Building Integrated SNSPDs to Develop an hBN Quantum Photonic Platform Including Single-Photon Emitters.

The rapid progress of quantum technologies has revealed two key challenges. First, we need to precisely control quantum systems without disturbing their sensitive states — meaning keeping their quantum coherence. Second, we must find efficient ways to convert quantum information into classical signals, so that the results of quantum operations can be measured and used at large scale. In quantum photonics, information is carried by individual photons. This approach depends on two main building blocks: single-photon sources, which generate one photon at a time, and single-photon detectors, which can detect them individually. These components are essential for many areas of quantum information science, such as quantum computing and quantum simulation. So far, the most advanced systems use either external single-photon emitters that are distributed across several channels (demultiplexed), or on-chip processes that create photons in a probabilistic way, along with external detectors. However, these methods are still limited in efficiency, which makes it very hard to scale up to experiments involving many photons.

This technological bottleneck mainly comes from the fact that we still lack reliable fabrication methods to integrate high-performance photon sources and detectors directly onto photonic chips.

This proposal focuses on the experimental realization of integrated superconducting nanowire single-photon detectors [1, 2, 3, 4](**SNSPDs**) in hexagonal boron nitride (hBN) photonic circuits. The project aims to achieve a fully integrated quantum photonic platform where single photons are generated, routed, and detected on the same chip with high efficiency.

The intern will develop NbN-based superconducting nanowire single-photon detectors (SNSPDs) integrated into hBN waveguides. This internship is expected to lead to a PhD project funded by the ANR BONI&CLIDE in collaboration with GEMac group and LPENS [5, 6, 7, 8].

Through three main research axes during this PhD project such as fabrication and optimization of SNSPDs, experimental characterization of detector performance, and integration into quantum photonic demonstrators, we will develop an hBN-based platform for on-chip quantum experiments.

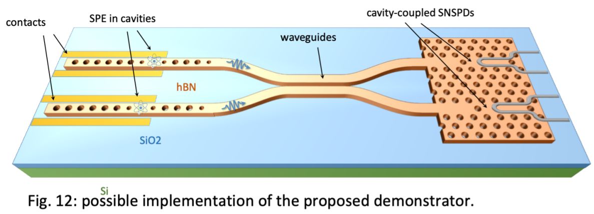

Figure 1: An hBN-based platform for on-chip quantum experiments

The PhD candidate will receive a full training on nanofabrication techniques in the Paris Center cleanroom, and will acquire strong experience in the domains of quantum technologies and condensed matter physics, superconductivity as well as advanced electromagnetism.

Prerequisite: A strong background in quantum physics and/or solid state physics. A taste for nanofabrication and transport measurements under cryogenic environnement.
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References:

[1] Iman Esmaeil Zadeh et al. Superconducting nanowire single-photon detectors: A perspective on evolution, state-of-the-art, future developments, and applications. *Applied Physics Letters*, 118:190502, 05 2021.

[2] Cheryl Feuillet-Palma. Transport et interaction matière–rayonnement dans des matériaux corrélés. *Comptes Rendus. Physique*, 26:129–180, 2025.

[3] Paul Amari et al. Scalable Nanofabrication of High-Quality YBCO Nanowires for Single-Photon Detectors. *Physical Review Applied*, 20(4):044025, October 2023.

[4] Sergei Kozlov et al. Dynamic metastable vortex states in interacting vortex lines. *Communications Physics*, 7(1):1–8, June 2024.

[5] Clarisse Fournieret al. Position-controlled spes with reproducible wavelength in hbn. *Nature Communications*, 12(1):3779, 2021. [Open Access].

[6] Domitille Gérard et al. Quantum efficiency and vertical position of quantum emitters in hbn determined by purcell effect in hybrid metal-dielectric planar photonic structures. *ACS Photonics*, 11:5188, 2024. [Open Access].

[7] Clarisse Fournier et al. Investigating the fast spectral diffusion of a quantum emitter in hbn using resonant excitation and photon correlations. *Physical Review B*, 107:195304, 2023. [Open Access].

[8] Domitille Gérard et al. Crossover from inhomogeneous to homogeneous response of a resonantly driven hbn quantum emitter. *Physical Review B*, 111:085304, 2025.