Predicting galaxy quenching in CAMELS

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CAMELS Workshop 2022

Flatiron Institute, Simons Foundation, NYC

On the quenching of star formation in observed and simulated central galaxies: evidence for the role of integrated AGN feedback

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1) Classify galaxies into star forming and quenched [threshold at log (sSFR/yr^{-1}) = −11]
   - Simulations: Illustris, TNG, Eagle
   - Observations: SDSS
2) Train Random Forest Classifier to predict quenching status based on:
   - Stellar mass: proxy for the strength of supernova feedback
   - Halo mass: linked to CGM gas heating via virial shocks
   - Black hole mass: traces integrated energy input via AGN feedback
   - Accretion rate: instantaneous AGN feedback energy injection
3) Feature importances → Quenching mechanism?

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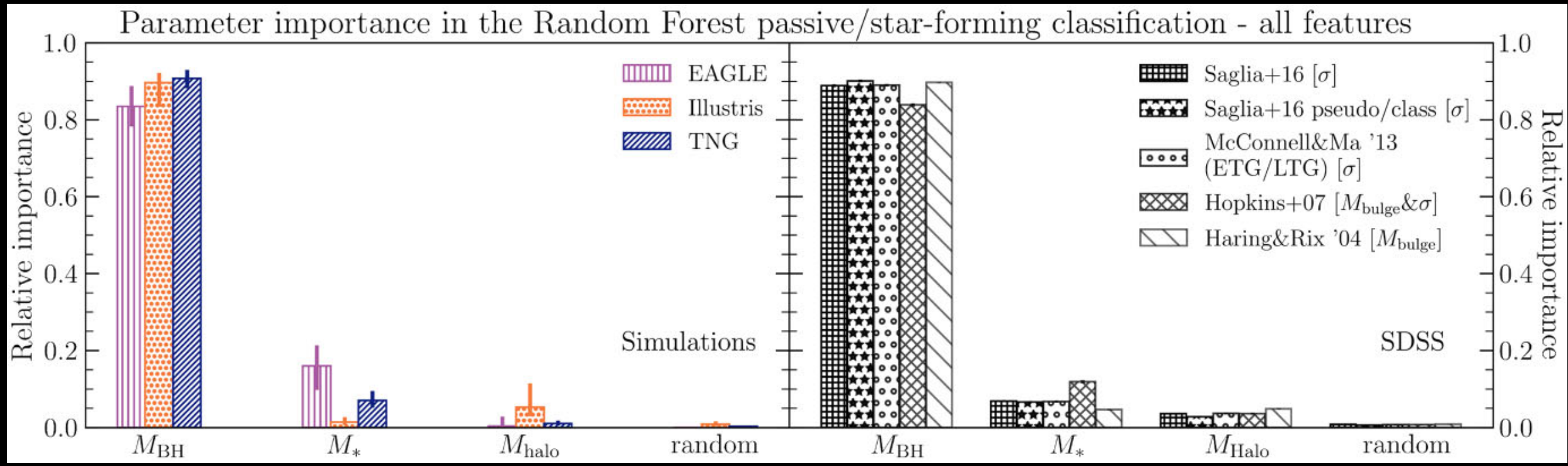
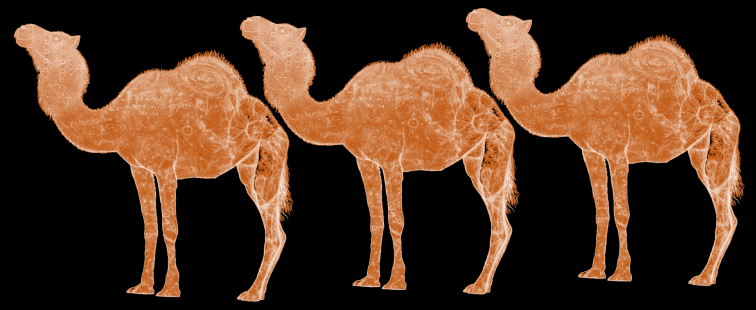
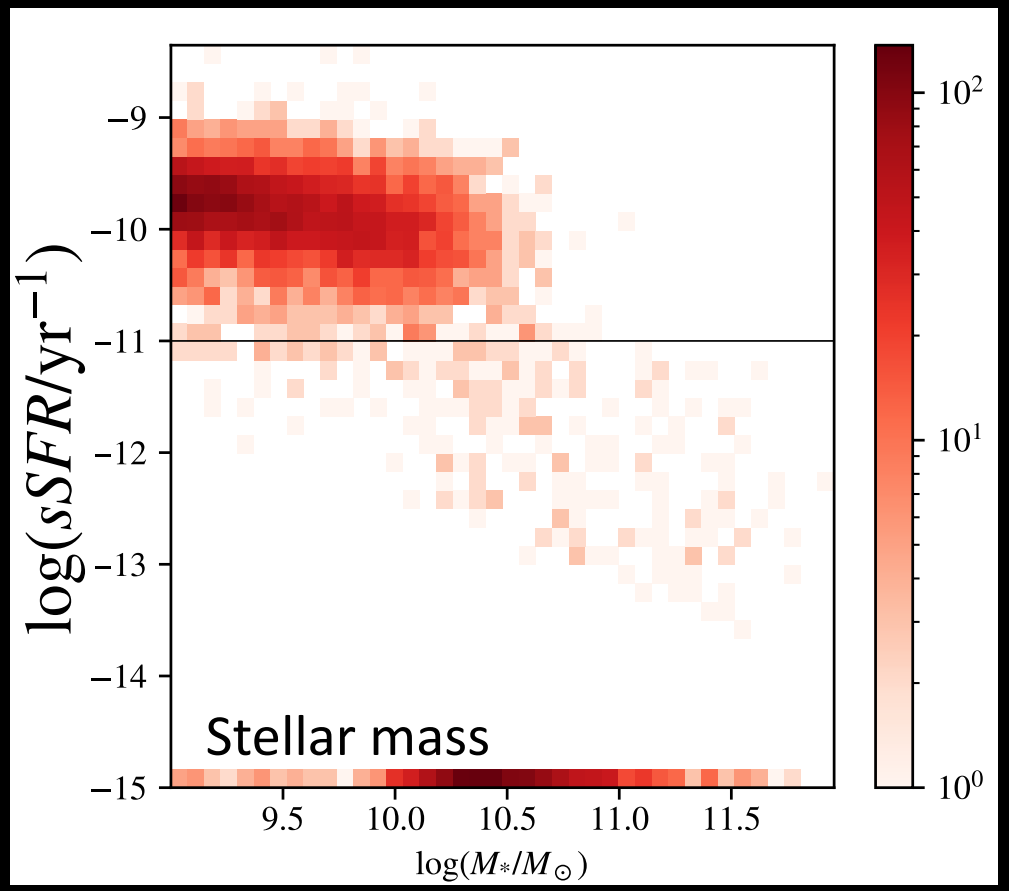


Black hole mass is the most predictive feature for all simulations and observations!

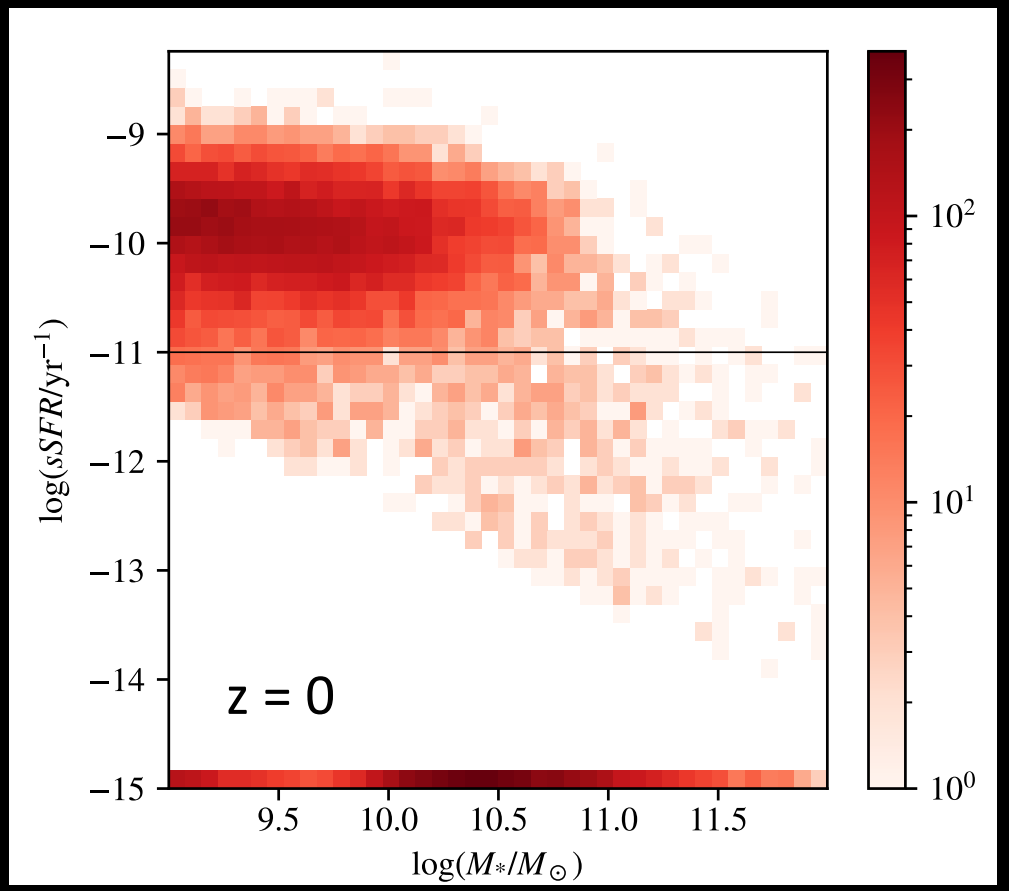
Really??? How robust is this to changes in cosmological and feedback parameters?



TNG CV set (fixed parameters)



TNG LH set (varying 6 parameters)



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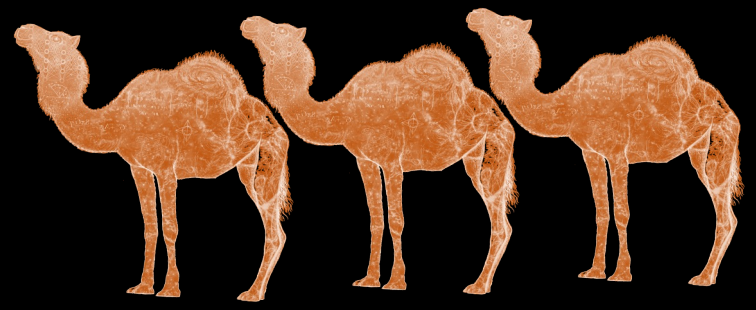

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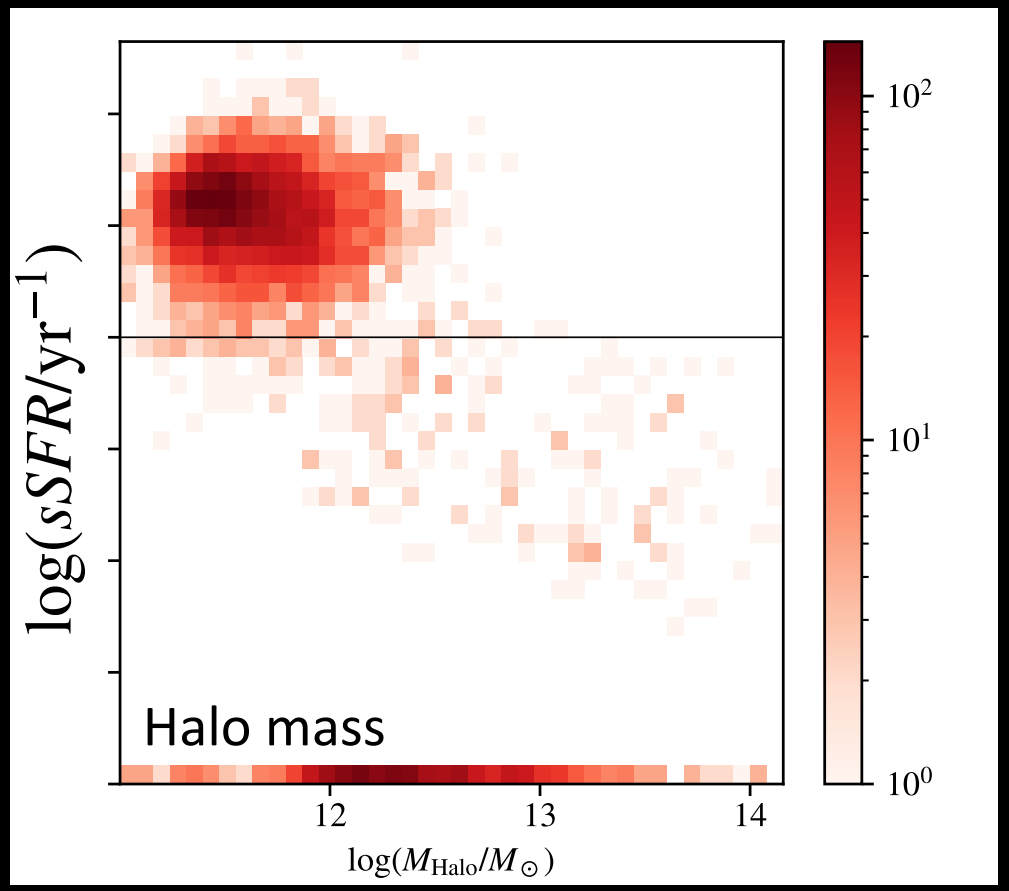

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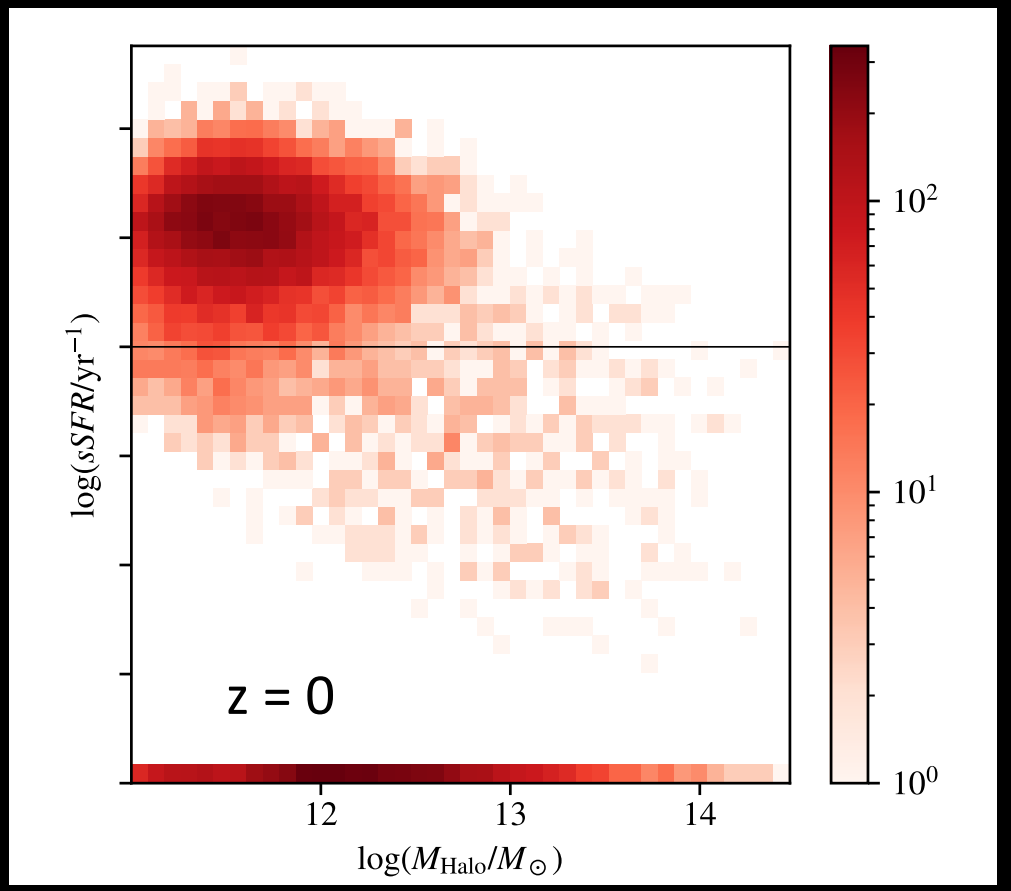

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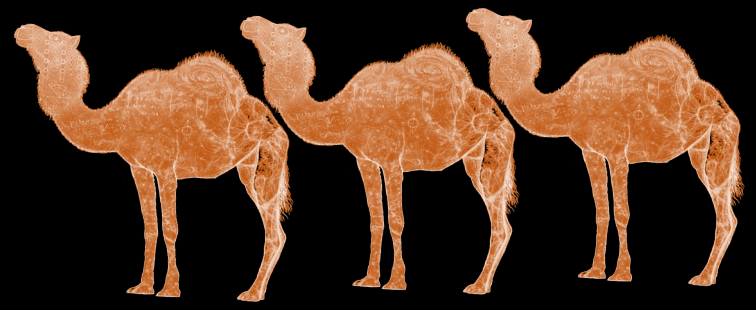

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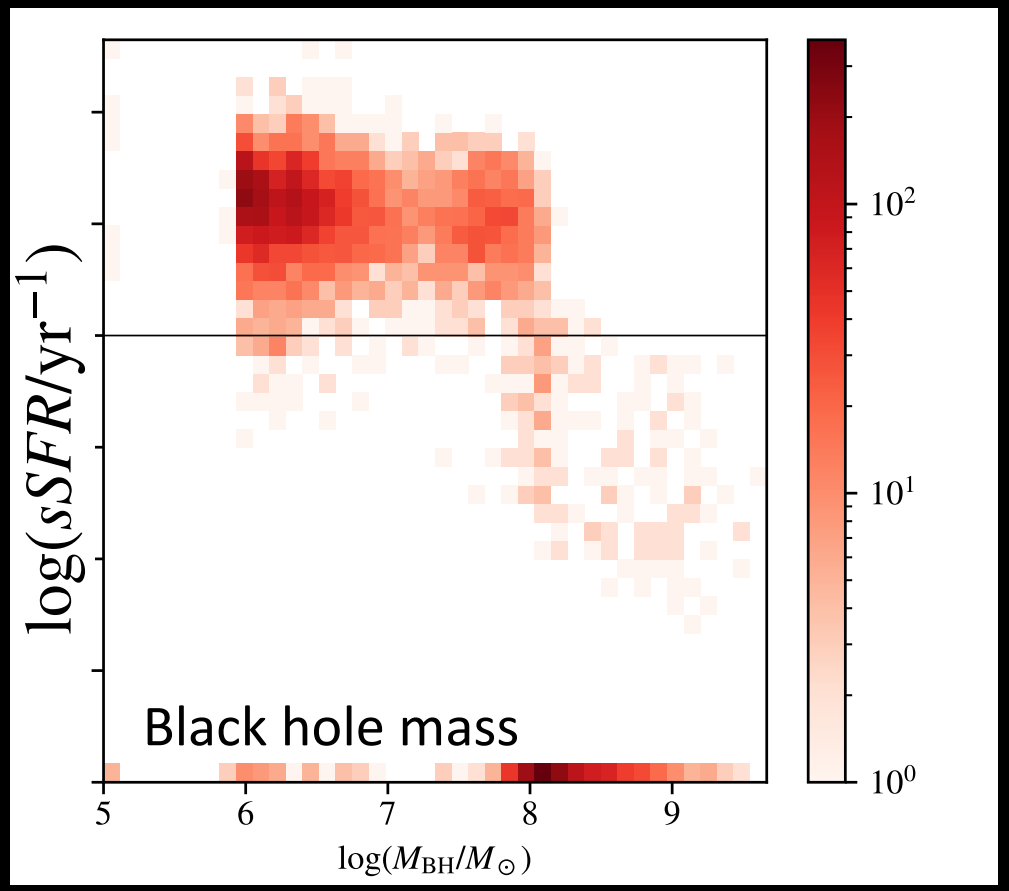

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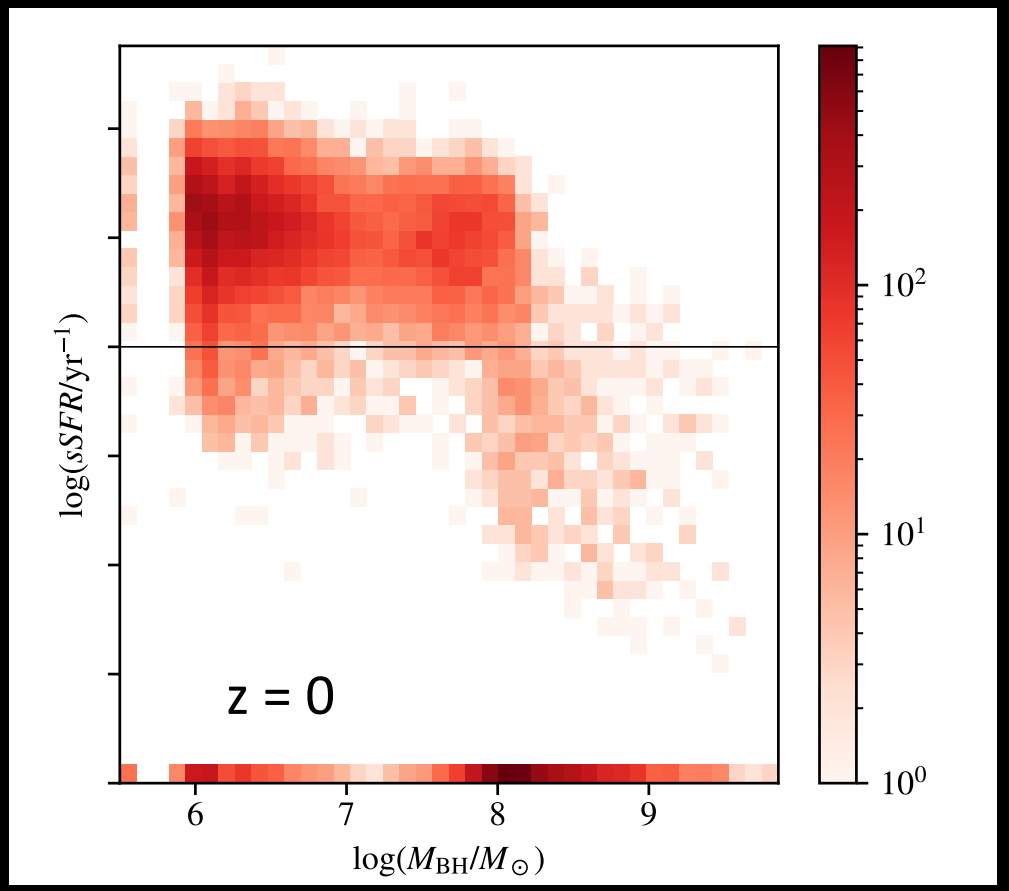

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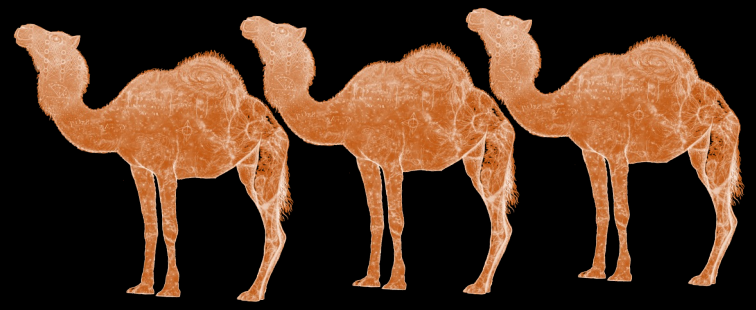

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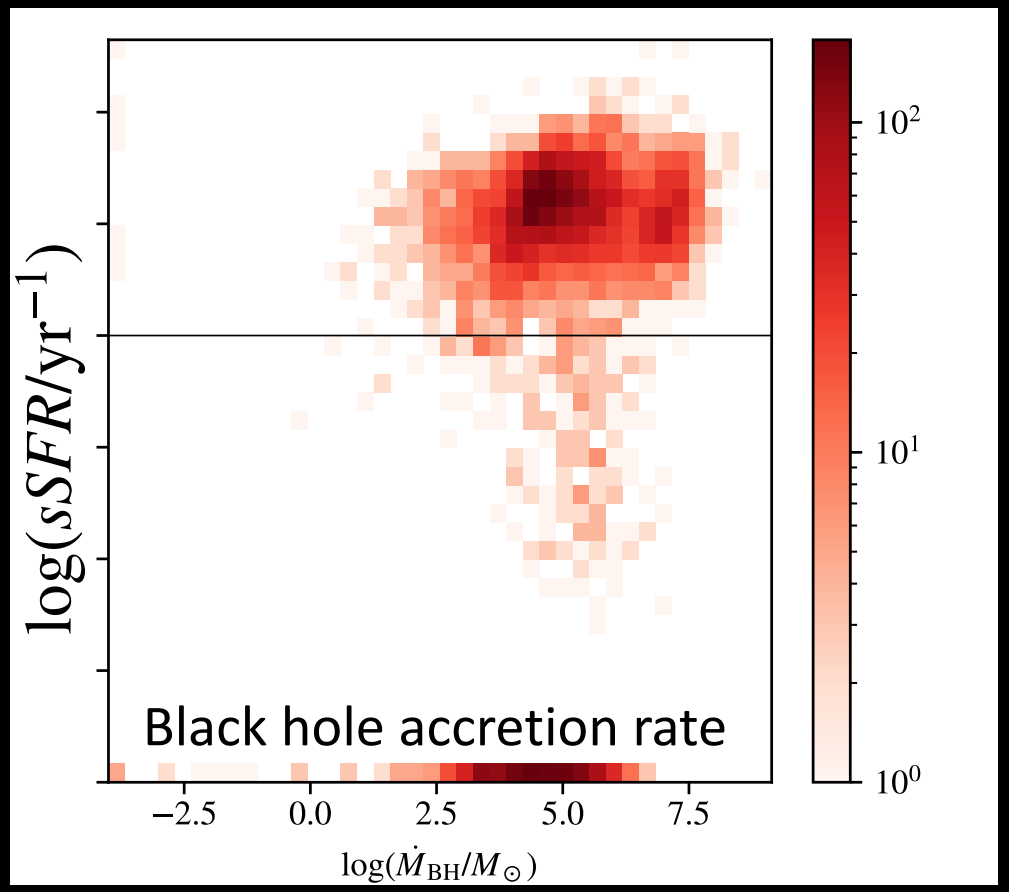

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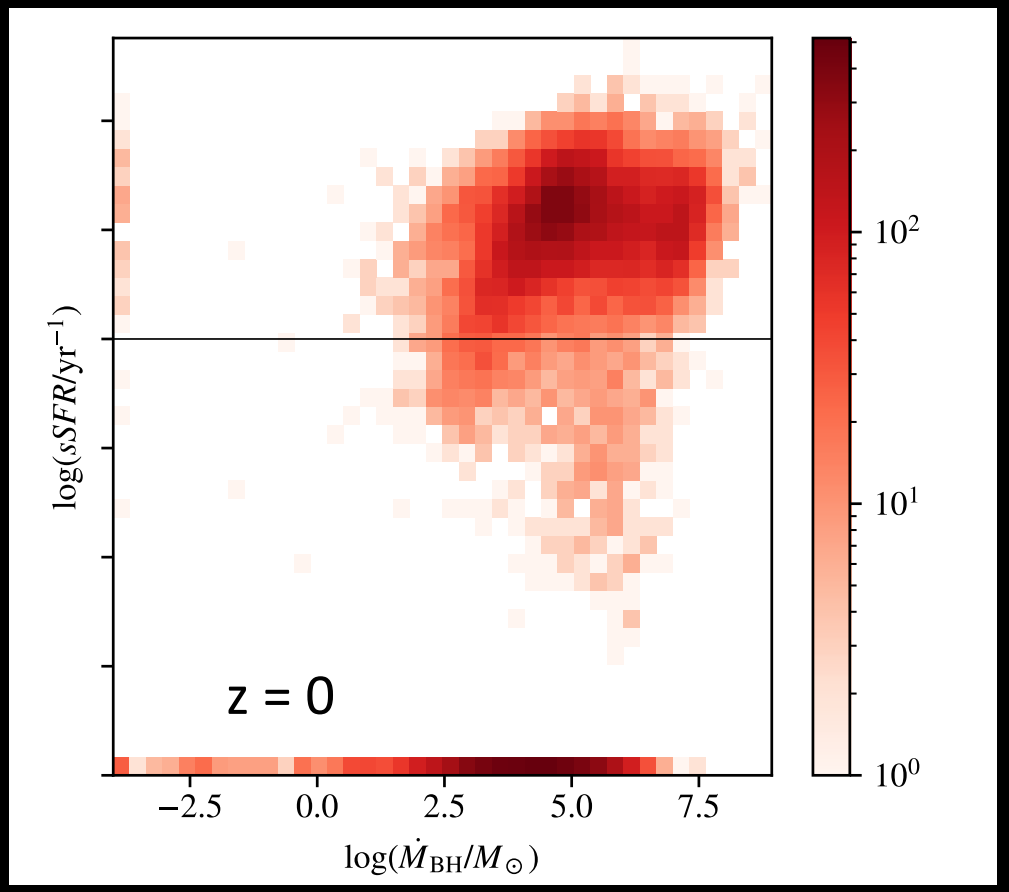

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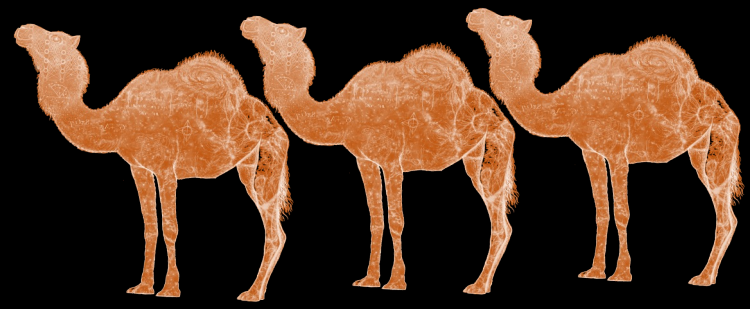
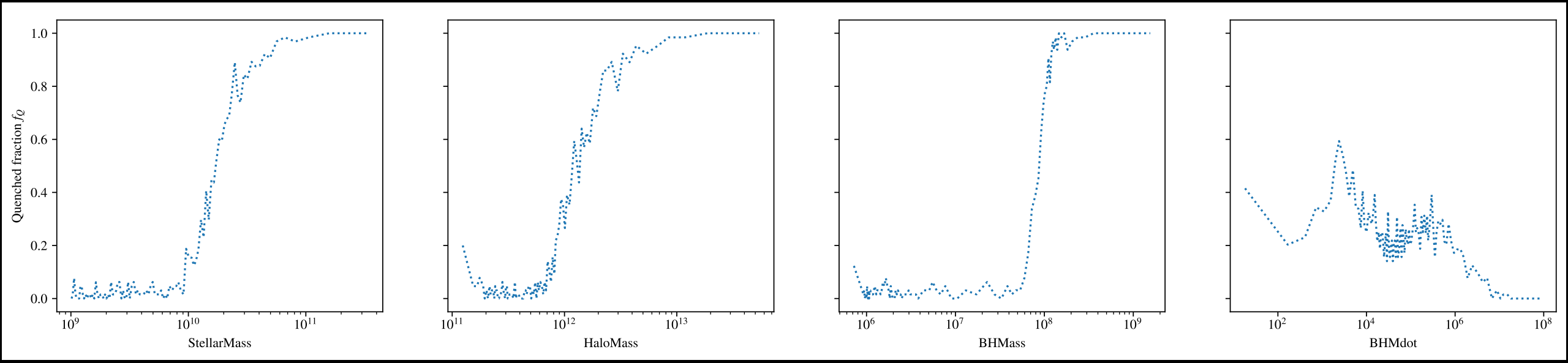


Galaxy quenched fraction

TNG CV set (fixed parameters)

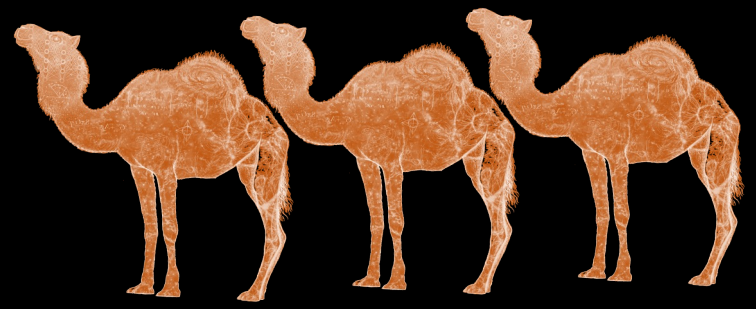


Stellar mass | Halo mass | BH mass | BH accretion rate

→ Sharpest increase in quenched fraction around M_{BH} = 1e8 $M_\odot$

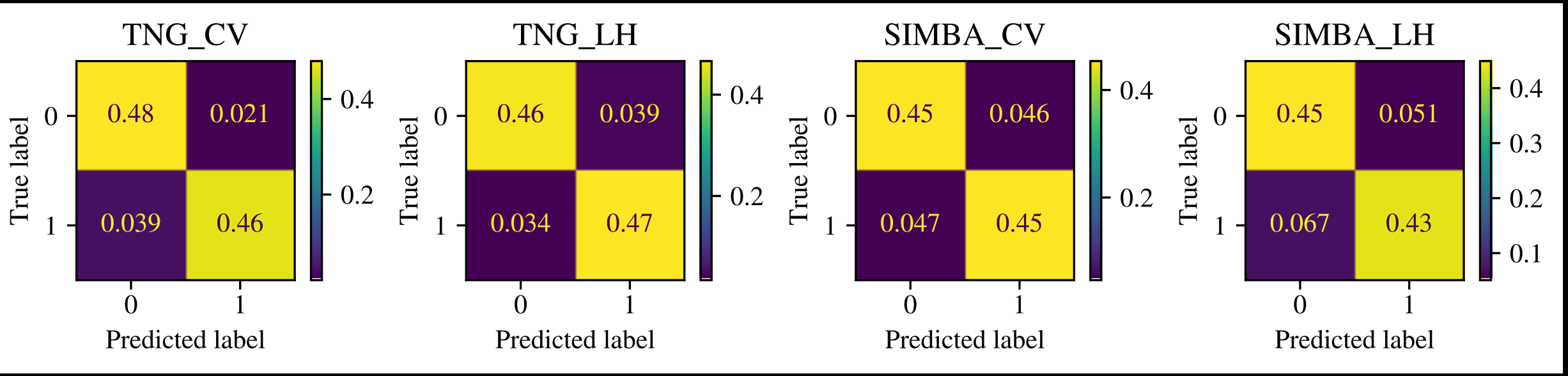
Weinberger+ Habouzit+
Terrazas+ Zinger+

Random Forest performance



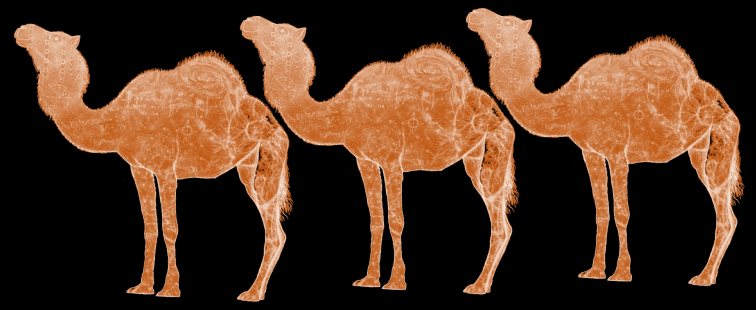
Classification success rate =

94% 93% 90% 88%

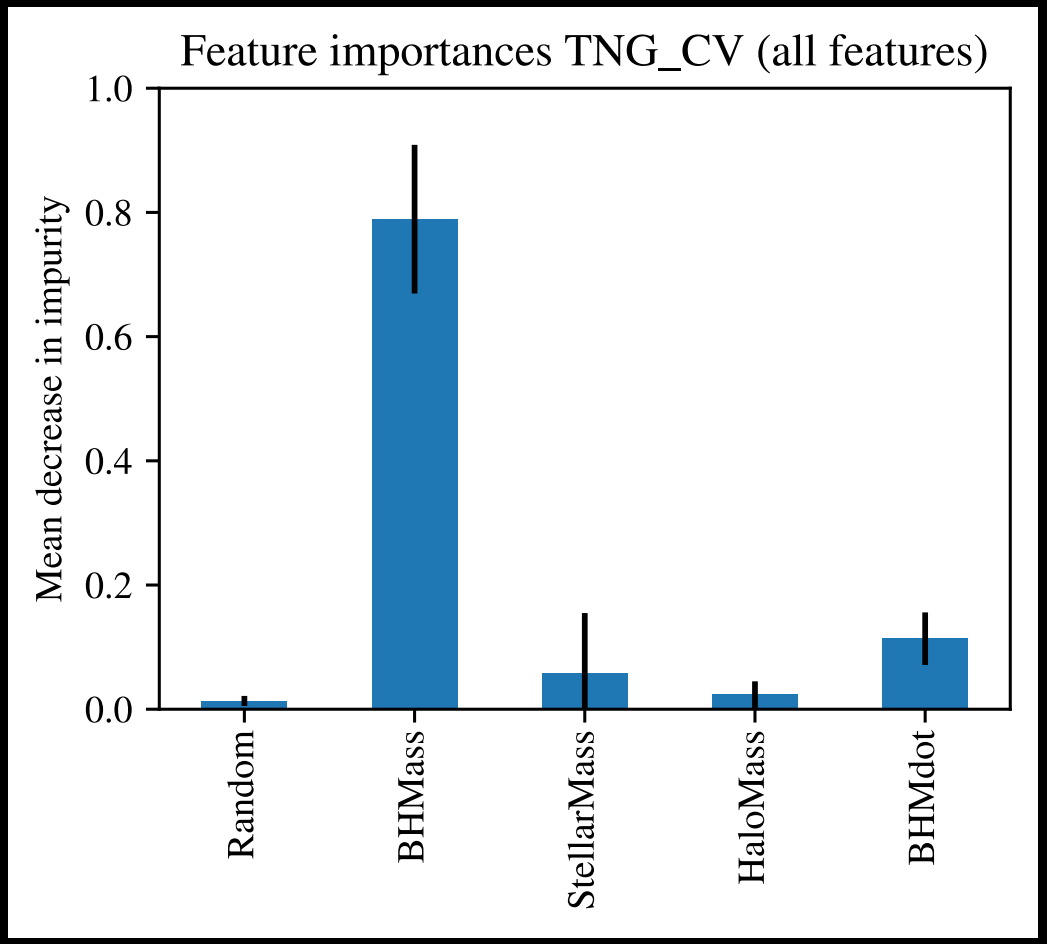


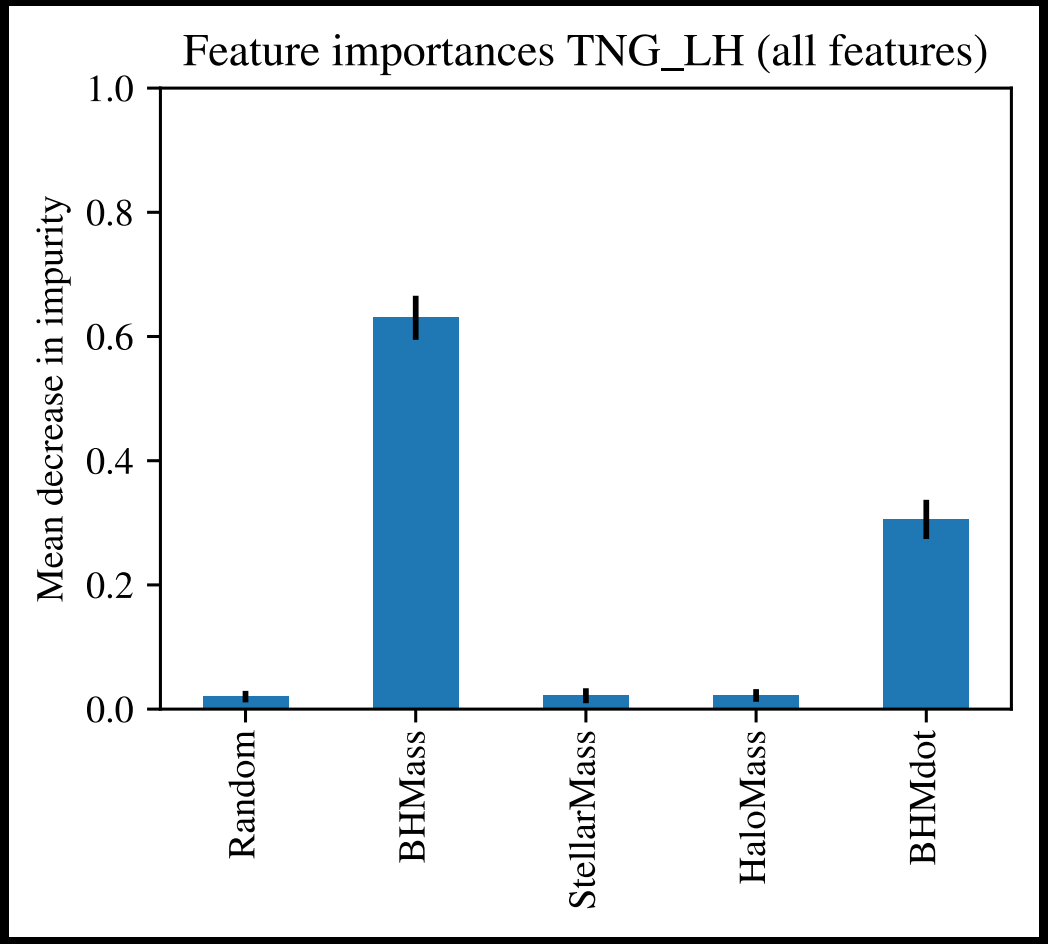
- Almost as good prediction training on the LH set varying all parameters
- Slightly worse for SIMBA compared to TNG

And feature importances…



- SMBH mass is still the most predictive





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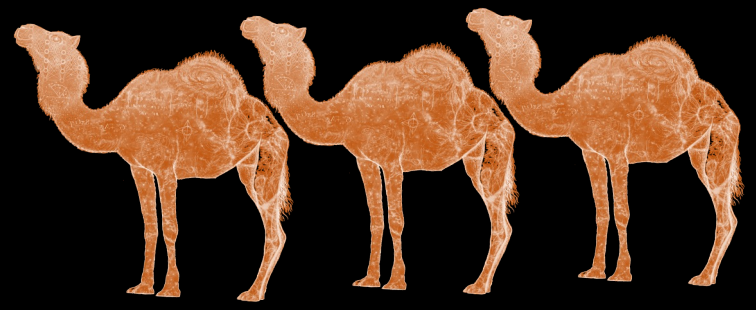

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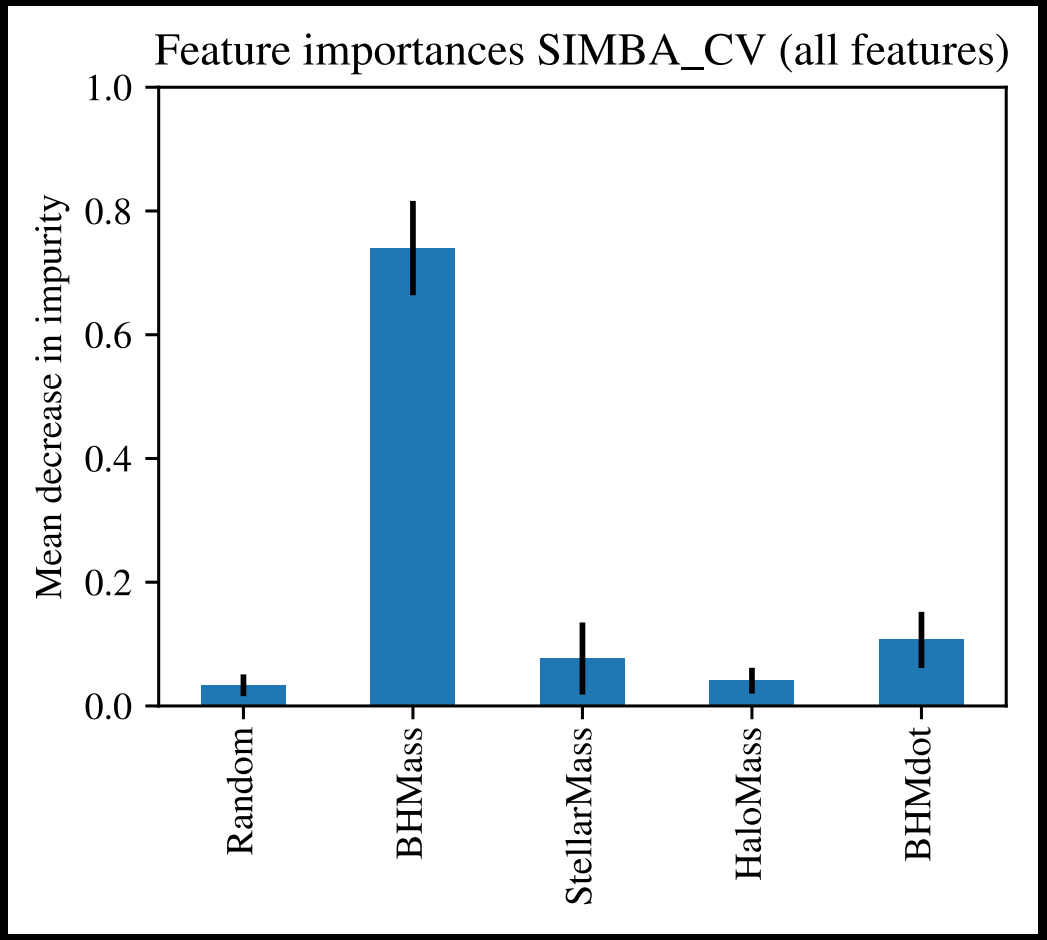

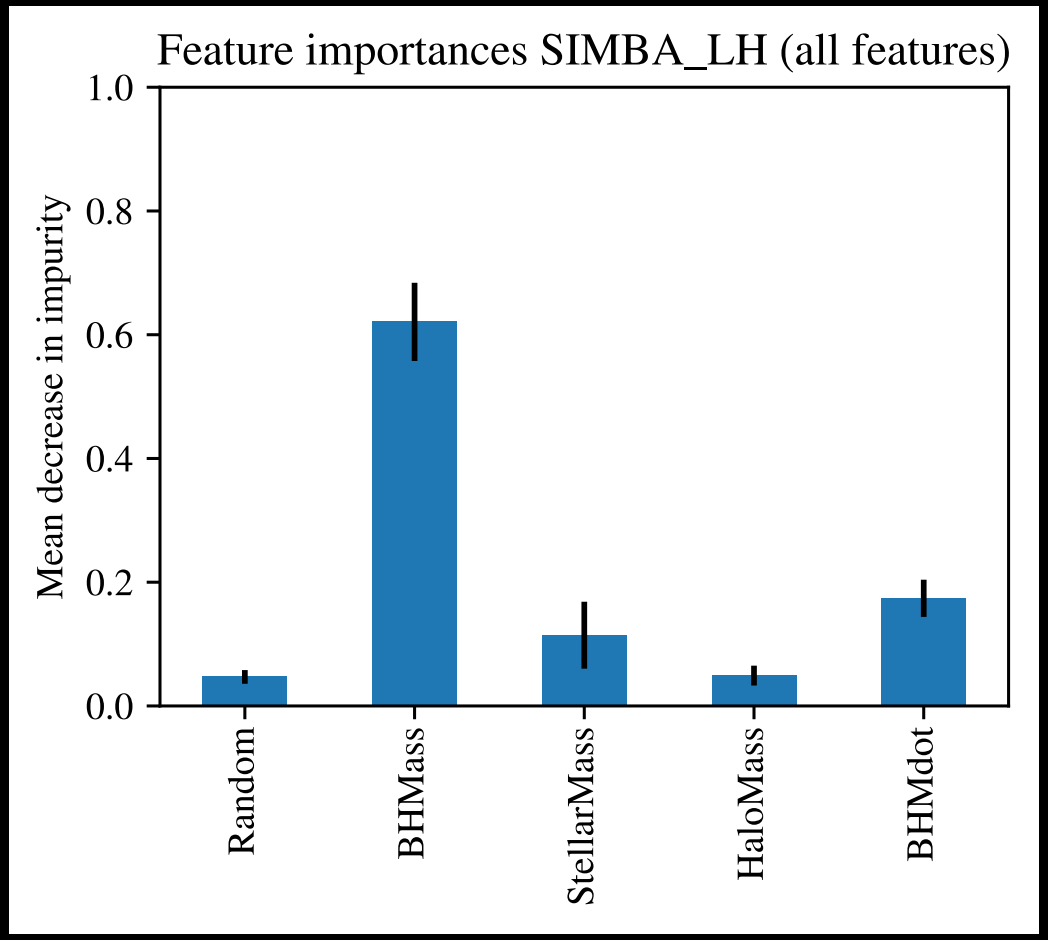

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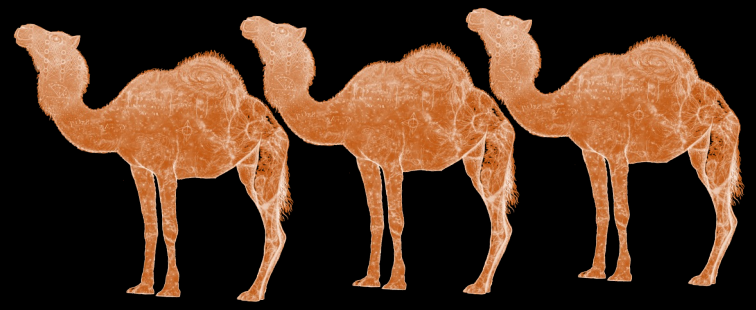
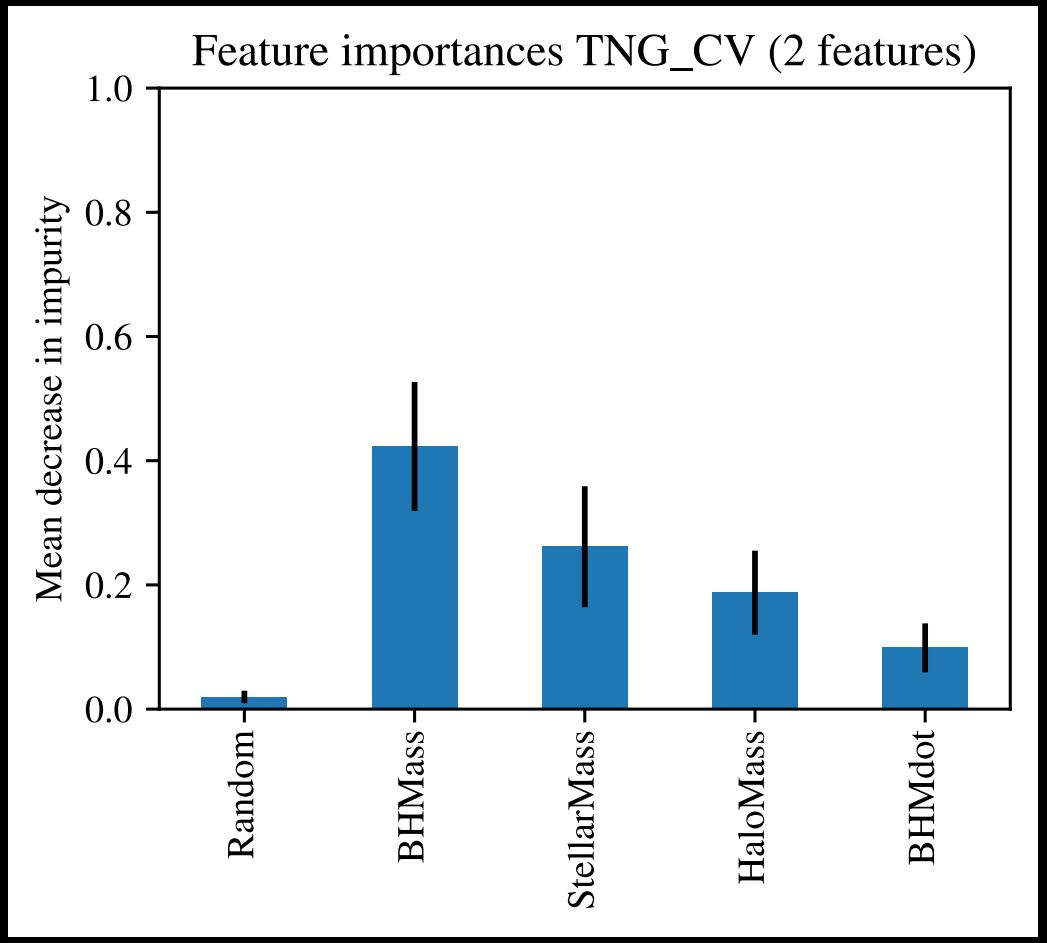
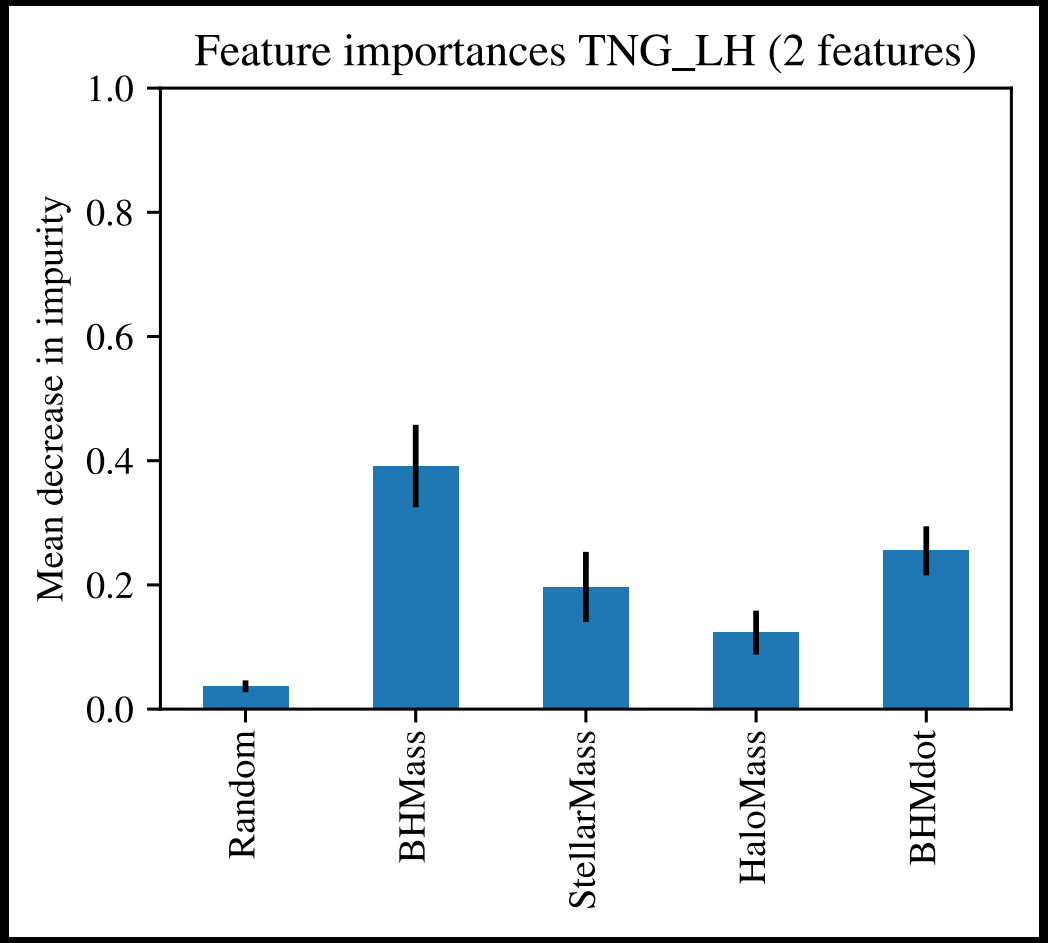
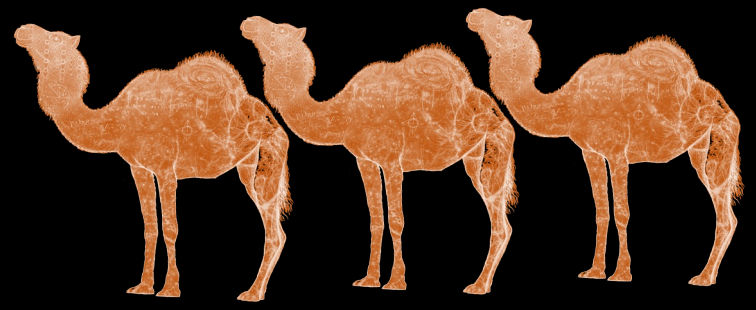


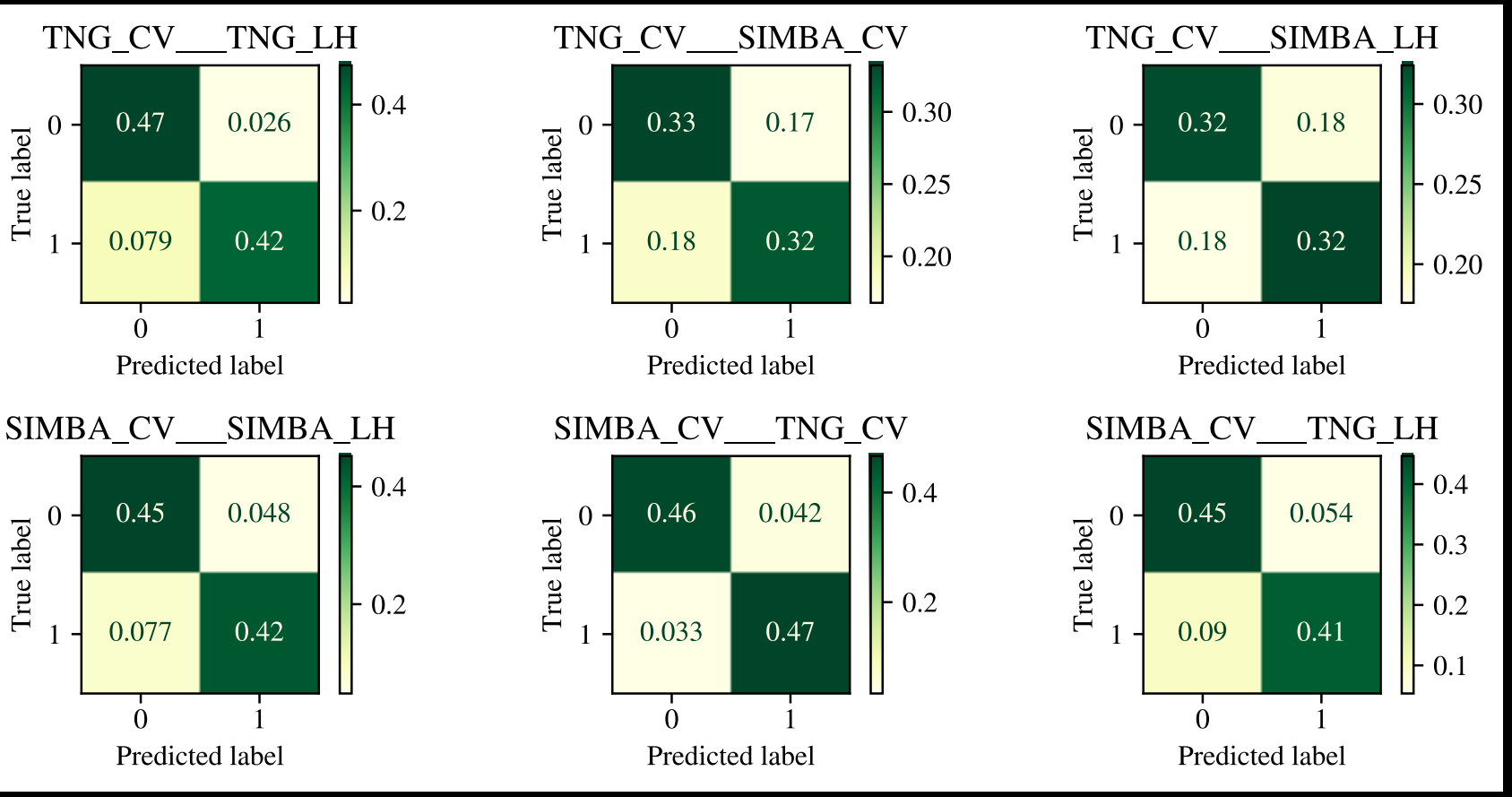
- SMBH mass is still the most predictive, BUT…





Cross testing?





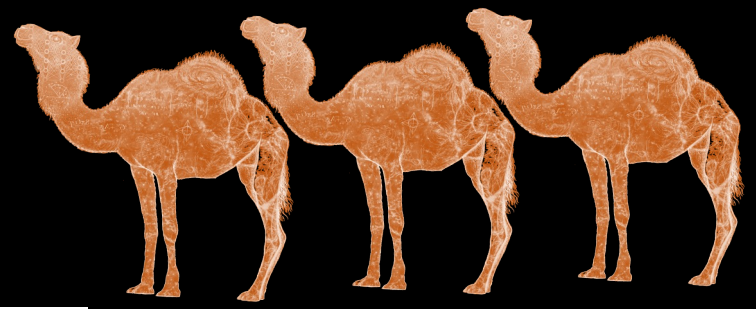
Train → Test

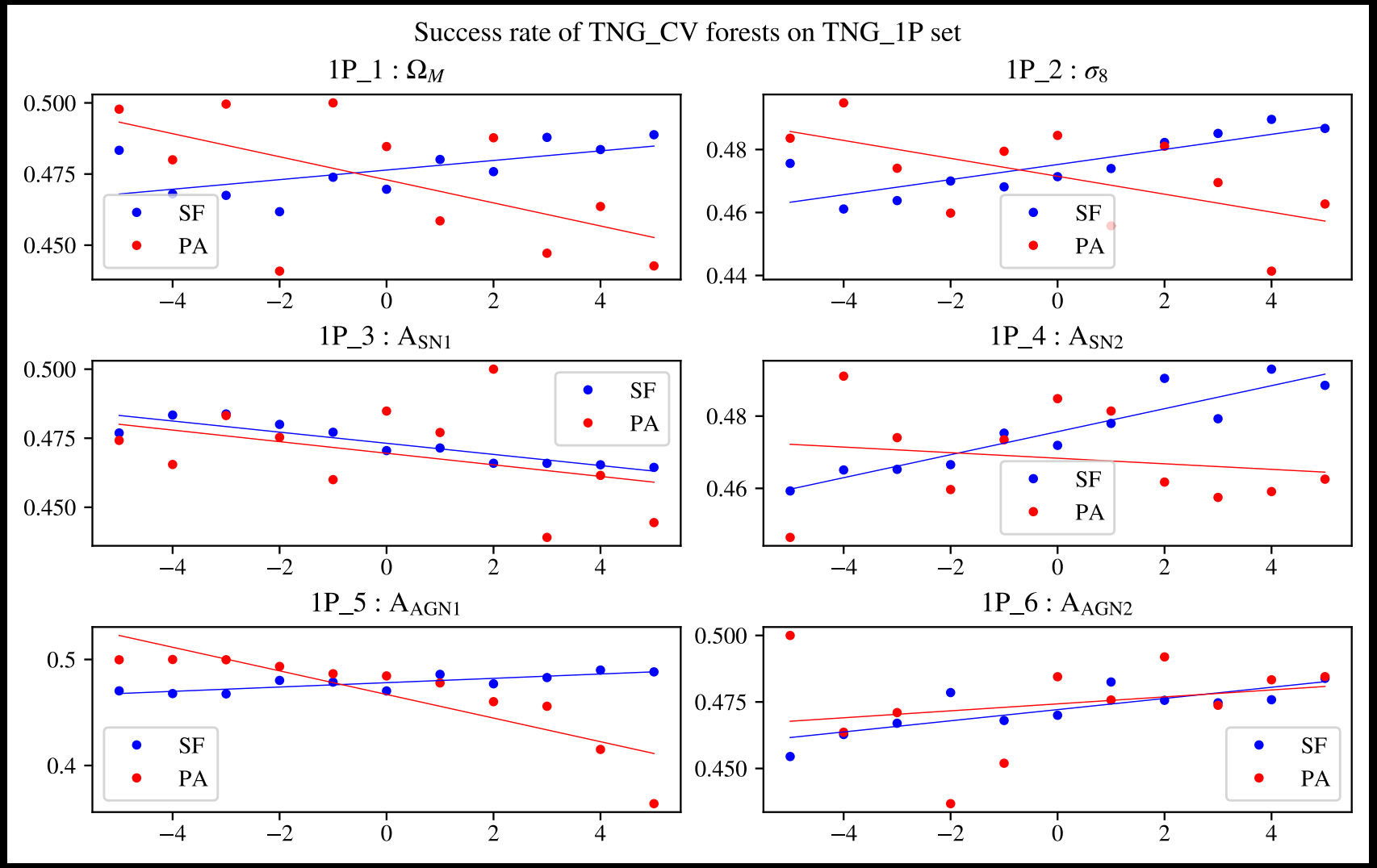
CV → LH ✓

SIMBA → TNG ✓

TNG → SIMBA X

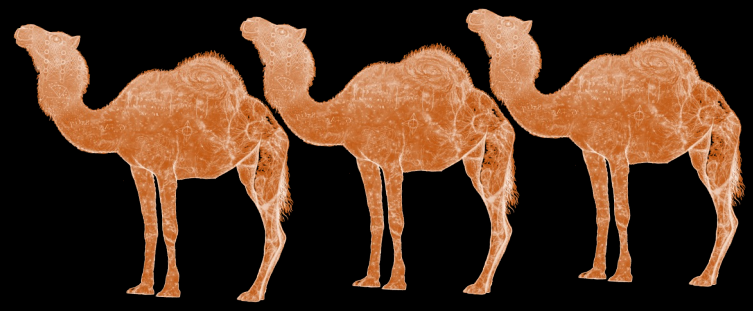
Cross testing?





- Systematic effect of 1P variations

SMBH mass tracks total feedback energy
but… how much of that is useful feedback?



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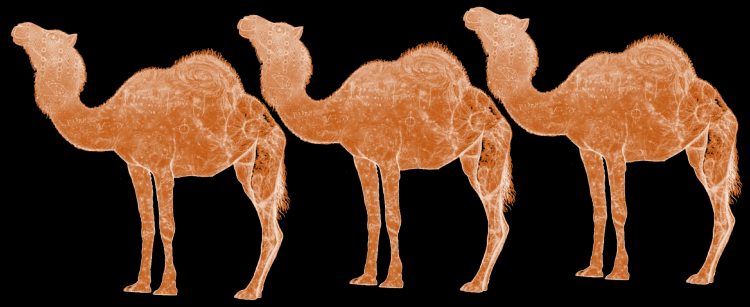
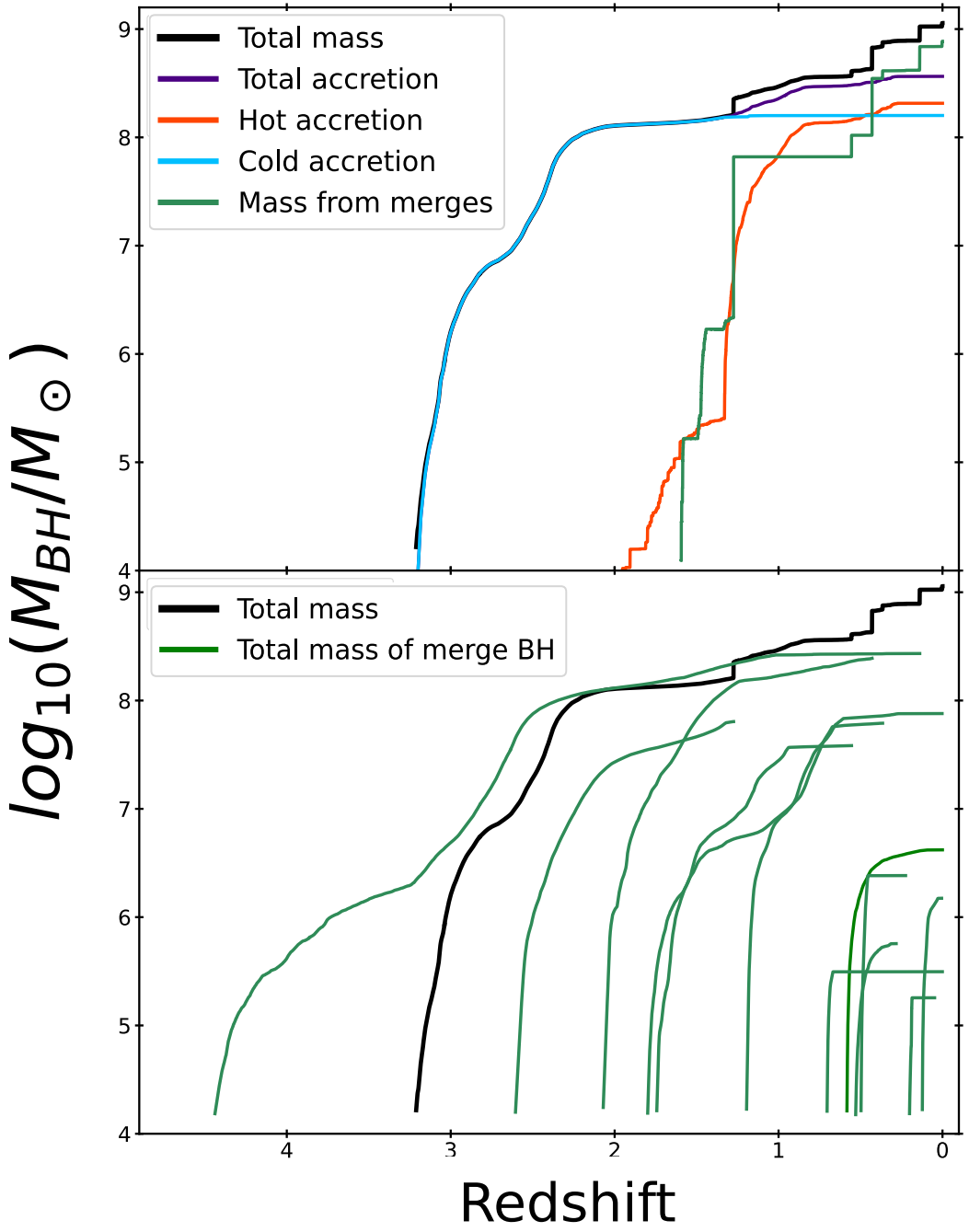


Sofya Levitina
UConn Undergrad

We can answer that!
Tracking contribution of different accretion and feedback modes in SIMBA



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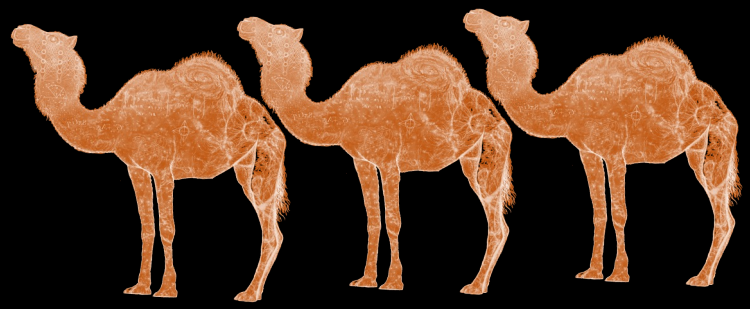

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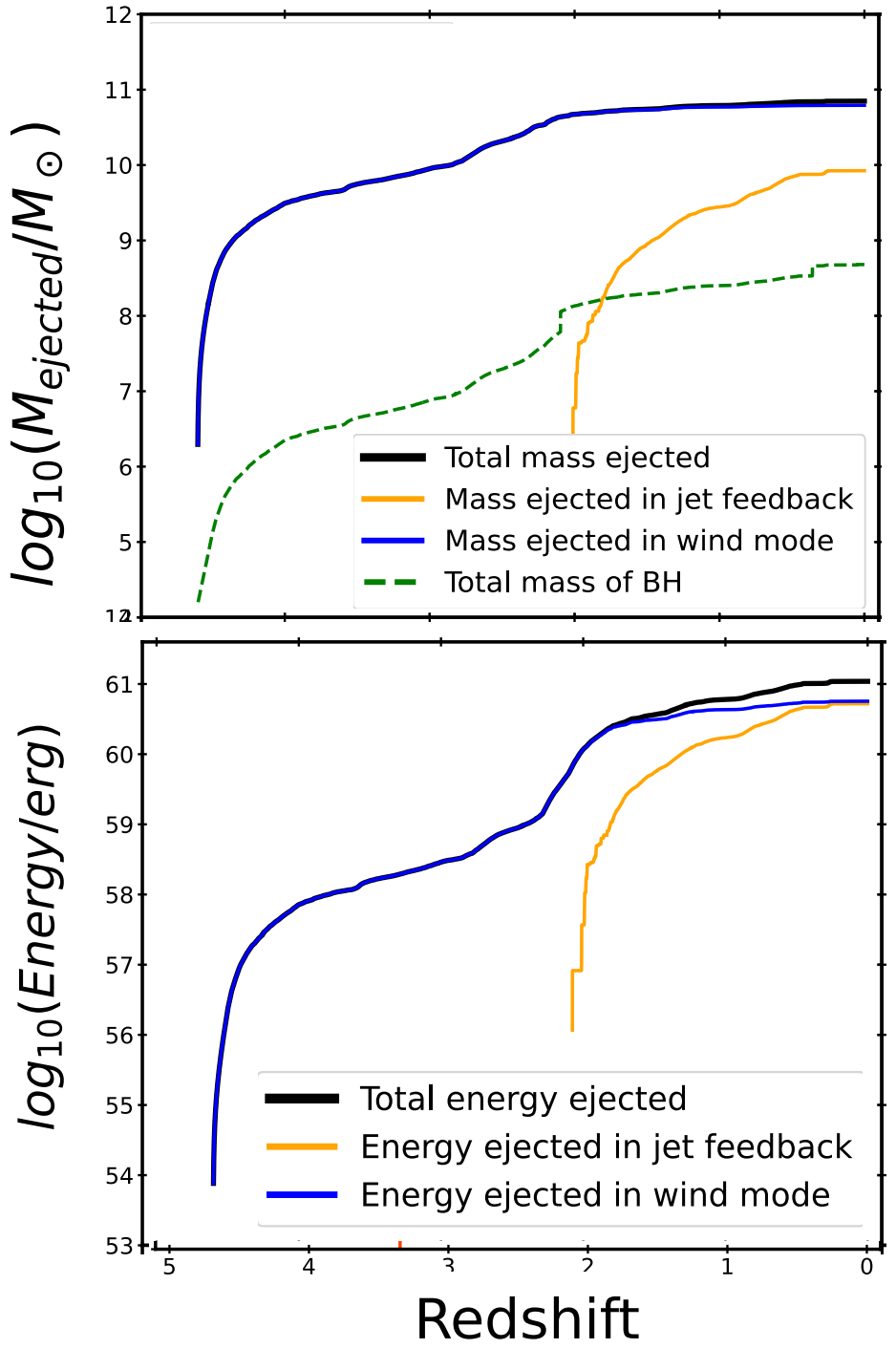
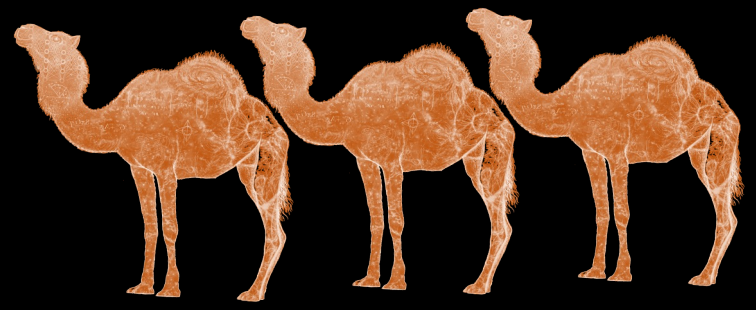


And what about satellites?



Questions?

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