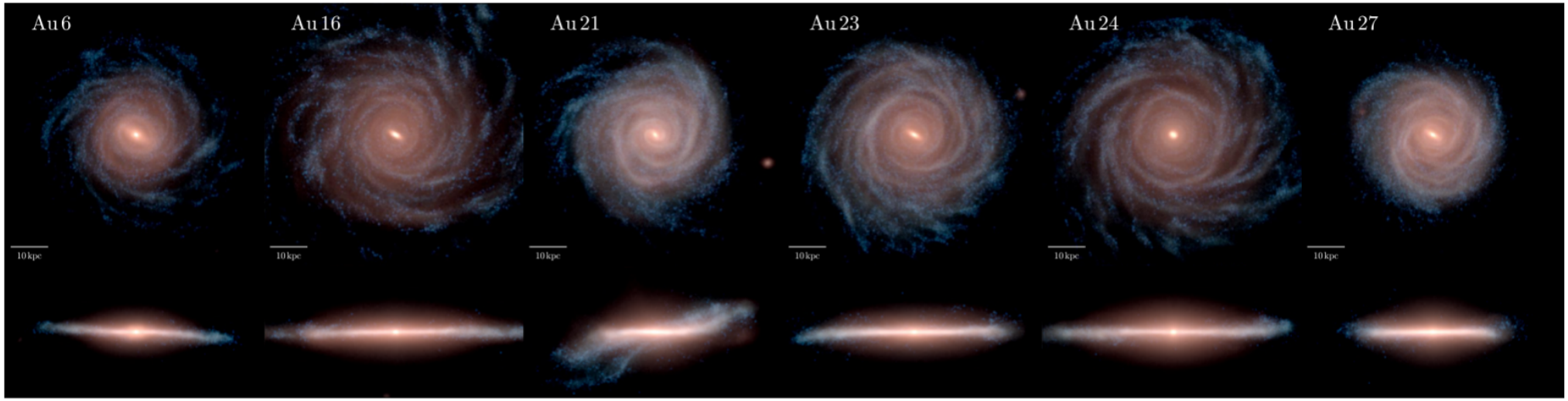
The origin of the inner stellar halo anisotropy

Azadeh (Azi) Fattahi
ICC, Durham University

With
Vasily Belokurov, Alis Deason, Carlos Frenk



Outline

A.

Inner stellar halo anisotropy

Lessons from Auriga simulations

Belokurov+2018, AF+ in prep

B.

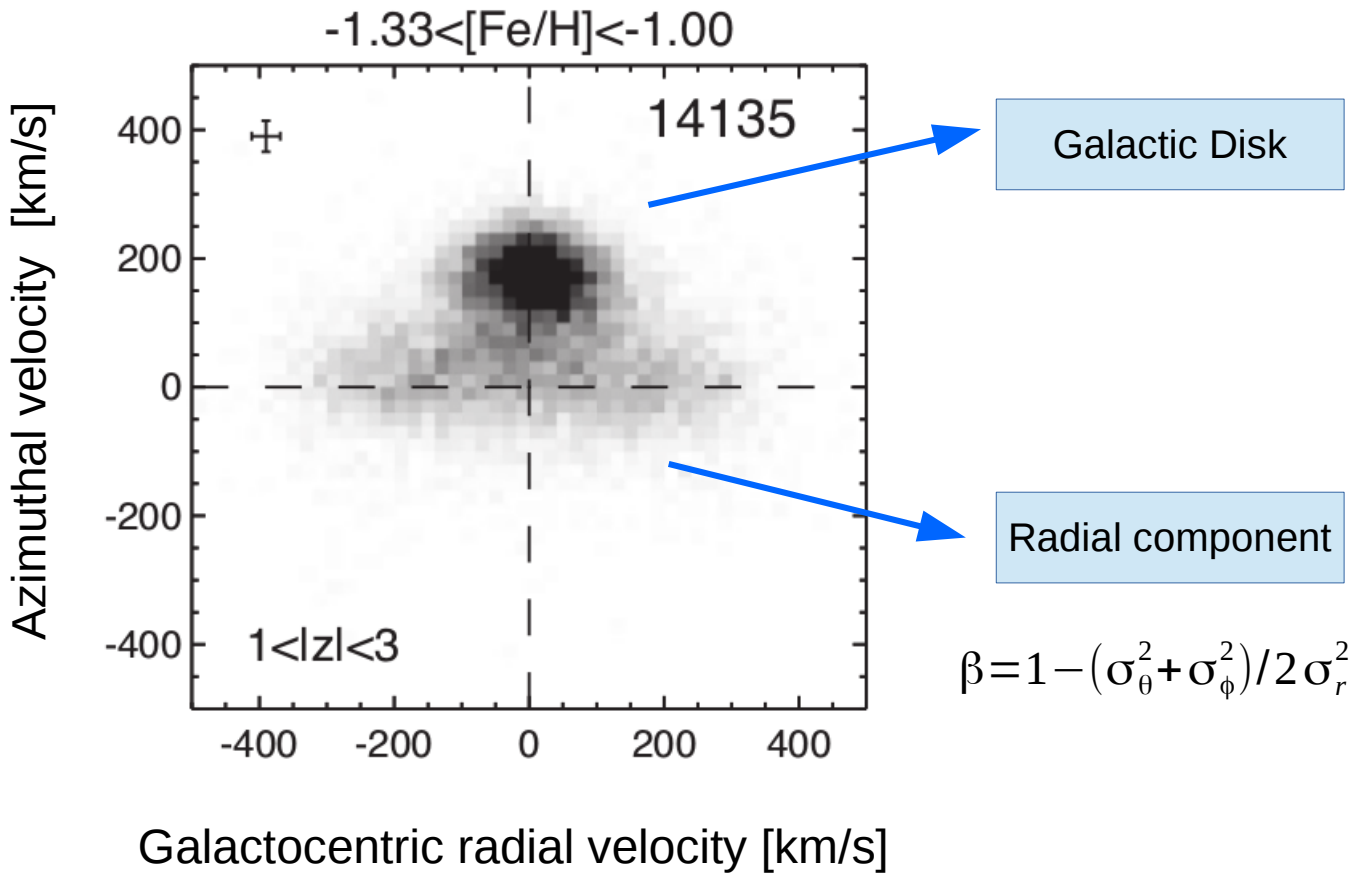
Aurigaia – Gaia mock catalogs based on Auriga simulations

Grand+ 2018 (AF, Cooper, Simpson, Cautun, Frenk)

Kinematics of the inner stellar halo

SDSS+Gaia DR1 (Belokurov+2018)

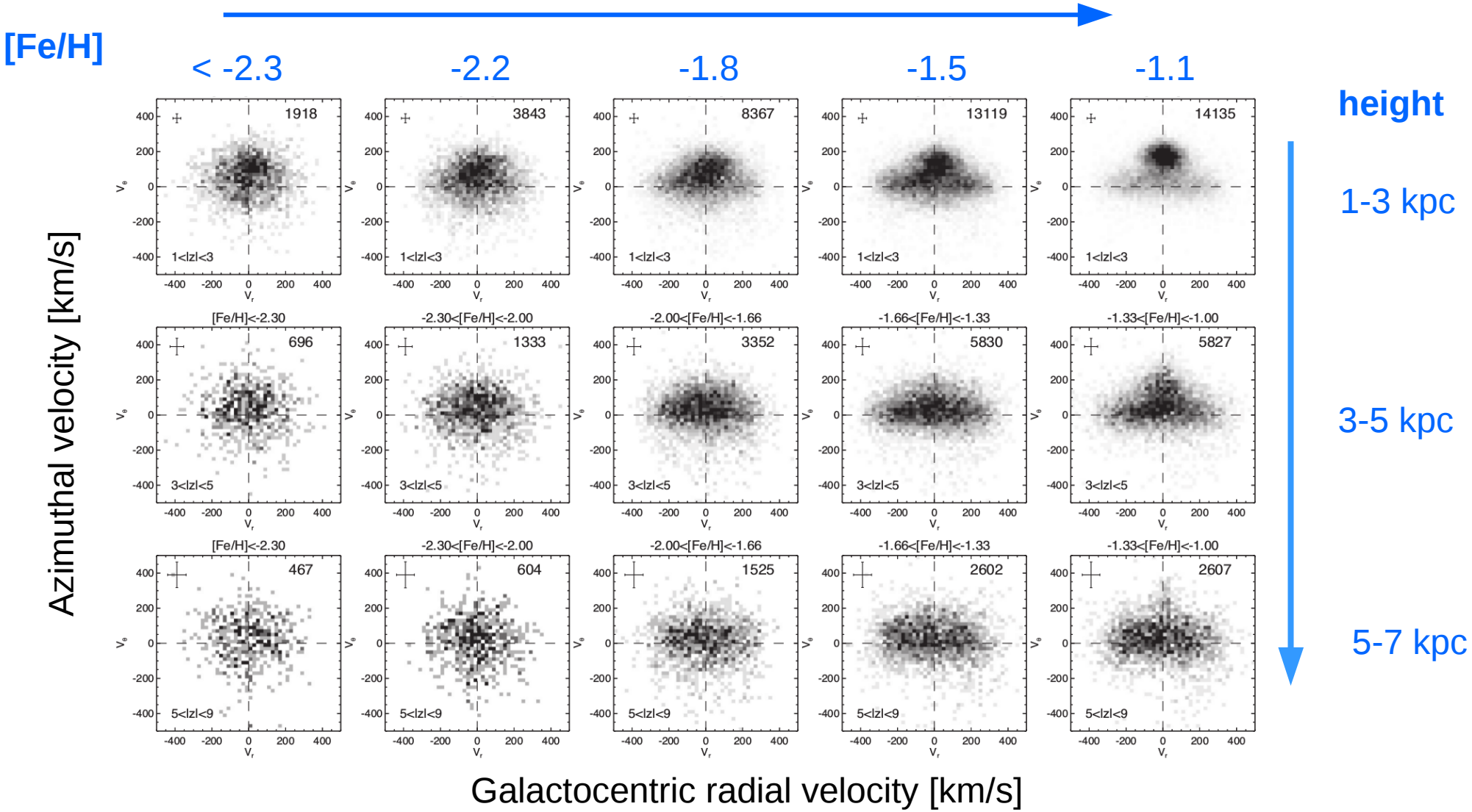
SDSS+Gaia DR1 : 6D phase-space, [Fe/H] (Belokurov+2018)



$$\beta = 1 - (\sigma_\theta^2 + \sigma_\phi^2)/2\sigma_r^2 \sim 0.9$$

Kinematics of the inner stellar halo

SDSS-Gaia DR1 (Belokurov+2018)

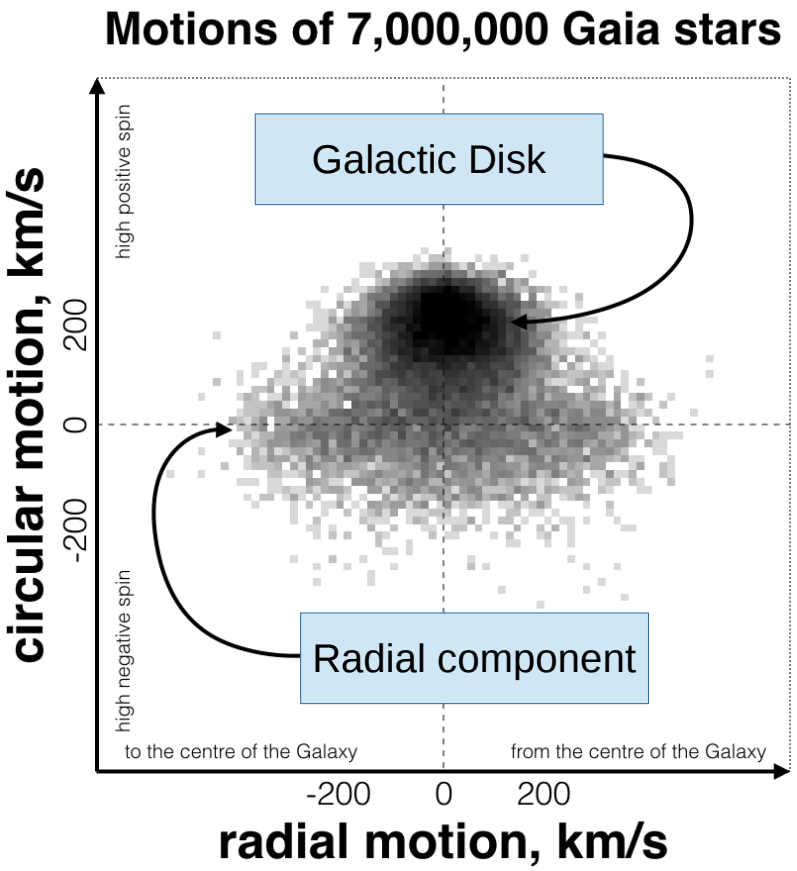


Kinematics of the inner stellar halo

Gaia DR2: RVS stars with good parallaxes

1 < |Z| < 4 kpc

-1.6 < [F/H] < 1.0



Kinematics of the inner stellar halo

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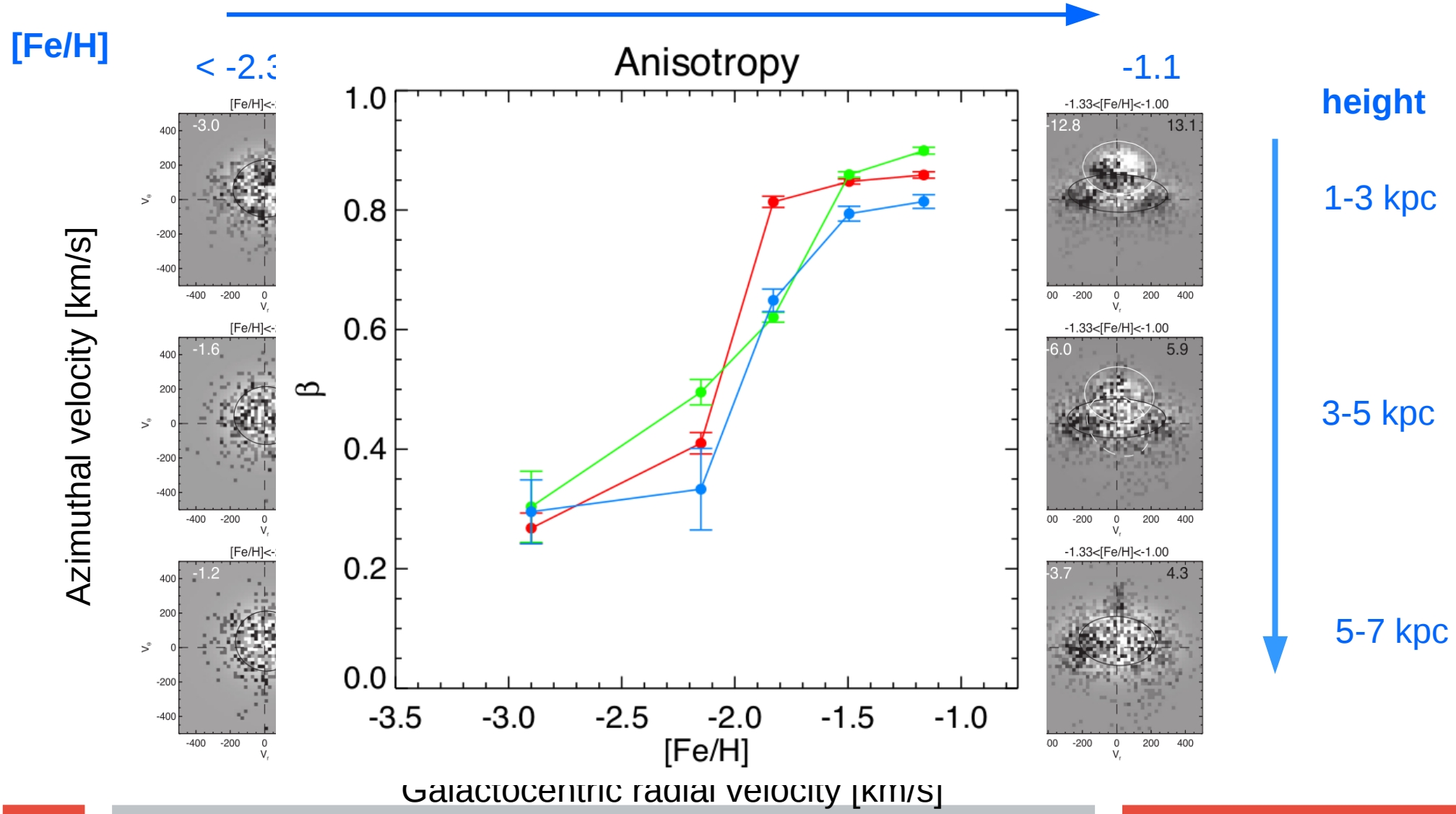
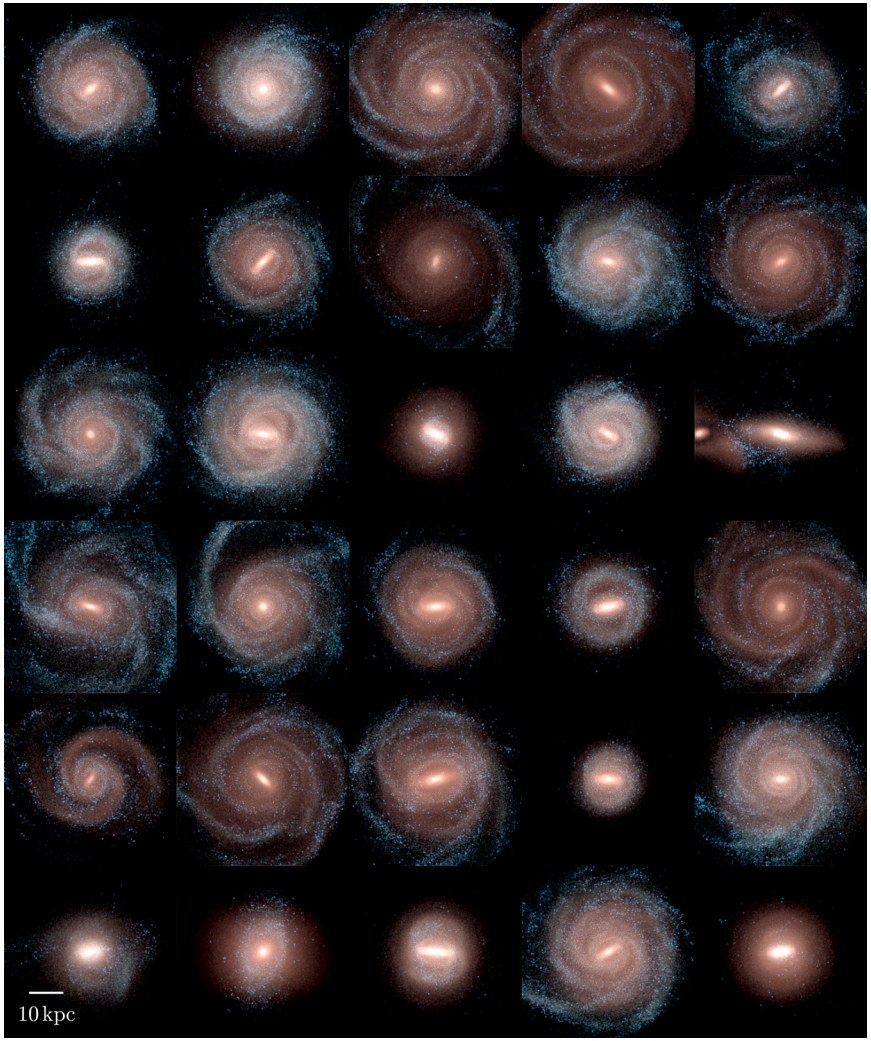


Auriga hydrodynamical simulations

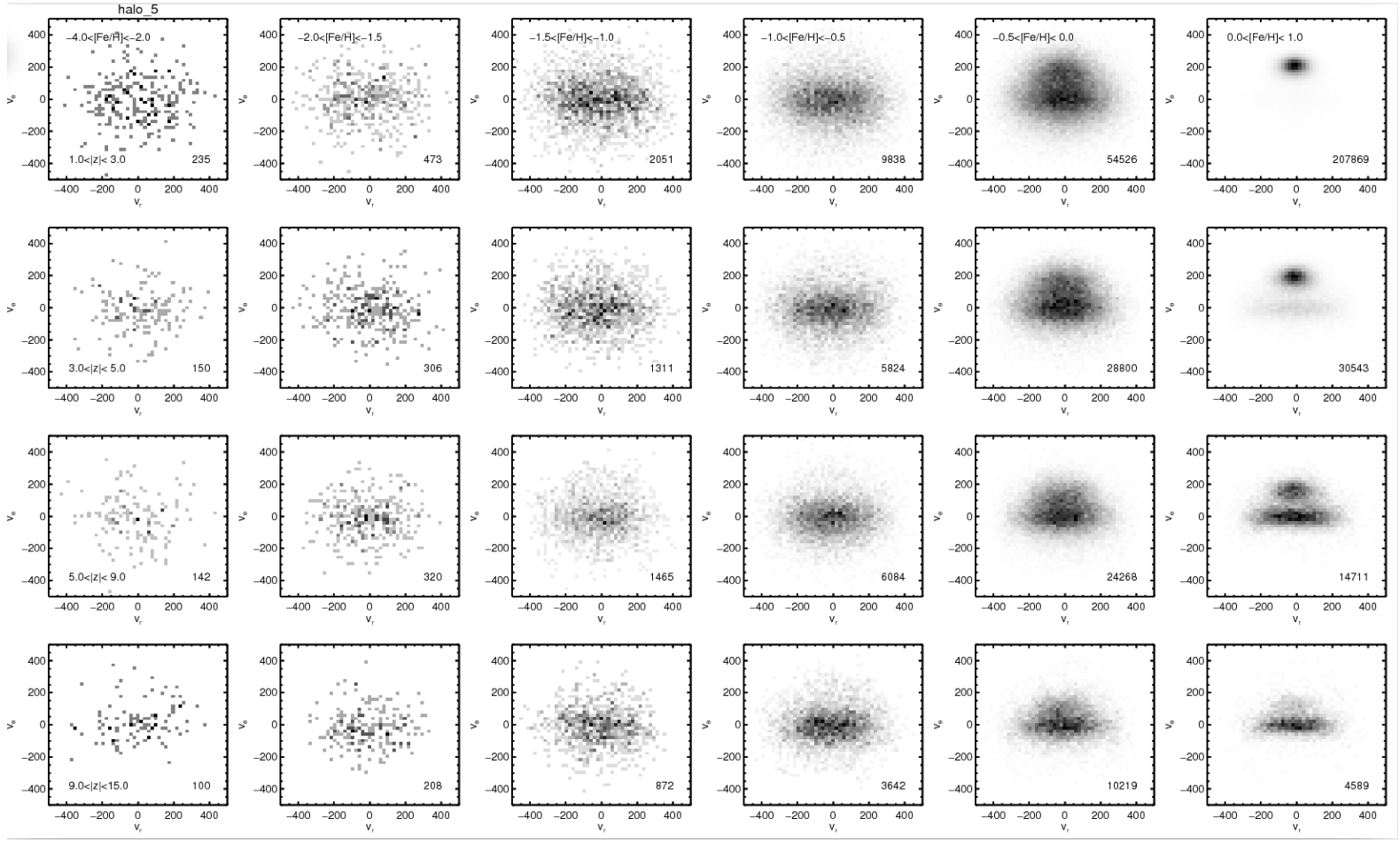
(see Grand+2017 for details)

- Zoom-in hydrodynamical simulations of Milky Way-like halos
- Isolated halos with mass ~ 10^{12}
  - 30 halos at level 4
  - 6 halos at level 3
- Run with Arepo (Springel 2010) full hydrodynamics + MHD



Inner stellar halo in Auriga: examples

Increasing metallicity



Azimuthal velocity

Increasing height

Galactocentric radial velocity

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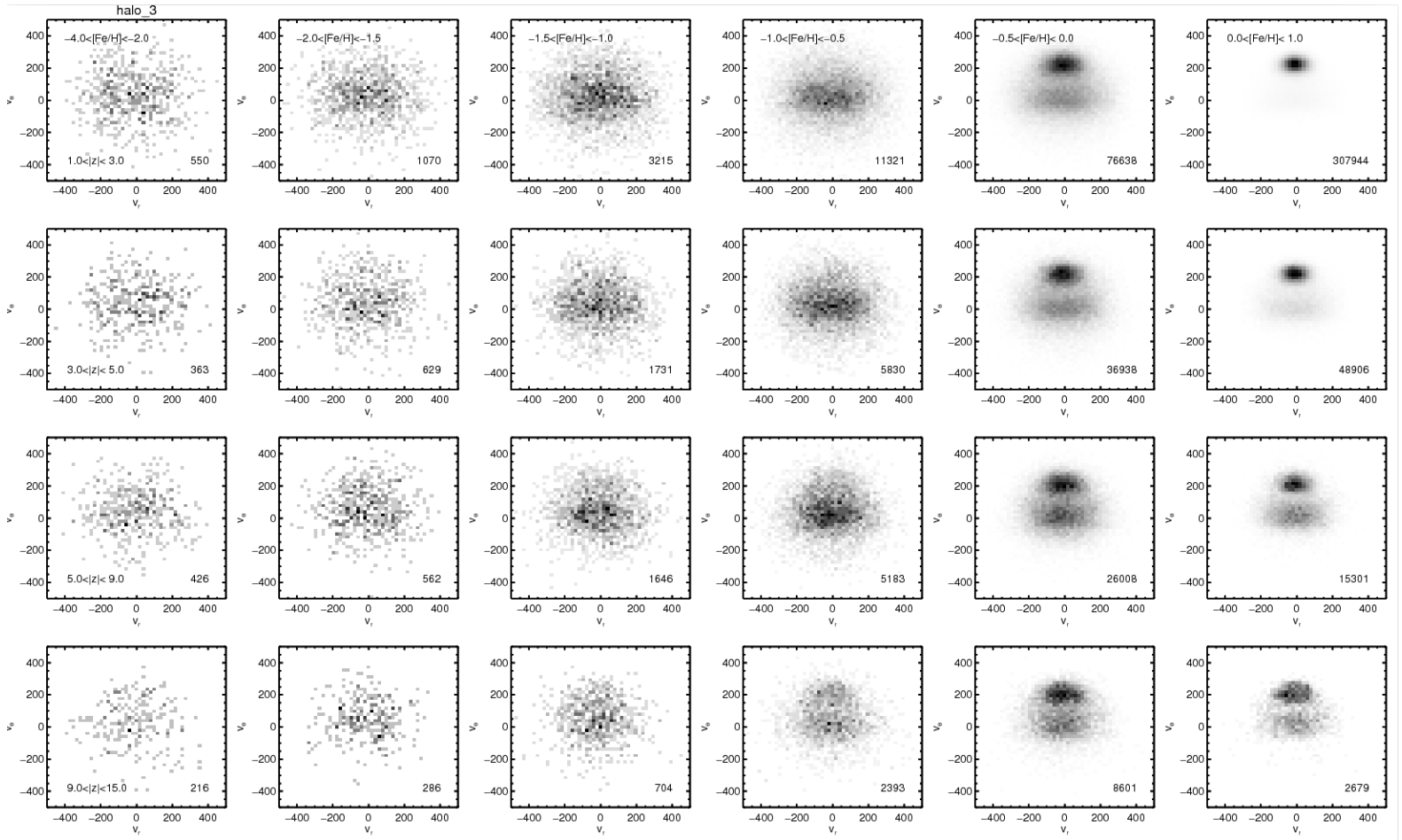

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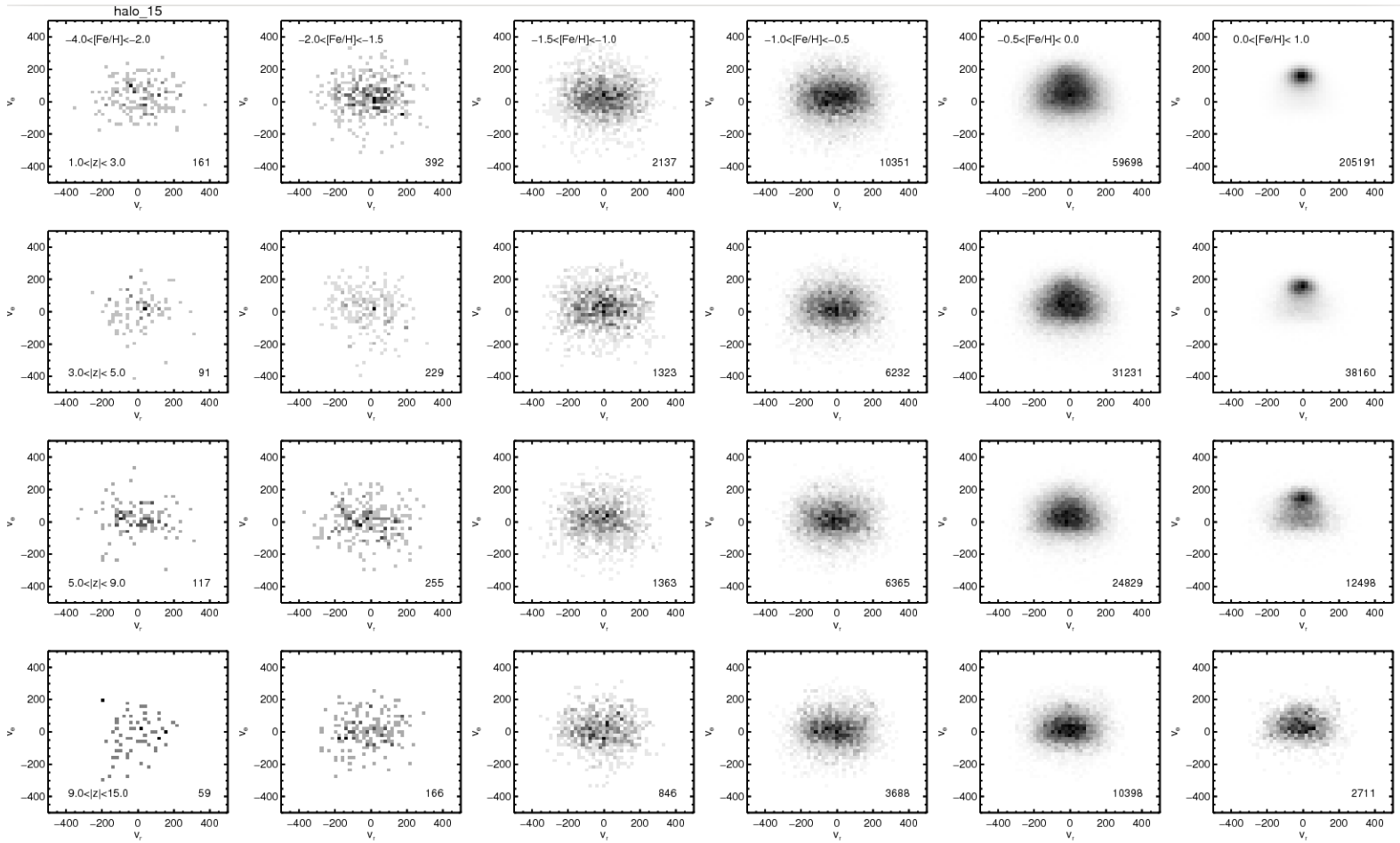

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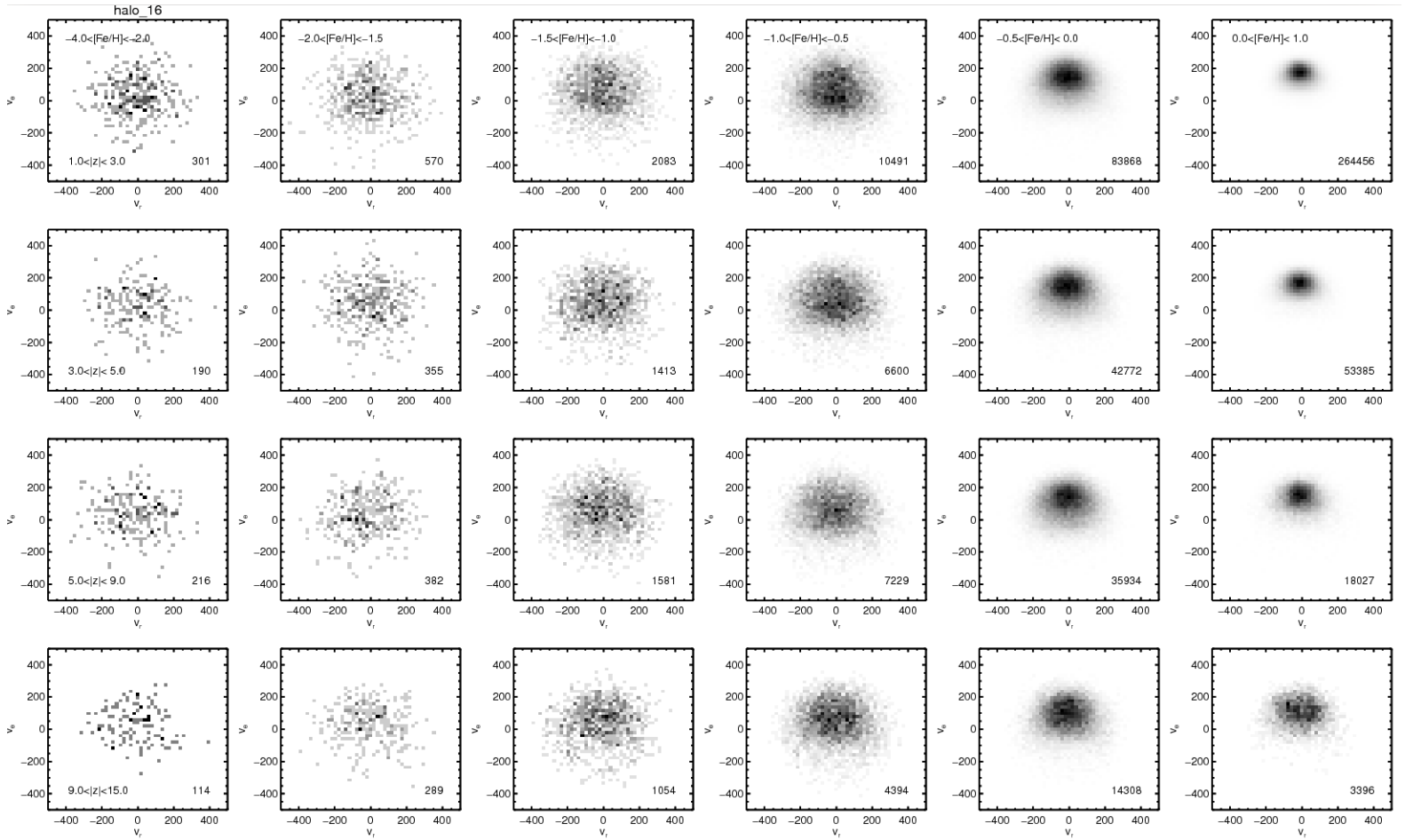

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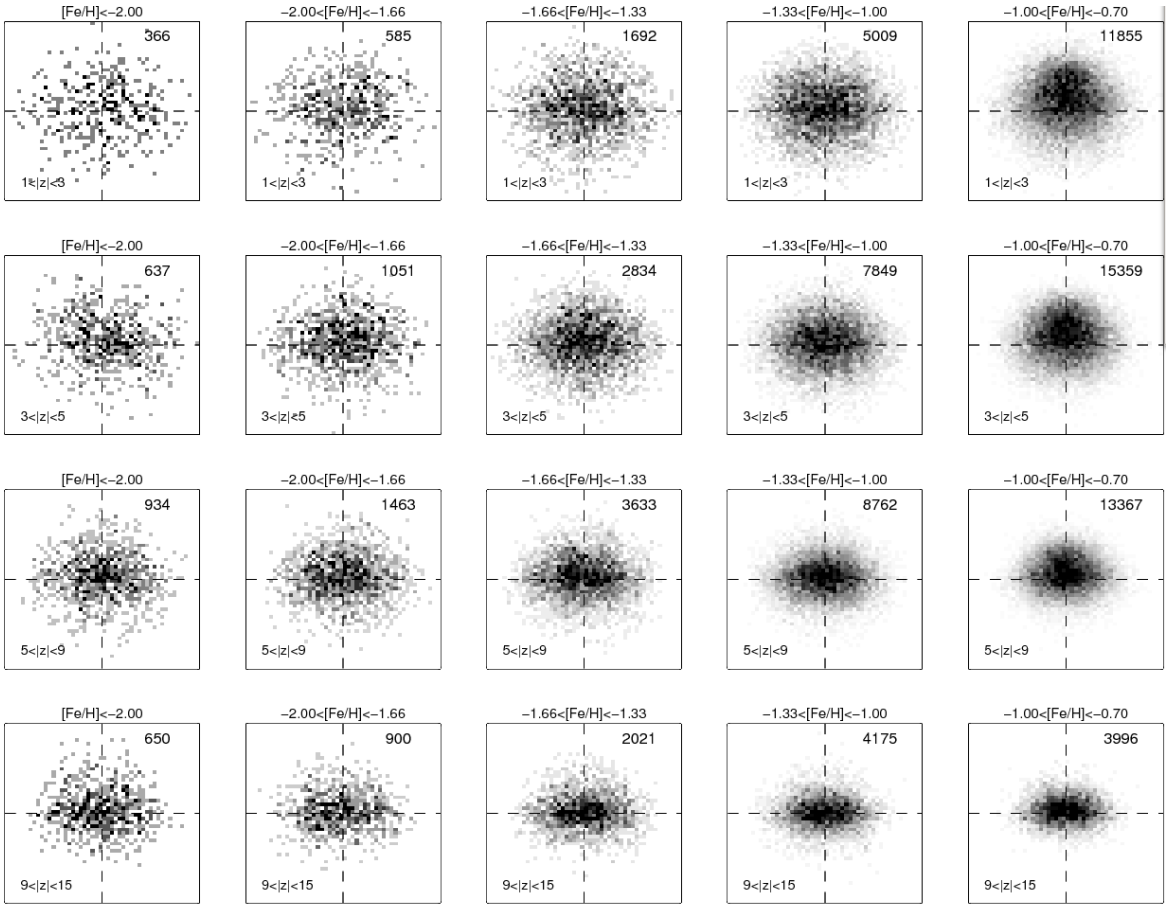
Galactocentric radial velocity

Lessons from Auriga:

galaxies with highly radial stars

Increasing metallicity



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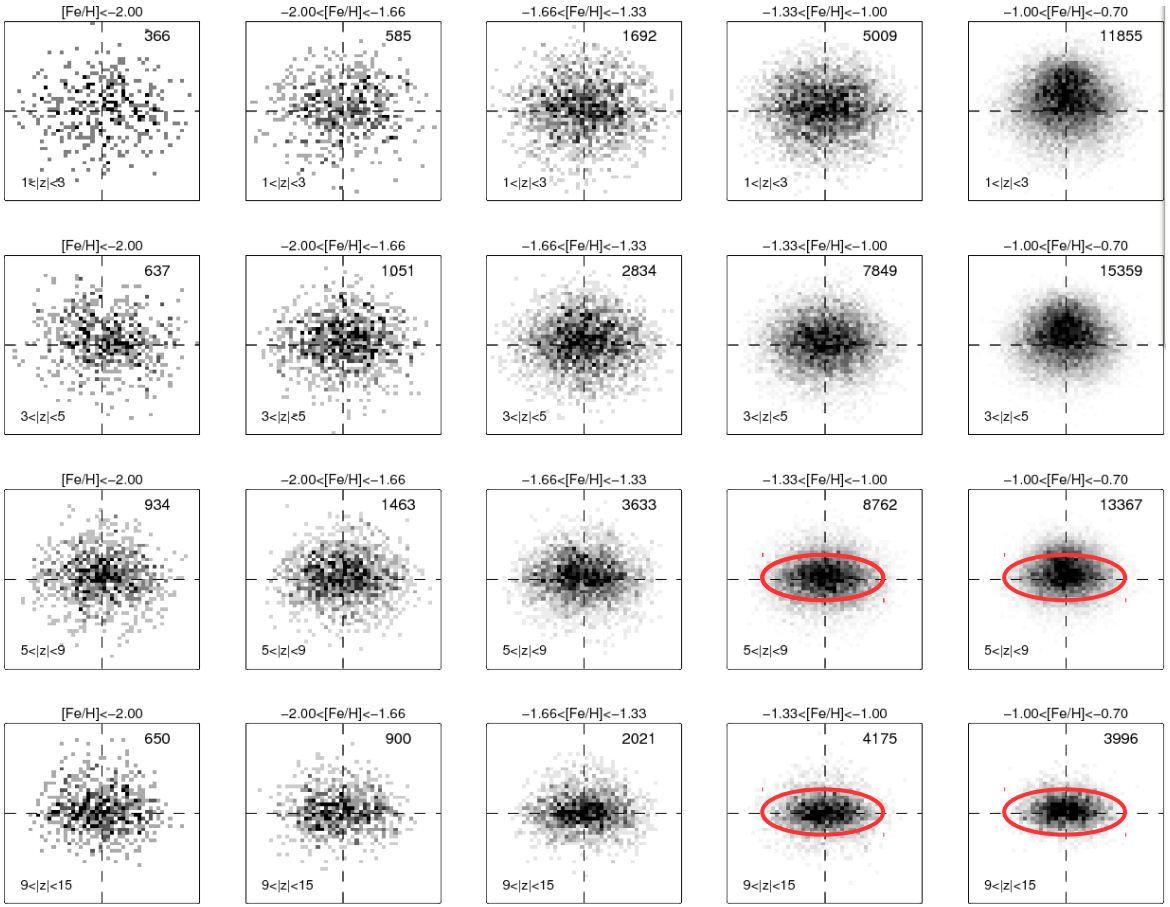


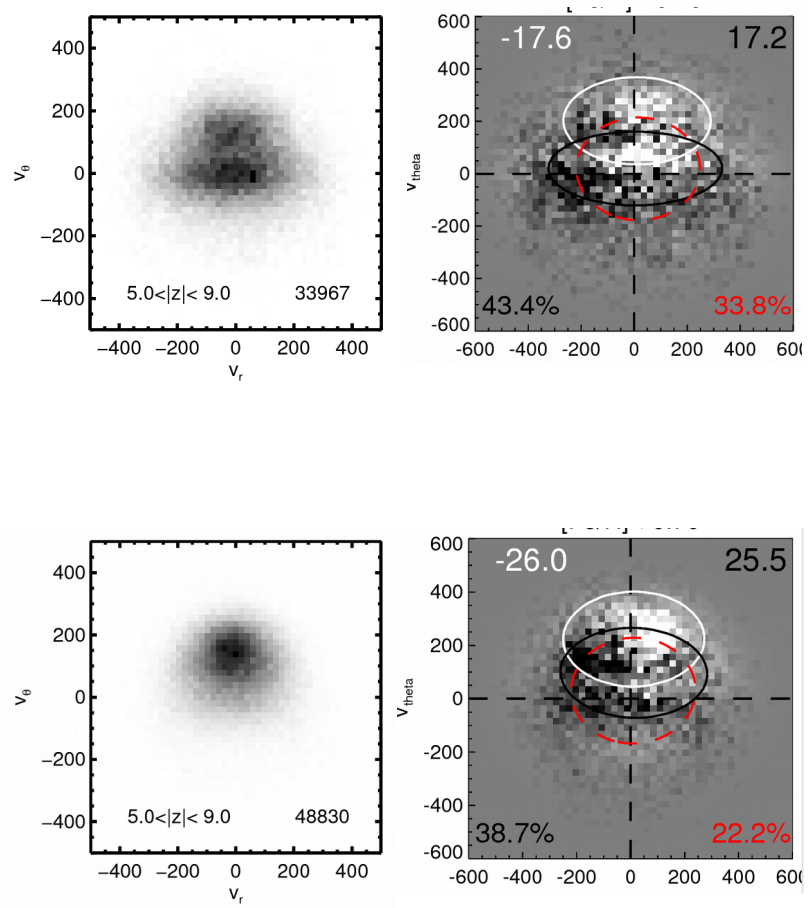
Increasing height

Galactocentric radial velocity

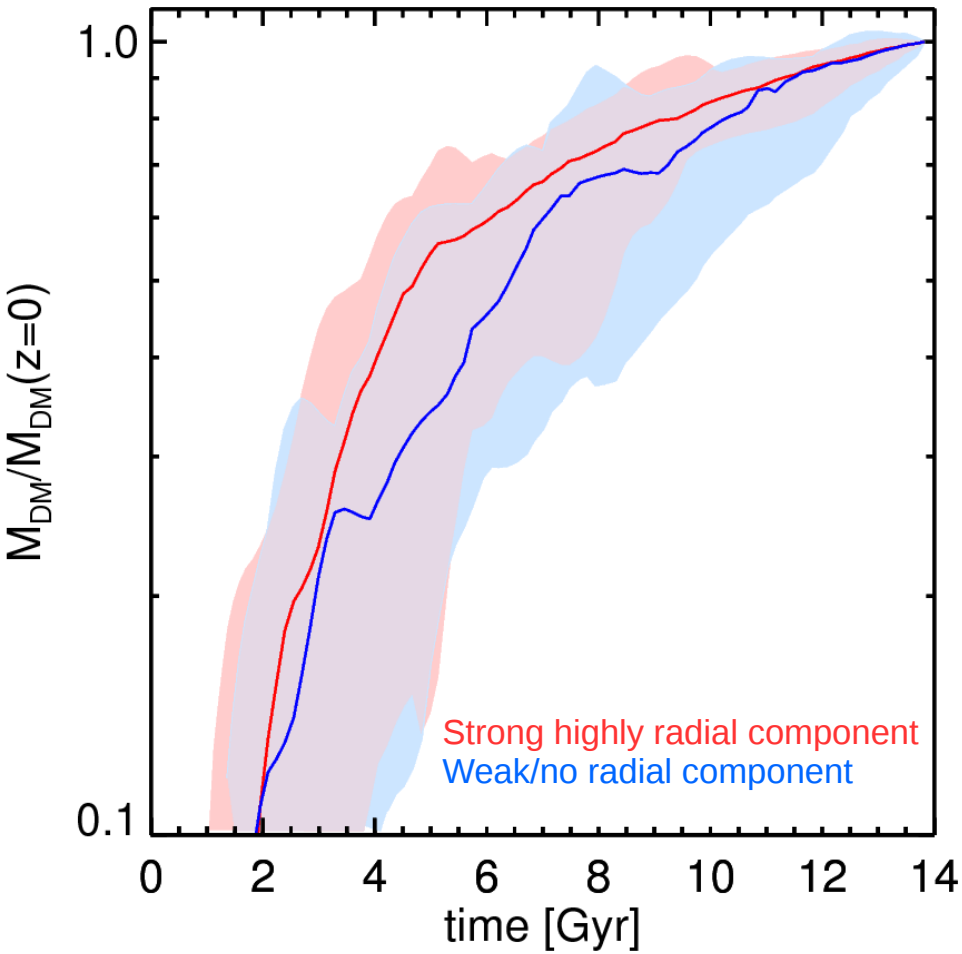
Lessons from Auriga:

where do highly radial stars come from?

Fitting velocity ellipsoids:

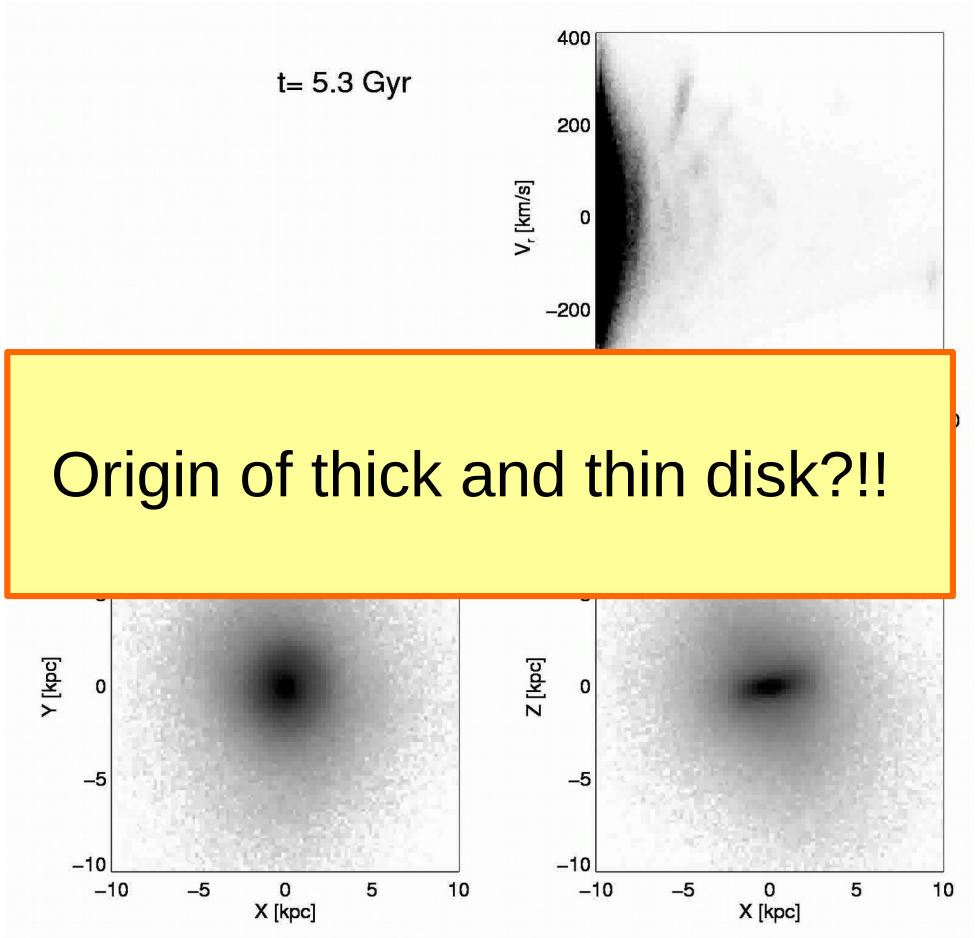


Accretion history



Lessons from Auriga:

what happens to the galaxy disks?



Origin of thick and thin disk?!!

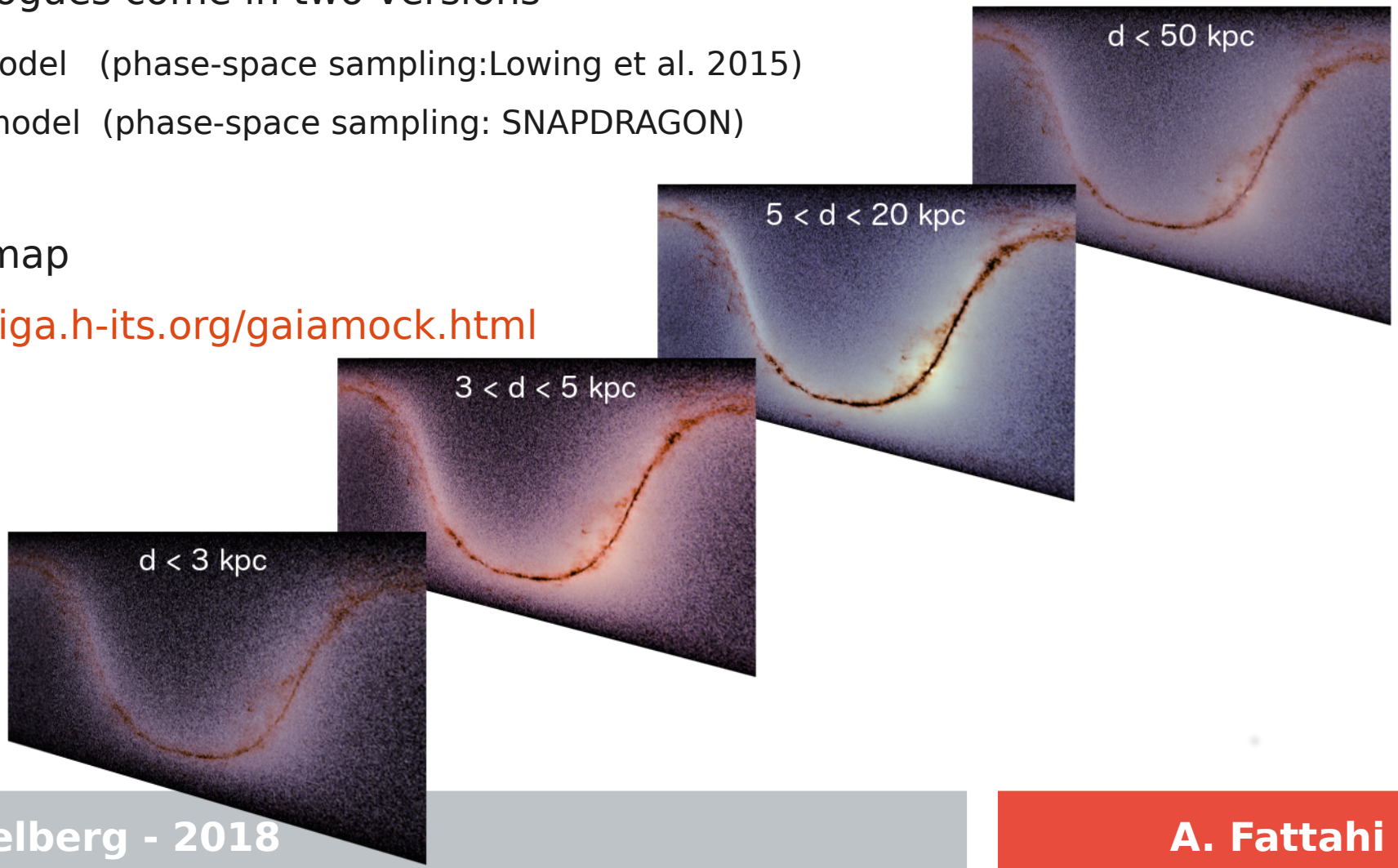
Take home messages

- Inner stellar halo has a significant highly radial component.
- This kinematic property is common amongst Auriga galaxies
- The origin of this component is a big merger with an LMC mass subhalo ~6-10Gyr ago.
- The merger has a big impact on the stellar disk and it can be the event that created thick disk

Aurigaia: Auriga Gaia mock catalogs

Grand+2018

- Based on 6 Auriga level 3 halos
- The catalogues come in two versions
  - ICC model (phase-space sampling:Lowing et al. 2015)
  - HITS model (phase-space sampling: SNAPDRAGON)
- MW dust map
- http://auriga.h-its.org/gaiamock.html



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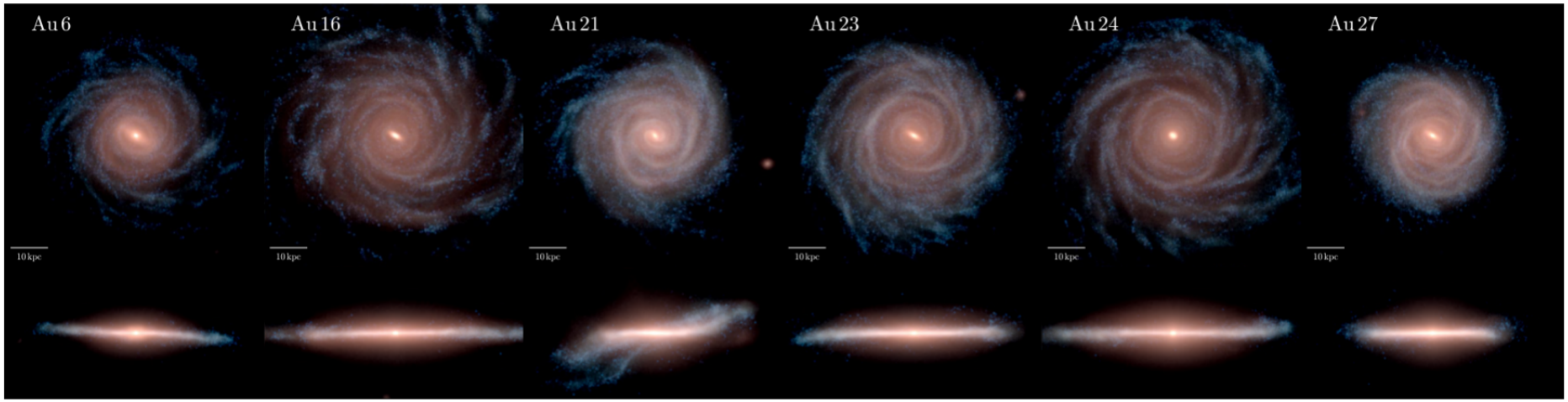

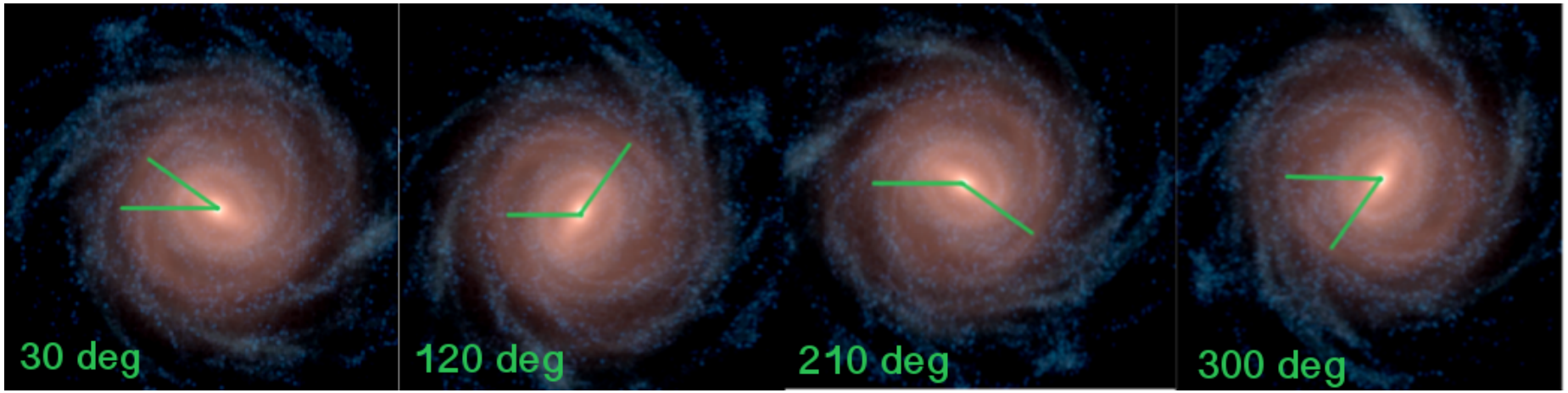

Aurigaia: Auriga Gaia mock catalogs

Grand+2018

Catalogue field name	Units	Description
AccretedFlag	-	equal to either (-1, 0, 1) for (in-situ, accreted, in existing sub-halo)
Age	gigayears	the look back time at which the parent star particle is born
EffectiveTemperature	Kelvin	the true effective temperature of the synthetic star
EffectiveTemperatureError	Kelvin	the error in effective temperature of the synthetic star
EffectiveTemperatureObs	Kelvin	the observed effective temperature of the synthetic star
[a]Extinction31	magnitudes	V-band extinction value
GBmagnitude	magnitudes	true *Gaia* blue $G_{\rm B}$-band luminosity
GBmagnitudeError	magnitudes	error in *Gaia* blue $G_{\rm B}$-band luminosity
GBmagnitudeObs	magnitudes	observed *Gaia* blue $G_{\rm B}$-band luminosity
GRmagnitude	magnitudes	true *Gaia* red $G_{\rm R}$-band luminosity
GRmagnitudeError	magnitudes	error in *Gaia* red $G_{\rm R}$-band luminosity
GRmagnitudeObs	magnitudes	observed *Gaia* red $G_{\rm R}$-band luminosity
Gmagnitude	magnitudes	true *Gaia* white light G-band luminosity
GmagnitudeError	magnitudes	error in *Gaia* white light G-band luminosity
GmagnitudeObs	magnitudes	observed *Gaia* white light G-band luminosity
GravPotential	$\mathrm{km^2\,s^{-2}}$	gravitational potential of the parent star particle
HCoordinateErrors	(radians, radians, arcsec)	2D array of errors in (α, δ, π)
HCoordinates	(radians, radians, arcsec)	2D array of true (α, δ, π)
HCoordinatesObs	(radians, radians, arcsec)	2D array of observed (α, δ, π)
HVelocities	$(\mathrm{arcsec\,yr^{-1}}, \mathrm{arcsec\,yr^{-1}}, \mathrm{km\,s^{-1}})$	2D array of true $(\mu^*_\alpha, \mu_\delta, v_r)$
HVelocitiesObs	$(\mathrm{arcsec\,yr^{-1}}, \mathrm{arcsec\,yr^{-1}}, \mathrm{km\,s^{-1}})$	2D array of observed $(\mu^*_\alpha, \mu_\delta, v_r)$
HVelocityErrors	$(\mathrm{arcsec\,yr^{-1}}, \mathrm{arcsec\,yr^{-1}}, \mathrm{km\,s^{-1}})$	2D array of errors in $(\mu^*_\alpha, \mu_\delta, v_r)$
IabsMagnitude	magnitudes	I-band absolute magnitude
Magnitudes	(magnitudes)×8	2D array of apparent magnitudes in the (U, B, R, J, H, K, V, I) bands
[b]InitialMass	solar masses	mass of the star when it was born (before mass loss occurs)
Mass	Solar masses	mass of the star
Metallicity	-	metallicity of the star
ParticleID	-	unique ID of the parent particle
SurfaceGravity	log	logarithm of the true surface gravity of the star
SurfaceGravityError	log	logarithm of the error in surface gravity of the star
SurfaceGravityObs	log	logarithm of the observed surface gravity of the star
VabsMagnitude	magnitudes	V-band absolute magnitude