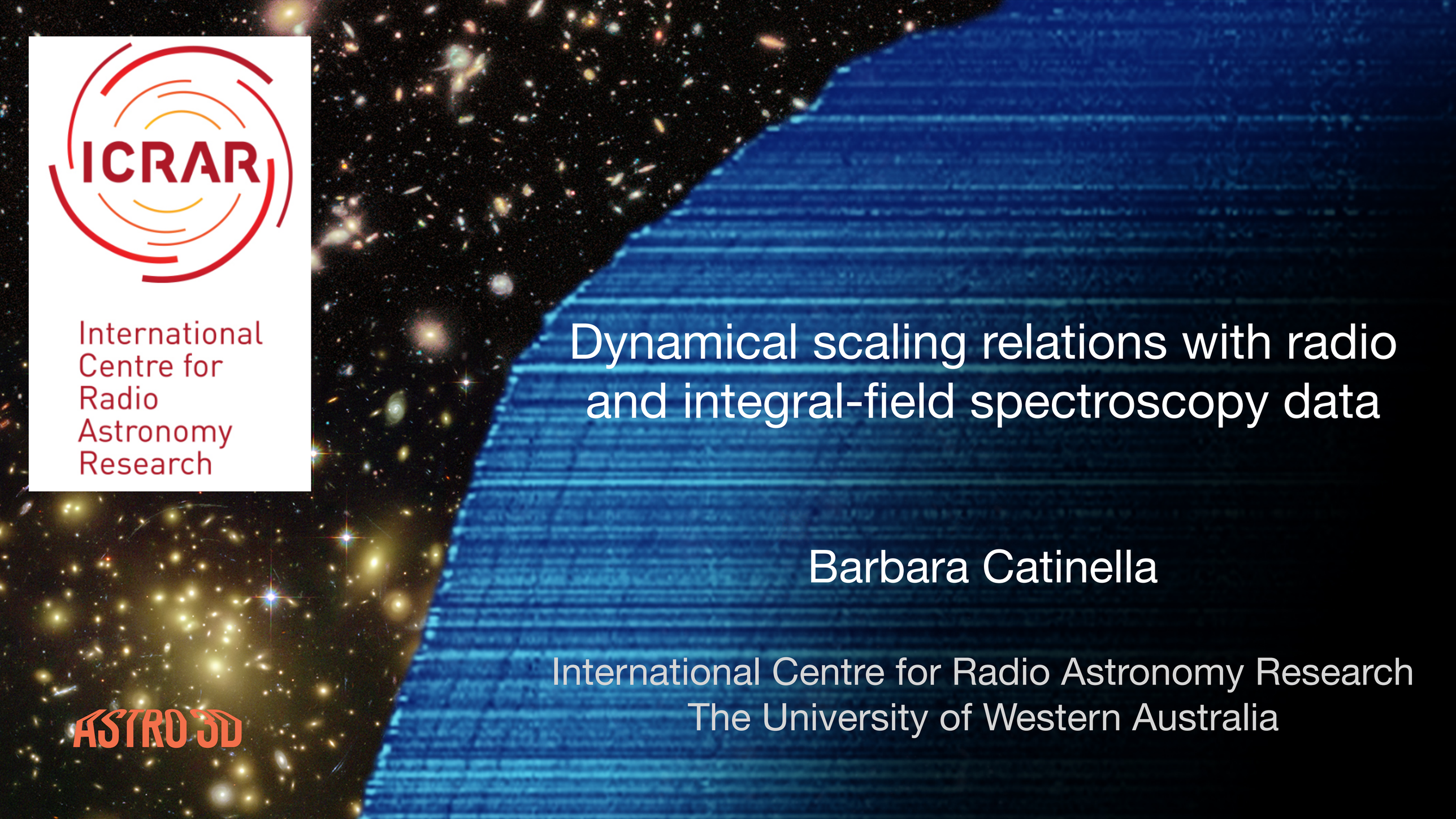
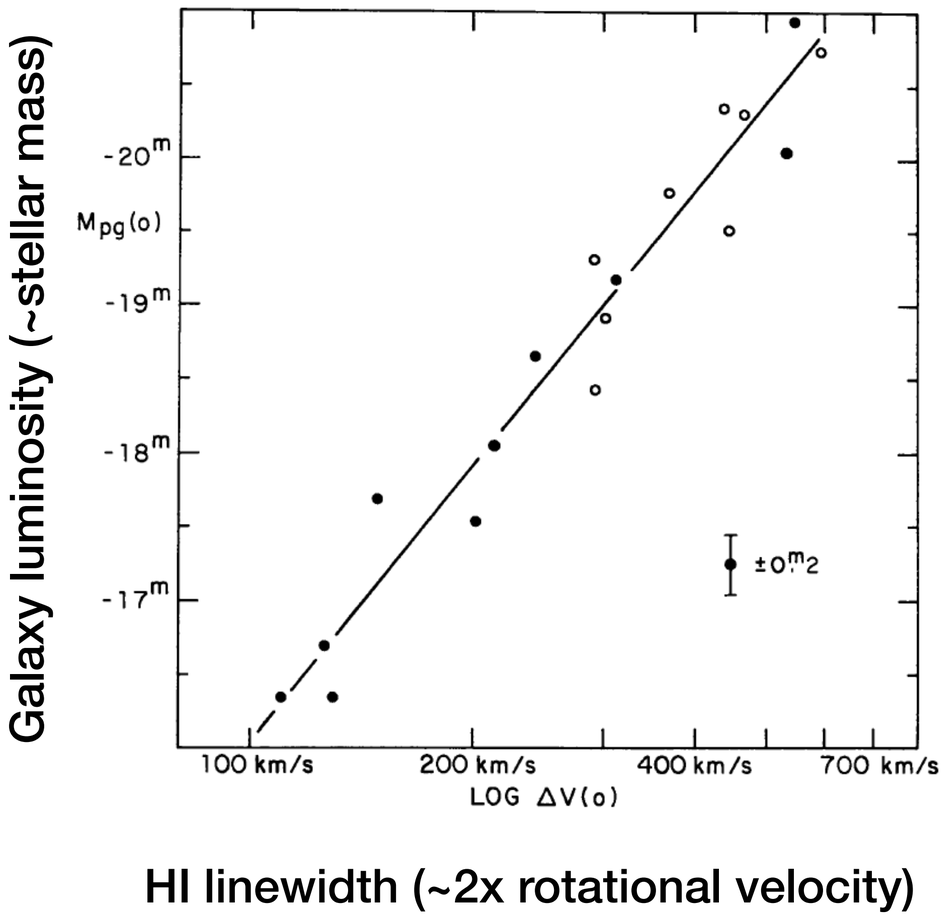


Dynamical scaling relations with radio and integral-field spectroscopy data

Barbara Catinella

International Centre for Radio Astronomy Research
The University of Western Australia

Dynamical scaling relations: Tully-Fisher relation

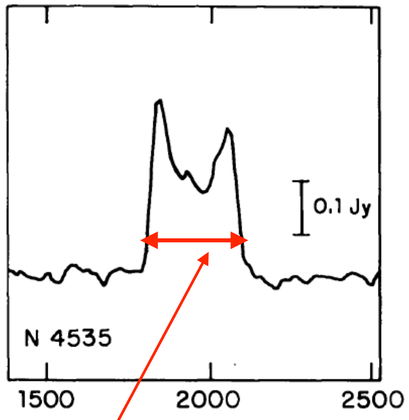


HI linewidth (~2x rotational velocity)

Tully-Fisher (1977) relation

- ✦ luminosity vs. rotational velocity
- ✦ inclined spirals (i > 45 deg)
- ✦ distance indicator
- ✦ constraint for galaxy evolution models & simulations

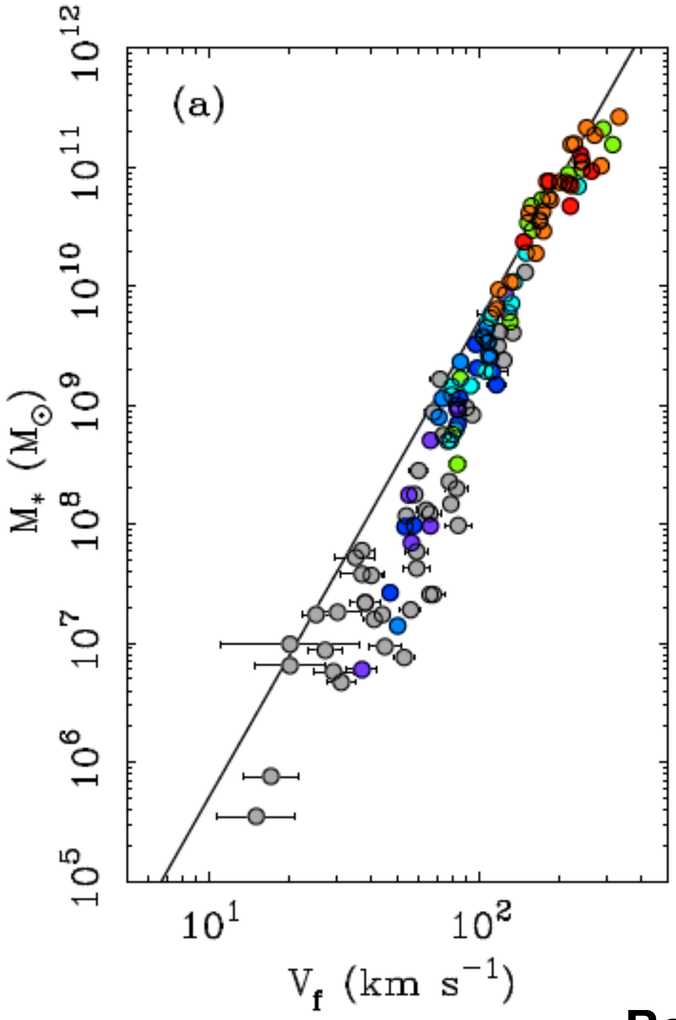
Global HI profile



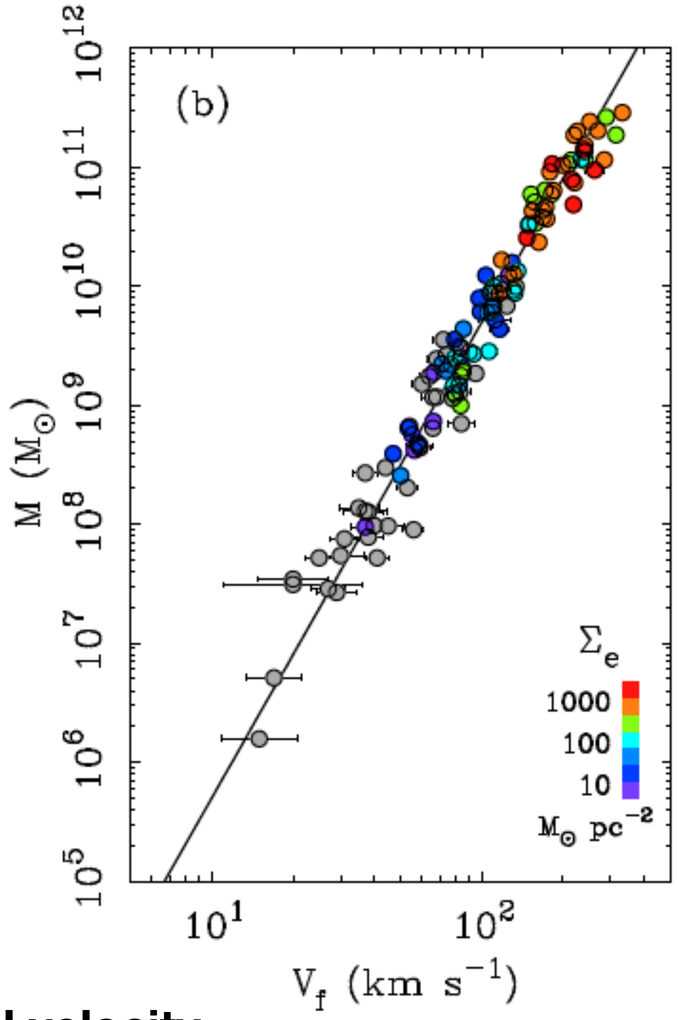
HI linewidth
(needs to be corrected for inclination)

Tully-Fisher relation: the HI view

Stellar mass



Baryonic mass ($M_\star$+M_{HI})



Rotational velocity

Small scatter, inclination cut

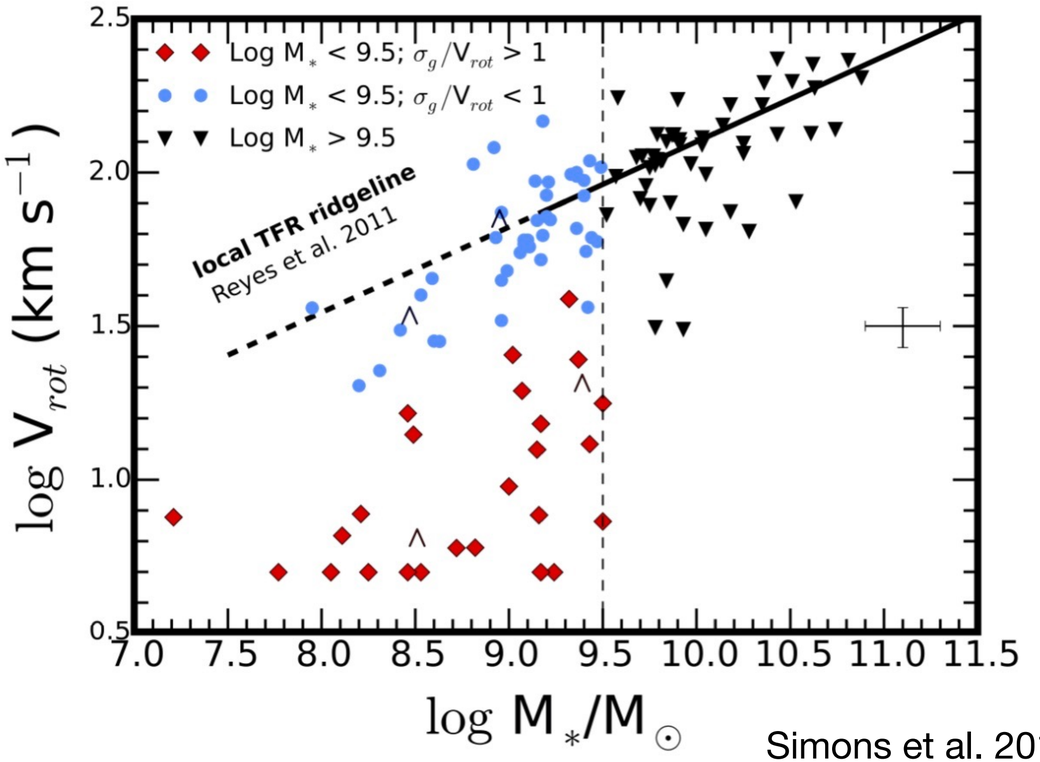
Dwarfs ($M_\star$ <10^9 $M_\odot$) scatter to **high** V_f at fixed $M_\star$ — but are <u>not</u> outliers of baryonic TFR

McGaugh et al. (2020)

Tully-Fisher relation: the optical view

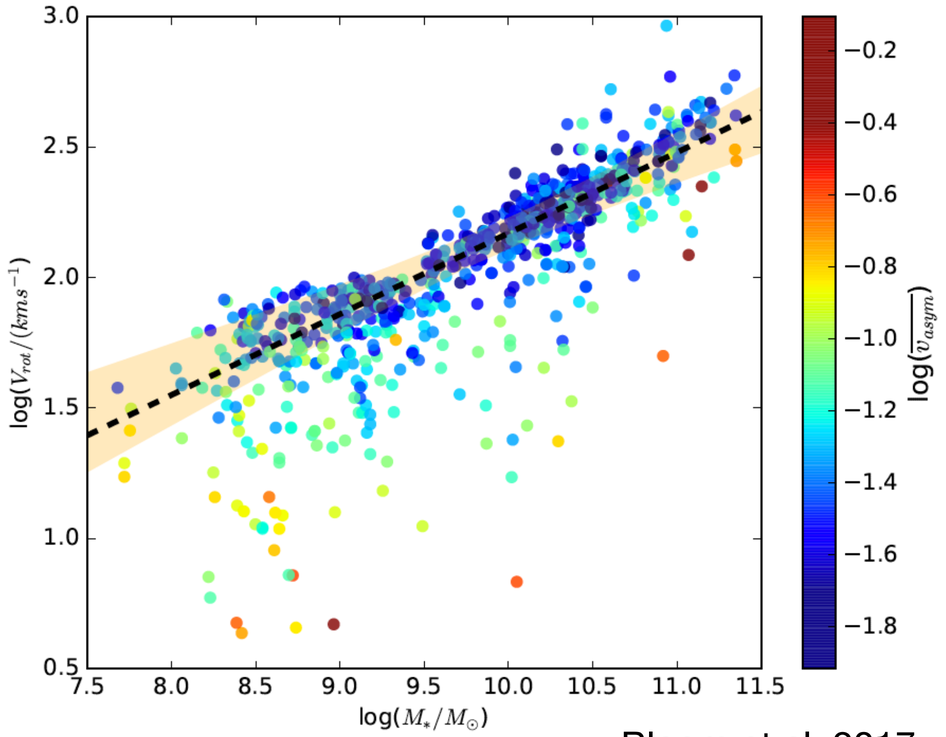
Recent long-slit/IFS studies show that TF is not as tight as we might expect

Large scatter at low-mass end (**opposite direction** to HI case): physical or observational bias?



Simons et al. 2015

z~0.2, long-slit RCs, 30^0<i<70^0
no morphology selection (but Hα emitters)
Scatter related to high velocity dispersion

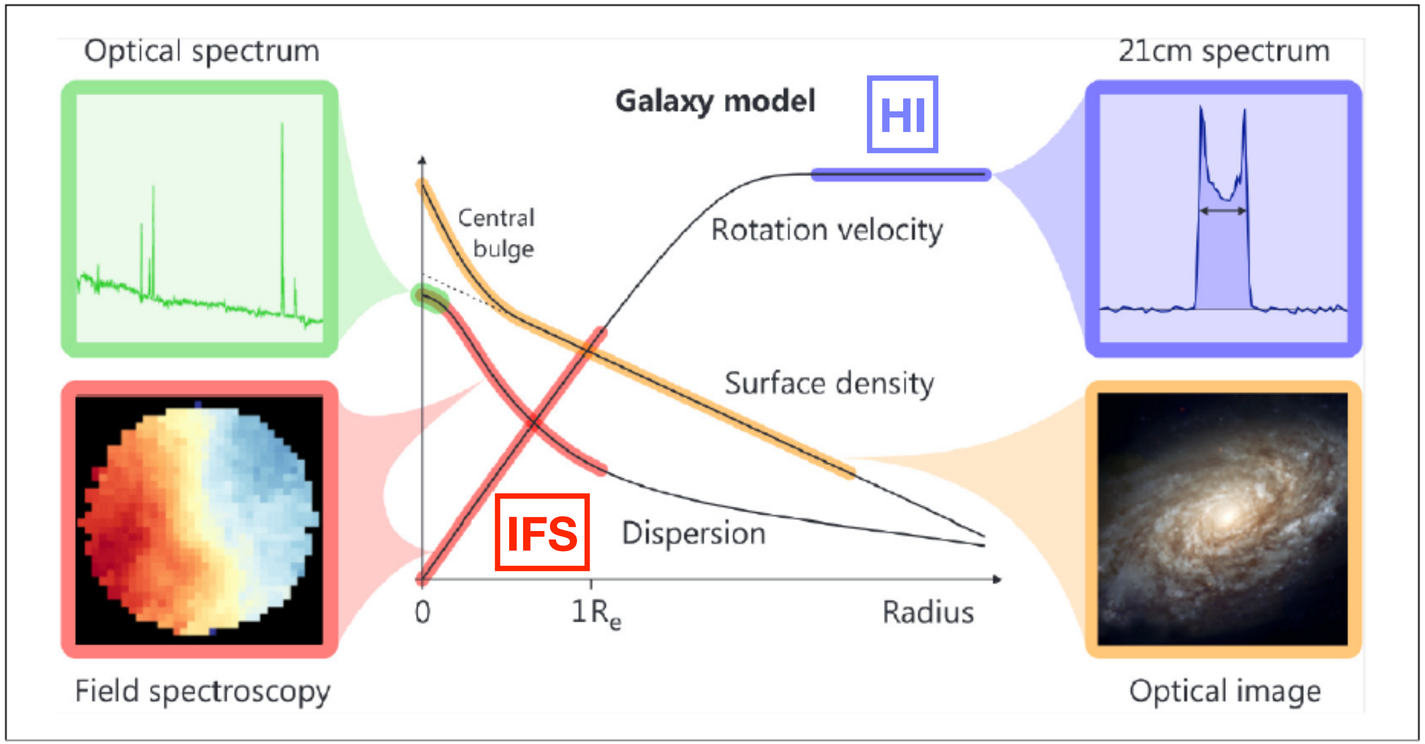


Bloom et al. 2017

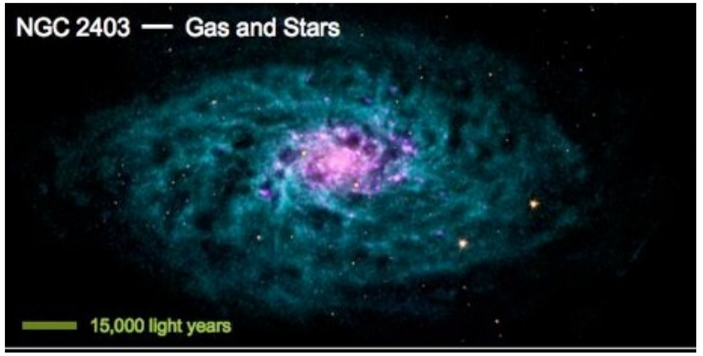
z~0, SAMI IFS, no inclination cut
no morphology selection (but Hα emitters)
Scatter related to kinematic asymmetry

Synergy between HI and IFS

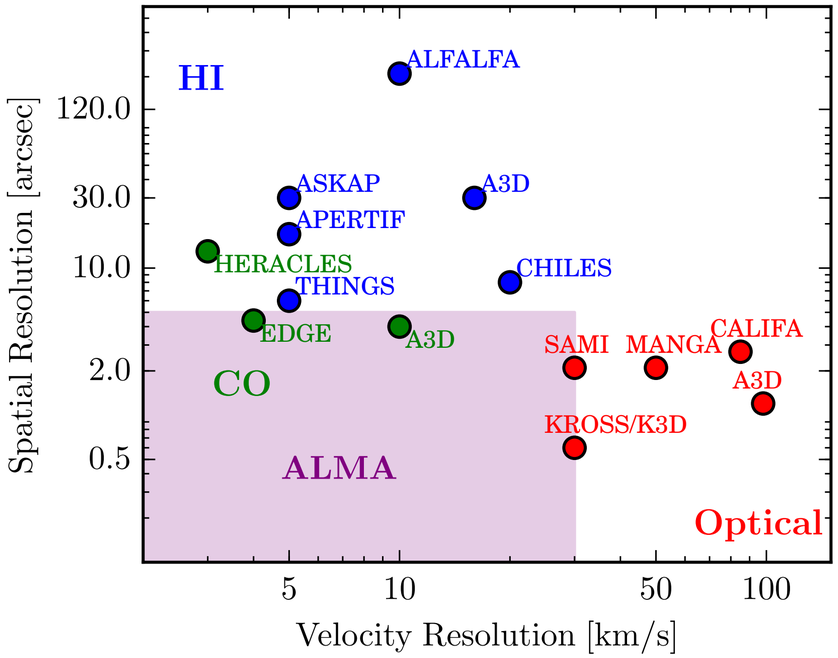
- HI and optical 3D observations cover significantly different parameter space in terms of FOV, spatial and spectral resolution
- Very little overlap between samples



Taranu et al. 2017



THINGS, Walter et al. 2008



Credit: Luca Cortese

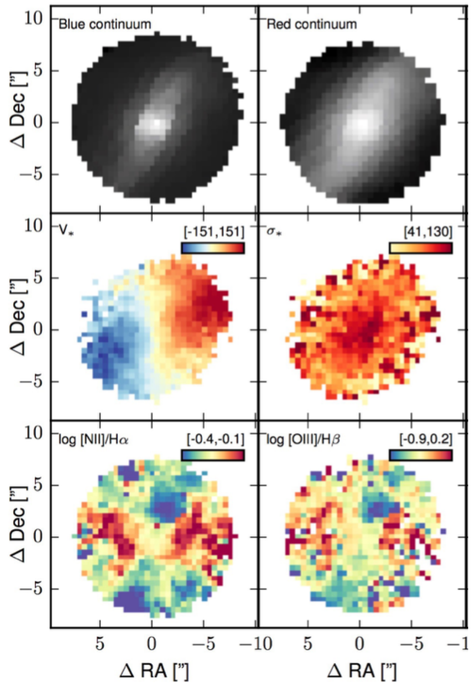
SAMI Galaxy Survey

IFS survey with the 3.9m Anglo-Australian Telescope

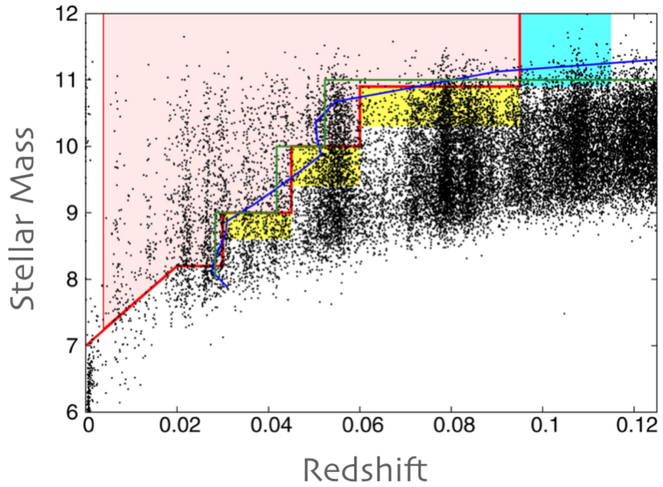
- ✦3068 galaxies, log $M_\star/M_\odot$ > 7, 0.004<z<0.095 (Croom+2021)
- ✦Selection from GAMA fields (~2400) + 8 clusters (~600)
- ✦http://sami-survey.org/

SAMI: Sydney-AAO Multi-object Integral field spectrograph

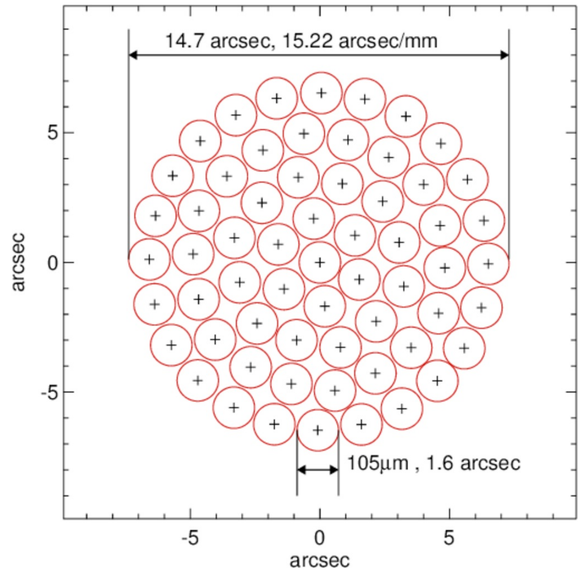
- ✦13x61 fibre IFUs
- ✦Fused fibre bundles; high fill factor (~75%)
- ✦15” bundle diameter (each fibre is 1.6”)
- ✦Feeds AAT AAOmega spectrograph (1 degree diameter FOV)

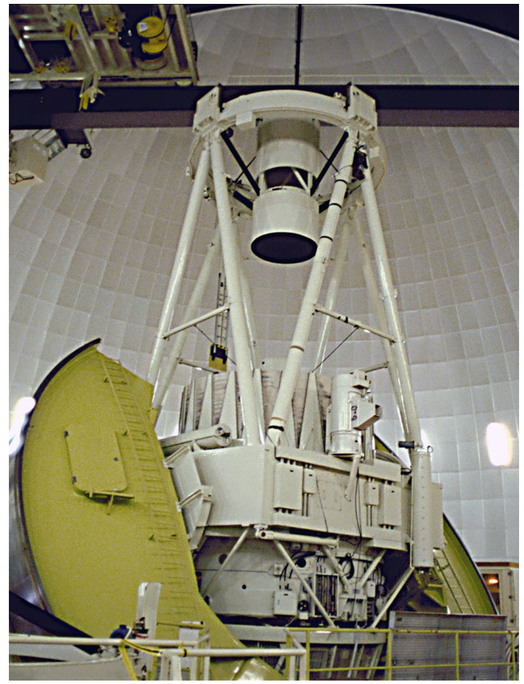


Arm	λ_{range} [Å]	$\lambda_{central}$ [Å]	FWHM [Å]	$\Delta\sigma$ [km s^{-1}]
Blue	3750-5750	4800	$2.66^{+0.076}_{-0.070}$	70.4
Red	6300-7400	6850	$1.59^{+0.049}_{-0.040}$	29.6



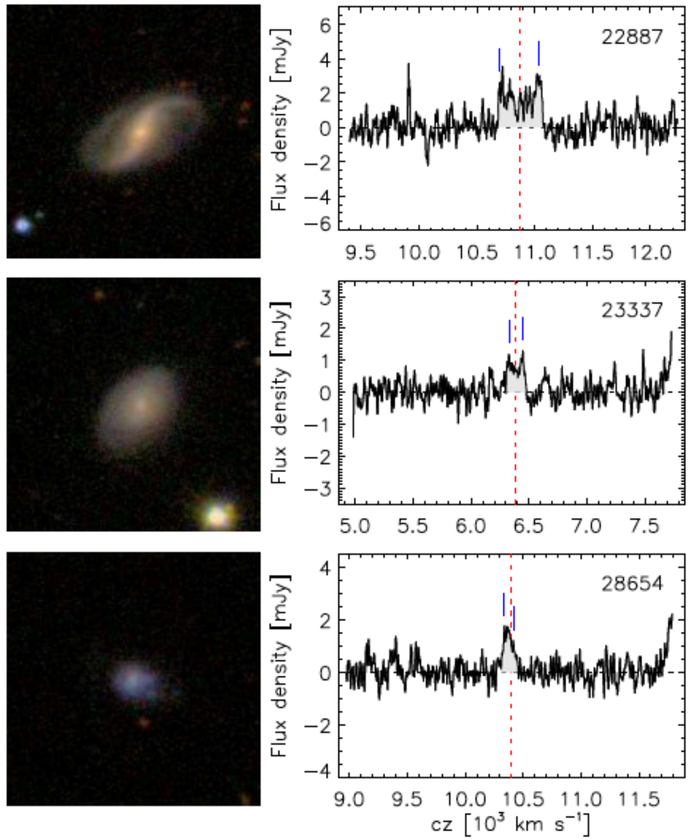
Bryant et al. 2015; Scott et al. 2018; Croom et al. 2021

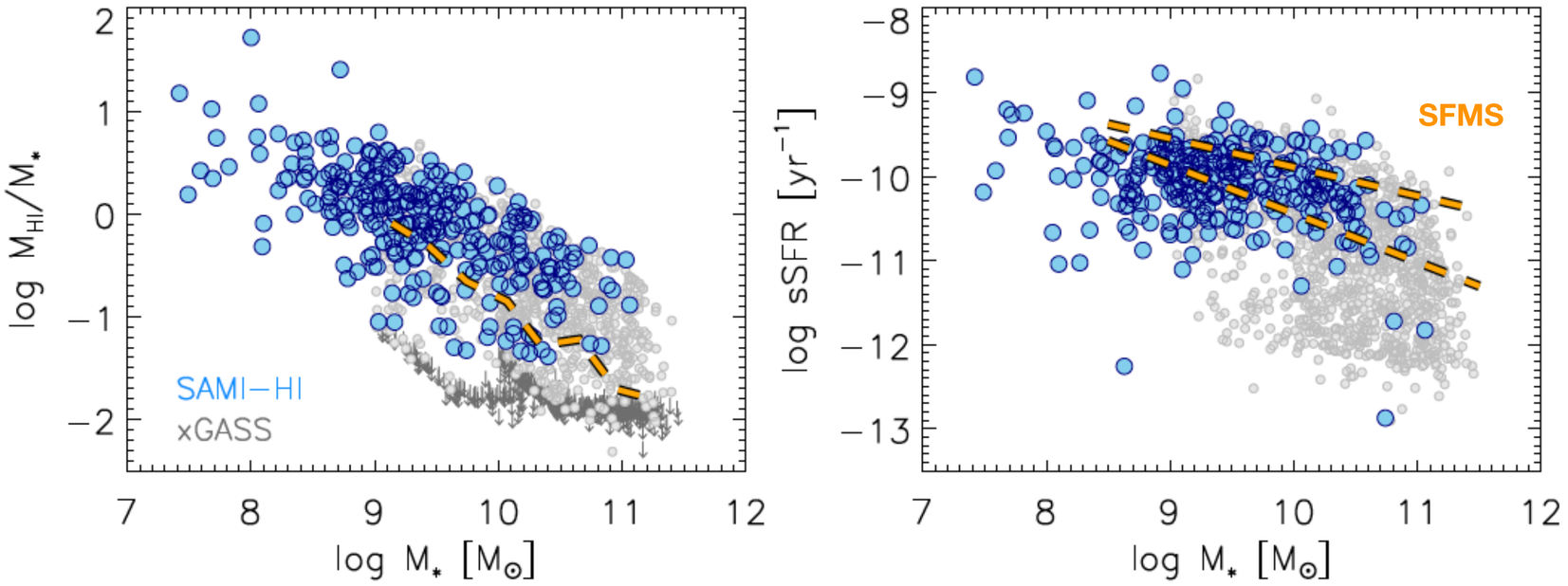




SAMI-HI survey

- ✦Two Arecibo proposals, awarded 160 hr in 2015-17
- ✦**296 galaxies** (including ALFALFA detections) in GAMA equatorial fields, z<0.06
- ✦HI masses, velocity widths, accurate z. No spatial info (beam~3.5')
- ✦Designed to increase overlap b/w HI and IFS samples — ideal to compare HI and optical TFRs

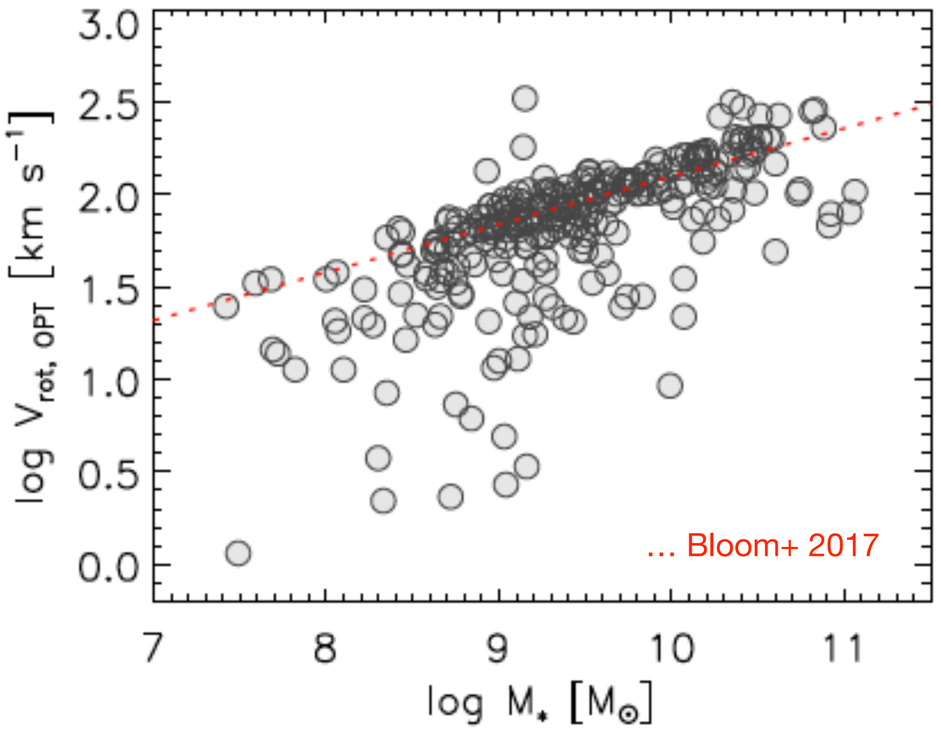




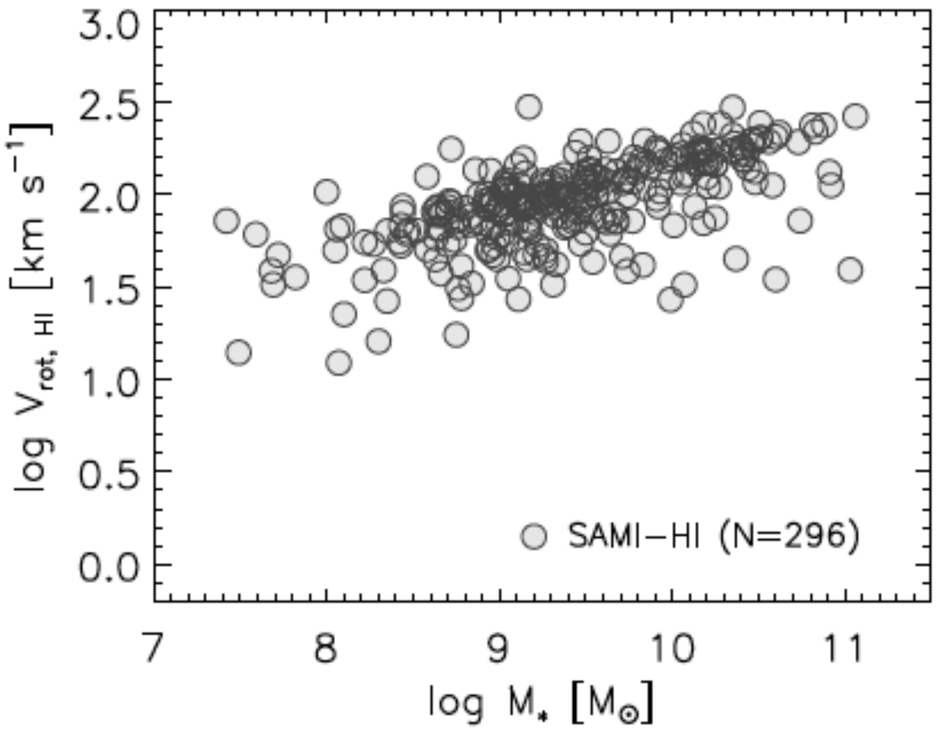
Catinella et al. (in prep.)

TFR comparison

OPTICAL TFR



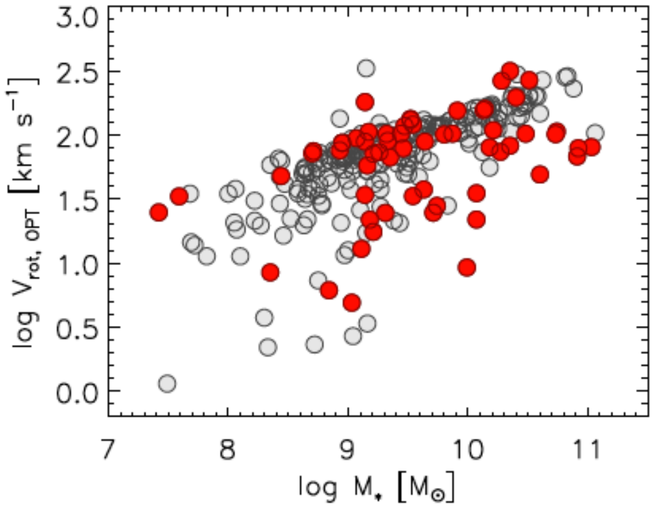
HI TFR

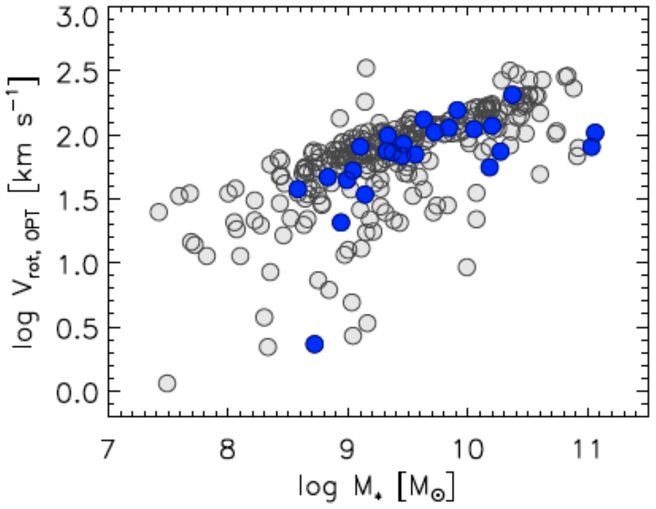


- All galaxies included
- Vrot,OPT = observed Hα rotational velocity at 2.2 rd, corrected for inclination and beam smearing
- **Outliers at low stellar mass in optical TFR not seen in HI TFR**

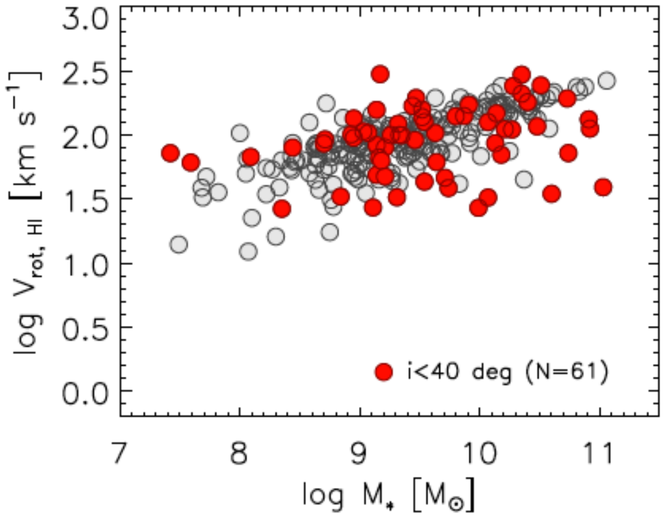
Pruning the HI TFR

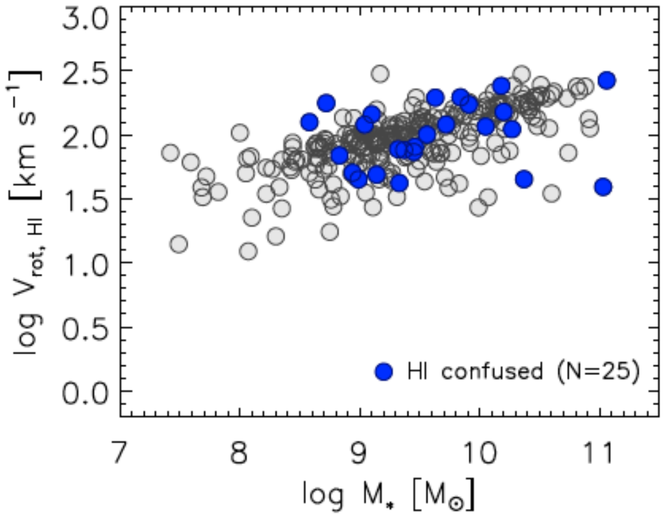
OPTICAL TFR



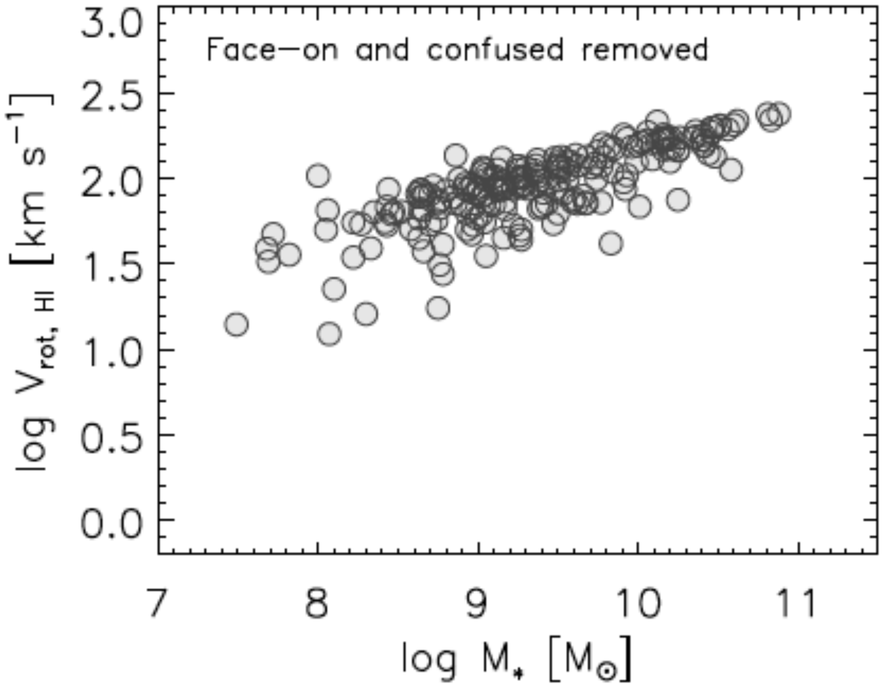


HI TFR





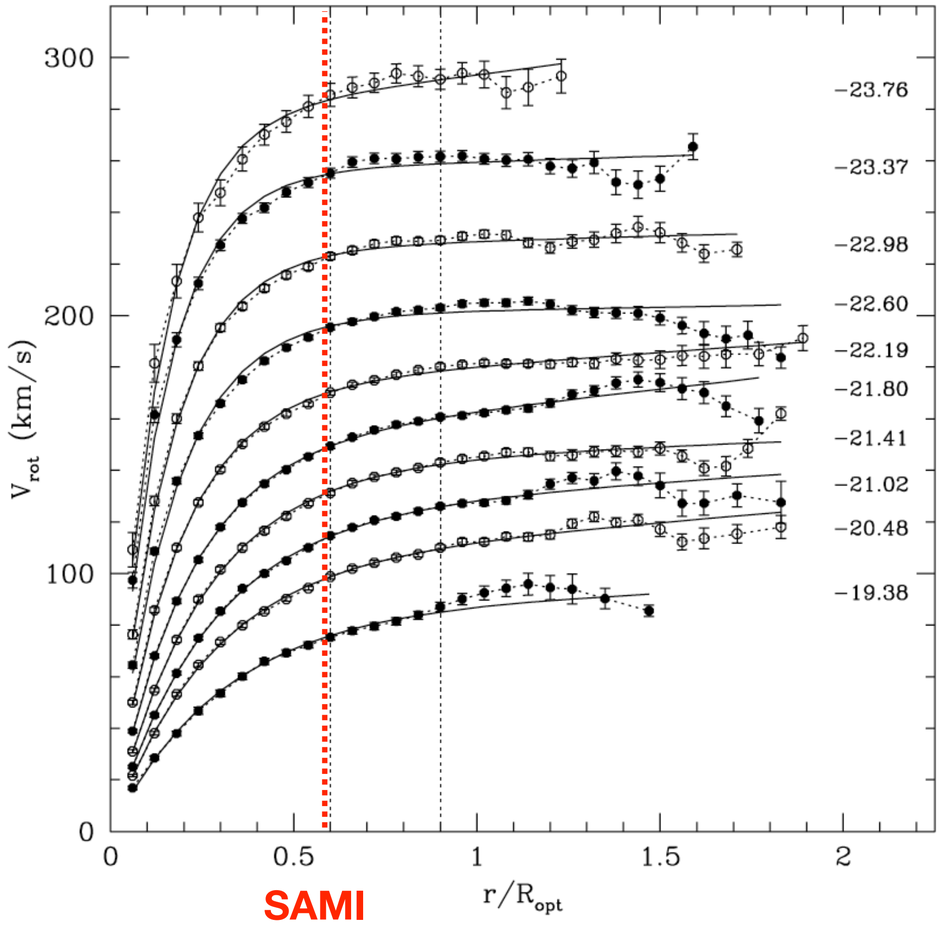
Pruned HI TFR



At high M★ (>10^9 $M_\odot$), most outliers of both relations have low inclination. At lower M★ there is still a population of outliers in the optical TFR

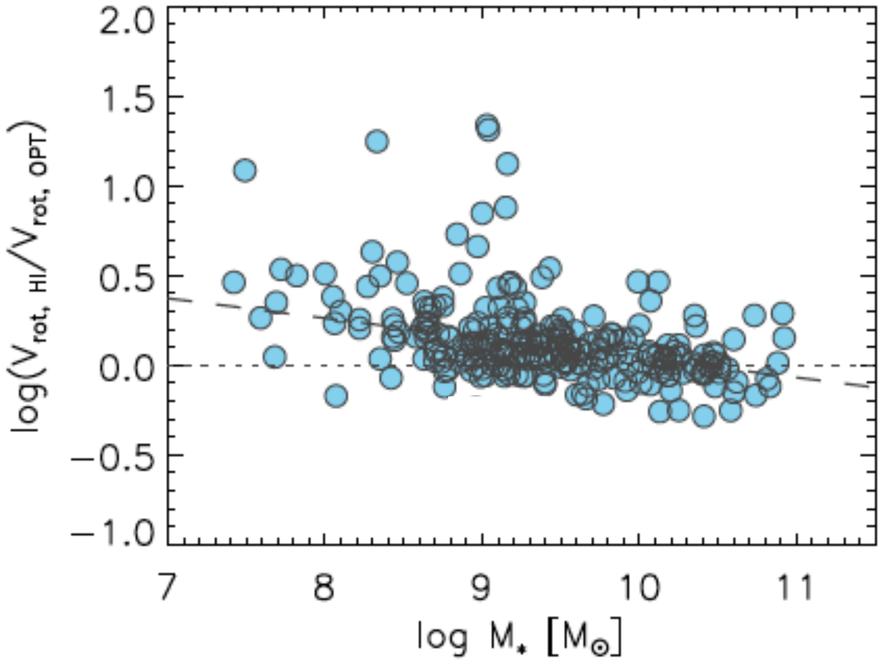
Are low M★ outliers due to an aperture effect?

Average RCs in luminosity bins (~stellar mass)



Catinella et al. 2006

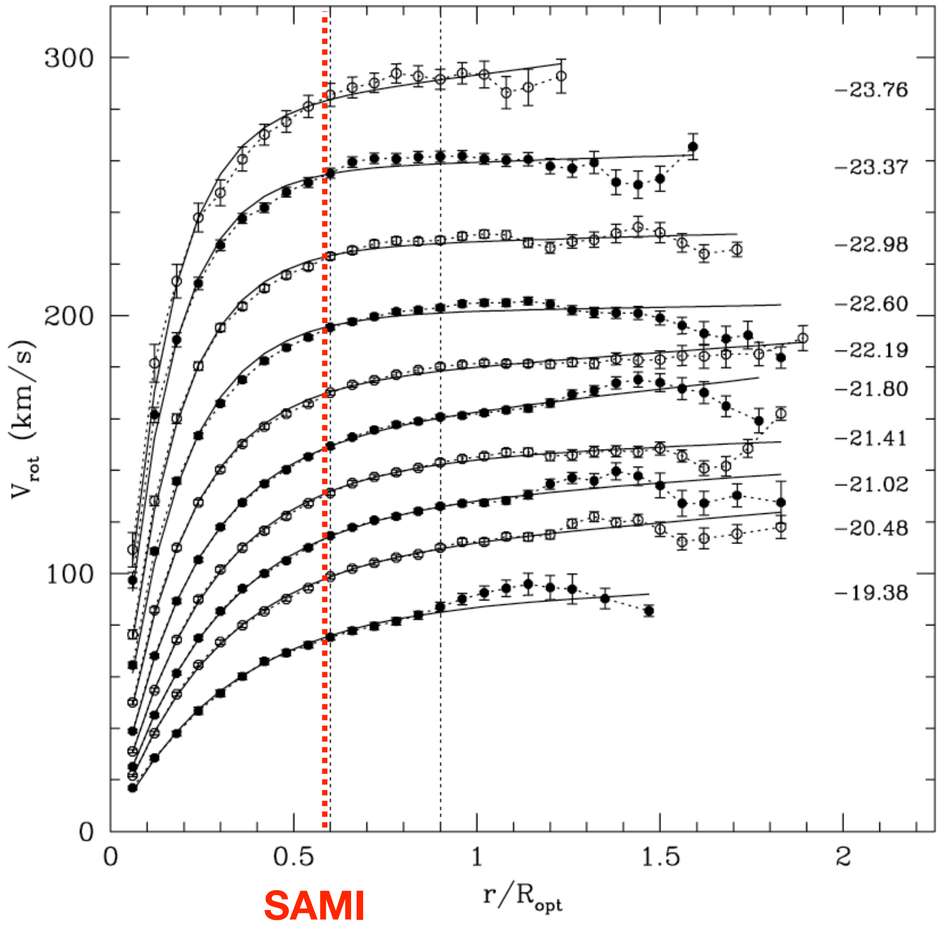
HI/OPT rotational velocity ratio (independent of inclination) as a function of M★



- Optical velocities underestimate HI ones, especially at low M★
- Trend of velocity ratio with stellar mass is due to RC shape + aperture effect

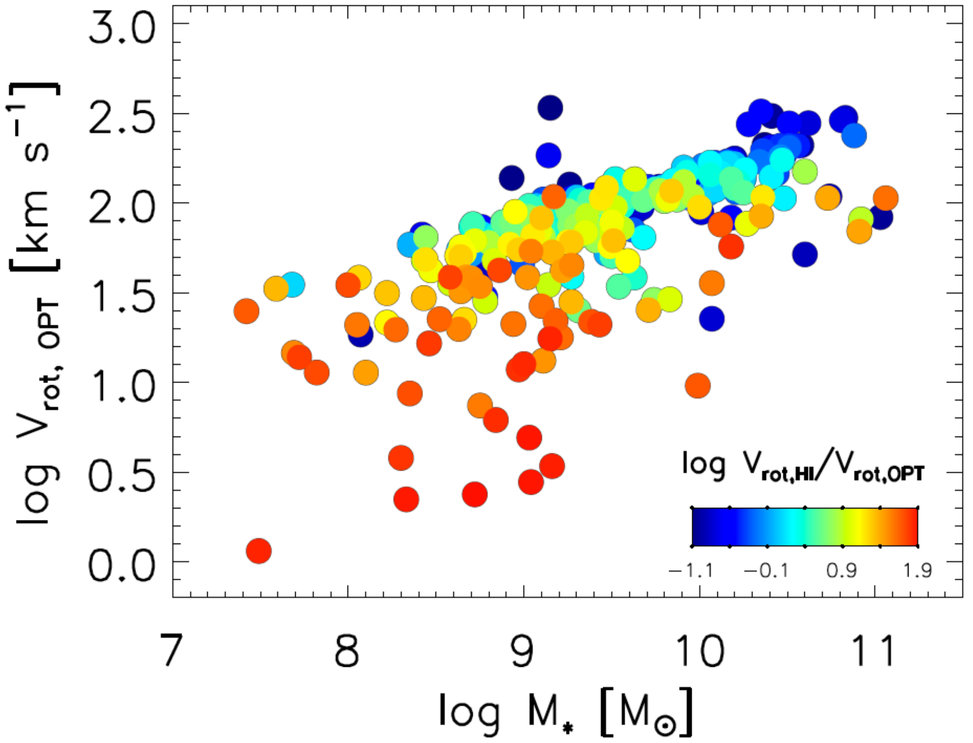
Are low M★ outliers due to an aperture effect?

Average RCs in luminosity bins (~stellar mass)



Catinella et al. 2006

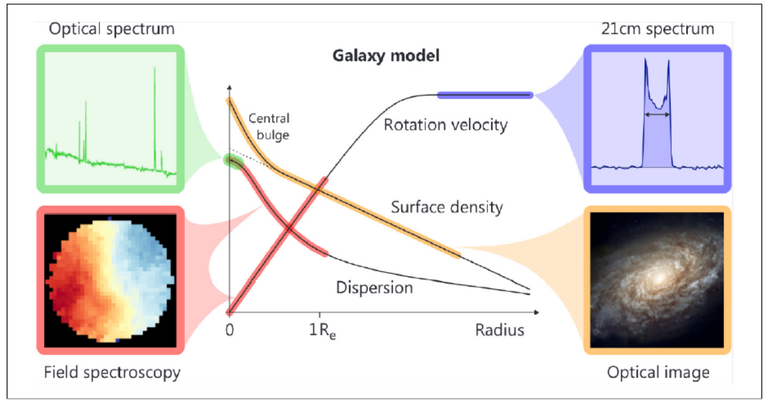
SAMI TFR color-coded by HI/OPT velocity ratio

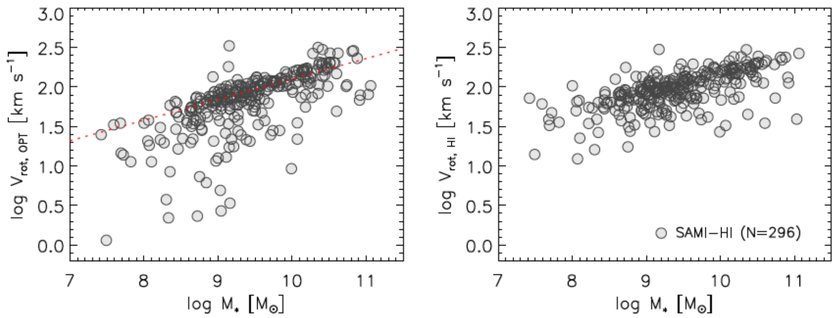


- ✦ Optical velocities underestimate HI ones, especially at low M★
- ✦ Trend of velocity ratio with stellar mass is due to RC shape + aperture effect

Take-home messages

- Synergy between HI and IFS is not trivial
- **SAMI-HI** survey: designed to increase the overlap between IFS and HI samples
- SAMI TFR shows outliers at low M★ that are not seen in the HI TFR
- These can be explained by the fact that, at low M★, RC are rising and SAMI does not reach the flat part
- Implication: careful interpreting TFR offsets (e.g., high z) based on data that do not reach the flat part of the RC





Outlook

- SKA (and precursor) HI surveys will improve statistics (tremendously) and spatial resolution
- If kinematic Hα asymmetry is important at low M★, how does it connect to HI asymmetry? → check Adam Watts' pre-recorded talk in session 3!