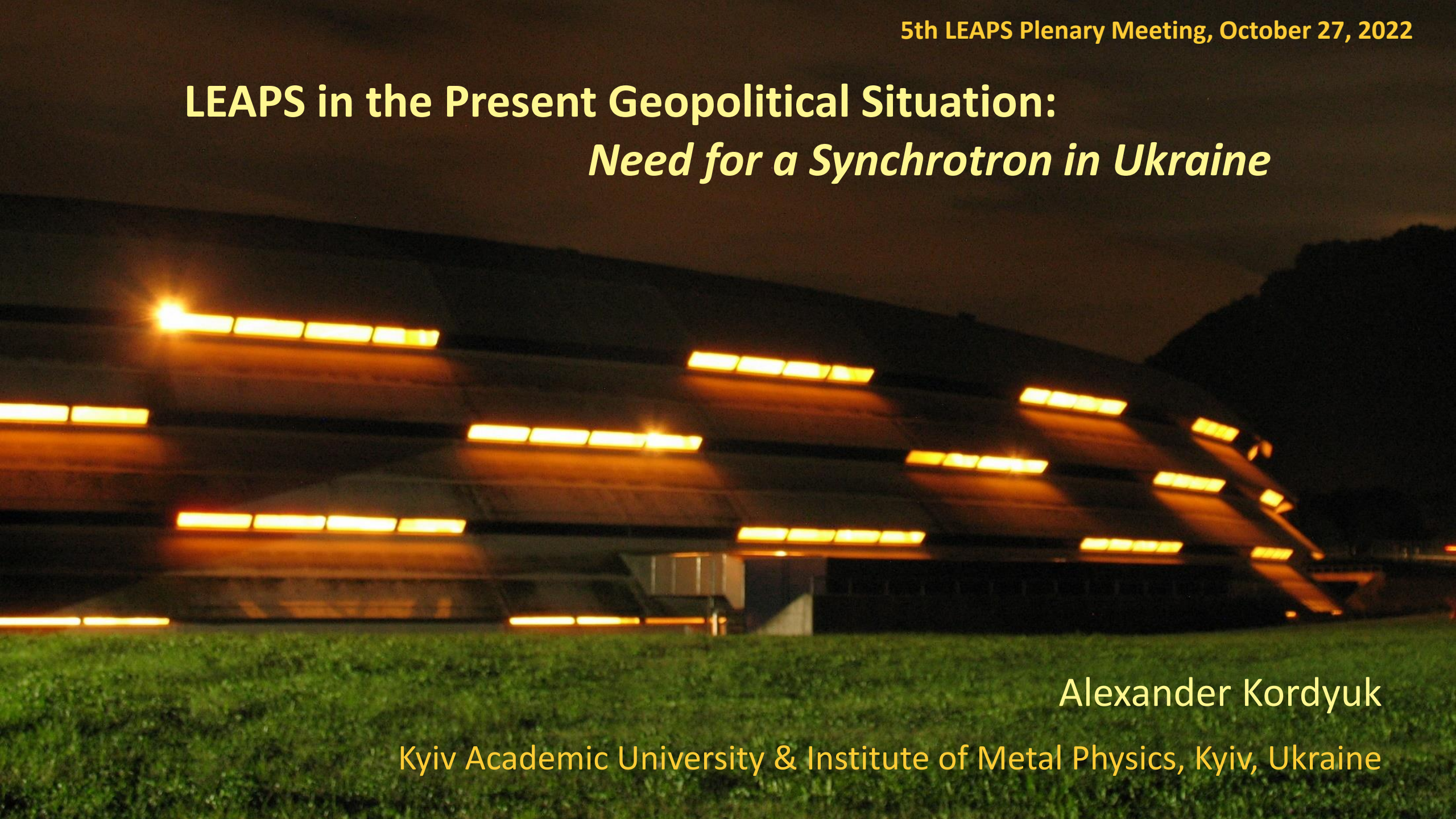
5th LEAPS Plenary Meeting, October 27, 2022

LEAPS in the Present Geopolitical Situation:
Need for a Synchrotron in Ukraine



Alexander Kordyuk

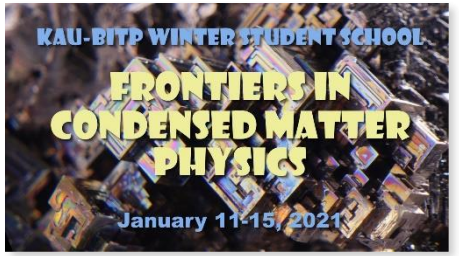
Kyiv Academic University & Institute of Metal Physics, Kyiv, Ukraine

Why do we need a synchrotron in Ukraine?

- **Kyiv Academic University** and the **National Academy of Sciences of Ukraine**
- The attempt to build a synchrotron in Kyiv in the 1990s
- Examples among Ukrainian researchers who have experience and need in synchrotron radiation

KYIV ACADEMIC UNIVERSITY

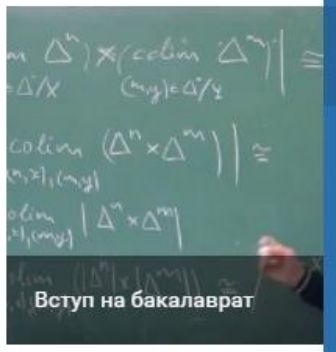
learning by doing research internationally

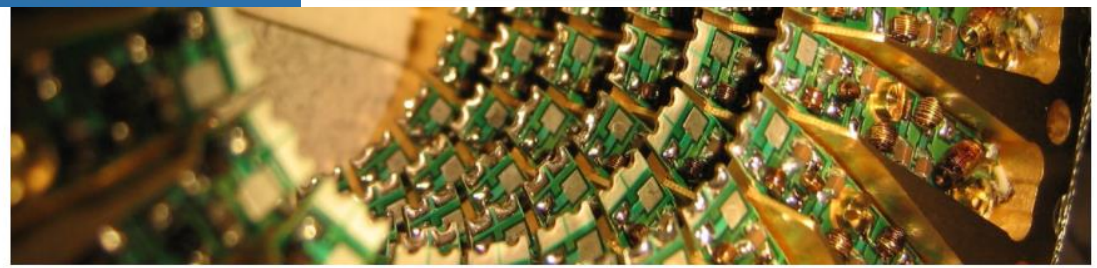


Головна | Новини | Освіта | Кафедри | Наука | Випускники | Контакти

- Центр дослідження даних
- Центр квантових матеріалів та технологій
- German-Ukrainian Lab (UKRATOP)
- Науково-освітній центр КАУ-Risen (KRREC)
- Інноваційний центр
- Лабораторія електронного приладобудування

Проєкт Багатозонність





KAU Research Center for Quantum Materials and Quantum Technologies (Q^2RC)

The Center is focused on synergy of deep understanding of quantum materials and

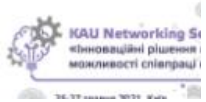
https://kau.org.ua/qredu

Останні новини

- Анонси
- Семінари
- Школи, конференції
- Новини науки

- 27.05.2021 "Інноваційні рішення в енергетиці: можли науки та бізнесу"
- Стартувала реєстрація на ЄВІ/ЄФВВ для вступу до магістратури
- 05.05.2021. Квантовий семінар КАУ: Д.Якименко, Огляд проблем теорії квантових обчислень

27.05.2021 "Іннов енергетиці: можл науки та бізнесу"



Quantum Materials Group

Design of smart quantum materials for quantum technologies of the superconducting order parametes. Search for new supe


Alexander Kordyuk


Alexander Plyushchay


Volodymyr Bezguba

http://kau.org.ua
http://kau.org.ua/centers/qmtech

Останні новини

Анонси

Семінари

Школи, конференції

Новини науки

ls

rg.ua/qredu

- ✓ KAU is a research intensive university of NAS of Ukraine (since 1978, rebranding 2018)
- ✓ 50-60 Master students in 5-7 Departments at key academic institutes
- ✓ about 1:1 students to professors ratio (all profs are researchers)
- ✓ The main topic for students is the Research
- ✓ the Research = international collaboration
- ✓ = “Learning by doing research internationally”
- ✓ Main challenge: brain drain -> brain circulation

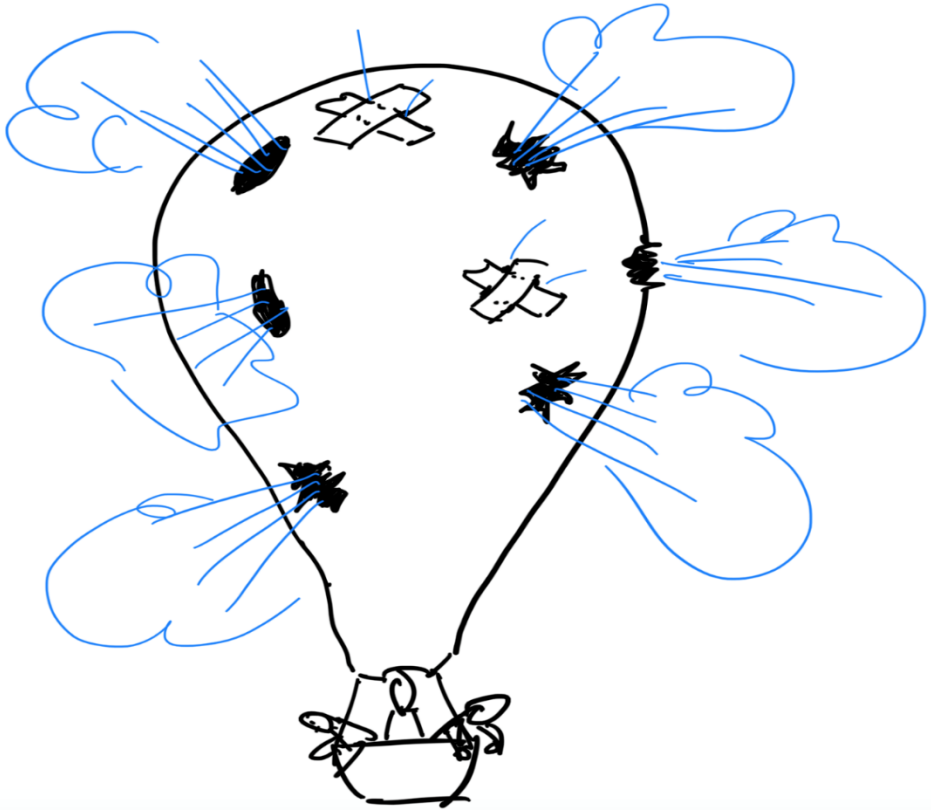
http://kau.or

http://kau.or

Volodymyr Bezguba

Challenges of International Collaboration for Ukraine

1. Modern Science is essentially international
2. Key element of Science development – Young People
3. Best way to learn physics:
   “Learning by doing research (internationally)”

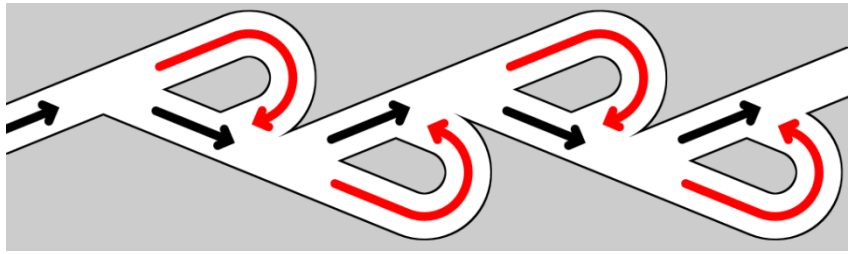


Main problem and main challenge:

Brain Drain ⇨ Brain Circulation

Solution: **Sustainable Collaboration**

- Long term collaboration (confidence)
- Interesting topic – cool results (turbulence)
- Mutual interest
- Youth friendly **infrastucture** in Ukraine (for back flow)

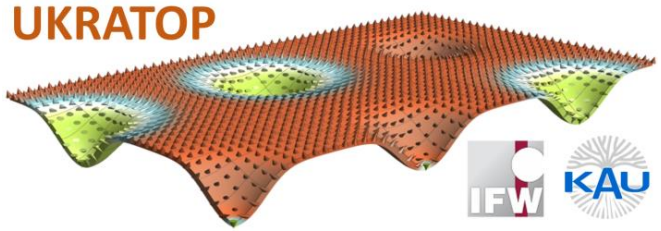


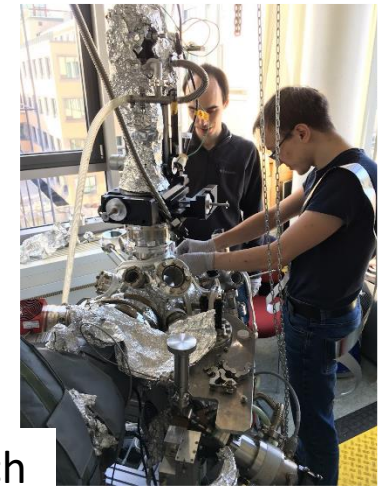
Our examples: **UKRATOP** and Academ.city RESEARCH EDUCATION TECHNOLOGY

UKRATOP – a research+ bilateral project on Topological Quantum Materials

KAU+IFW & TU Dresden: 1 000 000 EUR/4 years

kau.org.ua/centers/ukratop



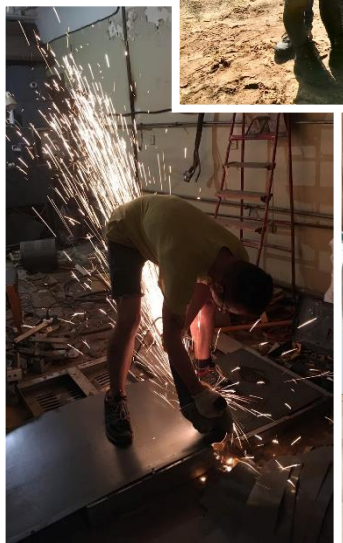


Scholarships: **21** MSc students;
2 PhD students; **5** PostDocs.

Experience in highest level research and communication, strengthening p2p collaboration

All MSc and PhD students defended their degrees in Ukraine

Exp. equipment from IFW Dresden installed in Kyiv



https://kau.org.ua/ukrapro

UKRAPRO

KAU

IFW Leibniz Institute for Solid State and Materials Research Dresden

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

About the National Academy of Sciences of Ukraine

According to the current legislation, the National Academy of Sciences of Ukraine (NAS of Ukraine, Academy) is the highest scientific self-governing organization of Ukraine based on state property.
https://www.nas.gov.ua/EN/About

On 01.01.2022, NASU consists of

- **149** scientific institutions
- 35 RND enterprises
- **27 173** employees, including
  - 14 212 scientists (2 485 DSc and 6 598 PhD)

- **Section of Physical, Engineering and Mathematical Sciences**
  - Department of Mathematics (4 institutes)
  - Department of Informatics (9 institutions)
  - Department of Mechanics (6 institutes)
  - **Department of Physics and Astronomy (15 institutes)**
  - Department of Geosciences (14 institutions)
  - **Department of Physical and Technical Problems of Materials Science (14 institutions)**
  - Department of Physical and Technical Problems of Power Engineering (13 institutions)
  - **Department of Nuclear Physics and Power Engineering (6 institutions)**
- **Section of Chemical and Biological Sciences**
  - **Department of Chemistry (13 institutions)**
  - **Department of Biochemistry, Physiology and Molecular Biology (8 institutions)**
  - Department of General Biology (21 institutions)
- **Section of Social Sciences and Humanities (3 Departments, 36 institutions)**

G. V. Kurdyumov Institute for Metal Physics
(~ 350 empl.)

Institute of Physics

B. Verkin Institute for Low Temperature Physics and Engineering

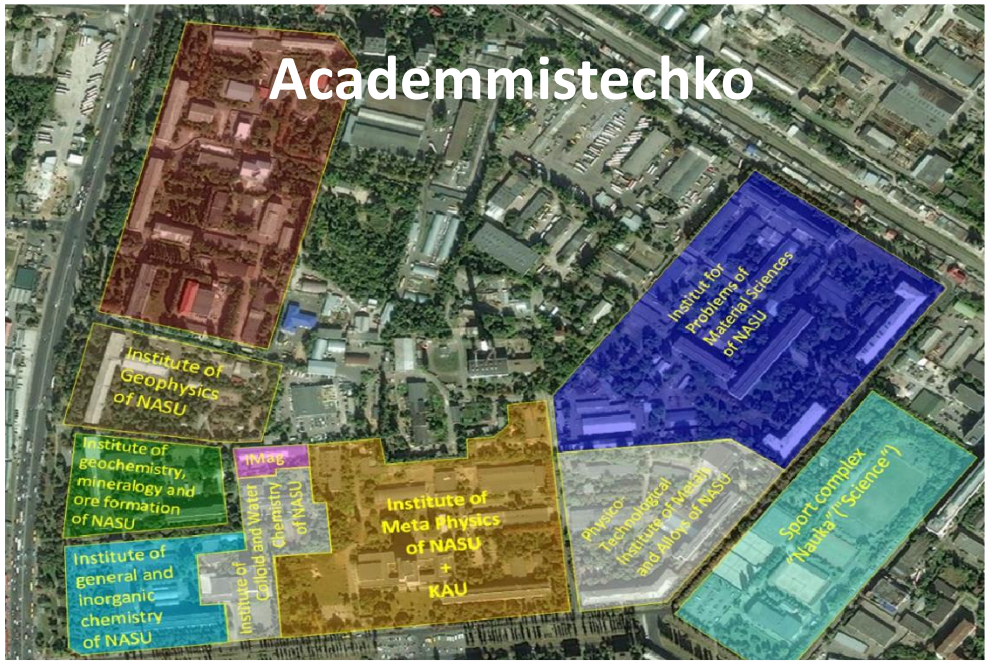
V. Bakul Institute for Superhard Materials

Institute of Molecular Biology and Genetics

academ.city

A Quadruple-helix project of creating a Deep Tech science park in Ukraine, based on the expertise of the scientific institutes of the National Academy of Science of Ukraine

kau.org.ua/en/science/innovation/academ-city



Recent achievements of the project team:

- 12 research institutes established association for Academic cooperation and science park development.
- A 140 sq.m. Deep Tech Co-working - > 30 events: technology transfer, start-up incubation, pitching and networking for scientists, students and business.
- A joint lab of fast prototyping is available for start-ups and researchers. A creative media lab for science popularization - Academ.Media Youtube channel. www.youtube.com/watch?v=ld1OZz8KJPw

KAU

HUMBOLDT-UNIVERSITÄT ZU BERLIN

WISTA we get ideas done

A SOURCE OF SYNCHROTRON RADIATION FOR RESEARCH AND TECHNOLOGY APPLICATIONS

V. Bar'yakhtar*, E. Bulyak, V. Chechetenko, A. Dovbnya, S. Efimov, A. Gevchuk, P Gladkikh, I. Karnaukhov, V. Kozin, S. Kononenko, V. Likhachev, V. Lyashchenko, V. Markov, N. Mocheshnikov, V. Molodkin*, V. Moskalenko, A. Mytsykov, V. Nemoshkalenko*, Yu. Popkov, A. Shcherbakov, A. Shpak*, M. Strelkov, A. Tarasenko, Yu. Telegin, V. Trotsenko, A. Zelinsky

Kharkov Institute of Physics and Technology, 310108 Kharkov, Ukraine;
*Metallophysics Institute of the Ukrainian Academy of Sciences, 252142 Kiev, Ukraine

Abstract

The synchrotron ring for the scientific and industrial applications in designed at Kharkov Institute of Physics and Technology. The ring is dedicated for Ukrainian Synchrotron Radiation Center in Kiev. The synchrotron light generating by the 800 MeV electron beam with current up to 200 mA and the radiation emittance of $2.5*10^{-8}$ m*rad will be utilized by 24 beam lines. Two wigglers and an undulator will be inserted into the magnet lattice. The ring lattice is to provide large enough dynamic aperture and to decrease sensitivity to the collective effects.

Proceedings of International Conference on Particle Accelerators 1993
https://doi.org/10.1109/PAC.1993.309064

Electron beam energies, MeV	
injected	120
nominal	800
top	1000
Stored current, mA	200
Perimeter, m	46.729
Number of dipole magnets	12
Magnet curvature radius, m	2.005
Magnet length, m	1.05
Magnetic field, T (800 MeV)	1.34
Field index	3.0
Vertical gap, mm	36.0
Number of quadrupole lenses	24
Lens length, m	0.2
Highest gradient, T/m^2	300
Betatron tunes	
horizontal Q_x/vertical Q_z	4.26 / 3.20
Momentum compaction factor, α	0.0247
Natural chromaticity, ξ_x/ξ_z	-7.27/-7.24
Damping times, μs $\tau_x/\tau_z/\tau_s$	8.77/13.87/9.76
Emittance,nm rad $\varepsilon_x/\varepsilon_z$	27.6/1.38
Energy spread, %	$5.8\ 10^{-2}$
Energy losses per turn, keV	18.0
RF, MHz	699.3
Number of bunches	109
Accelerating voltage amplitude, kV	200
RF Power, kW	10
Critical photon energy, keV	0.6
Flux, phot/(A*sec*mrad*0.1%BW)	$1.25\ 10^{12}$

SYNCHROTRON RADIATION COMPLEX ISI-800

V.Androsov, V.Bar'yakhtar*, E.Bulyak, A.Gevchuk, V.Chechetenko,
A Dovbnya, S.Efimov, P.Gladkikh, I.Karnaukhov, S.Kononenko, V.Kozin, V.Lihachov, V.Lyaschenko,
N.Mocheshnikov, V.Molodkin*, V.Moskalenko, A.Mytsykov, V.Nemoshkalenko*, Yu.Popkov,
A.Shcherbakov, A.Shpak*,
M.Strelkov, Yu.Telegin, V.Trotsenko, A.Zelinskiy

Kharkov institute of physics and technology, 310108, Kharkov, Ukraine

* Institute of metallophysics of Ukraine science Academy, 252142 ,Kiev, Ukraine

The 800-MeV synchrotron radiation source ISI-800 will be a national user-based facility, which is designed to produce photon beams in the ultraviolet and soft x-ray region of the electromagnetic spectrum. The complex consists of an injection system (linac 120 MeV and beam transport system) and a low emittance storage ring, several insertion devices (wigglers and undulators) located in the free-disperse storage ring straight sections (about 3.5m) and beam lines from the insertion devices and bending magnets. Storage ring performance is analyzed in terms of lattice and beam dynamics. Beam current at 800 MeV will be 200 mA and beam lifetime will be about 6 h. Spectral characteristics of the radiation are presented. The construction of this 800-MeV electron storage ring will be started in 1994.

The design accommodates the requirements of a broad range of scientific disciplines, including atomic and molecular physics, biology and medicine, chemical dynamics, materials and surface science, and industrial research and technology.

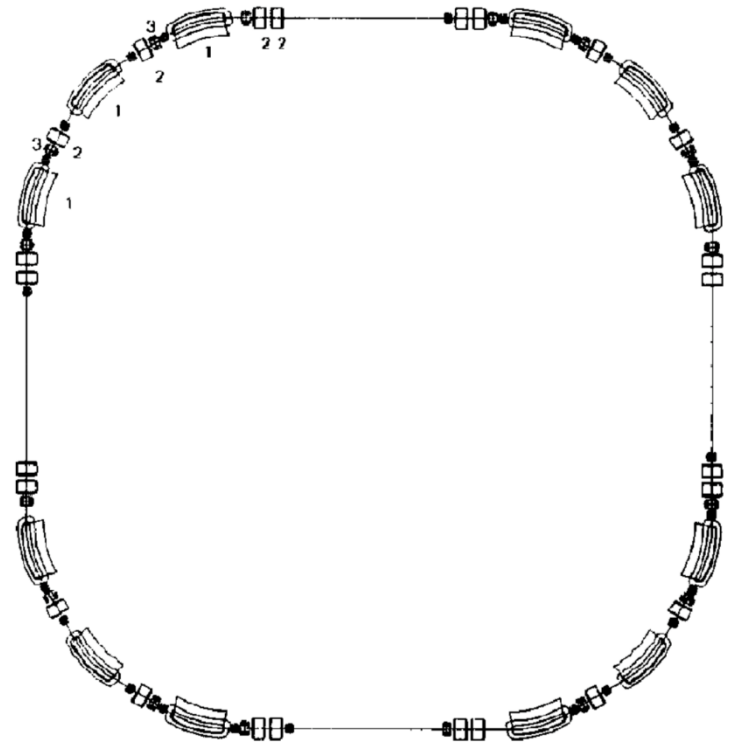


Fig. 2. Lattice of the ISI-800 storage ring.
1 are dipoles; 2 are quadrupoles;3 are sextupoles.

Journal of Electron Spectroscopy and Related Phenomena, 68 (1994) 747–755

National Science Center
Kharkov Institute of Physics and Technology

https://www.kipt.kharkov.ua/en.html

- Institute of solid-state physics, materials science and technologies
- Institute of high-energy physics and nuclear physics
- Institute of plasma electronics and new methods of acceleration
- Institute of plasma physics
- Akhiezer Institute for theoretical physics
- Laboratory of Radiation Research and Environmental Protection
- Separated departments

“Accelerator” Science and Research Establishment

https://www.lrt.kipt.kharkov.ua/en/nik-accelerator-nnc-khfti.html

- Development and use of linear electron accelerators
- Researches in the field of charged particle beam physics, nuclear and radiation physics
- Development and use of radiation technologies

For the last twenty years (1991-2011) **8 linacs** with various characteristics have been developed and created (modernized), today 6 of them work in “Accelerator” Science and Research Establishment.

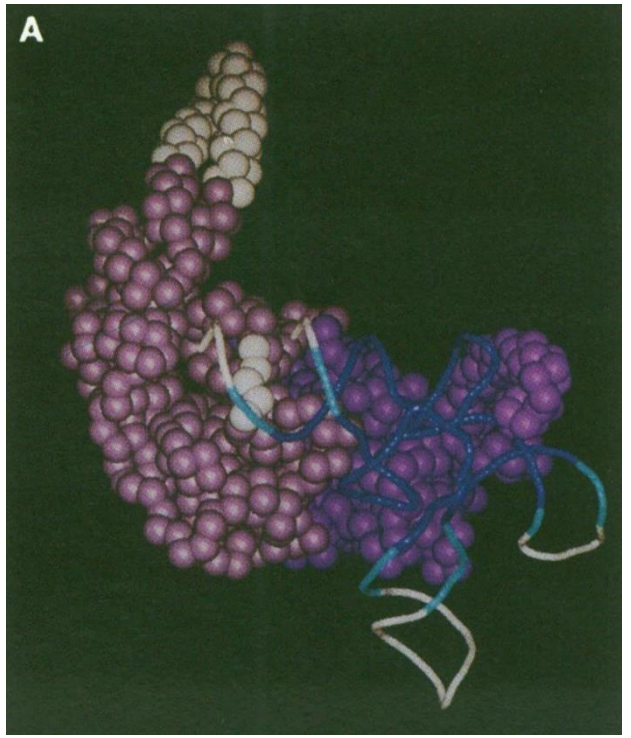
Institute of Molecular Biology and Genetics

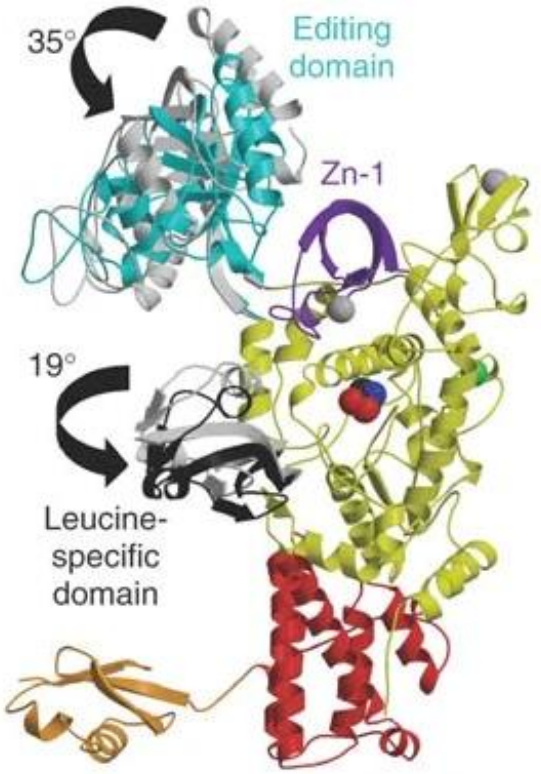
Mykhaylo Tukalo

Study of the molecular structure of protein-protein and protein-nuclein complexes involved in the process of translation of genetic information.

X-ray structural analysis of crystals of macromolecule complexes. Energy range: 5-20 keV.

- Beamline X8C at the National Synchrotron Light Source, Brookhaven National Laboratory;
- European Synchrotron Radiation Facility (ESRF)





- Biou, V., Yaremchuk, A., Tukalo, M., Cusack, S. The crystal structure of a complex between seryl-tRNA synthetase and tRNASer from *Thermus thermophilus* at 2.9 Å resolution. ***Science*** **263**, 1404 (1994).
- Tukalo, M., Yaremchuk, A., Fukunaga, R. *et al.* The crystal structure of leucyl-tRNA synthetase complexed with $tRNA^{Leu}$ in the post-transfer–editing conformation. ***Nat Struct Mol Biol*** **12**, 923–930 (2005). https://doi.org/10.1038/nsmb986

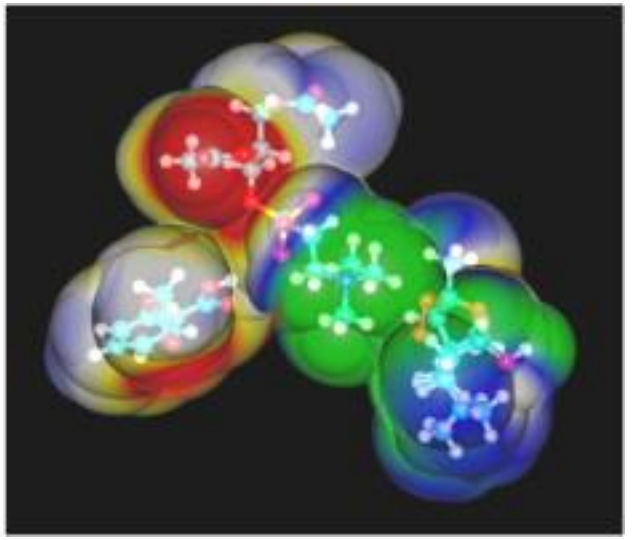
B. Verkin Institute for Low Temperature Physics and Engineering

Vlada Pashynska

Study of intermolecular interaction of biologically active compounds and drugs with target biomolecules, formation of nanobiocomplexes.

Tomographic Microscopy.
Energy range: 8-45 keV.

Competition of artemisinin-type agents and acetylsalicylic acid for binding with phospholipids



- **V. Pashynska**, S. Stepanian, A. Gomory, K.Vekey, L. Adamowicz. Competing intermolecular interactions of artemisinin-type agents and aspirin with membrane phospholipids: Combined model mass spectrometry and quantum-chemical study ***Chemical Physics***, **455**, 81-87 (2015). http://dx.doi.org/10.1016/j.chemphys.2015.04.014

- **V. Pashynska**, S. Stepanian, Á. Gömöry, L. Adamowicz. What are molecular effects of co-administering vitamin C with artemisinin-type antimalarials? A model mass spectrometry and quantum chemical study ***Journal of Molecular Structure***, **1232**, 130039 (2021). https://doi.org/10.1016/j.molstruc.2021.130039

V. Bakul Institute for Superhard Materials

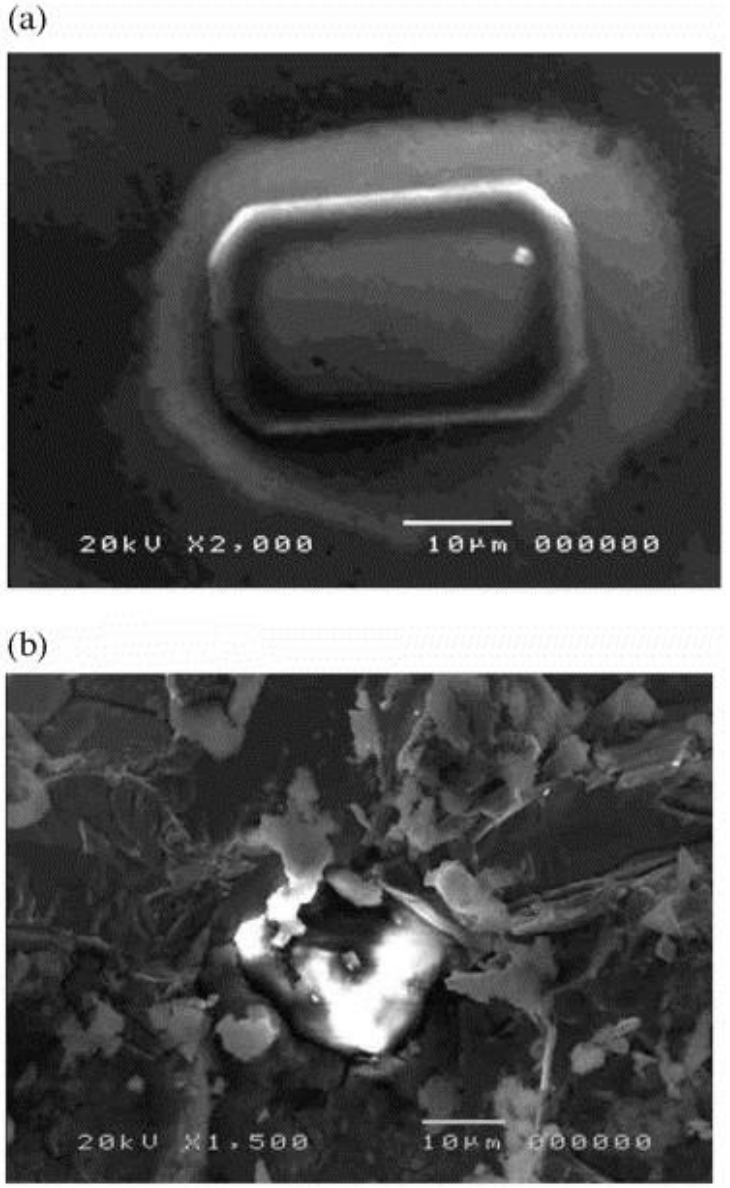
Volodymyr Turkevych

Study of phase transformations at high pressures and temperatures of crystallization or sintering of superhard phases.

Energy dispersive diffractometry. Radiation source: banding magnet in the energy range of 10-70 keV.

- DESY (Germany)
- SPRING-8 (Japan)

- Kinetics of diamond spontaneous crystallization from the melt of the Fe–Al–C system at 6.5 GPa / V. Turkevich, T. Okada, W. Utsumi and A. Garan // Diamond & Related Materials – 2002. –Vol. 11, Is. 10. – P.1769-1773..
- *In situ* studies of boron nitride crystallization from BN solutions in supercritical N–H fluid at high pressures and temperatures / V. L. Solozhenko, Y.L. Godec, S. Klotz, M. Mezouar, V.Z. Turkevich, J.M. Besson // Phys. Chem. Chem. Phys. – 2002. – Vol. 4, Is. 21.– P. 5386 – 5393.

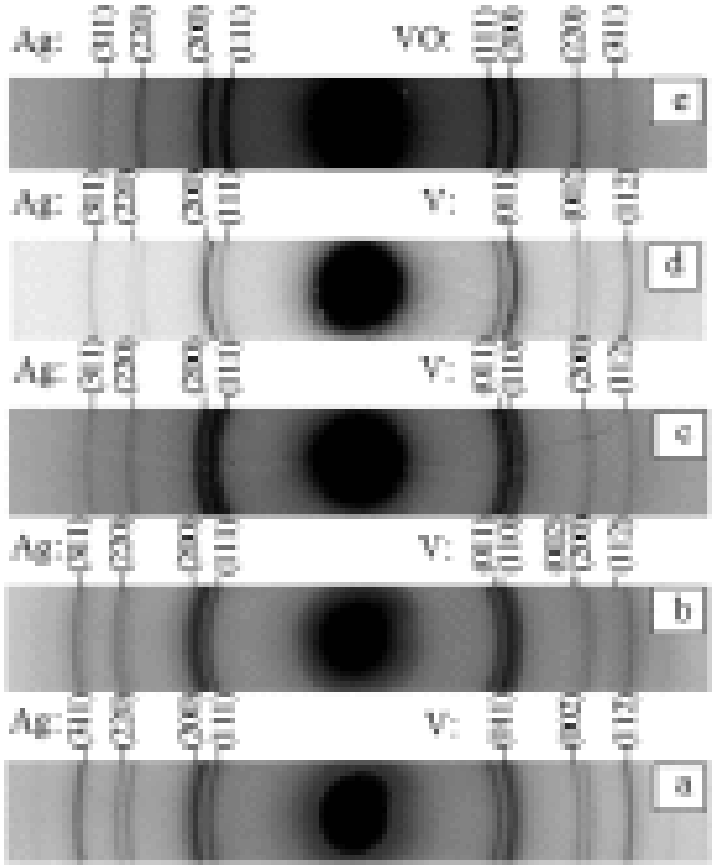


Y. O. Paton Educational and Research Institute of Materials Science and Welding
of the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”

Igor Vladymyrskyi

Structural and phase transformations in nanoscale film systems of various functional purposes.

Powder diffraction
GIWAXS/GISAXS (15-20 keV),
XPS (0,5-2 keV), HAXPES (10-20 keV),
XRR (10-30 keV).



- A.K. Orlov, I.O. Kruhlov, O.V. Shamis, I.A. Vladymyrskyi, I.E. Kotenko, S.M. Voloshko, S.I. Sidorenko, T. Ebisu, K. Kato, H. Tajiri, O. Sakata, T. Ishikawa, Synchrotron analysis of structure transformations in V and V/Ag thin films, ***Vacuum*** **150**, 186-195 (2018). https://doi.org/10.1016/j.vacuum.2018.01.044 .

G. V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine

Dynamical diffraction on single crystals with microdefects, phase-contrast imaging, coherent X-ray diffractive imaging.

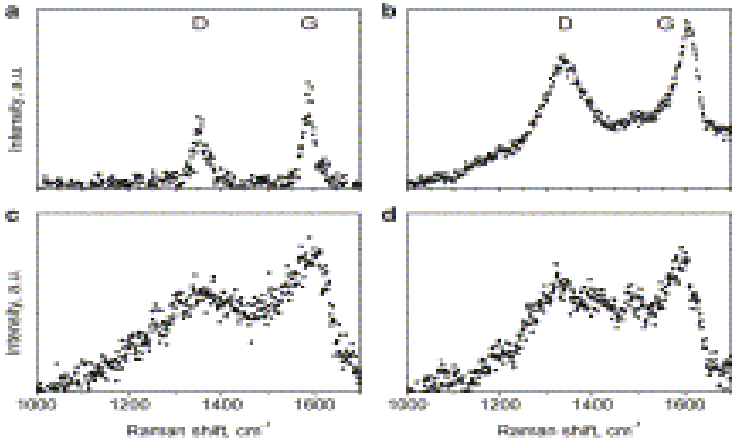
Reciprocal-space map, rocking curves, analyzer-based imaging with three-axis geometry — 5-60 keV.

- **V. B. Molodkin**, S. I. Olikhovskii, S. V. Dmitriev, and **V. V. Lizunov**, Dynamical effects in the integrated X-ray scattering intensity from imperfect crystals in Bragg diffraction geometry. II. Dynamical theory. — Acta Cryst. — 2021. — A77. — p. 433–45

The structure of disordered, including amorphous, metallic and carbon materials

X-ray structural analysis — 24-62 keV.

- **A.D. Rud**, A.M. Lakhnik. Effect of Different Carbon Allotropes on the Structure and Hydrogen Sorption during Reactive Ball-Milling of the Mg-C powder mixtures. *International Journal of Hydrogen Energy*, 2012, v. 37, p. 4179-4187. doi:10.1016/j.ijhydene.2011.11.123

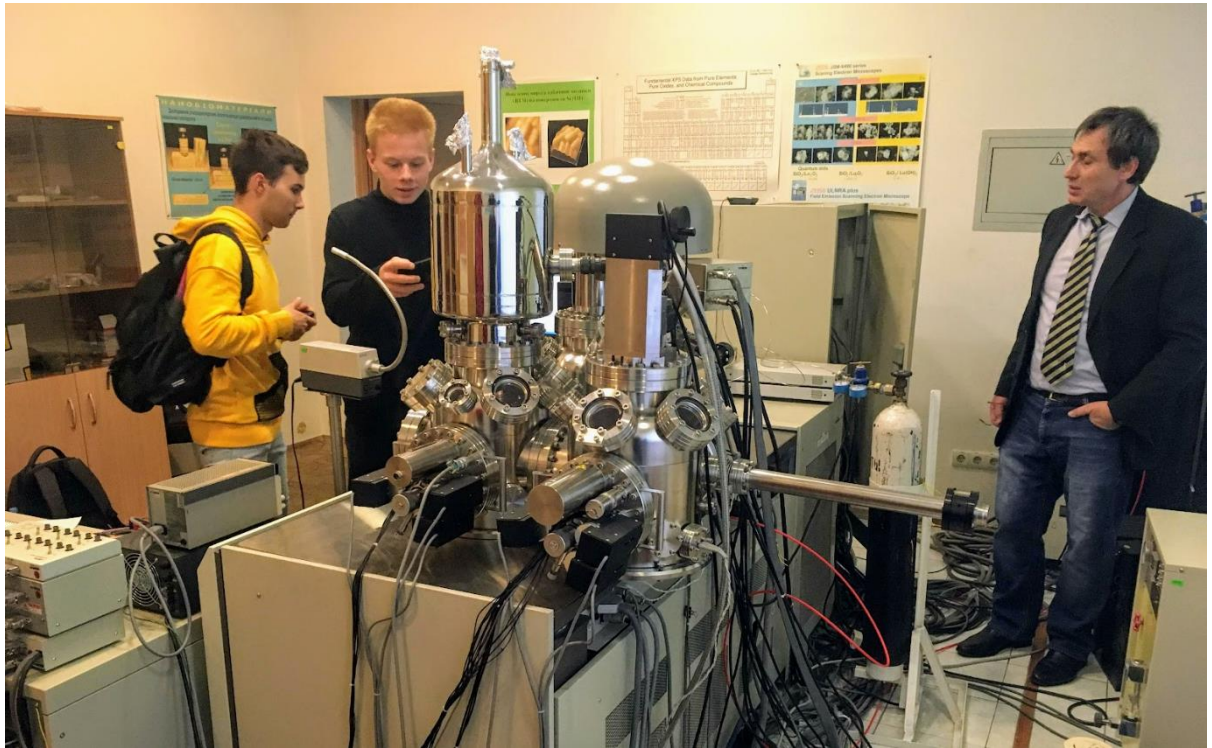


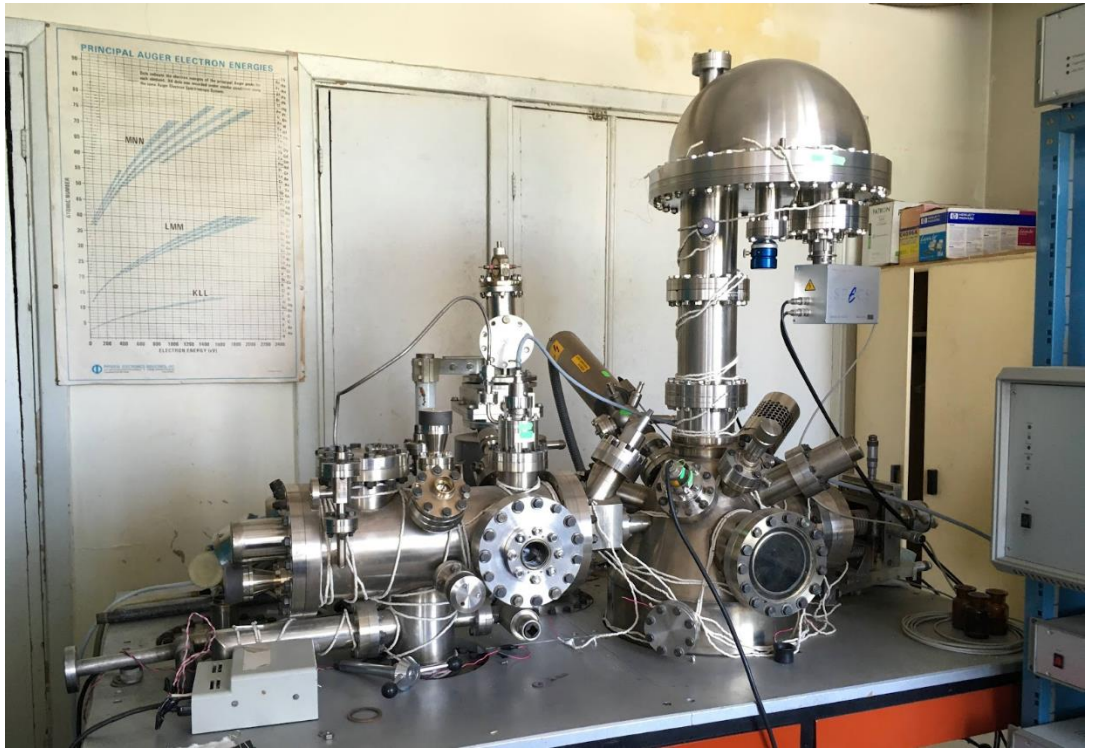
G. V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine

Atomic and electronic structure of disordered systems

UVS - Ultraviolet photoelectron spectroscopy (up to 40 eV) and EXAFS, XANES spectroscopy (from hundreds to 2000 eV).

В.Л. Карбовский, А.П. Шпак. Рентгеновская и электронная спектроскопия // Киев, Наукова думка, 2010. – 214 с.





Institute for Problems in Materials Science

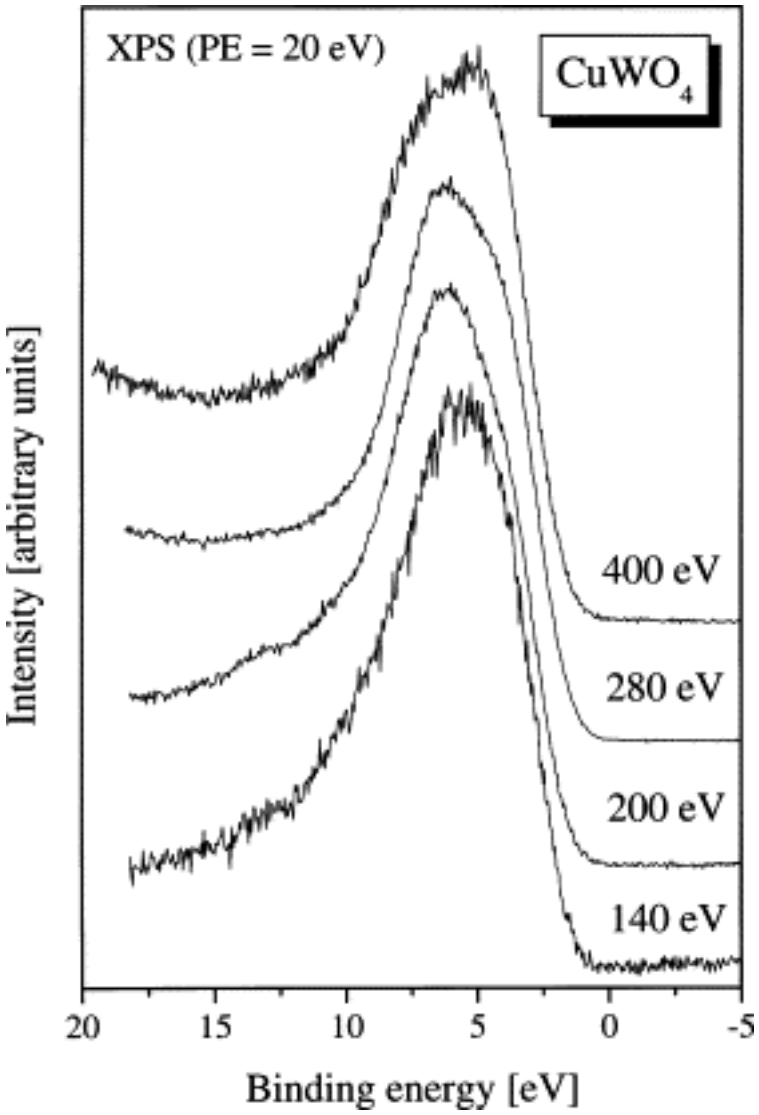
Oleg Khyzhun

Electronic structure of single crystals Tl 2 HgC IV Se 4 (C IV = Si, Ge, Sn), molybdates MMoO 4 (M = Ba, Pb, Zn) and tungstates MWoO 4 (M = Cd, Zn, Mn).

XPS (0-600 eB), UPS/Angle-resolved photoemissionspectroscopy (ARPES) (0-20 eB), EXAFS/NEXAFS (0-600 eB).

- BESSY II and DELTA synchrotron facilities

- O.Y. Khyzhun, T. Strunskus, S. Cramm, Y.M. Solonin. Electronic structure ofCuWO 4 : XPS, XES and NEXAFS studies // J. Alloys Compd. – 2005. – Vol. 389. – P.14–20
- O.Y. Khyzhun, T. Strunskus, W. Grünert, Ch. Wöll. Valence band electronic structureof V 2 O 5 as determined by resonant soft X-ray emission spectroscopy // J. Electron Spectrosc. Relat. Phenom. – 2005. – Vol. 149. – P. 45–50.



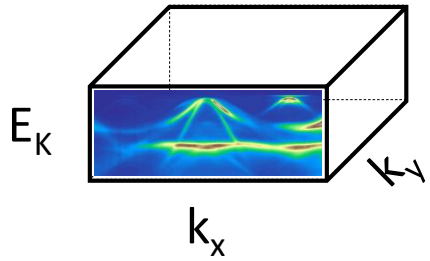
ARPES =

analyzer + manipulator (10^6 €)
+ sinchrotron

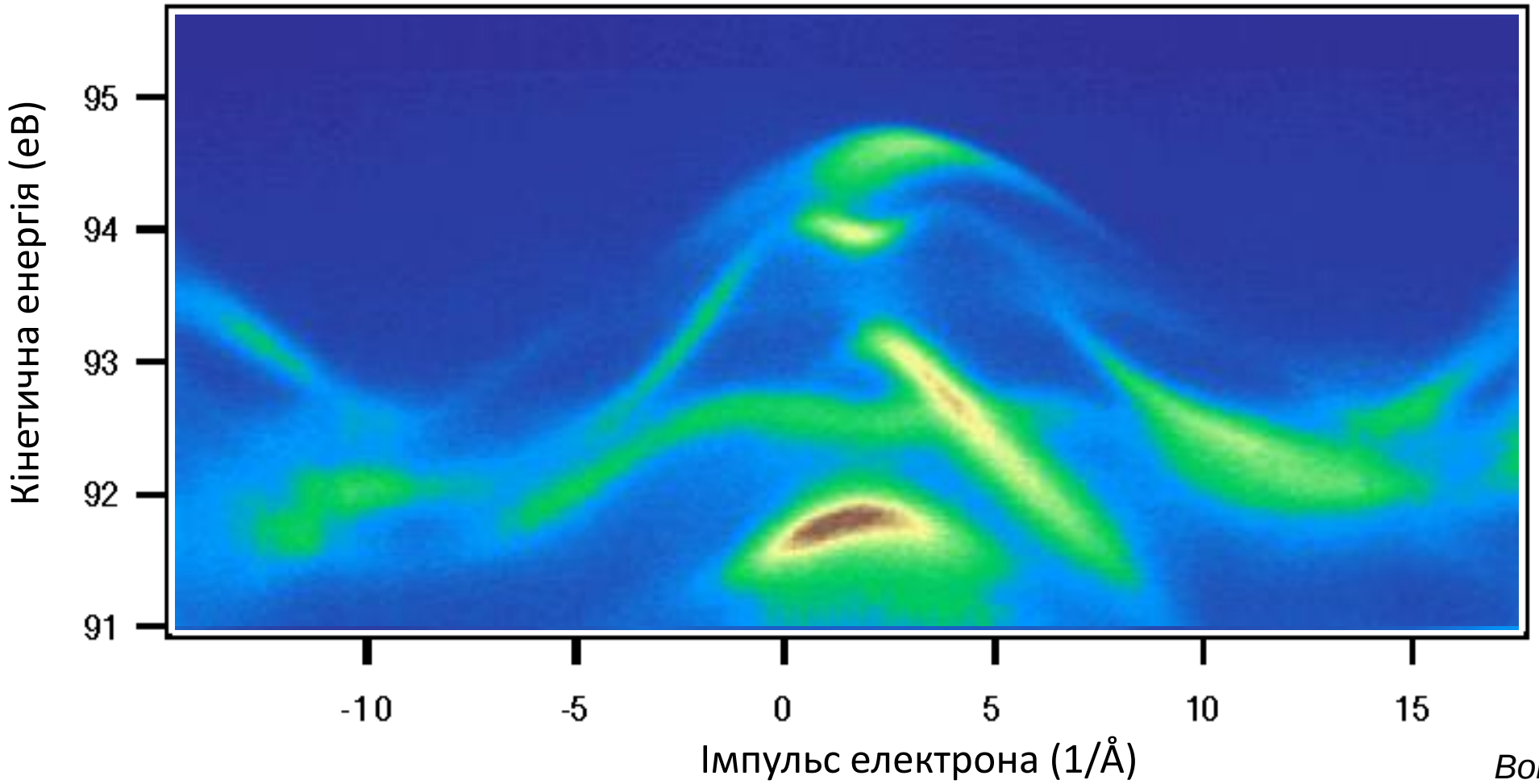
- New direction:
  time resolved ARPES,
  XFEL


05
03
01
57
55
53

Electronic spectrum in momentum-energy 3D space

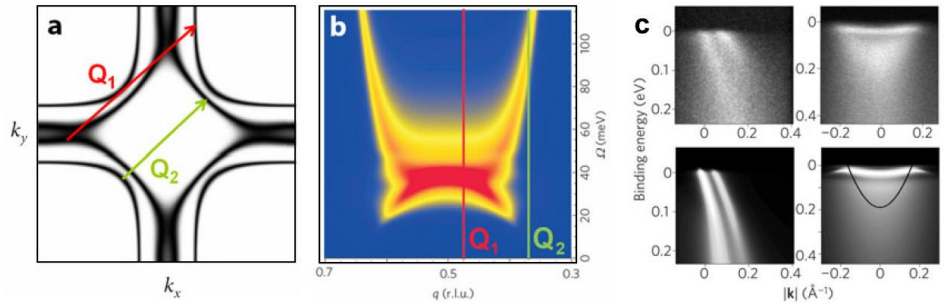


$TiSe_2$ - «excitonic insulator»



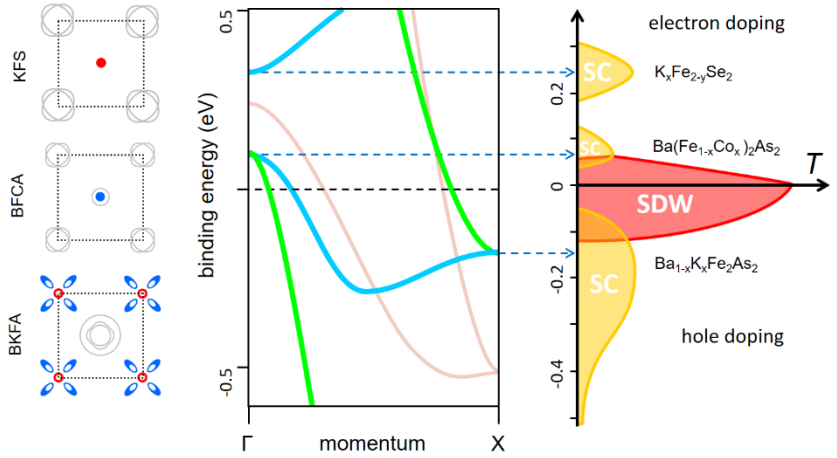
Borisenko JoVE 2012

My HTSC story



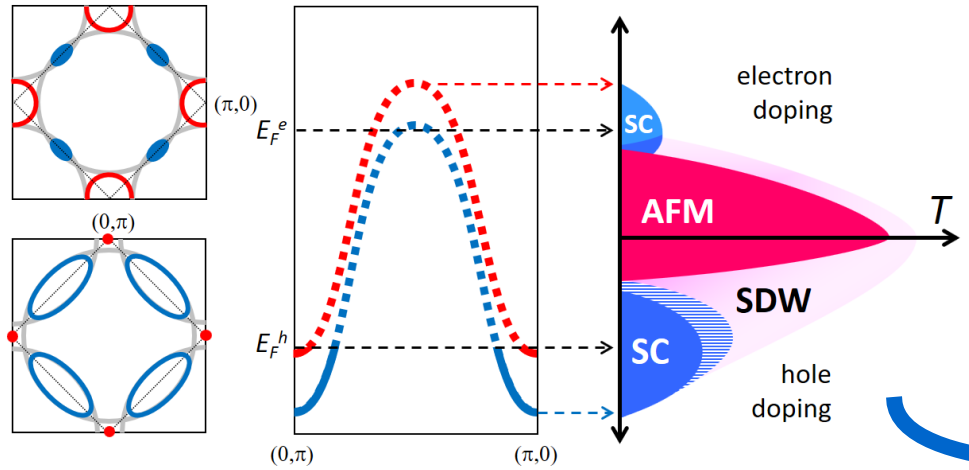
Band structure is important for Cu-SC

PRL 92, 257006 (2004); PRB 71, 214513 (2005); PRL 96, 067001 (2006); PRL 96, 117004 (2006); PRL 96, 037003 (2006); PRL 97, 017002 (2006); PRB 75, 172505 (2007); Nature Phys. 5, 217 (2009)...



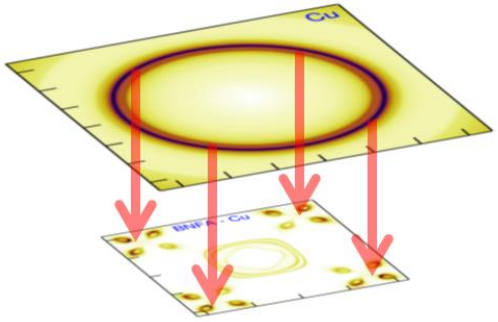
Multi-band structure is essential for SC in Fe-SC

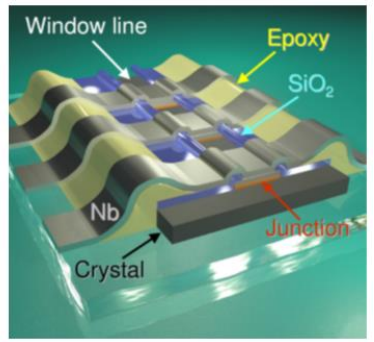
Nature (2009), PRB (2009)...
LTP 38, 888 (2012); JSNM 26, 2837-2841 (2013); PRB 88, 134501 (2013); PRB 89, 064514 (2014), LTP (2018)...



…and in Cu-SC

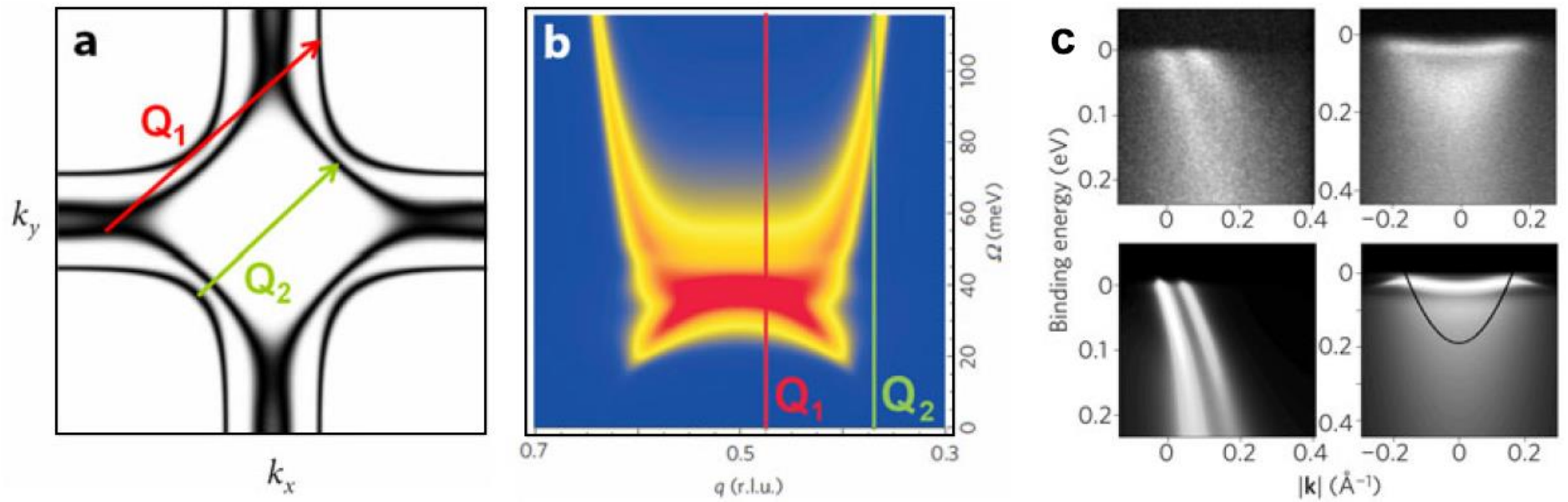
PRL 100, 196402 (2008); PRL 100, 236402 (2008); PRB 79, 020504 (2009); PRL 102, 166402 (2009); PRB 85, 064507 (2012)...





PRL (2018), PRB (2021), Nat Commun (2022)

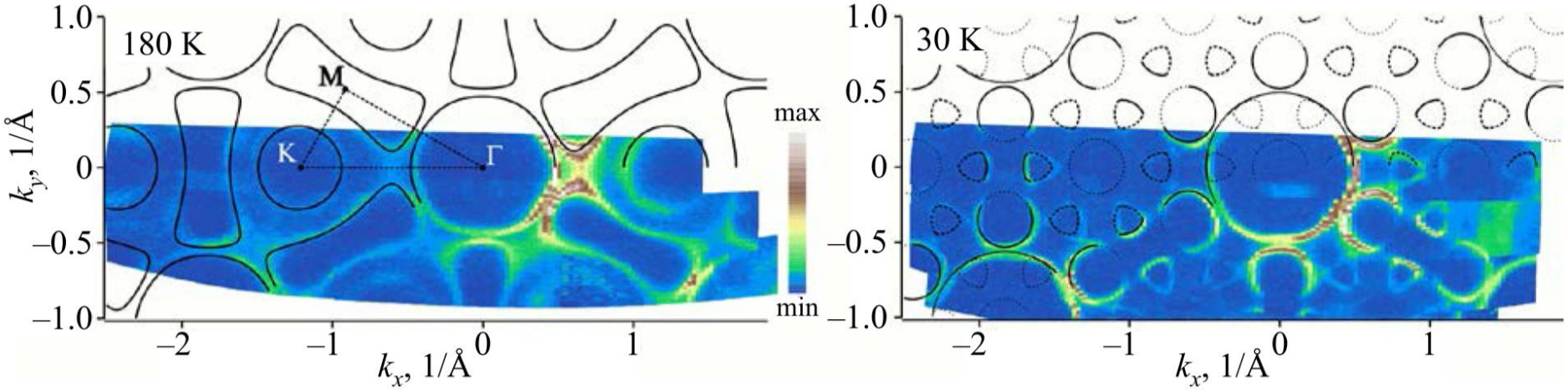
Electronic structure of Cu-SC defines their spin-fluctuation spectrum

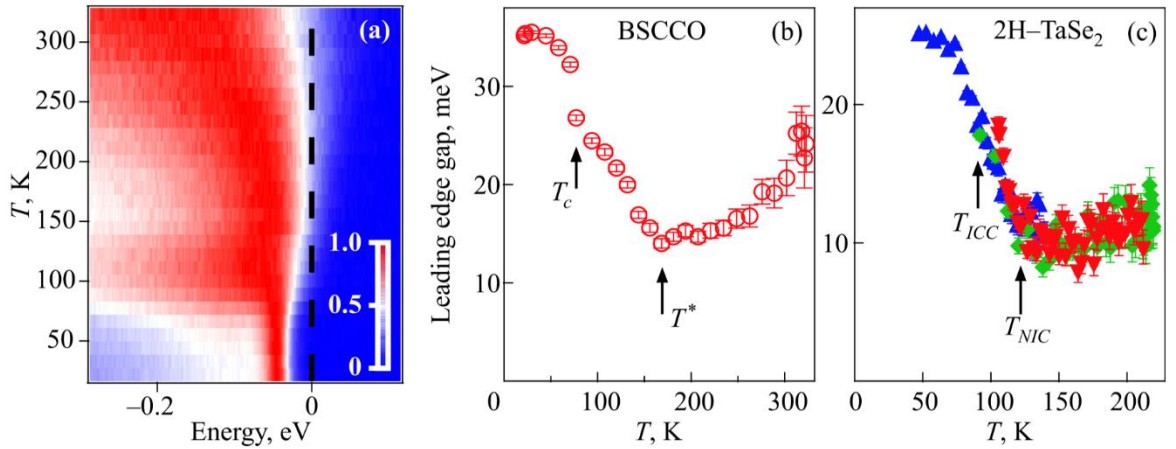


$$G^{-1} = G_0^{-1} - \bar{U}^2 G \star \underbrace{G \star G}_{\chi}$$

PRL 92, 257006 (2004); PRB 71, 214513 (2005); PRL 96, 067001 (2006); PRL 96, 117004 (2006); PRL 96, 037003 (2006); PRL 97, 017002 (2006); PRB 75, 172505 (2007); Nature Phys. 5, 217 (2009)...

… and the electronic ordering, which forms the pseudogap state

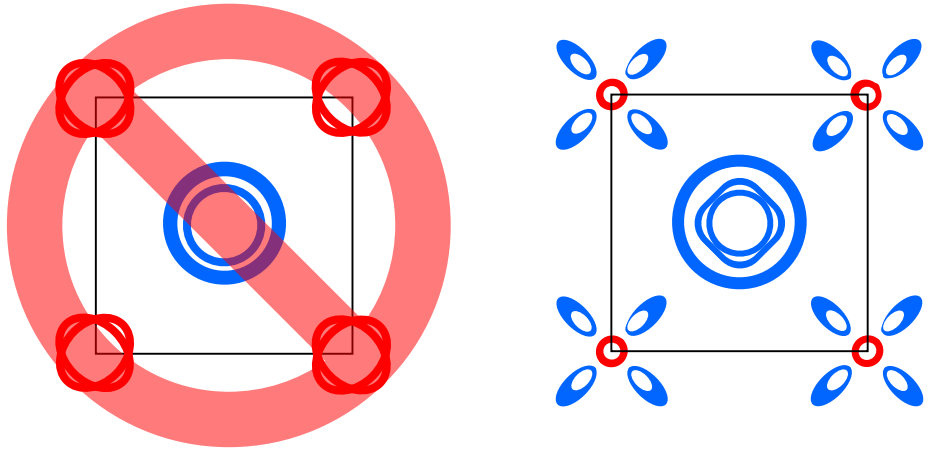


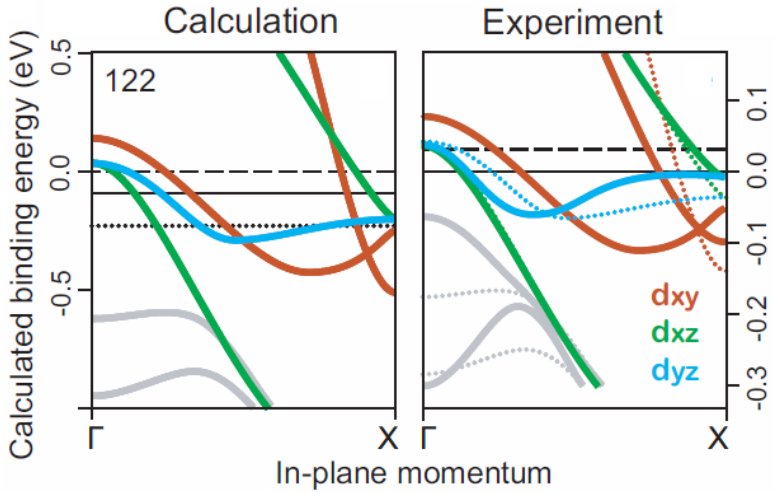


$$\mathrm{ES} + \mathrm{SF} - \mathrm{PG} \Rightarrow \mathrm{SC}$$

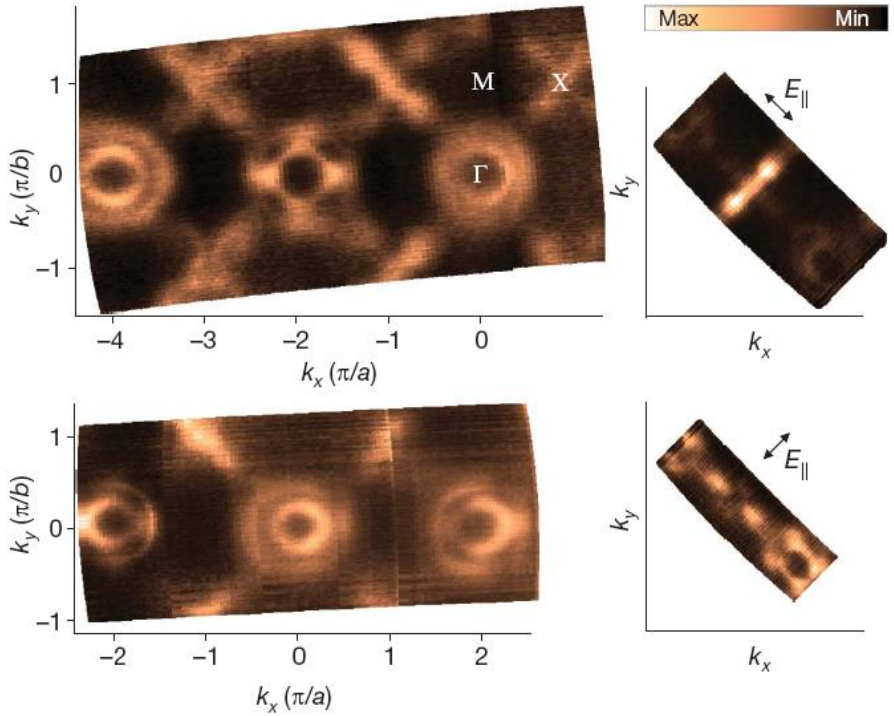
PRL 100, 196402 (2008); PRL 100, 236402 (2008); PRB 79, 020504 (2009);
PRL 102, 166402 (2009); PRB 85, 064507 (2012)...

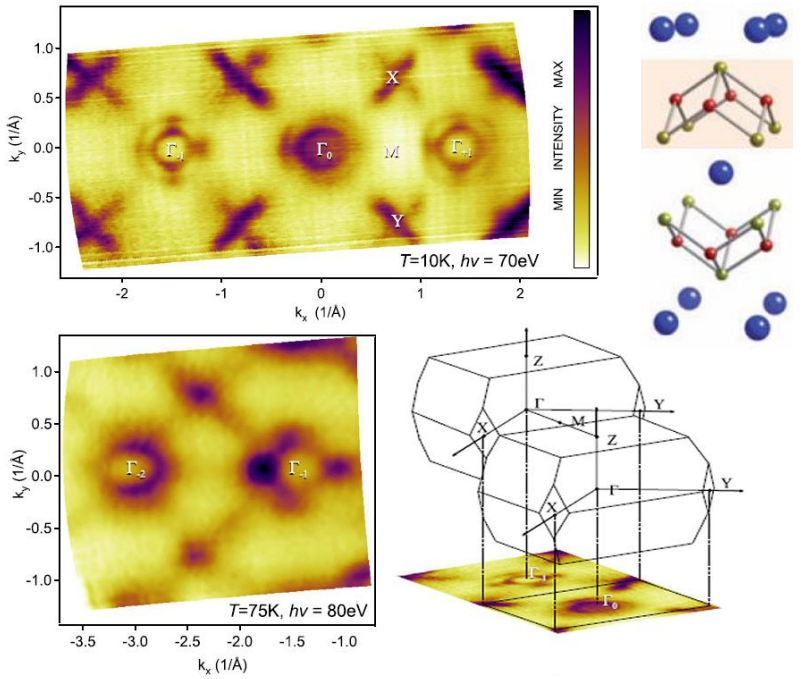
Fermi surface of BKFA





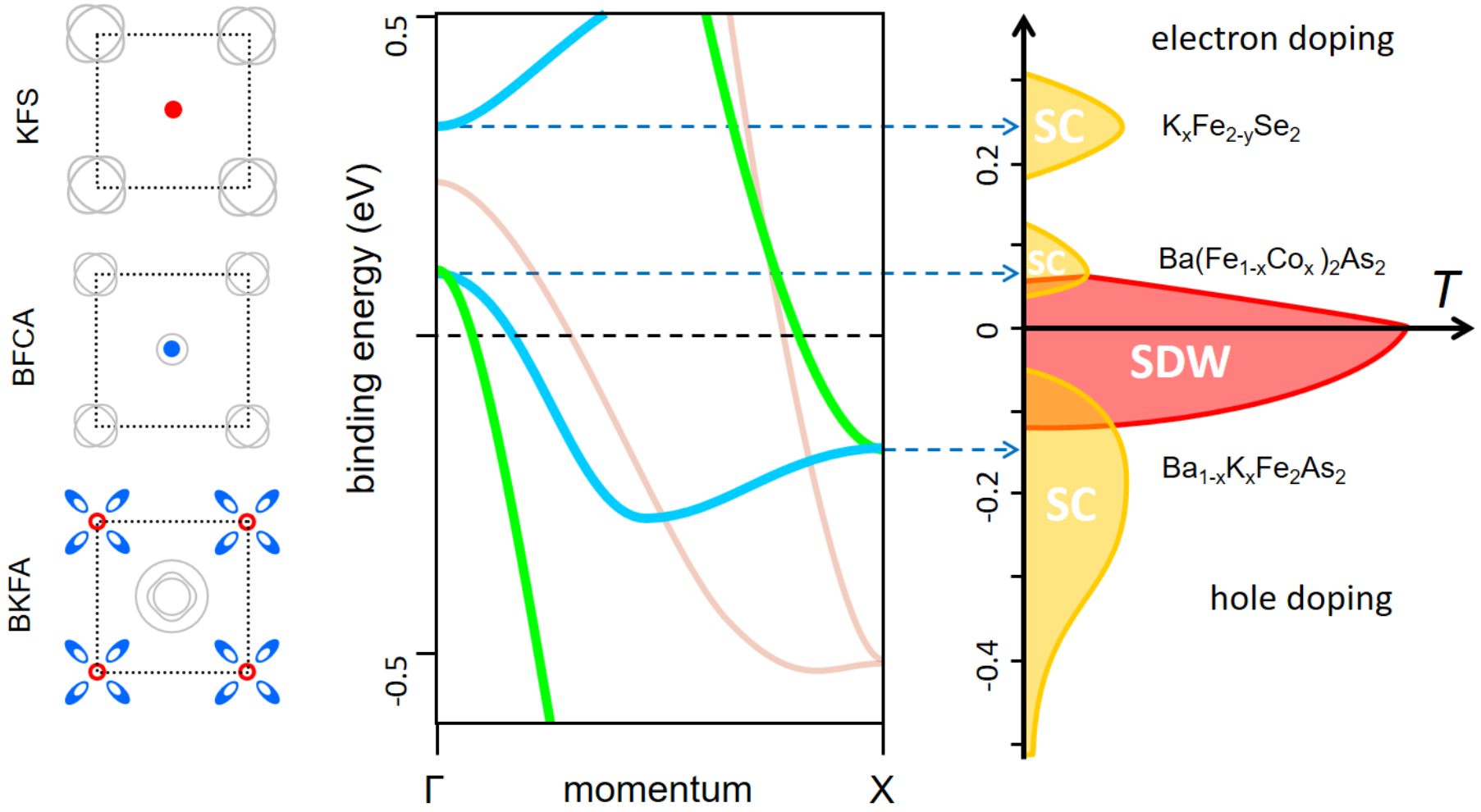
A. A. Kordyuk, *J. Supercond. Nov. Magn.* 2013





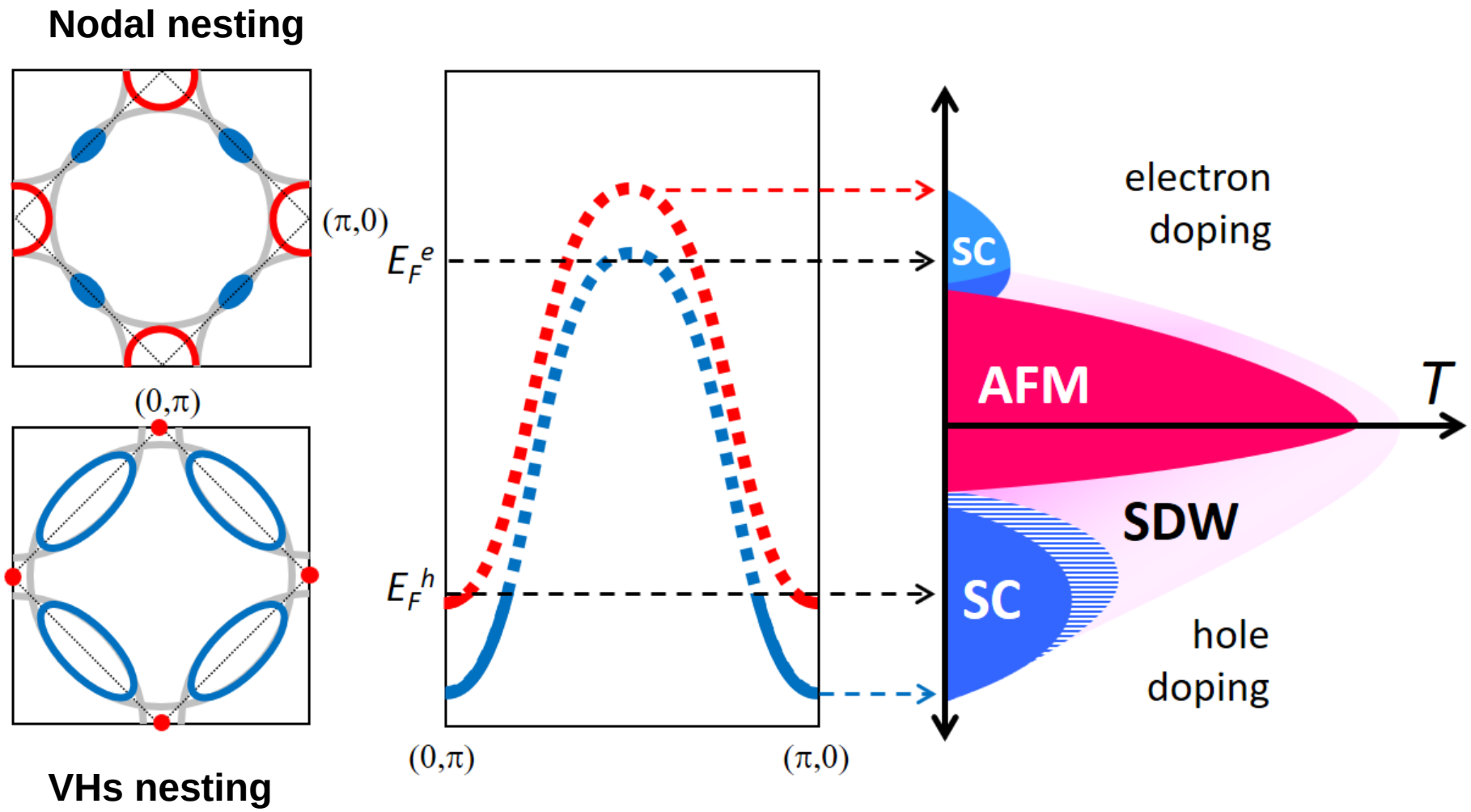
V. Zabolotnyy *Nature* 2009

"Topological" superconductivity in Fe-SC



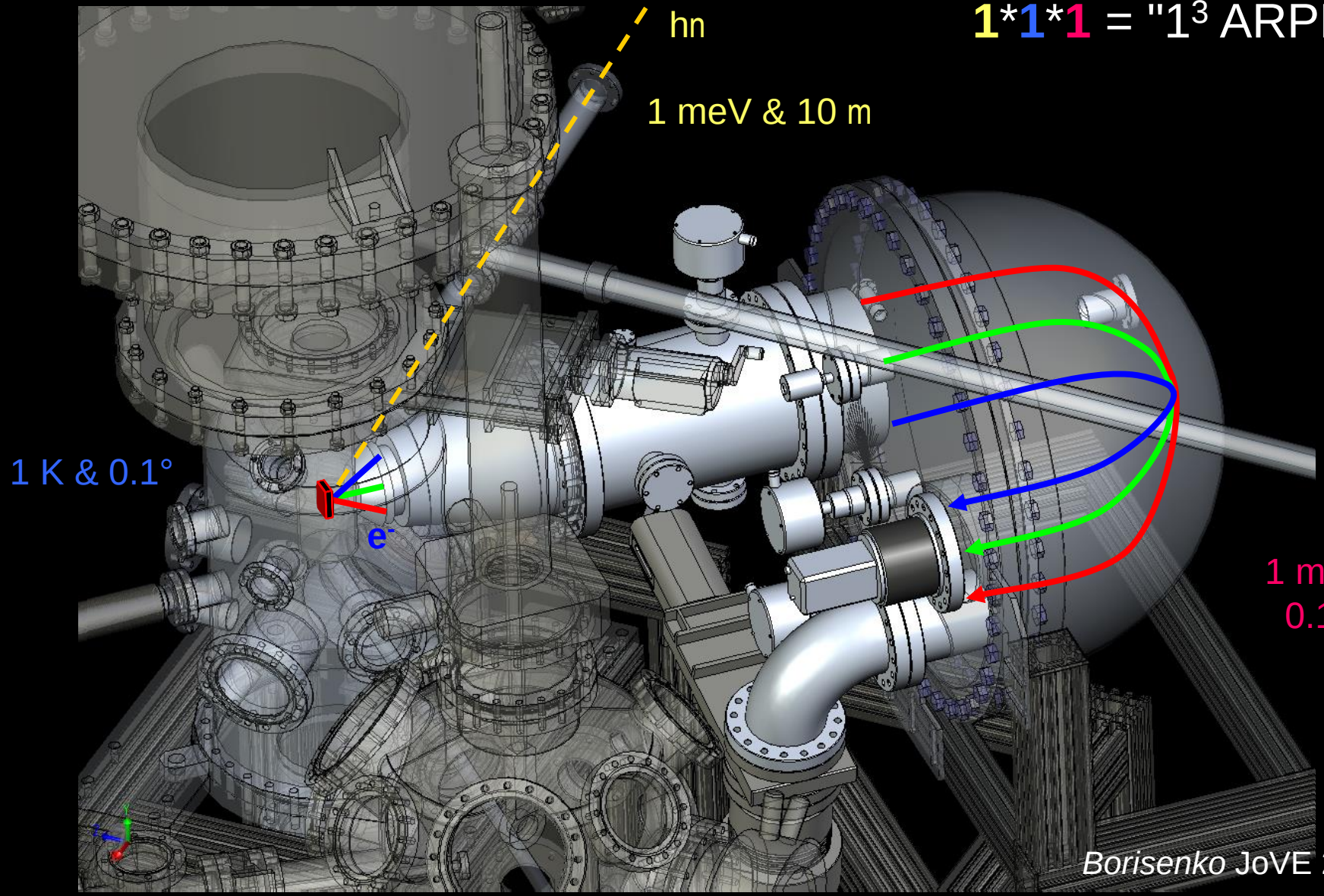
LTP 38, 888 (2012); JSNM 26, 2837-2841 (2013); PRB 88, 134501 (2013);
PRB 89, 064514 (2014), LTP (2018)...

SDW and superconductivity

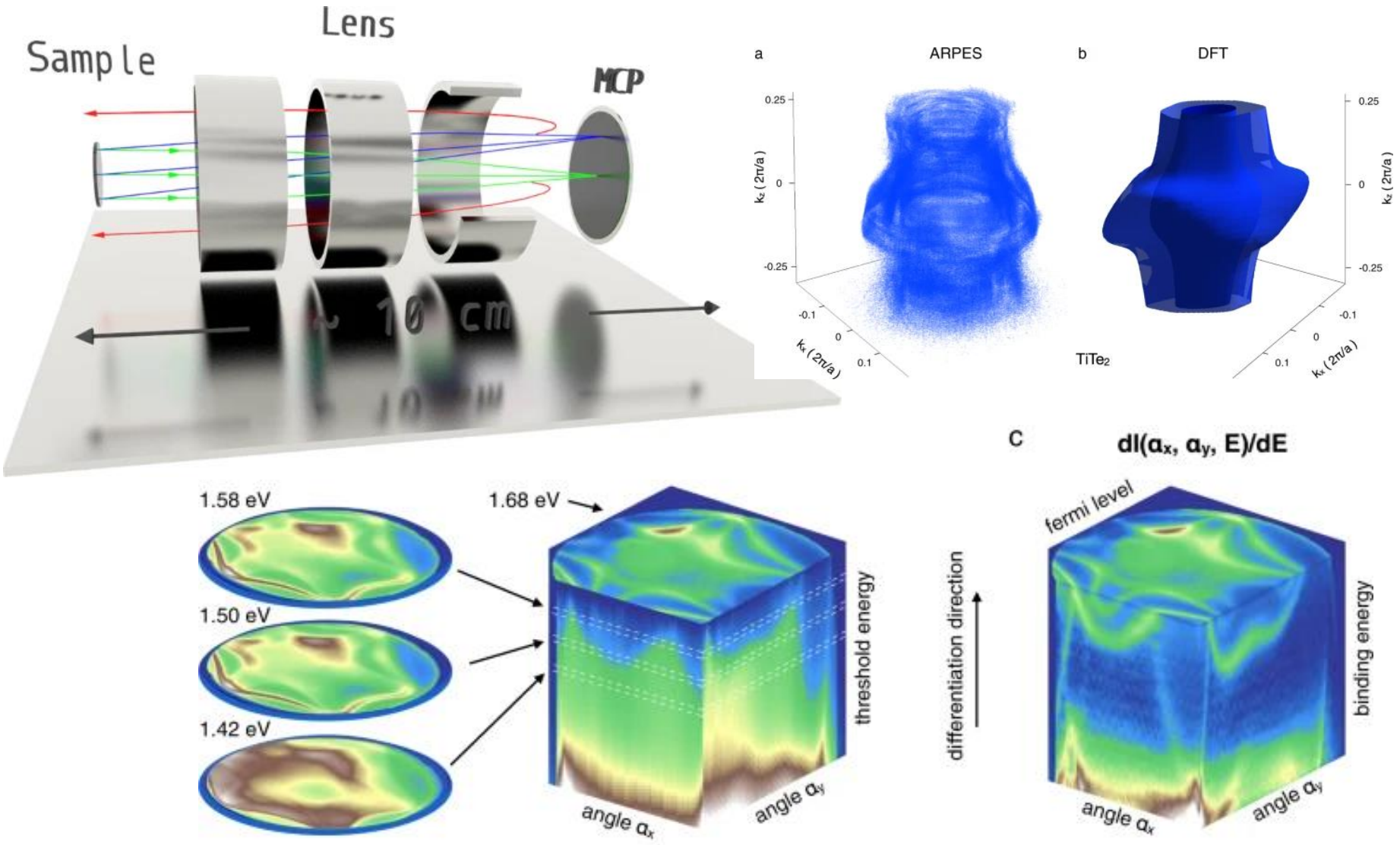


A. A. Kordyuk *Low Temp. Phys.* (2018)

ARPES anatomy



FeSuMa: Fermi surface tomography



S. Borisenko et al. *Nature Commun* **13**, 4132 (2022)

Why do we need a synchrotron in Ukraine?

- For students to keep them in science and in Ukraine
  - A point of attraction
- To reload Ukrainian science institutes
  - An example of faire competition
  - A source of international collaboration
- For us, the researchers, to do research
  - To compensate a deficiency of experimental infrastructure


Thank you!