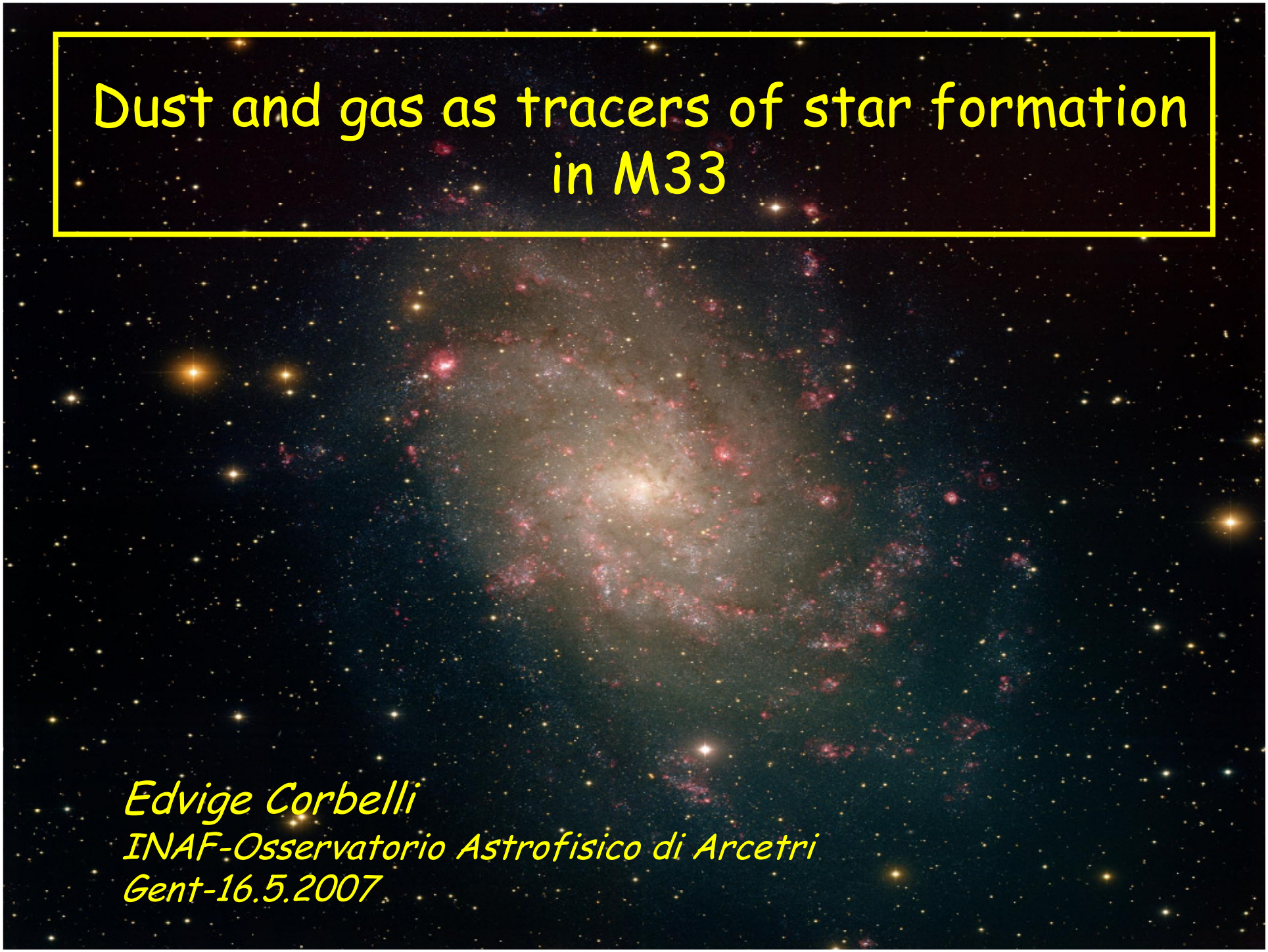
Dust and gas as tracers of star formation in M33
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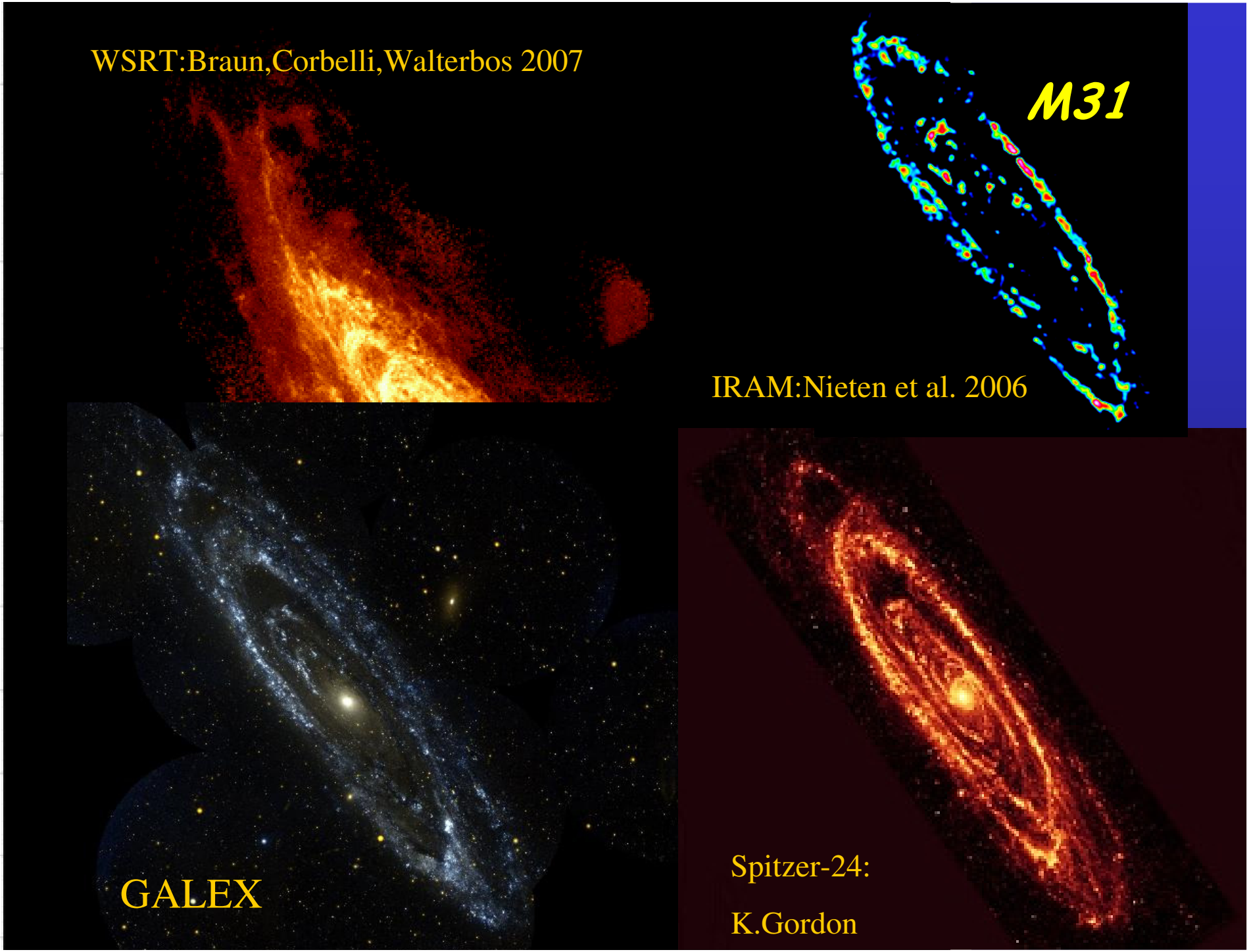
Gent-16.5.2007

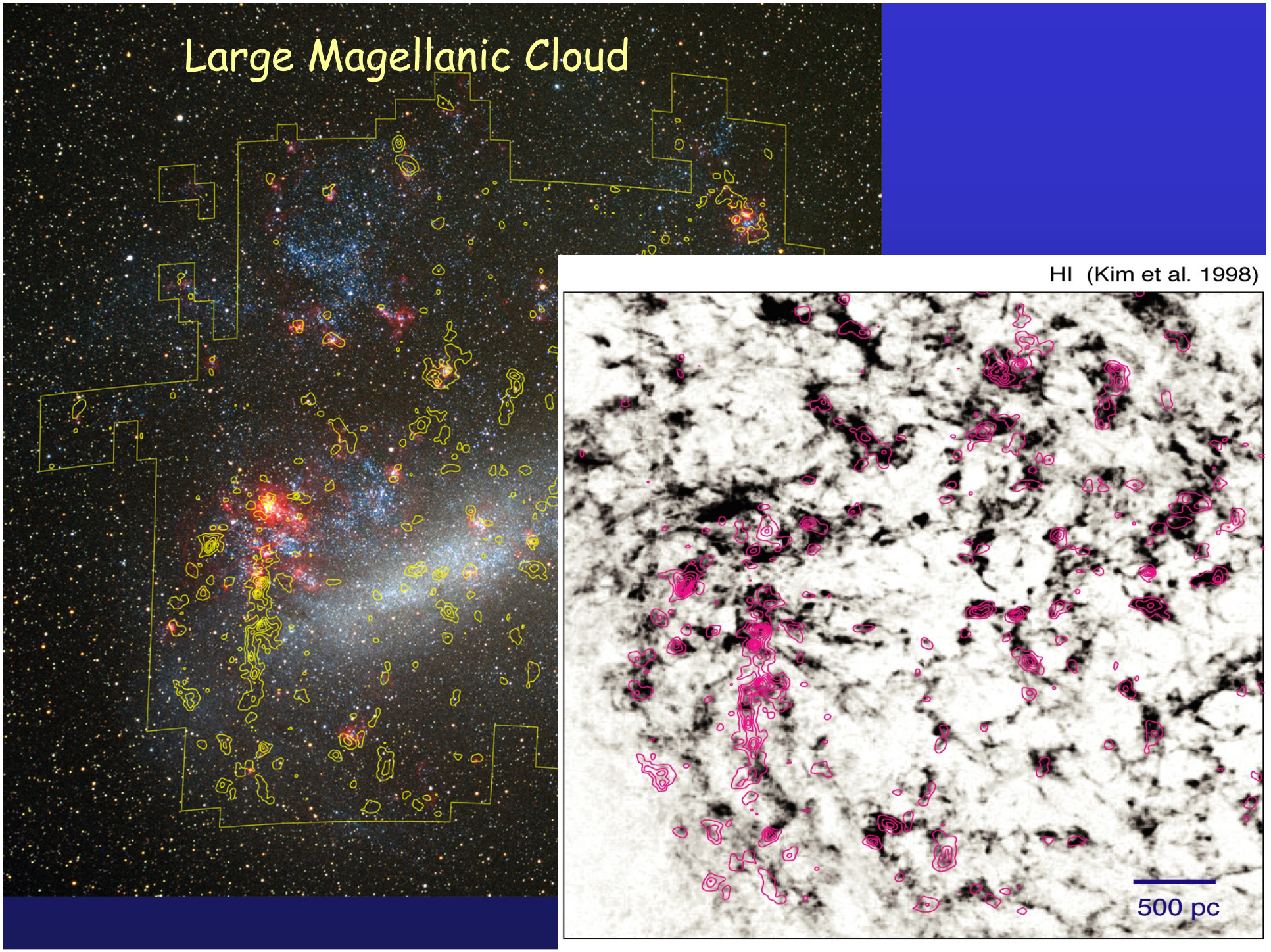
The spiral galaxy M33

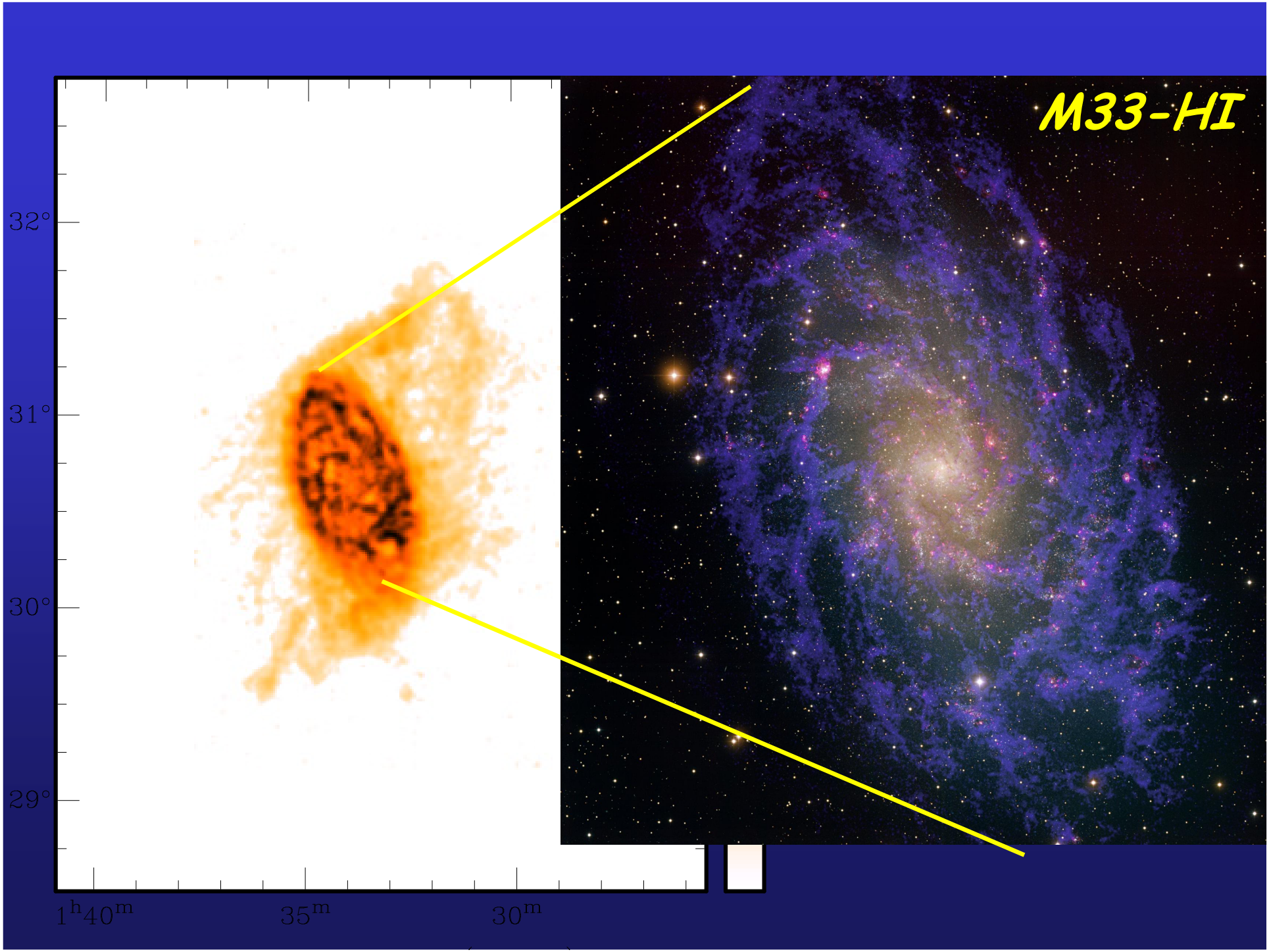
- Nearby, distance ~840 kpc (1″=4 pc)
- Scd of modest inclination (i=53°)
- Blue disk galaxy, no recent mergers
- $L_B = 6 \times 10^9 L_{sun}$
- $M_{stars} = 5 \times 10^9 M_{sun}$
- $M_{HI} = 2 \times 10^9 M_{sun}$
- $M_{H2} = 2 \times 10^8 M_{sun}$
- $L_{H\alpha} = 7 \times 10^6 L_{sun}$
- $L_{FIR(40-120)} = 6 \times 10^8 L_{sun}$
- $SFR = 0.5\ M_{sun}/yr$

M33 B-luminosities and gas masses are between those of M31 and LMC

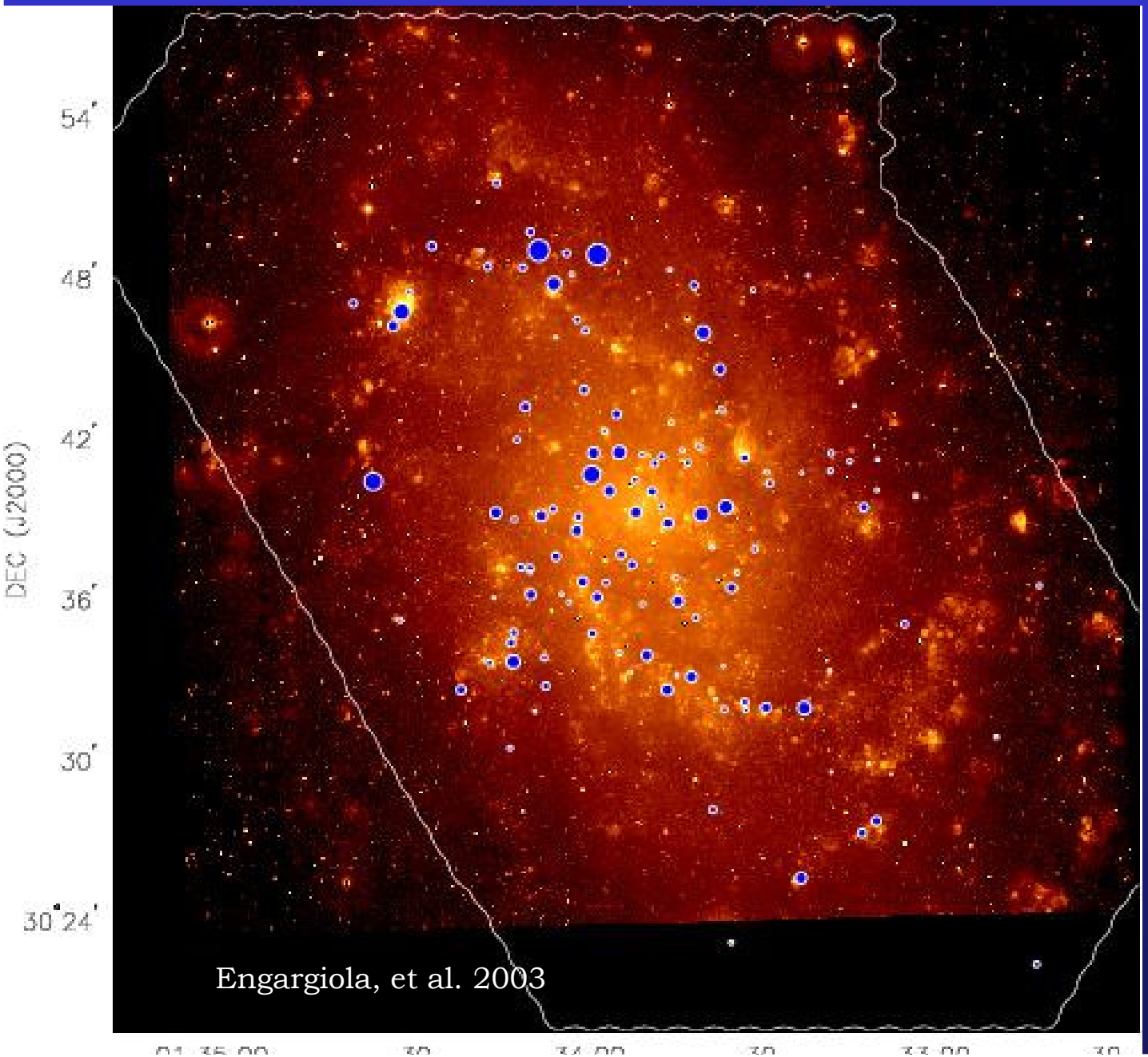
M(H2)/M(HI) ratio stays constant between these 3 LG galaxies !!


WSRT:Braun,Corbelli,Walterbos 2007
M31
IRAM:Nieten et al. 2006
GALEX
Spitzer-24:
K.Gordon


Large Magellanic Cloud
HI (Kim et al. 1998)
500 pc


M33-HI
32°
31°
30°
29°
1h40m
35m
30m

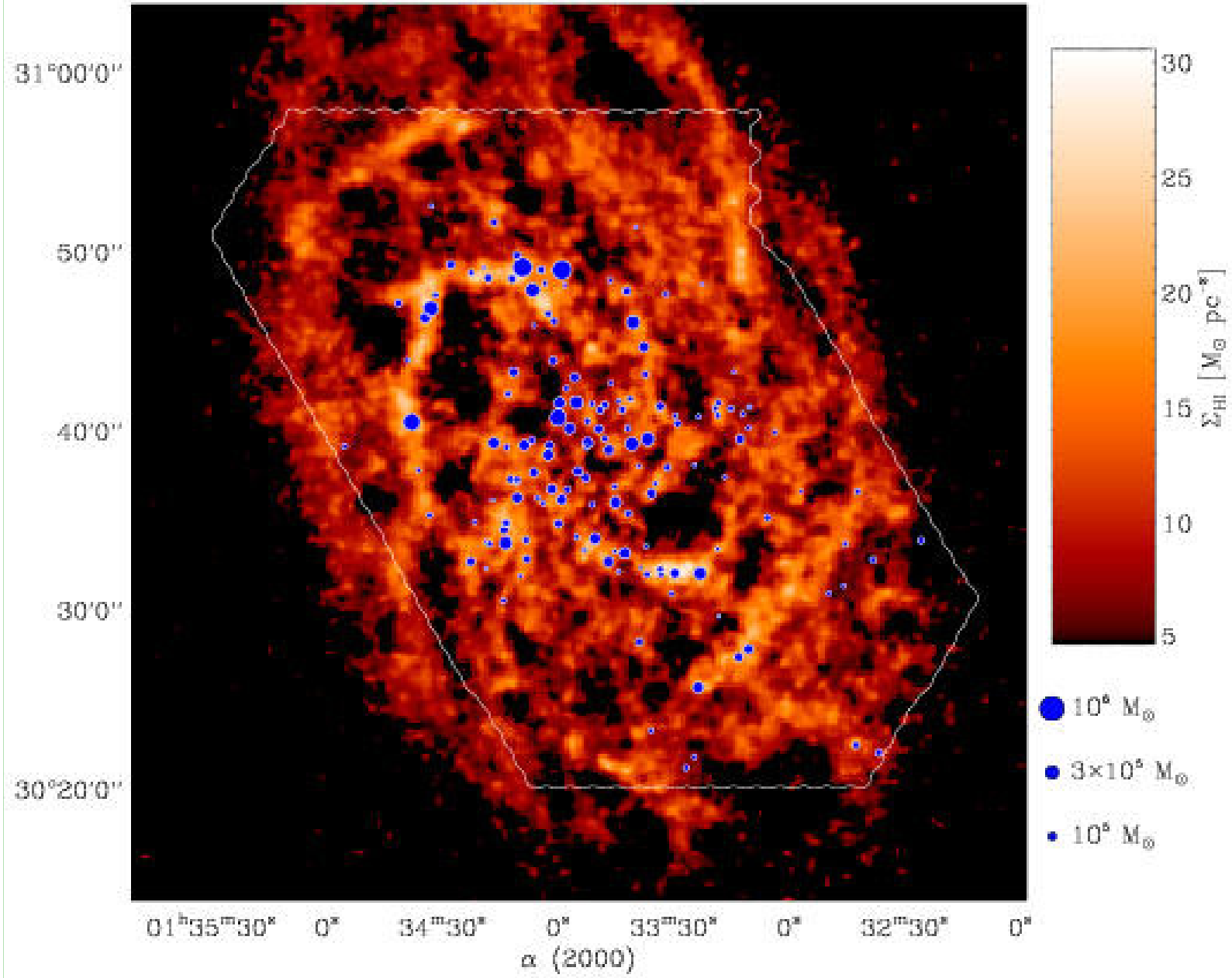
The GMCs in M33 over Ha

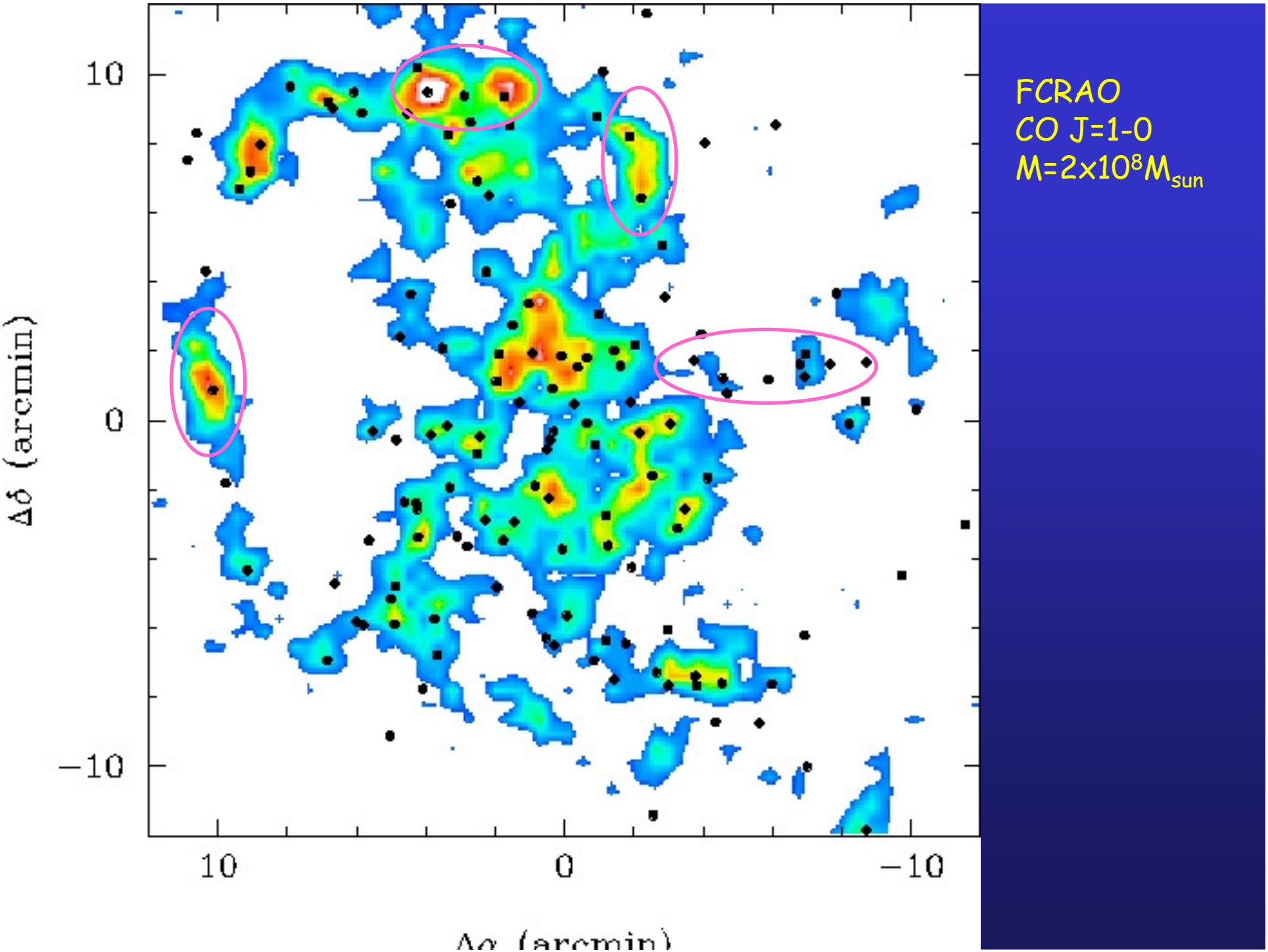


Bima CO **J=1-0**

$M_{H2}=3x10^7M_{sun}$

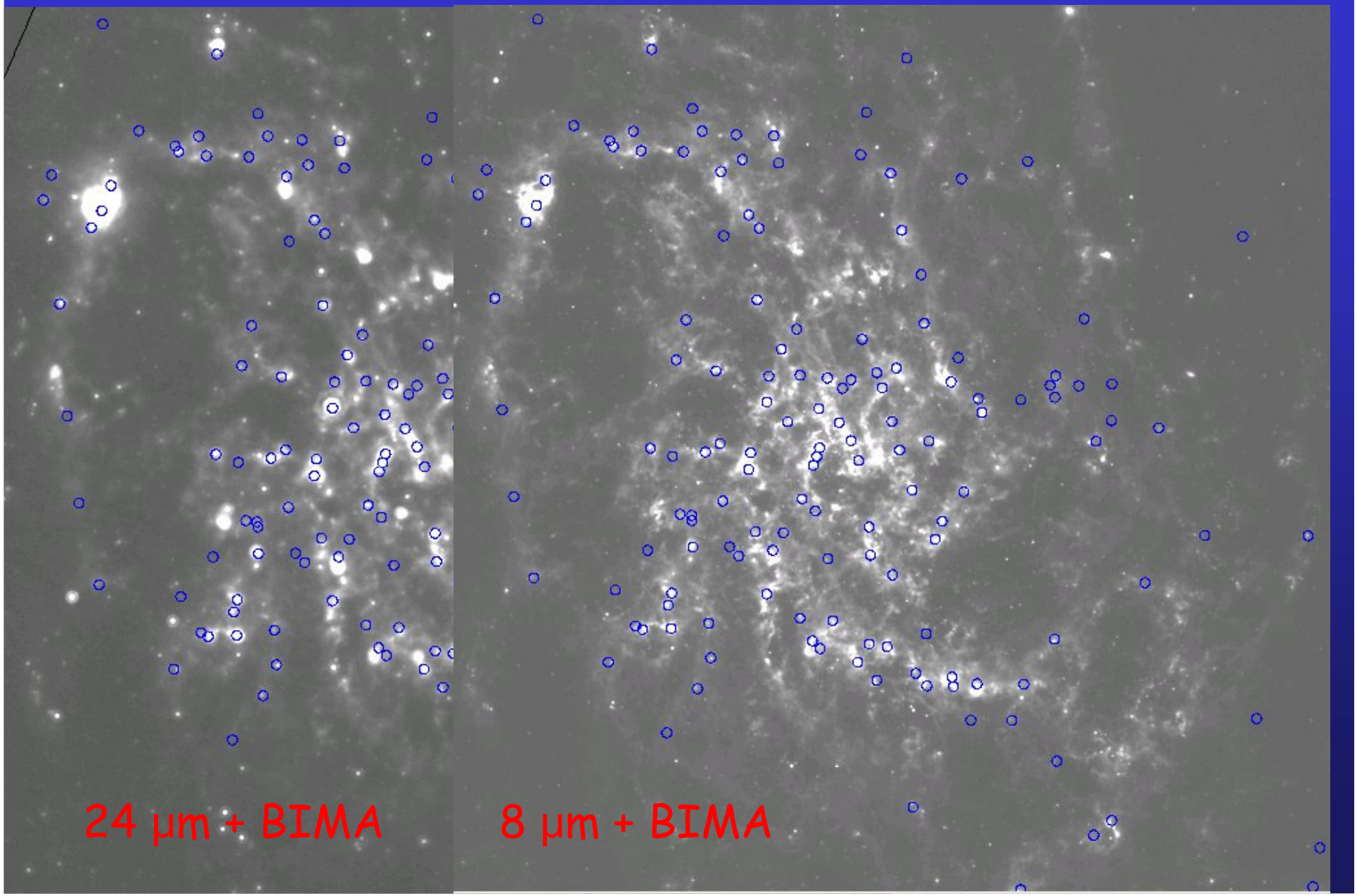
Correlation with HI

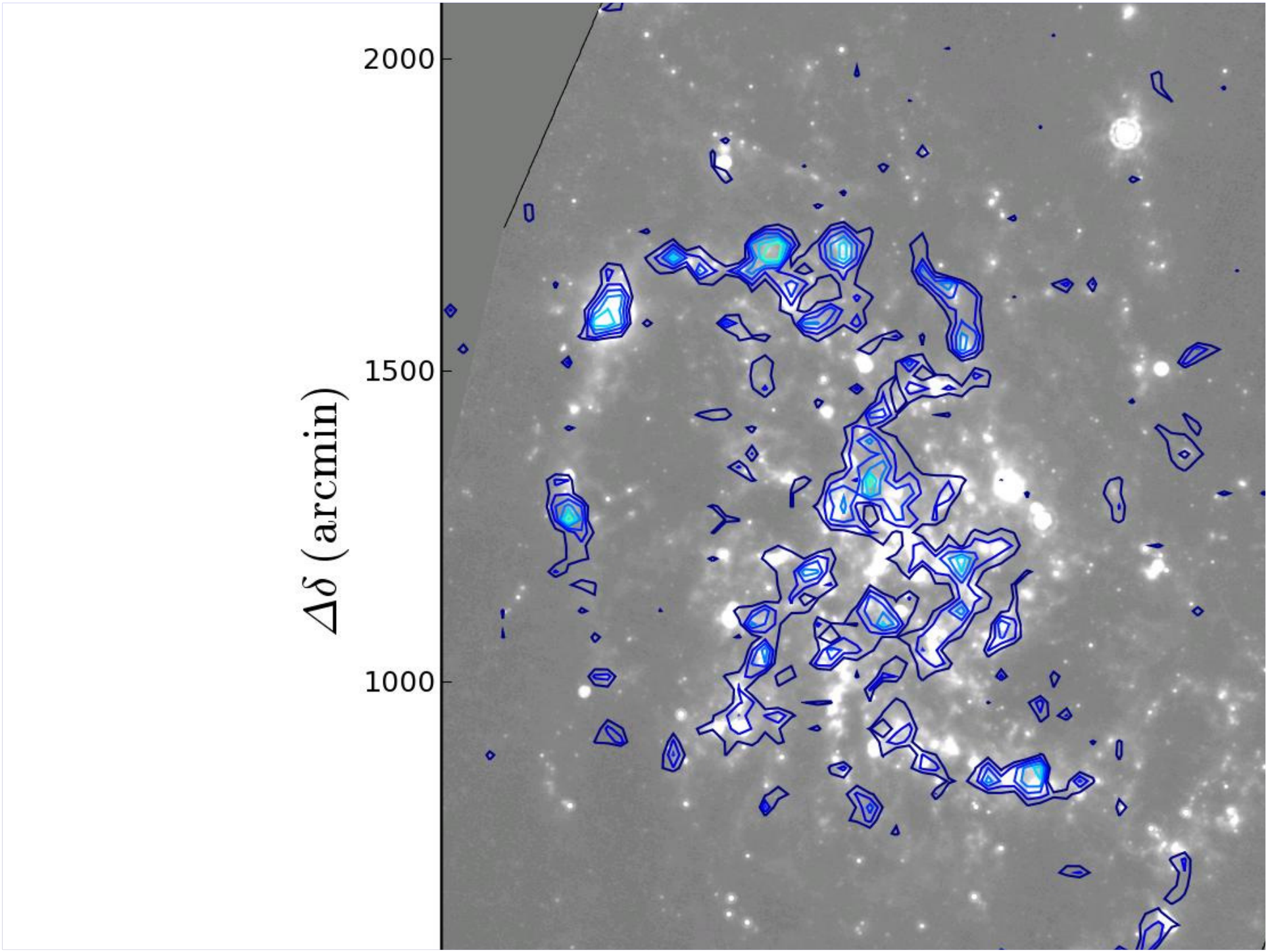


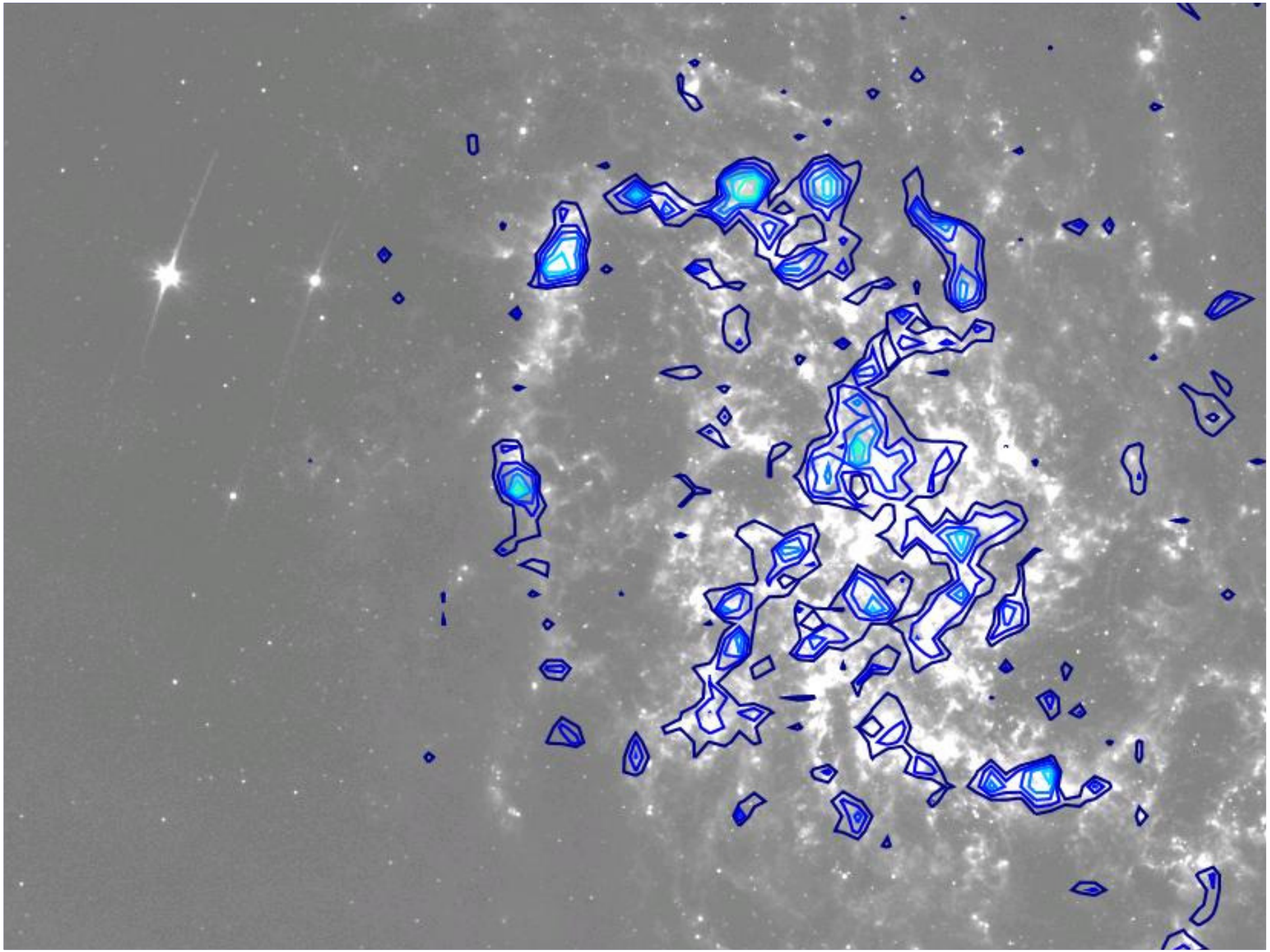

10
0
−10
Δδ (arcmin)
10
0
−10
Δα (arcmin)
FCRAO
CO J=1-0
M=2x10⁸M_sun

M33: the Spitzer view

S.Velrley, L.H.Hunt, E.Corbelli, C.Giovanardi




2000
1500
1000
$\Delta\delta$ (arcmin)



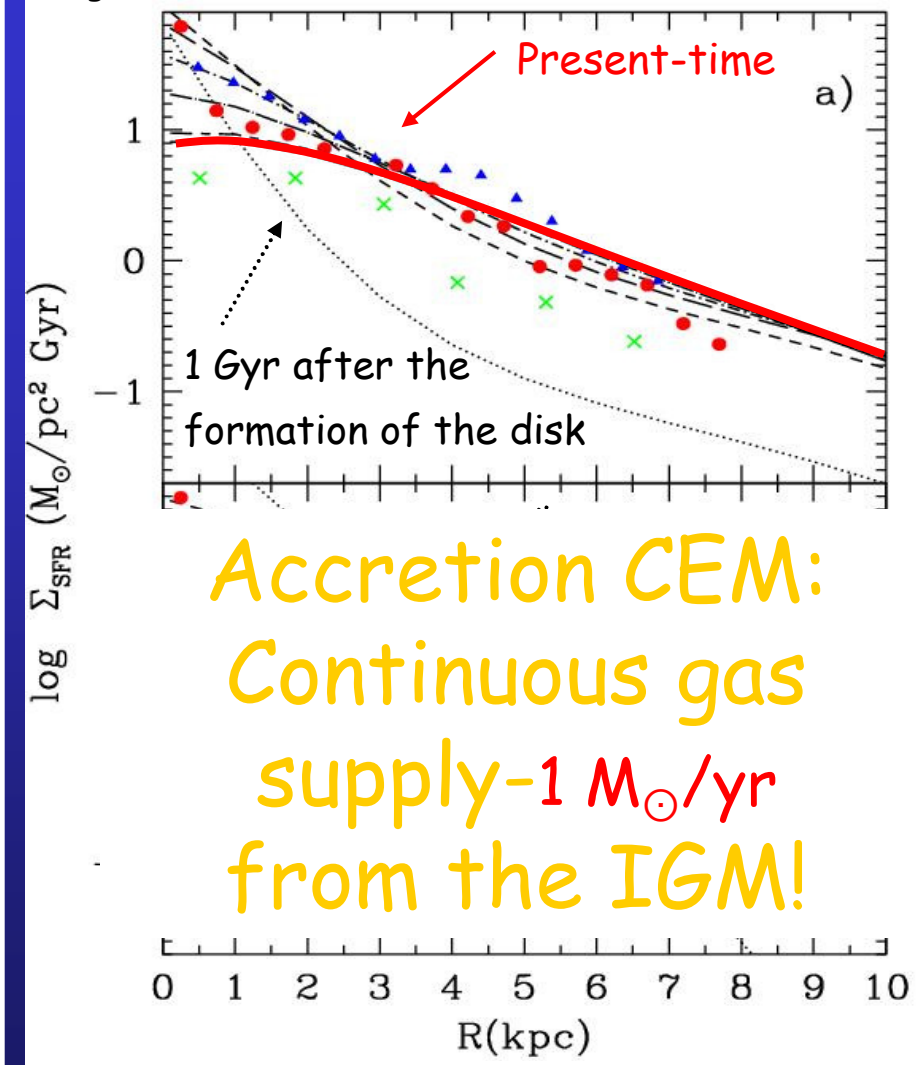
M33 radial distributions

from 0.5 to 6 kpc

- Old stars (3.6μm) : R_s = 1.5 – 2.0 kpc (Verley et al. 2007)
- PAH,Hot Dust (5.8,8.0μm) : R_s = 1.5 kpc (Verley et al. 2007)
- 24μm: R_s = 1.5 kpc, 60% diffuse (Verley et al. 2007)
- FIR: R_s = 1.7 kpc (Devereux et al. 1997)
- Hα: R_s = 1.7 kpc, drops at 6.5 kpc, 40% diffuse (Hoopes & Walterbos 2000)
- H_2 in GMCs: R_s = 1.4 kpc, fade beyond 4 kpc (Engargiola et al. 2003)
- H_2 diffuse: Rs = 2.5 kpc (Corbelli 2003)
- HI+H_2: R_s= 7.5 kpc (Corbelli 2003)
- *O/H* gradient = -0.067 dex kpc^{-1} **(Magrini, Corbelli, Galli 2007)**

The Star Formation Rate

Magrini, Corbelli, Galli 2007



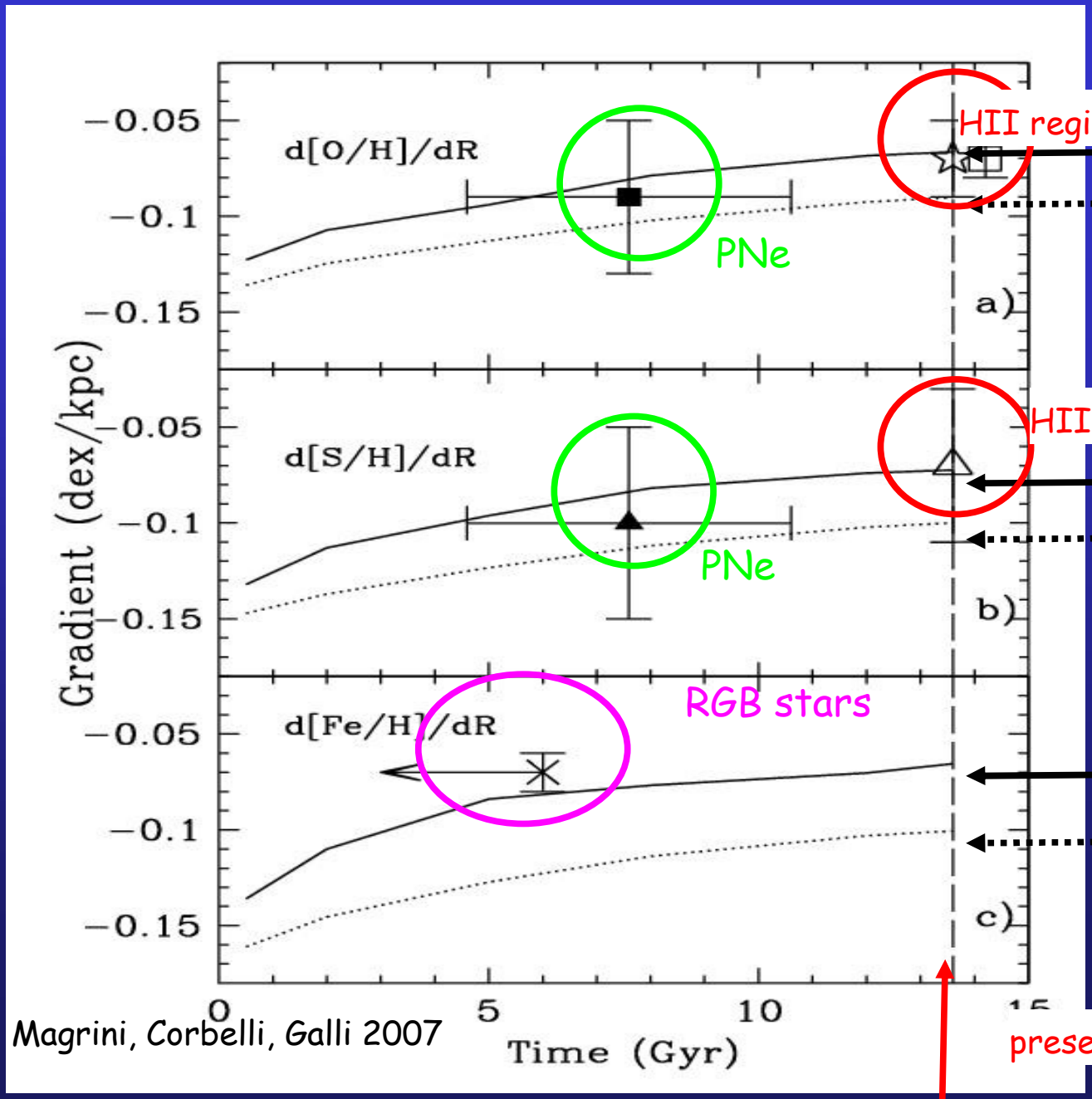
Accretion CEM: Continuous gas supply–1 $M_\odot$/yr from the IGM!

-- The disk of M33 is built by continuous accretion from the external medium, a process sustaining a substantial star formation even at all radii.

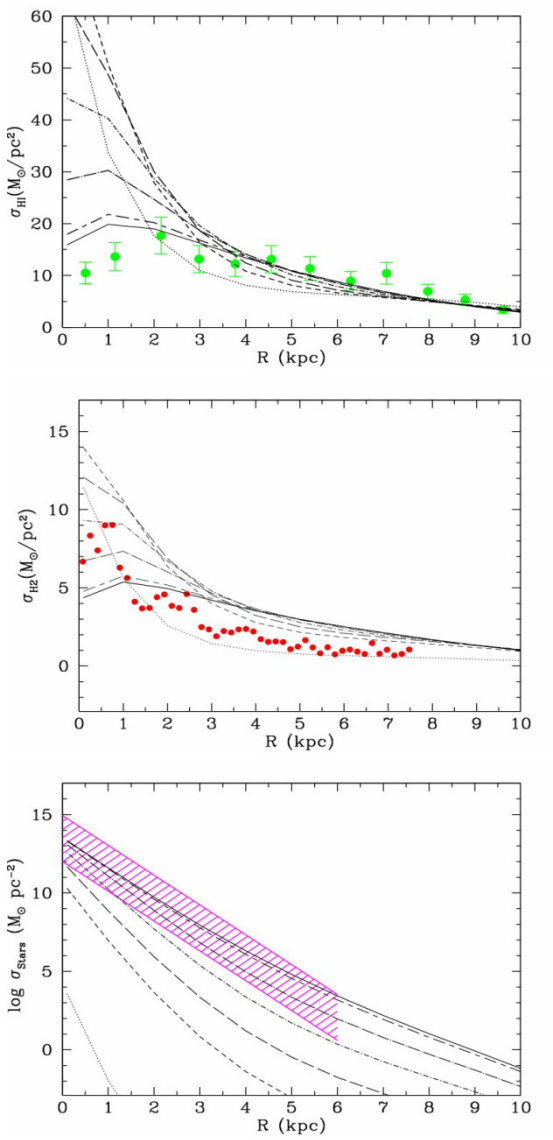
-- The disk is formed inside out. Scalelengths and chemical evolution model results indicate that an outward radial progression of the Star Formation activity in M33: this is due to the strong decrease of the SFR in the inner regions and to its mild increase at larger radii.

SFR: green Kennicutt (1989) from Ha luminosities of bright HII complexes
blue FIR SFR Heyer at al. (2004)
red from Ha images by Hoopes & Walterbos (2000)

Metallicity gradients are flatter than previously determined



The radial distribution of gas and stars



Enhanced formation of molecular clouds due to a small bar fueling gas towards the center.

Lower molecular abundance in outer regions
Cloud-collision destruction mechanism not effective.

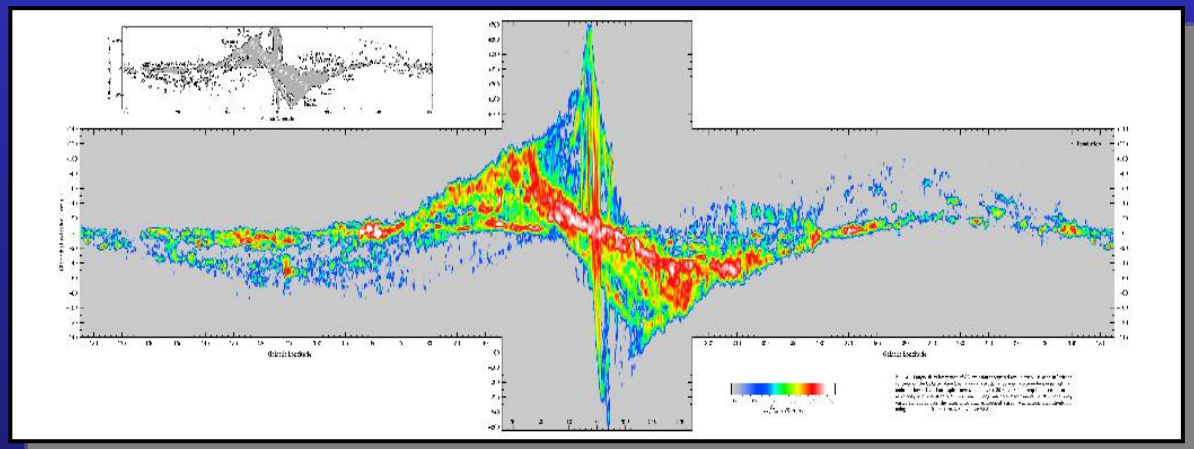
Observational data by Corbelli (2003), model by Magrini, Corbelli, Galli (2007)

- How is the Molecular Gas distributed in galaxies of different Hubble type?
- What regulates the H-H_2 conversion and the MCs survival in M33?
- Are SF sites embedded in MCs different characteristics than non embedded ones? Do their size and colors vary with galactocentric distance?

Integrated SFR over the M33 disk from 24 and 8μm Maps agrees with that from Hα. Extinction is low.

How is the Molecular Gas distributed in galaxies of different Hubble type?

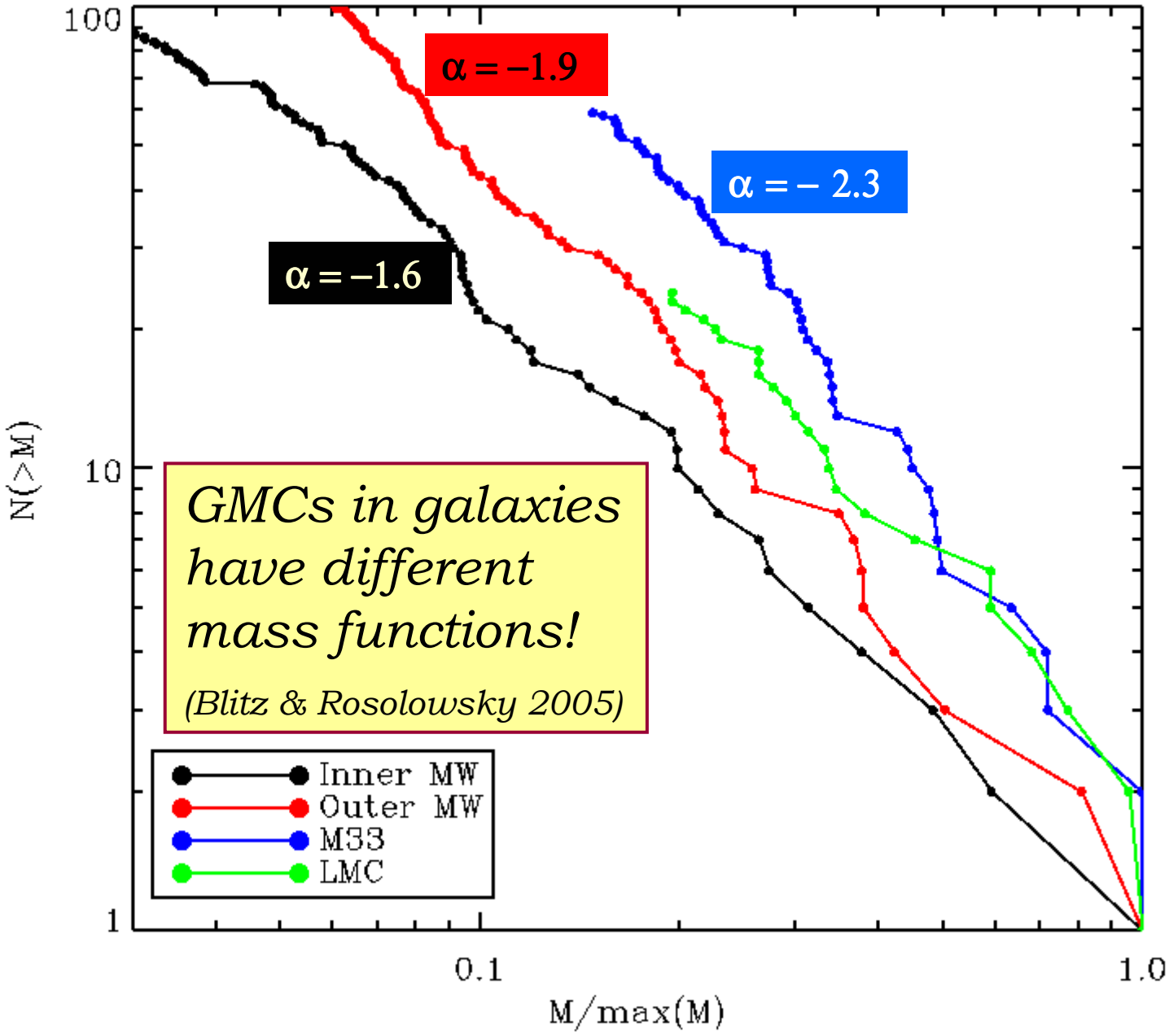
Mass Function of GMCs in the Milky Way



There is therefore no characteristic mass with which GMCs from.

Most of the mass is in the most massive clouds.

$$dN(M)/dM \sim M^{-1.6}$$


100
10
1
N(>M)
0.1
1.0
M/max(M)
α = –1.9
α = – 2.3
α = –1.6
GMCs in galaxies have different mass functions!
(Blitz & Rosolowsky 2005)
Inner MW
Outer MW
M33
LMC

The surface density of all self-gravitating GMCs in the Local Group is roughly constant.

$$V = \text{const}\ R^{1/2}$$

$$M = RV^2/G$$

$$M/R^2 = \text{const}$$

Regardless what the environment or metallicity is!

(Blitz & Rosolowsky 2005)

What determines the H-H_2 conversion in M33?

- Disk pressure – Radiation field

$$f_{mol} \propto P^{2.2}$$

(Heyer,Corbelli,Schneider & Young 2004; Theoretically predicted by Elmegreen 1993 for low molecular fractions)

- Fragmentation of HI filaments: GMCs masses

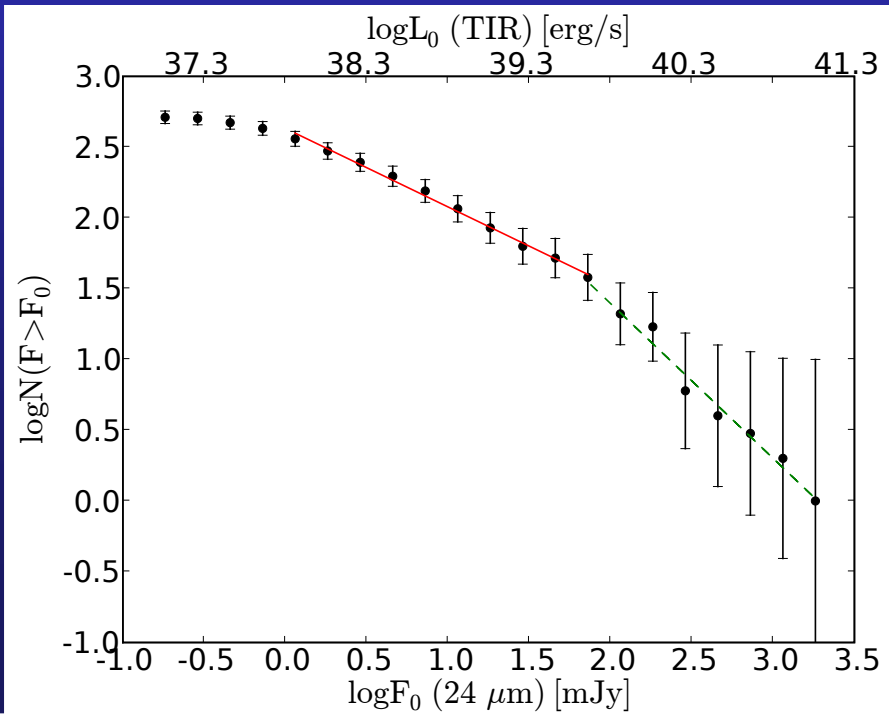
Why is there an unexpected radial threshold ??? Likely the decrease in P or rotation curve flattening prevents the formation of large fragments or keeps them atomic (Stellar disk surface density < gas surface density) .

SF continues further out.....
Small scale P enhancements make smaller MCs easily destroyed by the newly born stars ?
(On going searches).

IR properties of SF sites in M33

(Work in progress with S.Verley, L.K. Hunt, C. Giovanardi)

- 500 sources extracted from 24μm Spitzer map of M33
- Most of them have 8μm counterpart
- Half of them have Hα counterpart
- Here is their luminosity function:



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ERROR: invalidrestore
OFFENDING COMMAND: restore

STACK:

-savelevel-
-savelevel-
```