Gas in protoplanetary discs

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On behalf of the GASPS Team (PI: Bill Dent)

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Discs are sites of planet formation

Dissipation of abundant gas when disc evolves:

- limits timescale for giant planet formation
- controls dynamics of planetary bodies during formation
- determines final architecture of a planetary system

Gas makes up 99% of disc mass, but difficult to observe.
=> Not too much known about gas evolution

But brightest lines lie in Far-IR!

Earlier gas disc observations

- UV spectra H, C and some metals in inner regions
- Hot inner few AU discs: near-IR CO and H_2O
- 12.8 um line of [NeII] was detected by Spitzer (but only ionised component close to star)
- Cooler, outer disc: (sub)mm lines of CO and other molecules

But Far-IR lines trace disc radii 5 to 500 AU !

GASPS: the Goals

- Trace gas *and* dust in the planet formation region of discs across an extensive parameter space

- Provide measurement of the *gas* dissipation timescale, to compare with the *dust* dissipation time

- Evolutionary link between protoplanetary and debris discs

- Provide input for disc chemistry models

- Provide an extensive database of observations and models with long-lasting legacy value

GASPS in a nutshell

- ~ 250 sources
- ~ 450 hours
- Mainly gas line scans, some photometry
- Large modelling effort to interpret observations
- Auxiliary data obtained to support interpretation
- Providing an archive for future gas disc studies

The Dent grid: 300000 disc models

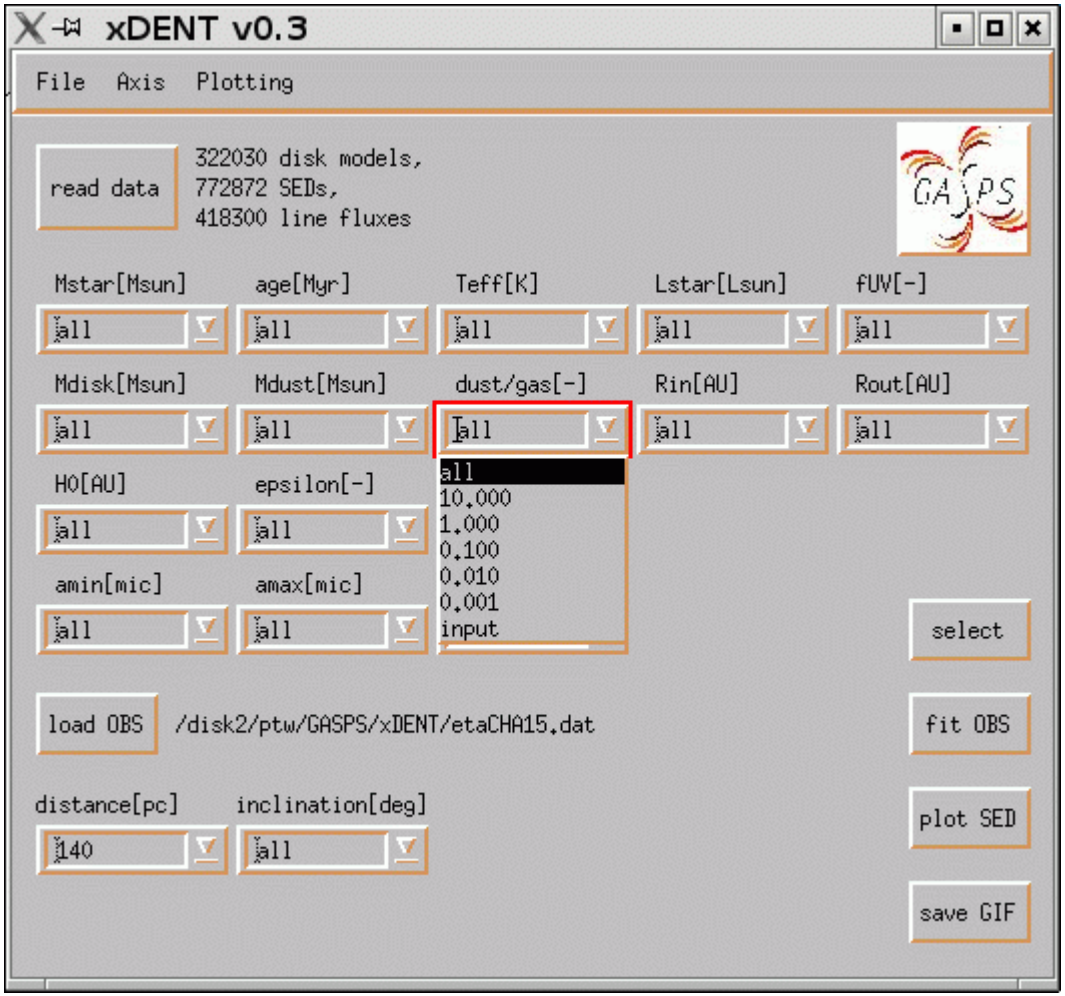
ProDiMo:

thermo-chemical disc code (2D radiative transfer, chemistry, ice formation,...)

MCFOST:

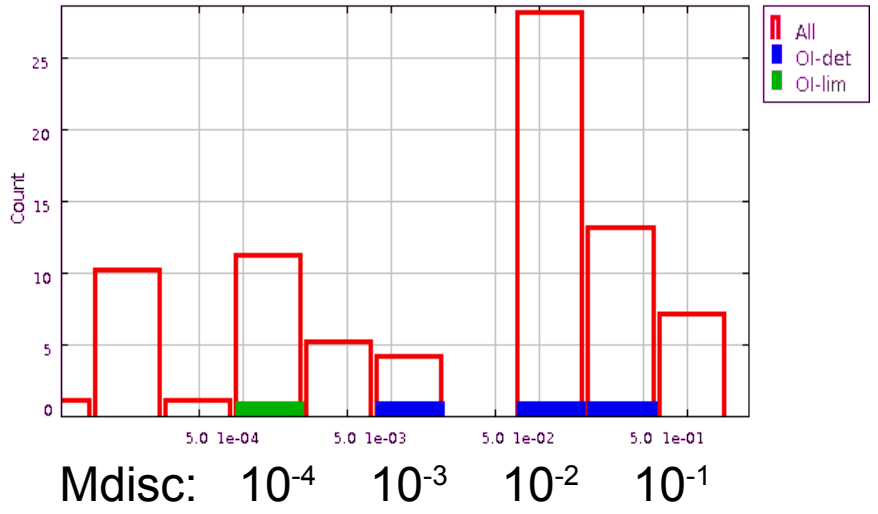
3D continuum and line radiative transfer code

Woitke et al. (2009)

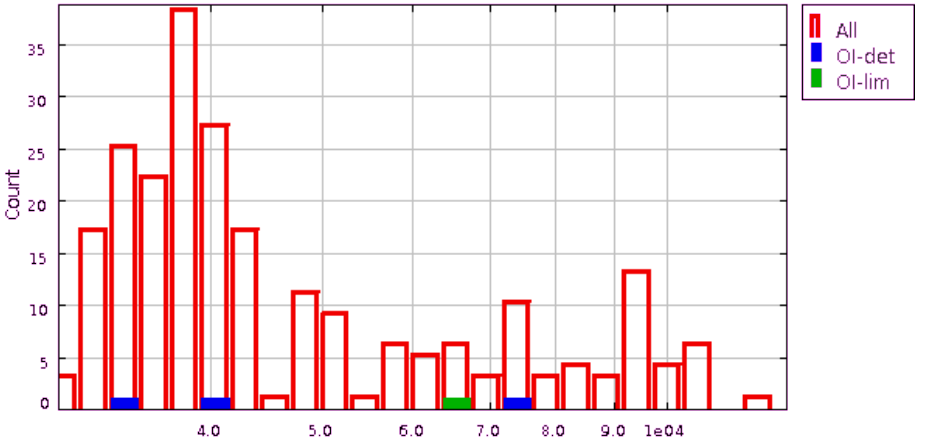


Target Selection

- Located in nearby star formation regions:
  Taurus, BPMG, ε Cha, Tuc Hor, Upper Sco + HAeBe stars
- Measured submm fluxes, Hα, near-IR photometry
- Wide range of dust disc M, sp. type, Lx, age, acc. rate



Mdisc: 10^{-4} 10^{-3} 10^{-2} 10^{-1}



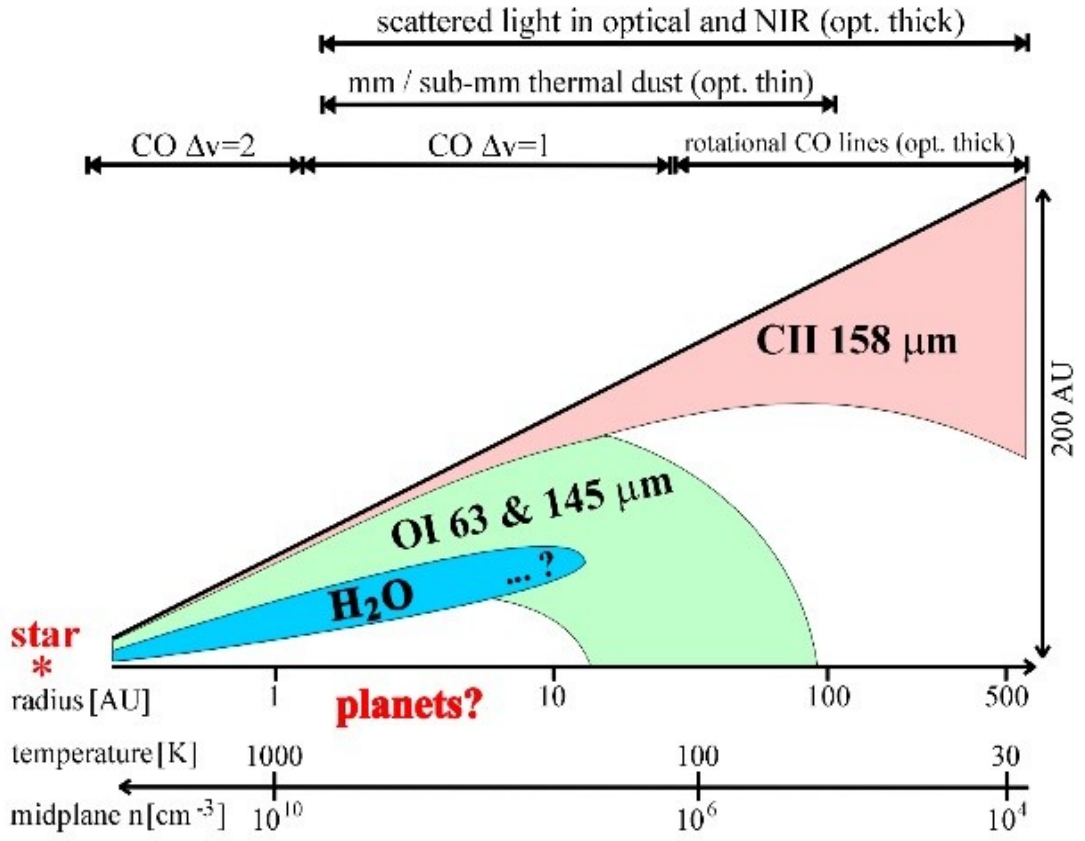
Teff: 4000 6000 8000 K

Blue: targets with OI-63um detections
Green: target with OI-63um upper limit

Different gas transitions trace different regions

Stellar irradiation & disc M determine size radiating region

Lower disc M: more photo-dissociation and ionisation



GASPS: Observations

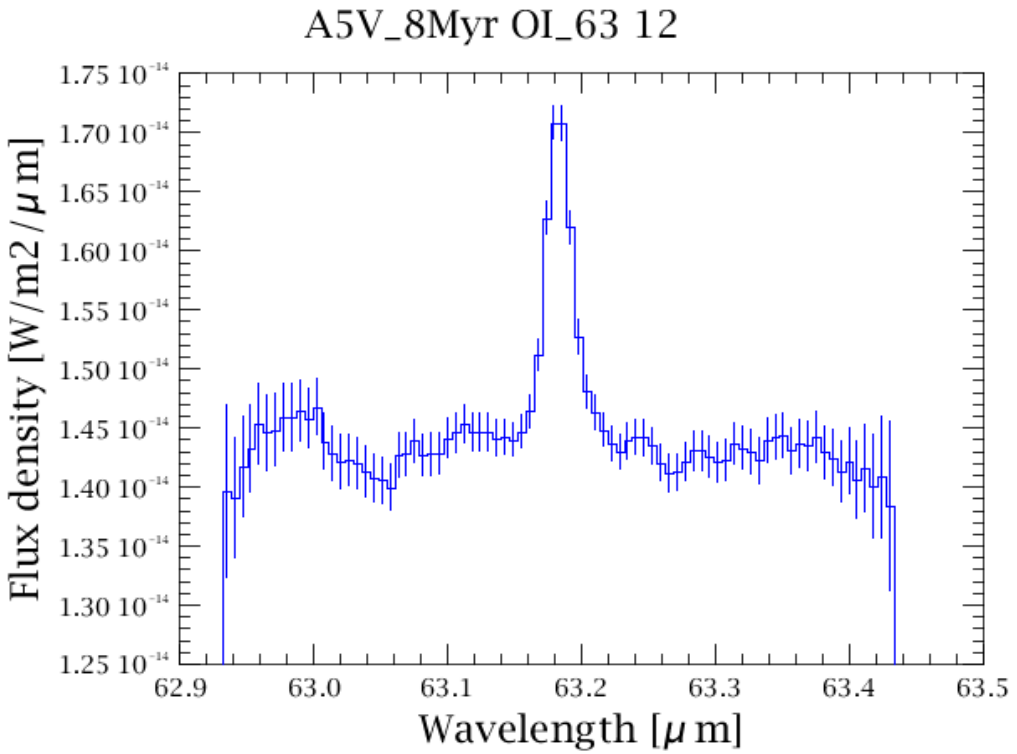
- [OI] at 63.2 and 145.5 micron
- [CII] at 157.7 micron
- H_2O and CO at various wavelengths

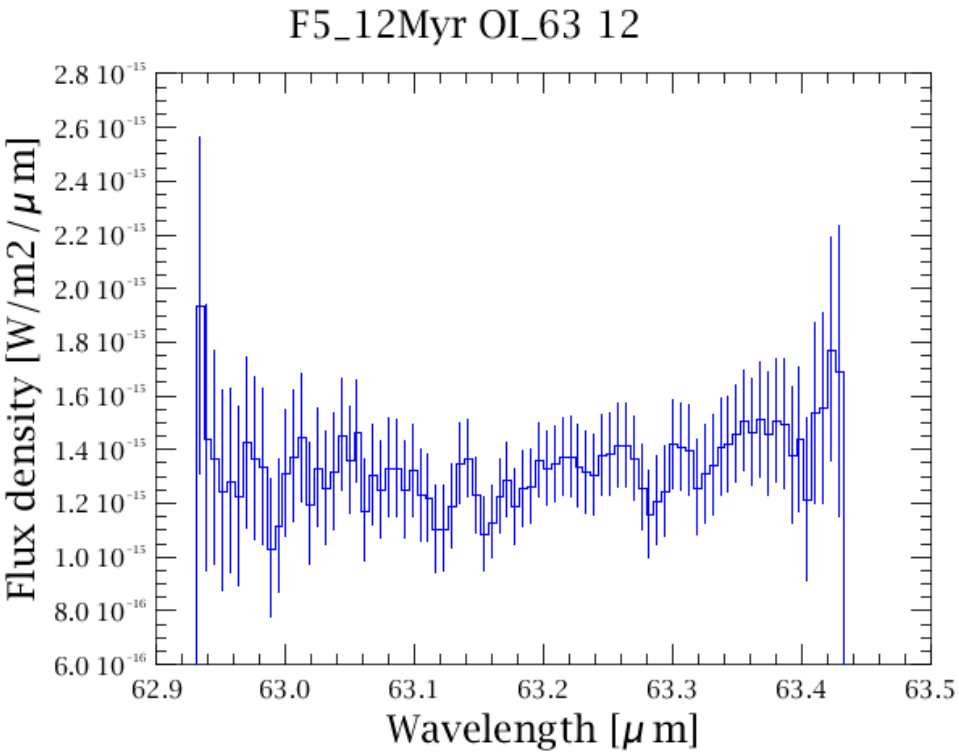
Phase I: PACS line-scan [OI]63 and [CII]158 for all targets

Phase II: PACS range-scan for most promising targets

+ PACS Photometry at 70 and 170 micron

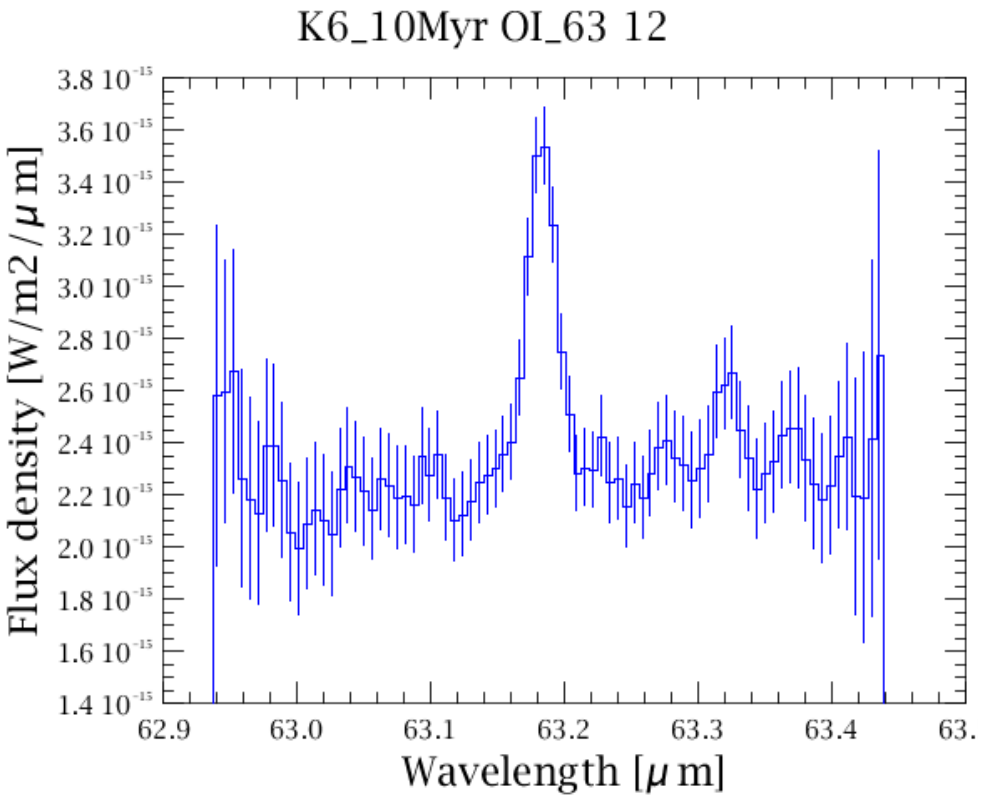
The [OI] 63 micron line

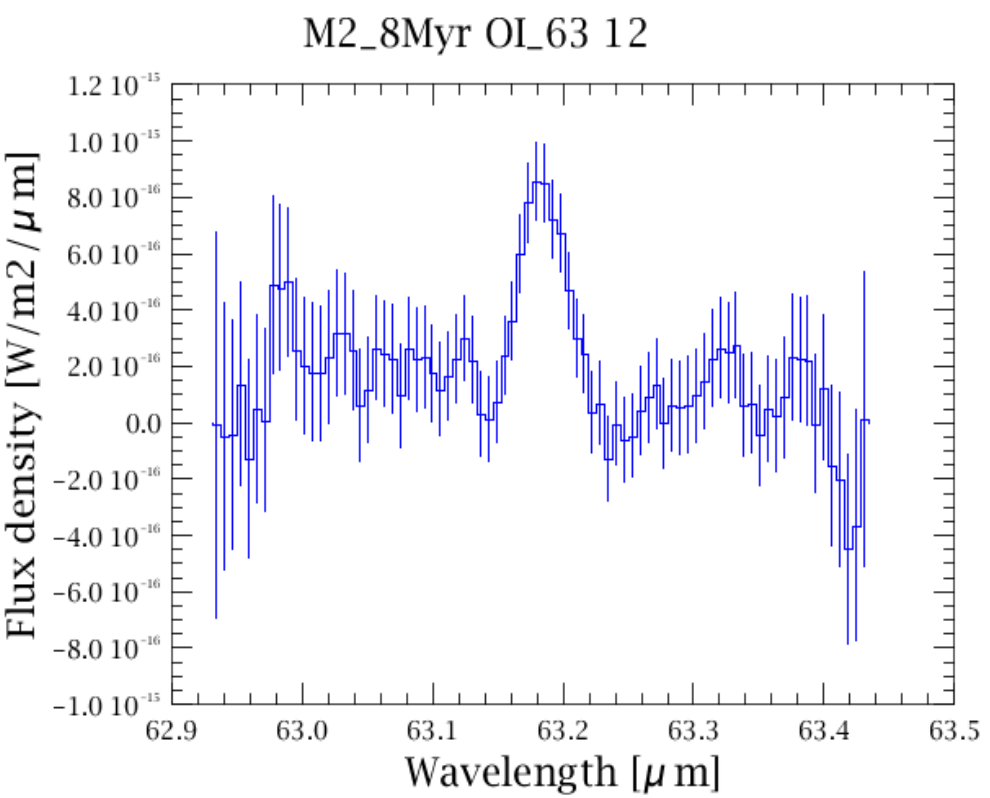




Data Reduction by G. Matthews, C. Howard and B. Vandenbussche

The [OI] 63 micron line





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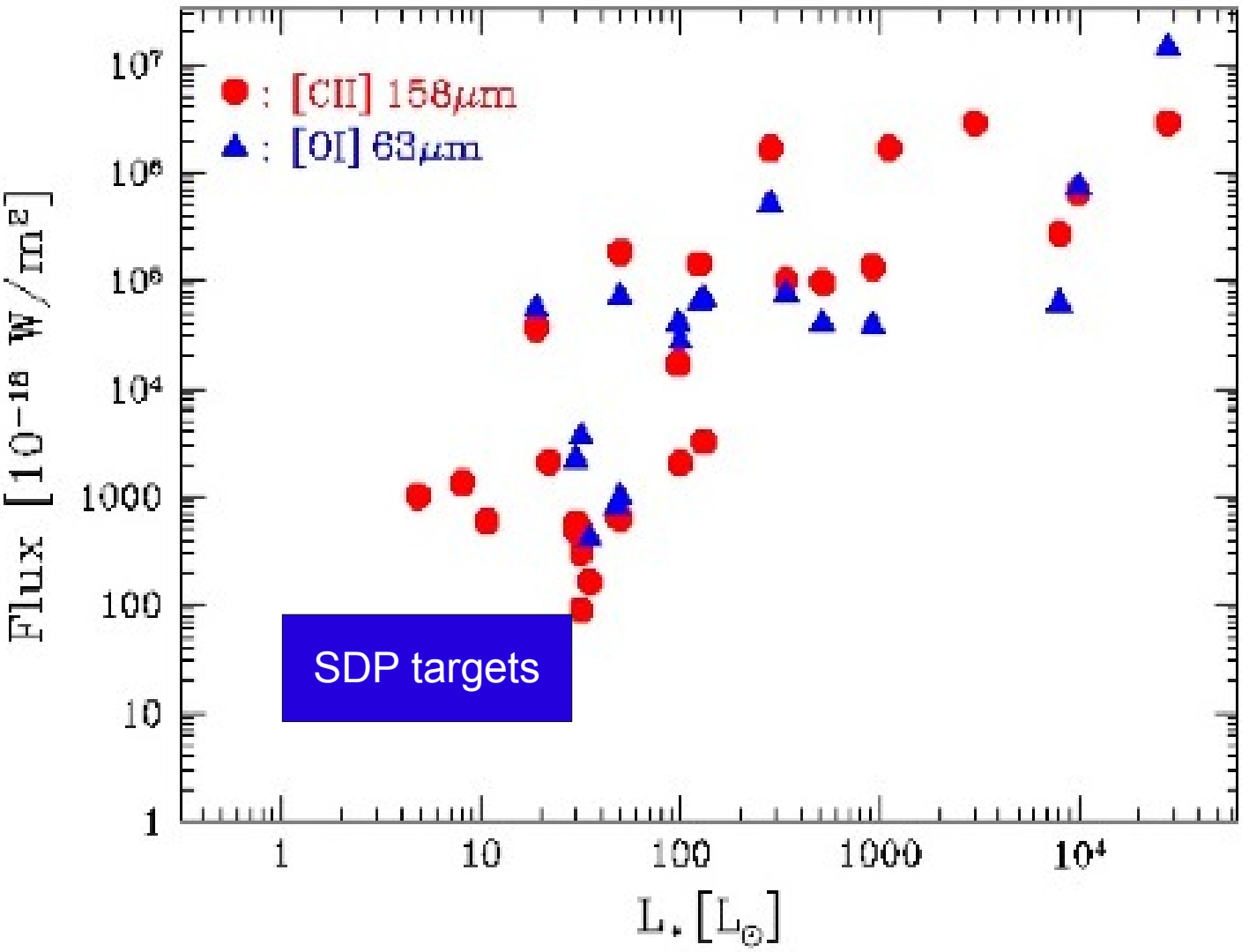
[OI]63 micron line flux

Herbig Ae	A5	8 Myr	6.7 E-17 W/m2
CTTS	K6	10 Myr	3.3 E-17 W/m2
CTTS	M2	8 Myr	2.9 E-17 W/m2
Debris disc	F5	12 Myr	< 3.3 E-18 W/m2

=> in agreement with model predictions

50% error max., to be revised downwards

[OI]63 micron line: comparison with ISO observations



ISO limit ←

Herschel limit ←

Based on data from Lorenzetti et al. 2002

More to come soon...