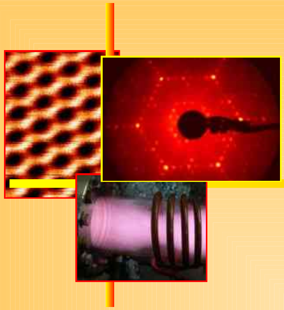


Graphite-enhanced NI surface production in H_2/D_2 plasmas

LCAM, Orsay

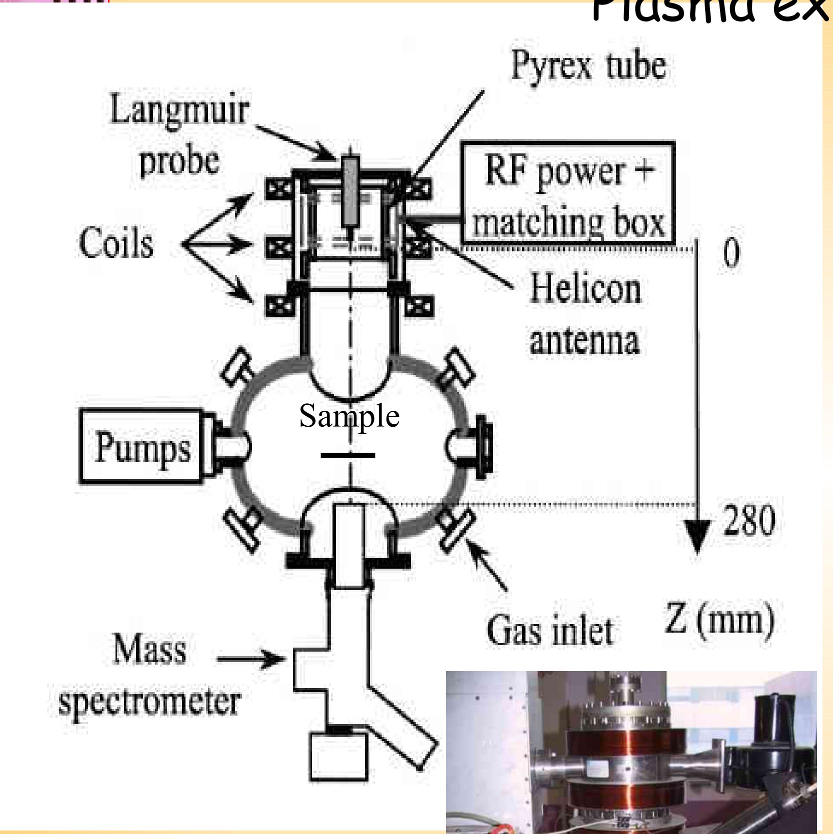
H. Khemliche, N. Bundaleski, V. Esaulov, P. Roncin

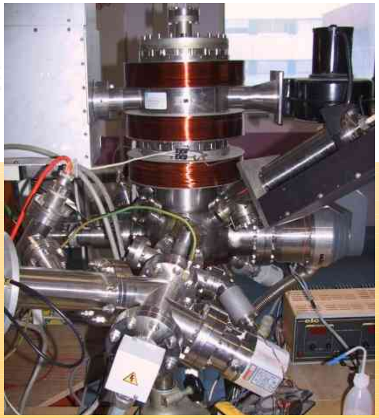
PIIM, Marseille

G. Cartry, L. Schiesko, M. Carrère, J.-M. Layet

PIIM experimental set-up

Plasma experiment

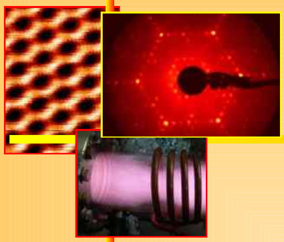




- Helicon reactor:
  - Discharges : H_2 and D_2
  - P = 30-1000 W
  - No magnetic field
  - Pr = 0.2 – 1 Pa
- Graphite sample:
  - Diffusion chamber
  - Faces QMS nozzle
  - Biased down to -80V

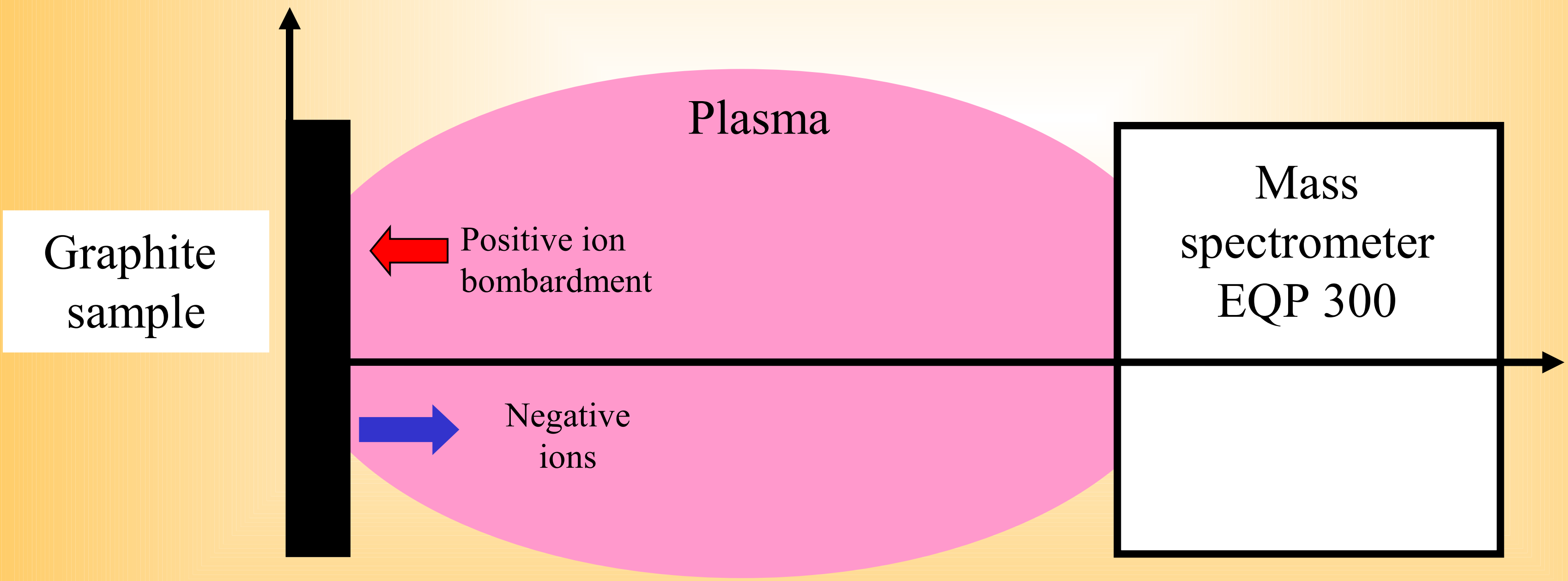
Measurement of surface-produced NI distribution functions

Plasma experiments
Graphite surface

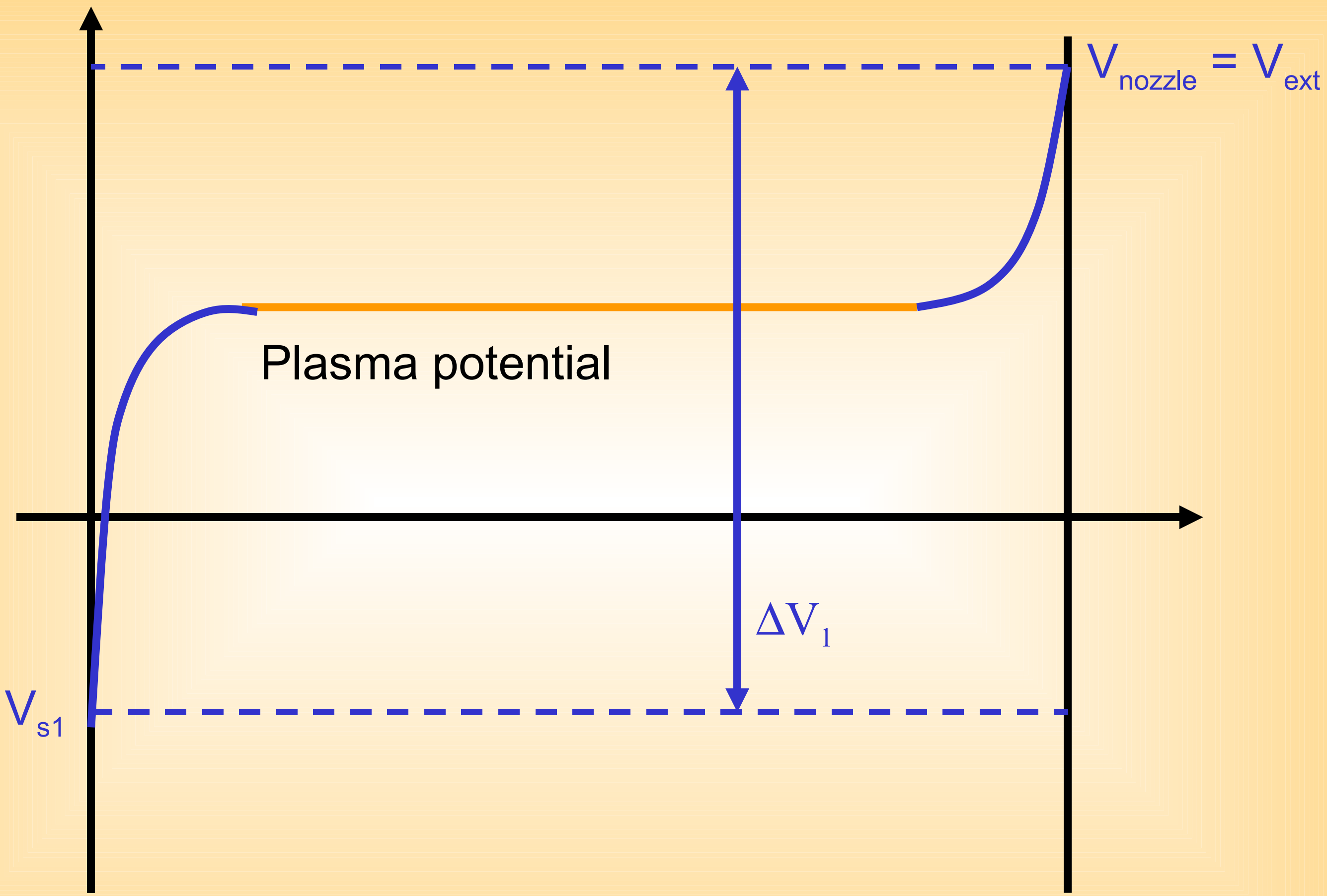


Plasma measurements

- Measurement of surface-produced NI distribution functions
- No absolute yield measurement, only relative measurements



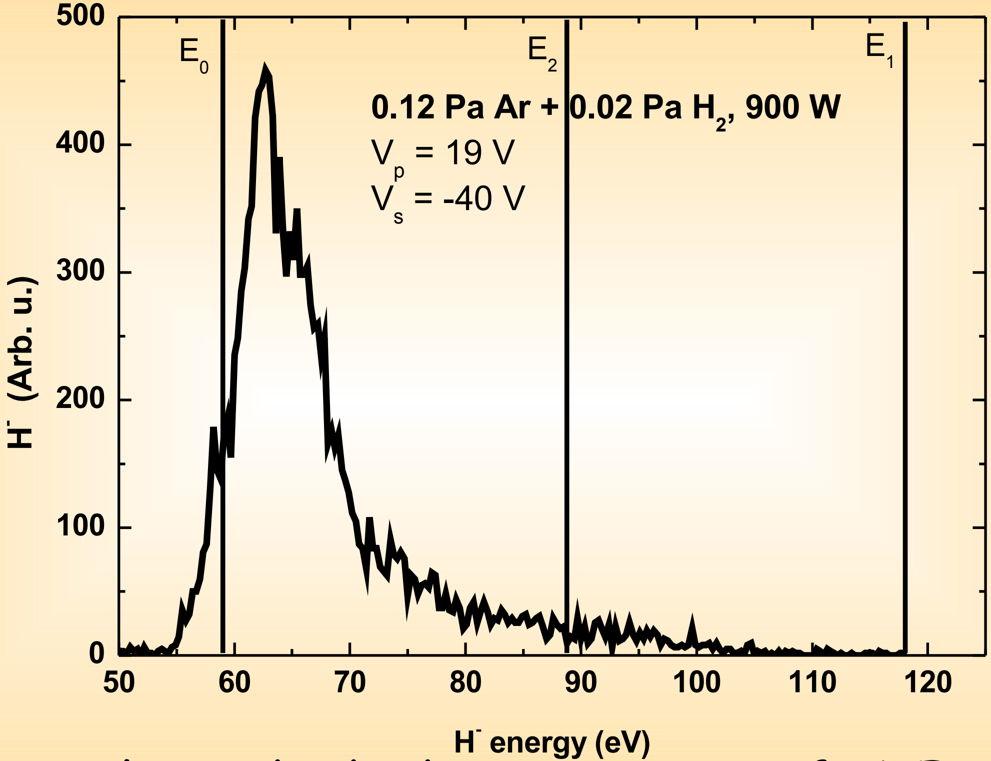
QMS energy transmission



Voltage Labelling technique

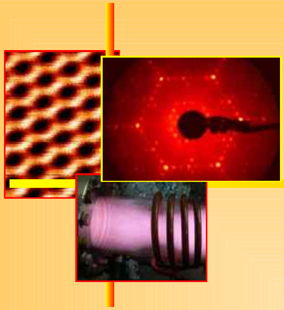
Double capture when H^+ is non negligible

0.12 Pa Ar et 0.02 Pa H_2, 900W: $H^+ \sim H_2^+$



- Double capture explains the high energy part of IDF
- Strong energy loss on surface during positive ions scattering

Evidence for mechanism where H+ positive ions are involved in the production of H- ions.



Simple voltage thresholds

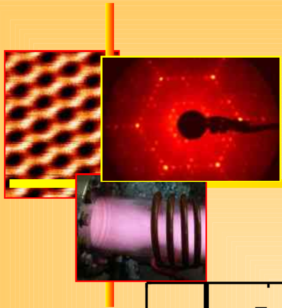
- H^- created at rest on HOPG surface will reach plasma with an energy at maximum equal to

$$E_0 = e(V_p - V_s)$$

- H^- created on HOPG surface via double capture from $\mathbf{H^+}$ will reach plasma with energy < $E_1 = e(V_p - V_s) + e(V_p - V_s) = \mathbf{2e(V_p - V_s)}$

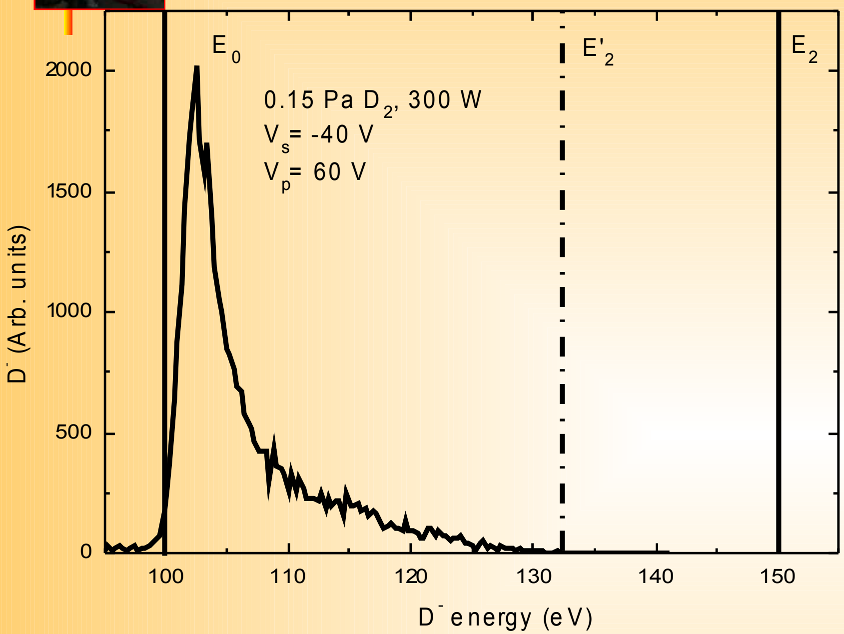
- H^- created on HOPG surface via double capture from $\mathbf{H_2^+}$ will reach plasma with energy < $E_2 = e(V_p - V_s) + 1/2\ (V_p - V_s) = \mathbf{3/2\ e(V_p - V_s)}$

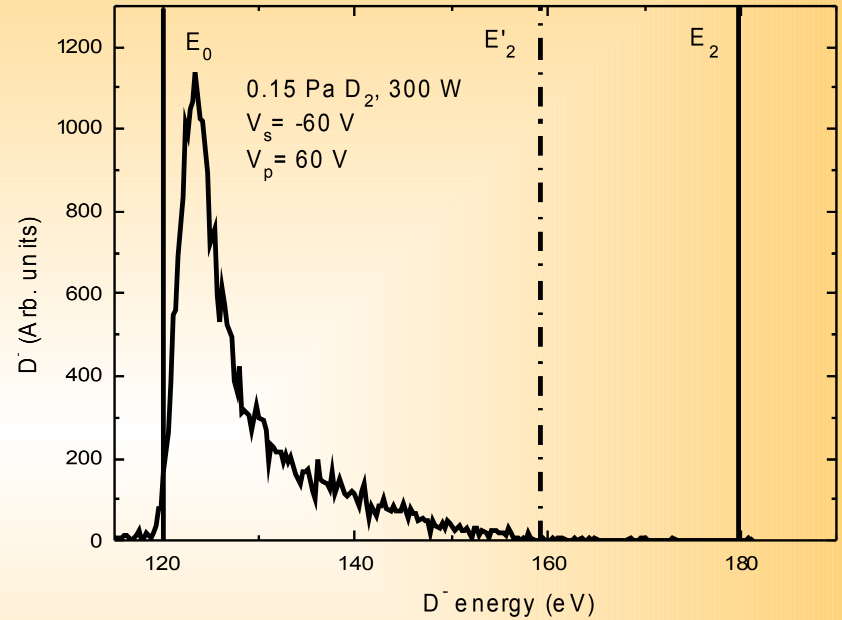
- H^- created on HOPG surface via double capture from $\mathbf{H_3^+}$ will reach plasma with energy < $E_3 = e(V_p - V_s) + 1/3\ (V_p - V_s) = \mathbf{4/3\ e(V_p - V_s)}$



Double capture when D_2^+ dominates

0.15 Pa D_2, 300W: D_2^+ dominates





- Maximum energy released on surface by $D_2^+ > H_2^+$: $\gamma = \dfrac{4m_1m_2}{(m_1+m_2)^2}$

$m_1=m_H$ or m_D and $m_2=m_C$

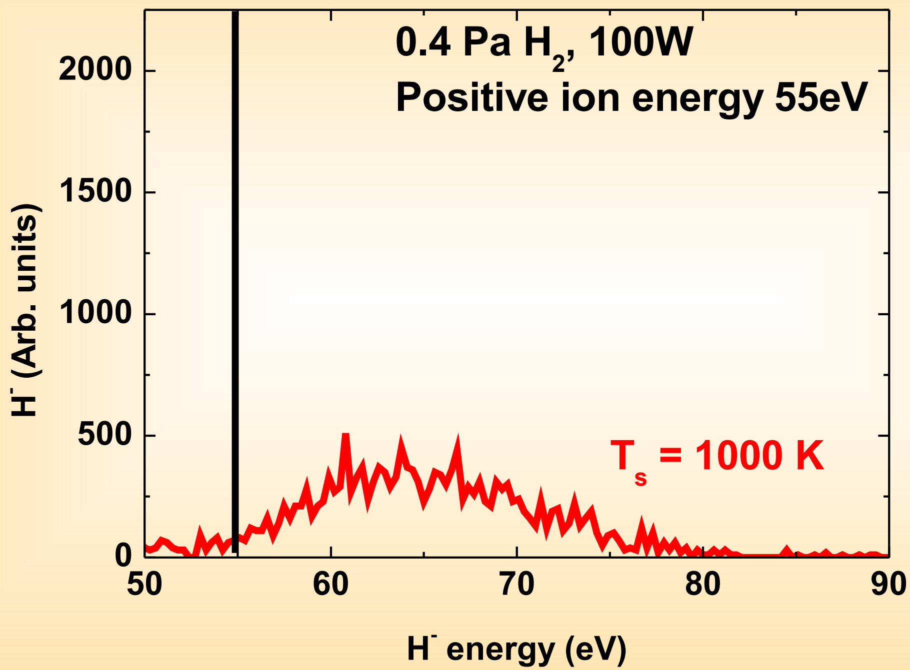
- A correction term is added in the maximum energy calculation:

$$E_2' = \frac{\gamma_{H_2^+}}{\gamma_{D_2^+}} E_2$$

Plasma experiments
Graphite surface 1000°

H- distribution function at high surface temperature (1000K)

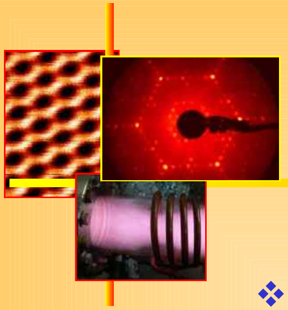
- At high temperature, no H is adsorbed on graphite
- Surface coverage is ~ zero like in beam experiments



Production mechanism has been identified as two e^- capture:

H_n^+ +Surface $\rightarrow$ H- , n =1…3

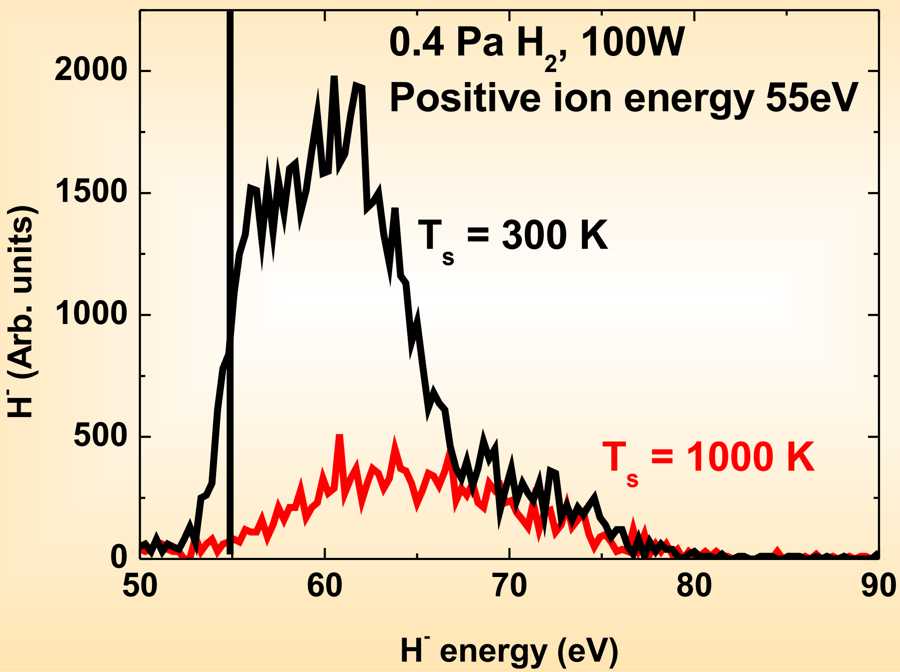
Similar to beam results, same mechanism



Plasma experiments
Graphite surface Room T

H- distribution function at low surface temperature

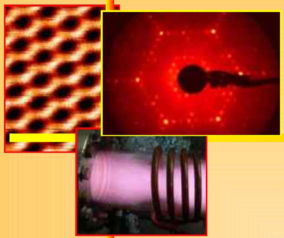
- At room temperature, H is adsorbed on graphite
- Surface coverage is "high" and different from beam experiments



Surface production is highly enhanced !!!

Minor contribution attributed to two e^- capture: H_n^+ +Surface → H- (25%)

Main contribution has been attributed to sputtering: $H_n^+ + H_{adsorbed}$ → H- (75%)



Conclusion of PIIM exp

Evidences for mechanism where H^+ positive ions are involved in the production of H^- ions.

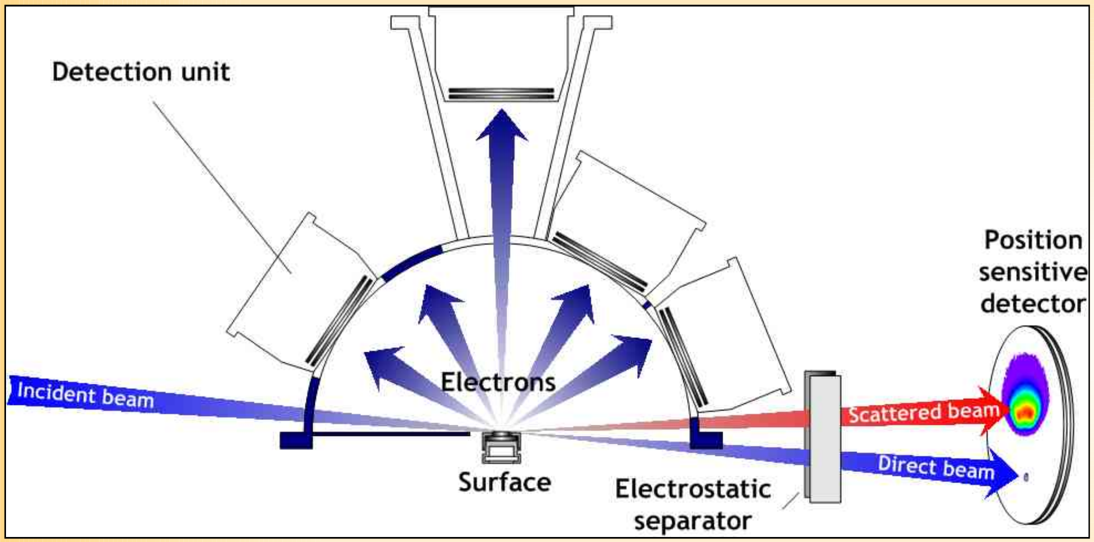
Evidence of two types of mechanisms,

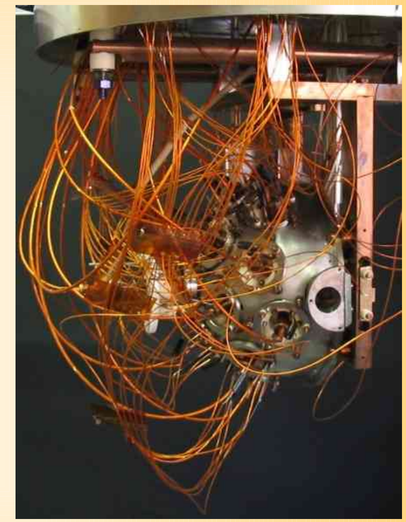
-one at work on hydrogen_free surface and

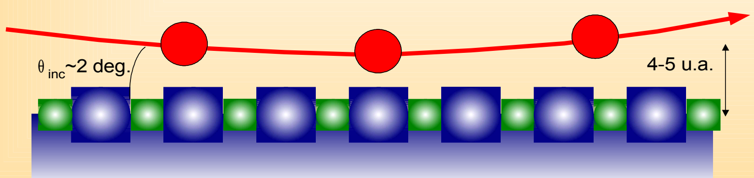
-one at work when the surface is already covered with hydrogen.

LCAM experimental set-up

UHV system:
- Well defined surface conditions
- hydrogen beams





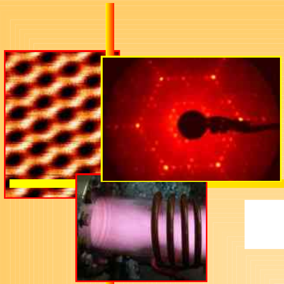


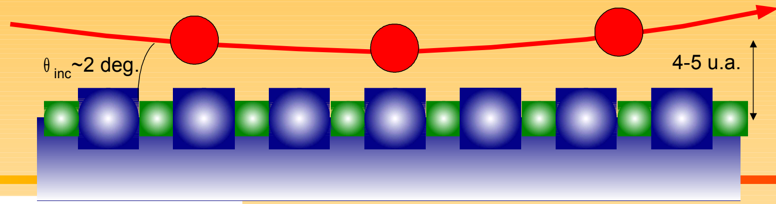
$200 < E_0 < 10000\ eV$

$20\ meV < E_\perp < 10\ eV$

Limited number of inelastic processes ⇒ access to individual basic processes

Angle resolved detection of species (NI, PI, atoms, e^-…)
Study of individual NI surface production mechanisms





Electron capture, electron loss, excitation mechanisms.

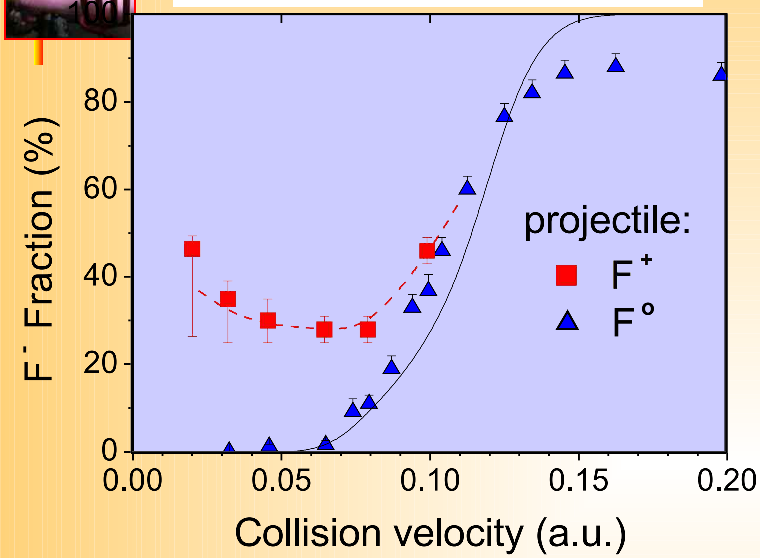
Why negative H-(0.75 eV) are formed on LiF (12 eV) ?
Why electron yield larger for LiF than for Au (5 eV) ?
(Madelung represent almost 8 eV)

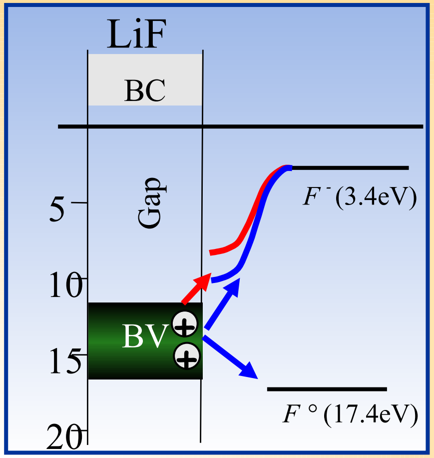
Do ions excite the target ?
Yes excitons and trions are formed as the negative ions tries to escape with its electron.

What if single capture is Quenched ?
Auger may not be allowed.
Double electron capture can be effective.

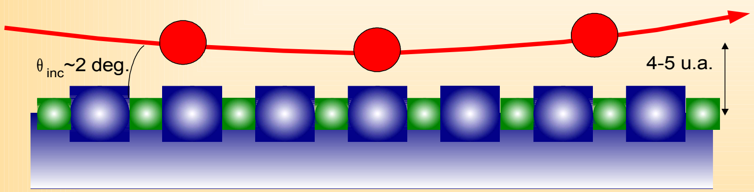
Strong collaboration with theory : A.G. Borisov, V. Sidis, J.P. Gauyacq etc…

Fundamental processes: simultaneous double capture





At low energy, it is easier to capture two electrons rather than one !!!

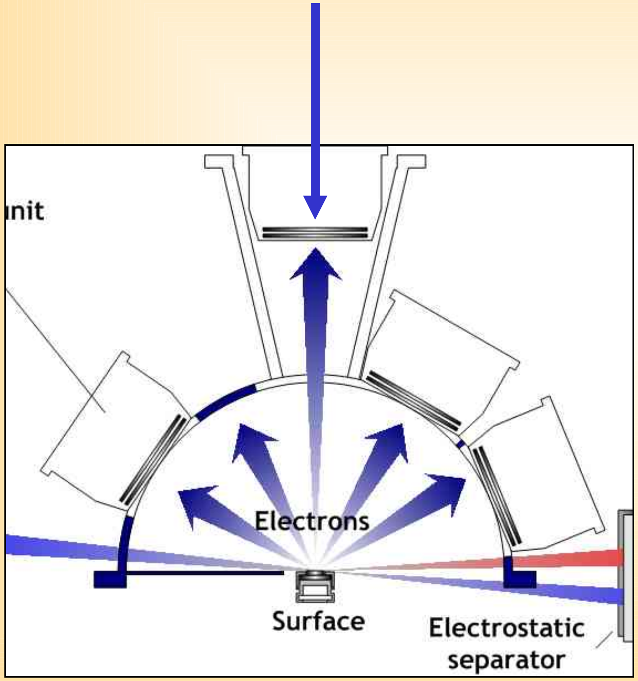


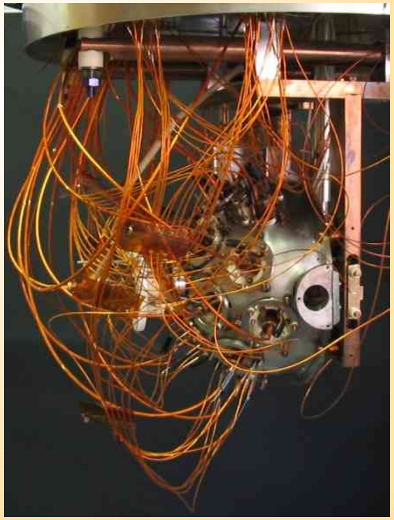
<u>Systemes where double capture has been obeserved:</u>

- F^+ on LiF(001) $\Rightarrow$ F^- fraction ~ 40 %
- O^+ on NaCl(001) $\Rightarrow$ O^- fraction ~ 7 %
- H^+ on NaCl(001) $\Rightarrow$ H^- fraction ~ 1 %

The challenge is to change geometry and energy

The ion or neutral beam will be injected from top.
And the probability to identify the projectile, its energy loss





$50 < E_0 < 1000$ eV