Thermospheric emission of the early Earth

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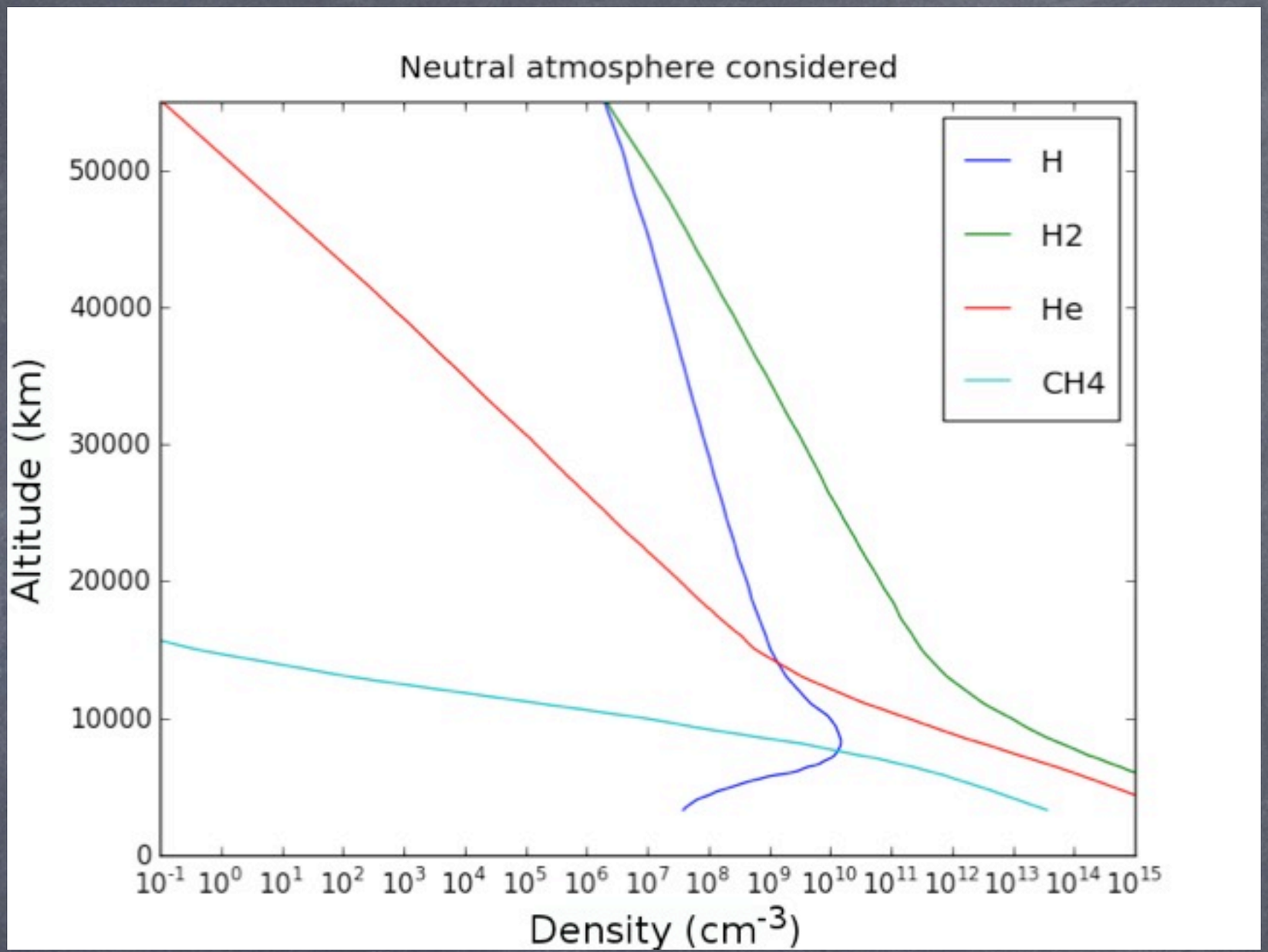
General Context

- Search for Earth-like exoplanets has become a tremendous part of planetary research
- Goal : Modeling the emission of the Earth along its history, to provide proxies for the research and characterization of earth-like exoplanets

I. Atmospheric model

- Primary atmosphere, inherited from the nebula -> mainly composed of H, H_2 and He
- Use of a jovian model, provided by *Grodent et al.(2001)*
- Scaled to fit the Early Earth characteristics (*Sasaki and Nakamura (1989), Pepin (1991)*) :
  - $T_{surf} \approx 2000$ K
  - $P_{surf} \approx 10$ bars

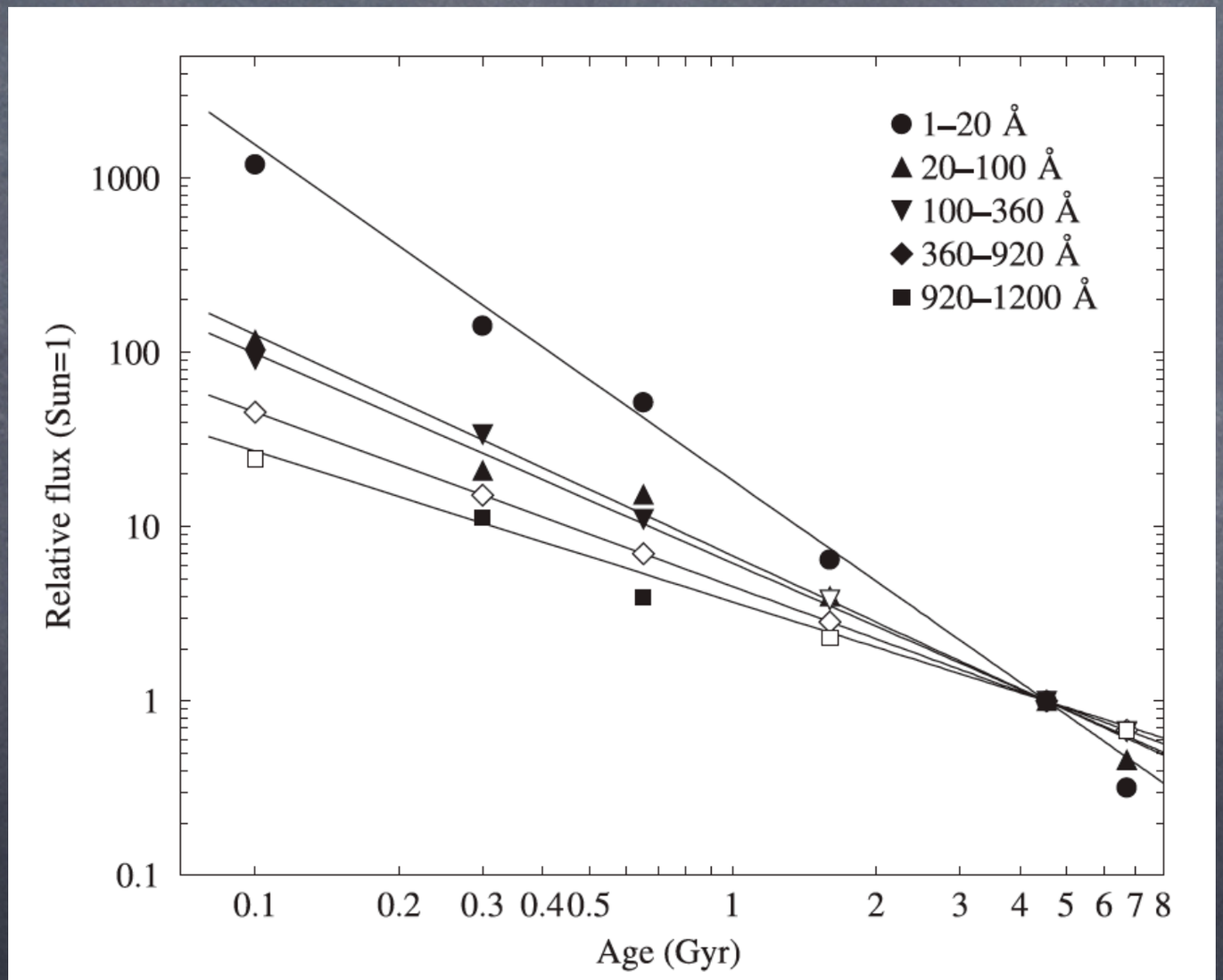


- Very extended atmosphere : ~ 10 Earth radii
- Isothermal temperature profile : T = 2000 K -> non determinant

II. Solar input

- Young sun was weaker (between 25 and 30 % less luminous)
- BUT harder! More powerful in the X-UV range

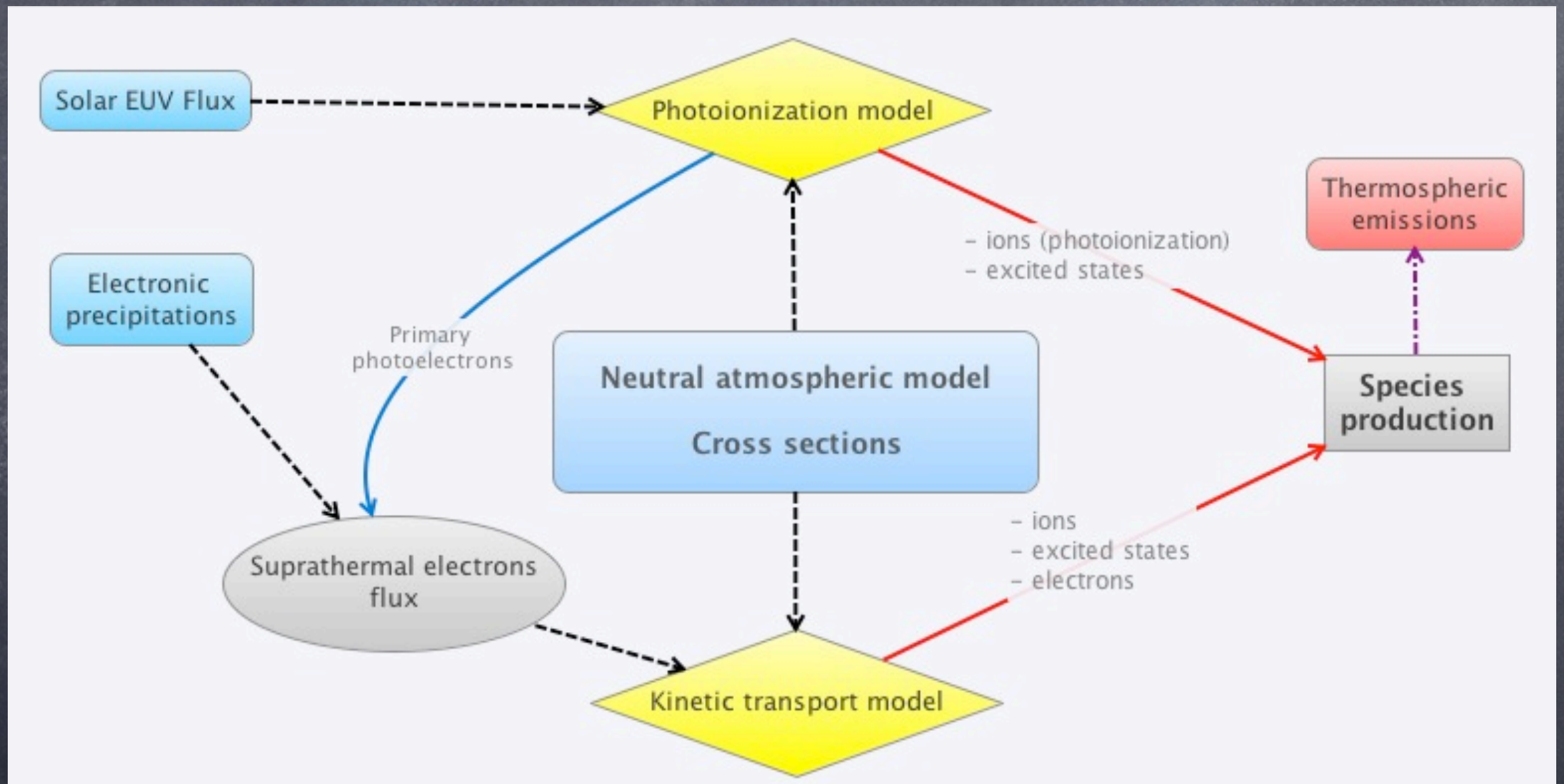
- *Ribas et al. (2005)* : Retrieve the irradiance of the sun in the far UV range (*Sun in Time* program)



III. Method

- Modeling of the ionization and excitation rates of the different species
- Use of a radiative transfert code to compute the optically thick Lyman Alpha line

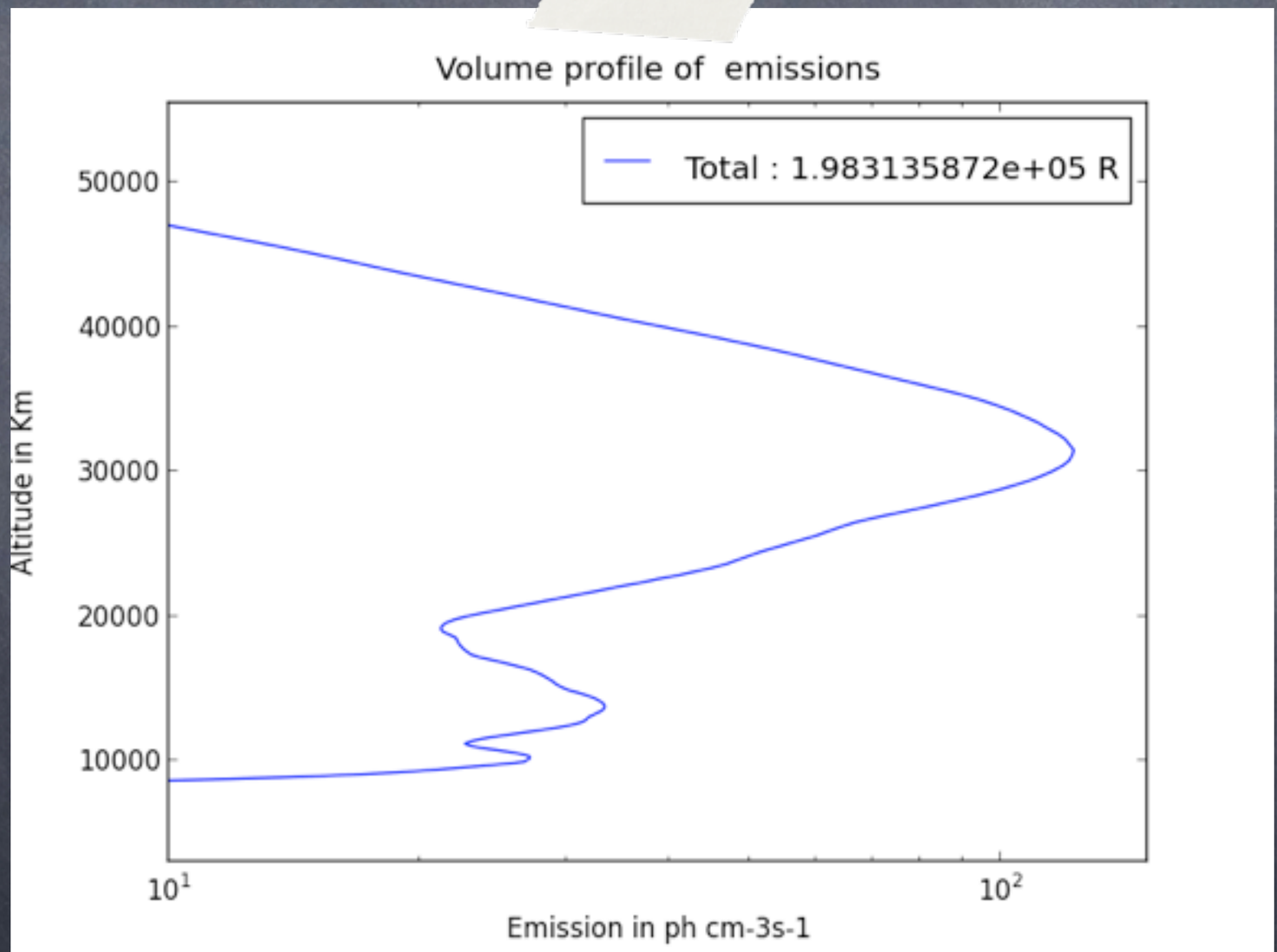
Modeling the ionization and excitation rates with *Aeroplanets*



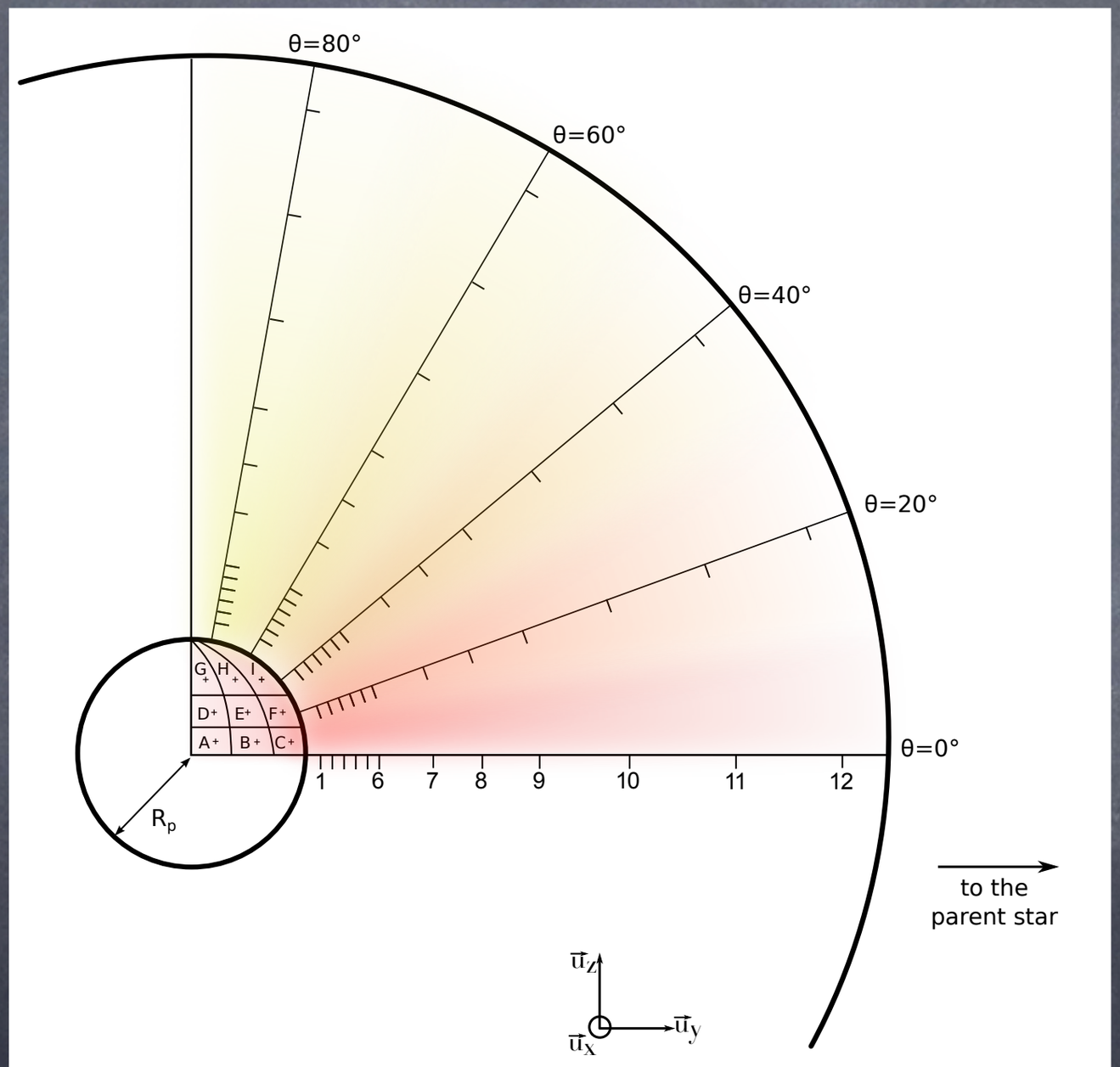
IV. Results

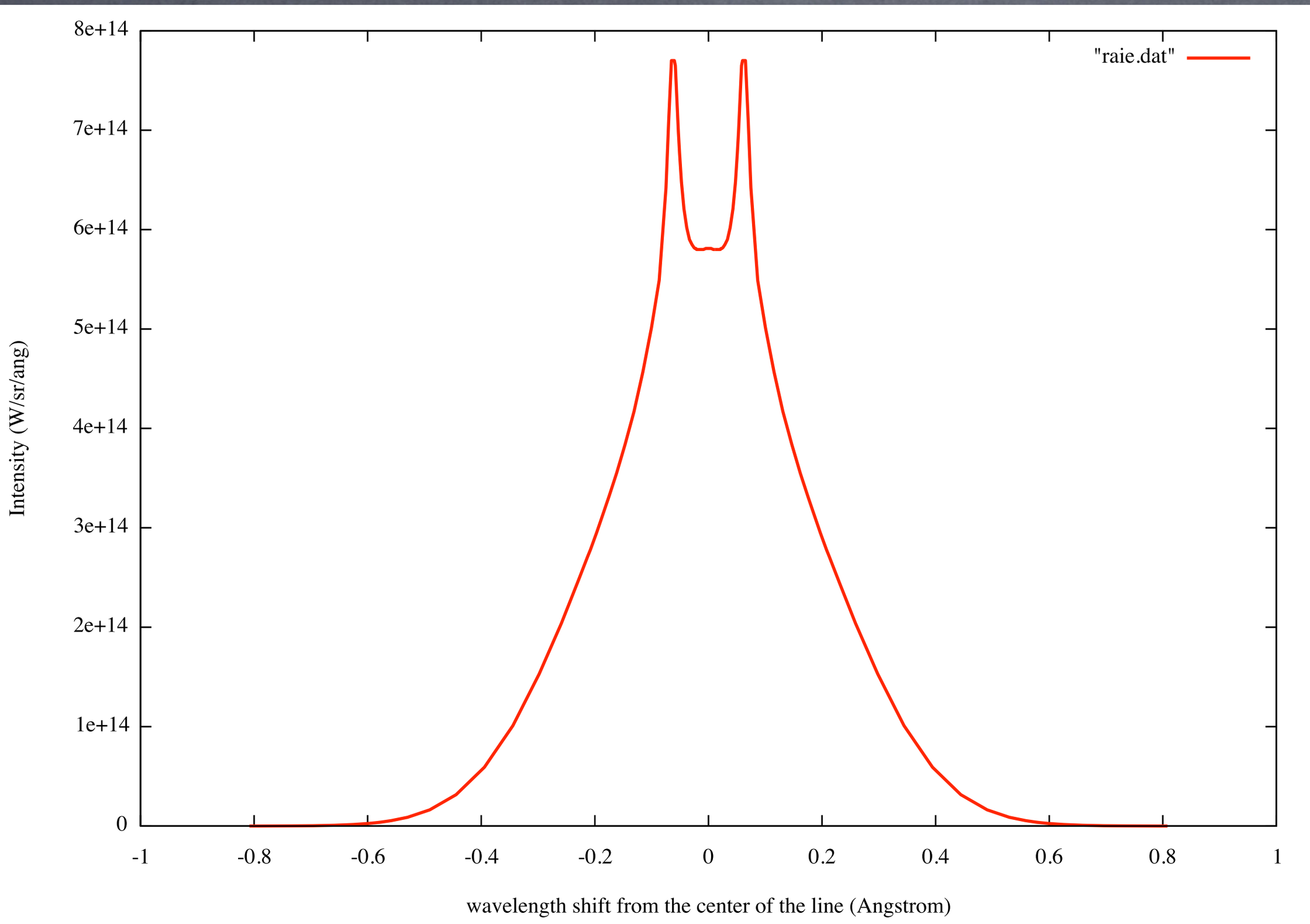
1) Lyman Alpha emission

- Internal source :



- Lignes of sight and integration over the all disk




"raie.dat"
Intensity (W/sr/ang)
8e+14
7e+14
6e+14
5e+14
4e+14
3e+14
2e+14
1e+14
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
wavelength shift from the center of the line (Angstrom)

- We calculate de ratio of the emission of the whole planet over the young sun one in Lyman alpha :

-> $R \sim 10^{-8}$

Conclusion

- For the first time, we have calculated the electrons and ion production in the atmosphere of the early earth under the young sun
- We calculated the total emission of the planet in the Lyman Alpha line
- Not suprinsingly, such an exoplanet would not be detectable from the Earth