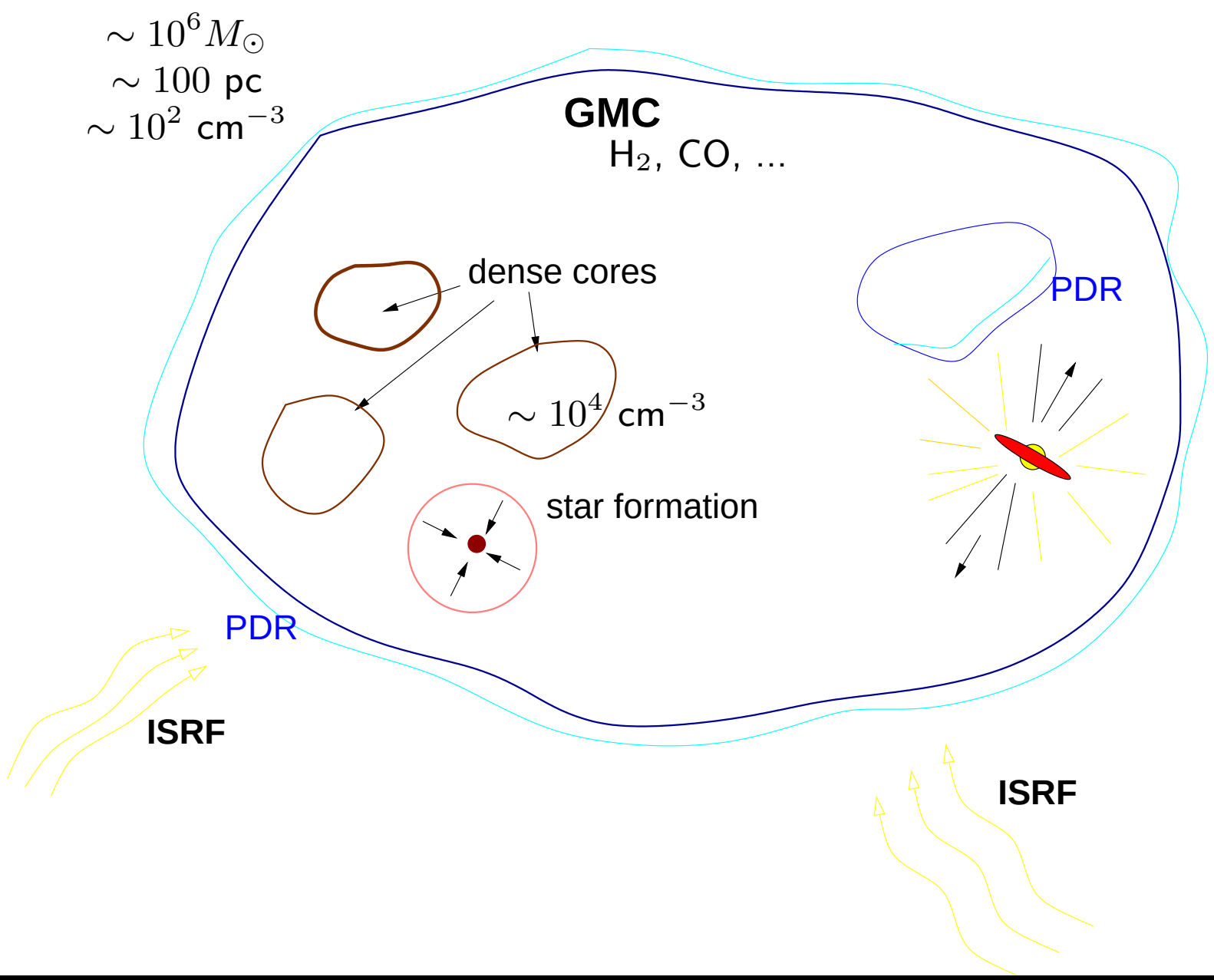
What molecules do we find in dense PDR's?

Òscar Morata and **Eric Herbst**
The Ohio State University

June 25, 2004
59th Ohio State Symposium on Molecular Spectroscopy
FD04

Giant Molecular Clouds (GMCs)



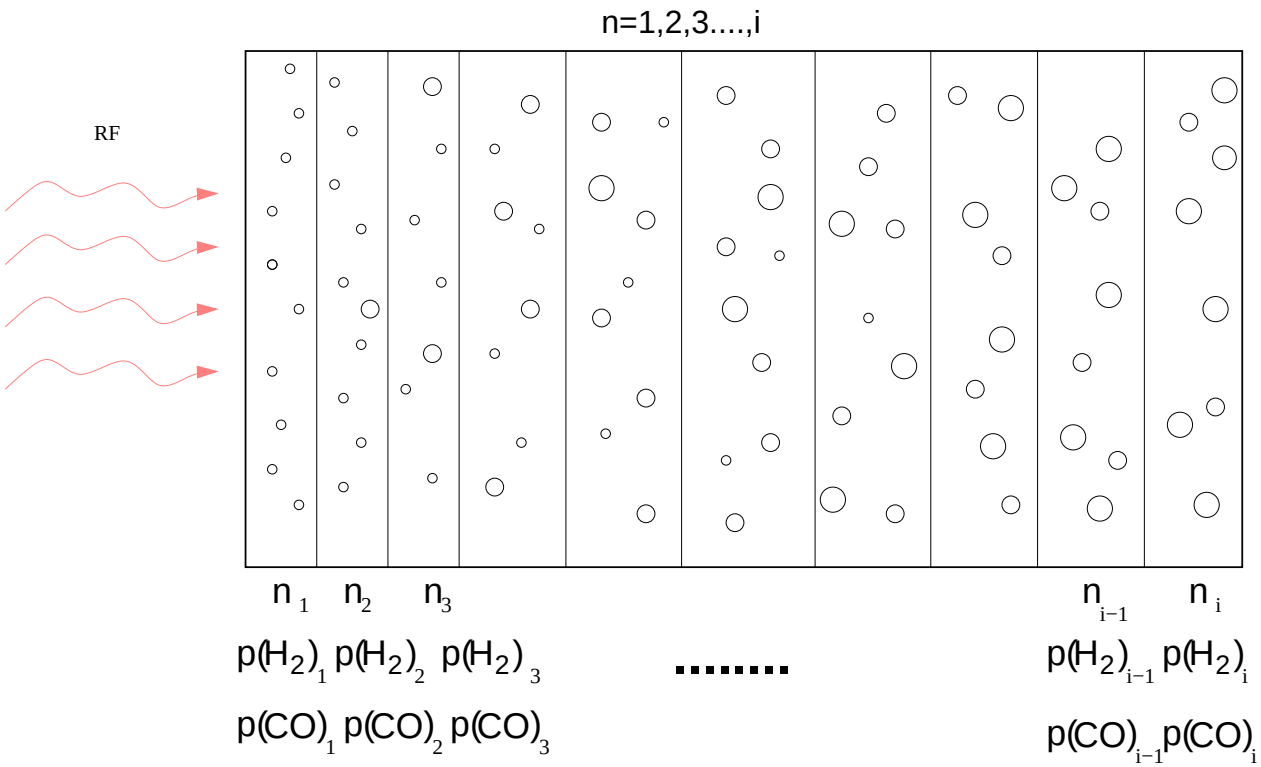
PDRs (Photon Dominated Regions)

- Physical and chemical processes are dominated by FUV radiation.
- Neutral, atomic, and molecular regions.
- Found in GMCs, planetary nebulae, winds of red giants and AGB stars, ISM of starbust galaxies, low metallicity dwarf galaxies, ...
- Observed through atomic and molecular spectral lines ([C II] 158μm, [O I] 63, 146 μm, [C I] 609, 370 μm), and in the mm and sub-mm bands: CO, ^{13}CO, C^{18}O, ...
- diffuse (~ 100 cm^{-3}) or dense ($> 10^4$ cm^{-3}) gas .

Horsehead Nebula

σOri

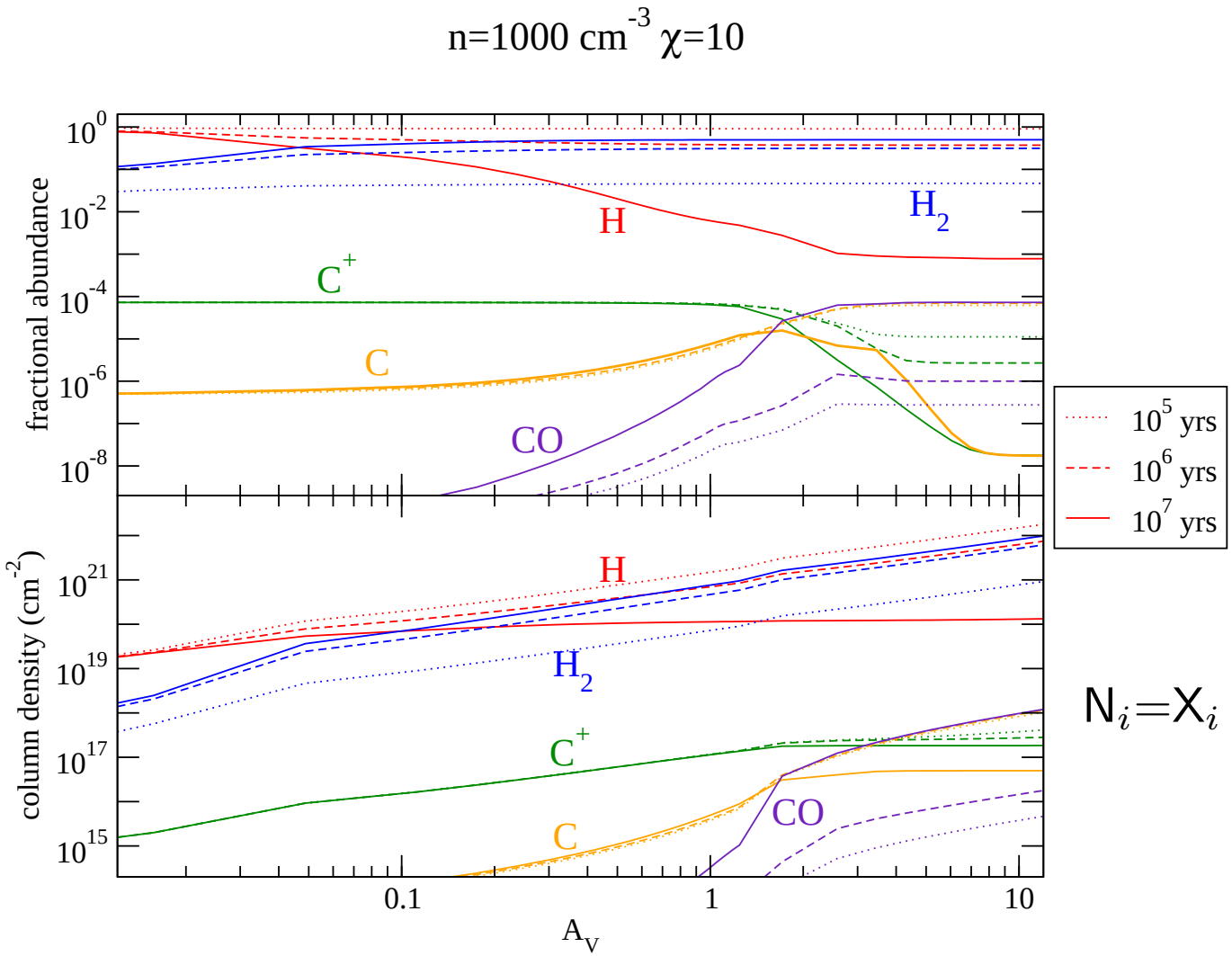
Modelling of PDRs



Lee et al. (1996)

- Semi-infinite plane-parallel cloud
- Isotropic UV radiation field (Mathis, Metzge & Panaggia, 1983)
- Time-dependent model. Run for every slab. H_2 and CO photorates from $(i-1)_{th}$ slab to i_{th} slab.
- Chemical network: *OSU 2003 gas phase model* (419 species, 4103 reactions)

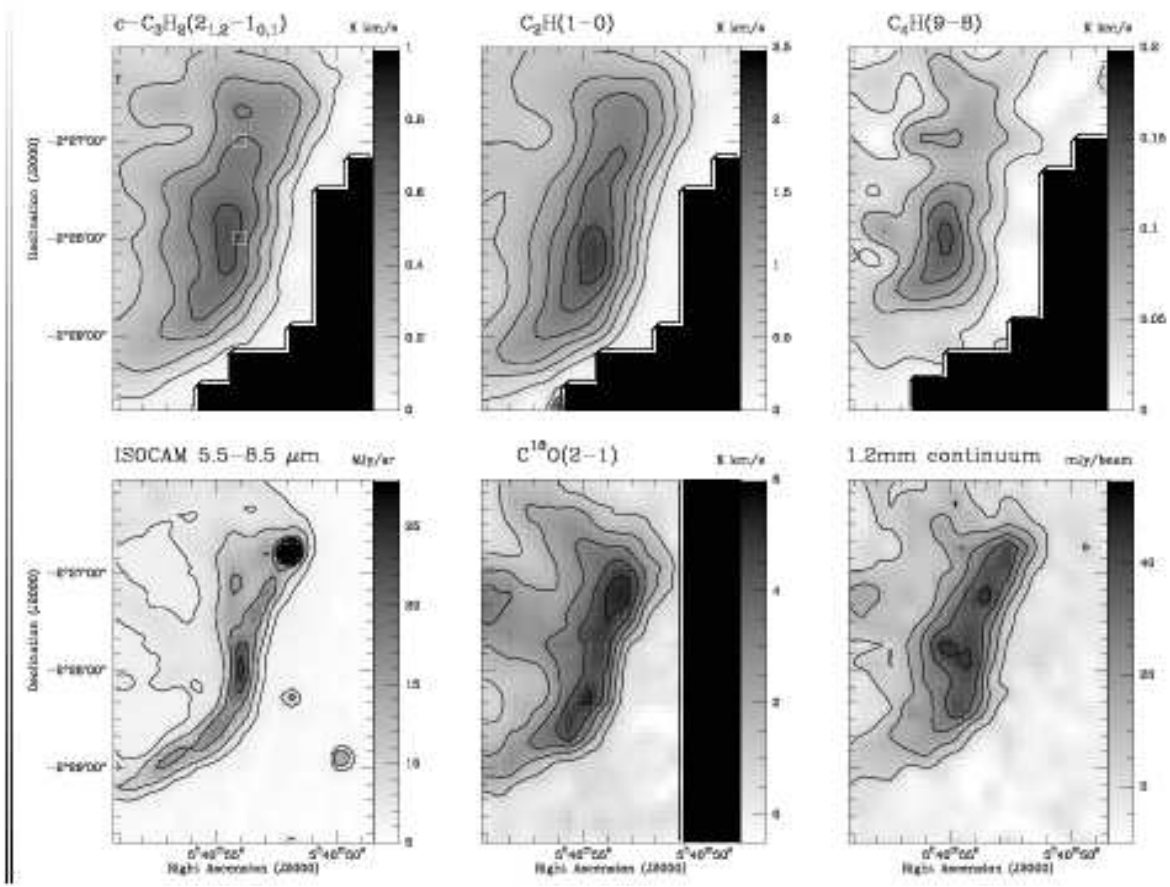
Plot of the results



$N_i = X_i * r_i$

Òscar Morata and Eric Herbst
The Ohio State University

Carbon molecules



Teyssier et al. (2004)

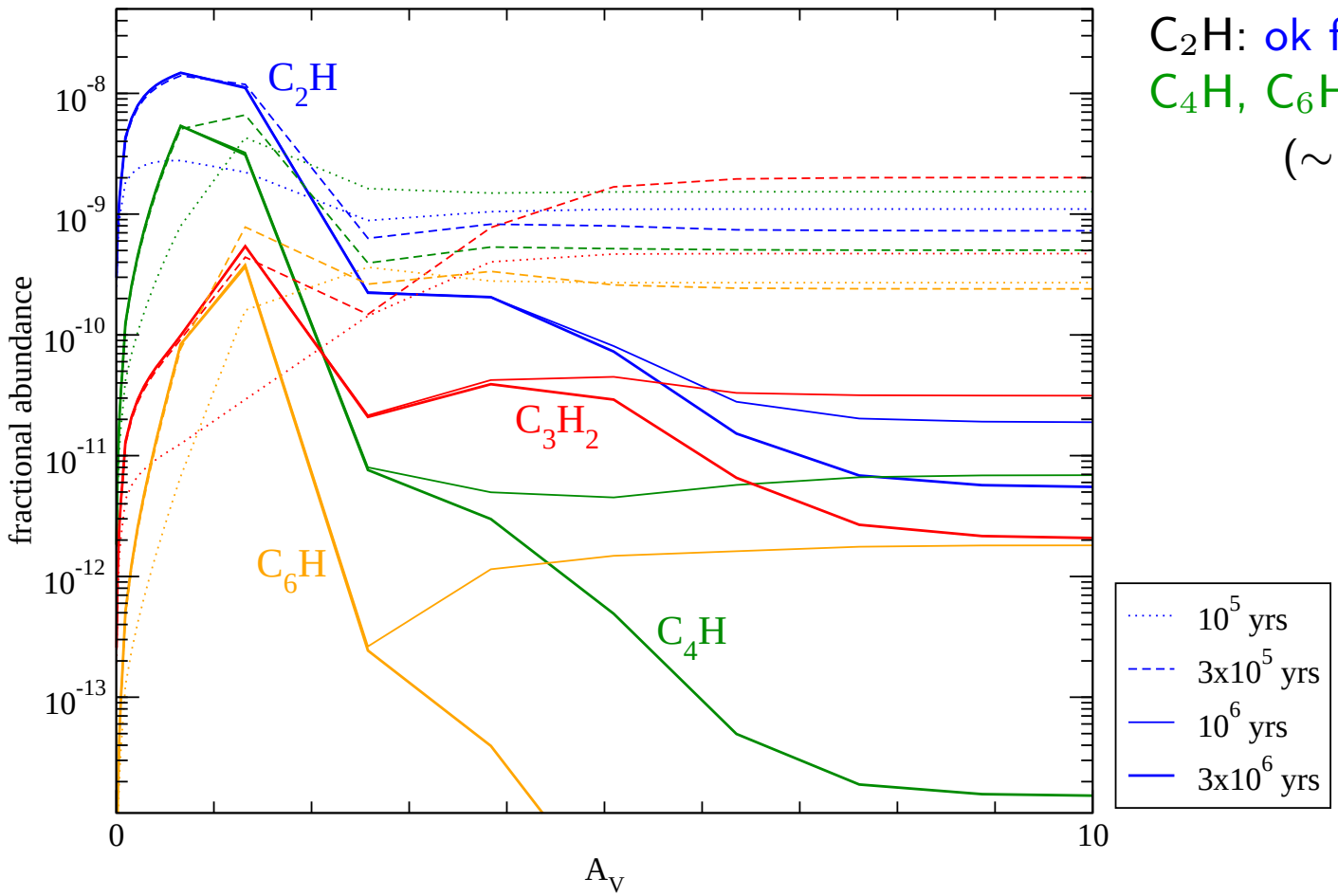
- X(C_2H)=1.9×10^{-8}; X(c-C_3H_2)=1.4×10^{-9}; X(C_4H)=1.1×10^{-9}
- [$C^{18}O$]/[C_2H]~ 2.5; [c-C_3H_2]/[C_4H]~ 1; [C_2H]/[c-C_3H_2]~ 15

Runs

- 43 slabs
- homogeneous density: n_H=2$\times 10^4$ cm^{-3}
- intensity of the radiation field: $\chi = 100$
- temperature: T=30 K
- A_V=3.1$\times 10^{-3}$ – 229
- total depth: 2×10^{19} cm
- "low-metal" elemental abundances, with all elements as ions, except H, He, O, and N.

It is run up to 10^8 yr.

Carbon molecules

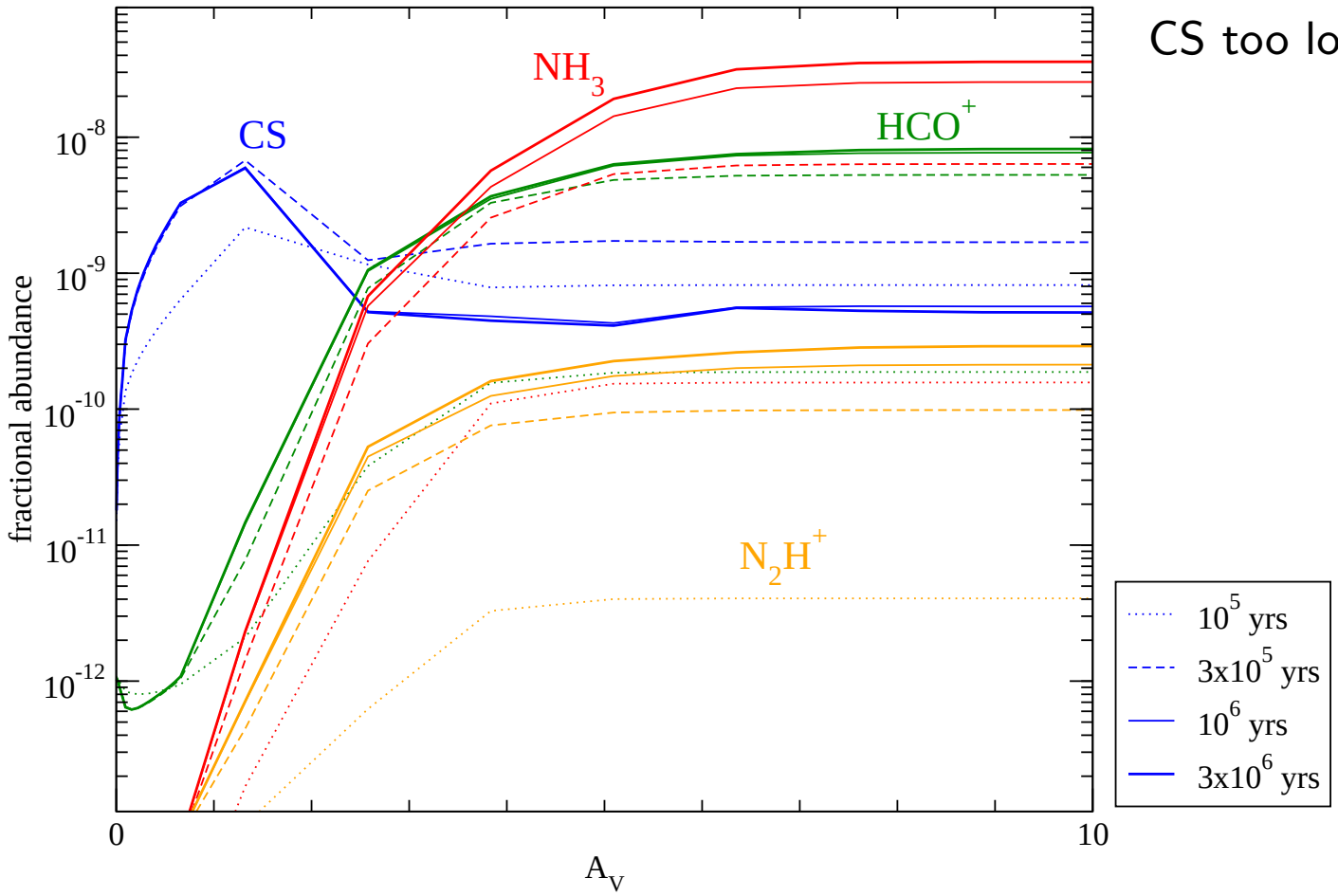


C_2H: ok fr. ab., no N

C_4H, C_6H, C_3H_2: ok

($\sim 3 \times 10^5$ yrs)

High density tracers



CS too low/ok

Final remarks

- Promising agreement with observations.
- But, some discrepancies $\Rightarrow$ improvements on the way.
- Enlarging the reaction set:
  - OSU gas–grain model
  - Deuterium reactions