

Observations of Molecular Outflow in a Radio-Quiet Quasar

Workshop on AGN and Starburst-driven Outflows
Wed 20 Nov, 462 Bloomberg

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with
Jenny Greene

Princeton University

SDSS J1356+1026 (Bubble)

$z=0.123$

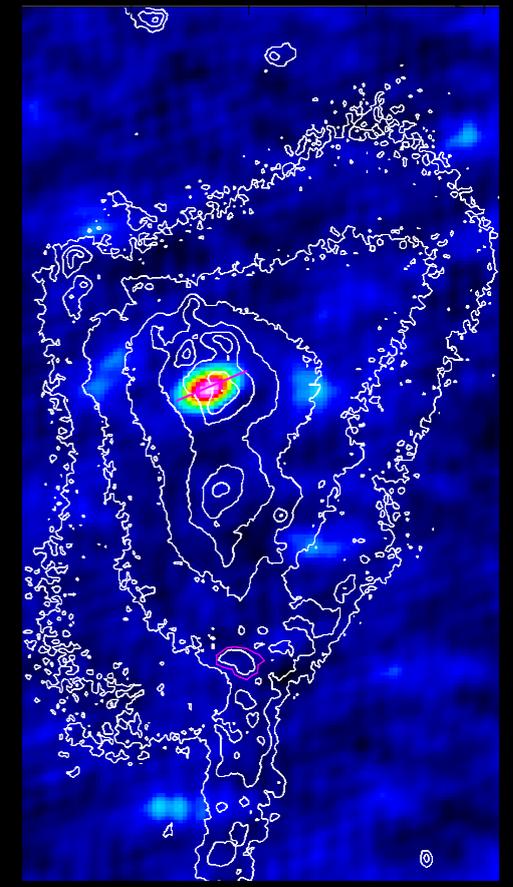
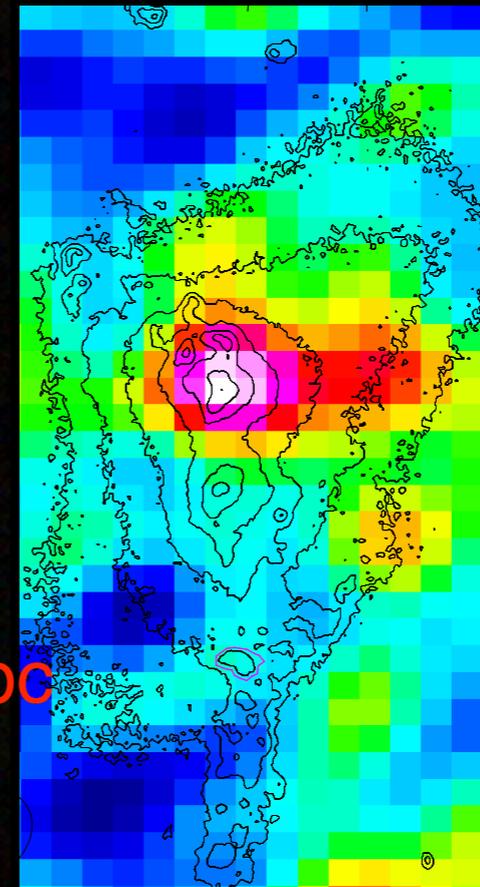
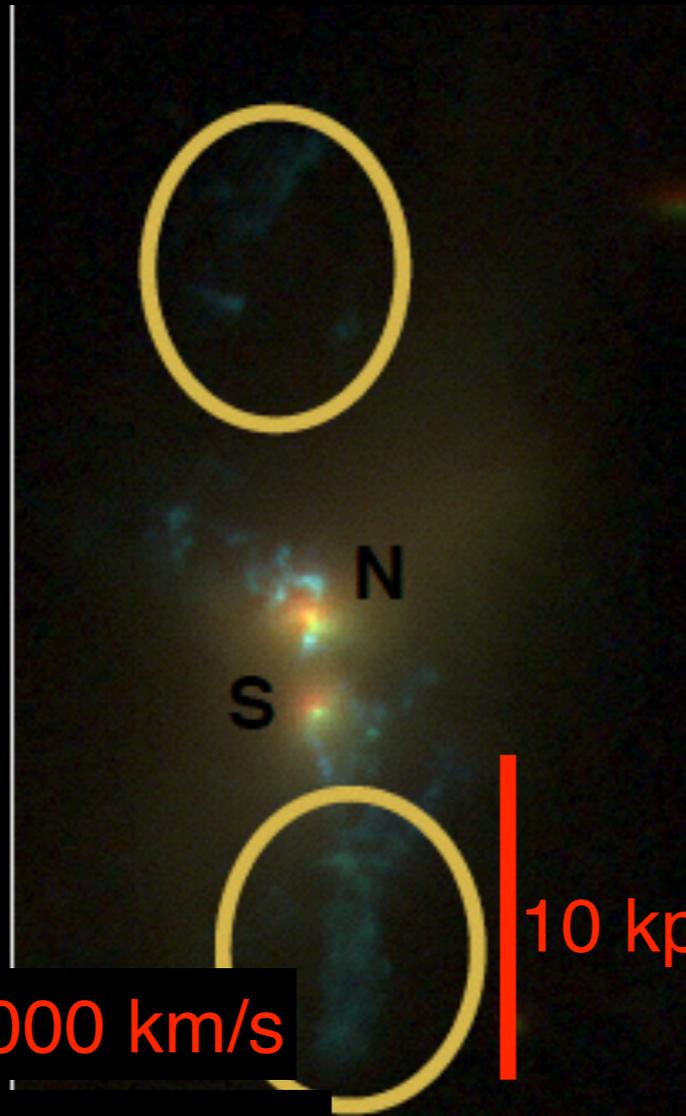
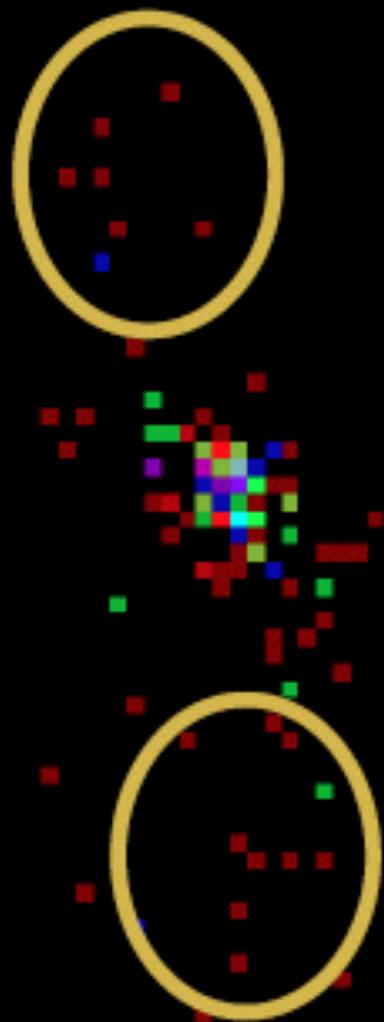
$M_* \sim 10^{11} M_\odot$

$M_{\text{mol}} \sim 10^9 M_\odot$

Radio-quiet AGN $L_{\text{AGN, bol}} \sim 10^{46}$ ergs/s

$L_{\text{IR}} \sim 3 \times 10^{45}$ ergs/s

$\text{SFR} < \sim 10 M_\odot/\text{yr}$



$V \sim 1000$ km/s

$T_{\text{dyn}} \sim 10\text{-}40$ Myr

$L_{\text{Kin, OF}} \sim 10^{44}\text{-}10^{45}$ ergs/s

10 kpc

Greene+12
Comerfield+in prep.

Chandra X-ray

HST Optical

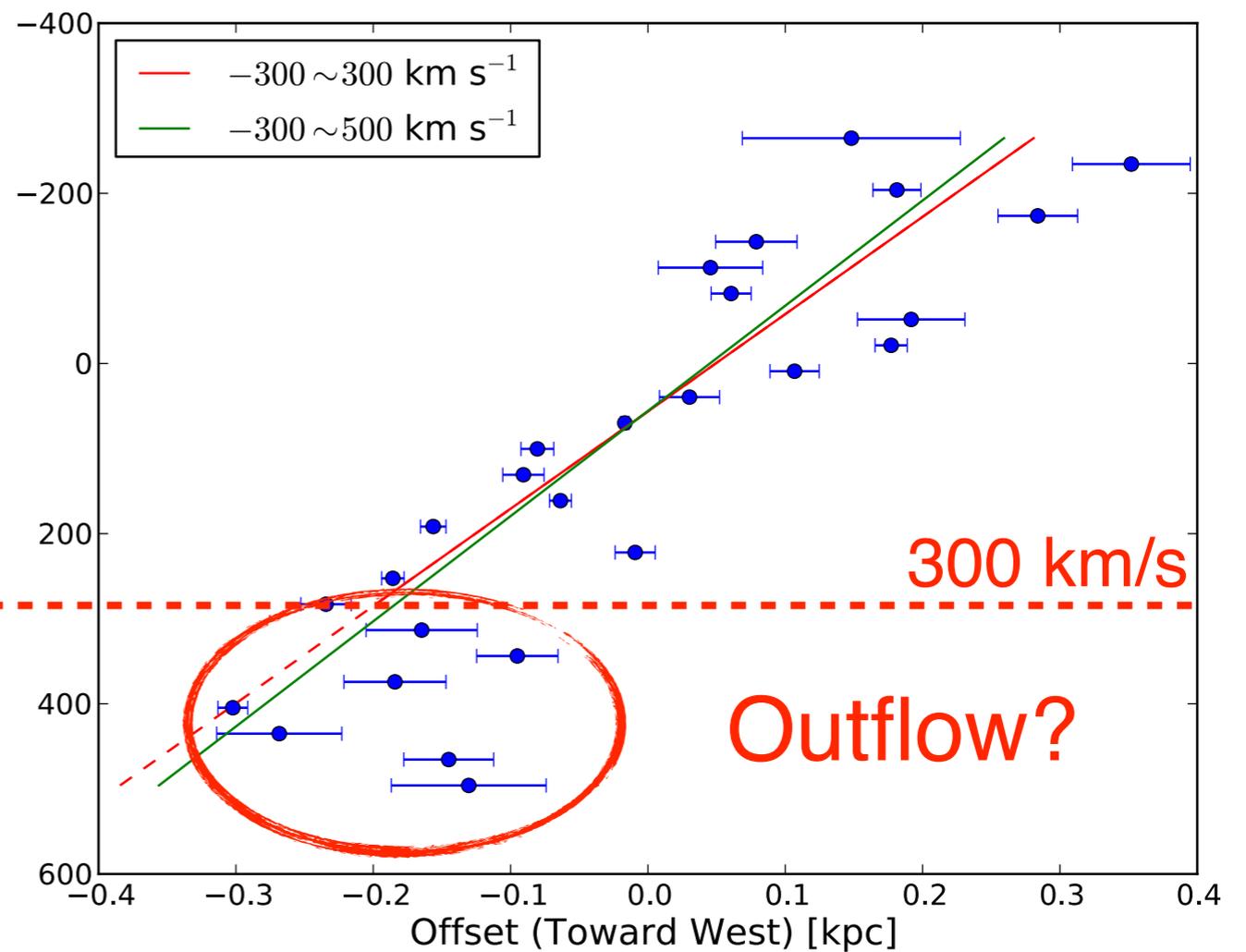
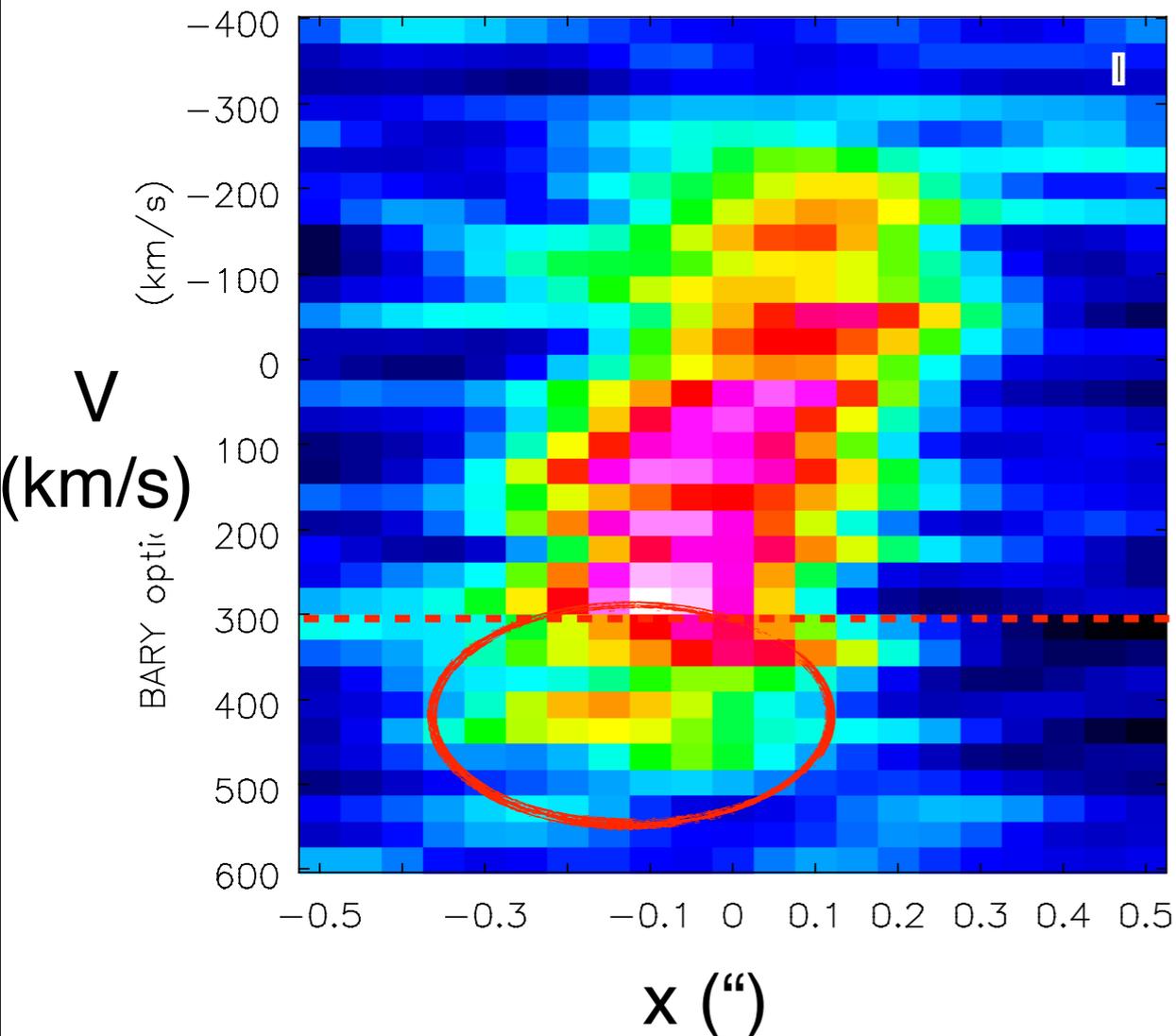
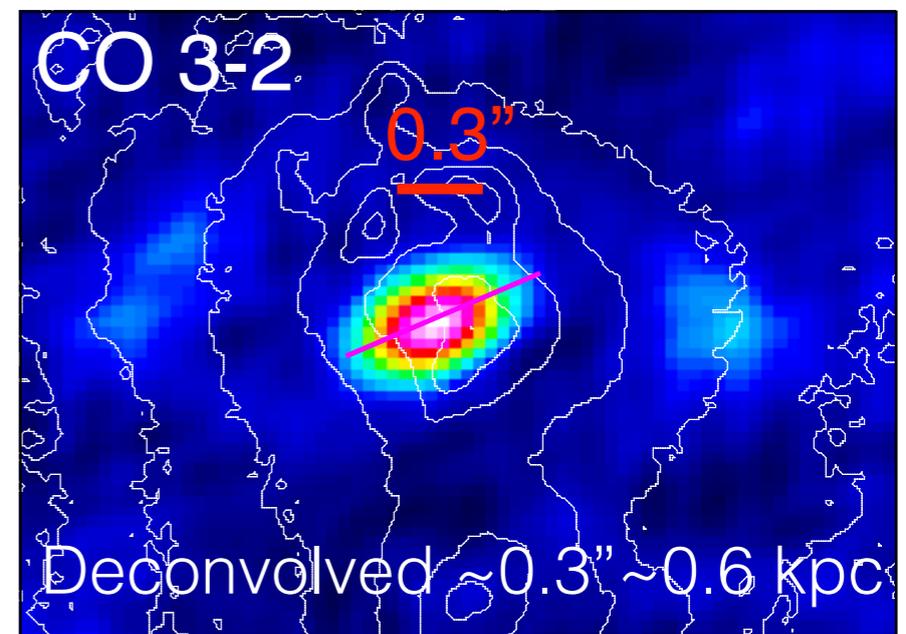
ALMA

CO 1-0

CO 3-2

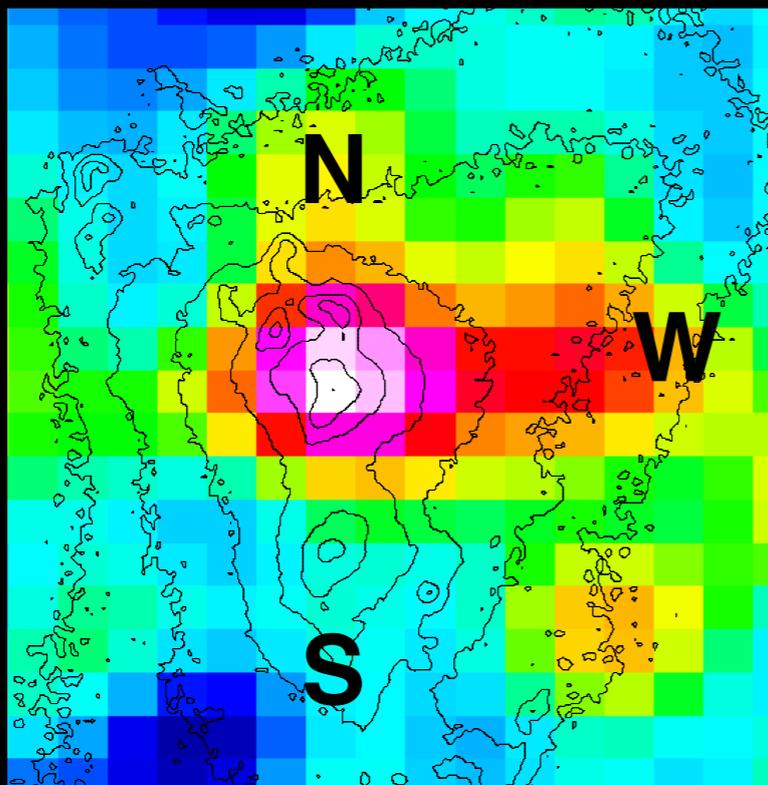
Northern Nucleus

$M_{\text{dyn}} \sim 4 \times 10^9 M_{\odot}$ $\sigma^* = 220 \text{ km/s}$
 $M_{\text{mol}} \sim 3 \times 10^8 M_{\odot}$ ($\rightarrow V_c = 310 \text{ km/s}$)

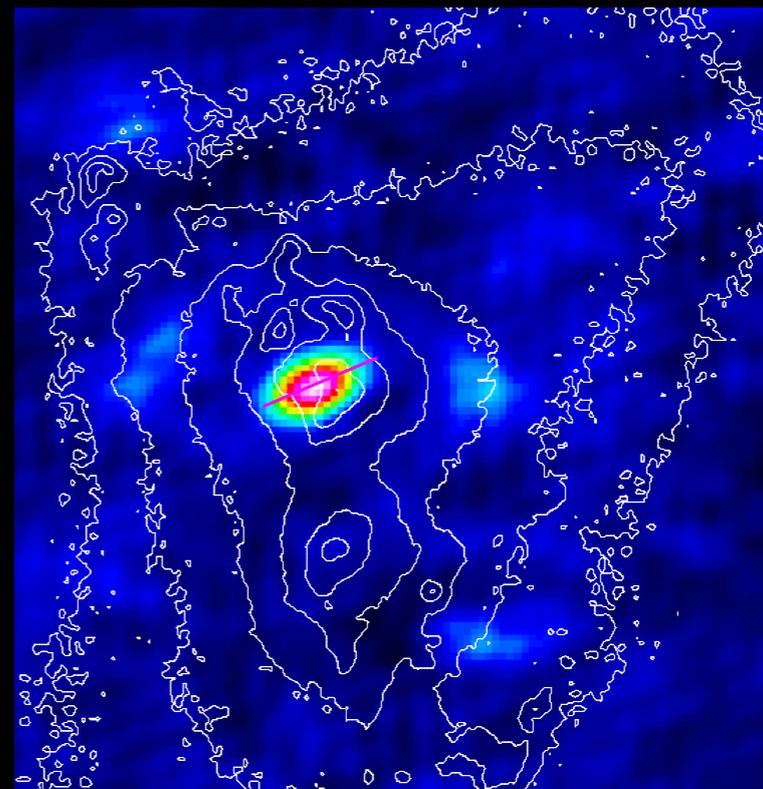


$M_{\text{mol,OF}} \sim 7 \times 10^7 M_{\odot}$ $T_{\text{quench}} \sim 3 \text{ Myr}$
 $dM_{\text{mol,OF}}/dt \sim 240 M_{\odot}/\text{yr}$
 (SFR $< \sim 10 M_{\odot}/\text{yr}$)

CO 1-0



CO 3-2



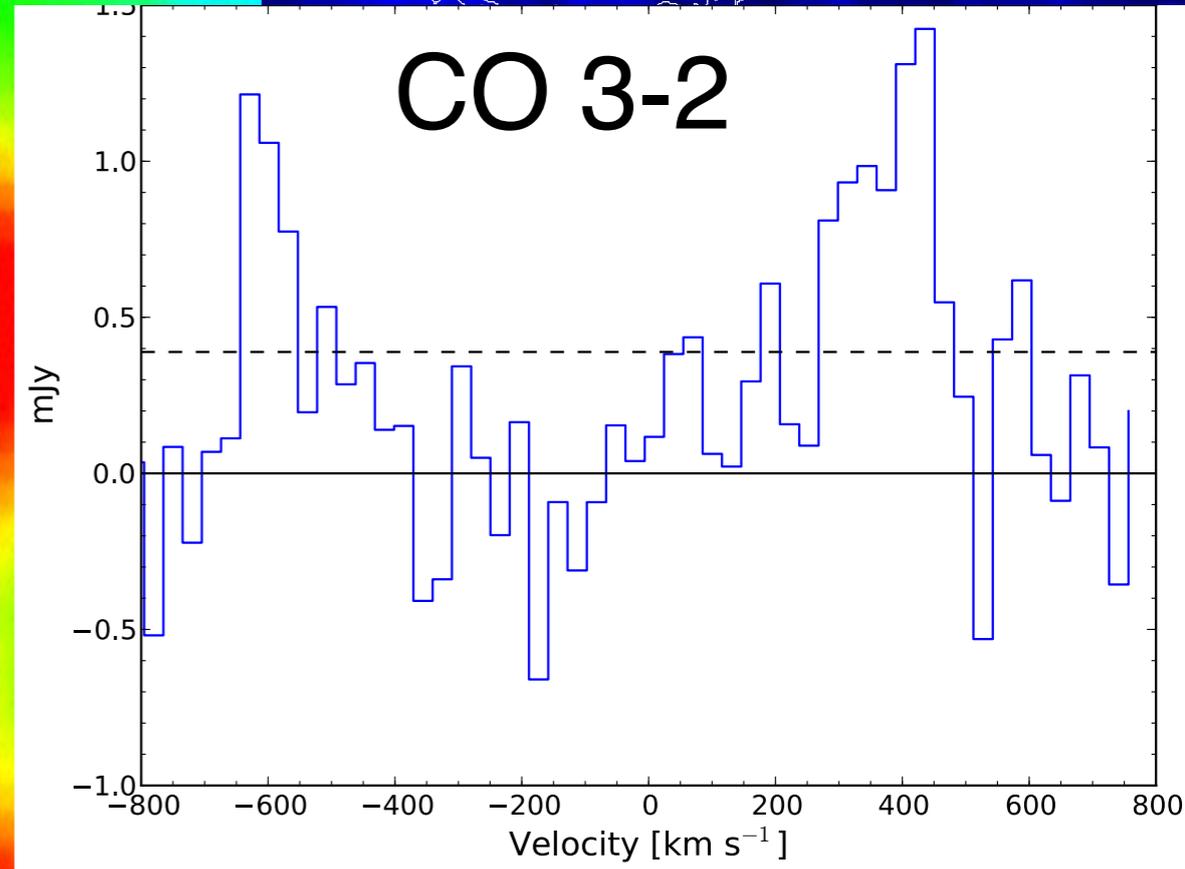
	Velocity [km/s]	$M_{\text{mol}} [M_{\odot}]$	$L'_{\text{CO1-0}}/L'_{\text{CO3-2}}$	
N Nucleus	-300 ~ 500	3×10^8	1.2 ± 0.7	QSO
W Arm	-250 ~ -50	5×10^8	0.4 ± 0.2	star-forming
S Nucleus	-80 ~ 50	8×10^7		
Total		9×10^8	0.6 ± 0.2	SMG

HST F438W
(Stellar & H β)

[OIII] Long-slit

ALMA CO 3-2

Red



High molecular mass loss rate \gg SFR
 $\sim 100 M_{\odot}/\text{yr}$ $\sim 10 M_{\odot}/\text{yr}$

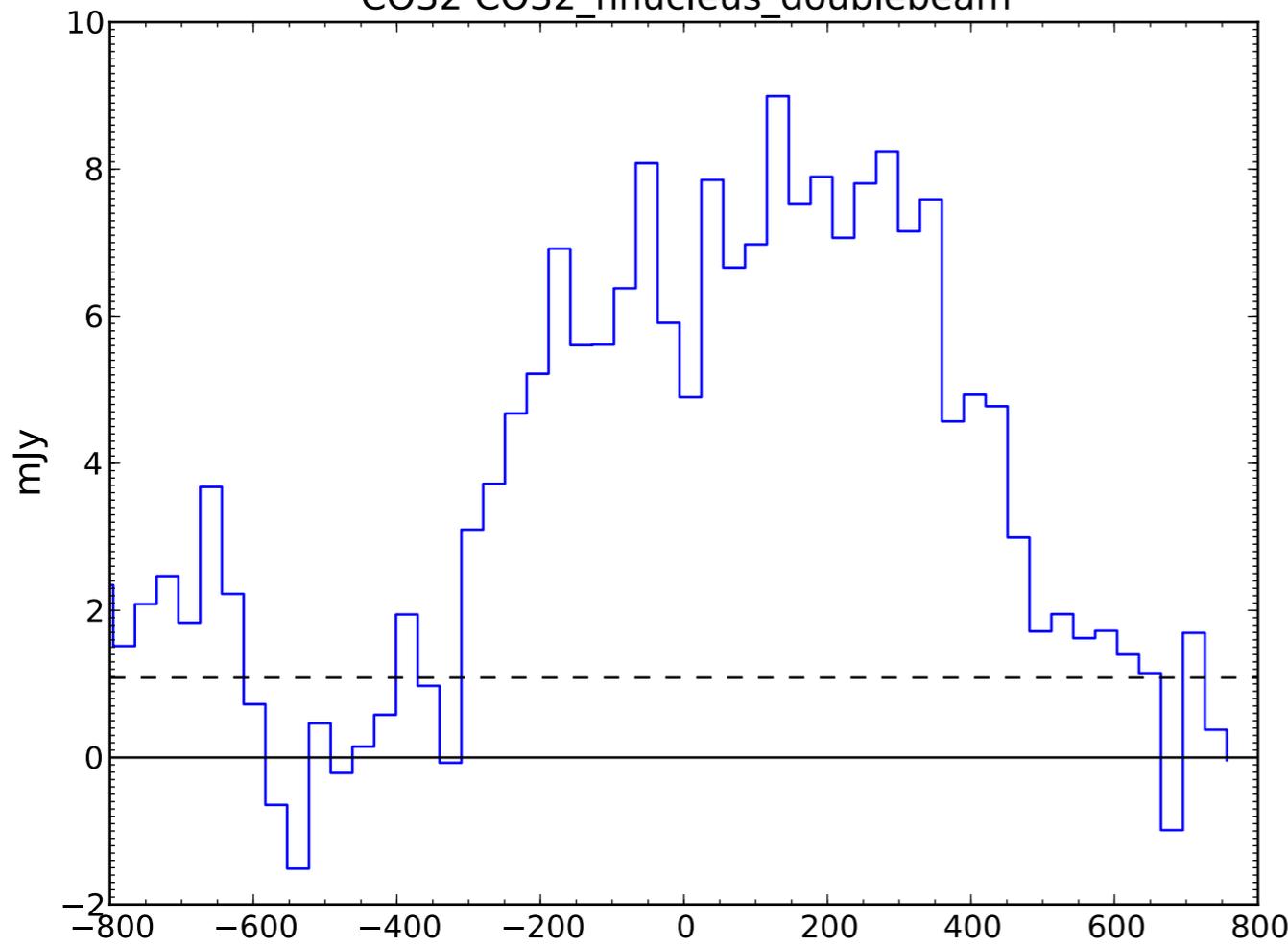
Ionized outflow perpendicular to extended molecular arm

Different time scales of **ionized** and **molecular** outflow

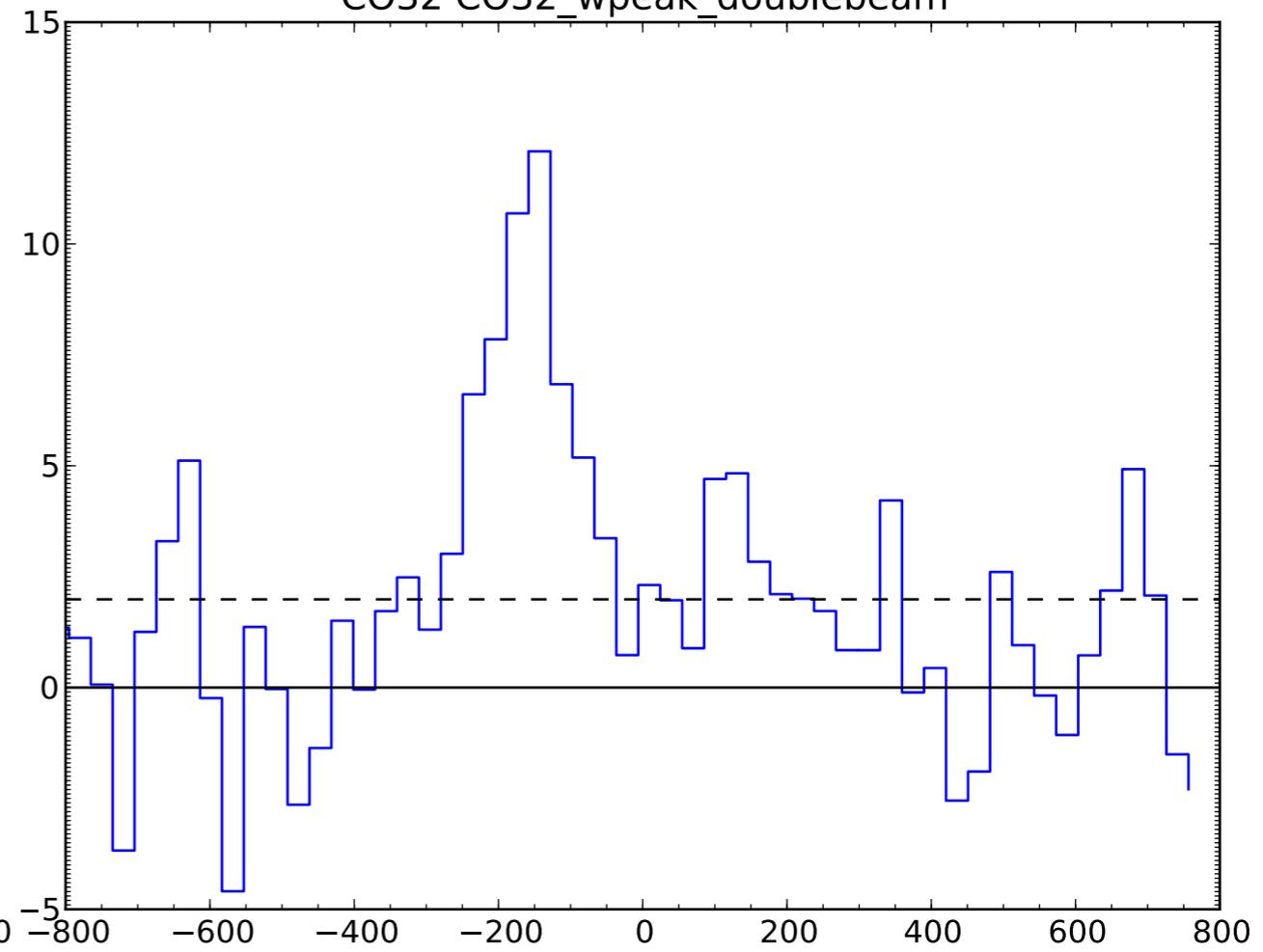
	10 - 40 Myr	0.5 Myr
size scales	10 kpc	0.3 kpc

High molecular excitation state

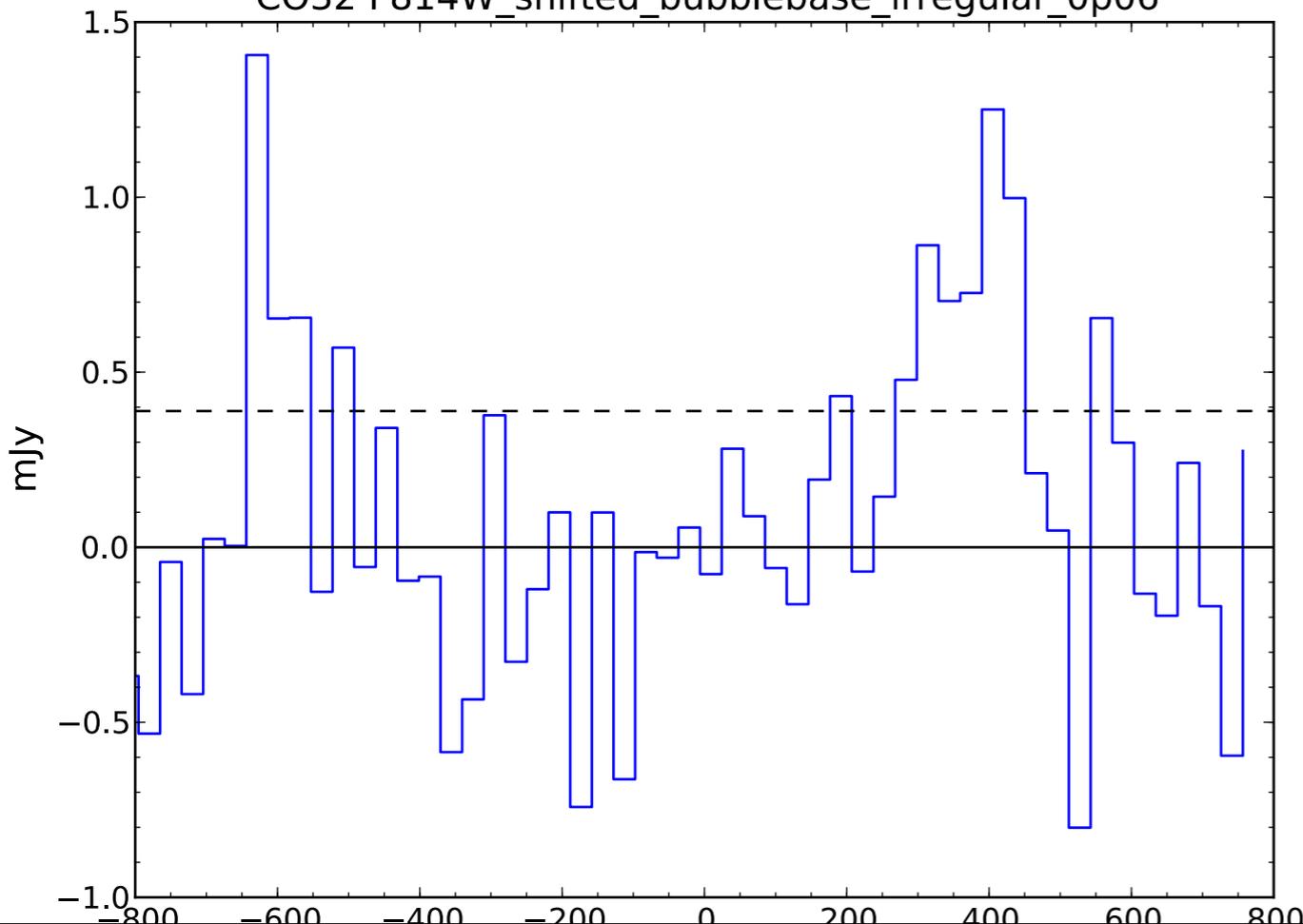
CO32 CO32_nucleus_doublebeam



CO32 CO32_wpeak_doublebeam



CO32 F814W_shifted_bubblebase_irregular_0p06



CO32 F438W_shifted_bubble_irregular

