ISMServices

PADC
Paris Astronomical Data Centre

ISMDB

InterStellar Medium DataBase

http://ism.obspm.fr

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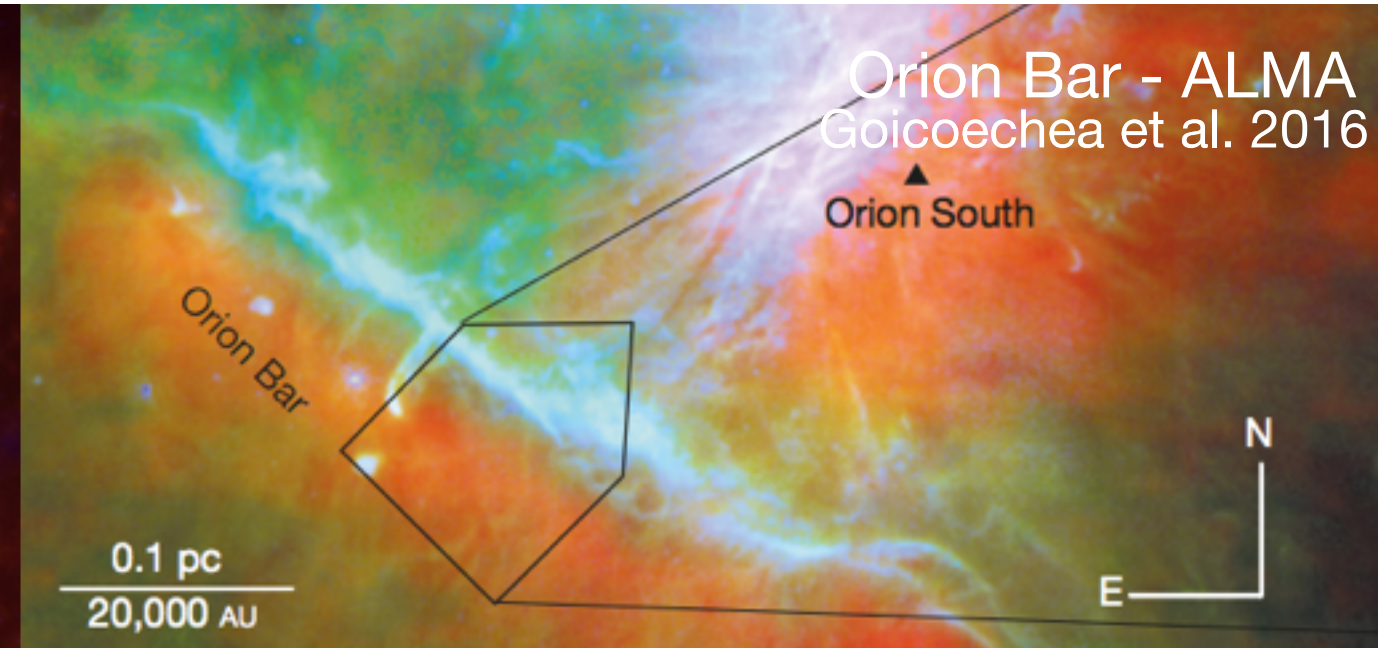
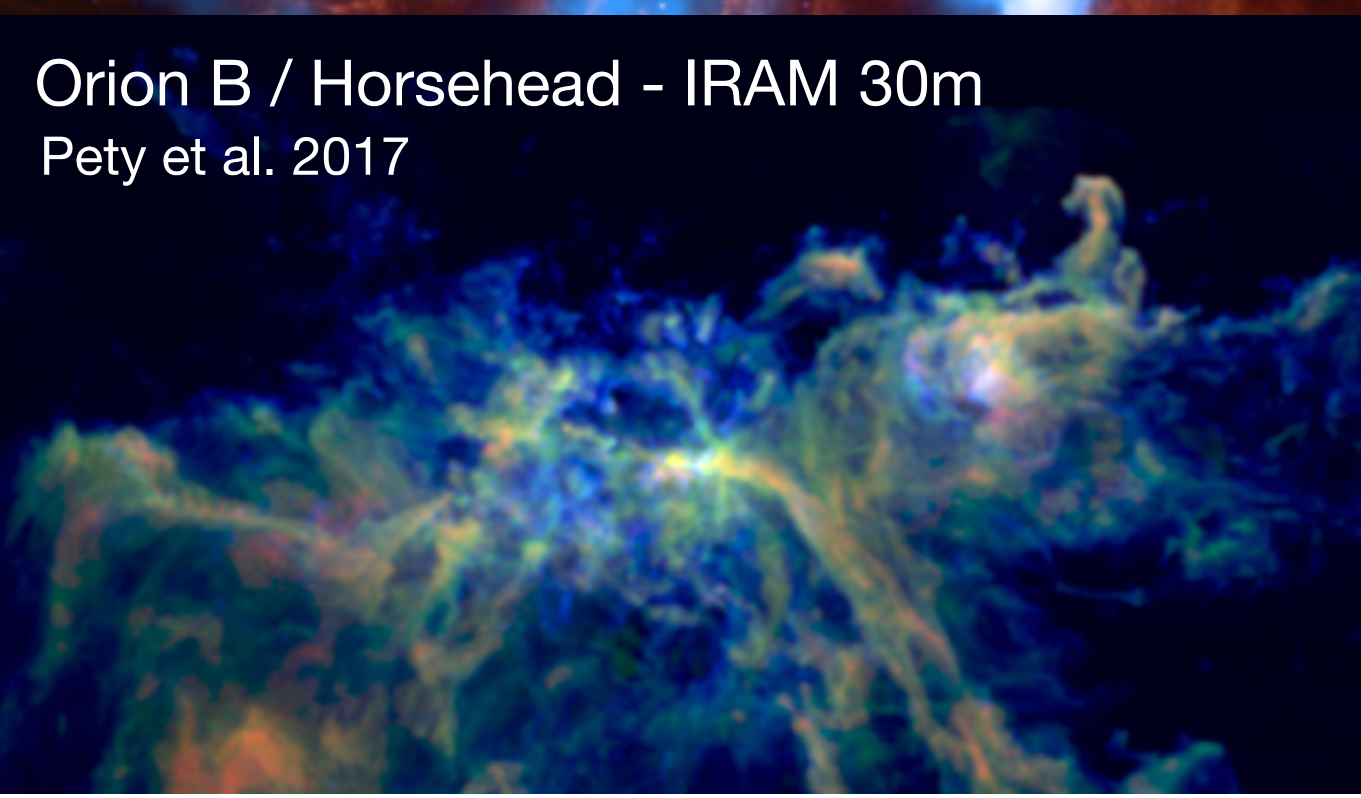
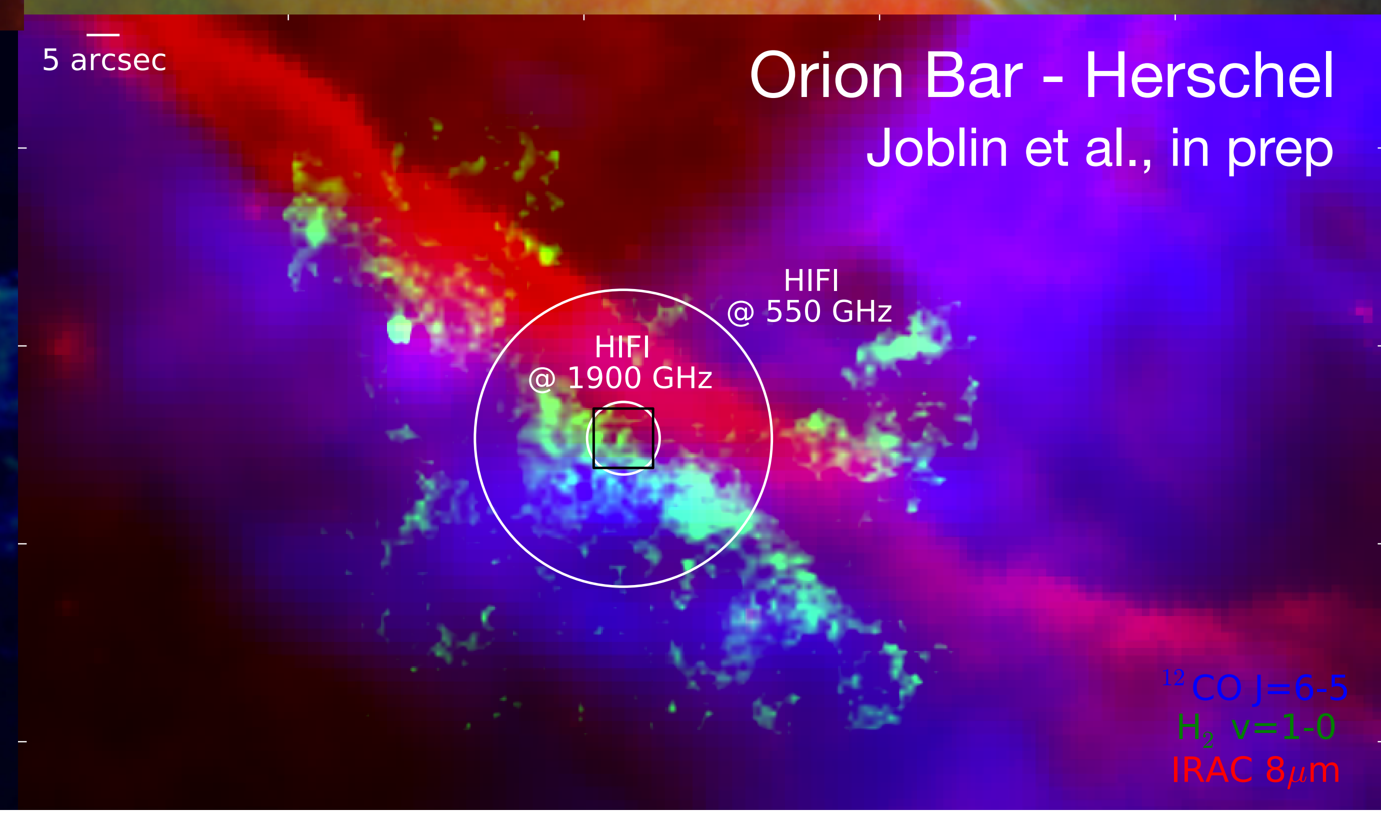
InterOp - Shanghai - 16th May 2017

ISMDB: Interstellar Medium DataBase

Goal: Provide numerical tools to interpret observations in the interstellar medium.





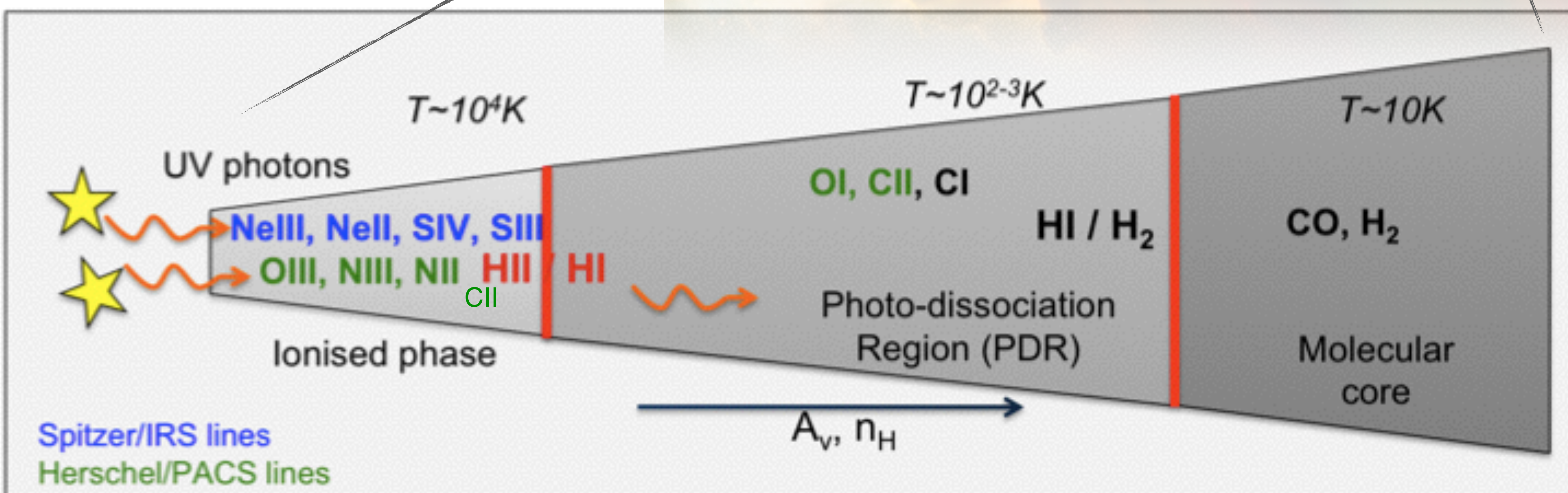


With the new instruments, observations of the ISM are:

- more and more detailed
- more and more difficult to interpret

Schema of the transition atoms / molecules

PDR: Photo-dissociation region
Transitions between H / H_2 regions



Mélanie Chevance
CEA - France

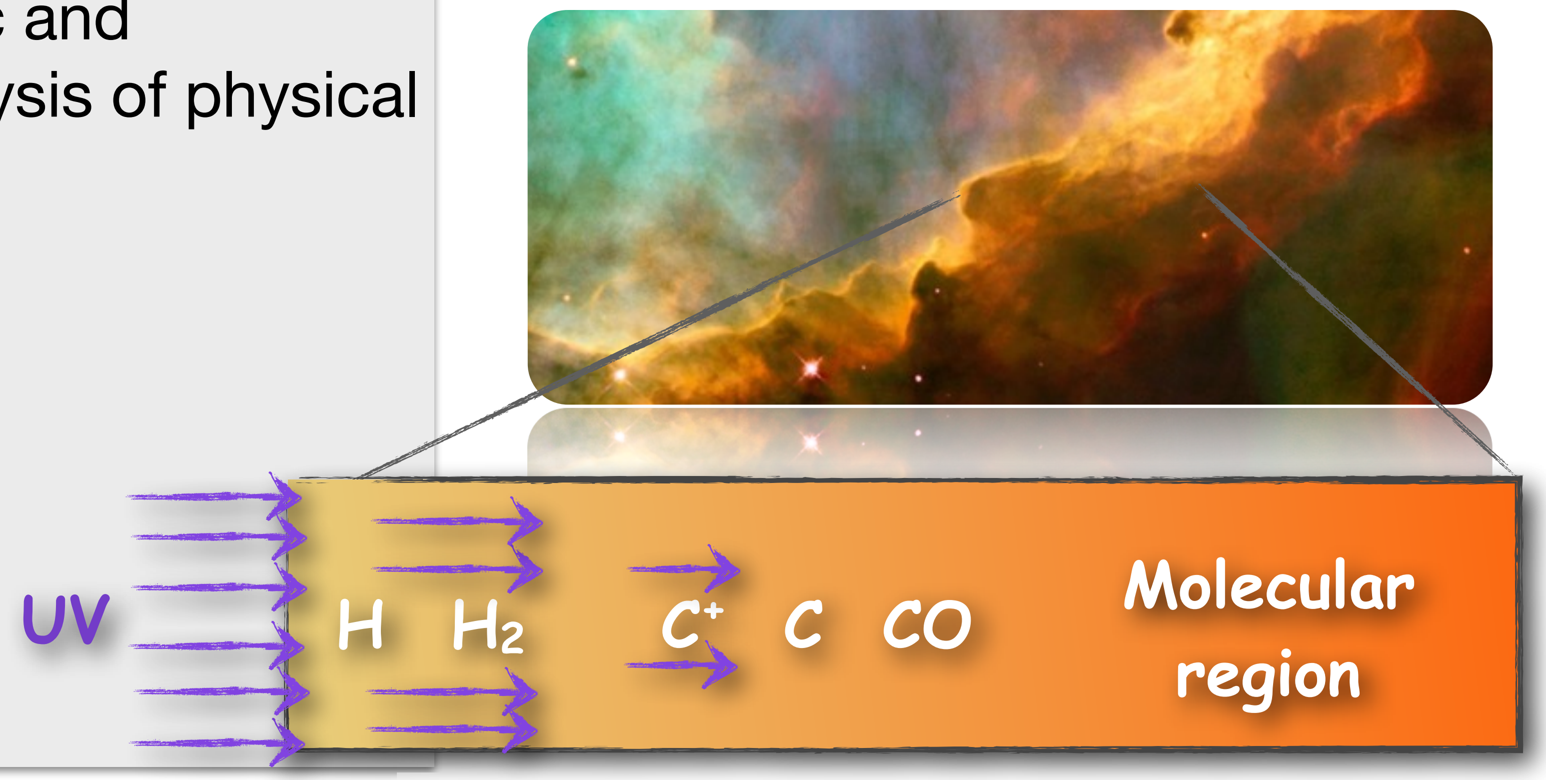
Simulation code: Meudon PDR code

Le Petit et al. (2006), Gonzalez-Garcia et al. (2008), Le Petit et al. (2009), Le Bourlot et al. (2012)

PDR Code : computation of the atomic and molecular structure of clouds and analysis of physical processes

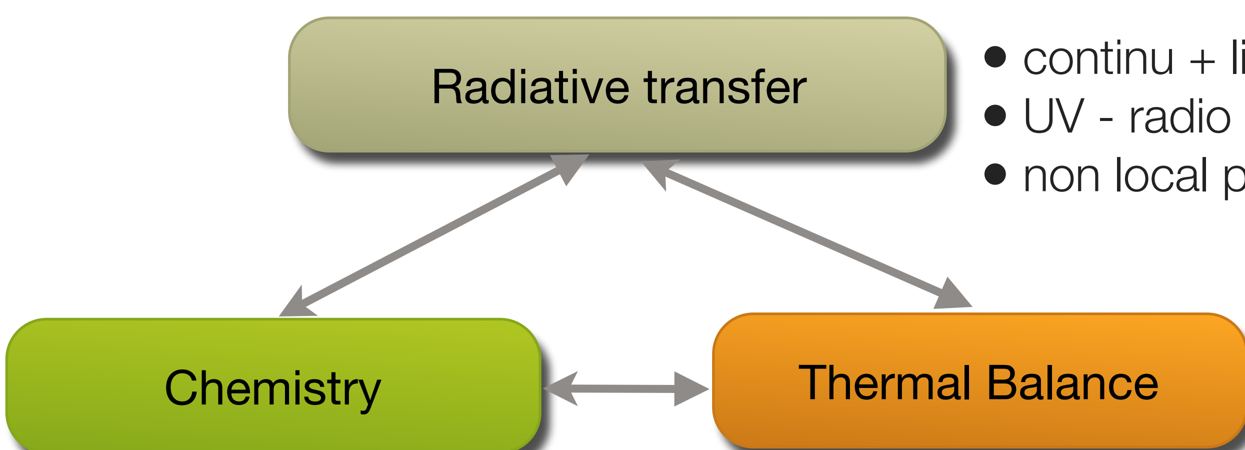
- abundances
- excitation states
- temperatures (gas & grains)

- Intensities (H_2, CO, H_2O, ...)
- Column densities



Interpretation of large instruments observations

ALMA, SOFIA, IRAM, HERSCHEL, Spitzer, VLT, HST, FUSE, ...



Radiative transfer:

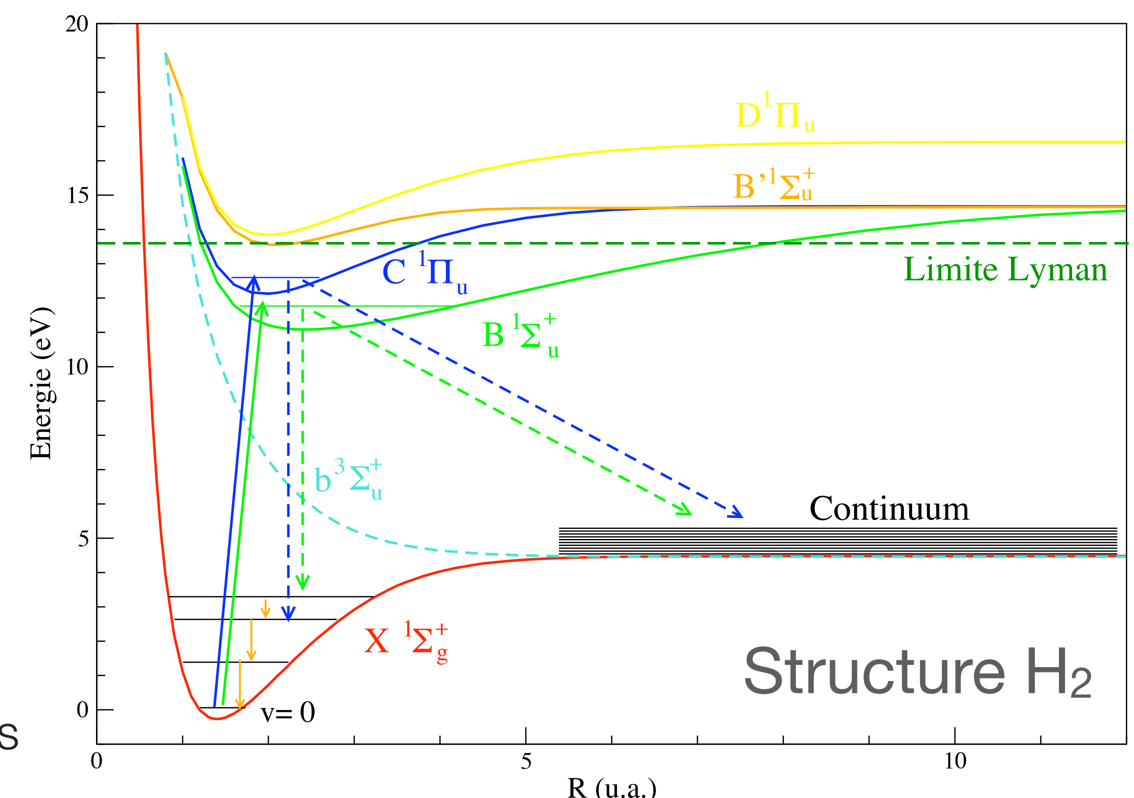
- continu + lines
- UV - radio
- non local pumpings

Chemistry:

- gas & grains chemistry
- several hundred species
- thousands reactions

Thermal Balance:

- Non LTE Detailed balance in levels
- Photo-electric effect, cosmic rays, chemistry, ...

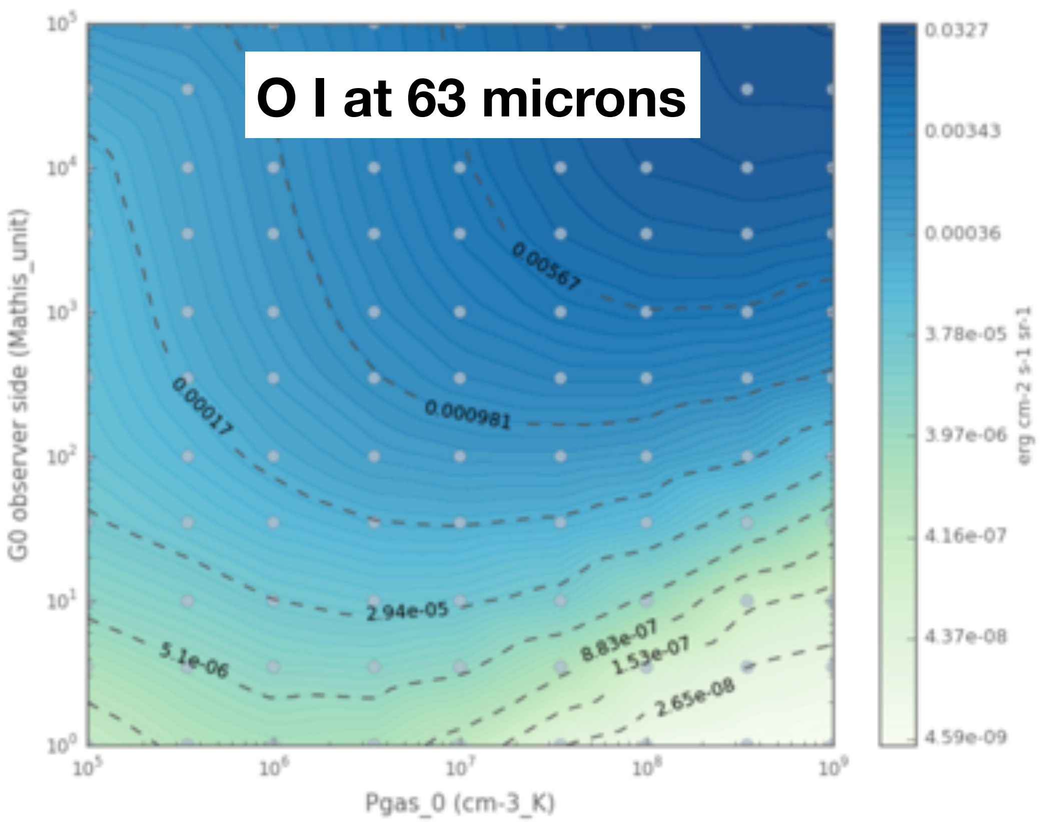


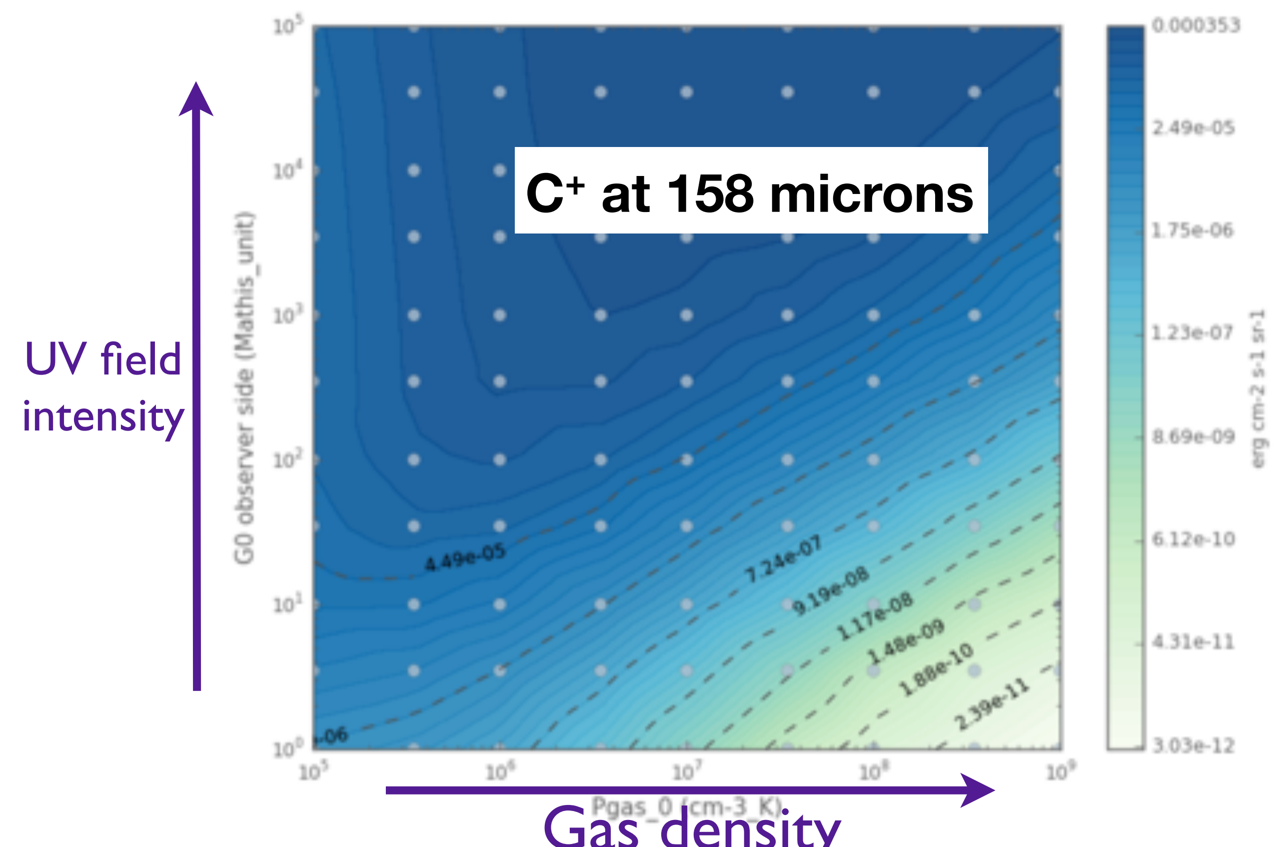
Interpretation of line intensities

Comparison of observations & grids of models
Determine physical conditions:

- density / pressure of clouds
- size of clouds
- intensity of radiation field : UV and X-rays
- metallicity
- ...

Grids of models:





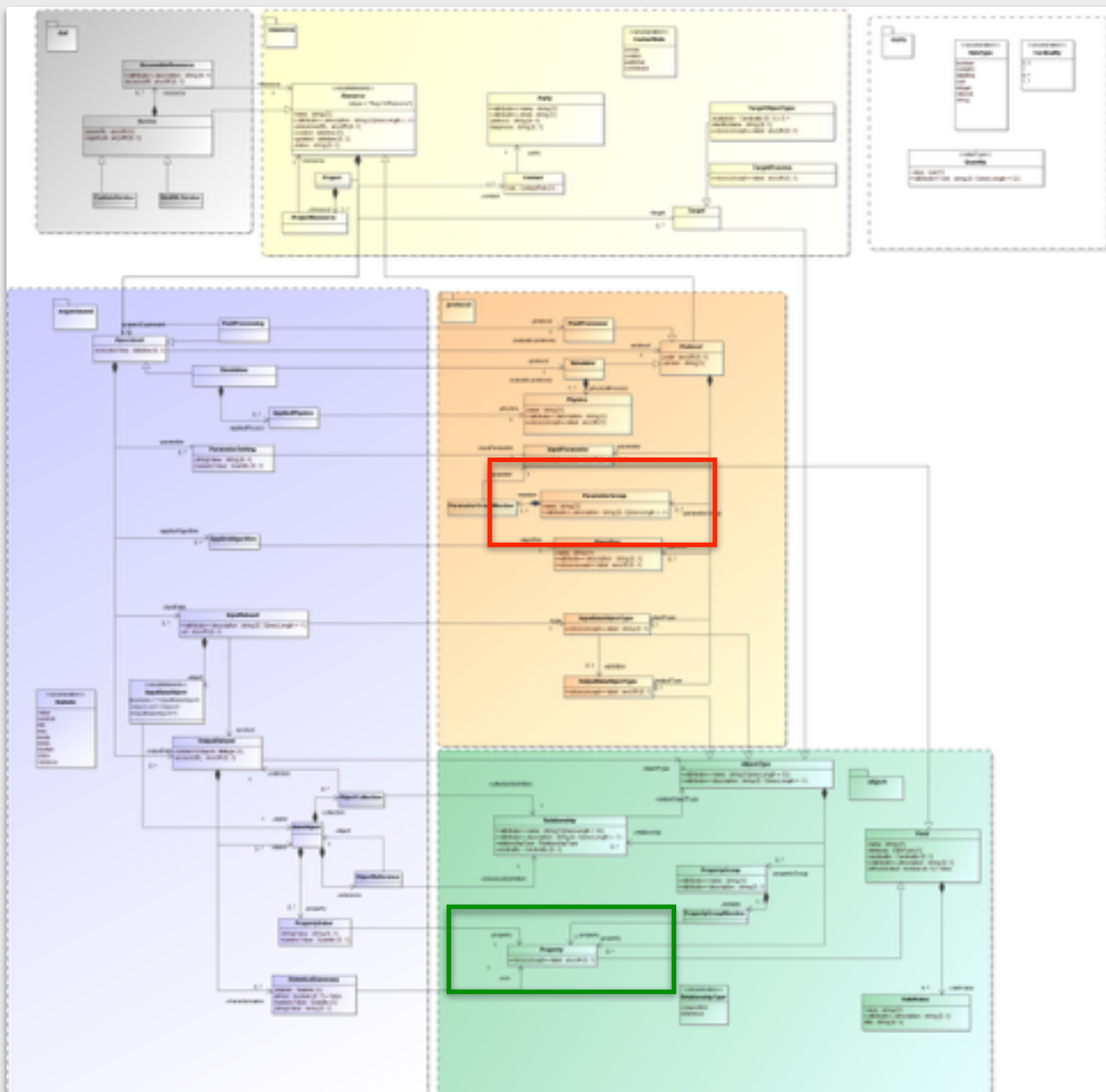
1 model : 6 hours to several days CPU time
Interpretation requires up to thousands models
➜ weeks or months of work
How to reduce this work to a few minutes ?

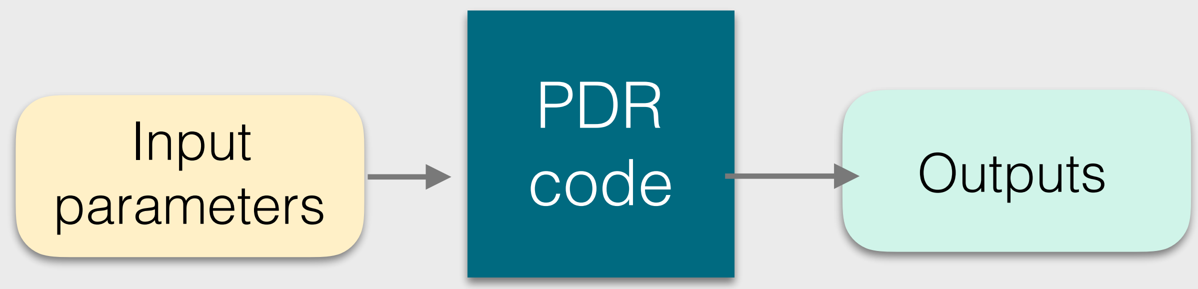
Production of grids of PDR models

- ~ 3000 PDR models in ISMDB for **standard galactic conditions**
- ~ 10 To of data

Cover: **PDR models for Herschel, IRAM/Noema, JWST, ALMA … observations**

Caracterisation of PDR models with the **Simulation DataModel :**





For each model:

InputParameters

- pressure, UV field, …
- **~ 20 quantities**

Properties / statistics

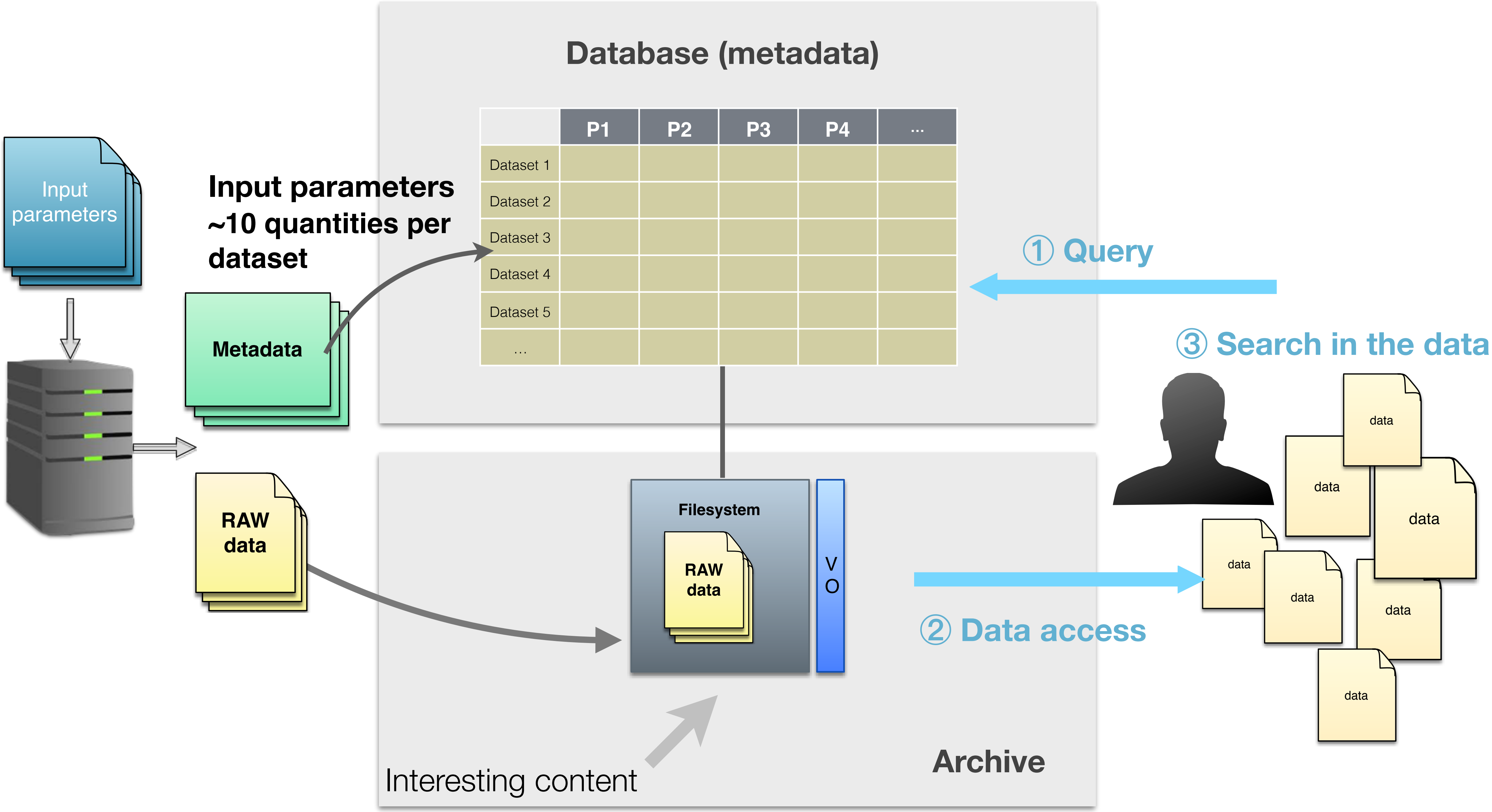
- line intensities: C^+, C, H_2, CO, H_2O, …
- **+150 000 metadata**

ISMDB

ISMDB: InterStellar Medium DataBase

- not only a classical database to find pre-computed models
- but **also a tool that can *interpret* observations**

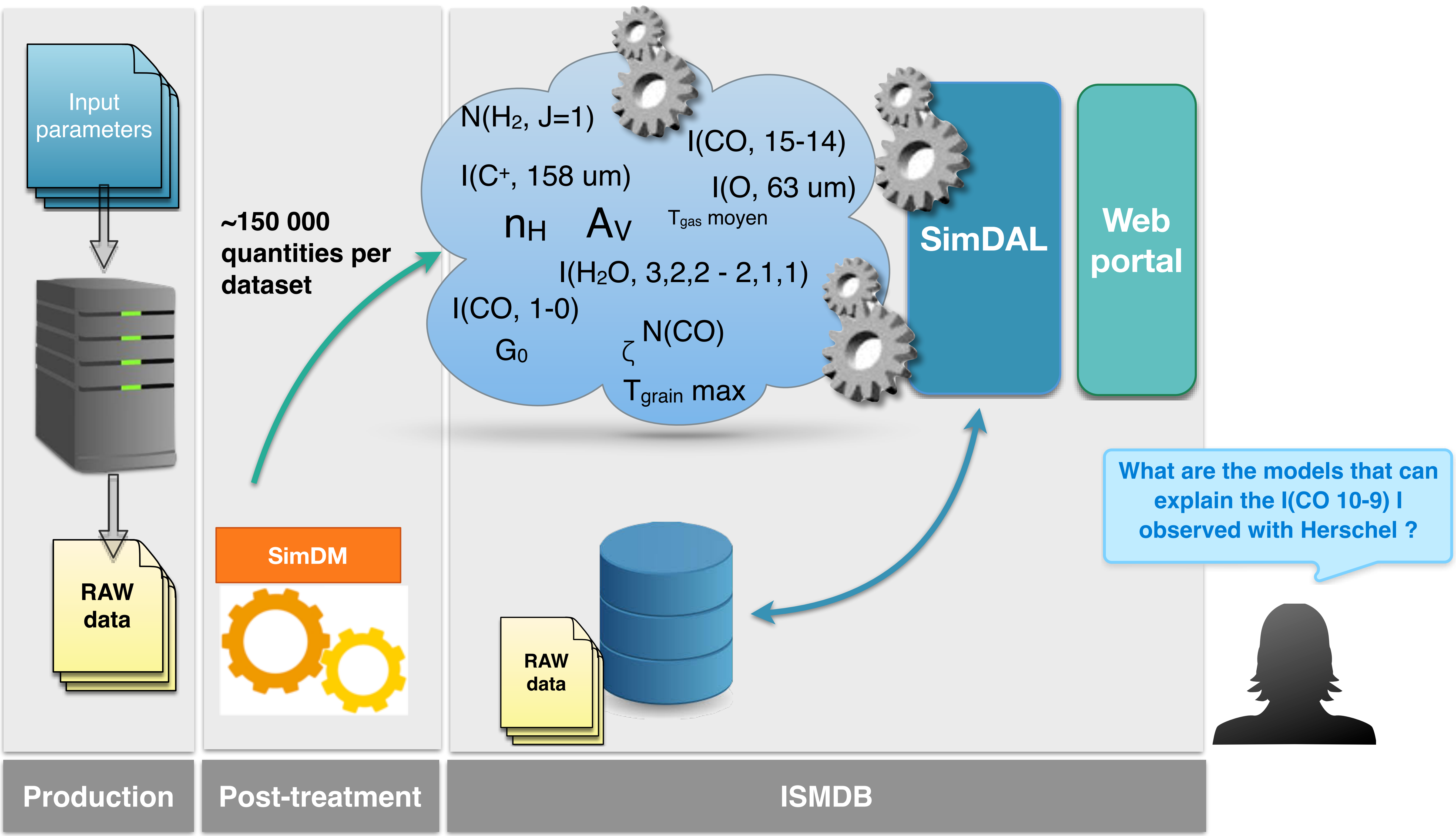
Standard databases:



ISMDB

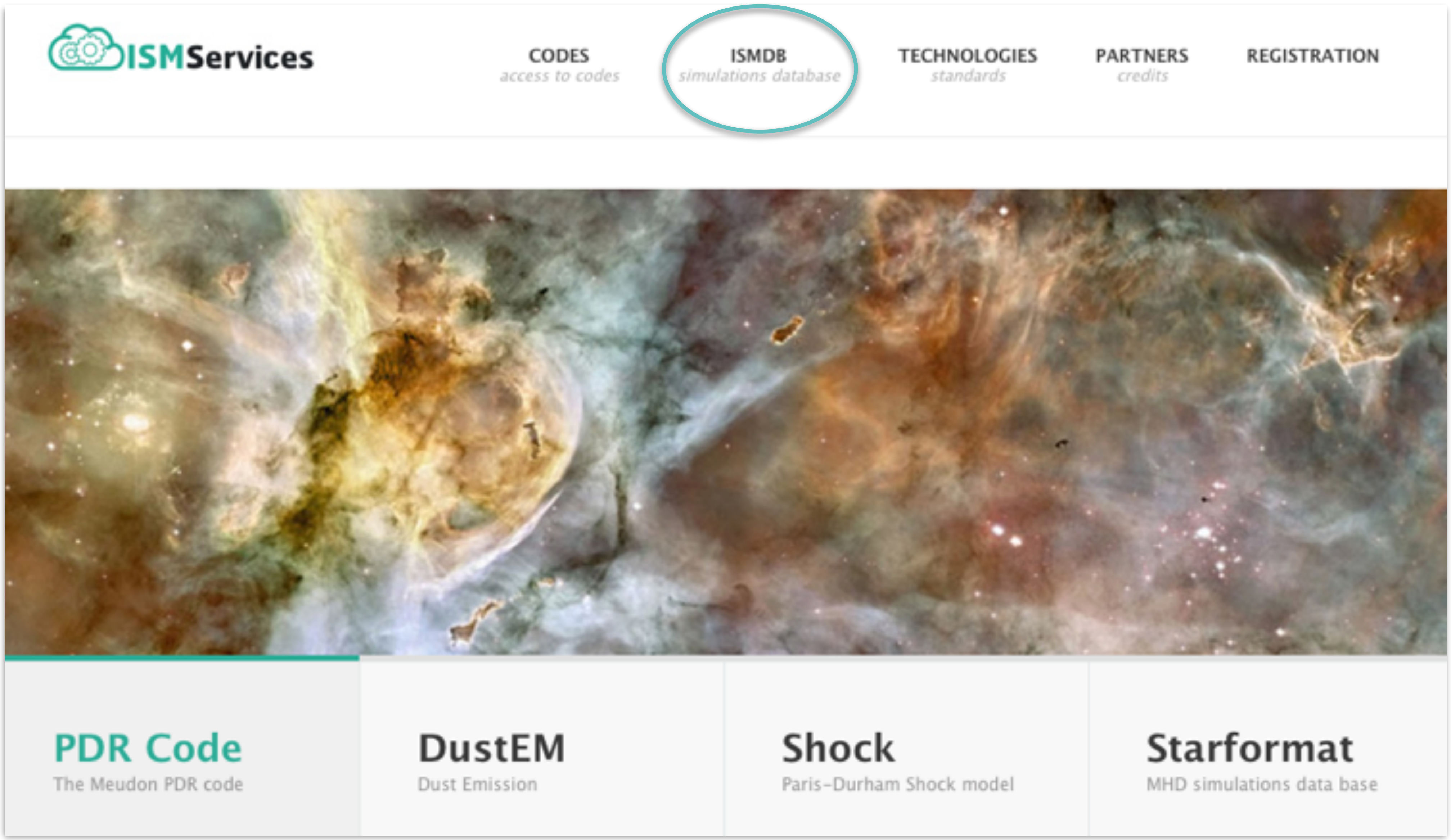
- not only a classical database to find pre-computed models
- but **also a tool that can *interpret* observations**

High dimentionnality
=> specific technologies required



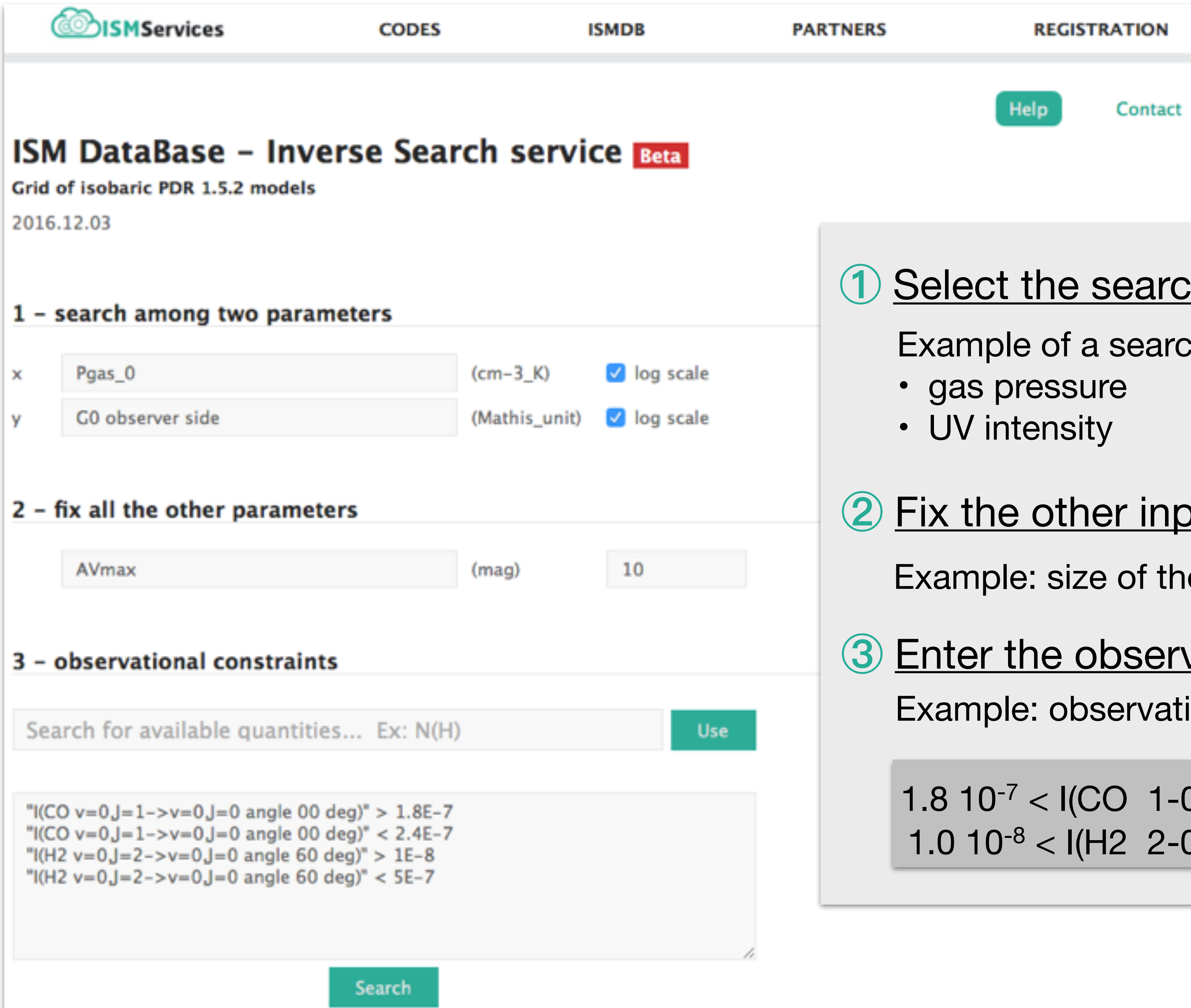
ISMDB

http://ism.obspm.fr



- Source codes & specific developments
- Online codes
- Tools to analyze results
  - Extractor & Chemistry Analyzer
- ISMDB

ISMDB



① Select the searched input parameters

Example of a search:
- gas pressure
- UV intensity

② Fix the other input parameters

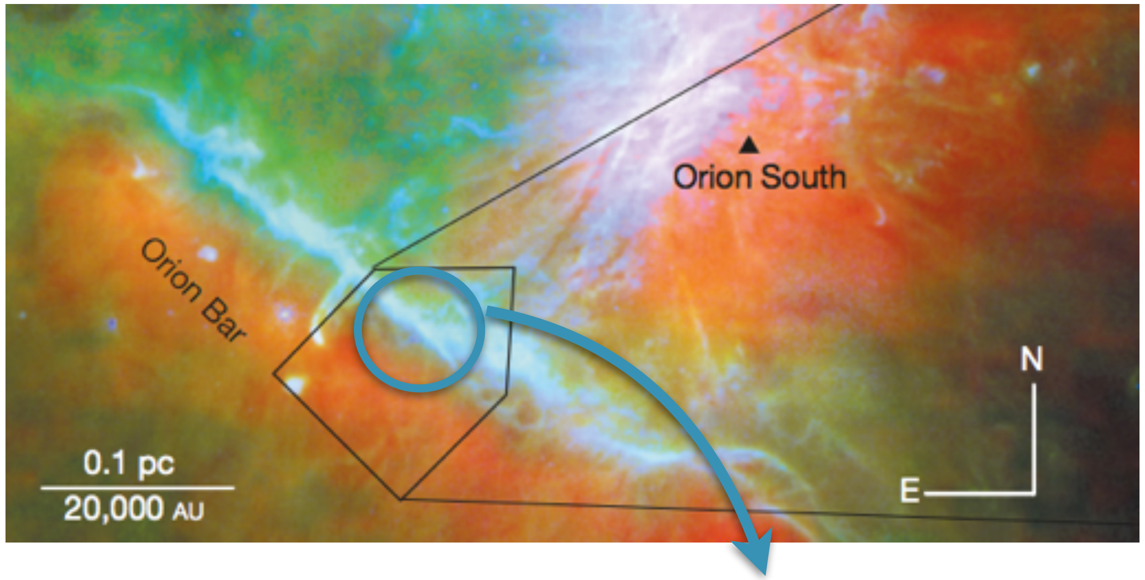
Example: size of the cloud

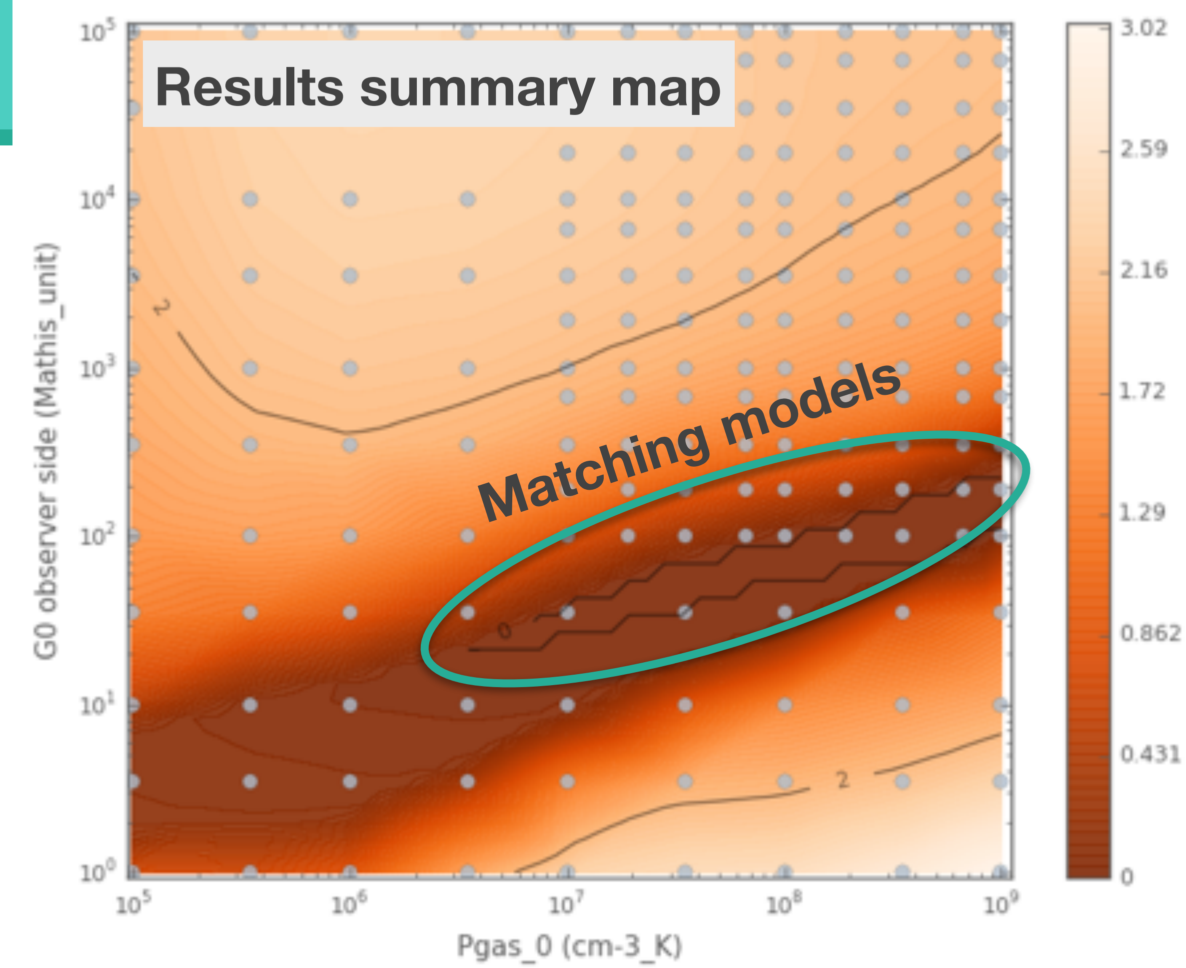
③ Enter the observations

Example: observations CO and H_2 intensities

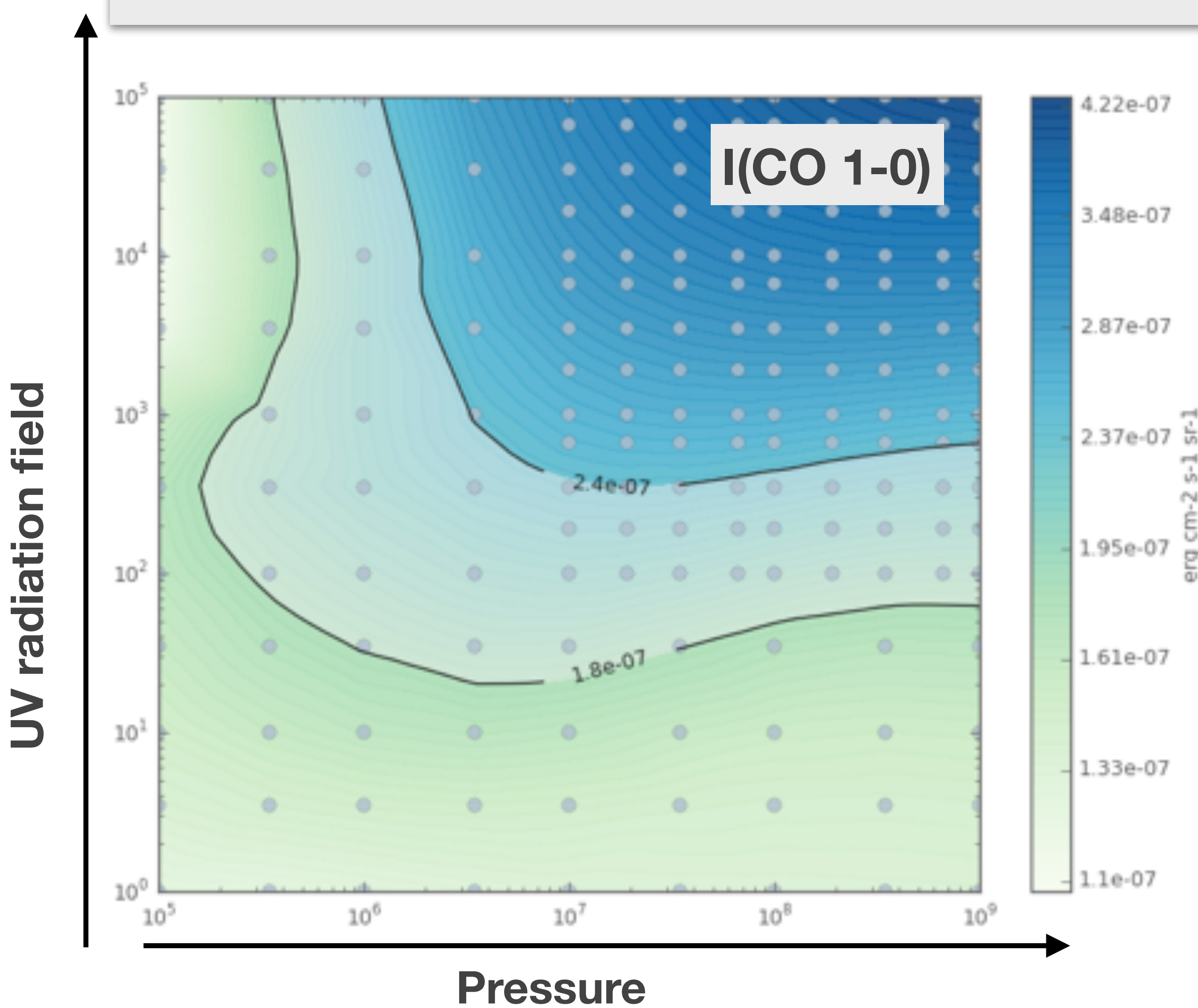
$1.8\ 10^{-7}$ < I(CO 1-0) < $2.4\ 10^{-7}$ erg cm-2 s-1 sr-1
$1.0\ 10^{-8}$ < I(H2 2-0) < $5.0\ 10^{-7}$ erg cm-2 s-1 sr-1

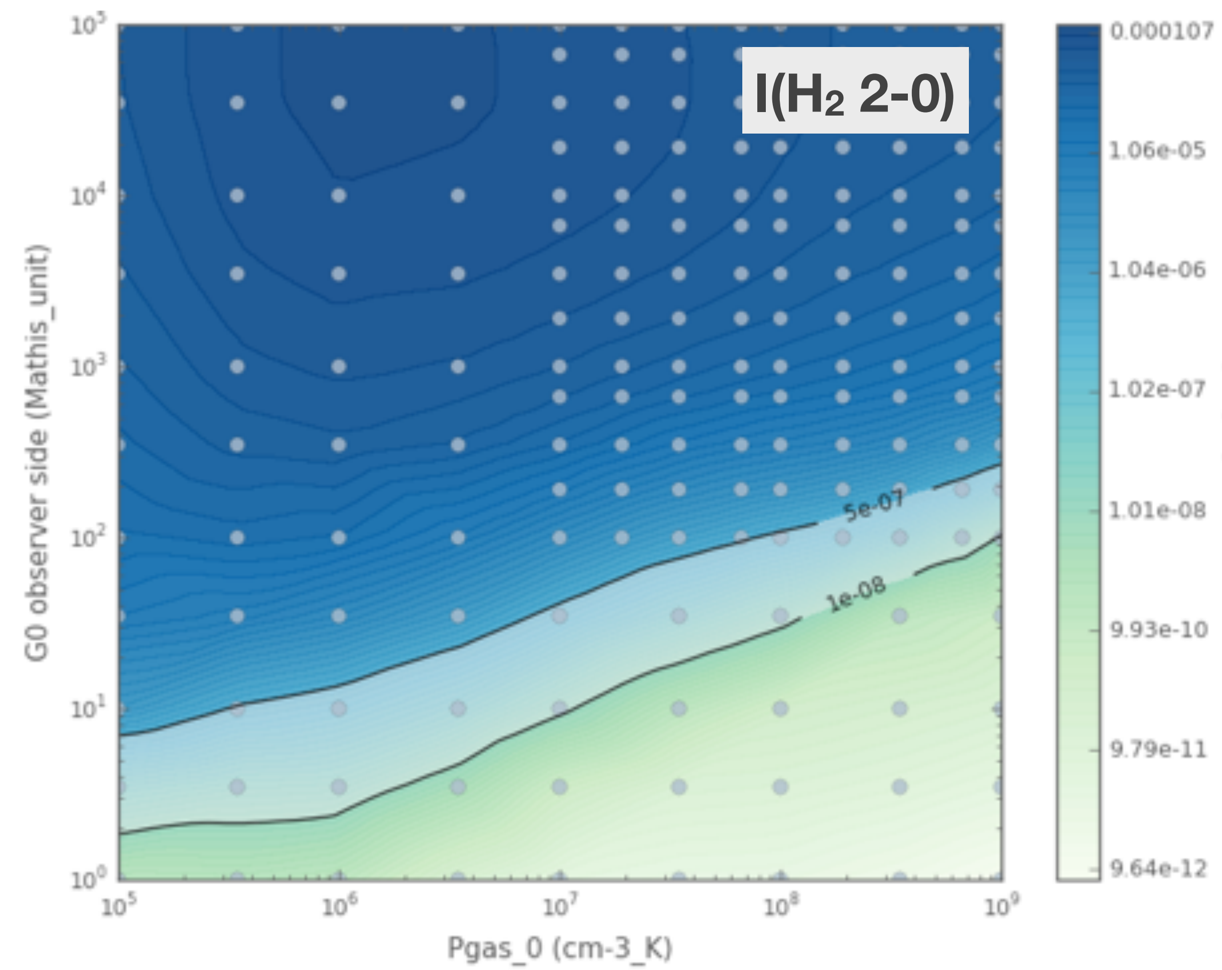
Interpretation of observations





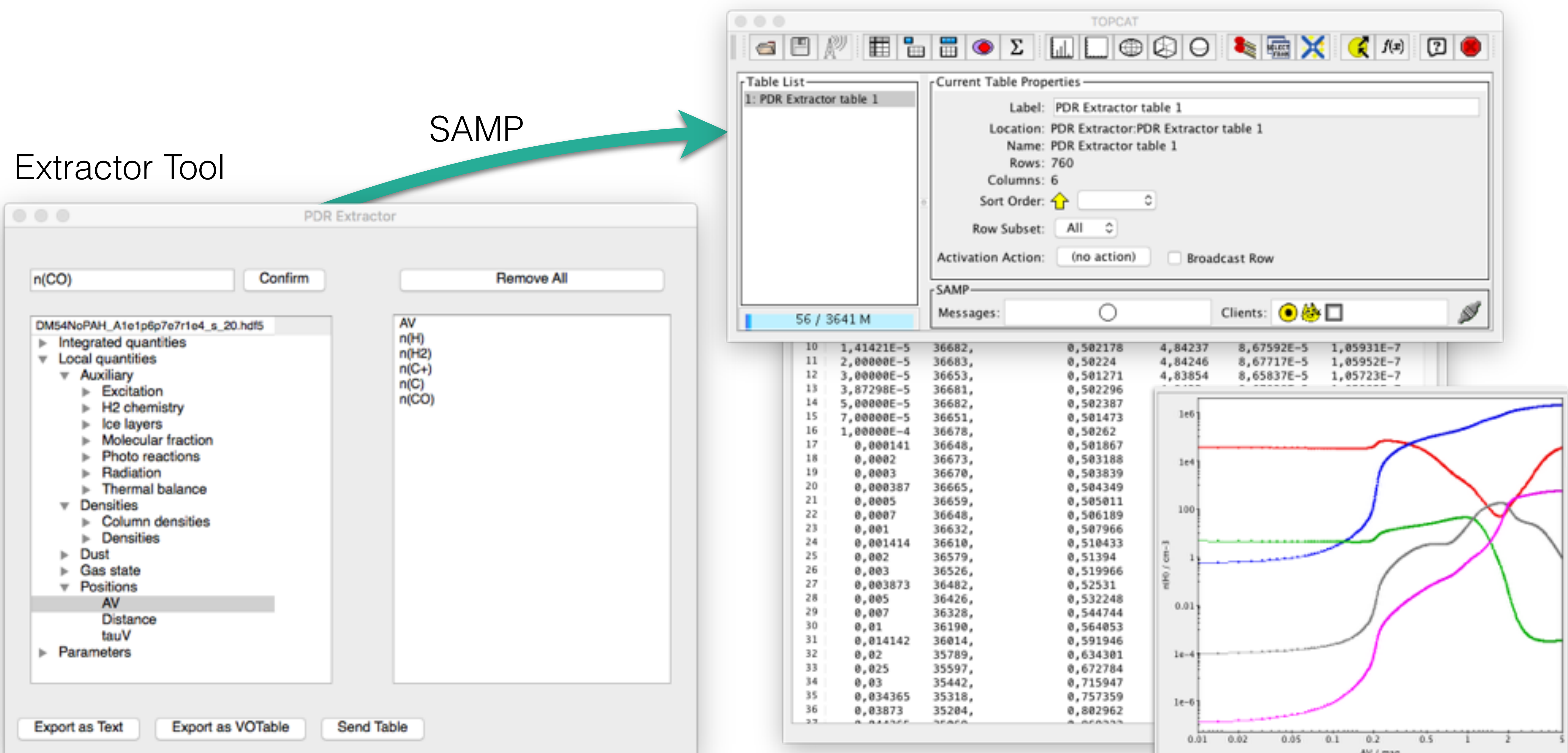
$1.8\ 10^{-7} < I(CO\ \ 1\text{-}0) < 2.4\ 10^{-7}$ erg cm-2 s-1 sr-1
$1.0\ 10^{-8} < I(H2\ \ 2\text{-}0) < 5.0\ 10^{-7}$ erg cm-2 s-1 sr-1





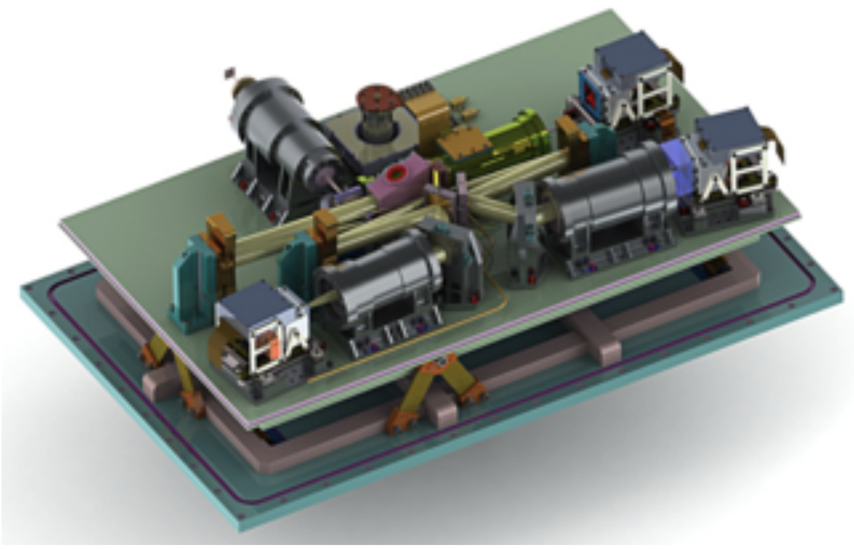
VO Integration

Metadata definition & organization	**Simulation Data Model (SimDM)**
Data Access	**Simulation Data Access Layer (SimDAL)**
Raw data (extractor tool)	**VOTable** **SAMP connector**



Interpretation of observations

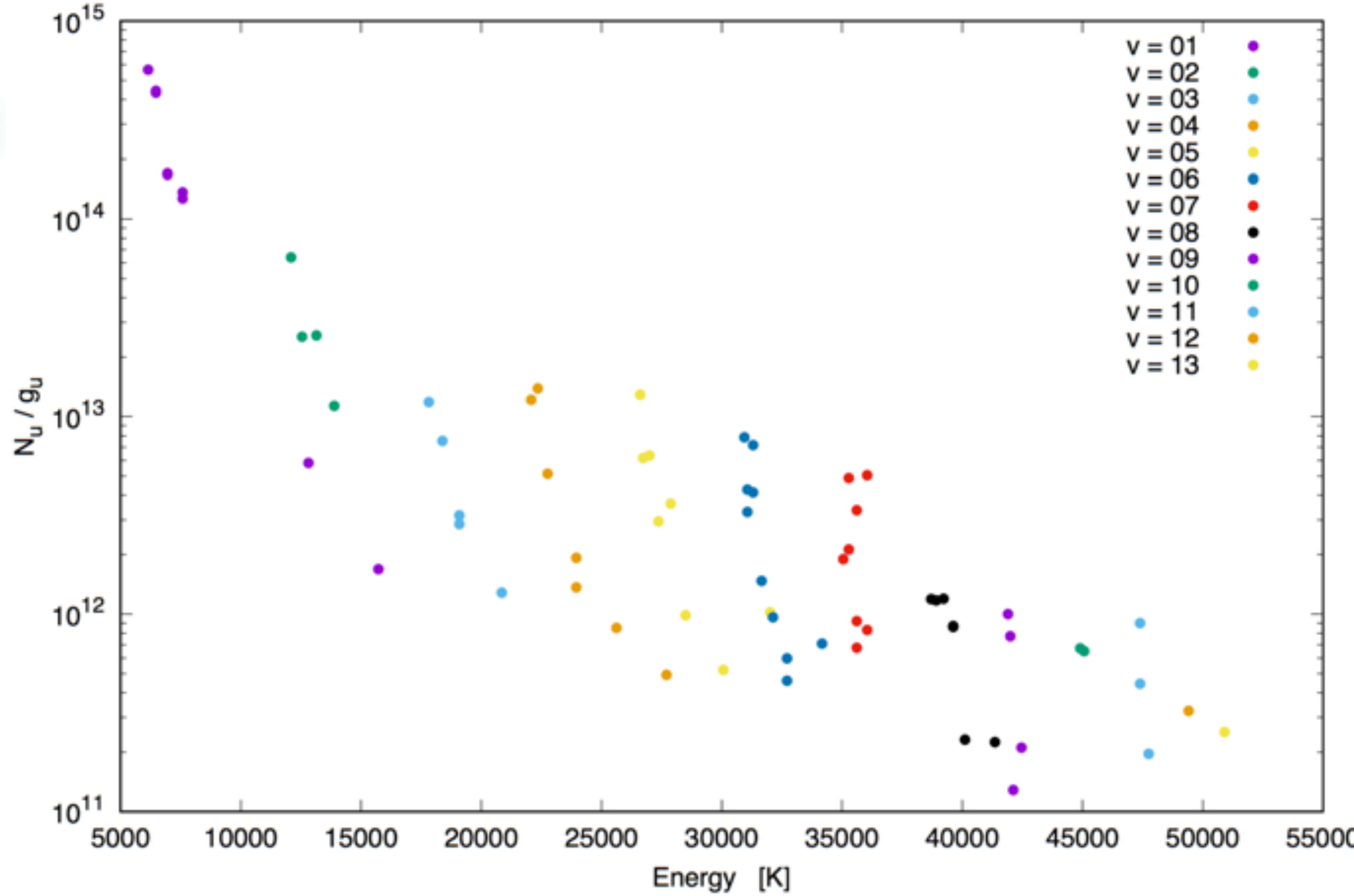
IGRINS observations
Instrument - Univ. Texas, Austin
Mc Donald observatory
Bands: H et K (1.5 to 2.5 microns)
R = 45 000



Observations of NGC 7023
(Le et al. - 2016 / ArXiV)

- Detection of 70 H_2 lines in NGC 7023
- Conclude to a clumpy medium

H_2 excitation diagram at position A



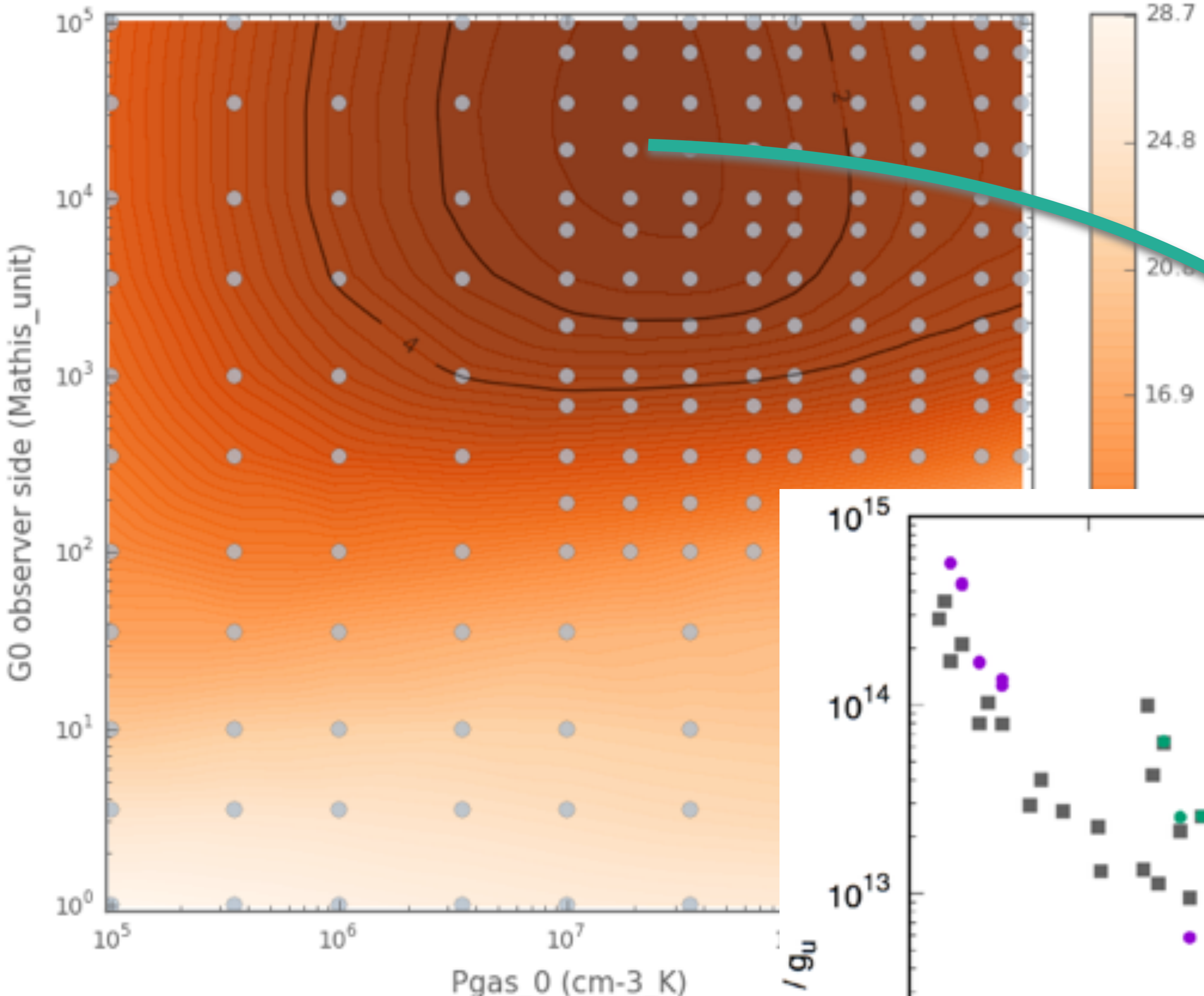
Interpretation of observations

Build the query for the 70 H_2 lines (140 constraints)

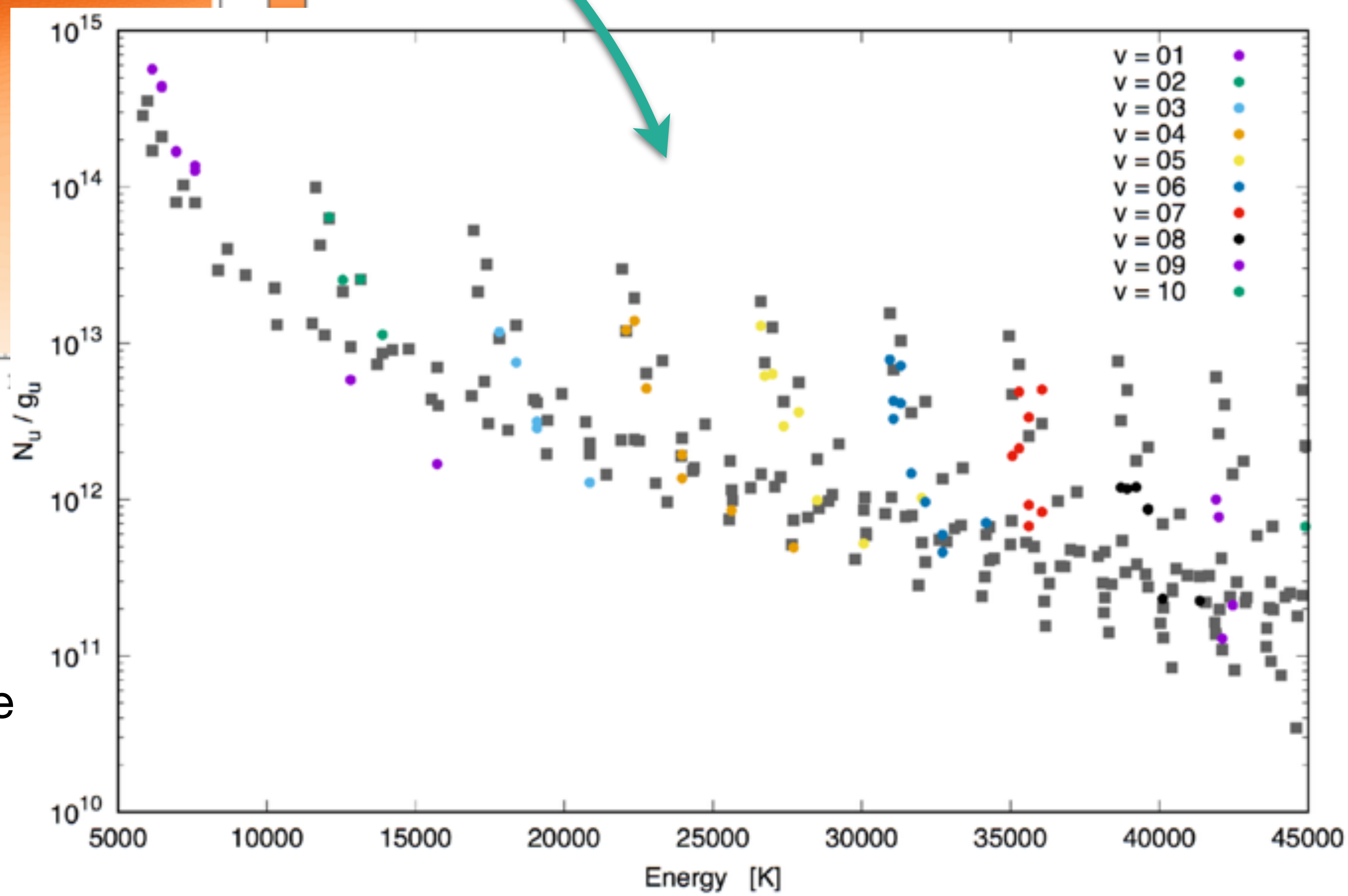
```
"I(H2 v=4,J=9->v=2,J=9 angle 60 deg)" < 5.408e-06
"I(H2 v=4,J=9->v=2,J=9 angle 60 deg)" > 2.912e-06
"I(H2 v=4,J=1->v=2,J=3 angle 60 deg)" < 2.665e-05
"I(H2 v=4,J=1->v=2,J=3 angle 60 deg)" > 1.435e-05
"I(H2 v=5,J=4->v=3,J=4 angle 60 deg)" < 9.659e-06
"I(H2 v=5,J=4->v=3,J=4 angle 60 deg)" > 5.201e-06
"I(H2 v=3,J=3->v=1,J=5 angle 60 deg)" < 1.2532e-05
"I(H2 v=3,J=3->v=1,J=5 angle 60 deg)" > 6.748e-06
"I(H2 v=5,J=5->v=3,J=5 angle 60 deg)" < 9.607e-06
"I(H2 v=5,J=5->v=3,J=5 angle 60 deg)" > 5.173e-06
"I(H2 v=6,J=2->v=4,J=0 angle 60 deg)" < 7.67e-06
"I(H2 v=6,J=2->v=4,J=0 angle 60 deg)" > 4.13e-06
"I(H2 v=10,J=1->v=7,J=3 angle 60 deg)" < 4.121e-06
"I(H2 v=10,J=1->v=7,J=3 angle 60 deg)" > 2.219e-06
"I(H2 v=5,J=0->v=3,J=2 angle 60 deg)" < 1.118e-05
"I(H2 v=5,J=0->v=3,J=2 angle 60 deg)" > 6.02e-06
"I(H2 v=5,J=7->v=3,J=7 angle 60 deg)" < 6.955e-06
"I(H2 v=5,J=7->v=3,J=7 angle 60 deg)" > 3.745e-06
"I(H2 v=4,J=2->v=2,J=4 angle 60 deg)" < 1.1531e-05
"I(H2 v=4,J=2->v=2,J=4 angle 60 deg)" > 6.209e-06
"I(H2 v=7,J=4->v=5,J=2 angle 60 deg)" < 5.109e-06
"I(H2 v=7,J=4->v=5,J=2 angle 60 deg)" > 2.751e-06
"I(H2 v=6,J=1->v=4,J=1 angle 60 deg)" < 1.846e-05
"I(H2 v=6,J=1->v=4,J=1 angle 60 deg)" > 9.94e-06
"I(H2 v=6,J=2->v=4,J=2 angle 60 deg)" < 1.599e-05
"I(H2 v=6,J=2->v=4,J=2 angle 60 deg)" > 8.61e-06
"I(H2 v=5,J=9->v=3,J=9 angle 60 deg)" < 1.729e-05
"I(H2 v=5,J=9->v=3,J=9 angle 60 deg)" > 9.31e-06
"I(H2 v=5,J=1->v=3,J=3 angle 60 deg)" < 2.379e-05
"I(H2 v=5,J=1->v=3,J=3 angle 60 deg)" > 1.281e-05
"I(H2 v=13,J=1->v=9,J=1 angle 60 deg)" < 9.334e-07
"I(H2 v=13,J=1->v=9,J=1 angle 60 deg)" > 5.026e-07
"I(H2 v=6,J=3->v=4,J=3 angle 60 deg)" < 1.287e-05
"I(H2 v=6,J=3->v=4,J=3 angle 60 deg)" > 6.93e-06
```

```
I(H2 v=7,J=3->v=5,J=1 angle 60 deg)" < 1.1531e-05
"I(H2 v=7,J=3->v=5,J=1 angle 60 deg)" > 6.209e-06
"I(H2 v=4,J=3->v=2,J=5 angle 60 deg)" < 1.2961e-05
"I(H2 v=4,J=3->v=2,J=5 angle 60 deg)" > 6.979e-06
"I(H2 v=6,J=4->v=4,J=4 angle 60 deg)" < 3.523e-06
"I(H2 v=6,J=4->v=4,J=4 angle 60 deg)" > 1.897e-06
"I(H2 v=6,J=5->v=4,J=5 angle 60 deg)" < 7.878e-06
"I(H2 v=6,J=5->v=4,J=5 angle 60 deg)" > 4.242e-06
"I(H2 v=3,J=5->v=1,J=7 angle 60 deg)" < 2.457e-06
"I(H2 v=3,J=5->v=1,J=7 angle 60 deg)" > 1.323e-06
"I(H2 v=11,J=1->v=8,J=1 angle 60 deg)" < 2.899e-06
"I(H2 v=11,J=1->v=8,J=1 angle 60 deg)" > 1.561e-06
"I(H2 v=7,J=2->v=5,J=0 angle 60 deg)" < 4.628e-06
"I(H2 v=7,J=2->v=5,J=0 angle 60 deg)" > 2.492e-06
"I(H2 v=8,J=7->v=6,J=5 angle 60 deg)" < 5.824e-06
"I(H2 v=8,J=7->v=6,J=5 angle 60 deg)" > 3.136e-06
"I(H2 v=5,J=2->v=3,J=4 angle 60 deg)" < 9.425e-06
"I(H2 v=5,J=2->v=3,J=4 angle 60 deg)" > 5.075e-06
"I(H2 v=6,J=0->v=4,J=2 angle 60 deg)" < 9.776e-06
"I(H2 v=6,J=0->v=4,J=2 angle 60 deg)" > 5.264e-06
"I(H2 v=6,J=7->v=4,J=7 angle 60 deg)" < 1.2532e-05
"I(H2 v=6,J=7->v=4,J=7 angle 60 deg)" > 6.748e-06
"I(H2 v=11,J=3->v=8,J=3 angle 60 deg)" < 1.924e-06
"I(H2 v=11,J=3->v=8,J=3 angle 60 deg)" > 1.036e-06
"I(H2 v=1,J=11->v=0,J=9 angle 60 deg)" < 4.407e-06
"I(H2 v=1,J=11->v=0,J=9 angle 60 deg)" > 2.373e-06
"I(H2 v=8,J=5->v=6,J=3 angle 60 deg)" < 5.122e-06
"I(H2 v=8,J=5->v=6,J=3 angle 60 deg)" > 2.758e-06
"I(H2 v=7,J=1->v=5,J=1 angle 60 deg)" < 1.2922e-05
"I(H2 v=7,J=1->v=5,J=1 angle 60 deg)" > 6.958e-06
"I(H2 v=8,J=4->v=6,J=2 angle 60 deg)" < 5.109e-06
"I(H2 v=8,J=4->v=6,J=2 angle 60 deg)" > 2.751e-06
"I(H2 v=6,J=1->v=4,J=3 angle 60 deg)" < 2.405e-05
…
…
…
…
```

Interpretation of observations



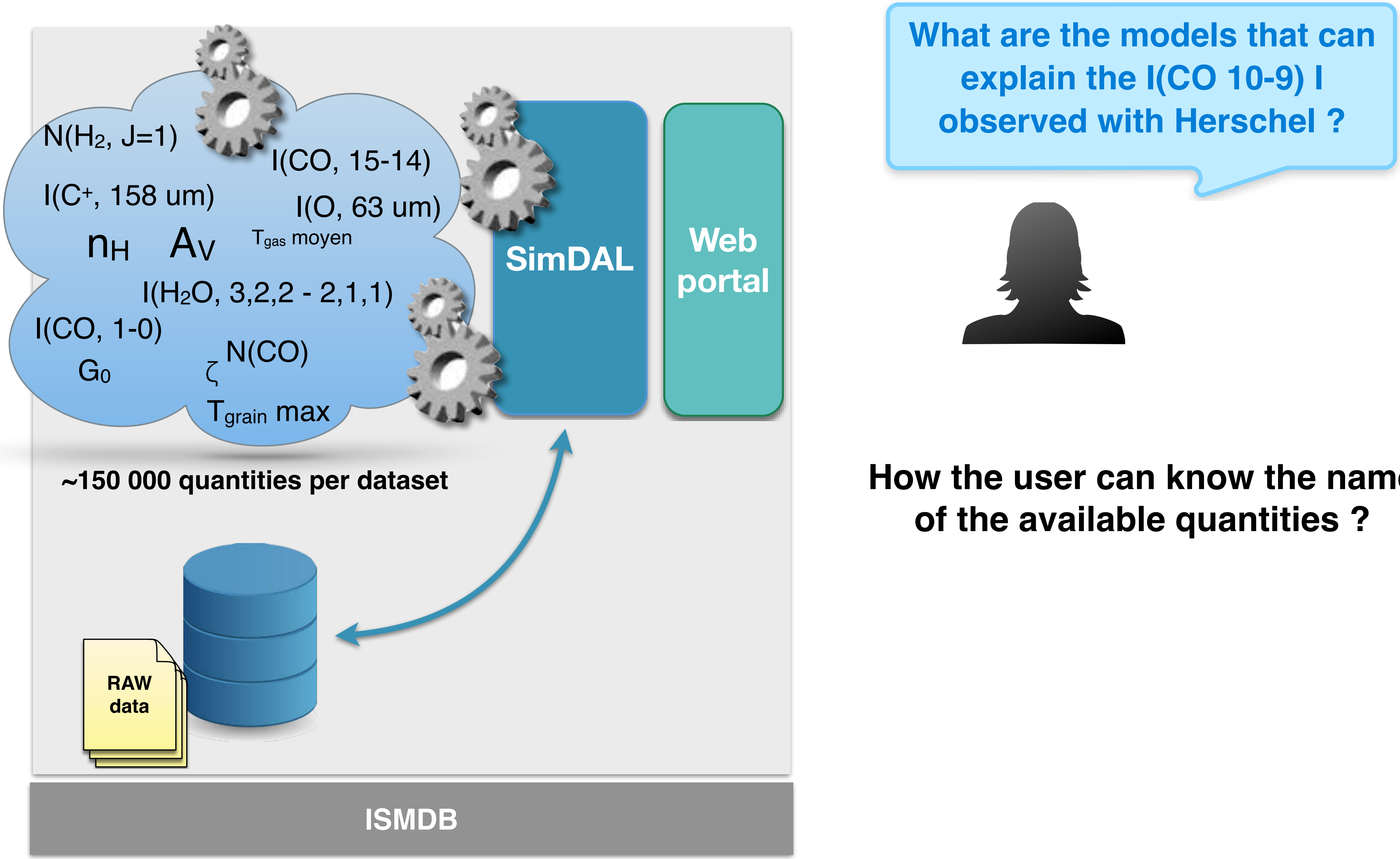
Download models



First order solution in 1 minute
instead of weeks of work

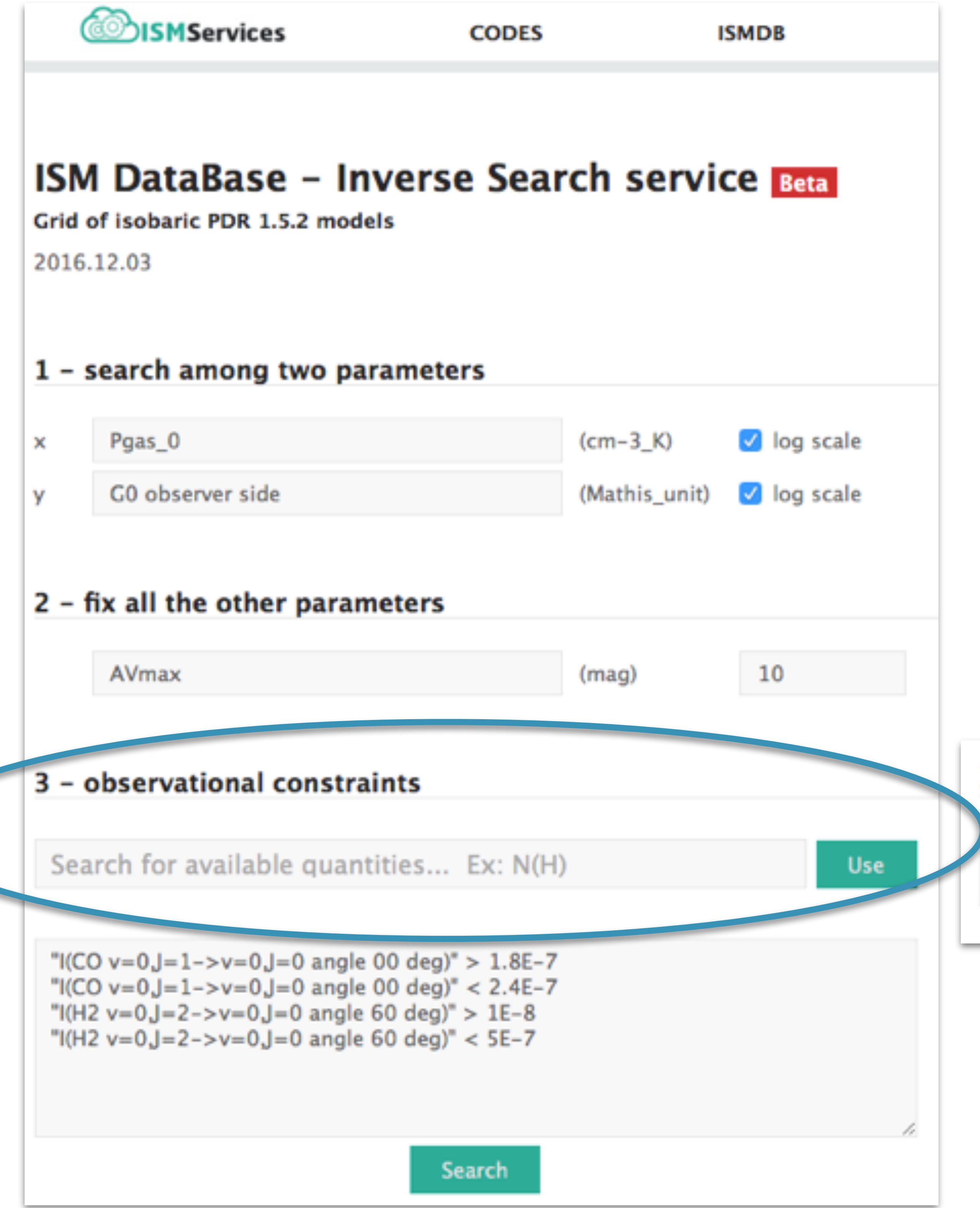
Semantics

Interaction between a human and the system



How the user can know the name of the available quantities ?

Semantics

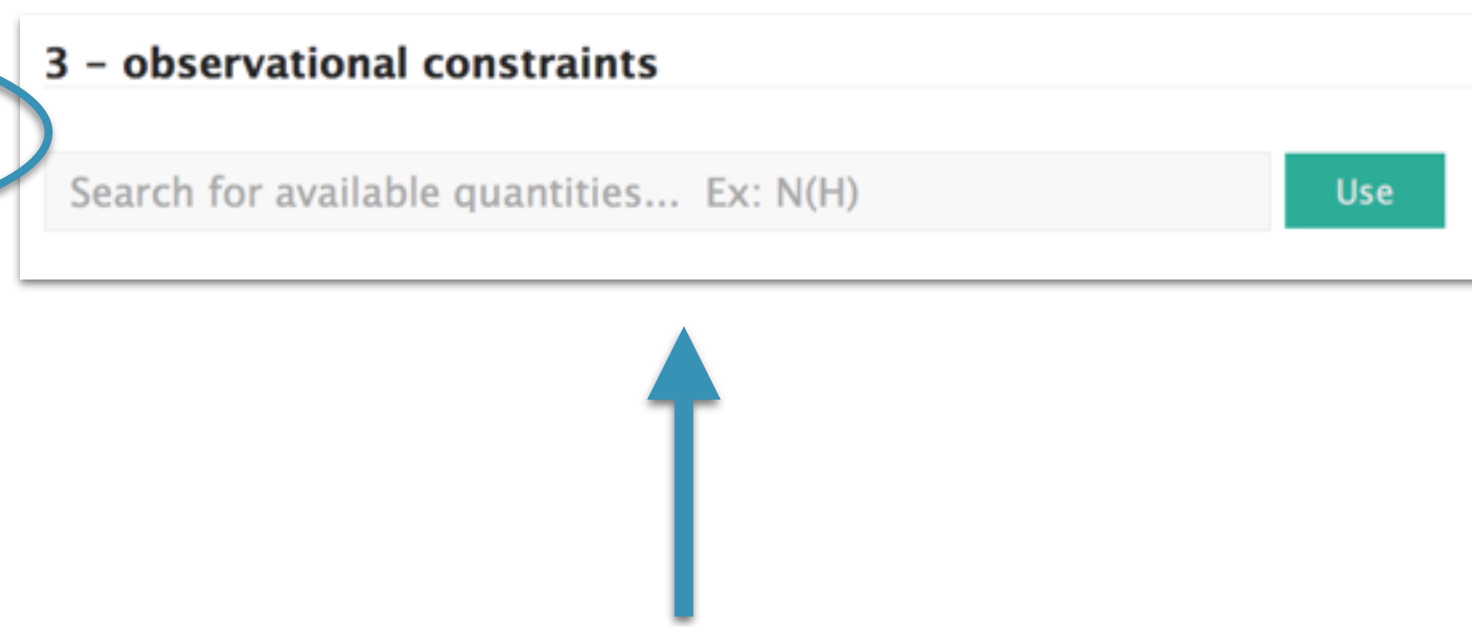


More than 150 000 queriable quantities in the database

- users do not know all the available list
- users do not know how these quantities are named

Example:

- H_2 line at 12 microns
- H_2 0-0 S(2)
- H_2 v=0, J=4 -> v=0, J=2



Semantics interpreter

Semantics : SKOS vocabularies

Each metadata is taggued by:

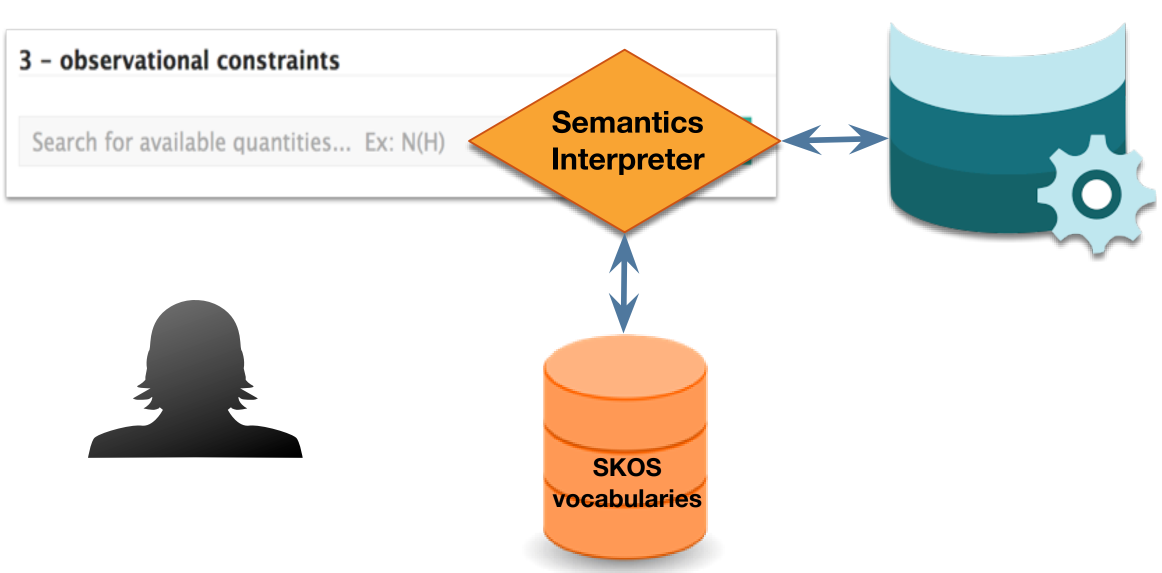
- ID
- name
- unit
- utype
- description
- **label (UCD / SKOS)**
- …

Simulation DataModel

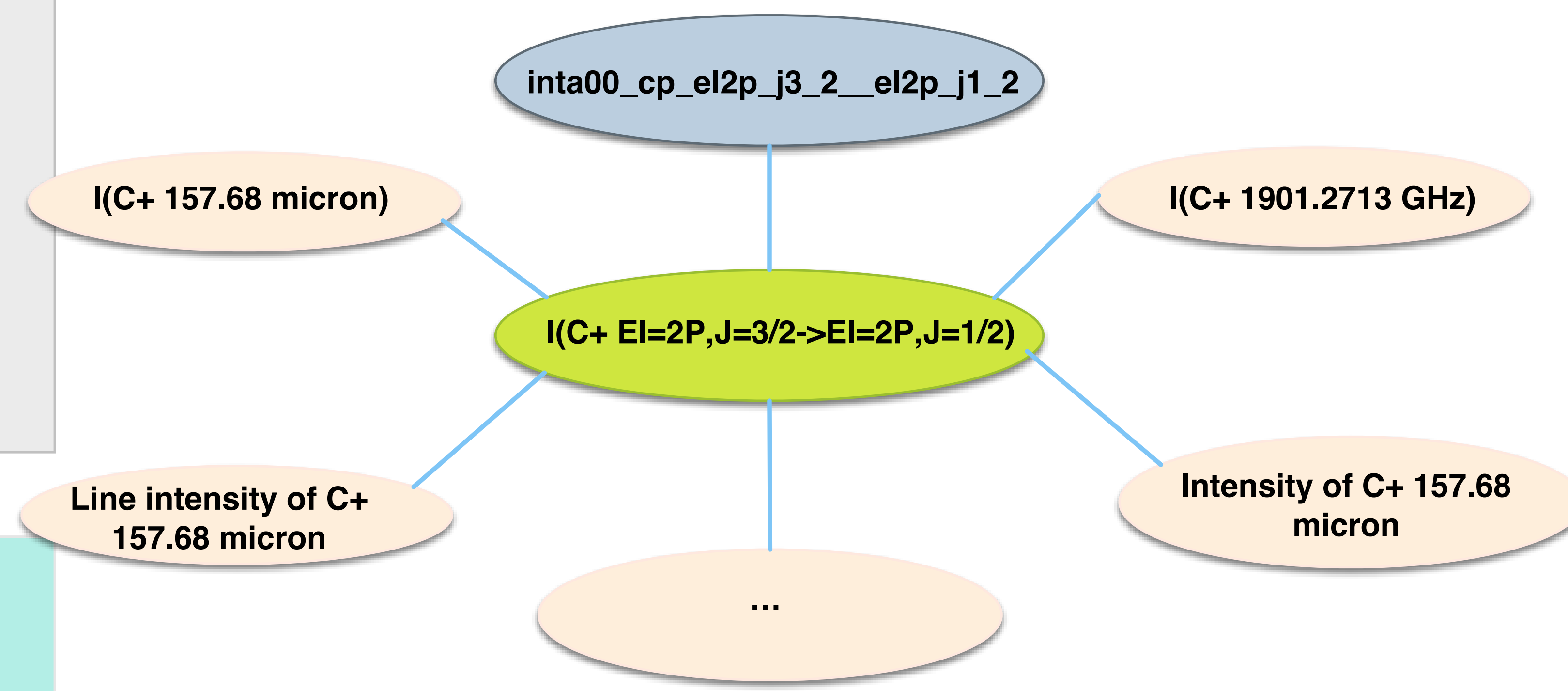
SKOS vocabulary

For each quantity several synonyms (name, units, …)

~ 300 000 terms for the PDR code

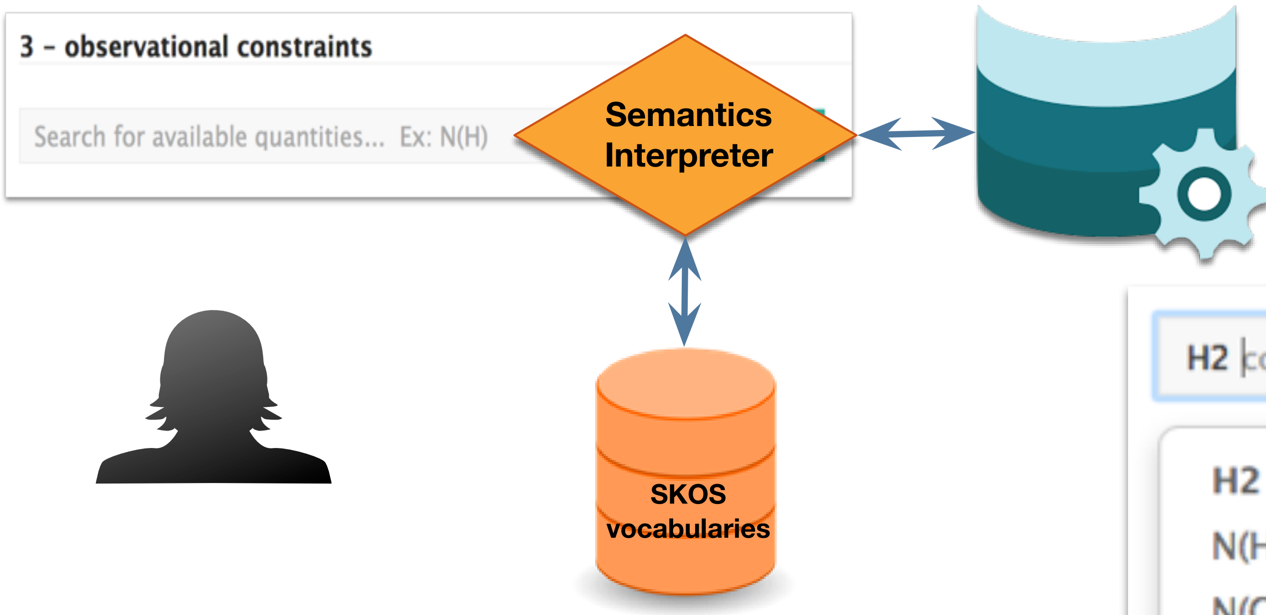


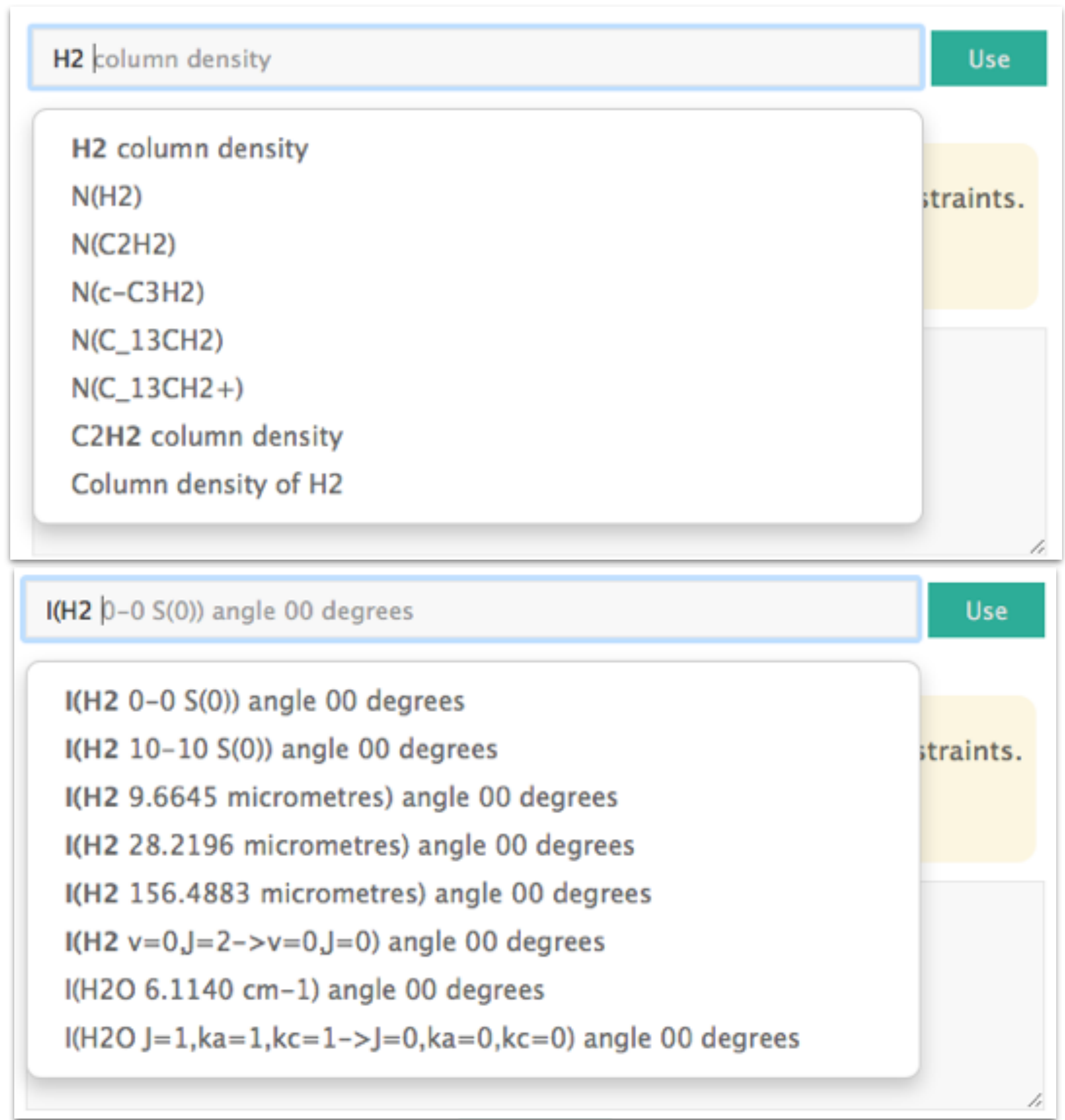
Example of the 157.7 micron C+ line intensity



ID: inta00_cp_el2p_j3_2__el2p_j1_2
PREF: I(C+ El=2P,J=3/2->El=2P,J=1/2)
ALT: I(C+ El=2P,J=3/2->El=2P,J=1/2) face on
ALT: I(C+ 157.68 micron) face on
ALT: Intensity of C+ 157.68 micron face on
ALT: Line intensity of C+ 157.68 micron face on
ALT: I(C+ 1901.2713 GHz) face on
ALT: Intensity of C+ 1901.2713 GHz face on
ALT: Line intensity of C+ 1901.2713 GHz face on
…

Semantics : SKOS vocabularies





Semantics Interpreter

Semantics

SKOS: PREF + ALT

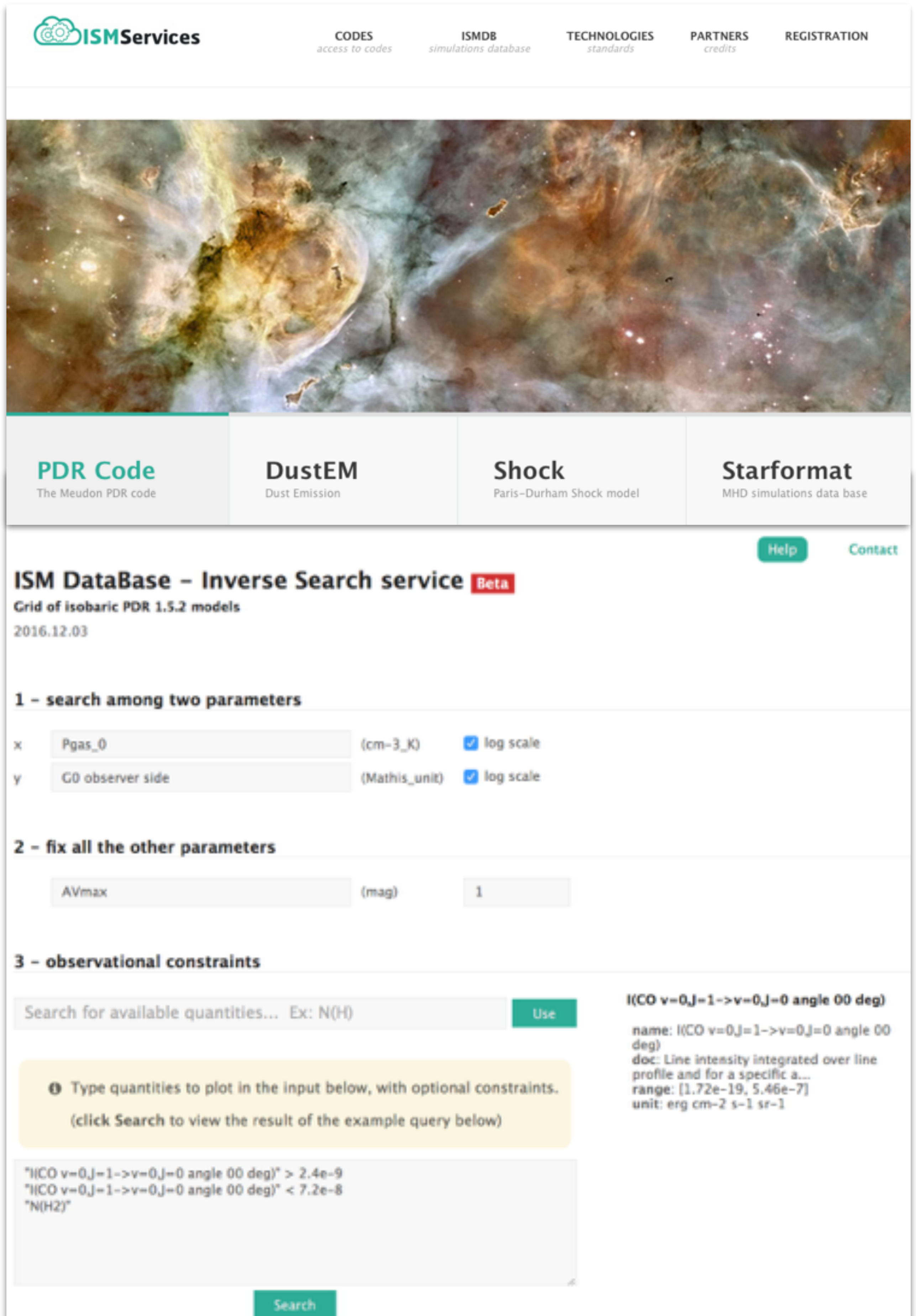
➔ synonyms

\+

Ranking system

(learn from users)

ISMDB



Status

- Available at http://ism.obspm.fr
- Grids of PDR models

Starts to be used:

- Individual teams: ALMA, IRAM, NOEMA, …
- Projects as SPICA, GUSTO (NASA/CNES)
- JWST ERS

Plans - short term

- Grids of shocks models
- Operations on quantities

Plans - medium term

- Quickviews on models
- Interpretation of images (pixels)

Plans - long term

- Search in N-dimension space
- Machine Learning technics
- Suggestions of observations