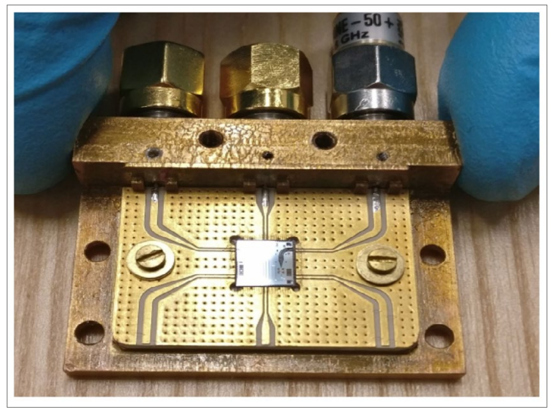
PROJECT QUANDO SC3

QUANtum technologies for Defence with application to Optronics

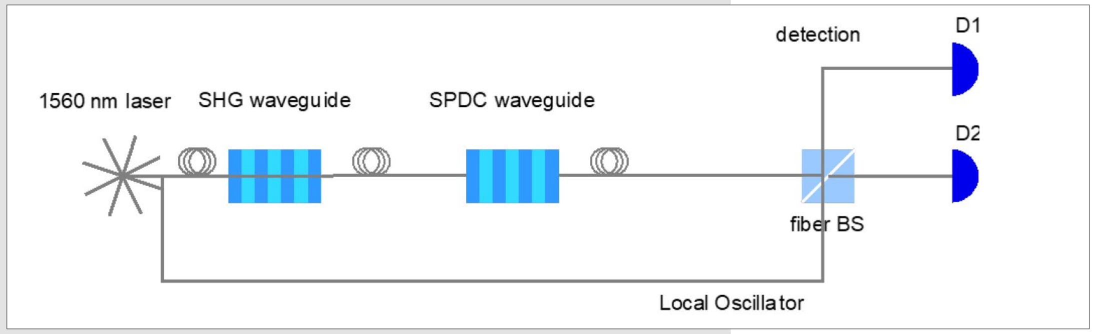
Quantum sensors harness fundamental quantum principles like superposition and entanglement to approach the inherent measurement limits set by physics. They promise significantly enhanced precision and accuracy, revolutionizing scientific, industrial, and commercial applications. These sensors excel in measuring various physical quantities—magnetic, electric, and gravitational fields, times, frequencies, temperatures, and pressures—with unparalleled accuracy.
Typically, a quantum sensor employs discrete quantum states (qubits) dependent on the parameter being measured.
A protocol initializes the system in a known quantum state, interacts it with the measured system, and measures the qubits. This iterative process significantly improves accuracy compared to traditional sensors by utilizing entanglement techniques, quantum control, or squeezing protocols that surpass the Heisenberg limit.
Quantum sensor advancements are poised to transform defense domains like C4ISR and navigation, with the potential to disrupt defense operations. The QUANDO Consortium, under EDA's directive, investigates quantum technologies for defense, focusing on quantum sensing. Collaborators across research organizations, large industrial partners, and SMEs are involved in this initiative, investigating quantum technologies' potential in optronics and radio frequency domains.
The current phase aims to synthesize an Electro Optical/Radio Frequency (EO/RF) quantum technology to solidify earlier studies and outline a potential EU defense quantum sensing roadmap. The project's objectives encompass technology identification, demonstrator design, realization, experimental testing, and result analysis, aligning with EDA's directive for an EO/RF quantum sensing proof-of-concept demonstrator.
The project evaluates EO and RF quantum sensing technologies, exploring non-classical light sources, Optical Parametric Oscillators for mid-IR radiation, cryogenic Josephson Parametric Amplifiers, and Nitrogen-Vacancy centers in diamond for compact antenna receivers. Quantum Radar, utilizing quantum properties to enhance signal processing and counteract stealth properties, stands as a promising technology offering superior target detection capabilities and resilience against electronic countermeasures.

[2] D. Luong, C. W. S. Chang, A. M. Vadiraj, A. Damini, C. M. Wilson and B. Balaji, "Receiver Operating Characteristics for a Prototype Quantum Two-Mode Squeezing Radar," in IEEE Transactions on Aerospace and Electronic Systems, vol. 56, no. 3, pp. 2041-2060, June 2020.

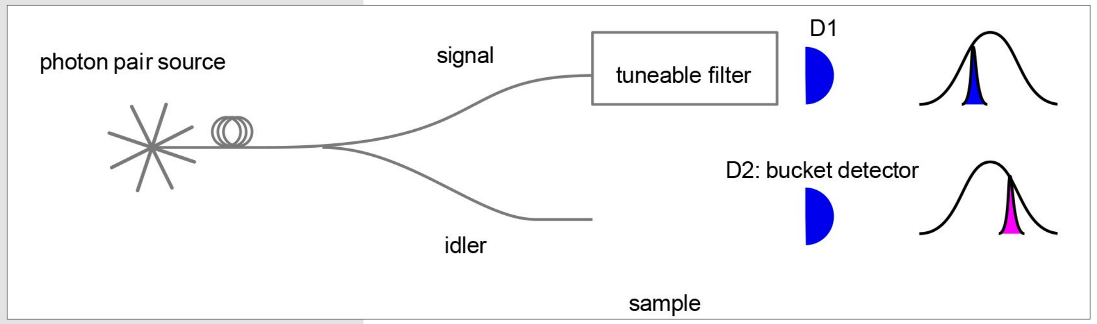
Technical Sheet
Funding institution:
EDA
Project partners
CNR, FLYBY S.R.L., LEONARDO S.P.A., TECNOBIT, THALES R&T, DLR
Project duration
December 2022 - December 2023
Involved countries
Italy, France, Germany, Spain



(a) Josephson Parametric Amplifier [2]



(b) Demonstrator components



(c) Demonstrator high-level scheme

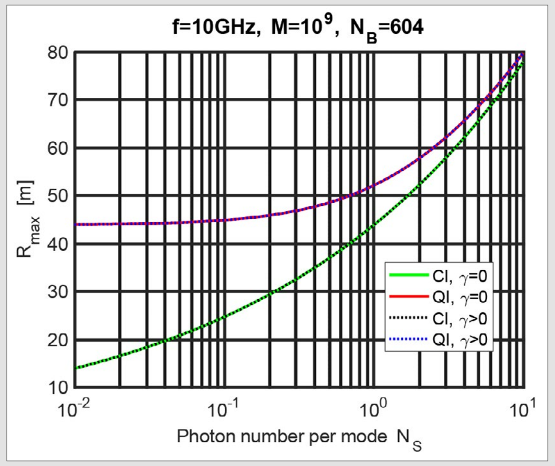
PROJECT QUANTUM RADAR

Quantum Radar

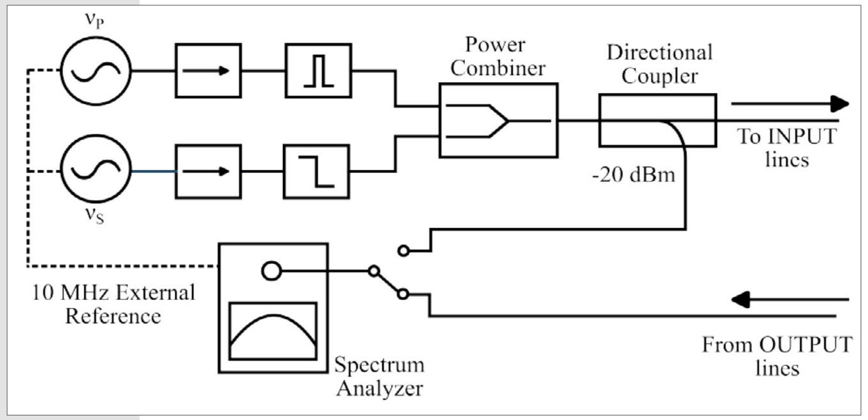
The project focuses on exploring novel quantum techniques using microwave radiation states (1-10 GHz) to develop a prototype Quantum Radar. This radar aims to enhance precision in interferometric measurements by employing entangled microwave beams, reducing destructive effects from environmental noise when detecting non-cooperative targets.
The specification outlines a three-phase plan: Phase 1 involves design and testing, Phase 2 includes quantum design at contingent on Phase 1 success, and Phase 3 focuses on quantum detection upon Phase 2 achievements.
While the contract is for Phase 1, subsequent phases rely on funding confirmation, operational interest, and meeting prior phase objectives.
The overarching research objectives aim to experimentally verify a 6 dB Signal-to-Noise Ratio (SNR) increase using quantum illumination compared to classical Radar protocols. This involves generating twin signals in a Two-Mode Squeezed Vacuum (TMSV) state, where one signal is retained while the other, affected by environmental interactions, rapidly loses its entanglement.
The project seeks to harness quantum properties like superposition, entanglement, and photon indistinguishability to create robust experimental models for improved detection in both microwave and optical domains. By optimizing detection methods, post-processing, and developing a superconducting parametric amplifier, the goal is to create a Quantum Radar prototype with superior SNR, power, and target distance capabilities compared to current scientific benchmarks.

[3] D. LuongarXiv:2108.10151 [quant-ph]
[4] S. Barzanjeh et al. Microwave quantum illumination using a digital receiver. Sci. Adv.6,eabb0451(2020)

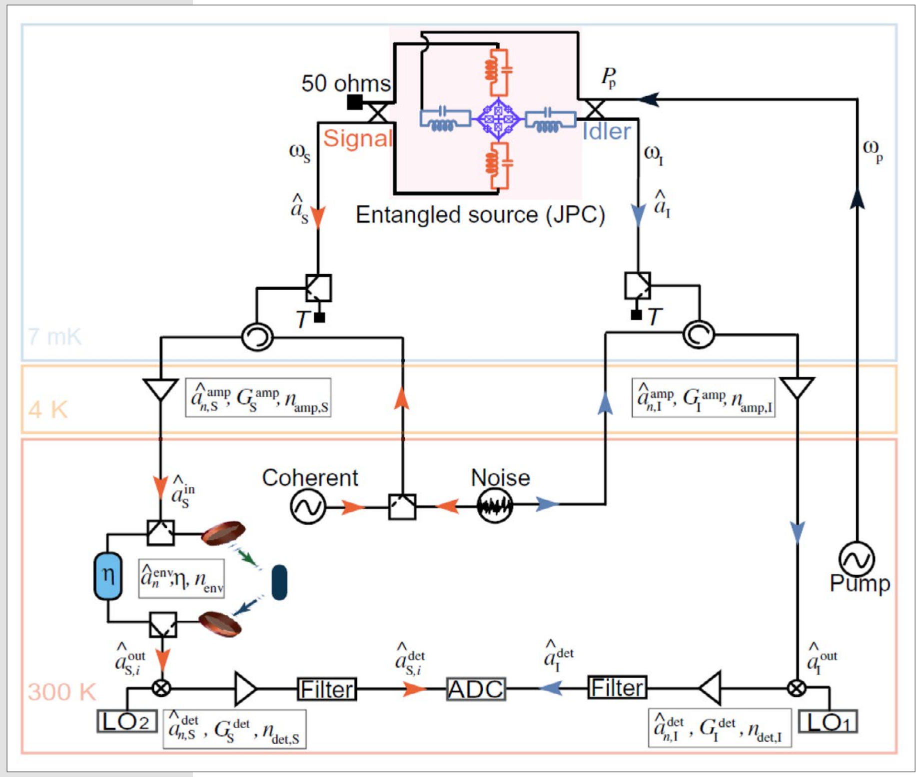
Technical Sheet
Funding institution:
Italian MoD
Project partners
UniCAM, INRIM
Project duration
July 2021 - July 2025
Involved countries
Italy



(a) Quantum gain in ranging with power w.r.t. Coherent Illumination



(b) Schematic representation of the roomtemperature microwave circuit used for characterizing the JTWPA prototype [3]



(c) Description of the apparatus for implementing a PCR (Phase Conjugated Receiver [4])