太阳附近年龄-速度弥散关系

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Background

- Velocity dispersion increases with age (Dehnen & Binney 1998; Nordström et al 2004)
  - Evolution history of Milky Way
- Velocity ellipsoid
  - Structure of Milky Way: non-axisymmetric
    - Covariance
    - Tilt
    - Ratio

Age-velocity dispersion relation (AVR)

- Increasing velocity dispersion
  - Internal heating
    - Spiral arms (in-plane)
    - Giant Molecular Clouds (scattering)
    - Bar (inner disk)
    - Radial migration(*)
  - External heating: merger events
  - Old stars born with higher velocity dispersion
    - Turbulent gas disc (e.g. Förster Schreiber et al 2009)

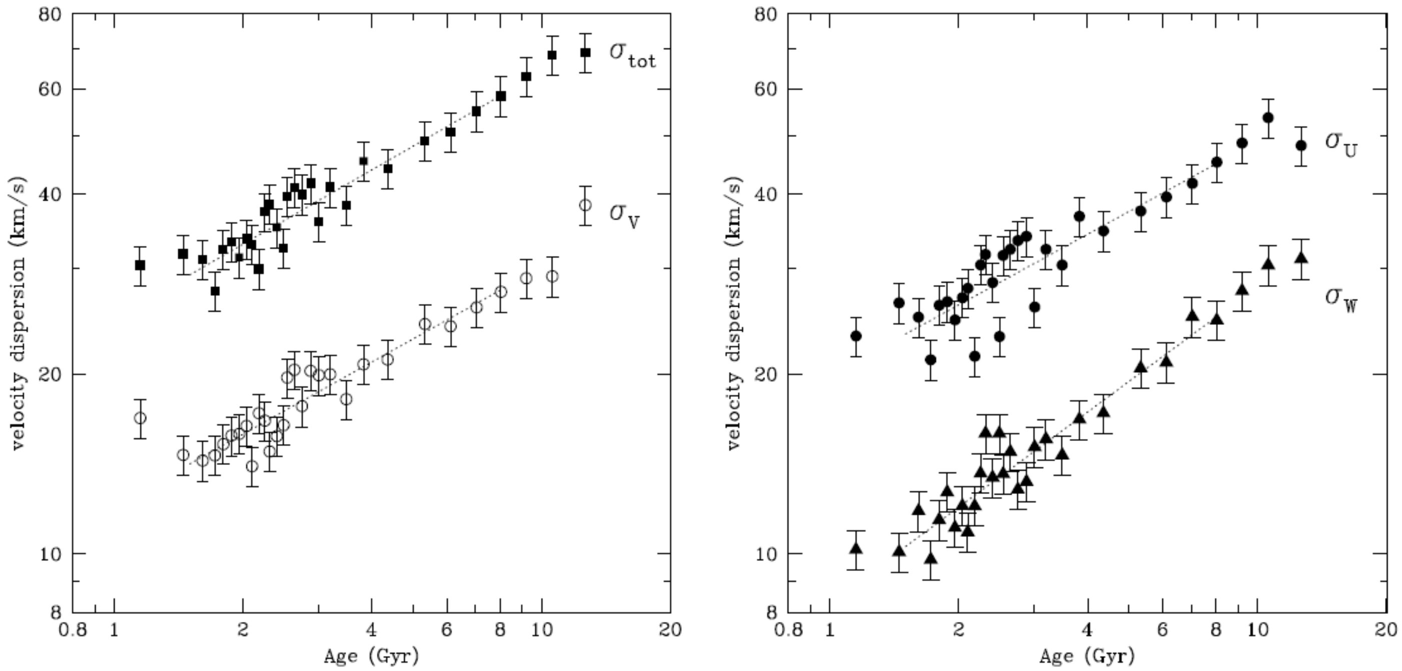
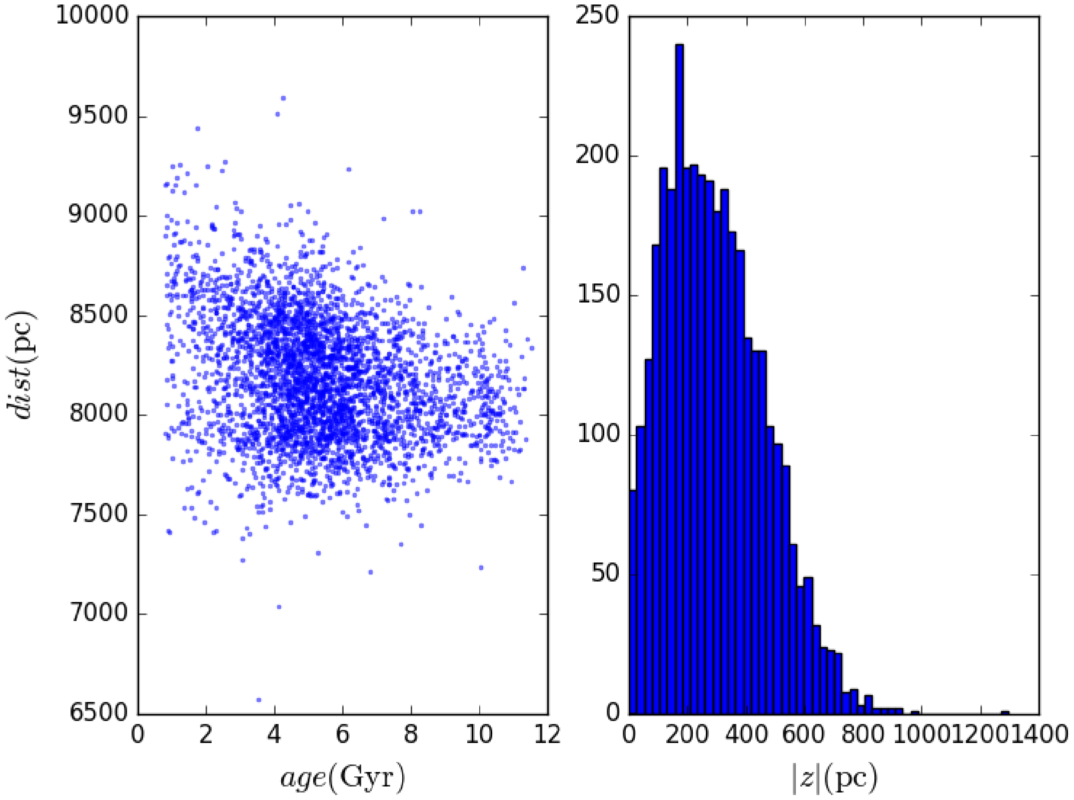


Fig. 7. Velocity dispersions vs. age for the subsample with $\sigma_{Age} < 25\%$. The 30 bins have equal numbers of stars (88 in each); the lines show fitted power laws. The 3 youngest and oldest bins were excluded from the fit.

Holmberg, Nordström & Andersen 2009

Our Sample

- 3564 sub-giant stars with LAMOST DR3 radial velocity and TGAS proper motion and parallax
  - 30% age uncertainties



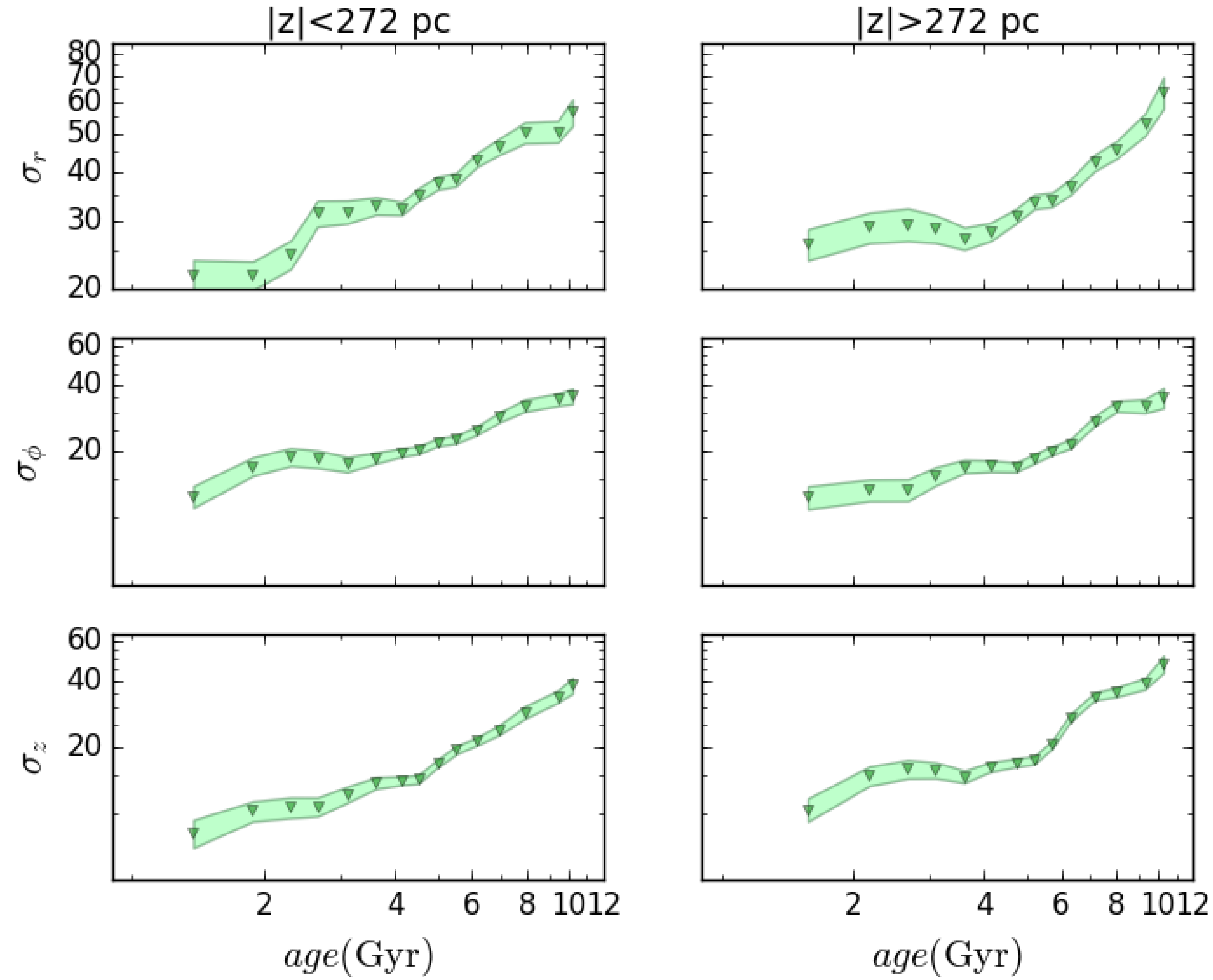
Our method

- Likelihood
  - $L = \prod_i \frac{1}{(2\pi)^{n/2}|\Sigma|} \exp\left[-\frac{1}{2}(\mathbf{v_i} - \boldsymbol{\mu})^T \Sigma^{-1} (\mathbf{v_i} - \boldsymbol{\mu})\right]$
  - Σ is the convolution of intrinsic variance and the observed uncertainties

- Dynamical running-median technique so that stars in each bin have similar age
- Use MCMC method to obtain the velocity and velocity dispersion tensor

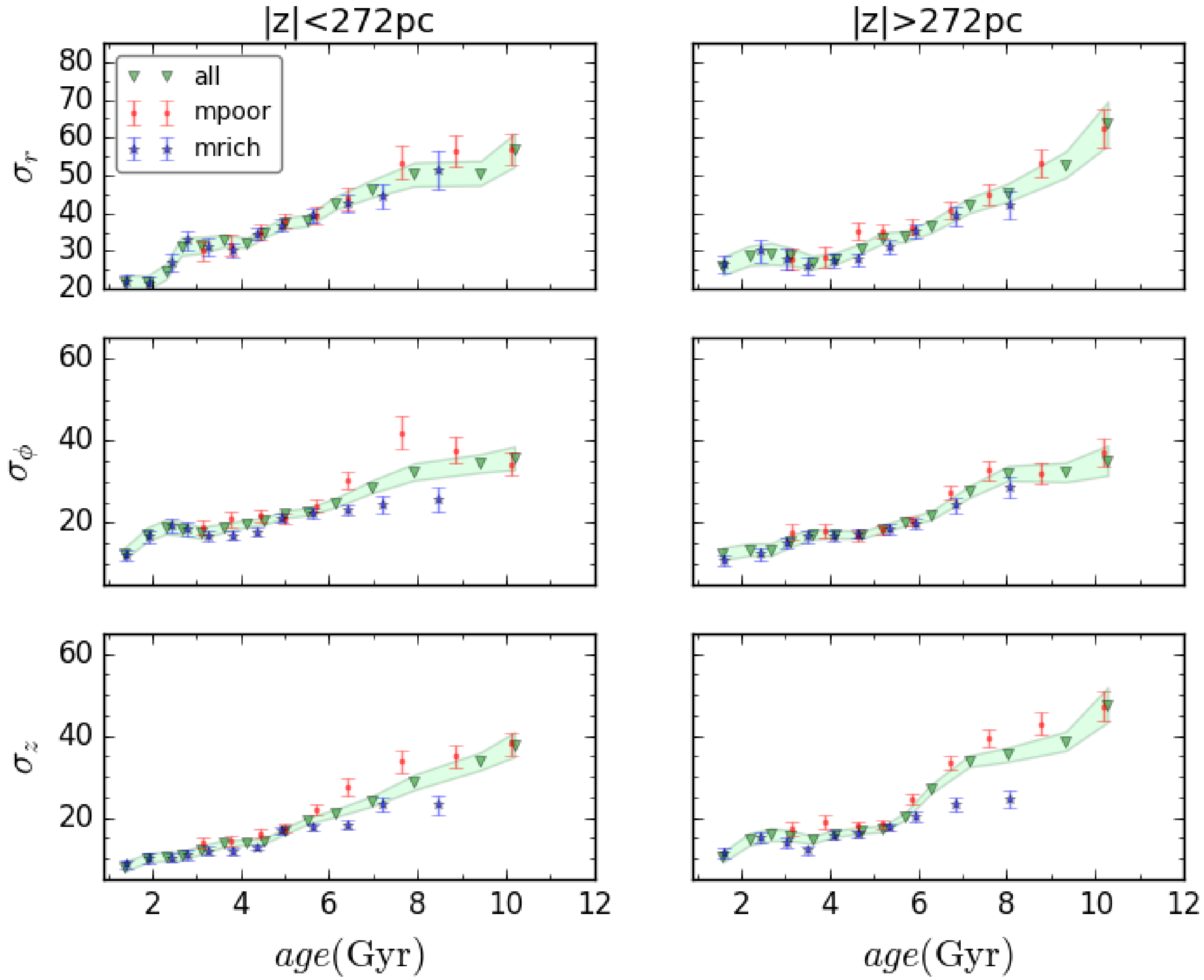
Age-velocity dispersion relation (I)

- Old stars have larger velocity dispersion
- Deviate power law relation
- Jump at ~6 Gyr



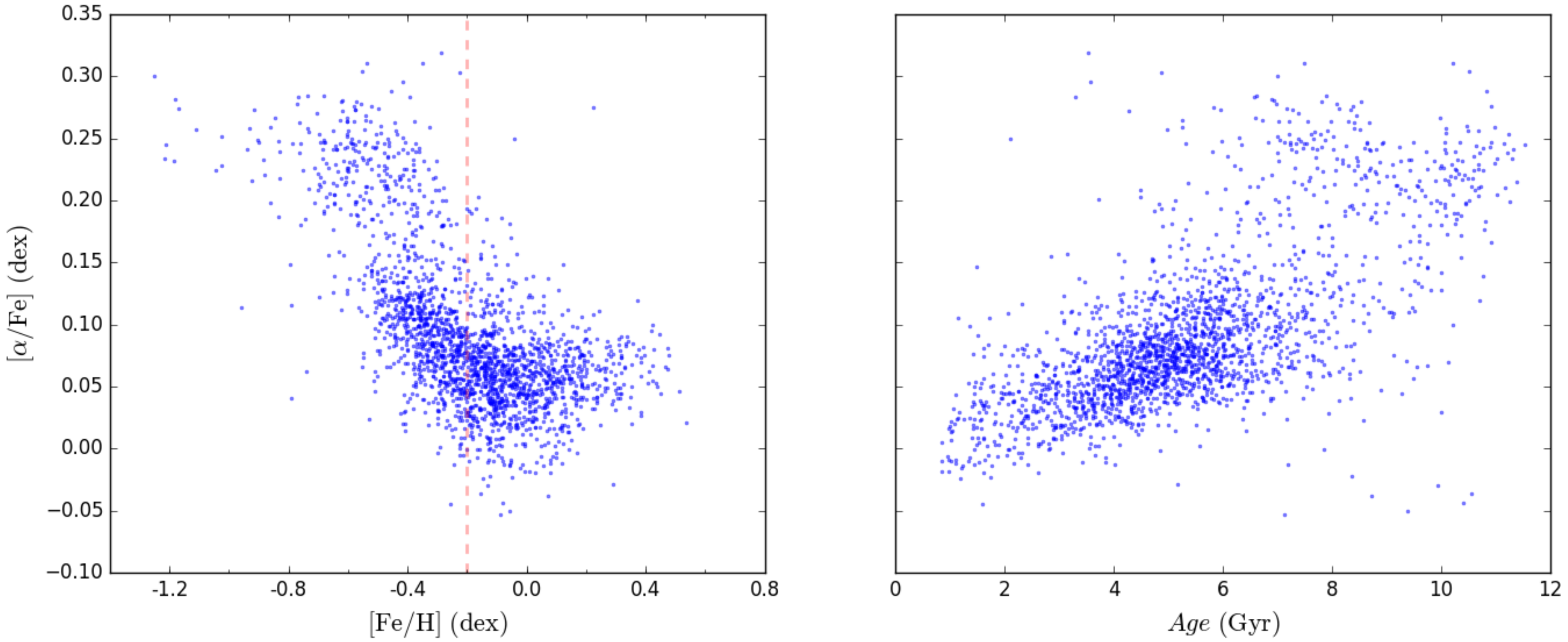
Age-velocity dispersion relation (II)

- Discrepancy for different metallicity populations
  - Metal rich ([Fe/H] > -0.2)
  - Metal poor ([Fe/H] < -0.2)



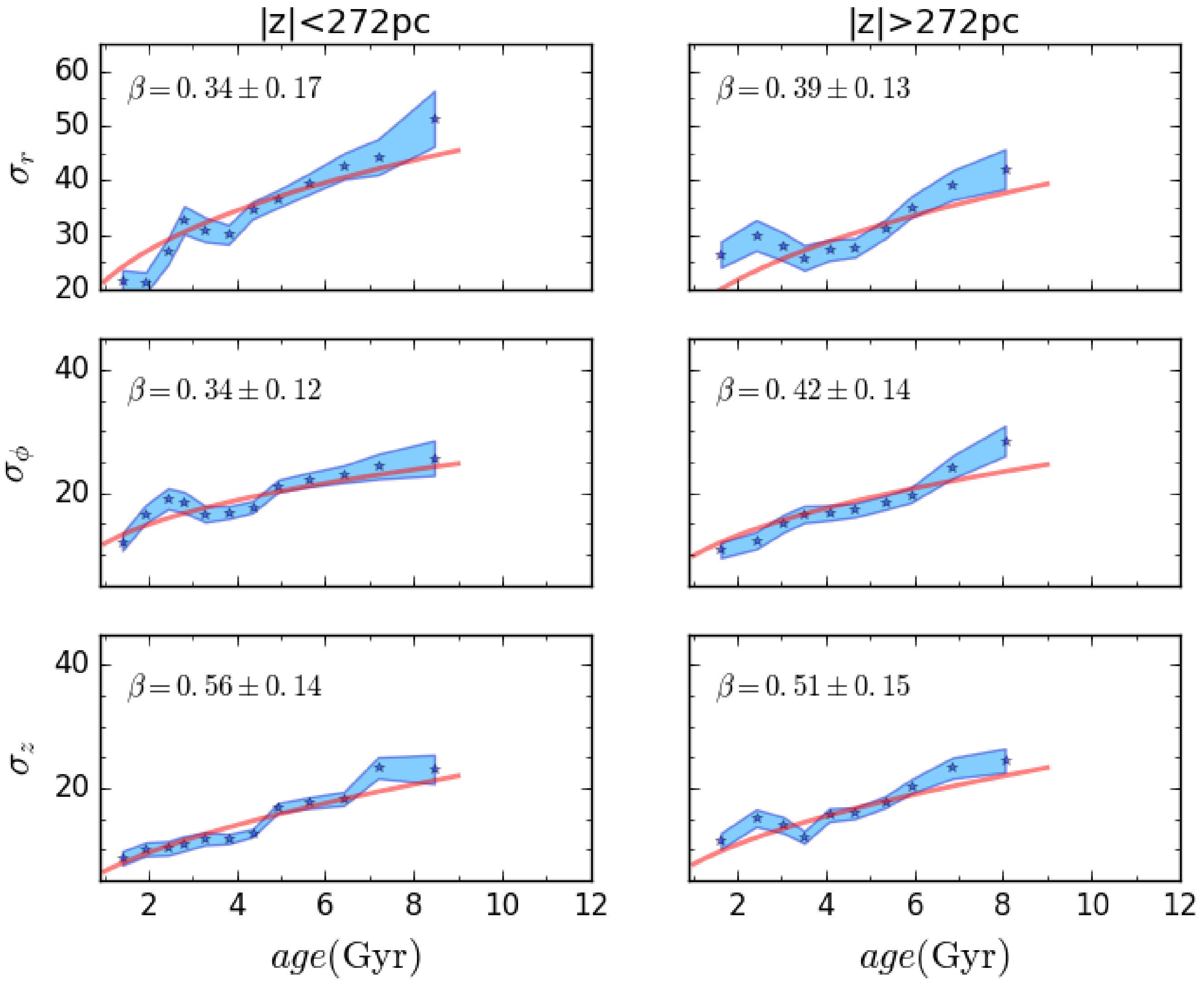
- Disk heating:
  - Spiral arms (in-plane heating) (e.g. Carlberg 1987, Sellwood 2013)
  - Giant Molecular Clouds (both in-plane and vertical) (e.g. Sptizer & Schwarzschile 1953, Lacey 1984)

- A certain fraction of metal poor stars is α-enhanced, while most metal rich stars have lower α abundance
- The α abundance is correlated with age – The σ of old, metal poor stars is dominated by thick disc component



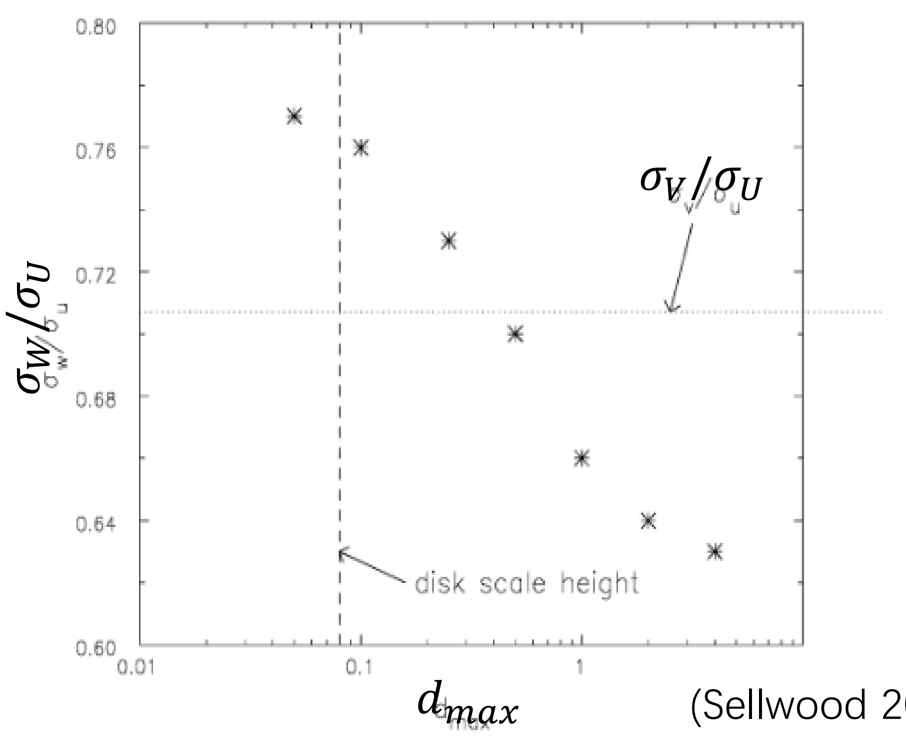
Metal rich population

- Power law fitting
  - $\sigma \propto t^{\beta}$
  - In-plane exponents ~ 0.3
  - Vertical exponents ~ 0.5
- Impact of age uncertainties
  - Flatten the age-velocity dispersion relation (Aumer, Binney & Schönrich 2016)



Ratio of Velocity ellipsoid

- $\sigma_r > \sigma_\phi > \sigma_z$ ($\sigma_U > \sigma_V > \sigma_W$)
  - Efficient redirecting of GMCs (Lacey 1984)
  - Distant clouds preferentially redirect the in-plane velocity components

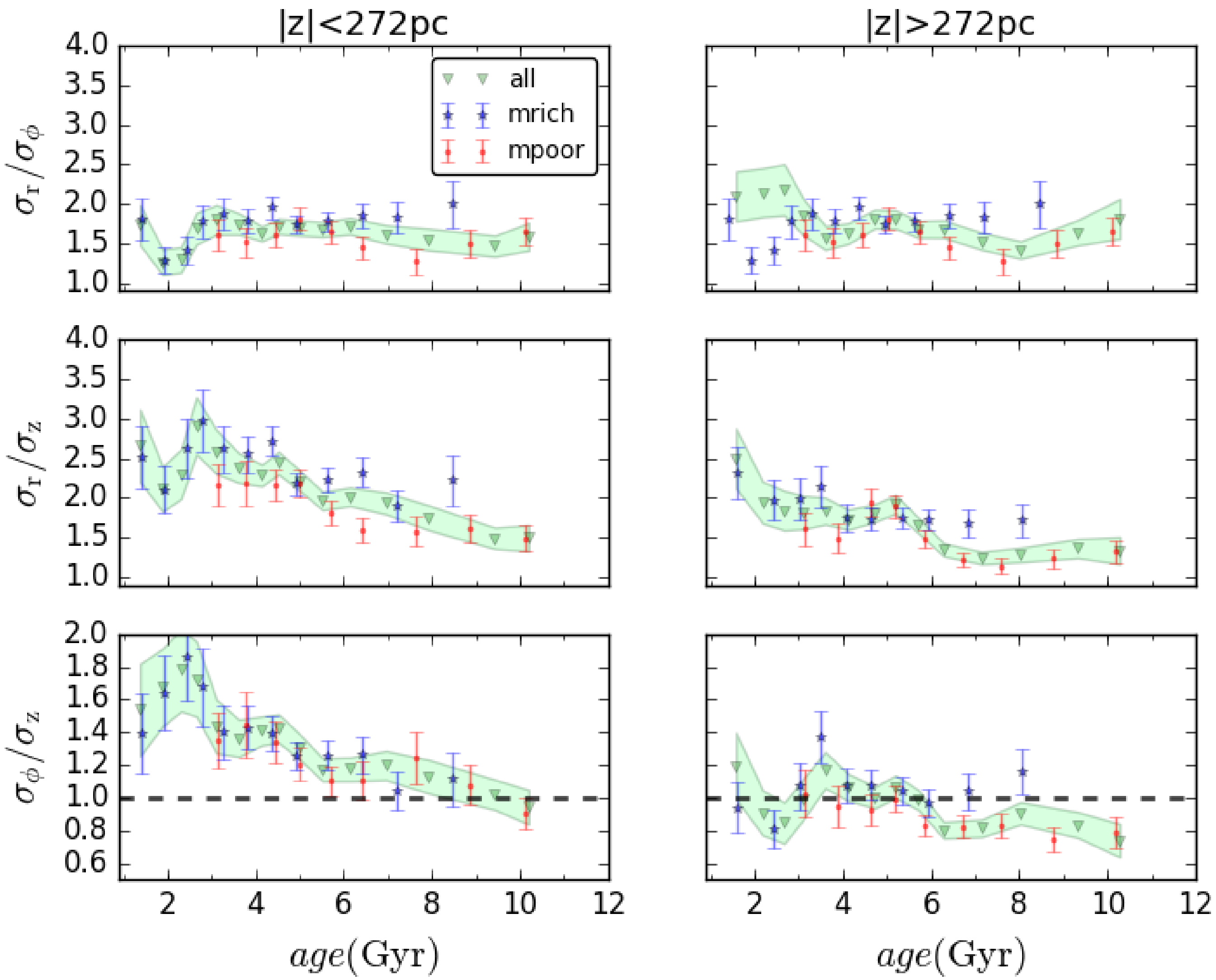


(Sellwood 2008)

Figure 1. The effect on the equilibrium axis ratio of the velocity ellipsoid of limiting the range of the perturbation forces from the heavy particles.

Ratio of velocity ellipsoid

- $\sigma_\phi < \sigma_z$ for metal poor stars at $|z| >$ 272 pc



Summary

- Increasing trend of age-velocity dispersion relation
- Discrepancy of age-velocity dispersion relation for different population
- Velocity dispersion of metal rich population increases mainly by disk heating, while metal poor population may be born with higher velocity dispersion
- The velocity ellipsoid is rounder for old stars, σ_{ϕ} to be smallest for metal poor stars at $|z| > 272$ pc