Circumstellar Discs

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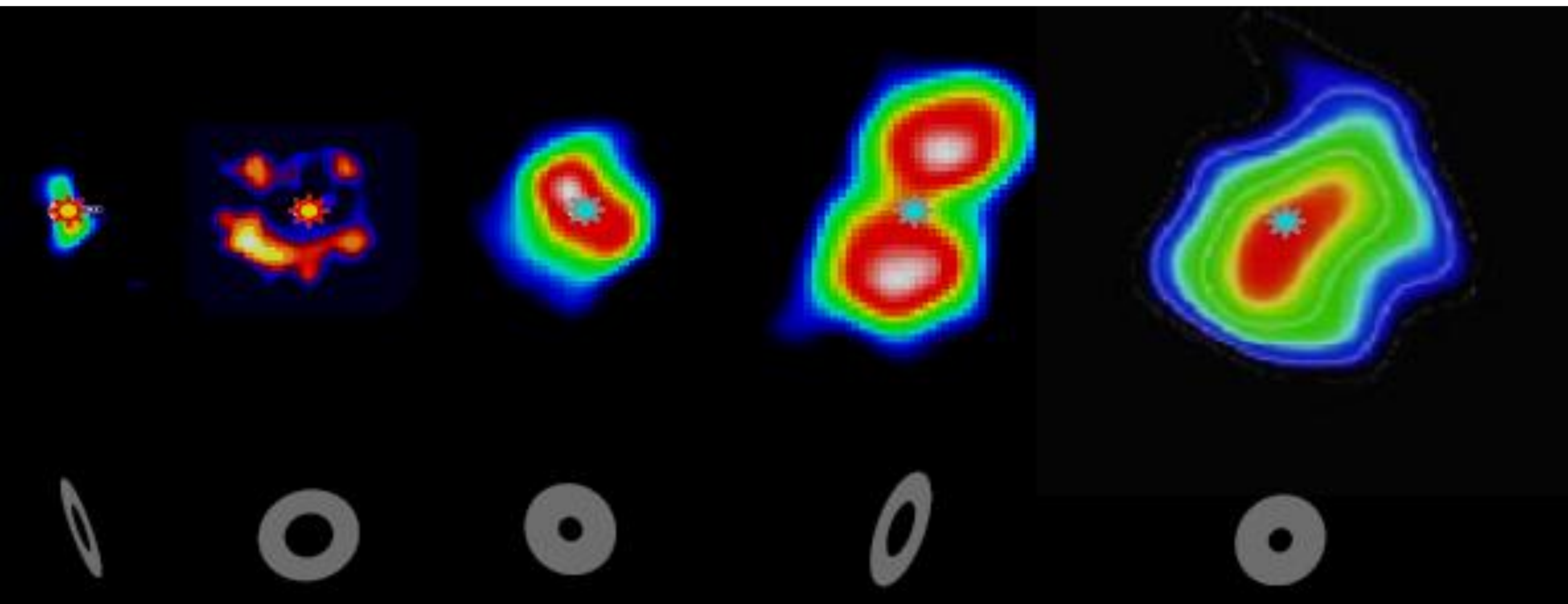
big questions

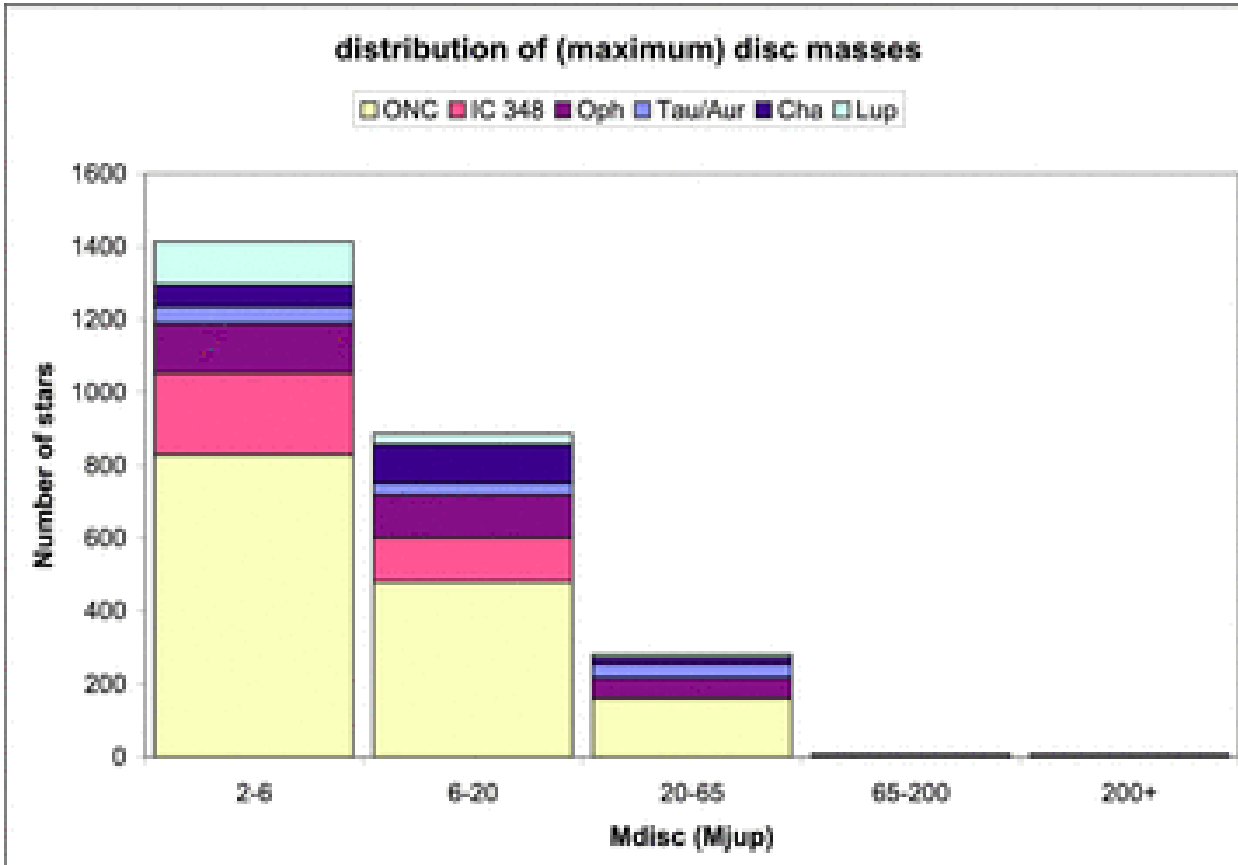
- do all star systems form planets?
- what disc and/or environment properties dictate the planetary system architectures?
- what is the disc like internally? (chemistry, ionisation, flows…)
- can stars form without discs?
- when do stars lose discs?
- is the Solar System unusual?

the past & the present

- SCUBA opened up debris disc imaging
  - unique data on perturbations by planets

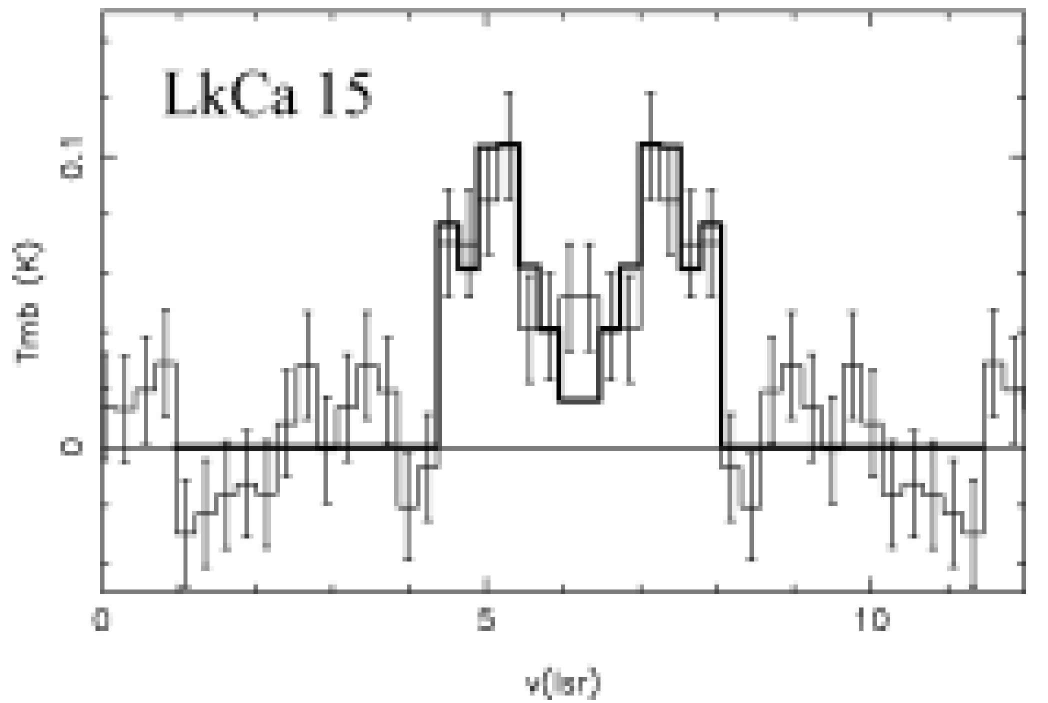


- submillimetre surveys have also been very sensitive to dust(+gas) mass in proto-planetary discs



Greaves & Rice (2010)

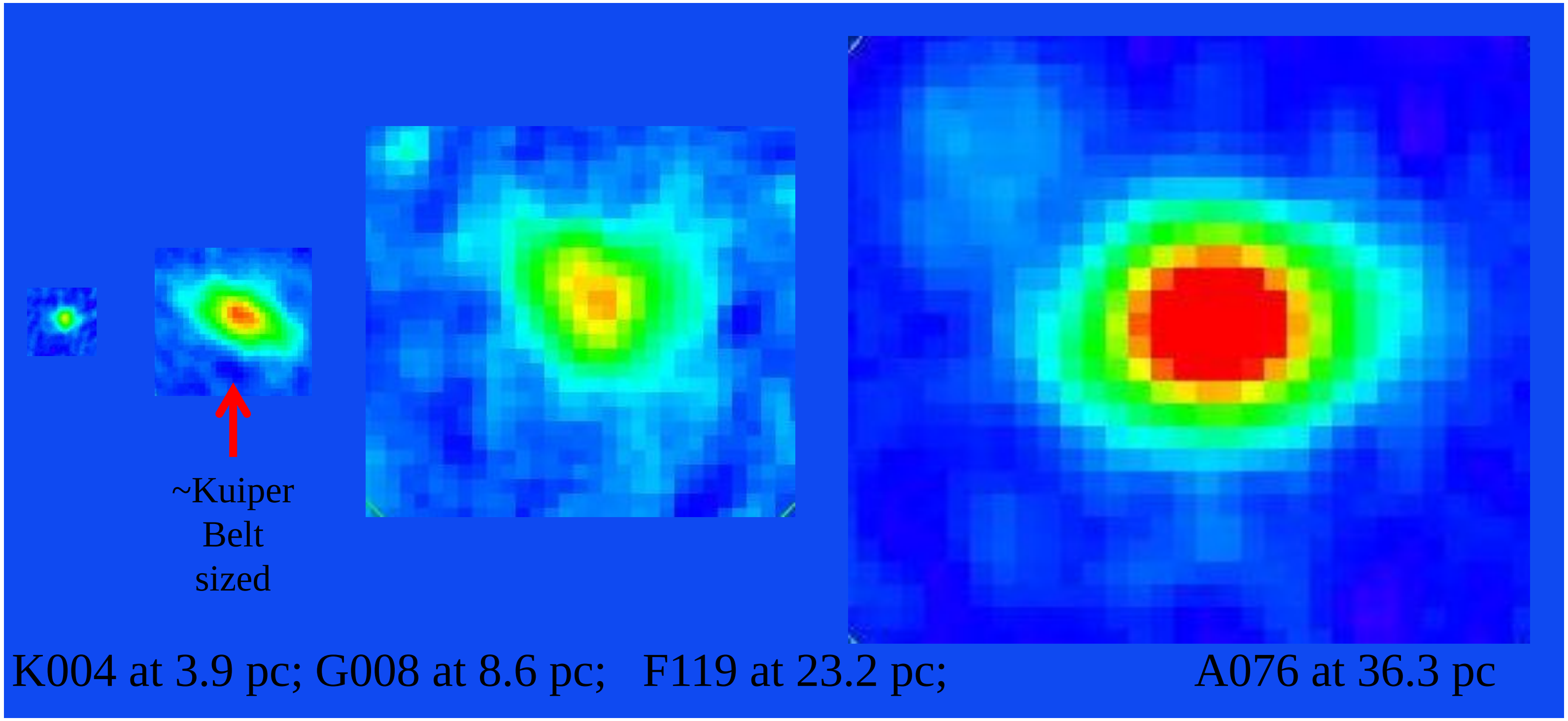
- while detecting the gas component in proto-planetary discs is slow, even for receivers near the quantum limit



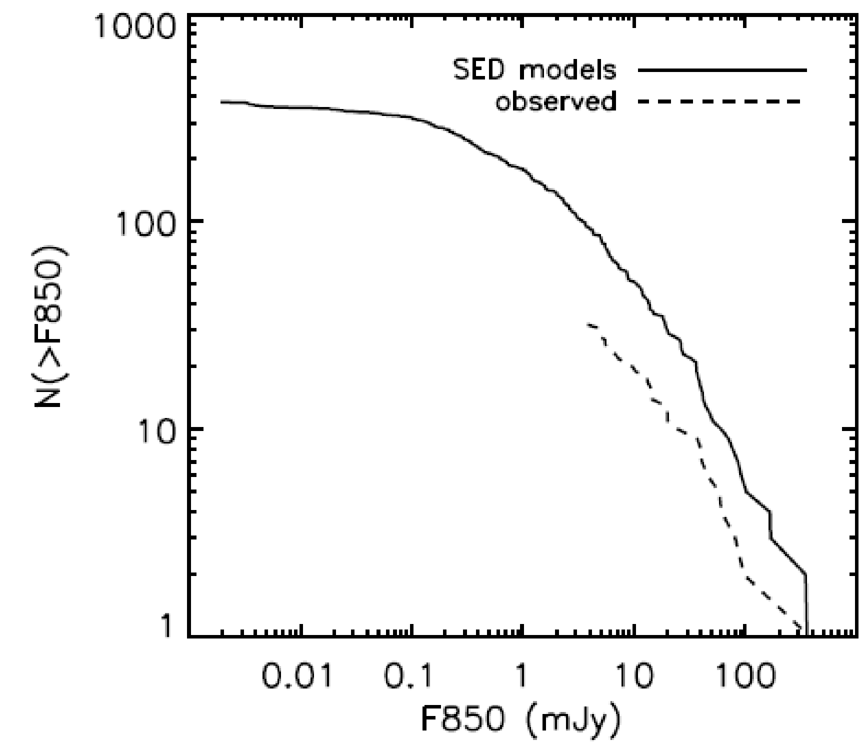
HCO+ 4-3 in a transition disc, ~2 hours of observation

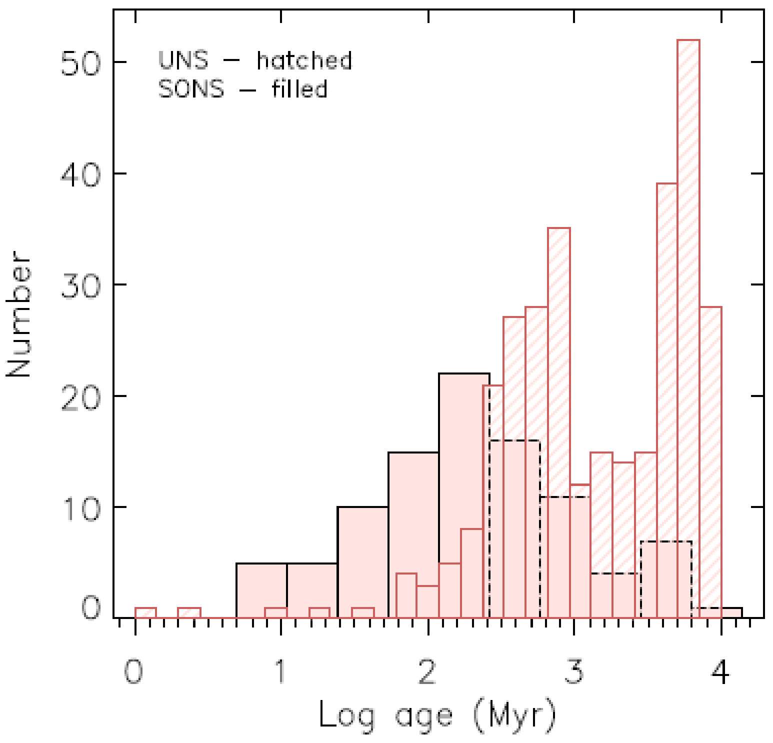
the survey era

- complete volumes have been explored for debris discs, with Spitzer and Herschel

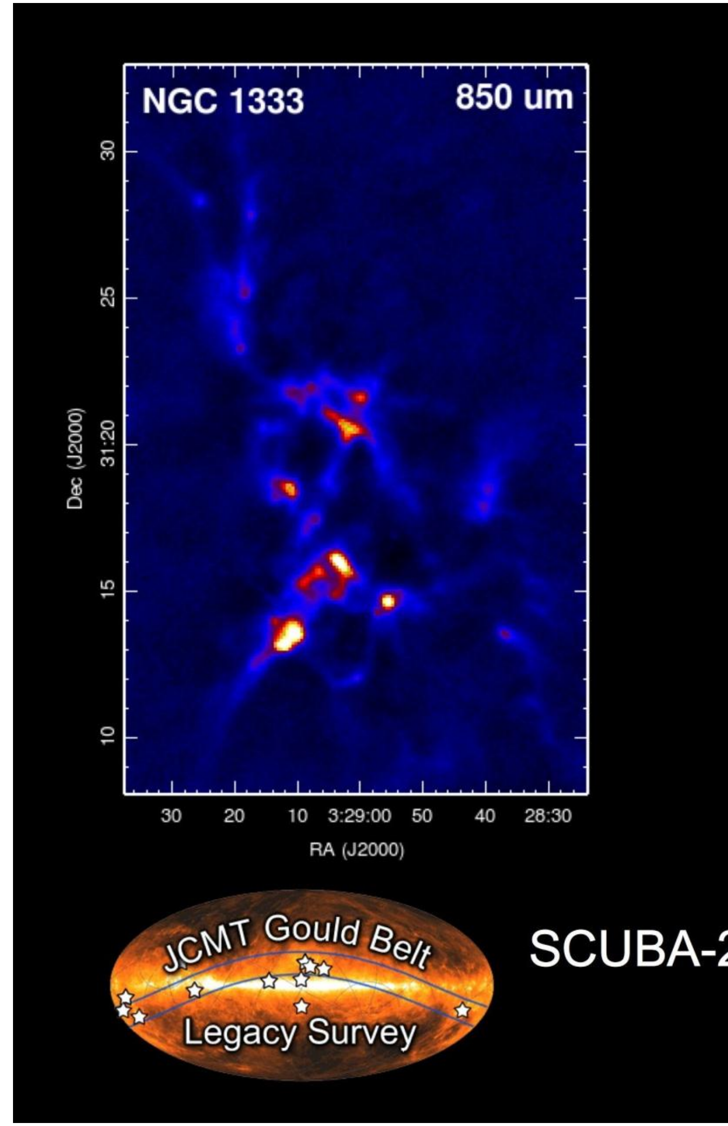


- SONS is expected to be 'definitive' for debris discs out to ~75 pc
  - to near 850 micron confusion limit
  - comprehensive parameter space of M_*, r_{disc}, t, planets…



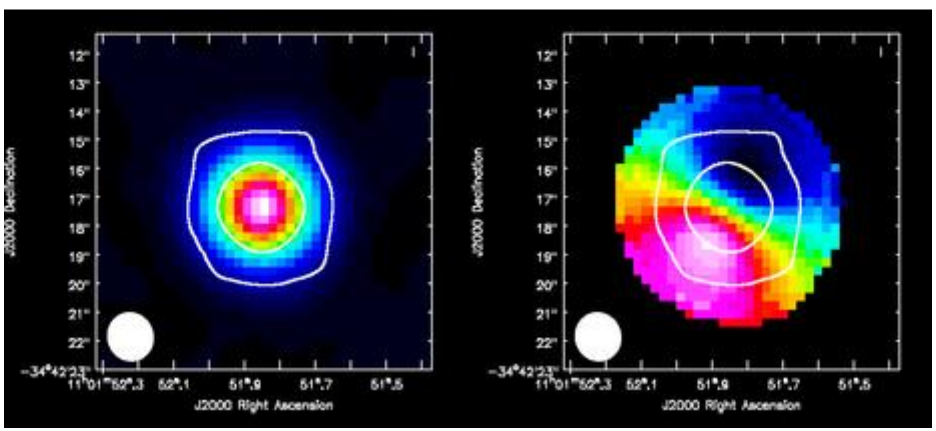


- Gould Belt and Galactic Plane surveys cover ~all known modes of star formation
  - with SCUBA-2, deep enough for discs to 100's pc
  - but $^{(13)}C^{(18)}O$ spectra *not* suitable

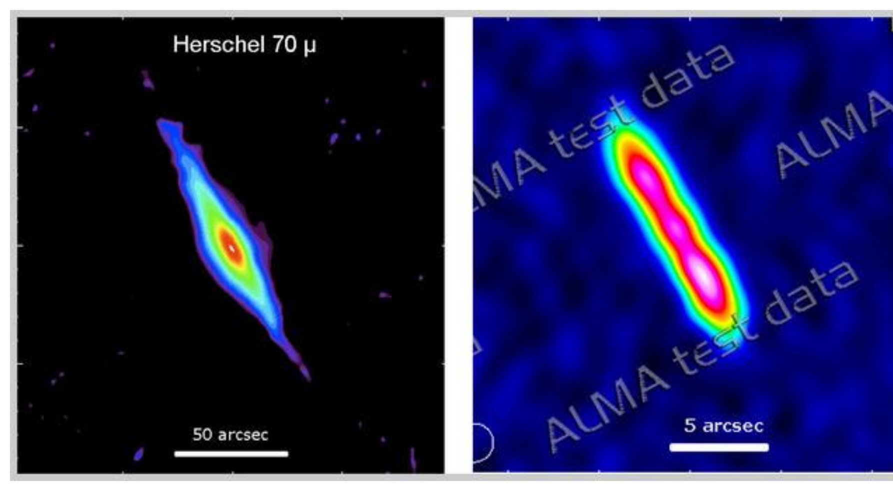


the high resolution era

- with SMA, CARMA, EVLA and ALMA, internal structures of many discs can be imaged (at least, one by one… insight via details)



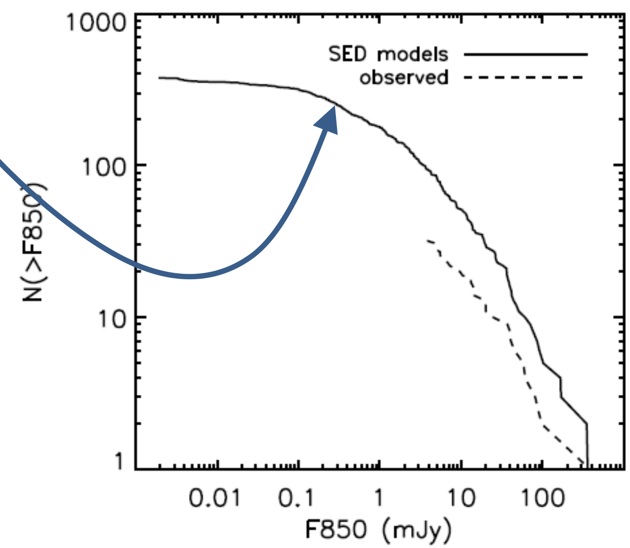
TW Hya in HCO^+ 4-3 with ALMA



ALMA test image of beta Pic at 850

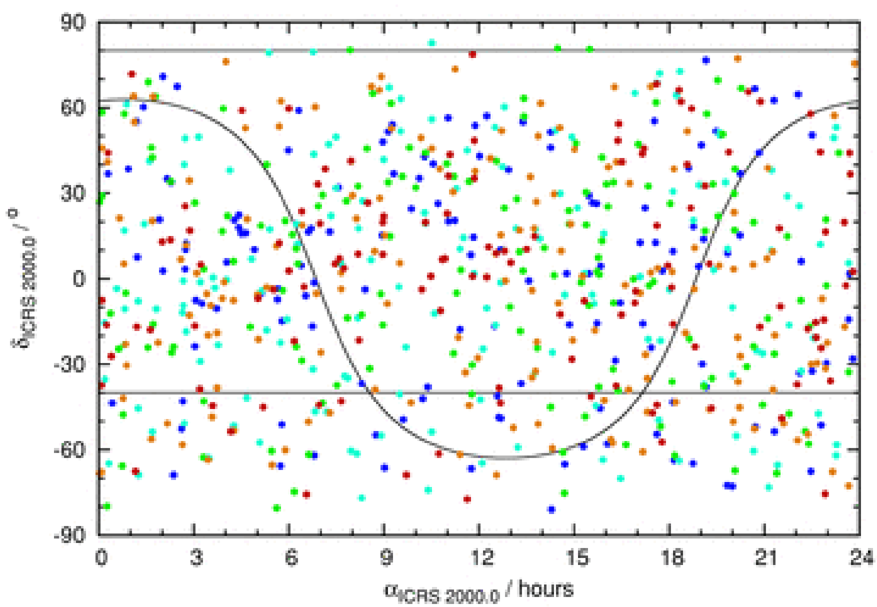
- CCAT will offer good resolution, low confusion and high sensitivity for wider-ranging disc surveys

	NEFD	confusion	beamsize
	(mJy Hz$^{-1/2}$)	(mJy/beam)	(arcsec)
350 μm	23	1.3	3.5
850 μm	7	0.9	8.5



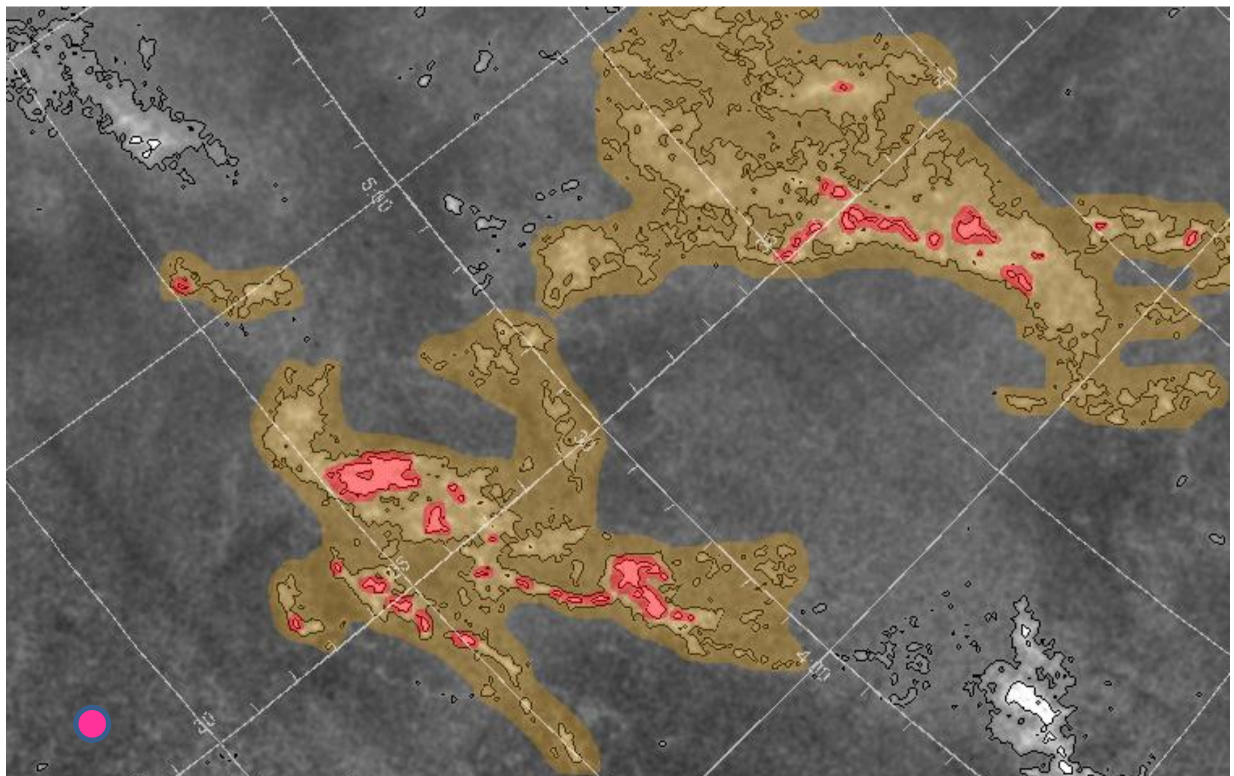
the wide-field era of ~2020

- circumstellar discs are by nature *compact!*
  - young discs lie in tight groups → loose associations
  - debris discs are scattered on the sky
    - *not* natural targets for wide-field imaging, except for limited categories such as wide multiple systems



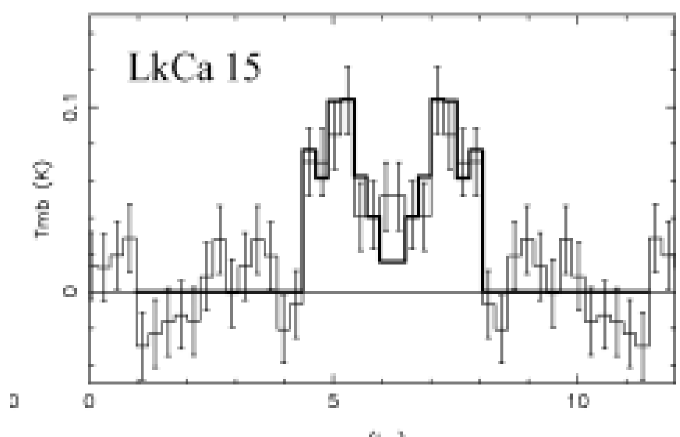
SUNSS targets (Neil Phillips)

- ~0.5° field is ideal for looking at the environments feeding circumstellar discs… *where do future planet-hosts come from? is accretion stochastic? does ejection cut off growth? when do discs disperse and why? etc etc etc etc…*

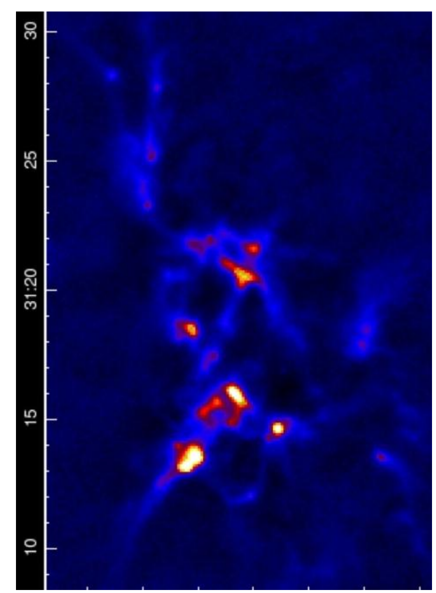


Taurus/Auriga (Dave Nutter)

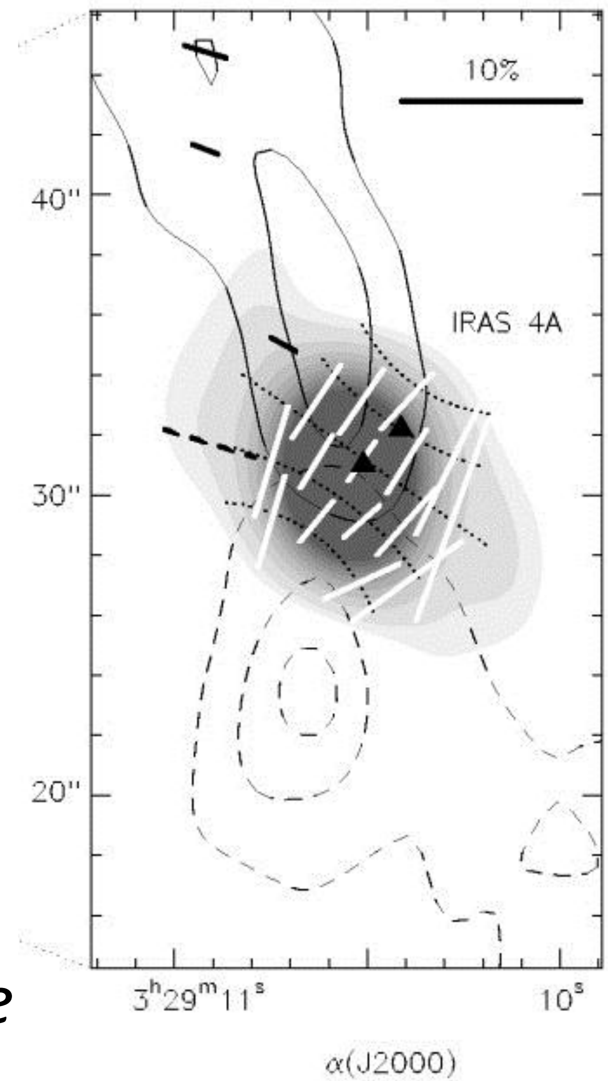
- multi-object spectroscopy is vital for studying disc structure through density tracing lines… *when do inner holes form in relation to planet formation timescales? what is the distribution of mass? what stellar drivers enhance or kill planet-forming processes? etc etc etc …*



improving this spectrum is a current 30-hour project… but many discs in clusters!



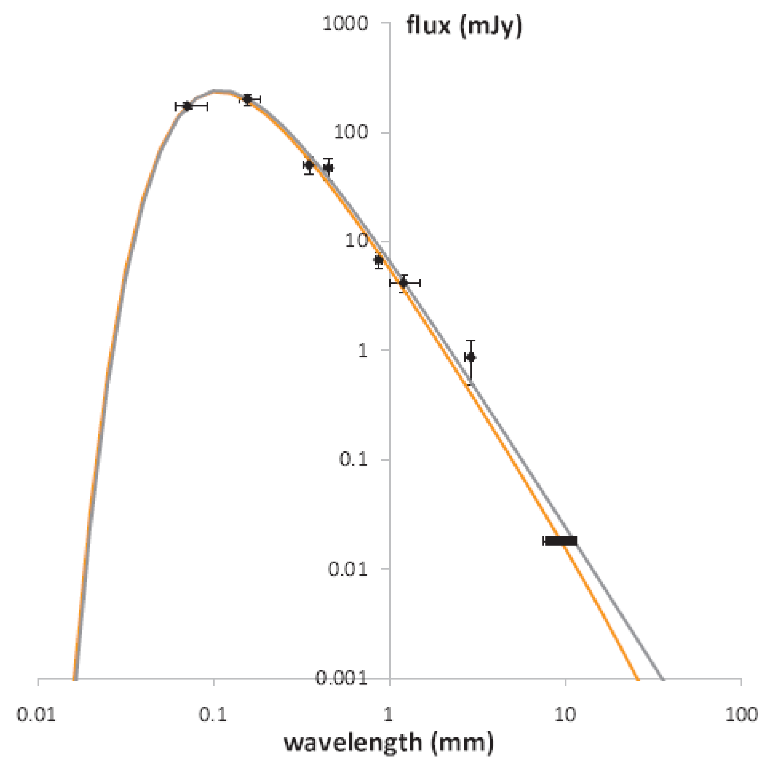
- similarly, polarimetry (continuum and line) vitally depends on having multi-object capability… *are discs magnetised, as in MHD models of star formation? where are the magnetised zones? do the circumstellar fields promote outflow? can they provide a brake for stellar spin-up? etc etc etc etc…*



Girart et al. (1999!)

guest instruments

- a multi-band photometer would be highly useful!
    - e.g. student-led instrument?
  - e.g. this debris disc study includes photometry from ~10 telescopes
  - 0.2-2mm photometer could give fast and reliable disc science!



conclusions

- much ground will have been covered by the 2020 era…
- but for proto-planetary discs, there is much we will *not* know about the cloud-star-disc-planet connection
- wide-field capability is key
  - imaging whole clusters
  - multi-object spectroscopy, polarimetry and spectro-polarimetry