



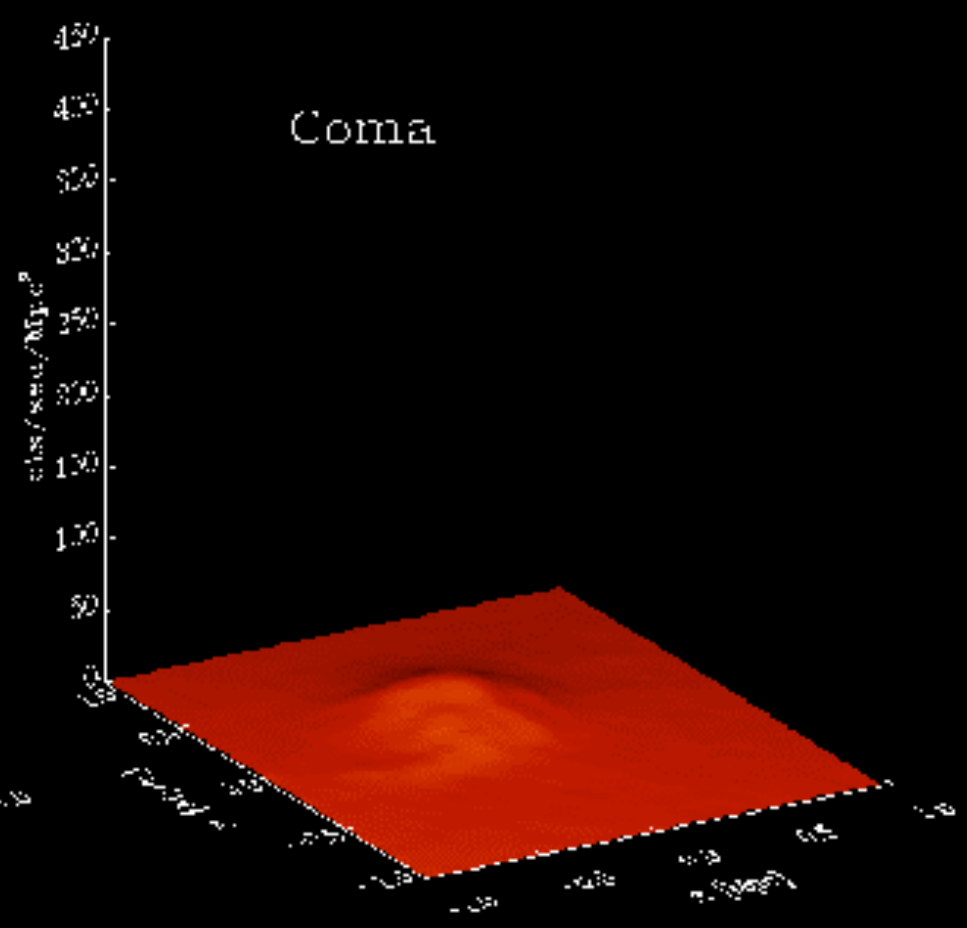
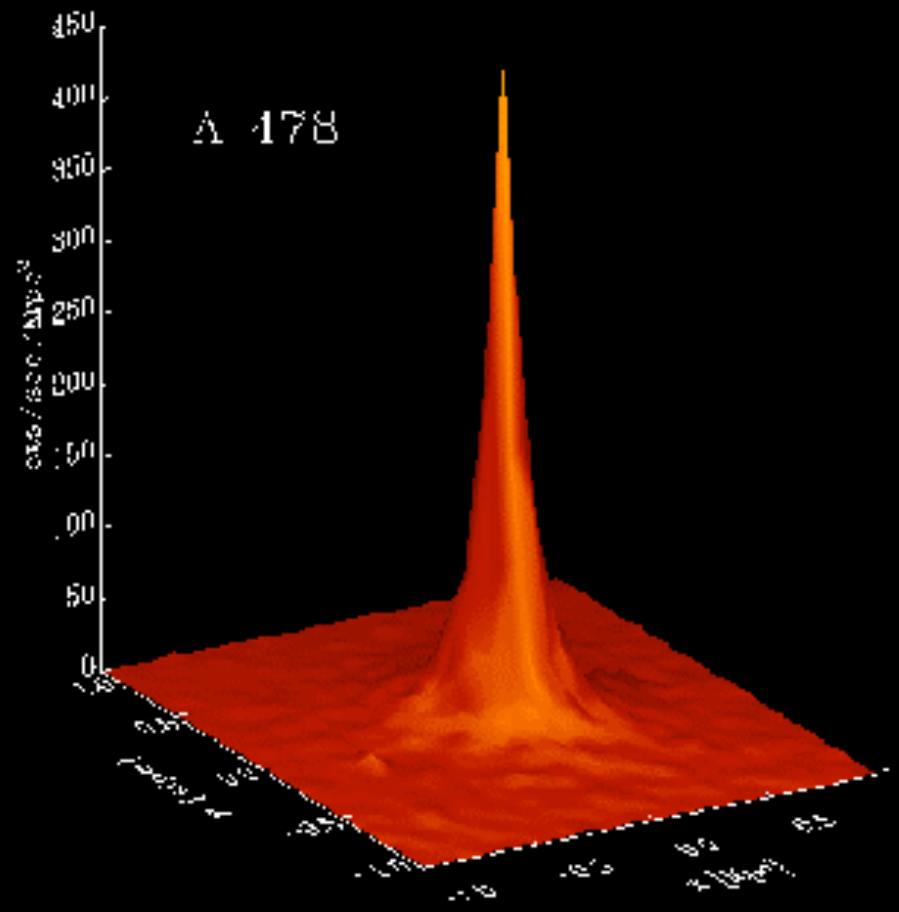
Brightest Cluster Galaxies in Cool Core Clusters

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Rupal Mittal (Rochester),
and 25 co-investigators

Motivation

The cores of a significant fraction of all X-ray luminous clusters have X-ray emission in their cores that implies cooling times of less than 10^9 years.

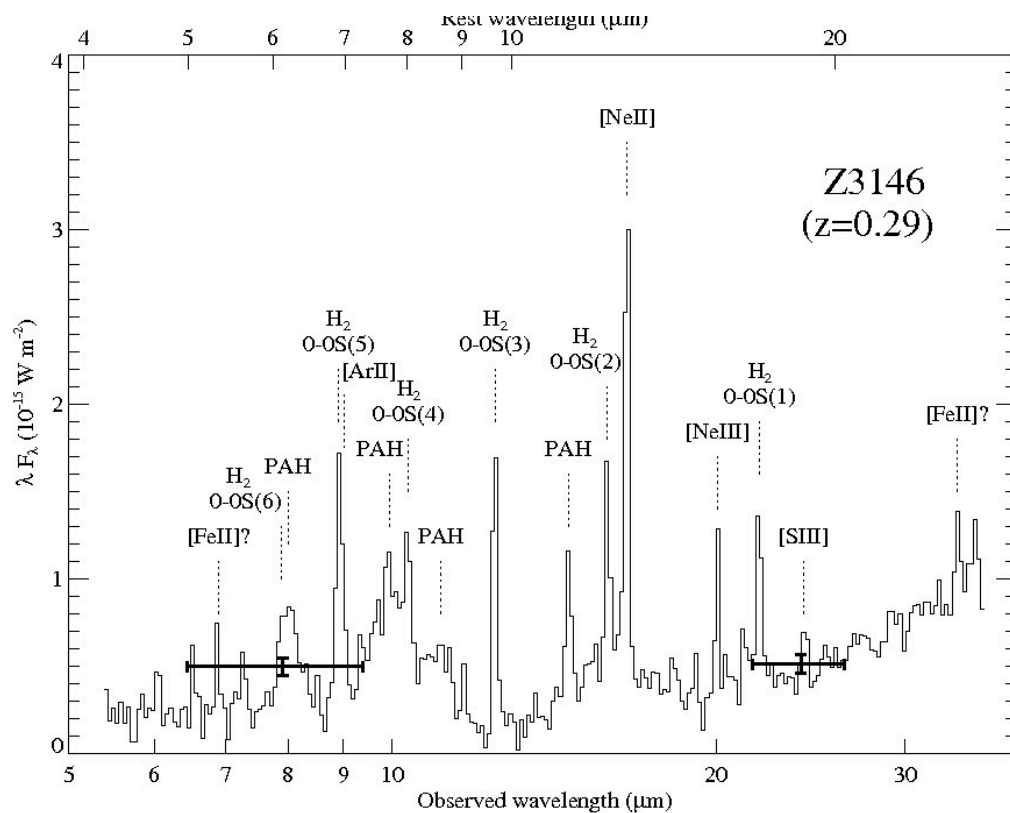
The implied rates of cooled gas deposition are $1-300 M_{\odot} \text{yr}^{-1}$ in that central region.



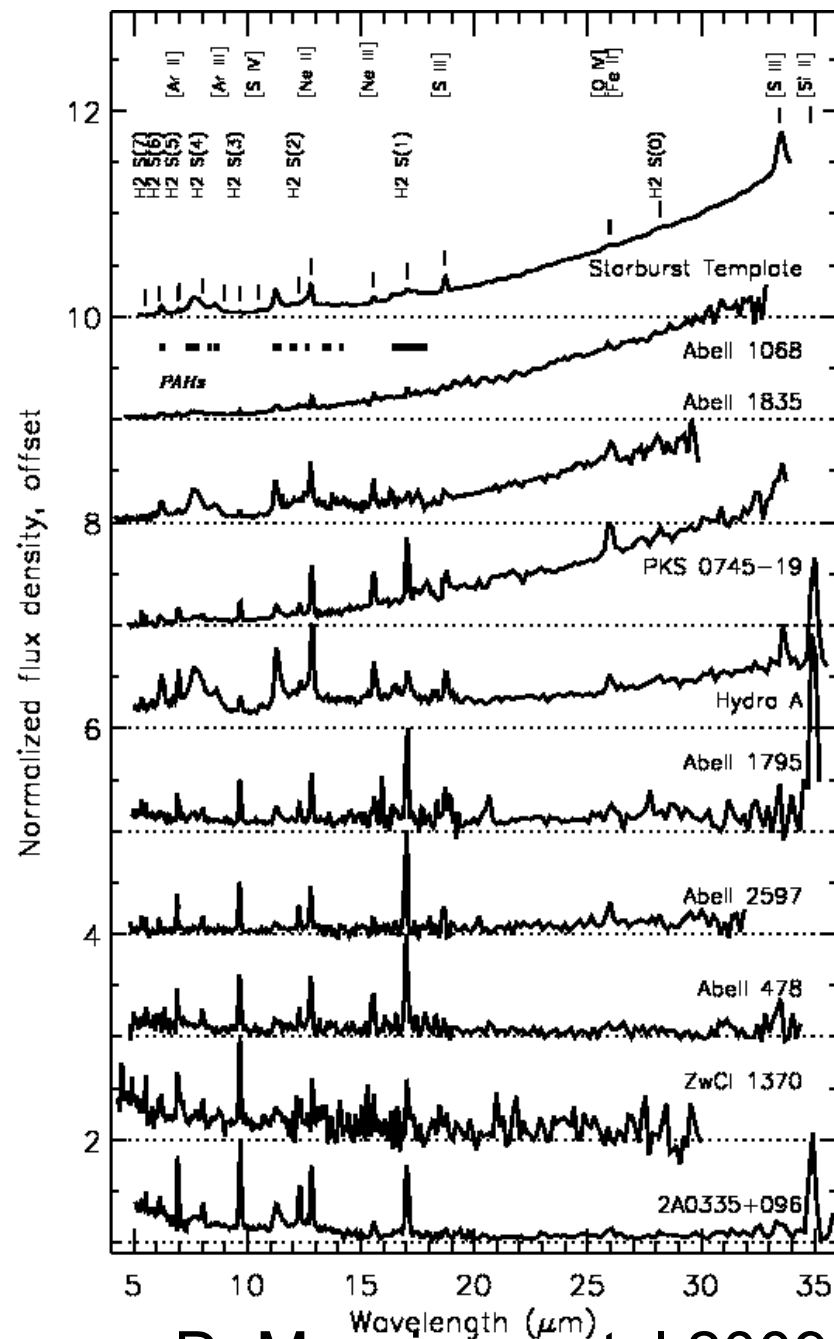
Where's the beef?

The crucial issue with the prediction of significant gas cooling is to find where it goes.

The discovery of CO in a significant number of cluster cores (now more than 40) points to 10^9 - $10^{11.5}M_{\odot}$ in molecular gas.



Egami et al 2006



DeMessieres et al 2009

Our OTKP strategy

The key objectives of our OTKP is to obtain the line fluxes and velocity widths of as many as 6 atomic cooling lines (CII, OI, NII, OIII, NIII and SiI) with PACS and to obtain 70 to 500 μ m photometry with PACS and SPIRE for 11 brightest cluster galaxies.

Herschel OTKP observations

Our SDP and routine observations cover 7 of our 11 objects (selected to have a range of optical line flux, L_{IR} and radio power).

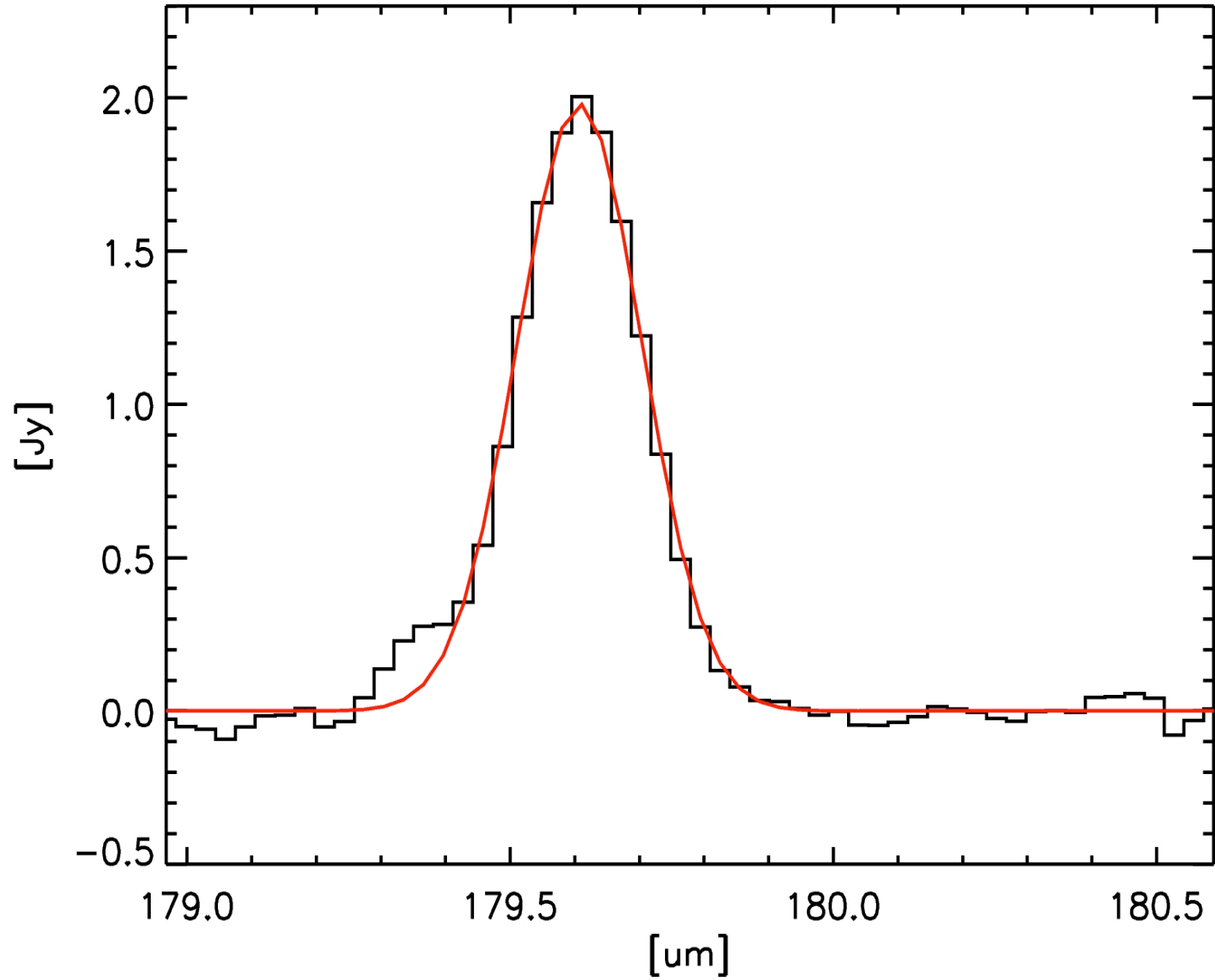
The observations to date include all the lines and both PACS and SPIRE photometry.

The results

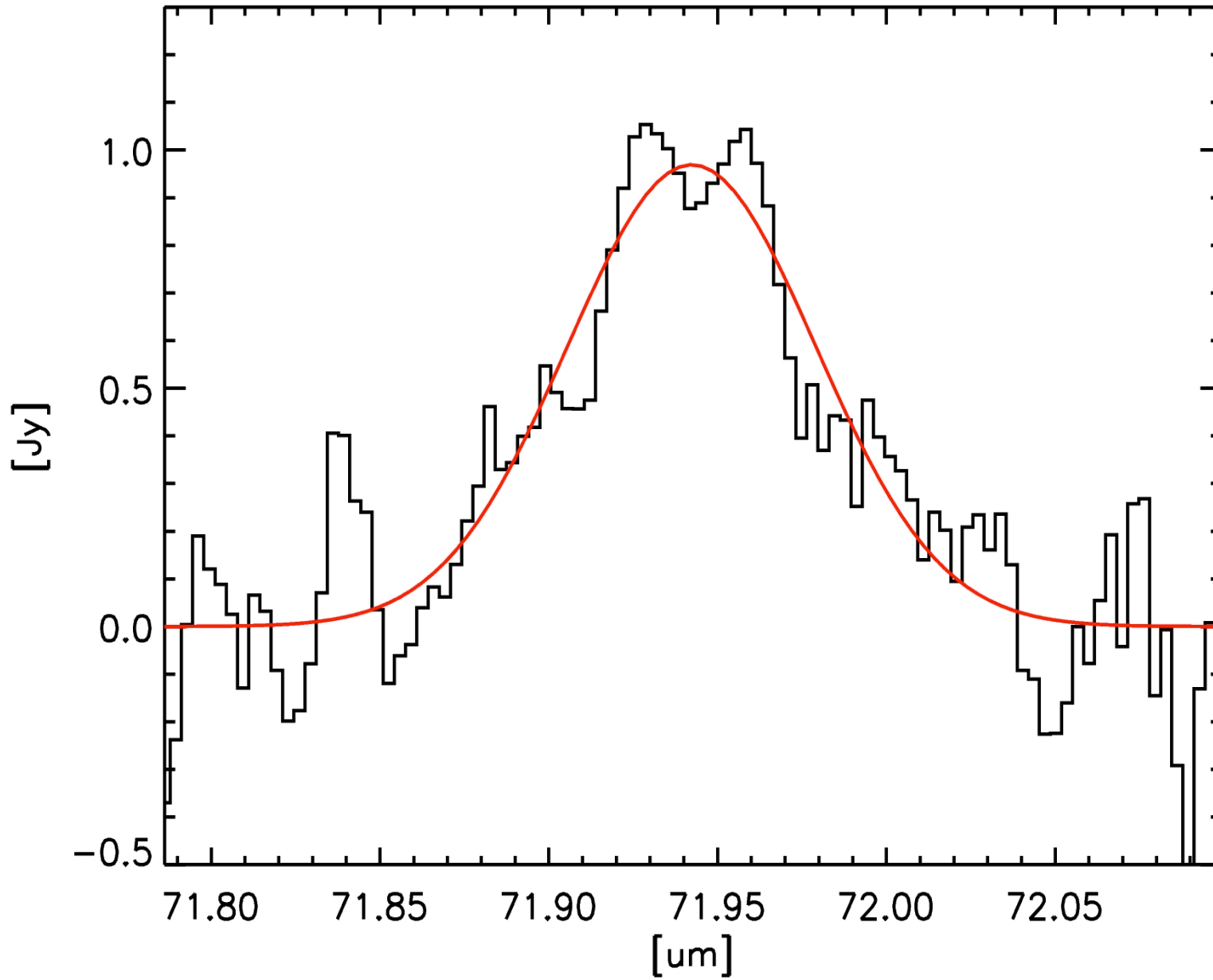
The spectra are of excellent quality and the lines are detected all seven of the observed BCGs.

All of the following results are included in the two A&A Special Issue papers from this OTKP (Edge et al. 2010a&b).

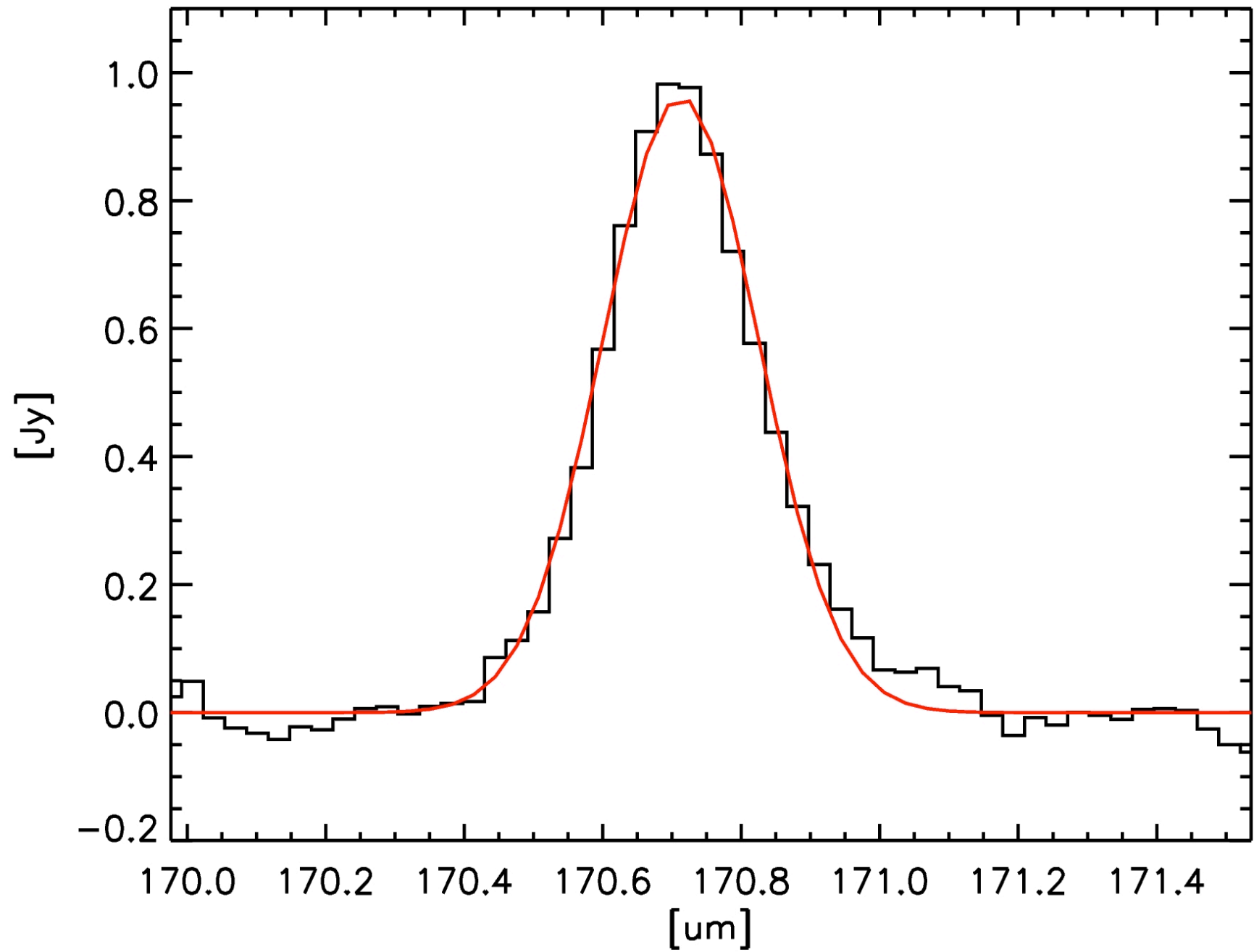
A1068 CII



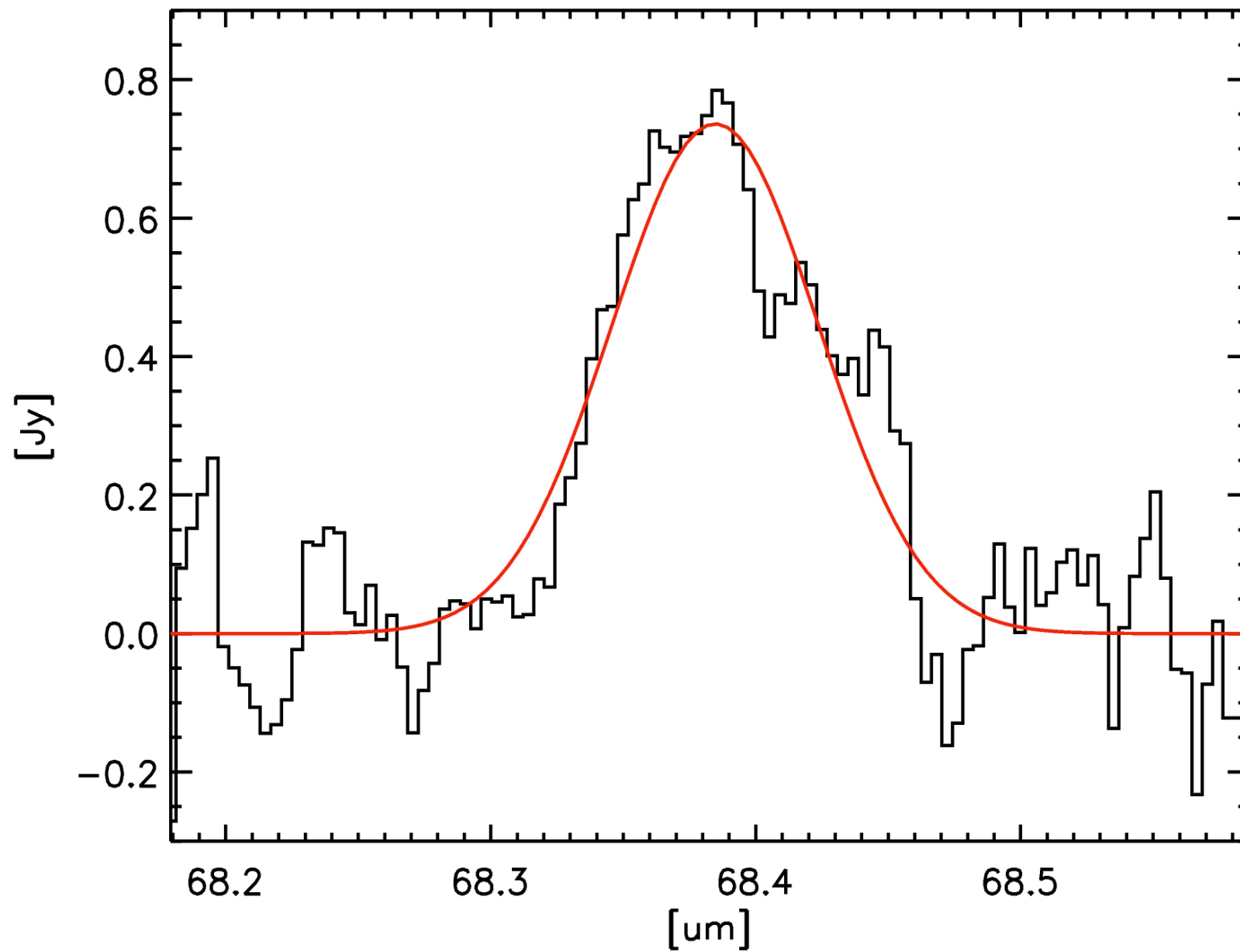
A1068 OI



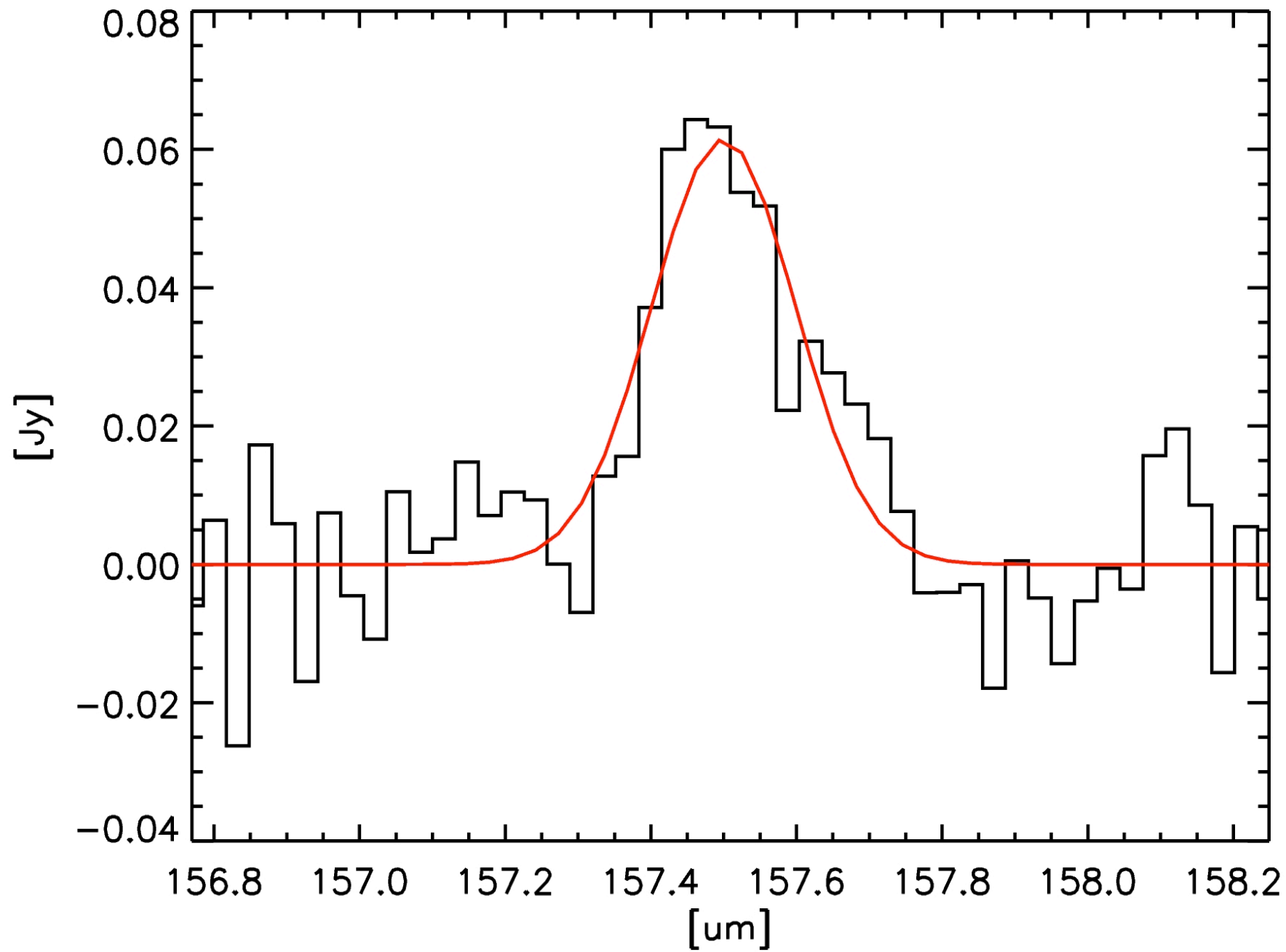
A2597 CII



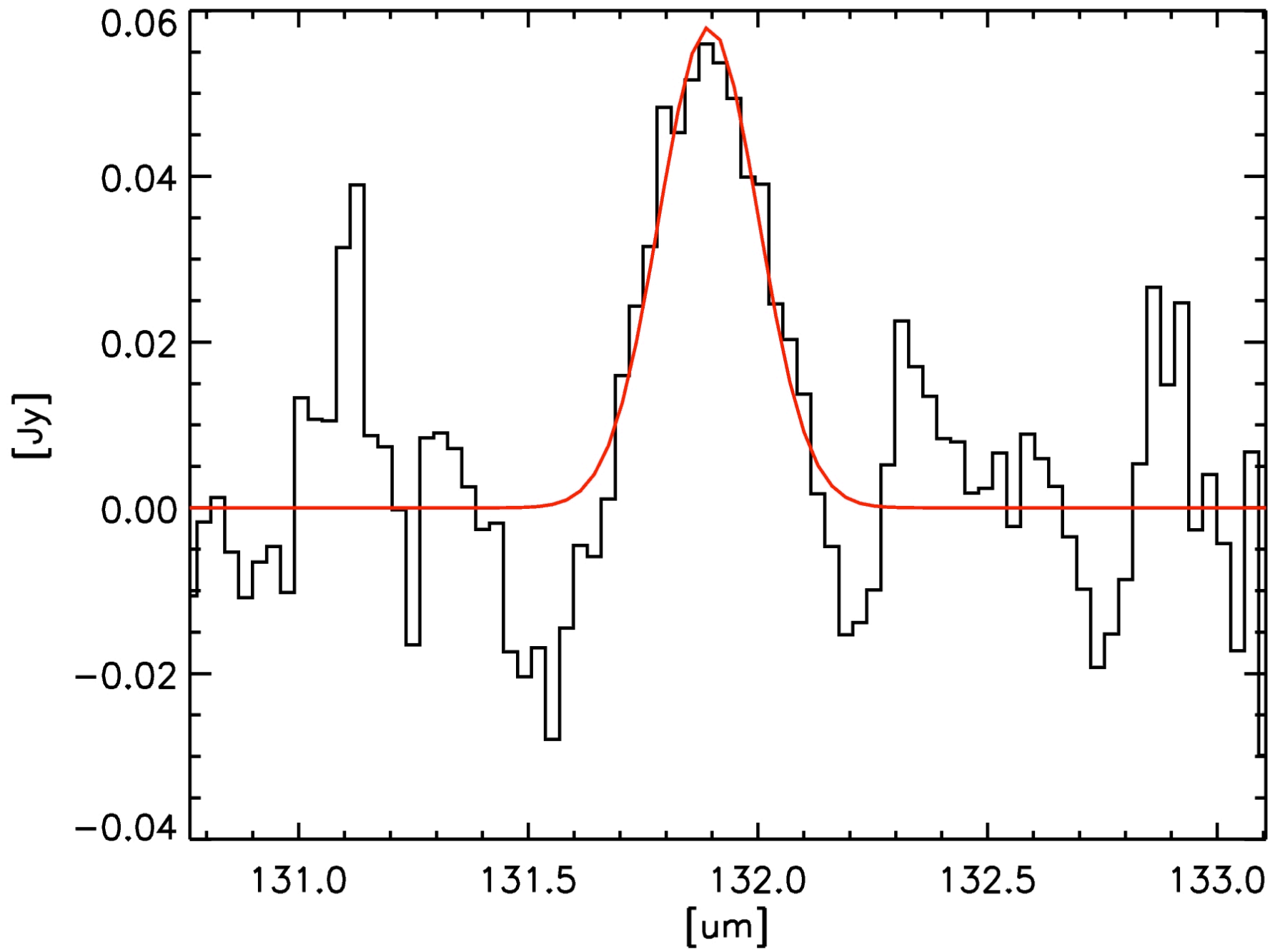
A2597 OI



A2597 OIb



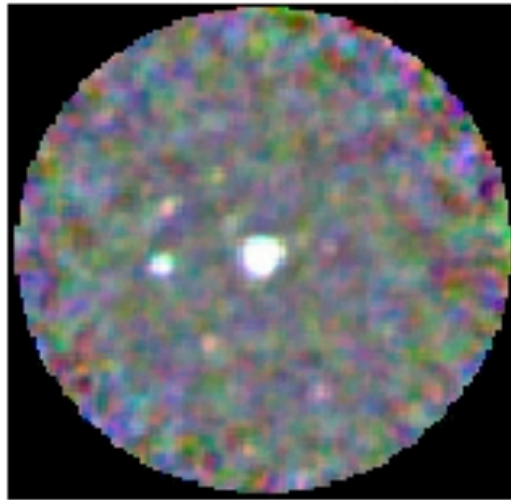
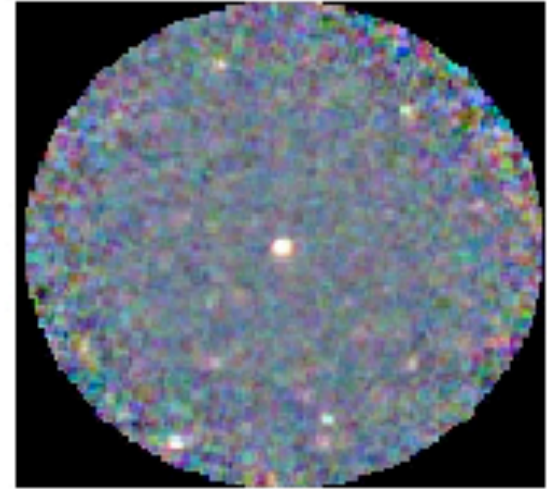
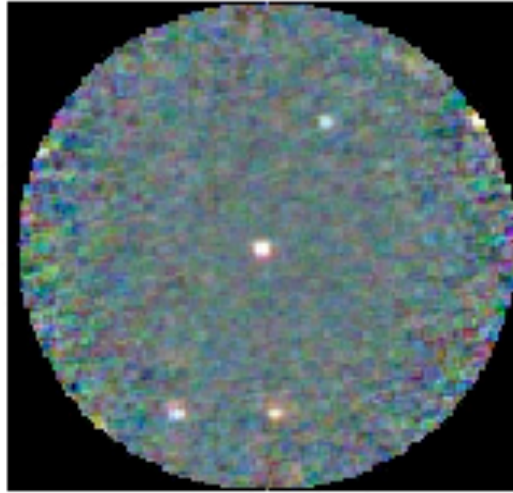
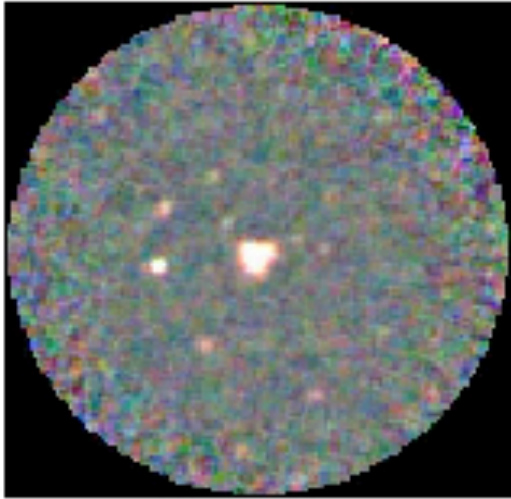
A2597 NII



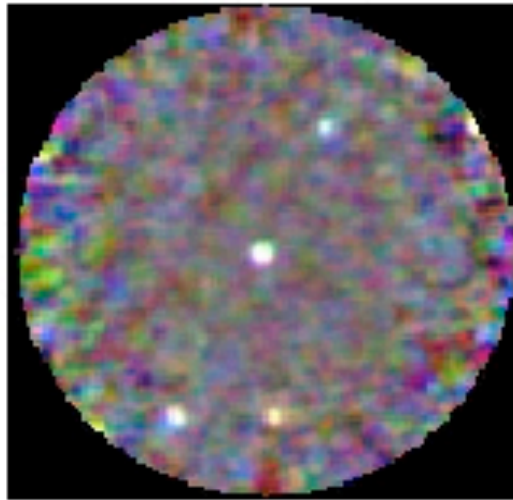
The results

The photometry was equally successful and each of the 5 BCGs observed is detected.

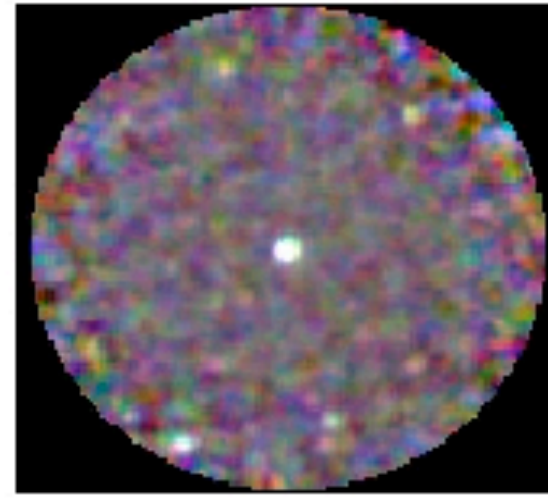
PACS Images



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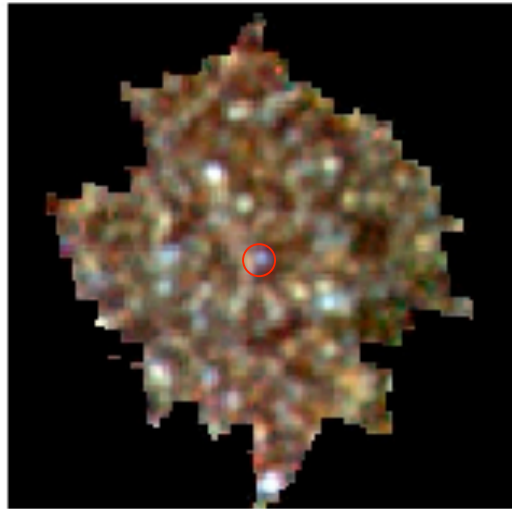
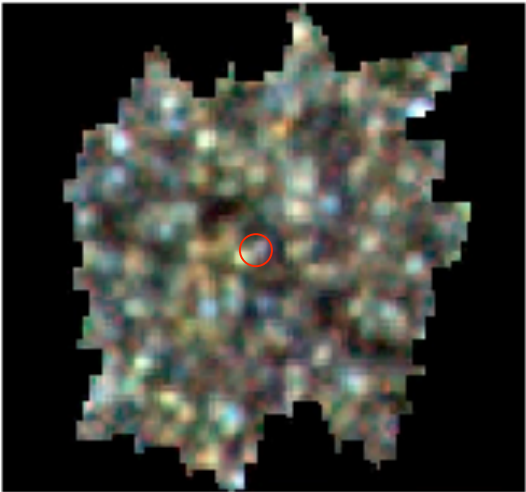
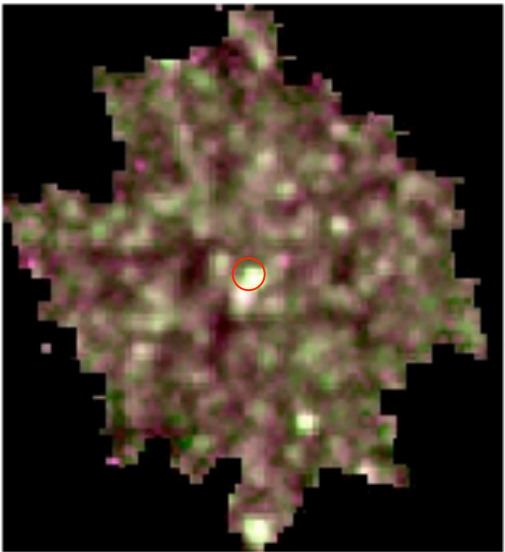
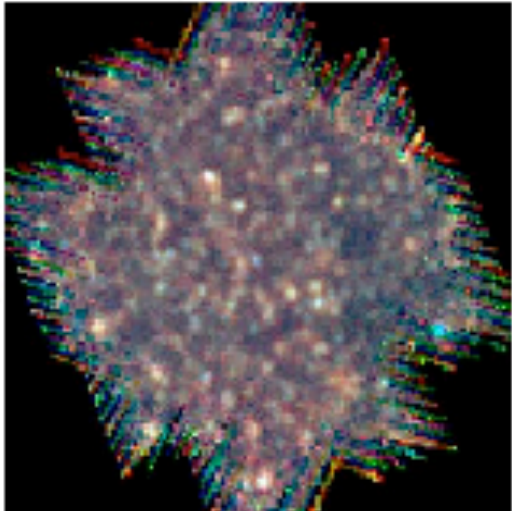
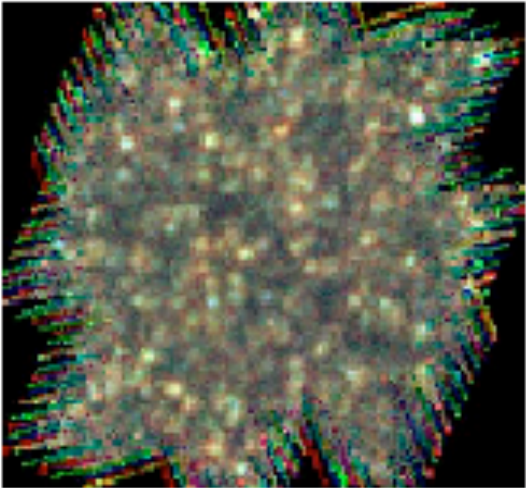
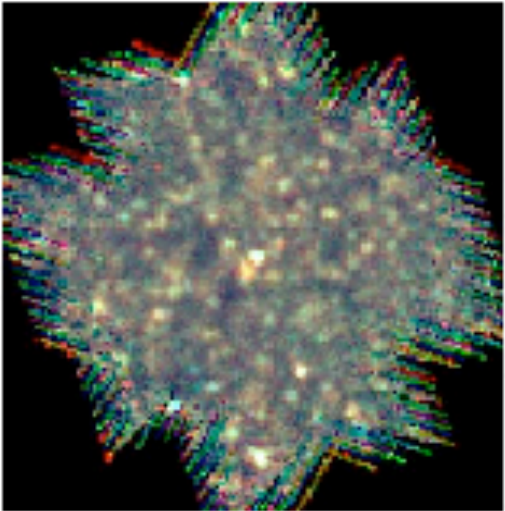


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SPIRE Images



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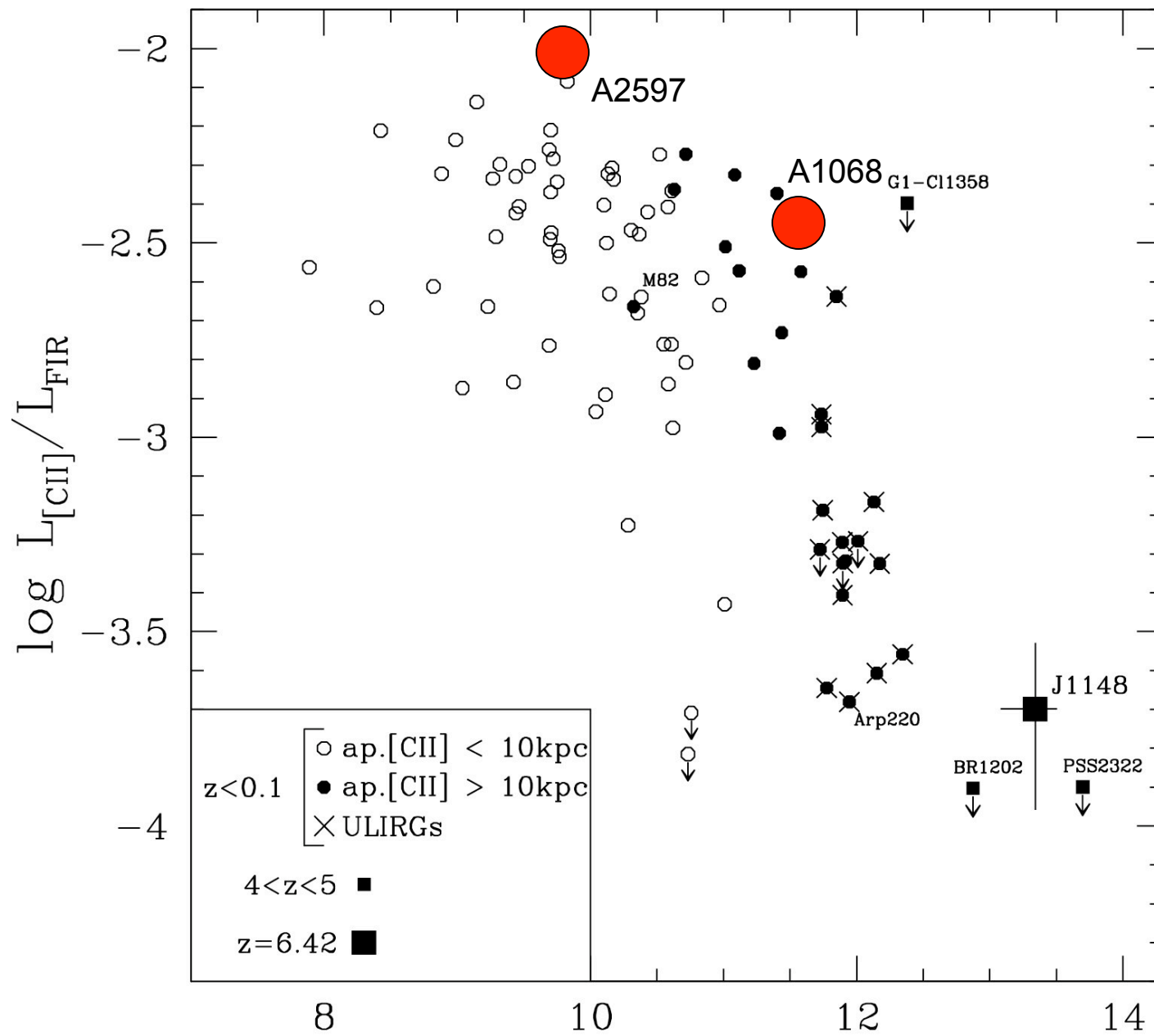
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What does it all mean?

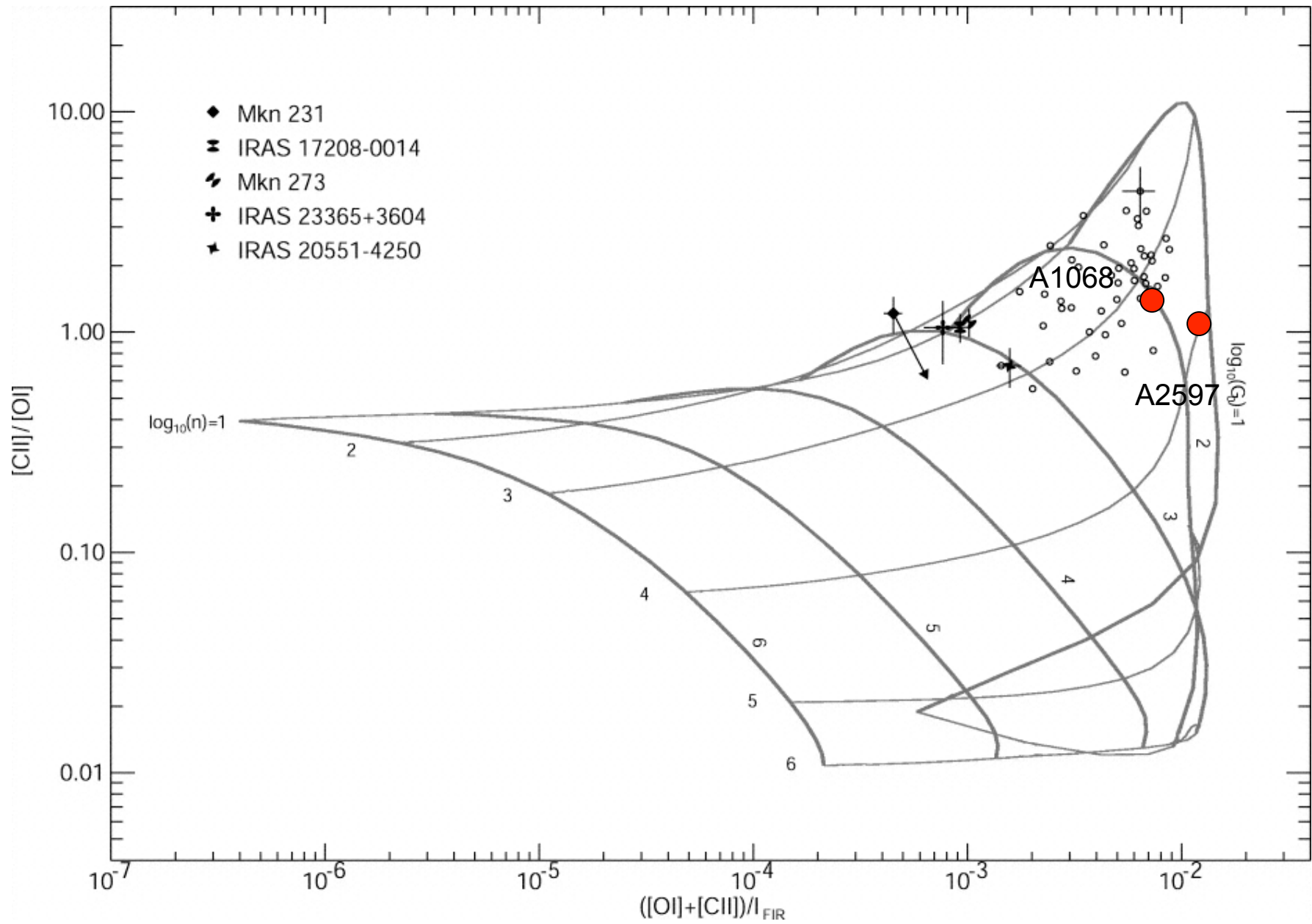
The spectra imply that the BCGs have the same CII line emission with respect to L_{IR} as other galaxies and ULIRGs.

The ratio of CII and OI are also consistent with other star-forming galaxies.

But the line widths are broader than expected from CO.

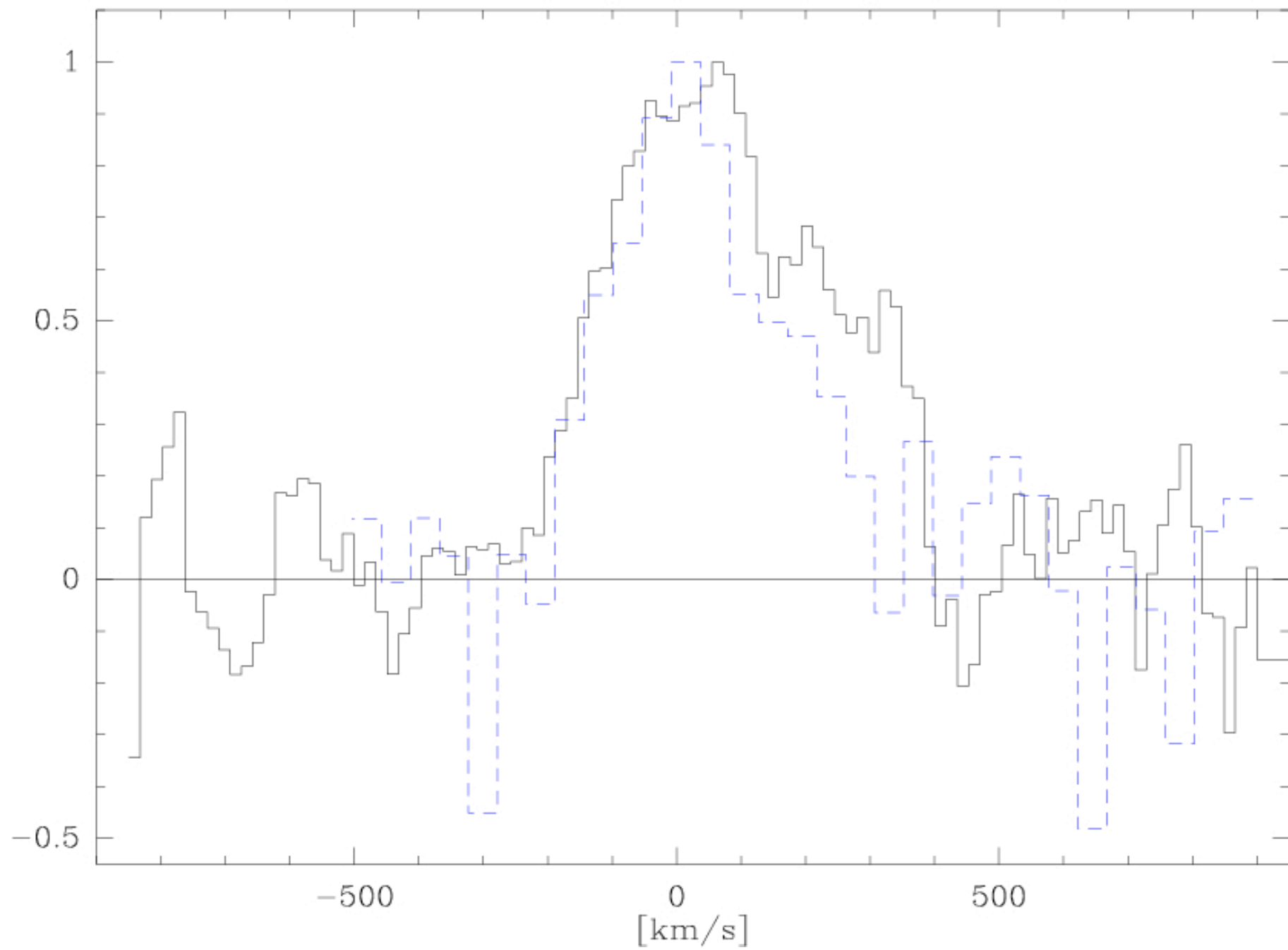


From Maiolino et al 2005 $\log L_{\text{FIR}} (L_{\odot})$

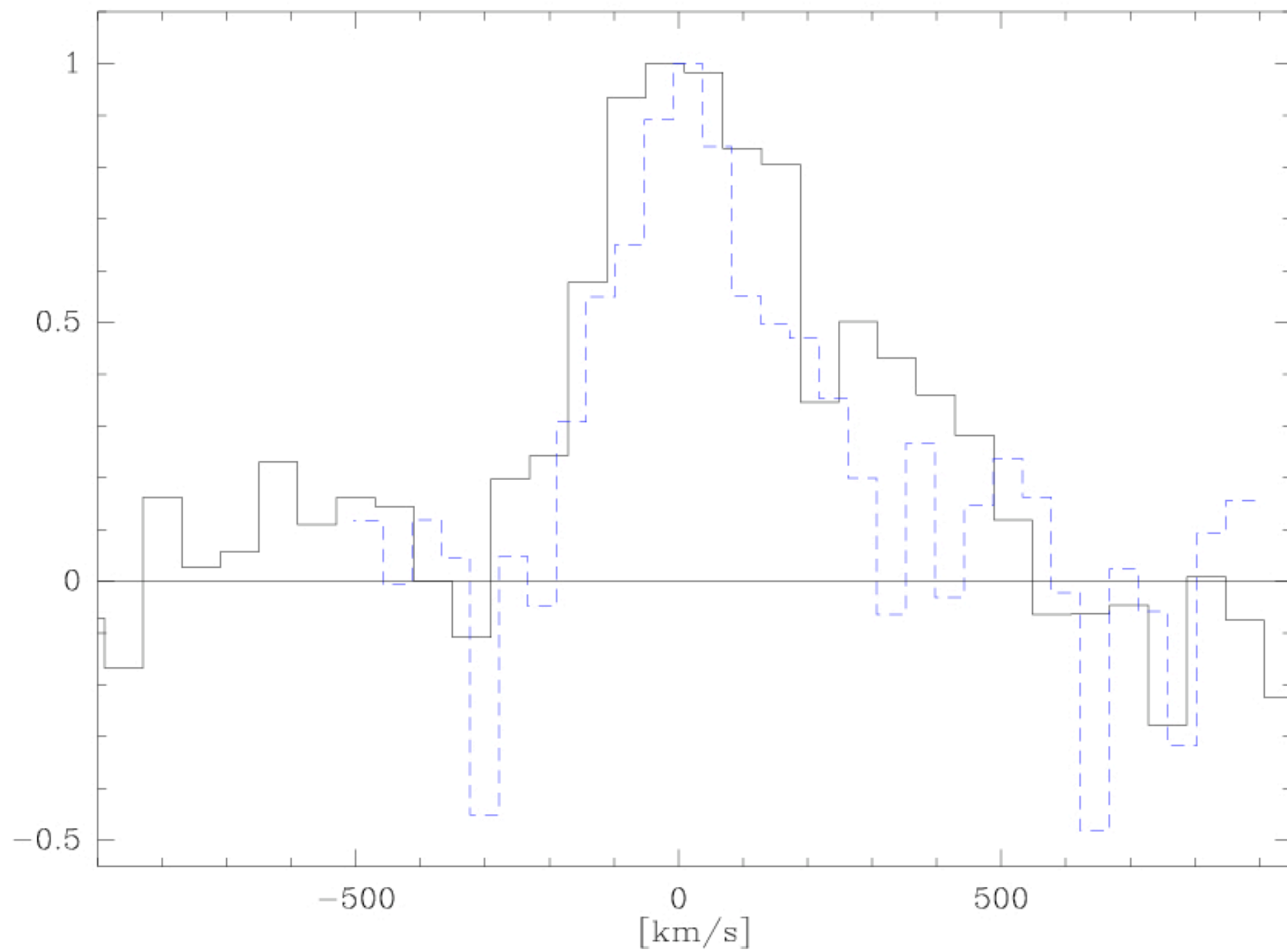


From Luhman et al 2003

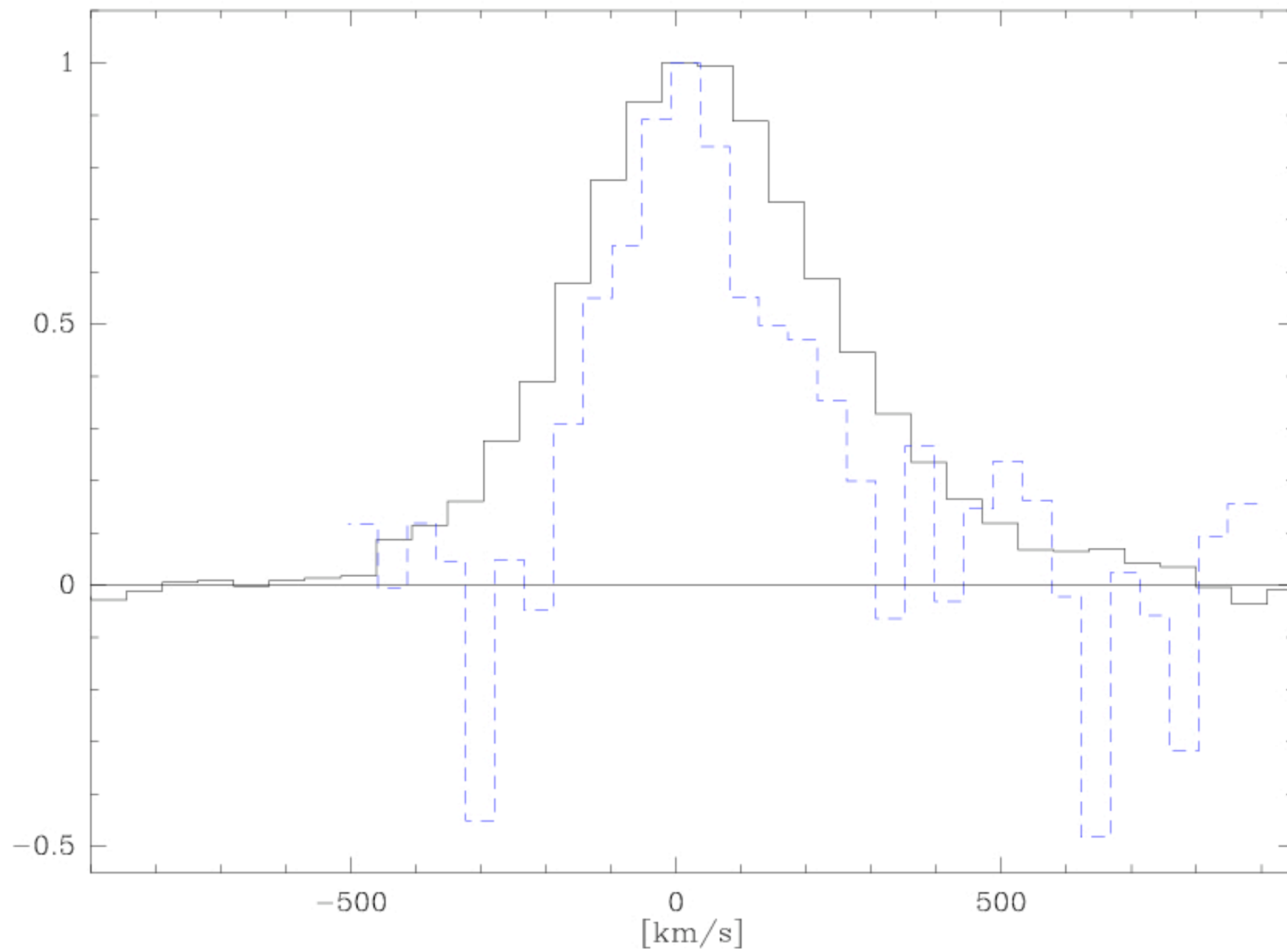
A2597 OI and CO(2-1)



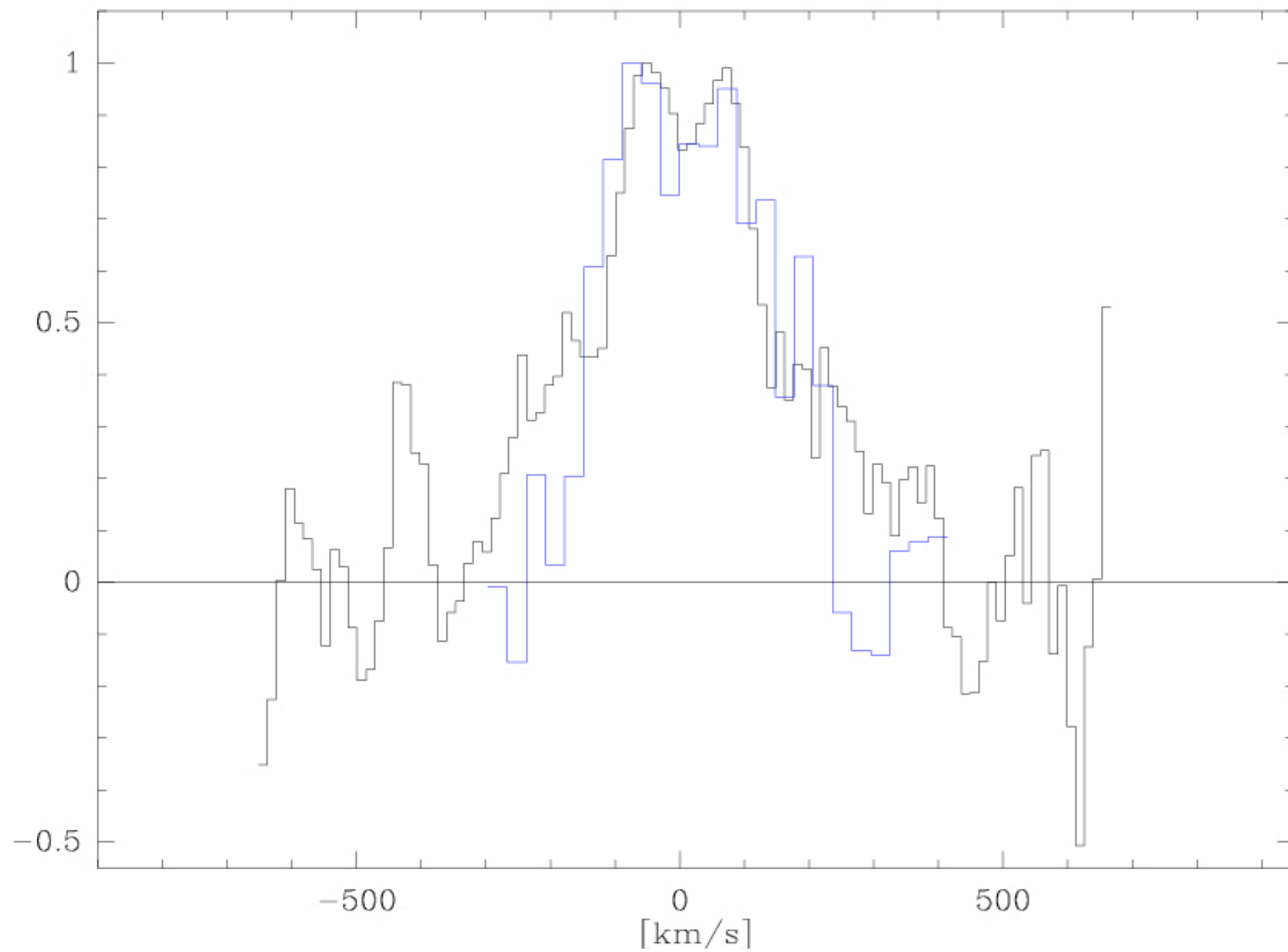
A2597 OIb and CO(2-1)



A2597 CII and CO(2-1)



A1068 OI and CO(2-1)

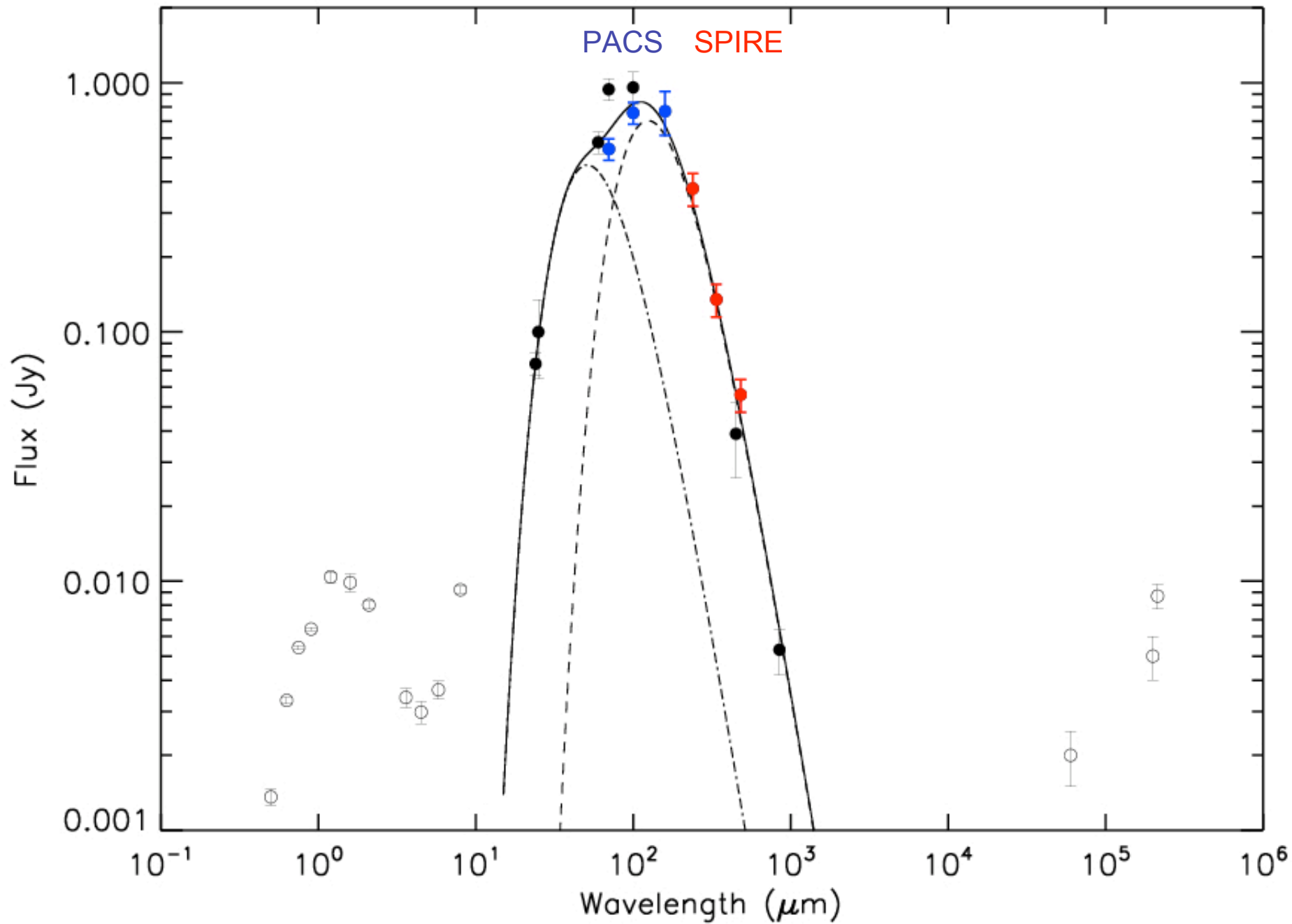


What does it all mean? II

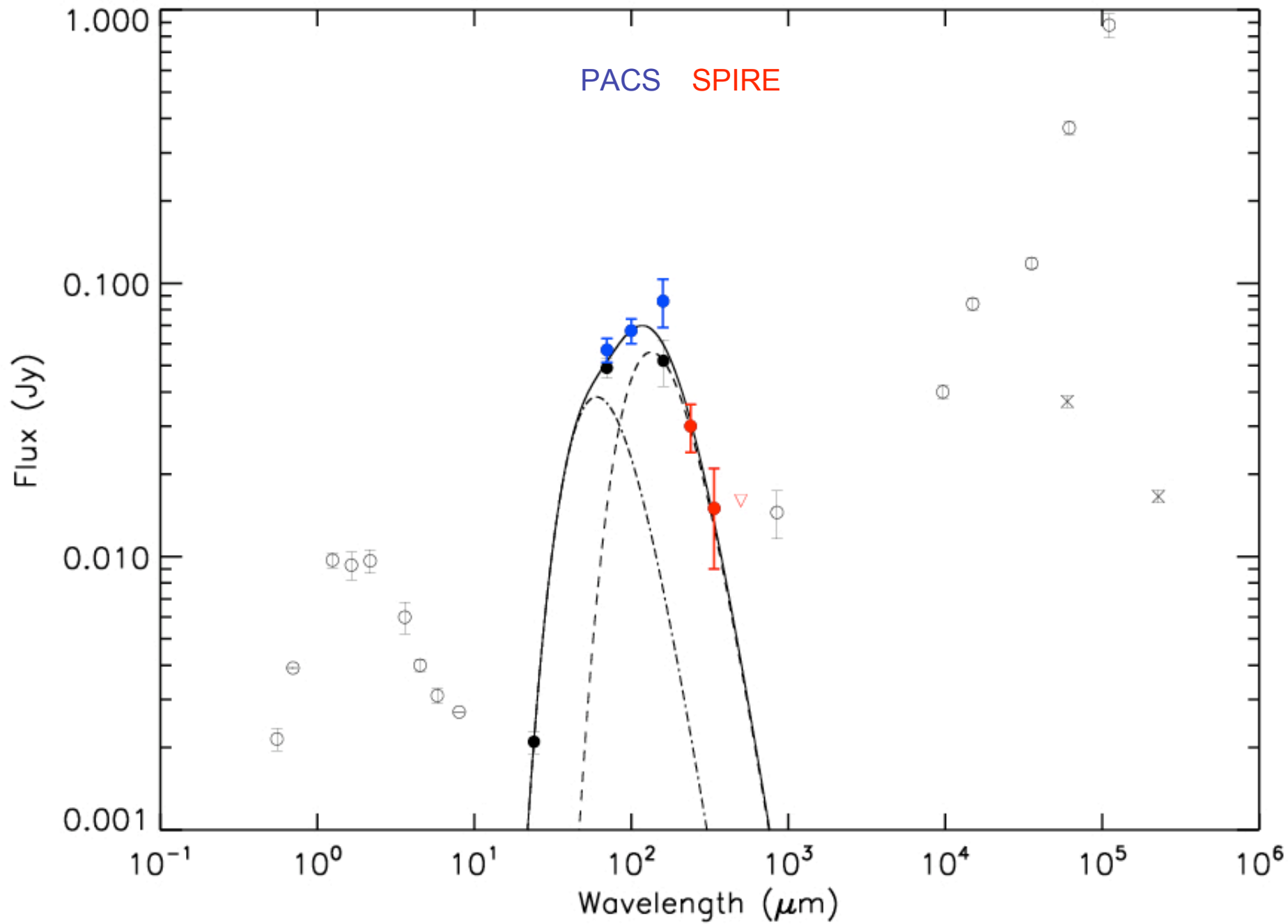
The photometry are consistent with the expected dust temperature of $\sim 25\text{-}30\text{K}$ and L_{IR} of $10^{10\text{-}12}L_{\odot}$.

The other cluster OTKPs will detect many more BCGs (see previous talks by Egami and Smith).

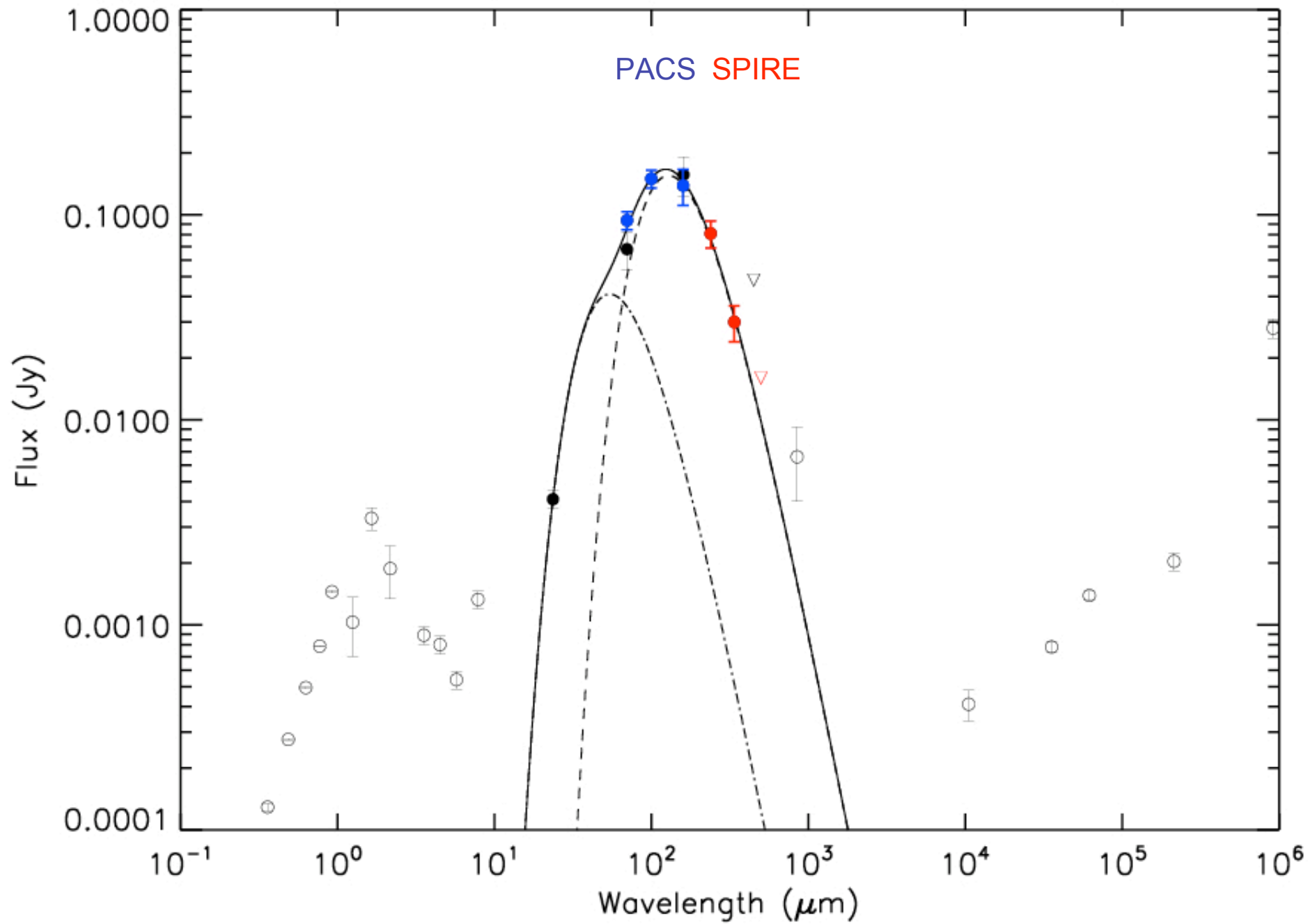
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What next?

We have spectra for 7 of our targets to date but only one with the full suite of lines.

We have PACS imaging for 5 clusters in total but only the 3 SDP SPIRE observations to date.

What next? II

The spectral maps of Centaurus and Perseus indicate that the FIR lines are extended on scales of 10-25kpc and show velocity structure.

The connection between the FIR atomic lines and the other tracers of ionised and molecular gas ($H\alpha$, CO, H_2 lines) will be the focus of our next papers.

Conclusions

Herschel has opened a direct observational window to the location, dynamics and properties of the cold molecular gas that is found in the cores of clusters of galaxies.

We await the rest of the OTKP and other Open Time observations with great excitement!