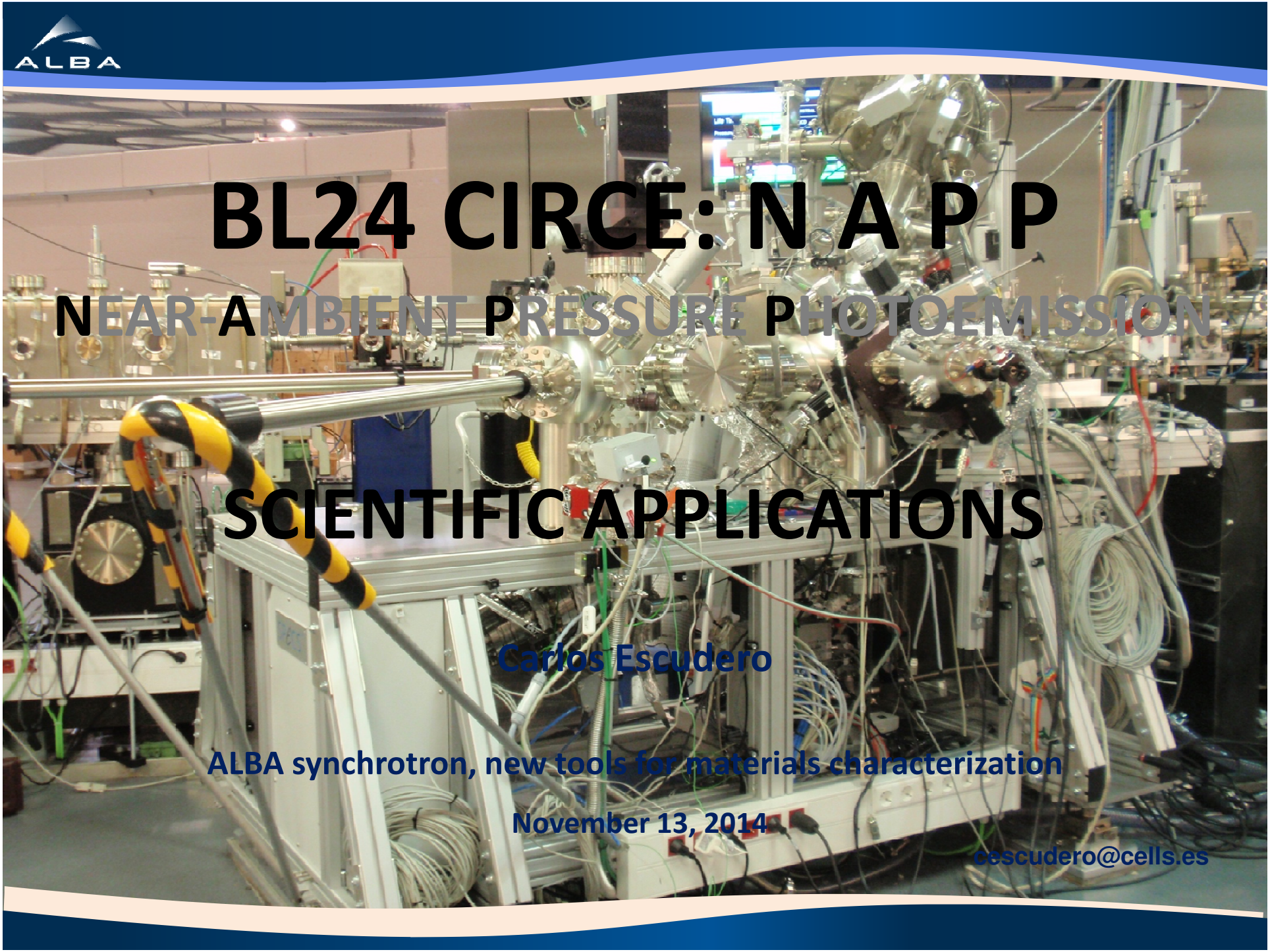


BL24 CIRCE: N A P P

NEAR-AMBIENT PRESSURE PHOTOEMISSION

SCIENTIFIC APPLICATIONS

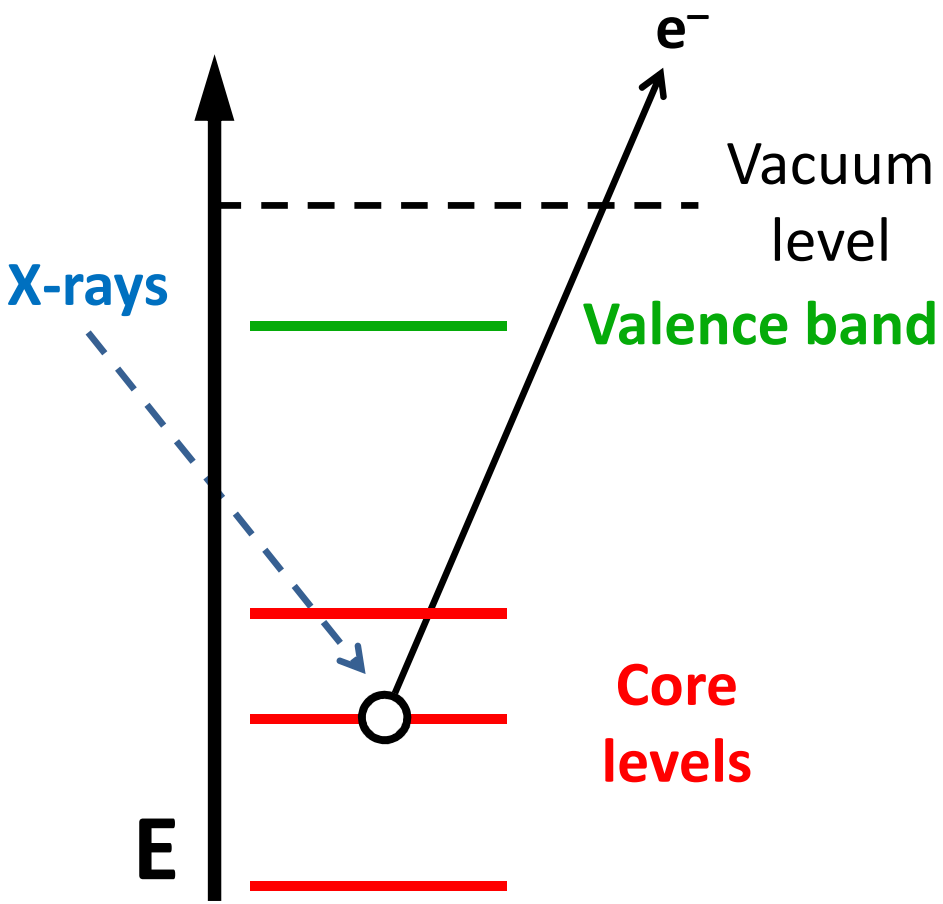
Carlos Escudero

ALBA synchrotron, new tools for materials characterization

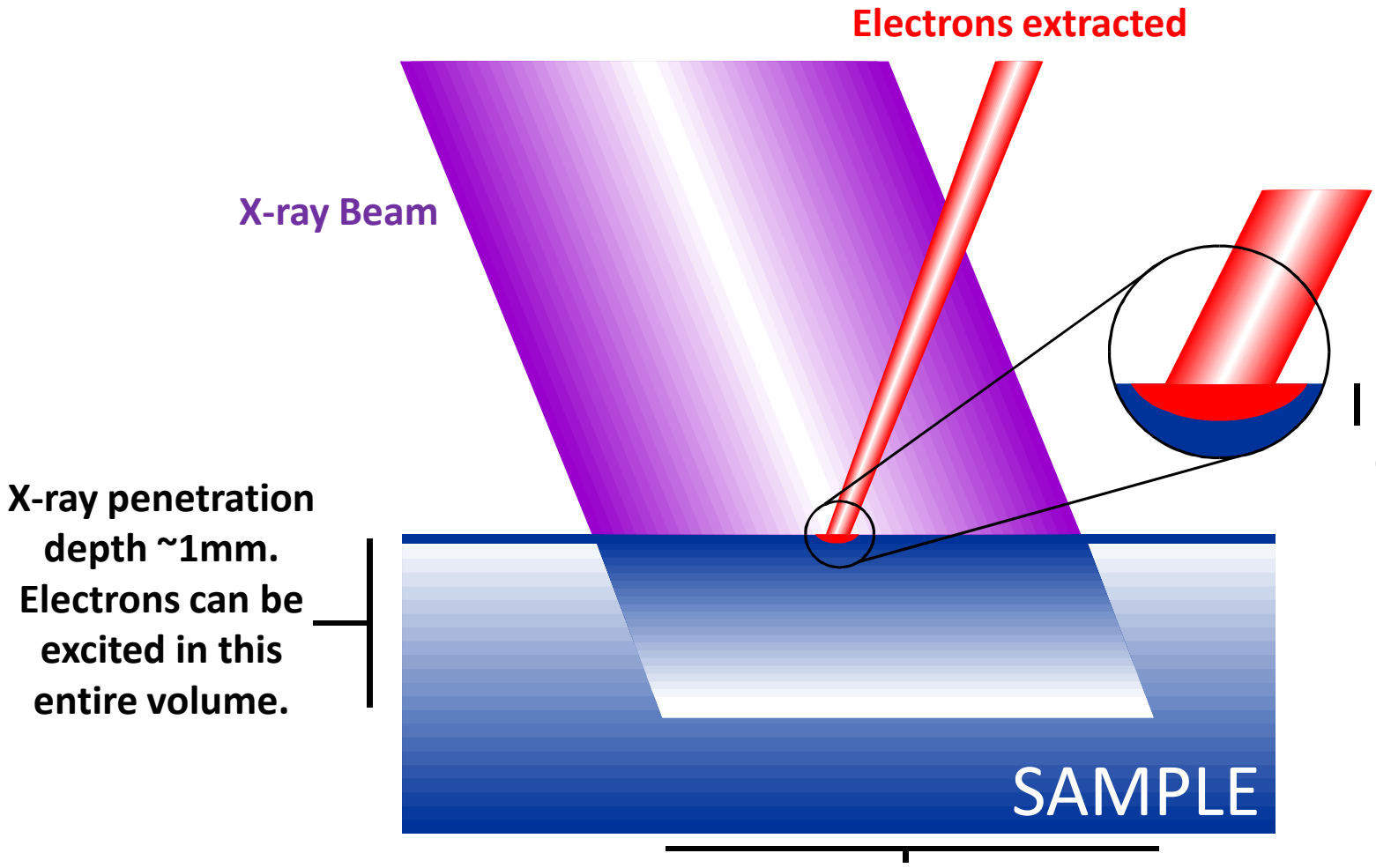
November 13, 2014

cescudero@cells.es

What is XPS?

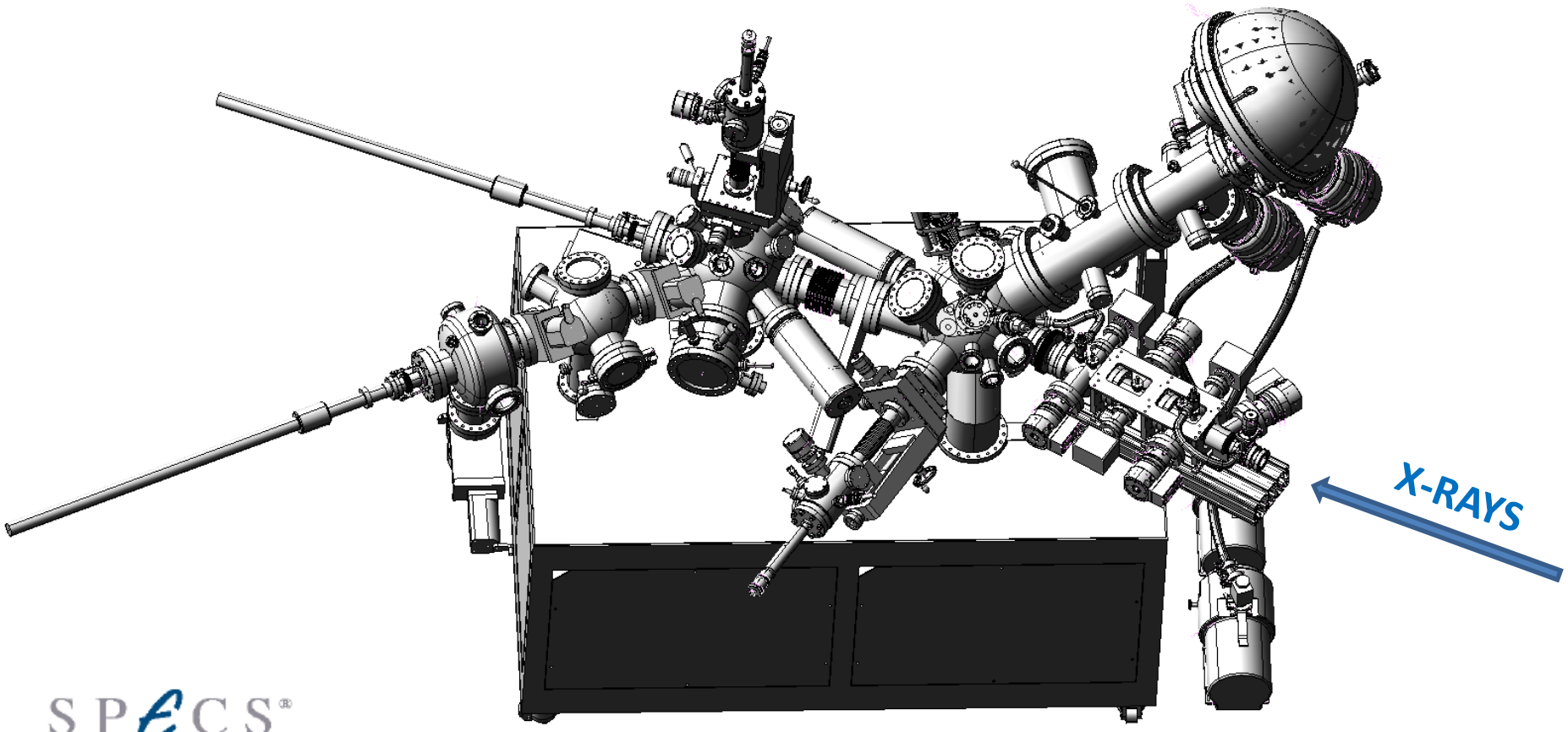


$$E_{binding} = E_{photon} - (E_{kinetic} + \phi)$$


Electrons extracted
X-ray Beam
10 nm
e⁻ escape
depth
X-ray penetration
depth ~1mm.
Electrons can be
excited in this
entire volume.
SAMPLE
X-ray excitation area. Electrons are
emitted from this entire area

NAPP endstation schematics

Soft X-Rays… from 100 eV to 2000 eV

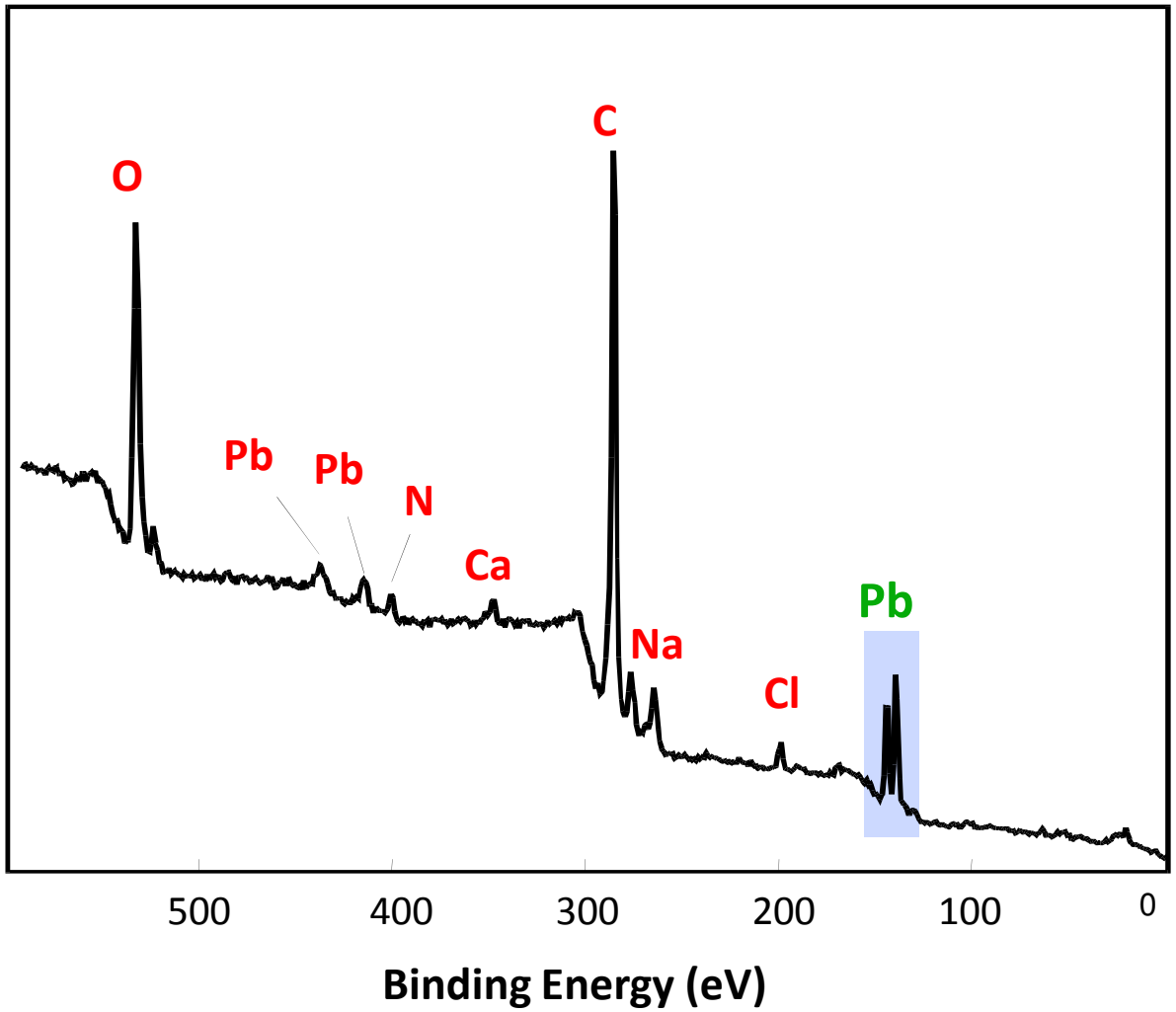


SPECS®


Conventional
UHV experiments

XPS Analysis of Pigment from Mummy Artwork

Egyptian Mummy
2nd Century AD
World Heritage Museum
University of Illinois



XPS Analysis of Pigment from Mummy Artwork

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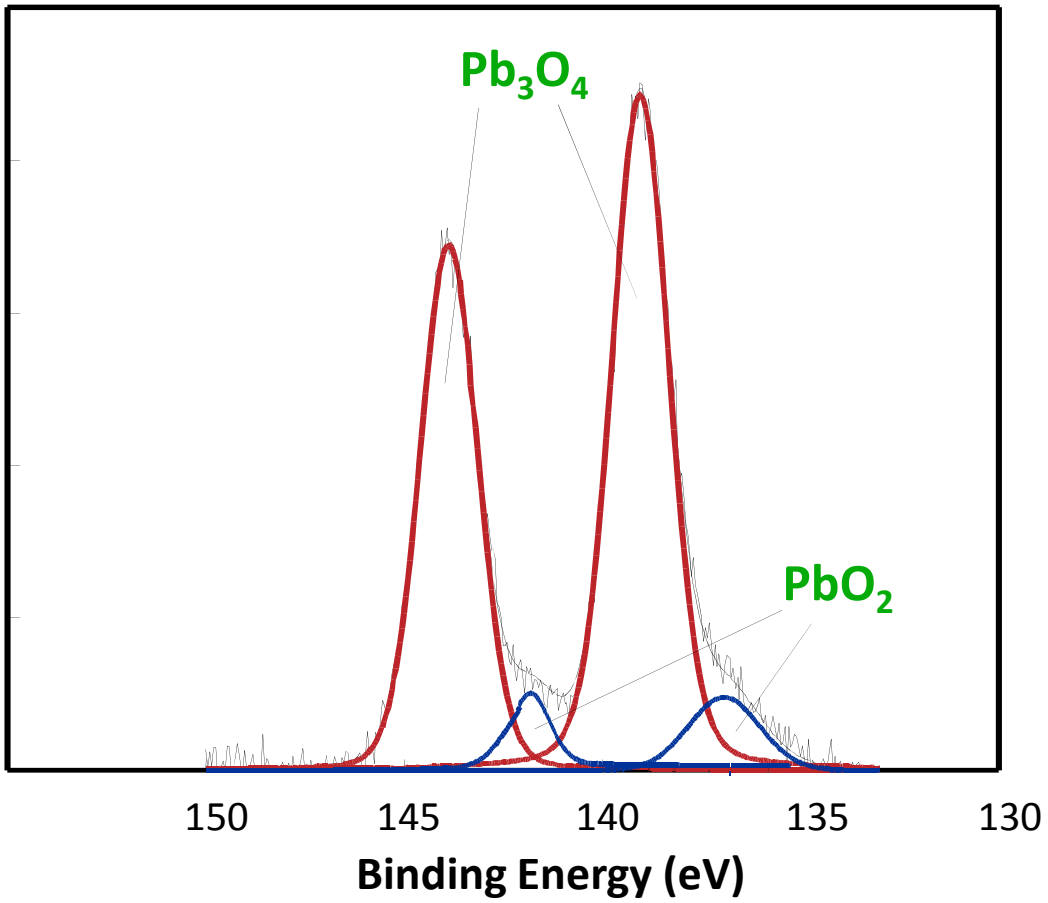
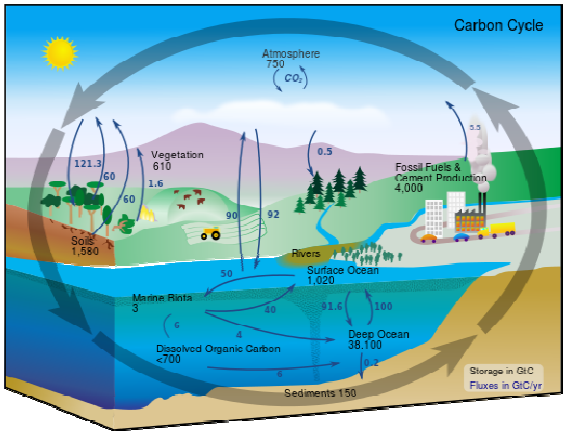
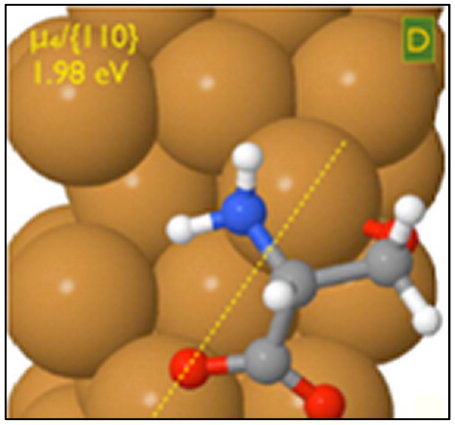


XPS analysis showed that the pigment used on the mummy wrapping was Pb_3O_4 rather than Fe_2O_3

Why is it important to study surfaces in equilibrium with gases and liquids at ambient pressures ?



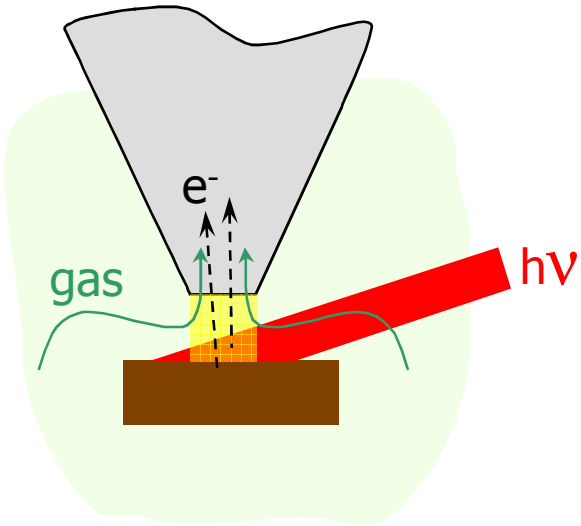
Environmental science
Study of liquid phases
Catalysis
Biological surfaces



We need to develop spectroscopy and microscopy techniques that can operate in relevant environments !

Problem:

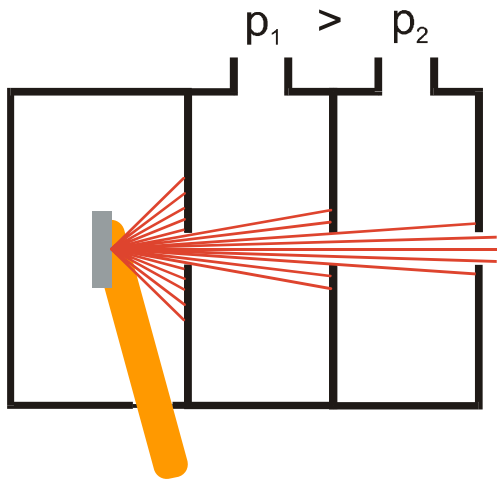
Scattering of electrons by gas or liquid phase molecules



Solution:

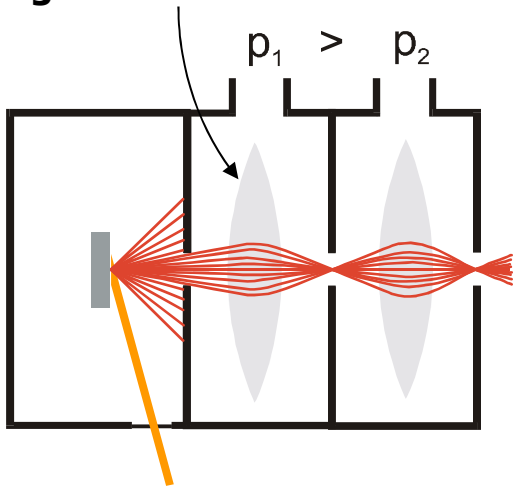
Capture the electrons before they collide with gas molecules by means of differential pumping

previous designs:



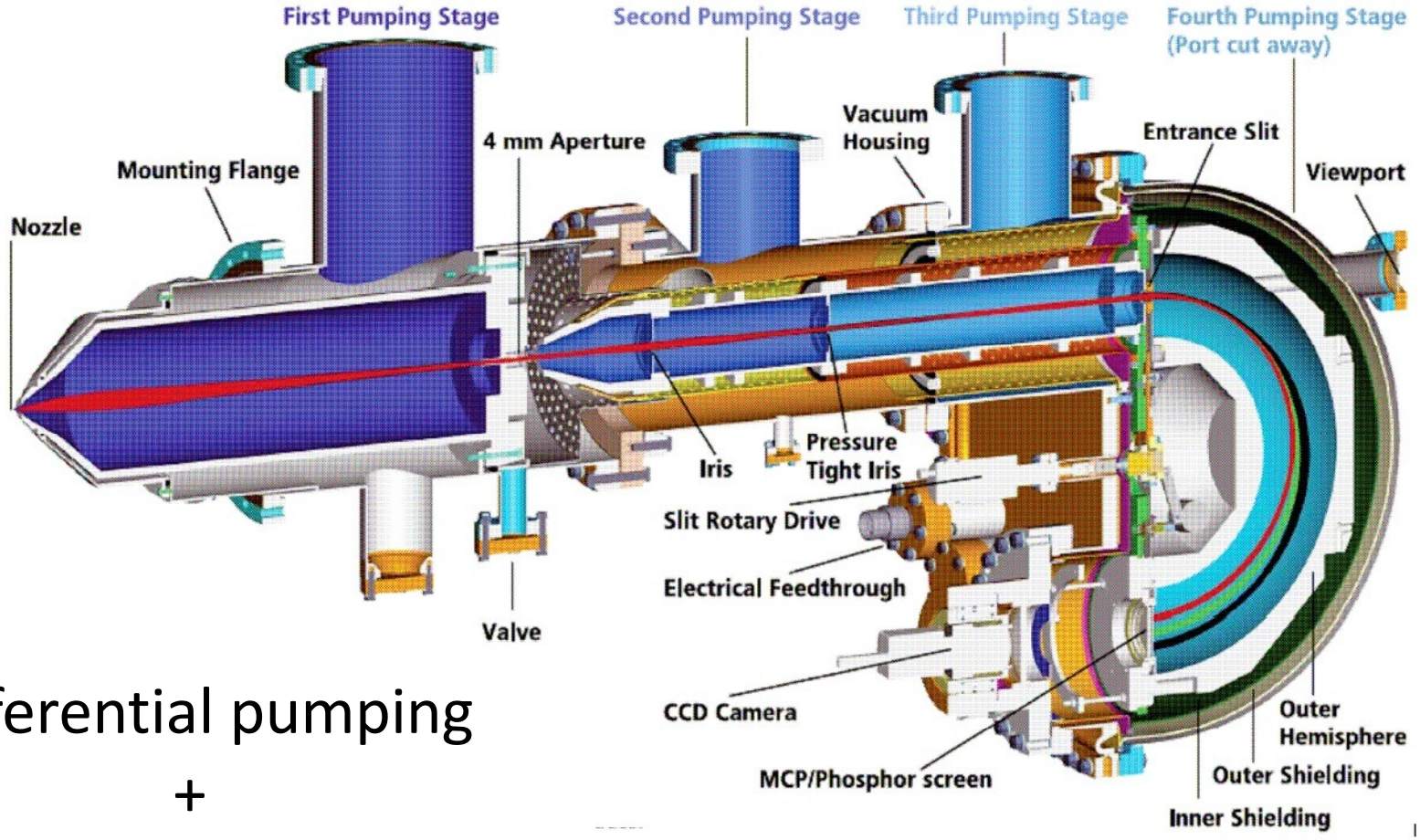
conventional X-ray source

our design: **electrostatic focusing !**



X-rays from synchrotron

Our hemispherical analyzer…



Differential pumping

+

Electrostatic focusing

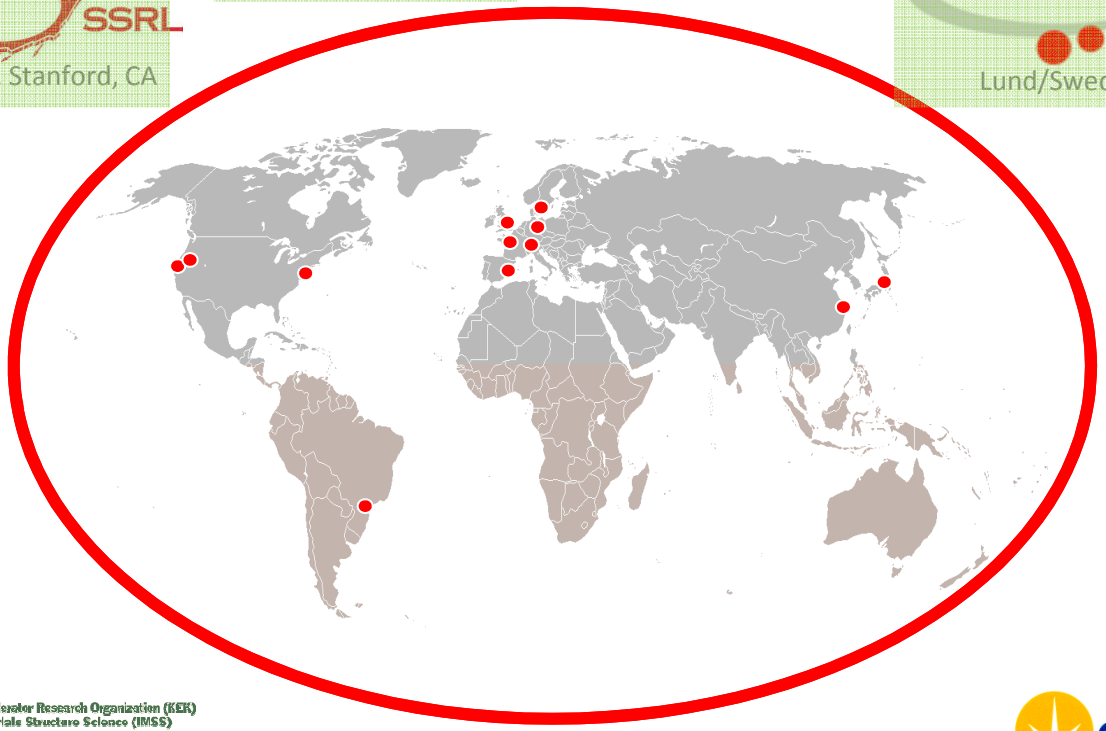
ALBA

ALS ADVANCED LIGHT SOURCE
LBNL, Berkeley, CA

BESSY
Berlin/
Germany

SSRL
SSRL, Stanford, CA

MAX-lab
Lund/Sweden



nsls
IR UV X
BNL, Upton, NY

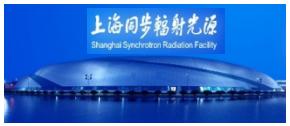
PAUL SCHERRER INSTITUT
PSI
Villigen/Switzerland*

LNLS
Campinas/Brazil*

Barcelona/Spain

High Energy Accelerator Research Organization (KEK)
Institute of Materials Structure Science (IMSS)
Photon Factory
Tsukuba/Japan

diamond
Oxfordshire/UK**

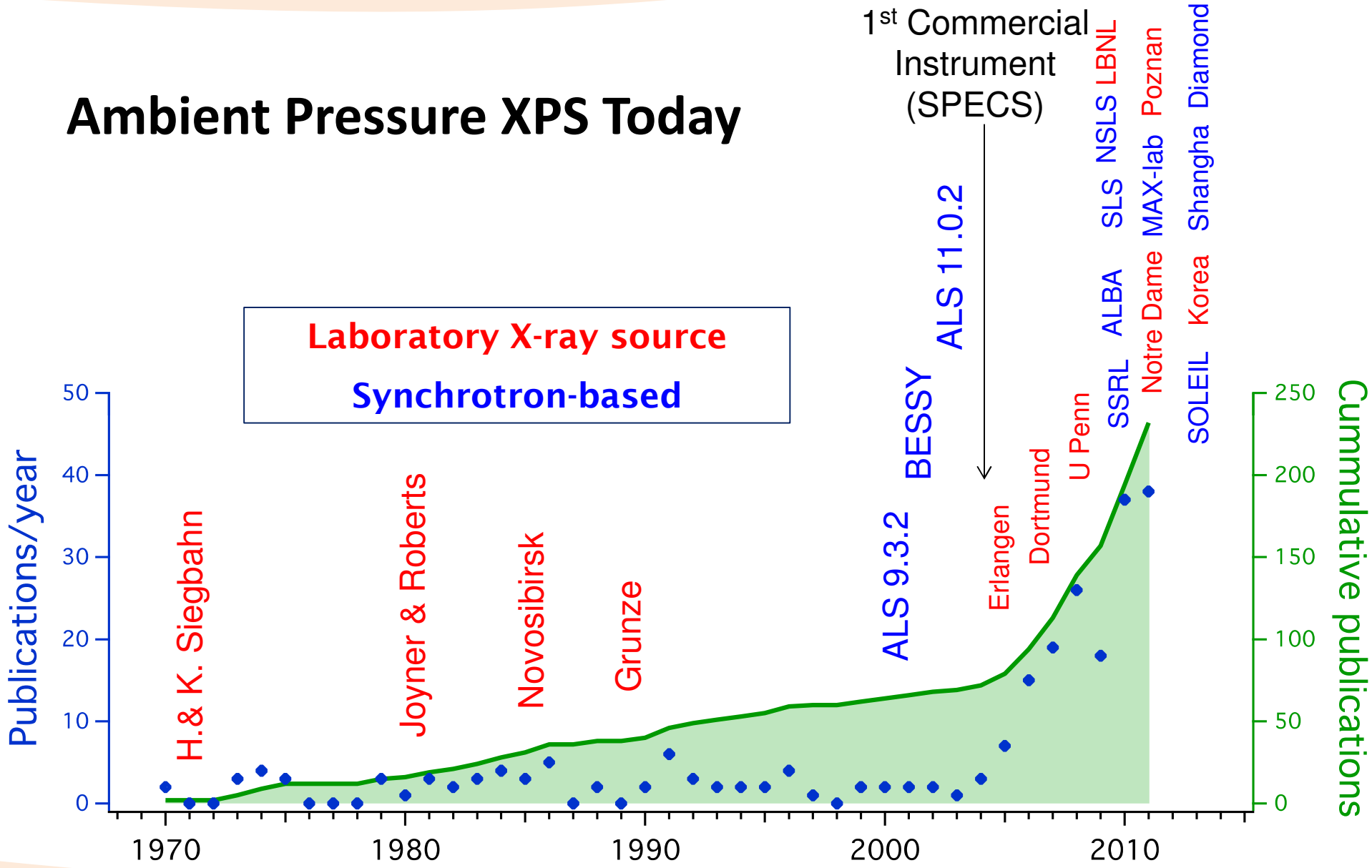


Shanghai/China**

SOLEIL
SYNCHROTRON
Saclay/France

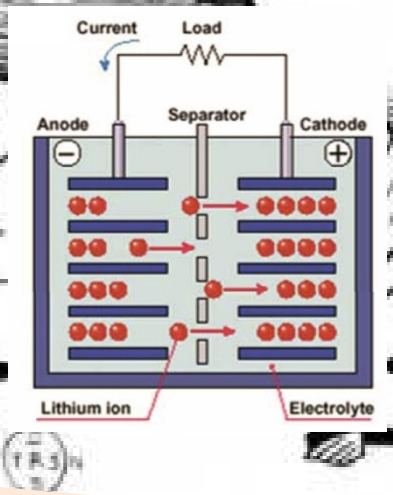
*in commissioning; **funded

Ambient Pressure XPS Today

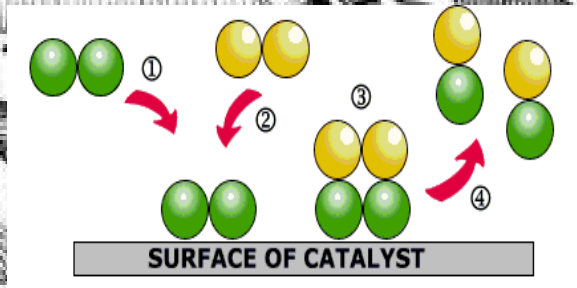


NAPP: scientific applications

Energy generation



Heterogeneous Catalysis



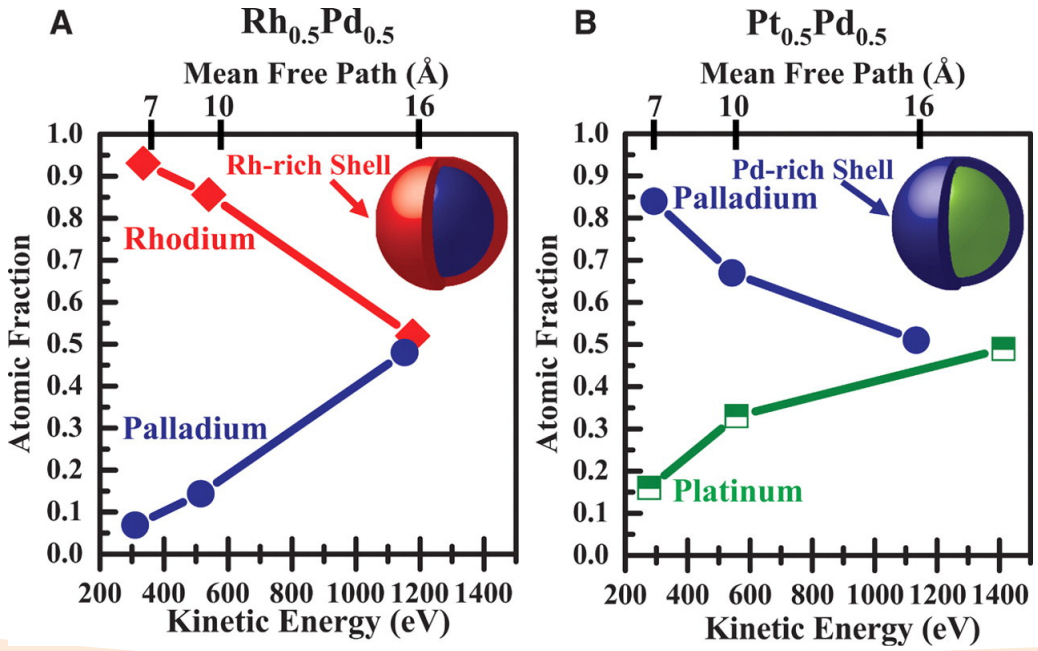
Environmental Science

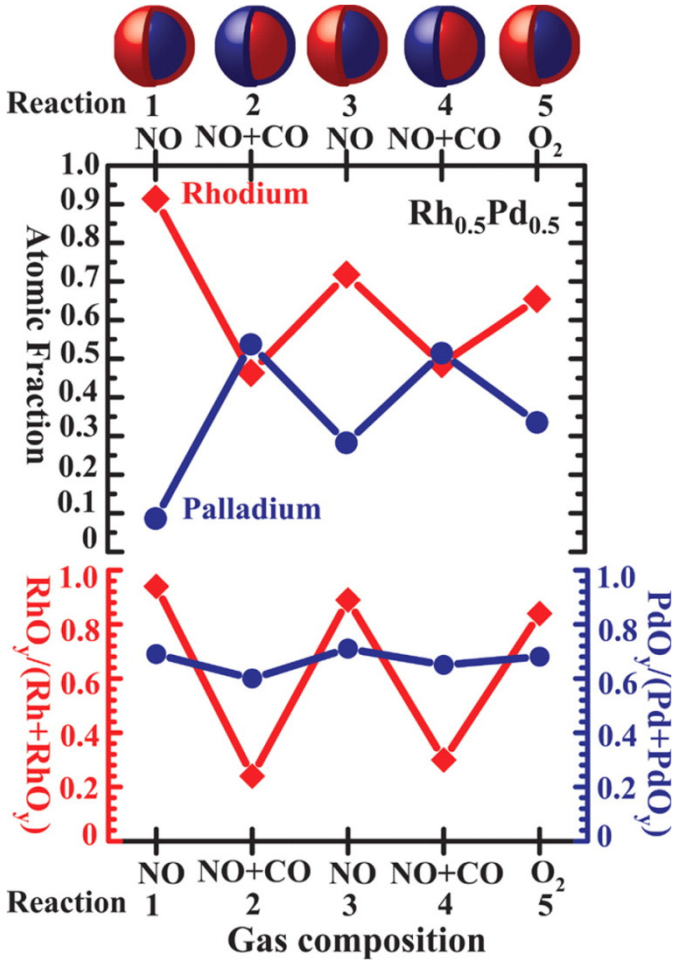
Heterogeneous catalysis

Science
AAAS

Reaction-Driven Restructuring of Rh-Pd and Pt-Pd Core-Shell Nanoparticles

Feng Tao,[1,2] Michael E. Grass,[1,2] Yawen Zhang,[1,2,5] Derek R. Butcher,[1,2] James R. Renzas,[1,2] Zhi Liu,[1,3] Jen Y. Chung,[3] Bongjin S. Mun,[3] Miquel Salmeron,[1,4]* Gabor A. Somorjai[1,2]*





Science AAAS

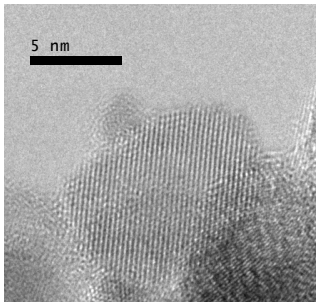
Influence of the support on surface rearrangements of bimetallic nanoparticles in real catalysts

Núria J. Divins[1], Inma Angurell[2], Carlos Escudero[3], Virginia Pérez-Dieste[3], Jordi Llorca[1,*]

ESR – Ethanol Steam Reforming

$C_2H_5OH + 3\ H_2O \rightarrow 6\ H_2 + 2\ CO_2$

- ✓ Can be obtained from renewable sources
- ✓ Low in toxicity, easy to store and transport
- ✓ On-site generation of H_2



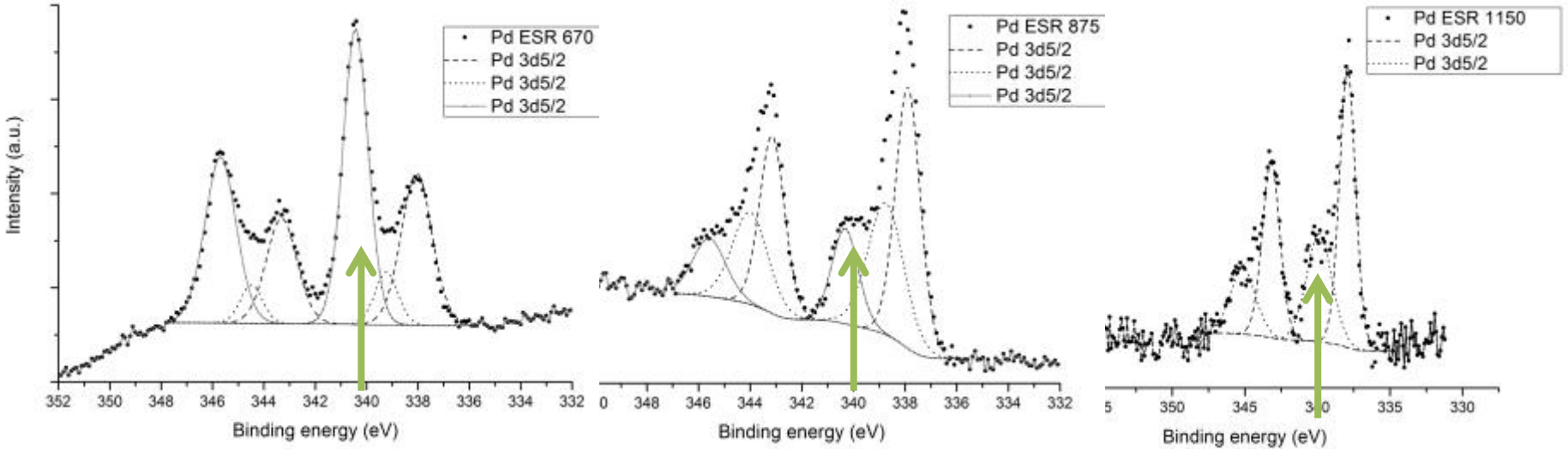
RhPd/CeO_2 NPs

- ✓ Synergic effect between Rh and Pd
  - Rh breaks C-C bond
  - Pd efficiently recombines H-H
- ✓ CeO_2 redox properties and OSC

How does CeO_2 influence the surface rearrangement of nanoparticles in real catalysts?

3% wt. $RhPd_{NP}/CeO_x$

ESR conditions

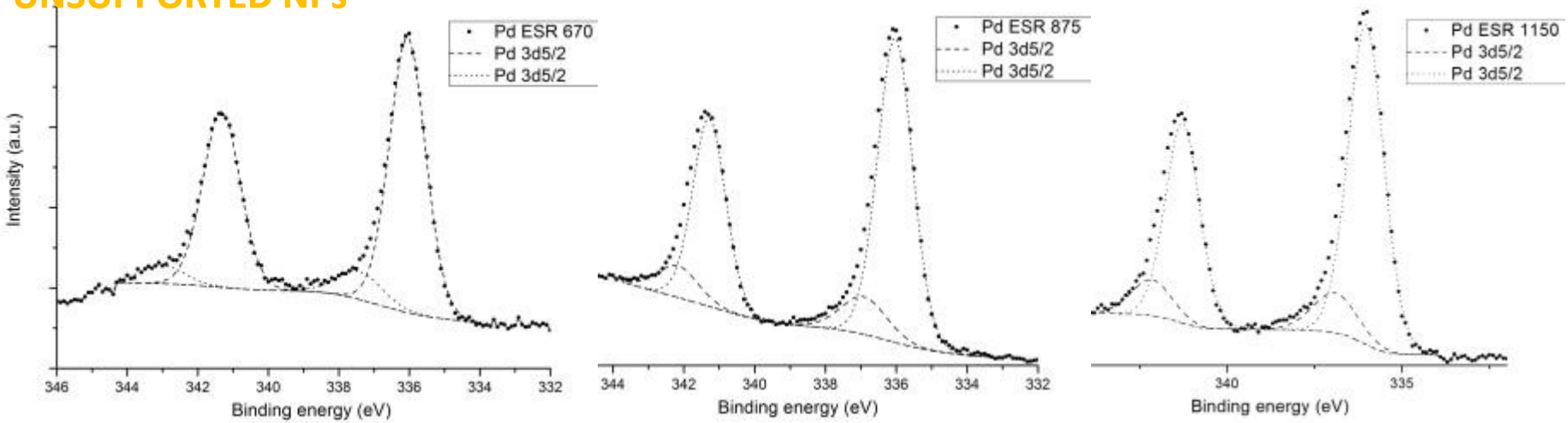


$h\nu_1 = 670$ eV

$h\nu_2 = 875$ eV

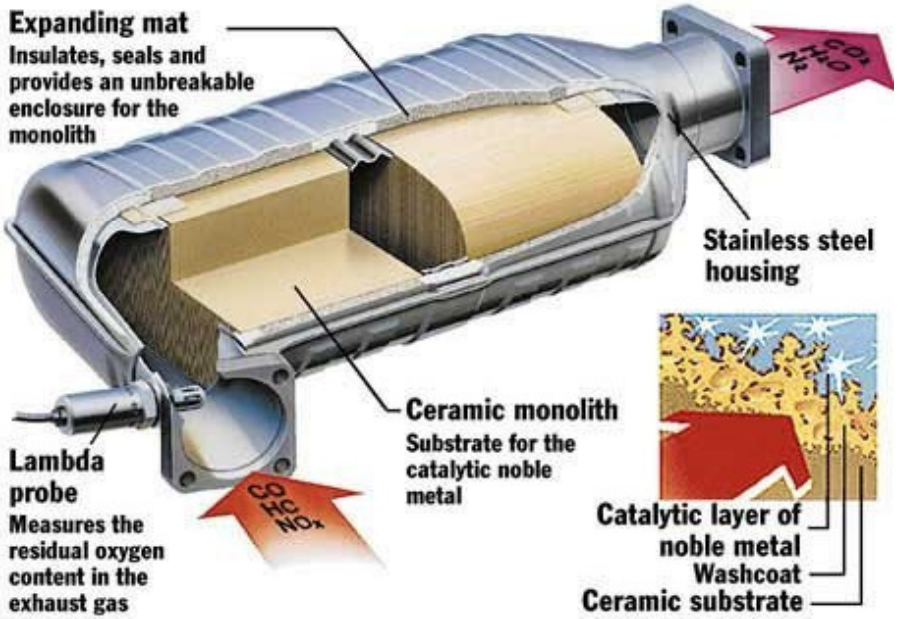
$h\nu_3 = 1150$ eV

UNSUPPORTED NPs

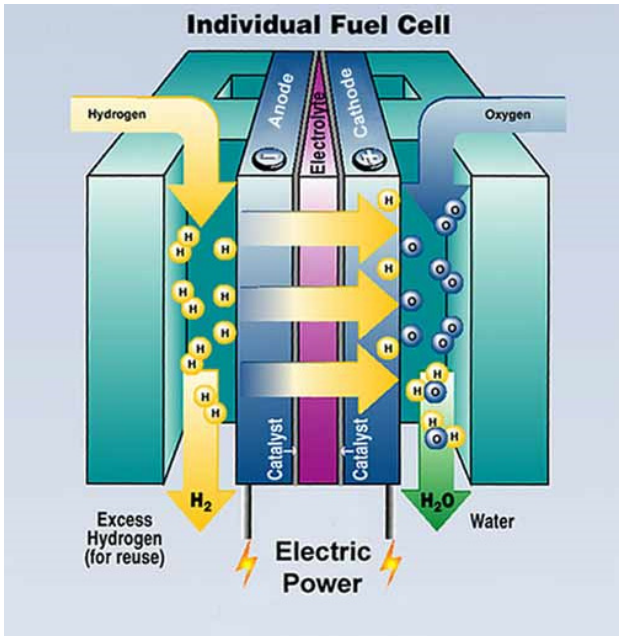


Environmental Science

Reduce pollution



Green energy



Vehicle emissions control

Fuel cells

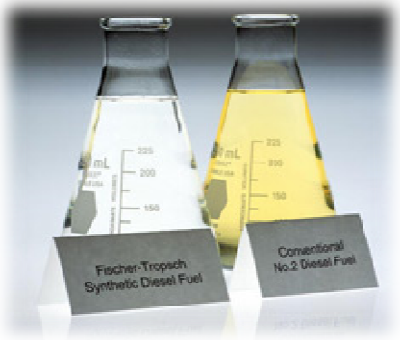
Catalyst

Prof. Franz Fischer

Catalysis: Fischer-Tropsch reaction

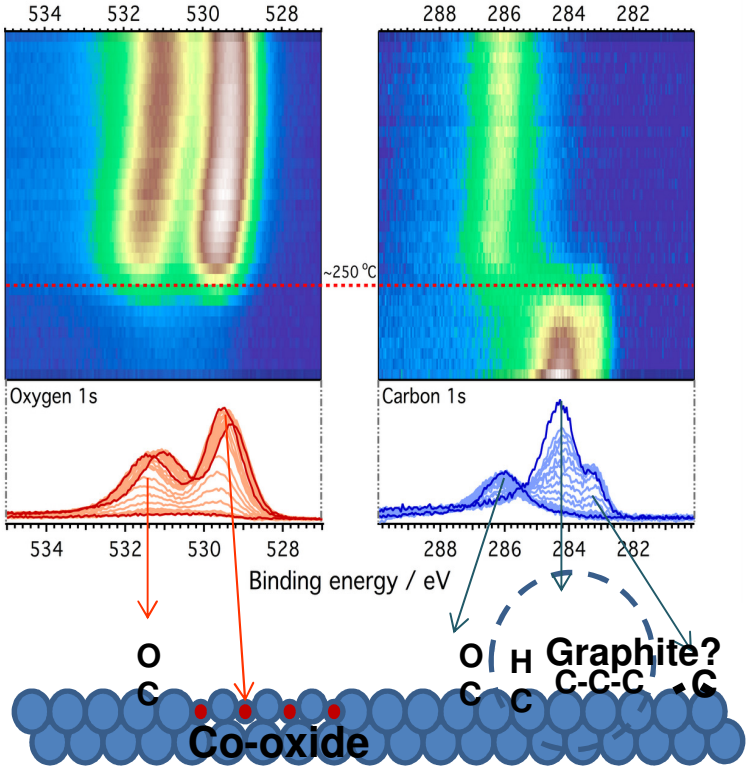
$$(2n + 1)H_2 + nCO \longrightarrow C_nH_{(2n+2)} + nH_2O$$

Dr. Hans Tropsch



- Crude oil is running out
- Cleaner fuels
- Gas-to-Liquid, storage and transportation

Shell GTL plant in *Bintulu, Malaysia: 14,700 barrels per day*



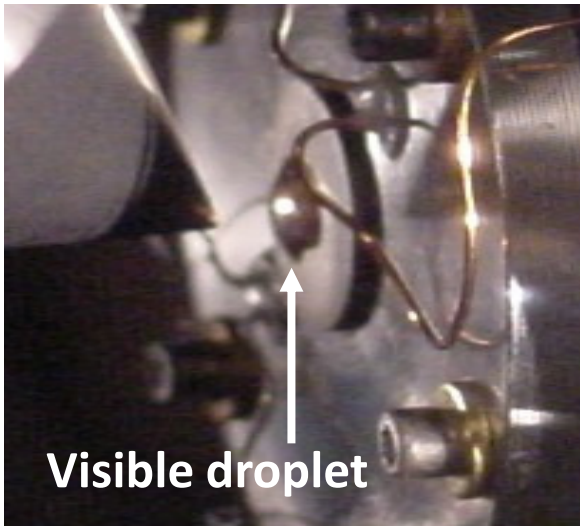

Liquid phase studies

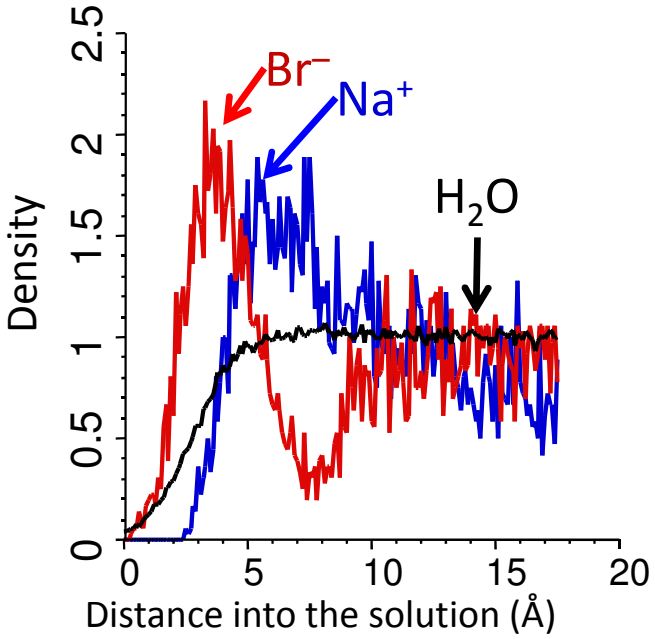
Science
AAAS

Electron Spectroscopy of Aqueous Solution Interfaces Reveals Surface Enhancement of Halides

Sutapa Ghosal[1,2], John C. Hemminger[1,*], Hendrik Bluhm[3], Bongjin Simon Mun[4], Eleonore L. D. Hebenstreit[2], Guido Ketteler[2], D. Frank Ogletree[2], Felix G. Requejo[2,5], Miquel Salmeron[2]

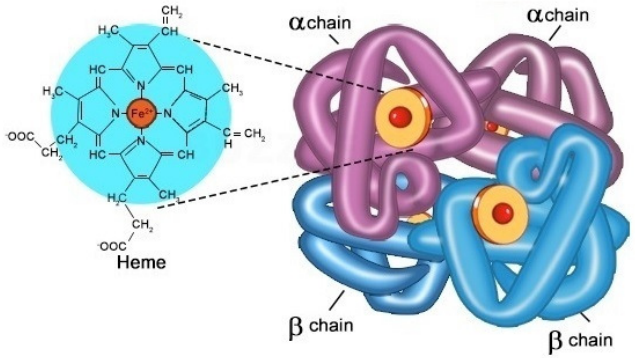
Chemistry happens at the surface of salty droplets

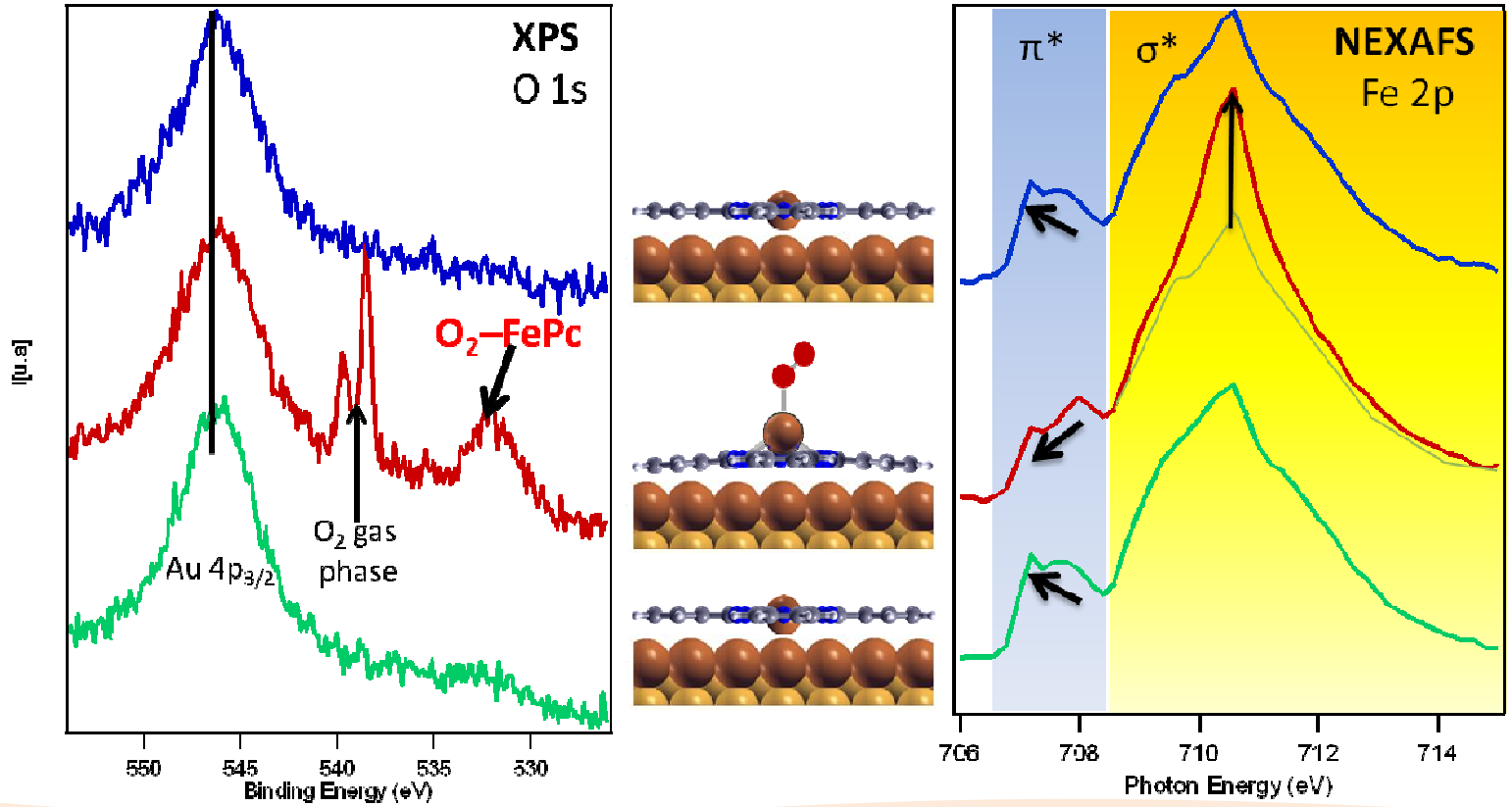




Breathing chemistry

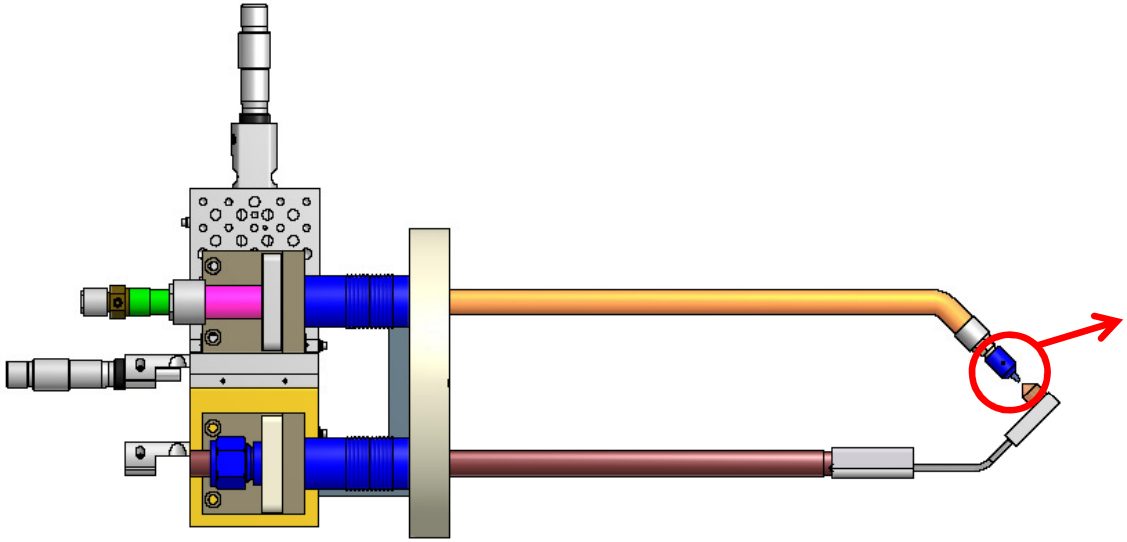
By courtesy of Dr. Celia Rogero (CSIC-UPV/EHU)

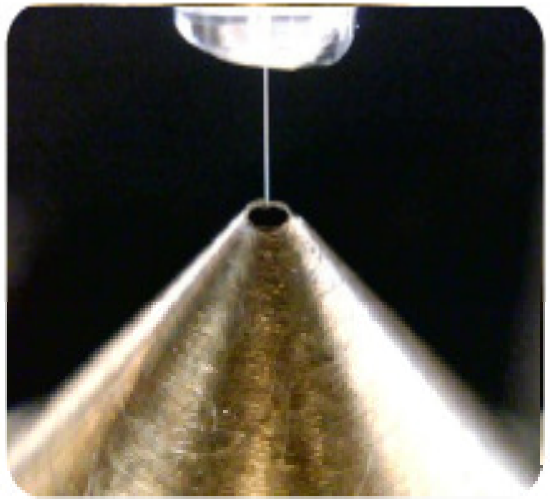




Future possibilities

Liquid jet system (medium term plan)





- Segregation phenomena of ions in solutions
- Adsorption of gas molecules on liquid films
- Electronic structure of biomolecules in water and other organic molecules in different solvents minimizing the potential beam damage


Thanks to ALBA staff for your contribution!
ALBA
GRUPO ESPECIALIZADO NANOCIENCIA Y MATERIALES MOLECULARES
R.S.E.F.
RSEQ
Real Sociedad Española de Química
... And thank you for your attention!