

Q2343-BX610

Deep3a-15504

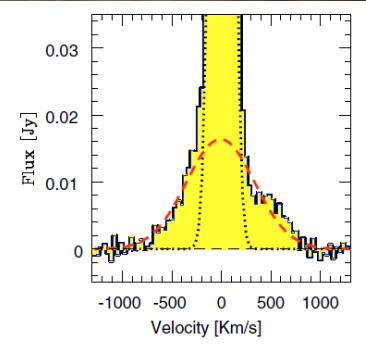
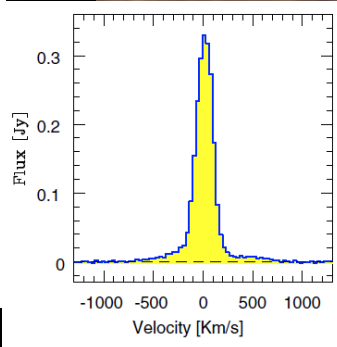
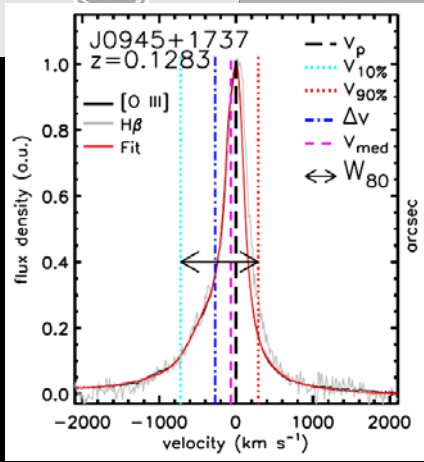
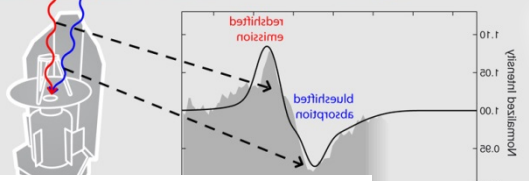
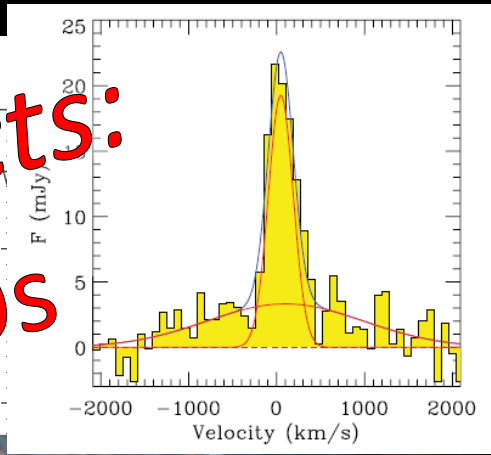
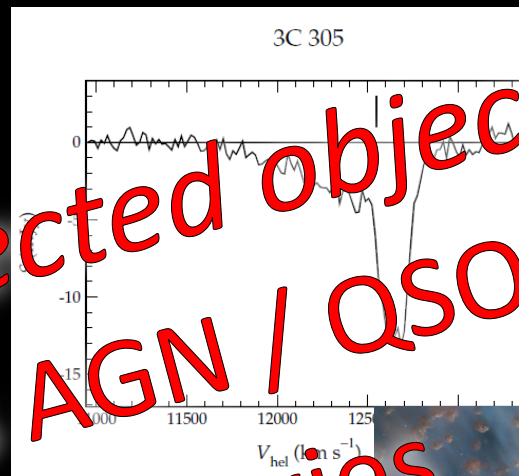
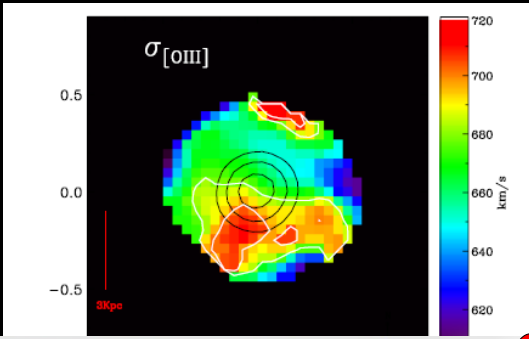
# AGN driven nuclear outflows in massive star-forming galaxies

Durham, July 31, 2014

(8.3 kpc) Dieter Lutz

Natascha Förster Schreiber, Reinhard Genzel, SINS, zC-SINF, LUCI, KMOS-3D

Rare preselected objects:  
 Luminous AGN / QSOs  
 Radio Galaxies  
 Obscured AGN  
 ULIRGs, SMGs

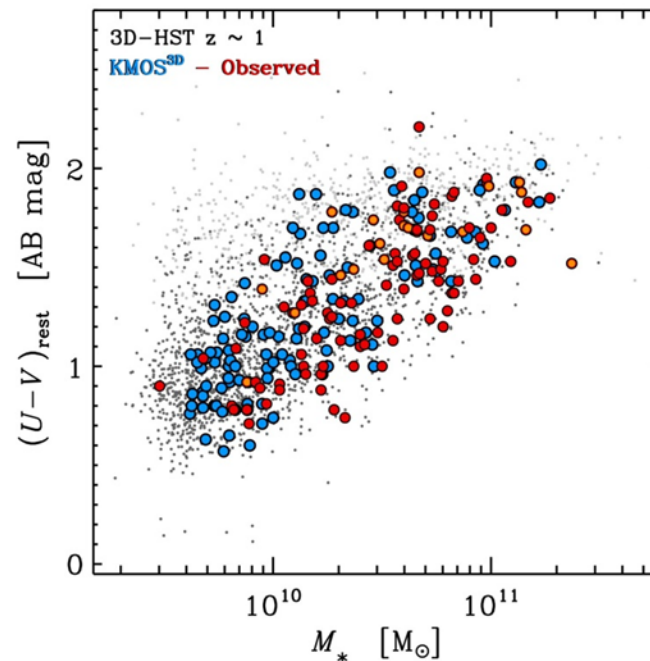
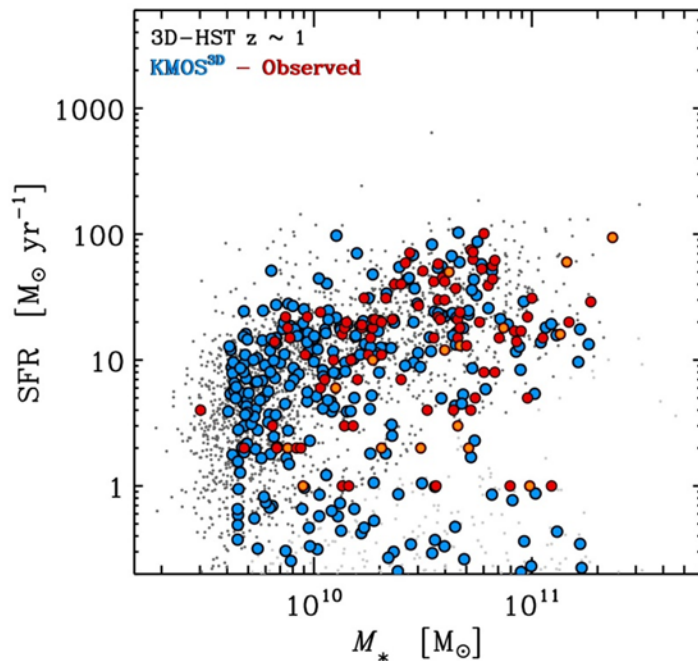


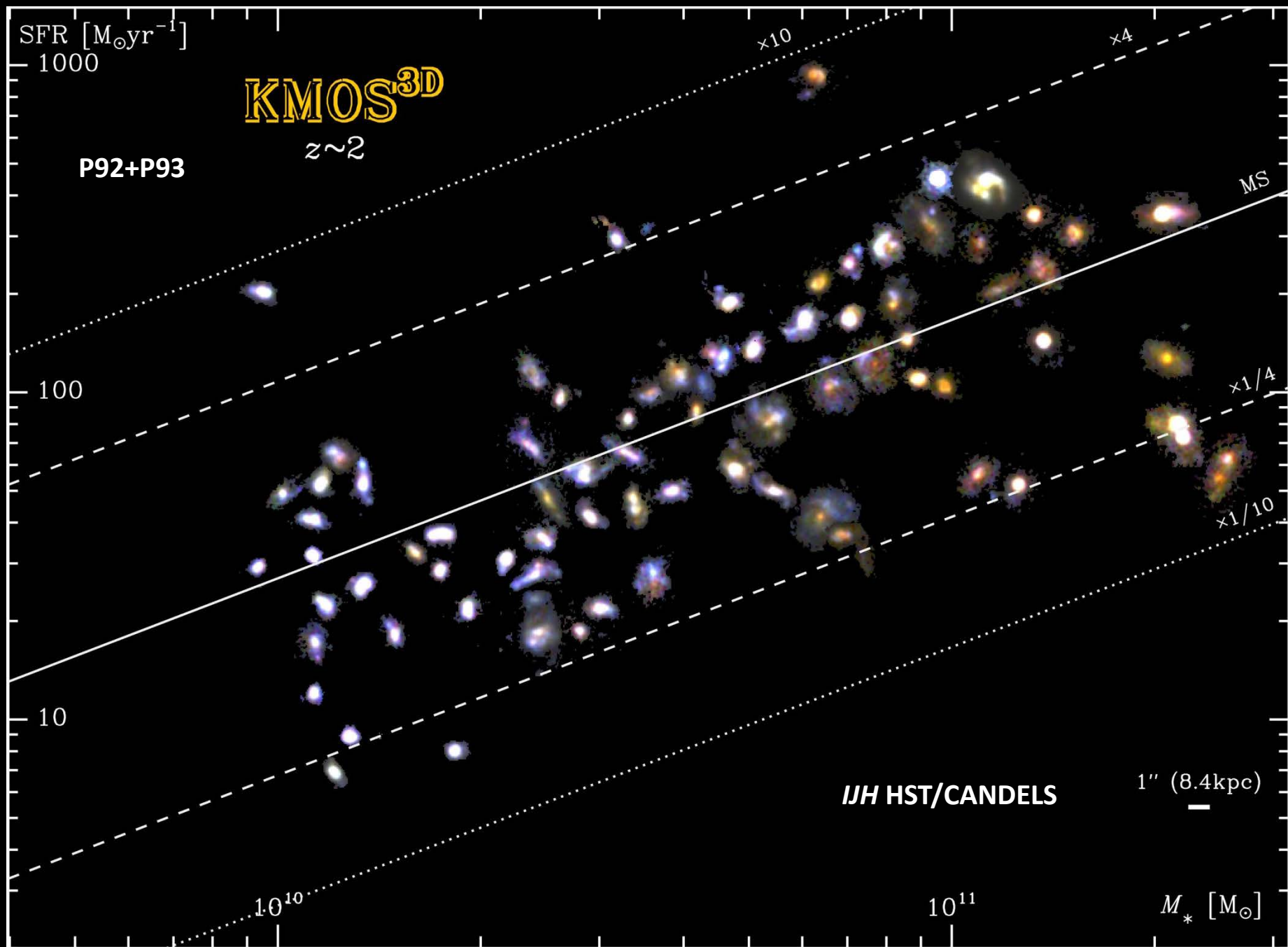
E.g. Cano Diaz+12, Cicone+14, Feruglio+10, Fischer+10, Harrison+12,14, Maiolino+12, Morganti+05, Nesvadba+06,08, Rupke+05,11, Sturm+11, Veilleux+13

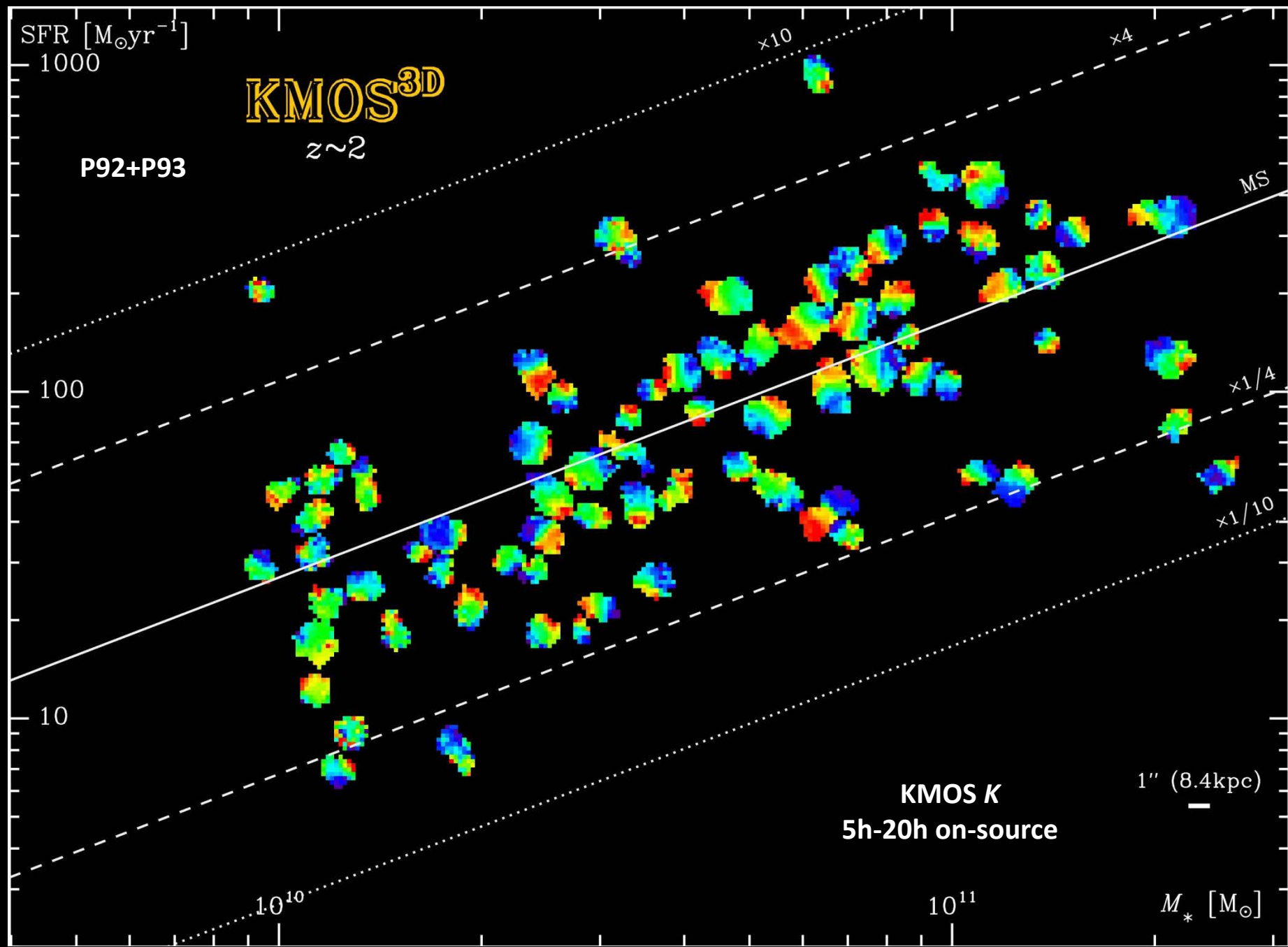
# Resolved near-IR IFU spectroscopic studies of normal $z \sim 1-2$ star forming galaxies

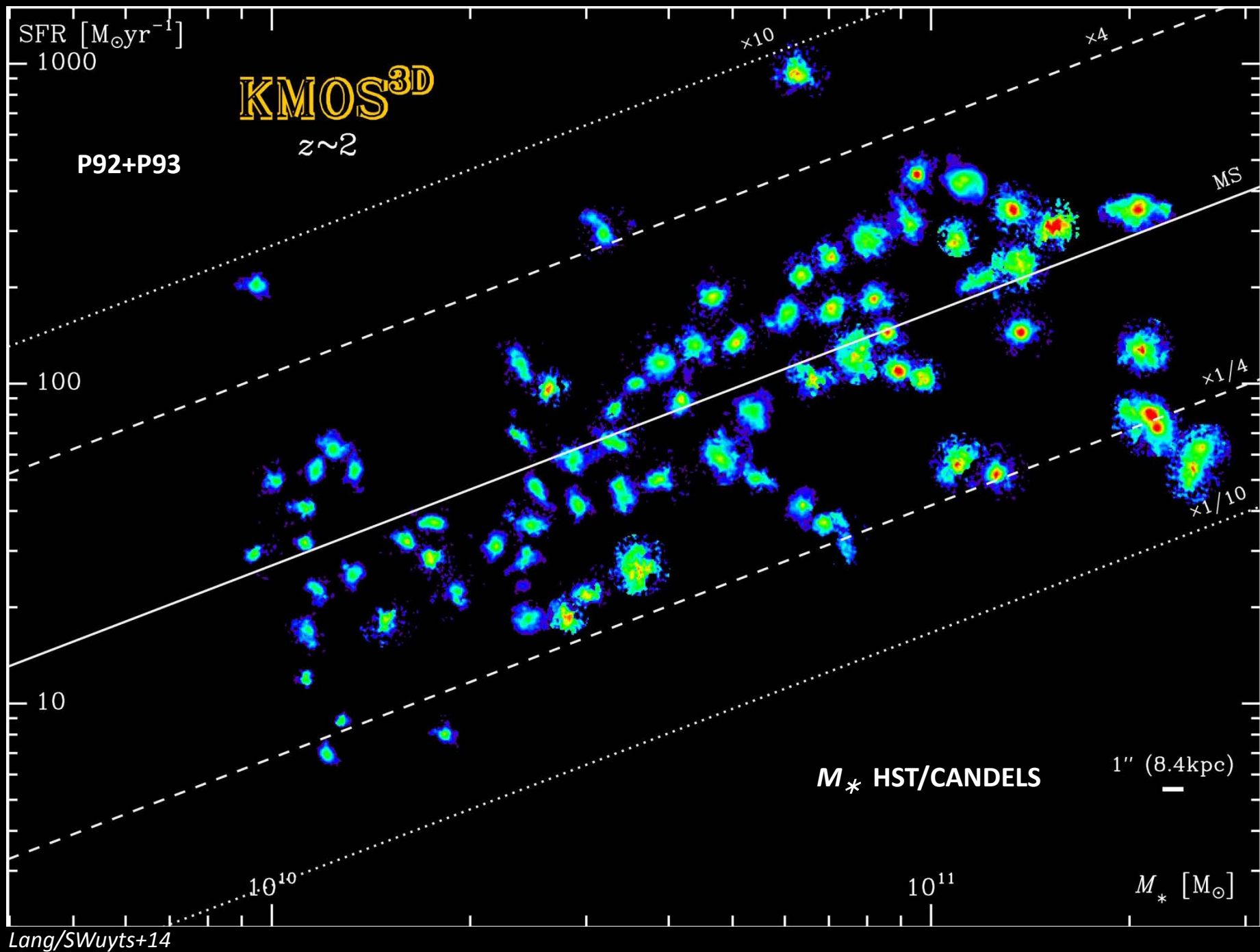
**SINS/zC-SINF:** 110 SFGs at  $z = 1.5 - 3$  — 35 with AO  
(Förster Schreiber+09,14, Mancini+11)

**KMOS<sup>3D</sup>:** 600+ mass-selected galaxies at  $z = 0.7 - 2.7$   
(1<sup>st</sup> yr: Wisnioski+14)

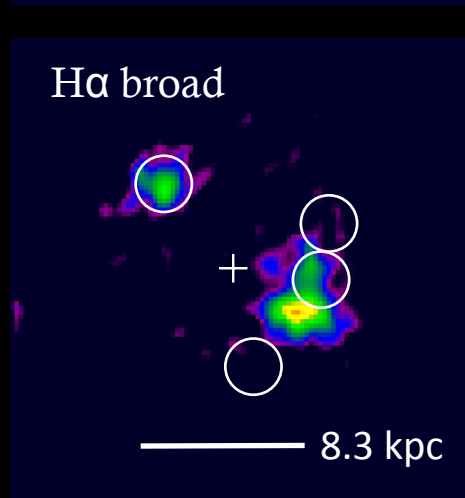
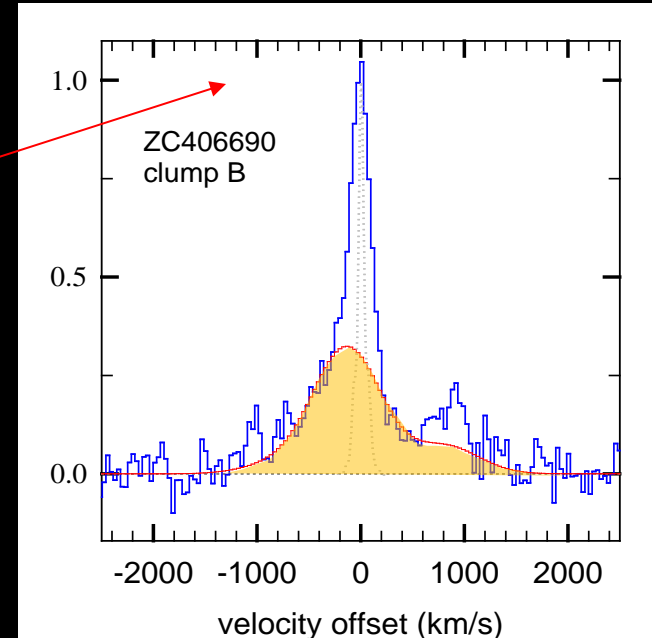
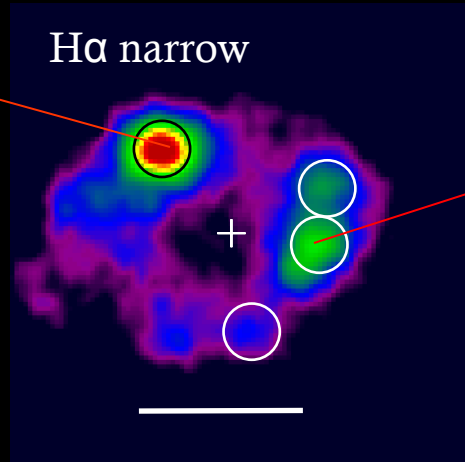
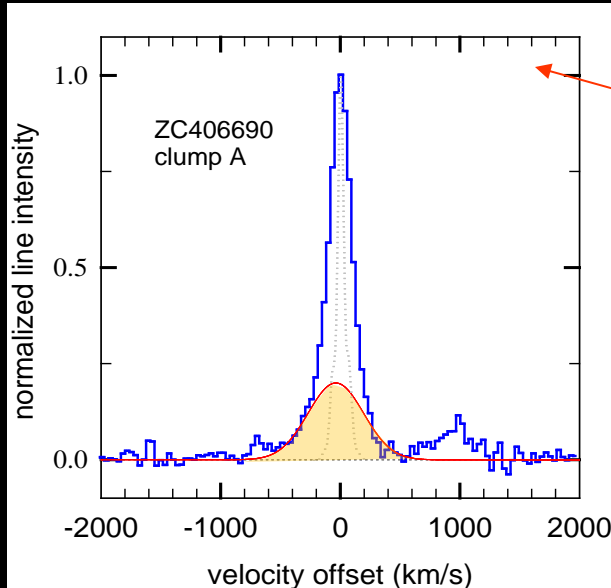








# Winds launched at giant star forming clumps



ZC406690

$z=2.19$

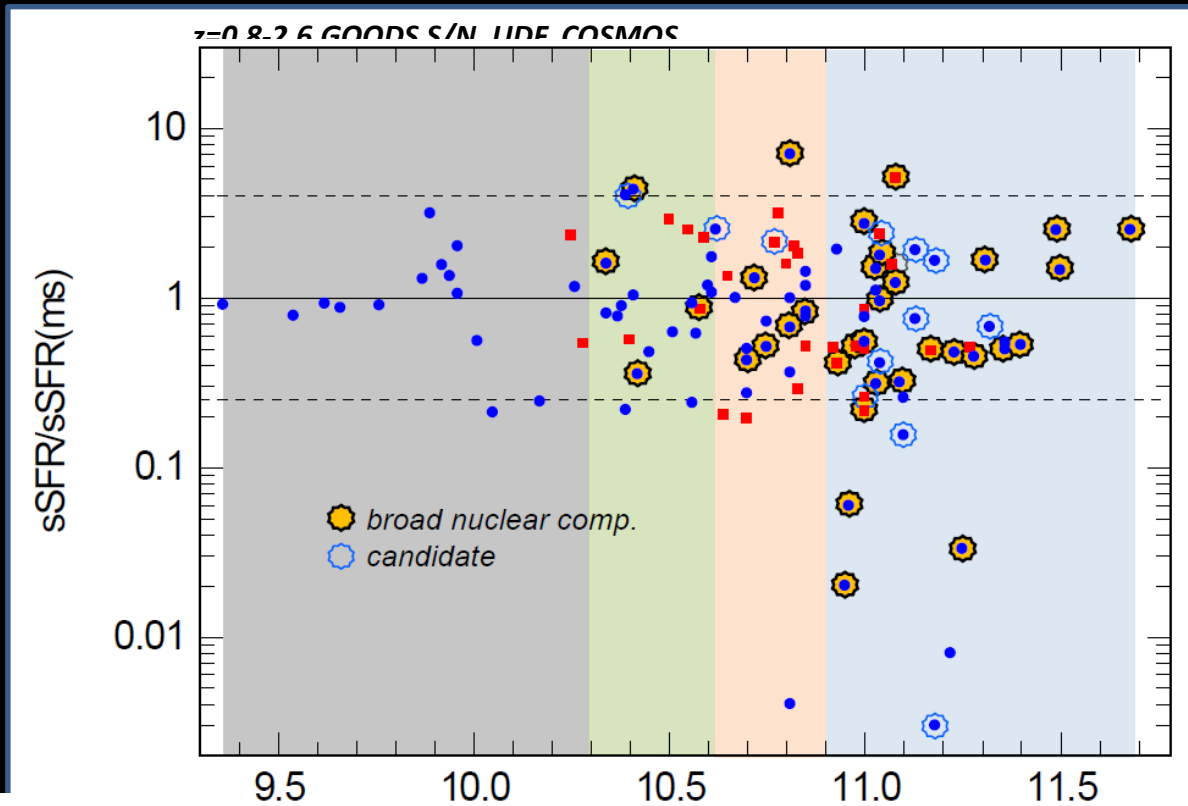
SINFONI/VLT + LGSF

$$\eta_{out} = \frac{dM_{out}/dt}{SFR} \sim 1...5$$

$$\Sigma_{SFR} > 1 M_{sun} yr^{-1} kpc^{-2}$$

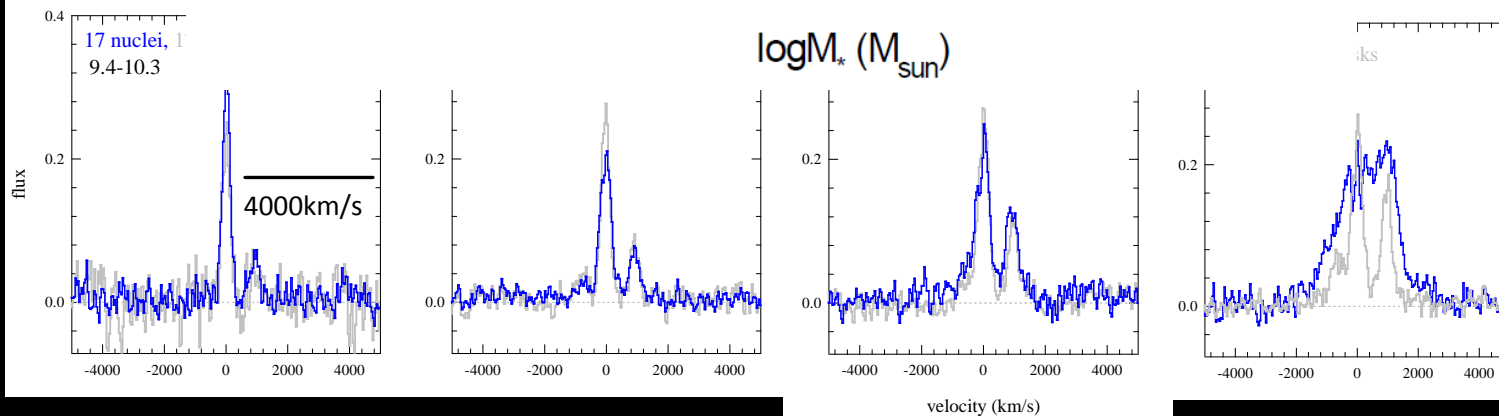
Genzel et al. 2011, Newman et al. 2012a,b, cf Pettini 2008. Shapiro et al. 2009, Steidel et al. 2010, Erb et al. 2006b, Erb 2008, Hopkins et al. 2012

# Evidence for widespread nuclear outflows



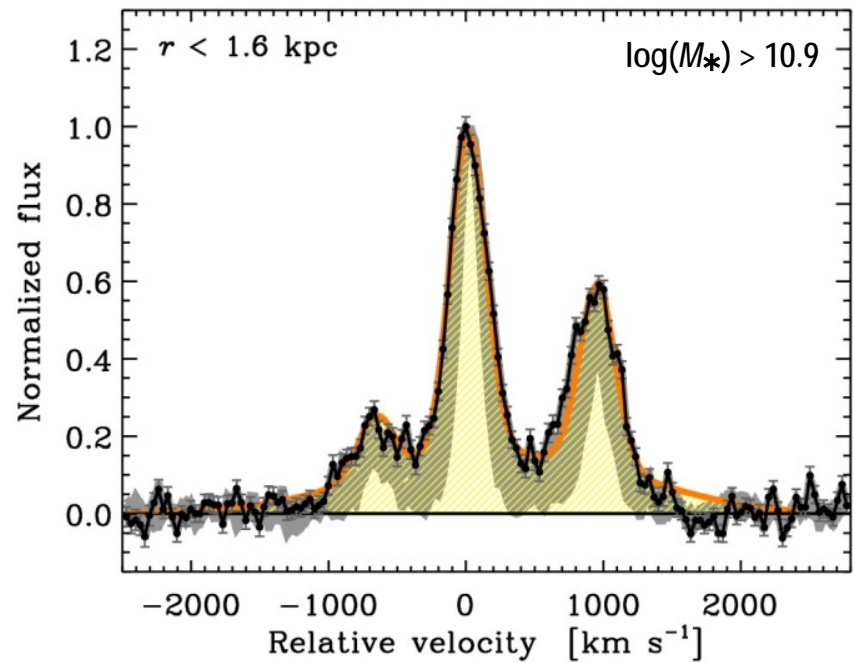
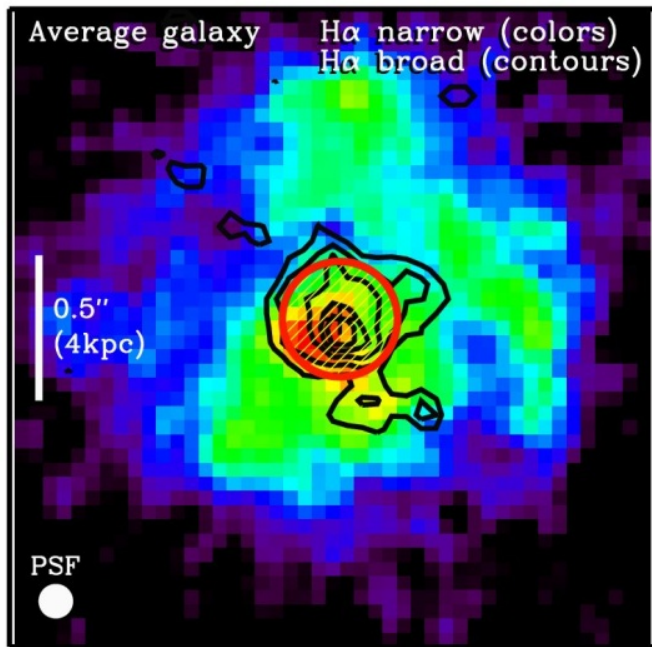
**110  $M_*$  and  
 $M_*$ -SFR selected  
SFGs  $z=0.8-2.6$**

Förster Schreiber et al.  
2014, Genzel et al. 2014

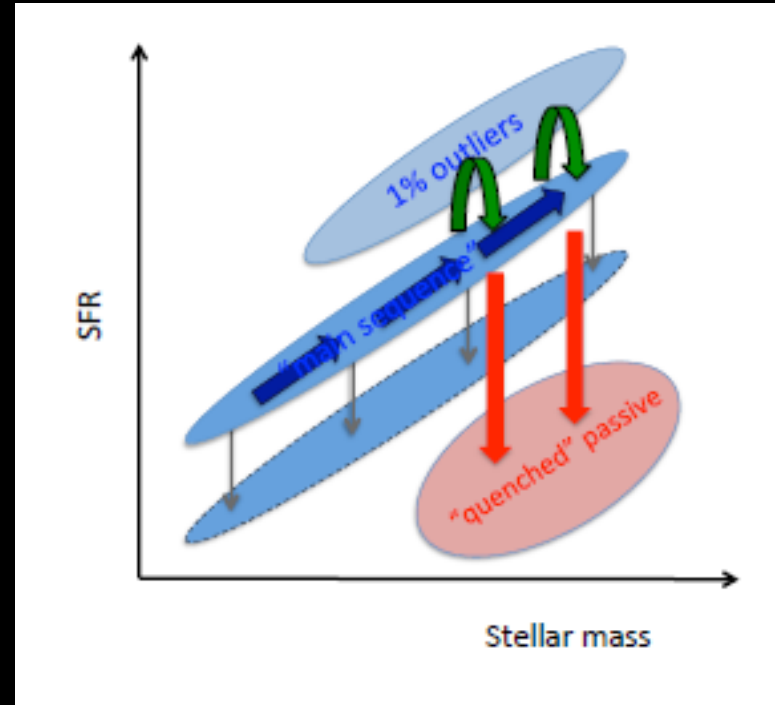
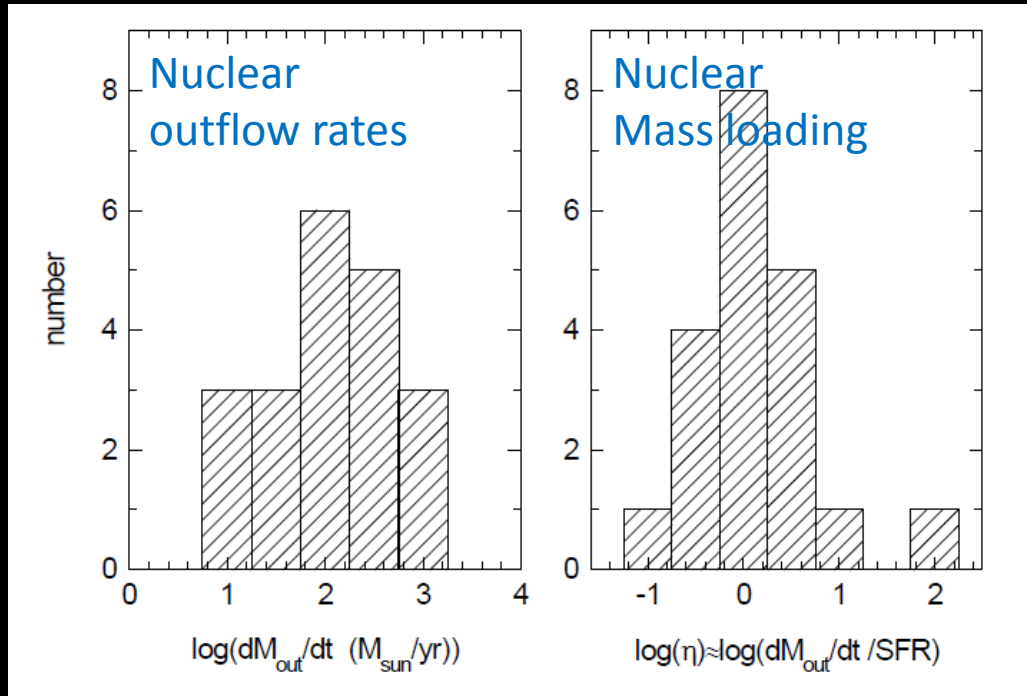




# Broad circumnuclear emission

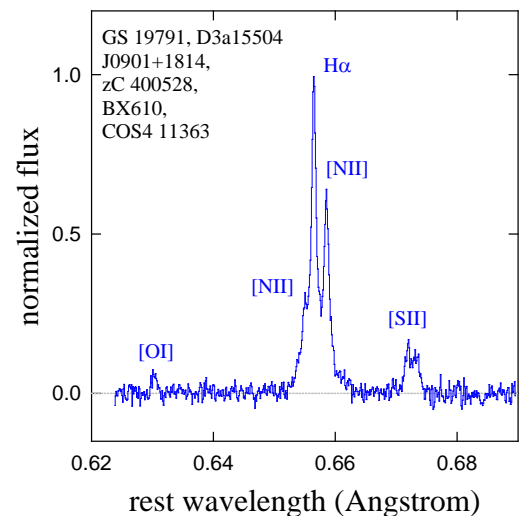


# Significant phenomenon near and above Schechter mass

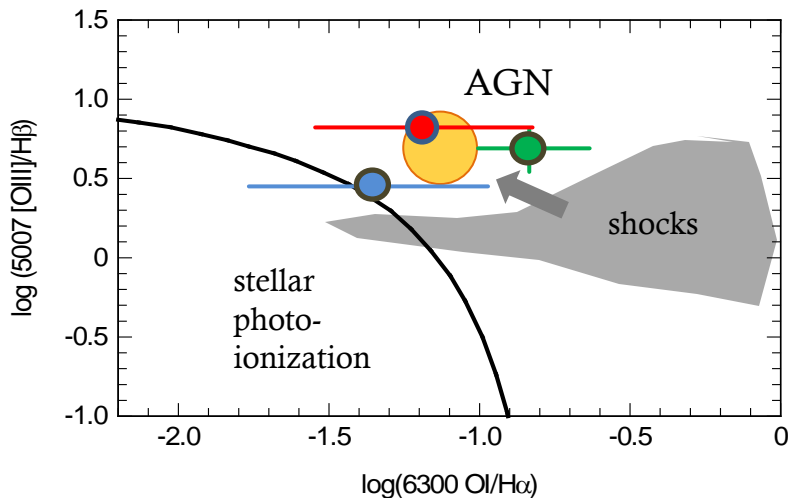
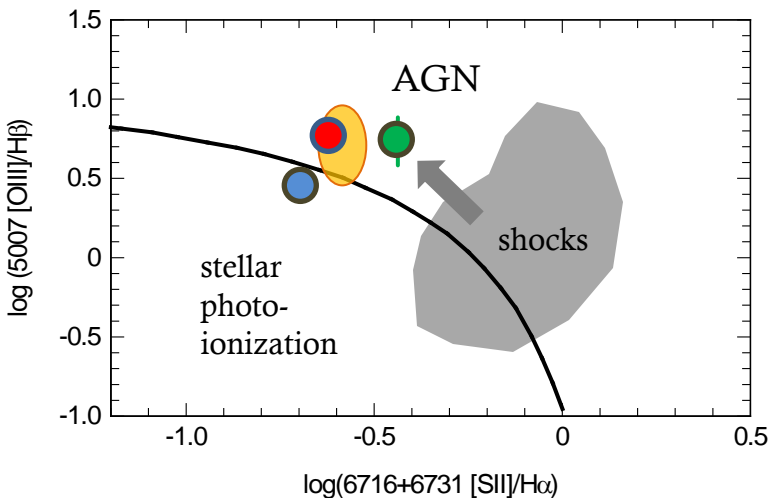
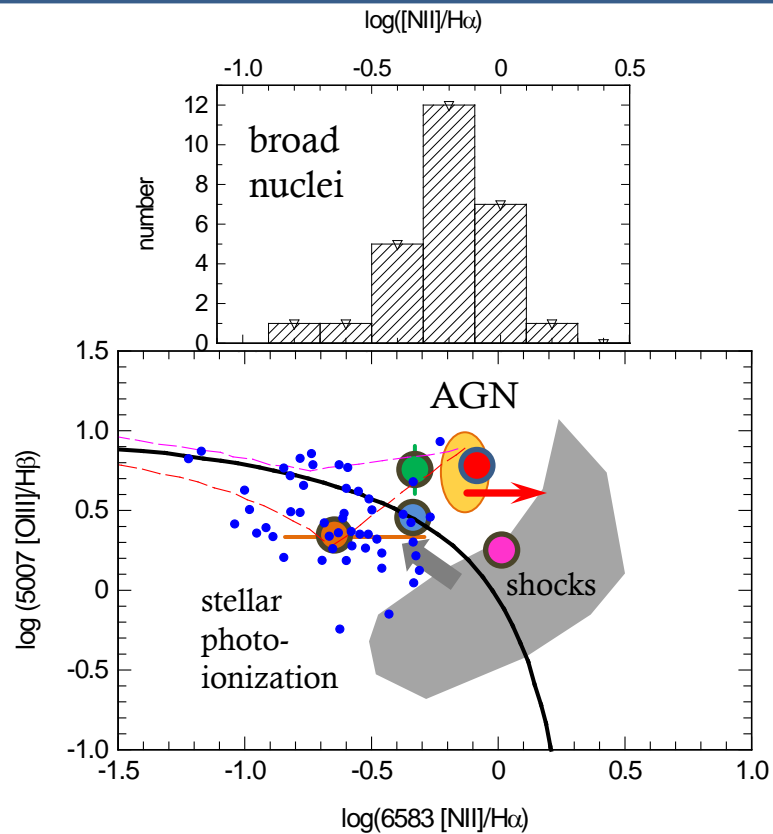


Note: About half of the galaxies with broad nuclear outflow match the Barro+13 compactness criterion

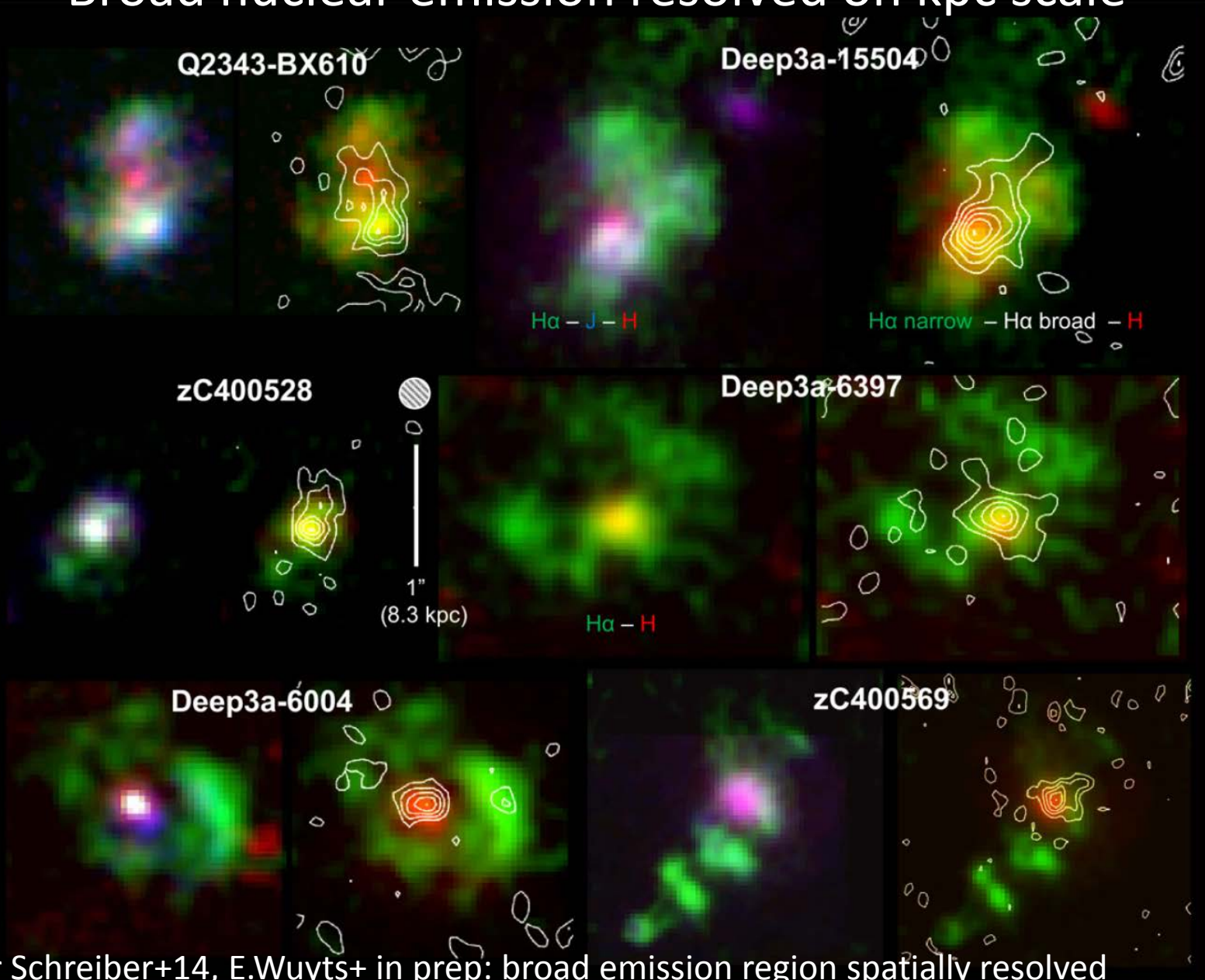
# AGN?



- GS 19791/K20 ID5
- D3a 15504
- BX 610
- D3a 6004
- GN 7923
- average: BX 610, GS 19791,  
D3a 15504, J 0901+1814,  
zC 400528

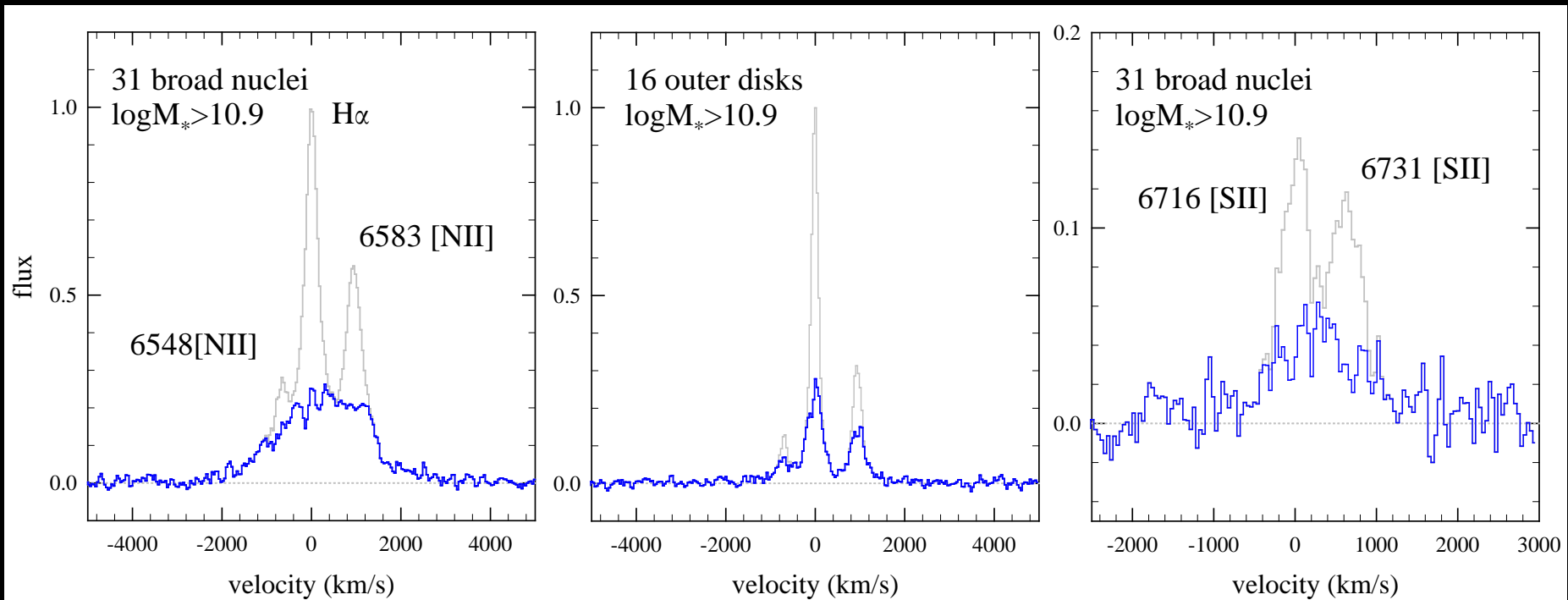


# Broad nuclear emission resolved on kpc scale



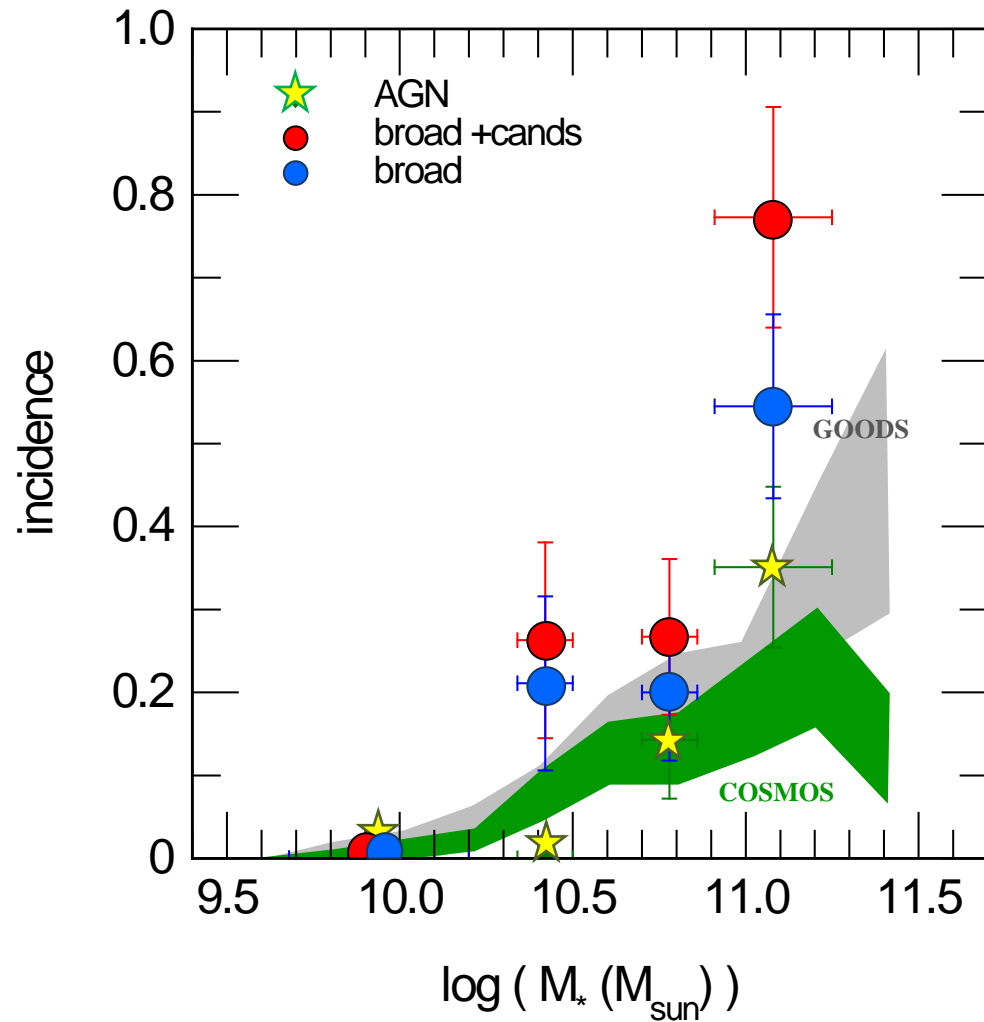
Förster Schreiber+14, E.Wuyts+ in prep: broad emission region spatially resolved on 2-3kpc scale in 5 of 7 systems with AO data

# Broad emission detected in forbidden lines



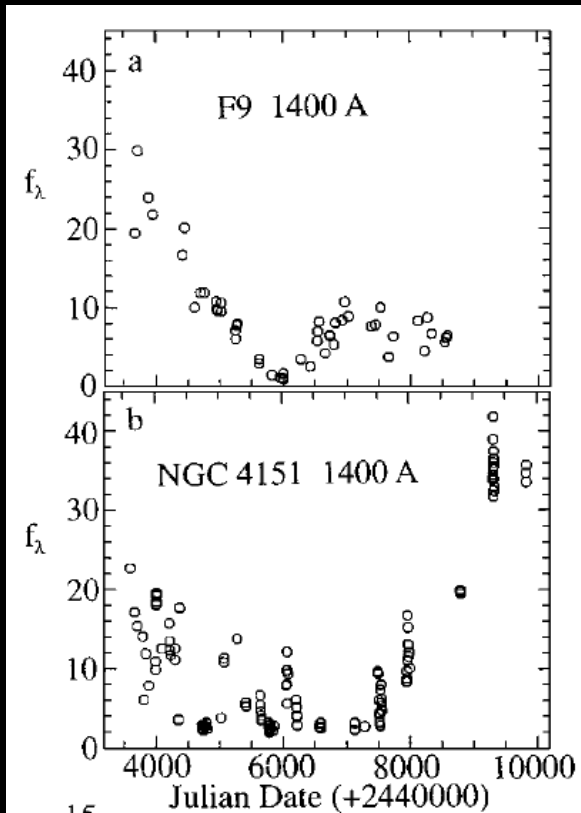
2-3 kpc diameter plus presence in [NII] and [SII]  
→ gas cannot be bound and must constitute an outflow with  
 $v_{\text{out}} \sim 500-1000 \text{ km/s}$

# High incidence at large stellar masses



# The influence of variability

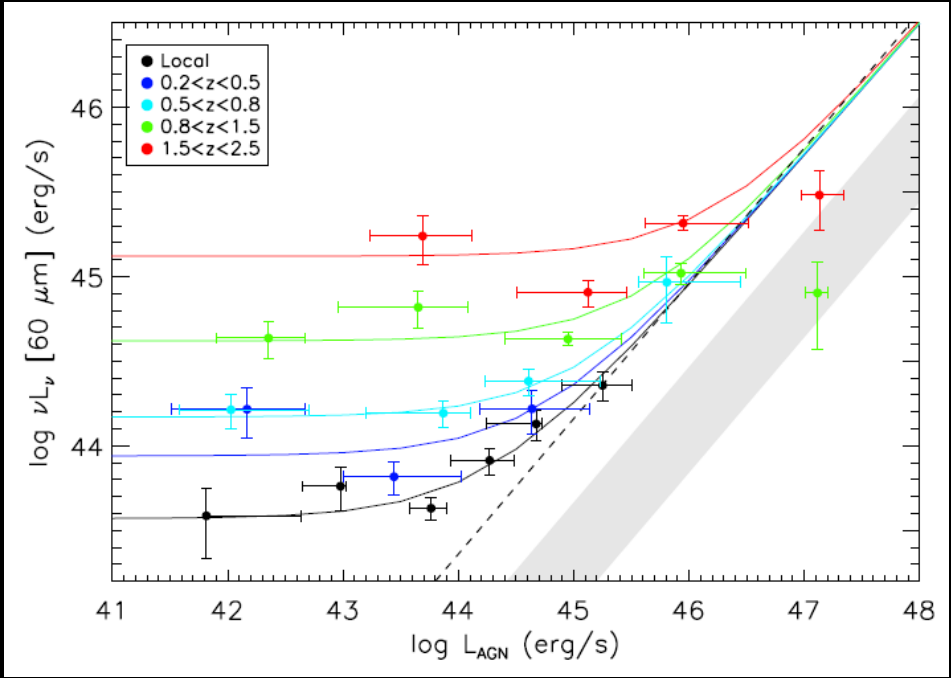
- X-rays follow variations of accretion on short timescale
- NLR/outflow average over  $\max(\text{light travel time, recombination time}) > 10^3\text{-}10^4\text{yr}$  – Larger duty cycle!



- Typical 'deep field' X-ray AGN vary by few tenths of a mag over few years (Salvato+11)
- Local type 1 AGN monitored over decades vary by large factors
- Typical slopes -1 in power spectral densities (e.g. McHardy+06)

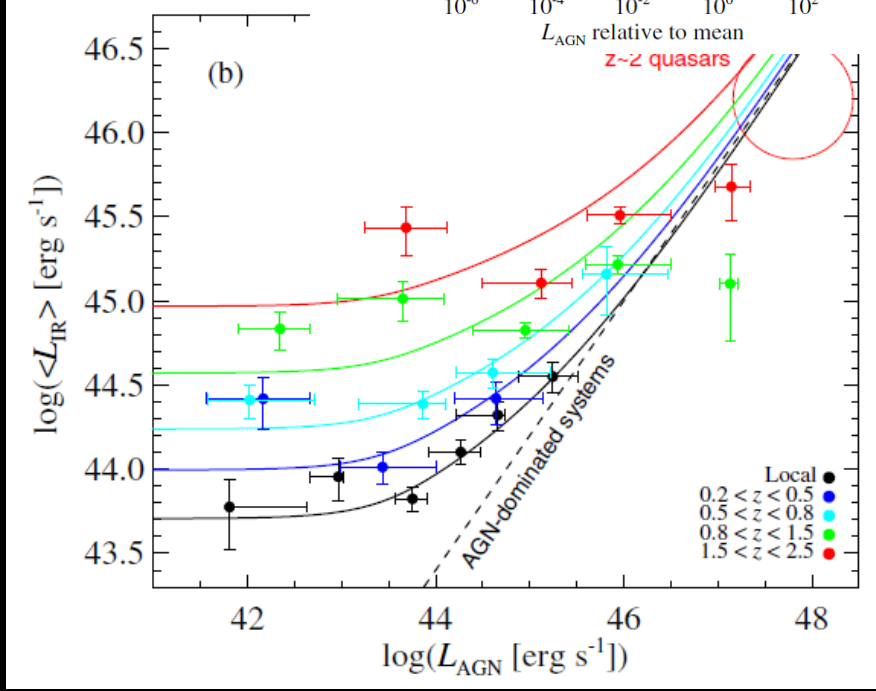
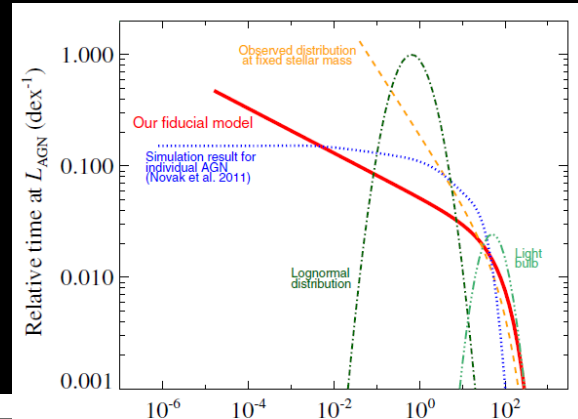
Ulrich+97: UV variation over  $\sim 20\text{yr}$

# Again: Interplay between long term correlation and short term chaotic variations?



Rosario+12 Herschel-PACS observations

Hickox+14 simple model with rapid AGN variability





# Summary

- A large fraction of the most massive  $\log(M^*) > 10.9$   $z \sim 1-2$  normal star forming galaxies exhibits nuclear outflows at  $\sim 100 M_{\text{sun}}/\text{yr}$
- ‘Mass loading’  $\frac{dM_{\text{out}}/dt}{SFR} \sim 1$  from these nuclear outflows
- The outflows are likely driven by SMBH accretion/activity
- Large incidence can be linked to averaging over fast accretion variations