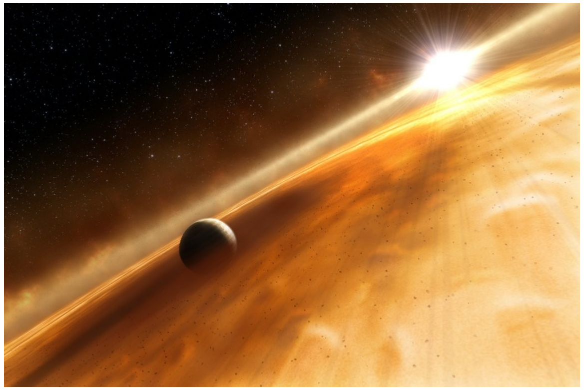
Early results from GASPS - Gas and Dust around Young Stars

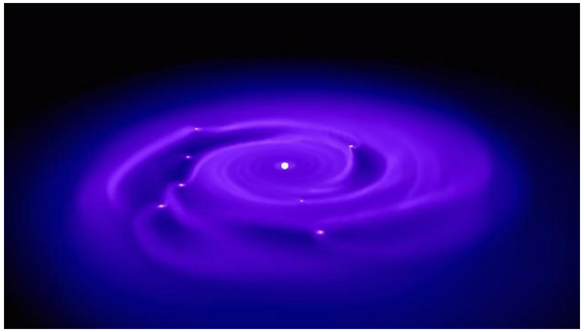
Bill Dent, for the GASPS team



- Aims and summary of GASPS
- SDP results – gas and dust in 4 protoplanetary systems
- New results – young stars in Taurus
- Systems with outflows

Co-Is & contributers

J.M.Alcid, S.M.Andrews, D.R.Ardila, G.Aresu, J.C.Augereau, D.Barrado, S.Brittain, D.R.Ciardi, W.Danchi, W.R.F.Dent, G.Duchene, C.Eiroa, D.Fedele, C.Grady, I. De Gregorio-Monsalvo, A.Heras, C.D.Howard, N.Huelamo, I.Kamp, A.Krivov, J.Lebreton, R.Liseau, C.Martin-Zaidi, G.S.Mathews, G.Meeus, F.Menard, I. Mendigutia, B.Montesinos, A.Mora, M. Morales-Calderon, H.Nomura, E.Pantin, I.Pascucci, N.Phillips, C.Pinte, L.Podio, D.Poelman, S.Ramsay, B.Riaz, K.Rice, P.Riviere-Marichalar, A.Roberge, G.Sandell, E.Solano, W-F.Thi, I. Tilling, B.Vandenbussche, H.Walker, G.J.White, J.P.Williams, P.Woitke, G.Wright

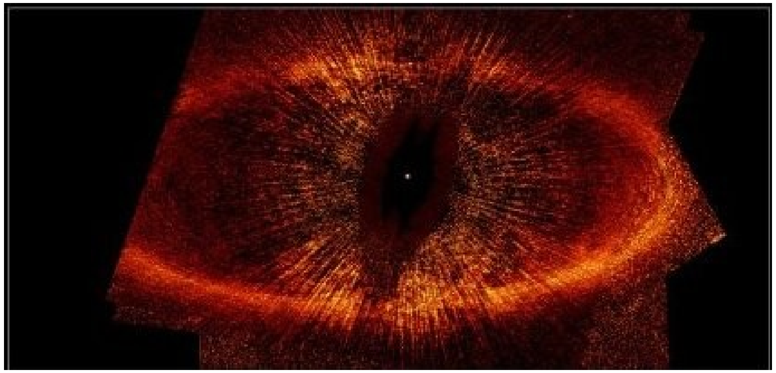


Disks are sites of planet formation. As disks evolve, gas & dust dissipate – but in different ways. The gas content of disks:

- ***Limits timescale for gas giant formation***
- ***Controls dynamics of all planetary bodies***
- ***Determines final architecture of planetary system***

AIM of GASPS:

- a statistical survey of the evolution of gas and dust as disks evolve from young gas-rich protoplanetary systems, to old "dry" debris disks



GASPS survey

Sample of ~200 protoplanetary through to debris disk systems studied using far-IR gas lines and dust continuum

- Ages 1 – 30Myr, nearby (100-200pc), SED Class II-III, stellar types M through A
- *Not* young nor embedded
- Wide range of Hα, Lx, disk dust mass (10^{-2} - 10^{-5}Mo)
- Well-known star-forming regions (Taurus, ηCha, βPic, TucHor, uppSco, HAeBe)
- Key far-infrared tracers: [OI], [CII], H2O, CO
- Photometry at 70 & 170μm

- Plus extensive modelling, and use of existing/followup data

Target lines

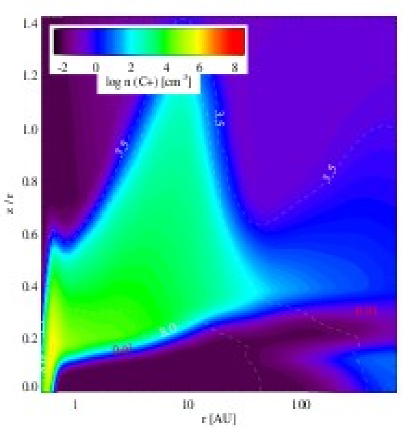
- **[OI] at 63.2** and 145.5 μm (228, 326K)
- [CII] at 157.7 μm (91K)
- H_2O at 78.4, 89.9, 144.5, 158.3, 180.5 μm (115-432K)
- CO J=18-17, 29-28, 33-32, 36-35 (945-3700K)
- OH, CH^+, DCO^+

Phase I: [OI]63um line-scan

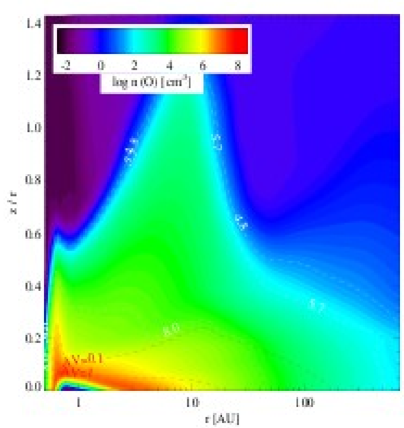
Phase II: range-scans with PACS, lines in both spectral orders simultaneously

Modelling disks

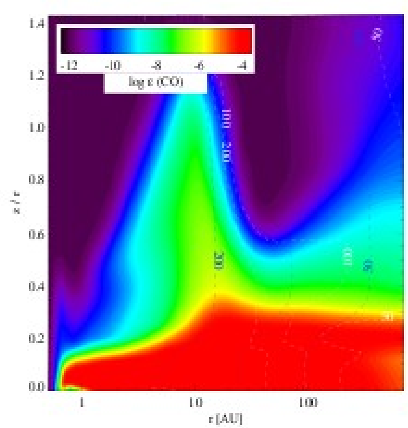
- Simultaneously model complete SED and key lines (far-IR & submm)
- Uses dust code MCFOST and gas code ProDiMo (chemistry & gas heating/cooling), with self-consistent disk model. Line rad. transfer => predicted strengths, profiles
- Large grid of models with varying disk/stellar parameters



[CII]



[OI]



CO

Woitke et al., 2009, 2010
Kamp et al., 2010, & poster
Pinte et al., 2006, 2010 (A&A)

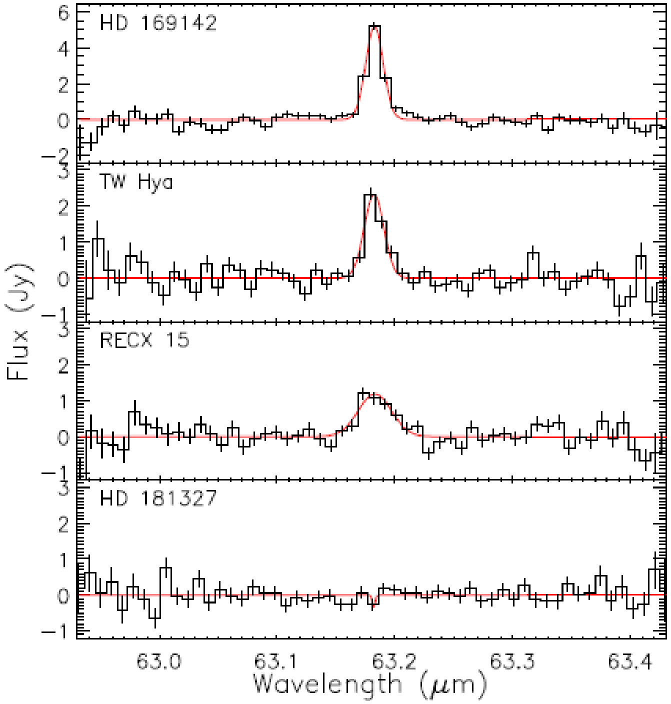
Initial results - SDP

4 targets:

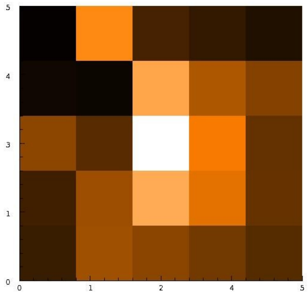
HD169142 (A5, 6Myr, known massive disk)
TW Hya (K7e, 10Myr, known disk)
RECX15 (M2e, 9Myr, no submm)
HD181327 (F5, 12Myr, debris disk)

Initial results - SDP

(a) OI 63um detected in 3/4 objects

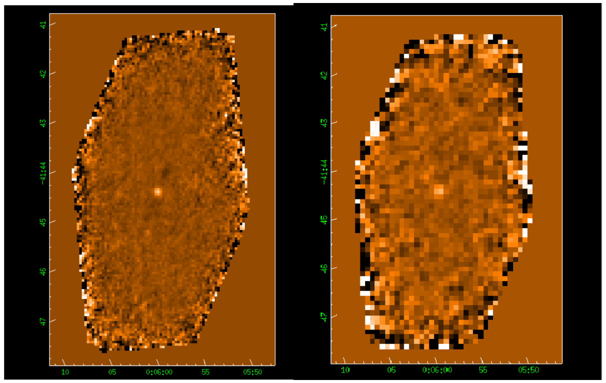


OI63um towards RECX15



45 arcsec

(4000au)



70,170um photometry of all objects

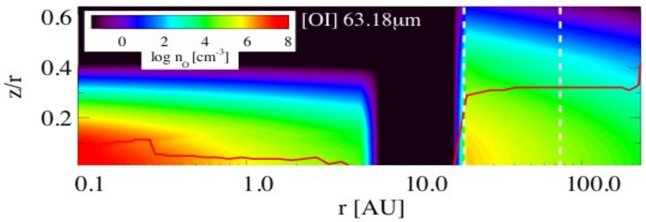
(b) [CII] 157um not detected

(c) tentative detections of some other lines

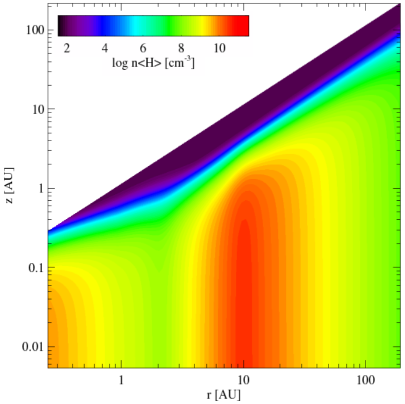
Meeus et al., A&A 2010
Thi et al., A&A 2010
Riaz et al (poster)
Lebreton et al (poster)

SDP results

HD169142: [OI], [CII], CO & SED constraints give gas/dust ratio ~ 40, very low UV excess



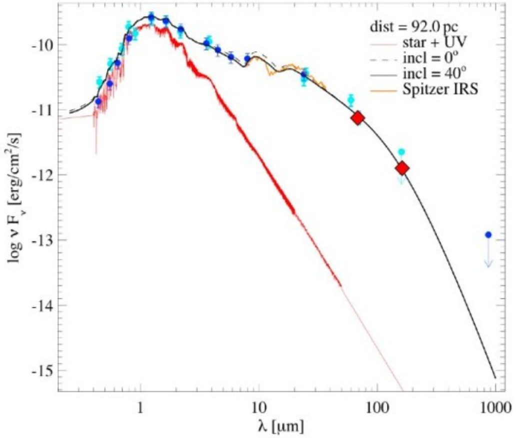
TWHya: gas/dust ratio 2.5-25, gas/"solids" ratio ~ 0.2-1.6



Meeus et al., A&A 2010
Thi et al., A&A 2010

SDP results

RECX15: Compact v. low-mass gas disk ($2.5x10^{-5}M_o$). Longest wavelength detection is PACS 160um

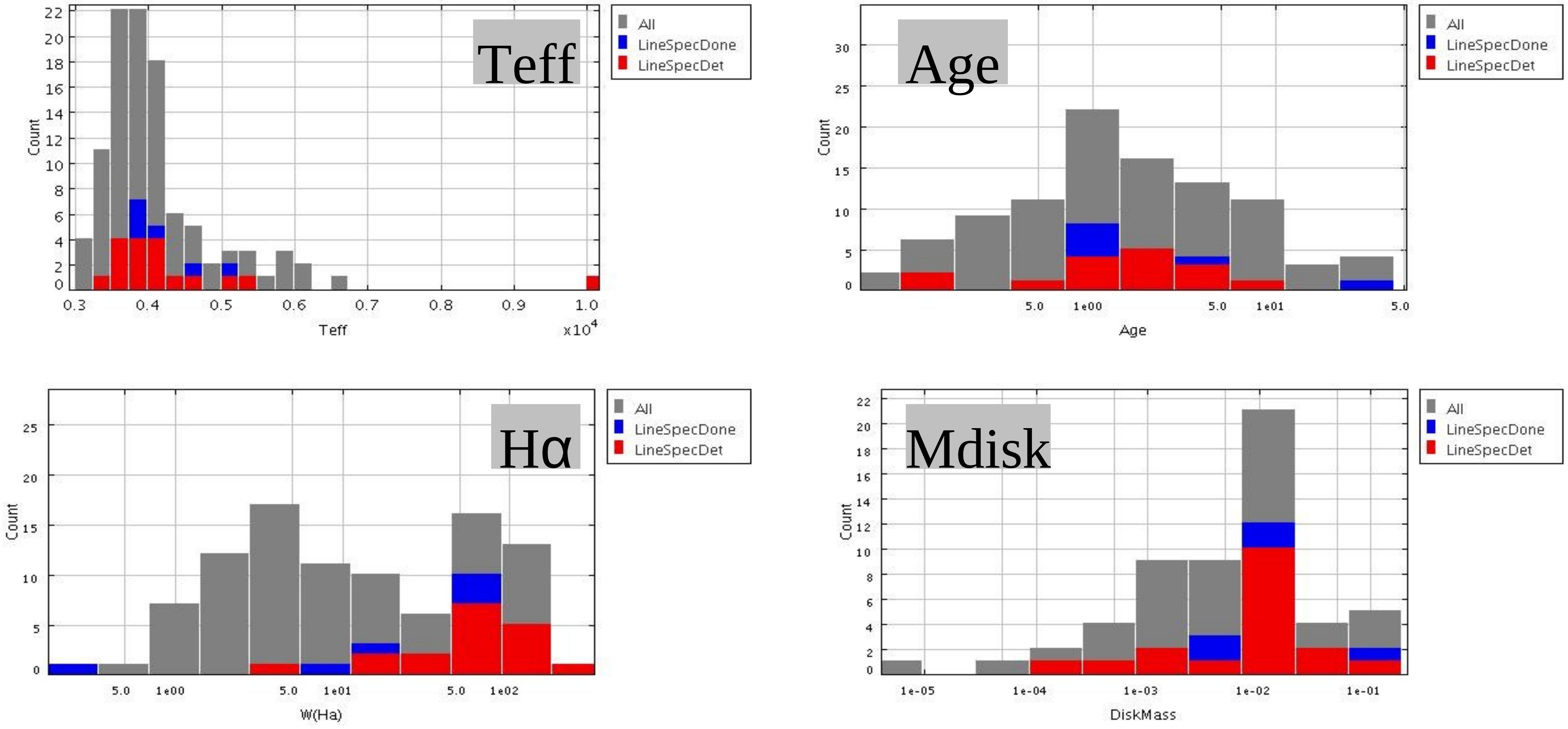


HD181327: Debris, bright in submm

Riaz et al (poster)
Lebreton et al (poster)

Results so far - Taurus

[OI]63um line is seen in TTS over full range of parameter space...

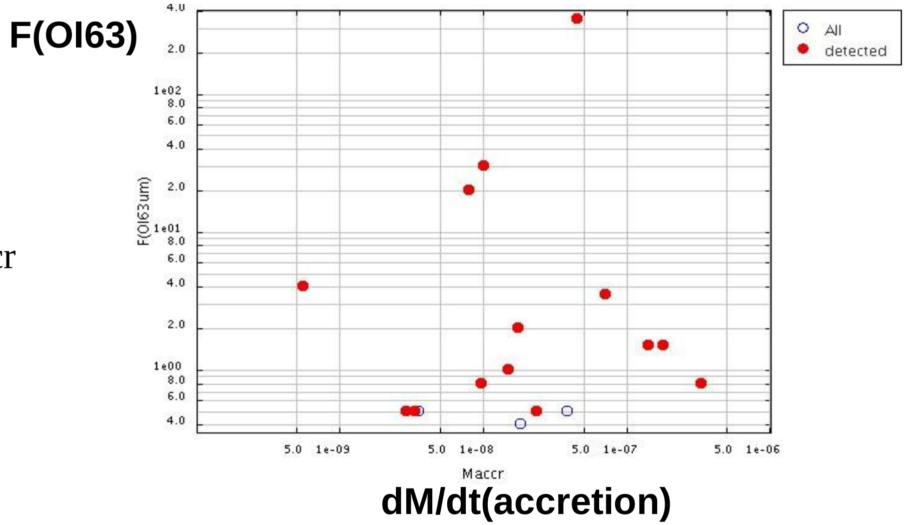


The origin of OI63 ?

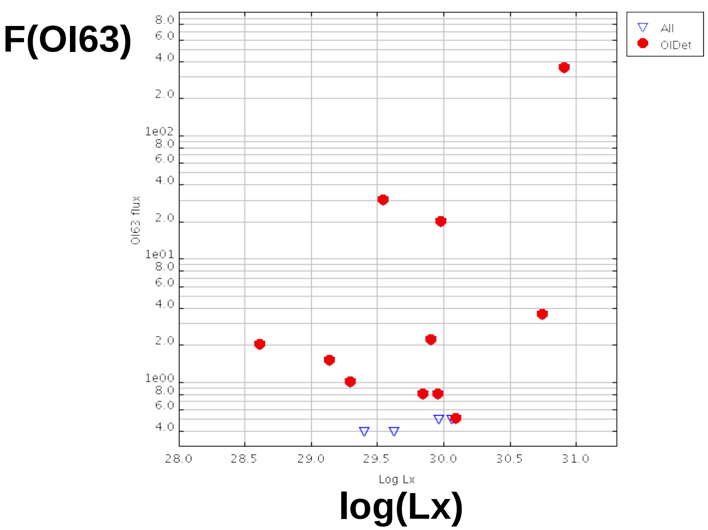
- Disk atmospheres?
- Outflow shocks?
- PDRs?
- Photoevaporated flows?

OI – outflows, X-ray driven?

F(OI63um) is not correlated with M_{accr}



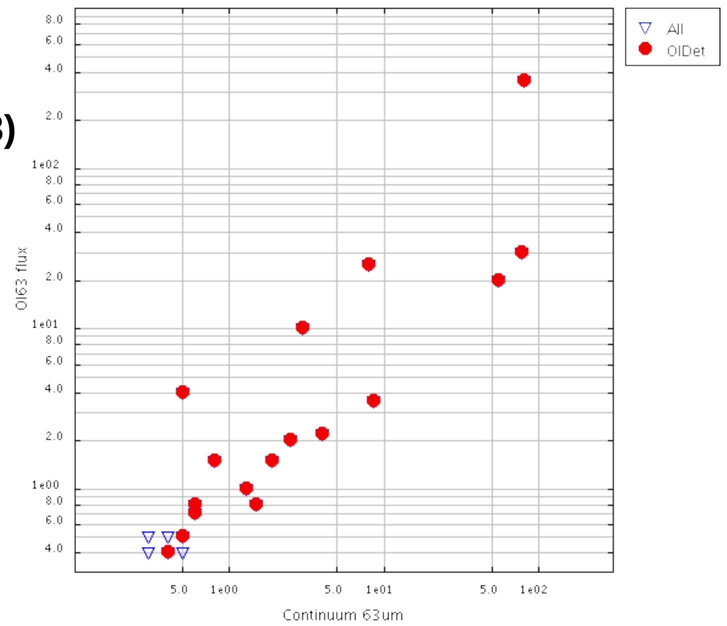
F(OI63um) is not clearly correlated with Lx



What affects OI?

F(OI63um) is correlated with FIR continuum flux

F(OI63)



F(continuum,63um)

Arise from similar disk radii:
=> heated disk atmosphere, good gas/dust mixing

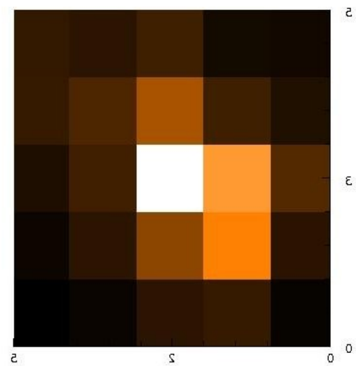
In most cases, line emission is spatially and spectrally unresolved:

- centred on star (radius < 700au)
- dv < 50km/s

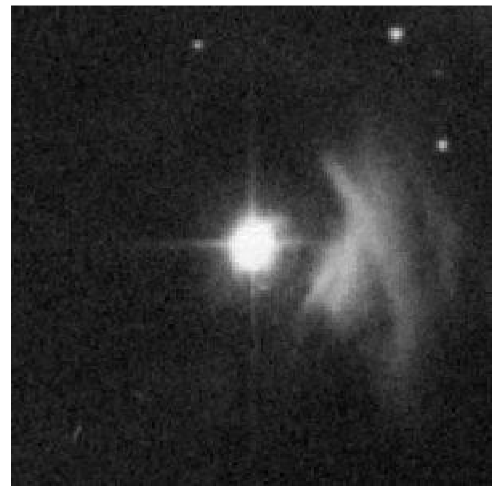
Extended emission cases

T Tau

OI Line emission

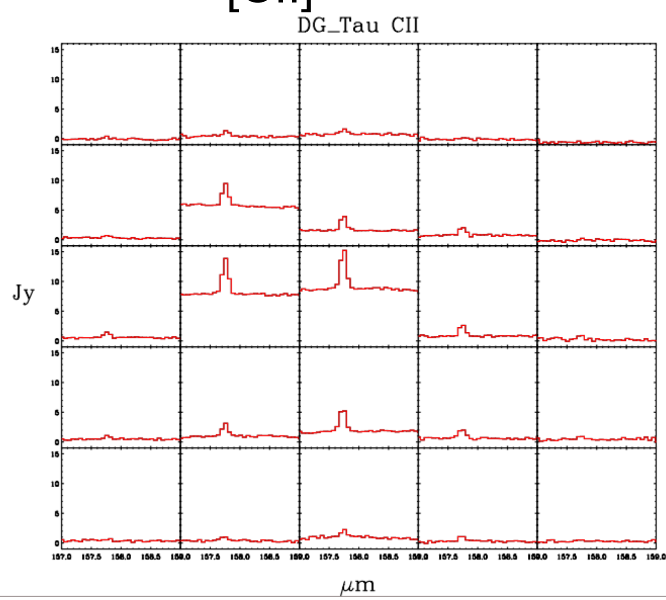


DSS red

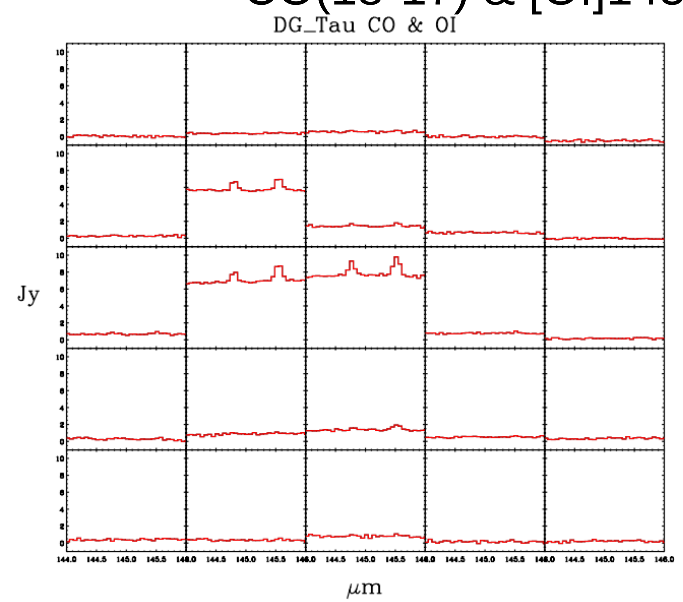


DG Tau

[CII]

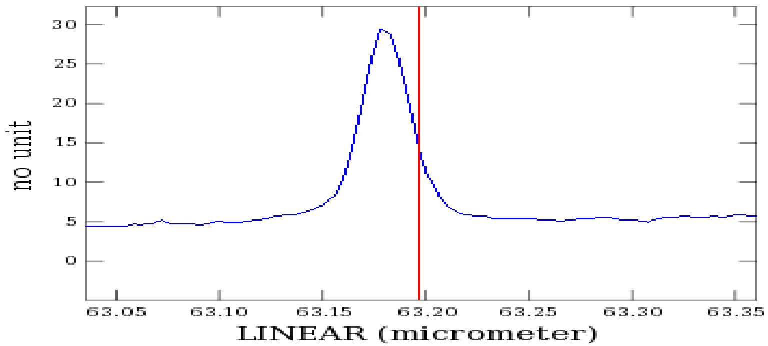


CO(18-17) & [OI]145

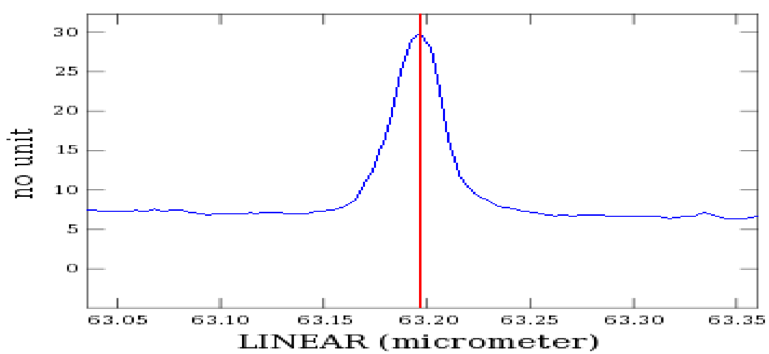


Velocity resolved case

DG Tau

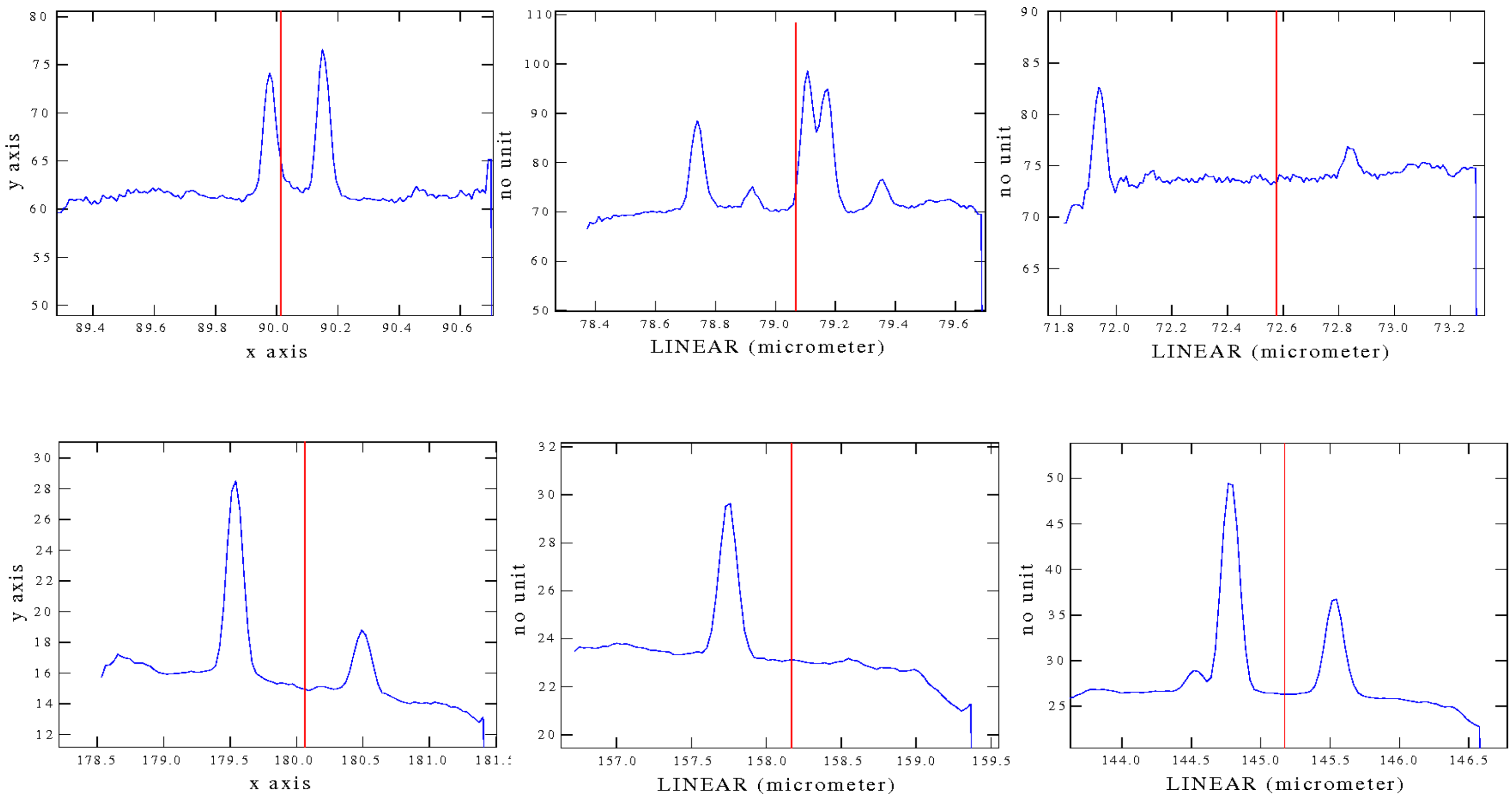


OI – centre



OI – 15arcsec SW (+75km/s)
(but data needs further analysis)

Other lines in T Tauri stars



[OI] 63,145um   [CII] 157um   H2O (5 lines)
CO (4 lines)

Summary (so far)

- [OI]63um is strongest line (by factor 5-10)
- Evidence that in most cases, [OI] is from disk
- In some cases, extended line emission seen (outflows)
- Detectable in disks down to $10^{-5}M_o$ around M stars (lower in HaeBe's)
- [CII] is lower than predicted
- Combining fine-structure lines, CO sub-mm lines and dust SED (mid-ir to submm) with models can give gas:dust ratios
- In some cases, gas/dust ratio ~1

Next steps

- Origin of OI ?
- Fine-structure line ratios ?
- Statistical study of far-ir gas/dust emission
- Comparison with grid of models
- Detailed study of individual systems
- Molecular lines – CO, H2O
- Evolution of gas/dust
- Outflow sources, extended gas & dust