# Stability of Hydrogenated Graphene in Ultra High Vacuum and in Air

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Ptolemy IT Meeting 19.02.25 - Roma



ROMA TRE UNIVERSITÀ DEGLI STUDI

LAboratorio di Spettroscopie Elettroniche e di Correlazione

LASEC

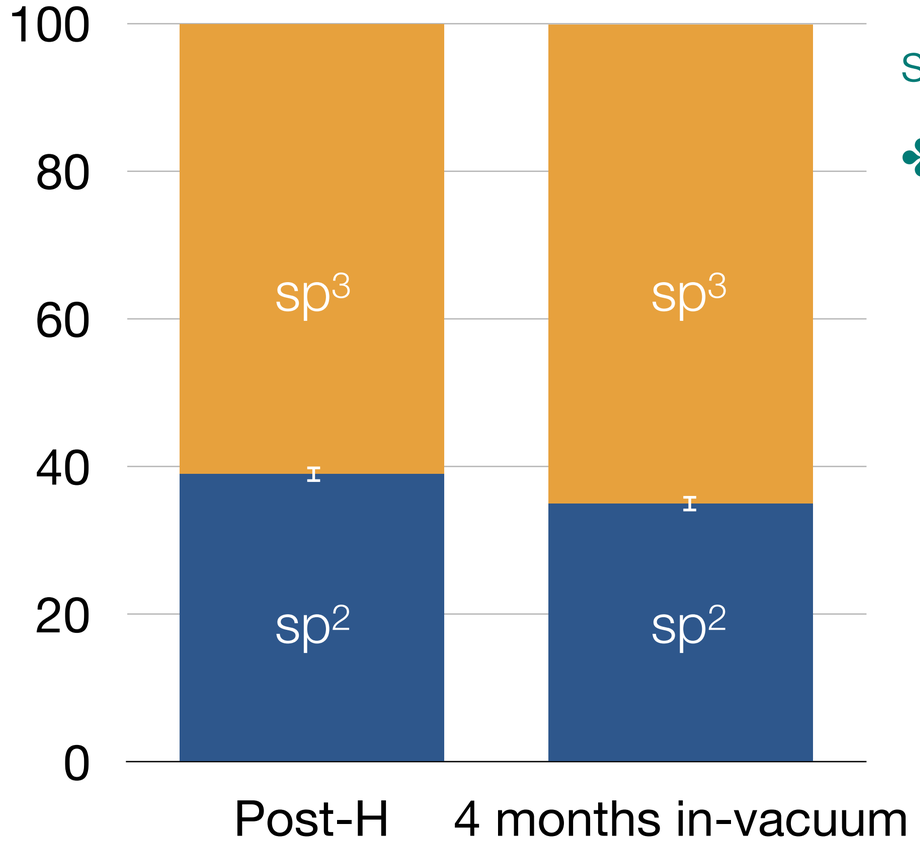
ANDROMEDA

Aligned Nanotube Detector for Research On MeV Darkmatter

INFN

Istituto Nazionale di Fisica Nucleare

# Hydrogenation Very Stable in UHV

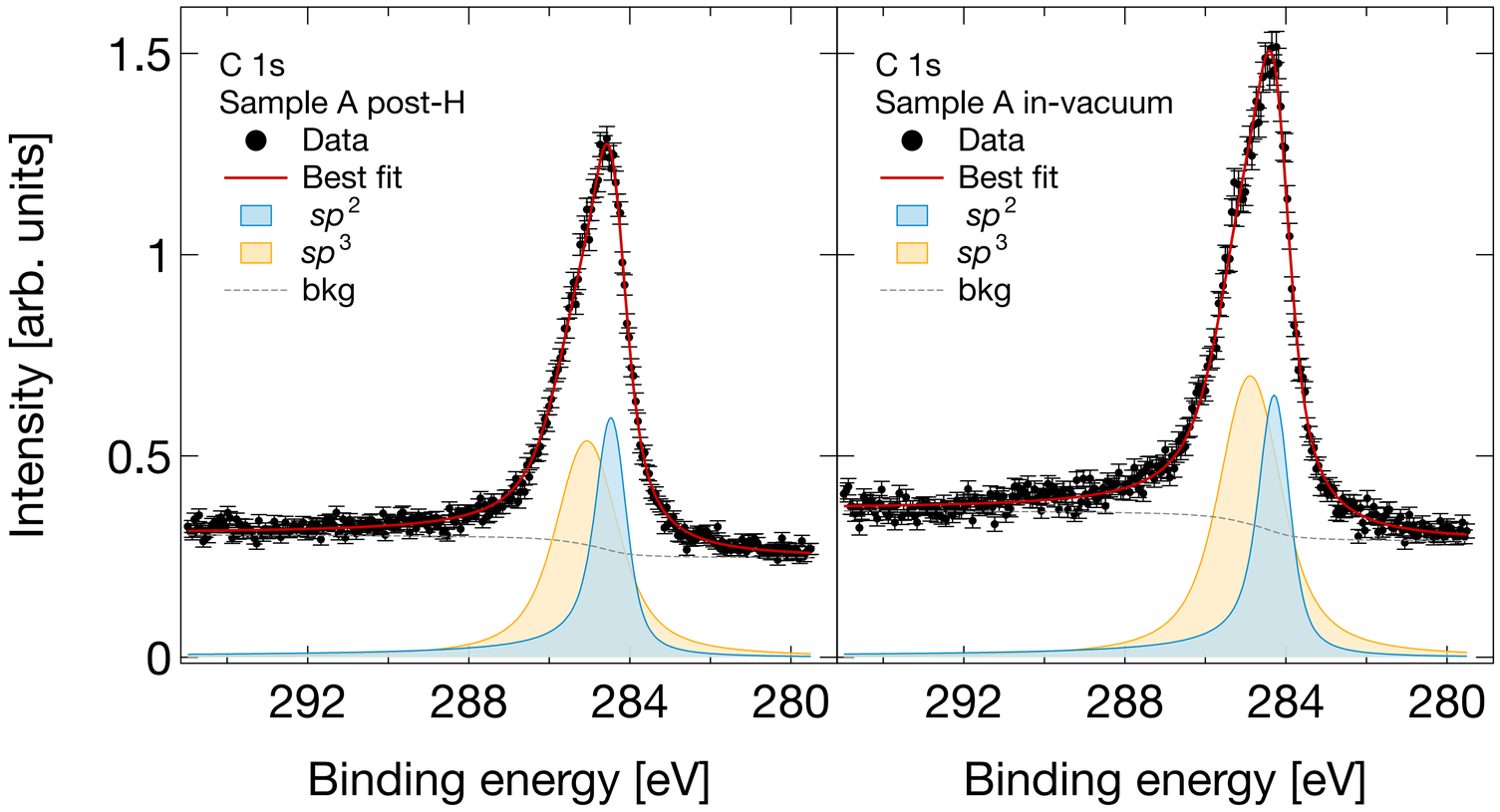



$sp^3$ relative variation:

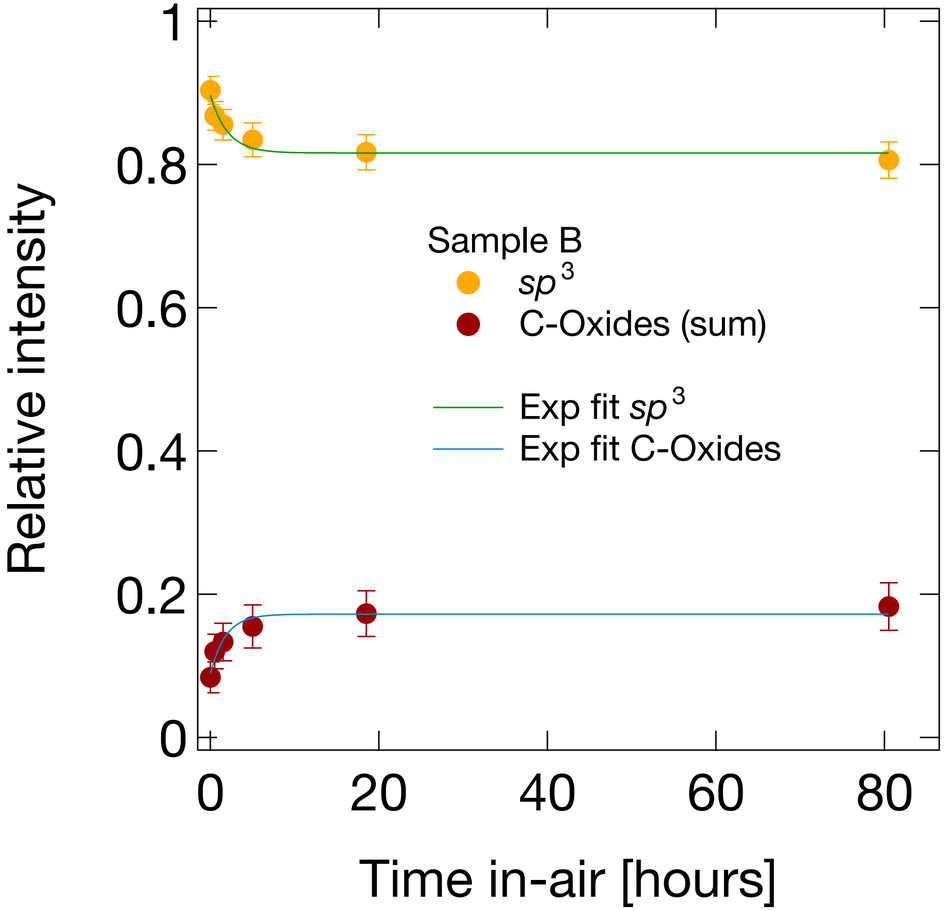
- 4 ± 2 %

~$10^{-10}$ mbar!

4 months

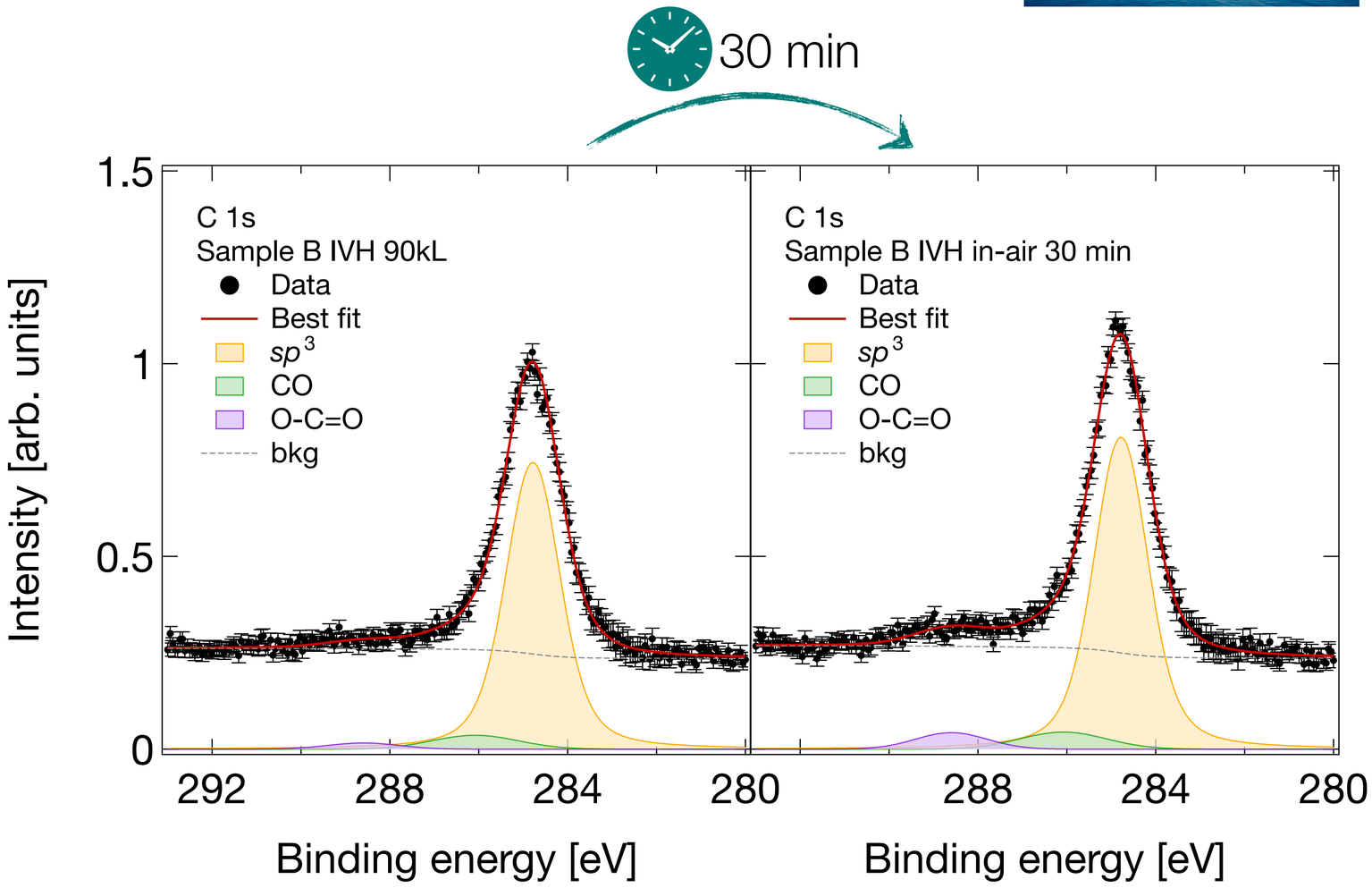


# Time-Scale of Oxidation is ~30 min

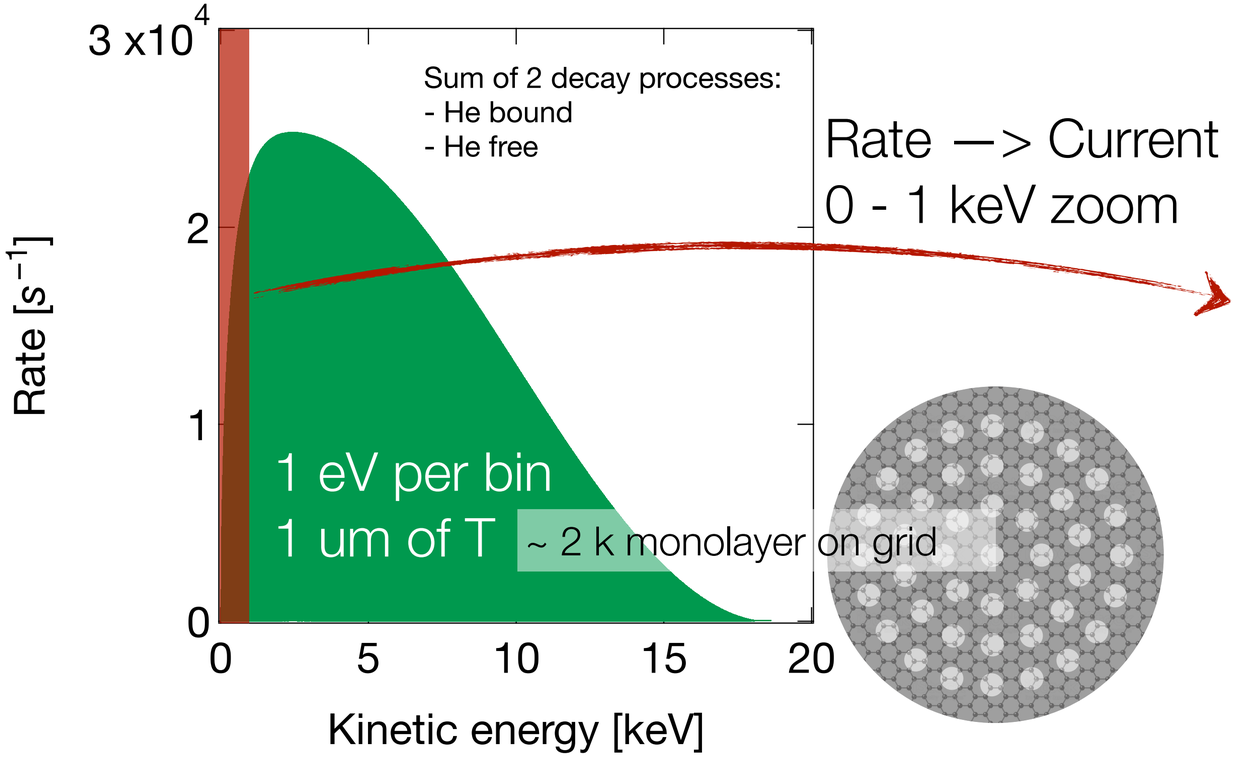


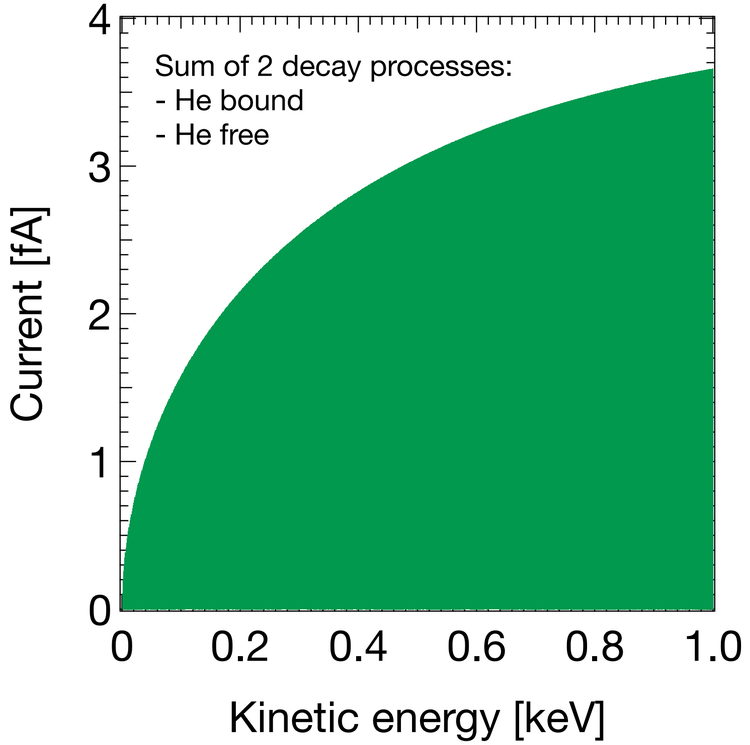

Exponential fit C-Oxides:

- $\tau$ = 1.8 ± 0.2 hours



# Radiolysis May Not Be a Problem




★ Thanks to A. Casale, A. Esposito, L. Cavoto

Radiolysis issue:

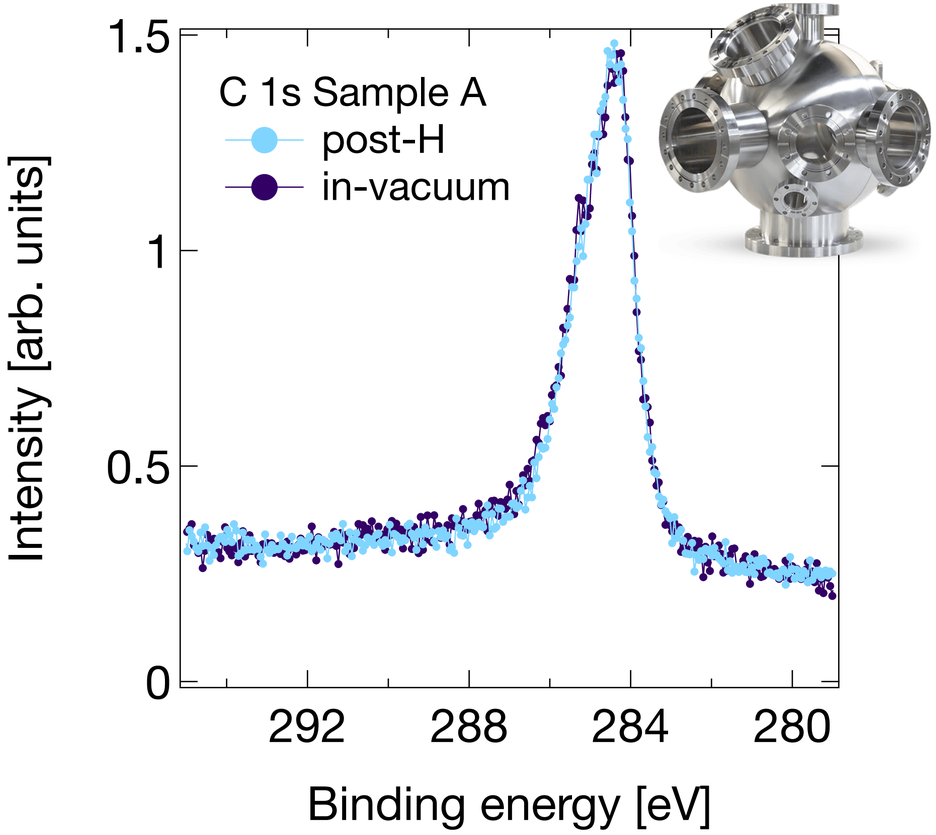
- “Dangerous” electrons ≤ 1 keV
- $^3He^+$ energy a few eV
- Integral current ~a few pA
- Current spread on whole surf. and on $4\pi$

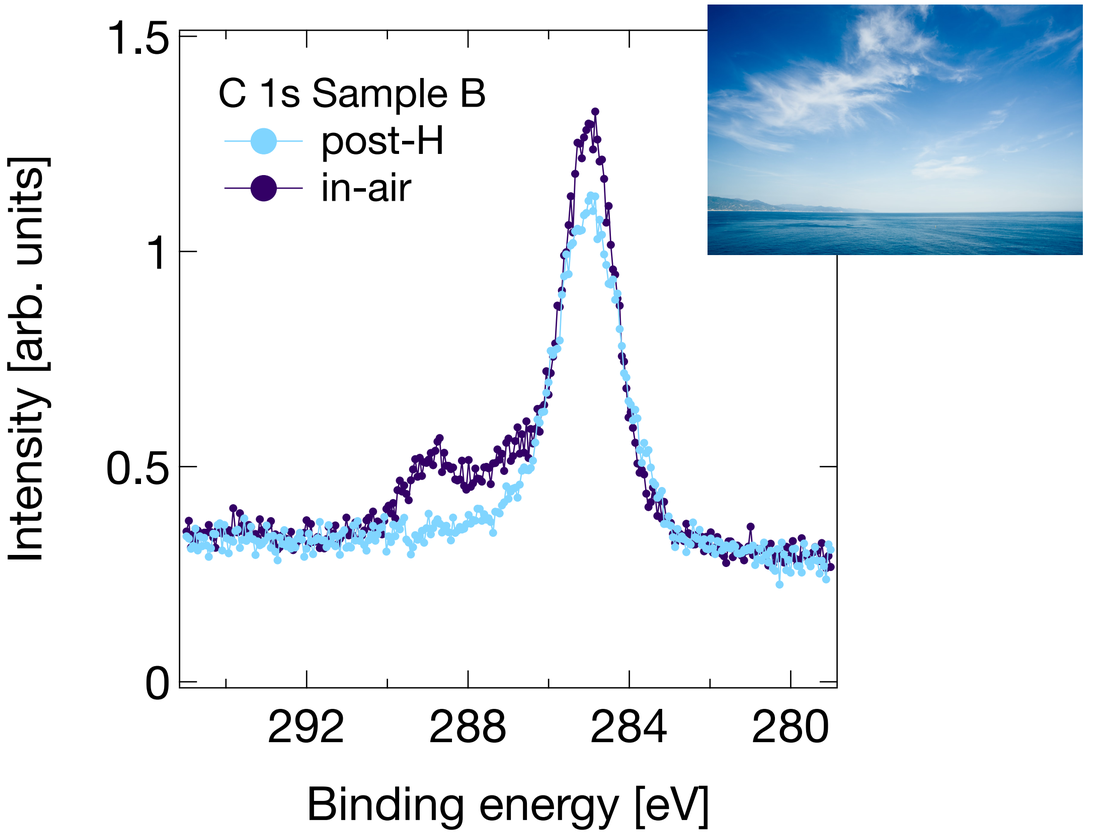
Experience-based considerations:

- EELS: $10^3$ pA/mm$^2$ —> no damages (at least a factor $10^6$ higher!)
- SPUTTERING: $Ar^+$ beam ~1 keV, ~100 nA/mm$^2$

BACKUP

# Hydorgenation Stability: Good in UHV, Oxidation in Air



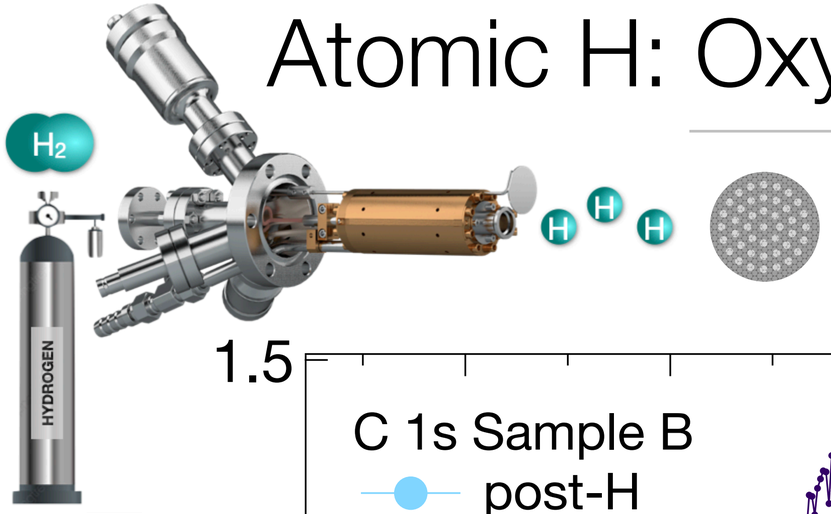

Sample A:

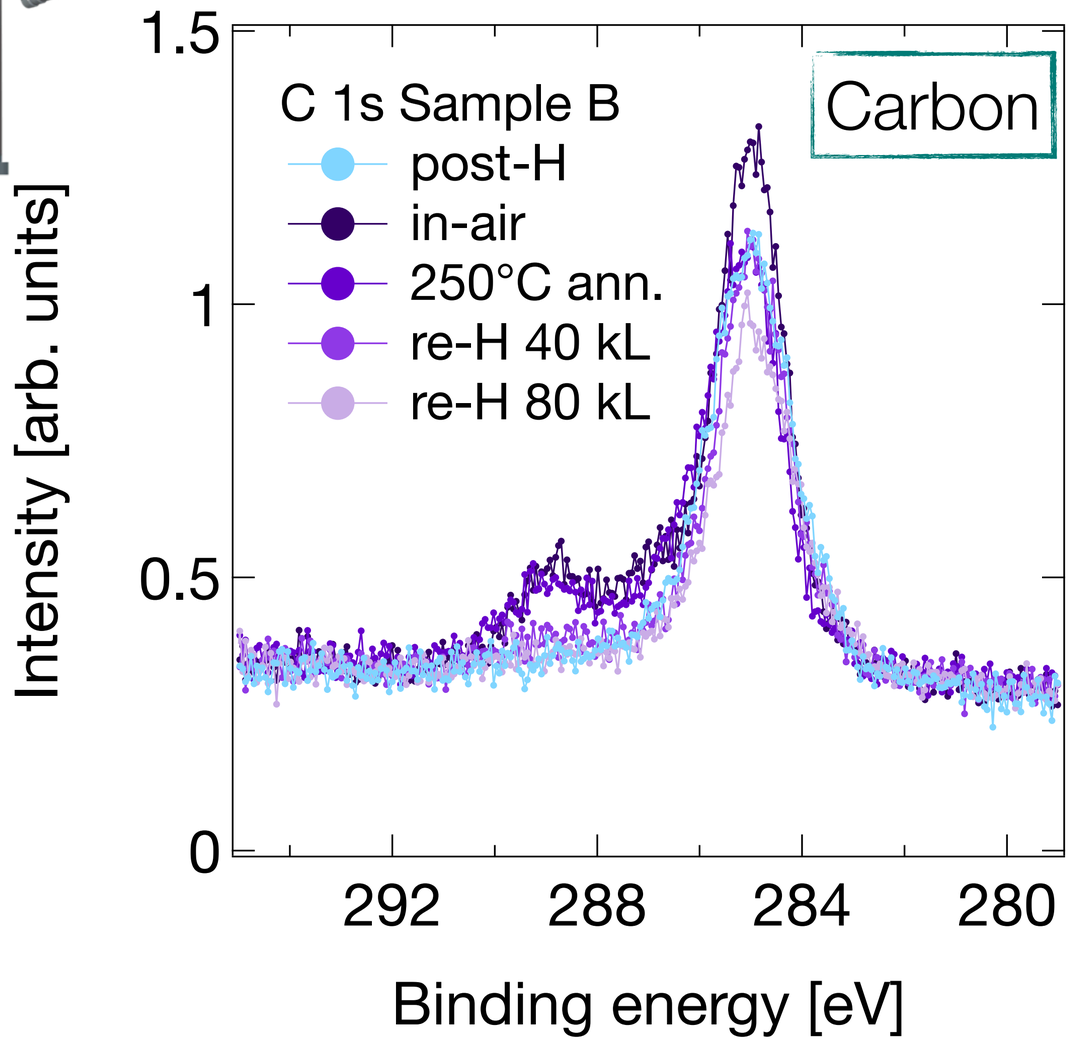
- 4 months in ultra-high vacuum ($10^{-10}$ mbar)
- Almost unchanged

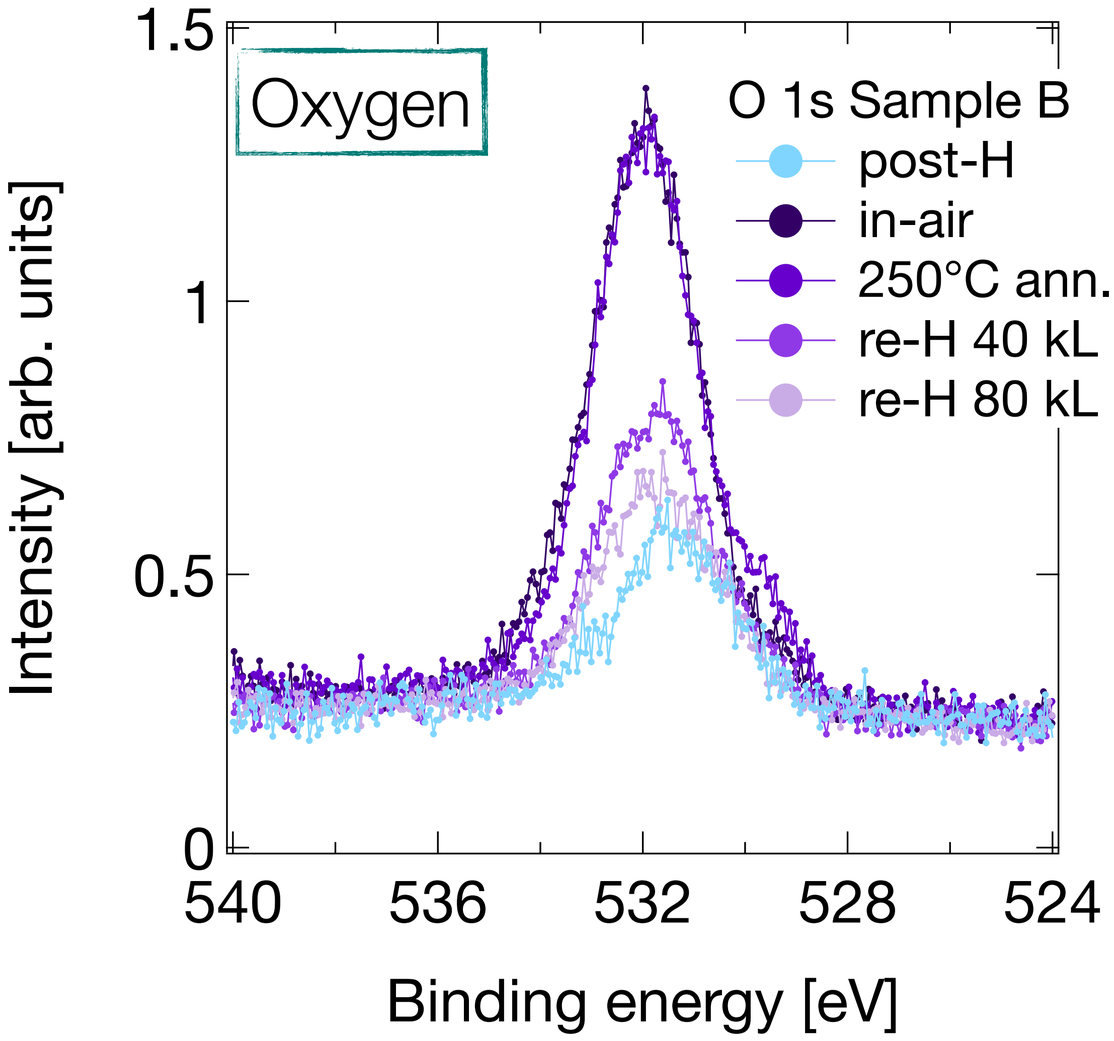
Sample B:

- 11 months in air
- Significant oxidation

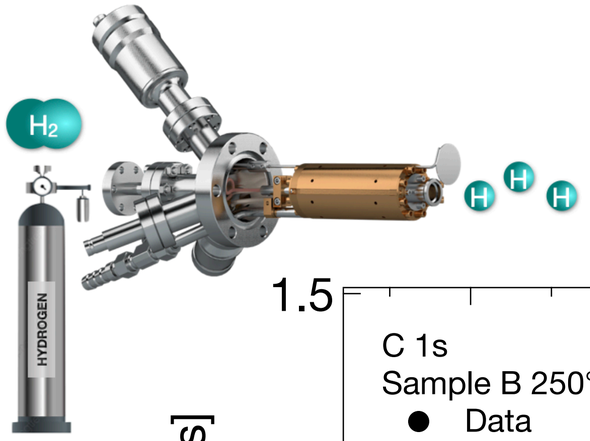
# Atomic H: Oxygen Substitution and Re-Hydrogenation



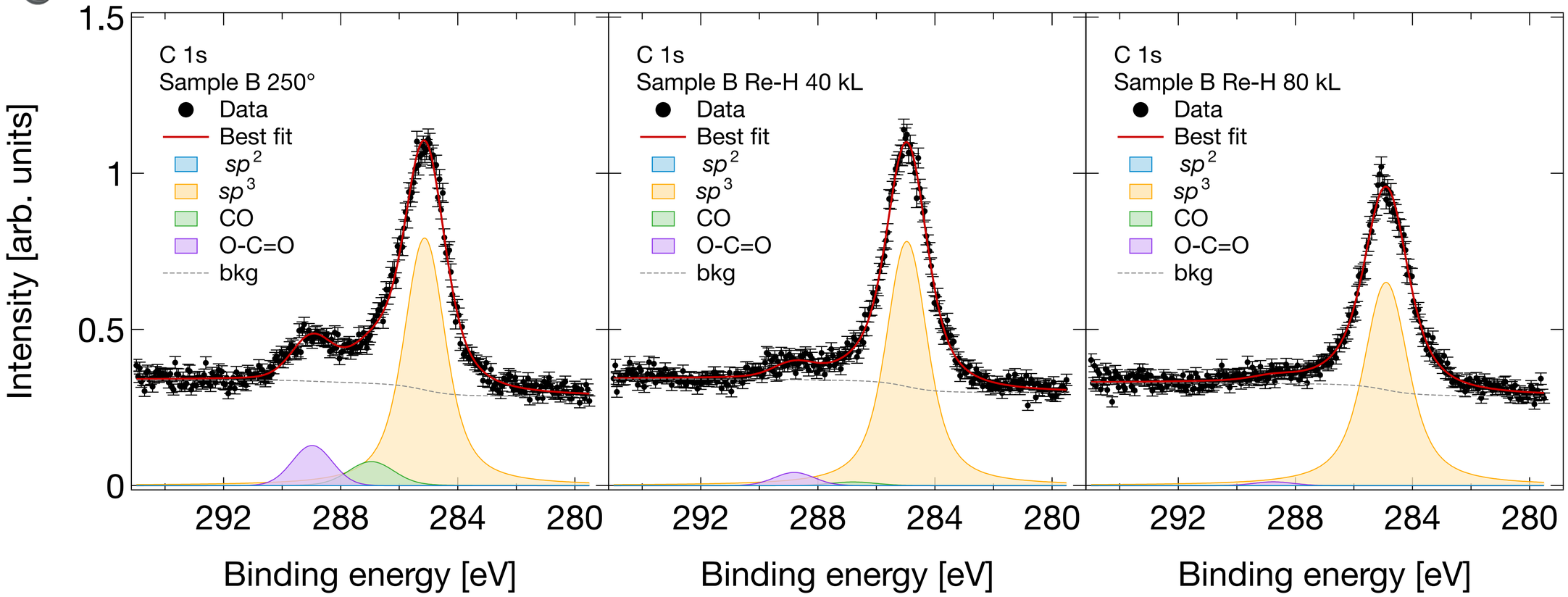



# Re-H: The $sp^3$ Is the Only Component Left Again



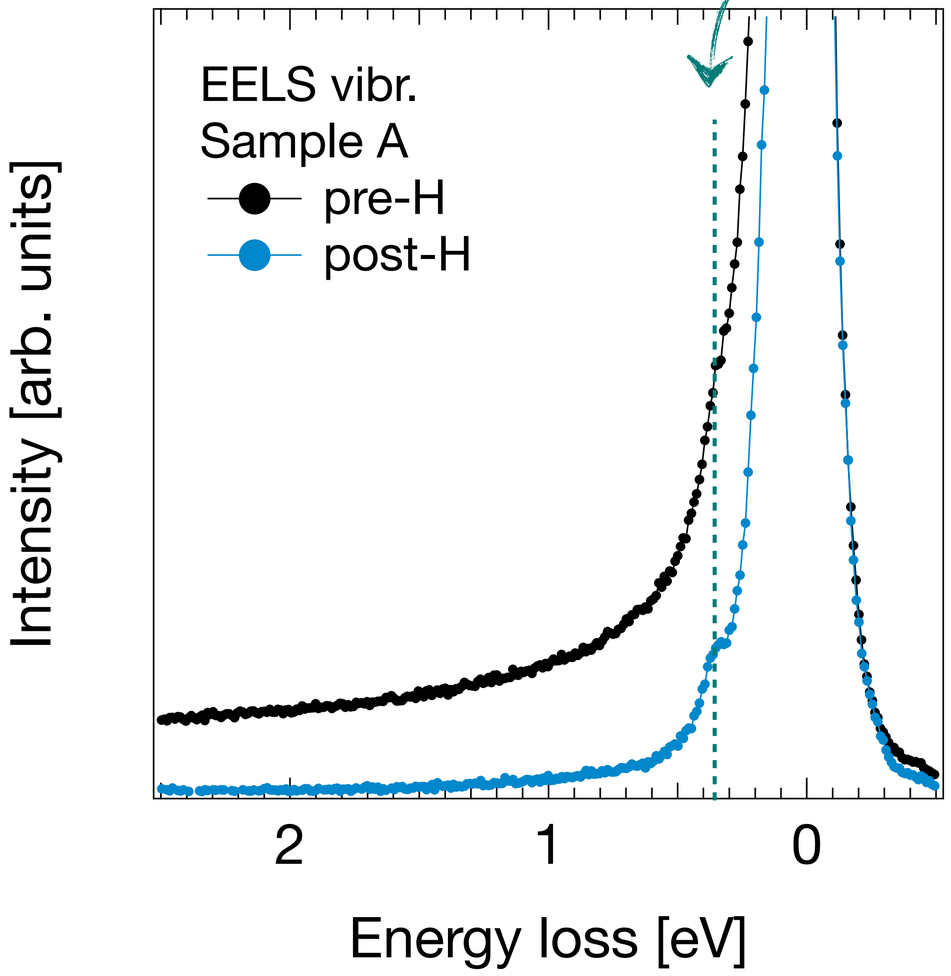


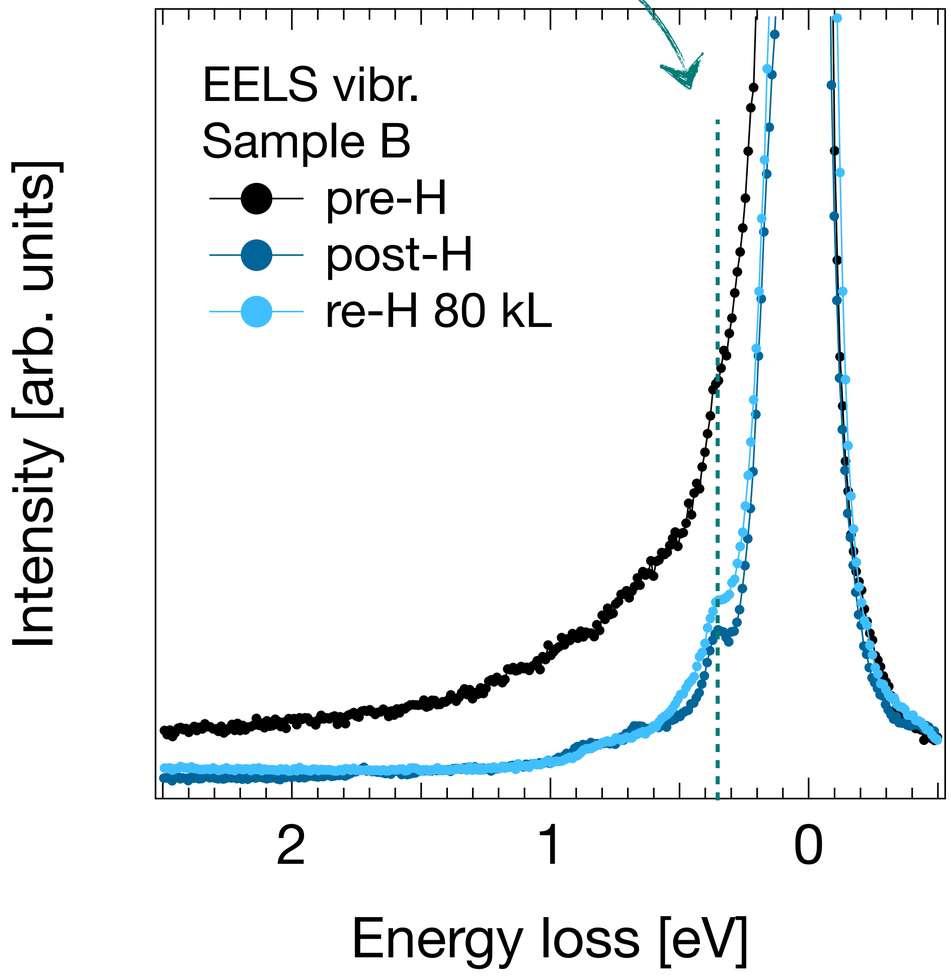


# EELS Confirms Hydrogenation and Re-Hydrogenation

DIRECT H FOOTPRINT!

C-H stretching
~360 meV

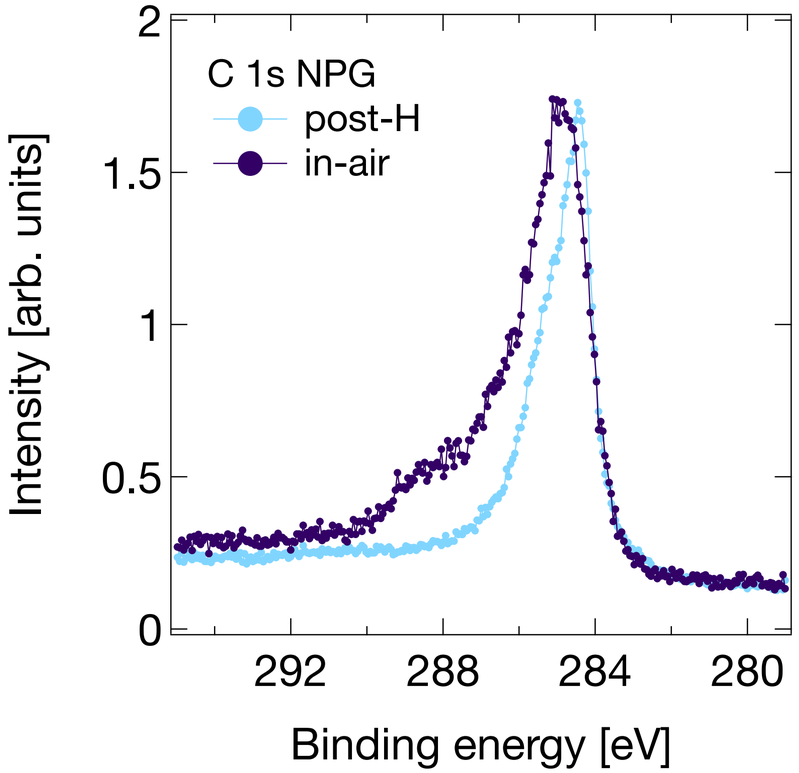


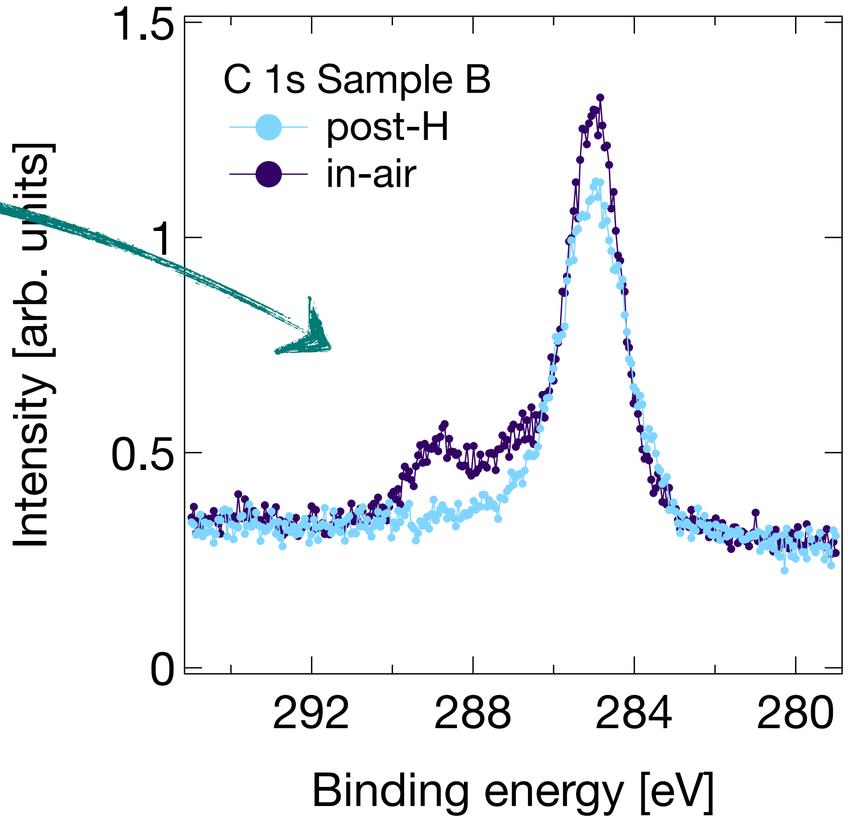



# Hydorgenation Stability: Good in UHV, Oxidation in Air

We saw something like this also

for NPG after 4 months in air!




Sample B:

- Hydrogenation ~100 % $sp^3$
- 11 months in air
- Significant oxidation

# Total C 1s Area Decreases With H Exposure