Jean-Claude Besse

ETH Zürich, Department of Physics
Laboratory for Solid State Physics
Otto-Stern-Weg 1, HPF D2
CH-8093 Zurich

Phone: +41.44.633.25.04

Email: jbesse@phys.ethz.ch
URL: https://jcbesse.ch
ORCID: 0000-0002-1490-0072

Born: July 9, 1992
Nationality: Swiss

Current position

2021-cur
4 years

Senior Assistant, ETH-PSI Quantum Computing Hub
Superconducting Circuits Nano-Fabrication, Modular Quantum Computing, Quantum Optics and Communication.

Areas of specialization

Quantum Computing; Quantum Optics; Superconducting Circuits; Nano-Fabrication

Past Appointments

2021-2021
1 year

Postdoctoral Researcher, ETH Zurich
Quantum Device Lab / Andreas Wallraff.

Education

2016-2021

PhD, ETH Zurich
Thesis: *Generation, Manipulation, and Detection of Complex States of Microwave Radiation.* Andreas Wallraff, ETH Zurich.
Awarded the ETH medal for outstanding PhD Thesis.

2013-2015

MSc Physics, ETH Zurich. GPA: 5.92/6.00
Master thesis: *Design, optimization and measurements of 2D photonic crystals with high photon-phonon cooperativity.* Oskar Painter, Caltech.

Semester thesis: *Piezoelectric actuation of GaAs NEMS.* Ataç İmamoğlu, ETH Zurich.

2013 *International Diploma*, Imperial College London. GPA: 89/100
Bachelor thesis: *Automated High-Resolution Structured Illumination Microscopy.* Peter Török, Imperial College.

2010-2013 *BSc Physics*, EPFL. GPA: 5.90/6.00. Second-best GPA award.
Summer project: *External Cavity Diode Laser.* Tobias Kippenberg, EPFL.

Research output

Major Achievement 1

Generation and detection of itinerant microwave radiation.
In my PhD work, I led the effort on the detection [1] of individual itinerant microwave photons generated by a quantum source internally developed and characterized [2]. This work was extended to realize a parity detector that heralded propagating cat states of microwave light [3]. A clicking detector, sensitive to parity of the incoming radiation field, may prove useful in distributed error-corrected communication protocols.

[1] Besse, J.-C., Gasparinetti, S., Collodo, M. C., Walter, T., Kurpiers, P., Pechal, M., Eichler, C. and Wallraff, A. (2017). Single-Shot Quantum Nondemolition Detection of Individual Itinerant Microwave Photons. Physical Review X 8, 021003. Open Access article.

[2] Pechal, M., Besse, J.-C., Mondal, M., Oppliger, M., Gasparinetti, S. and Wallraff, A. (2016). Superconducting Switch for Fast On-Chip Routing of Quantum Microwave Fields. Physical Review Applied, 6(2), 024009. Article. Open Access.

[3] Besse, J.-C., Gasparinetti, S., Collodo, M. C., Walter, T., Remm, A., Krause, J., Eichler, C. and Wallraff, A. (2020). Parity Detection of Propagating Microwave Fields. Physical Review X 10, 011046. Open Access article.

Major Achievement 2

Nano-Fabrication Techniques for Scalable Superconducting Quantum Processors.
My research has centered on pioneering nano-fabrication techniques to overcome critical hurdles in scaling superconducting quantum processors. I supervised work by PhD students to understand and mitigate performance-limiting losses in superconducting qubits, particularly those strongly coupled to defect modes [1]. We developed a novel polymer spacer process for 3D-integrated circuits [2], which significantly enhanced our control over circuit parameters, crucial to improving the yield and uniformity of quantum devices. The resulting high-quality and reproducible components paved the way for demonstrating cross-platform verification using modular superconducting devices [3], a vital step toward constructing reliable and scalable quantum computing architectures.
[1] Zanuz, D., Ficheux, Q., Michaud, L., Orekhov, A., Hanke, K., Flasby, A., Panah, M., Norris, G., Kerschbaum, M., Remm, A., Swiadek, F., Hellings, C., Lazăr, S., Scarato, C., Lacroix, N., Krinner, S., Eichler, C., Wallraff, A., Besse, J.-C. (2024). Mitigating Losses of Superconducting Qubits Strongly Coupled to Defect Modes. Physical Review Applied 23, 044054. Article. Open Access.

[2] Norris, G., Michaud, L., Pahl, D., Kerschbaum, M., Eichler, C., Besse, J.-C., Wallraff, A. (2024). Improved parameter targeting in 3D-integrated superconducting circuits through a polymer spacer process. EPJ Quantum Technology, **11**, 5. Article. Open Access.

[3] Dalton, K., Knörzer, J., Hoehne, F., Song, Y., Flasby, A., Zanuz, D., Bahrami, M., Besedin, I., Besse, J.-C., Wallraff, A. (2025). Resource-Efficient Cross-Platform Verification with Modular Superconducting Devices. Open Access.

Major Achievement 3

Quantum networks.
I have contributed, mostly in the nano-fabrication aspects, to a multi-year long effort geared at realizing non-local microwave quantum networks. This includes deterministic remote entanglement between superconducting qubits located physically on separate quantum devices [1], the engineering of a microwave quantum link that allows these two devices to be located in separate cryogenic systems [2], and the loophole-free experimental violation of a Bell inequality with a solid-state system [3].

[1] Kurpiers, P., Magnard, P., Walter, T., Royer, B., Pechal, M., Heinsoo, J., Salathe, Y., Akin, A., Storz, S., Besse, J.-C., Gasparinetti, S., Blais, A., and Wallraff, A. (2018). Deterministic quantum state transfer and remote entanglement using microwave photons. Nature, 558, 264–267. Open Access article.

[2] Magnard, P., Storz, S., Kurpiers, P., Schär, J., Marxer, F., Lütolf, J., Walter, T., Besse, J.-C., Gabureac, M., Reuer, K., Akin, A., Royer, B., Blais, A. and Wallraff, A. (2020). Microwave Quantum Link between Superconducting Circuits Housed in Spatially Separated Cryogenic Systems. Phys. Rev. Lett., 125, 260502. Article. Open Access.

[3] Storz, S., Schär, J., Kulikov, A., Magnard, P., Kurpiers, P., Lütolf, J., Walter, T., Copetudo, A., Reuer, K., Akin, A., Besse, J.-C., Gabureac, M., Norris, G. J., Rosario, A., Ferran, M., Martinez, J., Amaya, W., Mitchell, M. W., Abellan, C., Bancal, J.-D., Sangouard, N., Royer, B., Blais, A. and Wallraff, A. (2023). Loophole-free Bell inequality violation with superconducting circuits. Nature, 617(7960), 265–270. Open Access article.

Publications list

27 articles (in reverse chronological order below, including 2 Nature, 3 first-author and 1 last-author publications), >2600 citations total and h-index of 20 on Google Scholar.

[1] Colao Zanuz, D., Ficheux, Q., Michaud, L., Orekhov, A., Hanke, K., Flasby, A., Bahrami Panah, M., Norris, G., Kerschbaum, M., Remm, A., Swiadek, F., Hellings, C., Lazăr, S., Scarato, C., Lacroix, N., Krinner, S., Eichler, C., Wallraff, A., **Besse, J.-C.**,
Mitigating losses of superconducting qubits strongly coupled to defect modes,
Phys. Rev. Appl., **23**, 044054 (2025), Journal link

[2] Dalton, K., Knörzer, J., Hoehne, F., Song, Y., Flasby, A., Zanuz, D., Panah, M., Besedin, I., **Besse, J.-C.**, Wallraff, A.,
Resource-Efficient Cross-Platform Verification with Modular Superconducting Devices,
arXiv:2507.15302 (2025), Journal link

[3] Norris, G., Dalton, K., Zanuz, D., Rommens, A., Flasby, A., Panah, M., Swiadek, F., Scarato, C., Hellings, C., **Besse, J.-C.**, Wallraff, A.,
Performance Characterization of a Multi-Module Quantum Processor with Static Inter-Chip Couplers,
arXiv:2503.12603 (2025), Journal link

[4] O'Sullivan, J., Reuer, K., Grigorev, A., Dai, X., Hernández-Antón, A., Muñoz-Arias, M., Hellings, C., Flasby, A., Colao Zanuz, D., **Besse, J.-C.**, Blais, A., Malz, D., Eichler, C., Wallraff, A.,
Deterministic generation of two-dimensional multi-photon cluster states,
Nature Communications, **16**, 5505 (2025), Journal link

[5] Norris, G., Michaud, L., Pahl, D., Kerschbaum, M., Eichler, C., **Besse, J.-C.**, Wallraff, A.,
Improved parameter targeting in 3D-integrated superconducting circuits through a polymer spacer process,
EPJ Quantum Technol., **11**, 5 (2024), Journal link

[6] Song, Y., Beltran, L., Besedin, I., Kerschbaum, M., Pechal, M., Swiadek, F., Hellings, C., Zanuz, D., Flasby, A., **Besse, J.-C.**, Wallraff, A.,
Realization of Constant-Depth Fan-Out with Real-Time Feedforward on a Superconducting Quantum Processor,
arXiv:2409.06989 (2024), Journal link

[7] Lazăr, S., Ficheux, Q., Herrmann, J., Remm, A., Lacroix, N., Hellings, C., Swiadek, F., Zanuz, D., Norris, G., Panah, M., Flasby, A., Kerschbaum, M., **Besse, J.-C.**, Eichler, C., Wallraff, A.,
Calibration of Drive Nonlinearity for Arbitrary-Angle Single-Qubit Gates Using Error Amplification,
Phys. Rev. Appl., **20**, 024036 (2023), Journal link

[8] Reuer, K., Landgraf, J., Fösel, T., O'Sullivan, J., Beltran, L., Akin, A., Norris, G., Remm, A., Kerschbaum, M., **Besse, J.-C.**, Marquardt, F., Wallraff, A., Eichler, C.,
Realizing a deep reinforcement learning agent for real-time quantum feedback,
Nat. Commun., **14**, 7138 (2023), Journal link

[9] Storz, S., Schär, J., Kulikov, A., Magnard, P., Kurpiers, P., Lütolf, J., Walter, T., Copetudo, A., Reuer, K., Akin, A., **Besse, J.-C.**, Gabureac, M., Norris, G., Rosario, A., Martin, F., Martinez, J., Amaya, W., Mitchell, M., Abellan, C., Bancal, J.-D., Sangouard, N., Royer, B., Blais, A., Wallraff, A.,
Loophole-free Bell inequality violation with superconducting circuits,
Nature, **617**, 265-270 (2023), Journal link

[10] Marchiori, E., Ceccarelli, L., Rossi, N., Romagnoli, G., Herrmann, J., **Besse, J.-C.**, Krinner, S., Wallraff, A., Poggio, M.,
Magnetic imaging of superconducting qubit devices with scanning SQUID-on-tip,
Applied Physics Letters, **121**, 052601 (2022), Journal link

[11] Reuer, K., **Besse, J.-C.**, Wernli, L., Magnard, P., Kurpiers, P., Norris, G., Wallraff, A., Eichler, C.,
Realization of a Universal Quantum Gate Set for Itinerant Microwave Photons,
Phys. Rev. X, **12**, 011008 (2022), Journal link

[12] **Besse, J.-C.**, Gasparinetti, S., Collodo, M., Walter, T., Remm, A., Krause, J., Eichler, C., Wallraff, A.,
Parity Detection of Propagating Microwave Fields,
Phys. Rev. X, **10**, 011046 (2020), Journal link

[13] **Besse, J.-C.**, Reuer, K., Collodo, M., Wulff, A., Wernli, L., Copetudo, A., Malz, D., Magnard, P., Akin, A., Gabureac, M., Norris, G., Cirac, J., Wallraff, A., Eichler, C.,
Realizing a Deterministic Source of Multipartite-Entangled Photonic Qubits,
Nat. Commun., **11**, 4877 (2020), Journal link

[14] Collodo, M., Herrmann, J., Lacroix, N., Andersen, C., Remm, A., Lazăr, S., **Besse, J.-C.**, Walter, T., Wallraff, A., Eichler, C.,
Implementation of Conditional Phase Gates Based on Tunable ZZ Interactions,
Phys. Rev. Lett., **125**, 240502 (2020), Journal link

[15] Krinner, S., Kurpiers, P., Royer, B., Magnard, P., Tsitsilin, I., **Besse, J.-C.**, Remm, A., Blais, A., Wallraff, A.,
Demonstration of an All-Microwave Controlled-Phase Gate between Far-Detuned Qubits,
Phys. Rev. Appl., **14**, 044039 (2020), Journal link

[16] Magnard, P., Storz, S., Kurpiers, P., Schär, J., Marxer, F., Lütolf, J., Walter, T., **Besse, J.-C.**,

Gabureac, M., Reuer, K., Akin, A., Royer, B., Blais, A., Wallraff, A.,
Microwave Quantum Link between Superconducting Circuits Housed in Spatially Separated Cryogenic Systems,
Phys. Rev. Lett., **125**, 260502 (2020), Journal link

[17] Scigliuzzo, M., Bengtsson, A., **Besse, J.-C.**, Wallraff, A., Delsing, P., Gasparinetti, S.,
Primary Thermometry of Propagating Microwaves in the Quantum Regime,
Phys. Rev. X, **10**, 041054 (2020), Journal link

[18] Andersen, C., Remm, A., Lazăr, S., Krinner, S., Heinsoo, J., **Besse, J.-C.**, Gabureac, M., Wallraff, A., Eichler, C.,
Entanglement stabilization using ancilla-based parity detection and real-time feedback in superconducting circuits,
npj Quantum Information, **5**, 69 (2019), Journal link

[19] Collodo, M., Potočnik, A., Gasparinetti, S., **Besse, J.-C.**, Pechal, M., Sameti, M., Hartmann, M., Wallraff, A., Eichler, C.,
Observation of the Crossover from Photon Ordering to Delocalization in Tunably Coupled Resonators,
Phys. Rev. Lett., **122**, 183601 (2019), Journal link

[20] Gasparinetti, S., **Besse, J.-C.**, Pechal, M., Buijs, R., Eichler, C., Carmichael, H., Wallraff, A.,
Two-photon resonance fluorescence of a ladder-type atomic system,
Phys. Rev. A, **100**, 033802 (2019), Journal link

[21] Kurpiers, P., Pechal, M., Royer, B., Magnard, P., Walter, T., Heinsoo, J., Salathé, Y., Akin, A., Storz, S., **Besse, J.-C.**, Gasparinetti, S., Blais, A., Wallraff, A.,
Quantum Communication with Time-Bin Encoded Microwave Photons,
Phys. Rev. Appl., **12**, 044067 (2019), Journal link

[22] **Besse, J.-C.**, Gasparinetti, S., Collodo, M., Walter, T., Kurpiers, P., Pechal, M., Eichler, C., Wallraff, A.,
Single-Shot Quantum Non-Demolition Detection of Individual Itinerant Microwave Photons,
Phys. Rev. X, **8**, 021003 (2018), Journal link

[23] Heinsoo, J., Andersen, C., Remm, A., Krinner, S., Walter, T., Salathé, Y., Gasparinetti, S., **Besse, J.-C.**, Potočnik, A., Wallraff, A., Eichler, C.,
Rapid High-fidelity Multiplexed Readout of Superconducting Qubits,
Phys. Rev. Appl., **10**, 034040 (2018), Journal link

[24] Kurpiers, P., Magnard, P., Walter, T., Royer, B., Pechal, M., Heinsoo, J., Salathé, Y., Akin, A., Storz, S., **Besse, J.-C.**, Gasparinetti, S., Blais, A., Wallraff, A.,
Deterministic quantum state transfer and remote entanglement using microwave photons,
Nature, **558**, 264–267 (2018), Journal link

[25] Magnard, P., Kurpiers, P., Royer, B., Walter, T., **Besse, J.-C.**, Gasparinetti, S., Pechal, M., Heinsoo, J., Storz, S., Blais, A., Wallraff, A.,
Fast and Unconditional All-Microwave Reset of a Superconducting Qubit,
Phys. Rev. Lett., **121**, 060502 (2018), Journal link

[26] Gasparinetti, S., Pechal, M., **Besse, J.-C.**, Mondal, M., Eichler, C., Wallraff, A.,
Correlations and entanglement of microwave photons emitted in a cascade decay,
Phys. Rev. Lett., **119**, 140504 (2017), Journal link

[27] Pechal, M., **Besse, J.-C.**, Mondal, M., Oppliger, M., Gasparinetti, S., Wallraff, A.,
Superconducting Switch for Fast On-Chip Routing of Quantum Microwave Fields,
Phys. Rev. Appl., **6**, 024009 (2016), Journal link

Teaching

Lecturer for postgraduate students at ETH Zurich, on
Quantum Information Processing II: Implementations (2x, ca. 100-150 students)

Quantum Science with Superconducting Circuits (3x, ca. 40-80 students)
Quantum Science with Superconducting Circuits: Advanced Topics (1x, ca. 20 students).
Teaching assistant for undergraduate students at EPFL and ETH Zurich on Informatique, Physik I, Physik II.
Supervision of ca. 12 semester and master theses.

Services

Reviewer for Nature, Nature Physics, Nature Communications, Nature Communications Materials, PRX, PRX Quantum, PRL, PRApplied, PRA, PRB, npjQI, WWTF, ...

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