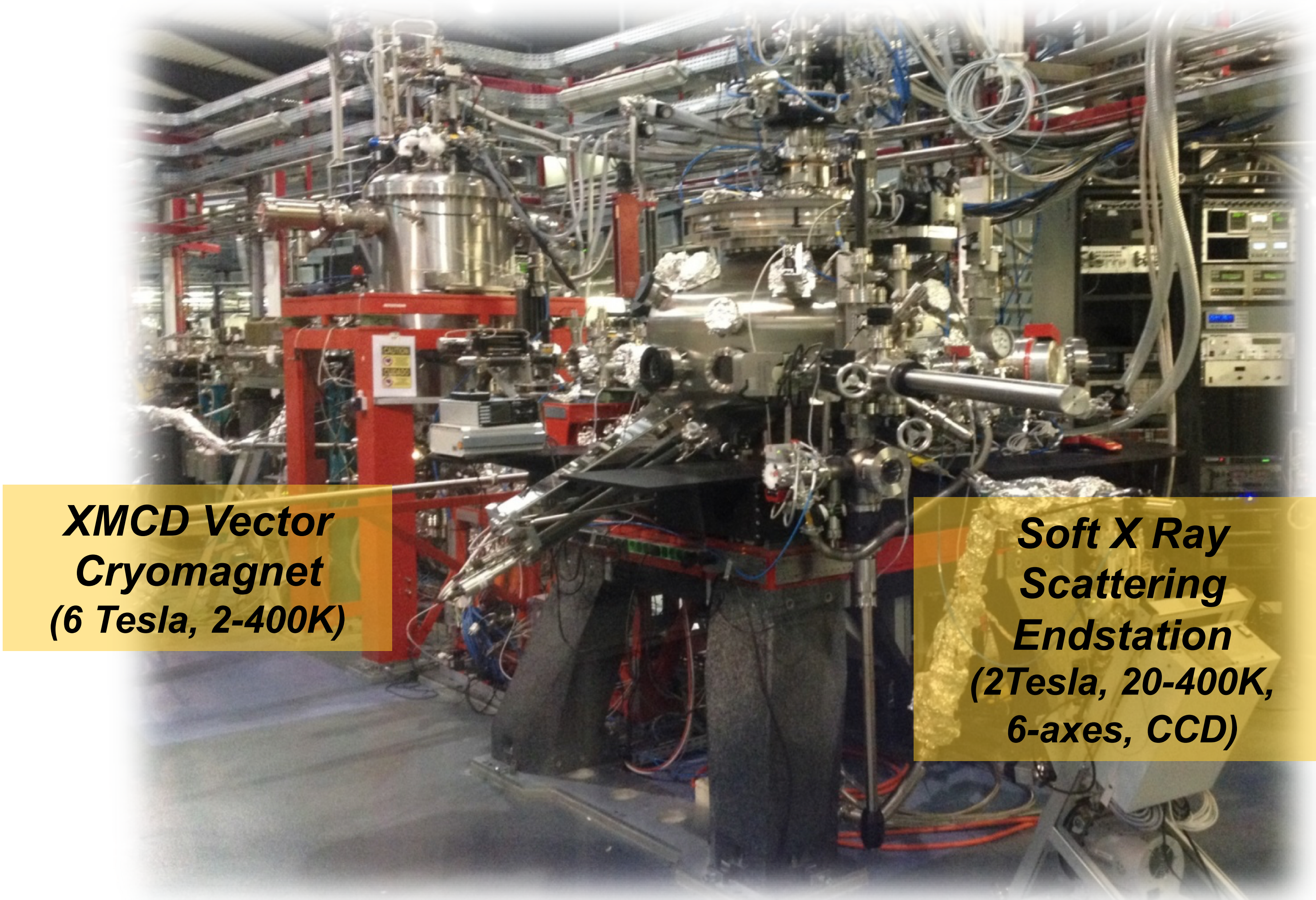
ALBA beamline for soft X-Ray polarization dependent Absorption Spectroscopies (XMCD, XMLD) and Resonant Scattering (80-4000 eV)



Manuel Valvidares - “BOREAS” BL29 at ALBA

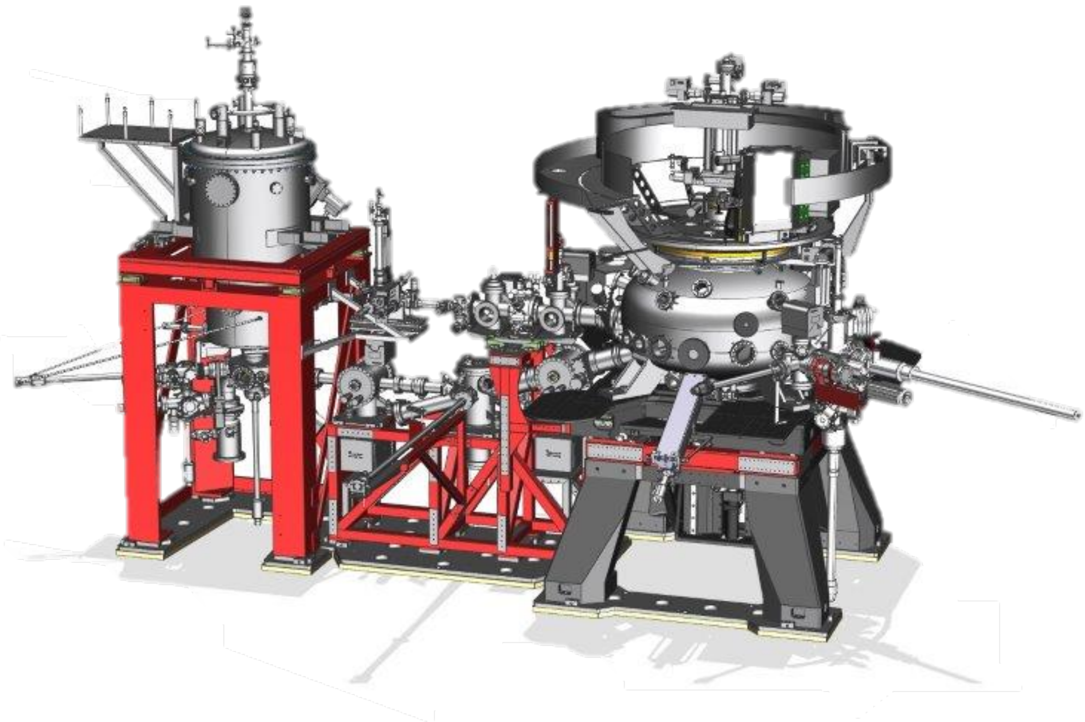
https://www.cells.es/en/beamlines/bl29-boreas

Beamline 29 in brief

- Variable polarization APPLE-II source, 80-4000eV energy range
- 3 VLS plane grating (LEG,MEG,HEG) + 2 spherical mirrors (fixed included angle)
- Adjustable monochromator entrance and exit slits
- KB mirror with adjustable focusing (about 80x30 µm @ES1, 250x150 µm @ES2)

- HECTOR High-field (6T-2T) vector magnet endstation for XAS/XMCD with TEY, TFY, transmission detection modes
  user operation since MAY 2012,
  big re-installation summer 2013
  on-the-fly spectra mid 2014

- MaReS double circle UHV reflectometer for magnetic resonant scattering, with HTS magnet (2T), two detector ams (CCD+diode/CEM),
  started early user operation late 2015, full setup by OCT 2016 (big repair summer 2016), CCD control improved mid 2017



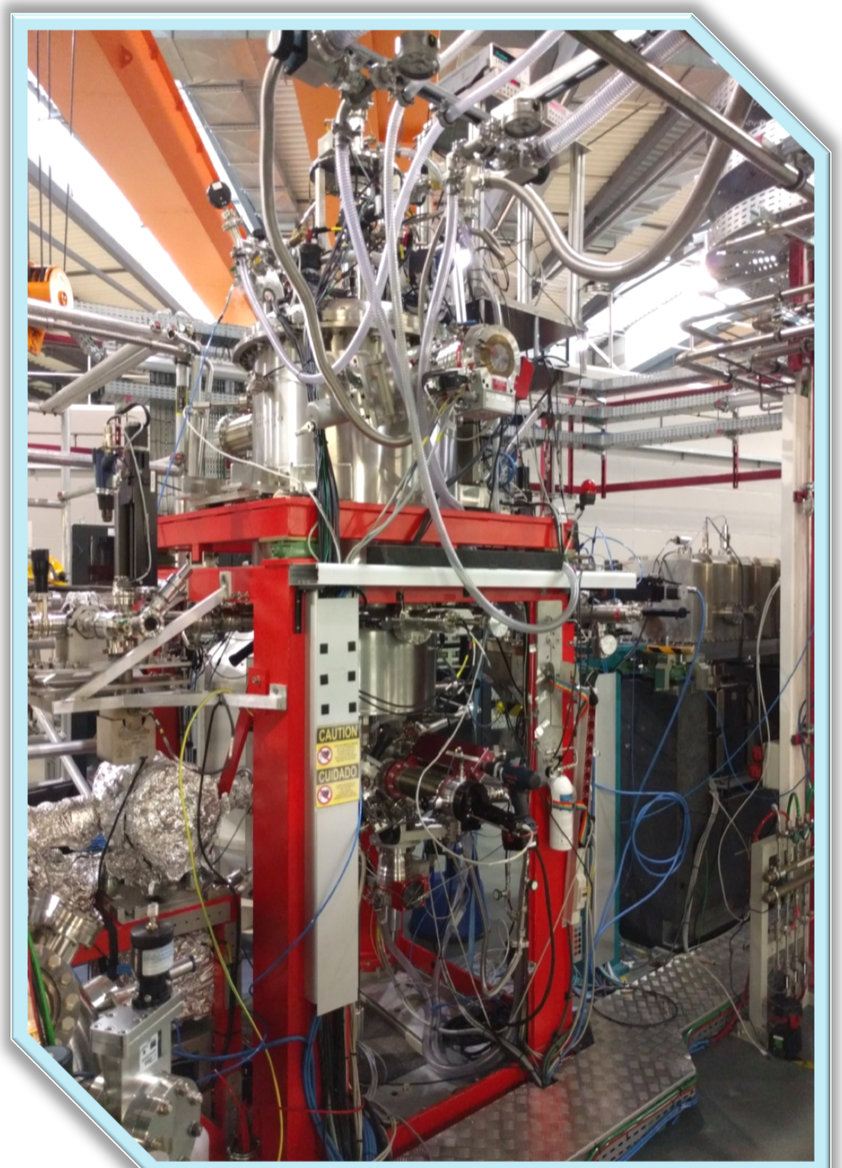
Beamline demand, usage and productivity

CYCLE	TOTAL NUM SUBMITTED PROPOSALS (XMCD, SXRS) *although some use both	% INTERNATIONAL PROPOSALS SUBMITTED	TOTAL PERFORMED PROPOSALS IN CYCLE (*INCLUDES WAITING LIST AND RECOVERED/BUFFER)	PUBLISHED ARTICLES	HIGH IMPACT PUBLICATIONS (IF>7)
2016-1	39 (XMCD=32,SXRS=7)	32% (12/38)	14+1* (XMCD=15, M=4)	9	1
2016-2	24 (XMCD=14, SXRS=10)	45% (10/24)	17 +1* (XMCD=12,M=6)		
2017-1	27 (XMCD=17, SXRS=10)	42% (14/27)	17 +1* (XMCD=10, M=8)	14	6
2017-2	36 (XMCD=30, SXRS=6)	50% (18/36)	19 +2* (XMCD=15, M=6)		
2018-1	31 (XMCD=22, SXRS=9)	48% (15/31)	19+1* (XMCD=13,M=7)	17	8
2018-2	32 (XMCD=27, SXRS=5)	37% (12/32)	16+2* (XMCD=14, M=4)		
2019-1	42 (XMCD=30, SXRS=12)	57% (24/42)	22+1* (XMCD=17 , M=6)	18+2 (Oct2019)	4 (Oct2019)
2019-2	38 (XMCD=26,M=12)	60% (23/38)	18+1 or +2 * (XMCD=13 , M=6)		
2020-1	42 (XMCD=29 , SXRS=13)	64% (27/42)	--	--	--

some selected recent publications (topics)

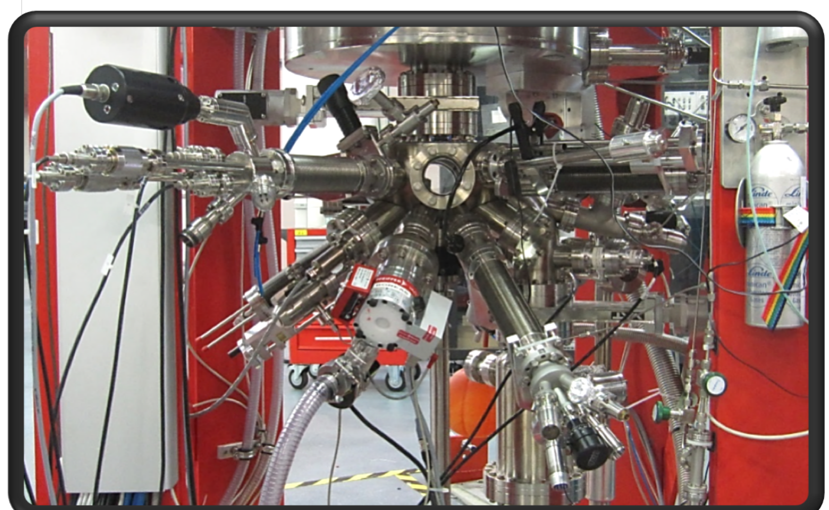
Year	Title	Authors	Journal
2014	Two-Dimensional Electron Gases at $LaAlO_3/SrTiO_3$ Interfaces: Orbital Symmetry and Hierarchy Engineered by Crystal Orientation	D. Pesquera, M. Scigaj, P. Gargiani, A. Barla, J. Herrero-Martín, E. Pellegrin, S. M. Valvidares, J. Gázquez, […], J. Fontcuberta, F. Sánchez, and G. Herranz. *ICMAB-CSIC*	Physical Review Letters 113 156802 (2014)
2016	Emerging Diluted Ferromagnetism in High TC Superconductors Driven by Point Defect Clusters	J. Gazquez, R. Guzman, R. Mishra, E. Bartolome, J. Salafranca, […], T. Puig, and X. Obradors. *ICMAB-CSIC*	Advanced Science, 1500295 (2016)
2017	FePc Adsorption on the Moire Superstructure of Graphene Intercalated with a Cobalt Layer	G. Avvisati, S. Lisi, P.Gargiani , [..], and M. G. Betti. *Rome-La Sapienza, University.*	J. PHYSICAL CHEMISTRY C
2017	Emergent magnetism at transition-metal–nanocarbon interfaces	Fatma Al Ma'Mari, […] B. J. Hickey, and Oscar Cespedes. *LEEDS University.*	PNAS (2017) 10.1073/pnas.1620216114
2017	Graphene-based synthetic antiferromagnets and ferrimagnets	P. Gargiani, R. Cuadrado, H. B. Vasili, M.Pruneda, and M. Valvidares. *ALBA BL29 – Theory group CIN2*	Nature Communications
2018	Imposing long-range ferromagnetic order in rare-earth-doped magnetic topological-insulator heterostructures	L.B. Duffy, A. Frisk, D.M. Burn, N.-J. Steinke, J. Herrero-Martin, A. Ernst, G. van der Laan, and T. Hesjedal. *Oxford University - Daresbury*	Phys. Rev. Materials, 2, 054201 (2018)
2018	Unravelling Dzyaloshinskii-Moriya interaction and chiral nature of Graphene/Cobalt interface	F. Ajejas, A. Gudín, R. Guerrero, M. A. Niño, S. Pizzini, J. Vogel,[…] R. Miranda, P. Perna. *IMDEA Nanociencia*	*Nano Lett. 18, 9, 5364-5372 (2018)*
2018	Resonant X-Ray Holographic Imaging of the Insulator-Metal Phase Transformation in VO_2	L. Vidas C. M. Guenther, […] , S. Eisebitt, and S. Wall, *ICFO*	Nano Lett. 18, 6, 3449-3453 (2018)
2018	Magnetoresistance in Hybrid $Pt/CoFe_2O_4$ Bilayers Controlled by Competing Spin Accumulation and Interfacial Chemical Reconstruction	H. B. Vasili, M. Gamino,J. Gazquez, F. Sanchez, M. Valvidares, P. Gargiani, E. Pellegrin, J. Fontcuberta *ICMAB-CSIC -ALBA BL29*	ACS Appl. Mater. Interfaces 10, 12031–120412018 (2018)
2019	soft X-ray spectroscopy, scattering & imaging studies of skyrmion-hosting compound $Co_8Zn_8Mn_4$	V. Ukleev, Y. Yamasaki, […], Y. Tokura, and T. Arima	Phys. Rev. B 99, 144408 (2019)
2019	Independent Tuning of Optical Transparency Window and Electrical Properties of Epitaxial $SrVO_3$ Thin Films by Substrate Mismatch	M. Mirjolet, H. B. Vasili, L. López-Conesa, S. Estradé, F. Peiró, J. Santiso, F. Sánchez, […] and J. Fontcuberta	Adv. Funct. Mat. 9, 1904238 (2019)

XMCD endstation



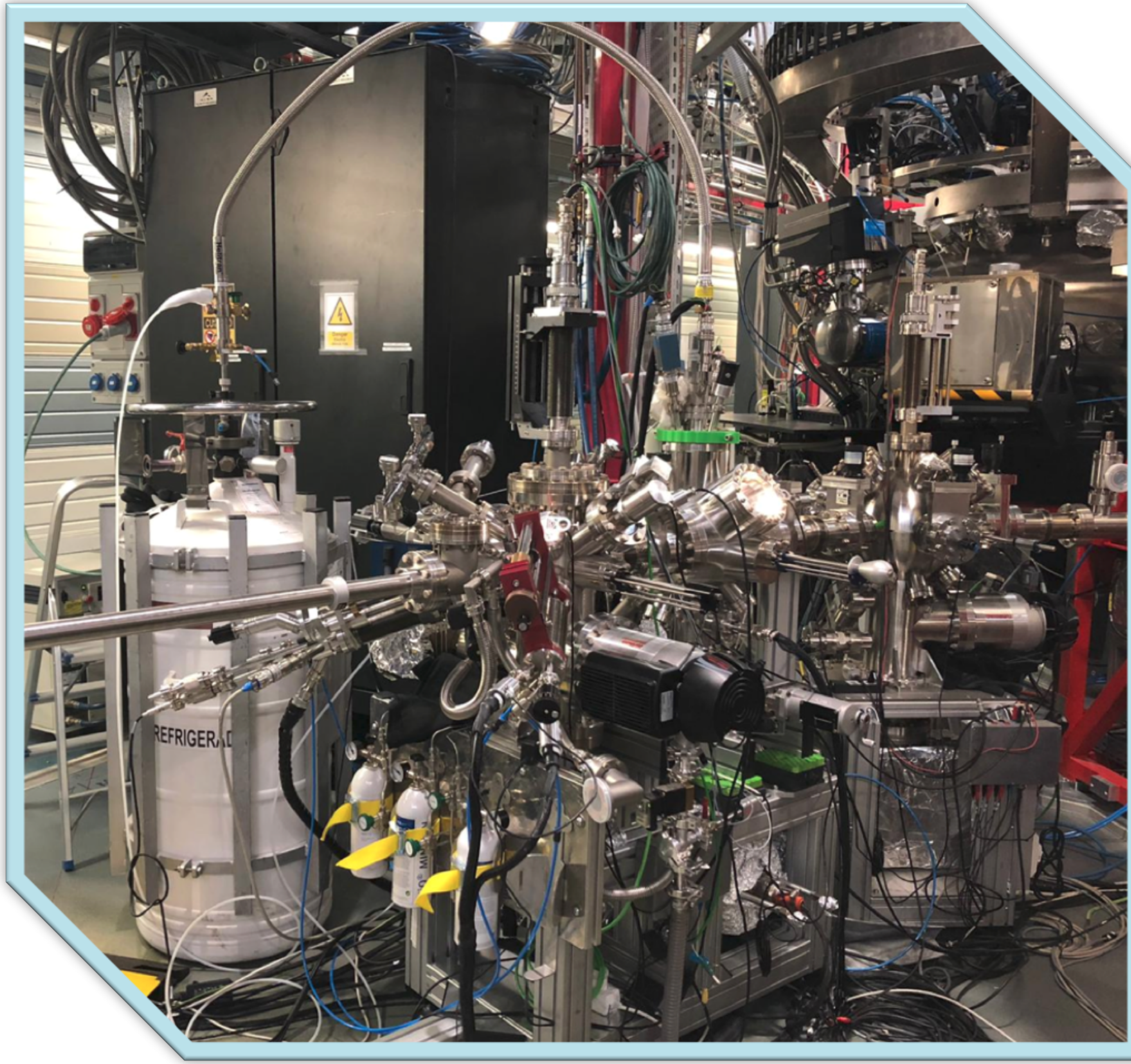
main characteristics

- vector magnet with 6T along beam, 2T 3D mode
- TEY drain current detection (K428)
- TFY, transmission (silicon diodes)
- 4 sample contacts
- VT cryostat, 1.5-370 K
- Complete surface preparation with mini LEED/AES and e-beam heating up to ~2000 C
- In-situ cleaver and scraper
- Large sample holders (~ 20x10 mm)
- SPECS/Omicron plate sample adapters



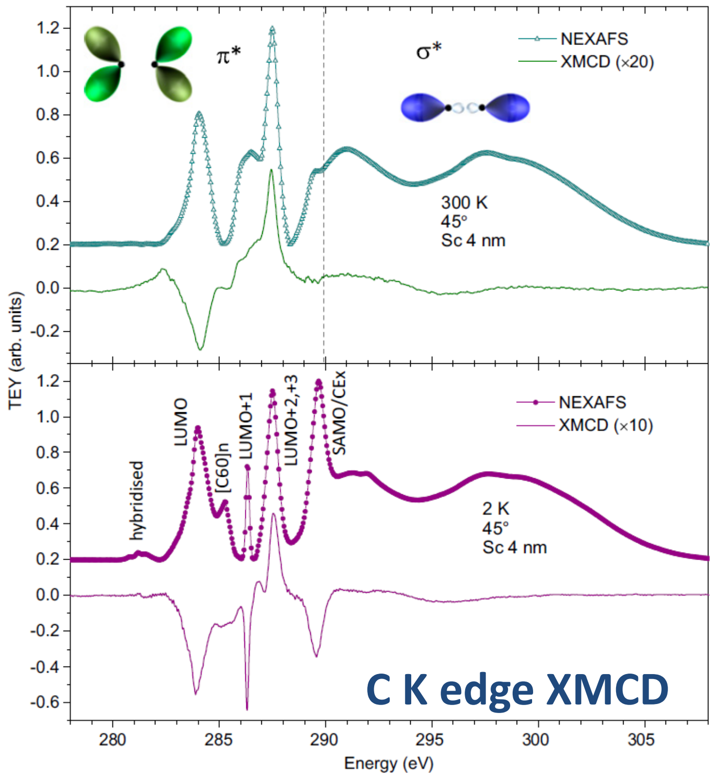
surface science capabilities

- Complete surface preparation LEED/AES, sputtering & e-beam heating, quartz balance
- E-beam evaporator
- Low temperature effusion cells for molecule evaporation
- In-situ rack&pinion transfer to both XMCD and XRMS endstations
- LT STM/AFM Q-Plus (RHK) with independent prep chamber for PhD work
- Glove box with UHV loadlock (missing & desirable)



C magnetism, Cu magnetism,...

Emergent magnetism at transition-metal–nanocarbon interfaces

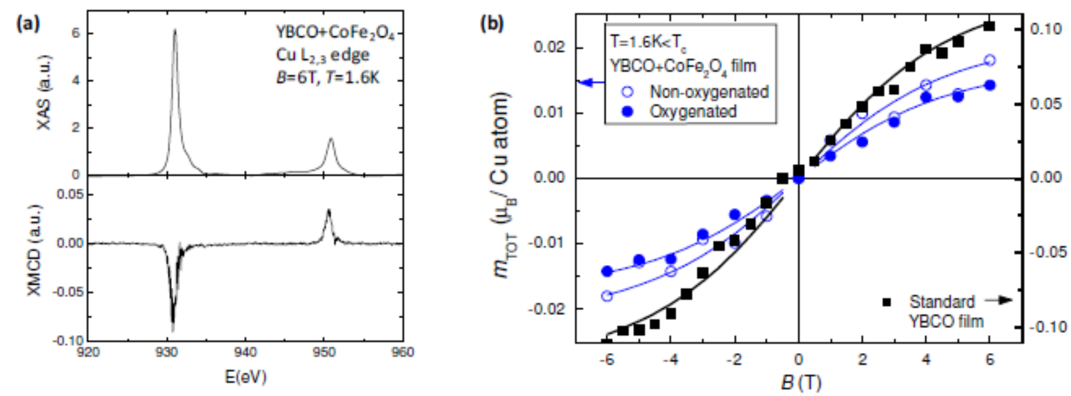


from Fatma Al Ma'Mari et al, PNAS 2017
(Cespedes group, Leeds Univ.)

Copper magnetism in hybrid YBCO thin films with NPs

Goals: enhanced vortex pinning SC materials, fundamental studies of SC/FM

Defect Induced Cu magnetic moment confirmed by element specific XMCD hysteresis loops at Cu L3 absorption edge

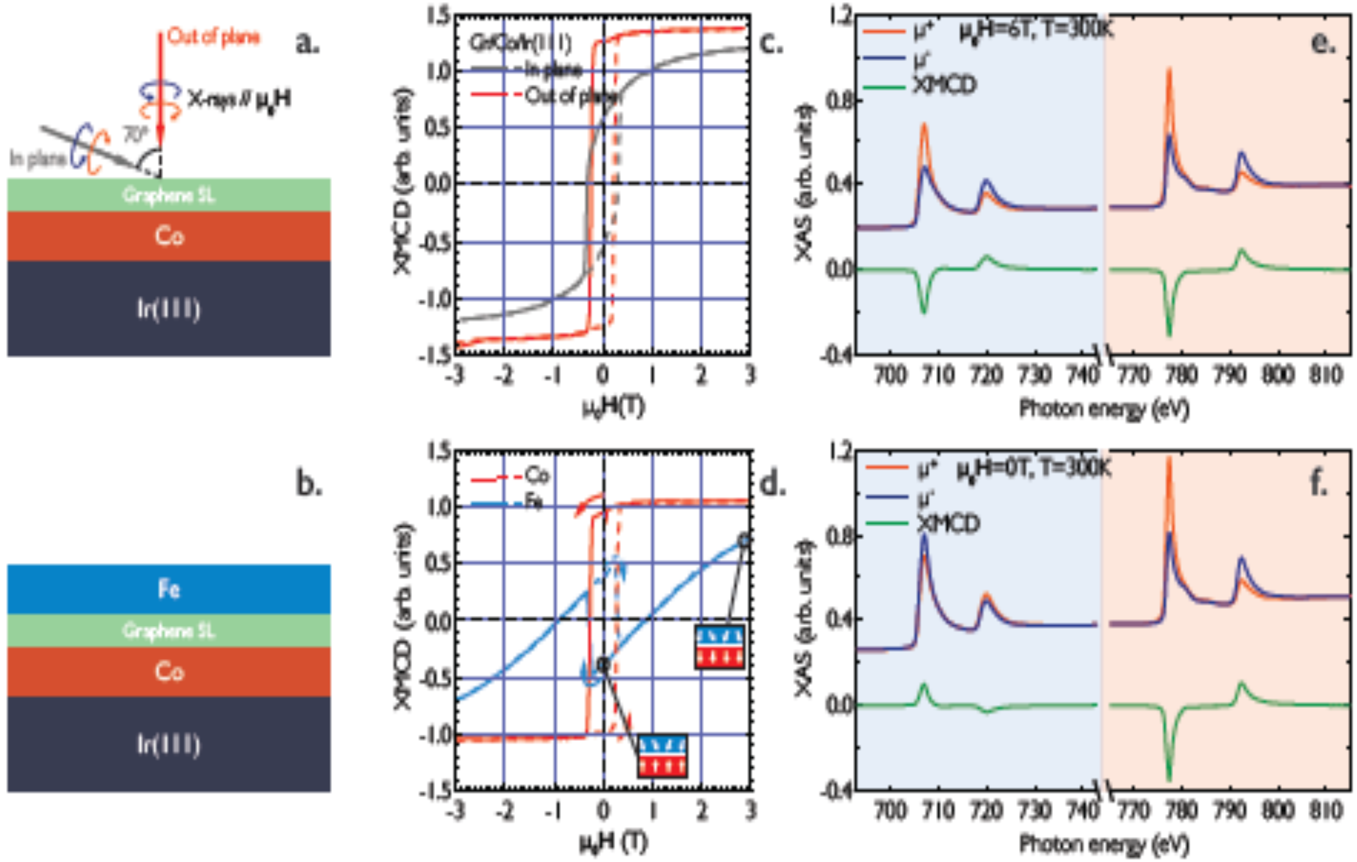


E. Bartolome et al, Adv. Electronic Materials, 2017

Work lead by X. Obradors group from ICMAB institute, Barcelona
Colls.: Univ. Barcelona(NPs), Univ. Ghent&Antwerpen,
I.N. Aragon (TEM), ALBA BL29 (XAS,XMCD), Soleil(XRD & EXAFS)

in-house research: Graphene & 2D

Goal: fundamental studies of Gr/FM nanoscience in the context of graphene spintronics

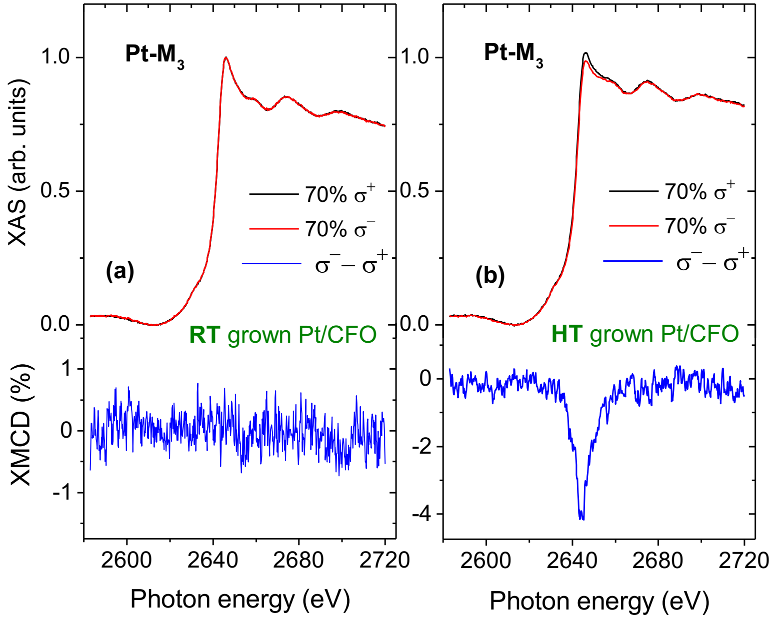


Acknowledgement: Mineco grant (FIS2013-45469-C4-3-R)

Graphene-based synthetic ferrimagnets and antiferromagnets, Nat. Comm. 2017
P. Gargiani*, R. Cuadrado$, H. B. Vasili*, M. Pruneda$, and M. Valvidares*, *:ALBA synchrotron, $:CIN2 CSIC

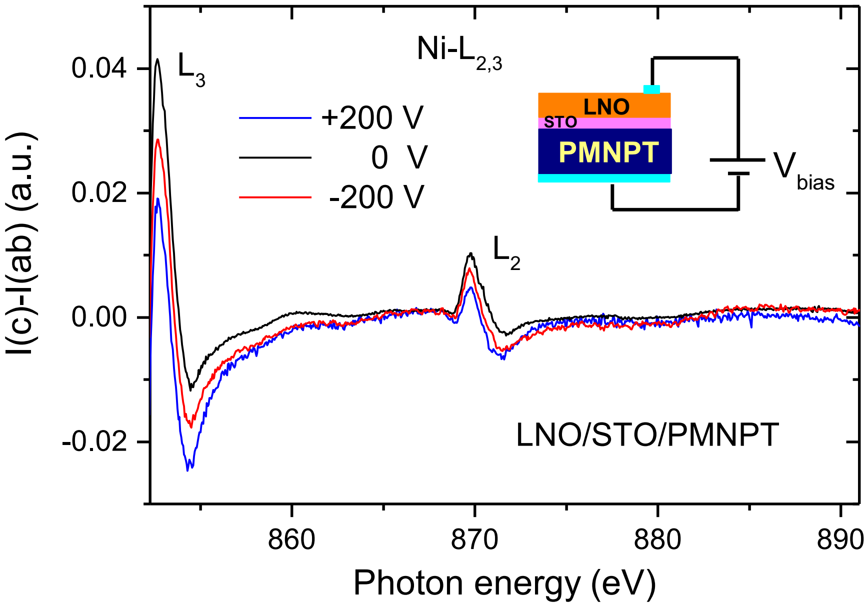
Oxides interfaces: proximity, strain effects

materials for Spin Hall applications



Magnetoresistance in Hybrid Pt/CoFe2O4 Bilayers Controlled by Competing Spin Accumulation and Interfacial Chemical Reconstruction
H. B. Vasili, J. Fontcuberta et al, ACS Appl. Mater. Interfaces 10 (2018)

strain control of electronic orbitals

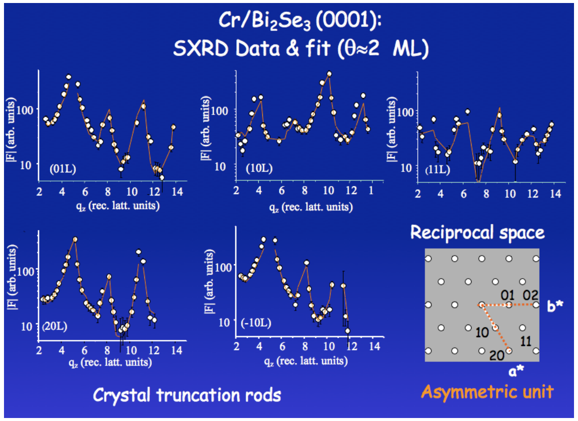


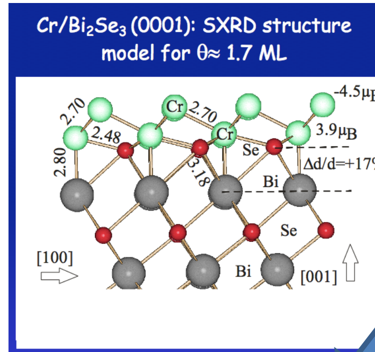
In-operando adjustable orbital polarization in nickelate perovskites
H. B. Vasili, J. Fontcuberta et al (submitted)

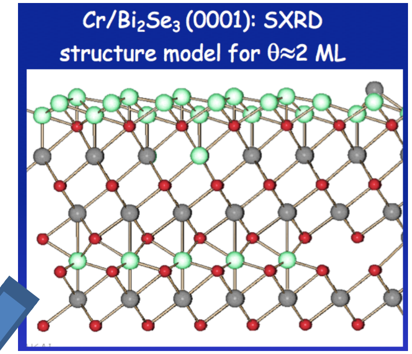
research projects in collaboration with Prof. J. Fontcuberta group at ICMAB-CSIC
XAS and XMCD measurements lead by *bl29 postdoc H. B. Vasili*

in-situ surface doping studies in Tis: Cr in Bi2Se3

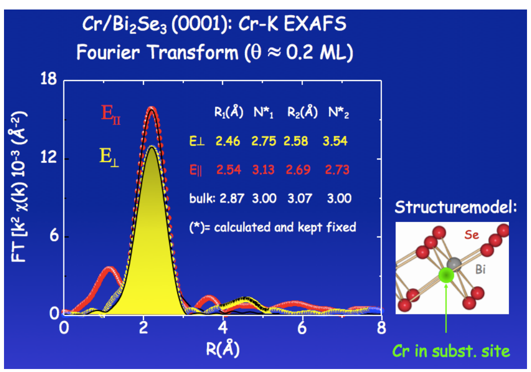
Beautiful complementarity example of SXRD+EXAFS, XMCD and theoretical simmulations

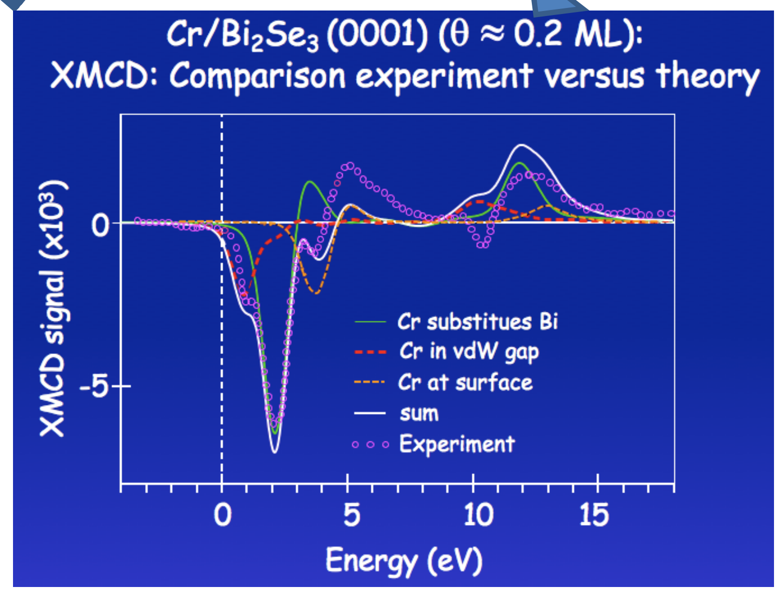






+



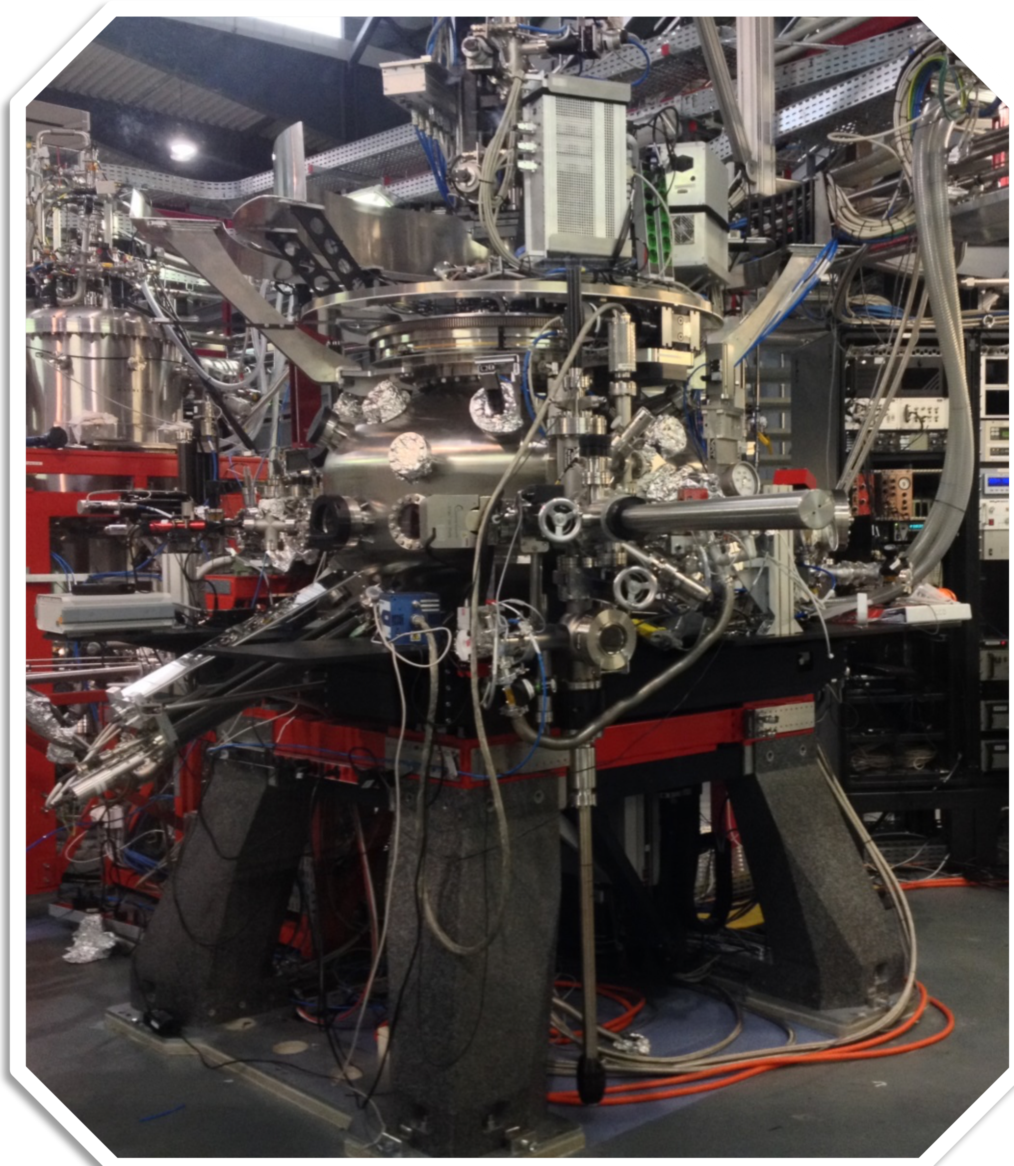


Cr/Bi$_2$Se$_3$(0001): Cr-coverage dependence of XMCD signal at 4K

courtesy Holger Meyerheim, Halle MPI

A. Polyakov, K. Mohseni, H. B. Vasili, P. Gargiani, M. Valvidares, L. V. Bekenov, V. N. Antonov, M. M. Otrokov, E. D. Crozier, E. V. Chulkov, A. Ernst, H. L. Meyerheim, and S. S. P. Parkin (to be submitted)

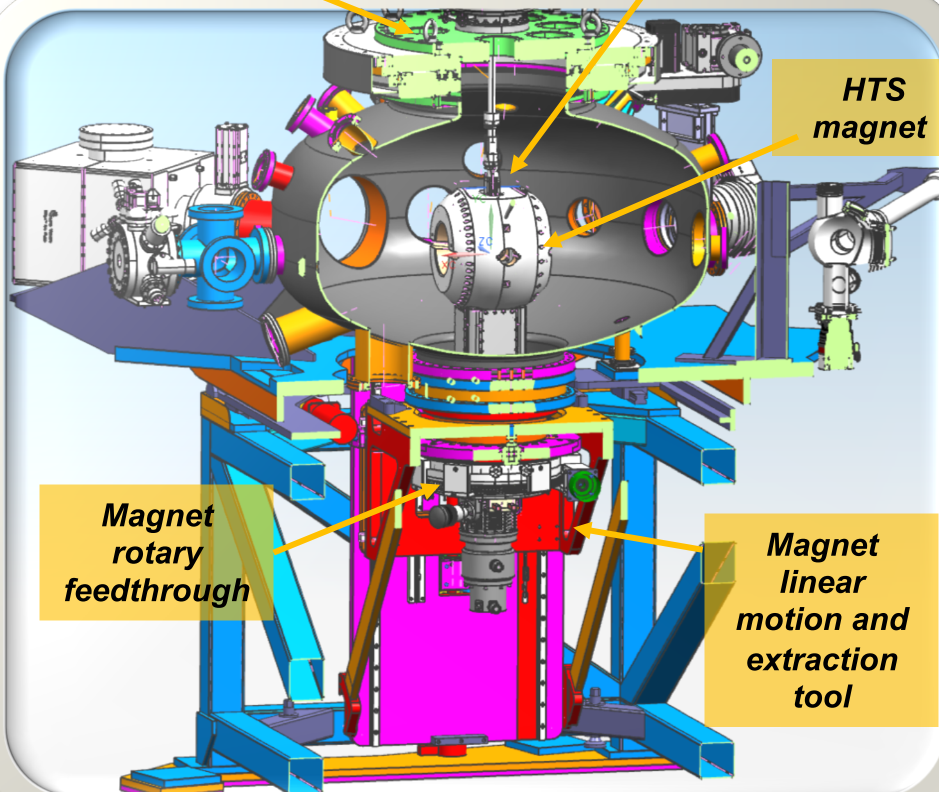
SXRS & XRMS endstation

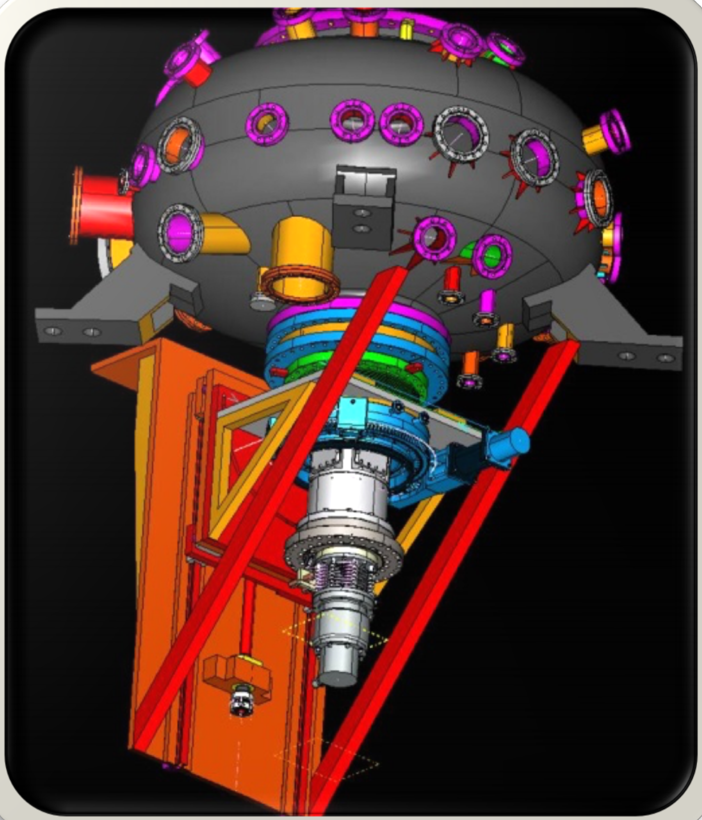


"MARES" main characteristics

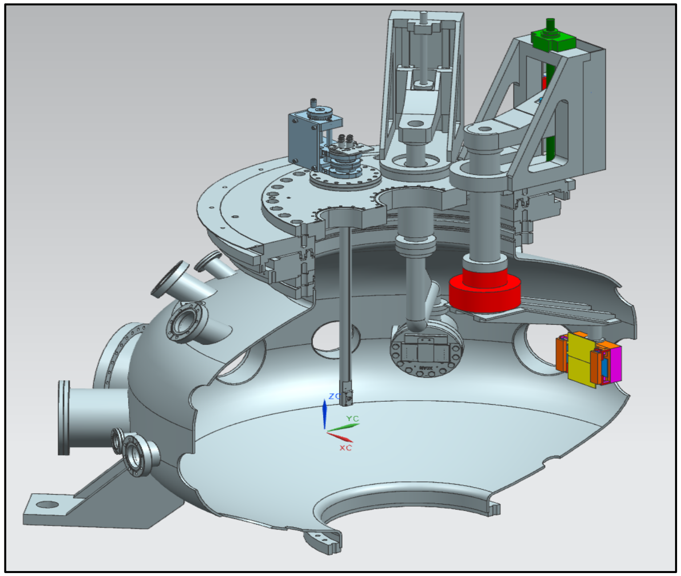
- 2 circle large diffractometer (PINK)
- 6-axis, 20-380 K cryomanipulator with tilt, azimuth (VG C6)
- Diode/MCP/channeltron detector arms with adjustable slits (smartact)
- In-vacuum CCD detector arm (XCAM)
- 2Tesla HTS closed cycle magnet (HTS110)
- Sample preparation: ion gun, heating stage 950 C (LEED in future)
- In-situ e-beam evaporator (Mantis)
- In-situ molecule evaporator source (*?)
- Adapter for specs/omicron stm plates and sample transfer system
- Entrance slits, beamstops, photon shutter

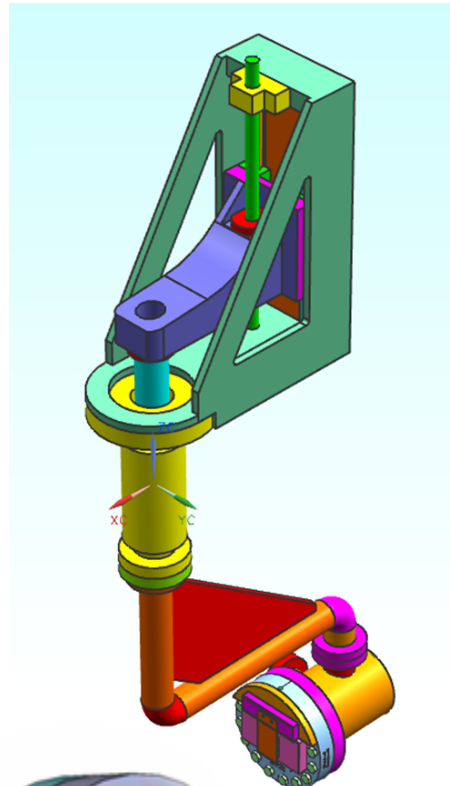
scattering endstation concept

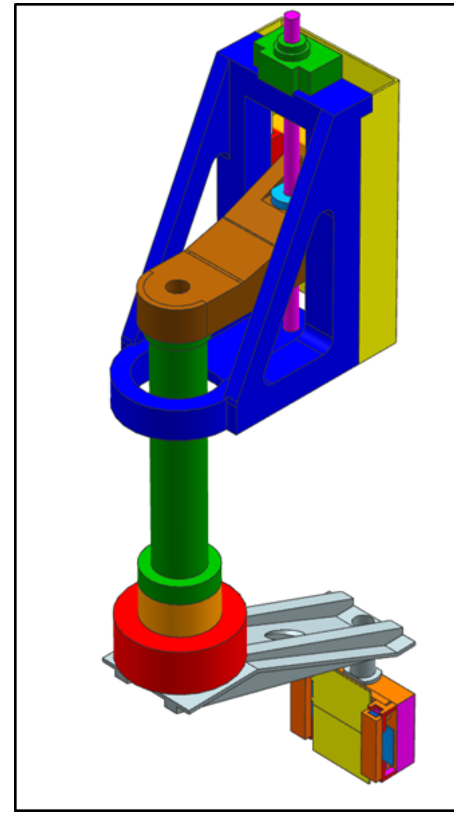


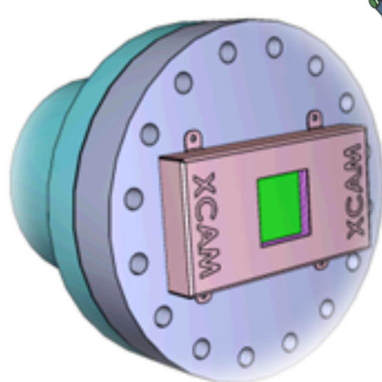


scattering endstation: detectors concept



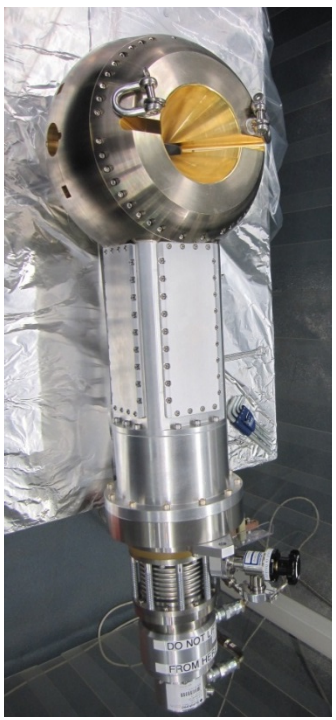


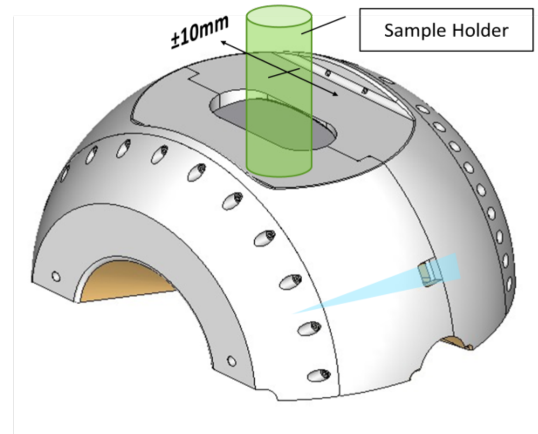


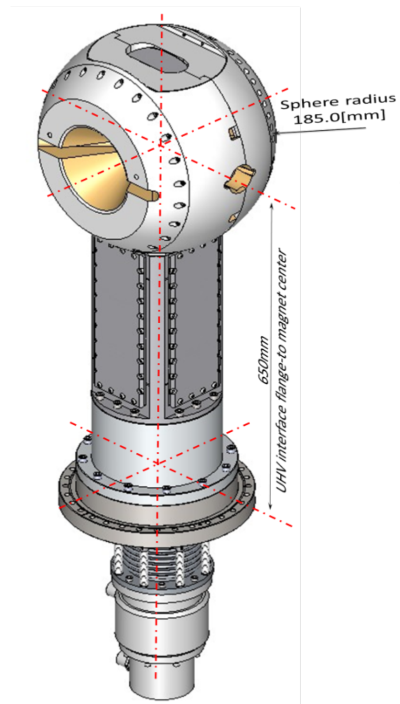


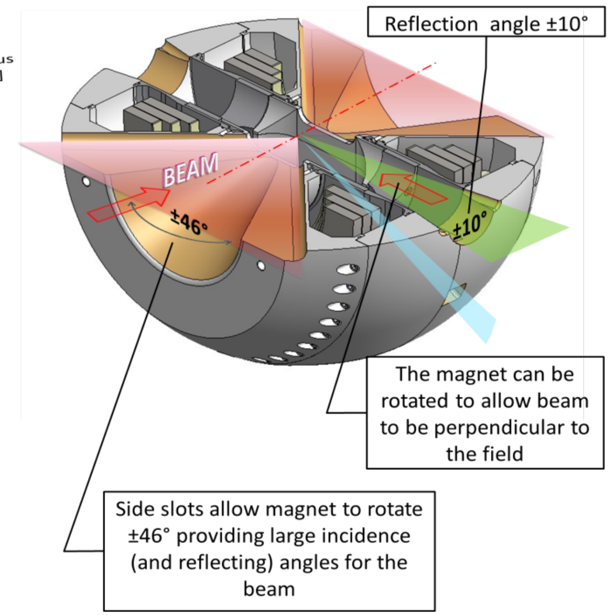
scattering endstation: magnet concept

- Manufactured by HTS-110, design by HTS-110, ALBA and ICMAB-CSIC
- 2 Tesla, 1st gen Bismuth strontium calcium copper oxide (BSSCO)
- Large-diameter coil packs for wide optical access, 50mm gap
- Cryo-cooler (28hours cool down, Temp range 2nd stage 15-22 K approx.)
- Small stray field (<50G at 250mm), around 150 Kg
- O-ring sealed, warm bore, dampening bellows



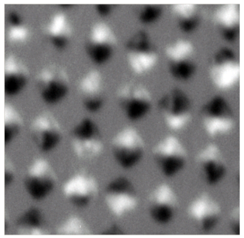






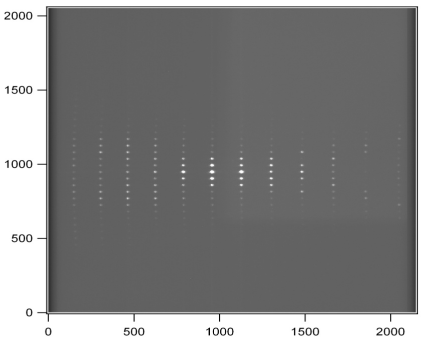
a versatile scattering endstation

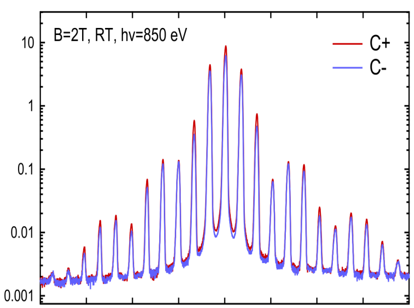
magnetic GISAXS in permalloy nano "dots"



PEEM3
ALS

BL29. ALBA

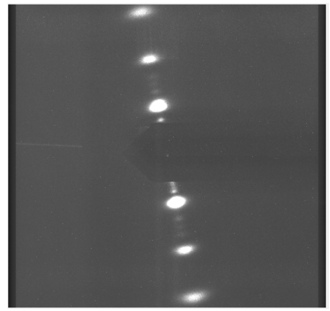




J. Diaz, M. Valvidares et al, Nanotechnology (2019)

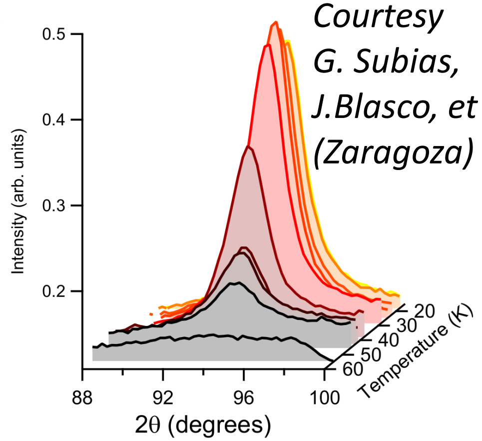
Resonant diffraction at C K edge in polymer films

Laser-Induced Periodic Surface Structures



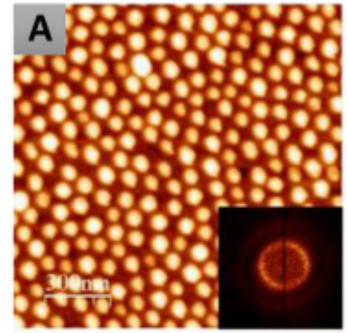
Courtesy M.C. Garcia and co-workers at IEM-CSIC, Madrid

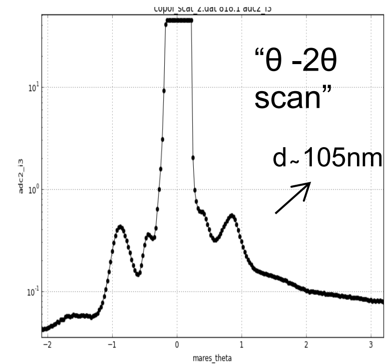
magnetic resonant diffraction in a La1.5Sr0.5CoO4 single crystal



Courtesy G. Subias, J.Blasco, et al. (Zaragoza)

Scattering and GISAXS at C K edge in polymers

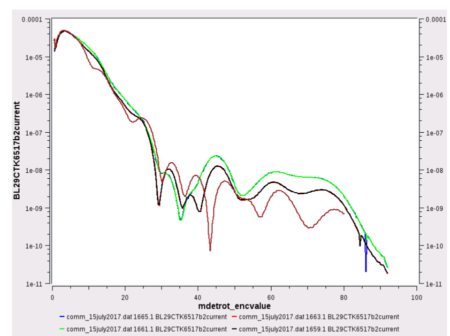


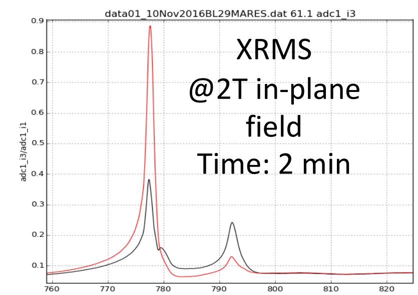


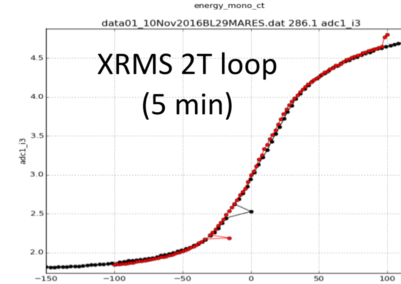
Courtesy F. Valdes-Bango and co-workers, Oviedo Univ.

on-the-fly fast scans, LT, high-field

magnetic reflectivity over 6 orders of magnitude, high-angle, 3 min

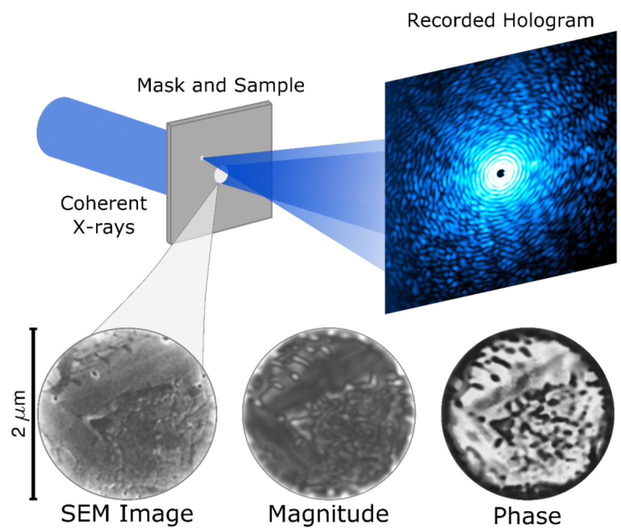




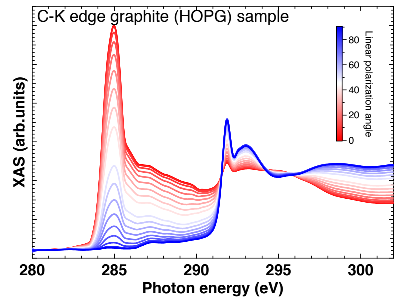


Courtesy J. Camarero and co-workers at IMDEA nanoscience, Madrid

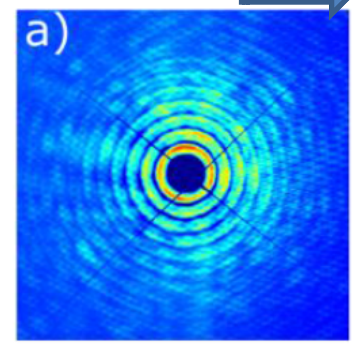
Lens-less nanoscale imaging by Soft X ray Holography



(Images taken at BESSY)

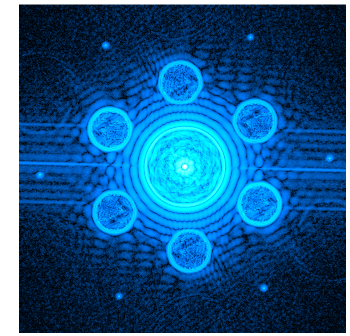


Recorded hologram

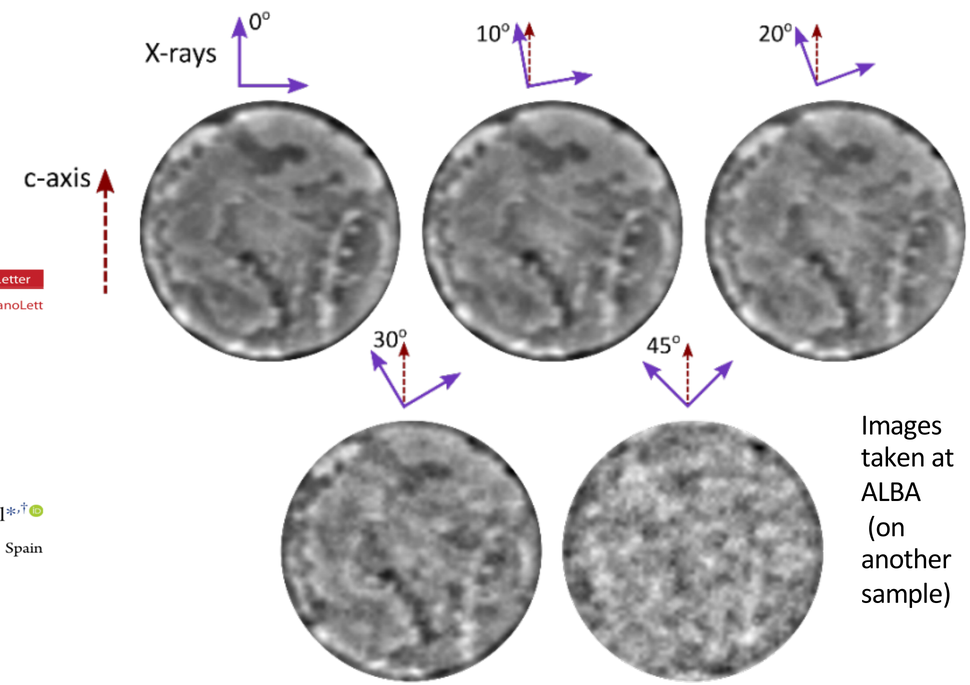


Fourier transform

Reconstructed hologram



XLD vs linear polarization angle (contrast mechanism)



Images taken at ALBA (on another sample)

NANO LETTERS Letter
Cite This: Nano Lett. XXXX, XXX, XXX−XXX pubs.acs.org/NanoLett

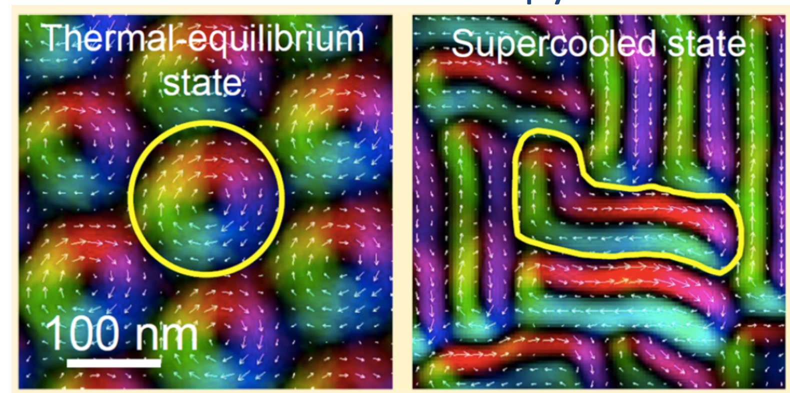
Imaging Nanometer Phase Coexistence at Defects During the Insulator−Metal Phase Transformation in VO_2 Thin Films by Resonant Soft X-ray Holography

Luciana Vidas,[*,†] Christian M. Günther,[‡] Timothy A. Miller,[†] Bastian Pfau,[§] Daniel Perez-Salinas,[†] Elías Martínez,[†] Michael Schneider,[§] Erik Gührs,[‡] Pierluigi Gargiani,[∥] Manuel Valvidares,[∥] Robert E. Marvel,[⊥] Kent A. Hallman,[⊥] Richard F. Haglund, Jr.,[⊥] Stefan Eisebitt,[‡,§] and Simon Wall[*,†]

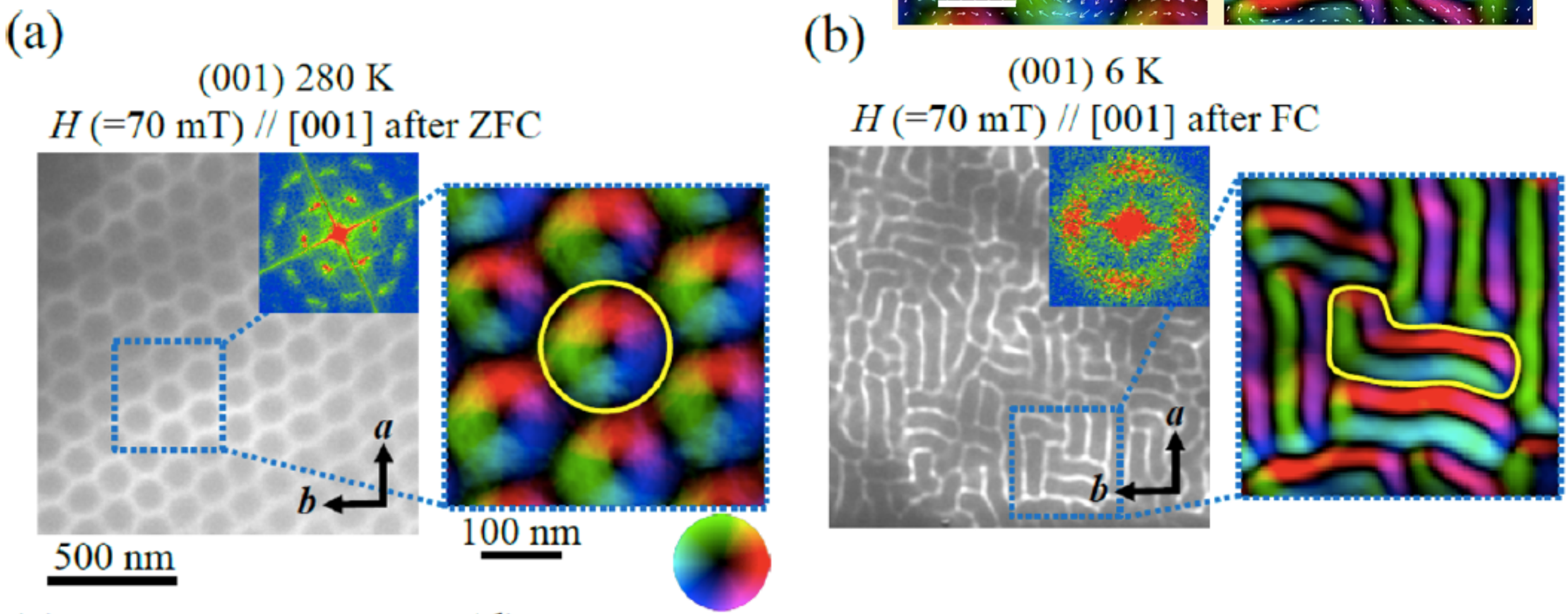
[†]ICFO—Institut de Ciències Fotòniques, The Barcelona Institute of Science and Technology, Castelldefels, 08860 Barcelona, Spain
[‡]Institut für Optik und Atomare Physik, Technische Universität Berlin, 10623 Berlin, Germany
[§]Max-Born-Institut, 12489 Berlin, Germany
[∥]ALBA Synchrotron Light Source, Cerdanyola del Vallès, E-08290 Barcelona, Spain
[⊥]Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee 37235-1807, United States

Soft X ray Magnetic Coherent Scattering and Holography of the skyrmion phase of helical magnet $Co_8Zn_8Mn_4$

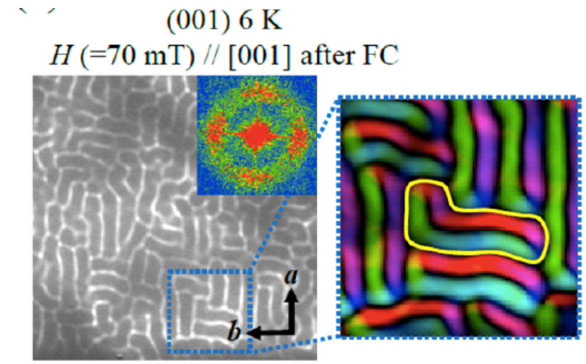
Lorentz microscopy

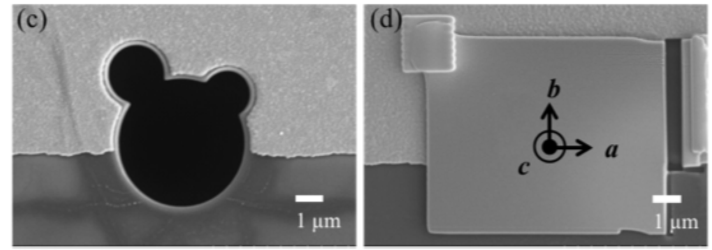


Deformation of Topologically-Protected Supercooled Skyrmions in a Thin Plate of Chiral Magnet Co8Zn8Mn4
D. Morikawa, X. Yu, K. Karube, Y. Tokunaga, Y. Taguchi, T. Arima, and Y. Tokura, Nanoletters, 2017

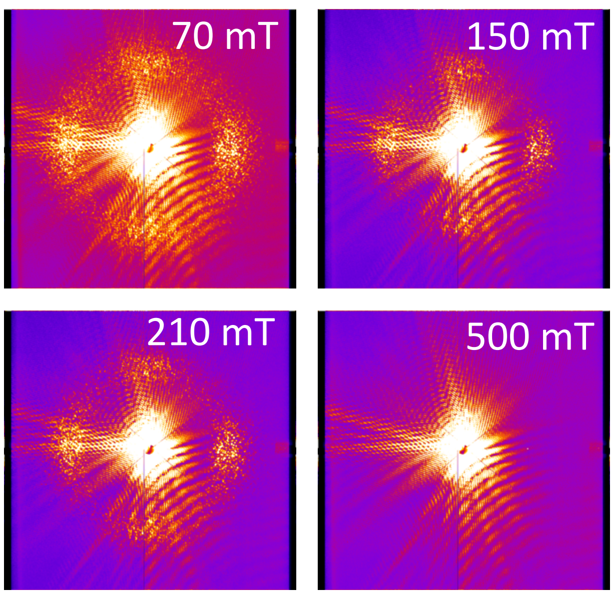


Soft X ray Magnetic Coherent Scattering and Holography of the skyrmion phase of helical magnet $Co_8Zn_8Mn_4$

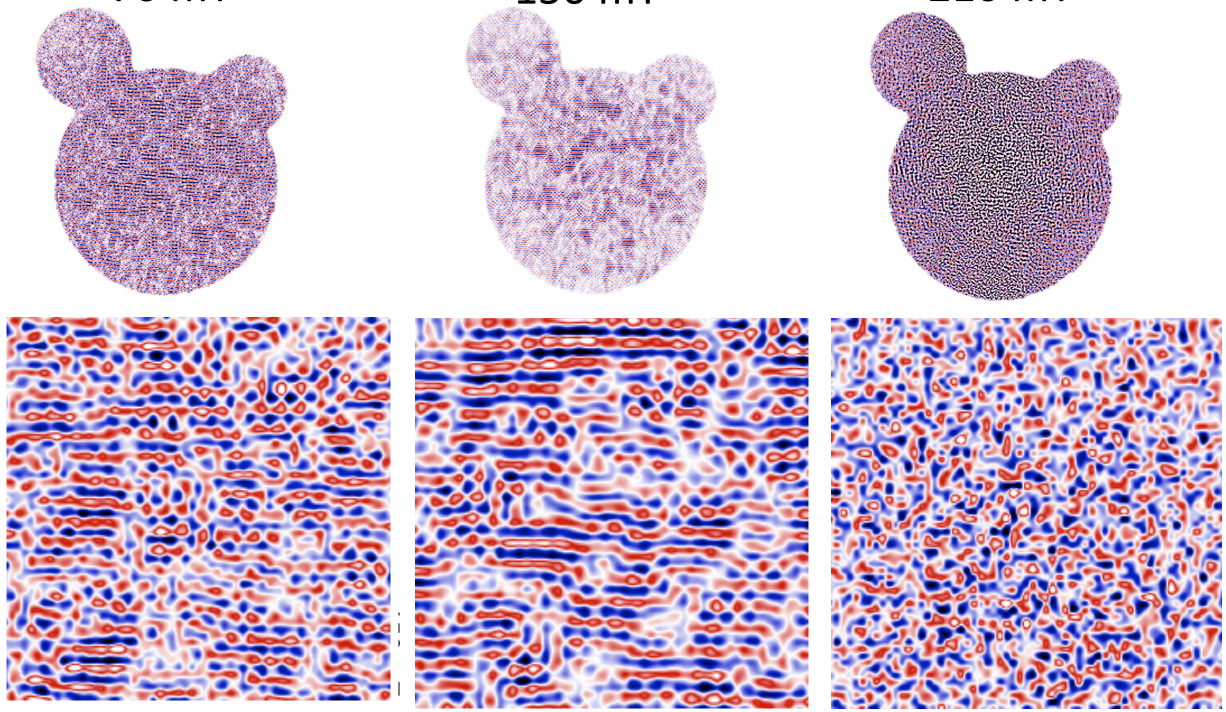




HIO algorithm



70 mT | 150 mT | 210 mT



T=23 K, hv=776.5 eV

V. Ukleev, Y. Tokura, T. Arima et al, RIKEN, Phys. Rev. B 2019

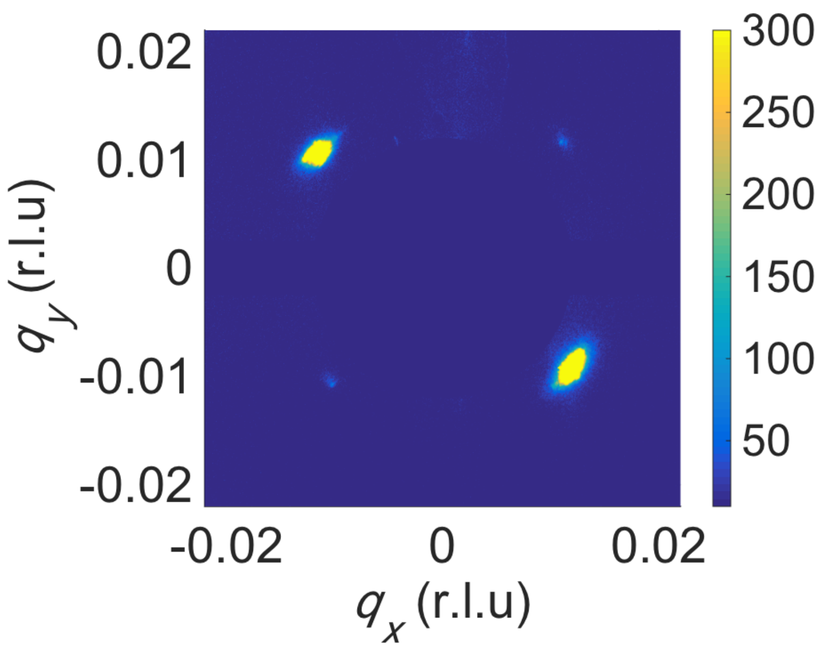
Skyrmion phase in Cu_2OSeO_3 single crystal

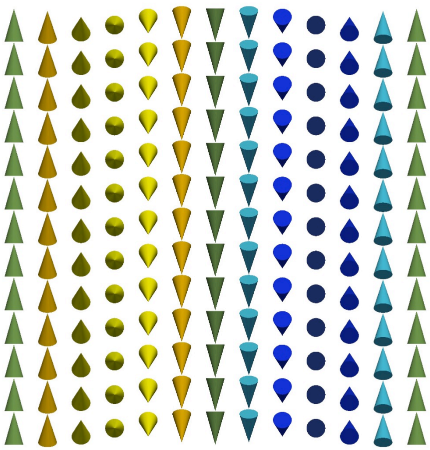
goal: study the transition from surface skyrmions to bulk skyrmions

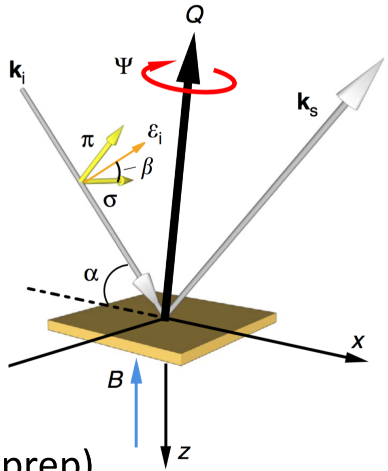
helical (i.e. stripe domain) state

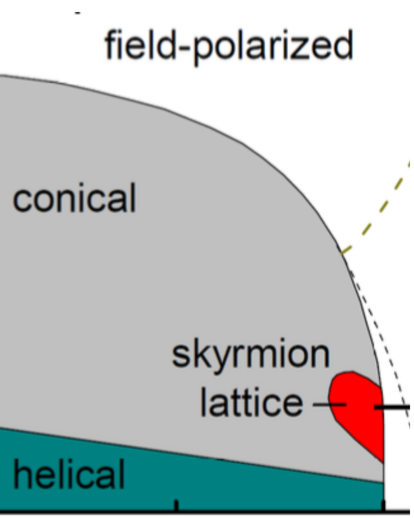
single crystal (about 3mm x 3mm x 1mm), 001 surface

sample provided by H. Berger (EPFL)









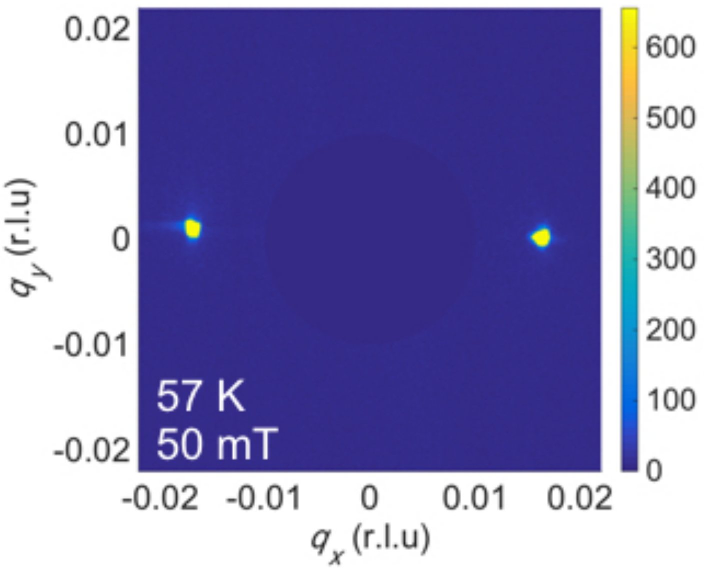
Direct experimental determination of the topological winding number of skyrmions in Cu_2OSeO_3

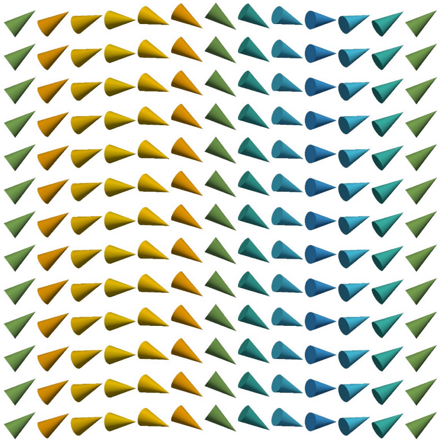
S.L. Zhang[1], G. van der Laan[2] & T. Hesjedal[1]

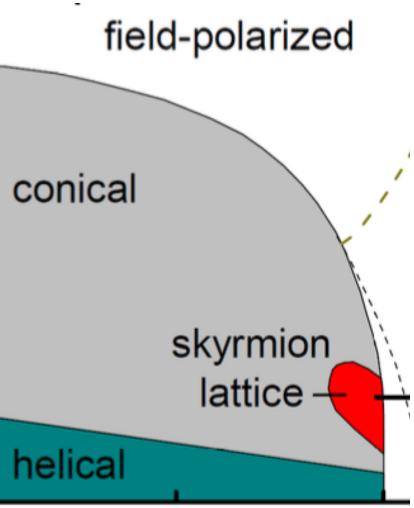
Courtesy Shilei Zhang,
T. Hesjedal and G. Van der Laan, 2017 experiment (in prep)

Skyrmion phase in Cu_2OSeO_3 single crystal

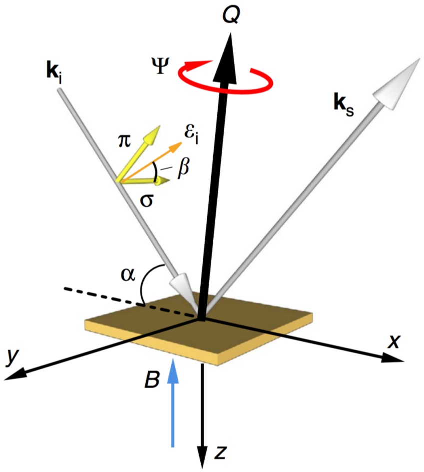
conical state





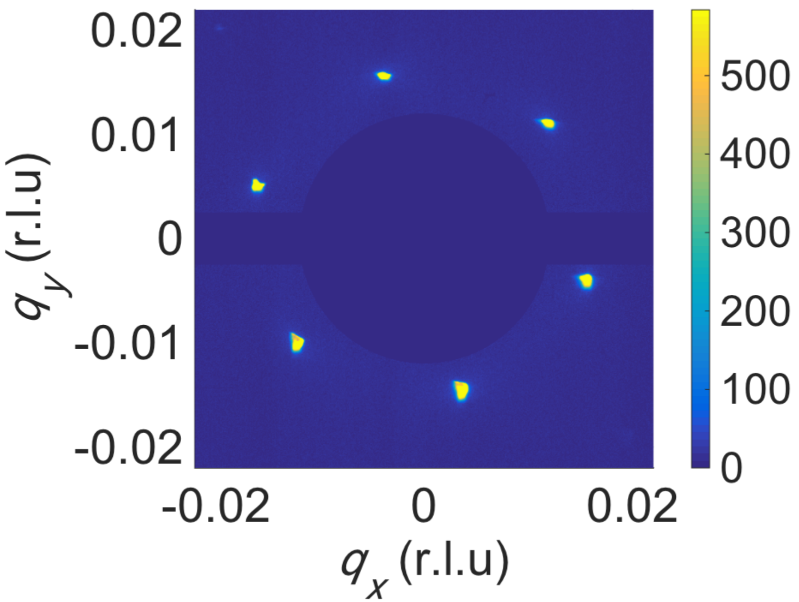


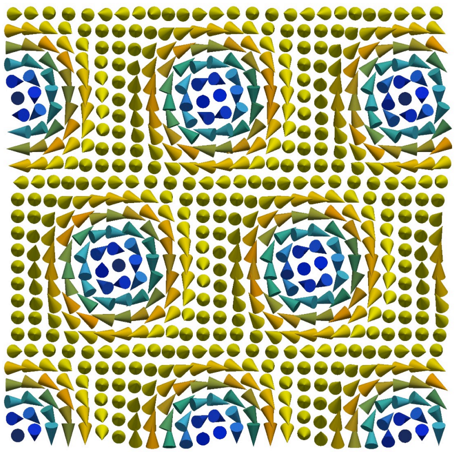
transition from surface skyrmions to bulk skyrmions

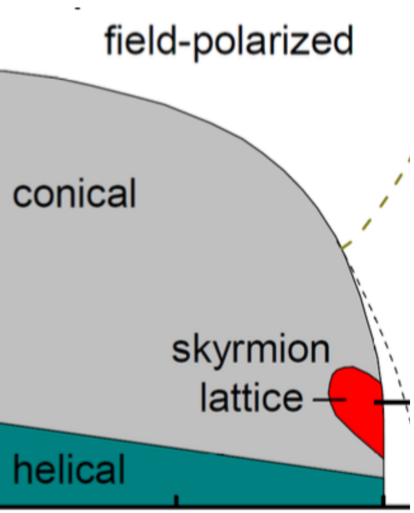


Skyrmion phase in Cu_2OSeO_3 single crystal

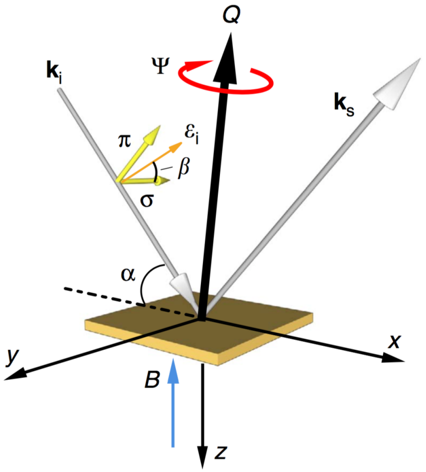
skyrmion state





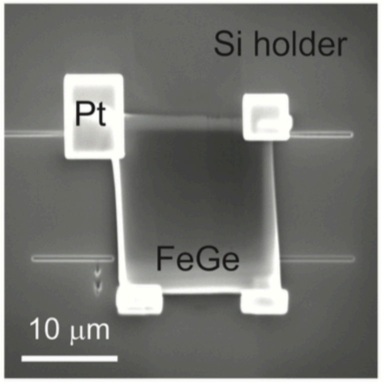


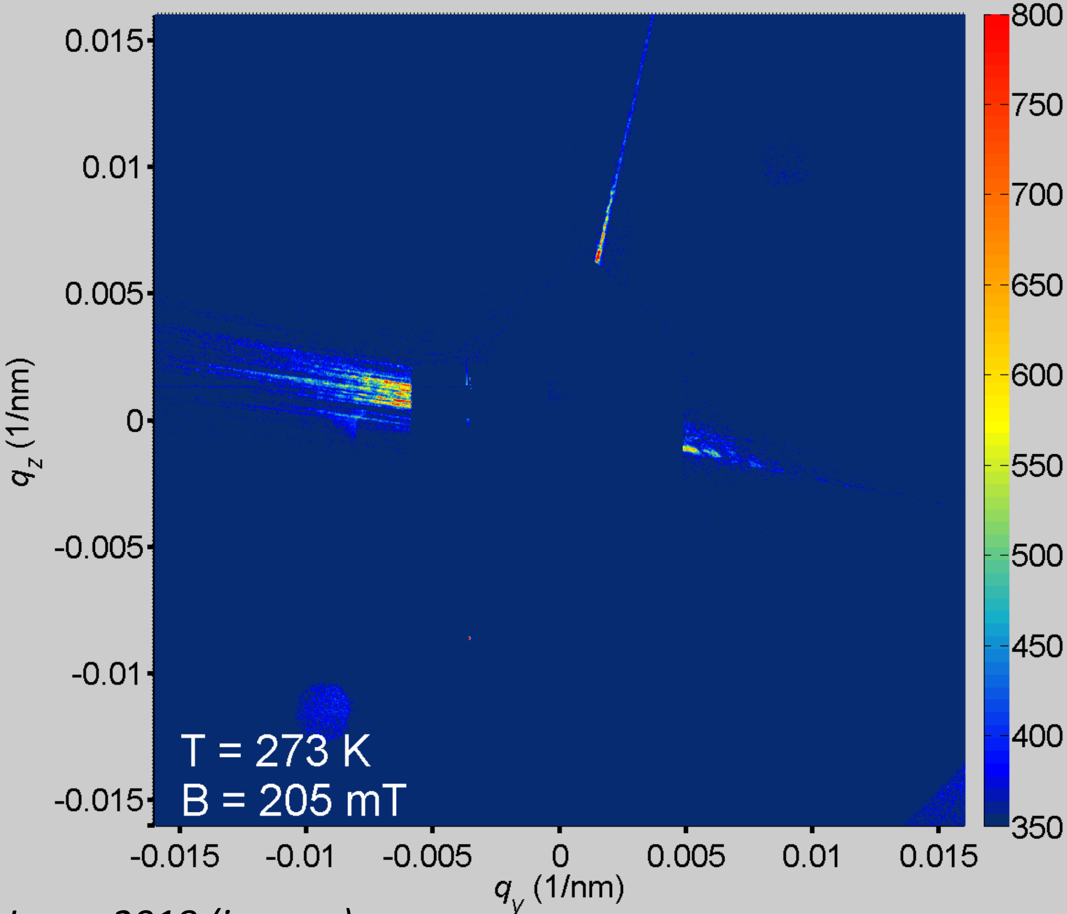
Courtesy Shilei Zhang,
T. Hesjedal and G. Van der Laan



FeGe (transmission scattering experiment)

sample was cut from a single crystal, and FIB into a 200 nm-thick, 10 um x 10 um size thin plate.

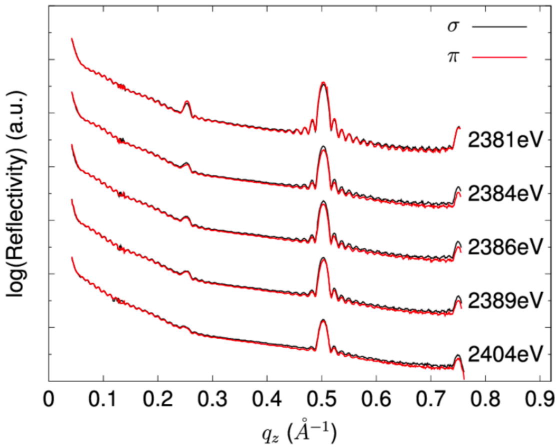


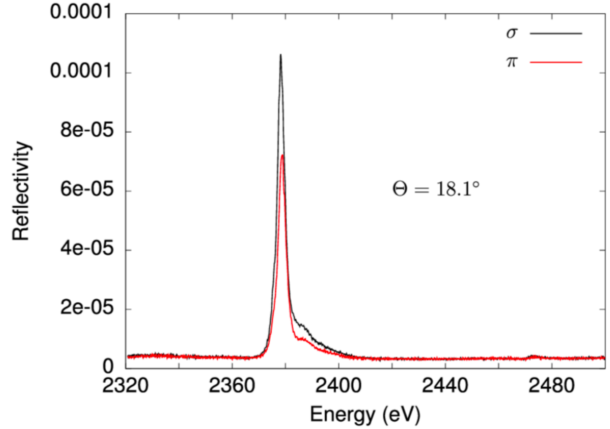


Courtesy Shilei Zhang, T. Hesjedal and G. Van der Laan, 2018 (in prep)

Reflectivity on rotationally disordered transition metal dichalcogenide heterostructures

FixE and FixTh scans atT=300K; B=0T

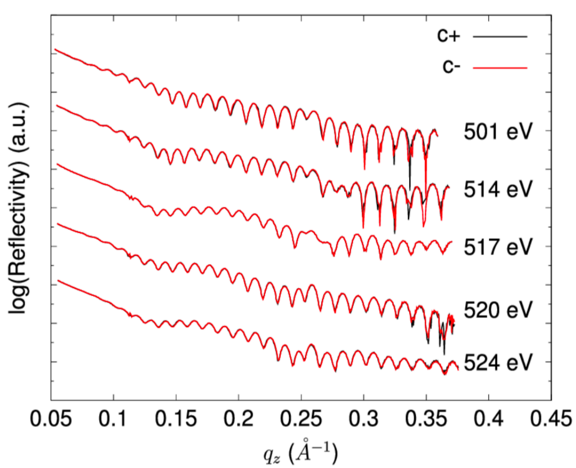


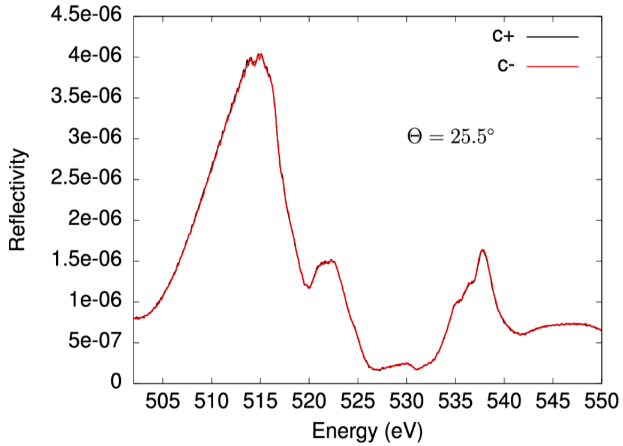


Si // [(PbSe)1/(NbSe2)3]x10 (~50nm thick film)

Interface reconstruction?
Origin for Tc changes?
Effect of number of NbSe2 layers?

FixE and FixTh scans at T=28K; B=2T // surface





Si // [(PbSe)1/(VSe2)1]x20 (~50nm thick film)

magnetism?
CDW?

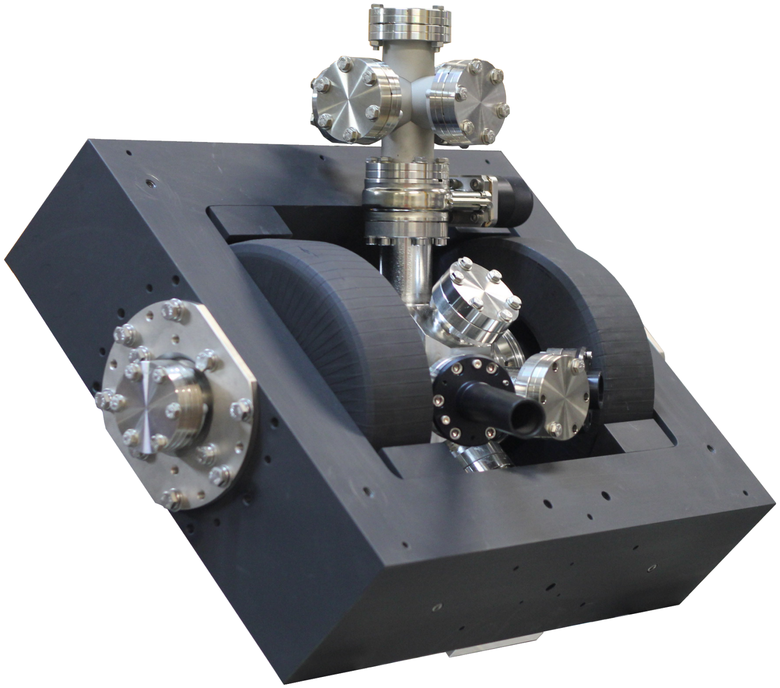
Courtesy Florian Rasch,
J. Hamann-Borrero,
IFW Dresden (in preparation)

past issues, difficulties & limitations

ENDSTATION- PROBLEM	SOLUTION/STATUS
HECTOR: Sample stuck in VTI	- Better sample alignment; sample transfer mostly by bl staff - Hard/soft and hard/hard VTI and sample approach
MARES: Parasitic light from heater	- Light screen installed, reduces to <1% or so effect.
MARES: Water de-icing yields anomalous diode dark currents	- Heating tapes applied, cooling power adjusted on cool down - Detector arms protected with impermeable adhesive tape
MARES: issue on rotation circle (bearings)	- Solving required very large dismounting and replacement of bearings, cages were deformed; bakeout or abrupt motion due to cable trays
MARES: CCD burnout	- Background burnout is pretty bad, but enough alleviated by increased peltier and CCD inversion voltages - Beamstop protocol, attenuator filters, low intensity protocol for eventual strong diffraction peaks ; CCD shutter installed
MARES: software	- Took 1+ year to solve CCD software crashes (new usb driver) - Took 2+ years to get CCD acquisition integrated - Continuous reflectivity scans available from 2017, improve x10
Mares: beamsize	- Variable beamsize is nice, however limit is > 100 x 200 micron approx
Mares: field geommetry	- Cannot do magnetic reflection under perpendicular field
Mares: sample contacts	- Cannot measure TEY or have sample contacts (under study)
Hector: refill Liq He	- Cannot measure during Liq He refill (noise)

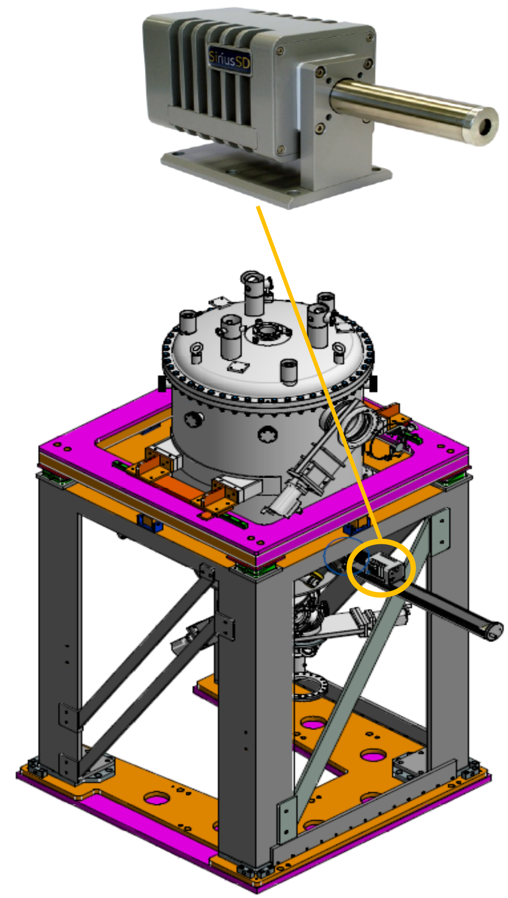
on-going, close term

2T fast ramp (<1s) electromagnet for off-line magnetic characterization via in-situ L,P,T-MOKE & bl sporadic use



ordering, to arrive December 2019
ALBA investment

single element Rayspec SDD detector (PFY)



Installed March 2019
ALBA investment 2017 + Mineco national grant

on-going close term

1. XMCD magnet

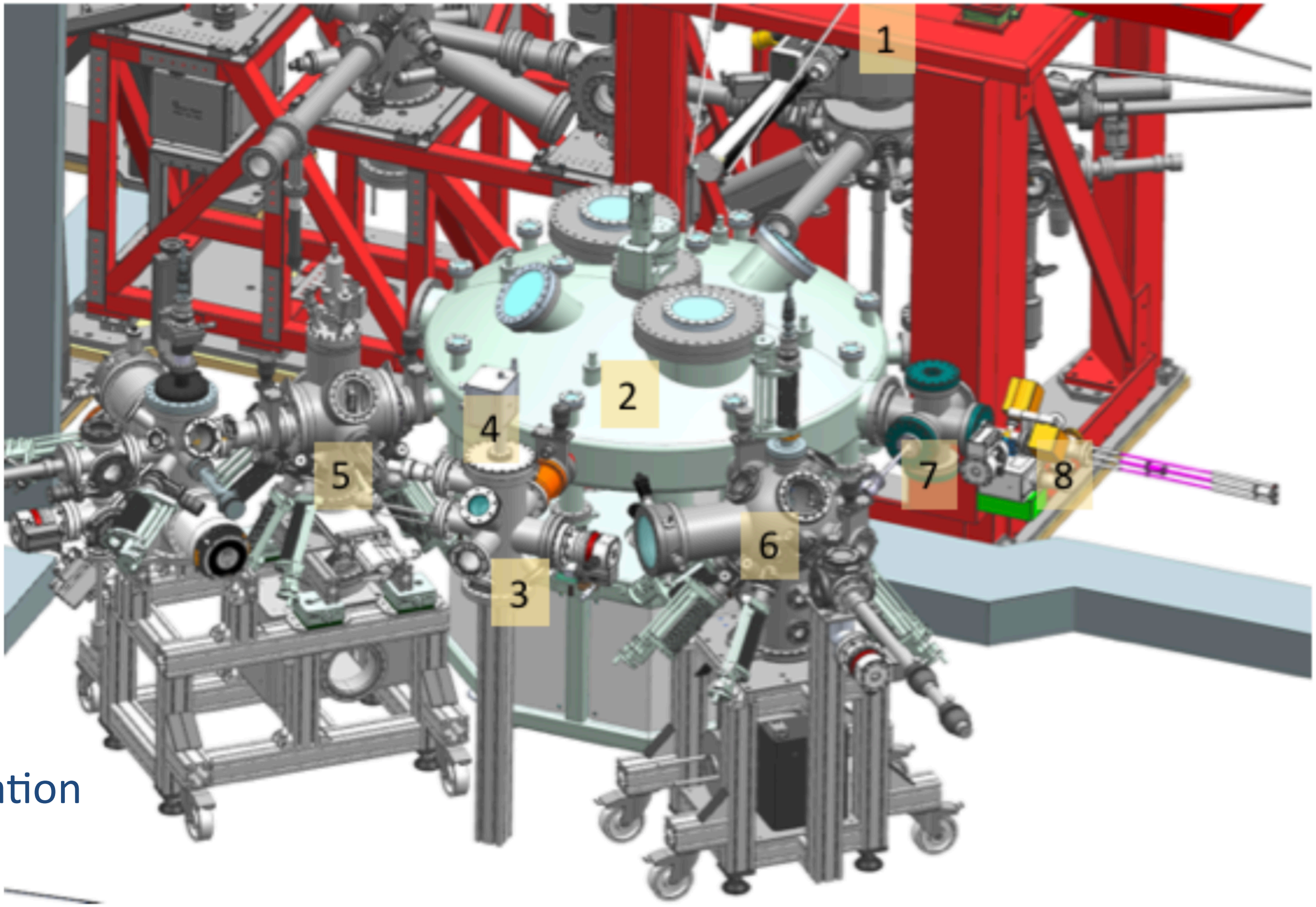
2. New Radial Distribution Chamber (OMNIVAC)

3&4. New Atomic Layer Injection system

5. STM/AFM with PhD/inhouse surface preparation chamber

6. user surface preparation chamber

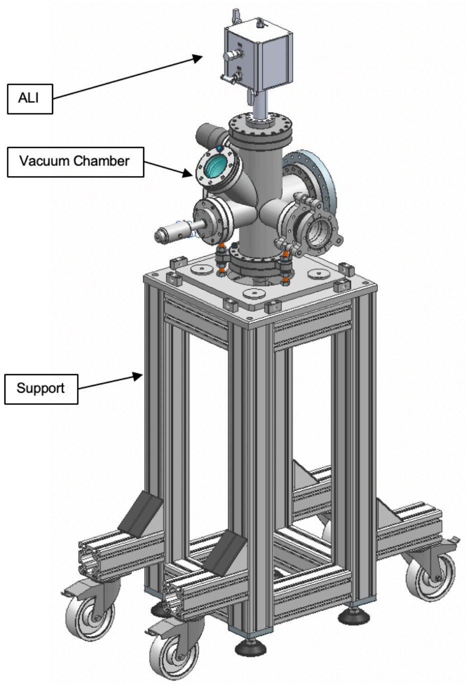
7&8 New docking port for UHV sample suitcase

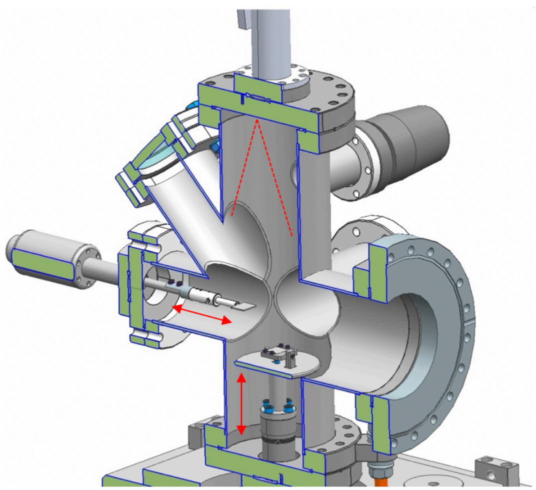


Installation November 2019
Funding: EFA194/16/TNSI **Poctefa-Interreg EU/Feder**

on-going, close/mid- term

Atomic Layer Injection system: deposition of molecules fragile for evaporation, NPs,… Collaboration Bihurcrystal (R. Gonzalez, F. Lopez) and ALBA BL29 (P. Gargiani, A.Carballedo and M.Valvidares). Various groups in project to use (Zaragoza, Donosti, …)





https://bihurcrystal.com

November 2019

Funding: EFA194/16/TNSI **Poctefa-Interreg EU/Feder**

Acknowledgements

BL29 Staff

H. B. Vasiili (postdoc), S. Agrestini (visiting MPI postdoc), P. Gargiani, J. Herrero and M. Valvidares (scientists), L. de Melo (PhD ALBA-IMDEA), J. Moldes (controls), A. Carballedo (engineer), A. Enrique (technician) , X. Fariña and X. Serra (electronics)

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Collaborators & Users

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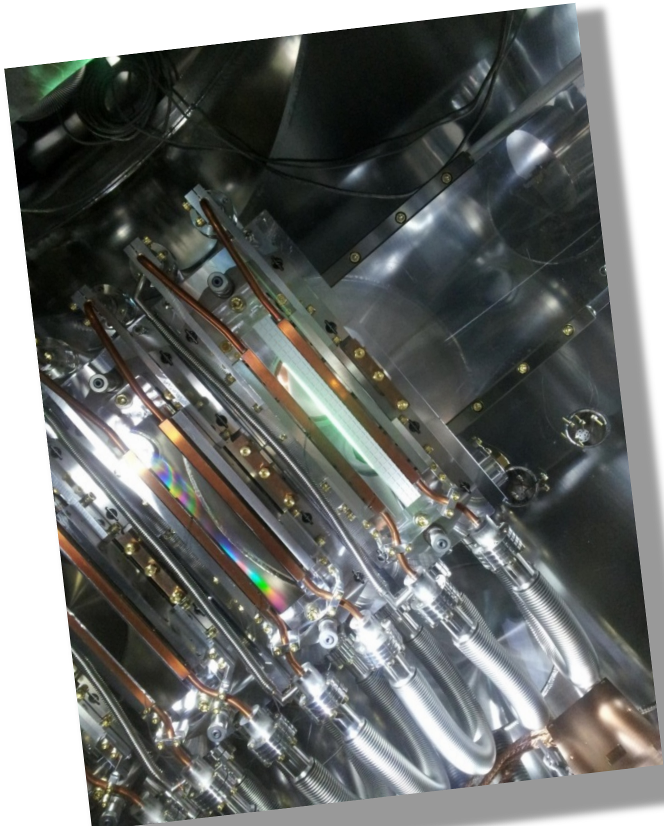
External companies

TOYAMA, SCI-MAG, CVT, RHK, SCHAEFFER, VG, HTS-110, PINK, SPECS, DODECON, FERROVAC, GAMMVAC, TECNOVAC, VAT, IBERLASER, HOSITRAD, VCS, AVS, AVACTEC,VAQTEC, MCALLISTER, HAMAMATSU, XCAM, AMBAR, INSERTY, SPARK, IBERICA, SJUTS, KONIK, MDC, TRINOS, VAT, Smaract, Mantis, Ferrovac, Vab-vacom, and many others



beam on fluorescence dummy grating in BL29 monochromator