Открытие чёрной дыры в ультракомпактной карликовой галактике

Статья принята к печати в MNRAS

Афанасьев А. В.
ГАИШ МГУ

A 3.5-million Solar Masses Black Hole in the Centre of the Ultracompact Dwarf Galaxy Fornax UCD3

Anton V. Afanasiev,[1,2]★ Igor V. Chilingarian,[3,1] Steffen Mieske,[4] Karina T. Voggel,[5] Arianna Picotti,[6] Michael Hilker[7], Anil Seth,[5] Nadine Neumayer,[6] Matthias Frank,[7] Aaron J. Romanowsky,[8,9] George Hau,[4] Holger Baumgardt,[10] Christopher Ahn,[5] Jay Strader,[11] Mark den Brok,[12,13] Richard McDermid,[14] Lee Spitler,[15] Jean Brodie[9] and Jonelle L. Walsh[16].

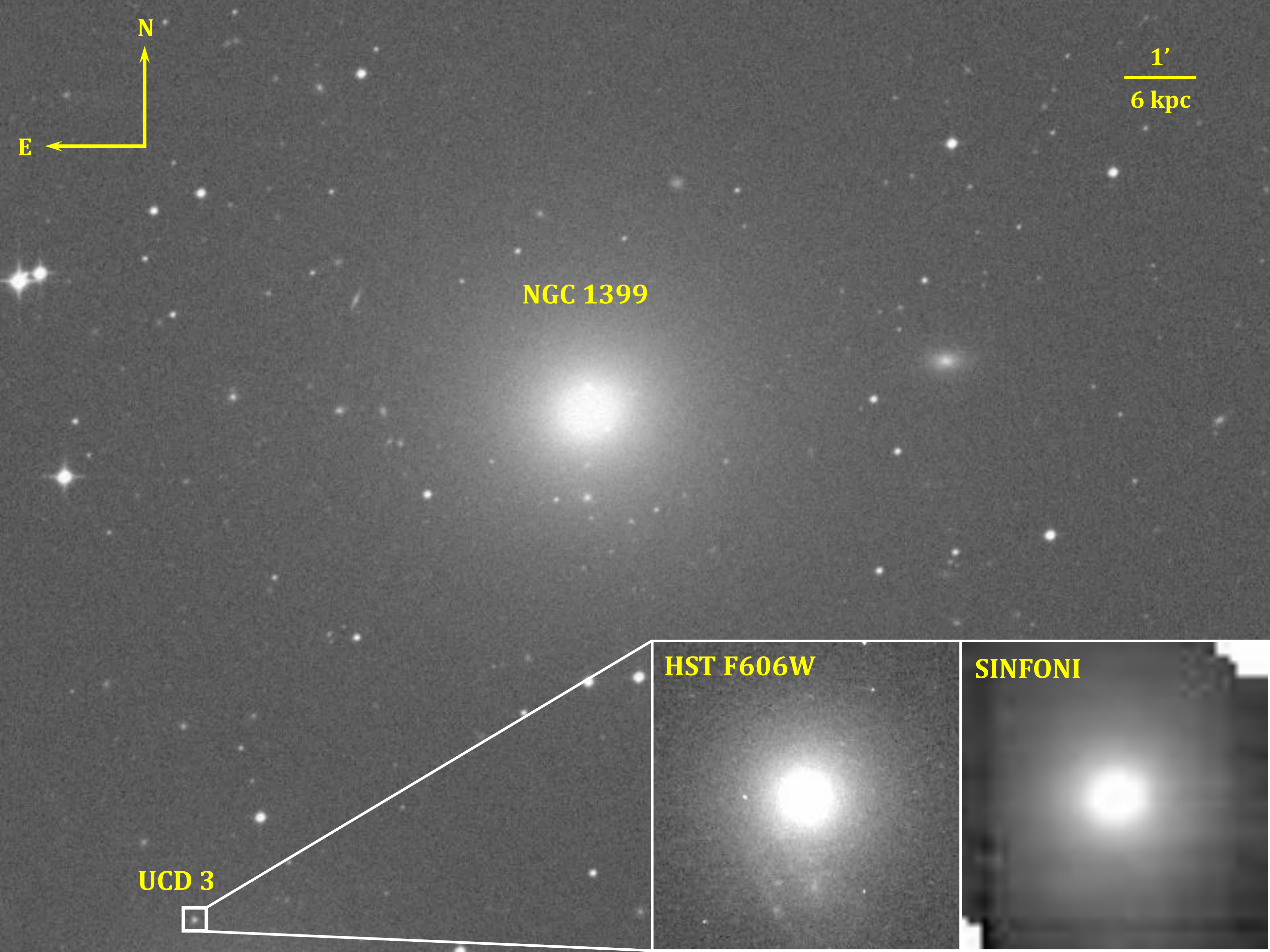
Accepted 2018 April 7. Received 2018 April 3; in original form 2018 February 28

ABSTRACT

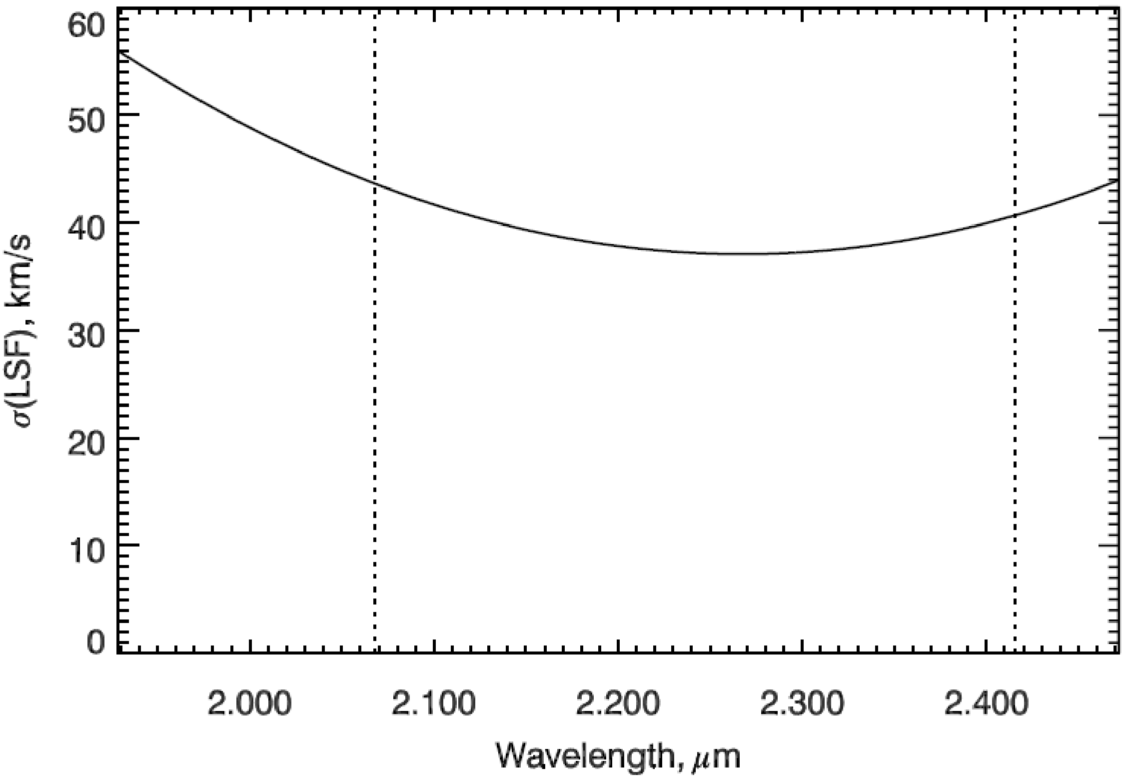
The origin of ultracompact dwarfs (UCDs), a class of compact stellar systems discovered two decades ago, still remains a matter of debate. Recent discoveries of central supermassive black holes in UCDs likely inherited from their massive progenitor galaxies provide support for the tidal stripping hypothesis. At the same time, on statistical grounds, some massive UCDs might be representatives of the high luminosity tail of the globular cluster luminosity function. Here we present a detection of a $3.3^{+1.4}_{-1.2} \times 10^6\,M_{\odot}$ black hole (1σ uncertainty) in the centre of the UCD3 galaxy in the Fornax cluster, that corresponds to 4 per cent of its stellar mass. We performed isotropic Jeans dynamical modelling of UCD3 using internal kinematics derived from adaptive optics assisted observations with the SINFONI spectrograph and seeing limited data collected with the FLAMES spectrograph at the ESO VLT. We rule out the zero black hole mass at the 3σ confidence level when adopting a mass-to-light ratio inferred from stellar populations. This is the fourth supermassive black hole found in a UCD and the first one in the Fornax cluster. Similarly to other known UCDs that harbour black holes, UCD3 hosts metal rich stars enhanced in α-elements that supports the tidal stripping of a massive progenitor as its likely formation scenario. We estimate that up to 80 per cent of luminous UCDs in galaxy clusters host central black holes. This fraction should be lower for UCDs in groups, because their progenitors are more likely to be dwarf galaxies, which do not tend to host central black holes.

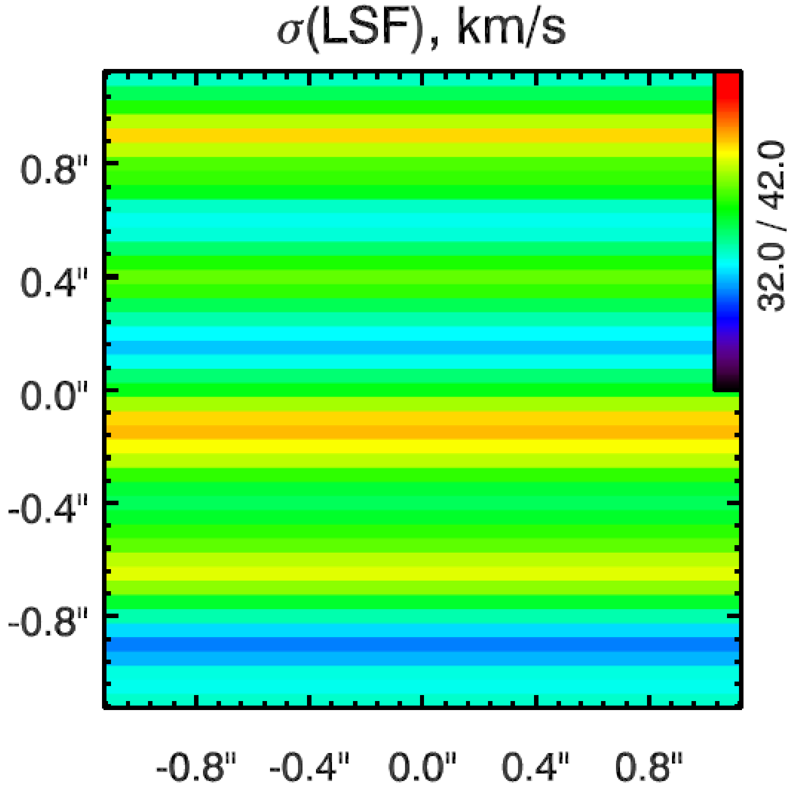
Структура работы:

1. Введение
2. Ультракомпактные карлики
3. Получение спектроскопических данных для галактики Fornax-UCD3
4. Джинсовское динамическое моделирование
5. Результаты
6. Выводы

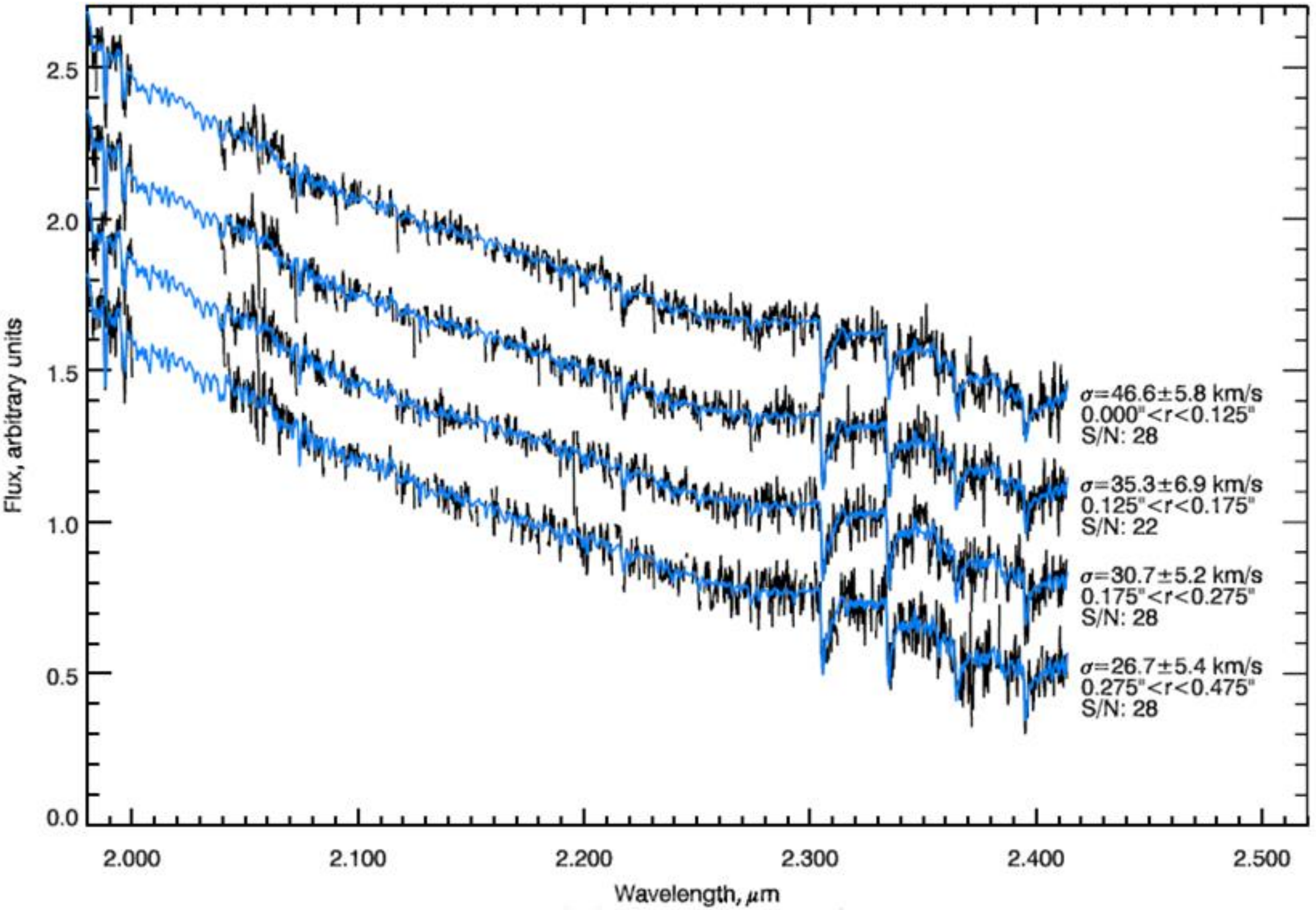

N
E
1’
6 kpc
NGC 1399
UCD 3
HST F606W
SINFONI

Получение данных





Получение данных



Джинсовское моделирование

Уравнения Джинса:

$$\frac{\rho\overline{v_R^2} - \rho\overline{v_\phi^2}}{R} + \frac{\partial(\rho\overline{v_R^2})}{\partial R} + \frac{\partial(\rho\overline{v_R v_z})}{\partial z} = -\rho\frac{\partial\Phi}{\partial R}$$

$$\frac{\rho\overline{v_R v_z}}{R} + \frac{\partial(\rho\overline{v_z^2})}{\partial z} + \frac{\partial(\rho\overline{v_R v_z})}{\partial R} = -\rho\frac{\partial\Phi}{\partial z},$$

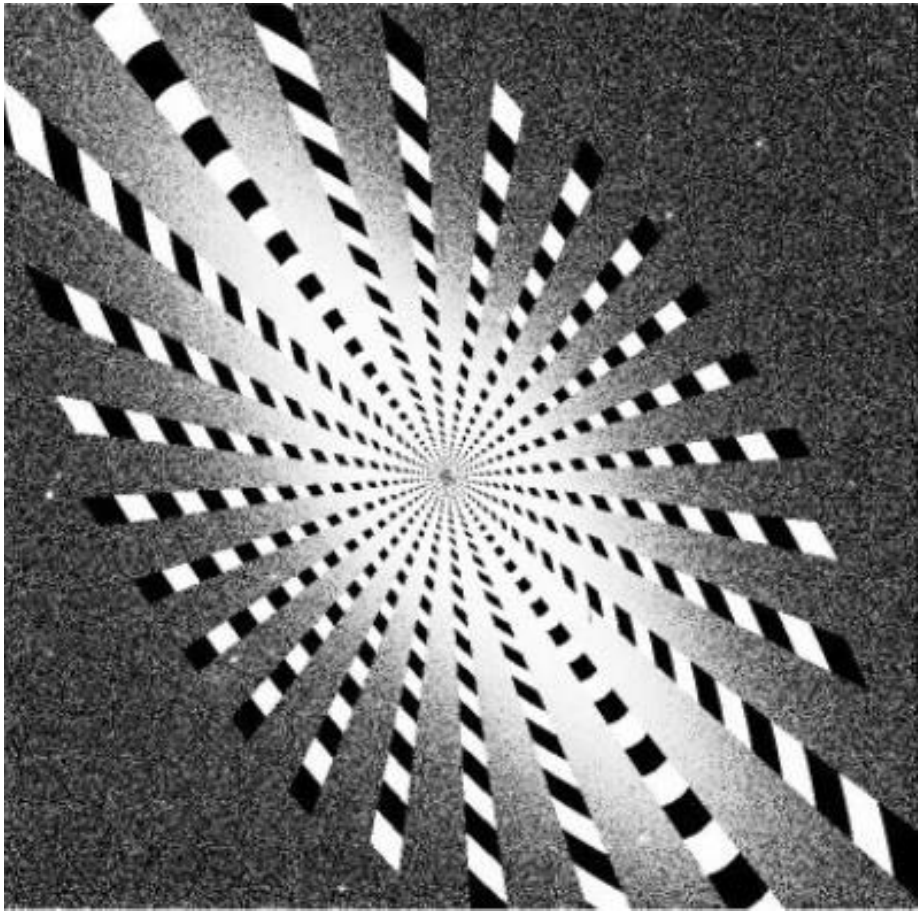
где ρ – плотность звёзд, Φ – потенциал.

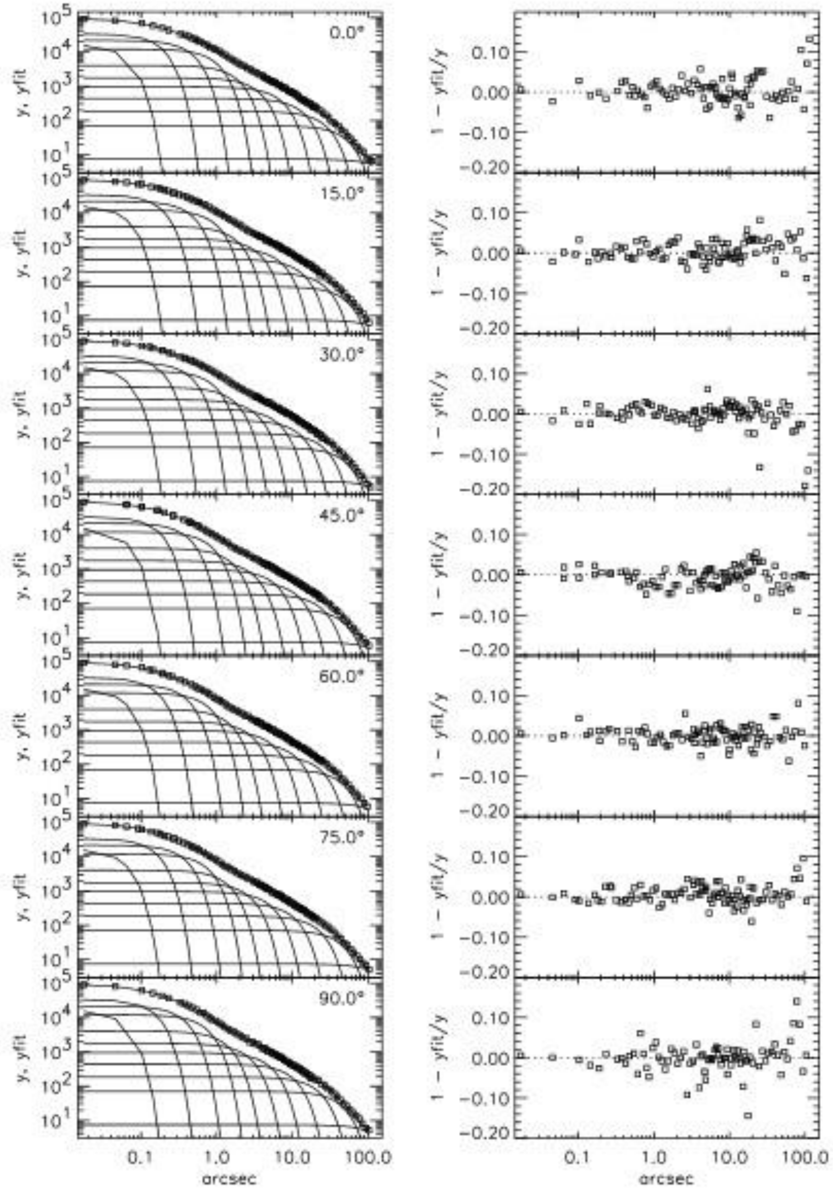
Обычно из наблюдений известно ρ (фотометрия).

Φ зависит от модельных параметров.

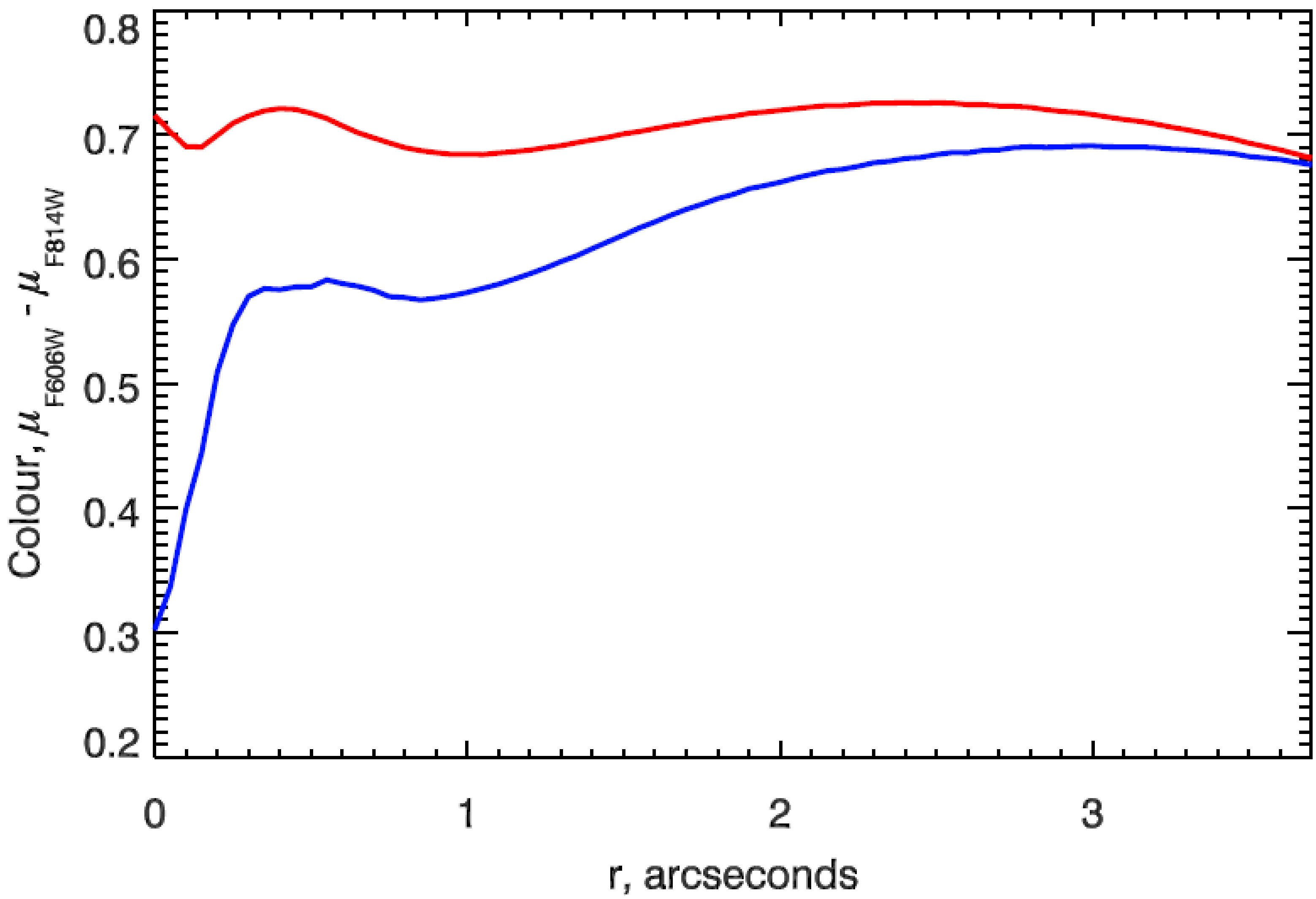
Моделирование позволяет получить распределение v и σ.

Multi Gaussian Expansion (MGE)

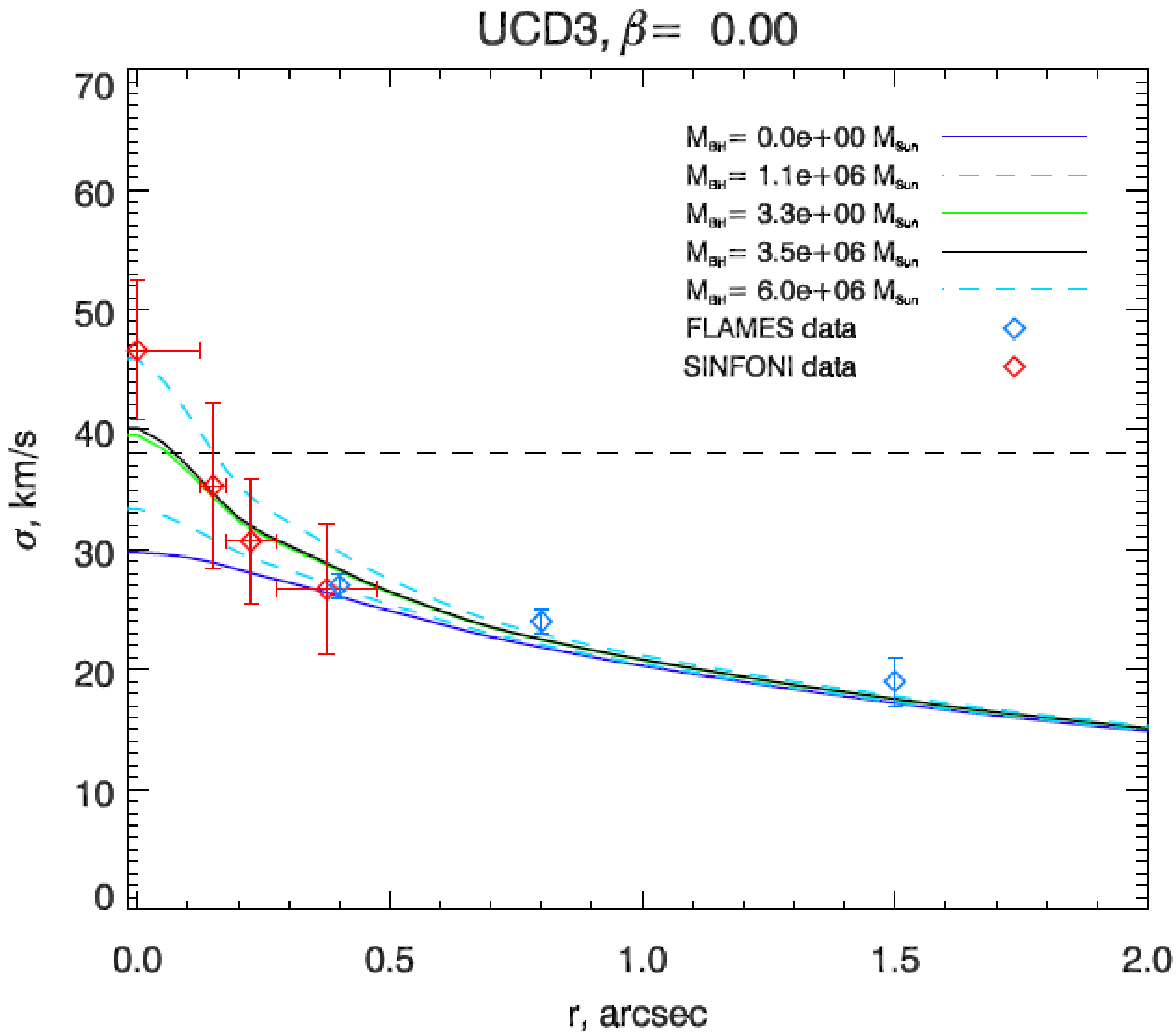




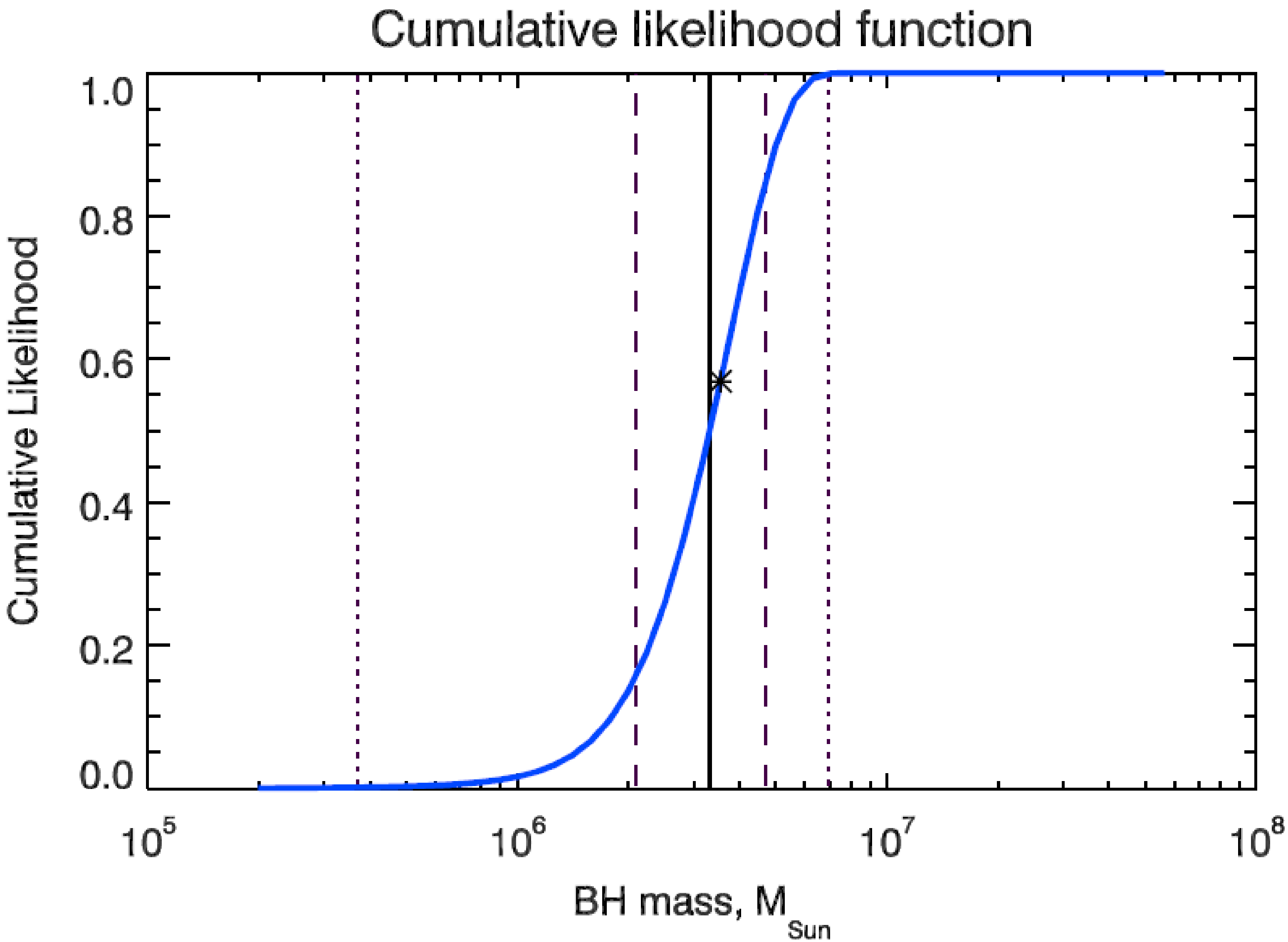
Учёт профиля цвета



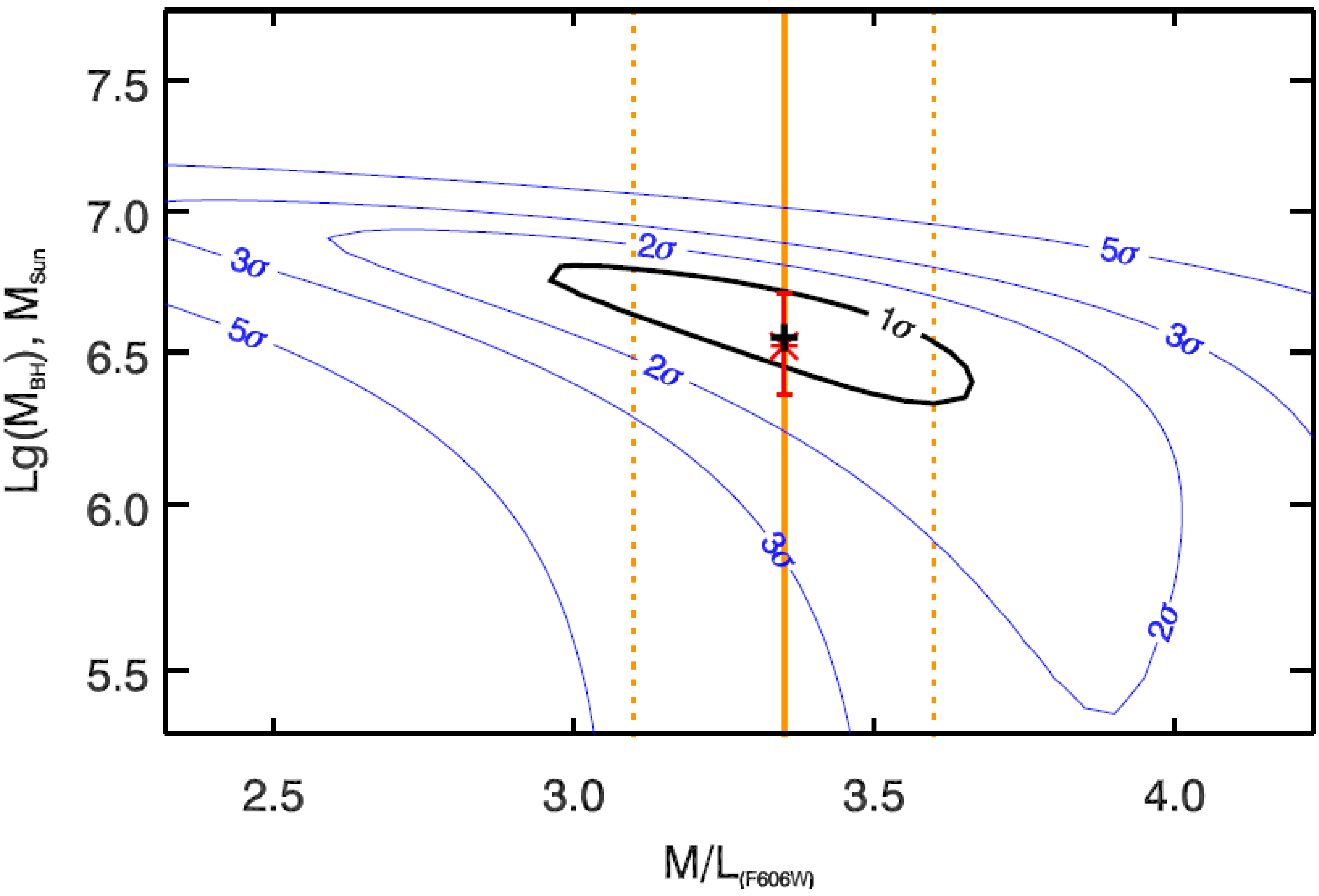
Результаты динамического моделирования



Определение M_{BH}

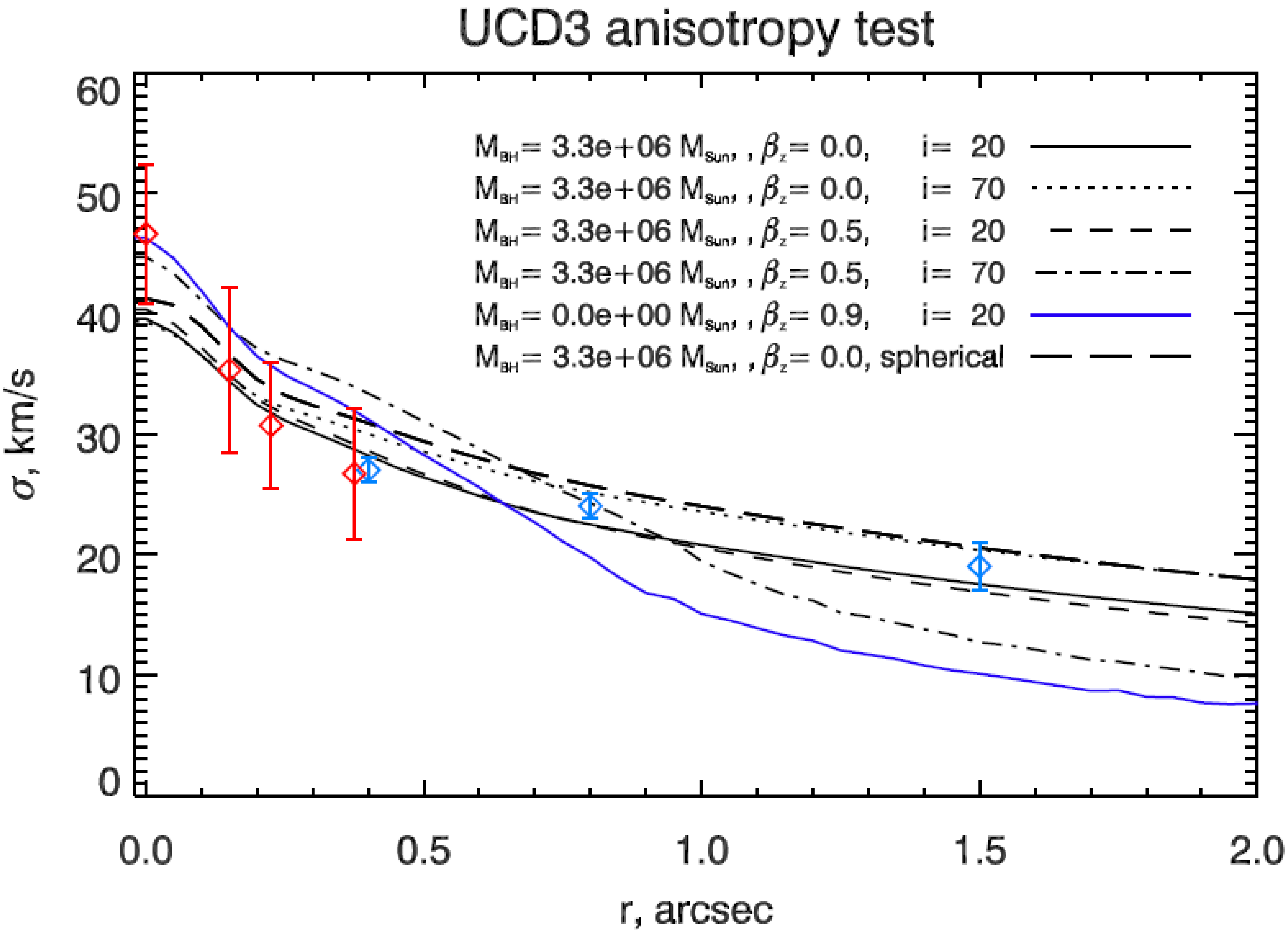


Карта χ^2



7.5
7.0
6.5
6.0
5.5
2.5
3.0
3.5
4.0
Lg(M_BH), M_Sun
M/L_(F606W)
1σ
2σ
2σ
2σ
3σ
3σ
3σ
5σ
5σ

Возможное влияние анизотропии



Выводы:

1. В Fornax-UCD3 обнаружена чёрная дыра, составляющая 4% её массы.
2. Подтверждается приливное происхождение большинства UCD
3. α-обогащение – *надёжный* маркер присутствия SMBH
4. До 80% UCD в скоплениях могут иметь сверхмассивные чёрные дыры

Спасибо за внимание!