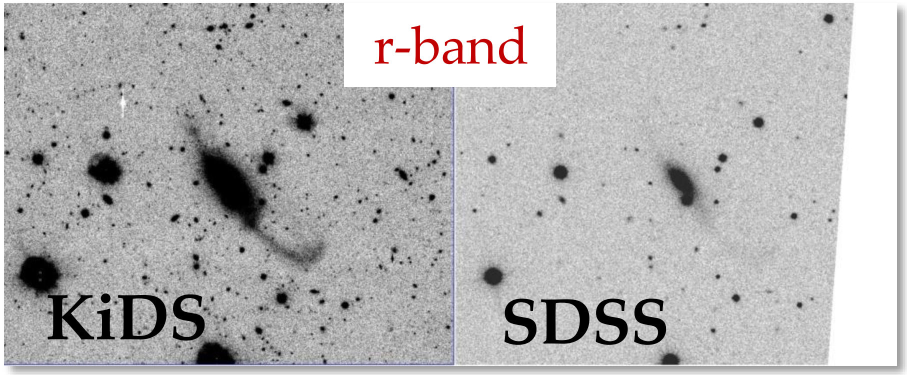
Galaxy mass assembly in KiDS: dynamics and gravitational lensing



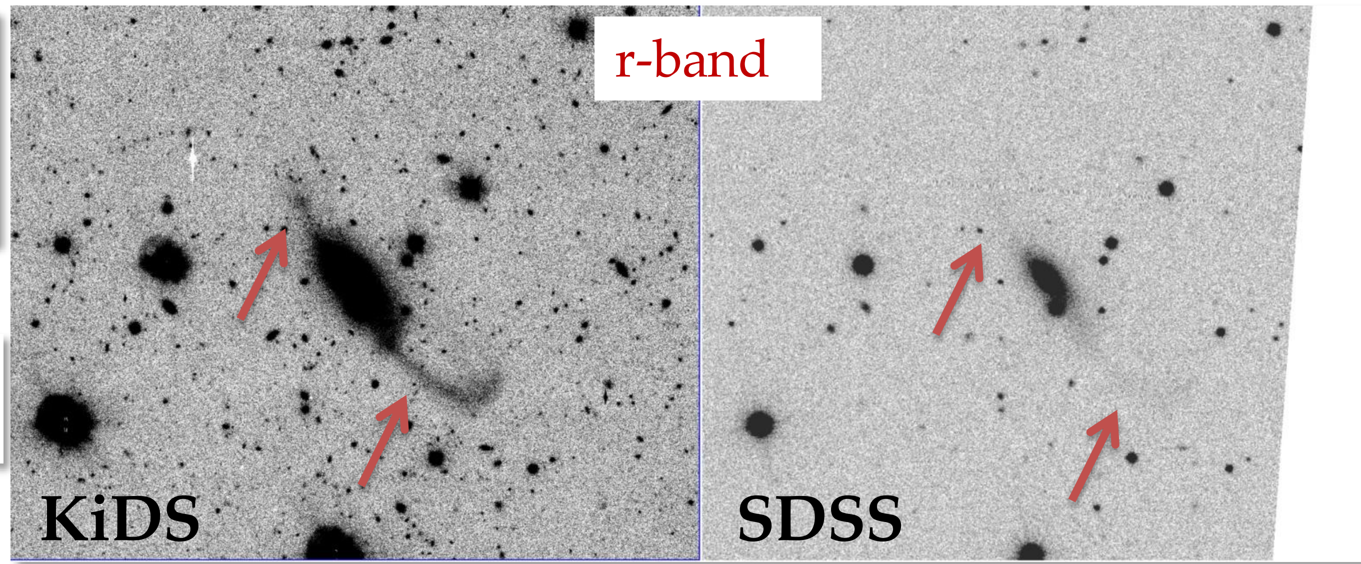
university of groningen

Crescenzo Tortora

KiDS@VST aims to image 1500 square degrees in 4 optical bands (complemented in the NIR with VIKING@VISTA).

Deeper and with better quality and higher spatial resolution than previous surveys.

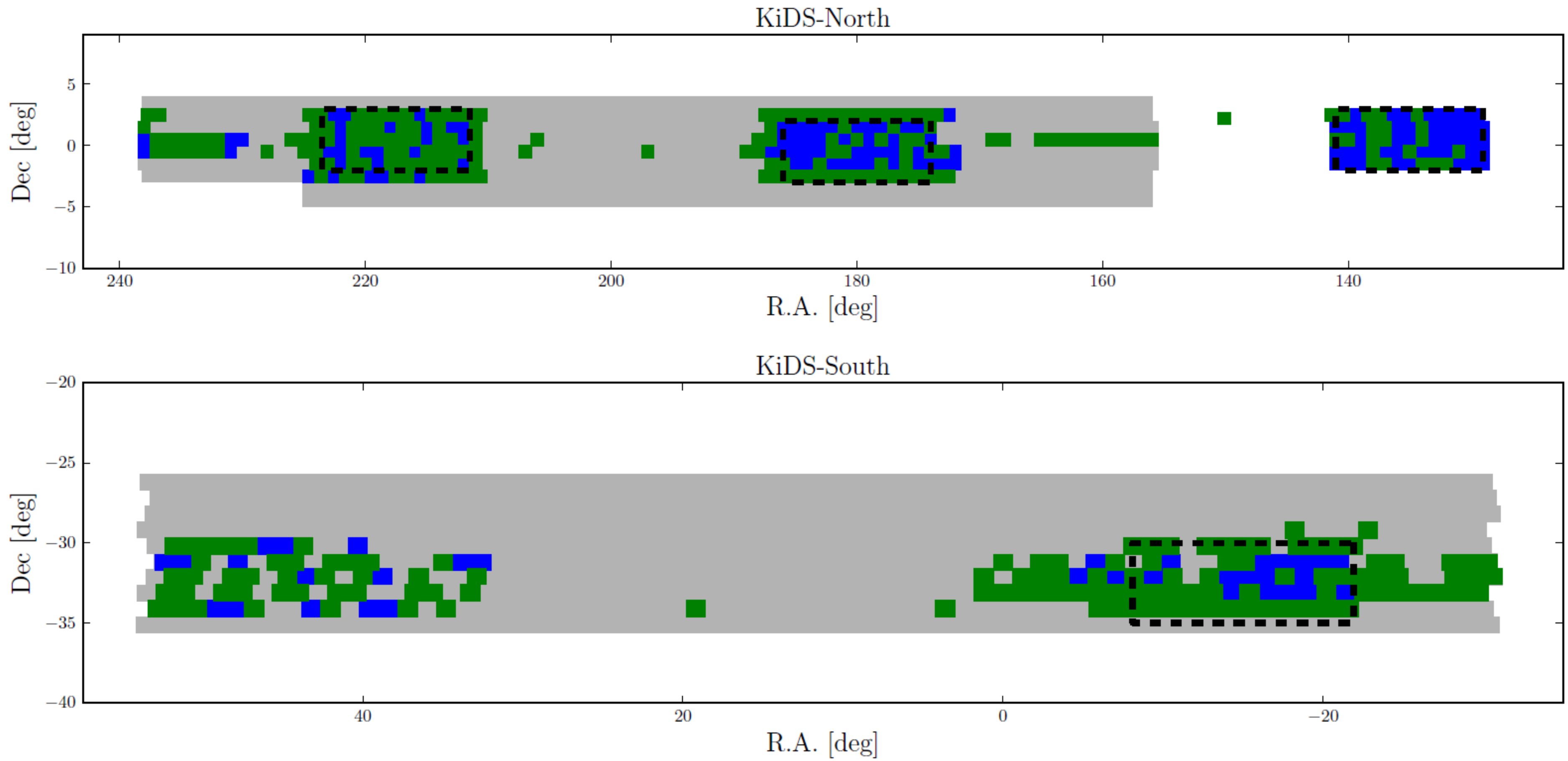
Pixel scale **0.21″/pxl**
Seeing **0.65″** (r-band)
Depth **r = 25** (r-band)



Why KiDS?

- dark matter and dark energy (via WL)
- **galaxy evolution**
- **search of strong lenses**
- search of galaxy clusters
- search of high redshift quasars.

Status of the survey (DR1+DR2+DR3)



440 tiles (447 sq. deg.)

The KiDS datasample (DR2+DR3)

440 tiles

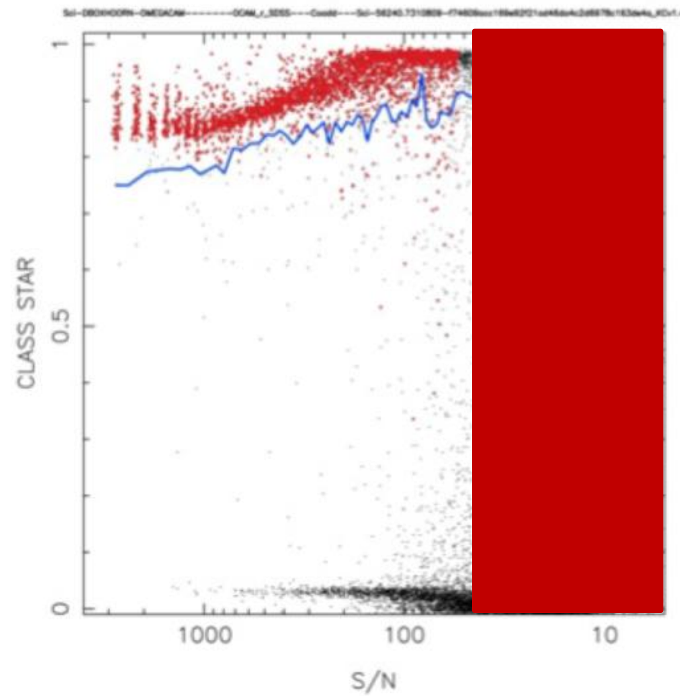
Sources: ~ 60 millions

Galaxies: ~ 22 millions (with BPZ redshift)
(after S/G separation with Sextractor)

> 3 millions with ML photo-z

High S/N_r (>50) galaxies: ~1 millions

Best surface photometry

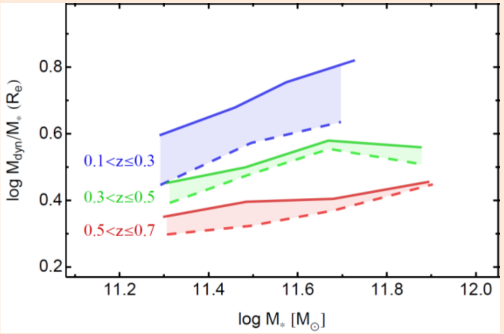


One of the largest datasamples with photometry and structural parameters measured in 4 bands up to z~0.5

KiDS outputs

1

Jeans modelling of massive ellipticals: dark matter and Initial mass function and constraints on physical processes
(Tortora et al. 2018, MNRAS, 473, 969)



2

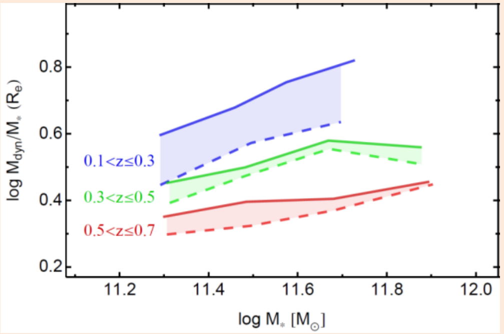
Census of **strong lenses** using
- **Visual inspection** *(Napolitano et al., in prep.)*
- **convolutional neural networks**

(Petrillo et al. 2017 MNRAS, 472, 1129; Napolitano et al,, in prep.; Spiniello et al. in prep.)

➤ Follow-up, in progress

1

Jeans modelling of massive ellipticals: dark matter and Initial mass function and constraints on physical processes
(Tortora et al. 2018, MNRAS, 473, 969)



The last 6 Gyr of dark matter assembly in massive galaxies from the Kilo Degree Survey

The sample

1

KiDS@VST aims to image 1500 sq. deg. in 4 optical bands

Pixel scale **0.21″/pxl**
Seeing **0.65″** (r-band)
Depth **r = 25** (r-band)

Deeper and with better quality and higher spatial resolution than previous surveys.

✓ Photometry for stellar masses
✓ high image quality for structural parameters

2

SDSS (BOSS and DR7) overlaps the KiDS fields and is the only chance to have spectroscopy for large samples of galaxies

✓ Spectroscopic redshifts
✓ Velocity dispersions

A complete sample of ~3800 galaxies (from 156 sq. deg.) with spectroscopic redshifts ($0 < z < 0.7$), stellar masses ($> 10^{11.2}$ solar masses), structural parameters and velocity dispersions.

The method

$$\frac{\mathrm{d}[j_\star(r)\sigma_r^2(r)]}{\mathrm{d}r} + 2\,\frac{\beta(r)}{r}\,j_\star(r)\sigma_r^2(r) = -j_\star(r)\,\frac{GM(r)}{r^2}$$

$$M_{\rm dyn}(R_{\rm e})/M_\star(R_{\rm e})$$

Assuming an isothermal profile and a Chabrier IMF

DM

$$f_{\rm DM}(R_{\rm e}) = 1 - M_\star(R_{\rm e})/M_{\rm dyn}(R_{\rm e})$$

References: Padmanabhan et al. 2004; Ferreras, Saha & Williams 2005; Bolton et al. 2006, 2008; Cappellari et al. 2006; Onorbe et al. 2007; Forbes et al. 2008; Cardone et al. 2009; Hyde & Bernardi 2009; Tortora et al. 2009; Ruszkowski & Springel 2009; Grillo et al. 2010; Napolitano, Romanowsky & Tortora 2010; Tortora et al. 2010; Auger et al. 2009, 2010; Cardone & Tortora 2010; Faure et al. 2011; Leier et al. 2011; More et al. 2011; Tortora et al. 2012; Cappellari et al. 2013; Oguri, Rusu & Falco 2014; Dutton & Treu 2014; Chae, Bernardi & Kravtsov 2014; Tortora et al. 2014; Beifiori et al. 2014; Nigoche-Netro et al. 2016; Remus et al. 2013, 2017, Xu et al. 2017, etc.

IMF

$$\delta_{\rm IMF} \equiv M_{\star,{\rm IMF}}(R_{\rm e})/M_\star(R_{\rm e})$$

References: Treu et al. 2010; Thomas et al. 2011; Conroy & van Dokkum 2012; Cappellari et al. 2012, 2013; Spiniello et al. 2012; Wegner et al. 2012; Dutton et al. 2013; Ferreras et al. 2013; Goudfrooij & Kruijssen 2013, 2014; La Barbera et al. 2013; Tortora et al. 2013; Weidner et al. 2013; Shu et al. 2014; Spiniello et al. 2014; Shetty & Cappellari 2014; Smith et al. 2014, 2015; Tortora et al. 2014a,c; Martin-Navarro et al. 2015; Posacki et al. 2015; Smith et al. 2015 ; Sonnenfeld et al. 2017; Leier et al. 2016; Lyubenova et al. 2016; Tortora et al. 2016; Corsini et al. 2017; Li et al. 2017; Sonnenfeld et al. 2017, etc.

5 question marks

- How DM fraction and IMF are correlated with galaxy mass?
- How DM is correlated with cosmic time (or redshift)?
- Is DM evolution explained by quasar feedback or galaxy merging?
- Is IMF evolution consistent with galaxy merging?
- Major or minor merging?

The last 6 Gyr of dark matter assembly in massive galaxies from the Kilo Degree Survey

C. Tortora[1⋆], N.R. Napolitano[2], N. Roy[2,3], M. Radovich[4], F. Getman[2], L.V.E. Koopmans[1], G. A. Verdoes Kleijn[1], K. H. Kuijken[5]

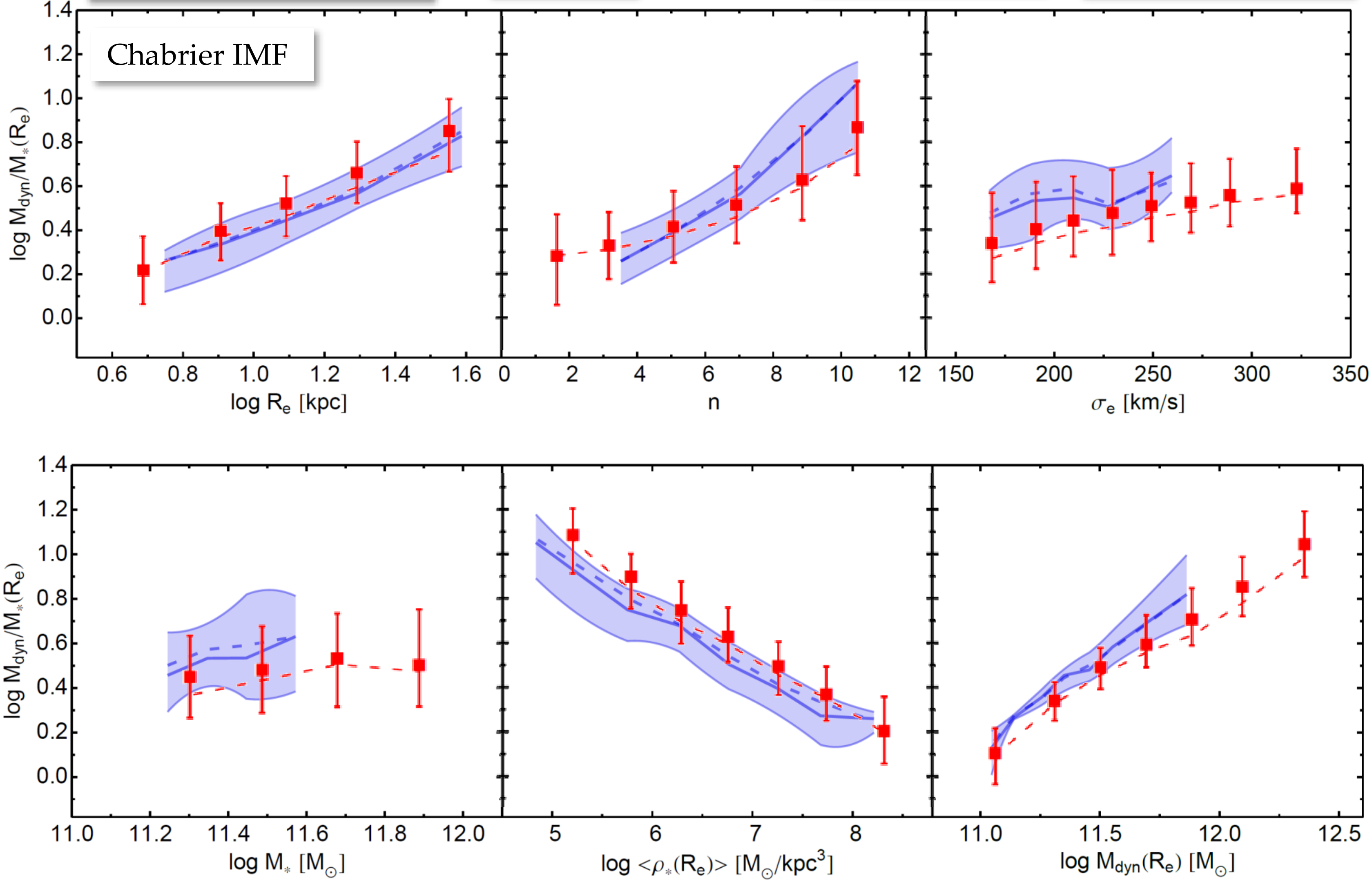
How DM fraction and IMF are correlated with galaxy mass?

DM scaling relations

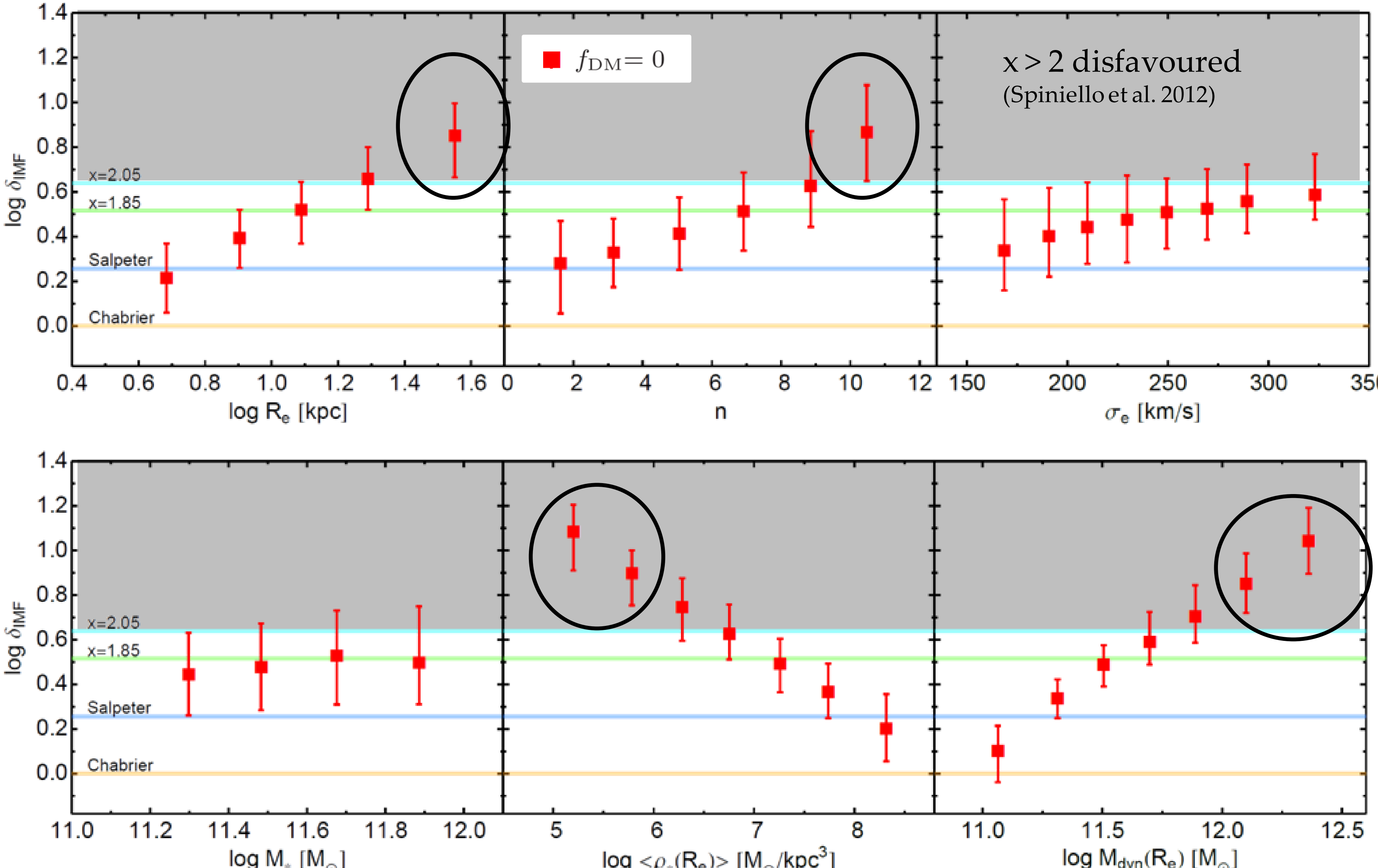
$\log M_{\star}/M_{\odot} > 11.2$ $z < 0.7$

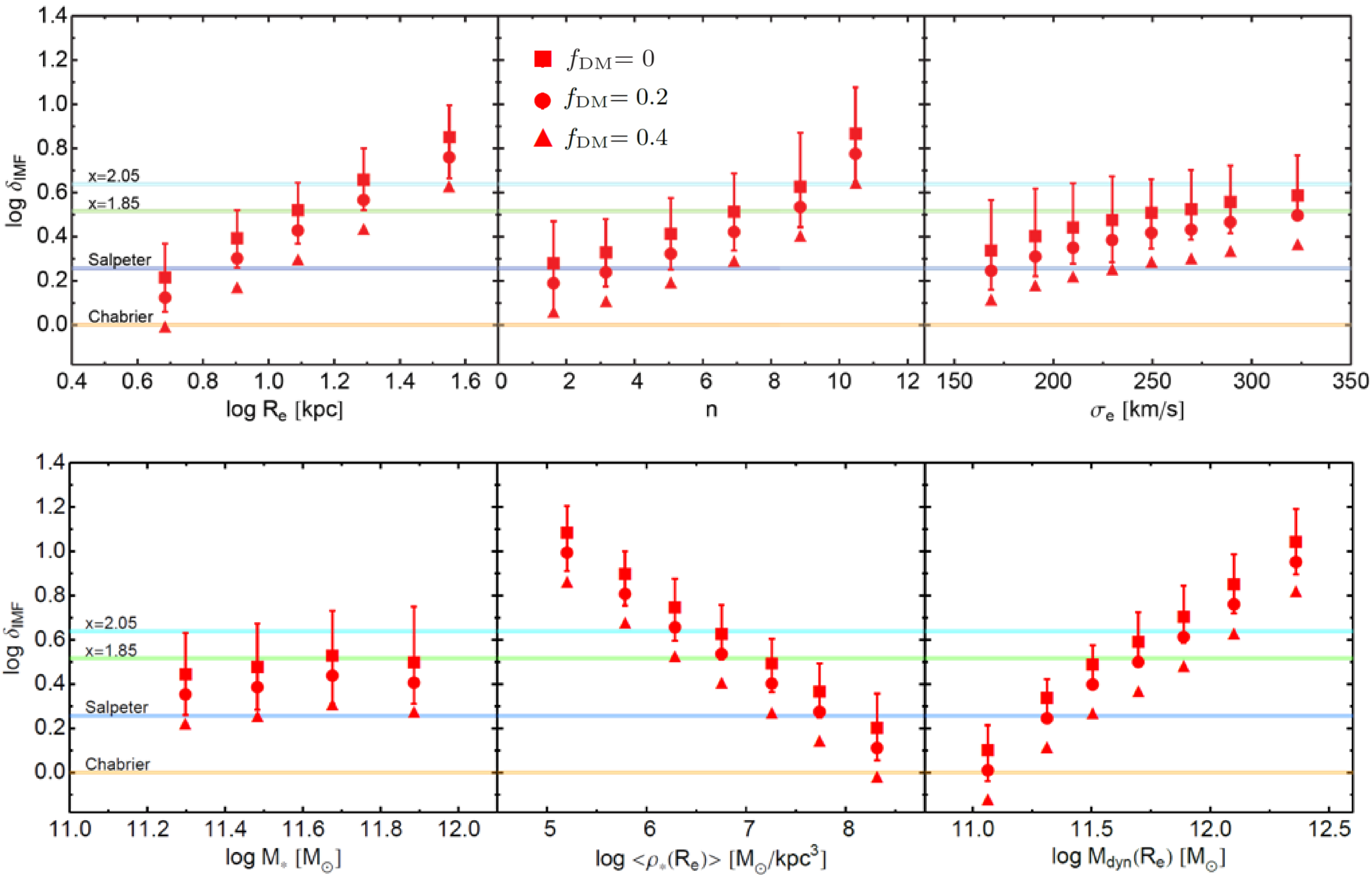
SPIDER ($z < 0.1$)

KiDS ($0 < z < 0.7$)



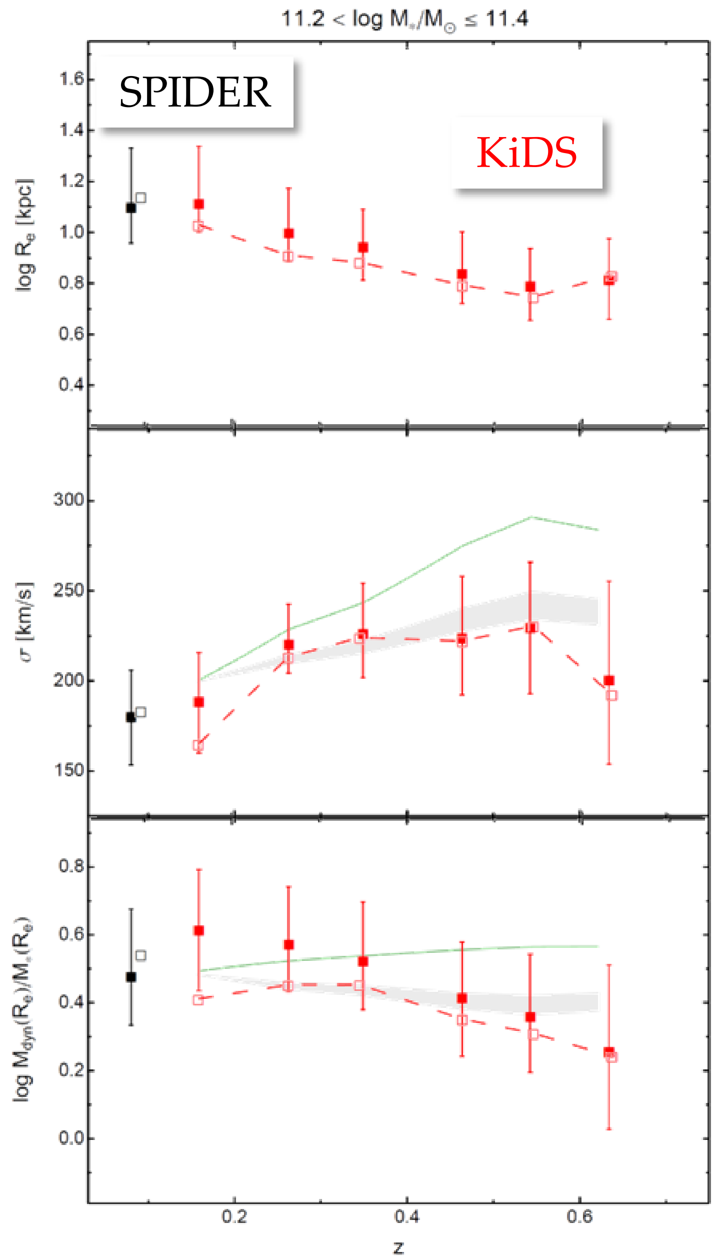
IMF?


$f_{DM} = 0$
x > 2 disfavoured
(Spiniello et al. 2012)
x=2.05
x=1.85
Salpeter
Chabrier
log δ_{IMF}
log R_e [kpc]
n
σ_e [km/s]
log M_* [$M_\odot$]
log $\langle\rho_*(R_e)\rangle$ [$M_\odot$/kpc^3]
log $M_{dyn}(R_e)$ [$M_\odot$]


f_{DM}= 0
f_{DM}= 0.2
f_{DM}= 0.4
x=2.05
x=1.85
Salpeter
Chabrier
log δ_{IMF}
log R_e [kpc]
n
σ_e [km/s]
log M_* [$M_\odot$]
log <$\rho_*(R_e)$> [$M_\odot$/kpc^3]
log $M_{dyn}(R_e)$ [$M_\odot$]

How DM is correlated with cosmic time (or redshift)?

Is DM evolution explained by quasar feedback or galaxy merging?



Evolution with redshift

- - - Progenitor bias (?)

Toy-models

— Puffing-up model
(Fan et al. 2008, 2010)

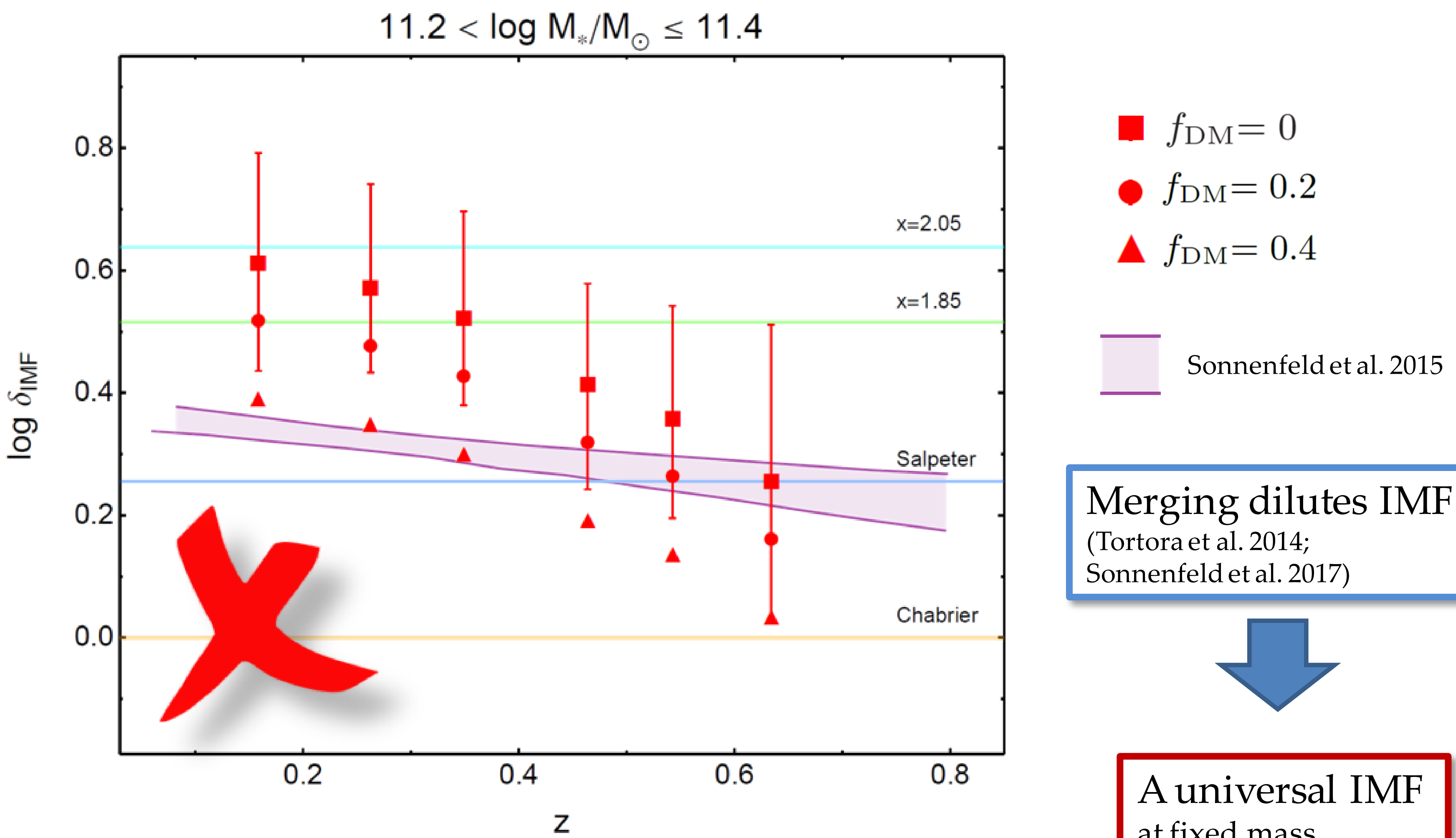
$$\sigma_\star(z) \propto R_e^{-1/2}$$

Merging model
(Hopkins et al. 2009)

$$\sigma_\star(z) \propto \frac{1}{\sqrt{1+\gamma}} \sqrt{\gamma + \frac{R_e(0)}{R_e(z)}}$$

$$\gamma \equiv (M_{halo}/R_{halo})/(M_\star/R_e)$$

Is IMF evolution consistent with galaxy merging?

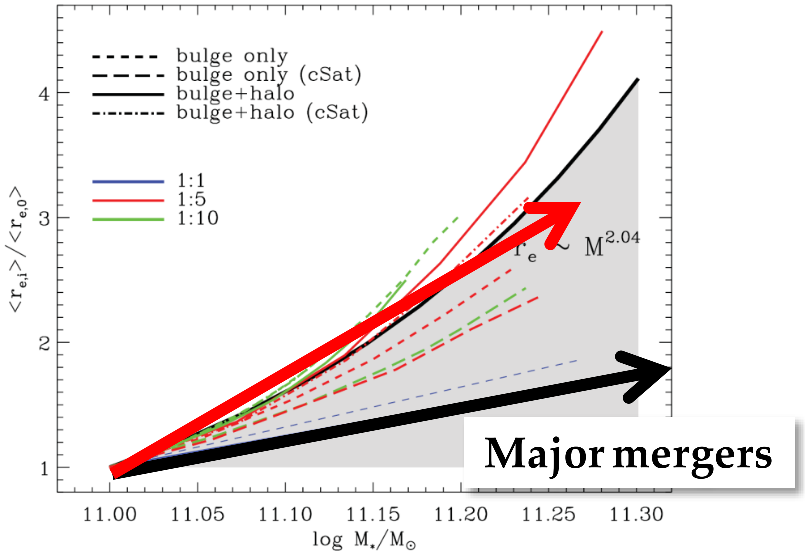


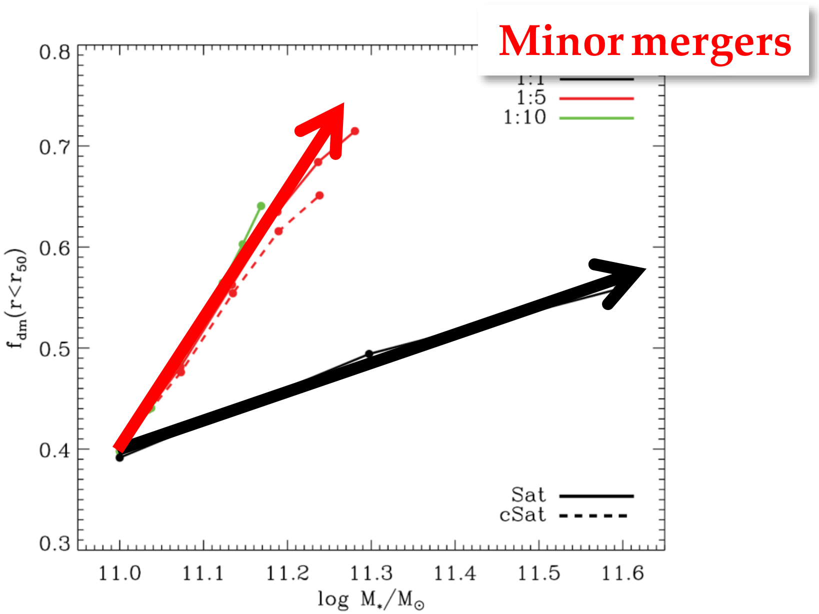
Merging dilutes IMF!!
(Tortora et al. 2014;
Sonnenfeld et al. 2017)

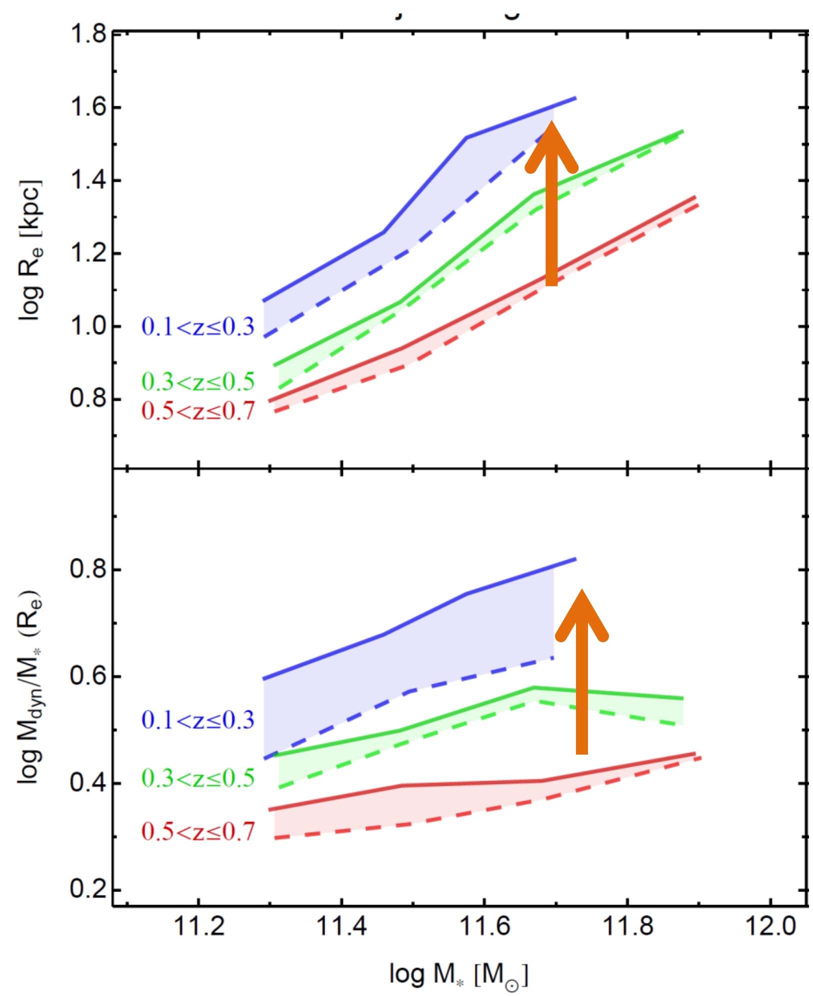
A universal IMF
at fixed mass

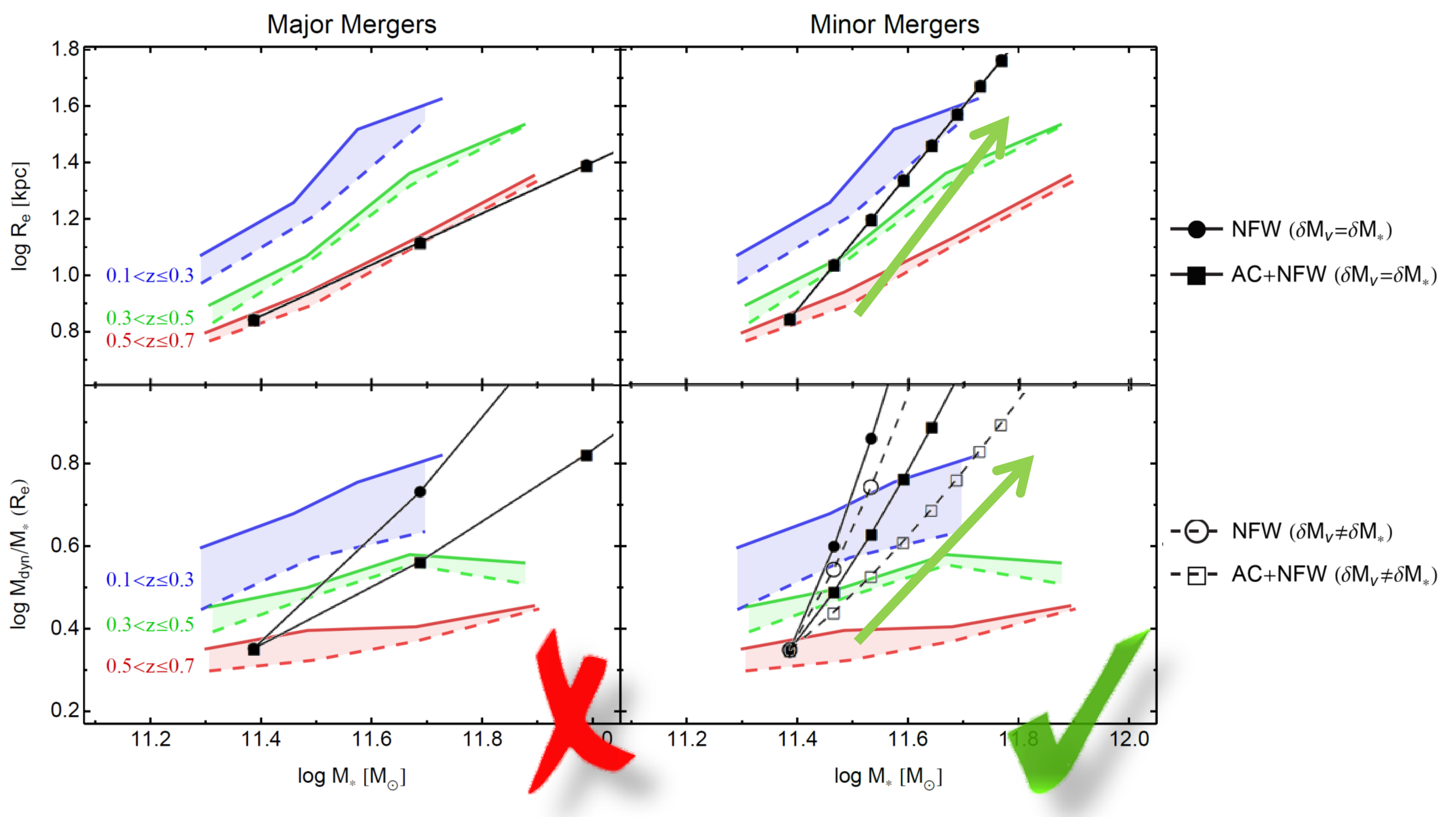
Major or minor merging?

Simulations of dissipationless mergers of spheroidal galaxies (Hilz et al. 2013)








Major Mergers
Minor Mergers
log Re [kpc]
log Mdyn/M* (Re)
0.1<z≤0.3
0.3<z≤0.5
0.5<z≤0.7
log M* [M☉]
NFW (δMv=δM*)
AC+NFW (δMv=δM*)
NFW (δMv≠δM*)
AC+NFW (δMv≠δM*)

Gravitational lenses in KiDS: the census

2

Census of **strong lenses** using
- **Visual inspection** *(Napolitano et al., in prep.)*
- **convolutional neural networks** *(Petrillo et al. 2017 MNRAS, 472, 1129; Napolitano et al,, in prep.; Spiniello et al. in prep.)*

➢ Follow-up, in progress

The census

Gravitational lenses: strategy

Now: ~ 600 lenses known

1. **Visual inspection**
2. **Automated search**

KiDS: ~ +1000 lenses

Gravitational lenses: strategy

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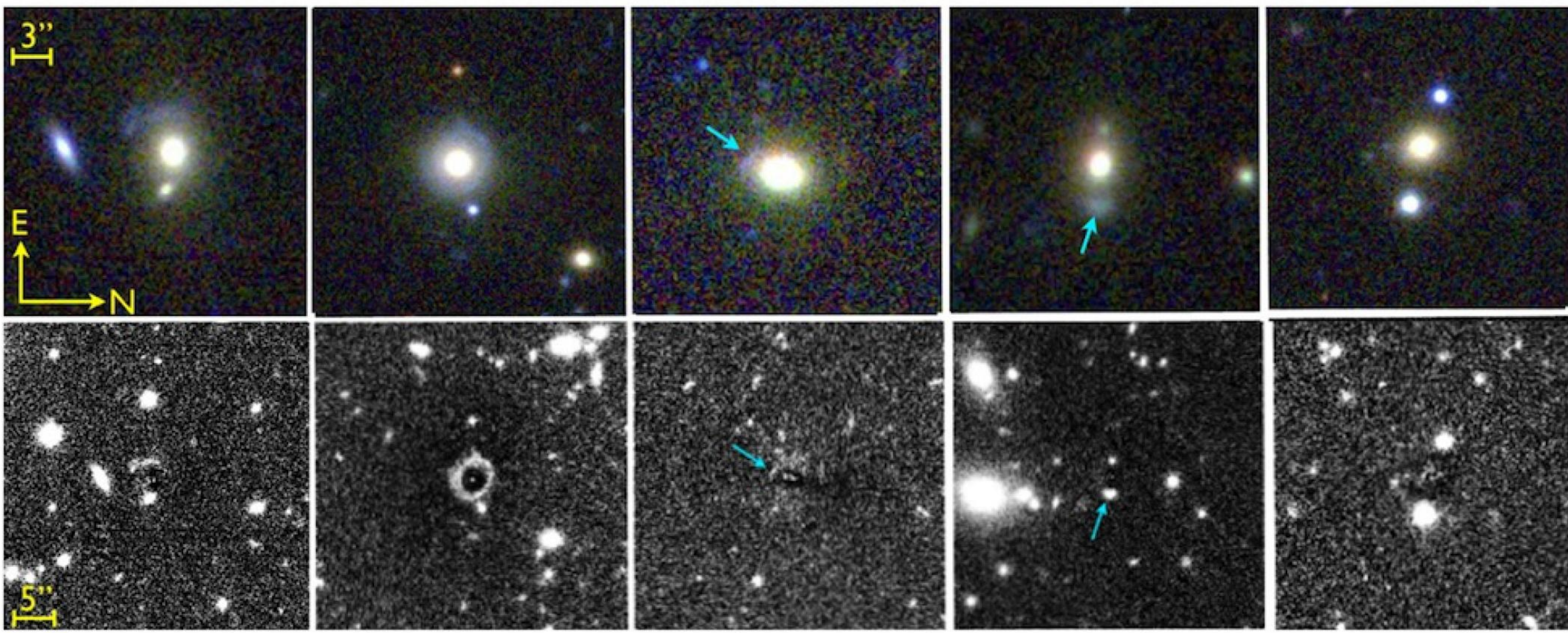


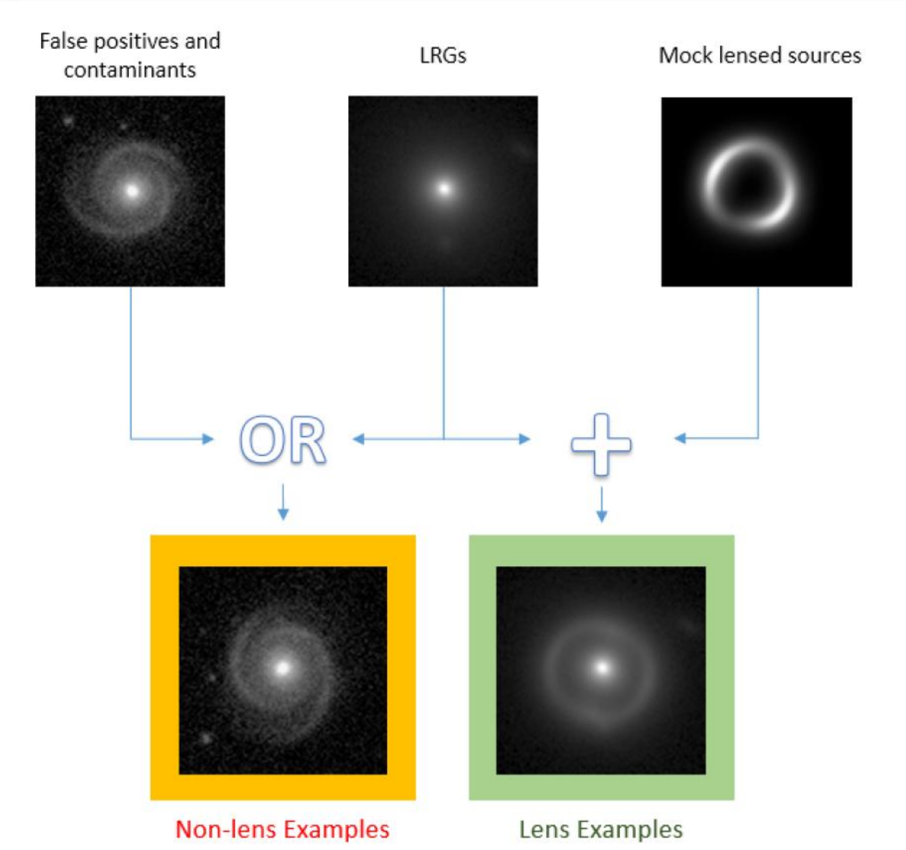
Gravitational lenses: strategy

Now: ~ 600 lenses known

KiDS: ~ +1000 lenses

1. **Visual inspection**
2. **Automated search**

Convolutional neural network



Petrillo et al. 2017, MNRAS, 472, 1129


KSL427 (70)


KSL317 (70)


KSL103 (64)


KSL627 (60)


KSL040 (60)


KSL327 (58)


KSL376 (48)


KSL086 (48)


KSL469 (46)


KSL351 (46)


KSL713 (42)

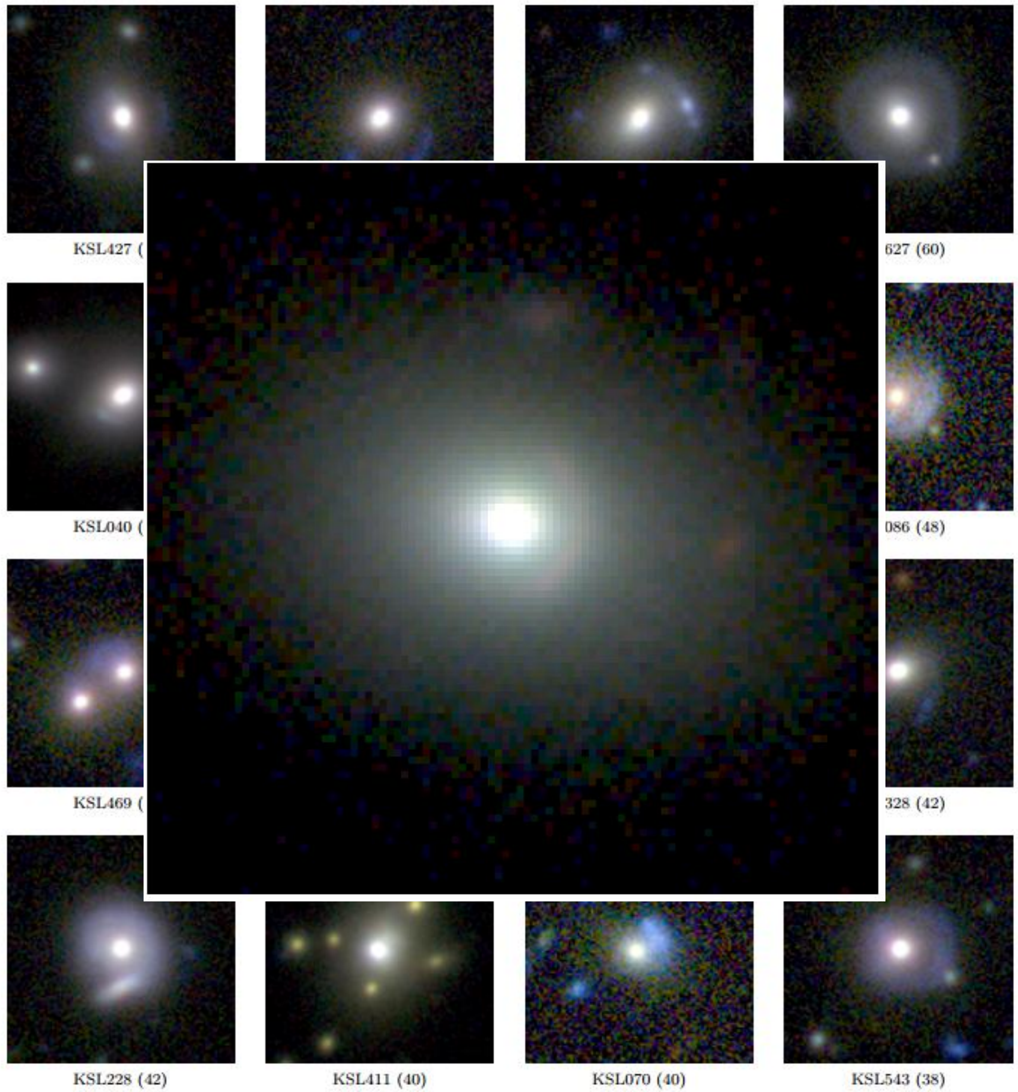

KSL328 (42)


KSL228 (42)


KSL411 (40)

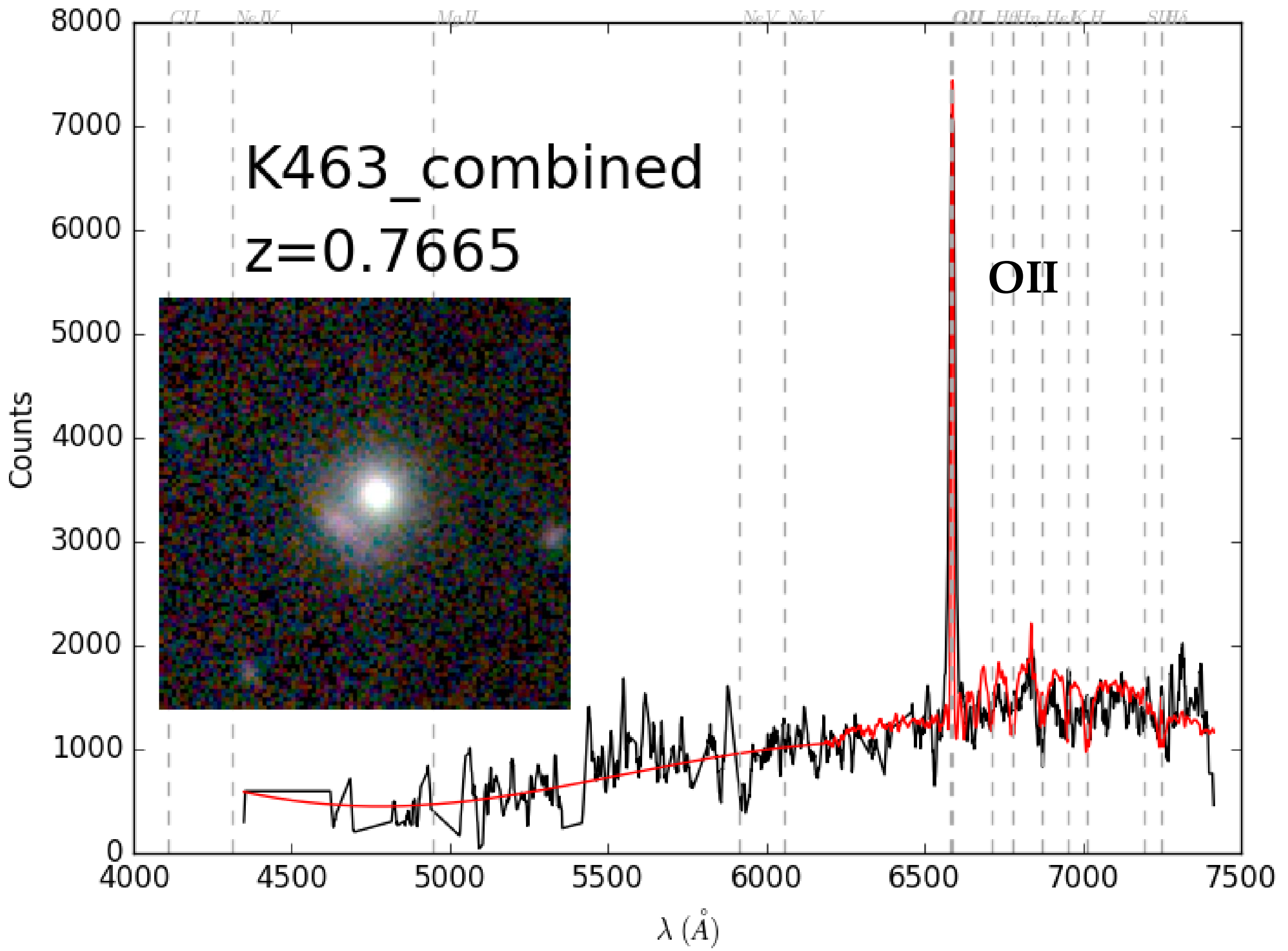

KSL070 (40)


KSL543 (38)


KSL427 (
627 (60)
KSL040 (
086 (48)
KSL469 (
328 (42)
KSL228 (42)
KSL411 (40)
KSL070 (40)
KSL543 (38)

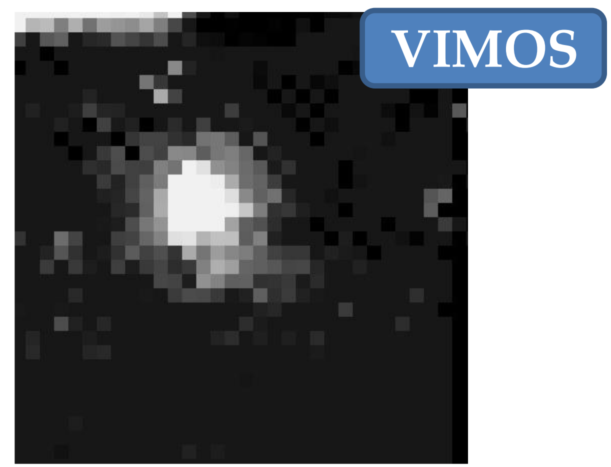
The spectroscopic follow-up

Spectroscopic follow-up - I (SALT)



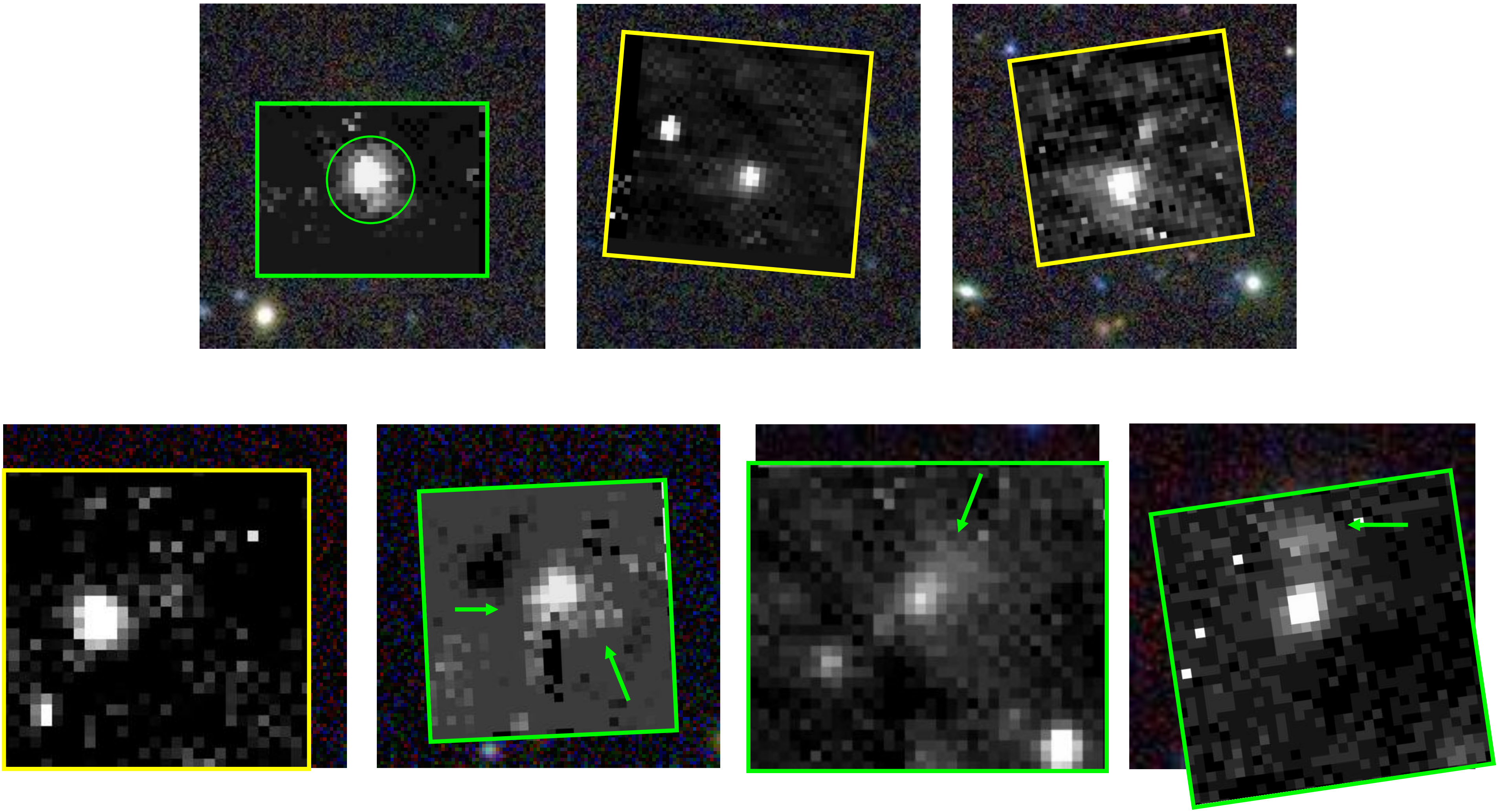
Spectroscopic follow-up - II (VIMOS@VLT)

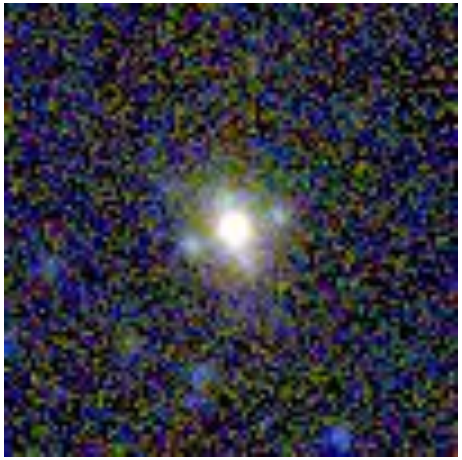
- First 11 candidates observed
- 1h OB per system (~40 mins on target)
- One lens confirmed (100%)
- One candidate excluded (star)
- Seven ON GOING but very promising
- Two new observed to reduce and analyze



First KiDS candidates

First KiDS candidates





Thanks

with new candidates from CNN!