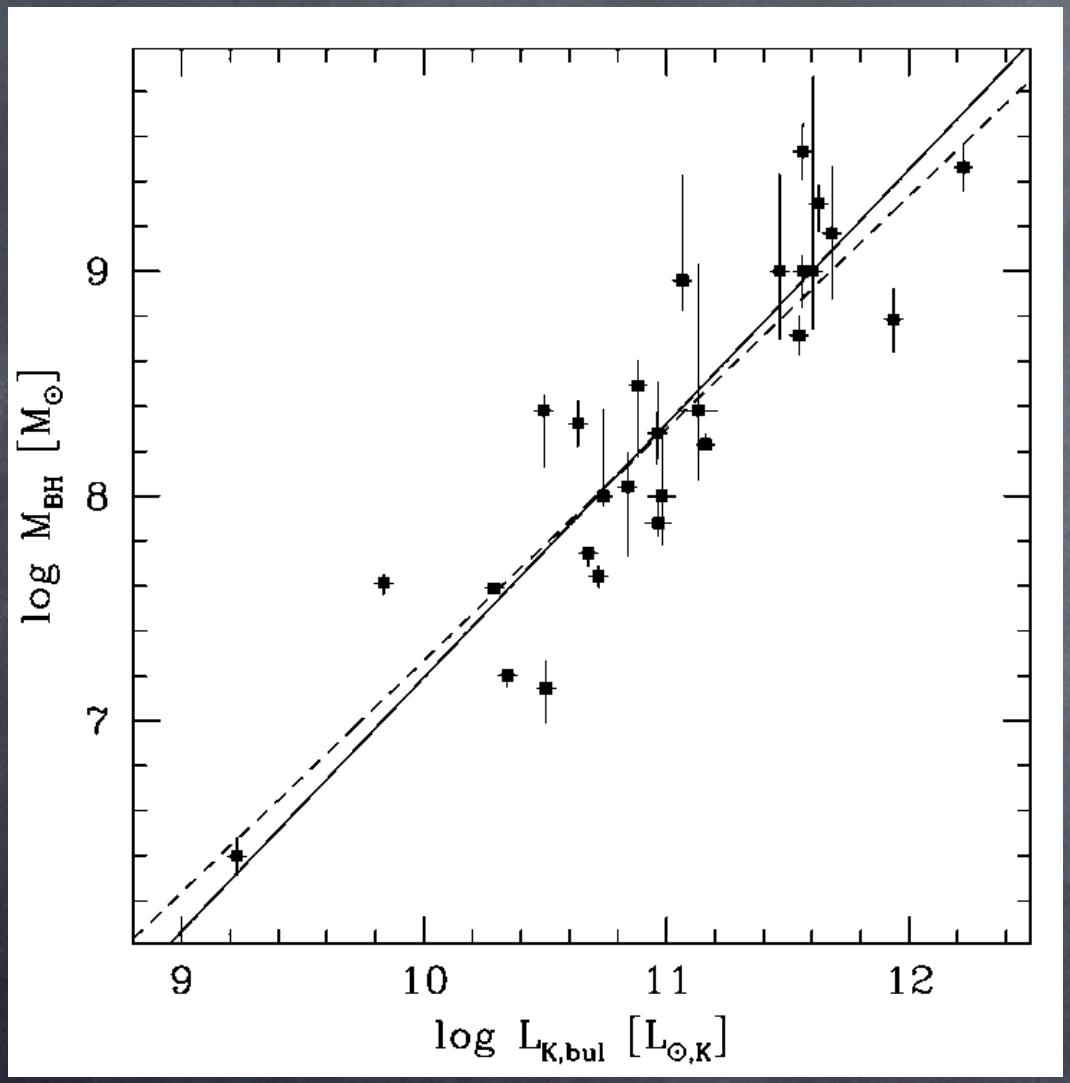
# Black Holes and their Host Galaxies -

## Is the $M_\bullet$-$L_{bulge}$ relation really fundamental ?

Ronald Läsker, Laura Ferrarese, Glenn van de Ven & Francesco Shankar

# Local M• - host galaxy relations




Marconi & Hunt 2003

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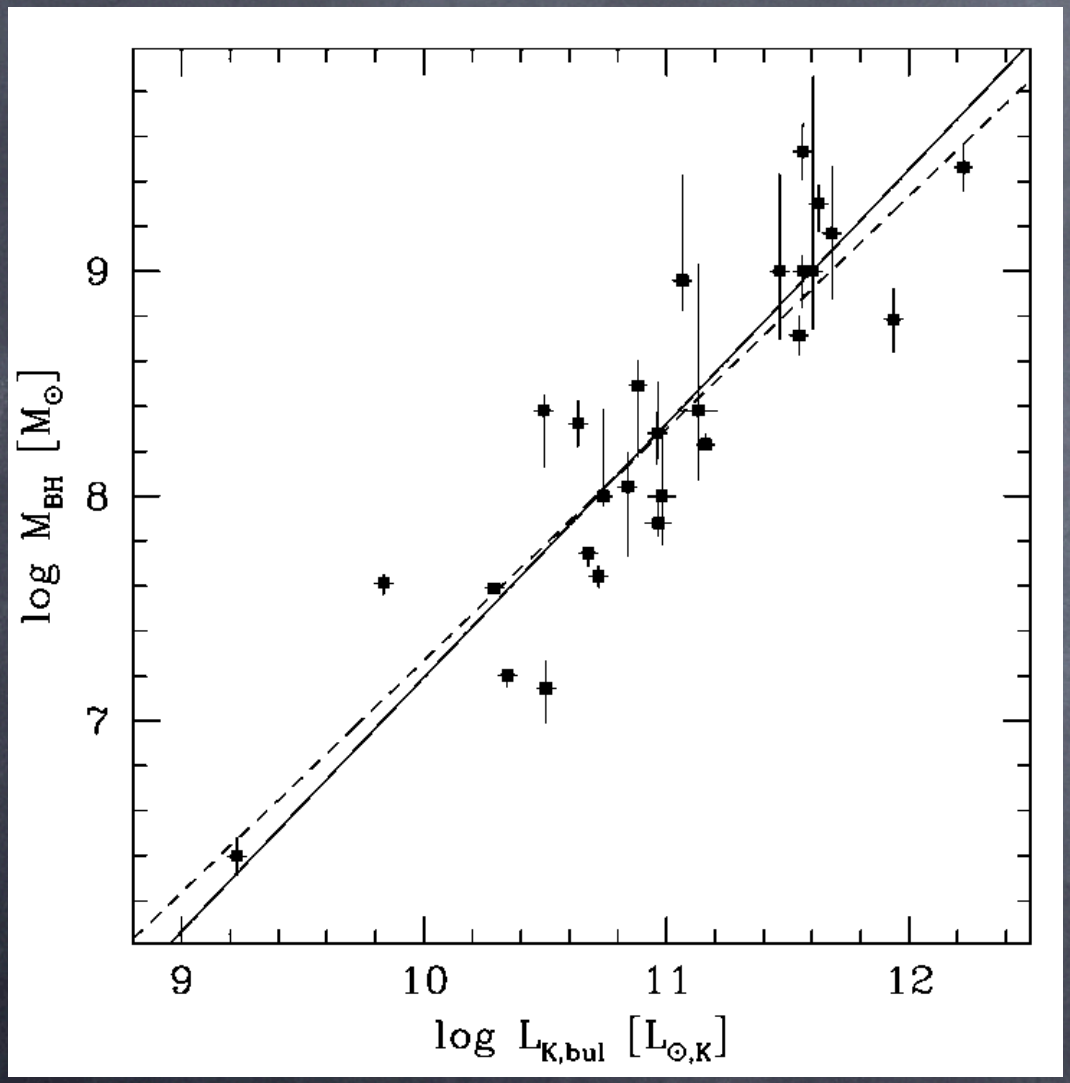


Marconi & Hunt 2003

- understand BH-galaxy connection

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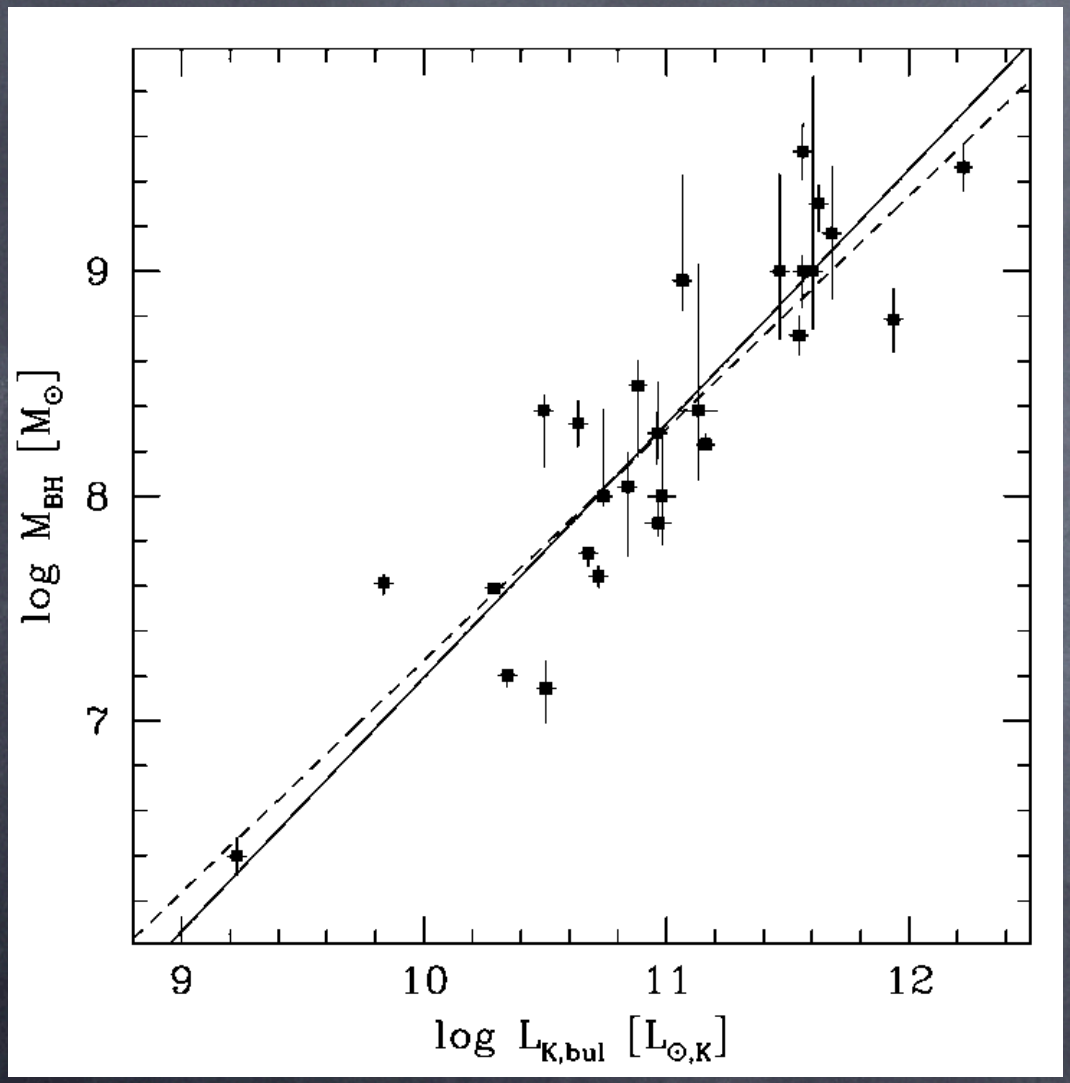


Marconi & Hunt 2003

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- e.g. AGN feedback, accretion ↔ merging

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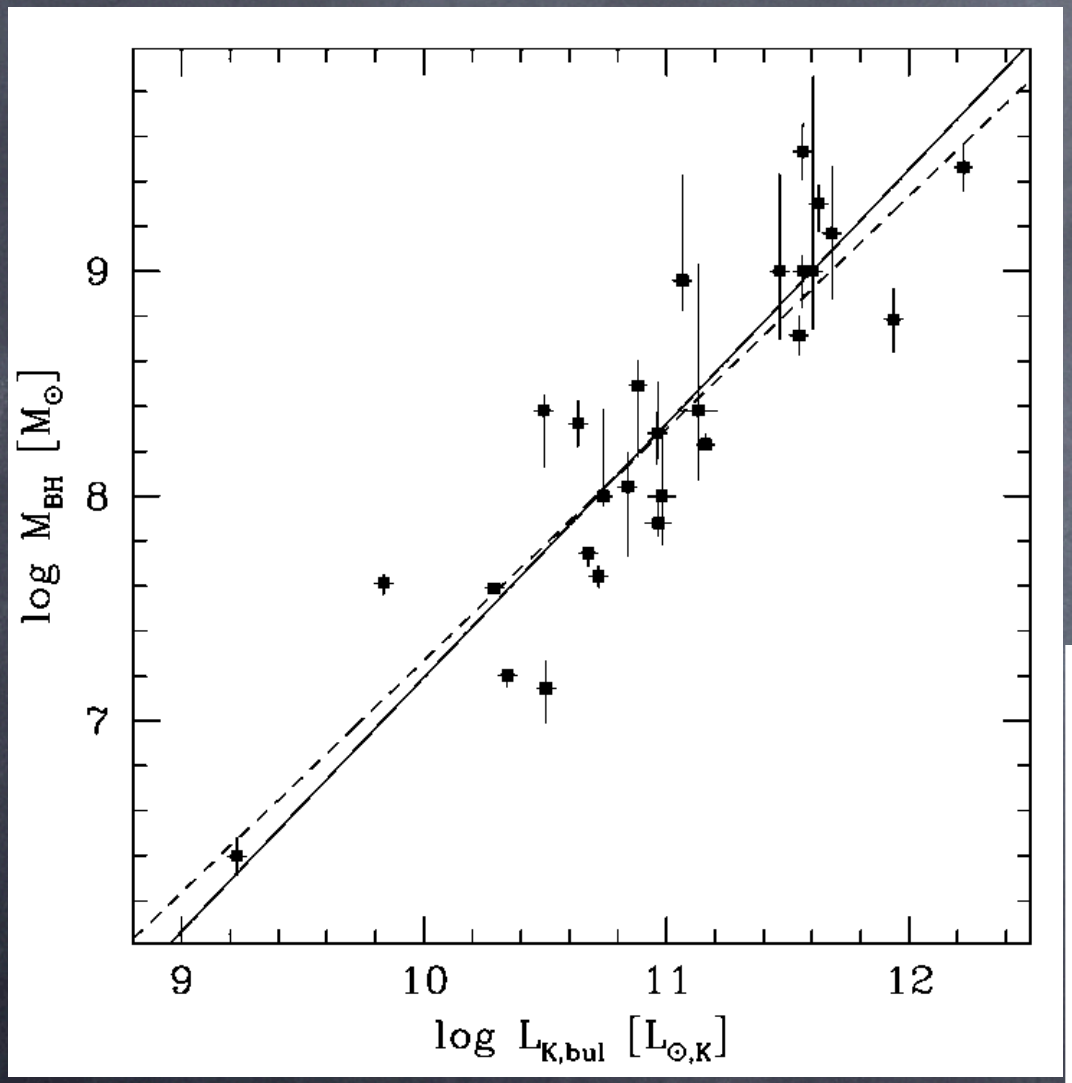


Marconi & Hunt 2003

- understand BH-galaxy connection
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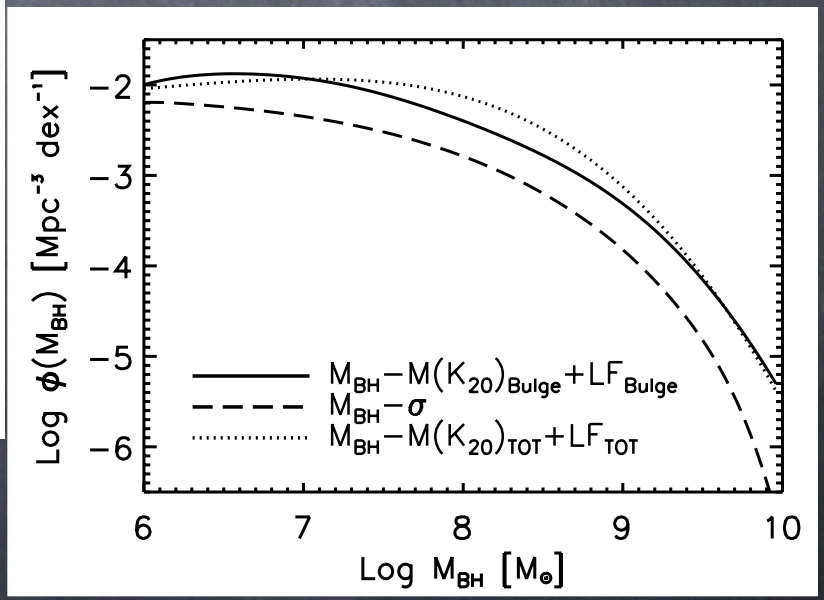


Shankar et al., in prep.

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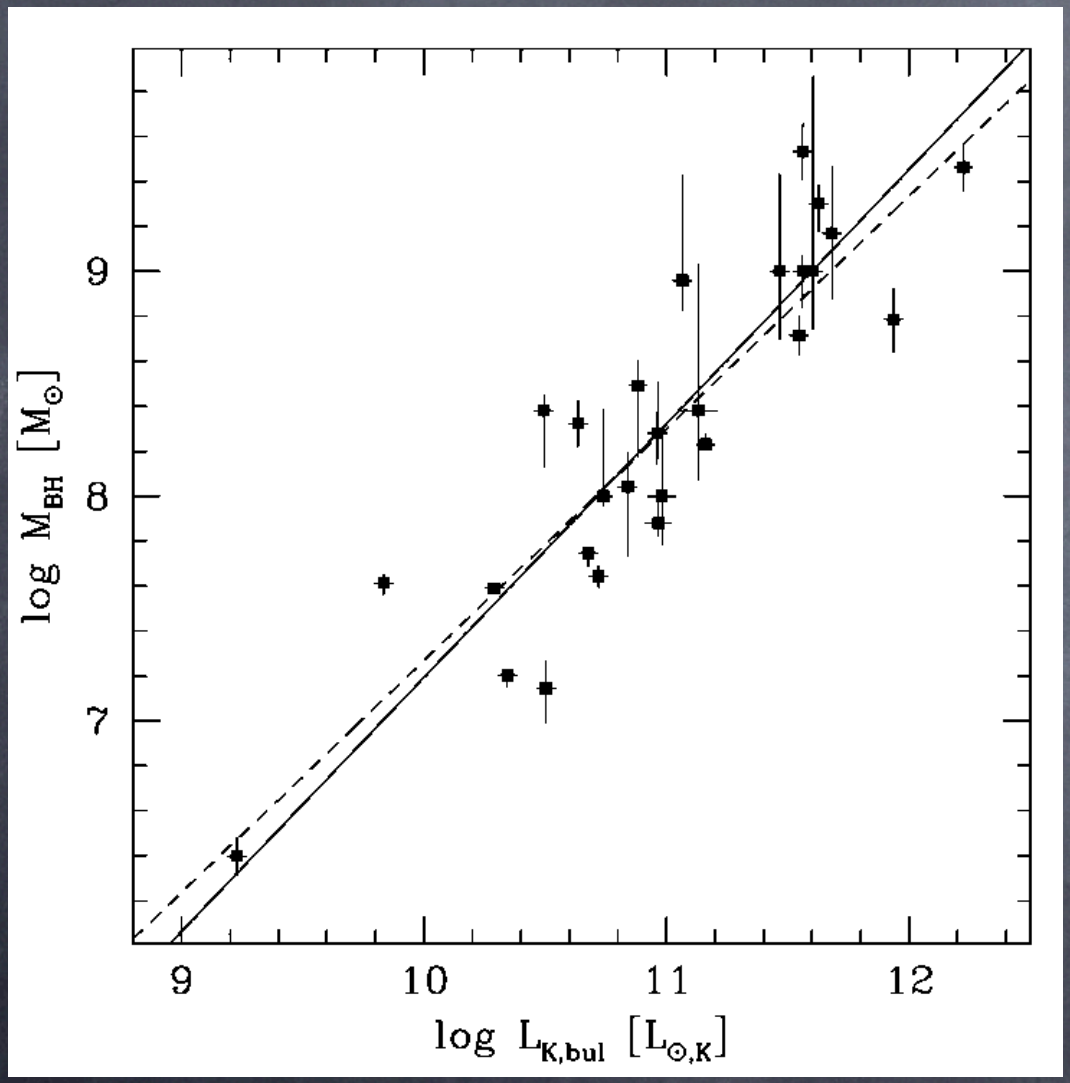
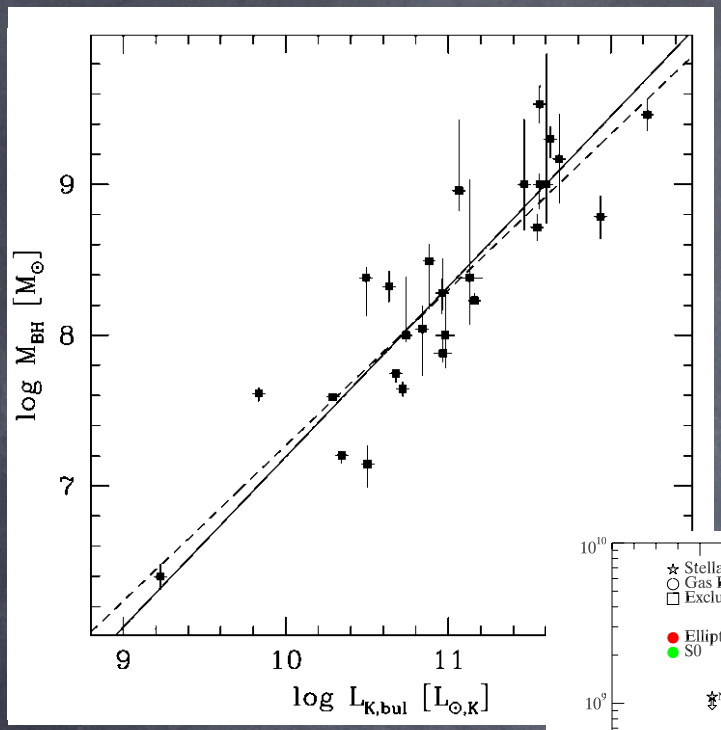



Marconi & Hunt 2003

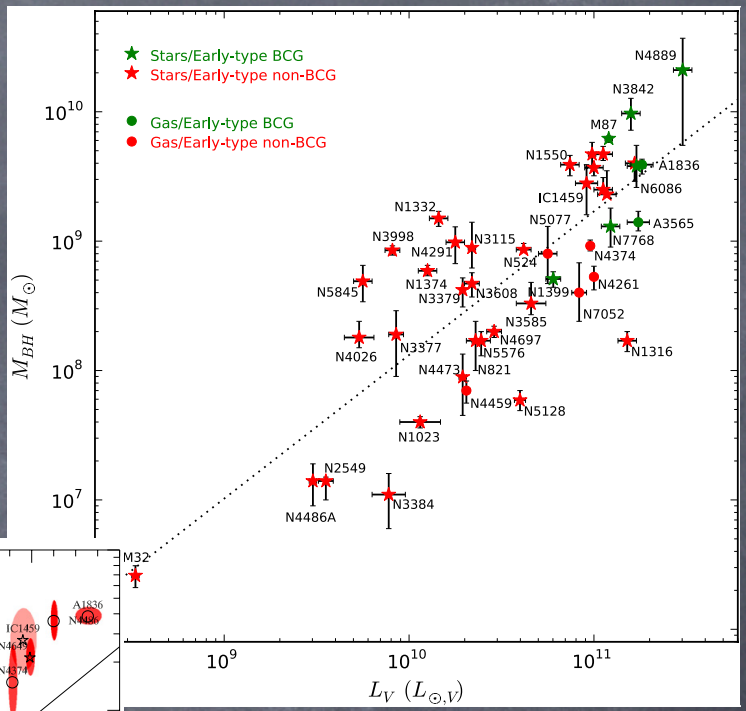
- understand BH-galaxy connection
- e.g. AGN feedback, accretion ↔ merging
- BHMF
- calibrate secondary / indirect M• measurement methods

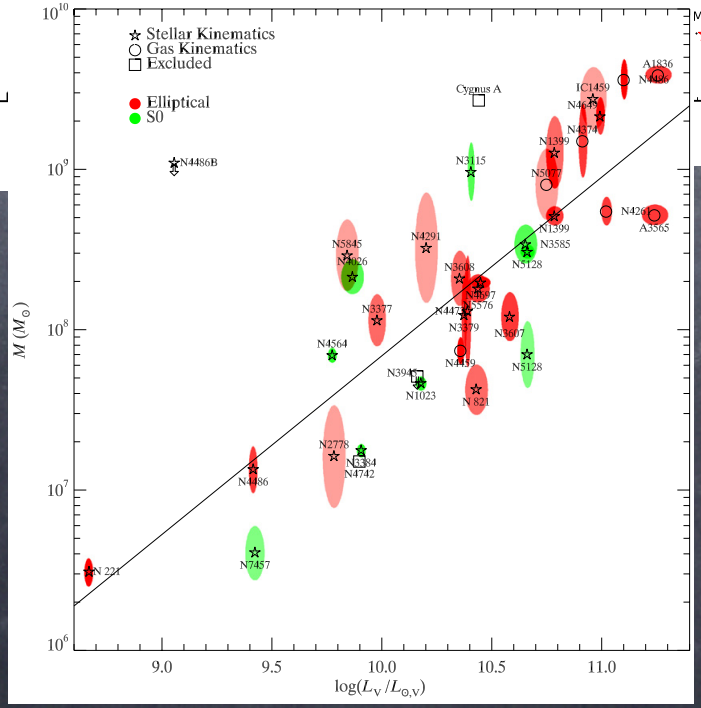
# Why another $M_\bullet$ - $L_{bul}$ calibration?




Marconi & Hunt 2003
K-band

Gültekin+09
V-band




McConnell & Ma 2013
V-band

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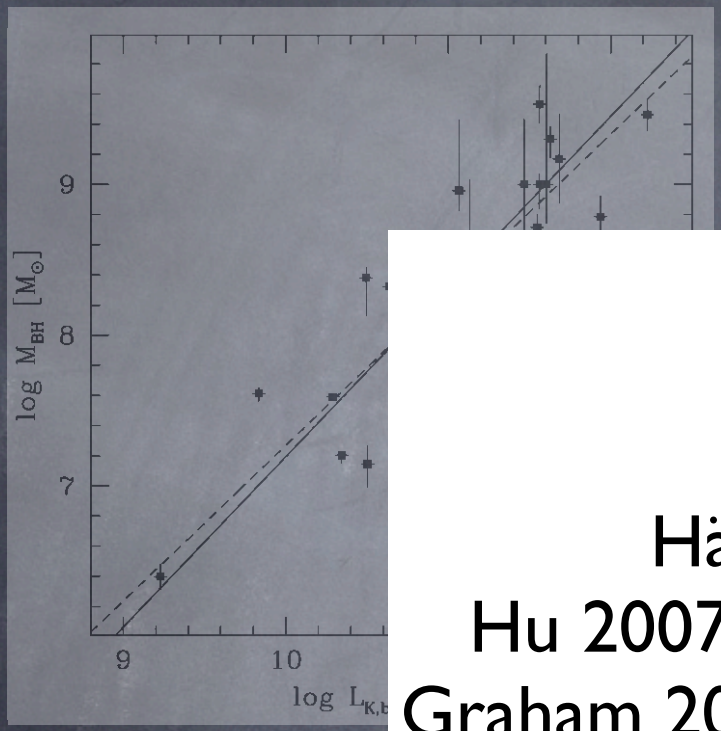
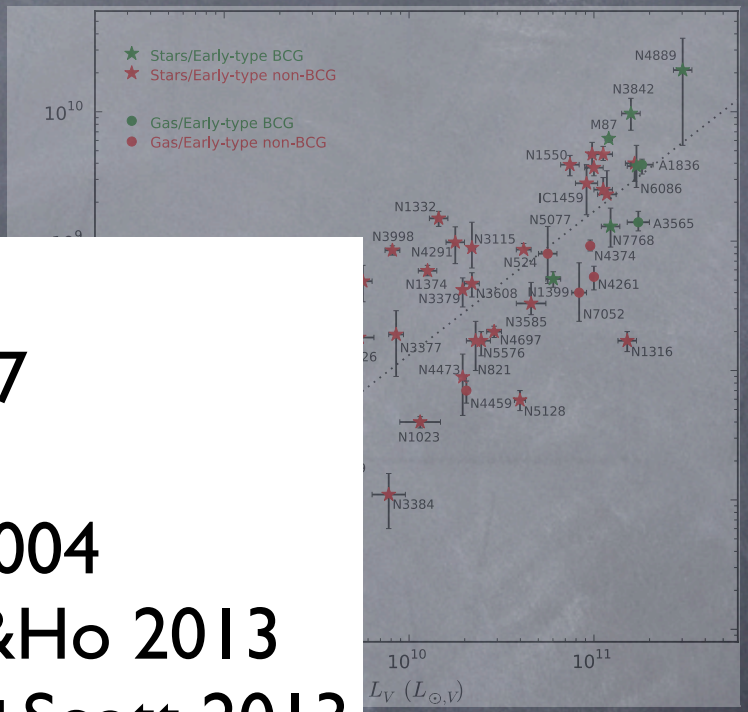
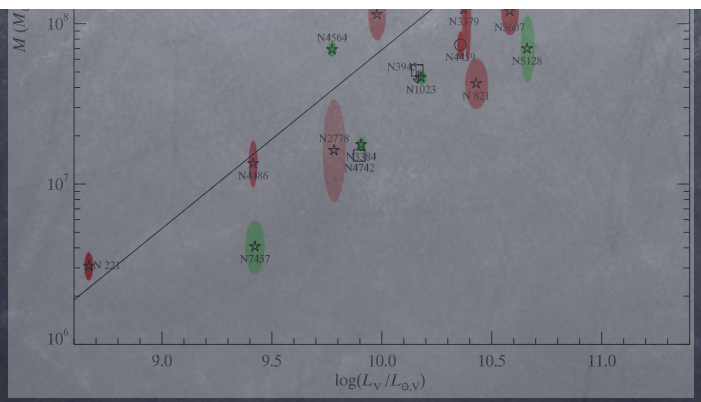



Marconi & Hunt 20
K-band




Connell & Ma 2013
V-band

... +
Graham 2007
Vika+2012
Häring & Rix 2004
Hu 2007, Kormendy&Ho 2013
Graham 2012, Graham+Scott 2013
+ ...



# Why NIR (K-band) ?

- better tracer of stellar Mass ($M_\star/L$) than visual $\lambda$
- little dust extinction

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Pending issues:

huge + variable background → subtraction?

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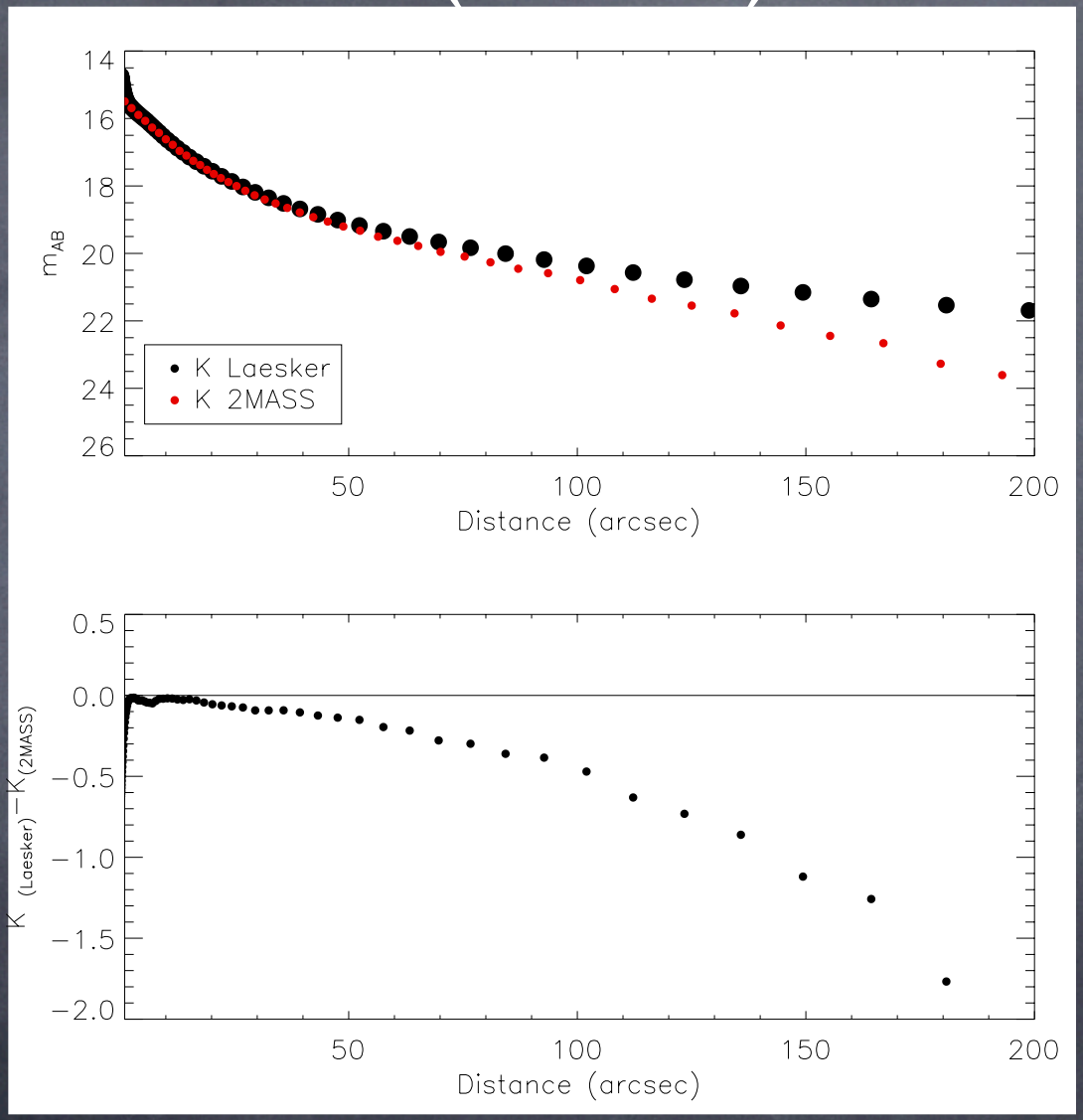



example: background oversubtraction in 2MASS

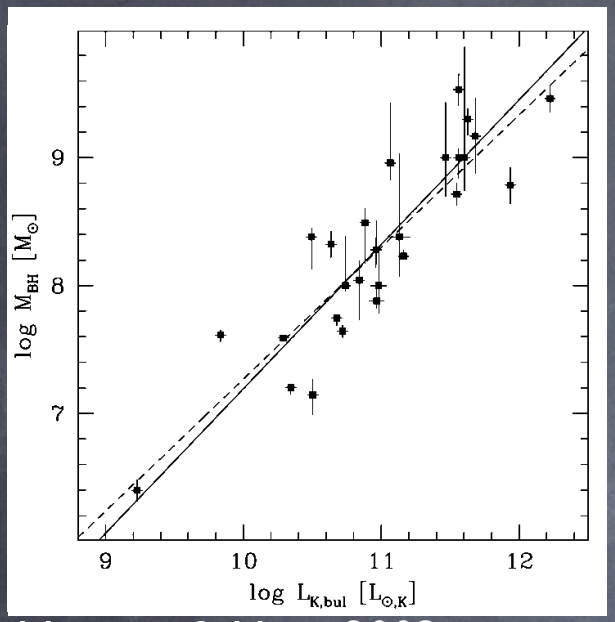
# NIR (K-band) !

Pending issues:

huge + variable background → subtraction?

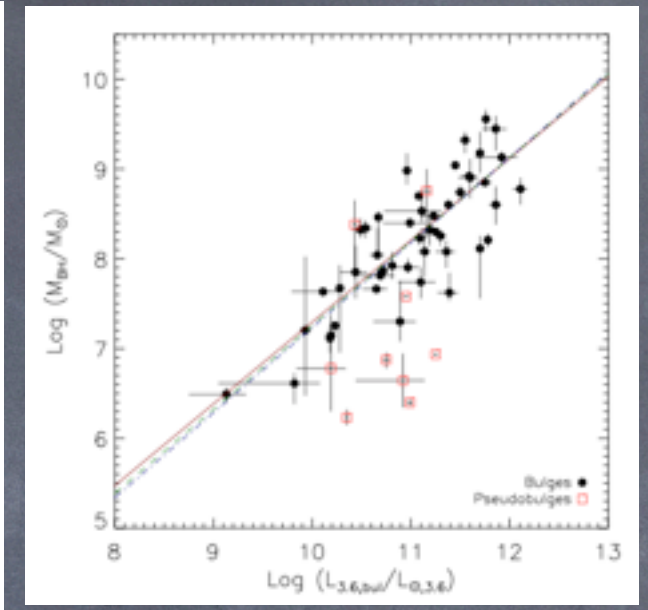
depth
resolution
decomposition

# Disparate Results



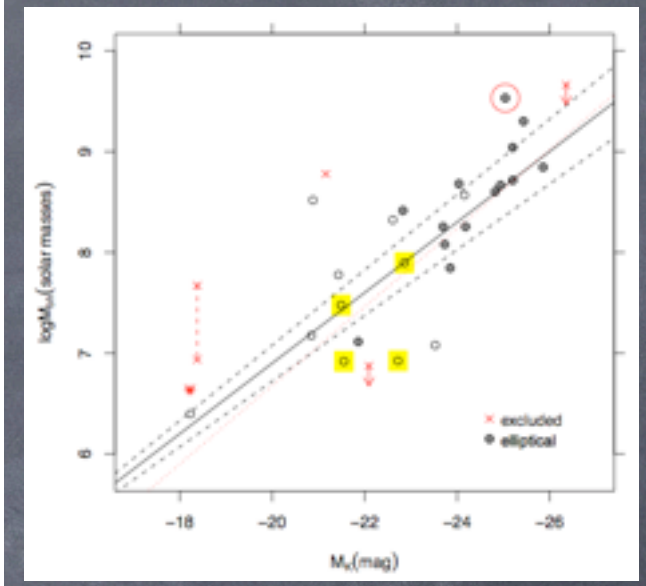

Marconi & Hunt 2003
37 (28) galaxies

b = 1.21±0.13
ε = 0.3




Sani+11
48 galaxies

b = 0.93±0.10
ε = 0.38±0.05




Vika+12
25 (19) galaxies

b = 0.88±0.06
$\varepsilon = 0.52^{+0.10}_{-0.06}$

# Solution:
# CFHT WIRCam (and some careful reduction)

- seeing FWHM 0.8” (cf. 2MASS: 2” - 3” )
  → nuclei, inner disks

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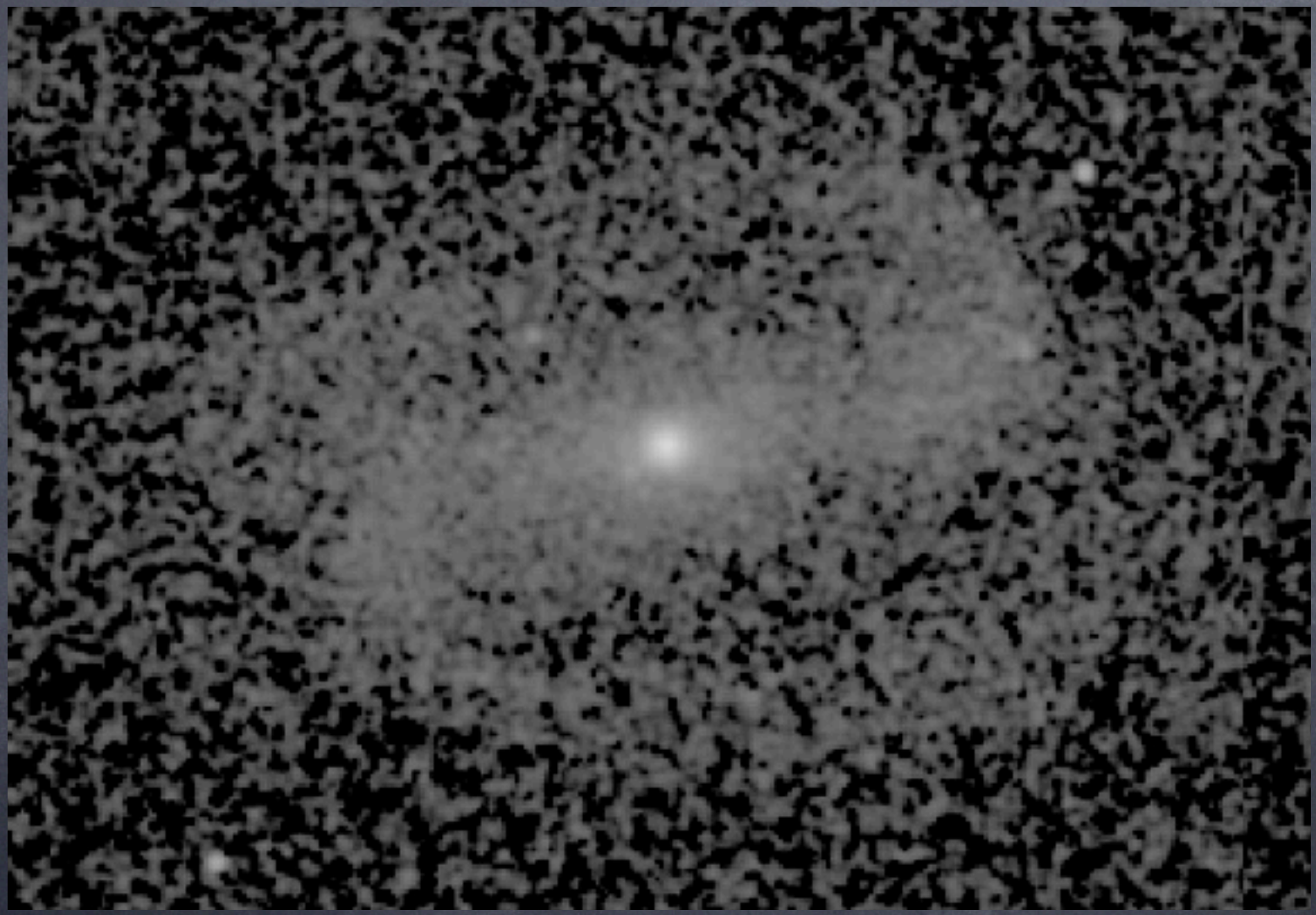
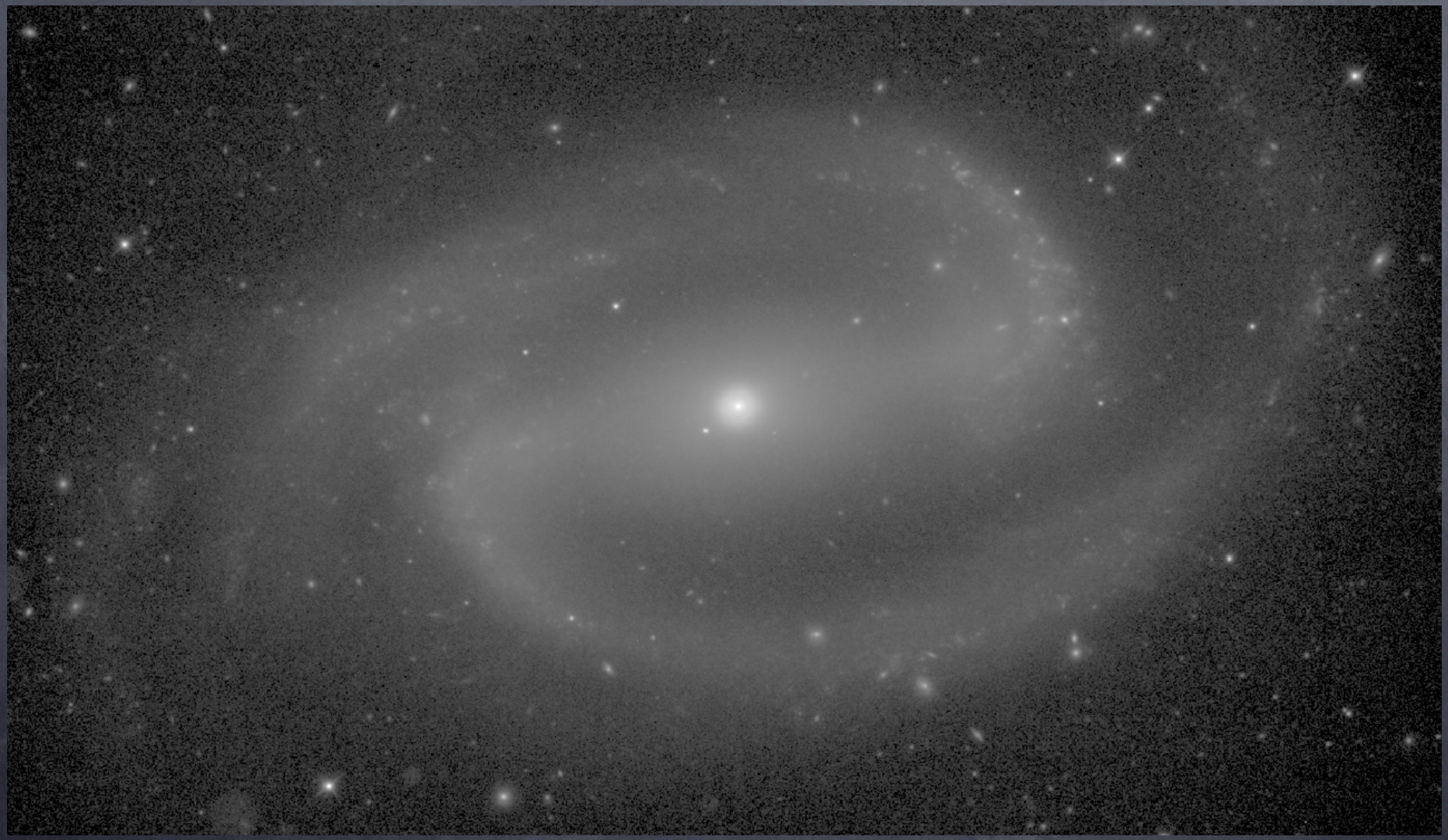
- Wide Field (20' x 20')

- Improved Dithering & Sky Modeling !!

# Efforts pay off: 2MASS versus ...



... didicated WIRCam data and reduction.



(note: outer disk extends much farther than shown area)

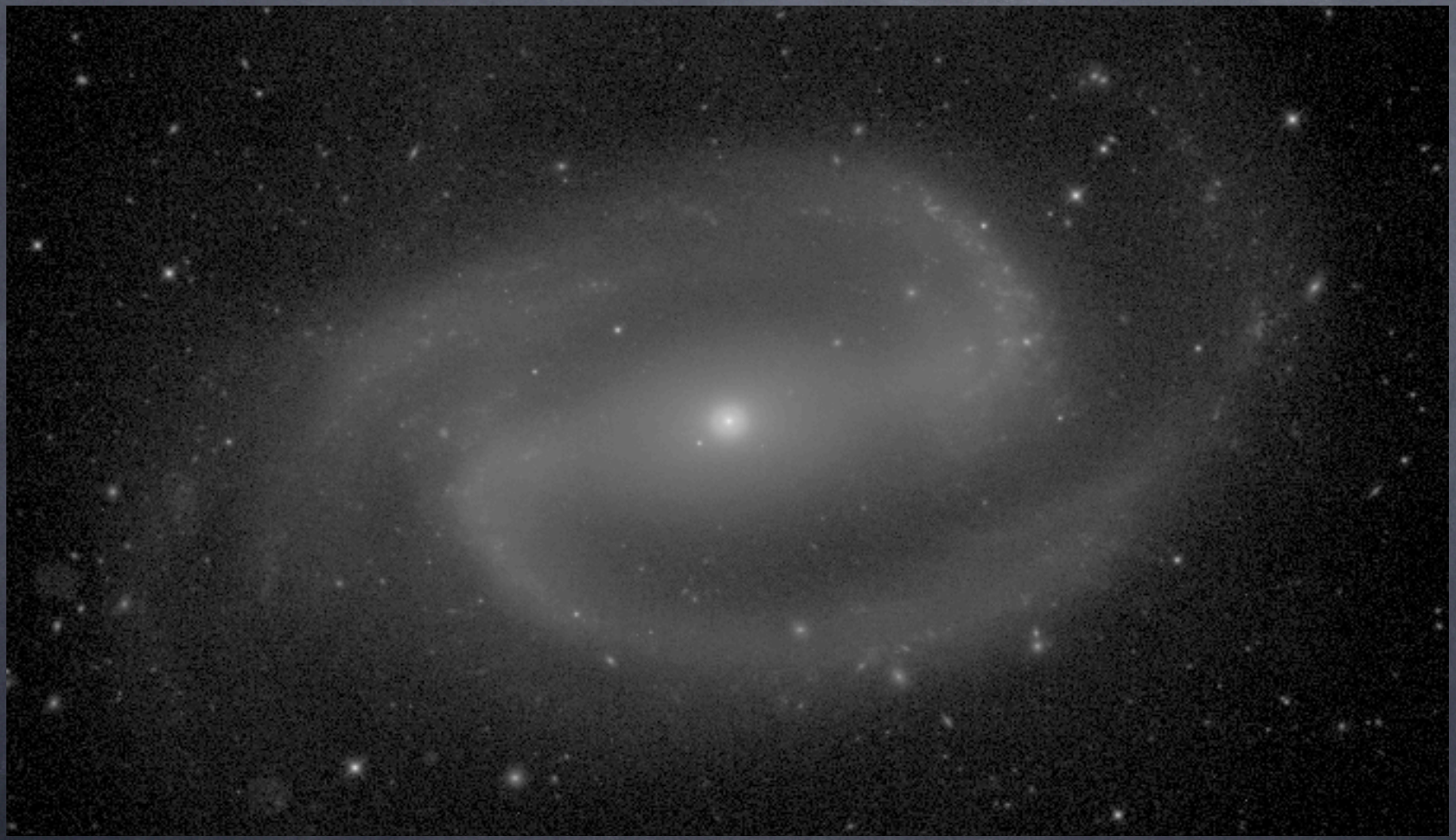
# Decompositions: GALFIT

- first "standard model":
  Sérsic Bulge (+ exponential Disk)

  → $L_{b,std}$ & $L_{t,std}$

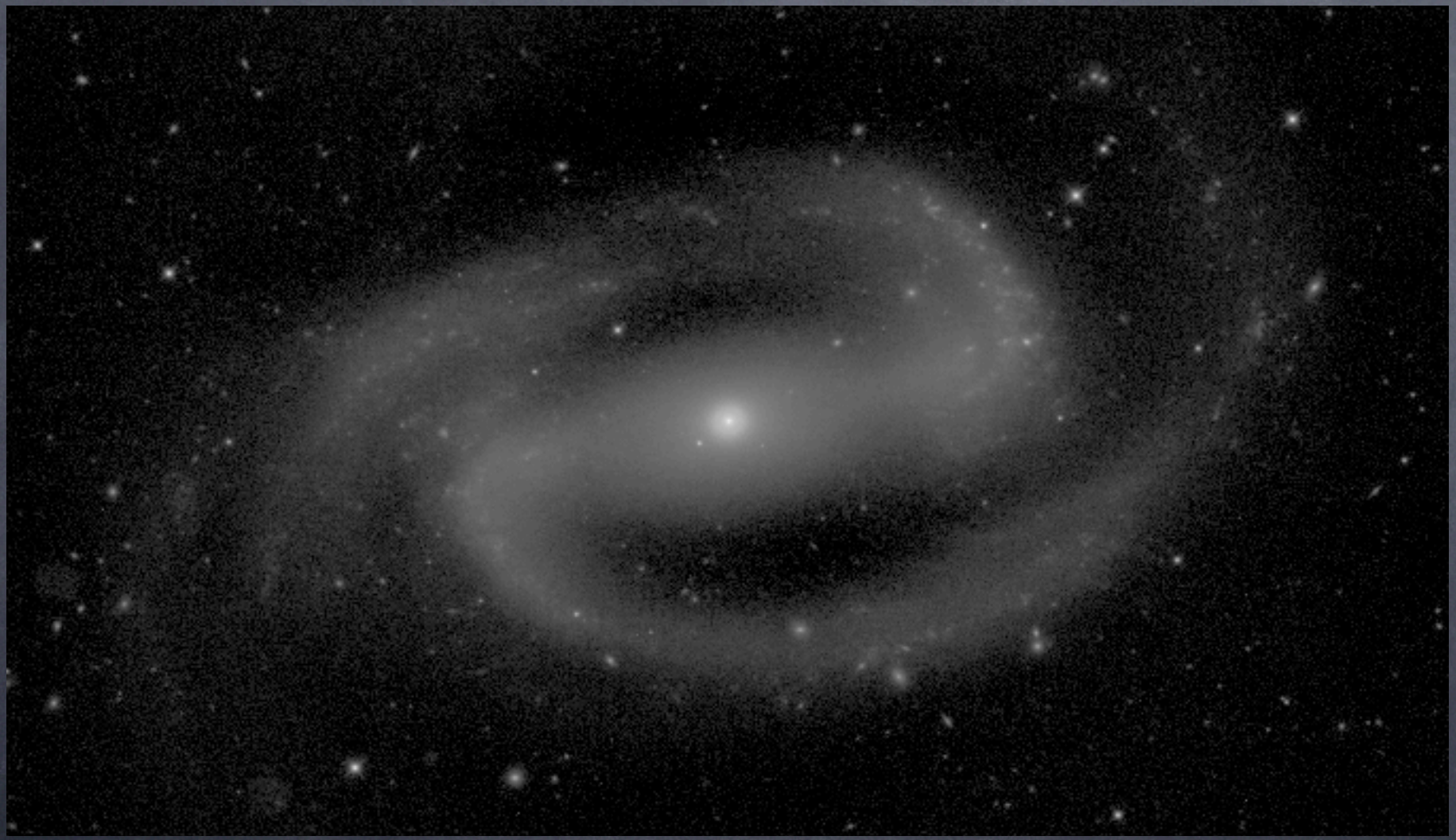
- then "improved model":
  - Ellipticals: mask core
  - other: Nucleus, Bar, Inner Disk, Spiral Arms, Envelope

# example: NGC1300



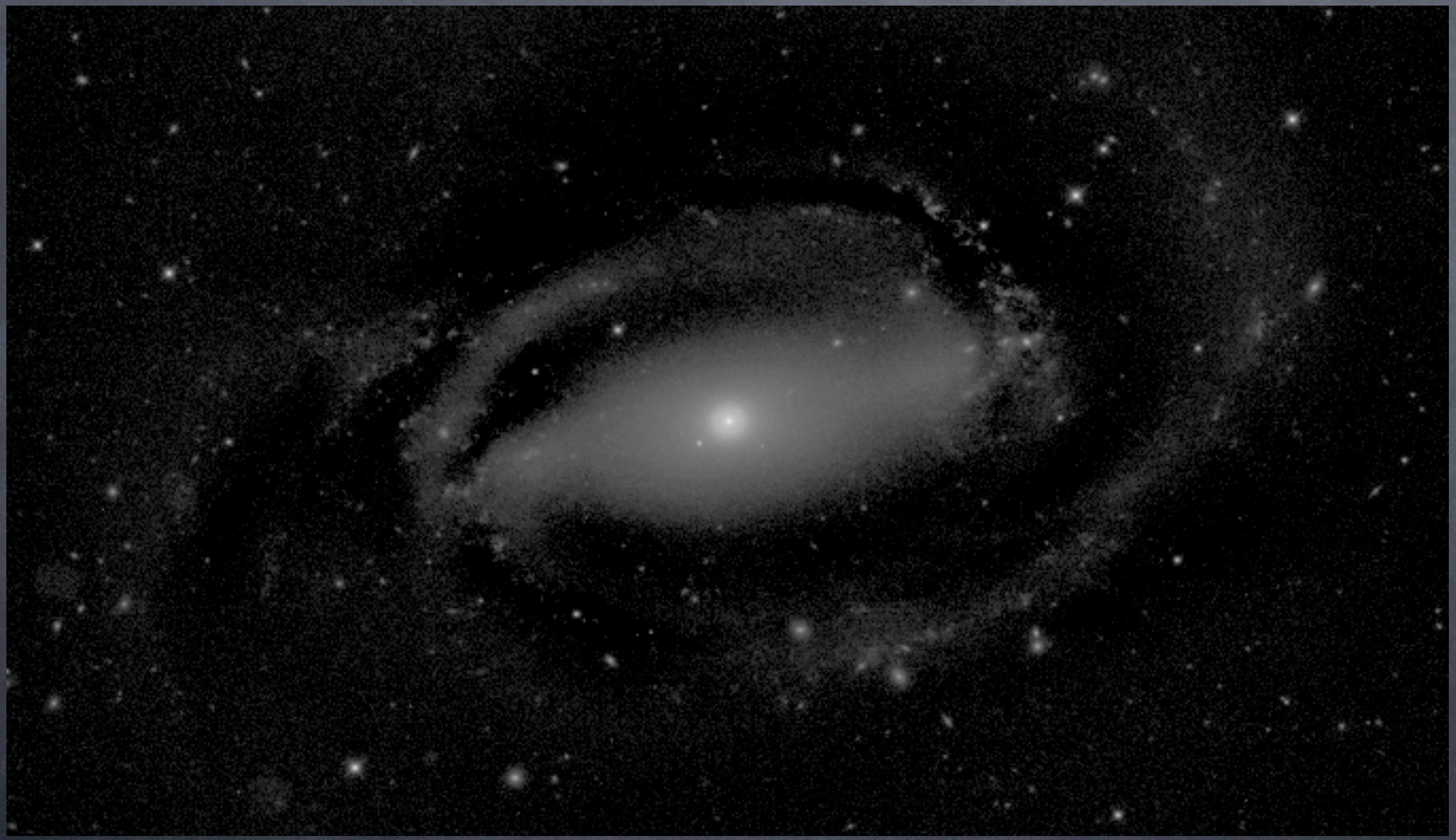
displayed area: approx.  7’ x 4’ (39 x 22 kpc)

subtracted: disk



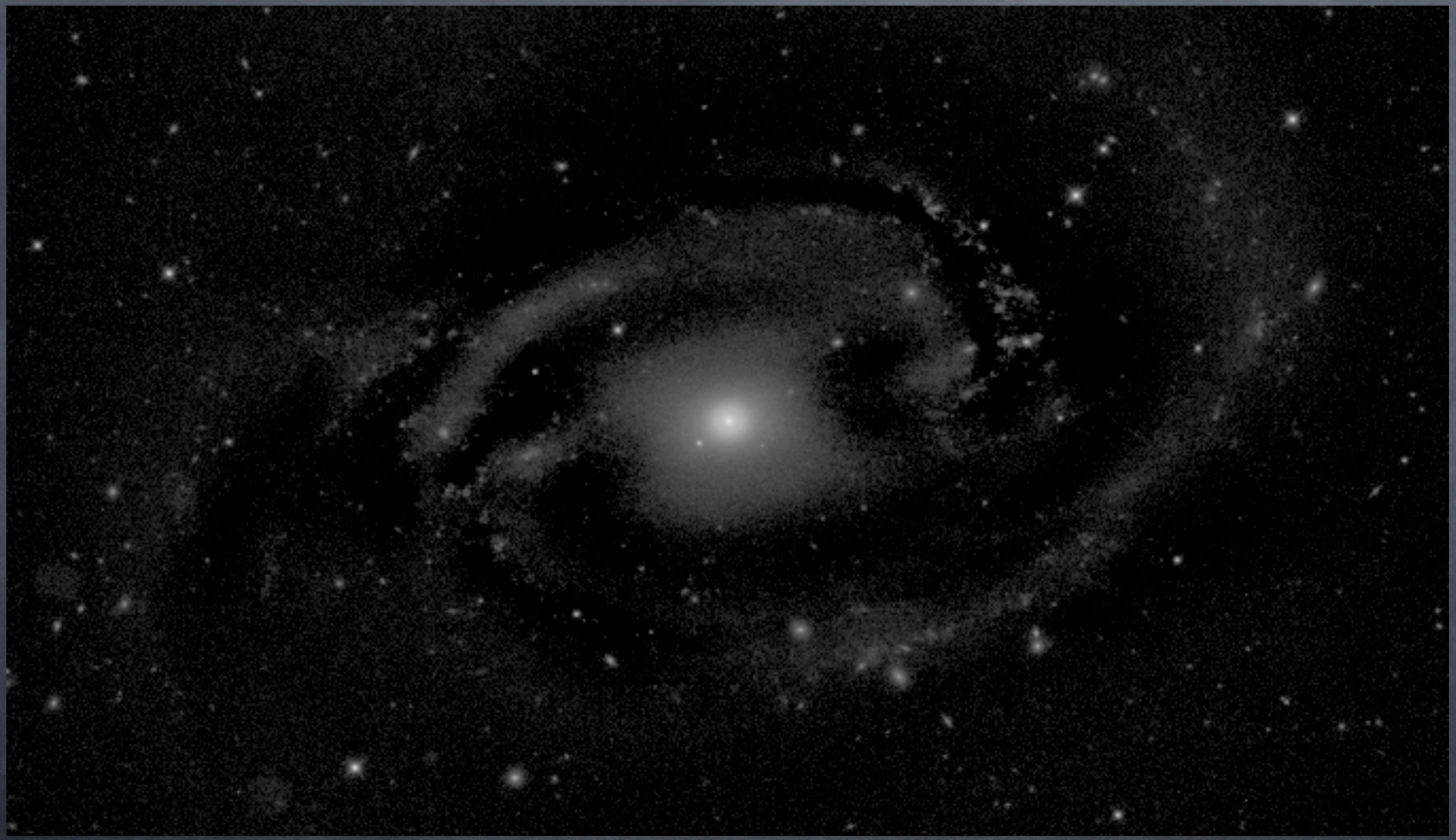
remaining: spiral, bar, bulge, inner disk and nucleus

subtracted: disk and spiral



remaining: bar, bulge, inner disk and nucleus

subtracted: disk, spiral and bar



remaining: bulge, inner disk and nucleus

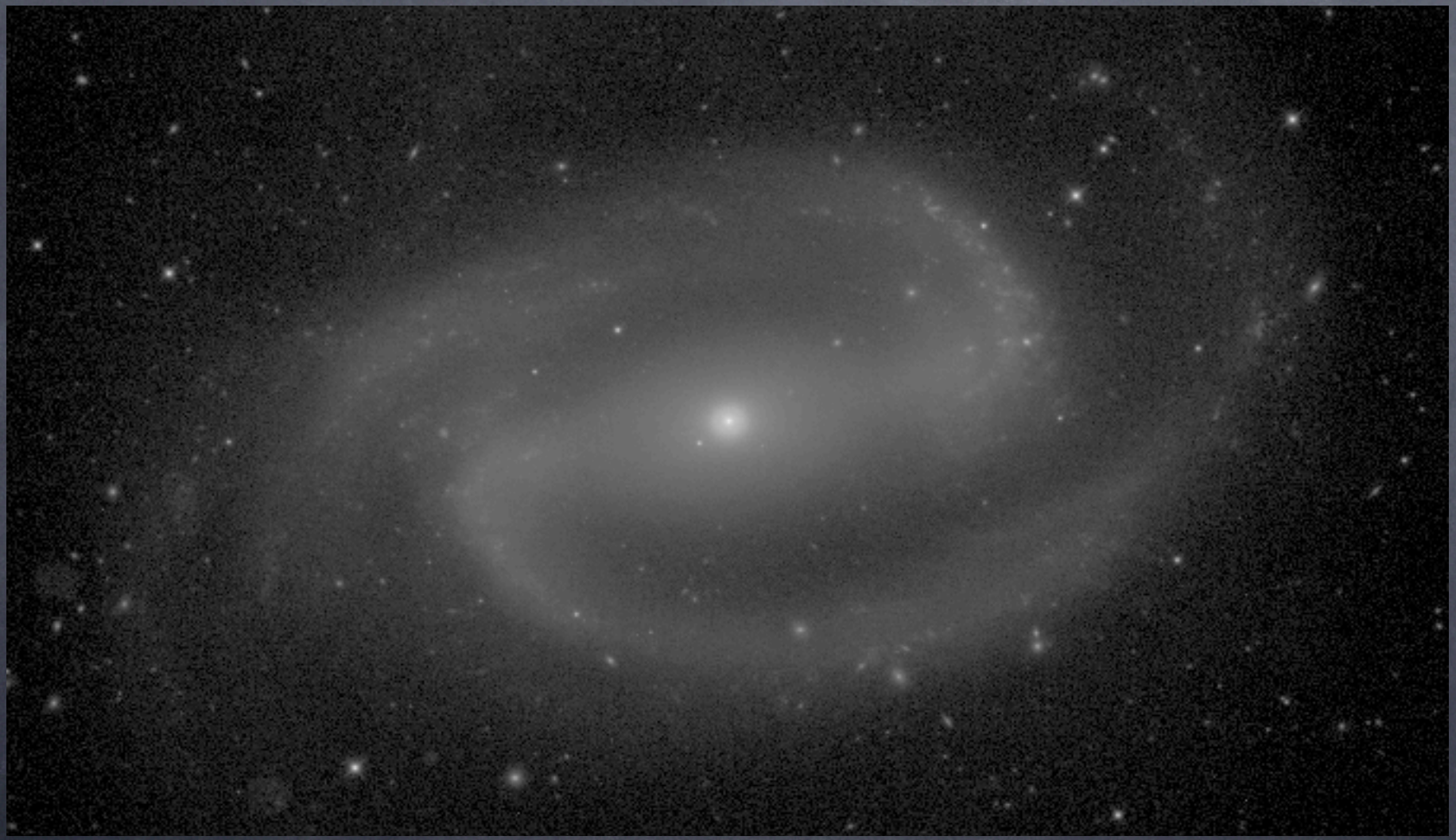
subtracted: disk, spiral, bar and bulge

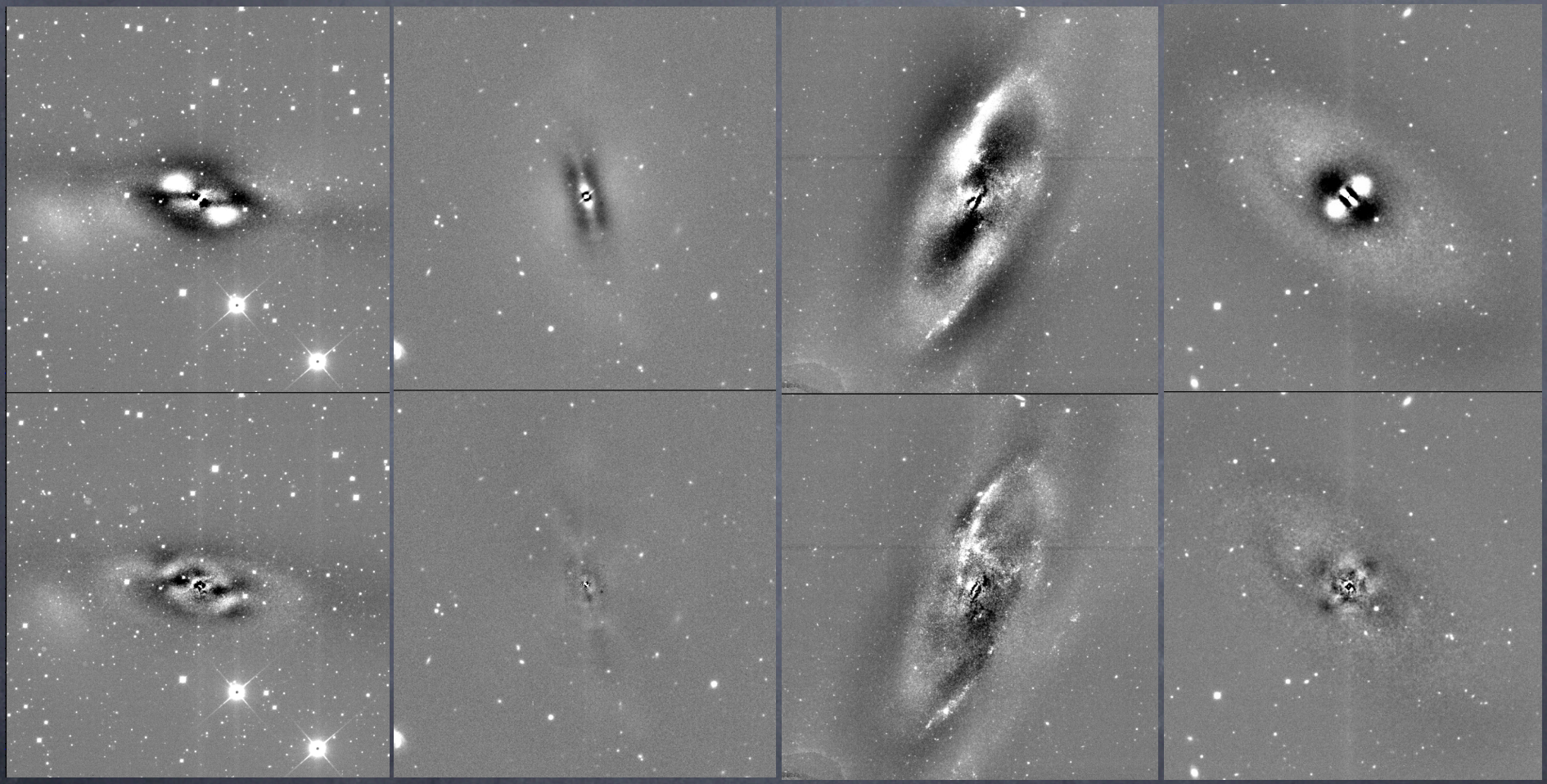
remaining: inner disk and nucleus

subtracted: disk, spiral, bar, bulge and inner disk

remaining: nucleus

# ... and all components added back in.






"Standard" (Bulge + Disk)

vs

extra component(s) included

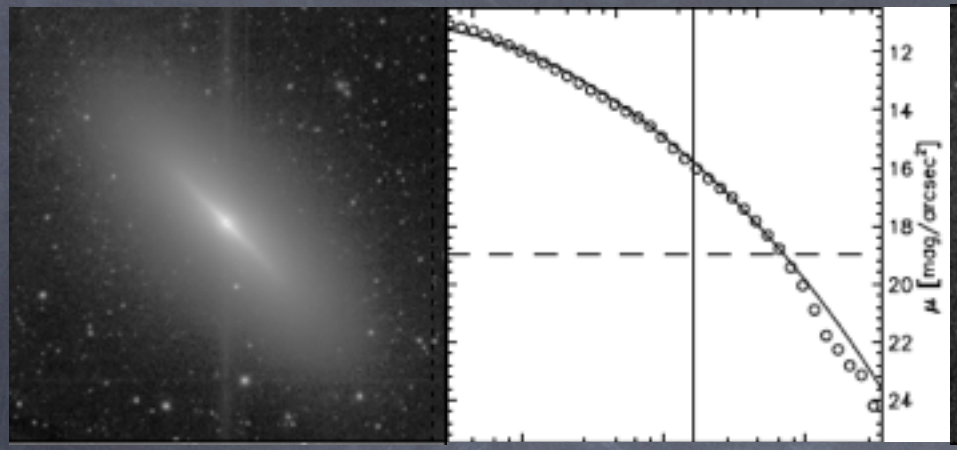
# “Envelopes”: necessary but ambiguous

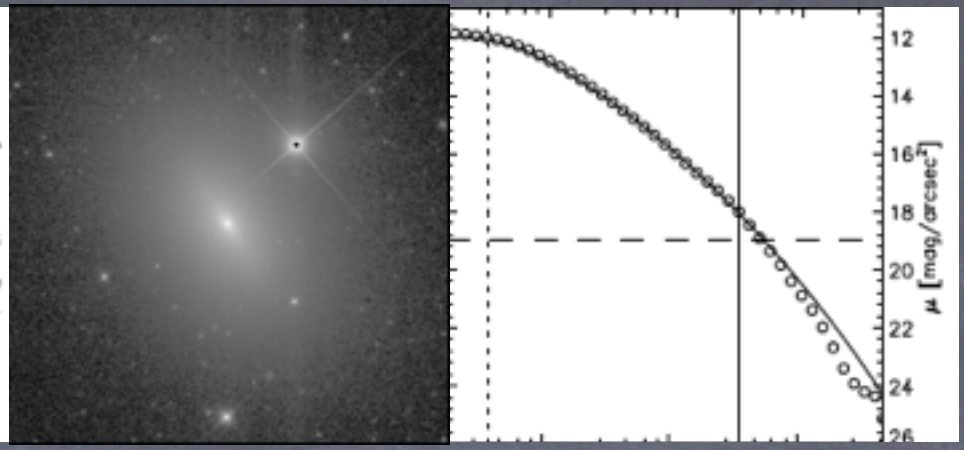
Data

– single Sersic

– (Bulge + Disk)

– (B+D + Envelope)


12
14
16
18
20
22
24
μ [mag/arcsec²]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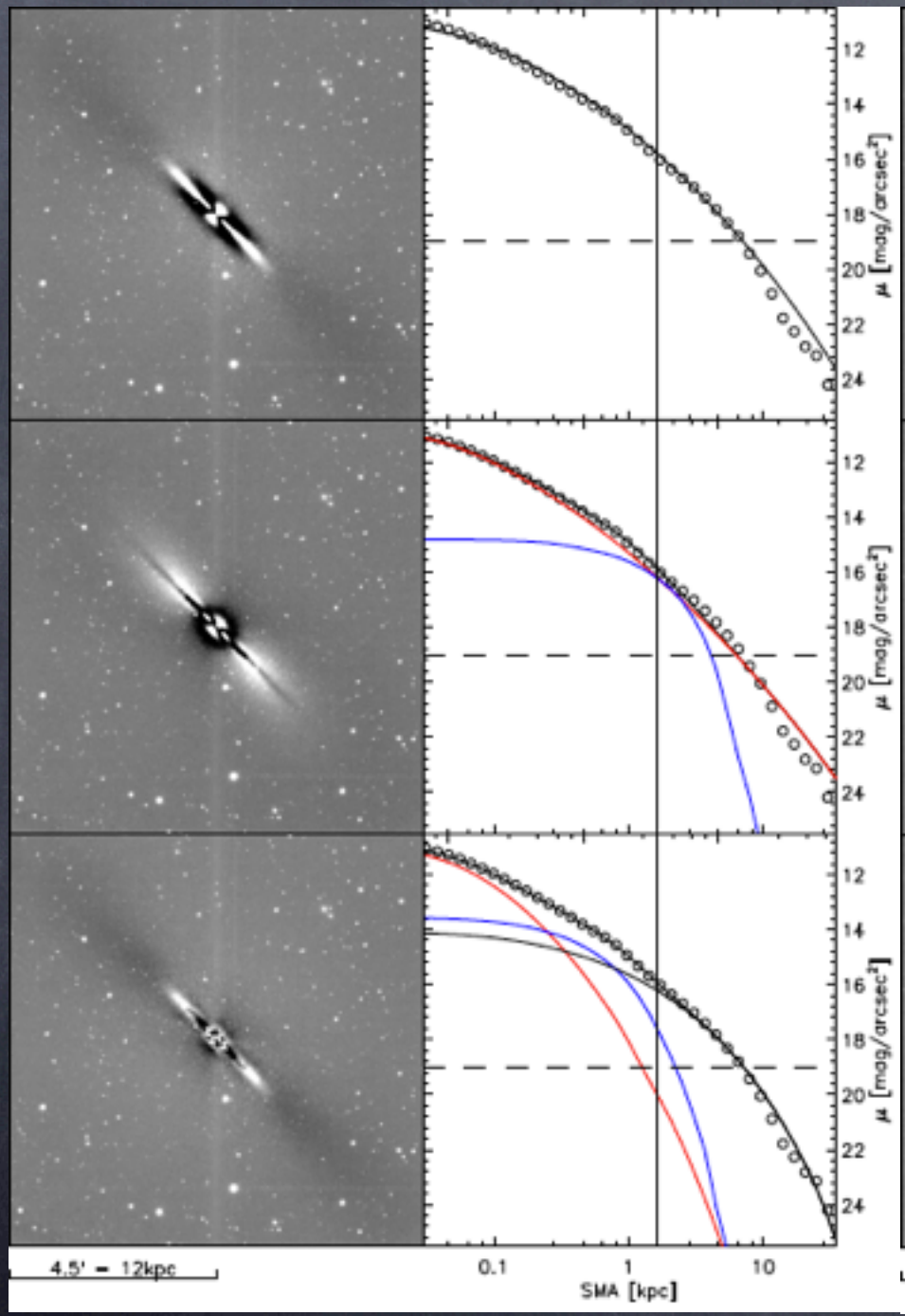
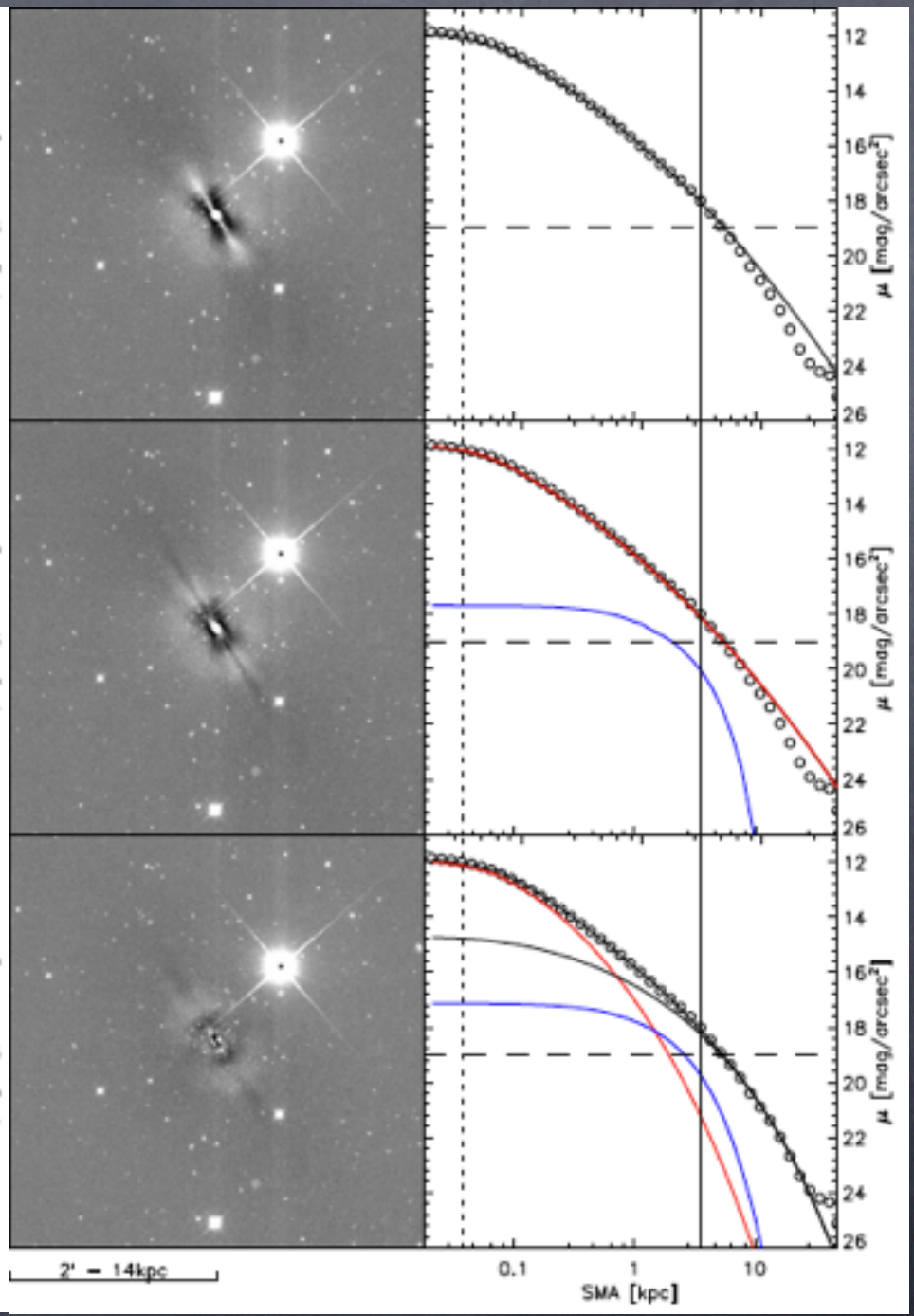
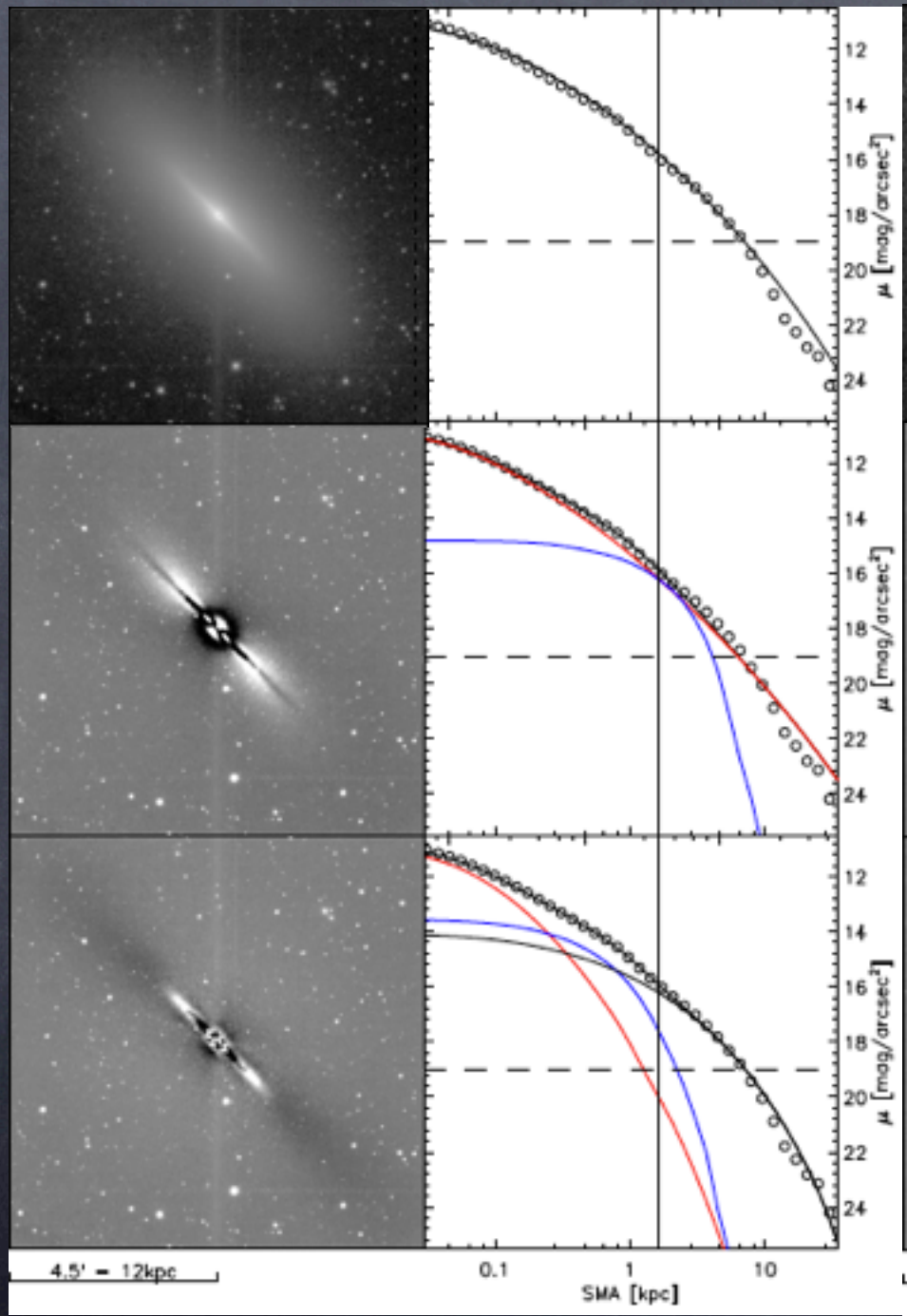

4.5' = 12kpc
μ [mag/arcsec²]
SMA [kpc]


2' = 14kpc
μ [mag/arcsec²]
SMA [kpc]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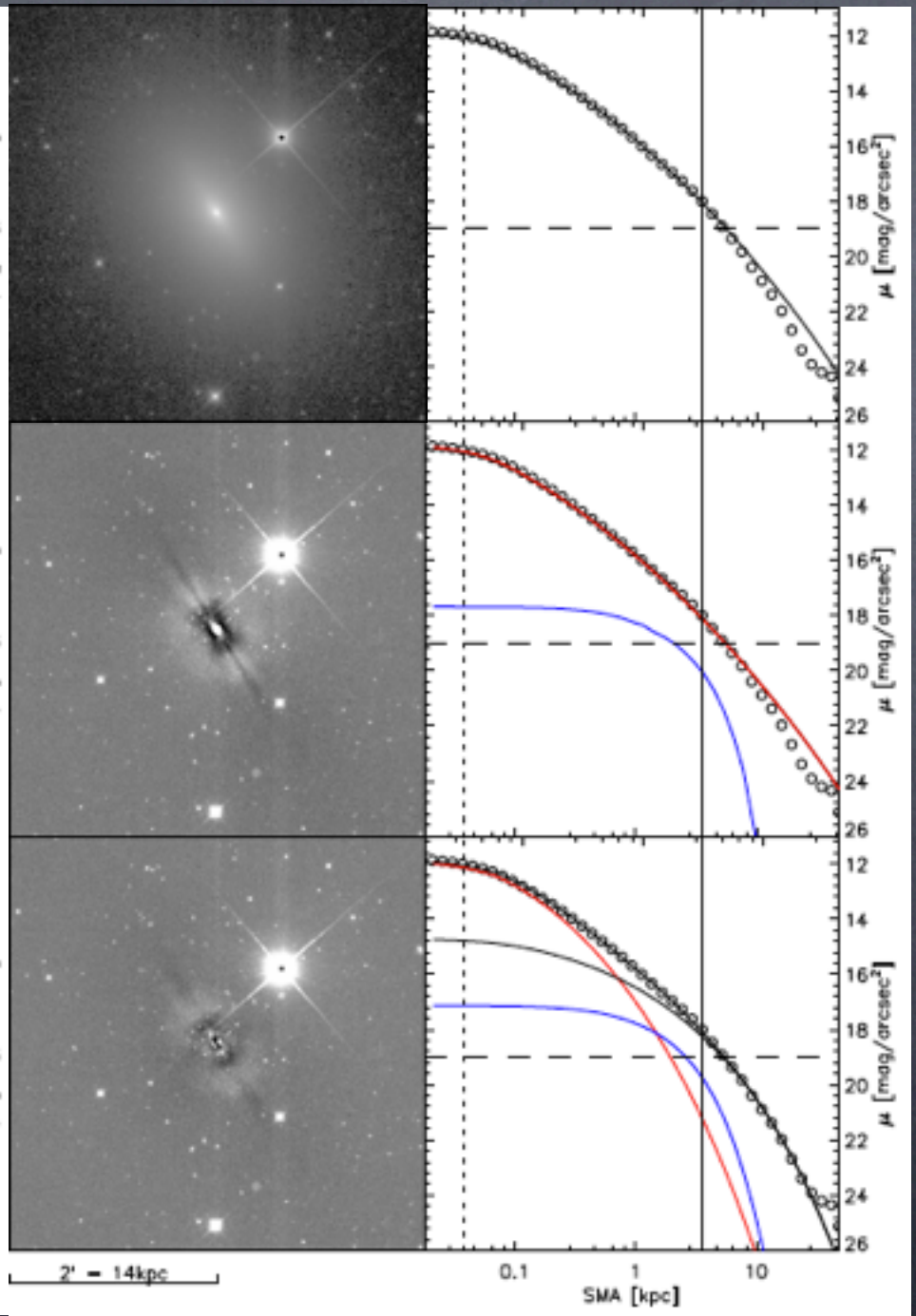
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# Decompositions: GALFIT

- first "standard model":
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  → $L_{b,std}$ & $L_{t,std}$

- then "improved model":
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  → $L_{b,min}$, $L_{b,max}$, $L_{sph}$ & $L_{t,imp}$

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  total - disk (- spiral)

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  only bulge

  "spheroid" : bulge (+ envelope)

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+ nonparametric $L_{24}$

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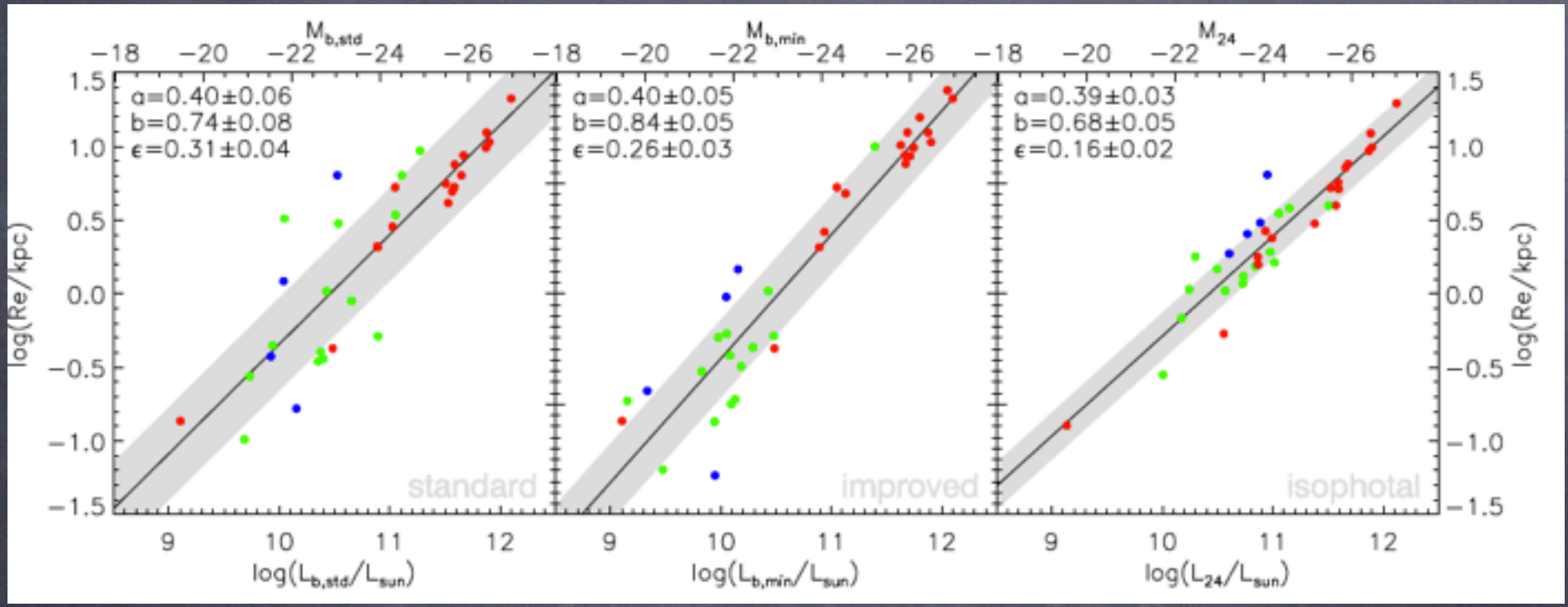
# Results: improved bulge parameters

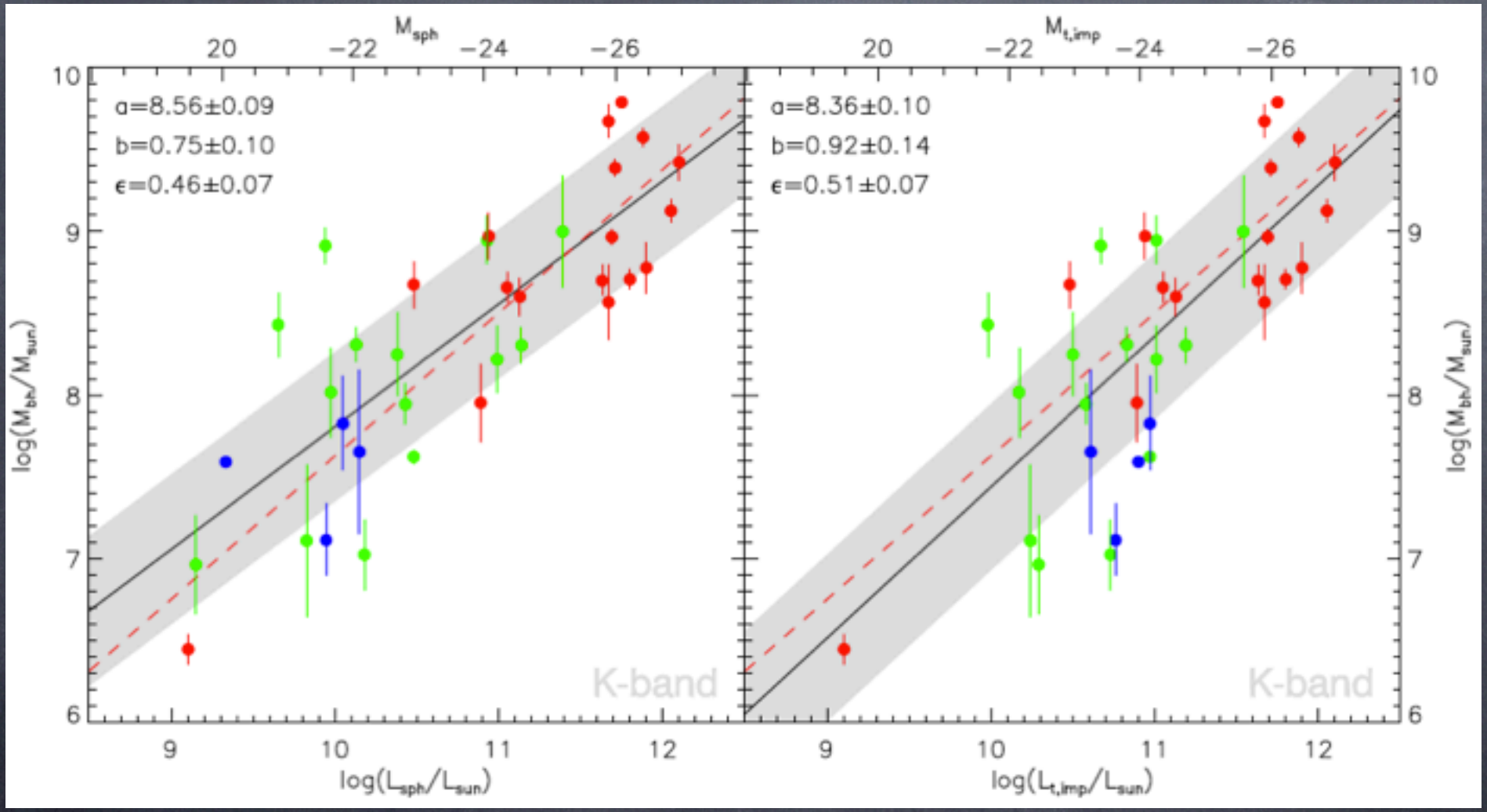



Bulge Size - Lum relation using simple bulge(+disk) model

... and using improved models (detailed decomp.).

However, Size - Lum of the total light distribution is even tighter.

# Results: BH Scaling Relations




x-axis: spheroid Luminosity

x-axis: total Luminosity

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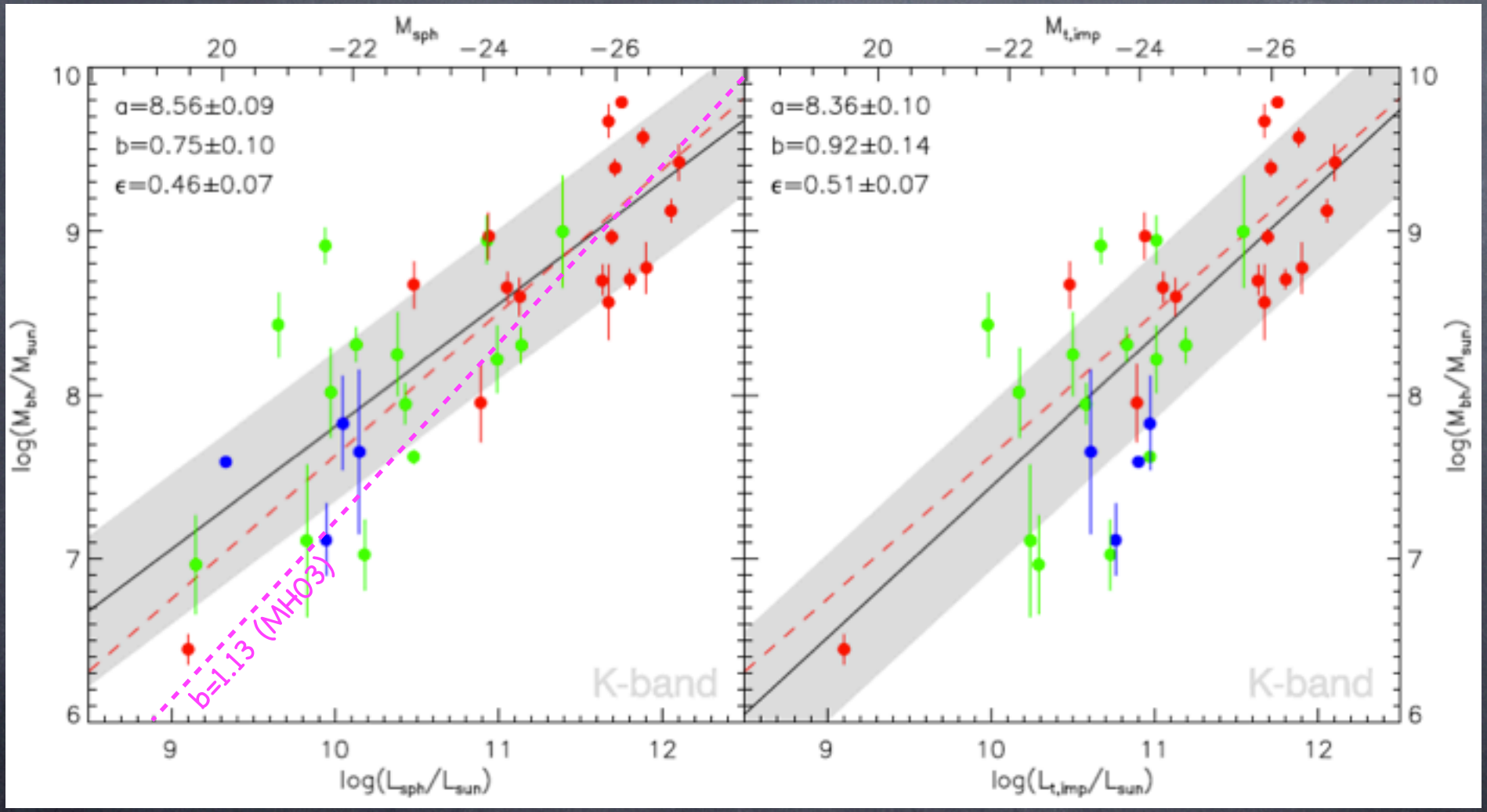


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2. and it depends on modeling detail.

3. The $M_\bullet$-$L_{tot}$ relation is robustly characterized
4. and its intrinsic scatter is consistent with $M_\bullet$-$L_{bul}$ .

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2. $M_\bullet$ - $L_{tot}$ ought to be considered, theoretically and as $M_\bullet$ indicator
3. Log-slope << 1 for $M_\bullet$ - $M_{bul}$
   → consequences for models (AGN feedback, gas accretion mode, mergers)

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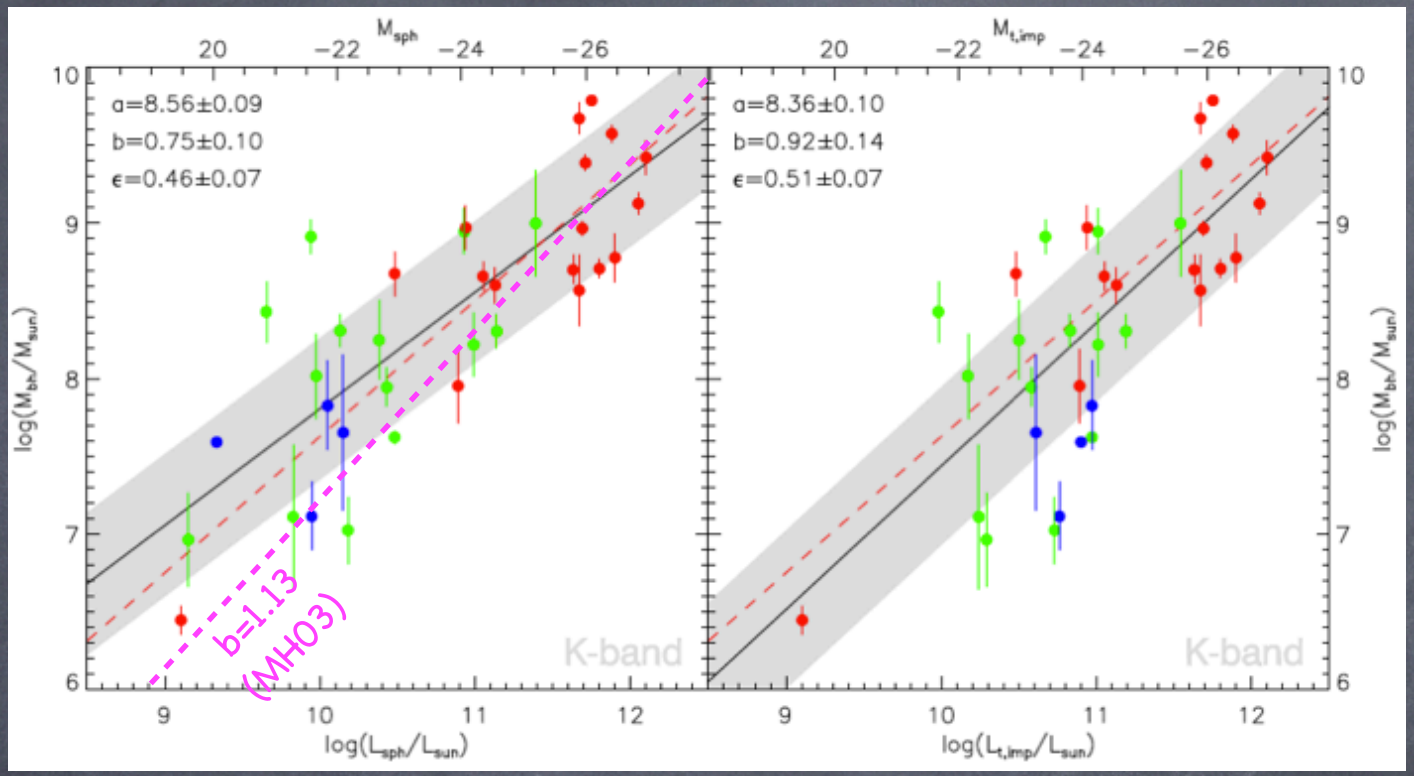


3. Log-slope << 1 for $M_\bullet$ - $M_{bul}$
   → consequences for models (AGN feedback, gas accretion mode, mergers)

# Summary

1. shallow $M_\bullet$ - $M_{bul}$ (log-slope << 1)
2. bulge properties difficult to determine
3. use NIR $M_\bullet$ - $L_{tot}$ instead of $M_\bullet$ - $L_{bul}$