SPIRE FTS observations of DR21 and other sources

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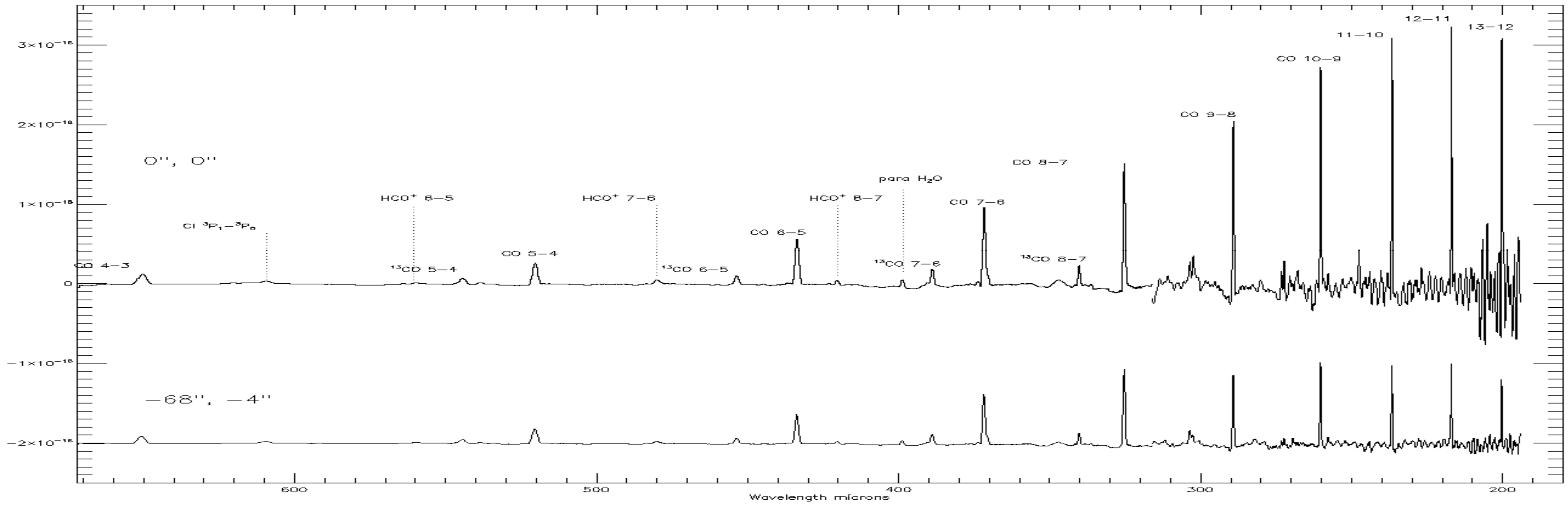
The SPIRE ICC and InstrumentTeam



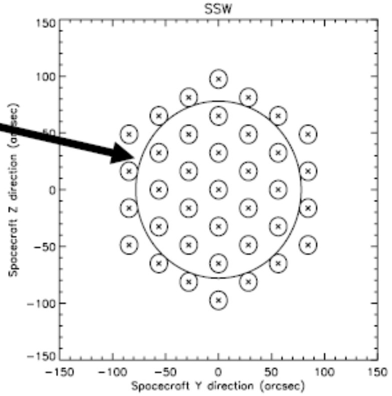
SPIRE FTS Spectroscopy

2.6’ unvignetted beam footprint

SSW

194 – 324 μm

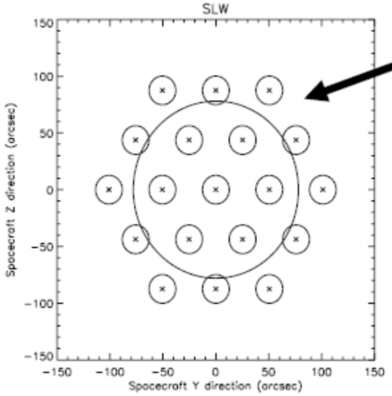
(1545 – 925 GHz)



Beam FWHM ~ 16”

316 – 672 μm

(949 – 446 GHz)

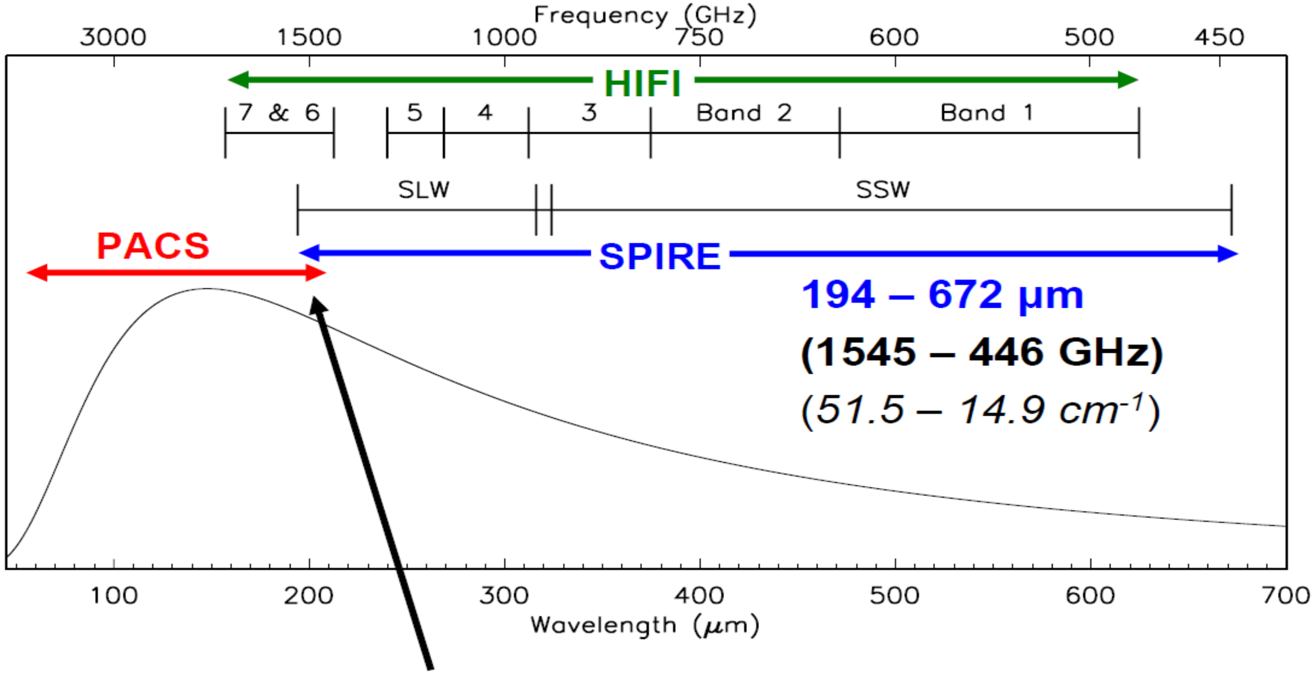


Beam FWHM ~ 34”

SLW

Pixel spacing
~ 2 beam widths

37 short bolometers
19 long bolometers



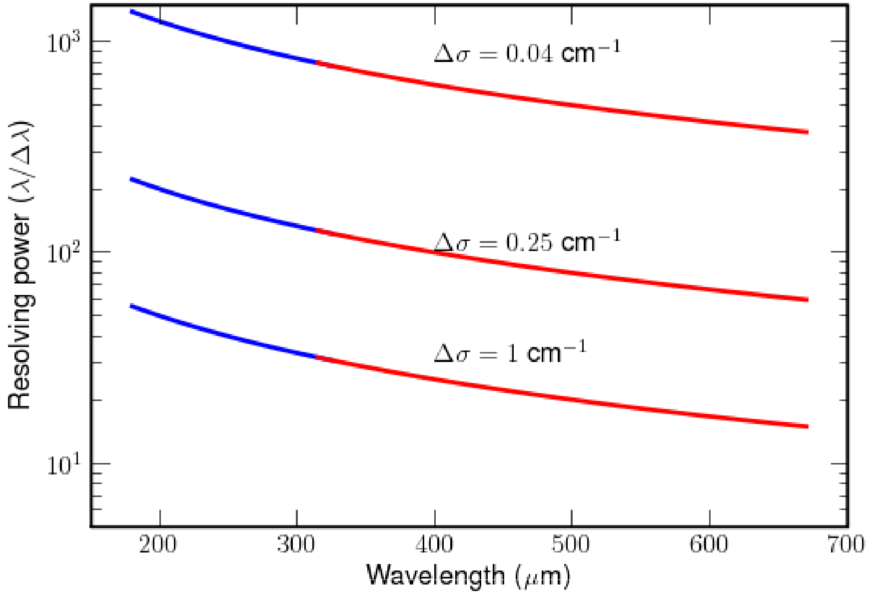
194 – 672 μm

(1545 – 446 GHz)

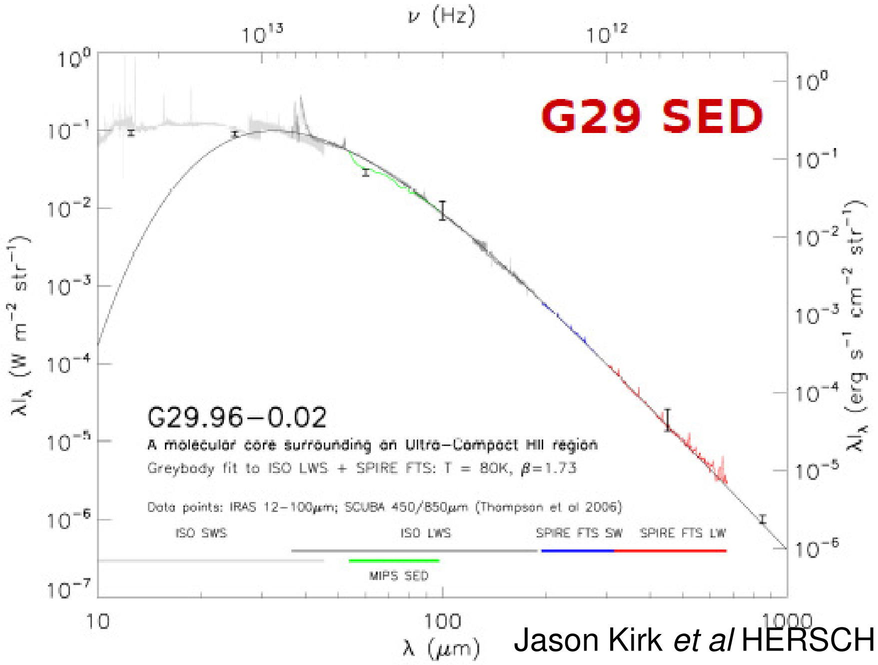
(51.5 – 14.9 cm^{-1})

Good overlap with PACS (194 – 210 μm)

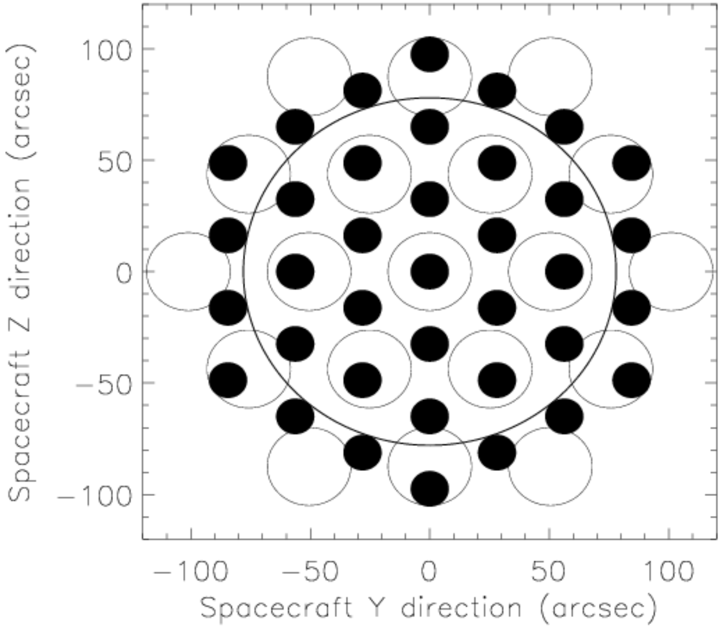
Resolution



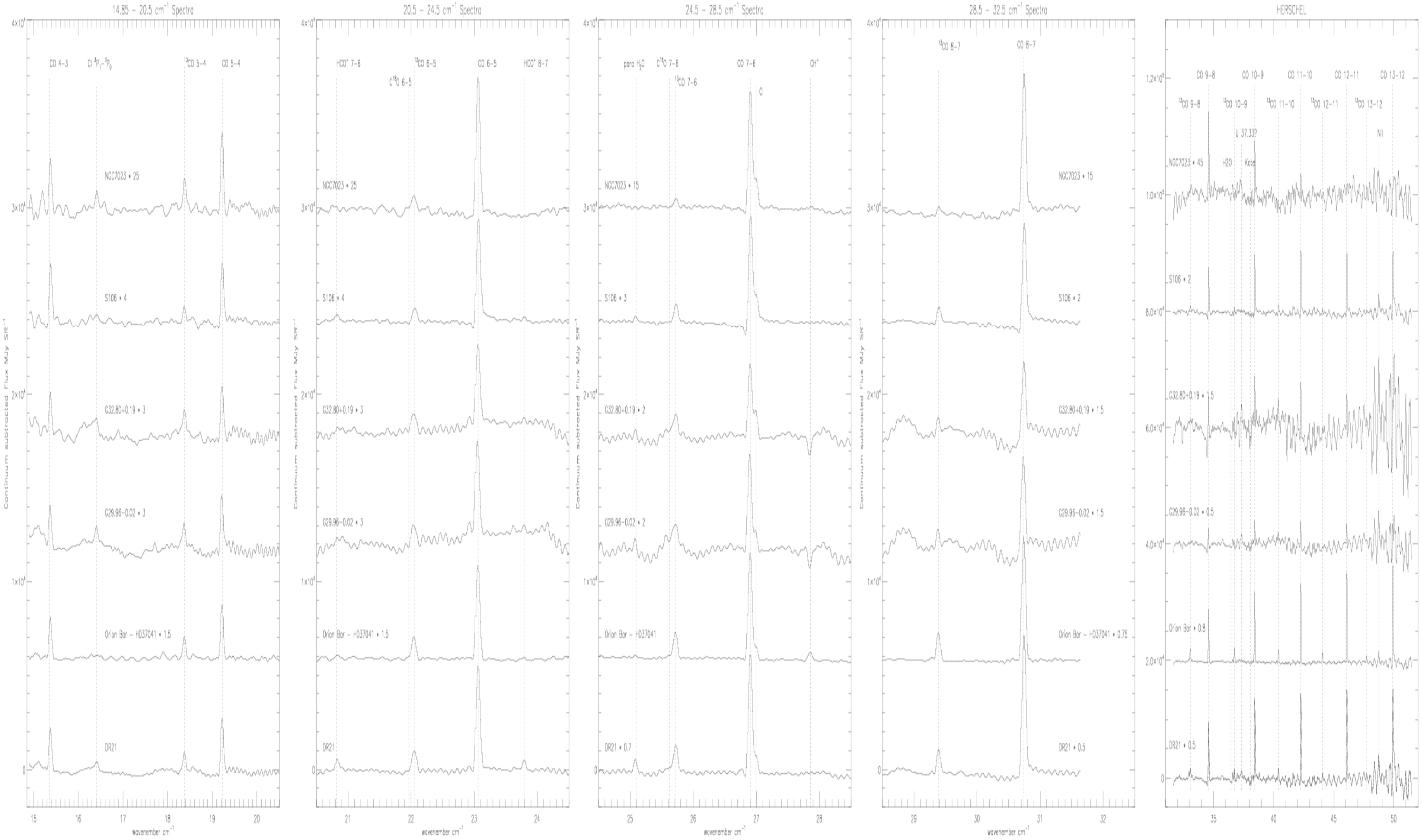
High resolution
1000 sec ~ 10^{-17} W m^{-2} ~ 1 Jy
R = 1290 – 370 or 280 – 840 km s^{-1}
Line + continuum



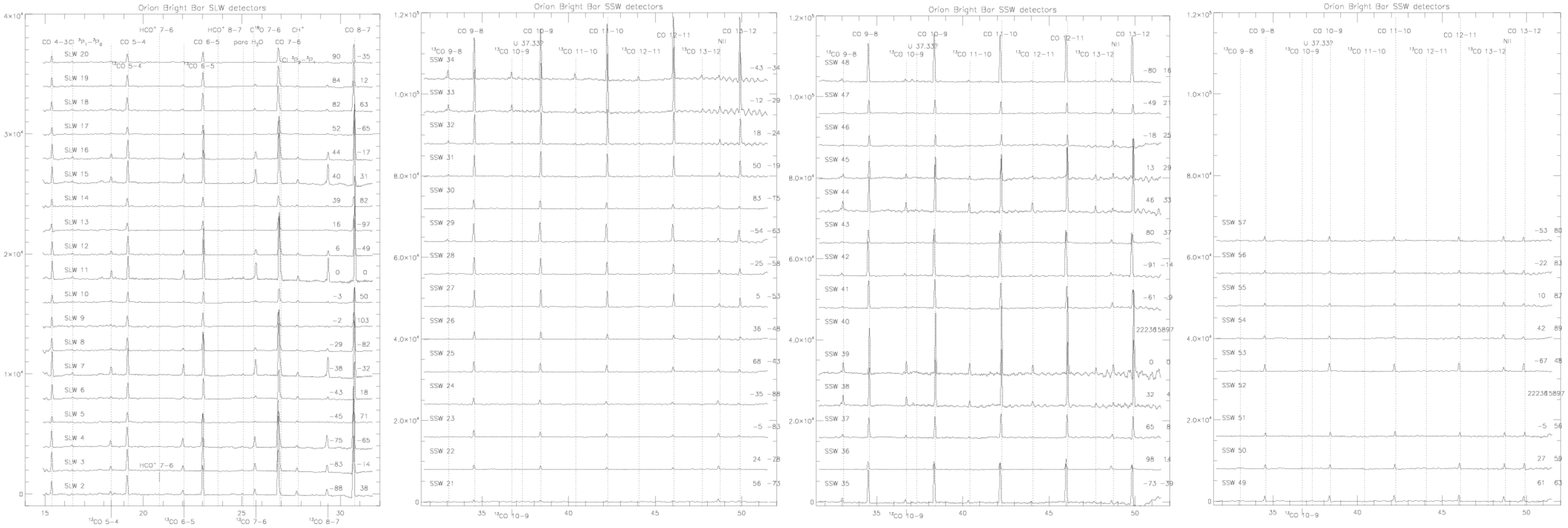
Jason Kirk *et al* HERSCHEL
Special Issue

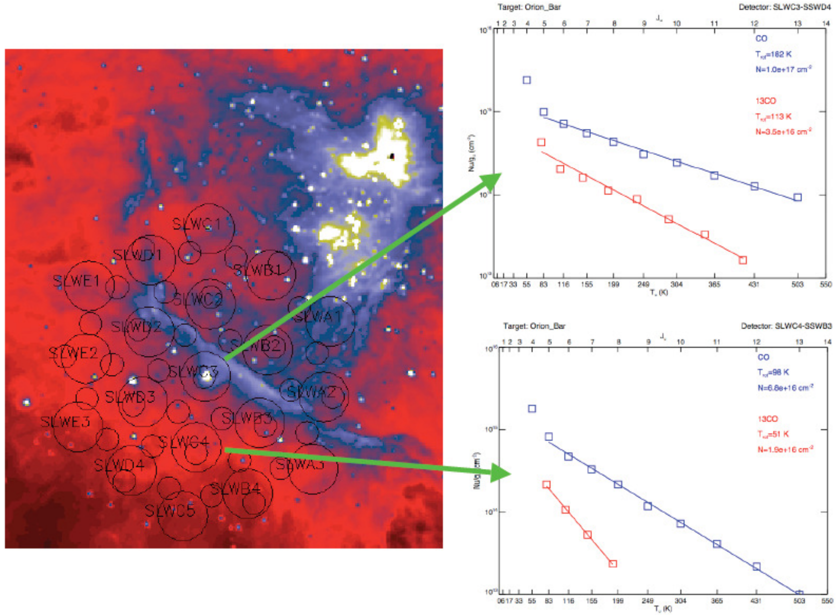


SPIRE FTS Spectra by SDP test sources 1st pass pipeline



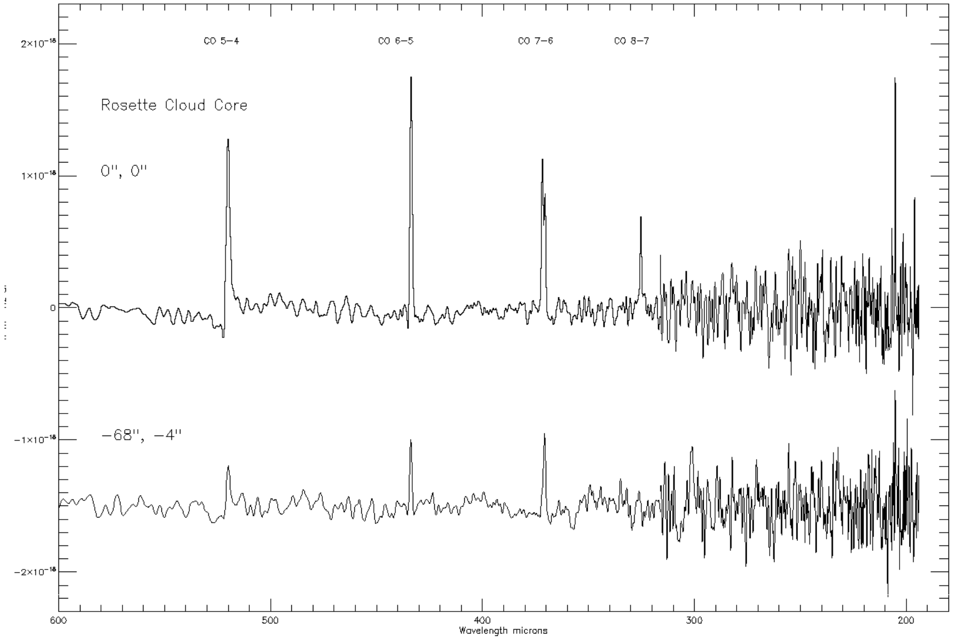
A real data cube – The Orion Bright Bar – from Habart et al this meeting

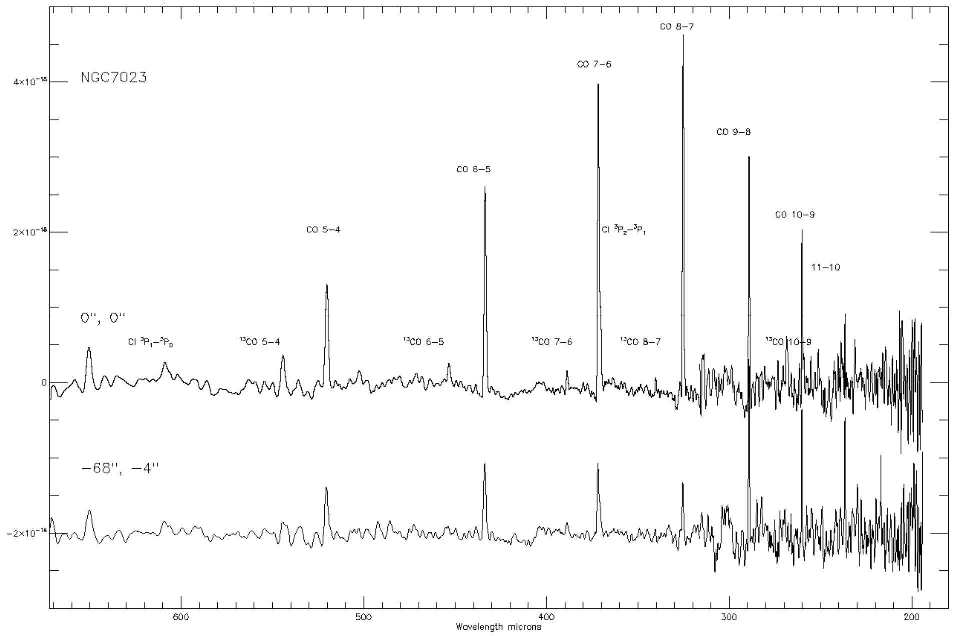




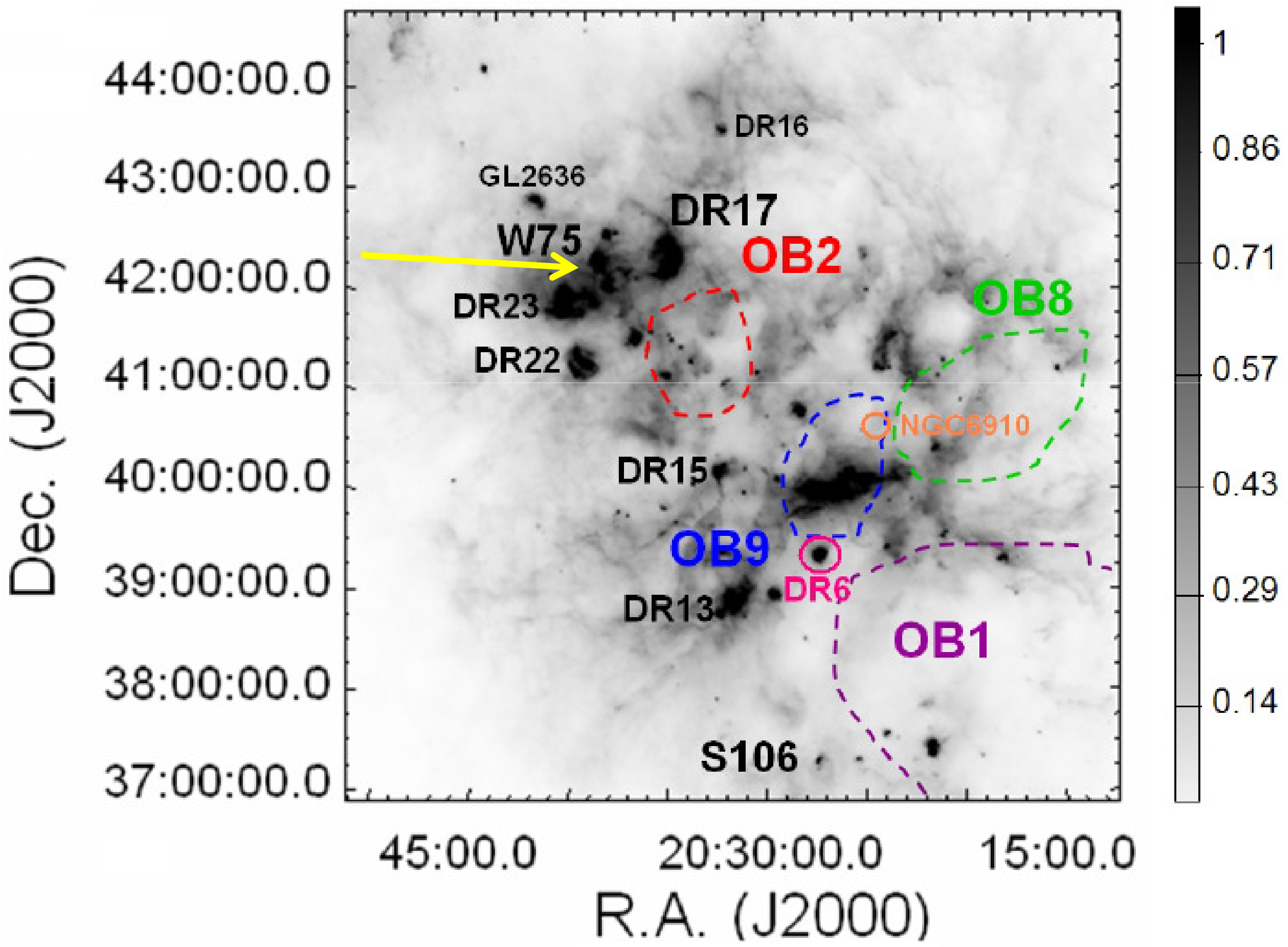
Habart et al – HERSCHEL Special Issue

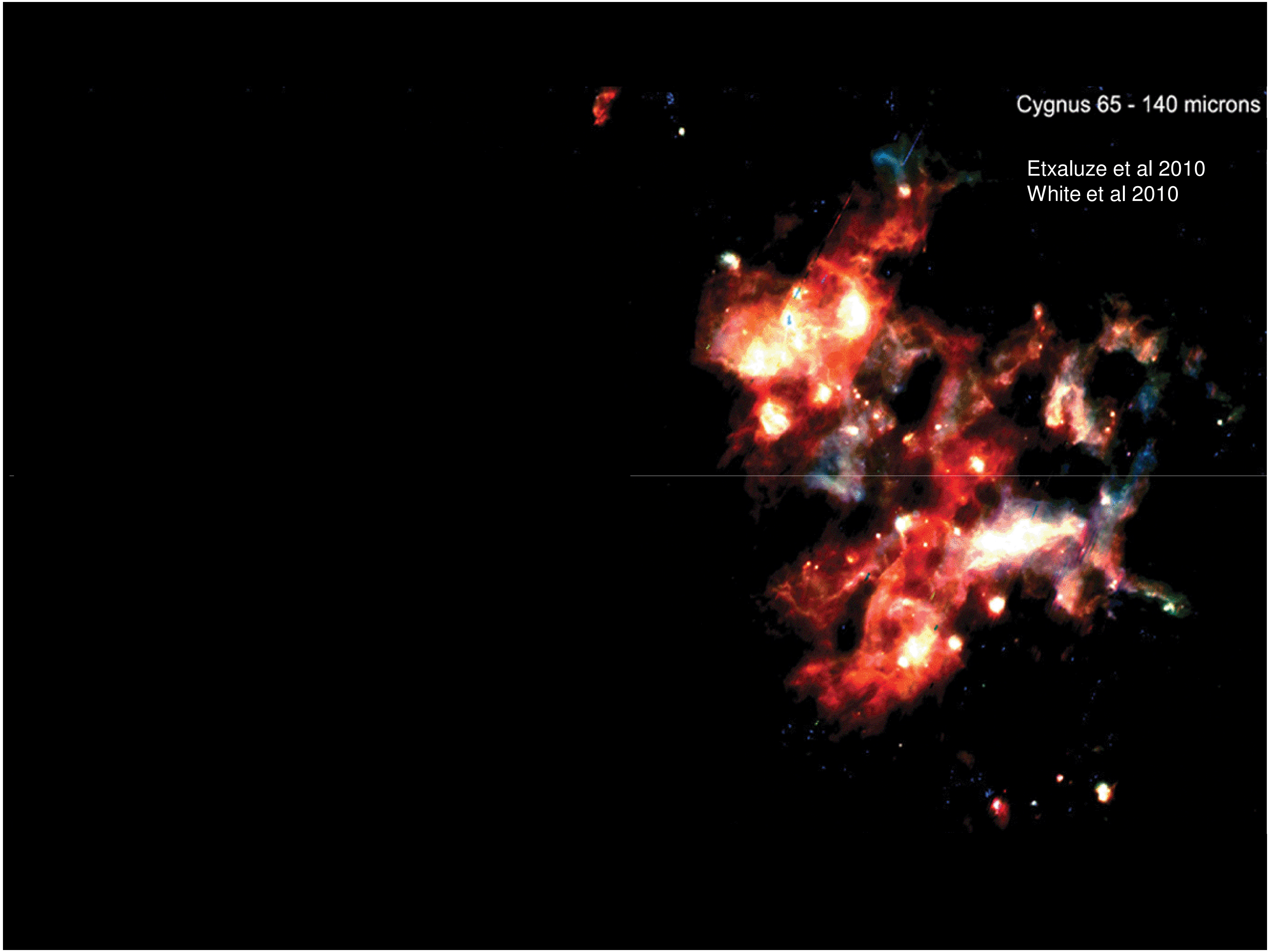
Rosette Cold Core and N7023 reflection nebulae – 800 and 2000 seconds integration





DR21 - AKARI 90 micron Galactic Plane survey – A&A AKARI Special Issue – out today!

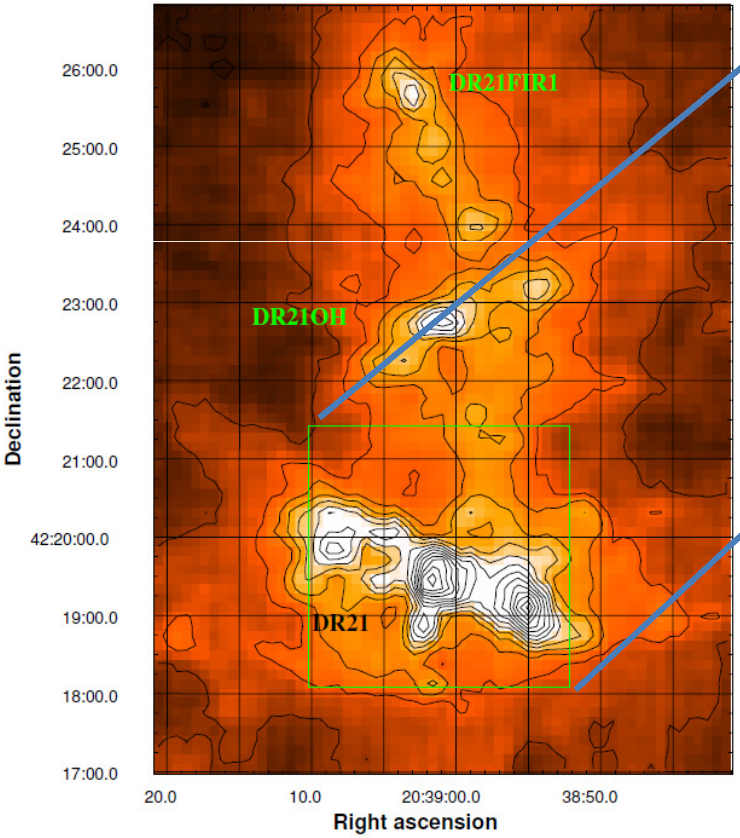


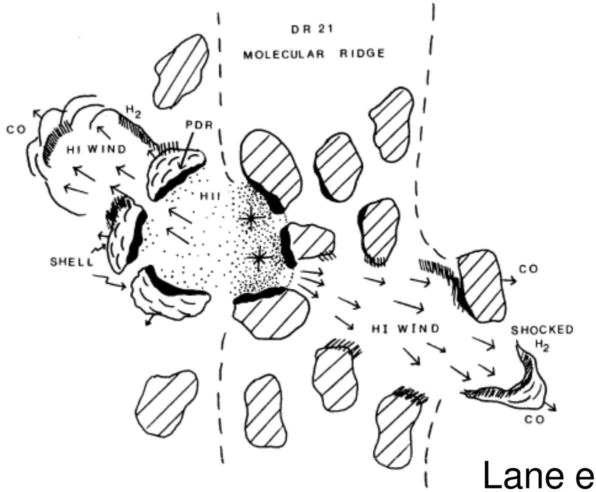


Cygnus 65 - 140 microns

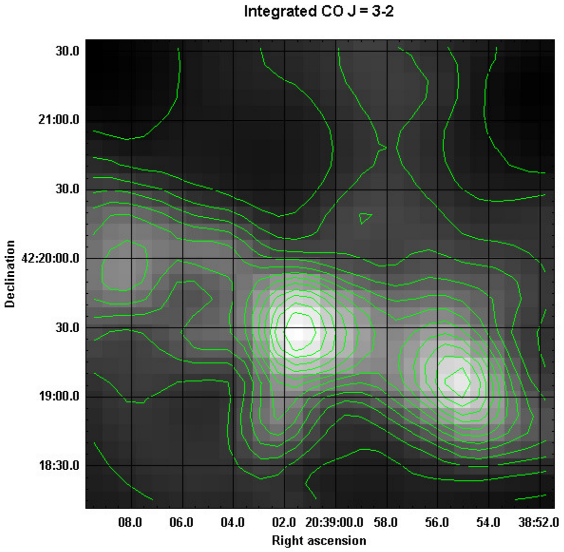
Etxaluze et al 2010
White et al 2010

DR21 outflow

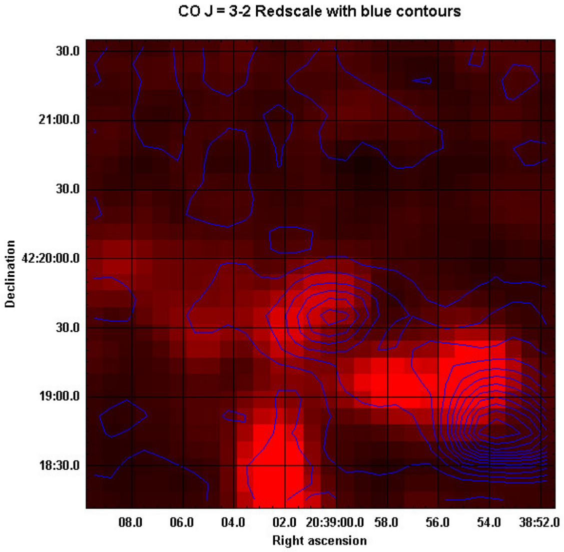




Lane et al 1990

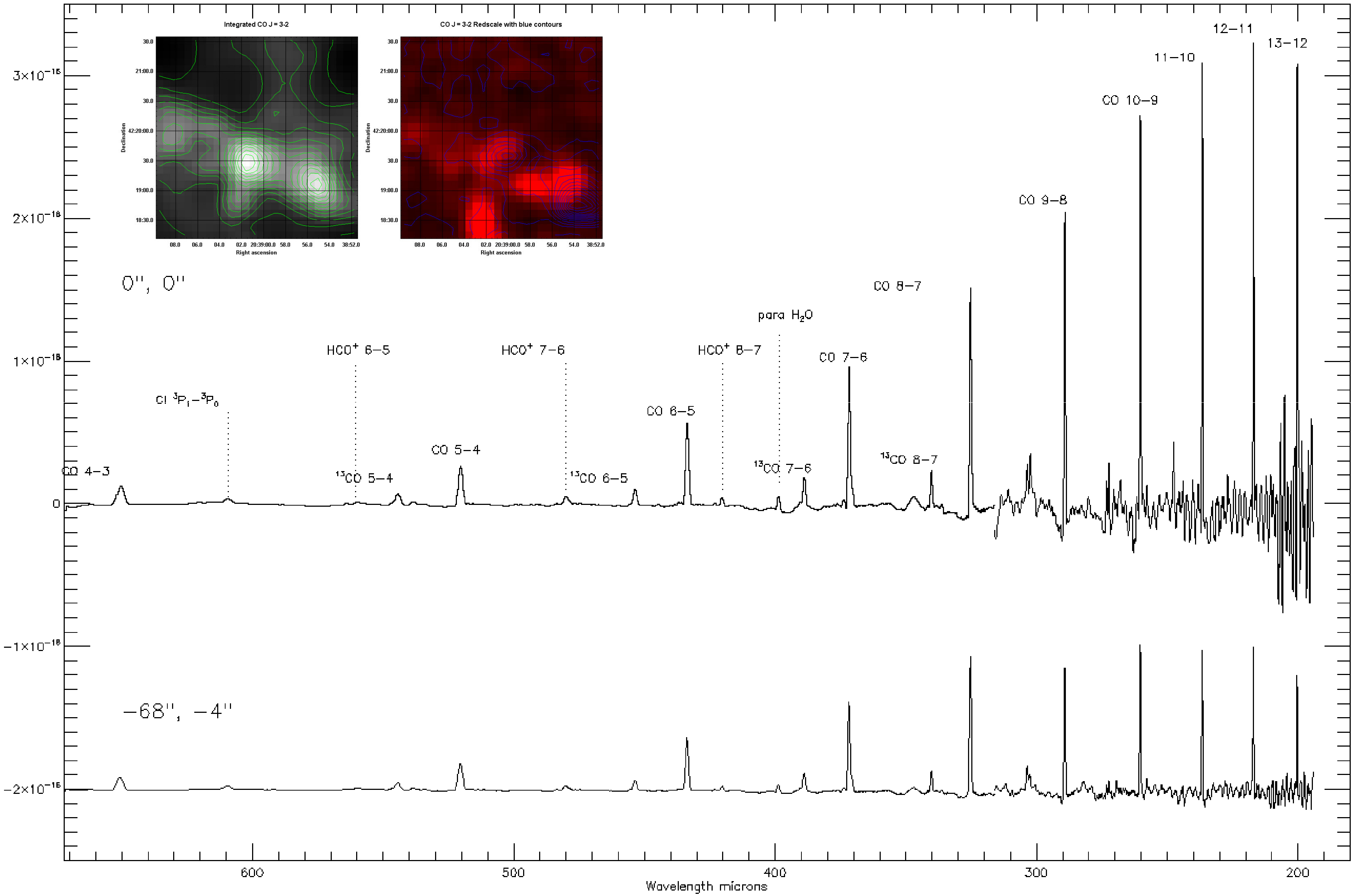


Integrated CO J = 3-2

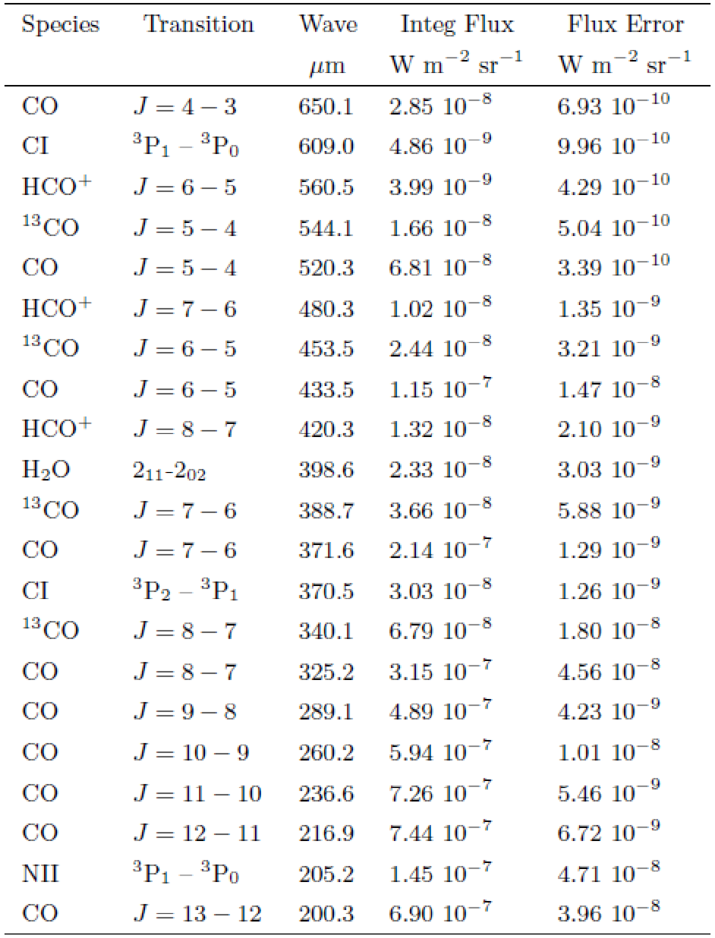


CO J = 3-2 Redscale with blue contours

DR21 core – 550 seconds integration



Central PIXEL DR21 fluxes



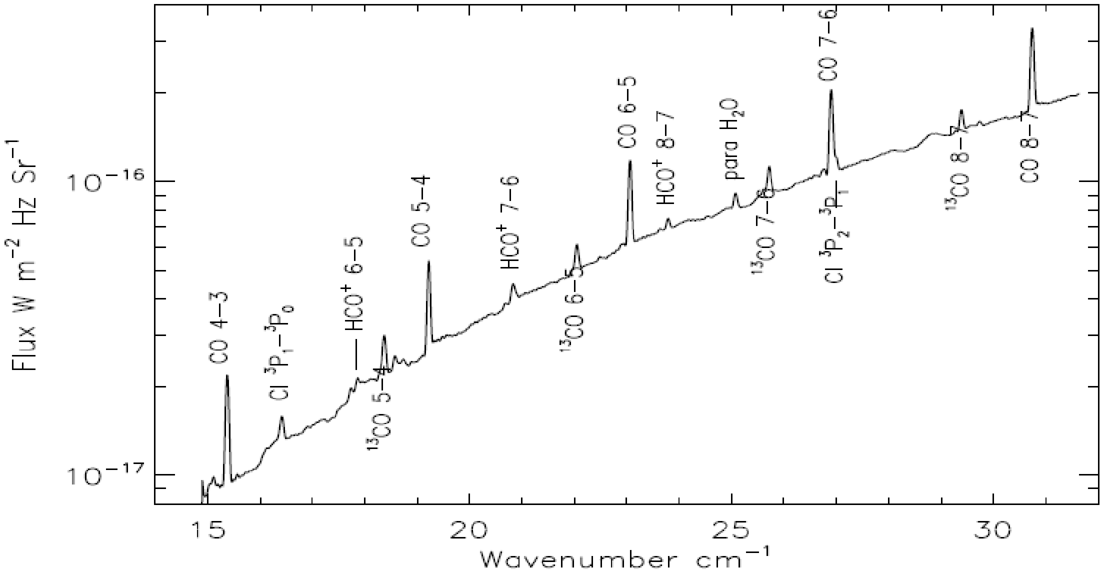
Species	Transition	Wave μm	Integ Flux W m^{-2} sr^{-1}	Flux Error W m^{-2} sr^{-1}
CO	$J = 4 - 3$	650.1	2.85 10^{-8}	6.93 10^{-10}
CI	$^3P_1 - {}^3P_0$	609.0	4.86 10^{-9}	9.96 10^{-10}
HCO^+	$J = 6 - 5$	560.5	3.99 10^{-9}	4.29 10^{-10}
^{13}CO	$J = 5 - 4$	544.1	1.66 10^{-8}	5.04 10^{-10}
CO	$J = 5 - 4$	520.3	6.81 10^{-8}	3.39 10^{-10}
HCO^+	$J = 7 - 6$	480.3	1.02 10^{-8}	1.35 10^{-9}
^{13}CO	$J = 6 - 5$	453.5	2.44 10^{-8}	3.21 10^{-9}
CO	$J = 6 - 5$	433.5	1.15 10^{-7}	1.47 10^{-8}
HCO^+	$J = 8 - 7$	420.3	1.32 10^{-8}	2.10 10^{-9}
H_2O	2_{11}-2_{02}	398.6	2.33 10^{-8}	3.03 10^{-9}
^{13}CO	$J = 7 - 6$	388.7	3.66 10^{-8}	5.88 10^{-9}
CO	$J = 7 - 6$	371.6	2.14 10^{-7}	1.29 10^{-9}
CI	$^3P_2 - {}^3P_1$	370.5	3.03 10^{-8}	1.26 10^{-9}
^{13}CO	$J = 8 - 7$	340.1	6.79 10^{-8}	1.80 10^{-8}
CO	$J = 8 - 7$	325.2	3.15 10^{-7}	4.56 10^{-8}
CO	$J = 9 - 8$	289.1	4.89 10^{-7}	4.23 10^{-9}
CO	$J = 10 - 9$	260.2	5.94 10^{-7}	1.01 10^{-8}
CO	$J = 11 - 10$	236.6	7.26 10^{-7}	5.46 10^{-9}
CO	$J = 12 - 11$	216.9	7.44 10^{-7}	6.72 10^{-9}
NII	$^3P_1 - {}^3P_0$	205.2	1.45 10^{-7}	4.71 10^{-8}
CO	$J = 13 - 12$	200.3	6.90 10^{-7}	3.96 10^{-8}

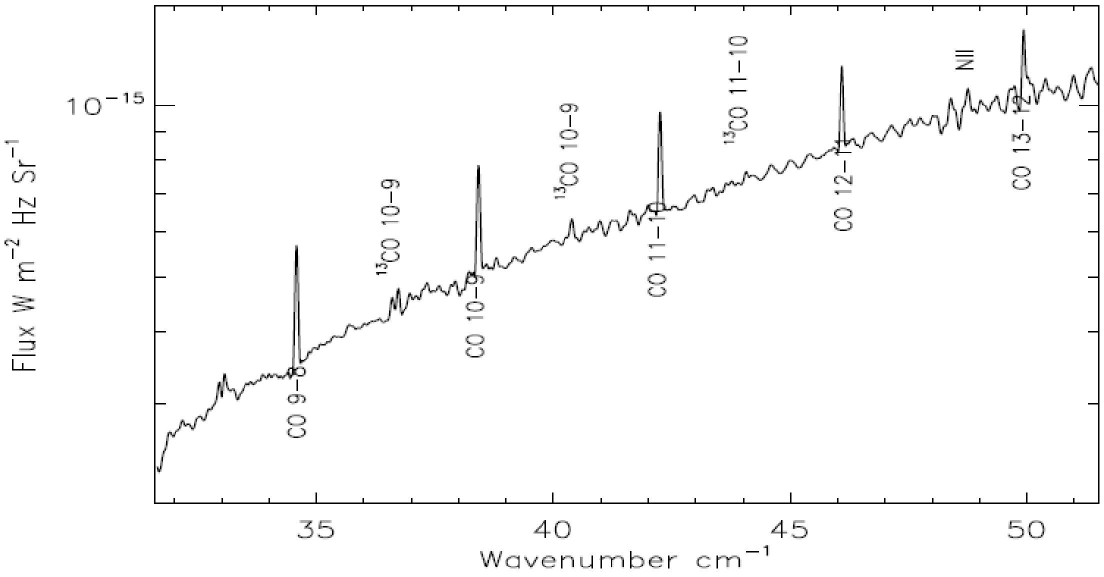
FTS pros and cons

- High sensitivity – lines ~ 1 K antenna temperature possible
- Avoid hot cores because of line confusion
- Lines with a significant self-absorbed component will be cancelled out and missed (CH^+, HF from David Neufeld’s talk)
- Poor velocity resolution and continuum contrast

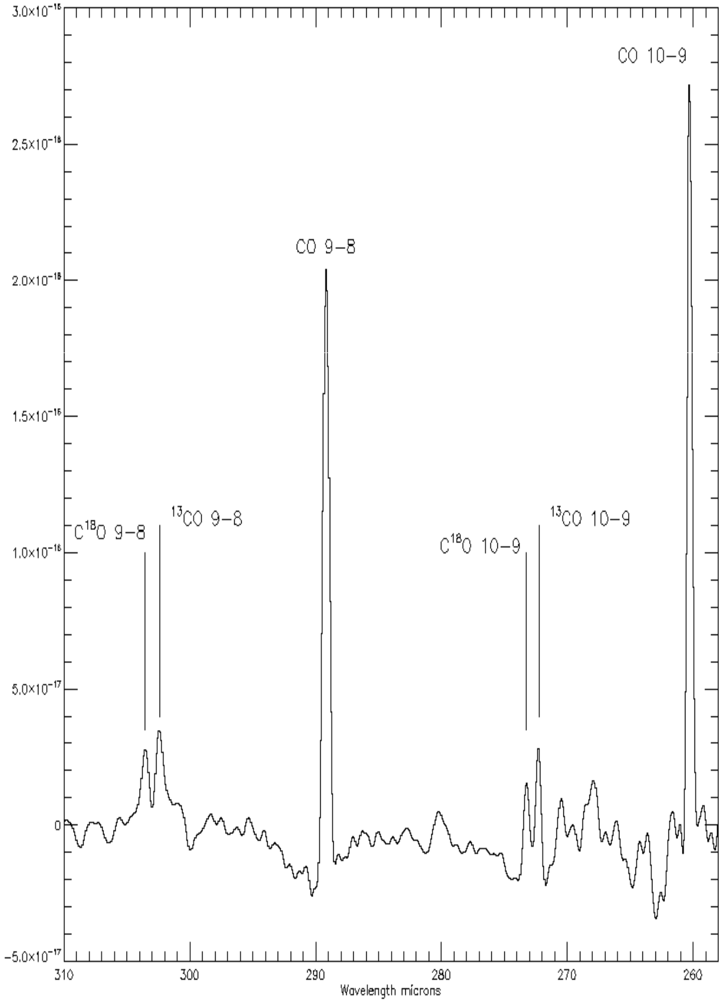
- Multi pixel maps
- Complete bandheads in short time (e.g. CO)
- Consistent calibration and beam sizes on individual detectors
- Optimised on broad lines with less pixel dilution

Continuum and faint line recovery

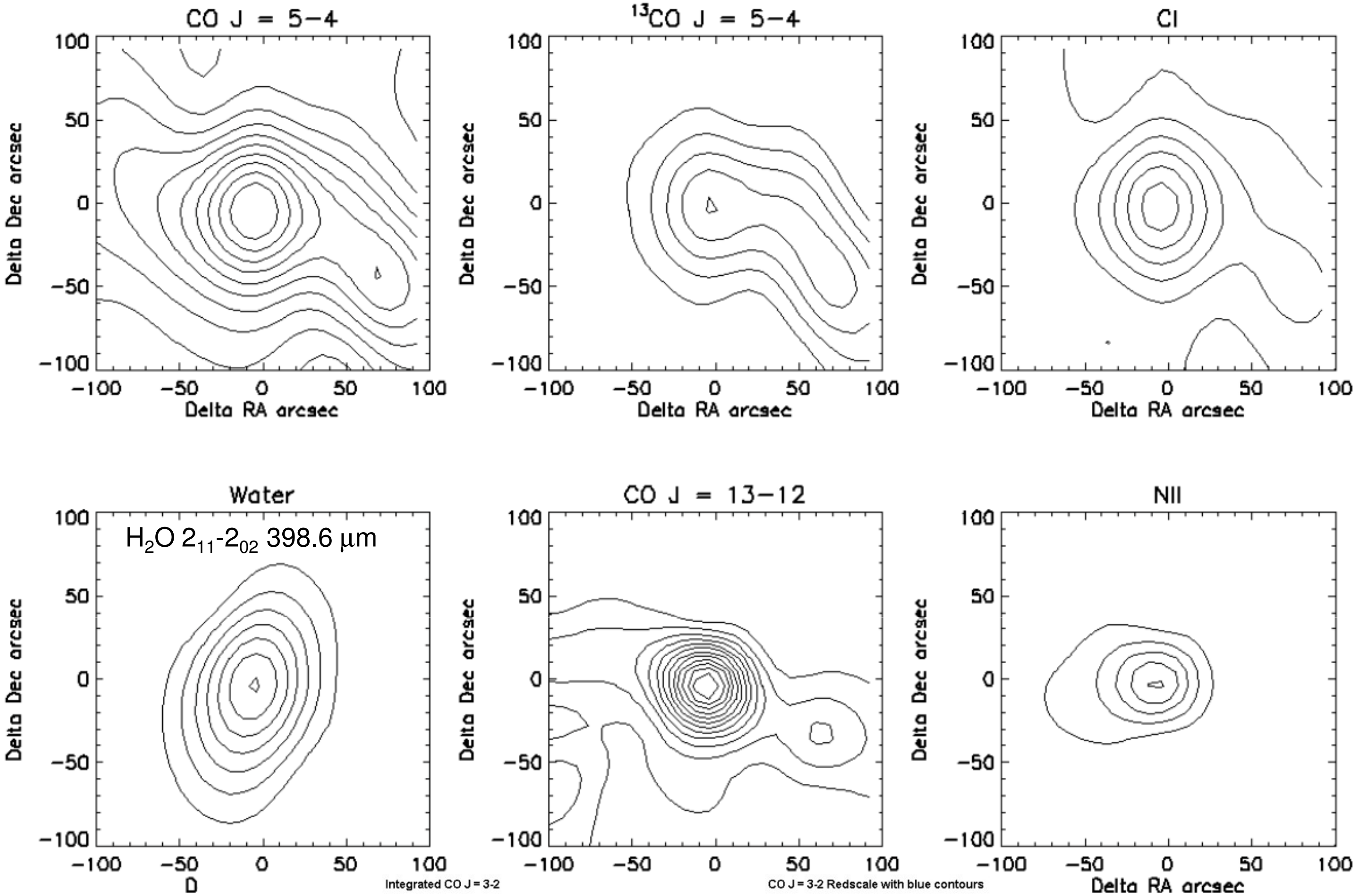


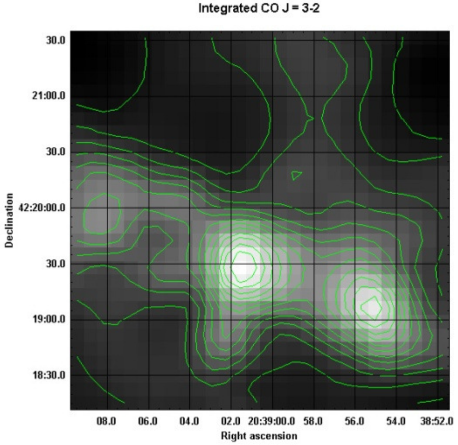


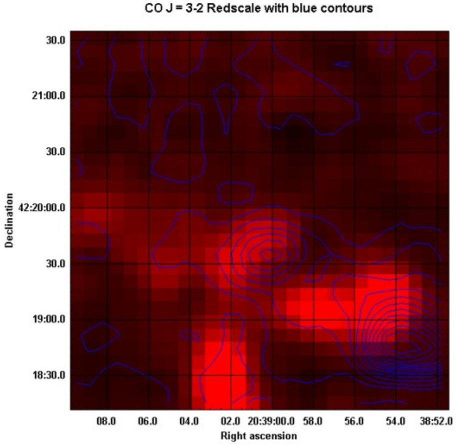
HIFI ^{13}CO *J* = 10-9 = 3.5 K



Selected SPIRE FTS lines

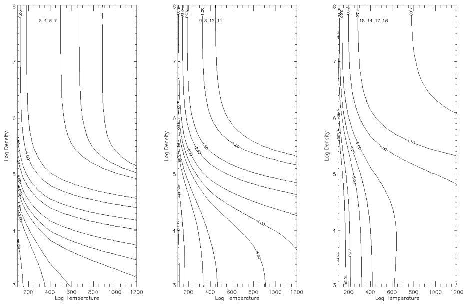


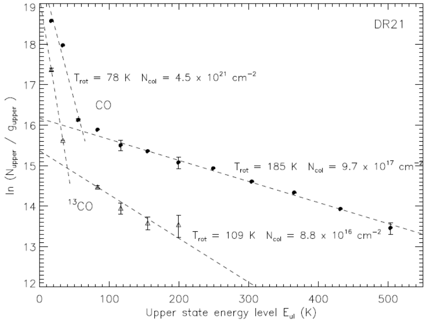




Modelling the excitation

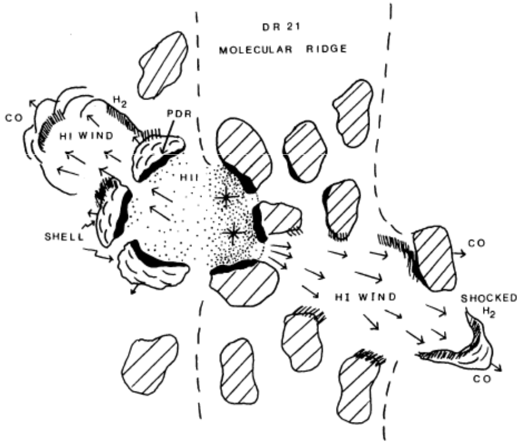
- Line ratios





Matched beam areas and co-spatial pixels – use same detectors and locations

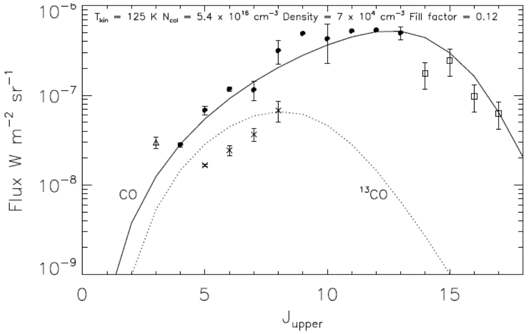
- Line profiles



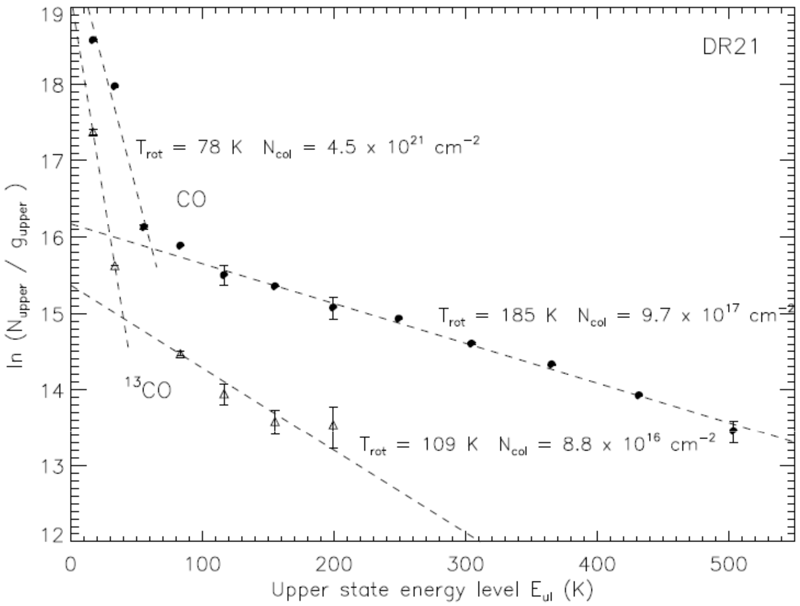
Sets the contributions of shocks, turbulence, chemistry

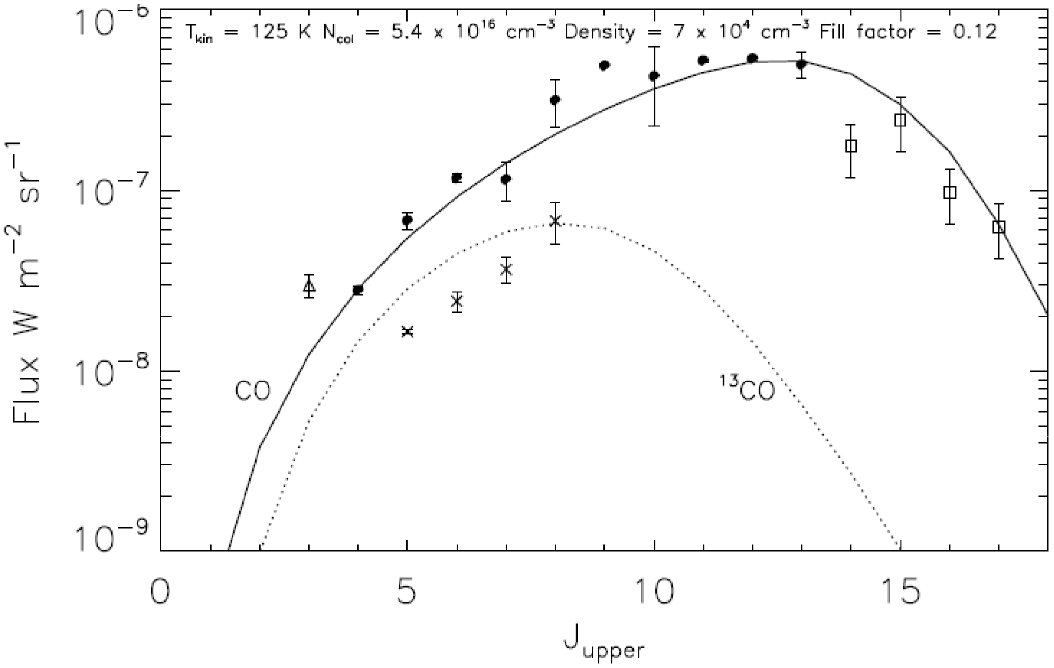
- UV excitation

- Radiative transfer



Modelling the DR21 CO lines





High J–lines from Jakob et al 2007

Low J-lines from JCMT (this work) and IRAM (Nicola Schneider et al in prep)

Lane et al 1990 showing that shock emission overwhelmed by far-UV excitation

Many public domain Radiative Transfer codes – e.g. RADEX/RATRAN, CASSIS

Markus Röllig et al Poster outside Excitation of carbon species in DR21 P2.14

Conclusions

- The SPIRE FTS sparse mode works very well – even in the SDP tests !
- SDP observations completed of DR21, Rosette, NGC7023, Orion Bright Bar. Remarkable diversity of lines, despite the moderate spectral resolution
- Complete inventory of gas + dust – with 10 – 1000 μm using ISO, HERSCHEL, Ground based submm
- Sparse sampling is able to detect outflow morphologies and spatial distributions on sub-arcmin scale – fully sampled soon
- All test sources show high-J lines above simple LTE models – warm gas ~ a few hundred K.
- DR21 situation has a very complex flow scenario – uv, shocks needed -> higher spectral resolution: T ~ 125 – 185K n ~ 7 x 10^4 cm^{-3}; plus lower excitation material an T ~ 80K – similar estimates to ground based.
- High J-lines accessible even in low density dark clouds
- CO, ^{13}CO, $C^{18}O$, HCO^+,CI, H_2O, NII all easily detectable in galactic sources ~ 10 minute integrations
- Thanks to the SPIRE FTS team, and all of our HERSCHEL Instrument and support colleagues