COMPARISONS OF H_2 FILLED RF CAVITIES IN VARIOUS COOLING CHANNELS

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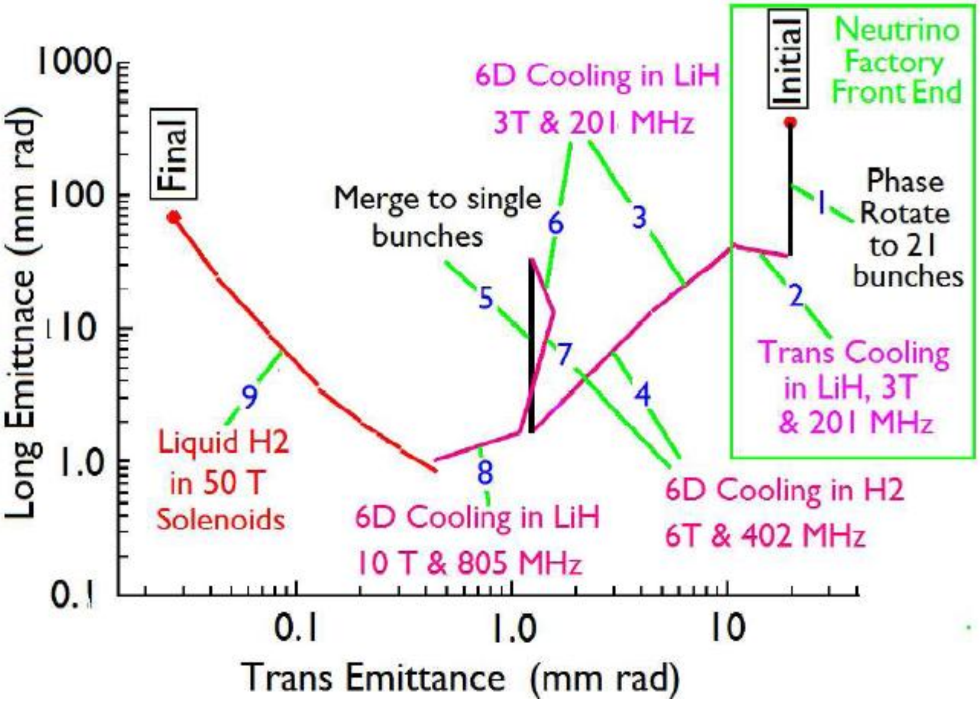
4 cases of HPRF in a linear cooling channel



- We will consider Regions:
- #2-#3 3T 201 MHz 10^{11}
- #4 6T 402 MHz 10^{11}
- #6 3T 201 MHz 2 10^{12}
- HCC 325 MHz 20 bunches 10^{11} / bunch
- For cooling channel details see:
- Gallardo-Zisman
- K. Yonahara

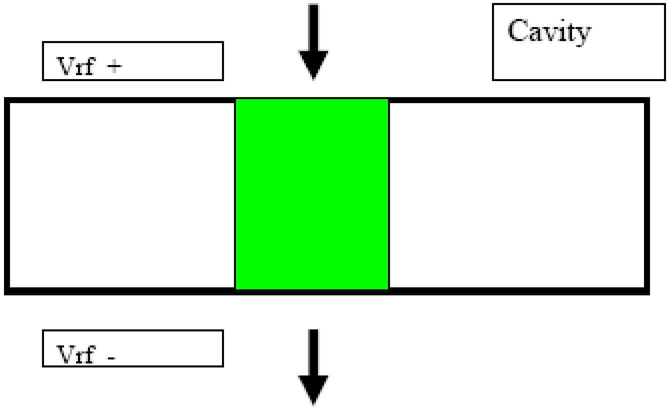
CAVITY ENVIRONMENT

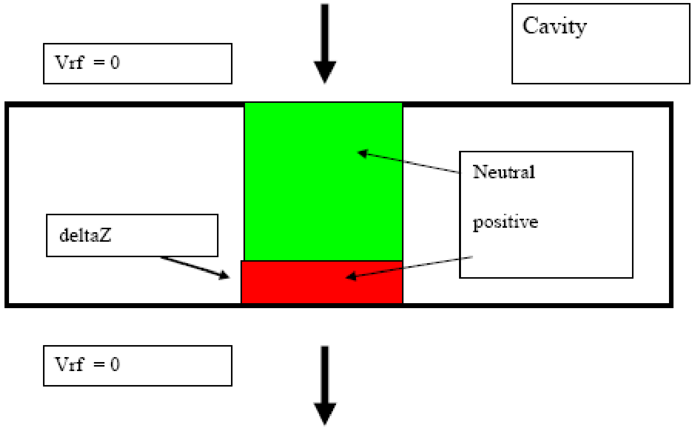
CASE	Mu/bun	Frf MHz	Gas ρ Grms/cc	Erf MV/m	Cavity h cm	#H2 / cc	# Ions/cc
2-3	10^{11}	200	.003	15	50	$9.1\ 10^{20}$	$1.74\ 10^{11}$
4	10^{11}	400	.003	15	50	$9.1\ 10^{20}$	$2.09\ 10^{12}$
6	$2\ \ 10^{12}$	200	.003	15	50	$9.1\ 10^{20}$	$2.61\ 10^{13}$
HCC	10^{11}	325	.0134	27	5	$4.03\ 10^{21}$	$1.85\ 10^{12}$

Gas physics 1a.

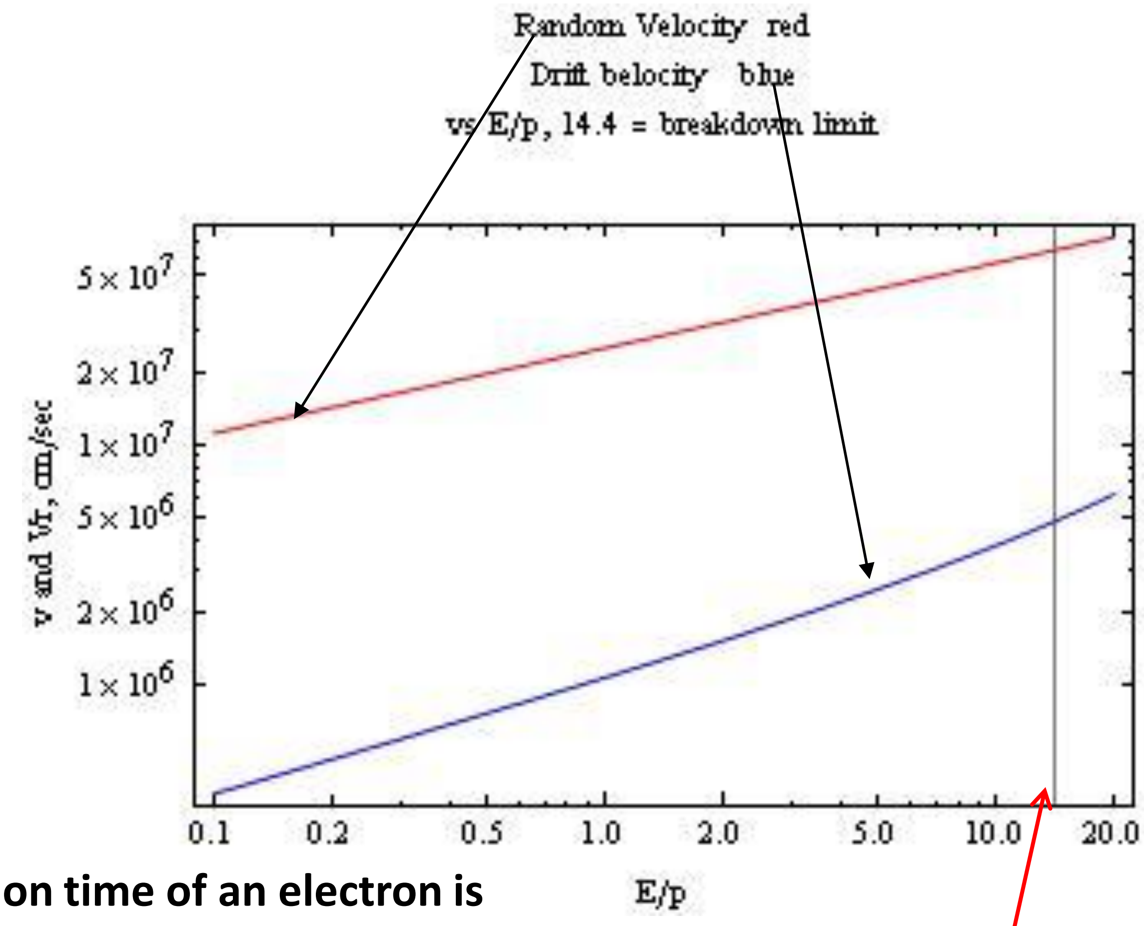
- 1. After the beam goes thru there are two immediate effects.
  - A. The beam charge + electrons from the plasma that get sucked up to the ends of the cavity reduce the cavity voltage by an amount of (delta q) / (total cavity charge). This is normal beam loading, but enhanced by the additional charge sucked out of the gas.
  - B. The electrons in the gas slosh back and forth under the influence of the cavity E field. They make inelastic collisions and loose energy. This loads the cavity and reduces its Q.

  Power $= j\ E = \rho\ v[E]\ E \qquad v[E] = \mu[E/P]\ E$





A.E.D. Heylen "Calculated electron mobility in hydrogen" Proc. Roy Soc. 76, 779 (1960)



The relaxation time of an electron is about 2000 collisions. The collision rate is greater than 10^{13} So $\tau < 0.1$ ns and thus v[E(t)] follows the above blue curve.

At E/p =14.1 the rms swarm energy is 2.33 eV

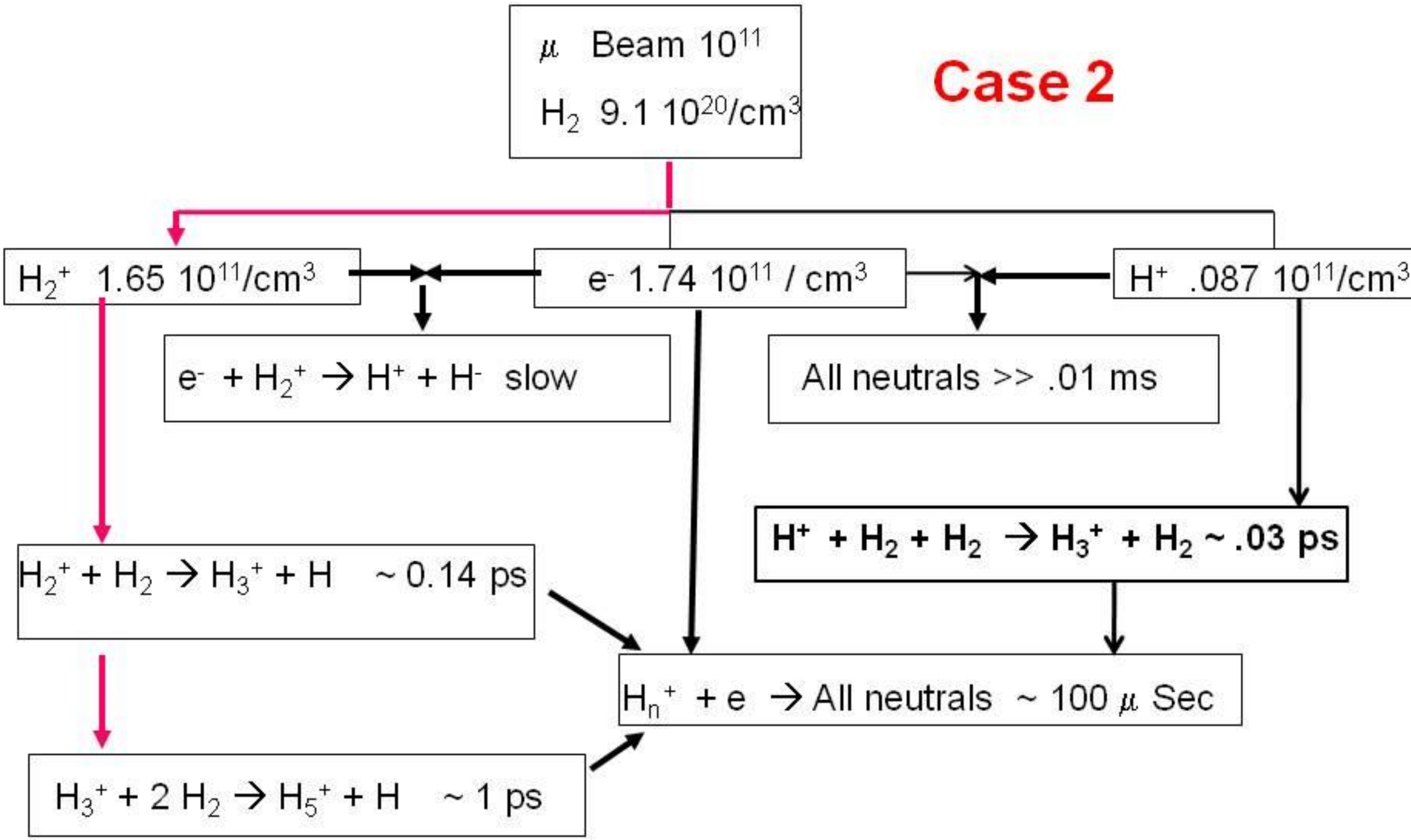
Assume electrons remain free after n cycles Vrf = Vo Exp[-α n (n+1)] where α= 0.5 Energy Stored/Energy lost /cycle

Case	α	Vrf[n=20] / Vrf[0]
2-3	0.00112	0.789
4	0.00223	0.625
6	Q=281 single bunch	
HCC	0.00274	0.562

SOLUTION:

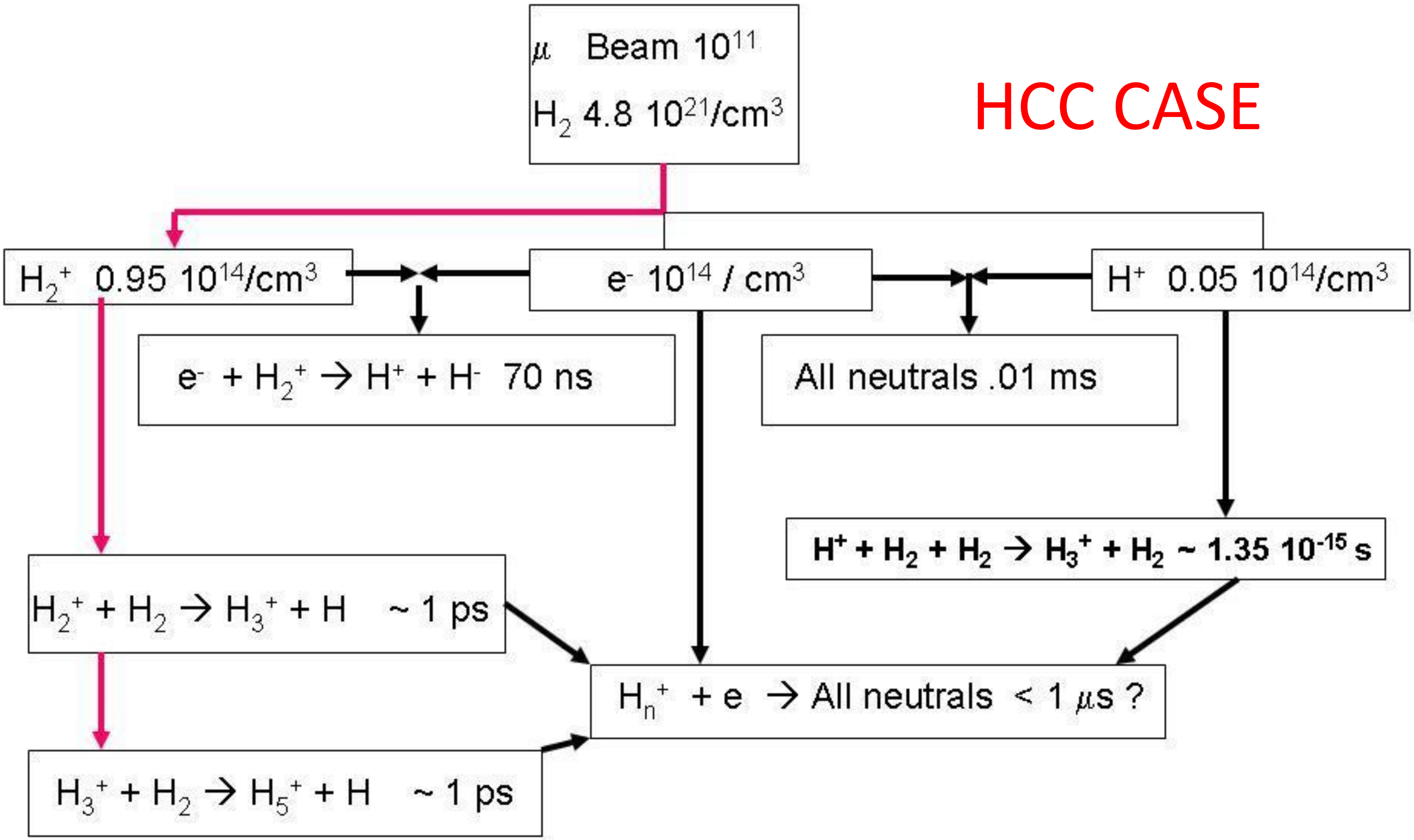
1. Neutralize plasma in times =.=0.1 ns <<period
2. Attach electrons to electro negative molecule making a heavy negative ion that can't wiggle in RF field. SF_6 for example.

Case 2



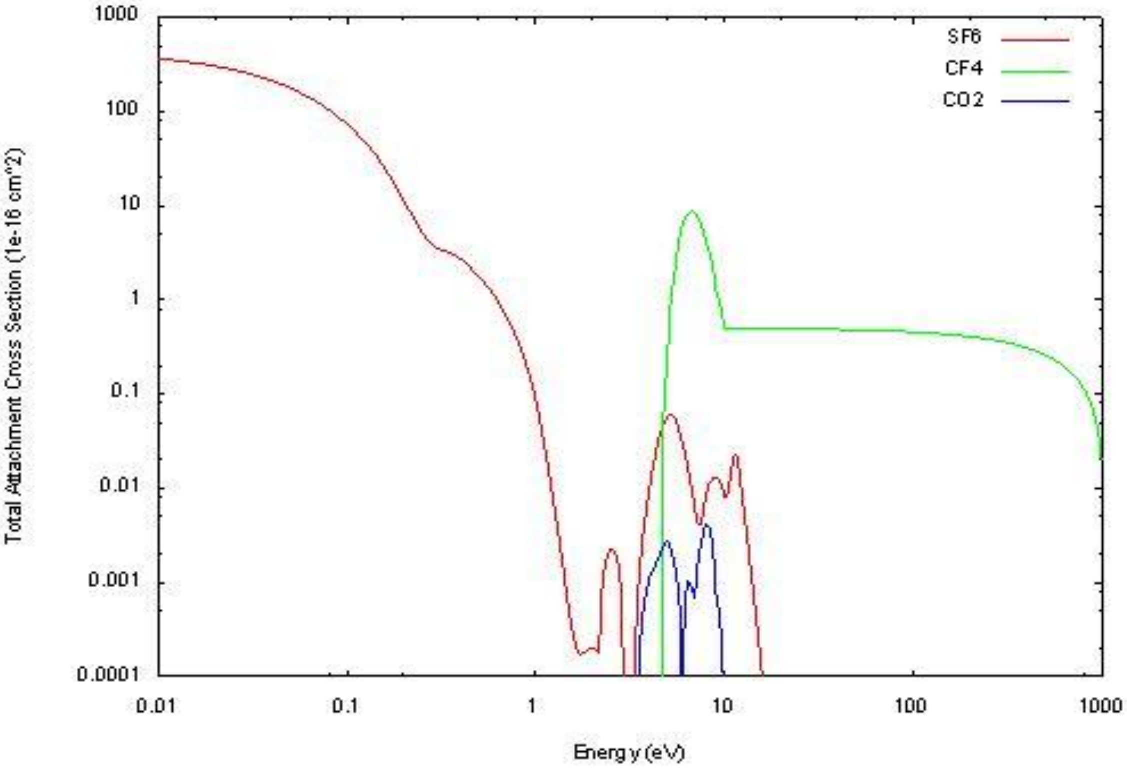
Hydrogen ion chemistry

HCC CASE



Hydrogen ion chemistry

e + SF_6 → negative ion



Rate = NSF6/cm^3 σ velocity of electrons. NSF6 = 5.8 10^{16} / cm^3 for 1% degrade Xo. We get $\tau = 1.2$ ns for 0.1 eV electron. The electrons will get completely absorbed as the RF cycle passes thru zero.