



International
Centre for
Radio
Astronomy
Research

Constant-Q disk stabilities result in uniform SFE

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The Changing Face of Galaxies, 22nd September 2016



Curtin University



THE UNIVERSITY OF
WESTERN AUSTRALIA



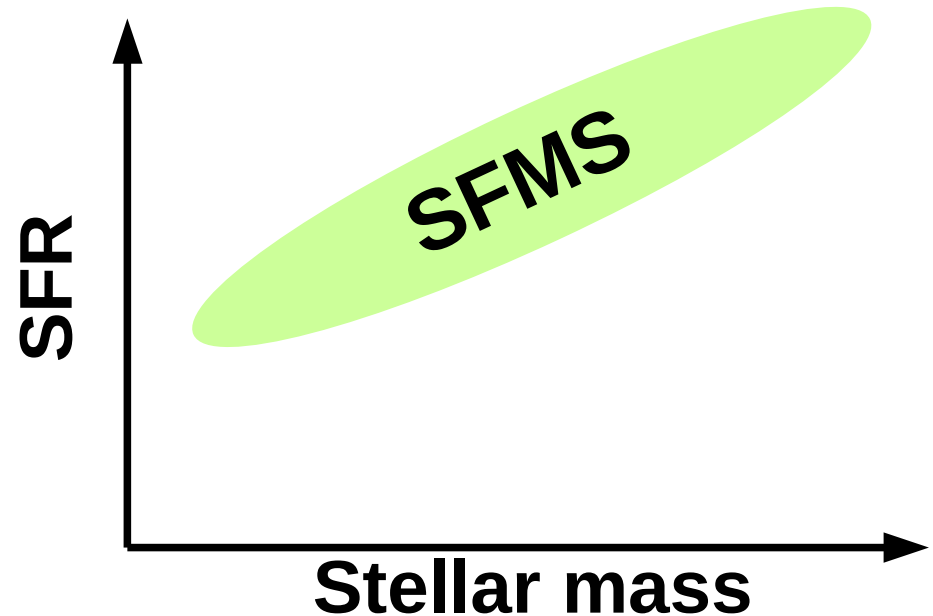
Motivation (1)



Star formation largely a local process

BUT,

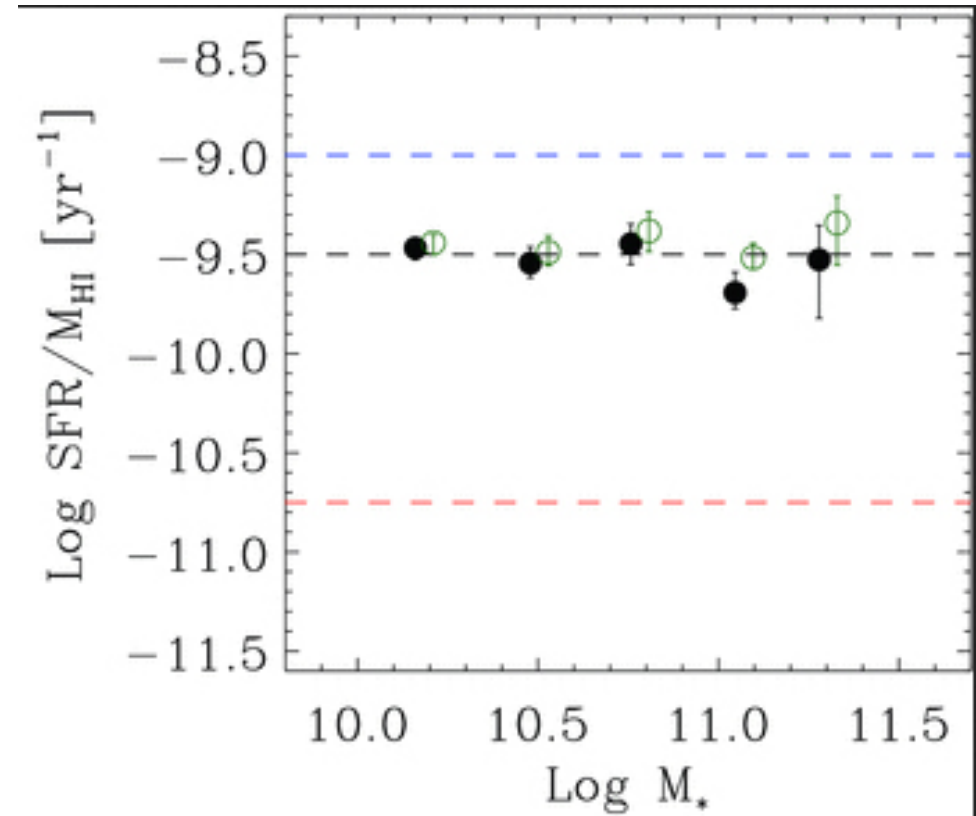
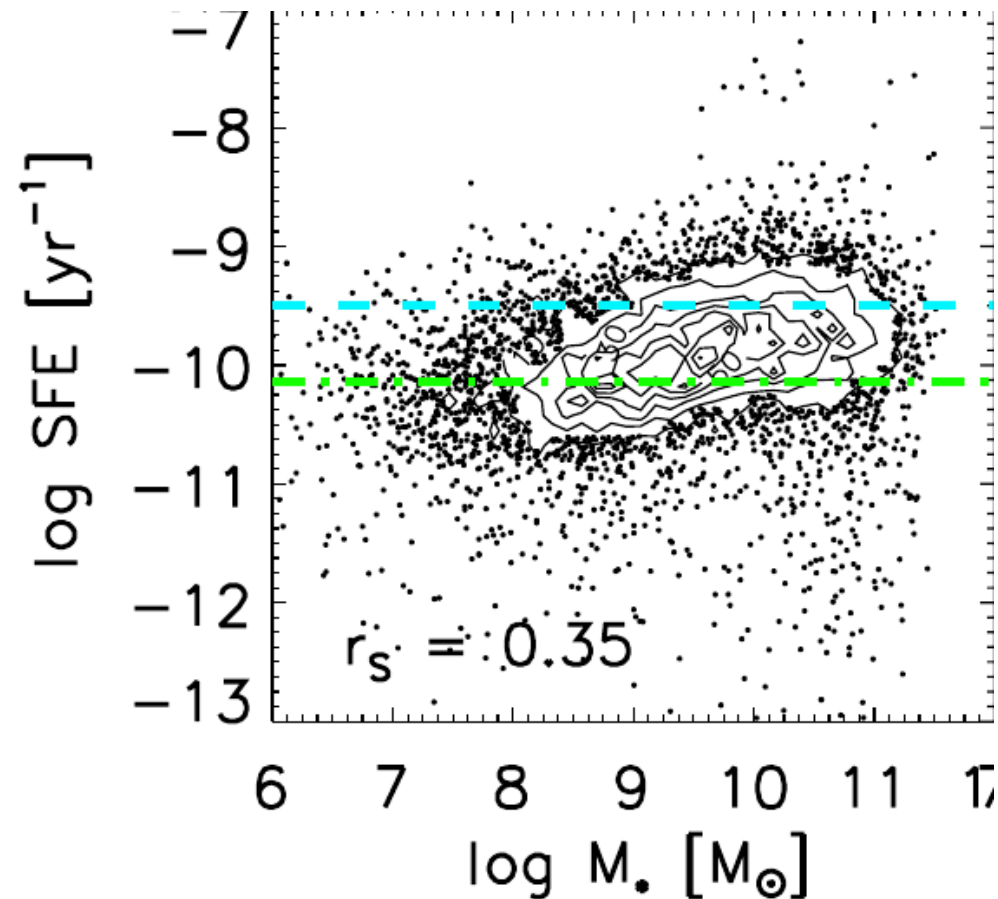
many global correlations imply uniform SFE (e.g. SF “main sequence”)





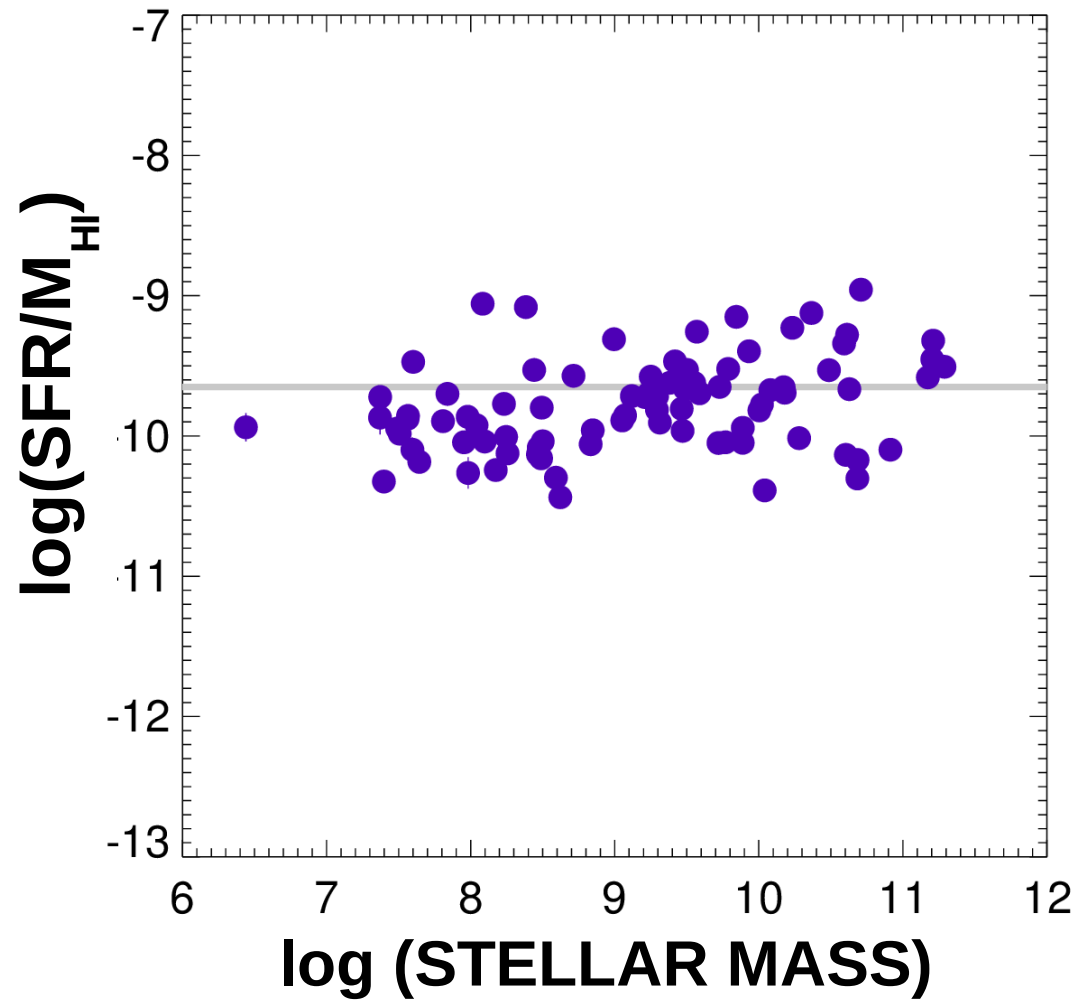
Motivation (2)

- Detailed multiwavelength mapping of gas & stars (eg THINGS)
→ SFR/H2 ~constant *but* HI/H2 varies
- *So what is driving SFR/HI to be constant?*

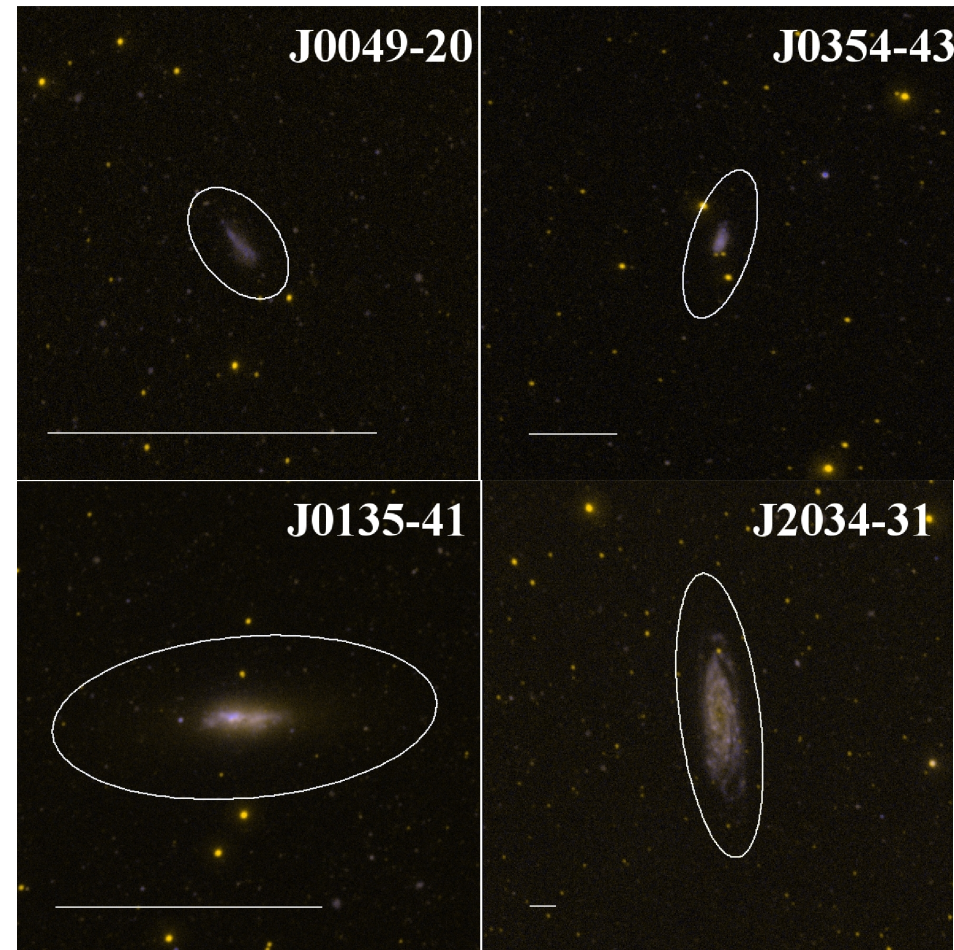
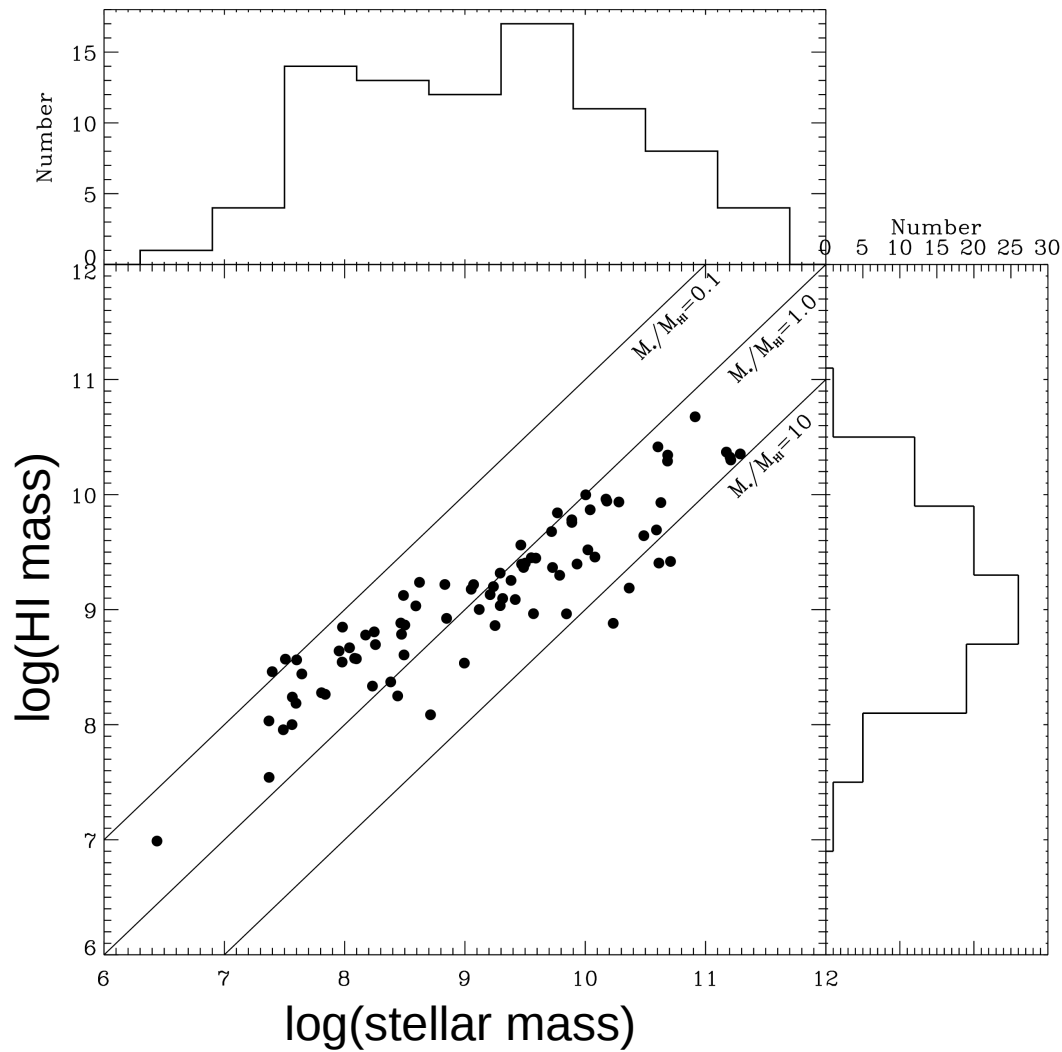




We see this in our sample too



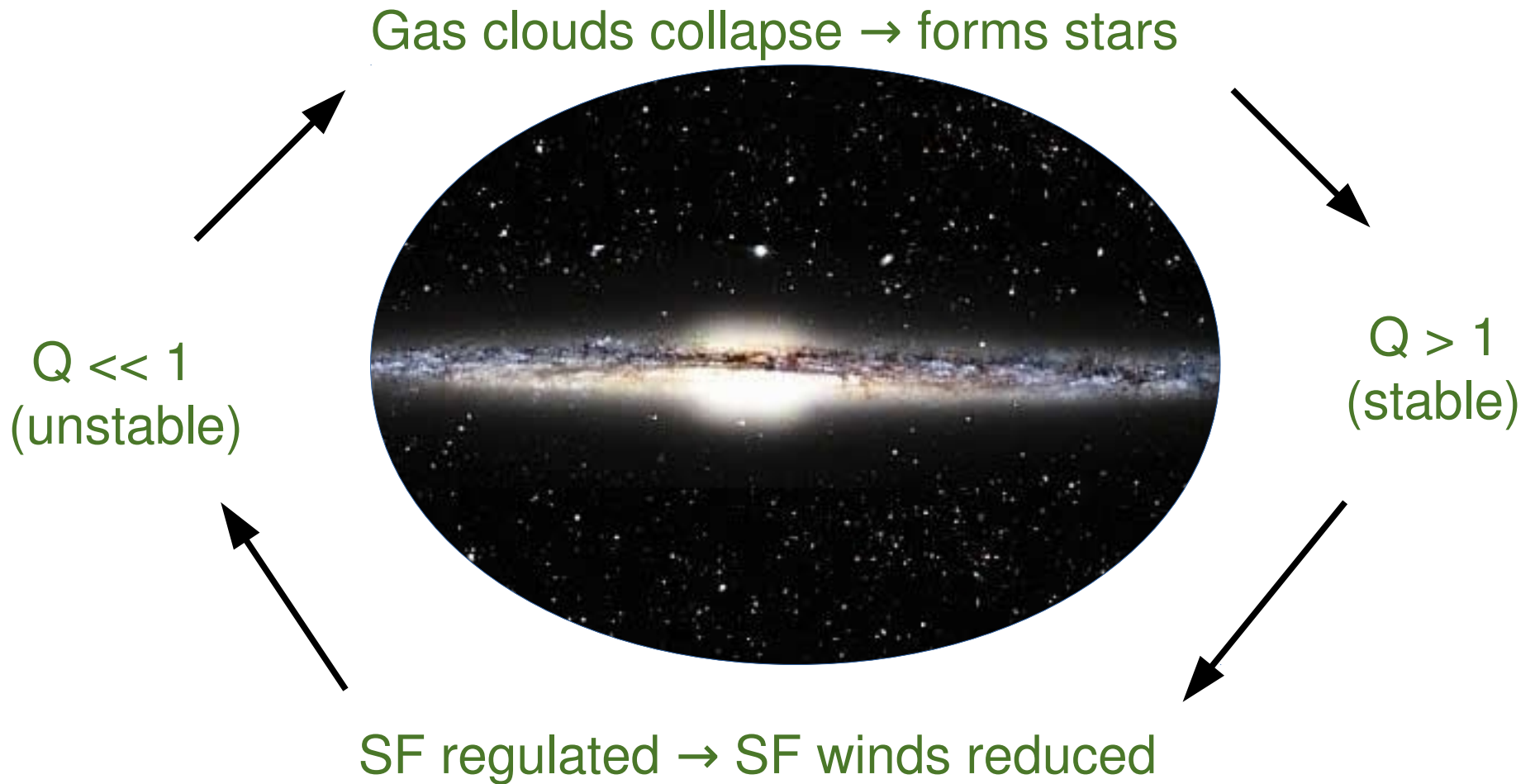
HI-selected sample ($z < 0.02$)





What is driving the global SFE to remain uniform ?

Regulation of SF in a disk via constant Q



Defining disk stability Q

$$Q \propto \frac{\sigma K}{\Sigma}$$

Toomre (1964), Wang&Silk (1994), Rafikov (2001)



2-fluid Q_{ws} (Wang&Silk 1994):

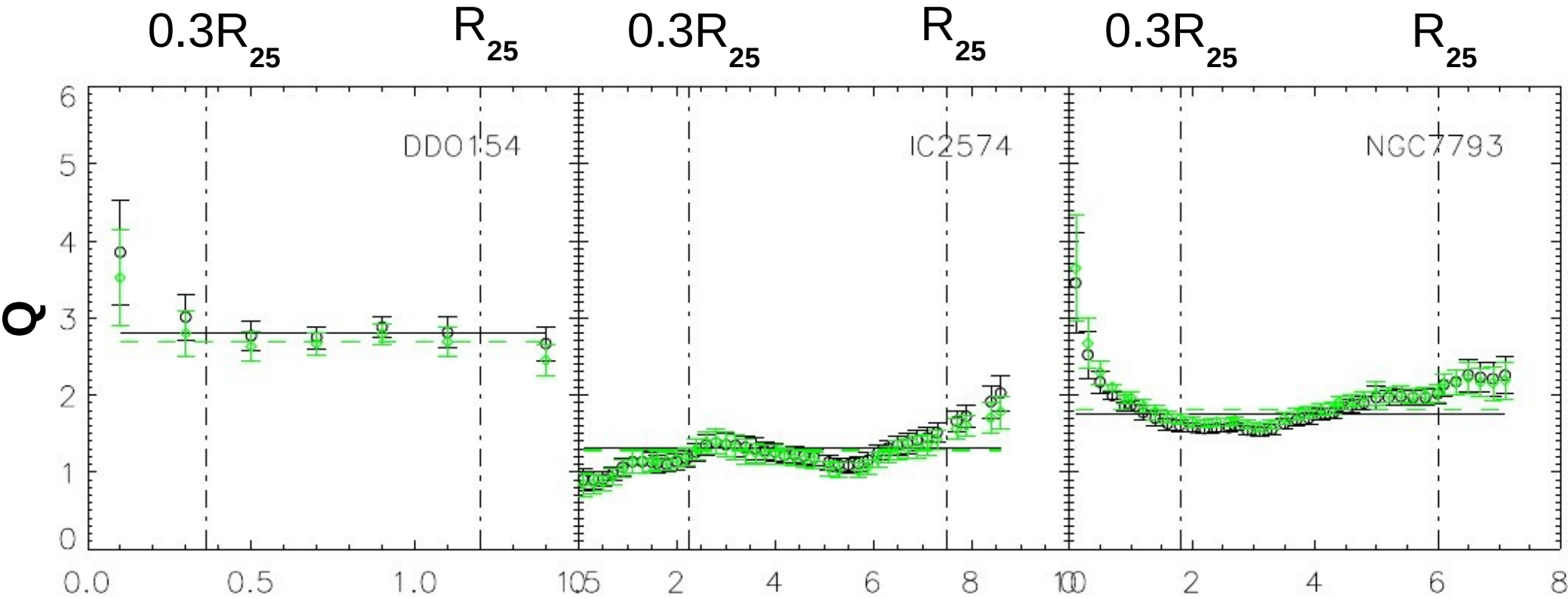
$$\frac{1}{Q_{WS}} = \frac{1}{Q_{gas}} + \frac{1}{Q_{stars}}$$

where

$$Q_{gas} = \frac{\sigma_{gas} K}{\pi G \Sigma_{gas}}, \quad Q_{stars} = \frac{\sigma_s K}{\pi G \Sigma_s}$$



Constant $Q = 1.6$



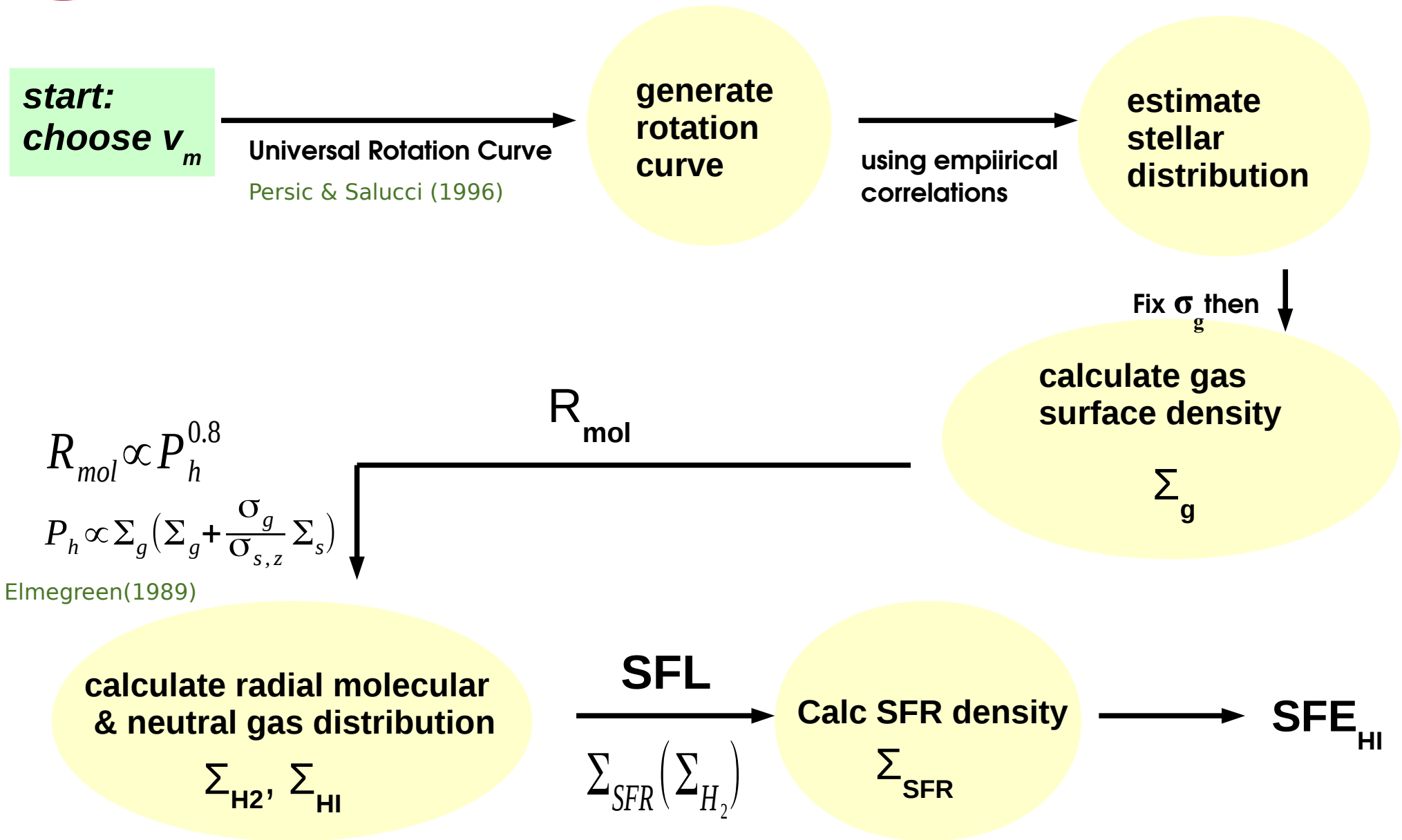
$\sigma_g = 11$ km/s (Leroy+2008)

measured σ_g

Zheng et al (2013)

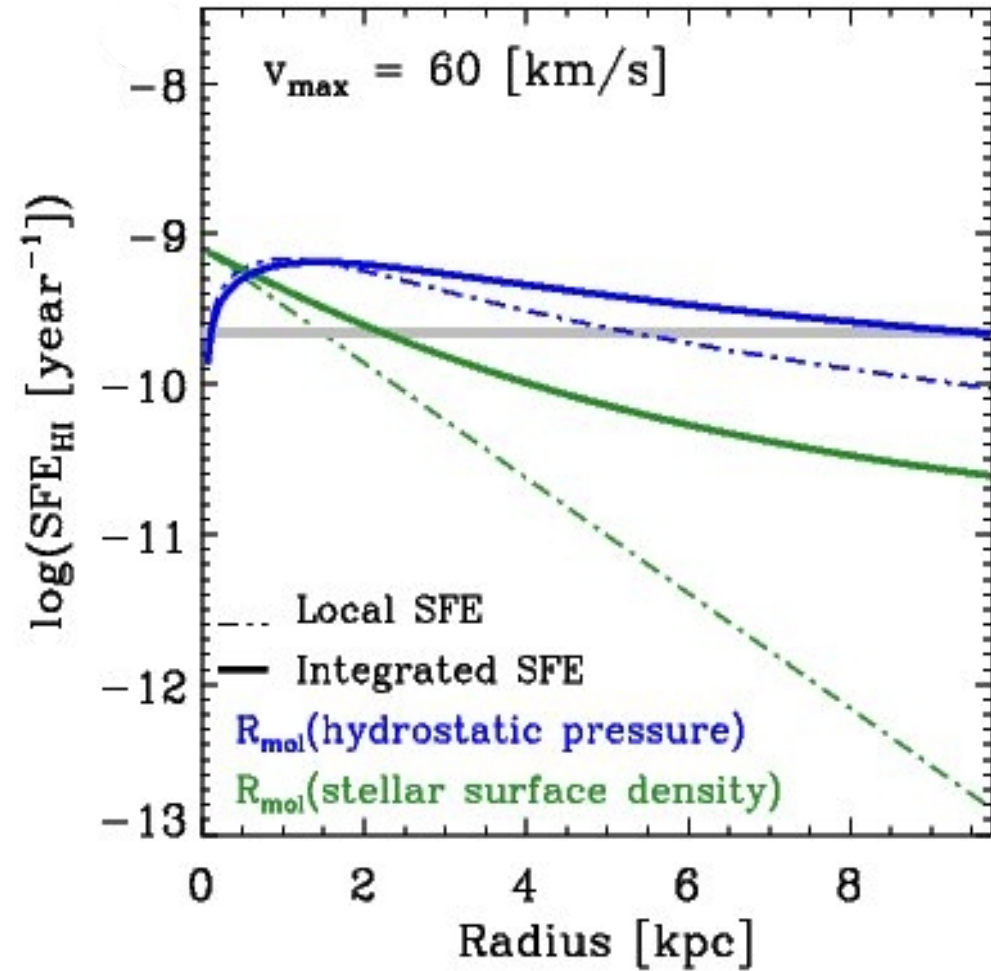
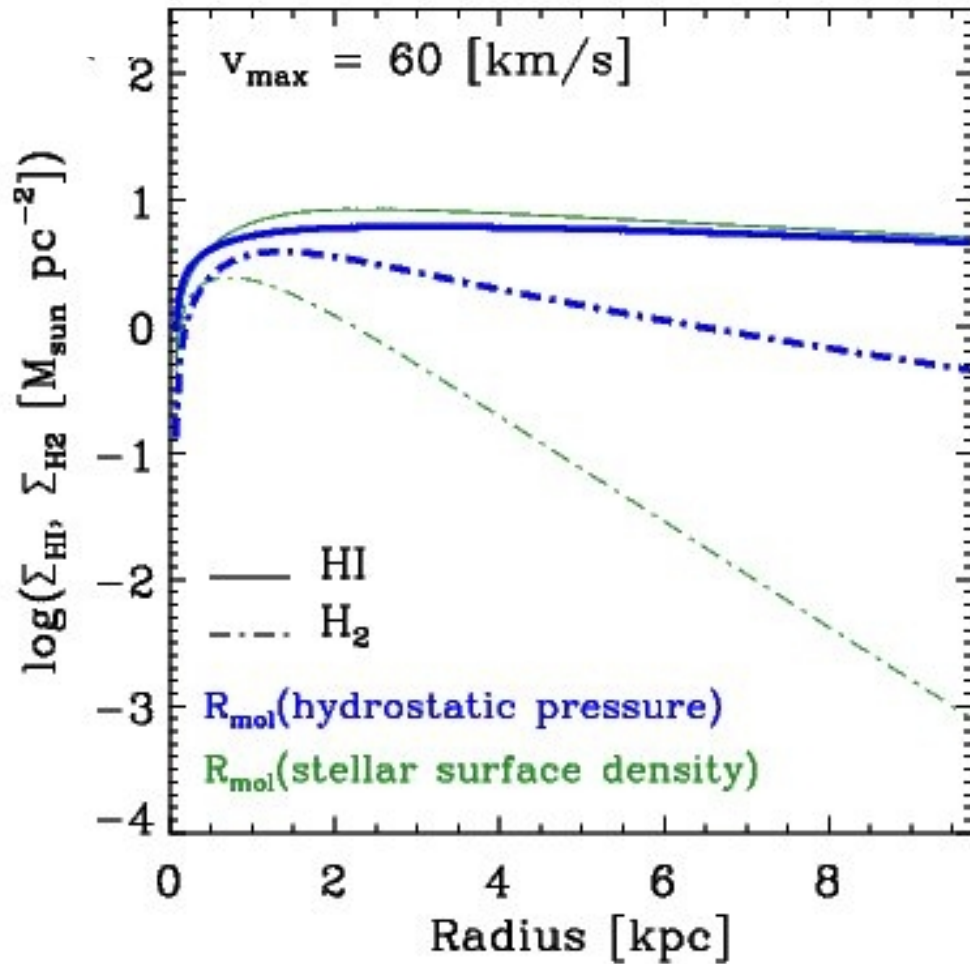


Our toy model assuming $Q_{2f} = 1.6$

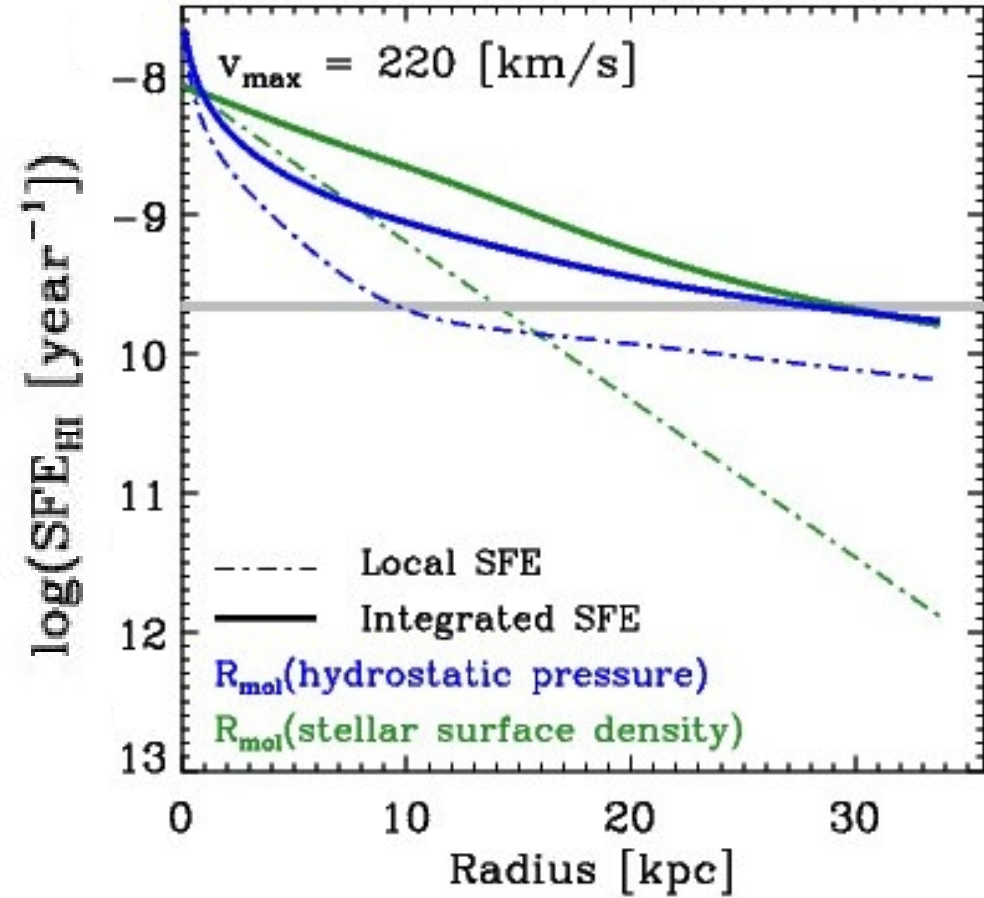
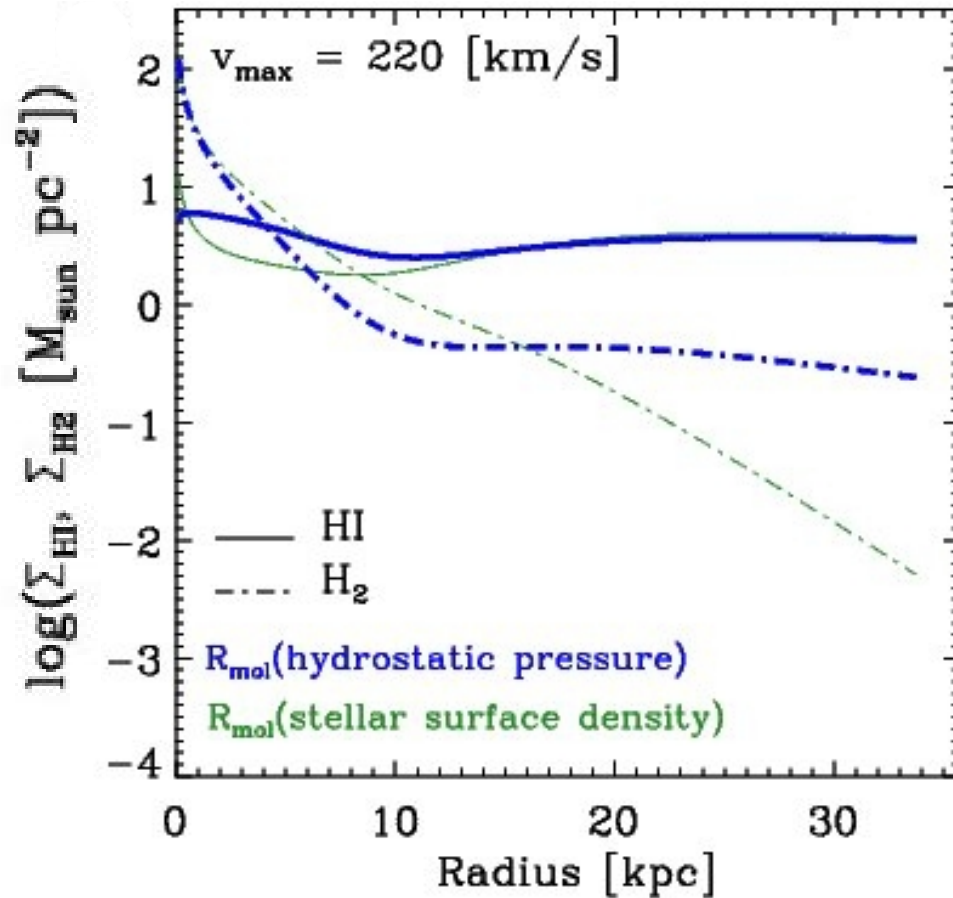




Example model of a small disk galaxy



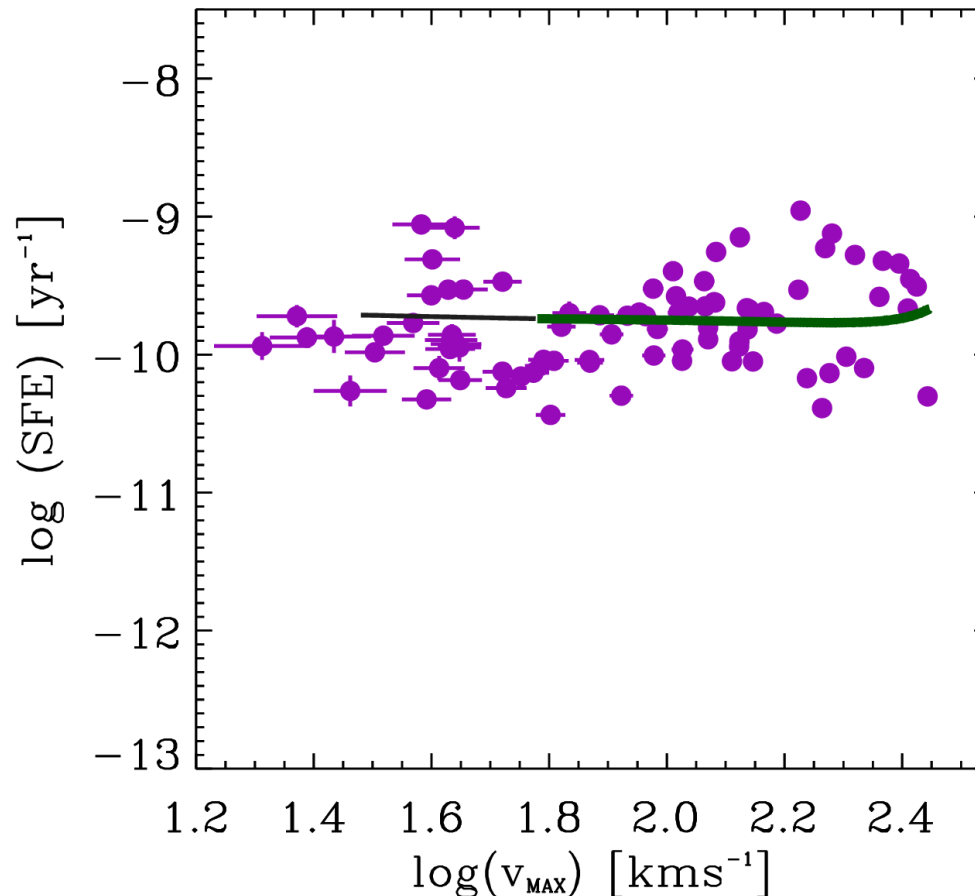
Example Milky Way

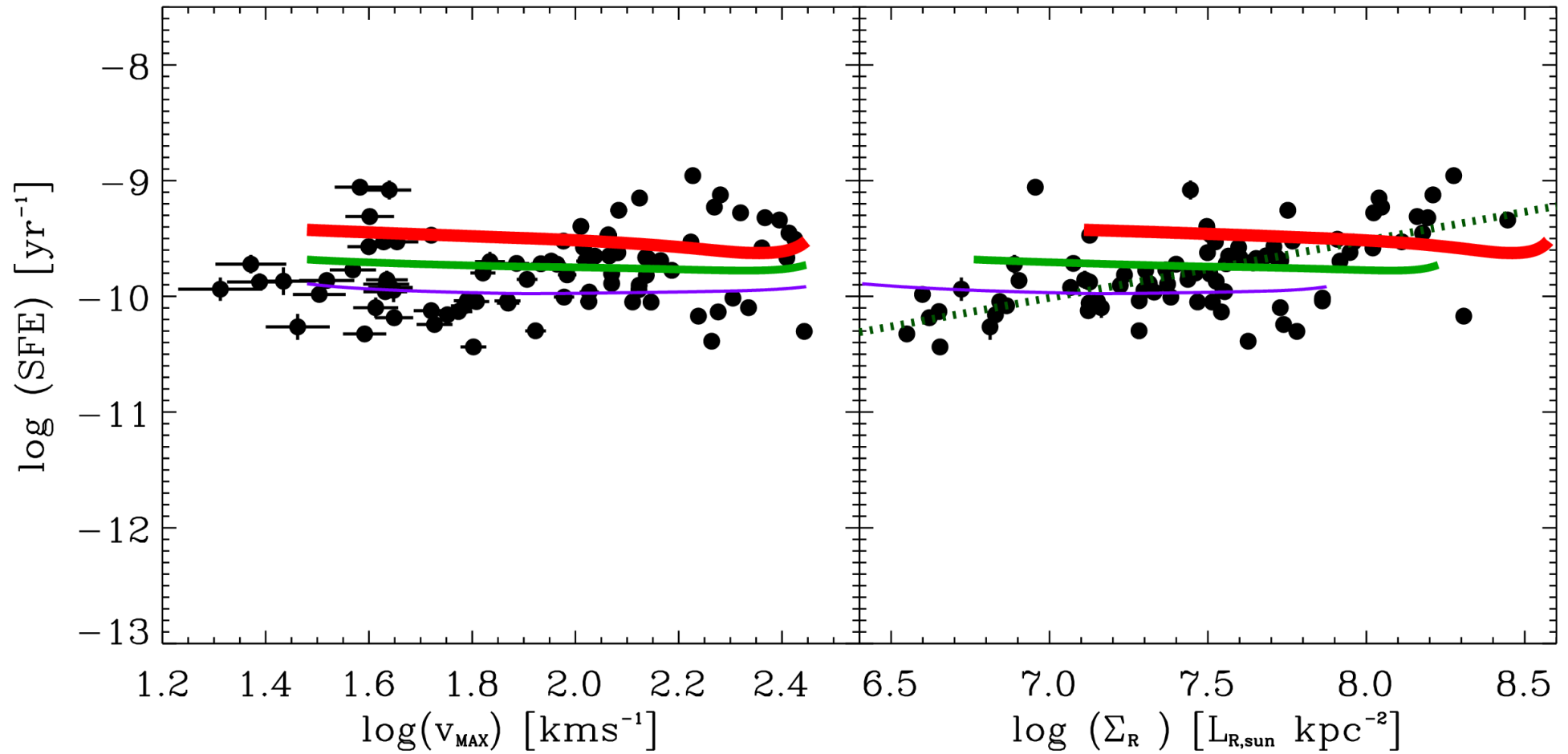




Toy model works even for smaller galaxies!

*Shows that uniform global SFE(HI) can be produced by:
→ a constant marginal disk stability + hydrostatic disk pressure*





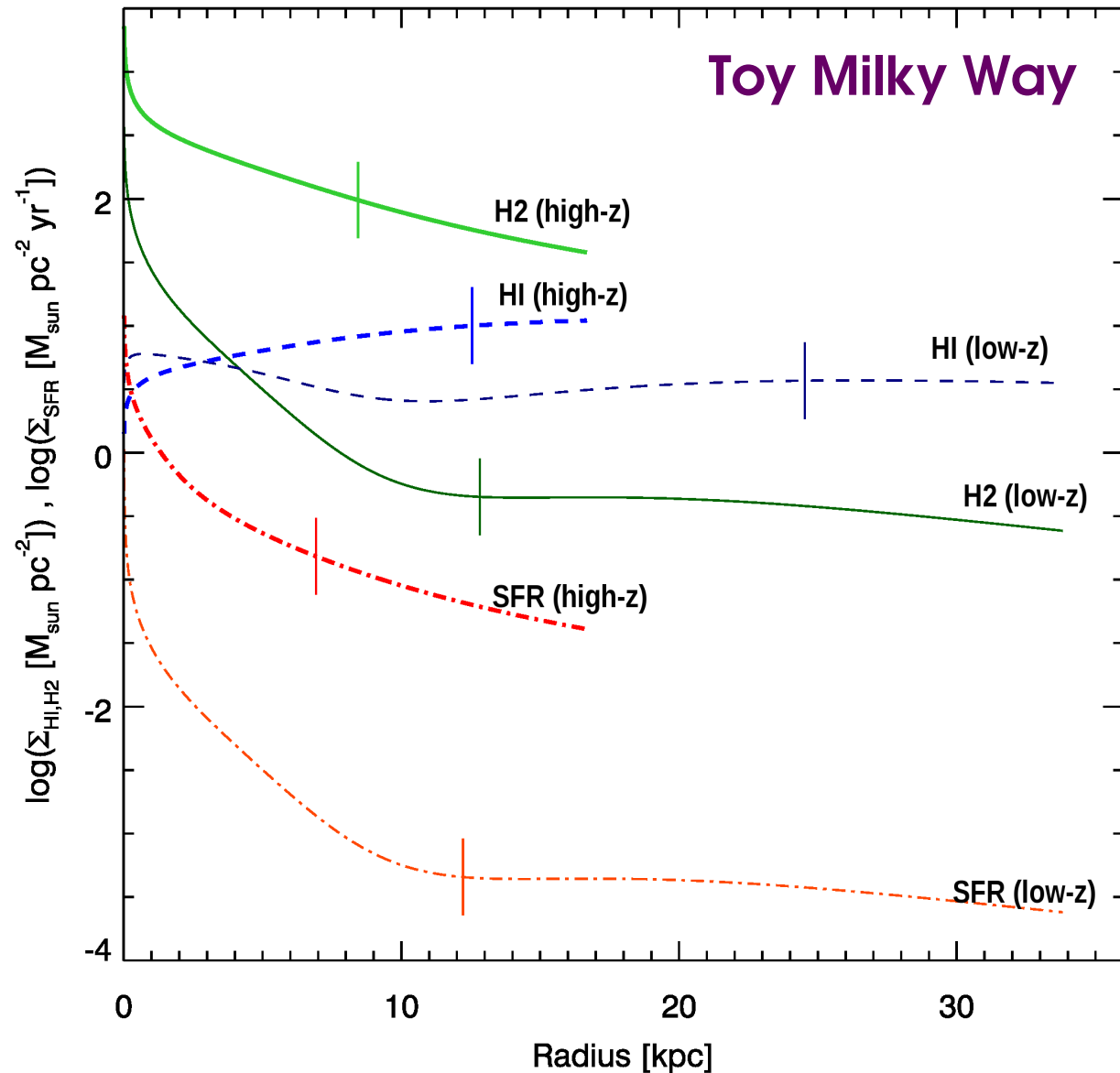


What about galaxies @ higher-z ?

We begin solely with $M_b = M_g$ && $\sigma_g = 60$ km/s

→ toy high-z galaxies are smaller with high SFRs

→ consistent with SINS (z=2 star-forming spirals)





Summary & conclusions

Our simple toy models with constant marginal disk stability + hydrostatic disk pressure can produce:

- uniform global SFR/HI (SFE) in the Local Universe*
- SFE scatter due to intrinsic variations in disk scale lengths*
- reasonable SF props of high-z galaxies too!*

Reference: Wong, O.I. et al 2016 MNRAS, 460, 1106



In other news:

Radio AGN dominates 1.4 GHz emission for radio-quiet AGN

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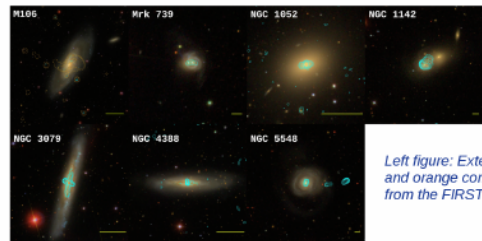
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We investigate the 1.4 GHz radio properties of 92 nearby ($z < 0.05$) ultra hard-X-ray selected Active Galactic Nuclei (AGN) from the Swift Burst Alert Telescope (BAT) sample. Through the ultra hard-X-ray selection, we minimise the biases against obscured & Compton-thick AGN as well as confusion with emission derived from star formation that typically affect AGN samples selected from the UV, optical and infrared wavelengths.



Our BAT sample are:

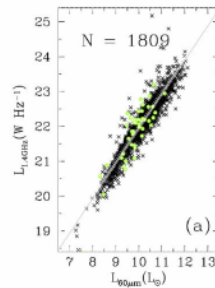
- * radio-quiet
- * 83% high-excitation galaxies (HEGs)
- * 17% low-excitation galaxies (LEGs)
- * 93% compact radio sources

Left figure: Extended radio emission from 7 Swift BAT AGN. Cyan and orange contours represent 1.4 GHz radio continuum emission from the FIRST (Becker et al 1994) and NVSS surveys, respectively.

Radio-quiet Swift BAT AGN sample follows the radio-FIR correlation, in a similar fashion to star-forming galaxies!

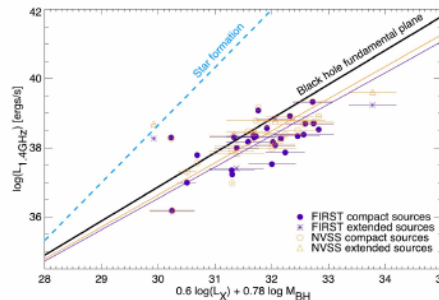
Right figure: Swift BAT AGN represented by green points. Black crosses represent star-forming galaxies from Yun et al 2001

However, the observed 1.4 GHz and X-ray luminosities of this sample is consistent with the black hole "fundamental plane" which describes the scale-invariant coupling between the accretion of matter onto a black hole and the observed synchrotron radio emission.



Left figure: Majority of our sample of Swift BAT AGN (with the exception of NGC 3079 & Mrk 766) fits on the black hole fundamental plane

The 1.4 GHz radio emission of radio-quiet Swift BAT AGN are due to the radio AGN and not star formation. Care should be taken when using the radio-FIR correlation to differentiate between star forming and AGN populations.



References:
More details about this result is published in Wong, O.I. et al 2016 MNRAS 460 1588
Other references: Becker, White & Helfand 1995 ApJ 450 559
Condon et al 1997 AJ 115 1693
Yun, Reddy & Condon 2001 ApJ 554 803

AGN hiding in radio-FIR correlation ...

Reference: Wong, O.I. et al 2016 MNRAS, 460, 1588

The Galactic and Extra-galactic All-Sky MWA (GLEAM) Survey
The GLEAM Team

MURCHISON WIDEFIELD ARRAY

GLEAM Ex-Gal Data Release 1:

- Data from 1st year of GLEAM
- Covers 24,831 deg² of ex-gal sky for Dec <= +30°
- 307,456 sources are detected @200 MHz, S_r>20 mJy
- 2' resolution
- 20 band photometry across 72–231 MHz for 99% of sources

Future Releases:

- Full Galactic Plane
- Years 1+2 (deeper)
- Deeper and all-sky observations from MWA Phase 2 (resolution x ~2)

MWA Galactic and Extra-Galactic (GEG) Contacts:

GEG Convener: nick_segura@curtin.edu.au
GEG Project Scientist: natalia.hurley-walker@curtin.edu.au

For more information:

<http://www.astronews.gov.au/galactic-extragalactic-survey>
Description: Wayth et al., 2015, PASA, 32, 25
DR1: Hurley-Walker et al., 2016, MNRAS (in press)
III Regions cat: Hindson et al., 2016, PASA, 33, 20
@mwatelescope | Murchison.Widefield.Array

Reference: Hurley-Walker, N et al 2016 submitted MNRAS



