Decomposition of the Galactic Disk: Kinematics and Abundances

Reddy, Tomkin, Lambert and Allende Prieto. 2003, MNRAS, 340, 304

Reddy, Lambert and Allende Prieto. 2006, MNRAS, 343, …

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IIA-in house- Sci. meet: 18 April 2006, 02:00 PM
IIA, Bangalore

Observations

- sample: ~200 F-G dwarfs

- Observations :

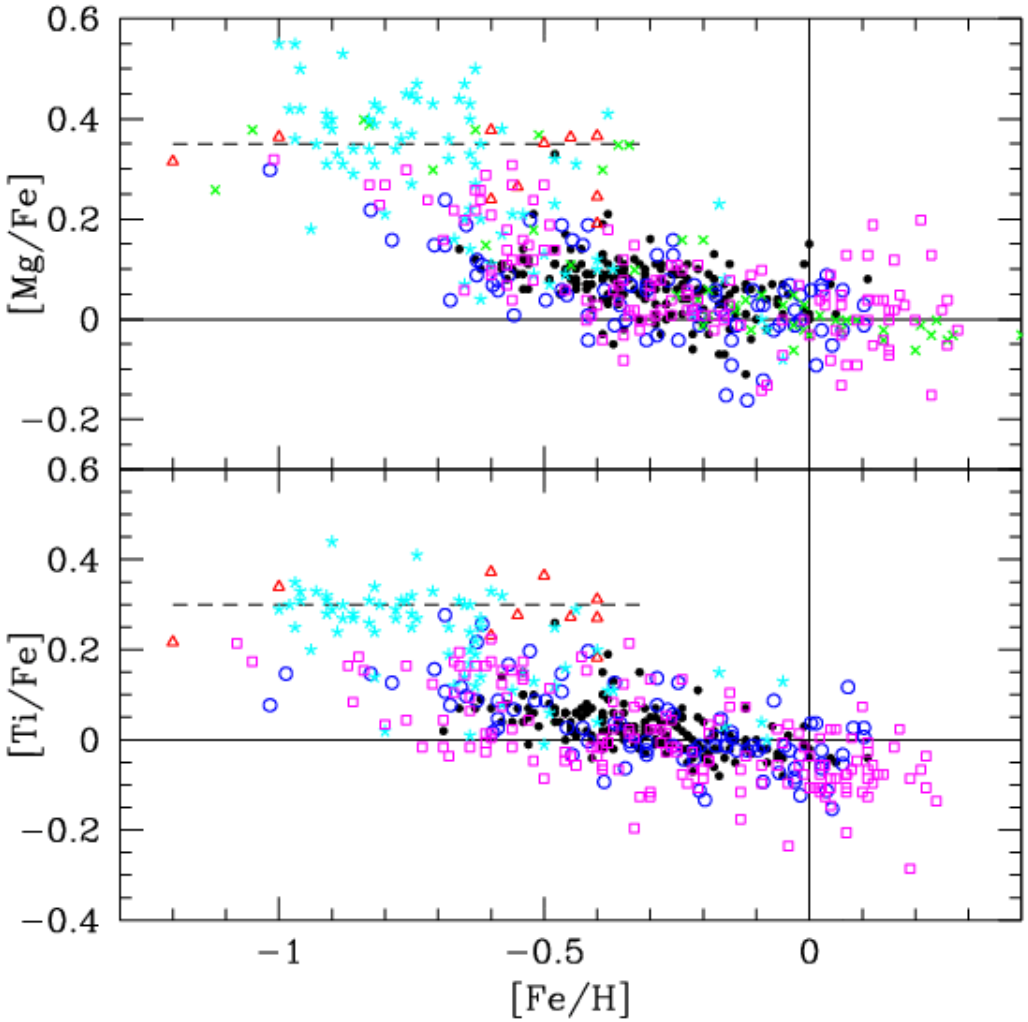
~400 spectra: two for each star and each one's S/N ~ 200 –400 with R~60,000

- Elements :

27 elements belonging to different nucleosynthesis histories: alpha process, proton capture, Fe-peak

Results: different components

Abundances



Note the increase in scatter at [Fe/H] =-0.35

Reddy et al. 2003

Chen et al. 2000

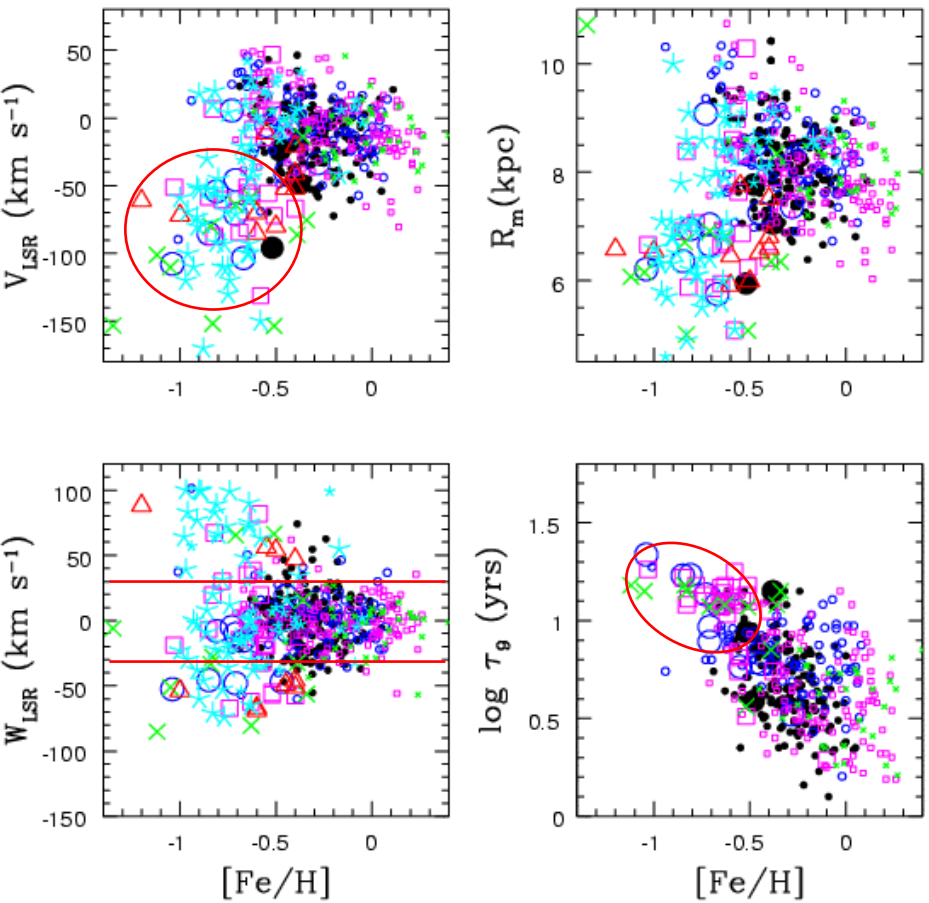
Fuhrmann 1998

Edvardson et al. 1993

Results: different components

Part I

Kinematics



Stars with [Mg/Fe] ≥ 0.2
(Bigger symbols)

V_{lsr} = -40 - -100 Km s^{-1}
W_{lsr} = |100| Km s^{-1}
[Fe/H] <= -0.4
Age >= 10 Gyrs

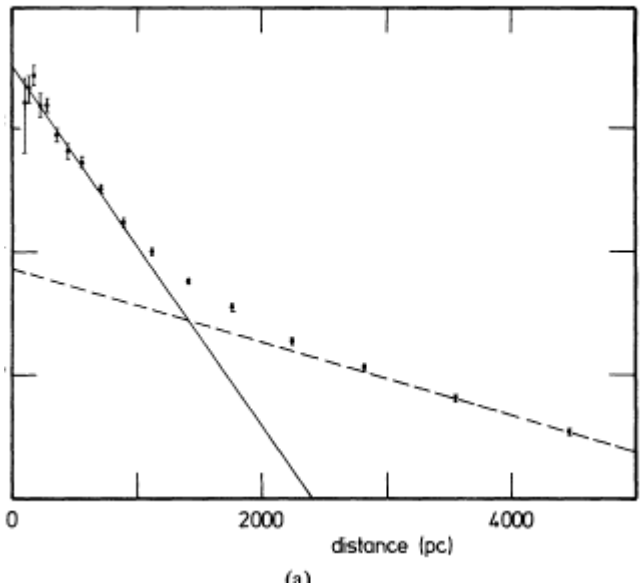
THICK DISK

V_{lsr} = +50 - -40 Km s^{-1}
W_{lsr} = |40| Km s^{-1}
[Fe/H] >= -1.0
Age < 10 Gyrs

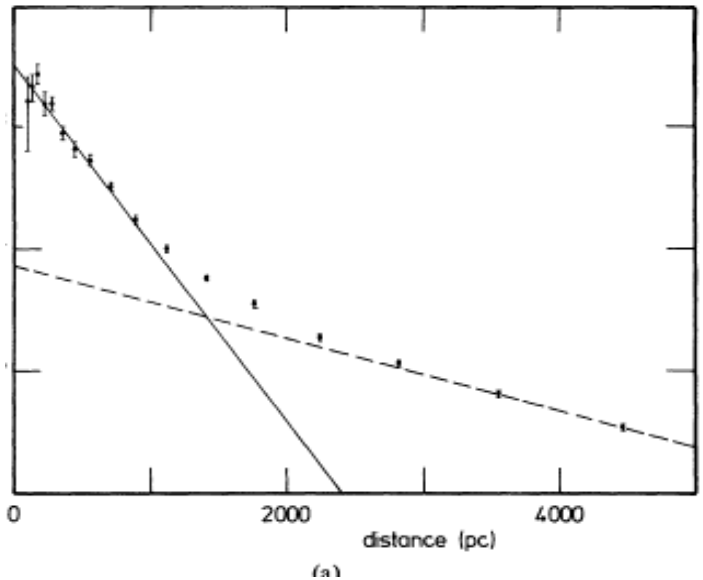
Thin Disk

Reddy et al. 2003

Concept of the Thick disk: Gilmore & Reid, 1983



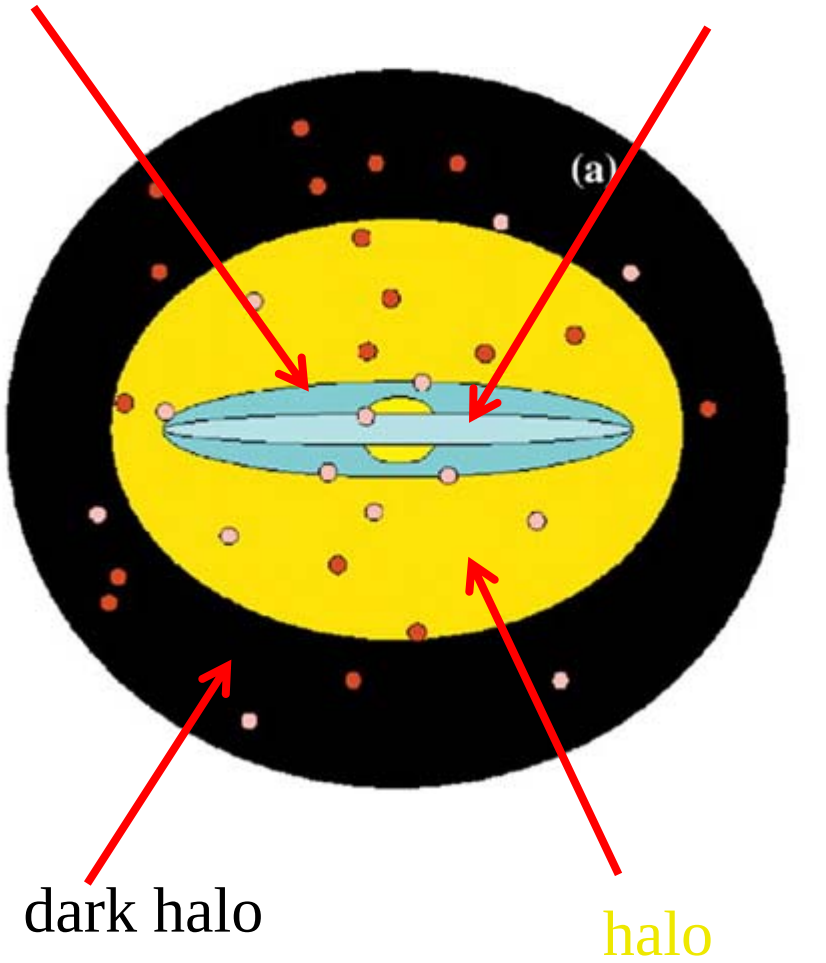
New light on faint stars – III



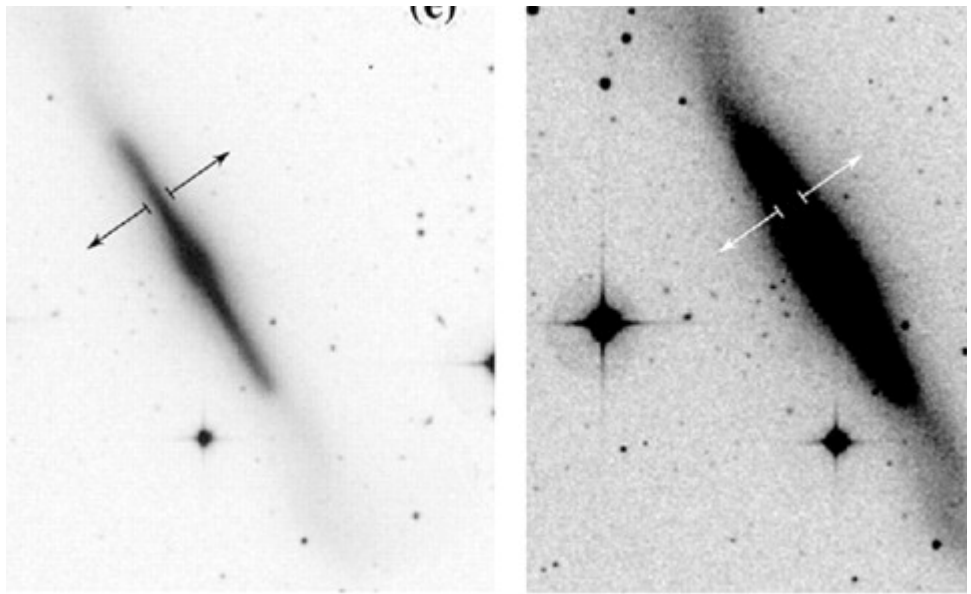
(b)

Figure 6. (a) The density distribution for stars with $4 \leqslant M_V \leqslant 5$ with distance from the Galactic plane. On this scale, a straight line represents an exponential decrease. The fitted lines correspond to exponentials with scale height 300 pc (solid line) and 1350 pc (broken line), and correspond to the 'old disc' and 'thick disc' respectively. (b) As for Fig. 6(a), for stars with $5 < M_V \leqslant 6$.

Sketch of Milky Way

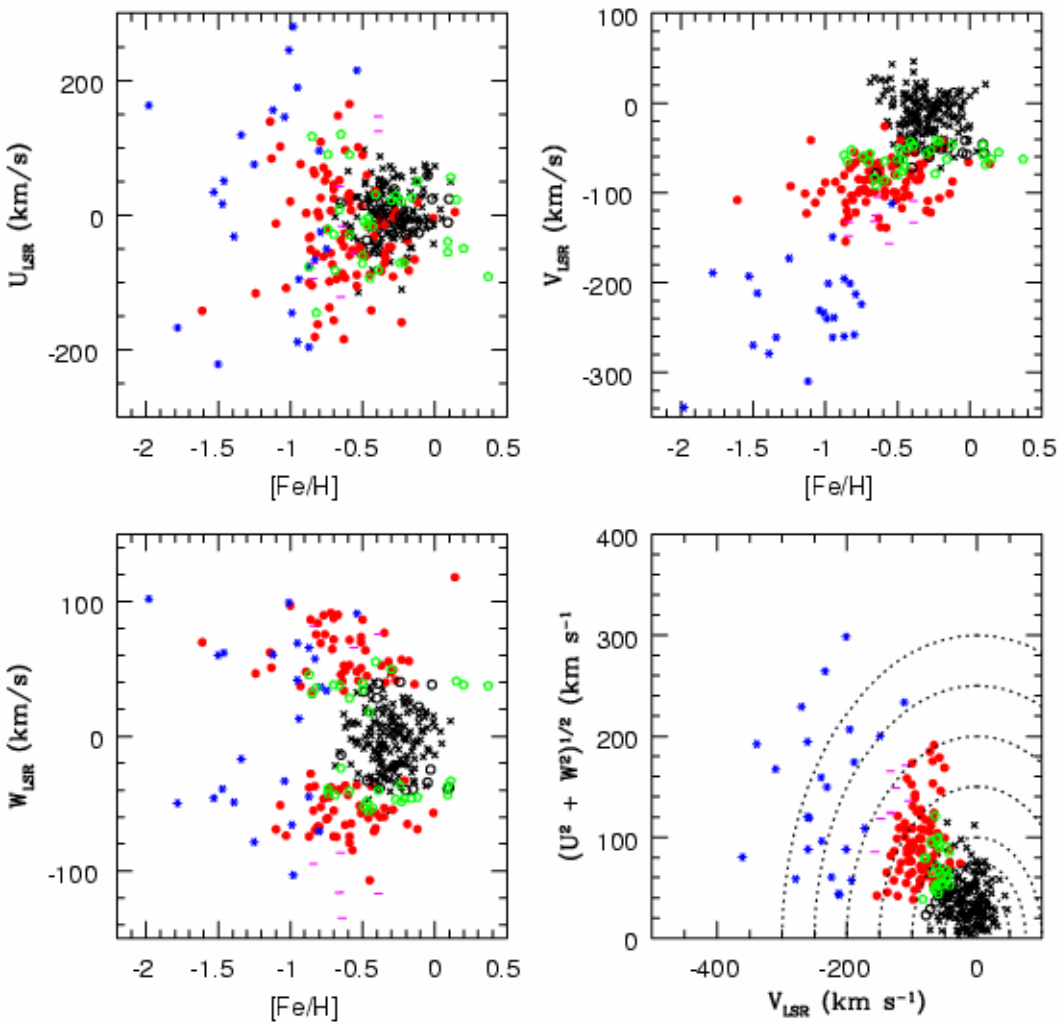


Images of NGC 4762 galaxy showing thin, thick, and bulge components



Freeman & Bland-Hawthorn, 2002

Sample and membership probabilities



P_thick >= 70% (93)

P_thin >= 70% (17)

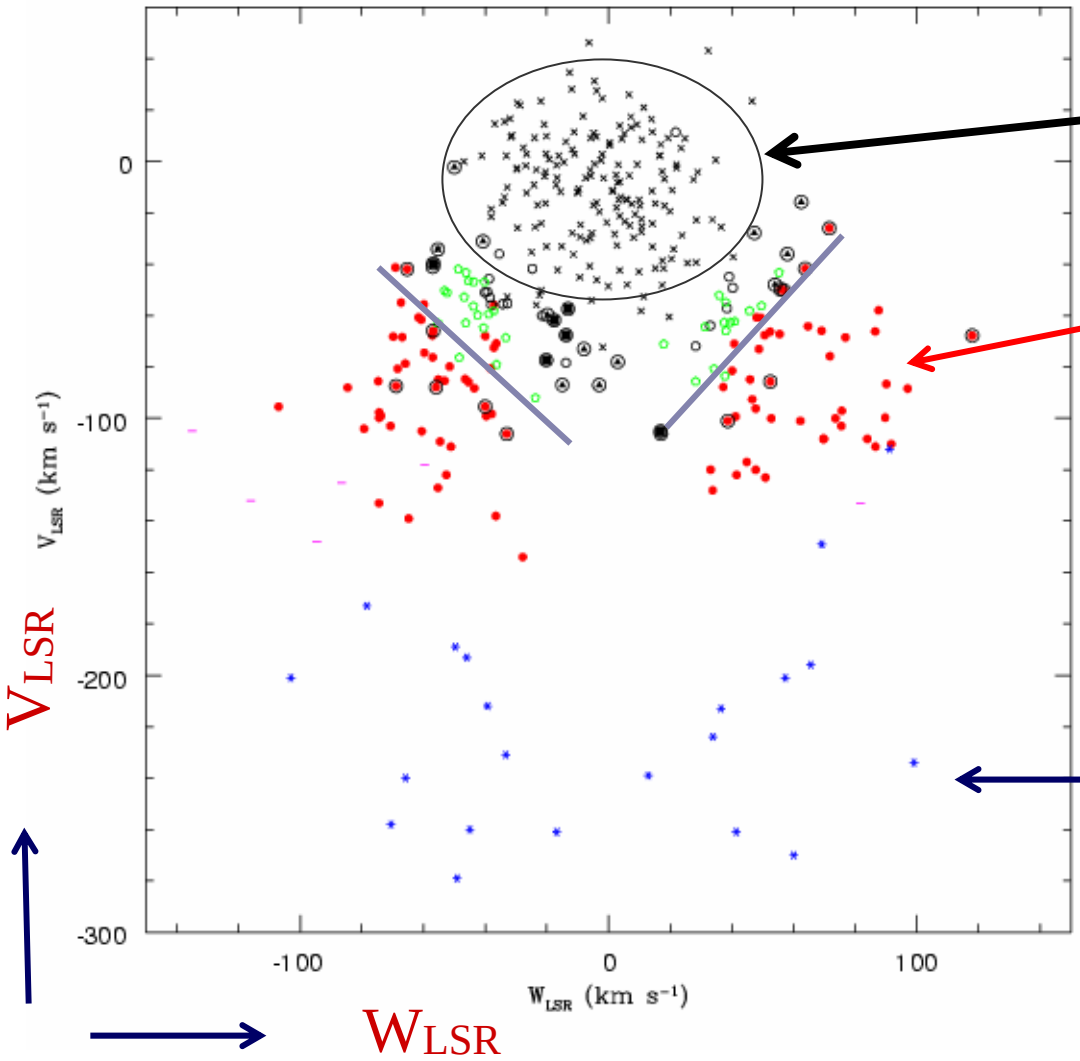
P_halo >= 70% (23)

Thin/Thick : 33

Thick/halo: 9

[errors in Rv, parallaxes, proper motions are taken into account]

V-W plane: thin, thick, halo, and thin-thick



Thin disk

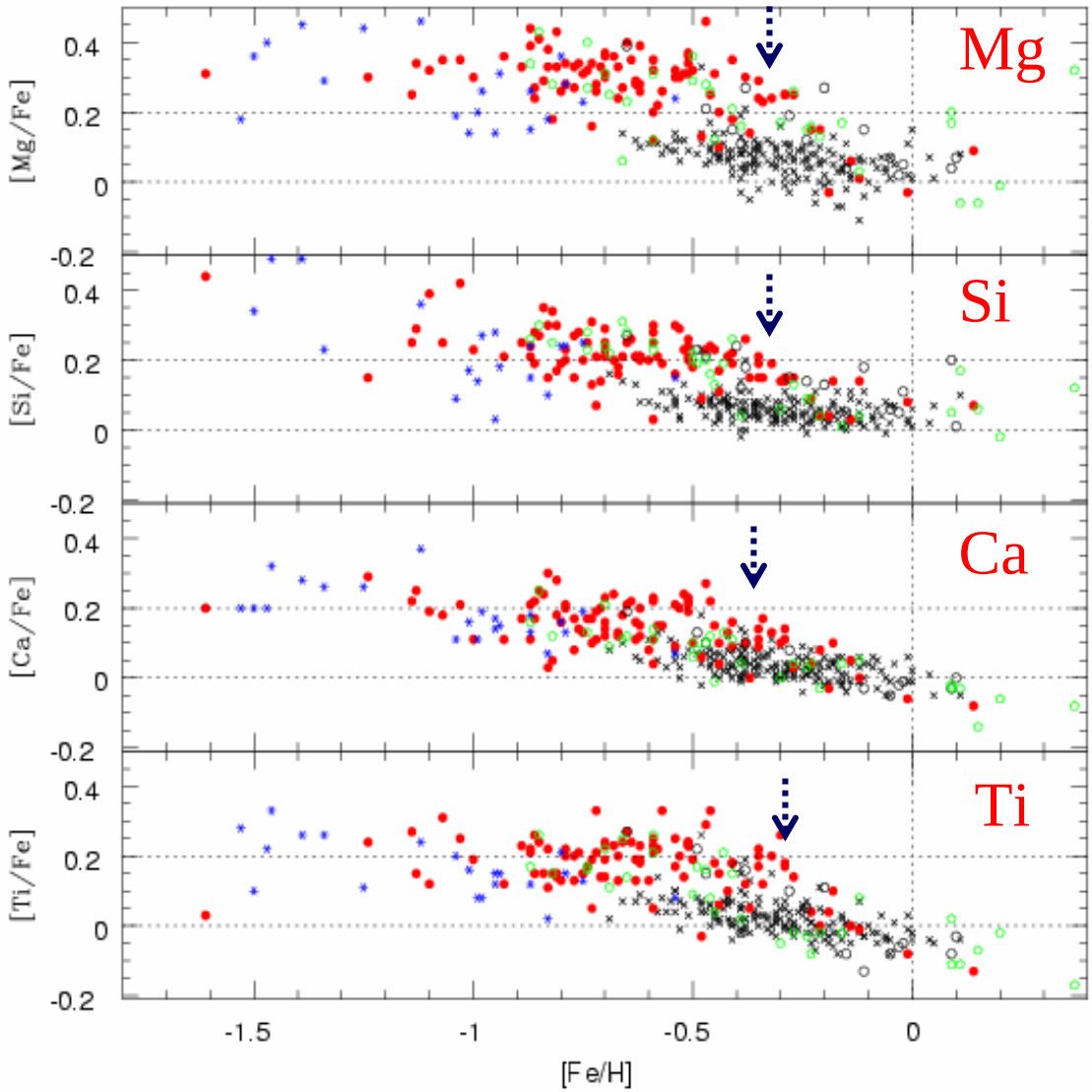
Thick disk

Halo stars

V_{LSR}

W_{LSR}

Results: α - process elements



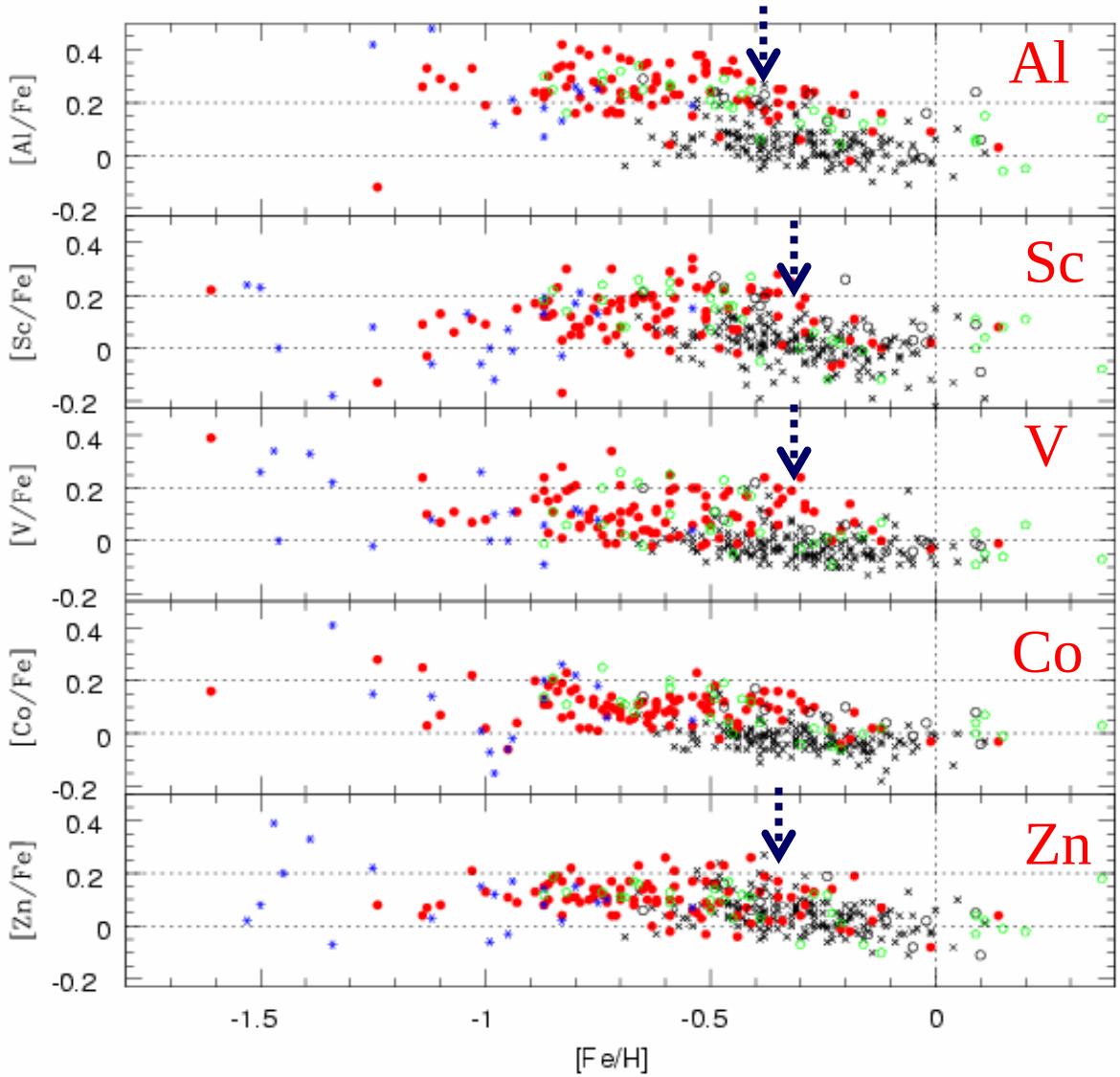
Great majority of thick disk stars show high ✂-ratio compared to thin disk

Thick and halo show similar ratios

Few thick disk stars show Thin disk abundances

Dominant contributor SNII

Results: Other Mg-like elements



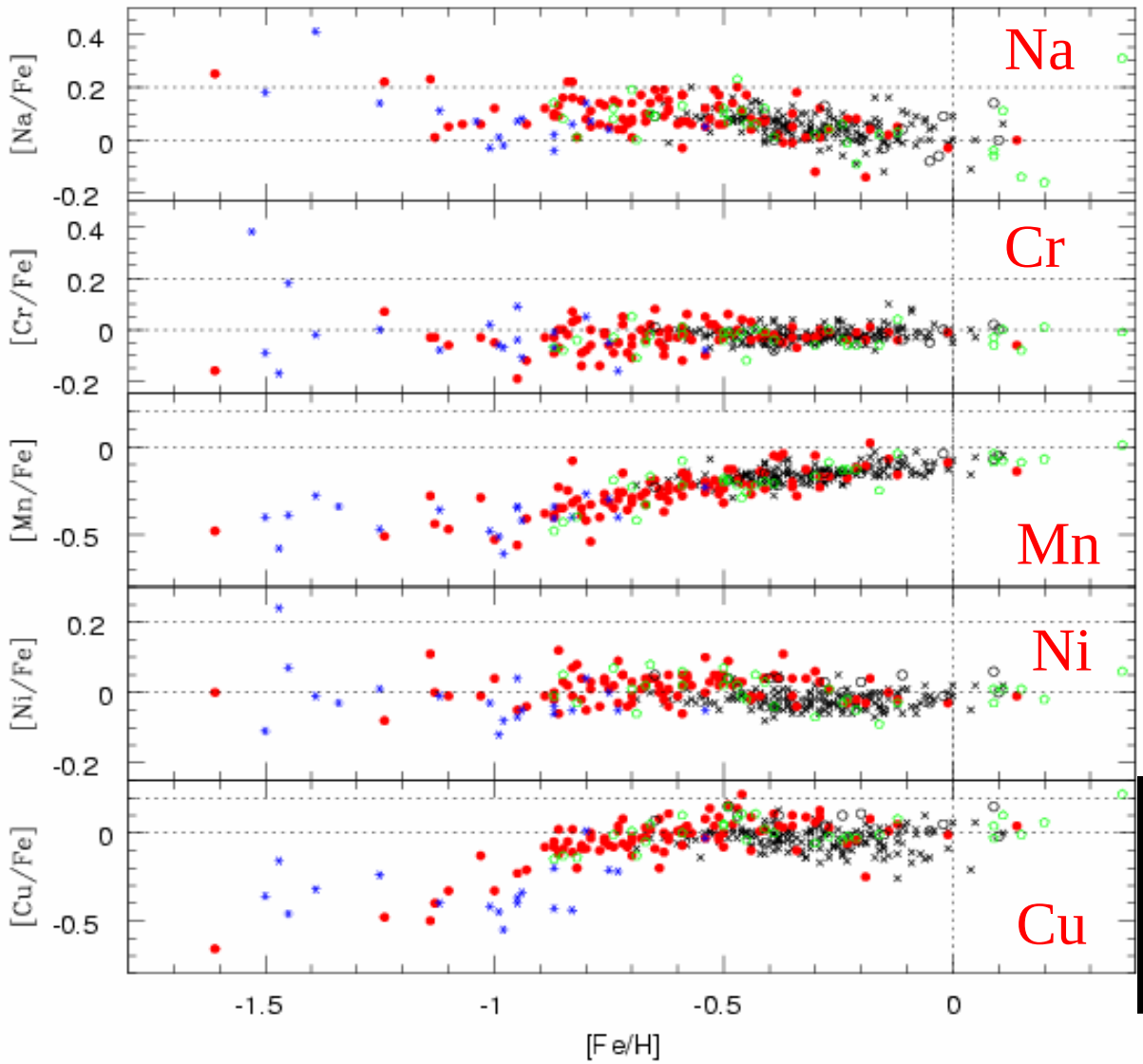
Known to behave similar to Fe-peak elements

[X/Fe] ratios are larger for thick disk than thin disk stars (puzzle!)

Implies they dominantly come from SNII.

A challenge to nucleosynthesis groups

Results: Ni-like Elements

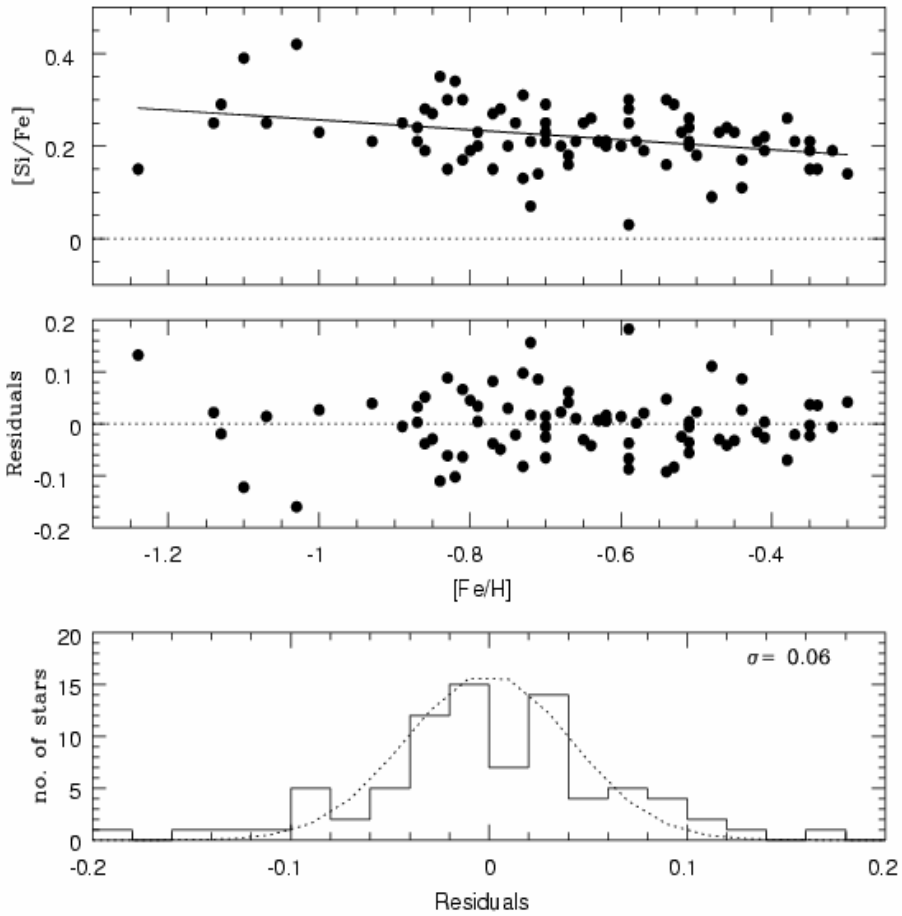


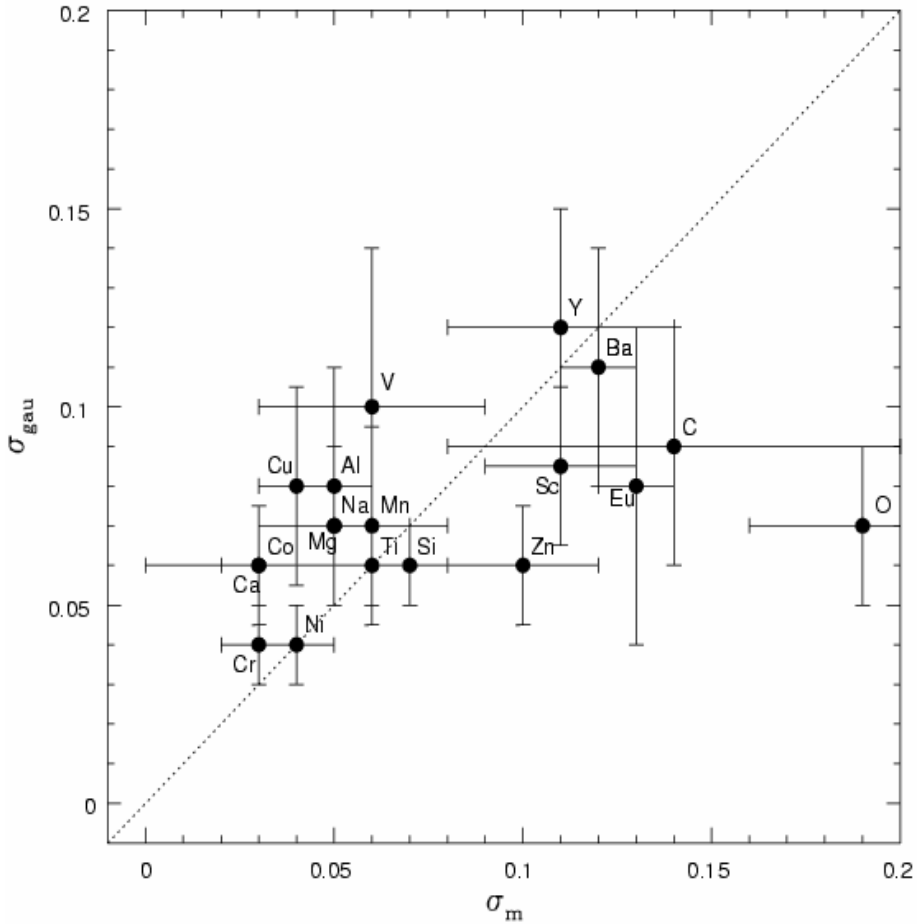
Abundance ratios for Na, Cr, Mn, Ni, Cu are same for thin and thick stars at overlapping [Fe/H]

The ratios show function of metallicity only

elements are produced in similar proportions in SNI and SNII

Results: Cosmic Scatter

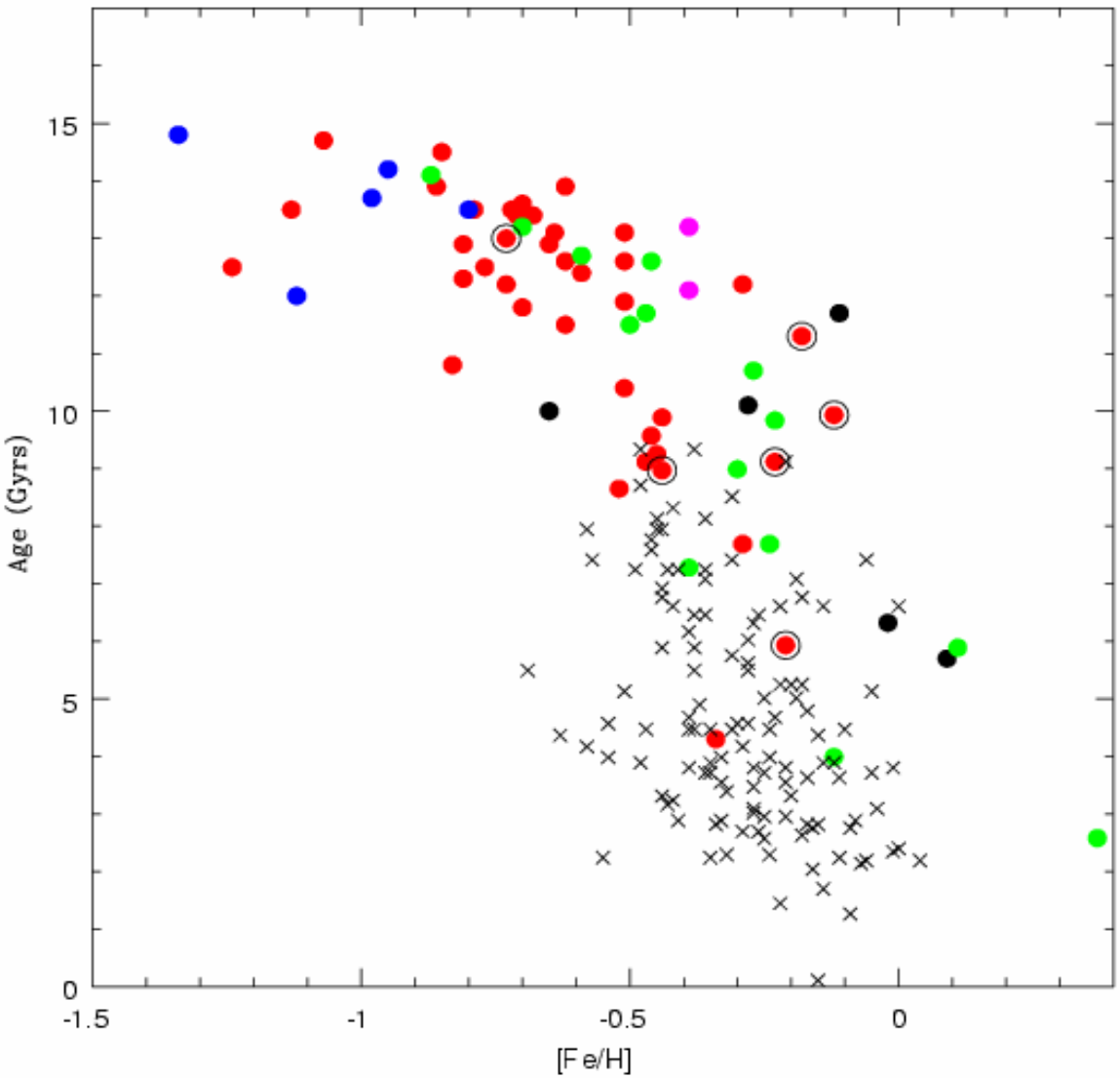




→ Observed scatter is comparable to the predicted scatter

→ Implying thick/also thin disk stars formed from well mixed gas

Results: Age vs Metallicity



Thick disk stars are old (8-15 Gyrs) compared to thin disk (1-10 Gyrs)

Mean age for the thick disk is 13 Gyrs (peak)

Halo stars 12-15 Gyrs

Age of the youngest Thick stars is the age of The oldest thin disk stars

Bigger picture: Formation of Thick Disk?

- Bottom up

→ Halo – thin – thick disk

- Top down

→ Halo – thick – thin disk

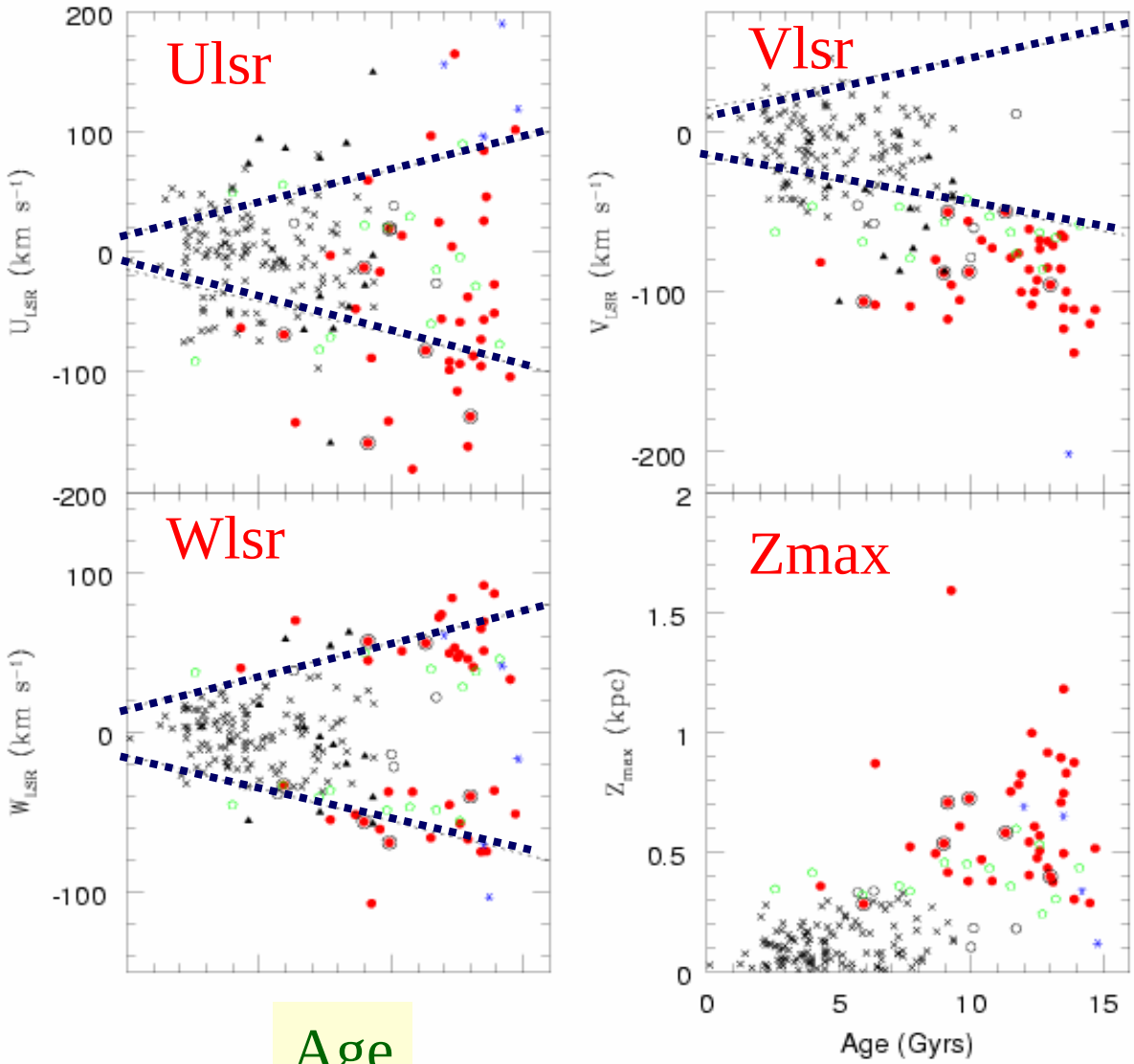
BOTTOM UP SCENARIOS - I

Kinematic heating of thin disk causes thick disk

→ Increase σu, σv, σw of thin disk vs age is fact with theoretical support

→ But difficult to get σv of thick disk

Bottom-up : Disk Heating



Age

Dispersion in kinematics increases with age

Vlsr for the thick disk is difficult to explain

Top down SCENARIOS - II

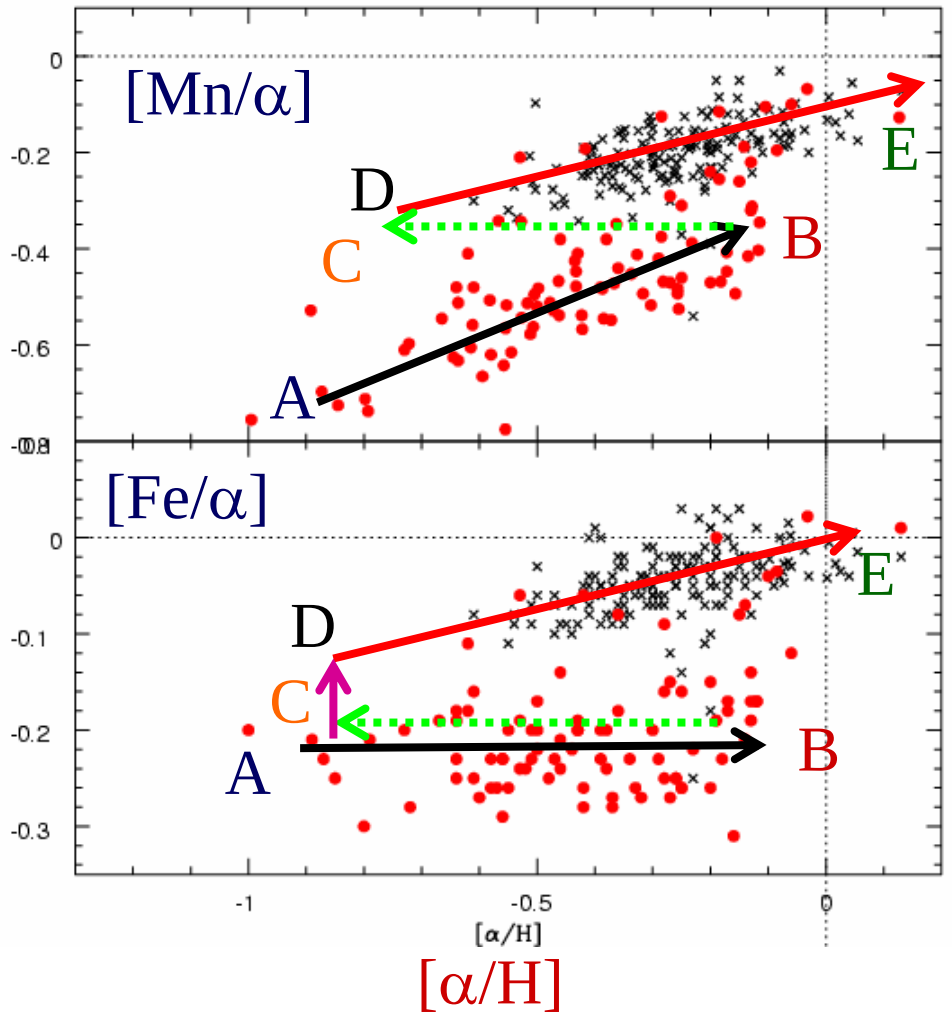
Merger with satellite galaxy (one or more)

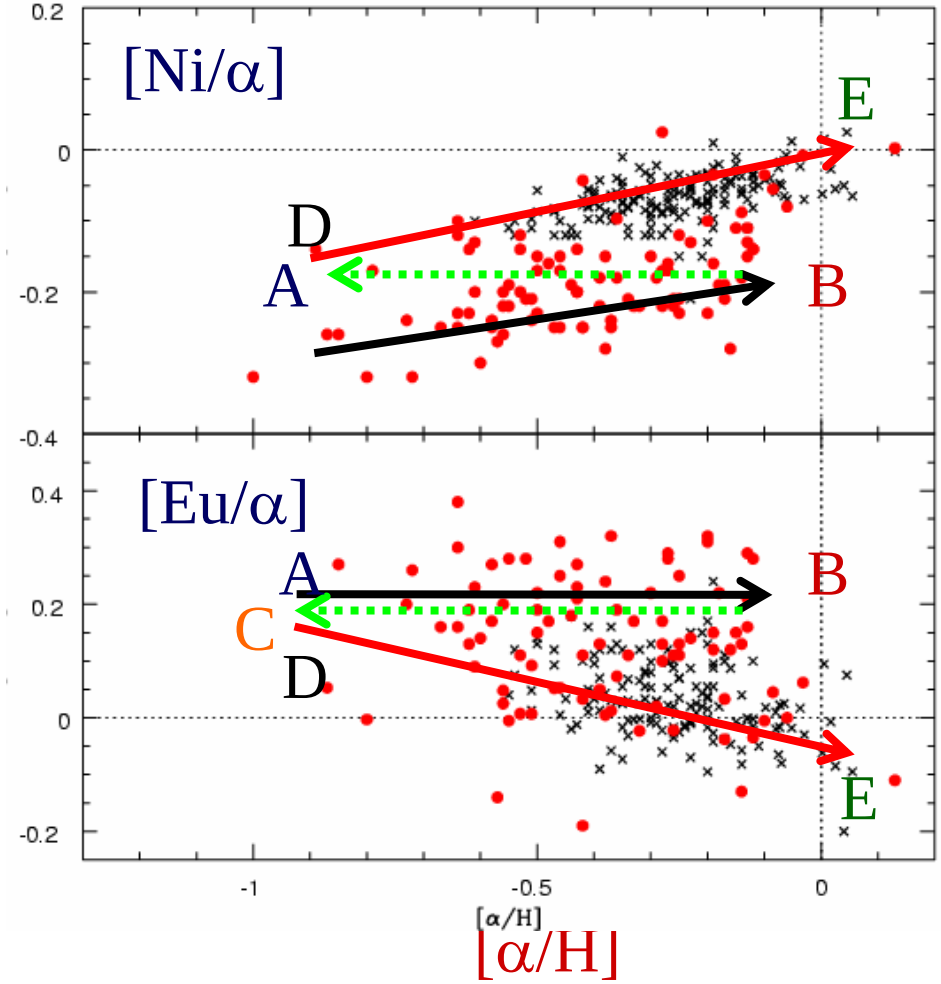
A ΛCDM - View

→ Thick disk primarily from tidal debris of satellites –
85% older than 10 Gyrs are from satellites

→ Thin disk mainly from mixed gas (Galactic plus satellites)

Evolution of Thin and Thick Disks: Merger scenario





CONCLUSIONS:

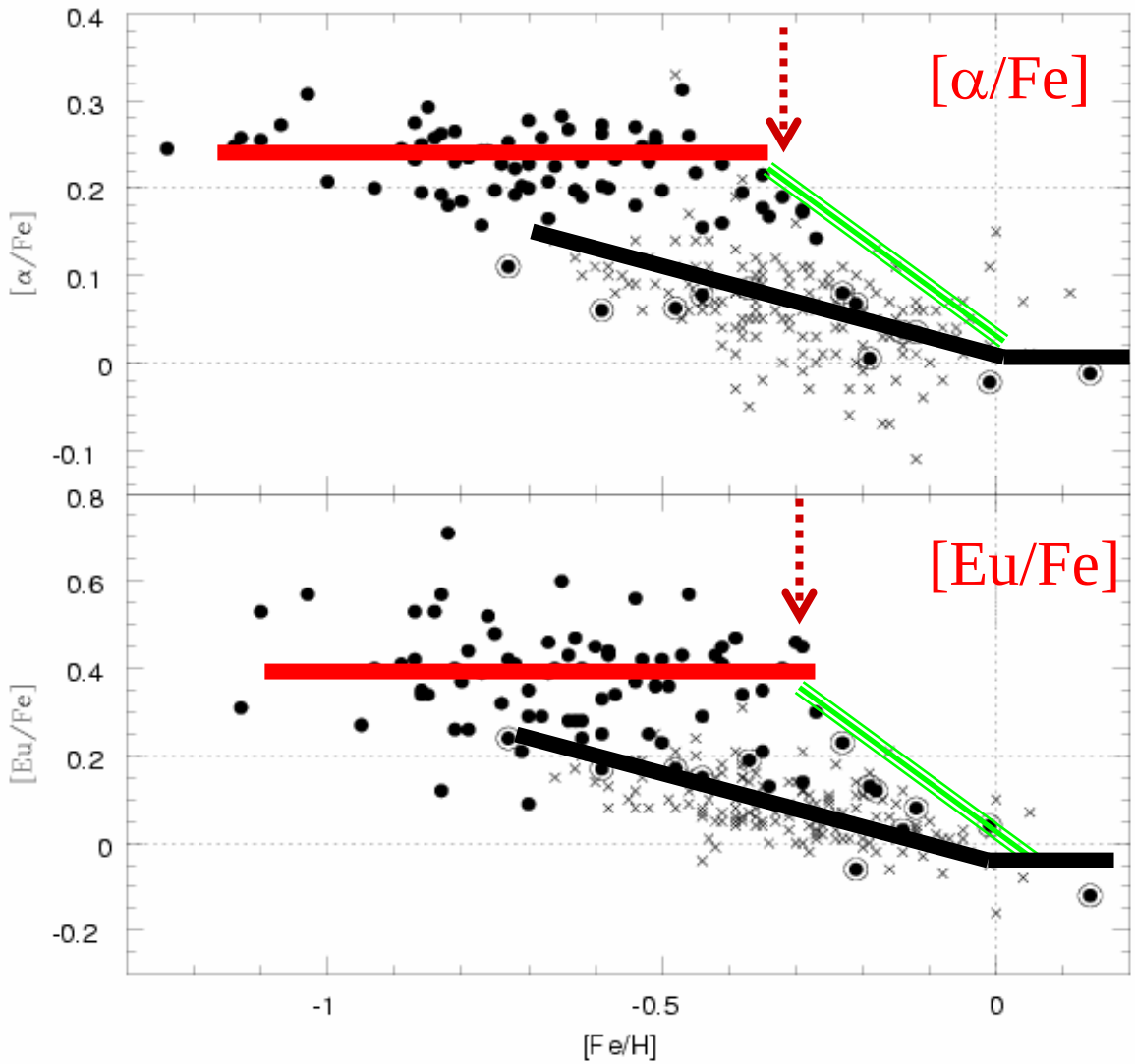
a. Thin and thick disks stars are two different populations of the Galactic disk with different chemical history.

b. [X/Fe] VS. [Fe/H] suggests that the scatter in abundances is comparable to the measurement errors implying both thin and thick disk stars formed from well mixed gas.

c. Abundances in thick disk are mostly attributed to SNII and show no visible trend with metallicity implying thick disk formed quickly may be in a span of 1-3 Gyrs.

d. Abundance data may suggest a merger of gas-rich metal-poor dwarf galaxy in the distant past.

New complications?



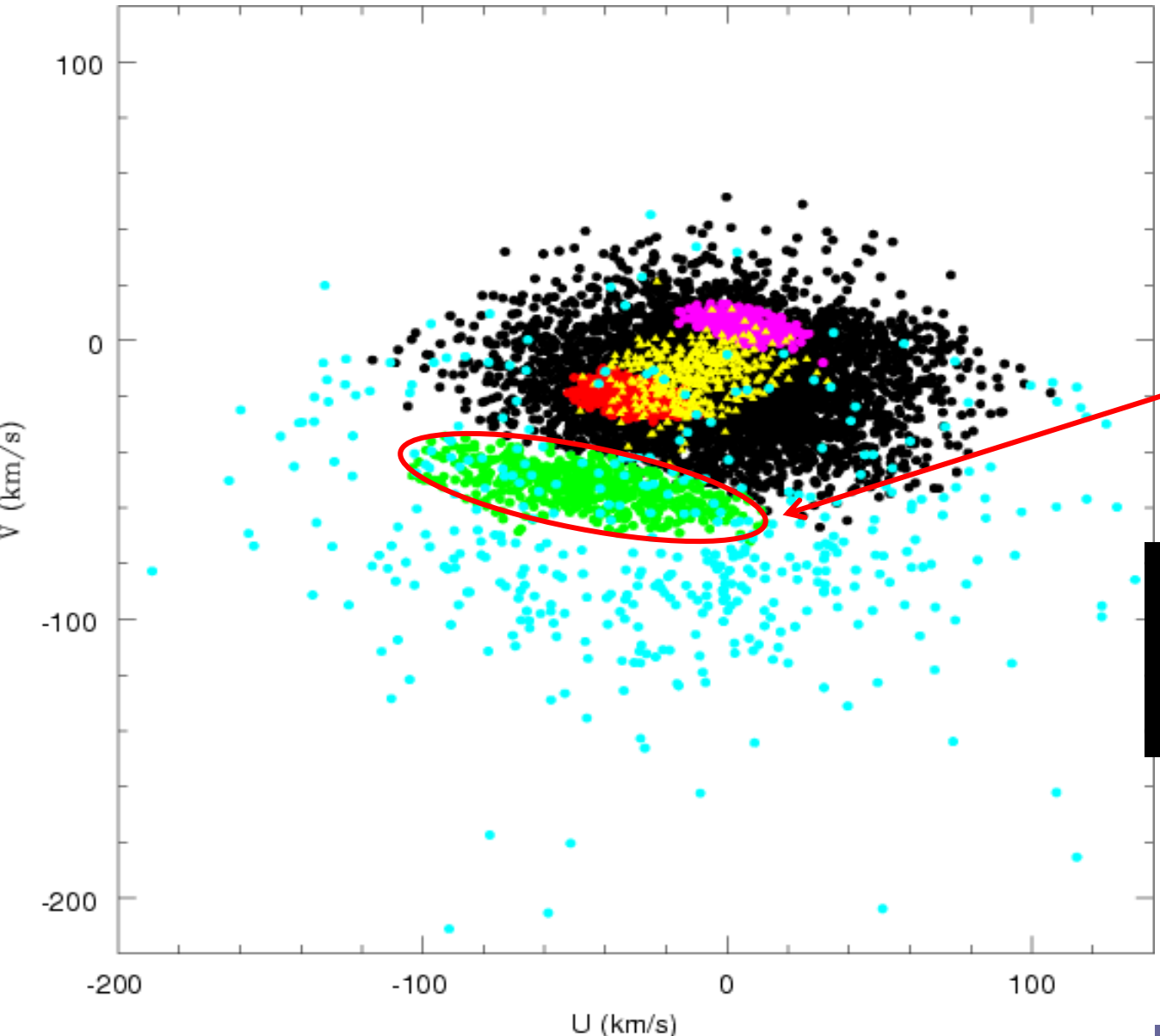
Thick disk kinematic
thin disk abundances

↓

TKTA Stars

If TKTA are real, thick disk star formation ceased at –0.3 if not thick disk has enough gas to sustain SF and form younger stars.

TKTA Stars: Moving groups in the disk



Hercules stream

In U-V plane thick and Hercules stars are indistinguishable.

Famaey et al. 2005