Lessons from Comparisons between the Nuclear Region of the Milky Way and Those in Nearby Spirals.

Jay Gallagher, Tova Yoast-Hull, Ellen Zweibel (U. Wisconsin)

Thanks to NSF for support through IceCube & Center for Magentic Self Organization NASA via Hubble Space Telescope, & Donors to the University of Wisconsin College of Letters & Science

Objective: place Milky Way nucleus in context

- Milky Way CMZ nearby→ best details (e.g., Sakamoto talk)

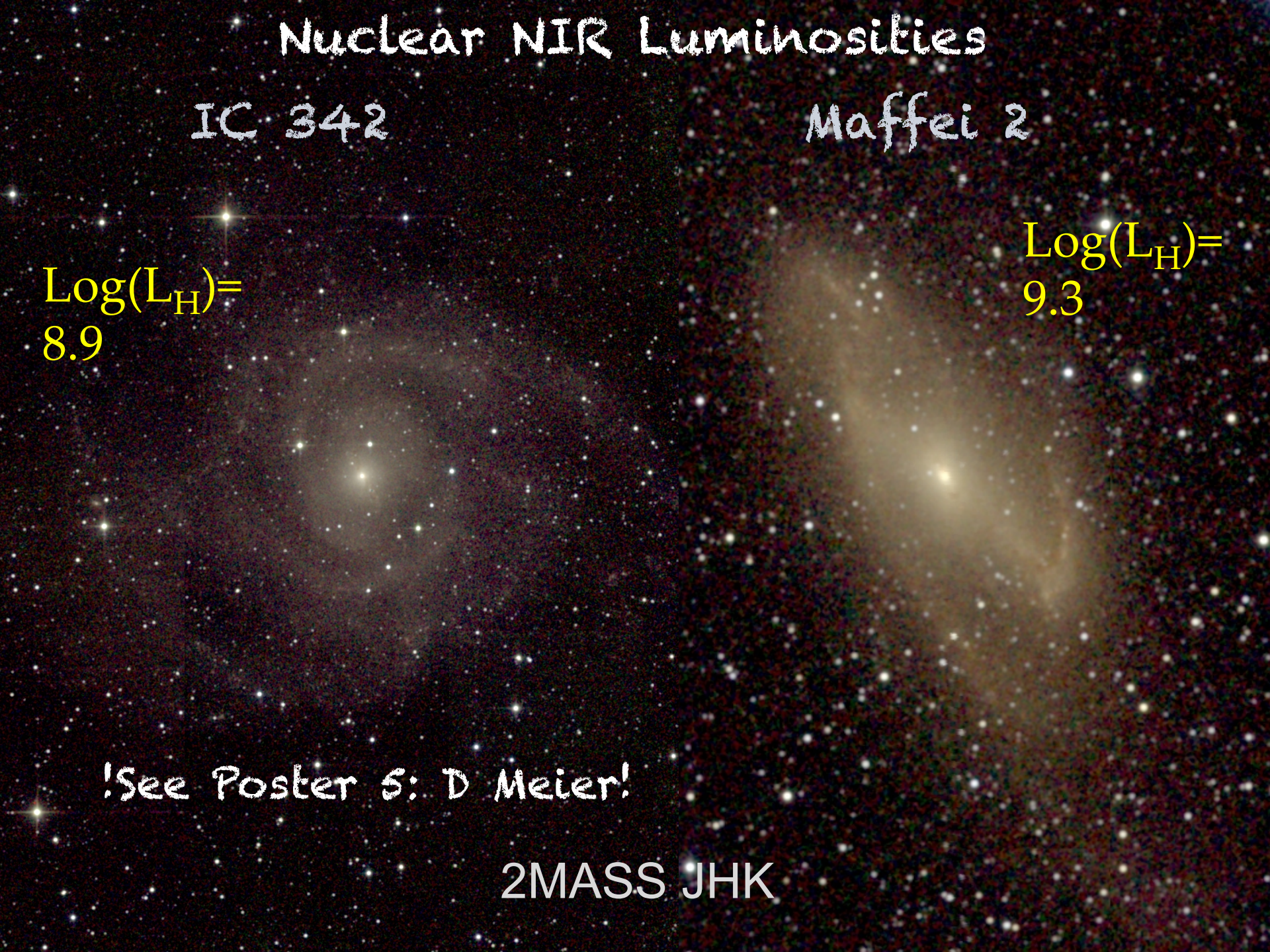
- Single example— unique vs. general characteristics
  - Supernova model cosmic ray interaction model fails in MW nucleus, works in NGC 253 (Tova Yoast-Hull poster): starburst ⟺ normal
  - Low star formation rate (SFR)
  - Quiet SMBH
  - Fermi bubble
  - ….

Milky Way Nucleus in Context: Struturally Similar Nearby Mildly Barred Spirals

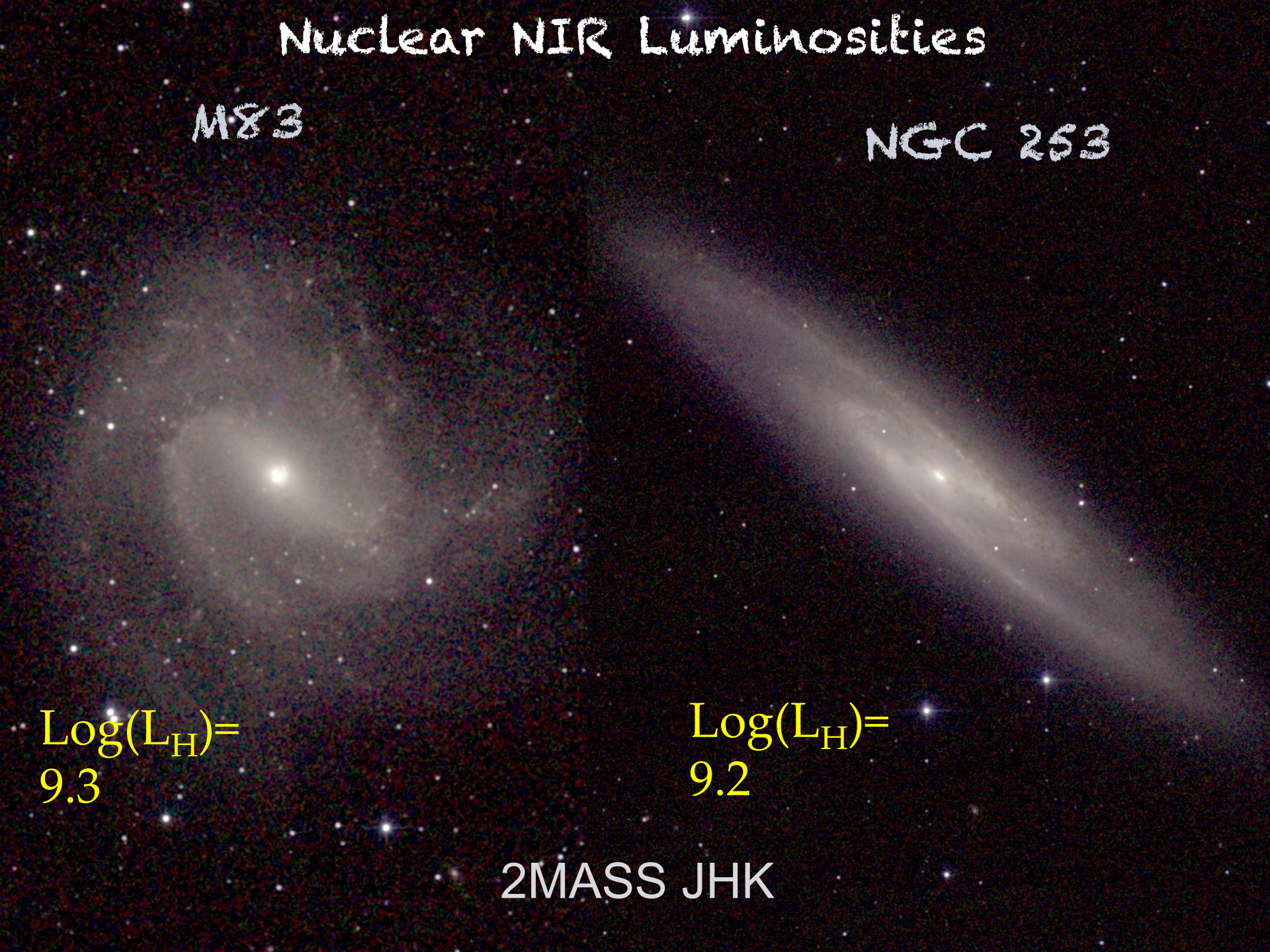
- IC 342 SAB(rs)cd D=3.5 Mpc M_B= -21.9
- Maffei 2 SAB(rs)bc: D=3.9 Mpc
- M83 SAB(s)c D=4.5 Mpc M_B= -20.4
- NGC 253 SAB(s)c D=3.9 Mpc M_B= -21.2
- Milky Way SABbc: M_B~ -20.5

Similarities

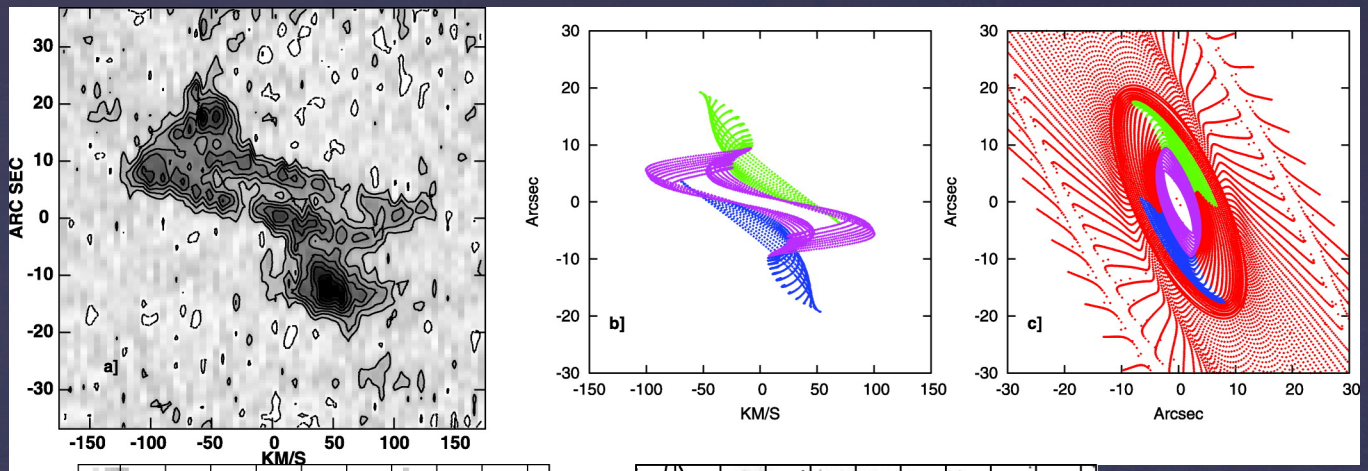
Nuclear NIR Luminosities



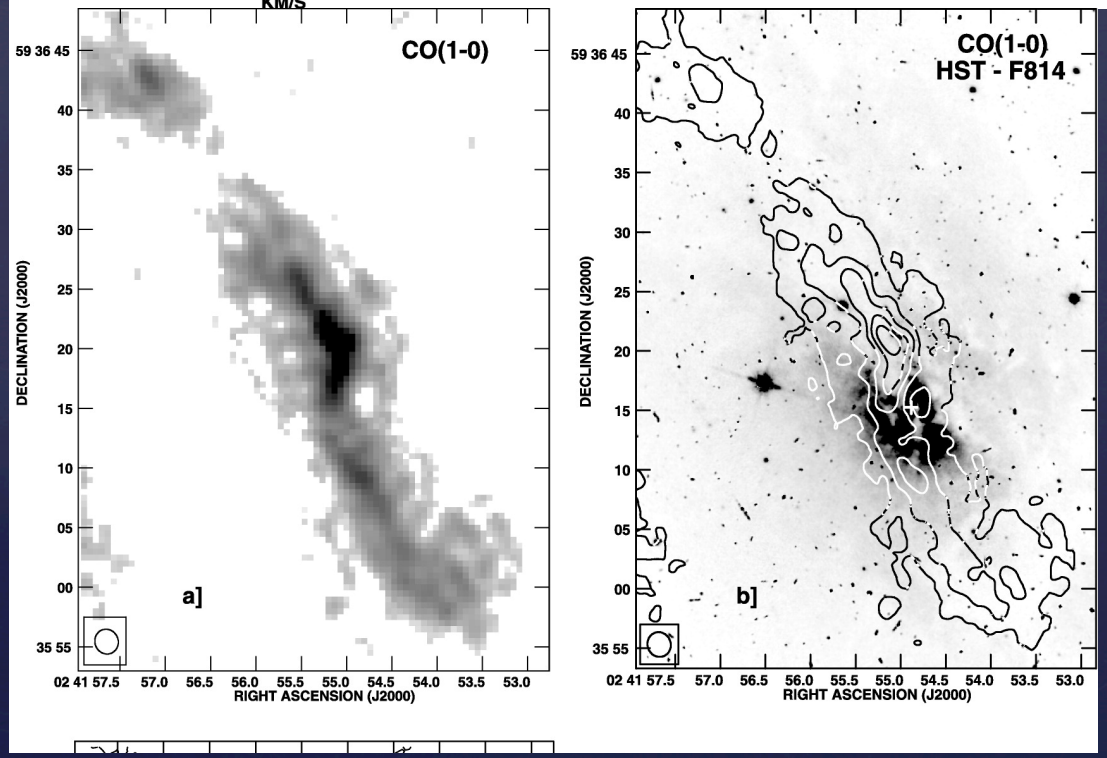
Nuclear NIR Luminosities



Maffei 2 CO – Bar + CMZ Disk

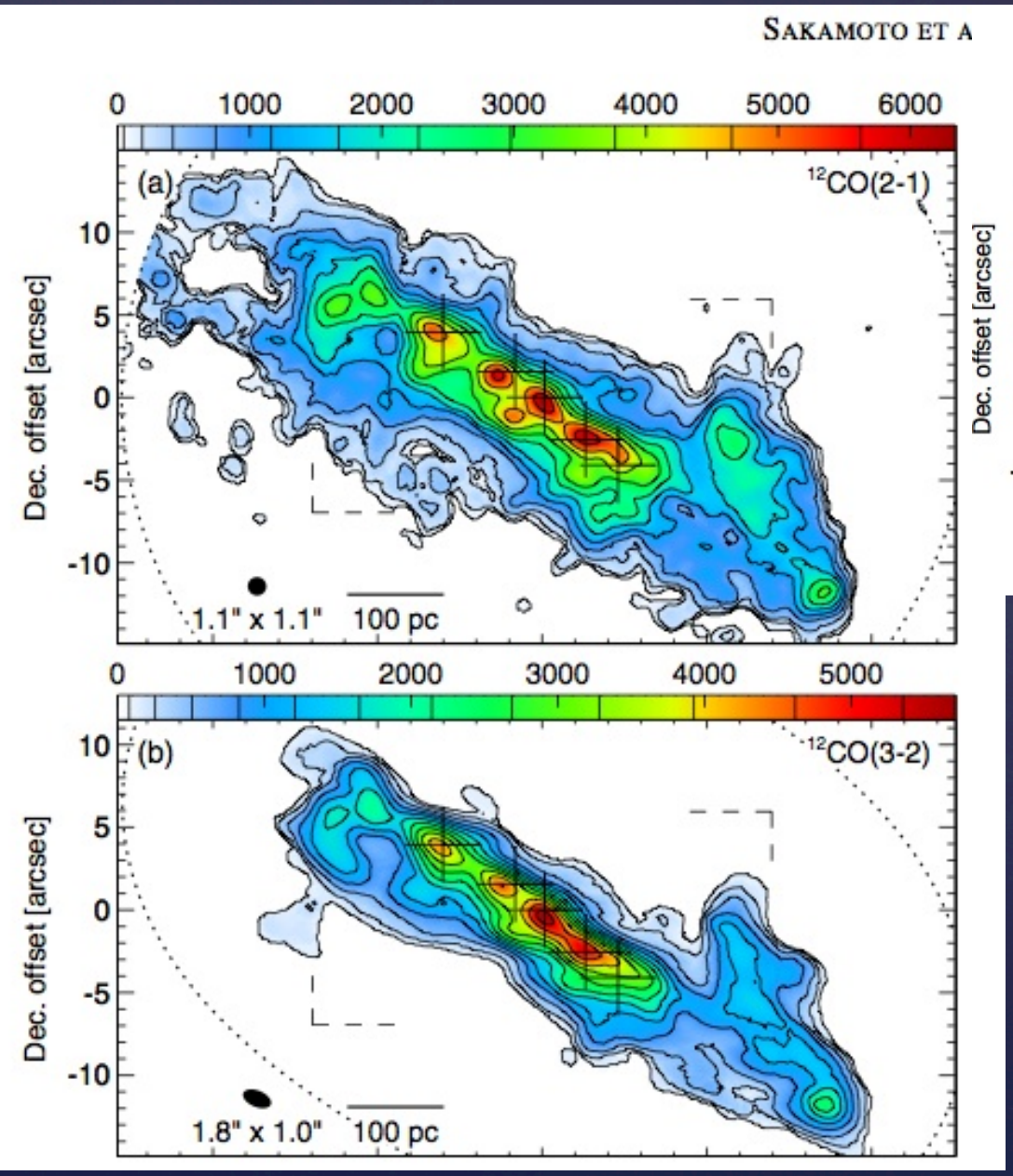


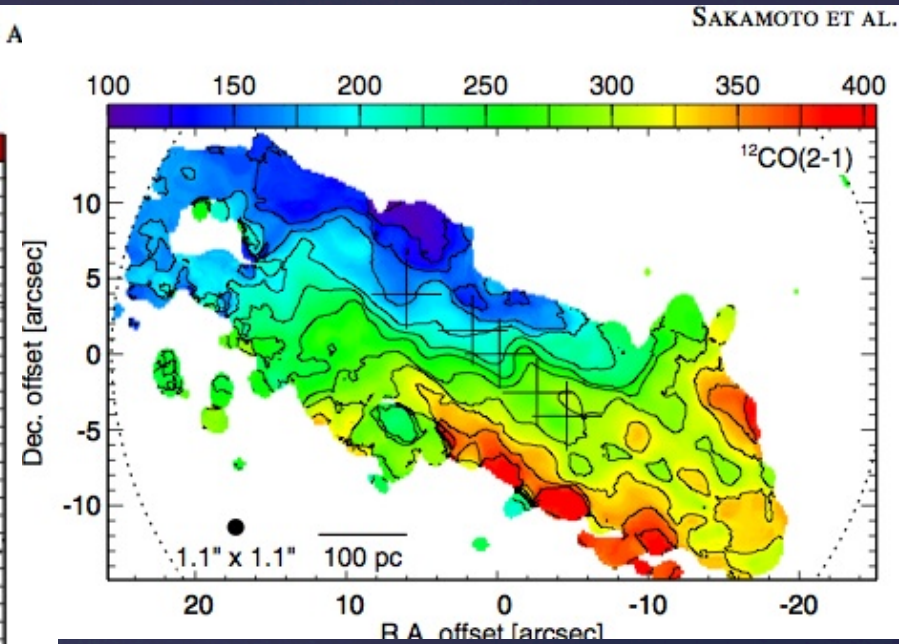
M(mol)$_{CO}$ ≈ 5E7 Msun



Meier + 2008, ApJ 675

NGC 253—Edge on CMZ

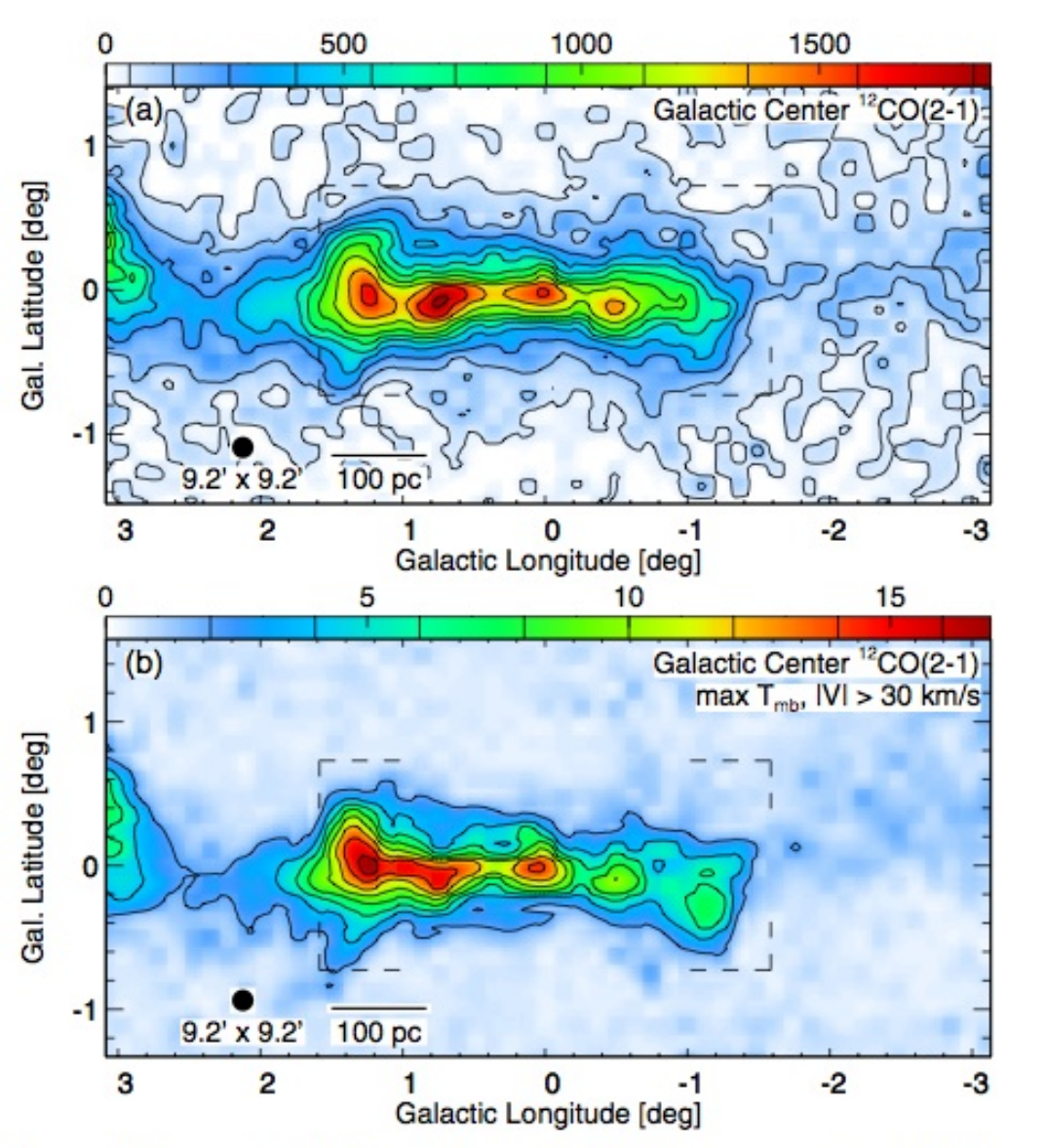




M(mol)$_{CO}$
≈ 1E8
Msun

Sakamoto+ 2011, ApJ, 735

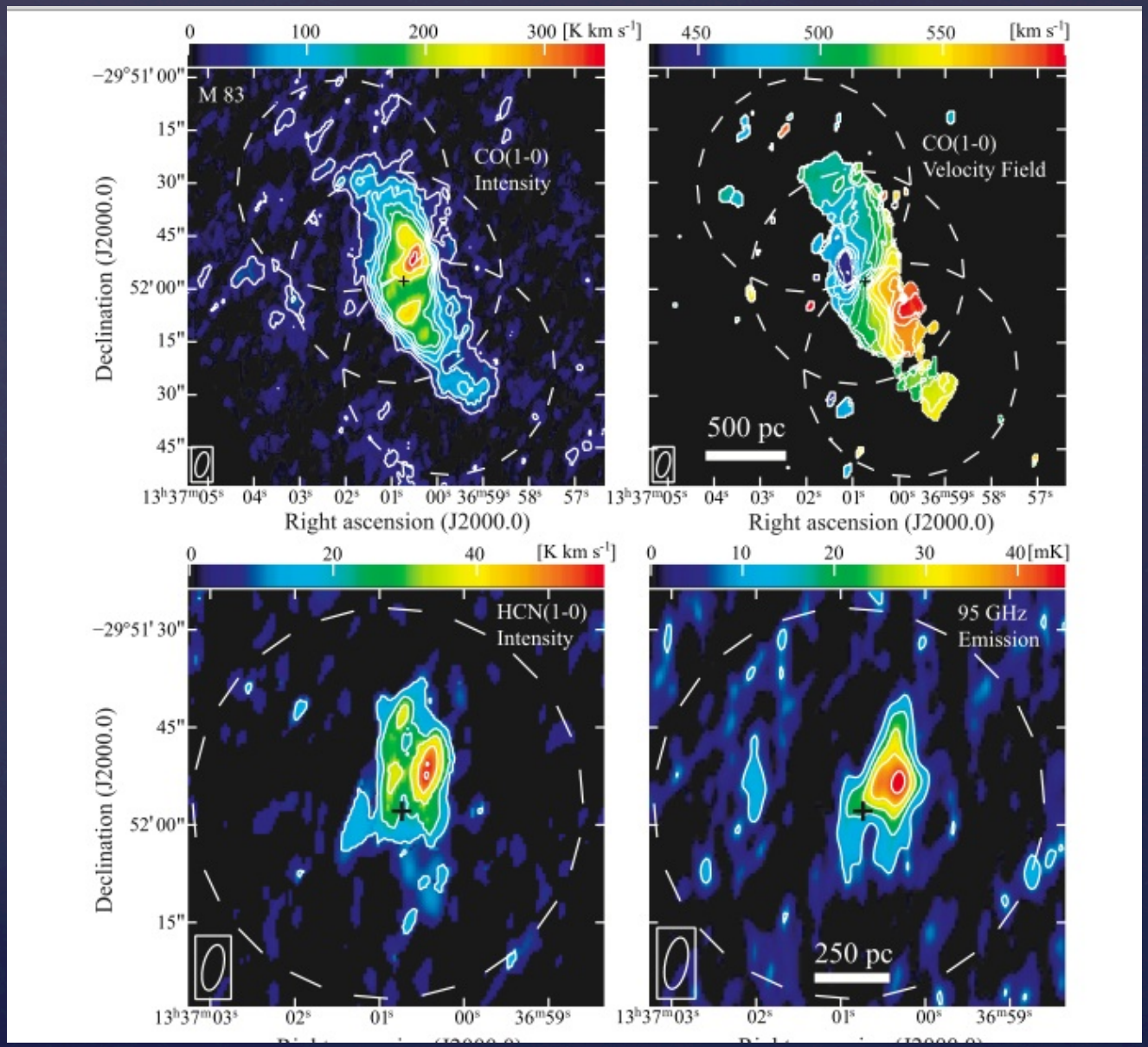
Sakamoto-NGC 253 Nucleus vs. MW CMZ



$M(mol)_{CO}$
$\approx$ 3-4E7
Msun

Sakamoto+ 2011

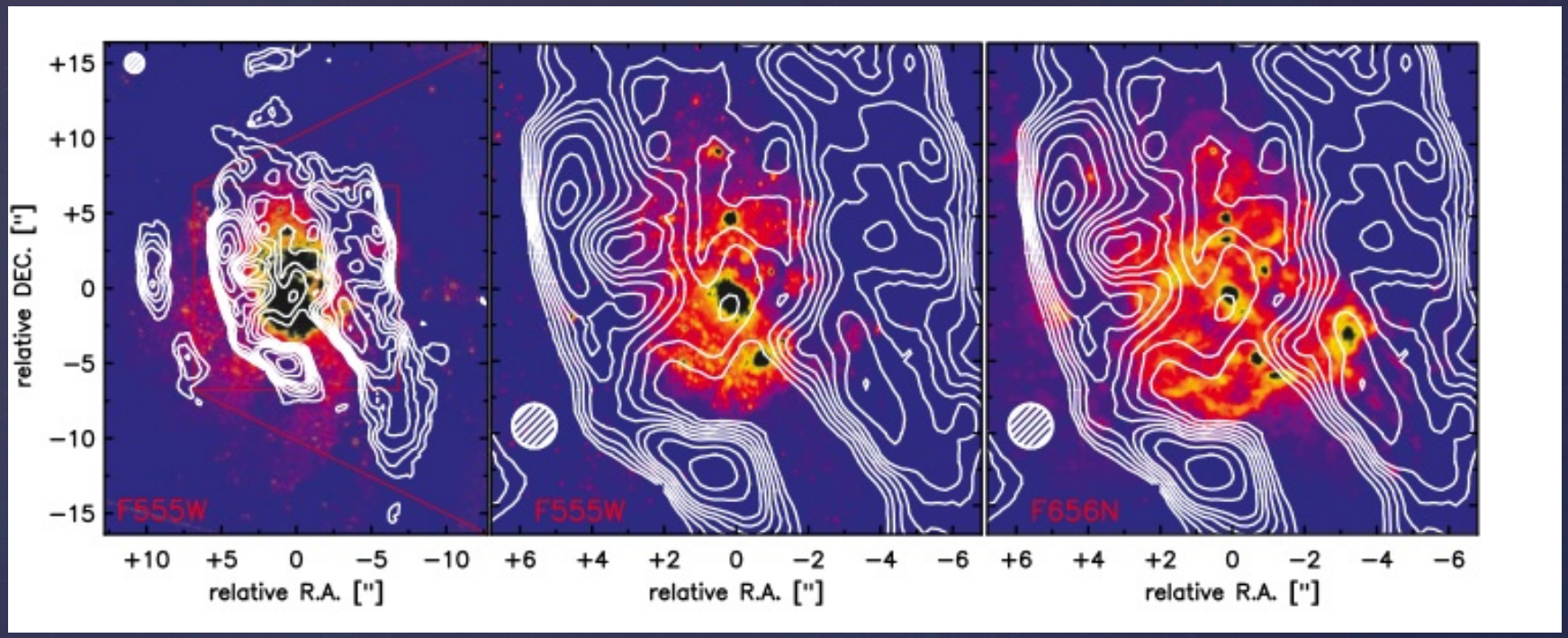
M83 NMA CMZ



M(mol)$_{CO}$ ≈ 5E7 Msun

Muraoka + 2009, PASJ, 61

IC342 NMA CMZ



Schinnerer+ 2003, ApJL, 591

$M(mol)_{CO}$
$\approx$ 2E7
Msun

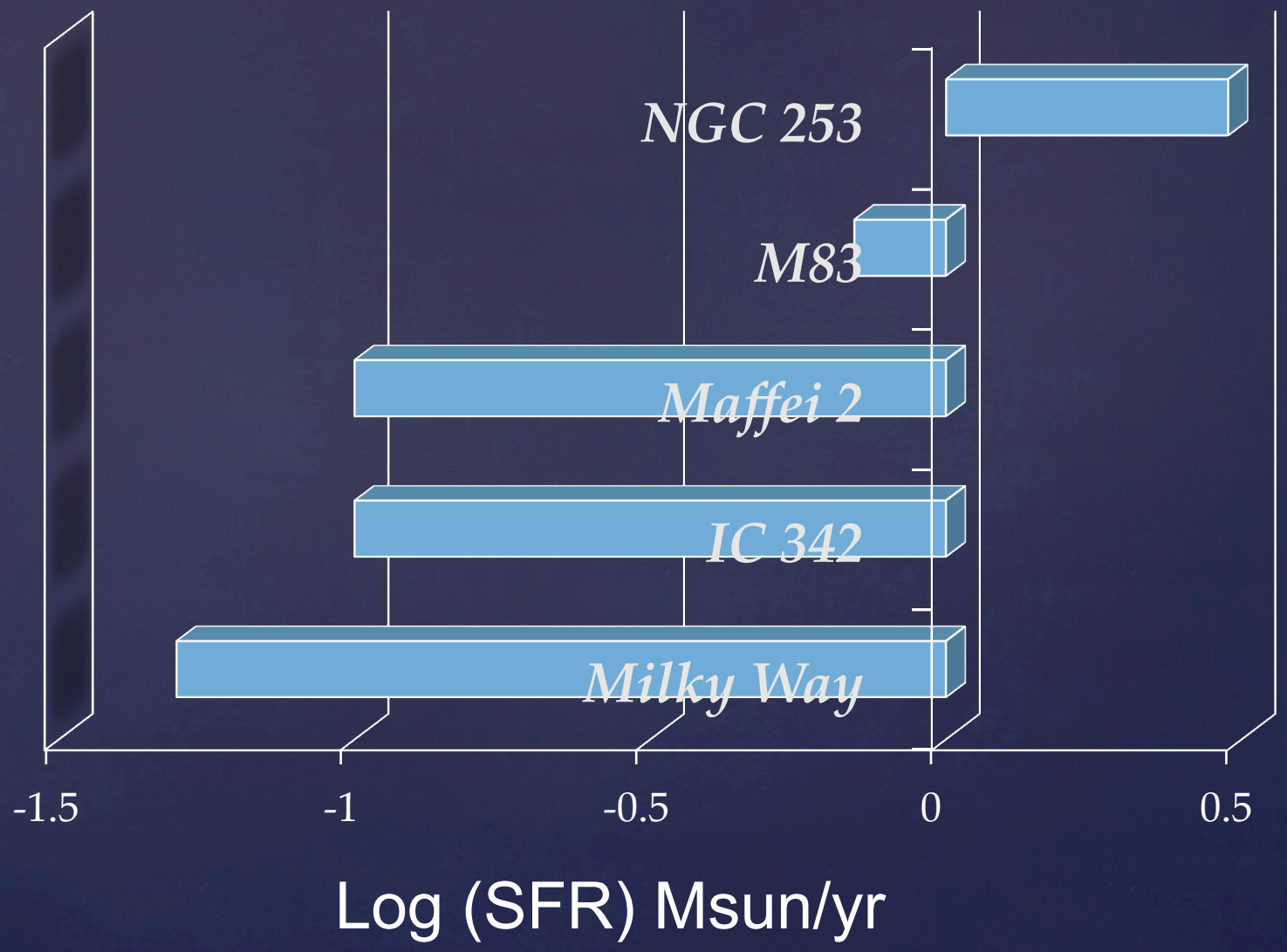
Fundamental Similarities

NIR luminosities of nuclear complexes in MW & neighbors are similar→ stellar masses $M_* \approx$ fewE8 Msun

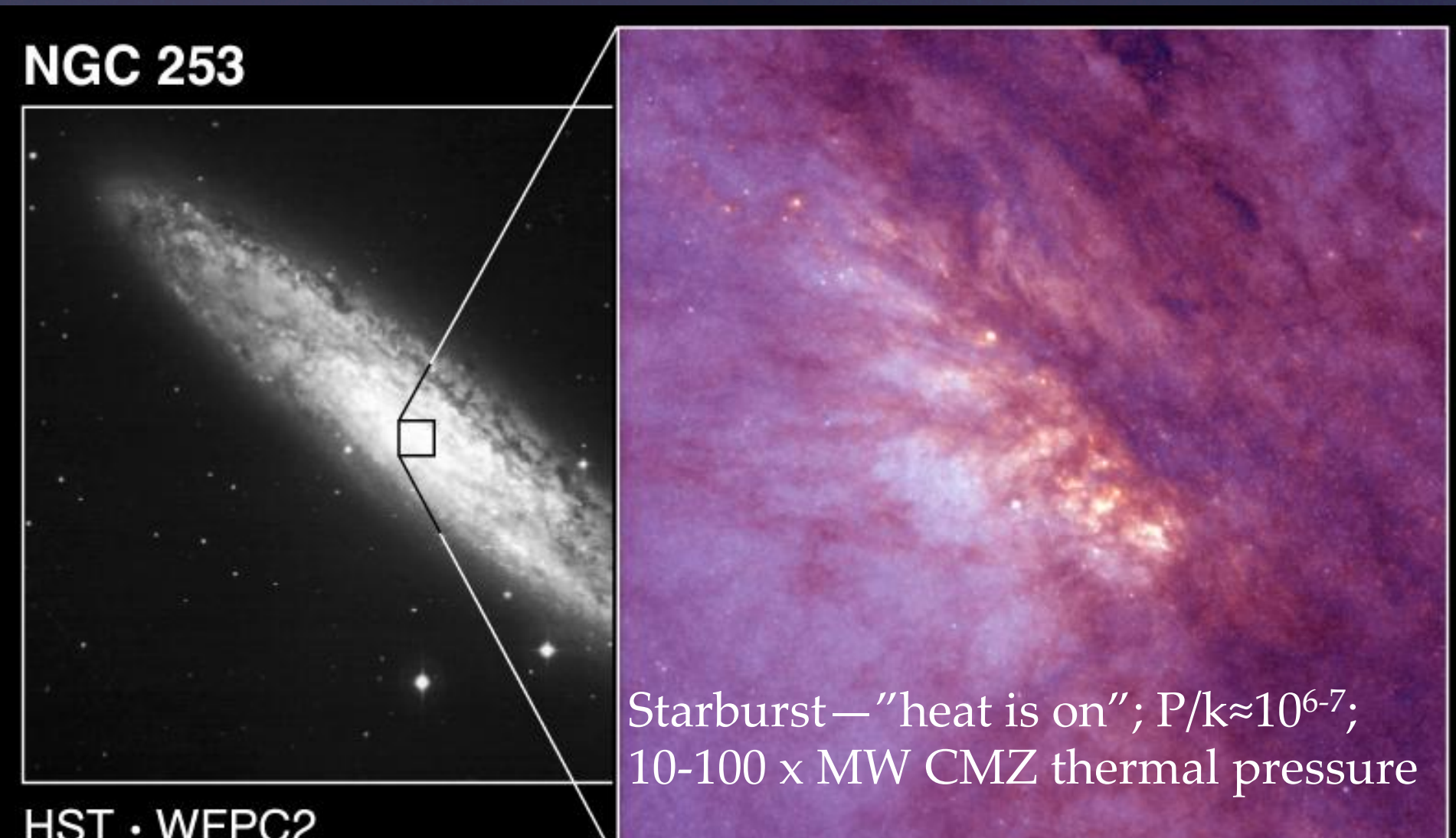
Molecular masses deduced from CO measurements yield similar masses in range ≈1-10E7 Msun

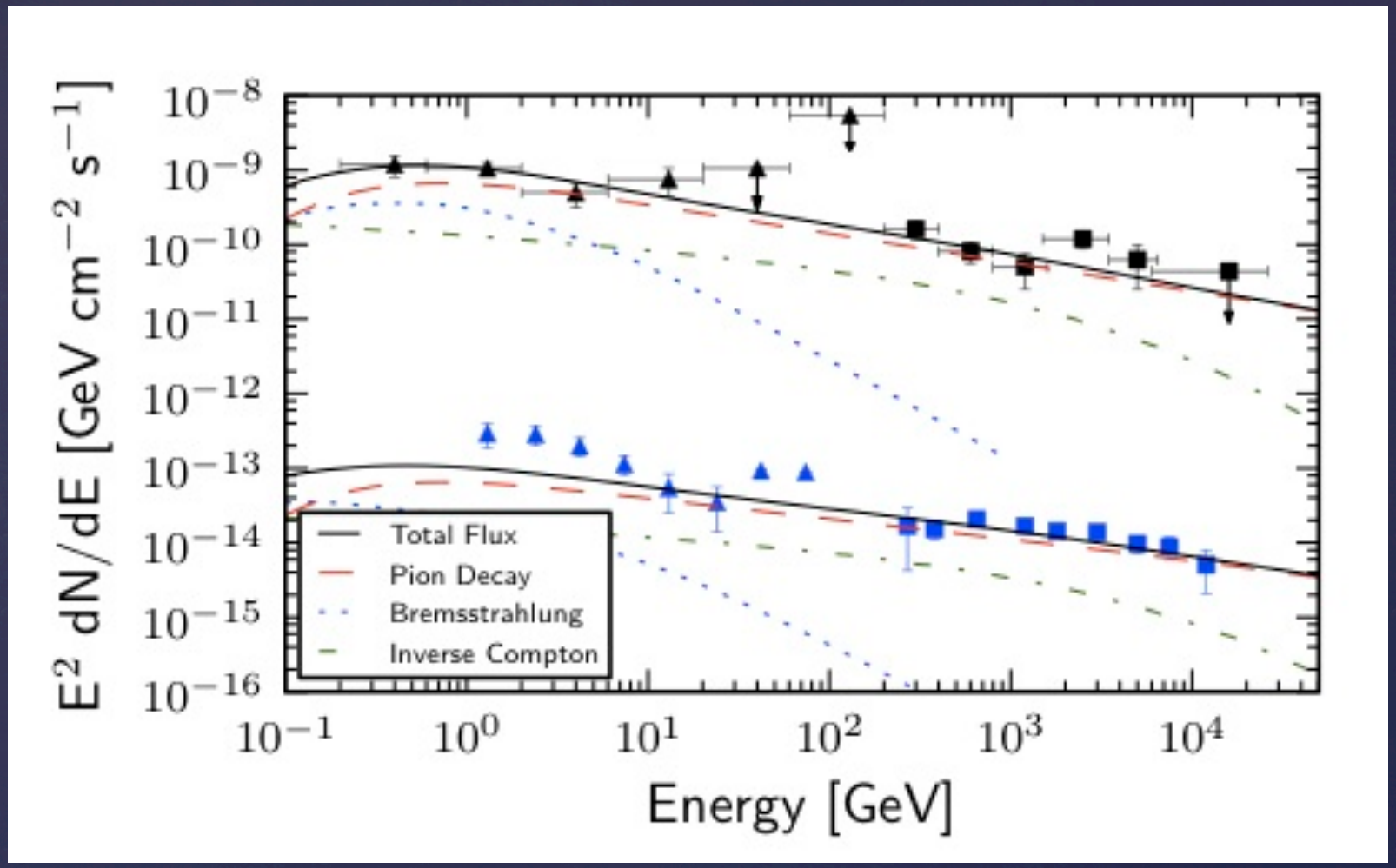
And Major Differences

Approximate Nuclear SFRs



SFR – Pressure-Wind Connection

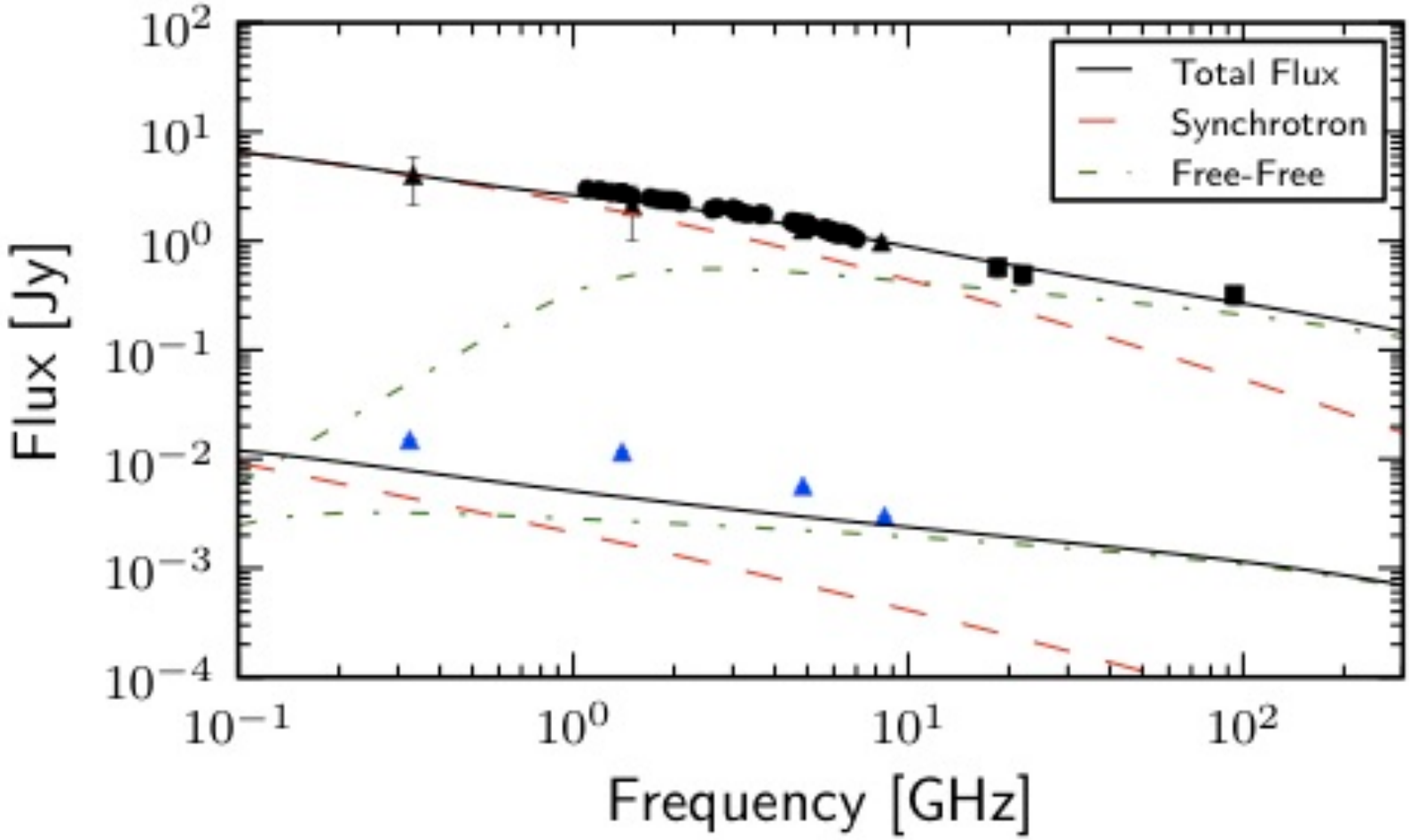




Milky Way – NGC 253 Nuclei γ-Rays

SFR? Molecular Mass? B-Fields? U(rad)? ***Winds?***

de Naurois Talk, Yoast-Hull+ Poster 37

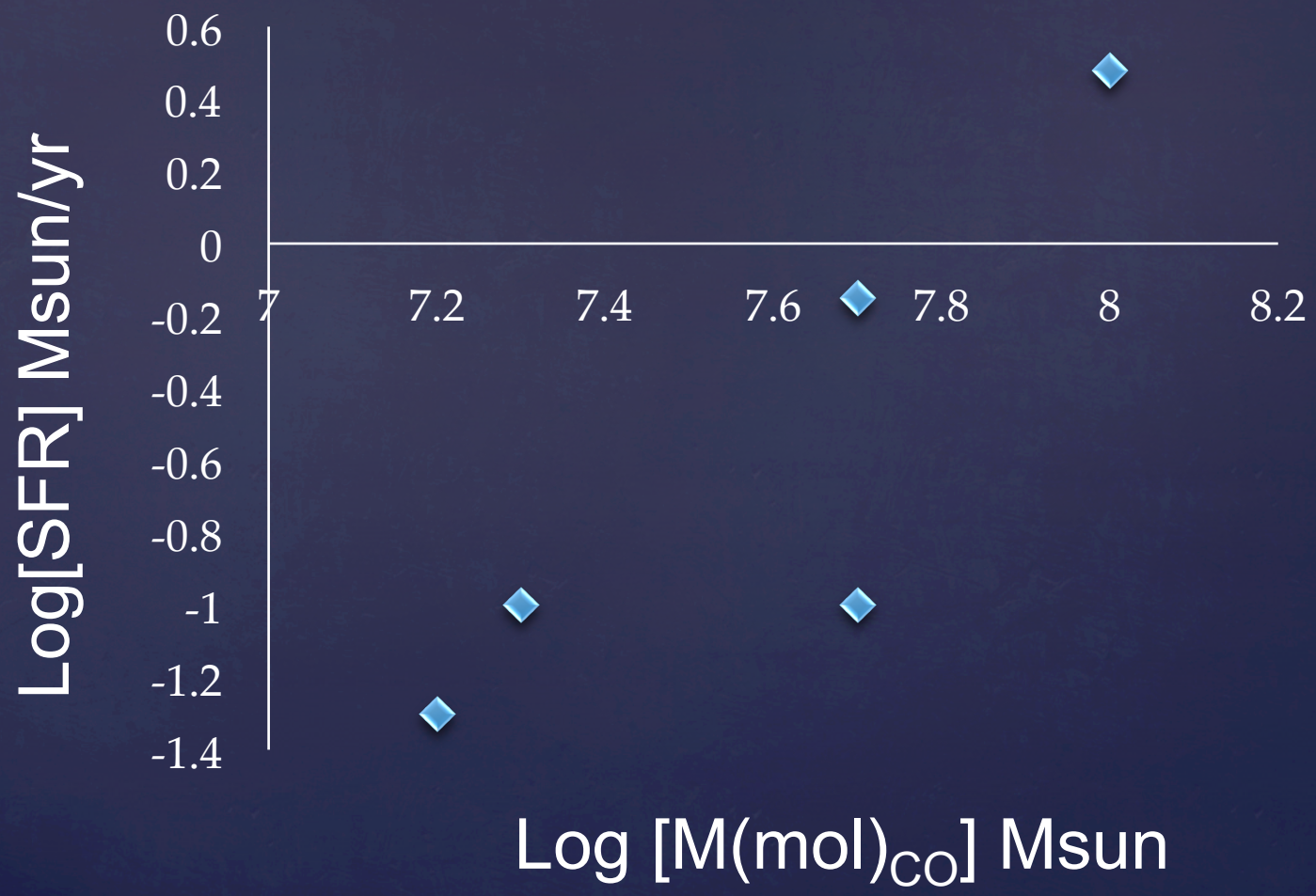


Milky Way – NGC 253 CMZ Radio

SFR? CR proton/electron, B-Fields? U(rad)? ***Winds?***

Yoast-Hull+ Poster 37

SFR - M(mol) Relationship Bimodal Behavior?



Star Formation Intensity: Key Factor in Milky Way-Like Nuclei

- ✧ Range in SFR intensity ~100
- ✧ Not tied to CO-based molecularISM mass; doesn't follow mean trends in galaxy disks
- ✧ Large range in efficiency of star formation?
- ✧ SFR does not appear to correlate with nuclear zone stellar mass
- ✧ ***<u>Milky Way center now in SFR down phase</u>***

Episodic Star Formation

Long expected given fueling inflow & short dynamical times. E.g, Bally Talk, Su P77,

"Bursts of star formation in the galactic centre" Loose, Kruegel, Tutukov 1982, A&A 105

MOLECULAR GAS AND THE NUCLEAR STAR CLUSTER IN IC 342: SUFFICIENT INFLOW FOR RECURRING STAR FORMATION EVENTS?
Schinnerer, Boeker, Meier 2003, ApJL, 591

GIANT GAMMA-RAY BUBBLES FROM FERMI-LAT: ACTIVE GALACTIC NUCLEUS ACTIVITY OR BIPOLAR GALACTIC WIND?
Su, Slatyer, Finkbeiner 2010, 724

But Beware of Possible Details

- Physical state of molecular gas varies due to extreme environment: temperature, chemistry (Aalto talk), turbulence, …

- If star formation levels bimodal, then need a transition from inactive to active states. Not simply mean molecular mass—but maybe molecular medium structure (dense cores)

- Watch out for unexpected impacts from the SMBH!

The Astronomical Journal: Innovating to Improve Scientific Communication

- Instrumentation/software articles
- Electronic presentation of data; data behind figures, FITs data sets
- Video content
- (Public abstracts – in the works)
- Other ideas? Email: aj@astro.wisc.edu