Cosmic Black-Hole Growth Tracked by Combining X-ray Surveys and Supercomputer Simulations

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Supermassive black holes grow through accretion and mergers

- Accretion: supermassive black holes can consume gas from their host galaxies.

Image by Nahks TrEhnl (Penn State)

- Mergers: two supermassive black holes can merge into a single, more massive one.

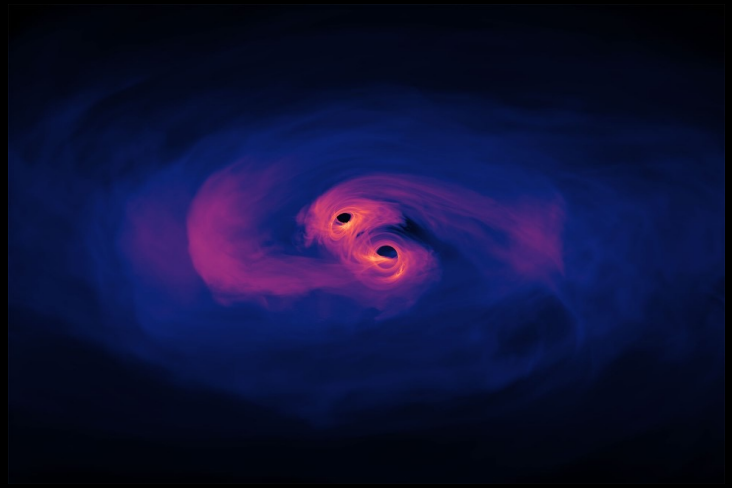
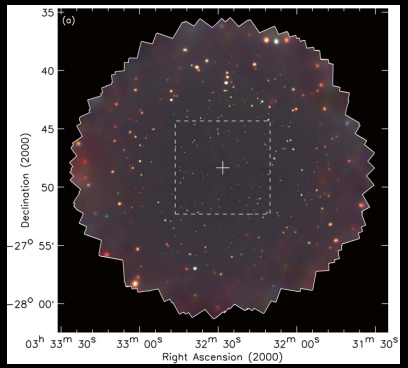
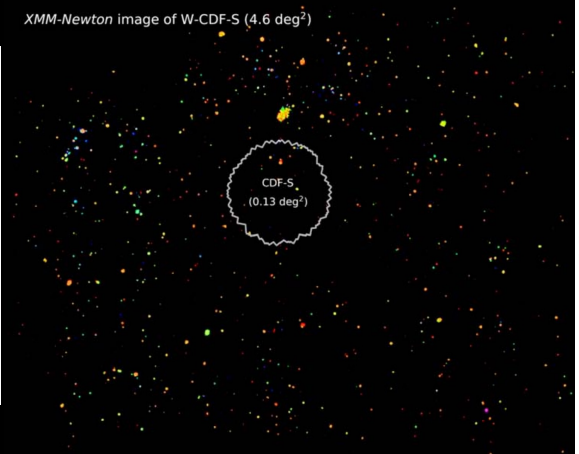


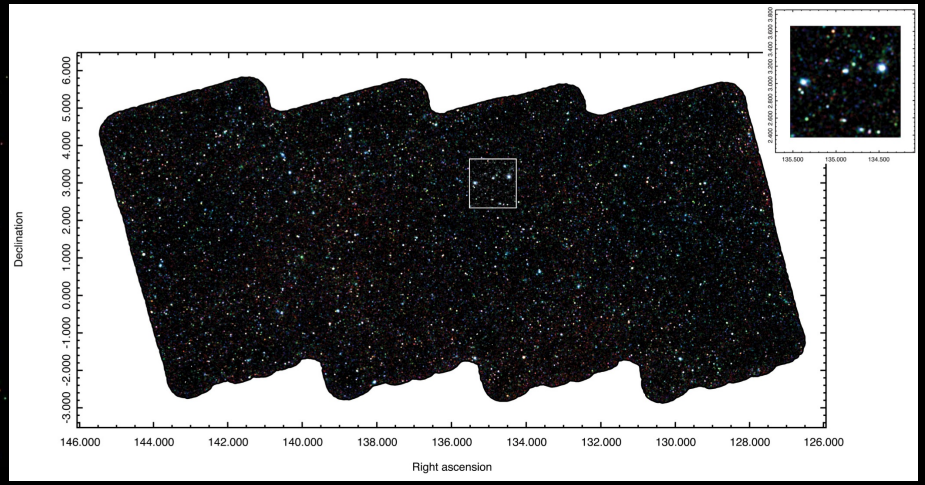
Image by Scott Noble (NASA GSFC)

The accretion power of supermassive black holes captured by X-ray surveys

- X-ray sky survey data accumulated over more than 20 years from three of the most powerful X-ray facilities





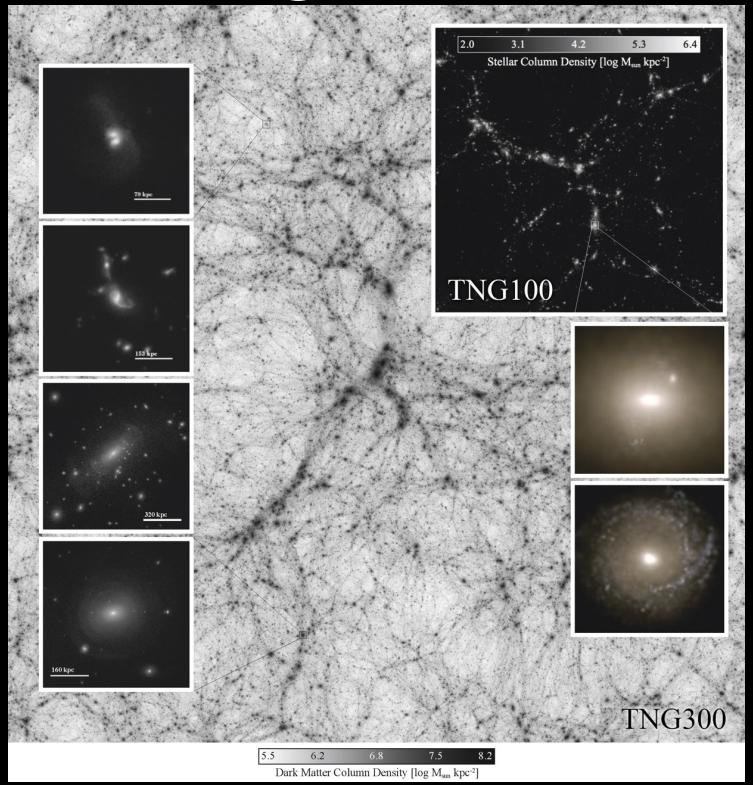


Chandra
Luo et al. (2017)

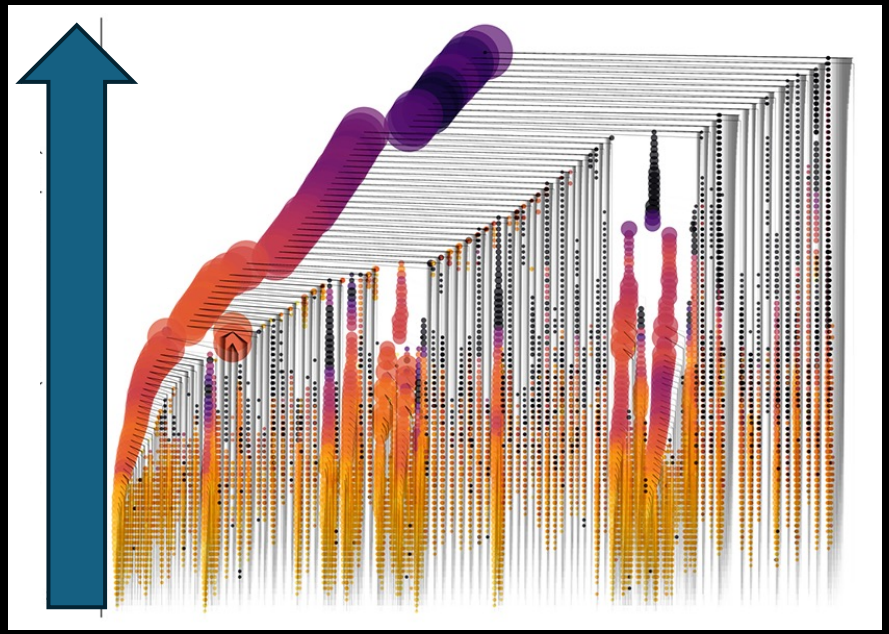
XMM-Newton
Ni et al. (2021)

eROSITA
Brunner et al. (2022)

The merger information from supercomputer cosmological simulations



TNG simulations



An example merger tree

X-ray and optical observations

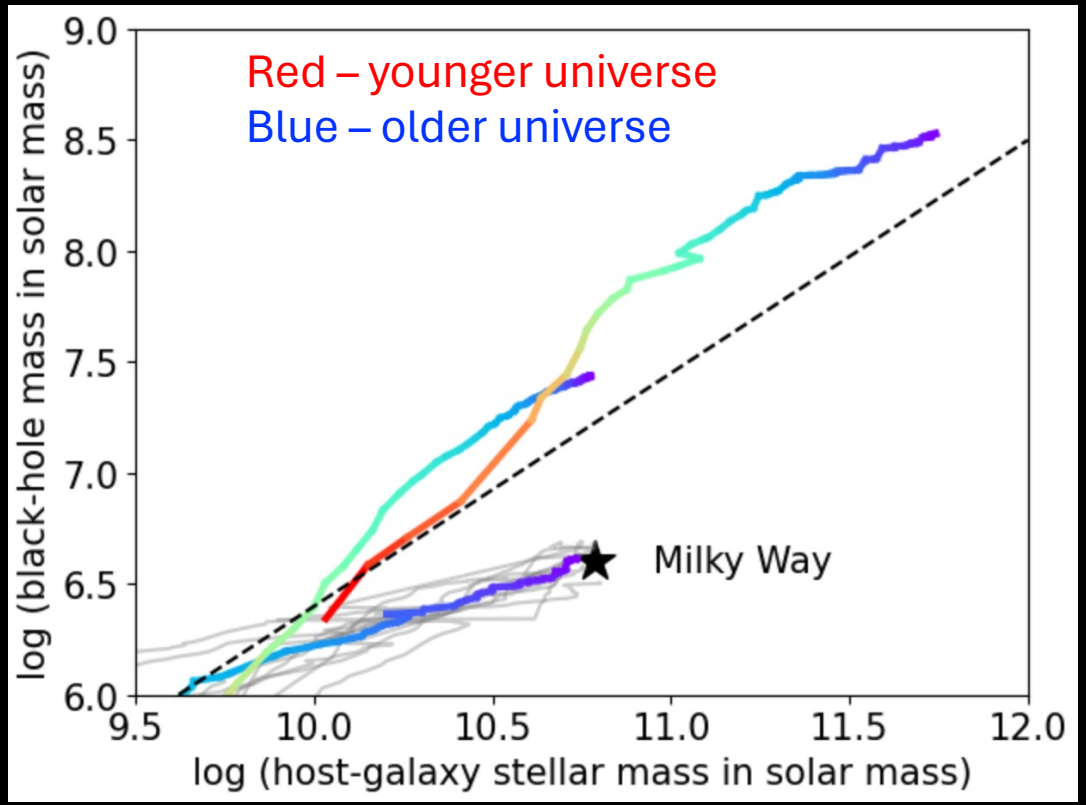
Supercomputer simulations

By combining both growth channels, we can track how supermassive black holes grow over cosmic time

- Accretion + mergers

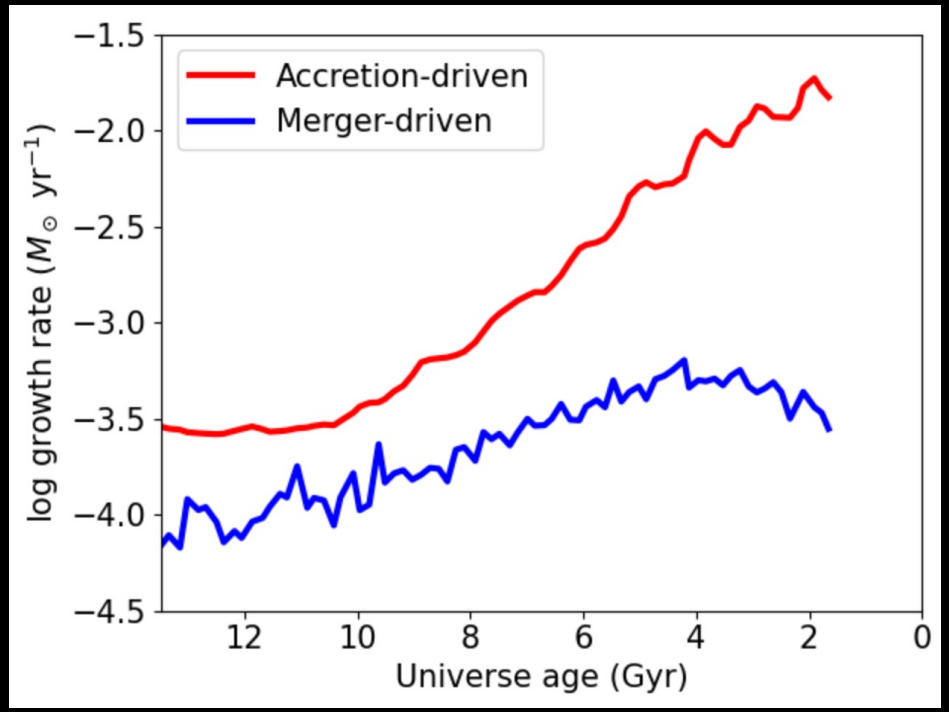
  (X-rays) (simulations)

  → a complete growth picture



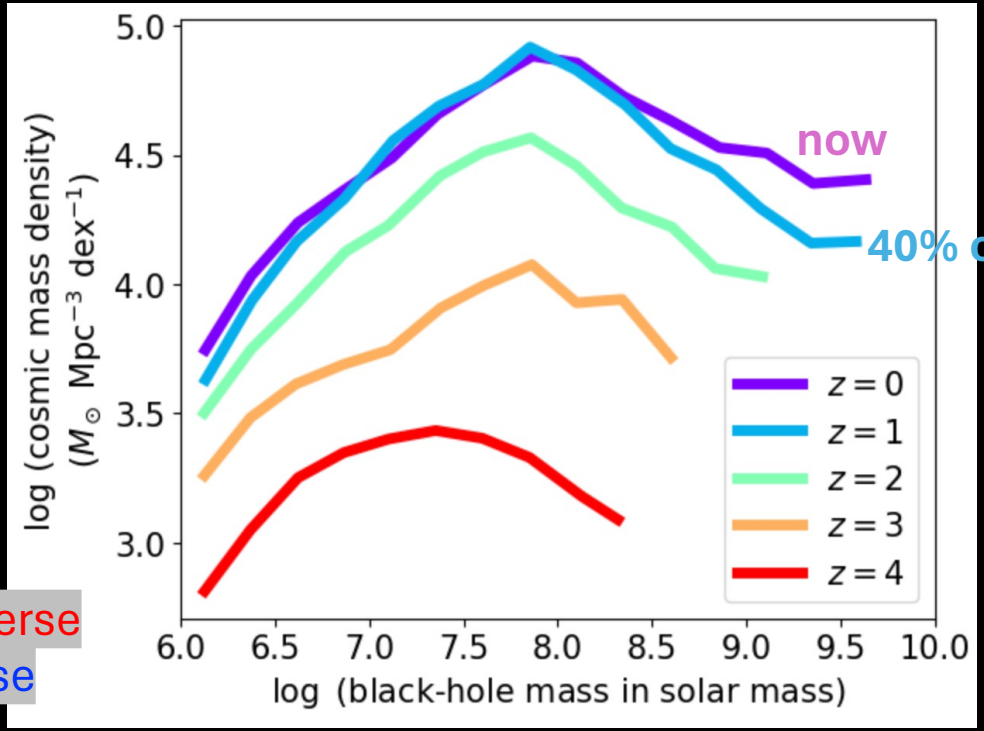
Zou et al. (in prep.)

Accretion dominated the supermassive black-hole growth in most cases, and mergers made notable secondary contributions



Zou et al. (in prep.)

We predict the overall demography of supermassive black holes over cosmic time



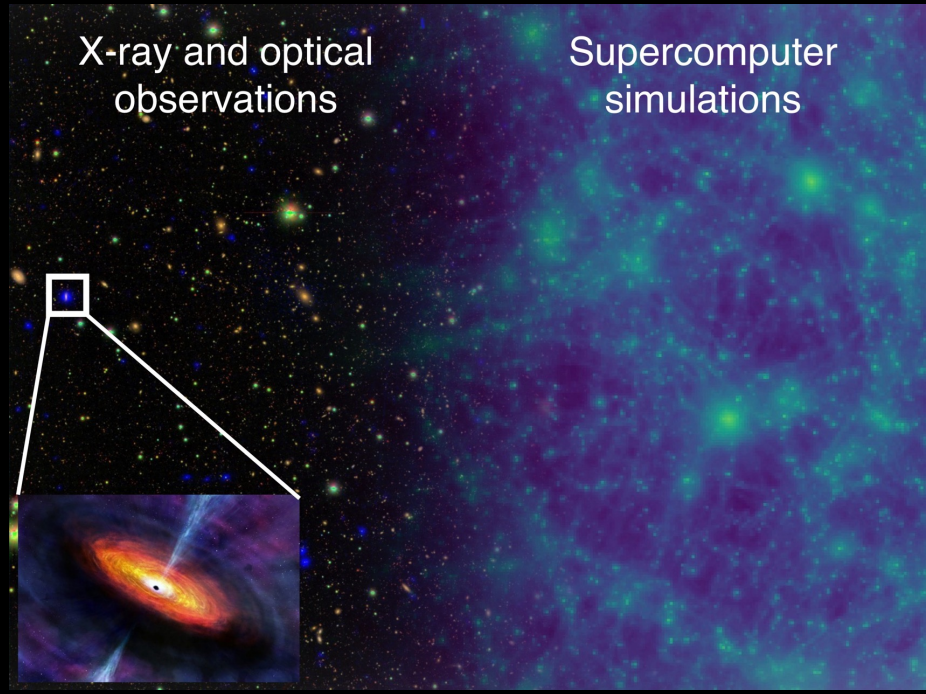
Red – younger universe
Blue – older universe

Zou et al. (in prep.)

Summary

- Accretion-driven growth traced with X-ray data accumulated over more than 20 years.
- Merger information from supercomputer TNG cosmological simulations.
- A combination of both returns the most realistic growth picture of supermassive black holes over cosmic time.

Zou et al. (2024); ApJ, 964, 183
Zou et al. (in prep.)



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