

UNIVERSITY OF  
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ioa



# The next frontier of cosmic structure formation simulations: a multi-messenger view of galaxies and their central black holes



DiRAC

Debora Sijacki



# Jet emergence in M87

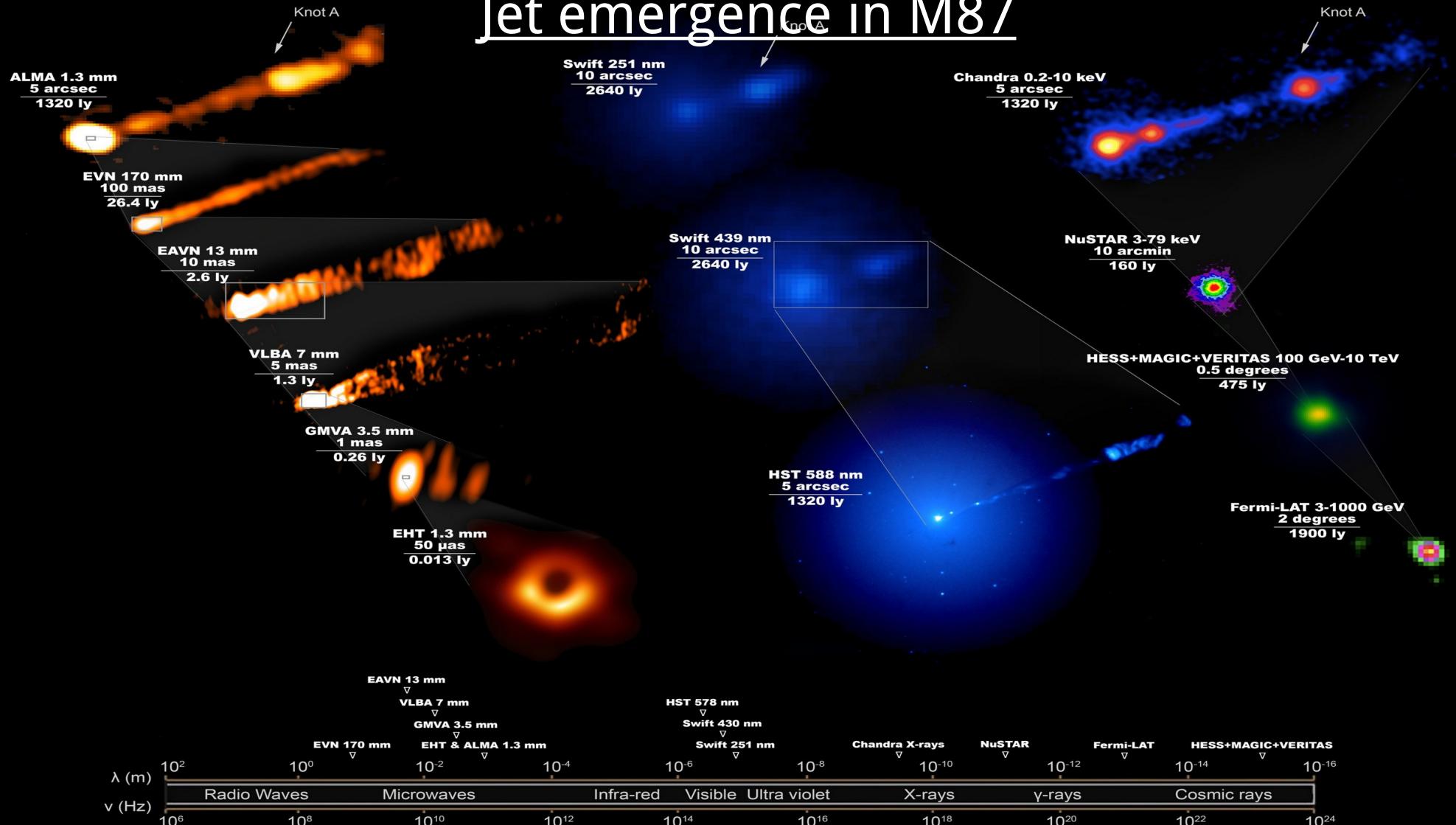
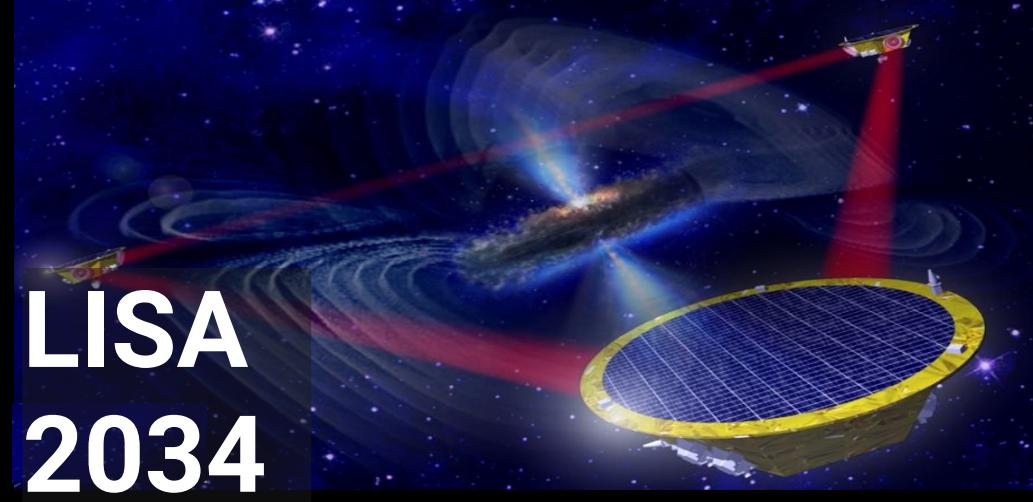


Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S. collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA. Composition by J. C. Algarra

# Upcoming observational facilities: revolution across the electromagnetic and gravitational wave spectrum



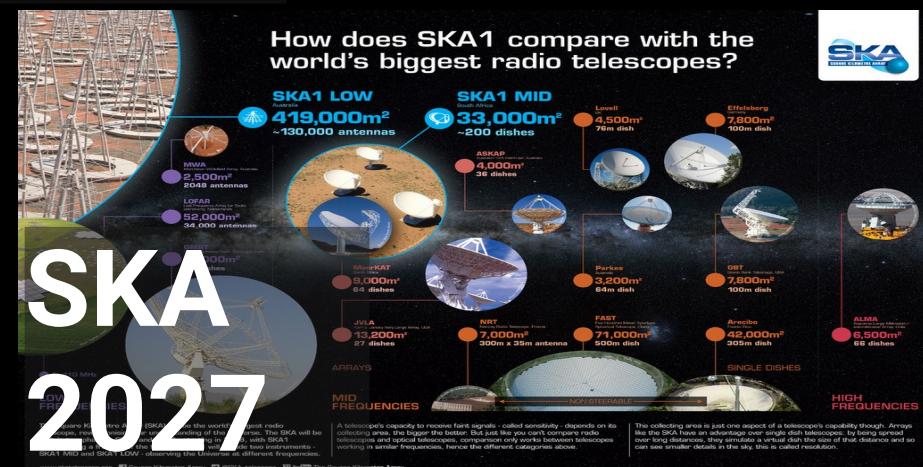
**JWST  
2021**



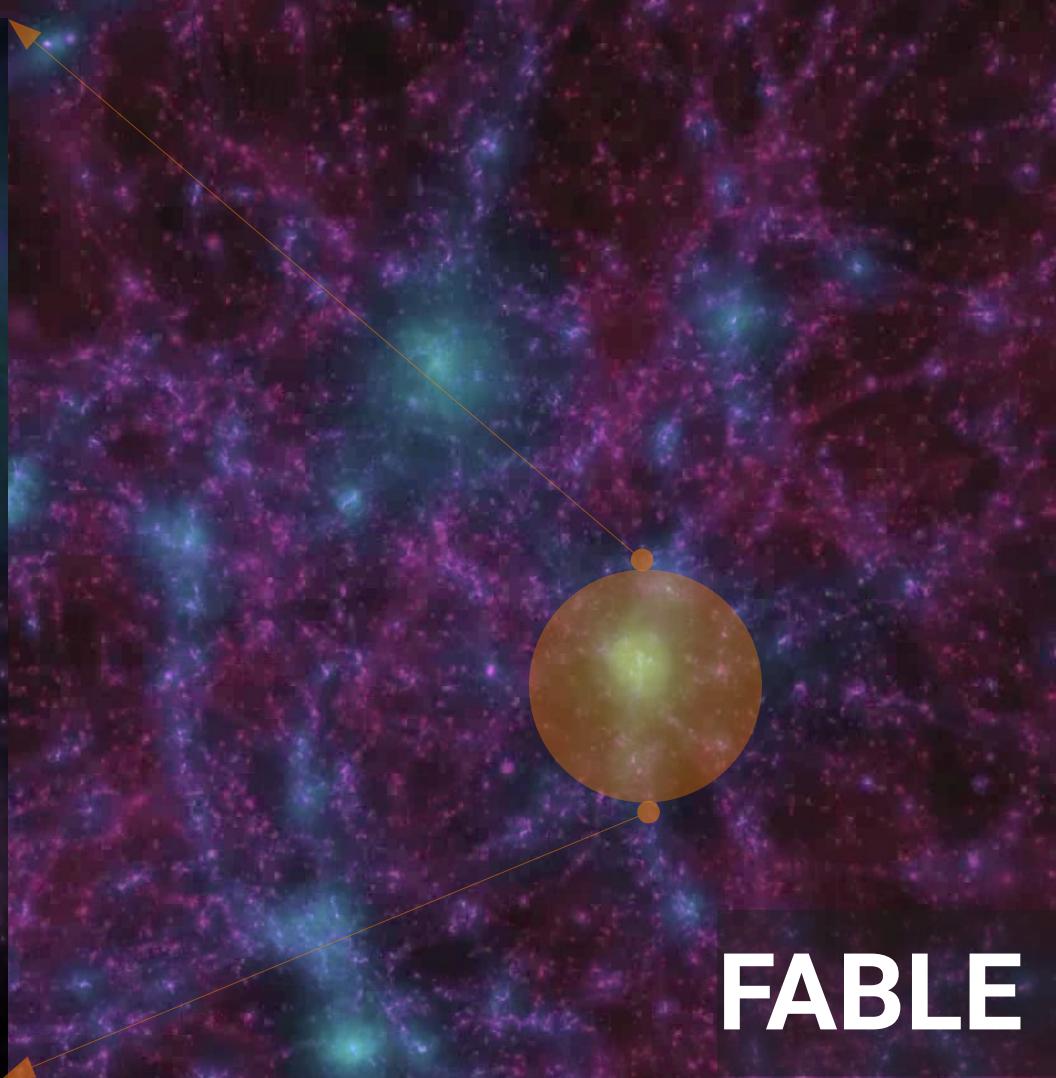
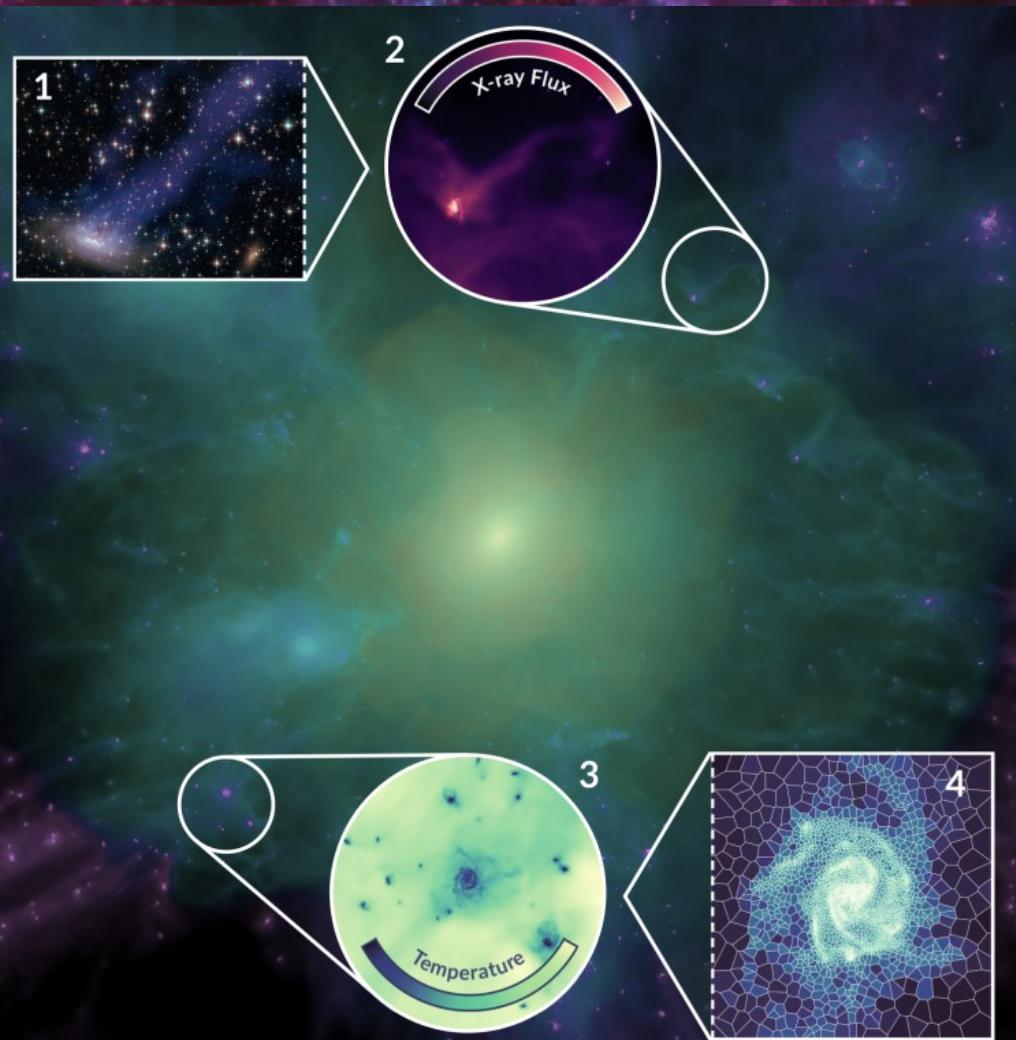
# LISA 2034



# Athena 2031+



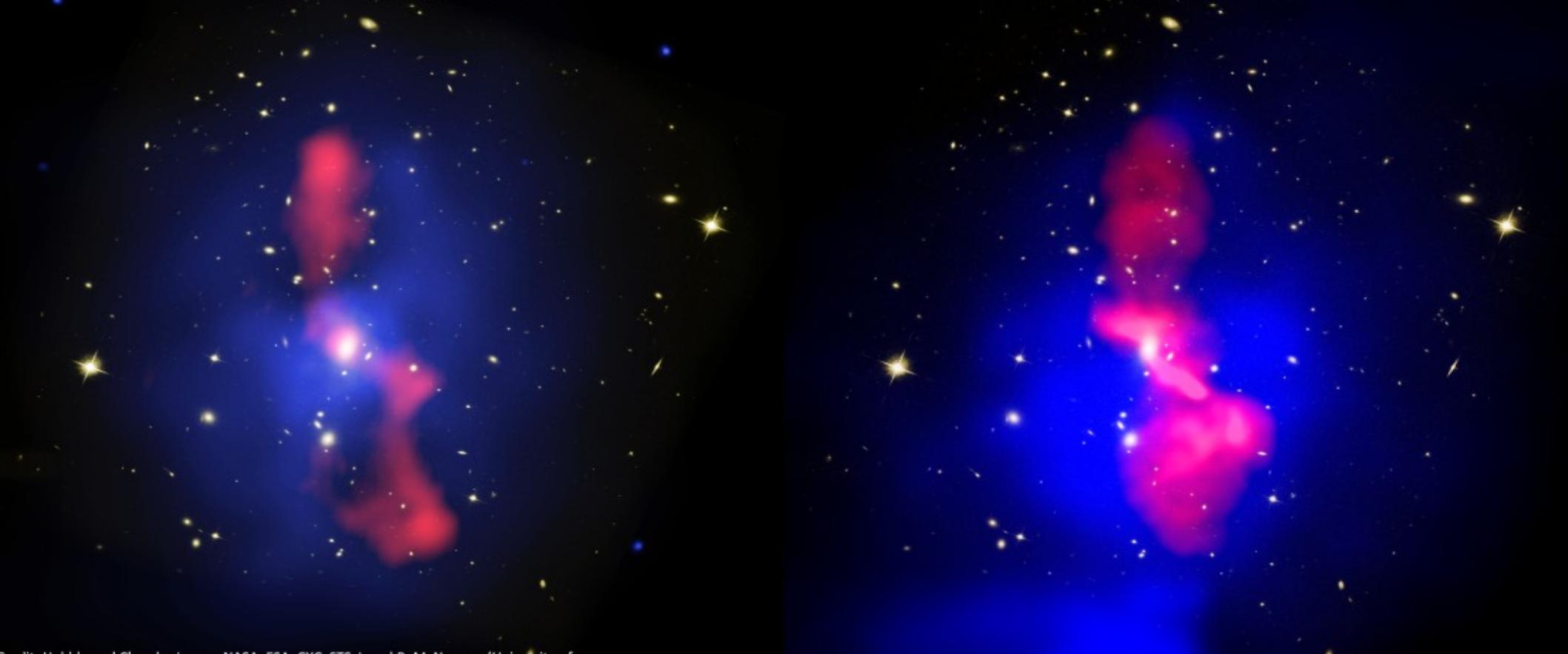
# Current state-of-the-art in cosmological simulations



# Black hole jets in full cosmological simulations

Cluster MS 0735

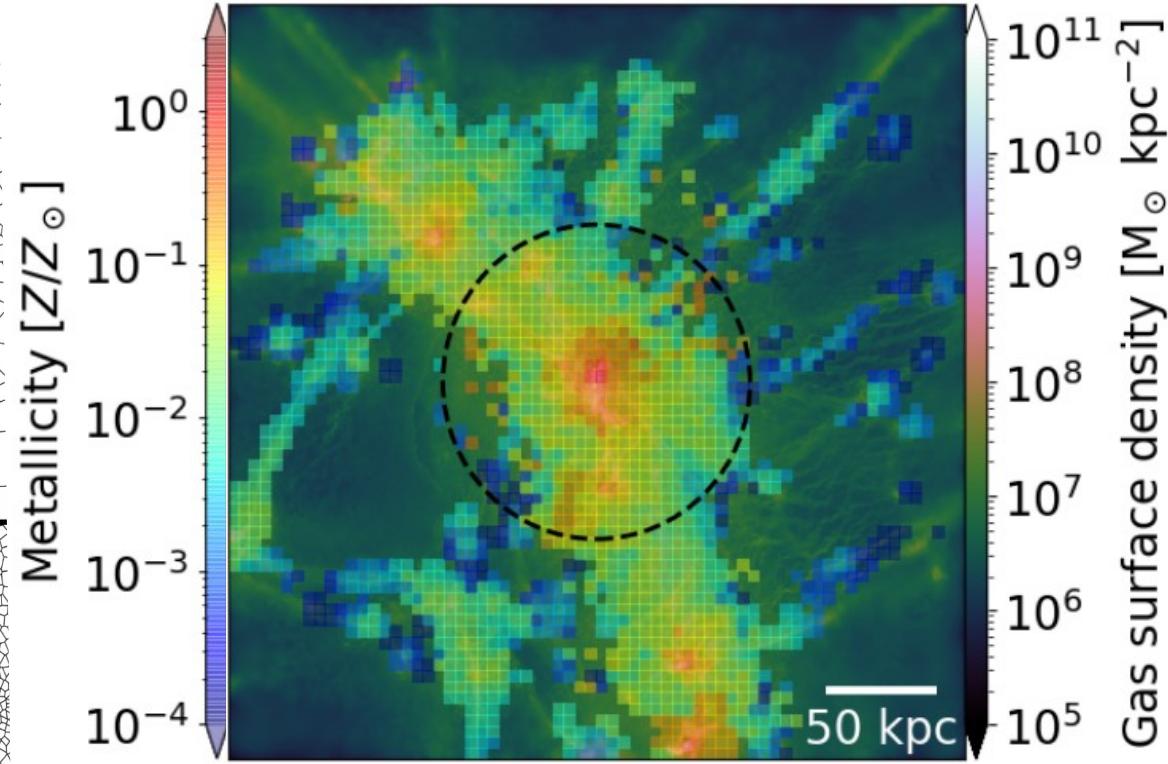
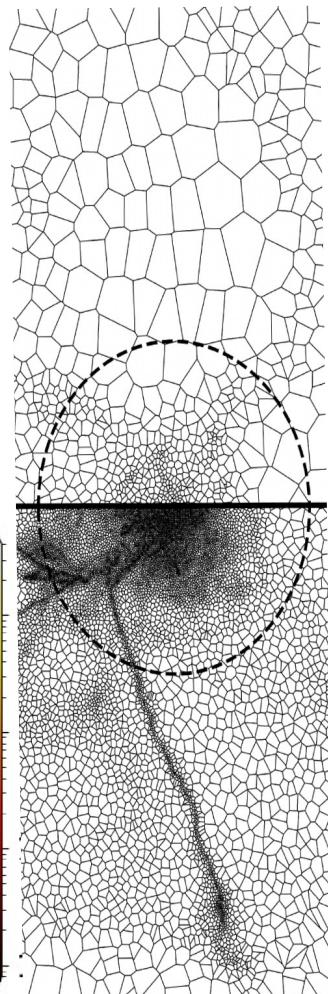
Simulated Cluster



Credit: Hubble and Chandra Image: [NASA](#), [ESA](#), [CXC](#), [STScI](#), and B. McNamara (University of Waterloo); Very Large Array Telescope Image: NRAO, and L. Birzan and team (Ohio University).

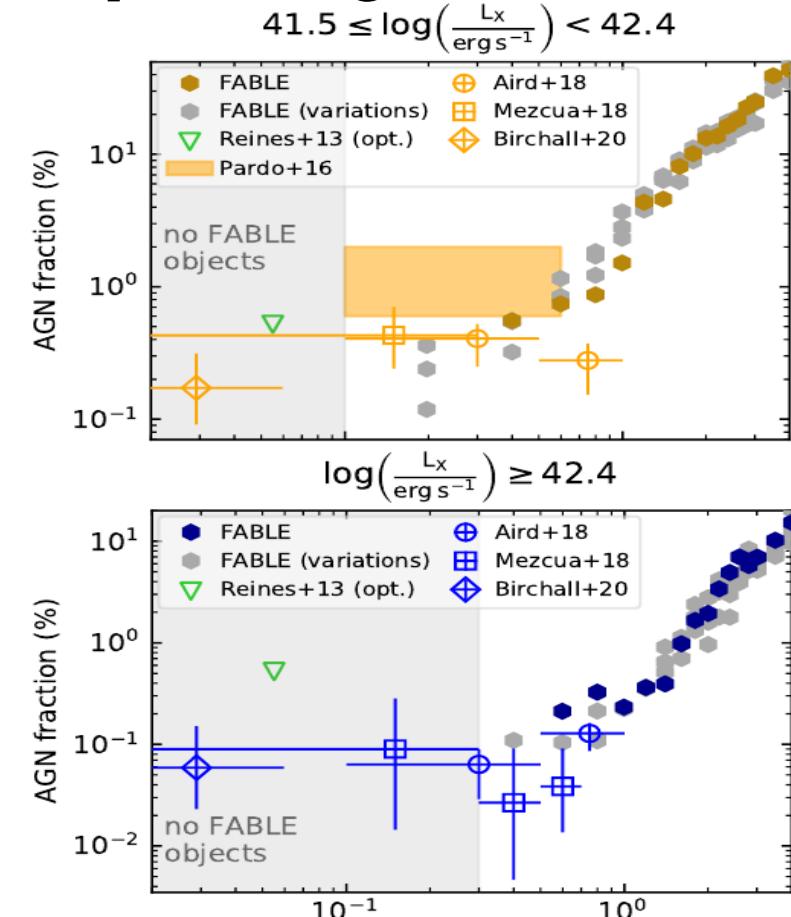
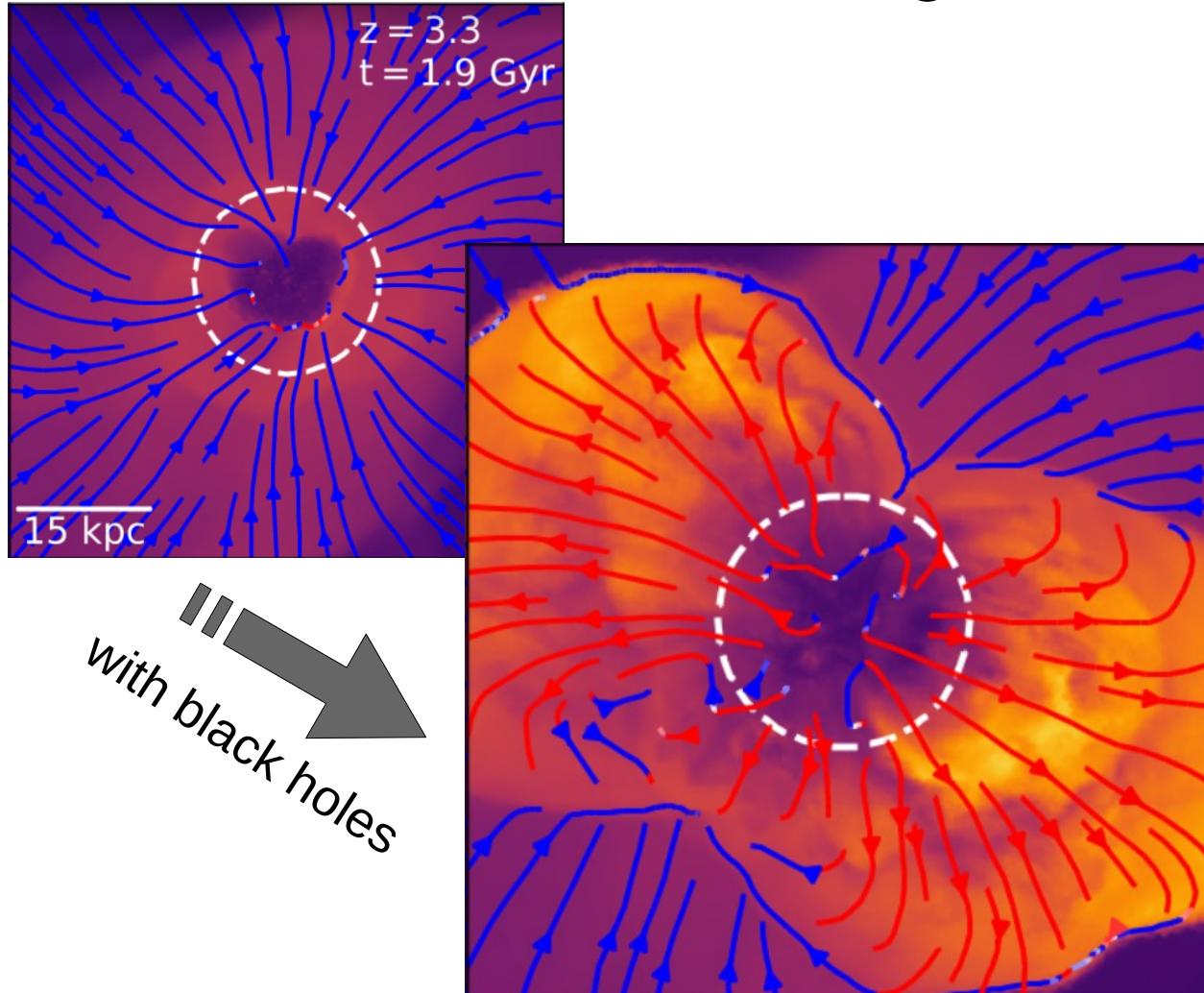
Credit: Hubble Image (background): [NASA](#), [ESA](#), and B. McNamara (University of Waterloo)

# Resolving galaxies and cosmic space between them



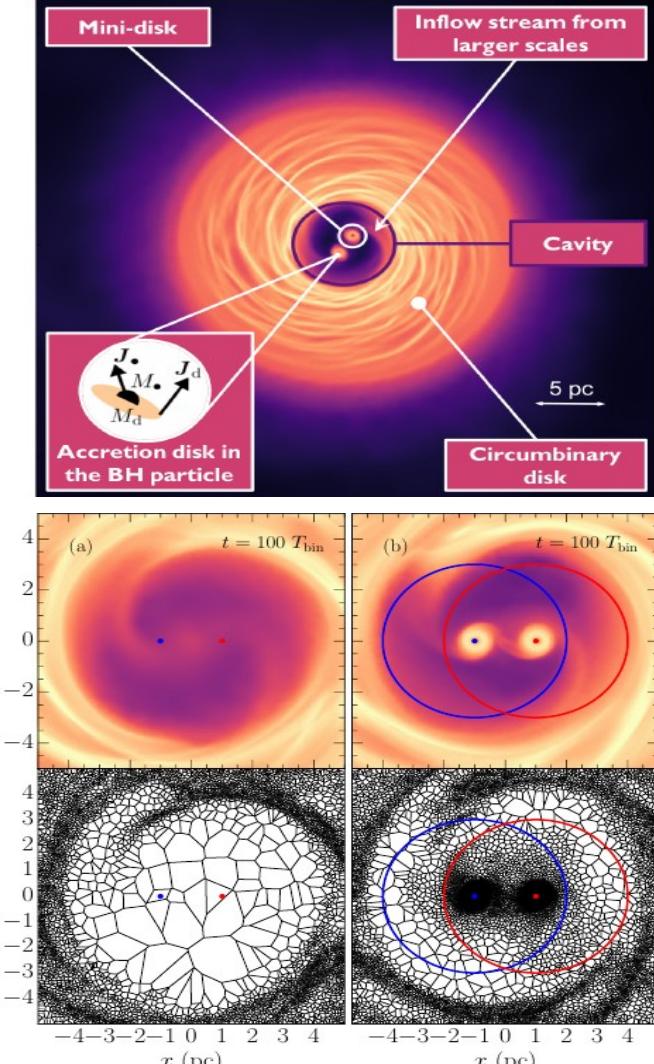
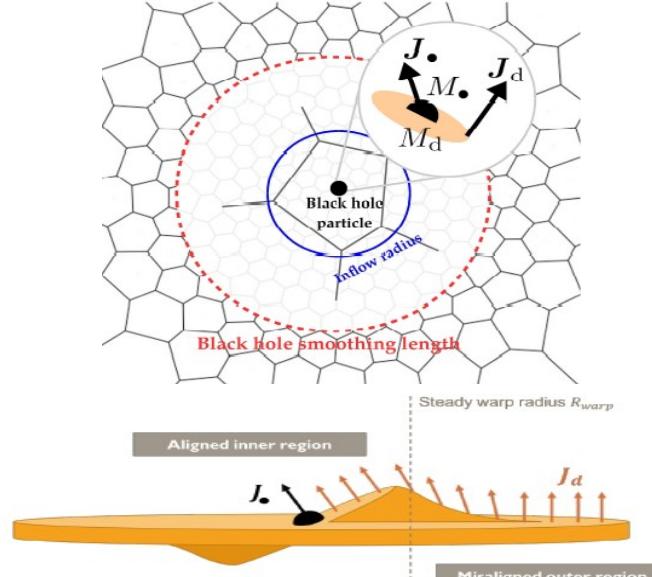
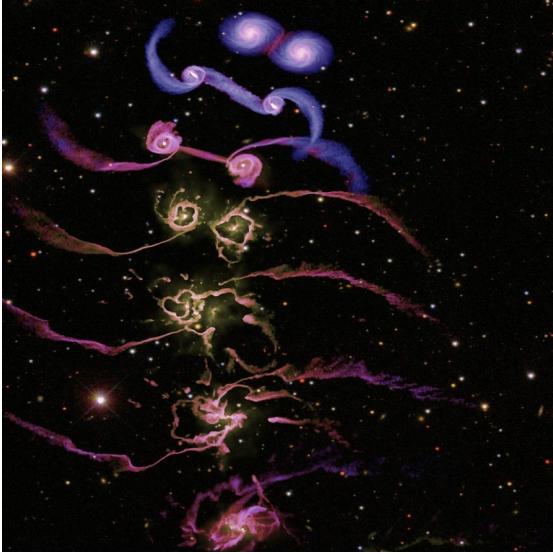
WITH MUCH HIGHER RESOLUTION IN  
COSMIC FILAMENTS LOW METALLICITY STARS  
FORM FROM (LARGELY) PRIMORDIAL GAS:  
PREDICTIONS FOR JWST

# Black holes in smallest galaxies: a paradigm shift?



ATHENA/LYNX SHOULD UNCOVER  
LARGE POPULATION OF BLACK  
HOLES IN SMALL GALAXIES

# Merging supermassive black hole binaries



**FROM GALAXY TO BLACK HOLE MERGER:  
FOLLOWING BLACK HOLE INSPIRAL TO  
MAKE PREDICTIONS FOR LISA**



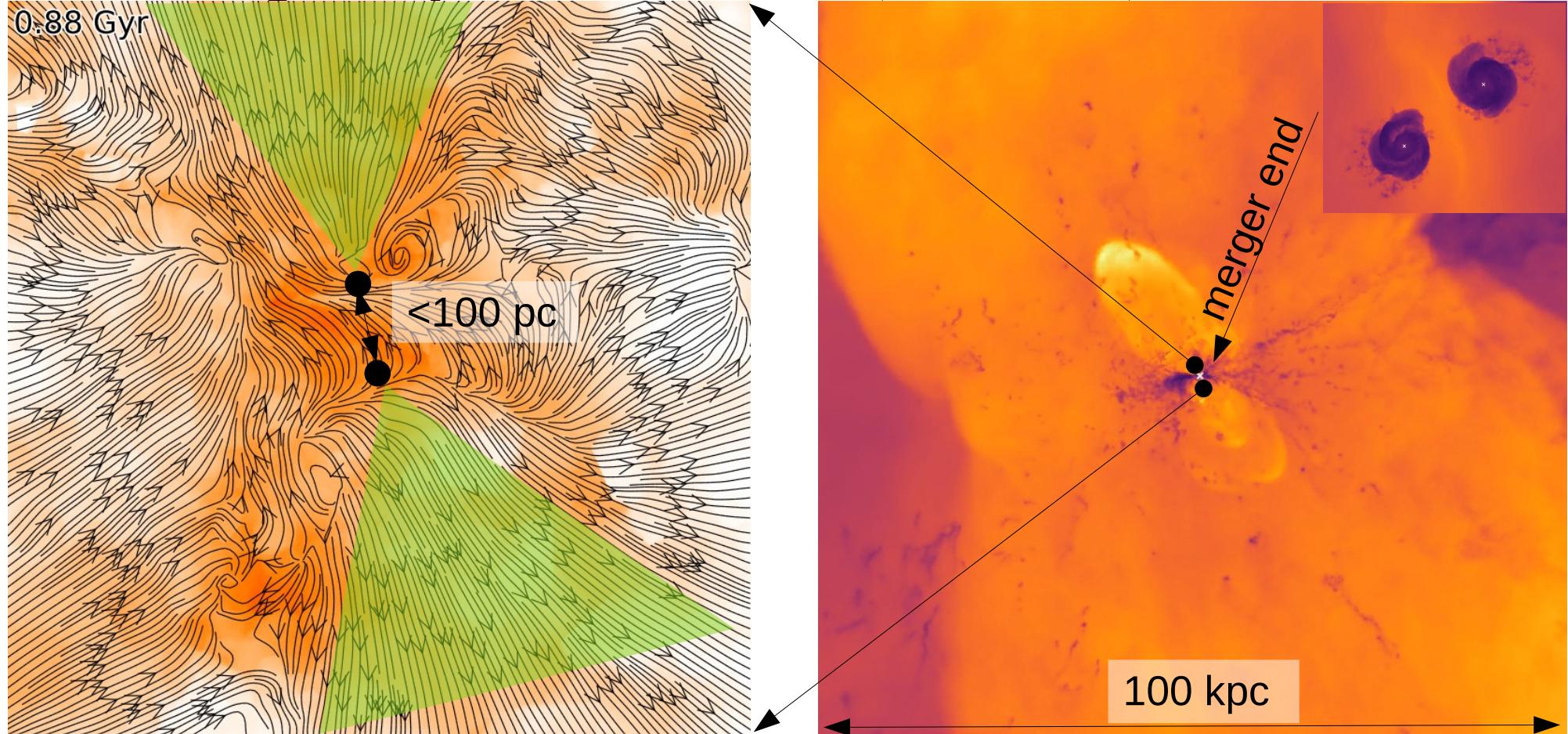
**Astrophysics Working Group**

Fiacconi, Sijacki & Pringle, 2018

Bourne, Fiacconi, Piotrowska & Sijacki, in prep.

Talbot, Bourne & Sijacki, MNRAS, 2022

# Next frontier in black hole growth and jet simulations: harnessing the power of JWST, Athena, LISA and SKA



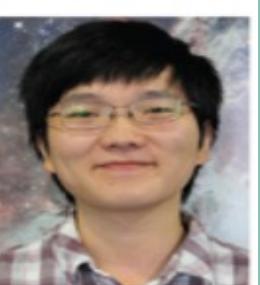
Talbot, Bourne & Sijacki, MNRAS, 2022 & in prep.; Koudmani, Talbot, Sijacki, in prep.

# Acknowledgements

Master students



PhD students

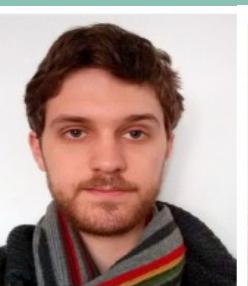


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