分子ガス観測から探る衝突銀河の進化

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Galaxy evolution after merging

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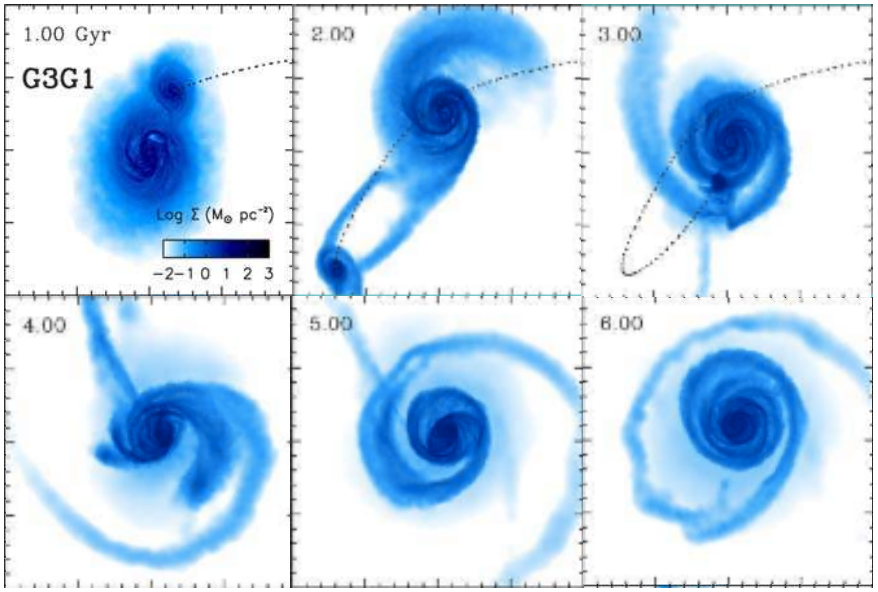
Not all of mergers will become an early-type galaxy, but some will reemerge as a disk dominated late-type galaxy (e.g., Springel & Hernquist 05; Robertson & Bullock 08).

Recent Simulations

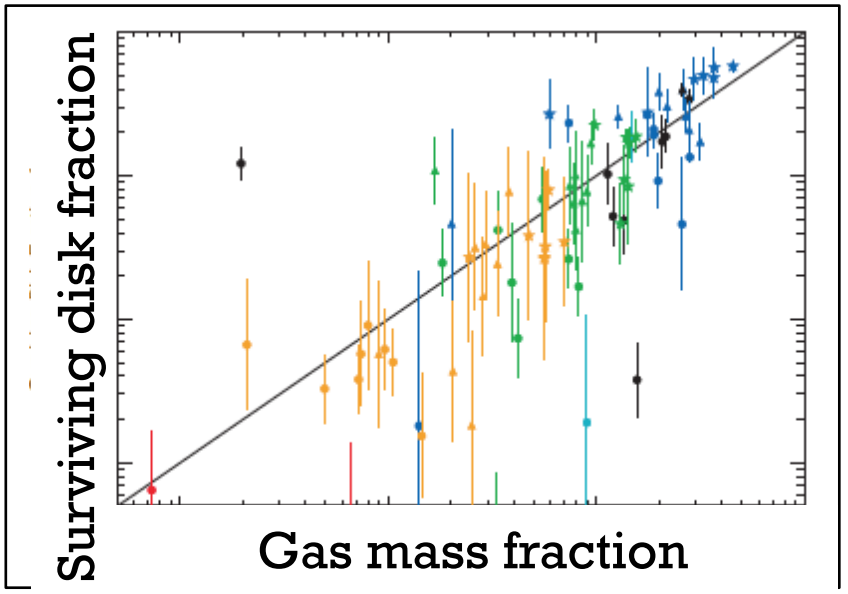
Formation of an extended gas disk

- While some part of gas fall to the nucleus and contribute to a nuclear starburst, gas that does not lose significant angular momentum through merging will reform an extended gas disk.

- The large gas mass fraction (M_{H2}/M^{*}) leads to a more efficient formation of an extended gas disk.



(Cox+08)



(Hopkins+09)

Merger Remnant CO Survey

The purposes of our merger remnant survey:

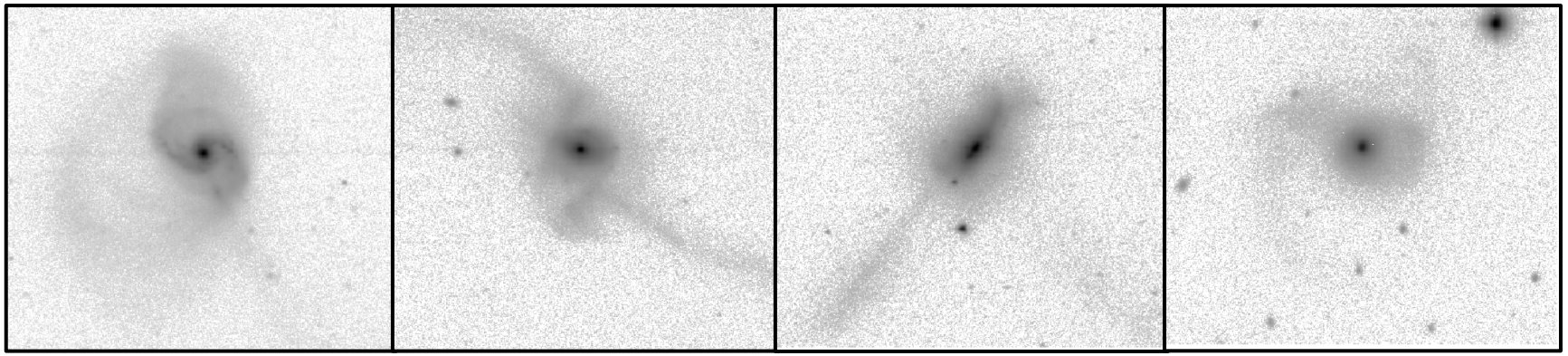
- Looking for an observational evidence of a reformation of an extended molecular gas disk
- Investigate what type of galaxy merger remnants are likely to evolve.
- Checking the new scenario that some mergers will result in disk dominated late-type galaxies.

Sample Selection

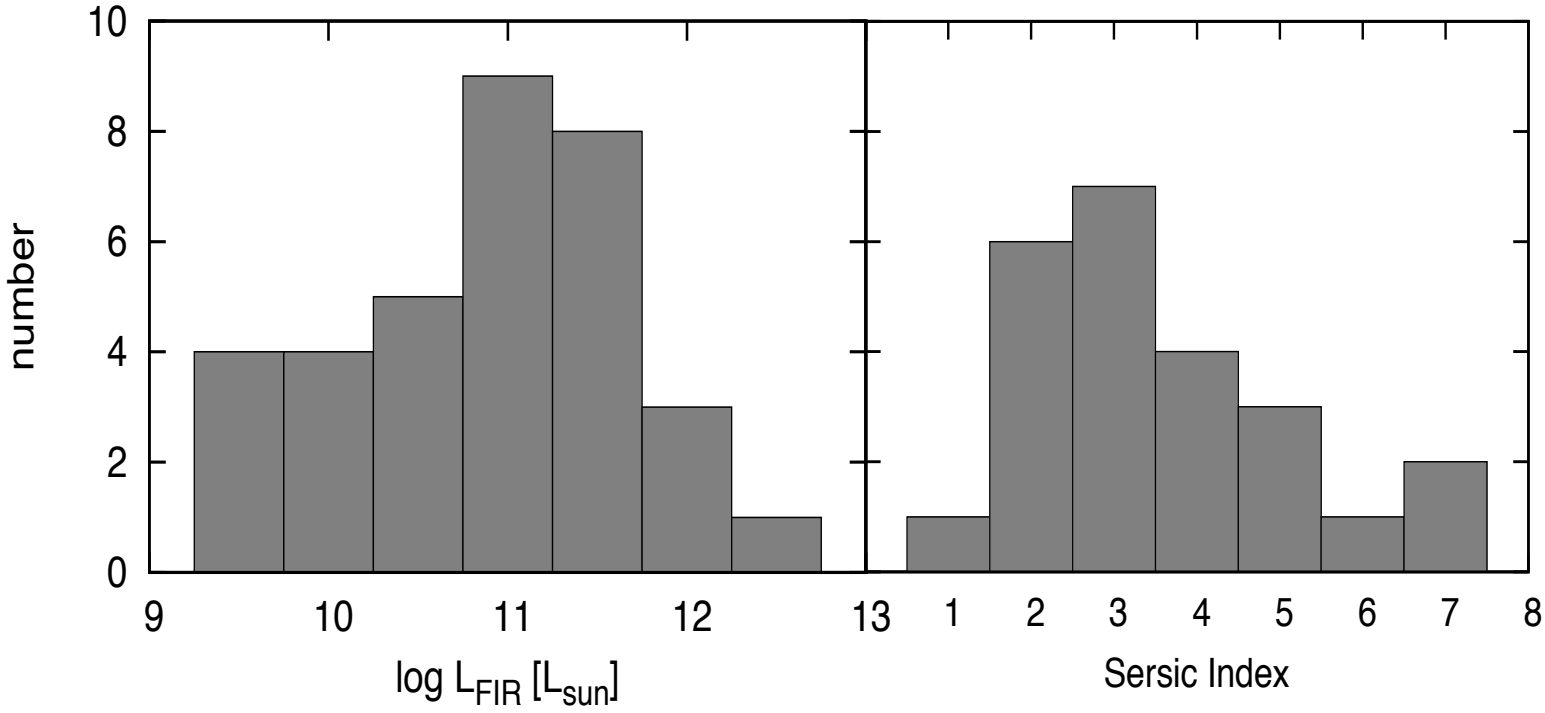
Our sample is drawn from the merger remnant sample studied in K-band (Rothberg & Joseph 2004).

The sample was selected based on optical morphology.

1. Tidal tails and shells
2. A single nucleus
3. The absence of nearby companions



Sample of Merger Remnants

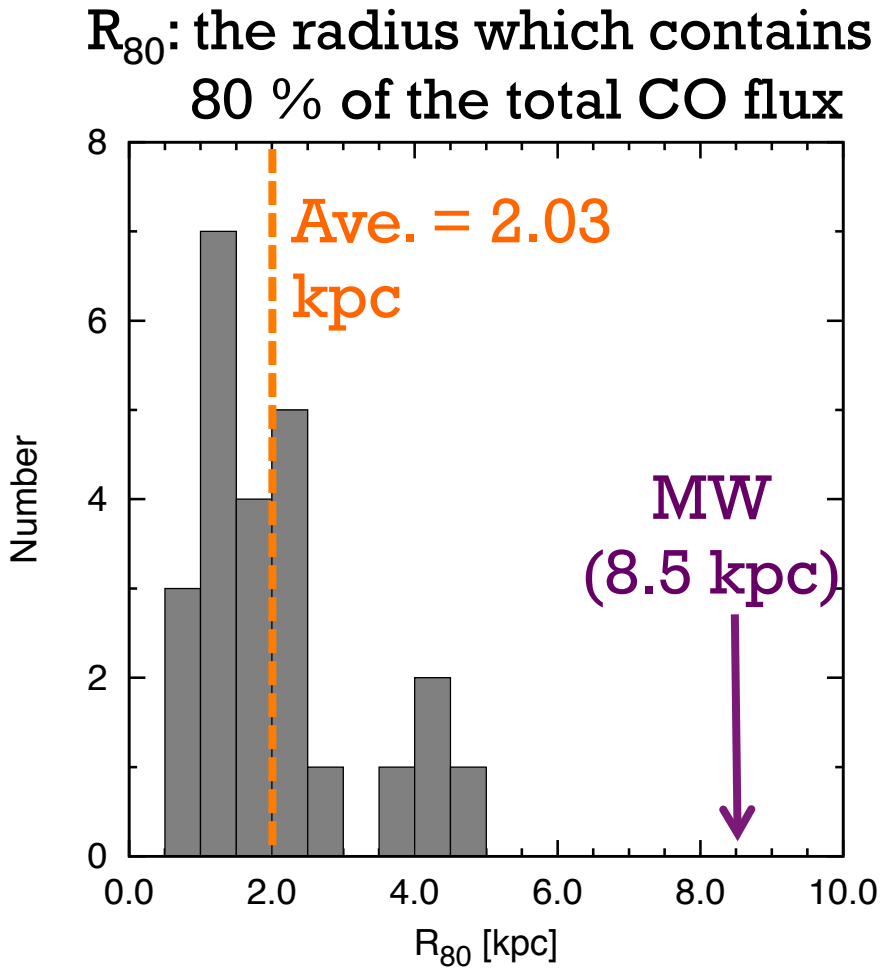


- The FIR luminosity ranges from normal galaxies to ULIRGs, and thus our sample is independent of the FIR properties.

Interferometric CO Observations & Data

	Telescope	No. of sources	CO line	Resolution [arcsec]	Noise level [mJy/ Beam]
Obs.	ALMA	20	CO (1-0)	1.2 – 6.4	1.3 – 5.8
	SMA	5	CO (2-1)	2.9 – 3.6	18 – 24
	CARMA	2	CO (1-0)	1.7	1.9 – 3.4
Archival Data	SMA	7	CO (2-1) /CO (3-2)	0.8 – 3.6	11 – 23
	PdBI	2	CO (1-0)	1.8 – 2.9	1.9 – 2.9
	ALMA	1	CO (1-0)	6.4	1.3

The Size of the Molecular Gas Disk



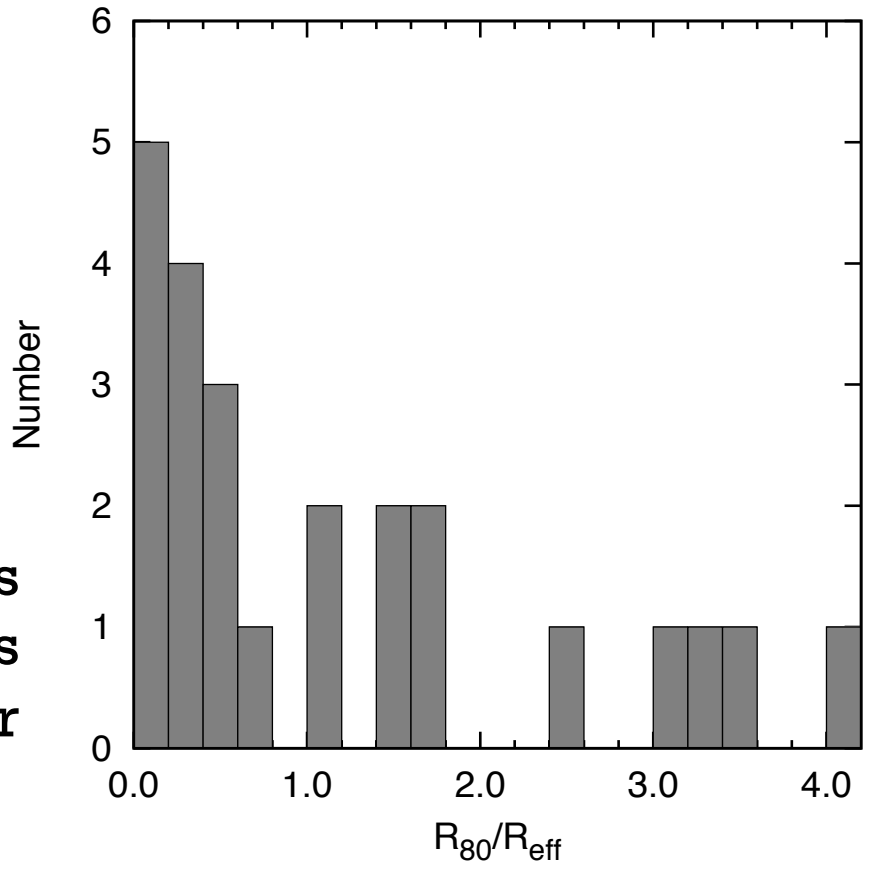
(0.4 kpc ~ 4.1 kpc)

Comparison the Sizes of the Molecular Gas Disk with Stellar Structure

R_{80}: the radius which contains 80% of the total CO flux.

R_{eff}: the K-band effective radius (the radius of the isophote containing half of the total K-band luminosity)

The ratio (R_{80}/R_{eff}) represents the size of the molecular gas disk in relation to the stellar component.



Gas Mass Fraction (M_{H2}/M^*)

Gas Mass Fraction (f_{gas})

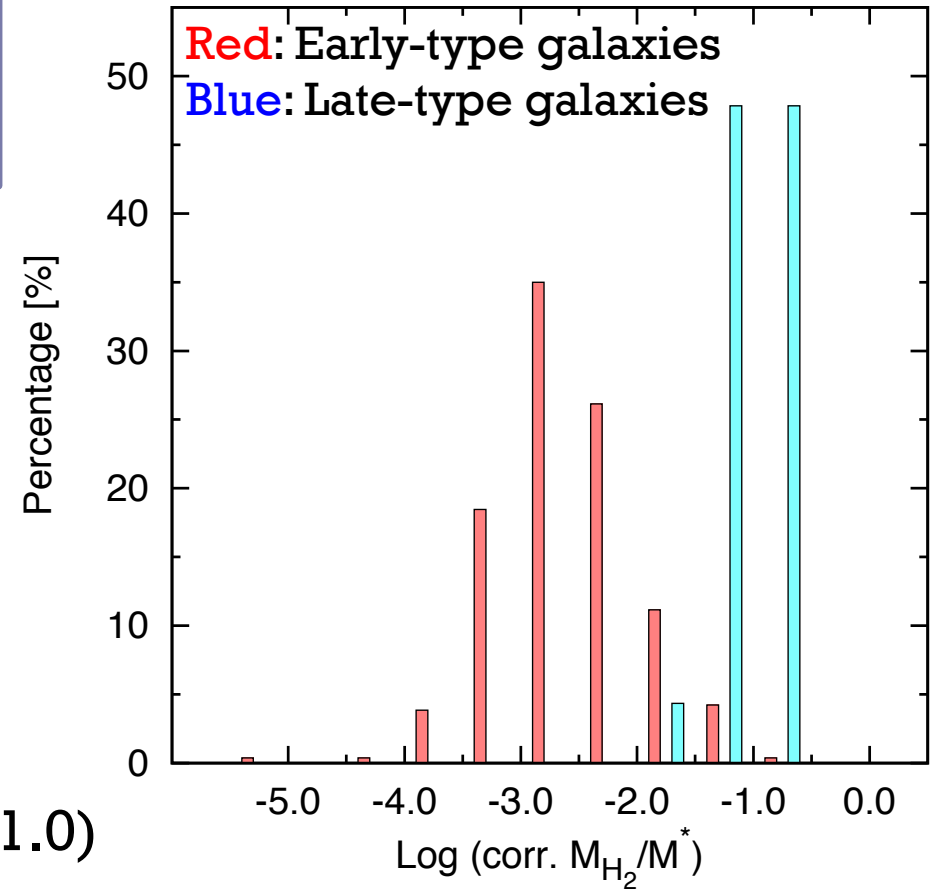
$$= \frac{\text{Molecular Gas Mass } (M_{H2})}{\text{Stellar Mass } (M^*)}$$

Early-type galaxies

- Sample : ATLAS^{3D}
- Typical f_{gas} < 1 %
  (Log (M_{H2}/M^*) < -2.0)

Late-type galaxies

- Sample : BIMA-SONG
- Typical f_{gas} = 1~10 %
  (Log (M_{H2}/M^*) = -2.0 ~ -1.0)



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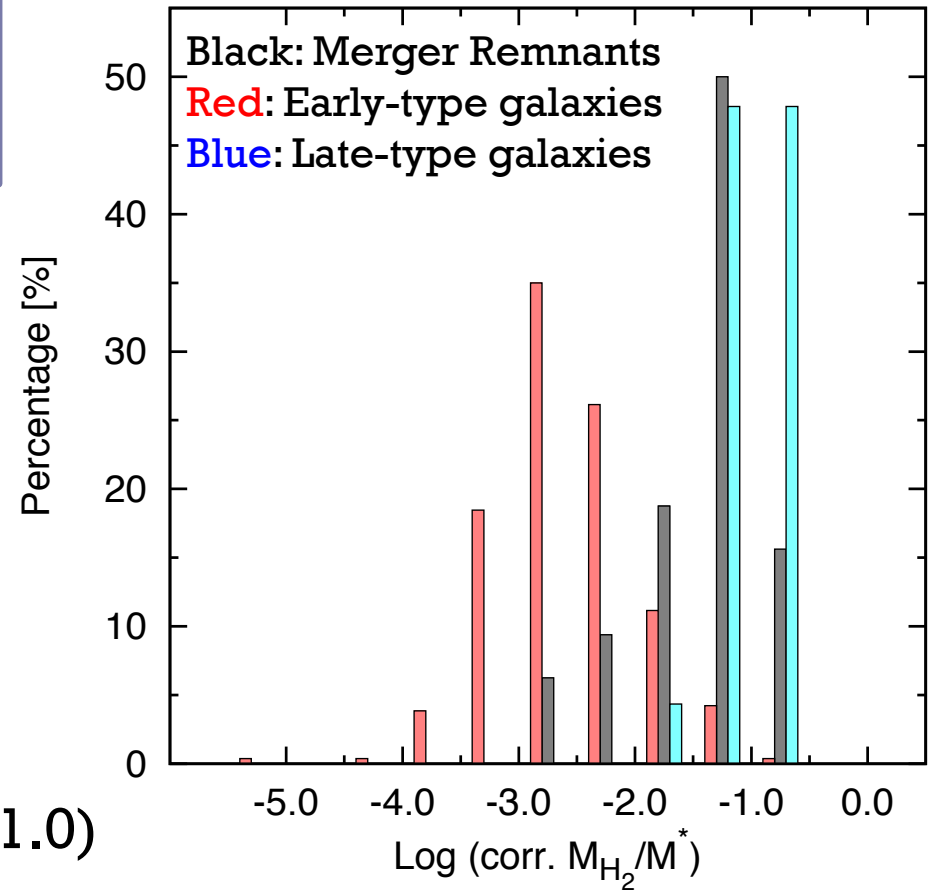
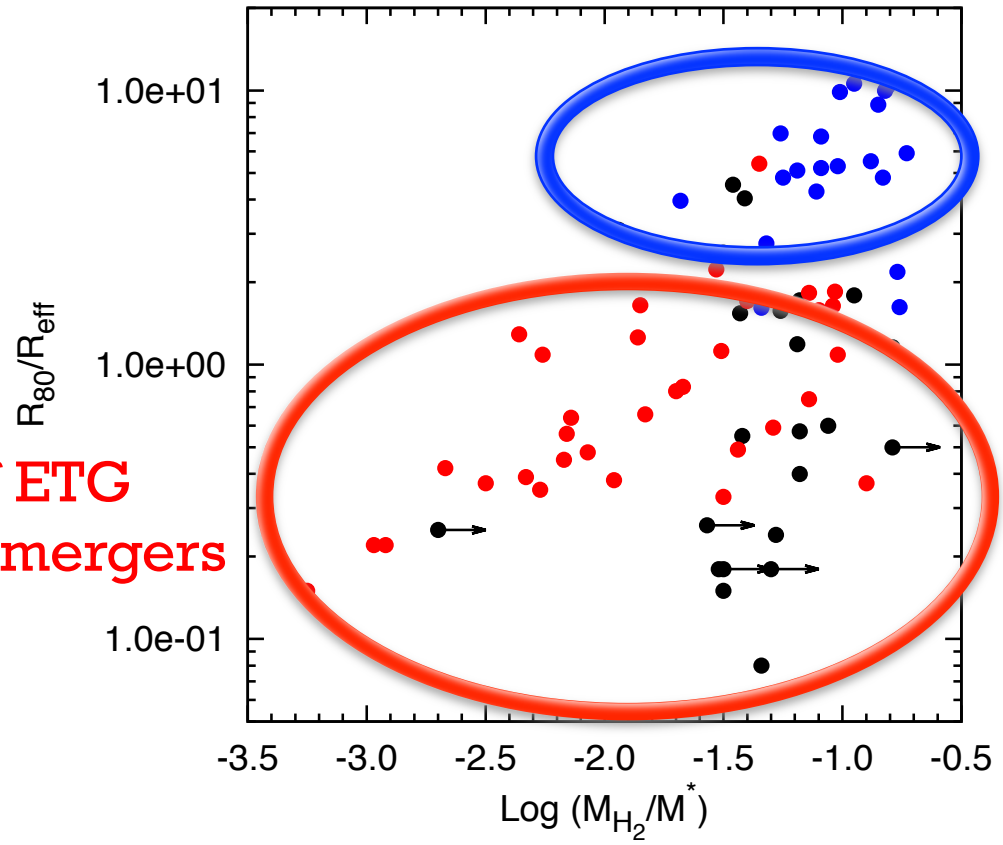


Normalized Radius vs. Gas Mass Ratio



Most of LTG and 4 mergers

Most of ETG and 13 mergers

Black: Merger Remnants
Red: Early-type galaxies
Blue: Late-type galaxies

※The ratio (R_{80}/R_{eff}) represents the size of the molecular gas disk in relation to the stellar component.

Summary

- We have been working on a merger remnant CO survey.
- We found disk-like CO distribution in 24/37 (65%) sources. The sizes of the CO disks range 1.4--9.6 kpc.
- While more than half of sources could be evolving into early-type galaxies, some sources with an extended gas disk and a large gas mass fraction may evolve into late-type galaxies