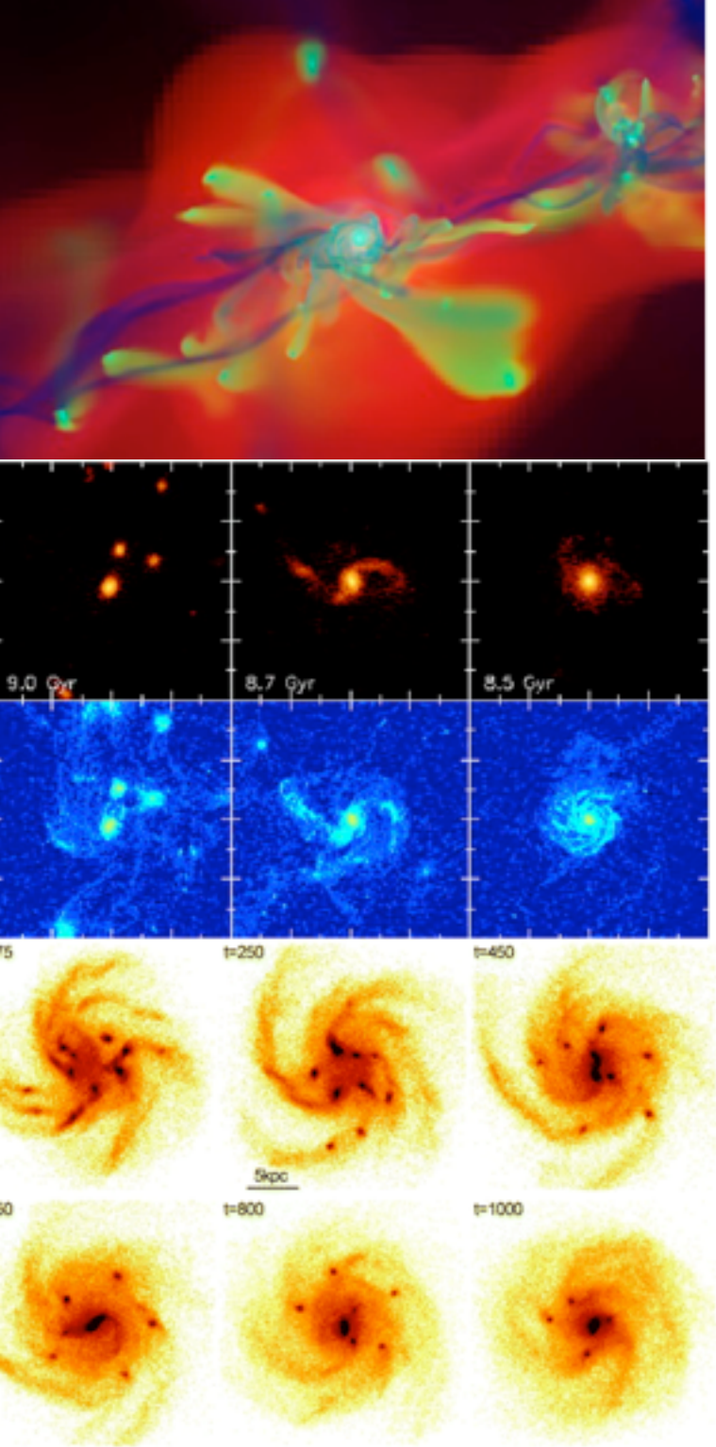
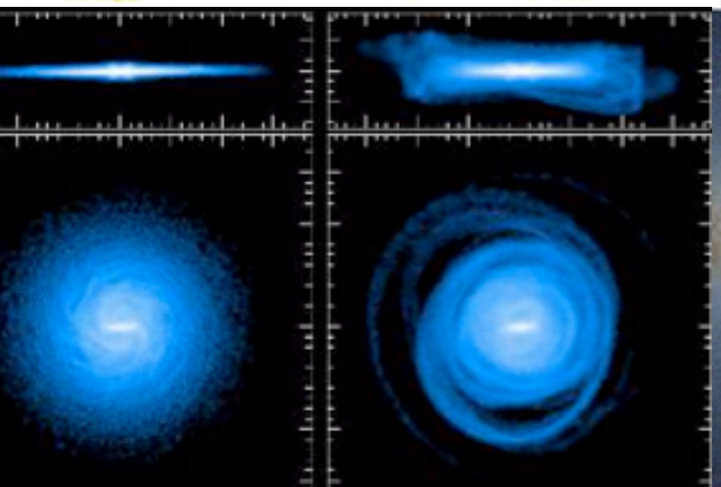
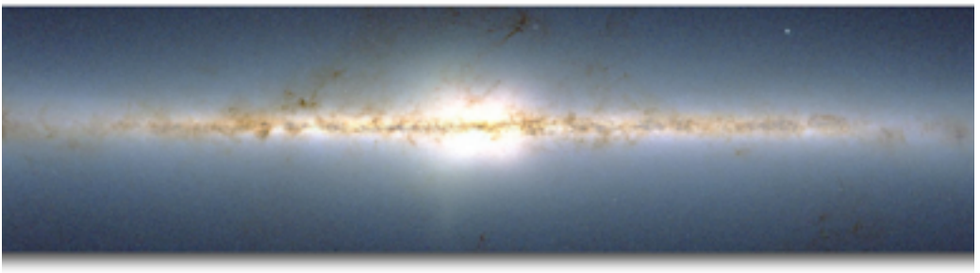


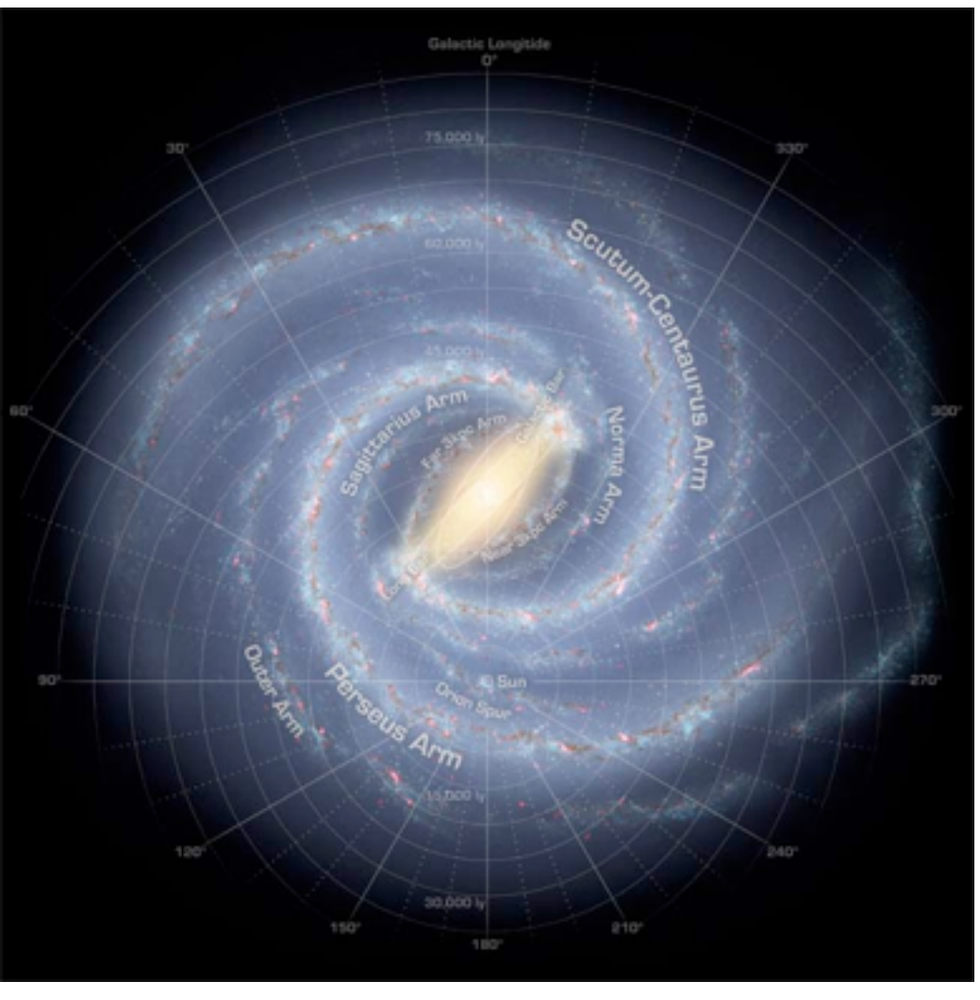
STRUCTURES AND SUBSTRUCTURES IN THE MILKY WAY: DISENTANGLING THE PROCESS OF ITS MASS ASSEMBLY

Paola Di Matteo
(Observatoire de Paris-Meudon)



HOW DID THE MILKY WAY EVOLVE INTO ITS CURRENT STATE?





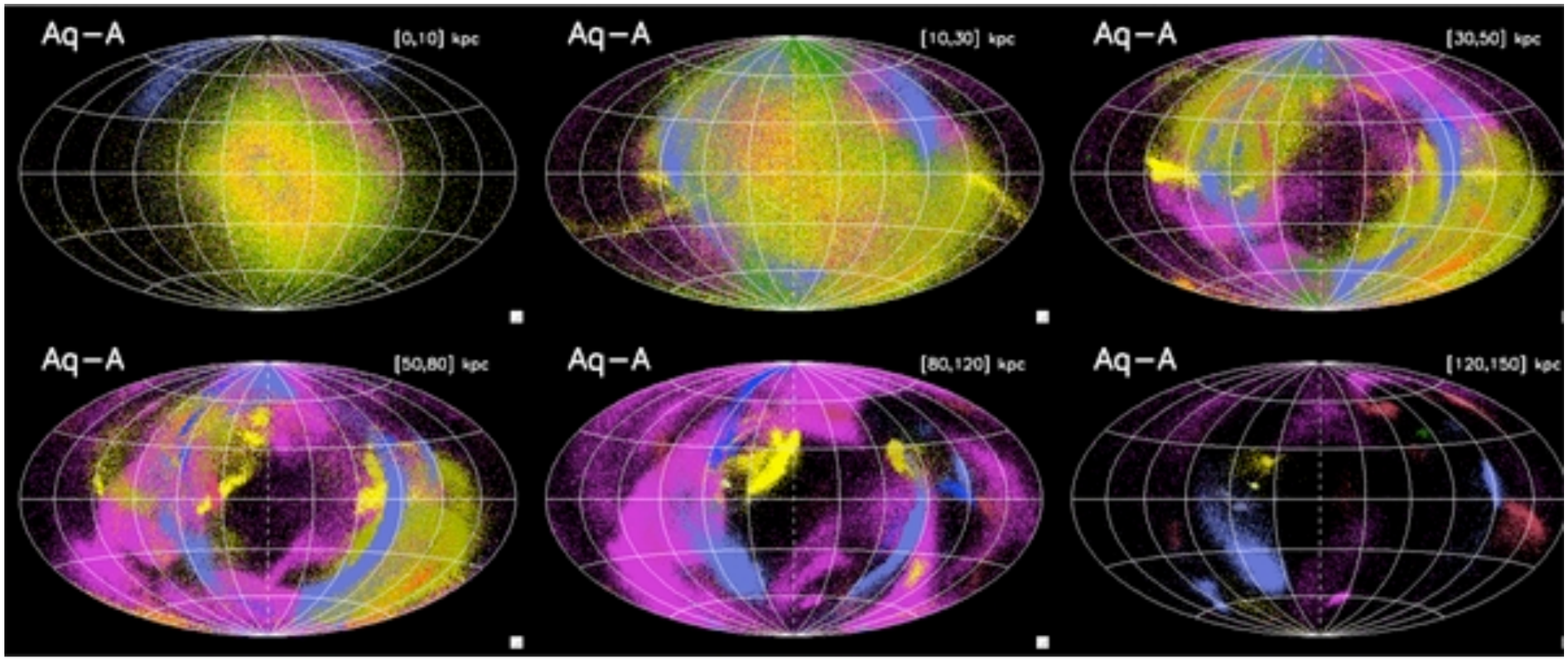
The Milky Way, as other galaxies,
is an evolving system,
due to internal and environmental processes as well.

There is not a unique process which determined the formation of the different Galactic components, but very likely several processes, which played a role (maybe?) at different times.

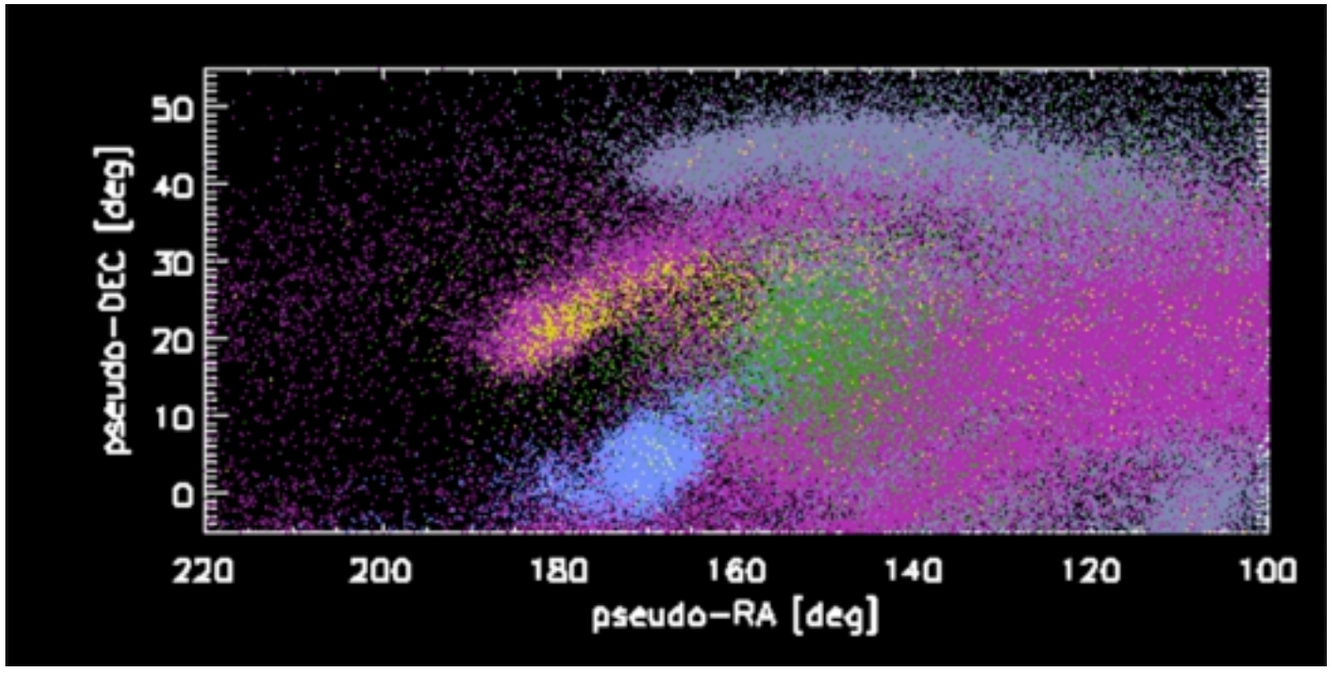
➡ What is the role that
the redistribution of angular momentum,
the accretion of satellites,
gas accretion from cosmological filaments,
starburst episodes, ..
had in assembling the Galaxy?

➡ Which signatures did these processes leave in the characteristics of the different components?

SIGNATURES OF MINOR MERGERS IN THE STELLAR HALO



Substructures in the simulated stellar halos, formed by the disruption of satellite galaxies



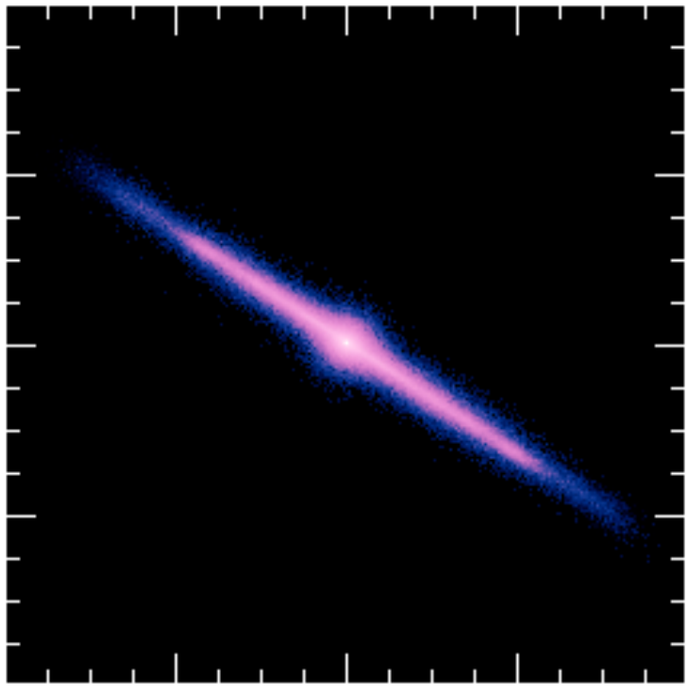
Helmi et al. 2011

Broad overdensities and very narrow faint streams like those observed around the Milky Way

The substructures are distributed anisotropically on the sky, because of the correlated infall directions and also due to group infall.

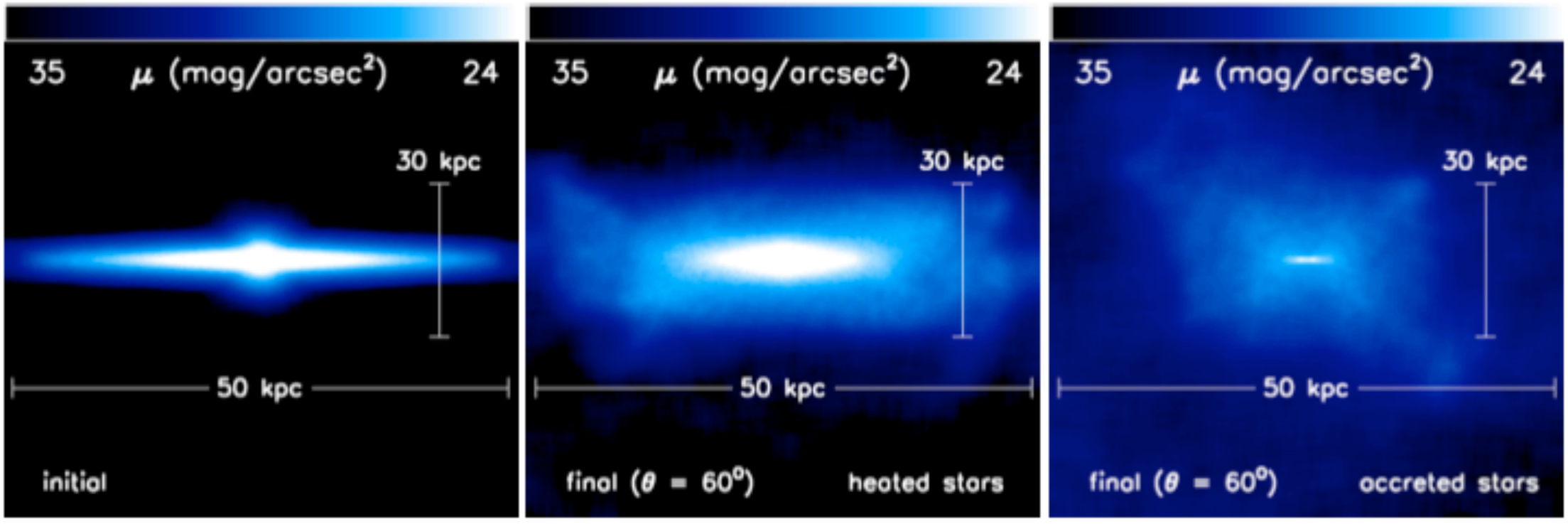
THE DUAL NATURE OF THE STELLAR HALO

see also Font et al. 2012



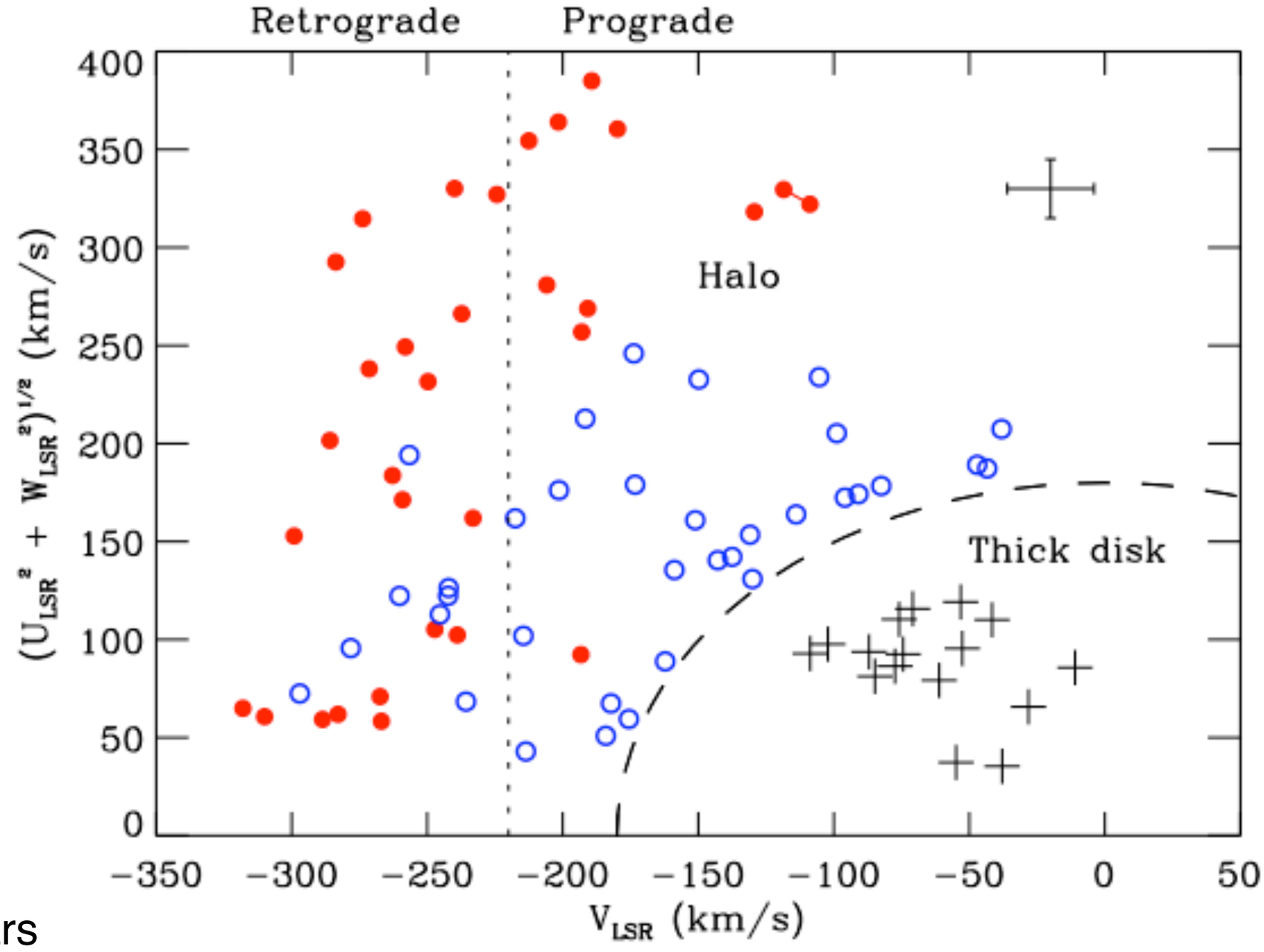
➡ Minor mergers can eject disc stars into a diffuse light component that resembles a stellar halo both spatially and kinematically

➡ ~ 1% of the initial disc stars in the solar neighbourhood would be classified kinematically as halo stars.



Purcell et al. 2010, see also Qu, Di Matteo et al. 2011

IS THERE ANY EVIDENCE OF THESE STARS IN THE STELLAR HALO OF THE MW ?



\+ thick disk stars

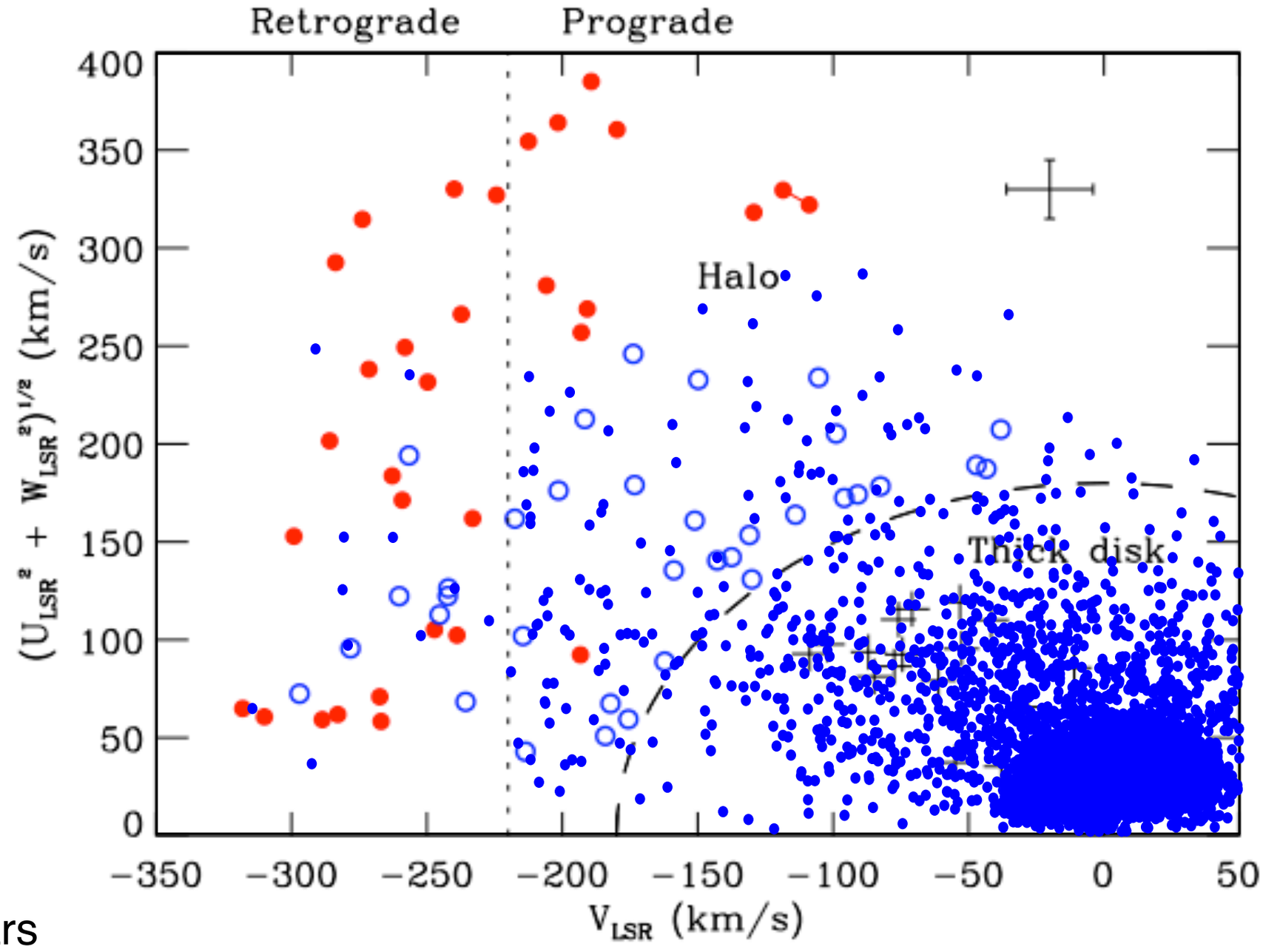
○ △ high alpha halo stars

● ▲ low alpha halo stars

• simulations : stars vertically heated during minor mergers

Nissen & Schuster 2010 + Qu et al. 2011

IS THERE ANY EVIDENCE OF THESE STARS IN THE STELLAR HALO OF THE MW ?



\+ thick disk stars

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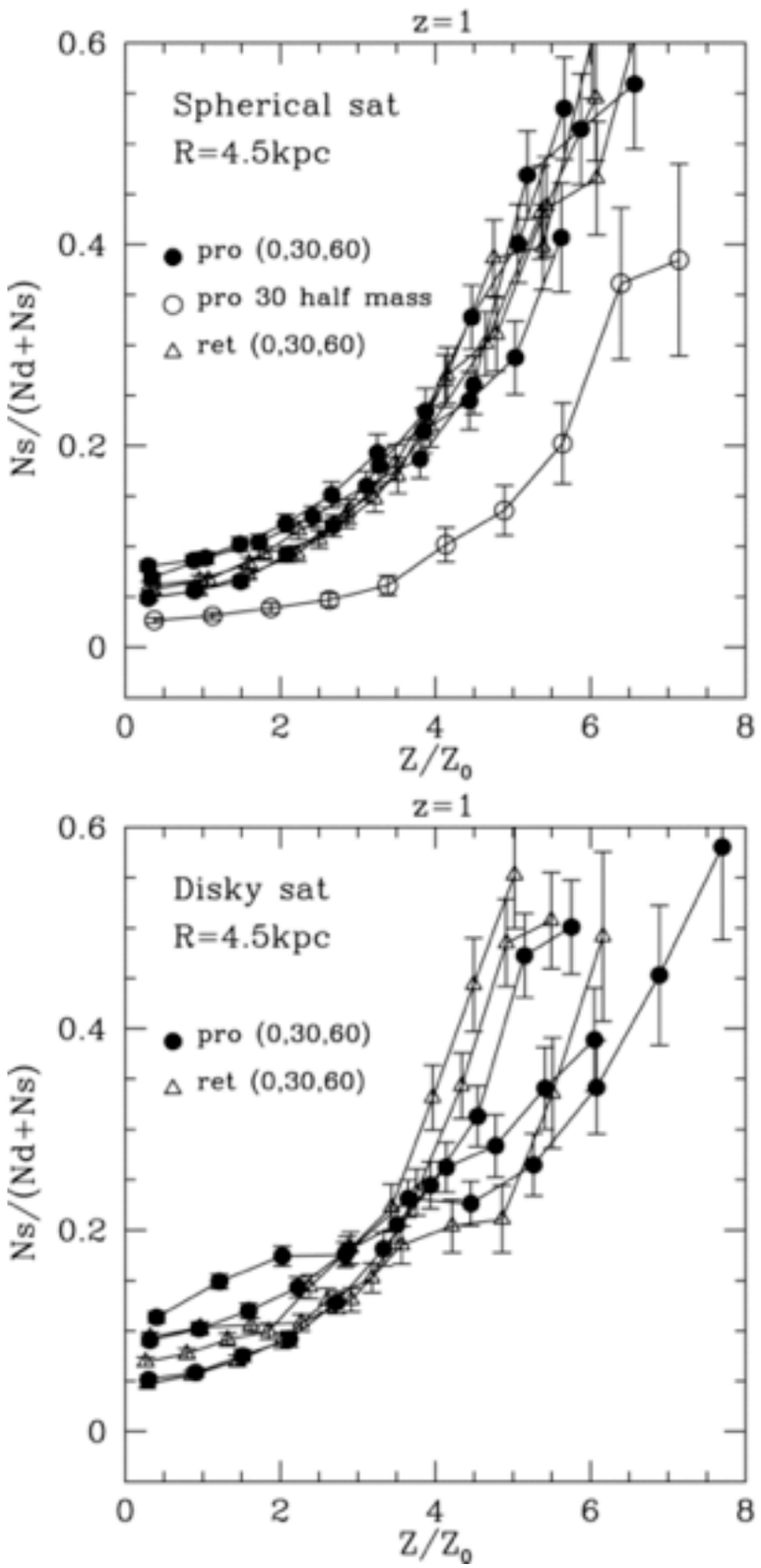
DISTINGUISHING IN SITU FROM ACCRETED HALO STARS



Simulations of minor mergers predict that at ~ z= 5 z_0, the fraction of accreted stars ~ fraction of heated stars.

➡ How to characterize and distinguish in situ and accreted stars?

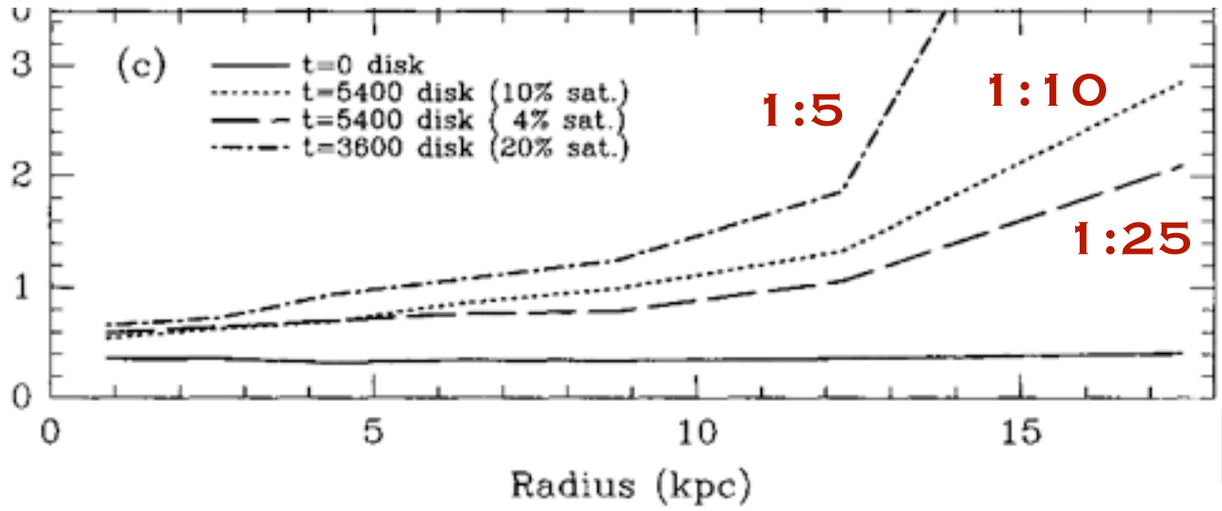
➡ What is the relation between in situ halo stars and thick disk stars?

➡ What is the continuity between the two populations?

Villalobos & Helmi 2008

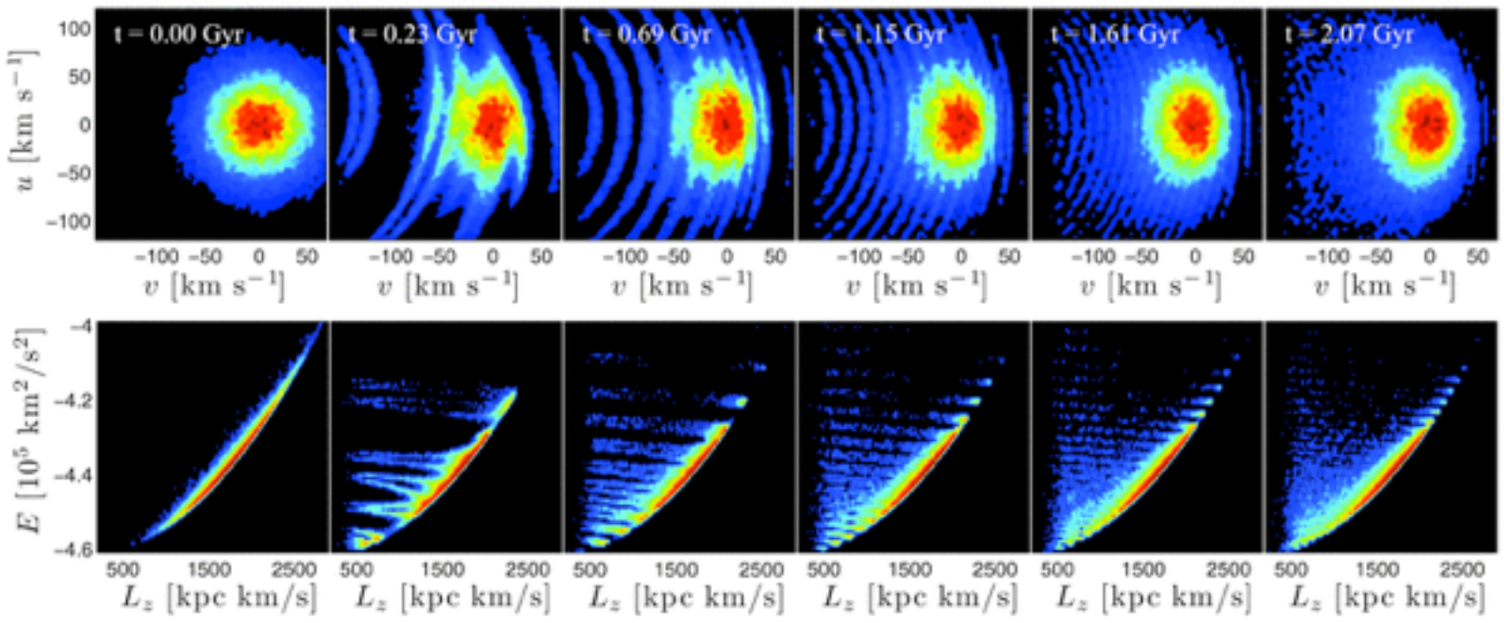
(GLOBAL AND LOCAL) SIGNATURES OF MINOR MERGERS IN THE MW THICK DISK

Flaring of stars in the outer disc



Quinn et al. 1993

Ringing of stars in the disk of the primary galaxy, due to the energy impulse imparted by the satellite when crossing the disk

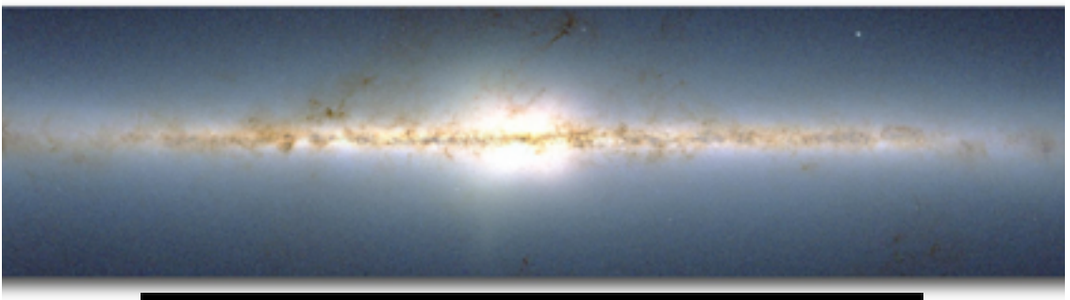


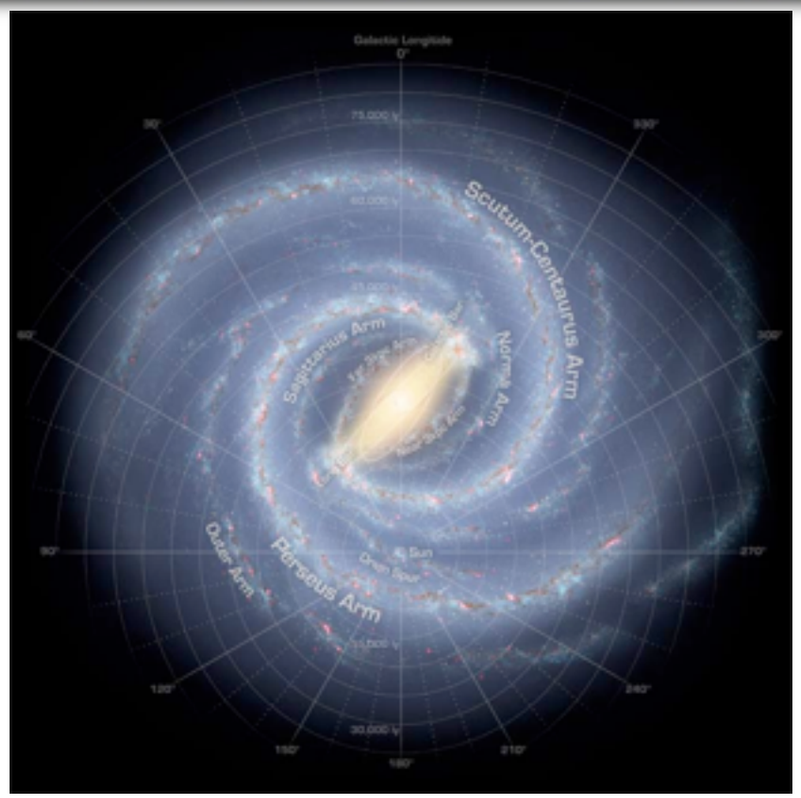
Gomez et al. 2012

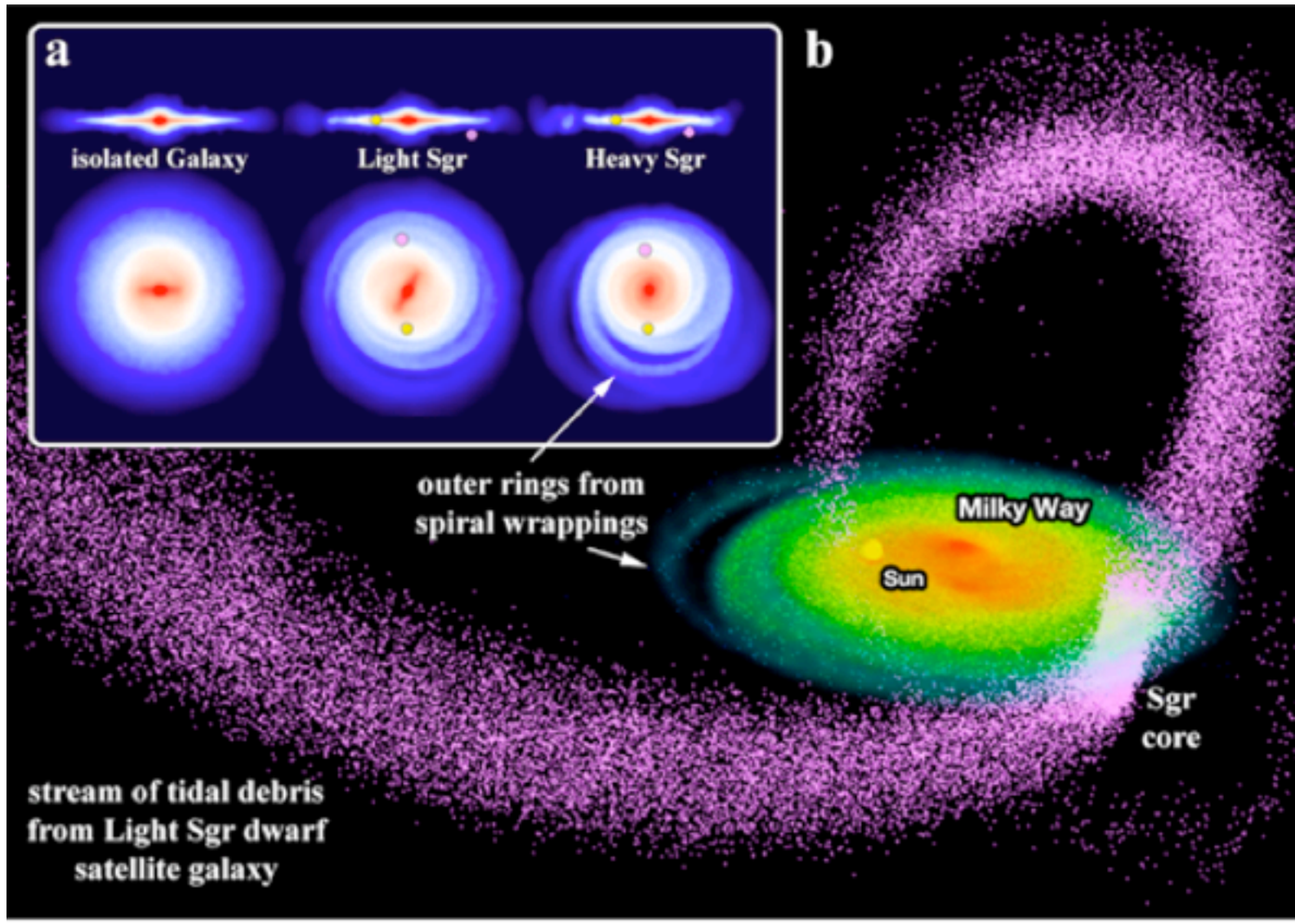
➡ Are there other signatures we can find to characterize the impact of minor mergers on the MW thick disk?

➡ Are these signatures erased if other processes intervene?

GLOBAL CHARACTERISTICS of the MW DISK



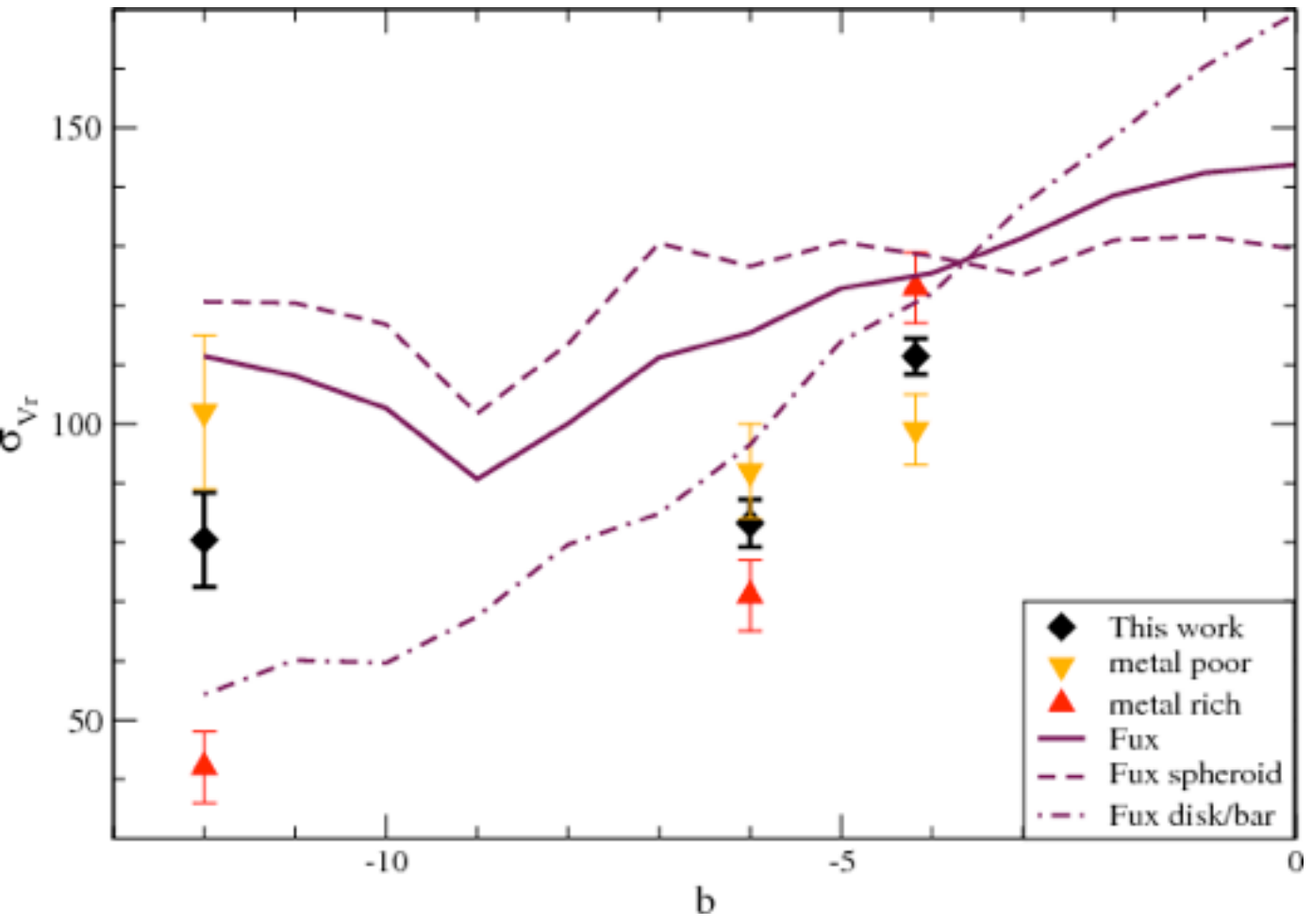




Purcell et al. 2011

➡ To what extent the Milky Way disk structure is secular in origin and how much minor interactions contributed in shaping it?

THE COMPLEXITY OF THE MILKY WAY BULGE

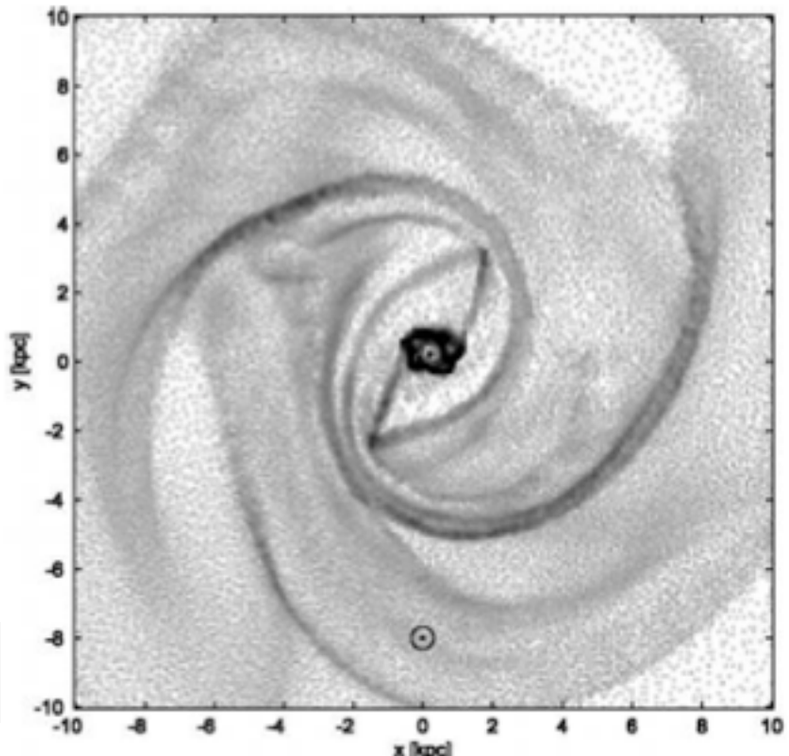


Babusiaux et al. 2010

Two distinct populations :

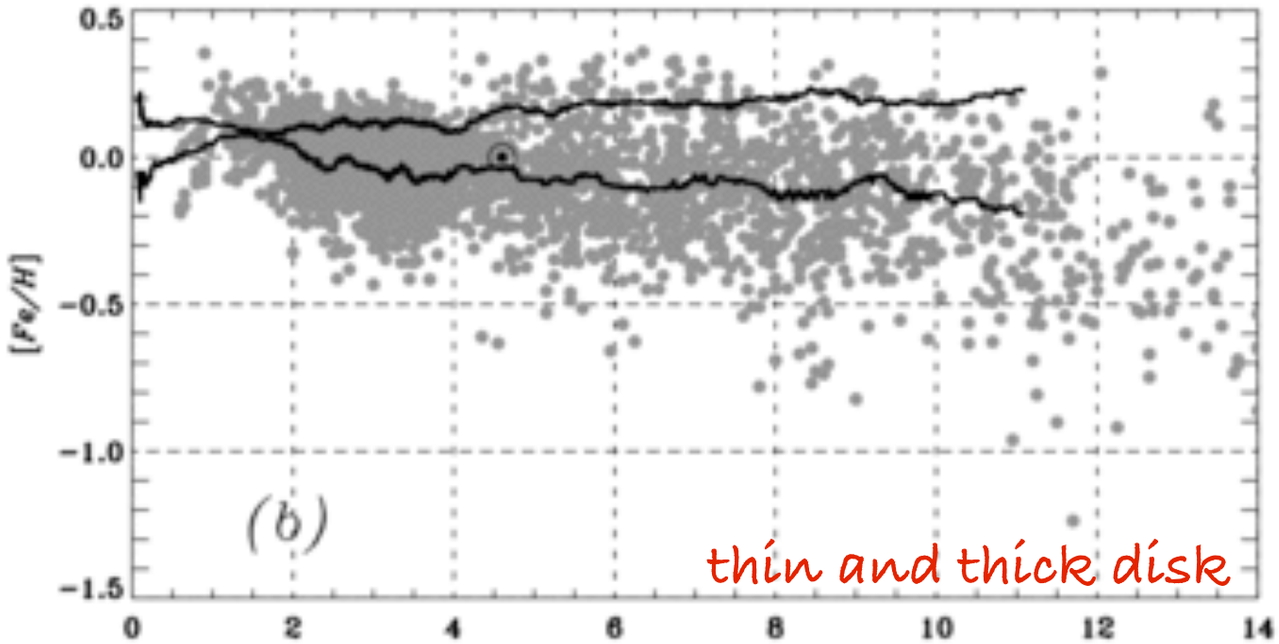
1. a metal-poor component that it is consistent with an isotropic rotating population and that is enriched in [Mg/Fe]
2. a metal-rich component consistent with that expected from a population with orbits supporting a bar and with [Mg/Fe] near solar.

Old spheroid with a rapid time-scale formation
+
pseudo-bulge formed over a long time-scale through disc secular evolution under the action of a bar

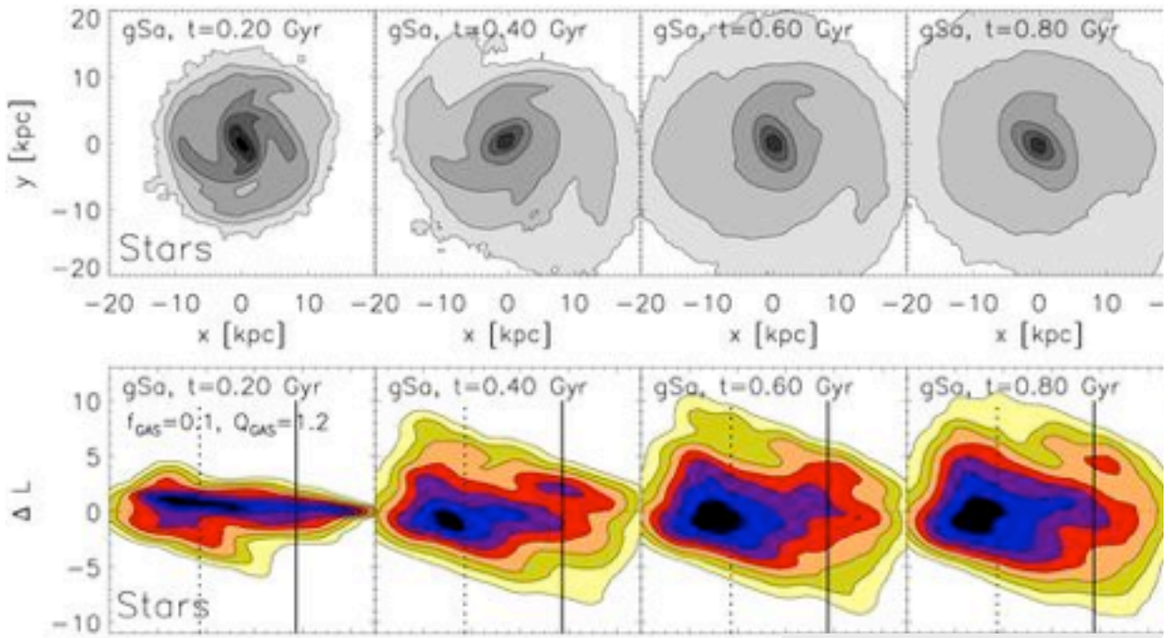


Fux et al. 1997

DISPERSION IN LOCAL SAMPLES



Haywood 2008

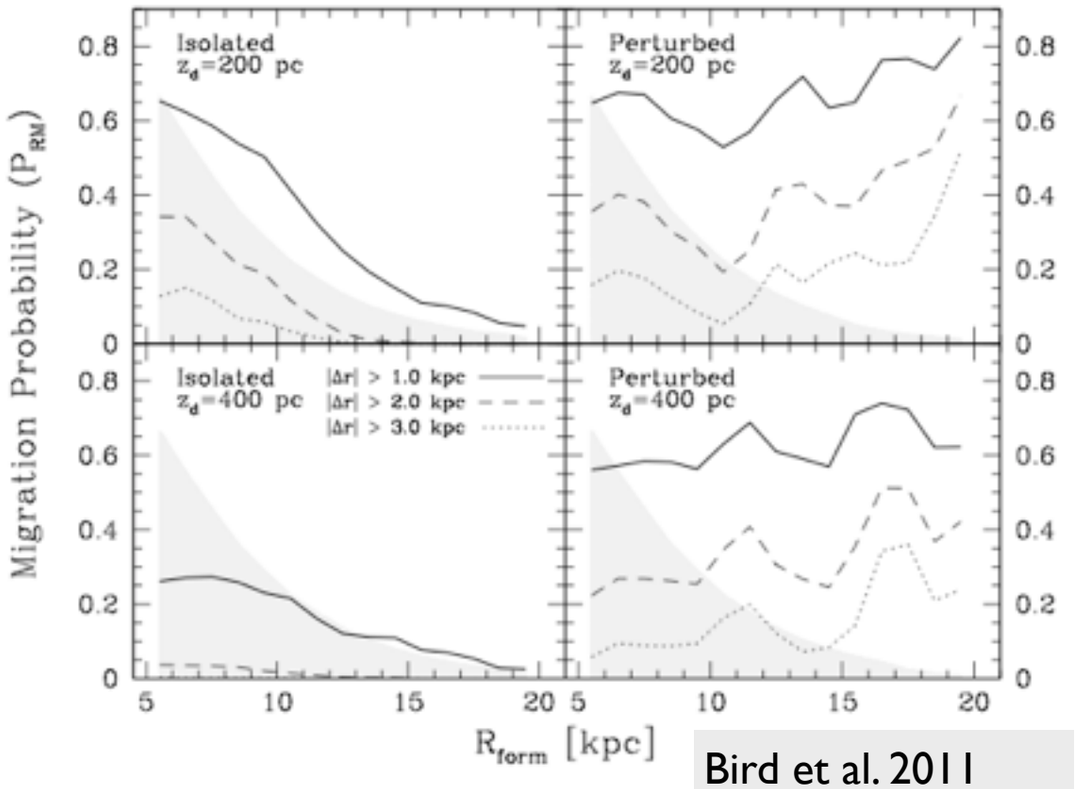


Minchev et al. 2010

High dispersion in the metallicity at every age

Very likely a sign of radial mixing due to the effect of bar and/or spiral arms

Radial mixing can be strengthened by external processes, like satellites accretion



Bird et al. 2011

N-body SIMULATIONS

<u>Waiting for Gaia data:</u>

keep characterizing the signatures of different formation scenarios on the Galactic components;

couple the dynamics and the chemical evolution, to look for a coherent picture of Galaxy formation and evolution

Are the structural, kinematical and chemical signatures we find unique?

Are they erased if other processes intervene?

Predictions need to be robust.

- Results often depend on an important number of parameters.

This dependence needs to be quantified. How probable a certain outcome is ?

➡ This requires a large number of realizations

- Need to explore structures and substructures.

➡ This requires a high spatial resolution (~ 10 pc), at the limit of the current simulations.

FROM N-body SIMULATIONS to MOCK CATALOGUES

➡ How many of the signatures predicted by the simulations are still visible in the catalogue?

➡ (*Daisuke*) How different the mock catalogue is from the simulations we have used to build it? If, for example, we compute the disk scale length from the mock catalogue, how different this value is from the value obtained analysing "directly" the simulations?

➡ How many different mock catalogues we can build, starting from the same simulation? How strongly the assumptions made in building the catalogue (ages and masses of stellar components, dust extintion, ..) impact on the final result?

➡ Need to be extremely cautious when comparing catalogues to observations (or catalogues between them).
The characteristics we will see may be not only a signature of the processes under study, but *also* of the way the catalogue has been built.