

Ultrafast spin-to-charge conversion and spin-dependent transport detected by THz emission

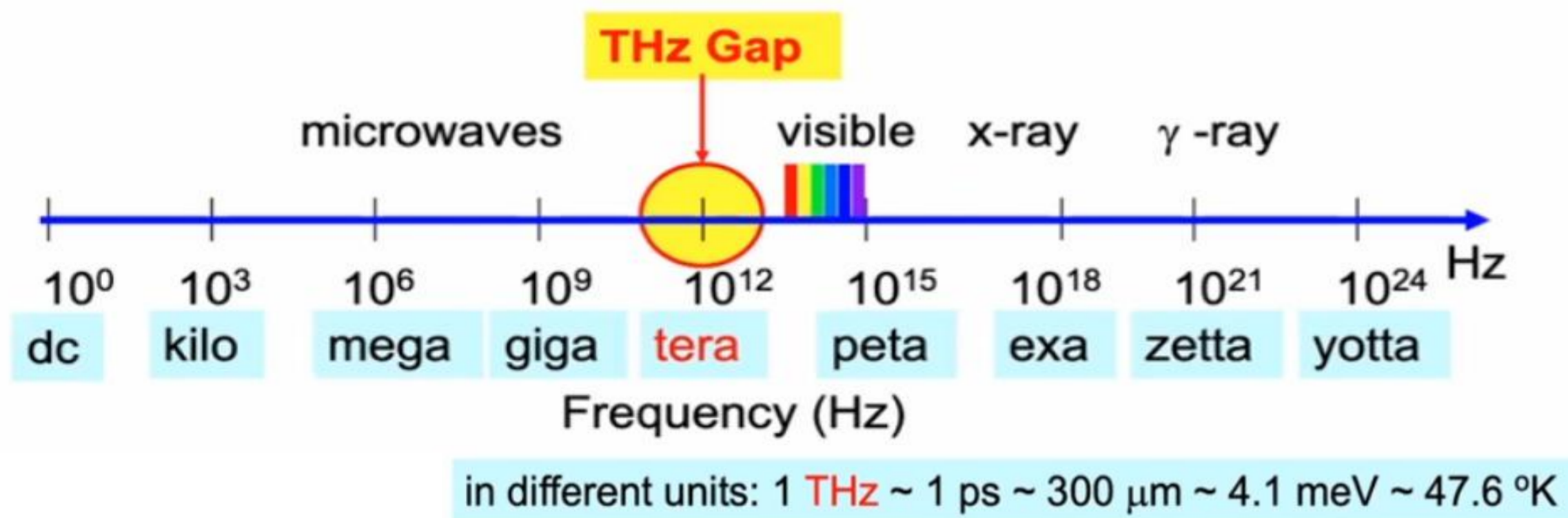
C. Q. Liu¹, Z. X. Wei², W. T. Lu³, C. Zhou¹, D. W. Yang², J. R. Zhang¹, Hong. Xia¹, Y.P. Liu^{1,2}, J. H. Liang¹, Z. Yuan³, J. B. Qi^{2*}, and Y. Z. Wu^{1*}

¹ Department of Physics, State Key Laboratory of Surface Physics, Fudan University

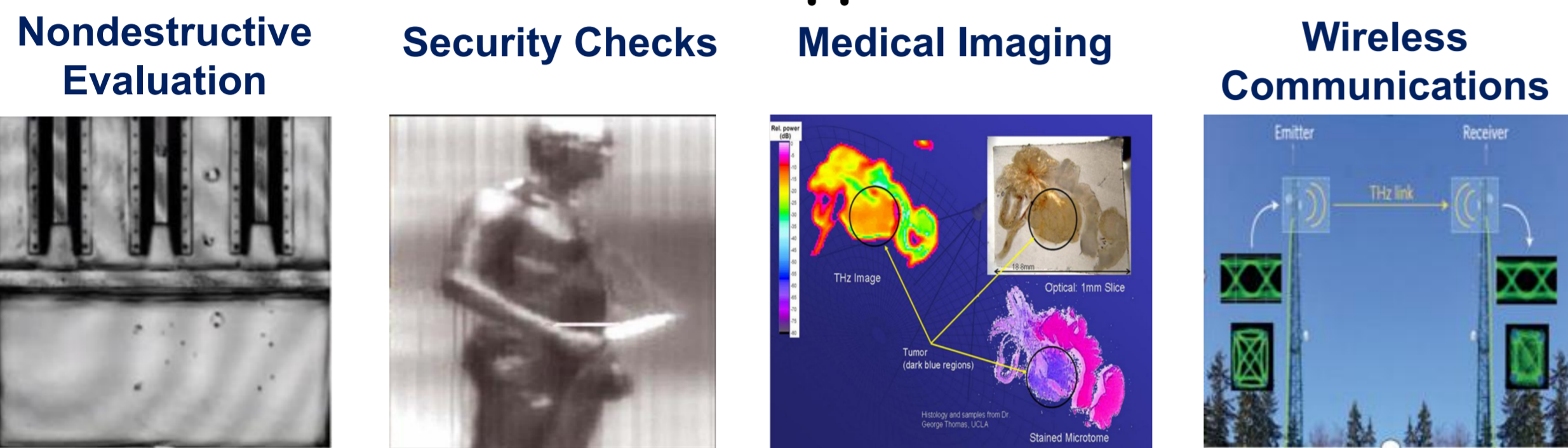
² State Key Laboratory of Electronic Thin Films and Integrated Devices, University of Electronic Science and Technology of China

³ The Center for Advanced Quantum Studies and Department of Physics, Beijing Normal University

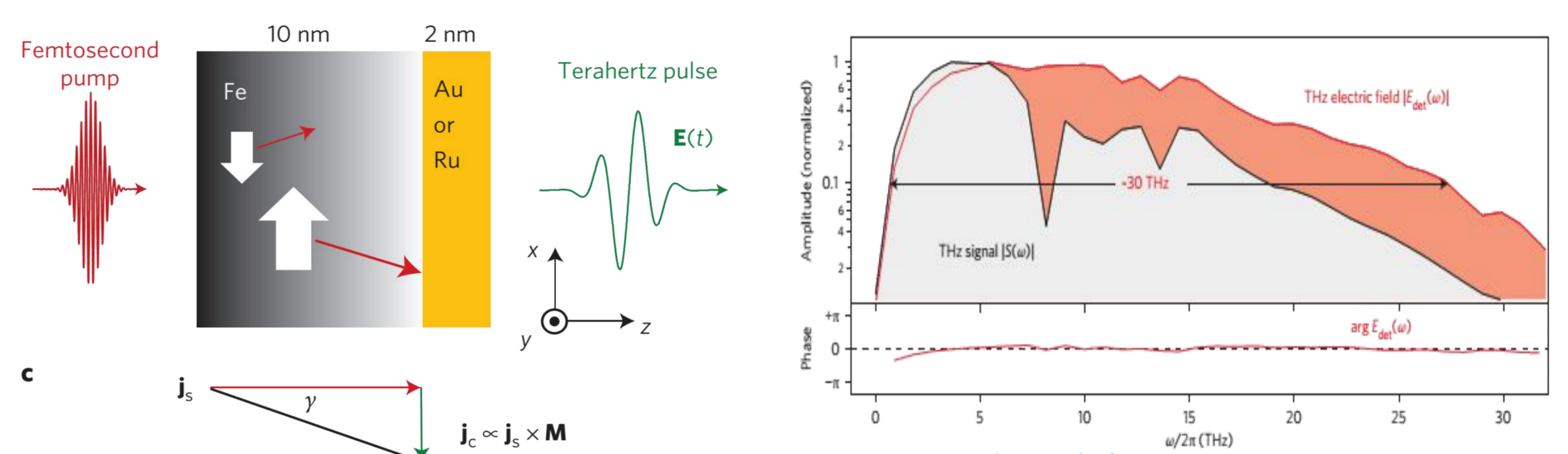
Introduction



Wide THz Applications



New THz emitter based on FM/NM bilayer



Band width covering 1-30THz

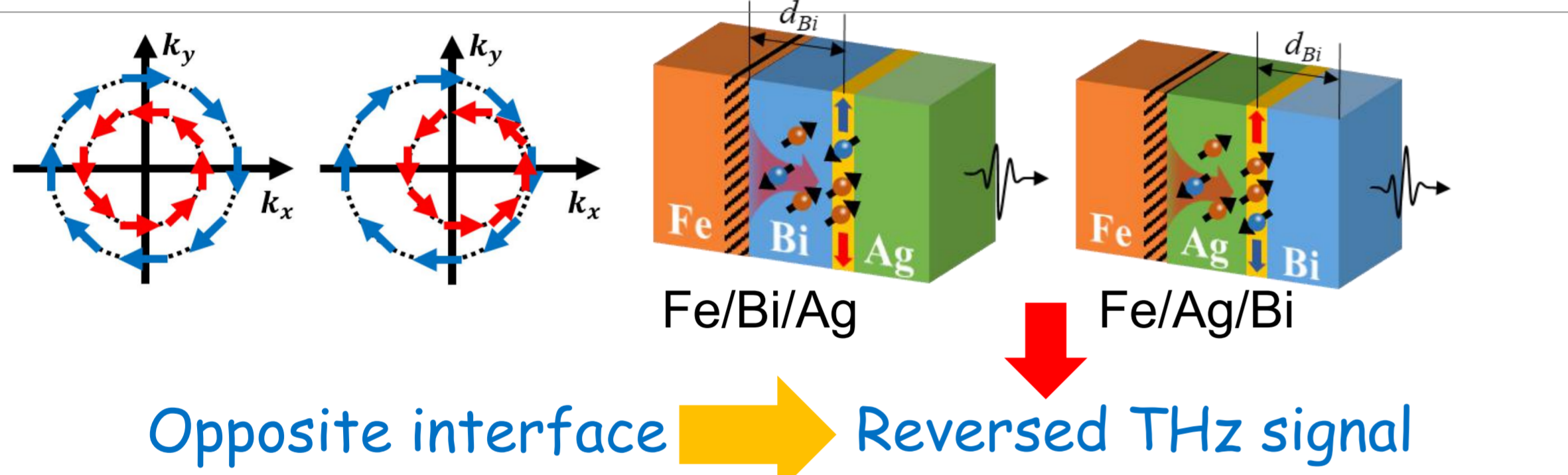
T. Kampfrath, et al. Nat. Nanotechnol. (2013)

T. Seifert, et al. Nat. Photonics (2016)

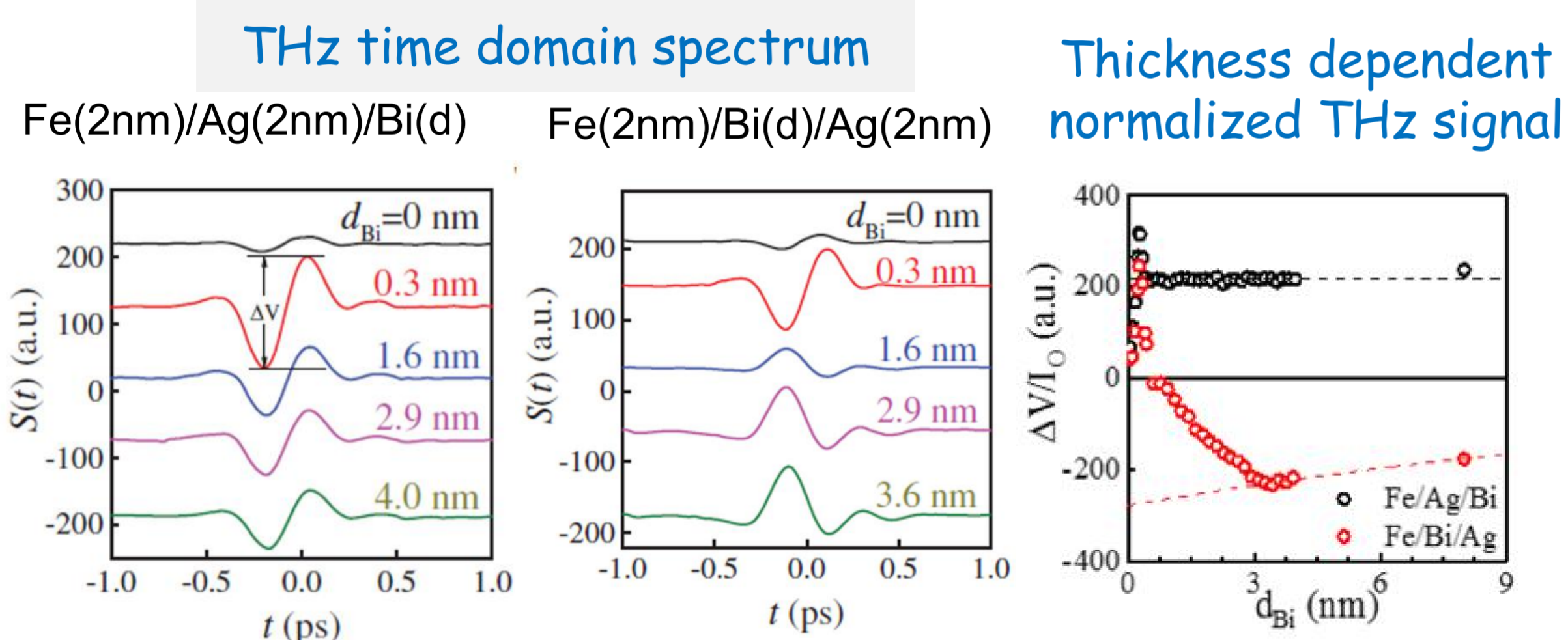
- New ultrafast spin-to-current conversion Mechanism ?
- THz emission in the confined pattern samples?
- Ultrafast spin current transport properties?
- Anisotropic terahertz emission in asymmetric crystals ?

THz Generation via the interface spin-orbit coupling

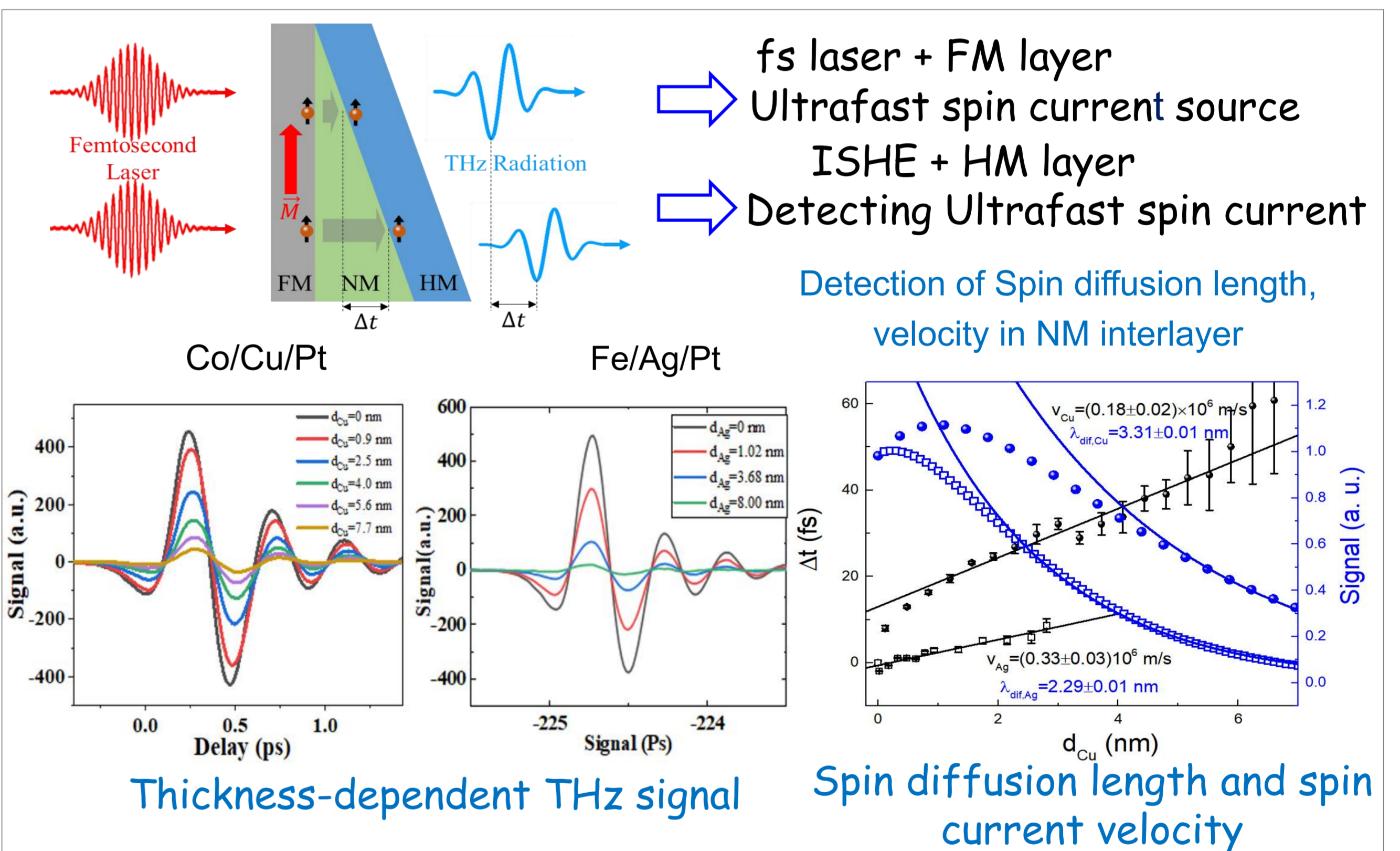
Spin current transport in Cu and Ag



Opposite interface → Reversed THz signal



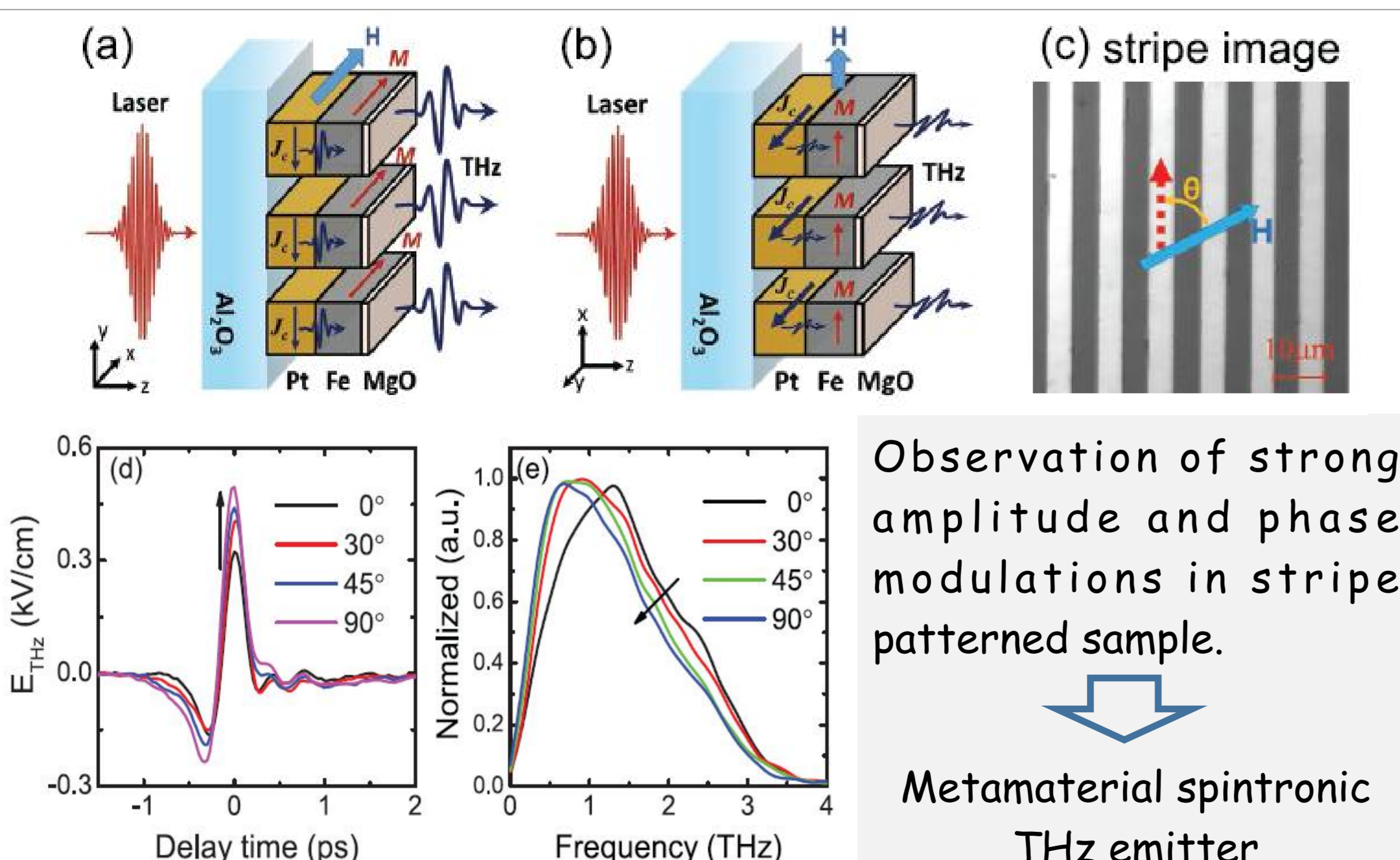
- Opposite THz signals in Fe/Ag/Bi and Fe/Bi/Ag trilayers with opposite Bi/Ag interface.
 - Constant THz signal independent of the Bi-layer thickness.
 - Prove that inverse Rashba effect can induce the ultrafast spin-charge conversion.
- C. Zhou *et al.* Phys. Rev. Lett. 121, 086801 (2018)



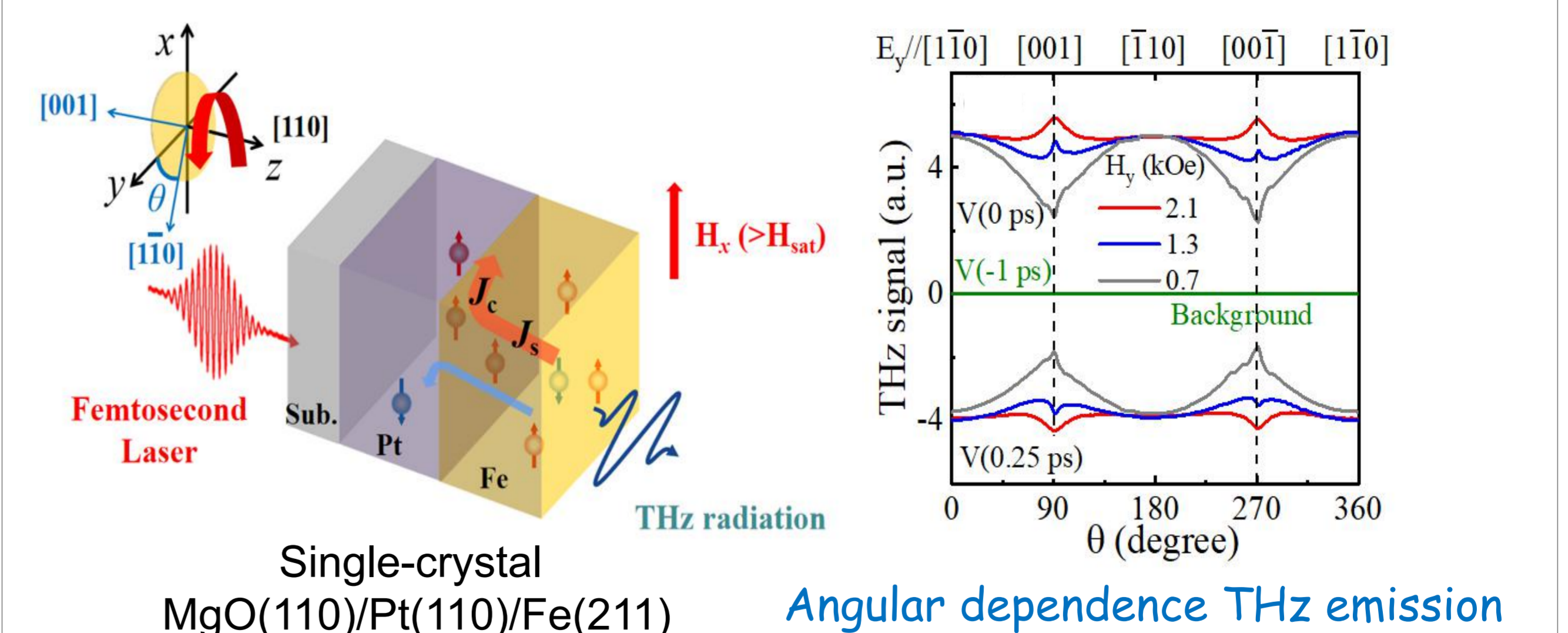
- Spin relaxation length of ultrafast spin current in non-equilibrium state is two order less than that of the equilibrium electron.
- The linear relation between the spin current velocity and the inserting layer thickness indicate the ballistic-like transport behavior.

Terahertz radiation in the patterned samples

Anisotropic THz emission in Fe/Pt(110) single crystal



D. Yang, et al. Adv. Opt. Mater. 4, 12 (2016)



- Observation of the stronger THz electric field intensity for M along MgO[001] axes than that along MgO[110] axes.
- The anisotropic THz emission is induced by the lattice distortion induced anisotropic spin Hall conductivity and longitudinal conductance in Pt layer.

C. Liu, et al. Phys. Rev. Applied. 15, 044022 (2021)