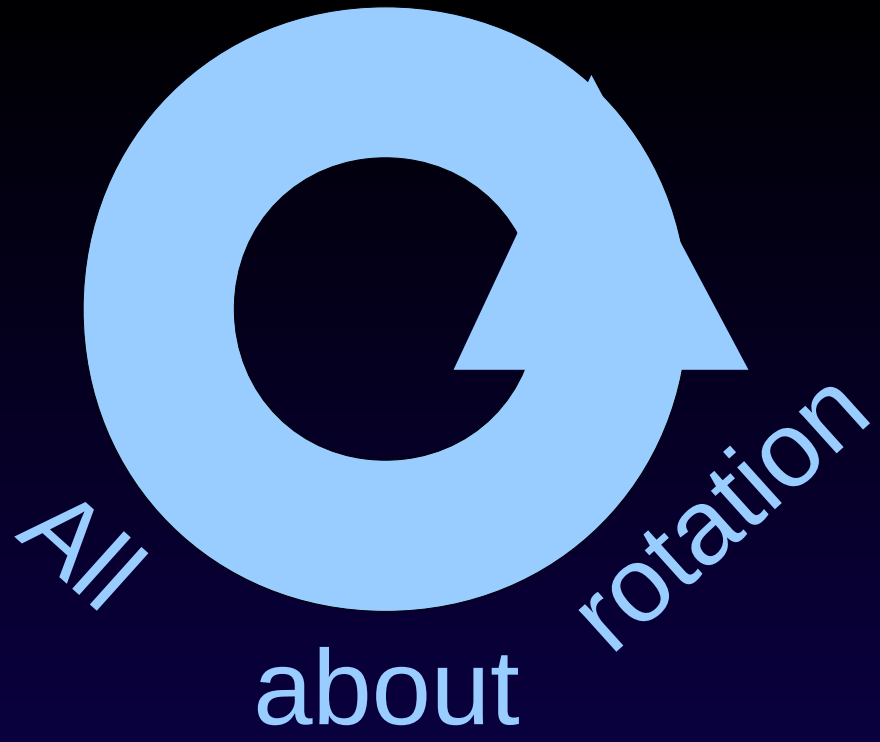


Ralph Schönrich (MPA, Hubble Fellow, OSU)

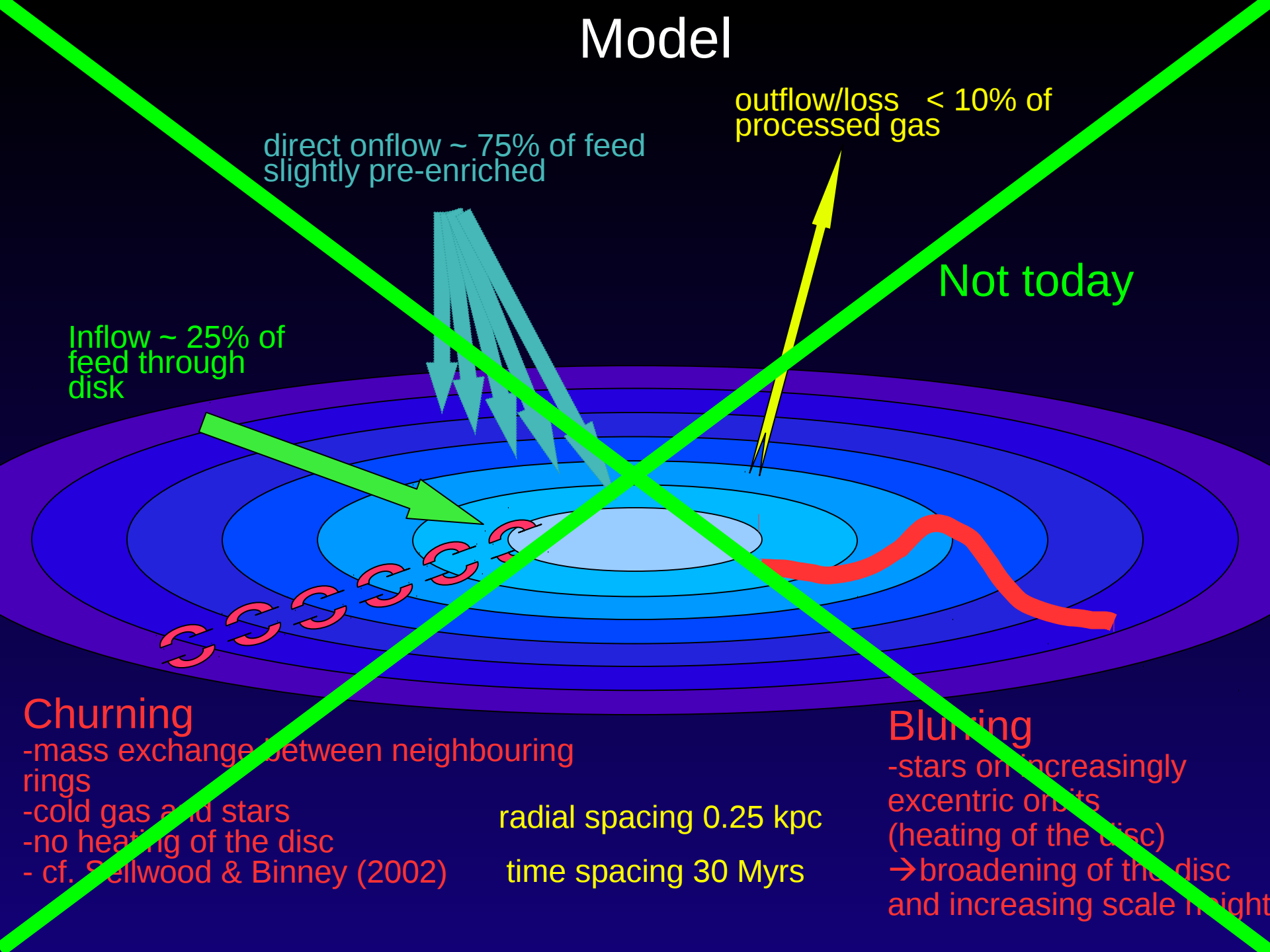
with

Martin Asplund, James Binney

Thomas Bilitewski, Luca Casagrande

Walter Dehnen, Heather Morrison

Model



Churning

-mass exchange between neighbouring rings
-cold gas and stars
-no heating of the disc
- cf. Sellwood & Binney (2002)

radial spacing 0.25 kpc

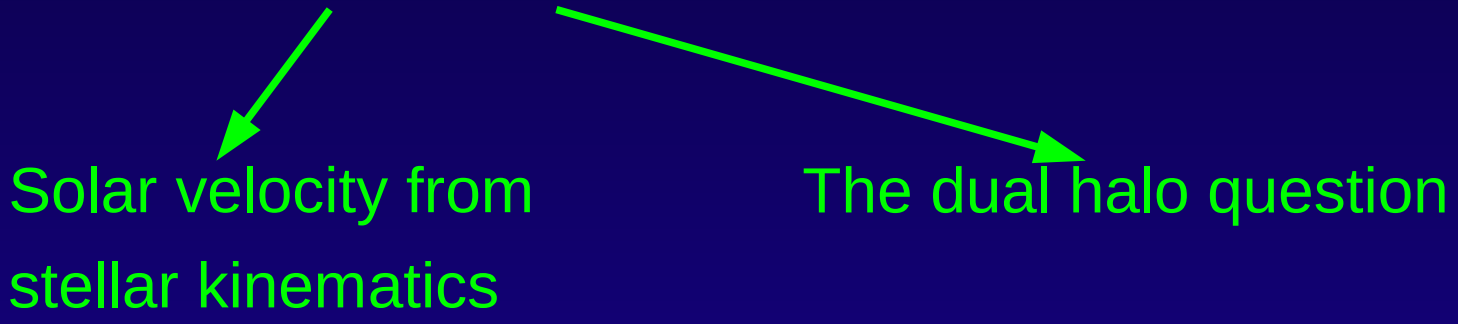
time spacing 30 Myrs

Blurring

-stars on increasingly excentric orbits (heating of the disc)
→broadening of the disc and increasing scale height

Main fields

- Galactic chemo-dynamics
- abundance gradients and their implications
- understanding the Galactic thick disc
- LSR determination
- stellar distance statistics
- Galactic rotation



Galactic Parameters - methods

Solar azimuthal V $V_{g,\odot} = V_\odot + V_c$ Disc circular velocity

Local Standard of Rest

Methods

Proper motion of Sgr A* (Reid et al. 2004) – requires R_0

HI terminal velocity (see McMillan 2011)

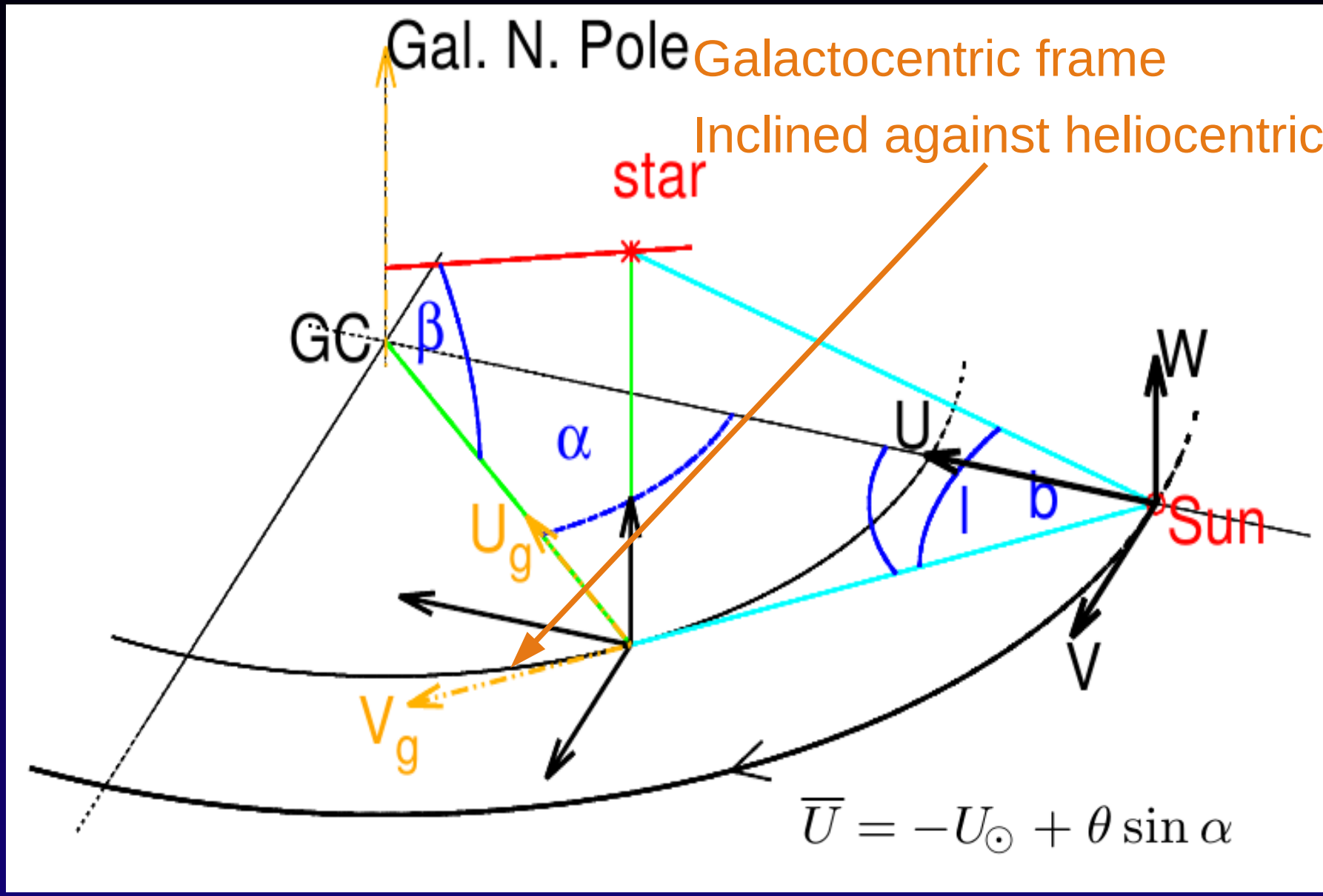
Molecular clouds / MASERs (Reid & Brunthaler 2004)

Halo Streams (Ibata et al. 2001, Majewski et al. 2006)

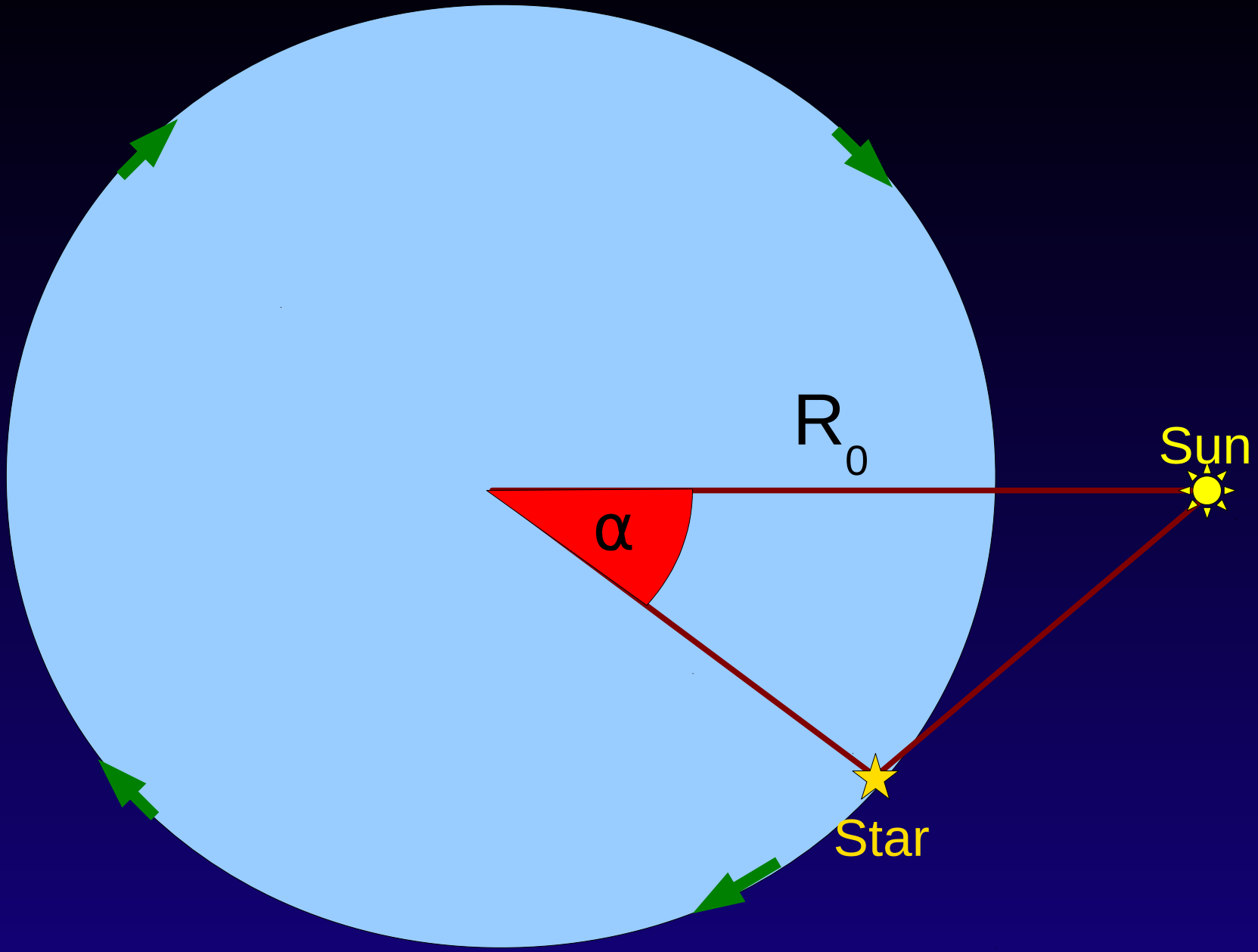
Oort constants (Oort 1927)

LSR (Strömberg 1947, Schönrich, Binney & Dehnen 2010)

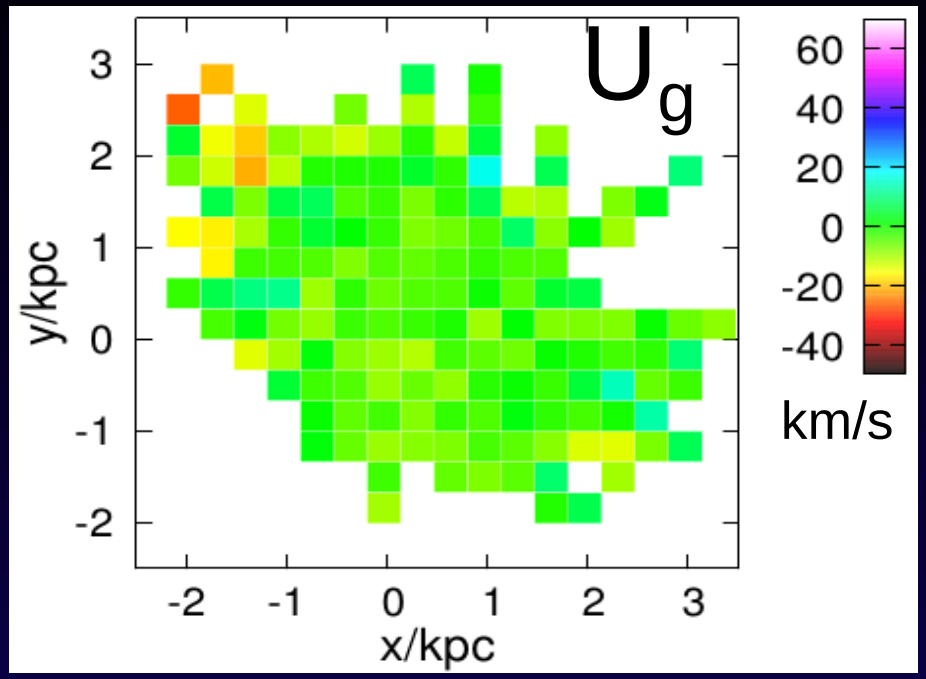
Rotation – the dry view



Seen from above

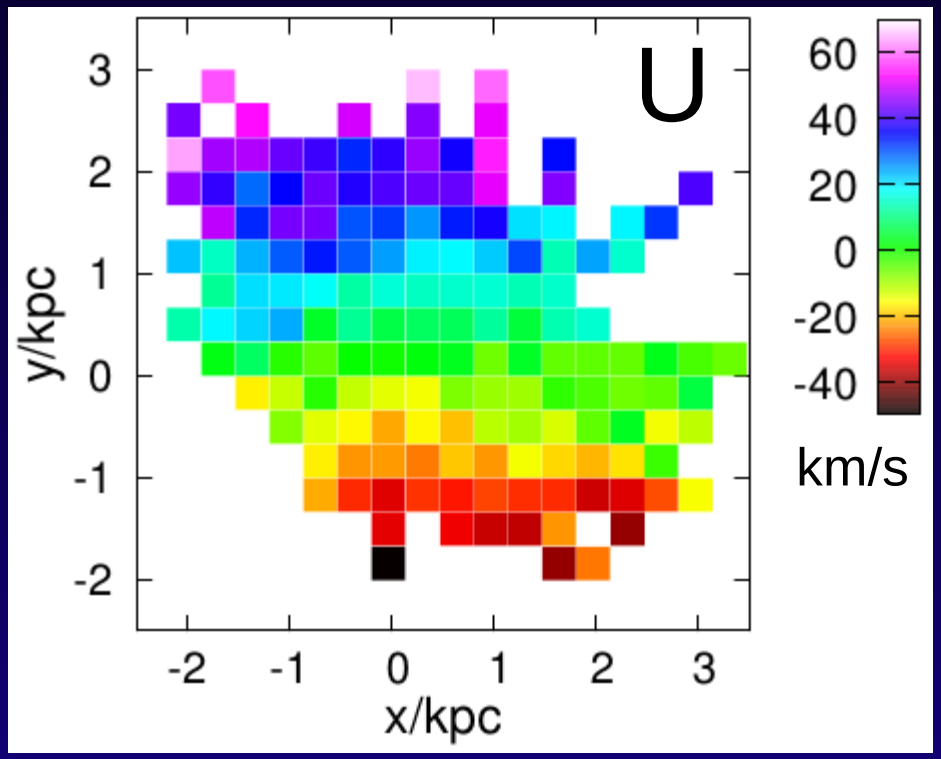


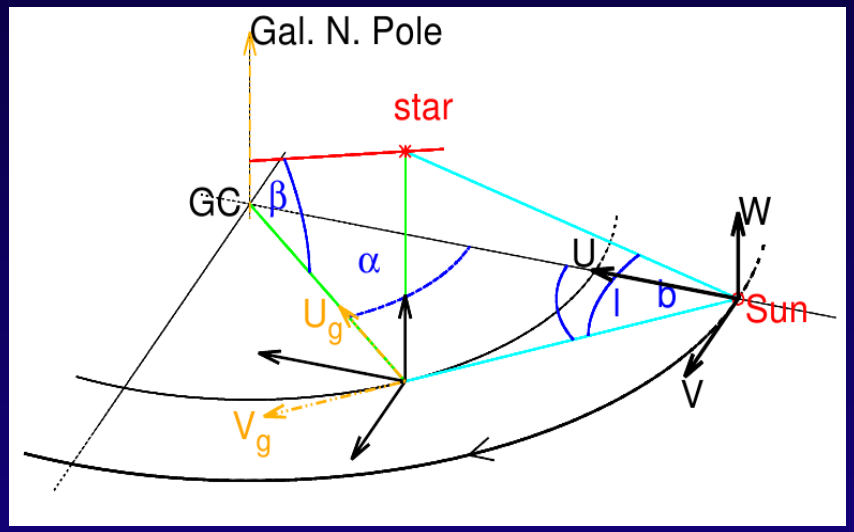
Radial velocities in the plane from SEGUE



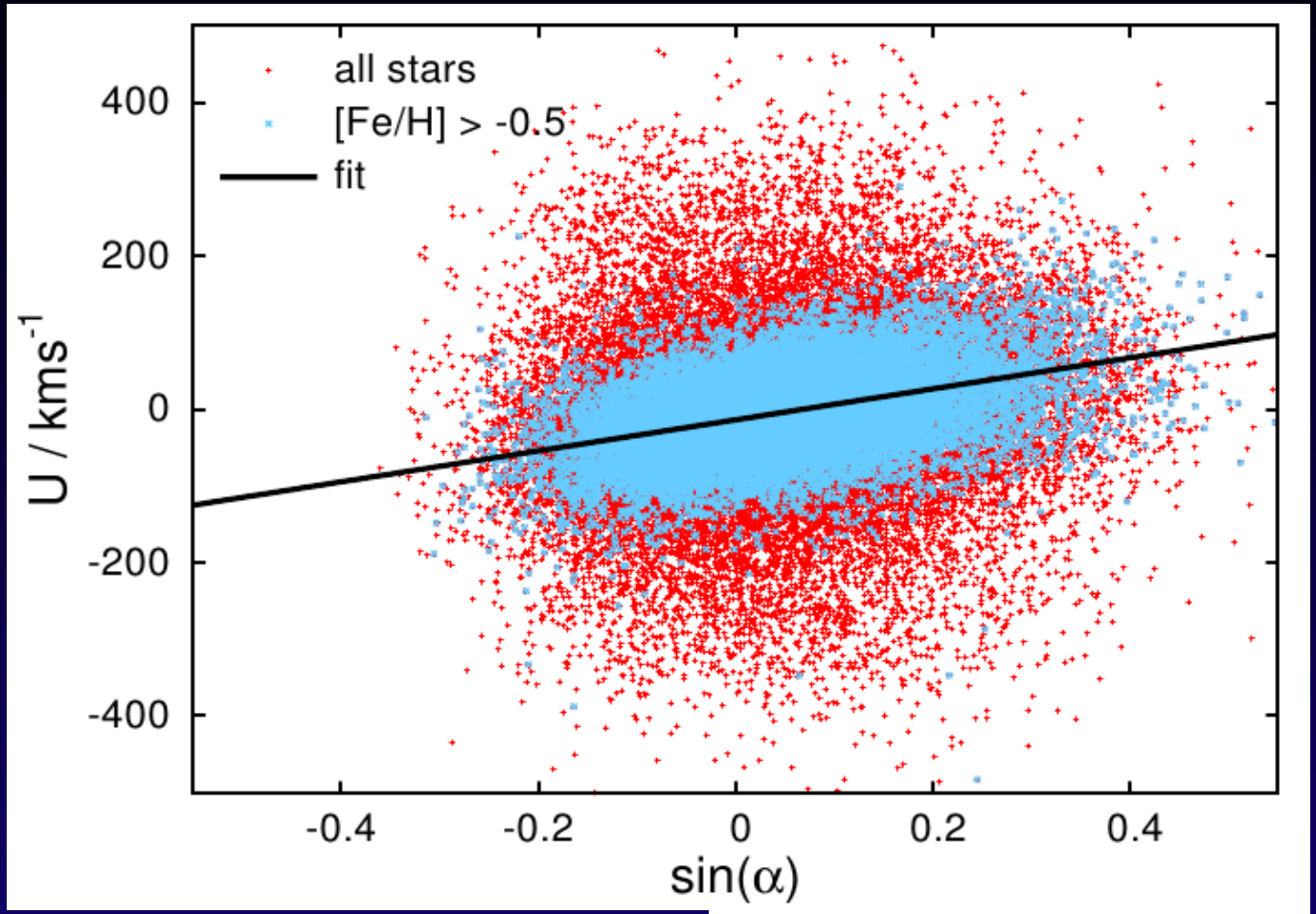
galactocentric

heliocentric





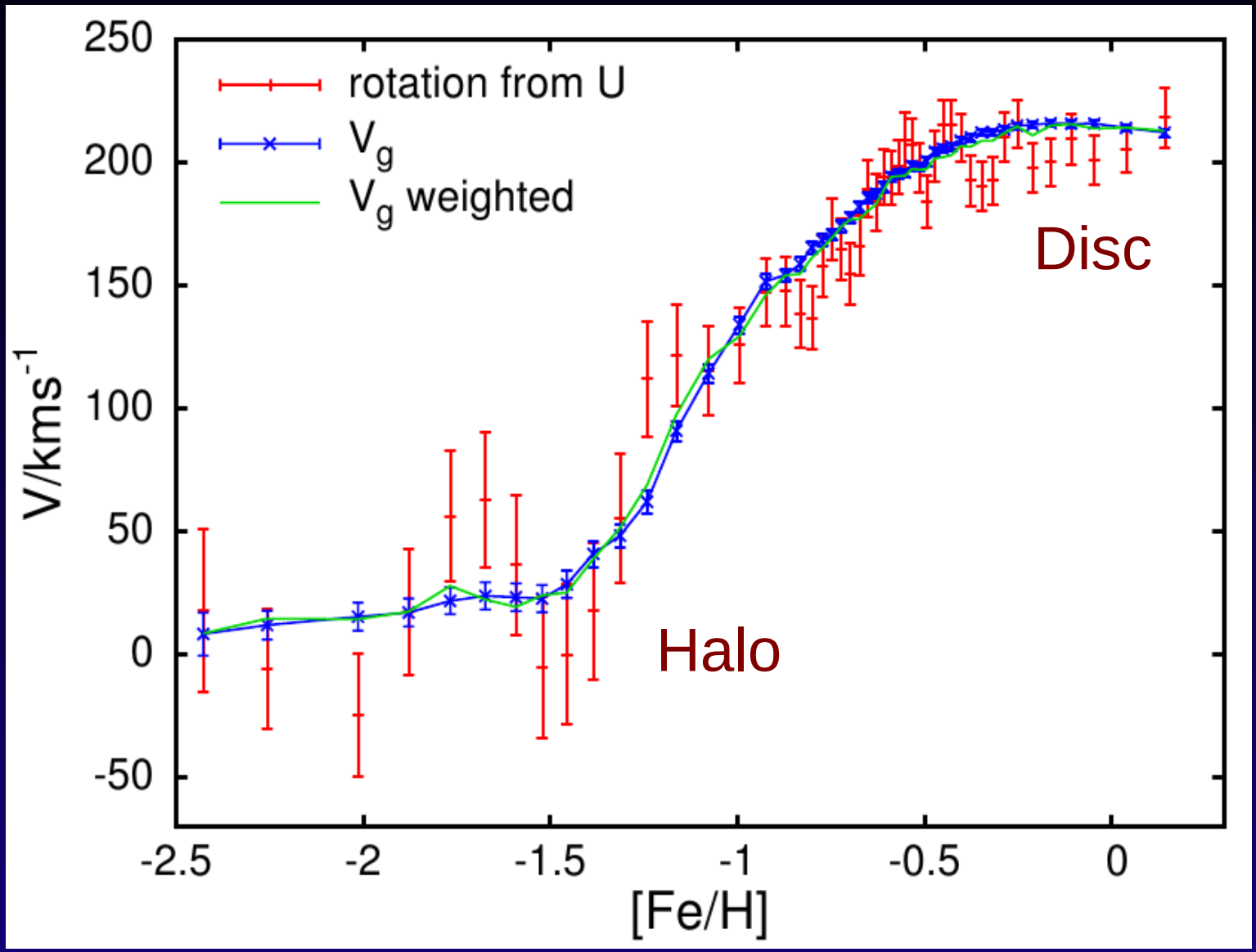
Rotation: A danger when measuring the solar motion



$$\overline{U} = -U_{\odot} + \theta \sin \alpha$$

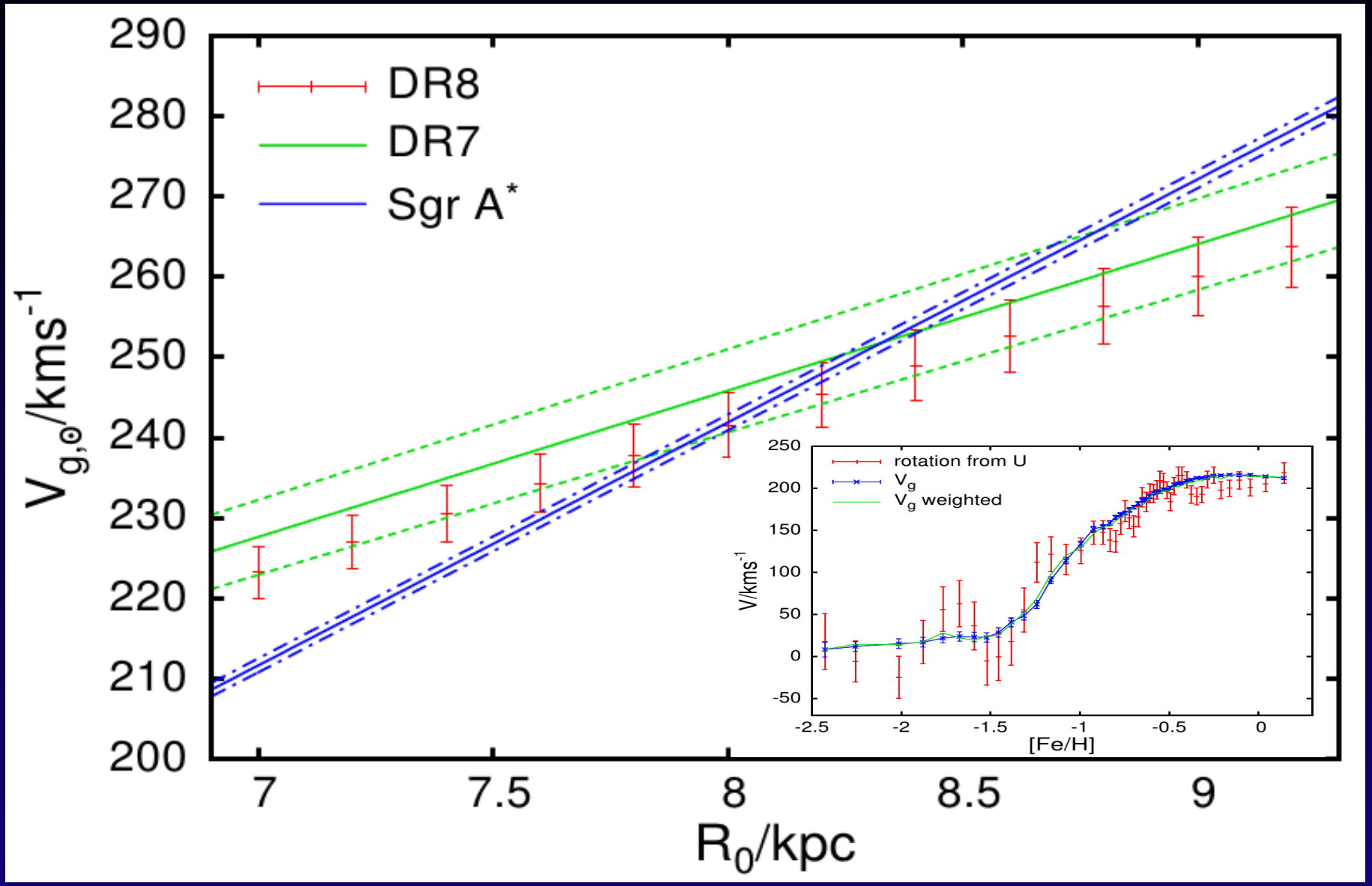
Samples are lopsided (northern/southern sky) → rotation bias

Divide and conquer:
The rotation of components



Get the absolute solar velocity

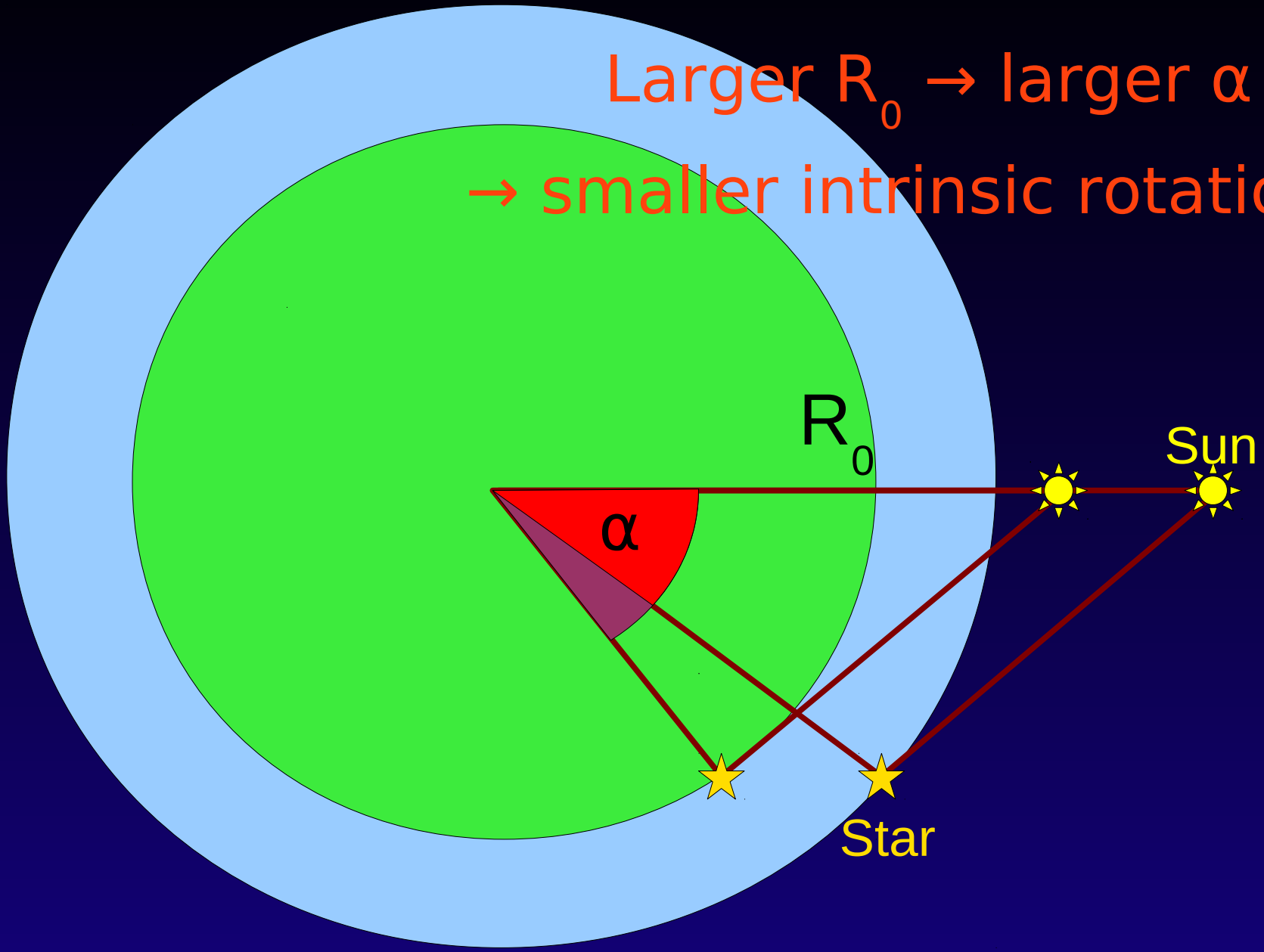
Simple: azimuthal velocities must match the absolute rotation



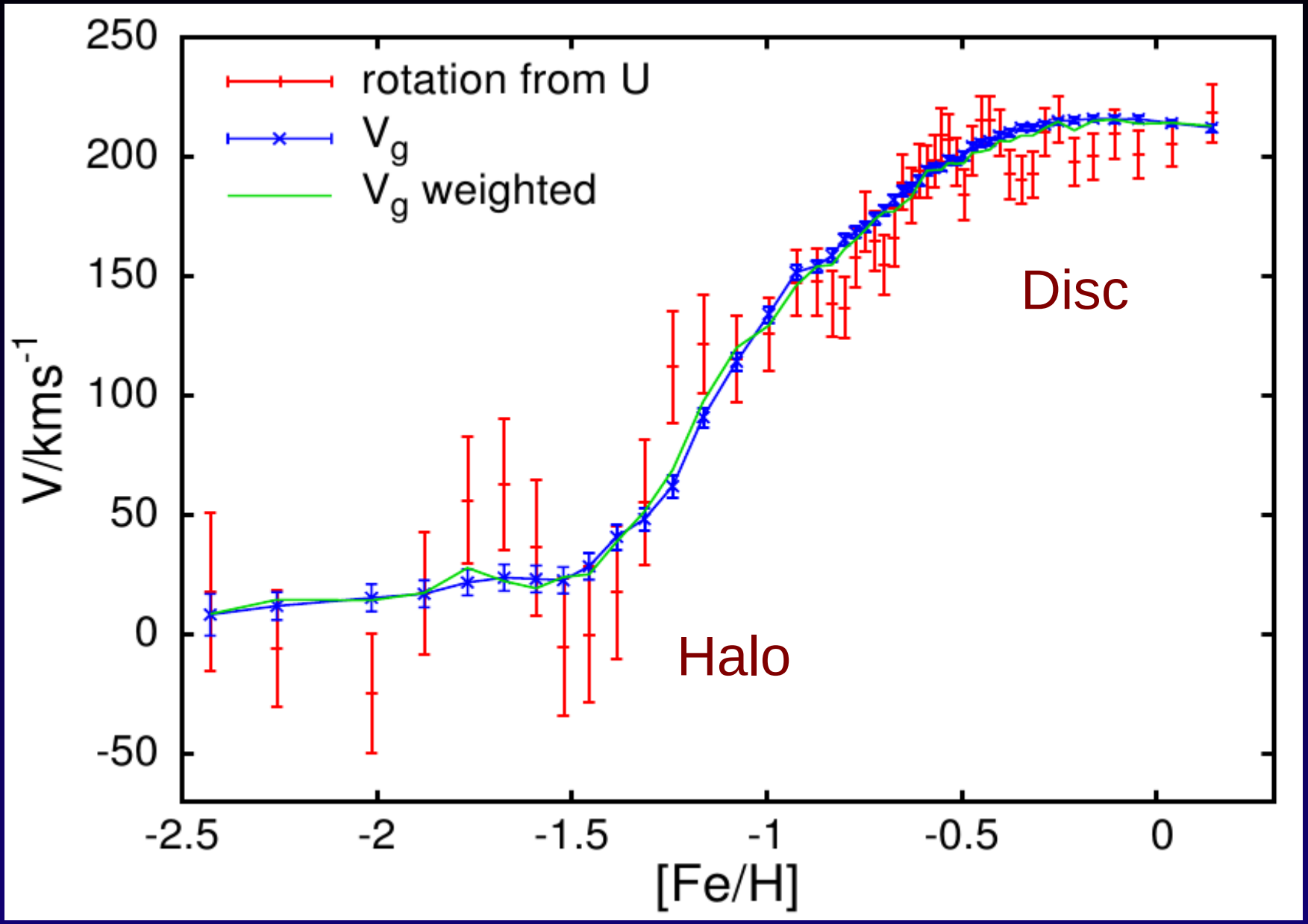
Behavioural differences

Larger R_0 → larger α

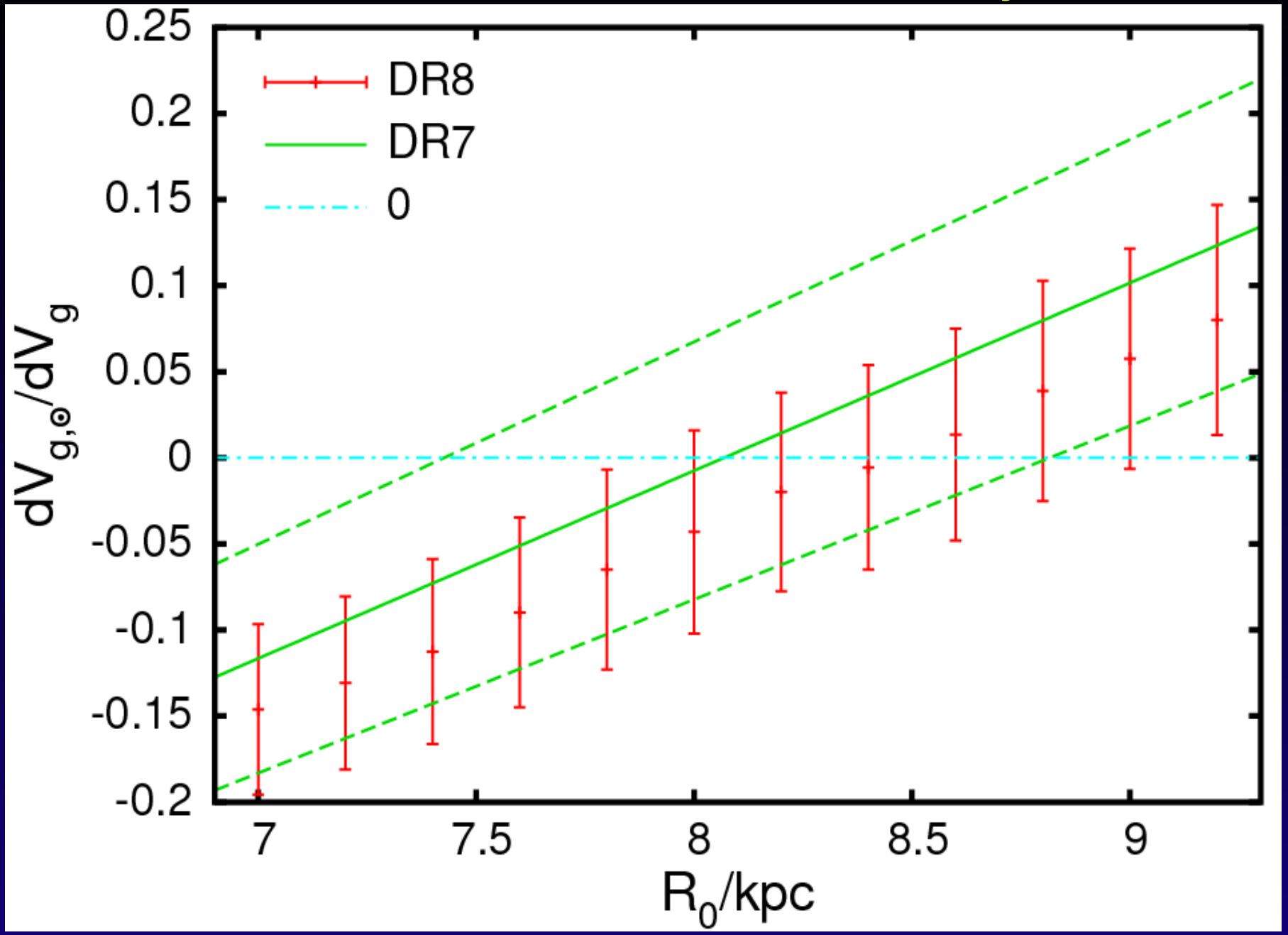
→ smaller intrinsic rotation



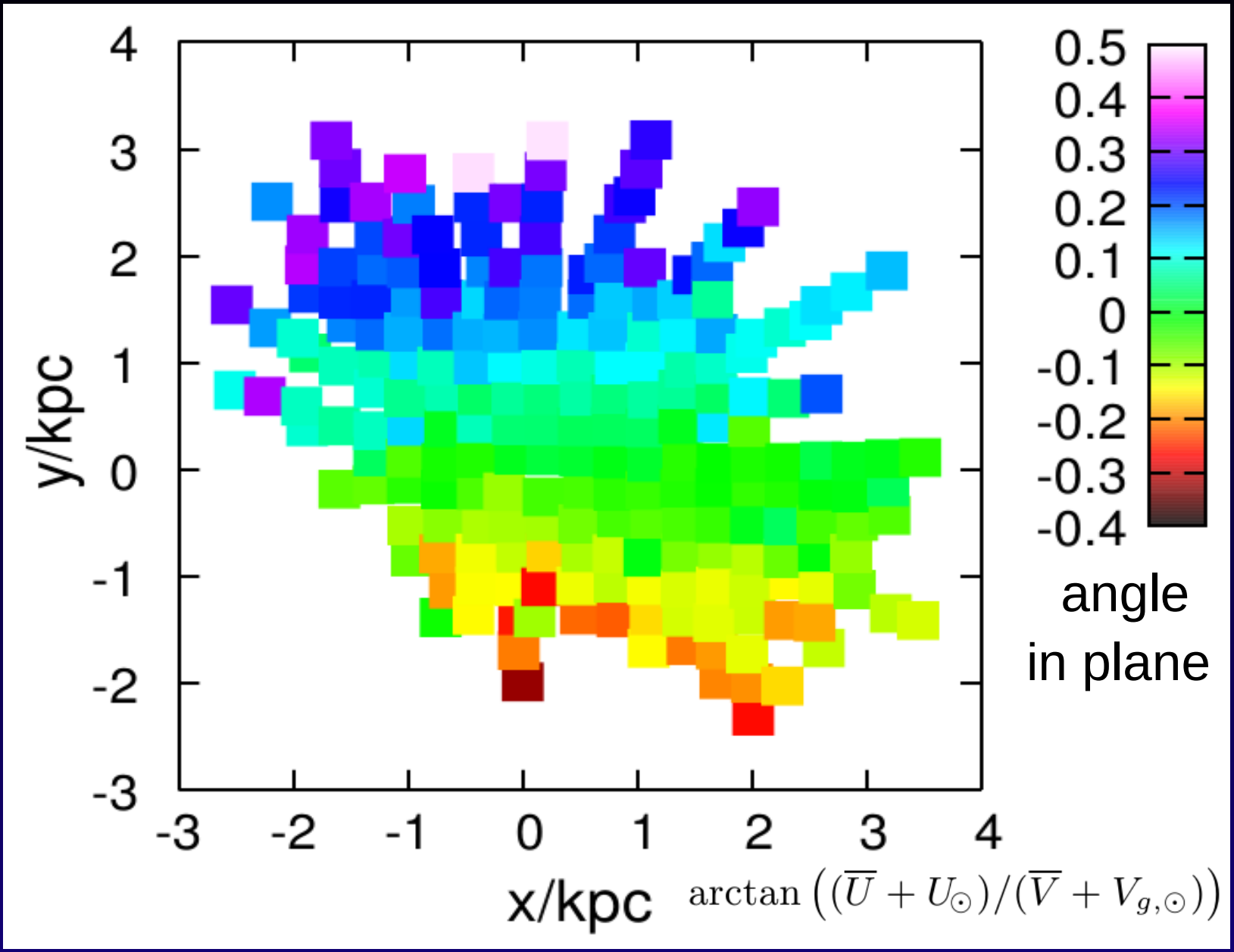
Behavioural differences



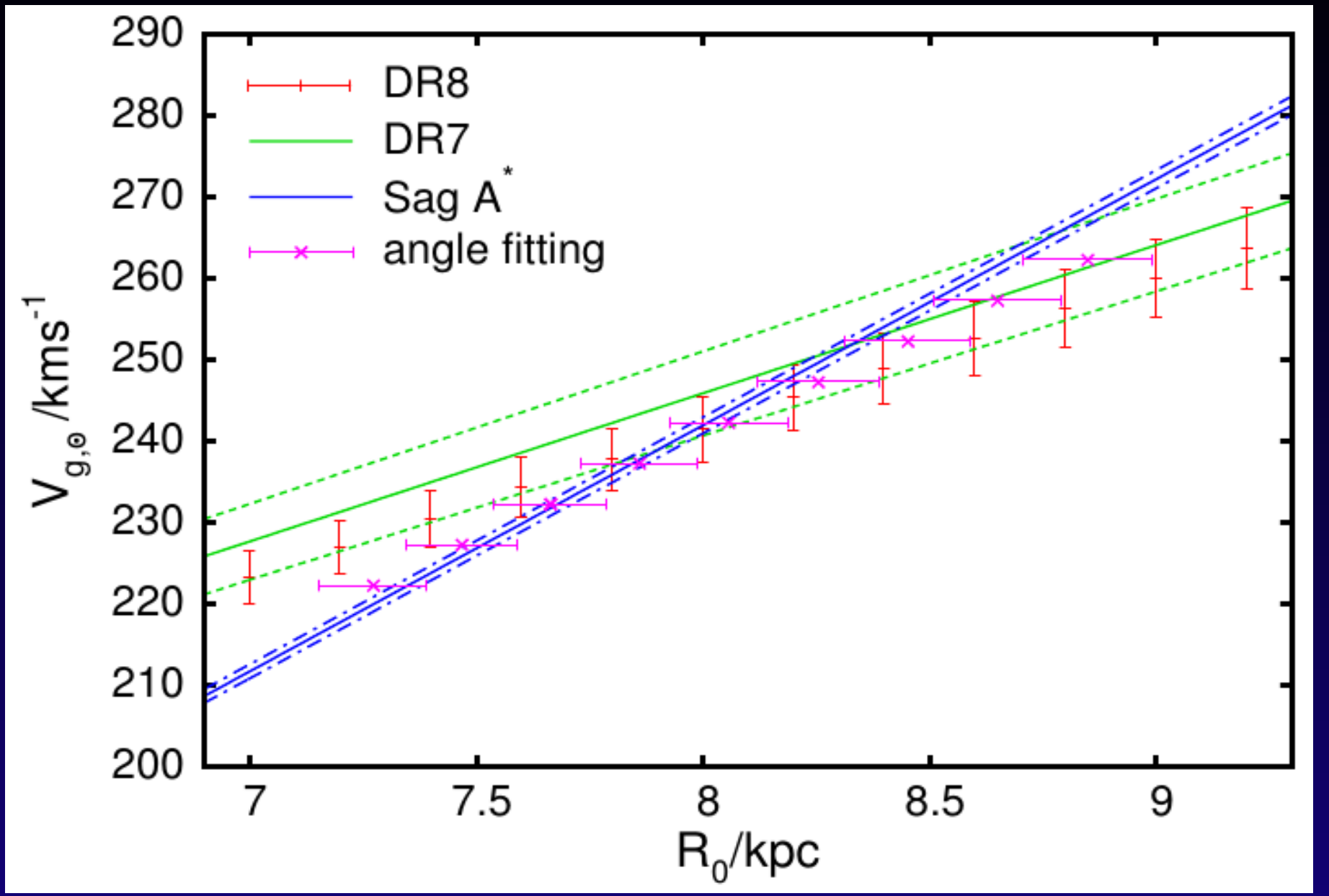
On the slide – radius from velocity trend



Quo vadis? Using the direction of motion

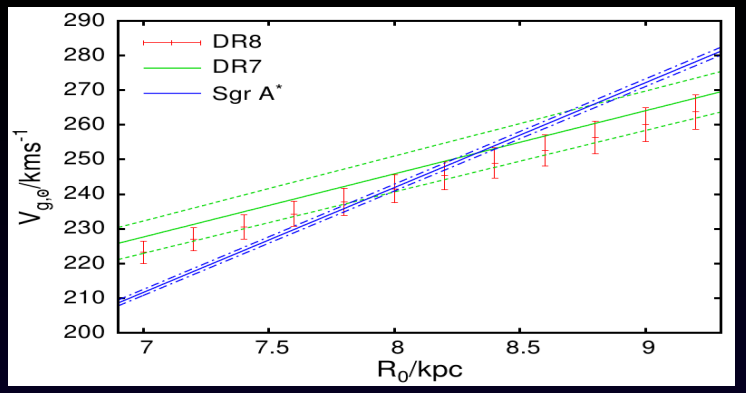


Applying the motion angle



preliminary

Values

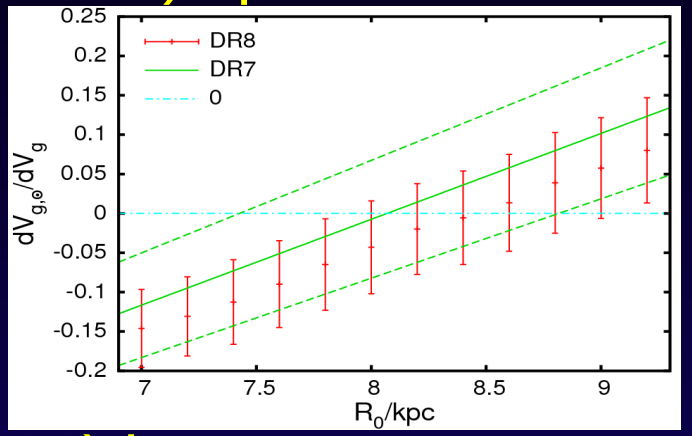


Velocity match + Sgr A*

V_{Sun} = (241 ± 10) km/s R_0 = (7.97 ± 0.35) kpc

Velocity trend

R_0 = (8.43 ± 0.57) kpc



Combined

V_{Sun} = (245 ± 9) km/s R_0 = (8.11 ± 0.29) kpc

V_C = (233 ± 9) km/s

Blended with McMillan(2011)

V_{Sun} = (249.5 ± 4.2) km/s R_0 = (8.25 ± 0.14) kpc

V_C = (237 ± 5) km/s

Summary

- Heliocentric radial velocities provide easy and less biased access to the rotation of components, without modelling

- Three new and independent estimators for Galactic rotation and solar position, competitive at SEGUE

- Requires large samples with significant spatial extent, hence far better with Gaia

- Radial velocity determinations for the Sun must account for the rotation of components

- method requires a low systematic distance error (reddening, metallicities, helium enrichment, etc.), currently using Schönrich, Binney & Asplund (2012)

- vulnerable to systematic proper motion errors

- requires approximate axisymmetry

Distances, Gaussianity and the alleged duality of the Galactic halo

The issue

Sample

SEGUE DR7 calibration stars

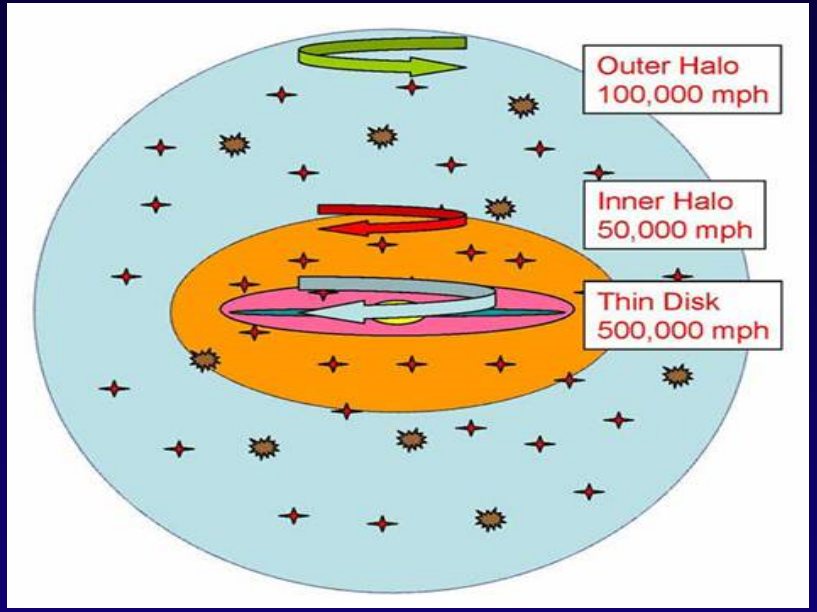
~ 33000 metal poor stars (metallicity bias, no kinematic bias)

- biased towards lower metallicities
- kinematics not biased against metallicity

Two distance scales:

Carollo et al. (2010) ⟷ Ivezic (2008)

(based on Beers et al. 2000)



?

Claims by Carollo et al. (2007, 2010)

10-20% distance errors

- Achieved by sorting stars into stellar branches

Gaussian analysis applicable

Three disc components

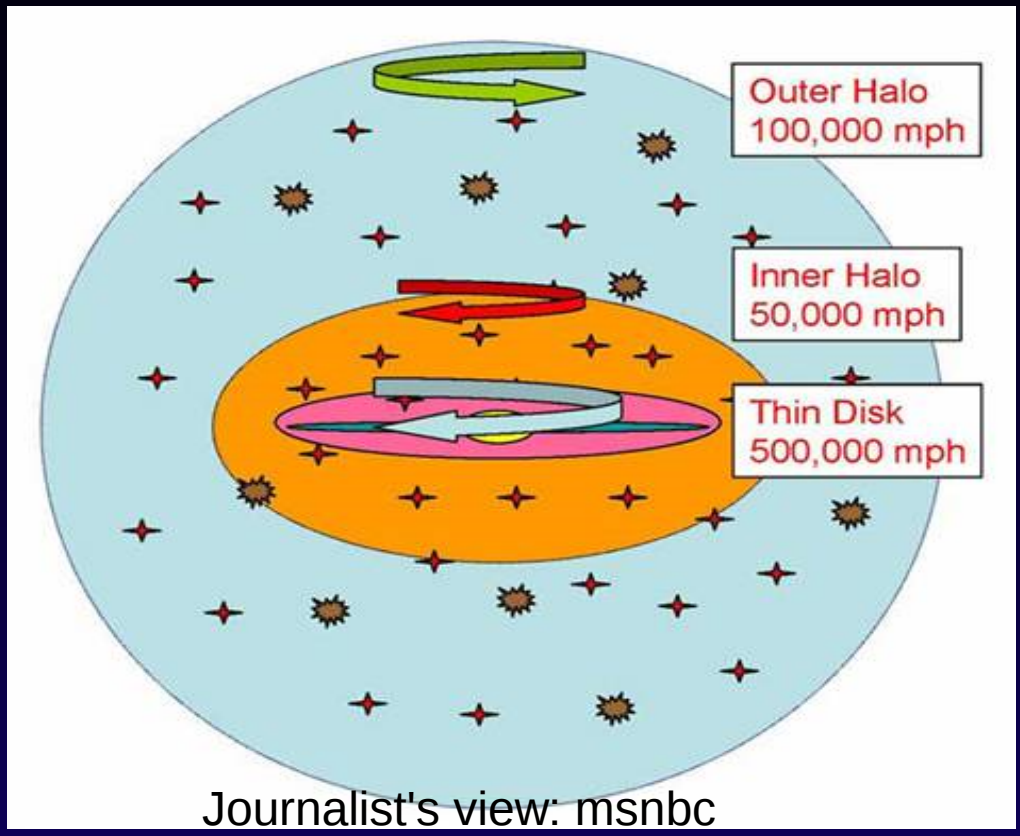
Two halo components

Distinct outer halo component

More metal poor

Very high vertical velocity dispersion

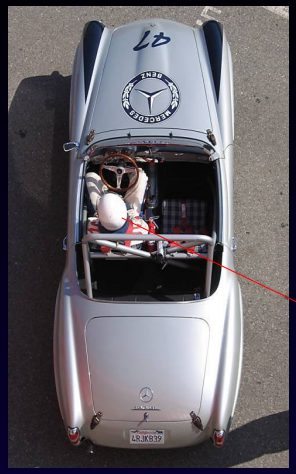
Retrograde motion

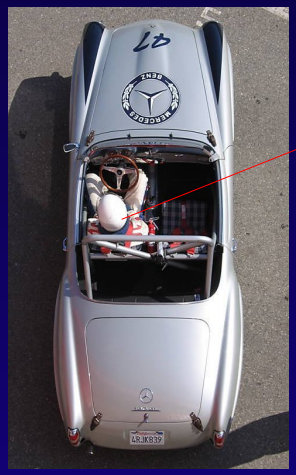


Journalist's view: msnbc

How to make trees run...
(if you are not J.R.R. Tolkien)

How to make trees run...

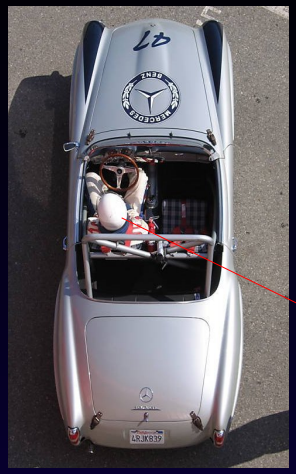


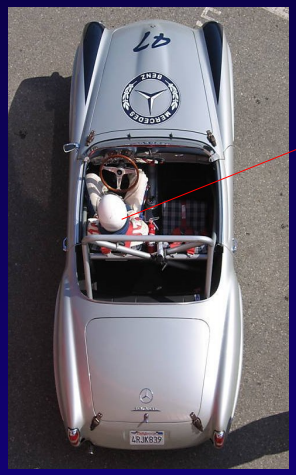


How to make trees run...

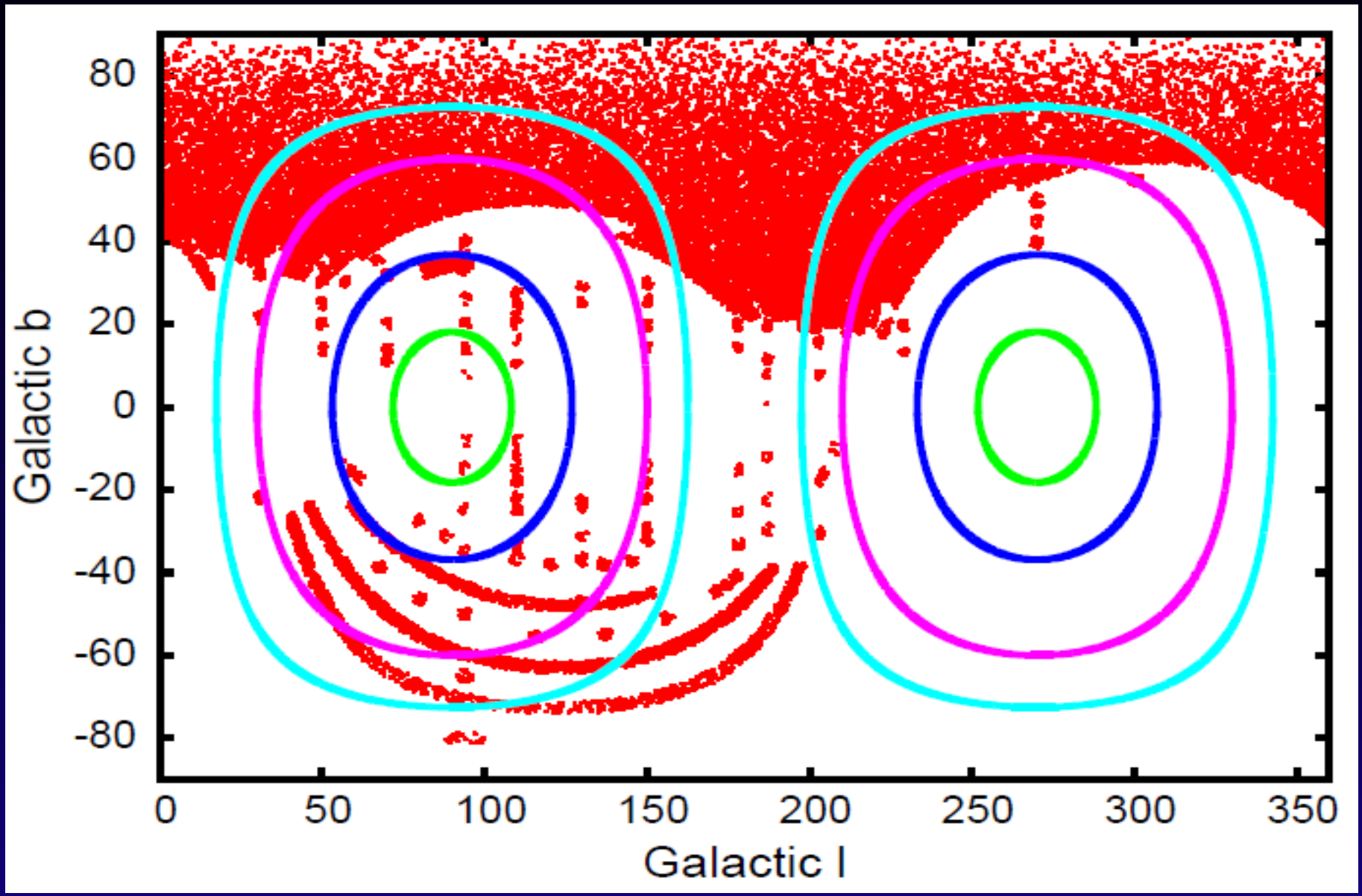
Over/-underestimate the distance!

Proper motion must not be aligned with the line of sight

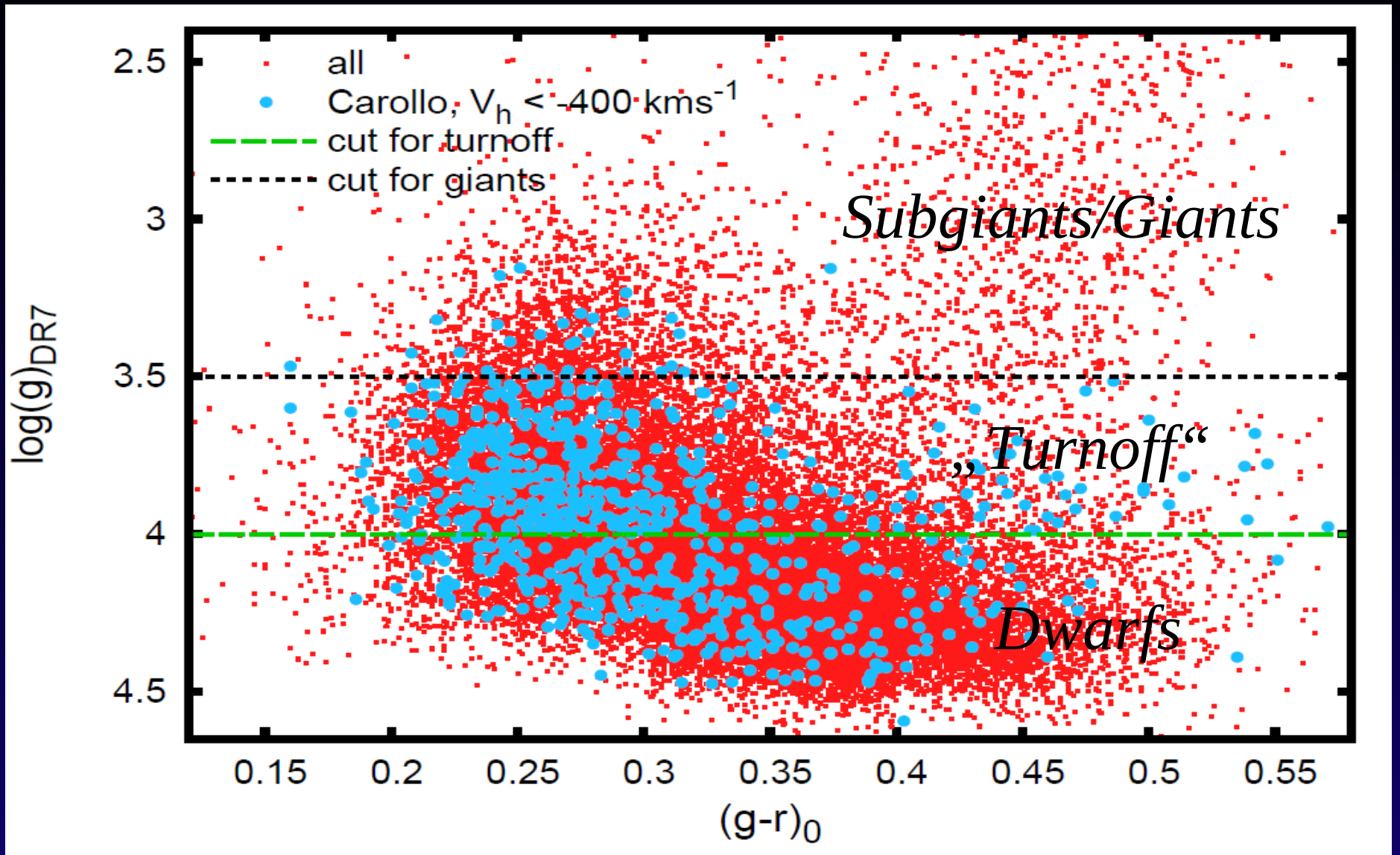




SEGUE azimuthal velocities have almost no radial velocity support

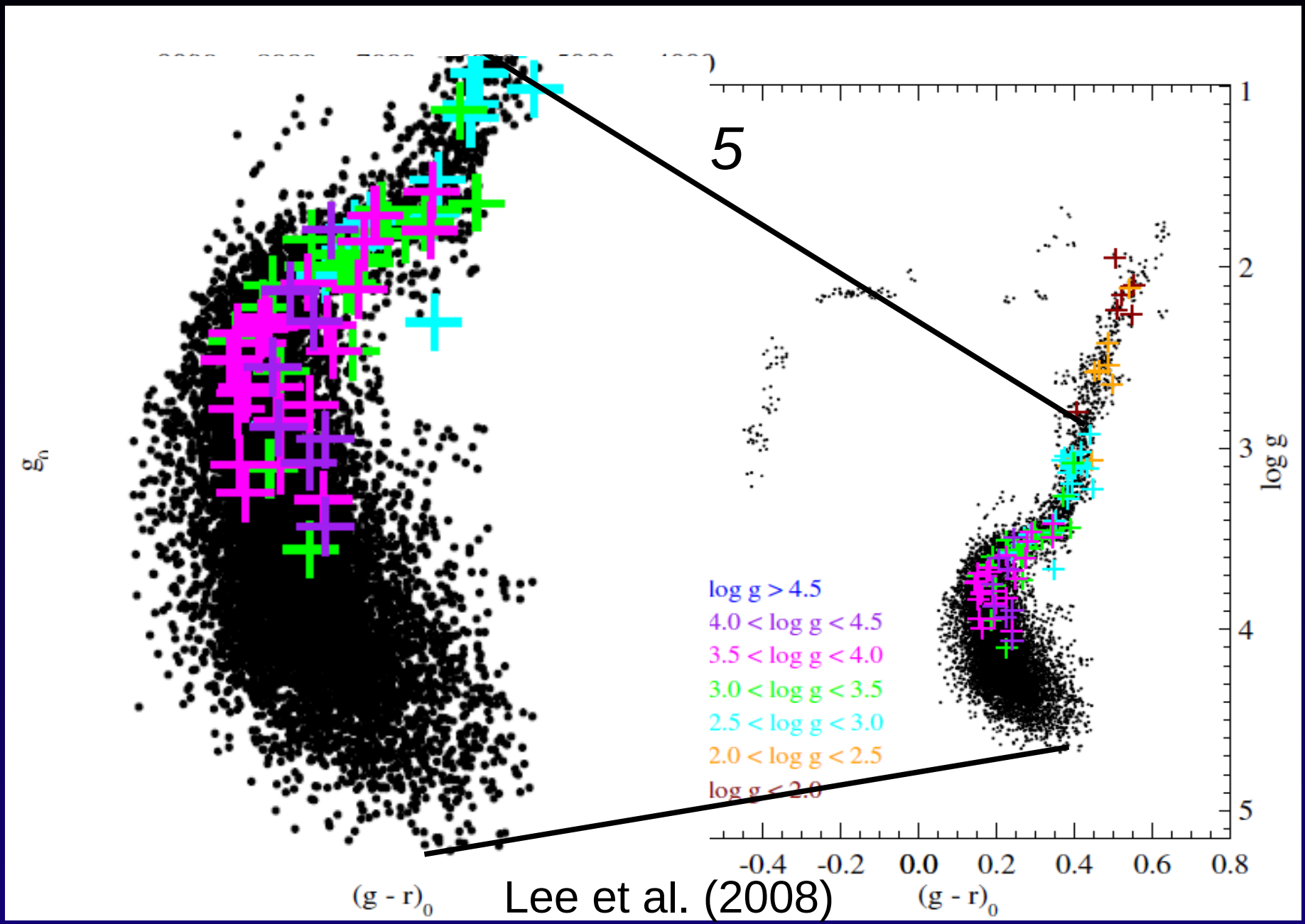


Gravities on colour



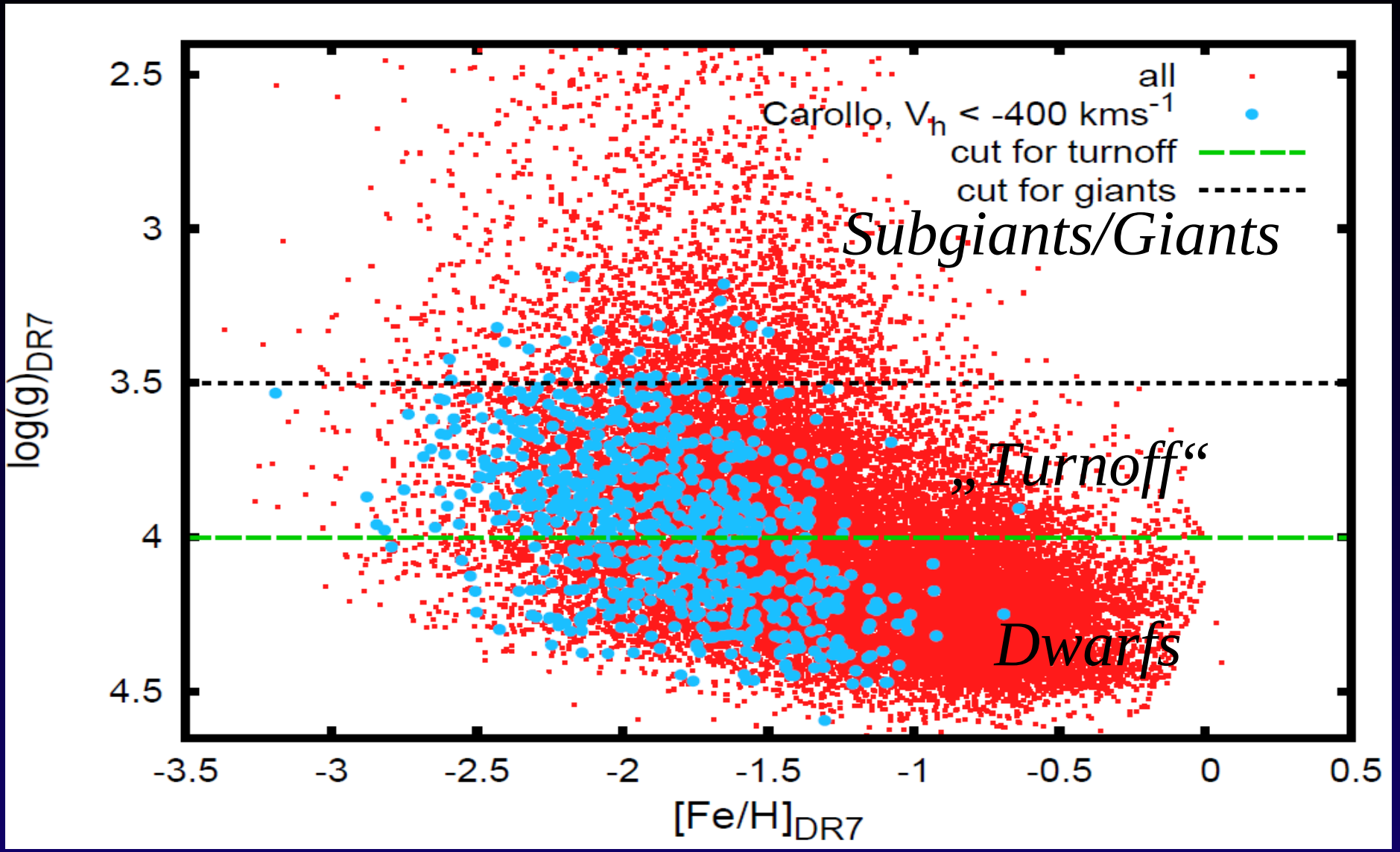
-almost no branches apparent - gravities do not allow for a clean cut
-crowding of counterrotating stars in the turnoff region

Gravities on colour



Lee et al. (2008)

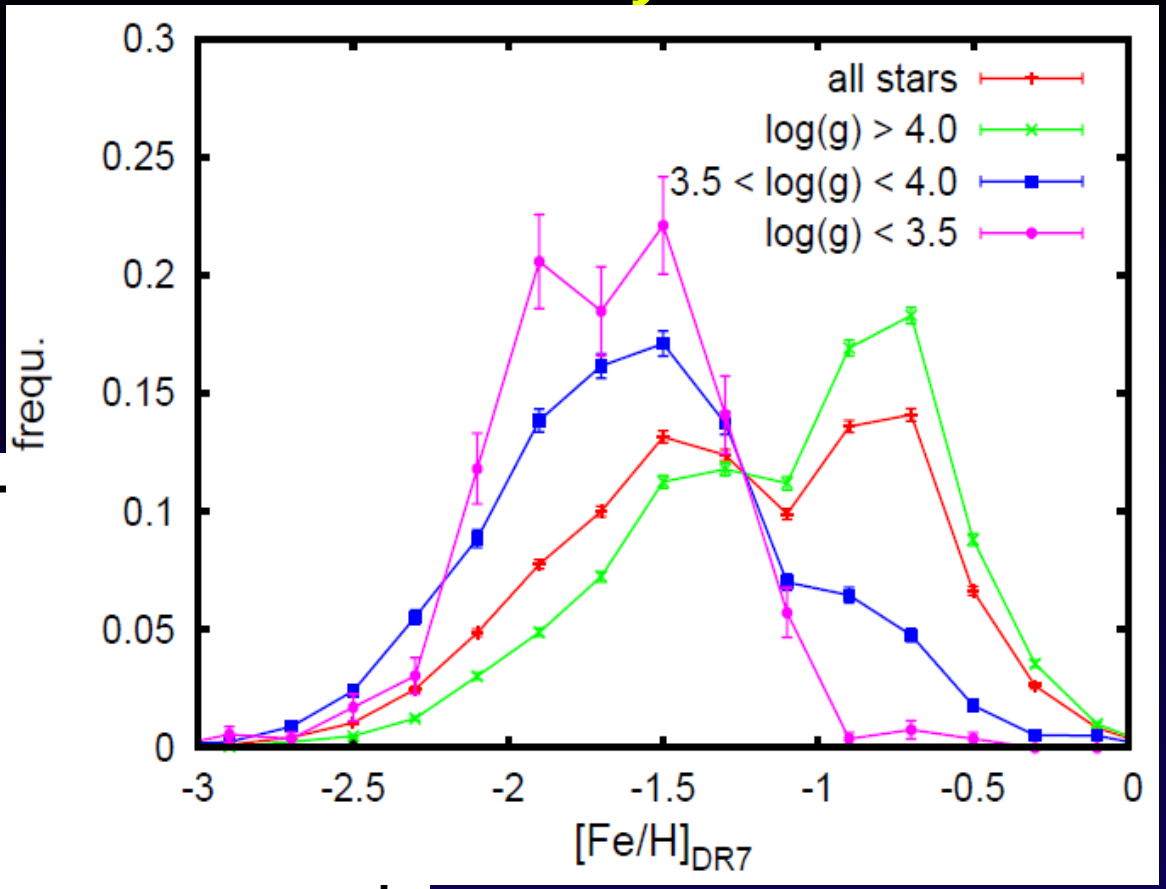
Gravities vs metallicity

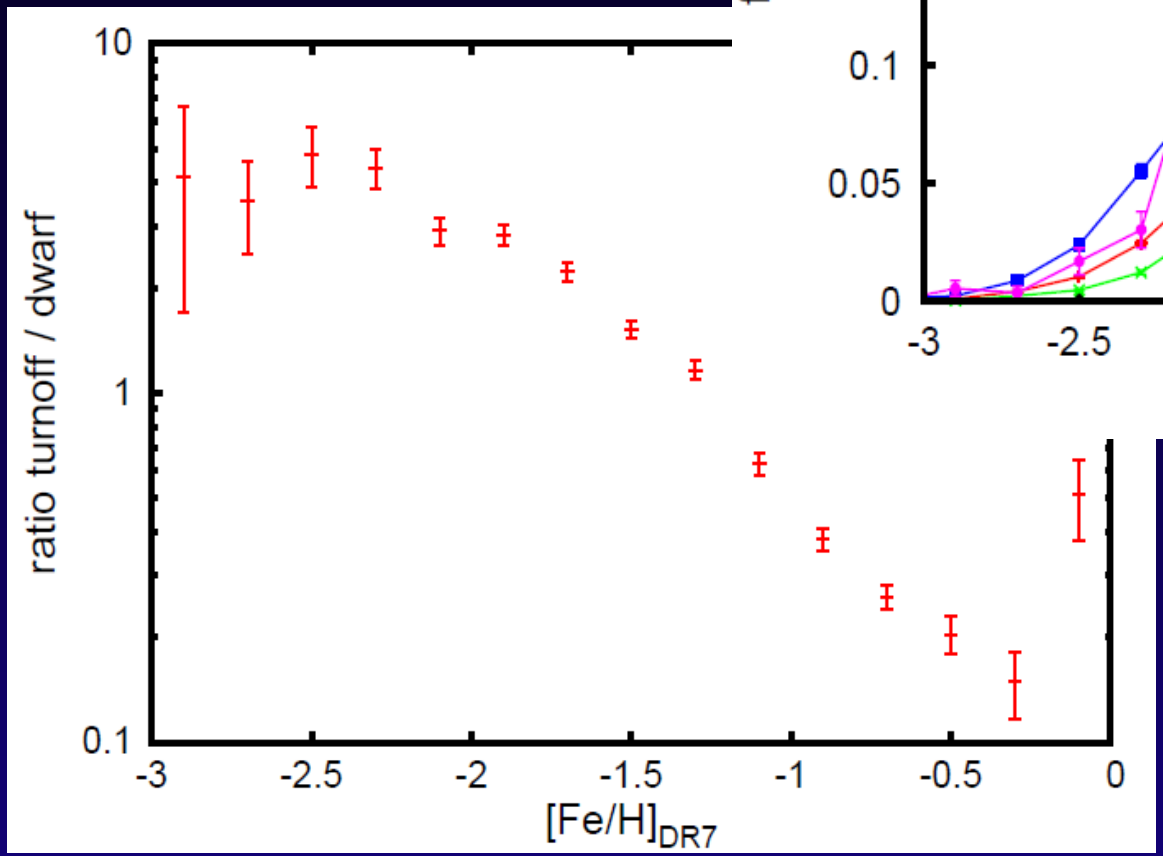


Downslope with metallicity increases relative number of metal poor turnoff stars

Gravities vs metallicity

Low gravity stars
are highly metal poor

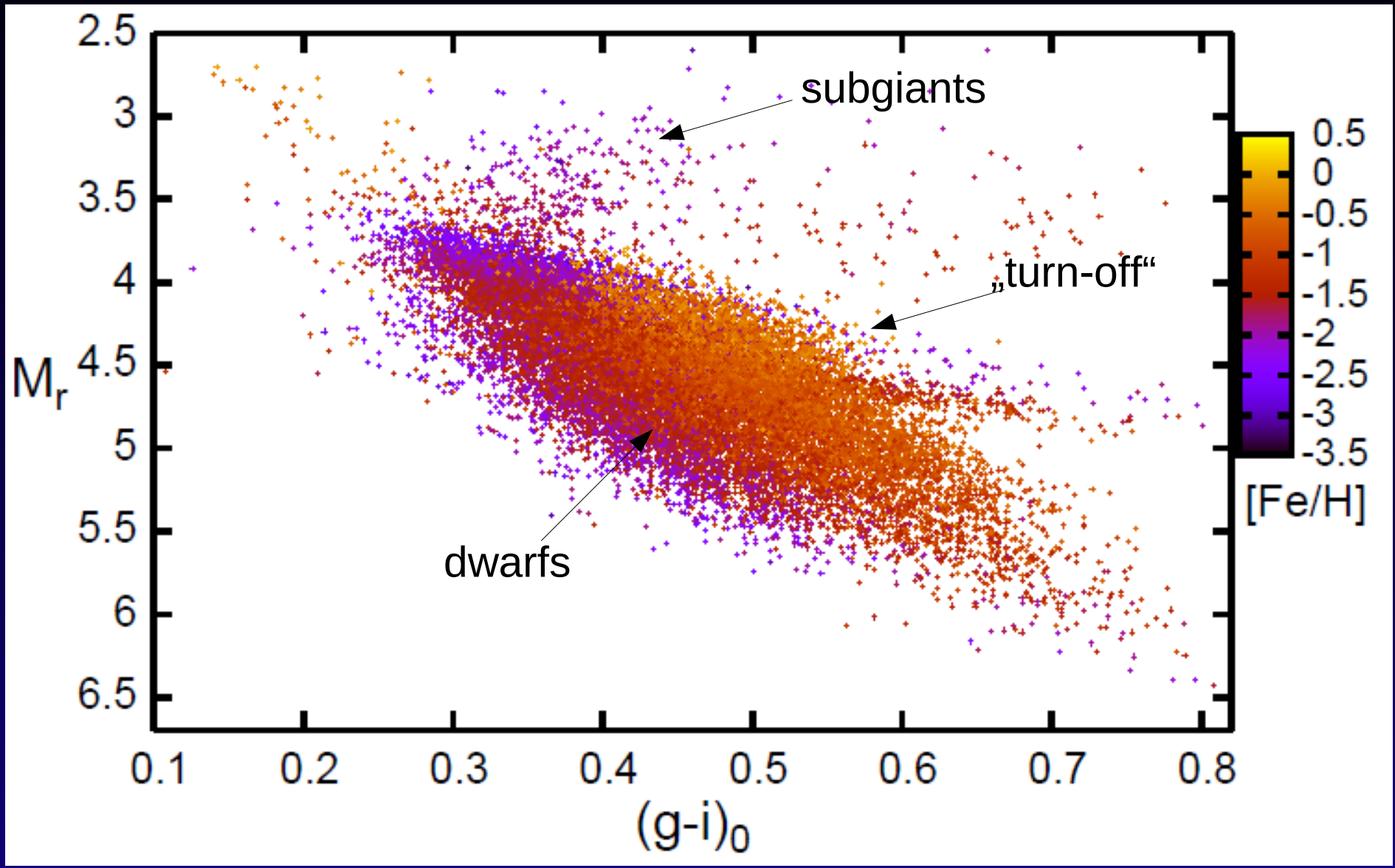




Ratio of thought-to-be
turnoff stars increases
towards metal poor halo

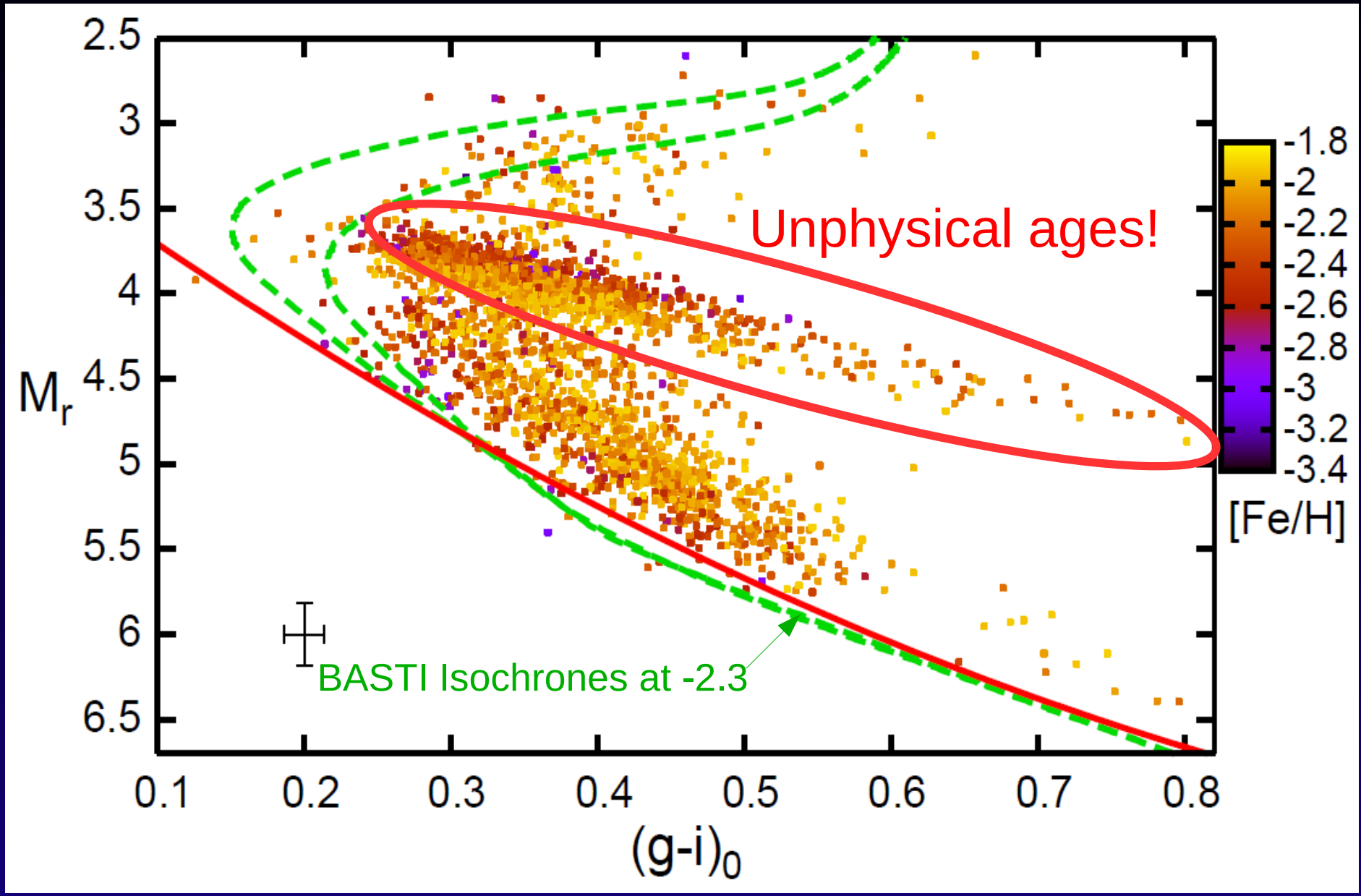
Reconstructed colour-magnitude diagram

Absolute magnitudes reconstructed from Carollo et al. (2010) distances and pipeline dereddened photometry

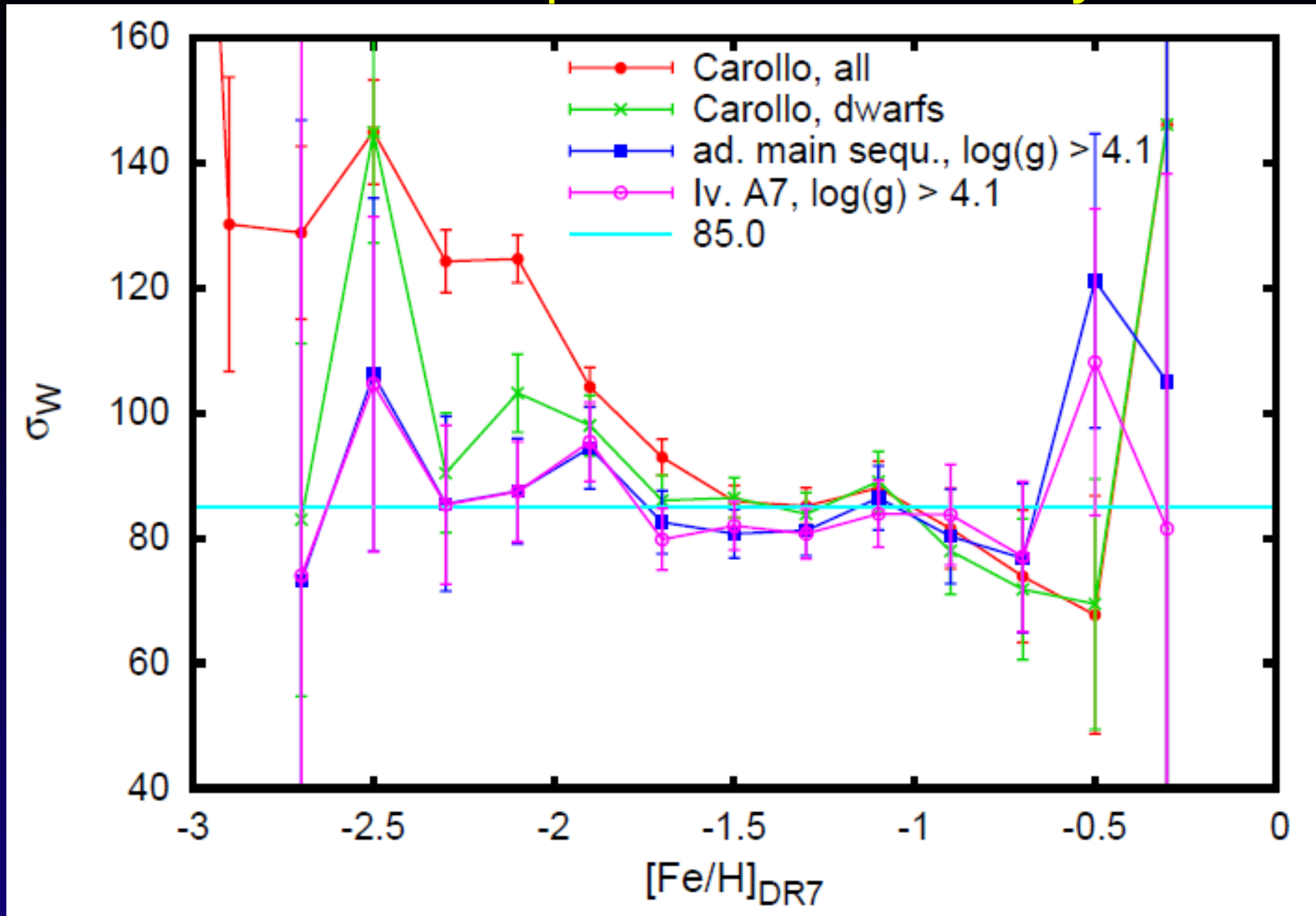


Reconstructed colour-magnitude diagram

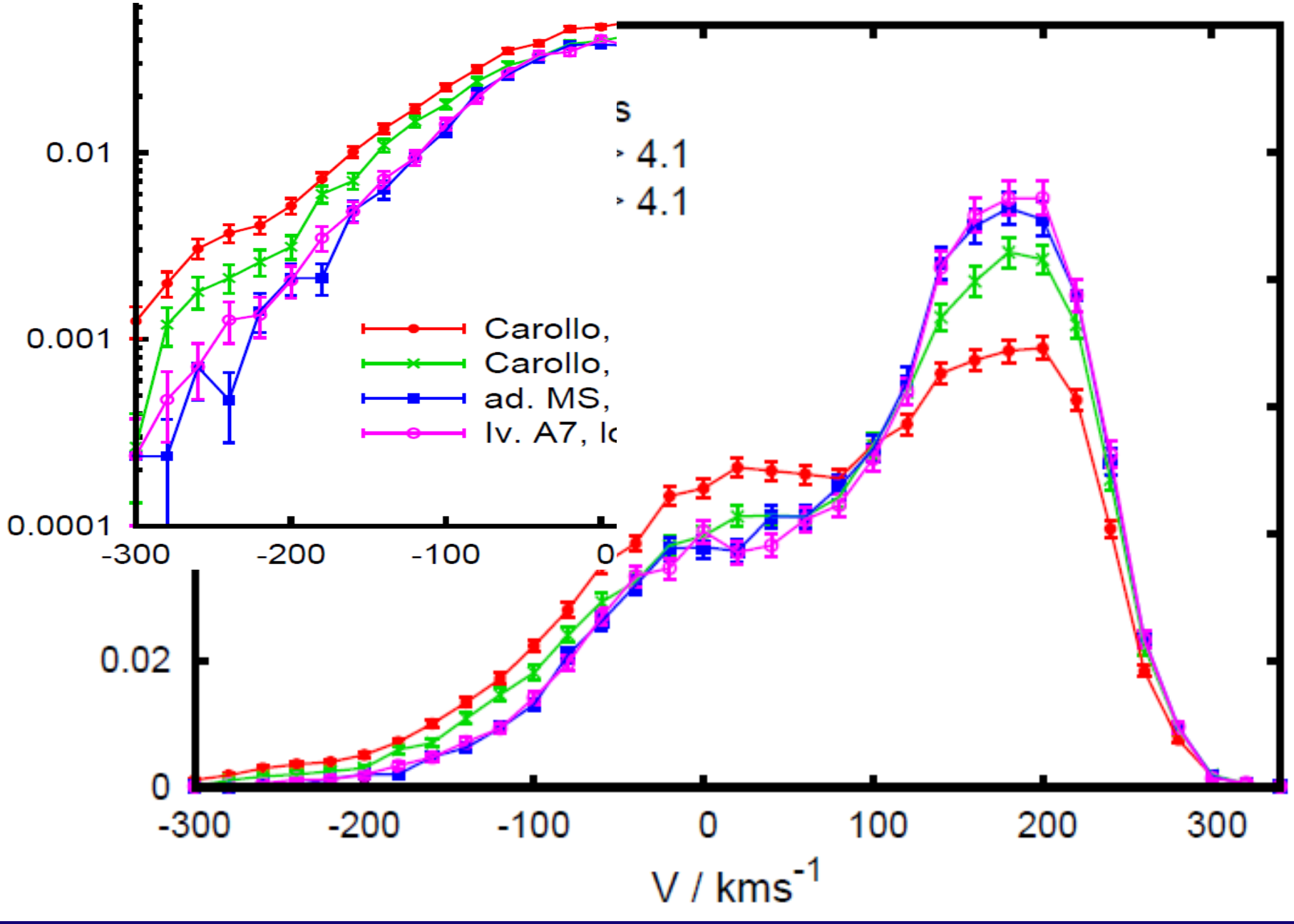
Metal poor stars



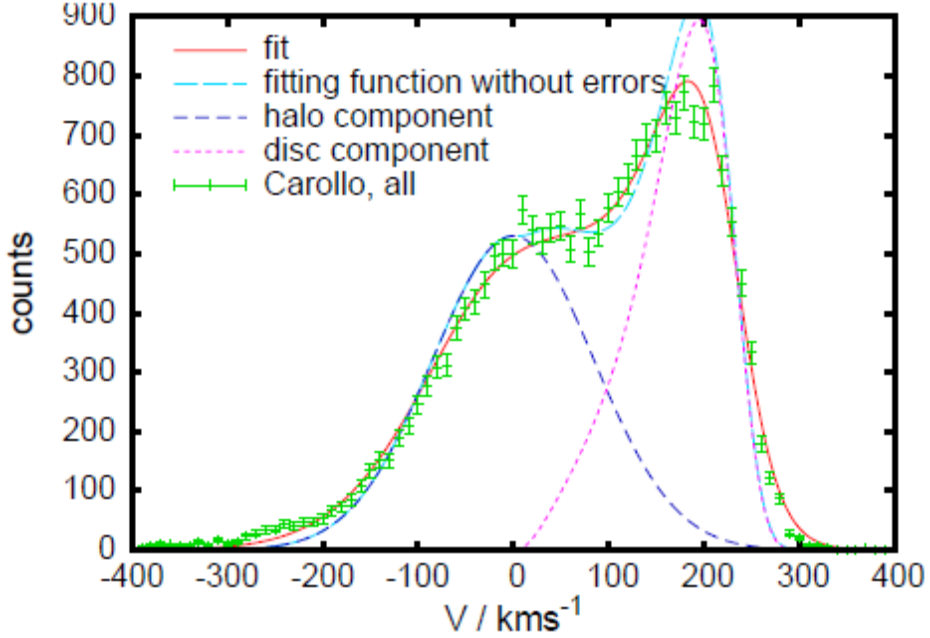
Vertical dispersion vs metallicity

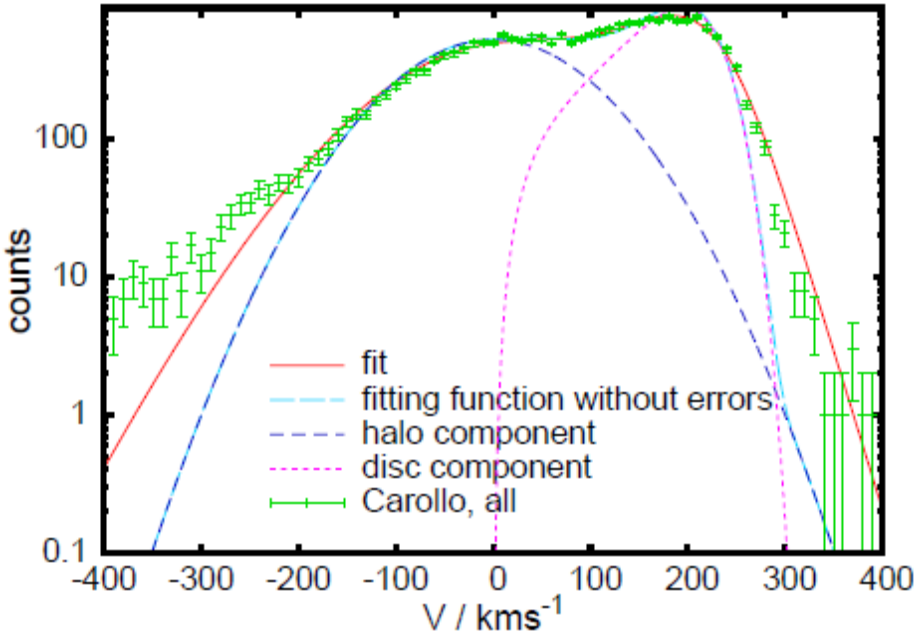


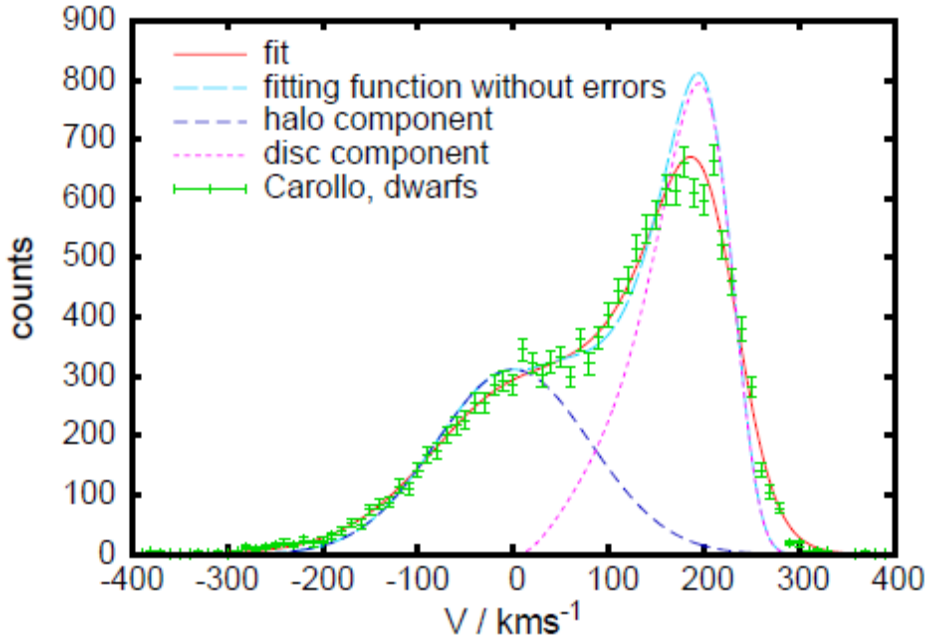
Velocity distributions

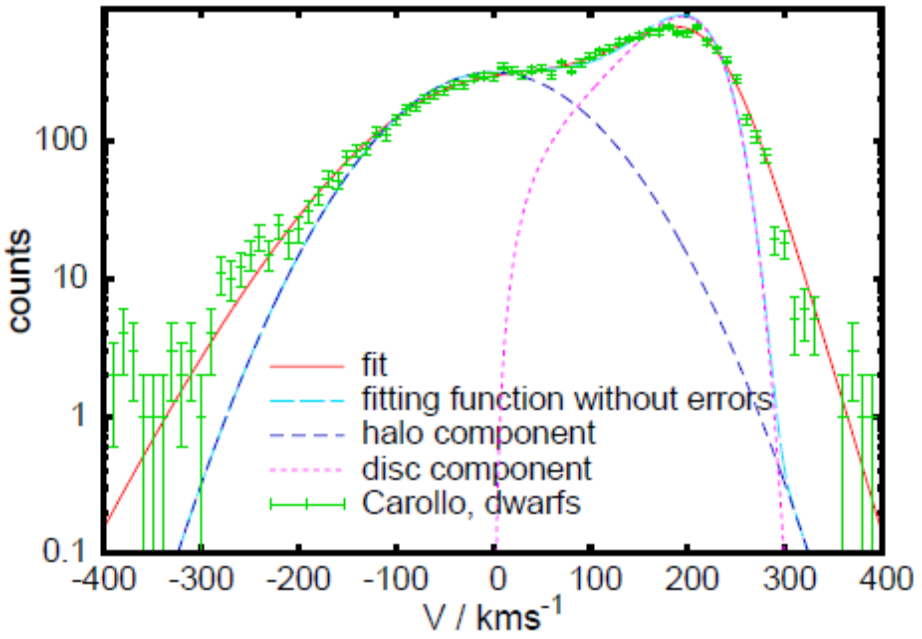


Fitting azimuthal velocities

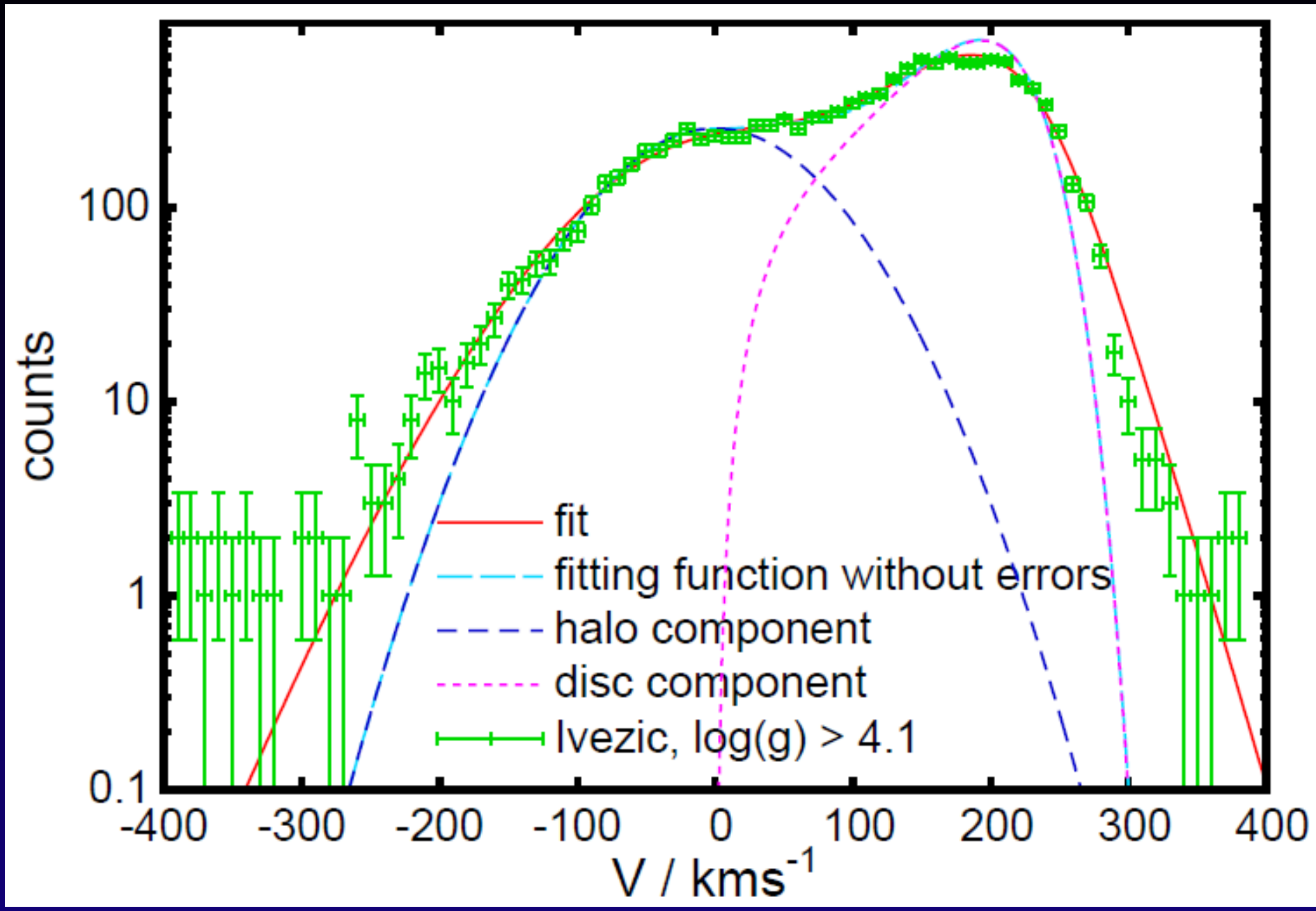








Fitting azimuthal velocities



Summary

The Carollo et al. outer halo is a consequence of distance errors (up to 50% in the tail) and use of Gaussian analysis (cf. Strömberg 1927)

- sorting stars into unphysical positions in CMD
- magnitude uncertainties in the turn-off region
- problems with gravities at lowest metallicities

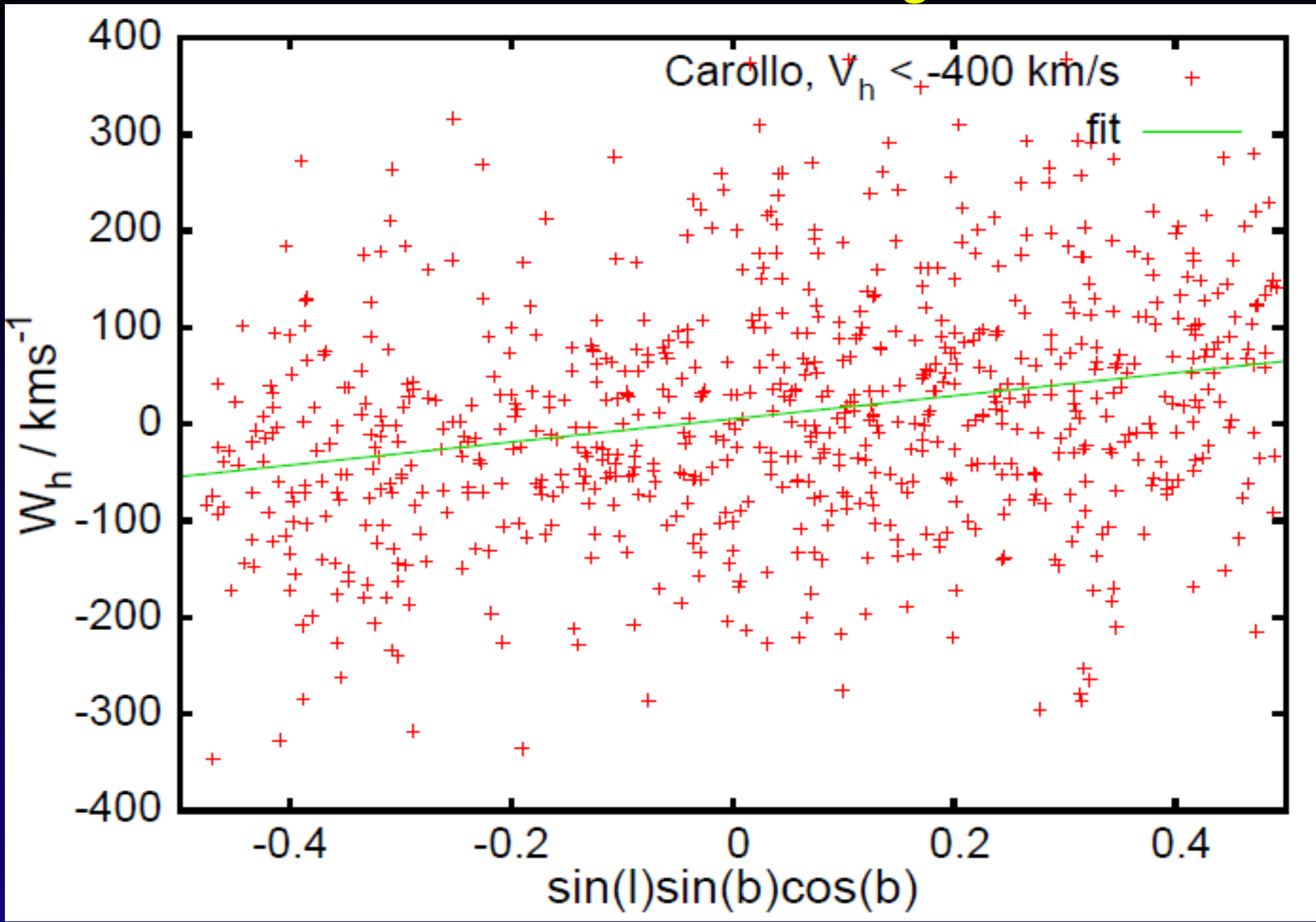
We cannot find any reliable distinct outer halo component

The azimuthal V distribution can be fit by single disc + halo

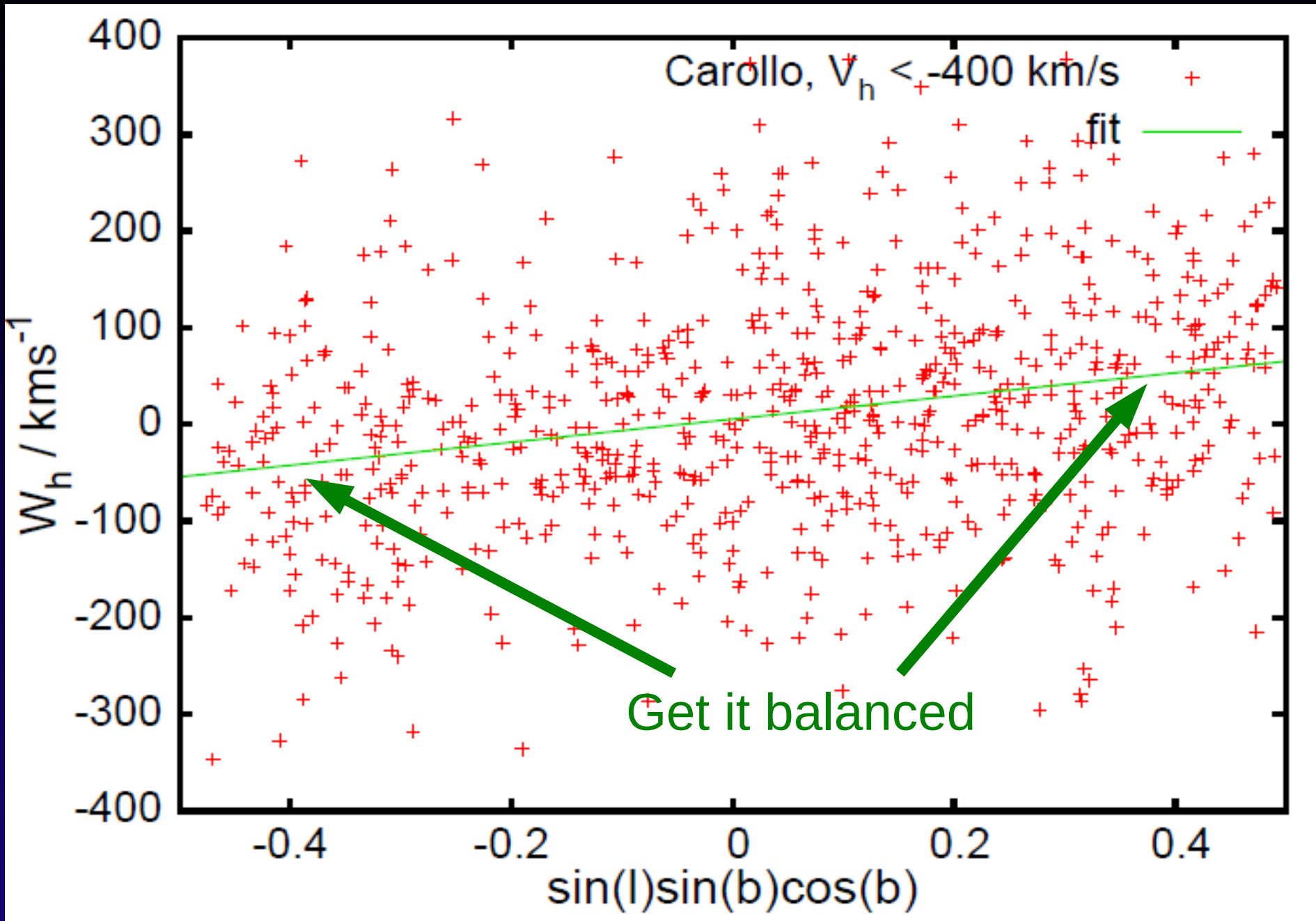
A slight excess of high vertical motion stars coincides with a stream found by Helmi et al. (1999)

Analysis provides an improved distance estimator

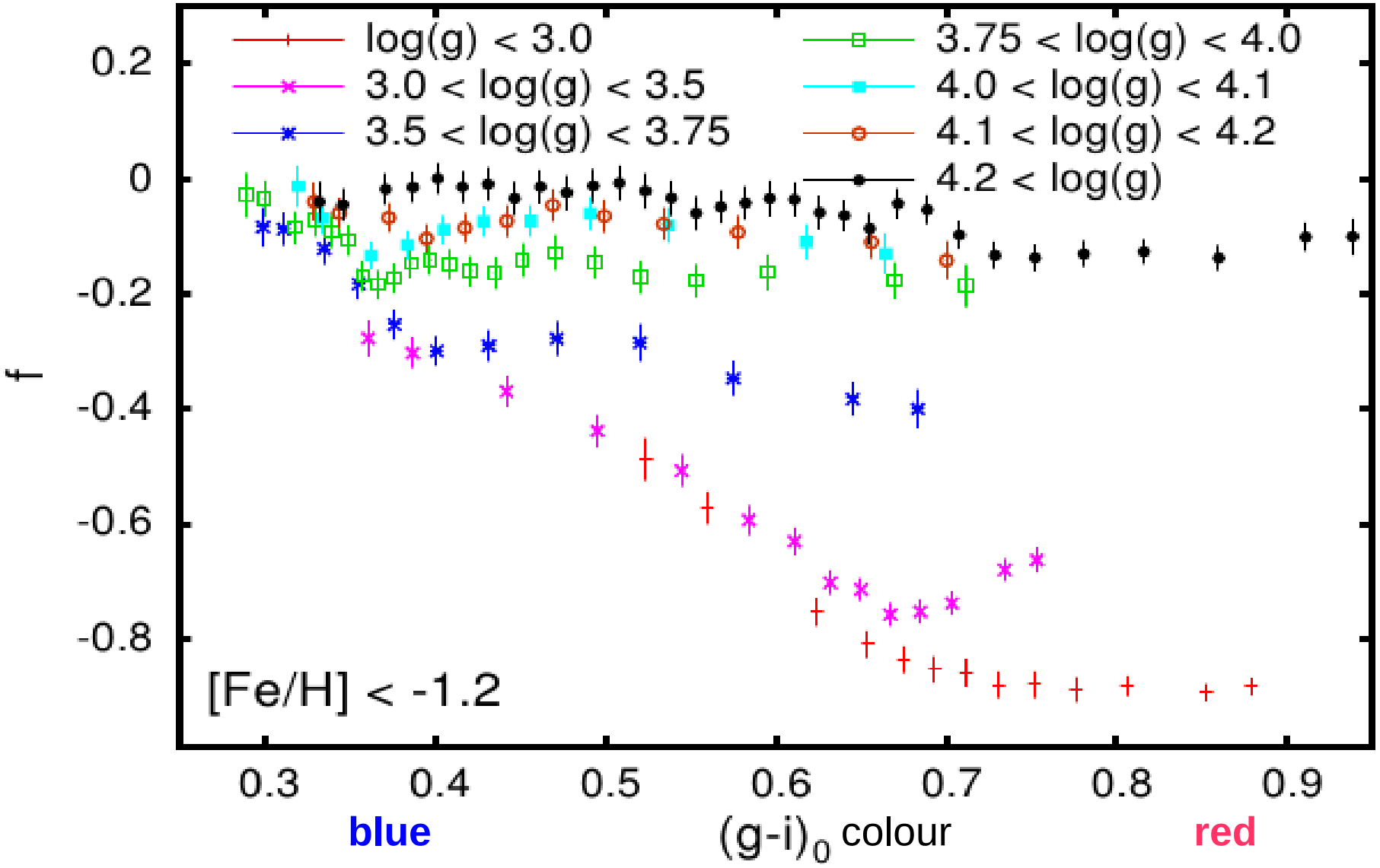
The skies are falling!



But that's not all .....



Gravity selection on samples



Can detect a distance spread