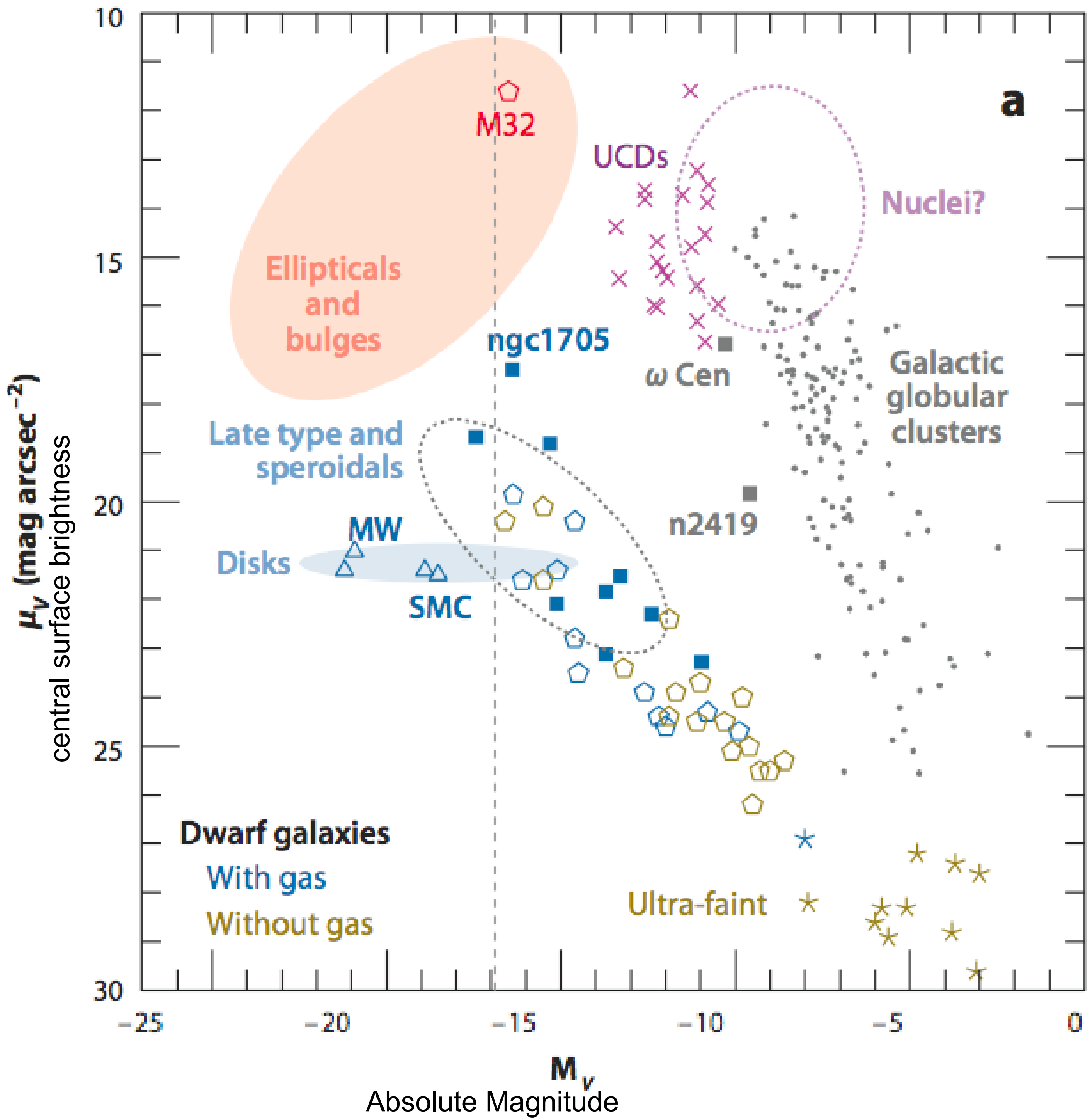
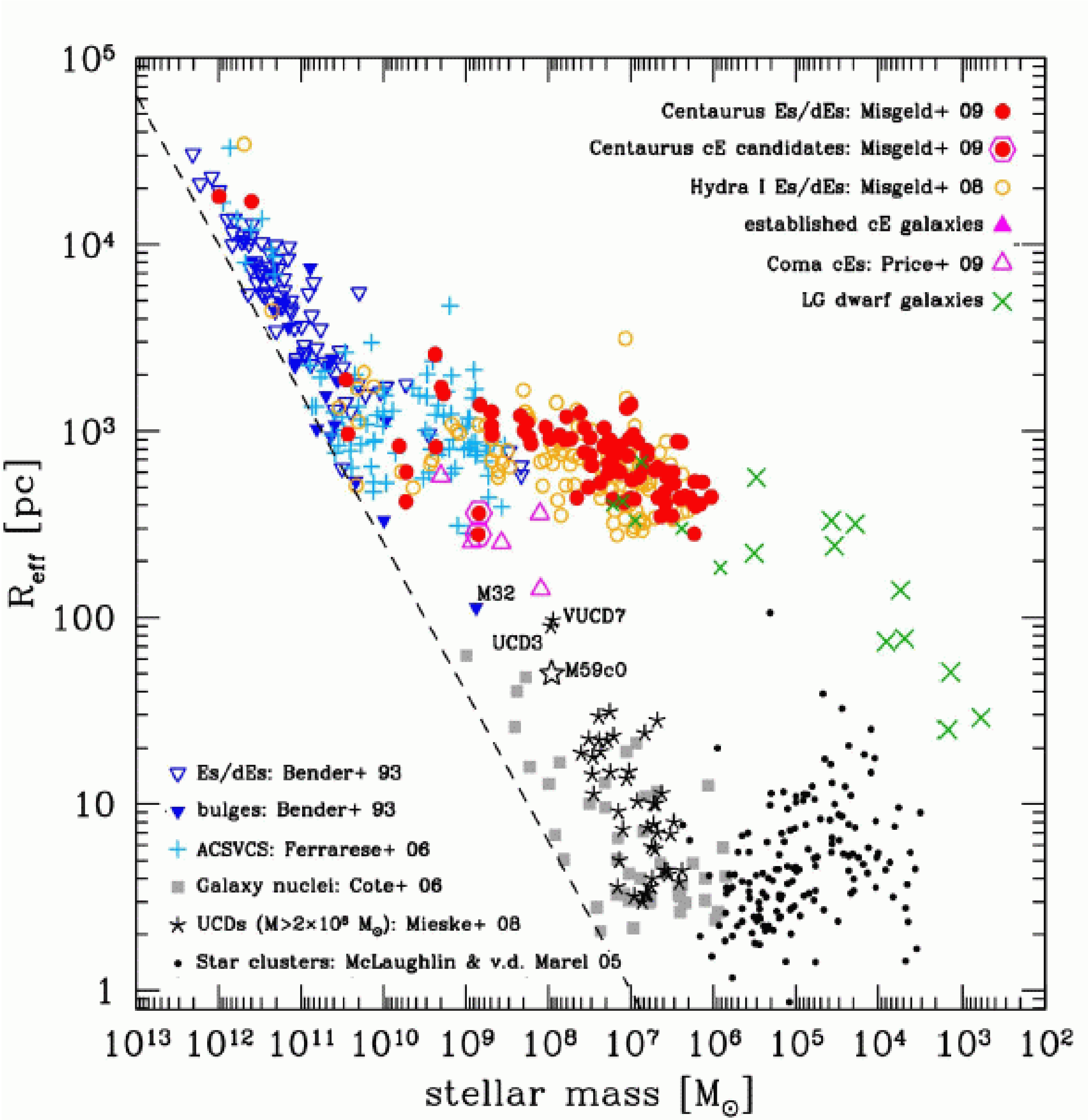


The Groningen view

(Some) dwarfs on top!

Tolstoy



The Heidelberg view

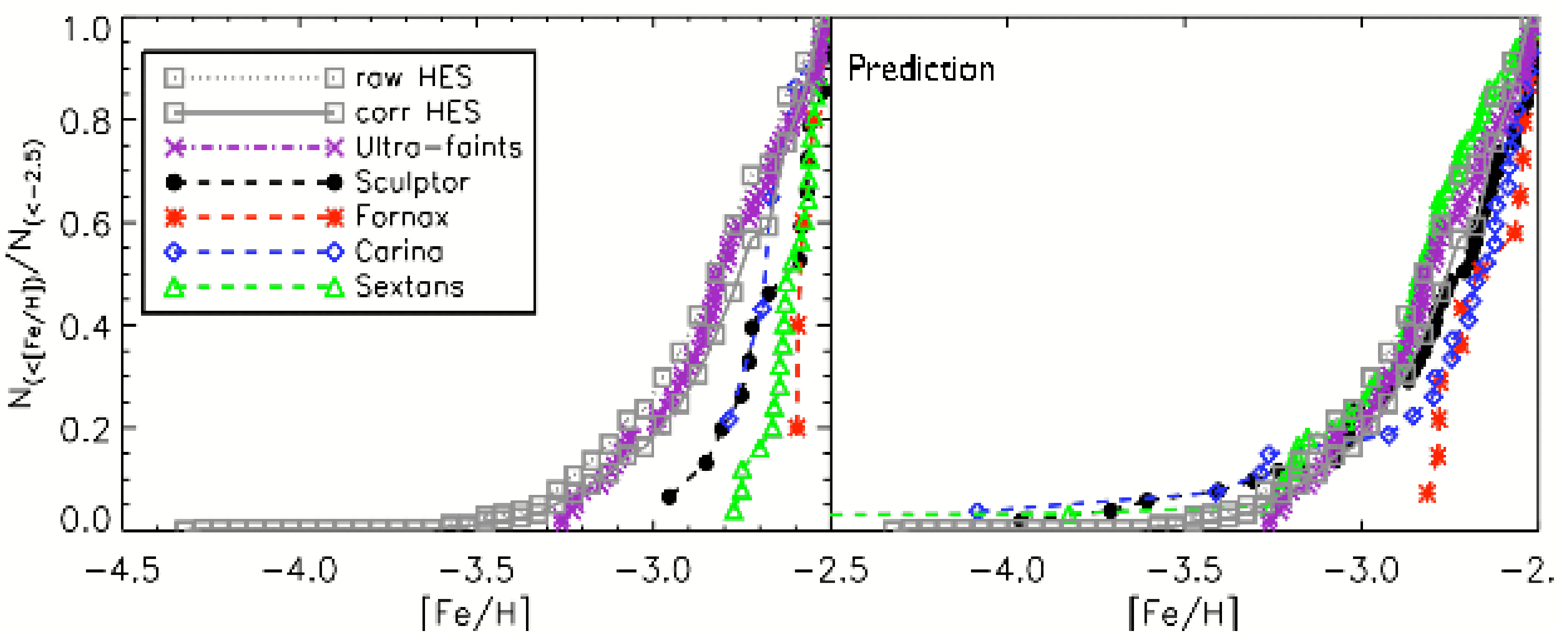
Galaxies according to their true stature

Lisker

Implications of the new CaT calibration

- Predicts better match with the metal-poor tail of the Milky Way

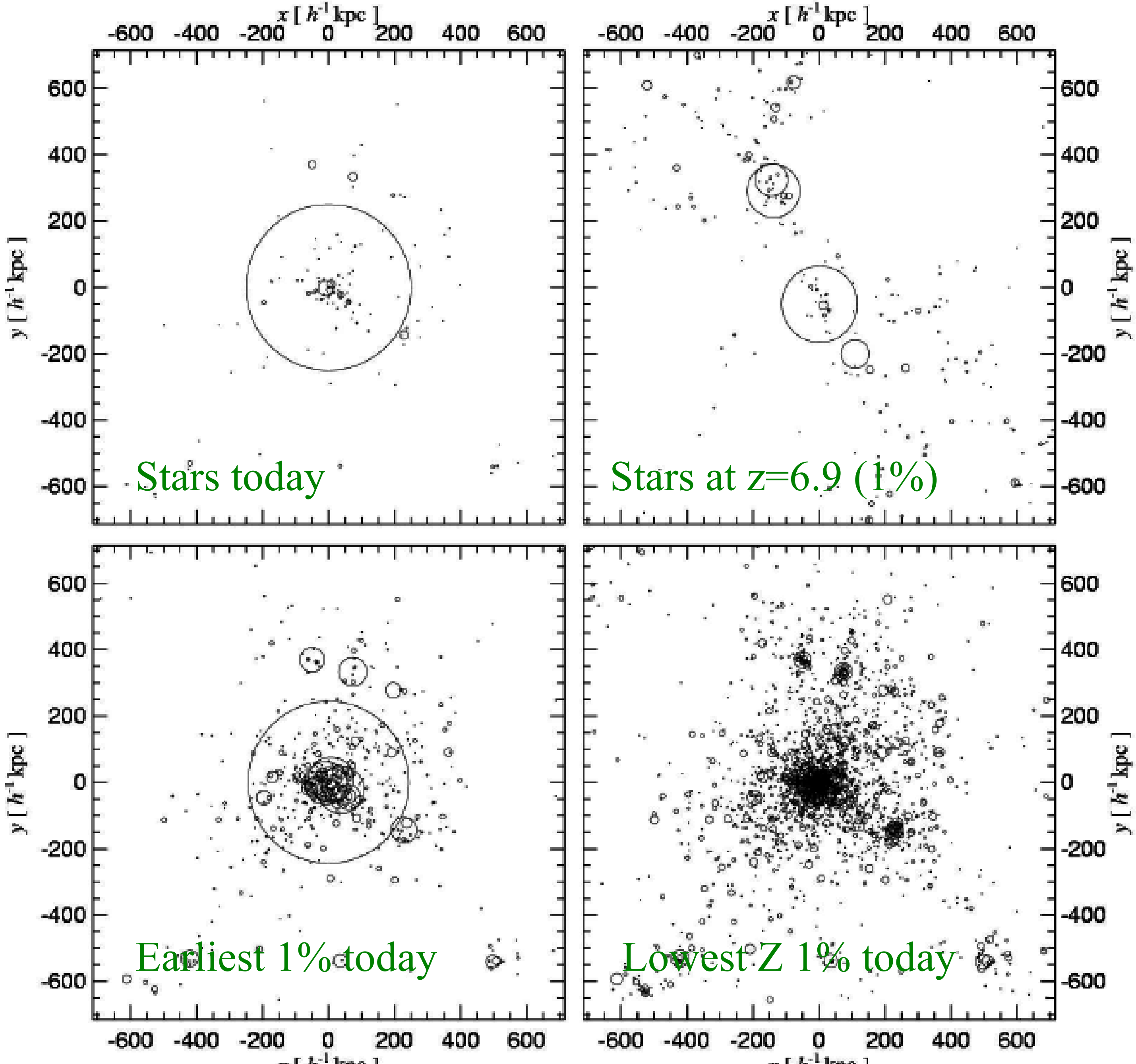
MW halo: Schörck et al. 2009
Ultrafaints: Kirby et al. 2008



Stellar halo could be made from dSphs?
Lowest Z's are the first stars?

Starkenburg

Where are the first (lowest Z) stars now?



Hi-res simulation of the formation of a “Milky Way” and its satellites

“First stars” have little correlation with “lowest Z” stars.

Most “old stars are in the bulge

Most lo-Z stars are in satellites (60%) or their debris (30%)

White & Springel 1999

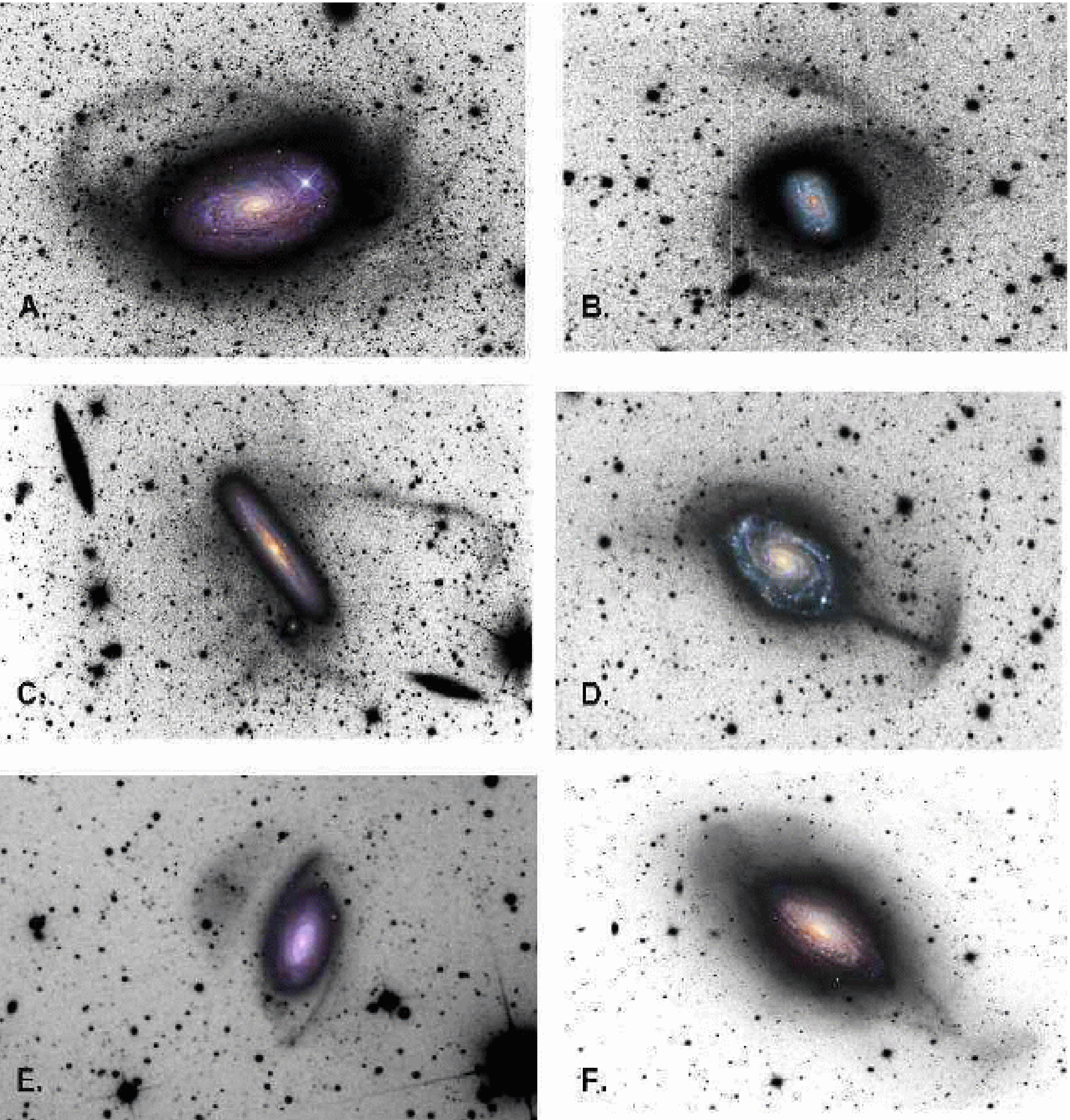
The first stars were metal-poor

but

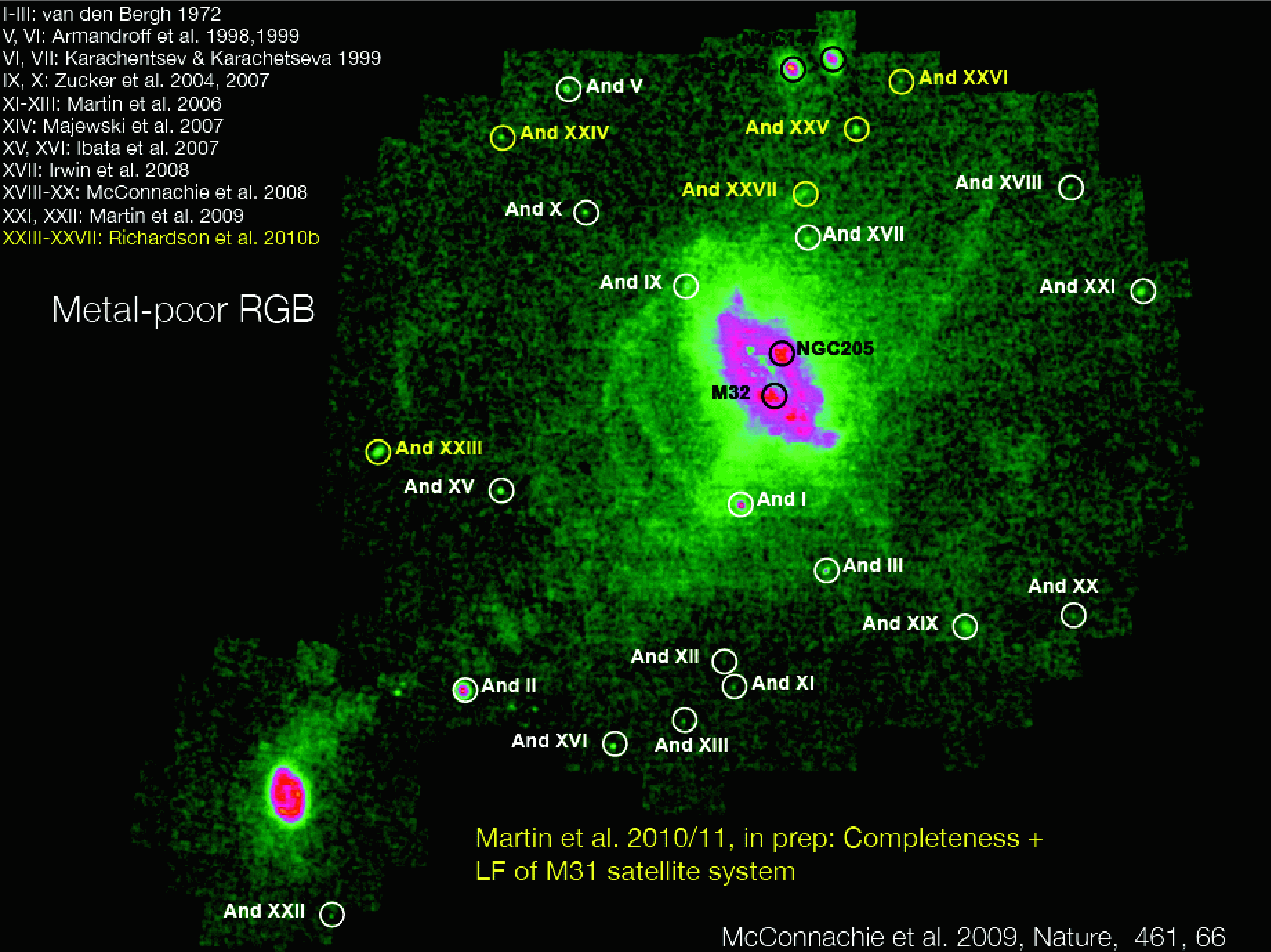
Today's most metal-poor stars are not the oldest stars
-- rather they formed in the smallest systems

While metal-poor stars are in all objects, metal-rich stars are only in massive objects

→ It is the <u>mean metallicity</u> of the MW halo which betrays its progenitors, not the low-Z tail



Martinez-Delgado et al 2010



I-III: van den Bergh 1972
V, VI: Armandroff et al. 1998,1999
VI, VII: Karachentsev & Karachetseva 1999
IX, X: Zucker et al. 2004, 2007
XI-XIII: Martin et al. 2006
XIV: Majewski et al. 2007
XV, XVI: Ibata et al. 2007
XVII: Irwin et al. 2008
XVIII-XX: McConnachie et al. 2008
XXI, XXII: Martin et al. 2009
XXIII-XXVII: Richardson et al. 2010b
Metal-poor RGB
And V
And XXVI
And XXIV
And XXV
And XXVII
And XVIII
And X
And XVII
And IX
And XXI
NGC205
M32
And XXIII
And XV
And I
And III
And XX
And XIX
And XII
And II
And XI
And XVI
And XIII
Martin et al. 2010/11, in prep: Completeness +
LF of M31 satellite system
And XXII
McConnachie et al. 2009, Nature, 461, 66

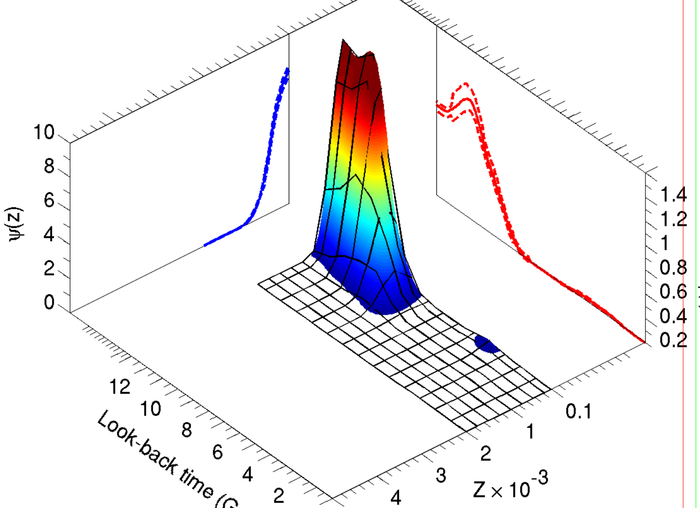
Results

The LCID project
Local Cosmology from Isolated Dwarfs

Sebastian L. Hidalgo & LCID team

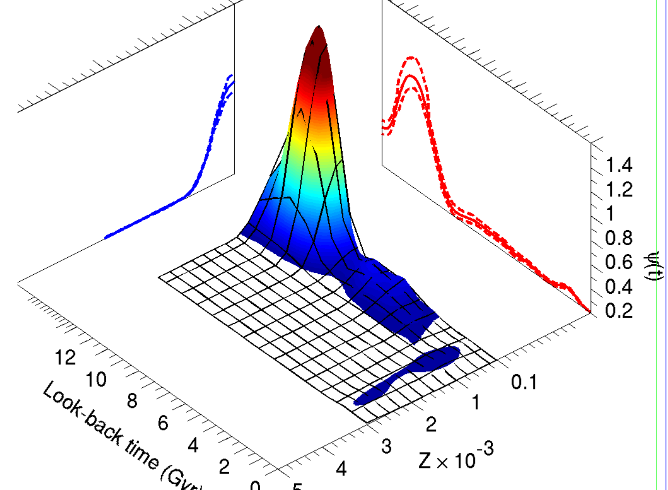
dSph | tran | dIrr

CETUS



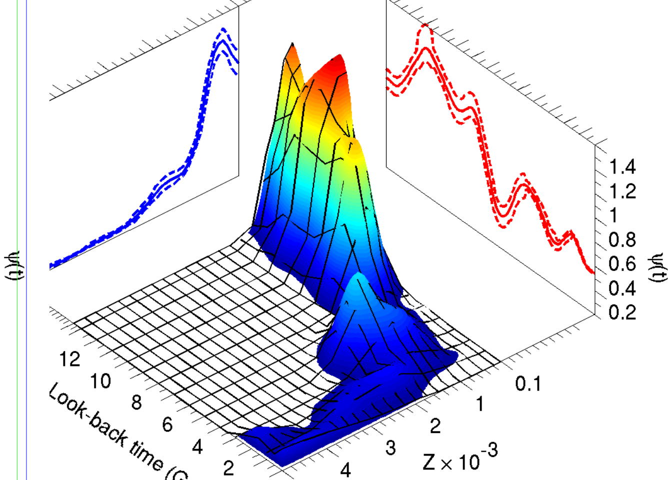
Monelli et al (2010)

LGS-3



Hidalgo et al (2010)

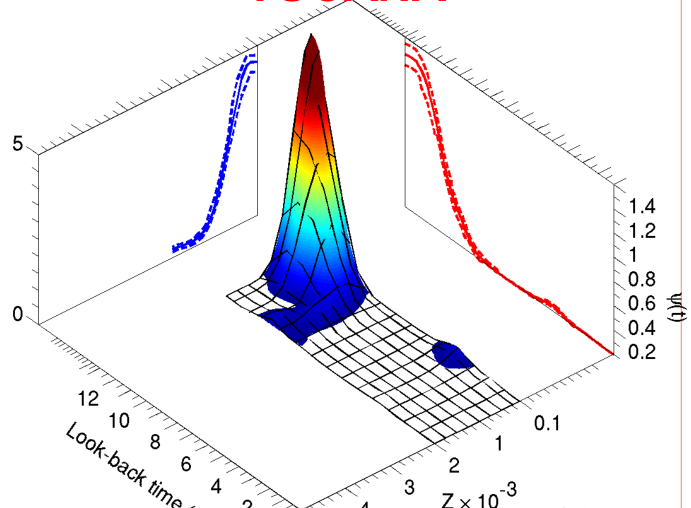
IC1613



Skillman et al (2010)

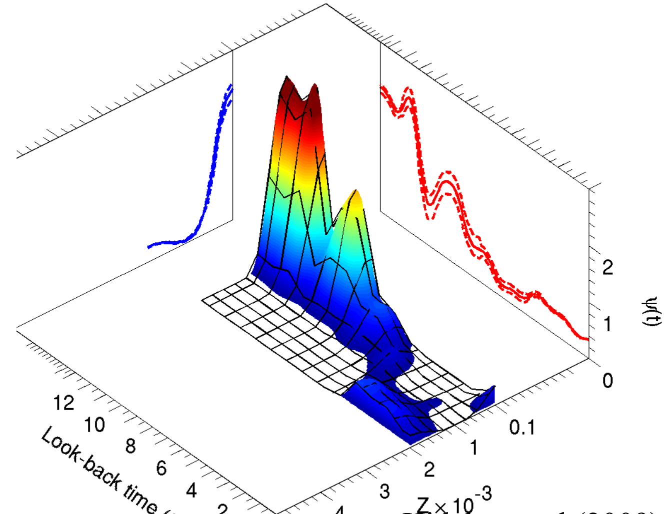
← MORE GAS CONTENT →

TUCANA



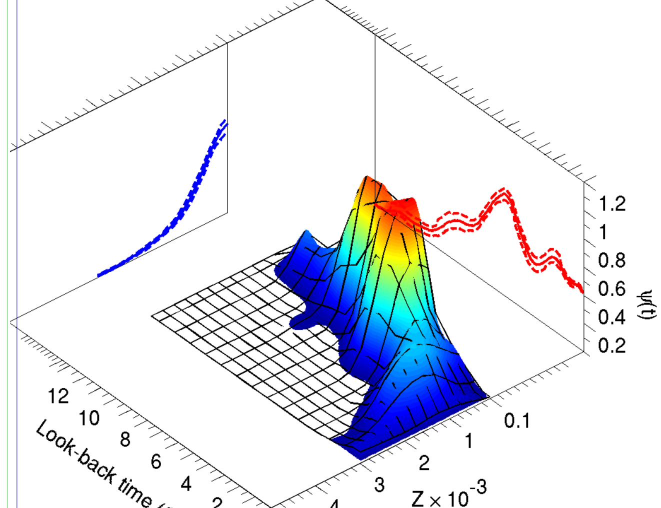
Monelli et al (2010)

PHOENIX

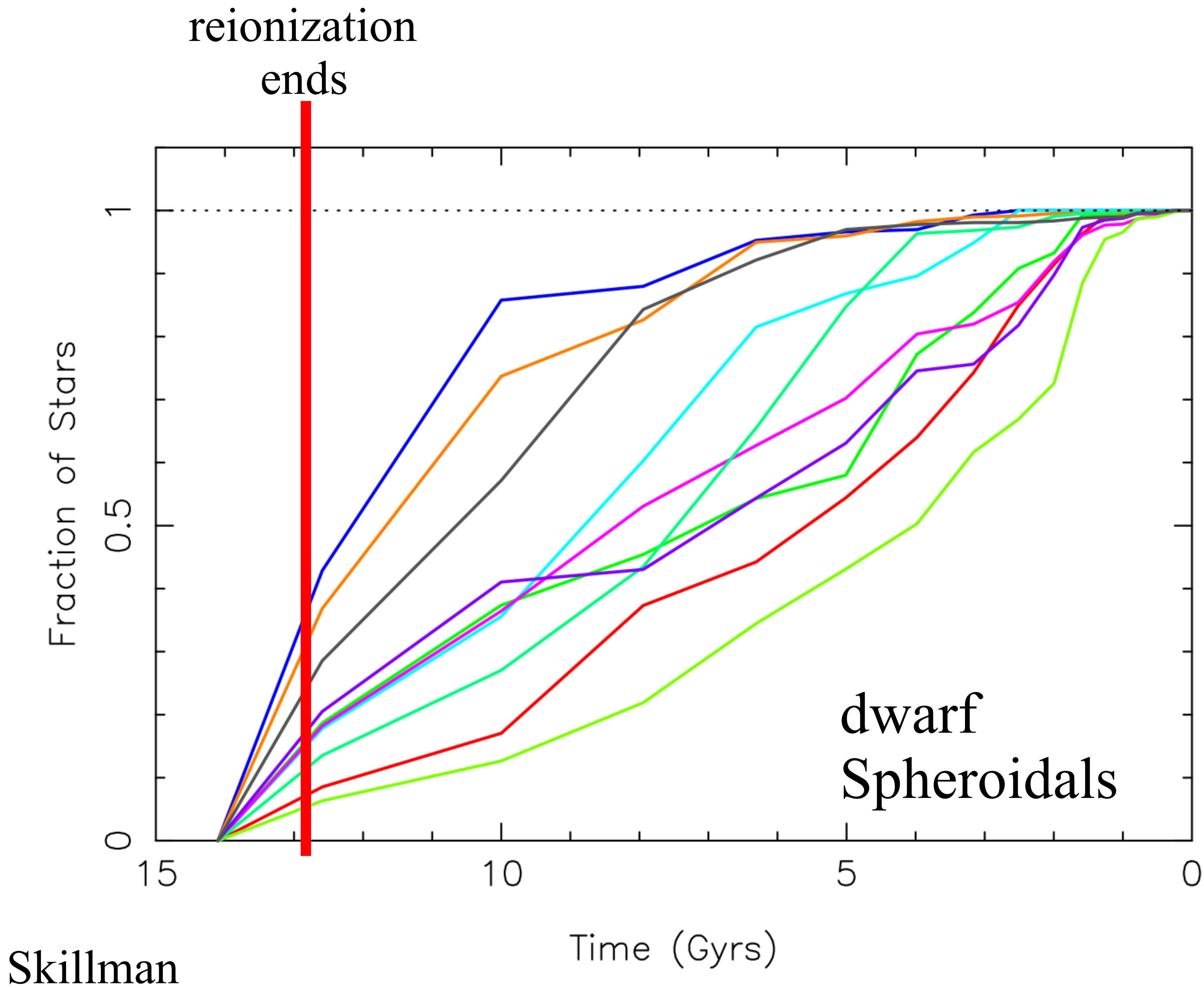


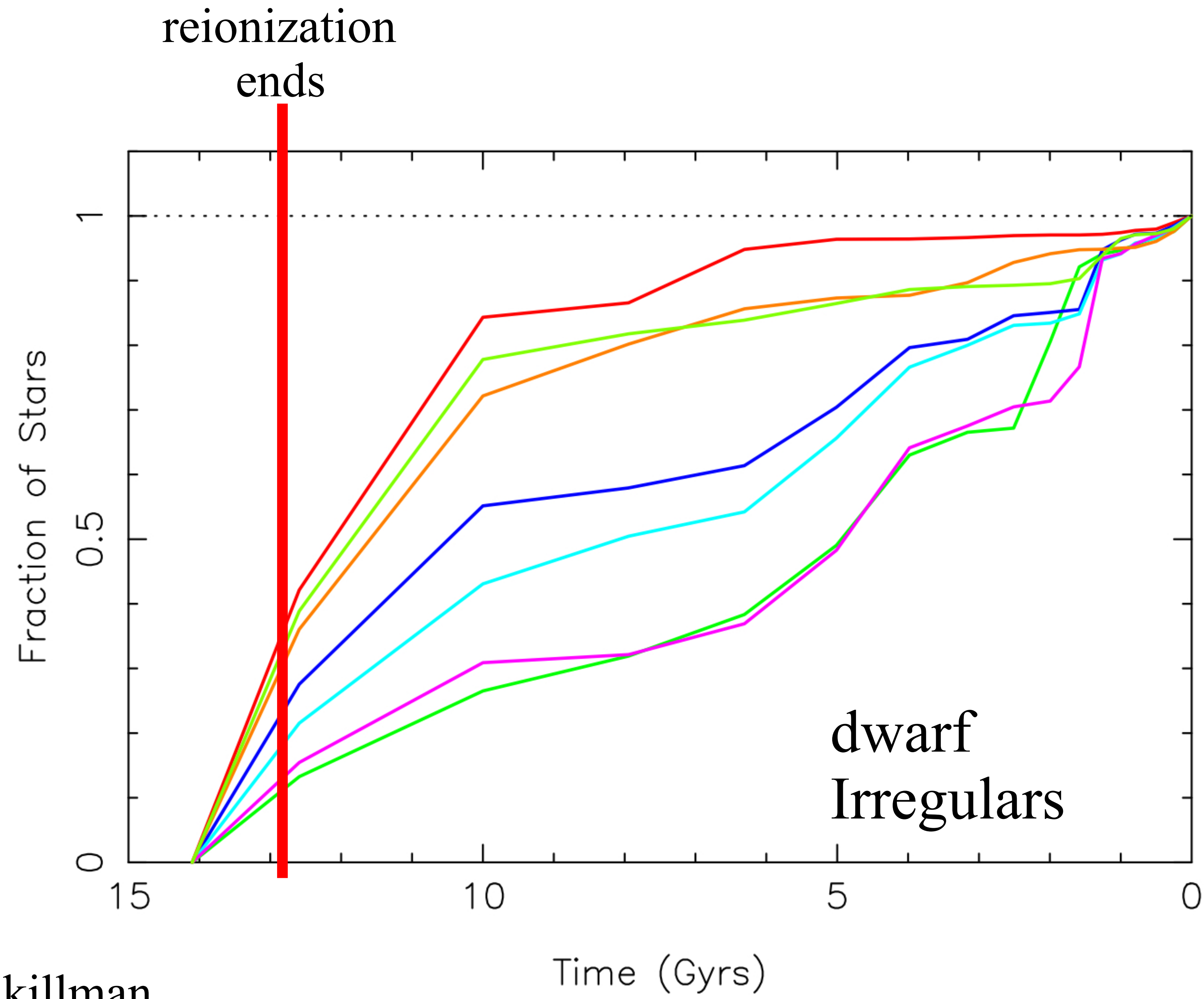
Hidalgo et al (2009)

LEO-A

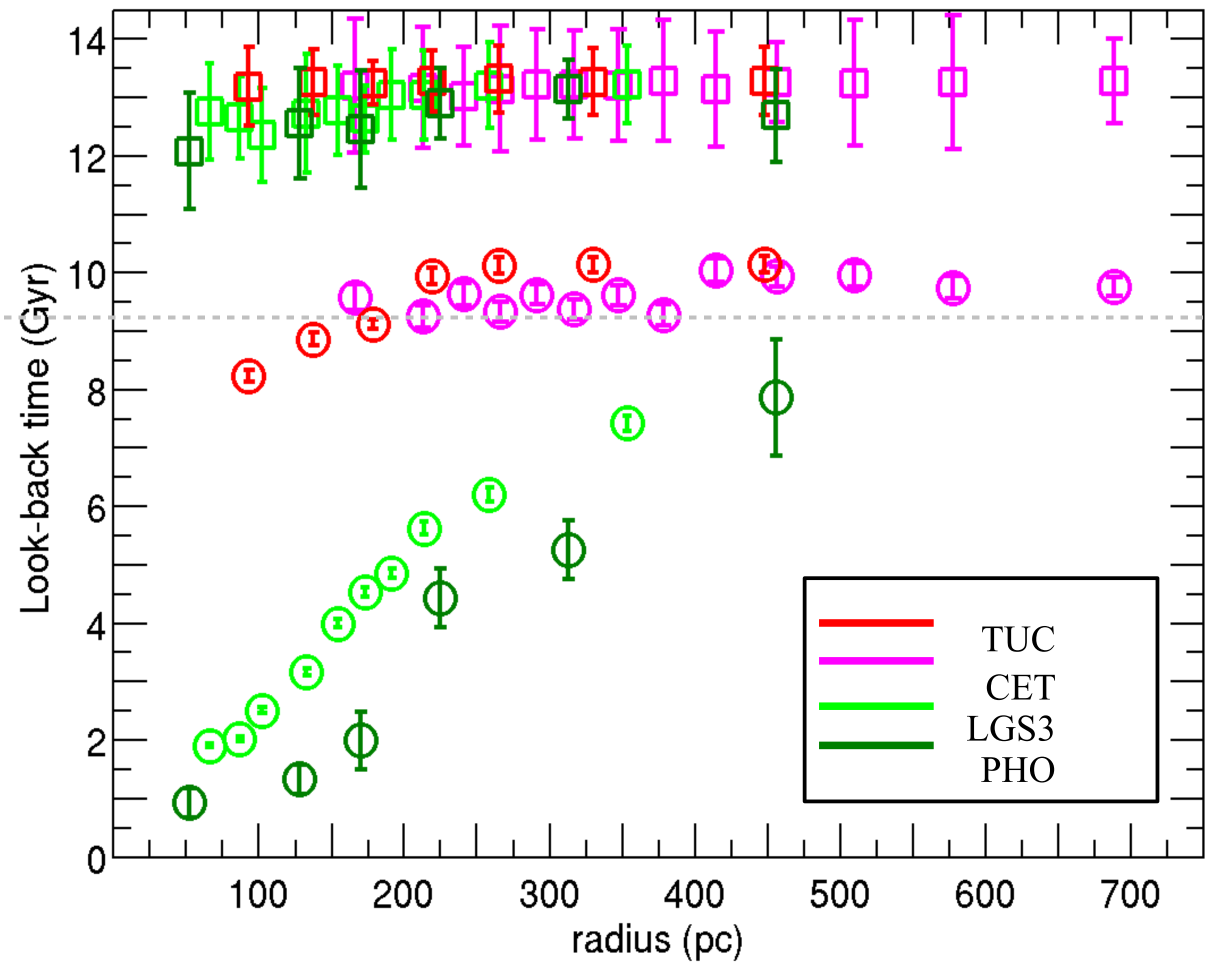


Cole et al (2010)


reionization
ends
Fraction of Stars
1
0.5
0
15
10
5
0
Time (Gyrs)
dwarf
Spheroidals
Skillman


reionization
ends
Fraction of Stars
1
0.5
0
15
10
5
0
Time (Gyrs)
dwarf
Irregulars

Skillman



□ 10-percentile of $\int \psi(t,r)$

(Age of the first star formation event as a function of radius)

○ 95-percentile of $\int \psi(t,r)$

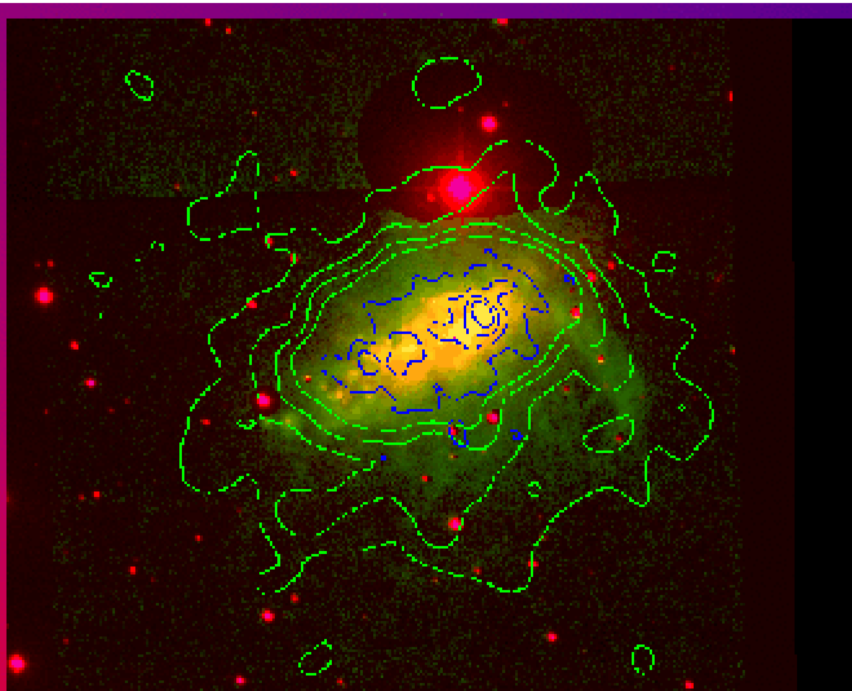
(Age of the last star formation event as a function of radius)

Younger LG dwarfs form outside in!
Little infall of new gas?

Hidalgo

NGC 1569

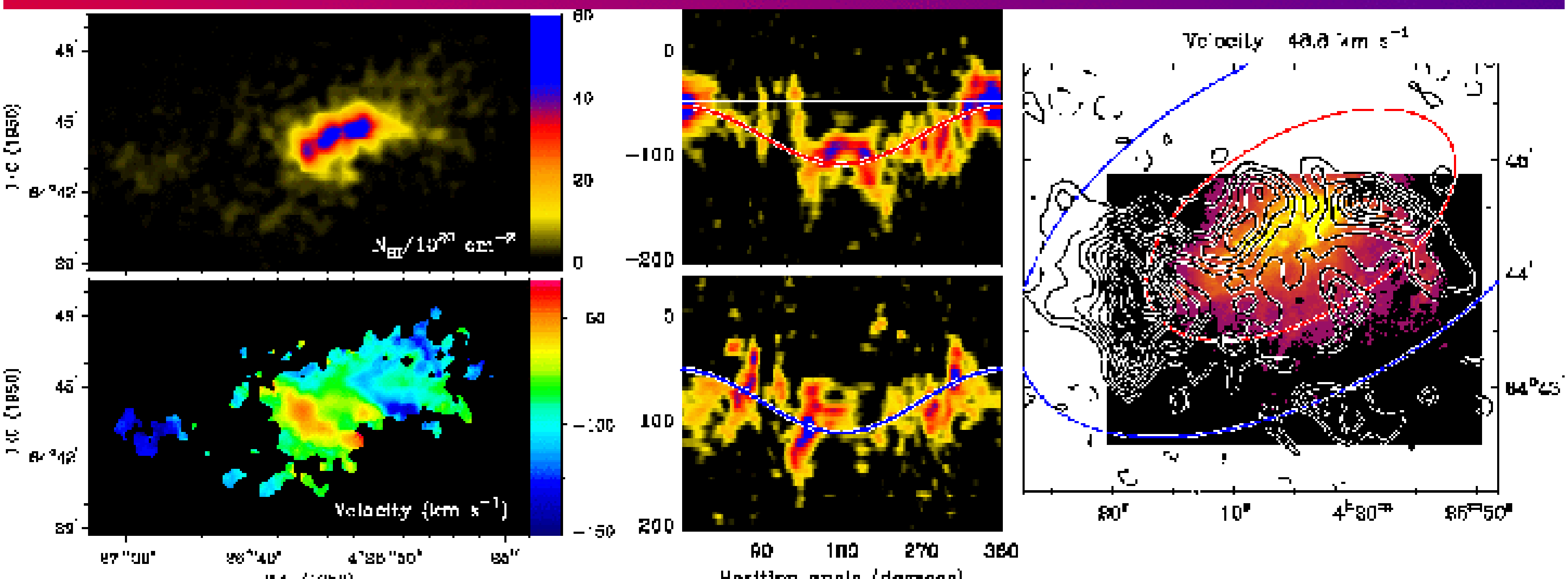
Gas Infall confirmed!?



H_α

HI

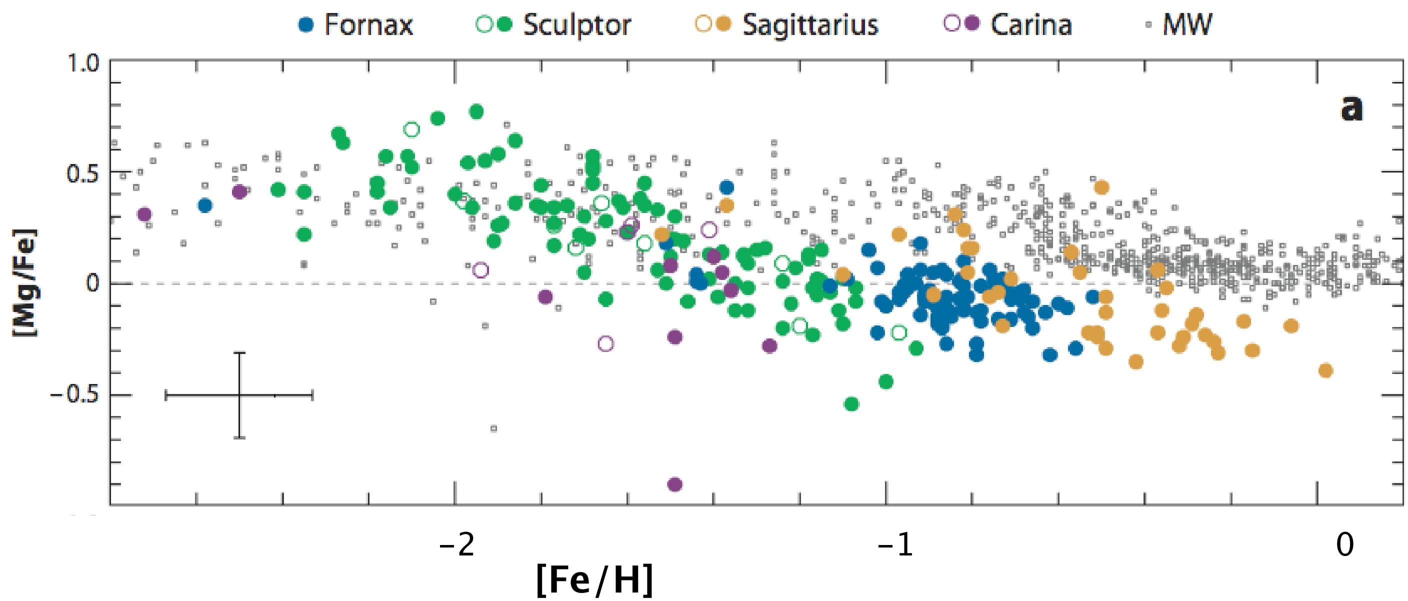
(Stil & Isreal, 2002)



Hensler

α-element abundances in dSph

M_v= -13.2 -11.2 -13.4 -9.3 -20.9



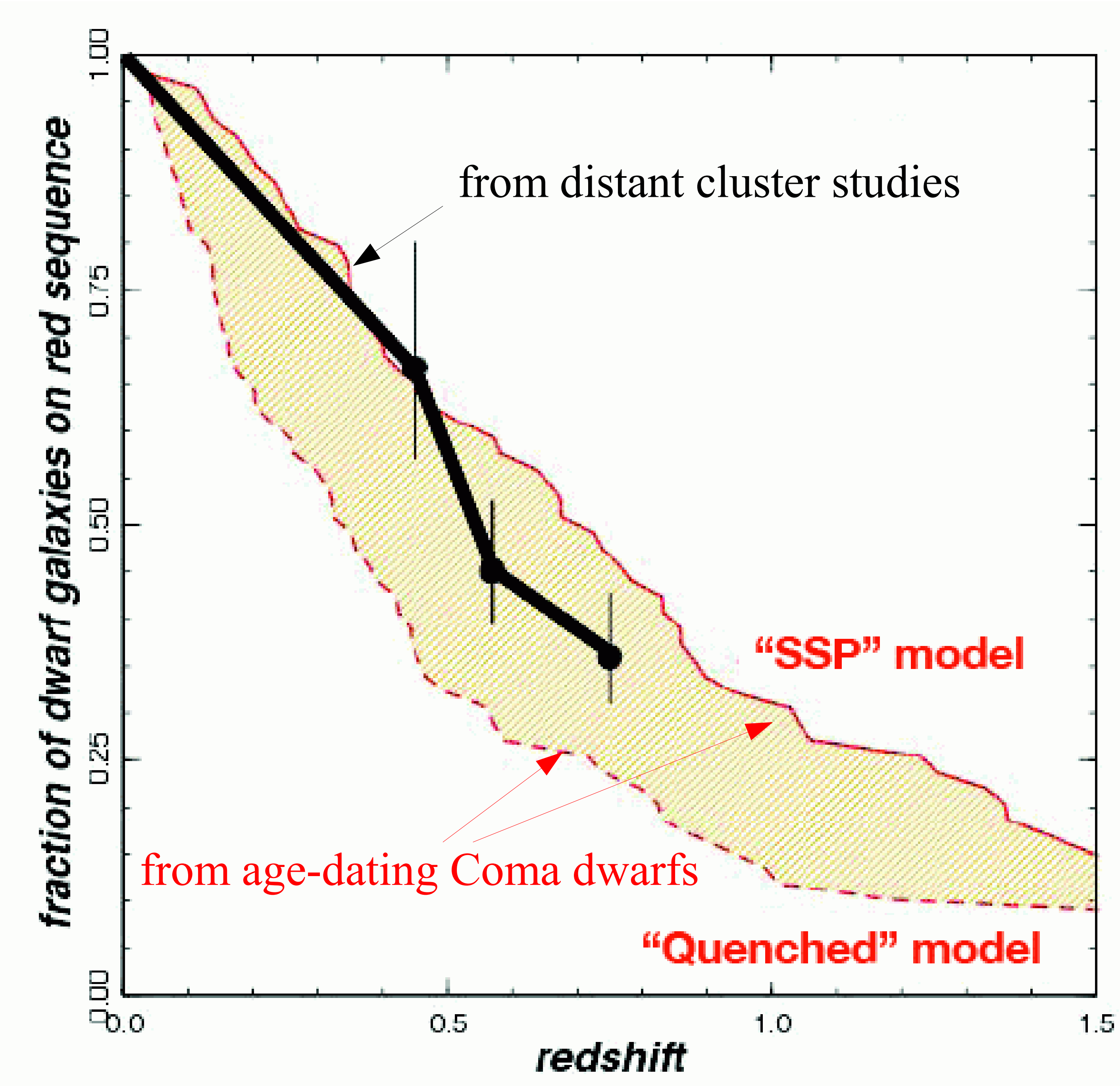
Tolstoy, Hill & Tosi 2009

Transition to solar abundance ratios occurs at lower iron abundance in dSph's than in the MW

Many stars have the SNIa-enhanced values

Tolstoy

Archaeology versus lookback for Coma low lum. E's



High S/N spectra of dE's in the Coma cluster show that many apparently joined the RS at low z

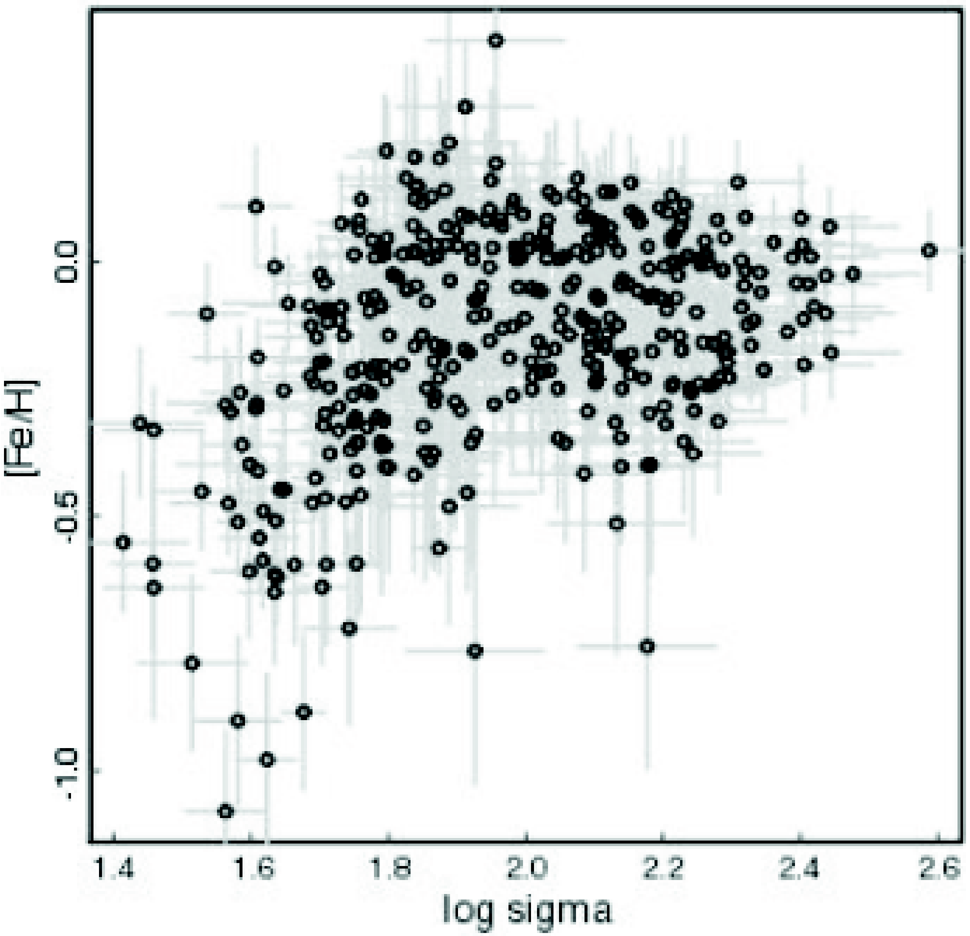
The numbers agree with depopulation of the faint red RS in high-z clusters

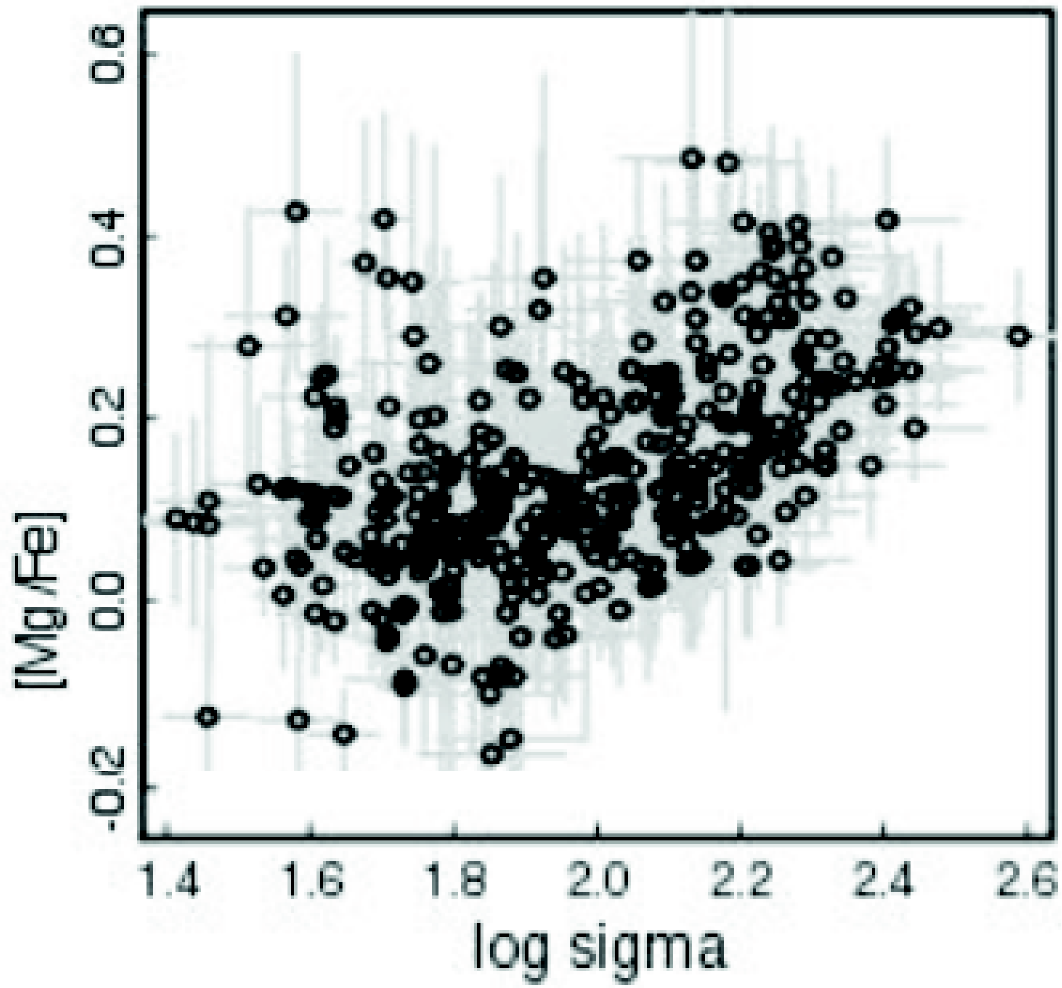
Smith

Dwarfs <u>cannot</u> be the building blocks of large galaxies because they formed later (bricks must predate houses!)

Reionisation cannot have truncated the star formation in most LG dwarfs because they formed most of their stars well after it had completed

Smith

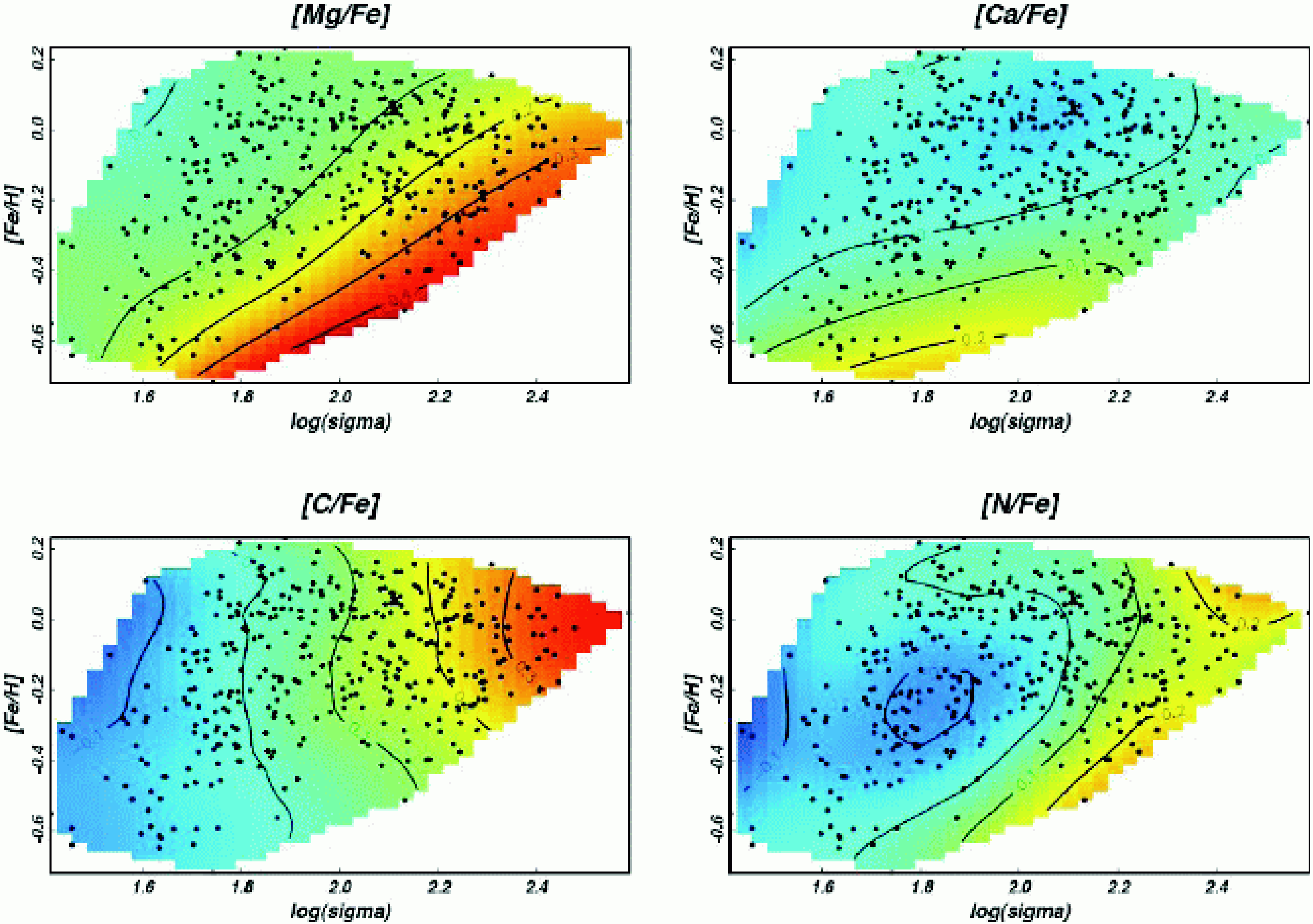




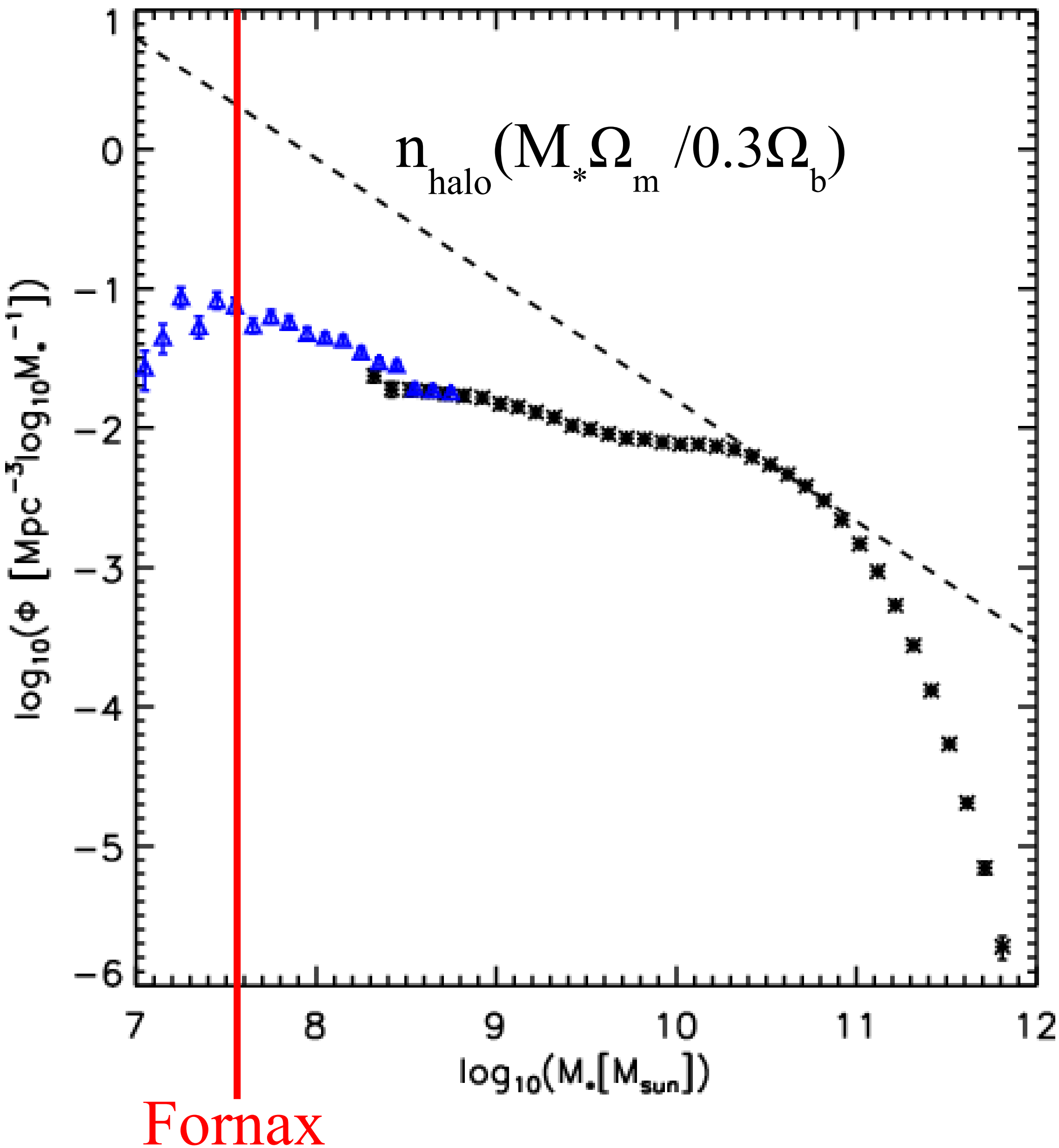
Both [Fe/H] vs. σ and [Mg/Fe] vs. σ show a break at σ = 70 km/s but [Mg/H] vs. σ does not. σ correlates better with metal abundances than M_* or R_e

Who can explain the X-planes?

Smith

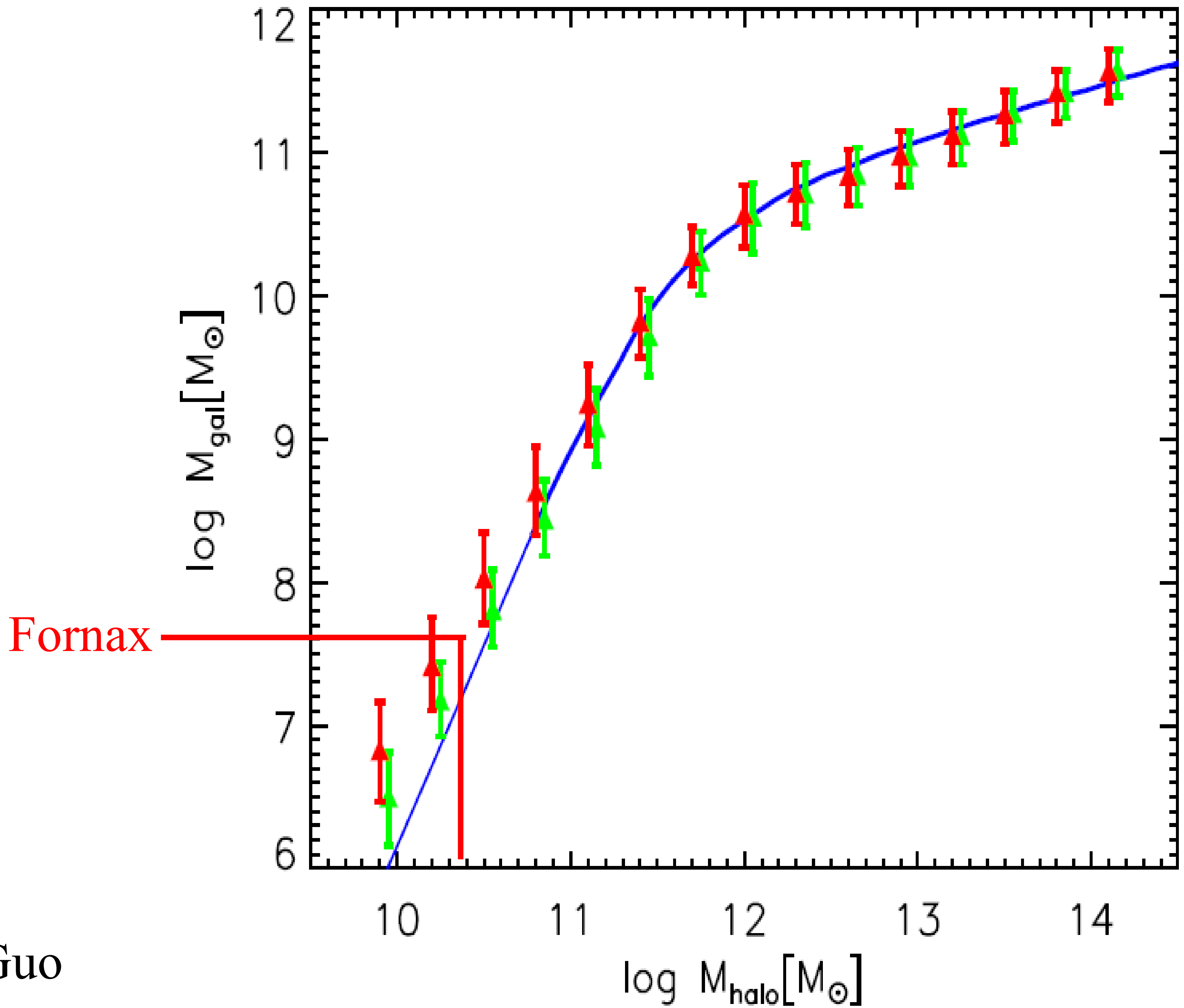


The problem with matching dwarfs in ΛCDM

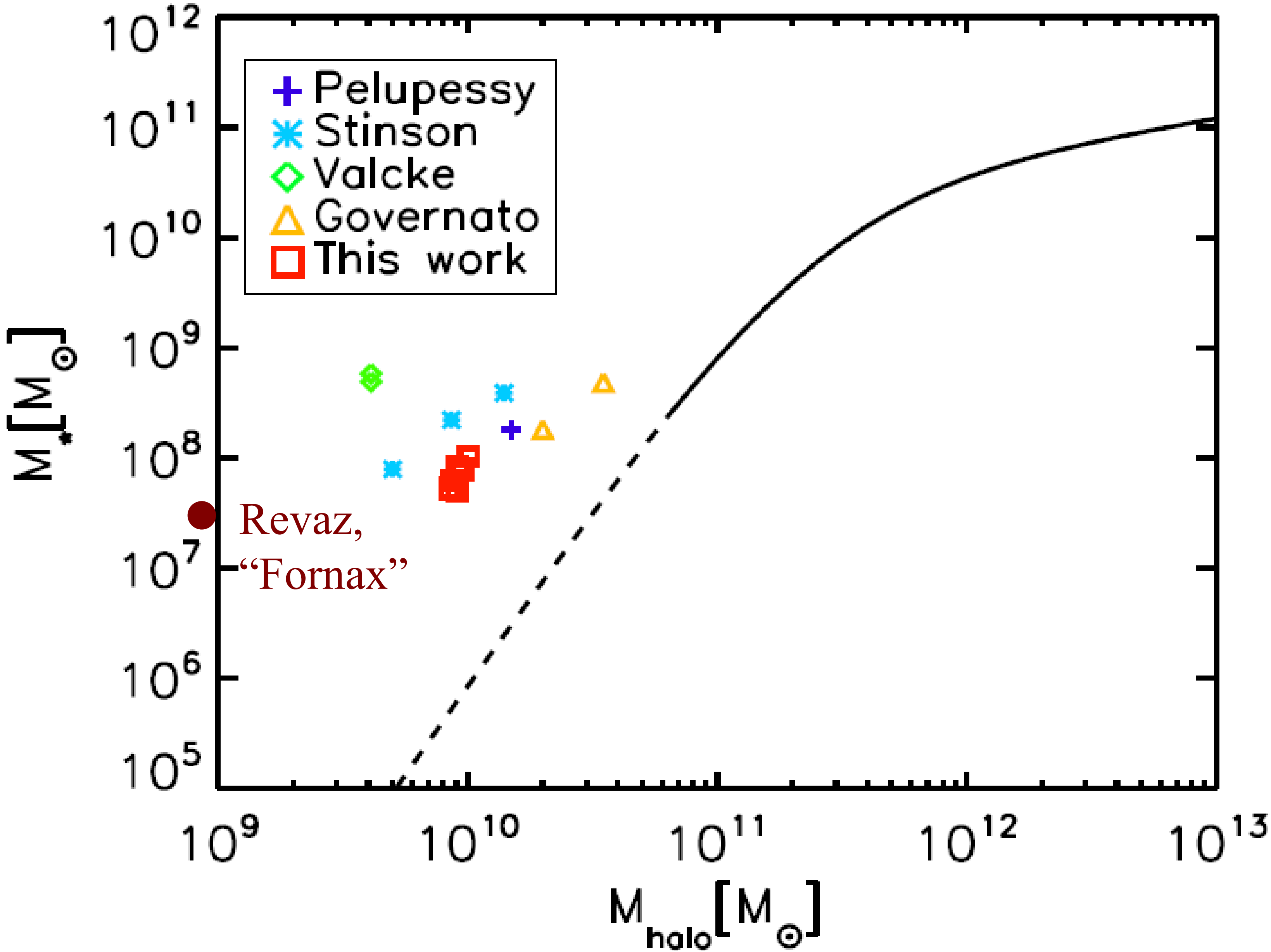


Guo

ΛCDM requires a typical "field Fornax" to have $M_{halo} \sim 2 \times 10^{10}\ M_{\odot}$



Guo



Sawala poster

Surely ΛCDM <u>must</u> be wrong?

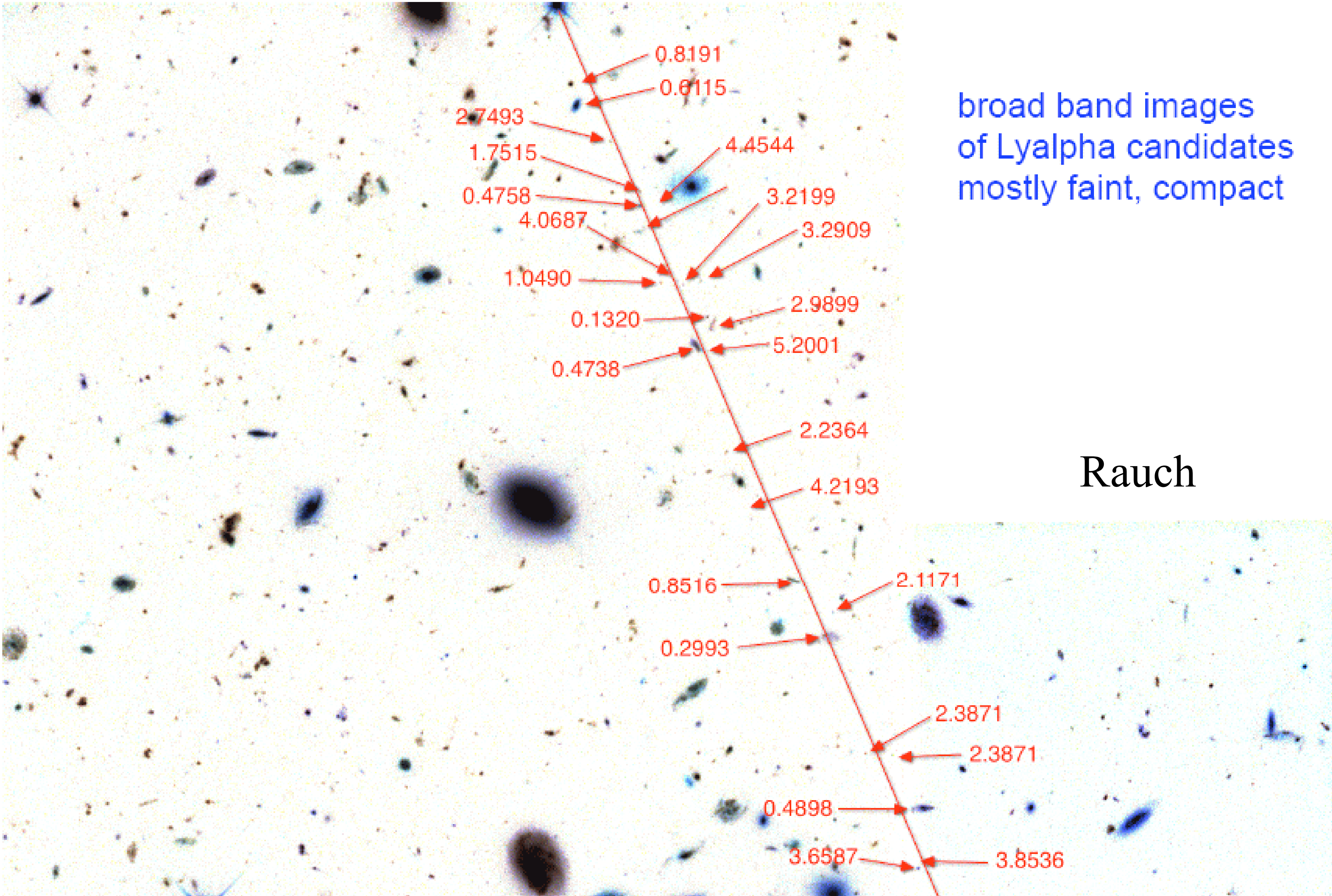
If the ΛCDM cosmogony is correct, most dwarfs have/had *more massive* dark halos than they are usually credited with.

All simulations of dwarf formation to date form stars *too efficiently* to be viable models for typical ΛCDM dwarfs

The ΛCDM halos of essentially all dwarfs are *too massive* to be affected by WDM, given the Ly α forest constraints on m_p

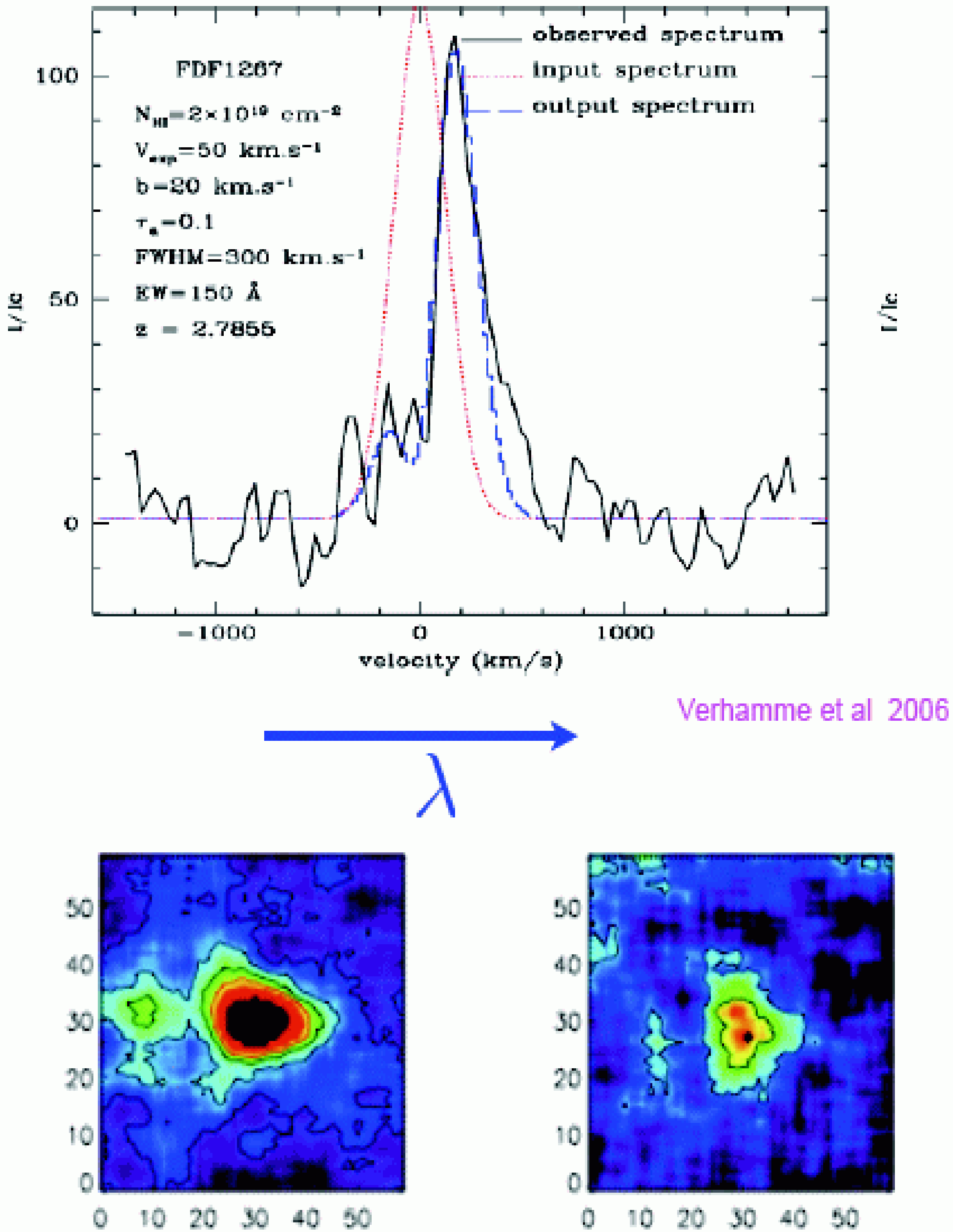
For ΛCDM to be right, winds must be very efficient in dwarfs, or an additional unknown process must prevent gas cooling

Emission line selected continuum sources in the HDFN



broad band images
of Lyalpha candidates
mostly faint, compact

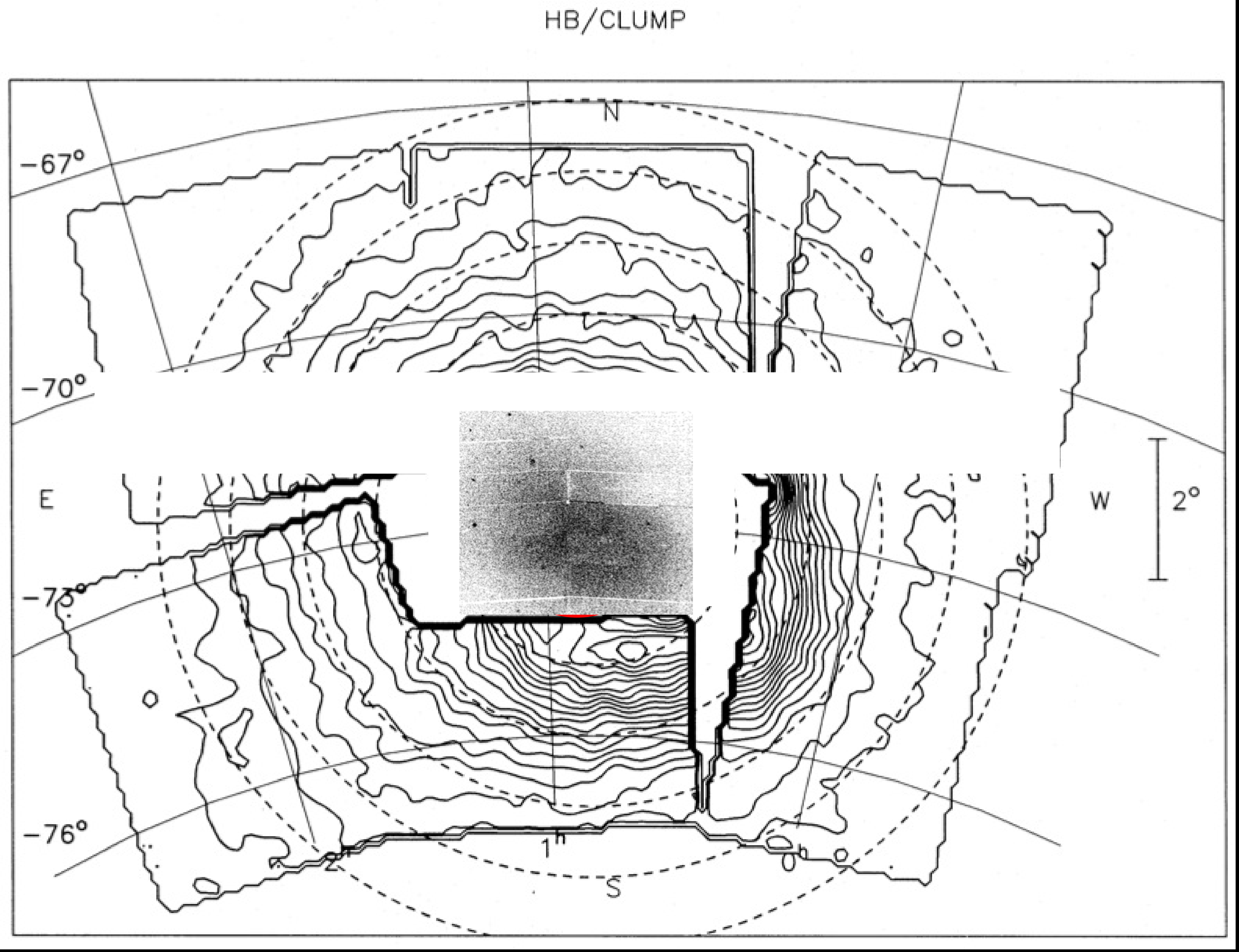
Rauch



High redshift star-forming dwarfs do *not* appear to be blowing strong winds.

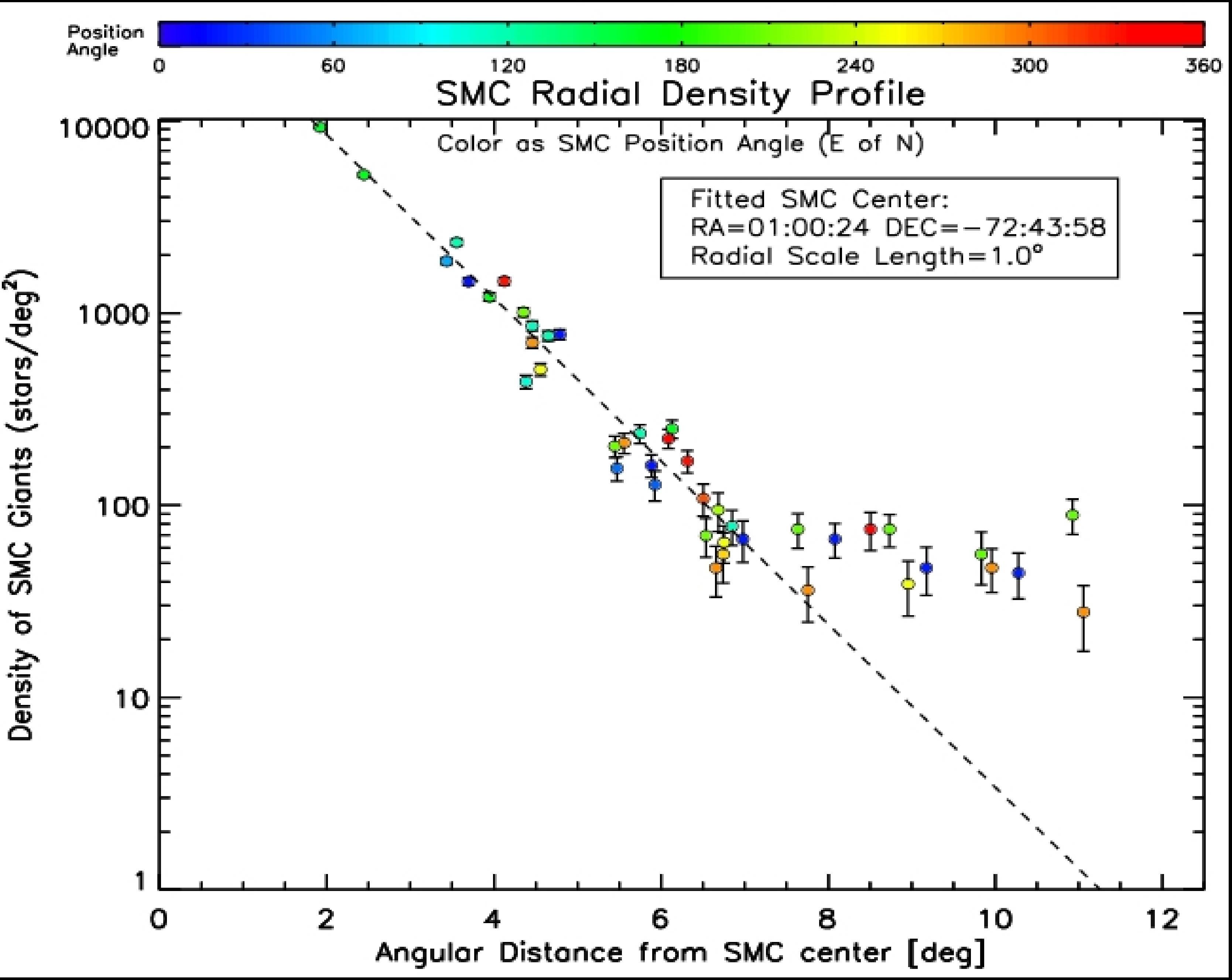
Rauch

Interactions



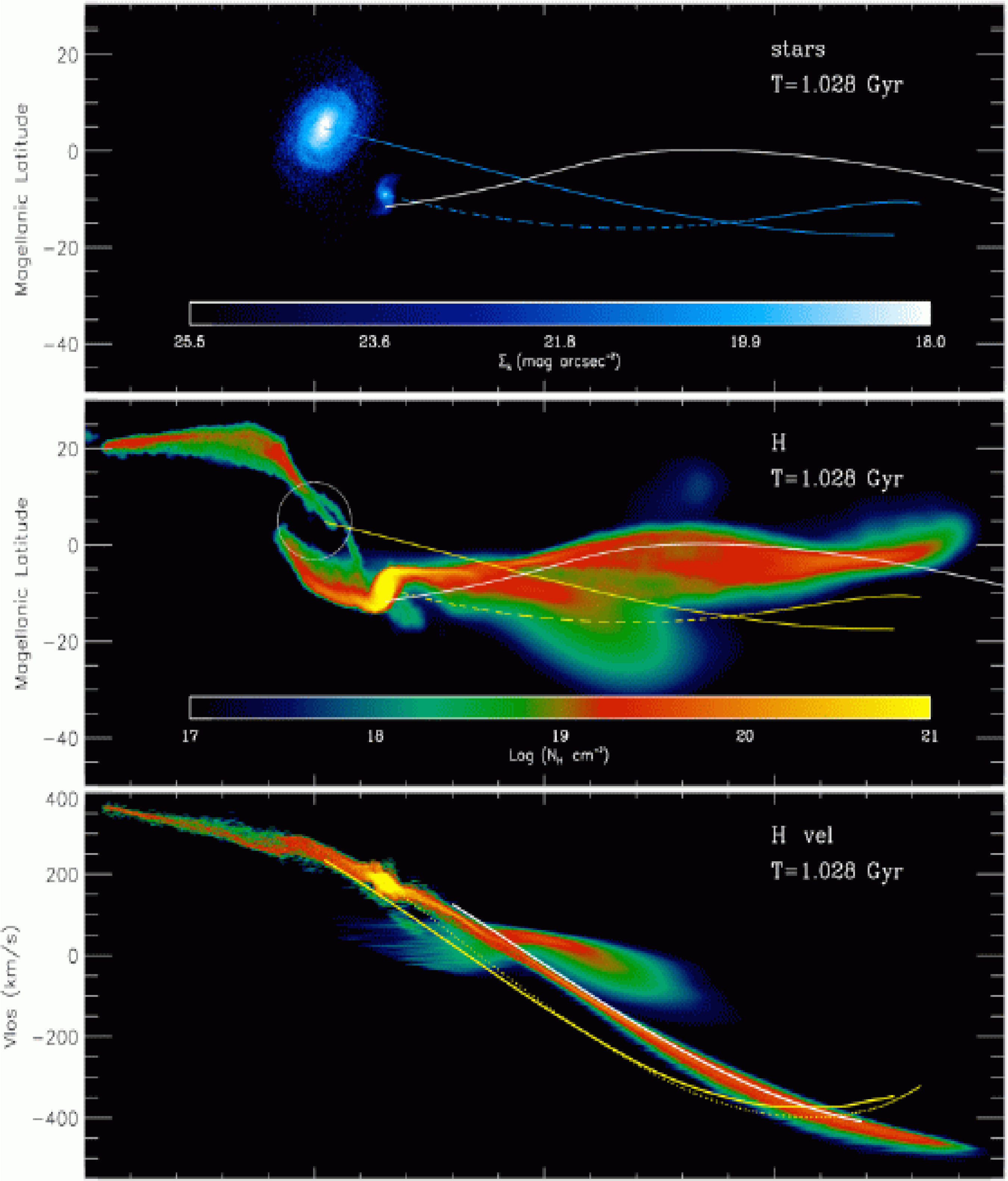
Nidever

Red clumps star distribution in the SMC



Nidever

Red clumps star distribution in the SMC



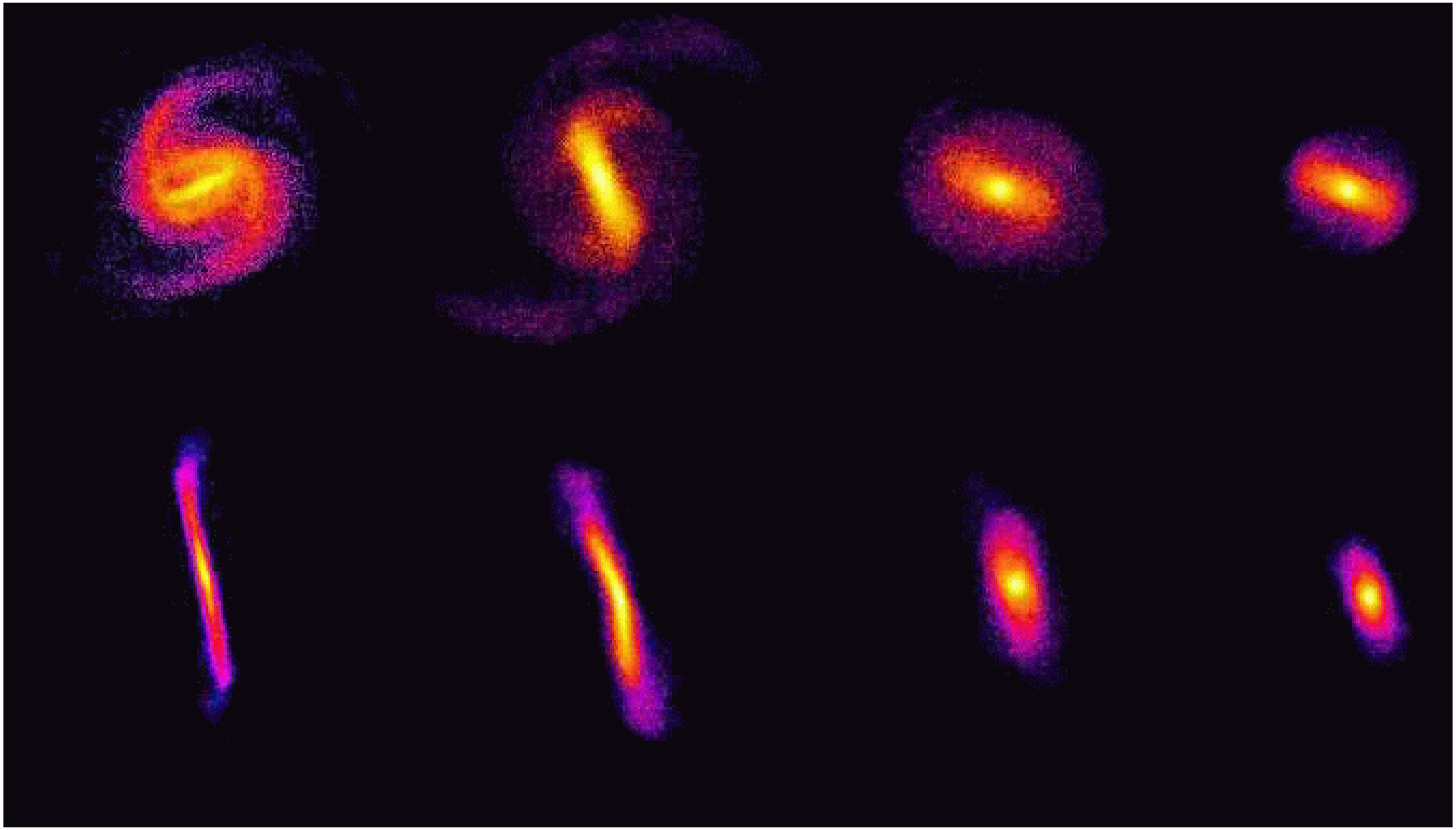
SMC tidally disrupted by LMC fits stream structure and new proper motion...

...but why don't the stars appear as a tail?

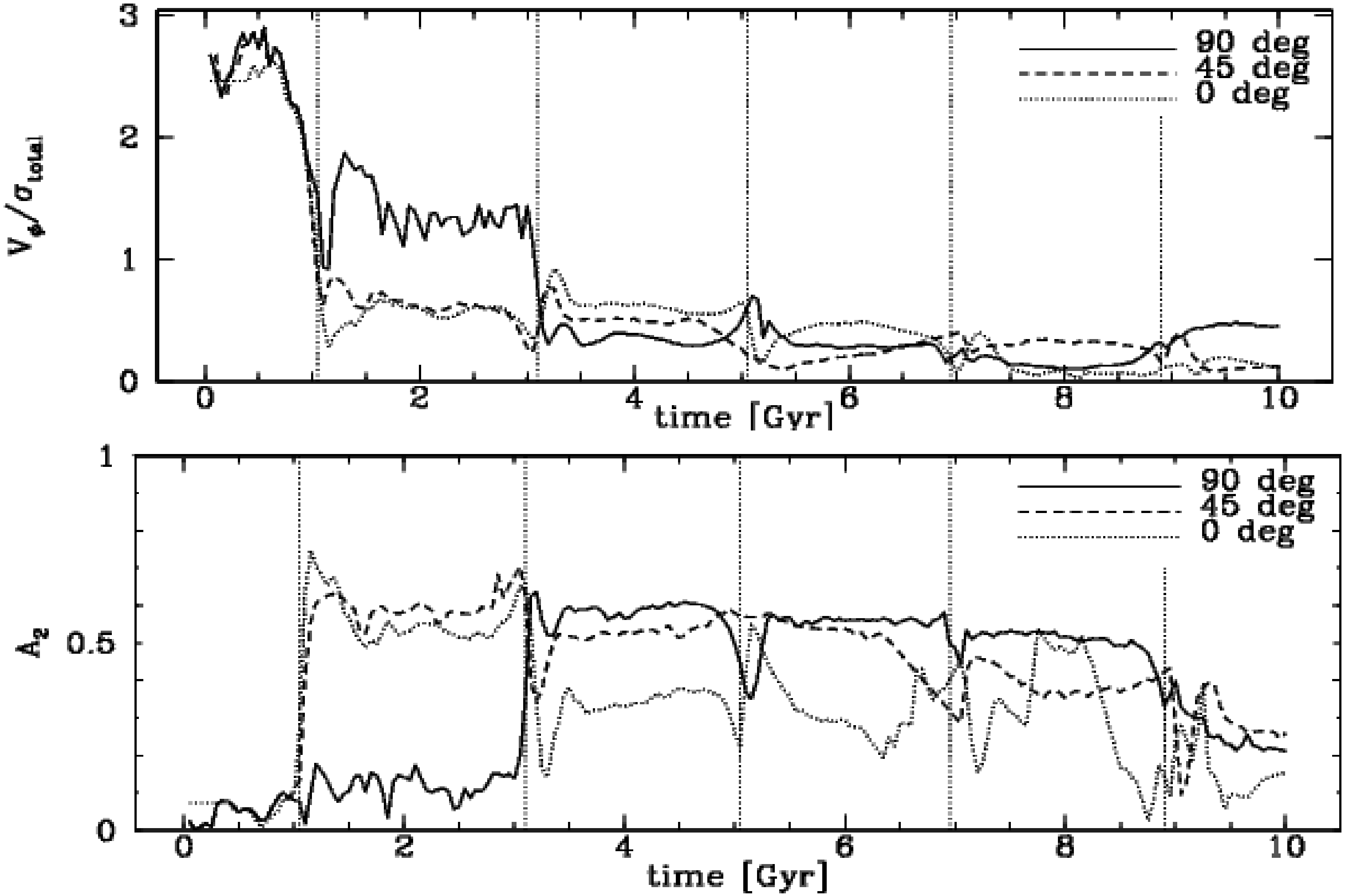
Related to depth of SMC?

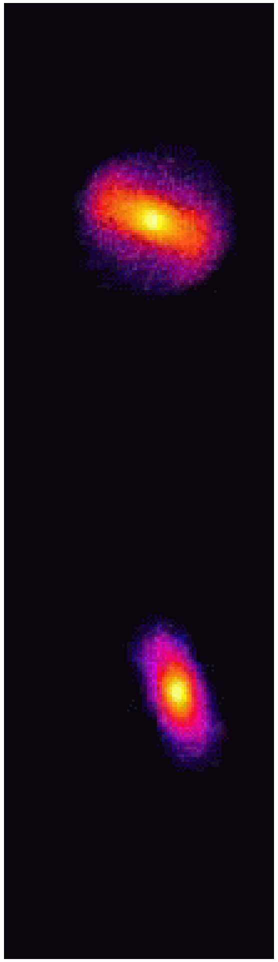
Besla

Tidal shocking of a dIrr turns it into a dSph - Mayer



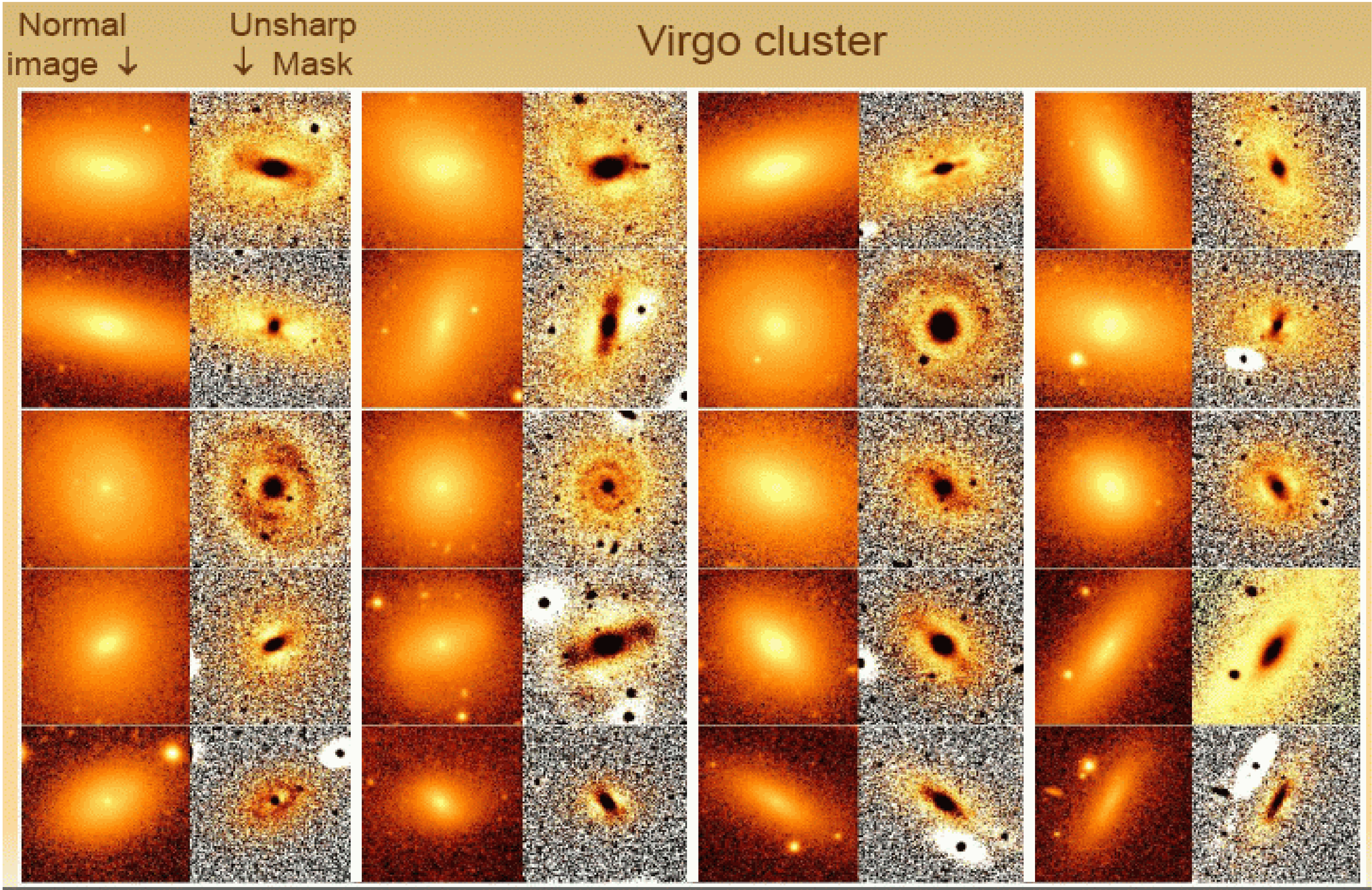
Tidal shocking of a dIrr turns it into a dSph - Mayer





Many dE's are disky
Some have bars/spirals

Lisker



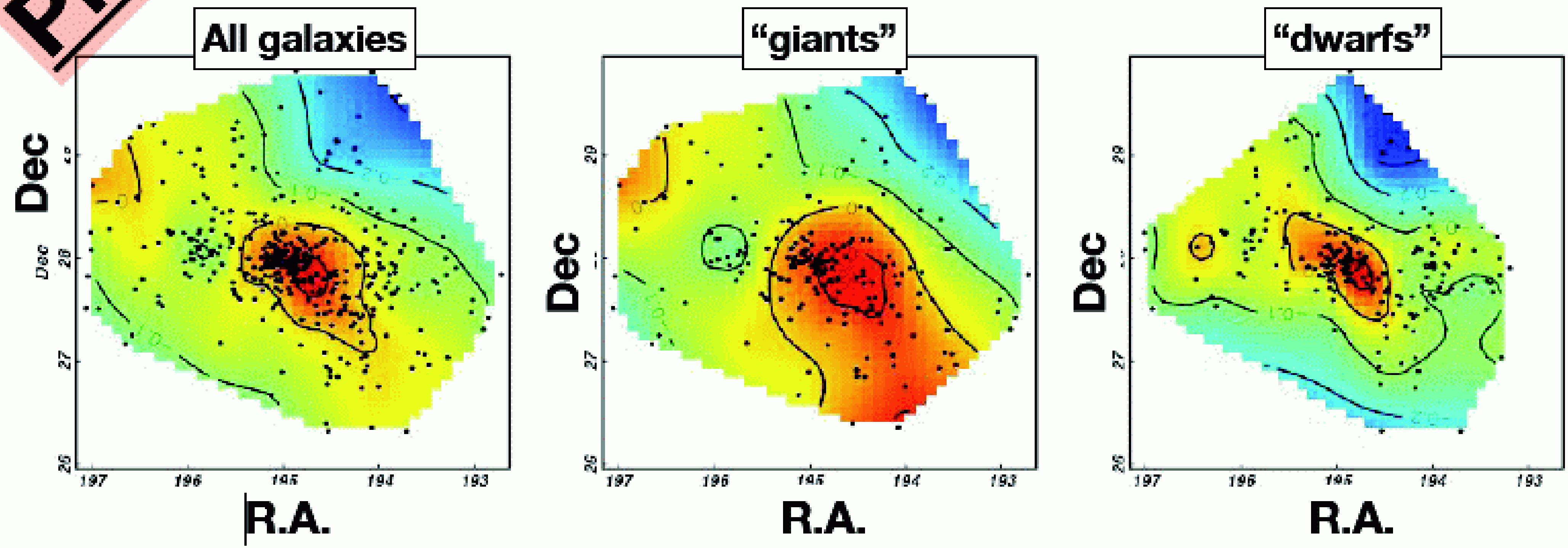
C3d S
Coma 3-degree Survey

Age vs location within cluster

Preliminary!

Smith

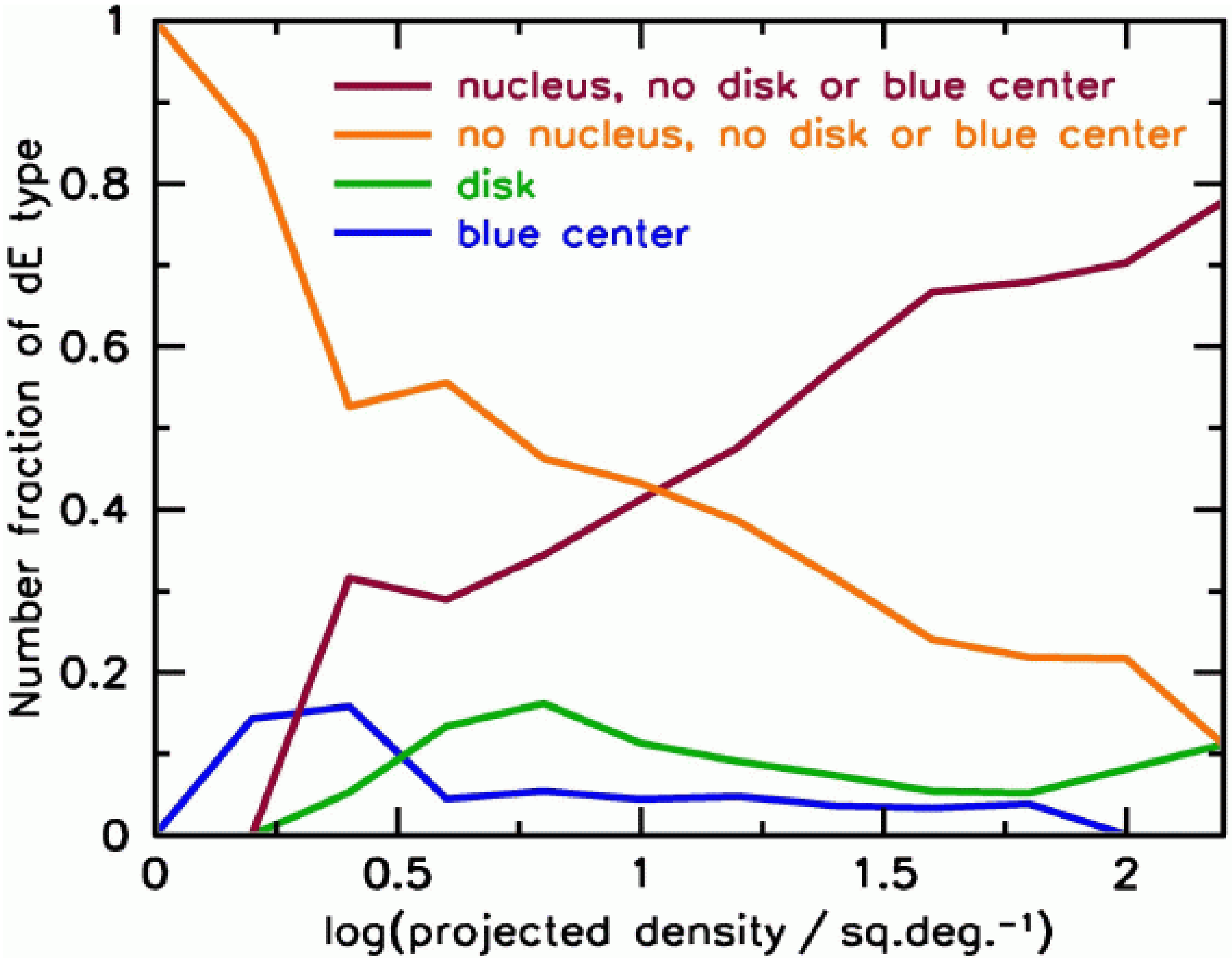
Colours: smoothed representation of Age-luminosity residual:
RED = older than average, **BLUE = younger than average**



Age-radius effect in dwarfs not limited to the South West…

It is the *centre* of the cluster that looks "different"

Lisker



Nucleated/blue dE's show a “late-type” behaviour with environment
dE's with no nucleus (red dEs) show “early-type” behaviour

An effect of ram pressure stripping?

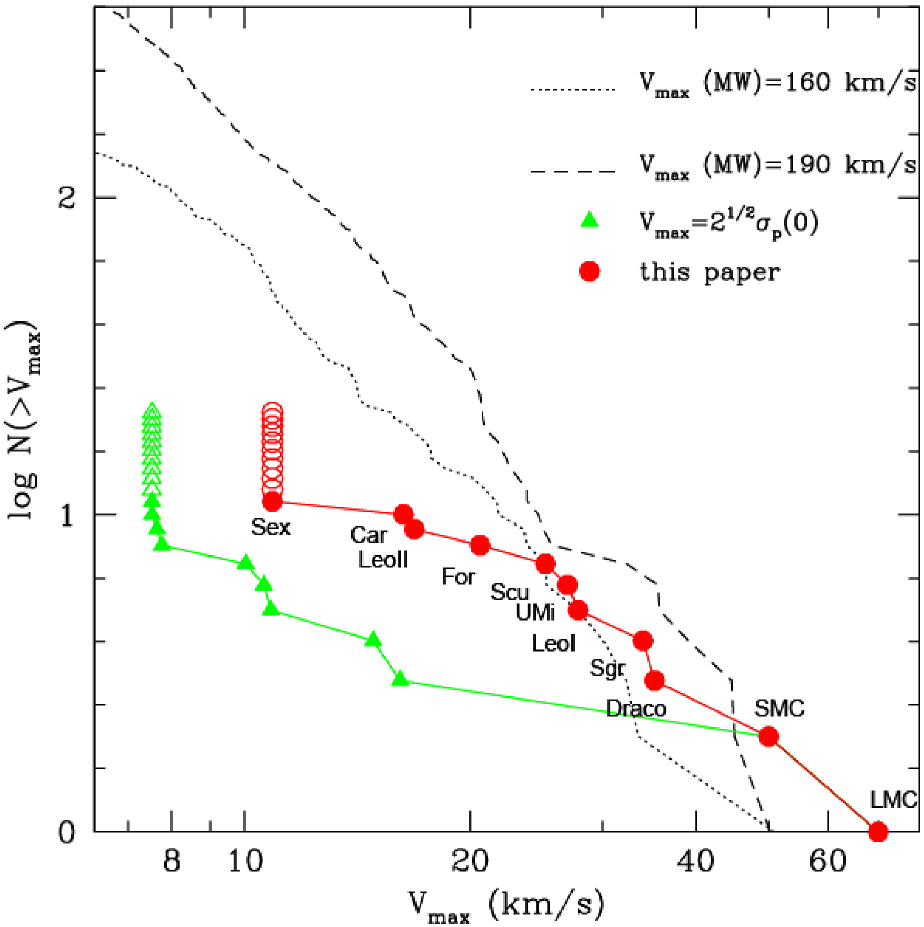
Other dwarf challenges to ΛCDM

Satellite problem -- A more complex version of the luminosity function problem

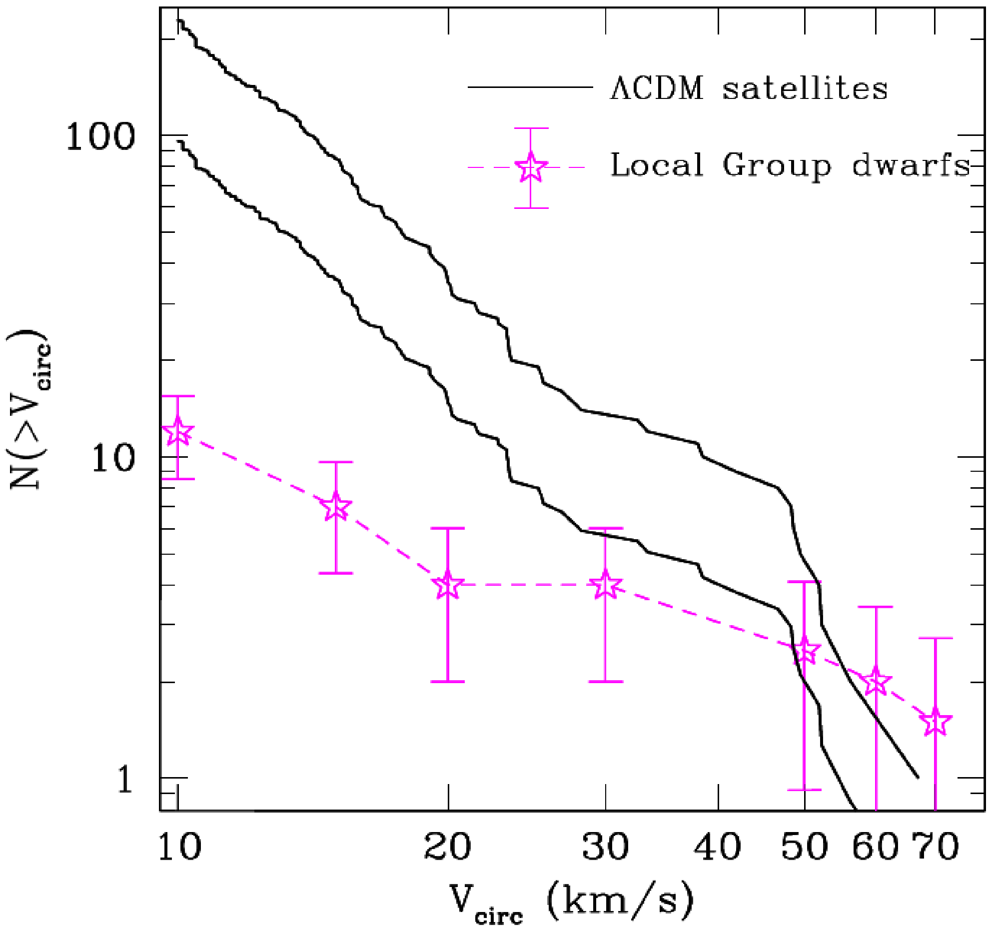
The core-cusp issue -- Are cusps there? Can they be removed?

CDM

Penarrubia et al 2008



Kravtsov 2010

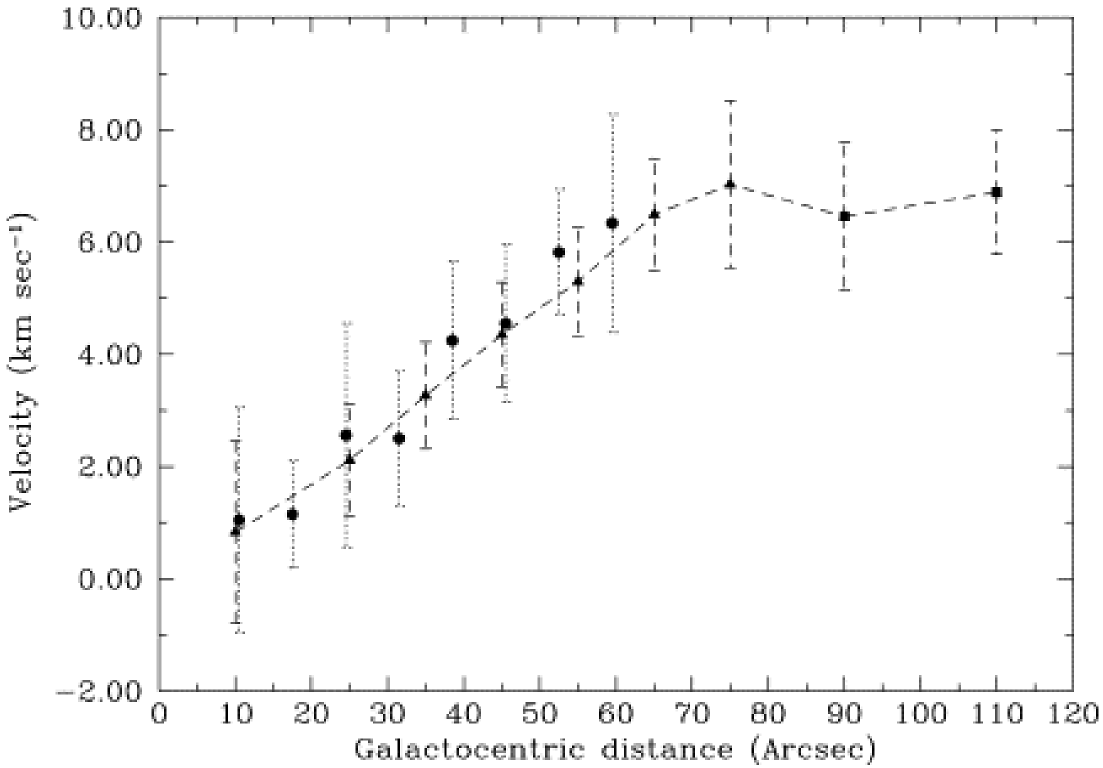


There may be no "satellite problem" if they live in LCDM subhalos

This was always true!

Cam B : Rotation Curve

Begum et al. New Ast, 2003, 8, 267

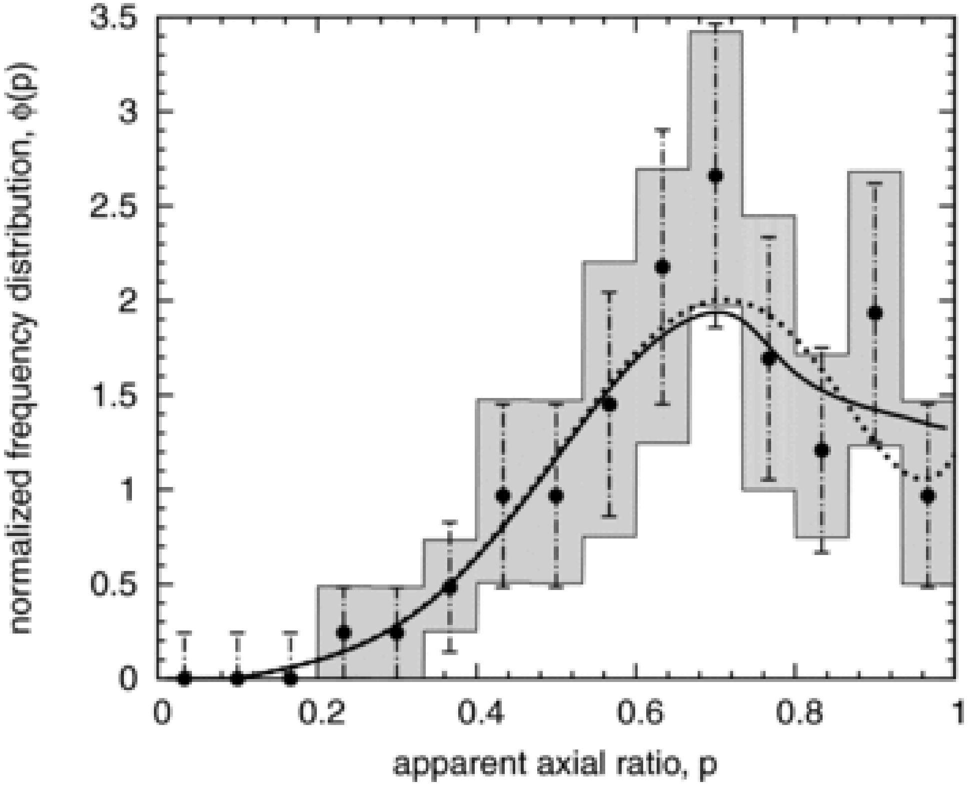


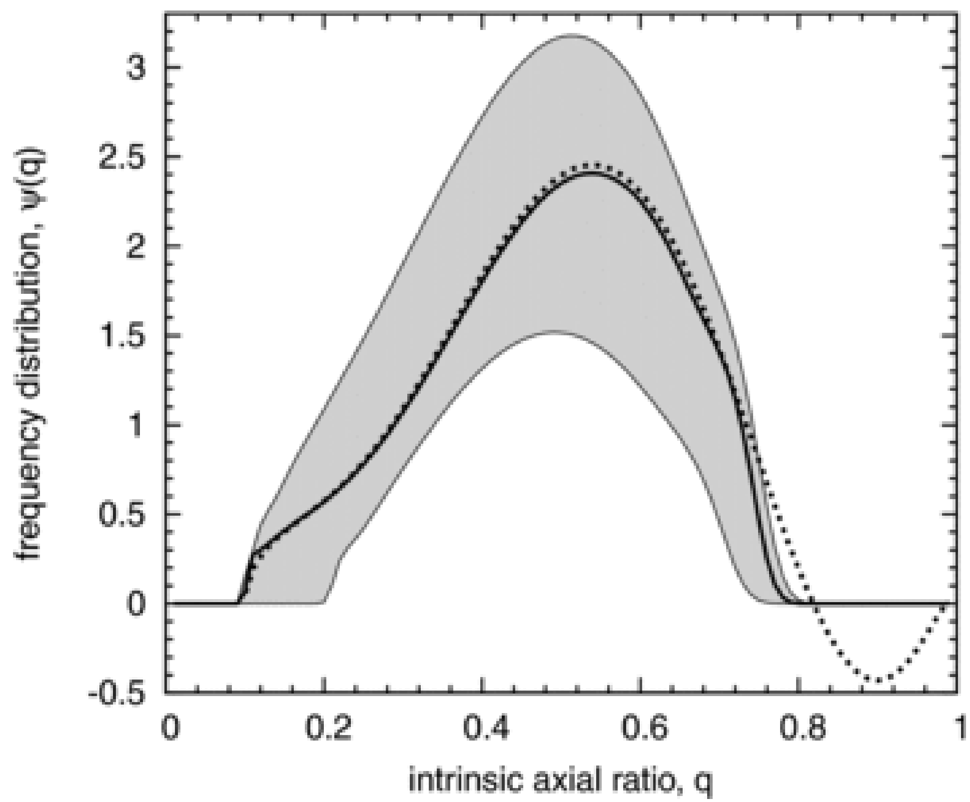
- Peak rotation velocity comparable to velocity dispersion
- Need to account for both the random and the rotational components while determining the total mass content
- $V_{rot}/\sigma \approx 1$ could lead to thicker gas disks

Chengalur

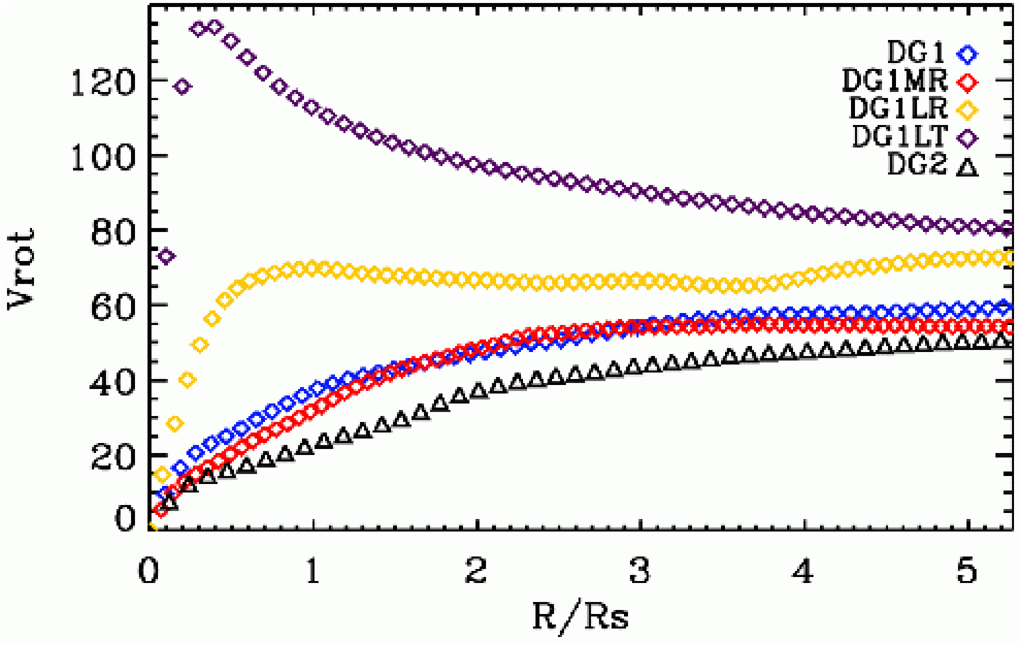
Rowchowdhury et al. (2010)

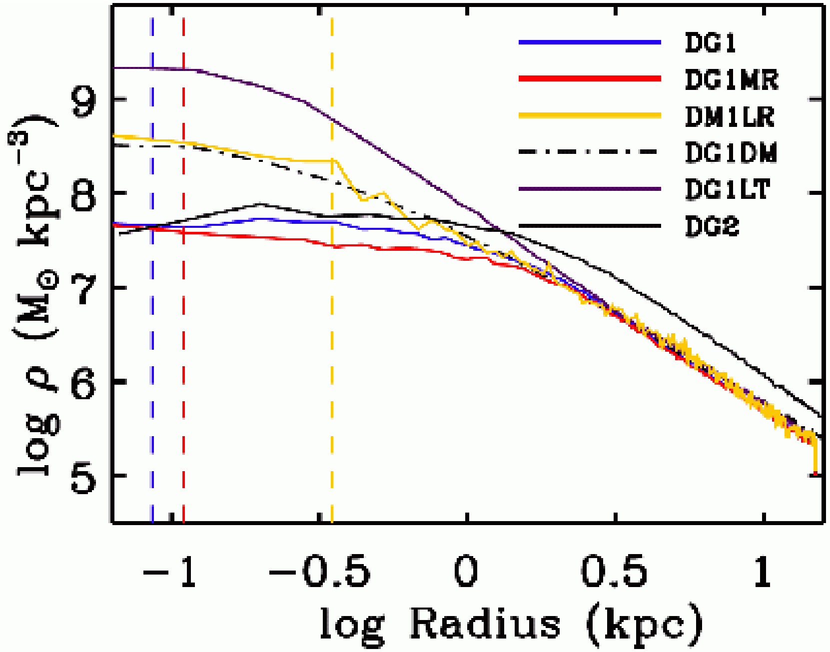
Thick gas disks in faint dwarfs

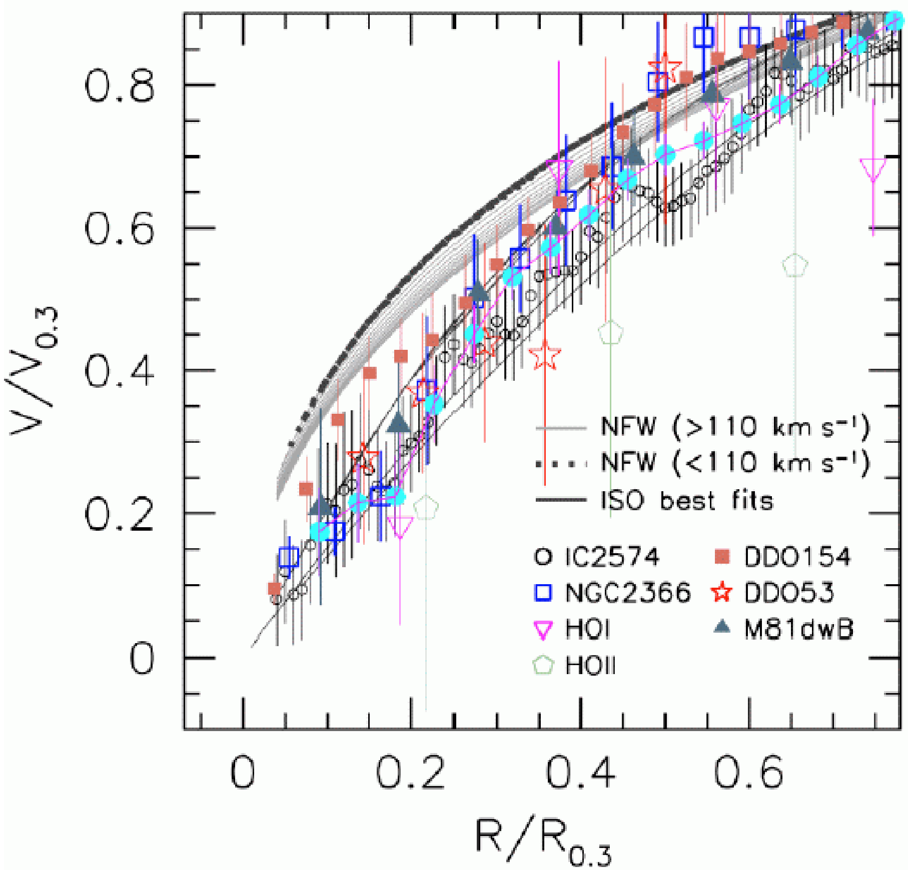




Chengalur





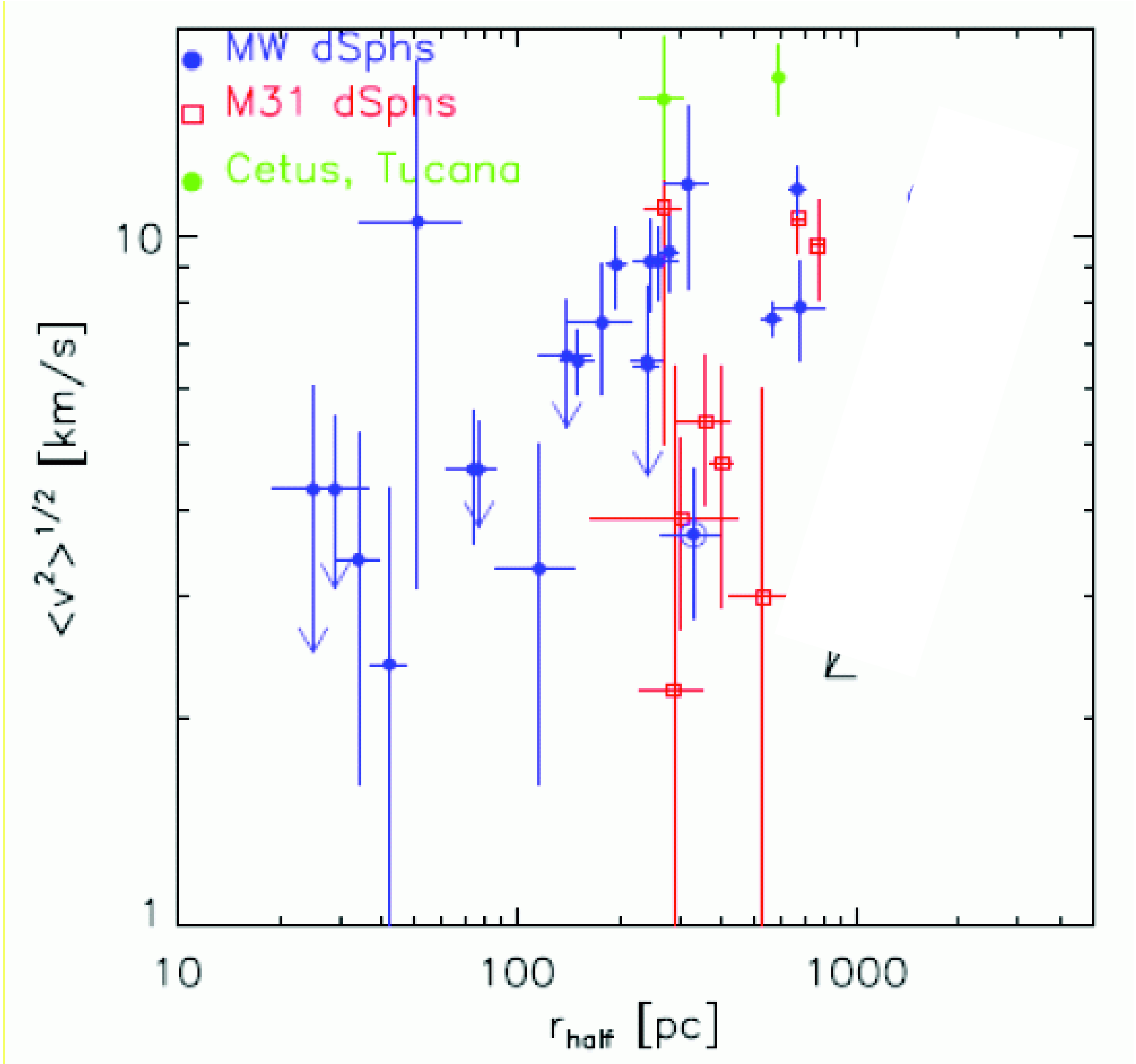


Simulations which allow star formation only above a high density threshold and which have efficient feedback can reduce the cuspiness of the DM profile below NFW

Mayer

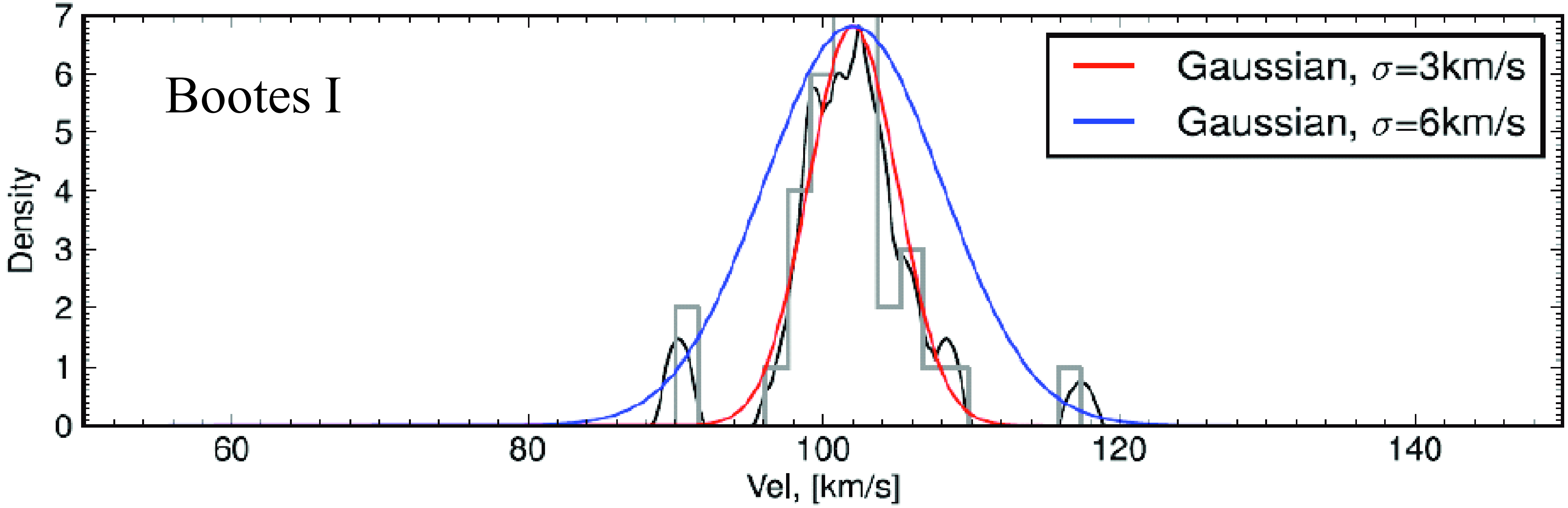
All the “real” information about halos of dSph's?

(“dSph's <u>appear</u> to have lots of dark matter” Matt Walker)



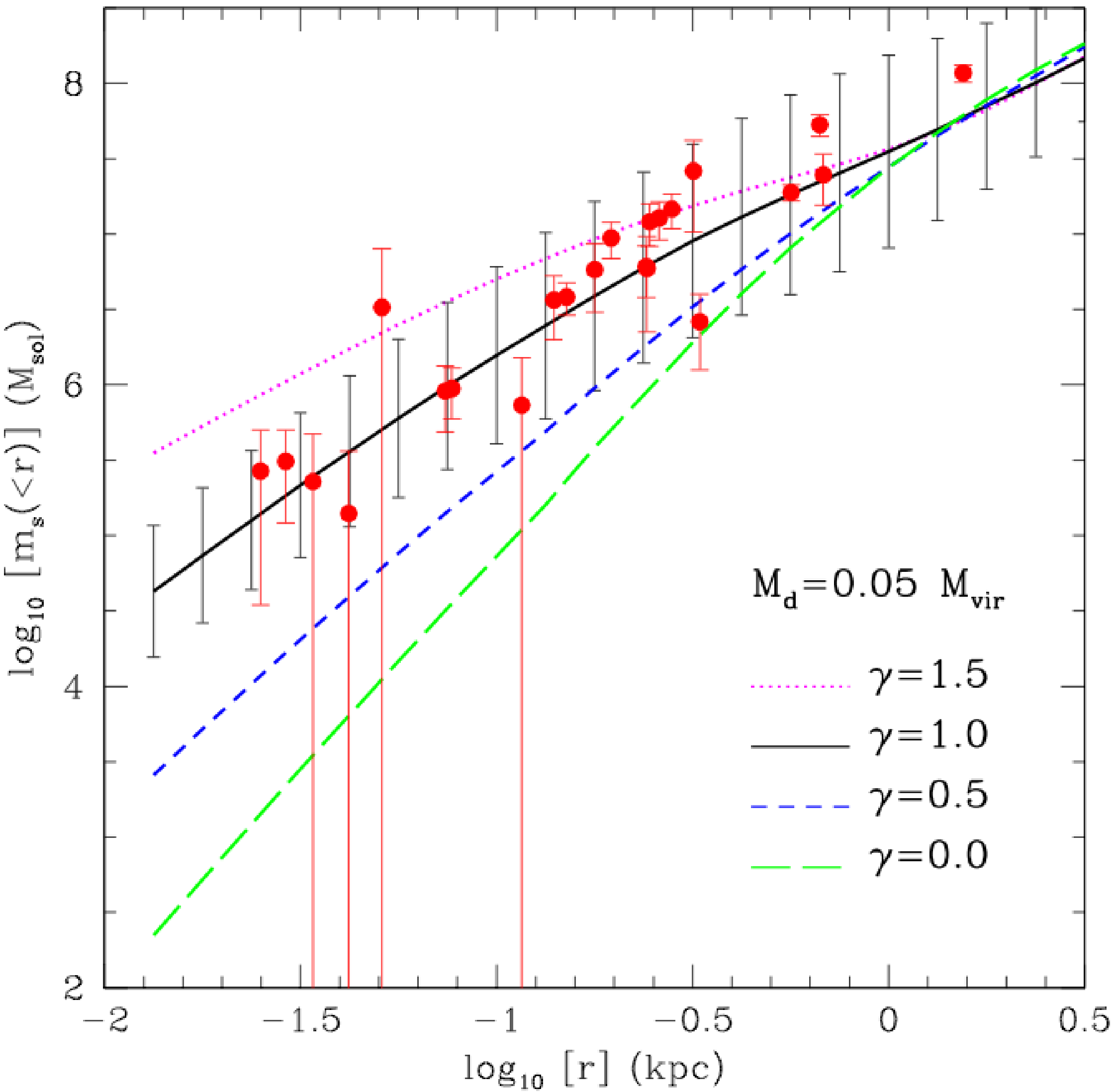
Walker, Wolf

....or maybe there is even less!

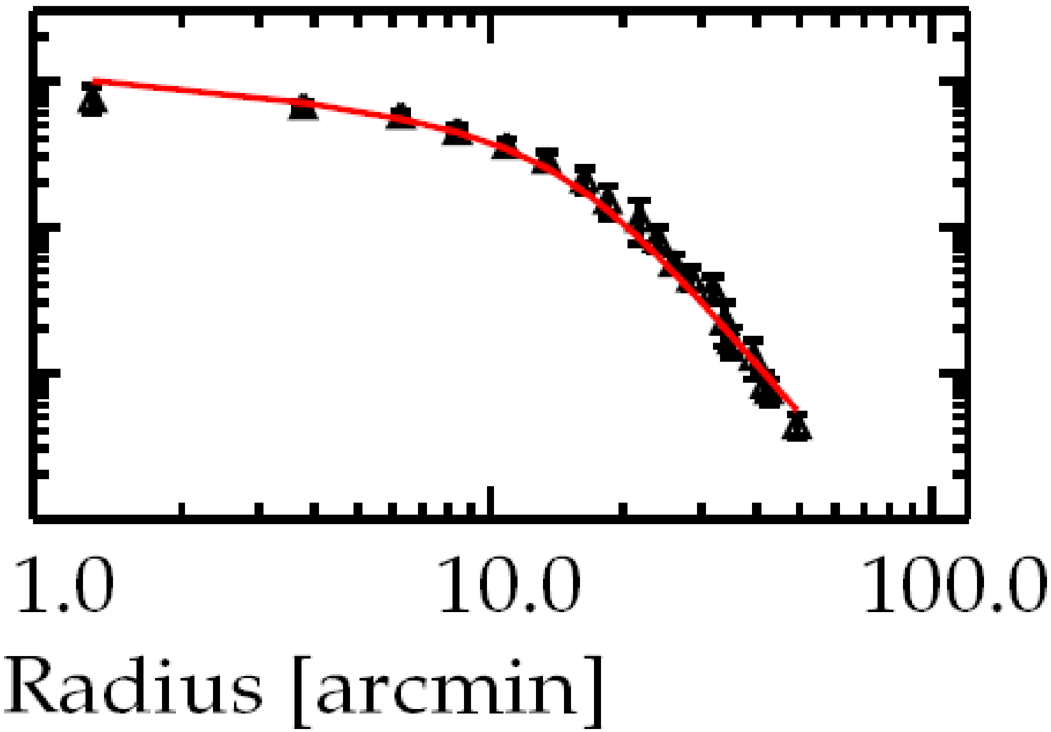


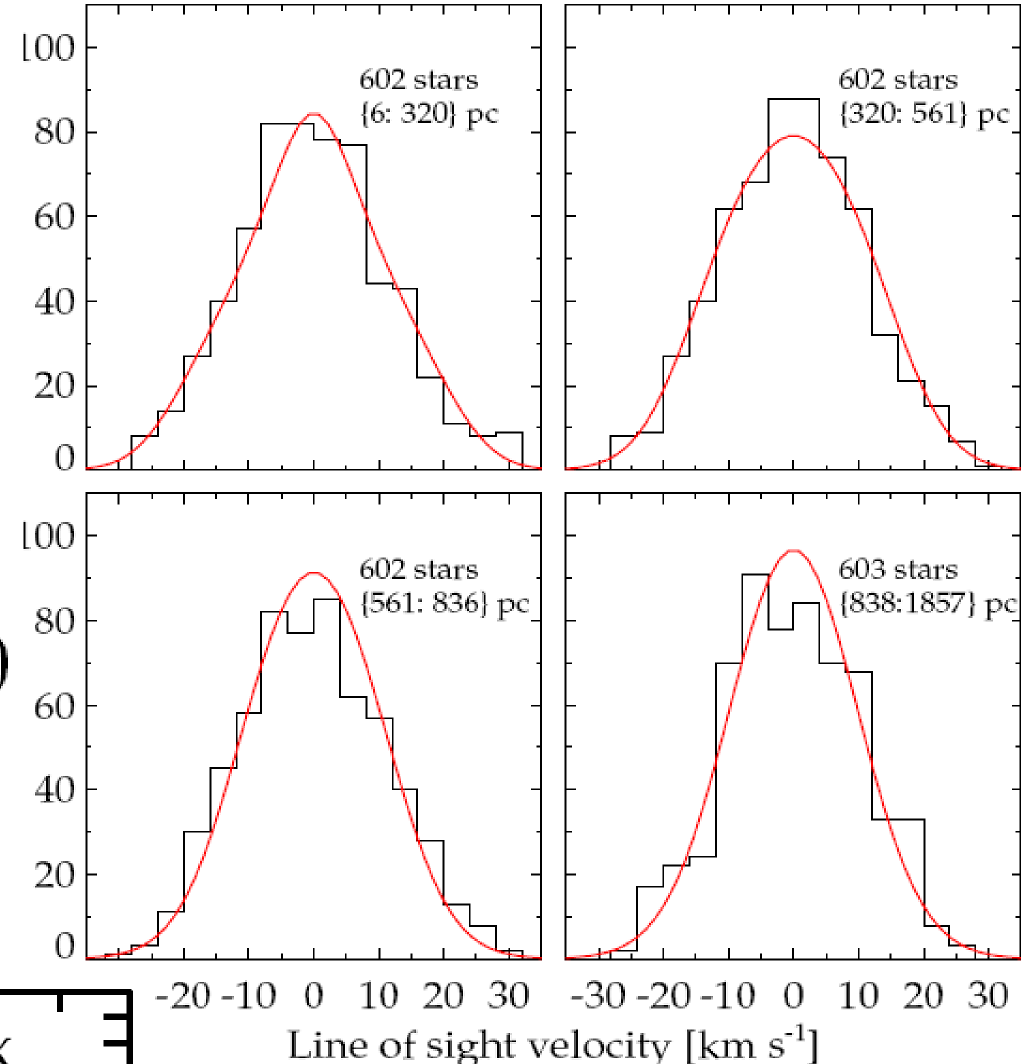
Walker, Koposov

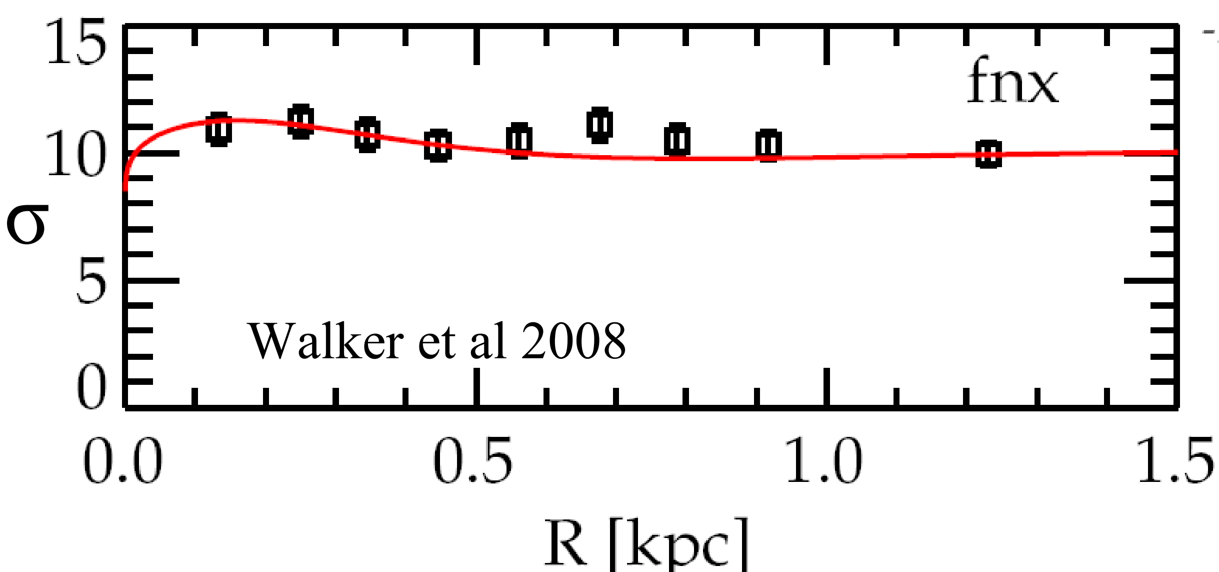
...but it is enough to prove NFW were right!!



Penarrubia







Fornax data are **consistent** with living in an Aquarius CDM subhalo with isotropic velocity dispersions

Strigari, Frenk & White 2010

Dwarfs may be small but there are certainly enough of them and enough important open issues to keep us all busy!

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Thank you to all the local organizers for giving us the chance to discuss them in Lyon!!