



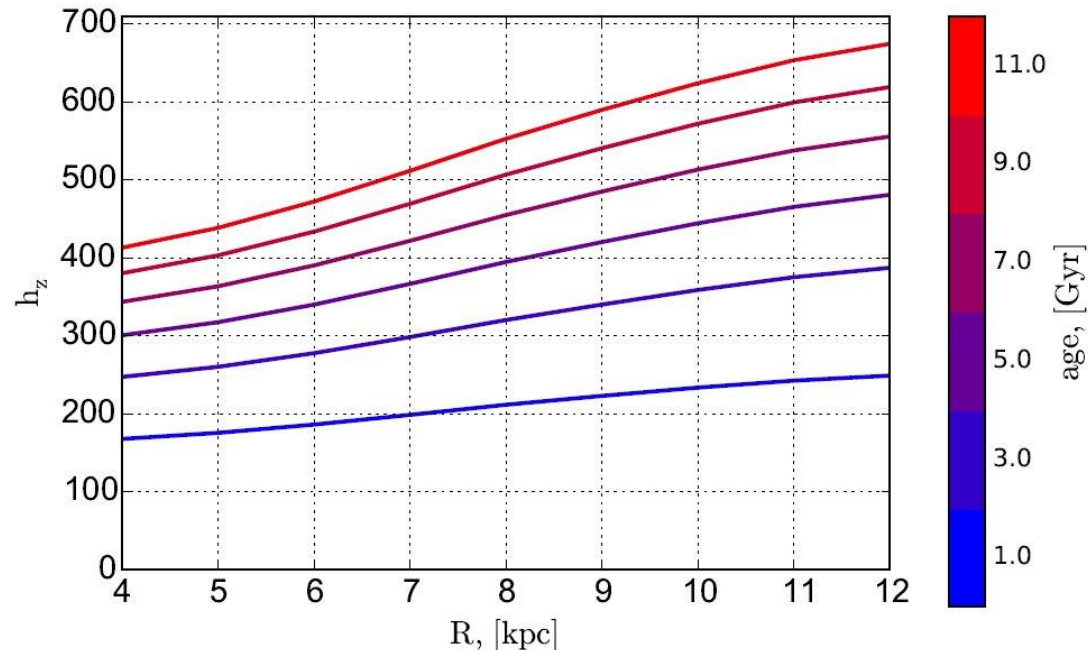
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The evolution history of the extended solar neighbourhood

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Content

- ❖ Dynamical disc model
 - Local model
 - Radial extension $SFR(R)$, $AVR(R)$, $AMR(R)$
- ❖ Inner structure of simple discs
 - Properties of mono-age and mono-abundance populations
- ❖ TGAS-RAVE data
 - Star counts and dynamics

JJ-model: local disc model

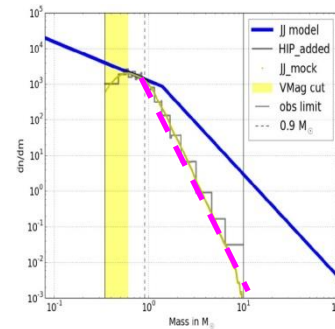
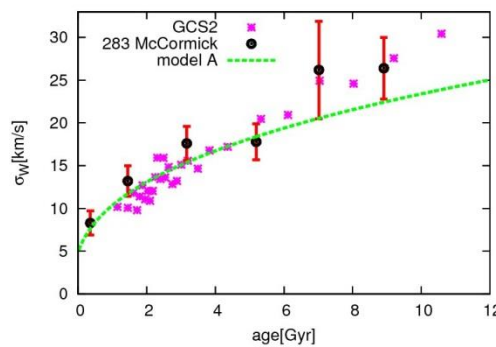
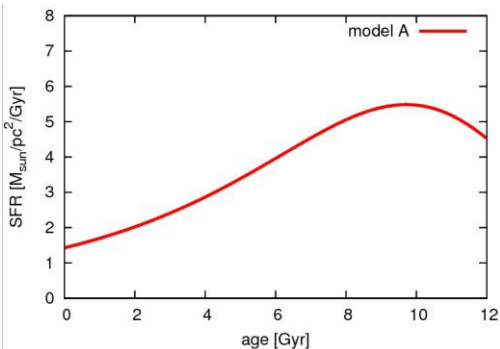
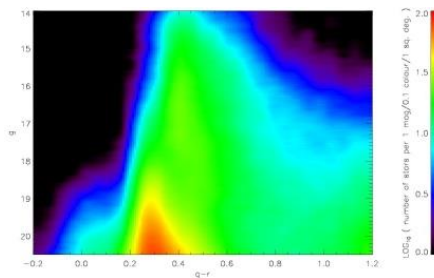
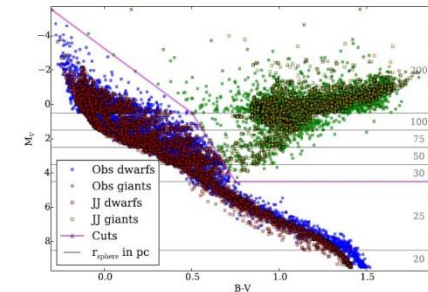
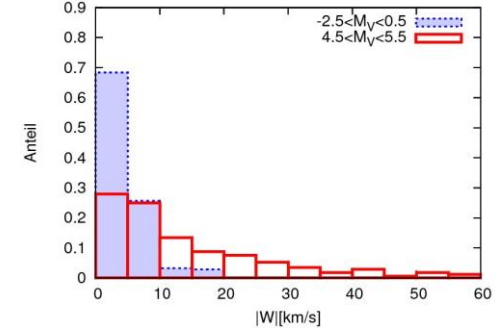
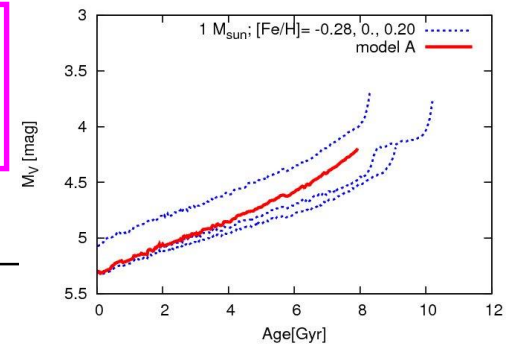
- Dynamical (evolutionary) model
 - Modelling the solar cylinder of Galactic disc
 - Dynamical equilibrium
 - Self-consistent vertical density profiles
- Input
 - **SFR(t)** + **$\sigma_w(\text{age})$** + **IMF** + **AMR**
 - Main sequence lifetimes for timeline
- Output
 - **vertical density profiles: $\rho_i(z|\text{age})$**
 - **Age distributions, CMDs** of all stellar types as function of height z above the plane

JJ-model

Just & Jahreiß, MNRAS 402, 461 (2010)
 Just et al, MNRAS 411, 2586 (2012)
 Rybizki & Just, MNRAS 447, 3880 (2015)

❖ Input functions / data / output

- Stellar evolution
- Local vertical kinematics $f(W)$
- Star counts: local & NGP(SDSS) CMDs
- Result
 - **Star formation history SFR(t)**
 - **Dynamical heating AVR= $\sigma(\text{age})$**
 - **Initial mass function IMF**
- Output
 - **Density and age distributions of all stellar types**

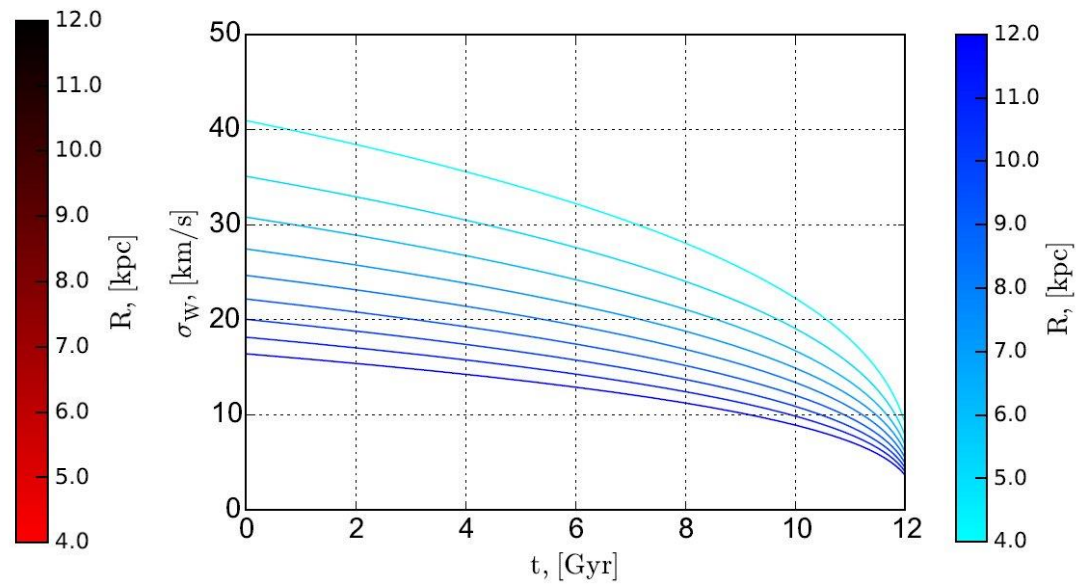
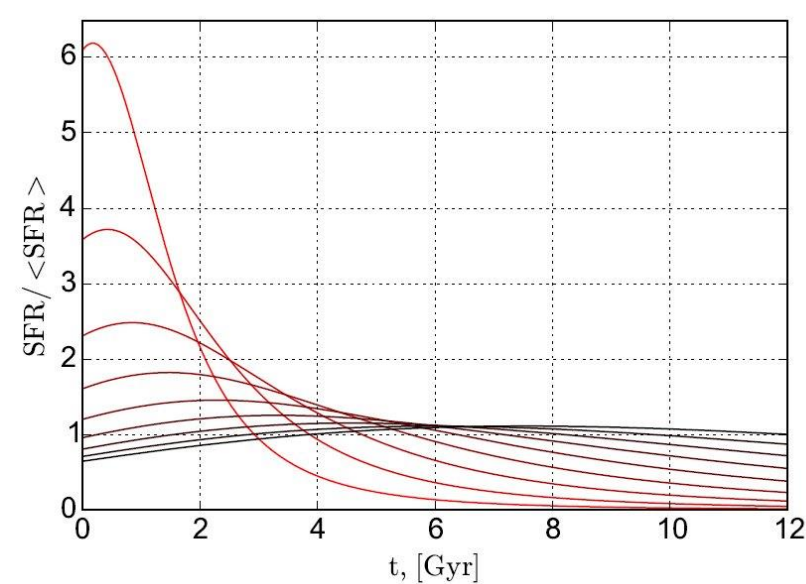


Radial extension

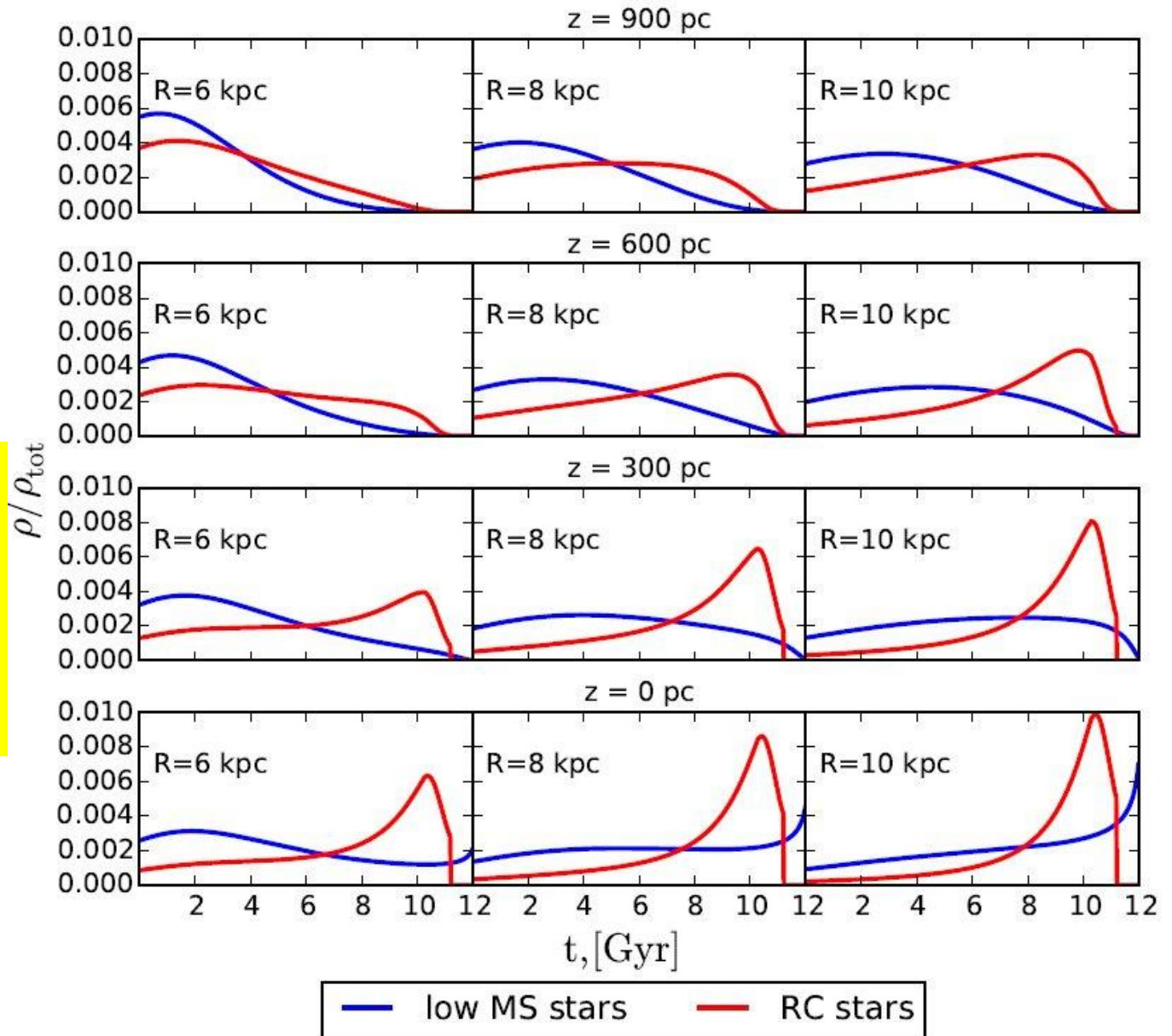
- ❖ Exponential disc with constant thickness
 - $R_d=2.5\text{kpc}$, $h_z=400\text{pc}$
- ❖ SFR, AVR as function of $R=4\text{-}12\text{kpc}$
 - SFR: strong peak in inner disc, $\sim\text{const.}$ in outer disc
 - AVR: scaled to give constant total thickness $h_z=400\text{pc}$

SFR(norm)

AVR(km/s)



Age distributions of MS & RC stars



RC stars:

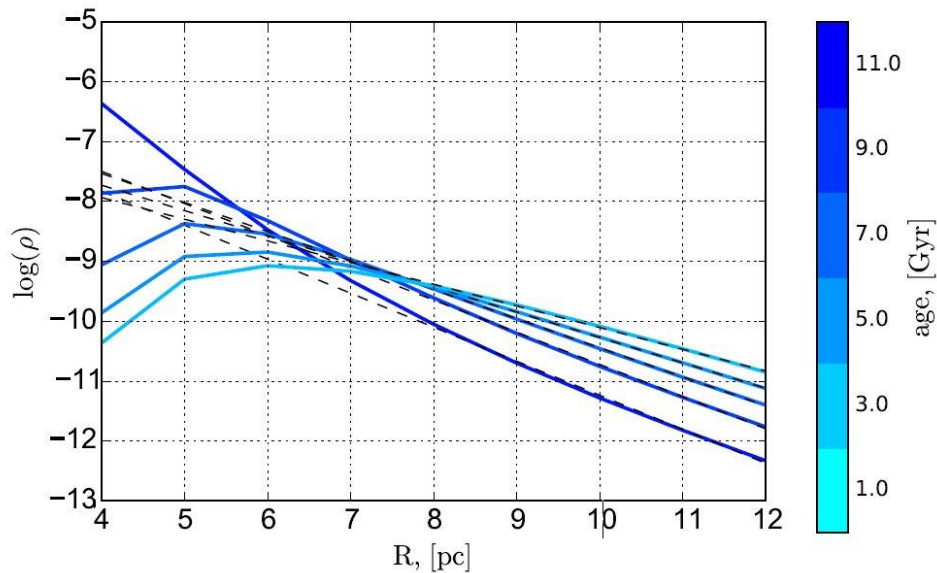
Strong peak at age = 2 Gyr; vanishes in the inner disc above the plane

Radial profiles and thickness

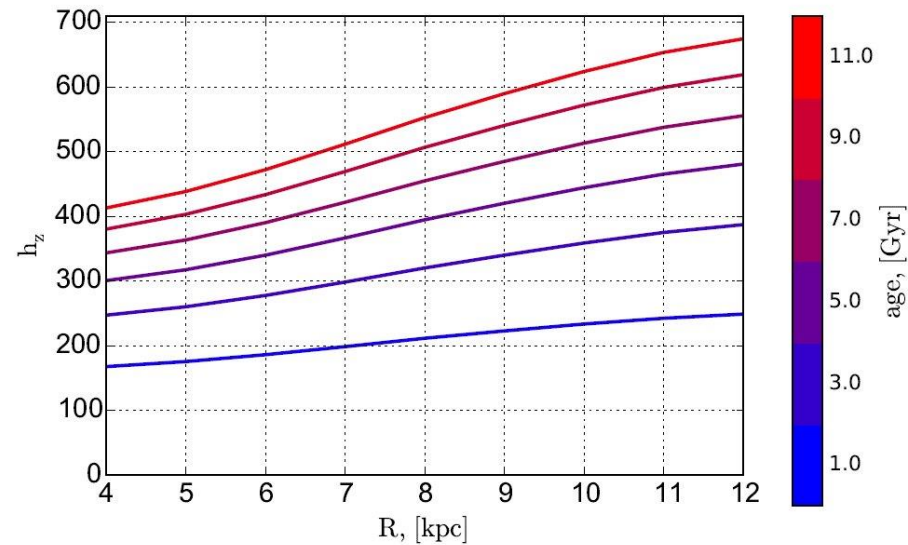
❖ Mono-age populations

- Density profile exponential in outer disc
 - Scalelength decreasing with age
- All populations are flaring

Radial $z=0$ density profiles $\rho(R)$

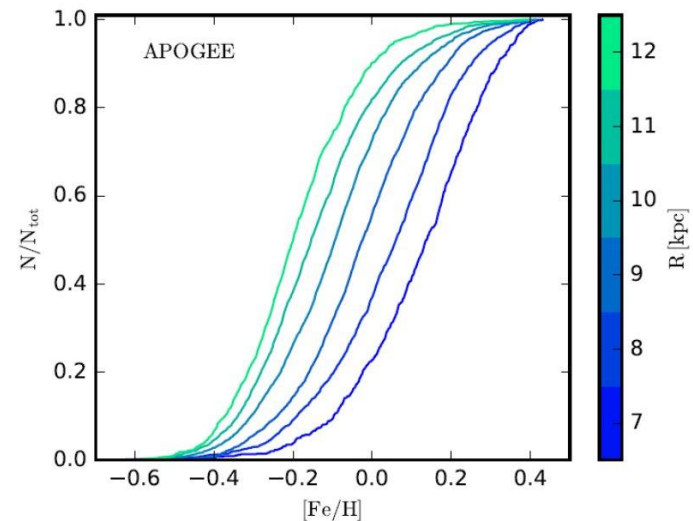
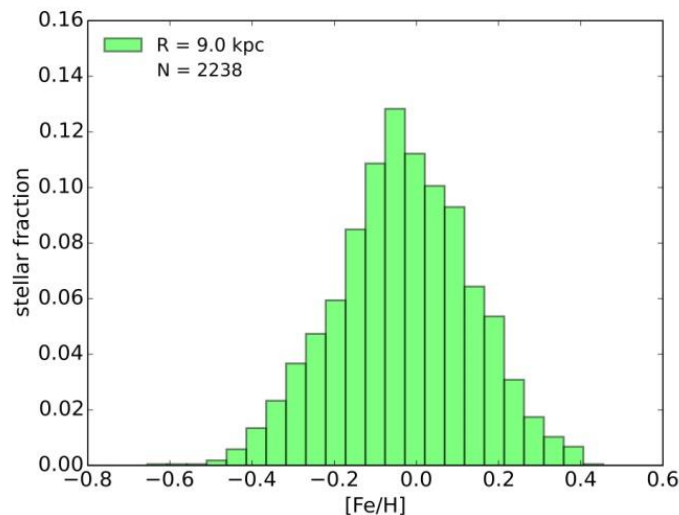


thickness profiles $h_z(R)$



Empiric chemical evolution

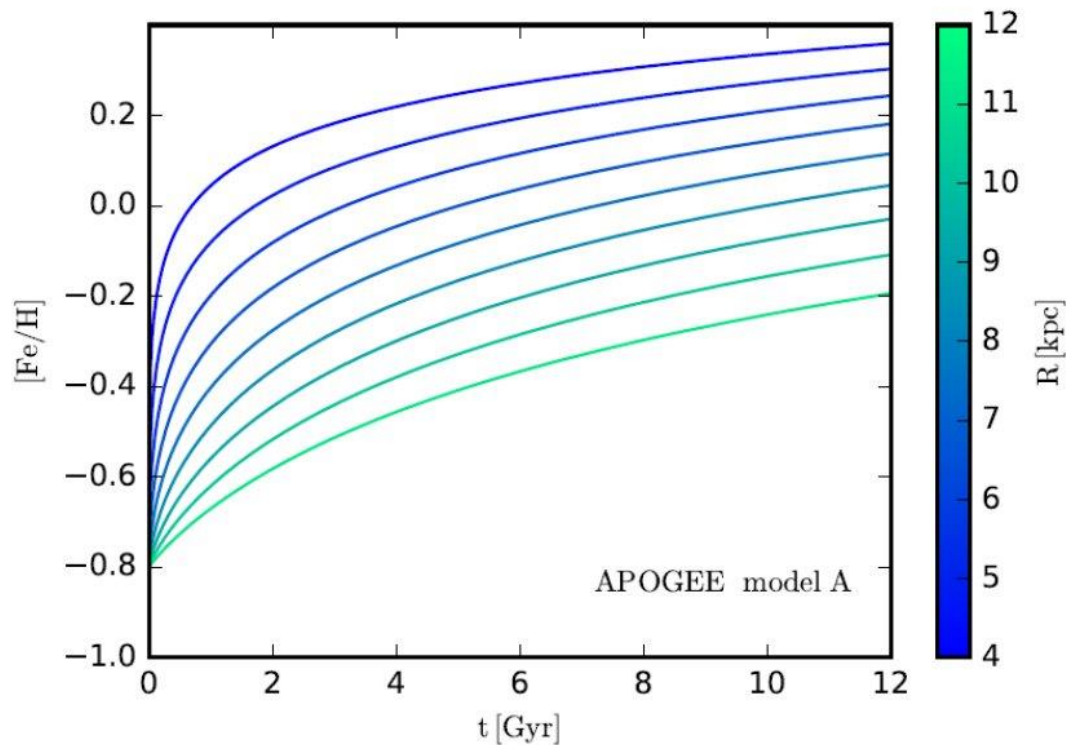
- ❖ Convert abundance distribution to cumulative $N_{\text{Fe}}(<[\text{Fe}/\text{H}])$
- ❖ Calculate the cumulative age distribution $N_t(<t)$ for the same population
- ❖ Identify both N_{Fe} and N_t to get AMR



APOGEE DR12 RC data ($|z| < 400$ pc)

Chemical enrichment AMR

- ❖ Fitting at each R an analytic N_t to N_{Fe}
 - Fast enrichment and higher present day metallicity in the inner disc
 - Present day abundance gradient -0.075dex/kpc



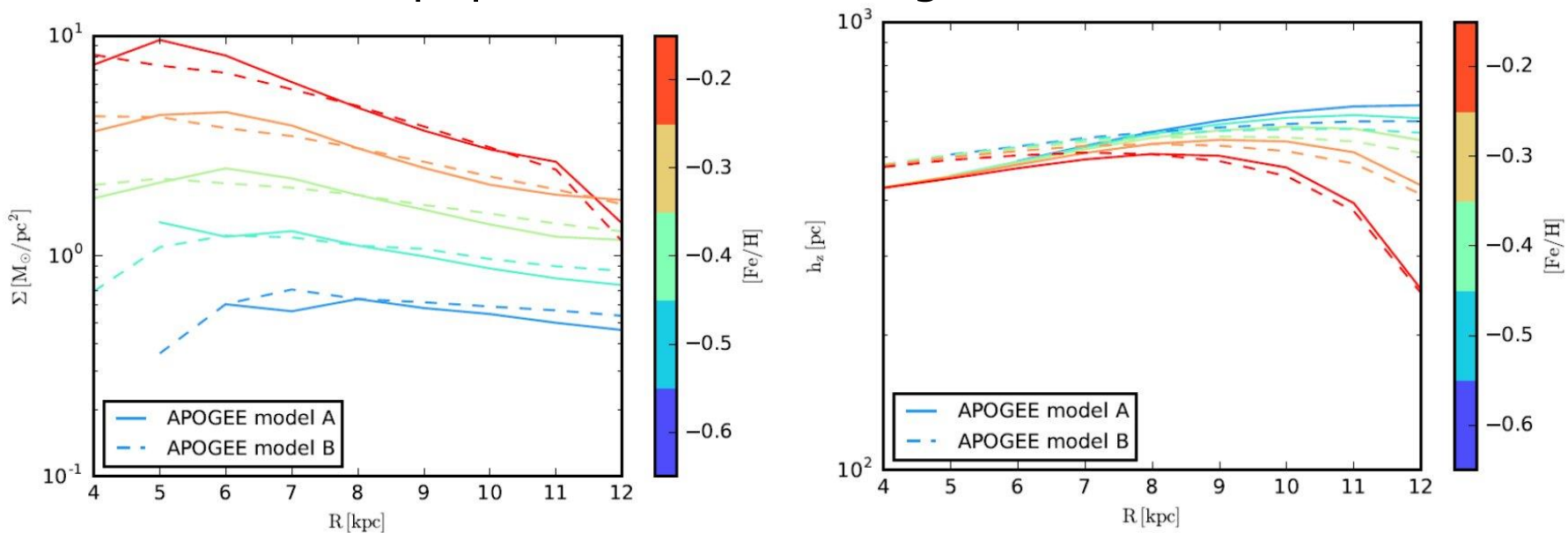
Mono-abundance populations

❖ Surface density

- Radial profiles \sim exponential
- Large scalelengths: 15 ... 4.5 kpc due to the different SFR weights

❖ Thickness

- All populations are flaring with outer turndown



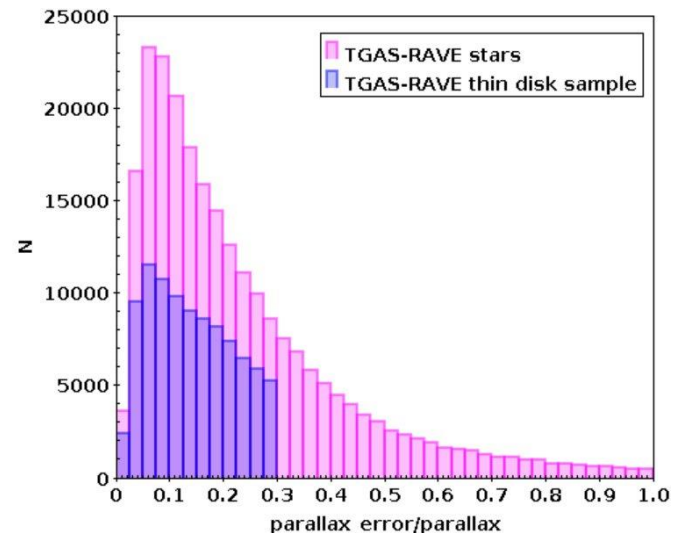
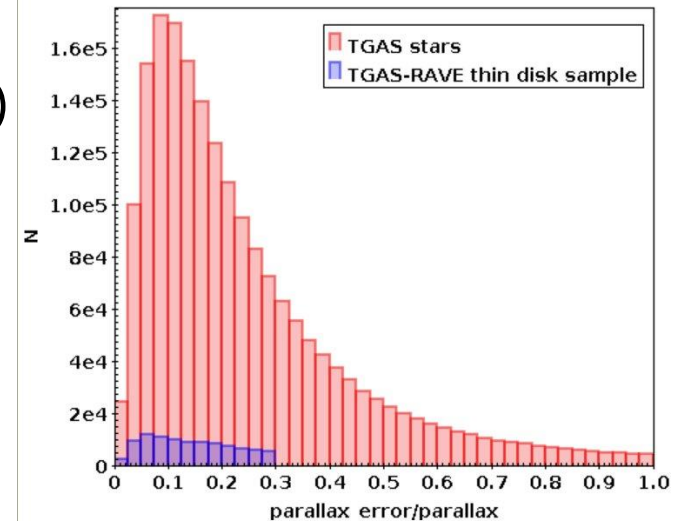
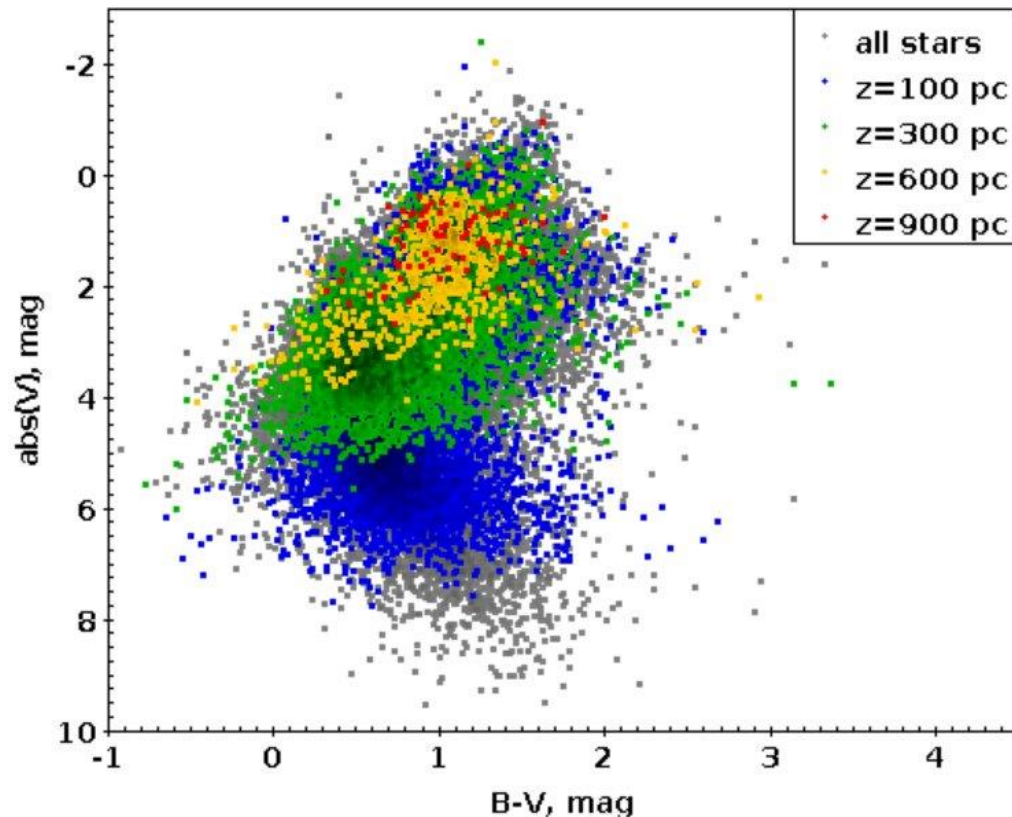
Gaia: TGAS data

- ❖ Unbiased parallaxes for ~ 1 Mio stars
 - Slice the model in Δz -sheets
- ❖ Improved proper motions
- ❖ Add RAVE data ~ 250000 stars
 - 3-D velocities
 - $f(W)$ for subsamples / z-slices
- ❖ TGAS-RAVE thin disc sample
 - $[Fe/H] > -0.6$, $[Mg/Fe] < 0.2$ ($N=92000$)
 - $D_{xy} < 300$ pc (solar cylinder)
 - Quality cuts ($n_{err}/n < 0.3$)
 - $N=48000$

TGAS-RAVE: Selection

❖ Selection functions

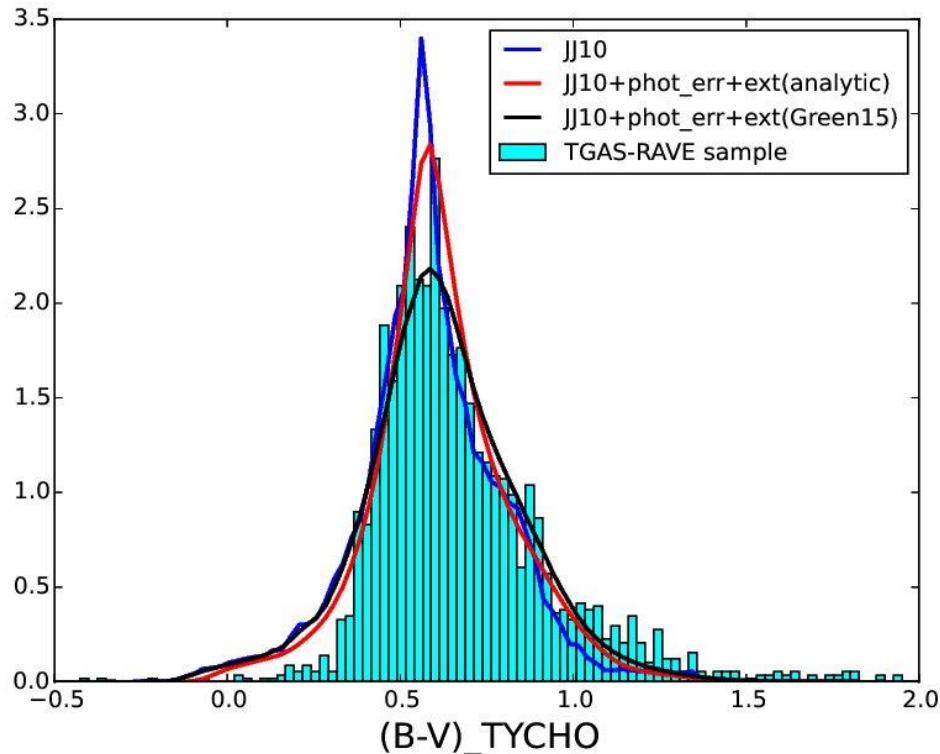
- Relative parallax error (right)
- CMD (bottom)



Model test with TGAS-RAVE data

❖ Local model (no free parameter)

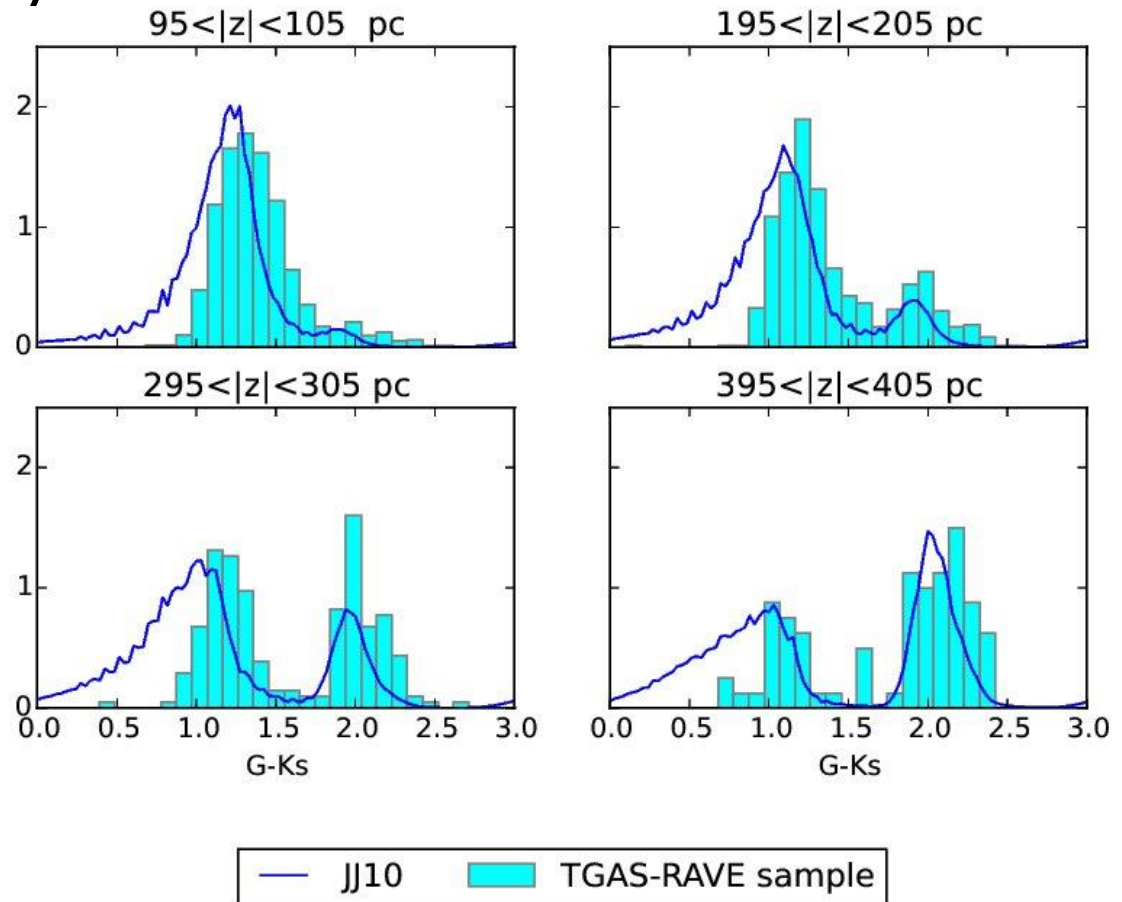
- SFR, AMR, AVR, IMF given
- Stellar evolution, extinction included
- RAVE + Tycho selection functions applied
- TGAS cuts of very blue stars not applied



3-D Extinction model:
PanSTARRS+2MASS,
Green et al 2015
Big improvement

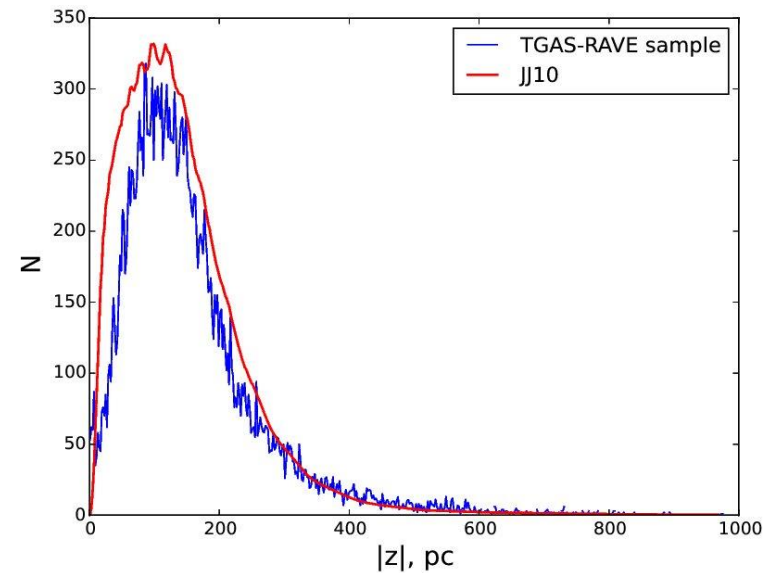
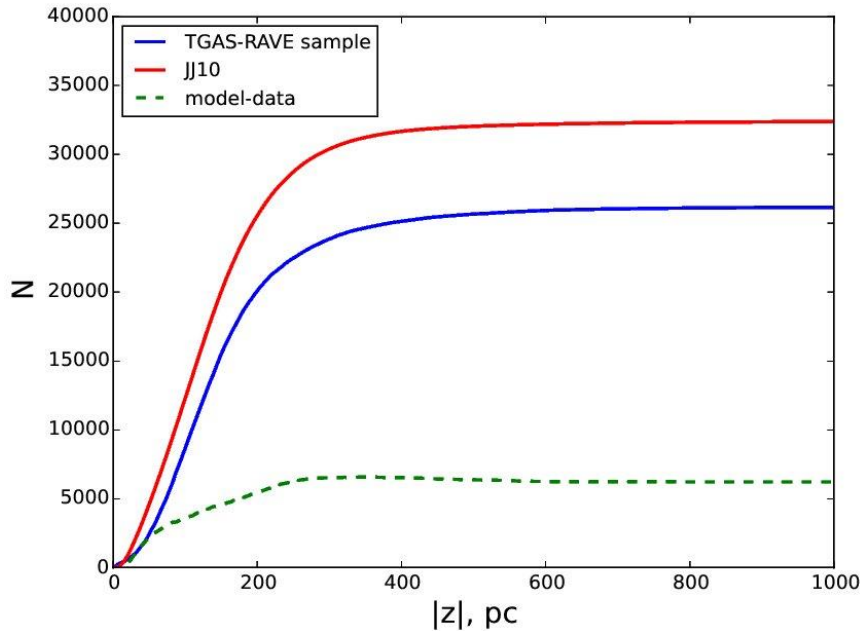
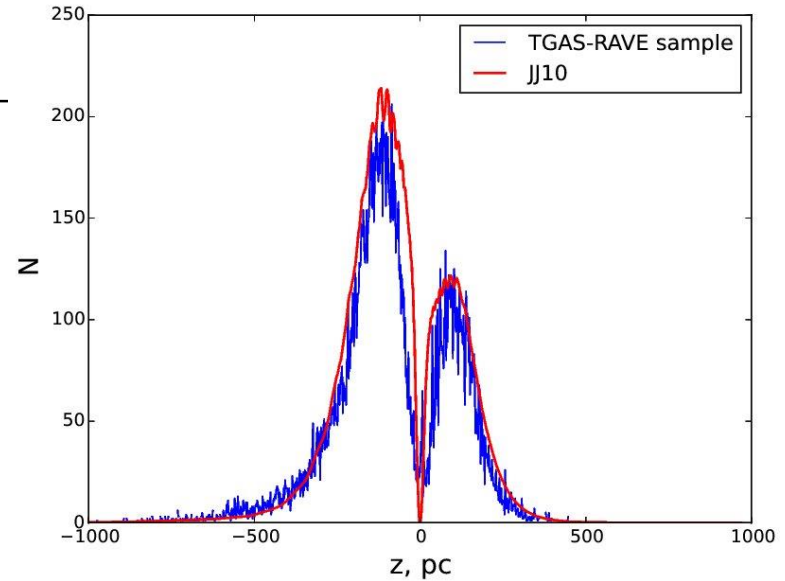
TGAS-RAVE: Colour distribution

- ❖ Very blue stars are missing in the data
- ❖ Model slightly bluer



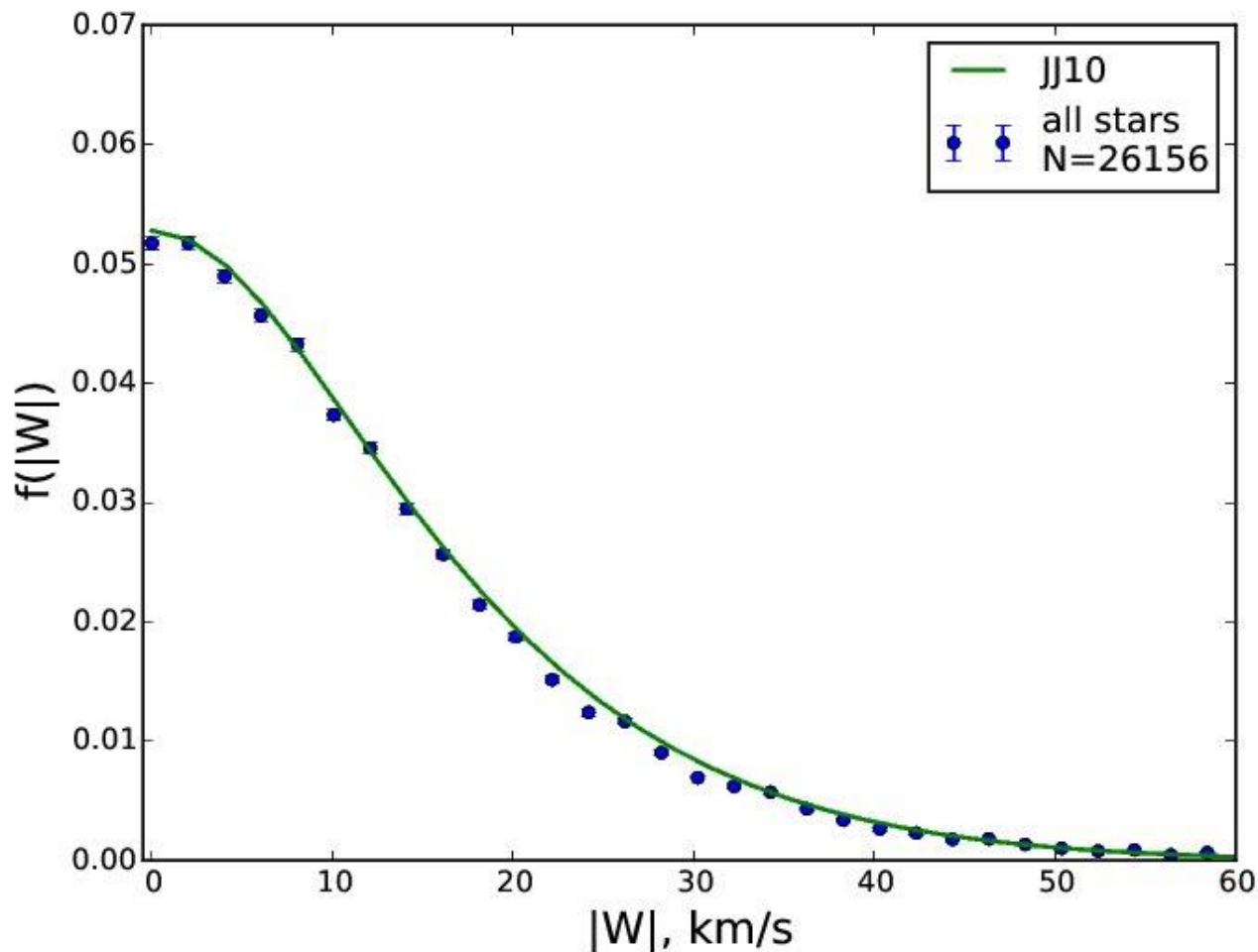
TGAS-RAVE: density profile

- ❖ Density profile in general reproduced
- ❖ Too many stars at $|z| < 200$ pc
 - Upper main sequence?



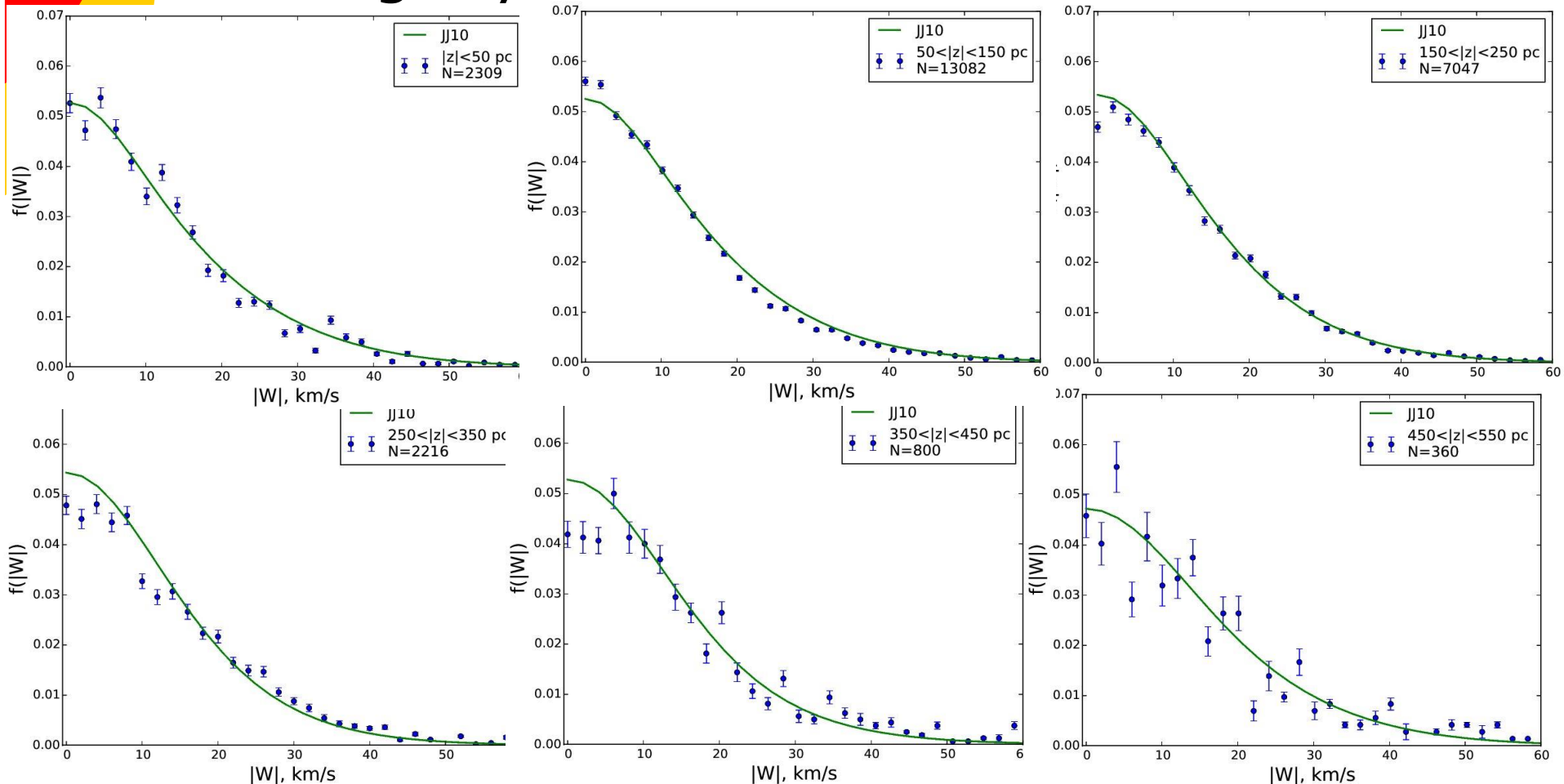
Vertical dynamics $f(|W|)$

- ❖ Velocity distribution function of all stars perfectly reproduced



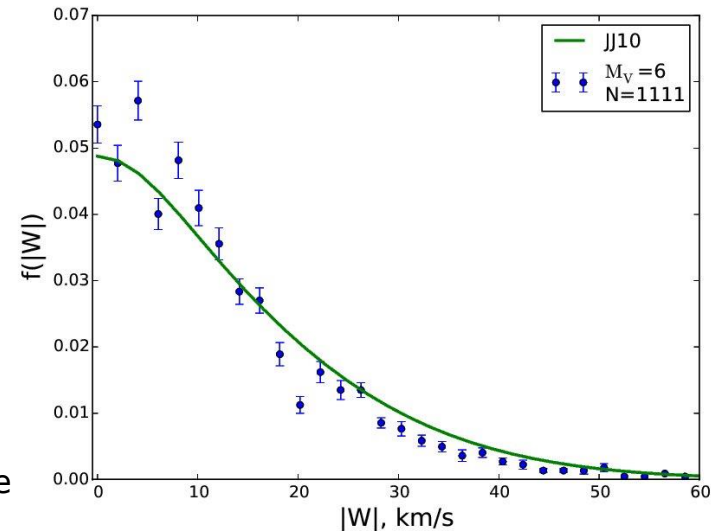
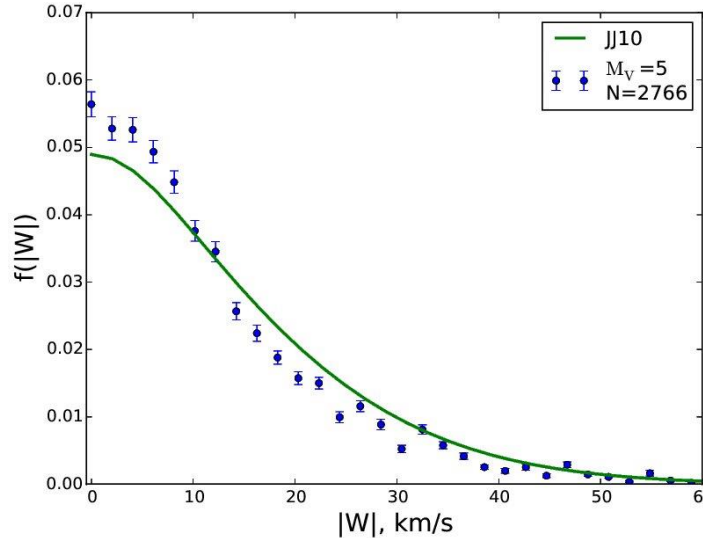
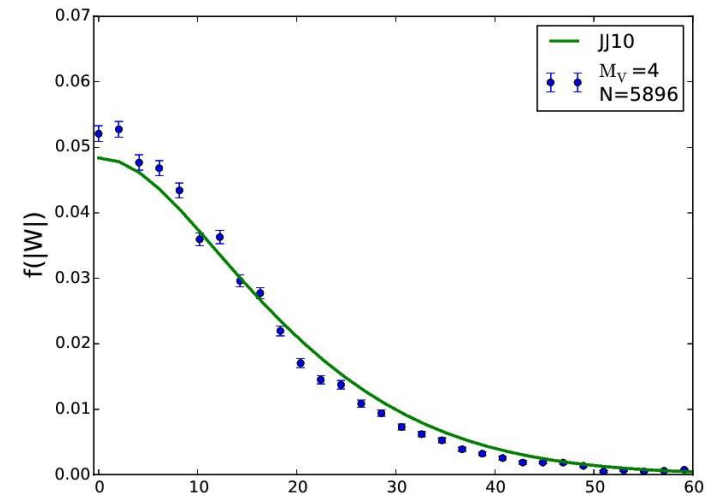
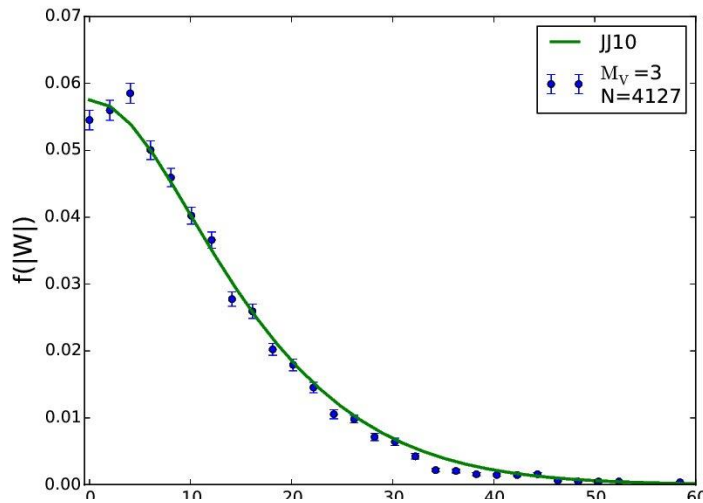
Kinematics in z-slices

❖ Gradual shape variation of $f(|W|)$
slightly different



Main sequence $M_V=3,4,5,6$

❖ older populations too hot in model?

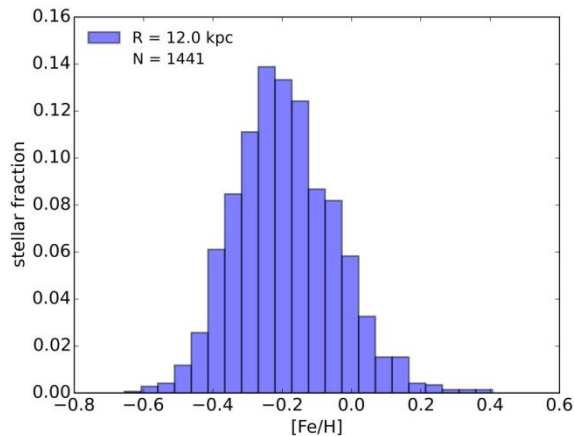
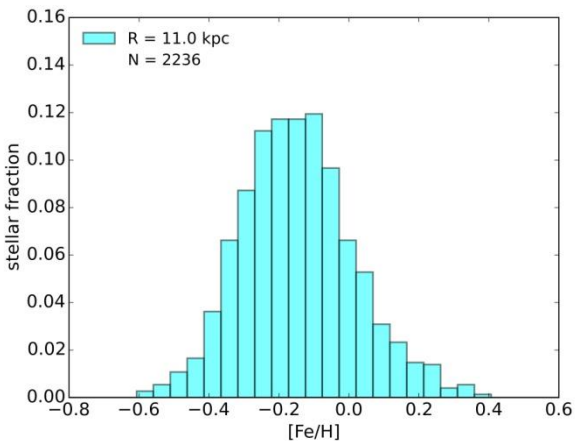
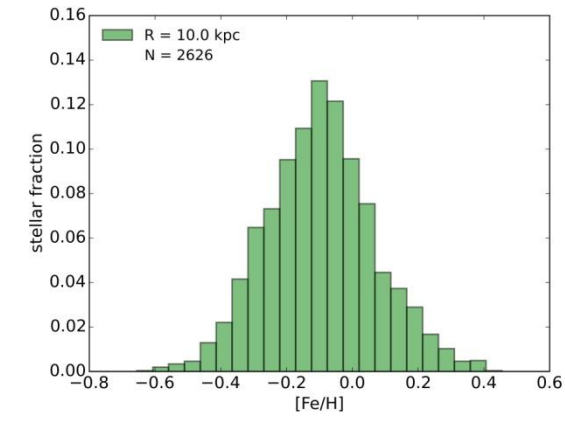
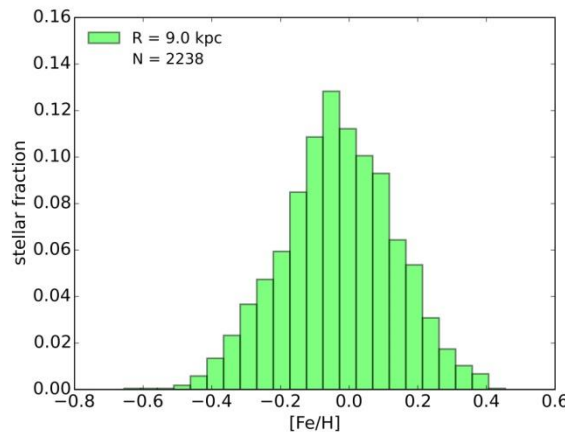
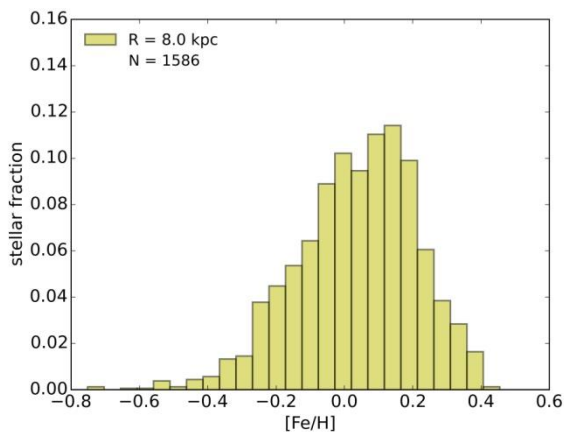
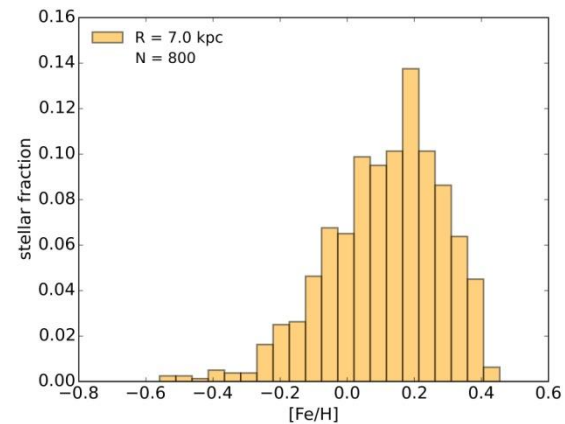
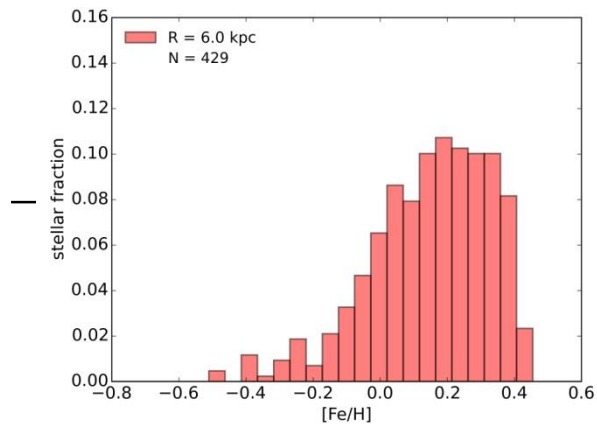
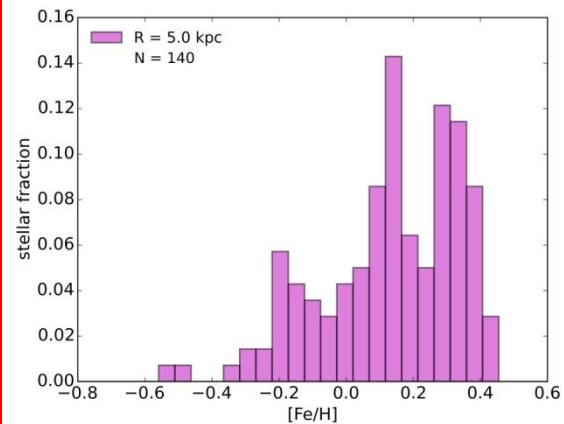


Nice

Andre

Summary

- ❖ Dynamical equilibrium thin disc
 - Consistent age distributions crucial for spatial distribution and kinematics
 - 3-D extinction model essential for star counts
- ❖ Inside-out growth of disc
 - Mono-age and mono-abundance populations flaring
- ❖ TGAS-RAVE data
 - Vertical kinematics well reproduced
 - Small systematic deviations visible due to good number statistics



APOGEE DR12 RC
 $|z| < 400 \text{ pc}$; $N[\text{Fe}/\text{H}]$
 $R = 5, 6, 7$
 $8, 9, 10$
 $11, 12 \quad \text{kpc}$