MASS CHARACTERIZATION OF STAR-FORMING GALAXIES IN THE LOCAL UNIVERSE

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Hel.a.S.et
Heraklion - 6th July 2017

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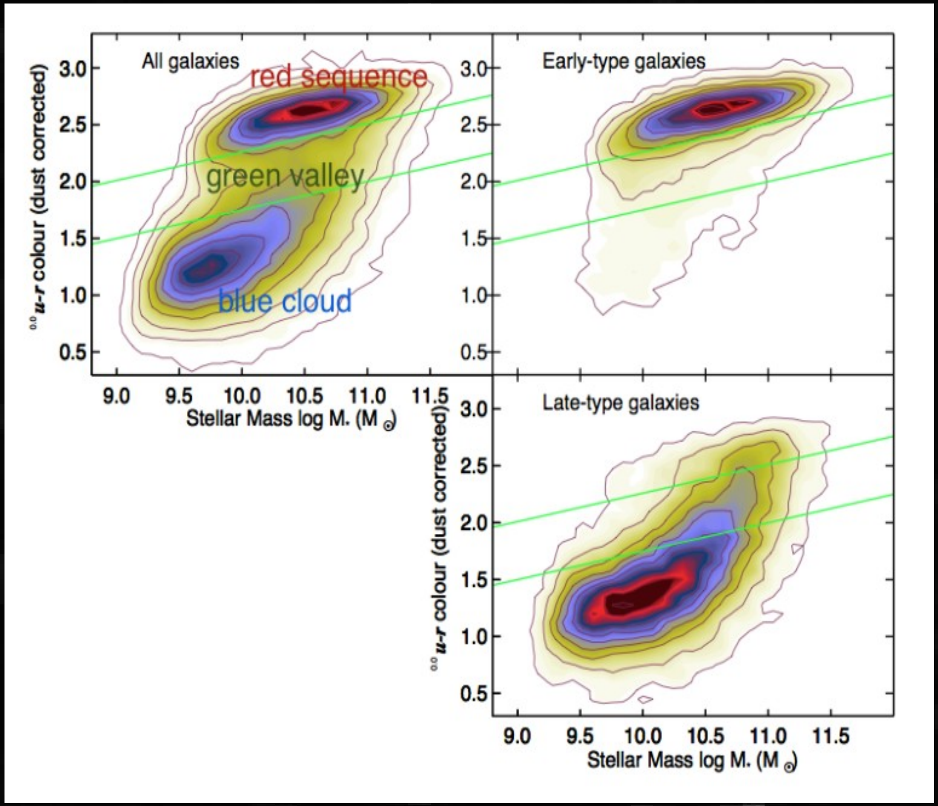
- ✪ Galaxy evolutionary tracks & star-forming galaxies
- ✪ Our working sample: the Star Formation Reference Survey
- ✪ Morphological decomposition of sample galaxies
- ✪ Mass functions (total & sub-components)

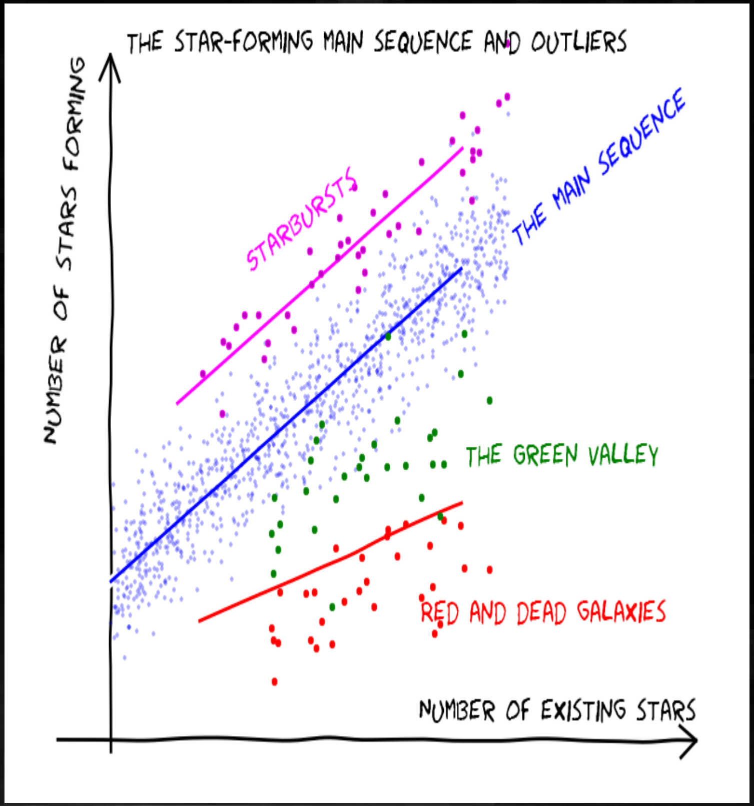
COLOR-MAGNITUDE DIAGRAM (CMD)

- CMD can be divided in broad groups:
  - blue cloud
  - red sequence
  - green valley
- … wich roughly relate to morphology:
  - late -type galaxies
  - early-type galaxies
  - mixed population
- … and to star-formation (SF) activity:
  - actively star-forming
  - poor star-formation
  - reducing star-formation (?)
- Green valley is poorly populated
  → transition red ⟷ blue must occur fast



[Image credit: Galaxy Zoo]

STAR-FORMATION MAIN SEQUENCE



[Image credit: CANDELS collaboration]

✪ If we look at the star-formation activity: (star-formation rate *vs* mass)

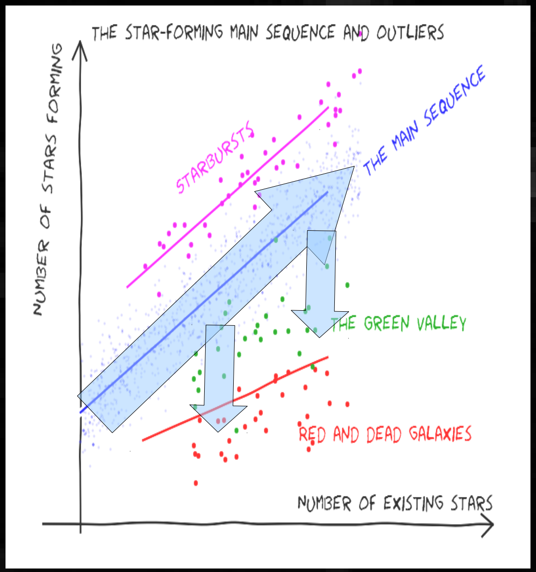
- ▸ star-forming galaxies form a “main sequence”
- ▸ “dead” galaxies form a “compact” cloud
- ▸ transitional objects
- ▸ merger-driven sturbust galaxies

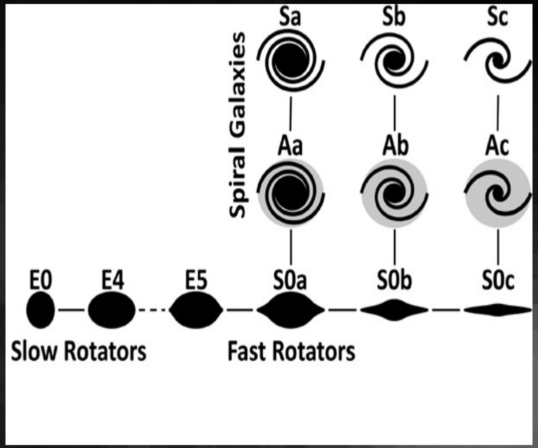
(e.g. Rodighiero 2011)
(see talk by Magdis, Charmandaris, etc.)

NOTE: the SF main sequence even holds at sub-galactic scales — similar slope (see talk by Maragkoudakis)

→ THESE RESULTS SUGGEST A GENERAL EVOLUTIONARY TRACK

GENERAL EVOLUTIONARY TRACK





[Image credit: ATLAS^{3D} collaboration]

- ✪ 0th order interpretation:
  - ▸ galaxies evolve along main sequence
  - ▸ if SF turns off / merger, they transit to the red cloud
  - ▸ then, they evolve passively

- ✪ Morphologically, this is consistent with the revised "tuning fork" from IFU studies

THE HARD REALITY

✪ SF → several mechanisms can tune the duration, e.g.:

(see talk by Naab)

▸ stellar/AGN outflows
(Di Matteo, Springel, & Hernquist 2005; Hopkins et al. 2010b; Fan et al. 2010)

▸ environment affects cold gas inflow
(e.g. Balogh et al. 1997; Lewis et al. 2002)

▸ morphological quenching
(Martig et al. 2009)

✪ Mergers → significance varies with mass scale
→ e.g. most massive early-types might require two-phase formation:

▸ direct collapse

▸ minor merger sequence

(Oser et al. 2010; Driver et al. 2013; Naab 2013)

HOW TO DISTINGUISH BETWEEN EVOLUTIONARY PATHS?

- Mass & morphology are fundamental parameters
  NOTE: stellar mass is the integrated product of star-formation + mergers → related to "timescale" of mass assembly

- We studied these properties on nearby, star-forming galaxies

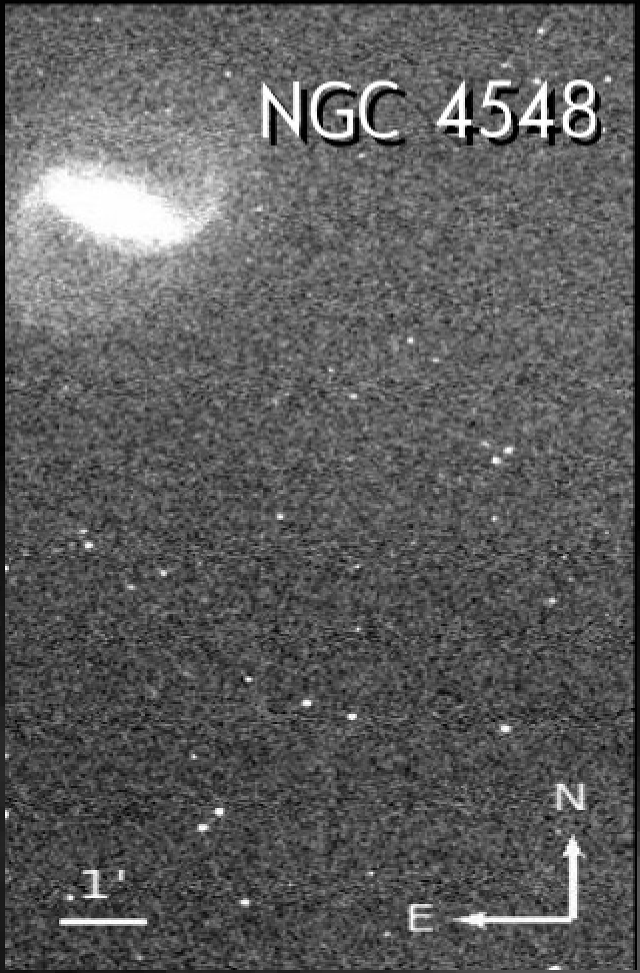
- We used the sample of the multiwavelength Star Formation Reference Survey (SFRS) *(Ashby et al. 2012)*

▸ Parent sample: IRAS PSCz catalogue *(Saunders, 2000)*

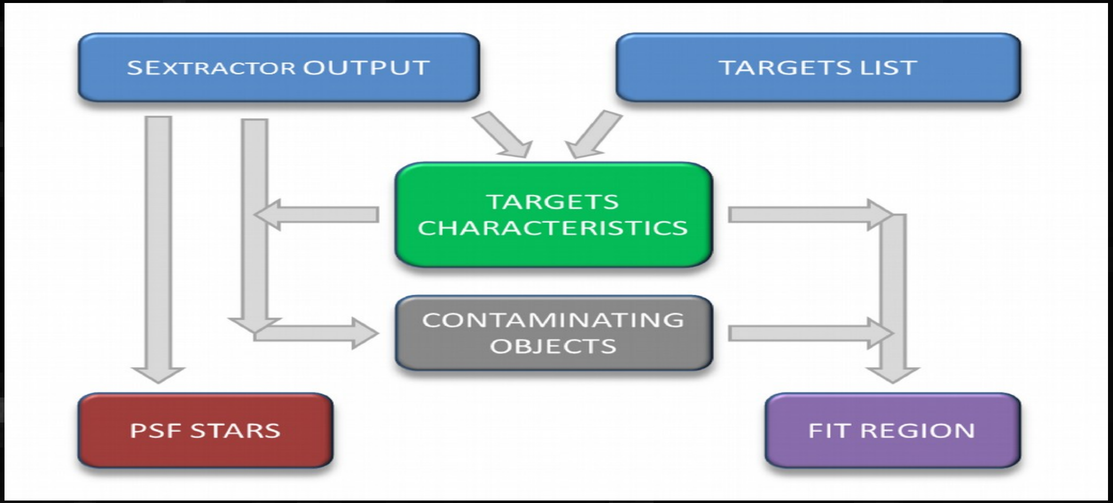
▸ 369 galaxies sampled from the 3D space:
Luminosity → IRAS 60μm
Specific SFR → F_{60} / K_s
Dust T → F_{100} / F_{60}

DATA & ANALYSIS PROCEDURE

- To study the galaxian masses, we used *K*-band images from 2MASS

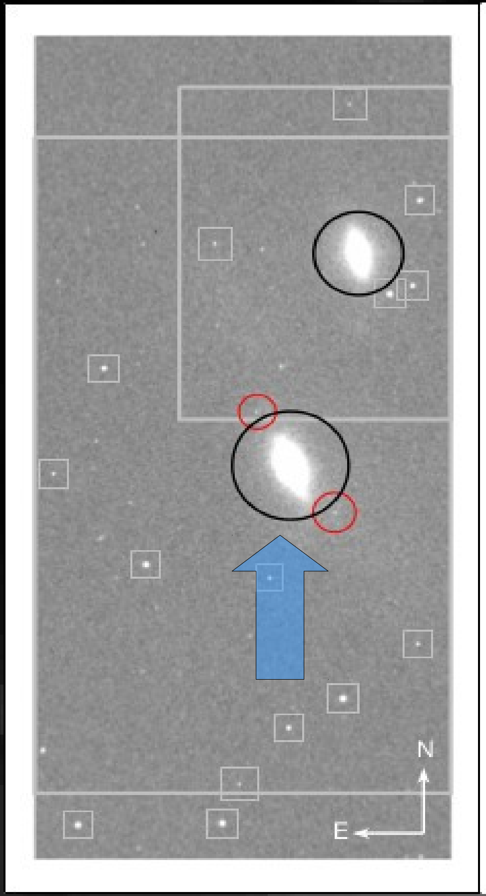


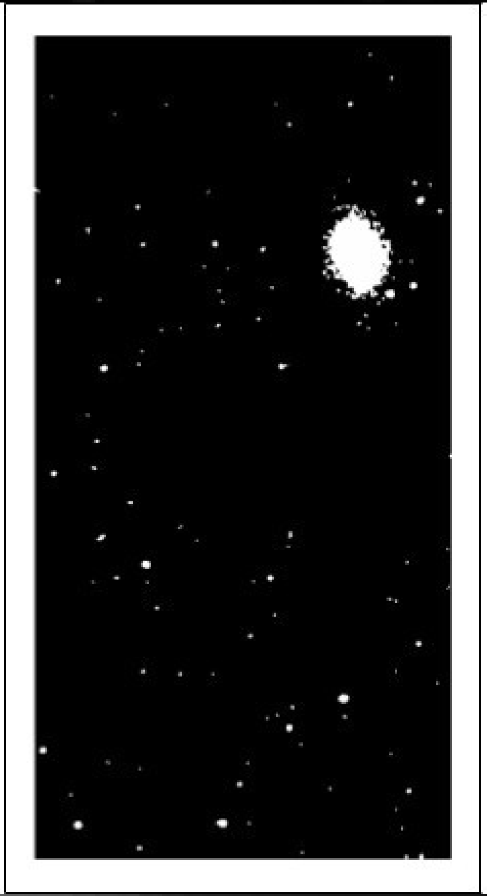
- We performed 2D bulge/disk decomposition (using GALFIT; *Peng 2010*)

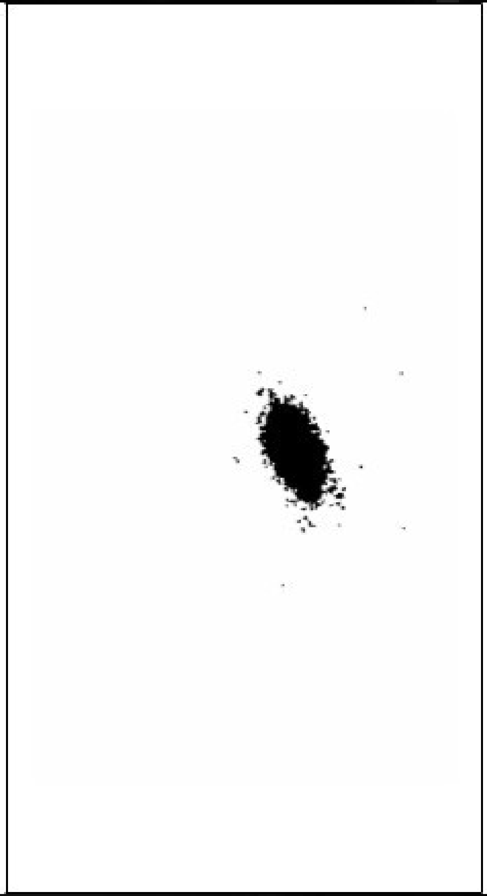


- Our pipeline automatically:
  - detect SFRS sources in 2MASS
  - masks/fits contaminanting objects
  - creates PSF (for fit convolution)
  - calculates zeropoint

PRE-FITTING: EXAMPLE







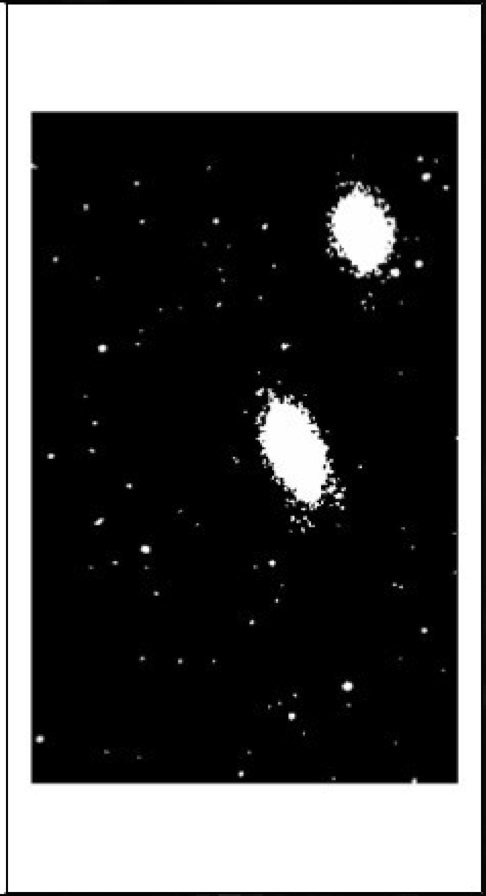
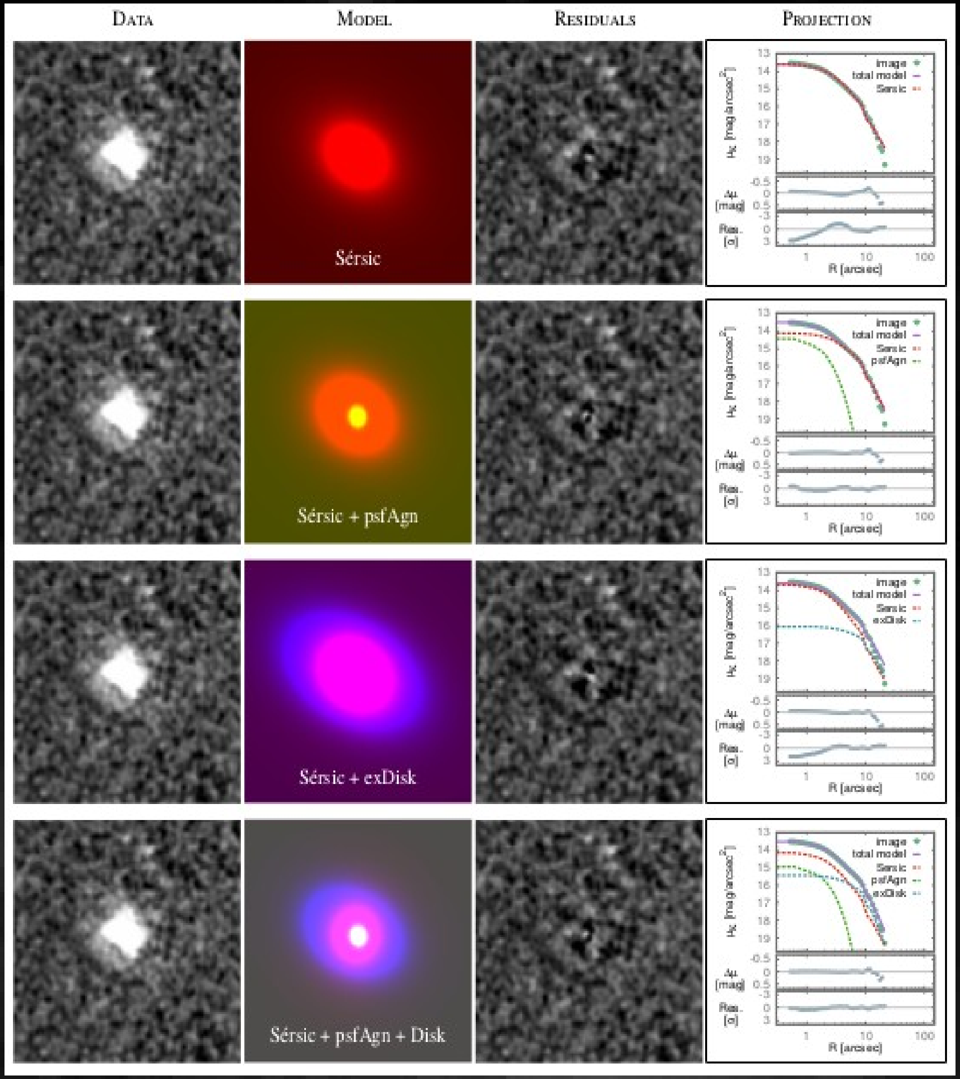


IMAGE MASK OBJECT AREA BACKG AREA

FITTING: EXAMPLE



- For each object, we attempt fitting:
  - Sersic
  - Sersic + PSF
  - Sersic + exDisk
  - Sersic + exDisk + PSF
- Models represent different bulge / total ratios (B/T)

→ *HOW TO SELECT BEST-FIT?*

BEST-FIT SELECTION

✪ We use a sophisticated, educated-guess procedure:

1 ▸ Accounting for central source
(identification by Maragkoudakis, A.)

➞ AGN (Sy) ↔ required a model with a PSF component
➞ HII ↔ no constraints
➞ T.O. ↔ priority to the Sersic + exDisk + PSF

2 ▸ Definition of best-statistics: excess variance *(Vaughan 2003)*:

$$\sigma^2_{XS} = \sigma^2_{objects} - \sigma_{sky}{}^2$$

$$\delta\sigma^2_{XS} = \sqrt{\frac{2}{N_{objects}} \cdot (\sigma_{sky}{}^2)^2}$$

NOTE: models use different number/type of components ➞ cannot use $\chi_\nu{}^2$

3 ▸ Selection of "pool" around $\sigma_{XS} \pm \delta\sigma_{XS}$

4 ▸ Selection of simplest model (least components)

BEST-FIT SELECTION

✪ We use a sophisticated, educated-guess procedure:

1 ▸ Accounting for central source
(spectral identification by Maragkoudakis, A.)

- ➞ AGN (Sy) ↔ required a model with a PSF component
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METHOD TESTED BY VISUAL INSPECTION OF RESIDUALS & RADIAL PROFILES

2 ▸ Definition of best-statistics: excess variance *(Vaughan 2003)*:

$$\sigma^2_{XS} = \sigma^2_{objects} - \sigma^2_{sky} \qquad \delta\sigma^2_{XS} = \sqrt{\frac{2}{N_{objects}}}(\sigma_{sky})^2$$

NOTE: models use different number/type of components → cannot use χ_ν^2

3 ▸ Selection [illegible] around σXS ± δσXS

4 ▸ Selection of simplest model (least components)

BULGE / DISK DECOMPOSITION

- ✪ Trivial in case best/fit model resulted the Sersic + exDisk + PSF:
  - ▸ Sersic → bulge
  - ▸ exDisk → disk
  - ▸ PSF → AGN

- ✪ In other cases, we also accounted for:
  - ▸ nature of central source
  - ▸ Sersic index
  - ▸ concentration *(followng Gadotti 2009 & Lackner & Gunn 2012)*

Decisional Algorithm for Bulge/Disk Decomposition

Model	Bulge component	Disk Component	Mixed Component	AGN Component
Sérsic$^{n=1}$	-	Sérsic$^{n=1}$	-	-
Sérsic$^{n=4}$	Sérsic$^{n=4}$	-	-	-
Sérsic	-	-	Sérsic $n > 1.5$	-
	-	Sérsic $n < 1.5$	-	-
Sérsic + psfAgn	[illegible]	Sérsic $n < 1.5$	-	psfAgn
	-	-	Sérsic $n > 1.5$	psfAgn
	psfAgn	Sérsic	-	-
Sérsic$^{n=4}$ + exDisk	Sérsic$^{n=4}$	exDisk	-	-
Sérsic$^{n=4}$ + exDisk + psfAgn	Sérsic$^{n=4}$	exDisk	-	psfAgn

IT'S COMPLICATED !

CONSTRUCTION OF MASS FUNCTIONS (MFs)

- From the *K*-band luminosities, masses are readily derived assuming M / L:
  We used Bell (2003) + SDSS colors

$$\frac{M}{M_\odot} = 10^{-0.273+(0.091\times(u-r))} \times \frac{L_K}{L_\odot}$$

- MF derivation with V/V MAX technique:
  - bin the M distribution
  - evaluate completeness (representativeness) of sources in bin
  - divide by the volume occupied by the sources in the bin

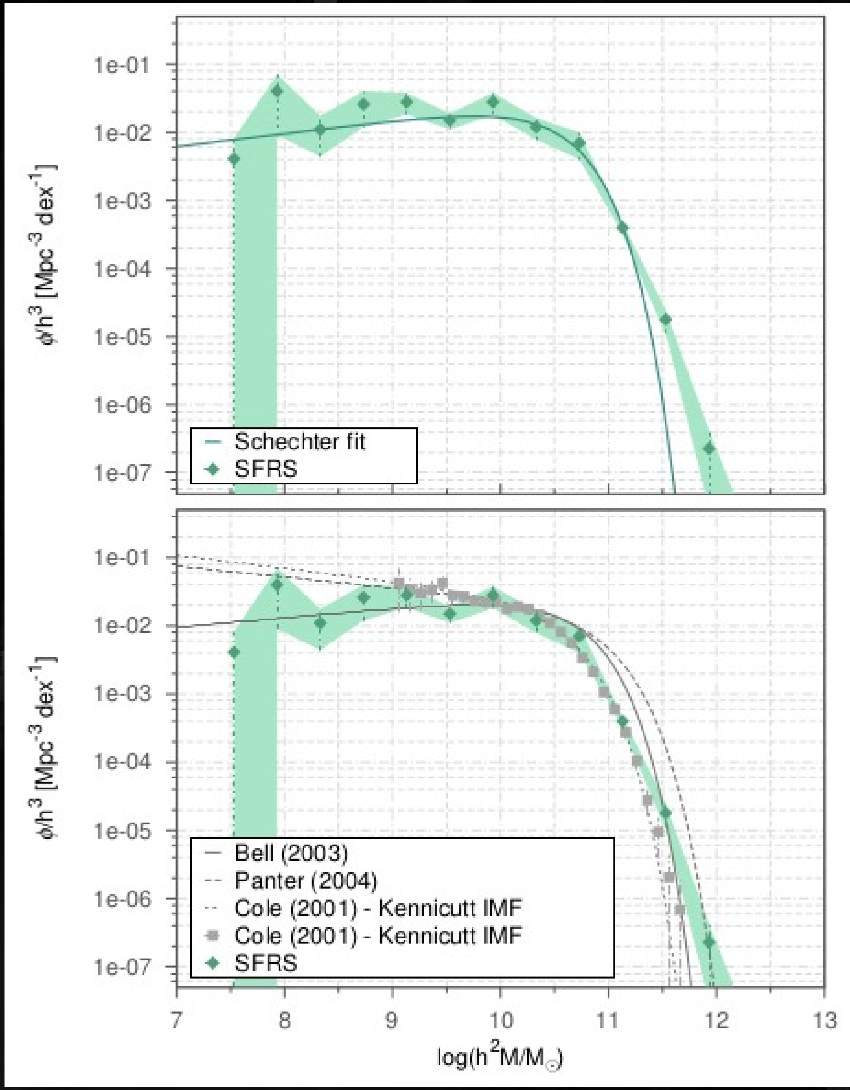
- We produced MFs for the total, and for the disk and bulge sub-components

MASS FUNCTION: TOTAL

✪ Comparison with optically-selected samples:
(Bell, 2003 – SDSS)
(Panter, 2004 – SDSS)

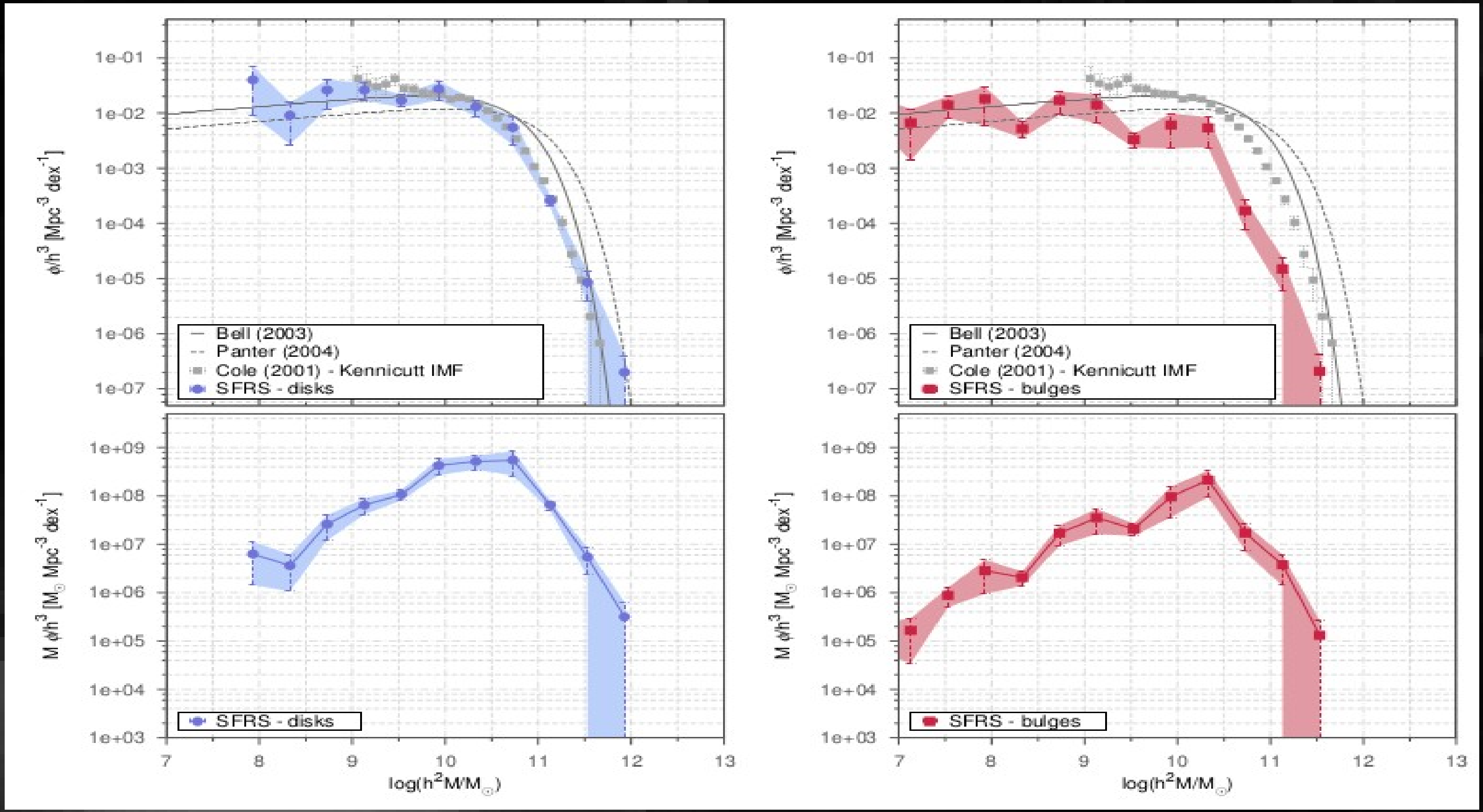
→ SFRS FIR-selection picks up less massive active galaxies

✪ Comparison with NIR-selected sample:
Cole (2001 – 2MASS)
▸ agreement all over the range
▸ low-end extends consistently



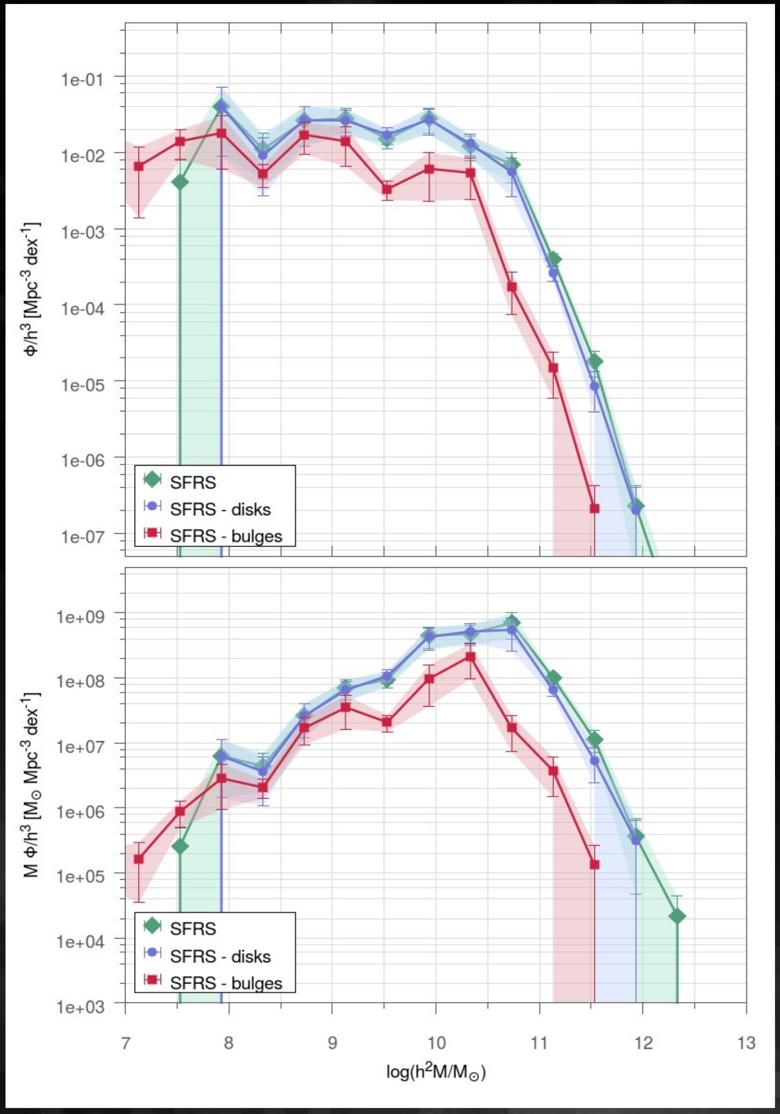
MASS & MASS DENSITY FUNCTION: DISKS & BULGES

TOP: Mass function = [local] # galaxies / co-moving volume



BOTTOM: Mass *density* function = [local] mass / co-moving volume

MASS & MASS DENSITY FUNCTION: COMPARISON



✪ Contribution of disks/bulges to mass-density:

- lowest-end → only bulges
- low-to-mid range → comparable
- high-end → disks dominate

→ most of mass of star-forming galaxies is in disks

✪ However: M* (disks) ~ M* (bulges)

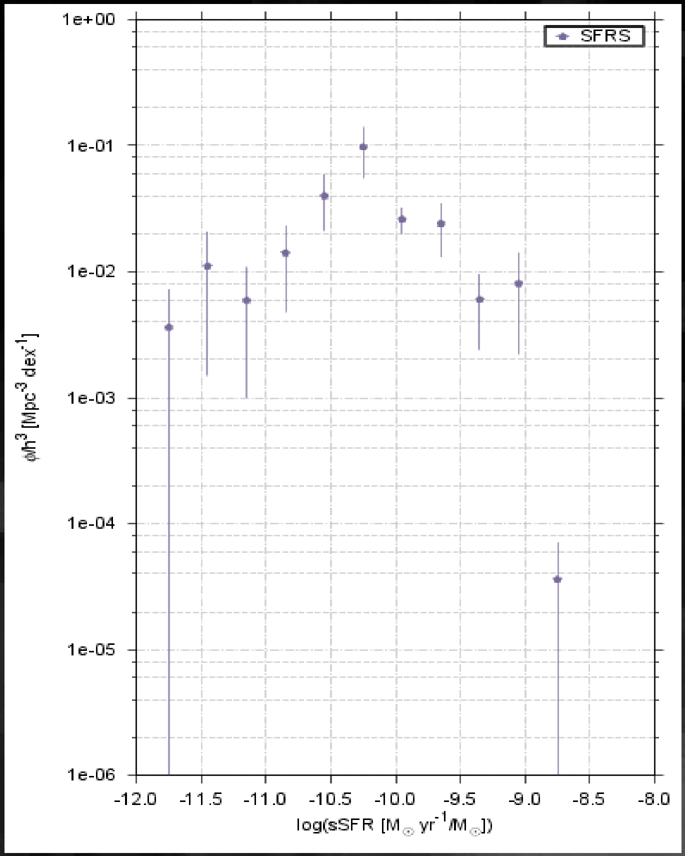
→ ON AVERAGE: same density of stars formed *now* and in the *past* (?)

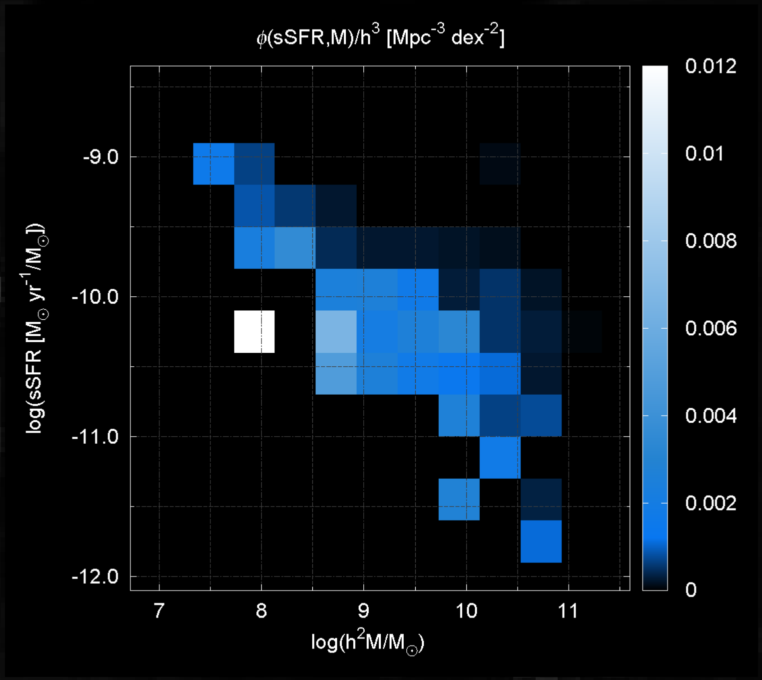
→ Bonfini, Zezas, Maragkoudakis et al. ready for submission

IN PREPARATION

LEFT: sSFR function
= *volume-weighted*
galaxies with given sSFR

RIGHT: bivariate sSFR – Mass function
= *volume-weighted*
galaxies with given sSFR and $M_\star$





→ proper way to study the SF main-sequence!
(previous studies to not weight by volume)

SUMMARY

- ✪ We developed a modern bulge/disk decomposition algorithm
- ✪ We produced stellar MF for star-forming galaxies
- ✪ We separated the contribution of disks and bulges

  → ideal benchmarks for cosmological simulations at z ~ 0

- ✪ Close future: sSFR & volume-weighted sSFR – $M_\star$ function
- ✪ Near future: sSFR (sub-galactic) maps of SFRS galaxies
  (in collaboration with Kouroumpatzakis, K. & Zezas, A.)

THANK YOU

Gratzy e
arrivedourci !