Unveiling the properties of low-metallicity galaxies using bayesian tools

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PLAN

I - Context & related questions

II- Modeling a galaxy

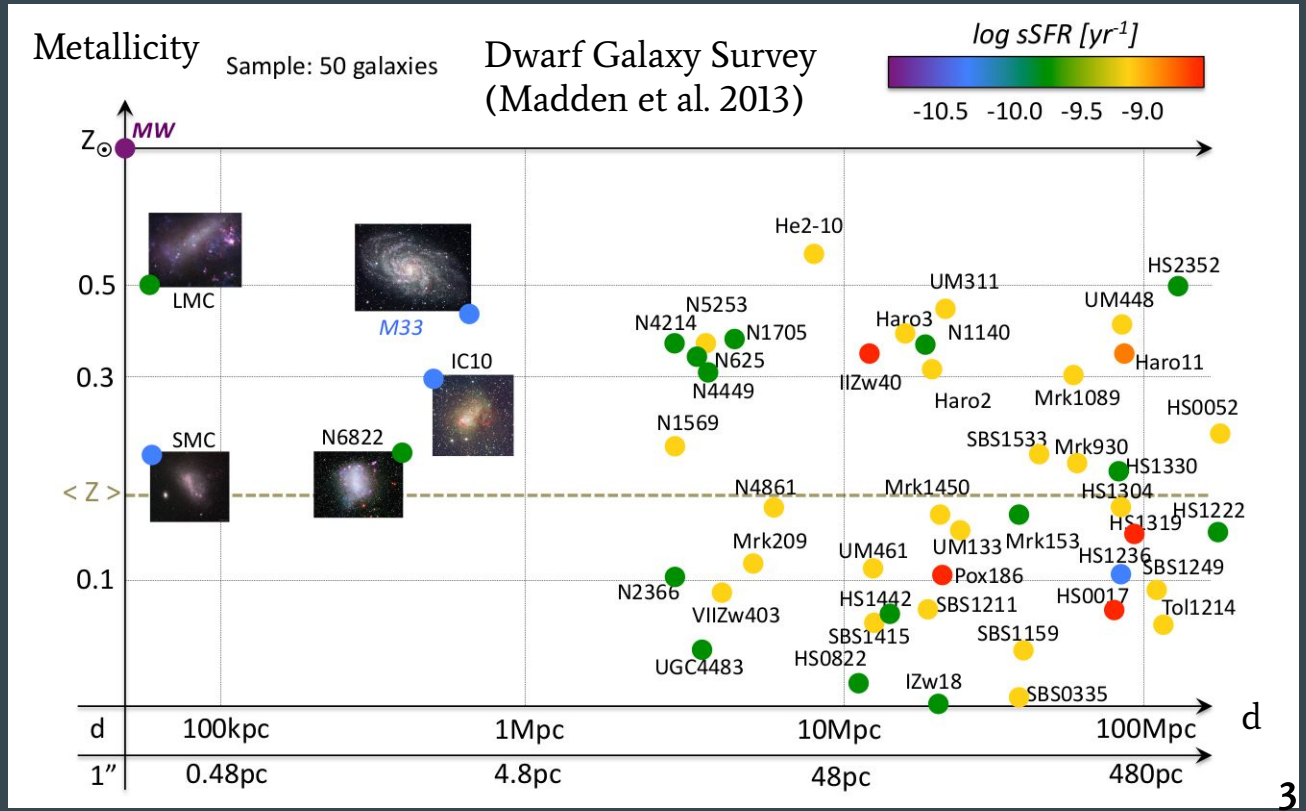
- ❖ Simple models
- ❖ Multi-sector modeling

III- PyMC3: a parameter inference bayesian tool

IV- Prospects with future missions

CONTEXT AND BIG QUESTIONS

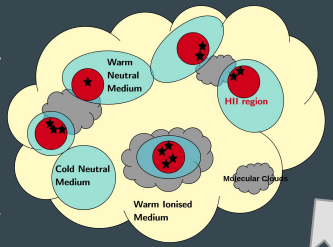
- Is molecular gas necessary to form stars ?
- How is it distributed in low-metallicity galaxies ?
- What is the influence of compact objects (intermediate mass BH, neutron star) ?



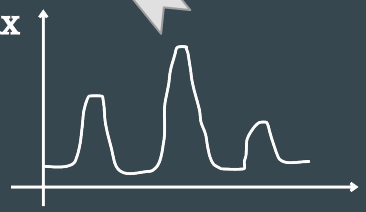
CONTEXT AND BIG QUESTIONS

Local low-metallicity galaxies = best analog to understand primordial galaxies

Model

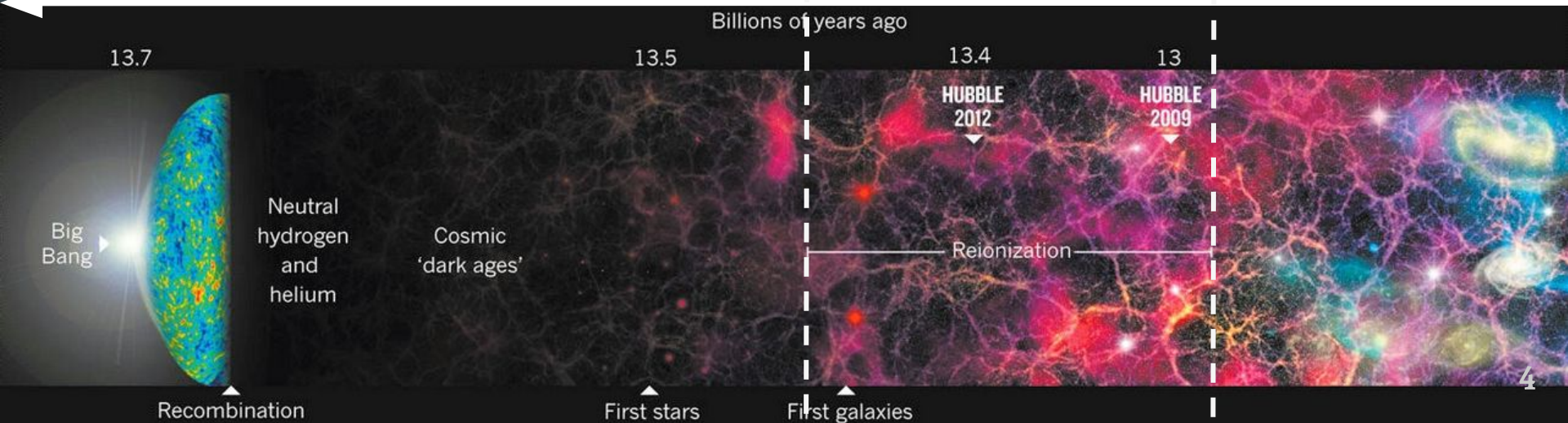


Structure of primitive galaxies ?

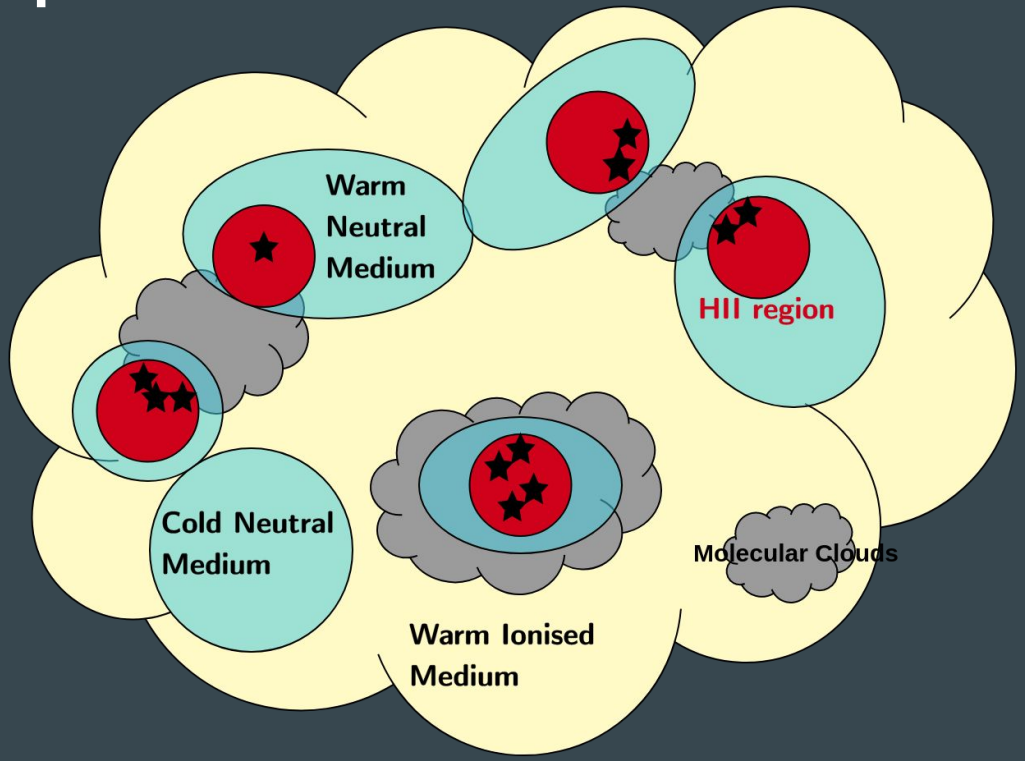


Redshift z

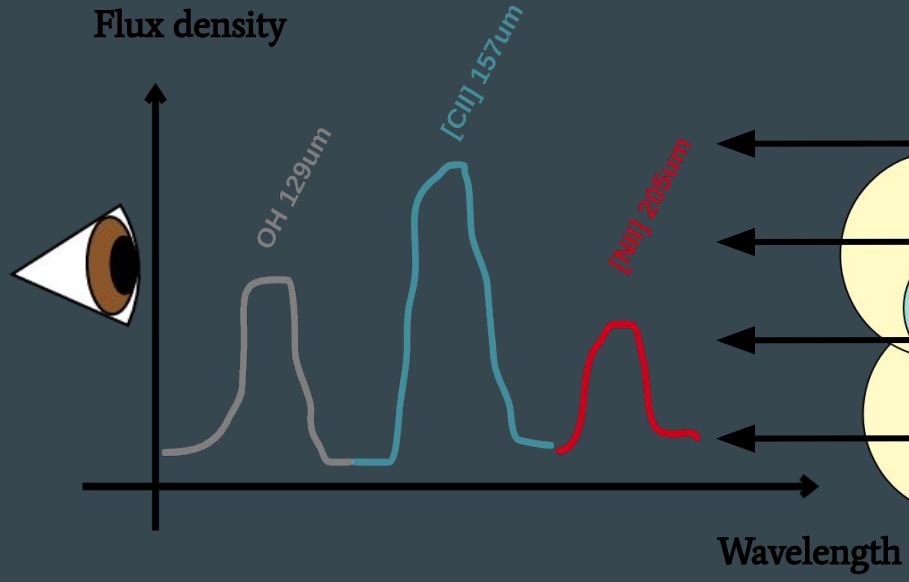
z~7 z~5 z=0

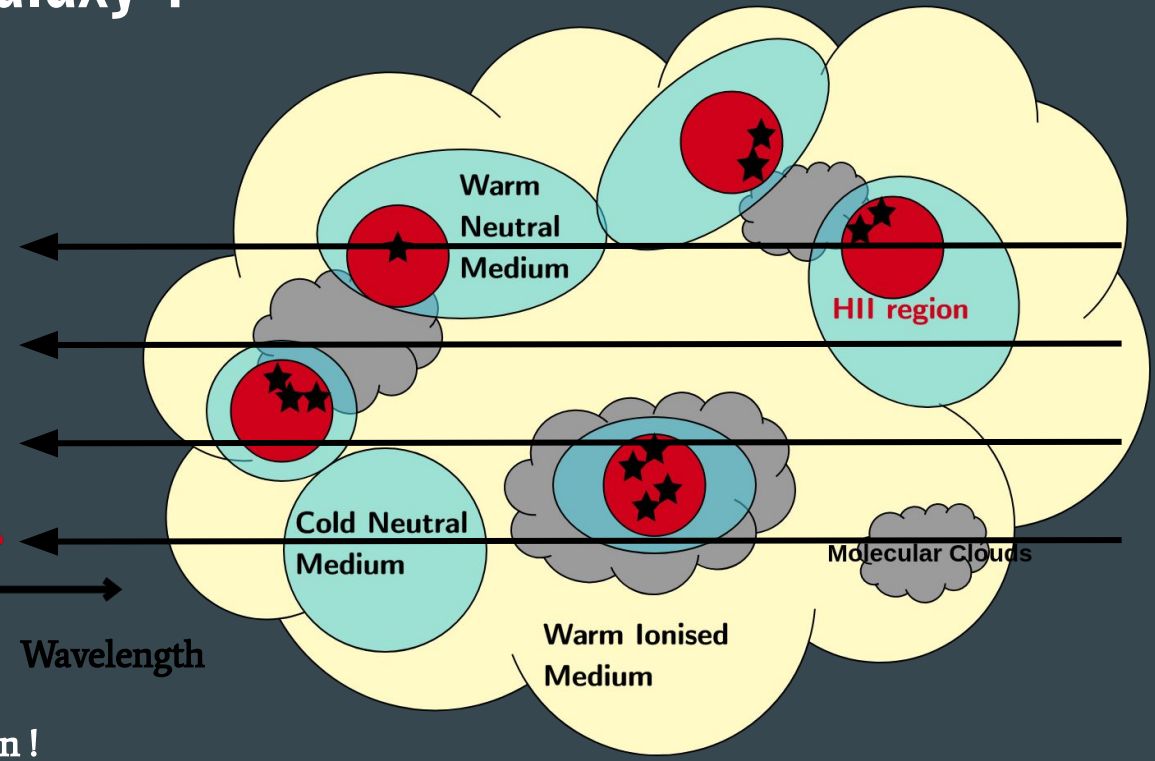


How do we model a galaxy ?



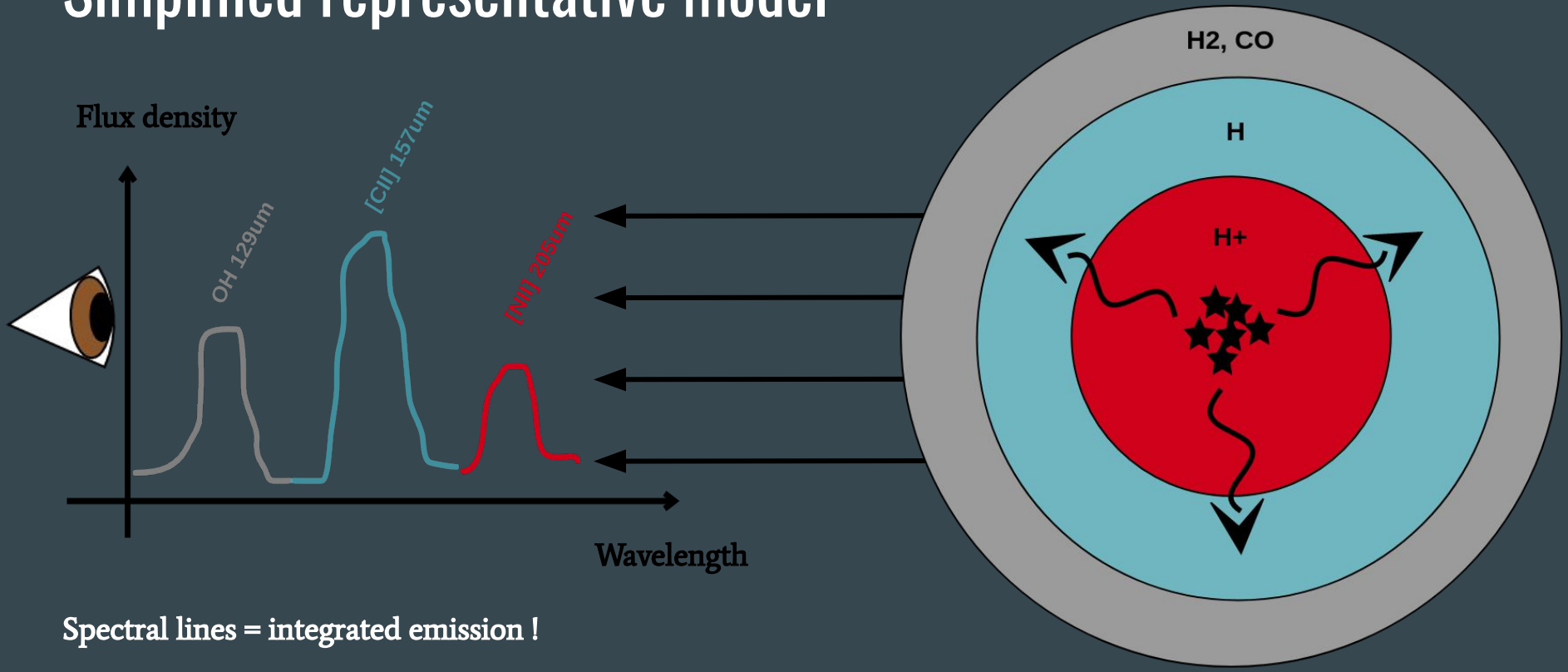
How do we model a galaxy ?





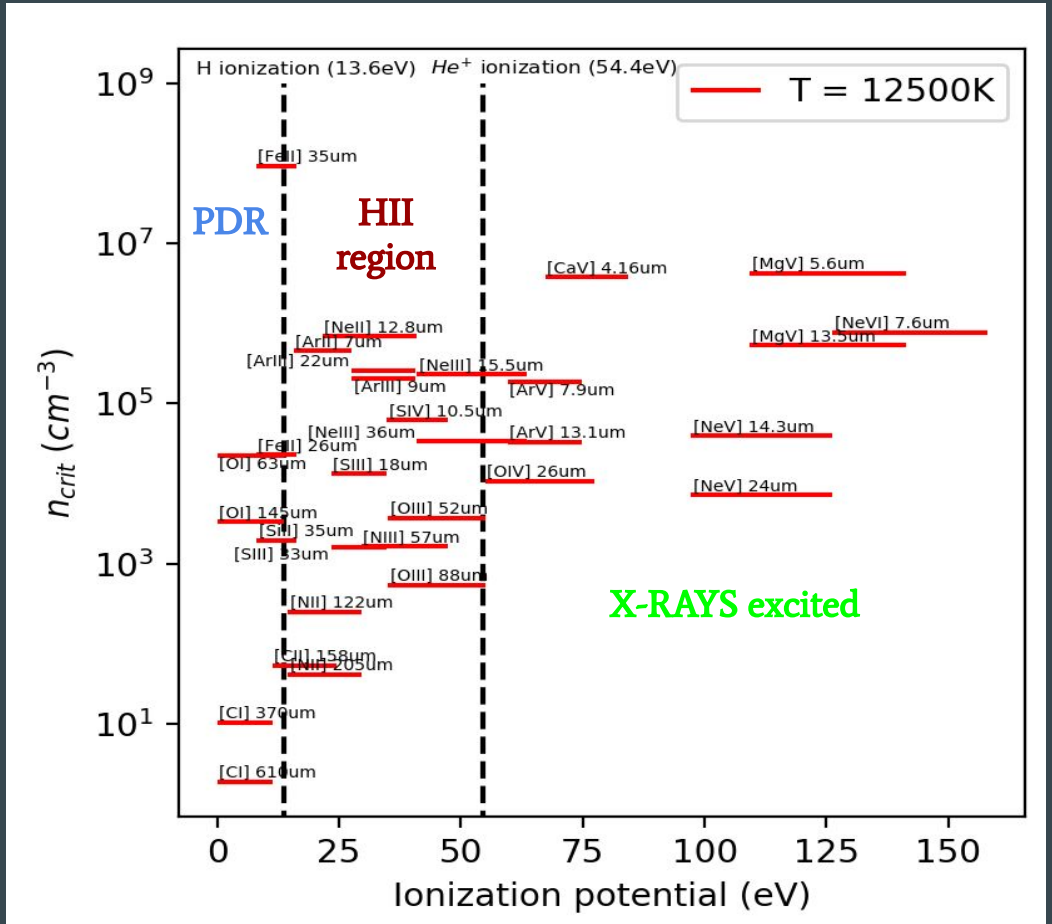
Spectral lines = integrated emission !

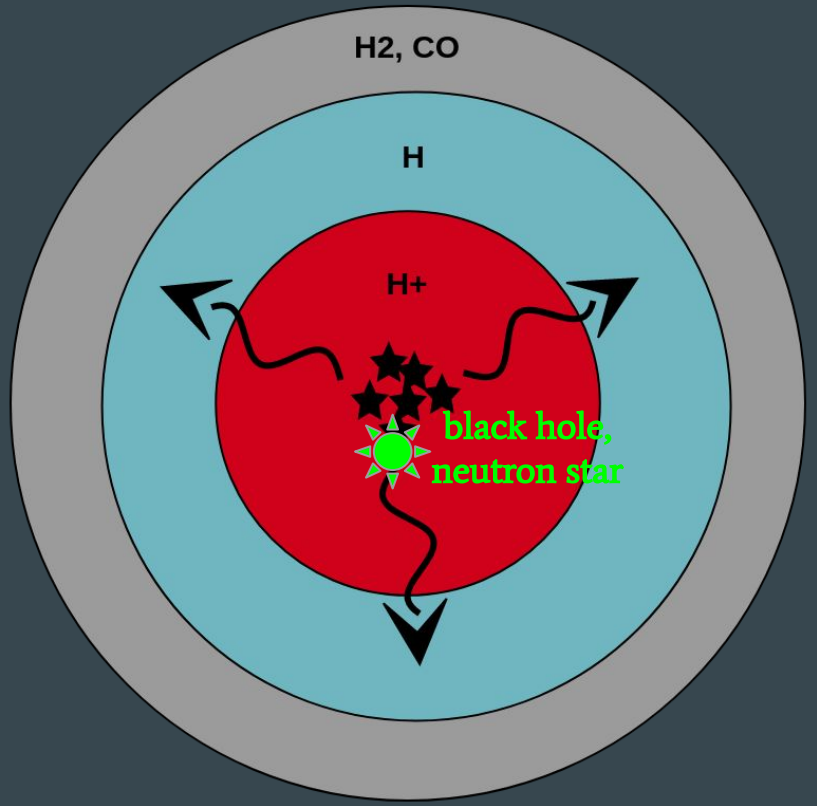
Simplified representative model



Spectral lines = integrated emission !

Differents lines probe different zones





Creating synthetic spectra with Cloudy (Ferland et al. 2017)

Inputs:

- **incident spectrum** (stellar + X-ray source)
- **metal and dust** abundances
- **density/pressure** profile
- distance to the source (**ionization parameter**)
- additional corrections for dynamical effects (turbulence, shocks)

Radiative transfer & Chemistry (photo-ionization & photo-dissociation)

Outputs

- lines fluxes
- continuum fluxes

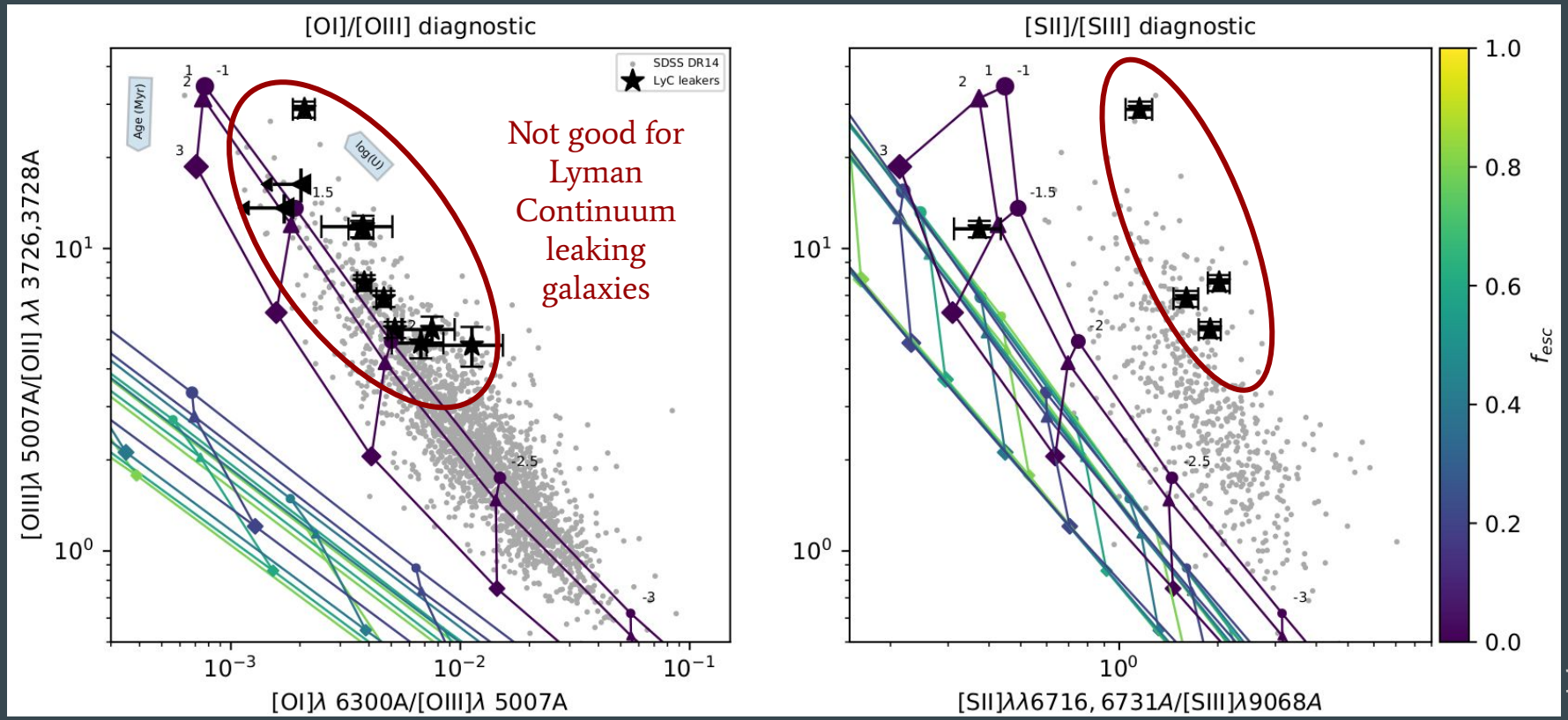
⇒ compared to observation

- temperature, density, pressure
- ionization state for every specie
- heating and cooling mechanisms
- molecular gas content

⇒ what we want to know!

Results of “simple” models

Ramambason et al. in prep



Results of “simple” models

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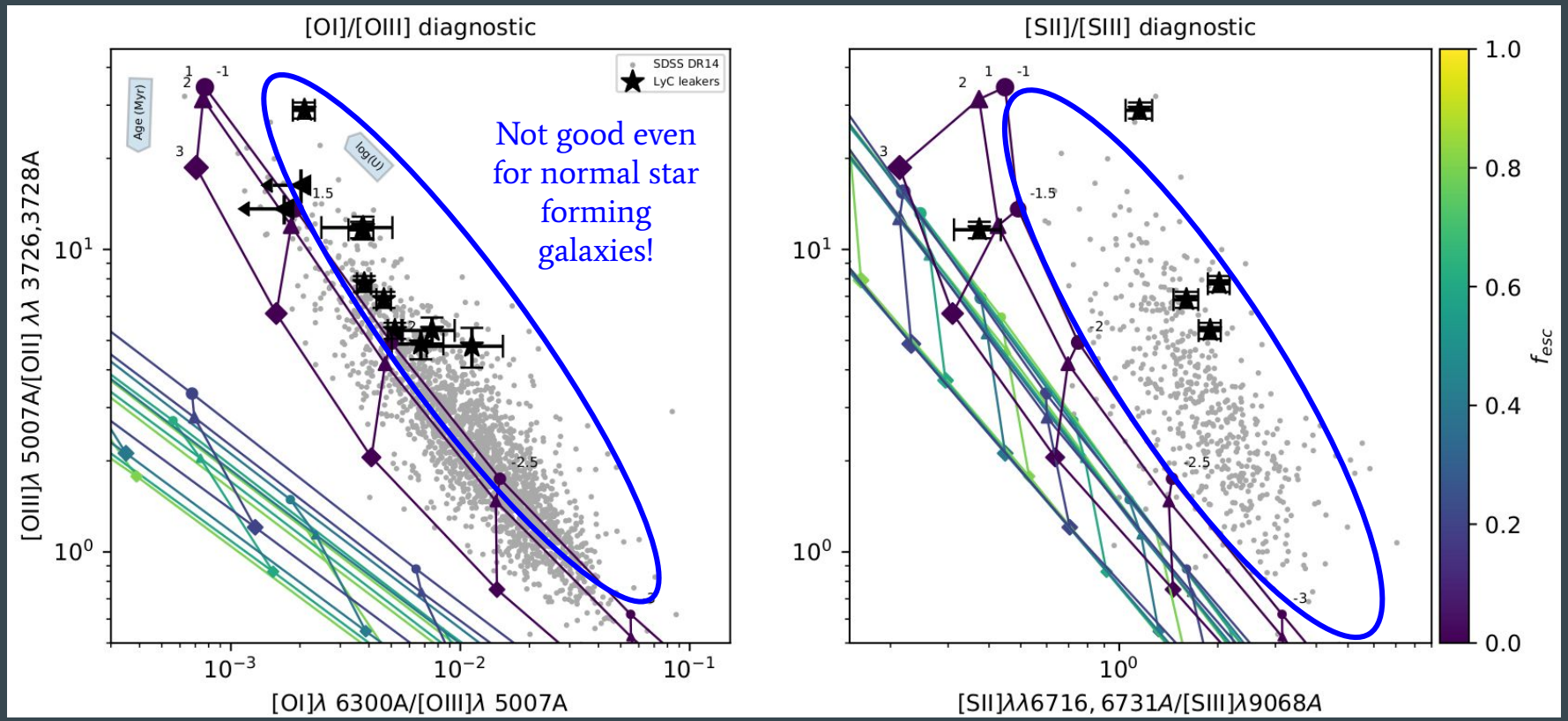
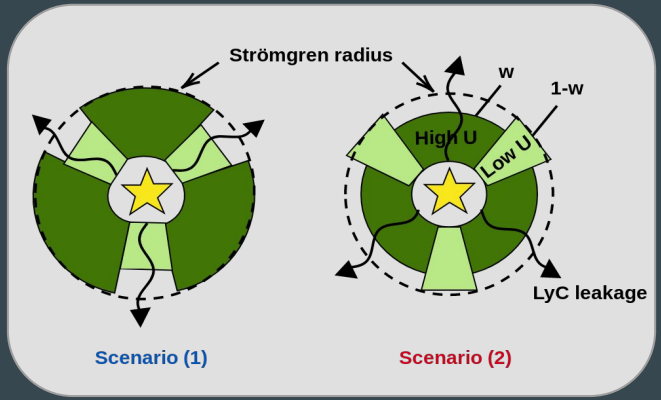
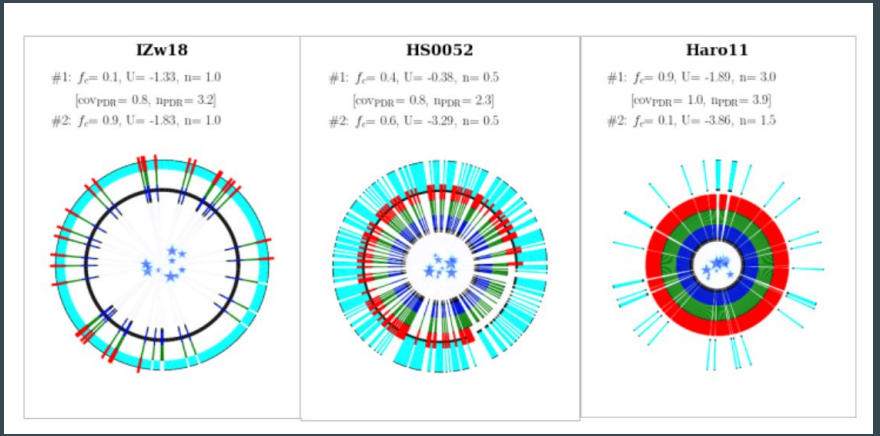


Need of multi-sector modeling

Two-components... (Ramambason et al. in prep)



Or more complicated! (Lebouteiller et al. 2017)



Parameter Space

N parameters
(age, density, pressure, covering factors..)

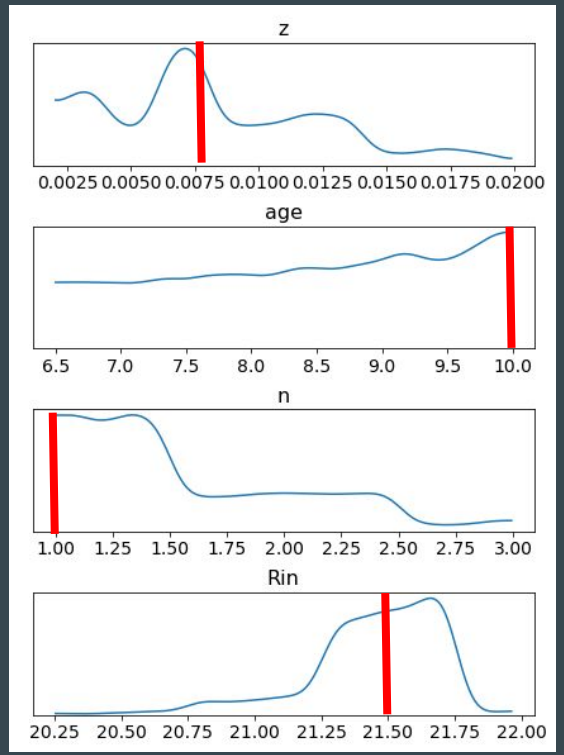
NxP-dimensions grid of Cloudy models

Observable Space

P spectral lines
= constraints

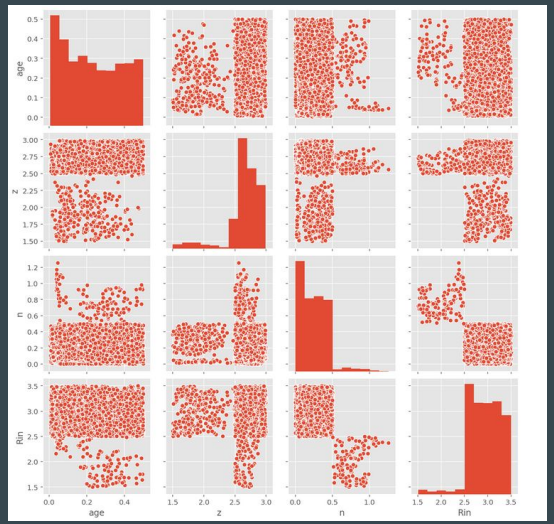
First results applied on synthetic observations

Probability distributions of parameters



PyMC3

Bayesian statistics (PyMC3)
\+ MCMC sampling

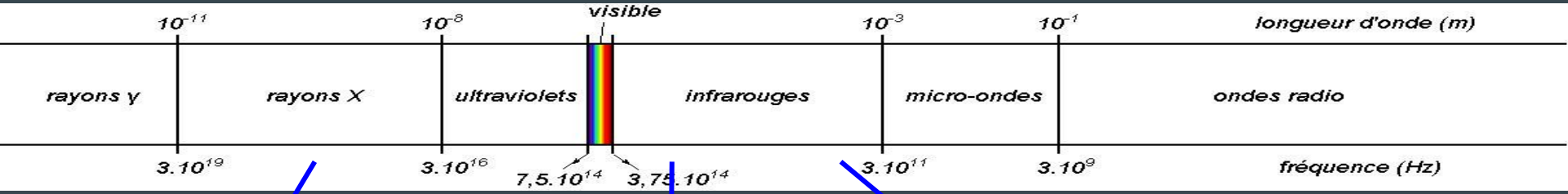


Observations in optical, infrared domain

Why?

- more robust to outliers
- can include priors on the parameter
- possibility to use upper limits

Prospects in the context of future spatial missions



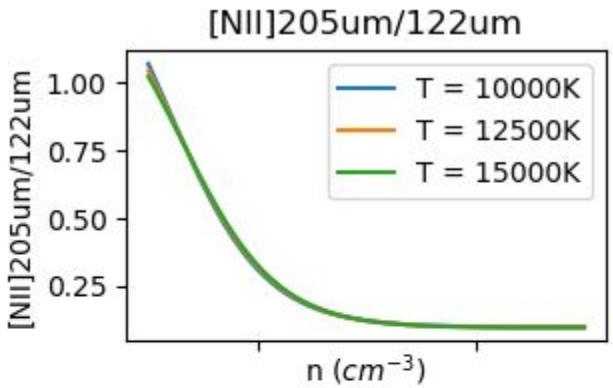
Athena (developing phase)

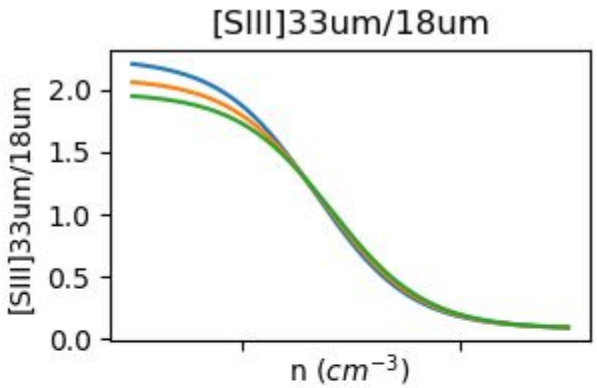
SPICA (pre-selected by ESA)

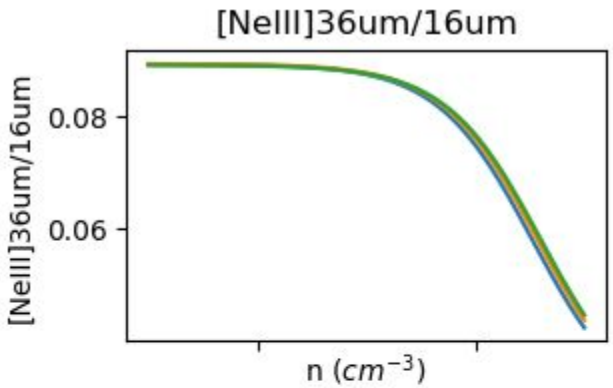
JWST (launch in ~2021)

Thank you for your attention !

Results of “simple” models







Lines ratios → parameter of the models

→ properties of the galaxies

⇒ **Mean parameters averaged on the whole galaxy**

Good iff:

- **morphology** is not too messy
- **the interstellar medium properties are globally uniform**