DiSCS:

A spatially and spectroscopically resolved survey of chemistry in protoplanetary disks

Karin Öberg

DISCS team:
Charlie Qi, David Wilner,
Sean Andrews, Catherine Espaillat,
Tim van Kempen, Ted Bergin,
Jeffrey Fogel, Ilaria Pascucci

Collaborators:
Brian Svoboda,
Christian Brinch

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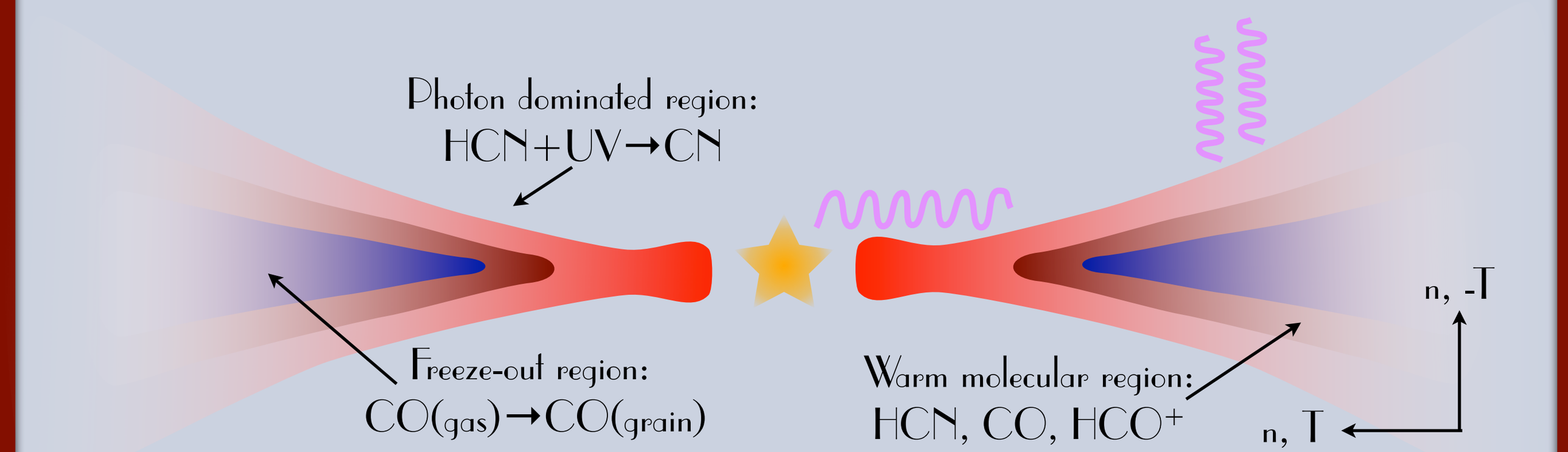
Connecting the physics and the chemistry

How is the physics traced by the chemistry?

How is the chemical evolution affected by the physics?

- ★ Disk structure: CO, ^{13}CO and HCO^+
- ★ Radiation: CN/HCN (Bergin et al. 2003)
- ★ Deuteration: DCO^+/HCO^+ and DCN/HCN
- ★ Cold grains/gas: N_2H^+, H_2CO, DCO^+



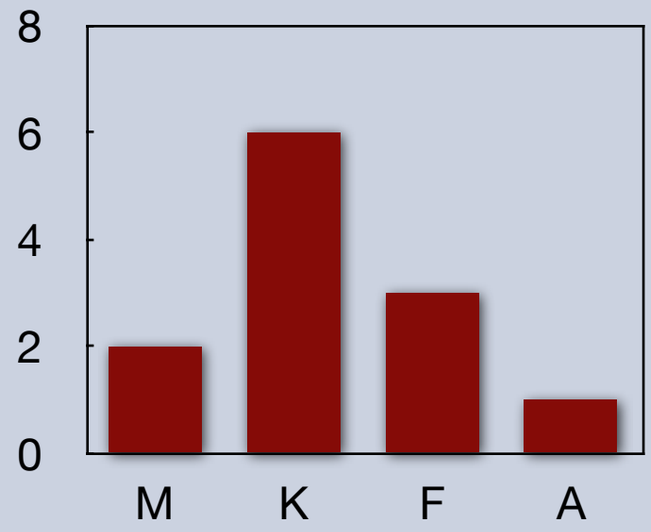
Single dish observations: Dutrey et al. 1997, Thi et al. 2004, Kastner et al. 2008
Resolved observations: Dutrey et al. 2007, Qi et al. 2008, Henning et al. 2010

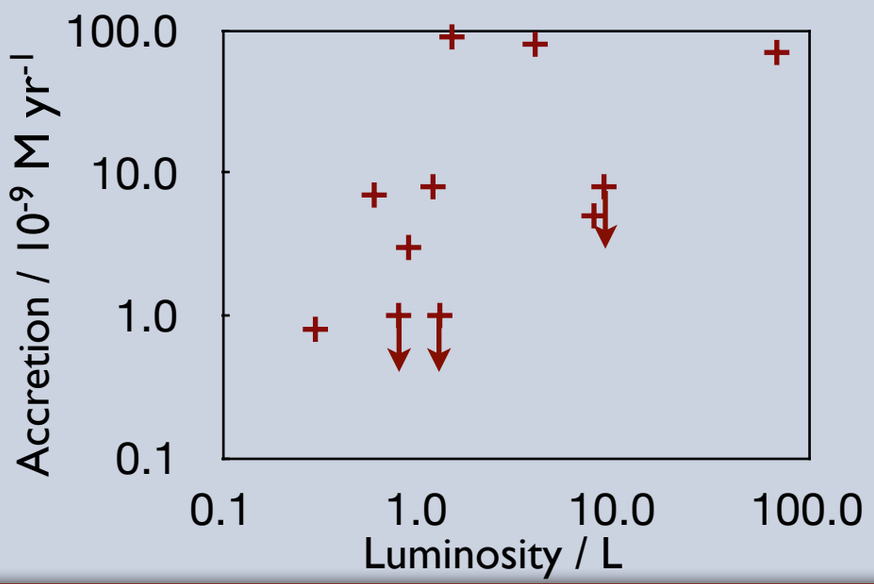
Disk Imaging Survey of Chemistry with the SMA

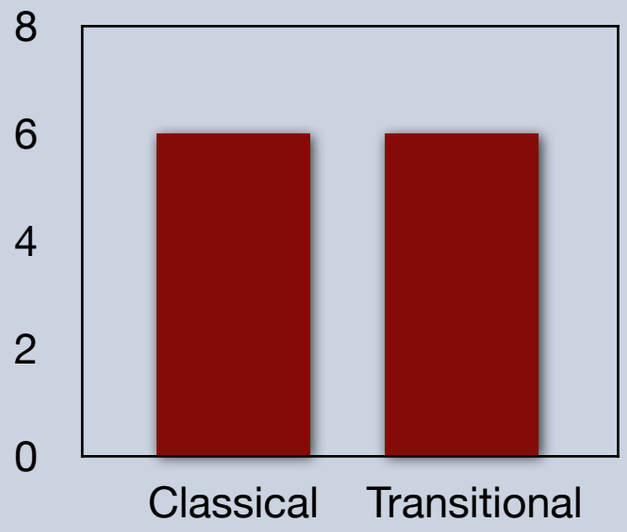
20 track survey of 10 molecular lines toward 12 protoplanetary disks:

CO 2-1, HCO^+ 3-2, DCO^+ 3-2, N_2H^+ 3-2, H_2CO 3-2, 4-3, HCN 3-2, DCN 3-2, CN 2-1

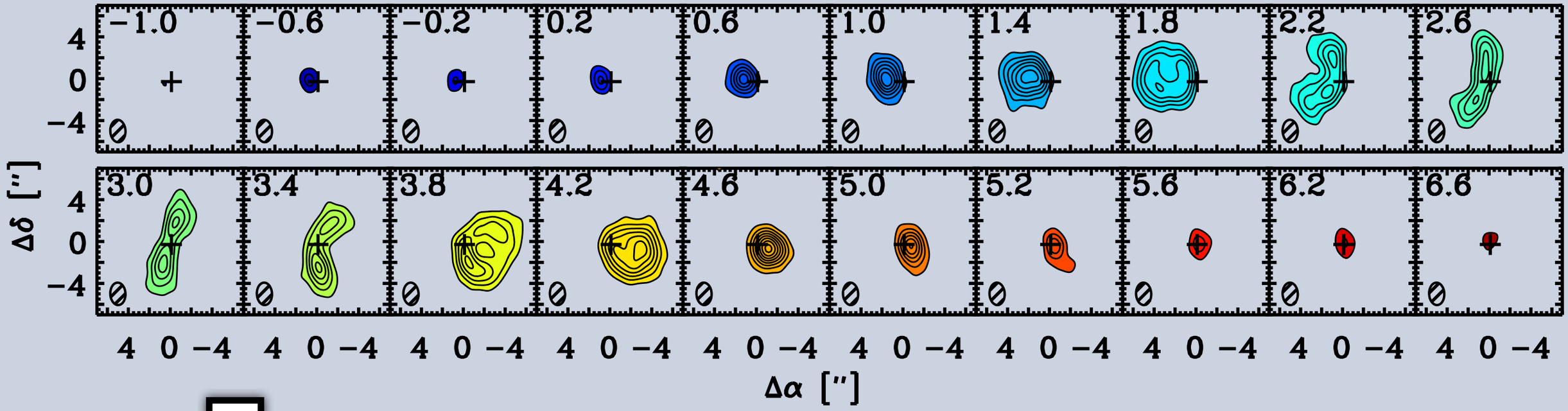
SMA compact configuration ~ 2-3” resolution ~ 100-400 AU

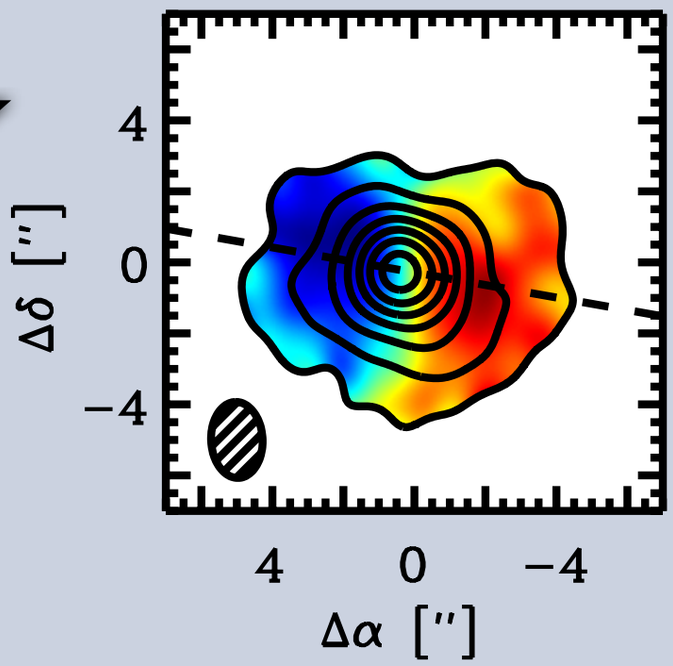


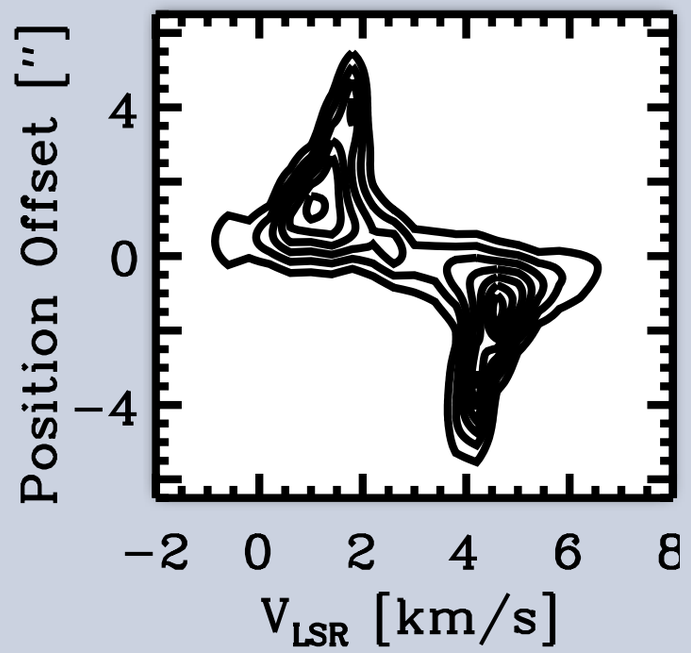


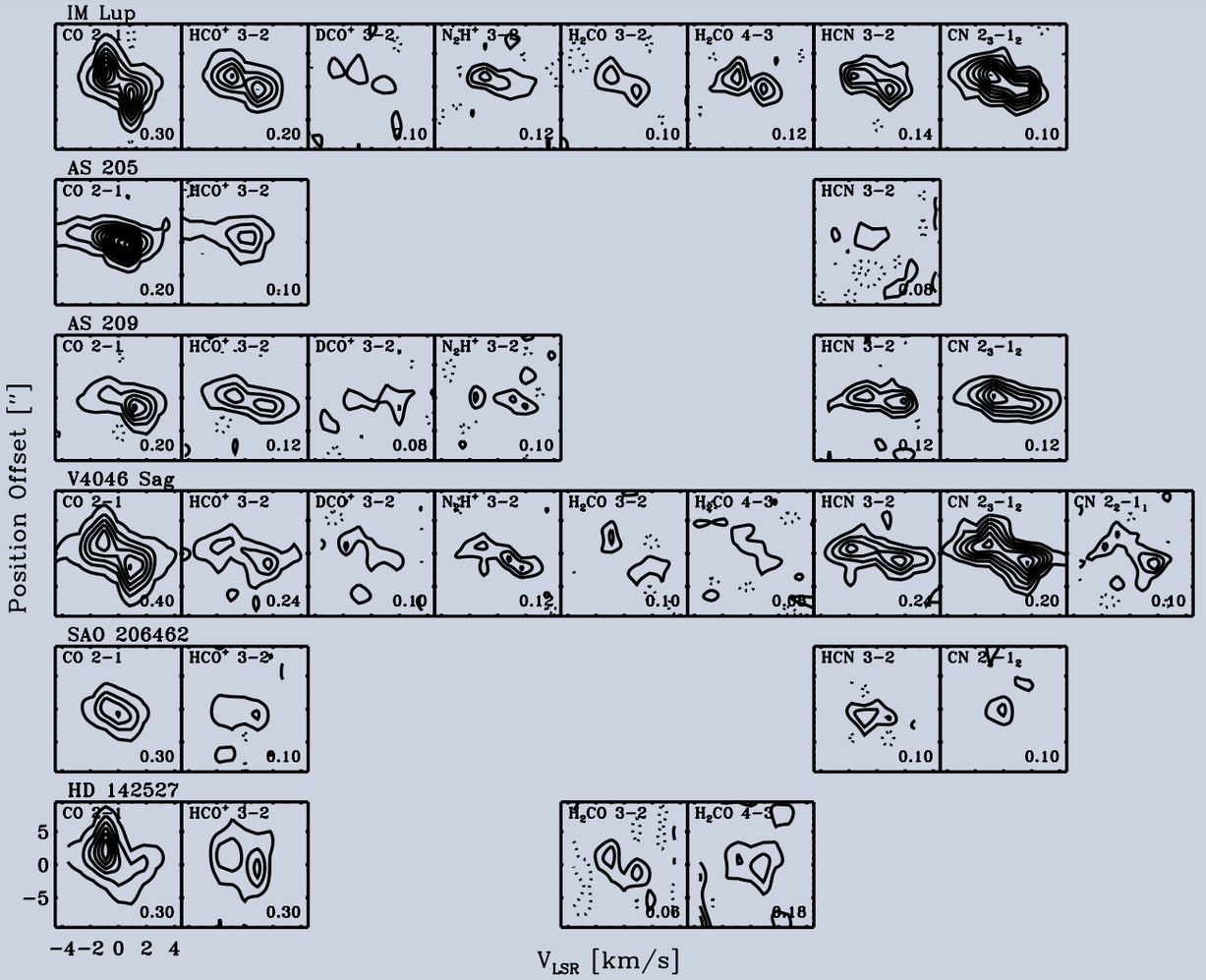


Visualizing spatial distributions:
CO in V4046 Sgr



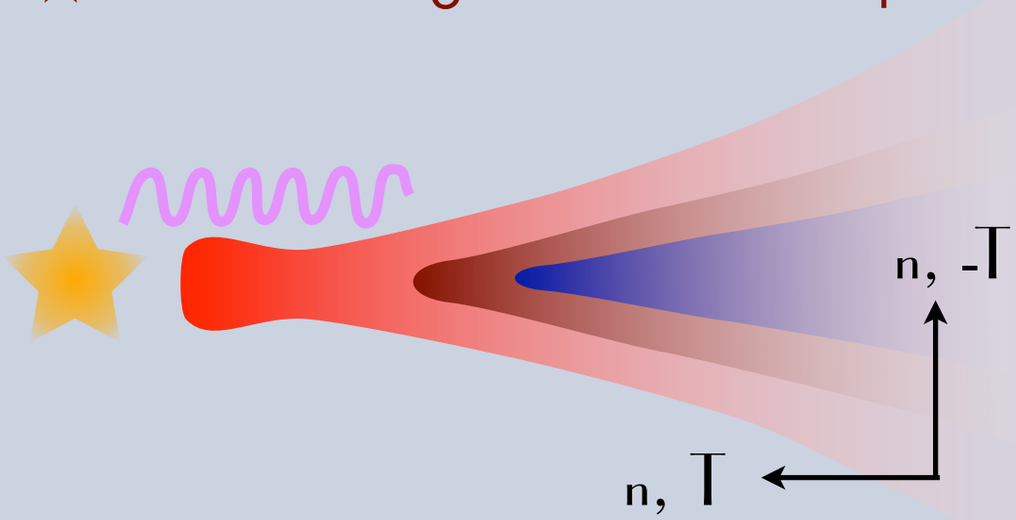


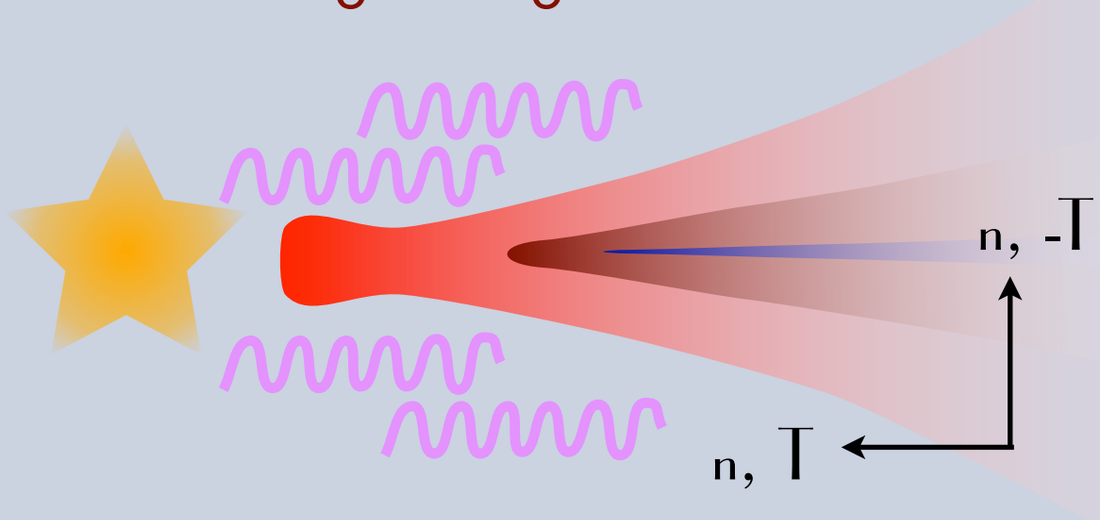




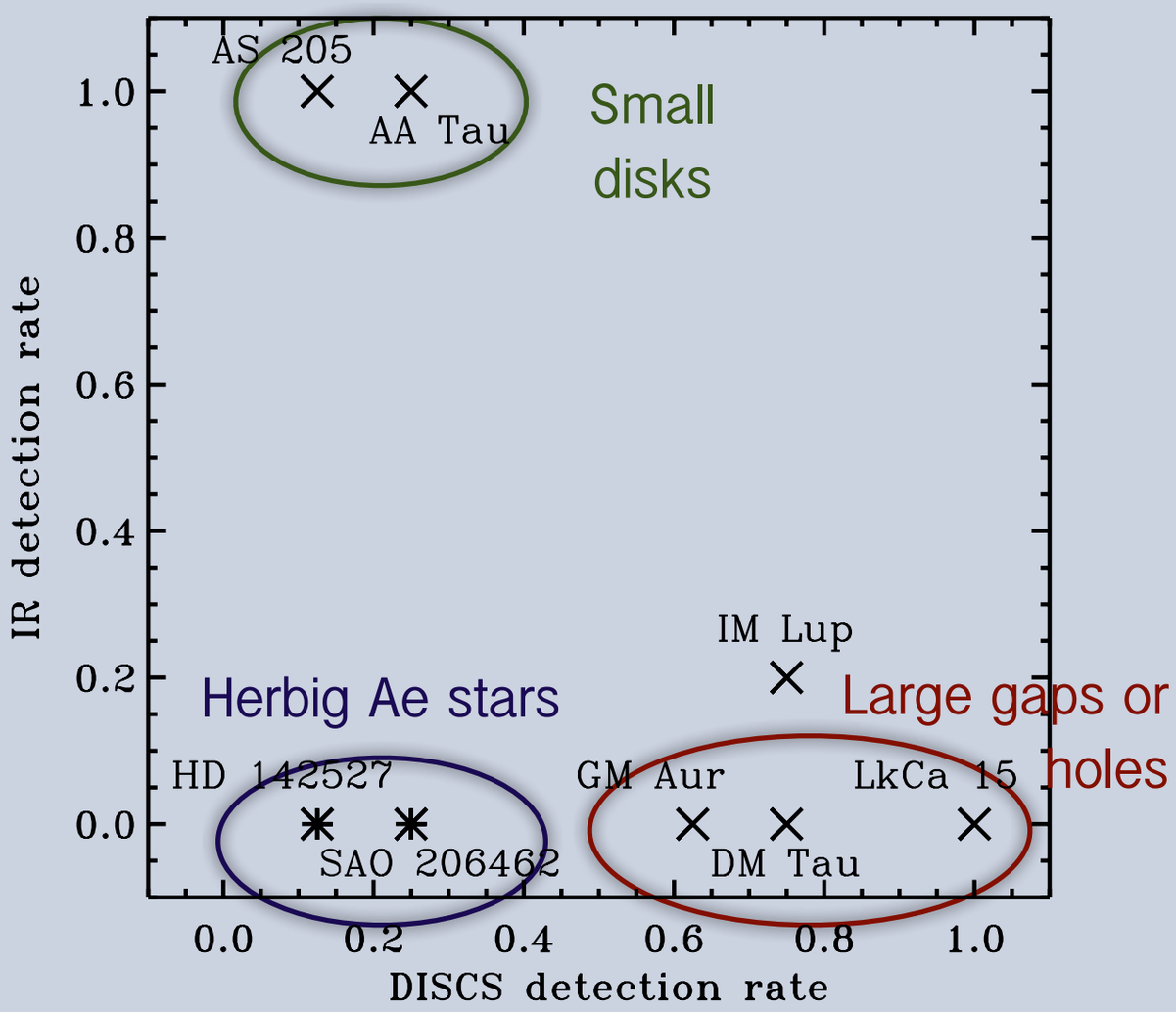
Rich T Tauri and poor Herbig Ae disks?

- ★ N_2H^+, H_2CO, DCO^+ detected toward T Tauri disks and lacking toward Herbig Ae disks
- ★ Most Herbig Ae disks lack protected midplanes for long enough time scales



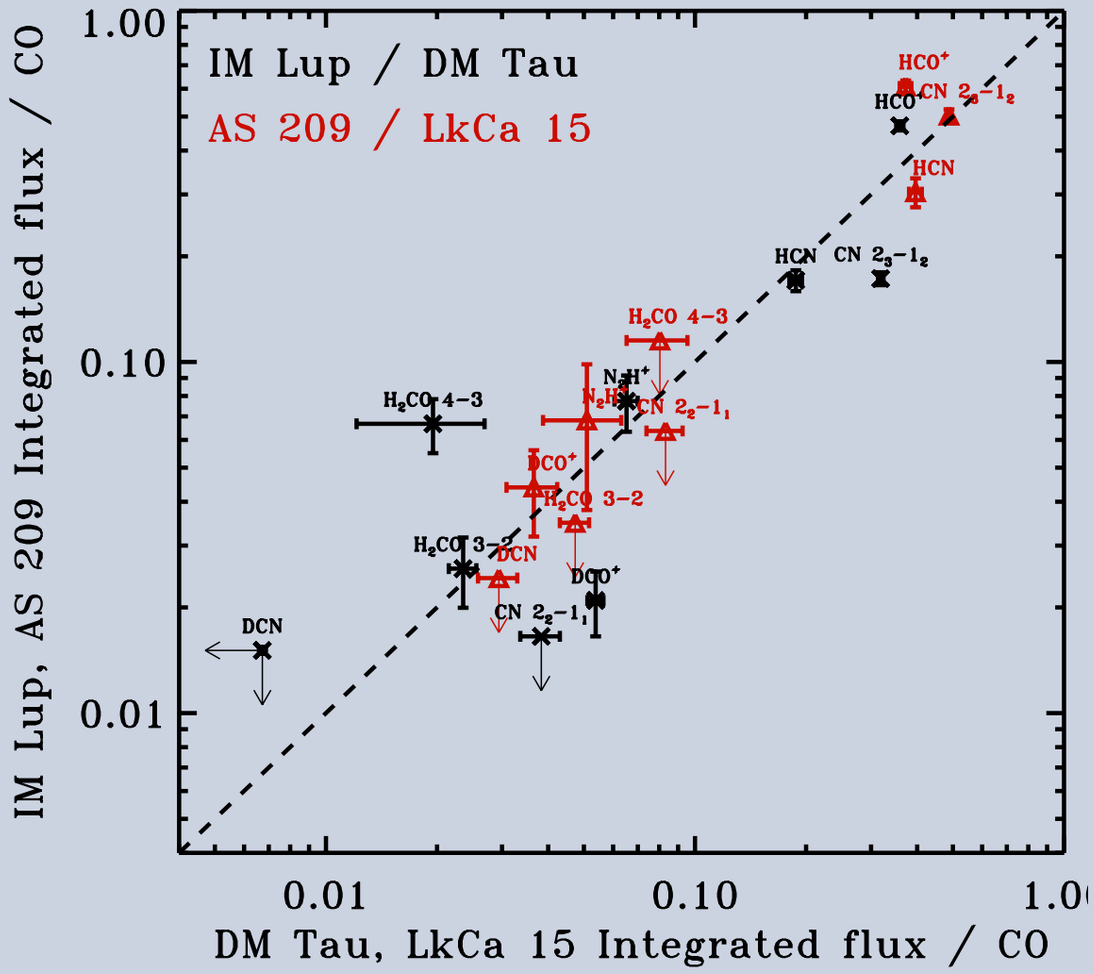


Inner vs. outer disk chemistry and physics

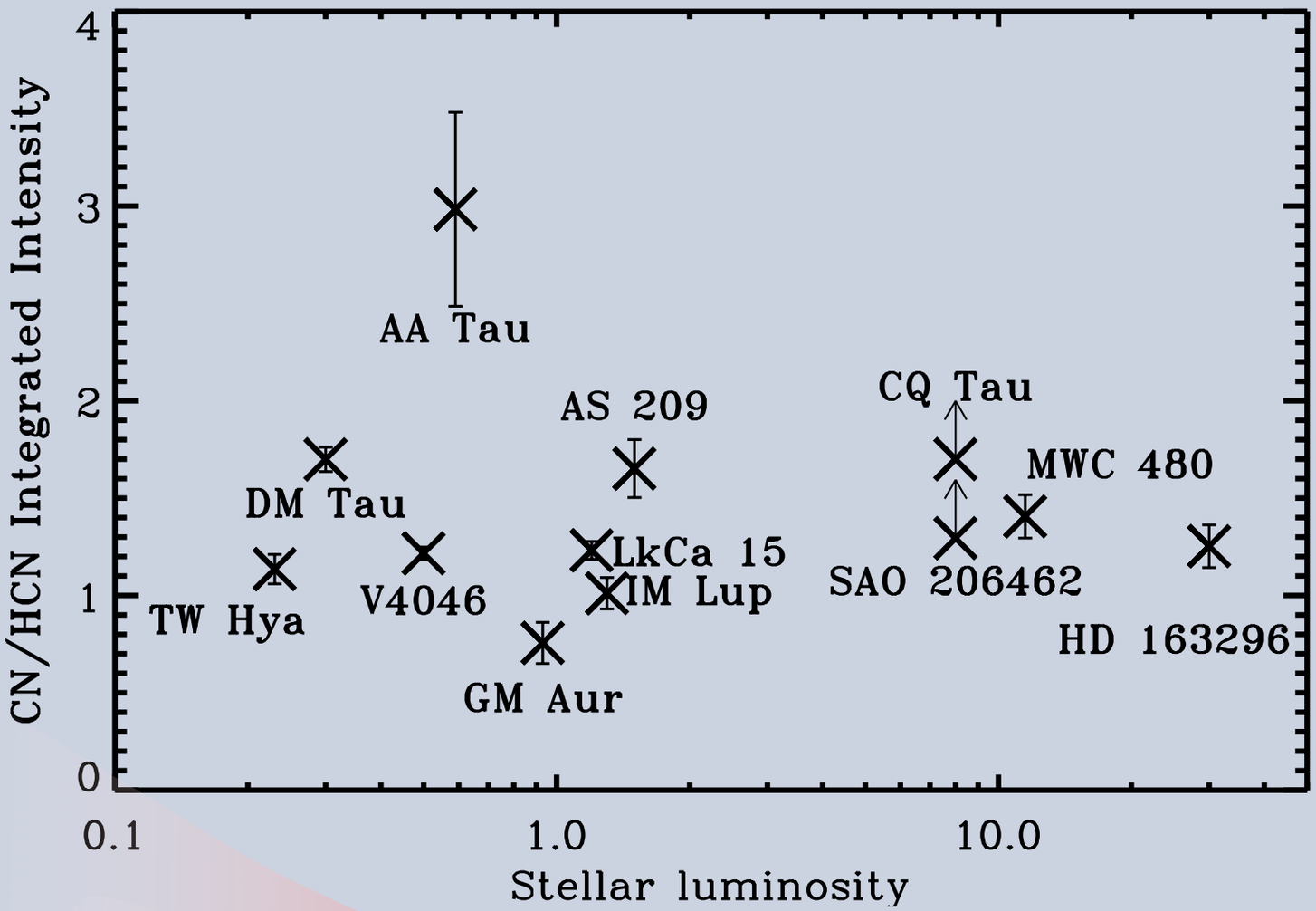


- ★ Some overlap between DISCS (R>100 AU) and infrared chemistry surveys (R<10 AU)
- ★ No normalized detection rate correlation

Outer disk seems oblivious to inner disk structure and accretion rate



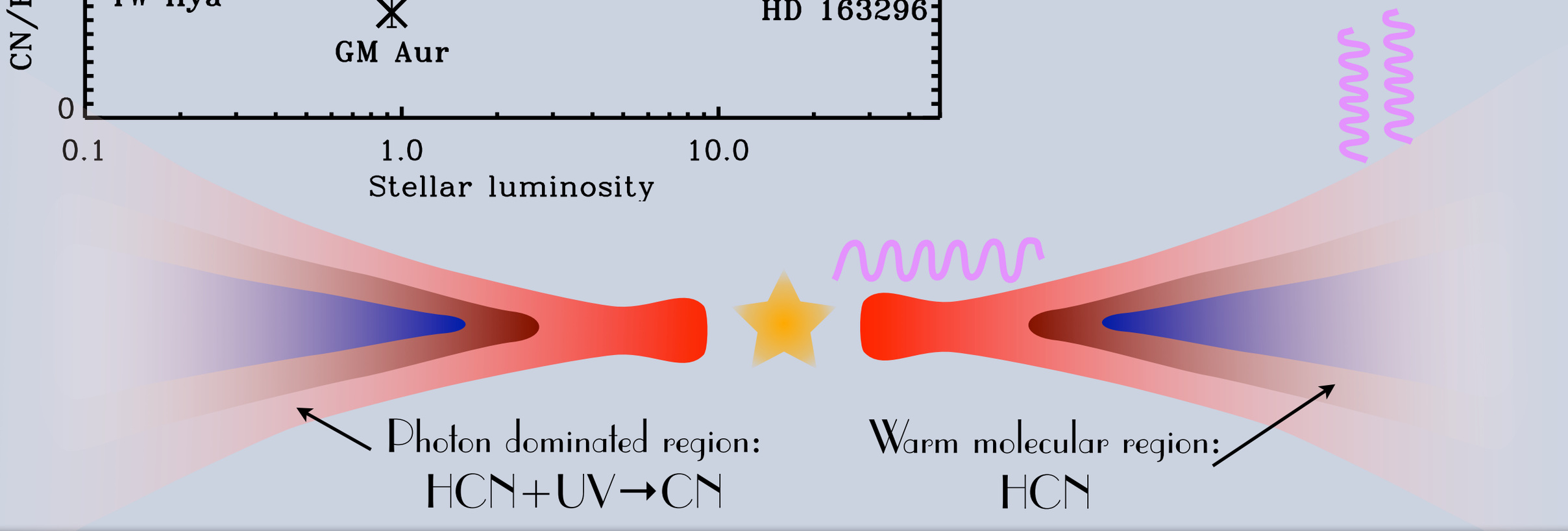
Radiation Chemistry: CN/HCN



★HCN+UV→CN; CN should be abundant at high UV

★Surprisingly constant CN/HCN emission ratio

★Disk averaged CN/HCN ratio is NOT a good radiation tracer.



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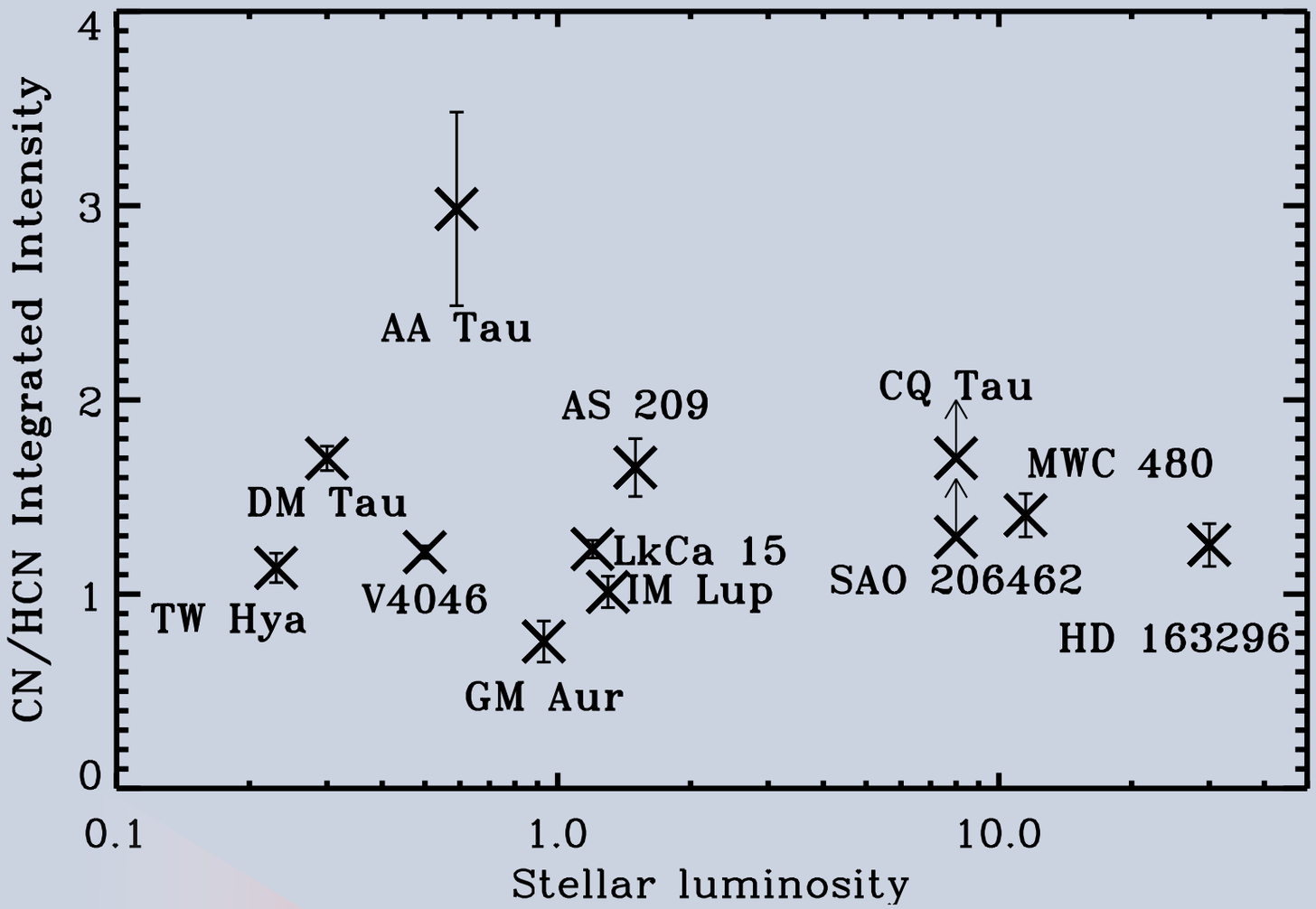

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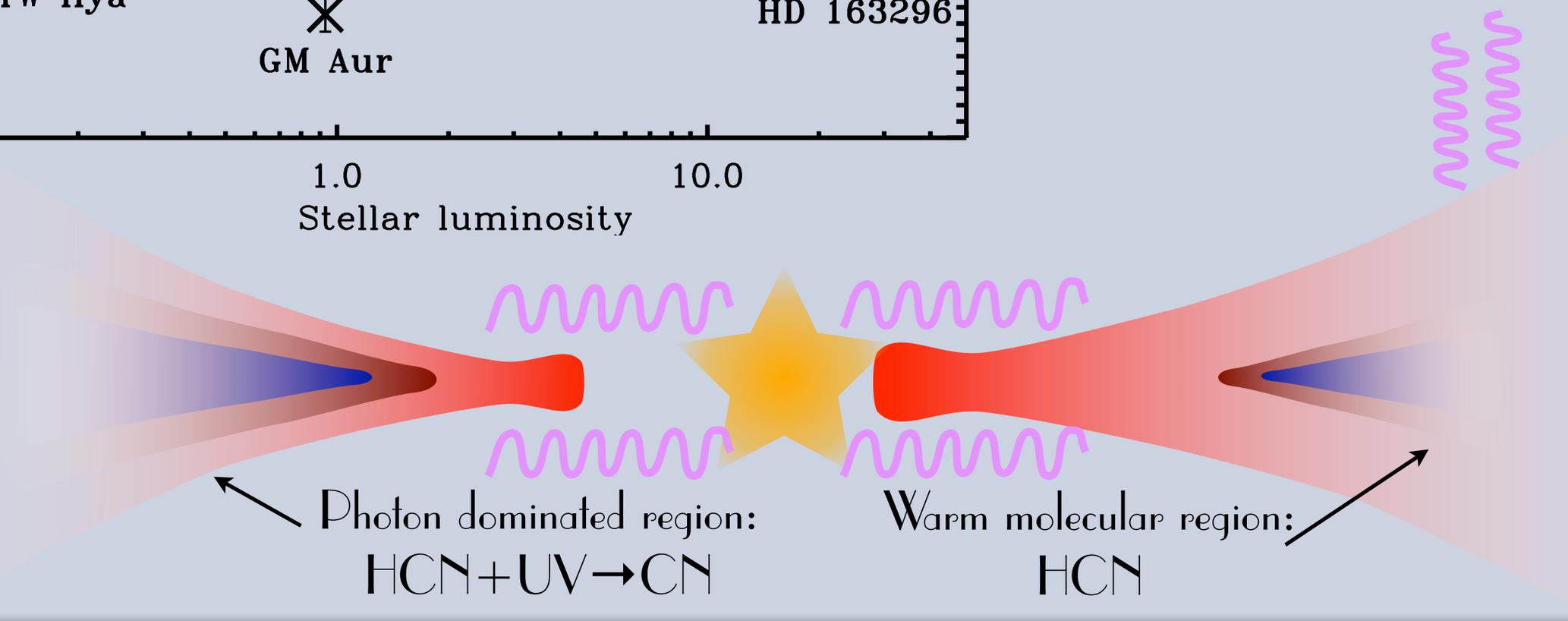
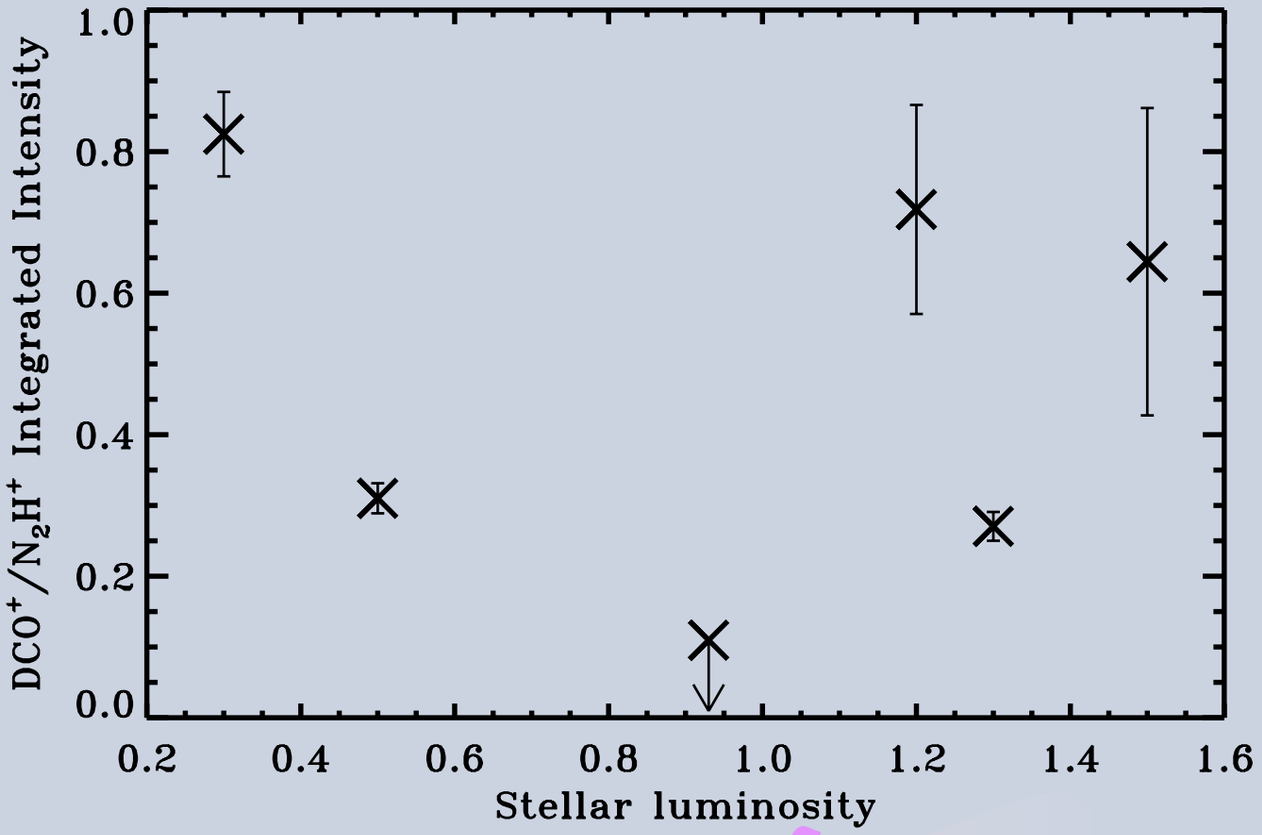
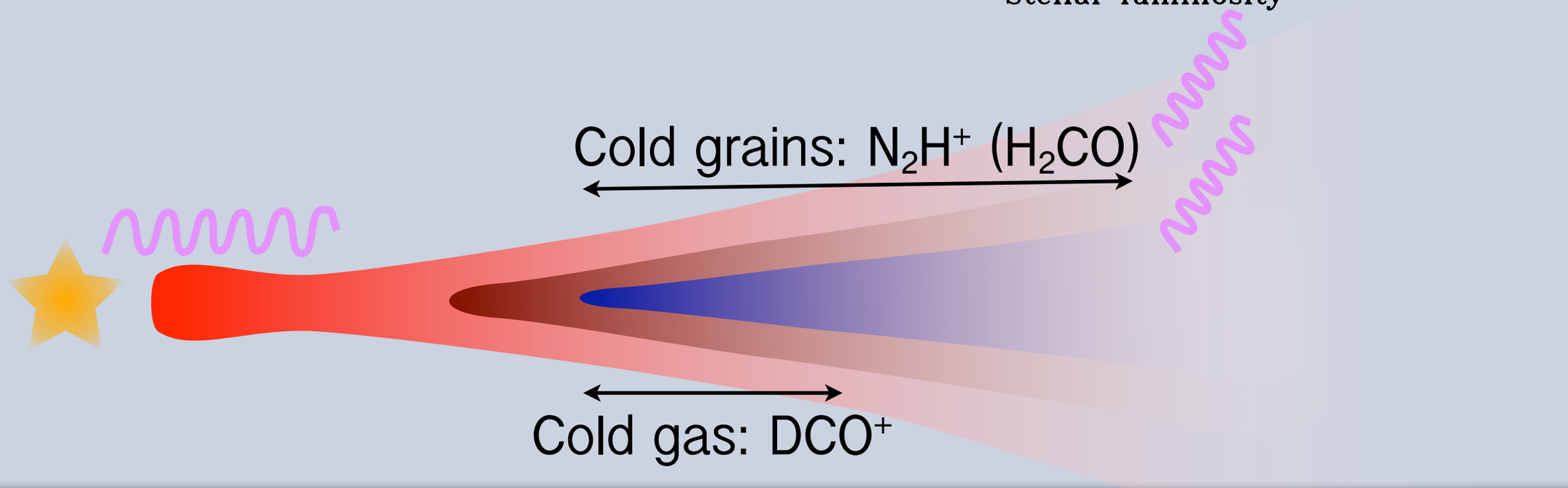


Different cold chemistries?

- ★ N_2H^+ and DCO^+ not correlated with each other across the sample
- ★ Order of magnitude range in DCO^+/N_2H^+ ratio suggests different emission conditions
- ★ Cold grains and cold gas not always coinciding?



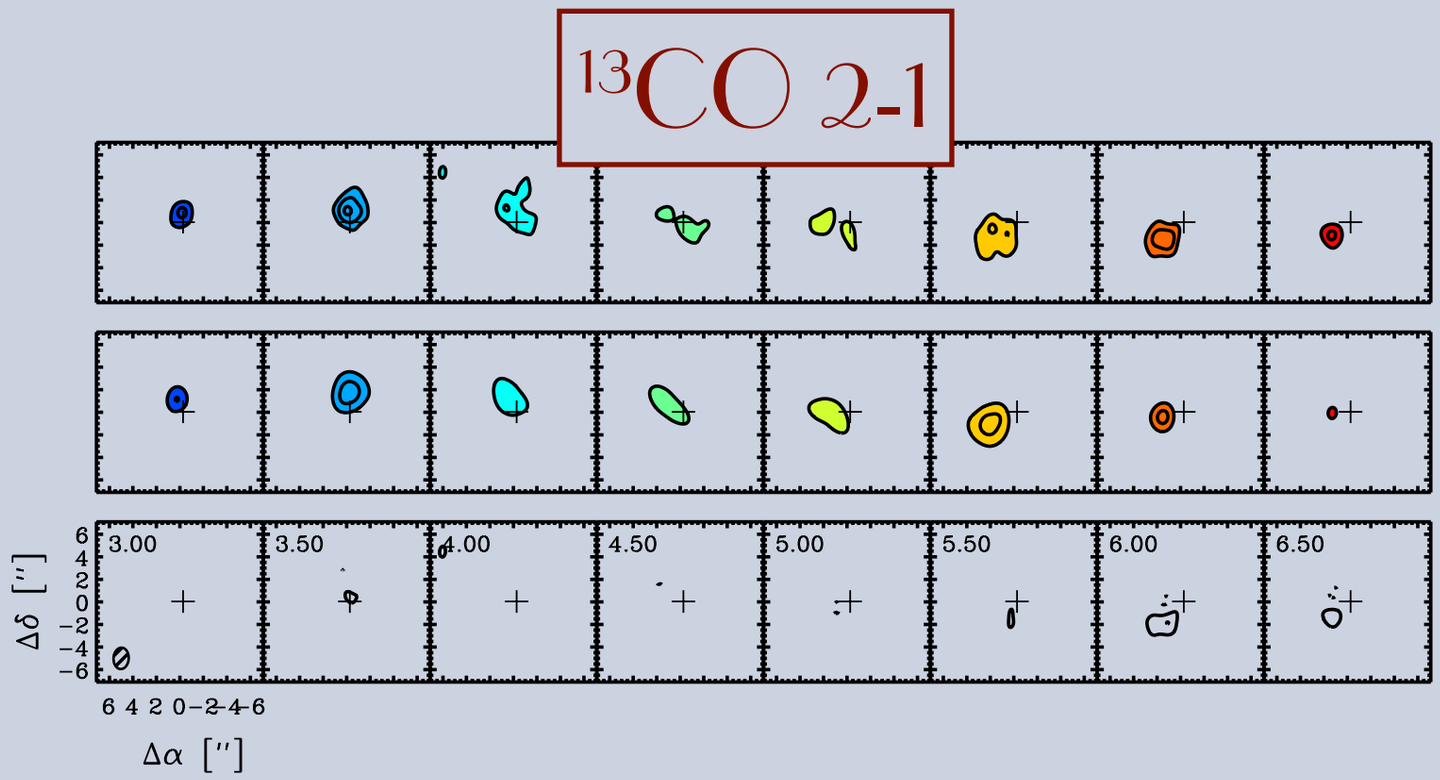


The gas distribution around IM Lup

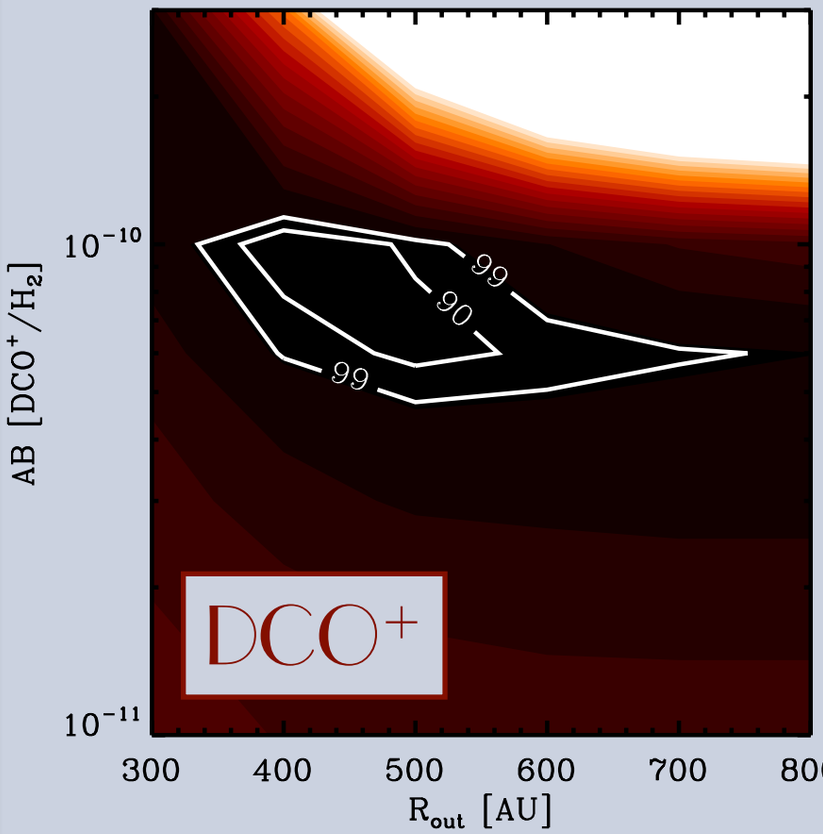
CO 2-1

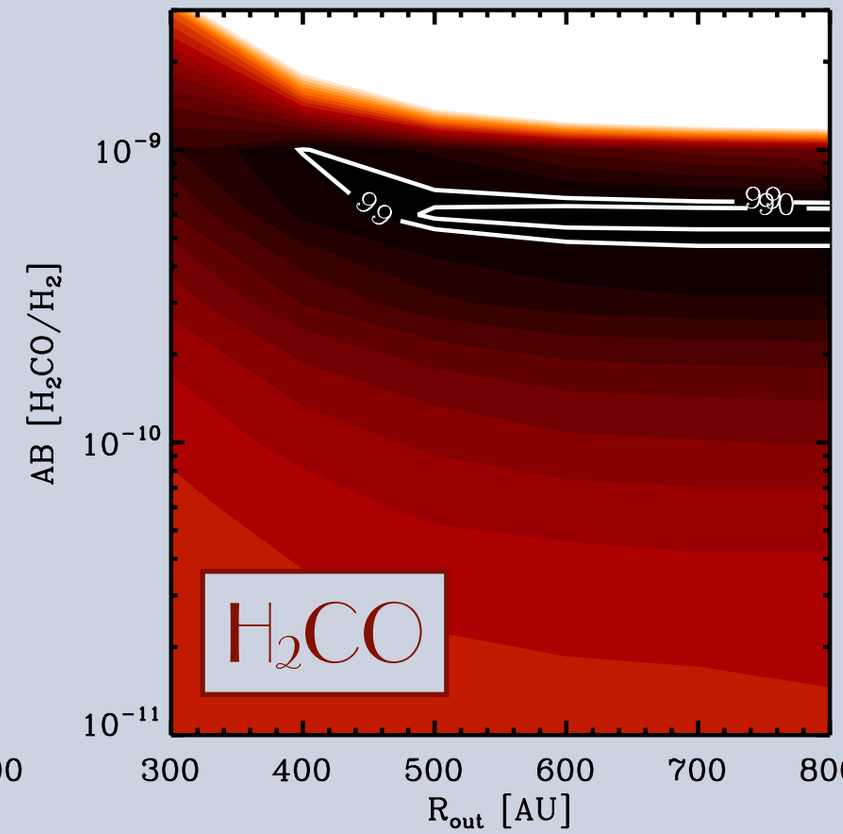
- CO data can be fit reasonably well with a tapered disk model
- Provides good enough template to investigate spatial distributions of minor species

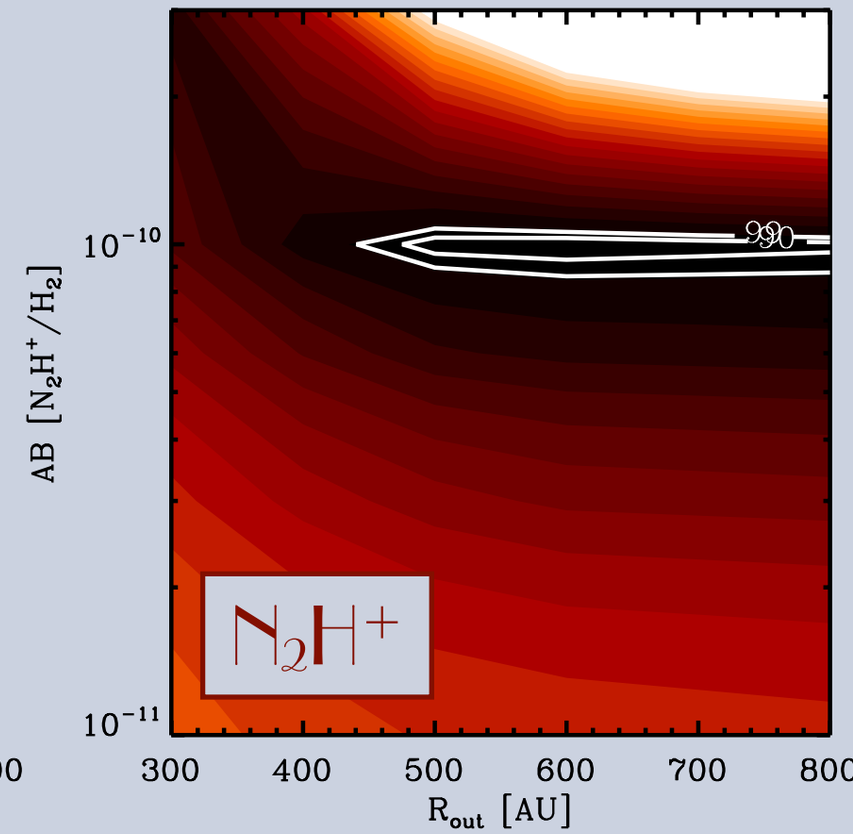
^{13}CO 2-1

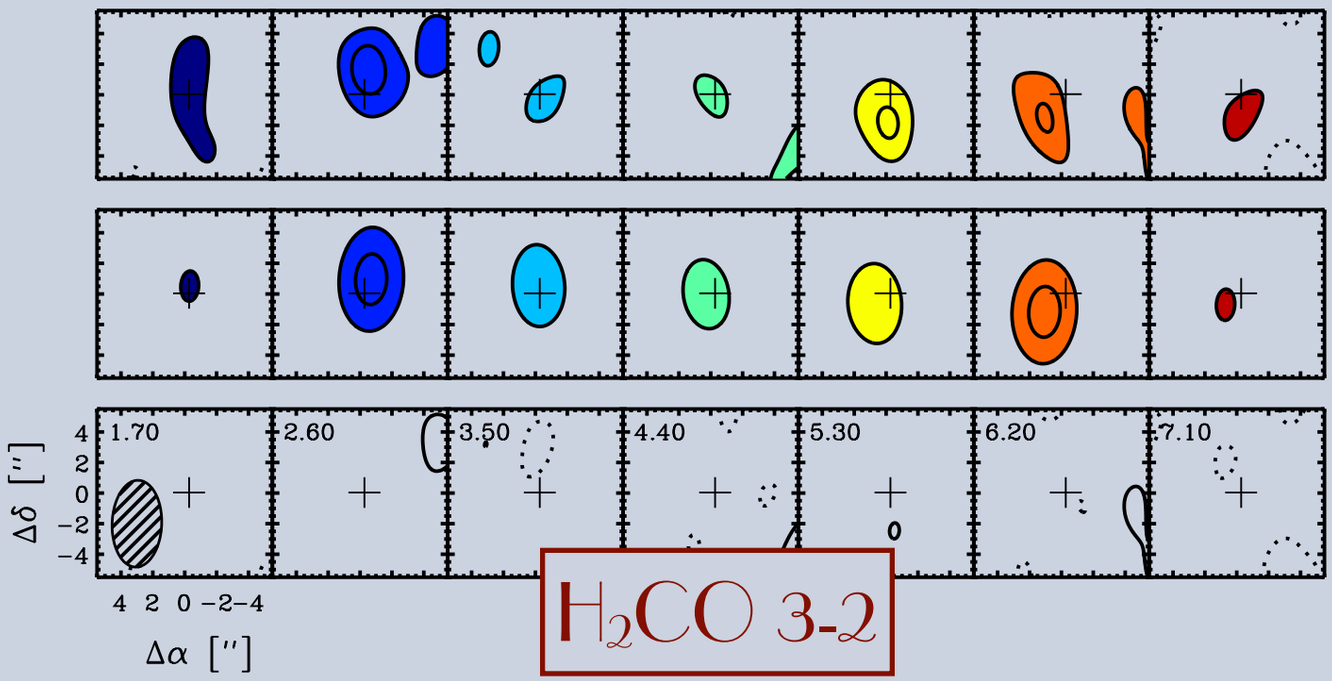


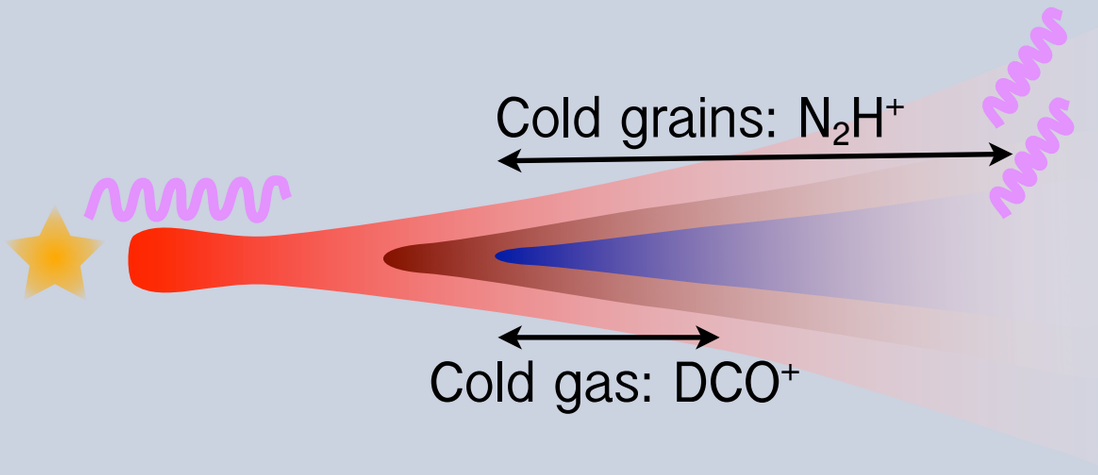
Different DCO^+, N_2H^+ and H_2CO outer disk distributions?











DiSCS

- ★ High detection rates of small molecules toward disks around low-luminosity stars - low detection rate toward high-luminosity stars: DCO^+, N_2H^+ and H_2CO require cold midplanes to be abundant
- ★ Chemical disconnect between inner and outer disk
- ★ The averaged CN/HCN emission ratio is constant across the sample, despite order of magnitude differences in radiation fluxes; the radial distributions of molecules in individual disks are potential tracers of disk physics e.g. CN/HCN and DCO^+/N_2H^+ radial distributions
- ★ Important pilot project for ALMA disk surveys