On the connection between the thick disk and the galactic bar

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Abstract

Although the thick disk in our Galaxy was revealed more than thirty years ago, the formation scenario is still unclear.
Recently, several studies of in-situ thick disk stars have evidenced a positive kinematic-metallicity correlation, dVphi/d[Fe/H] = 40-50 km/s/dex. Such a finding appears consistent with a mild positive radial metallicity gradient, d[Fe/H]/dR, for thick disk stars, which, differently from thin disk stars, show lower chemical abundances towards the inner disk.

Here, we discuss these results with respect to the expected evolution of a primordial disk population, as deduced through high resolution N-body simulations of a Milky Way-like disk galaxy. In particular, we analyse how the presence of a central bar may affect the disk evolution from the spatial and chemo-kinematical point of view.

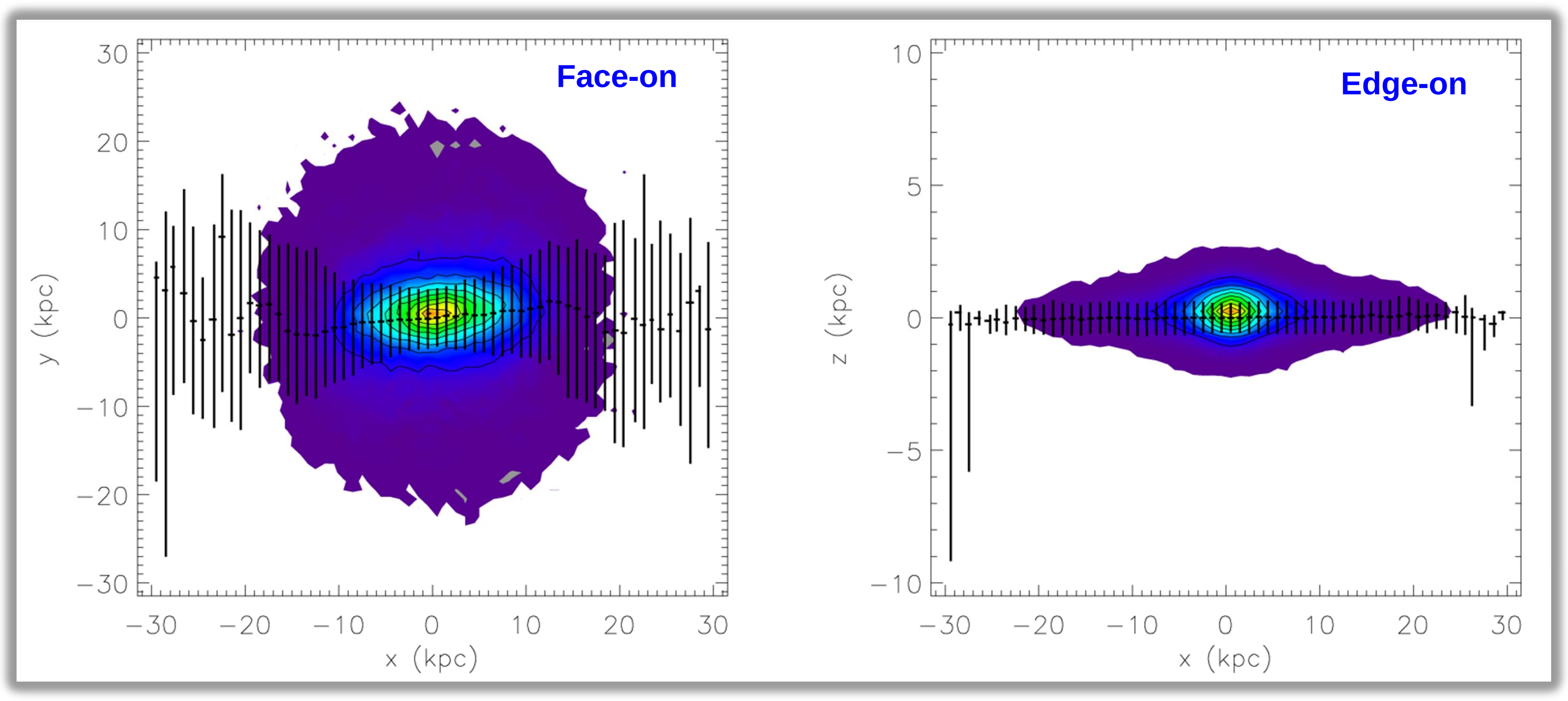

Fig. 1 - Barred galaxy: density distribution of the disk particles after a dynamical evolution of T= 6 Gyr

Bar *vs.* disk velocity distribution

Our simulations show that the bar produce a *thickening* in the inner-disk and a *flaring* in the outer disk (*Spagna* et al 2015, in preparation).
These results are not completely consistent with studies published by other authors (e.g. *Minchev* et al. 2012, A&A, 548, A127).

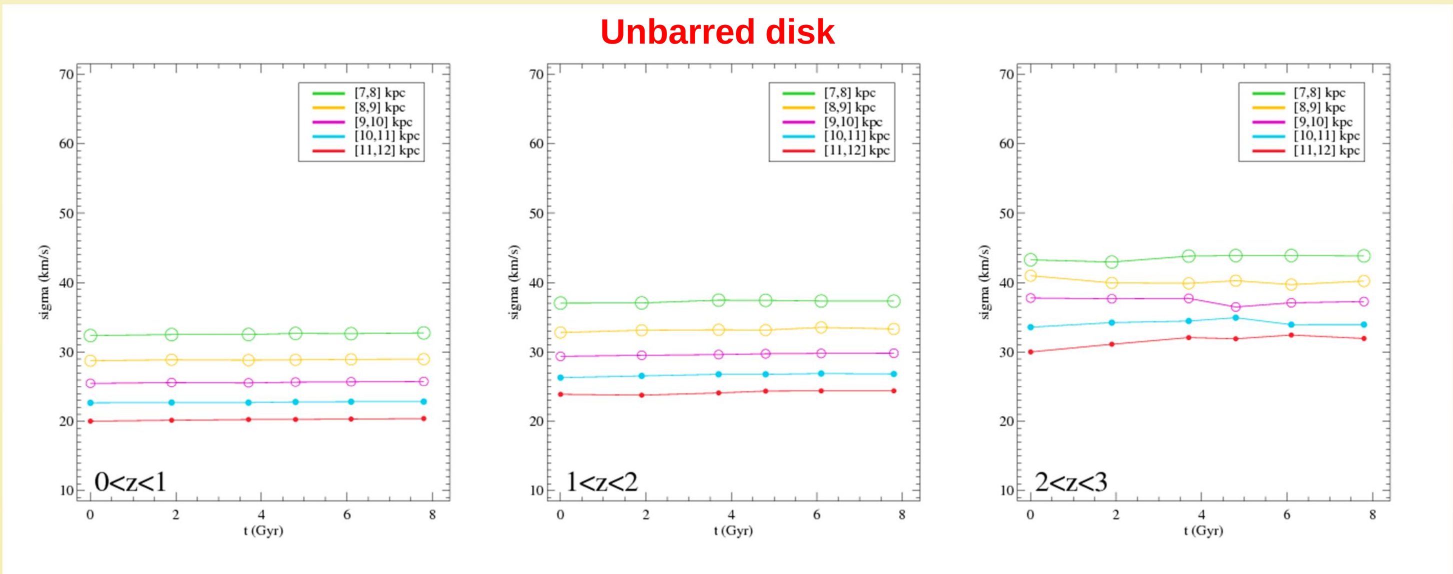

Fig. 2 - Unbarred disk: time evolution of the vertical velocity dispersion, σ_{Vz}
The disk particles show no significant changes

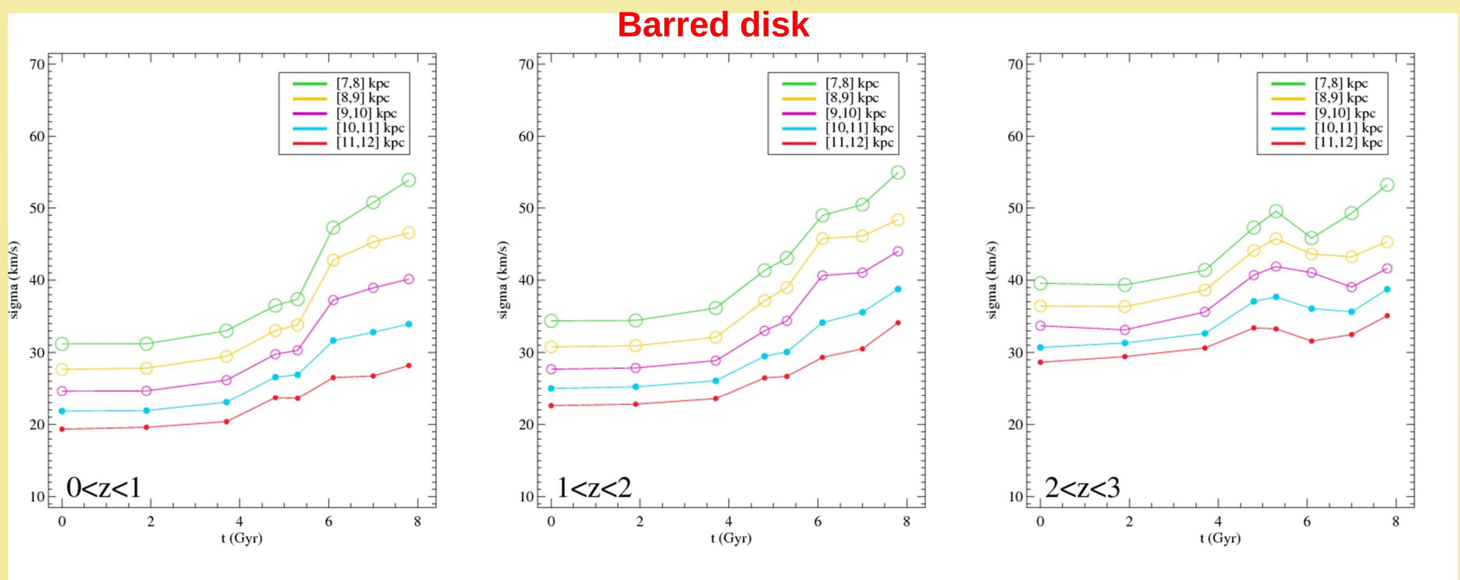

Fig. 3 - Barred disk: time evolution of the vertical velocity dispersion, σ_{Vz}
A disk "heating" greater than about 50% is observed for particles up to |z| = 2 kpc

N-body simulations

Two cases of a Milky Way-like galaxies (*Curir* et al. 2012, A&A, 545, A133):

a. **Barred disk galaxy**, produced by instability of a stellar disk (Tab. 2) within a DM halo (Tab. 1)
b. **Unbarred disk galaxy**, including an additional massive central bulge (Tab. 3)

Table 1. Halos properties (Navarro, Frenk and White profile)

DM	M_{vir}	R_{vir}	C_{vir}	R_{max}	N	ϵ	M_{DM}
Halo	10^{12}	258	7.40	336	10^7	0.11	1.07×10^5

Notes. M_{vir}: Halo's virial mass in $M_\odot$; R_{vir}: virial radius in kpc. C_{vir}: NFW concentration parameter. R_{max}: maximum radius. N: total number of Halo particles. ϵ: softening length in kpc. M_{DM}: mass of DM particle in $M_\odot$.

Table 2. Properties of the disk

Stars	M_*	M_{star}	h_d	z_d	N	ϵ	Q
Disk	$5.6 \cdot 10^{10}$	$7.47 \cdot 10^3$	3.5	0.7	$7.5 \cdot 10^6$	0.044	2

Notes. M_*: disk mass in $M_\odot$. M_{star}: mass of the disk particle in $M_\odot$. h_d: disk scale length in kpc. z_d: initial disk thickness. N: number of particles. ϵ: softening length in kpc. Q: Toomre parameter.

Table 3. Properties of the bulge (Hernquist profile)

Stars	M_*	N	ϵ	a	M_b
Bulge	$1.85 \cdot 10^{10}$	$2.5 \cdot 10^6$	0.044	1.12	$7.39 \cdot 10^3$

Notes. M_*:mass in $M_\odot$. N: number of particles. ϵ: softening length in kpc. a: Hernquist scale radius in kpc. M_b: mass of the particle in $M_\odot$.

Bar *vs.* disk vertical distribution

Consistently with σ_{Vz} (Figs. 2-3), the *unbarred* disk show no significant changes, while the barred disk show a relevant *thickening* and a mild *flaring* .

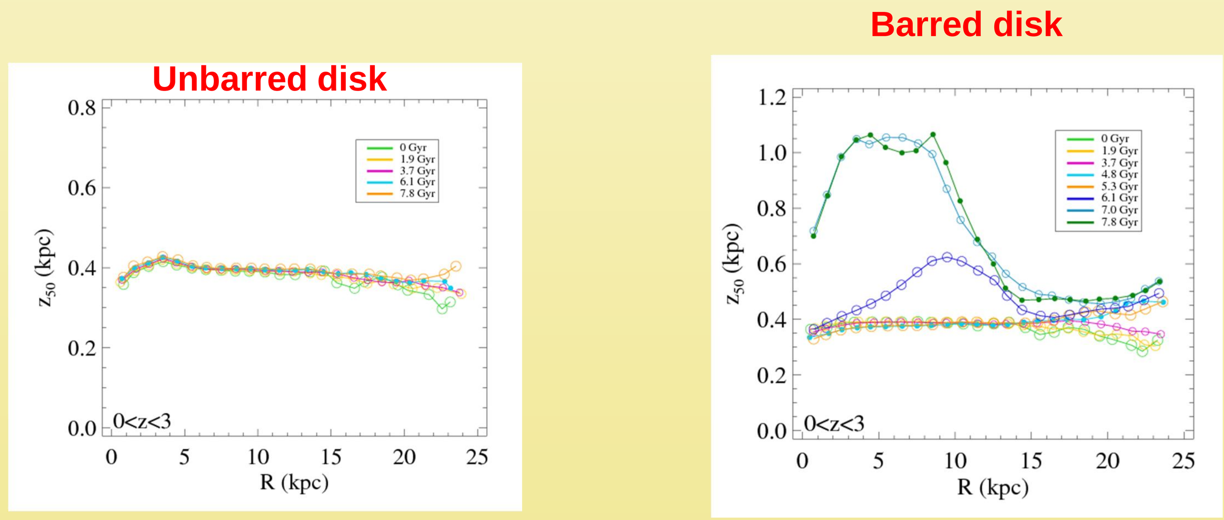

Fig. 4 – Disk vertical distribution vs. R. Here, the parameter, $\mathbf{z_{50}}$, indicates the height |z| above the plane that includes 50% of the total surface mass density, Σ.

Bar *vs.* chemical distribution

As shown by *Curir* et al. (2014, ApJ, 784, L24), the secular disk evolution does *not* seem to modify significantly the disk chemical profiles in *both* the barred/unbarred disks examined.
Then, although the radial chemical gradient of the thick disk represents a fossil signature of the original distribution, the *correlation* between the chemical abundances *and* kinematics needs to be considered to disentangle the formation processes of the early disk

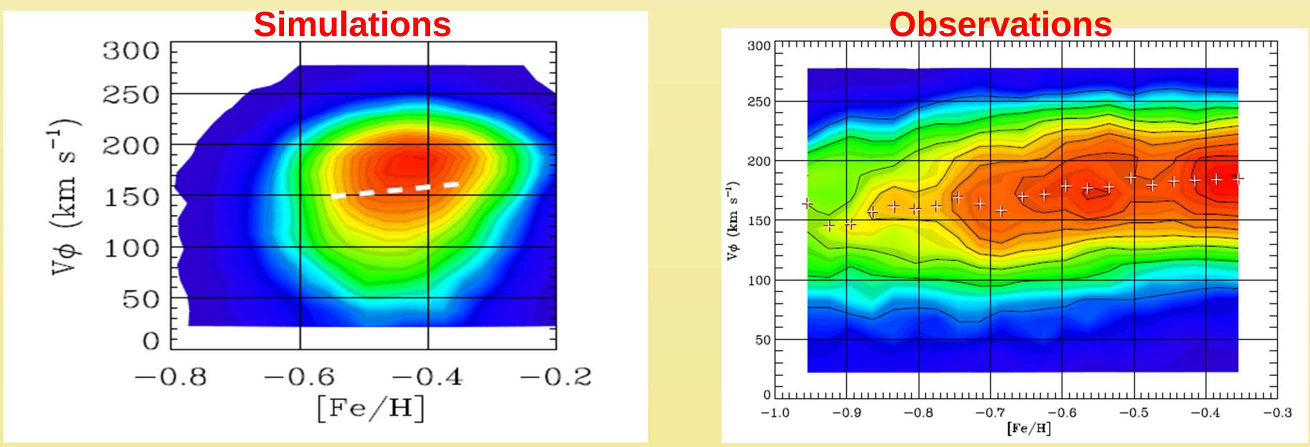

Fig. 5 – Correlation Vϕ – [Fe/H]. *Left panel:* simulations from *Curir* et al. (2012). Right panel: observations of thick disk stars by *Spagna* et al. (2010, A&A, 510, L4)