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On the size of the CO-depletion radius in the IRDC G351.77-0.51

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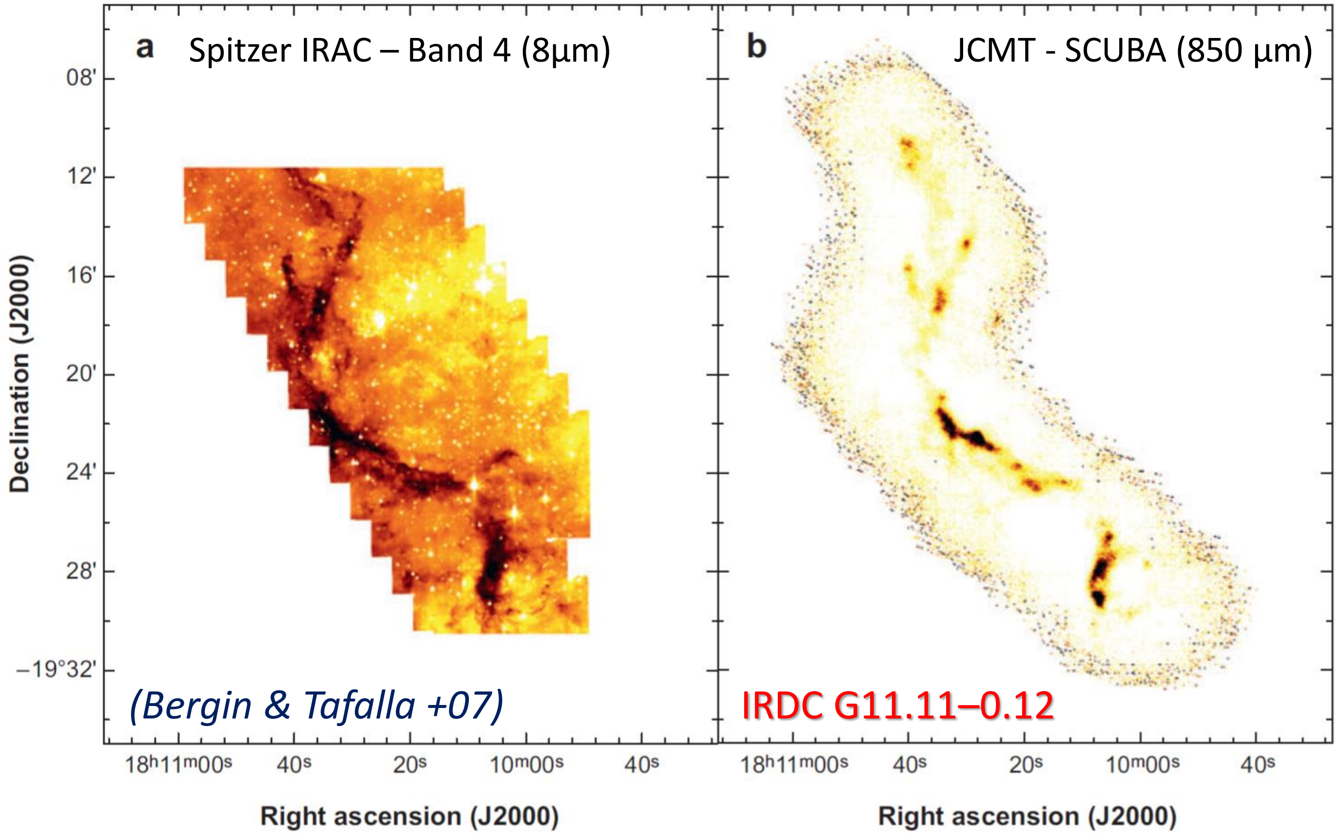
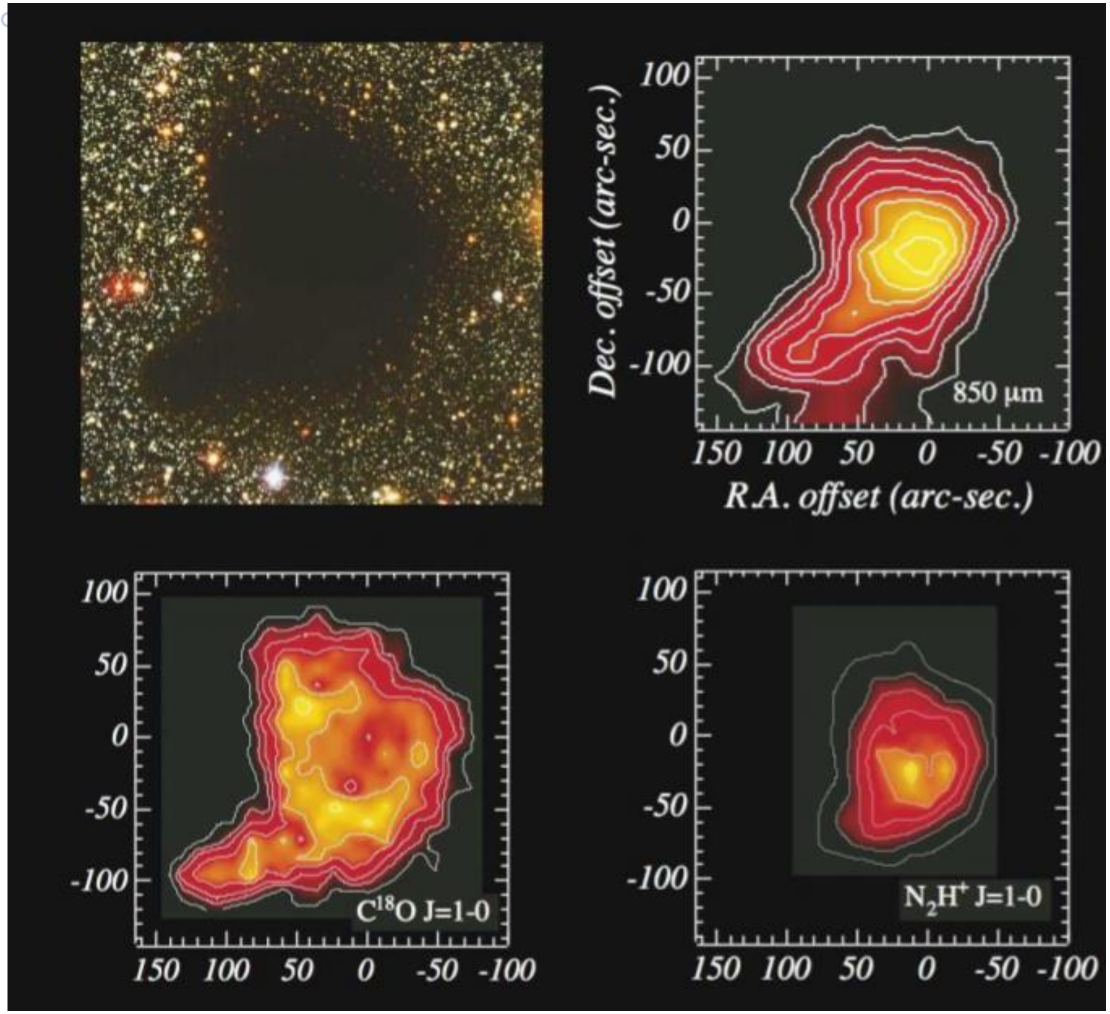
Infrared Dark Clouds (IRDCs)



- ❑ Dusty and obscured interstellar regions;
- ❑ In absorption against mid-IR background emission;
- ❑ Filamentary structures + cold massive cores;
- ❑ Nursery of massive stars or/and star clusters;

Infrared Dark Clouds (IRDCs)

Barnard 68 – Ophiuchus



(Bergin & Tafalla +07)

Internal structure:

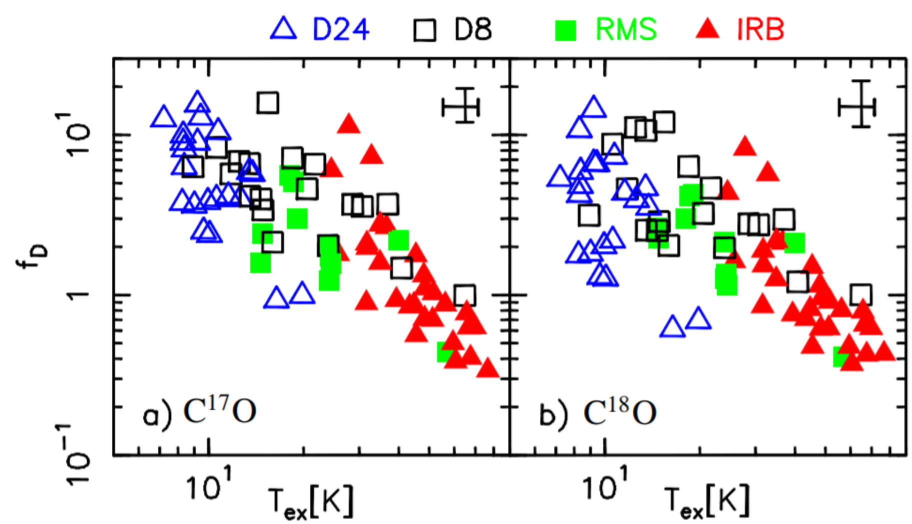
- **Nitrogen-bearing species** are good density tracers even in the central regions .
- **Carbon-bearing species** are unable to follow the cold gas distribution up to the central-collapsing regions.

CO-depletion:

Depletion factor (f_D)

Ratio between the '*expected*' abundance of CO relative to H_2 ($\chi^E_{C^{18}O}$) and the '*observed*' value ($\chi^o_{C^{18}O}$) :

$$f_D = \frac{\chi^E_{C^{18}O}}{\chi^o_{C^{18}O}}$$



(Giannetti +14)

In different samples of young high-mass star-forming regions (HMSFRs)

(e.g. Thomas & Fuller+ 08; Fontani +12) $\boxed{1 \lesssim f_D \lesssim 10^2}$ beam- and los-averaged values!

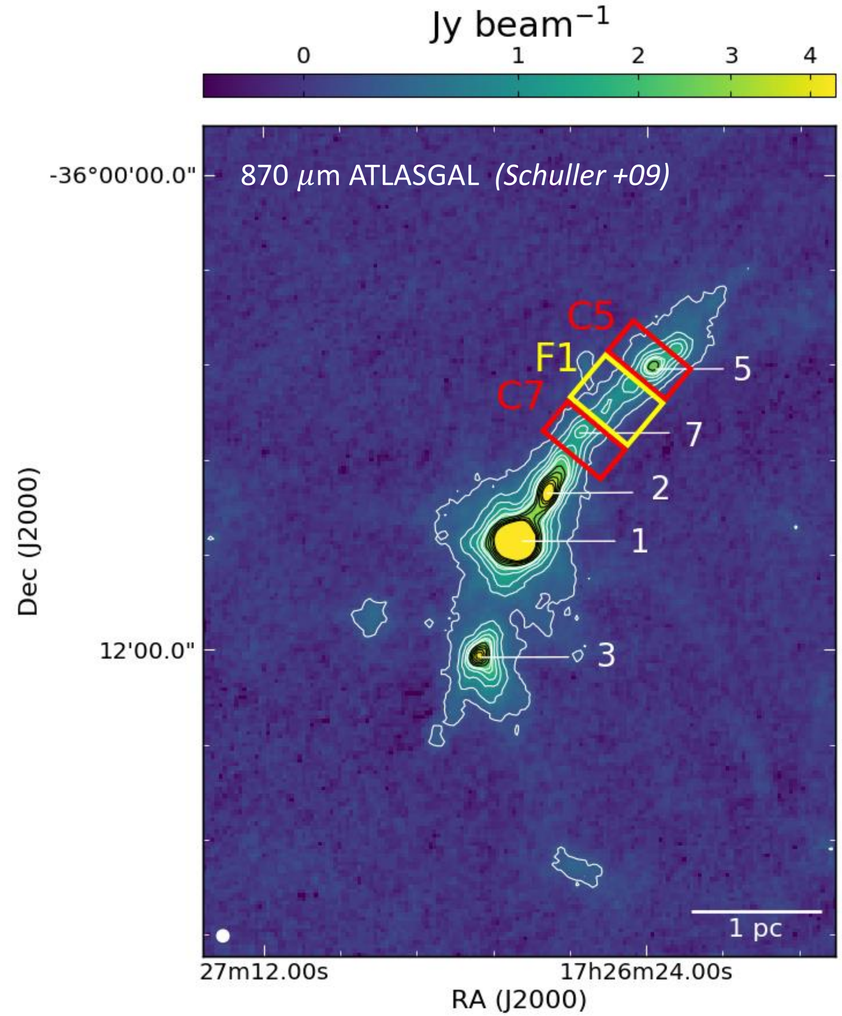
The size of the highly-depleted region (**depletion radius** - R_{dep}) gives us the spatial scales on which:

- ❑ different chemical processes operate in HMSFRs;
- ❑ the estimate of H2 from CO and/or the study of the gas-dynamics using CO lines could be misleading.

IRDC G351.77-0.51:

- Most massive, nearest filament in the ATLASGAL survey;
- Early evolutionary stage: lots of cold material and dark in the MIR;
- *$M \sim 2000\ M_{\odot}$*;
- Distance: 1 kpc
  ~ 7.8 kpc from Galactic centre;

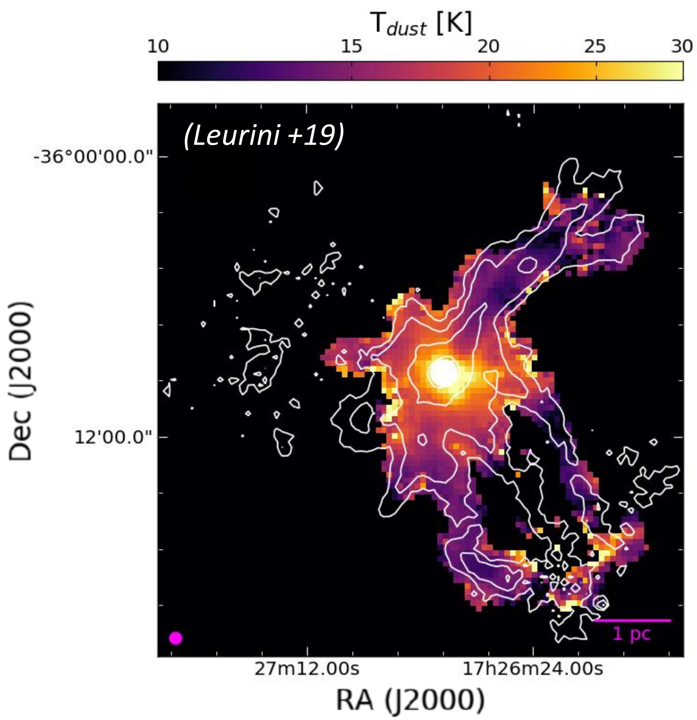
(Leurini +11; Leurini +19)

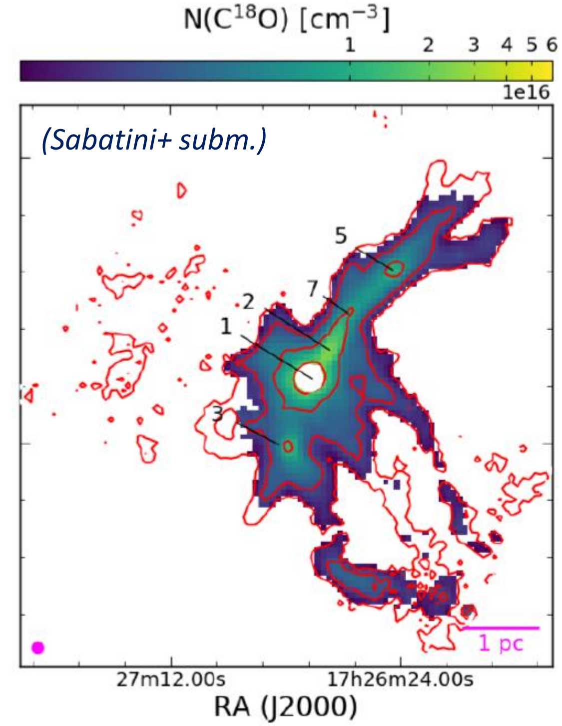


Proximity
Nearly perfect filamentary structure

Large scale depletion factor map
+ radial model

'Building blocks' for f_D:



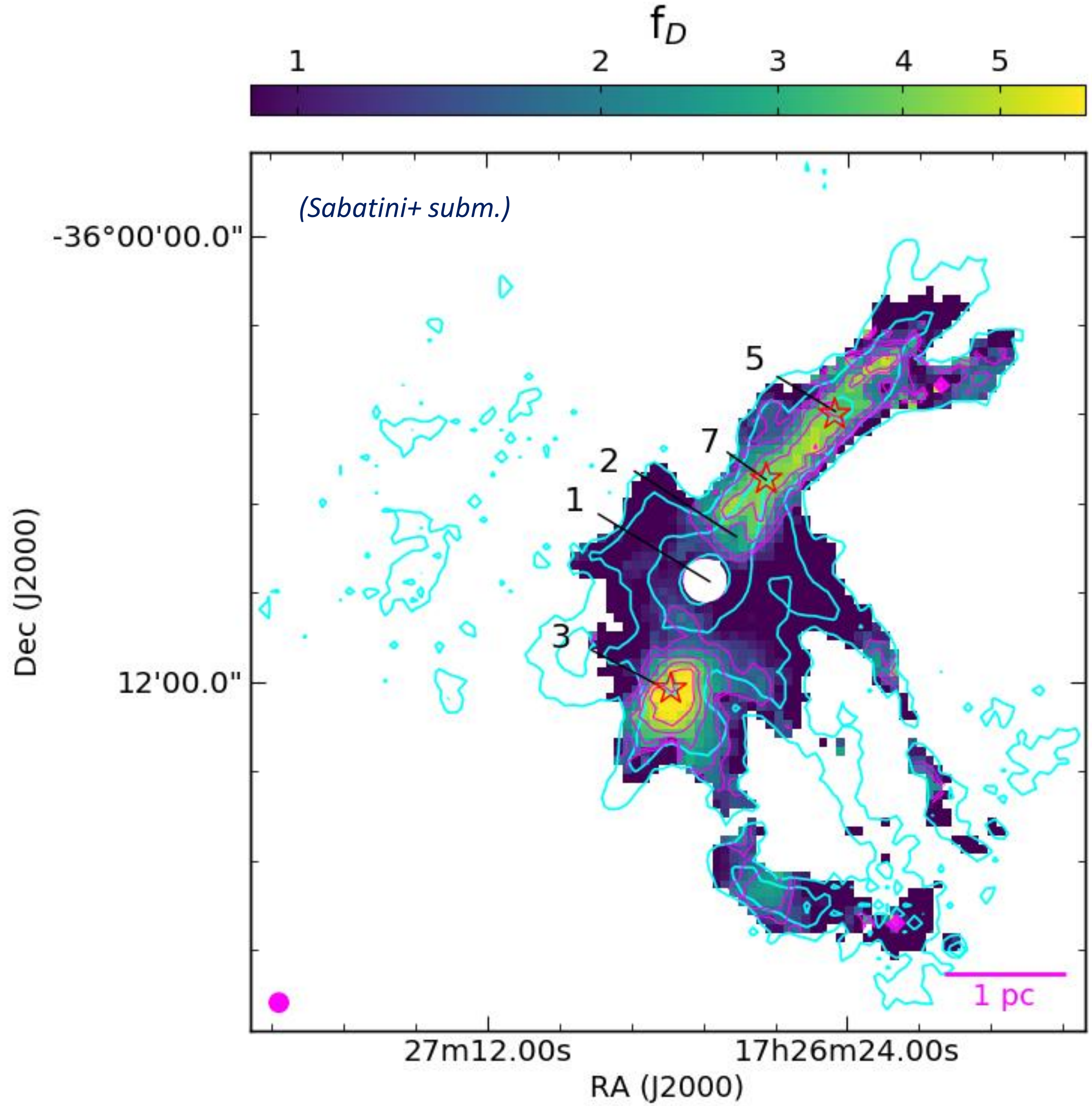


- From the pixel-by-pixel greybody SED-fitting of Herschel maps;
- Used to obtain 'expected' $\mathrm{N(C^{18}O)}$ from N(H_2) assuming a gas-to-dust ratio $\gamma = 120$ *(Giannetti +17b)*

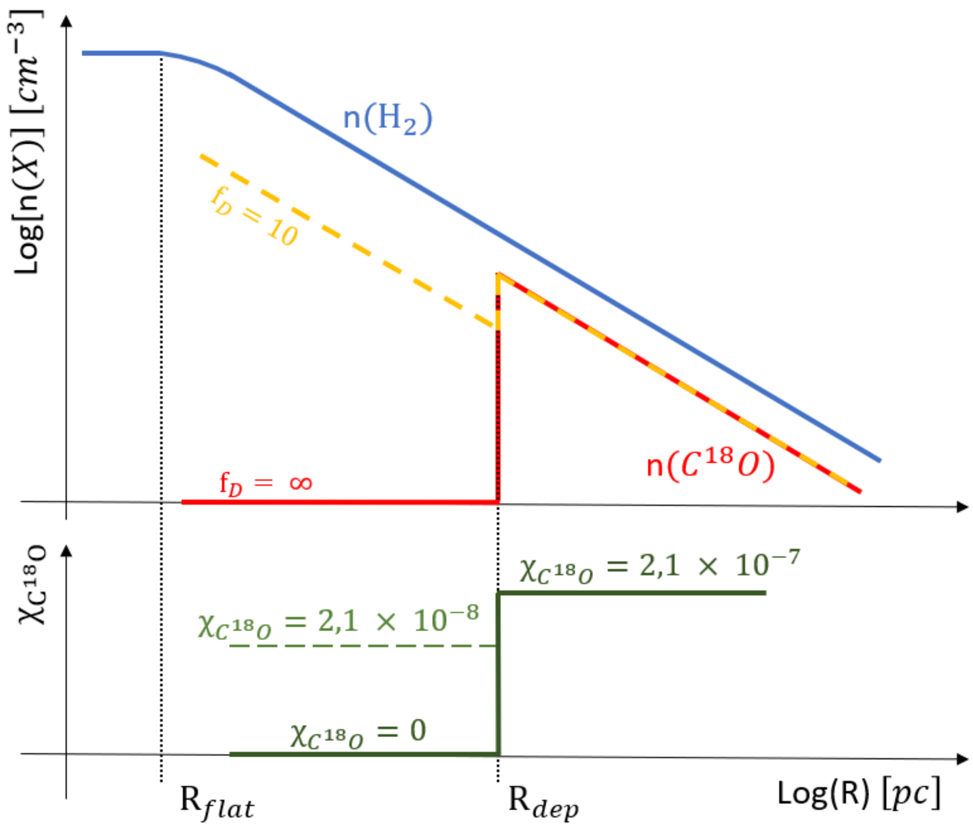
- Calculated $\mathrm{N(C^{18}O)}$ from the $C^{18}O$ J(2-1) map by APEX;
- $T_{ex}^{C18O} \longleftrightarrow T_{dust}$ *(Giannetti+17a)*
- Opacity correction applied

Depletion map:

- $1 < f_D < 6$
- High values of f_D both in the MR and in the sub-filaments;
- Lower values around YSOs due to the higher temperatures;



Depletion model:

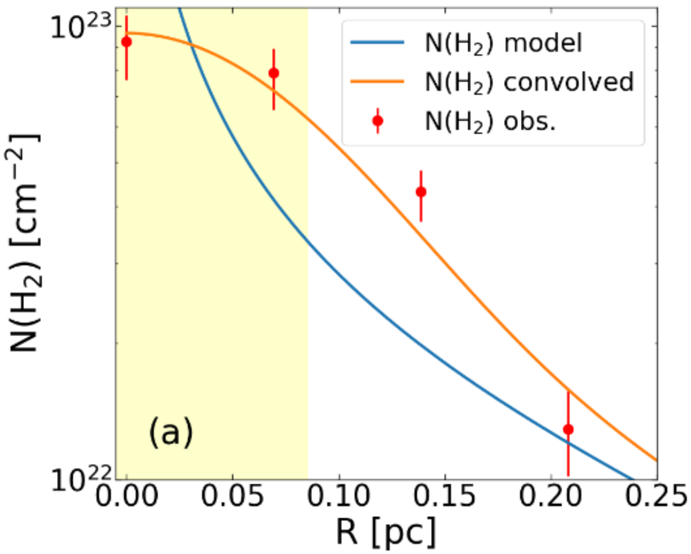


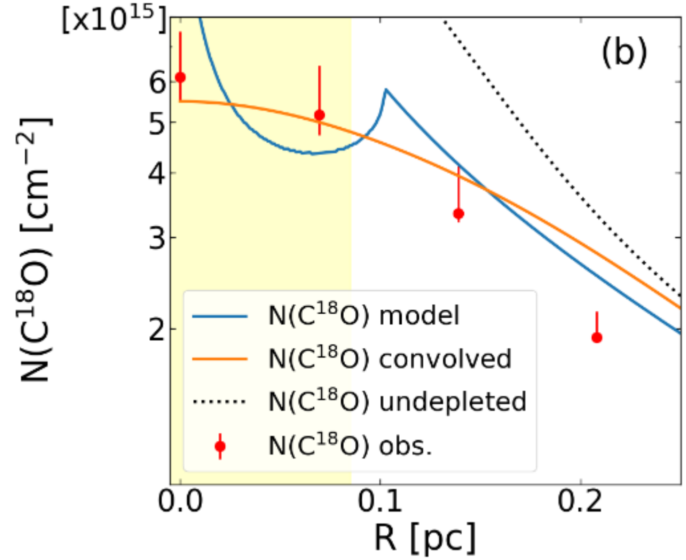
- Radial symmetry;
- $n(H_2)$ profile: $n(\mathrm{H_2}) = n(\mathrm{H}_{2,spine}) \left[1 + \left(\frac{R}{R_{flat}}\right)^{\alpha}\right]^{-p/2}$ *(Plummer+ 1991)*
- $n(C^{18}O)$ by defining a conversion factor with respect to H_2:

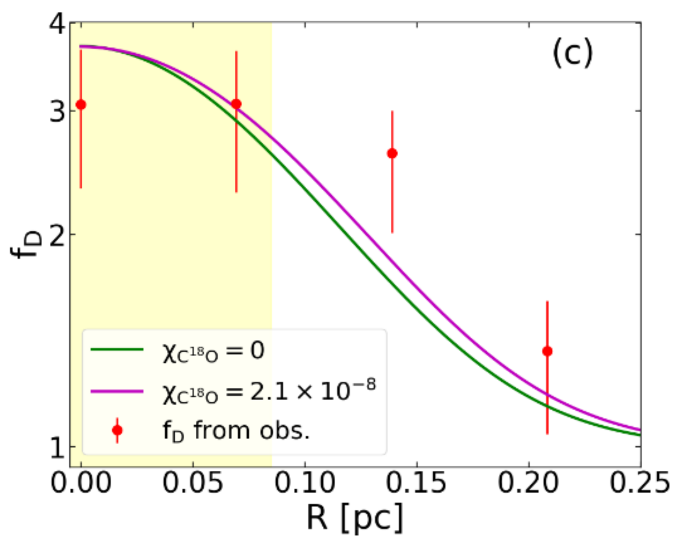
$$\left.\begin{array}{lll} R < R_{dep} & f_D = (10, \infty); & \chi_{\mathrm{C^{18}O}} = \dfrac{\chi^E_{\mathrm{C^{18}O}}}{f_D} \\ R > R_{dep} & f_D = 1; & \chi_{\mathrm{C^{18}O}} = \chi^E_{\mathrm{C^{18}O}} \end{array}\right\}$$

Depletion model:

C5







$$n(\mathrm{H}_2) = n(\mathrm{H}_{2,spine}) \left[1 + \left(\frac{R}{R_{flat}}\right)^{\alpha}\right]^{-p/2}$$

with $p = 2$ *(Tafalla+ 02)*

- $\alpha = 1.9 \in [1.1 < \alpha < 2.1]$ *(Beuther+ 02)*
- $n(H_{2,spine}) = 8 \times 10^6\ cm^{-3}$
- $R_{flat} = 5.5 \times 10^{-3}\ pc$

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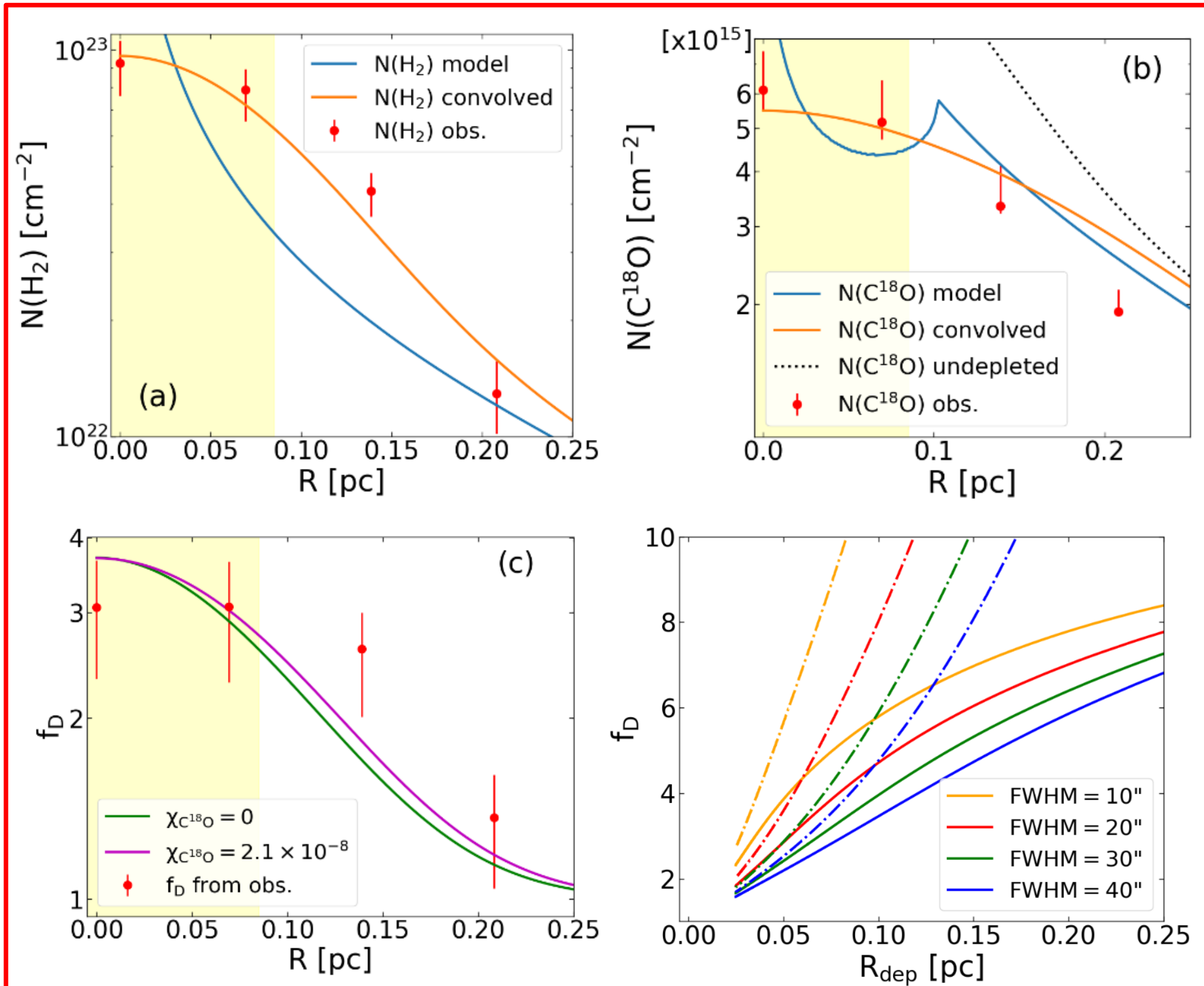
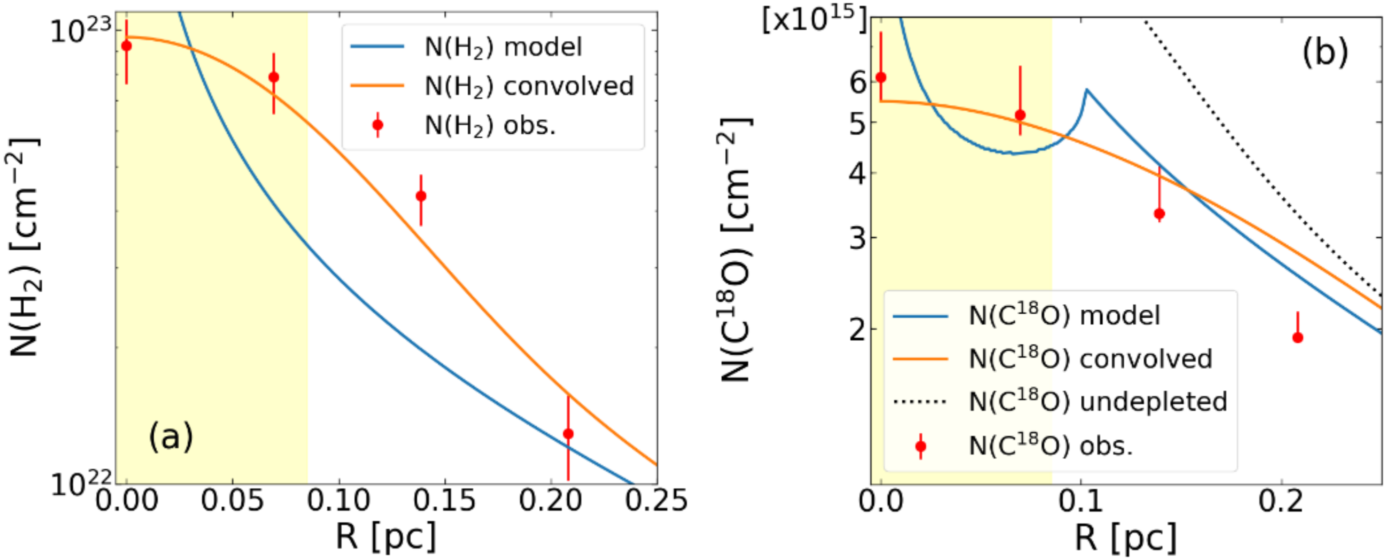
Depletion model:

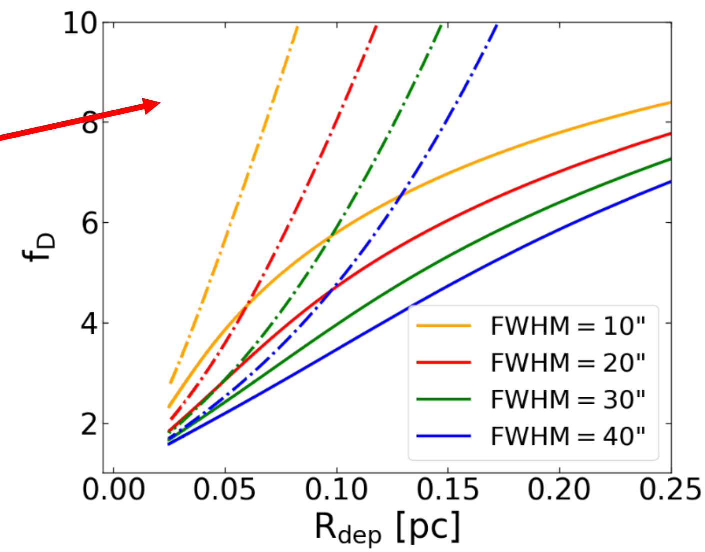
C5



Depletion model:

C5





Strongly dependent on the model's assumptions!

Caveats and limitations:

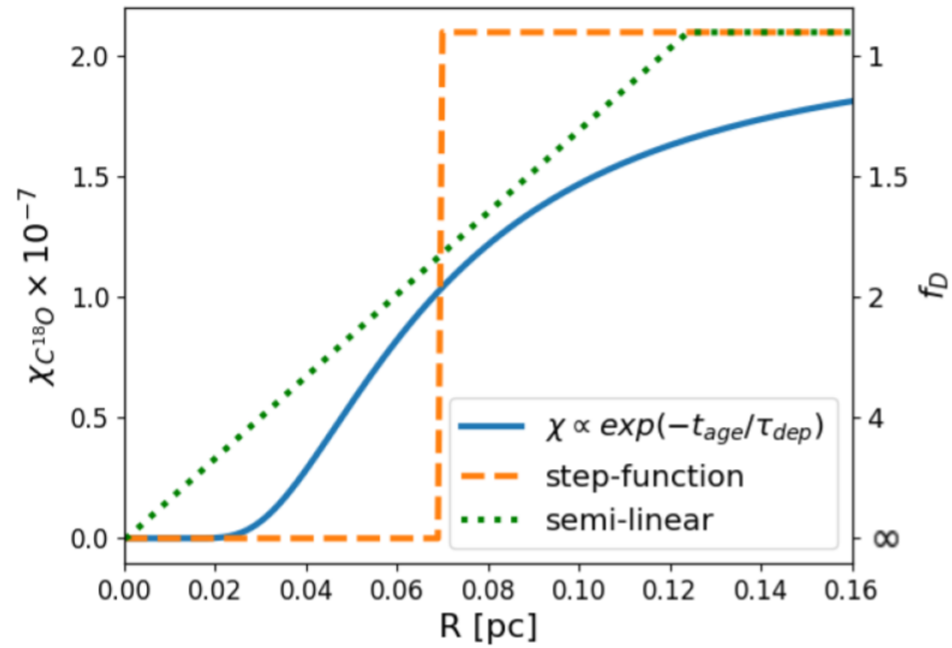
1. Canonical abundance:

$$\frac{C^{18}O}{H_2} = 2{,}1 \times 10^{-7}$$

(Giannetti +17b)

2. Plummer- like profile
3. Step-function:

How much R_{dep} size depend on this assumption?



Regions *Profiles*	**C5** [pc]	**C7** [pc]	**F1** [pc]
Step-function ($f_D = 10$; R< R_{dep})	0.10	0.12	0.15
Step-function ($f_D = \infty$; R< R_{dep})	0.07	0.07	0.08
Exponential	0.04	0.04	0.05
Semi-linear	0.02	0.02	0.03

The new R_{dep} estimated from the exponential profile are within a factor of about 2-3 of those found from the other two profile.

Conclusions:

1. Confirmed largescale CO-depletion in HMSFRs: both in main- and sub-filaments;

2. Chemistry of the ISM is altered by CO-depletion: suggest caution when using CO for kinematical studies in IRDCs or for estimate M_{H_2};

3. Estimated size of R_{dep} between 0.08 and 0.12 pc (step-function profile);

Future perspectives:

- Higher resolutions would still be necessary: stronger constrains on the models;

Thanks for your attention