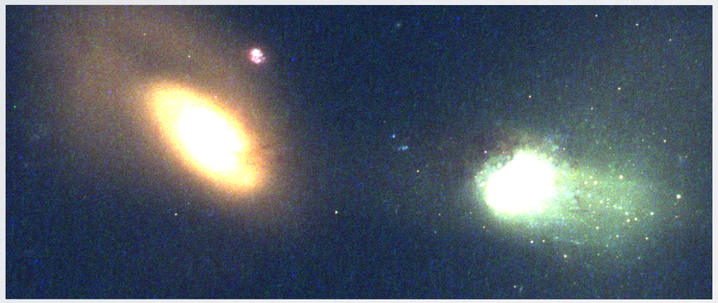
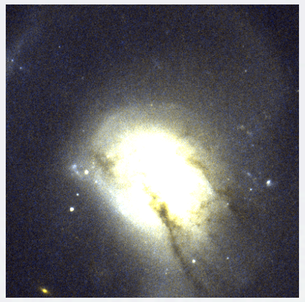
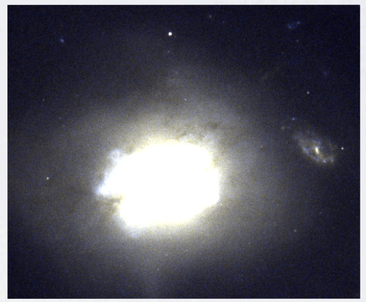
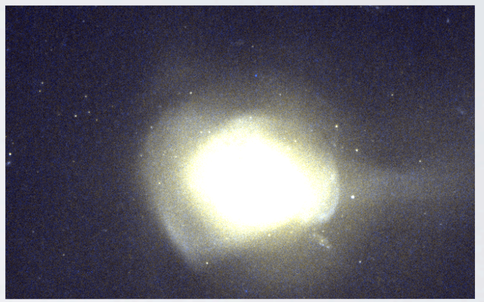
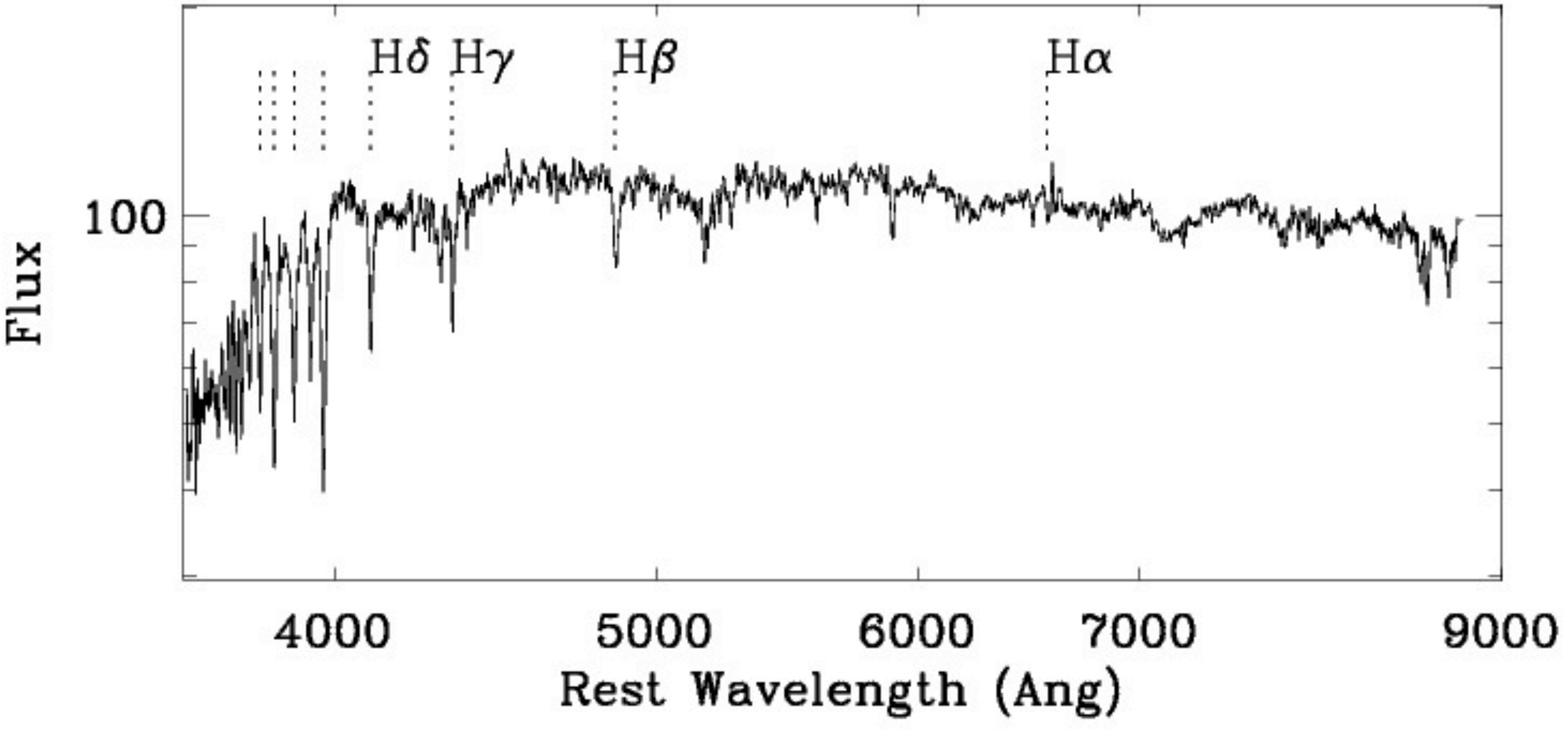
Tracing the Evolution of Post-Starburst (E+A) Galaxies Using Molecular Gas

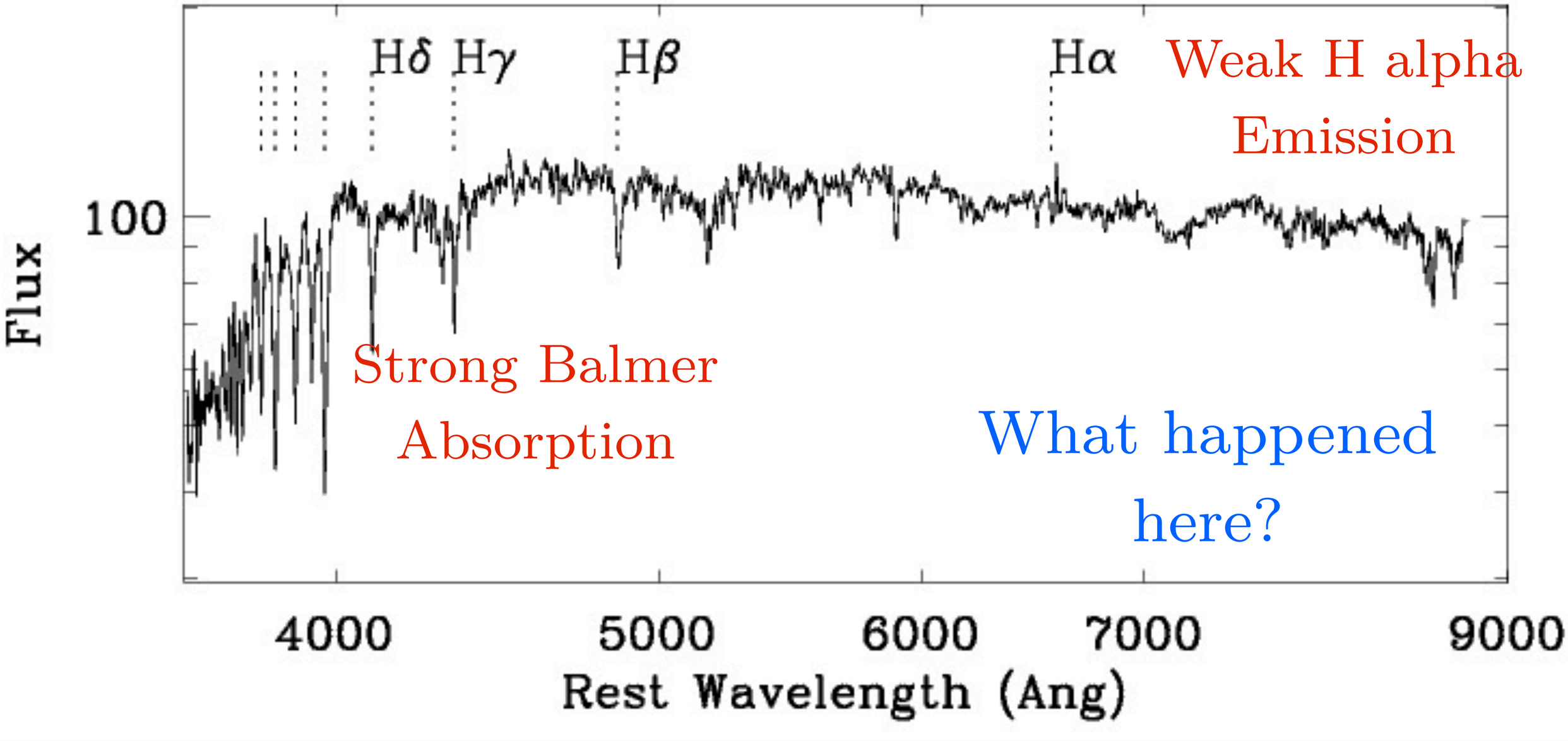
K. Decker French (Arizona)

Yujin Yang (Argelander-Institut), Ann Zabludoff (Arizona), Desika Narayanan (Haverford), Yancy Shirley (Arizona), Fabian Walter (MPIA), J.D. Smith (Toledo), Christy Tremonti (UWisc)

Why Post-Starburst Galaxies?



Why Post-Starburst Galaxies?

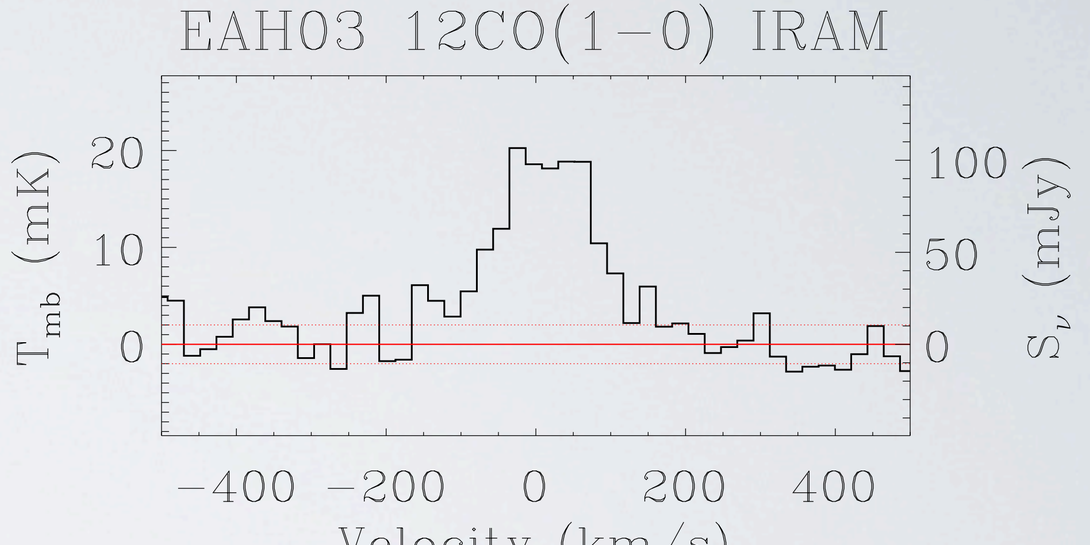


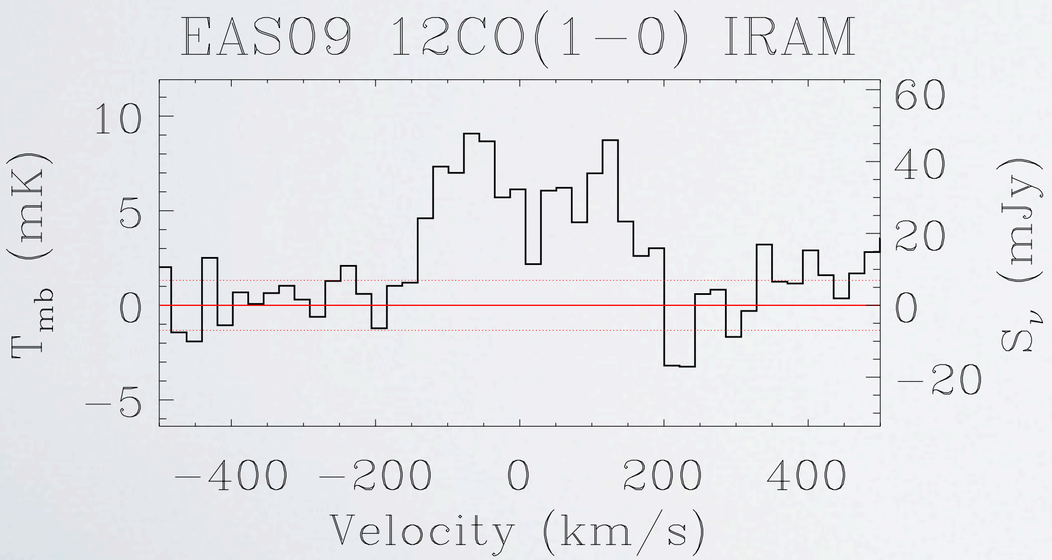
Detection of Molecular Gas

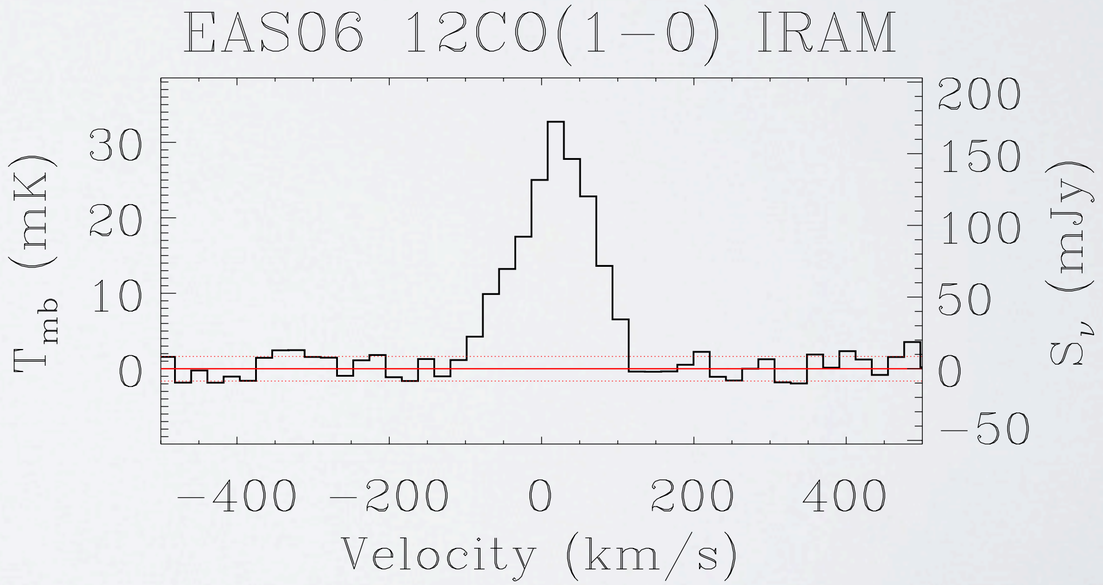
- 32 galaxies with IRAM 30m in CO (1-0) and CO (2-1)
- 13 galaxies with SMT 10m in CO (2-1)

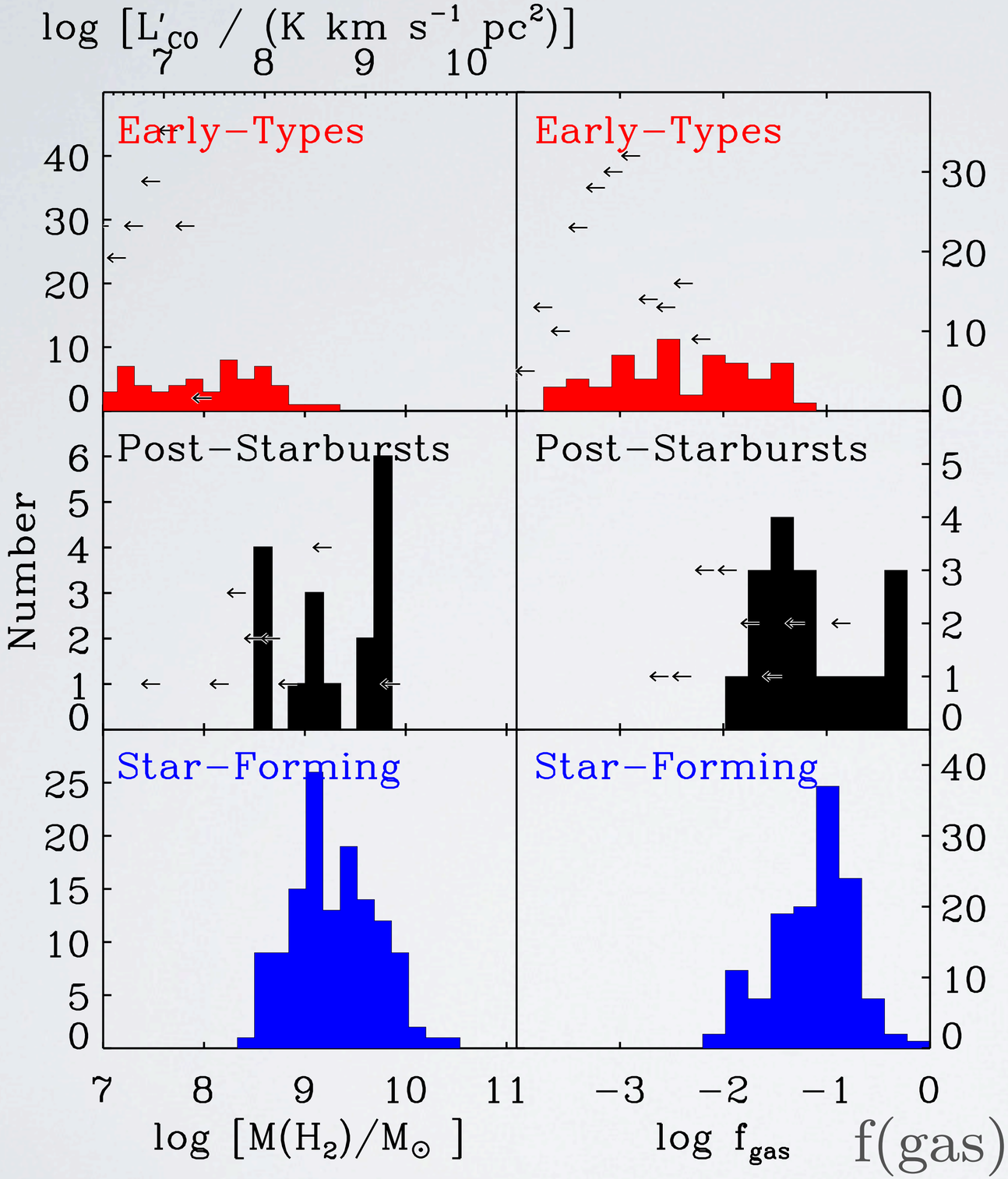
Detection of Molecular Gas

- 32 galaxies with IRAM 30m in CO (1-0) and CO (2-1)
- 13 galaxies with SMT 10m in CO (2-1)
- Detect 17/32 galaxies in CO (1-0)









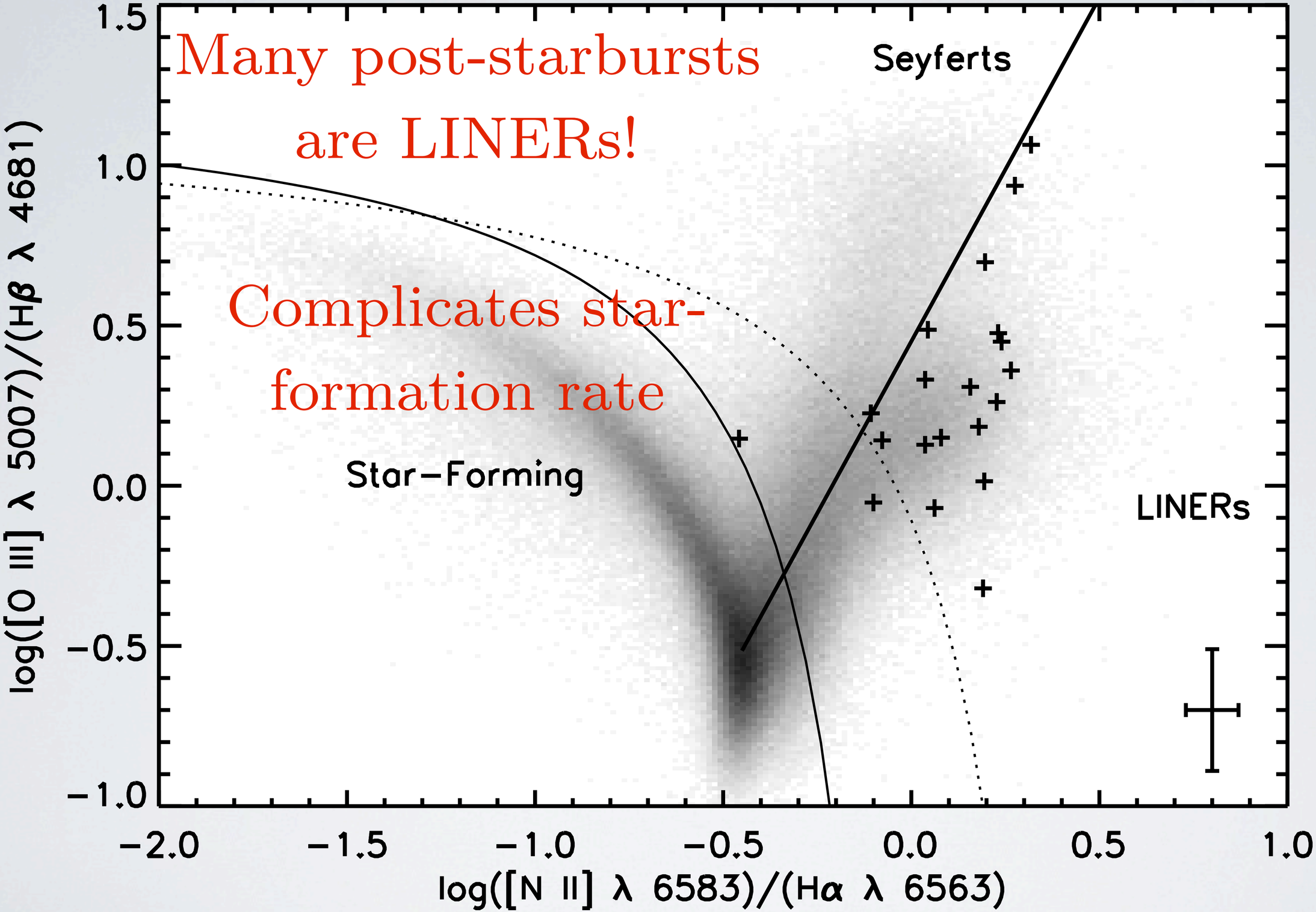
Molecular gas masses comparable with star-forming galaxies

Young+ 2011, Saintonge+ 2011

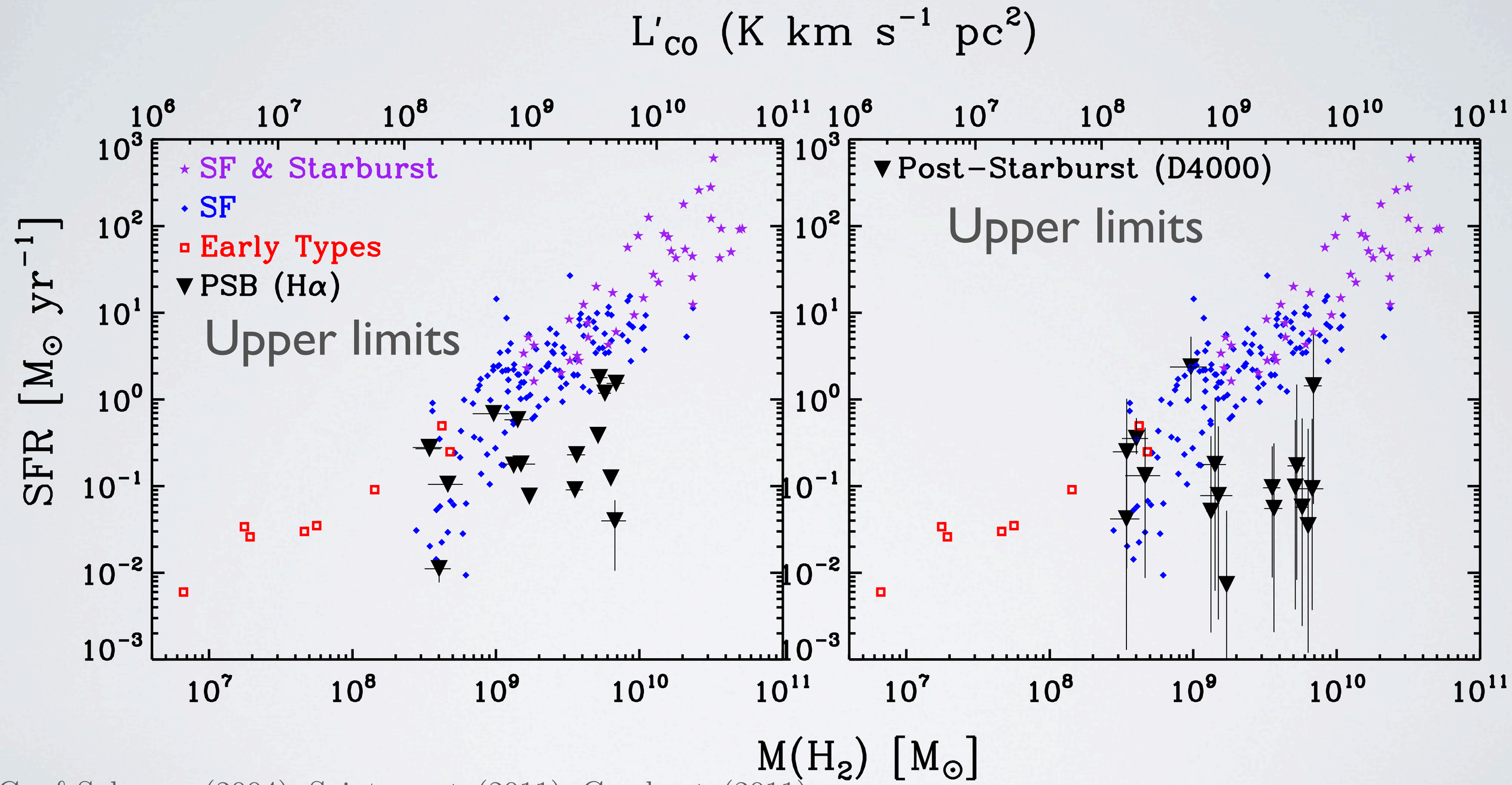
f(gas)= M(H2)/M★

Many post-starbursts are LINERs!

Complicates star-formation rate

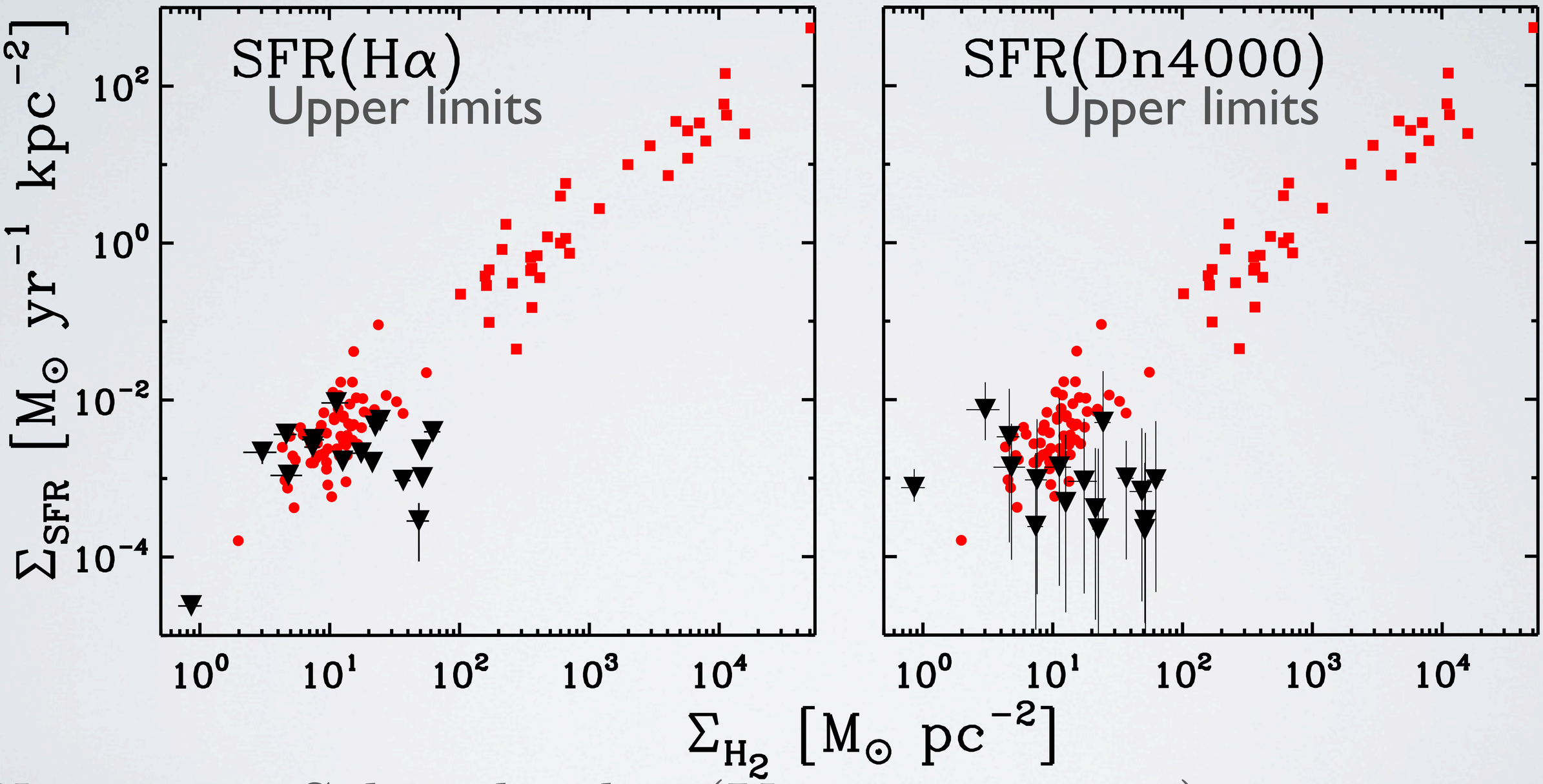


Star-Formation-Rate vs. M(H2)



Gao&Solomon (2004), Saintonge+ (2011), Crocker+ (2011)

Molecular gas vs. star-formation rate surface densities



Kennicutt-Schmidt plot (Kennicutt 1998)

Why are post-starbursts offset?

- CO-to-H2 conversion factor α_{CO}
  - ULIRG type value can provide consistency, but: t(post-burst) > t(dyn)
  - Stellar component not enough to lower α_{CO}

Why are post-starbursts offset?

- CO-to-H2 conversion factor α_{CO}
  - ULIRG type value can provide consistency, but: t(post-burst) > t(dyn)
  - Stellar component not enough to lower α_{CO}
- Distribution?
  - Some evidence from CO (2-1) comparison that CO is not extended enough to resolve offset
  - But, distribution of SF regions largely unconstrained

Why are post-starbursts offset?

- CO-to-H2 conversion factor α_{CO}
  - ULIRG type value can provide consistency, but: t(post-burst) > t(dyn)
  - Stellar component not enough to lower α_{CO}
- Distribution?
  - Some evidence from CO (2-1) comparison that CO is not extended enough to resolve offset
  - But, distribution of SF regions largely unconstrained
- Lowered star-formation efficiency? Bottom-heavy initial mass function?

What caused the sudden end to star formation?

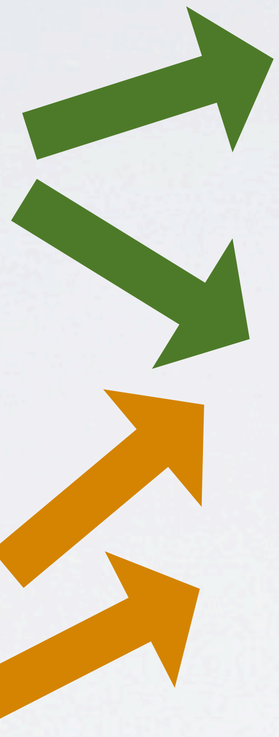
- Gas used up?
- Gas ejected or removed from galaxy?
- Gas dispersed within galaxy?
- Starvation?
- Gas heated?
- Morphological quenching? Other?

What caused the sudden end to star formation?

- Gas used up? →No, large molecular gas reservoirs
- Gas ejected or removed from galaxy? →No, large molecular gas reservoirs
- Gas dispersed within galaxy? →KS offset observed, need spatial info
- Starvation? →No, large molecular gas reservoirs
- Gas heated? ? Something else must happen to the gas
- Morphological quenching? Other? ?

Next Steps

Something else must happen to the gas



- Denser gas tracers
- HCN
- Resolved CO emission

KS offset observed, need spatial info

- H alpha mapping to observe current SF
- ALMA, as well as current optical/ IFU facilities will help understand the state of the molecular gas and current activity in this critical period in galaxy evolution

Conclusions

- Post-Starburst galaxies, in transition between star-forming and early type
- Molecular gas detected in ~half
- M(H2) $10^{8.6}$-$10^{9.8}$ Msol -- comparable to star-forming galaxies
- Gas fractions 10^{-2} - $10^{-0.5}$ -- comparable to star-forming galaxies
- Star formation rates ~10x lower
- Post-starbursts fall low on molecular gas - star formation rate surface density relation
- Rule out complete gas consumption/expulsion/starvation as end of starburst in this sample