Galpath16
Summary
Day 2

Sanders (1)
Scoville (12 !)
Discussion

Session 3: Mergers and the Role of AGN in Galaxy Transformation I - chair: Phil Appleton

Jorge Moreno - *Galaxy Mergers on FIRE*

Enhanced nuclear + suppressed off-nuclear (r>2-3kpc) SFR agrees with CALIFA

H. Jacob Borish - *Probing Ionization Mechanisms and AGN Activity in LIRGs with NIR Spectroscopy*

NIR Tspec obs of 42 LIRGs: opt vs. NIR diagnostics agree + discovery of faint broad em lines in Seyferts

Junko Ueda - *Does AGN and stellar feedback affect the molecular gas in merger remnants?*

Discovery of dense nuc disks in 22/28 merger remnants + HV Outflows (3/500 km/s) in 12CO, 13CO and HCN !

George Privon - *Large Scale Outflows and Dense Outflows in low-z ULIRGs*

Dense mol. Outflows in 2 nearby ULIRGs: MUSE (N6240) -> "Make IFUs Great Again"

Haussler, Hahn, Jagannathan, Johnston, Jorgensen, Joshi, Mo, Old, Pawlik, Peletier

Posters

Ezequiel Treister - *The Role of Major Mergers in (obscured) Black Hole Growth and Galaxy Evolution*

NuSTAR obs of LIRGs: 30% of AGN growth in CT phase + 60% of MBH due to major mergers

Kirsten Larson - *Clumpy Star-formation in Local Luminous Infrared Galaxies*

Paα Paβ maps GOALS LIRGs: SF clump R and SFRs overlap with local MS and with high-z clumps

Martin Sparre - *High-res cosmo simulations of major mergers: some remnants are SF + have stellar discs*

Illustrus higer res sims needed to correctly predict obs high SFRs + Merger remnants "are not quenched"

Rachael Beaton - *Rethinking the Narrative of a Micro-Merger: Impacts on the Host Galaxy Morphology*

All gals have μ-mergers: tracing results of >10:1 interactions over Virial R = galactic accretion histories

Session 4: Mergers and the Role of AGN in Galaxy Transformation II - chair: Tim Davis

Phil Hopkins - What Doesn't Quench Star Formation? The Need for AGN

"Back to his roots" … AGN feedback required for observed suppression of SF in high mass Galaxies/Haloes

Vivian U - A Near-Infrared View of Shocks in Nuclear Outflows

Osiris-AO NIR observations of local ULIRGs discovers geometry of shocked MG on 10s pc scales

Fred Hamann - Extreme Red Quasars in SDSS3-BOSS

ERQs are distinct pop with unique-exotic phys conditions: 1000s km/s outflows: ~0.2% of norm-QSOs

Ramos-Martinez, Shih, Shivaei, Smith, Suess, Terrazas, Vayner, Wender, Wiens, Lacy

Posters

Lauranne Lanz - Star Formation Suppression due to AGN Feedback

SF suprpessed by x2-3 in RGs with jets … and … SPOGs Unmasked: the 1st SPOG is not really a SPOG

Duncan Farrah - Star Formation in Luminous Quasars at 2<z<3

SFRs of lum QSOs remain "constant" (300M/yr !) over 2 < z < 3 + higher SFR correlates with higher accr rate

Brooke Simmons - Detailed visual morph of 200,000 gals at 0.25<z<4 from Galaxy Zoo and Hubble Legacy Imaging

150,000 Citizen Scis => 12M vis class of 200,000 HST images from HST Deep Fields: " they" are as good as "us"

what don't we understand ??

a little indulgence please, (ALMA in future)

Arp 220 @ 10 mas res. ➔ 40 pc

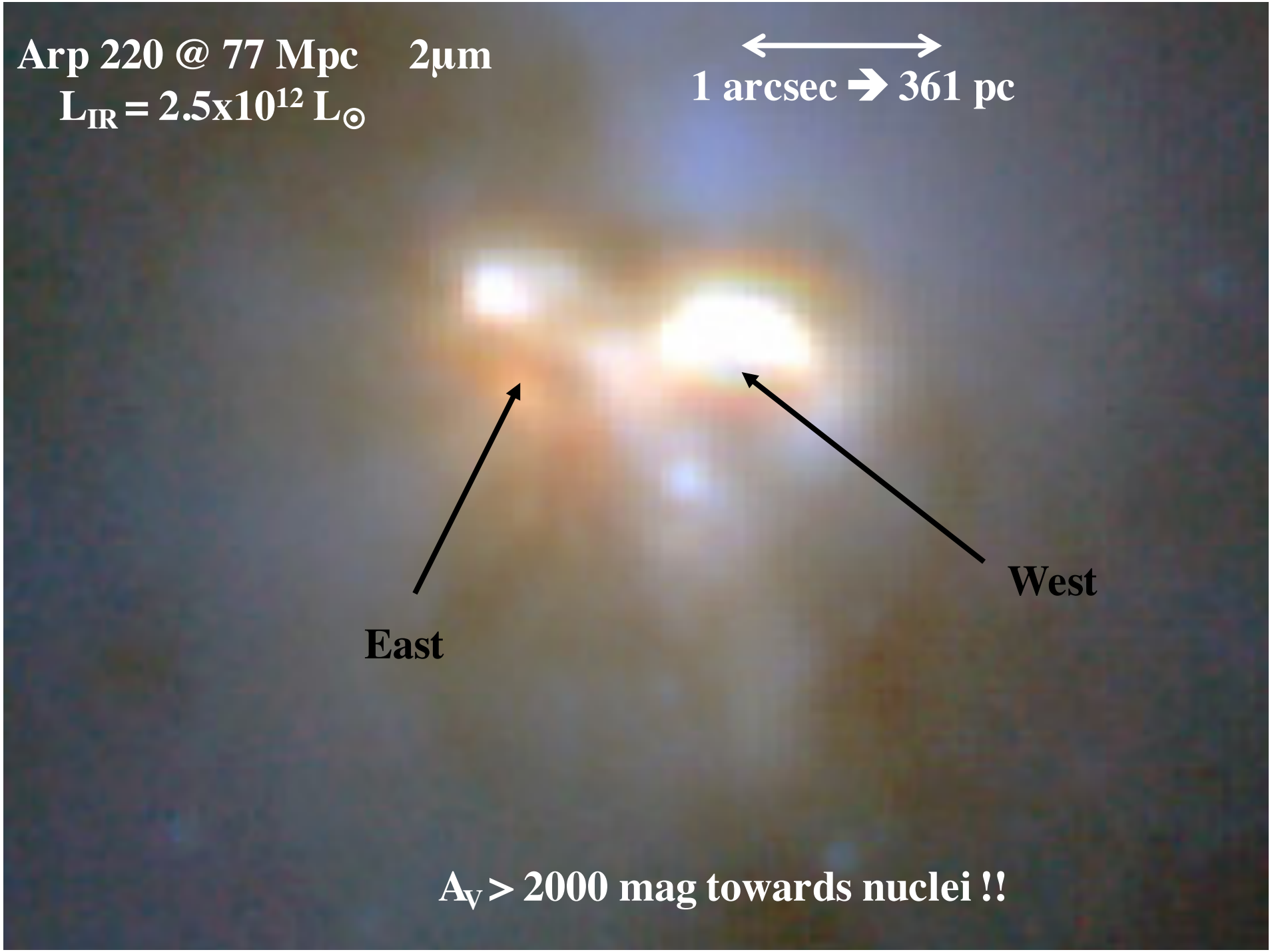
what are conditions in late stage merger

ISM evolution in 300 galaxies at z > 1

ISM is critical fuel for SF (& AGN)

➔ nature of starbursts in mergers

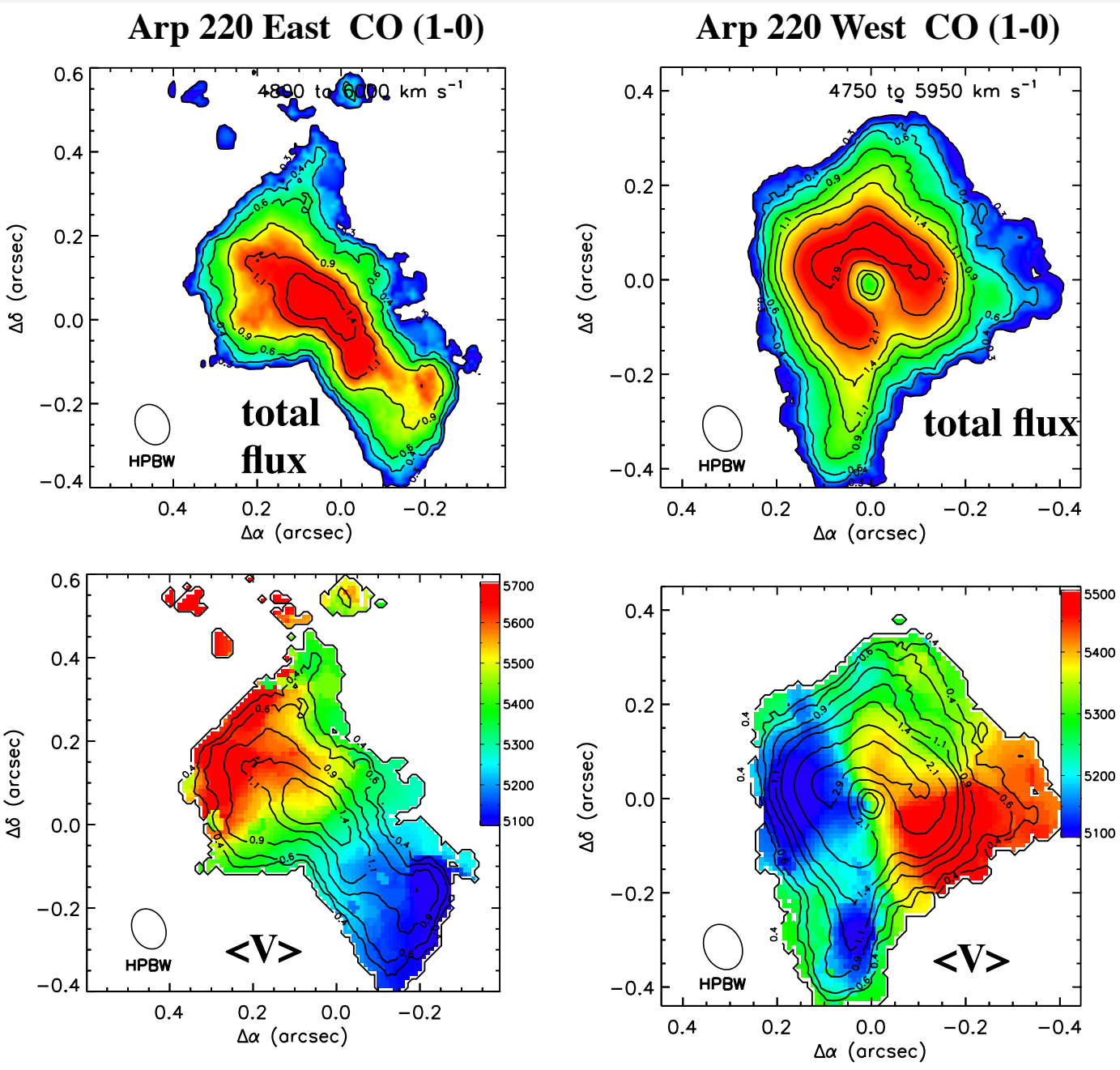
is SF different at high z ??

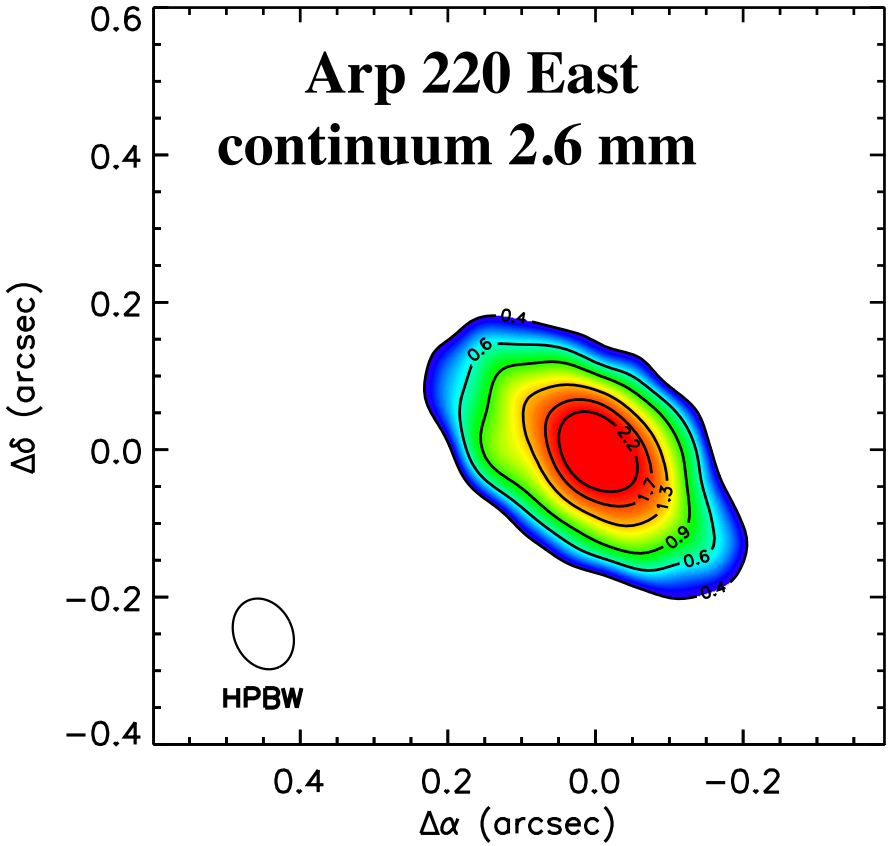

Arp 220 @ 77 Mpc 2μm
$L_{IR} = 2.5x10^{12} L_{\odot}$
1 arcsec → 361 pc
East
West
$A_V > 2000$ mag towards nuclei !!

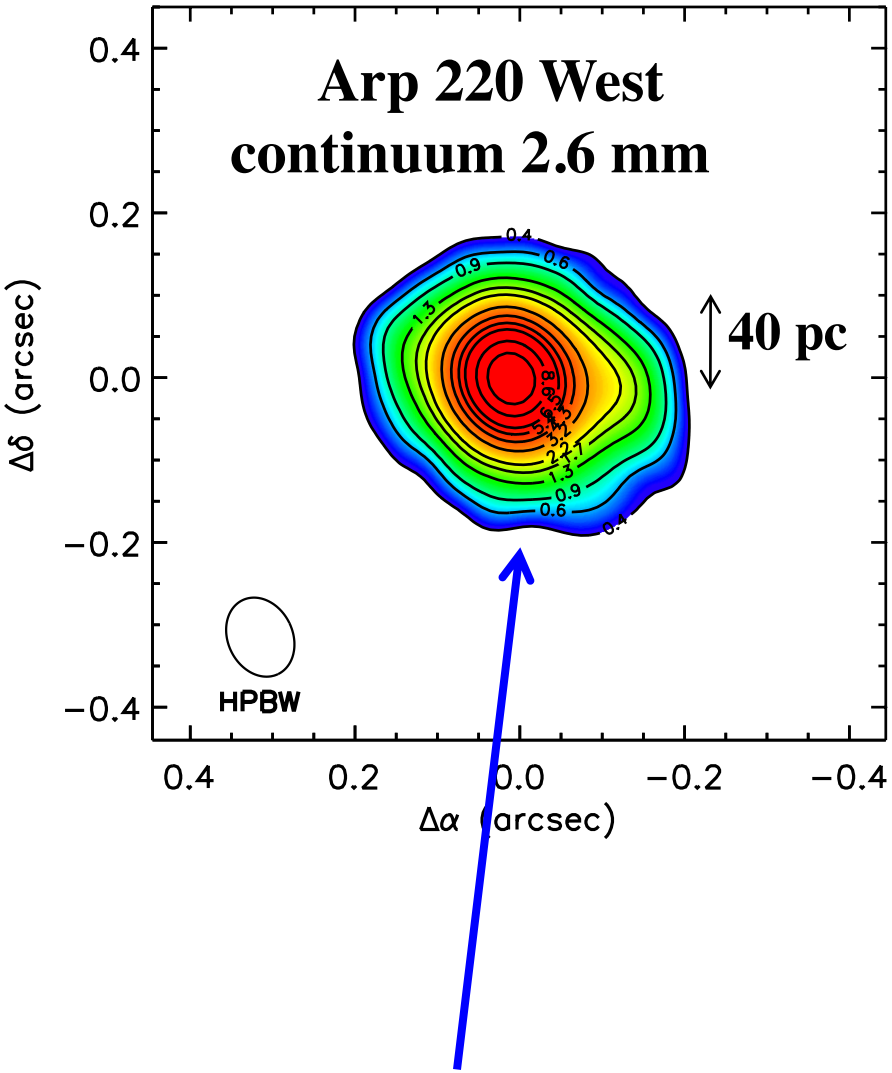
ALMA 0.1'' res integrated CO line and <V>

total emission ➔

velocities ➔







at 2.6 mm dust emission West $T_B = 120$ K ~ T_D

==> optically thick

at 2.6 mm dust emission West $T_B = 120$ K

(expect ~170 K for $10^{12} L_\odot$ R ~ 15 pc)

➔ $\tau \sim 1$ at 2.6 mm !!

➔ $N_{H2} = 2 \times 10^{26}$ cm^{-2} , $A_V = 10^5$ mags !!

M_{ISM} (west compact nucleus) ~ $2 \times 10^9 M_\odot$ R < 16 pc

$n_{H2} \sim 10^6$ cm^{-3}

dust column ➔ $A_V = 10^6$ mags !!!!!!!!

= 600 gr cm^{-2}

~ 2 m thick concrete wall !!

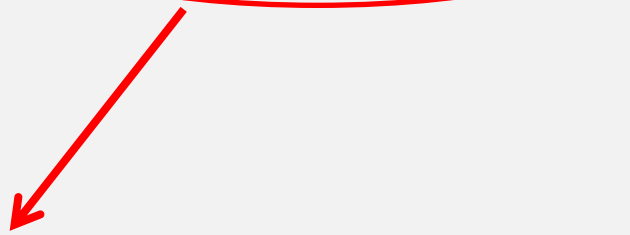
~ 1 ft of gold

can you suppress AGN feedback ?

ISM masses are critical to understanding galaxy evolution & SF and AGN activity

using long λ dust emission to estimate ISM masses

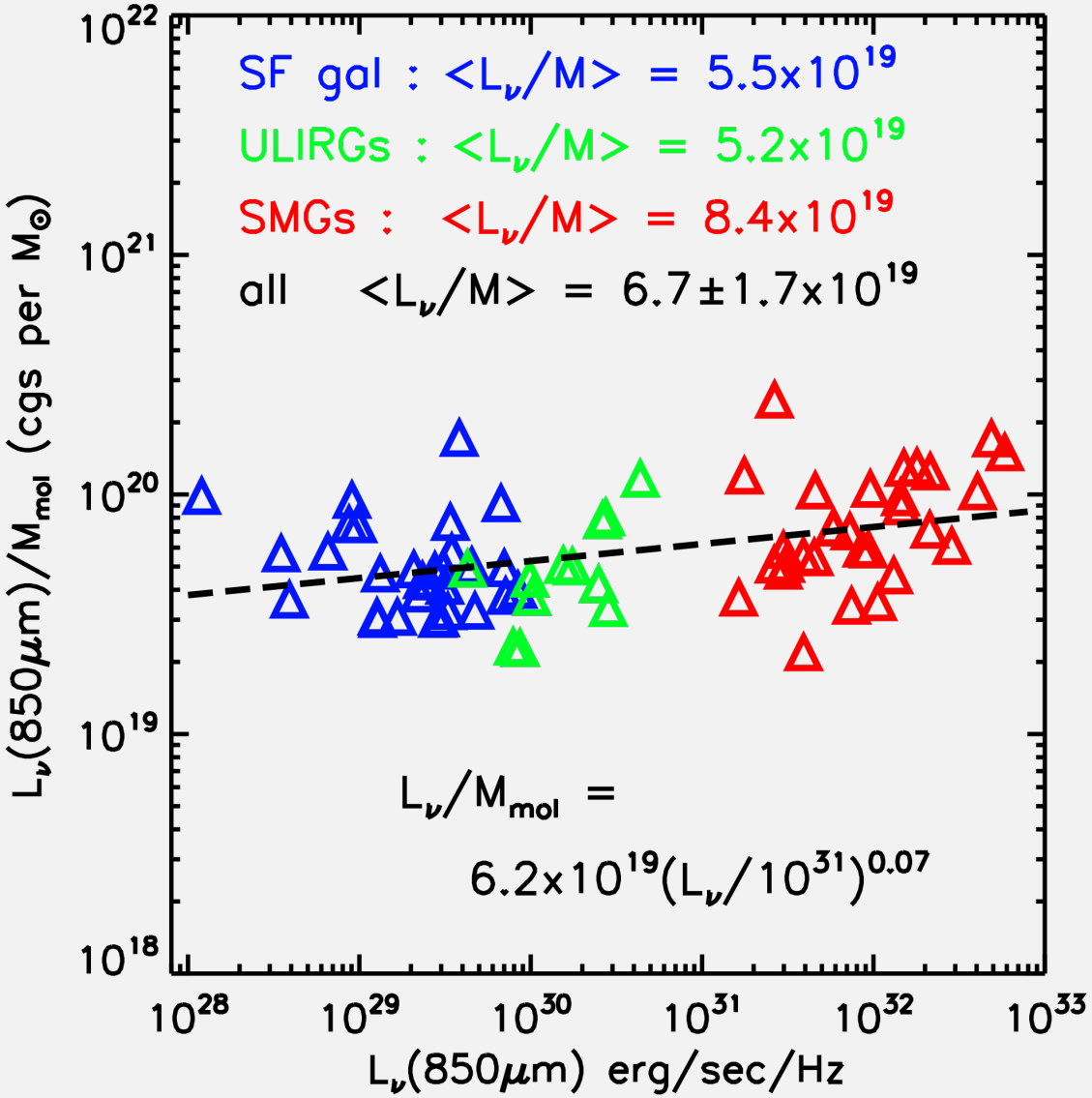
$$F_{RJ} \;\alpha\; M_{gas}\,(\text{dust/gas})\;\text{opacity}_{\nu}\,T_D/D^2$$



calibrate from local galaxies

using long wavelength dust emission to get ISM masses

empirical basis :



6.7×10^{19} erg/s/Hz/M

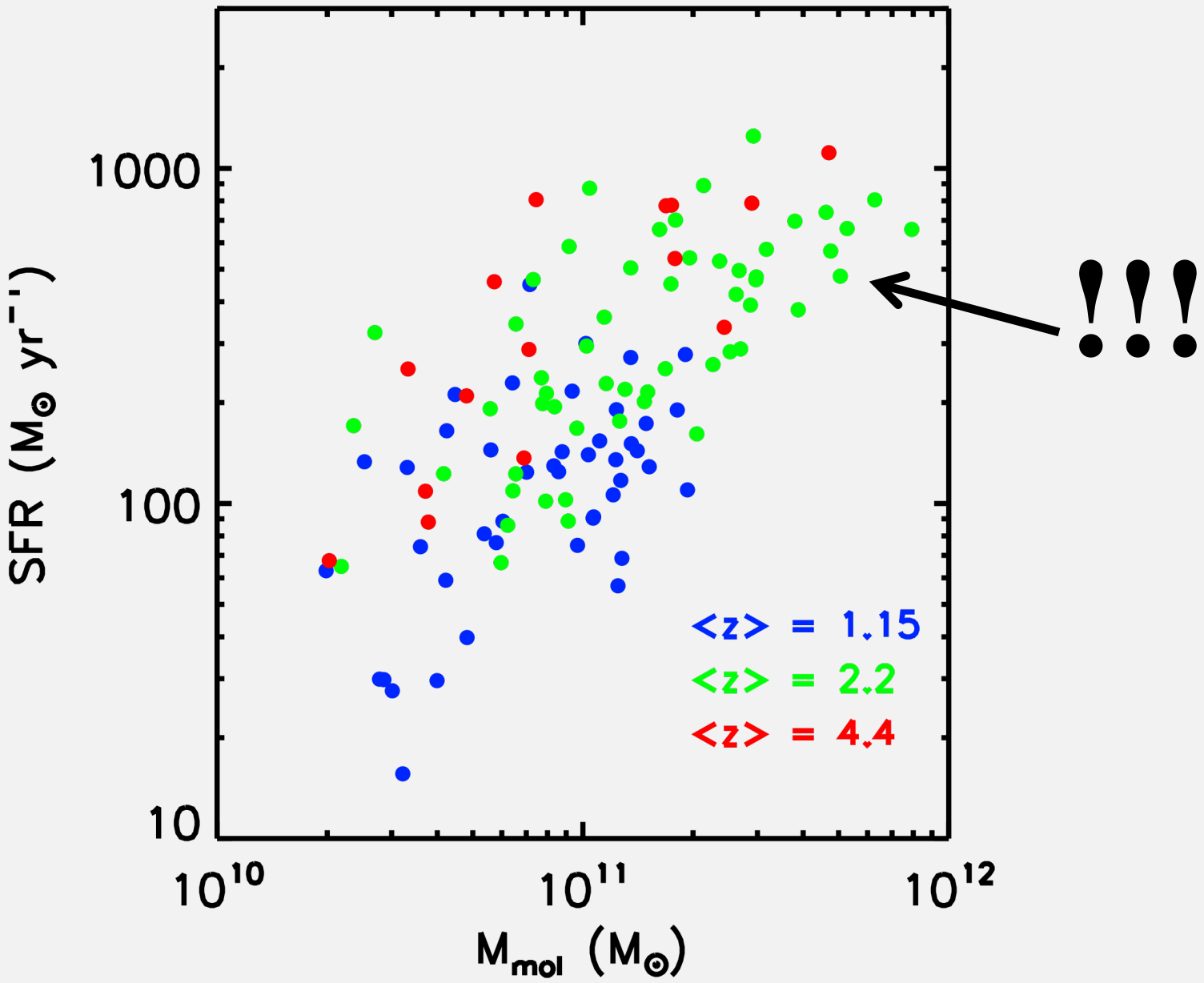
w/ less than factor 2 dispersion

Planck: Milky Way

6.2×10^{19} erg/s/Hz/M

$\beta = 1.8 +- 0.1$

gas masses from RJ dust emission



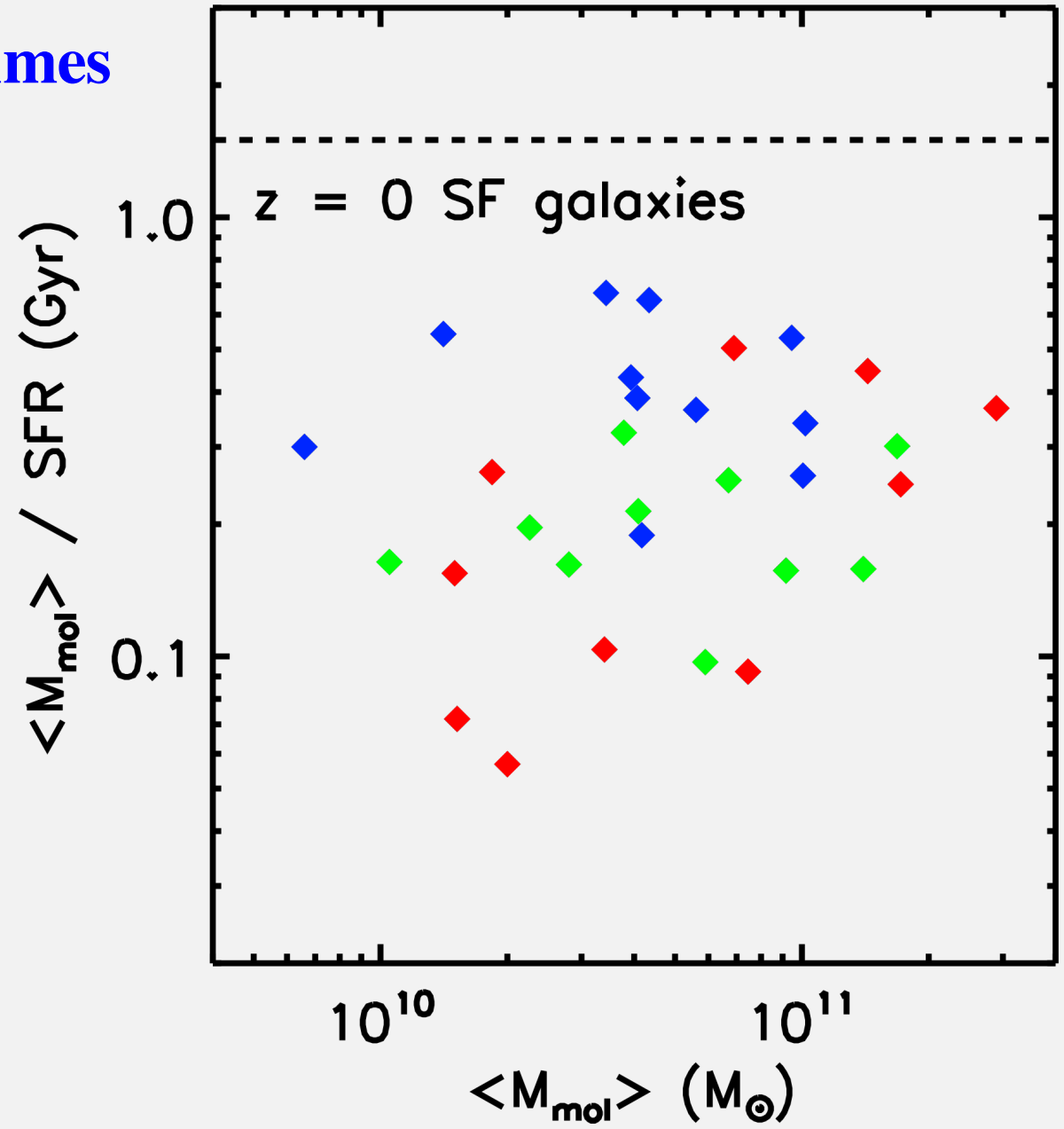
ISM masses increase above the main sequence !!

➔ **increase in SFRs above the MS**
largely due to larger ISM masses

analytic fit :

$$\mathrm{SFR} = 30 \pm 12 \left(\frac{M_{mol}}{10^{10} M_{sun}} \right)^{1.1 \pm 0.1} \left(\frac{1+z}{3} \right)^{0.8 \pm 0.3} M_{sun}\,yr^{-1}$$

gas depletion times



➔ high accretion rates !!!

our work ➔

single, linear SF law

at z = 1 to 6 and on MS and above MS

$$SFR = 30\left(\frac{M_{mol}}{10^{10}M_{sun}}\right)^{1.1\pm0.1}\left(\frac{1+z}{3}\right)^{0.8\pm0.3} M_{sun}yr^{-1}$$

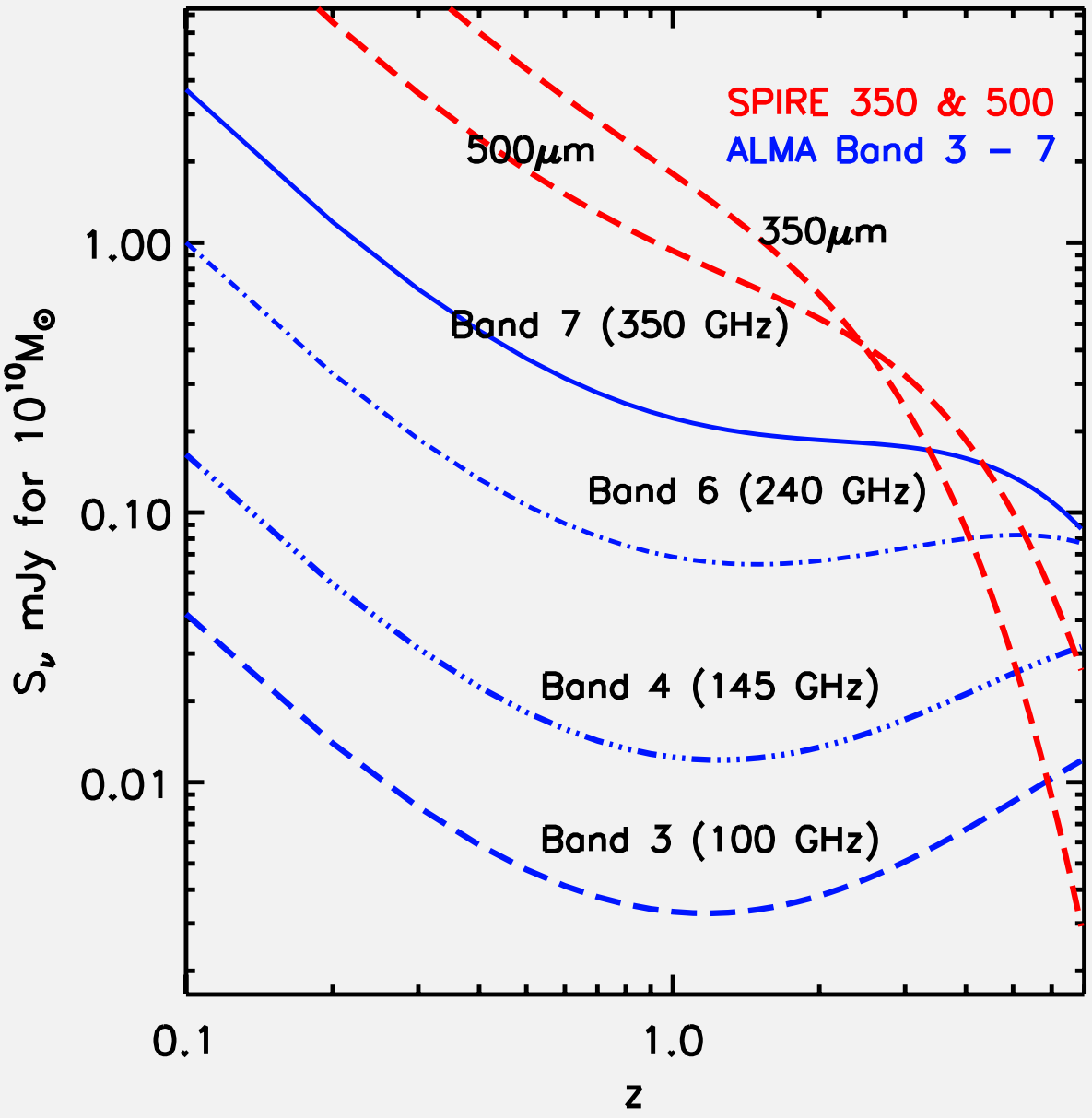
$$\Rightarrow \tau_{ISM\rightarrow stars} = \frac{M_{ISM}}{SFR} \approx 2-6x10^{8}\ yrs\ \ (2-5x\ faster\ than\ z=0)$$

huge accretion rates

replace entire ISM w/i 3-7x10^8 yrs

why is SF more rapid per unit gas mass at z > 1 ??

for ALMA Bands 3 - 7 predict :

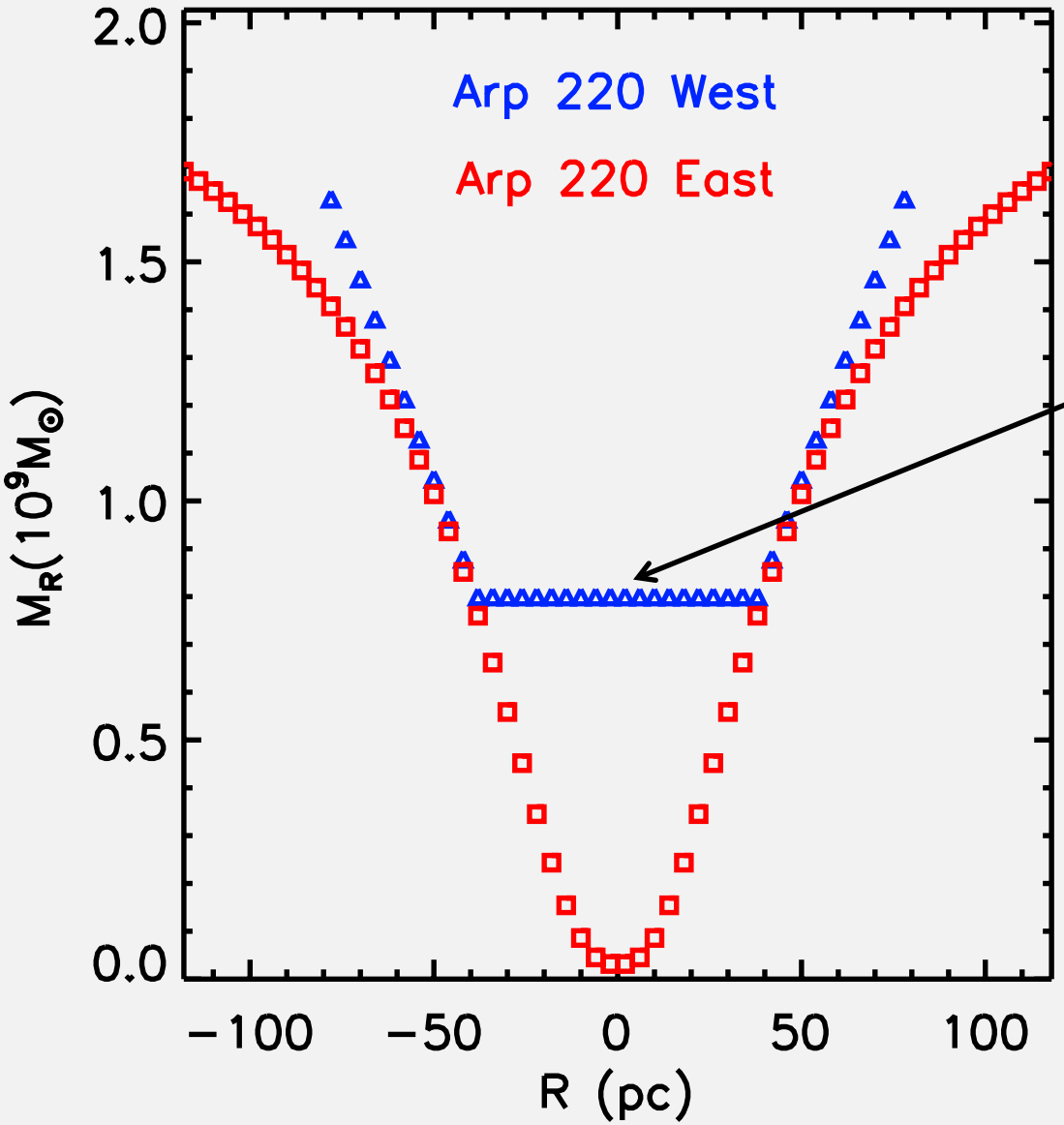


3 σ in ~2 min for $M_{ISM} = 1 \times 10^{10}$

20-50 x faster than CO !

avoid CO conv. fac.

dynamical mass from rotation curve



central point mass
BH ??

Nuclear Disk Emissivity and Kinematic Models

West Nucleus

systemic velocity	V_{sys}	5434 km s^{-1}
gas turbulence	FWHM Δv	250 km s^{-1}
disk inclination	i	30°
major axis	PA	265°
rotation curve:		
	point mass	8×10^8 $M_\odot$
	mass at $<$ 80 pc	$\sim 1.5 \times 10^9 M_\odot$
CO emissivity:		
	peak	at R$<$ 5 pc
	flat and 10× lower	at R = 10 - 50 pc
	axisymmetric	

central BH ?

East Nucleus

systemic velocity	V_{sys}	5528 km s^{-1}
gas turbulence	FWHM Δv	120 km s^{-1}
disk inclination	i	45°
major axis	PA	50°
rotation curve:		
	point mass	$< 10^8$ $M_\odot$
	mass at $<$ 130 pc	$\sim 1.5 \times 10^9 M_\odot$
CO emissivity:		
	0	at R$<$ 5 pc
	peak	at R$\sim$ 10 pc .
	falls a factor 2	out to 100 pc.
	receding side 2× brighter.	

velocity disp.
➔ disk thickness