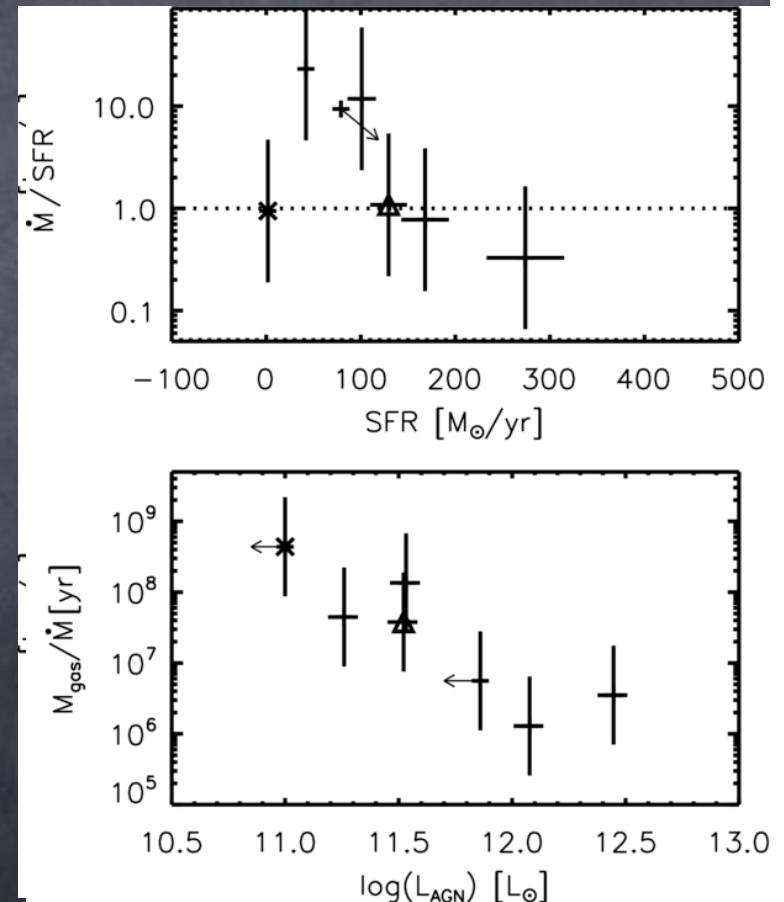
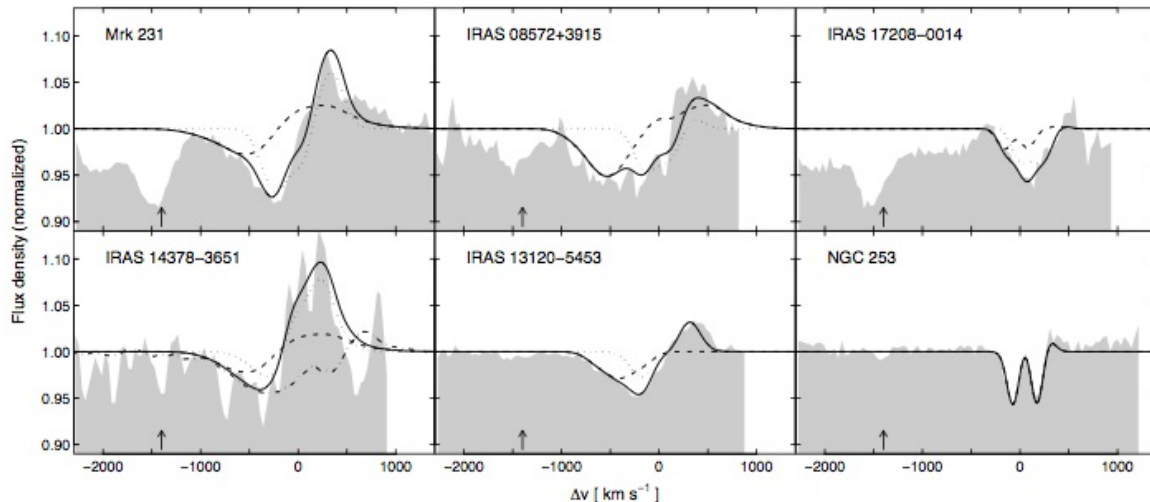


# AGN outflows vs star formation

Sturm+2011 Herschel PACS BAL spectra composite sample of both AGN and SF-dominated ULIRGS. Outflows detected through P-cygni profiles of OH. Mass loss rate depends on the OH abundance but  $>$  several hundreds  $M_{\text{Sun}}/\text{yr}$



What is powering the outflows?

Terminal velocity  $v_{\text{max}}$  correlated with LAGN  
--> powered mainly by the AGN

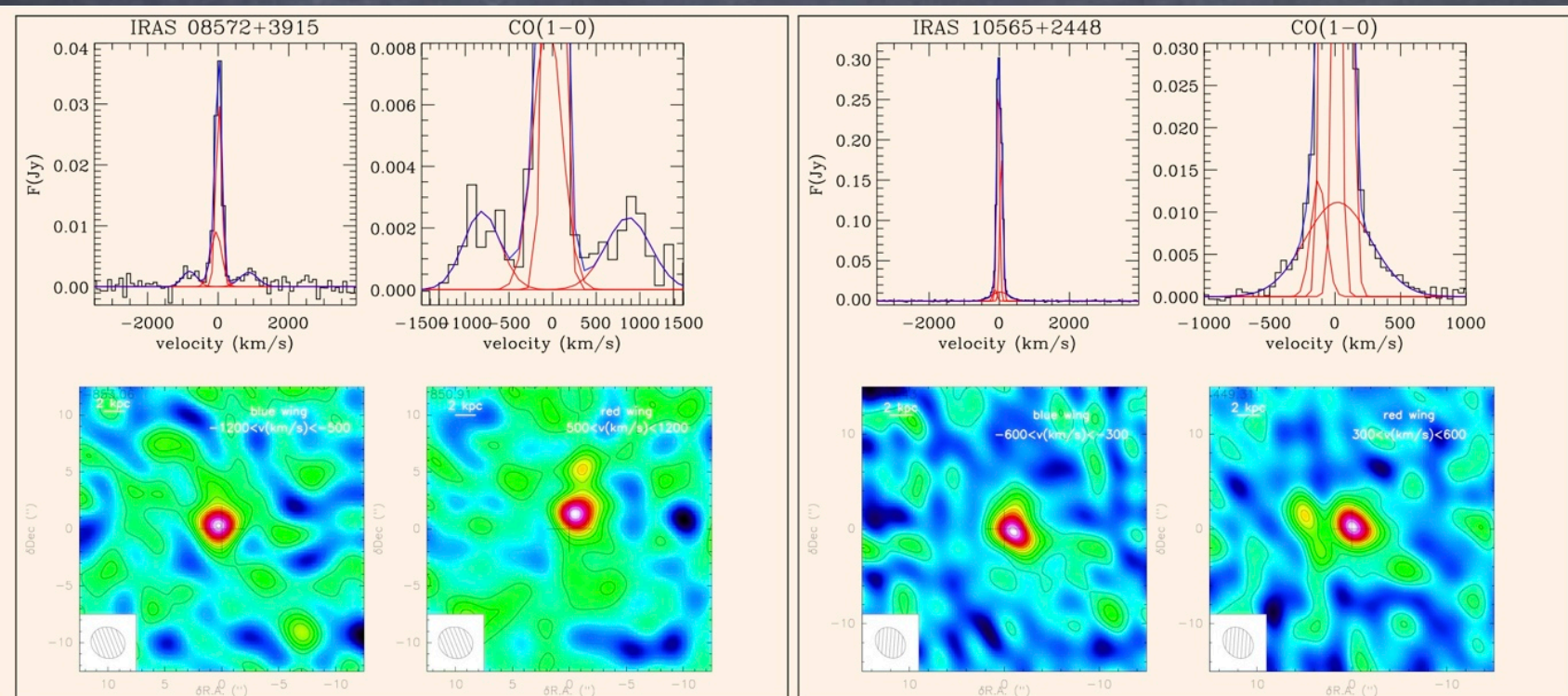
Terminal velocities  $>$  1000 km/s in AGN-dominated objects

# OUTFLOWS COMMON IN ULIRG/QSO?

On-going follow up with the PdBI to constrain sizes and mass loss rate

Broad wings detected, and resolved. Maps also show substructures (clumps)

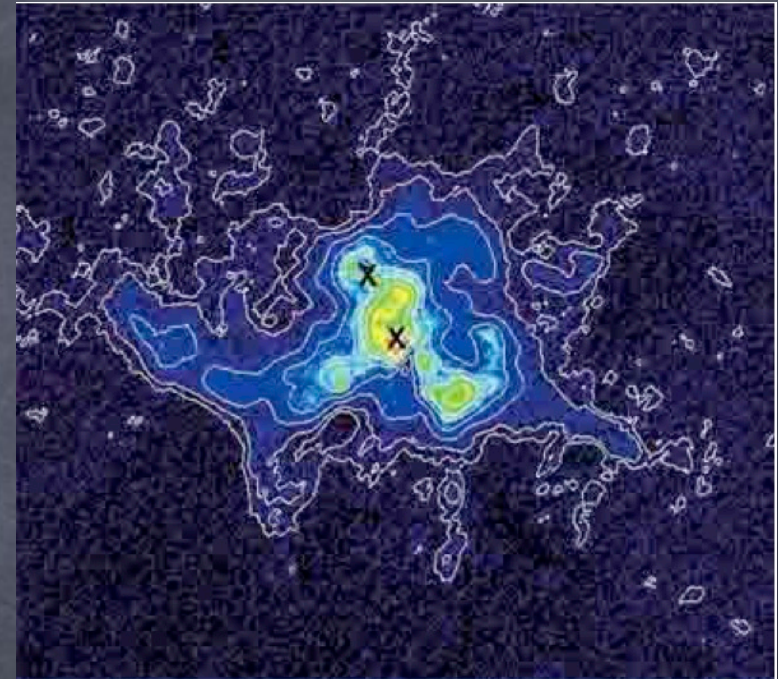
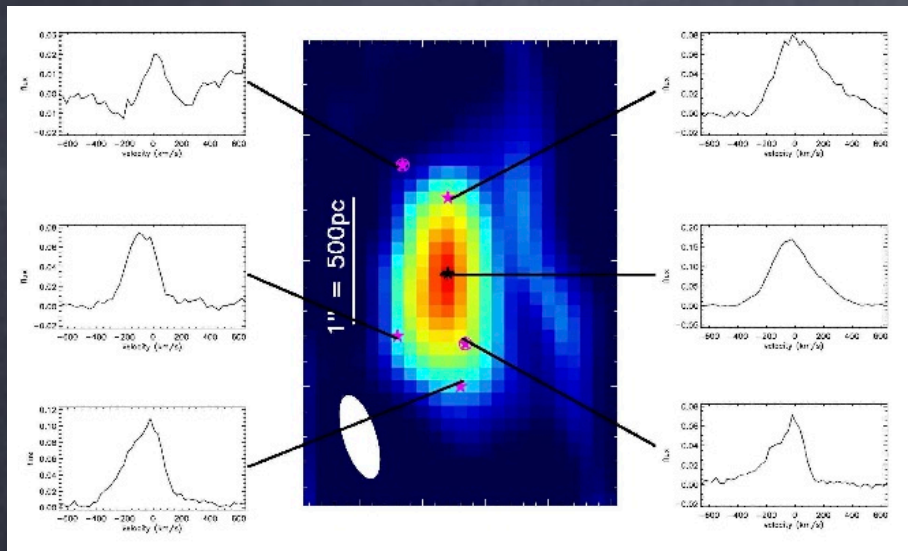
Mass loss rate  $> 600 M_{\odot}/\text{yr}$  and above  $1000 M_{\odot}/\text{yr}$  in AGN-dominated objects



Source	$\log(L_{\text{AGN}})$ [ $L_{\odot}$ ]	SFR [ $M_{\odot} \text{ yr}^{-1}$ ]	$v_{\text{OF,max}}$ [km/s]	FWHM (CO(1-0)) [kpc]	OF rate [ $M_{\odot} \text{ yr}^{-1}$ ]
Mrk 231	12.45	200	$\sim 1000$	1.2	$\sim 700\text{-}1000$
IRAS 08572+3915	12.08	42	$\sim 1500$	2.5	$\sim 1400$
IRAS 10565+2448	11.38	84	$\sim 600$	2.4	$\sim 600$

# NGC 6240

## a complex system with broad CO

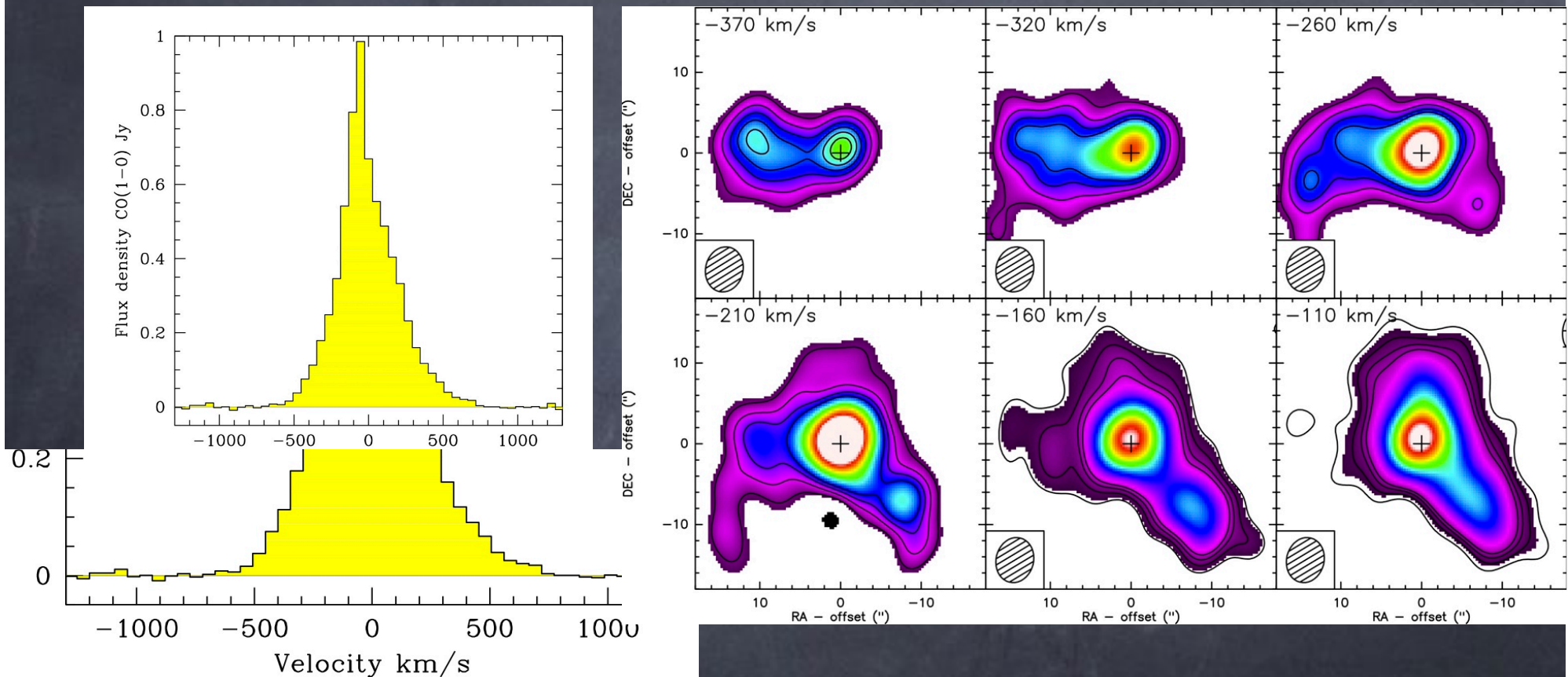


Major merger in early stage, with complex morphology, streamers, tidal tails, and 2 AGN nuclei both heavily obscured, with  $L(2-10)\text{ keV} > 10^{44}\text{ erg/s}$  and  $\text{MBH} > 10^8 M_{\odot}$

**SEVERAL MECHANISMS in ACTION !!**

# NGC 6240

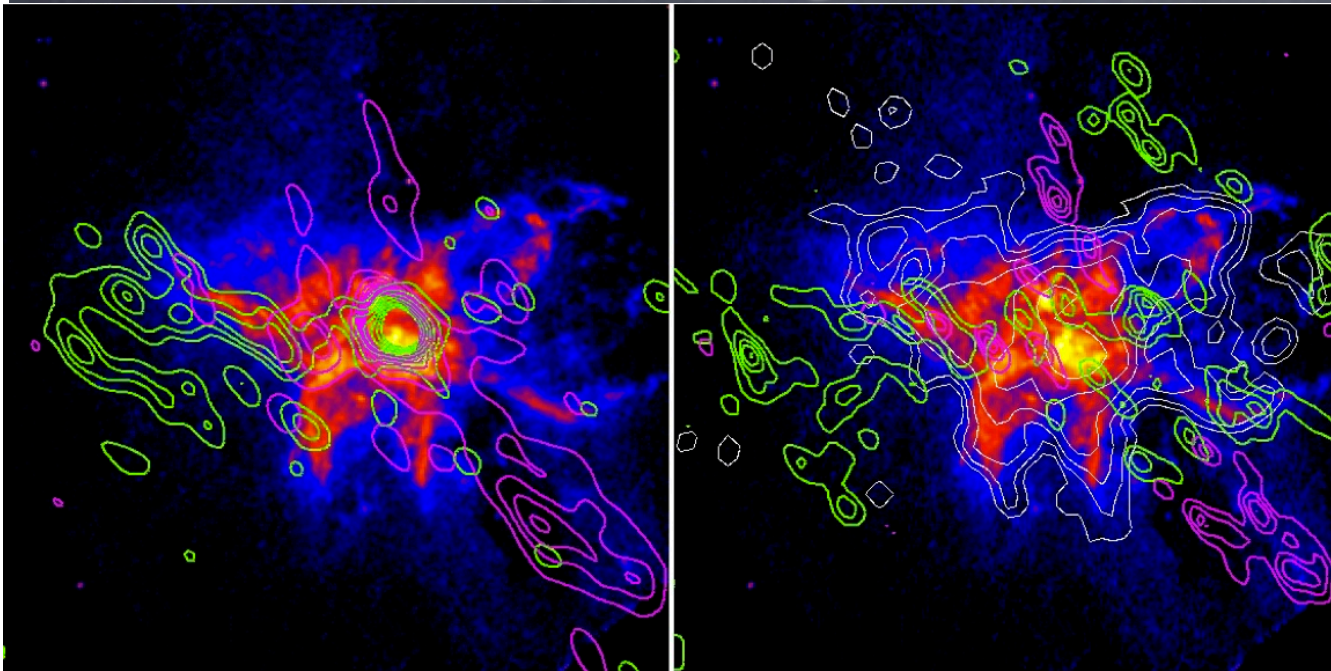
## a complex system with broad CO



New sensitive PdBI observations of CO(1-0): Broad CO(1-0) detected out to  $\pm 800$  km/s and a blue-shifted extended structure on scales of 7 kpc  
Feruglio+ 2012

# NGC 6240

## a complex system with broad CO

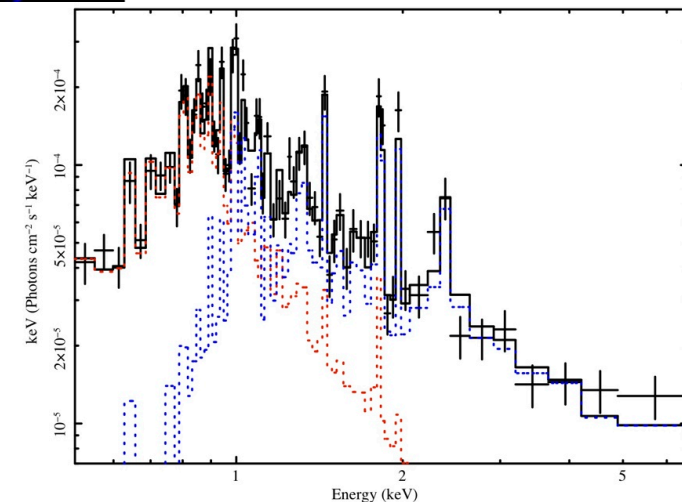


CO at -100 km/s coincides with the dust lane seen in HST image in the SW region

CO with -400 km/s coincident with H $\alpha$  filaments in the Eastern region

NGC6240 extended X-ray emission  
Thermal equilibrium plus shock model

Chandra spectra provide evidence for shocked gas at the position of the H $\alpha$  emission, and suggests that a shock is propagating eastward and it is compressing the molecular gas, while crossing it. **If CO outflow proceeds from the southern nucleus, as it is the case for H $\alpha$ , it carries several 100  $M_{\odot}$ /yr**

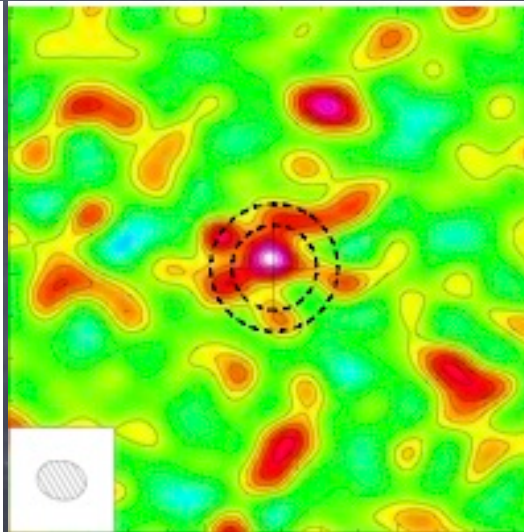
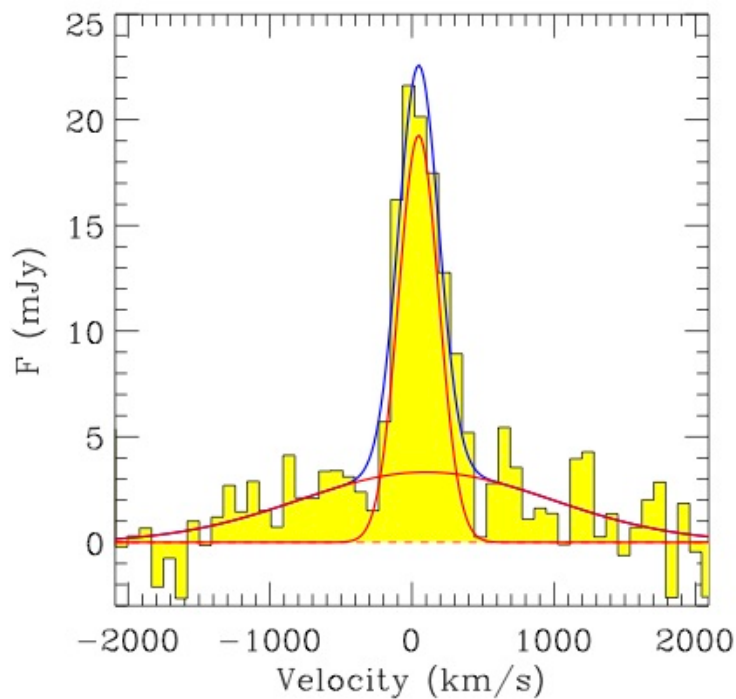


# Outflows in the distant Universe

Extremely luminous QSO SDSS J1148 at  $z=6.4$ . Host galaxy SFR  $\sim 3000 M_{\odot}/\text{yr}$  and  $M_{\text{H}_2} \sim 2 \times 10^{10} M_{\odot}$

Broad wings detected in  $[\text{CII}]\text{158}\mu\text{m}$  with FWHM=2000 km/s Maiolino+2012

$V_{\text{max}} = 1300 \text{ km/s}$  already points towards AGN-driven outflow and shocks



$M_{\text{out}} > 7 \times 10^9 M_{\odot}$  under conservative assumptions

Broad component concentrated in the center but extended on scales of 16 kpc

mass loss rate

$dM/dt > 3500 M_{\odot}/\text{yr}$  !!!

kinetic power  $P_{\text{kin}} > 2 \times 10^{45} \text{ erg/s}$   $< 1\%$  of the AGN

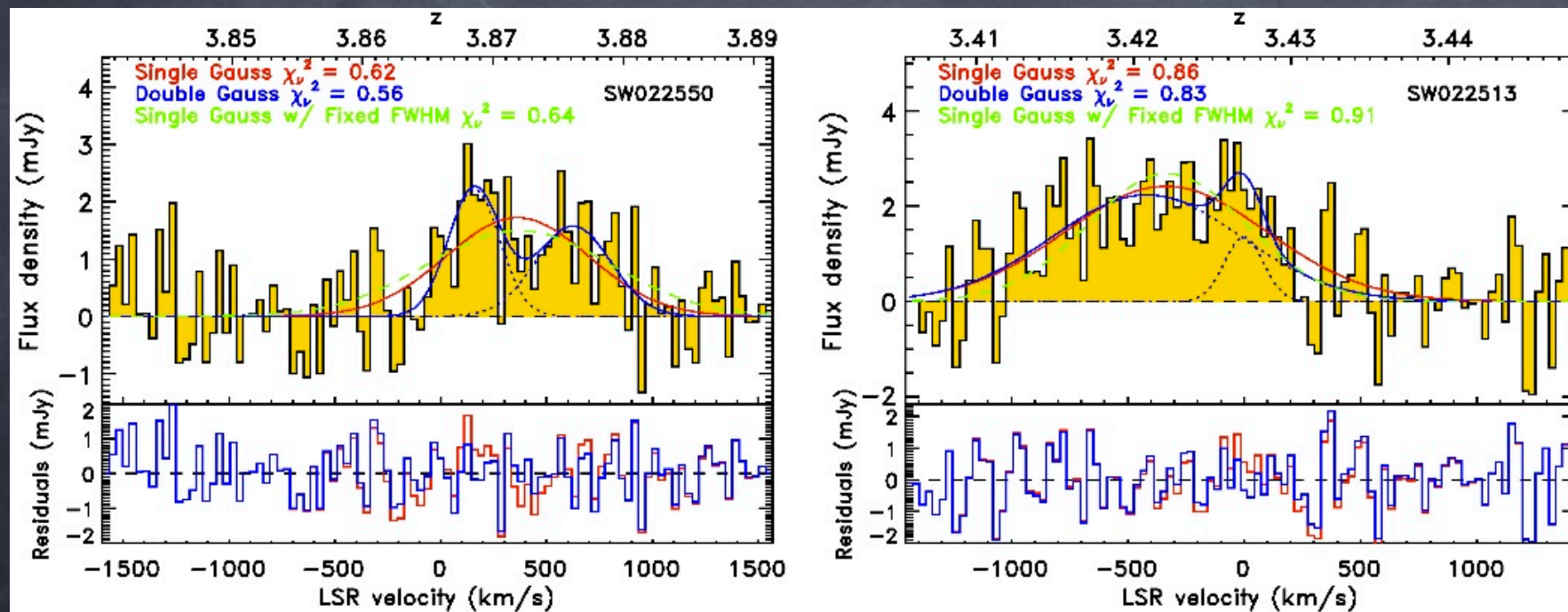
$L_{\text{bol}}$ , well above the power injected by SNa =  $\eta \times \text{SFR}$   
 $\times 7 \times 10^{41} \quad (\eta \sim 0.1)$

# Outflows at $z=3=4$

2 highly obscured QSOs at  $z > \sim 3.4$  with with Lbol (AGN)  $\sim 10^{47}$  erg/s

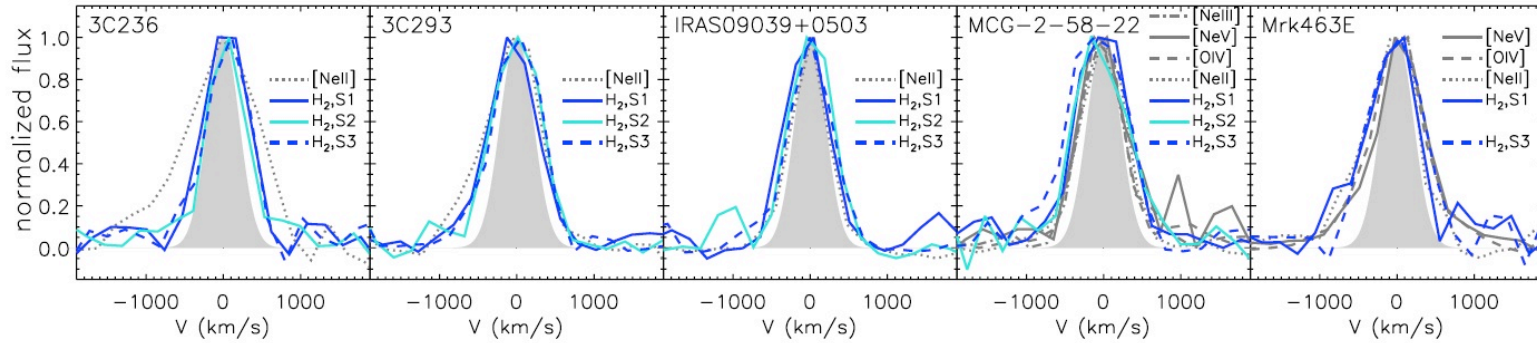
ULIRGs with SFR = 500-3000  $M_{\odot}$ /yr

Polletta+ 2011

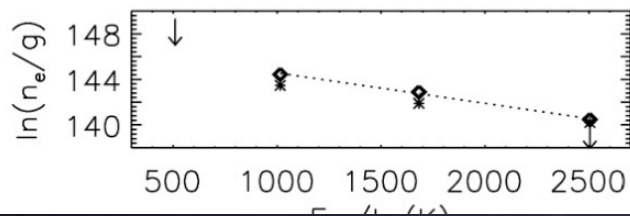
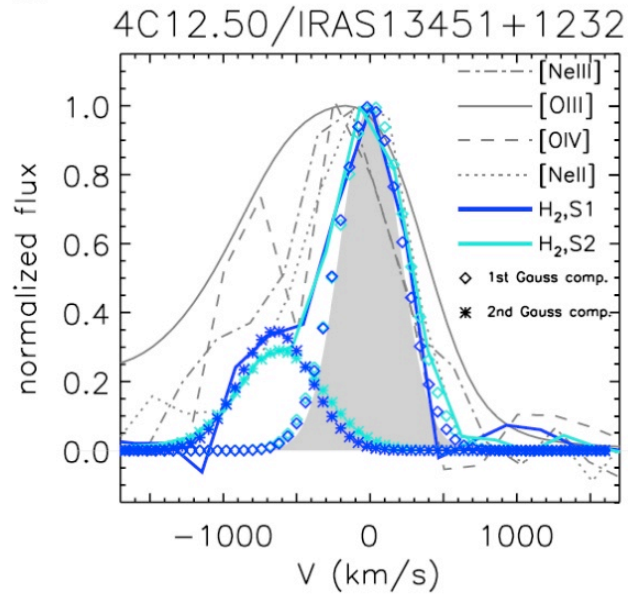


Very broad lines detected but unclear origin: merger or outflow?

Need high-resolution maps and sensitive observations to constrain morphology and gas dynamics.



## Dasyra & Combes 2011



## Warm H<sub>2</sub>

If combined with CO observations:

Warm to cold H<sub>2</sub> ratio in wings and core

Is the outflow warming up the gas?