Sticking and Recombination of spin-polarised Hydrogen Atoms

Complements to this story can be found on the "hydrogen" page of www.aecono.com

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"Sticking"

$$\tau = 10^{-13} \exp \varepsilon/kT_s \text{ (sec)}$$

ε/k	T_s 3	4	5	10
40	6.17E-08	2.20E-09	2.98E-10	5.46E-12
60	4.85E-05	3.27E-07	1.63E-08	4.03E-11
80	3.81E-02	4.85E-05	8.89E-07	2.98E-10
100	3.00E+01	7.20E-03	4.85E-05	2.20E-09
120	2.35E+04	1.07E+00	2.65E-03	1.63E-08
140	1.85E+07	1.59E+02	1.45E-01	1.20E-07
160	1.45E+10	2.35E+04	7.90E+00	8.89E-07
180	1.14E+13	3.49E+06	4.31E+02	6.57E-06
200	8.97E+15	5.18E+08	2.35E+04	4.85E-05
240	5.54E+21	1.14E+13	7.02E+07	2.65E-03
300	2.69E+30	3.73E+19	1.14E+13	1.07E+00
400	8.05E+44	2.69E+30	5.54E+21	2.35E+04
500	2.41E+59	1.94E+41	2.69E+30	5.18E+08
600	7.23E+73	1.39E+52	1.30E+39	1.14E+13

Binding Energies

Reference expts			Bolometer
5	**36**	**H/H_2**	
6	**42**	**H/D_2**	
5 + 6	**44**	**H/D_2**	**50±15**
7	**400±50**	**H/H_2O**	**320±70**
8	**250 to 800**	**$H/(H_2O)_{115}$**	
	most prob. 550		

(5) Crampton et al. Phys. Rev.B 1982 (exp.)
(6) Pierre et al. JCP 1985
(7) Al-Halabi et al. J.Phys.Chem.B 2002
(8) Buch & Zhang, Astrophys. J. 1991

See link on www.aecono.com

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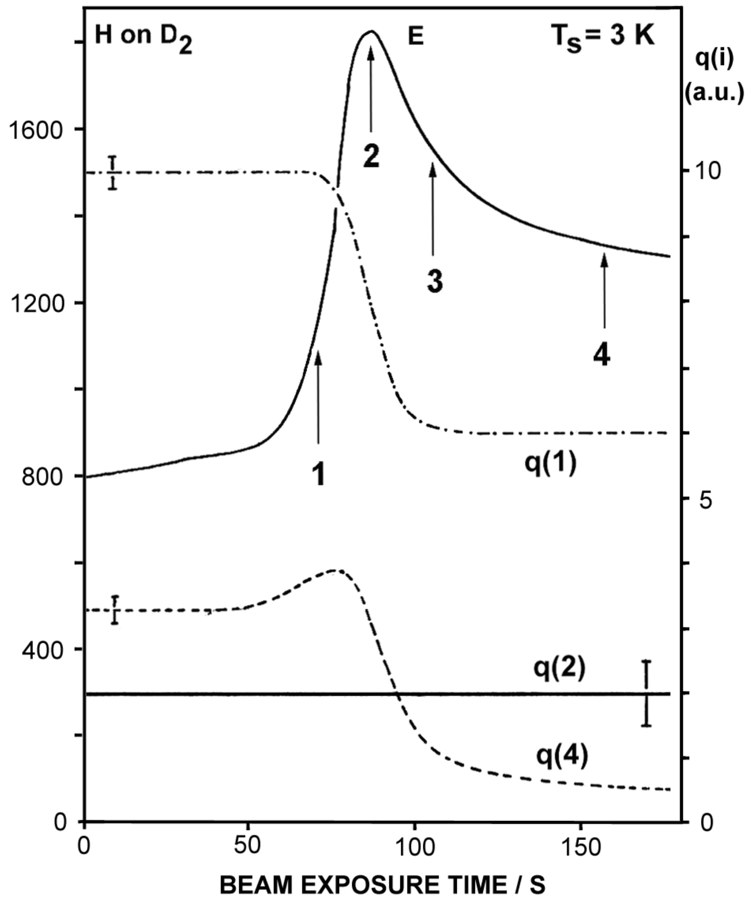
Coverage by molecular hydrogen increases S but decreases β



D_2 coverage, from initial 3×10^{15} cm^{-2} :

(1) 9×10^{14} cm^{-2}

(2) 1.9×10^{14} cm^{-2}

(3) 1.6×10^{14} cm^{-2}

(4) 4.5×10^{13} cm^{-2}

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Recombination efficiency Sβ is a compromise

On ice saturated with molecular hydrogen, S ≈ 1 (soft landing) but β ≈ 0 (no time to find partner)

On "bare" non-porous ice, S ≈ 0 (ping pong) but β ≈ 1 (every atom that sticks will remain long enough to find a partner)

Optimum S ≈ 0.8 β ≈ 0.3 occurs at *molecular* coverage of about 2 x 10^{14} cm^{-2}, where ε varies strongly

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On non-porous ice, recombination looks something like this

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What about electronic Spin ?

Is it reasonable to expect every hydrogen atom to recombine once it sticks on the surface ?

Or should we consider that β cannot exceed ¼ on non-porous ice, since the physisorbed H appears to be skating freely on the surface, much as if it were a two-dimensional gas ? I.e. should we expect only ¼ of the atoms to interact in the binding singlet potential ?

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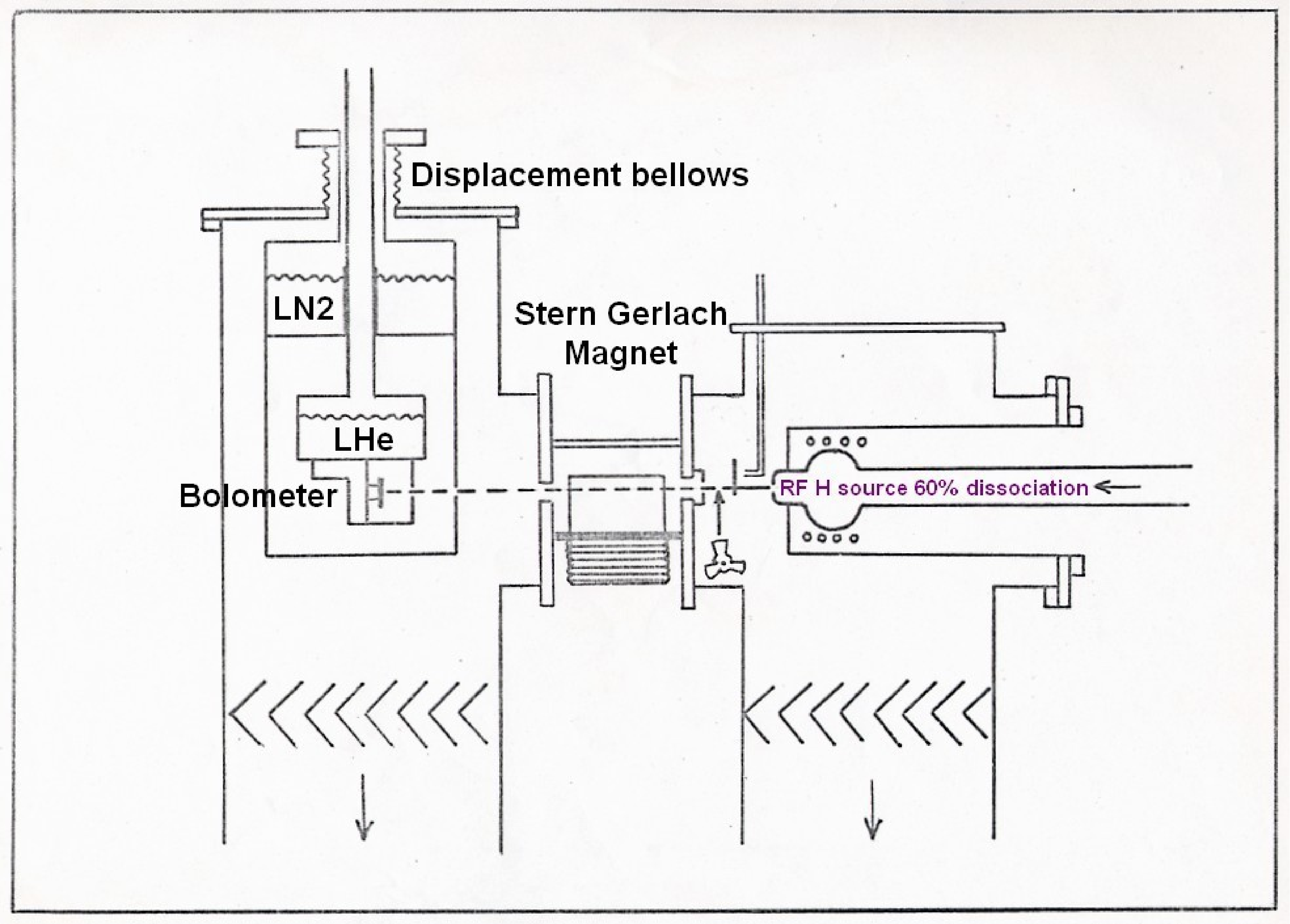
Stern-Gerlach Experiment



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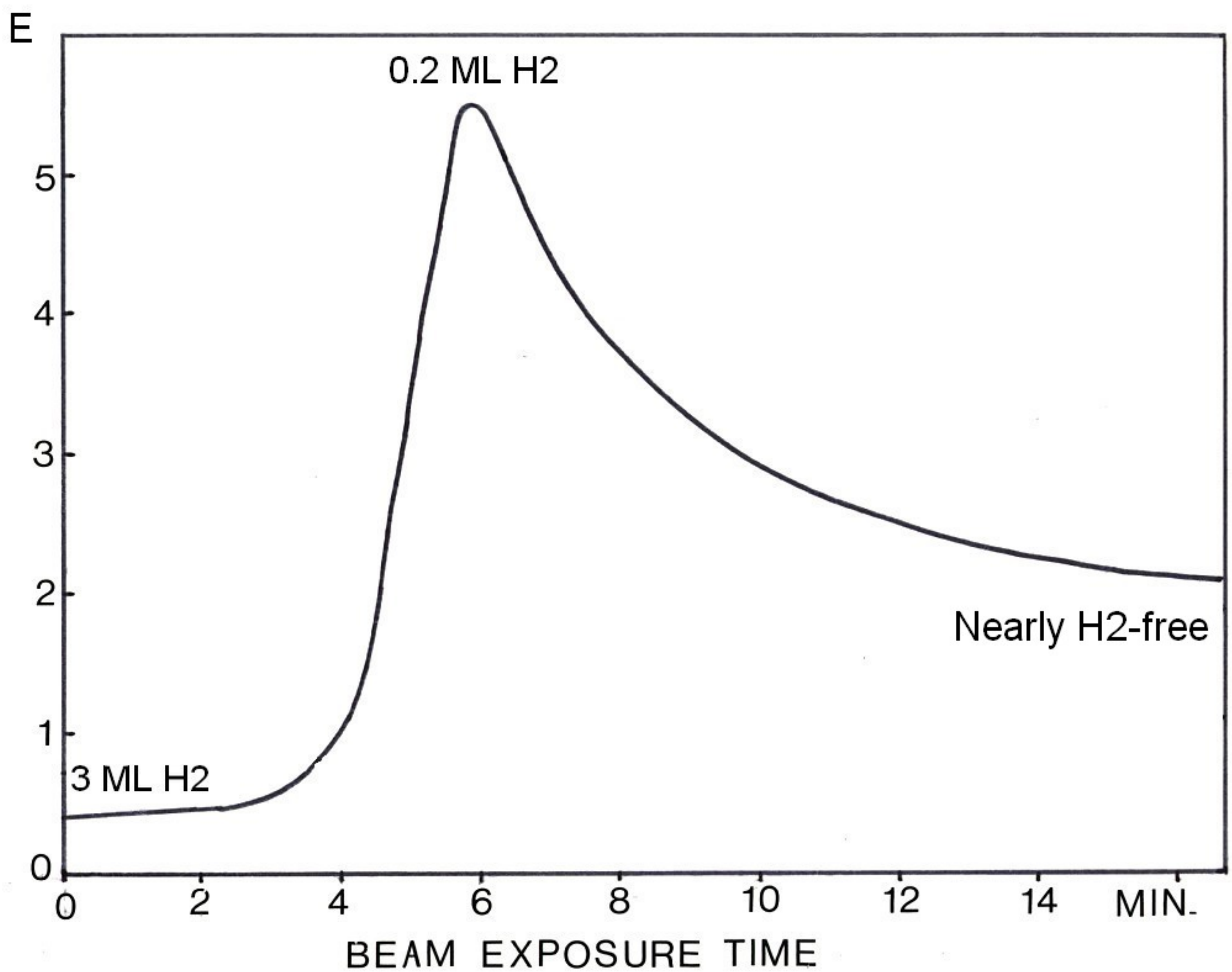
Energy released by H recombination depends critically on H_2 coverage



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Do we get same dependence with a polarised H beam ?

I.e. the H2 coverage dependence will serve as a signature for H recombination

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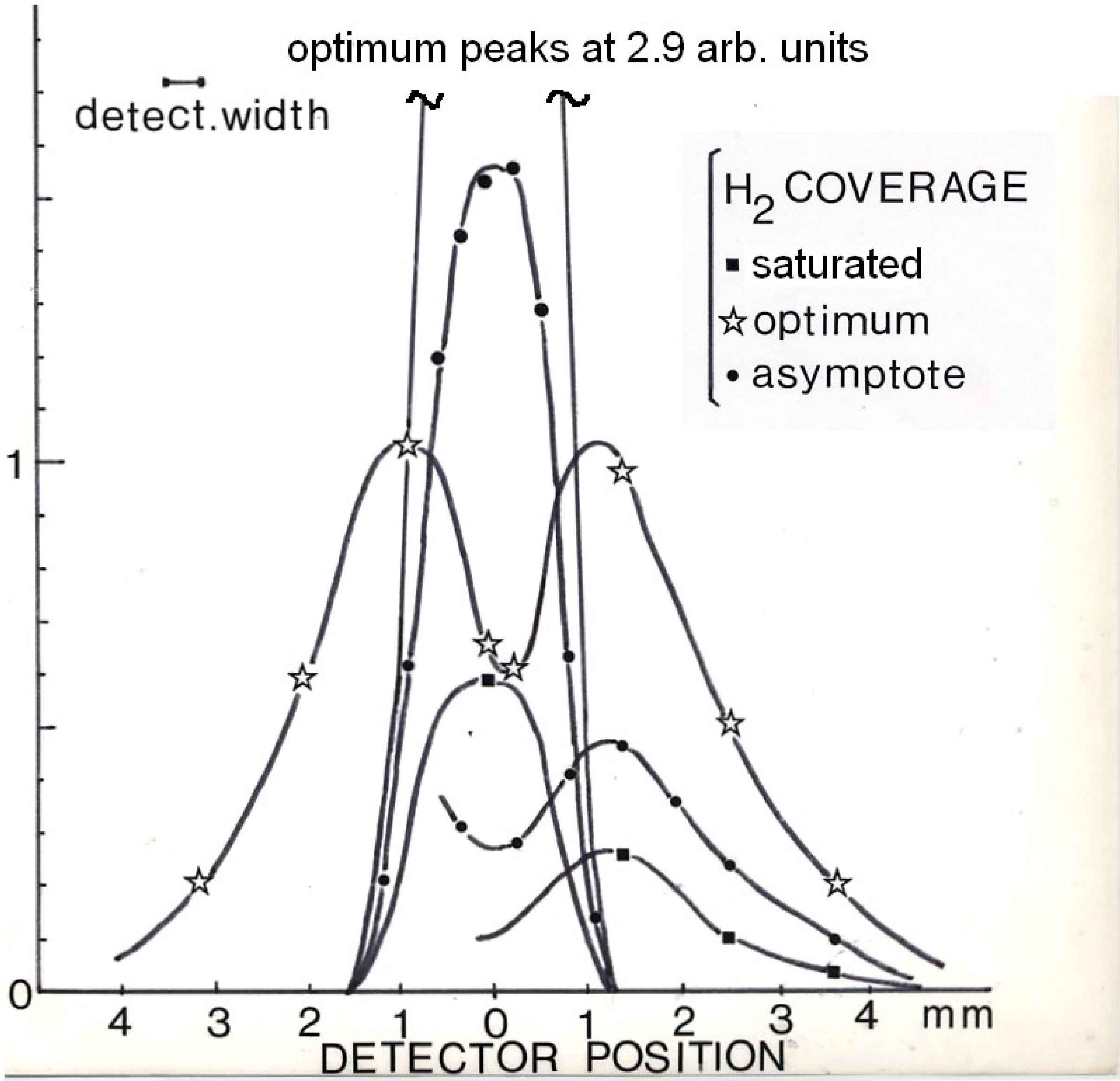
Do we get same dependence with a polarised H beam ?



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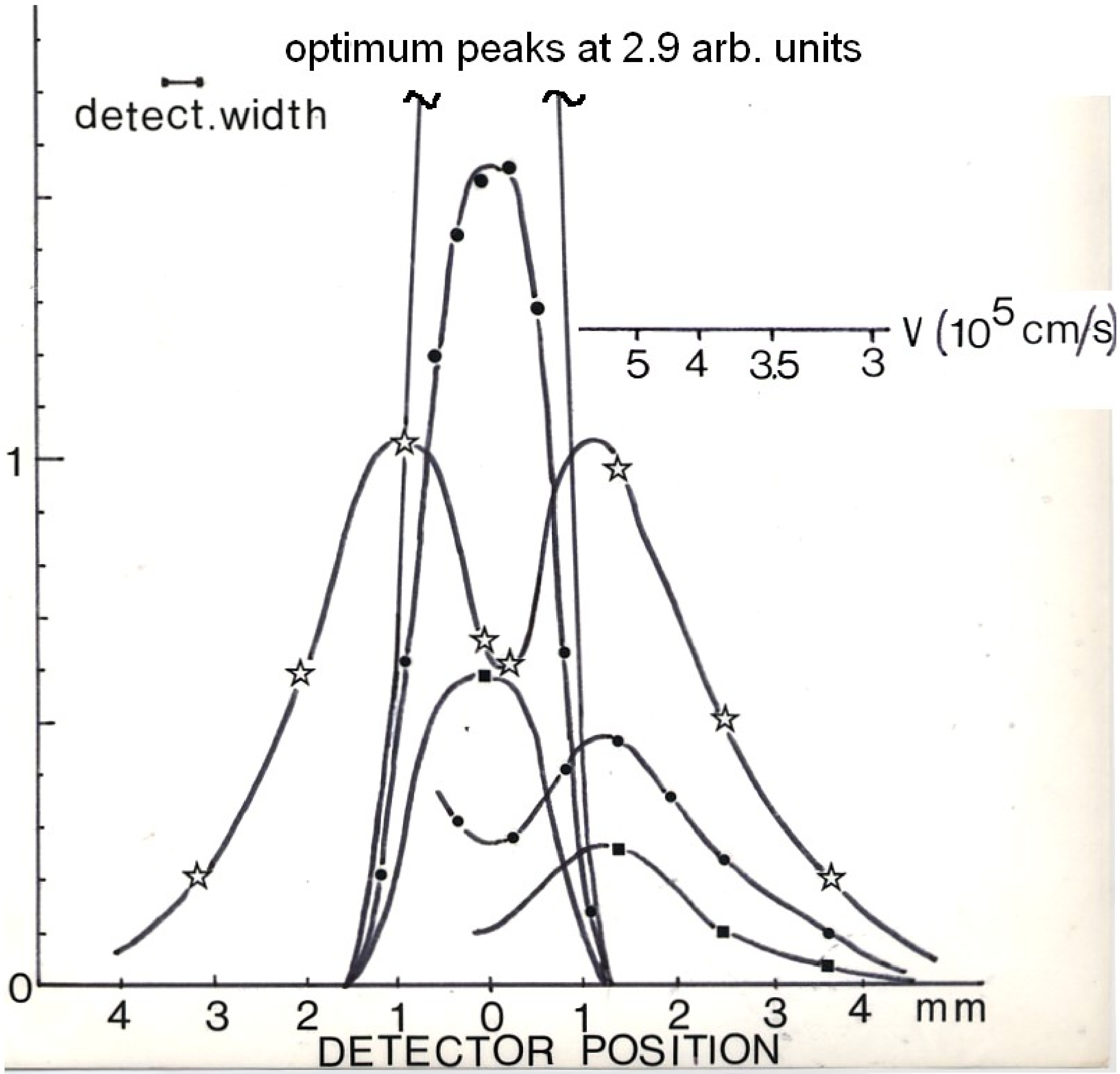
Do we get same dependence with a polarised H beam ?



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Conclusions and questions

- **This Stern Gerlach experiment does not show a signicant effect of electron spin polarisation**
- **But could it conceptually have done so ?**
- **The experimental set-up does offer the possibility to produce 100% pure H beams with some velocity selection**

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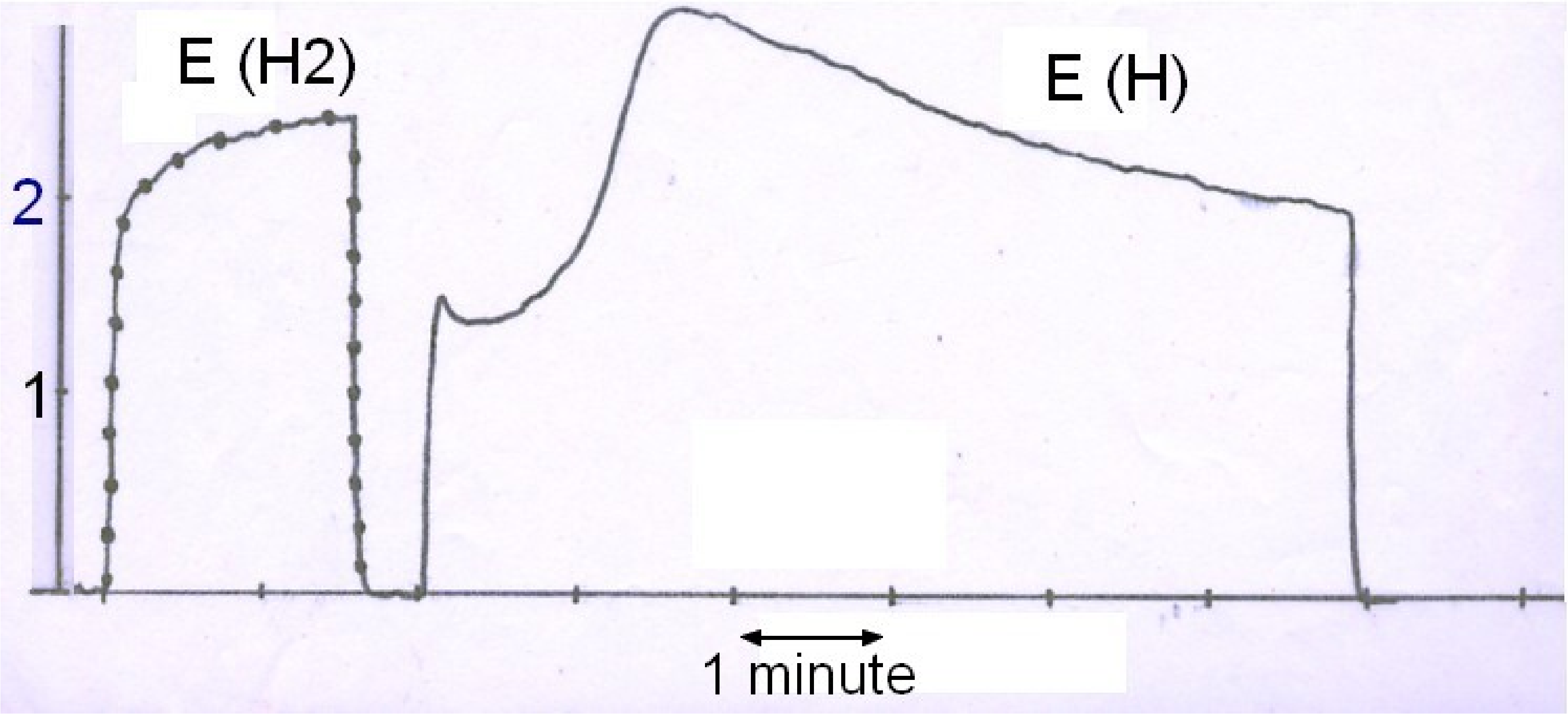
Example : probing H2 evaporation with a pure H beam



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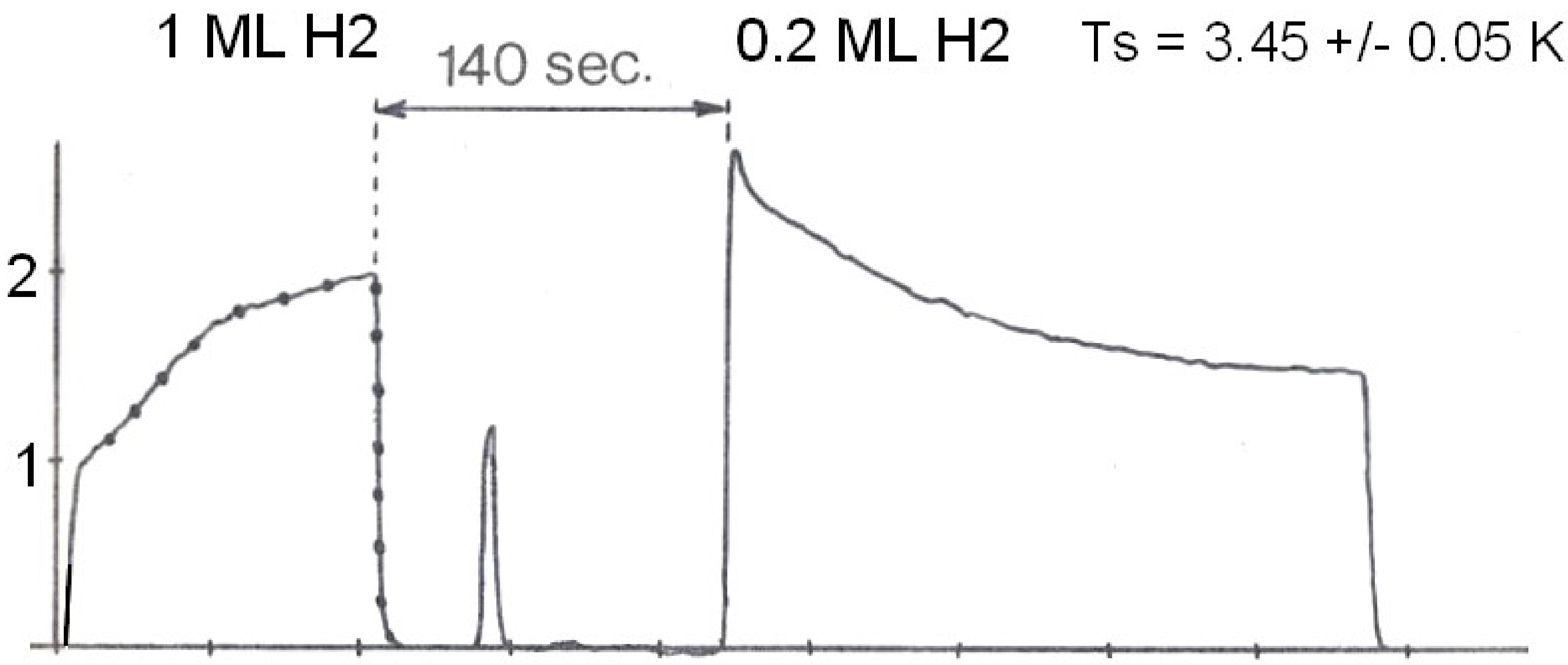
Example : probing H_2 evaporation with a pure H beam



Example : probing H2 evaporation with a pure H beam

We can now evaluate the binding energy of the evaporated H_2 layer :

$140 = 10^{-12} \times e^{\varepsilon/kT_s}$ yields $\varepsilon/k = 112 \pm 2$ K

$140 = 10^{-13} \times e^{\varepsilon/kT_s}$ yields $\varepsilon/k = 120 \pm 2$ K

NB Sublimation energy of solid H_2 is 90 K

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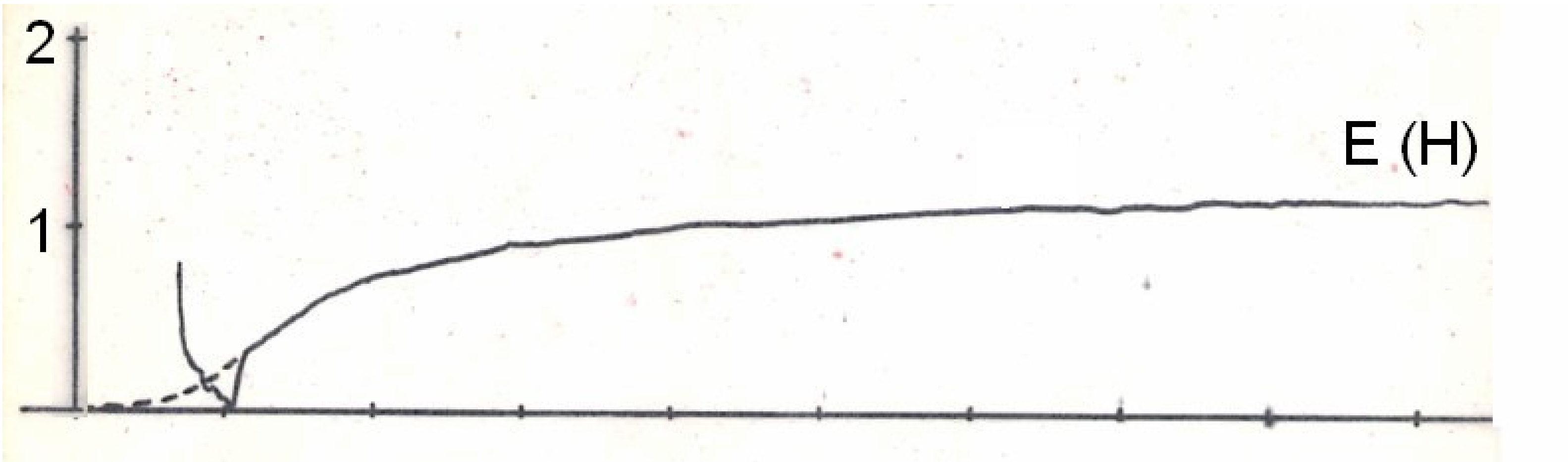
Other conclusion :



beam exposure time/minutes

When there is no molecular hydrogen on the surface, the polarised H beam does not show any recombination signal at all. So…..????

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