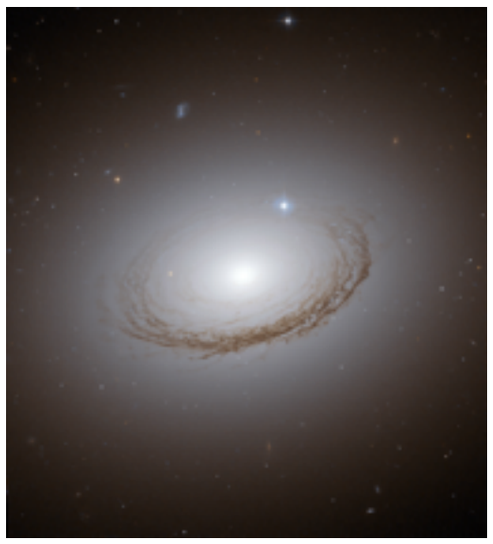
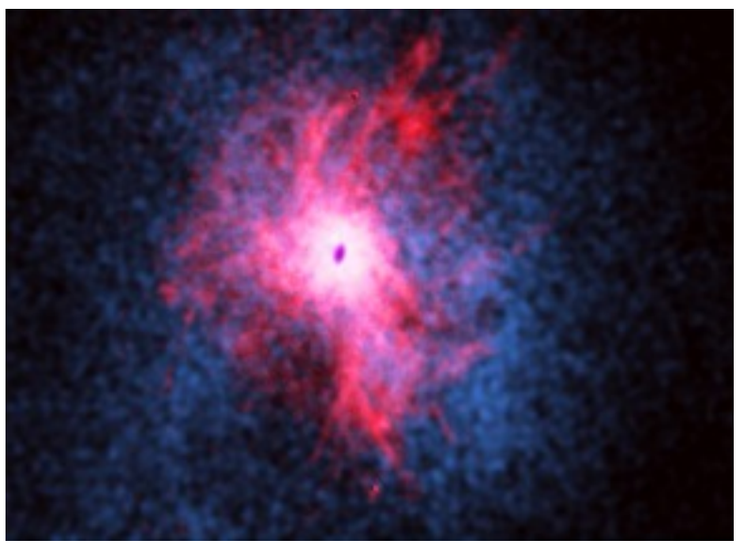
The origin of cold gas in giant ellipticals and its role in fueling AGN feedback

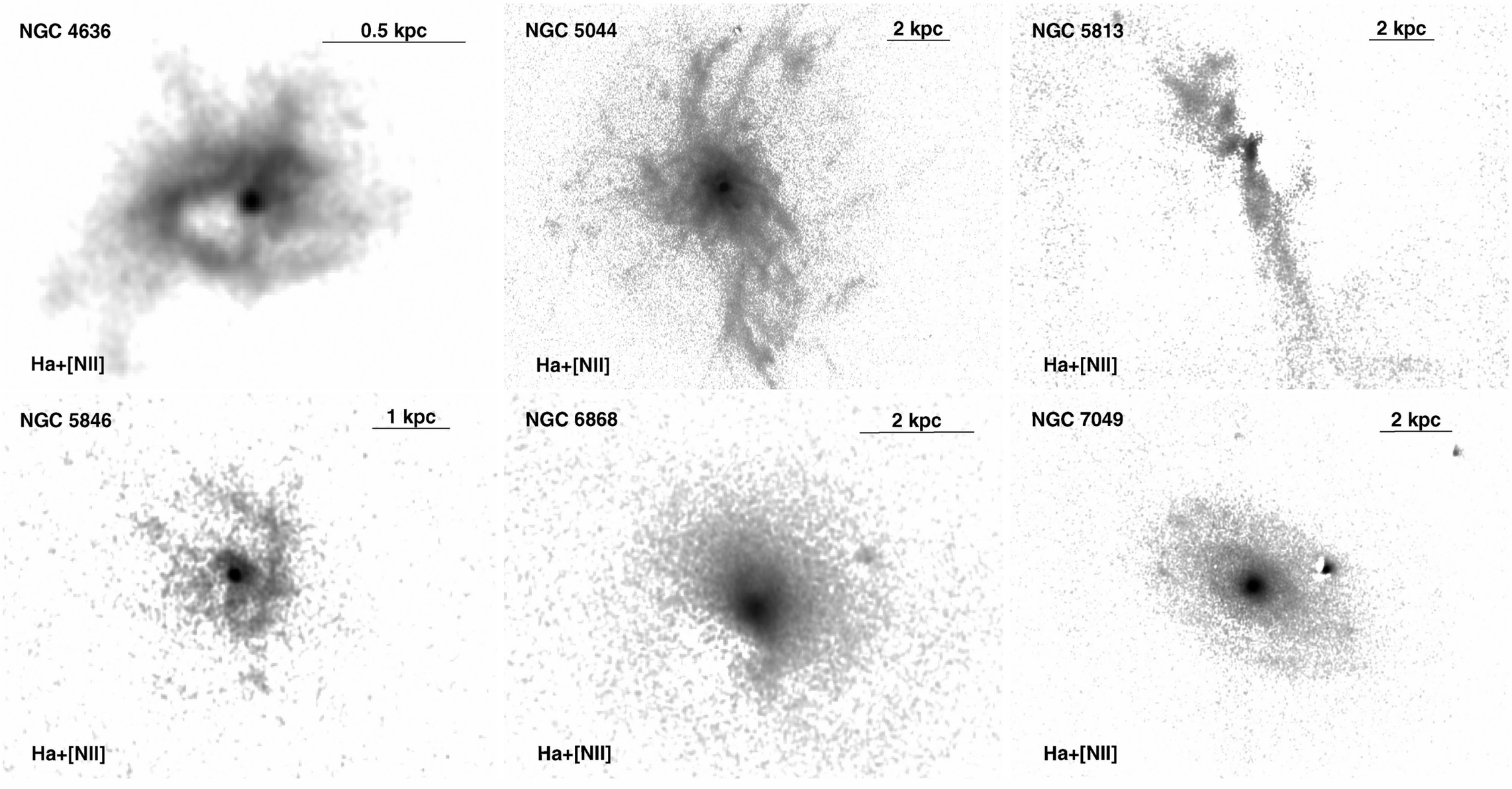





Norbert Werner

Stanford University

Red and dead giant elliptical galaxies

Hα emission (6/8)



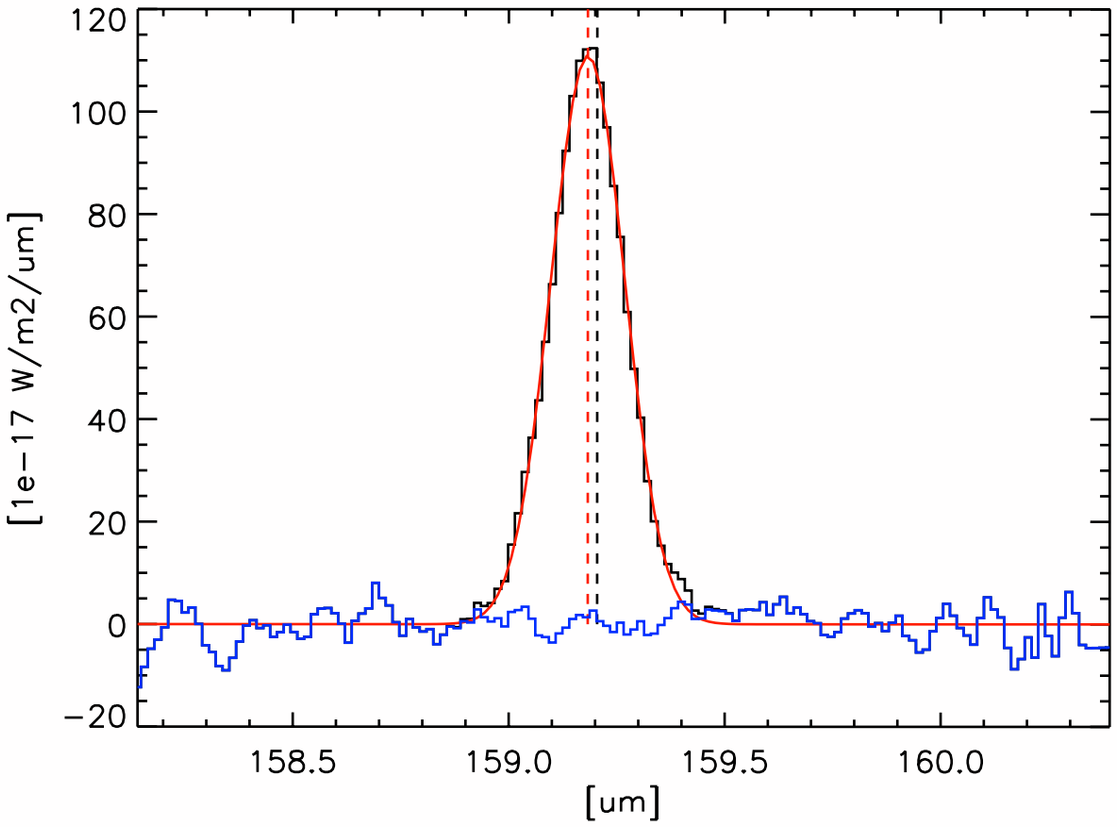
Werner et al. 2014

Search for cold gas with the Herschel space observatory

- we observed the cooling lines of [CII], [OI] with *Herschel*
- [CII] an excellent tracer of 100 K gas, its flux is usually a few thousand times stronger than CO

Werner et al. 2013a, 2014

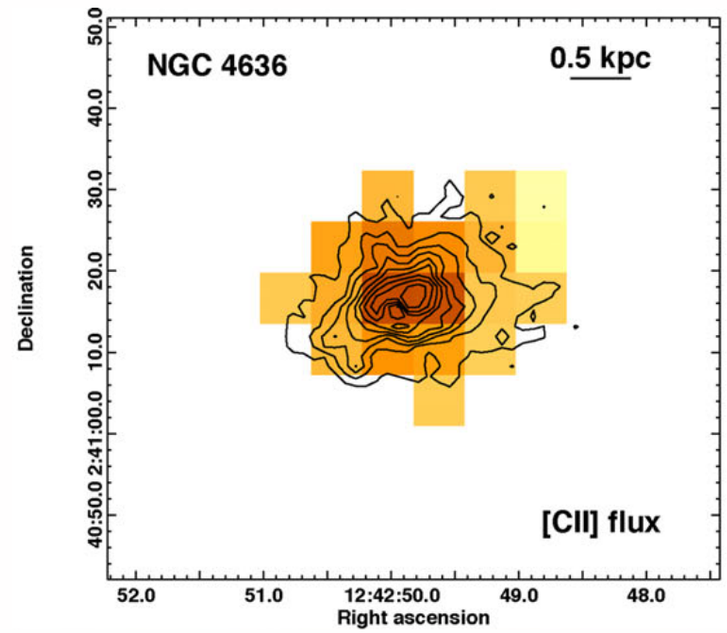
Far-infrared line detections in giant ellipticals

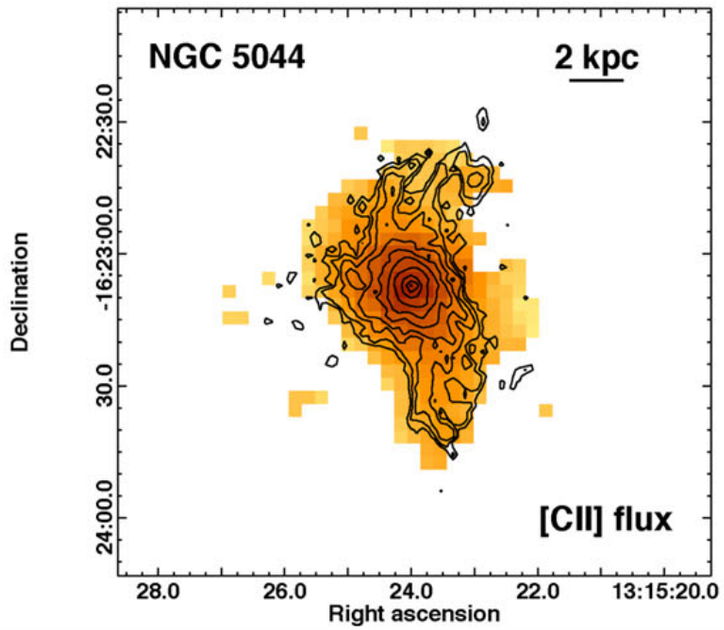


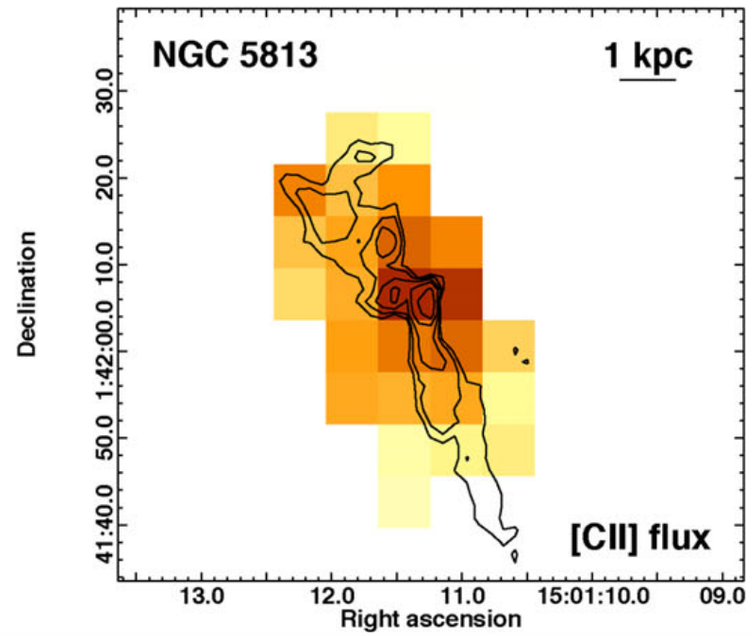
- [CII] detected in every single galaxy (6/8) with extended H**α** line emitting nebulae
- in 4/8 systems also detected the [OI] line and in 3/8 the [OIb] line

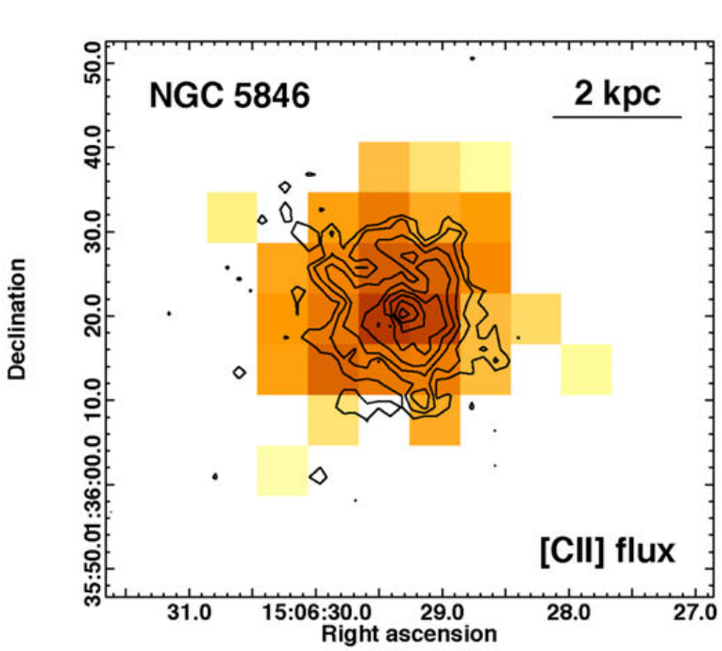
Werner et al. 2014

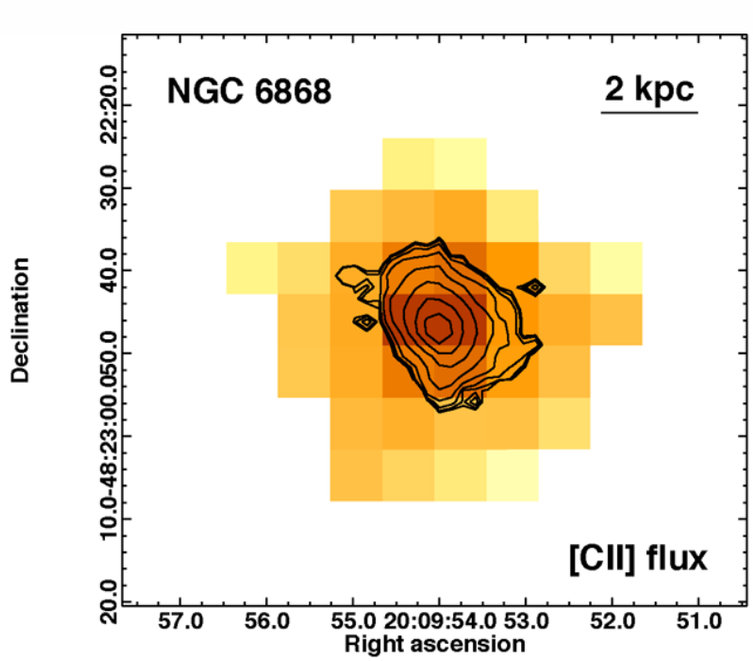
[C II] emission (6/8)

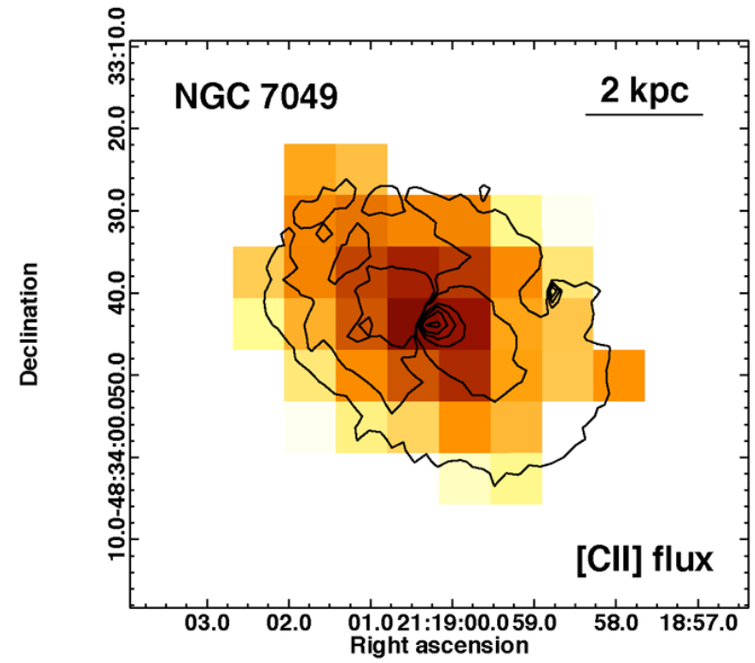






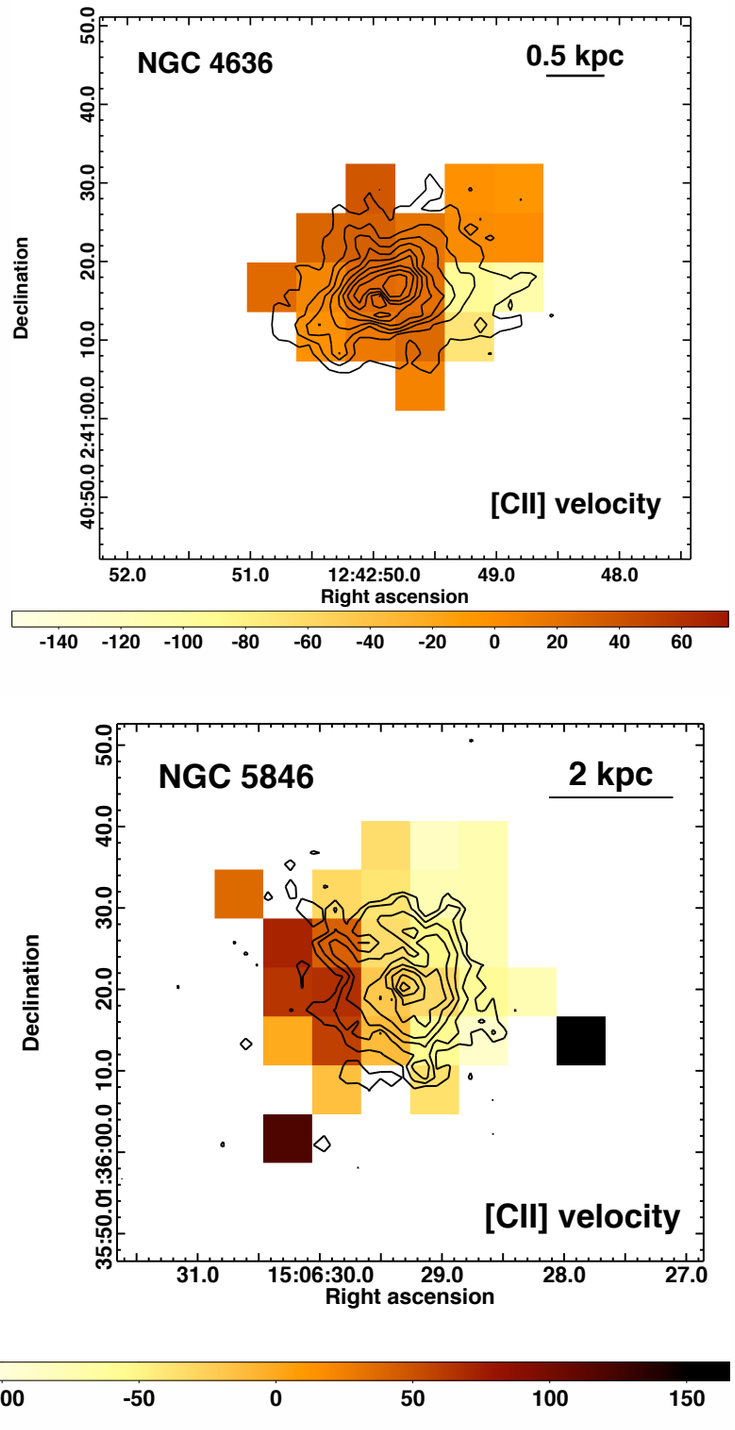


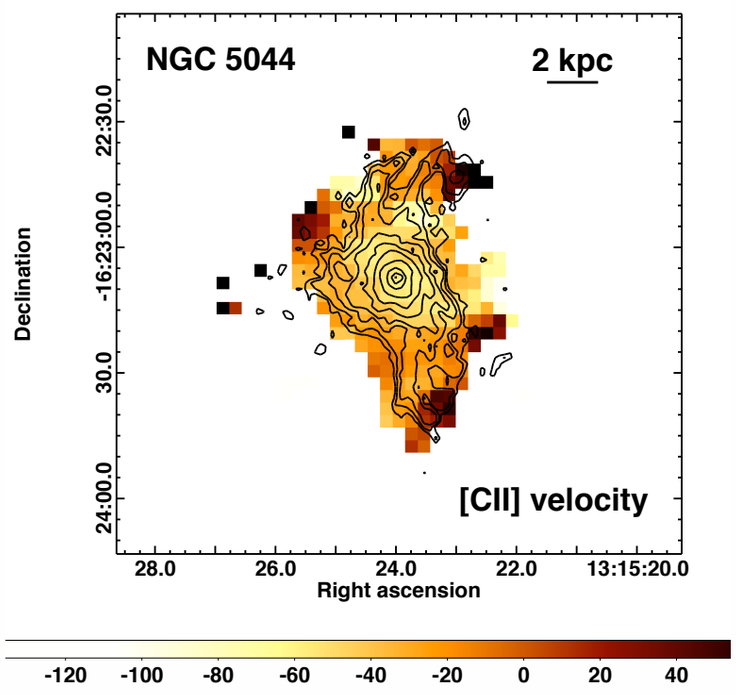


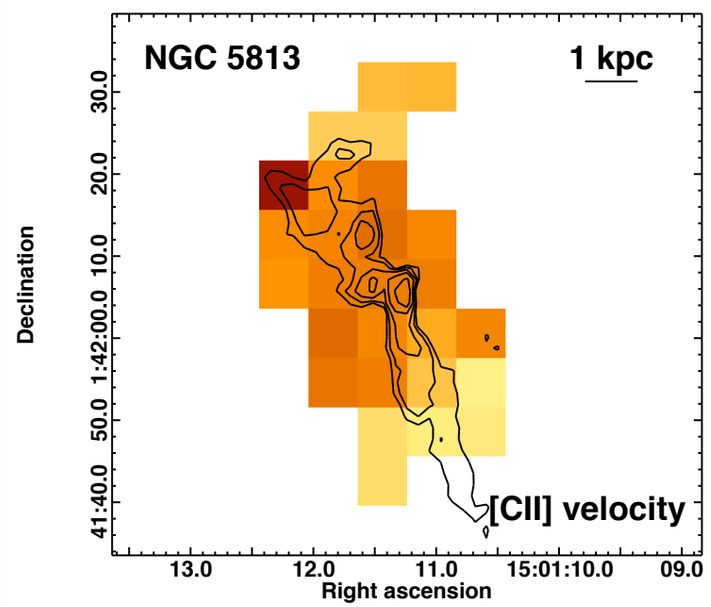


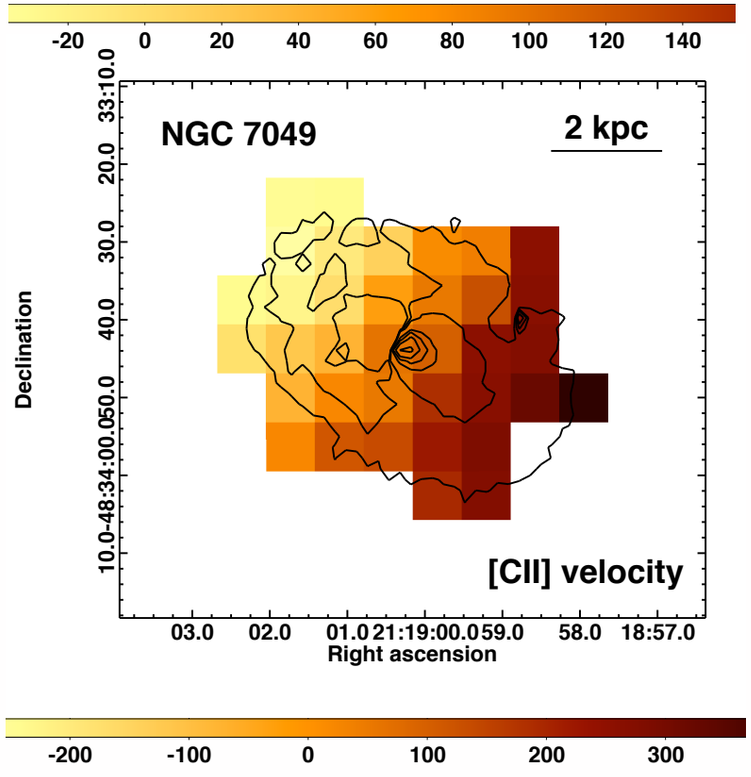
Werner et al. 2014

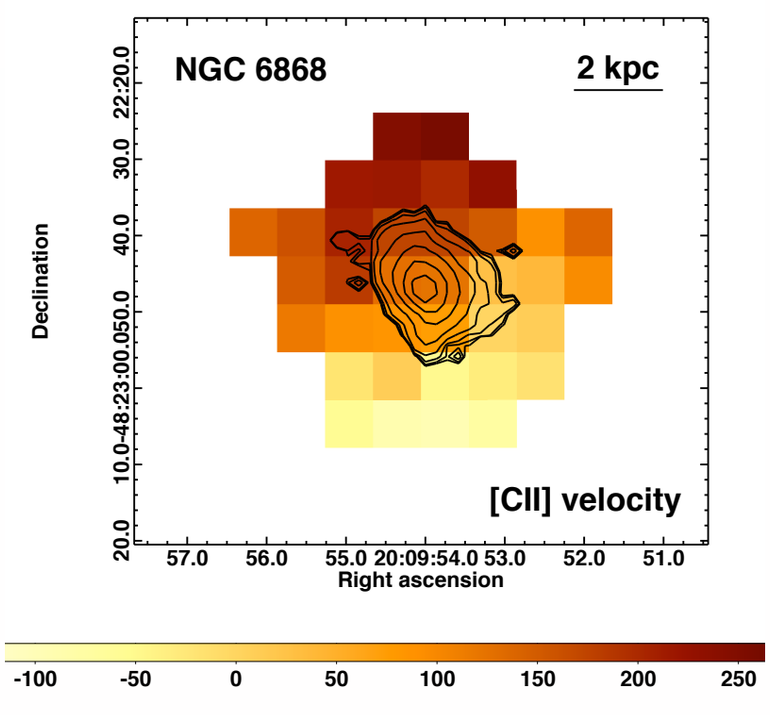
[C II] kinematics (6/8)





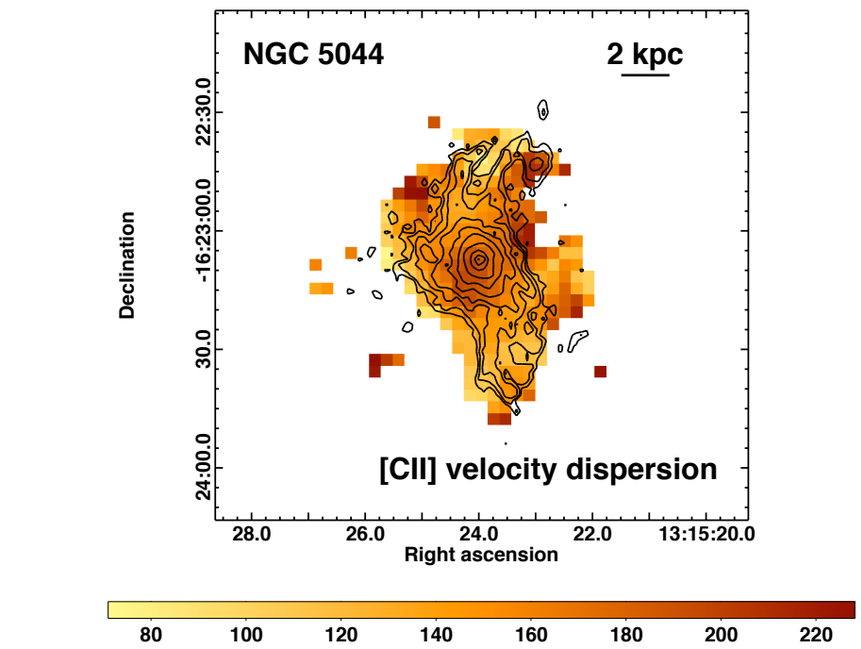


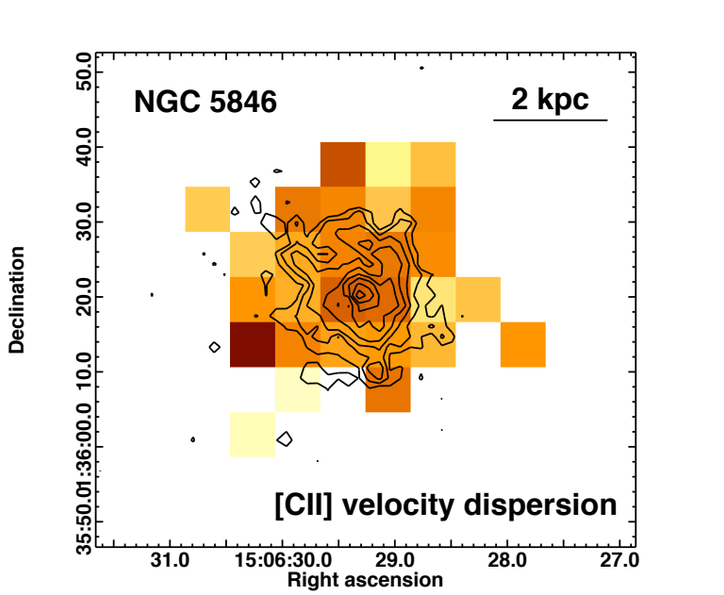


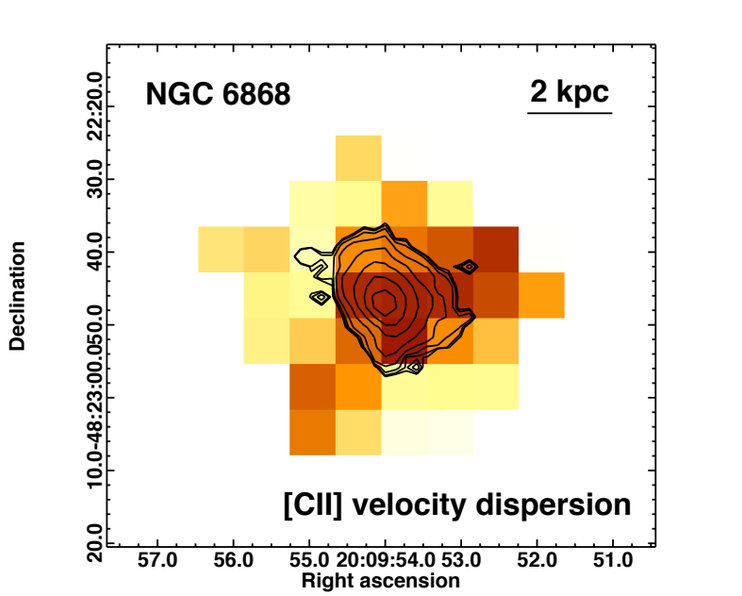


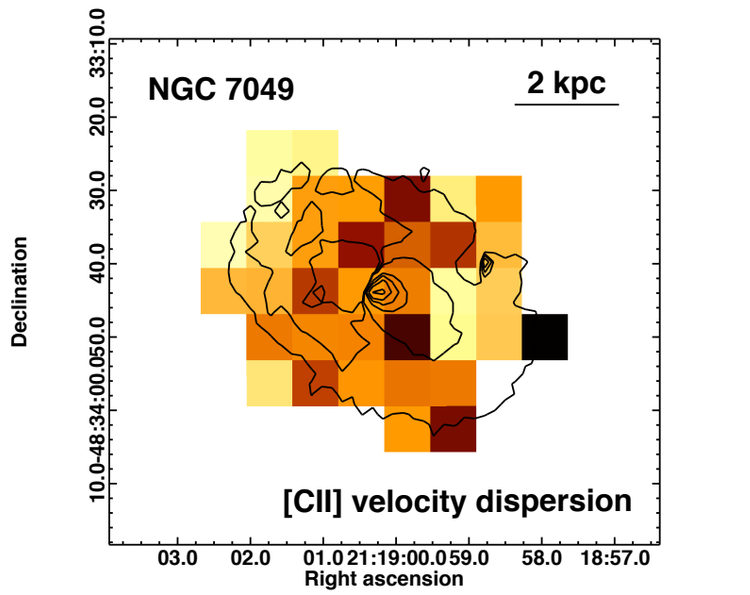
Werner et al. 2014

[C II] kinematics (6/8)

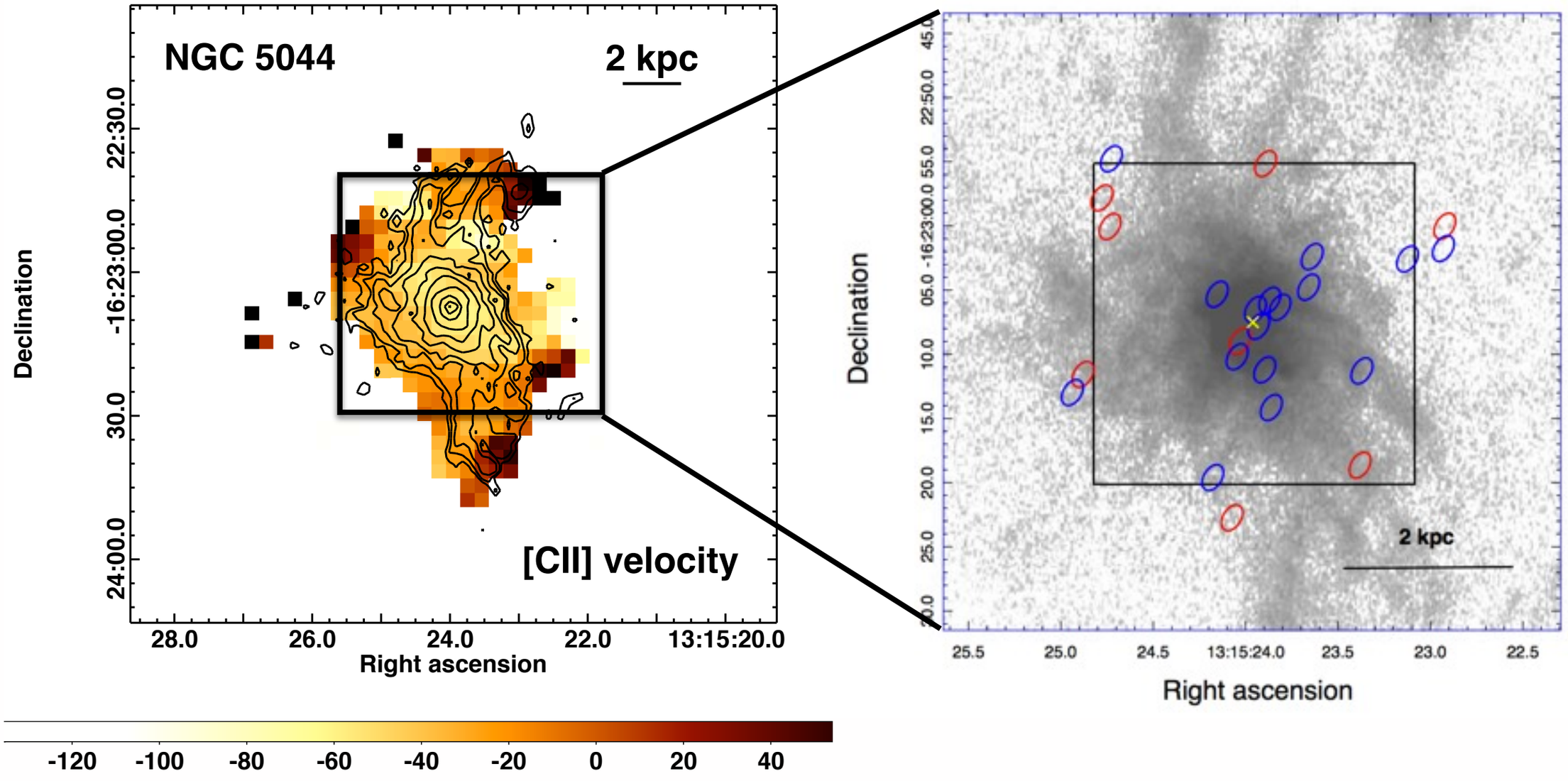








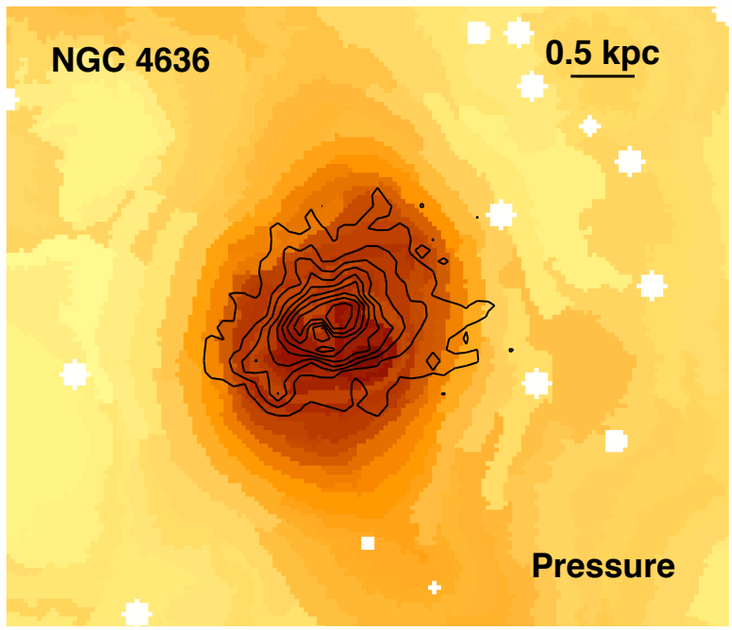
Werner et al. 2014

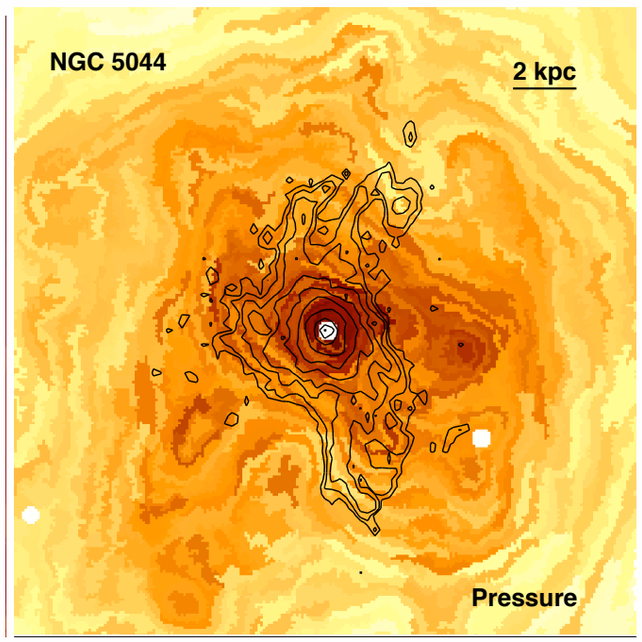


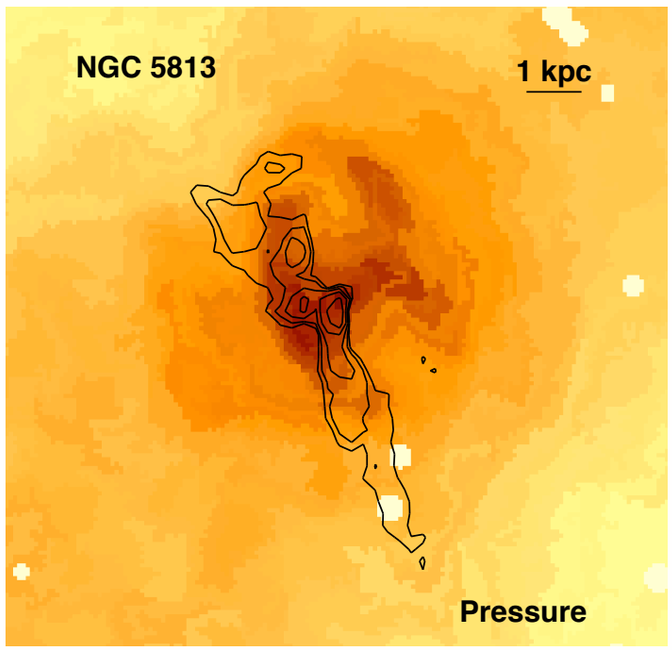
David et al. 2014

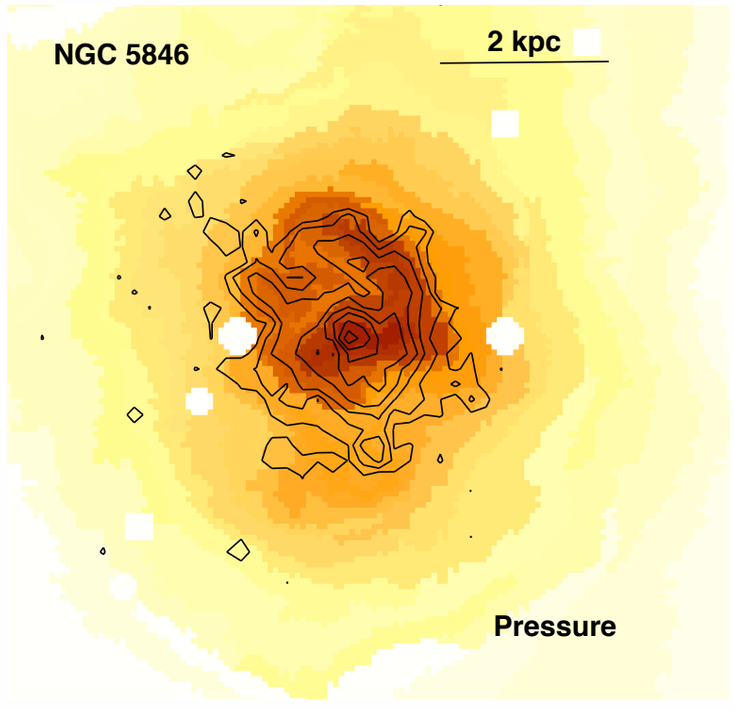
X-ray pressure

Cold gas rich







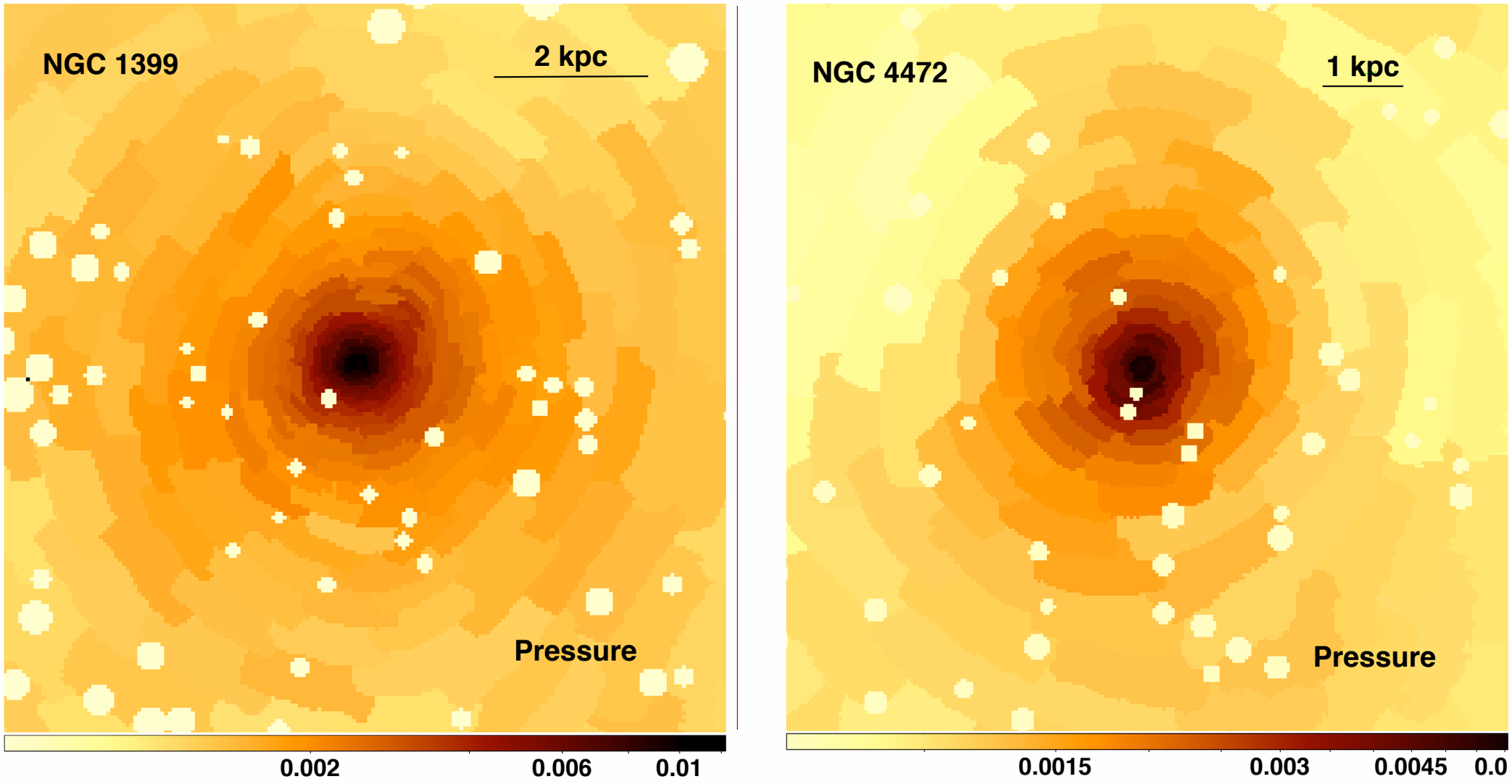


keV cm^{-3} $(l/20kpc)^{-1/2}$

Werner et al. 2014

X-ray pressure

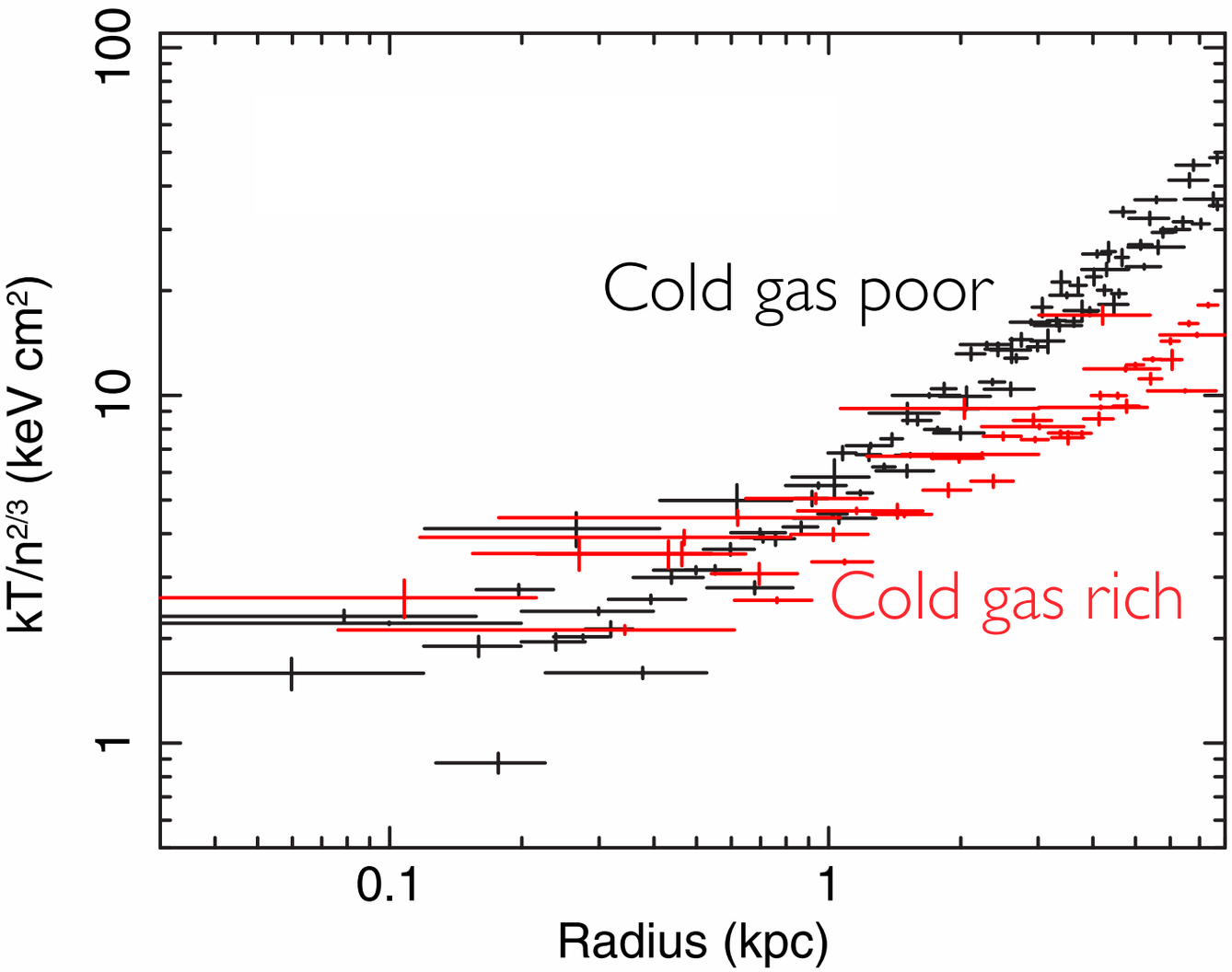
Cold gas poor



keV cm^{-3} (l/20kpc)$^{-1/2}$

Werner et al. 2014

Cold gas and hot gas

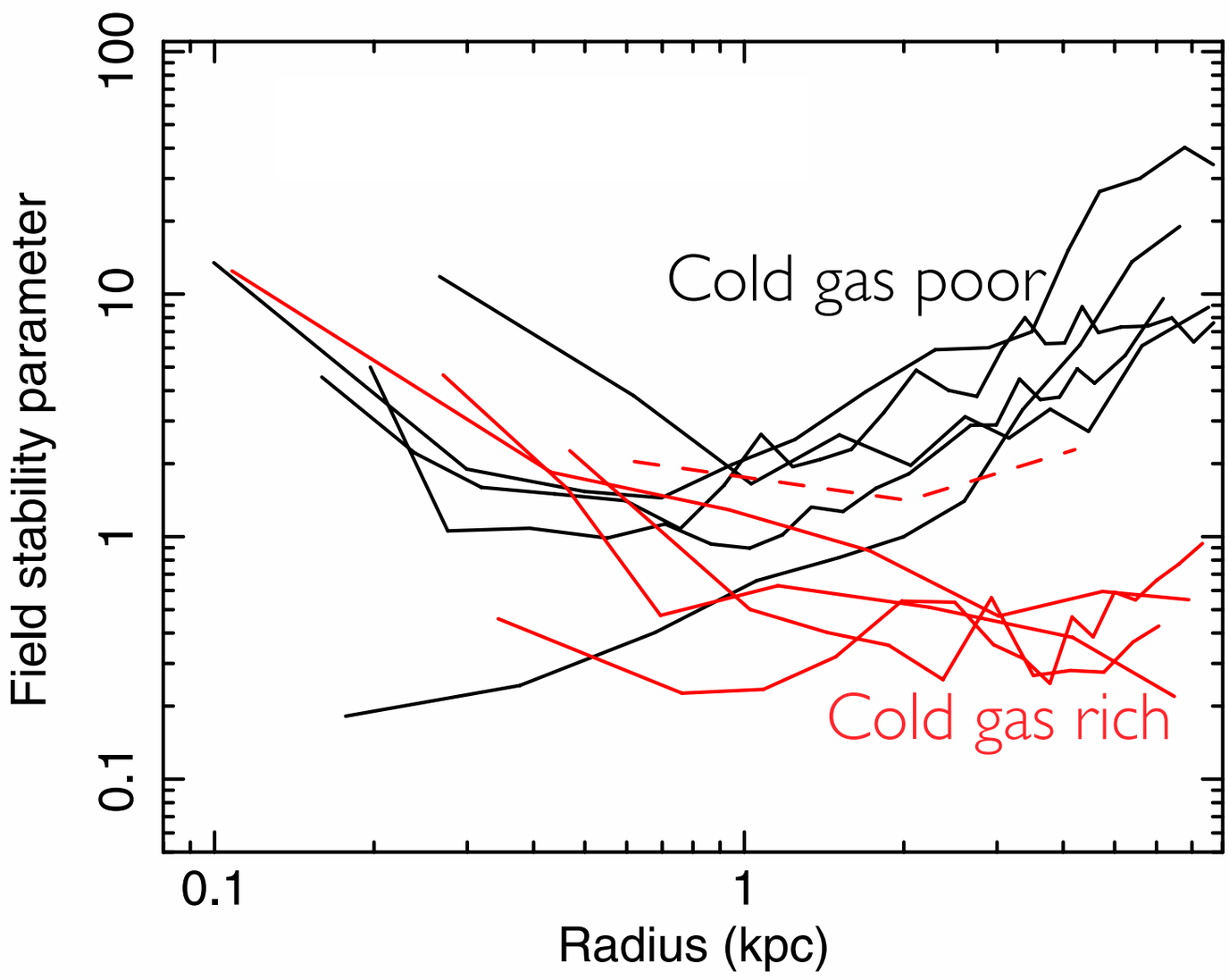


Including 3 additional relaxed GEs

Outside of the innermost core, the entropy of systems containing cold gas is lower

Werner et al. 2012, 2014

Cold gas and hot gas



The Field stability parameter, defined as

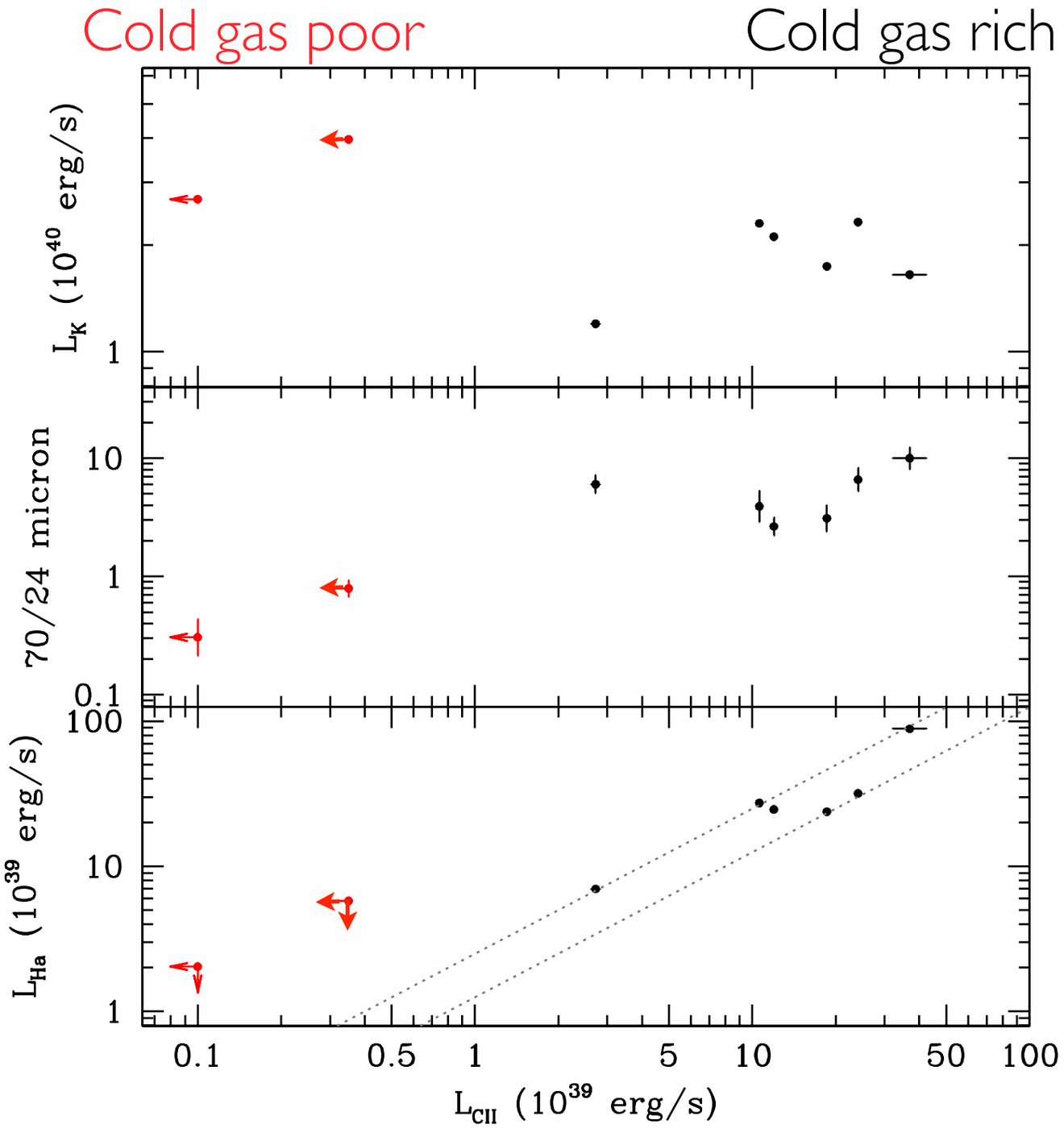
$$\Pi_{\rm F} = \frac{\kappa T}{n_{\rm e} n_{\rm H} \Lambda(T) r^2}$$

is the ratio of the conductive heating to the radiative cooling rate.

There is a dichotomy with the cold-gas-rich system remaining unstable out to relatively large radii.

Werner et al. 2014

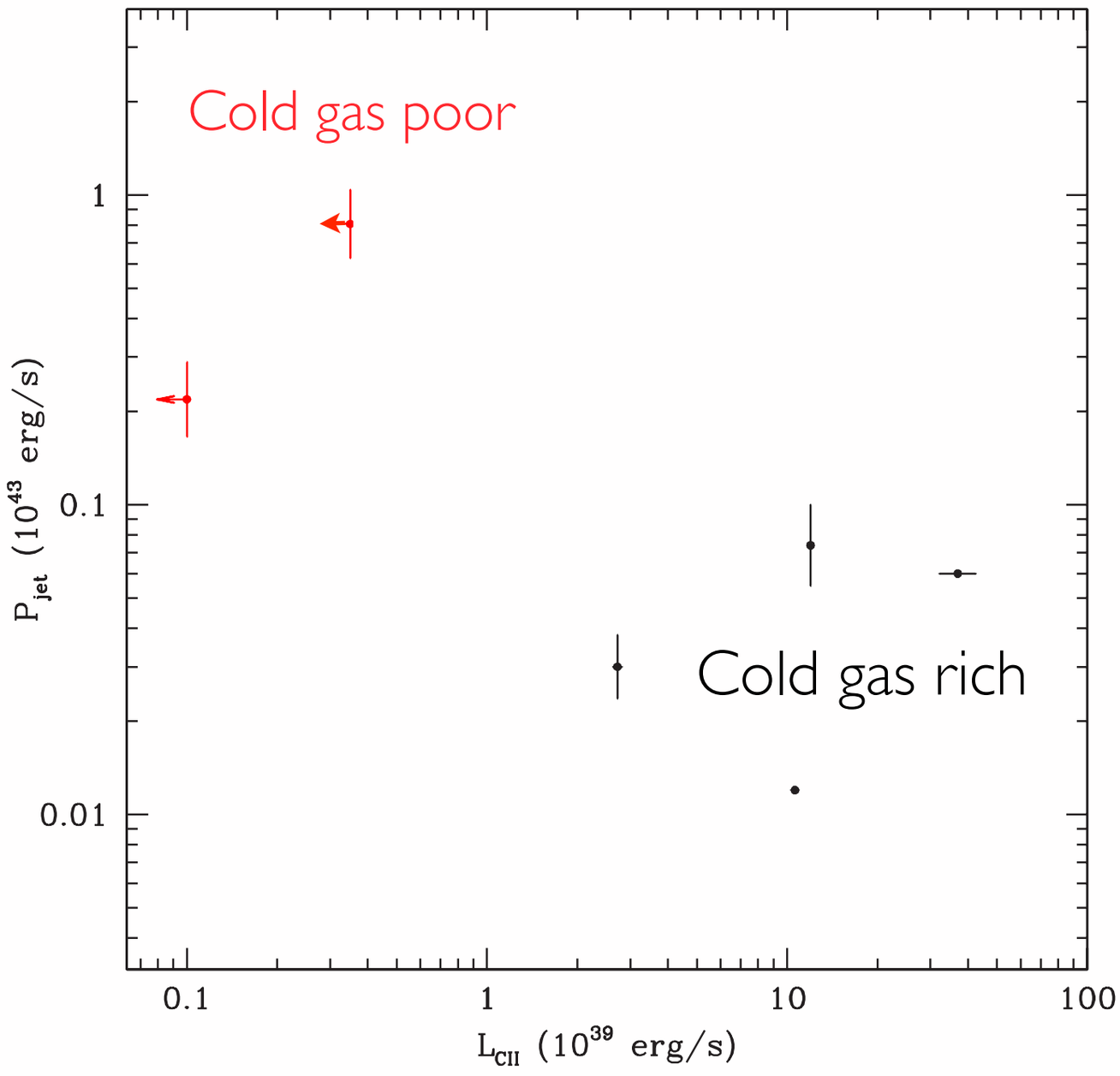
Properties of the filaments



- No correlation between the stellar mass and cold gas
- The extended nebulae are dusty and contain PAHs
- [C II]/Hα ratios similar (~0.4-0.8) in all systems with extended Hα emission
- The filaments are bright in thermal soft X-ray emission (FeXVII and Fe XVIII lines)

Werner et al. 2014

Jet powers and cold gas

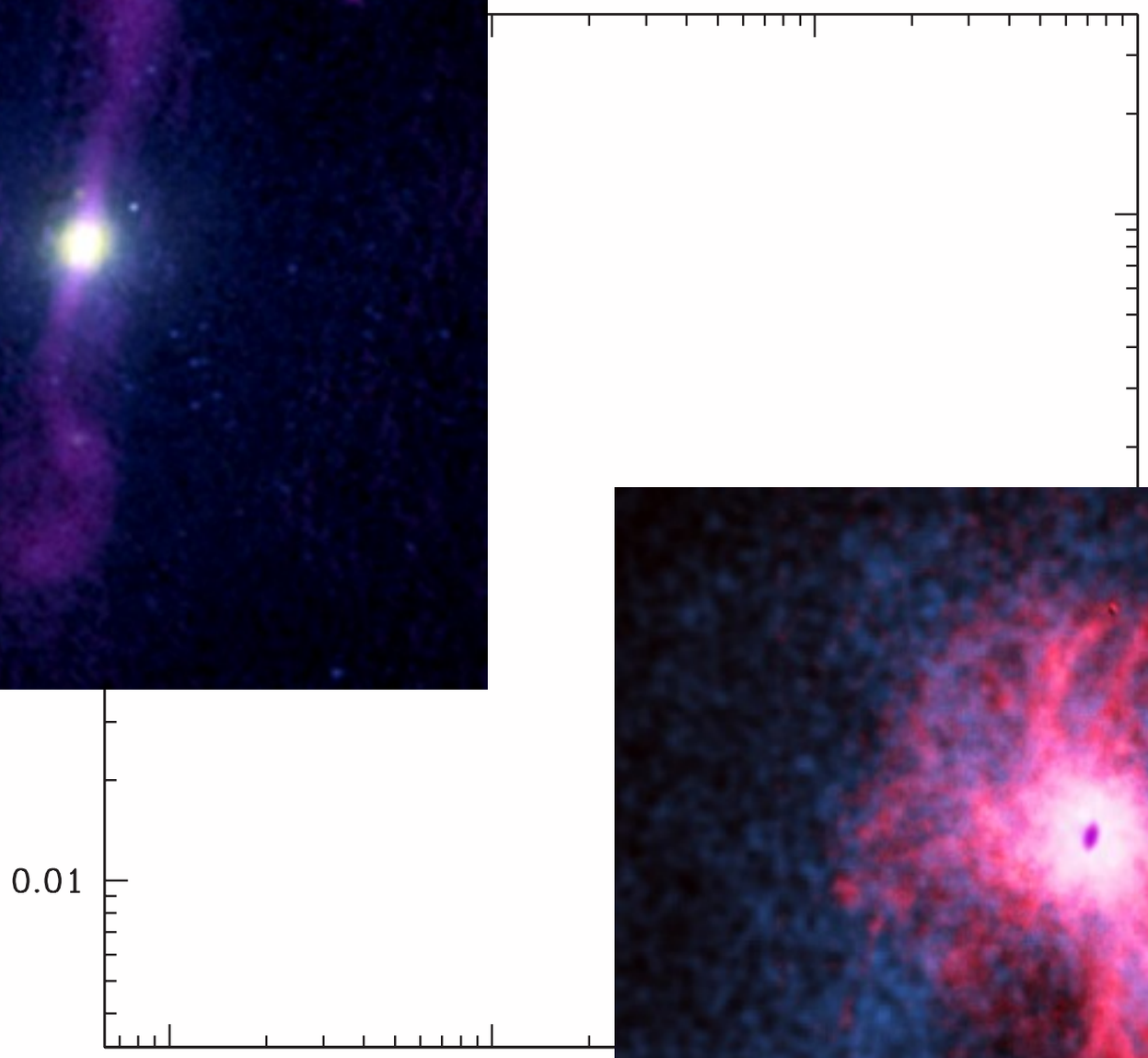


Power input (measured from X-ray cavities) into the ICM from radio mode AGN does not increase with the amount of cold gas

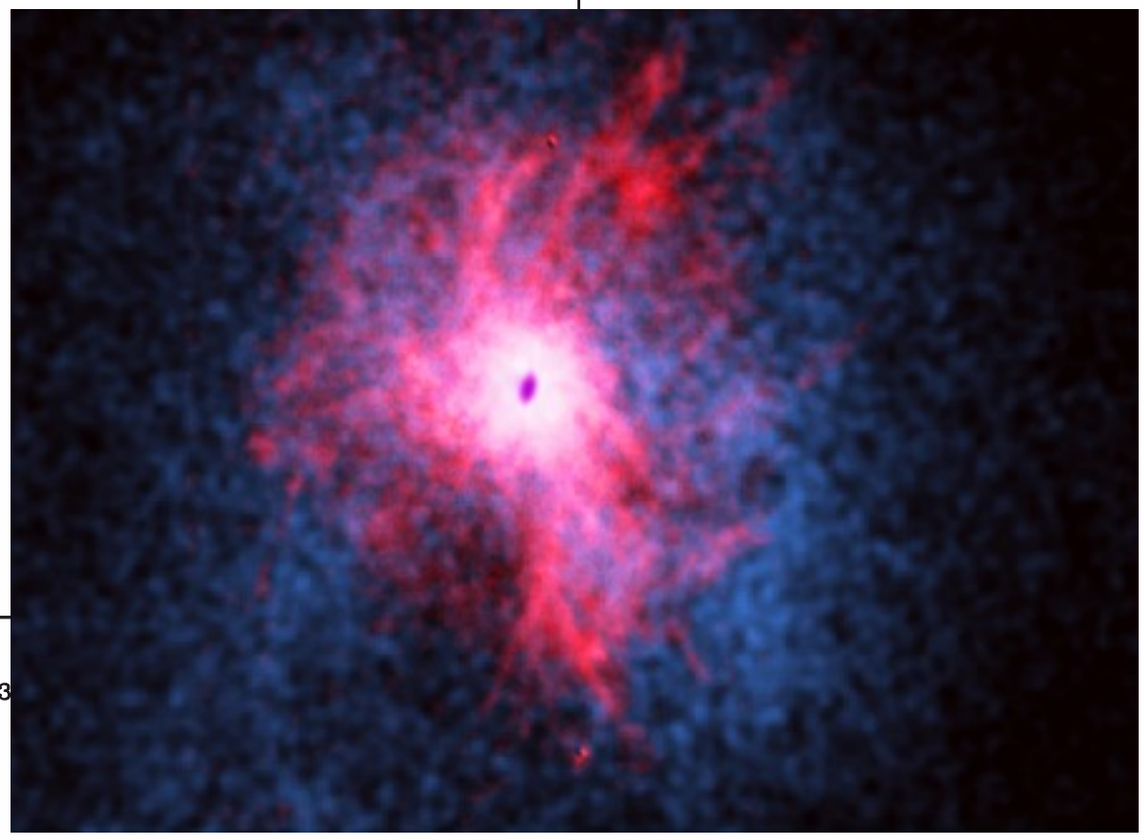
Werner et al. 2014

Jet powers and cold gas

Large jet power,
no cold gas,
relaxed X-ray

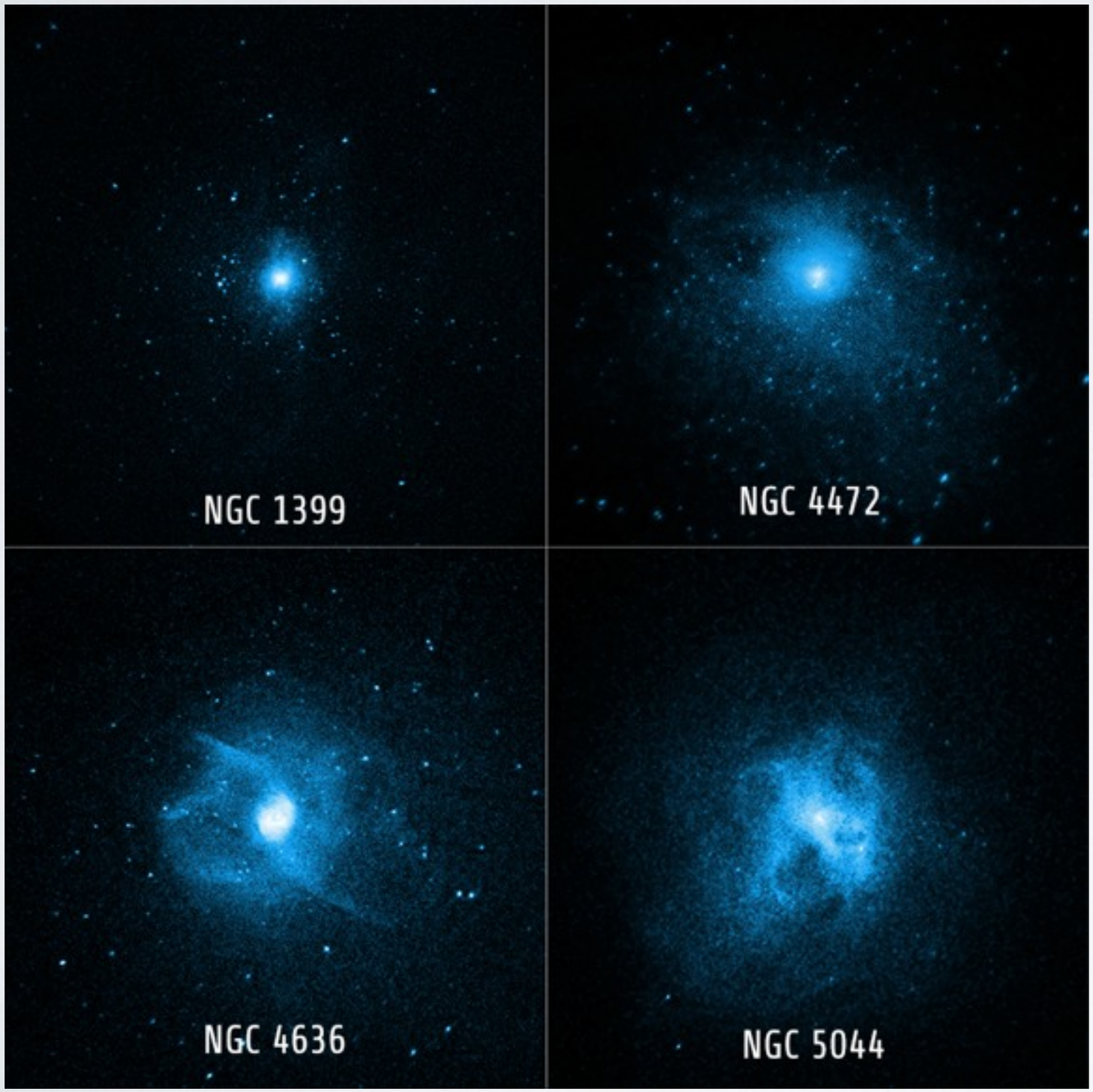


Small jet power,
many X-ray
cavities and
disturbed
morphology,
plenty of cold gas



Werner et al. 2014

An end state?



- High density X-ray gas powers strong persistent jets
- Cool and cold gas destroyed
- Jets propagate far, keeping the atmosphere hot

- Dynamically disturbed
- AGN activity less steady - clumpy cold gas?
- Jets interact with surrounding high density cool and cold gas

Werner et al. 2014

Summary:

8 nearby giant ellipticals with similar SFR, stellar masses and halo masses but very different cold gas properties and X-ray morphologies.

We identify two states:

1. X-ray morphologically relaxed - cold gas is not detected

2. X-ray morphologically disturbed - rich in cold filamentary gas

The cold gas likely originates from cooling of the hot ISM

Radio mode AGN interact with both hot and cold gas in massive galaxies quenching the star formation