

The asynchronous evolution of bulges and black holes in NGC4342 and NGC4291

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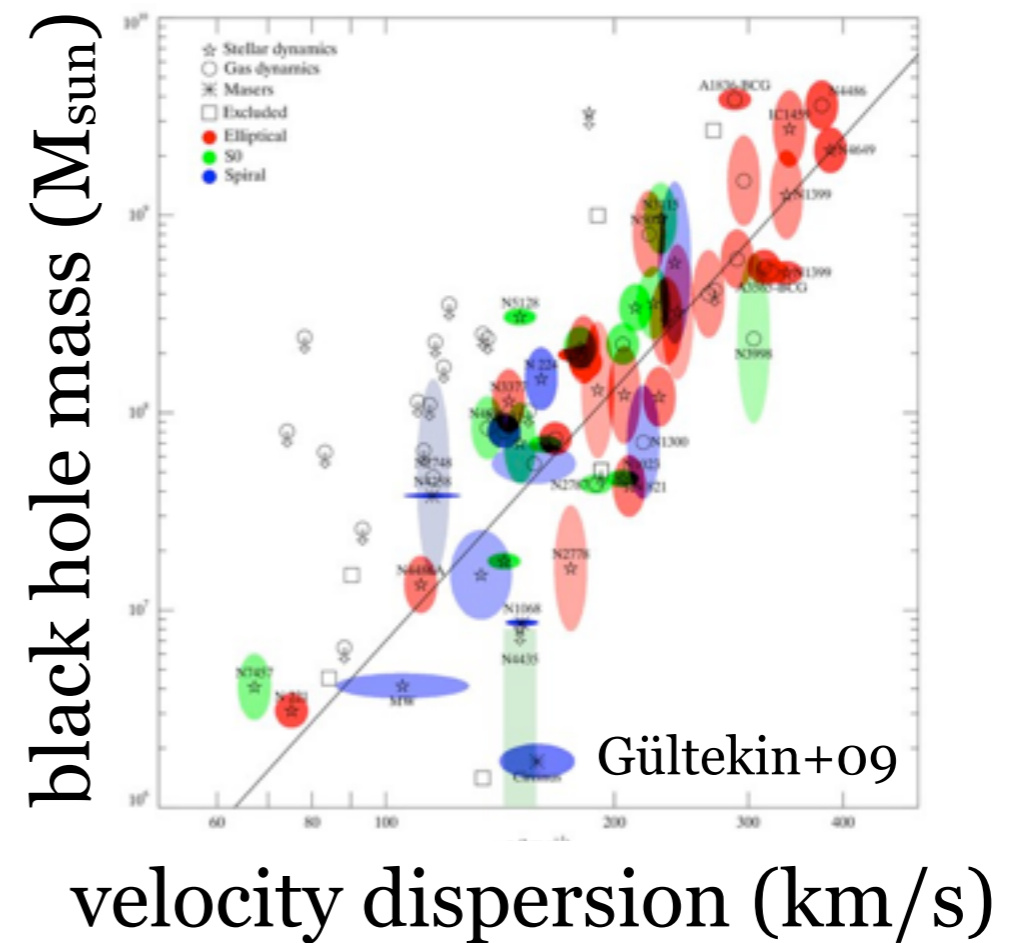
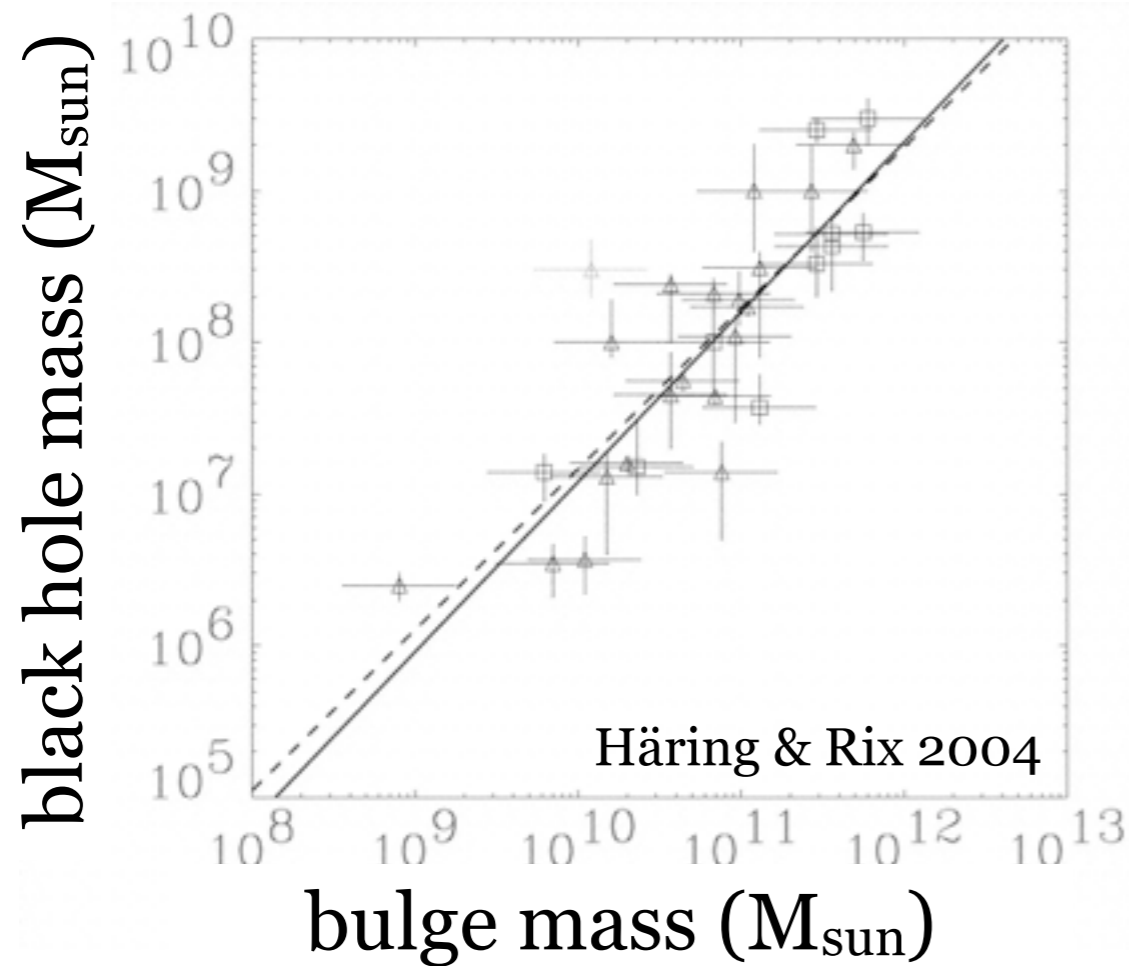
W. Forman, I. Zhuravleva, C. Mihos, R. Kraft, P. Harding, Q. Guo, Z. Li, E. Churazov, A. Vikhlinin, P. Nulsen, S. Schindler, C. Jones

Bogdan et al., 2012, ApJ, 753, 140

Bogdan et al., 2012, ApJ, 755, 25

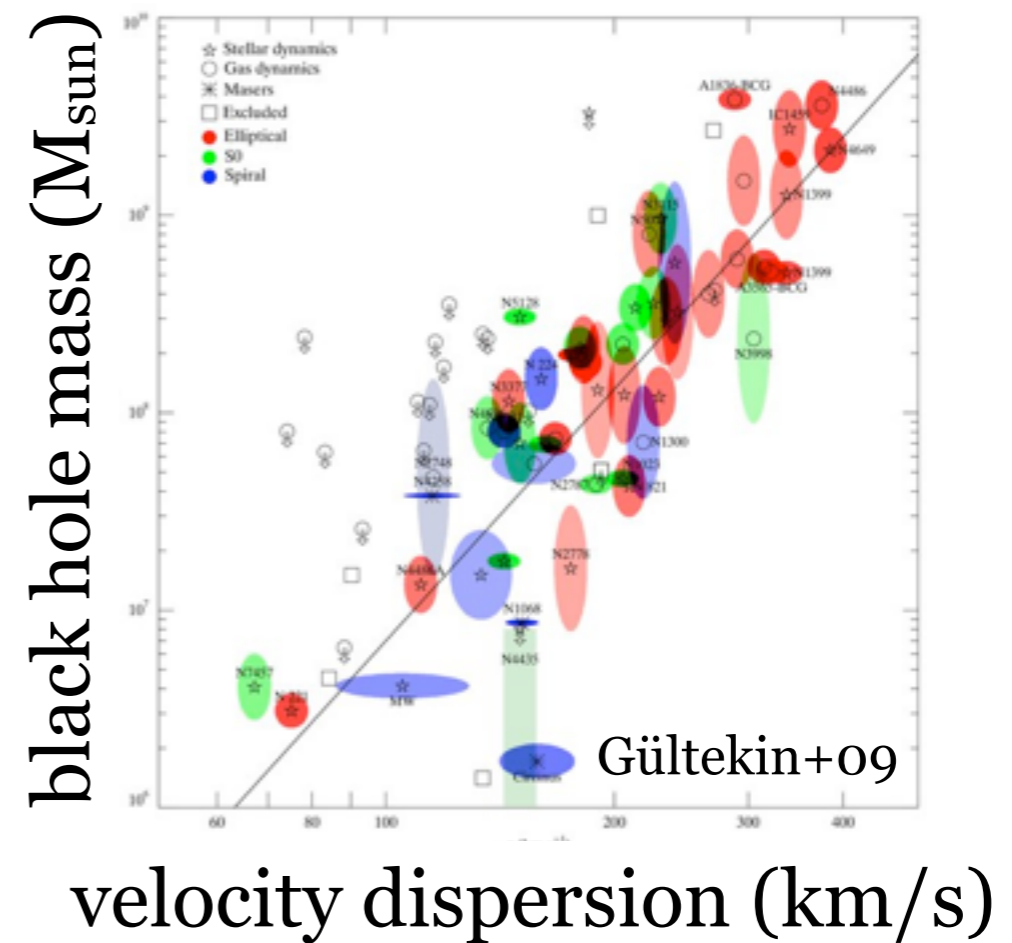
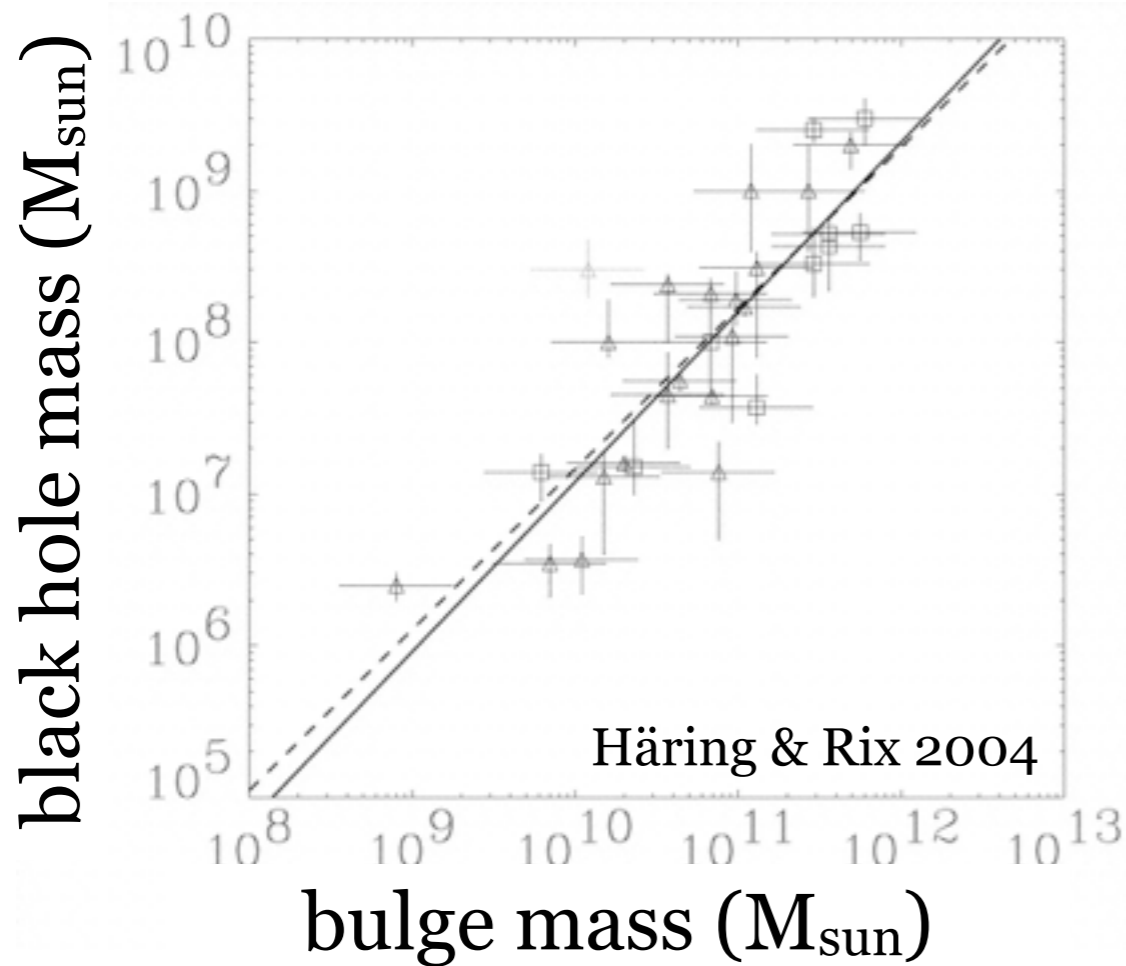


Correlations with the black hole mass



Tight correlations between the black hole mass and various galaxy properties

Correlations with the black hole mass

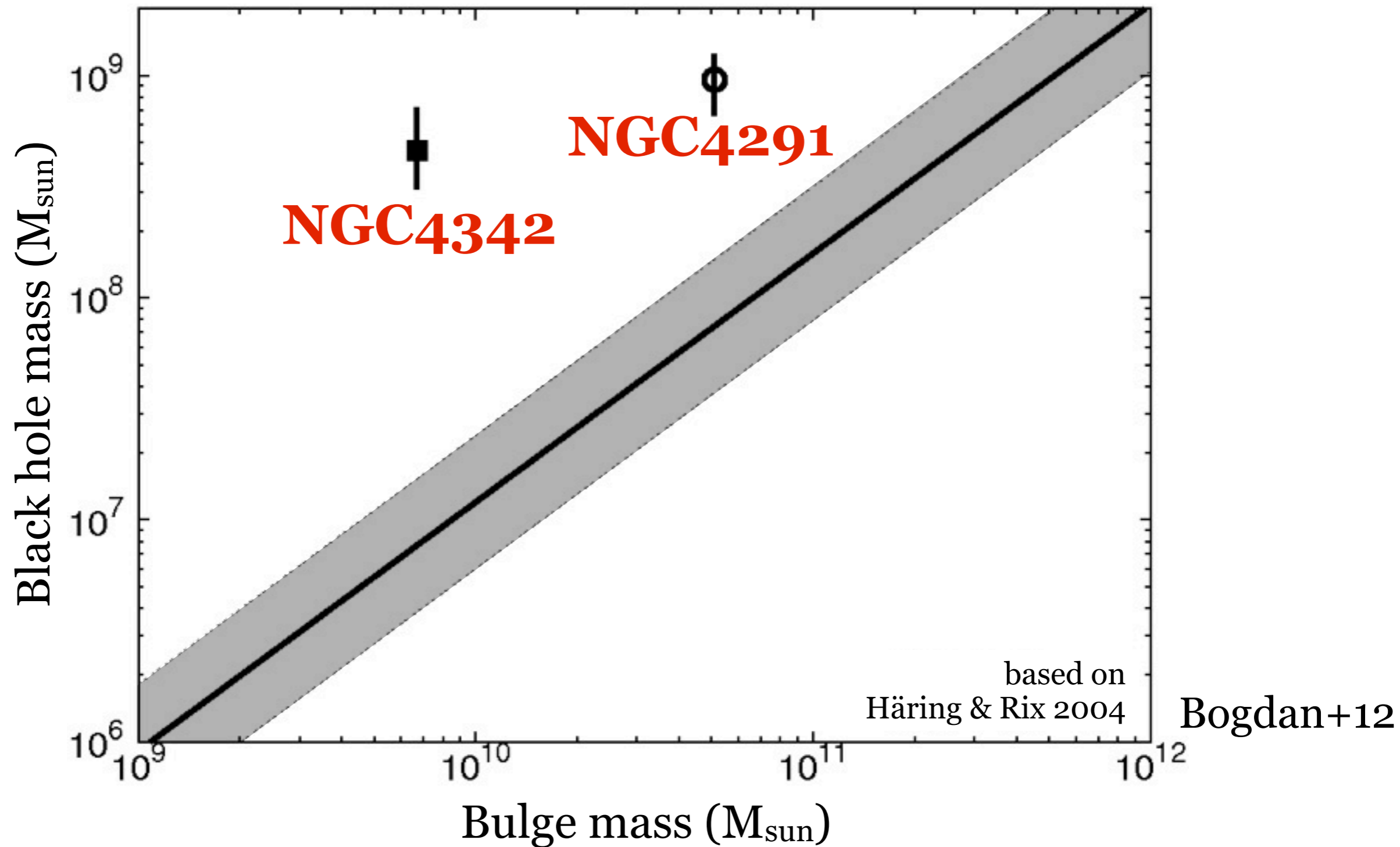


Tight correlations between the black hole mass and various galaxy properties



Co-evolution between black holes and bulges?

Galaxies with overly massive black holes



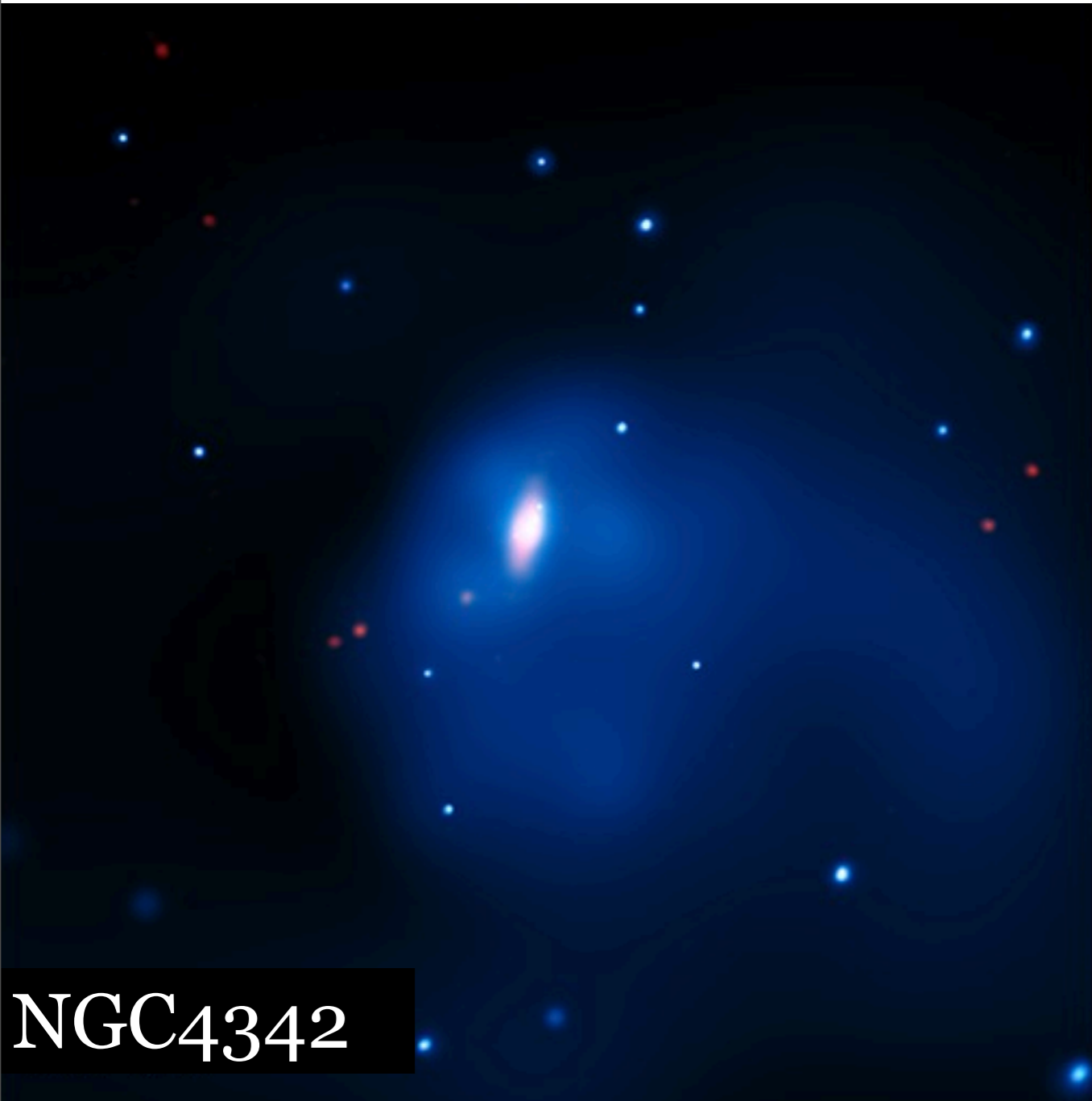
$M_{\text{BH}}/M_{\text{bulge}}$ ratio is $\sim 6.9\%$ and $\sim 1.9\%$ instead of the average $\sim 0.2\%$

Too massive black holes or missing stars?

- ★ They could have had more stars
- ★ More than 90% of stars were lost during an interaction
- ★ Specific binding energy of dark matter is lower than stars
- ★ **During the interaction first the dark matter is lost**

Does NGC4342 and NGC4291 have an extended dark matter halo?

X-ray/optical composite image



$M_{\text{bulge}} \sim 6.7 \times 10^9 M_{\text{sun}}$
 $M_{\text{BH}} \sim 4.6 \times 10^8 M_{\text{sun}}$

$M_{\text{bulge}} \sim 5.1 \times 10^{10} M_{\text{sun}}$
 $M_{\text{BH}} \sim 9.6 \times 10^8 M_{\text{sun}}$

Dark matter halo

Measure the total gravitating mass

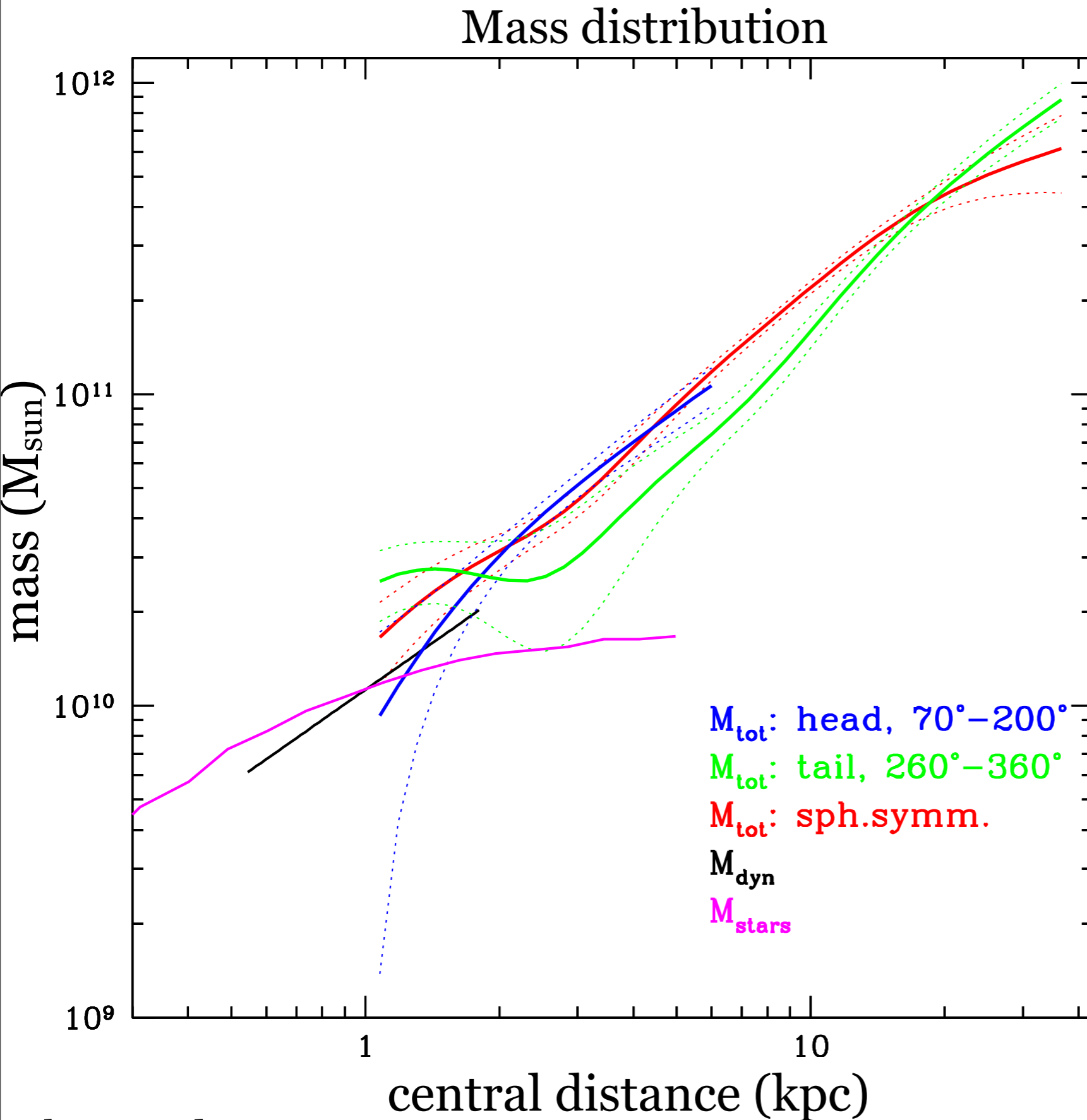
Assumption: hot X-ray gas is in hydrostatic equilibrium

$$M_{\text{tot}}(< r) = -\frac{kT_{\text{gas}}(r)r}{G\mu m_p} \left(\frac{\partial \ln n_e}{\partial \ln r} + \frac{\partial \ln T_{\text{gas}}}{\partial \ln r} \right)$$

Measure: gas density and temperature distribution



Dark matter halo of NGC4342

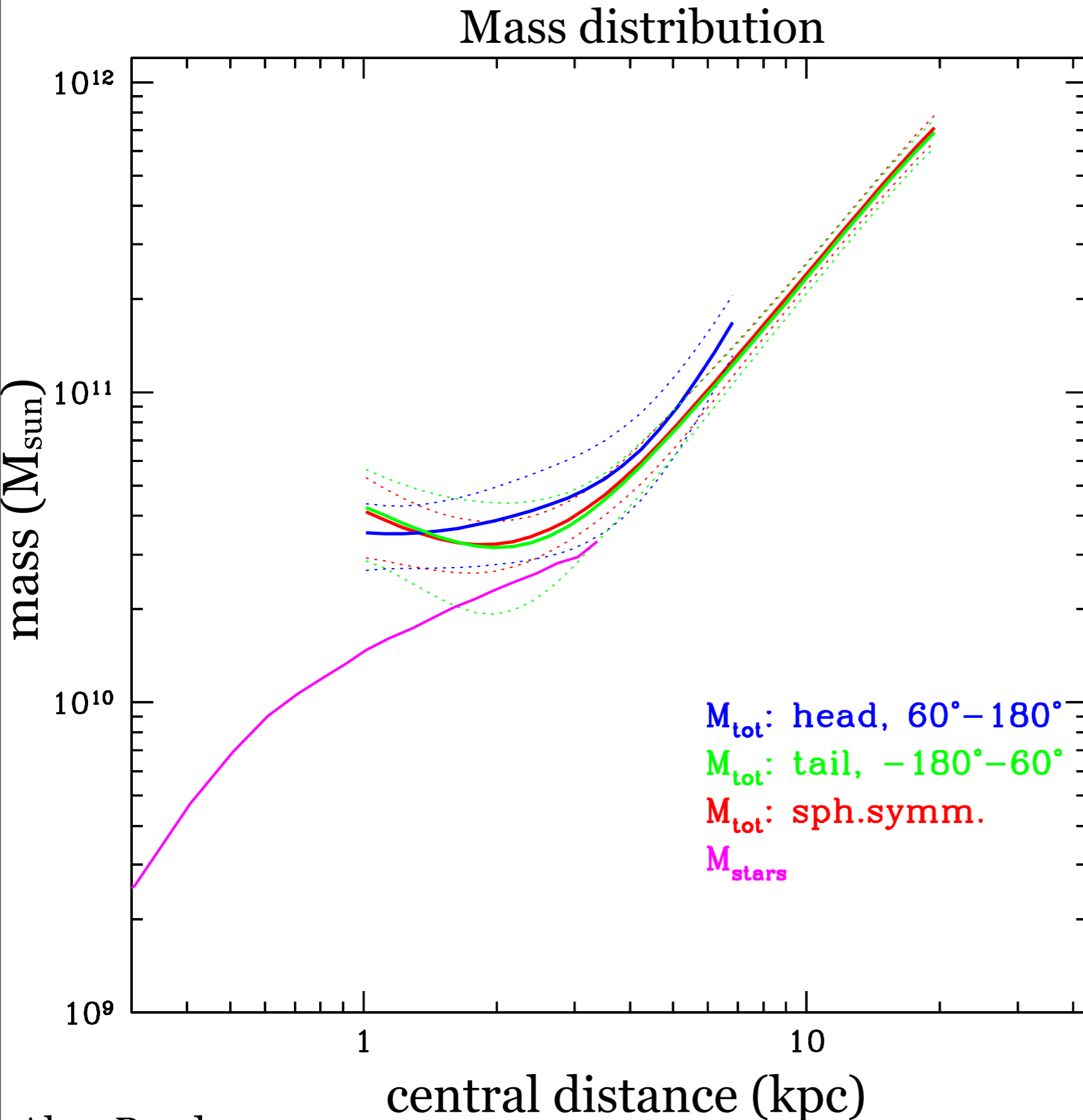


**Total mass exceeds
the stellar mass**

**within 10 kpc:
(1.4-2.3) $\times 10^{11} M_{\text{sun}}$**

Bogdán+12

Dark matter halo of NGC4291



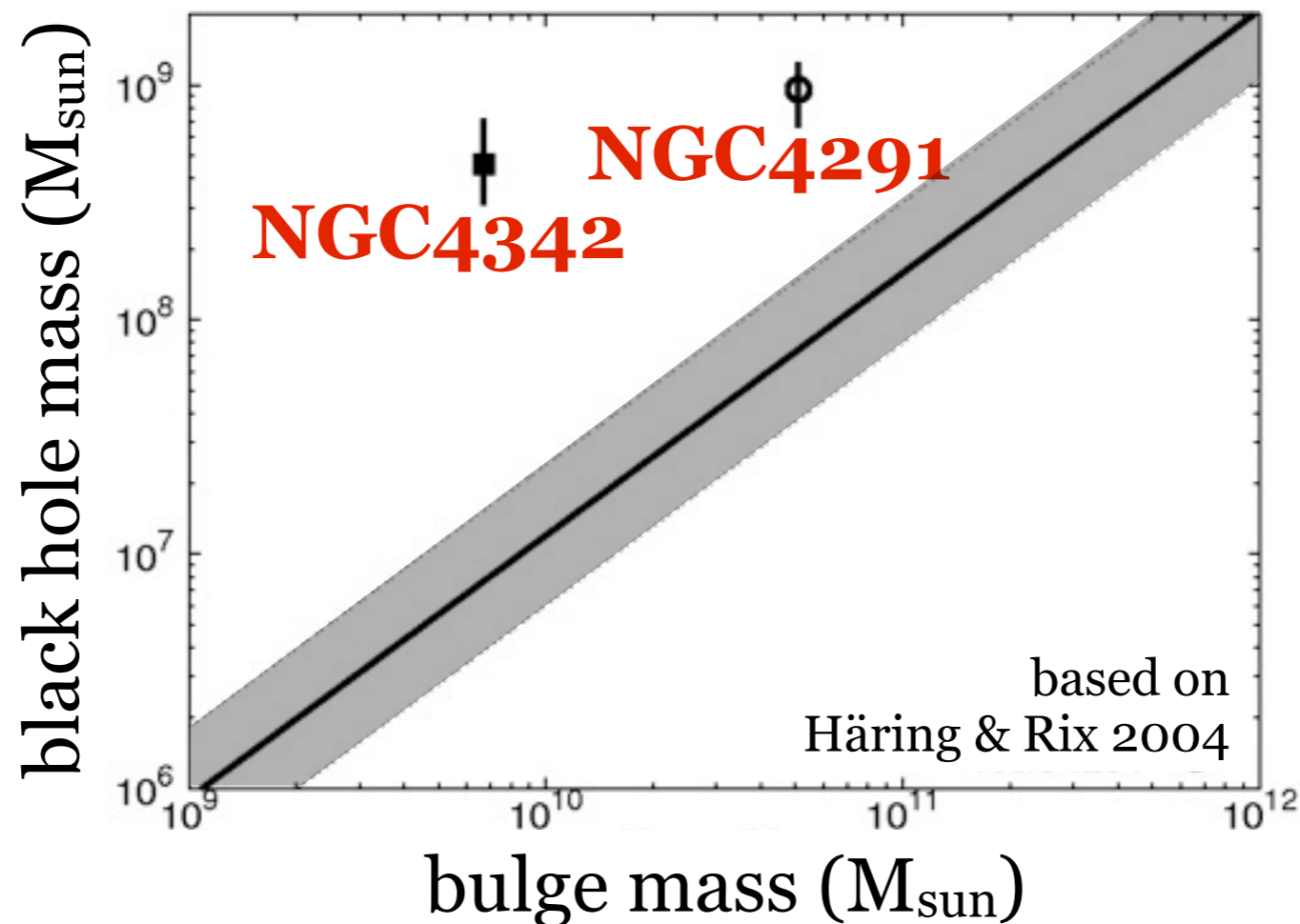
**Total mass exceeds
the stellar mass**

**within 10 kpc:
(2.1-2.6) $\times 10^{11} M_{\text{sun}}$**

Bogdán+12

Dark matter halo

- ★ Significant dark matter halo around both galaxies
- ★ Stars were not lost in tidal stripping
- ★ NGC4342/NGC4291 are real “outliers”

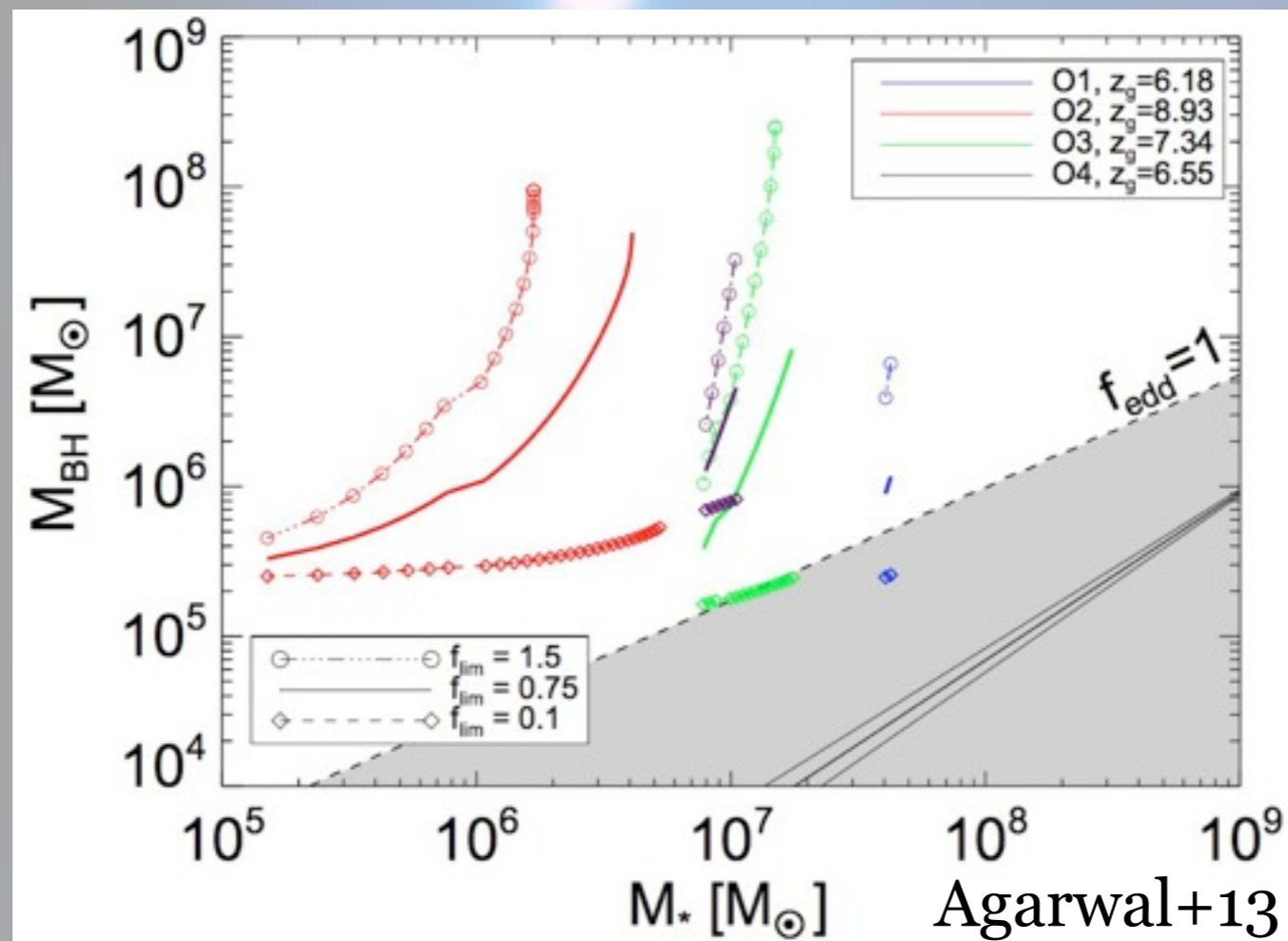


Consequences

1. Black holes and bulges did not co-evolve

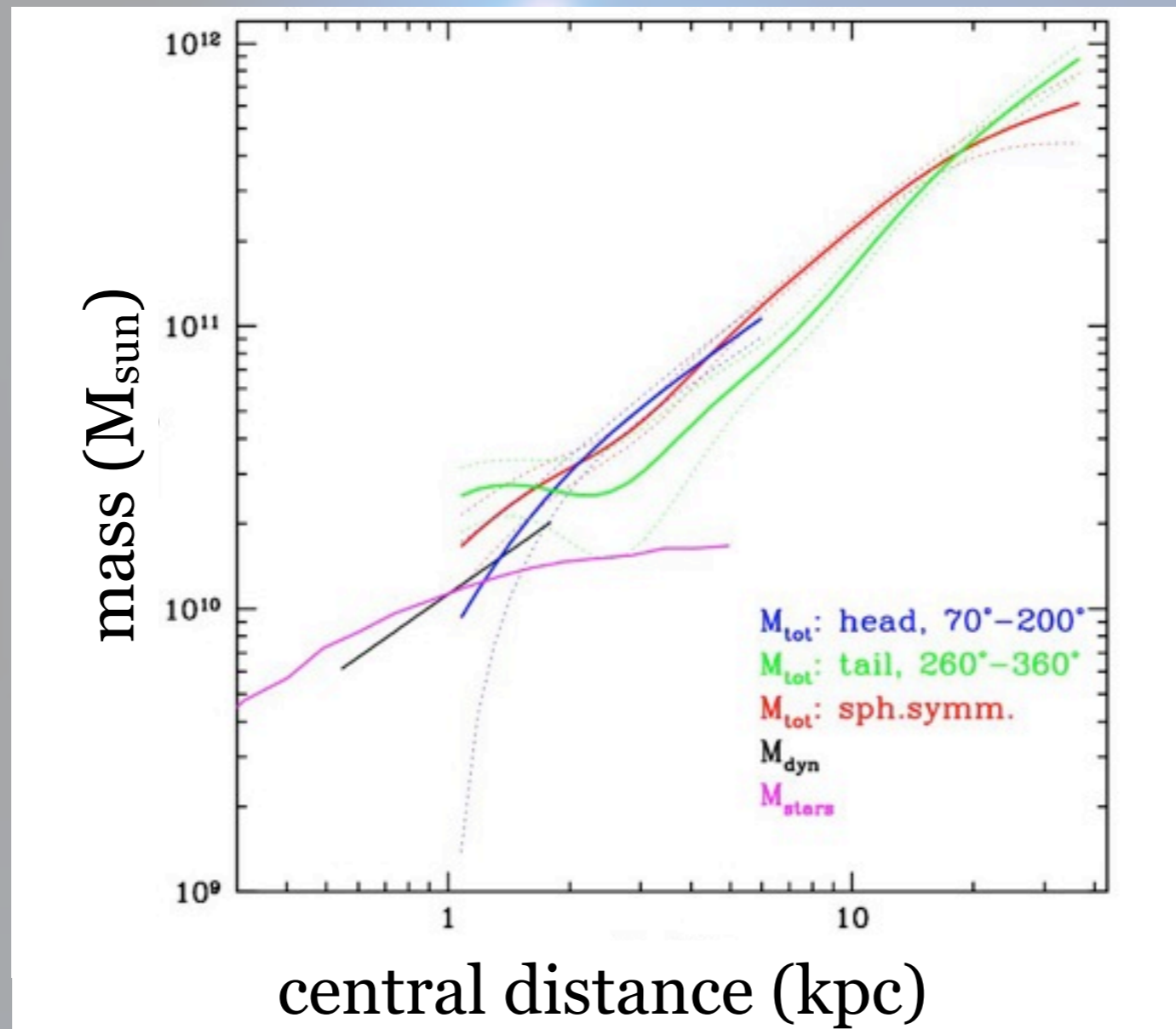
Consequences

1. Black holes and bulges did not co-evolve
2. Black hole grew faster than the bulge?



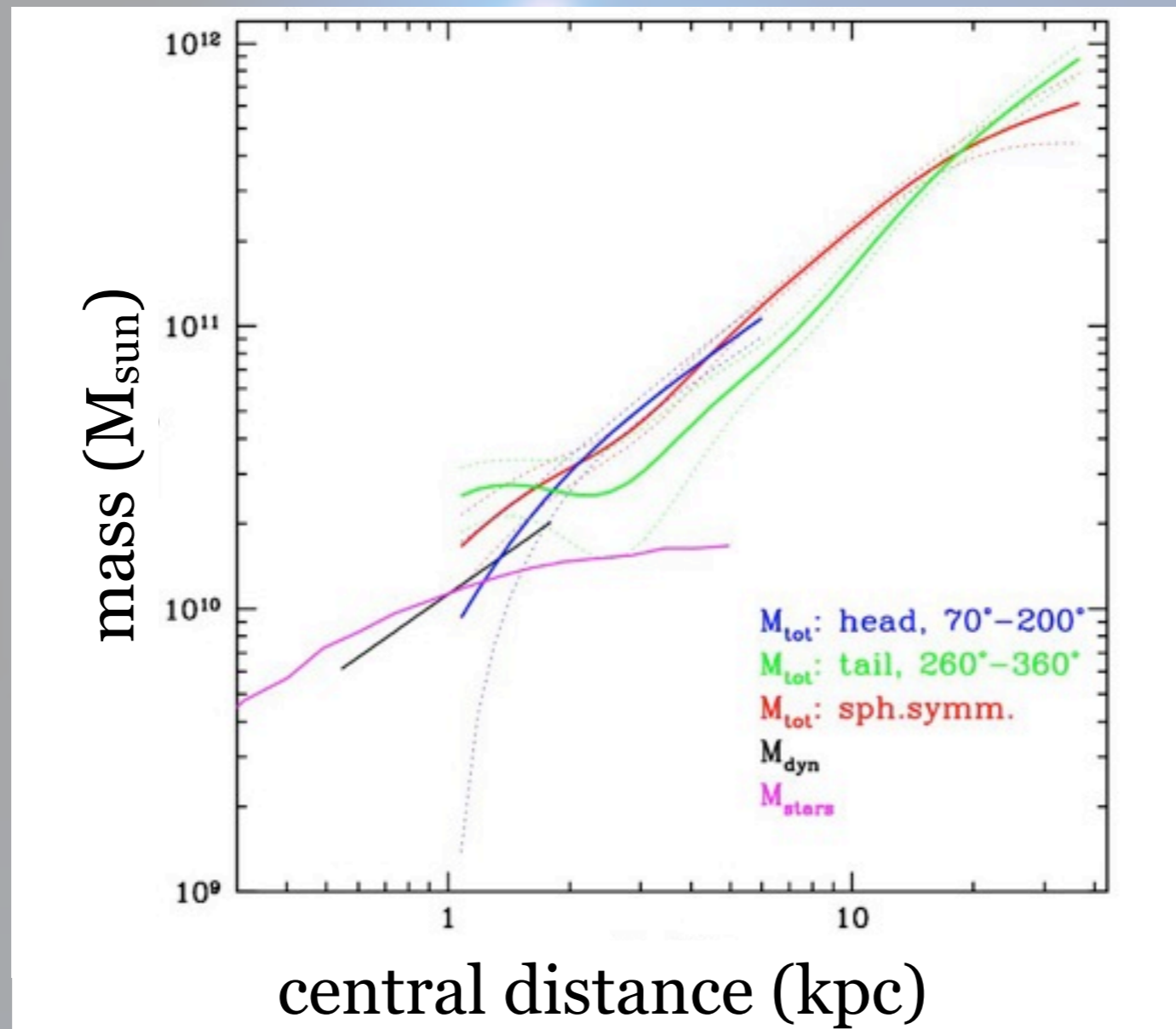
Consequences

1. Black holes and bulges did not co-evolve
2. Black hole grew faster than the bulge?
3. Black hole growth tied to the dark matter halo?



Consequences

1. Black holes and bulges did not co-evolve
2. Black hole grew faster than the bulge?
3. Black hole growth tied to the dark matter halo?
4. How common are these galaxies?



The background of the slide is a high-resolution image of a red planet's surface, likely Mars, showing various shades of red, orange, and brown. In the upper center, there is a bright, circular spot that appears to be a small crater or a landing site. A bright, white beam of light originates from this spot and extends upwards towards the top of the frame. The overall scene is set against a dark, starry sky.

Thank you!