# Workshop INFN CSN4&5 - Dipartimento di Fisica su Tecnologie Quantistiche


# Report of Contributions

https://agenda.infn.it/e/Workshop-Quantum-Torino

Contribution ID: **19** Type: **not specified**

# Piattaforme e metodi per il Quantum Computing

*Wednesday, 7 June 2023 14:30 (45 minutes)*

Keynote

**Presenter:** MONTANGERO, Simone

**Session Classification:** Quantum Computation

Contribution ID: **20** Type: **not specified**

# Algoritmi e applicazioni per computer quantistici near-term

*Wednesday, 7 June 2023 15:15 (45 minutes)*

Keynote

**Presenter:** BANCHI, Leonardo

**Session Classification:** Quantum Computation

Contribution ID: **21** Type: **not specified**

# Realizzazione e problematiche dei Qubit superconduttivi

*Wednesday, 7 June 2023 16:30 (30 minutes)*

Talk

**Presenter:** TANCREDI, Giovanna

**Session Classification:** Quantum Computation

Contribution ID: **22** Type: **not specified**

# Quantum Computation con sistemi ottici e a microonde

*Wednesday, 7 June 2023 17:00 (30 minutes)*

**Presenter:** FERRARO, Alessandro

**Session Classification:** Quantum Computation

Contribution ID: **23** Type: **not specified**

# Tavola Rotonda

*Wednesday, 7 June 2023 18:00 (1 hour)*

**Session Classification:** Quantum Computation

Contribution ID: **24** Type: **not specified**

# Simulazioni quantistiche con gas atomici ultrafreddi

*Thursday, 8 June 2023 09:00 (45 minutes)*

Keynote

**Presenter:** FERRARI, Gabriele

**Session Classification:** Quantum Simulation

Contribution ID: **25** Type: **not specified**

# Simulazioni quantistiche di Teorie di Gauge su reticolo

*Thursday, 8 June 2023 09:45 (45 minutes)*

Keynote

**Presenter:** ERCOLESSI, Elisa

**Session Classification:** Quantum Simulation

Contribution ID: **26** Type: **not specified**

# Interazioni luce-materia in circuiti superconduttori con qubit e metamateriali nelle microonde

*Thursday, 8 June 2023 10:30 (30 minutes)*

**Presenter:** GASPARINETTI, Simone

**Session Classification:** Quantum Simulation

Contribution ID: **27** Type: **not specified**

# Sensori multiparametro con ottica quantistica

*Thursday, 8 June 2023 11:30 (30 minutes)*

**Presenter:** BARBIERI, Marco

**Session Classification:** Quantum Simulation

Contribution ID: **28** Type: **not specified**

# Quantum metrology and quantum-enhanced measurements

*Thursday, 8 June 2023 14:30 (45 minutes)*

Keynote

**Presenter:** DEGIOVANNI, Ivo Pietro

**Session Classification:** Quantum Sensing

Contribution ID: **29** Type: **not specified**

# Principi del Quantum Sensing

*Thursday, 8 June 2023 15:15 (45 minutes)*

Keynote

**Presenter:** MACCONE, Lorenzo

**Session Classification:** Quantum Sensing

Contribution ID: **30** Type: **not specified**

Talk

**Session Classification:** Quantum Sensing

Contribution ID: **31** Type: **not specified**

# Registrazione

**Session Classification:** Quantum Computation

Contribution ID: **32** Type: **not specified**

# Saluti di Benvenuto

*Wednesday, 7 June 2023 14:00 (30 minutes)*

**Session Classification:** Quantum Computation

Contribution ID: **33** Type: **not specified**

# Quantum Imaging

*Thursday, 8 June 2023 16:30 (30 minutes)*

Talk

**Presenter:** D'ANGELO, Milena

**Session Classification:** Quantum Sensing

Contribution ID: **34** Type: **not specified**

# Quantum sensing con centri NV in diamante

*Thursday, 8 June 2023 18:00 (30 minutes)*

Talk

**Presenter:** FORNERIS, Jacopo

**Session Classification:** Quantum Sensing

Contribution ID: **35** Type: **not specified**

# Tavola rotonda

*Thursday, 8 June 2023 12:00 (1 hour)*

Roberta Ramponi, Caterina Braggio

**Session Classification:** Quantum Simulation

Contribution ID: **36** Type: **not specified**

# Tavola rotonda

*Thursday, 8 June 2023 17:00 (1 hour)*

Roberta Ramponi, Caterina Braggio

**Session Classification:** Quantum Sensing

Contribution ID: **38** Type: **not specified**

# Quantum Computing e ottica integrata

*Friday, 9 June 2023 09:00 (45 minutes)*

Keynote

**Presenter:** SCIARRINO, Fabio

**Session Classification:** Quantum Sensing

Contribution ID: **39** Type: **not specified**

# Simulazione di computer quantistici con rumore

*Friday, 9 June 2023 09:45 (45 minutes)*

Keynote

**Presenter:** BASSI, Angelo

**Session Classification:** Quantum Sensing

Contribution ID: **40** Type: **not specified**

# Quantum Machine Learning nella fisica delle alte energie

*Friday, 9 June 2023 10:30 (30 minutes)*

Talk

**Presenter:** VALLECORSA, Sofia

**Session Classification:** Quantum Sensing

Contribution ID: **41** Type: **not specified**

# Realizzazione di Quantum Computers con cavità

*Friday, 9 June 2023 11:30 (30 minutes)*

Talk

**Presenter:** PEDERIVA, Francesco

**Session Classification:** Quantum Sensing

Contribution ID: **42** Type: **not specified**

# Fondamenti e fenomenologia della decoerenza

*Friday, 9 June 2023 12:00 (30 minutes)*

Talk

**Presenter:** PEPE, Francesco

**Session Classification:** Quantum Sensing

Contribution ID: **43** Type: **not specified**

# Tavola Rotonda

*Friday, 9 June 2023 12:30 (1 hour)*

**Session Classification:** Quantum Sensing

Contribution ID: **47** Type: **Poster**

# Qibo: a full-stack framework for simulation, control and calibration of self-hosted qubit devices

We present the latest developments of Qibo, a full-stack and open-source framework for quantum computing. Qibo was initially born as a quantum circuit simulation tool, but over time we have developed new packages, through which quantum control (qibolab) and quantum calibration (qibocal) can be performed.
Through its modular layout for backend abstraction it is possible to change efforlessy between different backends, including an high-performance simulator based on just-in-time compilation able to simulate quantum circuits with large number of qubits (greater than 35). Due to its modularity, Qibo can easily be adopted as a tool for controlling and calibrating self-hosted quantum devices.
With the extension of this NISQ era, we still want to start relying on quantum computers in tackling real problems. In this context, the Qibo ecosystem becomes the perfect candidate to deepen the development of noise resistant solutions with the eye of research.

**Primary authors:** ROBBIATI, Matteo; CARRAZZA, Stefano (Istituto Nazionale di Fisica Nucleare)

**Presenter:** ROBBIATI, Matteo

Contribution ID: **48** Type: **not specified**

# Traveling Wave Parametric Amplifiers come metamateriali per le tecnologie quantistiche

*Wednesday, 7 June 2023 17:30 (30 minutes)*

**Presenter:** ENRICO, Emanuele

**Session Classification:** Quantum Computation

Contribution ID: **49** Type: **Poster**

# Dynamical Quantum Phase Transitions of the Schwinger Model: Real-Time Dynamics on IBM Quantum

Simulating the real-time dynamics of gauge theories represents a paradigmatic use case to test the hardware capabilities of a quantum computer, since it can involve non-trivial input states' preparation, discretized time evolution, long-distance entanglement, and measurement in a noisy environment. We implemented an algorithm to simulate the real-time dynamics of a few-qubit system that approximates the Schwinger model in the framework of lattice gauge theories, with specific attention to the occurrence of a dynamical quantum phase transition. Limitations in the simulation capabilities on IBM Quantum were imposed by noise affecting the application of single-qubit and two-qubit gates, which combine in the decomposition of Trotter evolution. The experimental results collected in quantum algorithm runs on IBM Quantum were compared with noise models to characterize the performance in the absence of error mitigation.

**Primary author:** POMARICO, Domenico (Istituto Nazionale di Fisica Nucleare)

**Co-authors:** LUPO, Cosmo (Politecnico di Bari); Dr PEPE, Francesco V. (Istituto Nazionale di Fisica Nucleare); COSMAI, Leonardo (Istituto Nazionale di Fisica Nucleare); FACCHI, Paolo (Istituto Nazionale di Fisica Nucleare); PASCAZIO, Saverio (Istituto Nazionale di Fisica Nucleare)

**Presenter:** POMARICO, Domenico (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **50** Type: **Poster**

# The power of photons: Cavity-mediated energy transfer between quantum devices

We investigate the coherent energy transfer between two quantum systems mediated by a quantum bus. In particular, we consider the energy transfer process between two qubits, and how it can be influenced by using a resonant cavity as a mediator. Inspecting different figures of merit and considering both on and off-resonance configurations, we characterize the energy transfer performances. We show that the cavity-mediated process is progressively more and more efficient as function of the number of photons stored in the cavity that acts as a quantum bus. The speeding-up of the energy transfer time, due to a quantum mediator paves the way for new architecture designs in quantum technologies and energy based quantum logics.

**Primary author:** CRESCENTE, Alba (Dipartimento di Fisica, Università di Genova)

**Co-authors:** Dr FERRARO, Dario (Università di Genova); Dr CARREGA, Matteo (CNR SPIN); Prof. SASSETTI, Maura (Università di Genova)

**Presenter:** CRESCENTE, Alba (Dipartimento di Fisica, Università di Genova)

Contribution ID: **51** Type: **Poster**

# Detection of orbital angular momentum states of entangled photons by means of local interferometry

Radiation carrying Orbital Angular Momentum (OAM) formalized in the late 20th century opened important perspectives in both classical and quantum domains. The enormous advantage is due to the additional degree of freedom characterized by an unlimited number of states that can be encoded using single photons. Generally, detection of OAM states in quantum experiments is performed using direct conversion of the states into the fundamental TE00 modes or by using geometric log-polar transformations with suitable refractive optical elements. Unfortunately, in these cases the entire radiation wavefront is required for conversion. Detection of quantum states cannot easily be performed without intercepting the entire wavefront, therefore, the natural divergence of light poses a fundamental limitation for the transfer of OAM states over long-distances. Within the ADAMANT and MOONLIGHT projects, we present a new strictly local sensing approach that exploits the transverse properties of radiation carrying orbital angular momentum to detect OAM states. Experimental results prove the effectiveness in distinguishing the OAM states of entangled photons generated via Parametric Down Conversion by receiving only a small portion of the radiation wavefront. The proposed approach exploits local interferometry in a very stable monolithic implementation, with important benefits in advanced quantum sensing for OAM states.

**Primary author:** PAROLI, Bruno (Istituto Nazionale di Fisica Nucleare)

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**Presenter:** PAROLI, Bruno (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **52** Type: **Poster**

# Enhancing Microwave Photon Counting: Superconducting Qubits and Traveling Wave Amplifiers in Quantum Sensing

Quantum Sensing is a rapidly expanding field with applications in Fundamental Physics, including Dark Matter (DM) search. Recent progress in superconducting qubits has enabled enhanced sensitivity and reduced dark count rates in microwave photon detection experiments. The INFN Qub-IT project aims to develop an itinerant qubit-based single-photon counter able to exploit Quantum Non-Demolition techniques in the search for axion-like DM. The design of Qub-IT's superconducting qubits have been optimized through in-depth simulations and will be fabricated at the Bruno Kessler Foundation (FBK) and the Institute of Photonics and Nanotechnology (CNR-IFN).
Qub-IT will benefit from the use of Travelling Wave Parametric Amplifiers (TWPAs) developed within the DARTWARS project. Such devices will offer broadband amplification with quantum or near-quantum limited noise, crucial for high-fidelity and multiplexed qubit readout. To achieve efficient readout we rely on RF engineering and Qibo, a full-stack open source software under development by the University of Milan and the Technology Innovation Institute in Abu Dhabi. This collaboration aims to advance microwave single-photon detection and broaden the qubit readout capabilities in Quantum Sensing.

**Primary author:** MORETTI, Roberto (Istituto Nazionale di Fisica Nucleare)

**Co-authors:** CORTI, Hervè Atsè (Istituto Nazionale di Fisica Nucleare); LABRANCA, Danilo (Istituto Nazionale di Fisica Nucleare)

**Presenter:** MORETTI, Roberto (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **53** Type: **Poster**

# Applications in Quantum Hypothesis Testing: from quantum reading to pattern recognition

Quantum resources can provide an advantage over classical schemes in many tasks. Quantum hypothesis testing aims at enhancing the discrimination among a finite set of hypotheses. In the optical domain, for example, the protocol of quantum reading demonstrated how the recovery of classical bits encoded in the cells of an optical memory can be dramatically enhanced by using entangled states in the readout. Here we show how this advantage can be achieved experimentally by means of entangled states paired with a photon counting receiver followed by a Bayesian post-processing.
Moreover, we show how the quantum sensing advantage can be sustained trough more complex domains, such as pattern recognition. We do this by analyzing the error in the classification of handwritten digits and showing that for a fixed number of readout photons there are parameter regions for which quantum resources reach an advantage of up to 4 dB in the classification over the classical case.

**Primary author:** ORTOLANO, Giuseppe (Inrim)

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**Presenter:** ORTOLANO, Giuseppe (Inrim)