Schmidt Laws at low densities from GALEX UV data and their interpretation

Samuel Boissier

LAM, Marseille - CNRS

Boselli, Buat, Burgarella (Marseille),
Gil de Paz, Muñoz Mateos (Madrid),
Prantzos (Paris), Cortese (Cardiff),
Madore (Pasadena), Thilker (Baltimore).

Outline

1) **Schmidt lawS** (Local, Azimuthal, Global)
2) Observational constraints on star formation
   in **low density regions**

1-Schmidt Laws

We use **several Schmidt Laws** $\Sigma sfr = a\ \Sigma gas^N$

Global (averaged) Schmidt Law
(e.g. Kennicutt 1998)

Azimuthal (radial) Schmidt Law
(e.g. Martin & Kennicutt 2001)

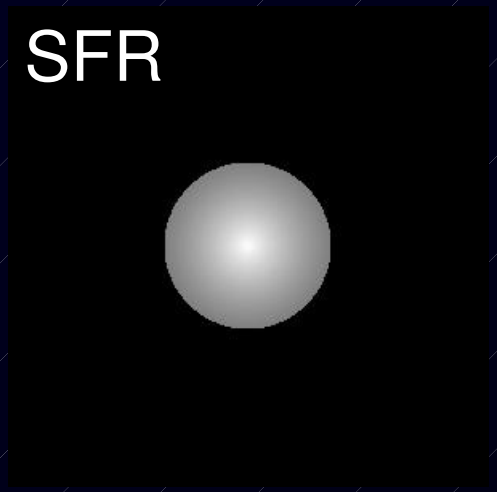
Local Schmidt Law
(e.g. Bigiel et al. 2009)

We can try to relate them with simple toy models...

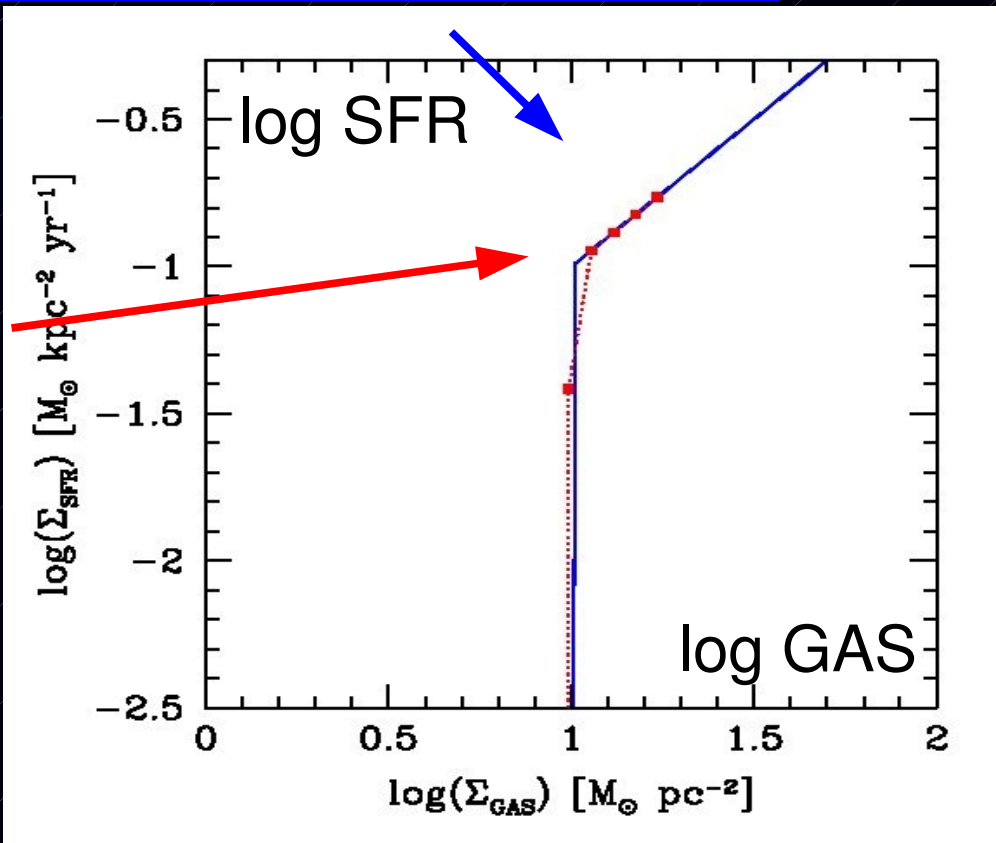
1-Schmidt Laws (toy model #1)

Toy-model #1:
- Exponential Gas Disk

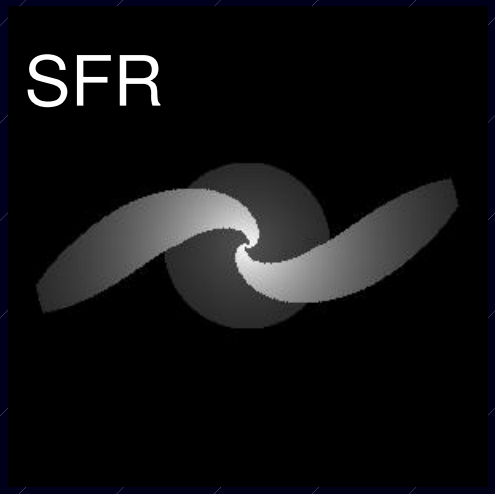
- Assuming a ***local*** star formation law:
  SFR = a x GAS
  Local Threshold (10 Msol / pc2)



Computing the ***azimuthal*** relationship

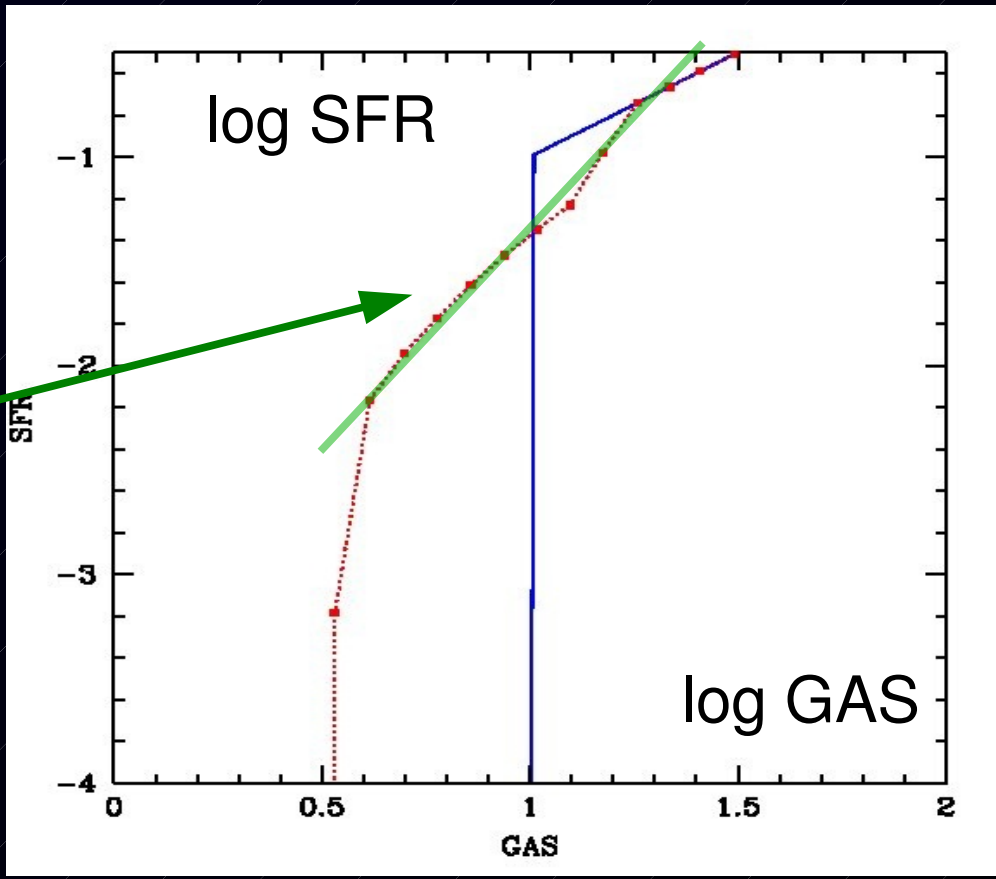


1-Schmidt Laws (toy model #1)

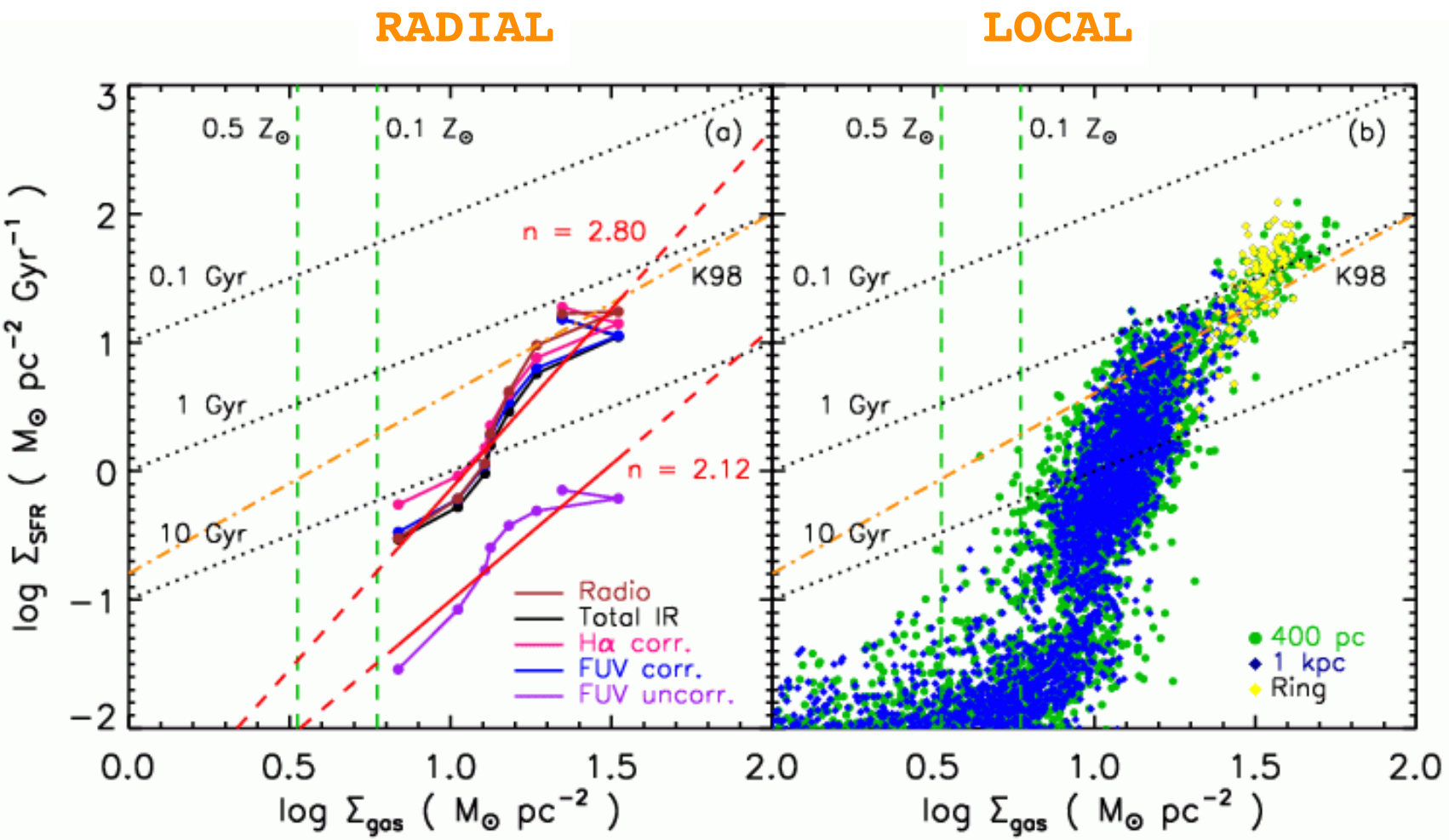


- Double arm spiral system, over-density=3, decreasing covering fraction with R

The azimuthal law present a break at much larger radius and a steeper slope



1-Schmidt Laws (toy model #1)



Comparison to the **observations** of Thilker et al. 2007:

- azimuthally averaged law steeper than local one
- Local “Threshold” invisible in the azimuthally averaged law

1-Schmidt Laws (toy model #2)

Toy-model #2:

- Gaseous disk

Inner disk : $\Sigma = \Sigma 0 \exp(-R/Rco)$; $Rco \sim R^* \sim R25/4.6$

Outer disk : $\Sigma = 3$ Msol / pc2

(profiles similar to those in Bigiel et al. 2008; Leroy et al. 2008)

Local assumptions:

- 2 phases : H2 and HI

GAS < 10 Msol / pc2 : H2=0

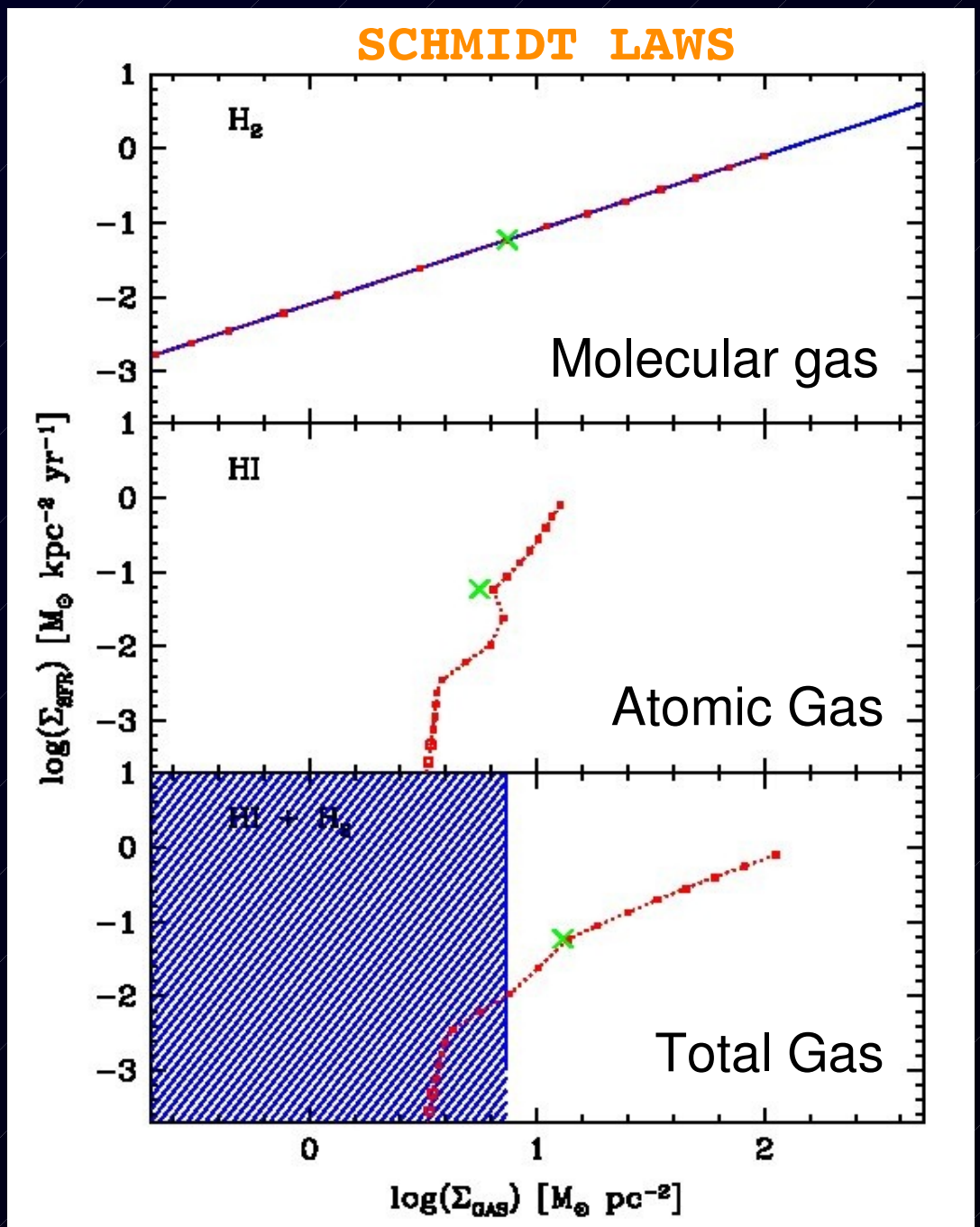
GAS > 10 Msol / pc2 : H2 / HI =Rmol

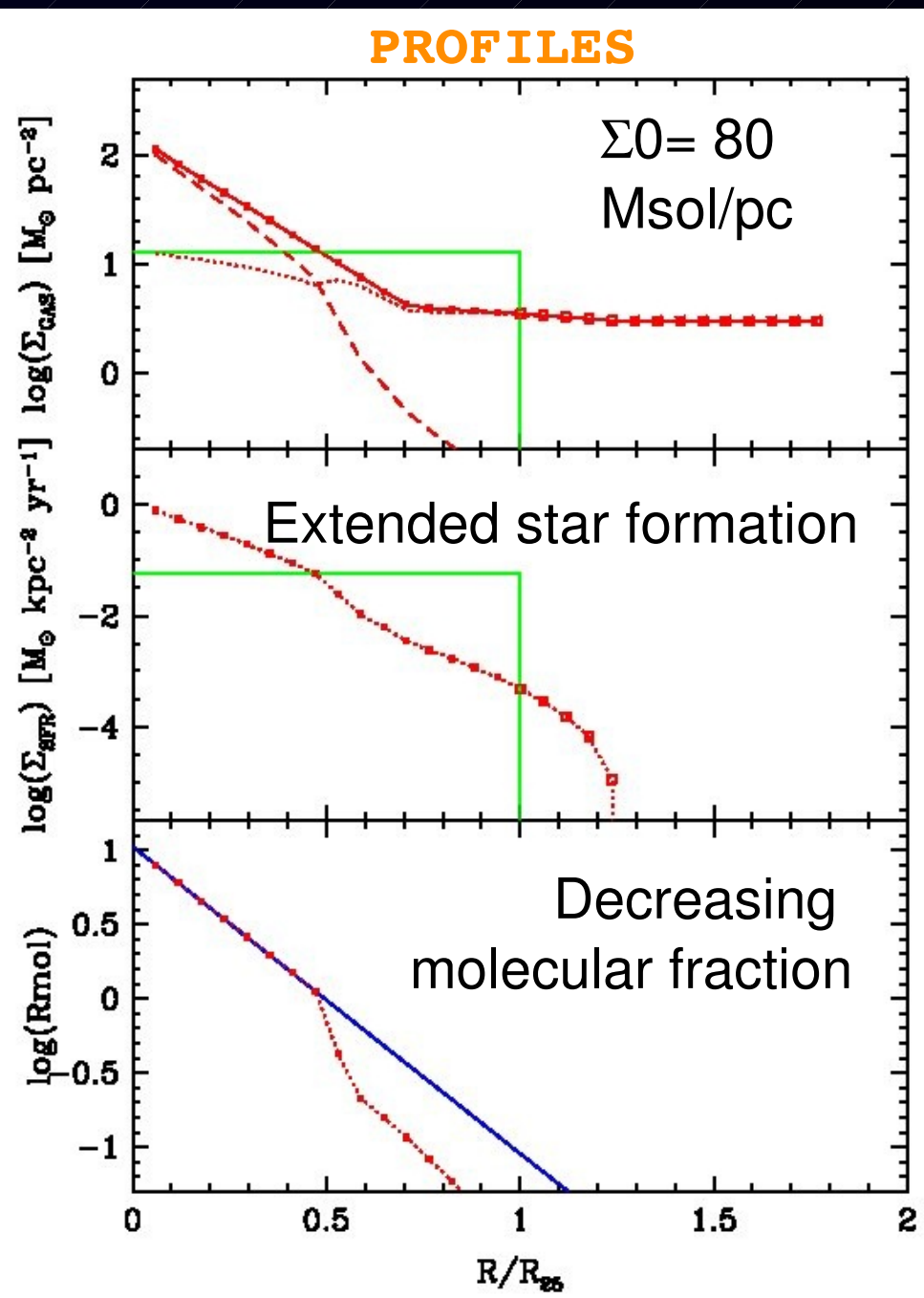
Rmol=10.6 exp (-R / 0.21 R25)

(e.g. Leroy et al. 2008)

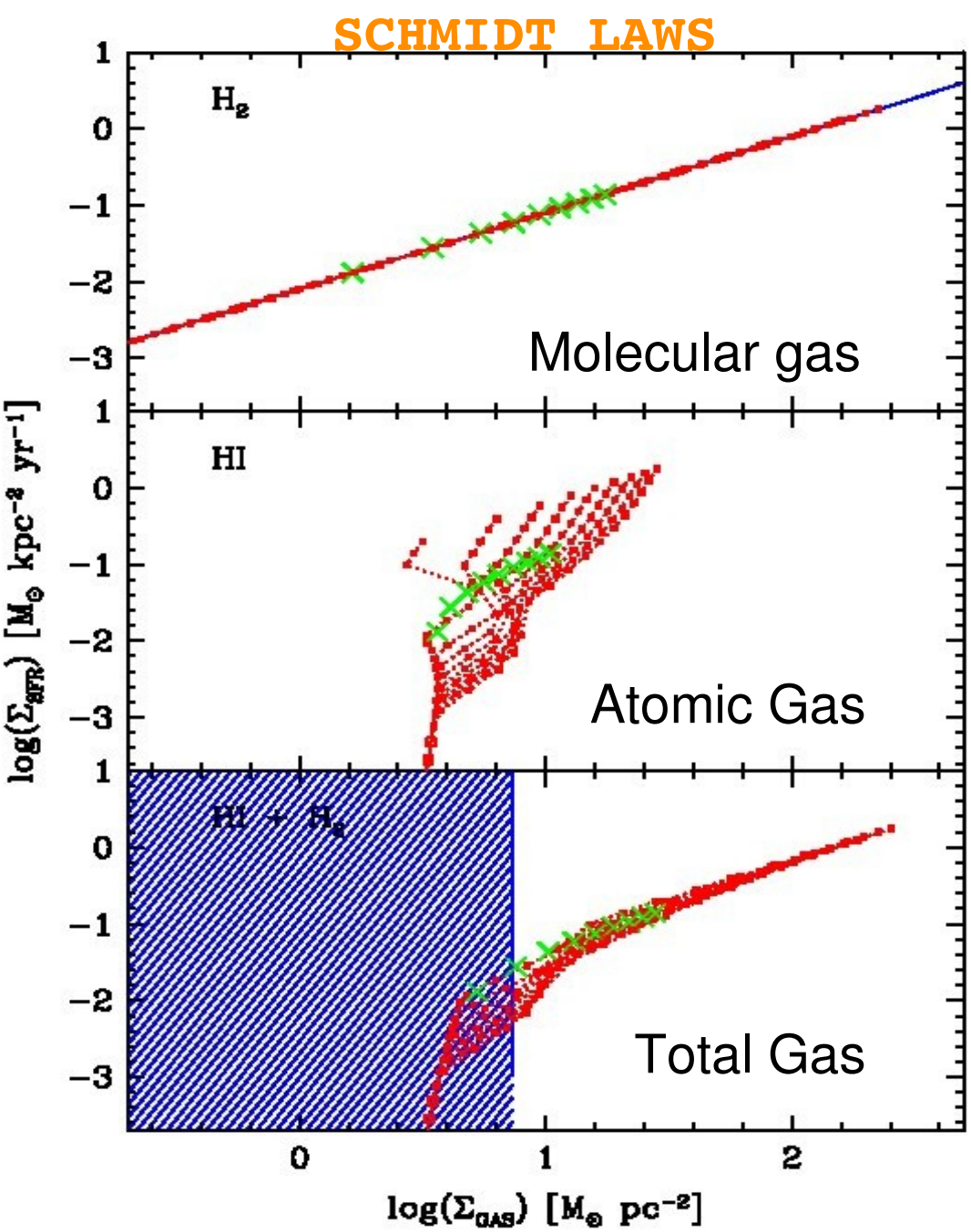
- SFR α H2 (Leroy et al., Bigiel et al.)

1-Schmidt Laws (toy model #2)





1-Schmidt Laws (toy model #2)



Σ0= 20 to 200 Msol/pc2

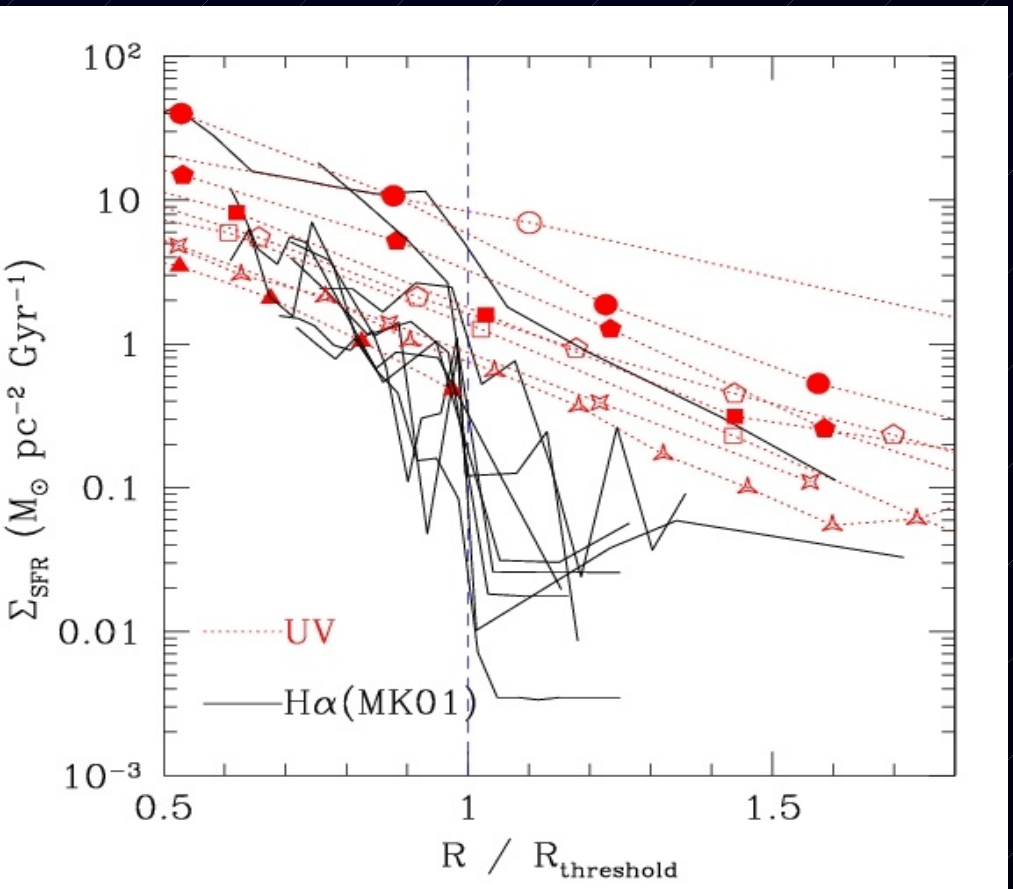
H2:Azimuthal & Global = Local

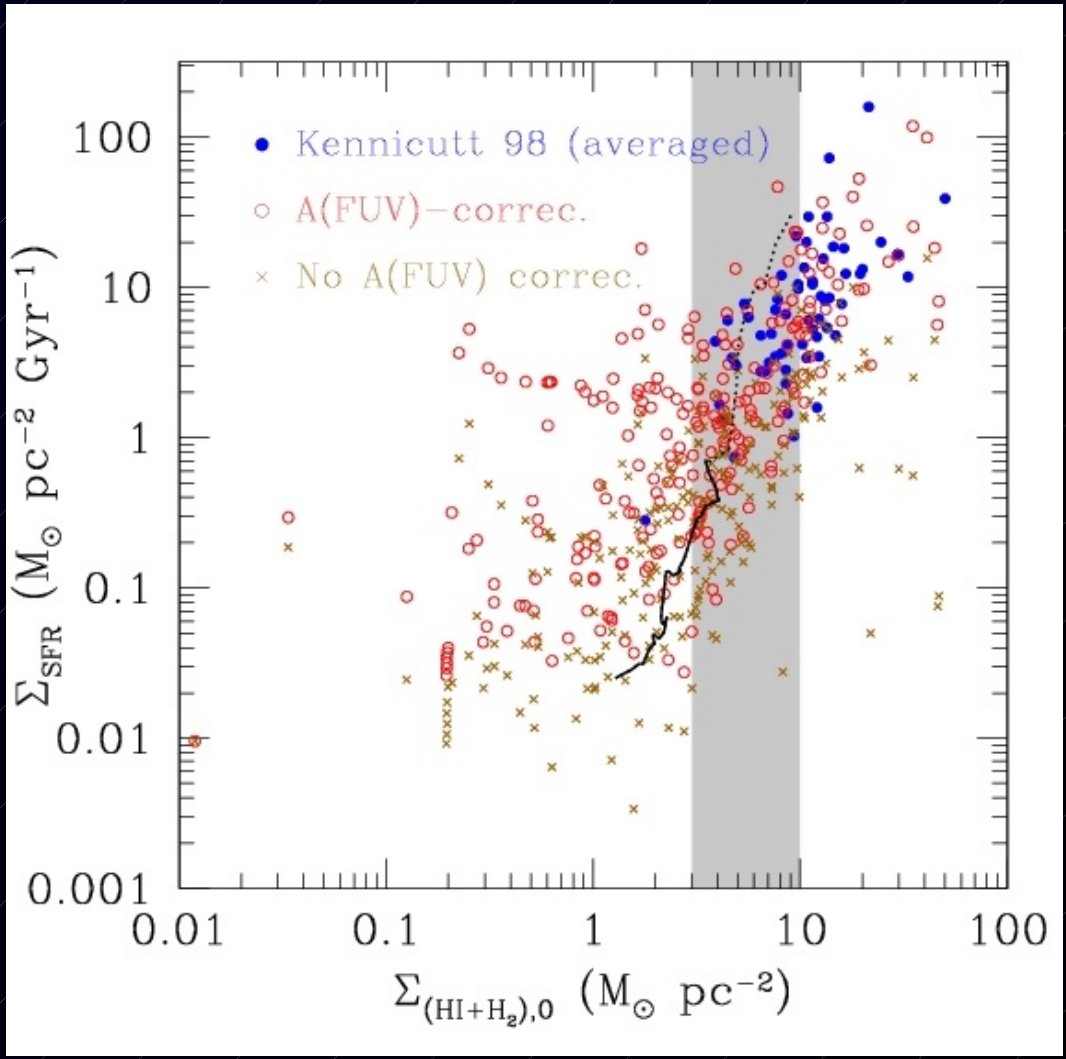
HI: Azimuthal = dispersed
Global = relationship,
steeper than H2

HI+H2:
Global nice relationship,
Azimuthal = dispersed
at low density, below the
local threshold...

2-Low densities (outer disks)

GALEX **UV** observations allowed to extend the Schmidt law at low densities (below the "Hα threshold")



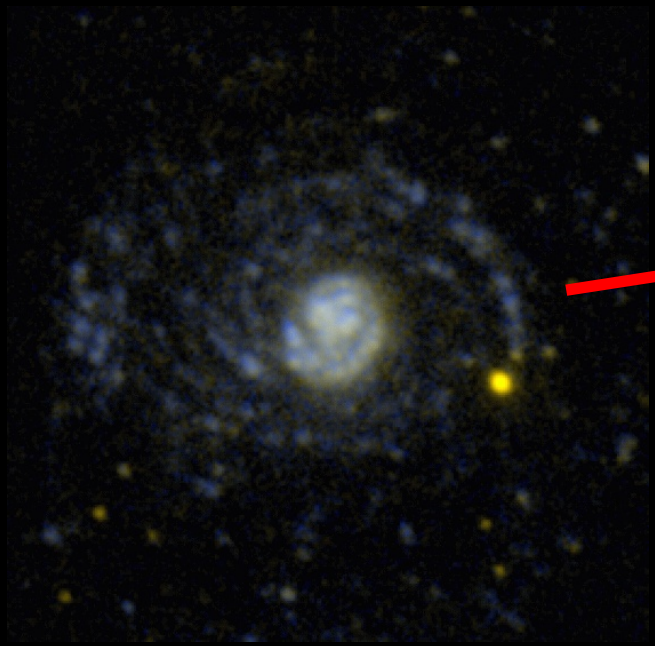


Boissier et al. 2007

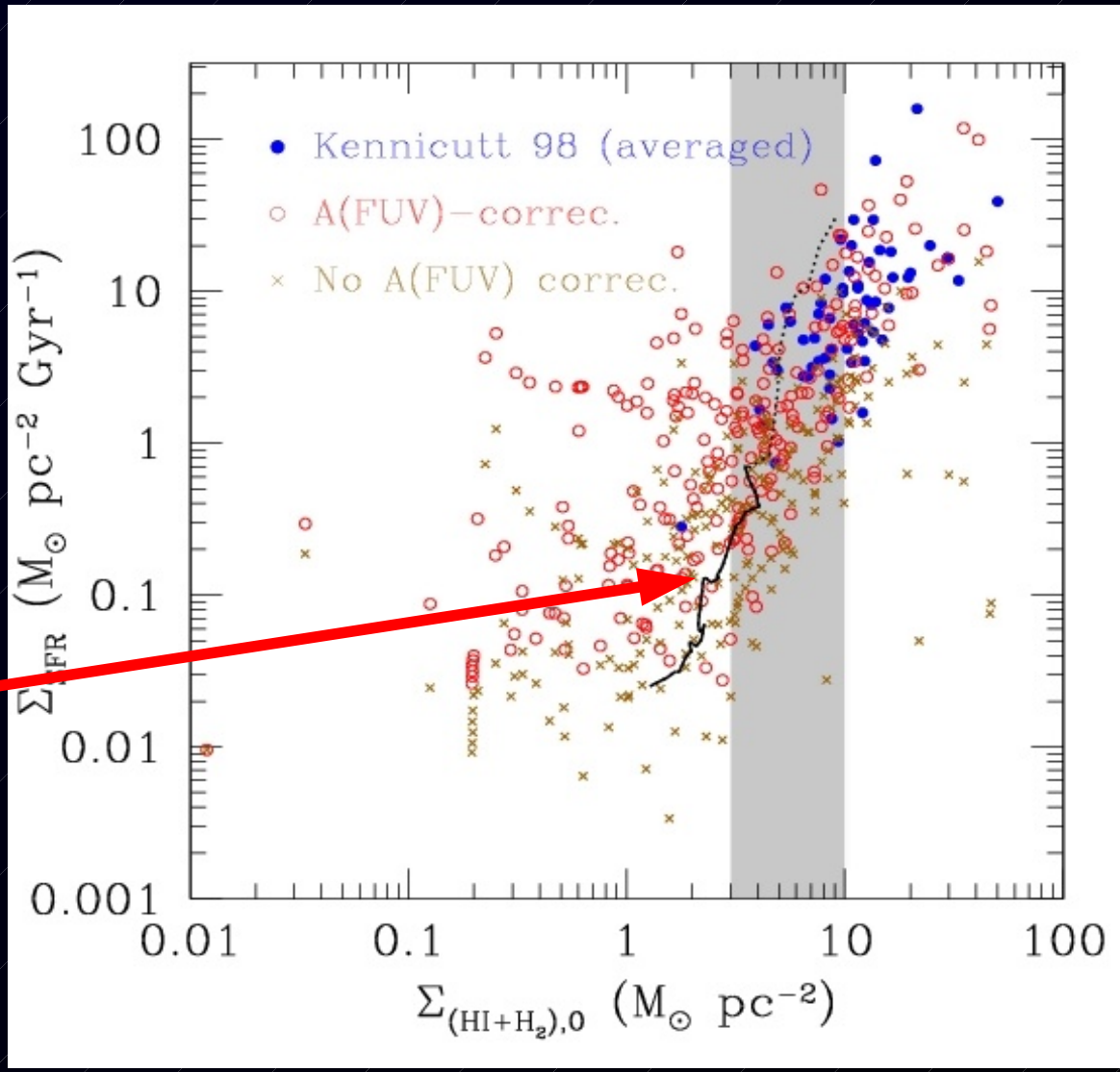
2-Low densities (XUV galaxies)

XUV galaxies
(e.g. Thilker et al. 2005, 2007):
N4625 seems to follow a Schmidt law ...

NGC4625



HI + UV profiles in
Gil de Paz et al. 2005



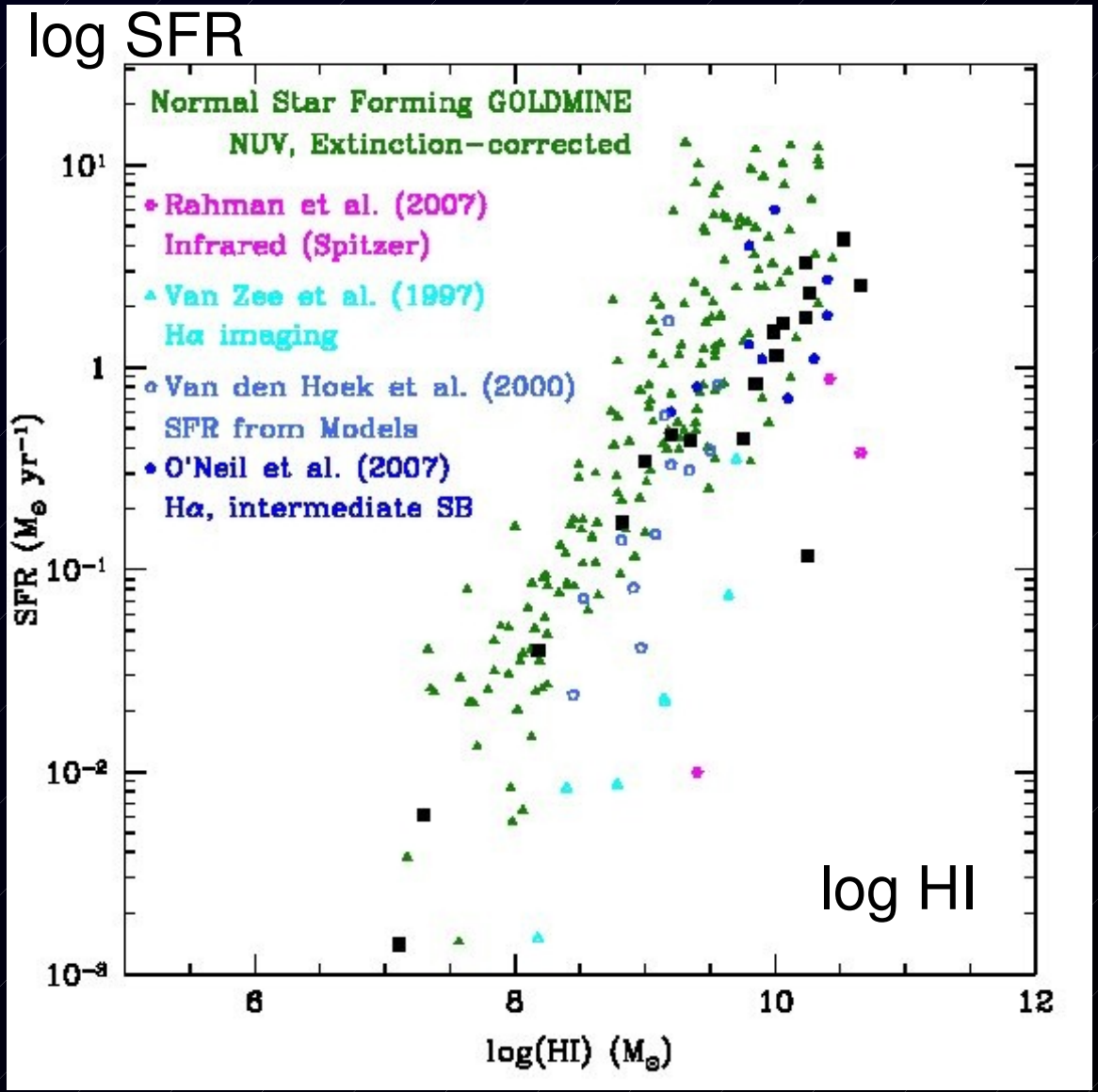
Boissier et al. 2007

2-Low densities (LSB galaxies)

Study of a sample of massive **L**ow **S**urface **B**rightness galaxies

- Lower star formation efficiency than normal spirals ***if UV taken as direct indicator of SFR with standard calibrations***

Wyder et al. (2009) also suggests a lower SF efficiency in his dwarfs/LSBs



Boissier et al. 2008

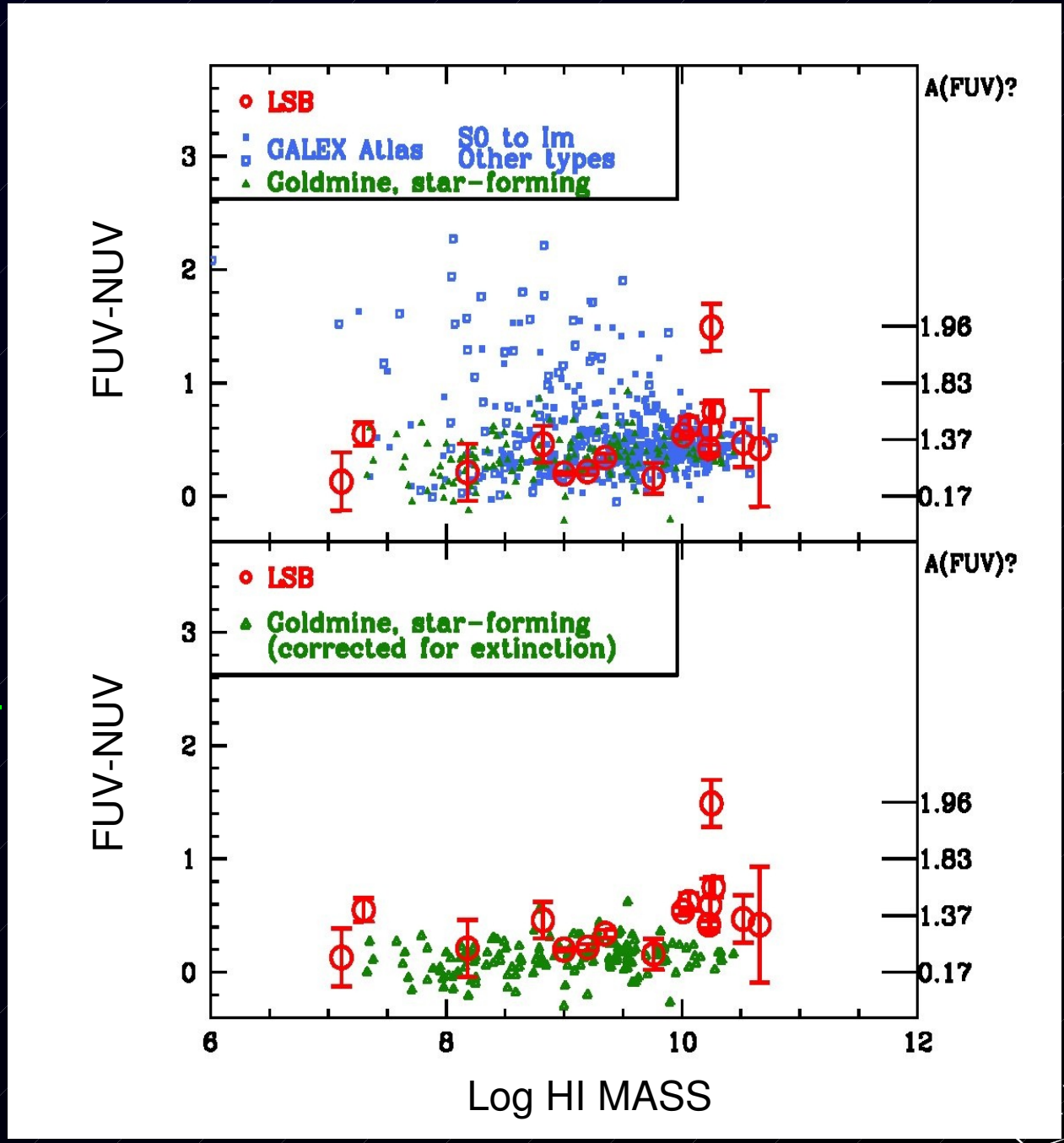
2-Low densities (LSB galaxies)

Some **LSB** galaxies have red FUV-NUV colors

Compared to OBSERVED spirals

Compared to EXTINCTION-CORRECTED spirals

(Boissier et al. 2008, updated with GR4 data release.)

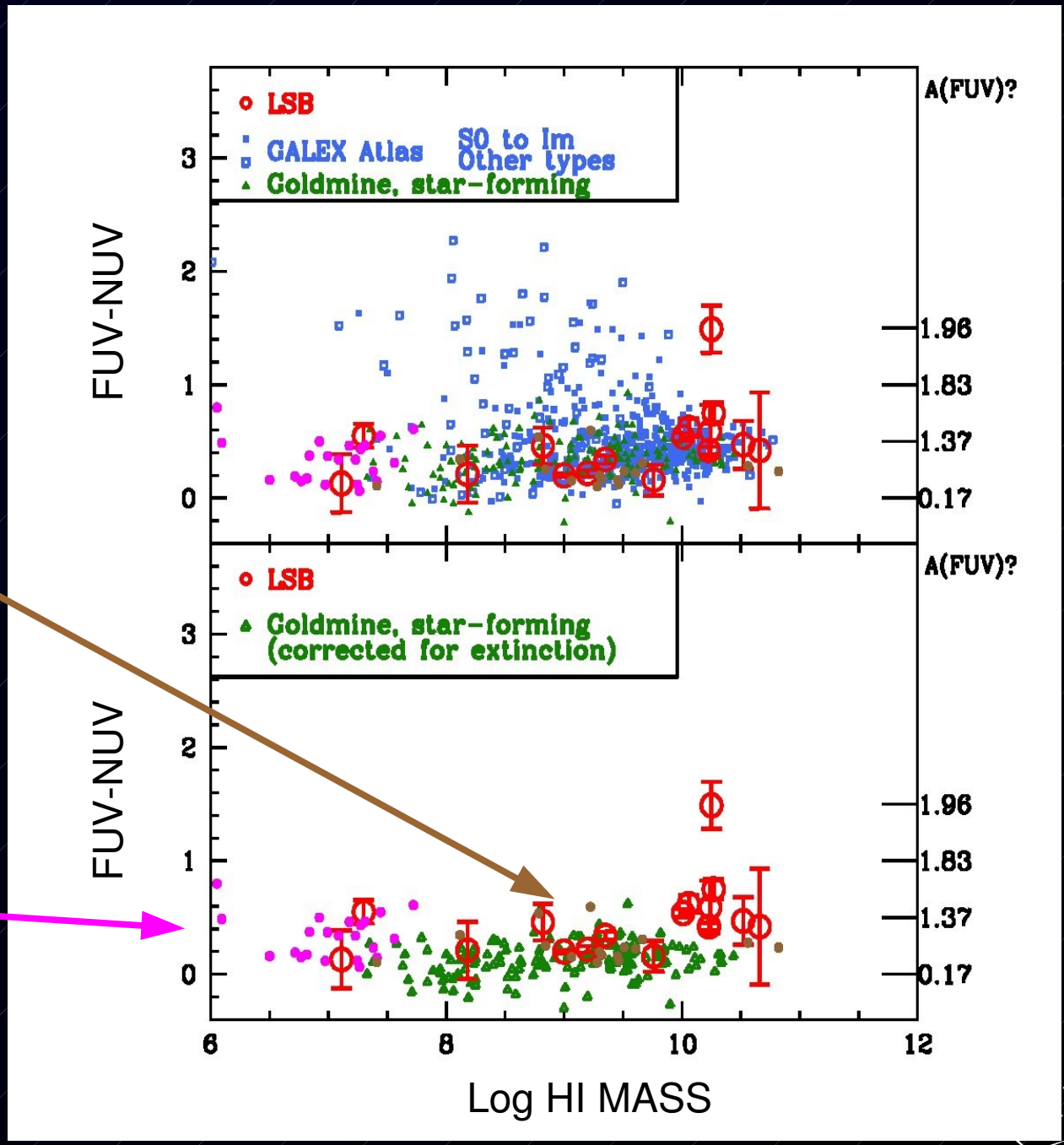


2-Low densities (LSB galaxies)

Comparison to other studies:

Wyder et al. (2009) : not really red

Roychowdhury et al. (2009): kind of red



2-Low densities (LSB galaxies)

How to explain red FUV-NUV colors ?

- Extinction ?
  Spitzer observations of a few LSB galaxies
  show no dust (Rahman et al. 2008, Hintz et al. 2008)

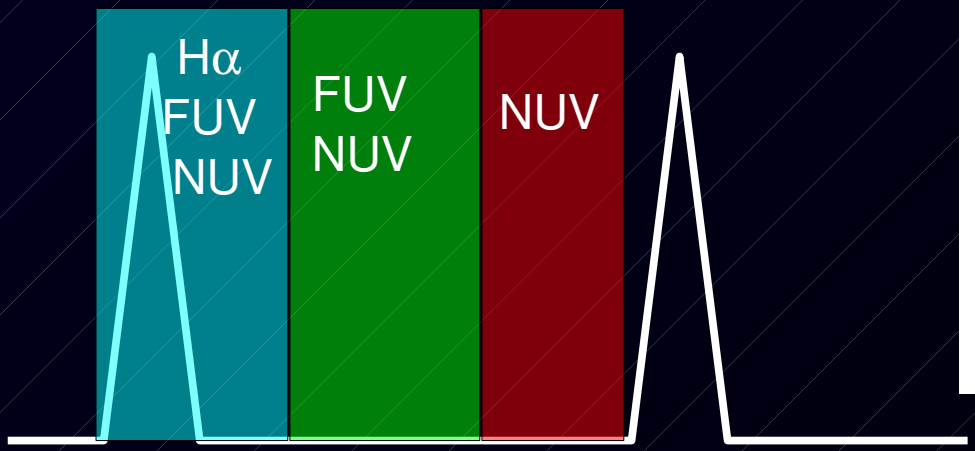
- Initial Mass Function ?
  Pflamm-Altenburg, Kroupa et al. suggest SFR-dependent
  Krumholz & McKee (2008) suggest Density-dependent
  (but we have red colors for the largest SFR)

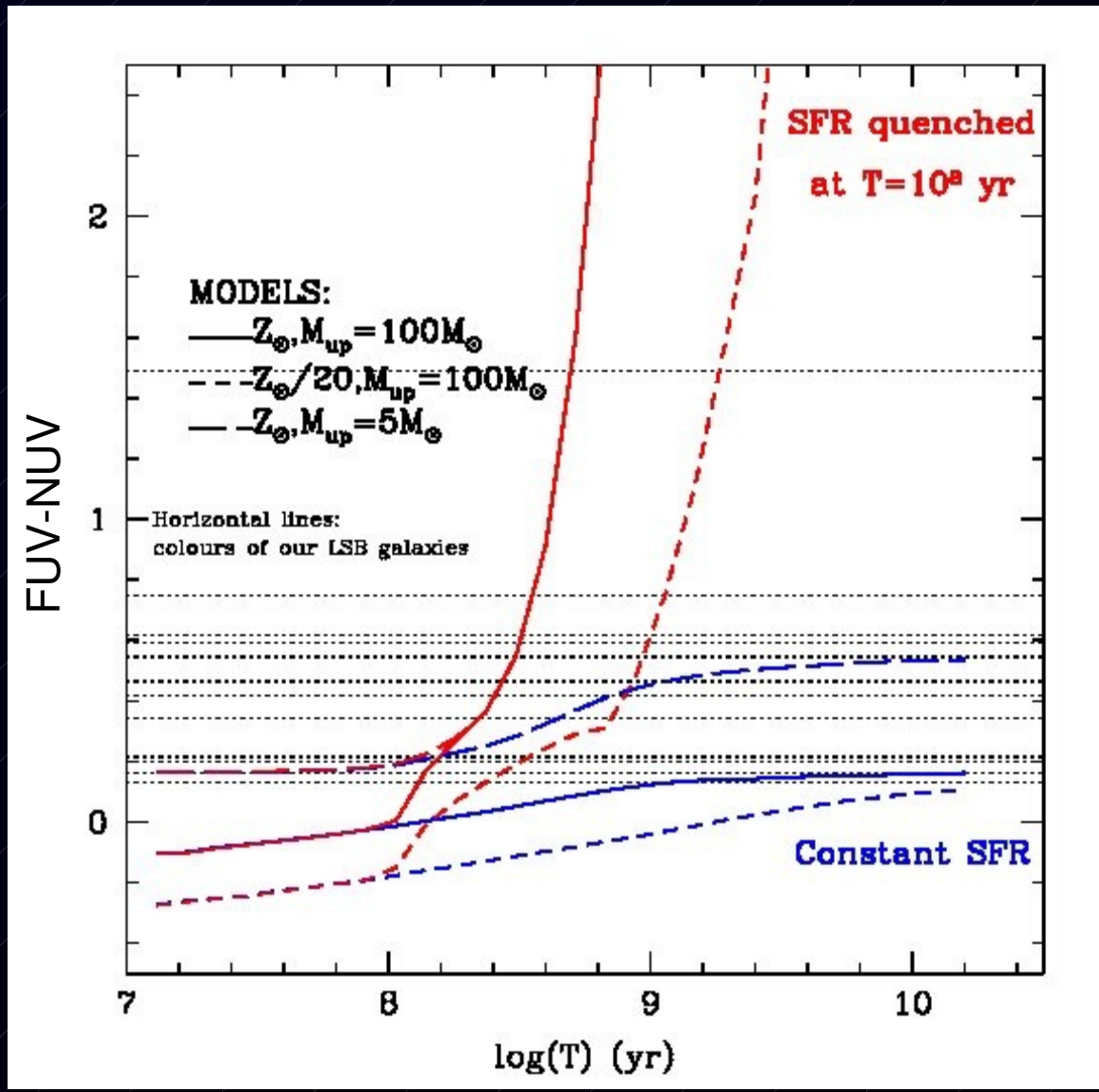
- **Aging burst**

2-Low densities (LSB galaxies)

The red FUV-NUV color can be explained with a time effect :

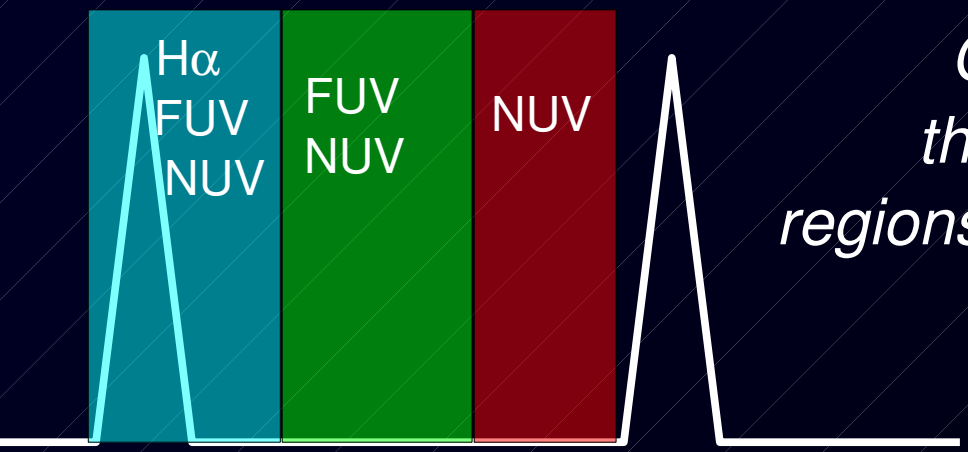
Bursty star formation histories, with latest burst within a few 100 Myr.





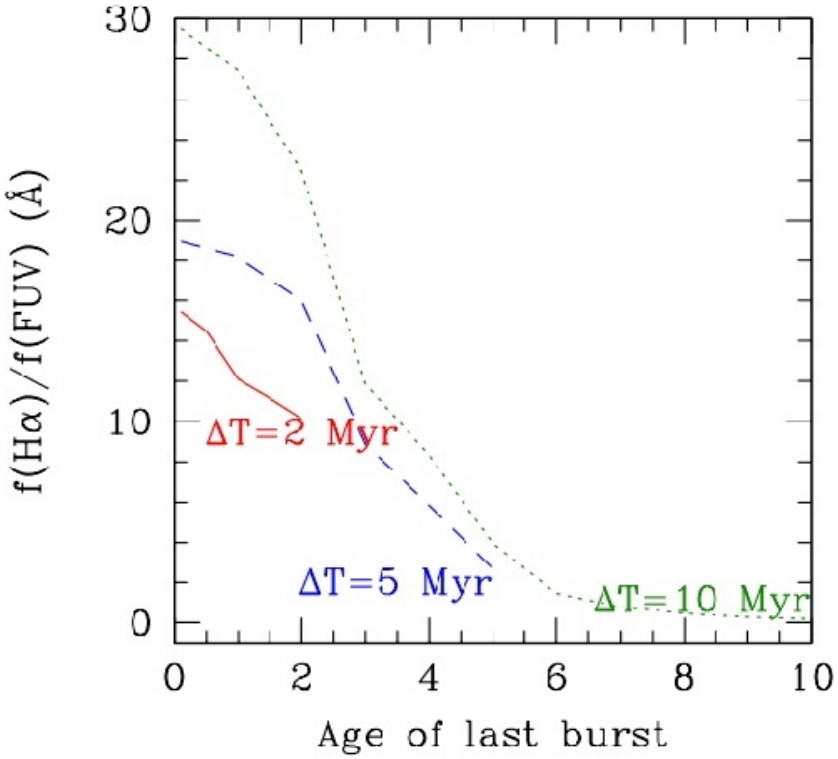
Boissier et al. 2008, updated with GR4 data

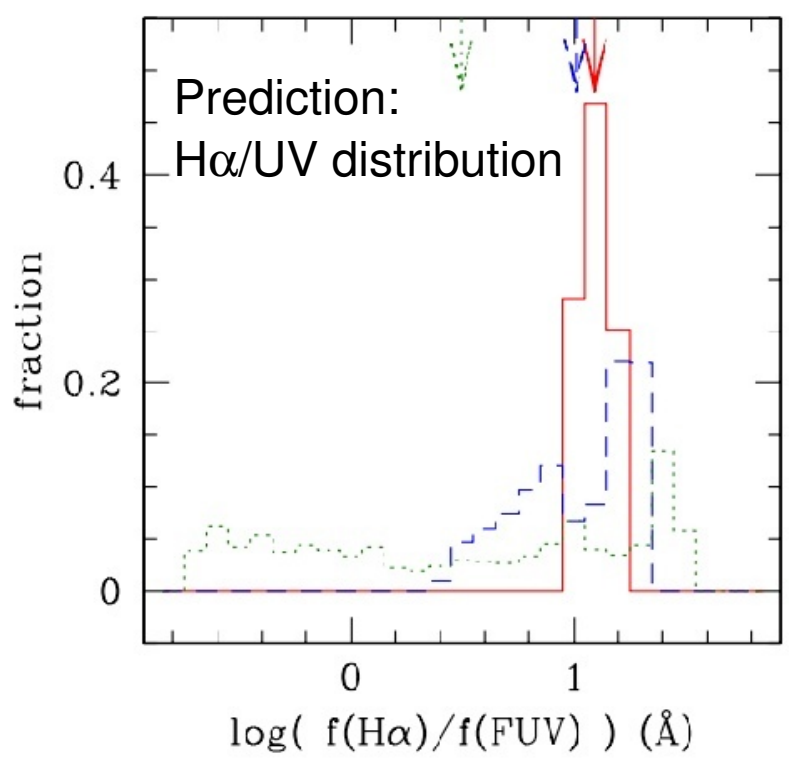
2-Low densities (Bursty SFR histories)



Could a similar time effect also explain the Hα vs UV discrepancy in low density regions/dwarfs ? (Boselli et al. in preparation)

Assuming SFRH of bursts each ΔT



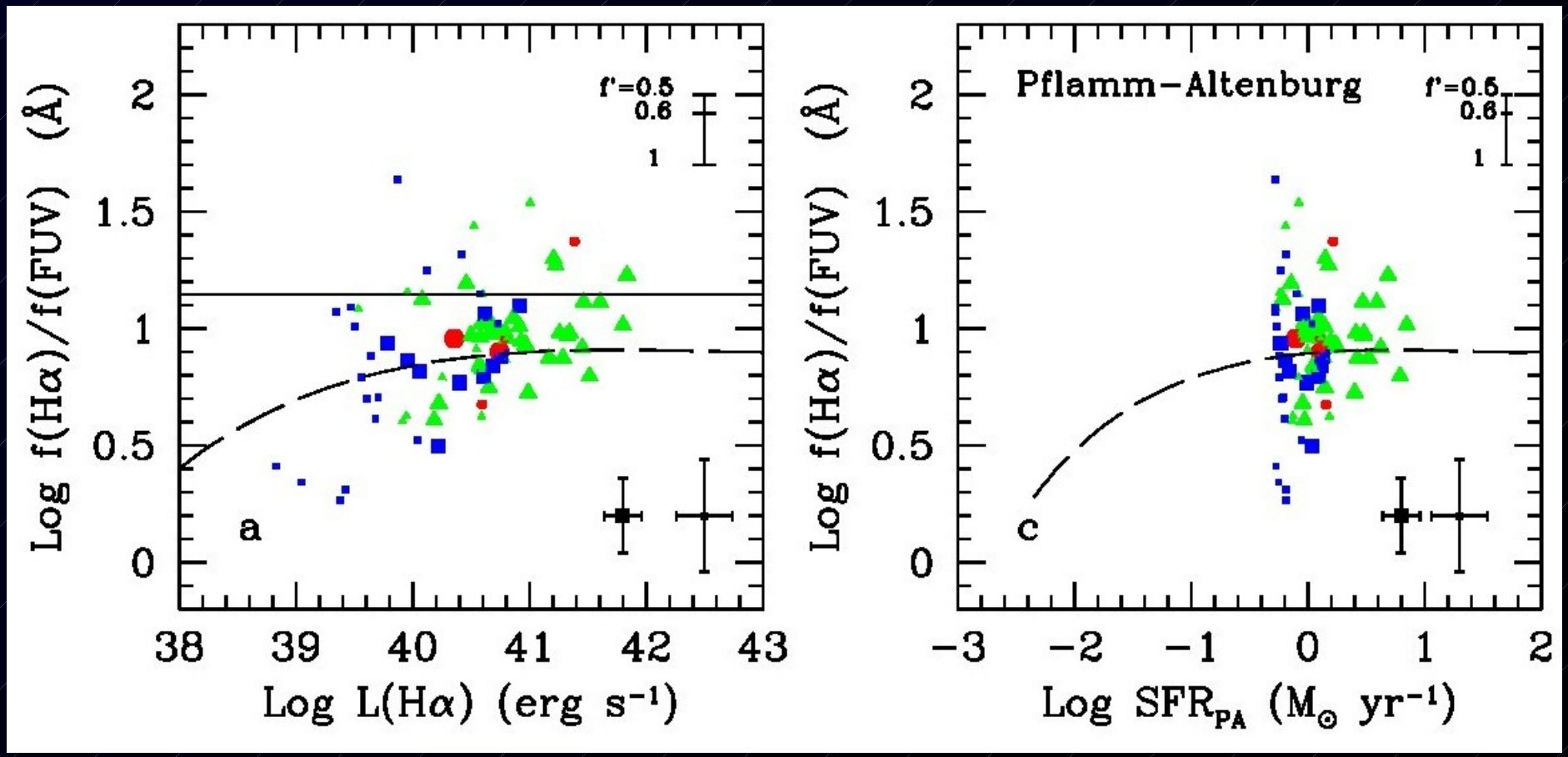


2-Low densities (Bursty SFR histories)

A **temporal effect** could explain:

- Large dispersion of Hα/UV
- Small trend from dwarfs (bursty) to spirals (continuous SF)
  (see also Fioc & Rocca-Volmerange, 1999)

What about the IMF ? (Pflamm-Altenburg, Kroupa et al.) ?

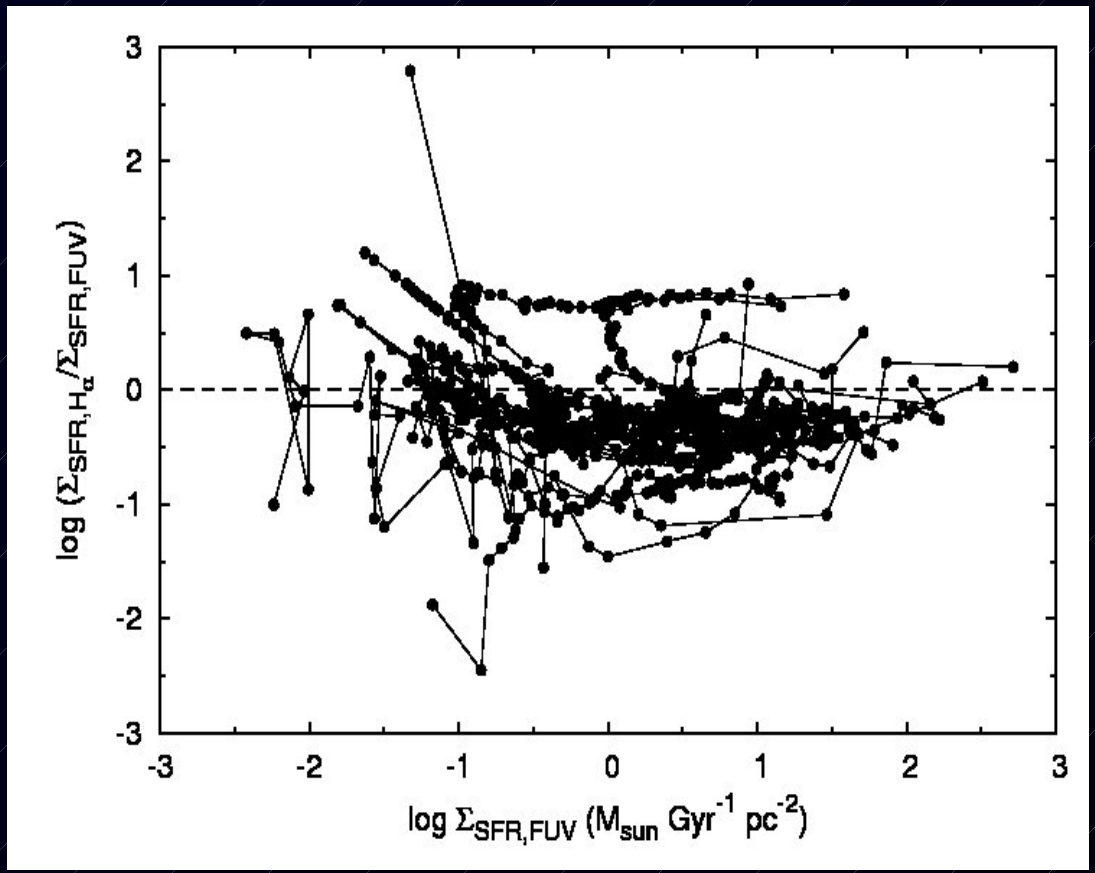


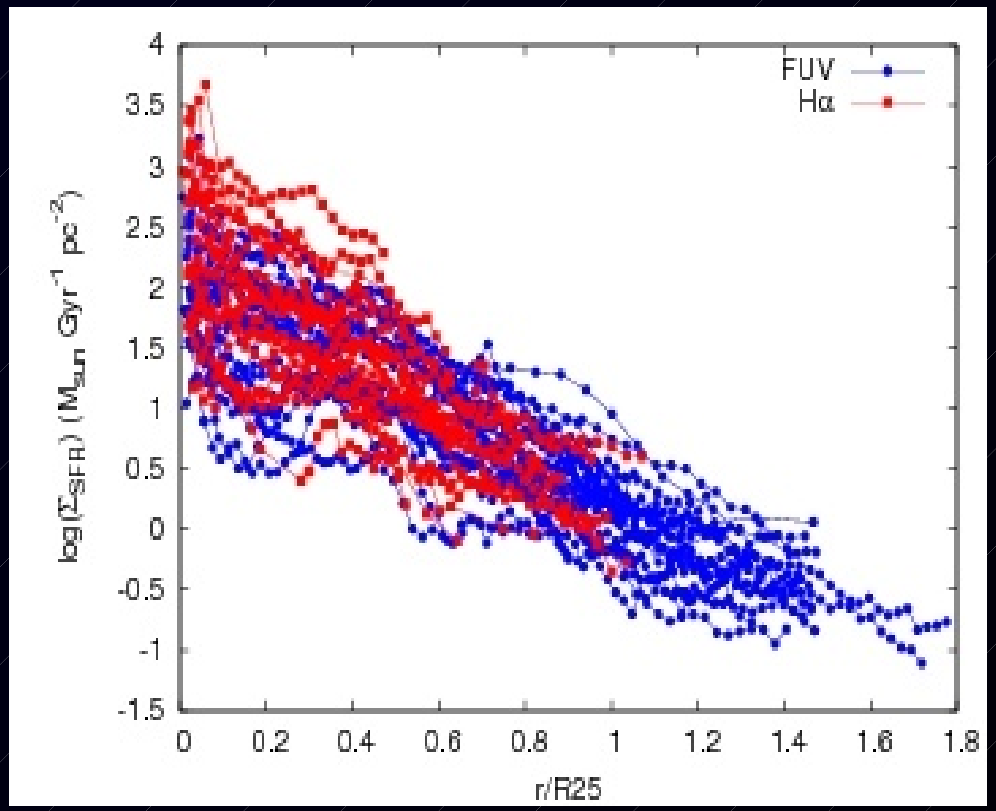
Boselli et al., in prep.

2-Low densities: coming next

Radial profiles:

UV and Hα in the **SINGS** sample





(Juan Carlos Muños Mateos thesis with Armando Gil de Paz)

2 – Summary

- Toy models allows to relate global and azimuthal Schmidt law to local ones; azimuthal laws may include some large scale SF trigger effect (e.g. spirals arms)

- Observations in low density regions/dwarfs suggest:
  - variable IMF ?
  - *bursty star formation histories* ?

We must **be careful** in the interpretation of “SFR” derived in low mass/ low density systems