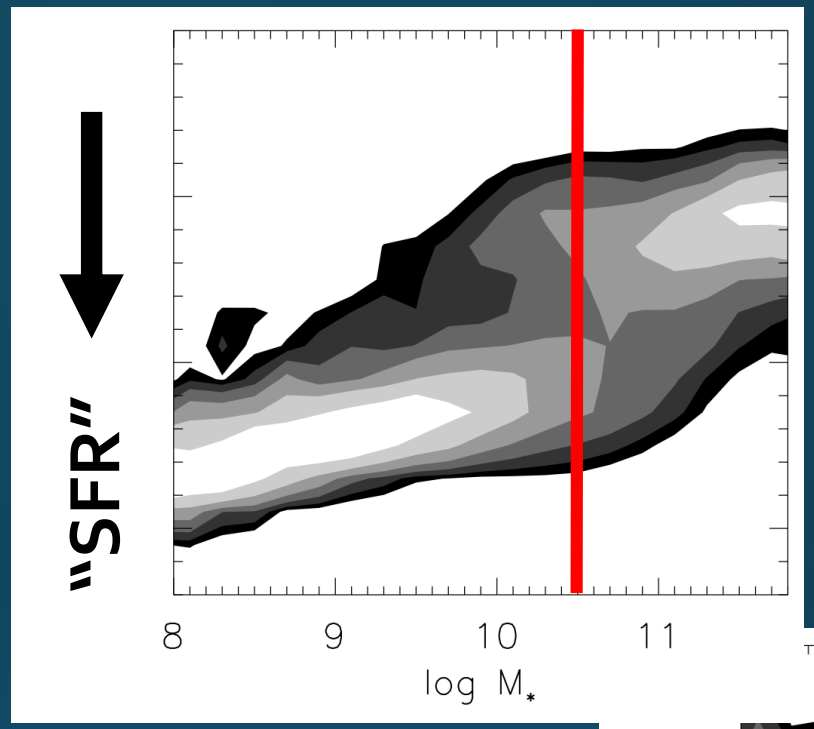
Galaxies Growing Old: The Transition to Quiescence at $3 \times 10^{10} M_{\odot}$

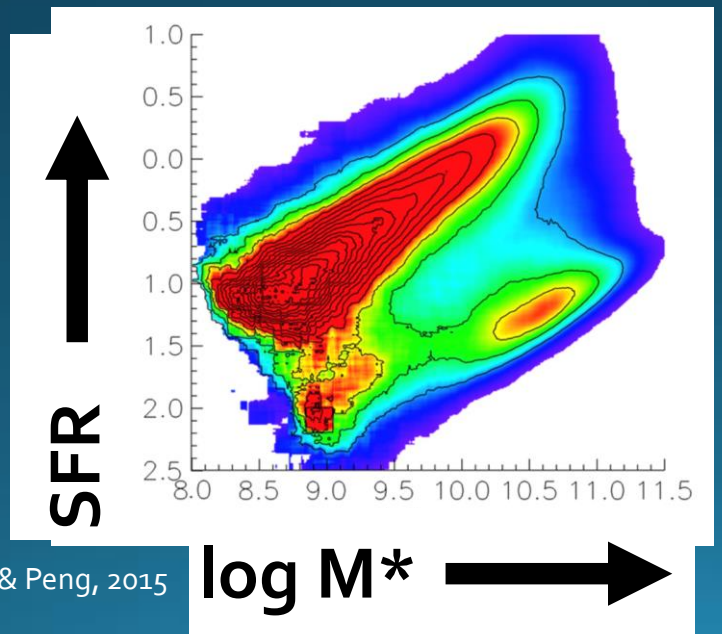
Philip Taylor (ANU) with Christoph Federrath (ANU) & Chiaki Kobayashi (UK)

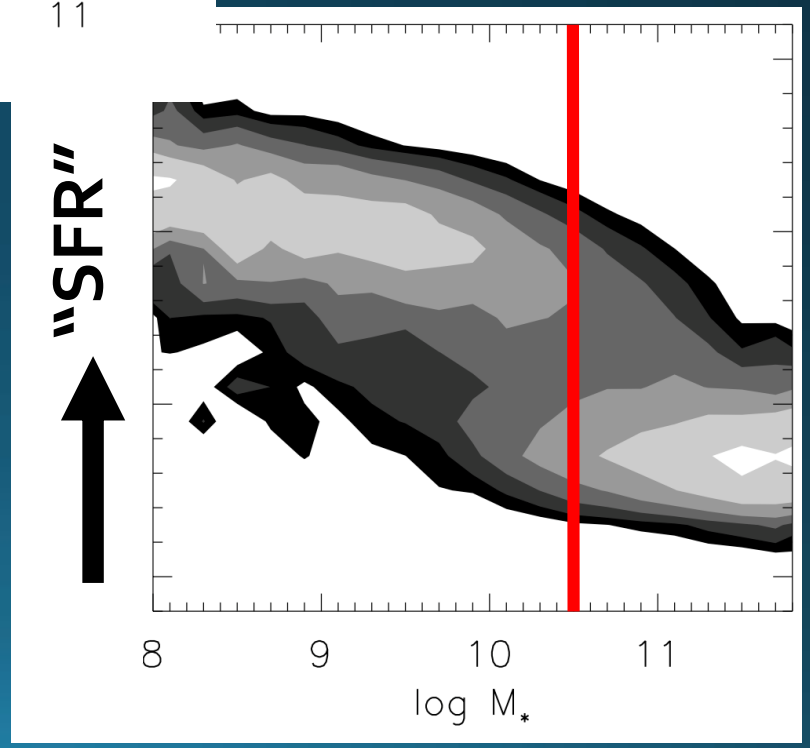
$3 \times 10^{10} \mathrm{M}_{\odot}$

- Kauffmann+03 find sharp transition in star formation properties of SDSS galaxies at $M_* = 3 \times 10^{10} \mathrm{M}_{\odot}$

- ETGs and LTGs clearly separated in SFR – M_* plane



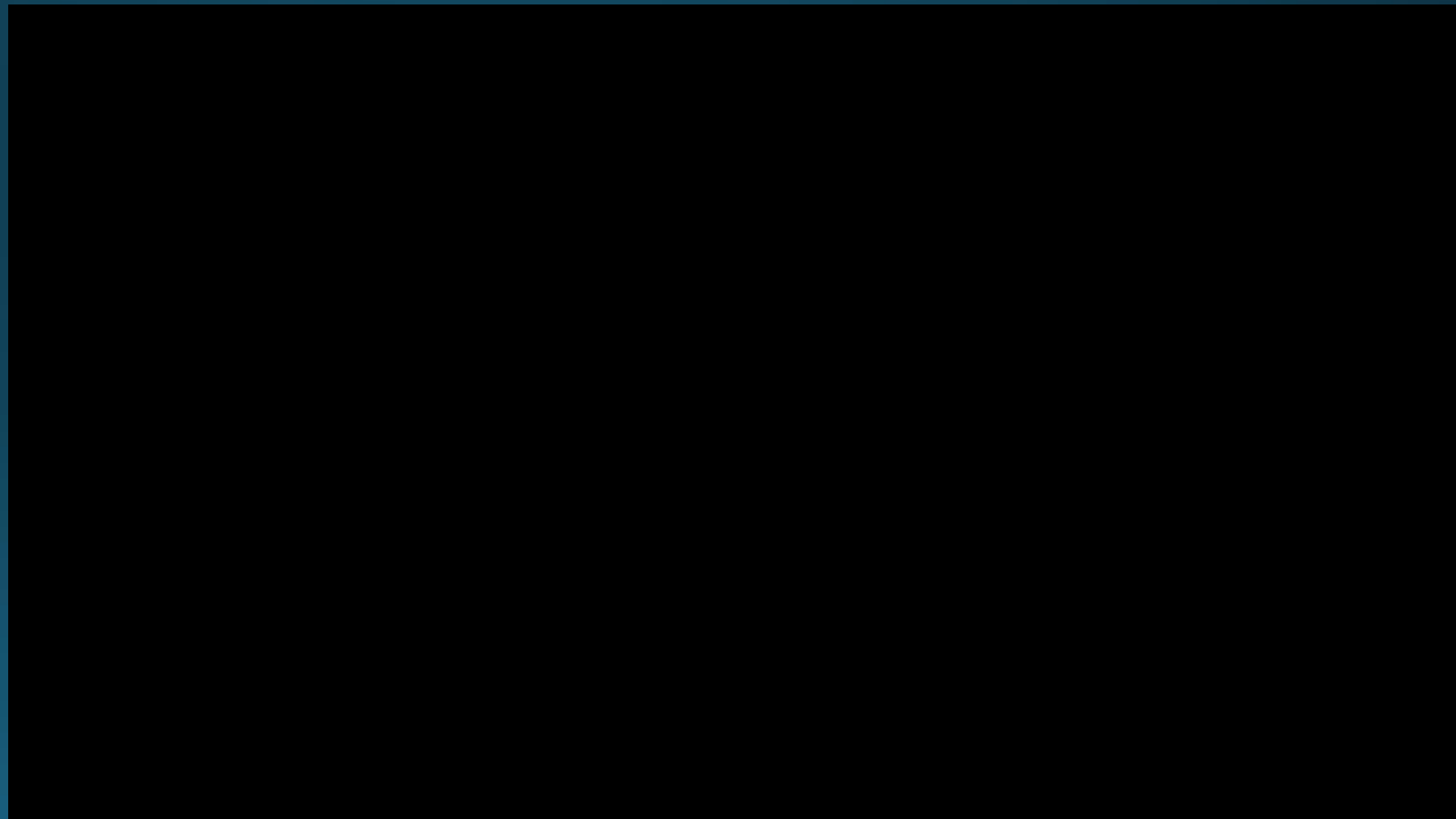




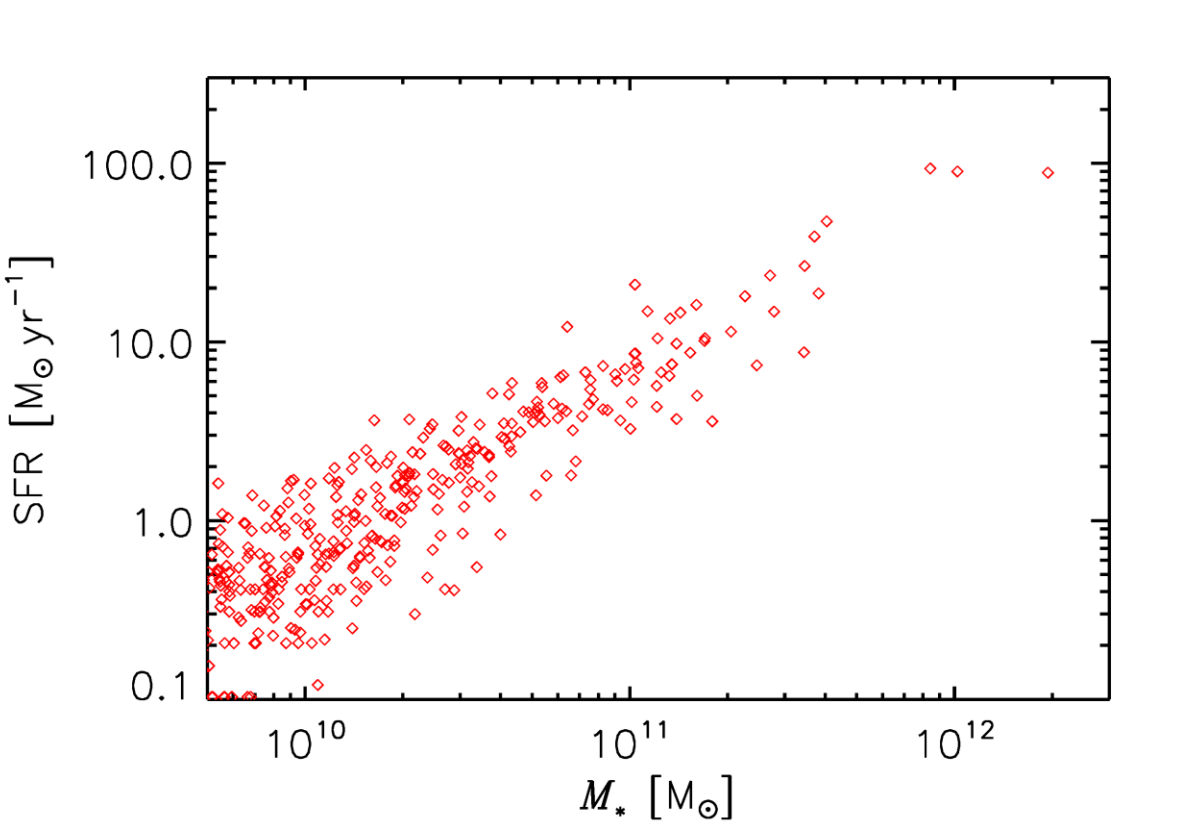
Renzini & Peng, 2015

My Simulations

- $(25h^{-1}\mathrm{Mpc})^3$ periodic box
- ICs have $(240)^3$ each DM & gas
- Star formation, evolution, & feedback (Kobayashi+04,06,07, 11)
- BH formation and growth, & AGN feedback (Taylor & Kobayashi 14)



Simulated SFMS



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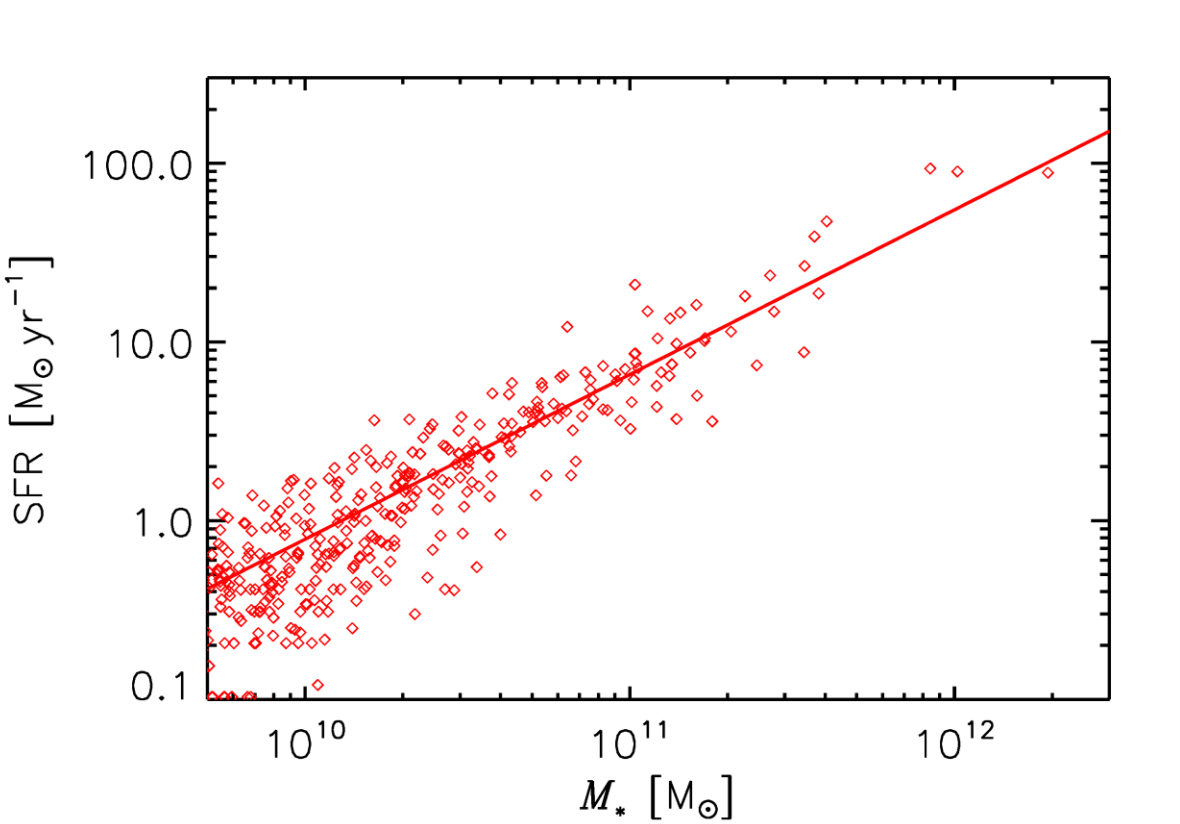

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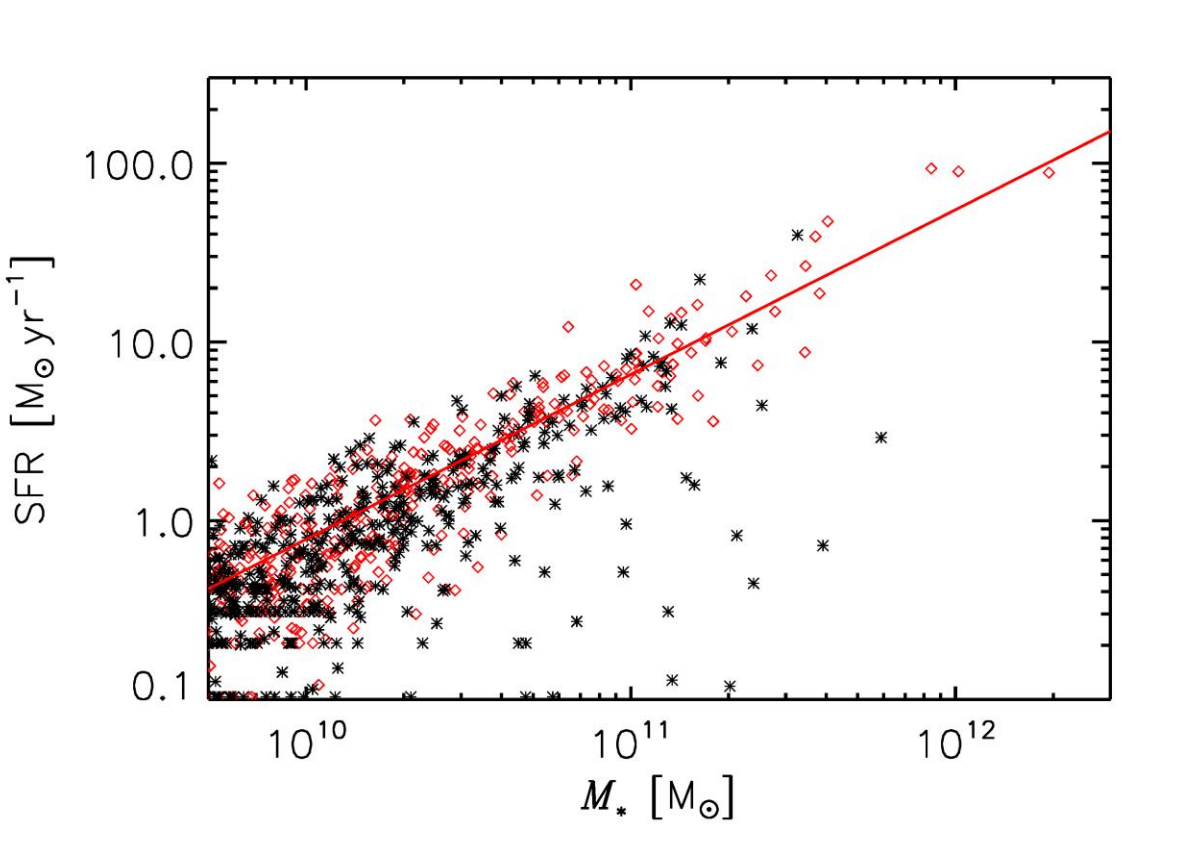

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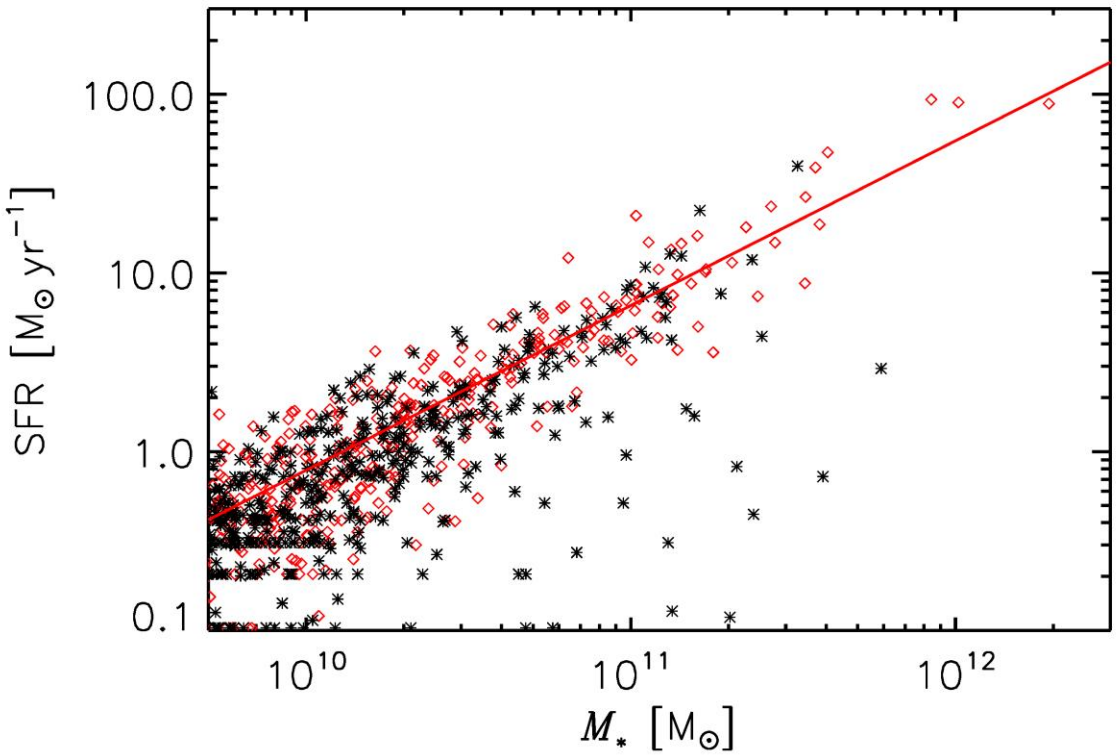
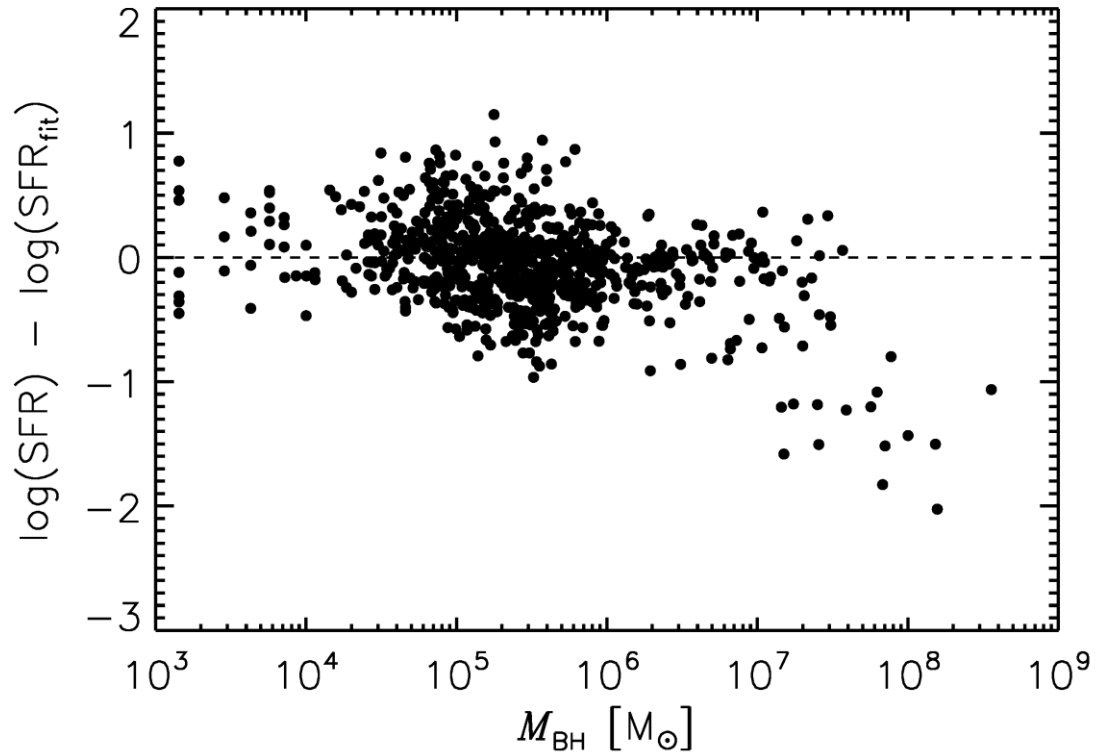




Modelling SFR of All Galaxies

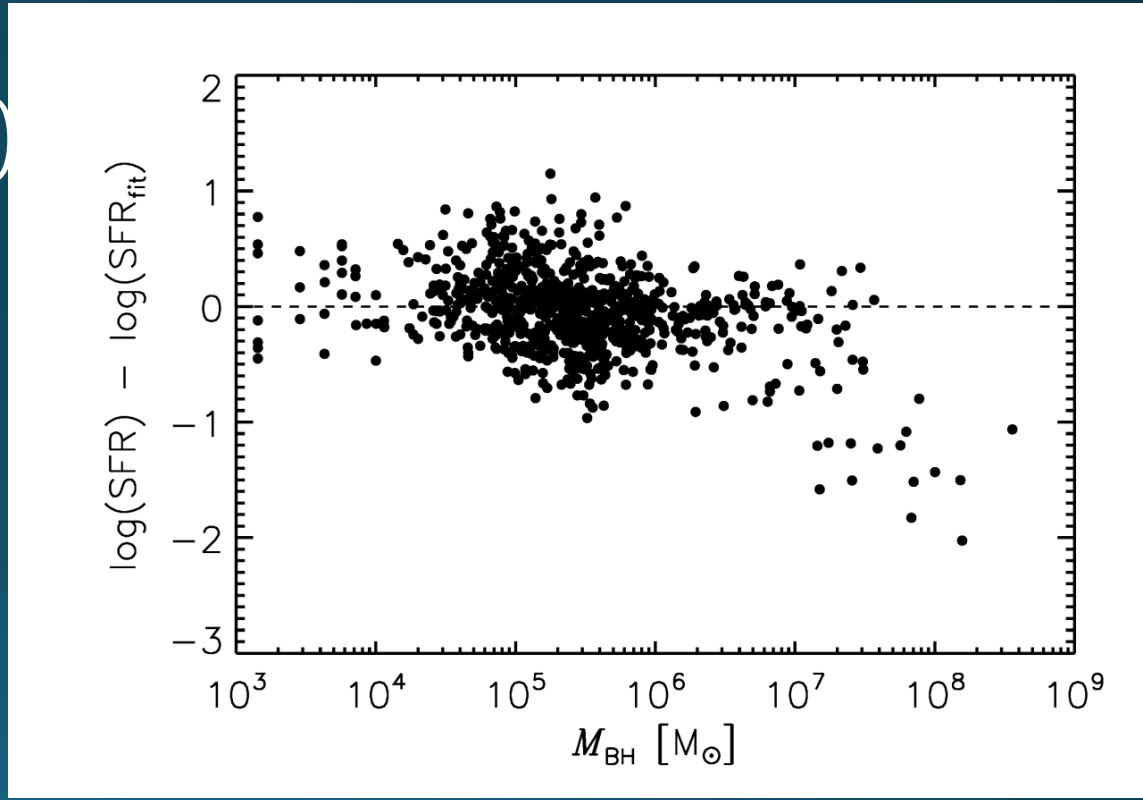
$$\mathrm{SFR} = A \times M_*^{\alpha} \times s_5^{\beta} \times M_{\mathrm{gas}}^{\gamma} \times f(M_{\mathrm{BH}})$$

Galaxy stellar mass

Gas mass in galaxy

5^{th}-nearest neighbour distance ≡ galaxy environment

$$\log f(M_{\mathrm{BH}}) = \begin{cases} k_1 \log M_{\mathrm{BH}} & M_{\mathrm{BH}} < M_b \\ k_2 \log M_{\mathrm{BH}} + (k_1 - k_2) \log M_b & M_{\mathrm{BH}} \geq M_b \end{cases}$$



Taylor, Federrath, Kobayashi 2017

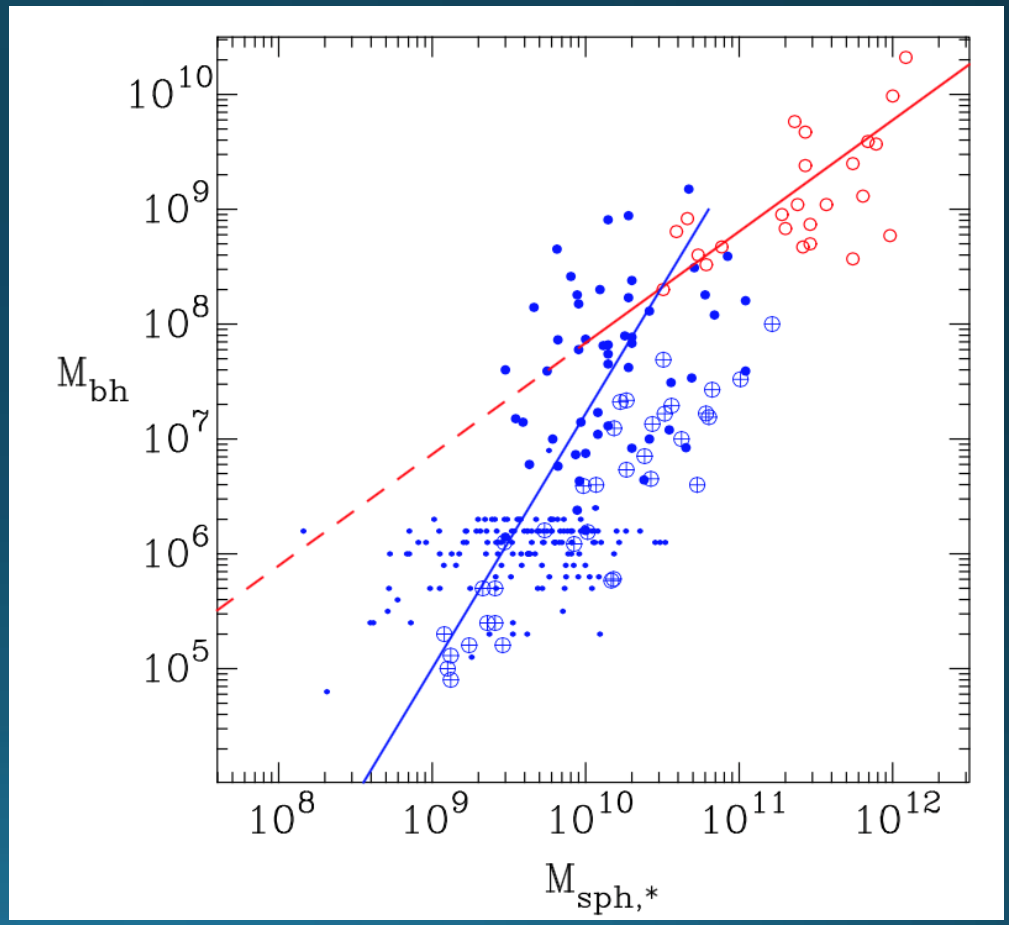
M_b

$$M_b \approx 2 - 5 \times 10^7 \mathrm{M}_\odot$$

$$\boxed{M_{\mathrm{BH}} - M_{\mathrm{bulge}} \text{ relation}}$$

$$M_{\mathrm{bulge}} \approx 1 - 2 \times 10^{10} \mathrm{M}_\odot$$

Graham & Scott, b2015



Other Implications

$$\log f(M_{\rm BH}) = \begin{cases} 0.00 & M_{\rm BH} < 10^{7.31} \\ -1.11(\log M_{\rm BH} - 7.31) & M_{\rm BH} \geq 10^{7.31} \end{cases}$$

$$\mathrm{SFR} \propto M_{*}^{0.21} \times s_5^{-0.17} \times M_{\rm gas}^{1.03} \times f(M_{\rm BH})$$

Weaker than implied by SFMS $\alpha \sim 0.75 - 1$
(e.g., Elbaz+11, Zahid+12, Renzini & Peng 15)

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$SFR \propto M_{\rm gas} \Longrightarrow \Sigma_{\rm SFR} \propto \Sigma_{\rm gas}$ i.e. Kennicutt-Schmidt law.

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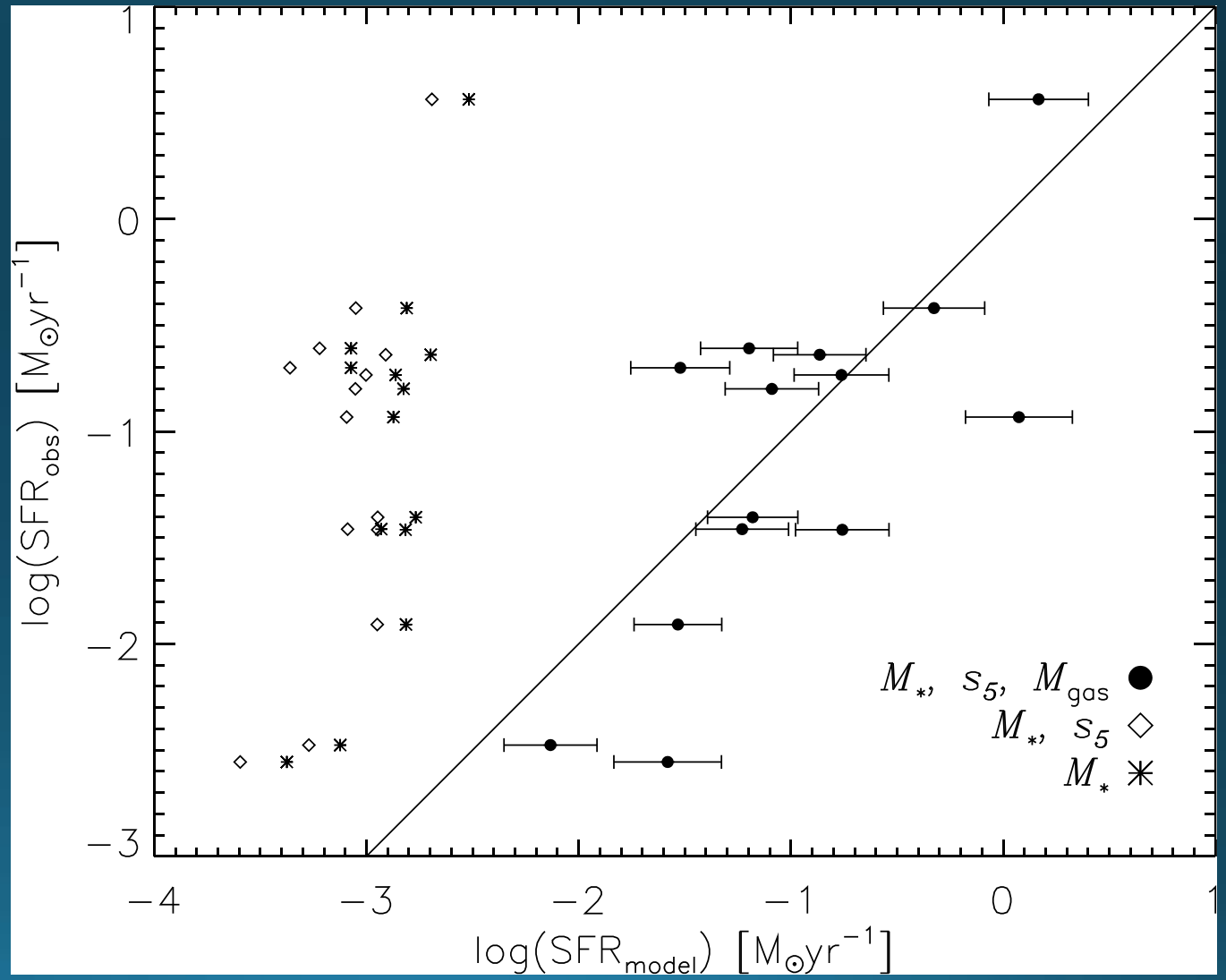
Comparison to Observations

Observational SFR, M_*, s_5 from GAMA.
M_{HI} from ALFALFA.

Associate detections separated by $0.^{\circ}01$ in RA and Dec.

Assume $M_{\mathrm{gas}} = M_{\mathrm{HI}}/0.75$



Conclusions

- By modelling simulated SFR in simple way, we find that BHs start to influence star formation in their host once they grow to about $2 - 5 \times 10^7 \mathrm{M}_\odot$. This mass is purely emergent, and corresponds to a bulge mass $1 - 2 \times 10^{10} \mathrm{M}_\odot$.

- Dependence of SFR on M_* weaker than implied by SFMS.

- Kennicutt – Schmidt law with $n = 1$ implied.

- Model matches fairly well with observations.