The Upper End of the Supermassive Black Hole Mass Function

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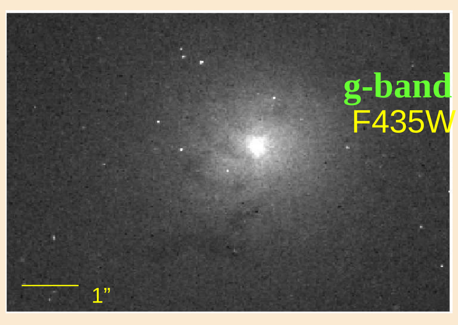
ABSTRACT

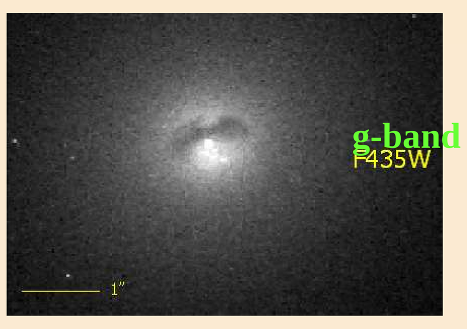
We want to characterize the high mass end of the local supermassive black hole (SMBH) mass function. Indeed, it is in the high mass regime that the unavoidable link between the evolution of SMBHs and the hierarchical build-up of galaxies leaves its clearest signature. We carefully selected three brightest cluster galaxies (BCG). Their large masses, luminosities and stellar velocity dispersions, as well as their having a merging history which is unmatched by galaxies in less crowded environments, make these galaxies the most promising hosts of the most massive SMBHs in the local Universe. We observed the BCG sample with the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS). For each target galaxy we performed high-resolution spectroscopy of the Hα + [NII] emission lines at three slit positions, to measure the central ionized gas kinematics. Two galaxies, named Abell 3565-BCG and Abell 1836-BCG, show a regular rotation curve and a strong central velocity gradient. ACS images with three filters (F435W, F625W and FR656N) have been used to determine the optical depth of the dust, the stellar mass distribution near the nucleus and an intensity map. We used a dynamical model of the gaseous disk taking into account the whole bidimensional velocity field and the instrumental set-up. The extension of the high mass end of the local SMBH mass function is necessary to improve our understanding of how SMBHs, and their hosts, formed and evolved.

SAMPLE SELECTION

The $M_\bullet$-σ_c relation (Ferrarese & Merritt 2000, Gebhardt et al. 2000), as well as hierarchical formation models, predicts the most massive black holes to reside in the most massive galaxies. The giant ellipticals which are brightest members of rich clusters (BCGs) are obvious targets. We selected our sample from Laine et al. (2003). The galaxies have the largest $M_\bullet$ (predicted from the $M_\bullet$-σ_c and the $M_\bullet$-M_B relations) and the most clearly resolved sphere of influence. Besides they have defined nuclear dust disk and emission lines in ground-based spectra.



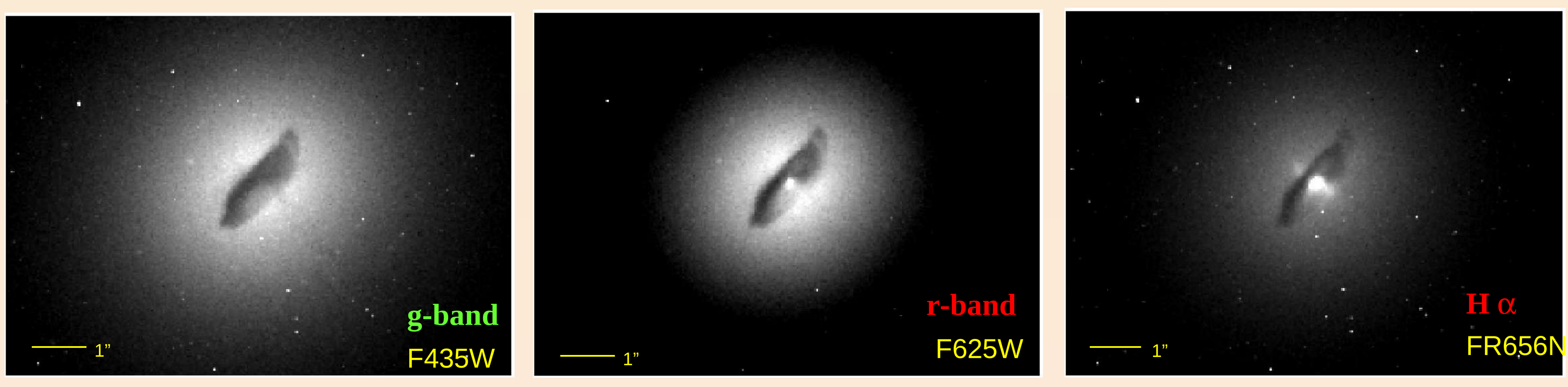
Abell 2052- BCG
D ≈ 138 Mpc, V=12.65 mag



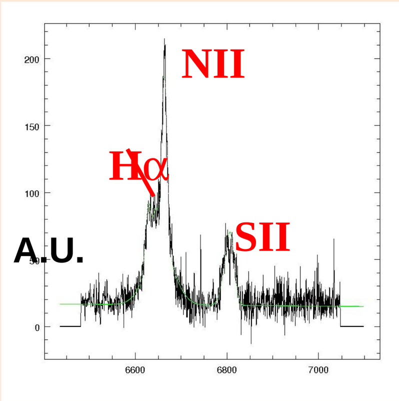
Abell 1836 - BCG
D ≈ 122 Mpc, V=12.30 mag

ACS OBSERVATIONS

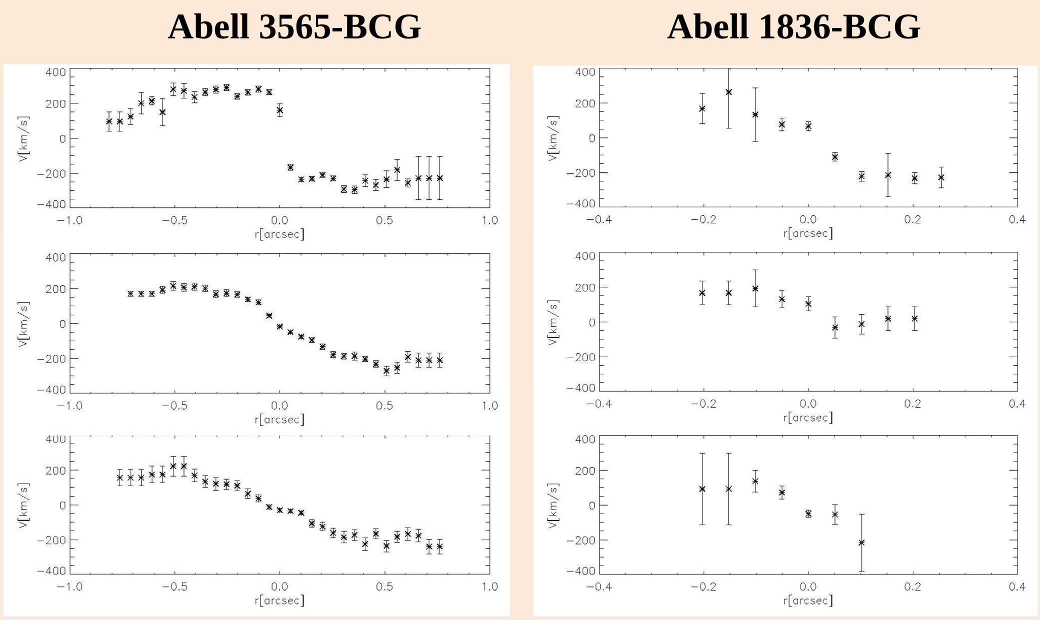
For each target galaxy ACS/HRC images with threee different filters have been taken. Observations with F435W and F625W, combined with the WFPC2/F814W data already existing in the HST archive have been used to determine the optical depth of the dust and the stellar mass distribution near the nucleus. Observations with the FR656N ramp filter were needed to characterize the morphology and spatial distribution of the line emission from the ionized gas associated with the nuclear dust disk.



Abell 3565- BCG, D 40 Mpc, V=9.96 mag



Spectrum Abell 3565-BCG. Sharp + wide Hα component: broad component is unresolved and coming from the nucleus.



Observed rotation curves of the upper offset slits (upper panels) the central slits (central panels) and of the lower offset slits (lower panels) for Abell 3565-BCG (left) and Abell 1836-BCG (right).

STIS OBSERVATIONS

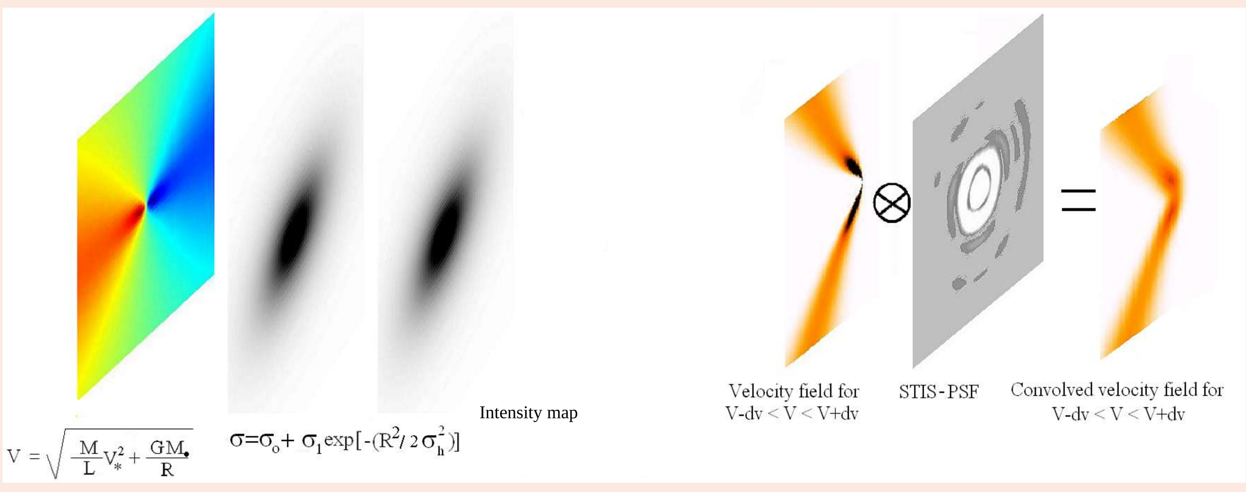
For each target galaxy we obtained the [NII] 6583 Å kinematics along the major axis and two offset positions on either sides of the nucleus (0.2 arcsec for Abell 3565-BCG and 0.1 arcsec for Abell 1836-BCG). The scale was 0.05 arcsec pixel^{-1}, the dispersion was 0.55 Å pixel^{-1} (~25 km s^{-1} at Hα) and the slit width was 4 pixels (0.2 arcsec) for Abell 3565-BCG and 2 pixels for Abell 1836-BCG.

For Abell 2052-BCG the velocity curve reveals a disturbed kinematics. This object shows also an irregular dust-lane morphology. On the contrary, Abell 3565-BCG and Abell 1836-BCG show a regular kinematics and also a regularity of dust-lane morphology. These galaxies are good candidates to model the velocity field for the determination of $M_\bullet$.

THE MODEL : Velocity Field

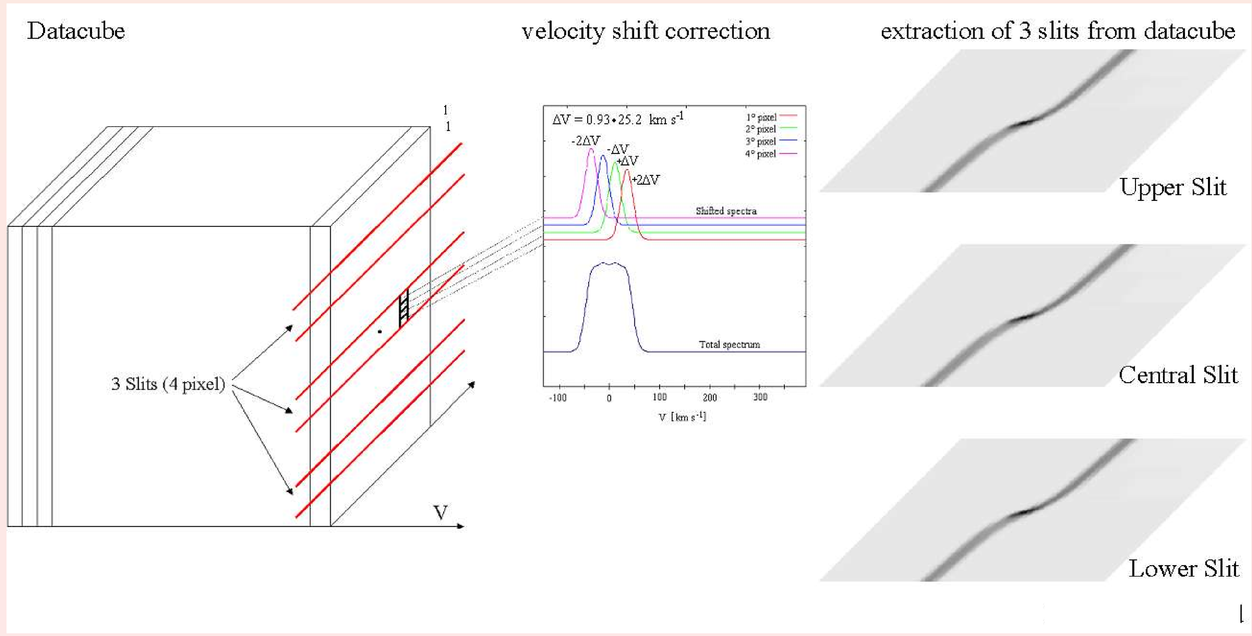
Building of:
- radial velocity field (assuming circular motions),
- velocity dispersion field,
- Hα intensity map.

The total circular velocity is determined by the contribution of the stellar potential (V_*) and of the SMBH.
Convolution of each velocity channel with STIS-PSF.



THE MODEL: Slits Extraction

Data-cube creation with all the convolved velocity channels.
4-2 pixel slit width has been taken into account.
Model spectra extraction from the three slits.



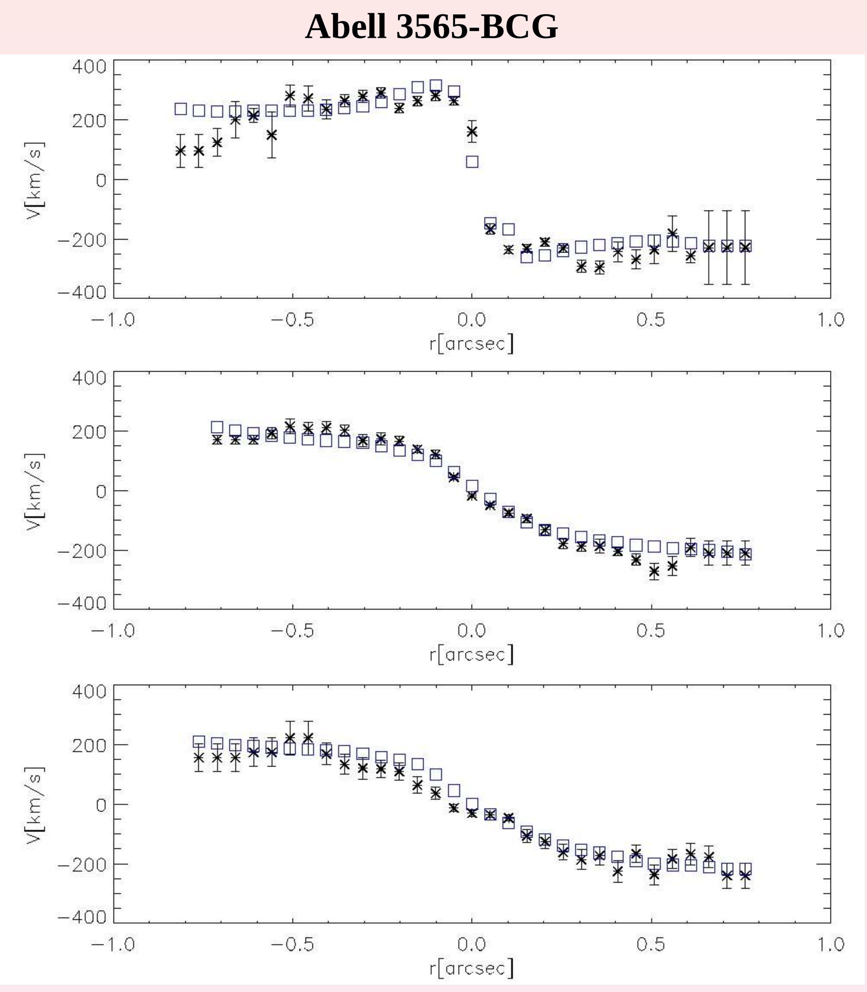
$M_\bullet$ FROM χ^2 MINIMIZATION

3 FREE PARAMETERS:

$M_\bullet$

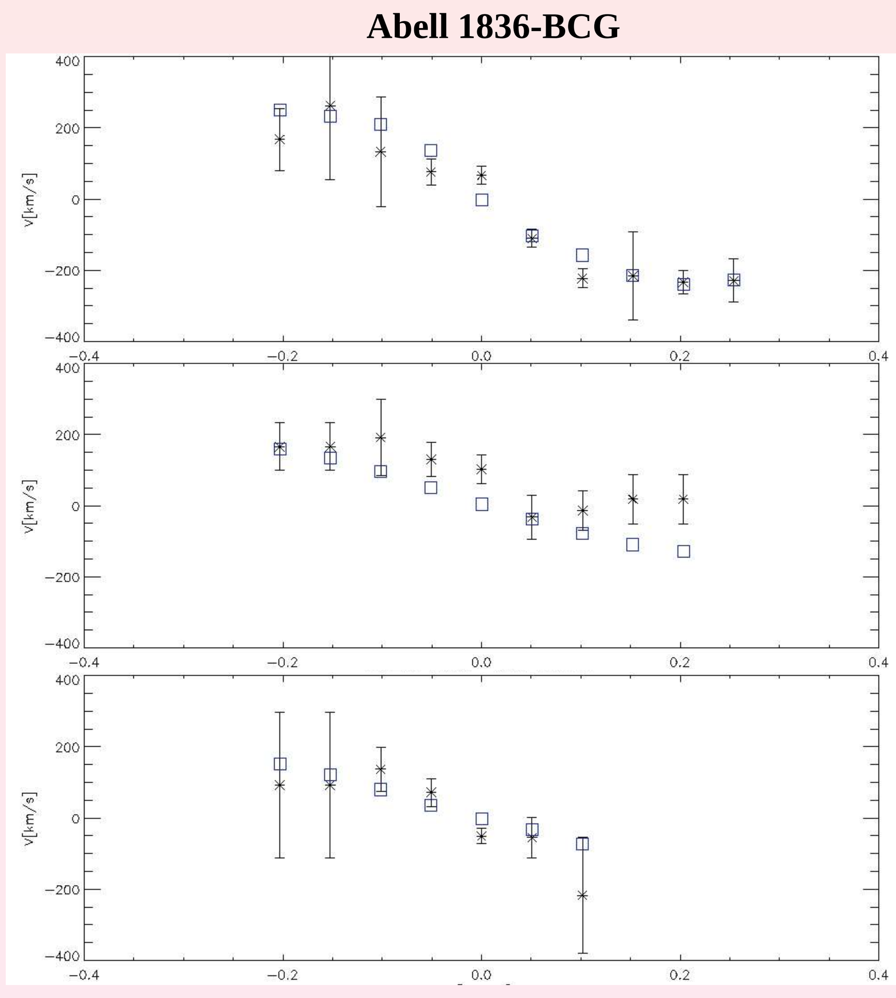
inclination

M/L



$M_\bullet$= 1.3 x 10^9 M_{sun} ± 0.4 x 10^9 M_{sun}

i= 50 ° M/L=9.0 M_{sun}/L_{sun}



$M_\bullet$= 4.8 x 10^9 M_{sun} ± 0.8 x 10^9 M_{sun}

i= 76 ° M/L< 4.0 M_{sun}/L_{sun}

Observed rotation curves (black symbols) of the upper offset slits (upper panels) the central slits (central panels) and of the lower offset slits (lower panels) for Abell 3565-BCG (left) and Abell 1836-BCG (right). Blue symbols show the best fit model.