

### Chemistry induced in molecular films by electronic irradiation

Quantitative analysis and role played by low energy electrons

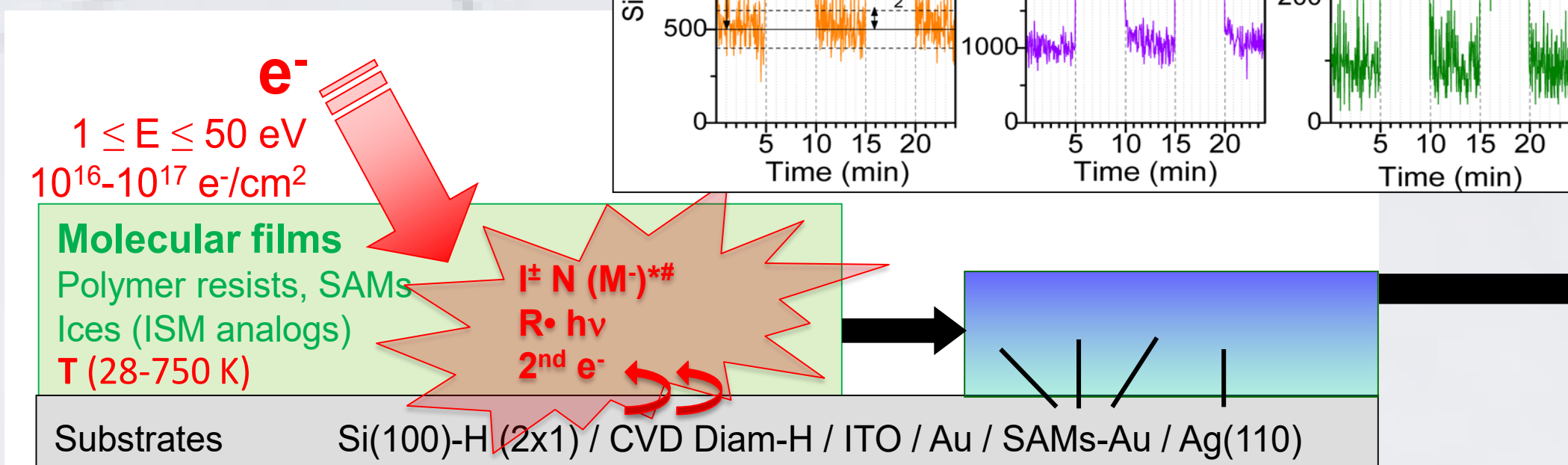
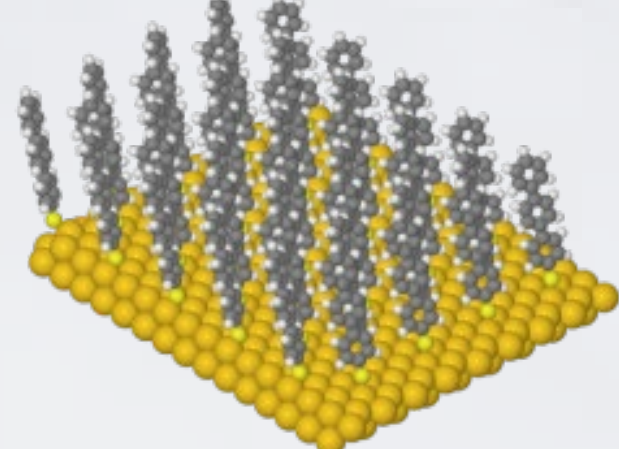
Anne LAFOSSE, Lionel AMIAUD, Céline DABLEMONT

#### Scientific Topics

- Understand & control the mechanisms behind the modifications induced by electron-molecule interactions
- Mimicking secondary electrons encountered in high energy irradiations
- Identify the reaction products (residues & desorbed species)
- Evaluate the reaction cross-sections

#### Research fields

Detectors, lithography, surface functionalisation, astrochemistry

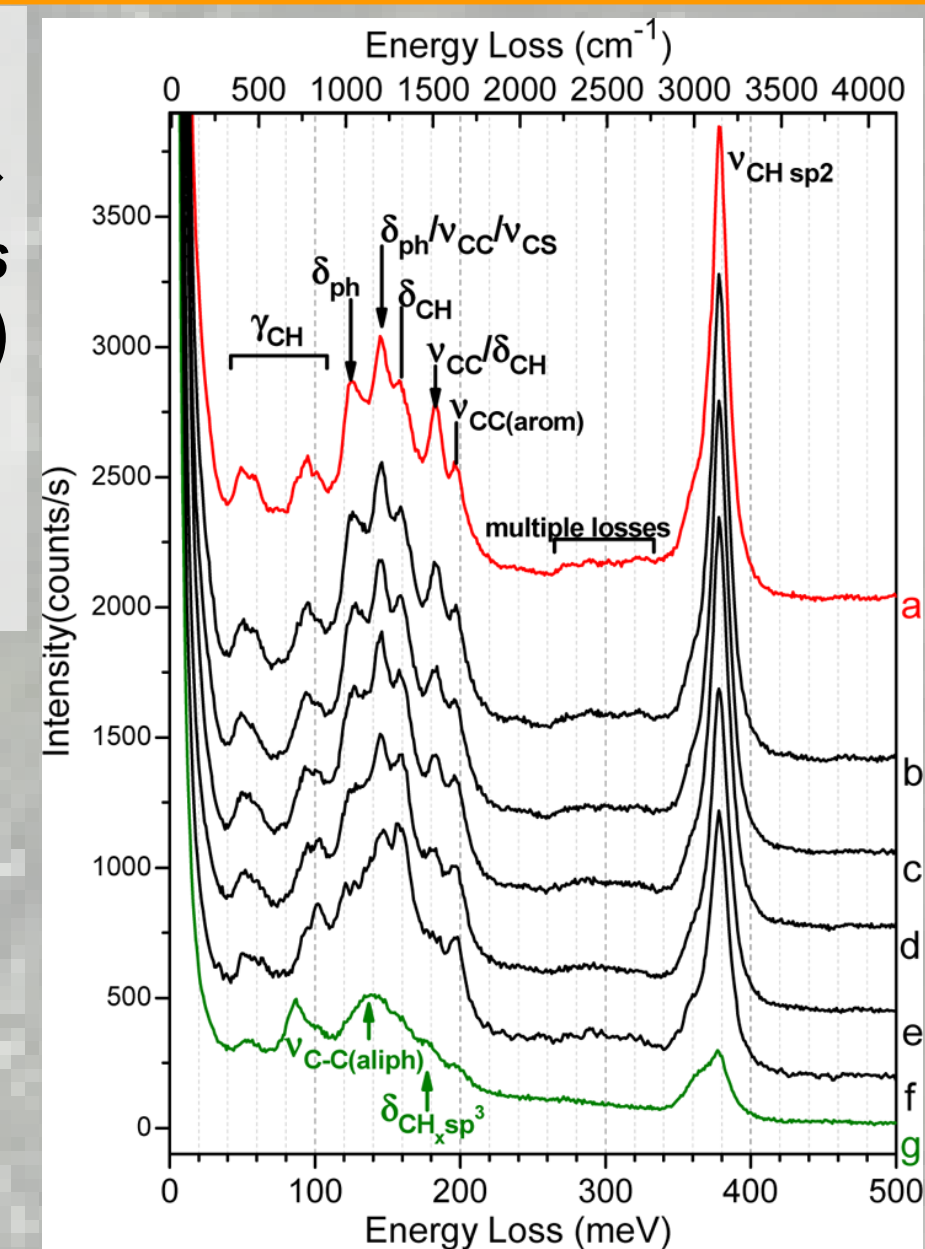


**Techniques**  
Residue analysis →  
**High-Resolution Electron Energy Loss Spectroscopy (HREELS)**

← Neutral desorbing fraction  
**Electron Stimulated Desorption (ESD)**

#### Collaborations

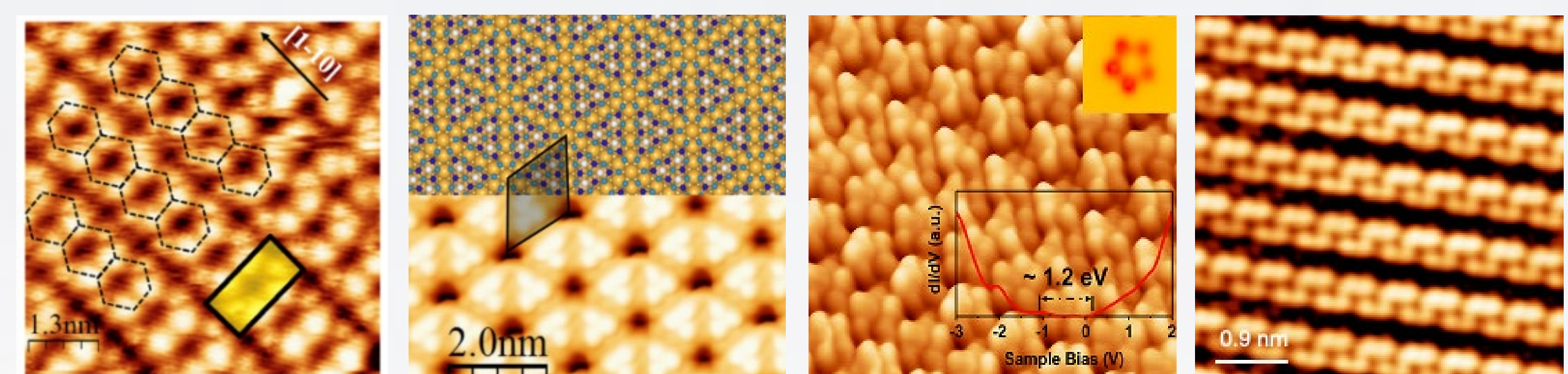
CEA-LIST & IRAMIS, LPS (Orsay)  
LERMA, LRS (Paris)  
JGU, (Mainz-Germany)  
Univ. Torun (Poland)



### New 2D Materials, Molecular networks & Molecular dynamics on metal surfaces

Hamid OUGHADDOU, Hanna ENRIQUEZ, Sven NAVE, Andrew MAYNE

#### Silicene & Phosphorene



K. Quertite, *ADFM*, 31, 2007013 (2021) W. Zhang, *Small* 14, 1804066 (2018); *ADFM* 30, 2004531 (2020); *Nat. Comm.* 12, 5160 (2021)

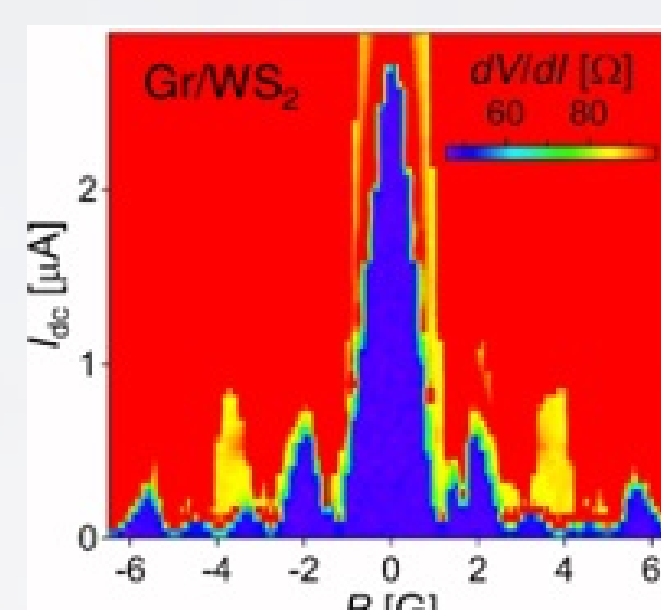
#### Scientific Topics

**New 2D materials:** Study of the growth processes, & atomic-scale characterisation of silicene & phosphorene on metal & insulating surfaces.

**Molecular networks on graphene:** Atomic scale studies of the electronic, magnetic, and optical properties of self-assembled molecular layers on graphene.

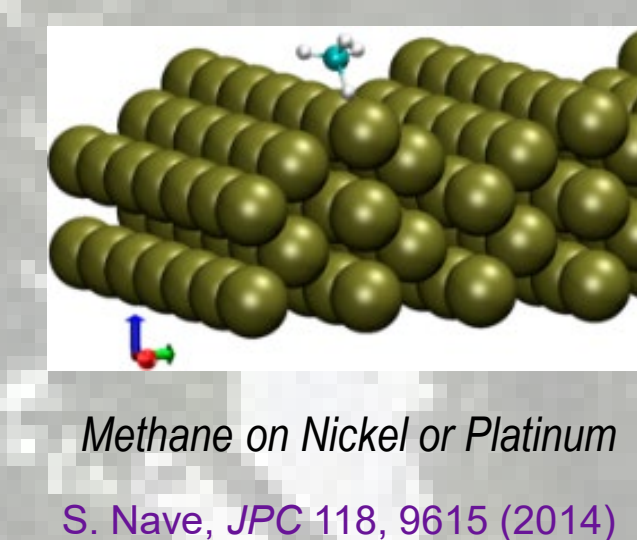
**Molecular dynamics at metal surfaces:** Mechanistic, dynamic simulations of molecular interactions at metal surfaces.

#### Electron transport in van der Waals heterostructures



T. Wakamura, *PRL* 125, 266801 (2020)

#### Molecular dynamics on metals



Methane on Nickel or Platinum  
S. Nave, *JPC* 118, 9615 (2014)

Ordered NiPc network on graphene

M. Zhao, *PCCP* 20, 19507 (2018)

**Collaborations :** SPEC-CEA, SOLEIL, LPS, University Central Florida, M5 University – Rabat

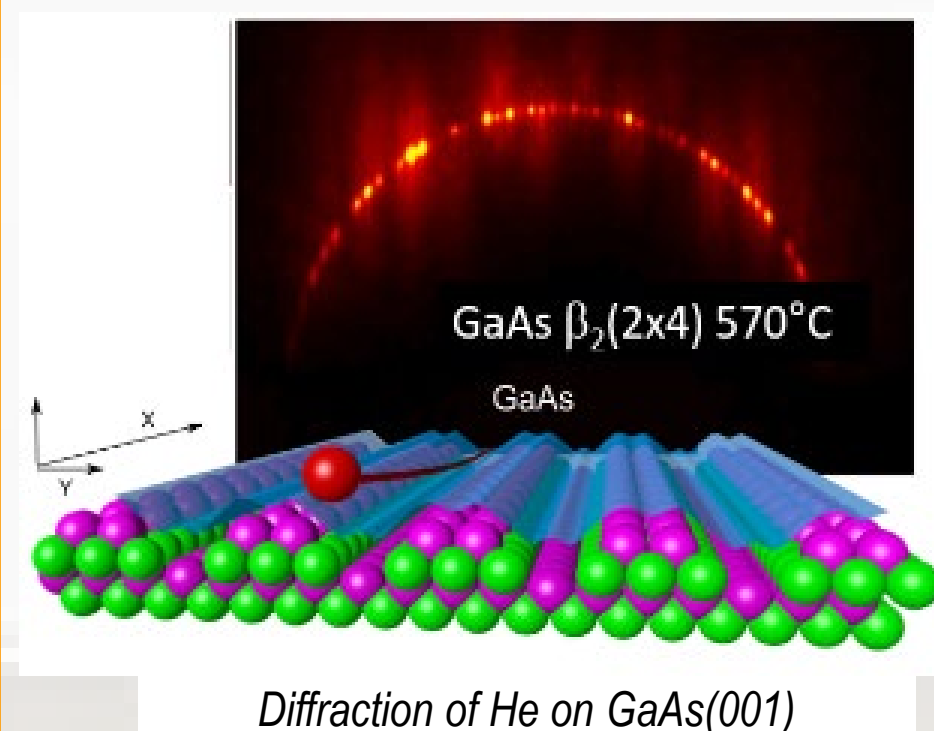
### Fast Atom Diffraction

Structural properties of crystalline surfaces – growth modes of thin films

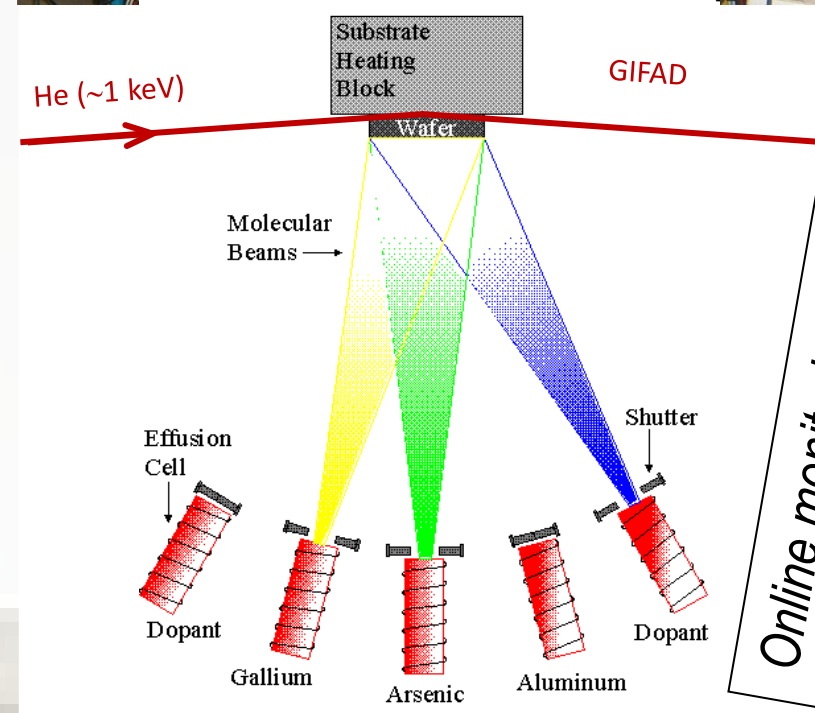
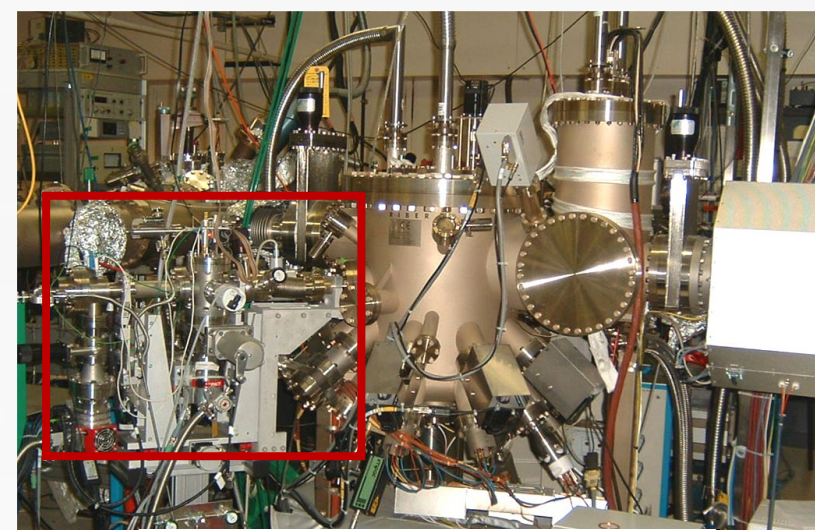
Philippe RONCIN

#### Scientific Topics

- Surface reconstructions, Phase transitions,
- Growth modes of semi-conductors and thin films
- Fundamental Processes, theoretical models for elastic and inelastic diffraction of fast atoms,
- Origins of decoherence in the scattering process

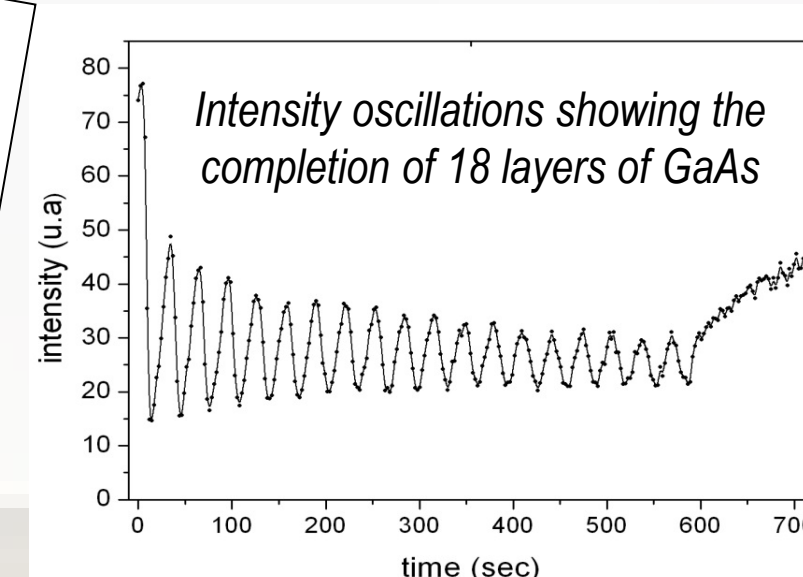


Diffraction of He on GaAs(001)

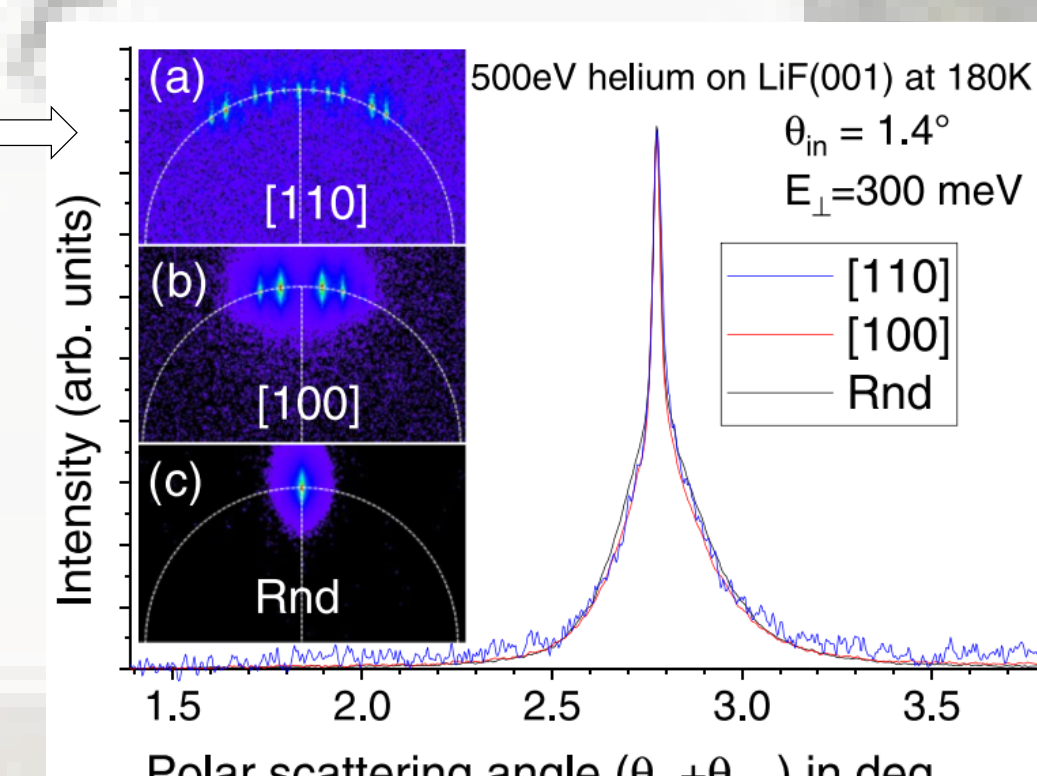


#### Techniques

Grazing-incidence fast atom diffraction (GIFAID) enables the profile of the density of states of the valence electrons above the surface atoms to be probed in the same way as an AFM. The Lamb-Dicke probability of recoilless emission explains that a projectile can be scattered from the surface without inducing a single vibrational transition. The inelastic diffraction is sensitive to the movement of the surface atoms.



The polar scattering profile does not depend on the crystallographic direction. It is sensitive to the attractive forces to the surface and to the vibration amplitude.



**Collaborations :** INSP-Paris, CSIC-Madrid, Lanzhou

### Nano-architectures of hybrid molecular interfaces

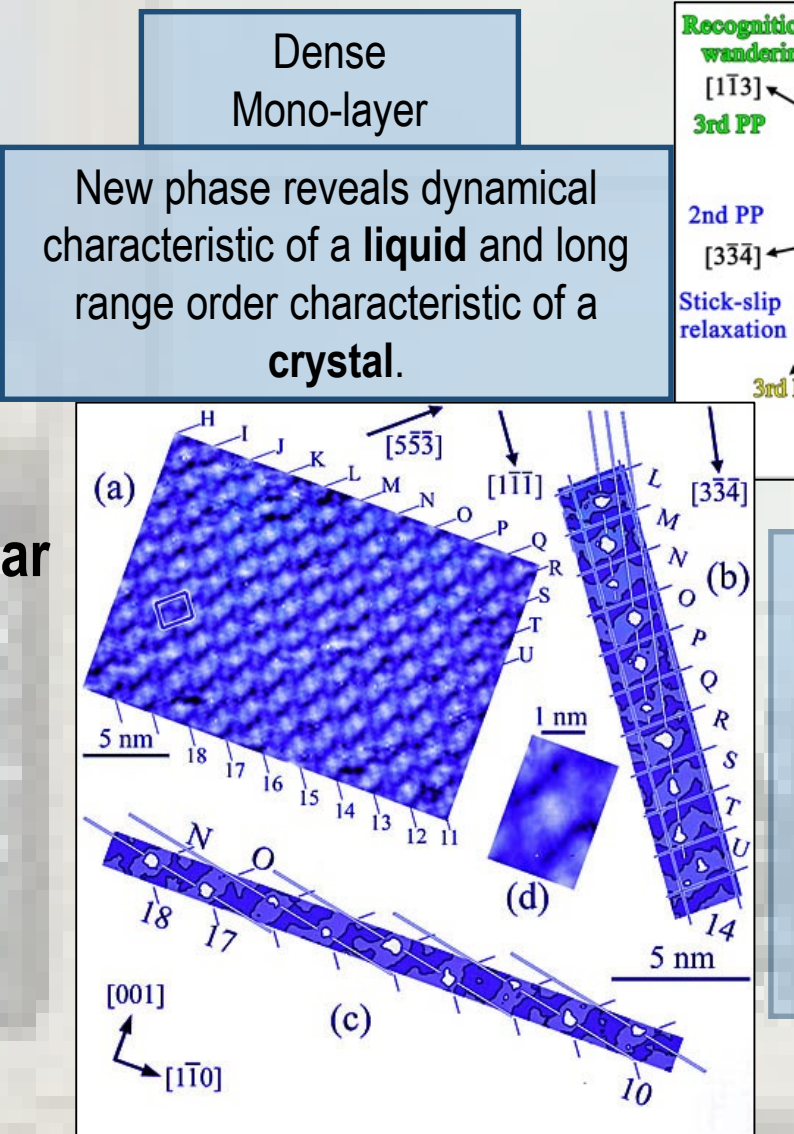
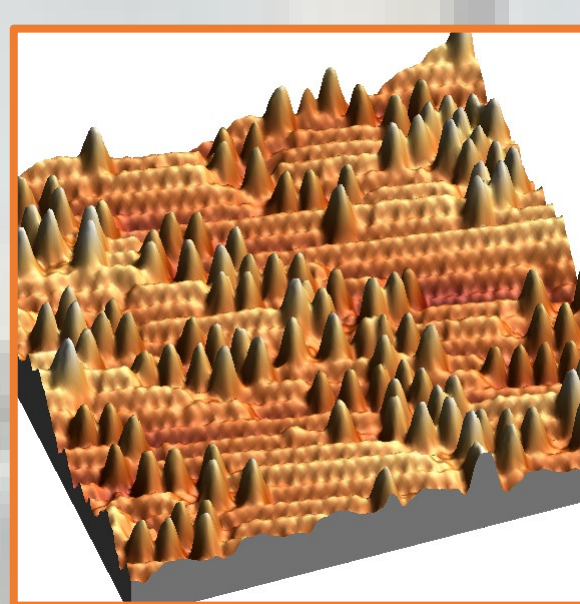
Laurent GUILLEMOT, Kirill BOBOV

#### Scientific Topics

- Master new organic-inorganic interfaces for Nanofabrication
- Probe how controlling the interface structure influences the electronic, optical, ... properties
- Achieve long-range ordered epitaxial molecular layers in thermal equilibrium.

#### Application fields

**Molecular Electronics:** OTFTs (Org. Thin Film Transistors), OLEDs (Org. Electroluminescent Diodes), OPVC (Org. Photovoltaic Cells)



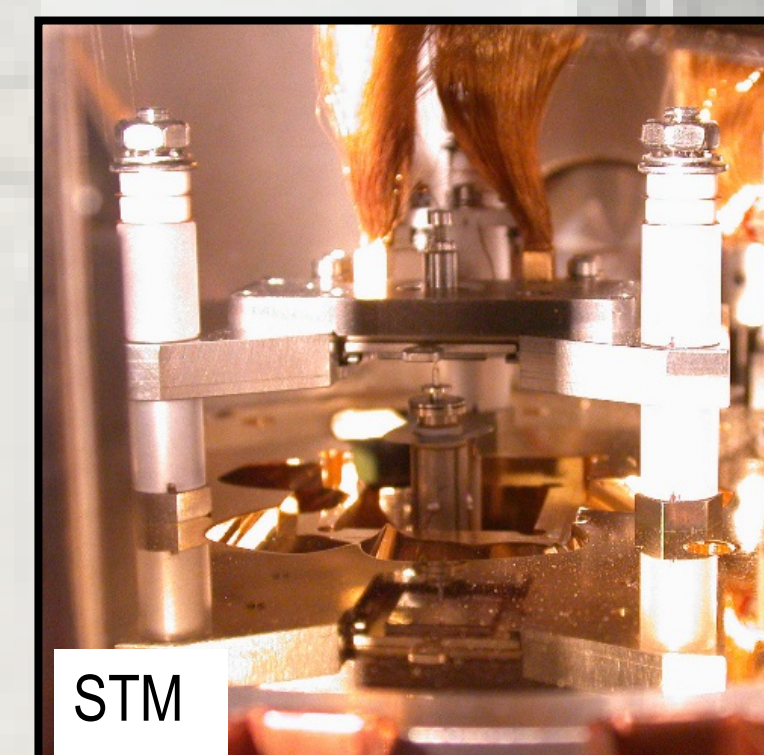
**Dense Mono-layer**  
New phase reveals dynamical characteristic of a liquid and long range order characteristic of a crystal.

**Multi-layer structure**  
New kind of interface: Dynamic state showing self assembling epitaxially related to the substrate, in thermal equilibrium.

**Growth & ordering of C<sub>60</sub> on Perylene multilayers**  
Assembly of  $\pi$ -stack molecular columns, with long-range spatial coherence reveals a « complete epitaxy »

#### Techniques

**STM** « Atomic-scale imaging »  
**XPS/UPS** « Probing the electronic properties »



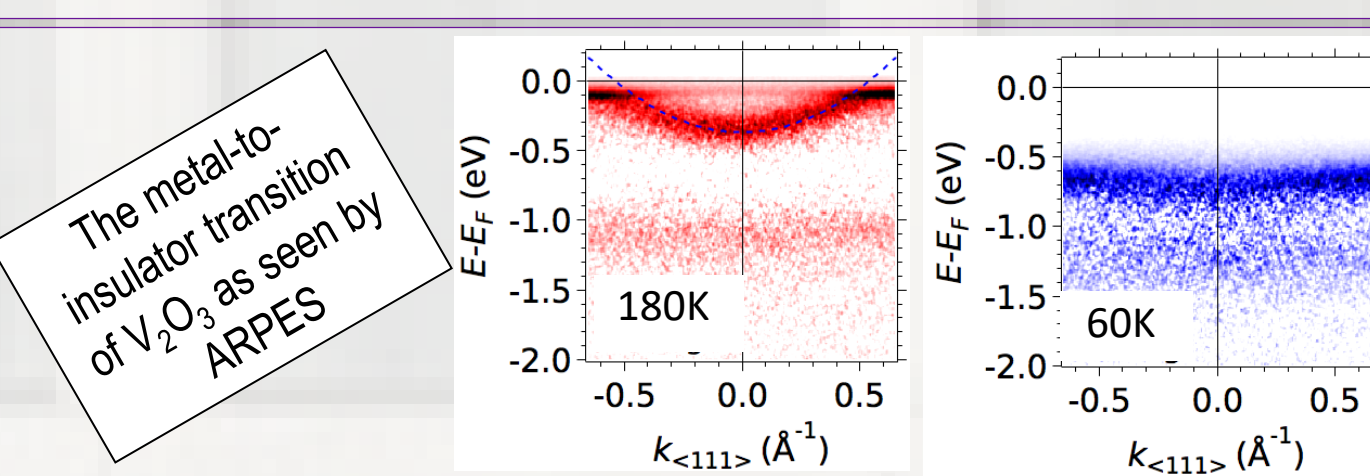
### Strongly correlated electron systems & Quantum materials

Emmanouil FRANTZESKAKIS, Franck FORTUNA, Andrés SANTANDER-SYRO

#### 2 Scientific Topics

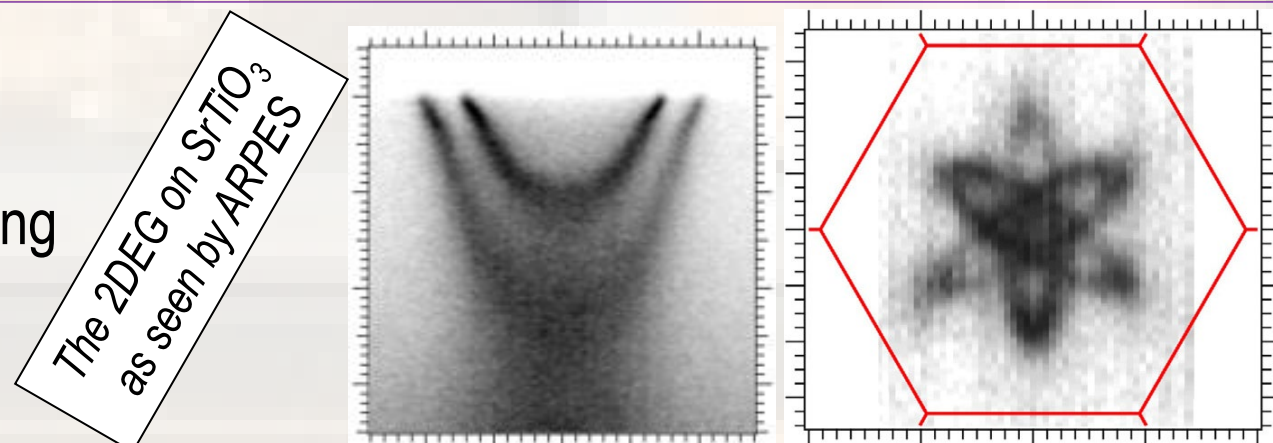
**1) Novel 2D Electron Gases on functional oxides:** At the forefront of condensed matter science and technology, we have discovered 2DEGs on numerous functional oxides such as SrTiO<sub>3</sub> (the "silicon" of functional oxides), BaTiO<sub>3</sub>, TiO<sub>2</sub>, SnO<sub>2</sub>, ZnO. These 2DEGs offer the possibility to explore new physics emerging from electron correlations and low-dimensional confinement.

[e.g. A. F. Santander-Syro et al. *Nature* 469, 189 (2011); E. Frantzeskakis et al. *J. El. Spectr.* 219, 16 (2017); T. C. Rödel et al. *Adv. Mater.* 28, 1976 (2016); Dai et al., *Phys. Rev. B* 101, 085121 (2020)]



**2) Correlated-electron materials:** At the forefront of quantum physics, we explore systems with strong interactions that lead to competing ground states, quantum phase transitions & exotic order parameters. For example, we have experimentally monitored the mechanisms behind the phase transitions of two paradigmatic materials: the heavy-fermion compound URu<sub>2</sub>Si<sub>2</sub> and the Mott-Hubbard insulator V<sub>2</sub>O<sub>3</sub>.

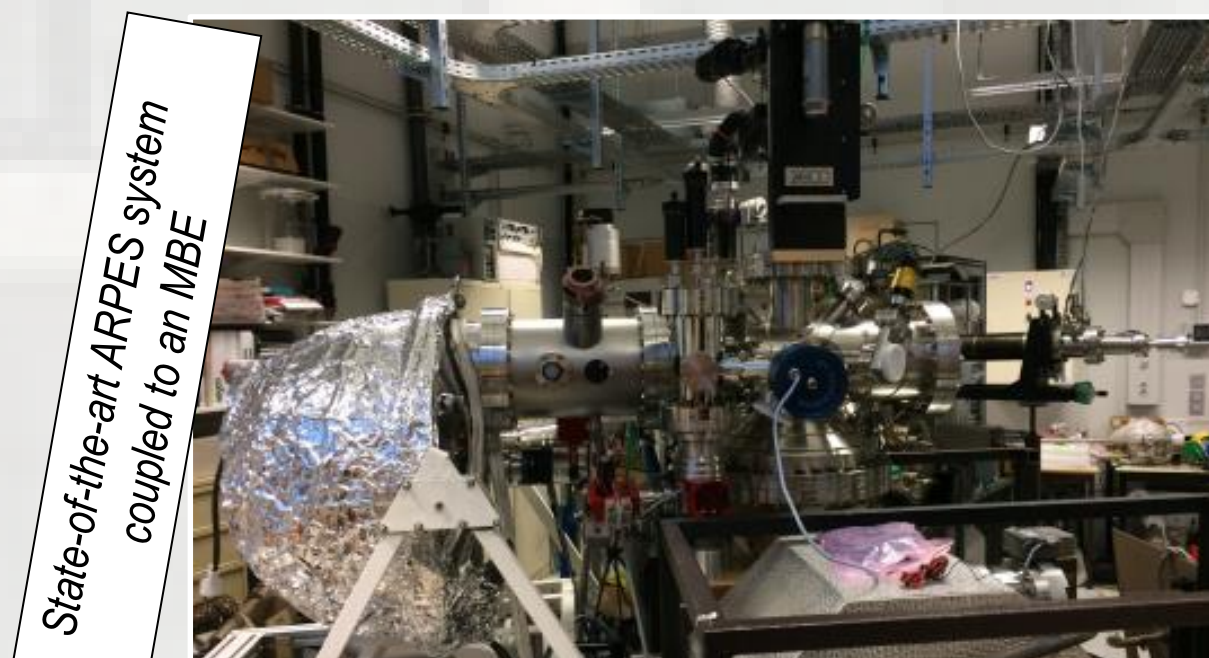
[e.g. M. Thees et al. *Sci. Adv.* 7, eabj1164 (2021); C. Bareille et al. *Nat. Commun.* 5, 4326 (2014); E. Frantzeskakis et al. *PNAS* 118, e2020750118 (2021)]



The 2DEG on SrTiO<sub>3</sub> as seen by ARPES

#### Techniques

**Angle Resolved PhotoEmission Spectroscopy (ARPES)**  
**X-ray Photoemission Spectroscopy (XPS)**  
**Molecular Beam Epitaxy (MBE) with LEED, RHEED, AES**

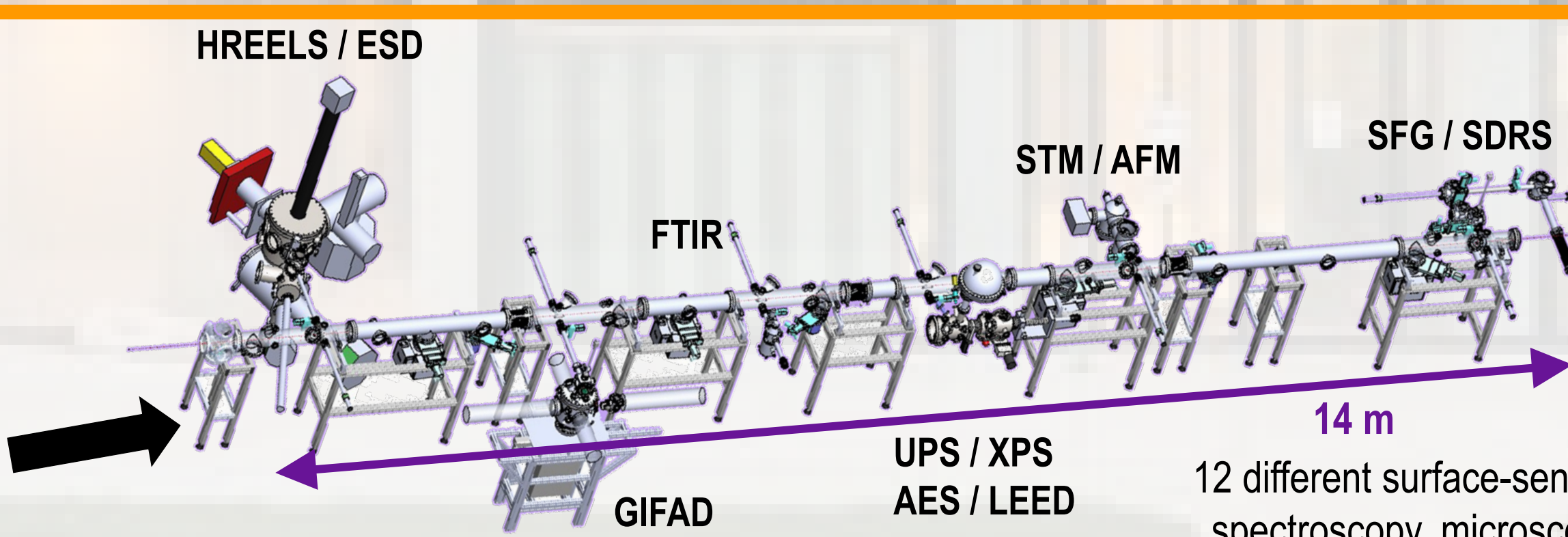


#### Collaborations

ISSP (Tokyo), IMRAM (Tohoku), Hiroshima Synchrotron, Univ. California (San Diego), MagLab (Florida), CNEA (Argentina), Univ. Würzburg, DIPAC (San Sebastian), C2N, CRISMAT, NEEL, LPS, SOLEIL

### Experimental Platforms

A wide range of complementary techniques for surface analysis ... interconnected by a UHV tunnel of 14m



A Focused Ion Beam Scanning Electron Microscope (FIB-SEM) for surface nanostructuring

