CORUS: a cryo nano bio-imaging beamline for ALBA-II

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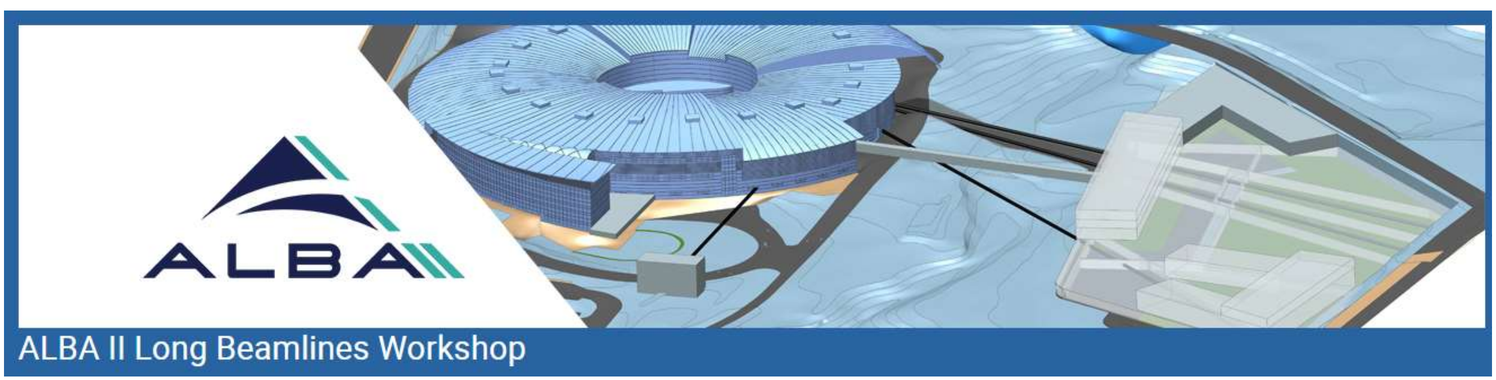
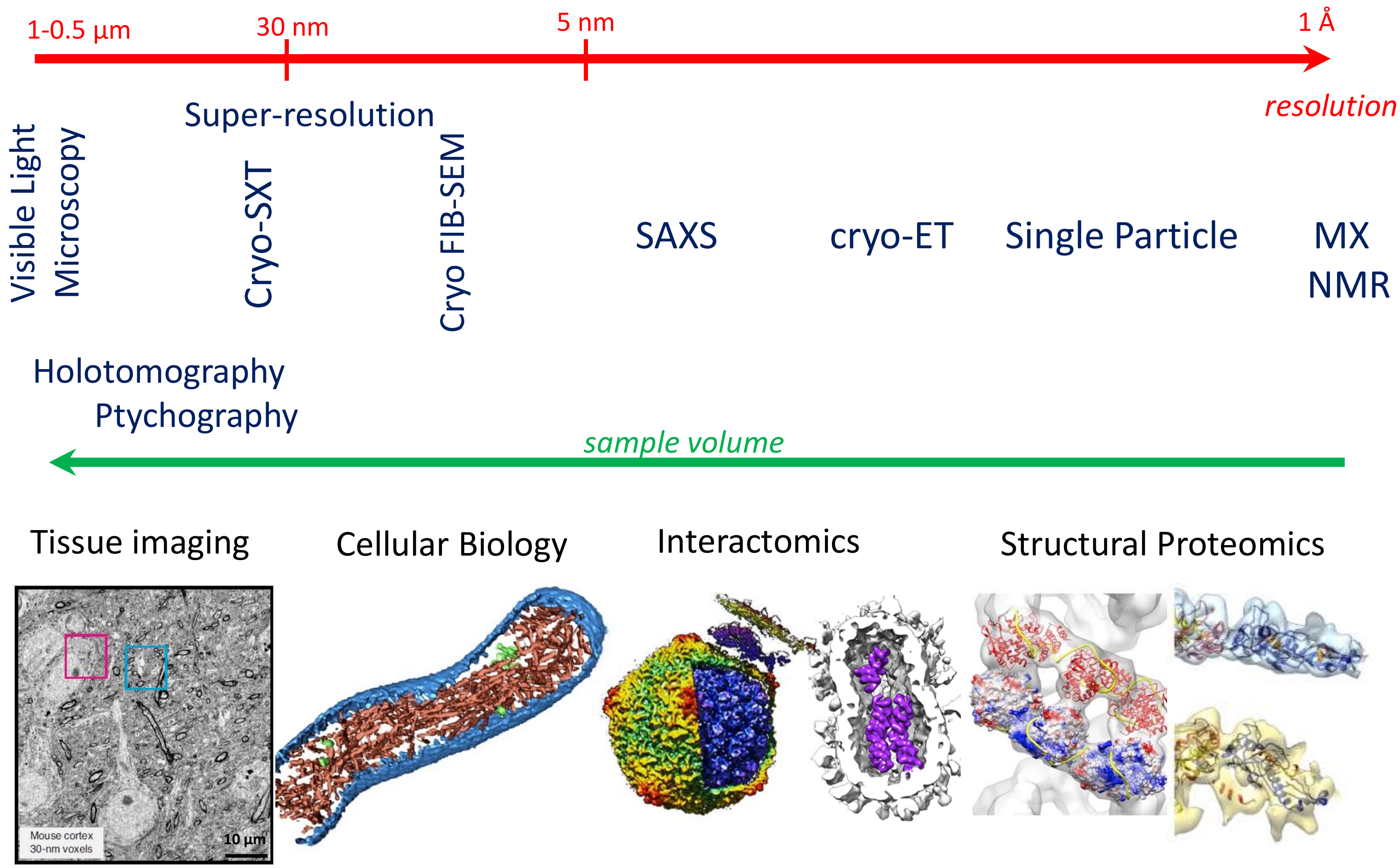
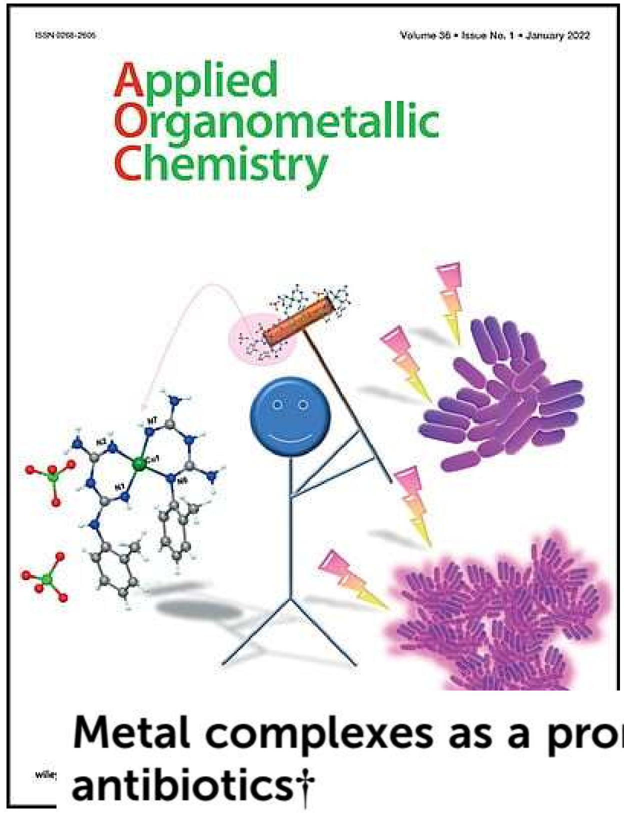
ALBA II Long Beamlines Workshop
15th Nov 2022, Barcelona

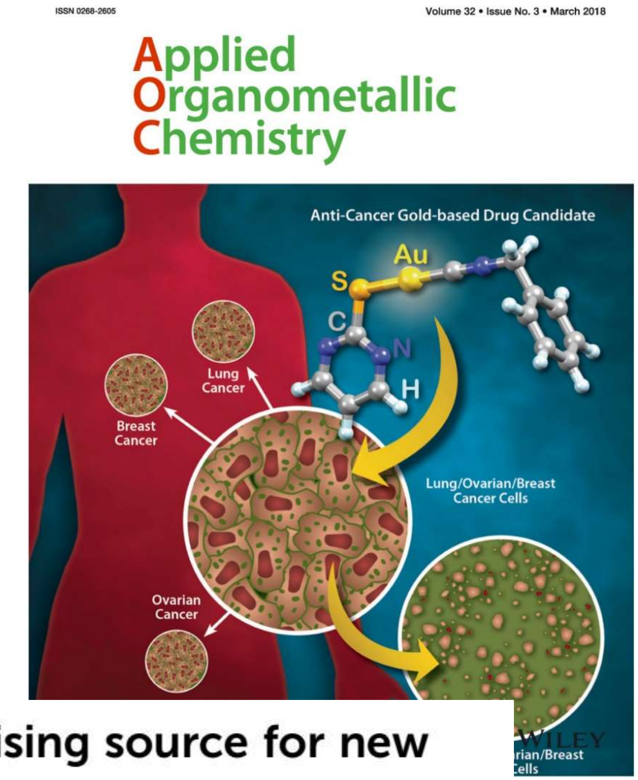


Structural Biology



Chemical imaging





Metal complexes as a promising source for new antibiotics†

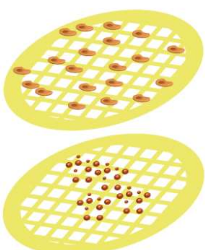
Angelo Frei,[‡*a] Johannes Zuegg,[‡a] Alysha G. Elliott,[a] Murray Baker,[b] Stefan Braese,[cd] Christopher Brown,[e] Feng Chen,[f] Christopher G. Dowson,[g] Gilles Dujardin,[h] Nicole Jung,[cd] A. Paden King,[i] Ahmed M. Mansour,[j] Massimiliano Massi,[k] John Moat,[g] Heba A. Mohamed,[l] Anna K. Renfrew,[m] Peter J. Rutledge,[e] Peter J. Sadler,[f] Matthew H. Todd,[mn] Charlotte E. Willans,[l] Justin J. Wilson,[i] Matthew A. Cooper[a] and Mark A. T. Blaskovich[*a]

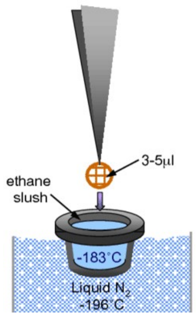
Cryopreservation

PLUNGE FREEZING

Well stablish method already implemented at ALBA

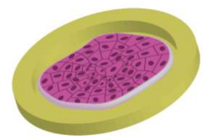
Cell monolayers
Purified samples

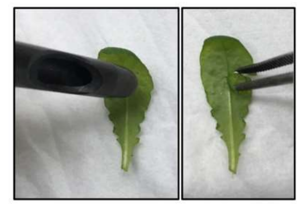


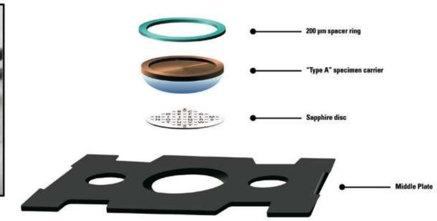


HIGH PRESSURE FREEZING

Tissue



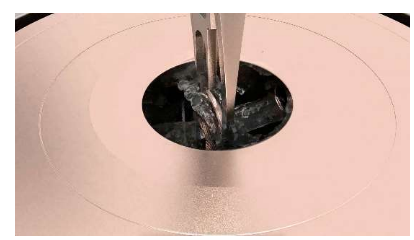




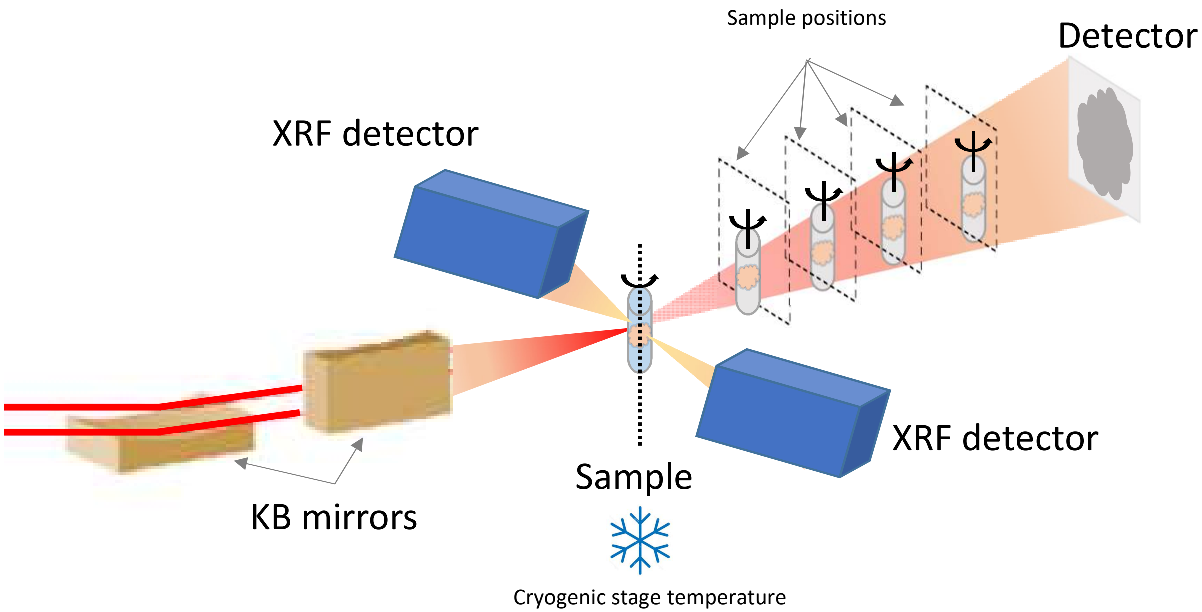
New approaches for cell vitrification under development:

Linkam: CRYOGENIUM

Jet vitrification



CORUS: cryo nano bio-imaging



ES1: "nanoImag"

- 30 nm focus: spatial resolution < cell organelle size
- Cryogenic capabilities & **multiple sample loading**: *increase throughput*
- 3D cryo-nanoXRF: endo/exogenous **elements (ppm)** in whole cells, tissue sections
- 3D phase-contrast (holotomography & ptychography) in organoids, tissue samples

Energies:
10 keV → low Z (endogenous) elements
20 keV → Ptychography (due to flux) and holotomo
27 keV → high transmission and interesting exogenous elements

ES2: "nanoSpec"

- 50-100 nm focus : spatial resolution < cell organelle size
- Cryogenic capabilities
- nanoXANES (4 to 25.5 keV, depending on the optics) → chemical state of elements in whole cells, organoids, tissue sections

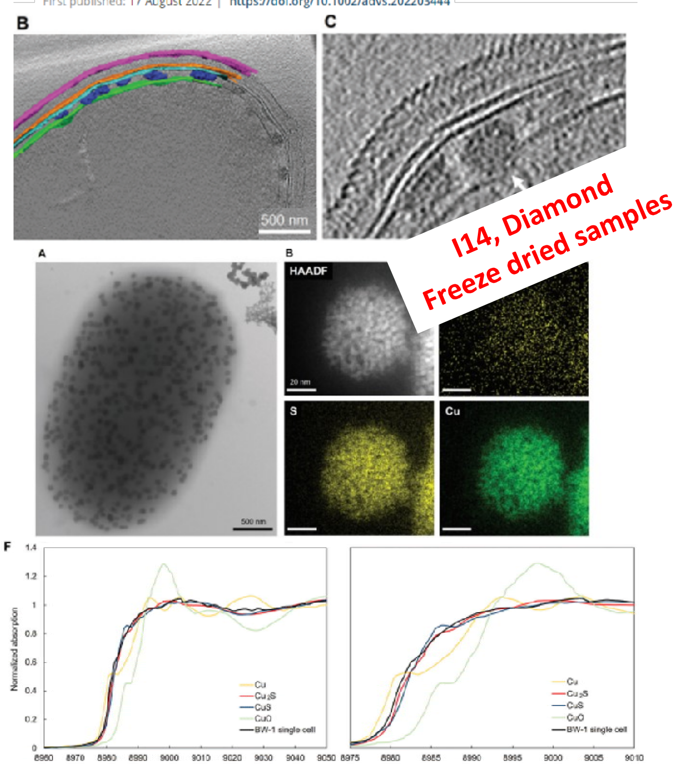
nanoXANES:
biological controlled mineralization

RESEARCH ARTICLE — ADVANCED SCIENCE — www.advancedscience.com

Periplasmic Bacterial Biomineralization of Copper Sulfide Nanoparticles

*Yeseul Park, Zohar Eyal, Péter Pekker, Daniel M. Chevrier, Christopher T. Lefèvre, Pascal Arnoux, Jean Armengaud, Caroline L. Monteil, Assaf Gal, Mihály Pósfai, and Damien Faivre**

First published: 17 August 2022 | https://doi.org/10.1002/advs.202203444



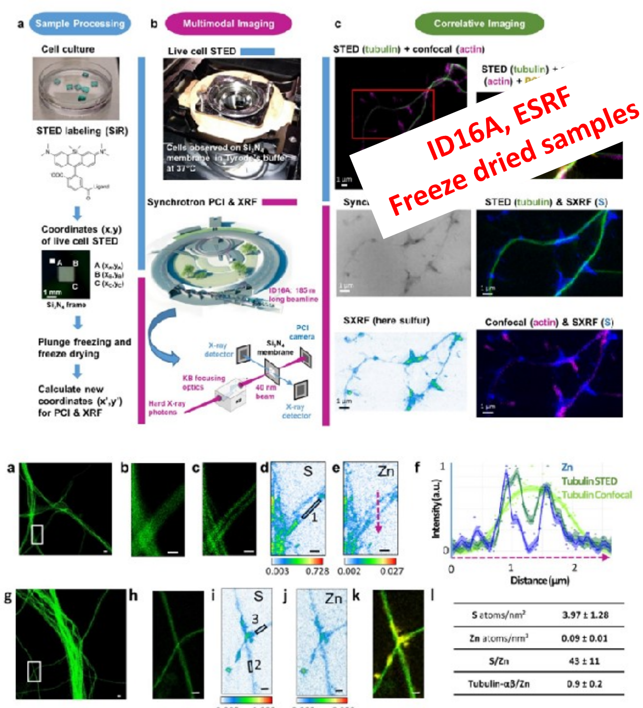
Hard X-ray Fluorescence (XRF):
Chemical imaging in neurons

eLife

Correlating STED and synchrotron XRF nano-imaging unveils cosegregation of metals and cytoskeleton proteins in dendrites

Florelle Domart[1,2,3], Peter Cloetens[4], Stéphane Roudeau[1,2], Asuncion Carmona[1,2], Emeline Verdier[3], Daniel Choquet[3,5†], Richard Ortega[1,2†*]

Dec 8, 2020 · https://doi.org/10.7554/eLife.62334



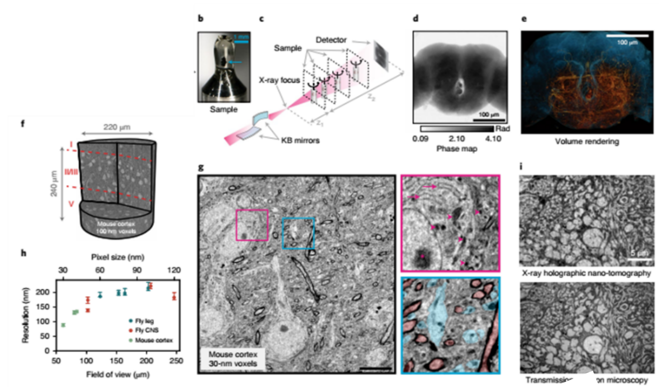
Phase Contrast Imaging,
holotomography:
Nervous system structure
mapping

nature neuroscience — TECHNICAL REPORT — https://doi.org/10.1038/s41593-020-0704-9

Dense neuronal reconstruction through X-ray holographic nano-tomography

Aaron T. Kuan[1,8], Jasper S. Phelps[1,2,8], Logan A. Thomas[1], Tri M. Nguyen[1], Julie Han[1], Chiao-Lin Chen[3], Anthony W. Azevedo[4], John C. Tuthill[4], Jan Funke[5], Peter Cloetens[6], Alexandra Pacureanu[1,6] and Wei-Chung Allen Lee[7]

14 September 2020 https://doi.org/10.1038/s41593-020-0704-9



ID16A, ESRF
Dried samples

Correlation with other imaging techniques

- CORRELATION:
  - With infrastructure already at ALBA:

    MIRAS (UV), FAXTOR (uCT), MISTRAL (cryoSXT), Visible Light Microscopy (3D-cryoSIM)
  - With other resources:

    CryoET, cryoFIB-SEM, Visible light microscopy (cryoconfocal, live imaging)
- very important especially for XRF since it lacks for sensitivity for low Z elements (biological structures).

XRF and cryoSXT: Intracellular metal tracking

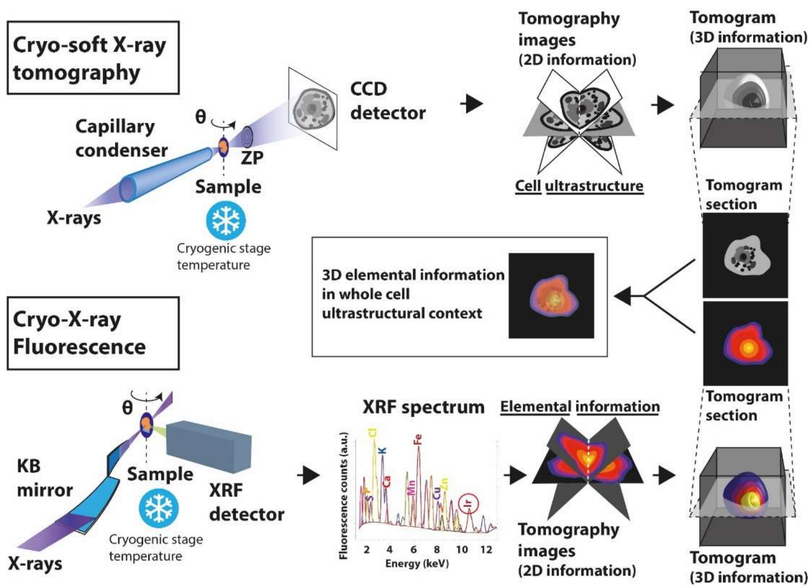
ID16A, ESRF
MISTRAL, ALBA

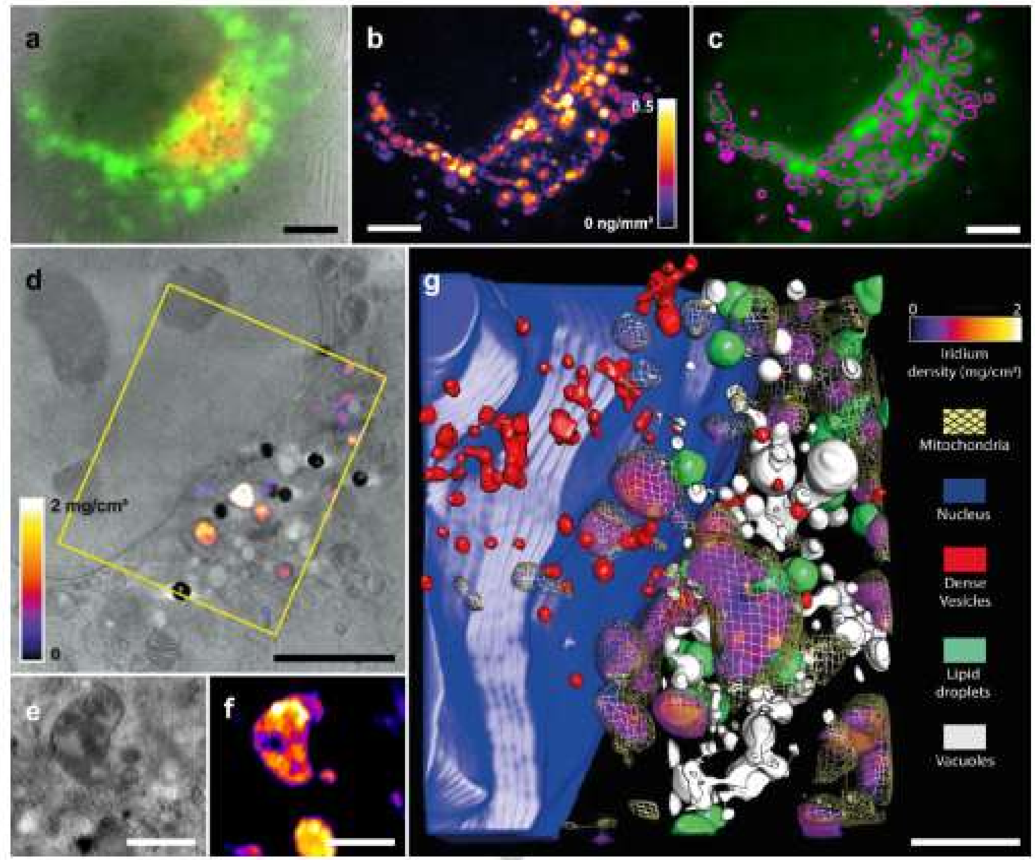
Angewandte Chemie International Edition
GDCh A Journal of the German Chemical Society

Unambiguous Intracellular Localization and Quantification of a Potent Iridium Anticancer Compound by Correlative 3D Cryo X-Ray Imaging

Dr. José Javier Conesa, Ana C. Carrasco, Dr. Vanessa Rodríguez-Fanjul, Dr. Yang Yang, Dr. José L. Carrascosa, Dr. Peter Cloetens, Dr. Eva Pereiro, Dr. Ana M. Pizarro

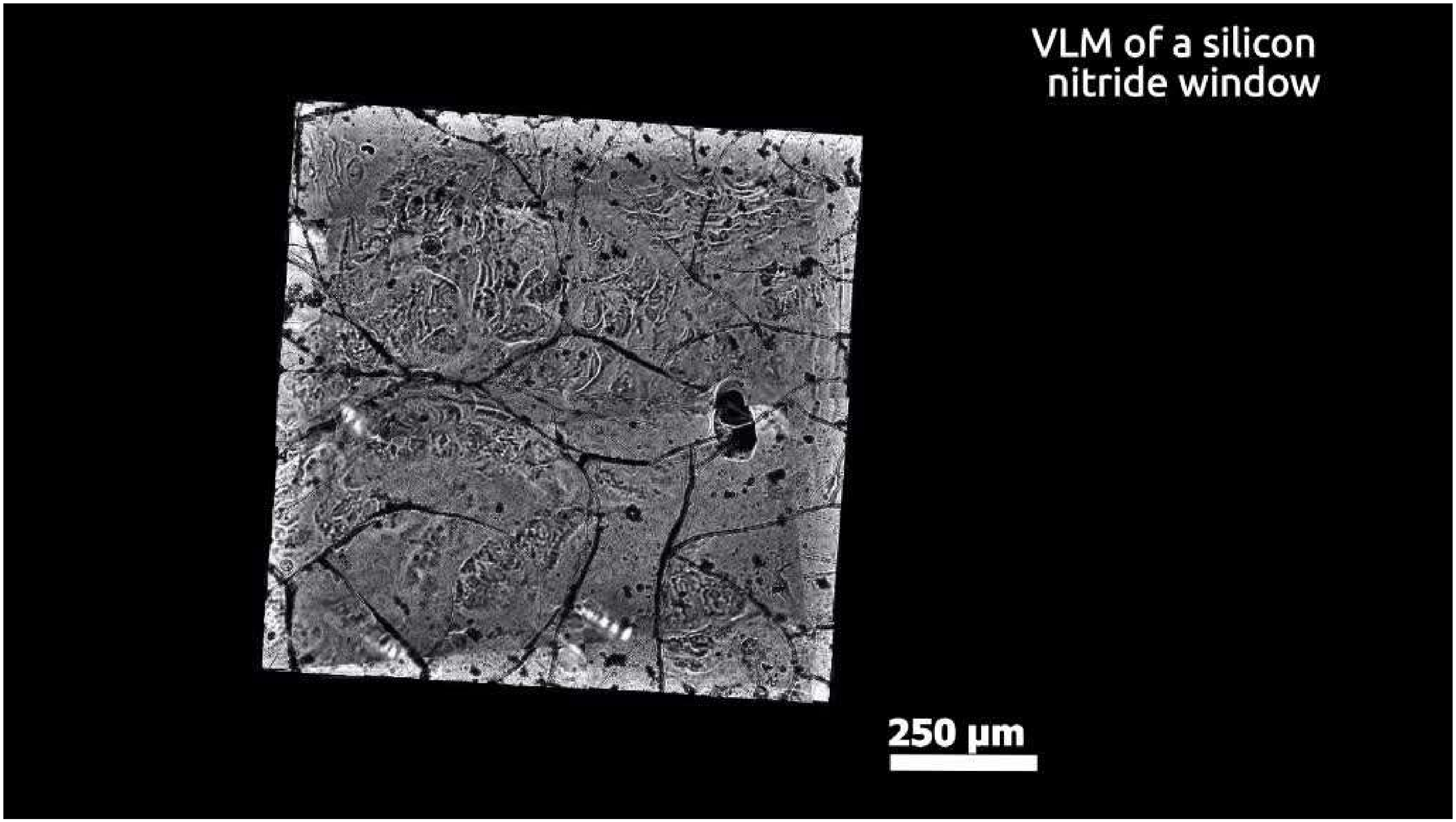
First published: 07 November 2019 | https://doi.org/10.1002/anie.201911510





XRF and cryoSXT: Intracellular metal tracking

ID16A, ESRF
MISTRAL, ALBA



Conesa *et al.*, 2020, Angewandte. doi: 10.1002/anie.201911510.

Summary

Unique (to the best of our knowledge):
- High flexibility energy selection (XRF endo/exogenous elements, transmission)
- Exploiting coherence of the new source at ALBA-II
- Multimodal cryo X-ray imaging (complementarity of both endstations)
- Multiple sample loading and exchange (**user friendly, increase throughput**)
- Cryogenic conditions, **including XANES**
- Correlation with other methods (including implemented facilties at ALBA)
- Oversubscription in EU related beamlines

Challenges
- Tight temperature control for nano focusing
- Data analysis developments at ALBA to optimize processing pipelines
- Beam stability for XANES at nanoSpec

Acknowledgments

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Alessandra Patera (ALBA)
Judith Juanhuix (ALBA)
Alberto Mittone (ALBA)
Frédéric Jamme (SOLEIL)
José Javier Conesa Muñoz (CNB)

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	Pierre Legrand	SOLEIL, France
	Pierre Montaville	SOLEIL, France
	Christophe Chevalier	INRAe
	Murielle Masi	INSERM, Aix-Marseille University