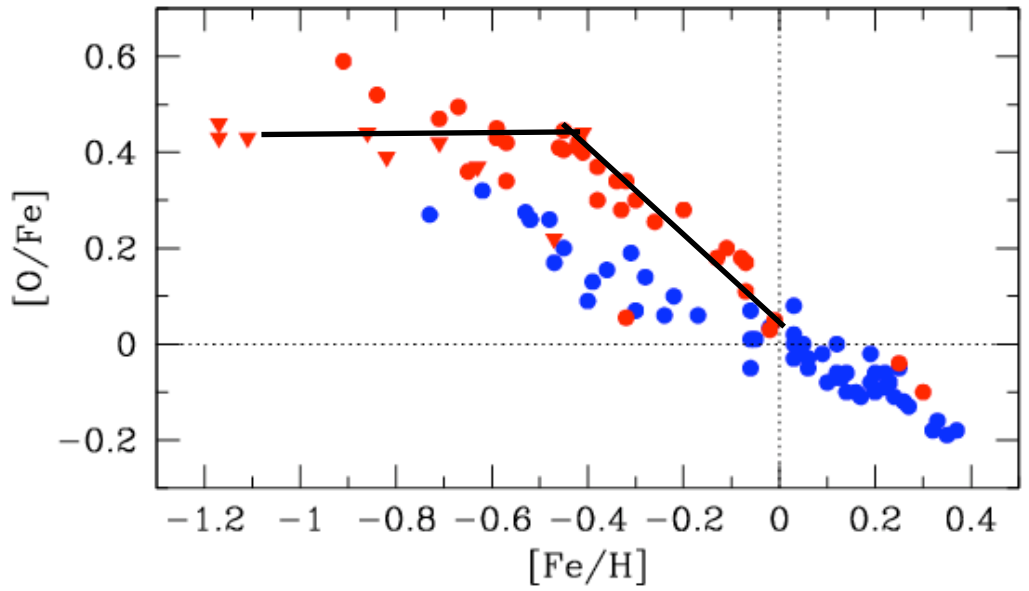

Thin disk
Thick disk

Signature of SNIa implies extended star formation (in time)

The duration depends on the SNIa lifetimes and their cumulative effect

Nissen et al. 2002 A&A 390 235
Bensby et al. 2004 A&A 415 155
Bensby et al. 2005 A&A 433 185

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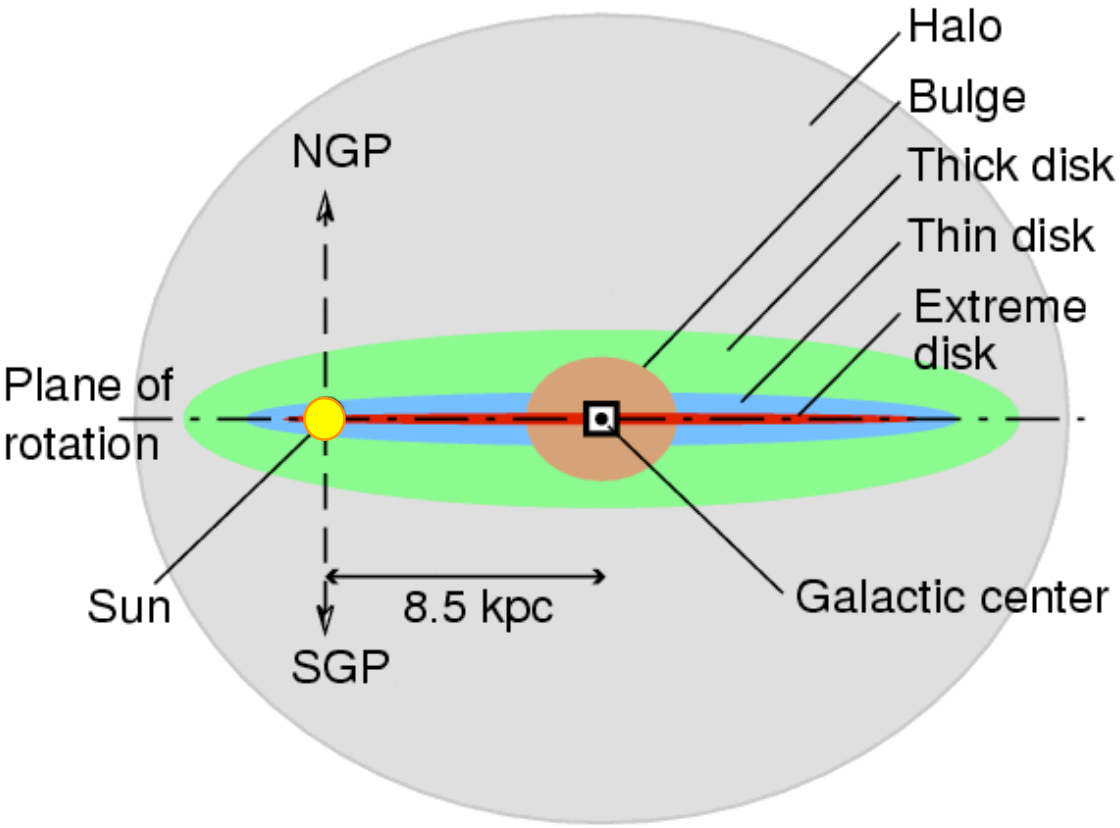
… we are sitting here extrapolating



The Galaxy is big; we are looking very locally; we use kinematics to find targets

Surveys can help us find better defined and better understood samples –
making our extrapolations less hair rising

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Impact of surveys

Major impact of surveys will be to provide targets for high-resolution differential studies of the stellar populations in the Milky Way disks

Completeness

Using differential (*detailed*) abundance studies is crucial

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Recent studies of the abundance trends in the disks include

Differential studies

Fuhrmann 1998 A&A 338 161 and 2004 AN 325 3
Chen et al. 2000 A&AS 141 491
Mashonkina et al. 2003 A&A 397 275
Gratton et al. 2003 A&A 406 131
Bensby et al. 2003 A&A 410 527, 2004 A&A 415 155
2005 A&A 433 185, 2006 MNRAS 367 1181
Mishenina et al. 2004 A&A 418 551

Thick disk only

Prochaska et al. 2000 ApJ 120 2513
Reddy et al. 2006 MNRAS 367 1329

Thin disk only

Reddy et al. 2003 MNRAS 340 304
Allende Prieto et al. 2004 A&A 420 18

Compilation studies

Venn et al. 2004 AJ 128 1177
Soubiran & Girard 2005 A&A 438 139
Marsakov & Borkova astro-ph/0507134

Three examples

The formation sites for elements

The streams

Moving outside the nearest neighbourhood

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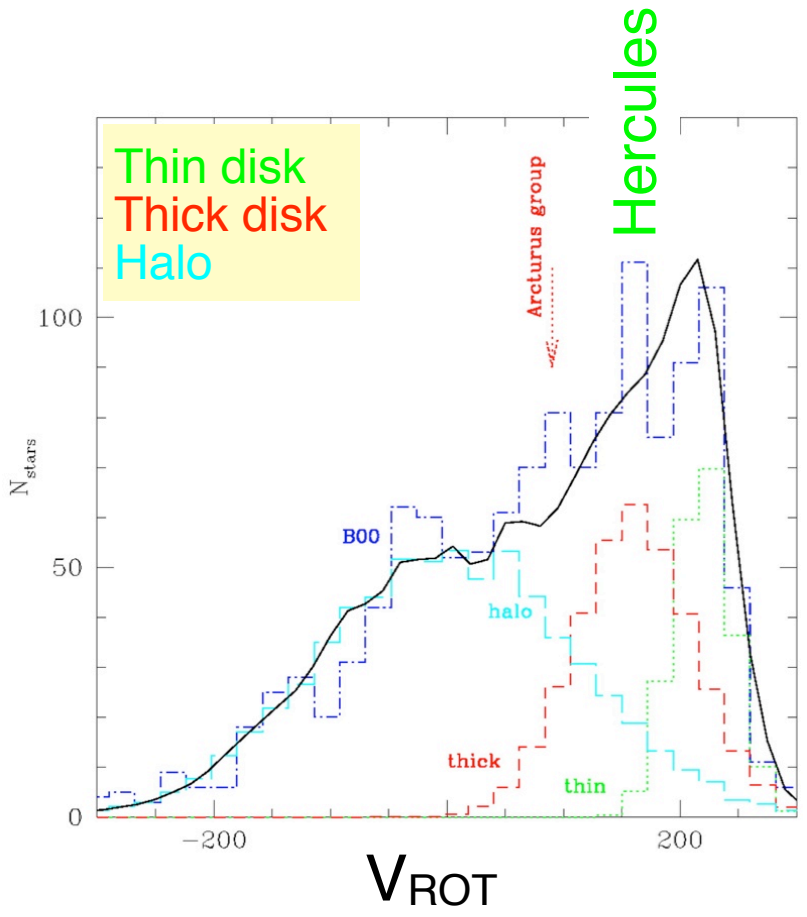
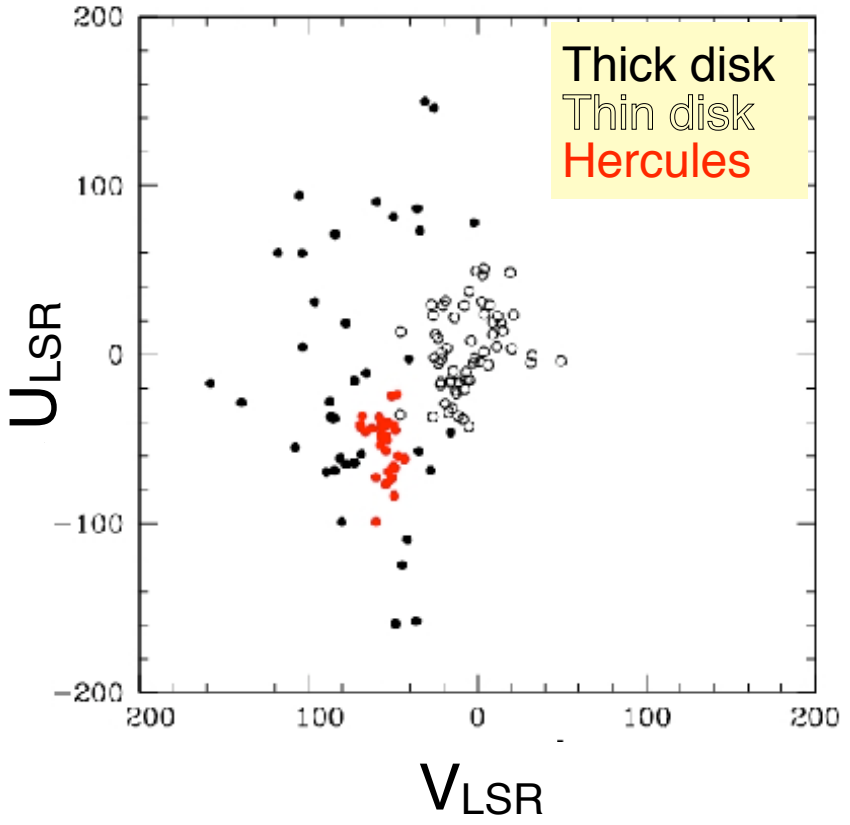
Hercules stream

Kinematic structure identified e.g. Famaey et al. (2005) and Navarro et al. (2004)





Navarro et al. 2004

Bensby et al. *in prep*

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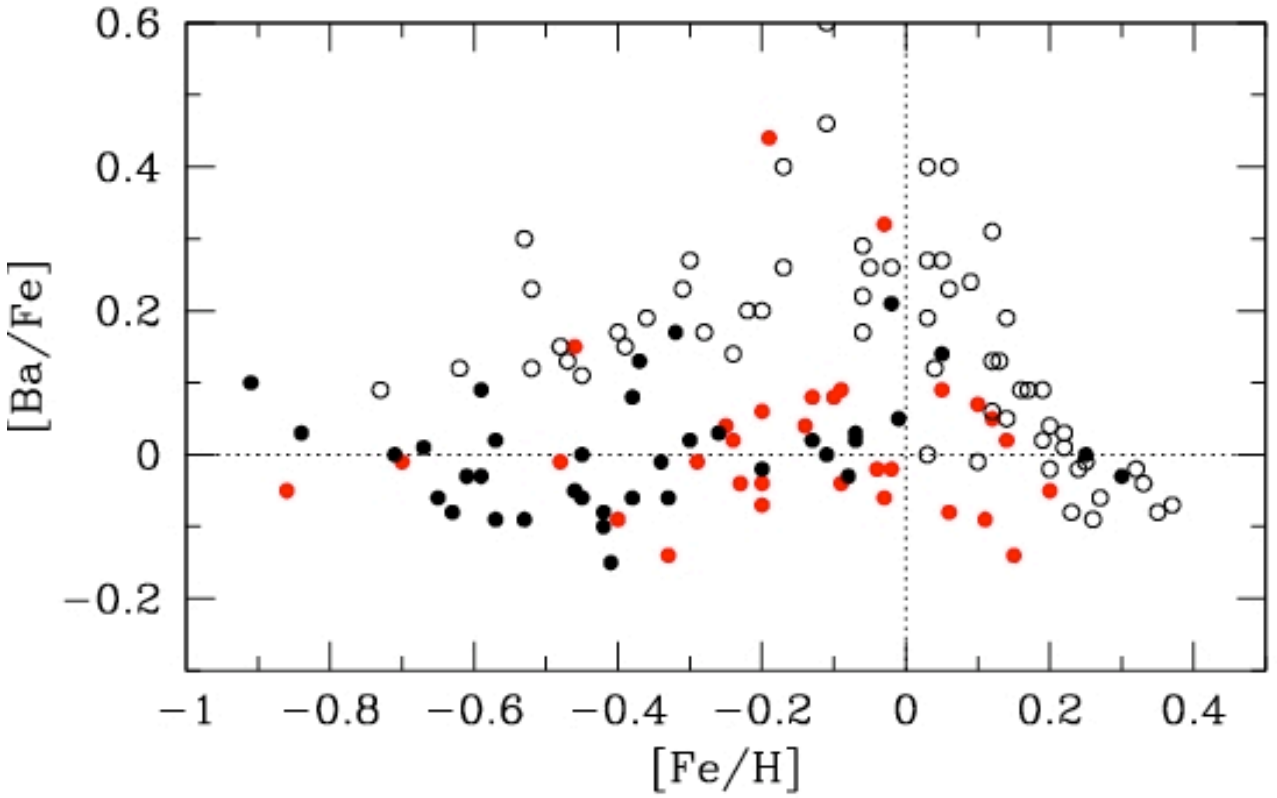
Hercules stream



Thick disk
Thin disk
Hercules

Chemical signature same as for the thick disk
But mean metallicity as the thin disk
What is it? Inner thick disk?
Heated thin disk?
Bulge stars?

Bensby et al. *in prep*

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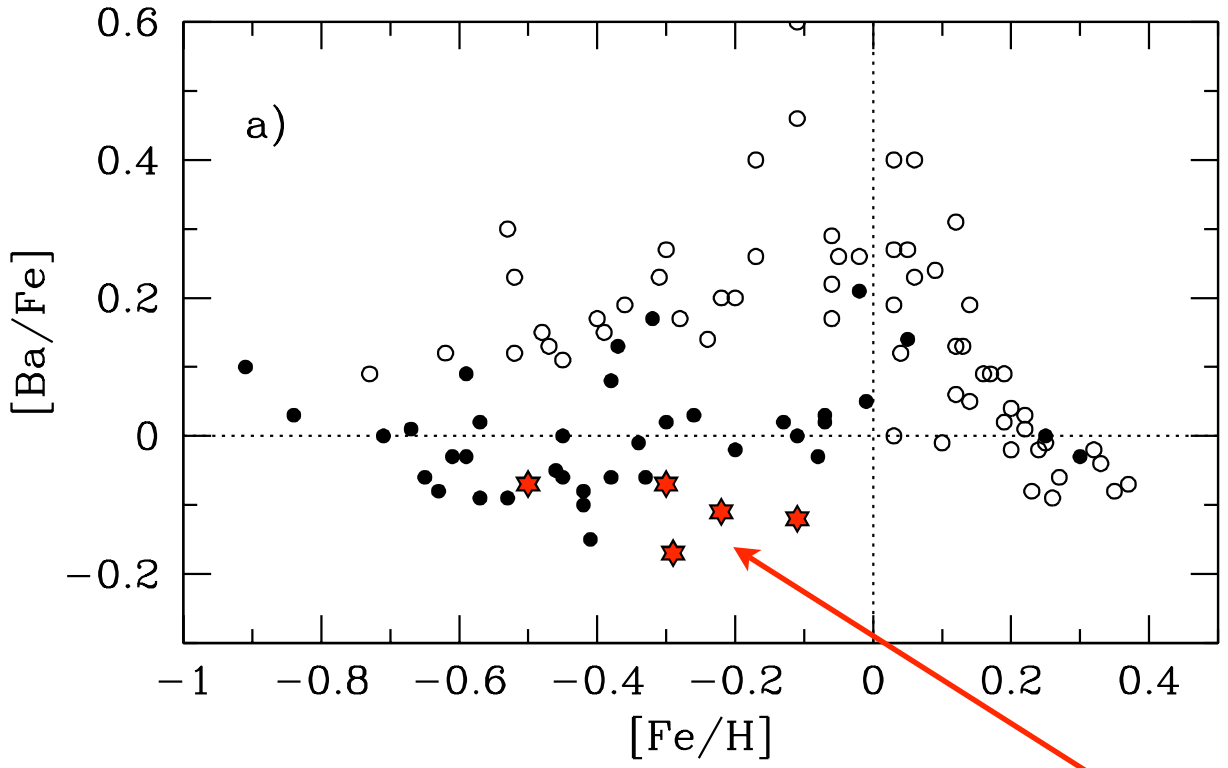
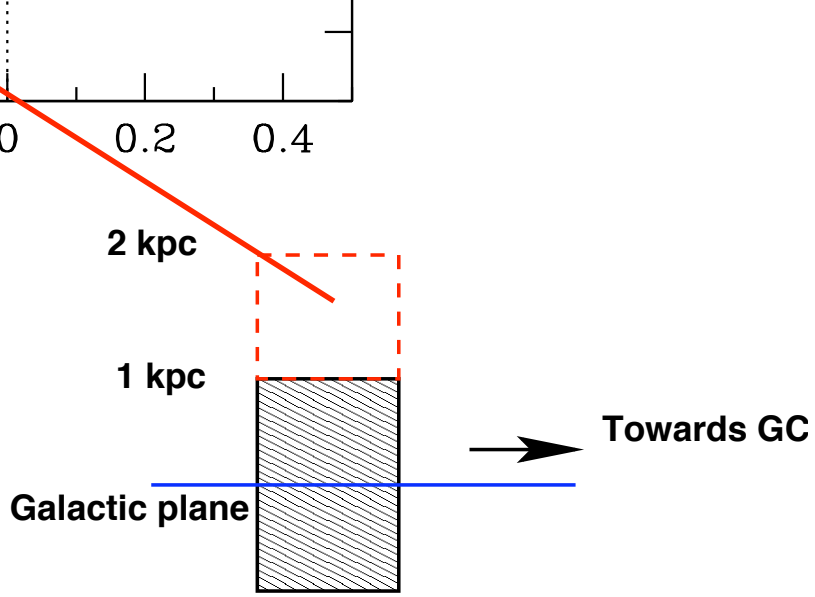
High above the plane – 5 *in situ* dwarf stars



Thick disk
Thin disk
In situ



A first study of five stars at 1 – 2 kpc above the Galactic plane show elemental abundance signatures akin to the local, kinematically selected, thick disk

Feltzing et al. *in prep*

S. Feltzing, JD13 at IAU General Assembly in Prague 2006

Abundances structure of the Galactic disk – summary

The stars with kinematics typical of the thick disk are, at a given [Fe/H], more enhanced in the α-elements than stars with kinematics typical of the thin disk. True also for other elements (e.g. Al, Ba and Zn)

The thick disk stars show evidence of extensive star formation
Evidence for pollution from SNIa
Evidence for pollution from AGB stars

Hercules stream engimatic - thick disk trends, < [Fe/H] > as thin disk

There is no change in the abundance trends with height above the galactic plane (~1000 pc)

The thick disk extends to [Fe/H] = 0

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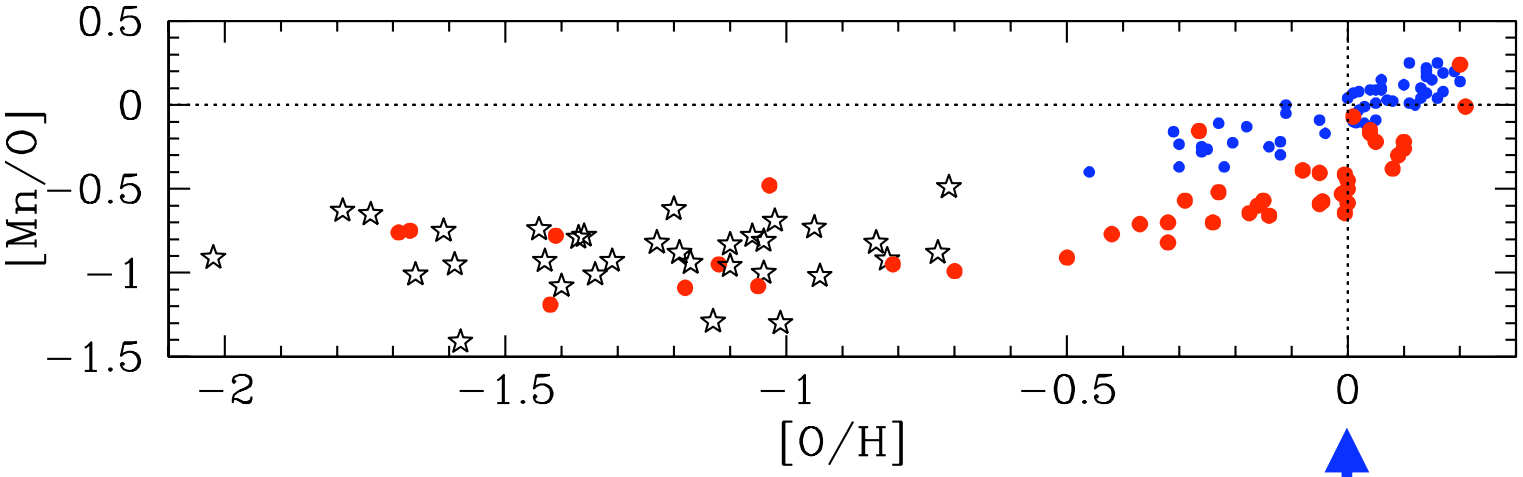
The origin of Mn



Thin disk
Thick disk
Halo

Only SNII up until here (from oxygen plot)

The abundance trends can overall be explained by metallicity dependent yields from SNII.

Previous works have suggested that SNIa also contribute – we may see a hint of this in the thick disk sample.

Feltzing, Fohlman, Bensby, 2006, A&A

What I've not talked about

Stellar ages

Implications for formation scenarios for the disk(s)

Elemental abundances for disk stars with kinematics "in between"

Ages

The solar neighbourhood thick disk stars that have been studied are all old

All thick disk stars that have been studied so far have been found to be older than the thin disk stars

A true age-gap between the end of star formation in the thick disk and the onset of star formation in the thin disk?

Age-metallicity relation in the thick disk
Bensby et al. 2004 and Schuster et al. 2006 A&A 445 939

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Summary

Abundance trends for kinematically selected samples differ

Stars with thick disk kinematics have enhanced α-elements

The elemental abundance trends in the kinematically selected samples are very tight

The thick disk shows evidence for extended star formation

No changes in abundance trends and/or metallicity distribution functions as a function of height above the galactic plane have been found (yet)

The real challenge for models of galaxy formation is to explain the tight elemental abundance trends found for kinematically selected populations of disk stars, i.e. the thin and the thick disk

Completeness