# TECHNOLOGIES AND PLATFORMS FOR QT WITHIN THE Q@TN JOINT LAB AND THEIR APPLICATIONS

## 8-9 SEPTEMBER 2021

**FBK, SALA STRINGA** | VIA SOMMARIVE 18 | TRENTO

The workshops will take place as hybrid meeting, with limited on-site participation, provided that the pandemic situation permits this. Otherwise it will be held remotly.

UNIVERSITÀ DI TRENTO

FONDAZIONE BRUNO KESSLER

INFN Istituto Nazionale di Fisica Nucleare

TO REGISTER FOR THE EVENT, PLEASE VISIT THE WEBSITE AT HTTPS://QUANTUMTRENTO.EU/ (DEADLINE: AUG 23 |12PM

# FBK BUILDING

## 8 SEPTEMBER

### 9:30 – 9:40 | Welcome and introduction to Q@TN

### 9:40 – 10:30 | Photonic Integrated Circuits (PICs)

In recent years, Q@TN developed integrated optical circuits in different material platforms (silicon-oxy-nitride, silicon-nitride and silicon on insulator) via the S and D facilities. These waveguides are transparent from 0.5 um to 6 um. Propagation losses range from 0.5 to 5 dB/cm depending on material and wavelength. Optical components realized are coupler, splitter, resonator, interferometers, in and output tapers etc. Nonlinear waveguides allow for the generation of entangled photons using an external pump laser. Tuning and switching with thermal heater technology. **Applications**: realisation of a few optical qubits, quantum optical experiments, quantum simulation, etc.

**09:40 – 10:00 | M. Ghulinyan (FBK), *PICs technologies at Trento***
**10:00 – 10:20 | A. Salamon (RM2), *Photonic Integrated Circuits (PICs)***
**10:20 – 10:30 | Questions, comments**

**10:30 - 11:00 | Coffee break**

### 11:00 – 11:50 | Ion deterministic implantation for colour centre formation

Equipment in the cleanrooms of FBK allows for the implantation of N and Si to realize local implant in SiC, diamond or other wide bandgap semiconductors. A vacuum furnace for colour centre formation is also present. Local implantation can be obtained either by masking or for silicon by local implantation with a focused ion beam.
Envisioned **applications** in QT:

- using electronic spin for a variety of measurements of magnetic and electric fields, temperature, pressure, pH, paramagnetic molecular species
- Single spin sensors (Quantum dots, semiconductor virtual atoms): using single spins in solid state electrical and optical schemes

**11:00 – 11:20 | J. Forneris (TO), *Deterministic implantation technologies and colour centres***
**11:20 – 11:40 | D. Giubertoni (FBK), *Experimental activities at Trento***
**11:40 – 11:50 | Questions, comments**

### 11:50 – 12:20 | Single photon detectors

The Iris Unit of FBK has outstanding experience in integrated radiation and imaging sensors. Single photon sensors like SPAD based on CMOS technology or silicon photomultipliers based on the in-house silicon technology are already used for QT experiments like imaging of correlated photons (super resolution microscopy) or ghost imaging. These sensors be used close to RT. There is also a very low noise cryogenic detector technology available. Timing resolution 200 ps for entangled photons.

**11:50 – 12:10 | M. Perenzoni (FBK), *Single photon detectors***
**12:10 – 12:20 | Questions, comments**

**12:20 – 13:45 Lunch break**

### 13:45 – 15:00 | RF technology

Control and use of radio waves plays an important role in a series of potential applications in QT especially in controlling the occupation of energy levels in colour centres. FBK has long experience in RF technologies and components: design, development, prototyping and experimental characterization of a wide variety of MEMS-based Radio Frequency passive components (RF-MEMS). The complexity of such devices rangers from simple electrostatically driven micro-relay, ohmic and capacitive (switched capacitors), to multi-state reconfigurable/tuneable networks, like phase shifters, power attenuators, switching matrices, resonators, filters, and so on. All the mentioned devices exhibit remarkable characteristics in terms of low-loss (below -1 dB up to 50-60 GHz for basic switches), high-isolation (better than -30 dB up to 30-40 GHz), linearity, power consumption, configurability and wide-frequency operability, from nearly-DC, up to 100 GHz, and depending on the design, up to sub-THz frequencies (200-300 GHz).

**14:00 – 14:20 | C. Braggio (PD)**
**14:20 – 14:40 | C. Gatti (LNF)**
**14:40 – 15:00 | I. Iannacci (FBK)**
**15:00 – 15:10 | Questions, comments**

### 15:10 – 16:00 | Fabrication technology for Josephson junctions, SQUIDs and parametric amplifiers

Josephson junctions are used as the key nonlinearelement for realisation of qubits based on superconducting circuits. Our technology for realisation of Josephson junction's is based on double angle evaporation using aluminium as superconductor and aluminium oxide as dielectric layer, Resonators are available in coplanar waveguides based on aluminium. SQUID circuits based on two Josephson junctionscan for example be realized. **Application** in precision metrology, quantum computing, digital computing, SQUID based parametric amplifiers

**15:10 – 15:30 | B. Margesin (FBK), *Superconductor technologies at Trento***
**15:30 – 15:50 | A. Giachero (MI-B), T*ravelling wave parametric amplifiers***
**15:50 – 16:00 | Questions, comments**

**16:00 – 16:20 | Coffee break**

### 16:20 – 16:50 | Ultracold atoms

Laser cooling is one of the key technologies leading to the application of atomic spectroscopy to QT. We have expertise in the laser cooling and the production of quantum degenerate gases of most of the atomic species of interest to QT, including most of the alkali (Li, Na, K, Rb, Cs) and strontium. We developed an innovative experimental setup which allows the study of Bose-Einstein condensates in magnetic fields stable at the micro Gauss level, hence opening to unexplored settings for quantum simulation of both magnetic materials and fundamental interactions.
Our innovative sources of cold atoms, strontium in particular, find **applications** in optical metrology, atomic clocks and Rydberg atom quantum logic.

**16:20 – 16:40 | G. Ferrari (TN), *Cold atoms at Trento***
**16:40 – 16:50 | Questions, comments**

**16:50 – 18:00 | Open discussion, planning**

## 9 SEPTEMBER

**Visit to the facilities for interested and available people.**
**FBK clean room, labs & UNITN labs (photonics, cold atoms, material depositions)**