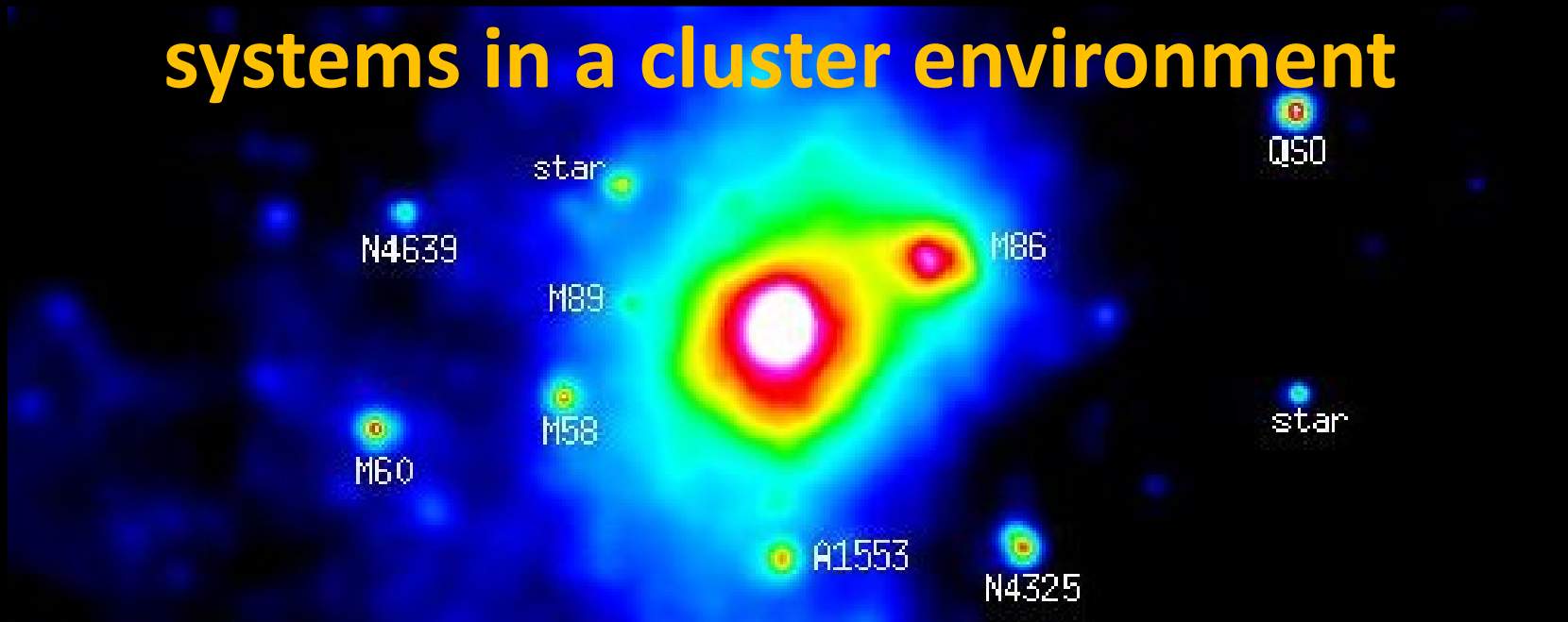
The interstellar medium of star-forming dwarfs In Virgo: probing the evolution of low-mass systems in a cluster environment



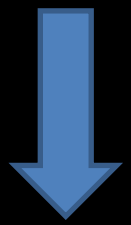
Marco Grossi - Observatório do Valongo, UFRJ
with the **Herschel Virgo Cluster Survey** (HeViCS) team

IGM@50, Spineto, 7-12 June, 2015

Objectives

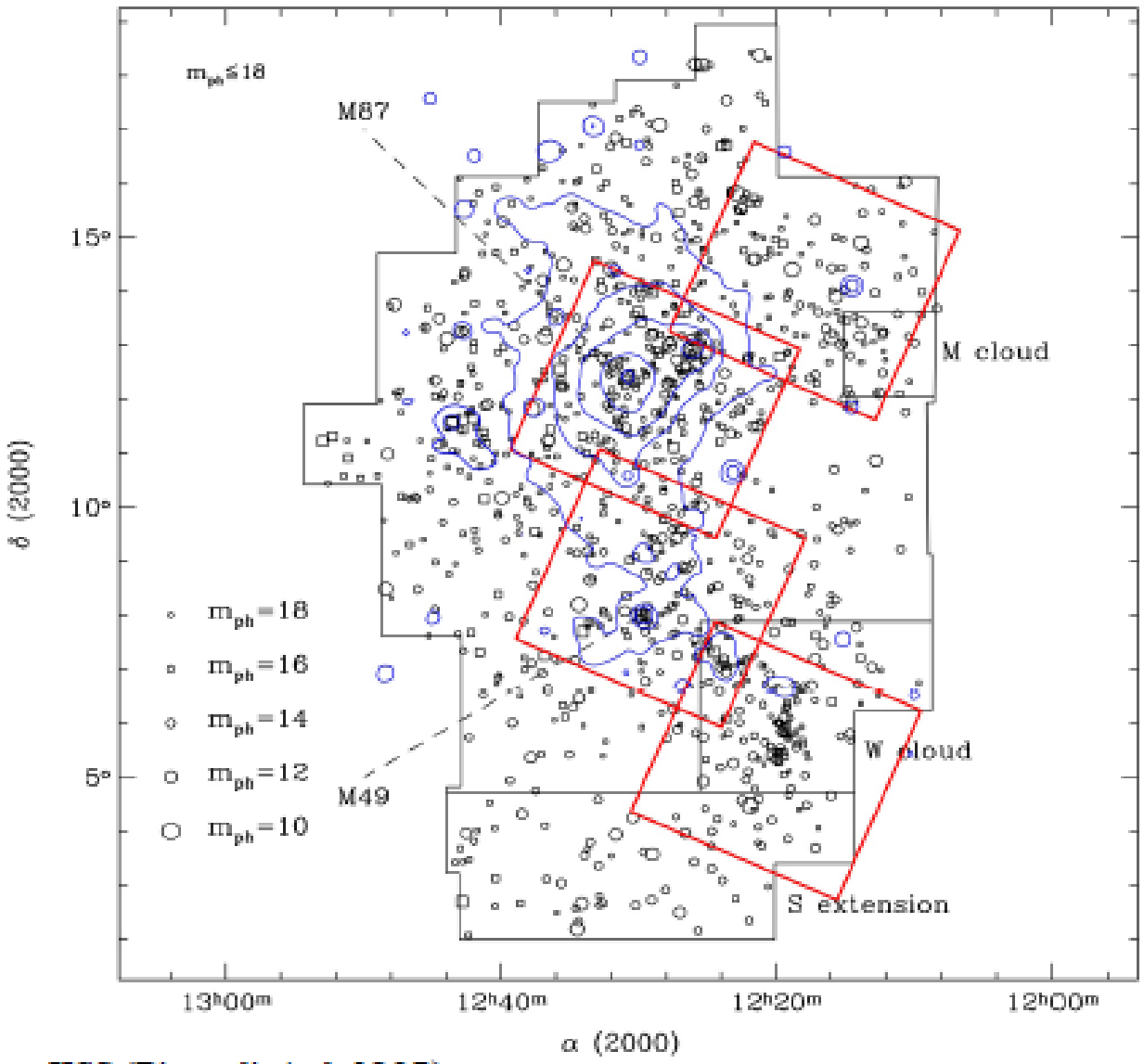
1. Investigate the effects of the environment on the dust component in star-forming dwarf systems.

2. Search for molecular CO emission in FIR-detected SF dwarfs



Evolution of SF dwarfs in a dense environment

The Herschel Virgo cluster survey



VCC (Binggeli et al. 1985)
ROSAT (Bohringer et al.1994)

P.I: J. Davies

Survey Area
≈ 60 deg^2

PACS/SPIRE
parallel mode
fast scanning

PACS B (100-μm)
PACS R (160-μm)
SPIRE (250, 350, 500-μm)

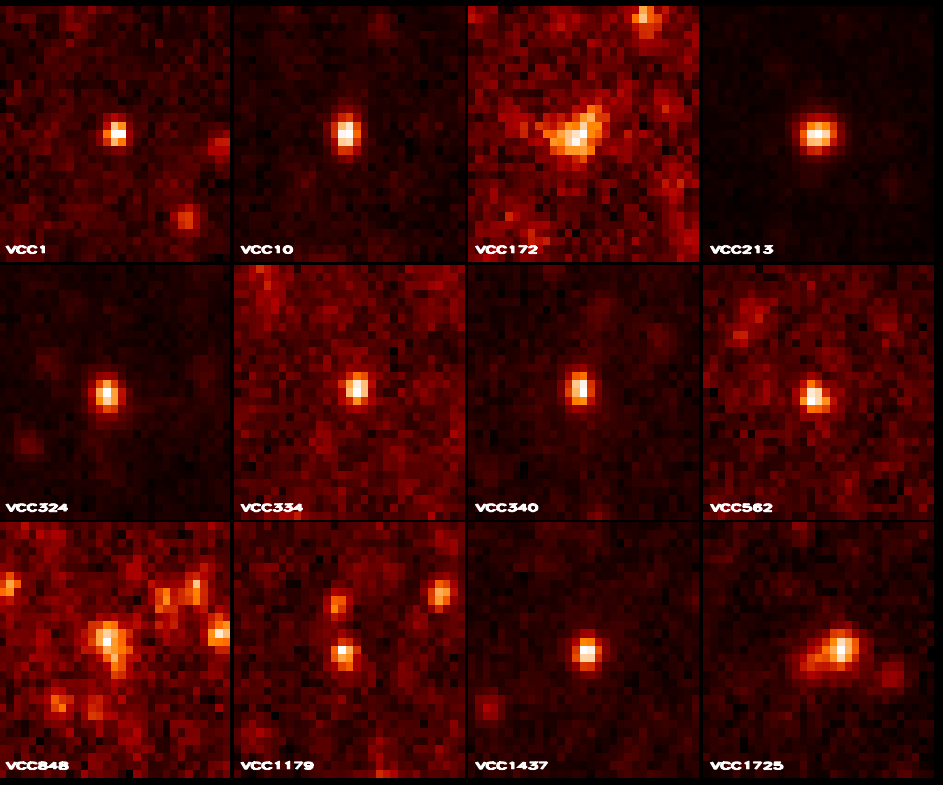
286 hours

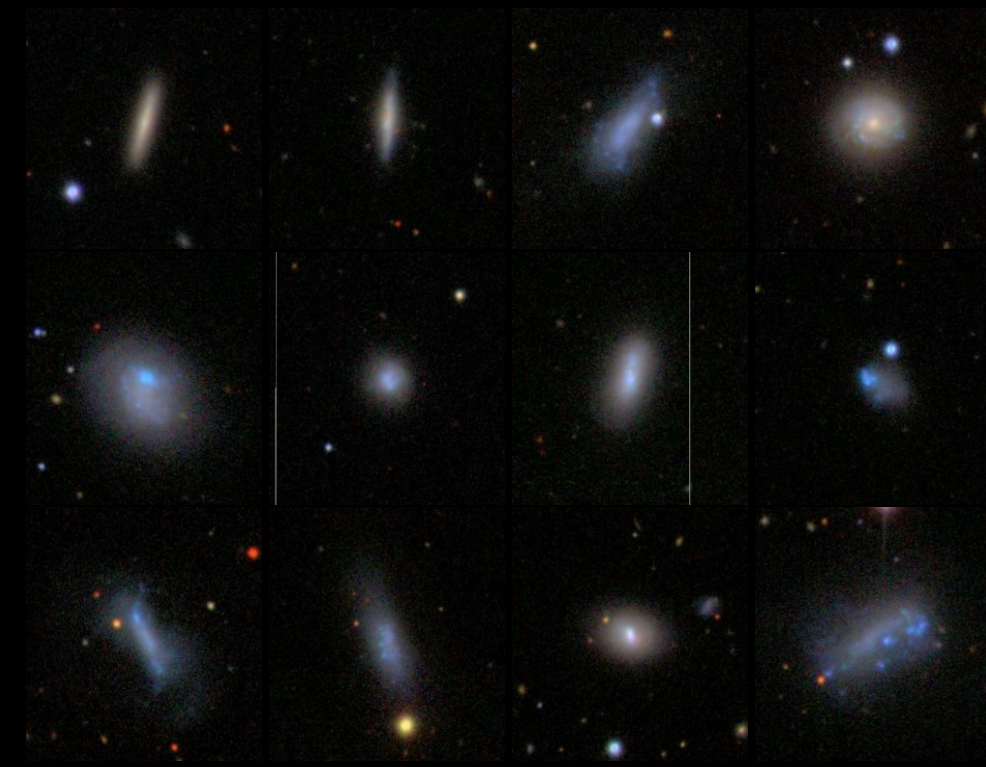
1-σ = 1 MJy/sr
at 250-μm
Confusion limit
For SPIRE

Davies +2012; Auld +2012

Dust in Virgo star-forming dwarfs

- 49 out of 140 galaxies classified as Sm, Im, BCD in the optically selected Catalog of the Virgo cluster (Binggeli et al. 1985, 1987).
- 43% detection rate considering completeness level of the catalog (mB < 18 mag)





Grossi +2015

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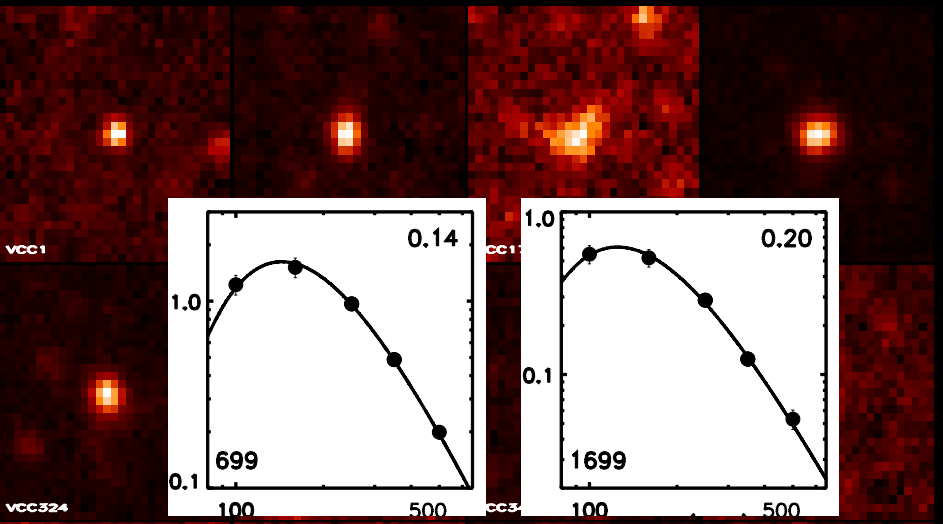
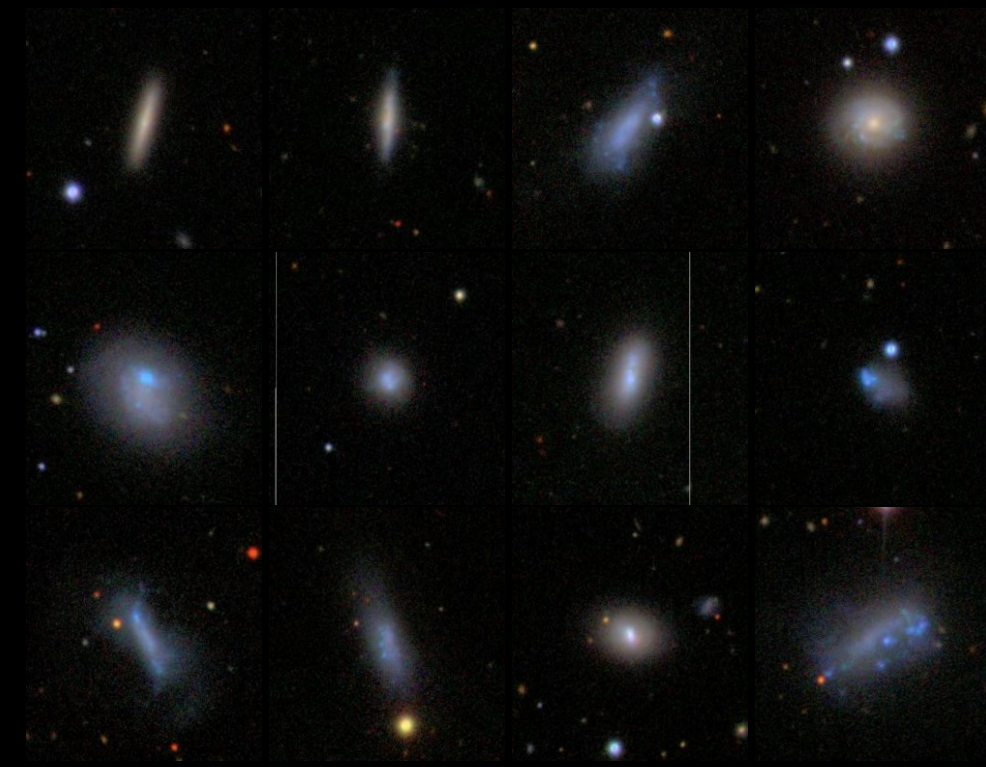


$$F_\nu = \frac{M_{dust}}{D^2} \kappa_{\nu_0} \left(\frac{\nu}{\nu_0}\right)^\beta B_\nu(T)$$

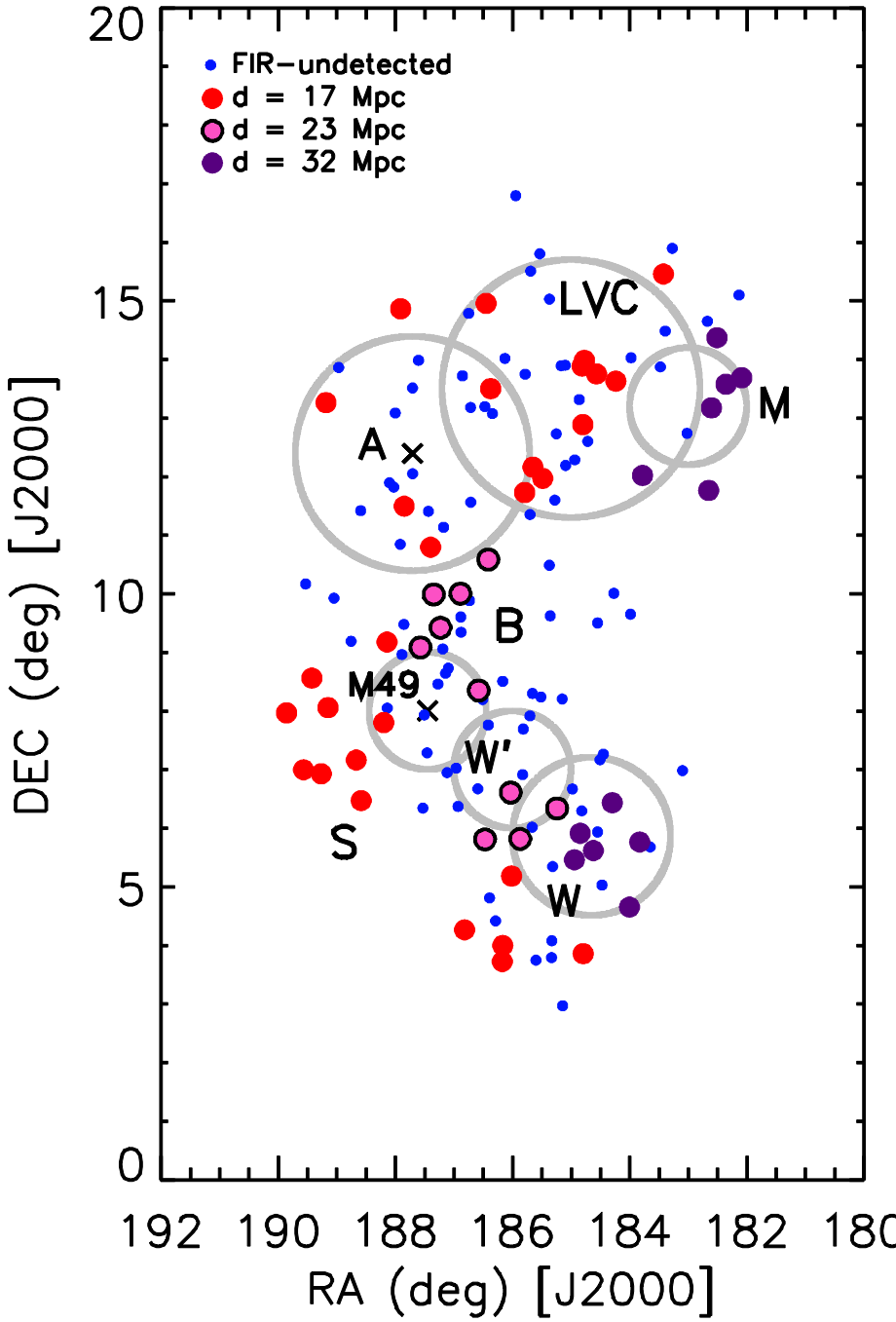
$\kappa_\nu = \kappa_0(\nu/\nu_0)^\beta$ (Hildebrand 1983).



Grossi +2015

Spatial distribution

As expected, dusty SF dwarf galaxies, tend to avoid the densest regions (cluster A and B).



HI mass fractions

Average scaling relations for HI-normal and extremely HI-deficient galaxies in Hα3 survey (Gavazzii+2013)

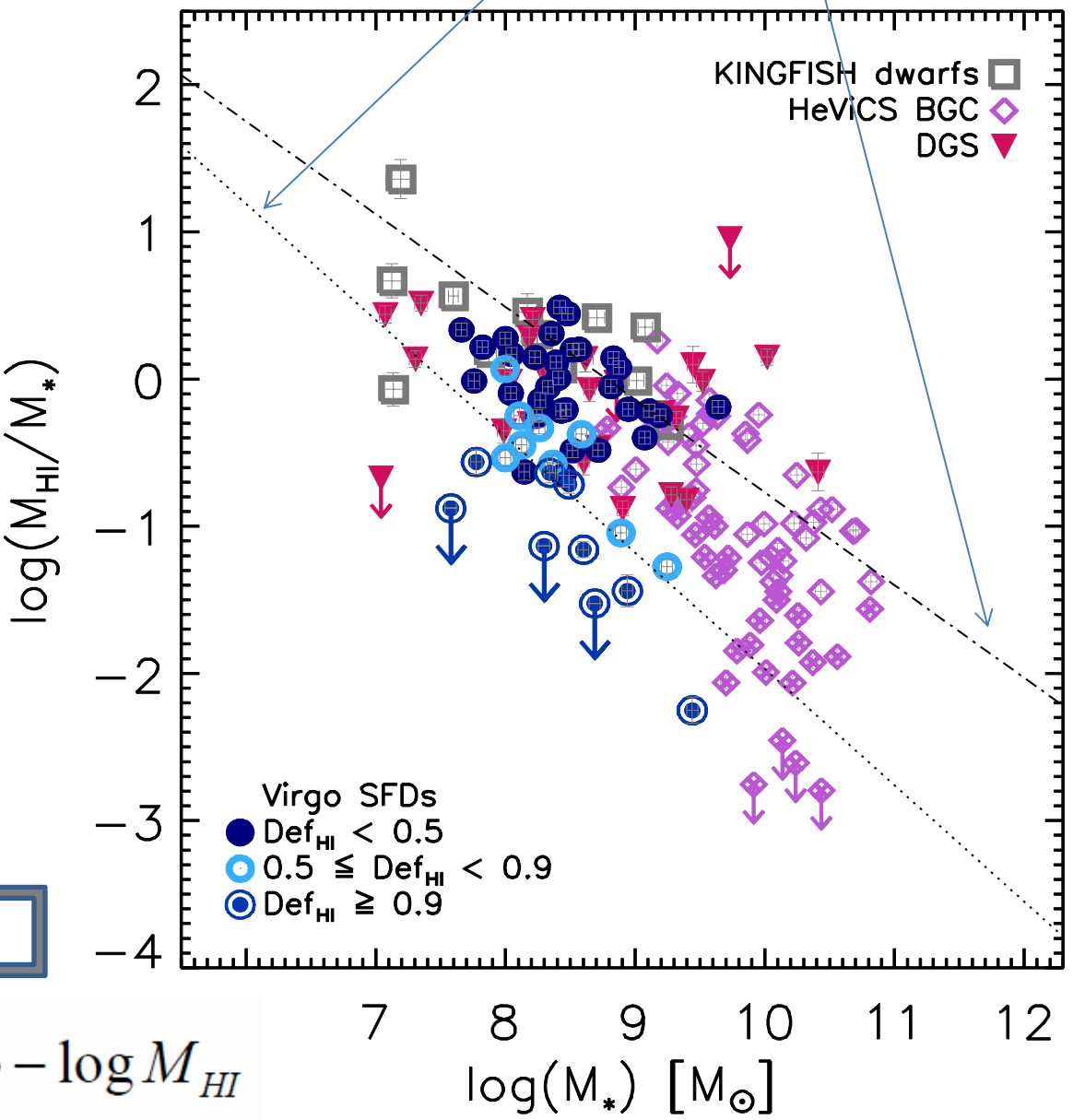
Comparison samples

HeViCS bright galaxy Catalogue(BGC) ◆

Davies+2012

Dwarf galaxy survey (DGS) Madden+2013 ▼

KINGFISH Kennicutt 2011 □



$$\langle DEF \rangle = \langle \log M_{HI}(D_{Opt}, T) \rangle - \log M_{HI}$$

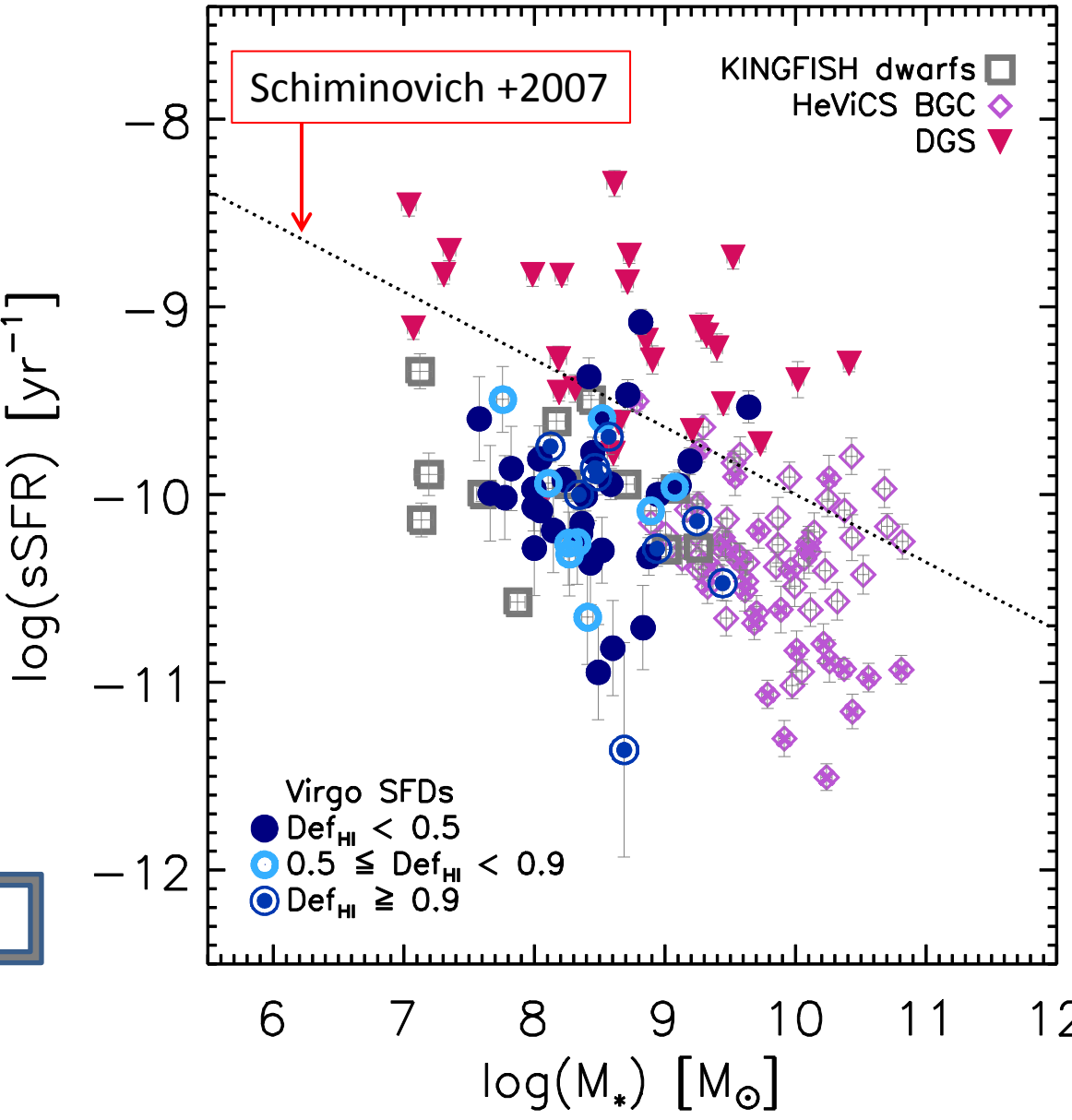
Specific star formation rates

Comparison samples

HeViCS bright galaxy Catalogue(BGC) Davies+2012

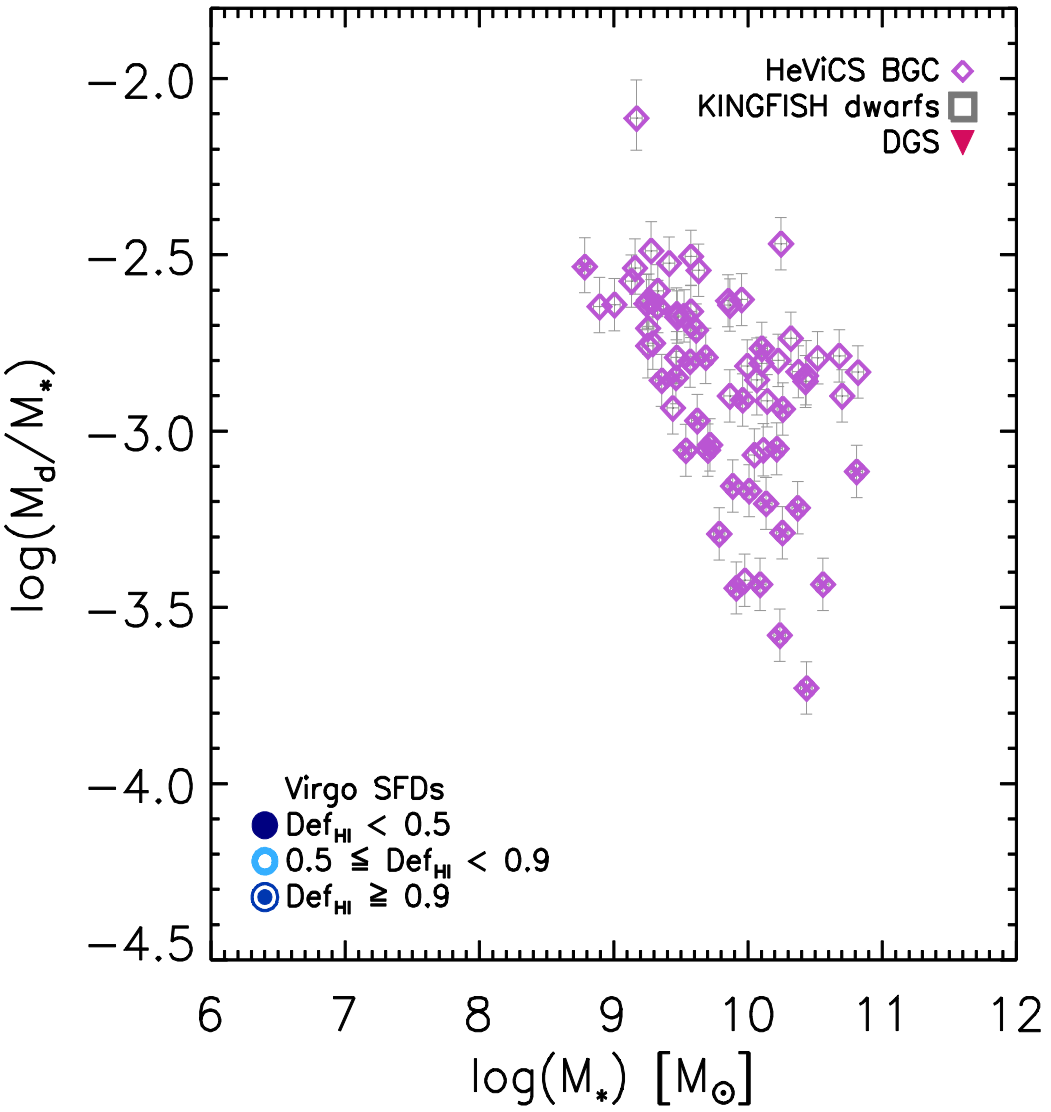
Dwarf galaxy survey (DGS) Madden+2013

KINGFISH Kennicutt 2011



Dust fraction vs stellar mass

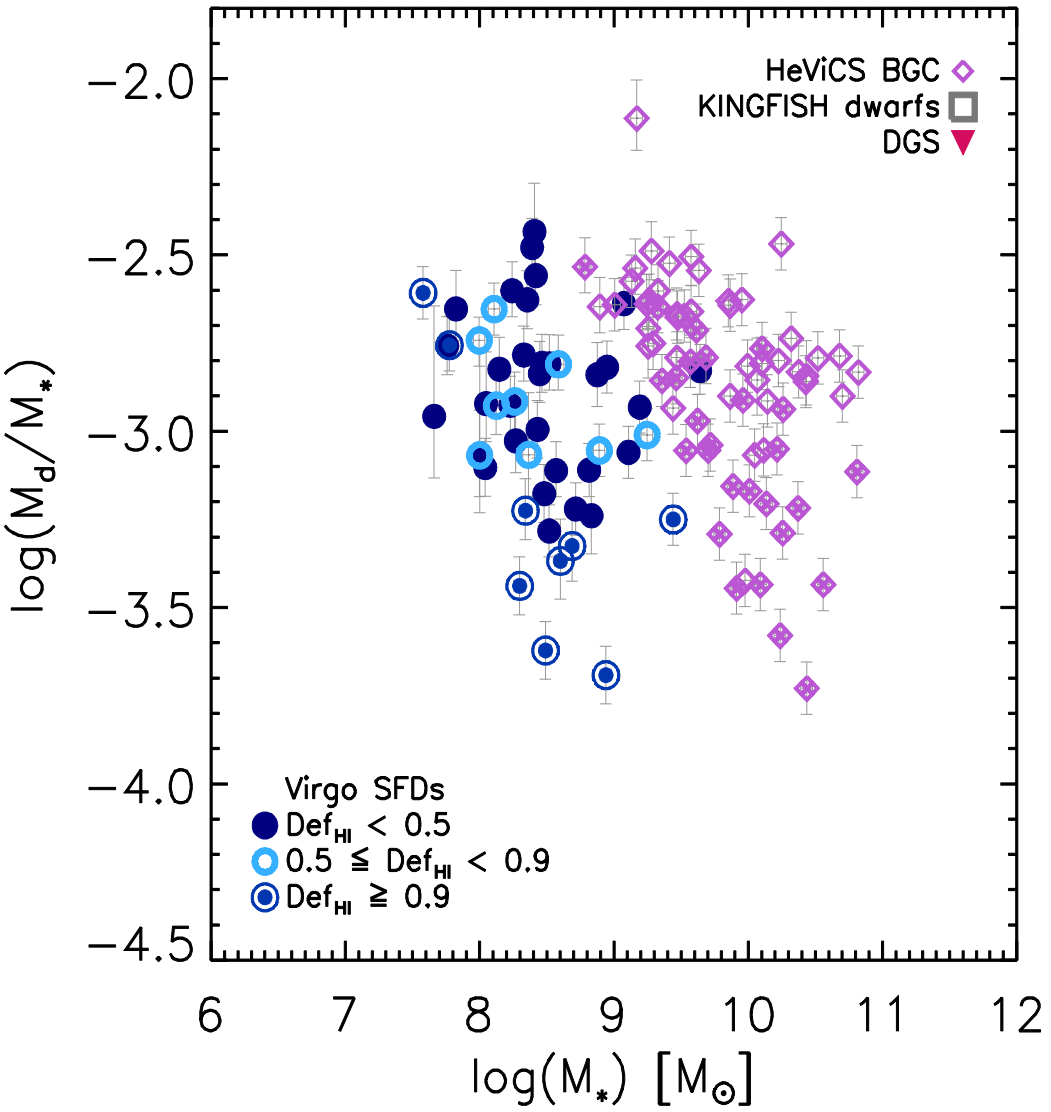
Massive galaxies:
Dust fraction decreases at higher stellar masses (HRS:Cortese+2012; Bekki+2013;)



Dust fraction vs stellar mass

Massive galaxies:
Dust fraction decreases at higher stellar masses

Virgo SFDs galaxies:
Poor correlation between M_d/M_* and stellar mass.

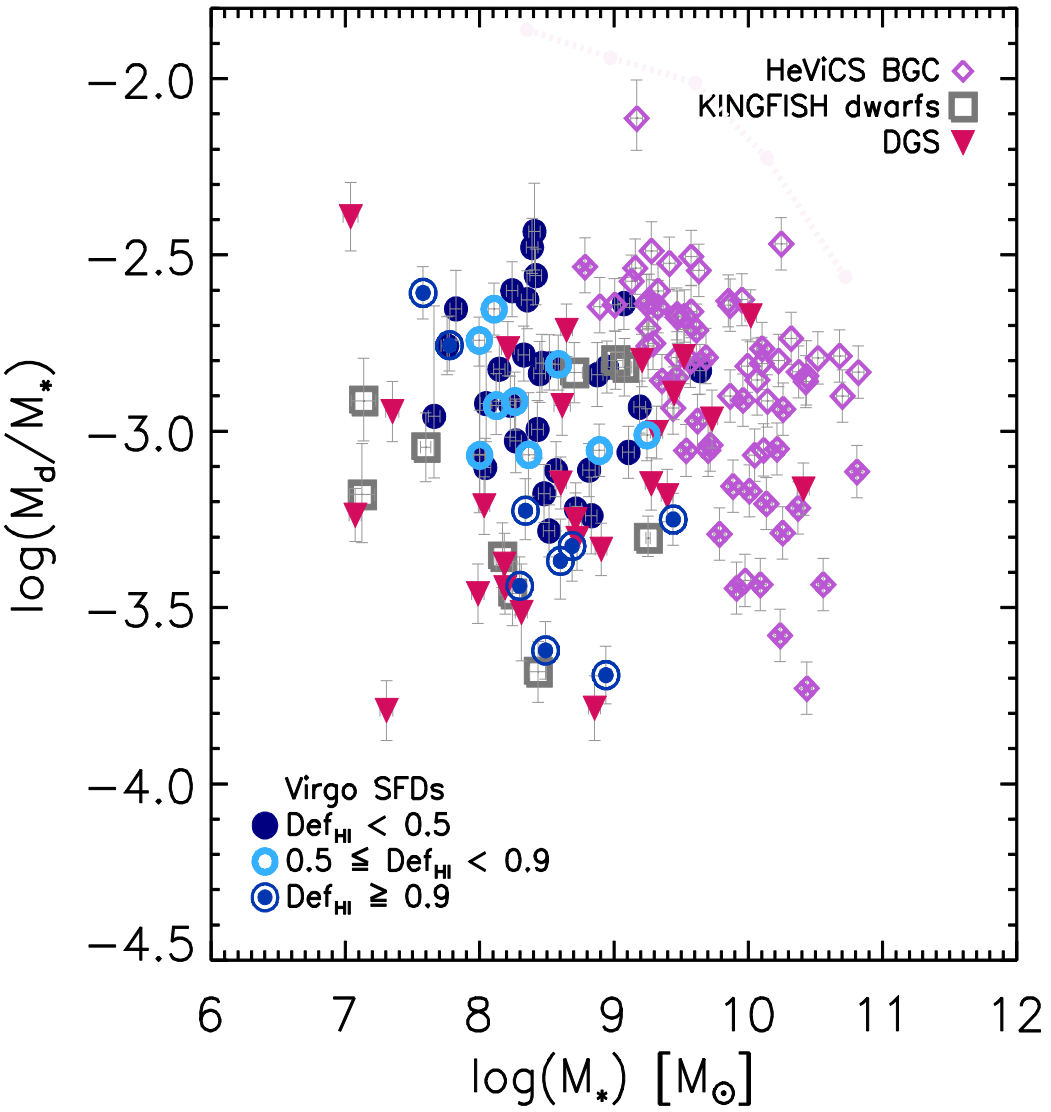


Dust fraction vs stellar mass

Massive galaxies:
Dust fraction decreases at higher stellar masses

Virgo SFDs galaxies:
Poor correlation between M_d/M_* and stellar mass.

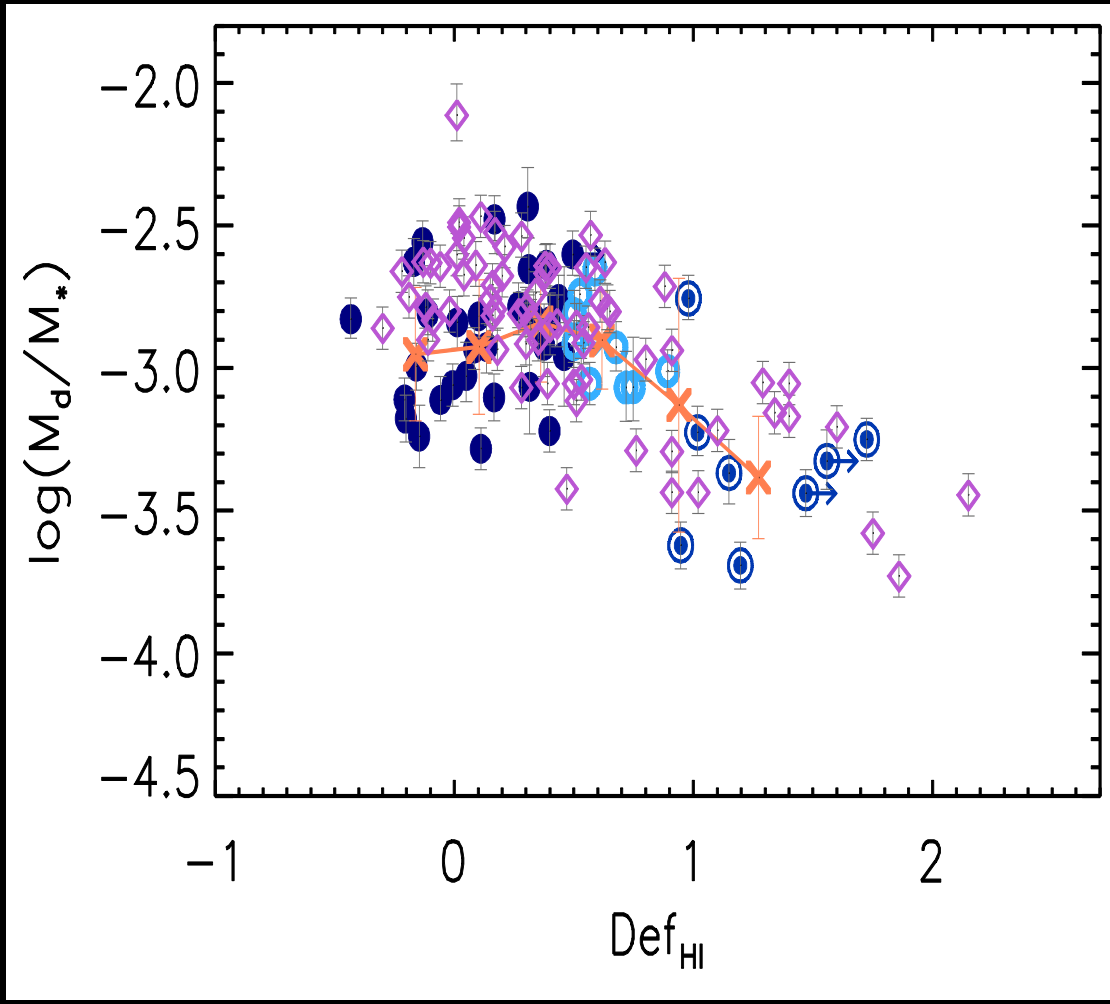
SF Active dwarfs:
No clear correlation between M_d/M_* and stellar mass.



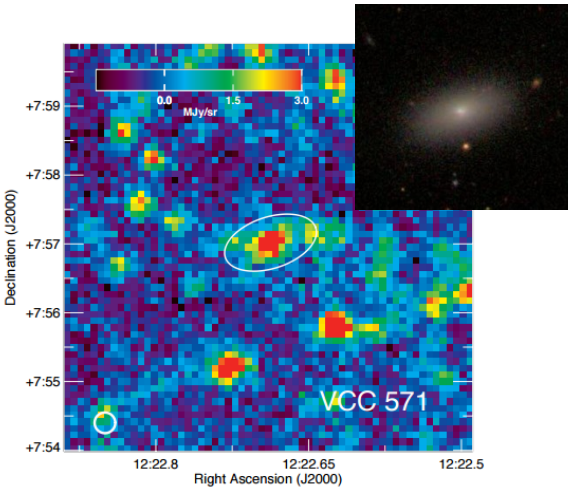
Dust fraction vs HI deficiency

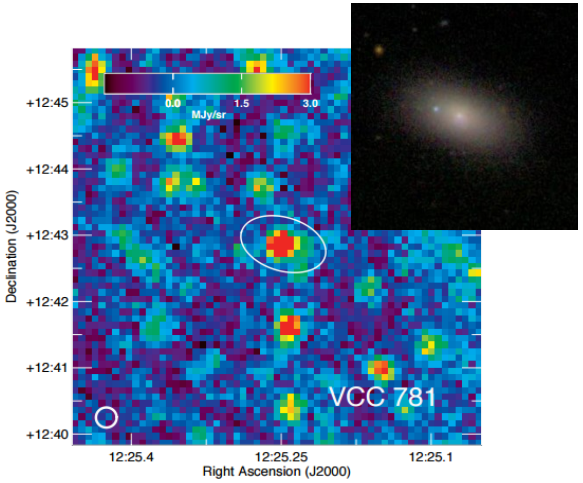
The most HI-deficient Virgo galaxies at both High (♦) and low (●) M* have on average lower dust fractions .

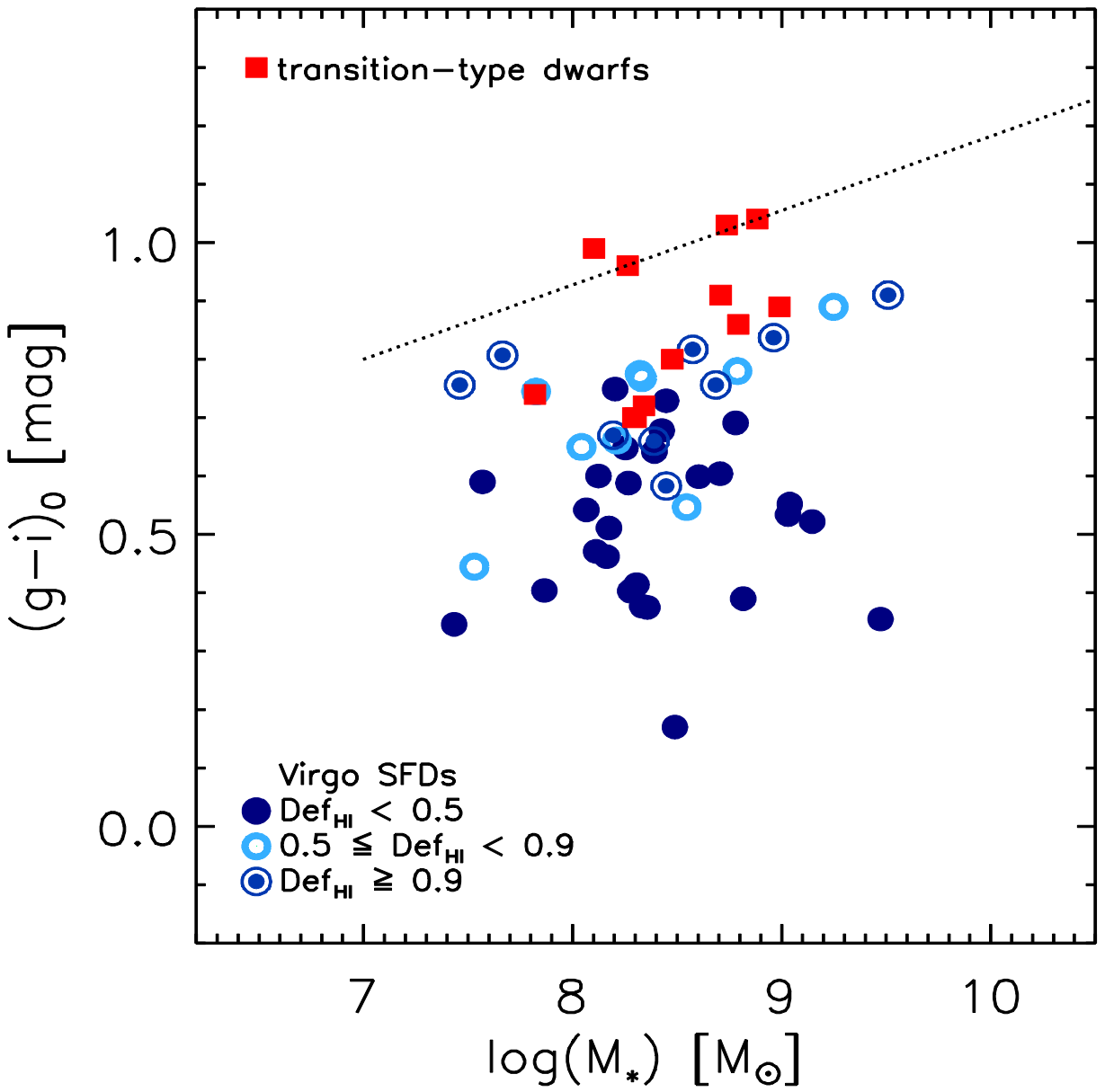
Dust and gas are removed outside-in during the interaction with the intracluster medium as galaxies infall into the cluster (Cortese+12,de Looze+2013, Gavazzi+2014;



Comparison with transition-type dwarfs

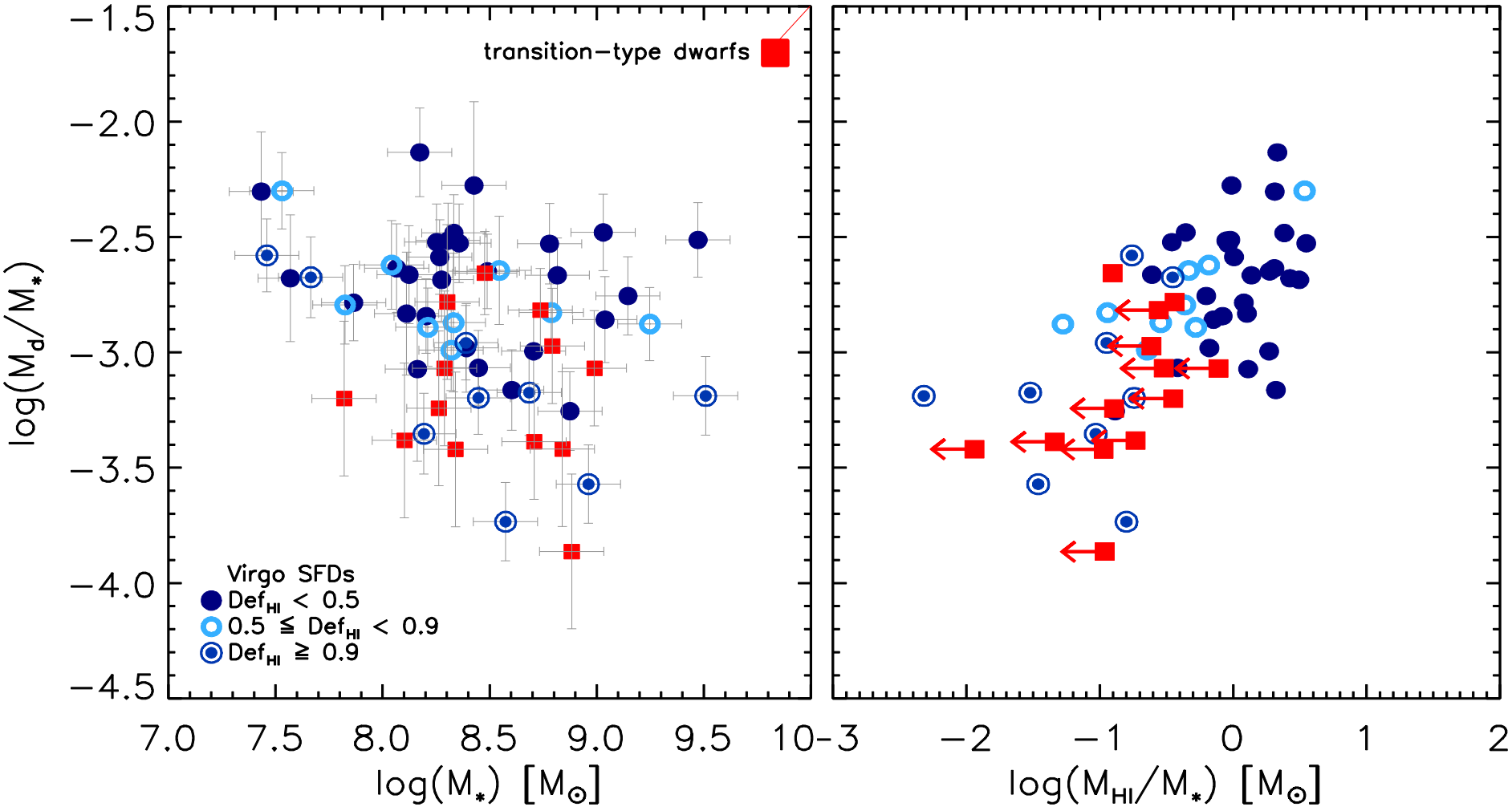






De Looze +2013
Di Serego+2013

Comparison with transition-type dwarfs

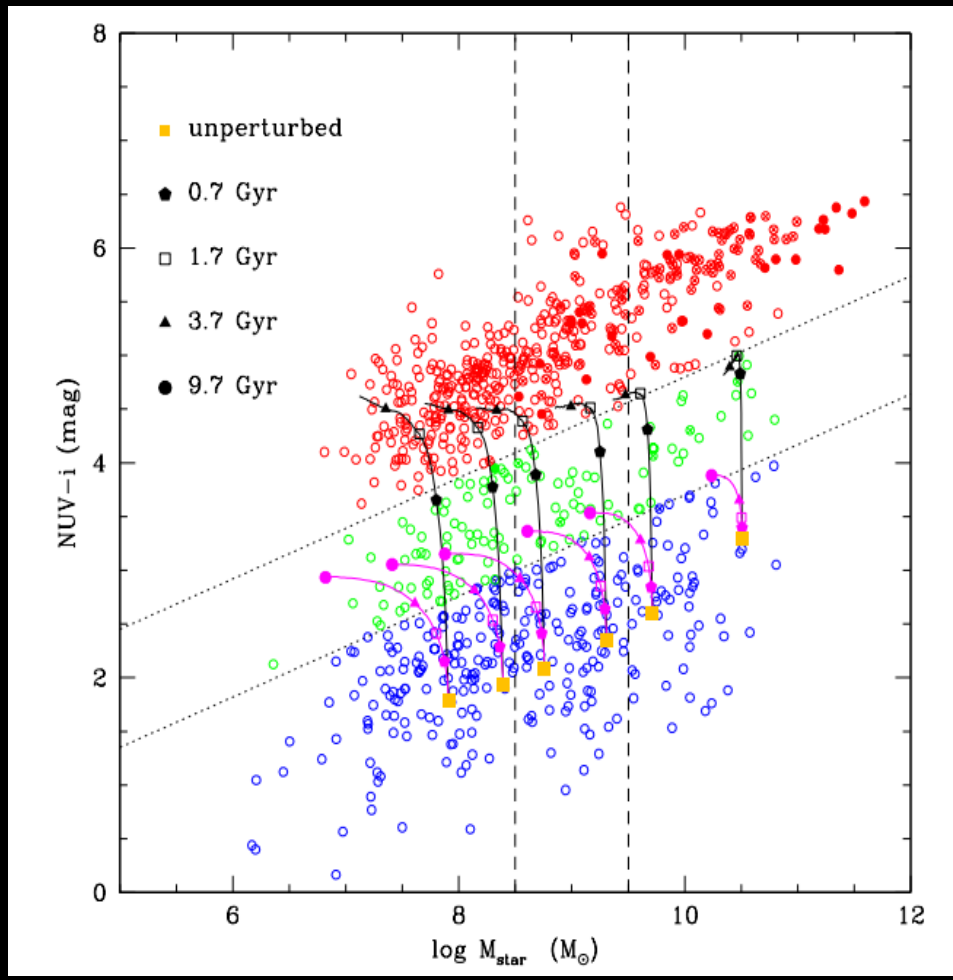


Ram-pressure stripping

- The ram pressure stripping exerted by the hot and dense intergalactic medium on dwarf galaxies moving within the cluster is sufficient to fully remove, on very short timescales (~200 Myr; Boselli+2014).

- Infalling galaxies stop the star formation activity, and are transformed in red systems in $\simeq$ 1 Gyr. The efficiency even increases with multiple crossings of the cluster (Boselli +2008).

- As galaxies fall into the cluster the interstellar medium can be retained only in the inner regions, with a higher gravitational potential well (de Looze+2013).



The CO content of FIR-detected Virgo SF dwarf galaxies

~40 hours @ IRAM using the Eight Mixer Receiver (EMIR)
Simultaneous observations in two bands E90 – E230
looking for CO(1-0) –> 115 GHz and CO(2-1) –> 230 GHz lines
8 GHz bandwidth per polarisation. **20 dwarfs observed.**

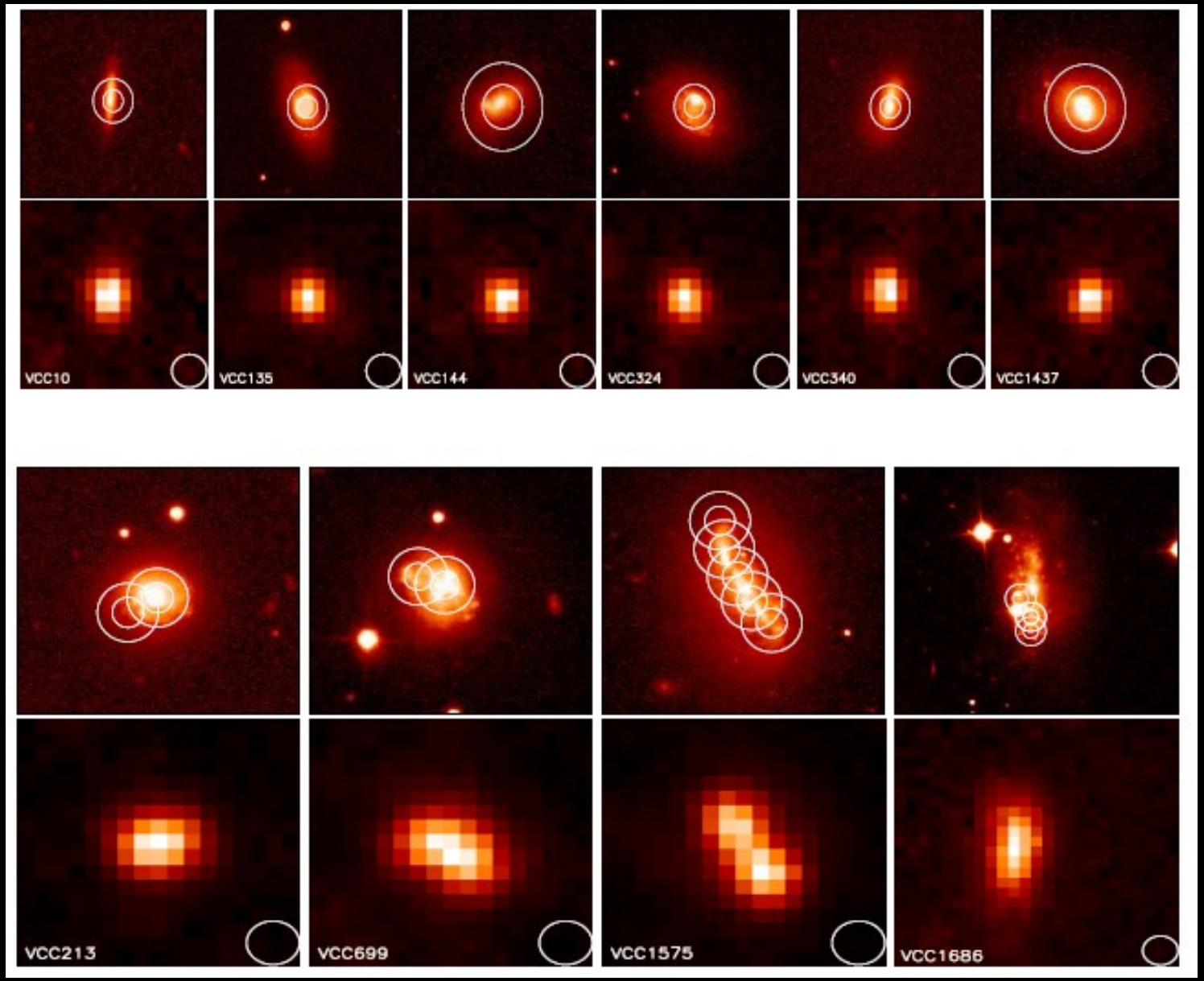
The beam size at 115 and 230 GHz is 22'' and 11'', respectively.
→ 1.8 and 0.9 kpc
@ 17 Mpc

Herschel/SPIRE beam @ 250 um is 18''.

The sample

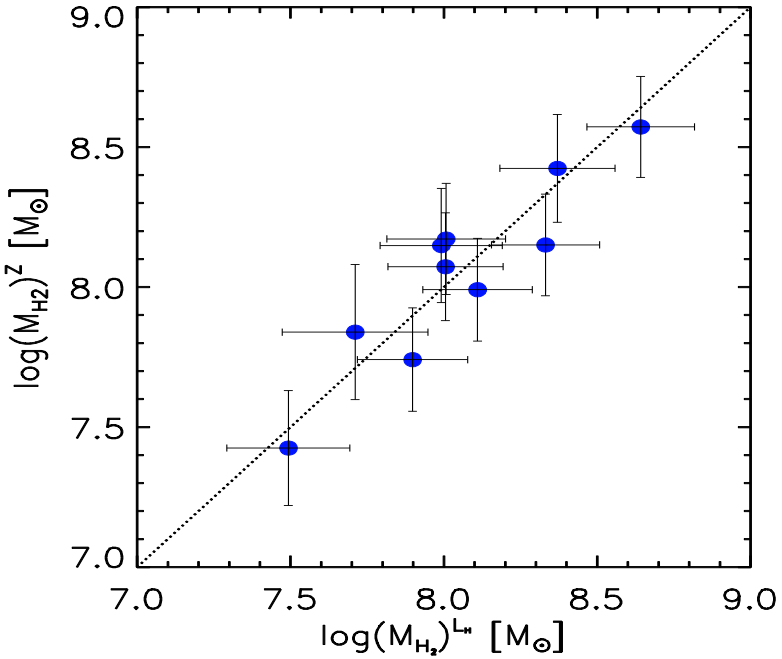
SDSS
g band

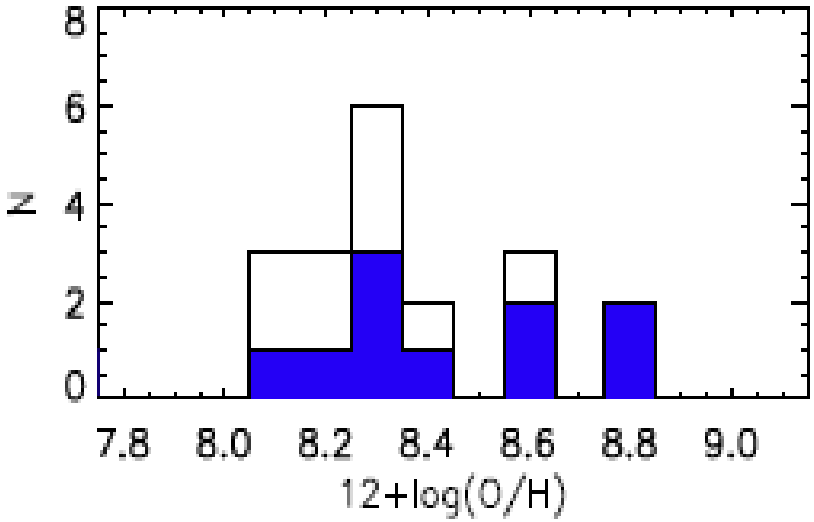
SPIRE
250 um

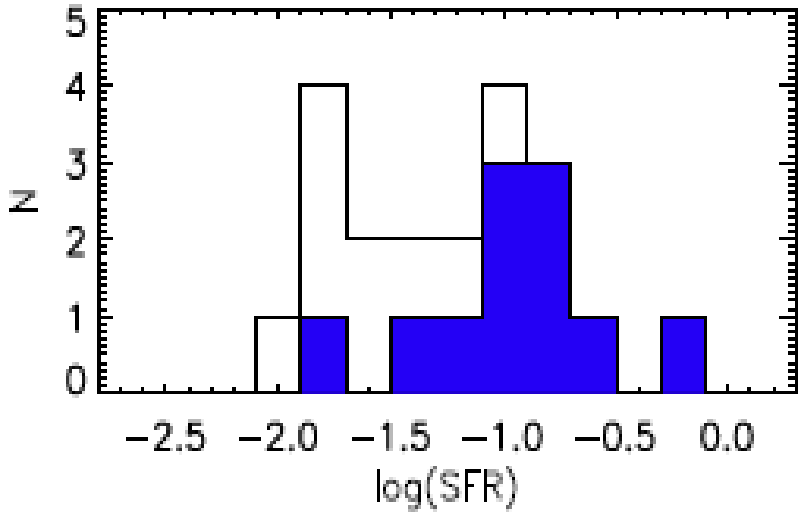


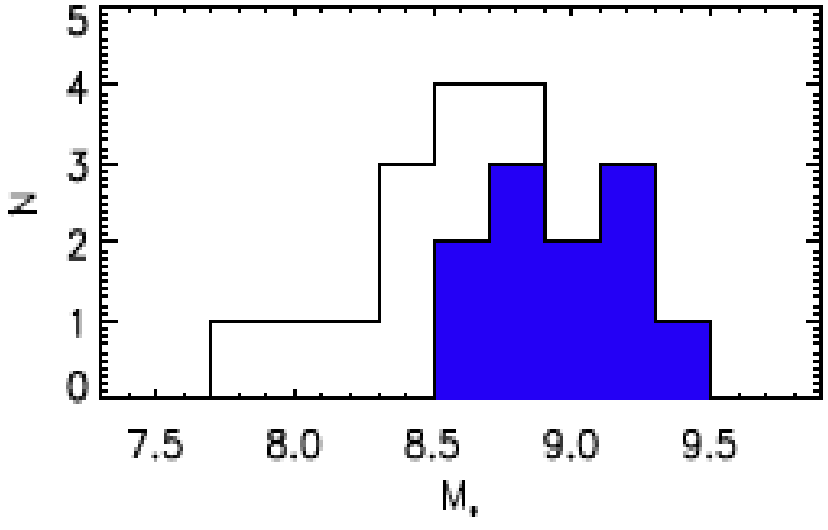
Detections vs non-detections

50% detection rate









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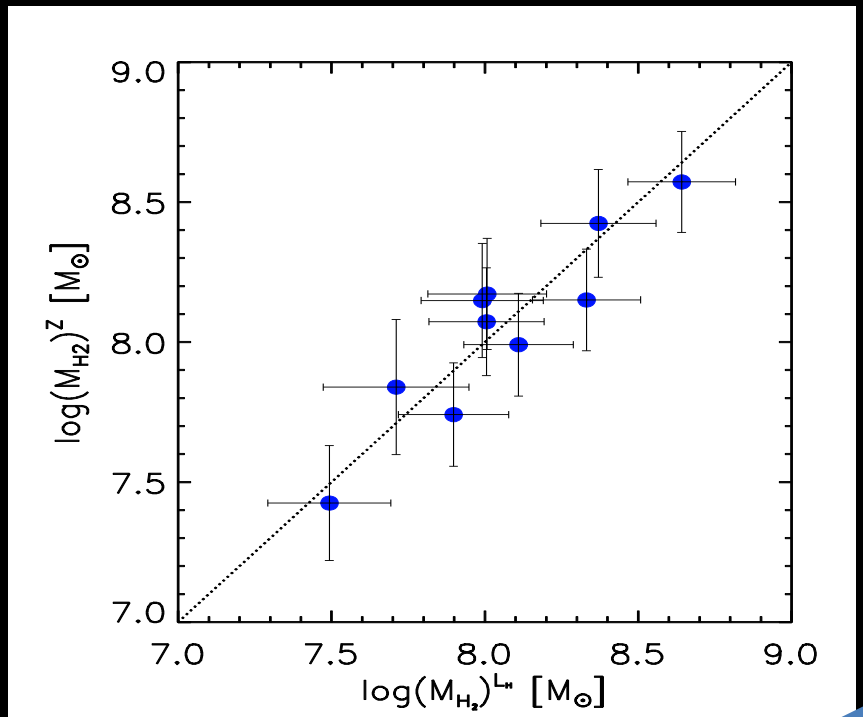

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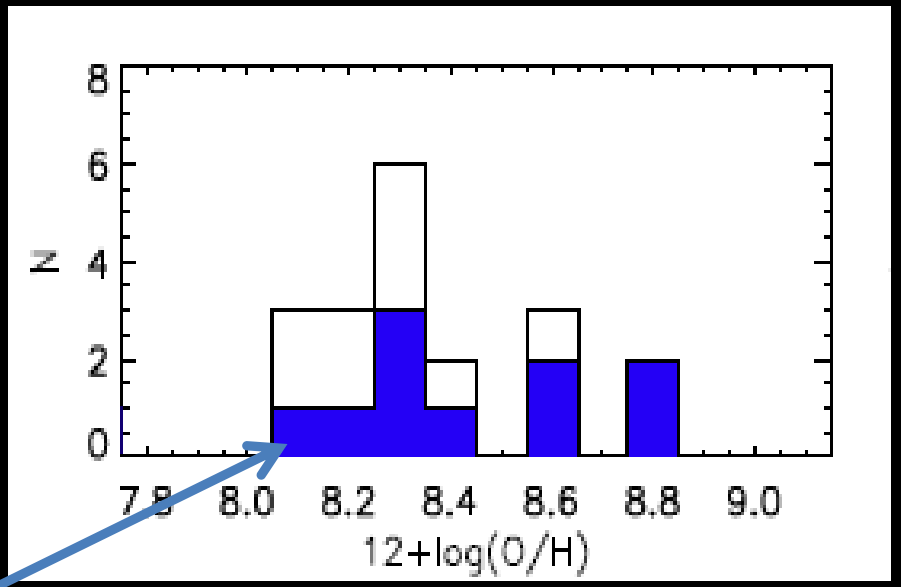
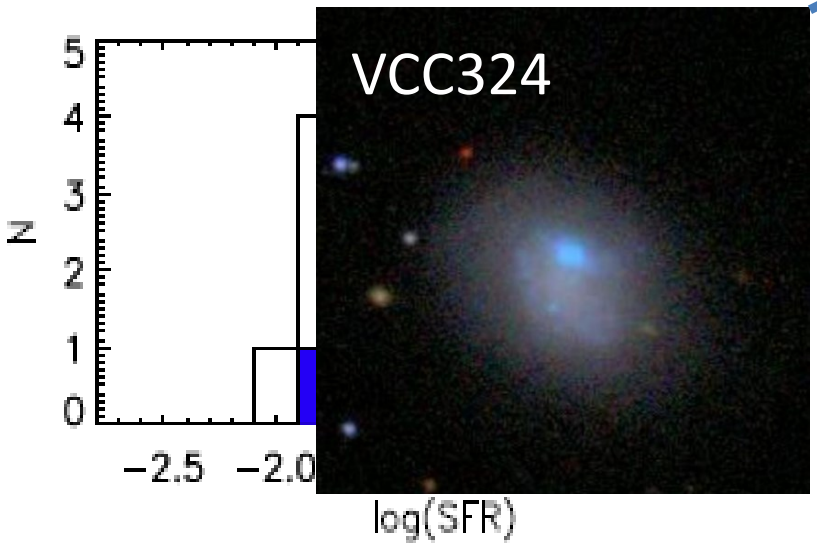
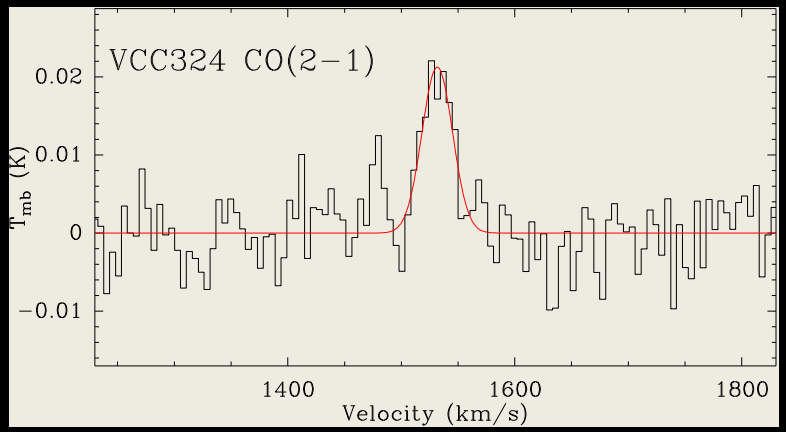




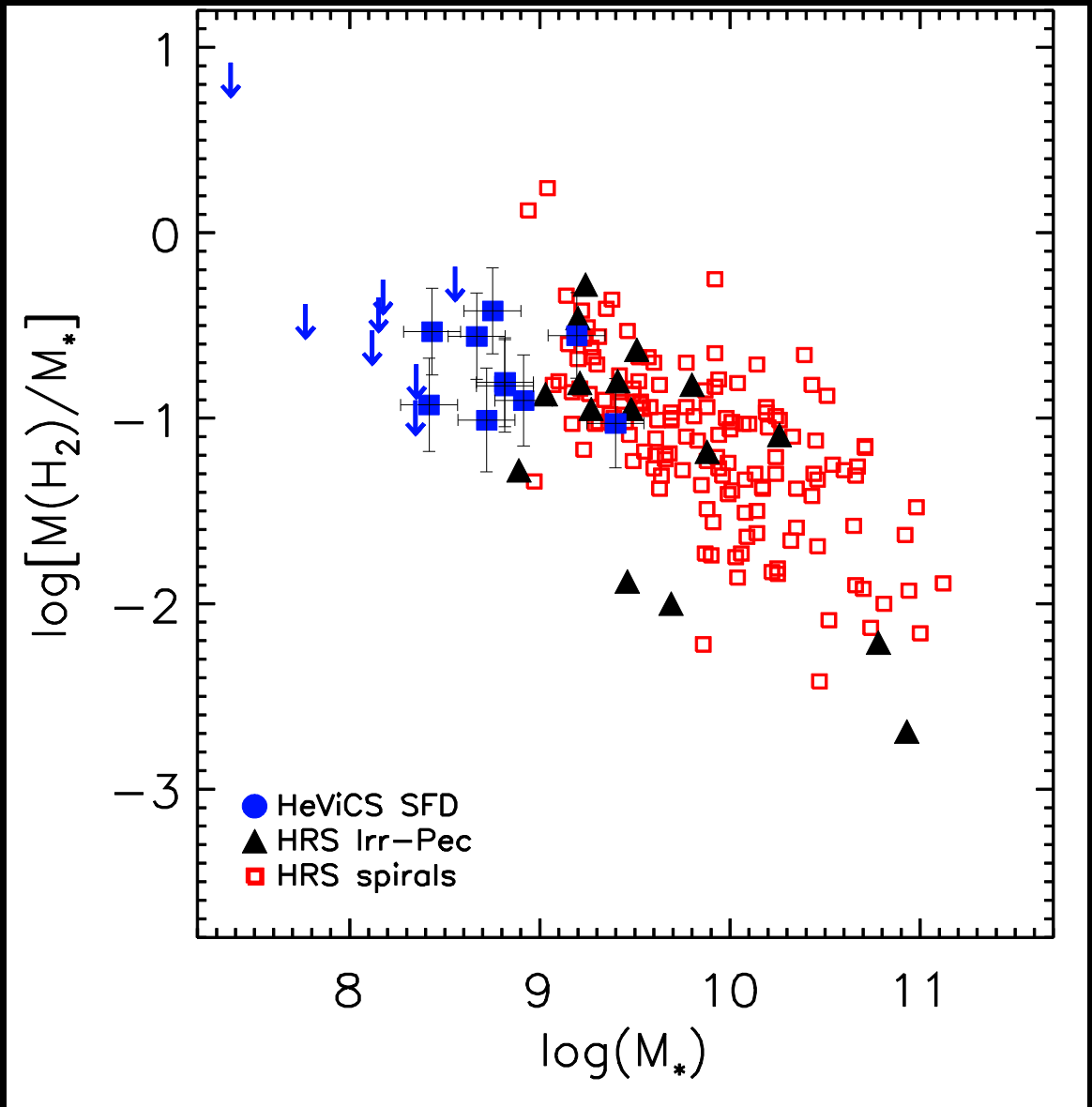


12 + log(O/H) = **8.14** ± 0.1

Scaling relations: H2 mass fraction vs stellar mass

Comparison with Samples of galaxies in different environments:

the **Herschel Reference Survey** (Boselli et al. 2010,2014), a K-band selected sample of 323 galaxies (15<d<25 Mpc), spanning Differente morphological types.

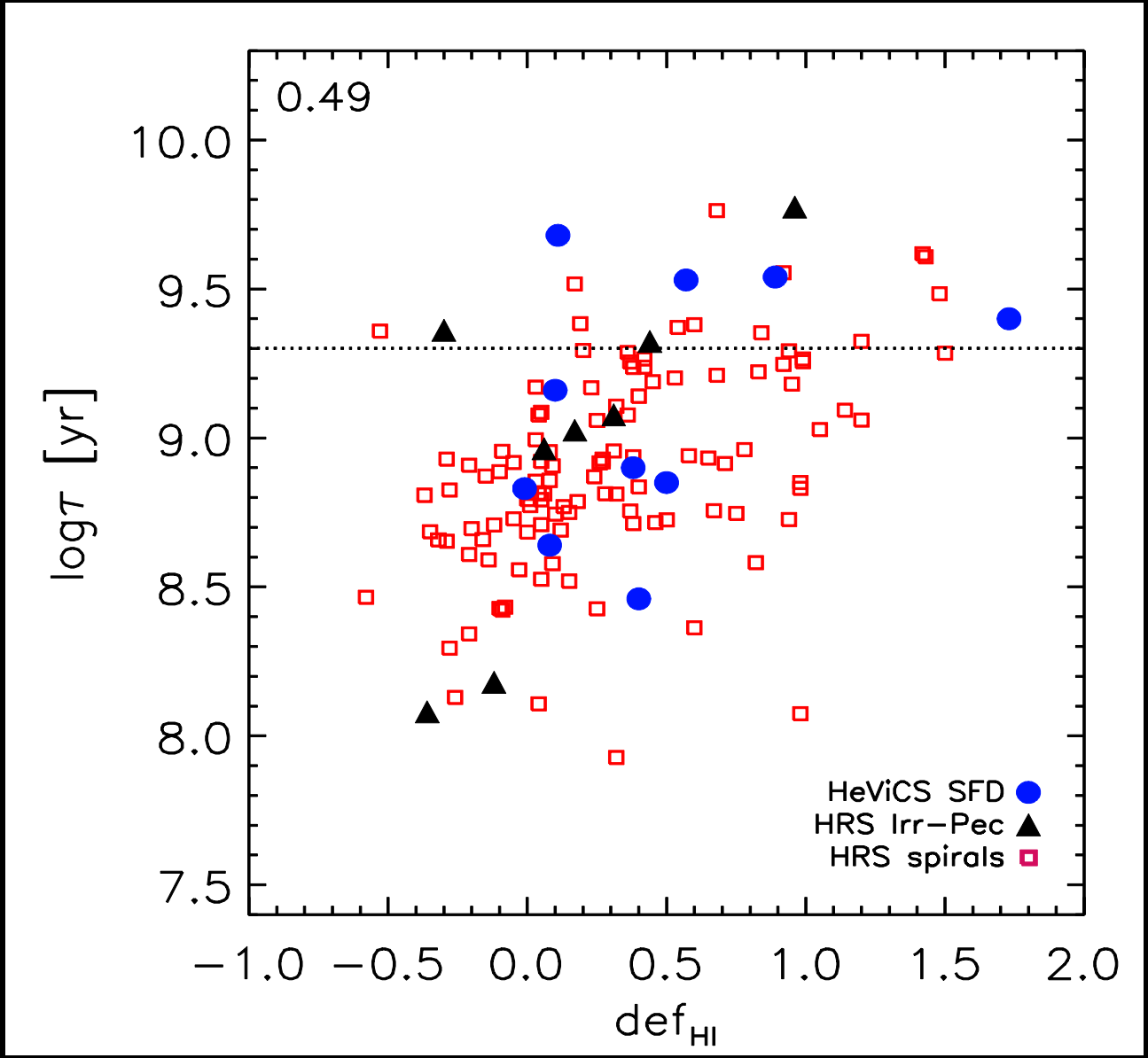


H2 depletion time vs HI deficiency

A moderate H2 deficiency Is observed in the Hi – Deficient galaxies of the Herschel Reference Survey (Boselli+14)

The extent of the molecular disc decreases with increasing Hi-deficiency in HRS spirals.

The molecular component is removed less efficiently than the atomic one in the HRS sample.



Summary

- Dust and gas are removed outside-in during the interaction with the intracluster medium as galaxies infall into the cluster

- Extremely HI-deficient star-forming dwarfs show lower dust fractions compared to HI-normal dwarfs.

- As galaxies fall into the cluster the interstellar medium can be retained in the inner regions (transition –type dwarfs). Dust and molecular disks are removed less efficientlt compared to HI.

- HI-deficient spirals appear to be also H2 deficient, however a larger sample of CO-detected dwarfs will be necessary to study environmental effects on the molecular component in SF dwarfs.