SMBH - galaxy scaling relations without self-regulating AGN feedback

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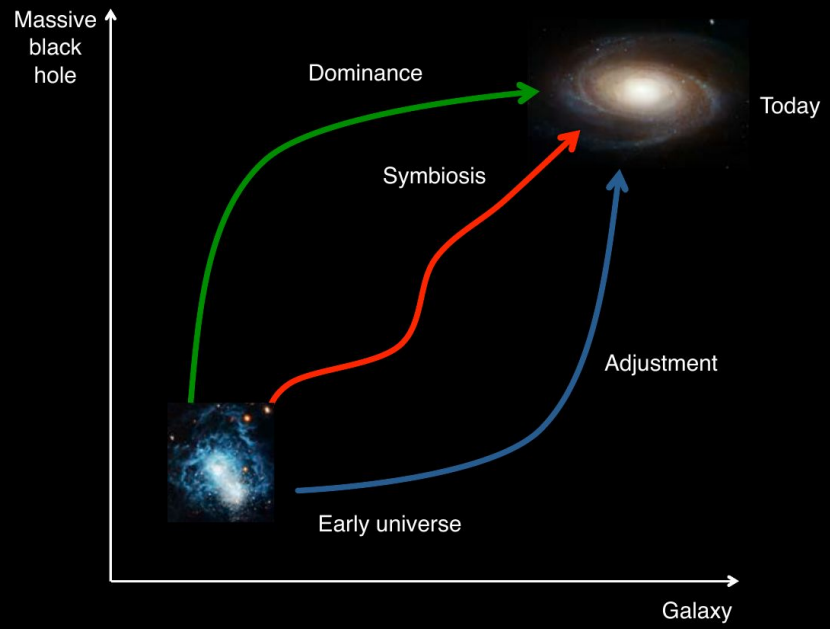
PHYSICAL INTERPRETATION

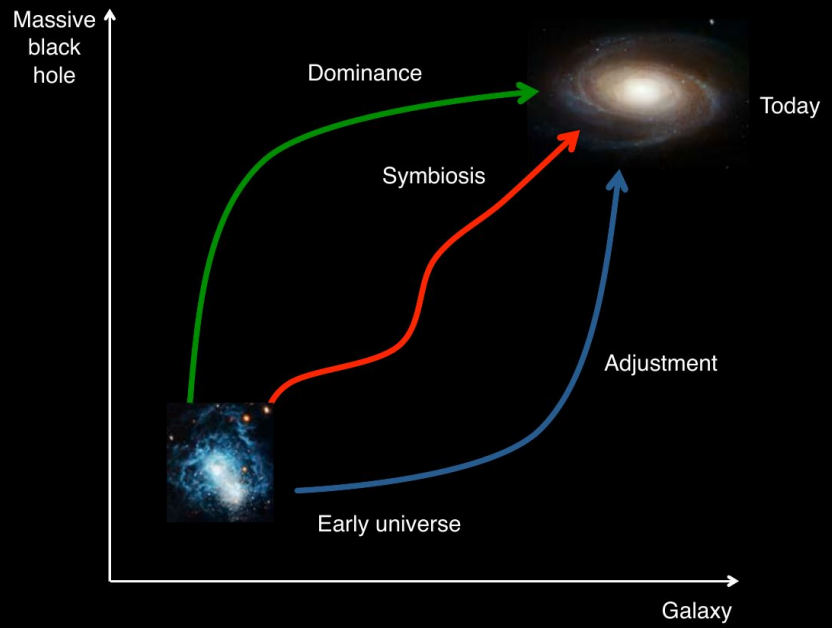


Volonteri - 2012

- $M_* - M_{BH}$ (Reines&Volonteri - 15, Savorgnan+16), $M_b - M_{BH}$ (Haring&Rix - 04, McConnell&Ma - 13, Kormendy&Ho - 13), σ-M_{BH} scaling relations.
- SMBH - Galaxy coevolution.
- Which evolutionary paths to follow?
- Scaling relations → sign of coevolution
- Galaxies → SFR, SMBH → Accretion rate
- Galaxies or SMBHs grow faster?
- Do they grow more or less symbiotically?

QUESTIONS TO ASK

- Responsible physical processes
- Which evolutionary path to reproduce local relations?
- Local scaling relations without self-regulating AGN feedback?
- If so, what more can we learn about the nature of SMBH-galaxy scaling relations?



Volonteri - 2012

MOTIVATION

What do we need?

- A cosmological context (Large Volume)
- High resolution
- Statistically important sample
- Wide redshift and halo mass range

MOTIVATION

PI: Robert Feldmann

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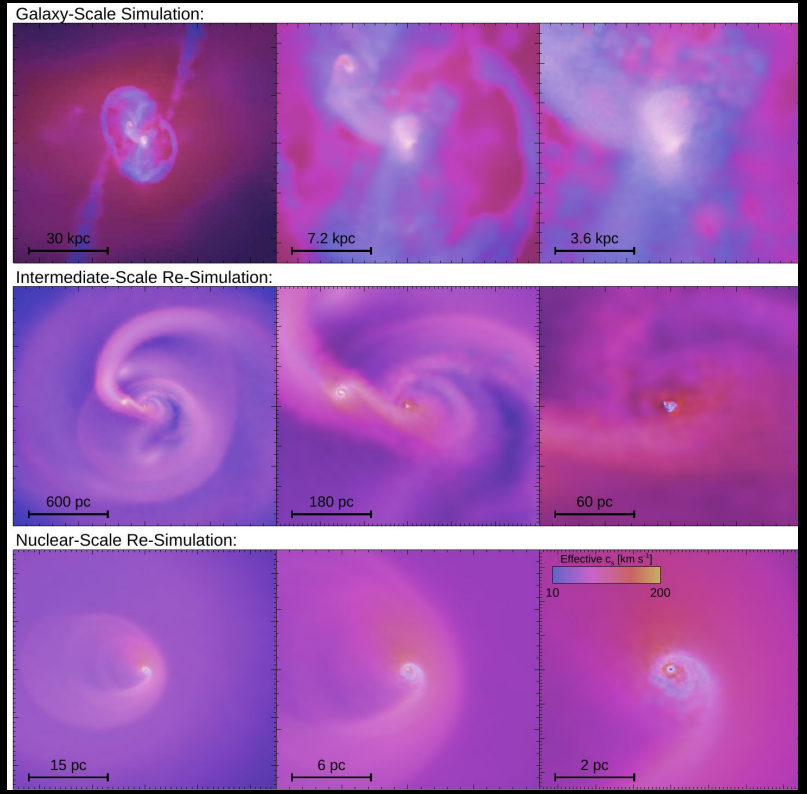
What we offer is:

- 37 large volume, high resolution cosmological simulations from MassiveFIRE suite.
- Post-processing analysis of SMBH growth using GTDA model.
- $2 < z < 12$, $9 < \log(M_H/M_\odot) < 13.5$

APPROACH

- **General Approach: Bondi Model**
- Scales with $\propto M_{BH}^{2}$, overprediction of M_{BH} --> AGN feedback solves this problem.
- **Alternative Approach: GTDA Model**
- Hopkins&Quataert - 10,11 performed nested simulations to understand how gas accretes from Mpc to sub-pc scale.
- Weakly dependent on M_{BH}
- Gravitational torques do the job, i.e. galaxy mergers, spiral instabilities and eccentric disk modes...



METHODOLOGY

?

Amiga Halo Finder (AHF) (Knollman & Knebe - 2009)

?

use AHF mergertree to trace halo back

?

put BH seed of $10^4\,M_\odot$ at the centre of the halo IF $M_* \geq 10^7\,M_\odot$

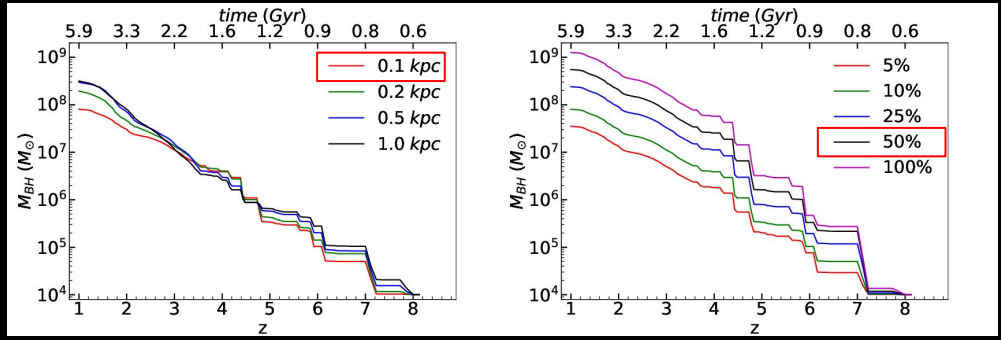
evolve black hole mass with GTDA model

$$\dot{M}_{torque} = \epsilon_m \alpha_T \times f_d^{5/2} \left(\frac{M_{BH}}{10^8 M_\odot}\right)^{1/6} \left(\frac{M_{tot}(< R_0)}{10^9 M_\odot}\right) \times \left(\frac{R_0}{100pc}\right)^{-3/2} \left(1 + \frac{f_0}{f_{gas}}\right)^{-1} M_\odot yr^{-1}$$

PARAMETER STUDY

Bigger radial aperture, slightly higher accretion rate.

Mass retention rate (ε_m) : percentage of gas accretes on BH.



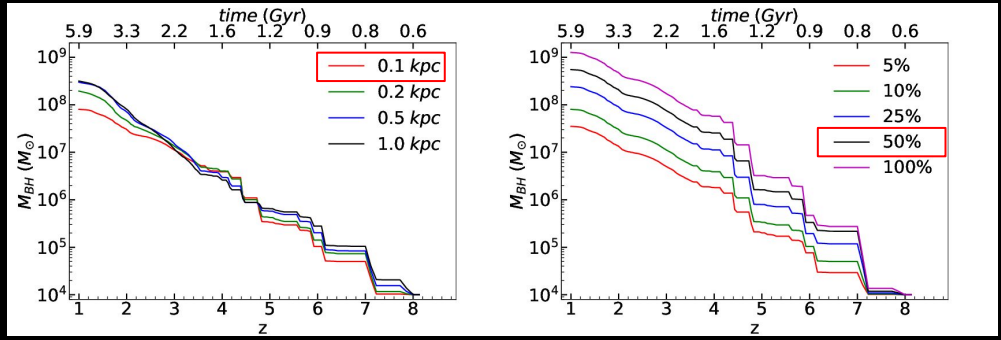
PARAMETER STUDY

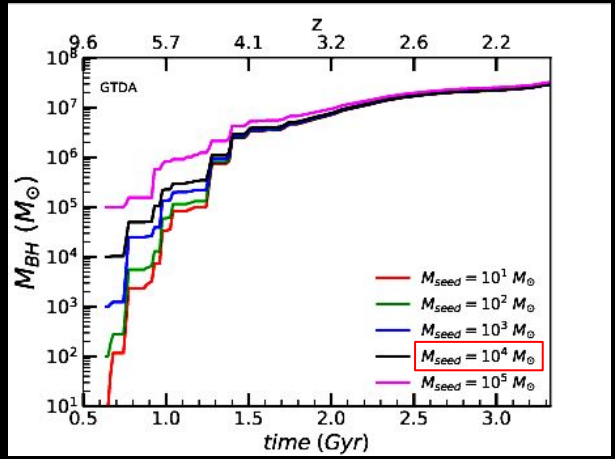
Bigger radial aperture, slightly higher accretion rate.

Mass retention rate (ε_m) : percentage of gas accretes on BH.

System loses its memory of seed mass choice after ~ 1 Gyr.

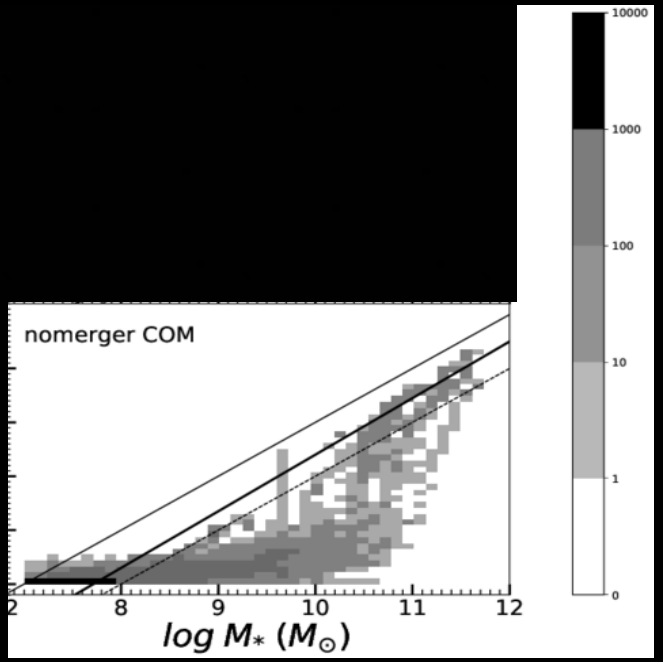
Fiducial case





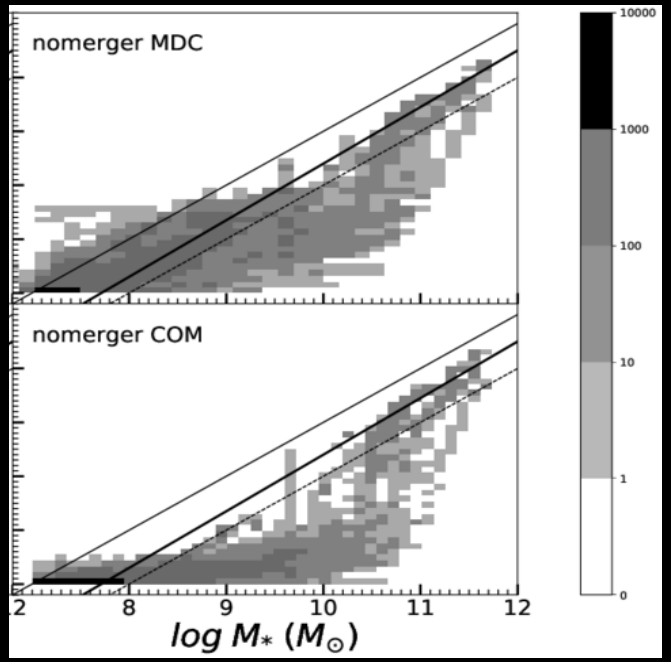
SCALING RELATIONS

- No gas, no merger = adjustment



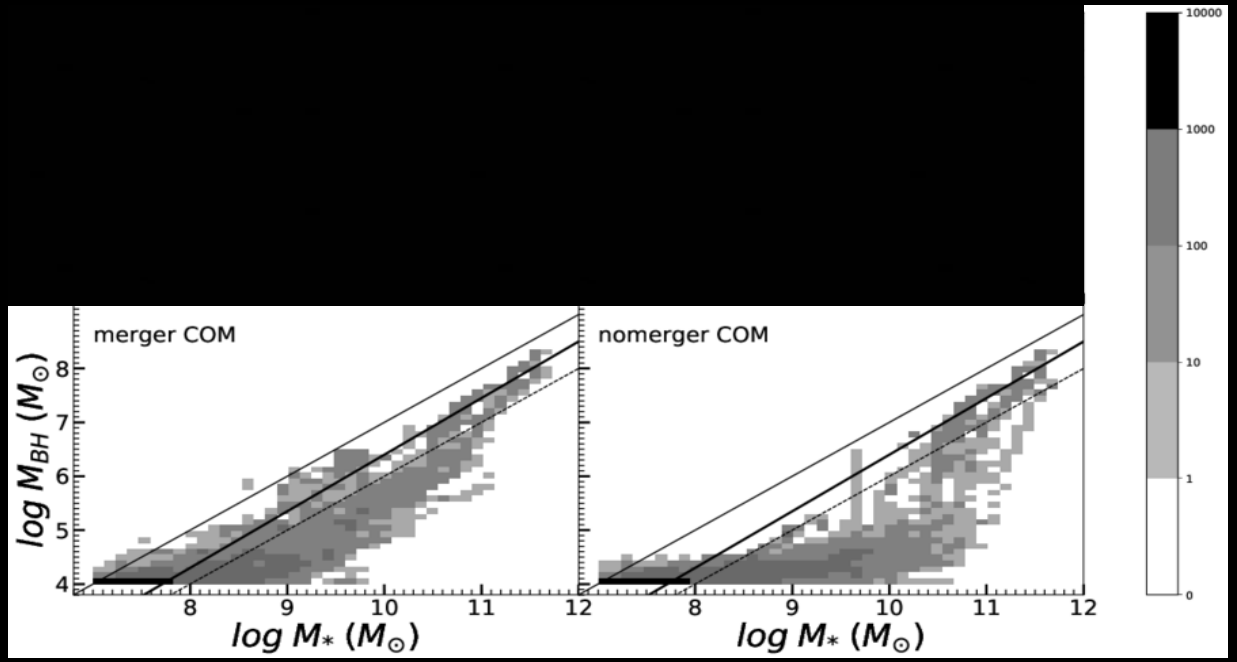
SCALING RELATIONS

- No gas + no merger = adjustment
- Gas + no merger = early growth pronounced

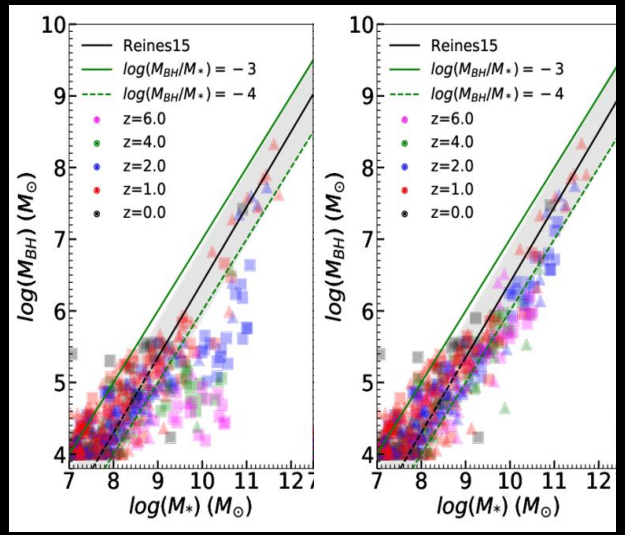


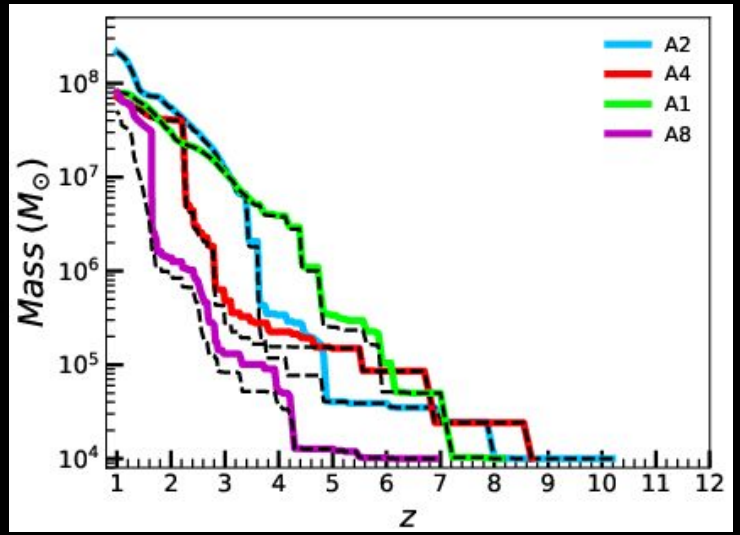
SCALING RELATIONS

- No gas + no merger = adjustment
- Gas + no merger = early growth pronounced
- No gas + merger = symbiosis



SCALING RELATIONS



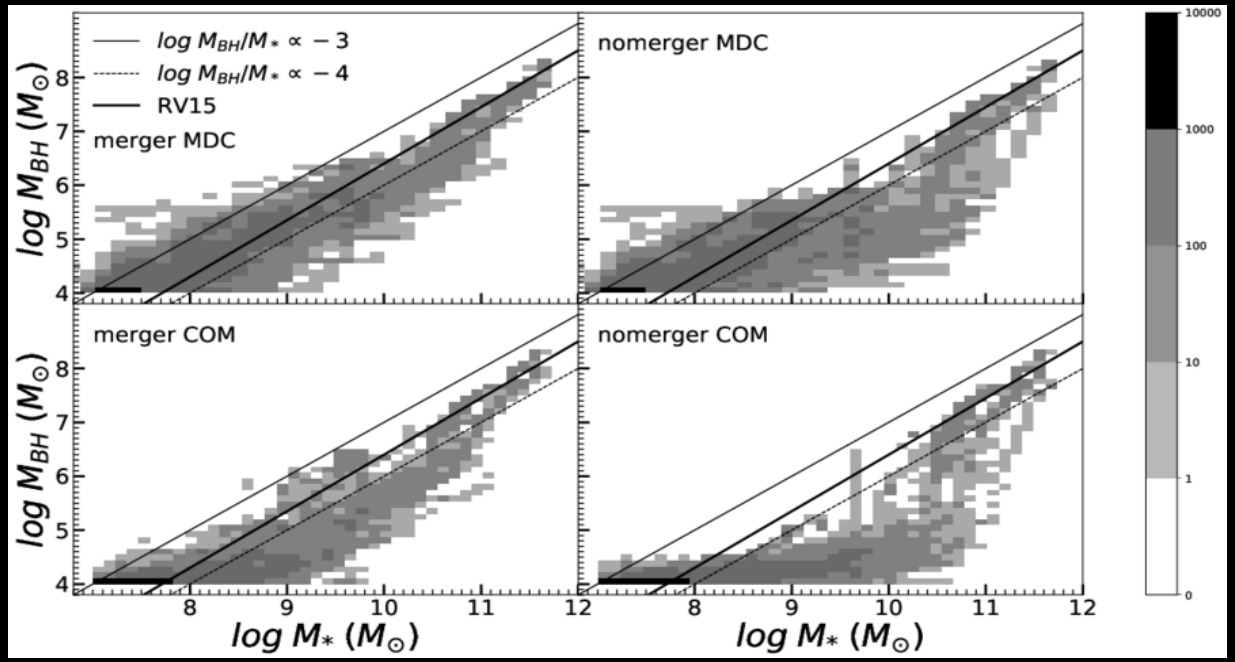


Merger treatment shifts up early trend of M_*-M_{BH} scaling relation.

Solid lines are total M_{BH}, dashed lines are accretion contribution to total M_{BH}.

SCALING RELATIONS

- No gas + no merger = adjustment
- Gas + no merger = early growth pronounced
- No gas + merger = symbiosis
- Gas + merger = from dominance to symbiosis
- Accelerated growth at $M_* \sim 10^{10} M_\odot$.
- No effect on the final SMBH mass.



SUMMARY

- SMBH-Galaxy scaling relations can be reproduced without self-regulating AGN feedback.
- Need for self-regulation depends on the accretion prescription.
- Early environment of BHs and merger treatment are important to set the trend of $M_* - M_{BH}$ scaling relation.
- Importance of seed mass choice is only pronounced in accretion models that have high M_{BH} dependence.
- Redshift evolution of $M_* - M_{BH}$ scaling relation? Come and talk to me.

THANK YOU