2015 Aspen Winter Conference

Weighing the Low Mass Central Black Hole in NGC 404

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NGC 404: An Introduction

- Distance: 3.1Mpc.

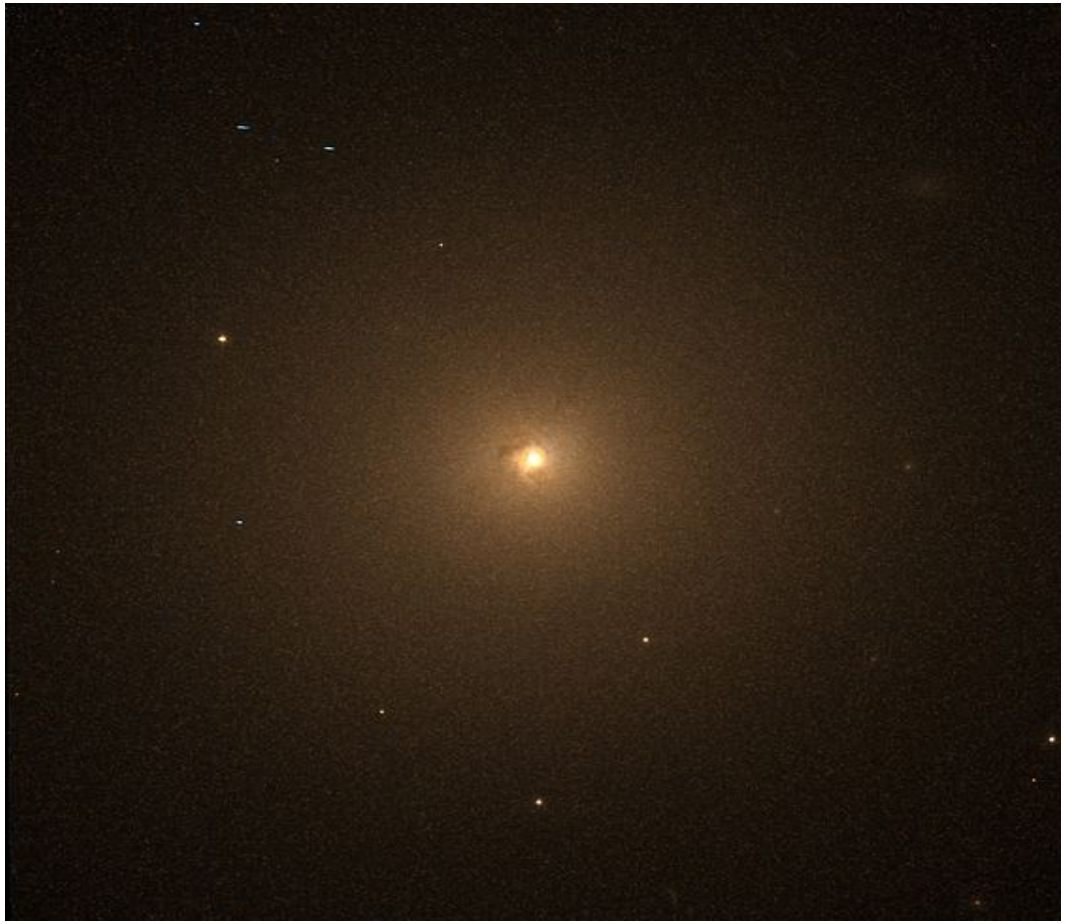
- Bulge-dominated galaxy with disp. velocity ~35 km/s (Seth+ 2010).

- Strong evidence for a central massive black

- Prominent Nuclear Star Cluster ~ 10 million Solar mass.

→ Study relationship BH, Bulge, and Nuclear Star Cluster.

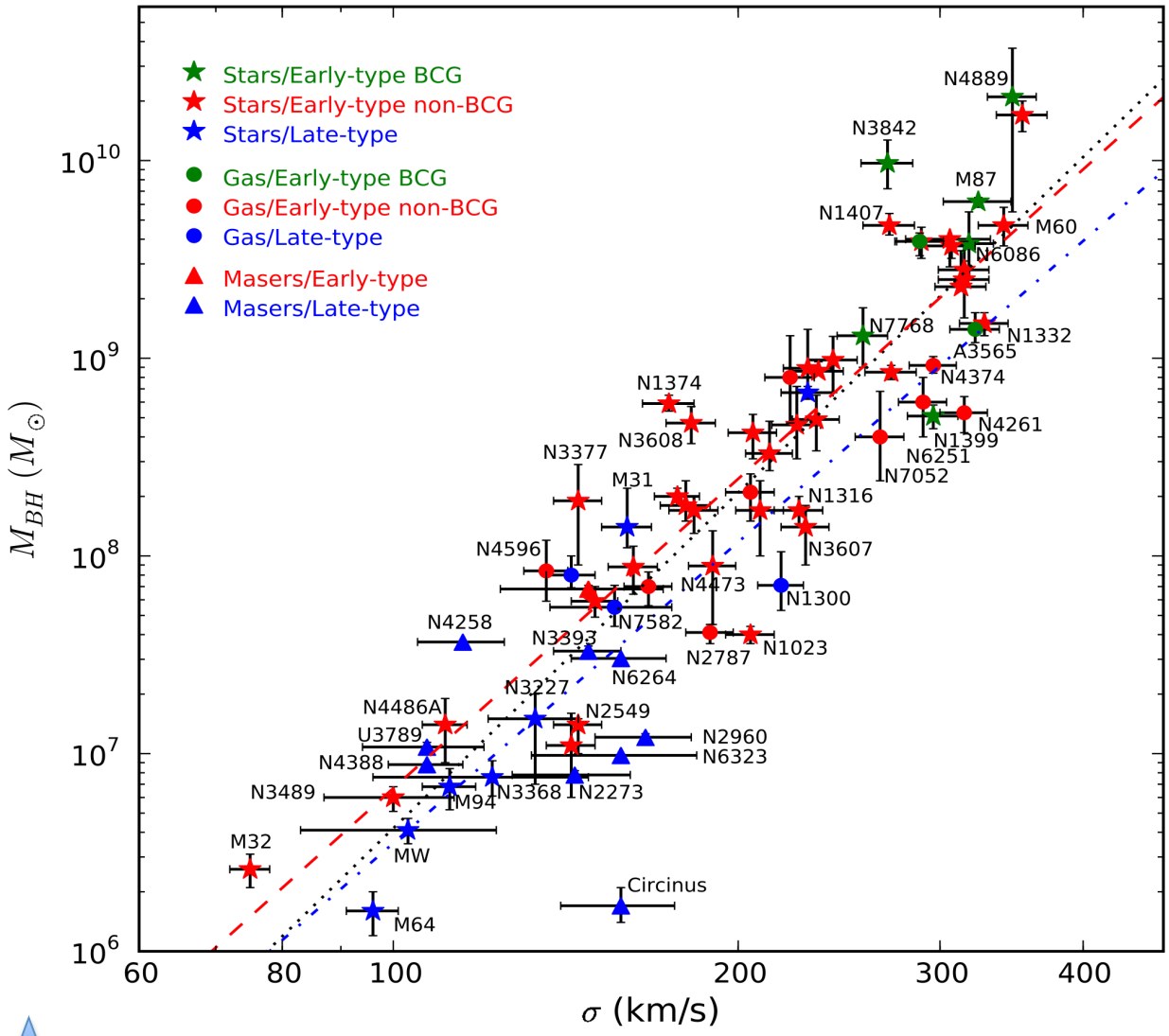
http://en.wikipedia.org/wiki/NGC_404



Why is the central BH of NGC 404 interesting?

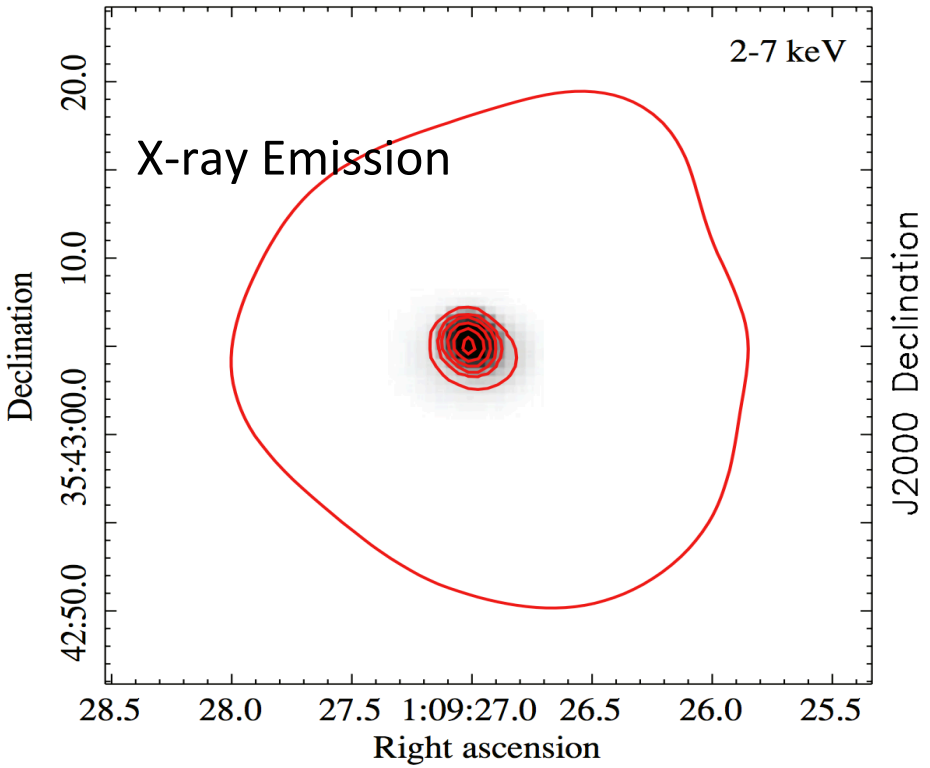
McConnell & Ma 2013

- Dynamically measure a sub-million massive black hole.
- Lowest central black hole mass was measured by dynamics → black hole formation + scaling relationship between massive black hole and galaxies at low mass end.

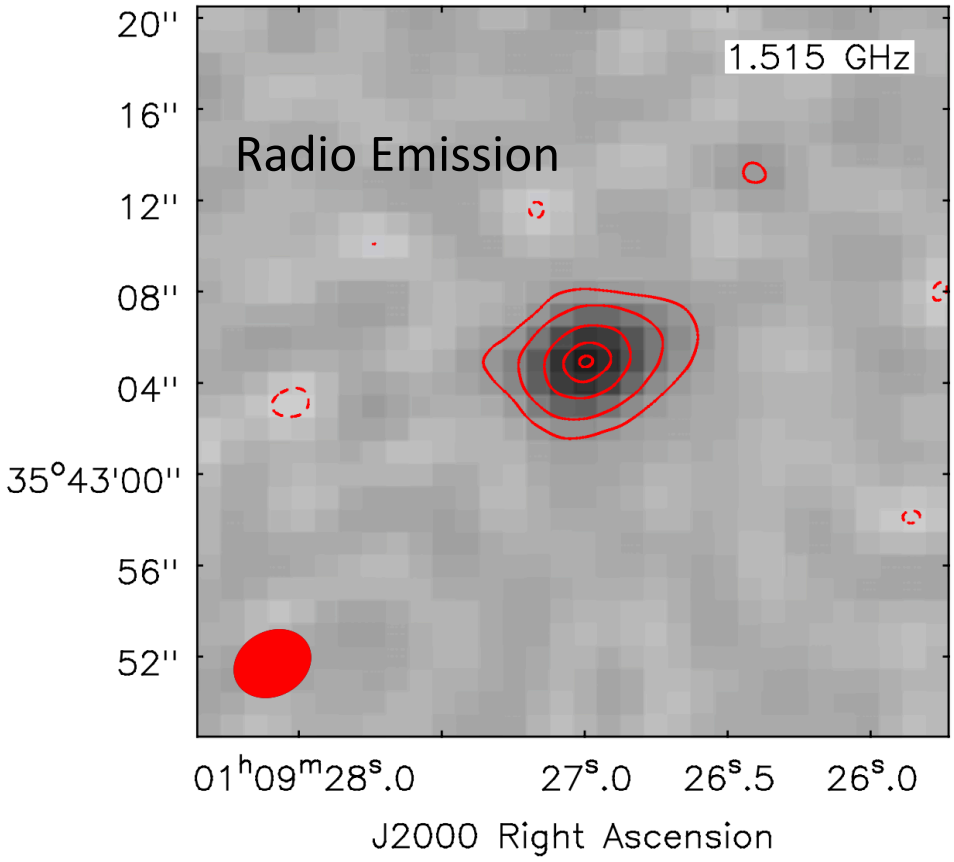


Strong Evidence for a Massive Black Hole

Binder+ 2011



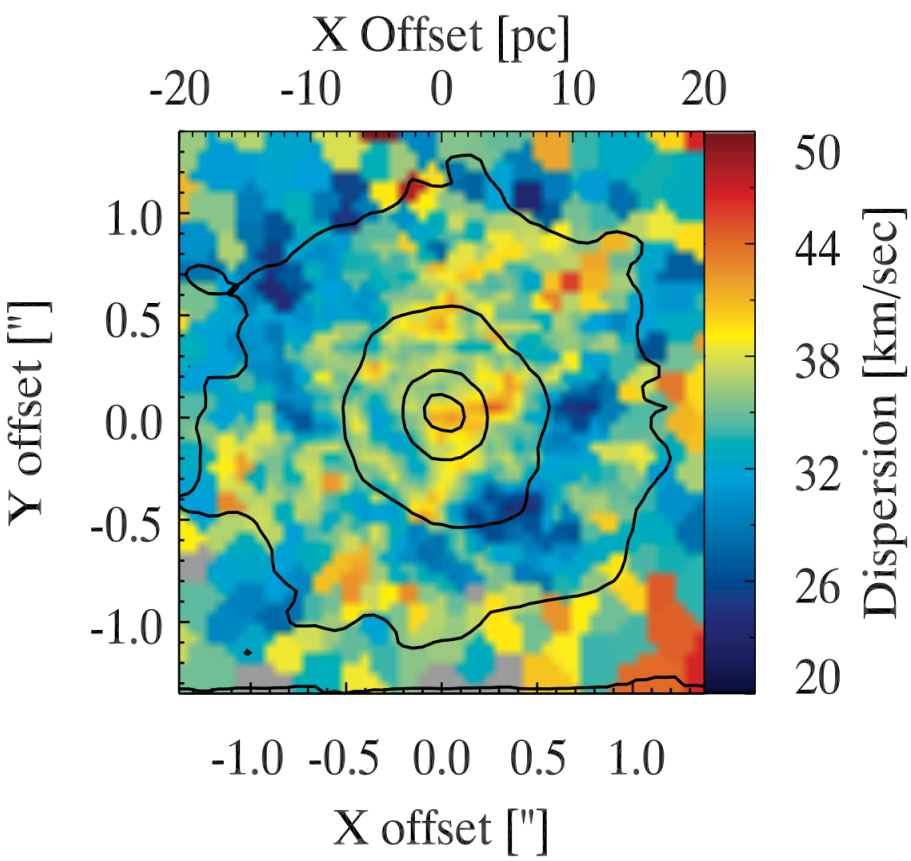
Nyland+ 2012



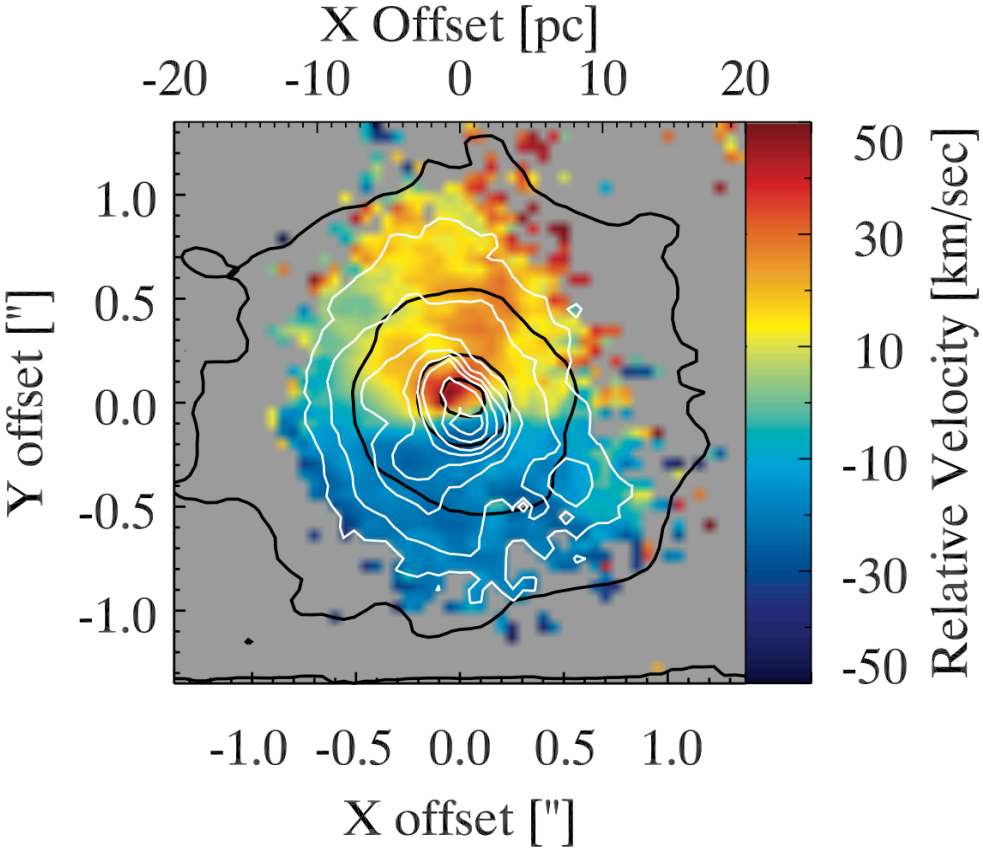
- Lr/Lx is consistent with Fundamental plane for ~1 million Msol BH (Nyland+ 2012), also LINER, variable UV emission

Dynamical BH Mass Determination
From Gemini/NIFS AO observations

Seth+ 2010



Stellar kinematics

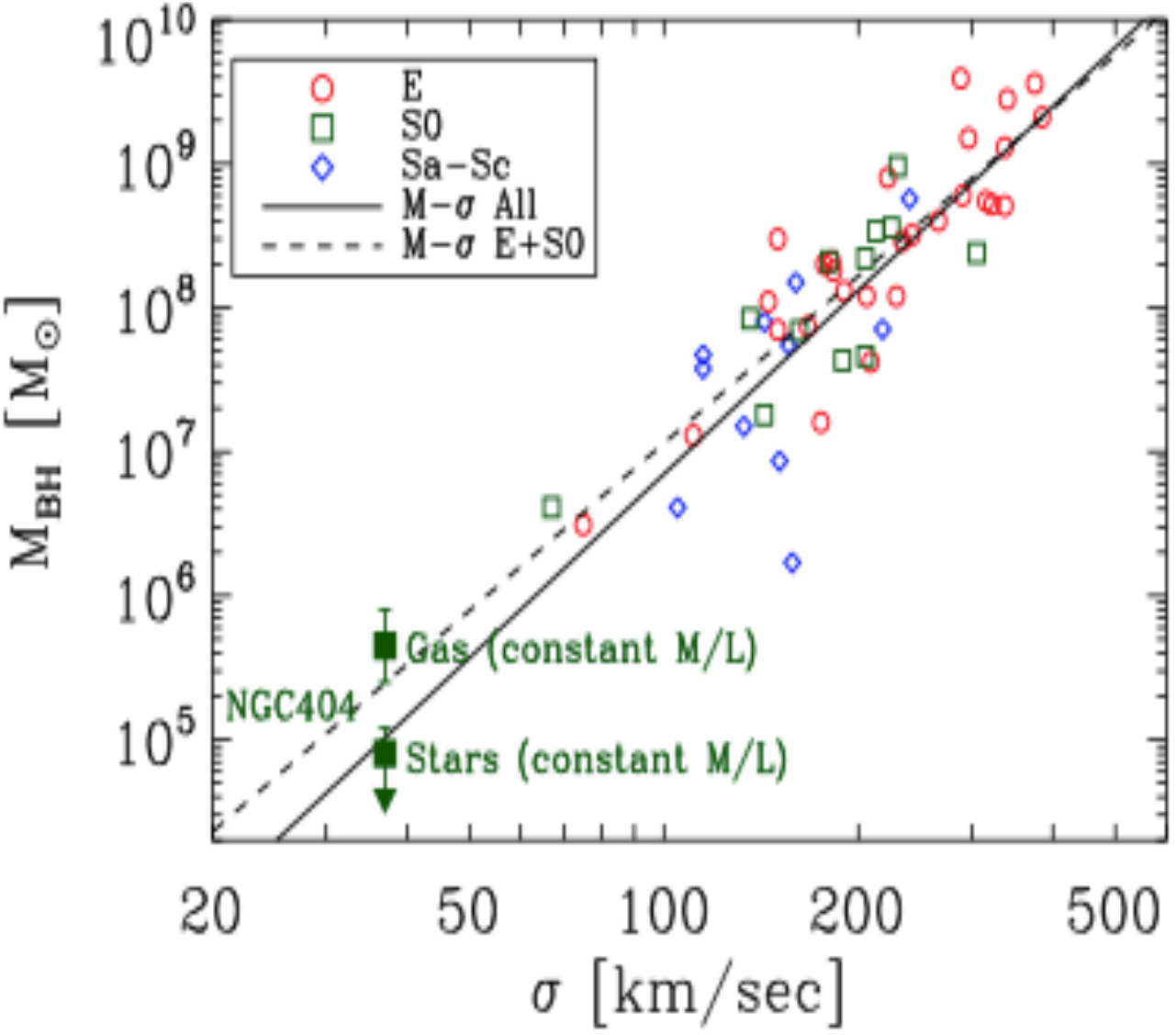


Gas kinematics

Previous Results

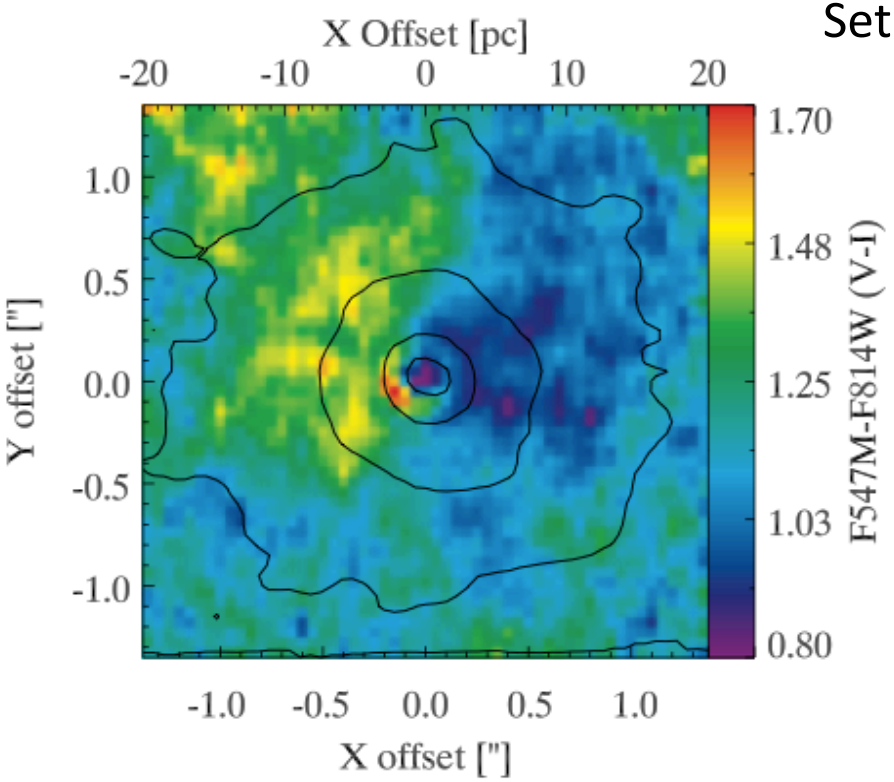
Assuming constant M/L

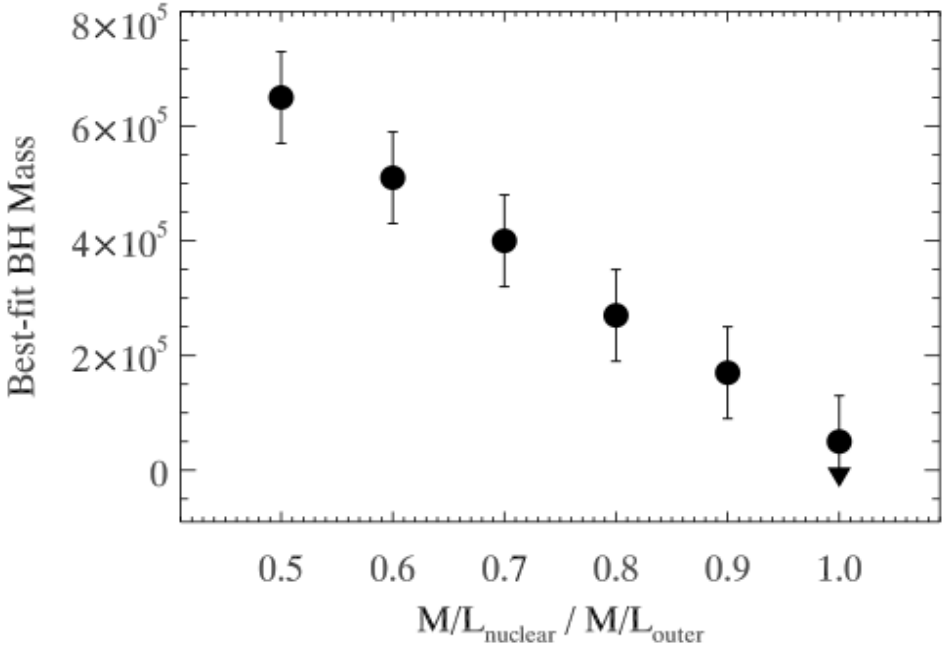
→ firm upper limit on the black hole with mass < 1 million Solar mass with large uncertainty.



However: In central arc second dynamical mass estimates vary with stellar mass-to-light ratio.

Seth+ 2010





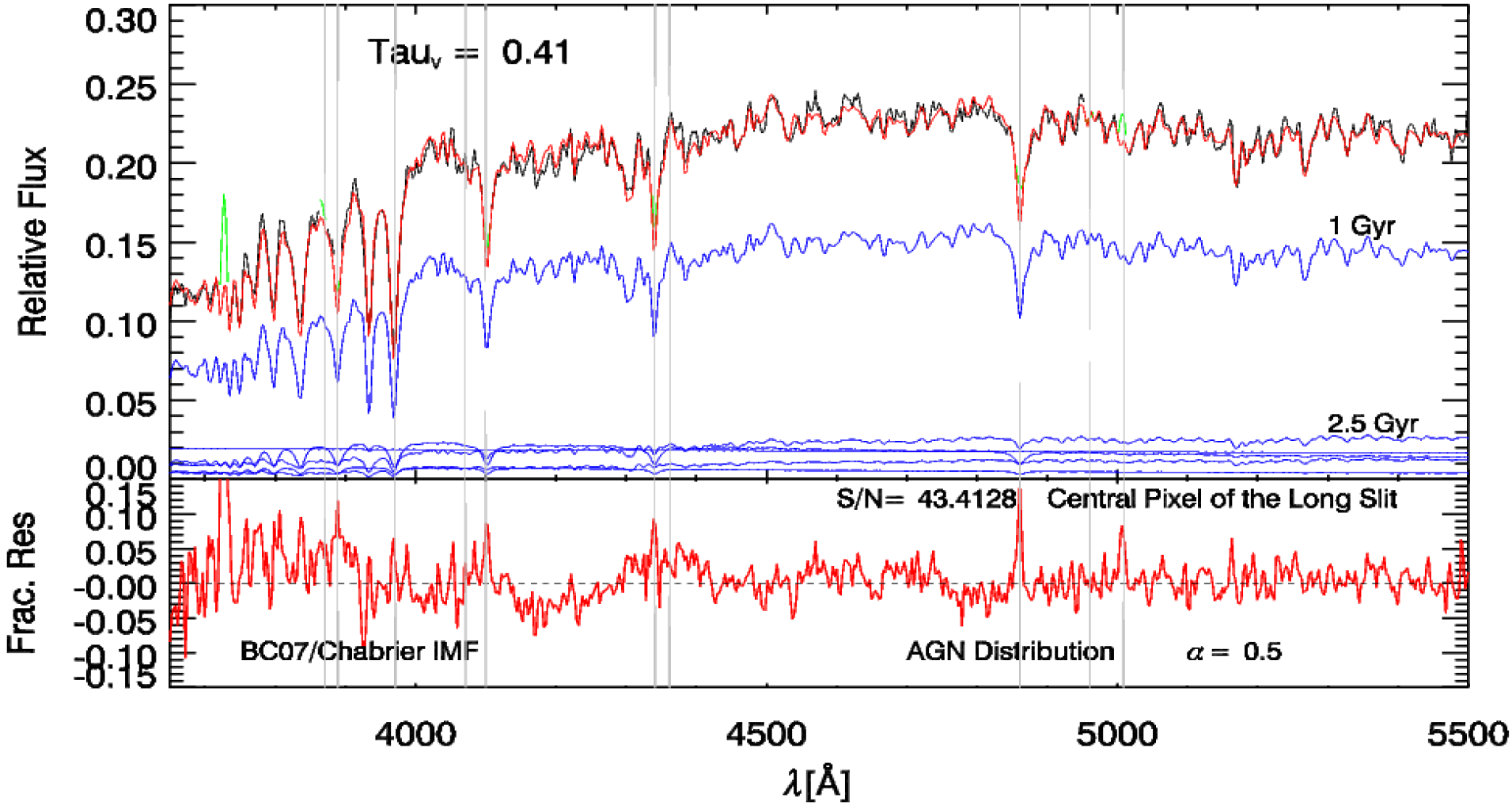
→Derive accurate mass-to-light ratio map.

Improve BH Mass in NGC 404 with HST/WFC3 & STIS data

New Method:

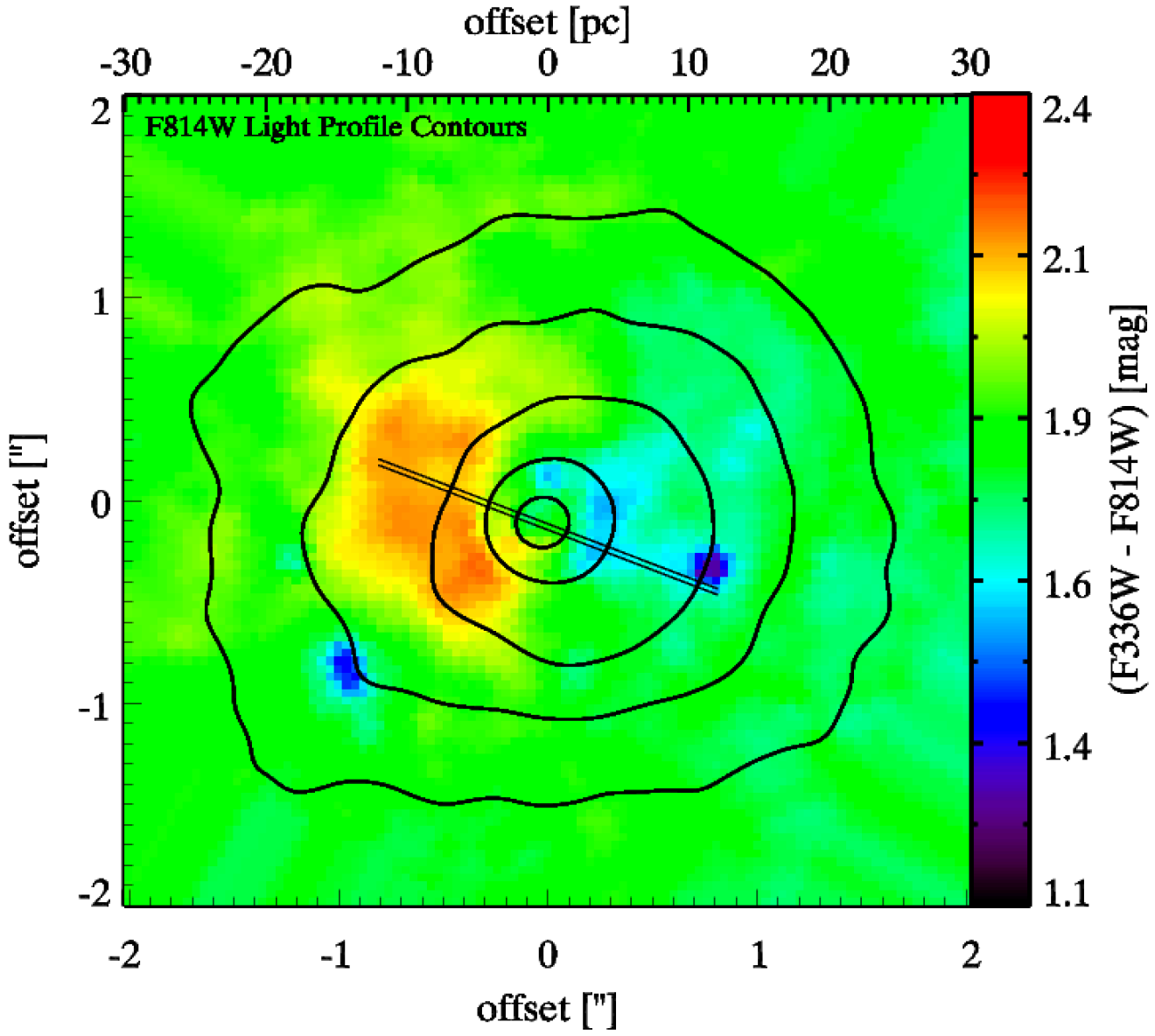
- Use long-slit STIS spectra to fit spectral synthesis mass-to-light ratio.
- Compare images to create mass-to-light ratio vs. color relation.
- Use this relation to create mass map of the nucleus.
- Combine with stellar & gas kinematics → increase accuracy of the black hole mass.

Fitting STIS nuclear spectra using stellar population synthesis

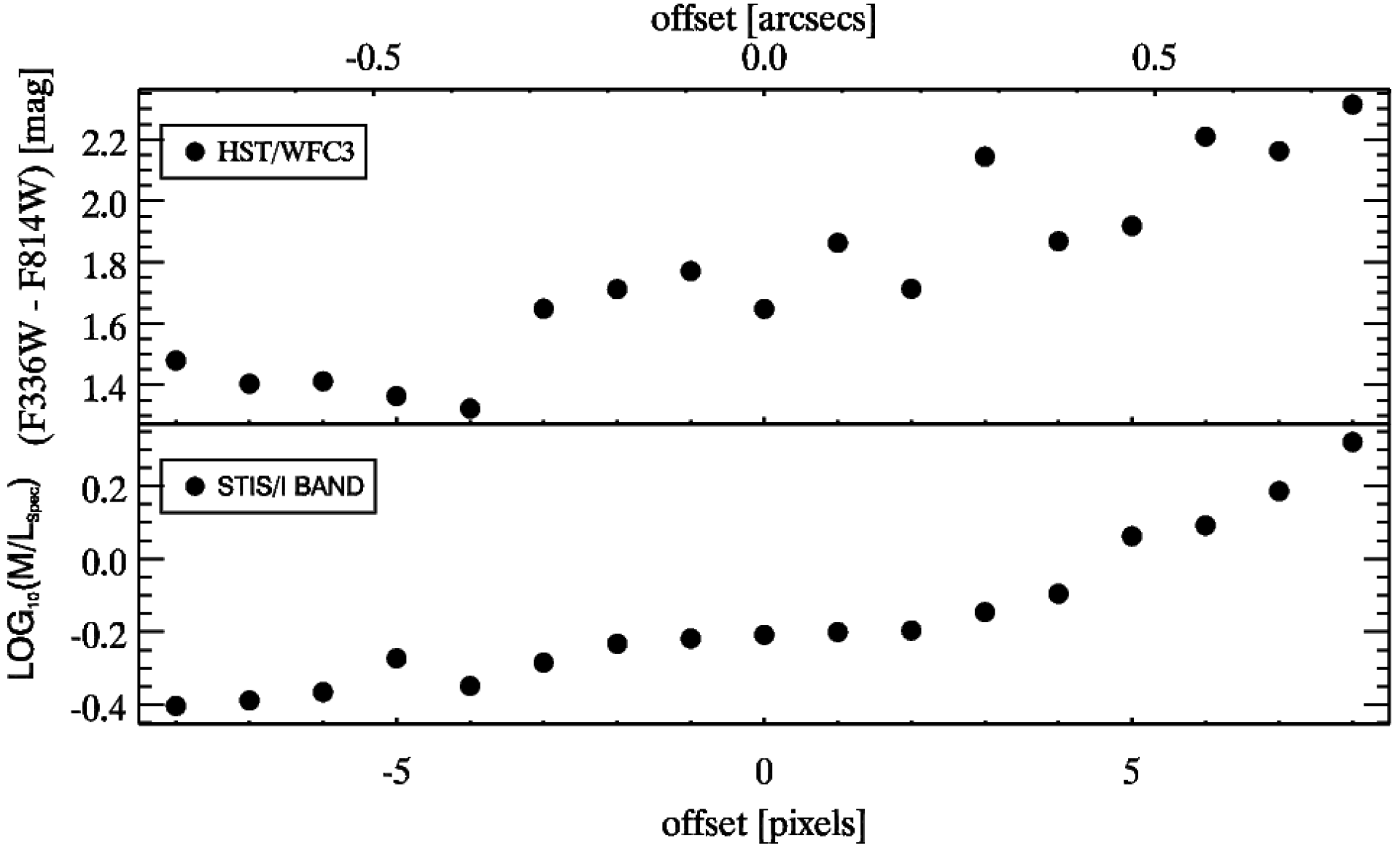


Use to obtain mass-to-light ratio estimates.

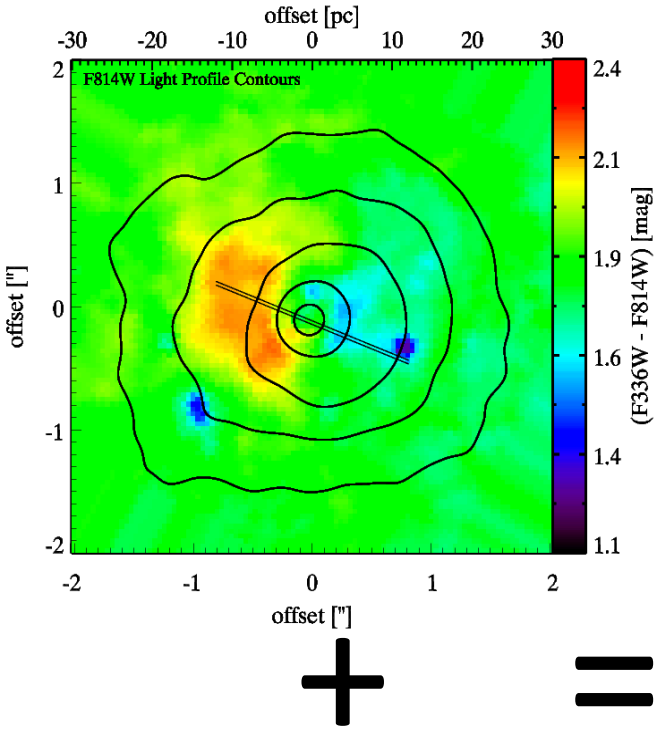
Color map within 2” radius of nucleus



Color and M/L vary with position along the slit

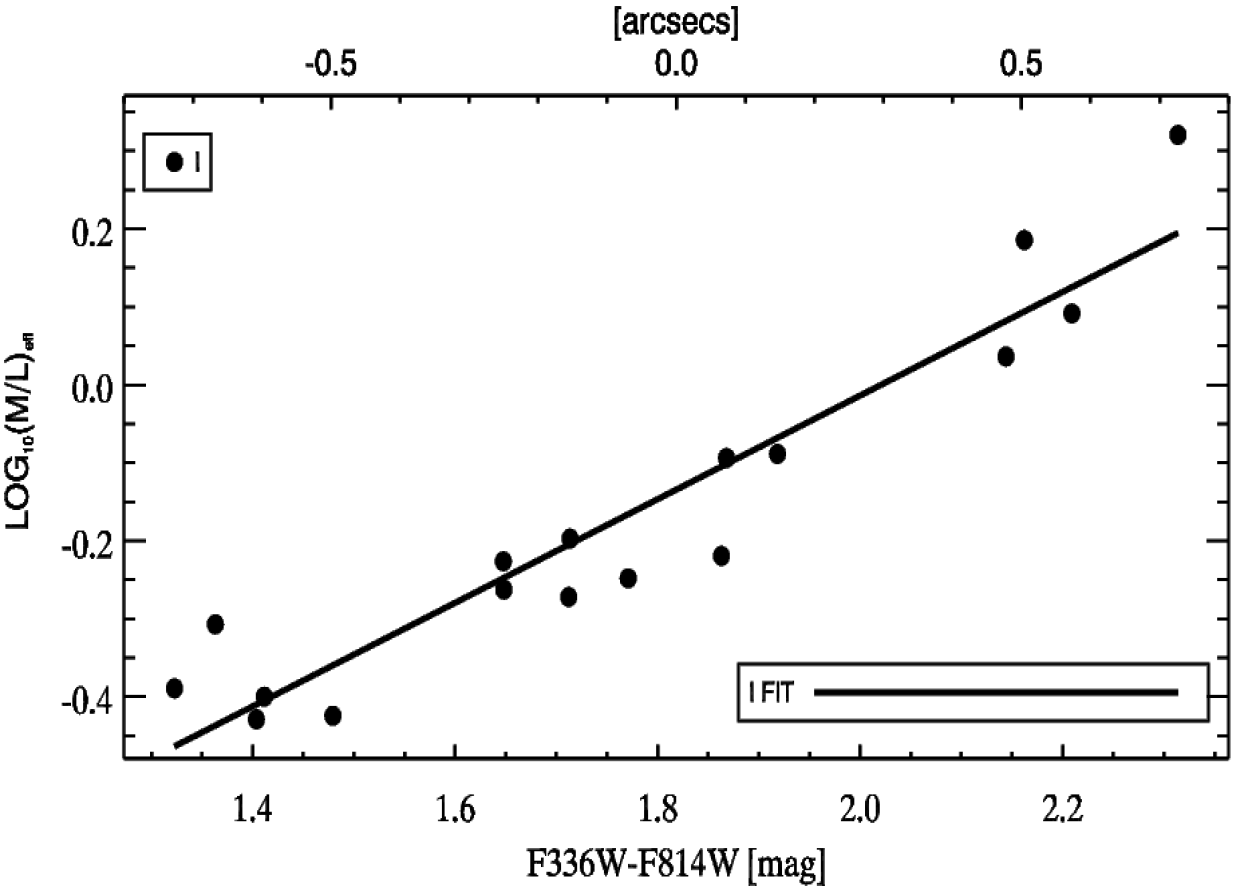


Broadband colors

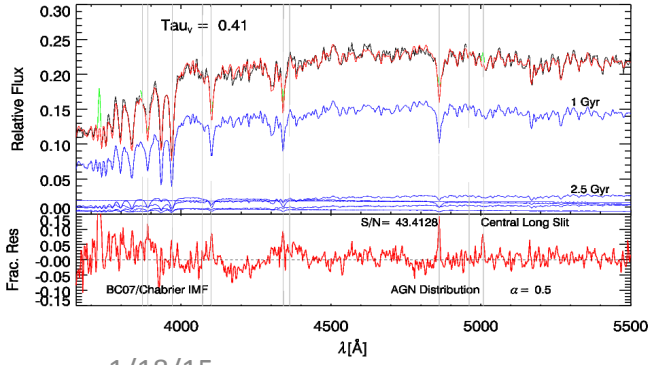


+ =

Color vs. M/L correlation

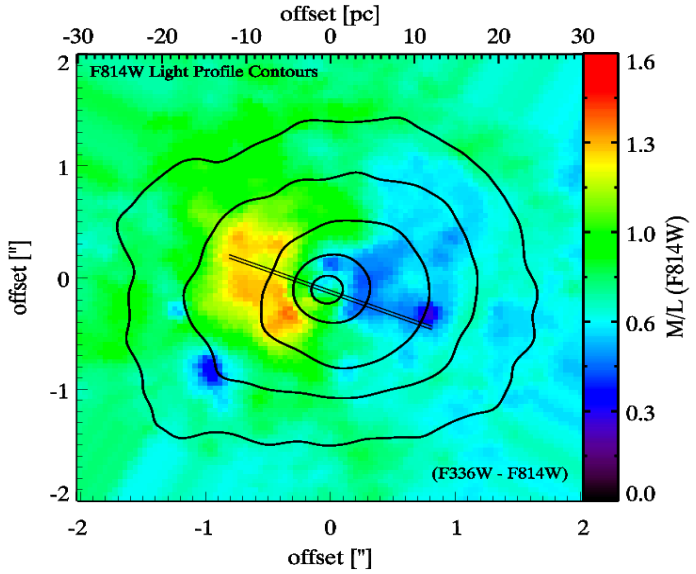


M/Ls from spectral fits



Broadband imaging also includes F547M

Color map



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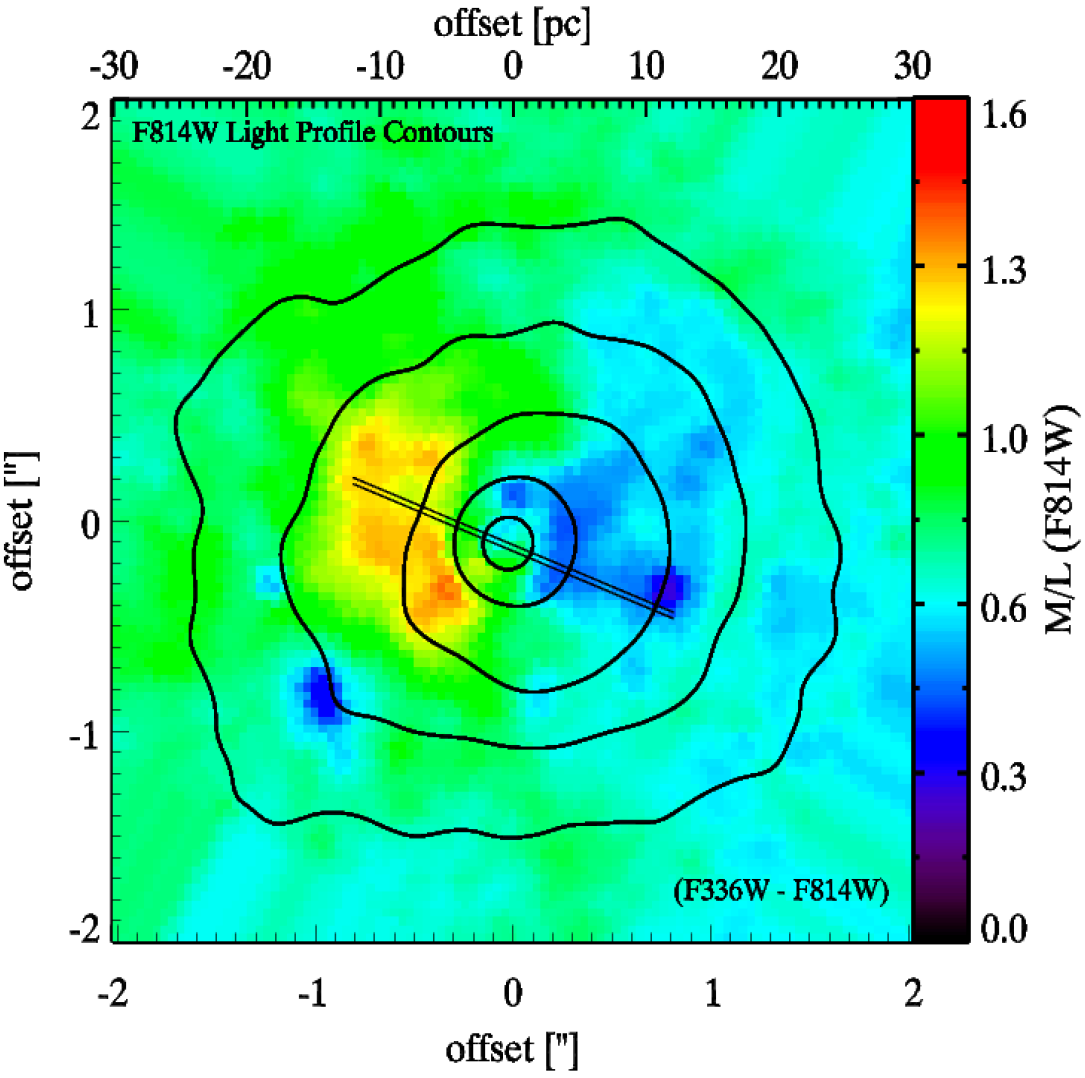
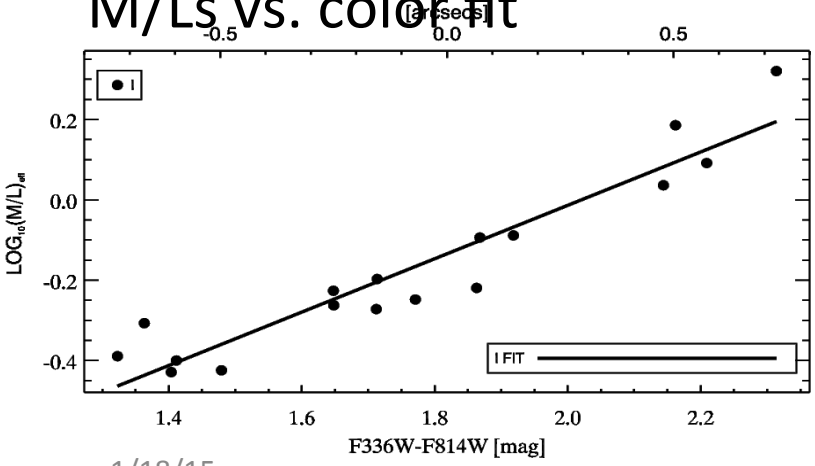
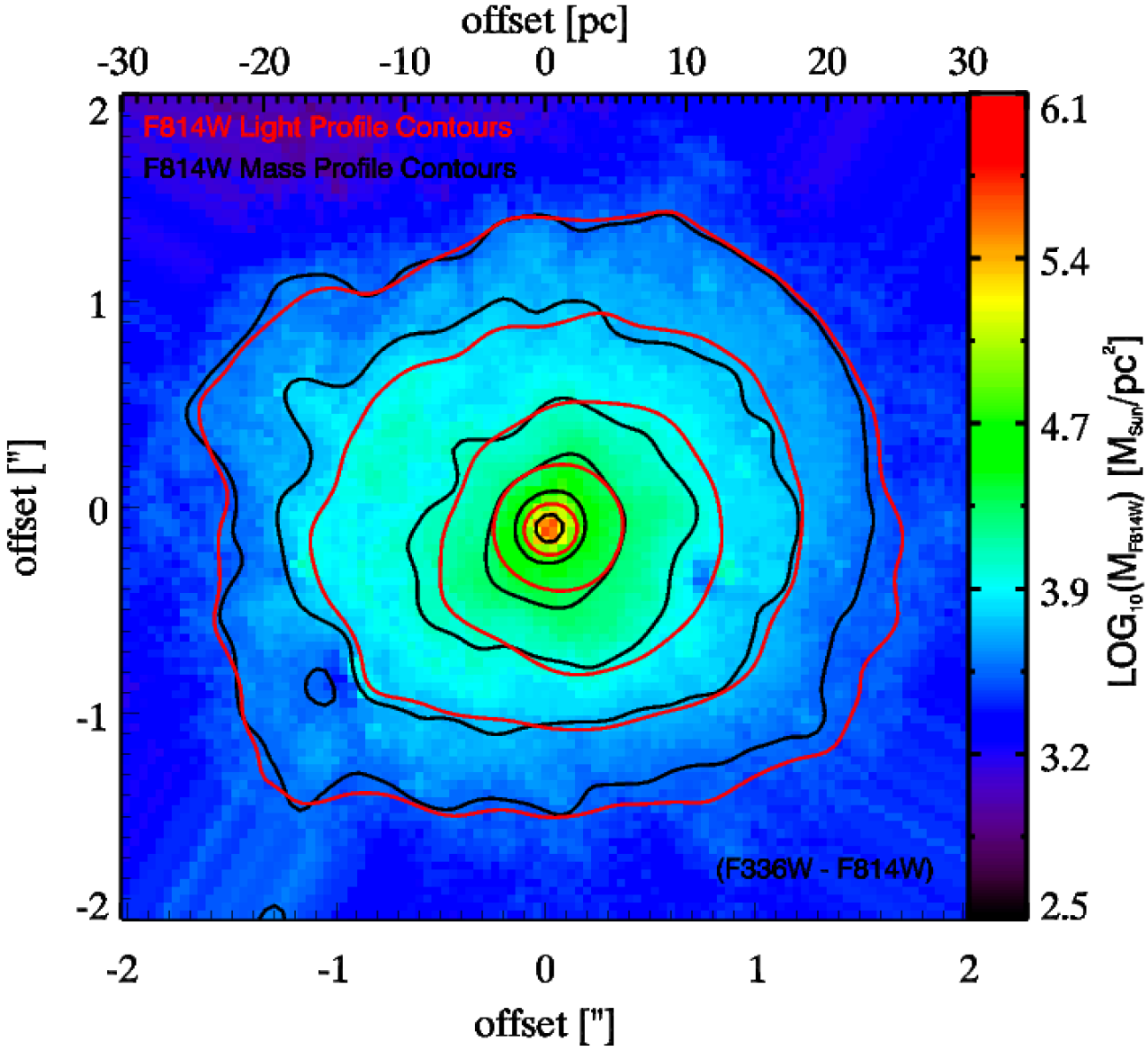
M/L map within 2” radius of nucleus



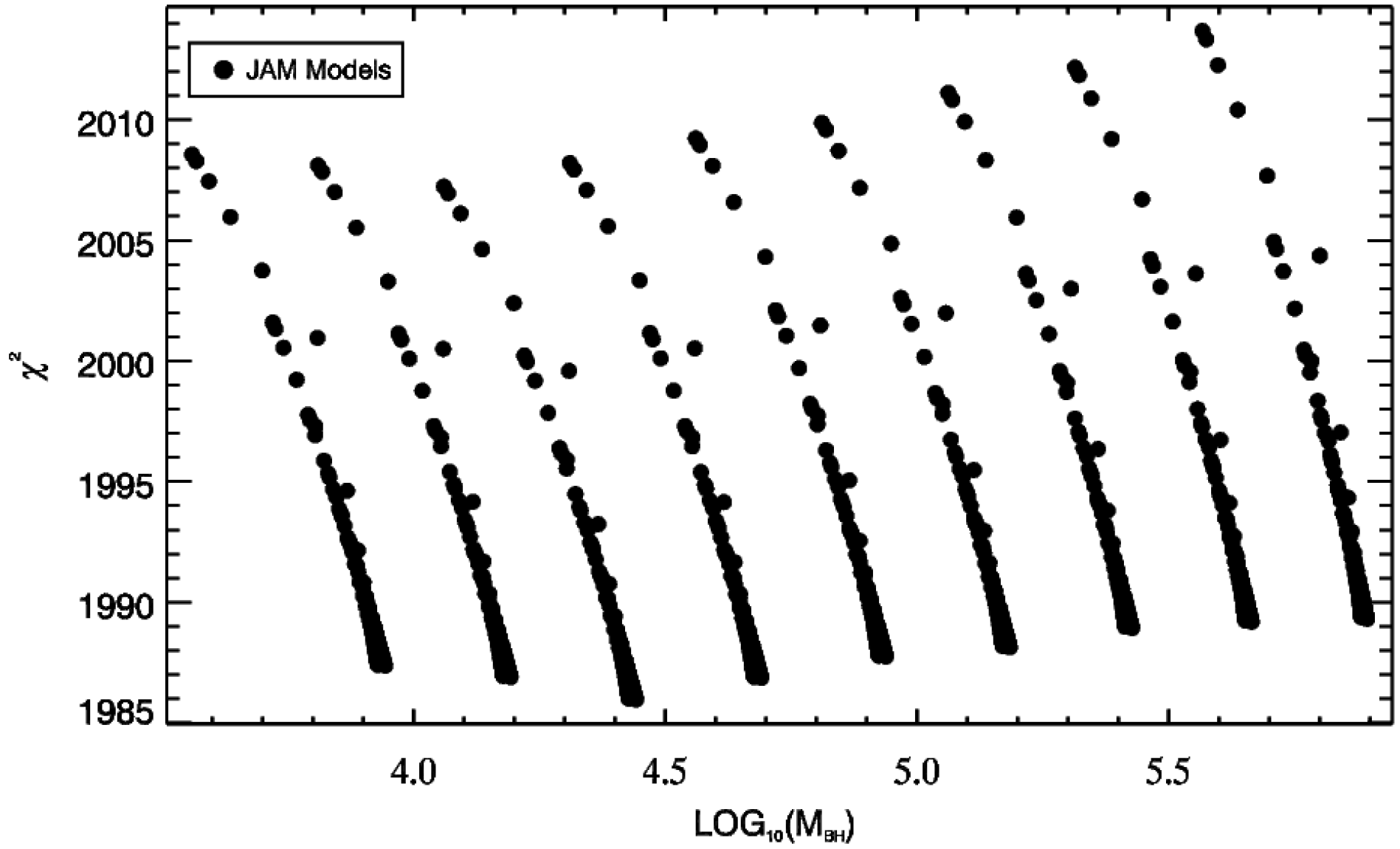
M/Ls vs. color fit



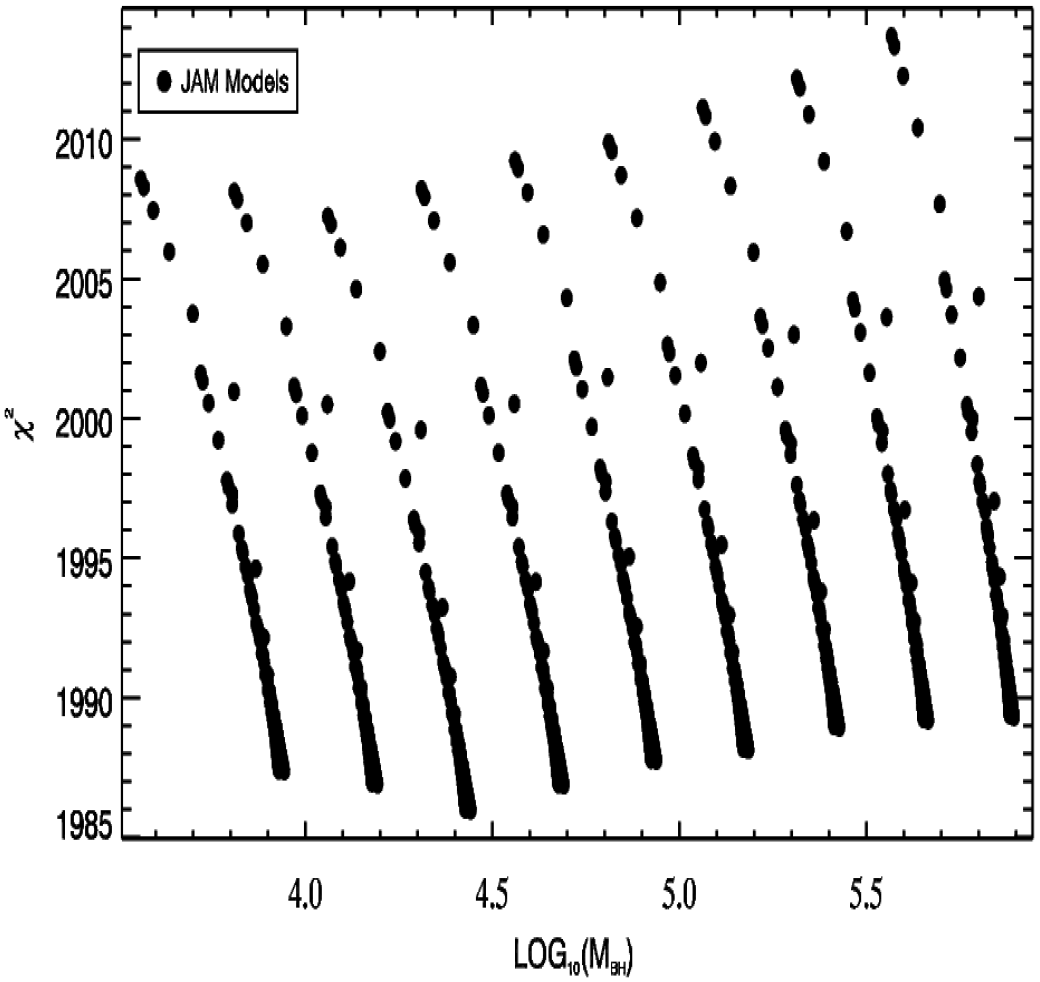
Mass map within radius of 2” nucleus

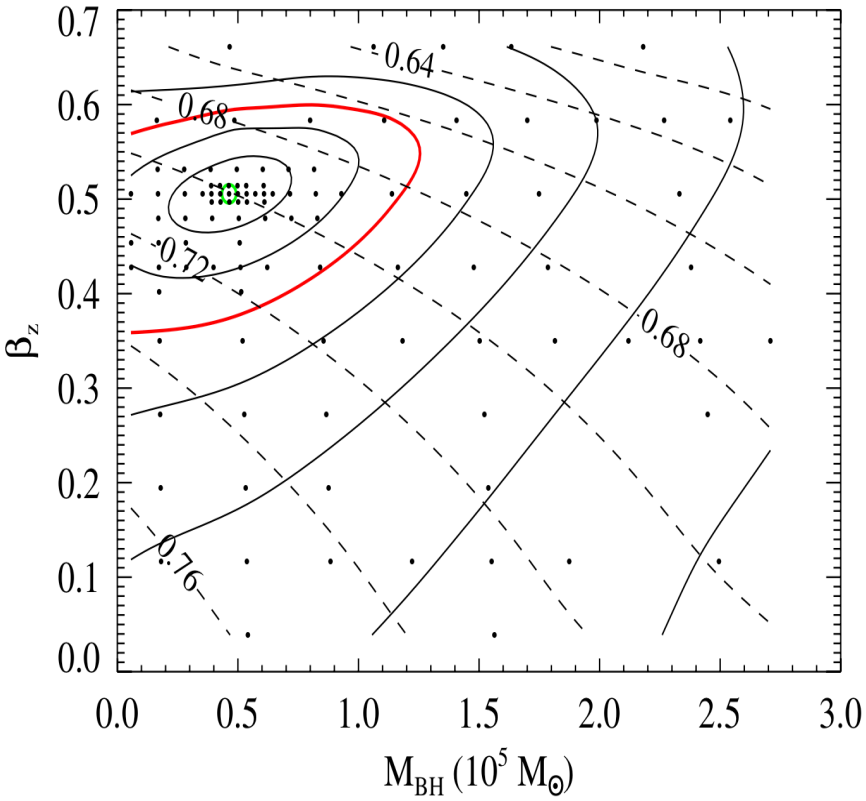


Jeans models for NGC 404 using Mass Map



Black Hole mass estimates Comparison





Seth+ 2010

Conclusions

- Developed new method to determine M/L variations within the nucleus of NGC404, the nearest S0 galaxy.

- Best fit BH mass is still $<10^5$ Msol.