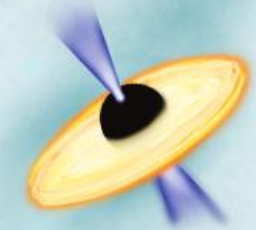
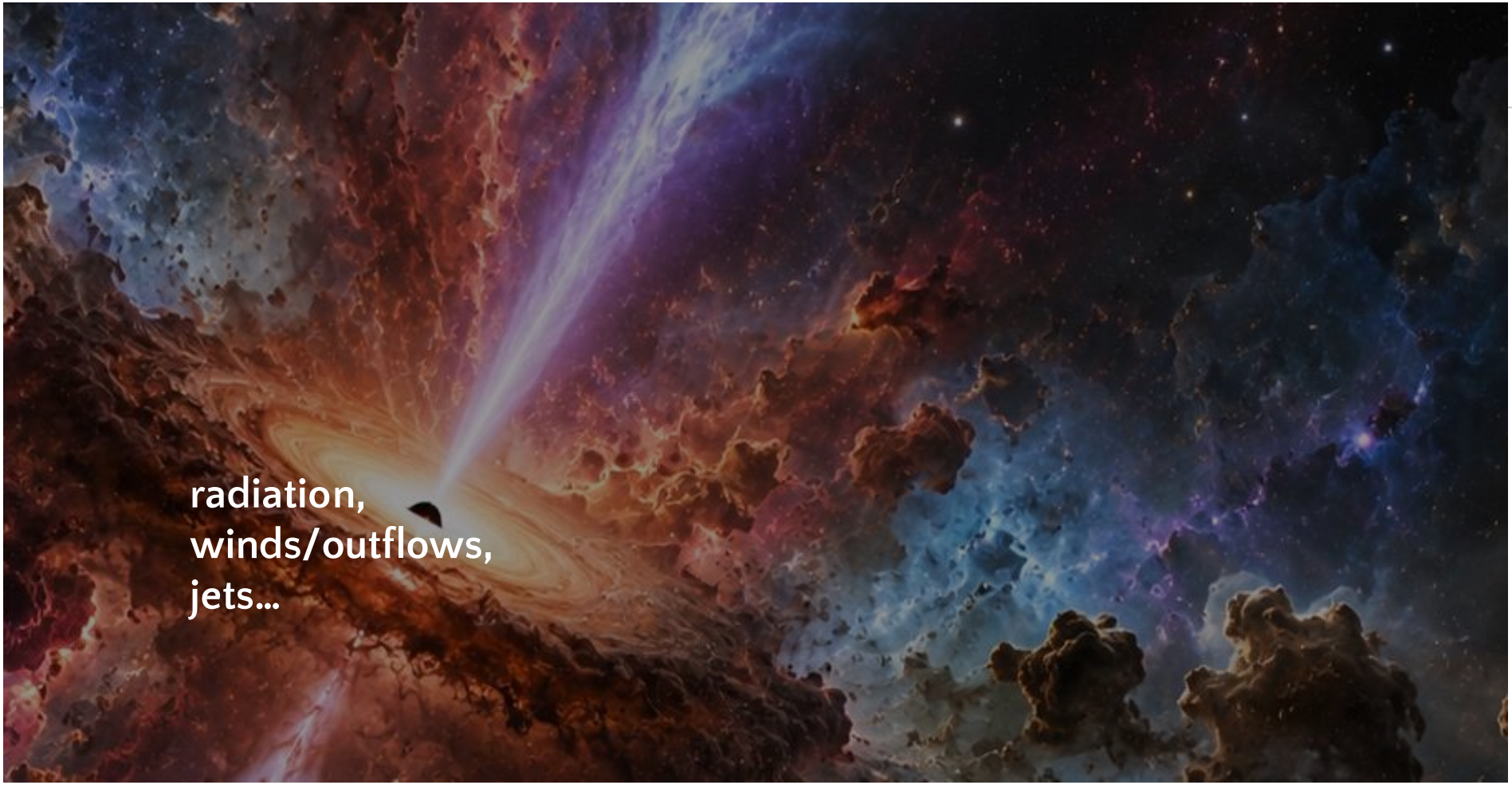
Tracing AGN Impact on the Multiphase ISM
Connecting Observations and Simulations

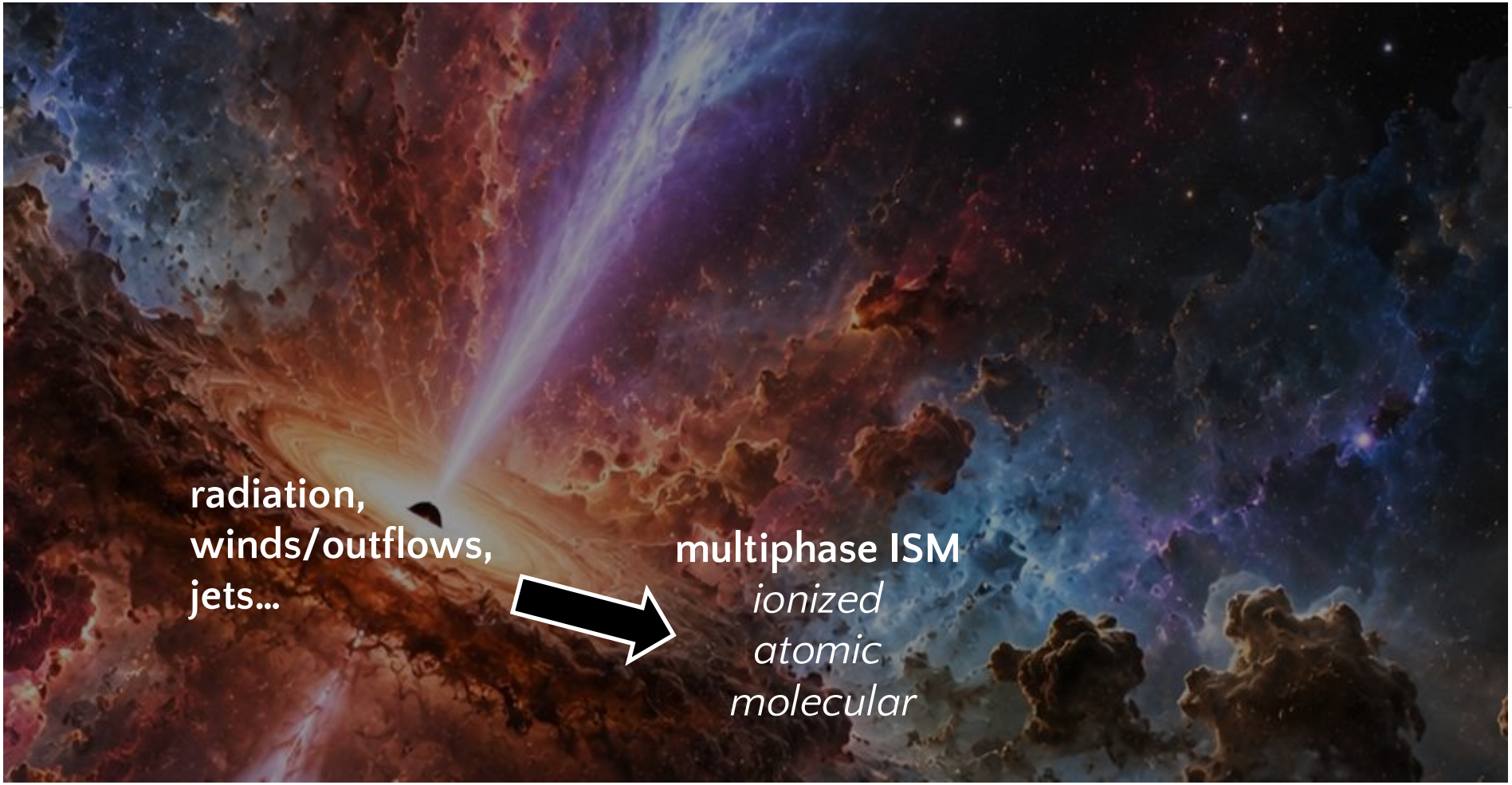
Karolina Garcia,
CAPS Postdoctoral Fellow
NCSA/University of Illinois

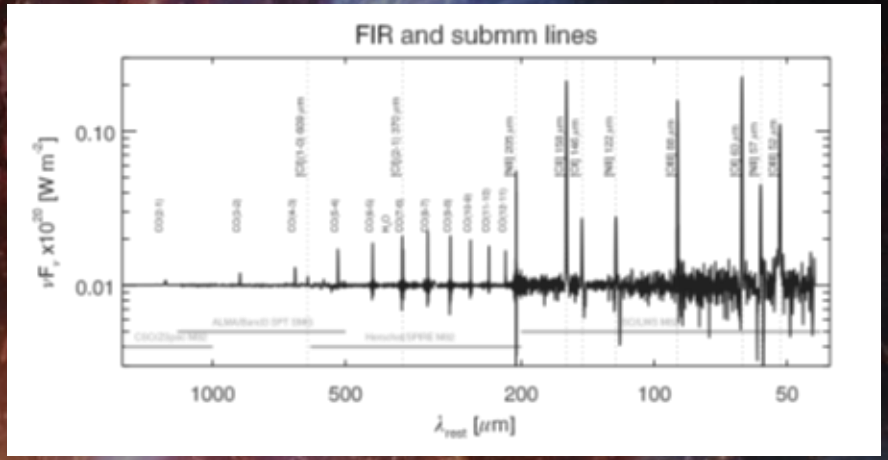
Pallavi Patil, Andreea Petric, Vivian U,
and the FIRESIDE collaboration






radiation,
winds/outflows,
jets...


radiation,
winds/outflows,
jets...
multiphase ISM
ionized
atomic
molecular

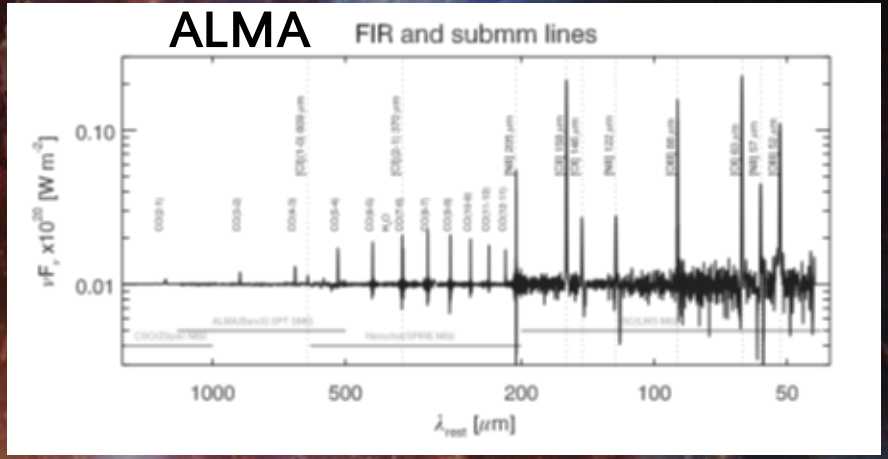


emission-line signatures

radiation,
winds/outflows,
jets...

multiphase ISM
ionized
atomic
molecular

ALMA FIR and submm lines

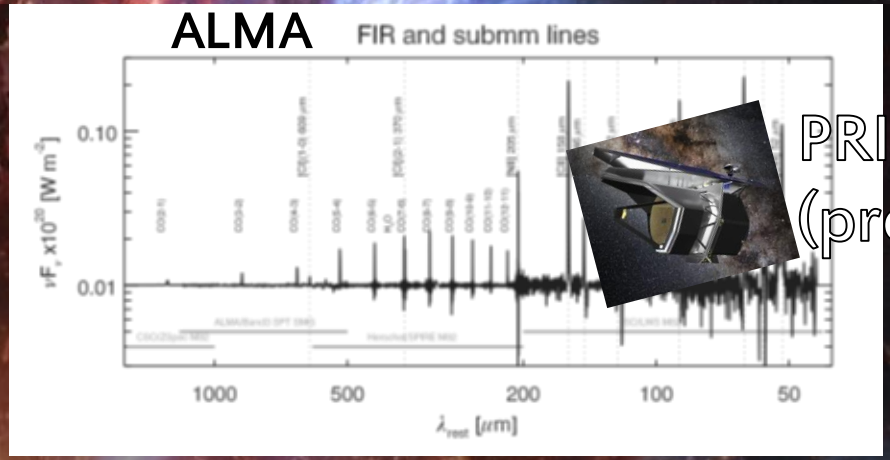


JWST

emission-line signatures

radiation,
winds/outflows,
jets...

multiphase ISM
ionized
atomic
molecular



JWST

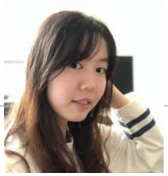
PRIMA (proposed)

emission-line signatures

radiation, winds/outflows, jets...

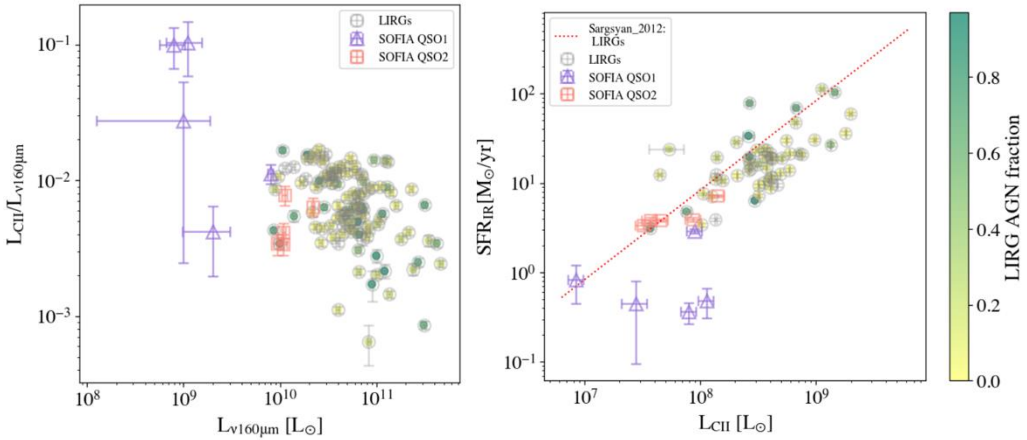
multiphase ISM
ionized
atomic
molecular

Observations don't point to a single ISM response



Yuanze Luo
(JHU, UTAustin)

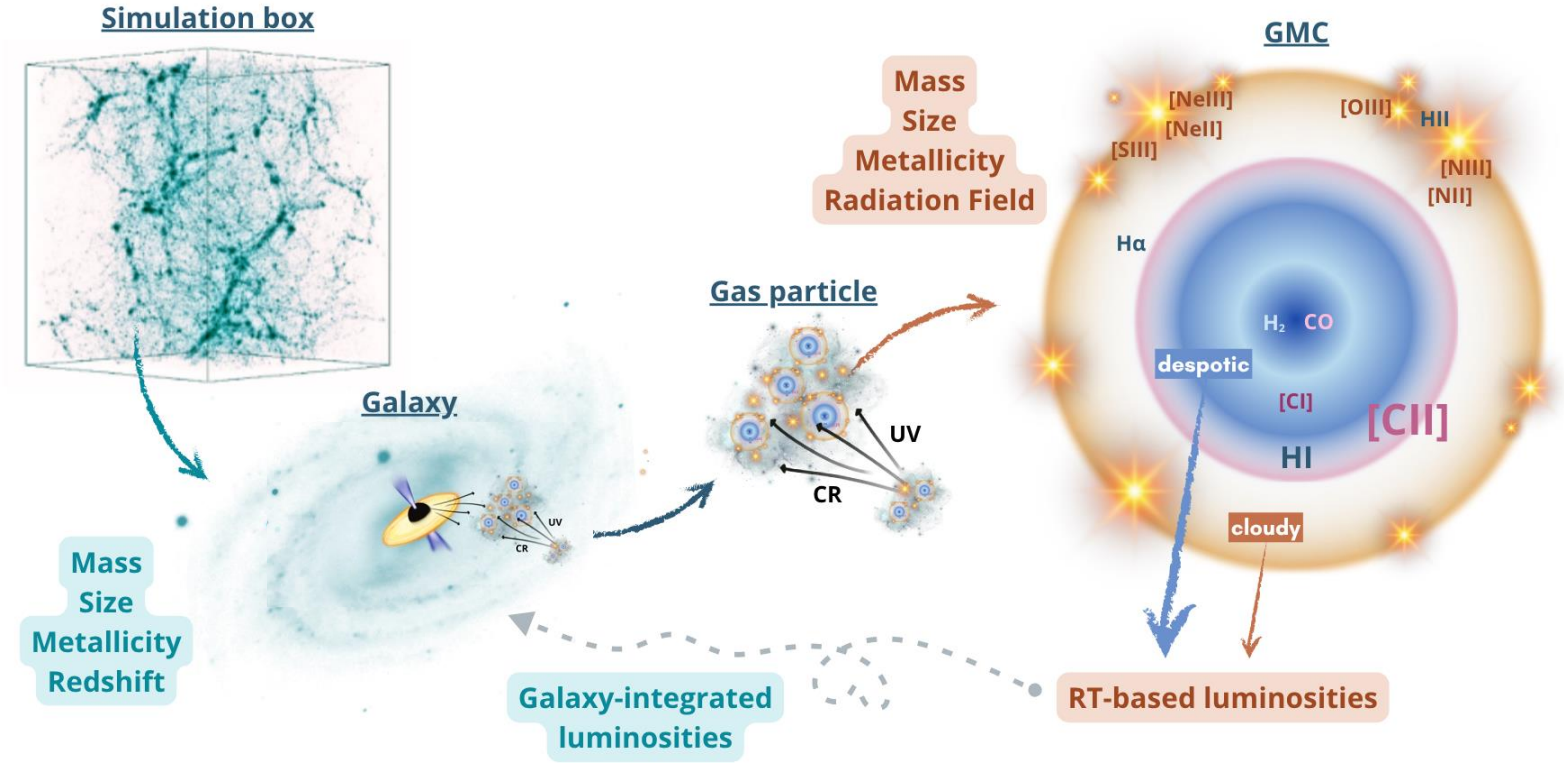
- **CO:** molecular gas and star-formation efficiencies are similar
- **[CII]/FIR:** QSO-IIs are similar to LIRGs
- **[CII]: enhanced in QSO-Is**, possibly tracing additional neutral/atomic gas



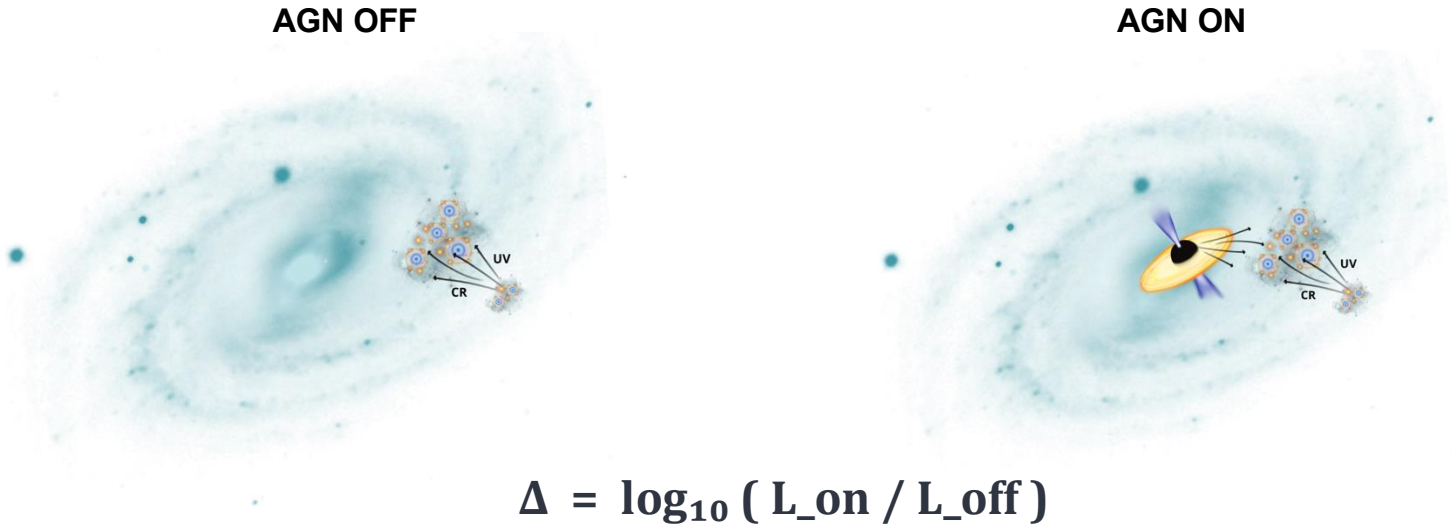
Luo et al., 2025

What is actually caused by the AGN?

SLICK: the Scalable Line Intensity Computation Kit



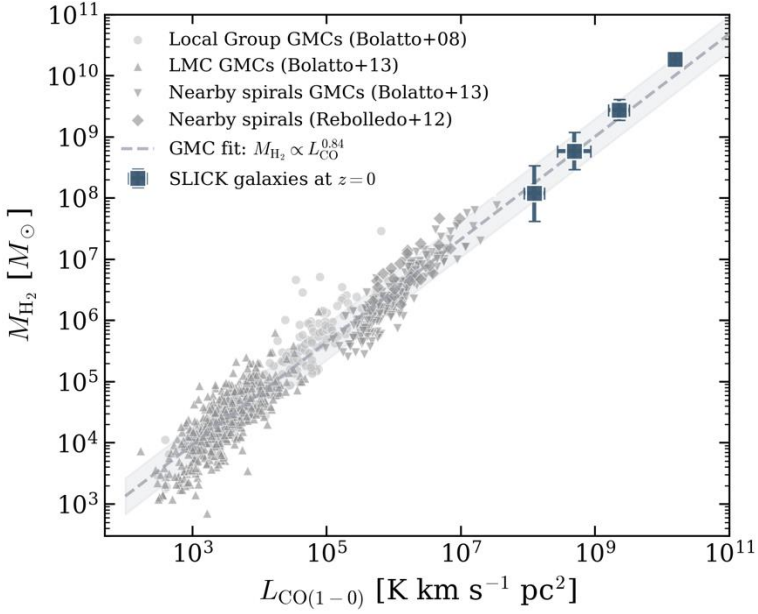
How it works

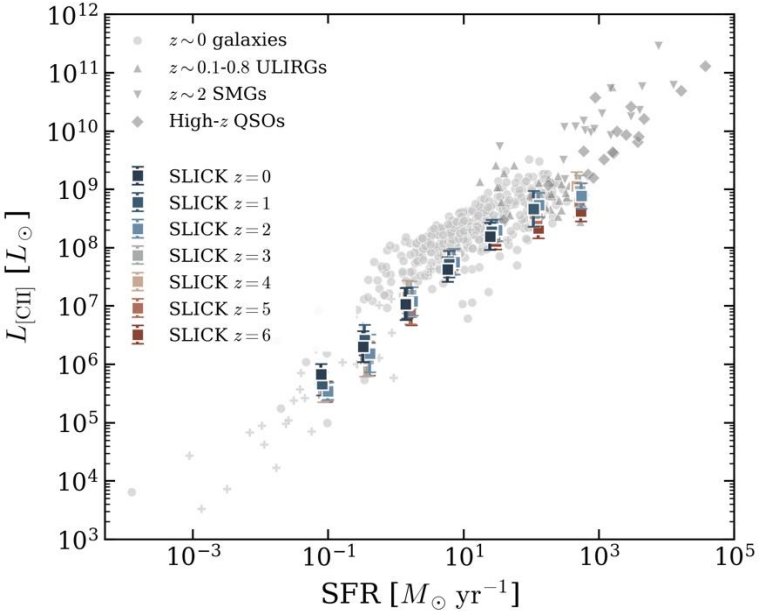


$$\Delta = \log_{10}(L_on / L_off)$$

Isolates the response to AGN radiation at fixed galaxy properties

SLICK reproduces observed line–galaxy scaling relations





From first-principles line emission calculations, SLICK reproduces the observed M_H_2–L_CO relation of resolved GMCs in the local universe, and the [CII]–SFR relation, from local galaxies to high-z QSOs.

Galaxy sample: TNG300 AGN hosts, z = 0–5

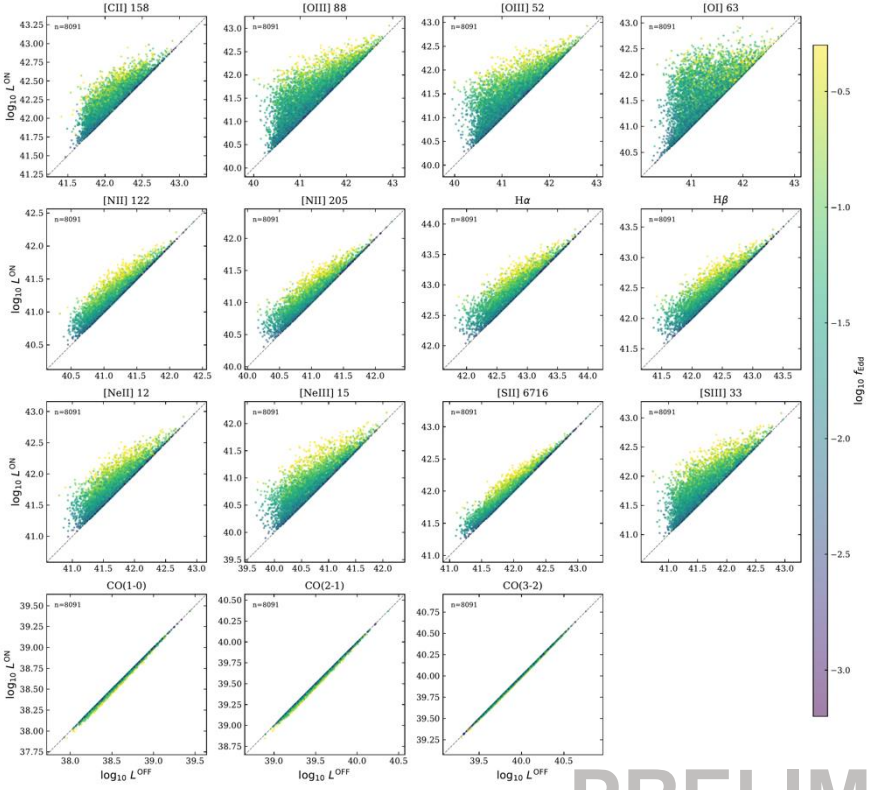
z	N_gal	median f_Edd	median SFR (M⊙/yr)
0	10	0.057	21.1
0.7	3,236	0.009	14.2
1	5,556	0.010	15.8
2	8,091	0.025	24.9
3	4,136	0.060	47.0
4	654	0.205	105.6
5	29	0.265	179.4

Selection

$M_\star > 10^{10}\ M_\odot$
$M_{BH} > 10^{8}\ M_\odot$
$L_{AGN} > 10^{42}$ erg/s
$L_{IR} > 10^{11}\ L_\odot$

The response to AGN radiation is strongly phase-dependent

z=2 (8091 galaxies)



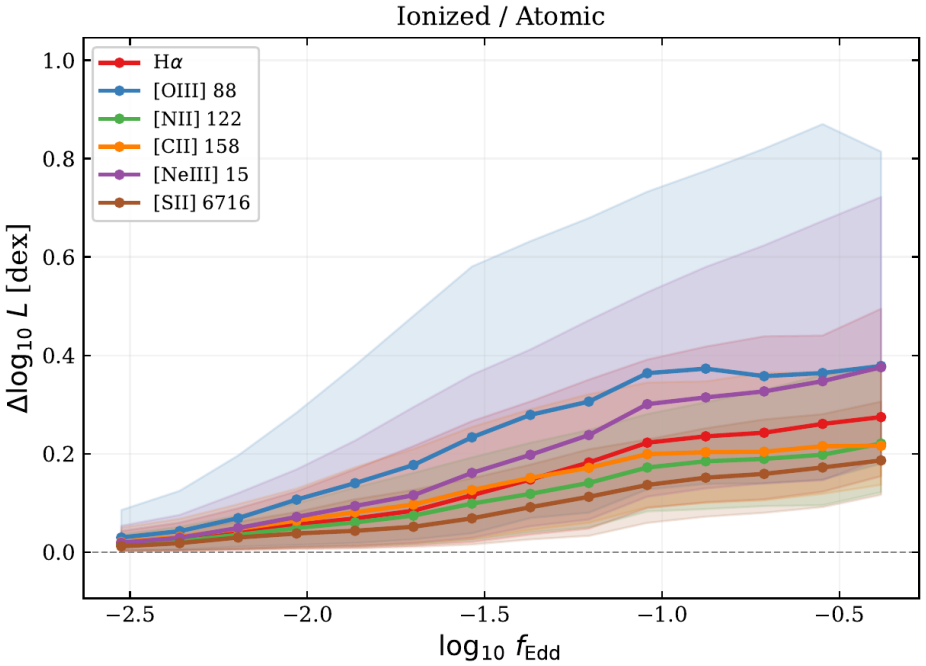
- **STRONG: [OIII], [NeIII], [SIII]**
  Ionized-gas lines show the strongest response to AGN radiation.

- **MODERATE: Hα, [NII], [SII], [CII]**
  Lower-ionization lines respond, but with smaller enhancements.

- **WEAKER: CO(1–0), CO(2–1), CO(3–2)**
  Low-J CO lines don't change much.

PRELIMINARY

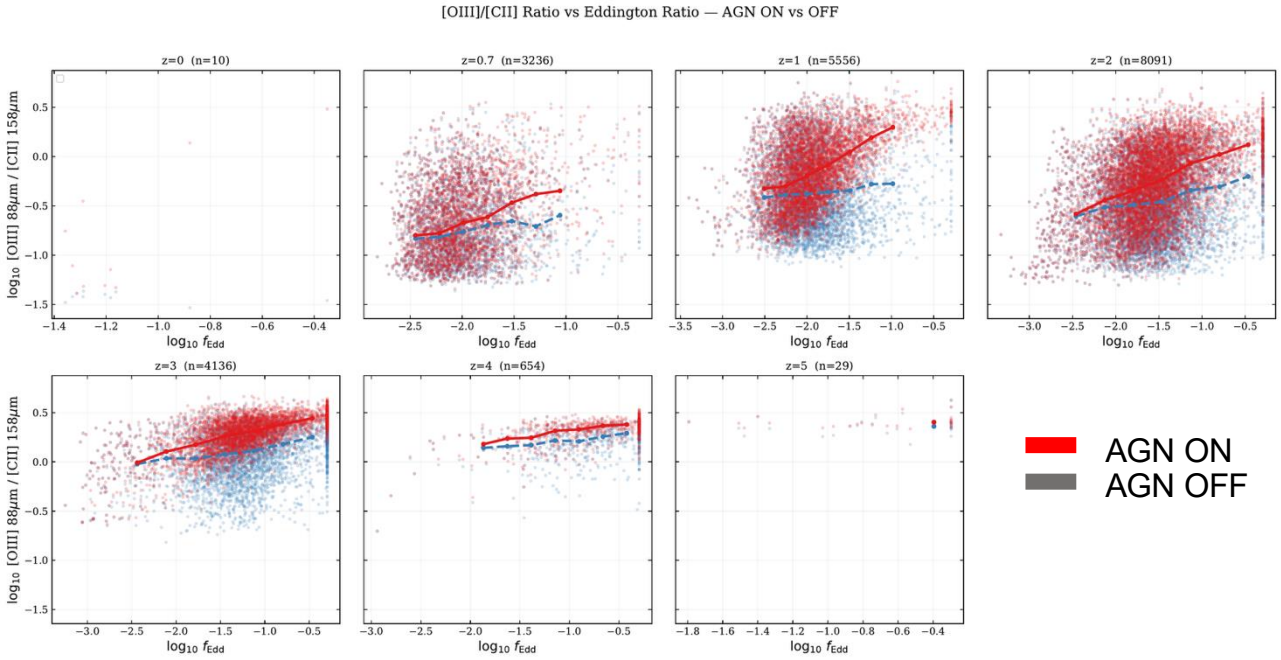
The line enhancement increases with Eddington ratio



- **The AGN imprint depends on accretion state**
- **Higher $f_{Edd}\rightarrow$ larger line enhancement**
- **The response is line-dependent:** [OIII] and [NeIII] show the strongest enhancement

PRELIMINARY

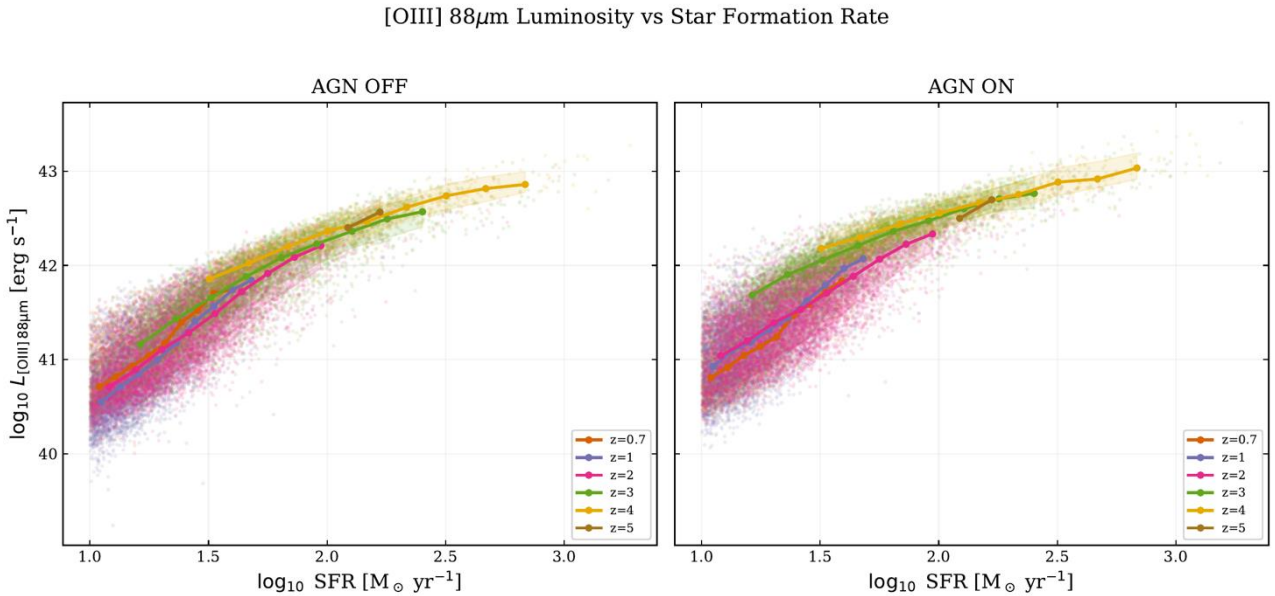
[OIII]/[CII] is sensitive to AGN radiation across cosmic time



- **AGN radiation systematically enhances [OIII]/[CII]:**
  → the AGN ON population is shifted toward higher ratios at nearly every redshift
- **The enhancement increases with f_{Edd}:**
  → more actively accreting systems show a stronger AGN imprint
- **A potential far-IR diagnostic of AGN radiation!**

PRELIMINARY

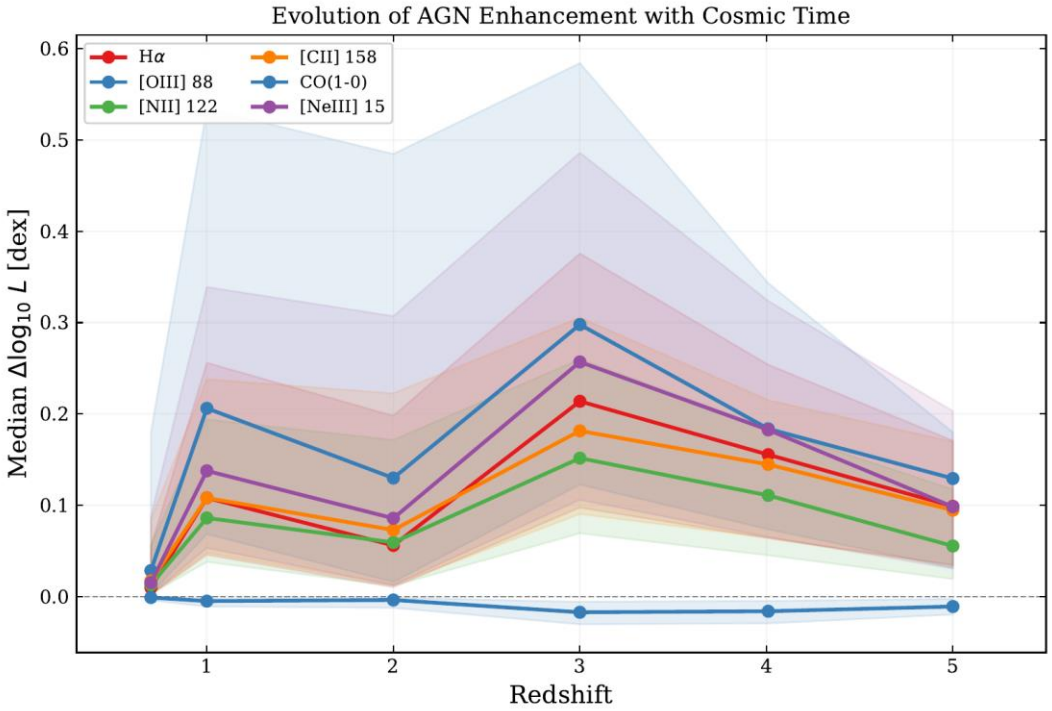
AGN radiation enhances [OIII] at fixed SFR



- At the same SFR, AGN-ON galaxies have higher [OIII] luminosities
- The effect varies across redshift
- Ignoring the AGN contribution can bias [OIII]-based SFRs

PRELIMINARY

The AGN-induced line response also evolves across cosmic time



- **The enhancement is not monotonic with redshift**

→ most lines show the strongest response around $z \sim 3$

- **Ionized-gas tracers show the strongest evolution**

→ [OIII] and [NeIII] remain particularly sensitive to AGN radiation

- **The high-z turnover should be interpreted cautiously**

→ model limits may suppress the recovered enhancement at z≳3

PRELIMINARY

Conclusions

- **SLICK enables controlled AGN ON/OFF experiments across the multiphase ISM**
- **AGN radiation produces a differential line response:** strongest in ionized lines
- **The response is connected to Eddington ratio**, with important consequences for line diagnostics and inferred galaxy properties
- **We can now study these effects statistically across thousands of simulated AGN hosts spanning** $z \sim 0.7\text{–}5$
- **PRIMA can bring this multiphase approach to large observed AGN populations**

Toward a statistical, multiphase view of AGN–galaxy interaction across cosmic time