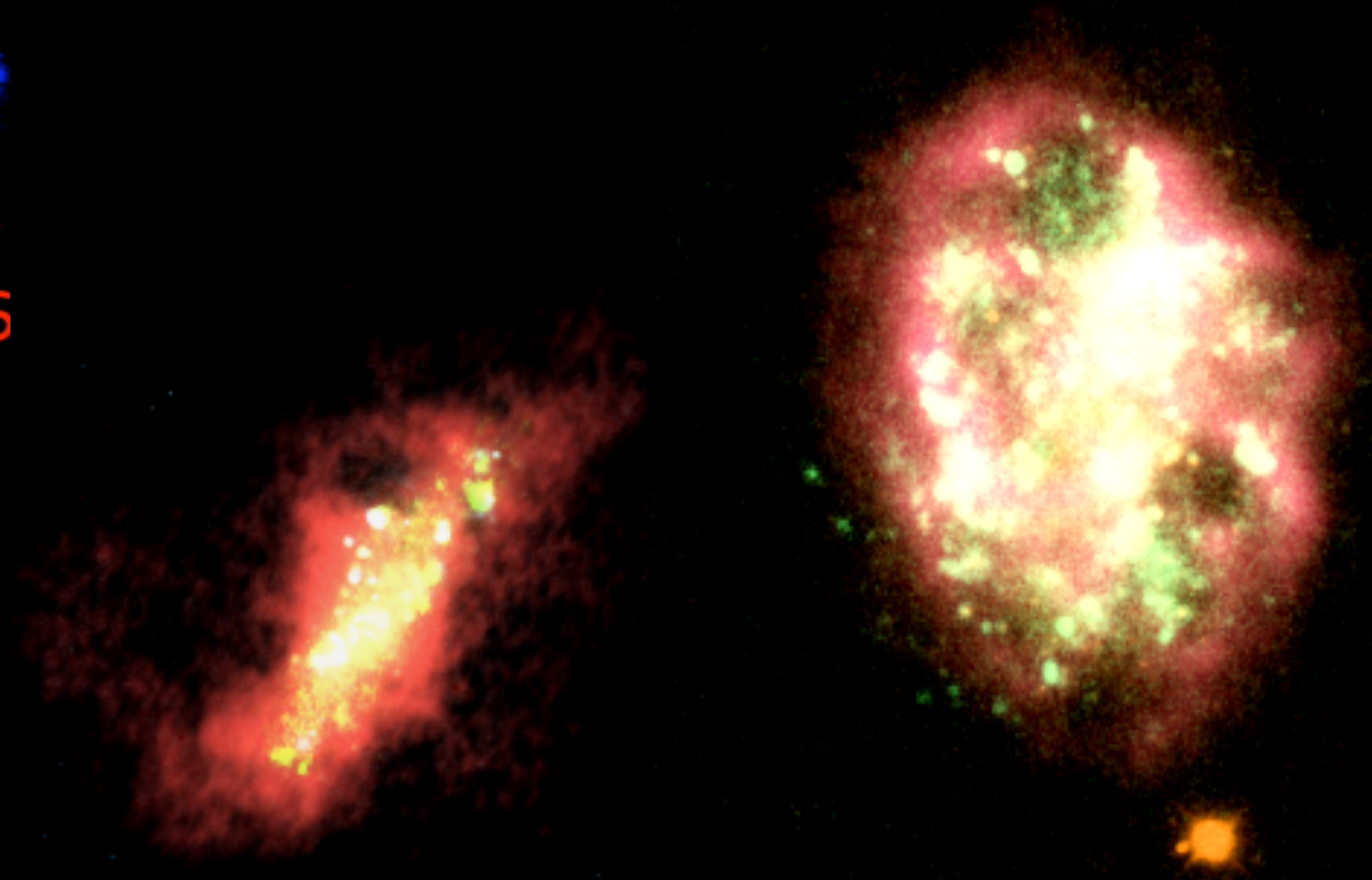
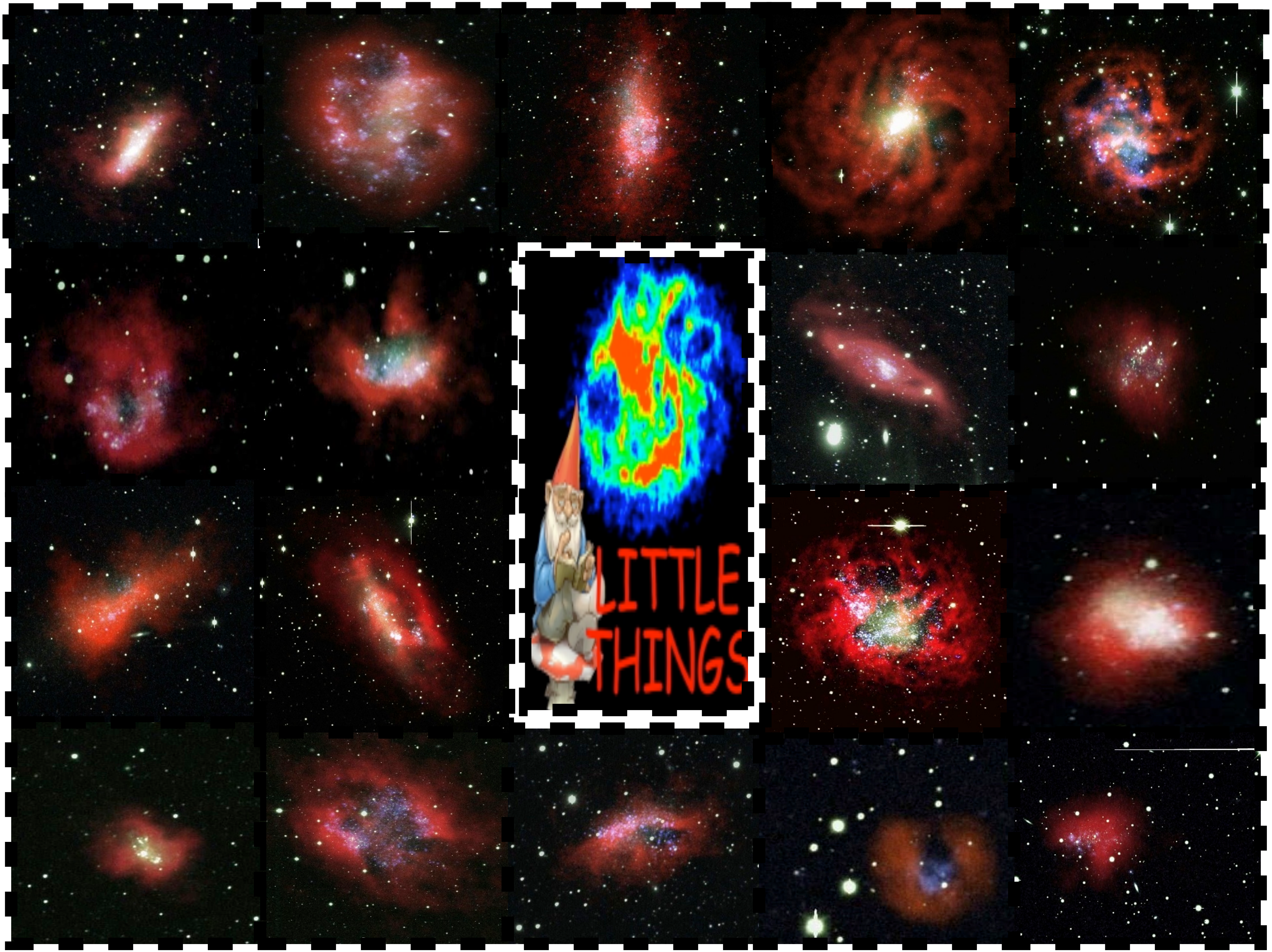


Star Formation Laws in LITTLE THINGS Dwarfs: The case of DDO133 and DDO168

Dana Ficut-Vicas


LITTLE
THINGS

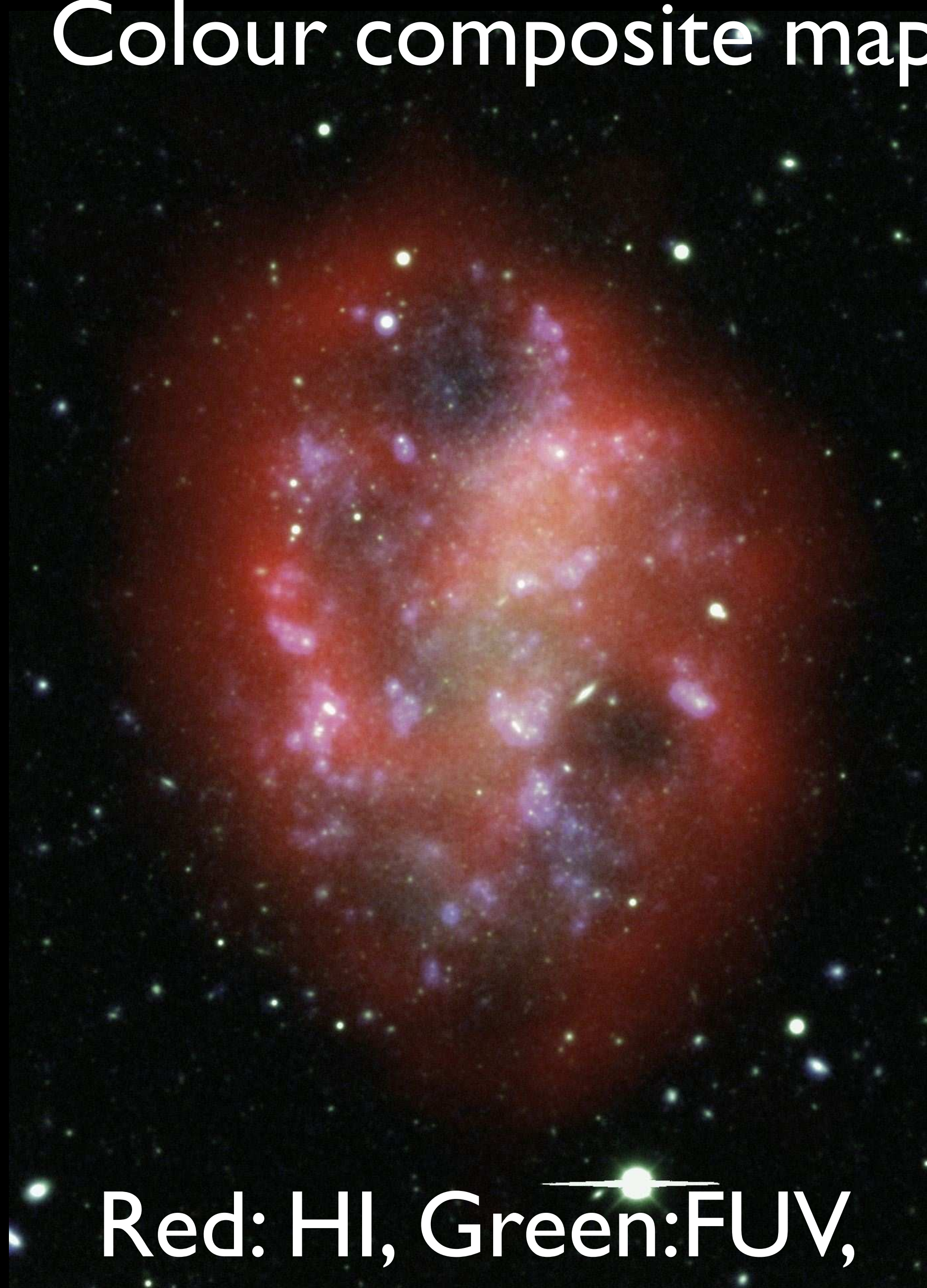
Little Things Project

LITTLE Local Irregular That Trace Luminosity Extremes
THINGS The HI Nearby Galaxy Survey

- What regulates star formation in small galaxies?
- What is the relative importance of sequential triggering for star formation in small galaxies?
- What is the relative importance of triggering by random turbulence compression in dwarf galaxies?
- What is happening in the far outer parts of dwarf galaxies, where star formation continues in gravitationally stable gas?

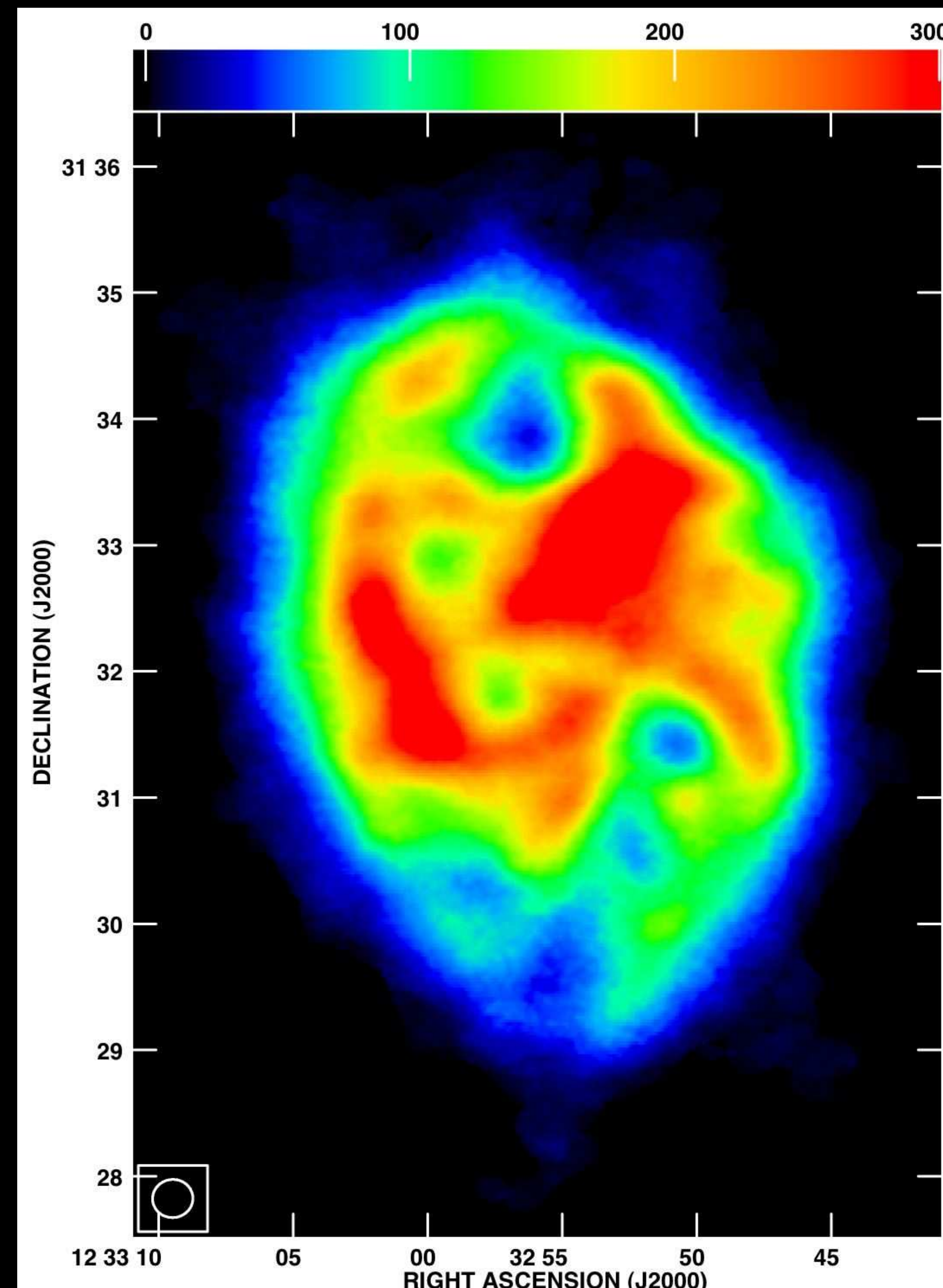
DDO 133

Colour composite map



Red: HI, Green:FUV, White:Optical

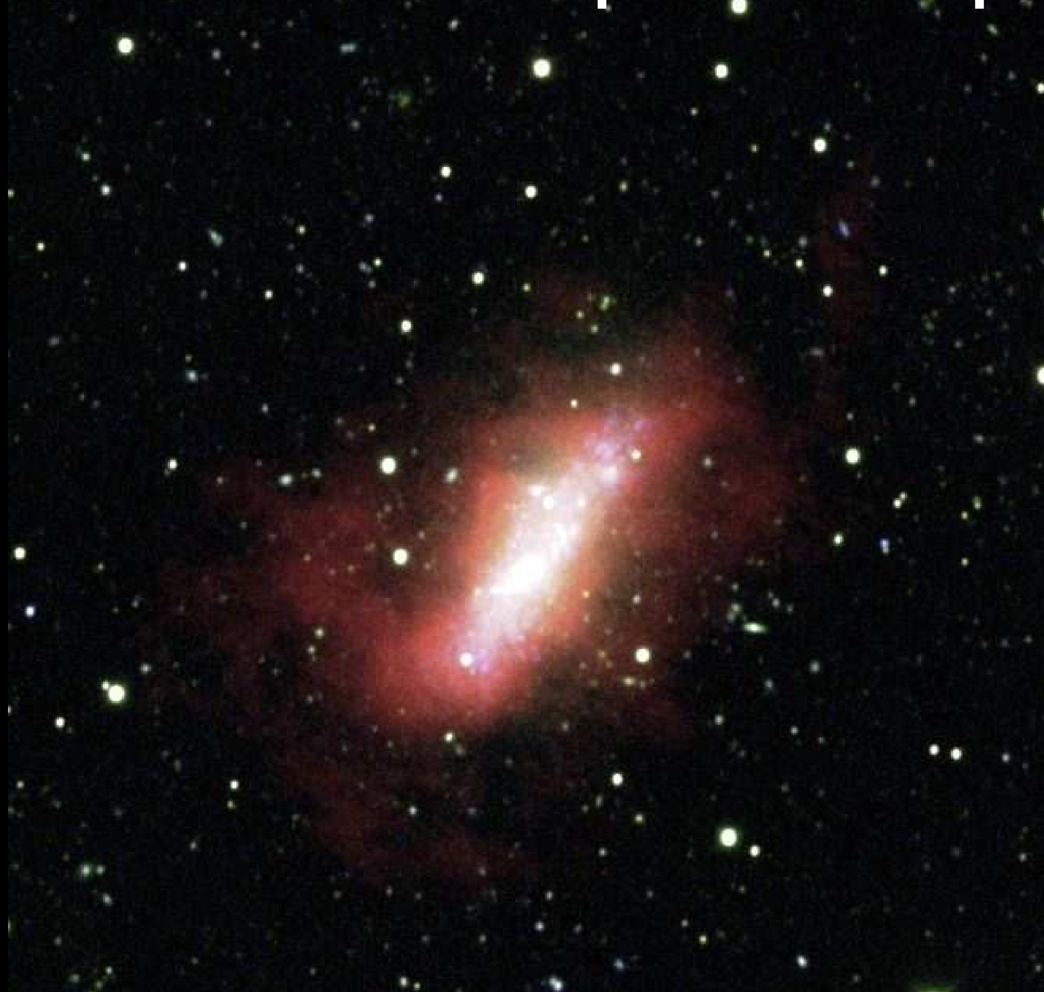
HI Map



Sunday, 24 June 2012

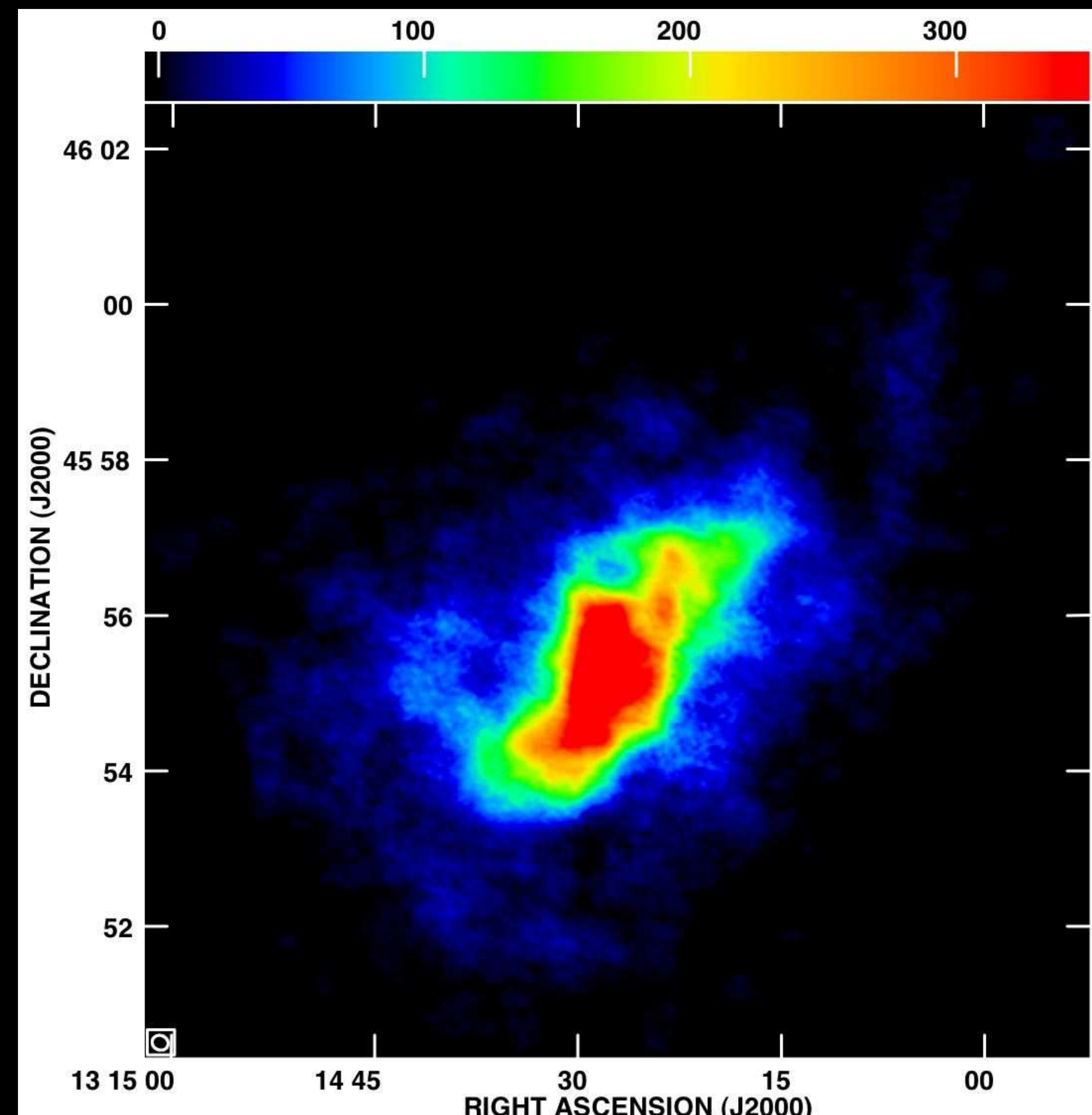
DDO 168

Colour composite map



Red: HI, Green:FUV, White:Optical

HI Map

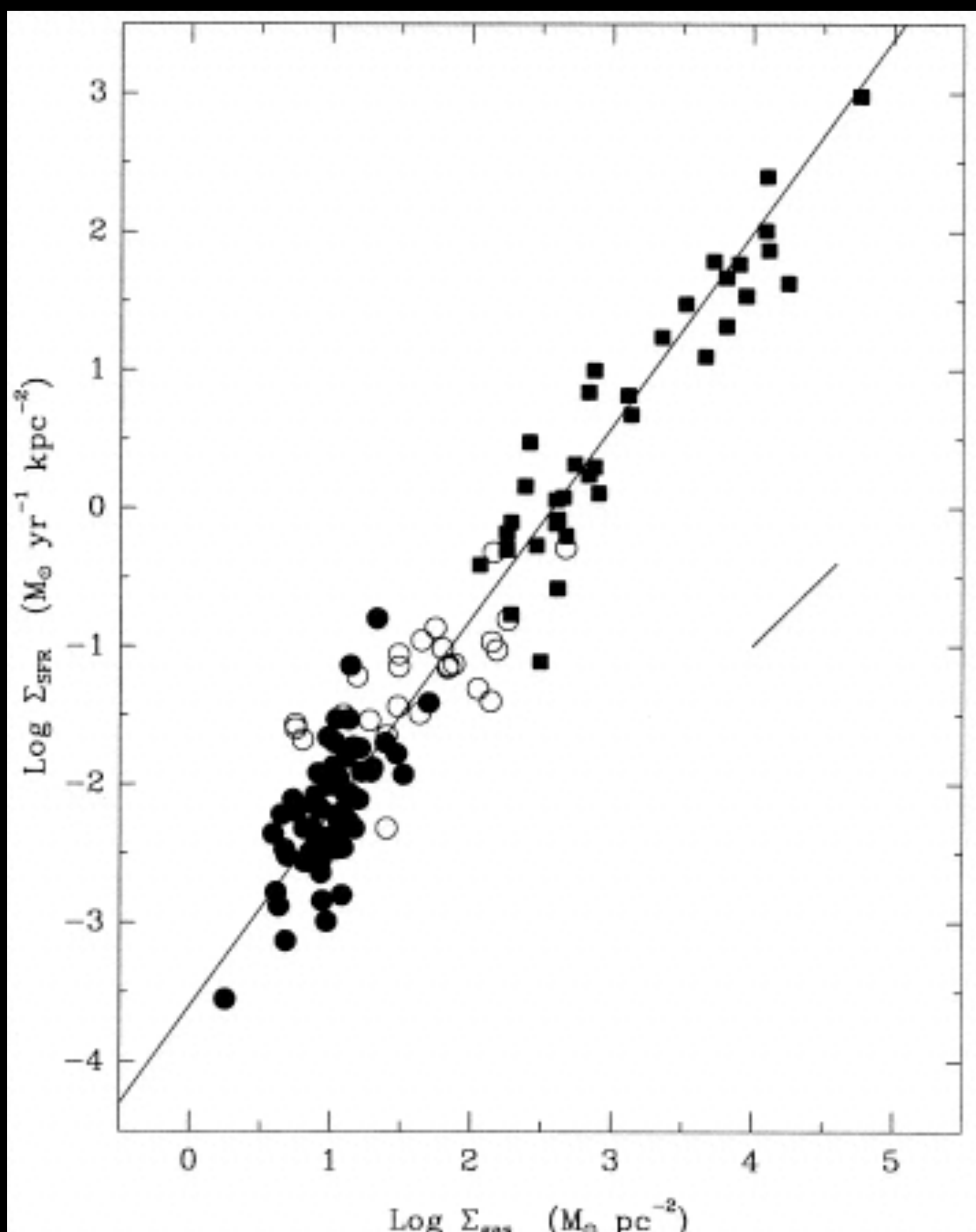


Project outline

- Why do stars form where they do?
- How do SF laws change depending on metallicity?
- What SF laws apply at the low luminosity end?

The Star Formation Law

A relation connecting $\sum_{SFR}$ to $\sum_{gas}$: $\Sigma_{SFR} = A \bullet \Sigma_{gas}^{N}$



Kennicutt (1998):
Disk-averaged SFR vs. gas surface densities (closed circles)
Starbursts (squares) and the centers of spirals (open circles)

Previous studies include e.g.

Schmidt (1959): N≈2 (Milky Way; based on volume density)

Kennicutt (1989,1998): N≈1.4 (sample of ~90 nearby galaxies)

Wong & Blitz (2002): N=1.2-2.1 (6 nearby spiral galaxies)

Boissier et al. (2003), Heyer et al. (2004): N≈2 (16 galaxies) and N≈3.3 (M33)

Key Observations

We consider the following SF tracers:

$H\alpha$ → most recent SF (10-20 Myr)
FUV → traces recent, unobscured SF (100 Myr)
Spitzer 24μm → dust from young stars

For gas distribution we consider:

HI → neutral gas
CO → molecular gas
Spitzer 8μm → PAH at large enough scales seems to trace the cool diffuse dust

LITTLE THINGS

Star Formation Maps Recipes

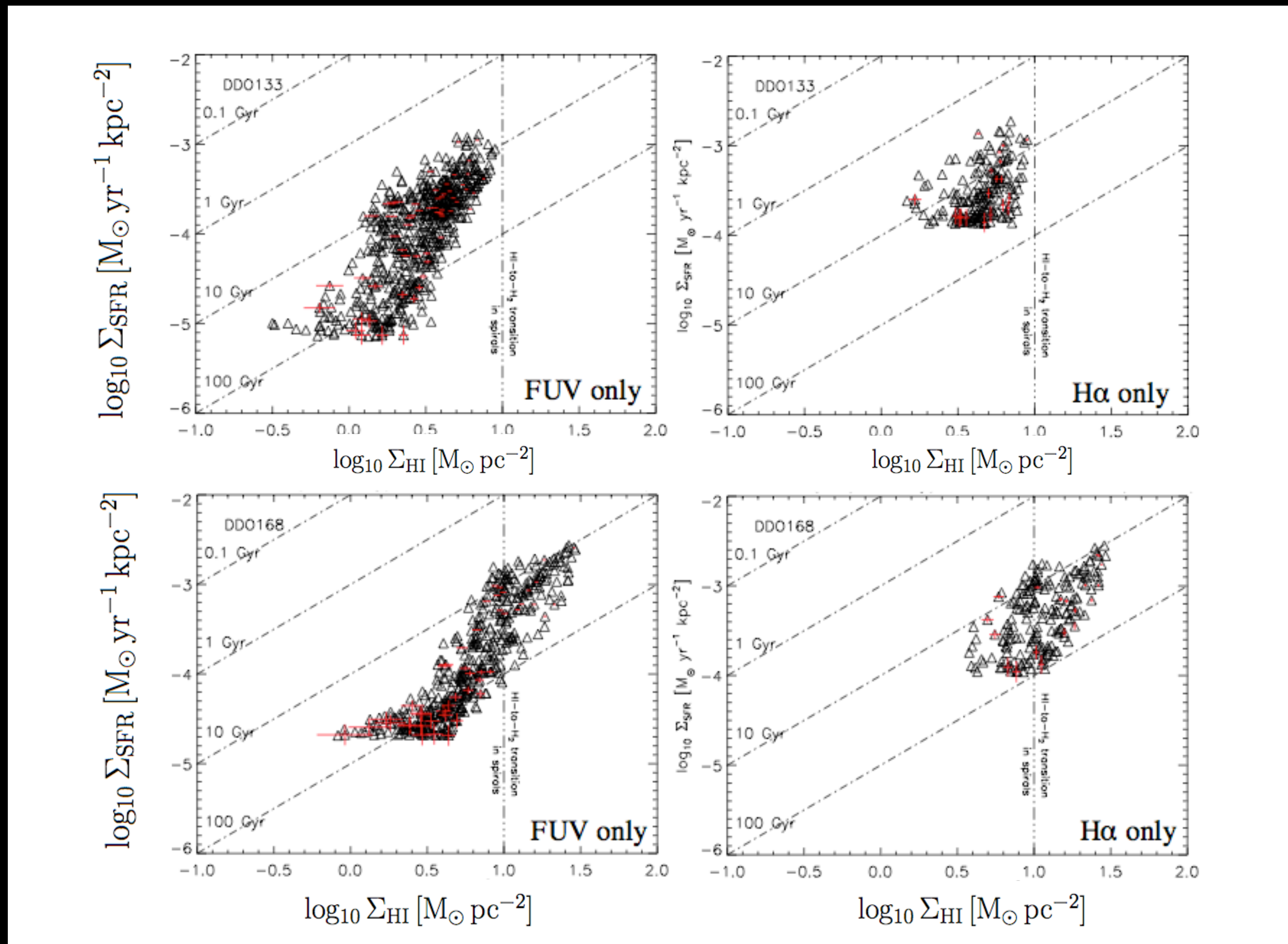
$$\Sigma_{\rm SFR}[{\rm M_\odot\,yr^{-1}kpc^{-2}}] = 634 \times {\rm I}^*_{({\rm H}\alpha)}[{\rm erg\,s^{-1}\,cm^{-2}\,sr^{-1}}] \quad (1)$$

$$\Sigma_{\rm SFR}[{\rm M_\odot yr^{-1}\,kpc^{-2}}] = 634 \times {\rm I}_{({\rm H}\alpha)}[{\rm erg\,s^{-1}\,cm^{-2}\,sr^{-1}}] + \\ +0.00246 \times {\rm I}_{24\,\mu{\rm m}}[{\rm MJy\,sr^{-1}}] \quad (2)$$

$$\Sigma_{\rm SFR}[{\rm M_\odot\,yr^{-1}\,kpc^{-2}}] = 0.081 \times {\rm I}^*_{\rm FUV}[{\rm MJy\,sr^{-1}}] \quad (3)$$

$$\Sigma_{\rm SFR}[{\rm M_\odot\,yr^{-1}\,kpc^{-2}}] = 0.081 \times {\rm I}_{\rm FUV}[{\rm MJy\,sr^{-1}}] + \\ +\,0.0032 \times {\rm I}_{24\,\mu{\rm m}}[{\rm MJy\,sr^{-1}}] \quad (4)$$

SF Tracers Compared



Final Setup

We use as a SF tracer:

FUV only→ traces recent, unobscured SF (100 Myr)

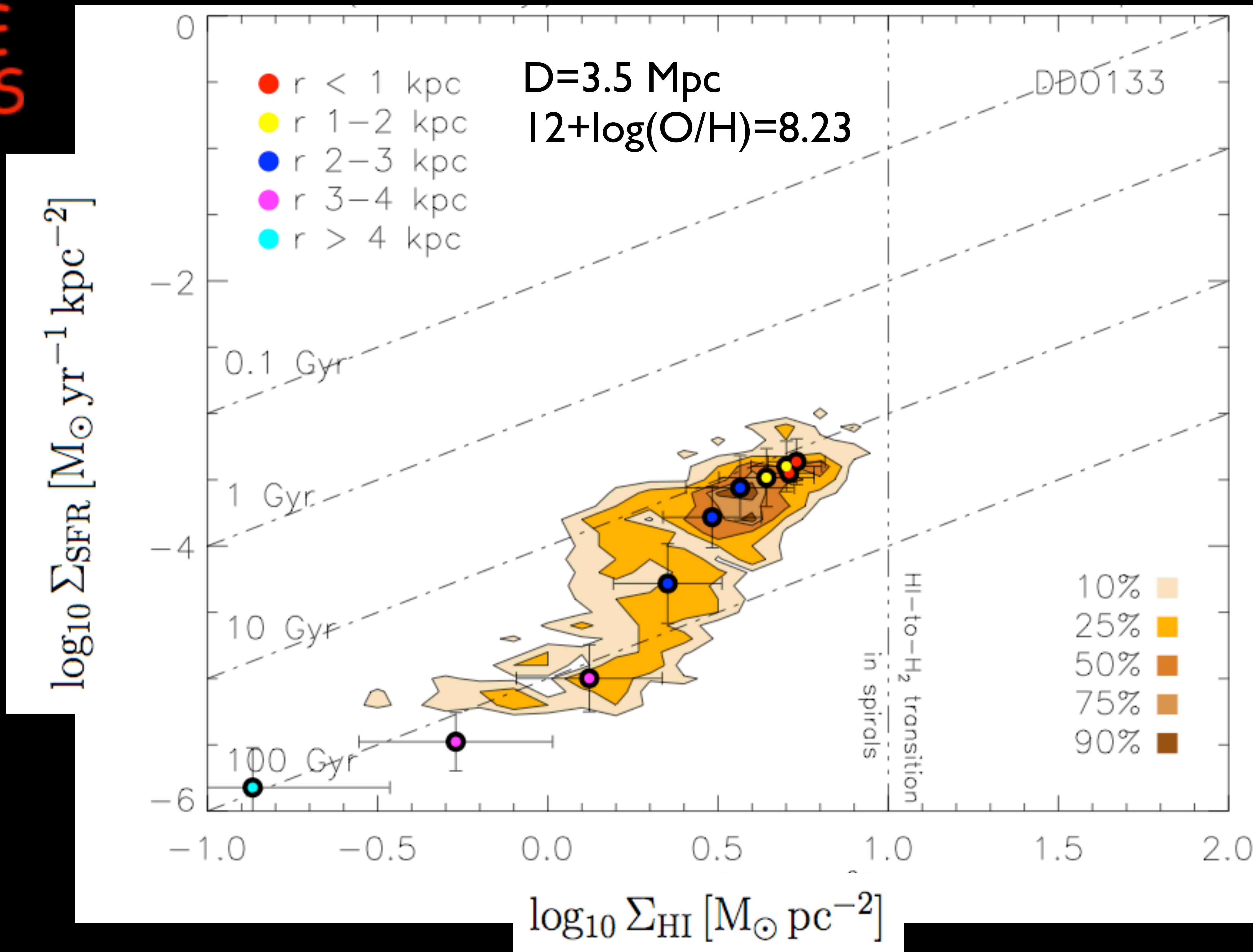
For gas distribution we use:

HI → neutral gas

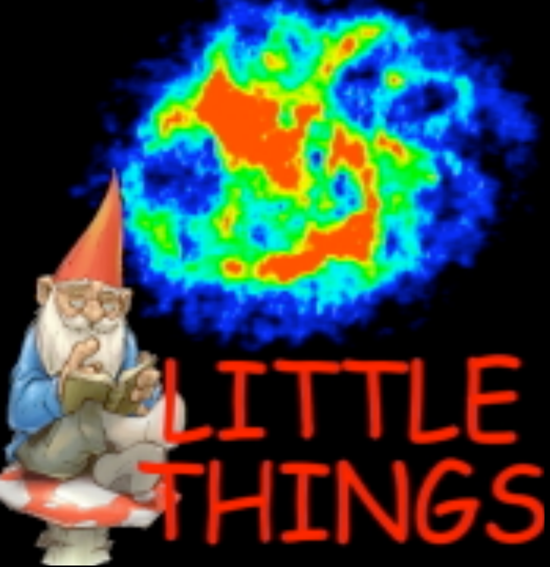
Applied corrections:

- all maps are corrected to face-on assuming an inclination of 47° for DDO133 and 51° for DDO168.
- all maps corrected to the same linear resolution of 400 pc
- FUV maps are corrected for foreground extinction only

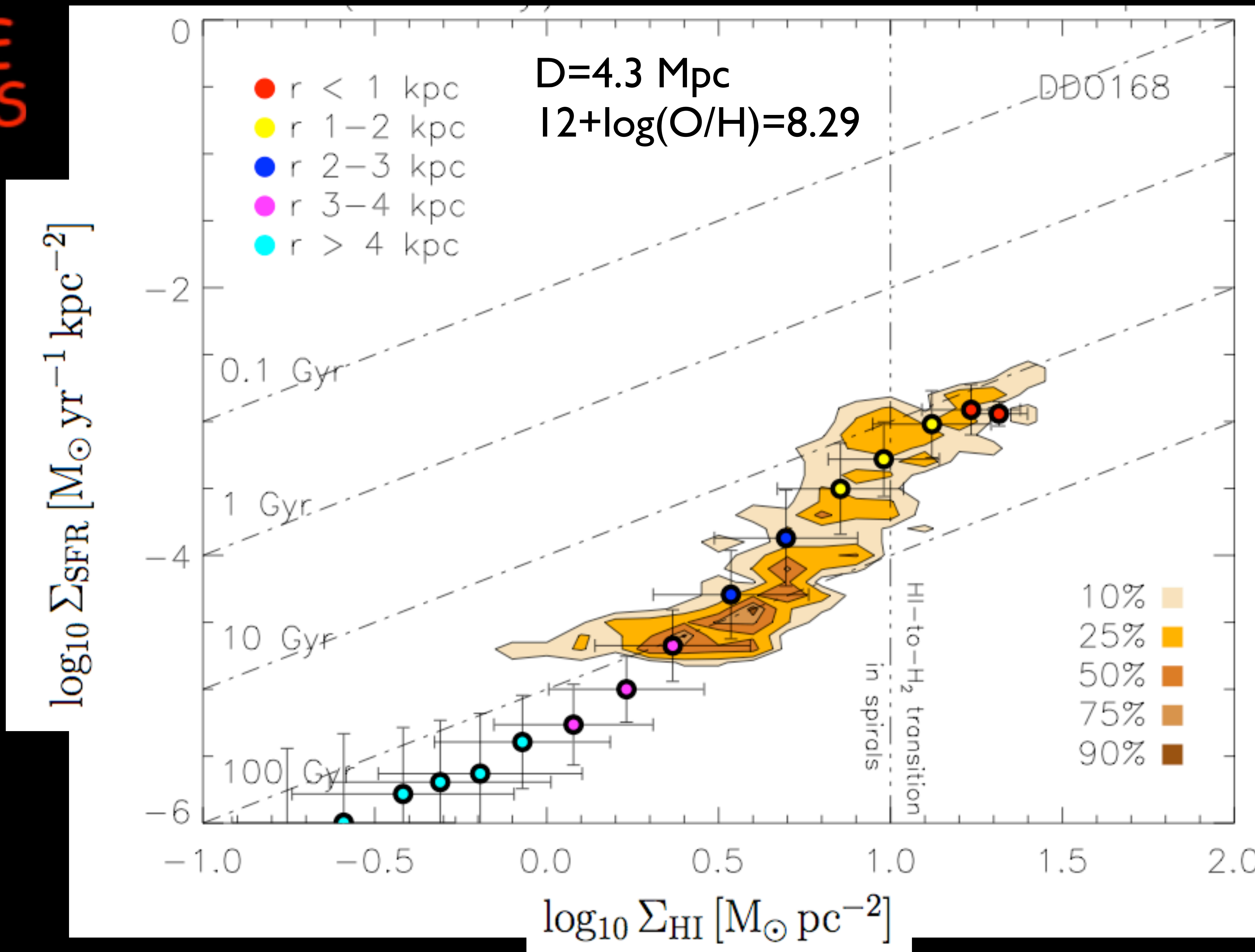
Our Results



D=3.5 Mpc
12+log(O/H)=8.23
DDO133
r < 1 kpc
r 1−2 kpc
r 2−3 kpc
r 3−4 kpc
r > 4 kpc
0.1 Gyr
1 Gyr
10 Gyr
100 Gyr
HI−to−H$_2$ transition in spirals
10%
25%
50%
75%
90%
$\log_{10} \Sigma_{SFR}$ [$M_\odot$ yr^{-1} kpc^{-2}]
$\log_{10} \Sigma_{HI}$ [$M_\odot$ pc^{-2}]

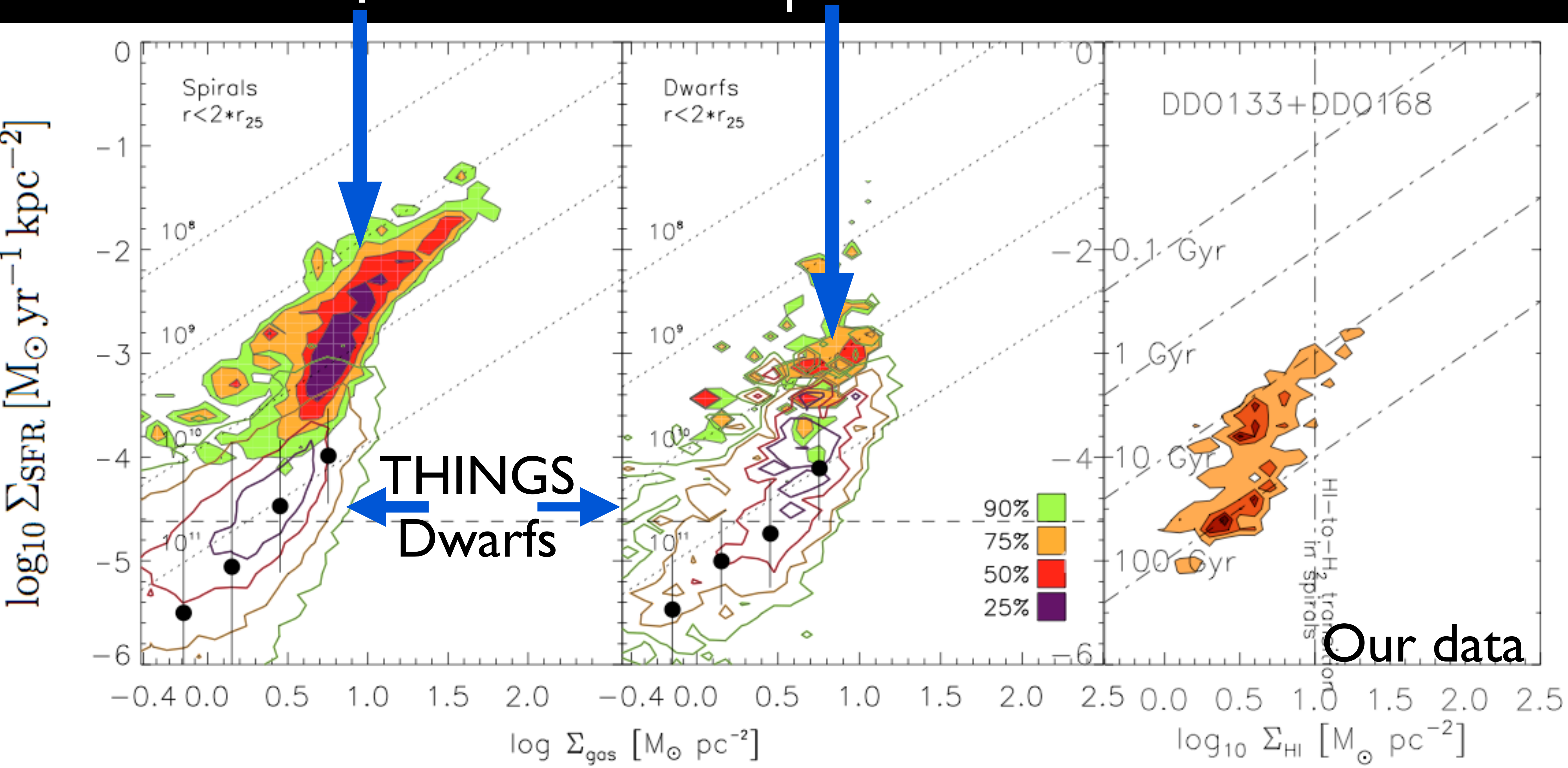

LITTLE THINGS

Our Results


D=4.3 Mpc
12+log(O/H)=8.29
DDO168
r < 1 kpc
r 1−2 kpc
r 2−3 kpc
r 3−4 kpc
r > 4 kpc
0.1 Gyr
1 Gyr
10 Gyr
100 Gyr
HI−to−H2 transition in spirals
10%
25%
50%
75%
90%
0
−2
−4
−6
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
log10 ΣSFR [M⊙ yr−1 kpc−2]
log10 ΣHI [M⊙ pc−2]

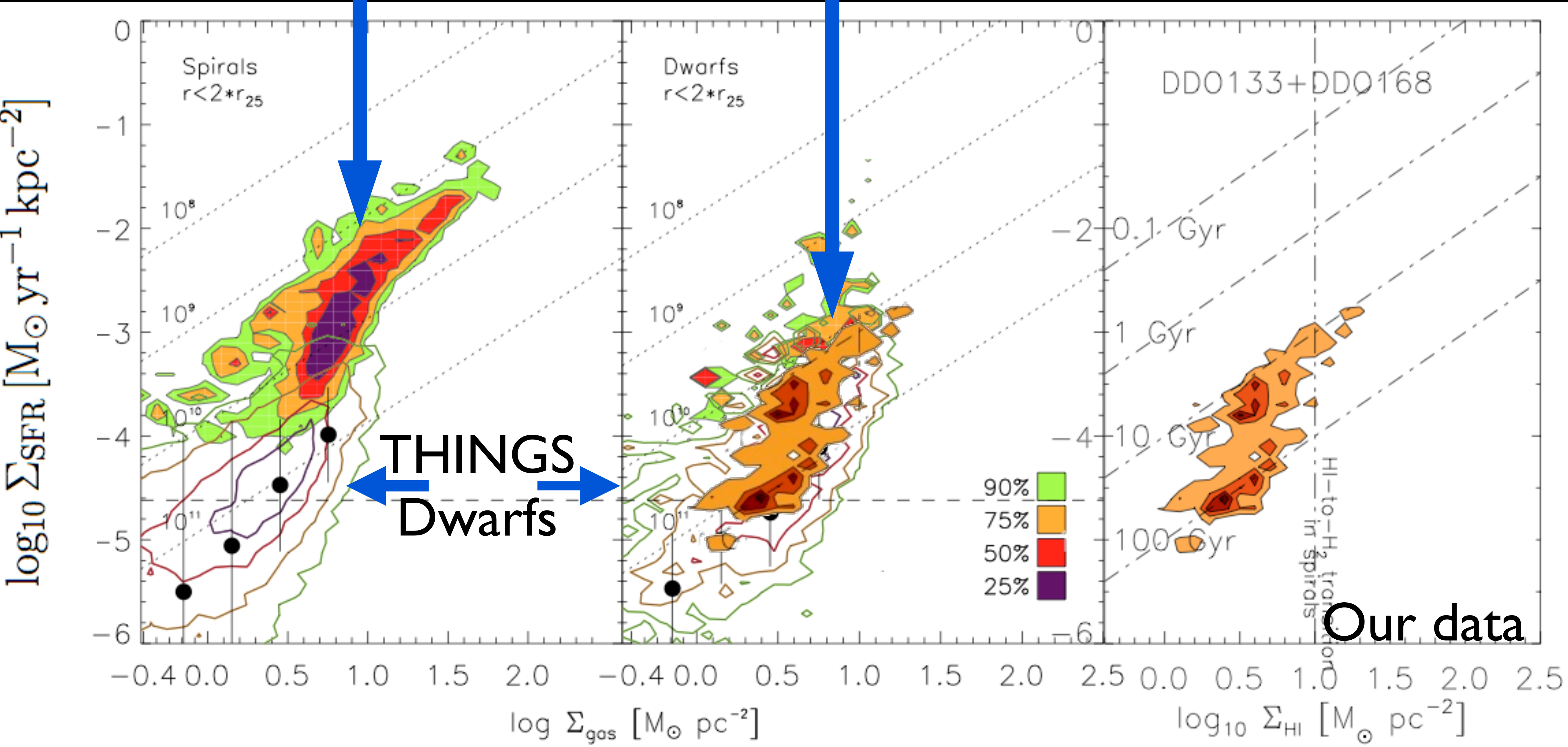
Our Results in the Literature Context

LITTLE THINGS



Bigiel et. al. (2010)

Our Results in the Literature Context

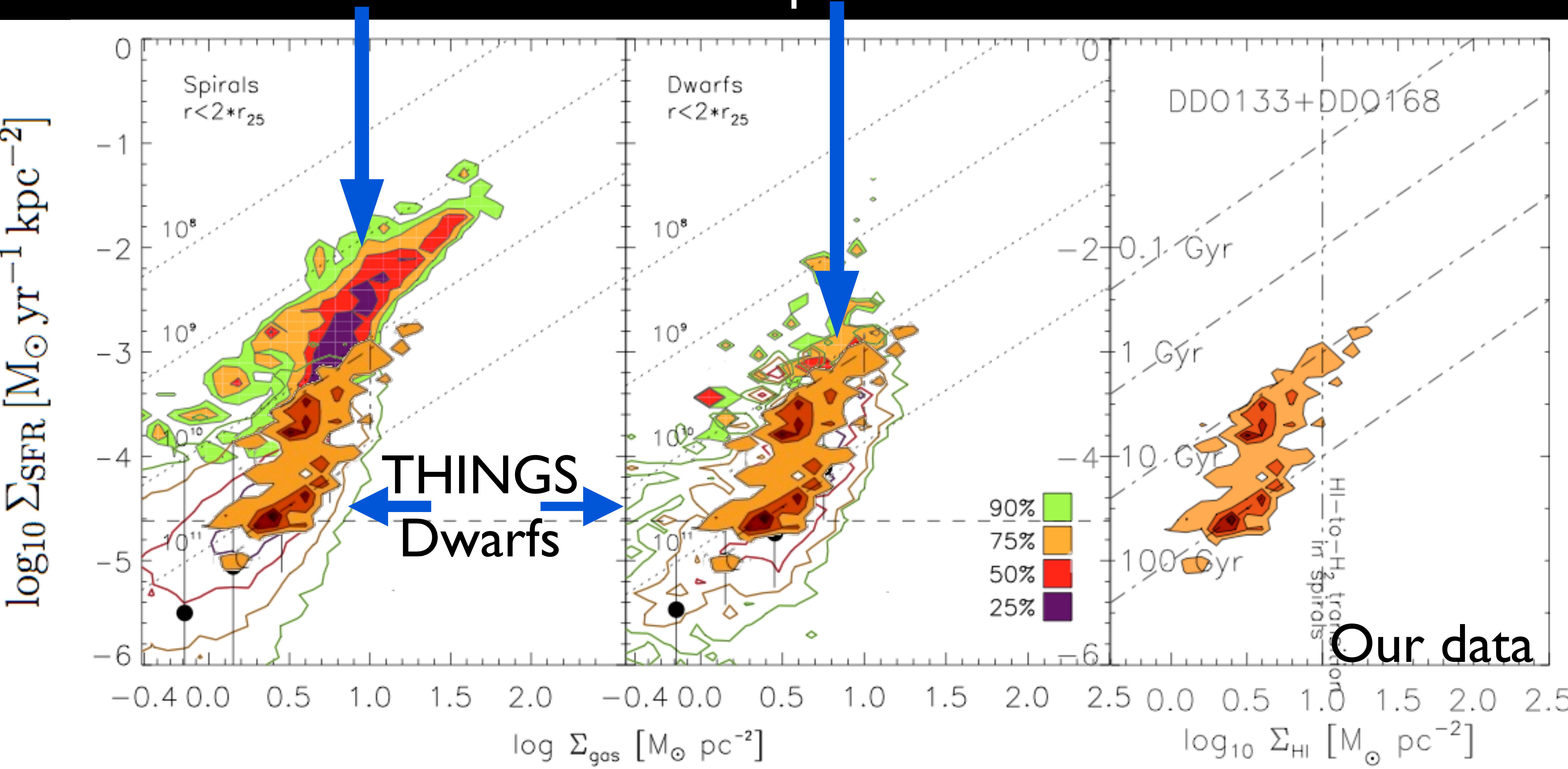


Bigiel et. al. (2010)

Our Results in the Literature Context

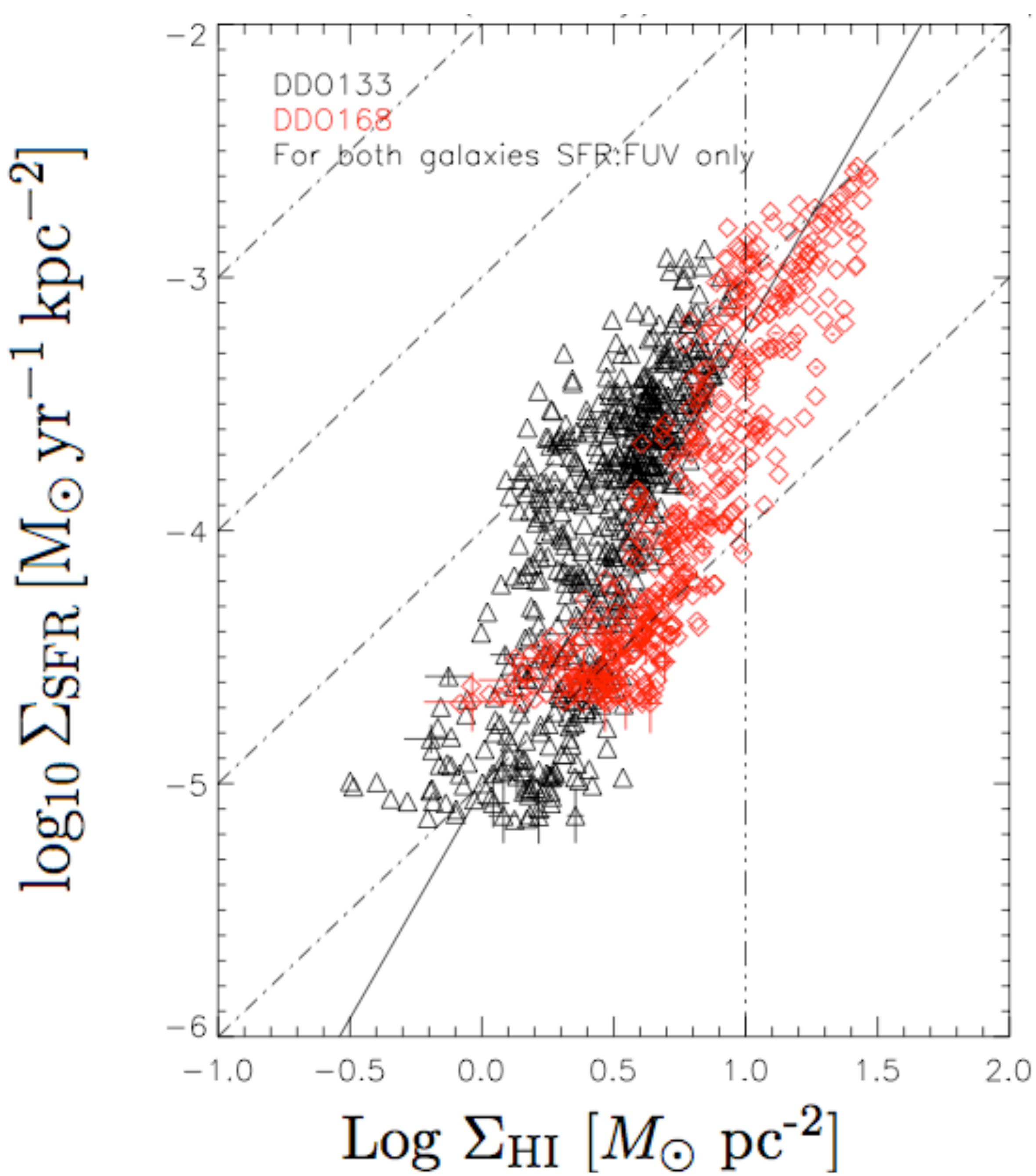
Spirals

Outskirts of spirals

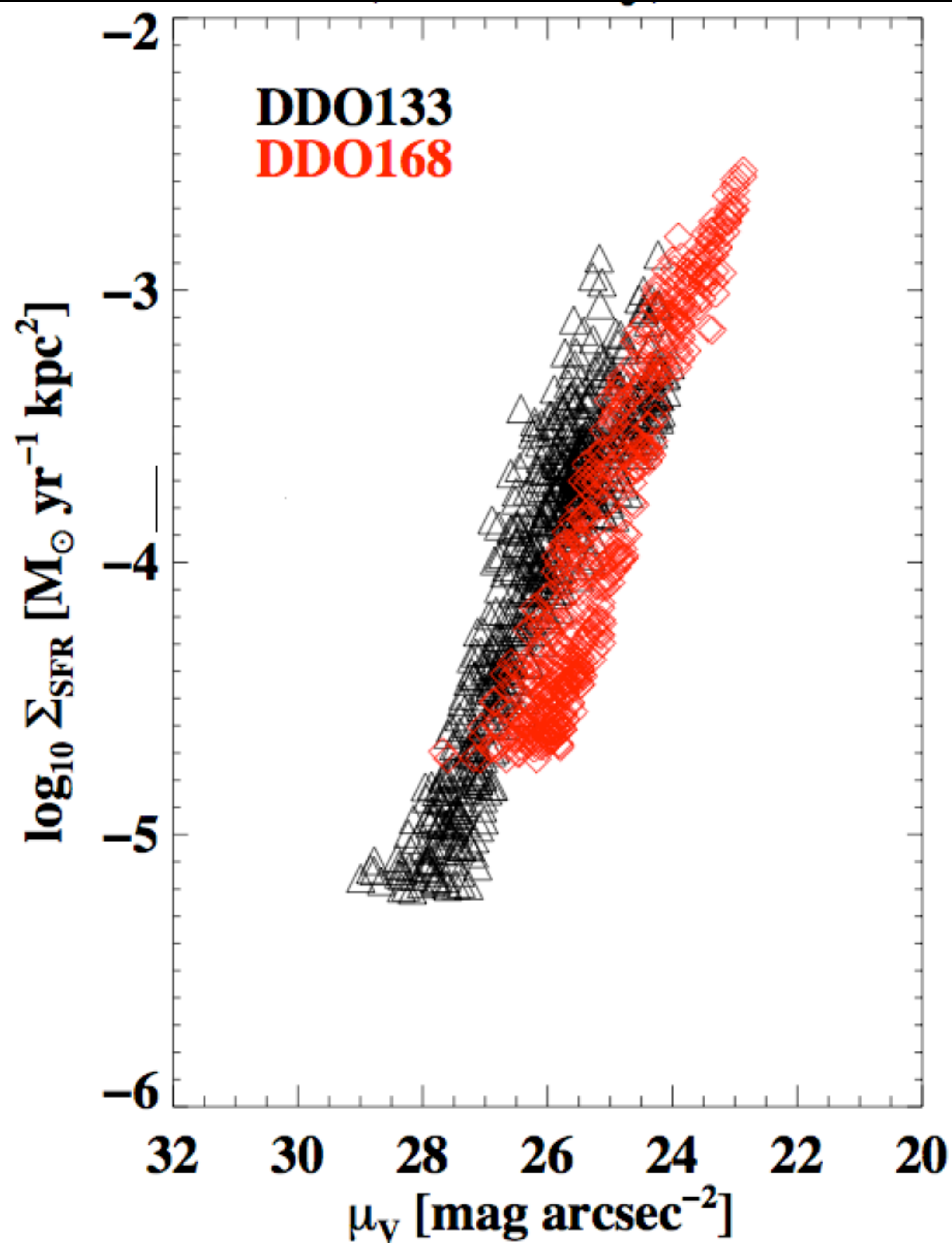


Bigiel et. al. (2010)

Our Results

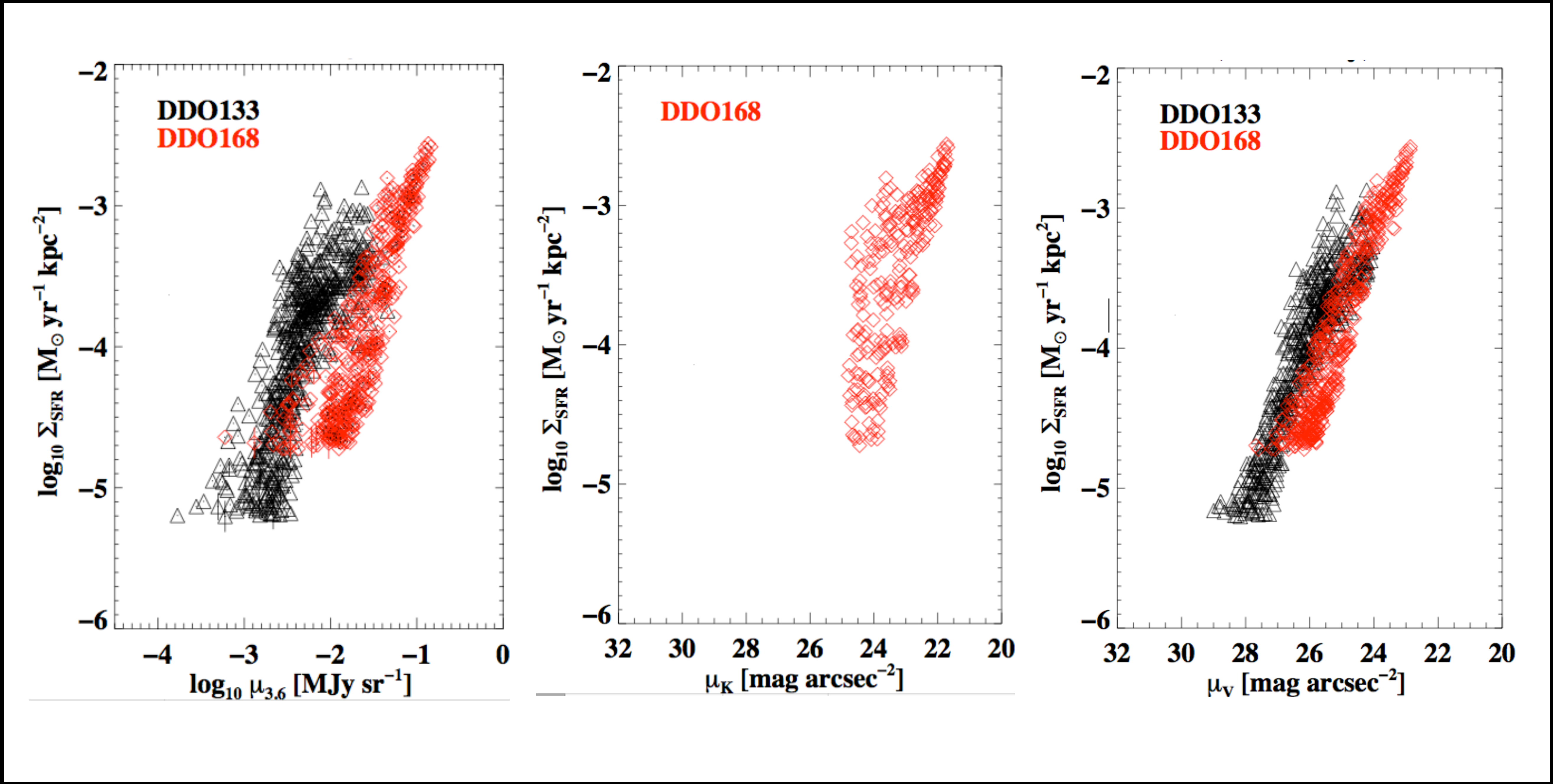


DDO133
DDO168
For both galaxies SFR:FUV only
$\log_{10} \Sigma_{SFR}$ [$M_\odot$ yr^{-1} kpc^{-2}]
Log Σ_{HI} [$M_\odot$ pc^{-2}]
−2
−3
−4
−5
−6
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0



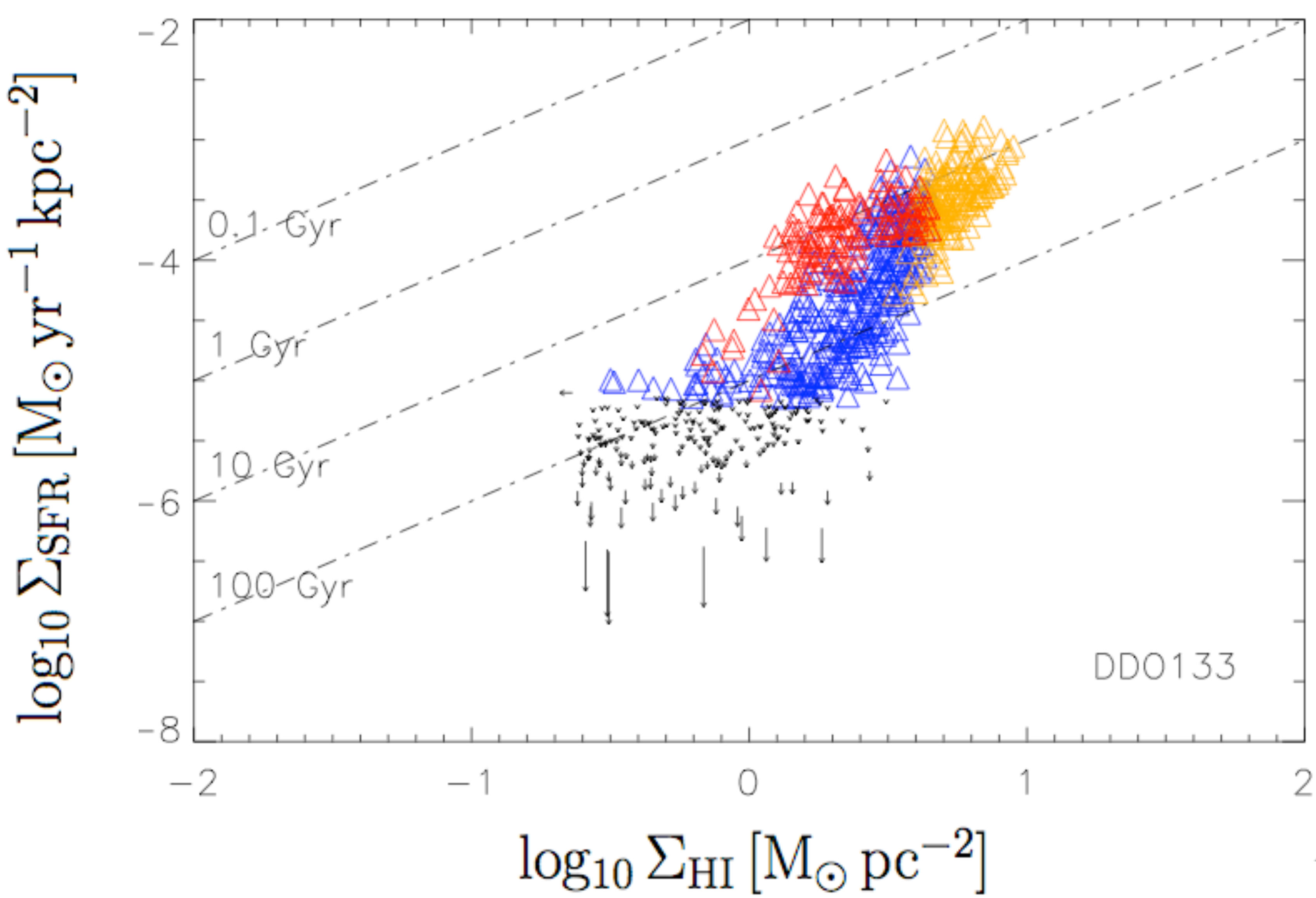
DDO133
DDO168
$\log_{10} \Sigma_{SFR}$ [$M_\odot$ yr^{-1} kpc^2]
μ_V [mag arcsec^{-2}]
−2
−3
−4
−5
−6
32
30
28
26
24
22
20

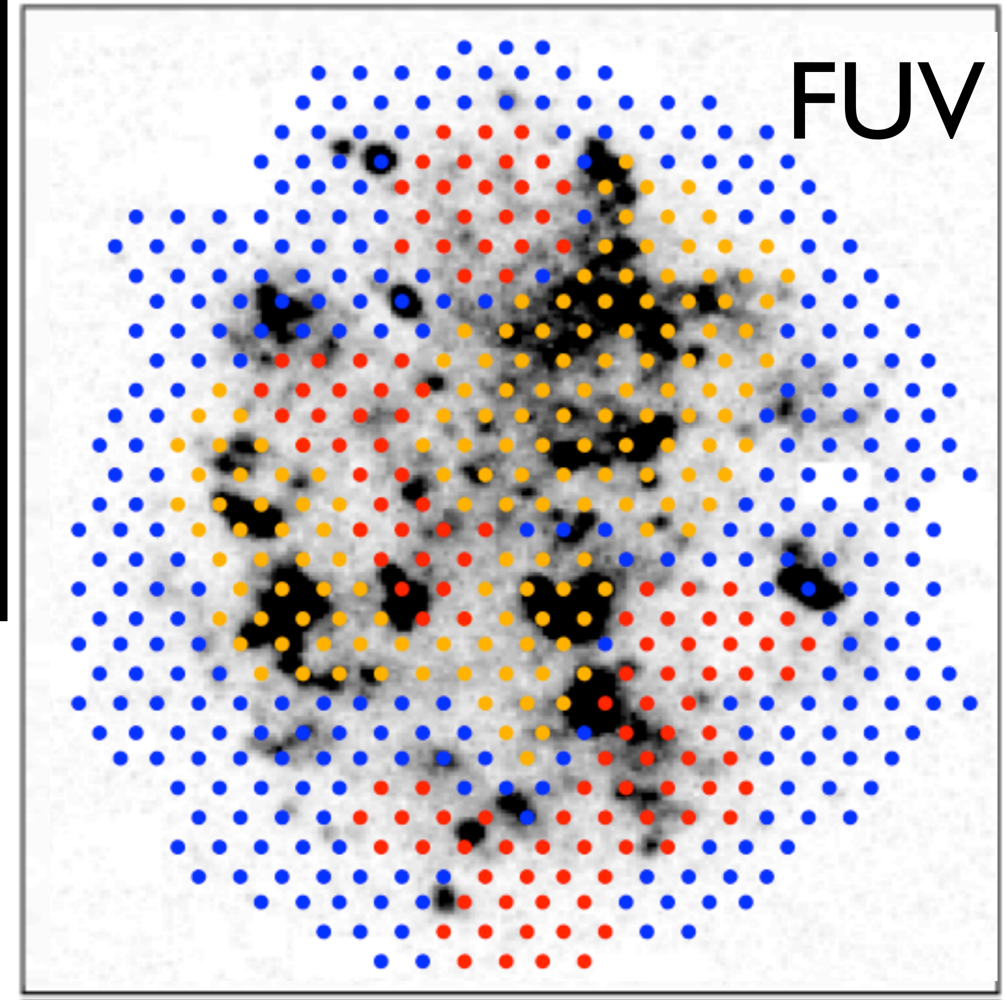
Our Results

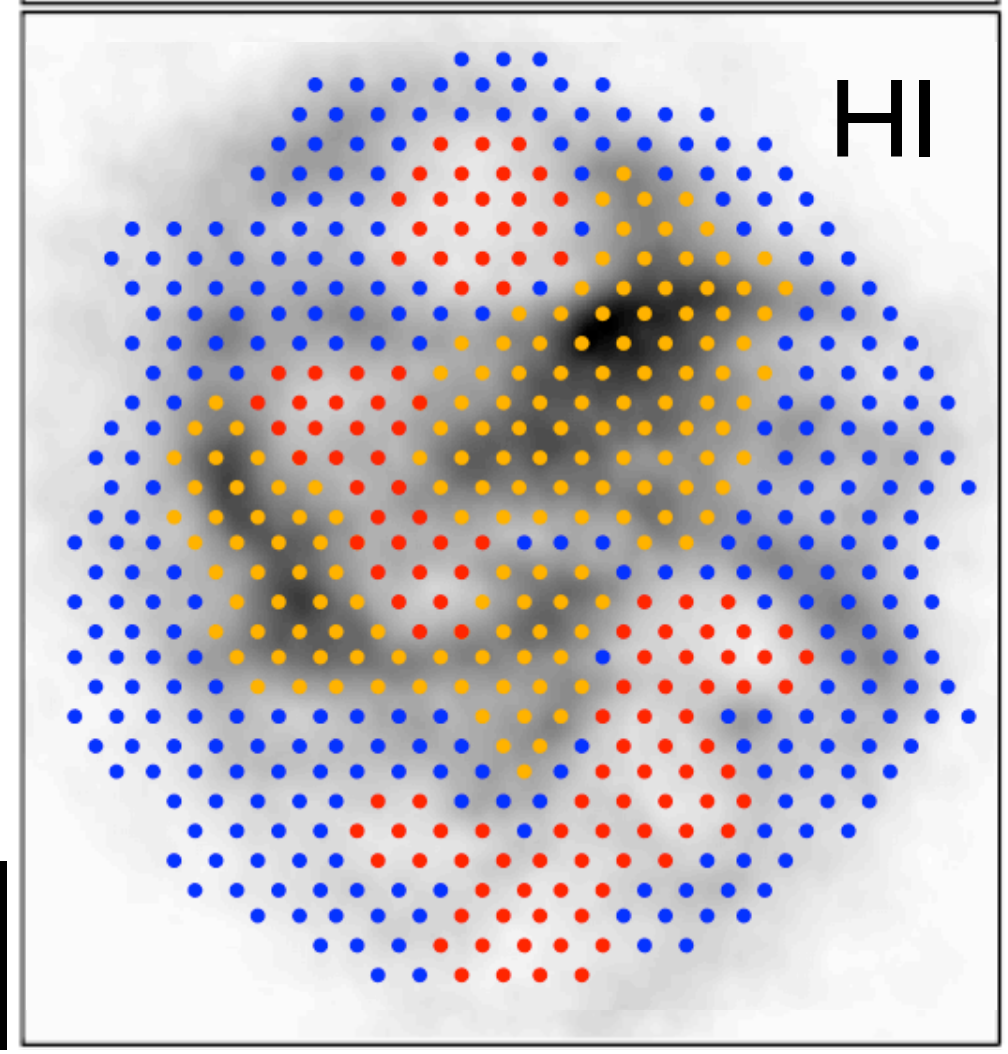


DDO133
DDO168
$\log_{10} \Sigma_{SFR}$ [$M_\odot$ yr^{-1} kpc^{-2}]
$\log_{10} \mu_{3.6}$ [MJy sr^{-1}]
DDO168
μ_K [mag arcsec^{-2}]
DDO133
DDO168
μ_V [mag arcsec^{-2}]

Peculiar Feature in DDO 133



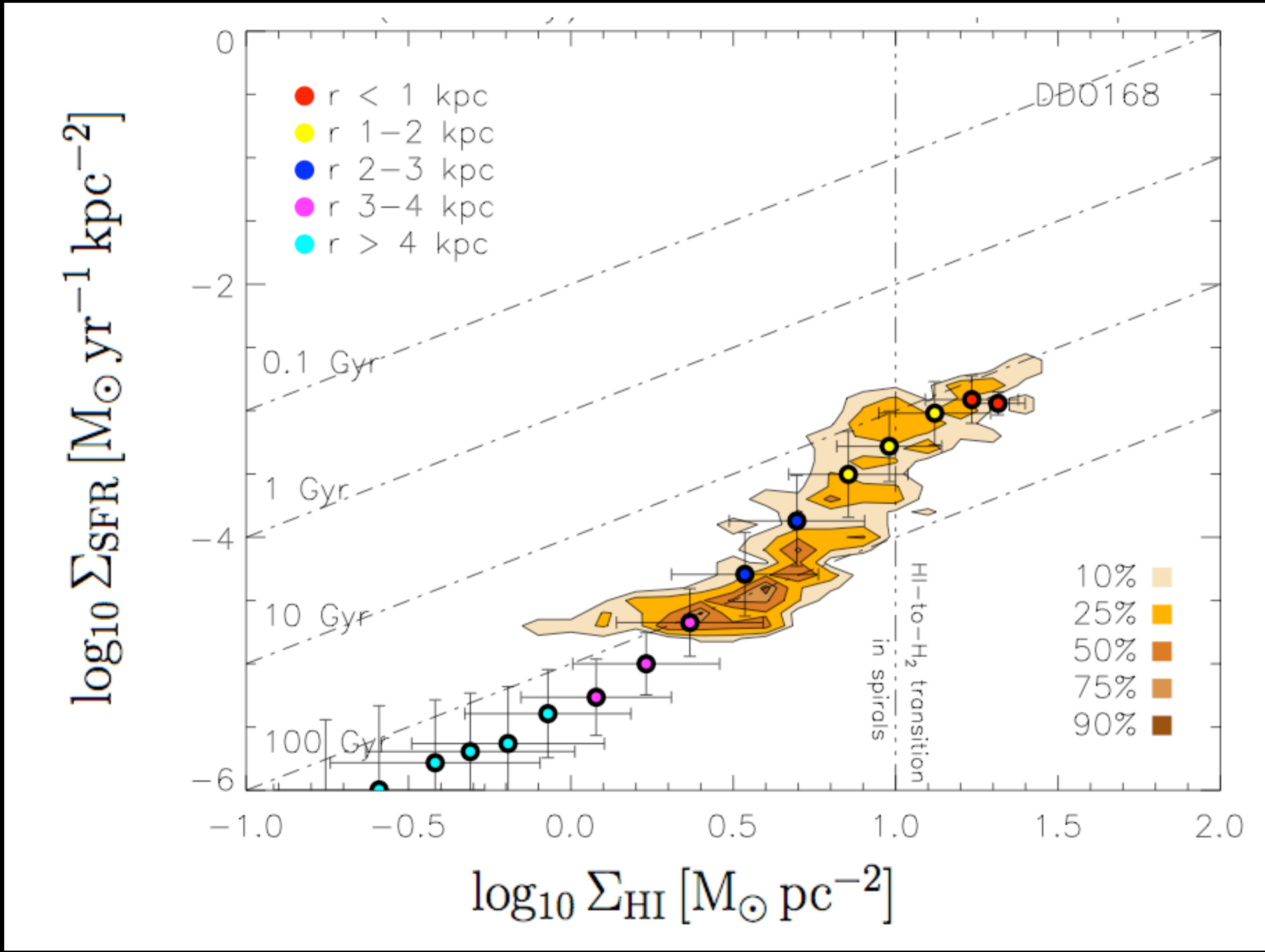




Peculiar Feature in DDO 168

Why?

The threshold where neutral gas turns molecular is higher than expected in DDO168

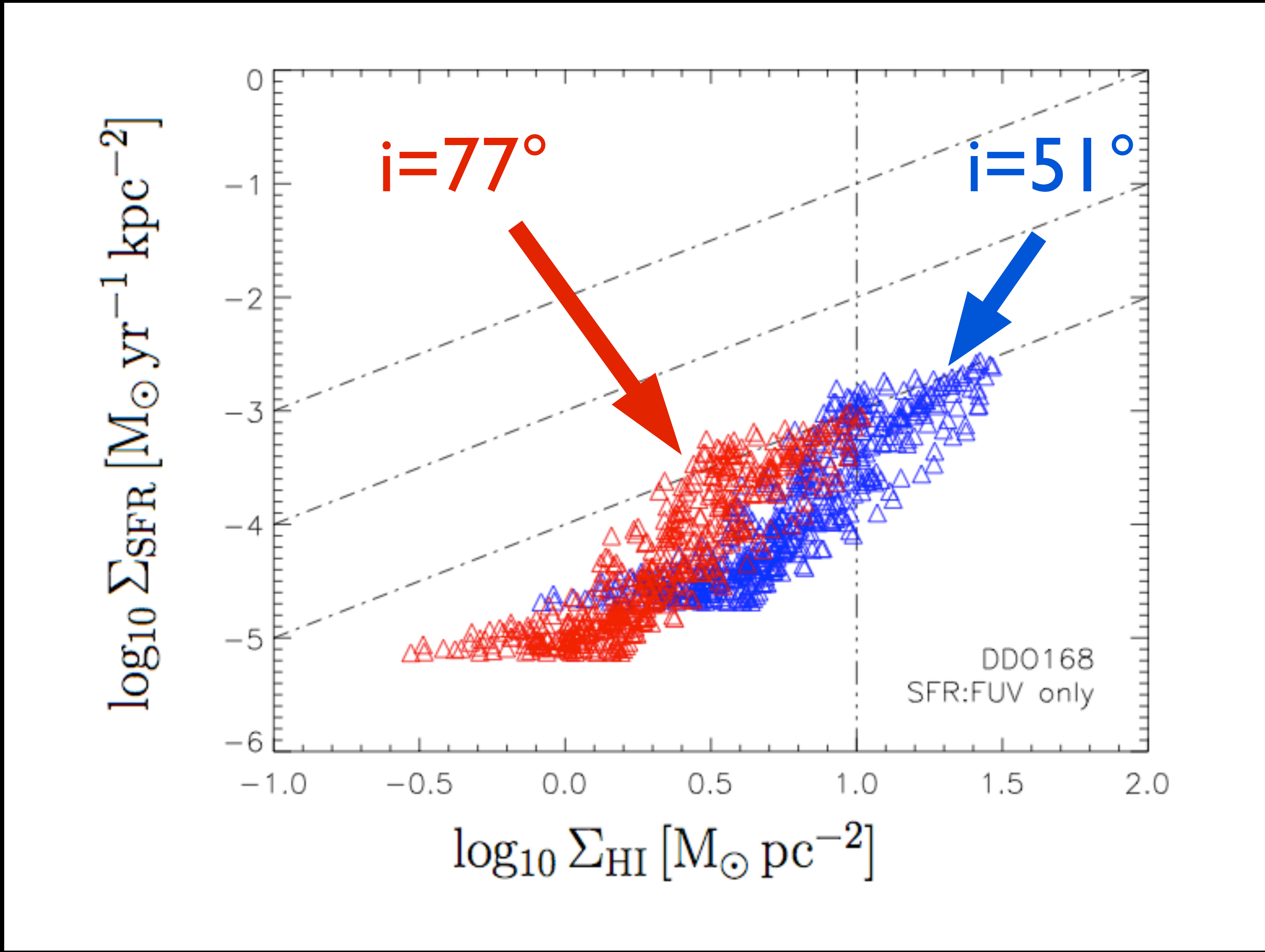


Peculiar Feature in DDO 168

Why?

✤Not an inclination effect

The threshold where neutral gas turns molecular is higher than expected in DDO168

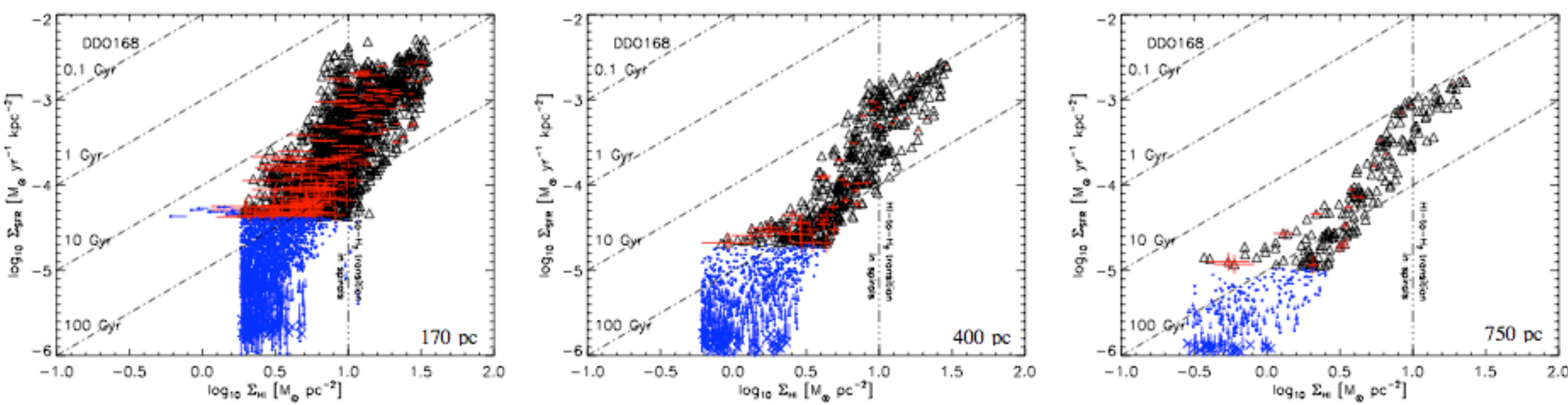


Peculiar Feature in DDO 168

The threshold where neutral gas turns molecular is higher than expected in DDO168

Why?

✤Not an inclination effect
✤Not a resolution effect



Peculiar Feature in DDO 168

The threshold where neutral gas turns molecular is higher than expected in DDO168

Why?

- Not an inclination effect
- Not a resolution effect
- Effect of the low metallicity environment .

Conclusions

- Internal Extinction is negligible.

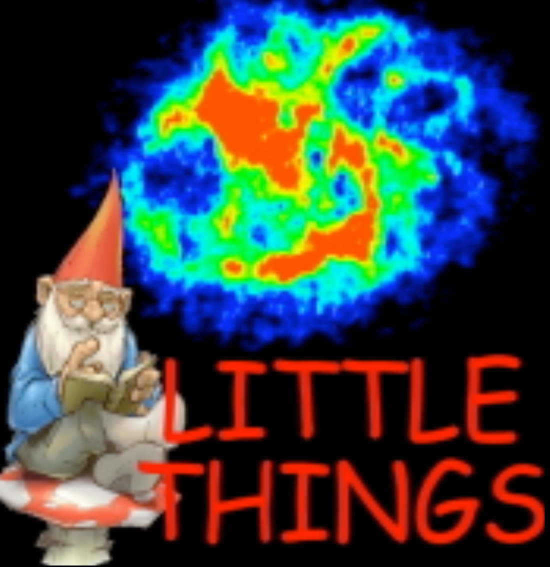
- SF relations found by Bigiel (2010) continue to be relevant.

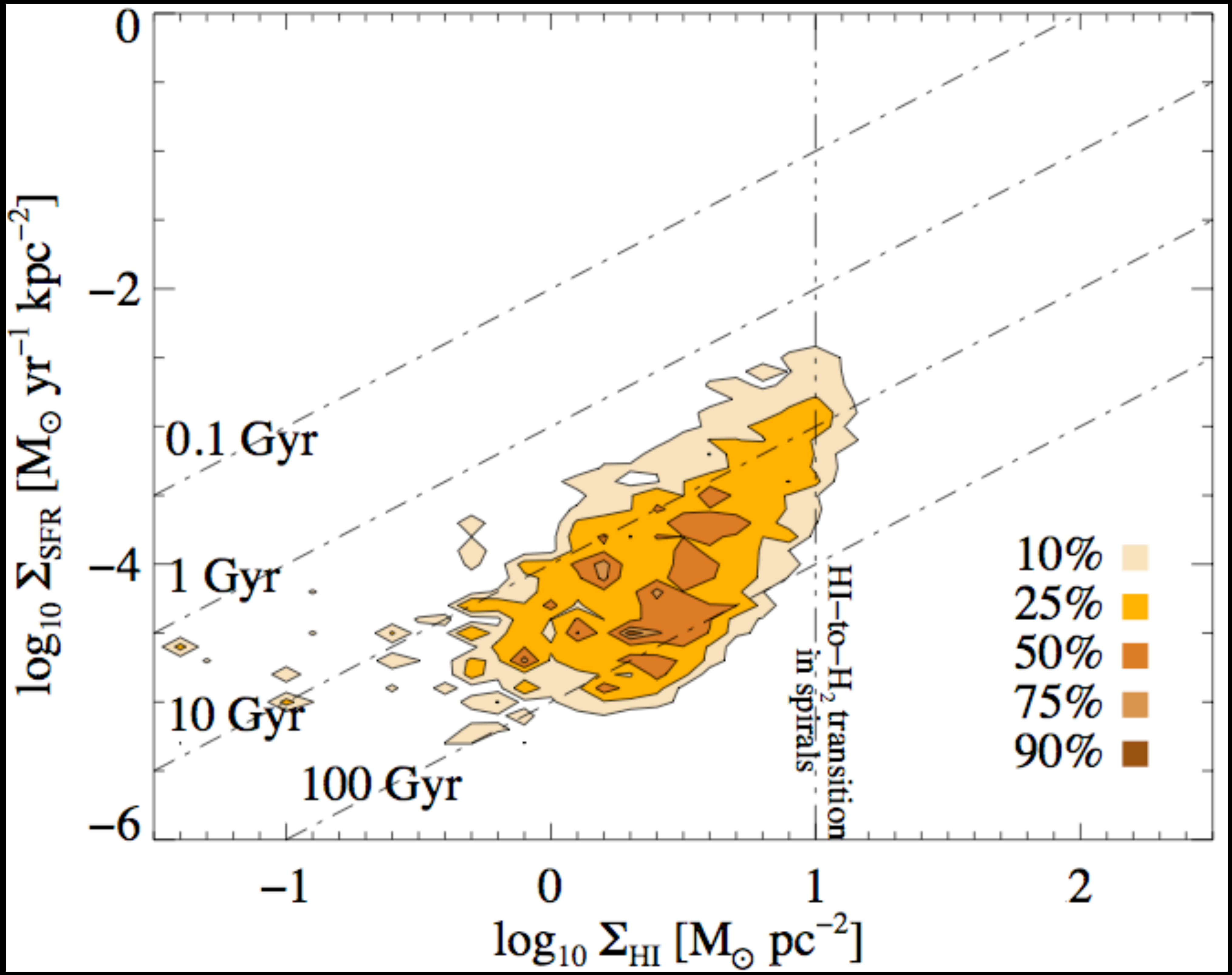
- The correlation between the SFR surface density and the V band emission suggests that stars are playing an important role in enhancing the conditions necessary for HI to turn molecular.

- At 400 pc resolution DDO 133 shows ageing stars in HI holes as distinct features on the KS plot.

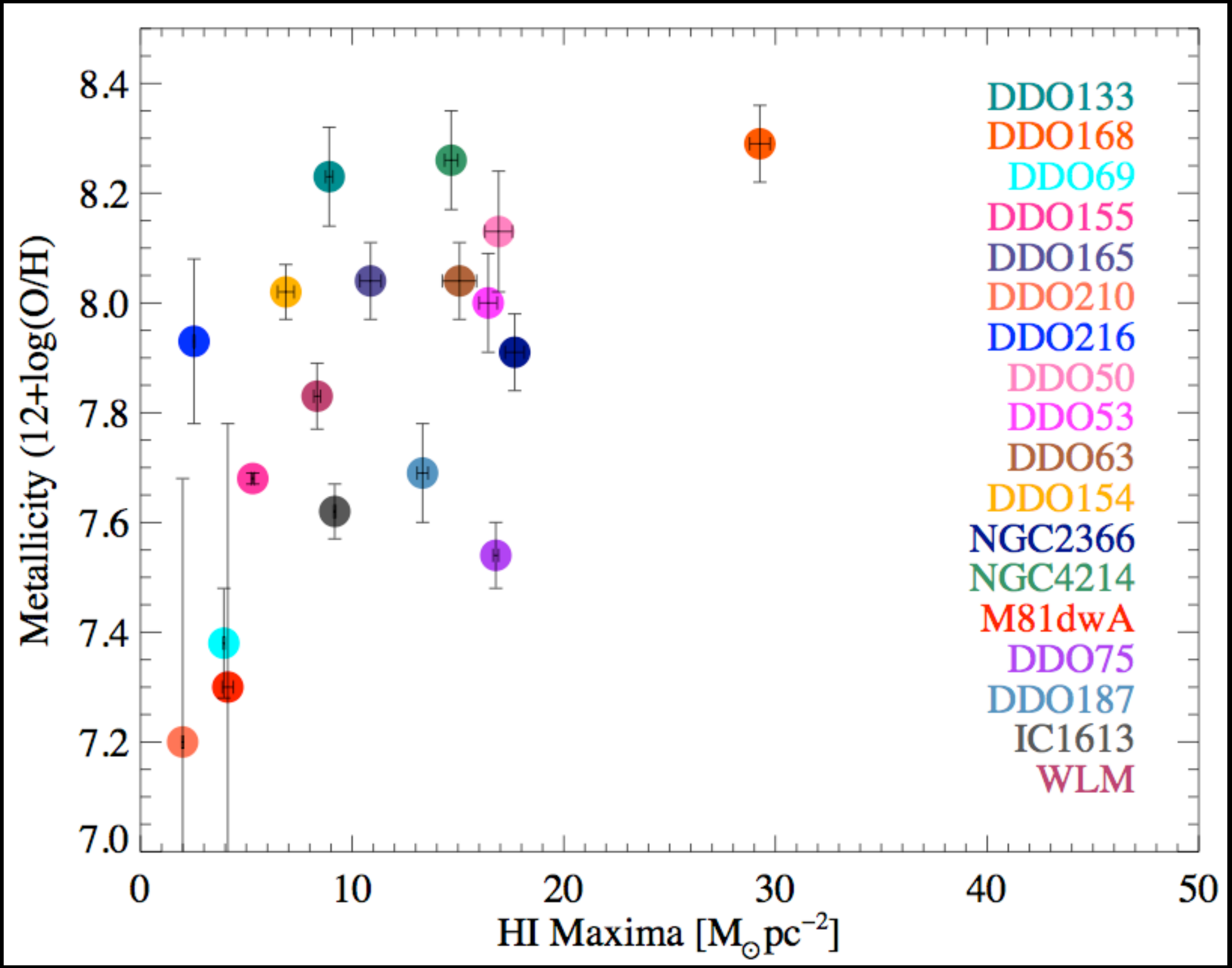
- For DDO168, the maximum HI column density is higher than it is in spirals,probably related with the extreme conditions characteristic to the low metallicity environment of dwarfs.

Bigger Sample Results

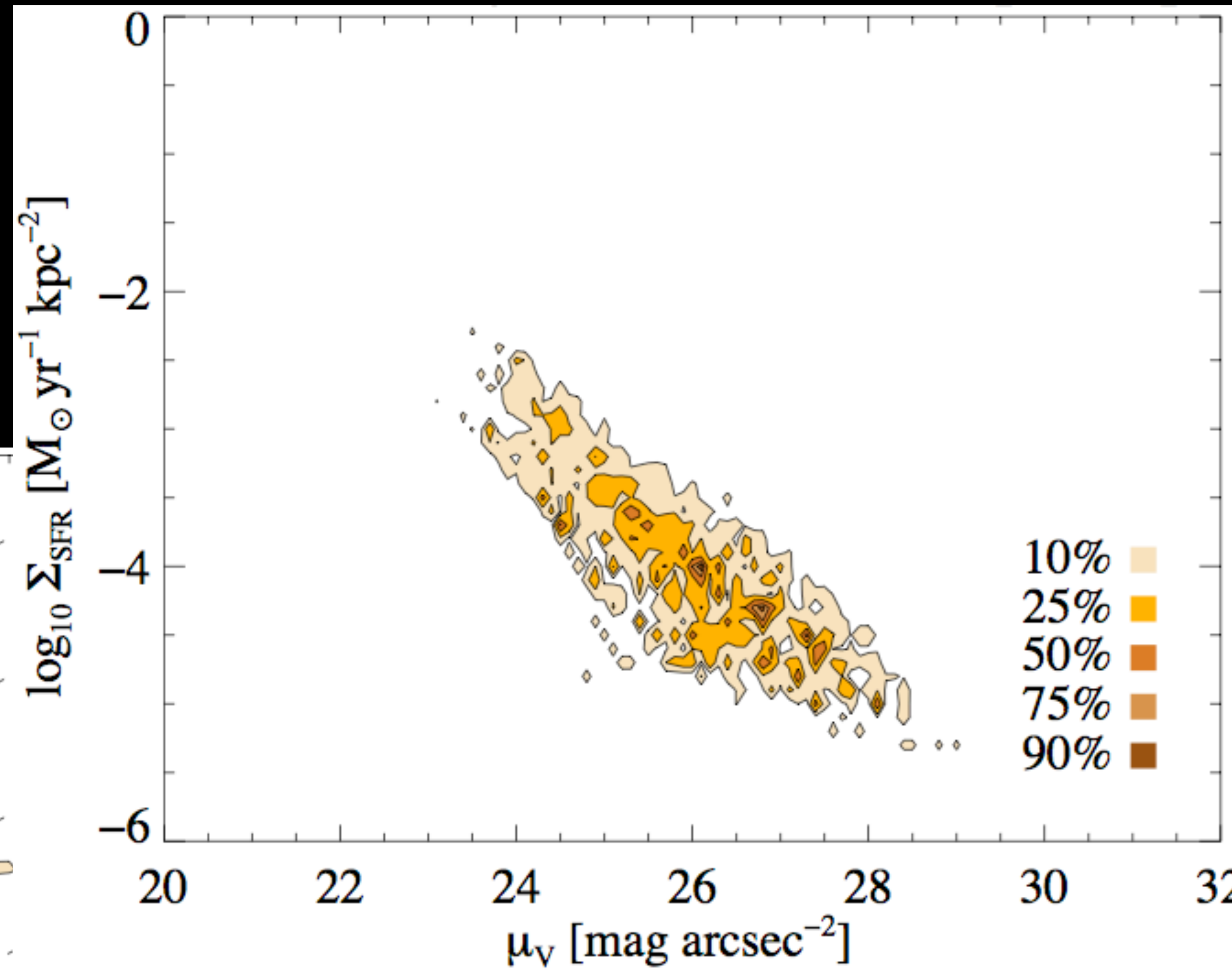


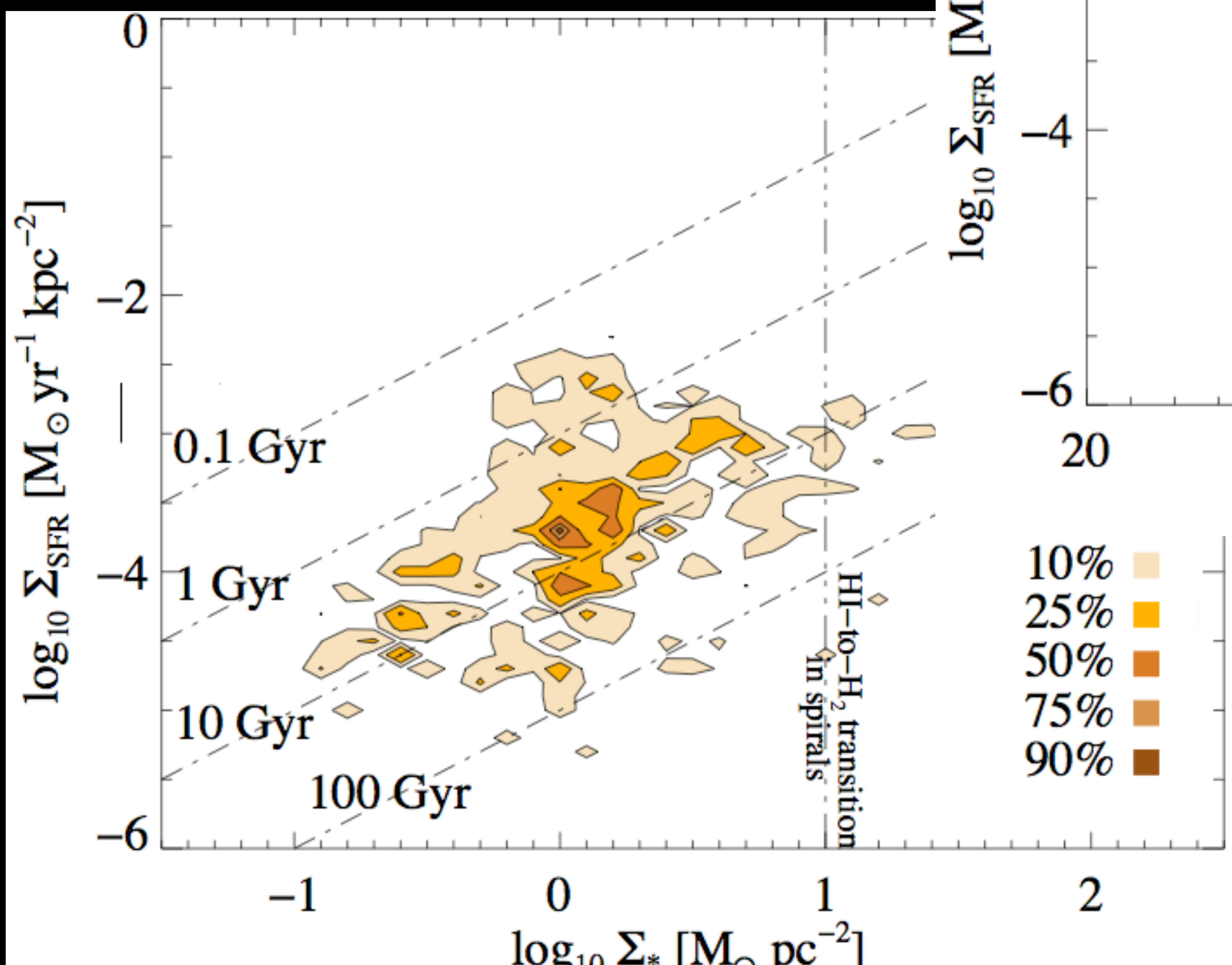


Bigger Sample Results



Bigger Sample Results





Thank You!

Thank You!

Thank You!

Thank You!

Thank You!

Thank You!