Chemical gradients in the Milky Way from the RAVE chemical abundances catalogue

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Heidelberg, 31 Aug-4 Sept 2009

Overview

- what is RAVE
- the RAVE chemical pipeline and chemical catalogue
- chemical gradients in the Milky Way
- works to come

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RAVE: the RAdial Velocity Experiment

RAVE is a large spectroscopic survey which aim to observe one million stars of the Milky way to obtain:

- radial velocities
- stellar parameters (temperature, gravity,metallicity)
- chemical abundances
- distances

(see M. Steinmetz's talk)

RAVE data

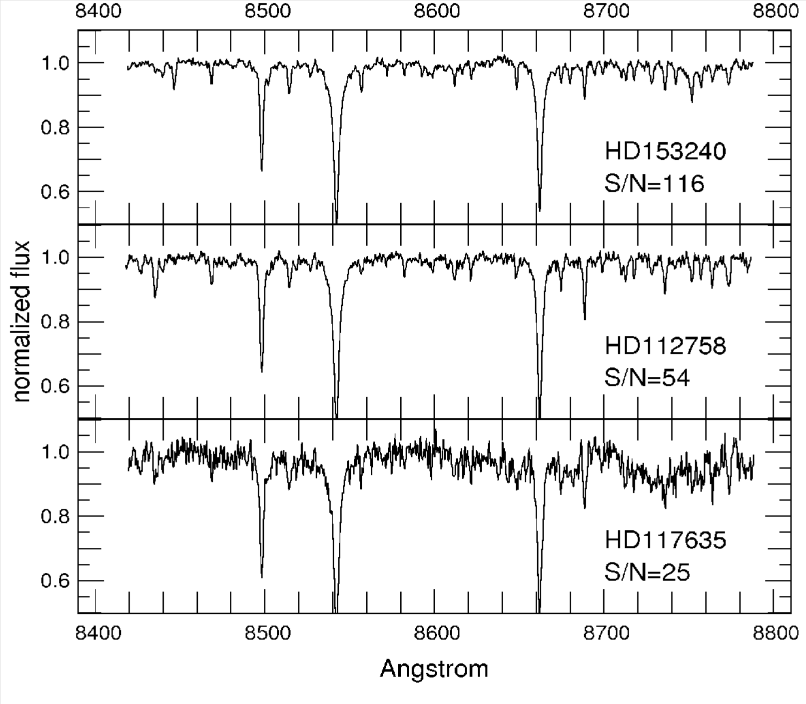
Up to now:

the internal data release holds 276024 spectra

Data published

50296 radial velocities + stellar parameters of 19779 stars

(second data release, Zwitter et al., 2008, AJ 136, 421)



λ range: 8410-8795Å

(Gaia 8479-8740)

Resolution R=7500 at 8600Å

(Gaia 11500)

Dispersion = 0.38Å/pix

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RAVE chemical abundances: the processing pipeline

The chemical processing pipeline relies on databases and auxiliary softwares.
The most important are:

- a list of absorption lines (with atomic parameters)
- stellar parameters (temperature, gravity, metallicity)
- EWFIND (Equivalent Width measurement code we wrote *ad hoc* for RAVE)
- MOOG (code by Sneden 2002, synthesis and LTE line analysis)

abundance estimations for up to 12 elements (O, Mg, Al, Si, S, Ca,Ti, Cr, Fe, Co, Ni, Zr)

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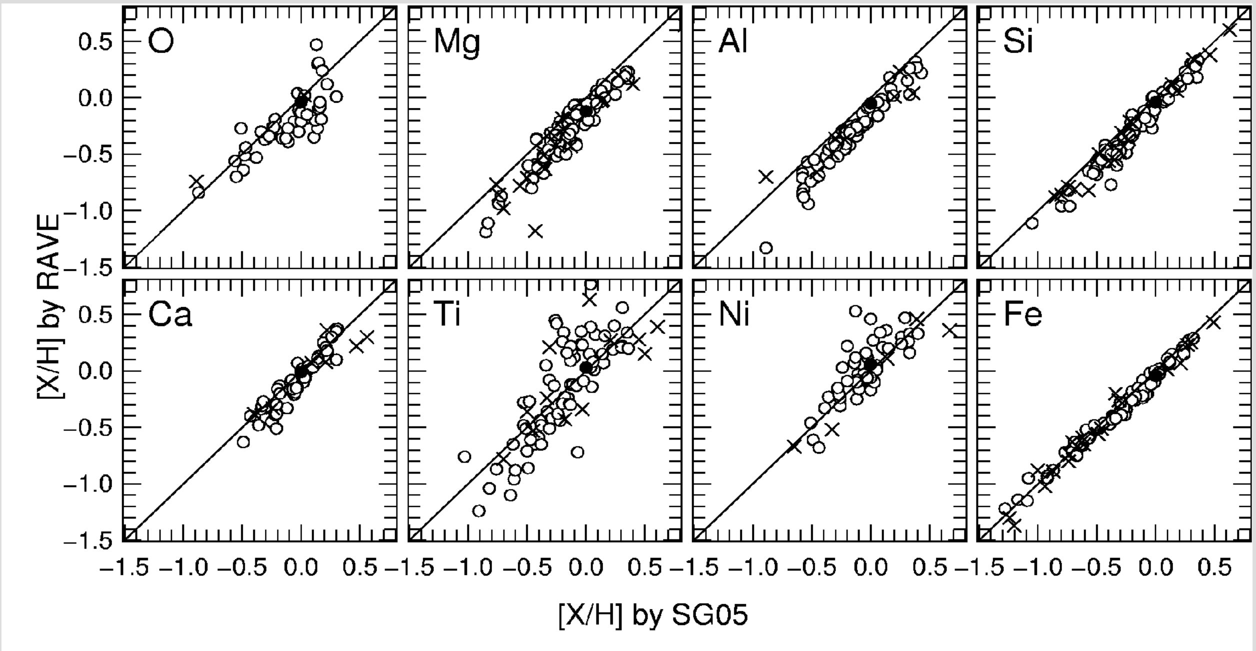
RAVE chemical pipeline: reliability and errors



residuals statistic

O = -0.11±0.15 dex

Mg= -0.13±0.13 dex

Al = -0.15±0.10 dex

Si = -0.08±0.07 dex

Ca= -0.09±0.12 dex

Ti= -0.05±0.30 dex

Fe= +0.04±0.06 dex

Ni= +0.08±0.20 dex

104 stars from Soubiran & Girard collection 2005 (SG05, A&A 438, 139) observed by RAVE.

O S/N>80

X S/N<80

SG05 stellar parameter are here used

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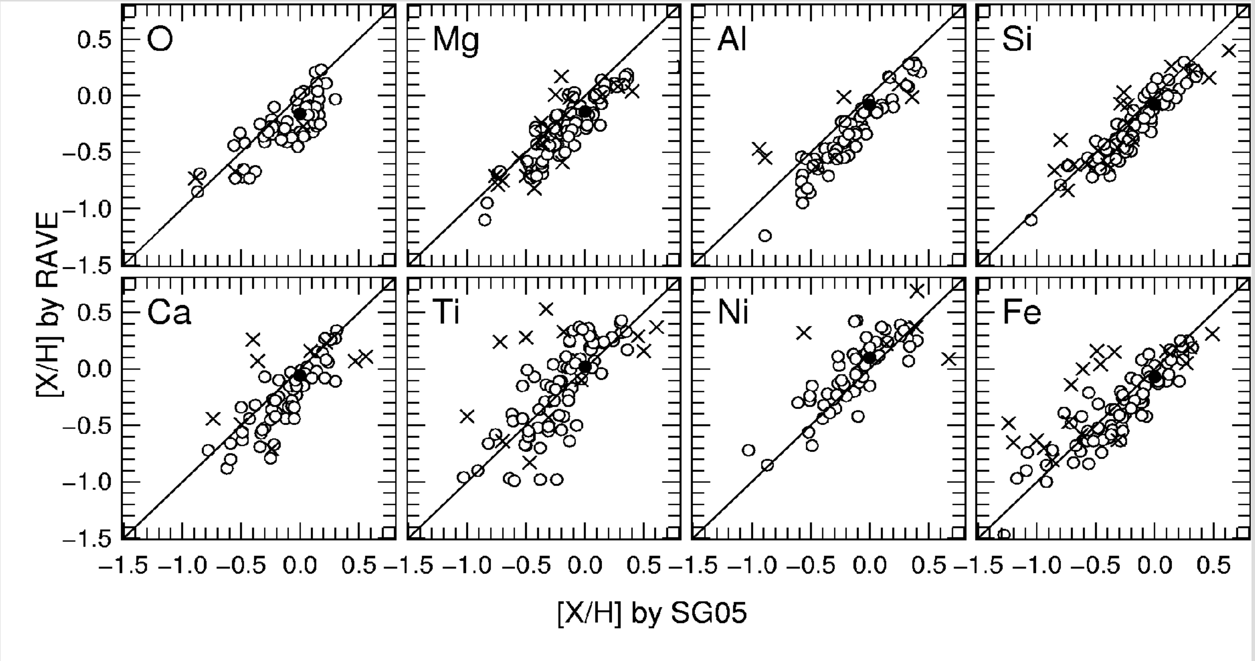
RAVE chemical pipeline: reliability and errors



residuals statistic

O = -0.14±0.17 dex
Mg= -0.13±0.15 dex
Al = -0.16±0.14 dex
Si = -0.08±0.13 dex
Ca= -0.11±0.20 dex
Ti= -0.06±0.30 dex
Fe= +0.00±0.23 dex
Ni= +0.10±0.18 dex

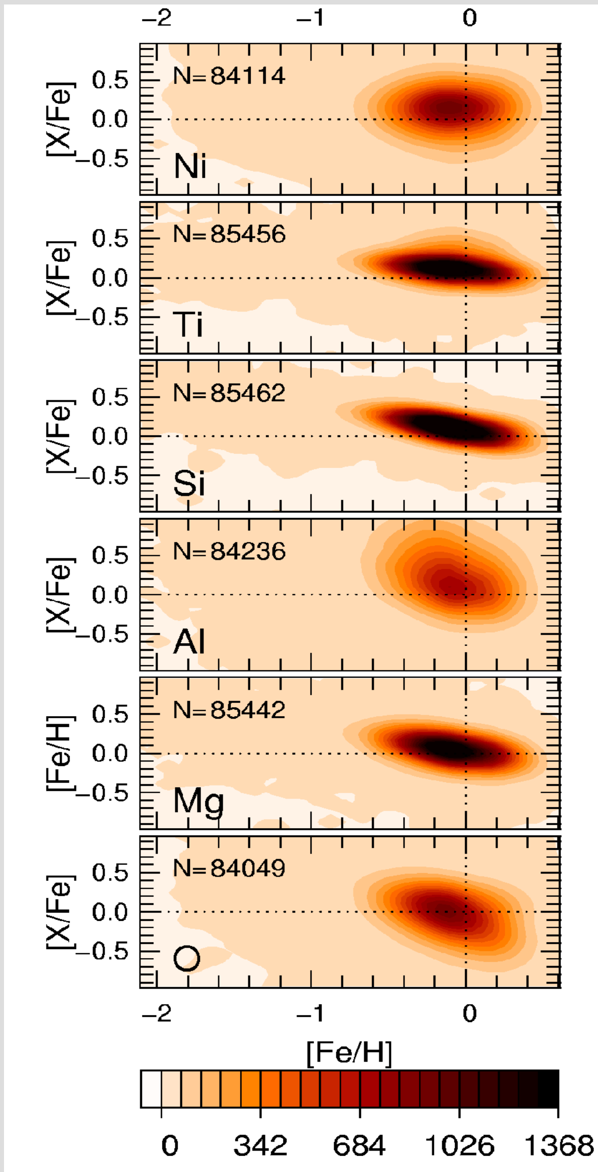
104 stars from Soubiran & Girard collection 2005 (SG05) observed by RAVE.

○ S/N>80
× S/N<80

RAVE stellar parameter are here used

espected errors:
σ≈0.3-0.4 dex at S/N<80
σ≈0.2 dex at S/N>80

RAVE chemical catalogue



to date the catalogue holds:

- chemical abundances for 87515 stars up to 12 elements (O, Mg, Al, Si, S, Ca, Ti, Cr, Fe, Co, Ni, Zr)

- kinematic informations (RVs, proper motions)
- distances (Breddels et al., 2009) --> absolute velocities, orbits
- stellar parameters (Teff, logg, [M/H])

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Chemical gradients in the Milky Way from the RAVE data

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Preprint online version: May 13, 2009

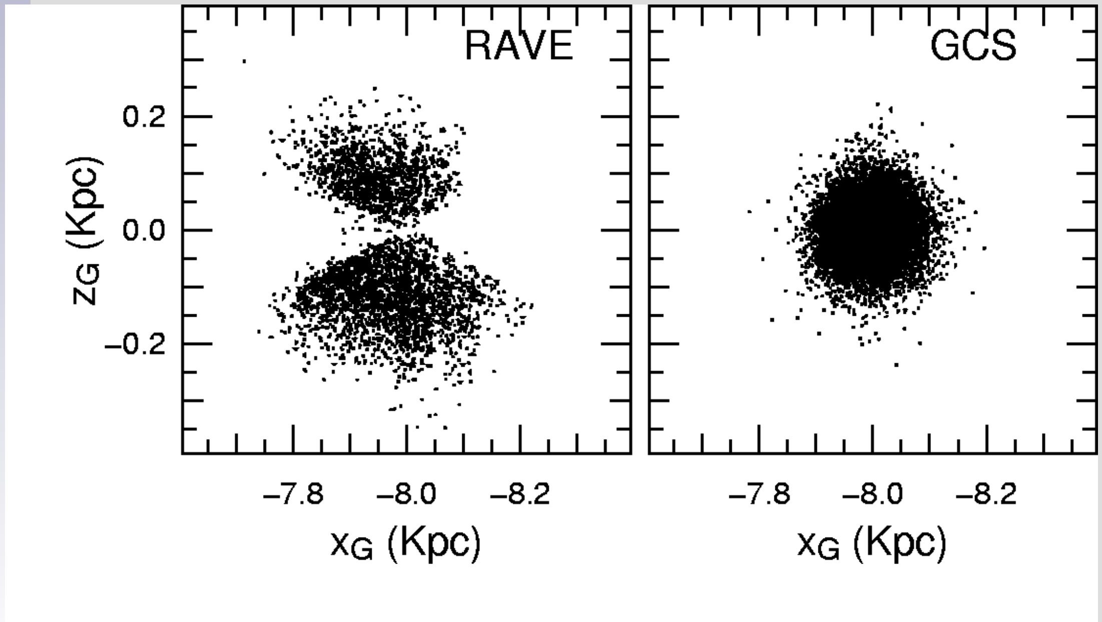
ABSTRACT

Aims. We want to measure the chemical gradients along the galactic radius of the elements Mg, Al, Si, Ca, Ti, Fe to provide new constraints to the chemical evolution models of the Galaxy. Thanks to the sheer number of stars of our RAVE sample we can study the gradients close to the galactic plane as well as at larger distances by analysing high vertical velocity stars which, along their orbits, reach higher altitudes from the galactic plane. In doing so, we can extend the chemical gradients investigation to the thick disk stars.

Chemical gradients in the Milky Way

We selected RAVE stars from the chemical catalogue with

- S/N>50
- 4000<Teff(K)<6600
- dwarf stars
- distances error<30% ---> 3549 stars



GCS=Geneve-Copenhagen Survey,
Nordström et al., 2004
(12087 stars selected)

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Chemical gradients in the Milky Way what do we expect

The chemical models predicts that the inner parts of the Galaxy experienced higher star formaton rate

-->inner regions are metal richer than outer region

$$d\frac{[Fe/H]}{dR_m} = -0.06 \pm 0.01\, dex/Kpc$$

(Friel et al., 2002)

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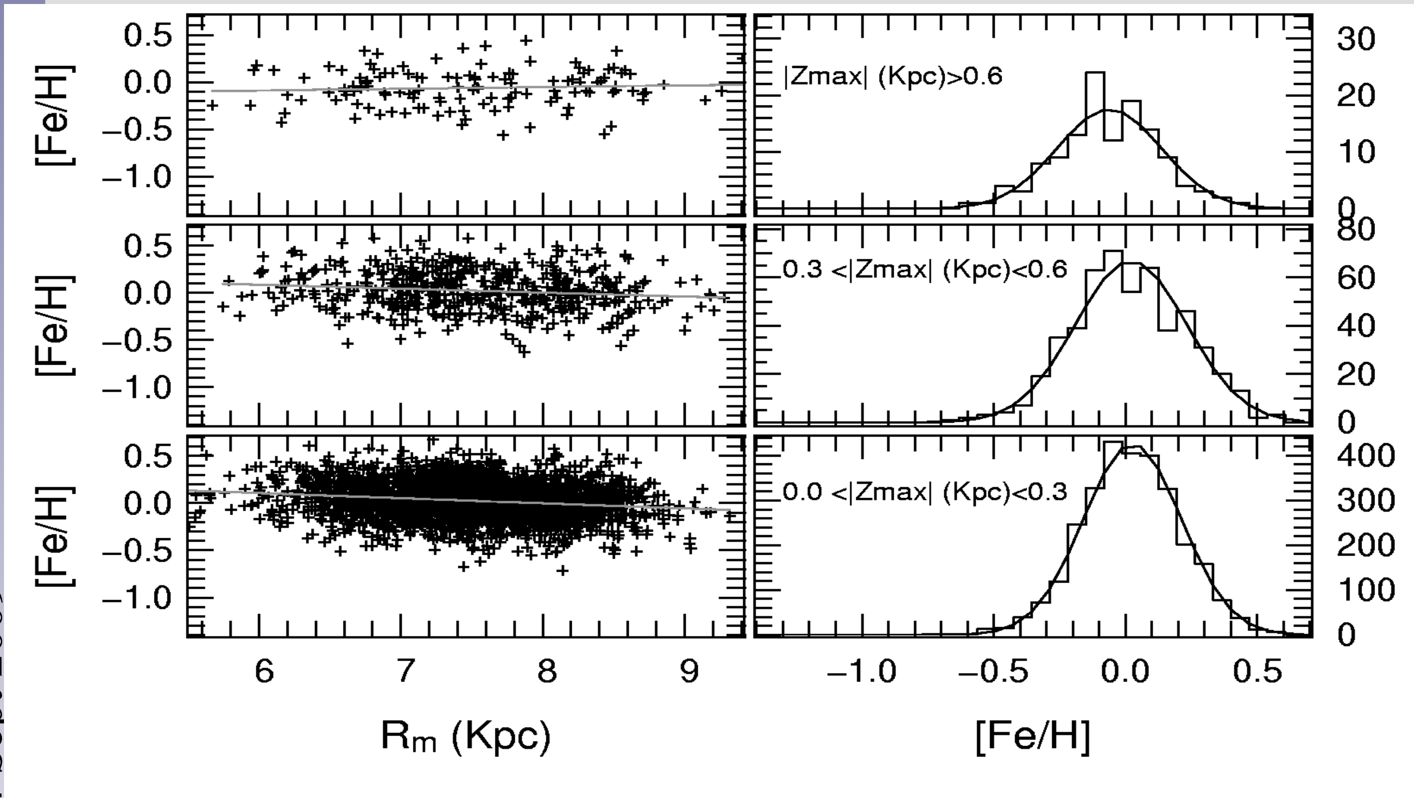
Chemical gradients in the Milky Way: RAVE data



125 stars

$$d\frac{[Fe/H]}{dR_m}=+0.014\pm0.020\,dex/Kpc$$

516 stars

$$d\frac{[Fe/H]}{dR_m}=-0.039\pm0.013\,dex/Kpc$$

2889 stars

$$d\frac{[Fe/H]}{dR_m}=-0.054\pm0.006\,dex/Kpc$$

Rm=(apocentre+pericentre)/2

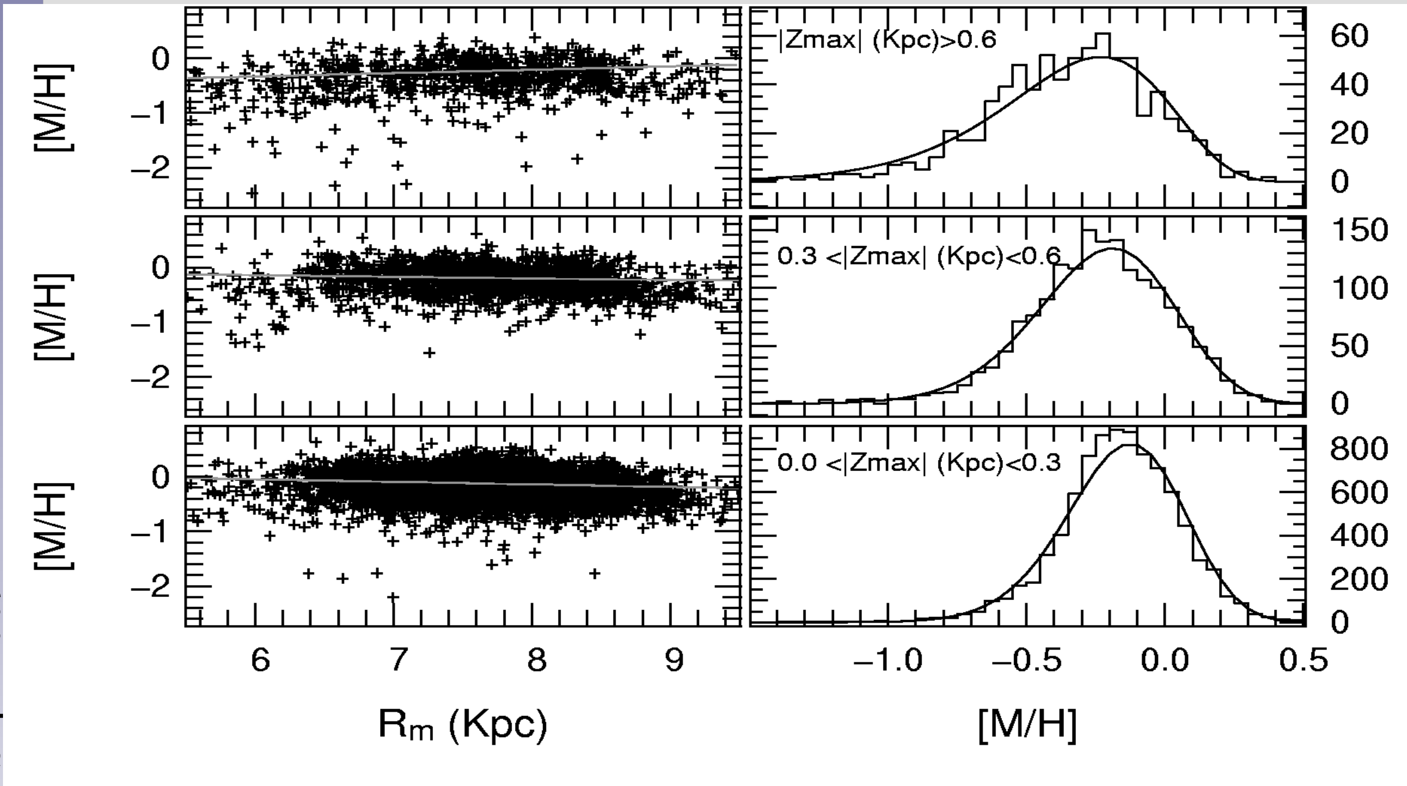
|Zmax|=max distance from the Galactic plane reached by a star along its galactic orbit

expected:

$$d\frac{[Fe/H]}{dR_m}=-0.06\pm0.01\,dex/Kpc$$

(Friel et al., 2002)

Chemical gradients in the Milky Way: GCS data



787 stars

$$d\frac{[M/H]}{dR_m} = +0.061 \pm 0.020\, dex/Kpc$$

1674 stars

$$d\frac{[M/H]}{dR_m} = -0.029 \pm 0.018\, dex/Kpc$$

8799 stars

$$d\frac{[M/H]}{dR_m} = -0.046 \pm 0.009\, dex/Kpc$$

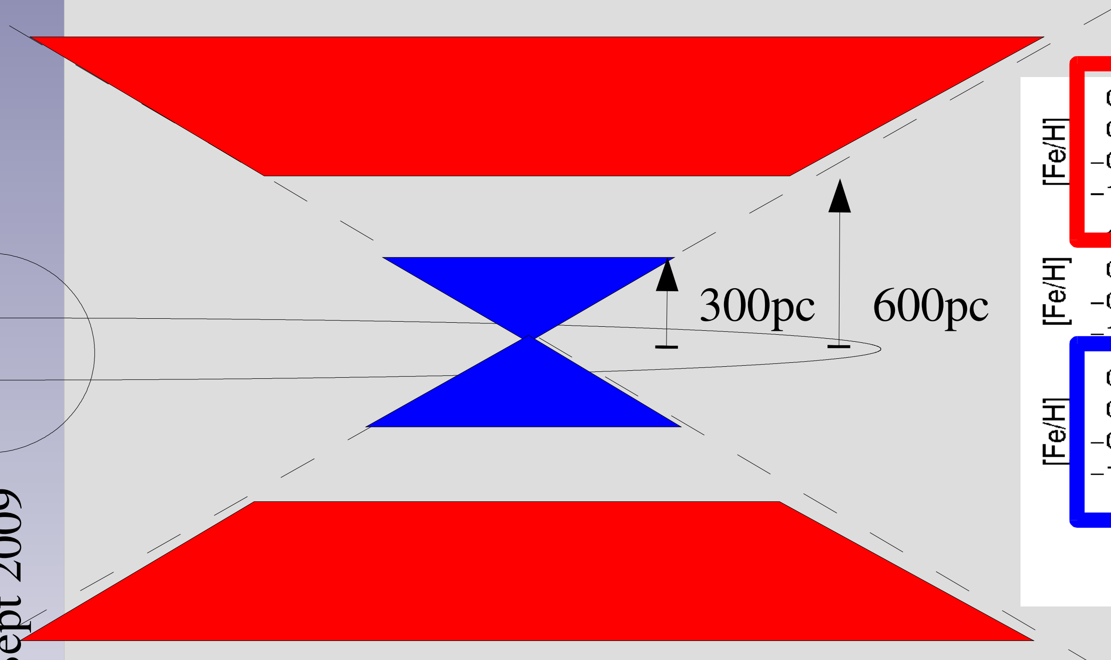
expected:

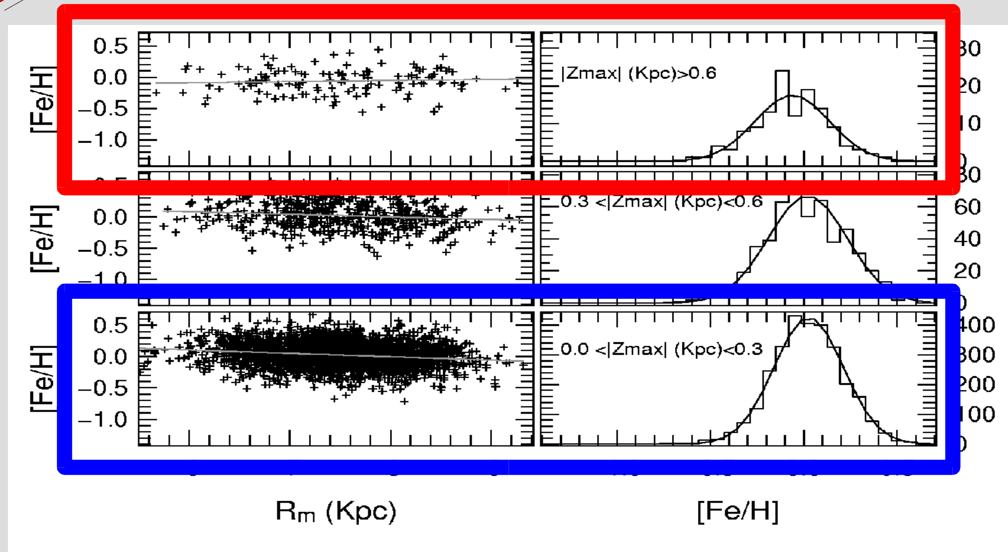
$$d\frac{[Fe/H]}{dR_m} = -0.06 \pm 0.01\, dex/Kpc$$

(Friel et al., 2002)

Rm=(apocentre+pericentre)/2
|Zmax|=max distance from the Galactic plane
reached by a star along its galactic orbit

2 samples: 1. closer to the disk (|Zmax|<300pc)
2. farer from the disk (|Zmax|>600pc)





What do we expect?

thin disk stars: younger, metal rich, not α-enhanced, V_{LSR}~ -10km/s, low eccentricity

thick disk stars: older, metal poor, α-enhanced, V_{LSR}~ -40km/s, high eccentricity

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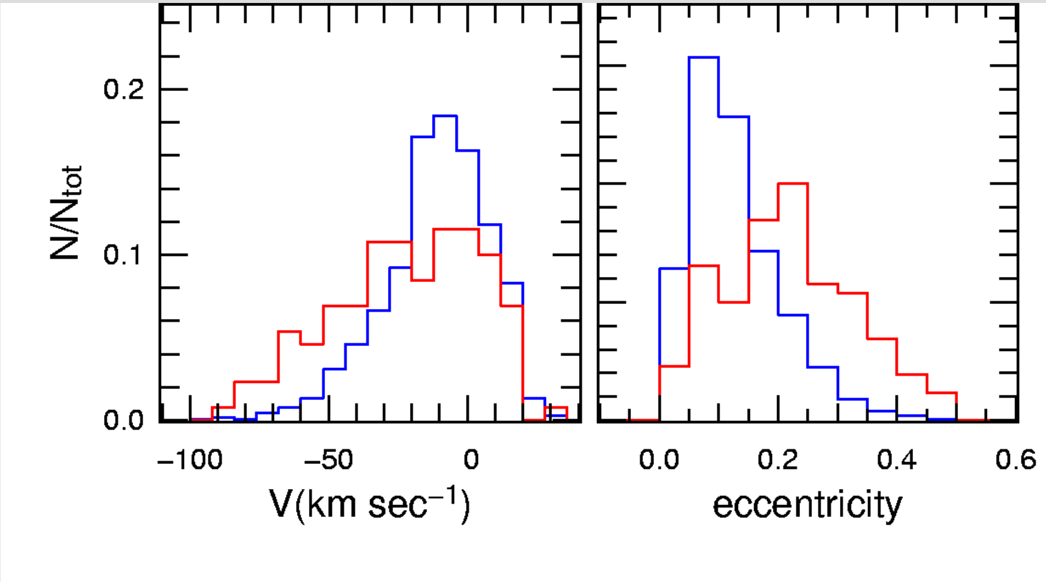
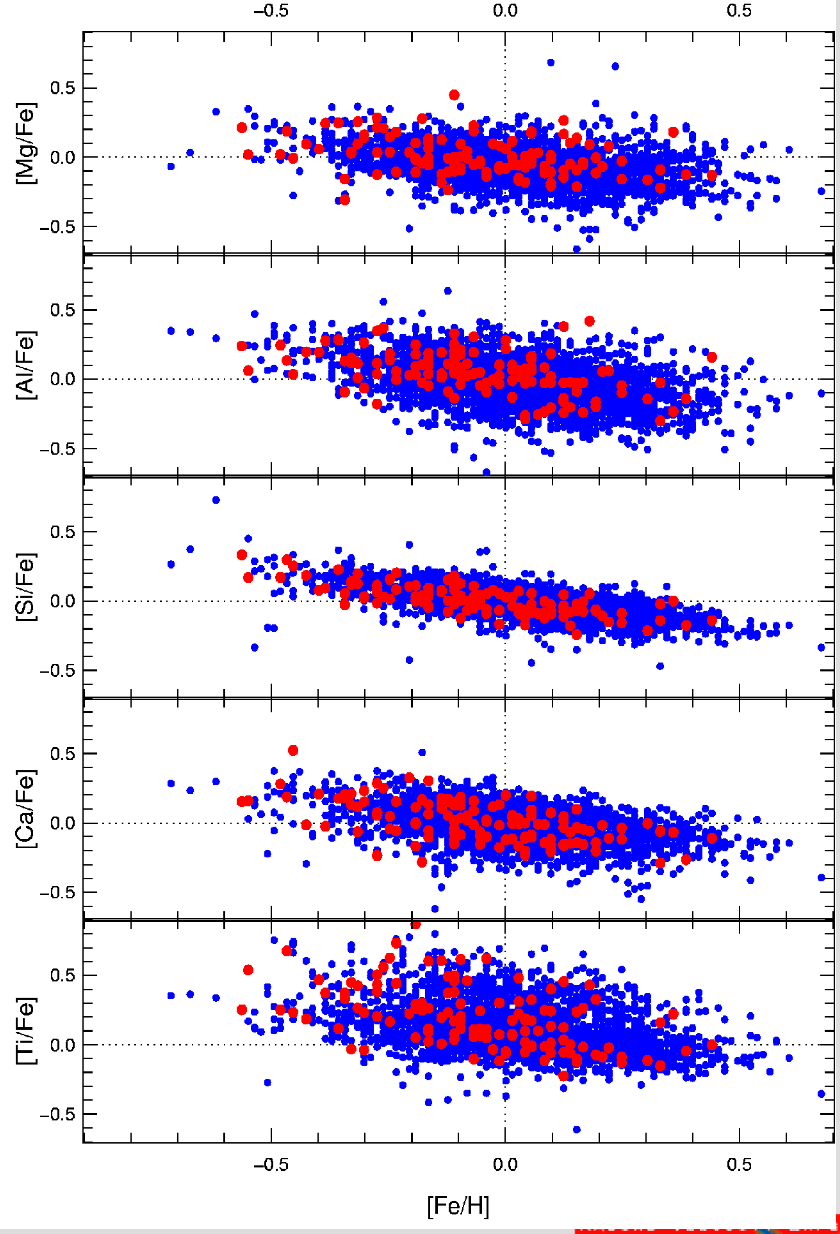
Chemical gradients in the Milky Way: RAVE data

|Zmax|<0.3Kpc

|Zmax|>0.6Kpc
from Schwarzschild velocity distribution
50-80% are kinematically thick
disk stars





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“Red sample”
Two extreme hypothesis: let's suppose that...

1) Stars with |Zmax|>0.6 Kpc are thick disk stars

because their kinematic

chemically not representative of the thick disk

(already found by Mishenina 2004, Bensy 2003, Reddy 2006)

- *the thick disc extends up to solar metallicities or/and*
- *they might come from the inner part of the MW (Schönrich & Binney 2008)*

their flat gradient means

a) formed in a homogeneus medium

b) efficient radial mixing

hypotheses a) and b) are defied by the gradient $d\frac{[Mg/Fe]}{dR_m} = -0.052 \pm 0.013\, dex/Kpc$

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“Red sample”
Two extreme hypothesis: let's suppose that...

2) Stars with |Zmax|>0.6 Kpc are thin disk stars

because their chemical composition

kinematically not representative of the thin disk

they might be thin disk stars kinematically heated up (Nordström 2004, Holmberg 2007)

kinematic heating require time --> they must be old stars

Why these old stars have such a high [M/H] and are no α-enhanced?

These stars do not fit into the usual Galaxy formation scenario...

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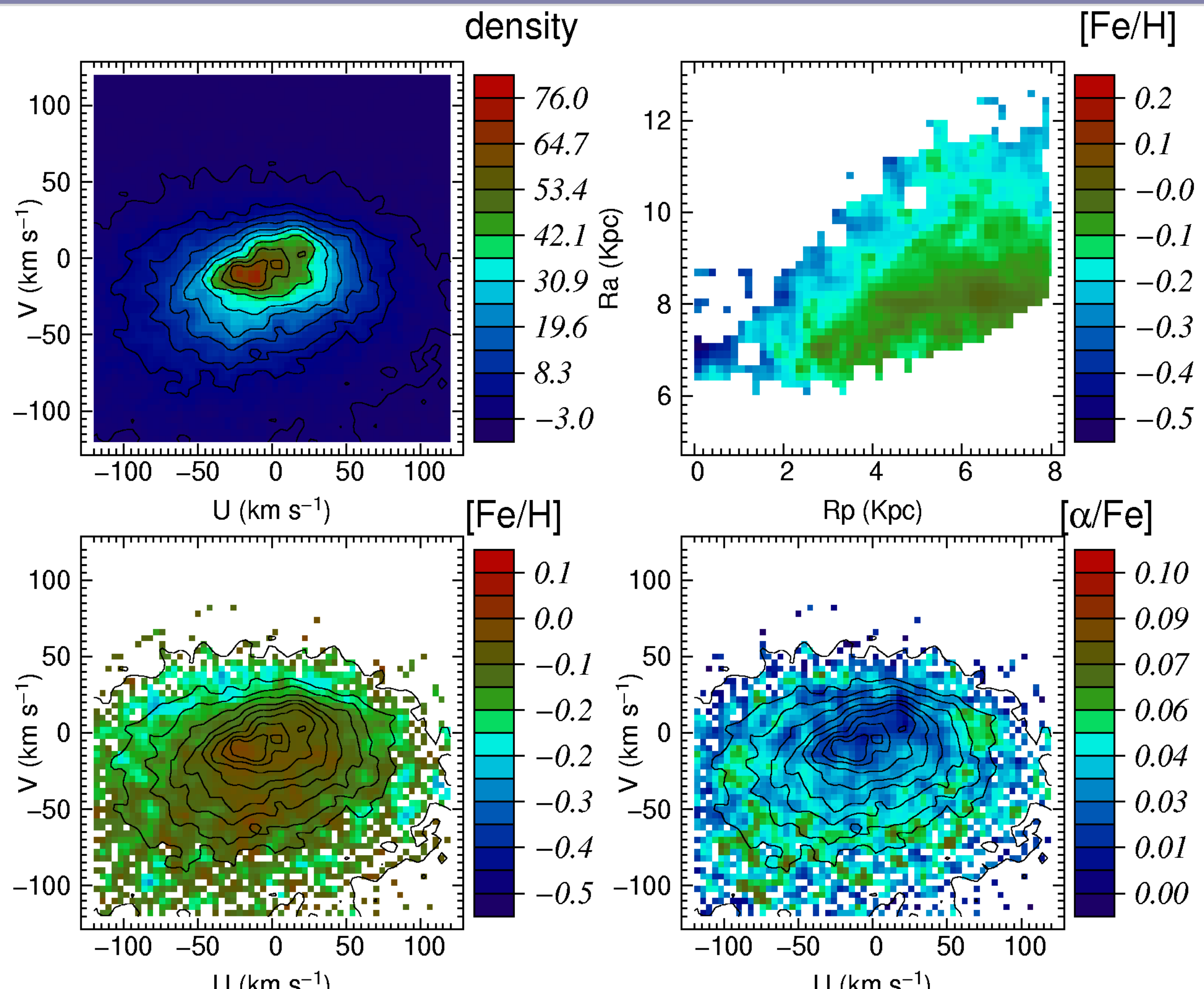
Proposing new constraints for the next MW chemical models

C. Boeche et al.: Chemical gradients in the Milky Way from the RAVE data

	$\frac{d[El/H]}{dR_m}$					
Z_{max} range (Kpc)	Fe	Mg	Al	Si	Ca	Ti
$0.0 \leq Z_{max} < 0.3$	$-0.054^{+0.005}_{-0.006}$	$-0.088^{+0.006}_{-0.005}$	$-0.073^{+0.006}_{-0.006}$	$-0.043^{+0.004}_{-0.005}$	$-0.046^{+0.005}_{-0.005}$	$-0.039^{+0.007}_{-0.006}$
$0.3 \leq Z_{max} < 0.6$	$-0.039^{+0.012}_{-0.013}$	$-0.030^{+0.010}_{-0.013}$	$-0.046^{+0.011}_{-0.012}$	$-0.027^{+0.008}_{-0.010}$	$-0.027^{+0.010}_{-0.012}$	$-0.044^{+0.012}_{-0.013}$
$Z_{max} > 0.6$	$+0.014^{+0.020}_{-0.018}$	$-0.021^{+0.013}_{-0.024}$	$+0.002^{+0.020}_{-0.022}$	$+0.001^{+0.015}_{-0.013}$	$+0.036^{+0.017}_{-0.016}$	$-0.018^{+0.023}_{-0.022}$
	$\frac{d[El/Fe]}{dR_m}$					
$0.0 \leq Z_{max} < 0.3$		$-0.014^{+0.006}_{-0.005}$	$-0.016^{+0.006}_{-0.005}$	$+0.015^{+0.006}_{-0.005}$	$+0.008^{+0.005}_{-0.006}$	$+0.014^{+0.006}_{-0.004}$
$0.3 \leq Z_{max} < 0.6$		$+0.004^{+0.008}_{-0.009}$	$-0.012^{+0.012}_{-0.015}$	$+0.008^{+0.006}_{-0.005}$	$+0.007^{+0.009}_{-0.007}$	$-0.011^{+0.011}_{-0.009}$
$Z_{max} > 0.6$		$-0.052^{+0.013}_{-0.013}$	$-0.042^{+0.017}_{-0.015}$	$-0.028^{+0.016}_{-0.010}$	$+0.015^{+0.012}_{-0.008}$	$-0.033^{+0.024}_{-0.022}$

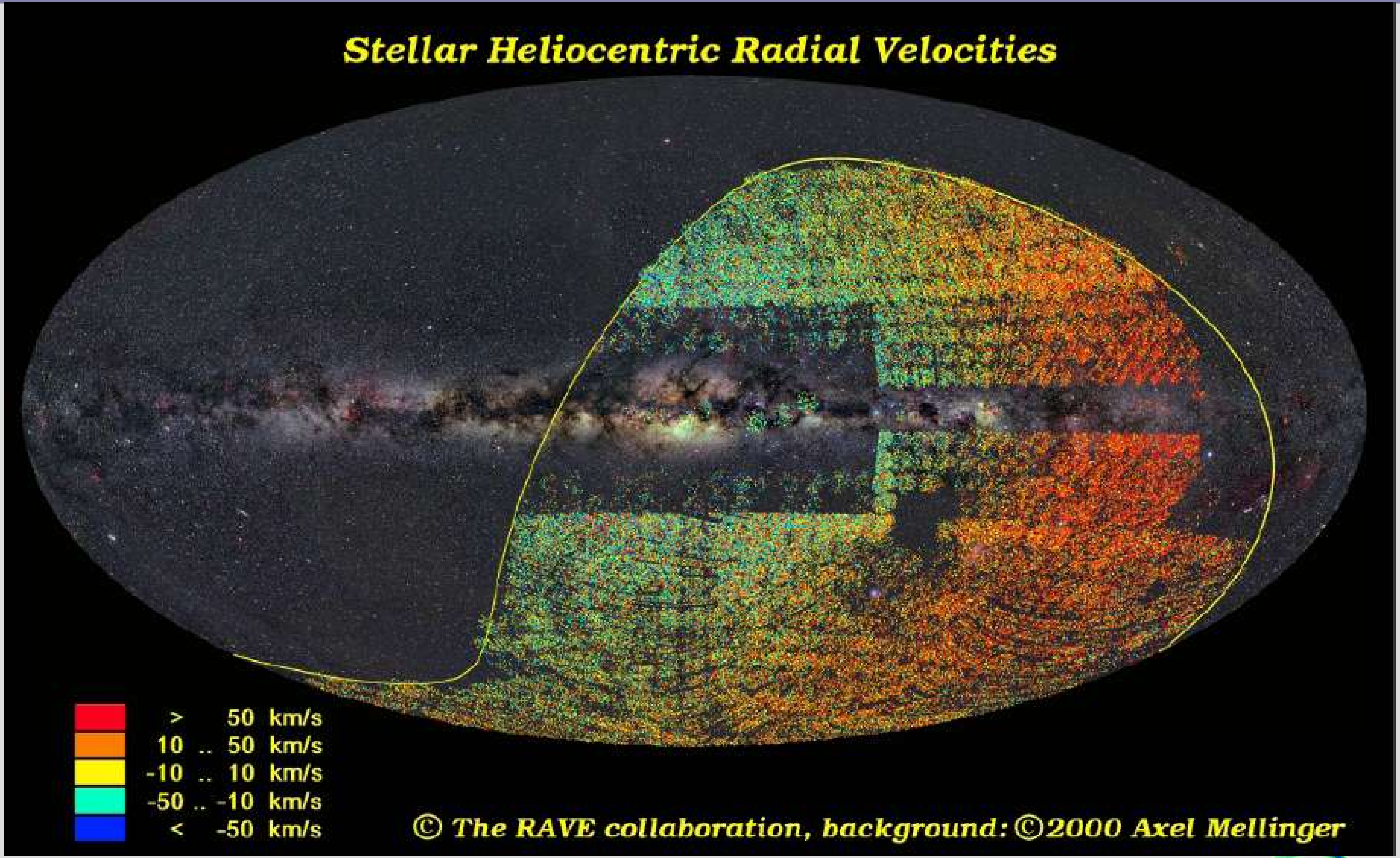
What next?

searching for signature of radial mixing, streams, moving groups...



32812 stars
S/N>50

Rp=perigalactic
Ra=apogalactic



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