LBTO Users' Meeting, Florence 23 June 2017

Extragalactic nuclei with LBT/ARGOS

Iskren Y. Georgiev

Galactic nuclei
MPIA, Heidelberg

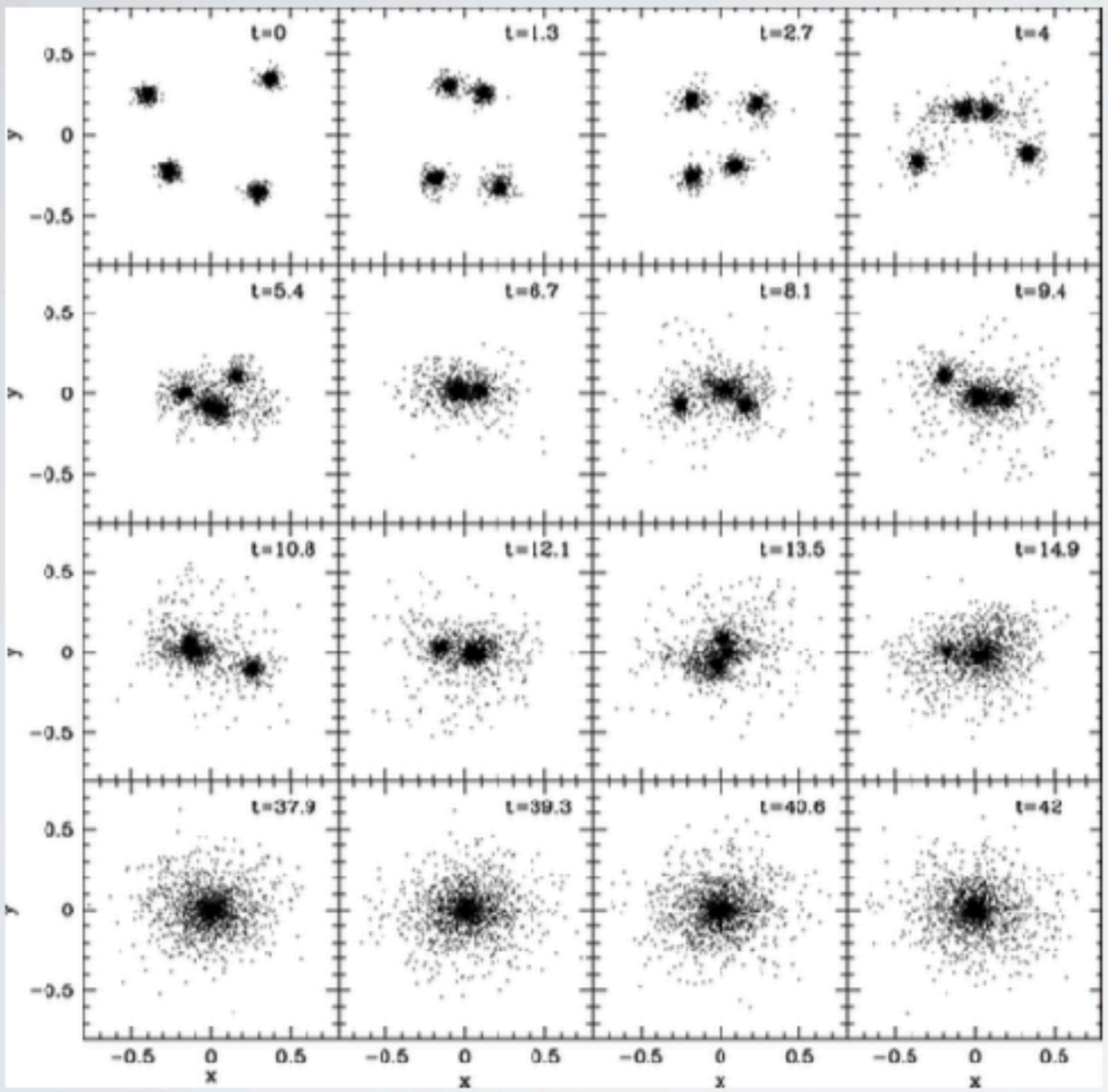
* Nuclear Star Cluster formation channels

- Mergers of orbitally decayed star clusters

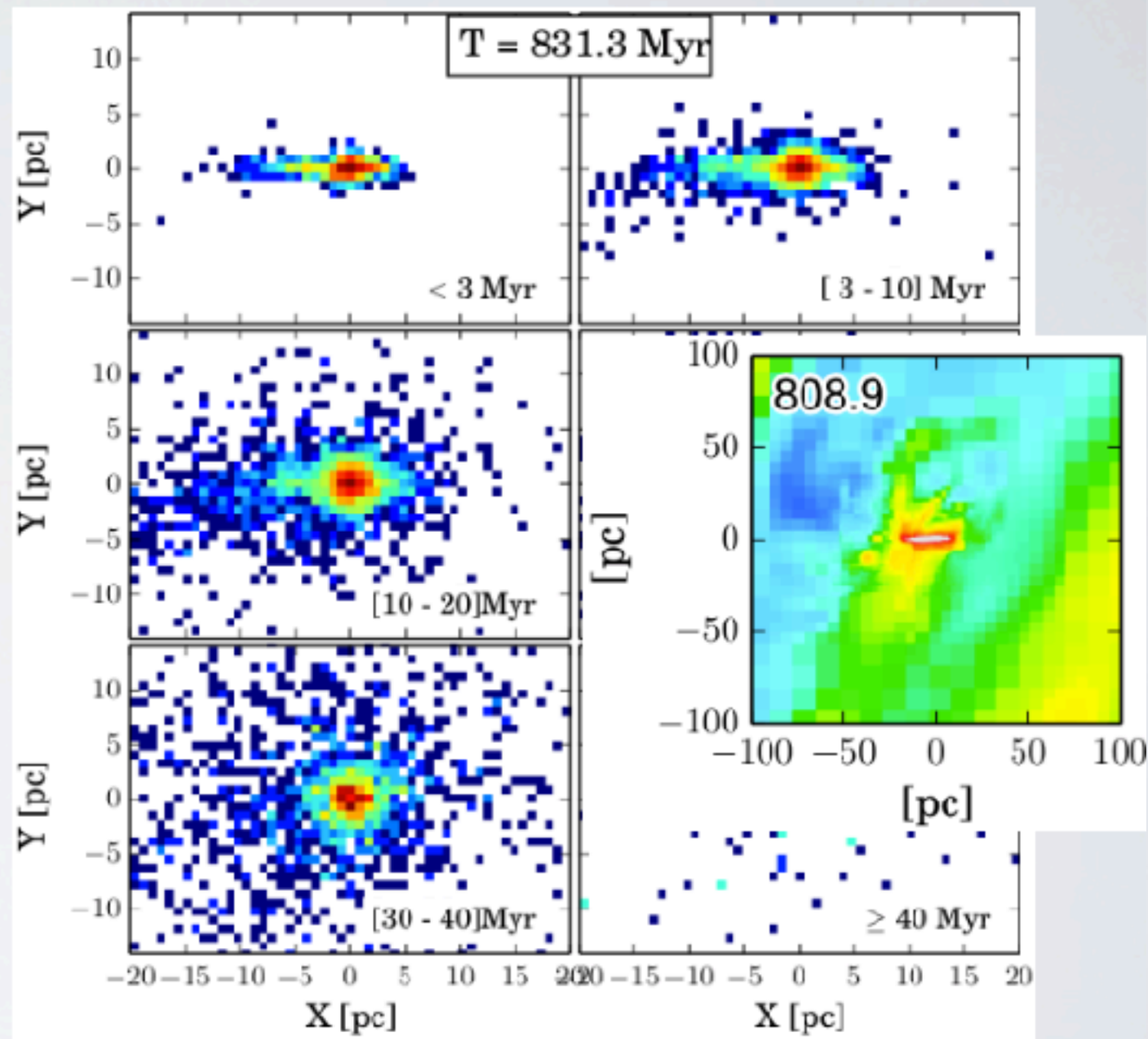
(Tremaine, Ostriker, Spitzer 1975, Fellhauer & Kroupa 2002, Bekki 2004, Antonini et al. 2012)

- In situ via gas dissipation onto the nucleus

(Shinerer et al. 2003, 2008, Miloslavlevic 2004, Bekki 2007, Harmann et al. 2011)



Capuzzo-Dolcetta & Miocchi (2008)



Emsellem et al. (2014)

* Nuclear Star Cluster formation channels

- Mergers of orbitally decayed star clusters

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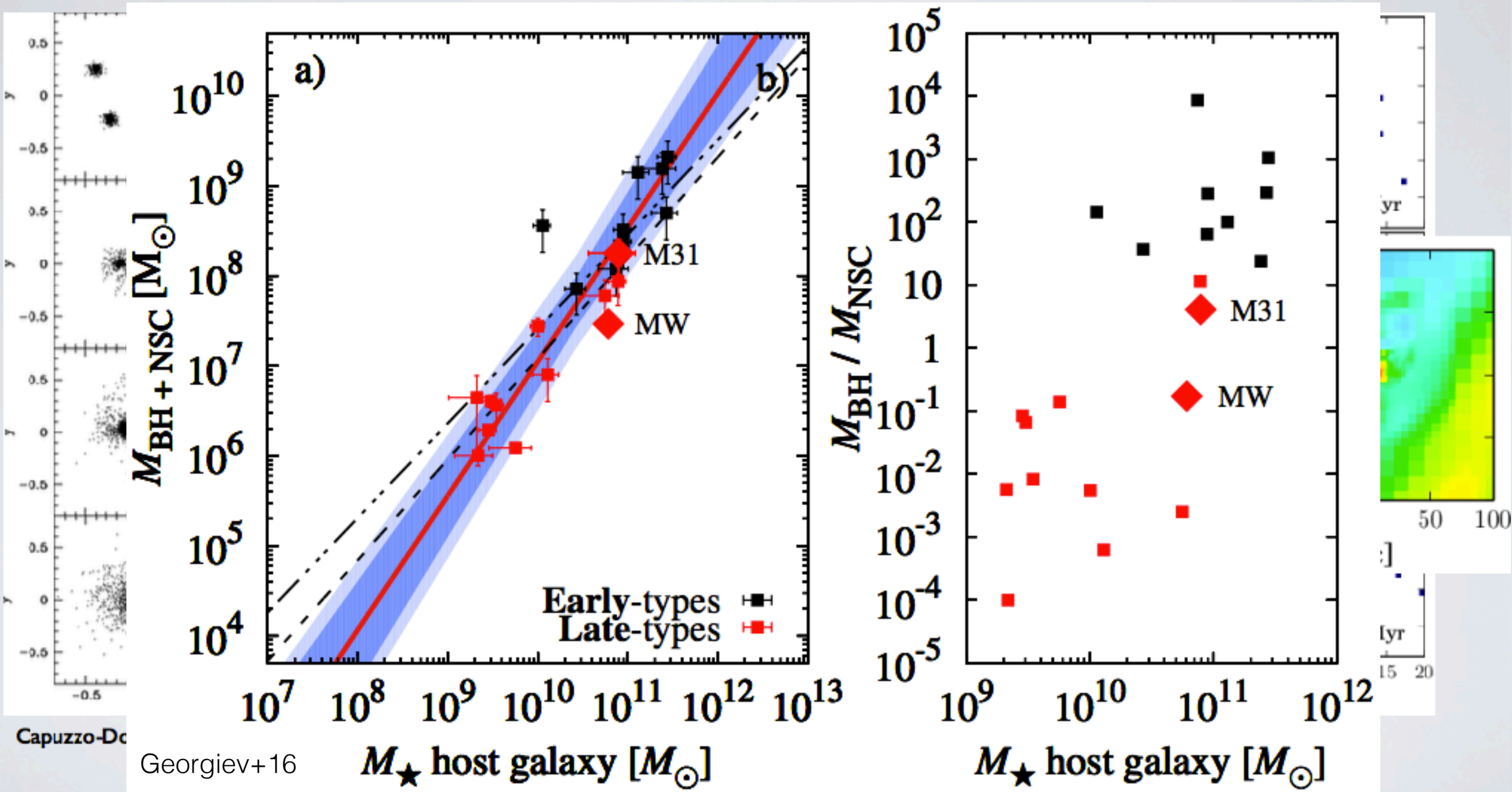
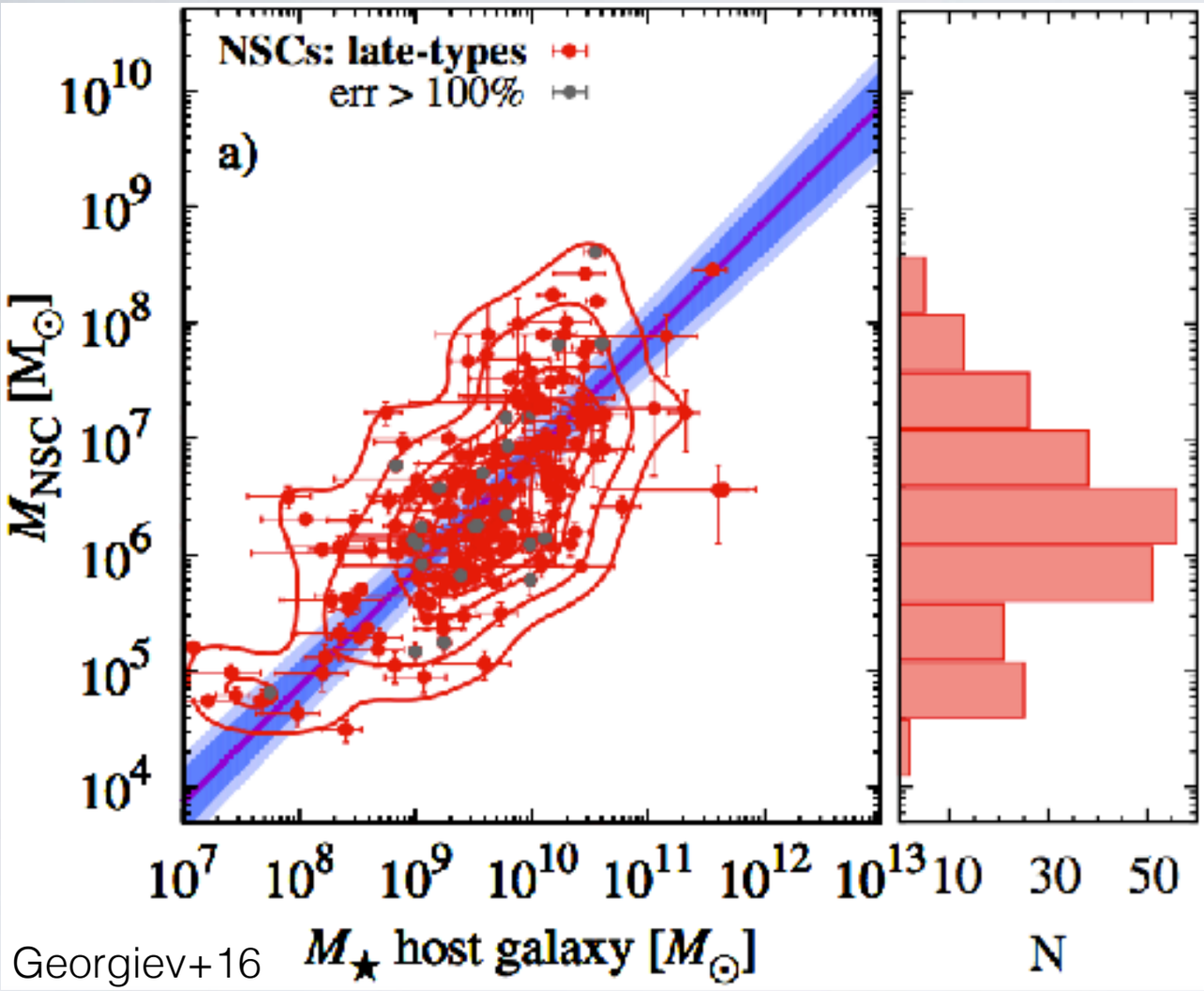
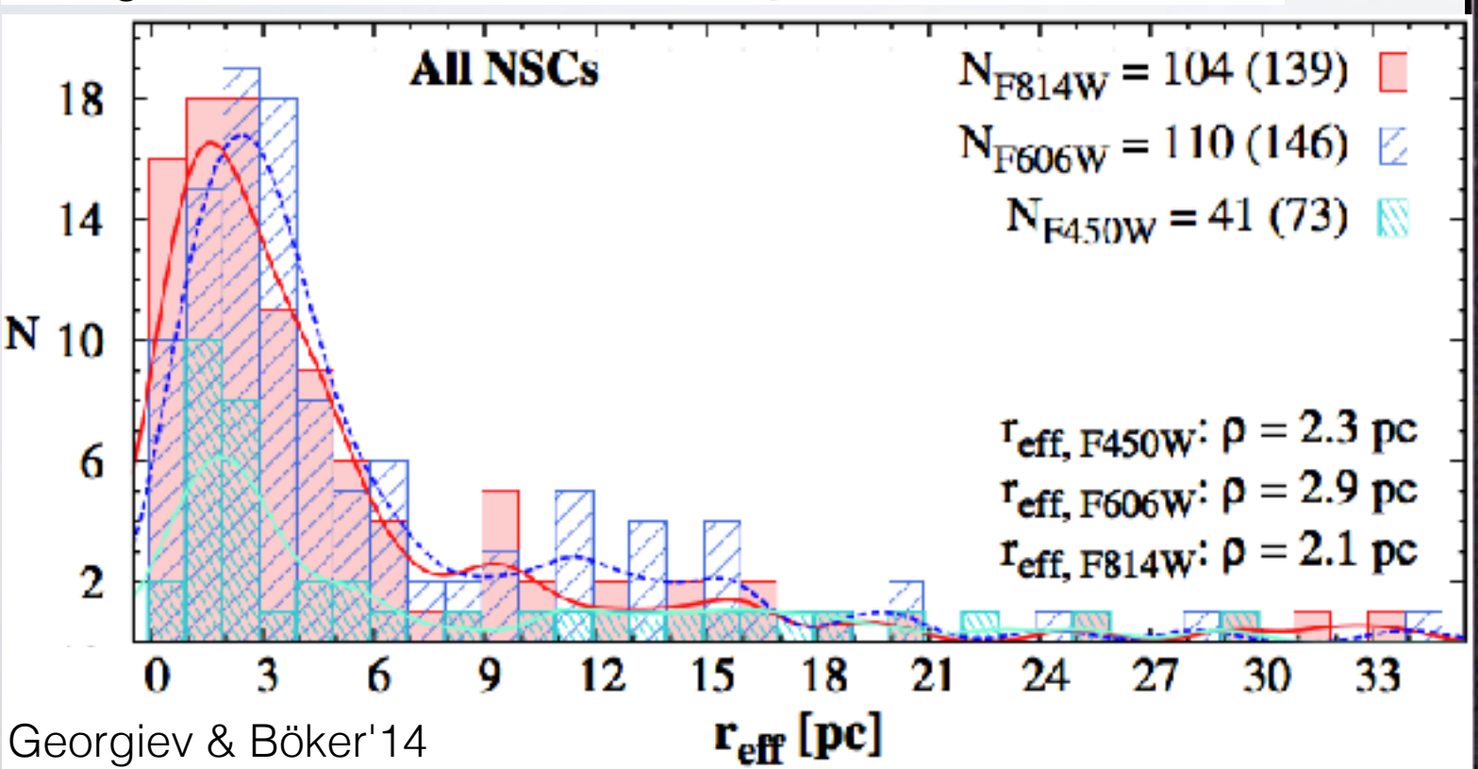


NUCLEAR STAR CLUSTERS

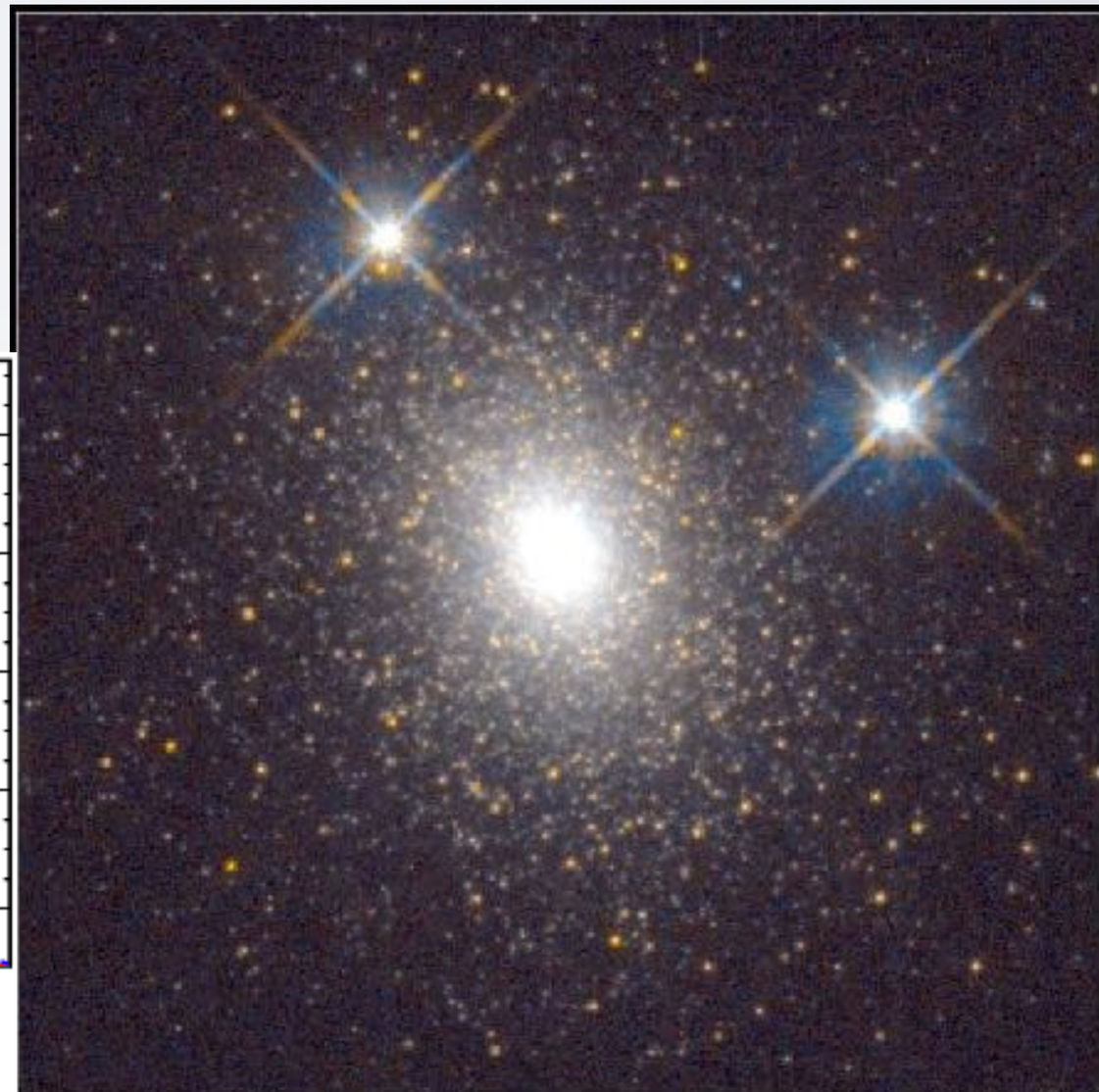


Georgiev+16

- $r_{eff,NSC}$ ~ 3-5 pc ~ 0.2”
- M_{NSC} ~ few x 10^6 $M_\odot$
- ~20% young stellar population



Georgiev & Böker'14

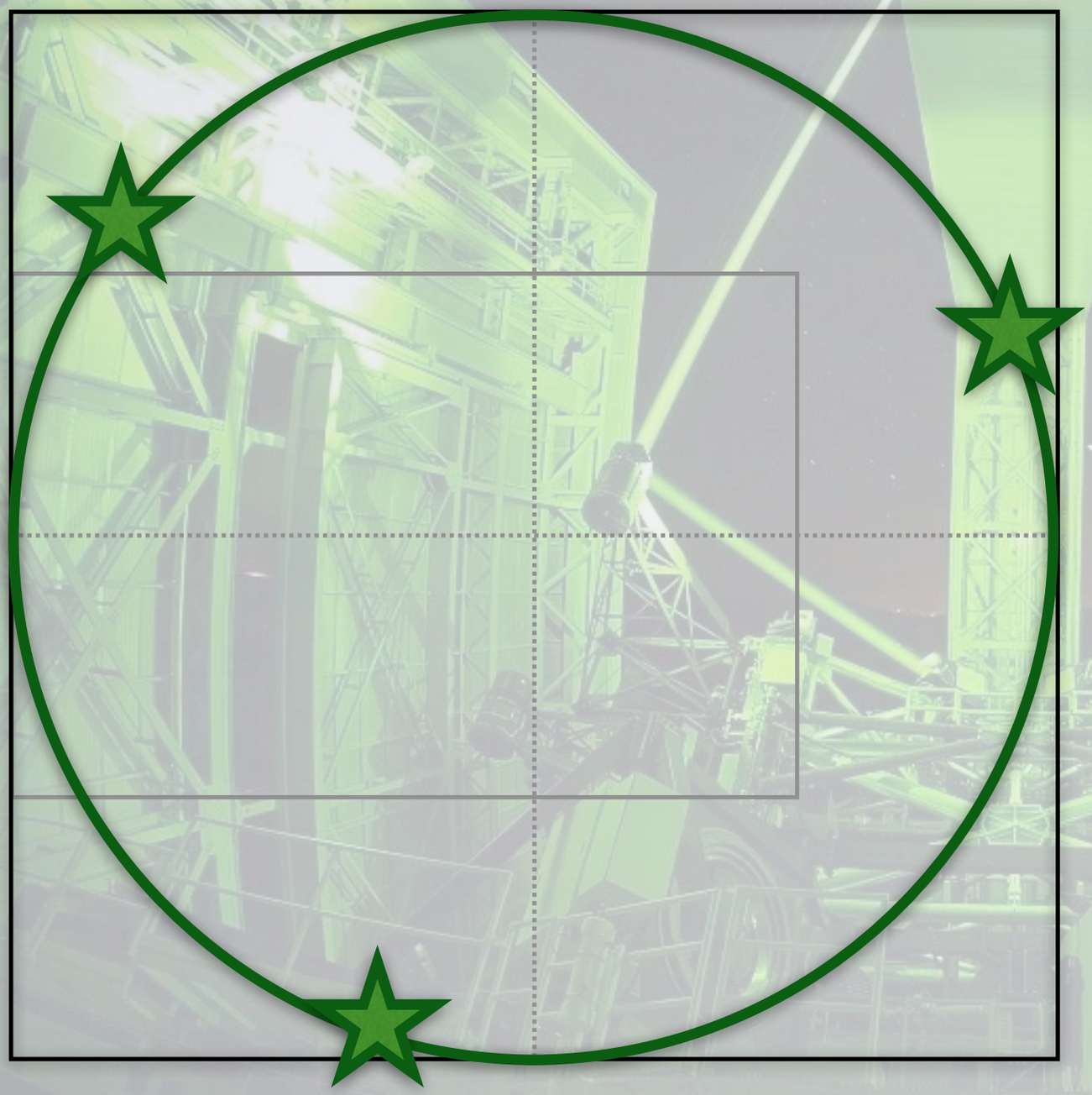


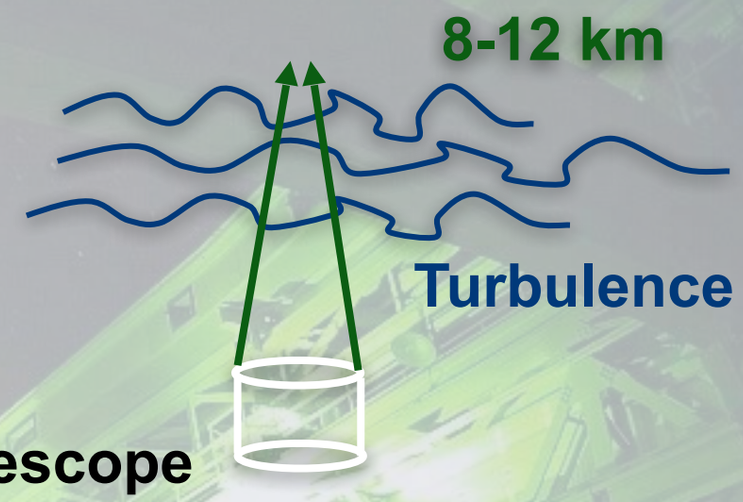

G1
M31
LBT / ARGOS & LUCI1
JHKs

Advanced Rayleigh Ground layer adaptive Optics System

ARGOS

LUCI FoV 4' x 4'

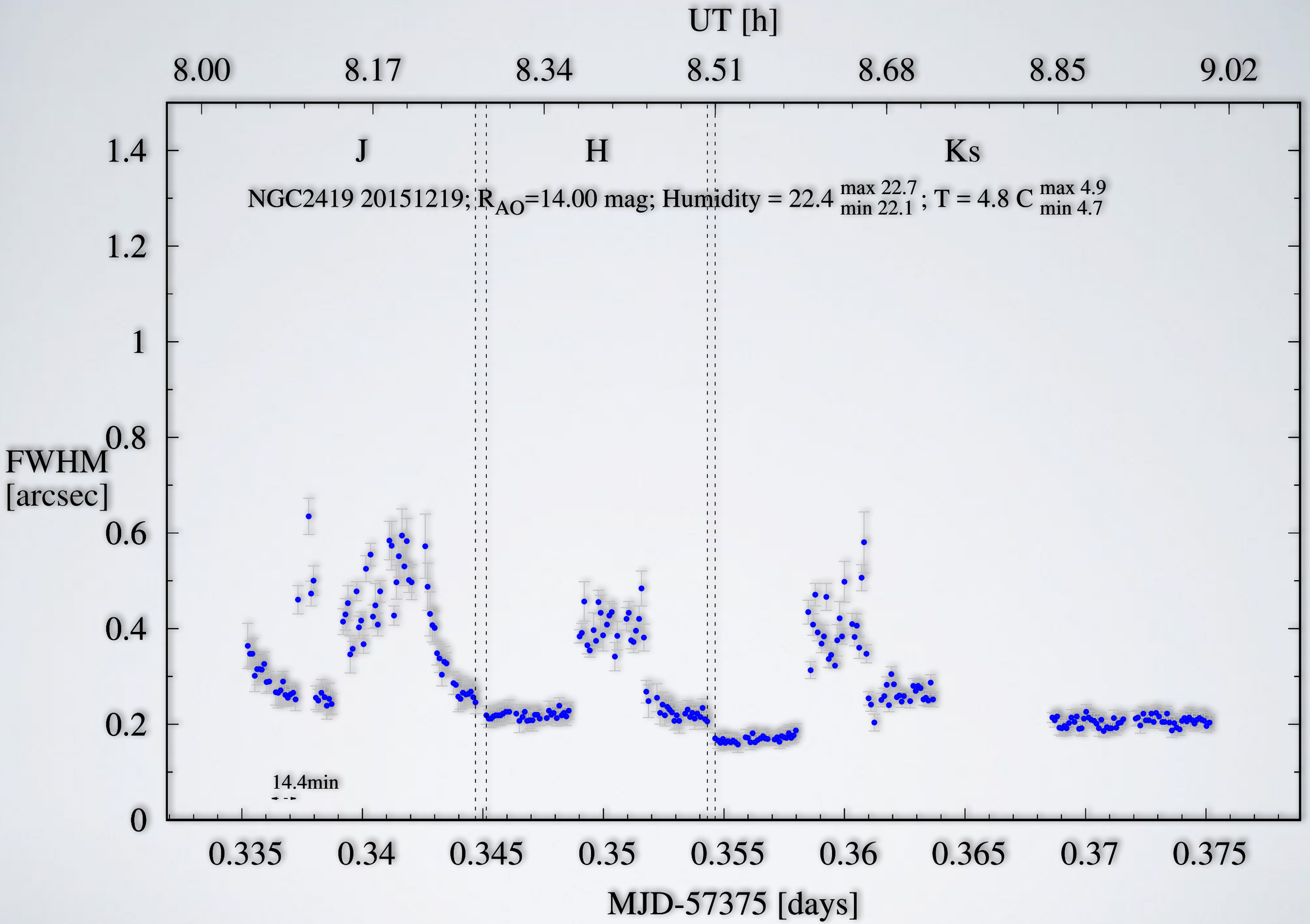


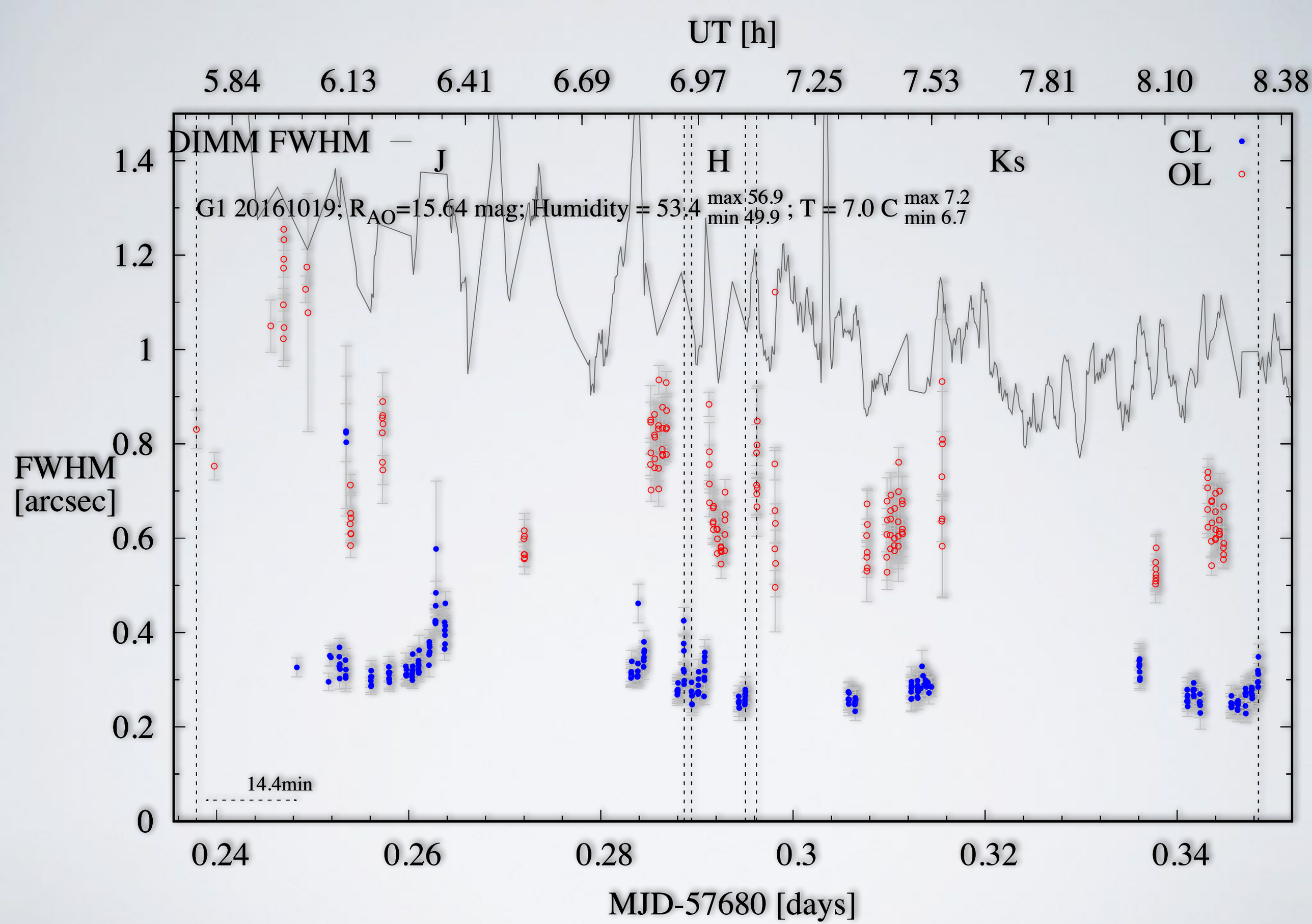


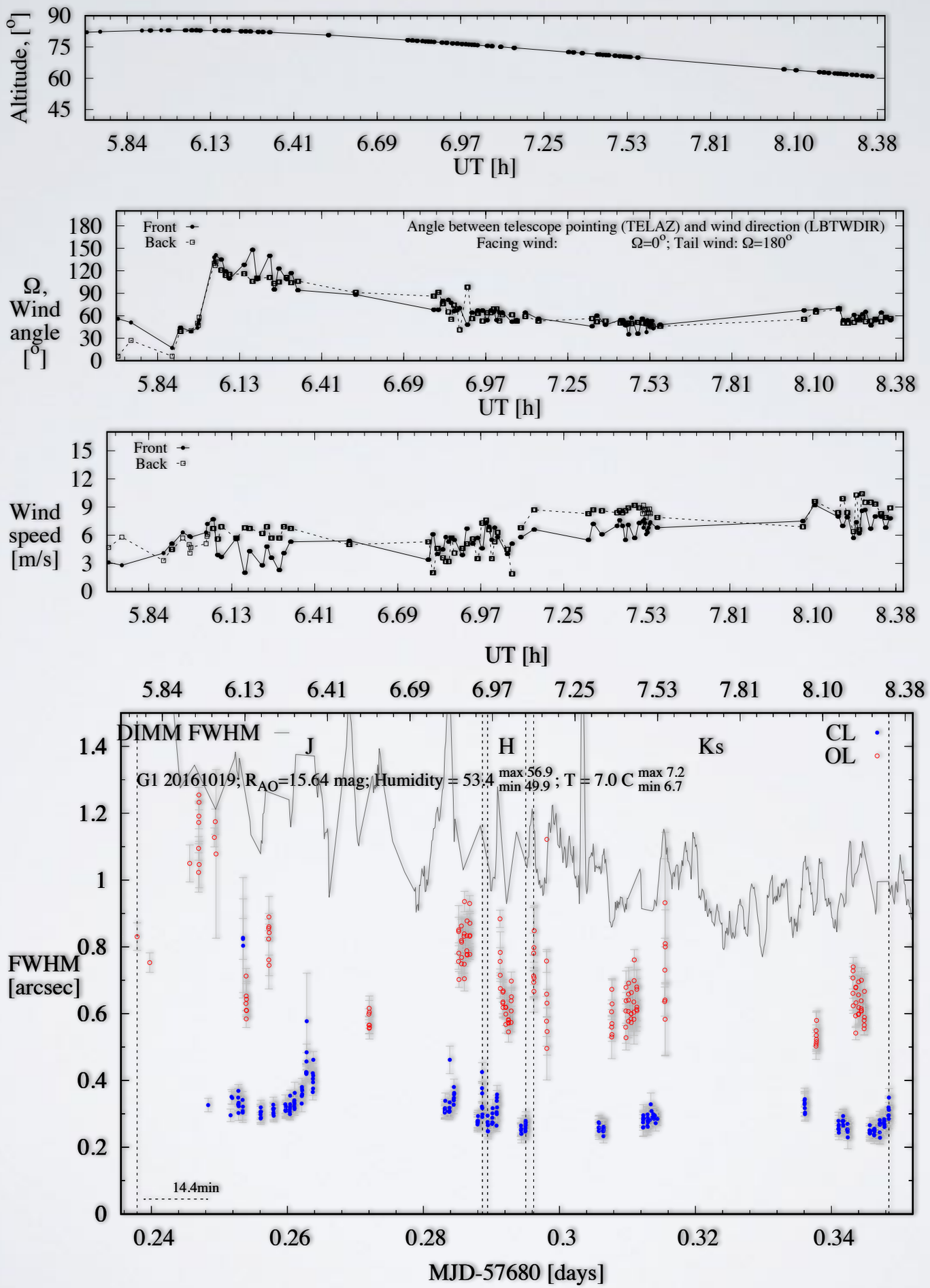
- **6 LGS** (3 per side)
- 3 LGS on a constellation of **2' radius**
- Focused at **12km**
- NGS **R<18.5mag**
- **FWHM$_{JHKs}$ ~ 0.25"** (var<25%), FoV **4'x4'**
- **>6x** less exposure time

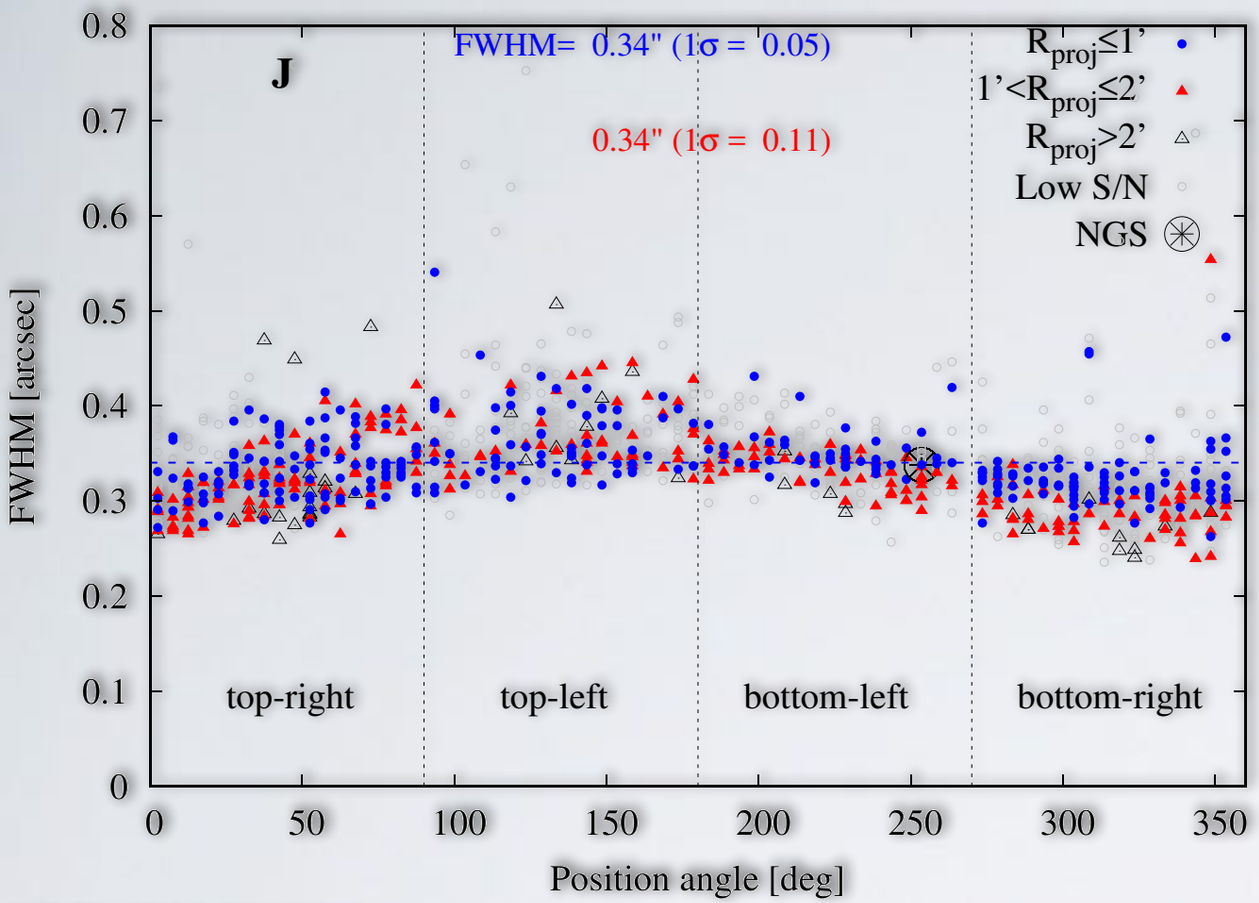
LUCI 1 & 2 (**PI** LSW)

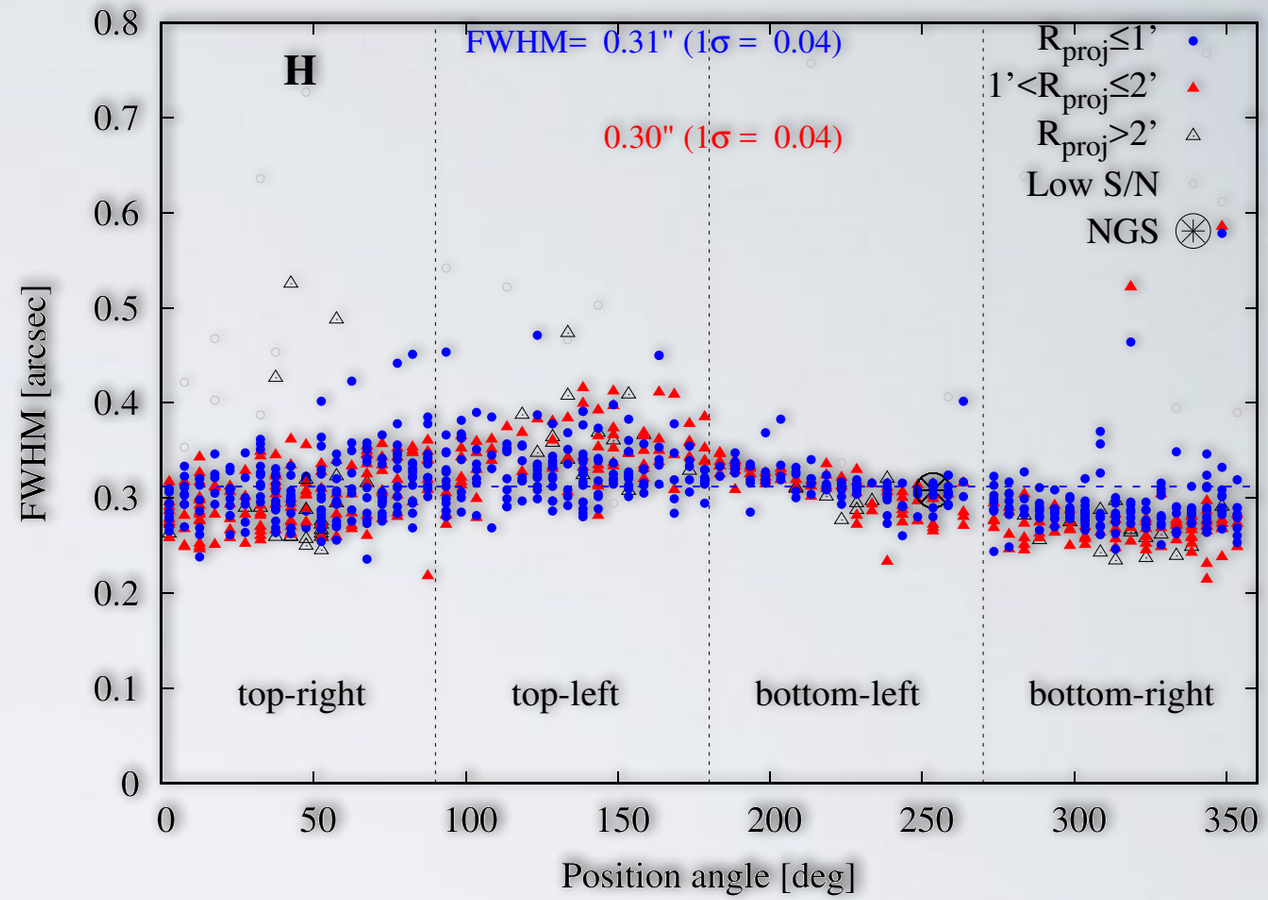
- **Imaging** (zJHK, 0.118"/pix w/ N3.75)
- **Spectra** (Slit$_{min}$=0.25", R$_{max}$=12 000)


UT [h]
8.00
8.17
8.34
8.51
8.68
8.85
9.02
J
H
Ks
NGC2419 20151219; R_AO=14.00 mag; Humidity = 22.4 max 22.7 min 22.1 ; T = 4.8 C max 4.9 min 4.7
FWHM [arcsec]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14.4min
0.335
0.34
0.345
0.35
0.355
0.36
0.365
0.37
0.375
MJD-57375 [days]

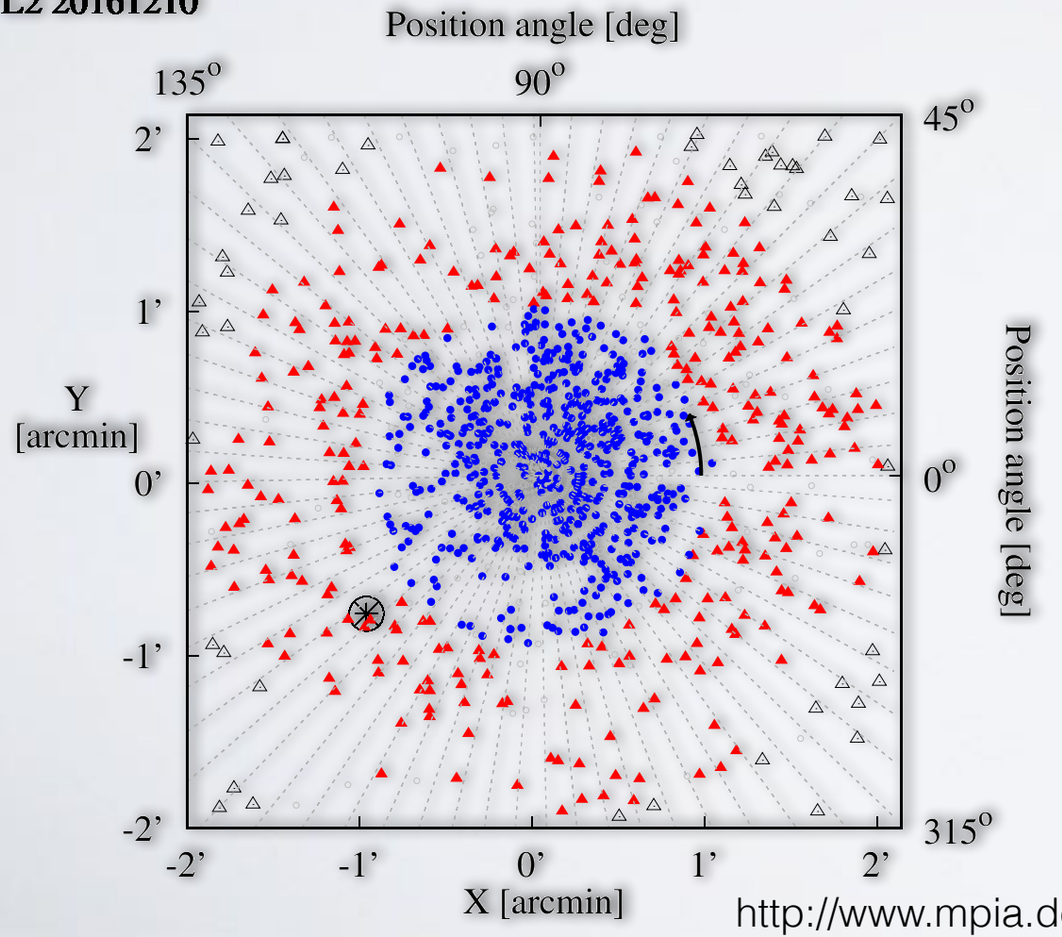

UT [h]
5.84
6.13
6.41
6.69
6.97
7.25
7.53
7.81
8.10
8.38
DIMM FWHM
J
H
Ks
CL
OL
G1 20161019; R_AO=15.64 mag; Humidity = 53.4 max 56.9 min 49.9 ; T = 7.0 C max 7.2 min 6.7
FWHM [arcsec]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14.4min
0.24
0.26
0.28
0.3
0.32
0.34
MJD-57680 [days]

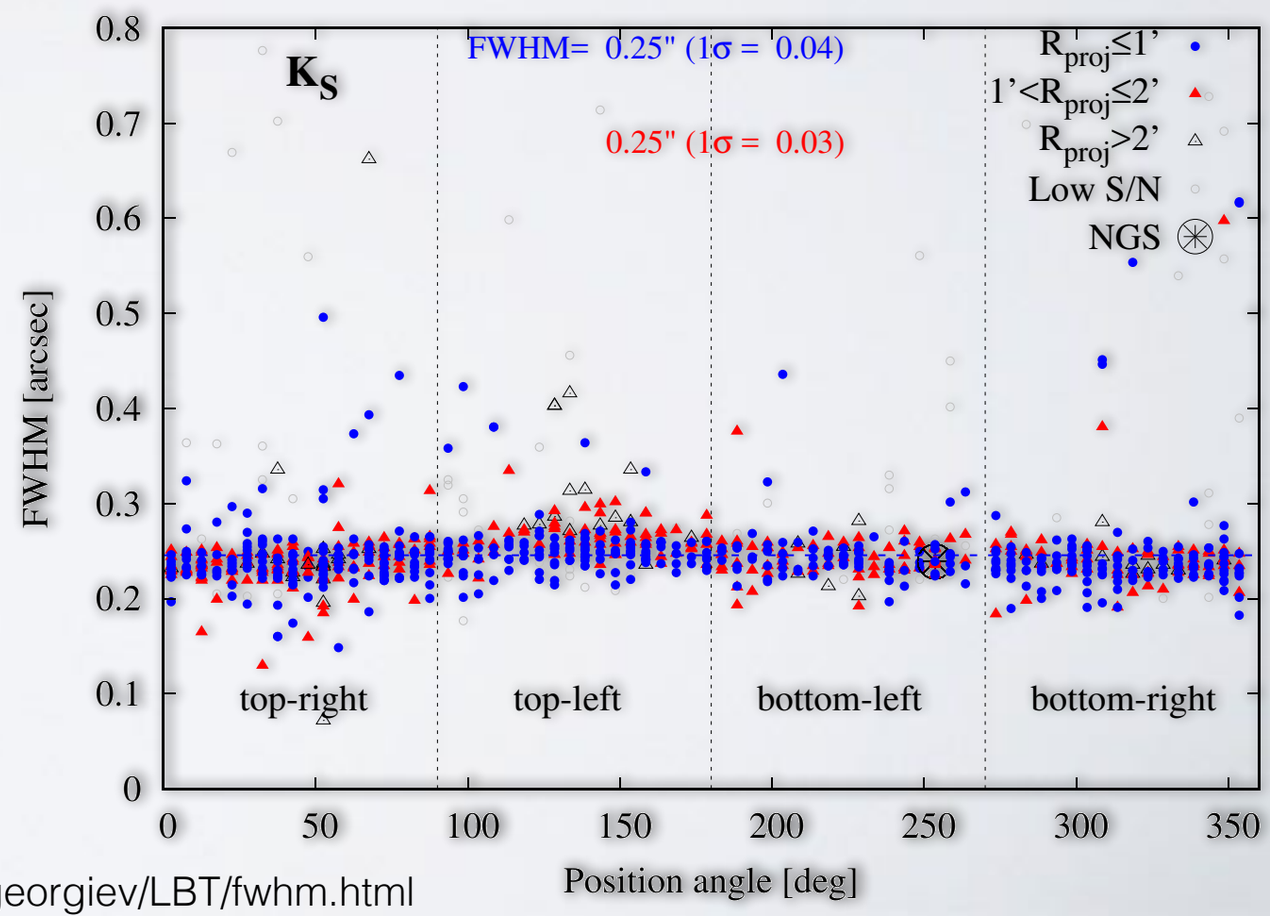

Altitude, [°]
90
75
60
45
5.84
6.13
6.41
6.69
6.97
7.25
7.53
7.81
8.10
8.38
UT [h]
Front
Back
Angle between telescope pointing (TELAZ) and wind direction (LBTWDIR)
Facing wind: Ω=0°; Tail wind: Ω=180°
Ω, Wind angle [°]
180
150
120
90
60
30
0
Wind speed [m/s]
15
12
9
6
3
0
DIMM FWHM
J
H
Ks
CL
OL
G1 20161019; R_AO=15.64 mag; Humidity = 53.4 max 56.9 min 49.9 ; T = 7.0 C max 7.2 min 6.7
FWHM [arcsec]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14.4min
0.24
0.26
0.28
0.3
0.32
0.34
MJD-57680 [days]





NGC2419 L2 20161210





http://www.mpia.de/~georgiev/LBT/fwhm.html

NGC6384

(2015/05/01-02)

Data

- J(775s),H(1030s), K_S (70s)
- FoV: 30 x 30 Kpc

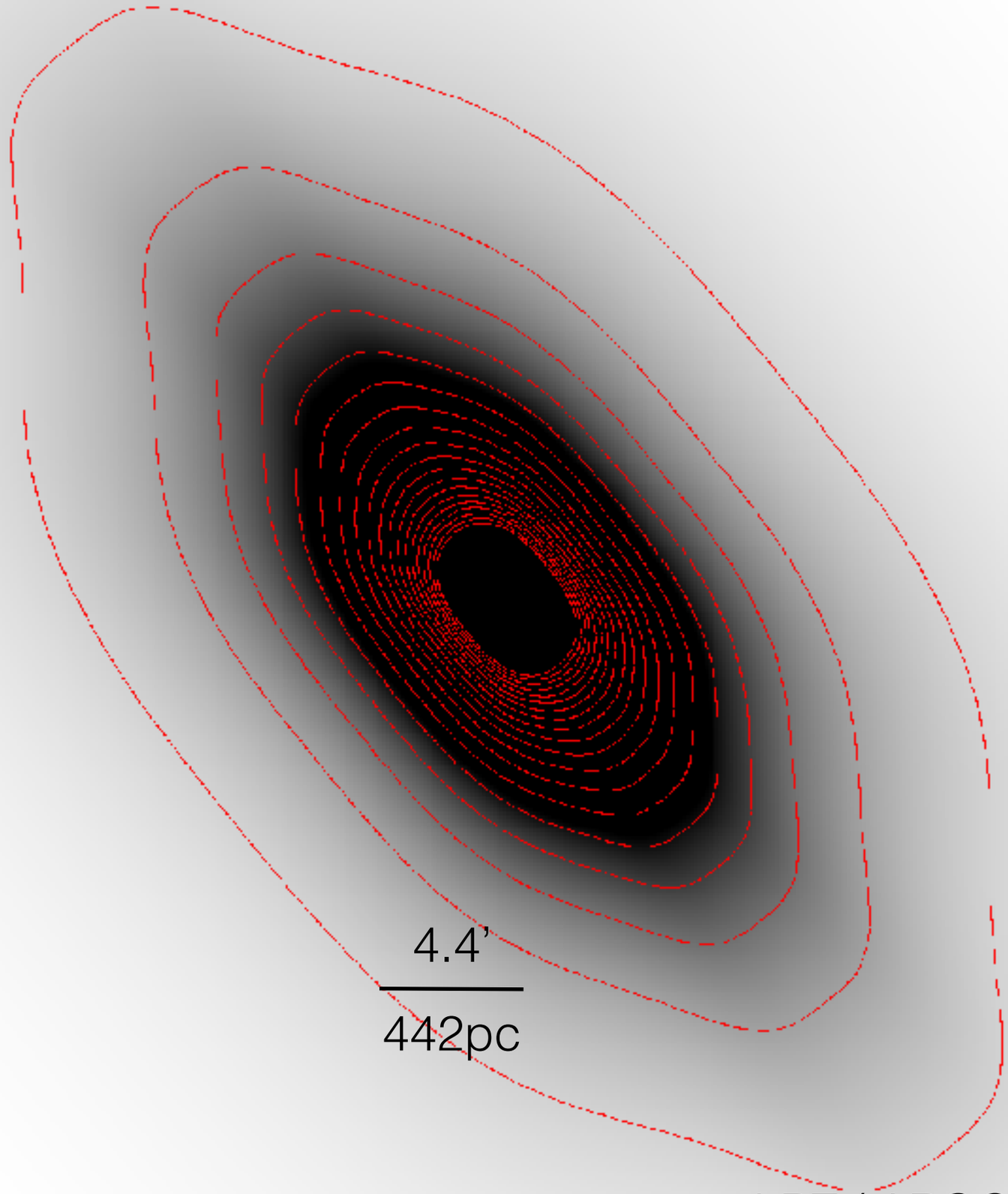
Business Card

- D=25Mpc
- $r_{PSF,10\%}$ = 2.8 pc
- $r_{V,eff,NSC}$ = 15pc (Georgiev&Böker'14)
- $M_n = 1.3 \times 10^7\ [M_\odot]$
- $M_g = 4.3 \times 10^{10} [M_\odot]$ (Georgiev+16)
- SED mass
- Structure
- Gradients

NGC6384

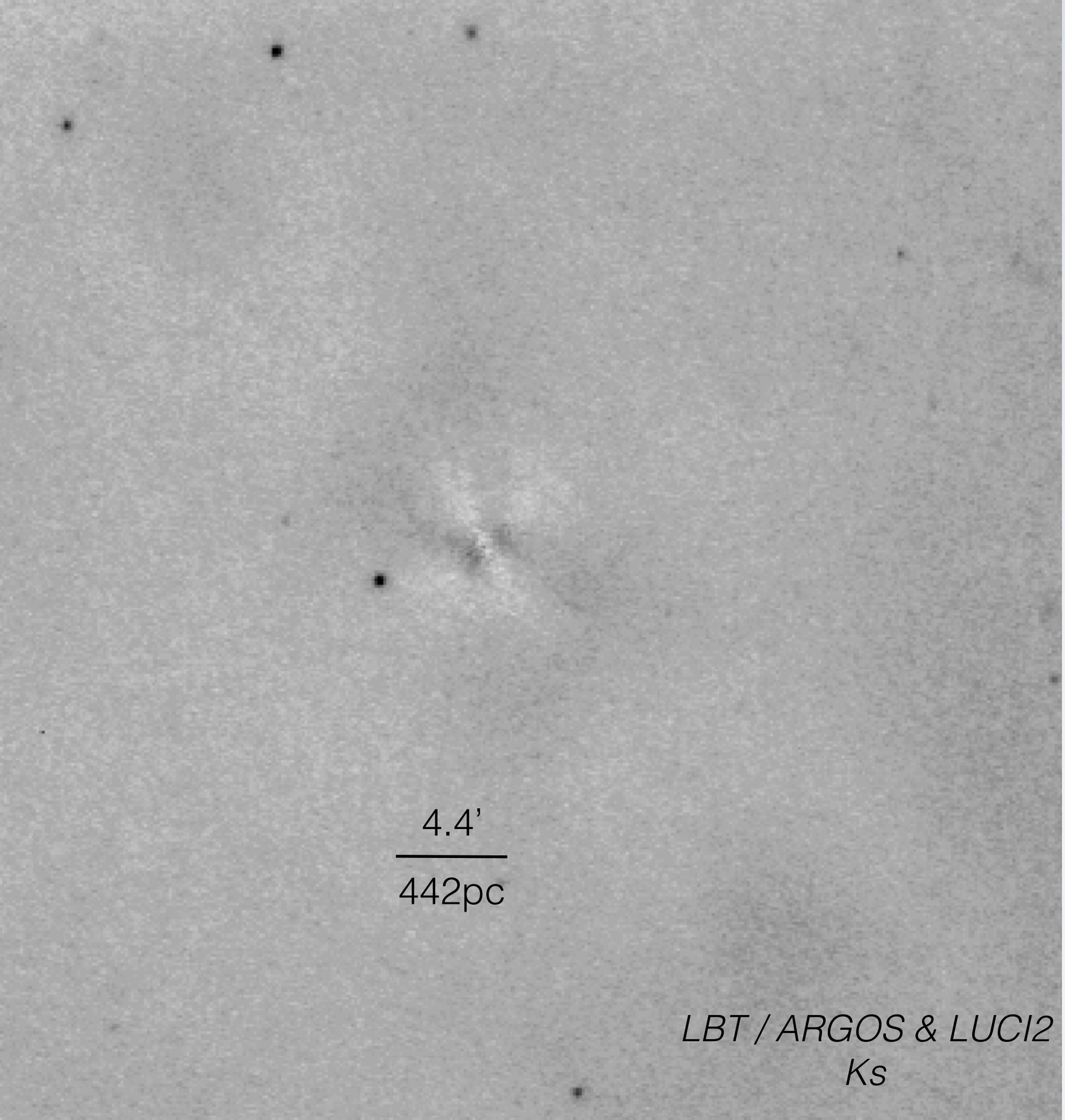
Fit to the central
5.7x5.7 kpc

2D model with
IMFIT (Erwin 2015)

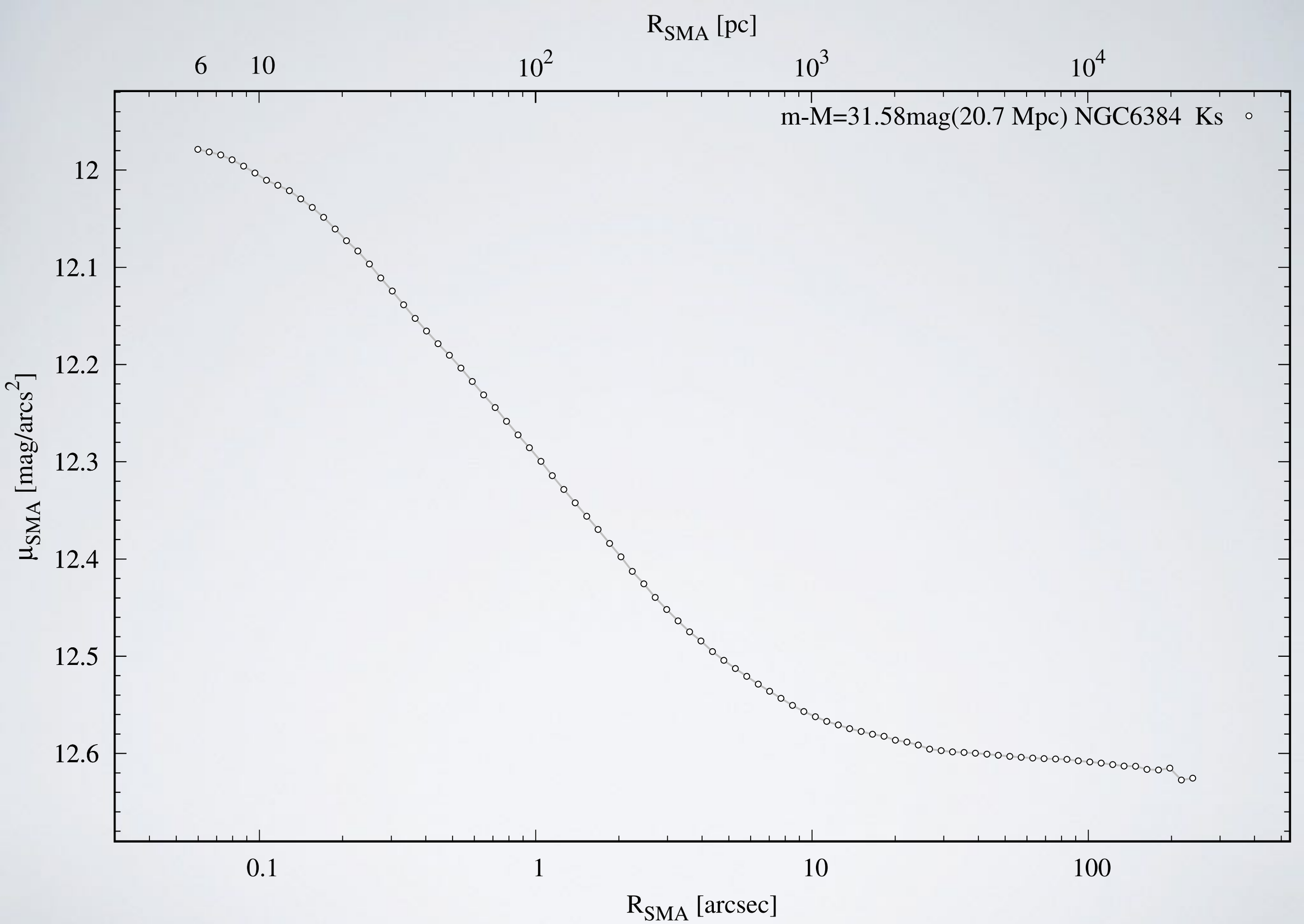


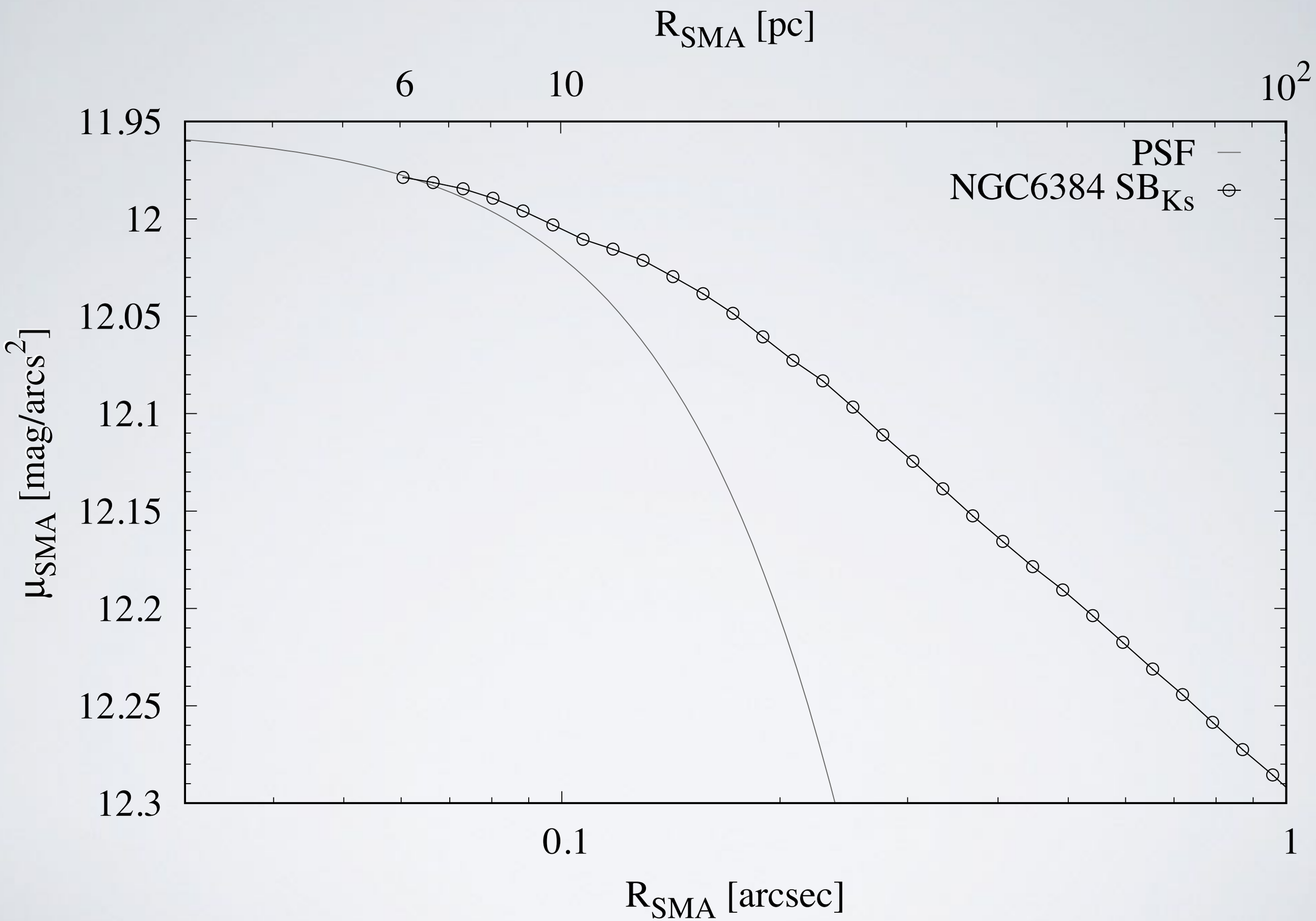
LBT / ARGOS & LUCI2
Ks

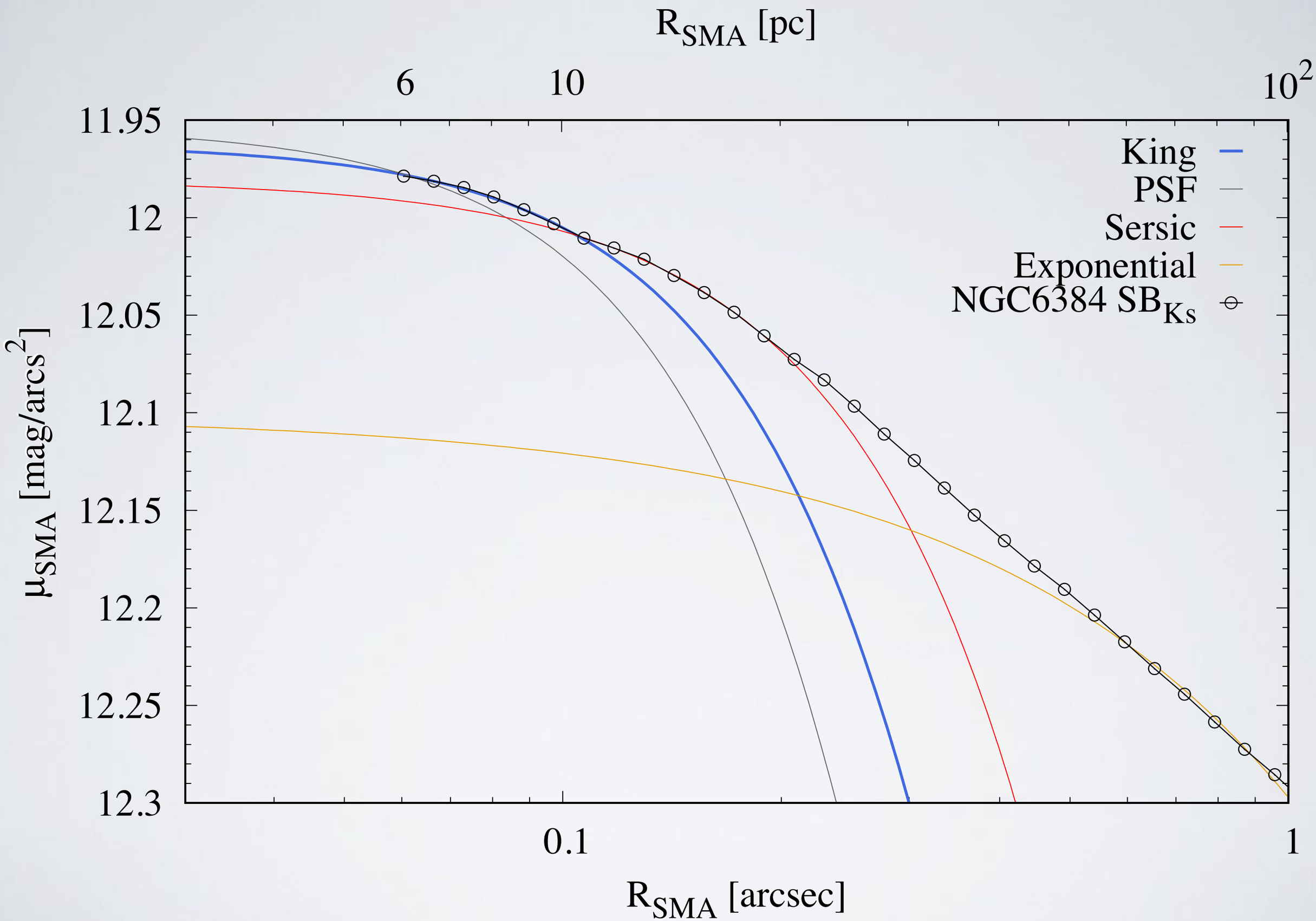
2D model with
(King,Sersic,Exponential)

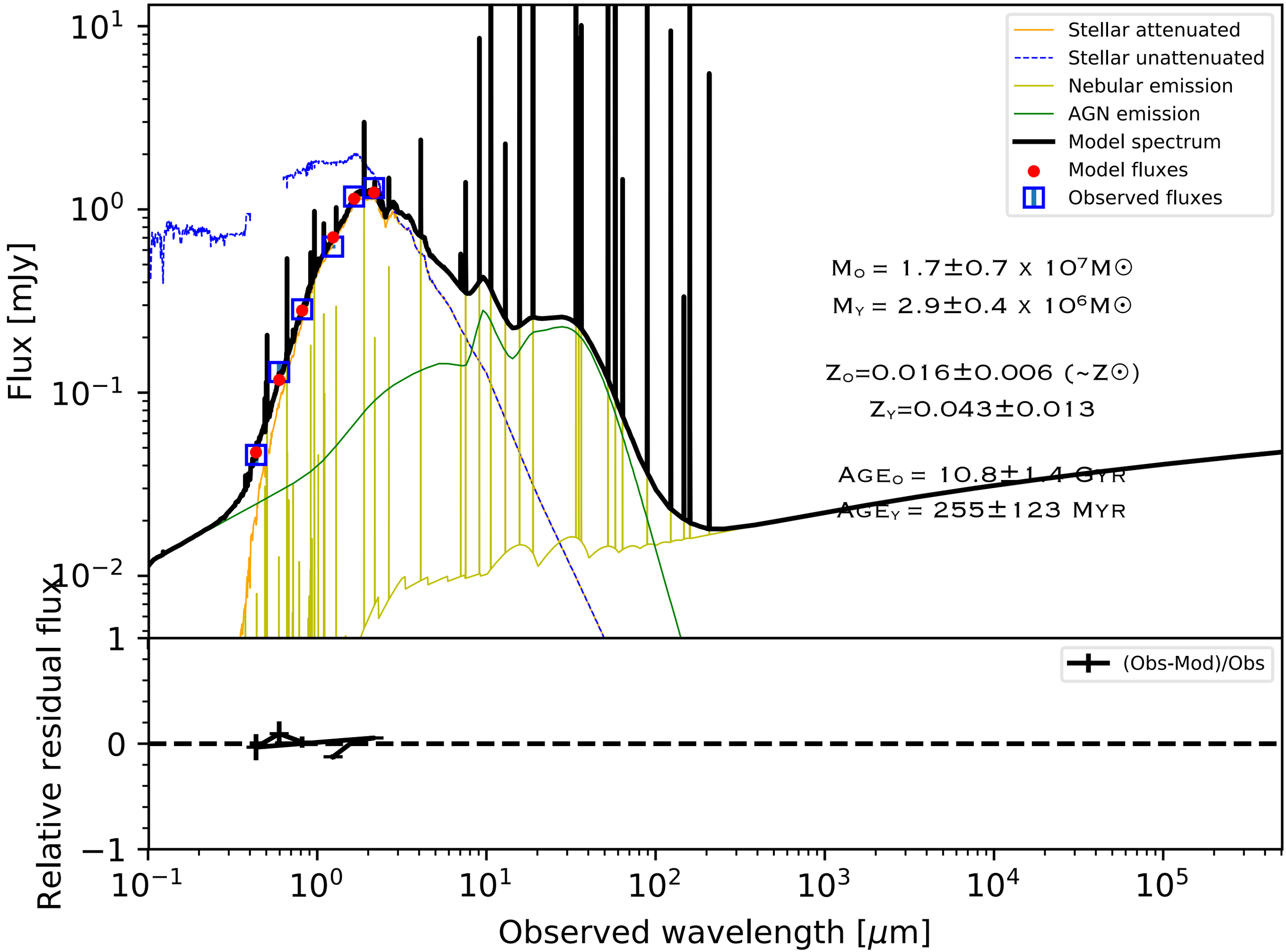


model - Data
(Residual)


R_SMA [pc]
6
10
10^2
10^3
10^4
m-M=31.58mag(20.7 Mpc) NGC6384 Ks
12
12.1
12.2
12.3
12.4
12.5
12.6
μ_SMA [mag/arcs^2]
0.1
1
10
100
R_SMA [arcsec]


R_SMA [pc]
6
10
10^2
11.95
12
12.05
12.1
12.15
12.2
12.25
12.3
μ_SMA [mag/arcs^2]
PSF
NGC6384 SB_Ks
0.1
1
R_SMA [arcsec]


R_SMA [pc]
6
10
10^2
11.95
12
12.05
12.1
12.15
12.2
12.25
12.3
μ_SMA [mag/arcs^2]
King
PSF
Sersic
Exponential
NGC6384 SB_Ks
0.1
1
R_SMA [arcsec]


Stellar attenuated
Stellar unattenuated
Nebular emission
AGN emission
Model spectrum
Model fluxes
Observed fluxes
M_O = 1.7±0.7 x $10^7 M_\odot$
M_Y = 2.9±0.4 x $10^6 M_\odot$
Z_O=0.016±0.006 (~$Z_\odot$)
Z_Y=0.043±0.013
AGE_O = 10.8±1.4 Gyr
AGE_Y = 255±123 Myr
(Obs-Mod)/Obs
Flux [mJy]
Relative residual flux
Observed wavelength [μm]

M51

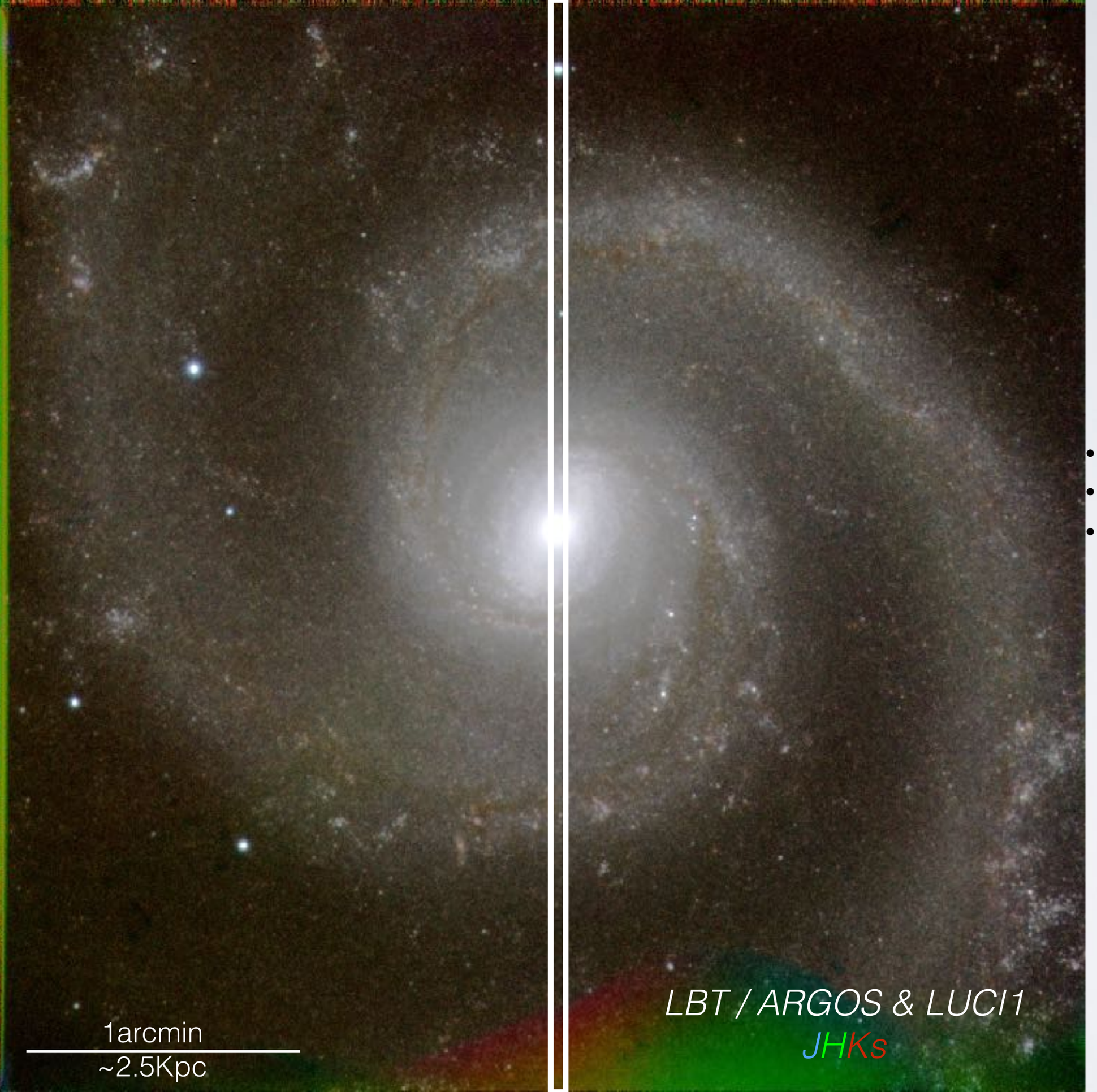
(2016/05/23)

Data

- *J* (48s), *H* (54s), K_S (60s)
- FoV: 10 x 10 Kpc
- LS0.25, 8x150s (20min), Tot=1hr

Science objectives

- D = 8.6 Mpc
- HST data
- Nuclear star cluster in NIR
- Coexisting with MBH?
- Old and young star cluster population (galaxy SFH)



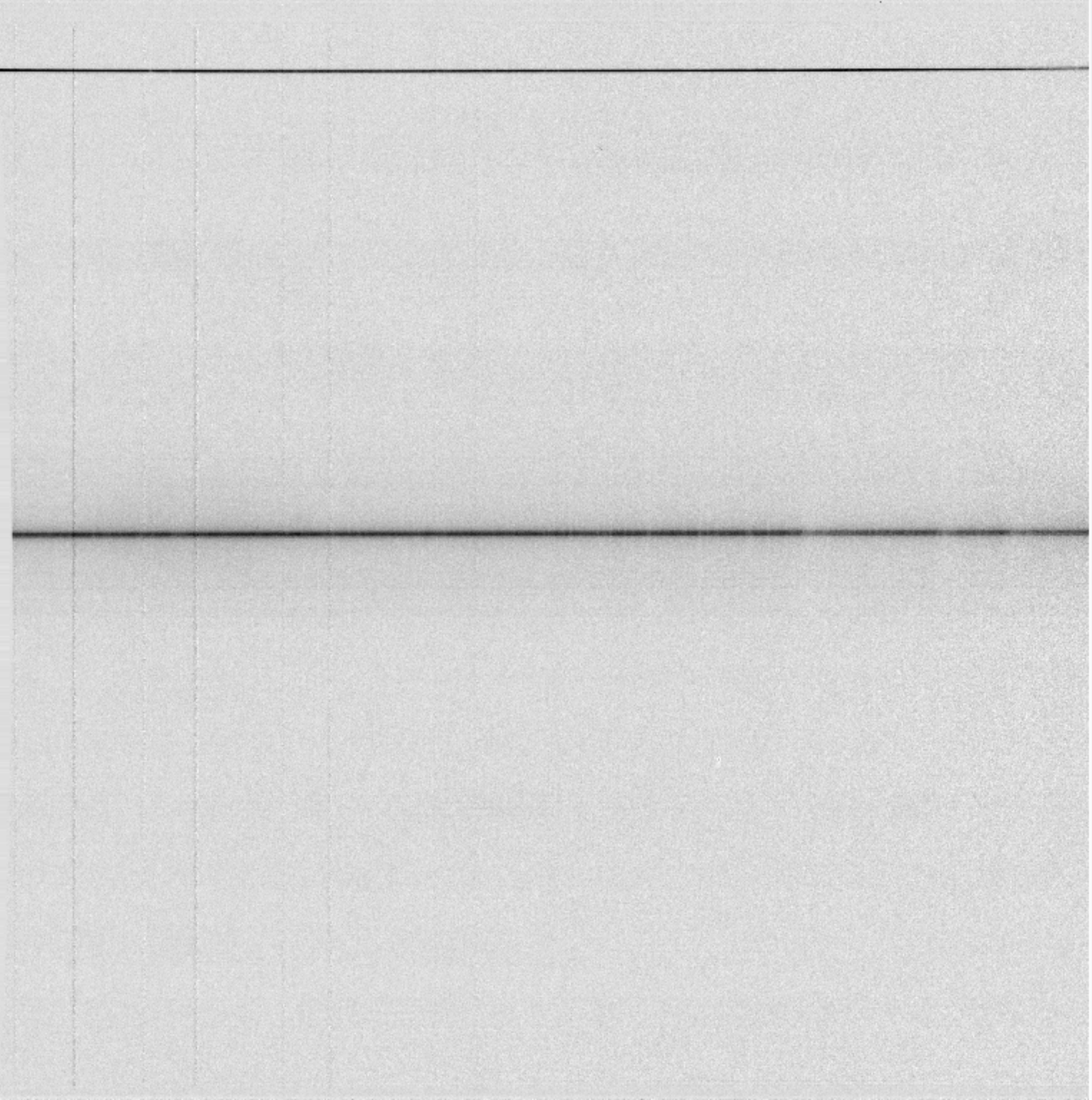
M51

(2016/05/23)

Data

- J (48s), H (54s), K_S (60s)
- FoV: 10 x 10 Kpc
- LS0.25, 8x150s (20min), Tot=1hr

10PC WIDE SLIT



M51

(2016/05/23)

Performance objectives

- Bright Tip Tilt star
- TT star off axis

Data

- J (48s), H (54s), K_S (60s)
- FoV: 10 x 10 Kpc
- LS0.25, 8x150s (20min), Tot=1hr

Science objectives

- D = 8.6 Mpc
- HST data
- Nuclear star cluster in NIR
- Coexisting with MBH?
- Old and young star cluster population (galaxy SFH)

M51

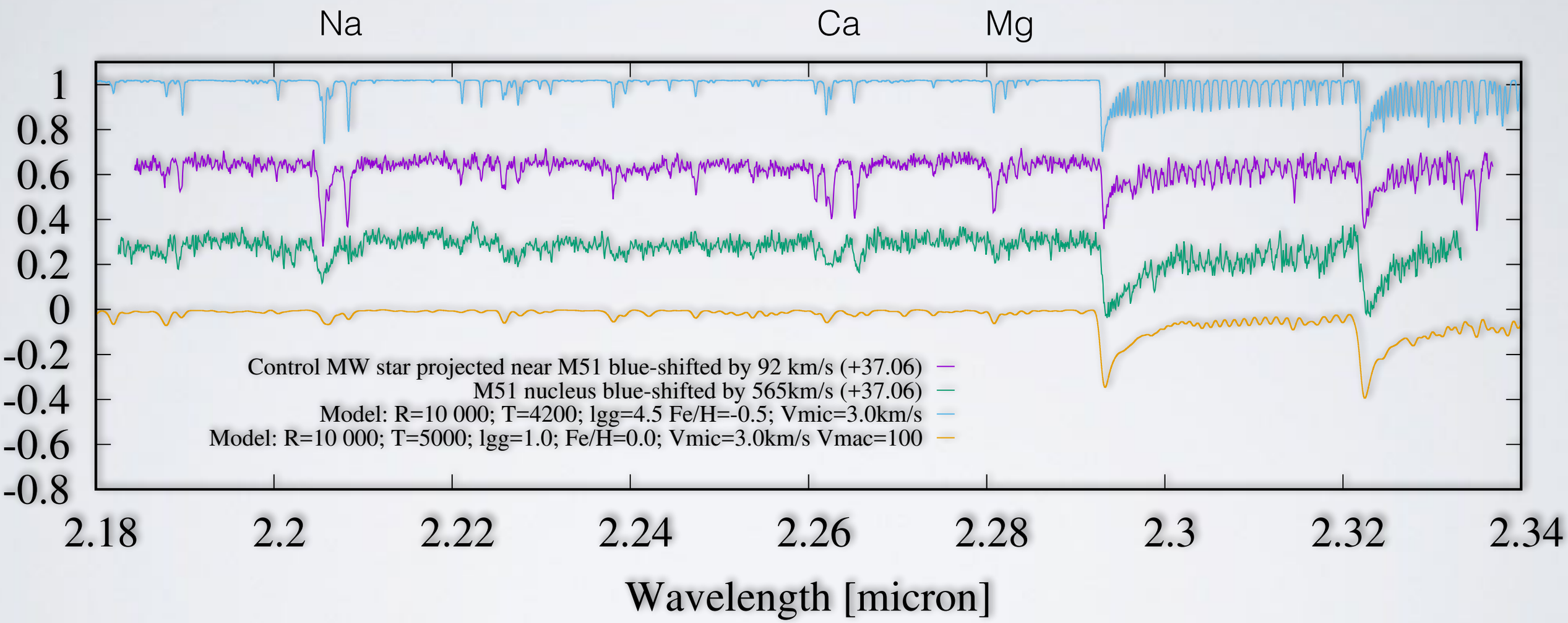
(2016/05/23)

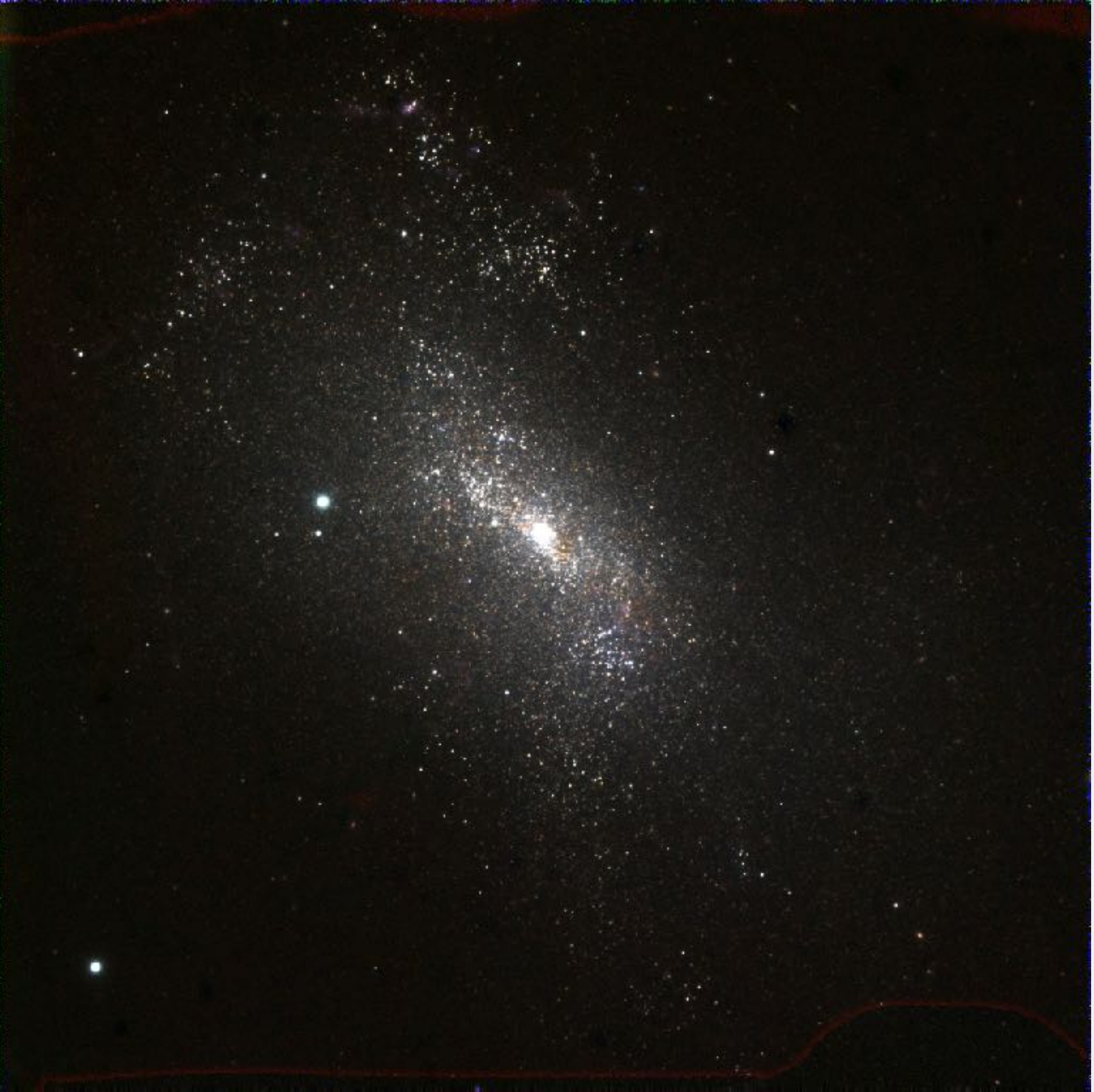
Data

- *J* (48s), *H* (54s), K_S (60s)
- FoV: 10 x 10 Kpc
- LS0.25, 4x150s, Tot=1hrs

Spectra

- *R~10 000*
- M51 nuc S/N ~15
- MW star S/N ~25

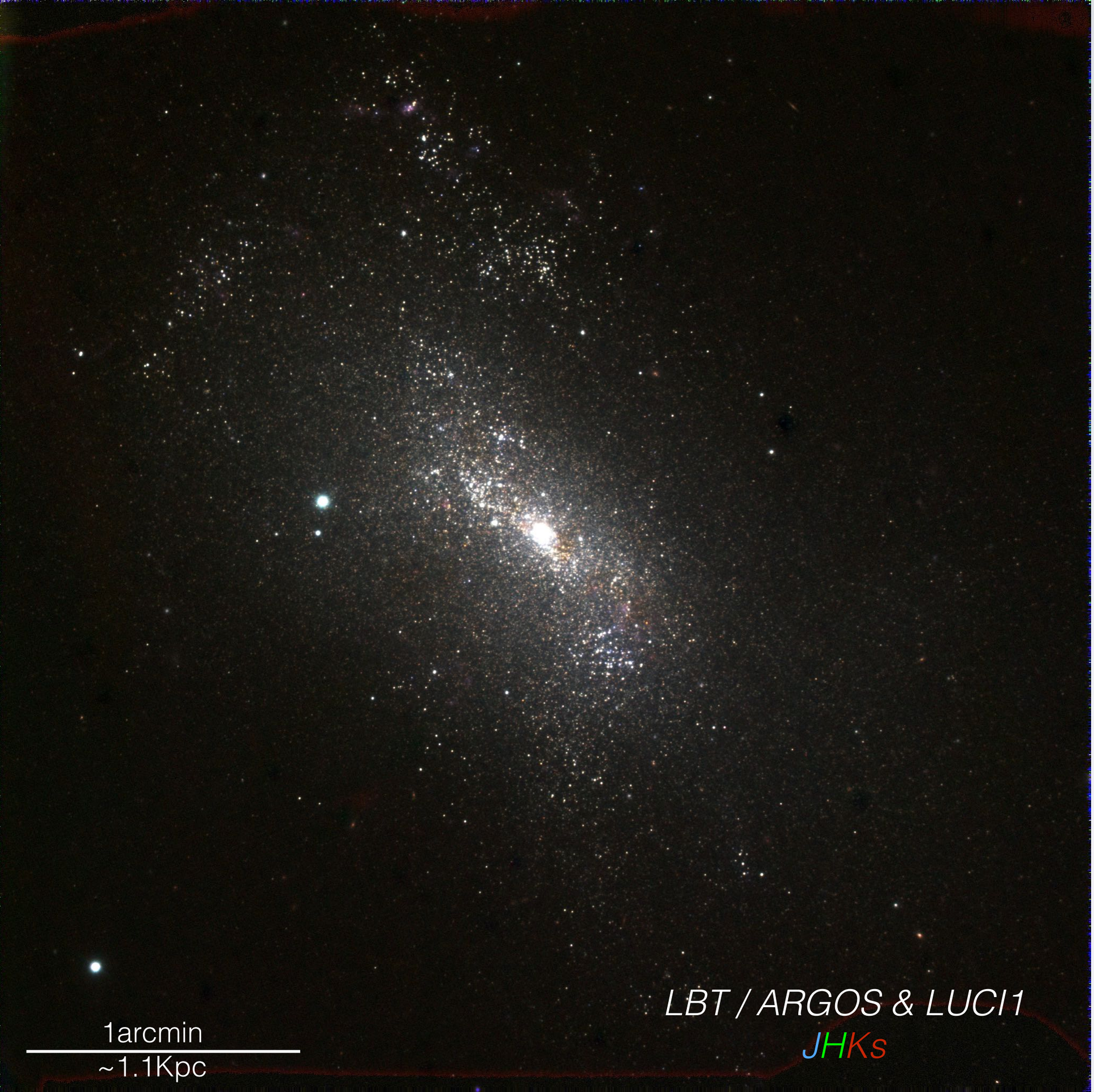




NGC4449

(2016/03/16)


NGC4449
(2016/03/16)



NGC4449

(2016/03/16)

Performance objectives

- Bright Tip Tilt star
- Many stars
- Off axis dither tests

Data

- *J* (90s), *H* (115s), K_S (155s)
- FoV: 4.4 x 4.4 Kpc
- TRGB (K_S~22mag @ N4449)
- Total execution time 30min

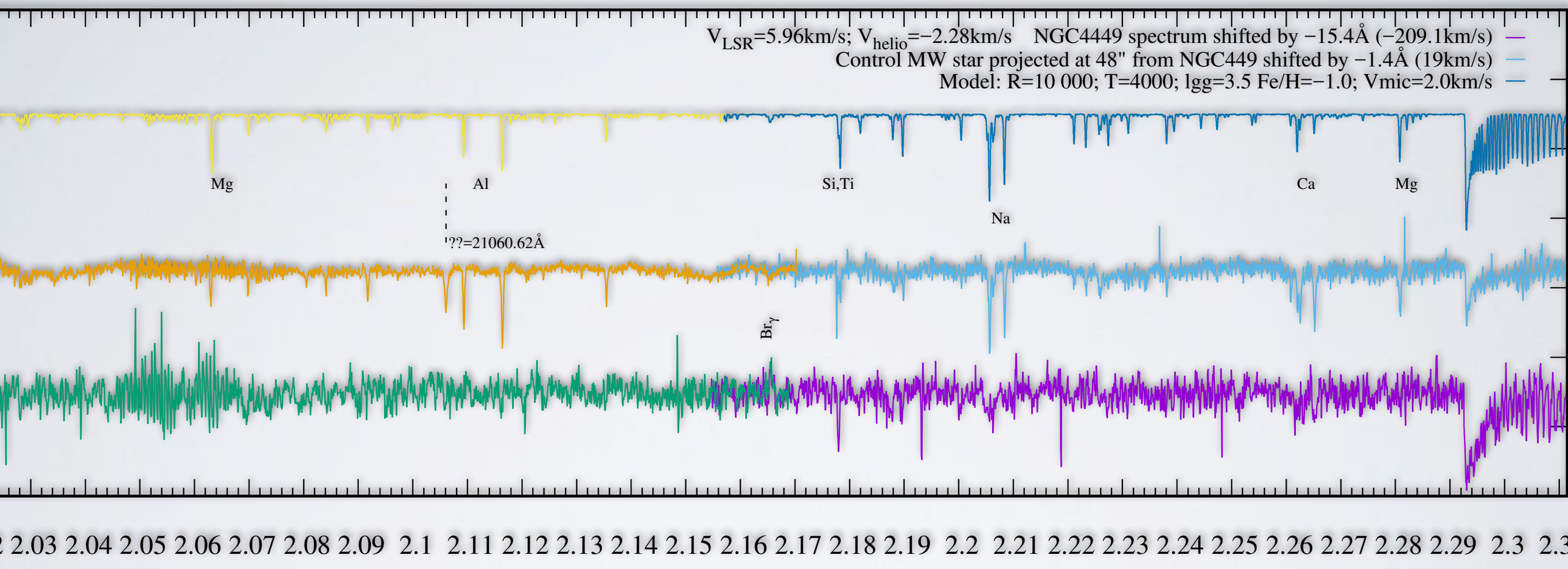
Science objectives

- D=3.8Mpc;Optical HST data
- Nuclear star cluster in formation?
- Old and young star cluster population (galaxy SFH)

NGC4449

(2017/03/11)

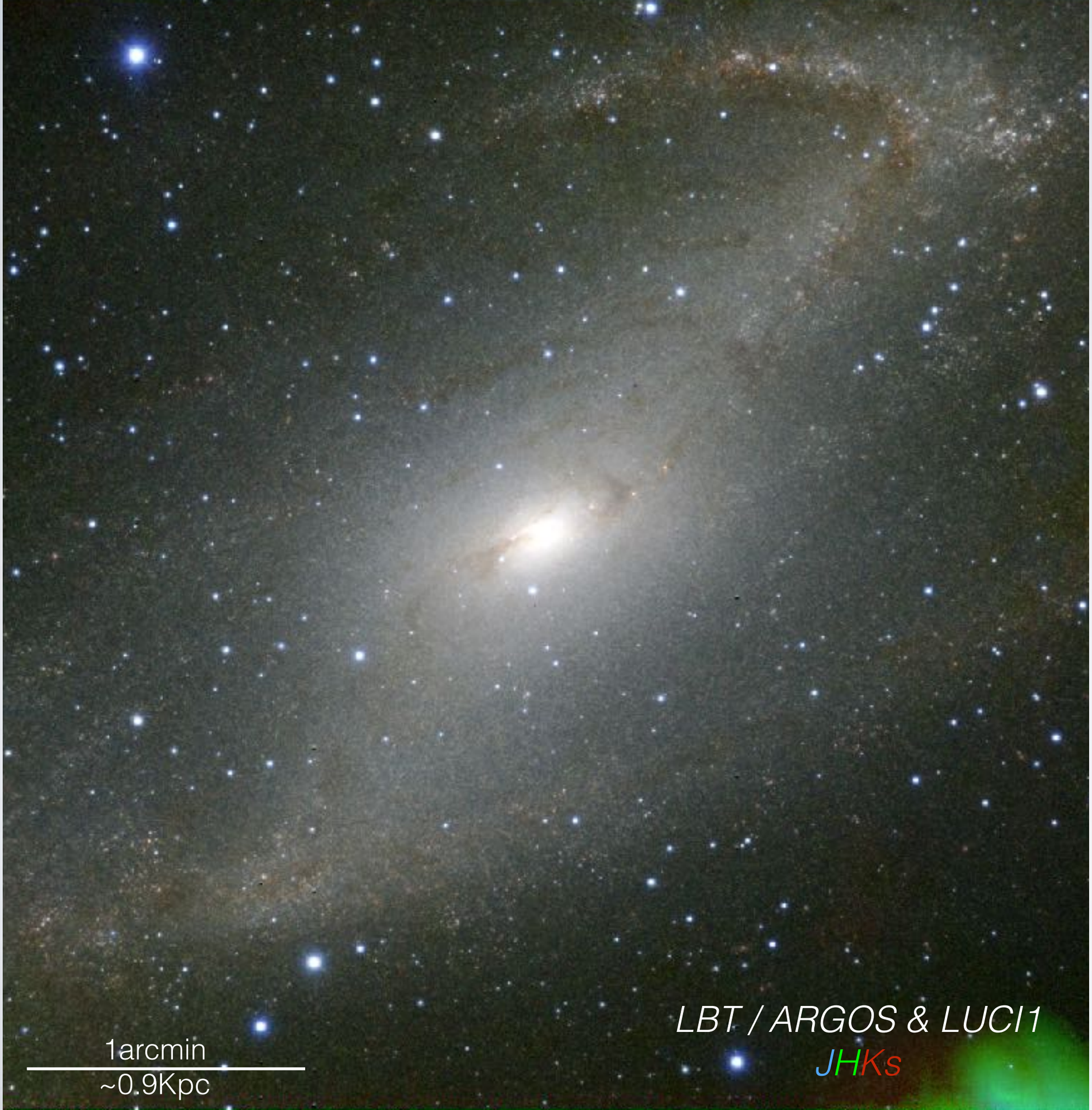
Binocular spectra!

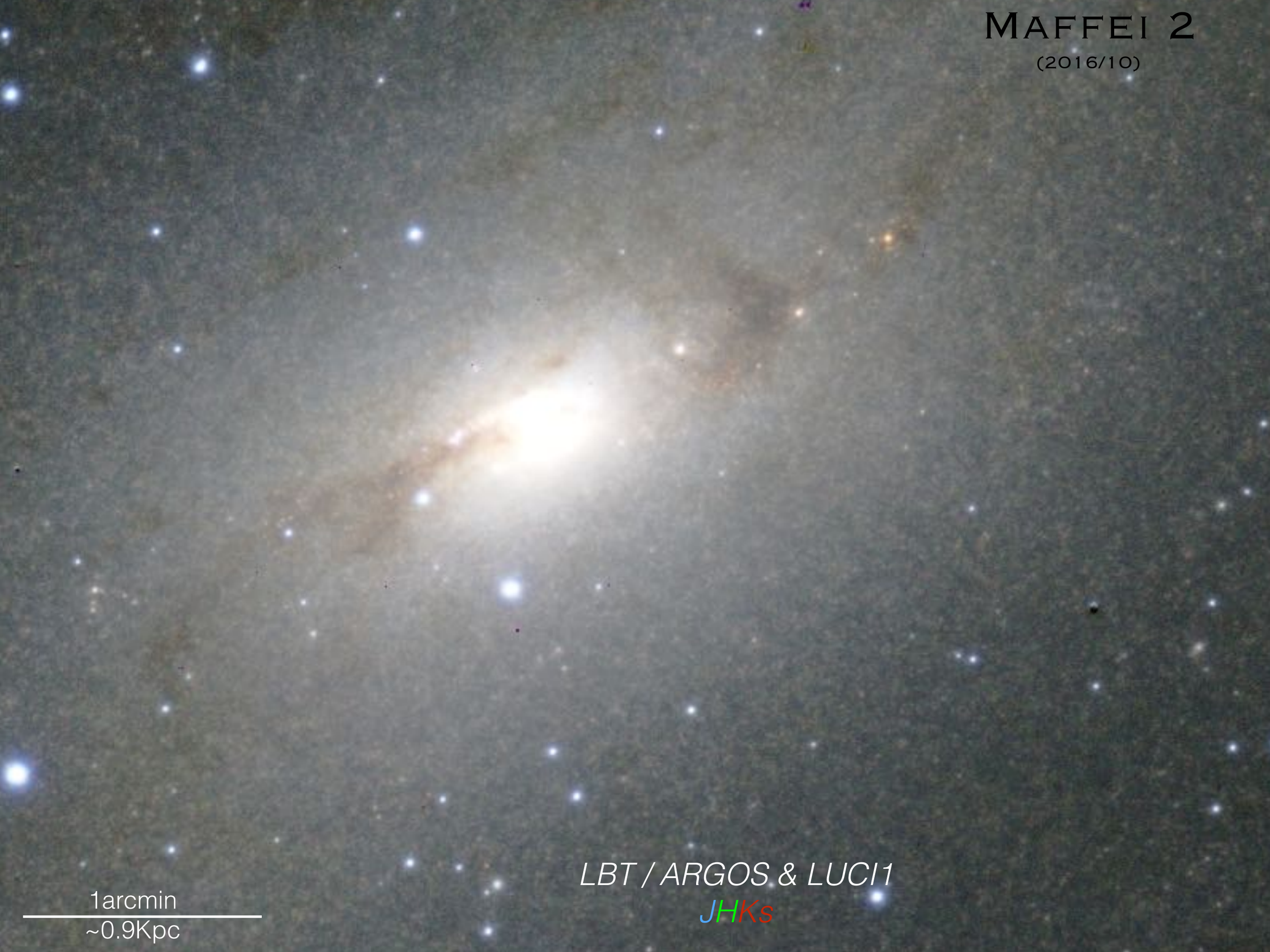


Wavelength [micron]

Maffei 2

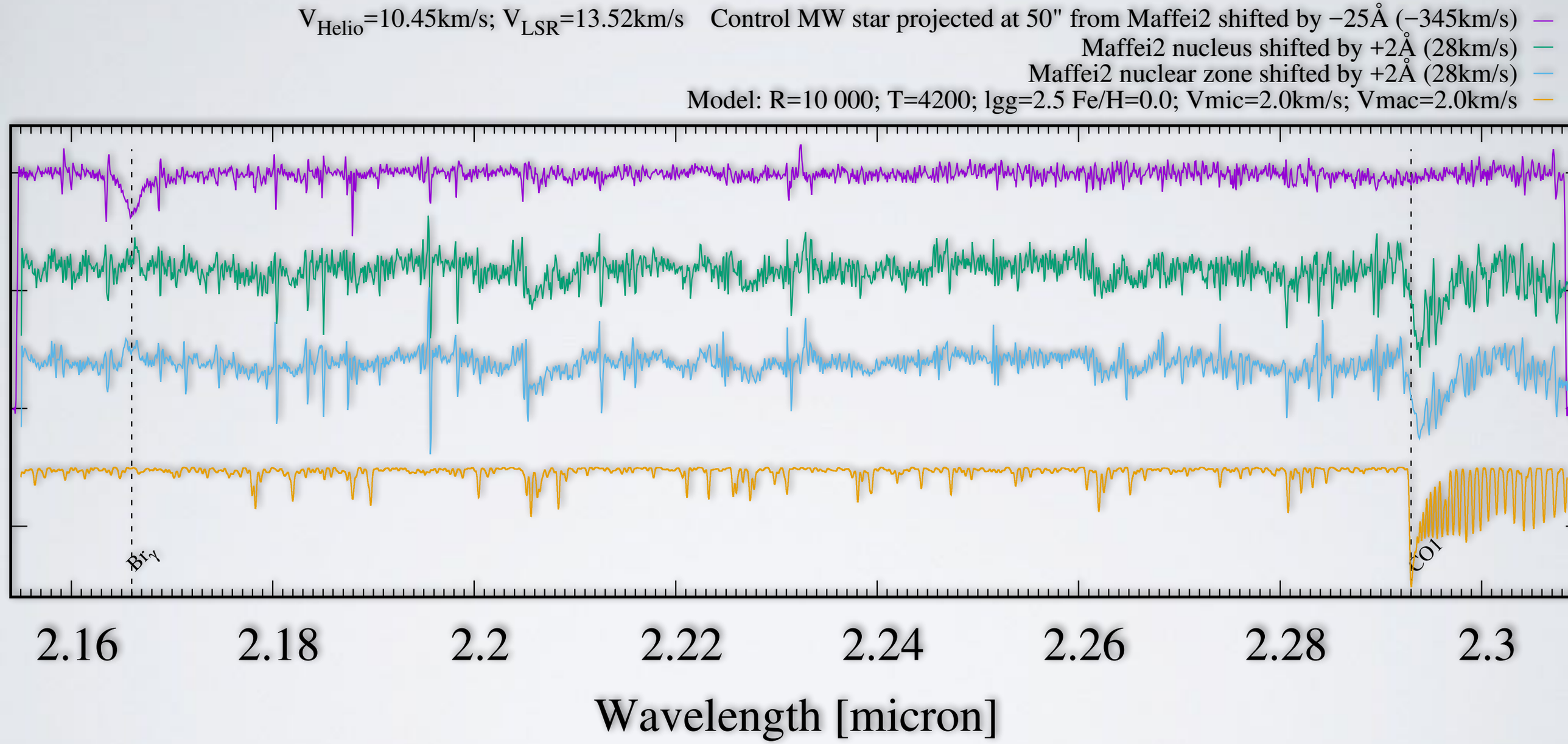
(2016/10)

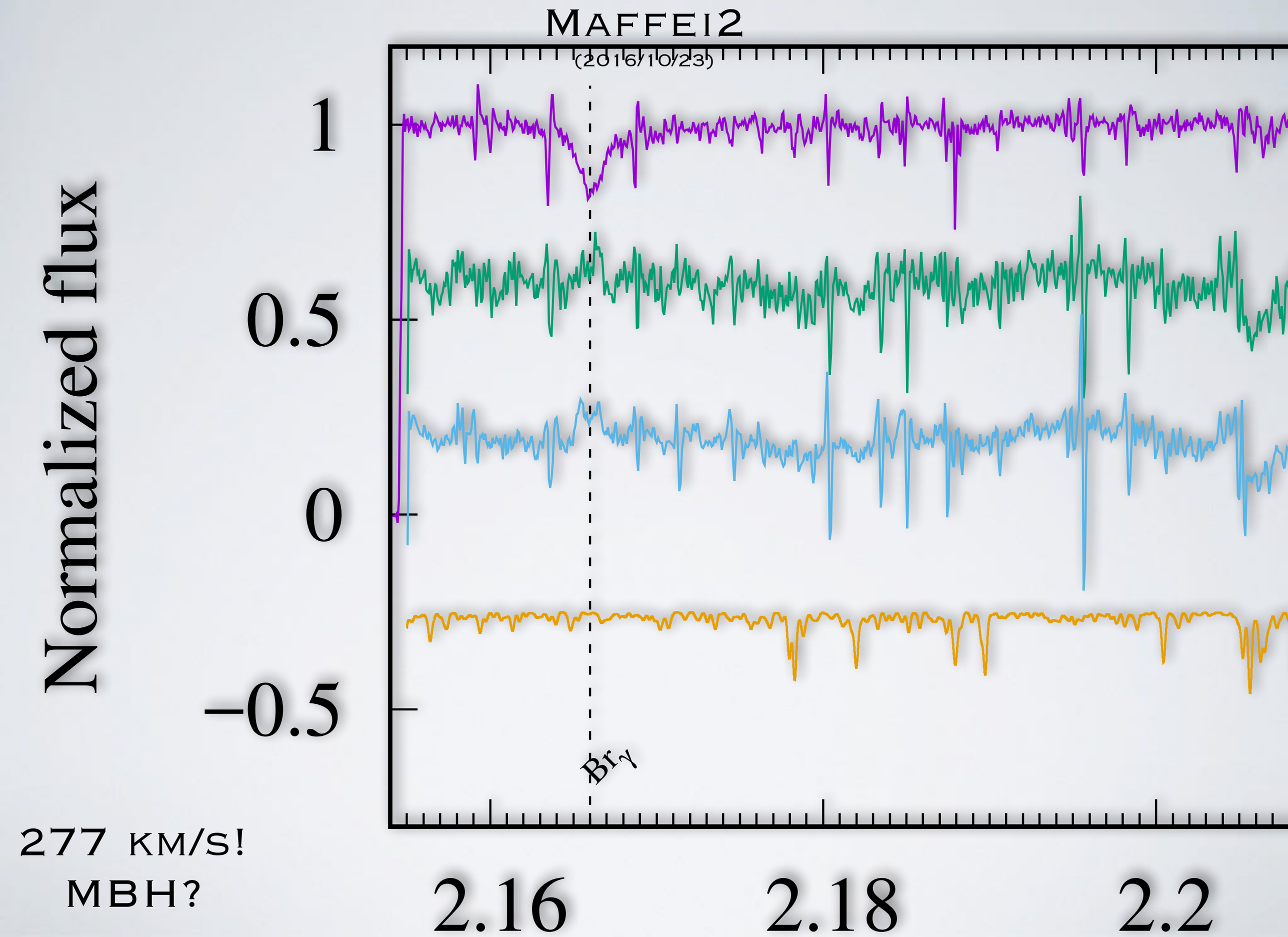



Maffei 2
(2016/10)
LBT / ARGOS & LUCI1
JHKs
1arcmin
~0.9Kpc

Maffei2

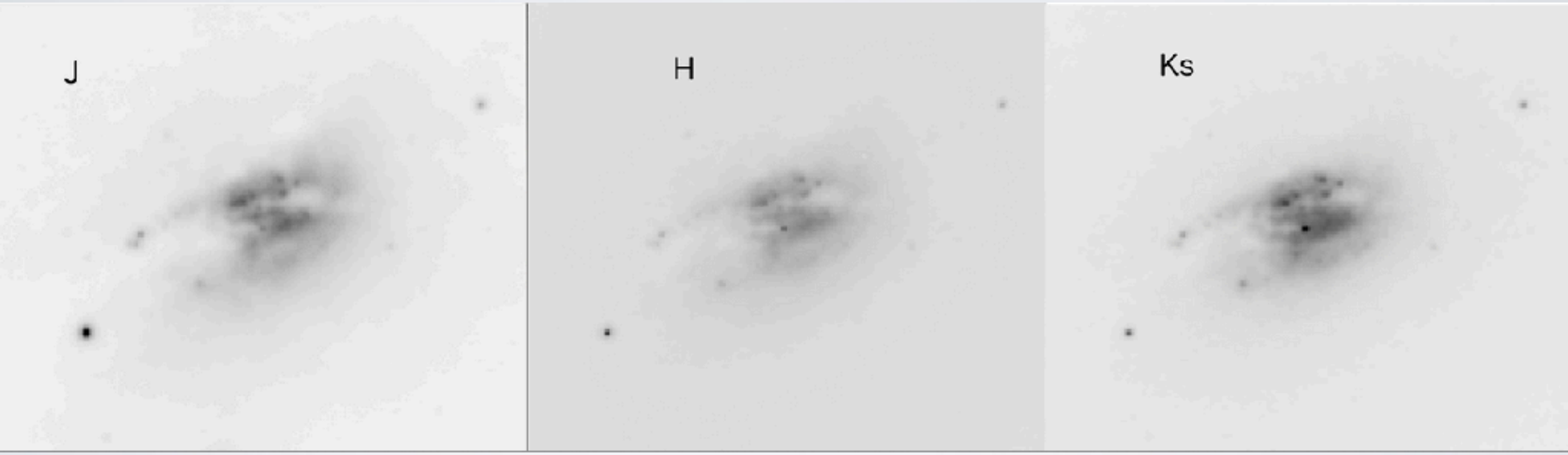
(2016/10/23)

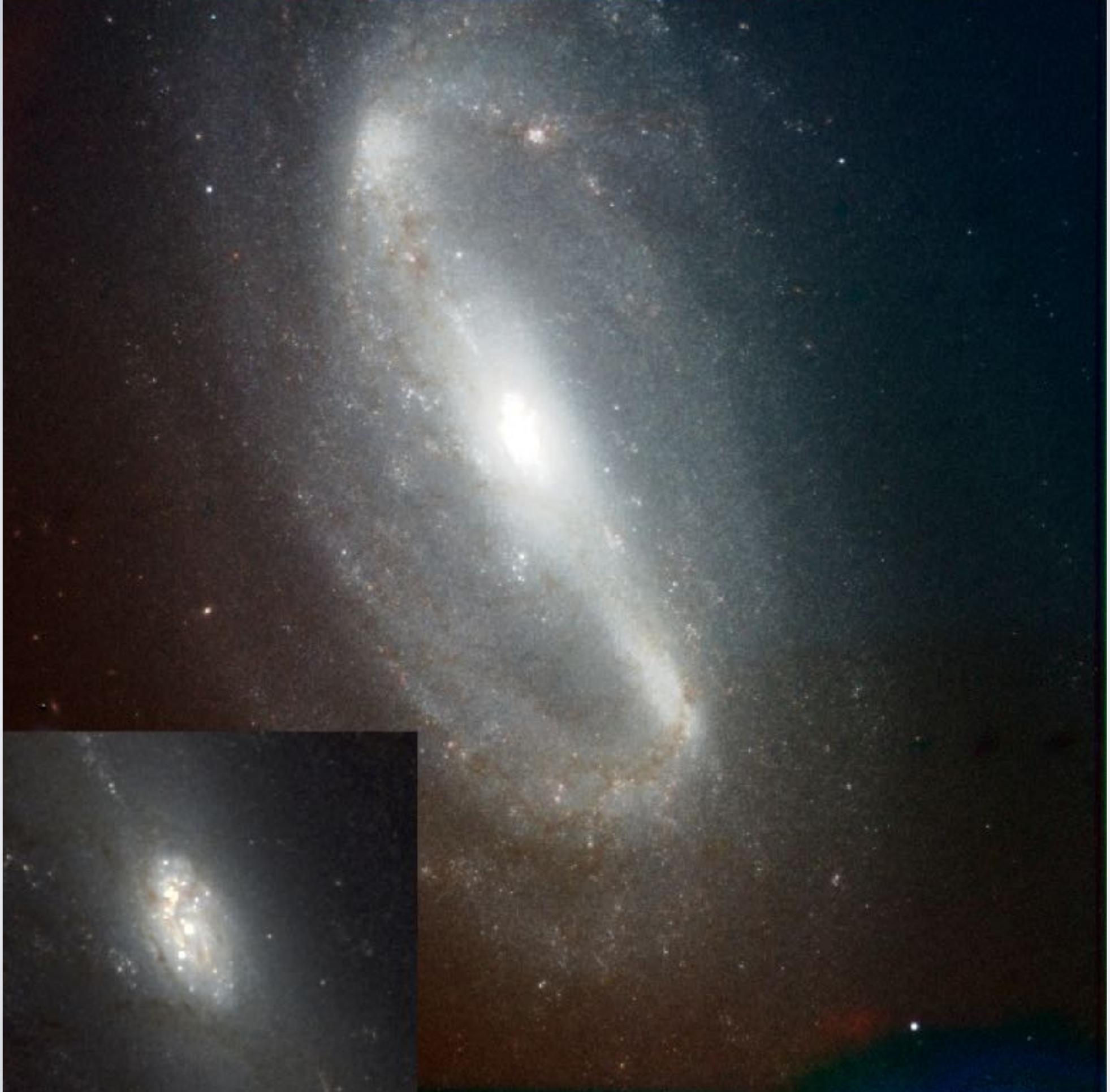



Maffei2
(2016/10/23)
Normalized flux
1
0.5
0
−0.5
Brγ
2.16
2.18
2.2
277 km/s!
MBH?

Maffei2

(2016/10/23)





NGC2903

(2017/03/14)

CONCLUSIONS

- Large Field High spatial resolution data is crucial!
- Multi-wavelength (HST+LBT): NSC stellar pops (AGN?)
- High-res K-band spectra: essential for NSC and MBH
- Reliable characterisation of NSC_s, host galaxies and their cluster populations

LBT/ARGOS/$LUCI_s$ expands the NSC scientific volume by **8x**

NIR Nuclear and Star cluster survey of late-type hosts:

Imaging (10)x30min JHKs: *M31, 51,101, Maffei 1&2, IC342, N2903, 4449, 6384, 6946*

Spectra(4)x1hr, K-band: *M51, Maffei 2, IC342, N4449*

http://www.mpia.de/~georgiev/LBT/colour.html