Hall thruster used as molecular gas dissociator

Francesco Taccogna
Pierpaolo Minelli

P.Las.M.I. Lab @ CNR-Nanotec
Bari

e-mail: francesco.taccogna@cnr.it

Outlines

- Molecular Propellants
- HT used as gas dissociator
- H2 chemistry
- H/H2 gas Monte Carlo model in a frozen plasma
- Results

Why using alternative molecular propellants

Usually not an optimum choice in terms of thrust.

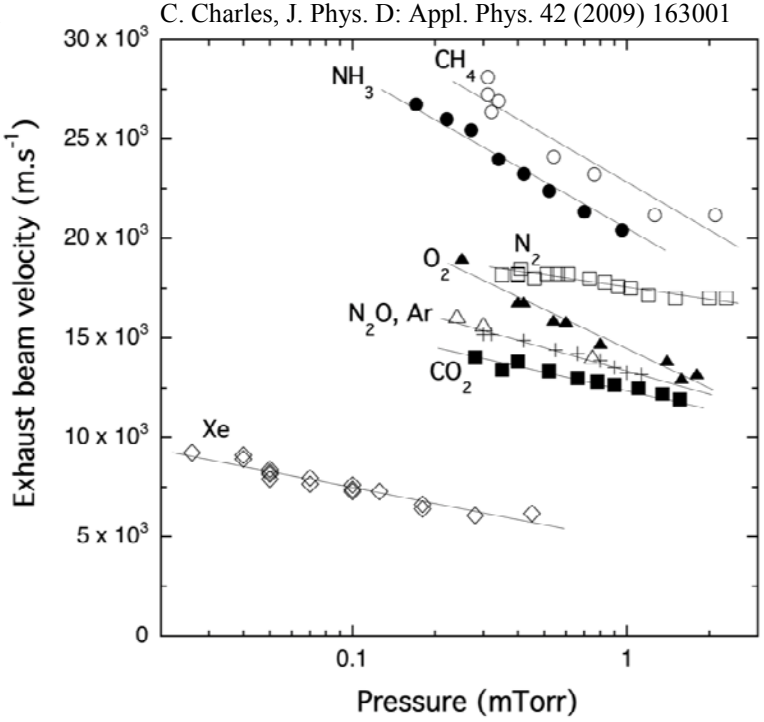
Nevertheless, potential applications include:

- the use/transformation of waste products in manned spacecraft
- the use of propellant residuals in chemically propelled spacecraft
- the use of propellants that are directly available in space (CO_2 from Mars/Venus atmosphere or from waste product of crewed missions and ISS)

Another possible reasons for investigating molecular propellant is to use HT as gas dissociator to:

- produce hot atoms for negative ion conversion on Caesiated grid
- produce atoms for Passive Hydrogen maser used as atomic clock

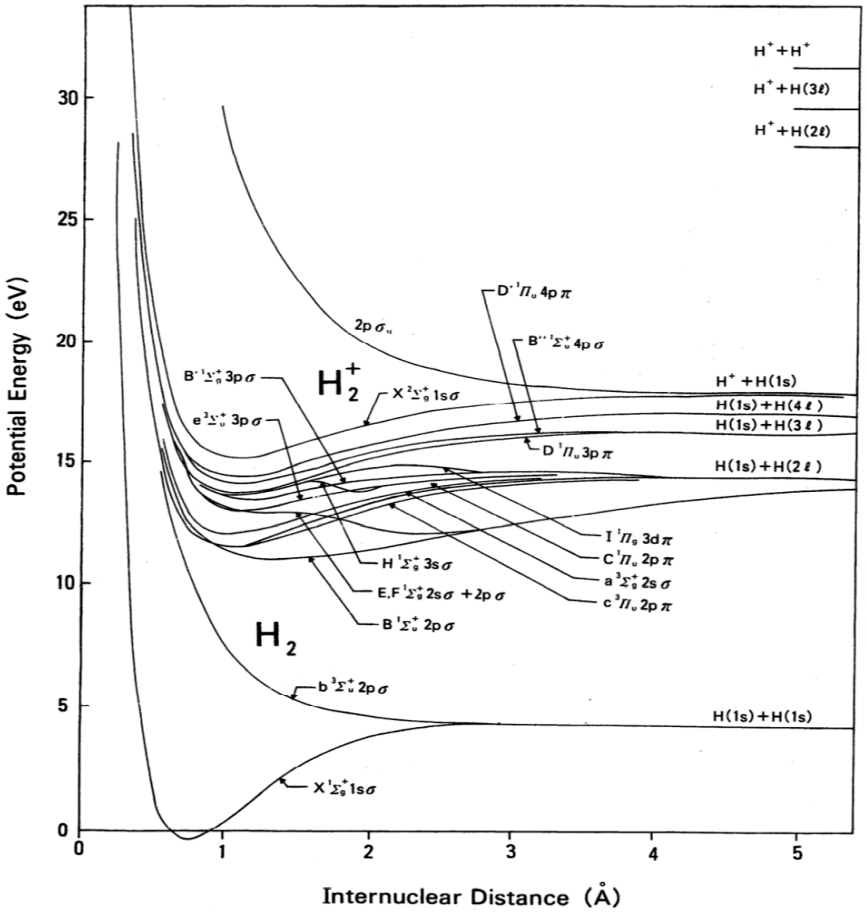
C. Charles, J. Phys. D: Appl. Phys. 42 (2009) 163001



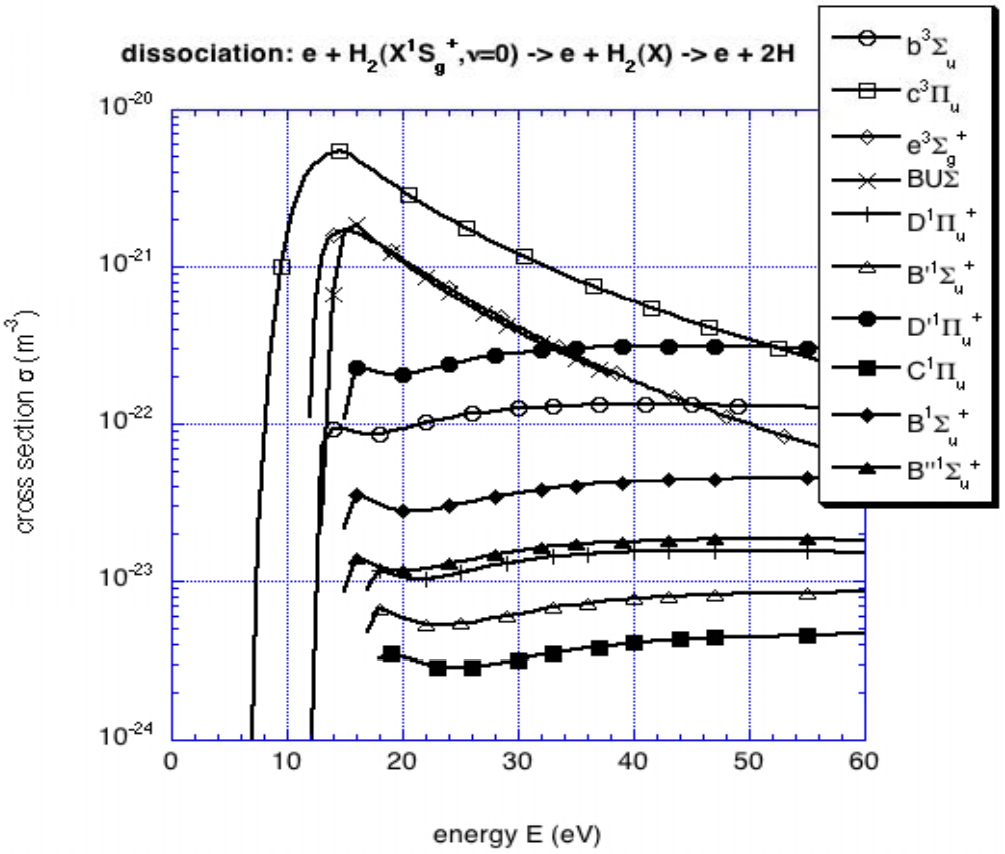
H_2 Chemistry: e-induced dissociation channels

H Atom e-induced production channels:

- dissociation e - $H_2(v) \rightarrow H_2^* \rightarrow H(m) - H(n)$ [E_H=3 eV]
- dissociative ionization e - $H_2(v) \rightarrow H(m) - H^+$ [E_H=0.5 eV]



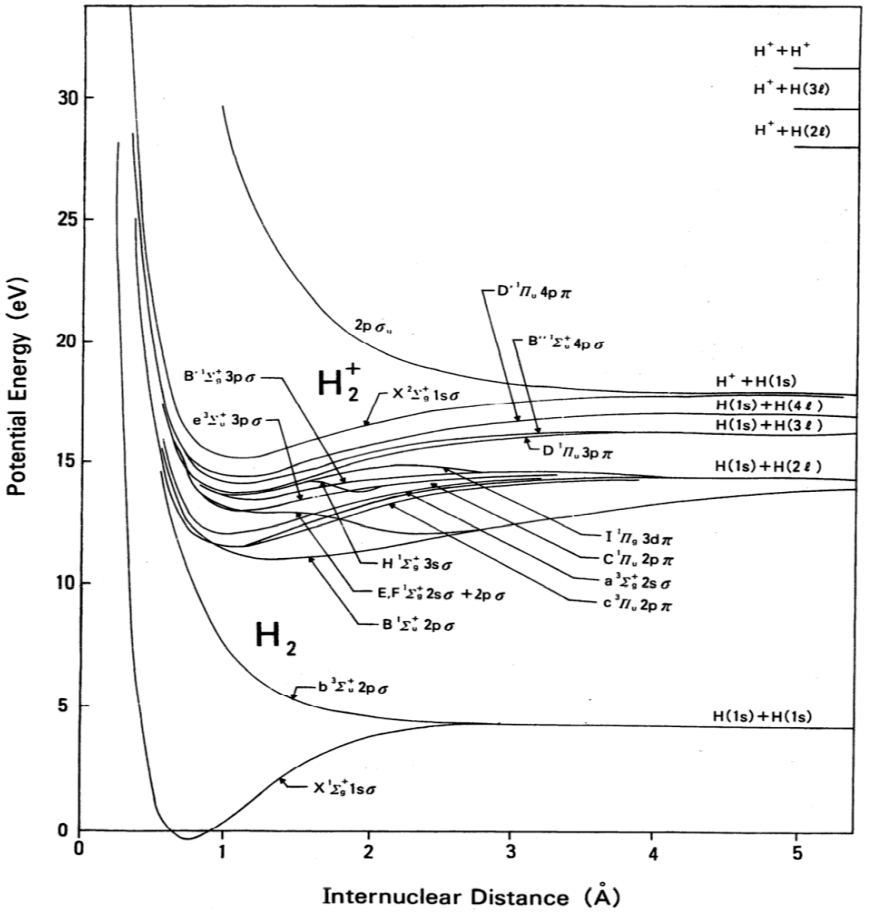
R. Celiberto et al., At. Data Nucl. Data Tables 77, 161 2001

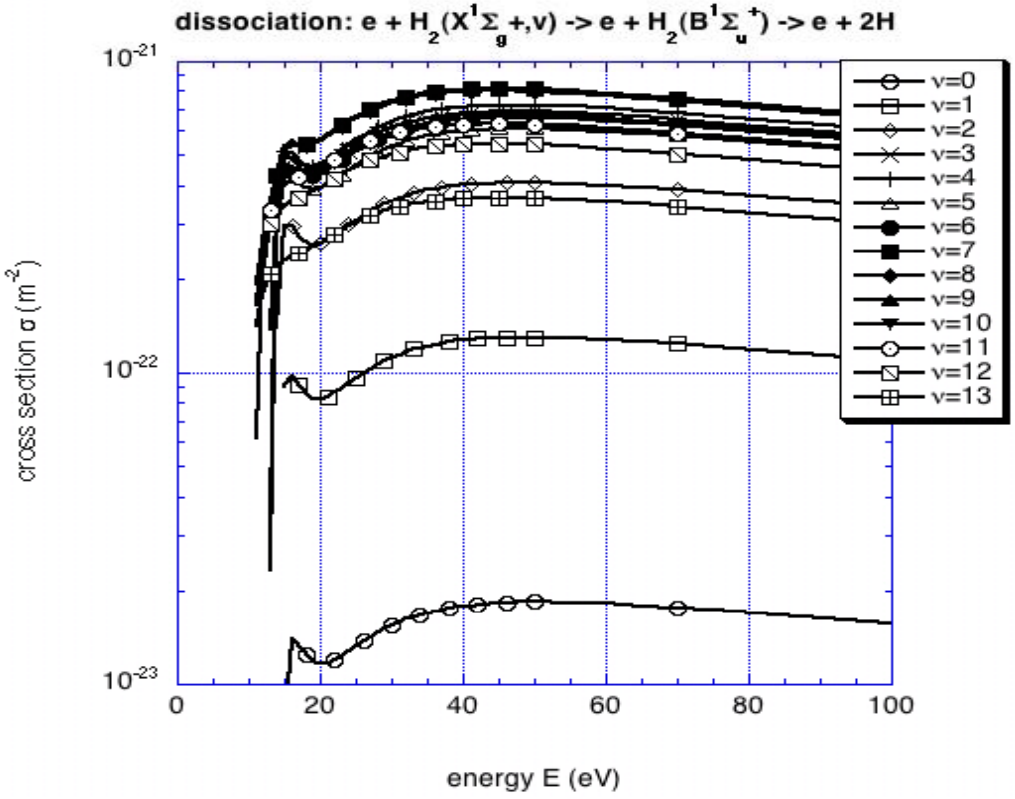


H_2 Chemistry: dependance from initial vibrational level

H Atom e-induced production channels:

- dissociation e - $H_2(v) \rightarrow H_2^* \rightarrow H(m) - H(n)$ [E_H=3 eV]
- dissociative ionization e - $H_2(v) \rightarrow H(m) - H^+$ [E_H=0.5 eV]



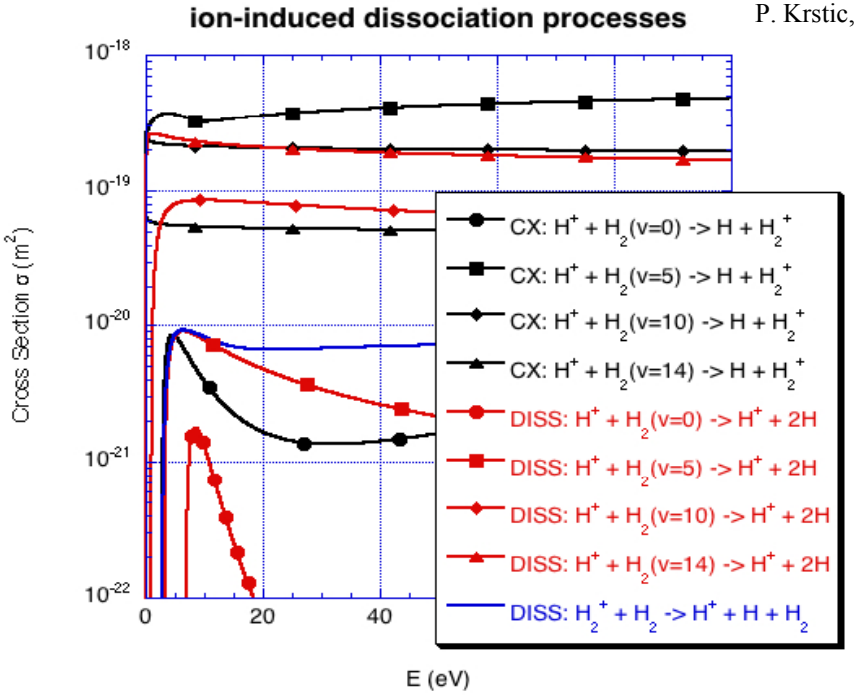


H_2 Chemistry: ion-induced dissociation channels

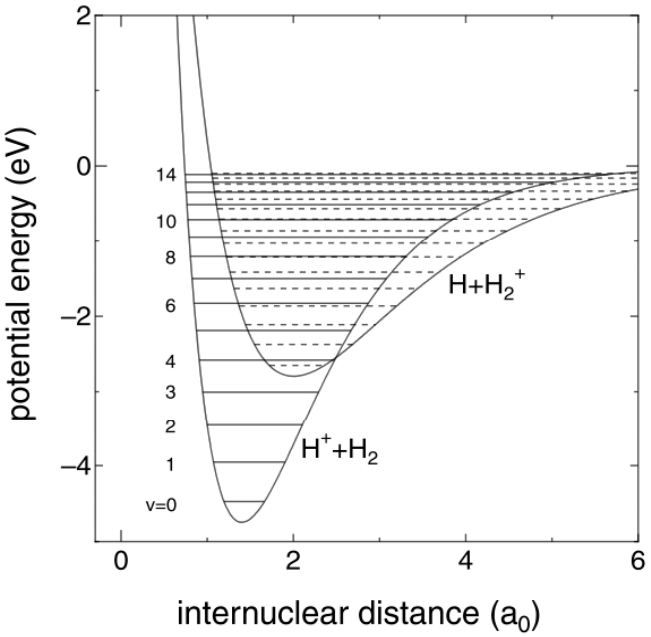
While the corresponding ion-induced vibrational excitation of molecules can be considered negligible in comparison to the electron-induced counterpart (adiabatic Massey parameter $P_{Ma} = \Delta E/\hbar\alpha v$),
the possible ion-induced dissociation processes

- CX $H^+ - H_2(v) \rightarrow H - H_2^+$
- H^+-induced dissociation $H^+ - H_2(v) \rightarrow H^+ - 2H$
- H_2^+-induced dissociation $H_2^+ - H_2 \rightarrow H^+ - H - H_2$

have cross sections 2 order of magnitude larger than electron-induced dissociation.
Therefore, one can thing using electrons to creates vibrational excited molecules-precursors and ions to dissociate them.

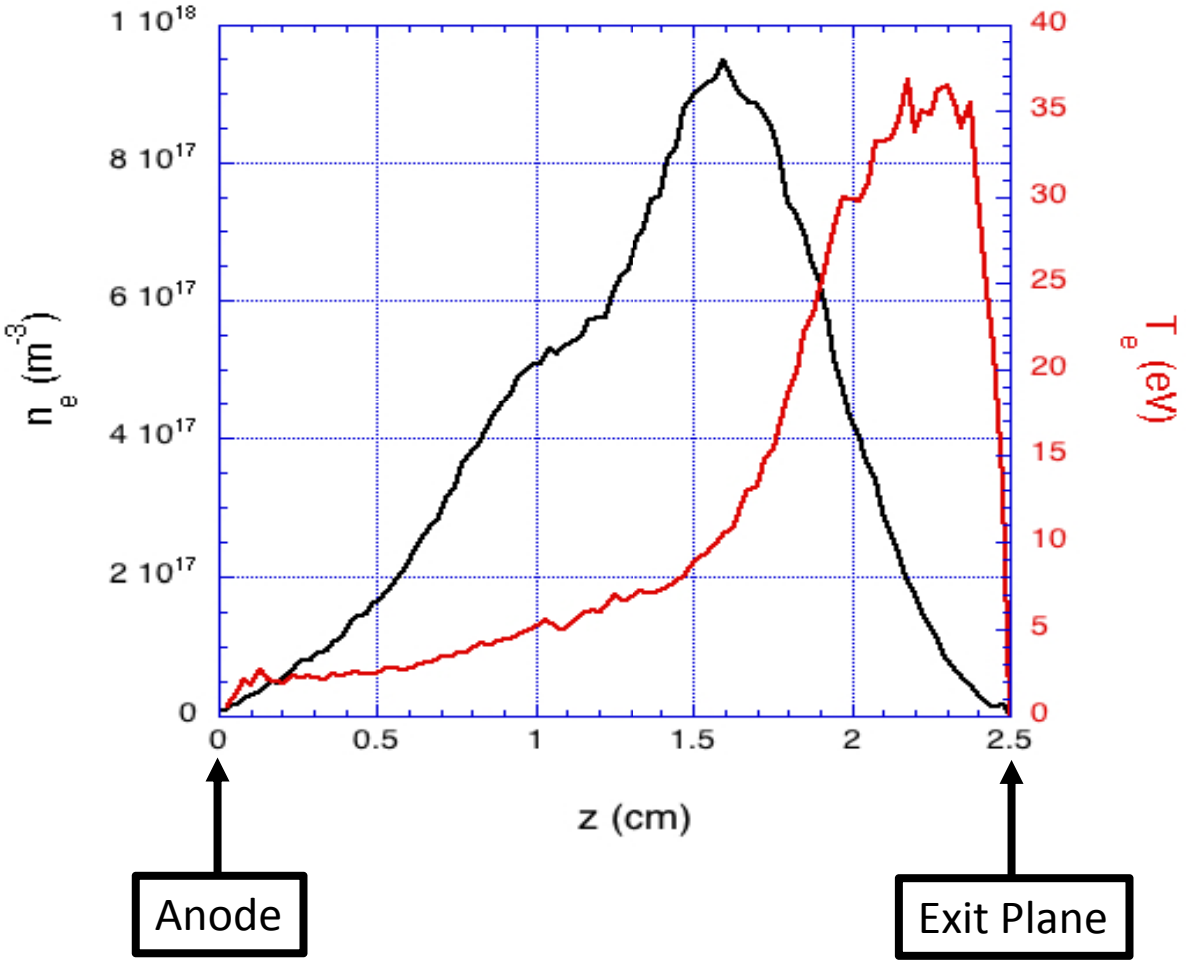


P. Krstic, PRA 66, 042717, 2002



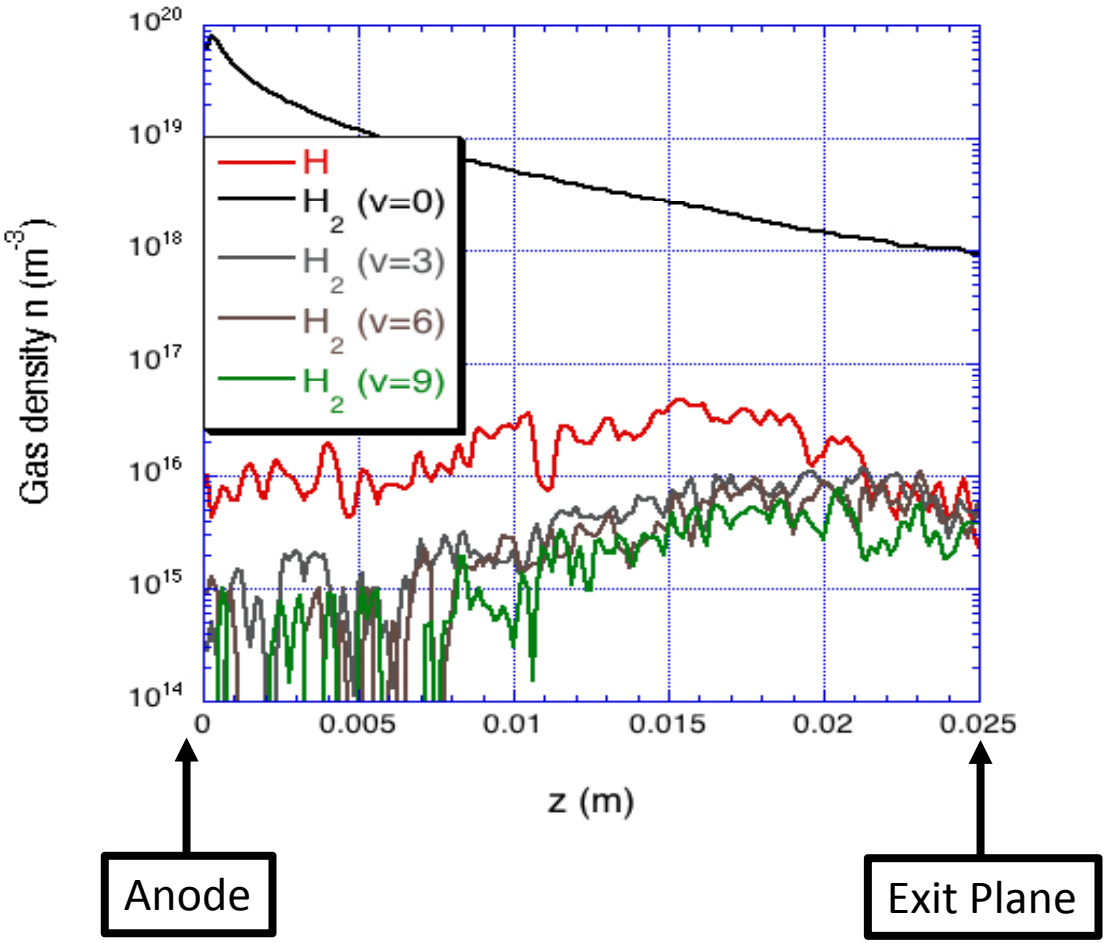
Preliminary Results with a gas MC-frozen plasma code

- **3D Monte Carlo gas dynamics/kinetics in fixed plasma background**



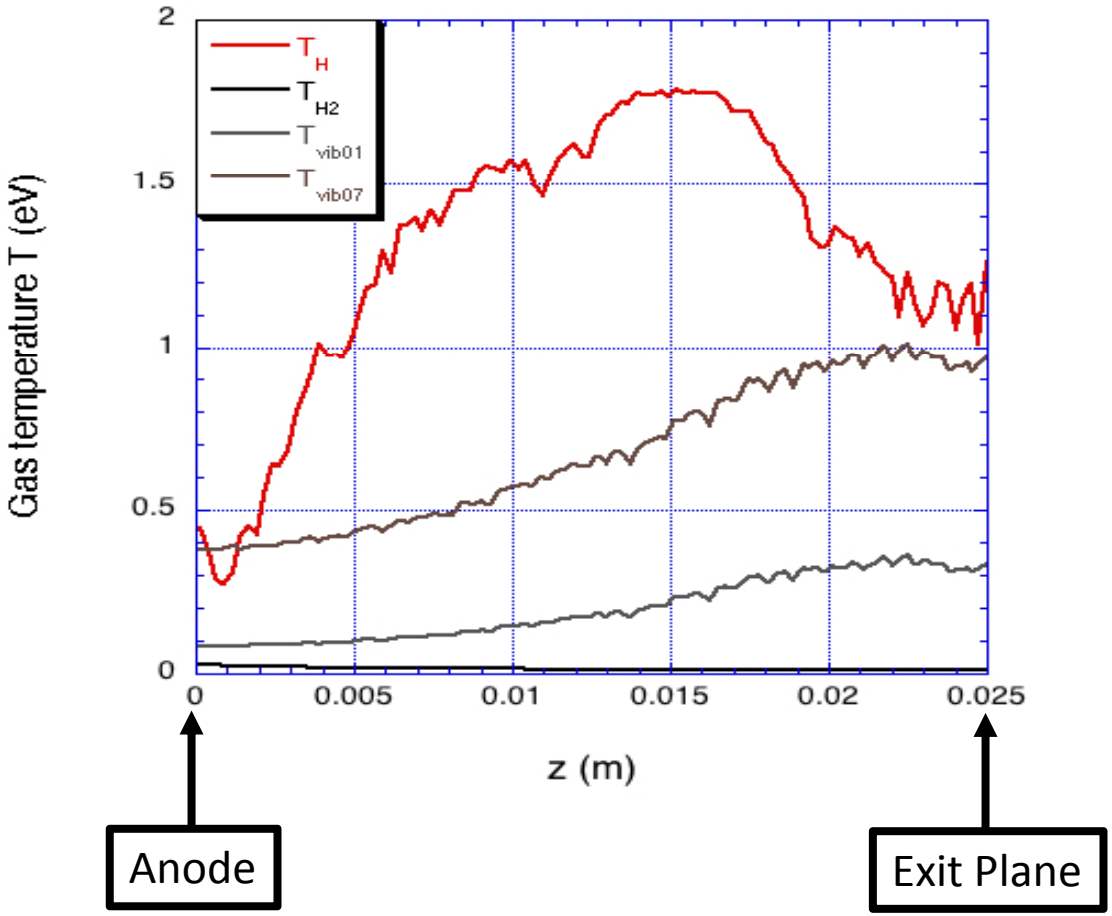
Preliminary Results with a gas MC-frozen plasma code

- **3D Monte Carlo gas dynamics/kinetics in fixed plasma background**



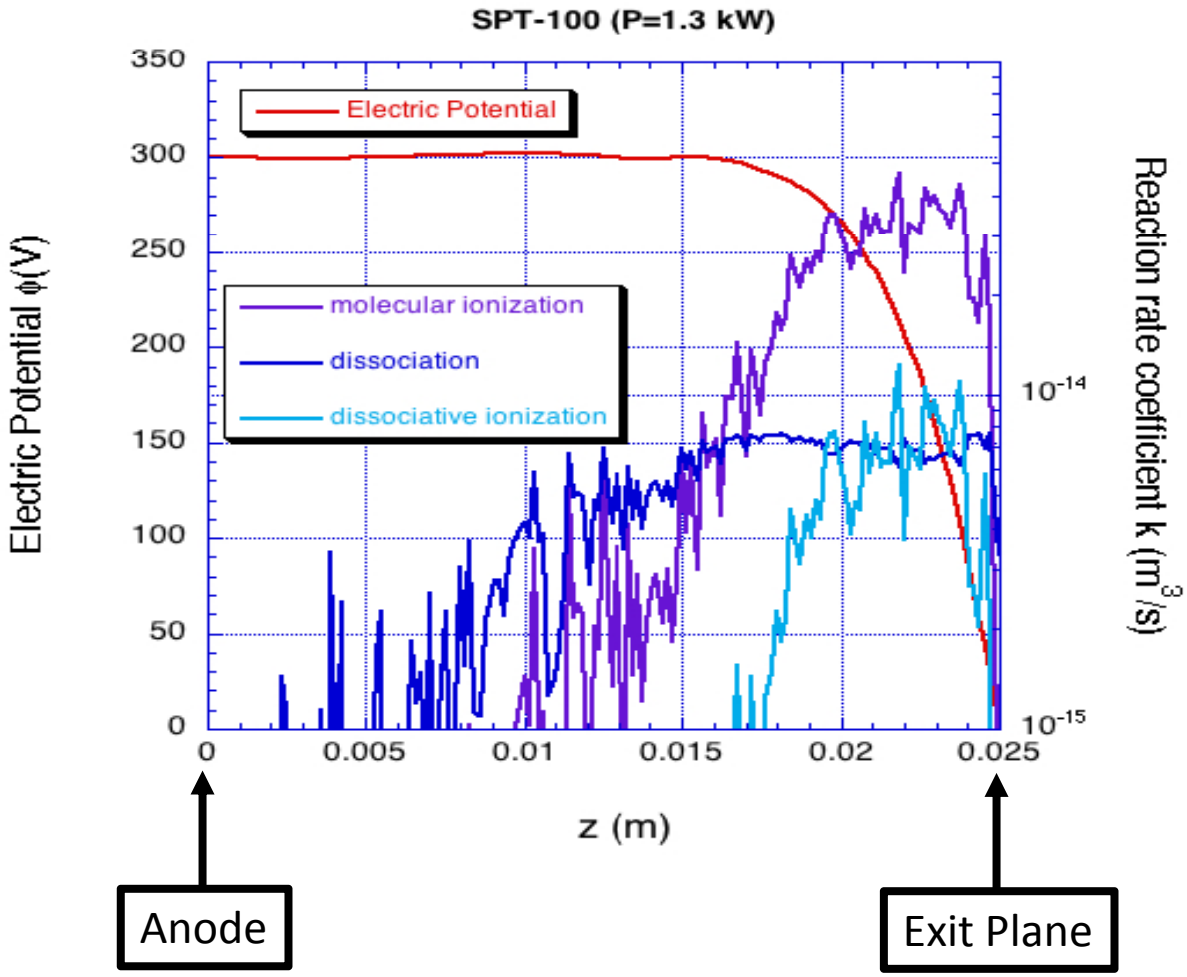
Preliminary Results with a gas MC-frozen plasma code

- **3D Monte Carlo gas dynamics/kinetics in fixed plasma background**



Preliminary Results with a gas MC-frozen plasma code

o **3D Monte Carlo gas dynamics/kinetics in fixed plasma background**



Conclusions

- **Importance of molecular propellants**
- **Numerical model able to resolve vibrational kinetics**
- **Plasma-gas coupling**
- **First results with a maxwellian plasma background**