

BETTER UNIVERSE MODELS, TOO MANY BINARY BLACK HOLE MERGERS

Cecilia Sgalletta

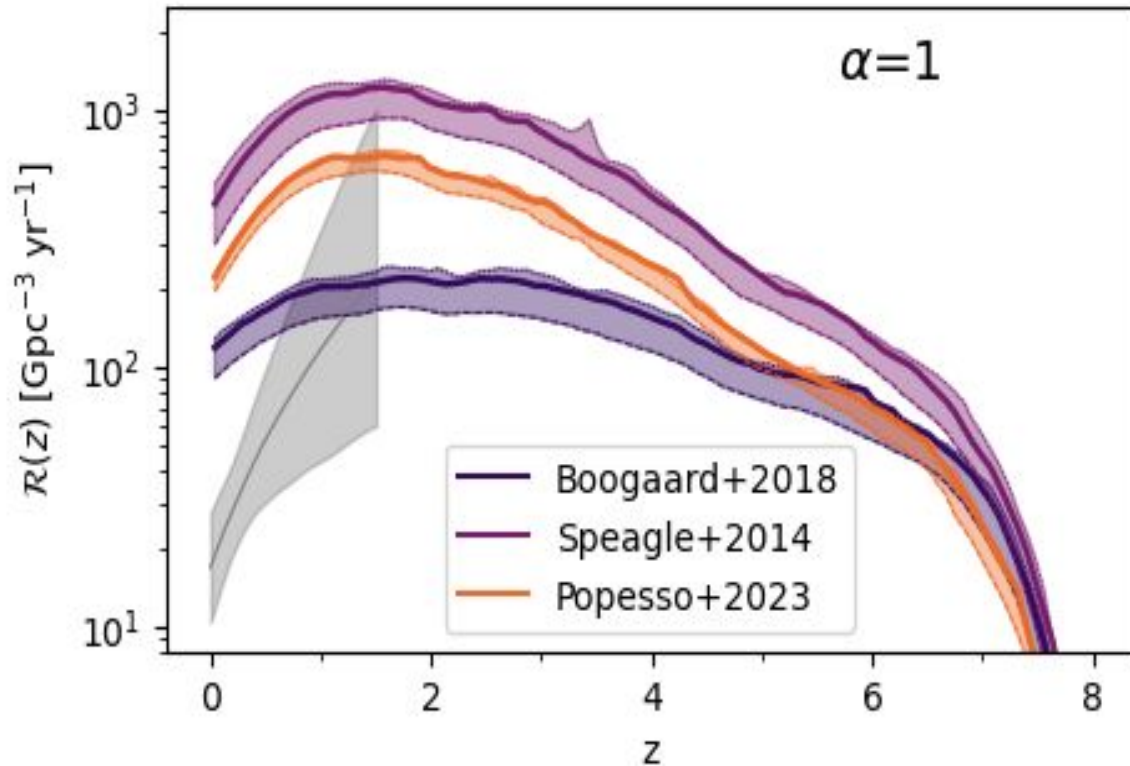
[The more accurately we model the metal-dependent star formation rate, the larger the predicted excess of binary black hole mergers - Astrophysics Data System](#)

ET-OSB DIV3, 29 NOVEMBER 2024

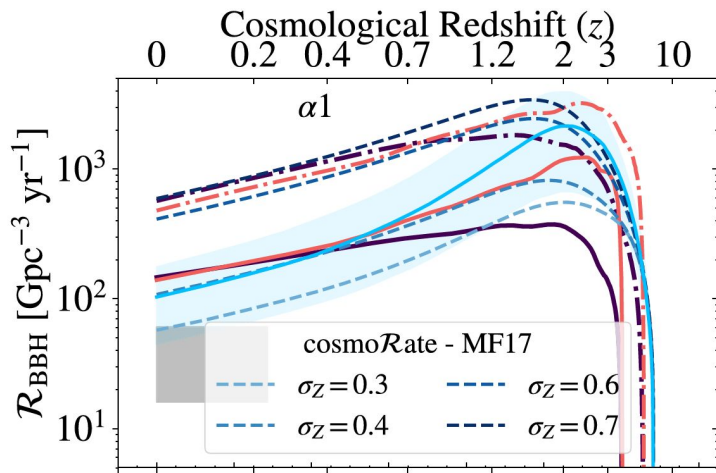
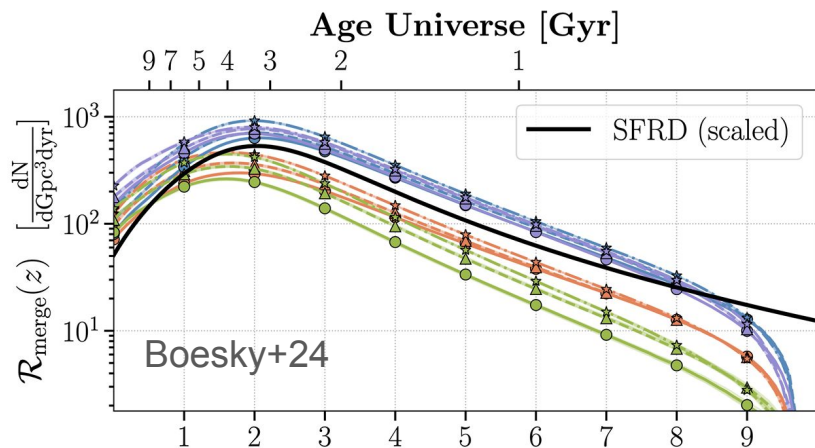
Main collaborators: Mario Spera, Michela Mapelli, Andrea Lapi, Giuliano Iorio, ...



BETTER MODELS OF THE UNIVERSE
LEAD TO HIGHER BBHS MERGER
RATES, COMPARED TO THE LVK DATA

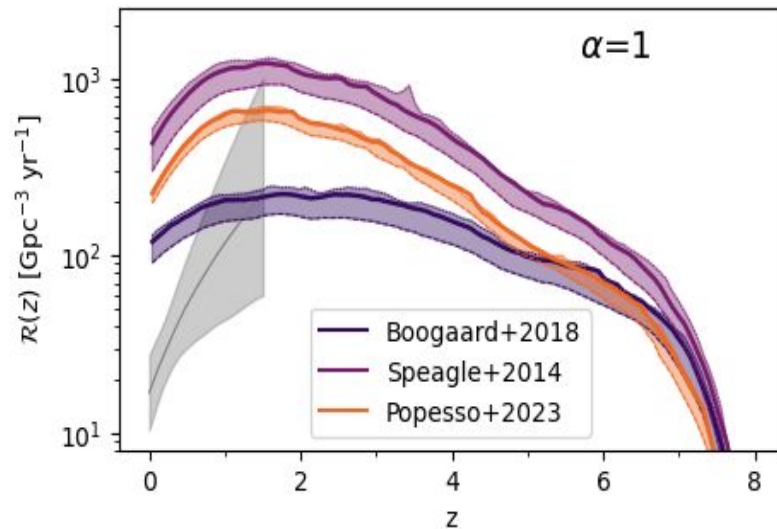


BETTER MODELS OF THE UNIVERSE
LEAD TO HIGHER BBHS MERGER
RATES, COMPARED TO THE LVK DATA



Santoliquido+22

Sgalletta+24



Cosmological context

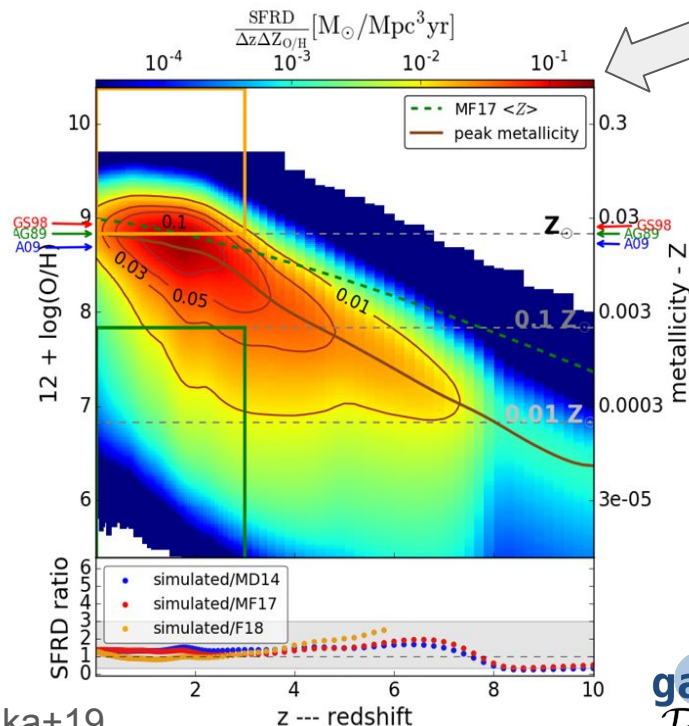
The metallicity-dependent cosmic star formation history can significantly affect the properties of binary compact object mergers



Spera+17, Spera+19, Iorio+23

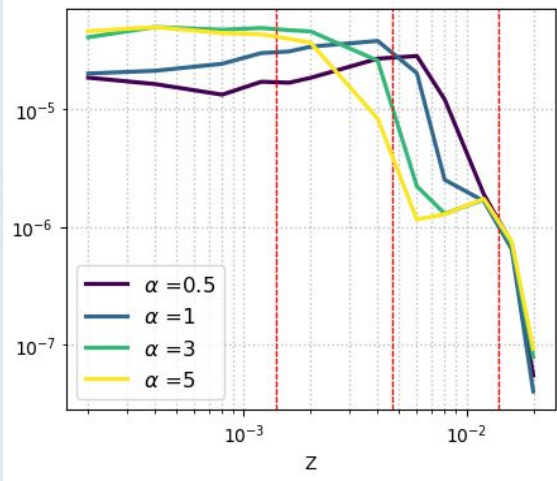
[SEVNcodes](#) / [SEVN](#) · [GitLab](#)

- Major issues:**
1. Star-forming metallicities are poorly constrained at $z > 3$ (JWST will improve it!)
 2. Low-mass galaxy properties are more difficult to observe and poorly constrained
 3. Metallicity calibration issues



Chruslinska+19

Merging efficiency



- stellar winds
- SN kicks
- radial expansion

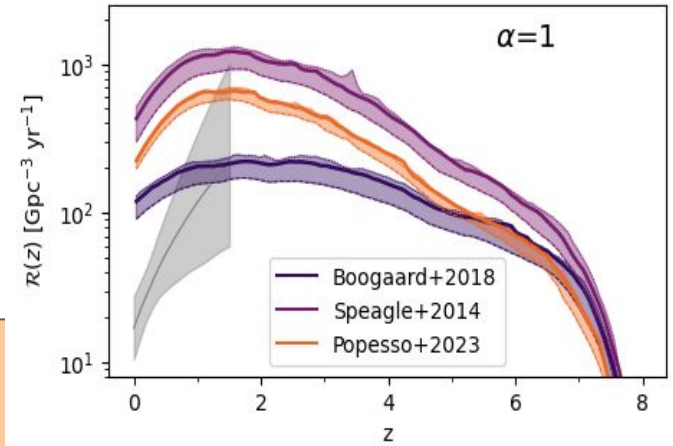
see Chruslinska2024 for a review

galaxy
Rate

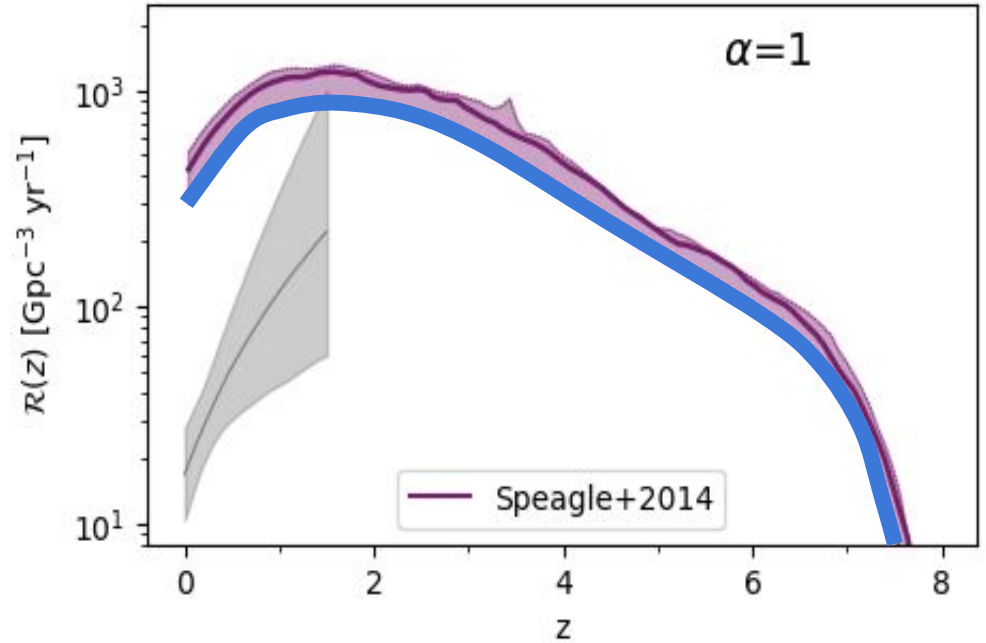
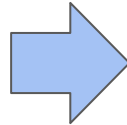
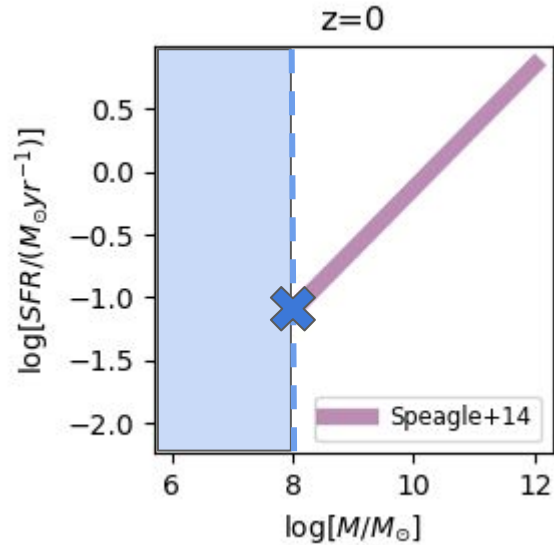
Santoliquido et al. 2022

WHAT IS THE IMPACT OF THE METAL-DEPENDENT STAR FORMATION RATE (SFR)
ON THE BINARY BLACK HOLE (BBH) MERGER RATE?

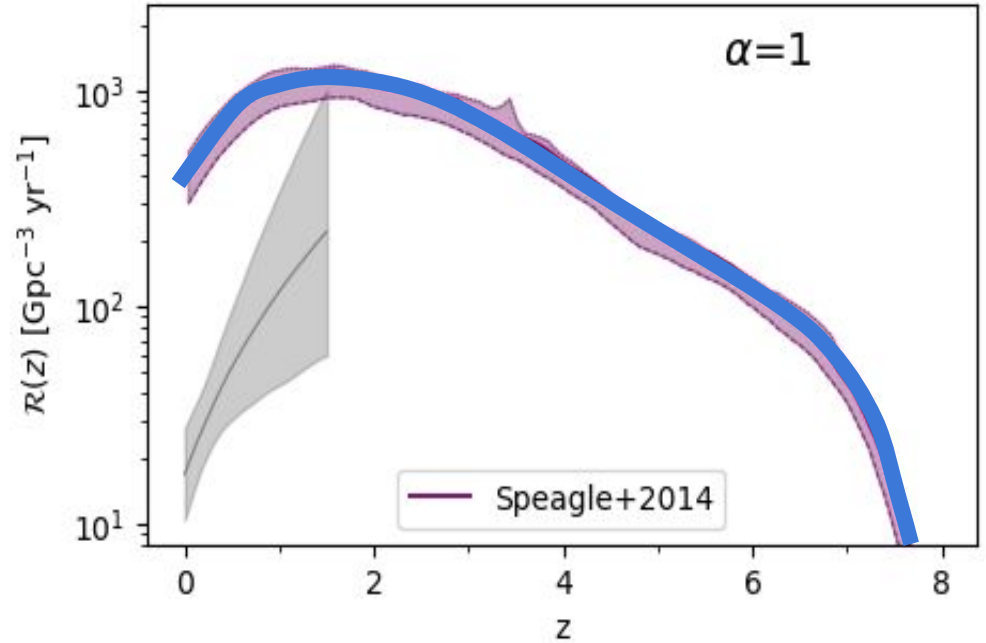
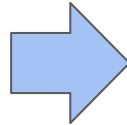
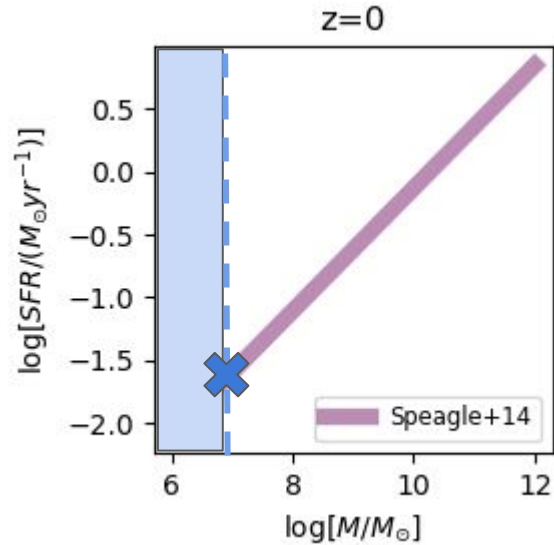
1. Low - mass galaxies impact
2. SFR - Galaxy mass relations
3. Fundamental metallicity relations



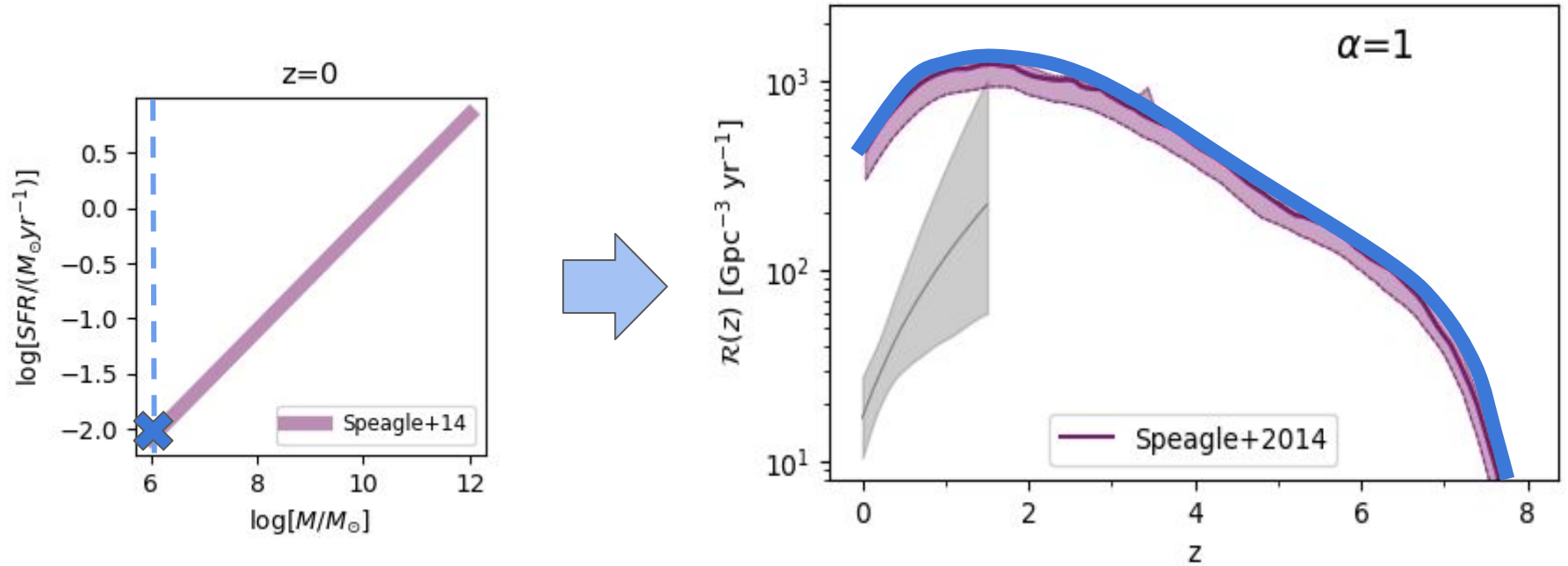
Minimum galaxy mass variations



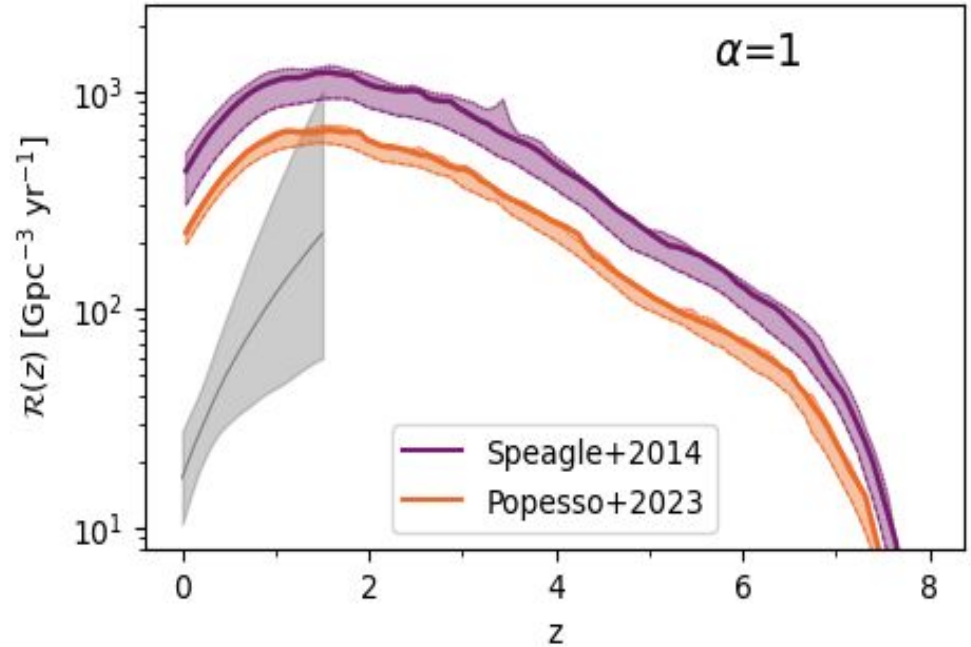
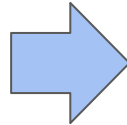
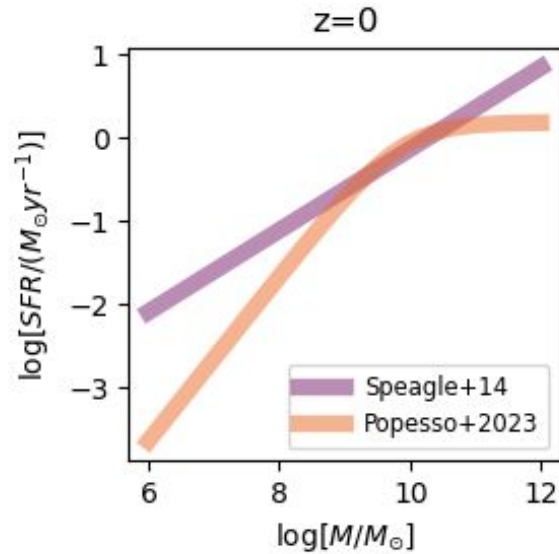
Minimum galaxy mass variations



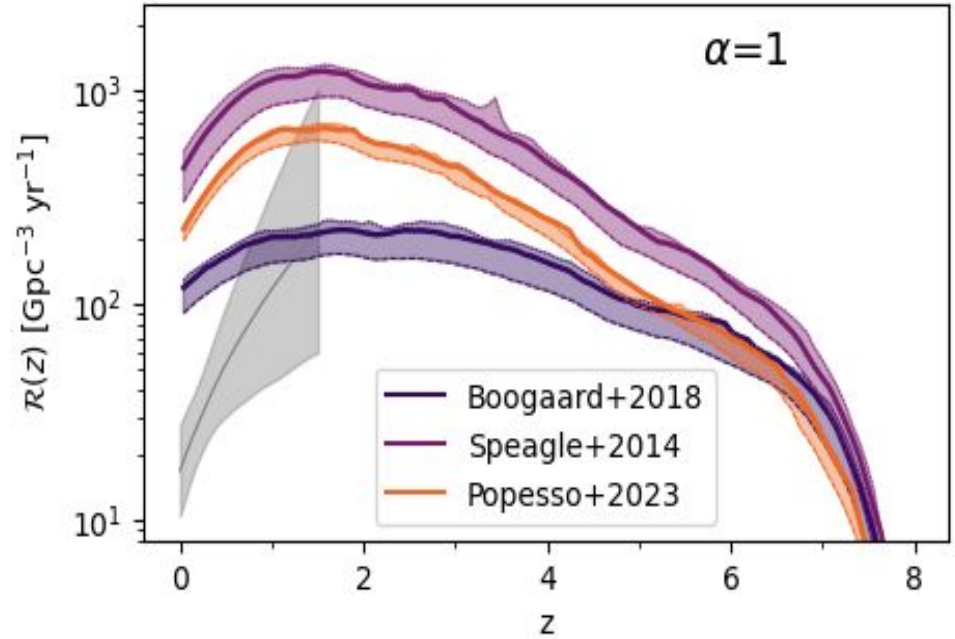
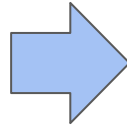
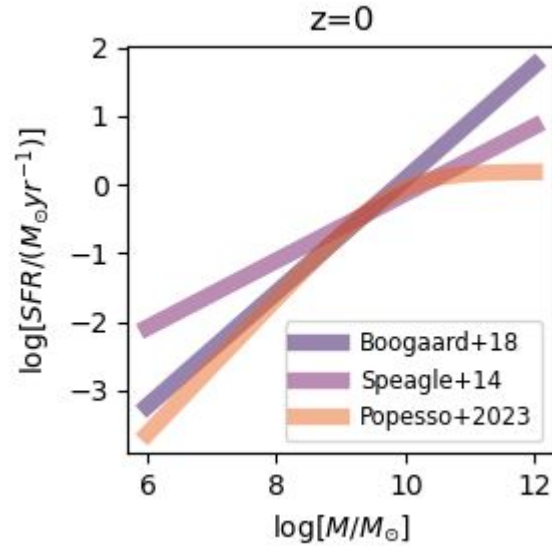
Minimum galaxy mass variations



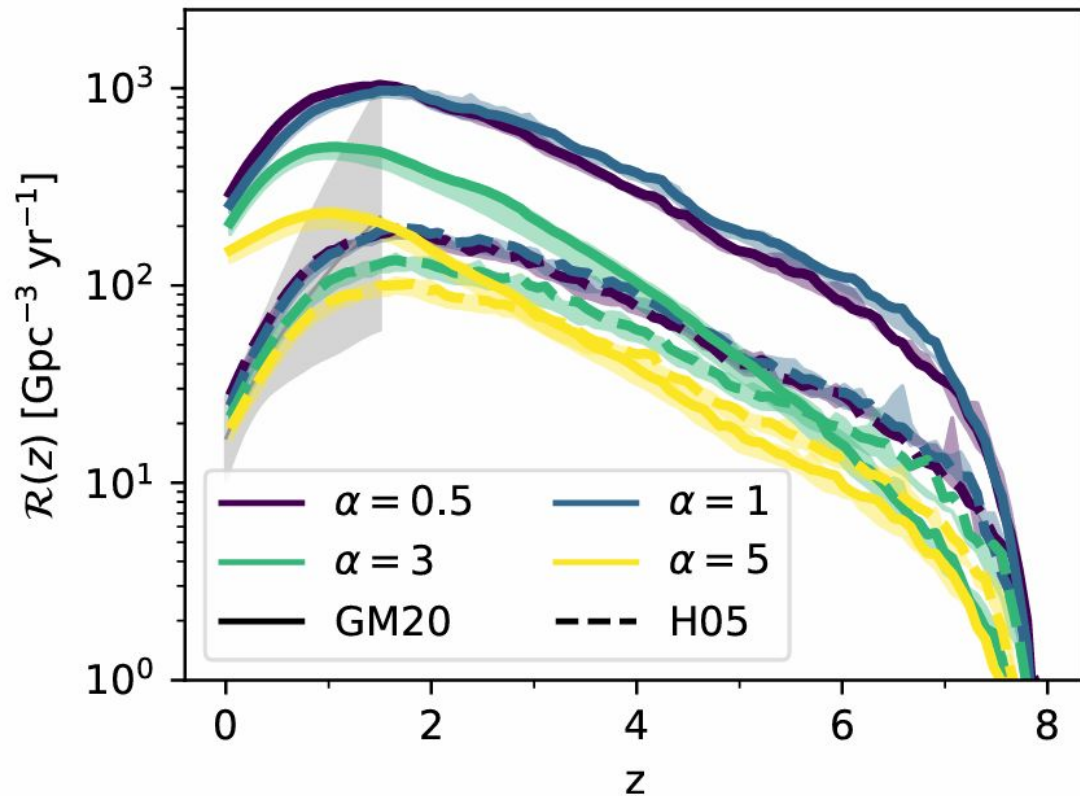
SFR - galaxy mass relations



SFR - galaxy mass relations



The impact of kicks



Conclusions

- STATE-OF-THE-ART BINARY POPULATION SYNTHESIS CODES PREDICT TOO HIGH BBH MERGER RATES
- THE CONTRIBUTION FROM LOW-MASS GALAXIES, DOES NOT IMPACT MORE THAN A FACTOR 2
- THE BBH MERGER RATE DENSITY DISCREPANCY STEMS FROM STELLAR EVOLUTION MODELS AND/OR BBH FORMATION CHANNELS



Spera+17, Spera+19, Iorio+23

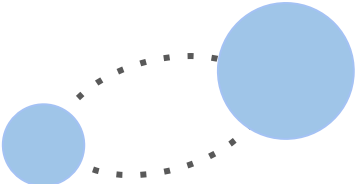
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- 
- A diagram showing two blue circles of different sizes representing stars in a binary system. A dashed line connects them, indicating their orbital path or the evolution of their separation over time.
1. Interpolation on the fly of precomputed stellar tracks
 2. Analytical and semi-analytical models for binary evolution

Evolution of the binaries across cosmic time

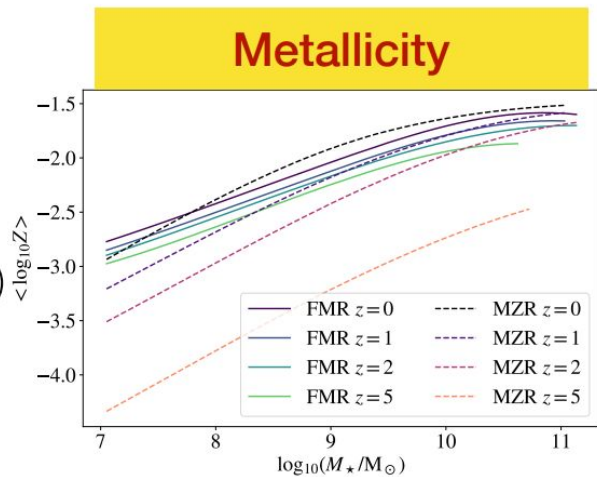
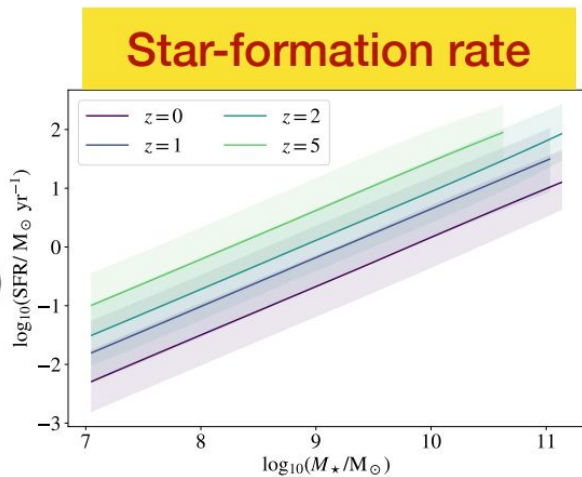
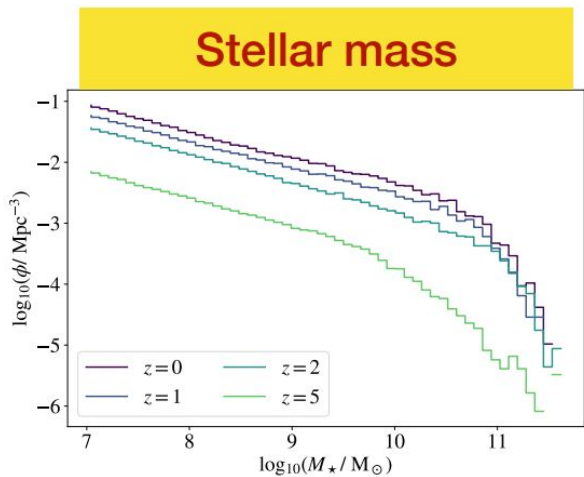
galaxy Rate

Estimates the merger rate density of binary compact objects and the properties of their host galaxies, based on observational scaling relations.

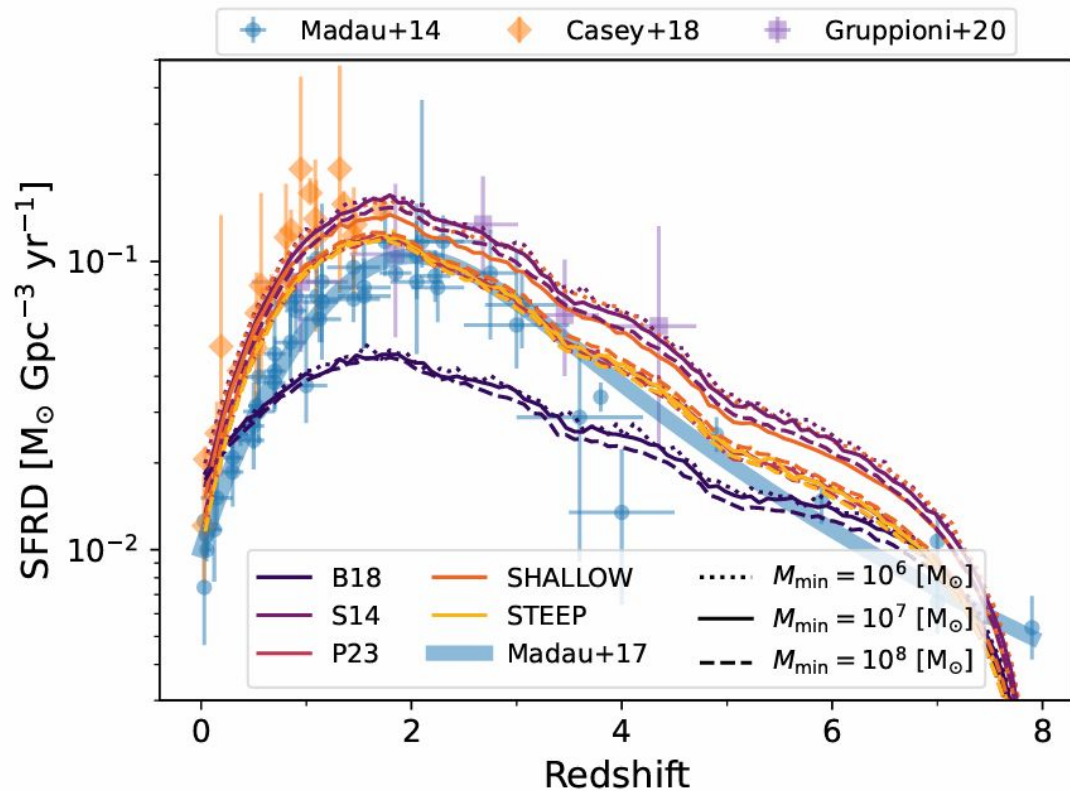
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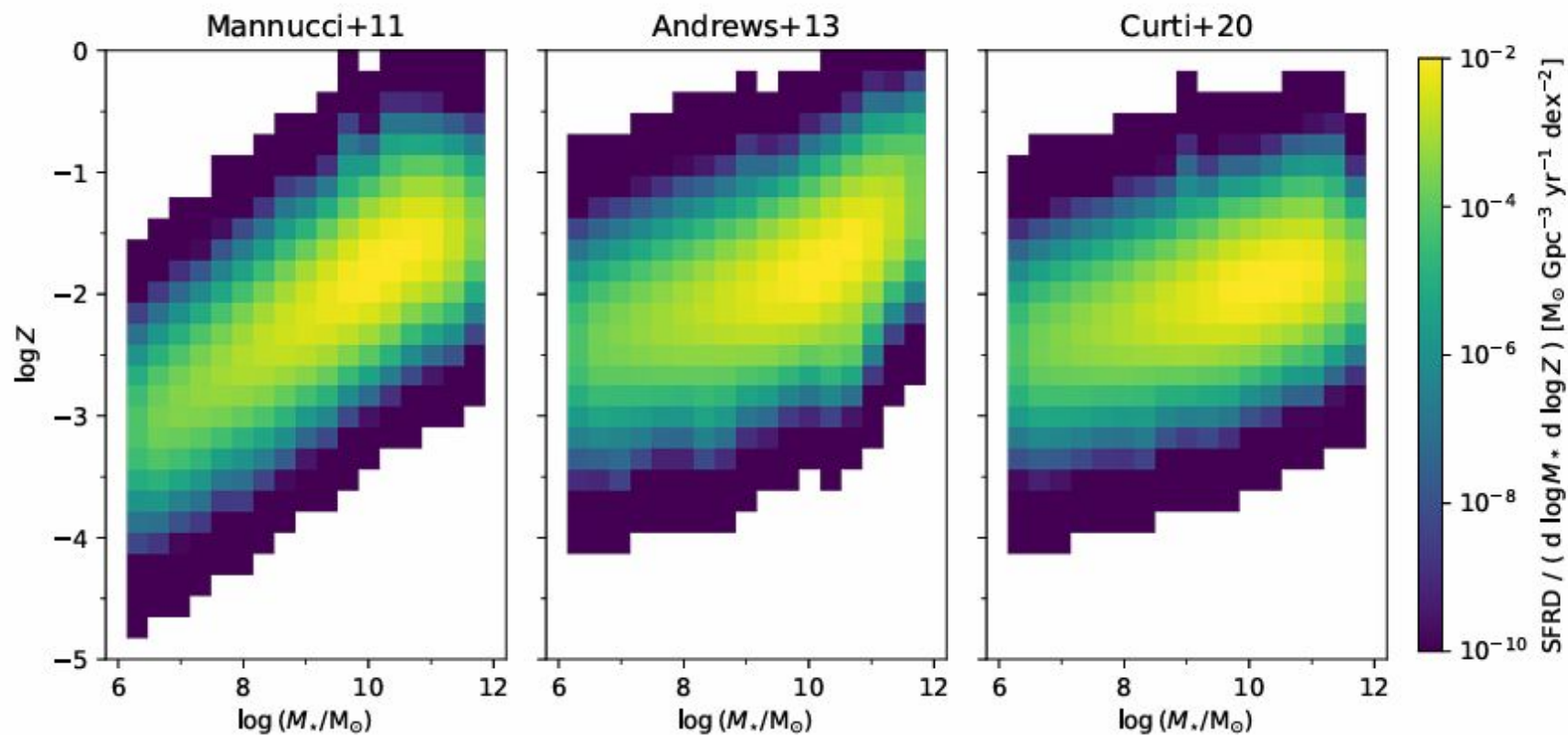
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Credit: Filippo Santoliquido

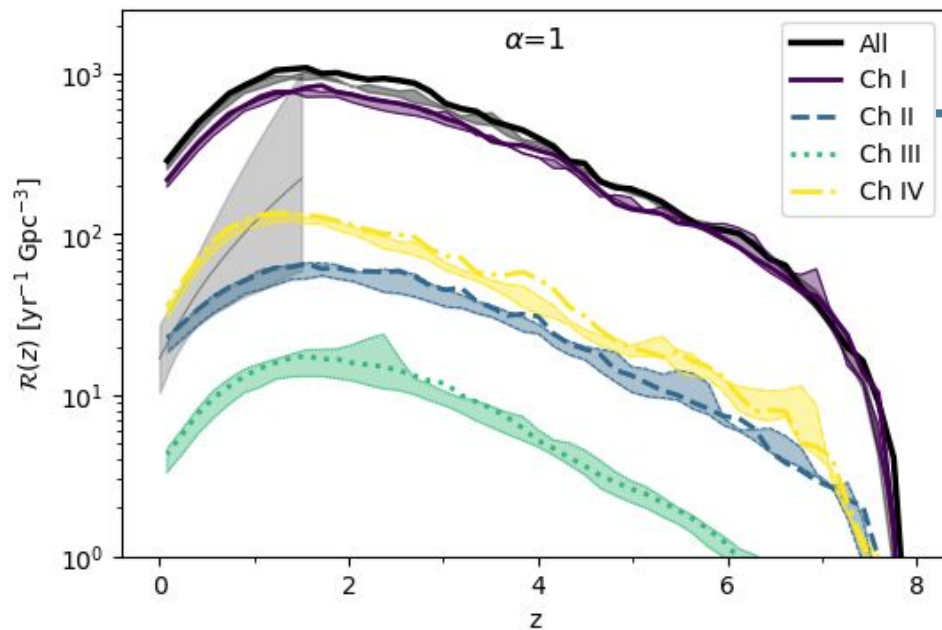


Star formation rate density

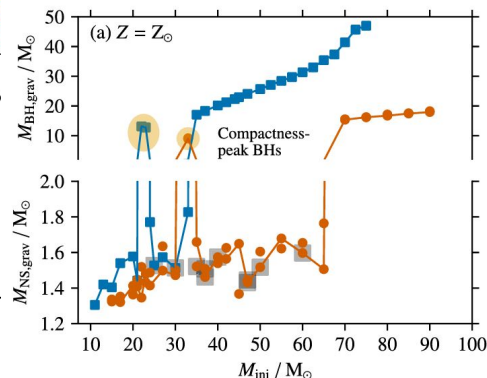
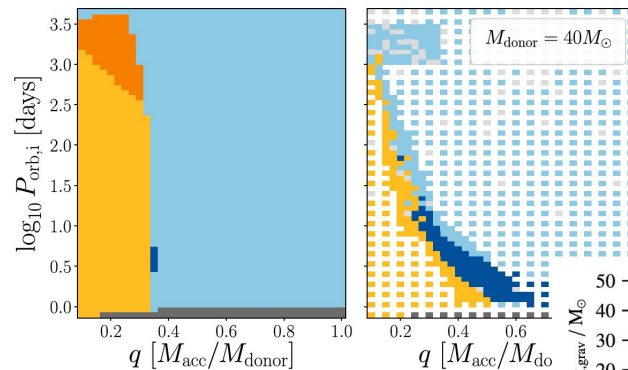




What is the formation channel contributions to the MRDs?

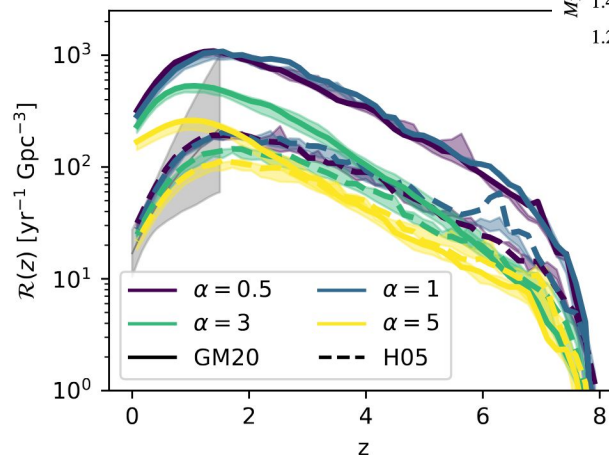


Ch II → only stable
mass transfer



Schneider+23

Sgalletta+24



1. TOO MANY SYSTEMS SURVIVE CE?
2. STRIPPED STARS SHOULD PRODUCE LESS BHs?
3. SN KICKS SHOULD BE HIGHER?