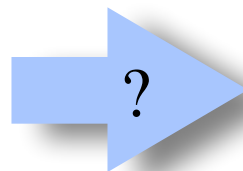
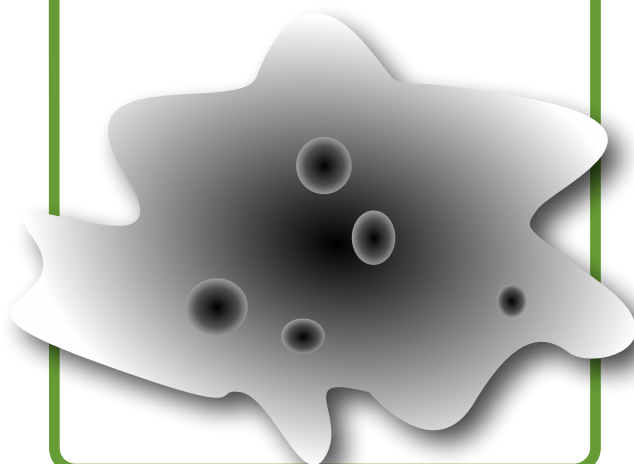




CygX-N63

Dark cloud



Massive
protostar



The **astrochemical link** between
dark clouds and hot cores

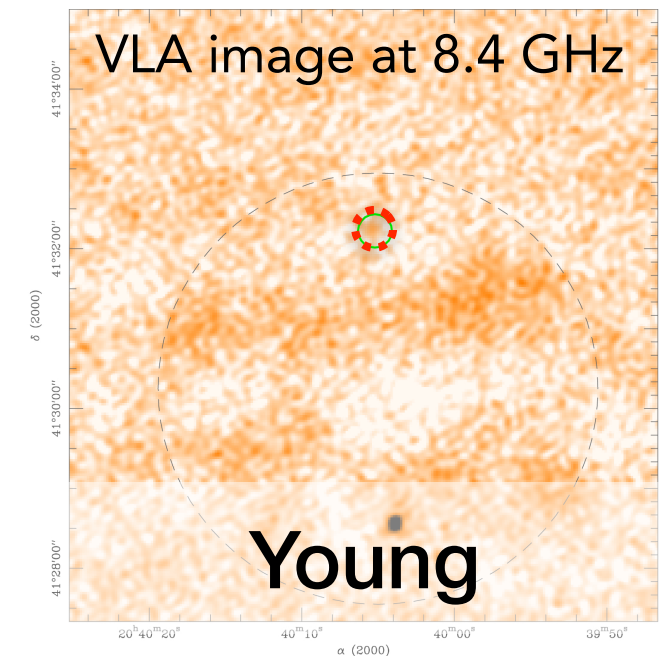
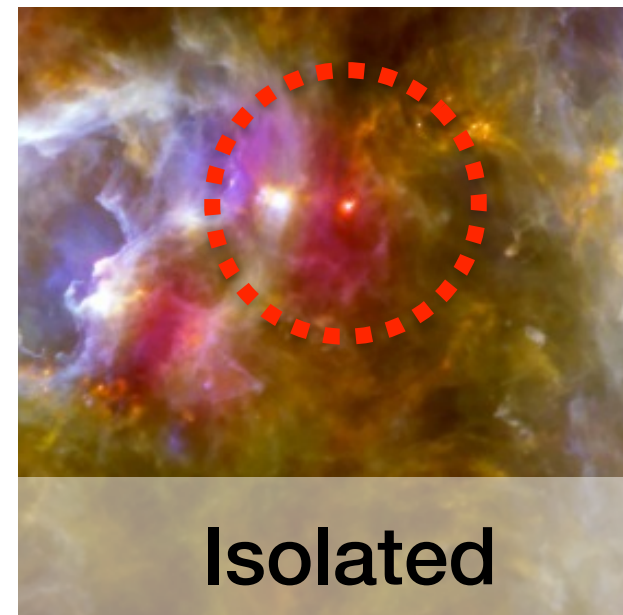
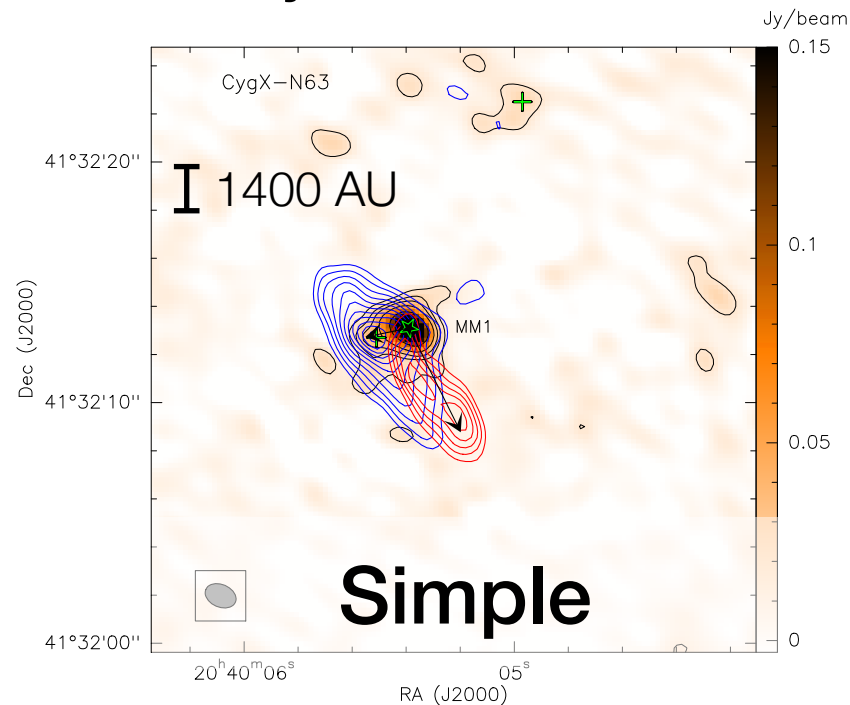
Sarah Fechtenbaum
SF2A
4 juin 2015

université
de BORDEAUX



CygX-N63: a lovely protostar

Found by Motte et al. 2007

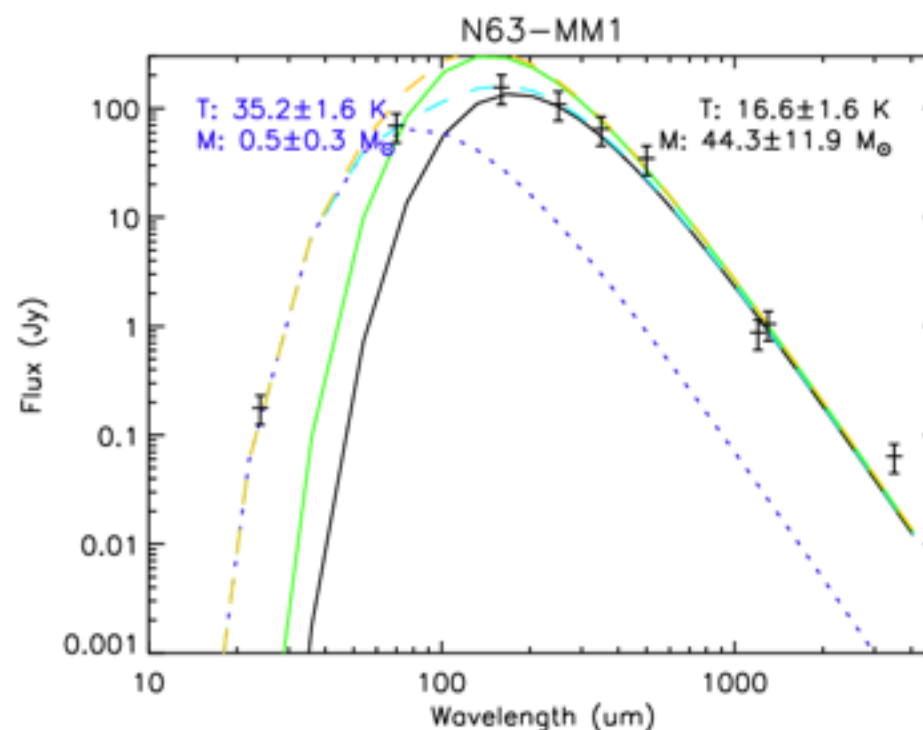


Massive

$\sim 44 M_{\odot}$ in 2500 AU

$350 L_{\odot}$

Duarte-Cabral 2013



Future star of
 $20-25 M_{\odot}$

Unbiased spectral survey

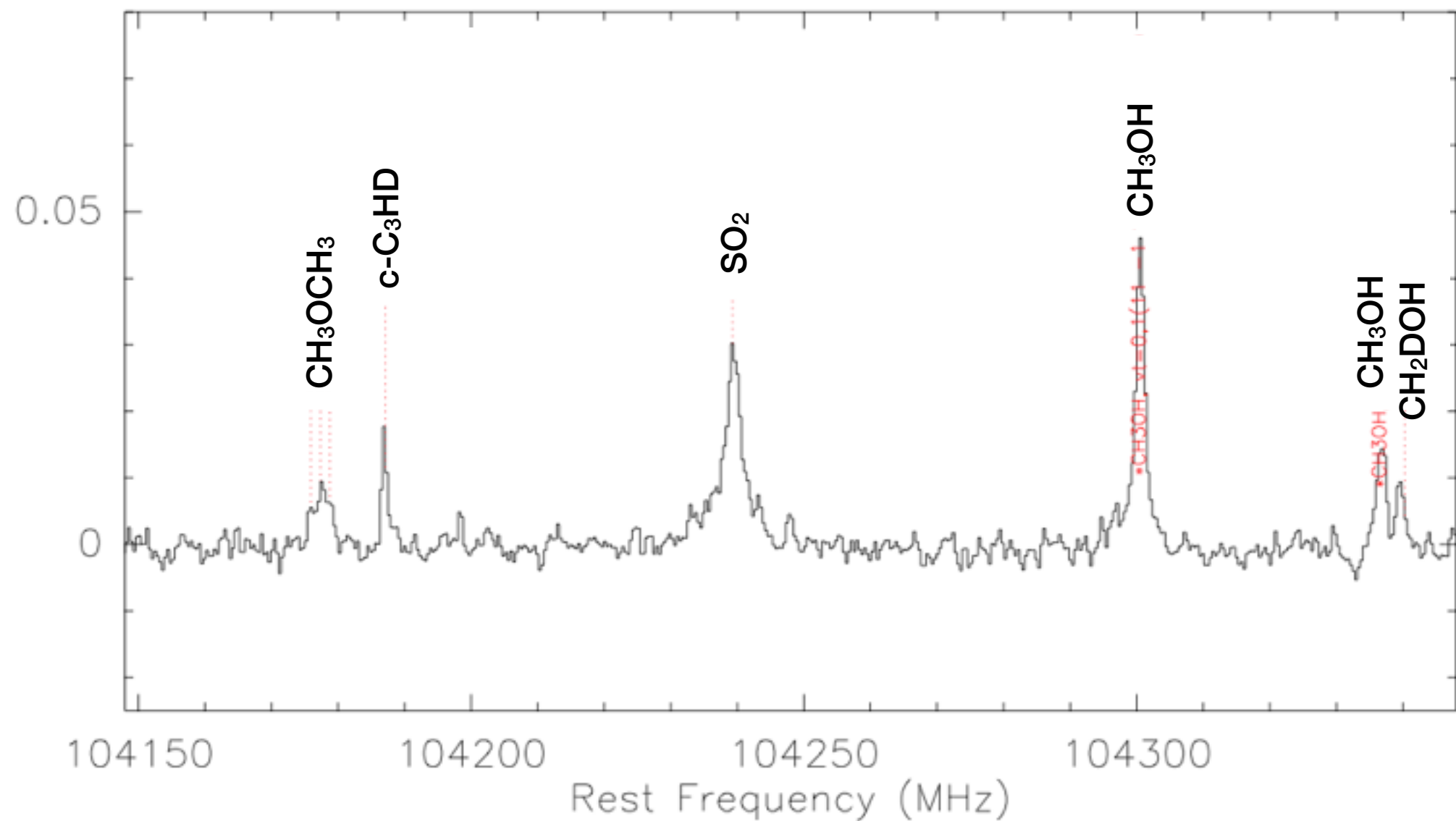
235 hours of observation



181 GHz
observed

~2600 lines
at a 4σ level

10 lines / GHz



Chemical composition

- 95% of the lines identified
- 67 molecules
- Abundances determined for 56 molecules

CO
HCO
HCO⁺
o/p-H₂CO
HOCO⁺
H₂CCO
t-HCOOH
H₂COH⁺ ?

CS
CCS
HCS⁺
o/p-H₂S
H₂CS
SO
SO⁺
SO₂
OCS
NS
CH₃SH ?

CH₃OH
CH₃CHO
CH₃OCH₃
CH₃OCHO
C₂H₅OH
CH₃COCH₃
Ethylene oxide

CN
N₂H⁺
NO
HCN
HNC
HC₃N
HC₅N
HNCO
HONC
CH₃CN
C₂H₅CN
HCCNC
CH₂NH
NH₂CHO

CCH
c-C₃H
C₄H
o/p-c-C₃H₂
a/e-CH₃CCH

N₂D⁺
DCN
DNC
NH₂D
CH₂DOH
CH₃OD
HDO
DCO⁺
DOCO⁺?
HDCO
o/p-D₂CO
DC₃N
CCD
c-C₃HD
CH₂DCCH
HDCS

SiO
CF⁺
PN ?

Comparison of the abundances

Dark clouds

Collated by Garrod
et al. 2007

L134

TMC-1

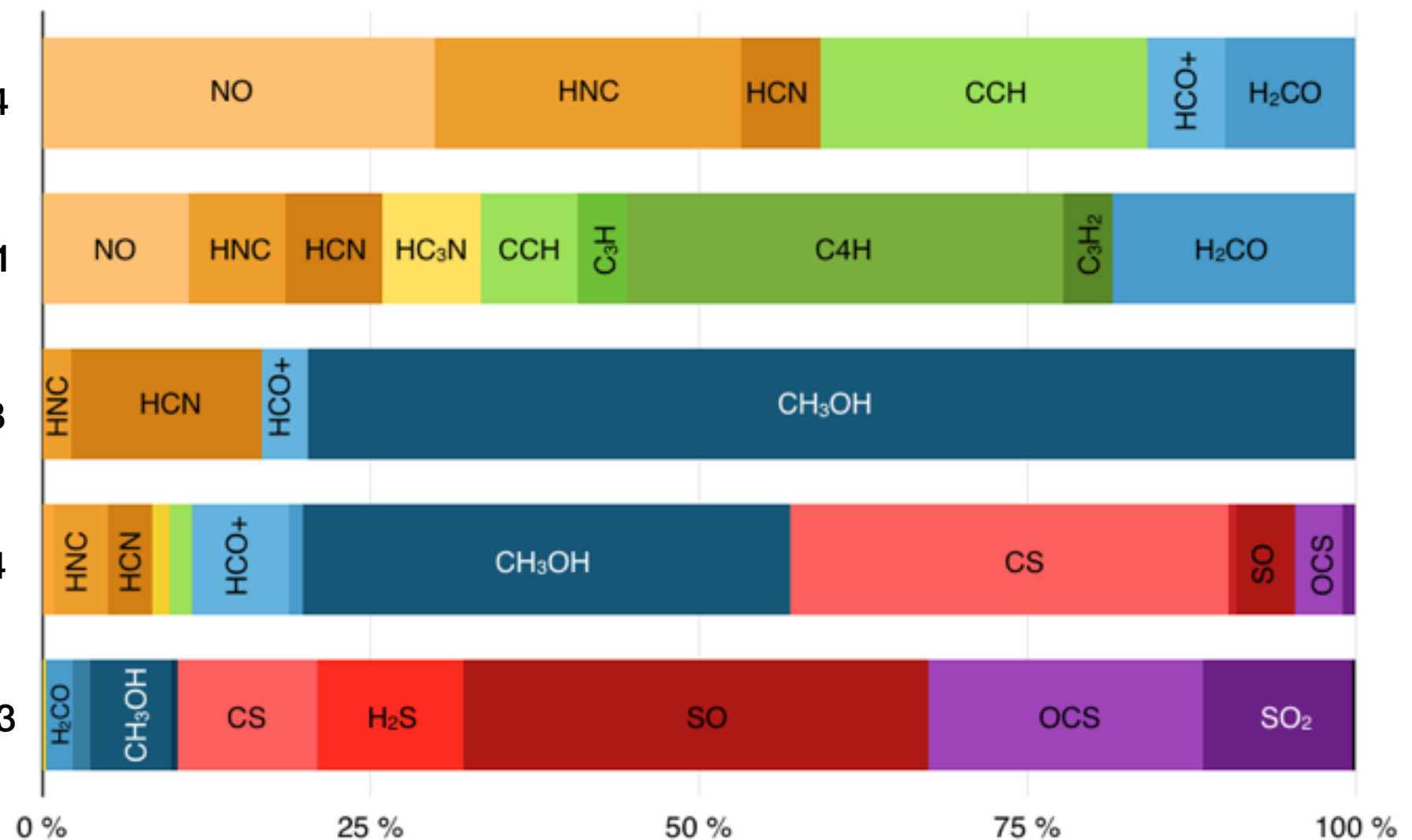
N63

Hot core → G34

Mookerjea et al. 2007

Hot corino → IRAS16293

Cazaux et al. 2003
Wakelam et al. 2003
Jorgensen et al. 2004
Bottinelli et al. 2007
Stäuber et al. 2011



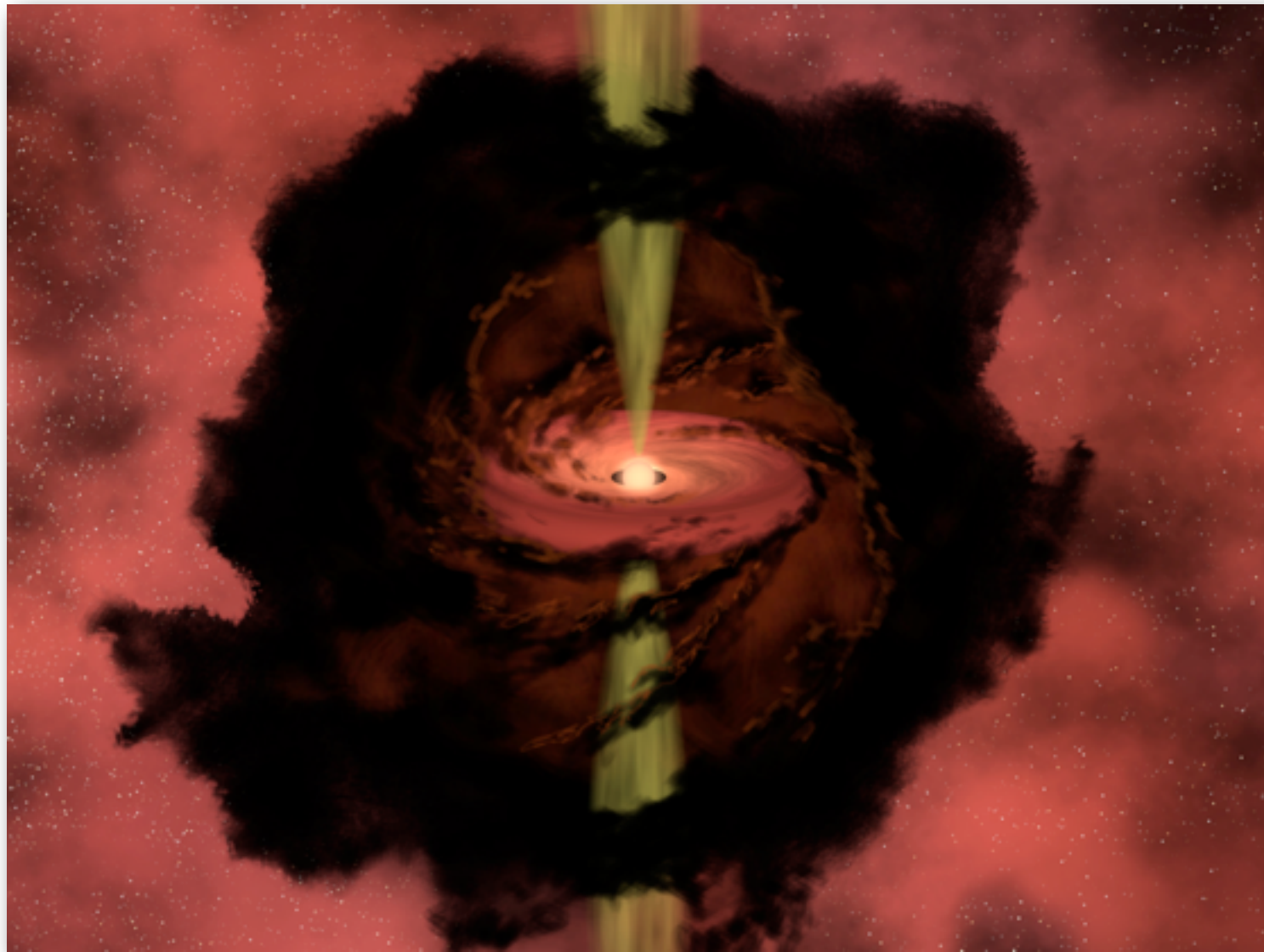
N-bearing species

Carbon chains

O-bearing and COMs

S-bearing

Spatial decomposition



**What is the origin of
molecular emission ?**

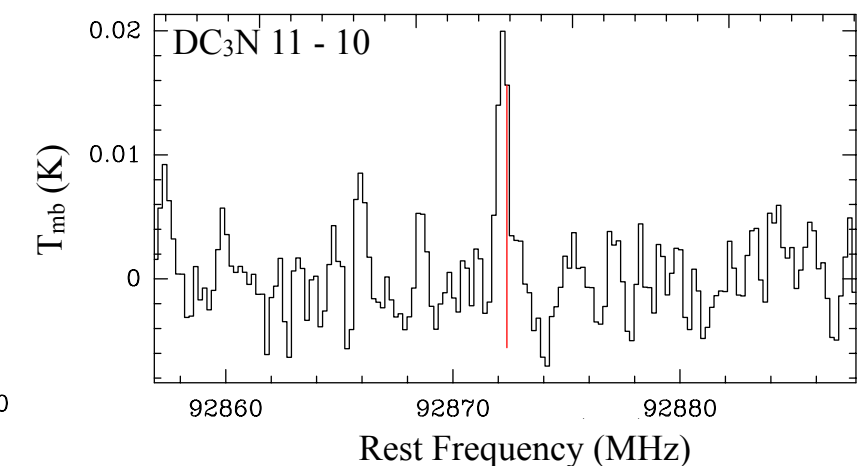
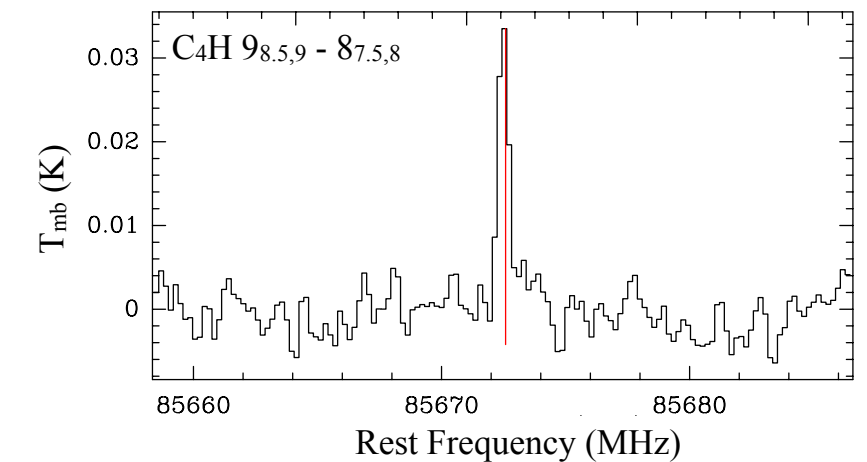
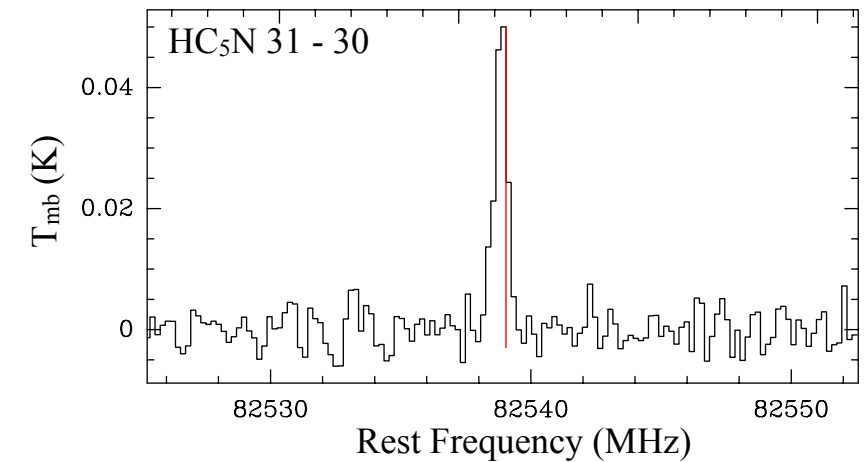
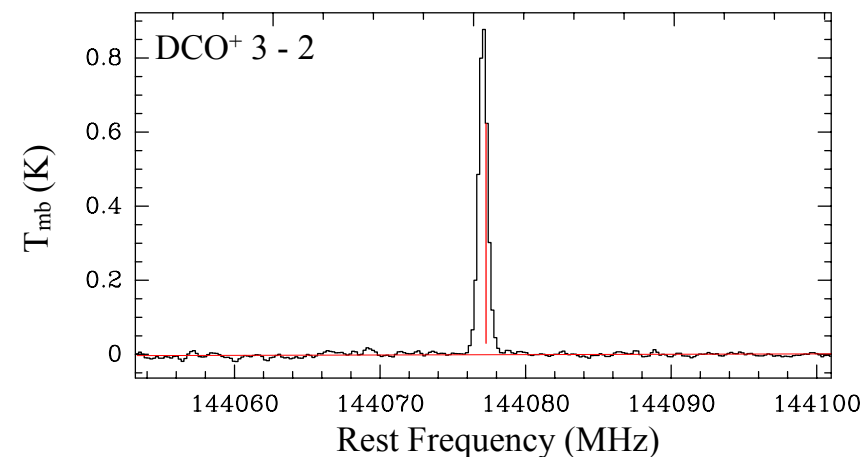
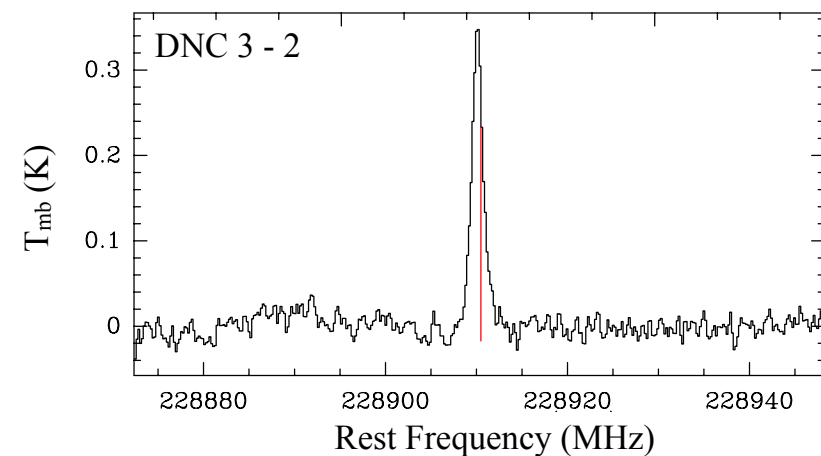
Spatial analysis: spectral profiles

Narrow lines $< 2 \text{ km s}^{-1}$

Including N_2H^+ , N_2D^+ , DNC, DCO^+ , NH_2D , C_3H , C_4H ...

$$T_{\text{ex}} = 13 \text{ K}$$

**Envelope
tracers**



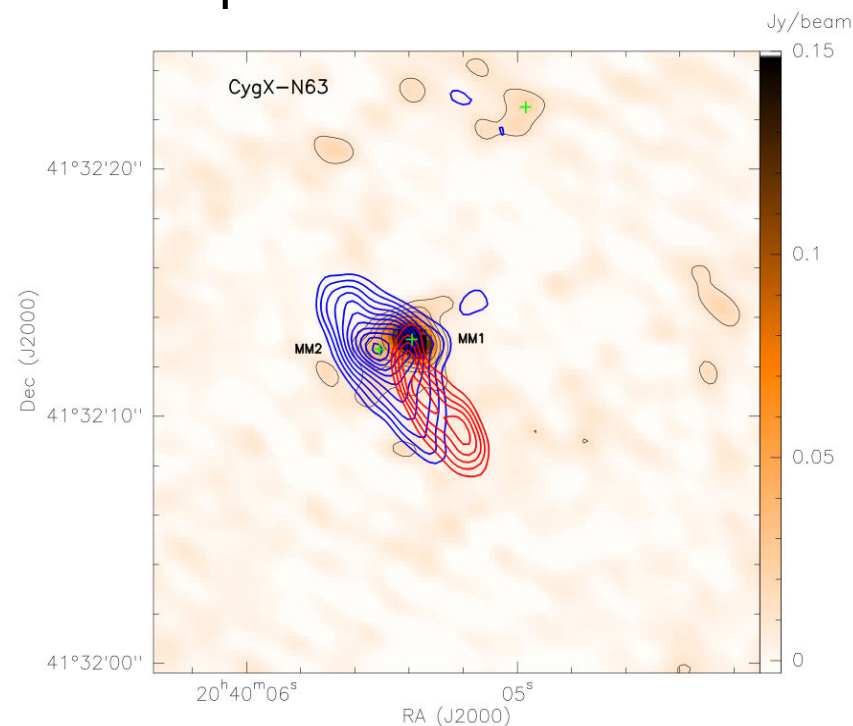
Spatial analysis: spectral profiles

Broad lines

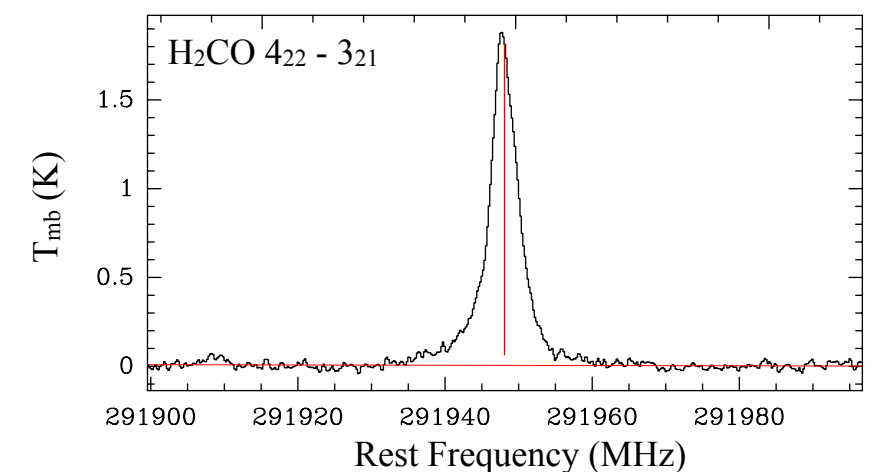
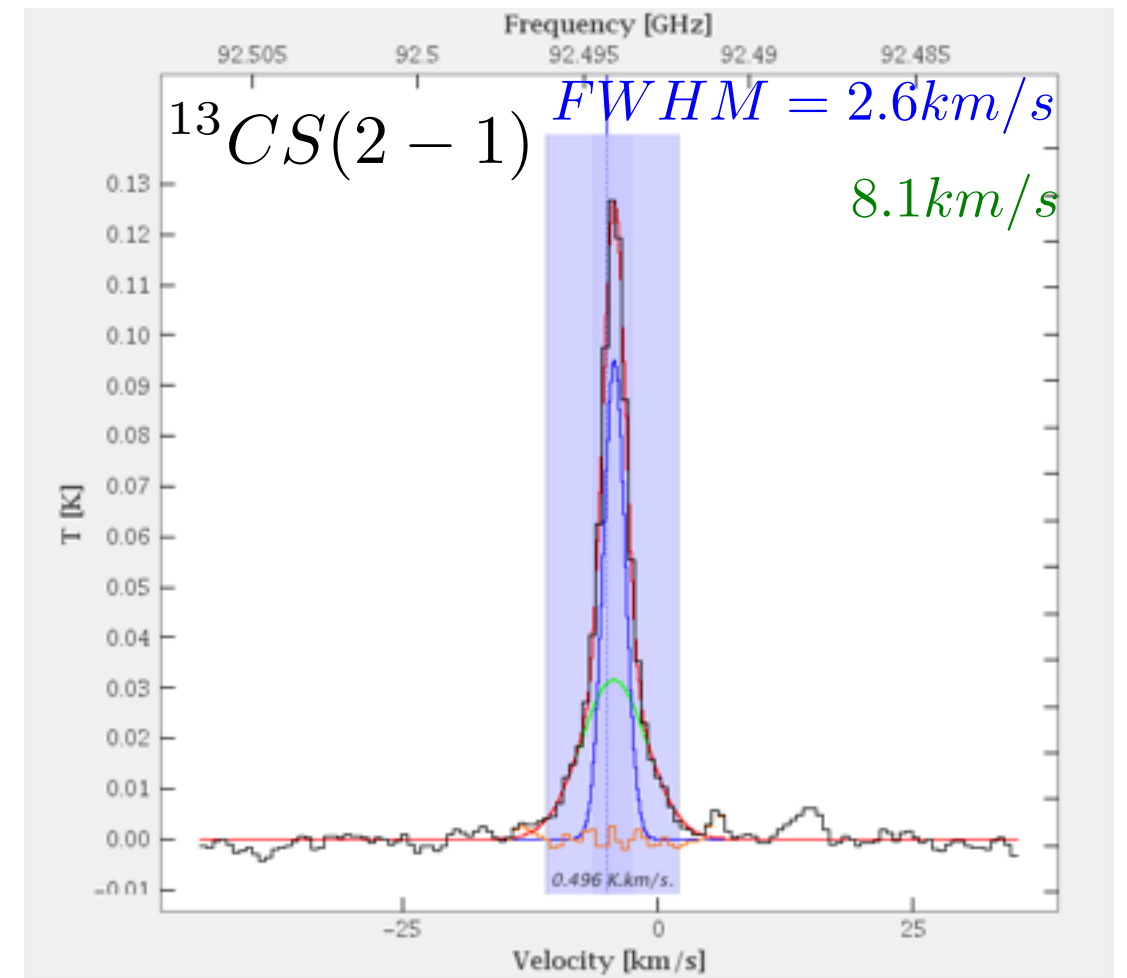
A large part of the molecules,
including H₂CO, HCN, CS, CN

$T_{\text{ex}} = 14$ and 17 K

SiO, SO have a very broad
component



**Probably
influenced by
the outflow**



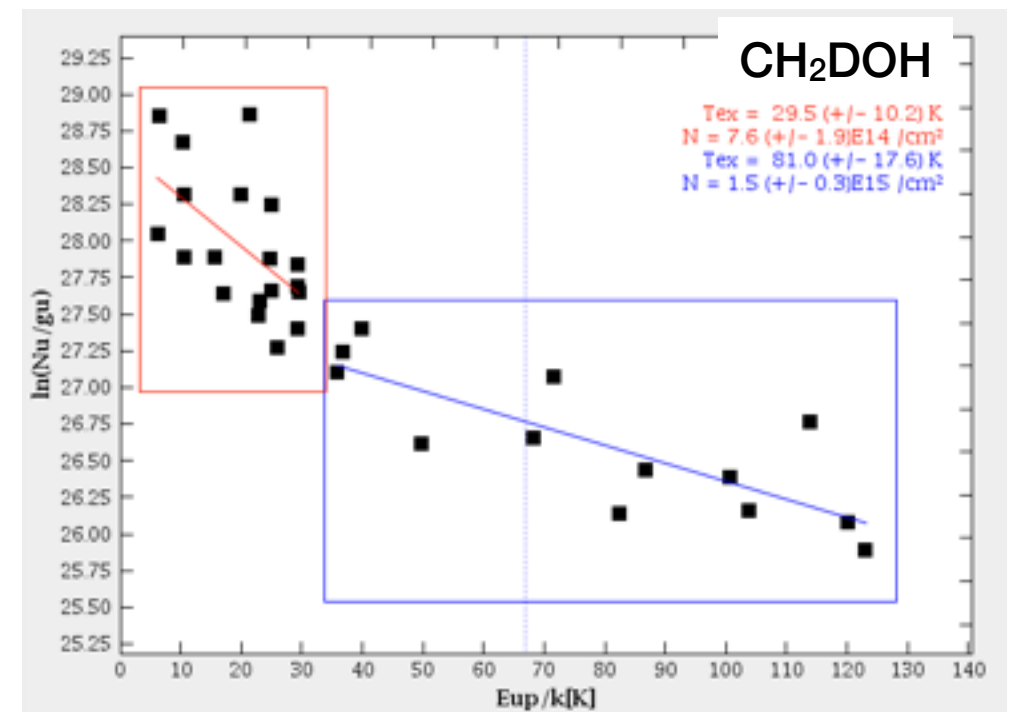
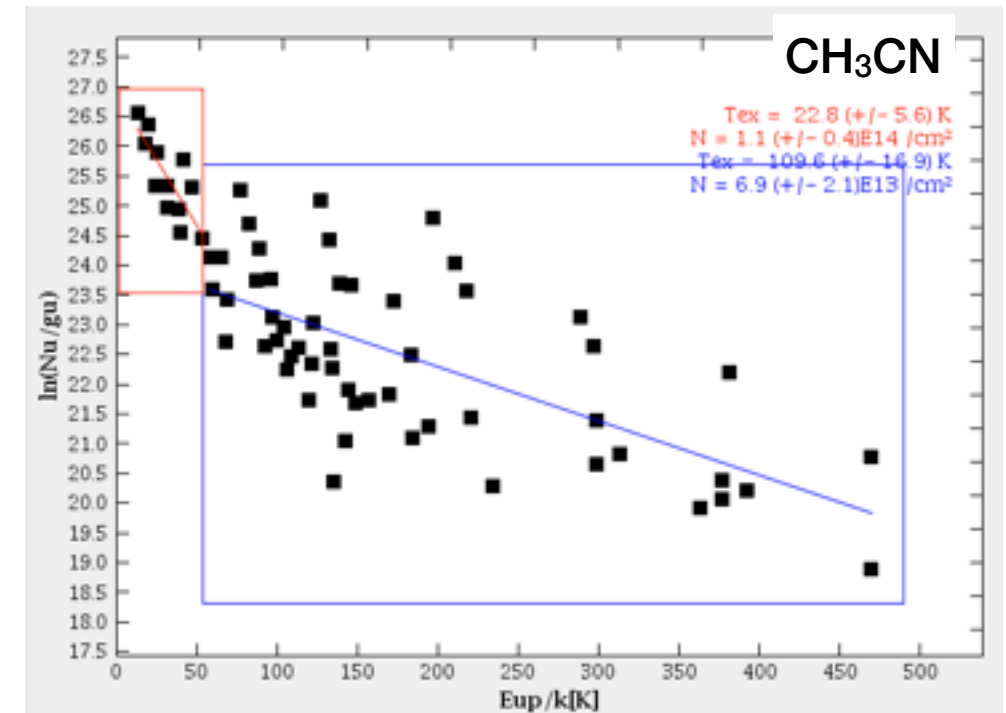
Spatial analysis: population diagrams

Most of the population diagrams show a unique slope.

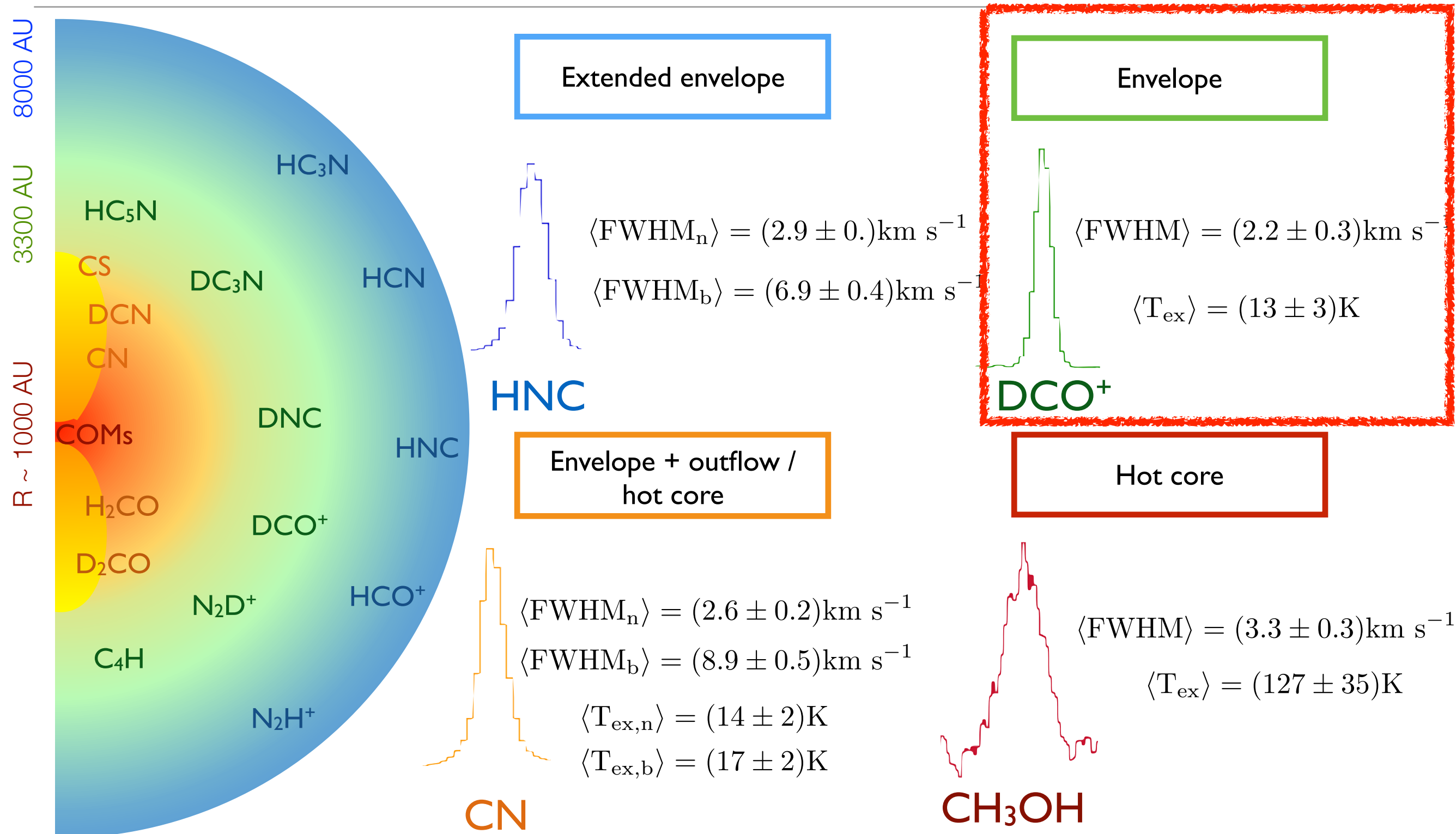
All oxygen-bearing COMs have two slopes: CH₃OH, CH₃CHO, CH₃OCH₃, CH₃OCHO, C₂H₅OH + CH₃CN

=> low $T_{\text{ex}} \sim 21$ K and high $T_{\text{ex}} \sim 130$ K

Hot core tracers



Spatial analysis - summary



We have found the pristine gas

Composition

N_2D^+
 DNC
 NH_2D
 DC_3N
 DCO^+
 C_3HD
 CH_2DCCH
 HDCS

N_2H^+
 HC_5N
 HCCNC

$c\text{-C}_3\text{H}$
 C_4H

Characteristics

- High density $\sim 6 \times 10^7 \text{ cm}^{-3}$

- High-level of depletion

$$f_D = \frac{x(C^{17}O)_{can}}{x(C^{17}O)_{obs}} = 16$$

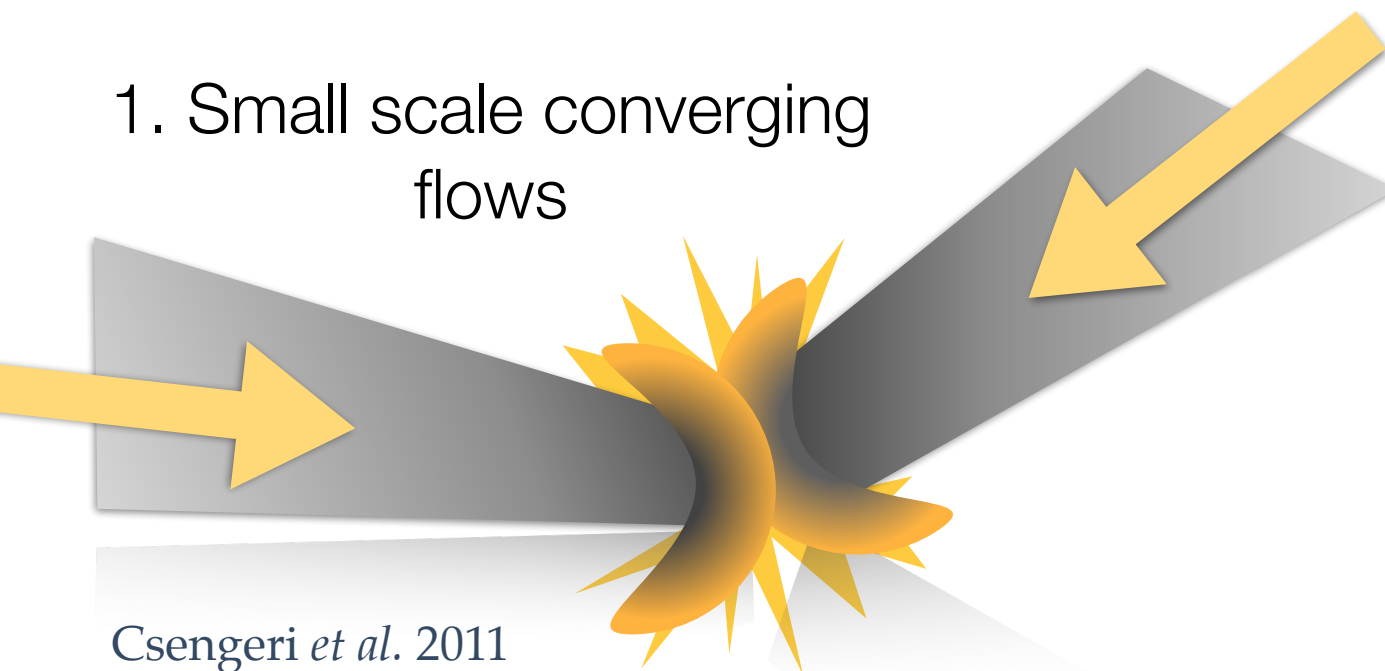
- $T \sim 12\text{-}13 \text{ K}$

- Mean FWHM = 1.9 km s^{-1}

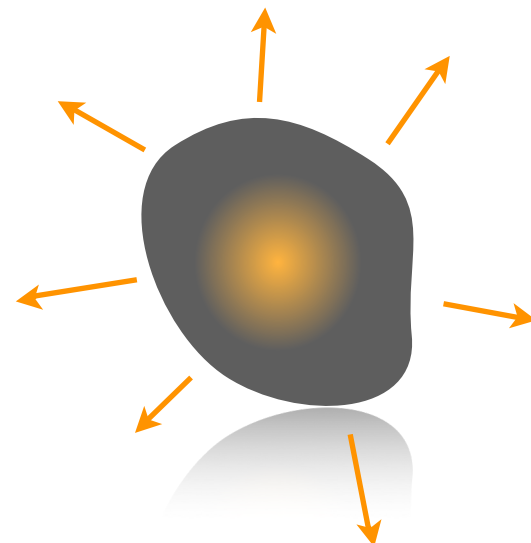
- Low deuteration level $\sim 6 \cdot 10^{-3}$

High-mass star formation possibility

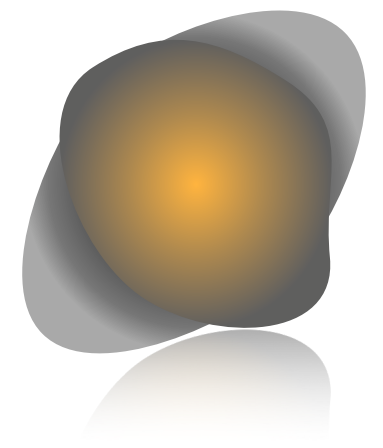
1. Small scale converging flows



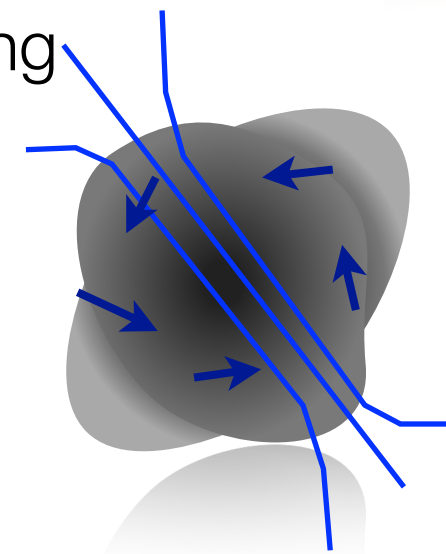
2. Cooling



4. Heating

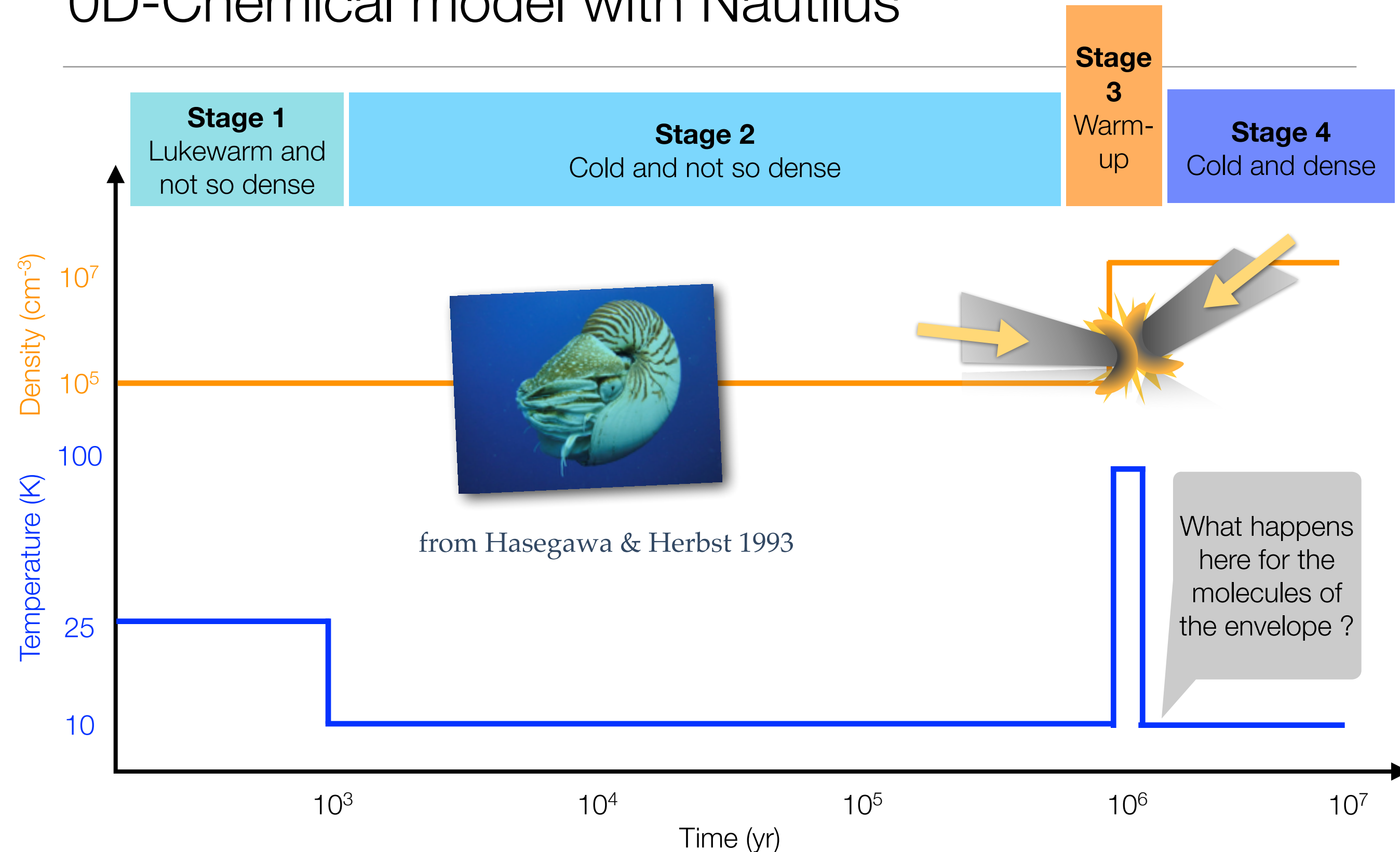


3. Magnetic braking



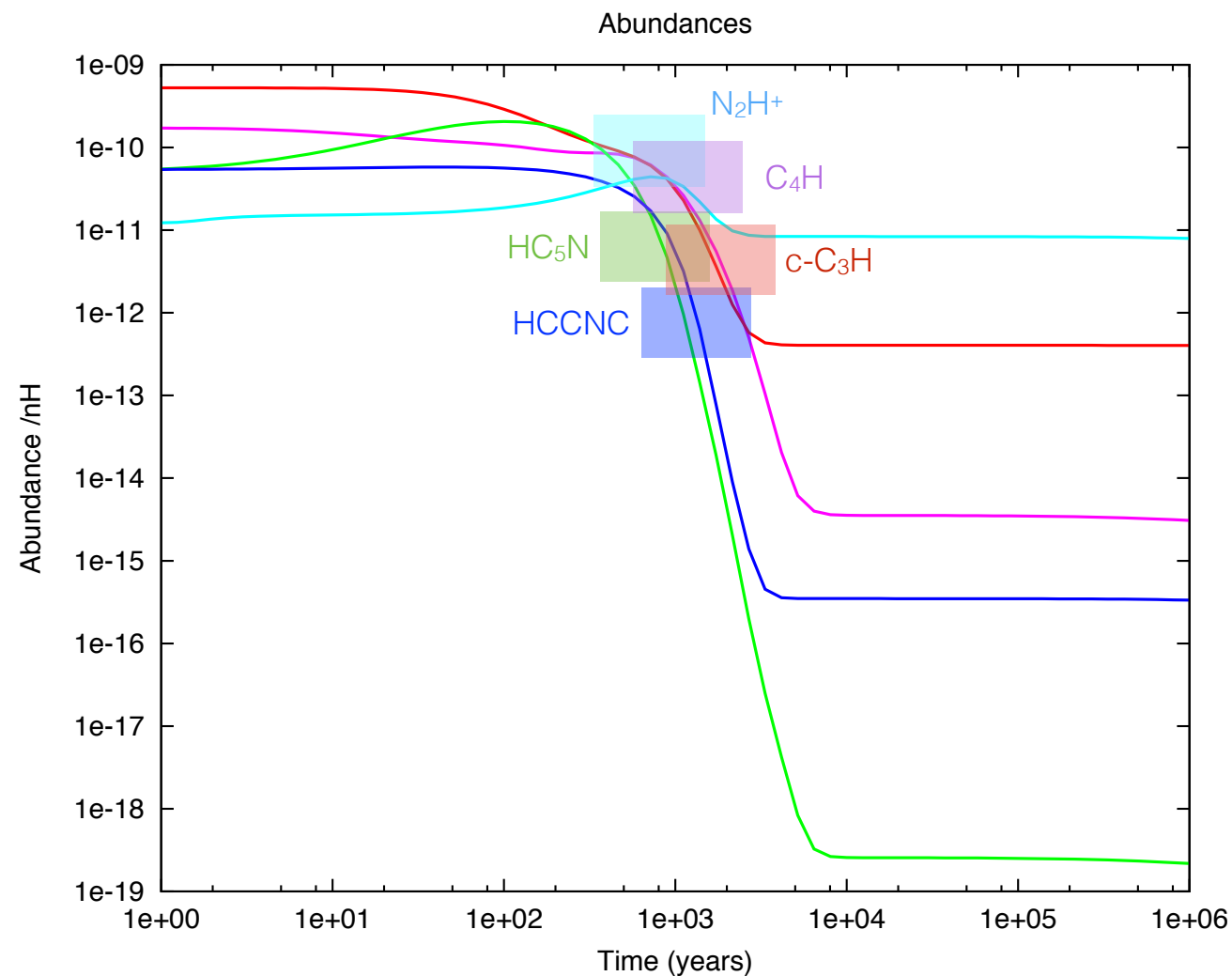
Commerçon et al. 2011 and 2012

0D-Chemical model with Nautilus

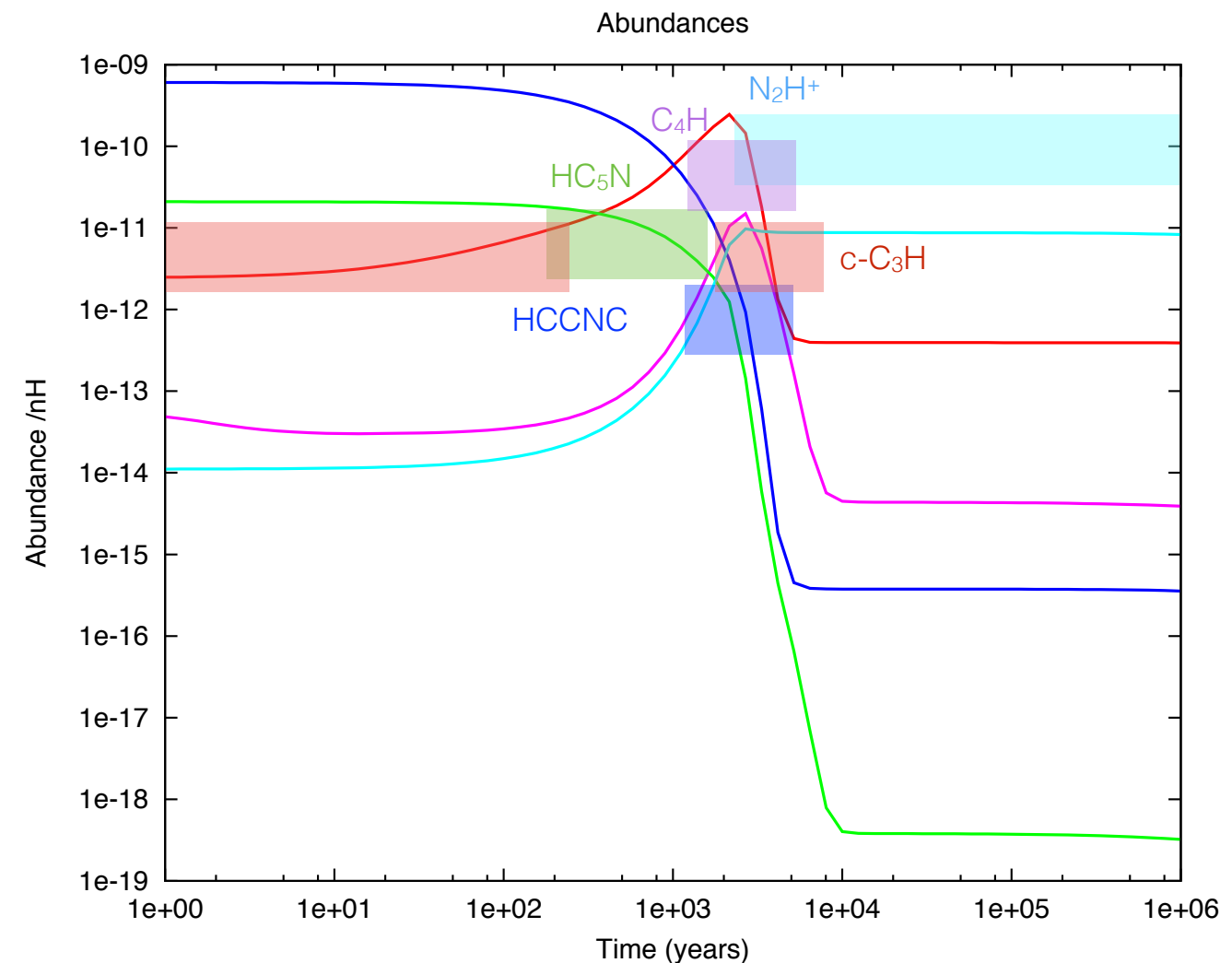


0D-Chemical model with Nautilus

Without early warm-up



With early warm-up



- This is nice !
- The molecules forget their past after 10^3 years at high density
- The high density stage is very recent in N63 : $< 5 \cdot 10^3$ years

CygX-N63 is a **nascent hot core**

- N63 is an individual massive Class-0
- Between a dark cloud and a hot core
- Chemically rich but not too much
- Tens of $M_{\odot}$ of highly depleted material
- Abundances determined for 56 species, including 13 deuterated species

see Fechtenbaum et al. 2015 in prep. !

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