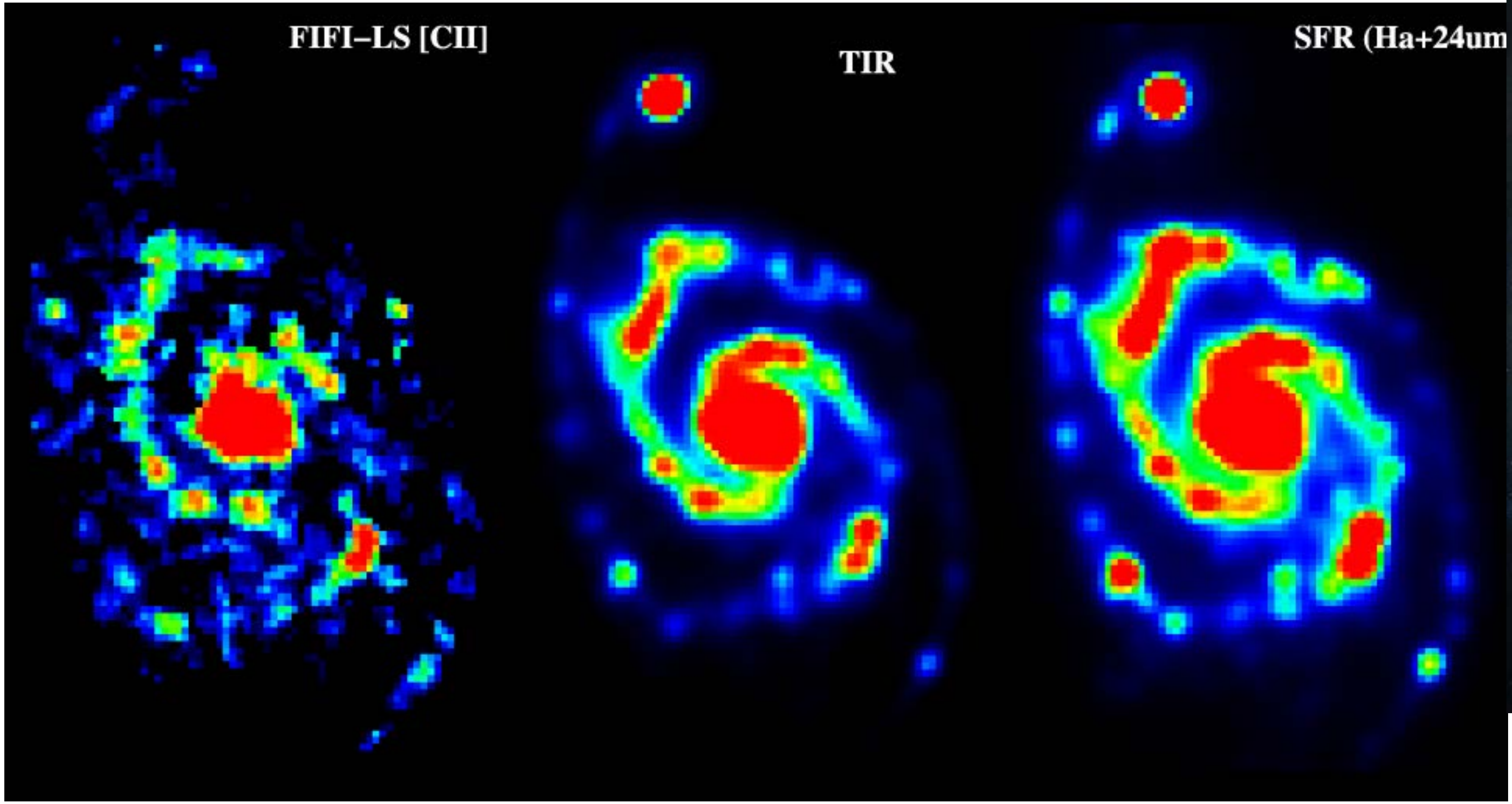
FIFI-LS Highlights

Robert Minchin

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation

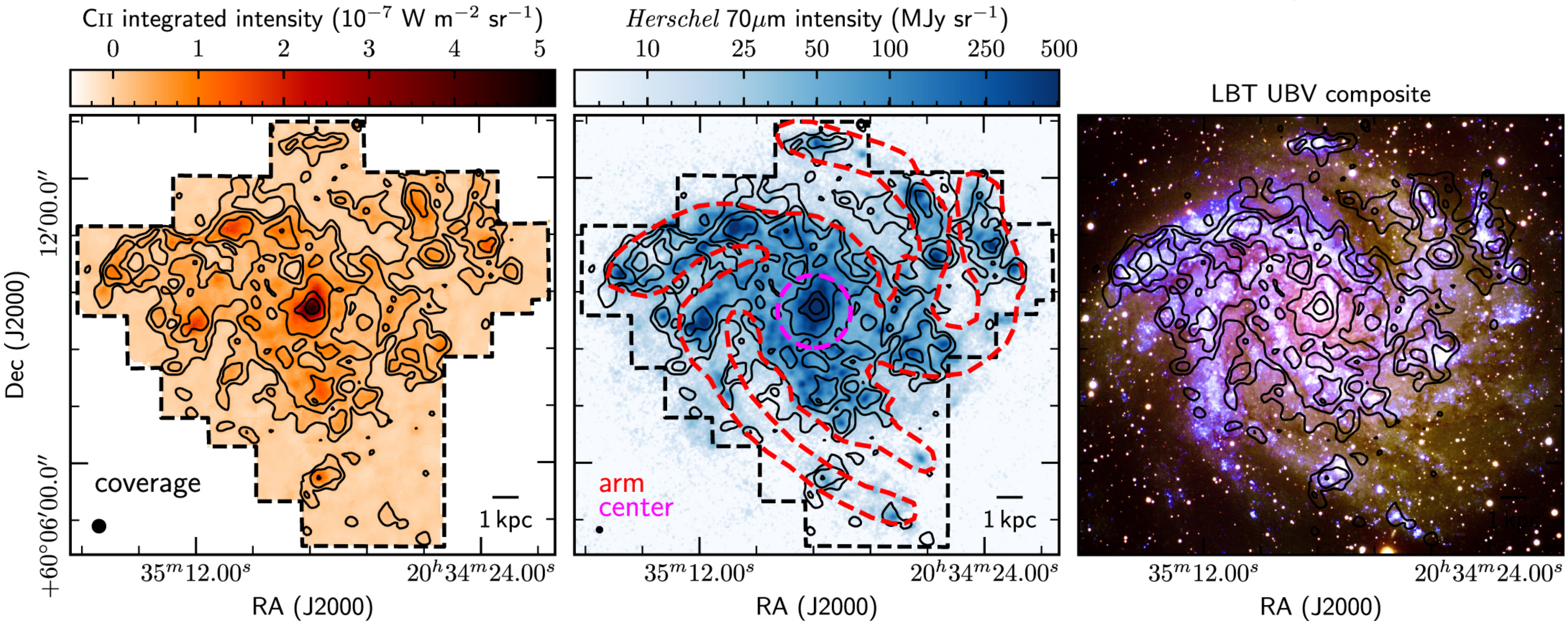
[CII] traces star formation in M51



Pineda et al. 2018

[CII] in NGC 6946

Bigiel et al. 2020

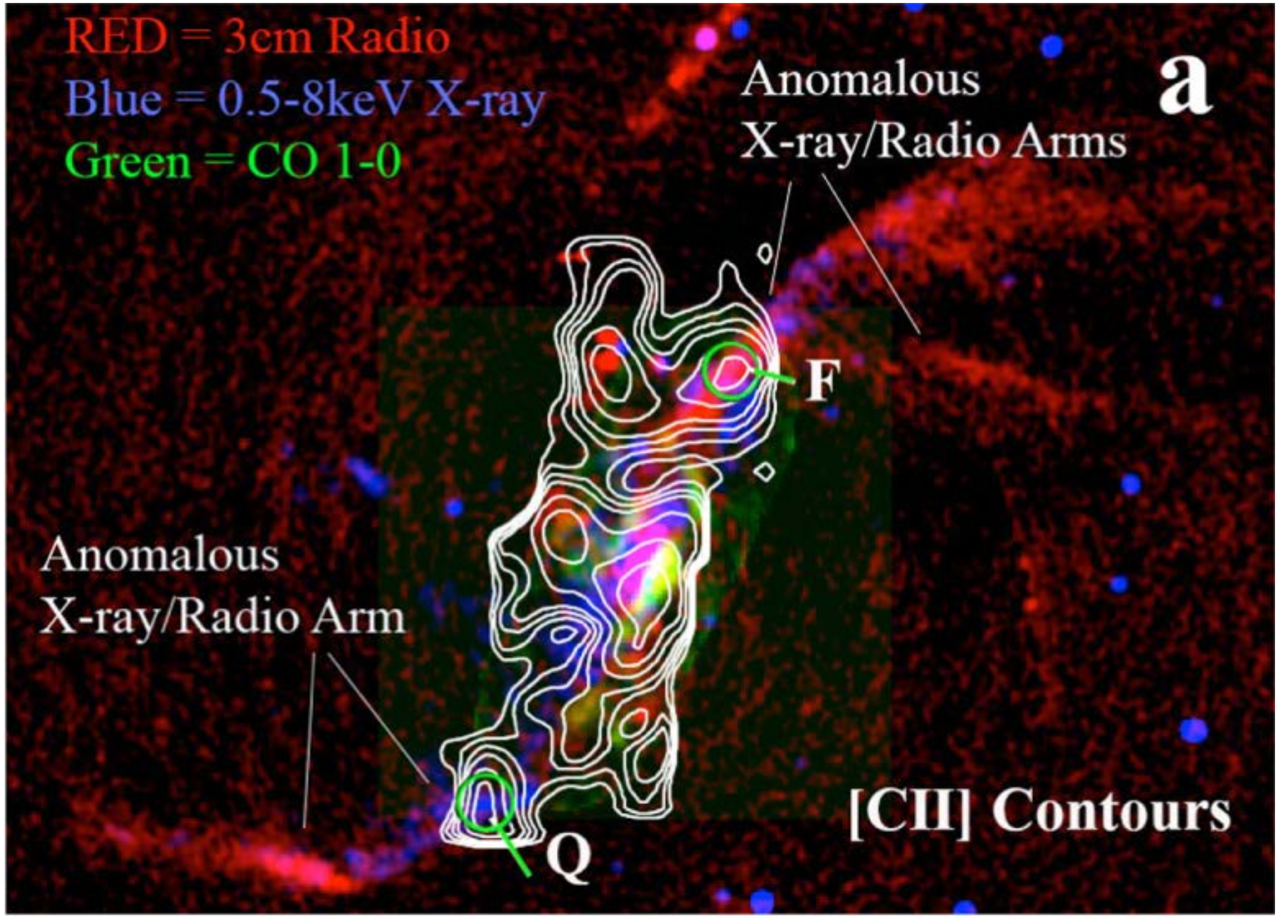


[CII] particularly important as H_2 & SFR tracer in inter-arm regions

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation

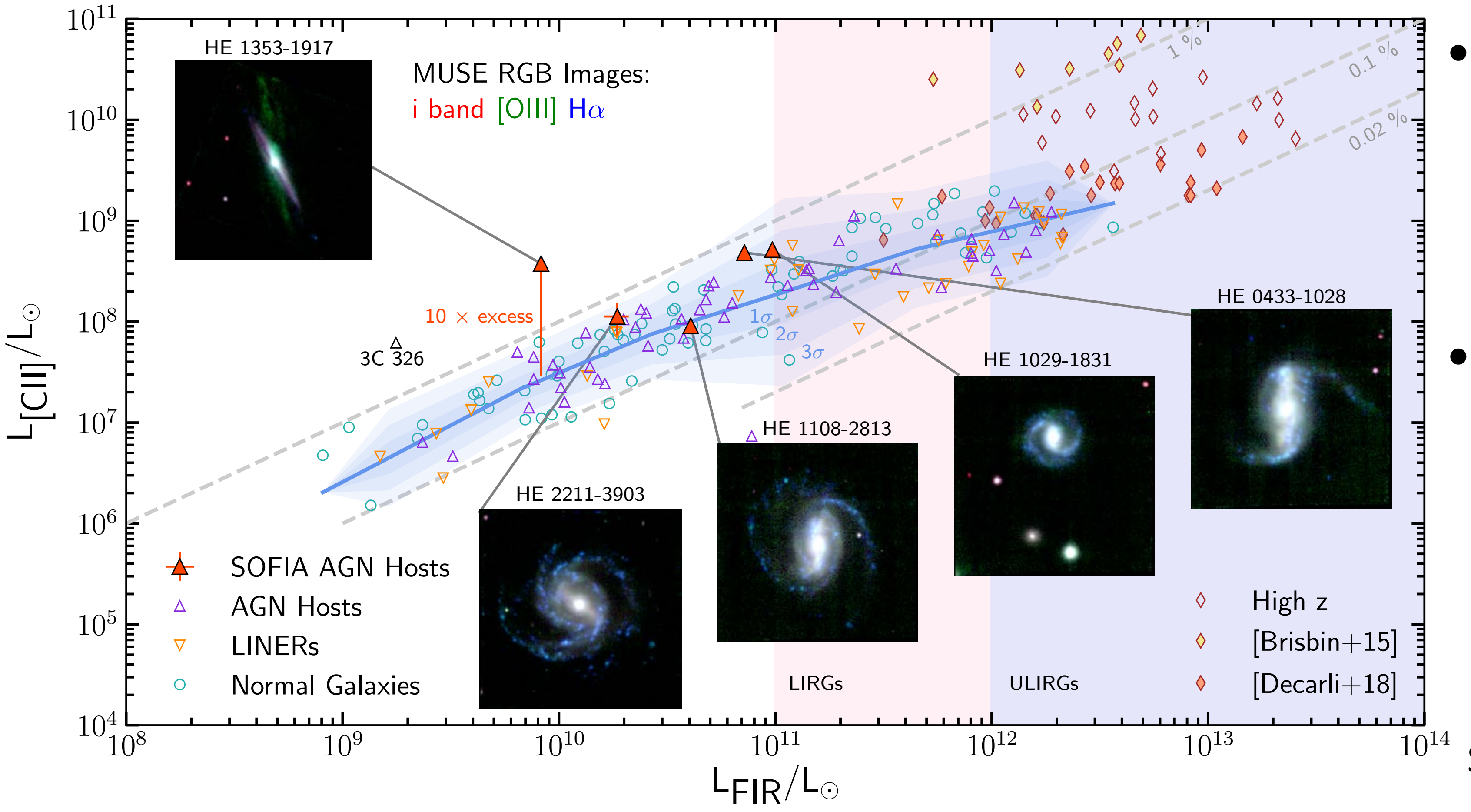
[CII] from shocks & turbulence in NGC 4258



- [CII] seen along X-ray/radio 'arms' of NGC 4258, associated with past or present jet activity
- [CII] excited by shocks and turbulence associated with the jet impacting the disk
- **NOT** star formation

Appleton et al. 2018

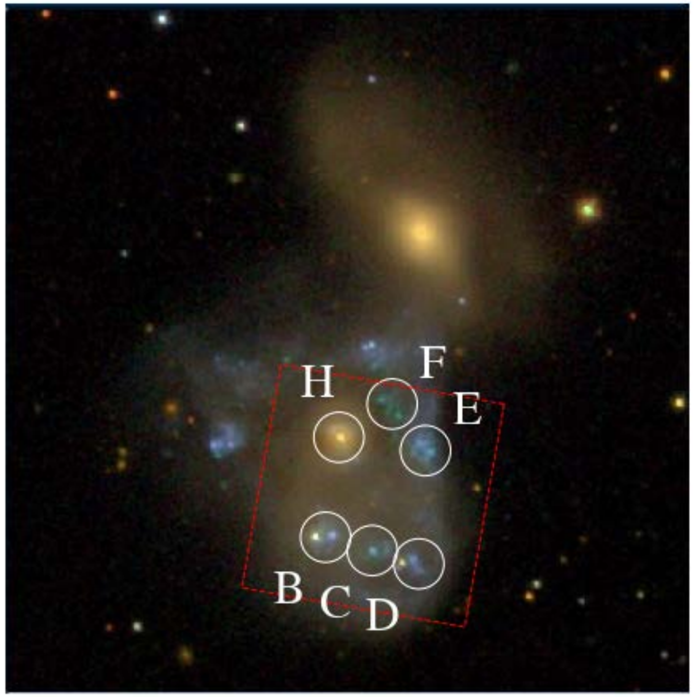
Excess [CII] in HE 1353-1917



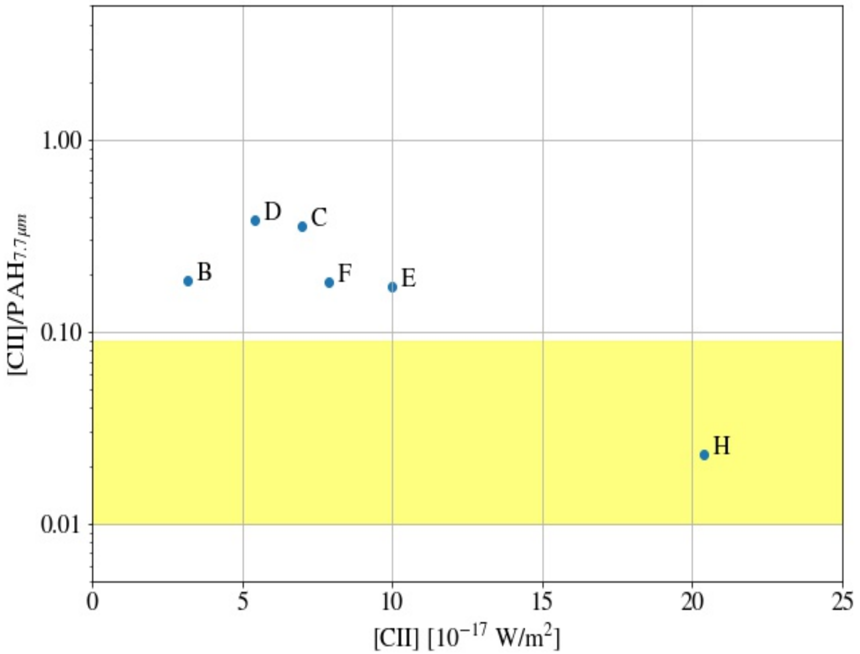
- HE 1353-1917 has a large excess in $L_{[CII]}/L_{FIR}$
- AGN ionization cone intercepts the cold galactic disk

Smirnova-Pinchukova et al. 2019

Shock-excited [CII] in NGC 2445



[CII] in the ring of NGC 2445 is enhanced compared to PAHs, showing a shock excitement origin rather than star formation

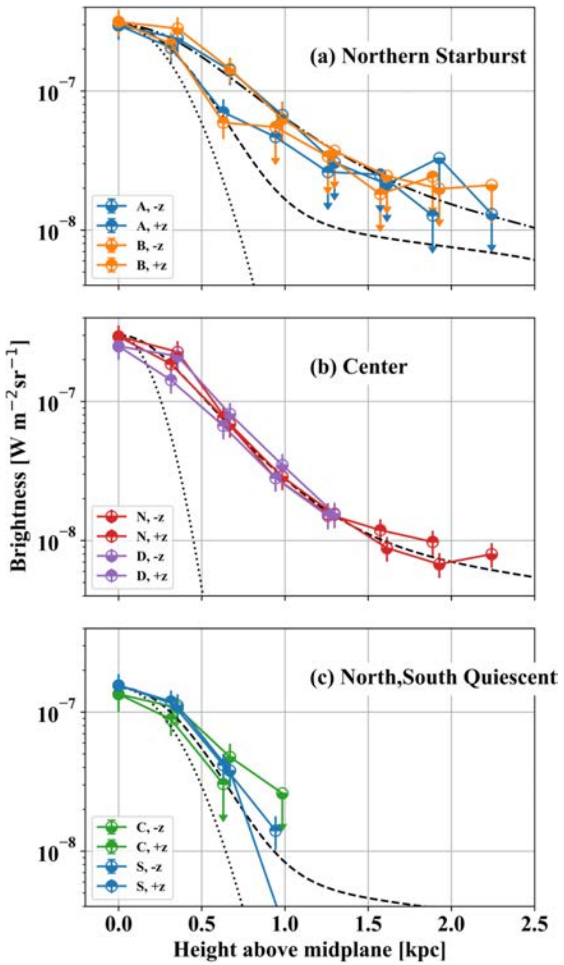


Fadda & Appleton, 2020, AAS Meeting 235

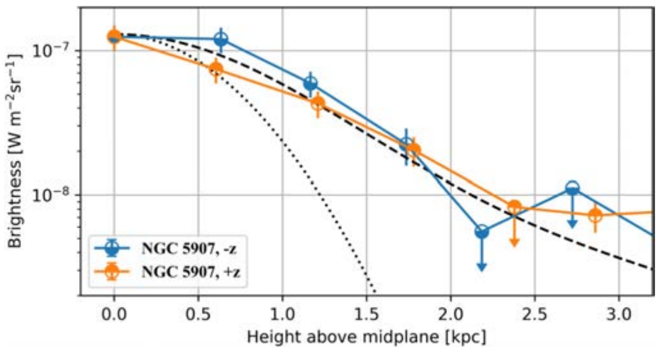
FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation
- Galaxies with gas away from the plane

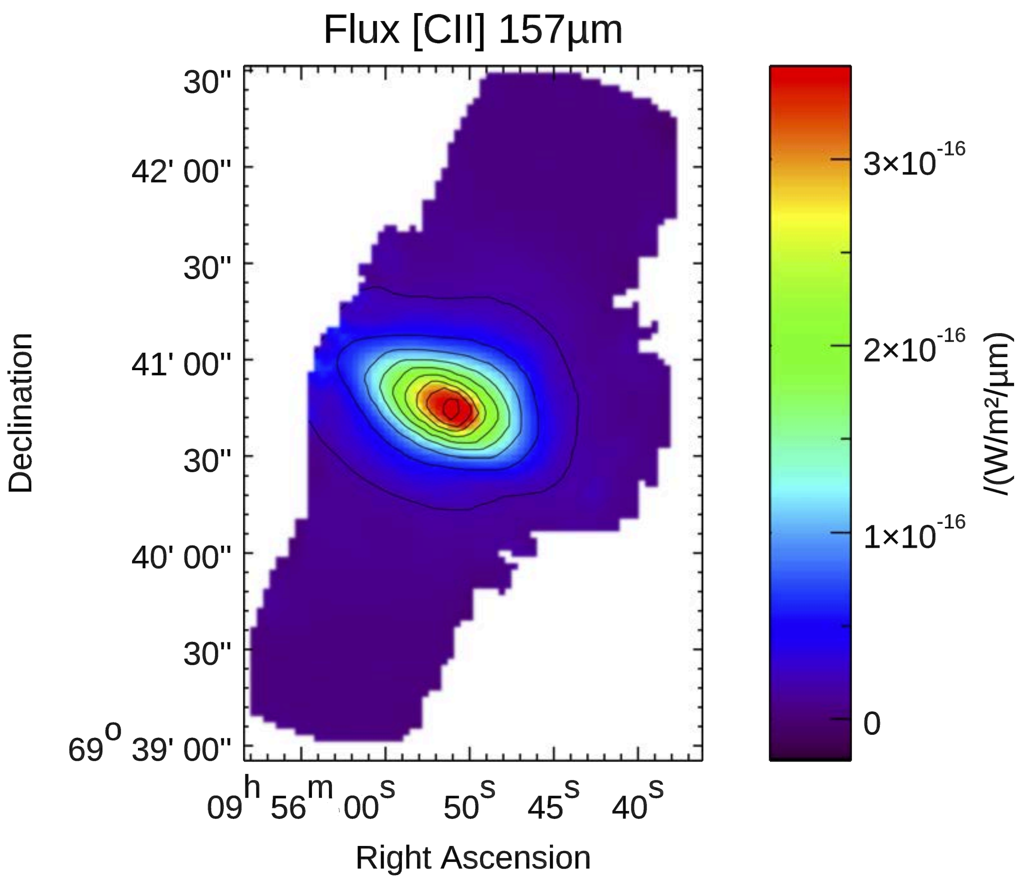
Extraplanar [CII] in edge-on galaxies



- Edge-on galaxies NGC 891 & NGC 5907 observed by Reach et al. (2020)
- Figures show [CII] off the plane of the galaxy in NGC 891 (left) and NGC 5907 (below right)
- [CII] much more extended than MIR emission, which traces current massive star-formation
- May arise in walls of 'chimneys' where winds and SNe from SF regions carry material up into the halo

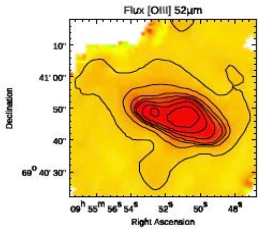


Outflows in M82



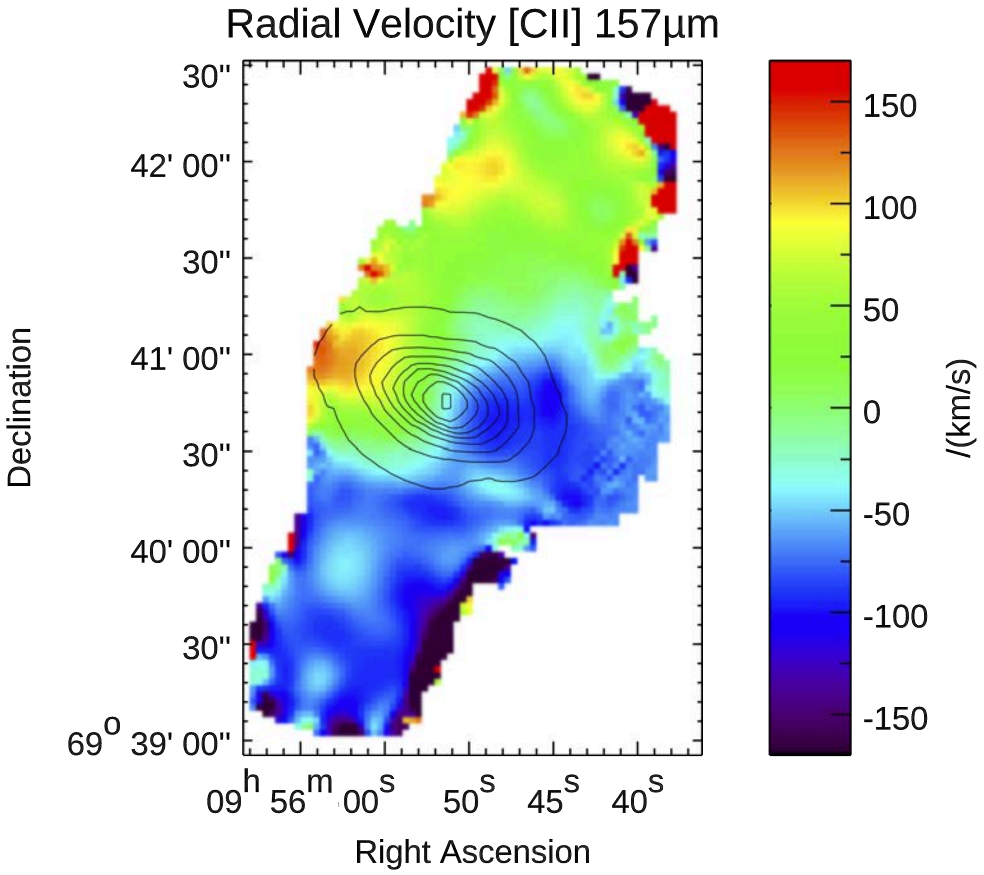
Latzko et al. 2018, KMOS@5 meeting

- Observations of M82 by Latzko et al. detect both [CII] and [OIII] 52 µm in the outflow
- Velocity field confirms that seen by PACS (central region only) for [CII]; [OIII] differs from [CII] (but has lower SNR)
- Also observed at 57 µm by Spilker et al.



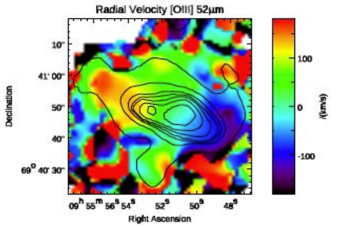
[OIII] 52 µm
(same scale)

Outflows in M82



Latzko et al. 2018, KMOS@5 meeting

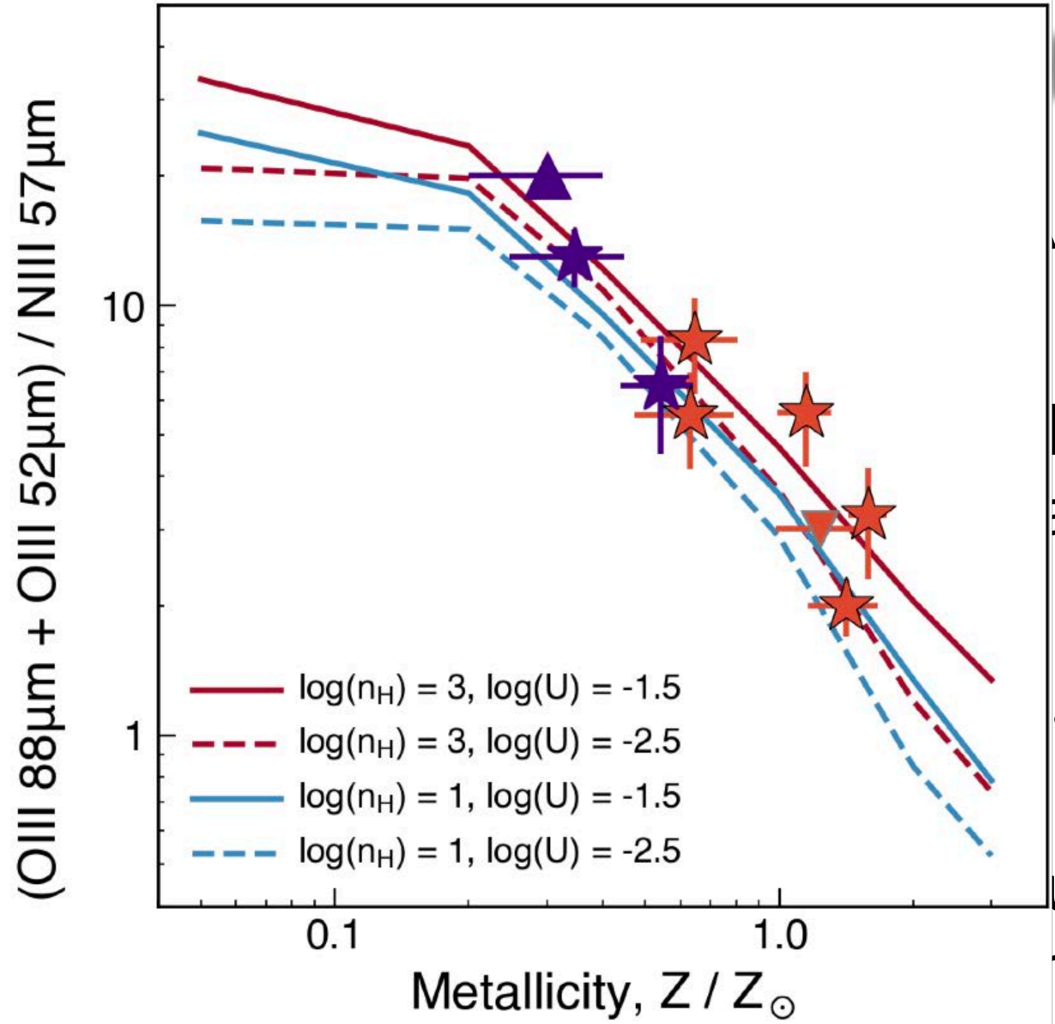
- Observations of M82 by Latzko et al. detect both [CII] and [OIII] 52 µm in the outflow
- Velocity field confirms that seen by PACS (central region only) for [CII]; [OIII] differs from [CII] (but has lower SNR)
- Also observed at 57 µm by Spilker et al.



[OIII] 52 µm
(same scale)

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements



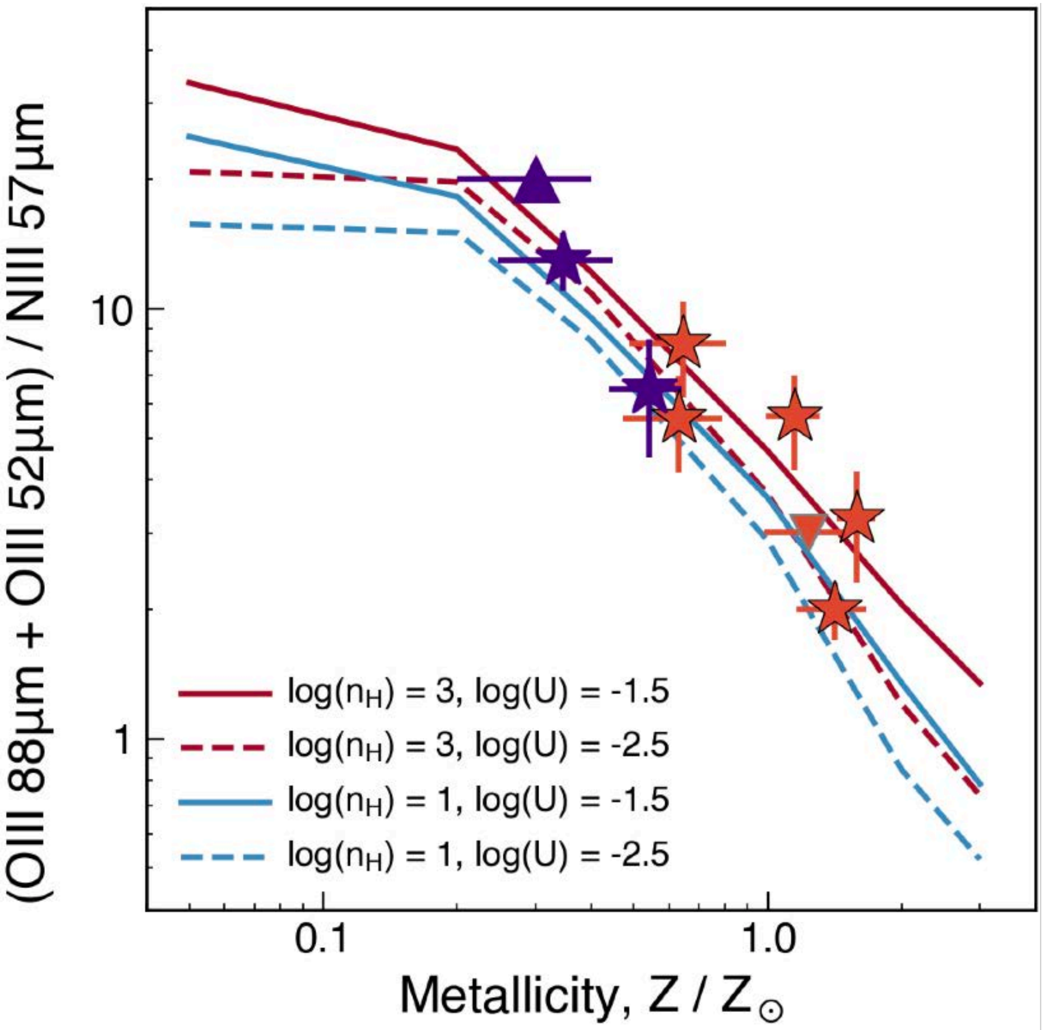
n-Free Metallicity Indicators

metallicities

licity
and

sing

ults
nents
by Spilker et al. (purple) and
existing ISO + Herschel + SOFIA
data (red)

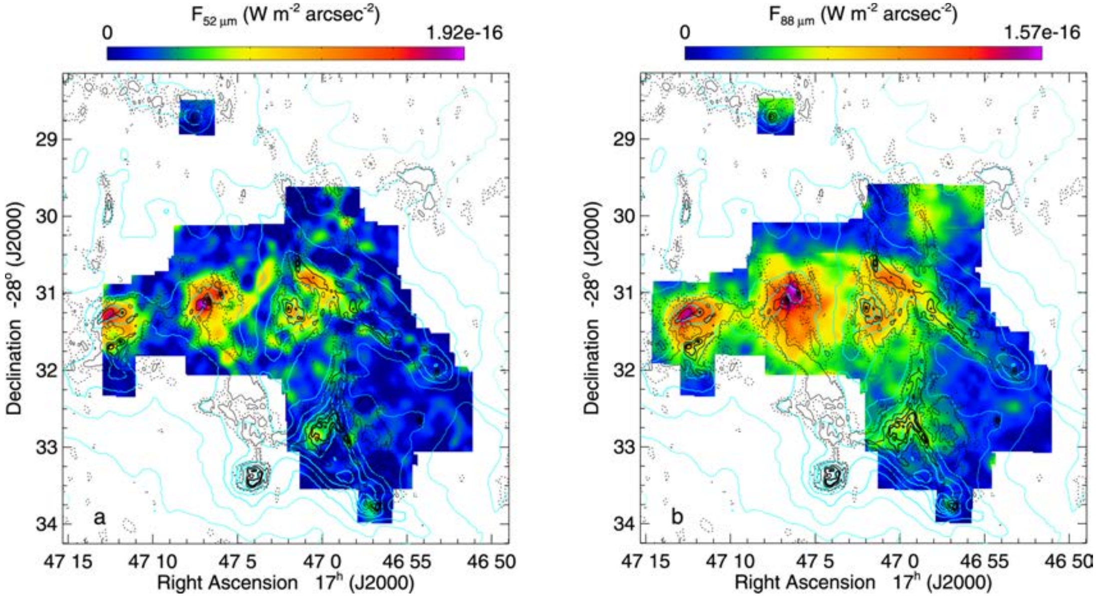


Spilker 2020, SOFIA Instrument Roadmap Workshop I

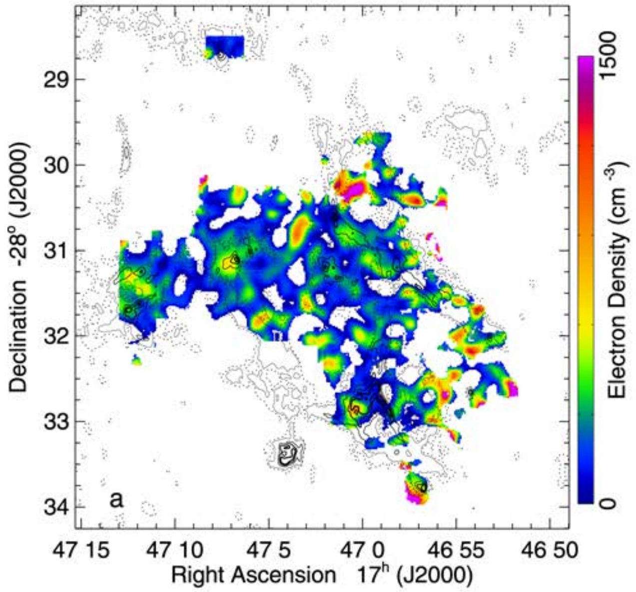
FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements
- Our Galactic Center

Sgr B1 – ionization structure & sources of excitation



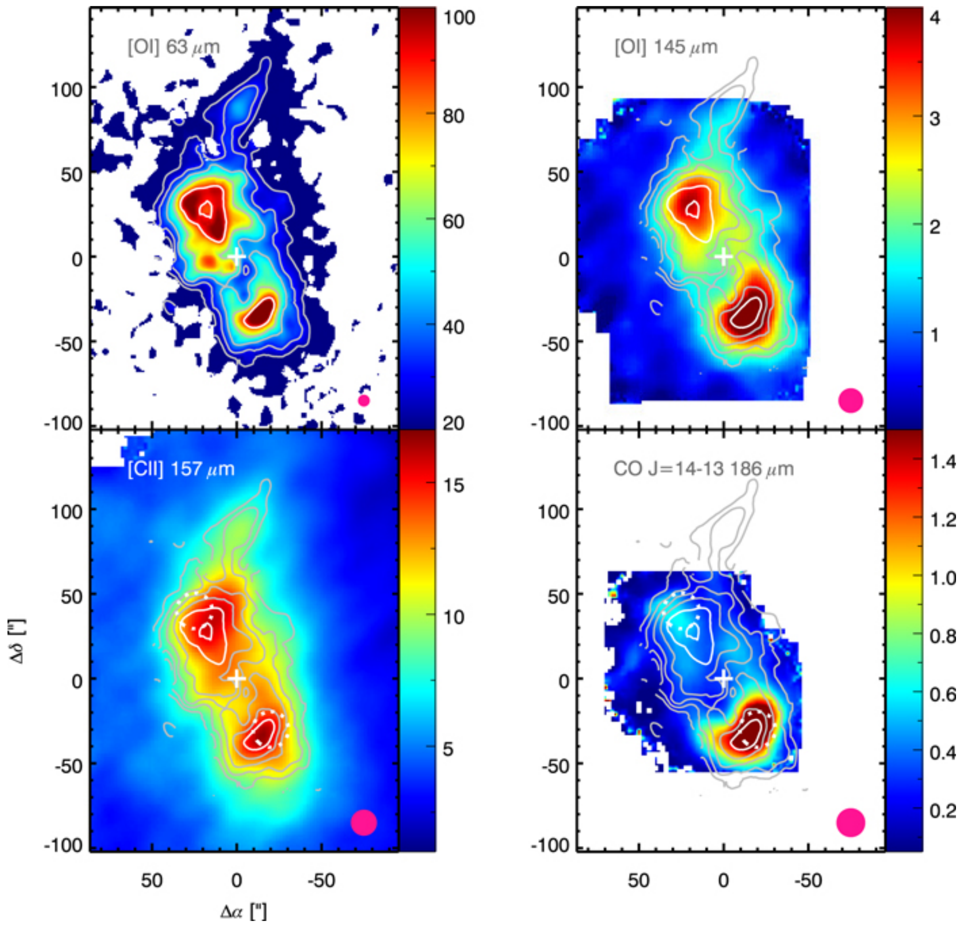
- [OIII] 52 and 88 μm maps (left) give the electron density (right)
- Combination with Spitzer data gives O^{++}/S^{++} and Ne^{++}/O^{++}



- Maps show at least eight scattered regions of high ionization, surrounded by areas of low ionization
- Likely that ionizing star cluster is at least a few Myr old and that the stars did not form in situ but are from a previous era of star formation

Simpson et al. 2018

The Circumnuclear Ring



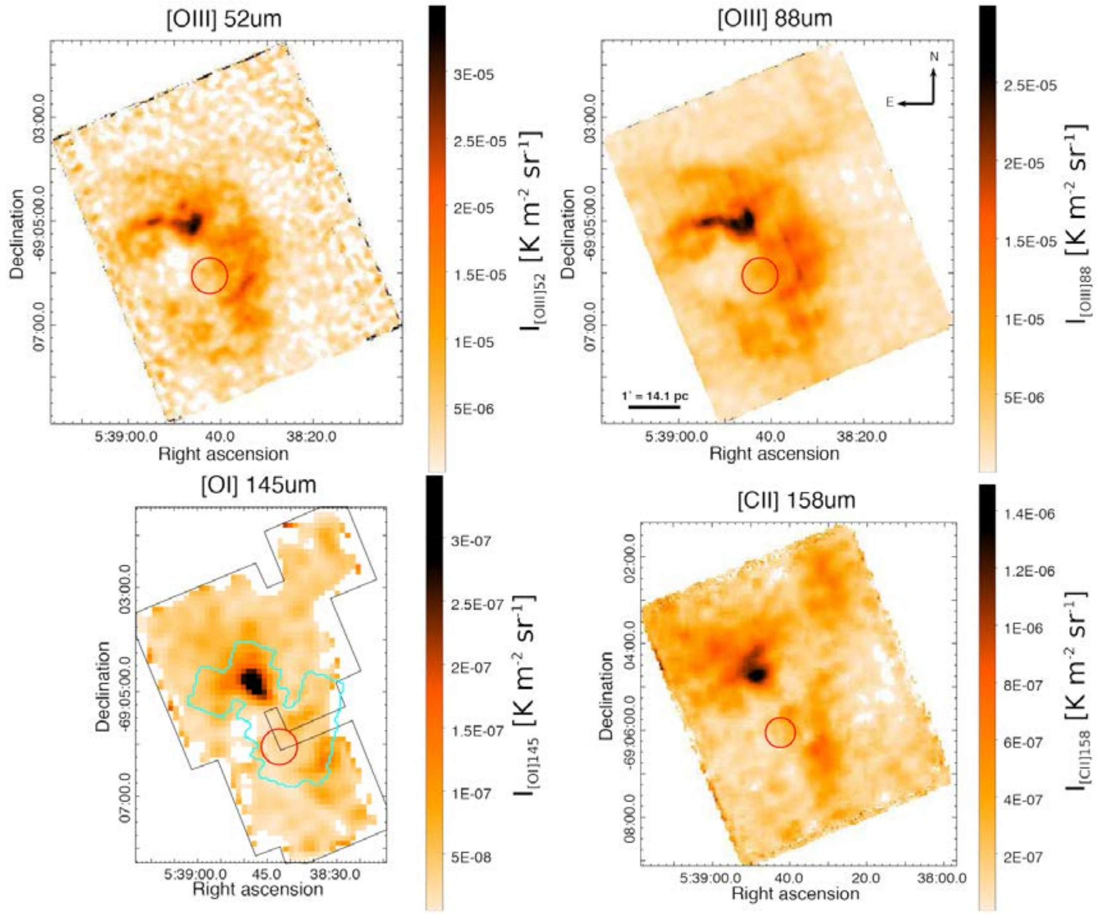
- Probe dense photodissociation region using [CII], [OI] (63 and 145 μm), and CO J=14-13 (186 μm)
- Also FORCAST images & PACS continuum
- Compare with PDR models
- Found consistent picture of CNR being a transient toroidal structure powered by cluster of O/B/WR stars orbiting Sgr A*

Iserlohe et al. 2019

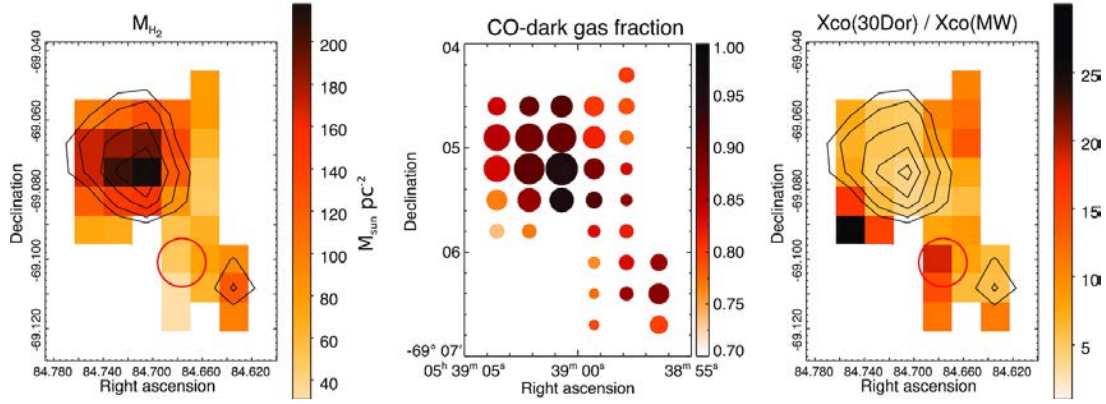
FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements
- Our Galactic Center
- CO-dark molecular gas

30 Doradus



- Observations of [OIII] at 52 and 88 µm combined with [OI] at 145 µm and [CII] & archival data
- PDR modelling used to find H_2 mass & CO-dark mol gas fraction
- $\gtrsim$75% of H_2 would be missed using standard X_{CO} factor

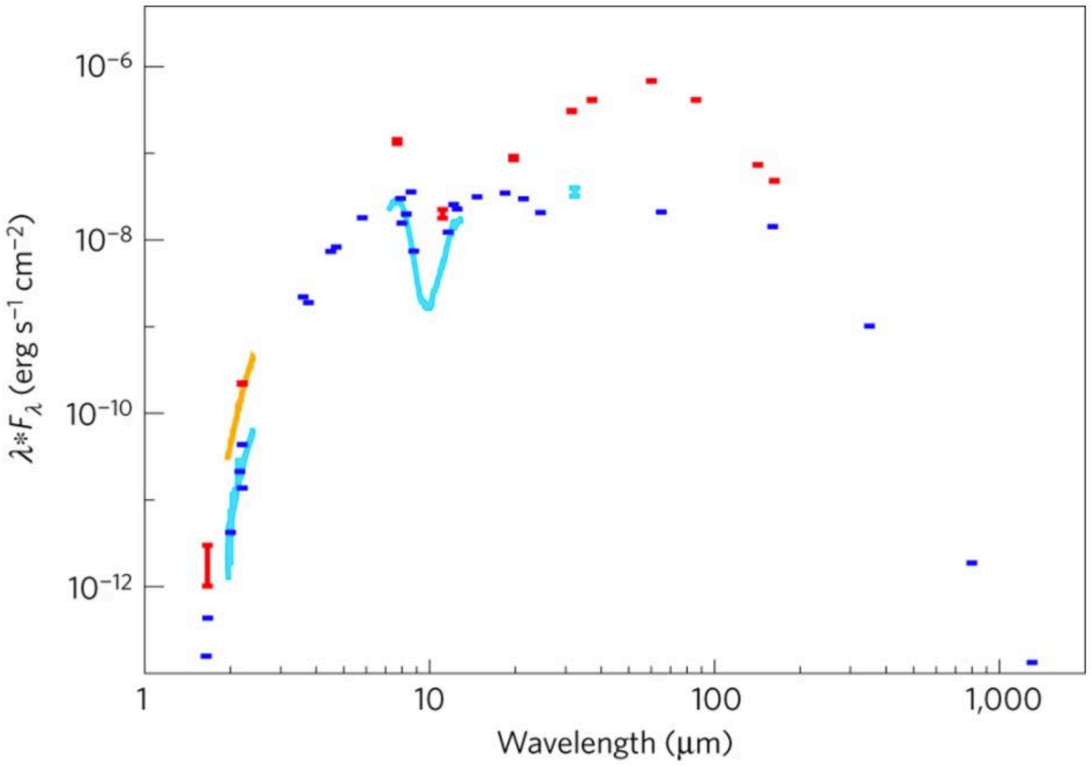


Chevance et al. 2020

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn’t trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements
- Our Galactic Center
- CO-dark molecular gas
- Accretion bursts in HMYSOs

S255IR NIRS 3



Caratti o Garatti, 2017

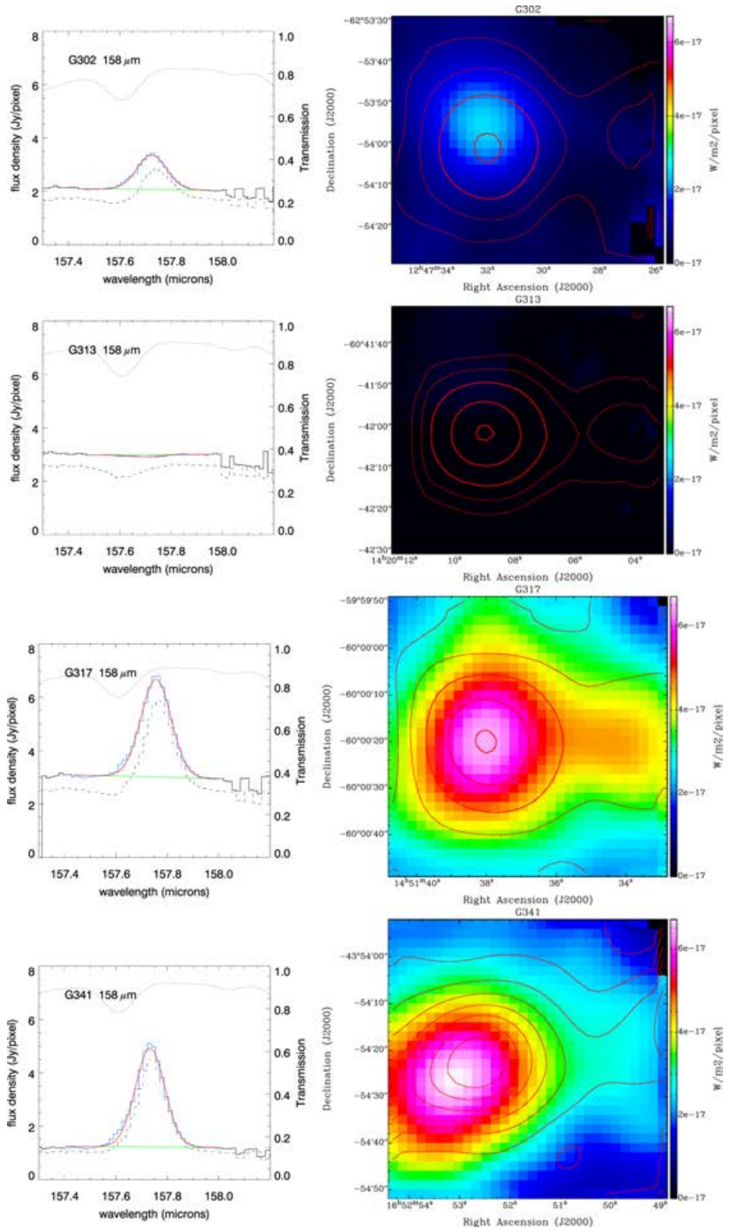
- FIR (including peak) from FIFI-LS; MIR from FORCAST
- Increase in accretion luminosity (ΔL_{acc}) of $(1.3 \pm_{0.3}^{0.4}) \times 10^5\ L_\odot$ and an energy release of $(1.2 \pm 0.4) \times 10^{39}$ J over nine months from start of burst
- Confirmed that HMYSOs form via disk accretion, not stellar mergers

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn't trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements
- Our Galactic Center
- CO-dark molecular gas
- Accretion bursts in HMYSOs
- Proto-stars and star forming regions

Star forming clumps in [CII]

- Does galactic [CII] emission arise from an ensemble of star-forming molecular clumps? Is [CII] a robust tracer of global star formation?
- Three of four clumps detected in [CII]
- Undetected clump factor > 100 below empirical correlation curve between [CII] and FIR found for galaxies
- Possibly early evolutionary stage w/o sufficient UV or dust attenuation of UV



Jackson, 2020

FIFI-LS Highlights

- Nice face-on galaxies where [CII] traces star formation
- Galaxies where [CII] doesn't trace star formation
- Galaxies with gas away from the plane
- Metallicity measurements
- Our Galactic Center
- CO-dark molecular gas
- Accretion bursts in HMYSOs
- Proto-stars and star forming regions
- …