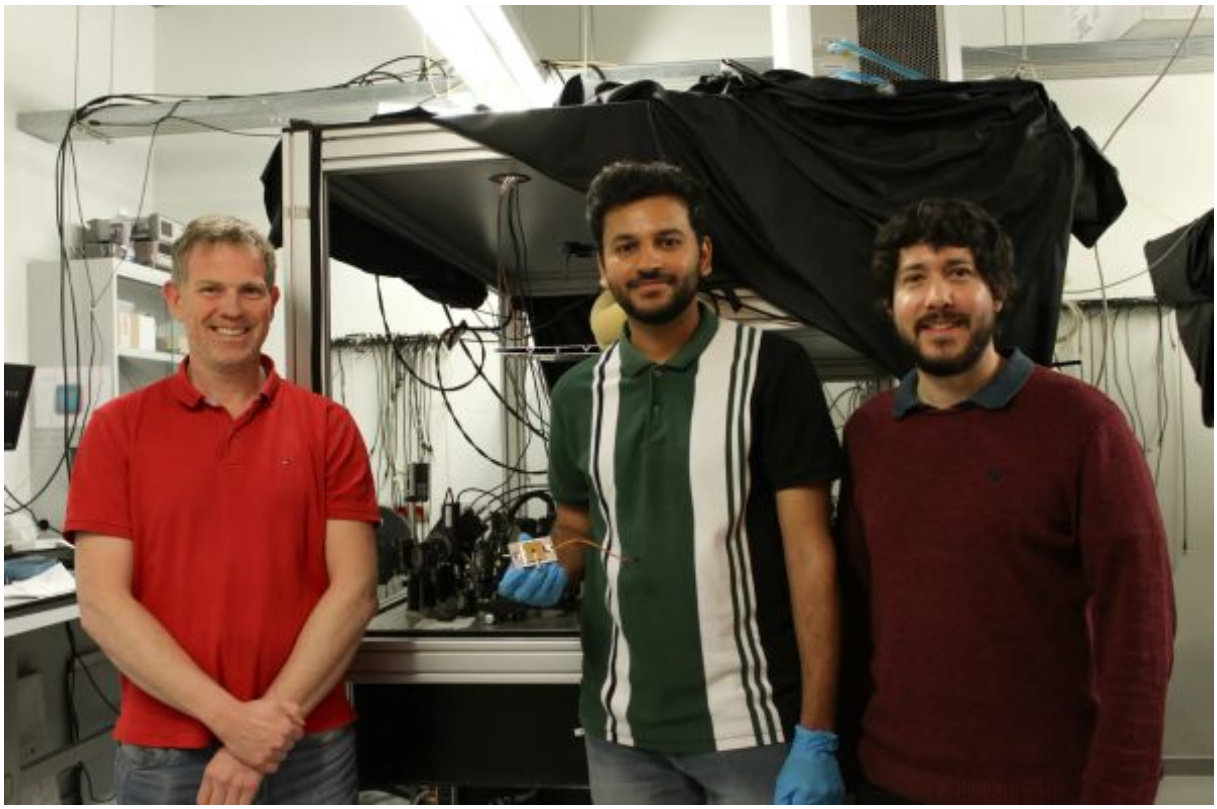


Graphene receivers bring energy-efficient 6G hardware closer to reality

The 6th generation (6G) communication technology aims to transmit data through an enhanced wireless connectivity infrastructure at higher speeds and with greater capacity than current 5G.
One major challenge is the detection of data signals, which requires receivers that operate in the sub-terahertz regime in a simple, compact, and energy-efficient manner so that they can be implemented in everyday devices. Recently, ICFO researchers and collaborators have demonstrated in Nature Communications that graphene receivers meet all these requirements, marking an important step toward energy-efficient 6G hardware.

March 25, 2026

Thanks to the 5th generation (5G) technology, we now enjoy unprecedented levels of

connectivity. Nevertheless, wireless data traffic is facing an increasing demand for an even higher capacity and faster data transfer -a demand that, according to Edholm's law, could exceed the terabit per second before 2035. Scientists are thus beginning to develop 6G, a technology that will accommodate higher speeds (around 1 terabit per second), ultra-low latency (below a millisecond), and advanced wireless connectivity.

Transitioning from 5G to 6G, however, entails one major challenge: moving from the microwave to the sub-terahertz (sub-THz) frequency range, where data signals can meet the demanding requirements in both capacity and reduced signal attenuation. The challenge lies in finding receivers (key components for signal detection) that operate efficiently in this frequency regime.

ICFO researchers, **Dr. Karuppasamy Pandian Soundarapandian**, **Dr. Sebastian Castilla**, and **Dr. Simone Marconi**, led by **ICREA Prof. Frank Koppens**, have now presented a promising solution in Nature Communications, demonstrating, for the first time, a **sub-THz graphene receiver**. The study was conducted in collaboration with ETH Zurich, the University of Ioannina, the Catalan Institute of Nanoscience and Nanotechnology (ICN2), and other institutions.

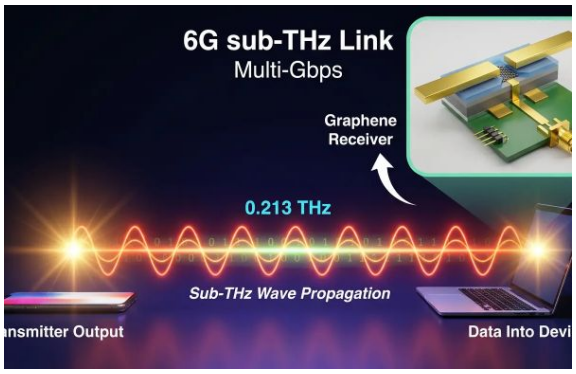
Previous sub-THz receivers were either energy-consuming or bulky, and not suitable for on-chip integration. The current approach, in contrast, simultaneously **meets all the requirements that future 6G technologies must satisfy**, including **multi-gigabit-per-second data rates**, **low complexity**, **compactness** (0.018 mm²), **CMOS compatibility** (the standard technology used for constructing integrated circuit chips), and **near-zero energy consumption** during operation.

i¿½Graphene is uniquely effective as a sub-THz receiver because it converts tiny induc
d changes in electron temperature into strong electric signals with zero energy consumptio
, all while operating at room temperature,i¿½ explains Dr. Karuppasamy Pan
ian Soundarapandian, first co-author of the arti
le. Previous graphene detectors, however, were either too slow or not sensitive enoug
 to perform wireless signal demodulation. The key to overcoming these longstanding limitat
ons was the integration of high-quality graphene with a carefully designed radiofrequency cir
uit and sub-THz cavity containing an antenna and a back mirror, which enhances the interac
ion between sub-THz radiation and graphene, boosting the speed and sensitivity required for reliable wireless signal detect
on. i¿½Ours is the first system-level validation showing that an atomically thin material can serve as a zero-power, ultra-compact sub-THz receiver,i¿½ shares Dr. Sebastian Castill
, first co-author of the article. And he adds: i¿½this advancement transforms graphe
e devices from promising laboratory detectors into practical miniaturized building blocks for future 6G wireless tech

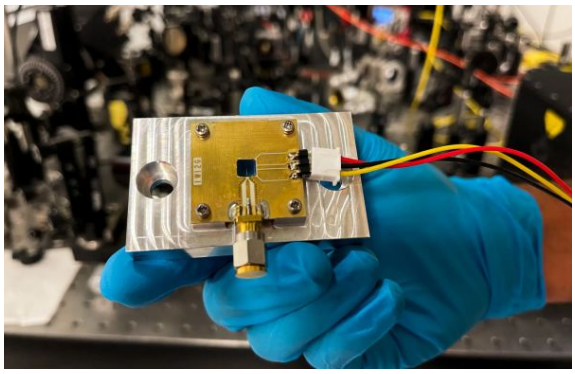
Reference:

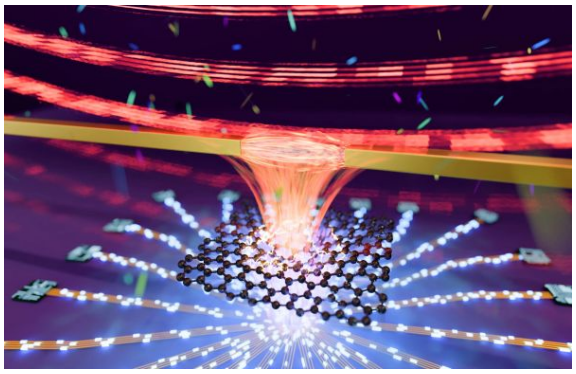
Soundarapandian, K.P., Castilla, S., Koepfli, S.M. et al. High-speed graphene-base sub-terahertz receivers enabling wireless communications for 6G and beyond.Nat Commun **17**, 2627 (2026).
DOI: https://doi.org/10.1038/s41467-026-69186-6

Acknowledgements:
F.H.L.K. acknowledges financial support from the Spanish Ministry of Economy and Competitiveness, through the i¿½Severo Ochoai¿½ Programme for Centres of Excellenc in R&D (SEV-2015-0522), support by Fundacio Cellex Barcelona, Generalitat de Catal nya through the CERCA program, and the Agency for Management of University and Rese rch Grants (AGAUR) 2017 SGR 1656. Furthermore, the research leading to these results has received funding from the European Union Seventh Framework Programme under g ant agreement no.785219 and no. 881603 Graphene Flagship for Core3. K.J.T. acknowle ges funding from the European Union's Horizon 2020 research and innovation program u der Grant Agreement No. 101125457 (ERC CoG "EQUATE"). ICN2 is funded by the C RCA Programme/ Generalitat de Catalunya and supported by the Severo Ochoa Centre of Excellence programme, Grant CEX2021-001214-S, funded by MCIN / A I / 10.13039.501100011033. Preliminary results-i.e., optimization of the electrical perform nce of the various heterostructures-were supported by the European Union's Horizon 020 research and innovation programme under Grant Agreement No. 101034929. S.C., S M., K.P.S. and F.H.L.K. acknowledge PDC2022-133844-I00, funde by MCIN/AEI/10.13039/501100011033 and by the i¿½European Union NextGenerationEU/ RTR". S.C., K.P.S. and F.H.L.K acknowledge funding by the European Union (ERC,TER COMM, 101113529), which supported the results obtained from devices D1 to D6.



Scheme showing the general idea of the study.


Evaluation kit featuring the fabricated printed circuit board with the integrated graphene sub-terahertz receiver, mounted on a metal support. Credit: ICFO.



Artistic representation of the graphene receivers explored demonstrated in the study. Credit: David Alcaraz.