

# Cosmic rays irradiation of interstellar dust analogues

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# Chemical reactions in ISM



Interstellar medium is everything except stars and planets.

Elementary composition : H(90%),He(9%),Others(1%)

Density: 10 to  $10^8$  H/cm<sup>3</sup>, T=10 to 1000 K

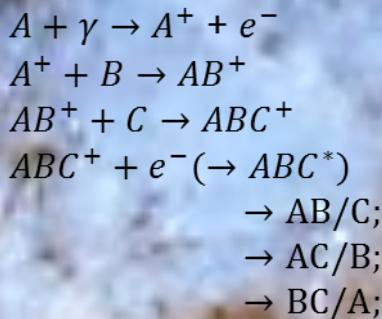
UV field : ambient (Av=0) to very few (Av> 100) (or more)

Ionizing particle field (CR) : 10-1000 MeV/u

Magnetic field : ISM is plasma !

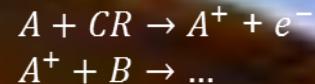
**Diffuse medium**  
( $N_H = 10 - 500/\text{cc}$ , T=(1-3)00K, Av=0)

*Ion molecule chemistry:*



**Dense medium**  
( $N_H = \text{few } 10^4/\text{cc}$ , T=10-30 K, Av=100)

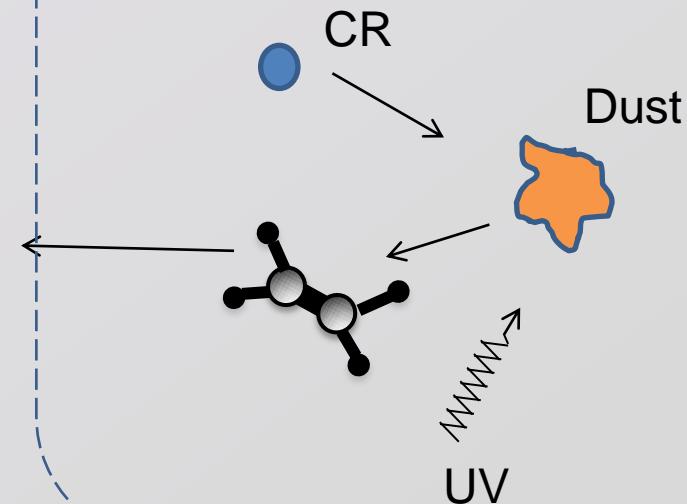
*Ion - molecule :*



*Neutral-neutral:*

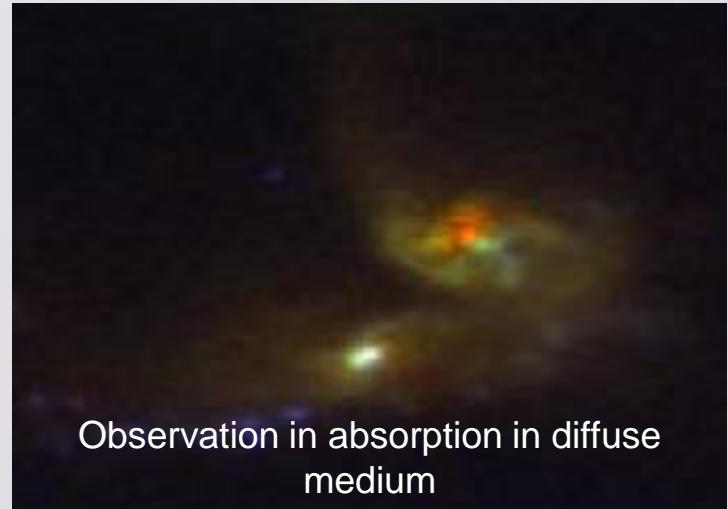
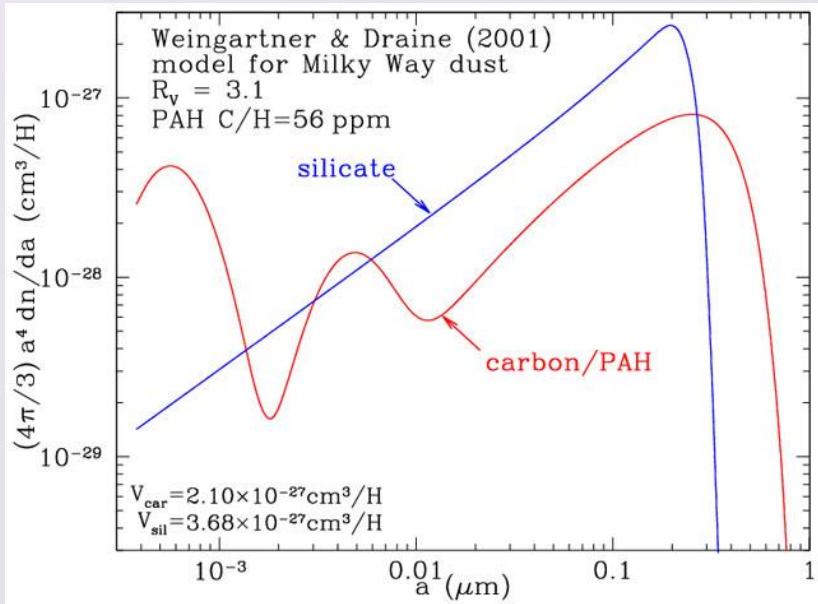


Under UV and CR, dusts inject molecules in the chemical « reactor » .

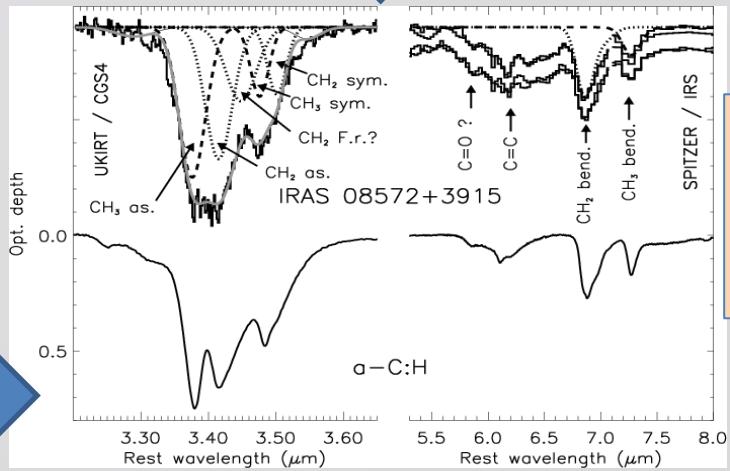
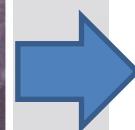
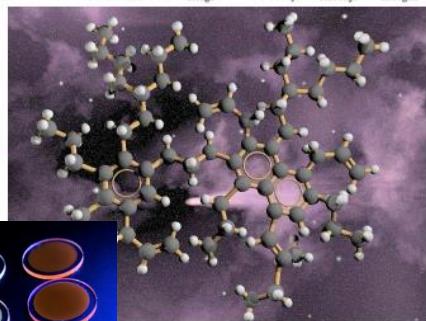
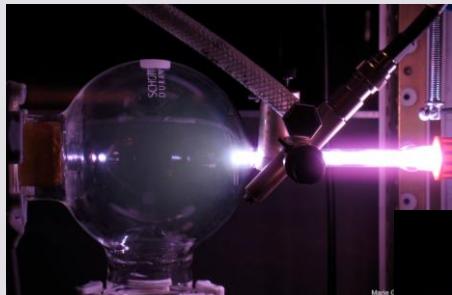


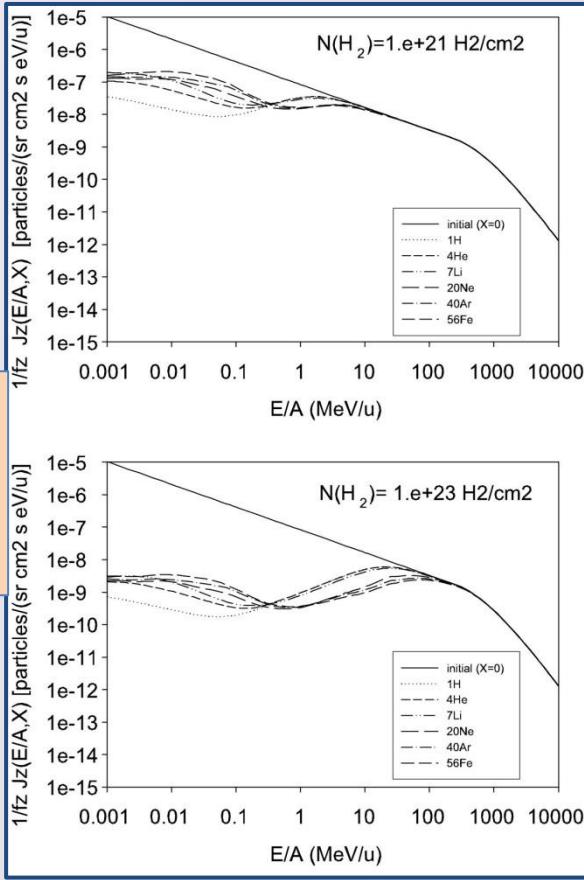


# Interstellar dust and carbon analogues

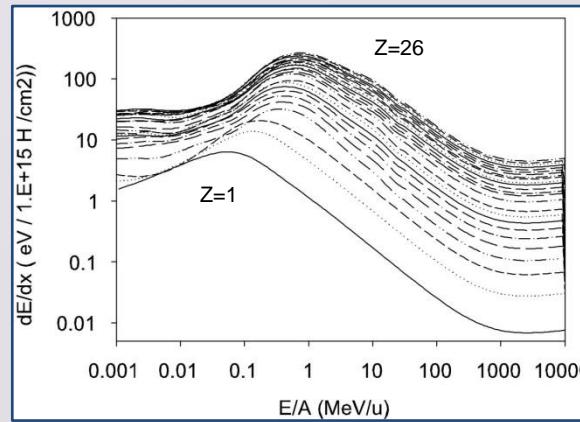


a-C:H analogue in lab (IAS).





# Low energy Cosmic rays

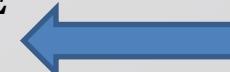


Ion matter interactions scale with  $dE/dx$

Low energy CR spectrum is determined by the propagation through the interstellar  $H_2$  gaz.

CR destroy dust and produce molecular species following :

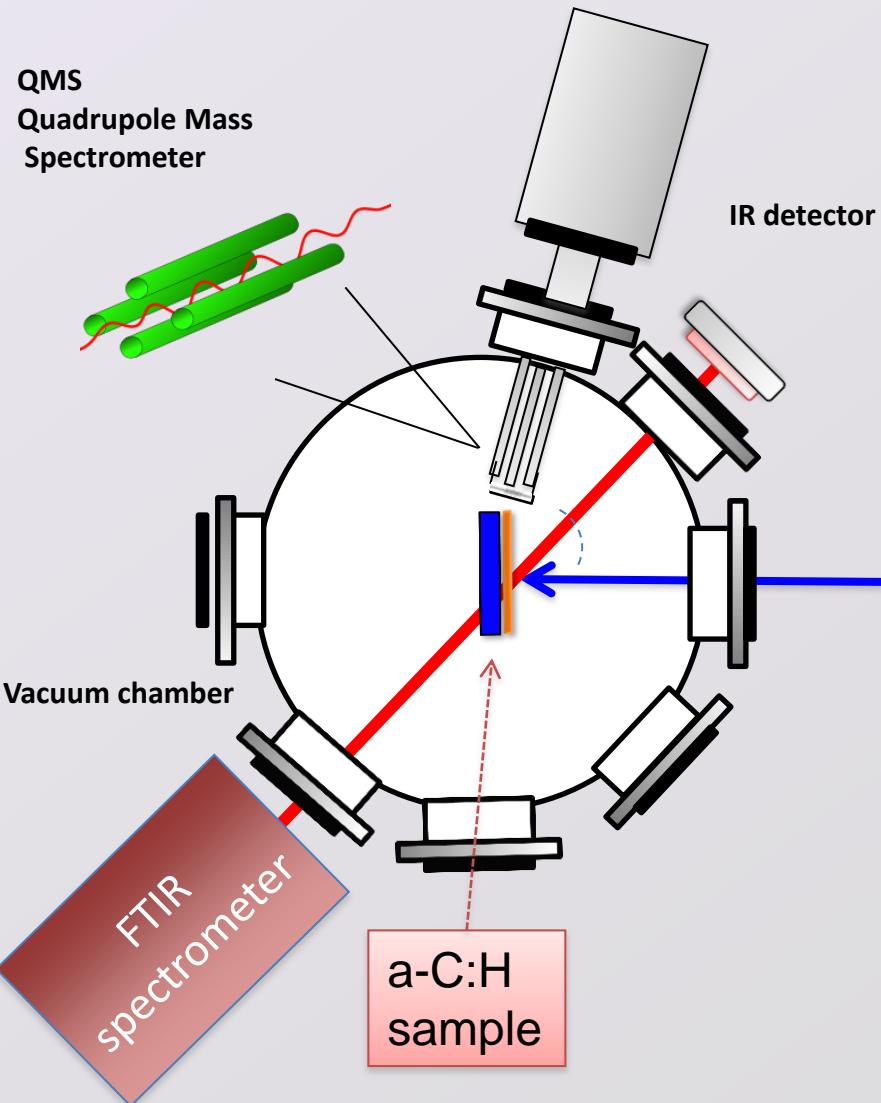
$$\tau = 4\pi \sum_Z \int j(E/A, Z) \times \sigma \left( \frac{dE}{dx} (E/A, Z) \right) dE$$



*Experimental input*

# Setup@GSI M-branch-3

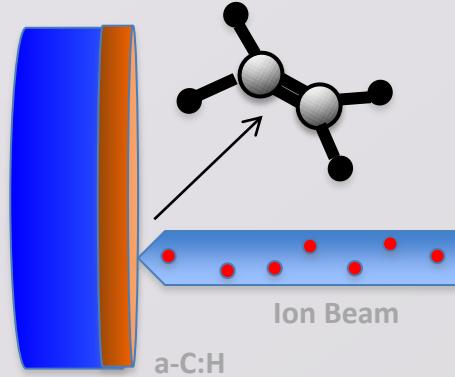
QMS  
Quadrupole Mass Spectrometer



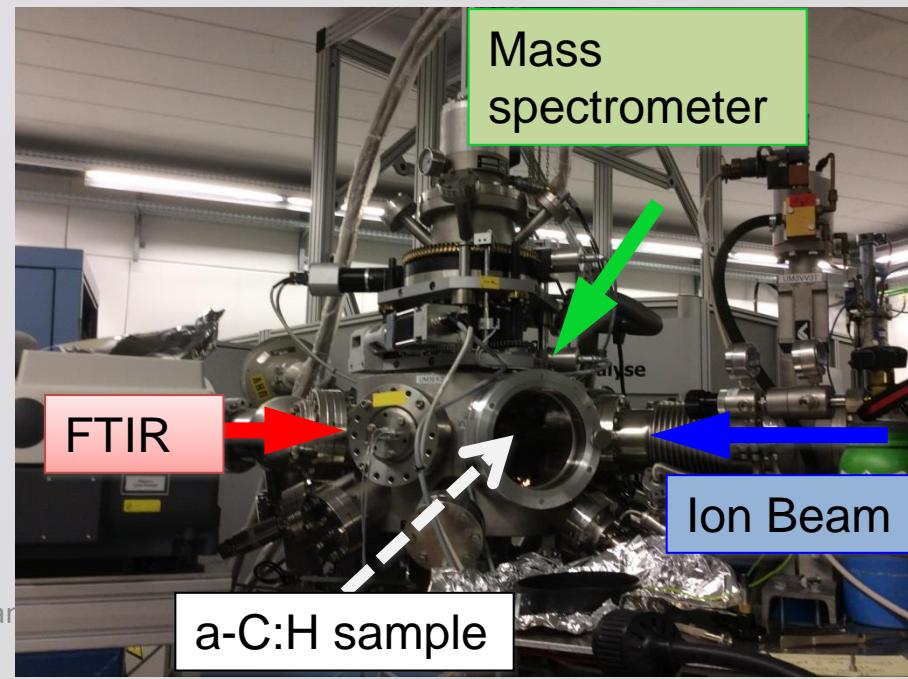
Irradiation at T=25-300 K

journées FAIR France

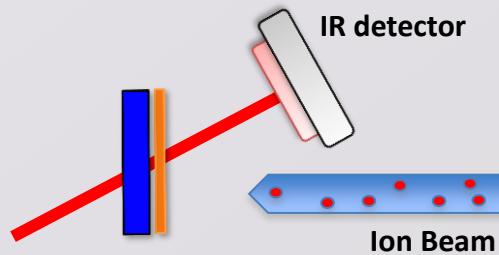
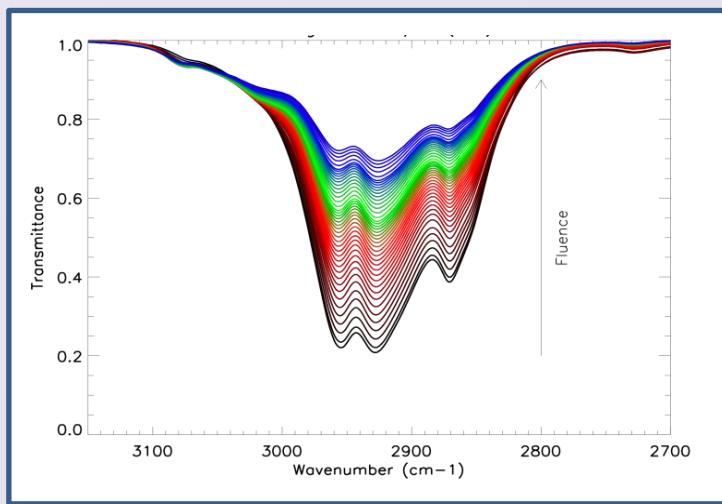
a-C:H sample



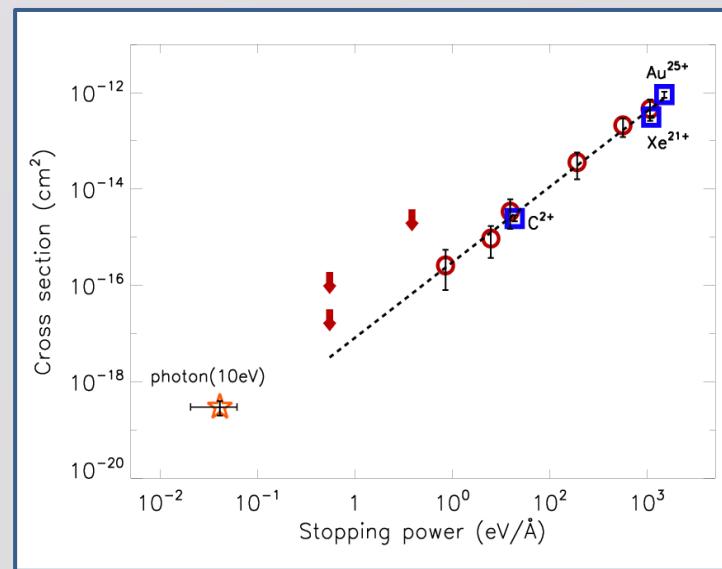
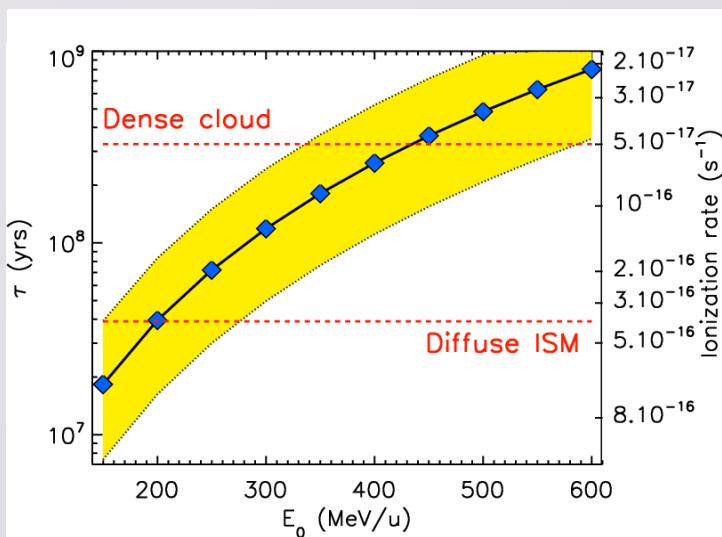
Unilac ion beam



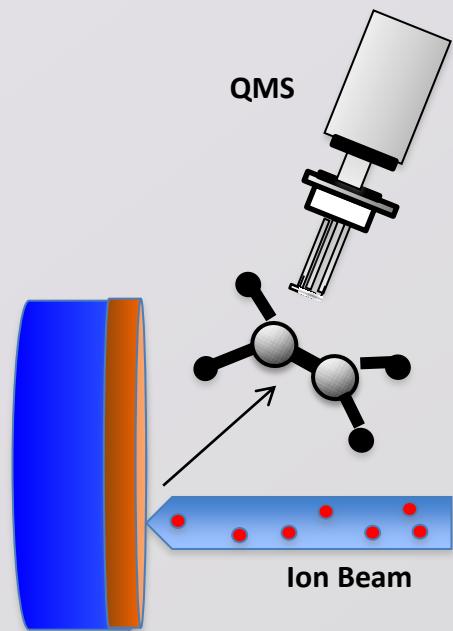
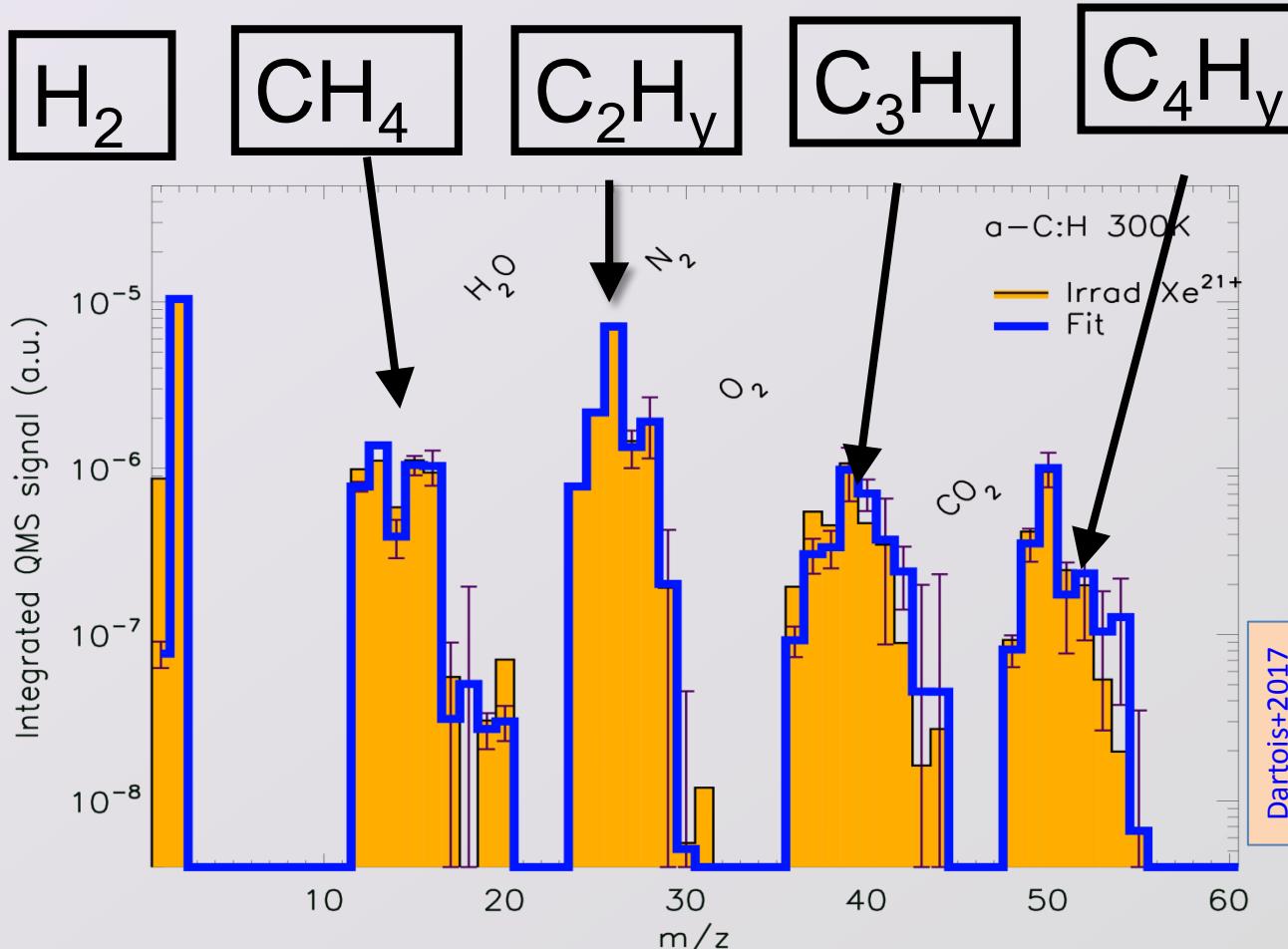
# Life time of a-CH



CRs lead to progressive graphitization of the a-C:H material ( C-H bond destruction).



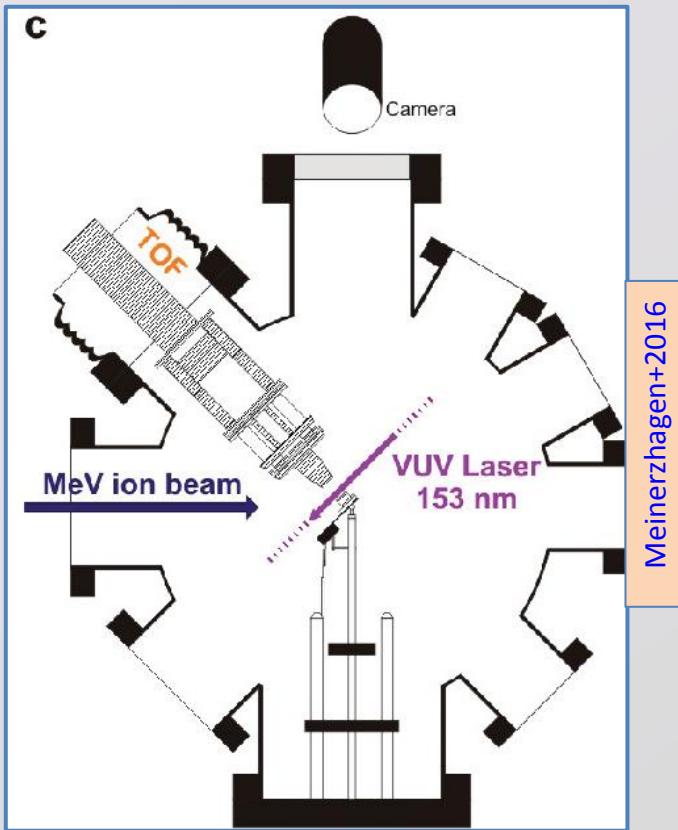
# Hydrocarbon production



Production of small hydrocarbons by CR is negligible as compared to UV in diffuse medium but not in dense cloud.

# Conclusion & future

- QMS cannot detect reactive species.
- New series of experiment with other detection technique has been started
- Soot and a-CNH analogues are also under interest.



Thank you for your attention