

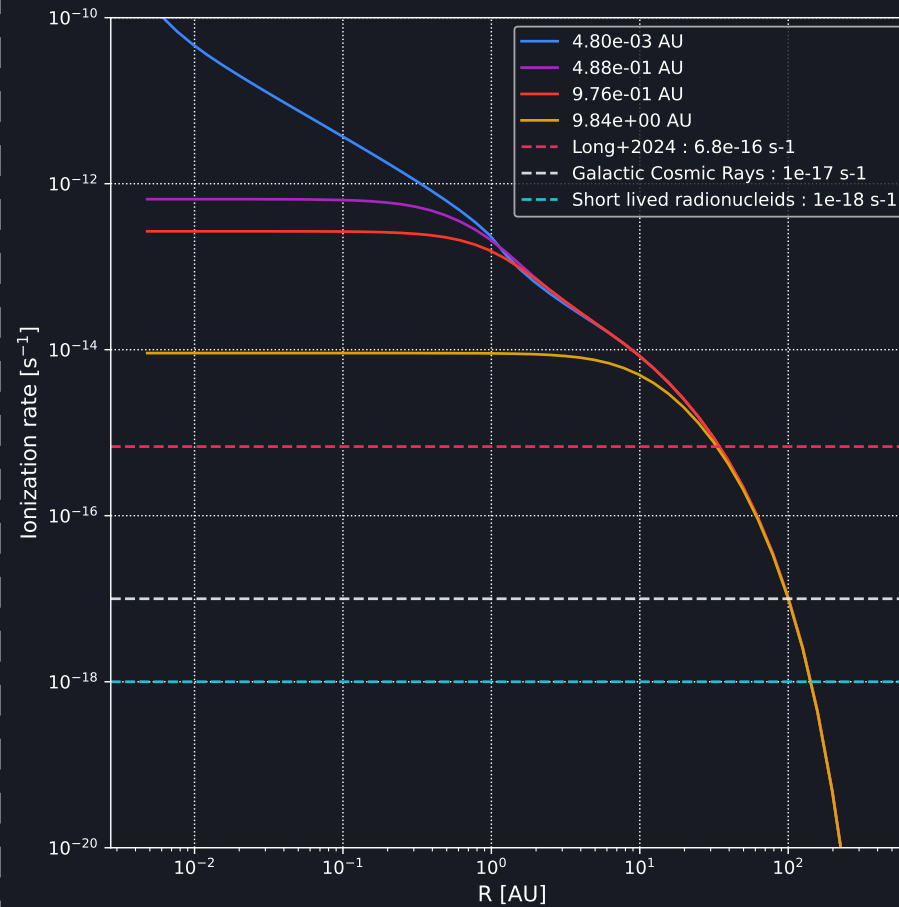
# Stellar Energetic Particles (SEP) strongly ionize protoplanetary disks

**HCO<sup>+</sup>** and **N<sub>2</sub>H<sup>+</sup>** abundances profiles in **DM Tau** protoplanetary disks require an **artificially high quantity of energetic particles** within 100 AU (Long et al 2024)

Chemical modelling account for :

1. X-ray / UV
2. Galactic Cosmic rays
3. Short lived radionuclide decay

**But no SEP**

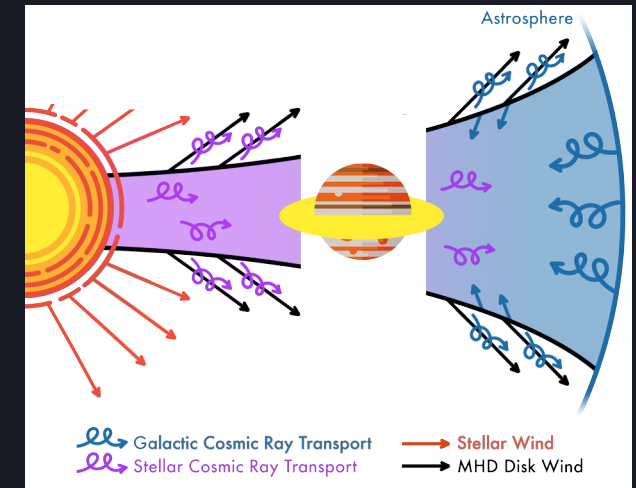


Stellar energetic particle ionization rate as function of DM Tau disk altitude

**SEPs account for the missing particle source up to 30 AU down to the midplane**

## The model

Diffusion of SEP in a protoplanetary disk with a turbulent magnetic field.



Large dependence to :

Parameter	Values/Origins
Energy spectrum range	0.1 – 300 GeV
Disk magnetic field	1 – 30 mG
Turbulence factor	1 – 180
Stellar wind model	Vidotto et al 2015