The large scale structure of isolated dwarf galaxies

A fresh view in the very LSB regime

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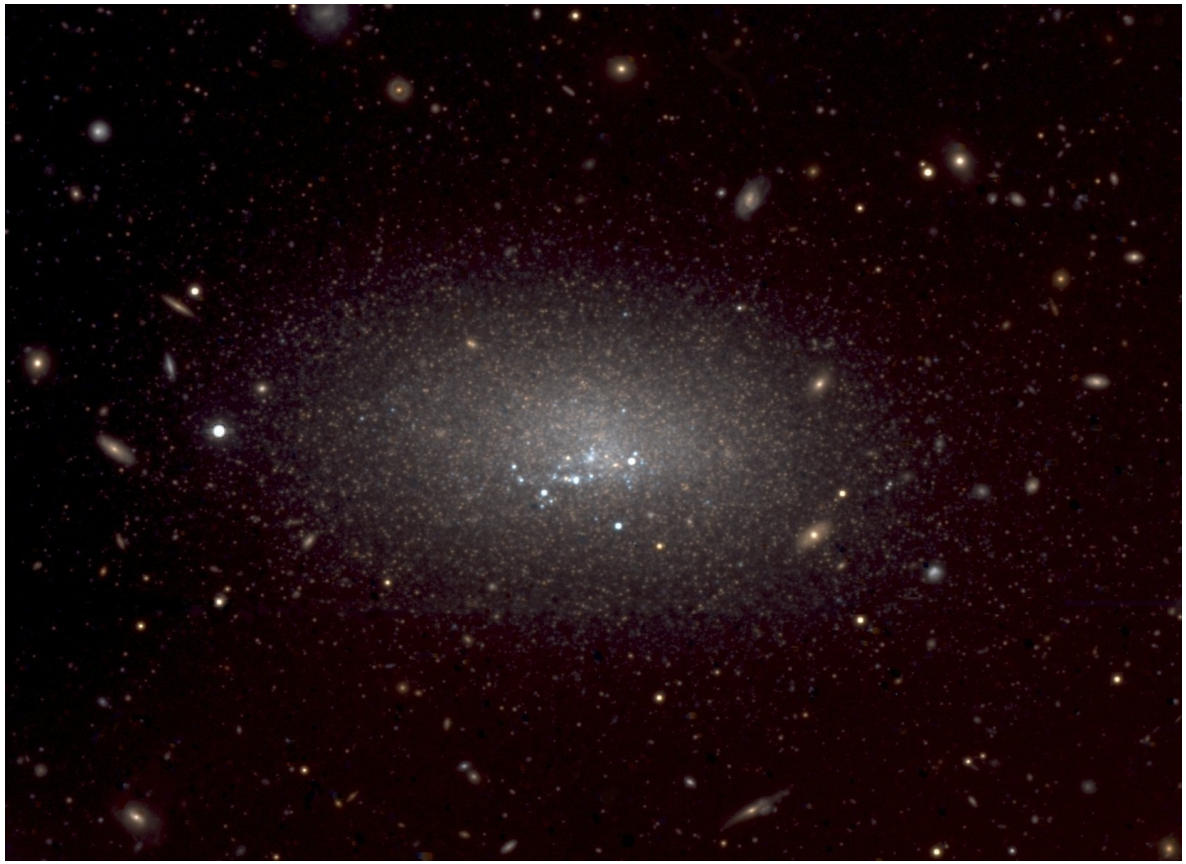
From Dwarfs to Giants: Mike Irwin's travels in the Local Group and beyond

Sesto Pusteria, July 29 – August 2, 2013



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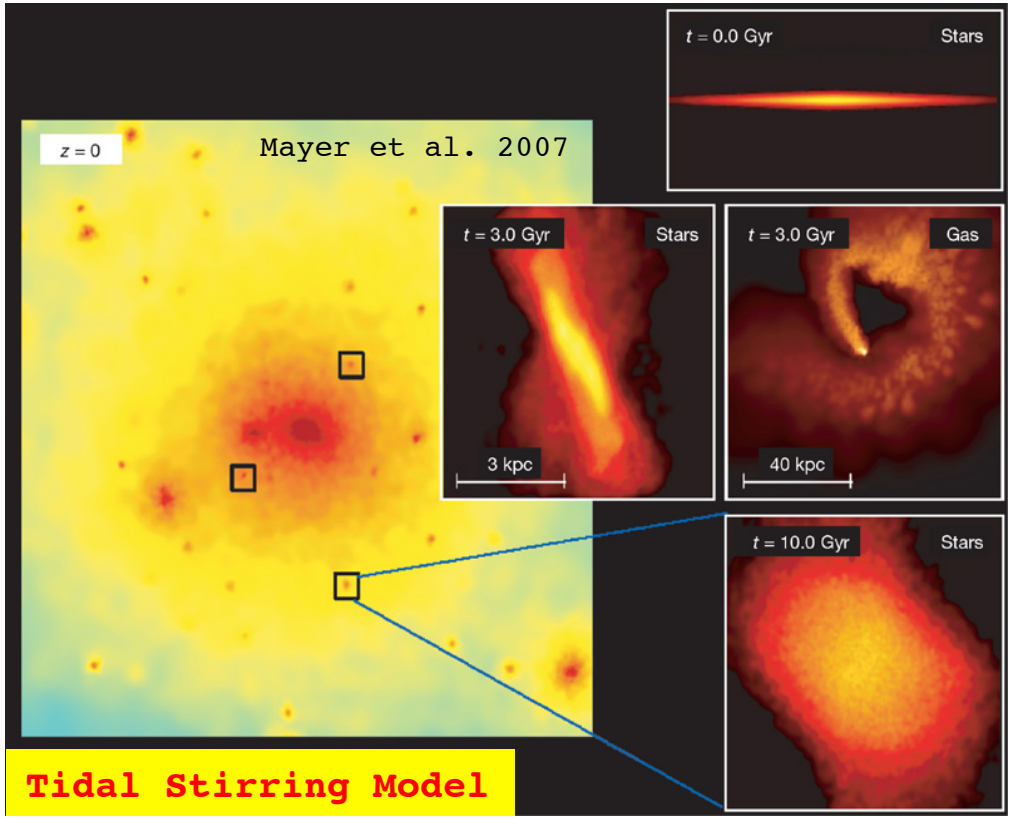
Premise: how did gas-less pressure-supported dwarf Spheroidal galaxies form ?

Are they the end-state of transformation of disky dIrr by interactions with the giant galaxy they are orbiting around?

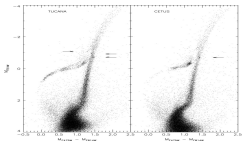
Tidal and ram-pressure stripping but also ionizing UV radiation and SNe feedback have likely played a role in the evolution of dwarf satellites, a path that can lead to dIrr, dSph, dE(n) etc. (see Sawala et al. 2010, 2011a,b).

What is the role of the various factors in the various cases?
How look like the progenitors of dSphs?



Isolated dwarf galaxies are especially interesting in this context. They can be considered as the test case excluding the effect a possible major factor (tidal interaction).

Moreover we can possibly learn something more on initial conditions in dSph progenitors.



Monelli et al. 2010

The large HST programme LCID [Gallart et al.] is aimed at extracting info on the evolution of isolated dwarfs **from their Star Formation Histories**, measured up to the beginning of Time (old turn off)

We choose a different approach, a different view

an observational project on VERY isolated dwarf galaxies, focusing on their STRUCTURE rather than their SFH, and, in perspective, on their DYNAMICS.

A galaxy that always evolved in isolation should be the ideal place to look for traces of the earliest kinematic status. Its Dark Matter halo should be untouched since the end of its collapse/assembling phase.

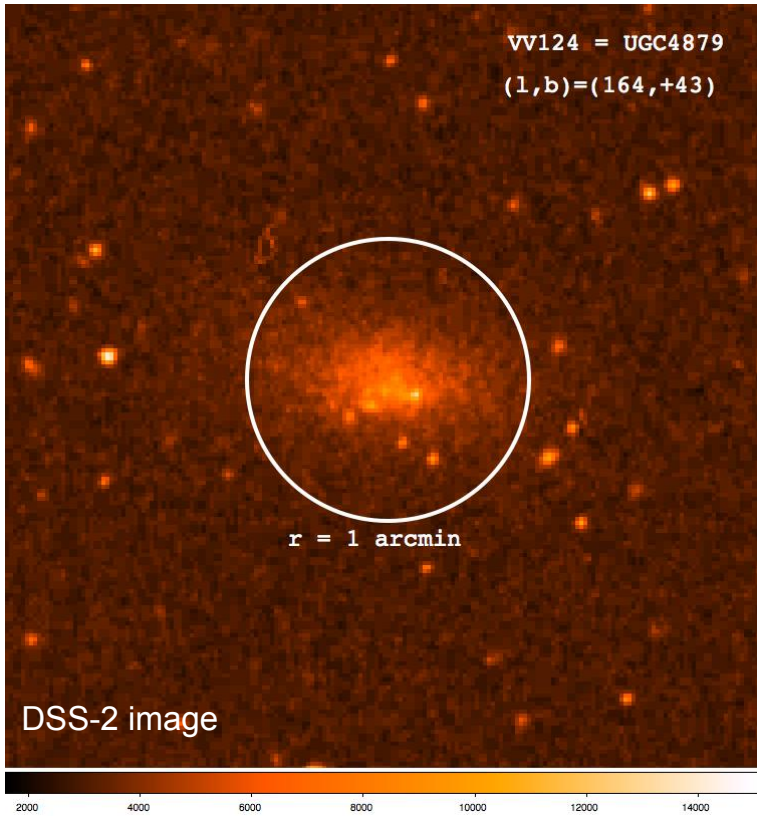
Any recent deep Wide Field photometry of this kind of galaxy has revealed that they are significantly more extended than previously believed (see e.g. Vansevicius et al. 2004 – Leo A; Sanna et al. 2010 – IC 10)

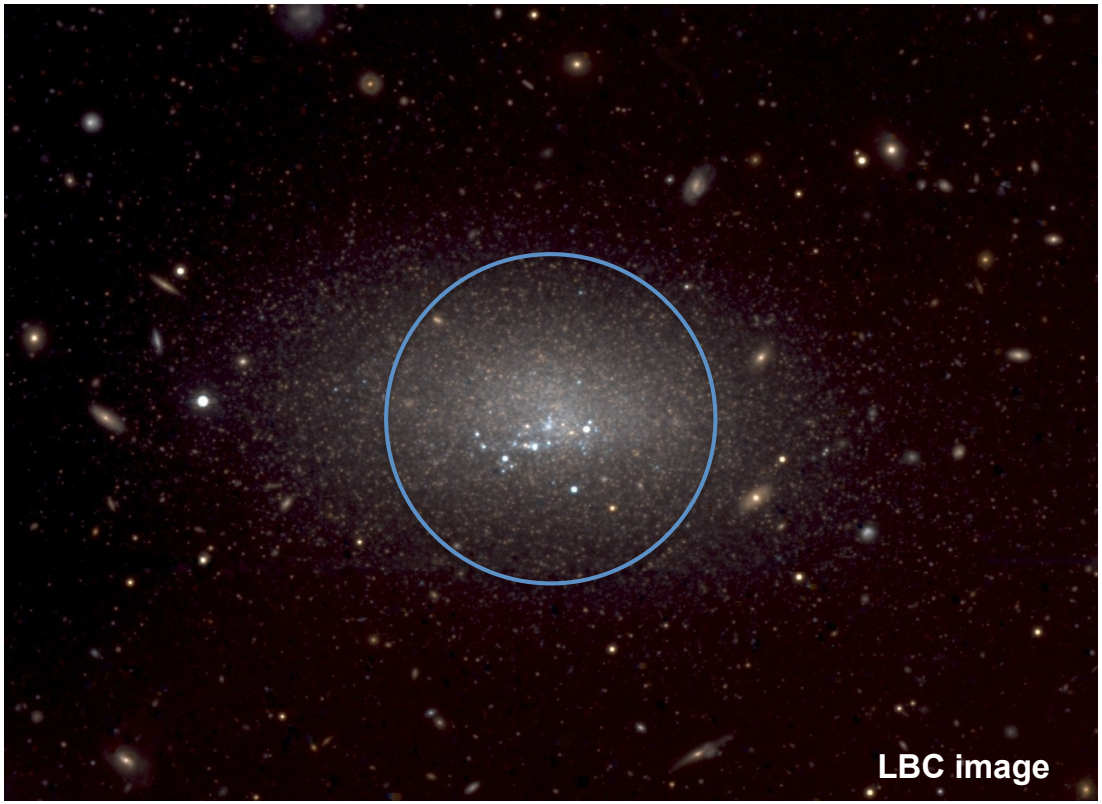
Three steps:

1. get very deep wide field photometry ➔ tracing the outer structure down to very low SB (~ 30 mag/arcsec^2)
2. Structure and kinematics of the neutral Hydrogen (if any)
3. Spectroscopic follow-up (distant systems ➔ very challenging)

The pilot project
VV124 = UGC4879: a dwarf galaxy just falling into the Local Group

Bellazzini et al. 2011a, A&A, 527, 58; 2011b, A&A, 533, A37; Kirby, Cohen & Bellazzini 2012, ApJ, 751, 46 – see also Kirby et al 2013 *ApJ 768 96*





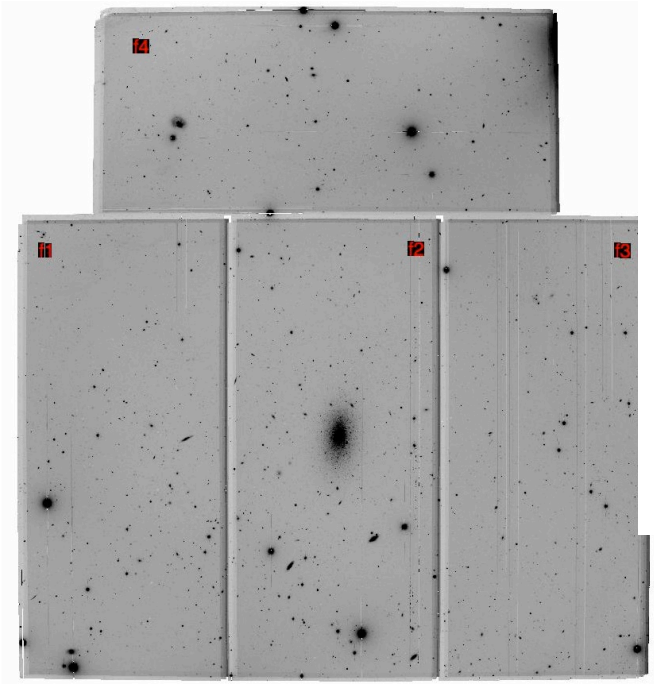
g,r photometry with LBC@LBT

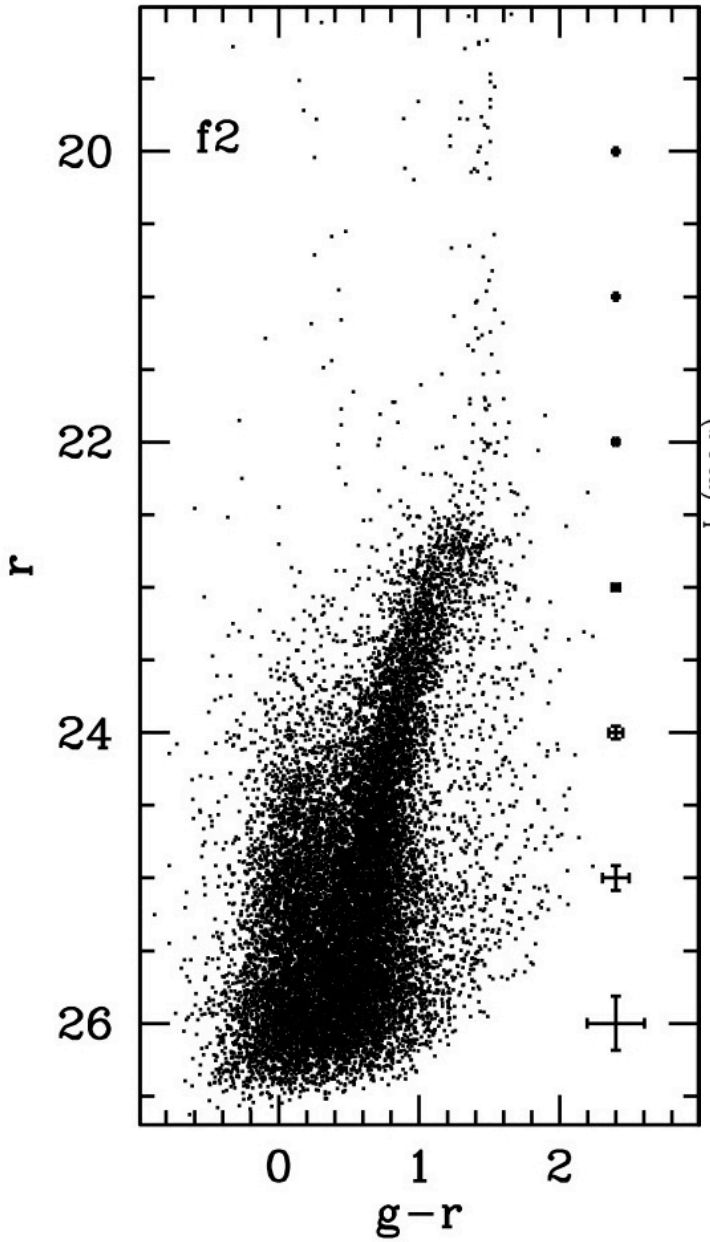
23′ X 23′ FoV

Half an hour time on target

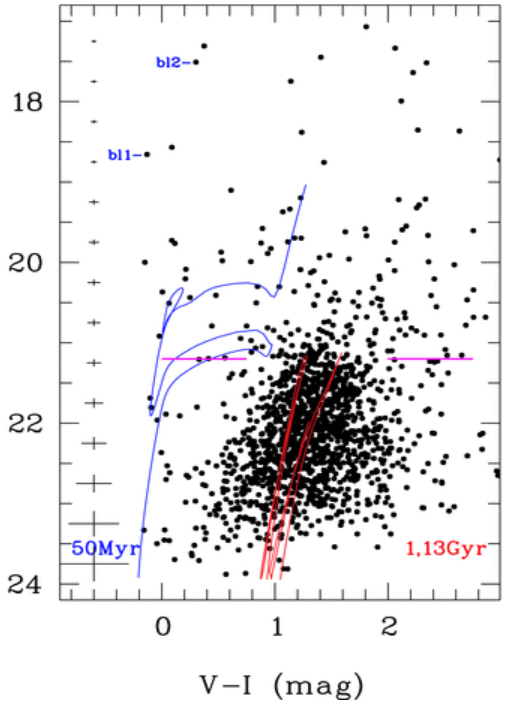
with 0.6″-0.7″ seeing

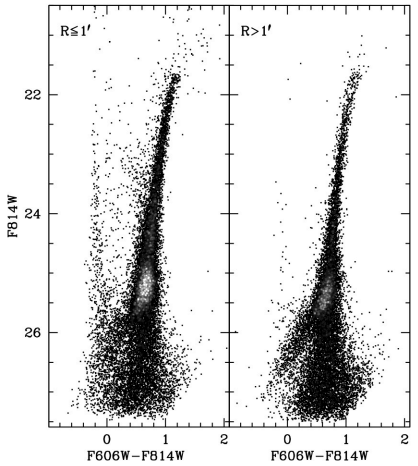
>2 mag deeper than K08
We reach the RC and the BHB



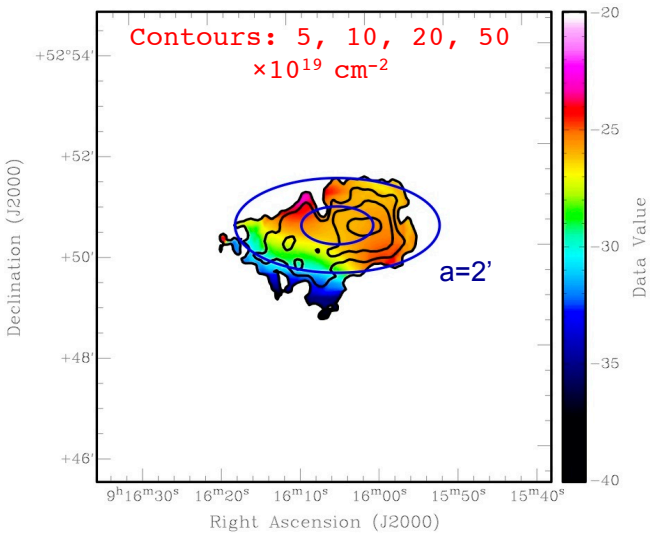


Kopylov et al. 2008

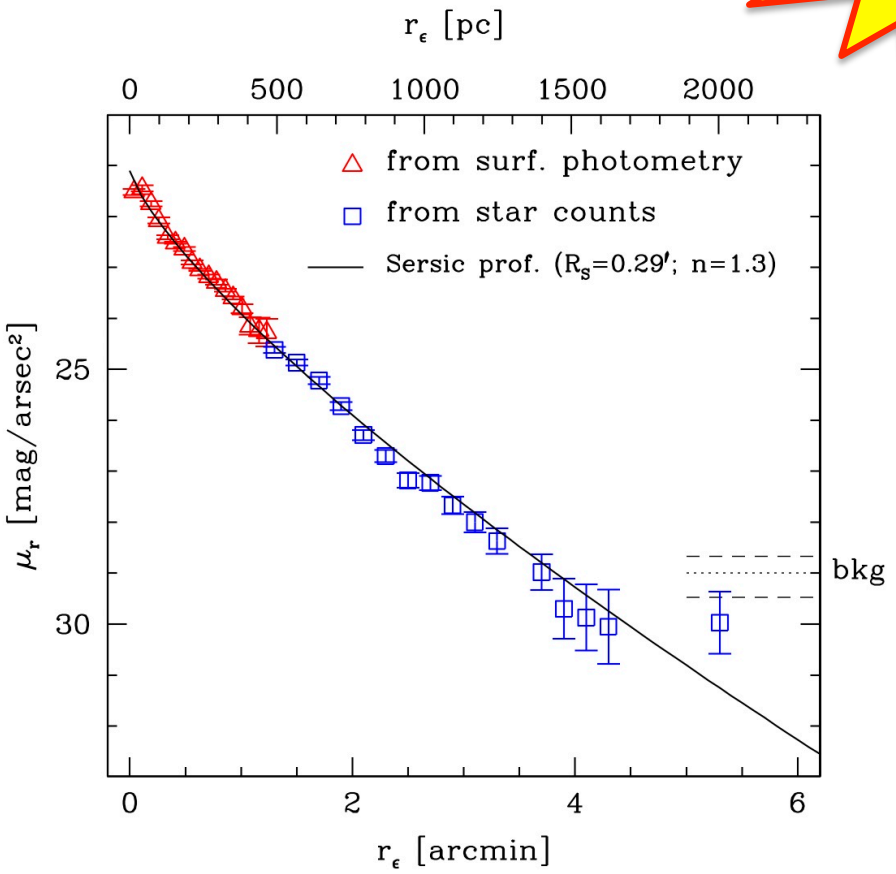




For a deeper insight: structure. Coupling surface photometry and star counts



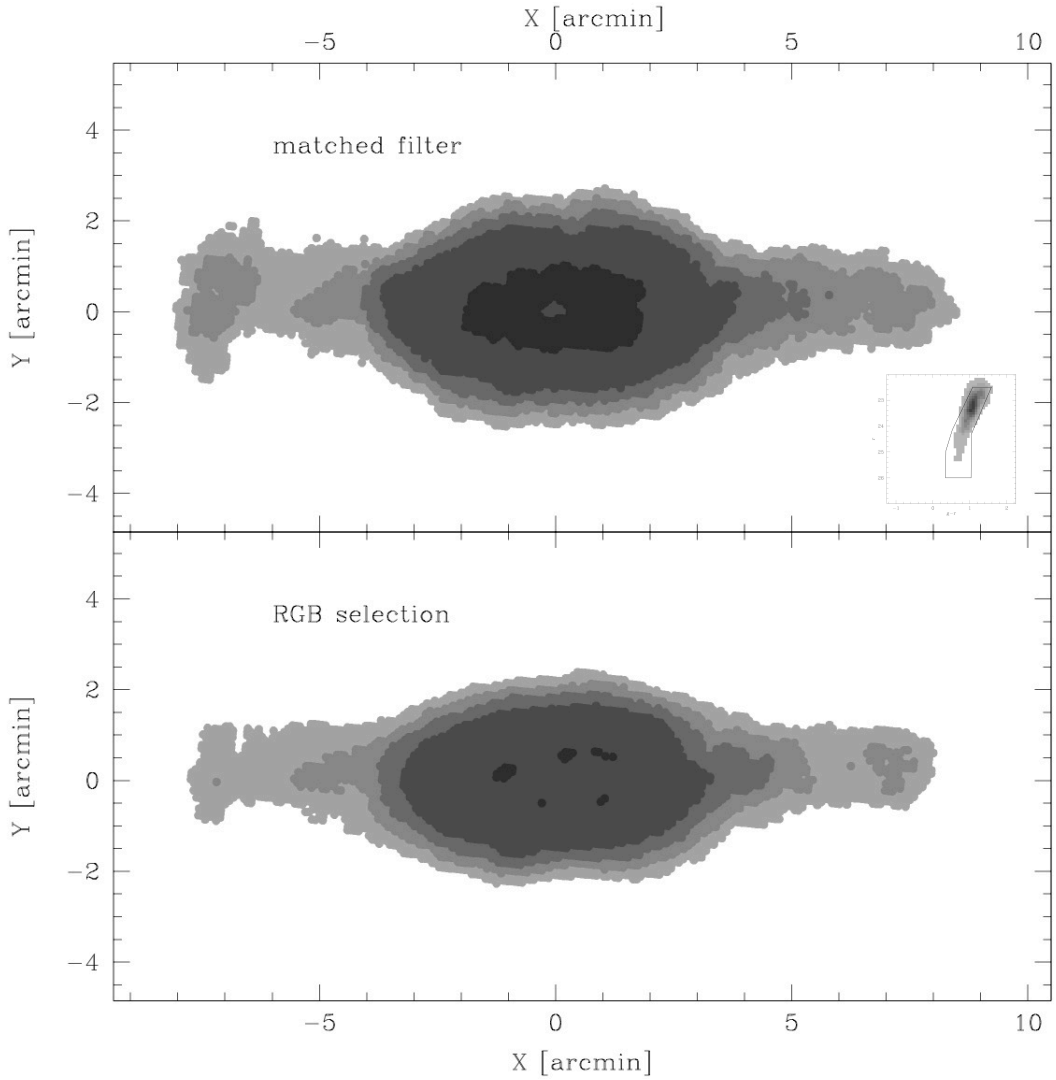
The LSB Realm



We are able to trace the SB profile out to ~5′=2 kpc, i.e. 5 times more extended than what previously available (Taylor et al. 2005; from surface photometry)

The line is the Sersic model that best fits the innermost ~1′

Density maps: significant “wings” beyond the elliptical core.



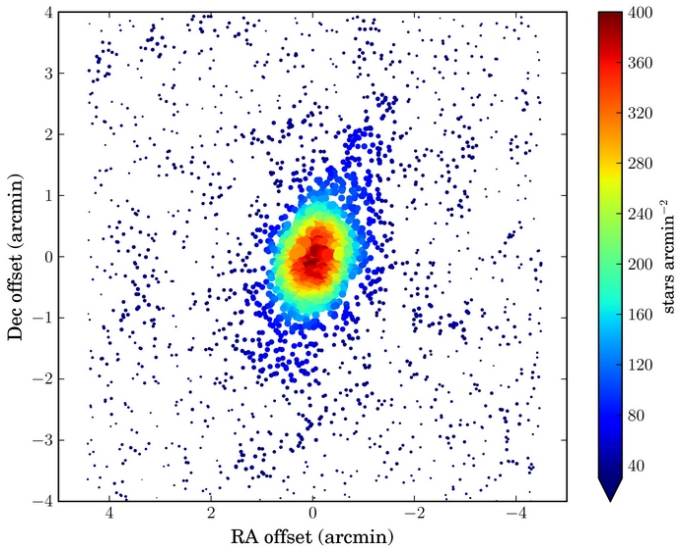
Are they the vestiges of an ancient disc?
This would be a striking confirmation of the scenarios envisaged by Mayer et al. and Kormendy at al.

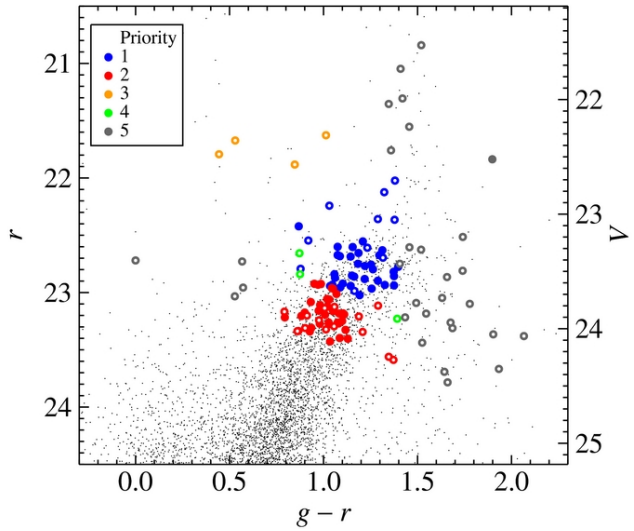
ALTERNATIVELY

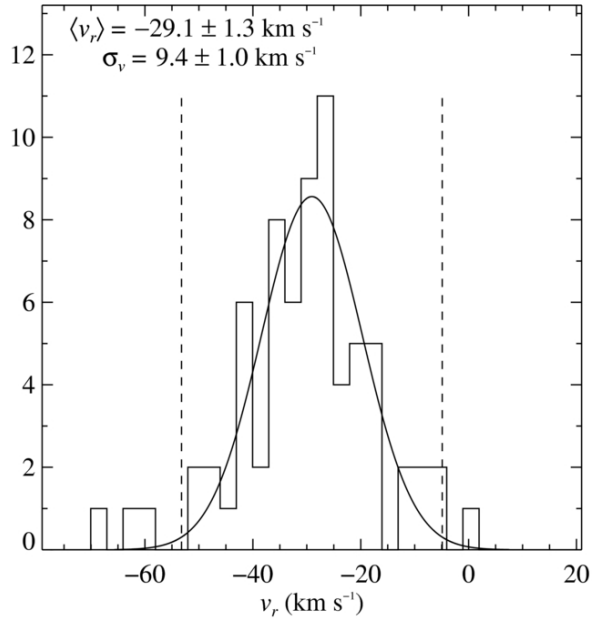
they may be of tidal origin: an ancient fly-by with a LG galaxy?

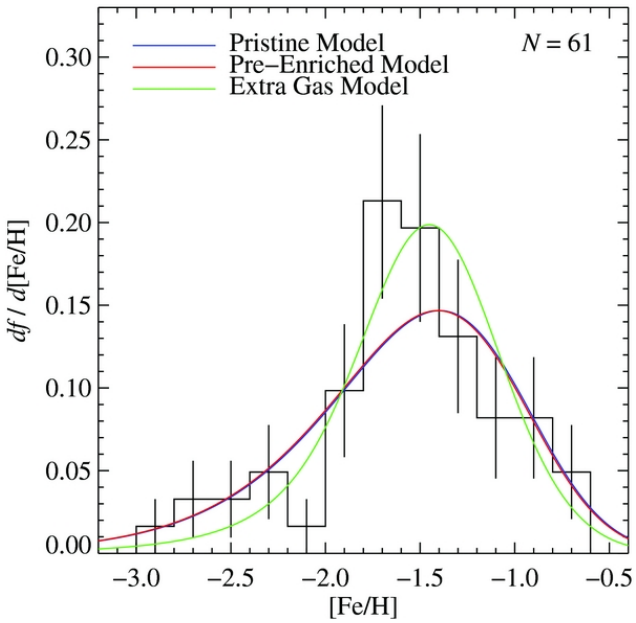
See Teyssier et al. 2012

Penny et al. 2012: Antlia







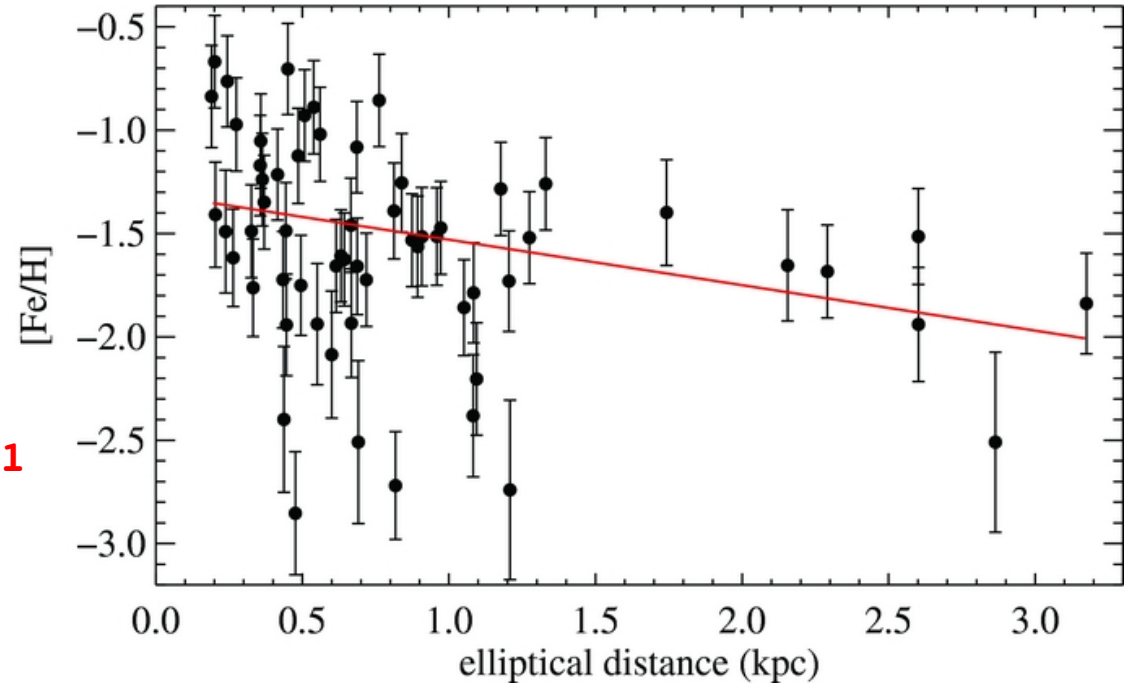


DEIMOS CaT R=6600 spectra of 67 member stars [half of the programmed sample]

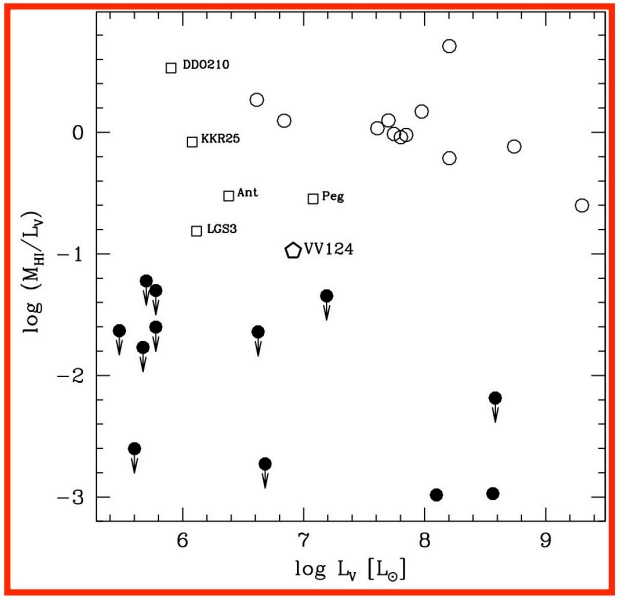
Sample not sufficient to constrain the kinematics in the wings:
but confirmed member stars in the wings

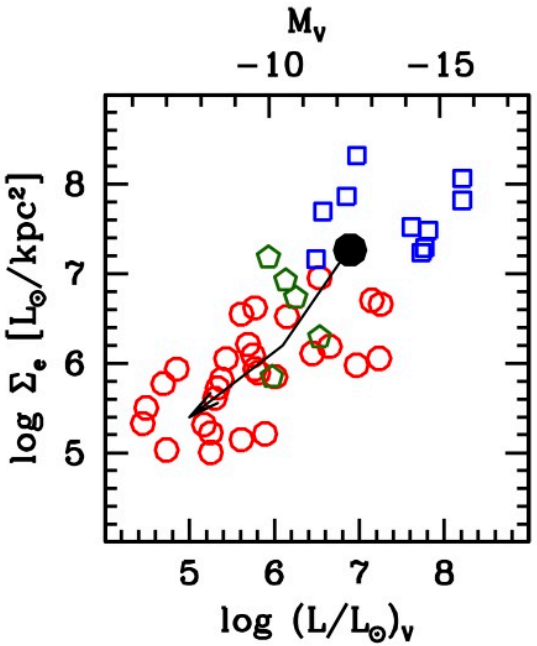
$M_{1/2}=2.1\times10^{7}\ M_{\odot}$ $(M/L_V)_{1/2}=5.2\pm1.1$

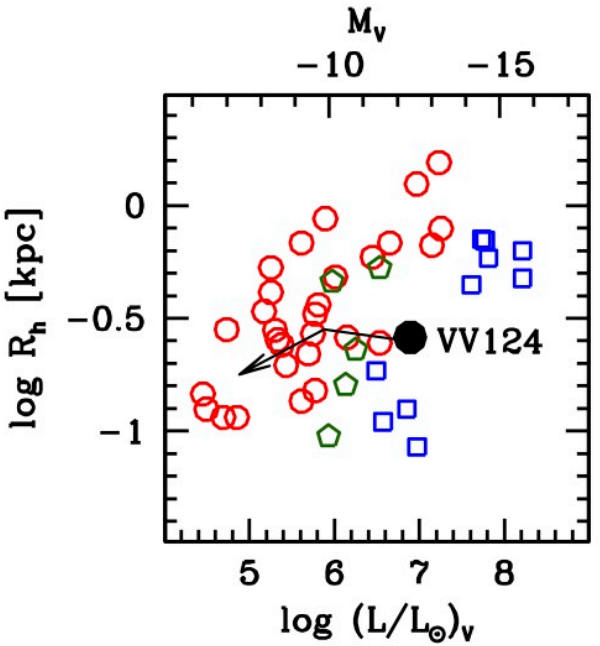
$M_{dyn}/M_{star} = 4.5\pm1.9$

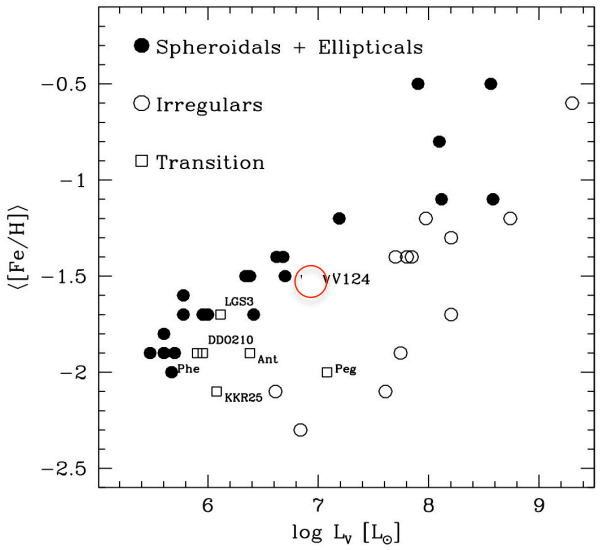


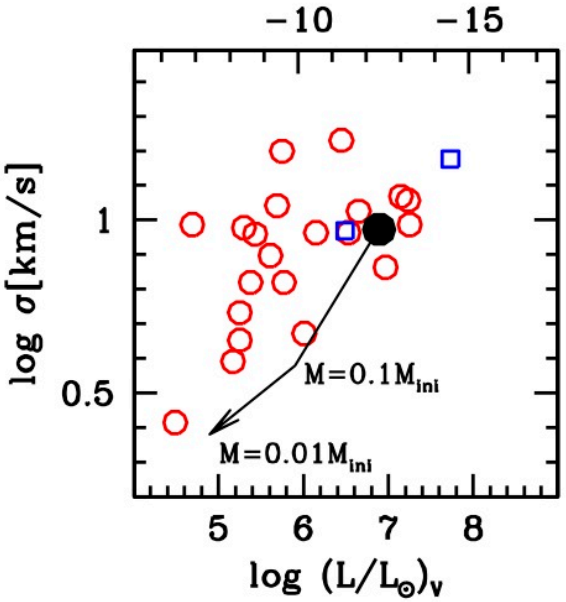
Can VV124 be a precursor of a dSph?











Tidal evolution tracks
from Penarrubia et al. (2008)

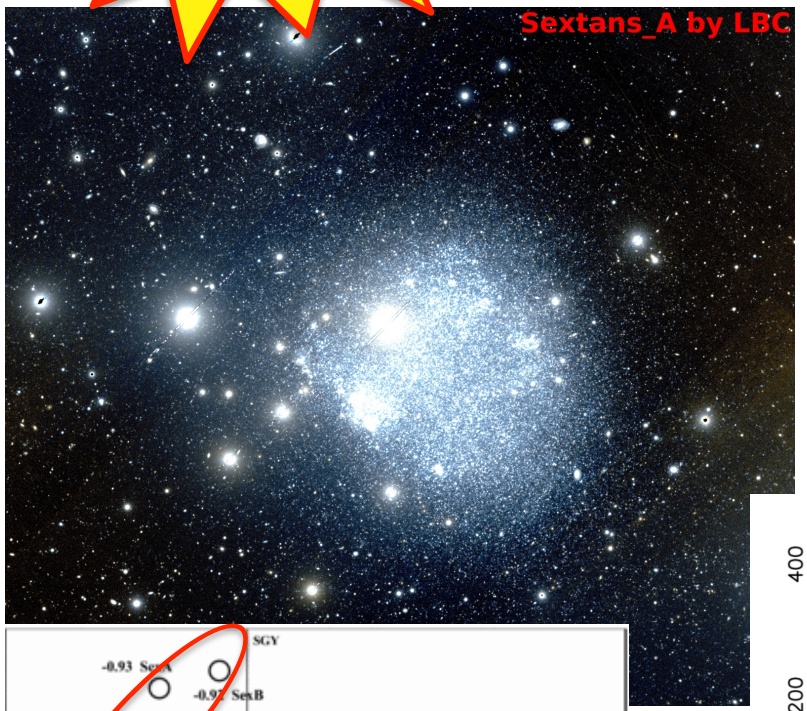
dwarf Spheroidals
dwarf Irregulars
transition type

We obtained data of similar quality for five additional targets to be analyzed as VV124. The next two of the list are Sextans A & B, hence ….

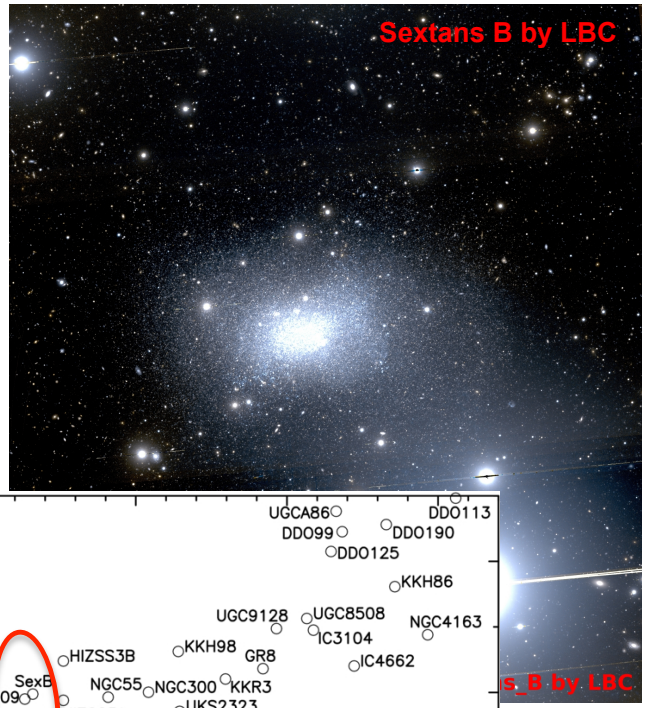
Preliminary results!

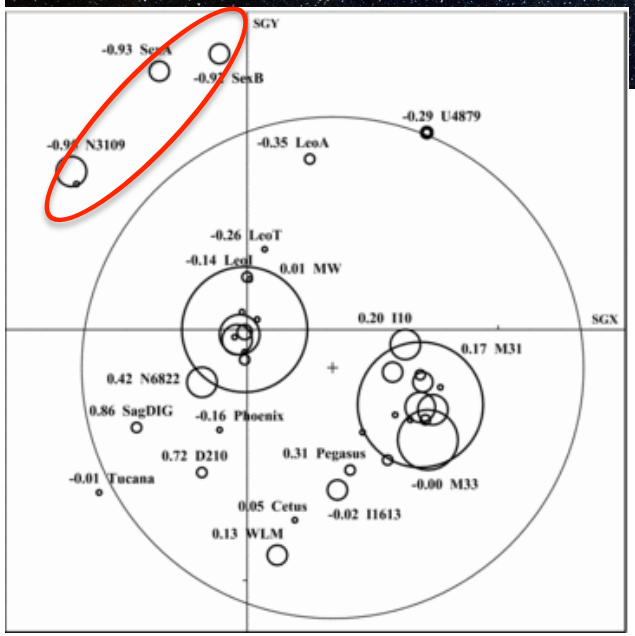
Sextans in Sexten

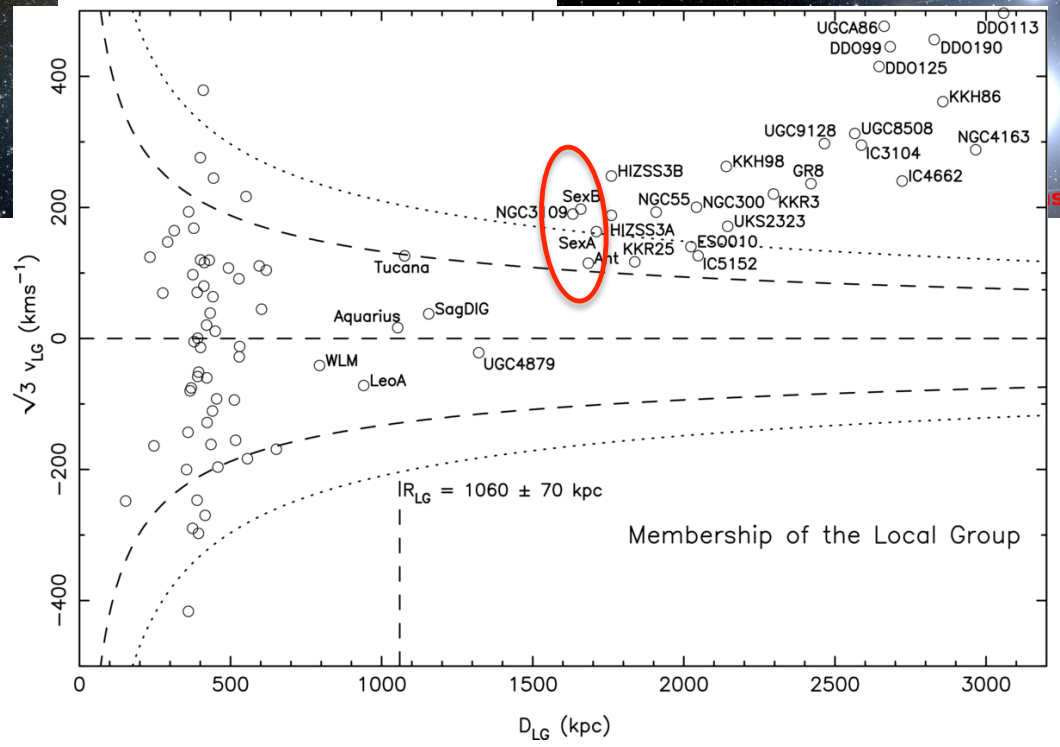
The LSB outskirts of Sextans A, Sextans B

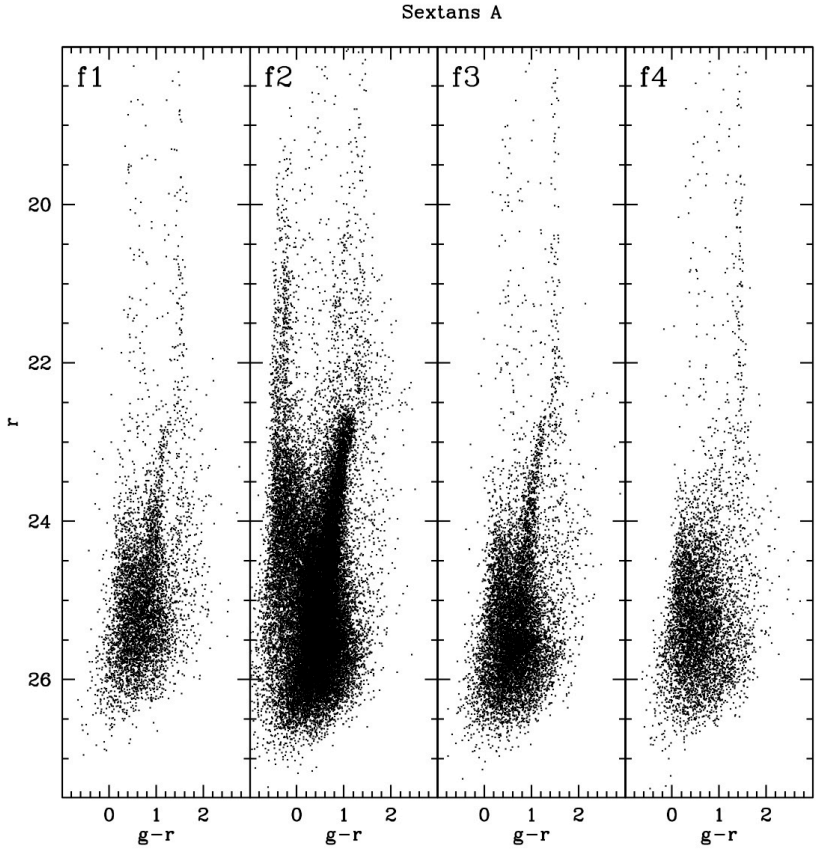


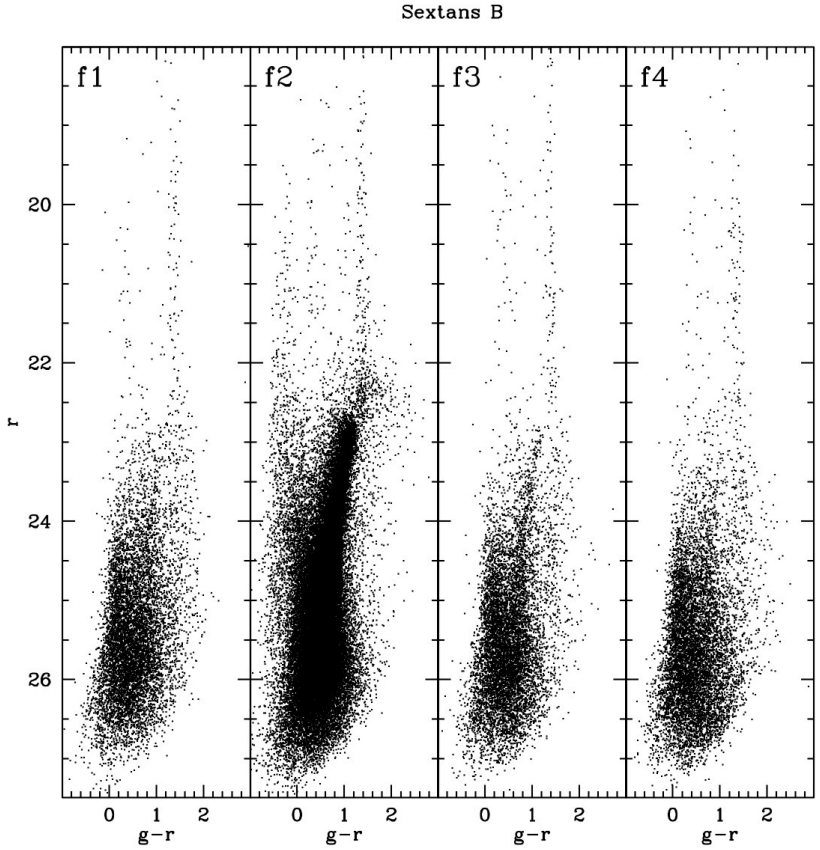
With NGC3109 and Antlia they are members of the NGC3109 sub-group





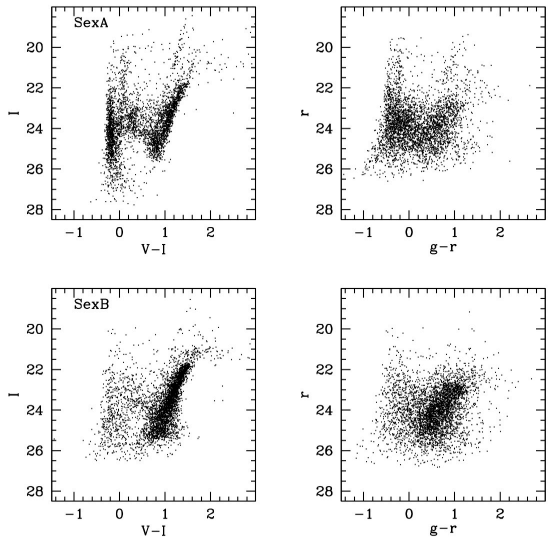




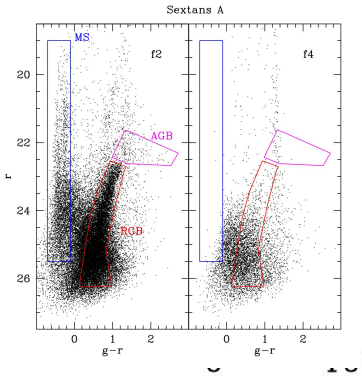


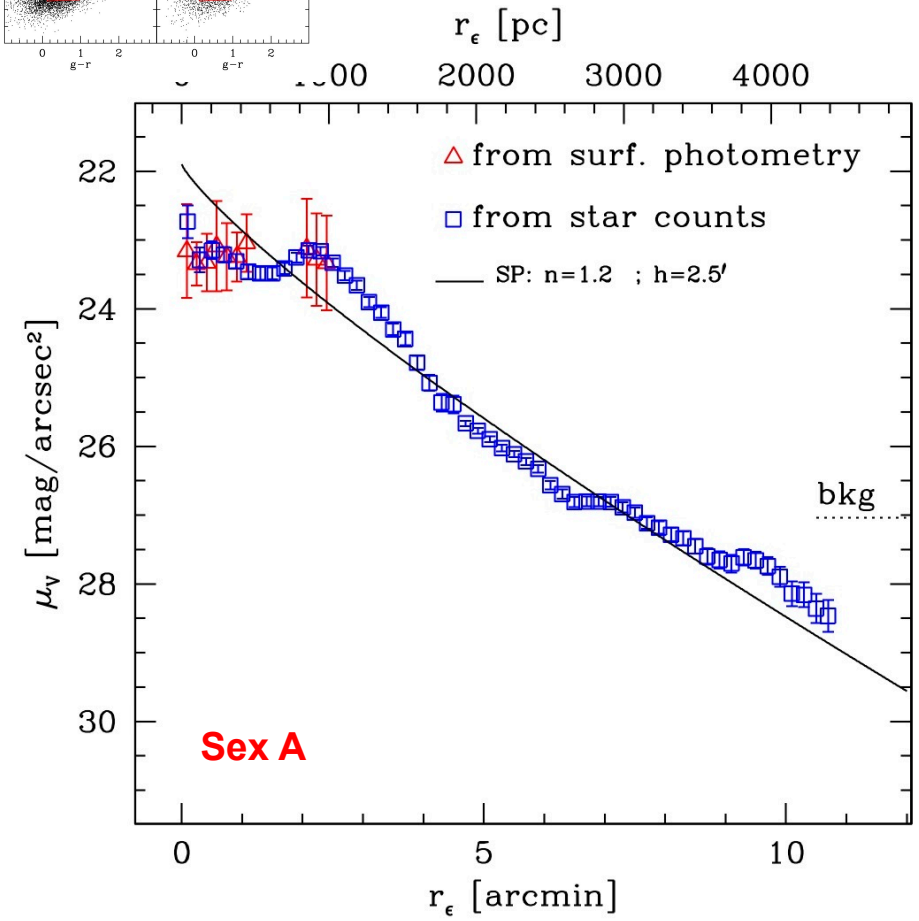
Each galaxy has been imaged with LBC@LBT in binocular mode

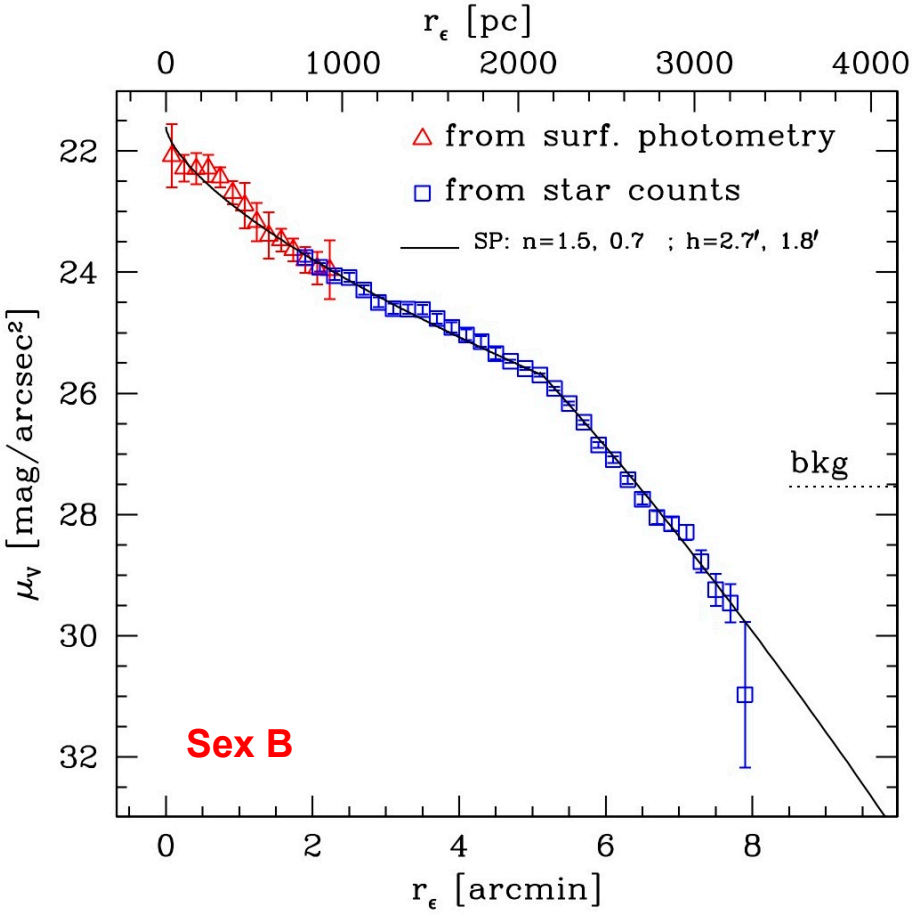
6 X 300s exposures per filter with seeing < 1.0″ FWHM

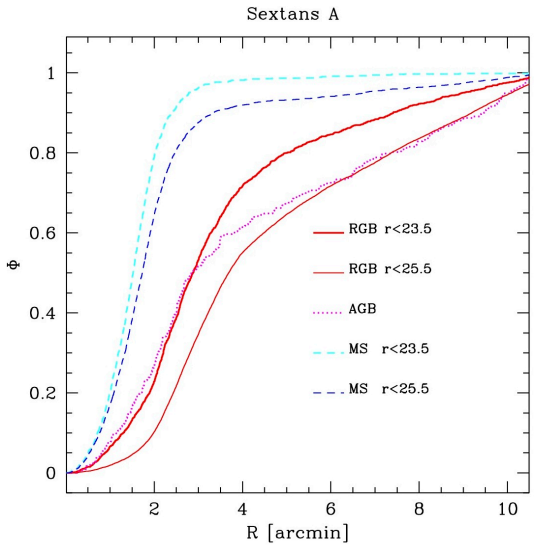


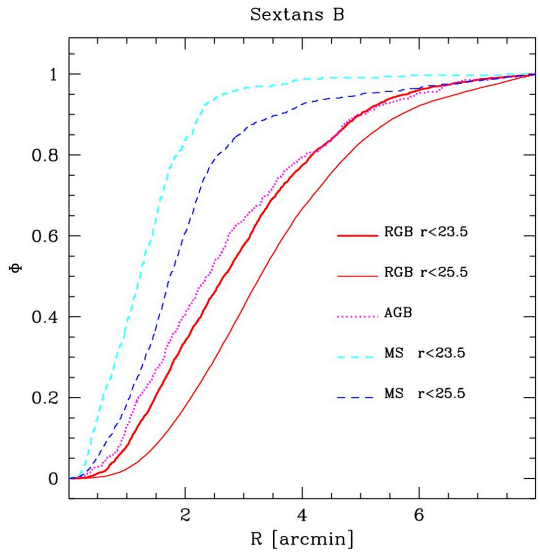
As for VV124 we couple surface photometry in the innermost parts to RGB+RG star counts to trace the major-axis SB profile.
The extension of the galaxies is more than double with respect to existing profiles.
At odds with VV124 a single Sersic profile is not an acceptable fit

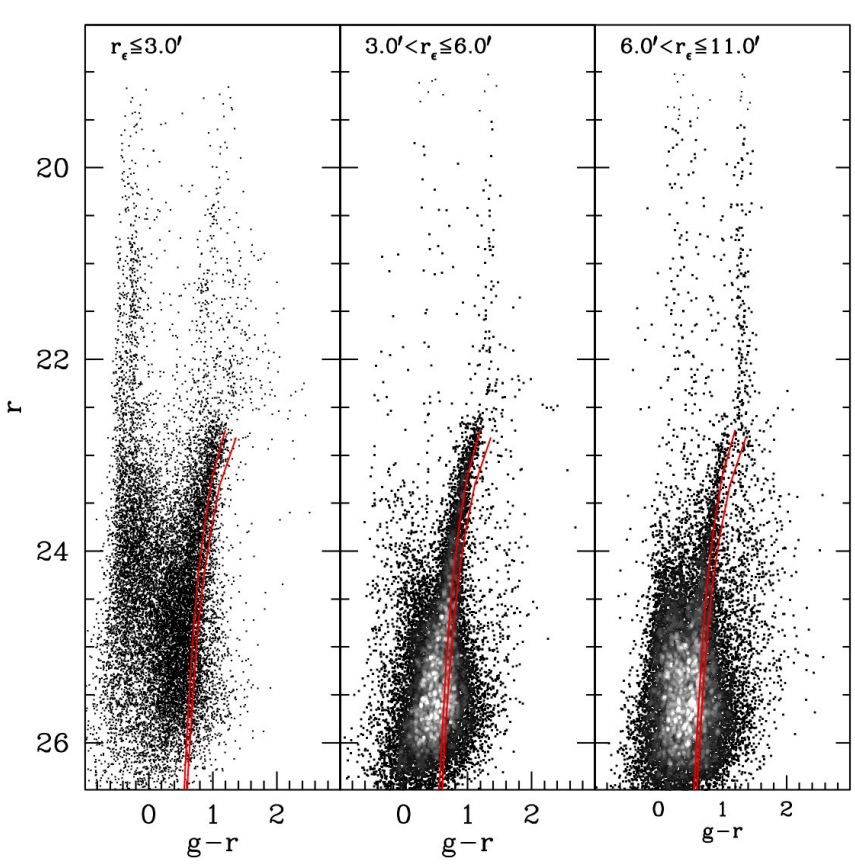


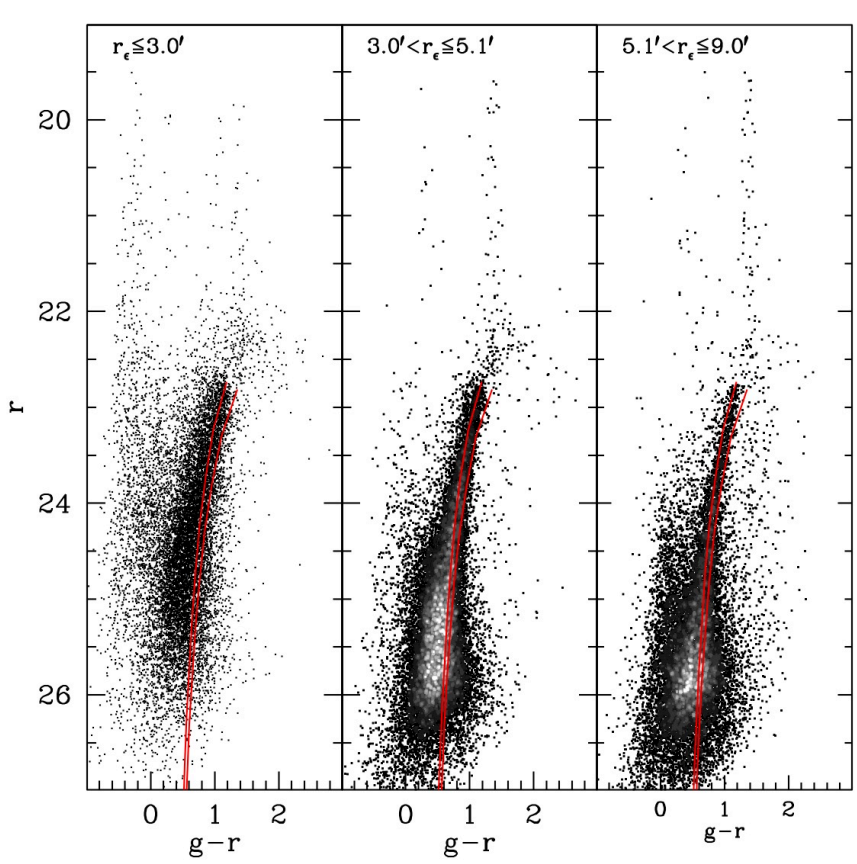




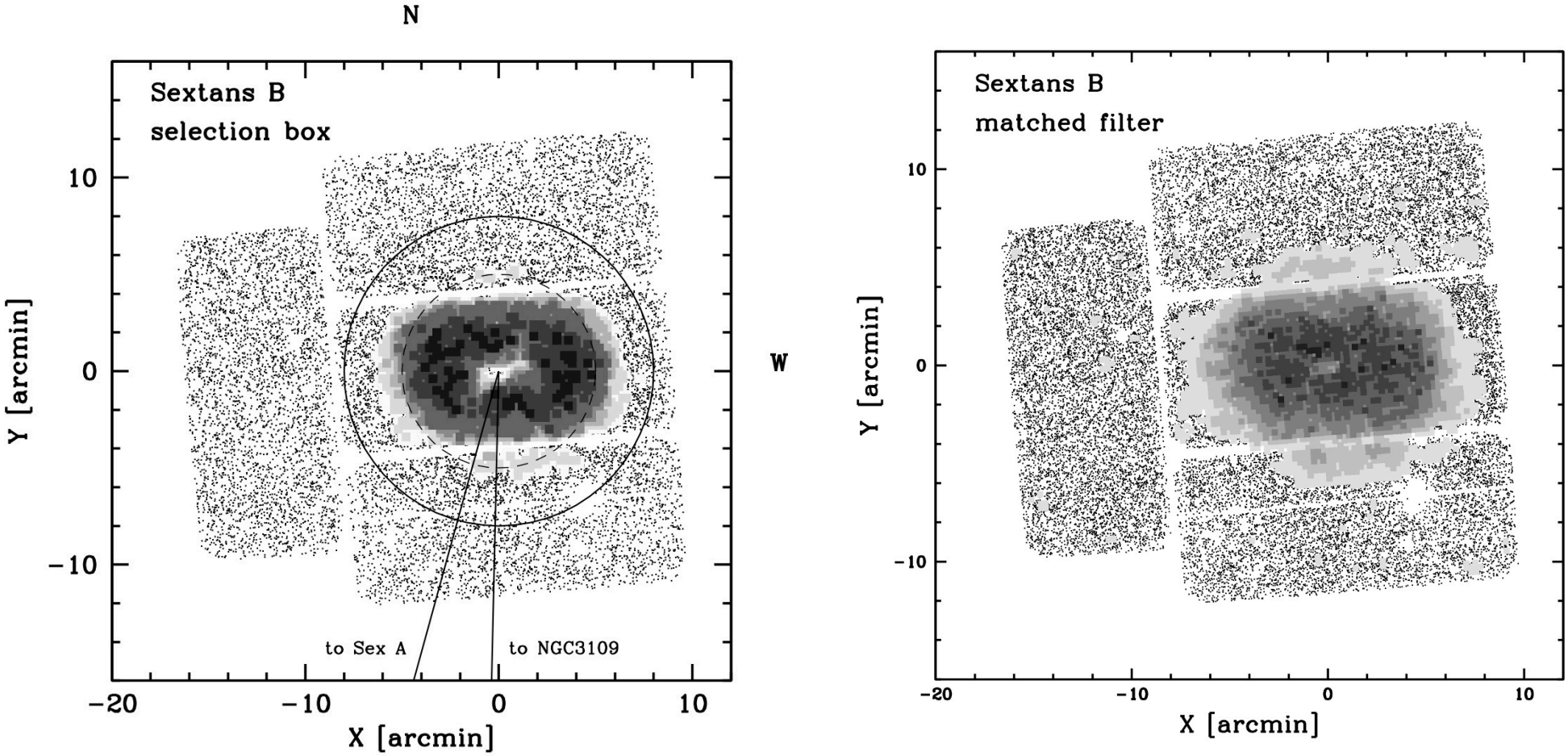

Sextans A
RGB r<23.5
RGB r<25.5
AGB
MS r<23.5
MS r<25.5
Φ
R [arcmin]

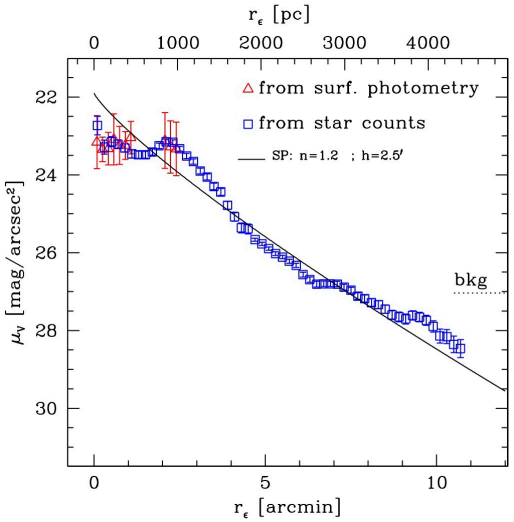

Sextans B
RGB r<23.5
RGB r<25.5
AGB
MS r<23.5
MS r<25.5
Φ
R [arcmin]


Sextans A
$r_\epsilon \leqq 3.0'$
$3.0' < r_\epsilon \leqq 6.0'$
$6.0' < r_\epsilon \leqq 11.0'$
r
g−r

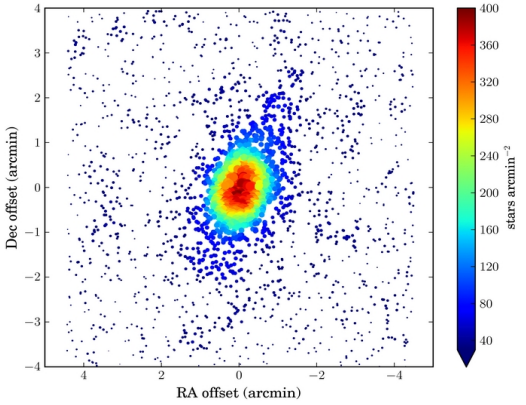

Sextans B
$r_\epsilon \leqq 3.0'$
$3.0' < r_\epsilon \leqq 5.1'$
$5.1' < r_\epsilon \leqq 9.0'$
r
g−r

Sextans B: pretty elongated but
very smooth and symmetric density map



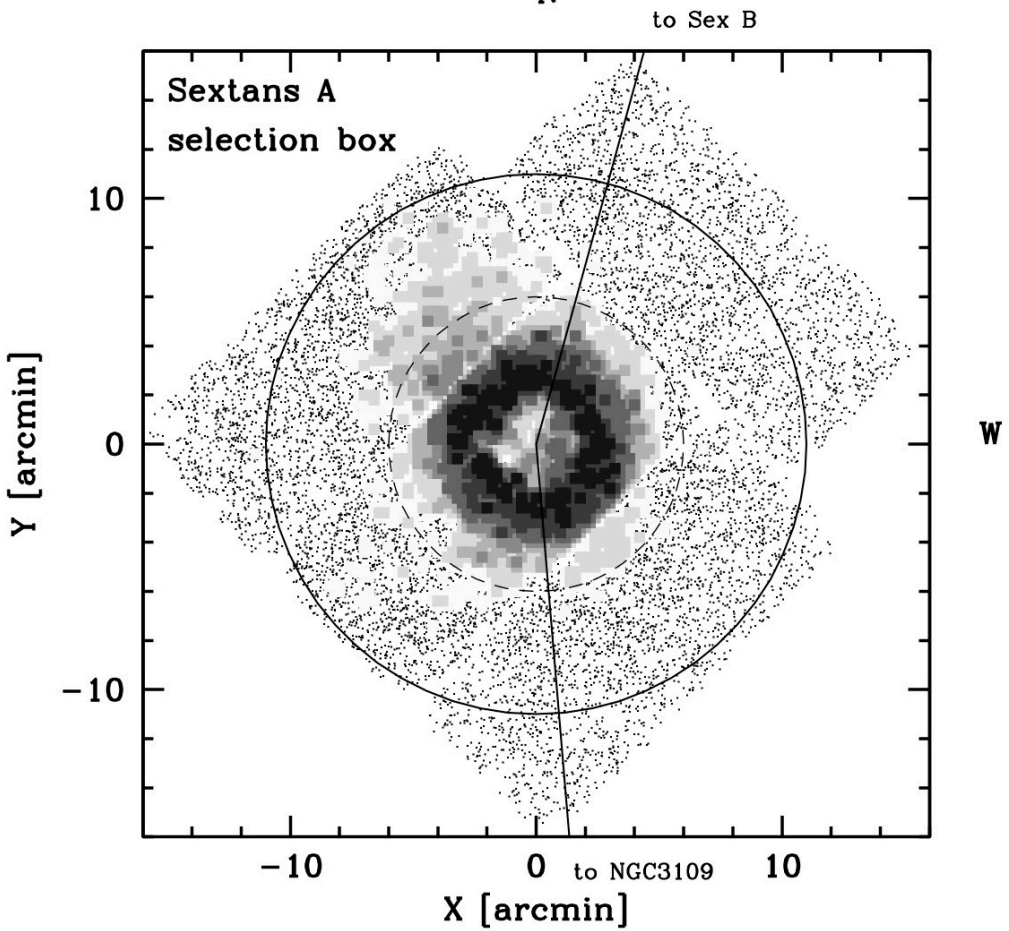


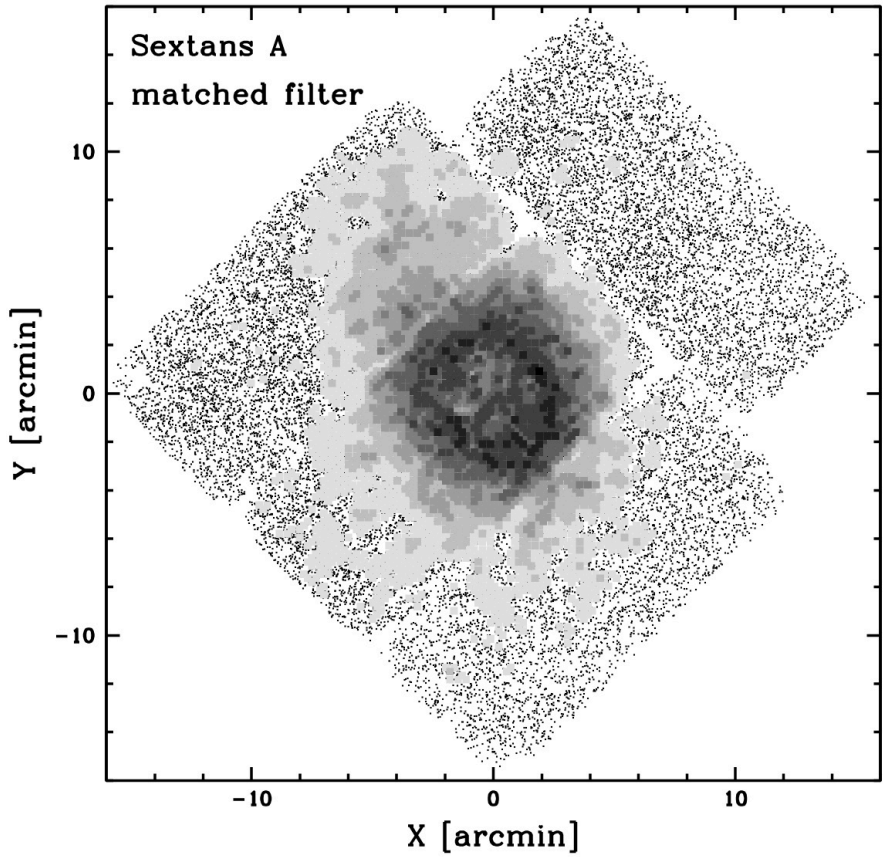
Penny et al. 2012: Antlia



Sextans A: Tidal Tails?

It may be worth to reconsider the whole N3109 group (see Tully et al 2006 for a recent discussion)

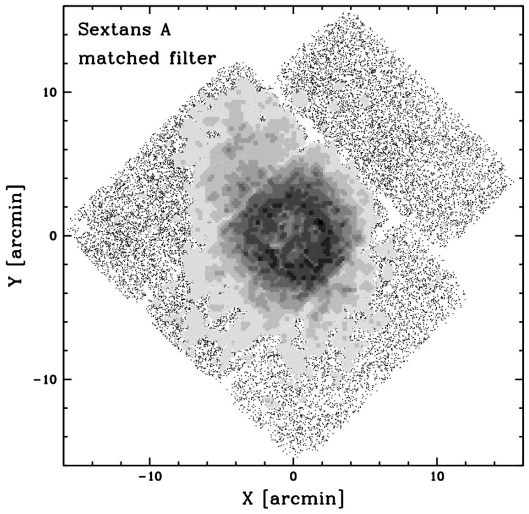


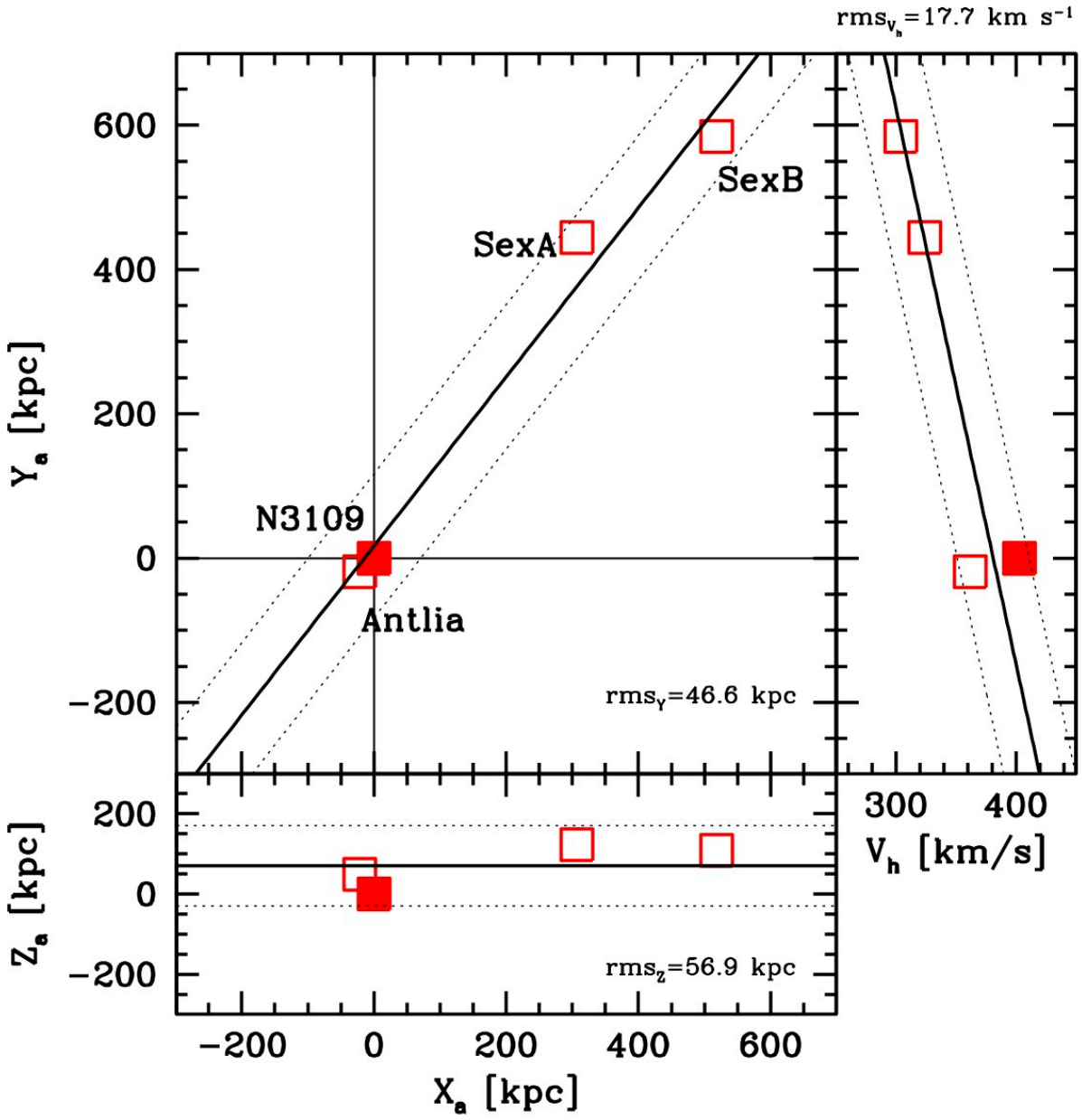


The group lie along a line in space

3D distance
N3109-SexB = 789 kpc
σ_R = 350 kpc
σ_Y = 252 kpc
rms_Y about the line = 46.6 kpc
rms_Z about the line = 56.9 kpc

σ_{Vh} = 43.7 km/s
rms_{Vh} about the line = 17.7 km/s





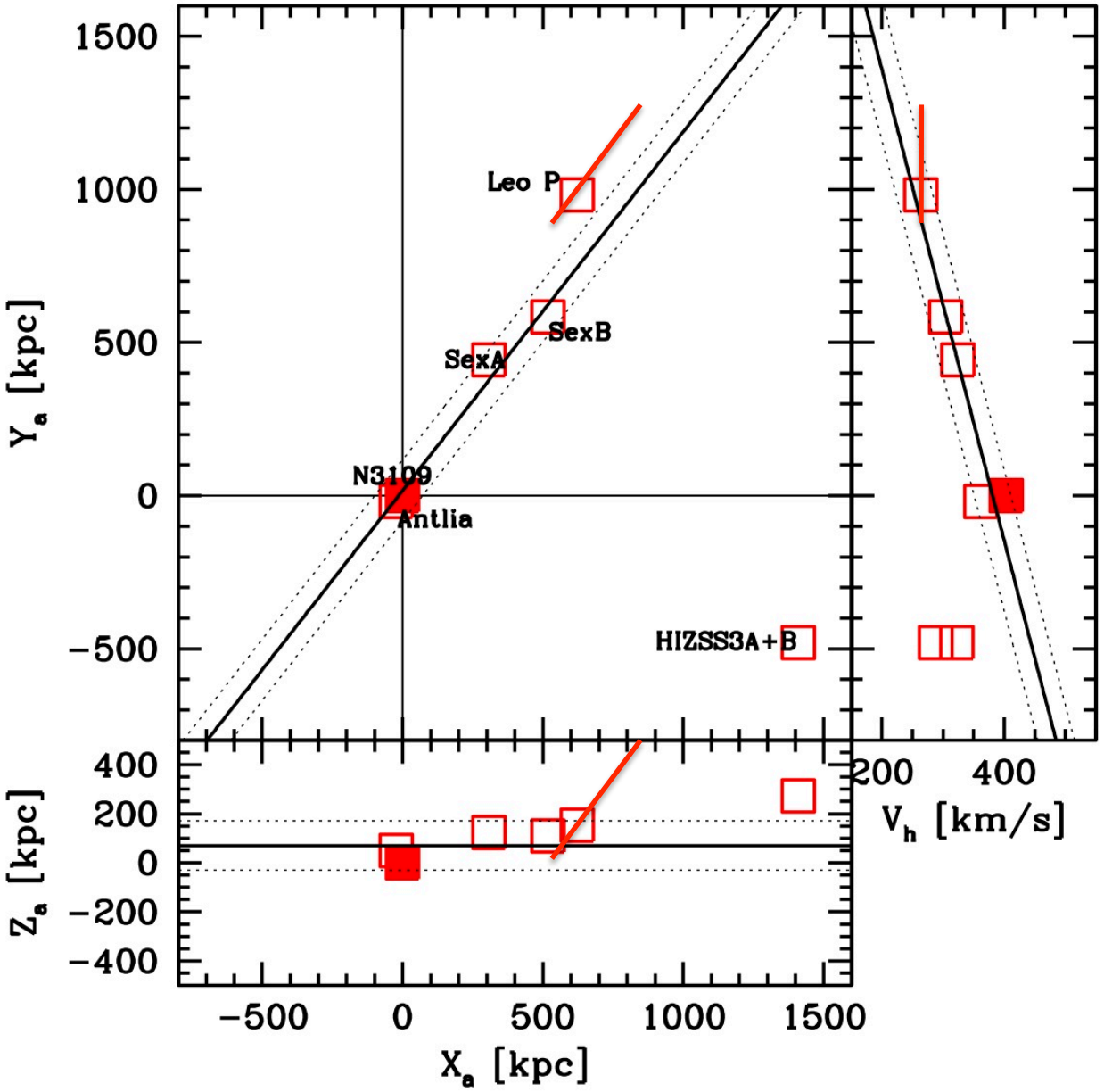
N3109 ➔ M_{*+HI}=34.8×10^7 $M_\odot$
Sex B ➔ M_{*+HI}= 9.5×10^7 $M_\odot$
Sex A ➔ M_{*+HI}=10.7×10^7 $M_\odot$
Antlia ➔ M_{*+HI}= 0.2×10^7 $M_\odot$

The group lie
along a line in space

Also the newly discovered ultra faint star-forming dwarf Leo P appears to belong to the structure!

All of them are gas-rich rotating disc galaxies

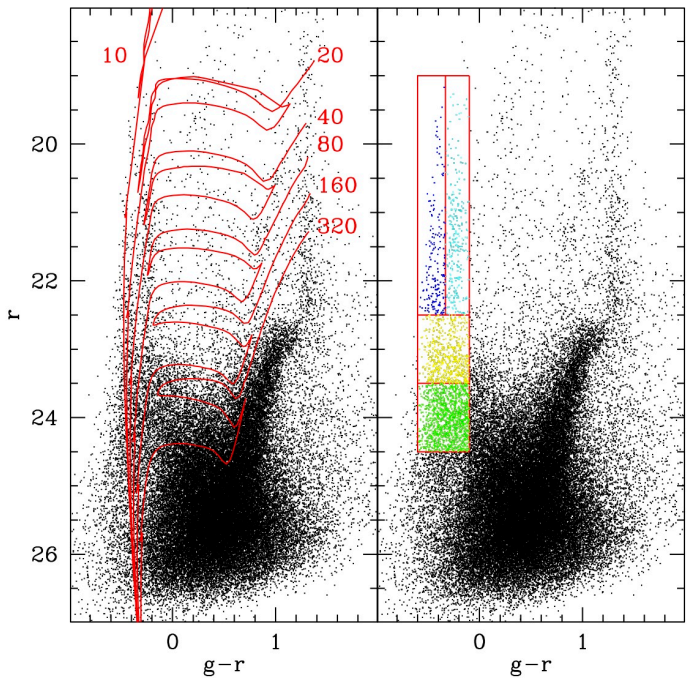
Giovannelli et al. 2013
Skillman et al. 2013
Rhode et al. 2013

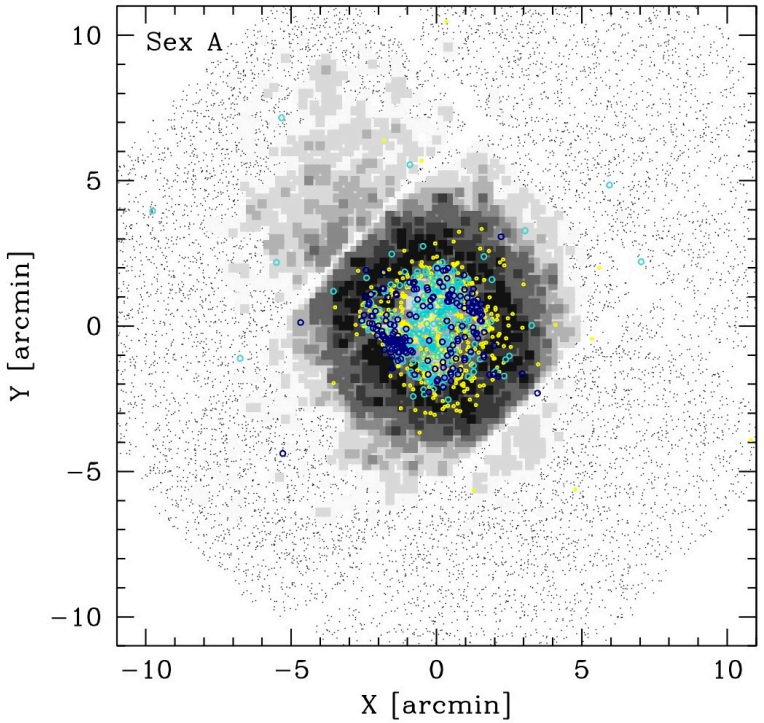


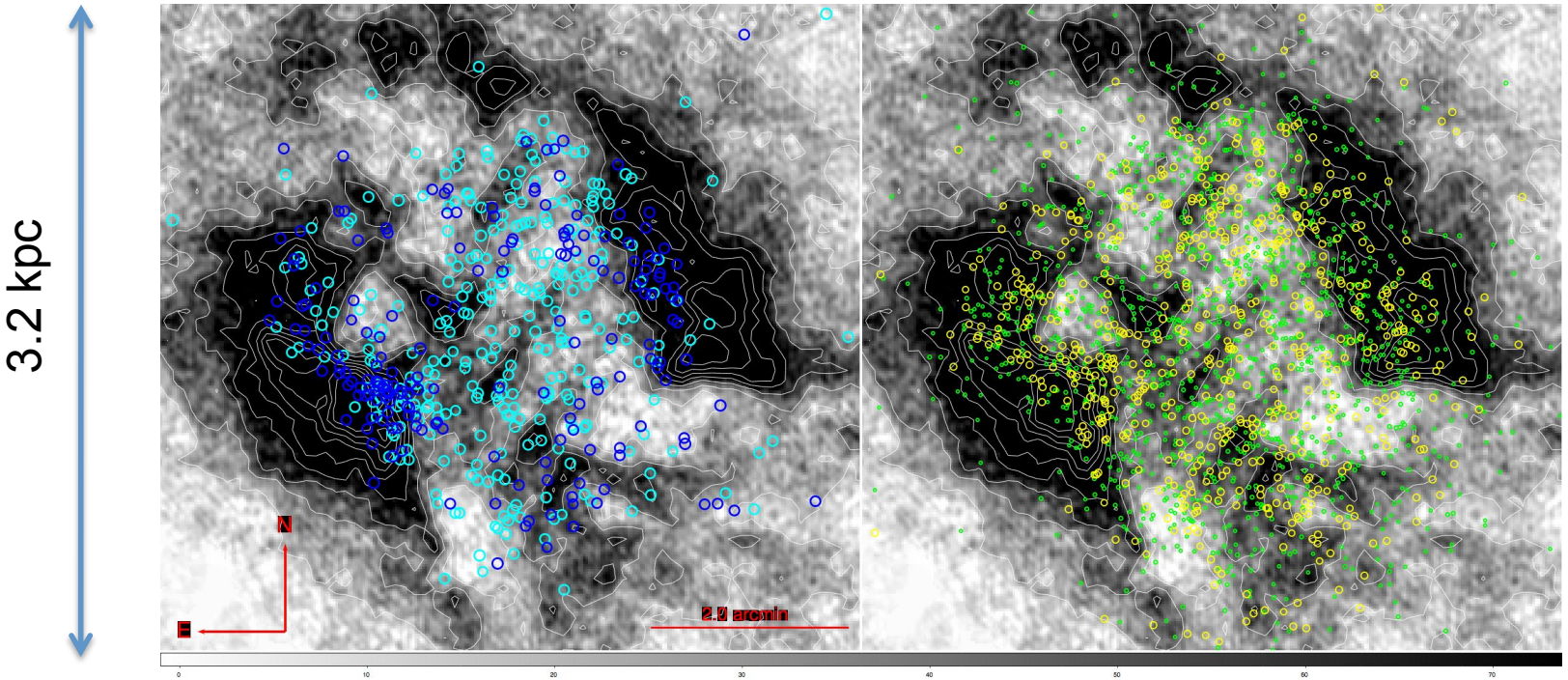
The young population and the gas

Sextans A

See Dohm-Palmer et al. 1997 and Weisz et al. 2011 for details on SFH





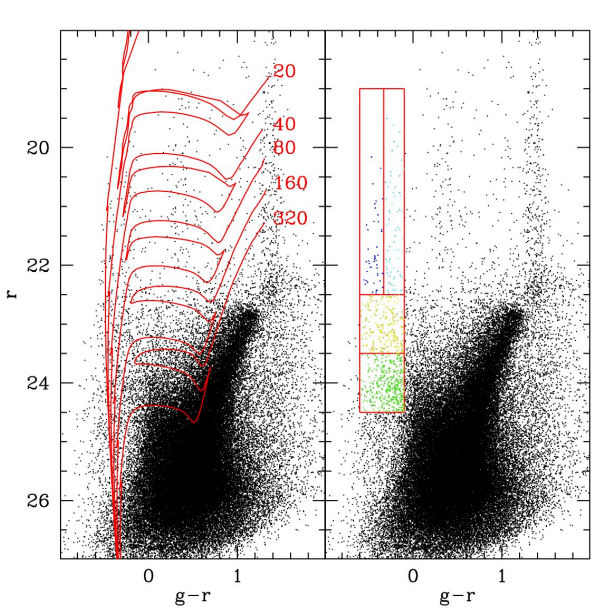


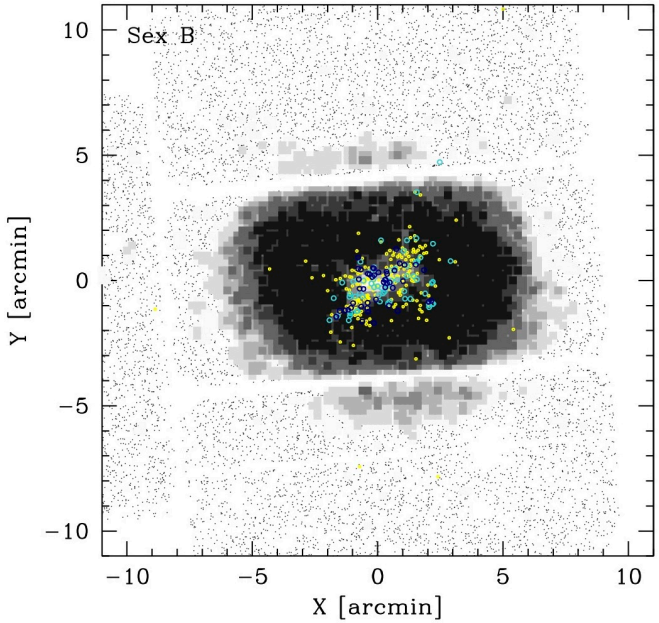
HI maps from LITTLE THINGS Hunter et al. 2007

The young population and the gas

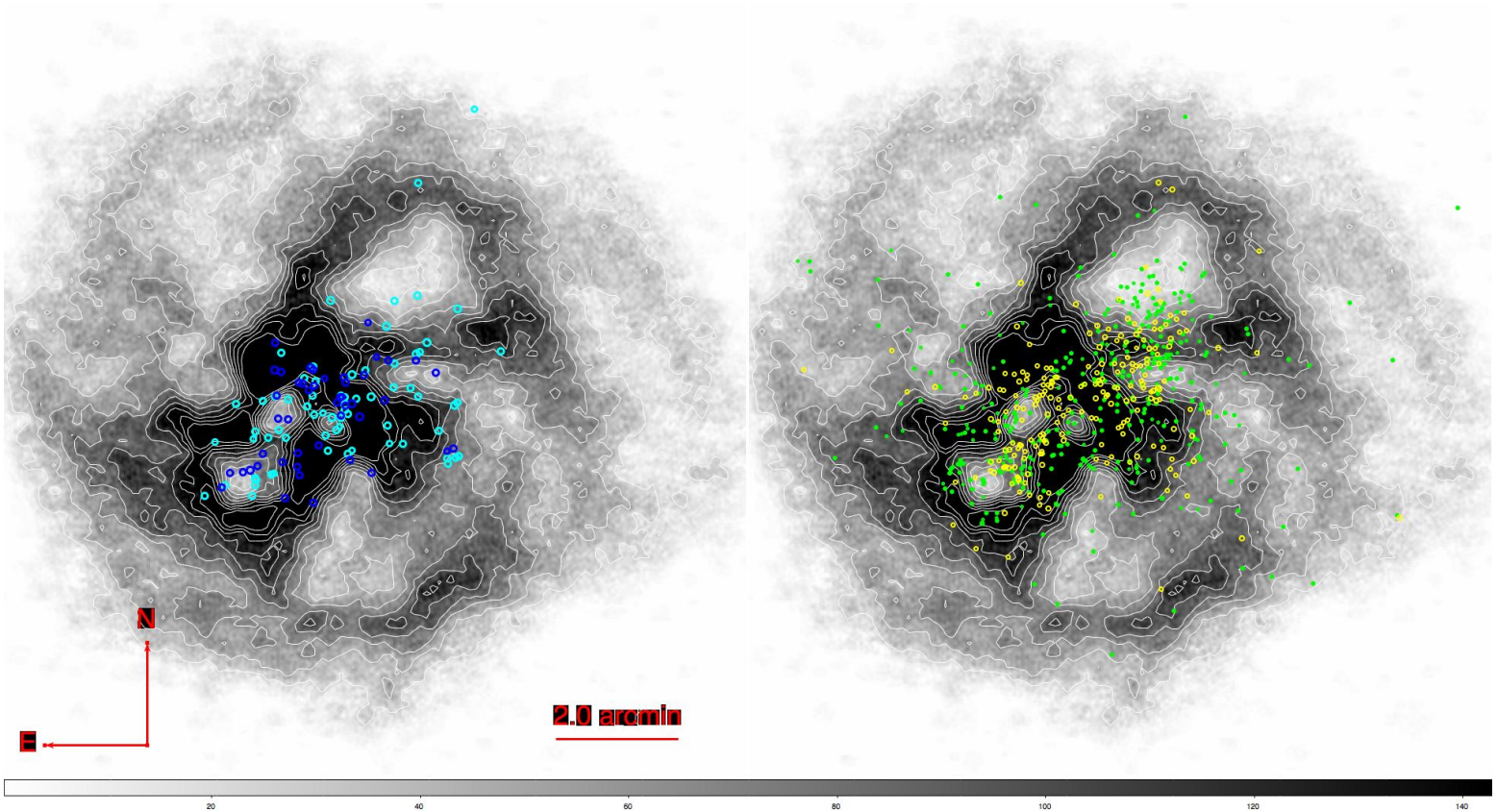
Sextans B

See Weisz et al. 2011 for details on SFH





5 kpc



HI maps from LITTLE THINGS Hunter et al. 2007

Next steps:

1. Kinematics and dynamical masses from HI [see e.g. Ott et al. 2012]

2. N-body simulations of the group

3. We have a few new candidate star clusters: follow-up

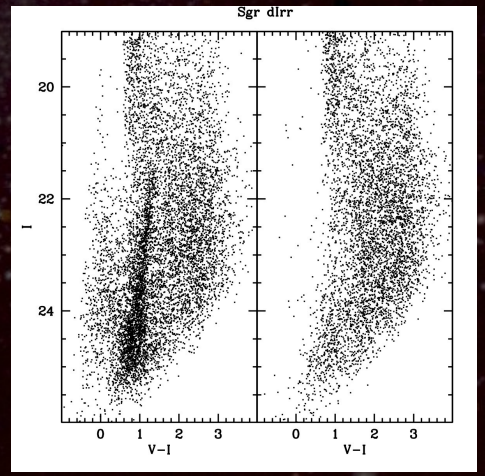
Next targets:

observed with VIMOS@VLT fov = 24′× 24′

1. Sgr dIrr

2. WLM

3. Tucana dSph



Data reduction in progress: stay tuned!