DO SUPERMASSIVE BLACK HOLES IMPACT A GALAXY'S ABILITY TO FORM NEW STARS?

MICHAEL COWLEY

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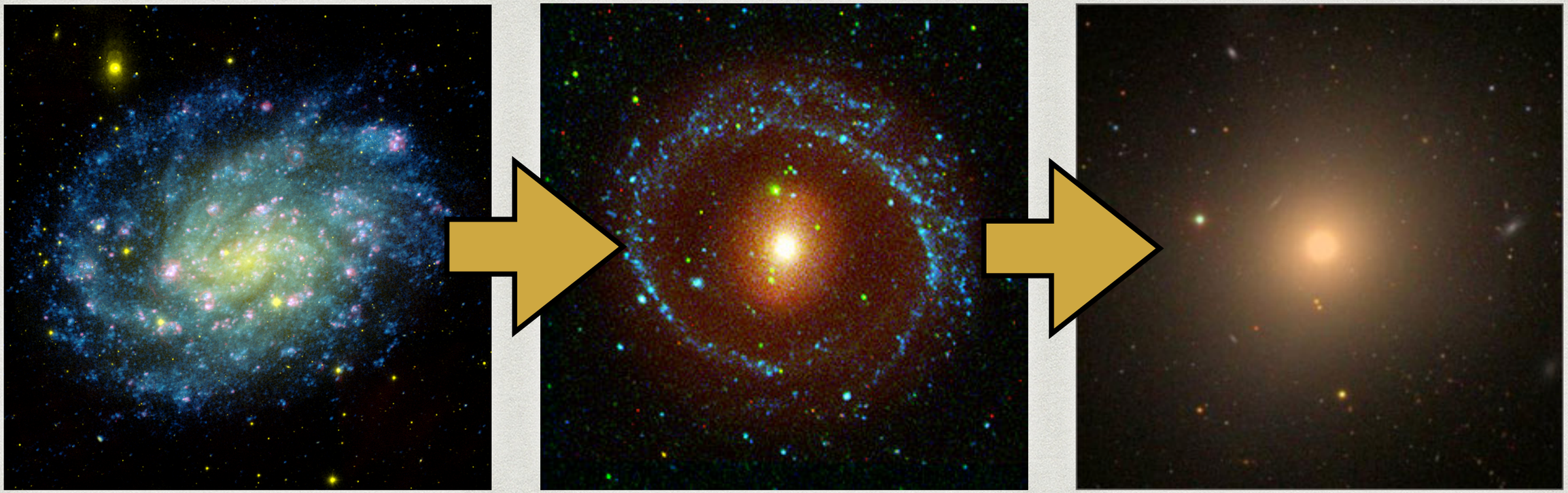
WHAT **SUPPRESSES** STAR-FORMATION IN GALAXIES?

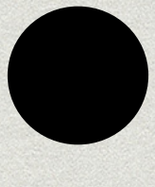


Younger Galaxies **Transitional** **Older Galaxies**

Understanding this is central to building a coherent picture of galaxy evolution

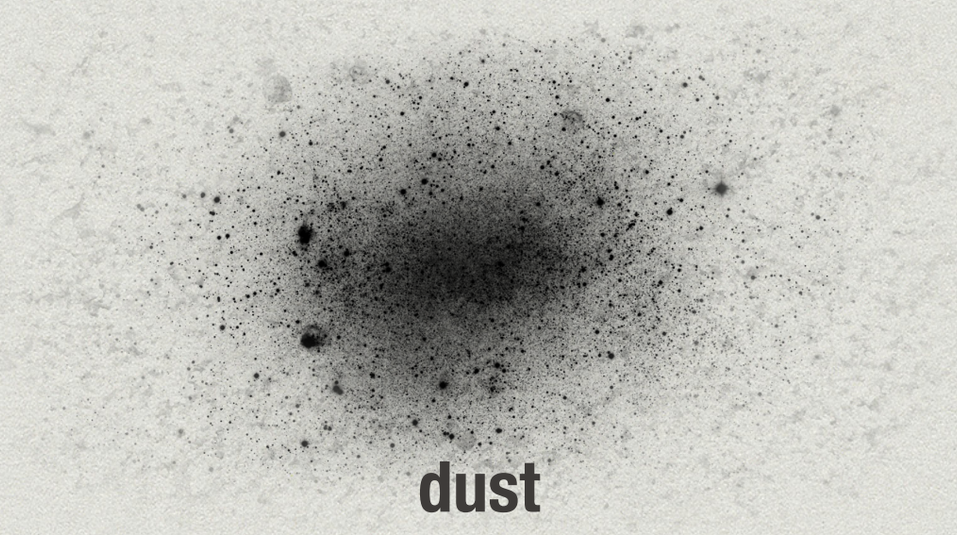
Image Credit: NASA/JPL-Caltech

SUPERMASSIVE BLACK HOLE



SUPERMASSIVE BLACK HOLE

gas



dust

stars

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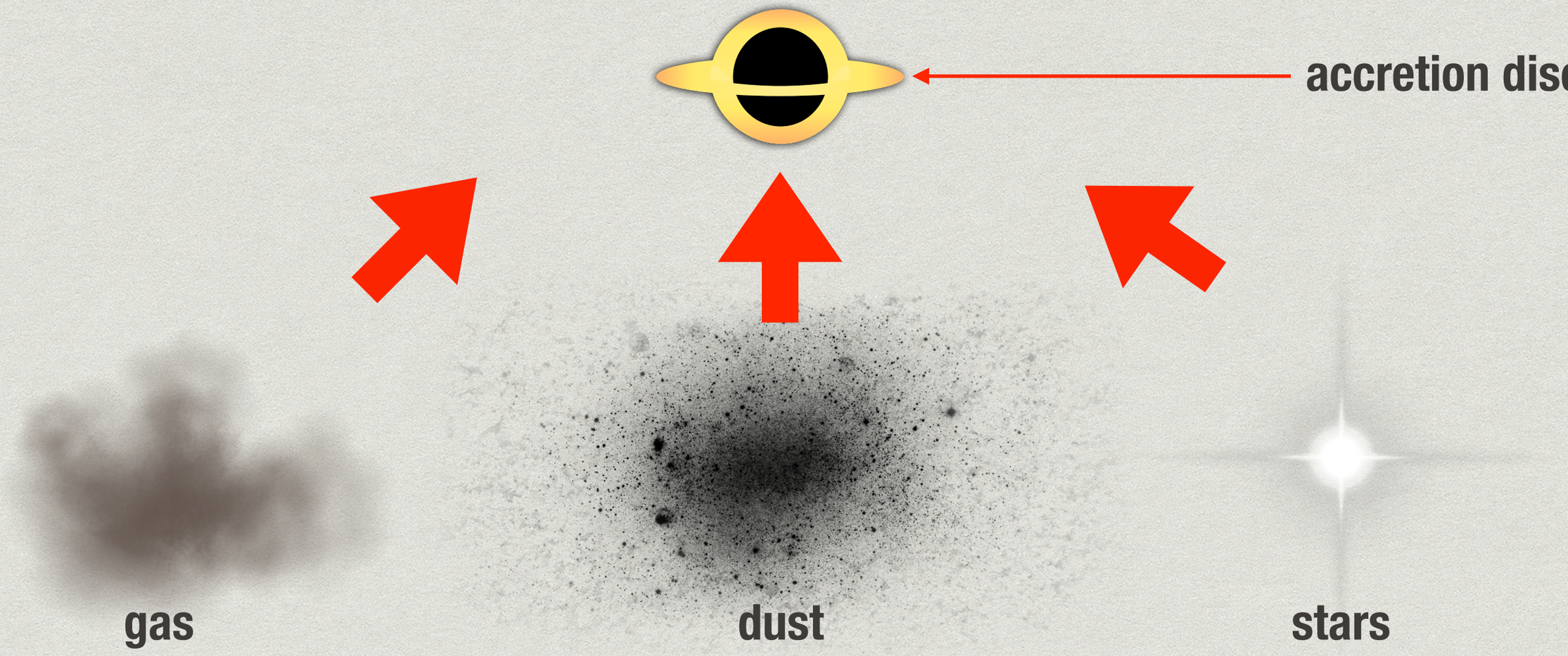
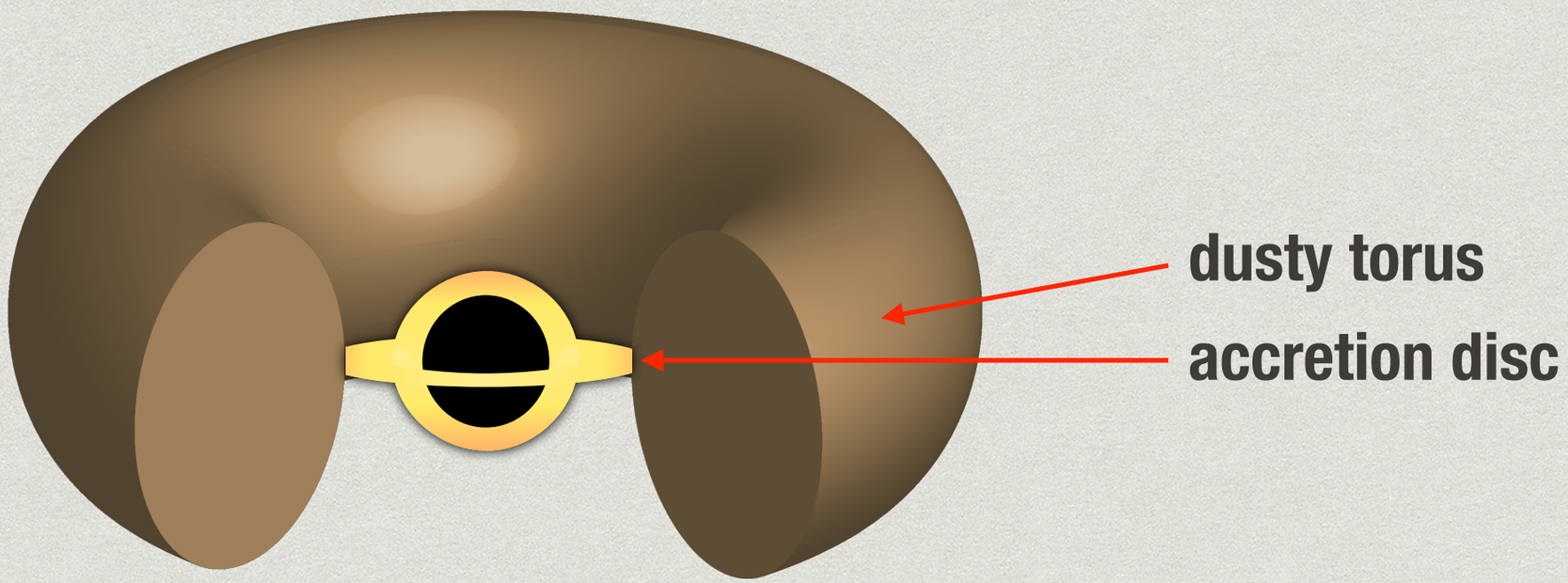
FEEDING A SUPERMASSIVE BLACK HOLE

Conservation of angular momentum causes fuel to form a disk as it spirals in



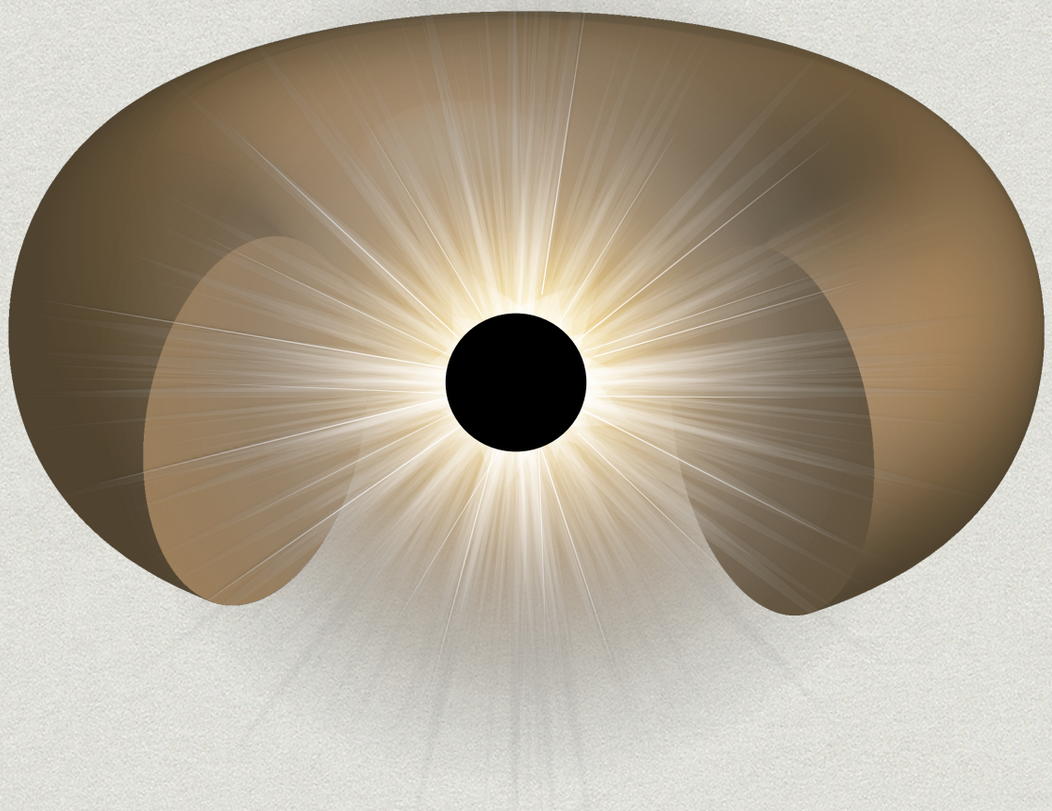
FEEDING A SUPERMASSIVE BLACK HOLE



ACTIVE SUPERMASSIVE BLACK HOLE

$L \sim 10^{37\text{-}41}$W

(i.e. $\sim 10^{10\text{-}14} L_{\odot}$)



Within this disc, there are dissipative processes, e.g. collisions, shocks, etc. This dissipated energy emerges as radiation

ACTIVE SUPERMASSIVE BLACK HOLE

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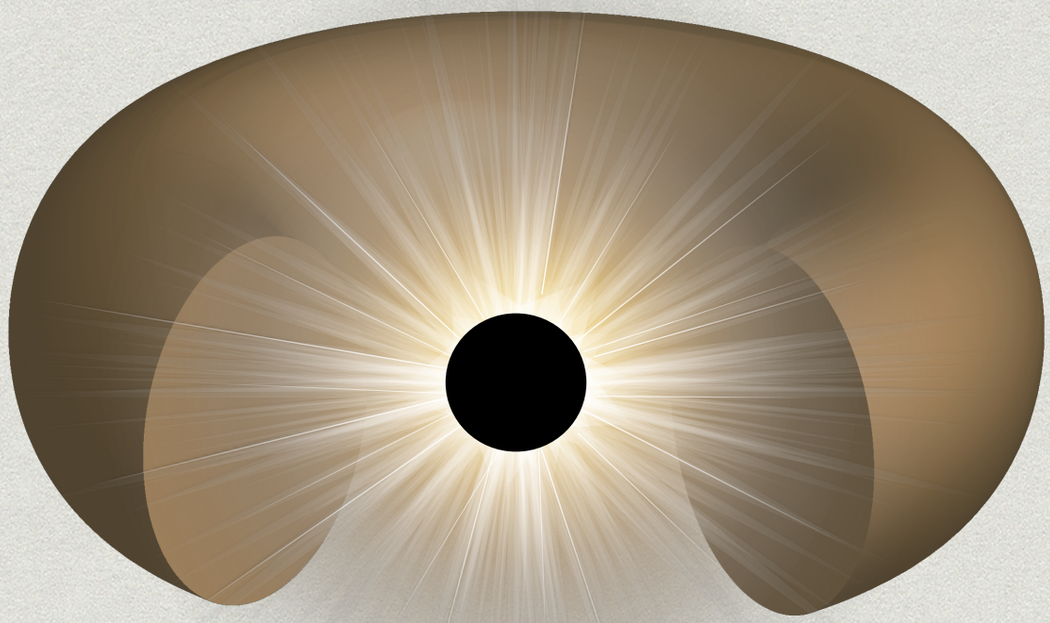
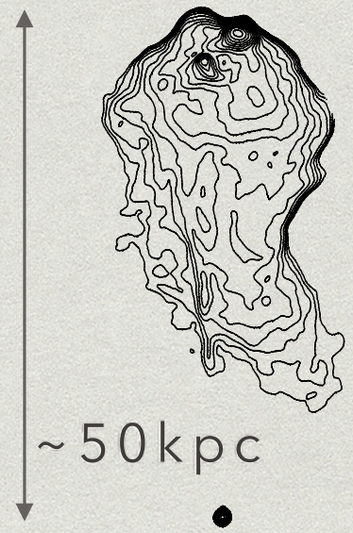
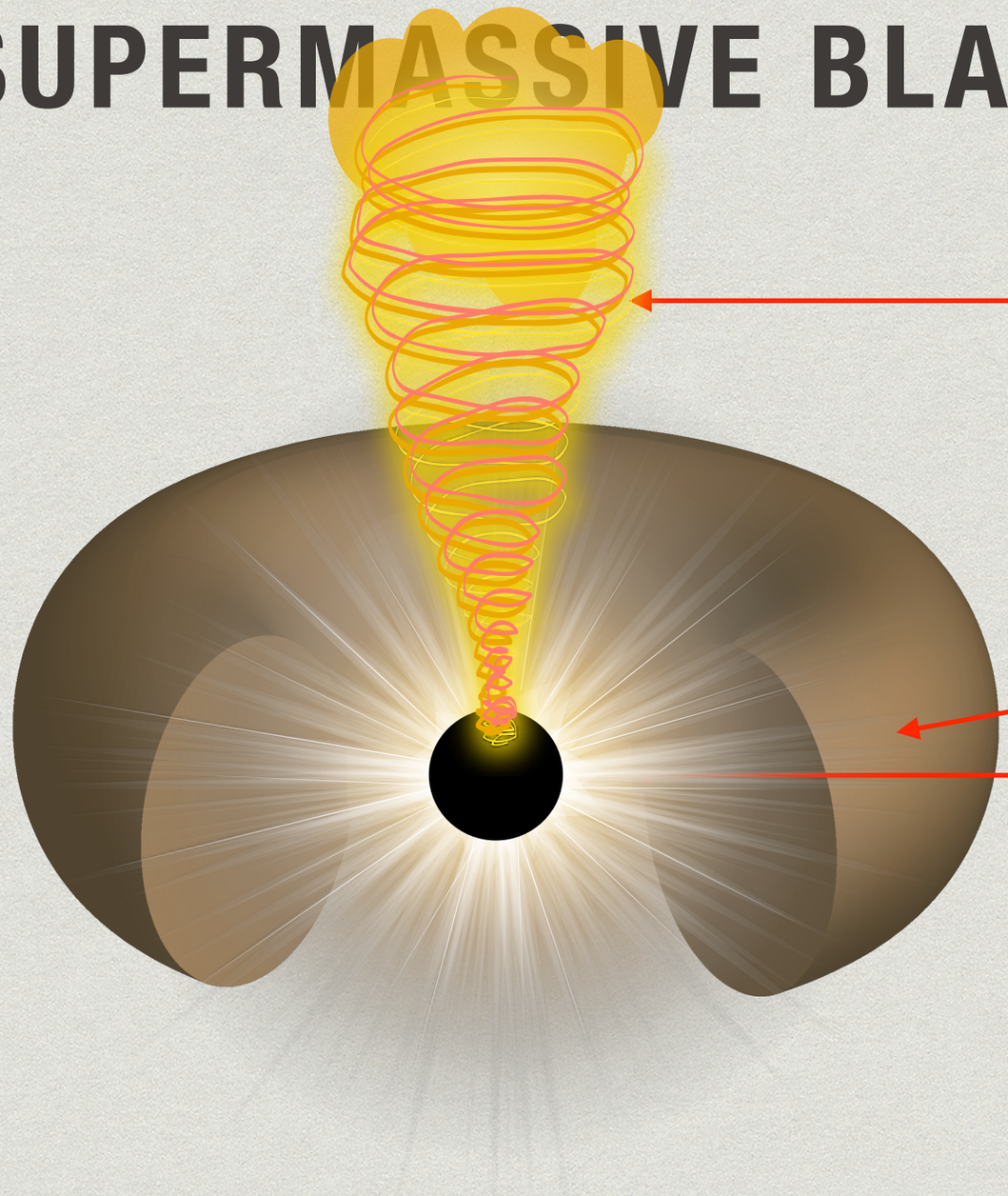


Accretion rate…

$$\dot{M} = \frac{L}{\eta c^2} = \frac{10^{10} L_\odot}{0.1 c^2} \approx 0.01 M_\odot \mathrm{yr}^{-1}$$

ACTIVE SUPERMASSIVE BLACK HOLE





Jets of ionised gas that propagate perpendicular to the plane of the accretion disc emit radio emission

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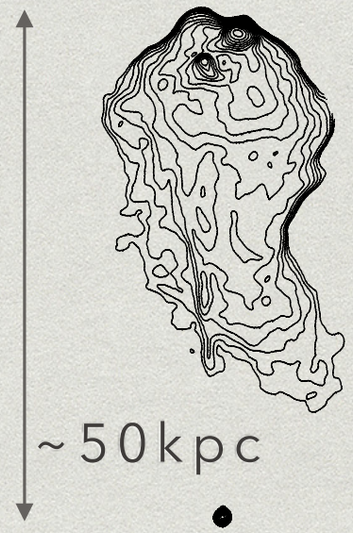
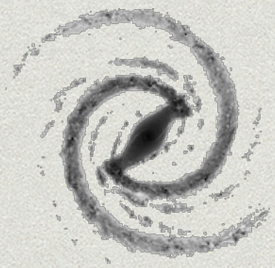
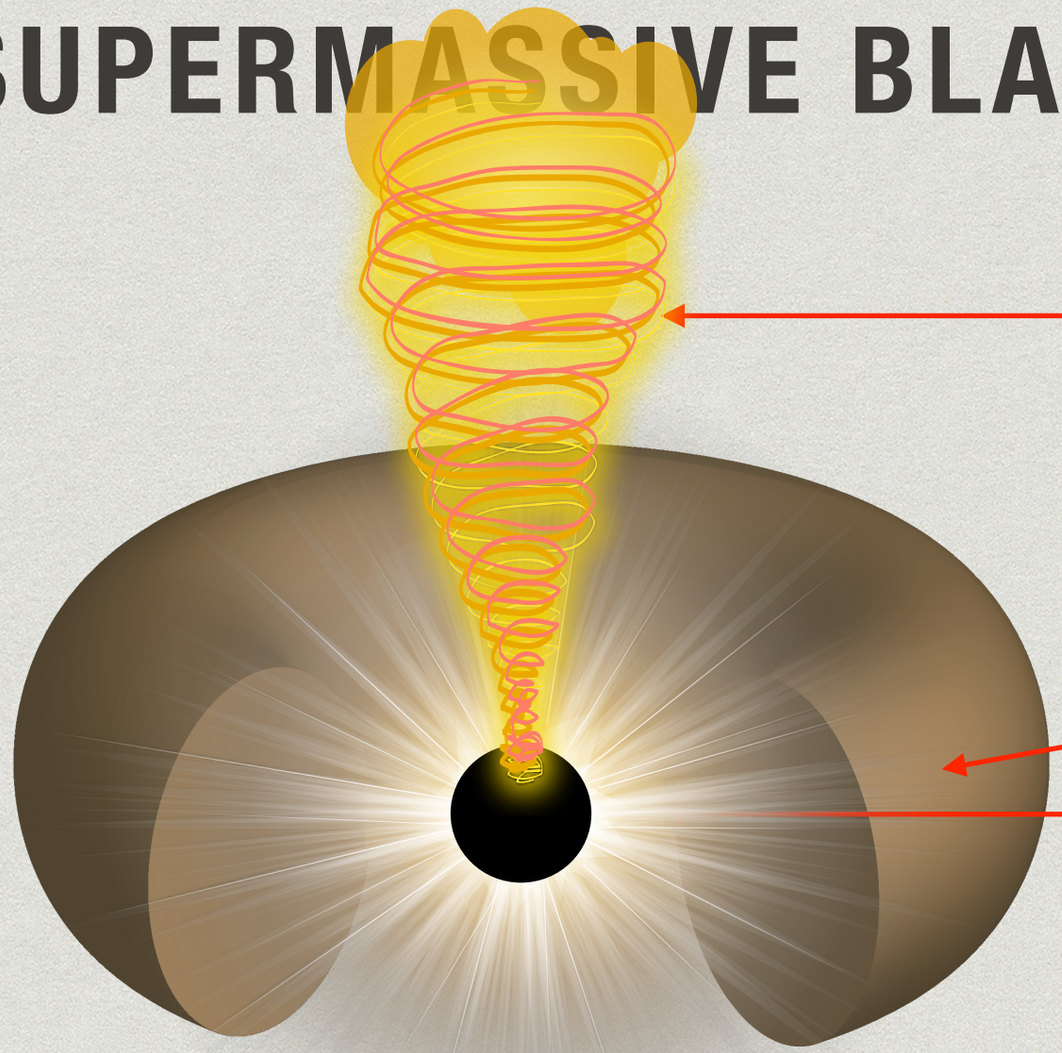
ACTIVE SUPERMASSIVE BLACK HOLE



Milky Way





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SUPERMASSIVE BLACK HOLE FEEDBACK

The gravitational energy of material falling into the centre of a galaxy toward the central supermassive black hole is released in the form of

- **radiation ranging from IR to X-rays**
- **mildly relativistic accretion winds**
- **relativistic radio jets**

Radiation, winds and jets "feed back" energy and momentum into the surrounding area of the galaxy

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WHY IS FEEDBACK IMPORTANT?

Feedback may help suppress ongoing star formation

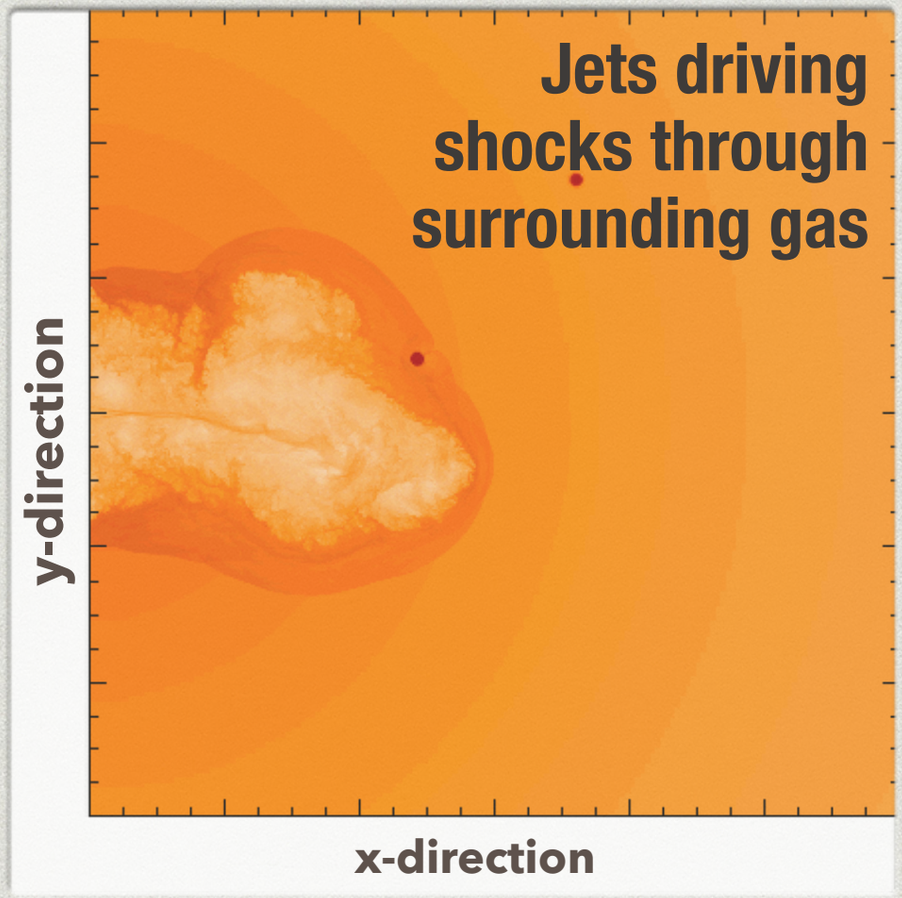
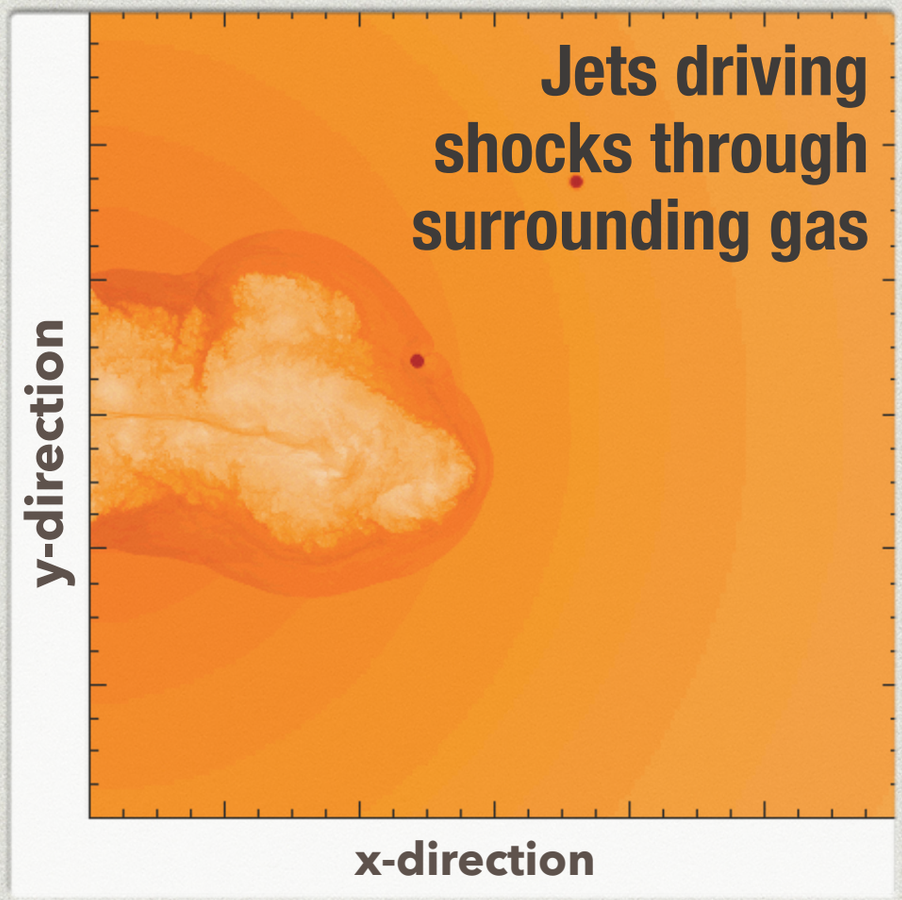


Image Credit: Vincenzo Antonuccio-Delogu

WHY IS FEEDBACK IMPORTANT?

Feedback may help suppress ongoing star formation and reduce the overproduction of massive galaxies seen in models



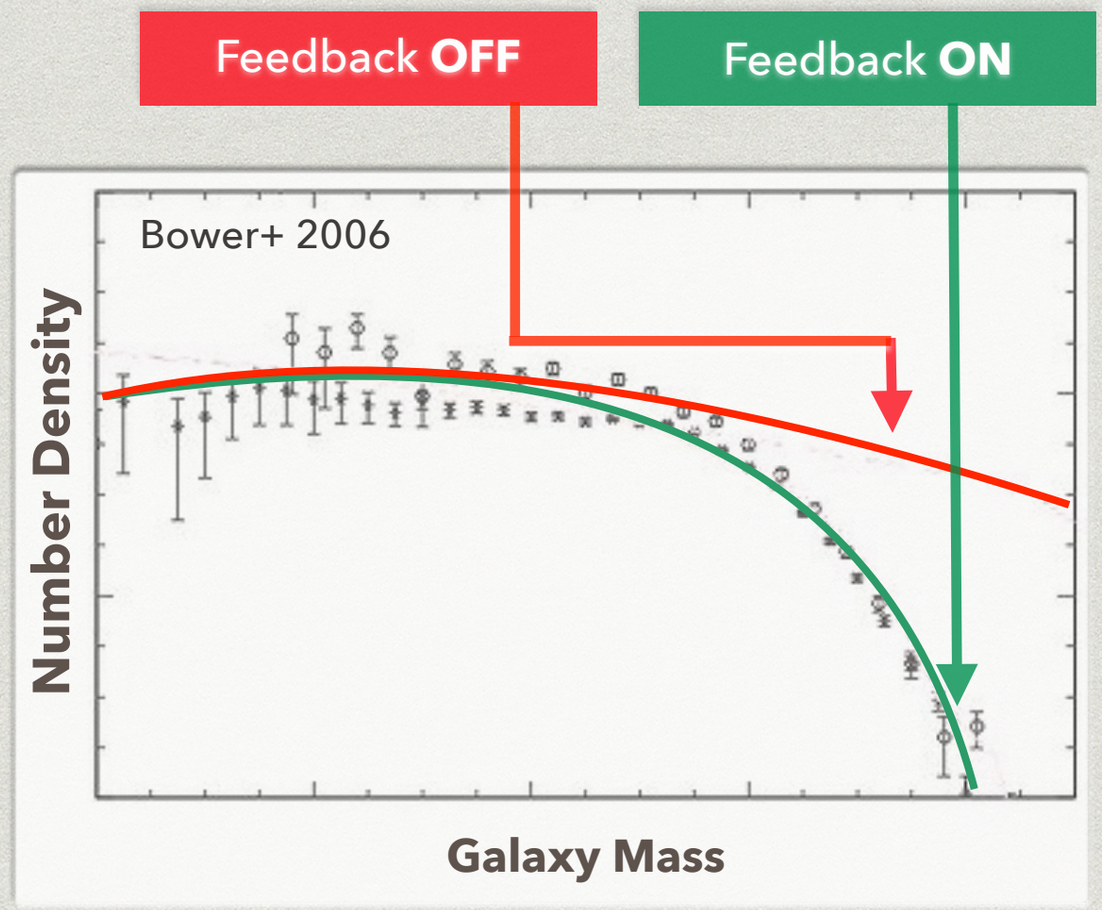


Image Credit: Vincenzo Antonuccio-Delogu

GOAL:

1) IDENTIFY A DIVERSE POPULATION OF GALAXIES HOSTING AN ACTIVE BLACK HOLE OVER A LARGE CHUNK OF COSMIC TIME

2) COMPARE THE STAR-FORMATION ACTIVITY OF THIS POPULATION WITH THOSE LACKING AN ACTIVE BLACK HOLE

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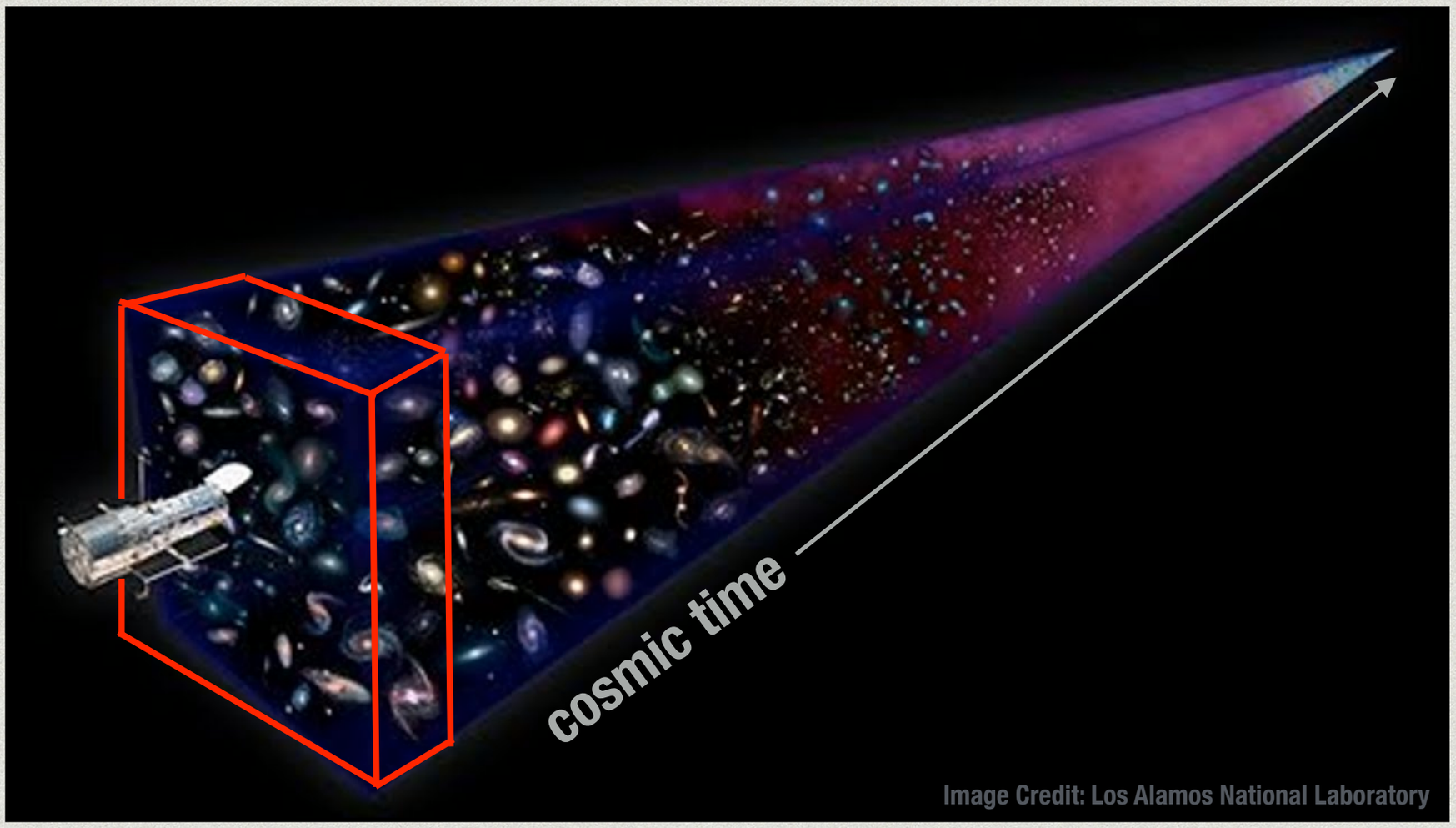

Image Credit: Los Alamos National Laboratory

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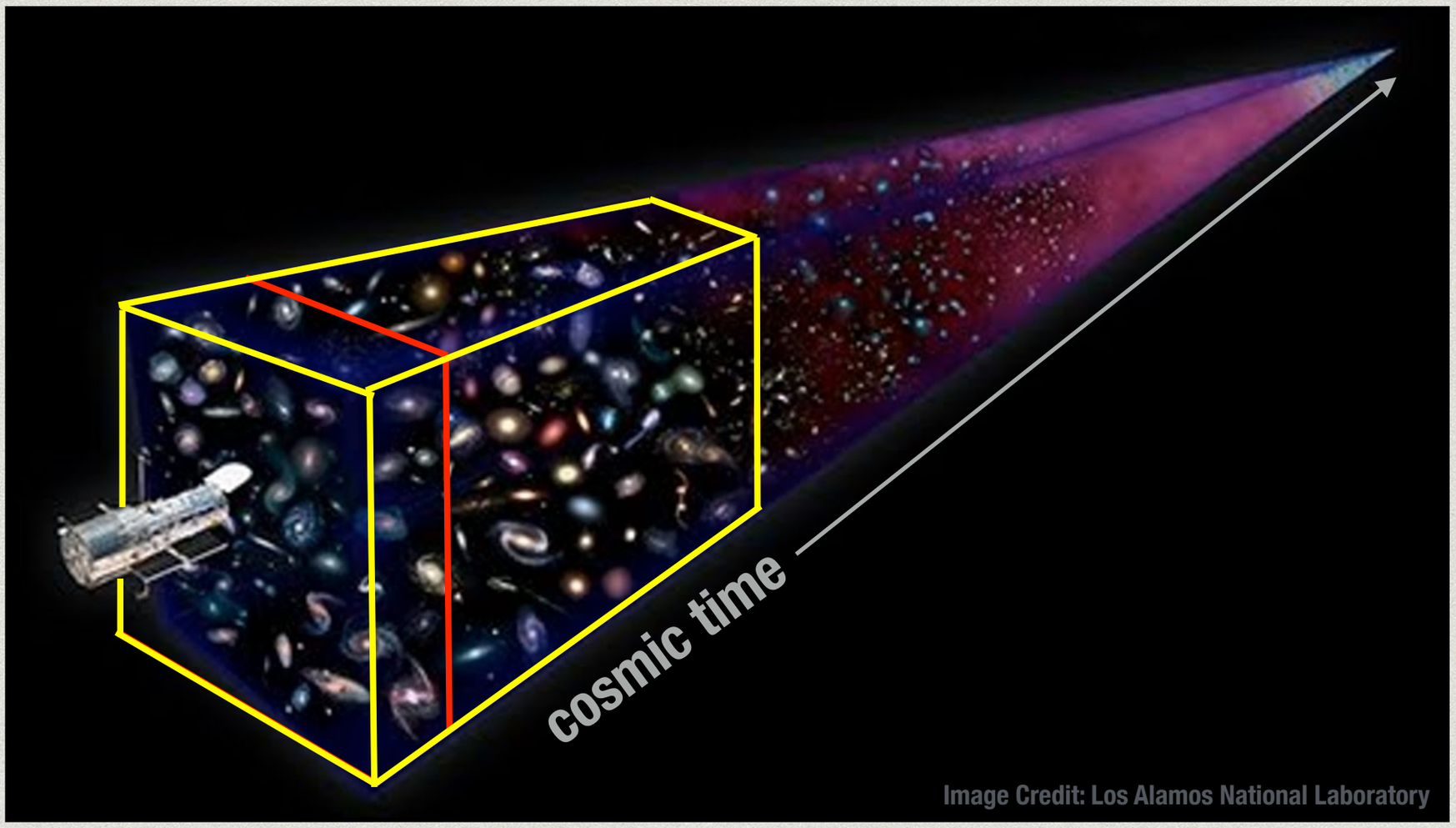

Image Credit: Los Alamos National Laboratory

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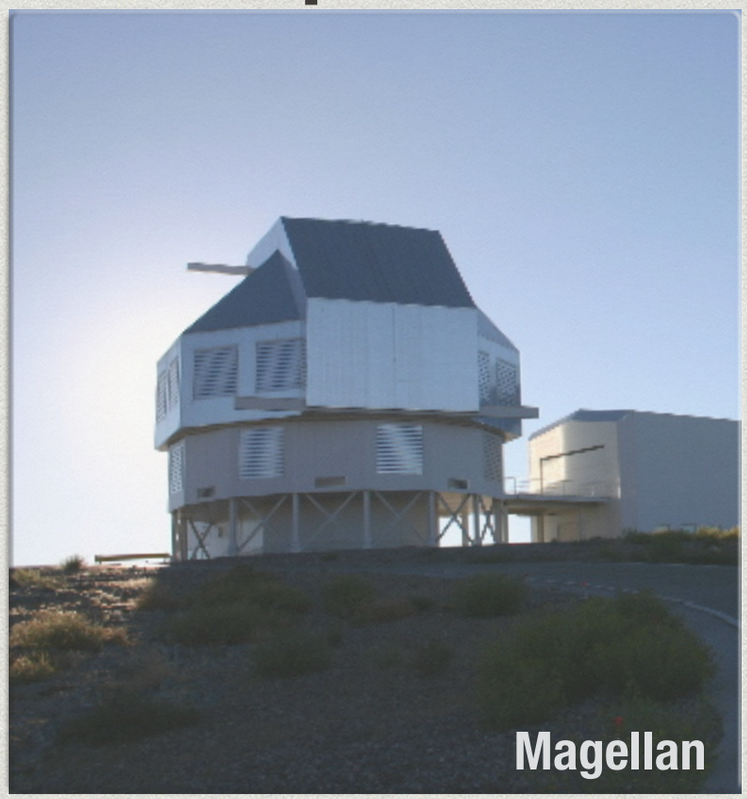
1) IDENTIFY A POPULATION OF GALAXIES HOSTING AN ACTIVE BLACK HOLE OVER A LARGE CHUNK OF COSMIC TIME

A multi-wavelength approach

Optical

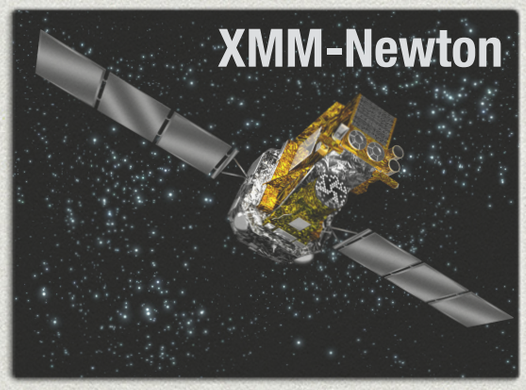


Radio

Optical/IR

Infrared

Infrared



X-Ray

X-Ray

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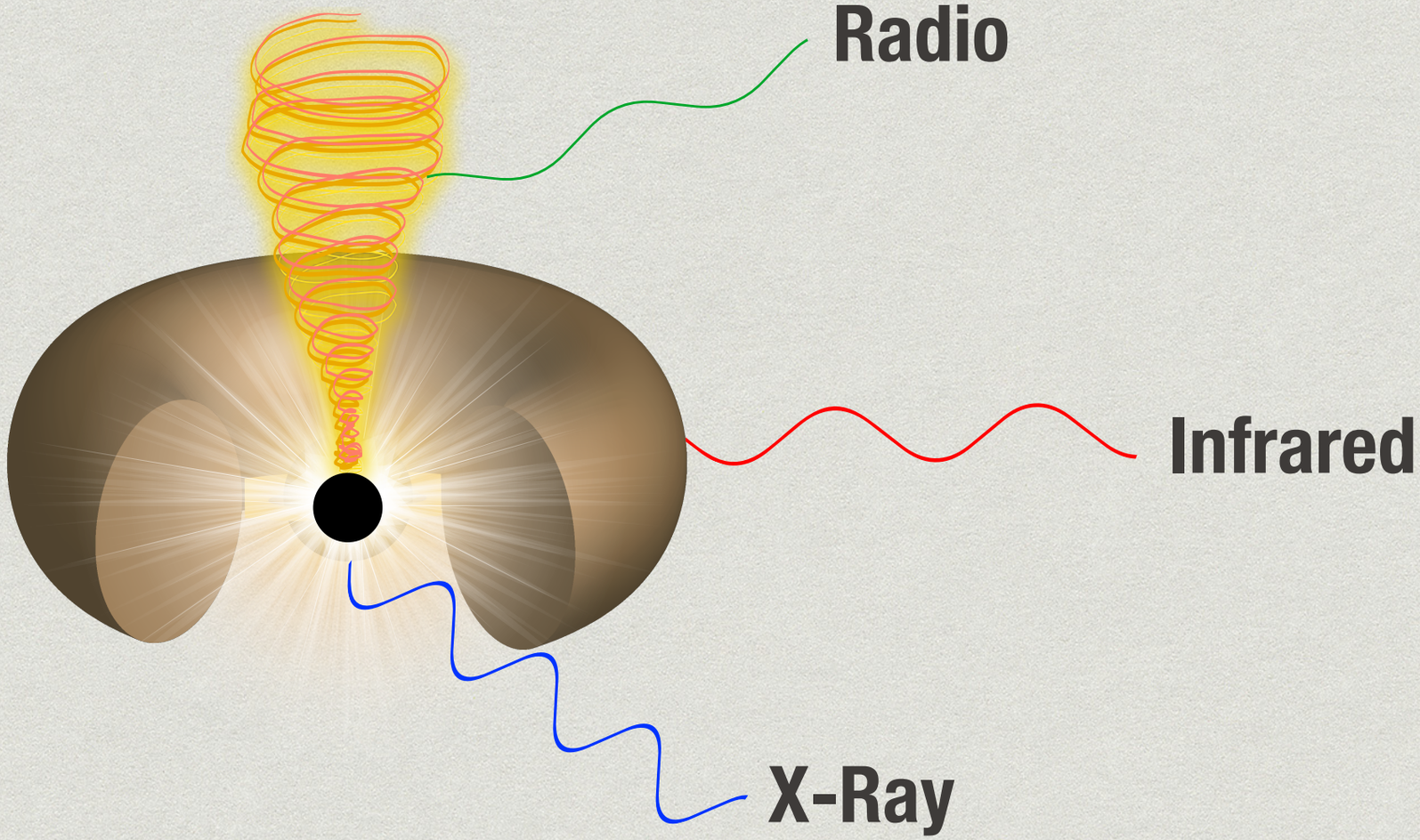
Requires a multi-wavelength approach



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Control Sample

Image Credit: NASA/JPL-Caltech

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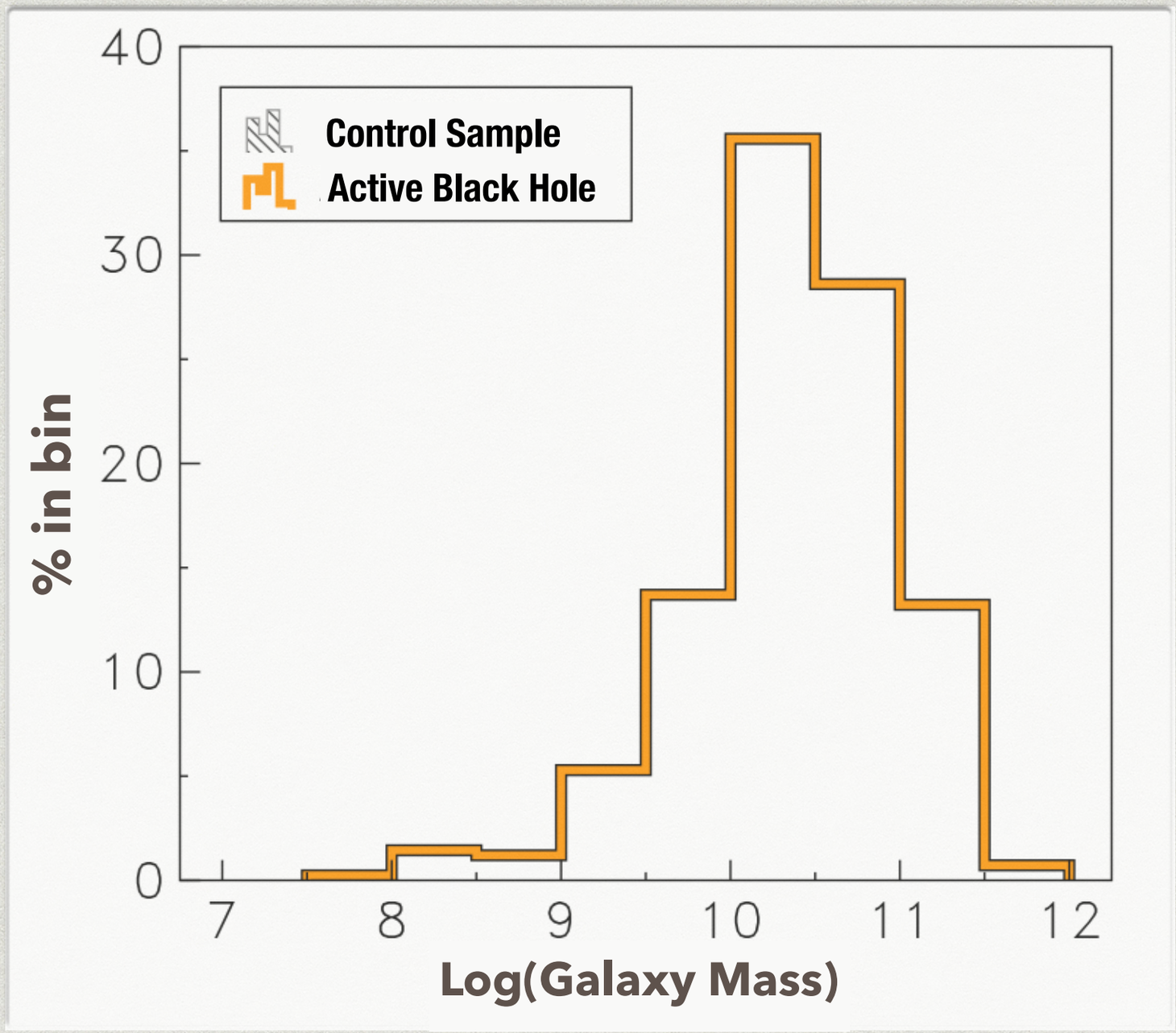

Active supermassive black holes are preferentially hosted in galaxies with a high stellar mass (e.g., Aird+12)

A galaxy's stellar mass is tightly correlated with its star-formation rate (e.g., Noeske+07)

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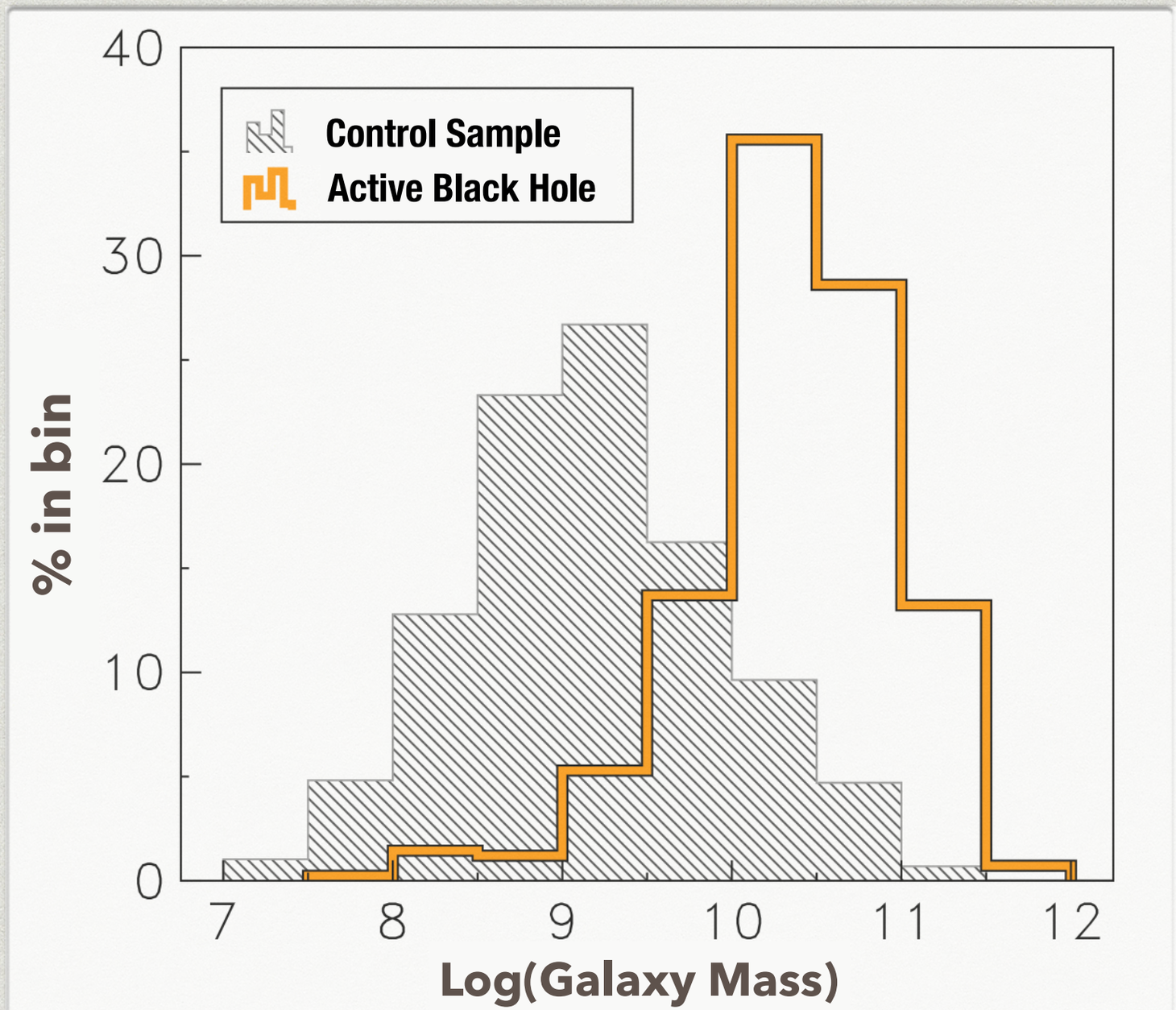

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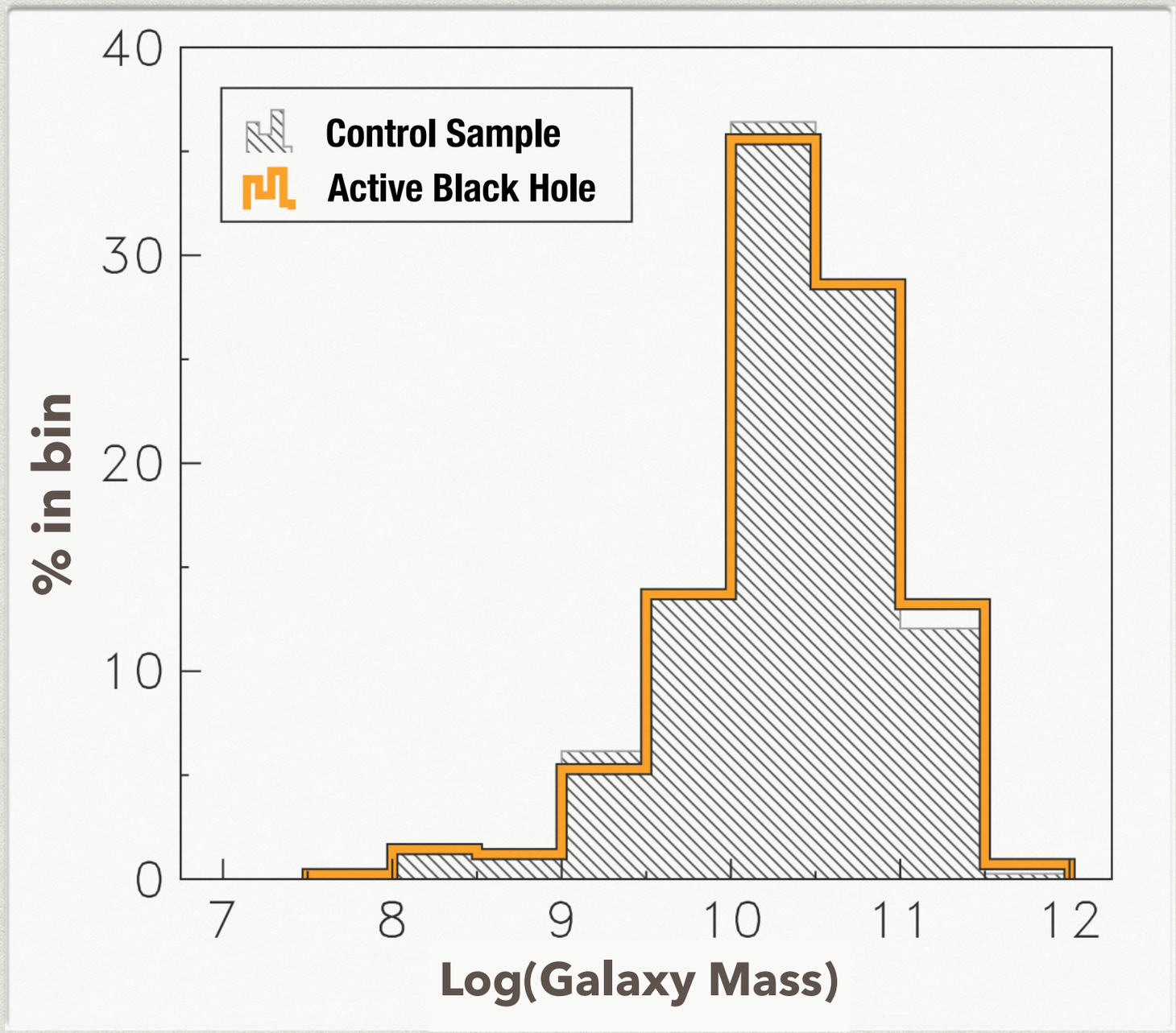

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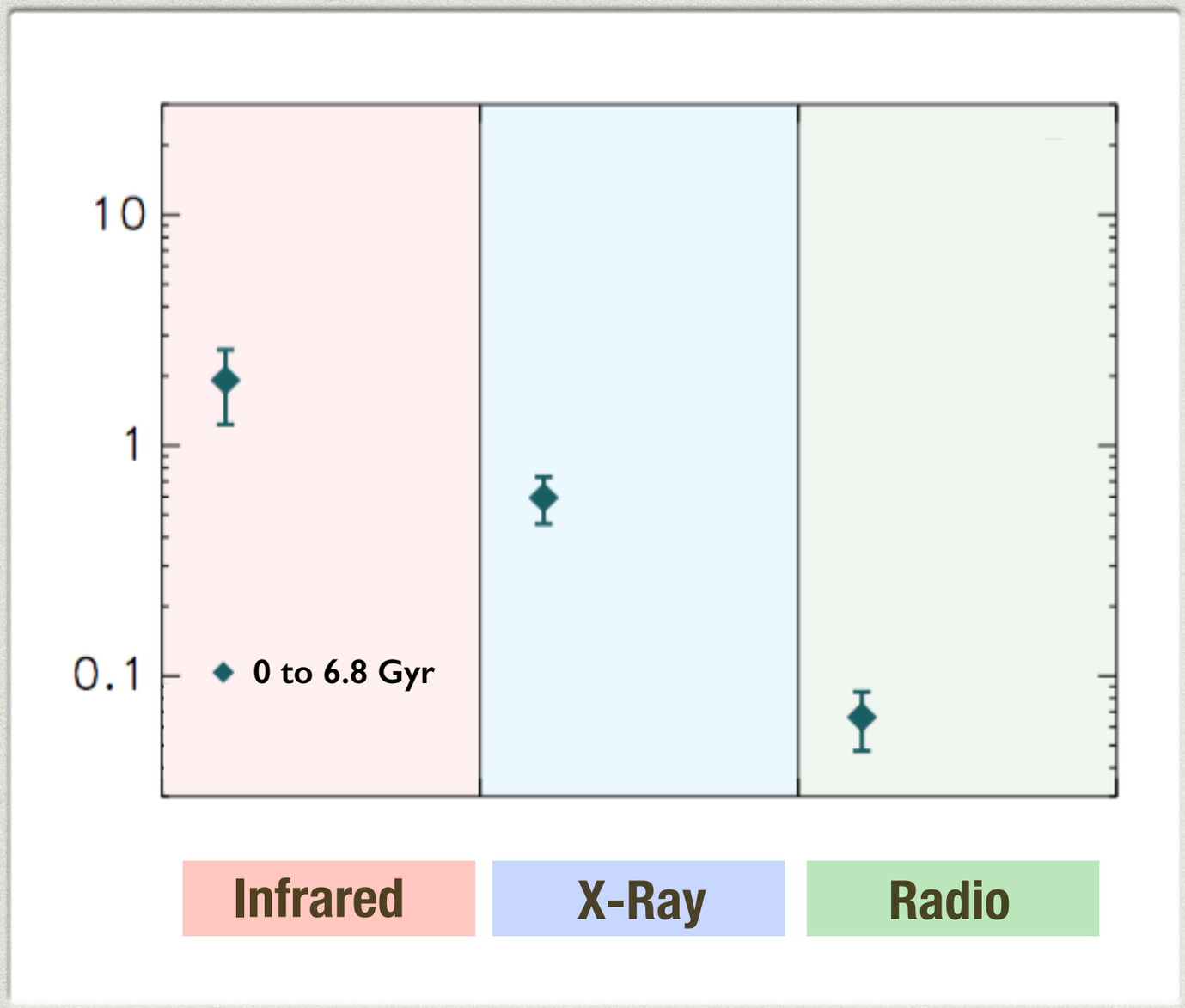

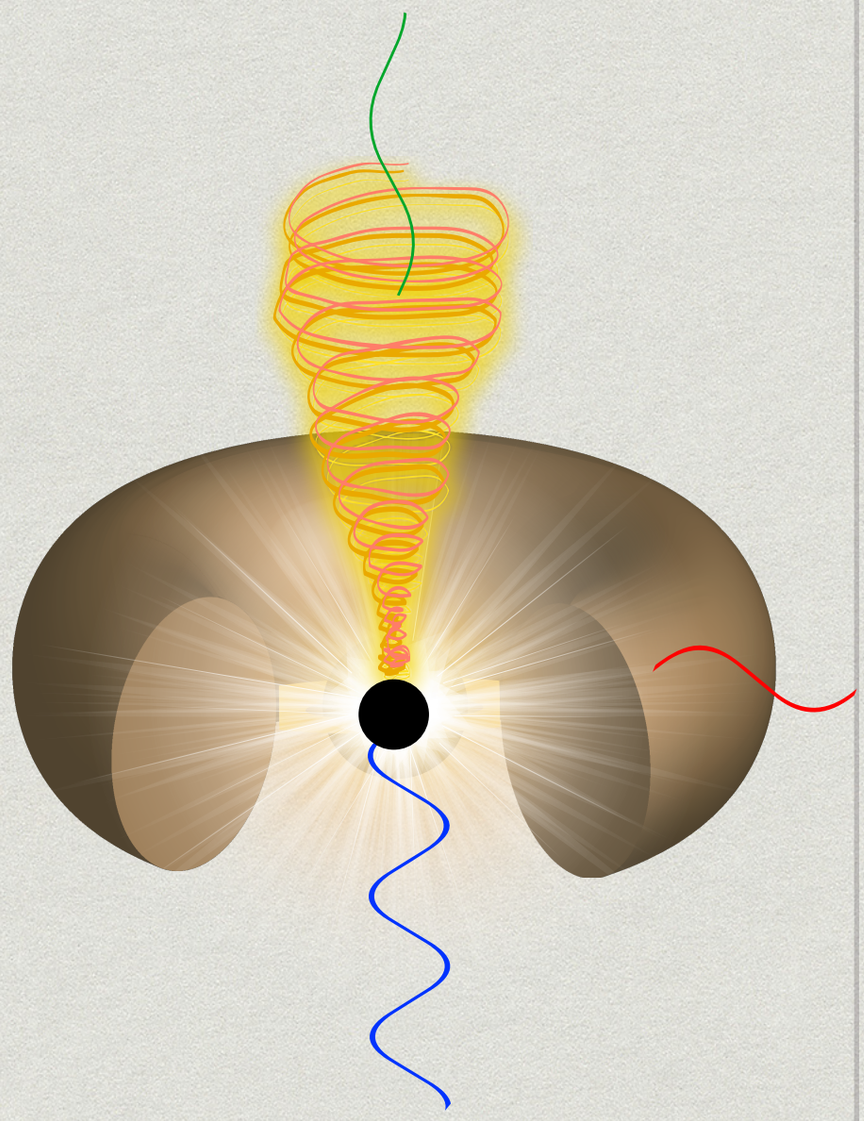

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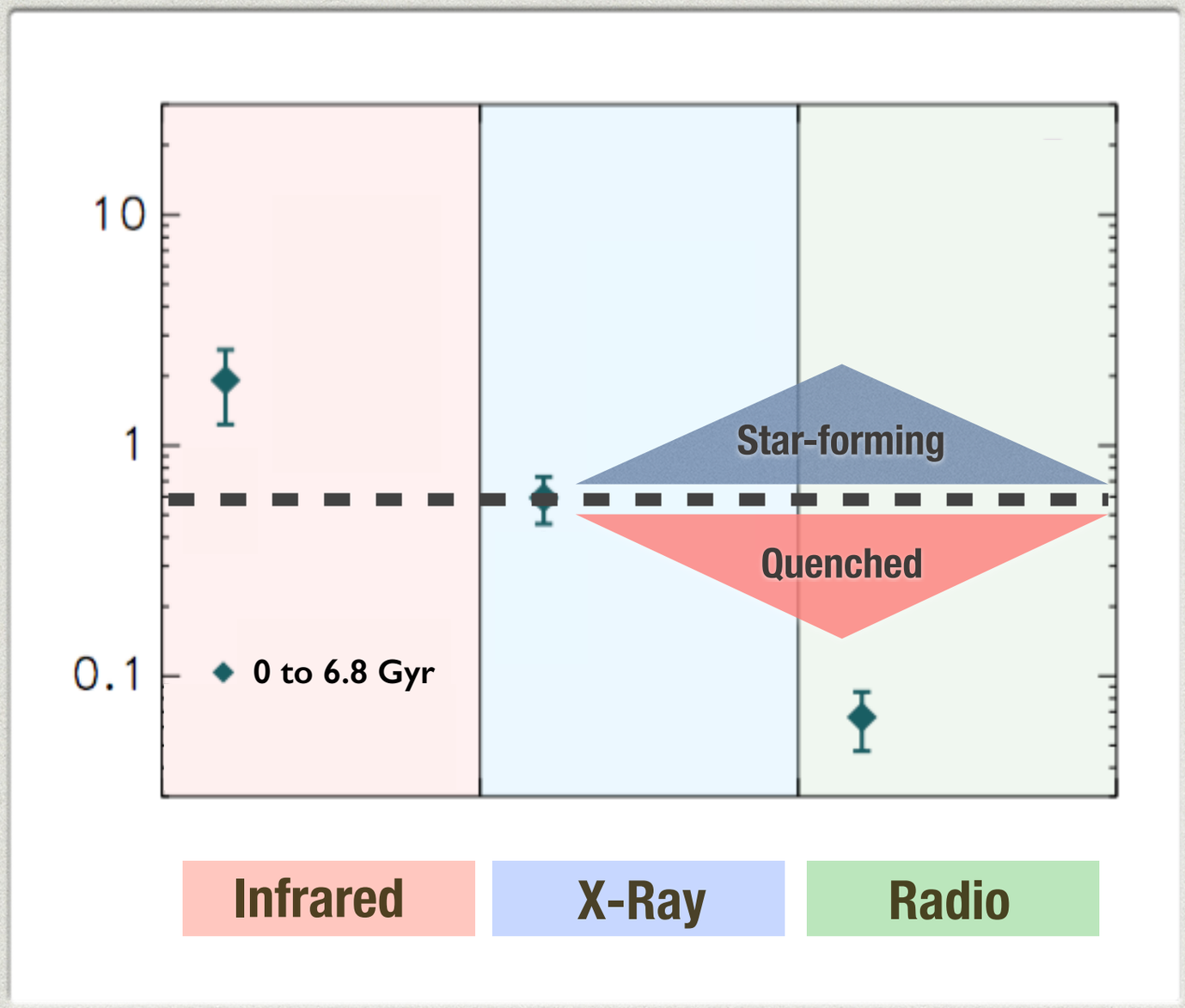

Infrared w/ Active Black Hole

Star forming hosts

X-ray w/ Active Black Hole

Straddles between star-forming and quiescent

Radio w/ Active Black Hole

Quenched hosts

GOAL:

COMPARE THE STAR-FORMATION ACTIVITY OF GALAXIES HOSTING AN ACTIVE BLACK HOLE TO THOSE WITHOUT

Infrared w/ Active Black Hole

Younger Galaxies

X-Ray w/ Active Black Hole

Transitional

Radio w/ Active Black Hole

Older Galaxies

Image Credit: NASA/JPL-Caltech

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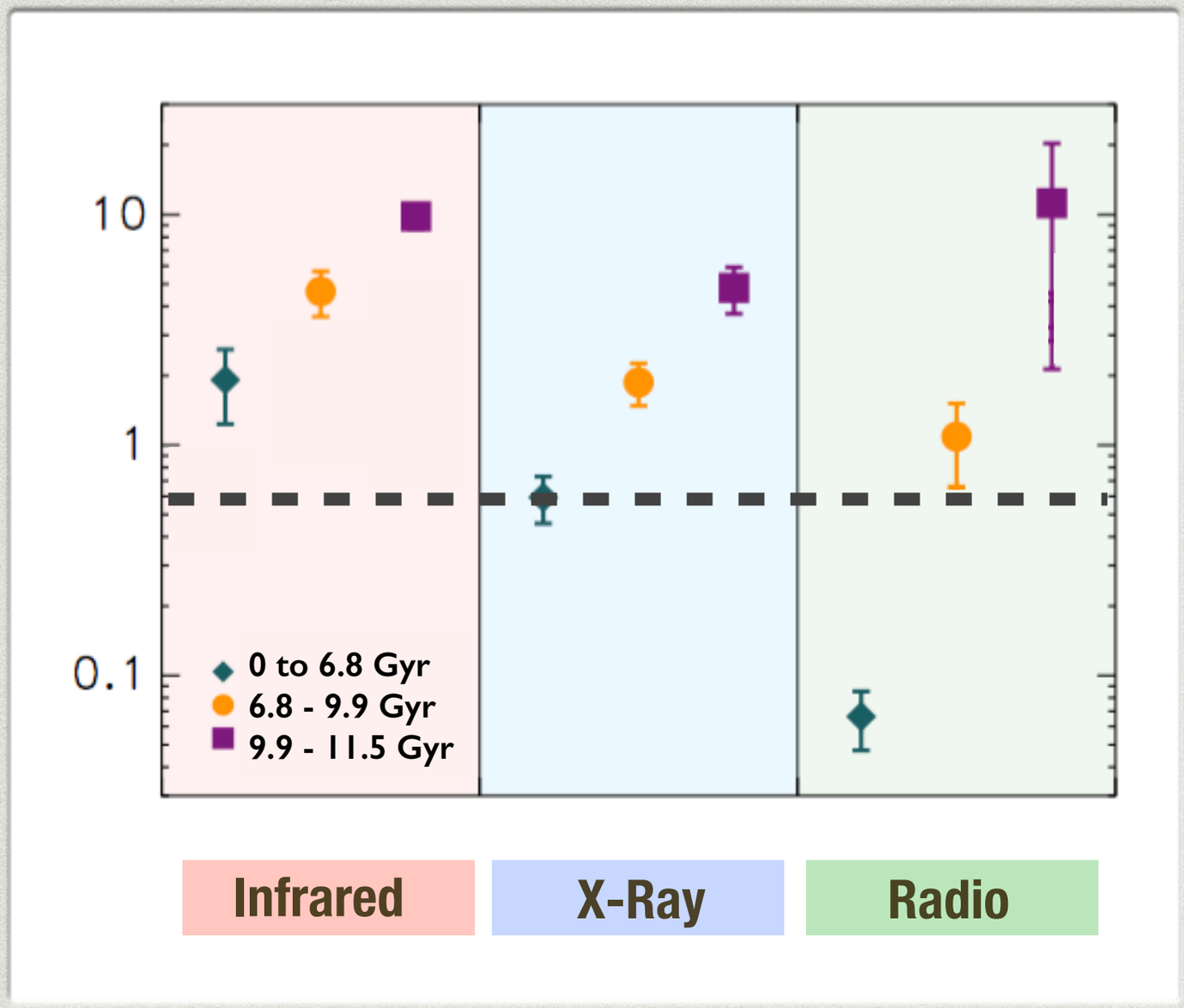

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Star forming hosts

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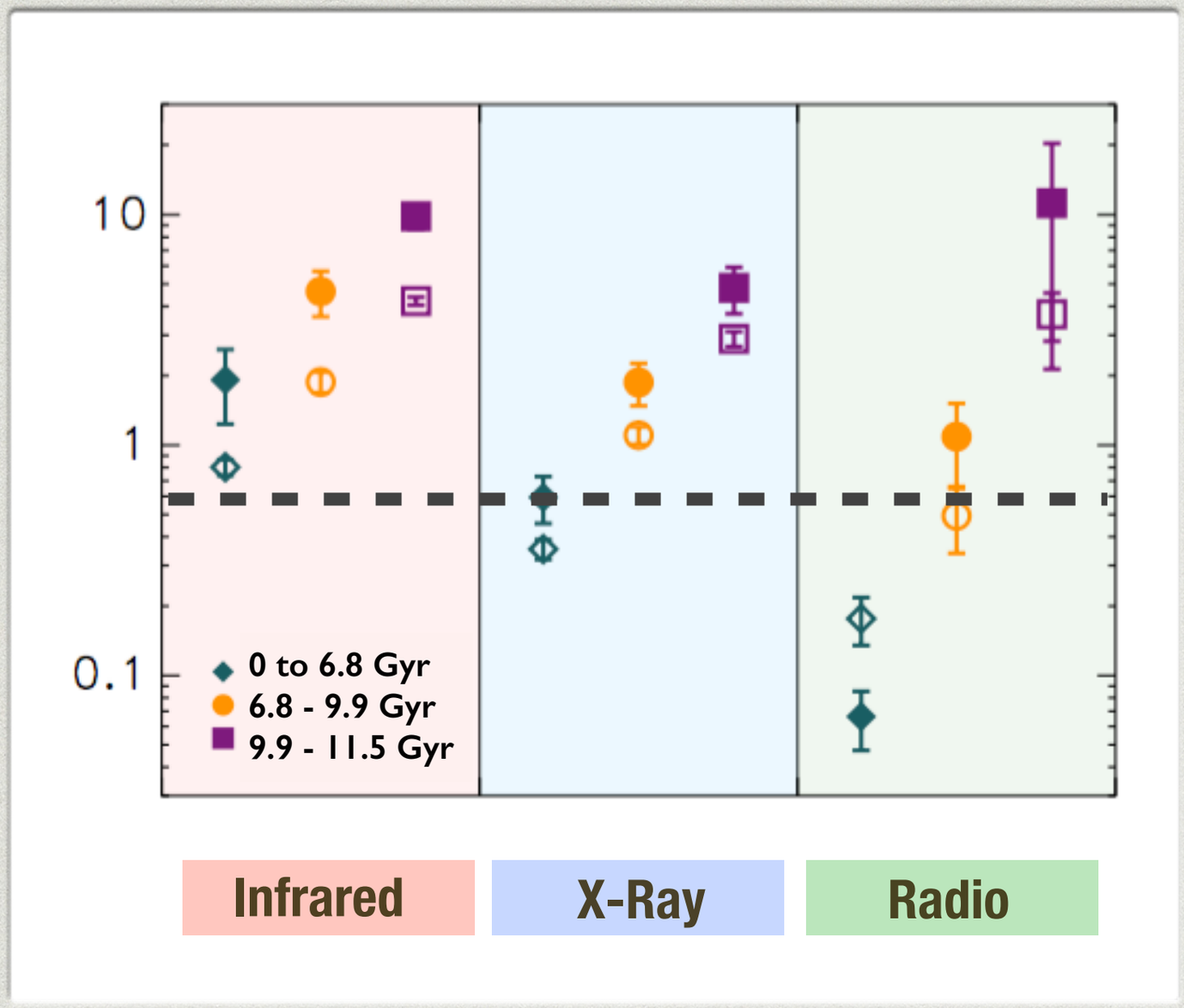

Infrared w/ Active Black Hole

Star forming hosts

X-ray w/ Active Black Hole

Star forming hosts

Radio w/ Active Black Hole

Star forming hosts

“Normal” Galaxies

Lower SF activity!

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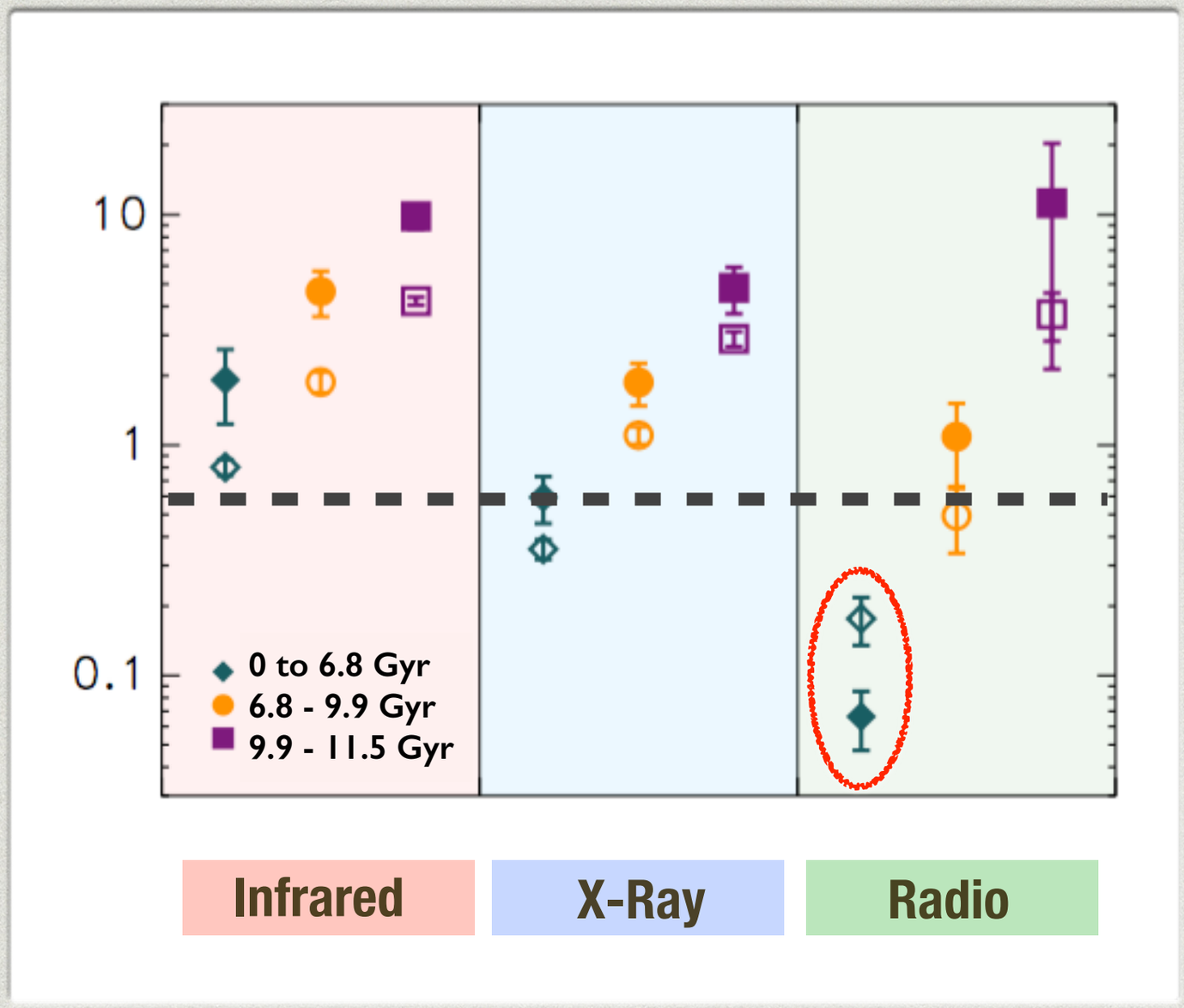

Infrared w/ Active Black Hole

Star forming hosts

X-ray w/ Active Black Hole

Star forming hosts

Radio w/ Active Black Hole

Star forming hosts

“Normal” Galaxies

Lower SF activity!

SUMMARY

- The mean star-formation activity of the control sample or “normal” galaxies tends to be lower than galaxies hosting an active supermassive black hole
- This calls into question the significance of black hole feedback being a primary mechanism for the suppression of star-formation in galaxies
- The only instance the above is not true is the radio-selected galaxies in the “local” universe

… what about the rest of cosmic time?