QUANDELA

PRODUCT CATALOGUE

2024

www.quandela.com

Quantum Technologies
Fabricated in France

QUANDELA
Quantum Solutions

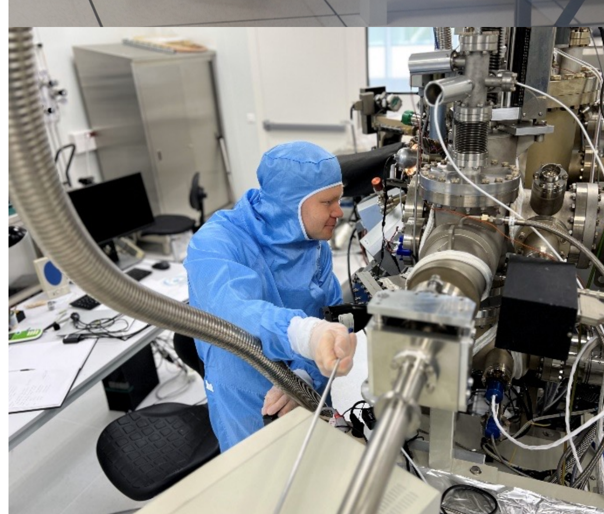
Photons at the heart of Quantum Transformation

Established in 2017 by Prof. Pascale Senellart, Niccolo Somaschi, and Valérian Giesz, Quandela pioneers a groundbreaking synergy between photonics and quantum technologies. Our innovative work centers around the development of eDelight, a cutting-edge solid-state single-photon source that effectively eliminates all remaining barriers to the scalable manipulation of single photons.

Over the past years, we have harnessed our collective expertise to craft highly performant modules tailored for the emission, manipulation, and detection of single photons. These modules serve the research community and contribute to the advancement of quantum computing.

At Quandela, we firmly believe in the transformative potential of photonics at the quantum level. Our commitment to pushing the boundaries of technology underscores our mission to propel the development of quantum technologies into new realms of possibility.

Pascale, Niccolo and Valérian
Founders of Quandela



MosaiQ

HPC-Ready Full-Stack Quantum Computer

Quandela Cloud

Cloud Quantum Computing from anywhere in the world

eDelight & Prometheus

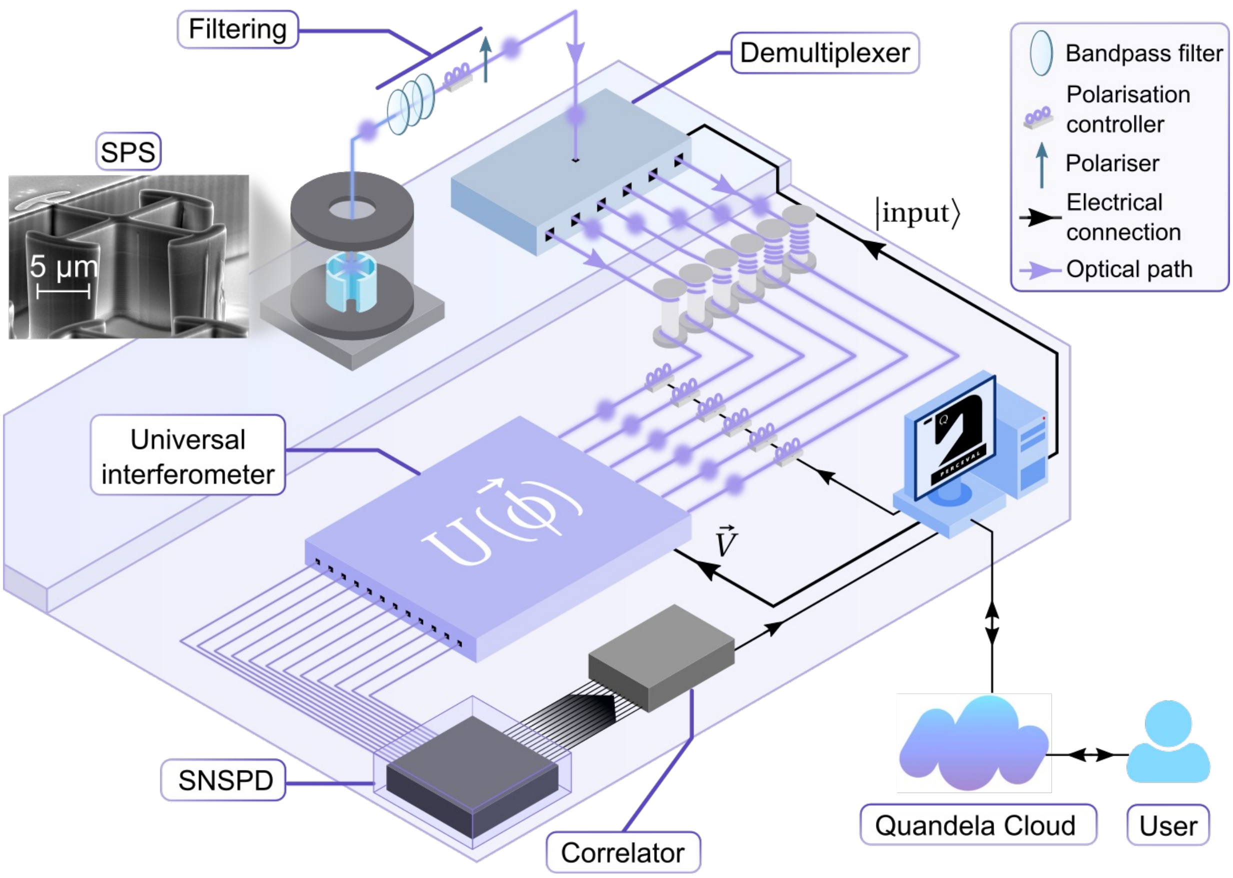
Efficient Generation of Pure Single Photons

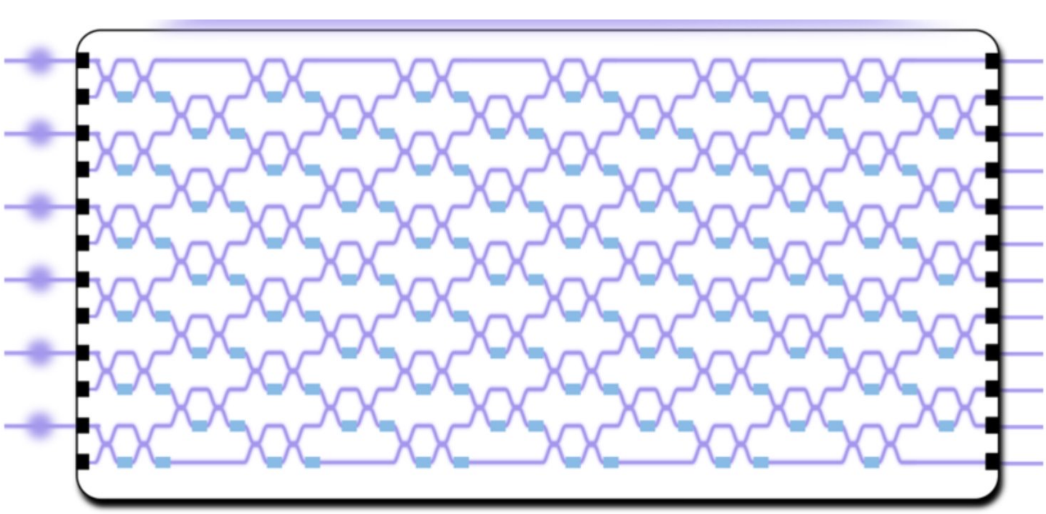
Q-DMX

Transparent & Active Time-to-Space Demultiplexing

PERCEVAL

First generation of quantum computers by generating and manipulating single photons in a universal interferometer integrated on a photonic circuit.



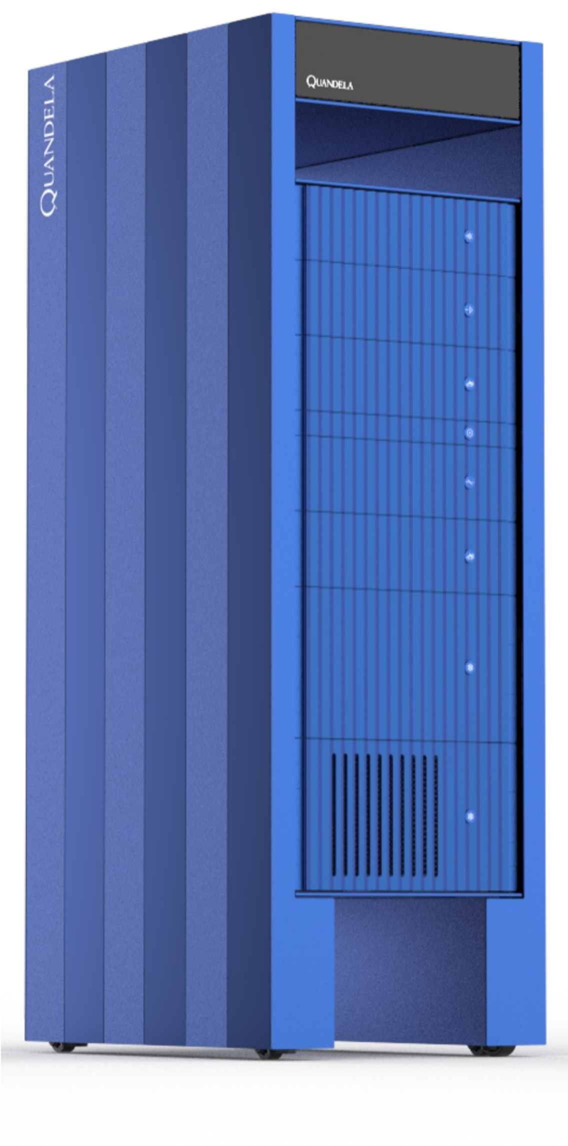


Under Publication in Nature Photonics

QUANDELA

MOSAIQ

Full-stack Quantum Computer



- State-of-the-Art Universal Photonic Quantum Computer - From 2 to 12 qubits
- Fock Space ready - Photon Number Resolution Available
- Fully Integrated in Standard Rack
- Running Quandela OS – with full control stack, scheduling, monitoring, REST API
- Datacenter ready
- Low Energy Usage ***(from 2.3kW)***
- Industrial lead-time ***(<8 months)***
- Fully Upgradable

QUANDELA

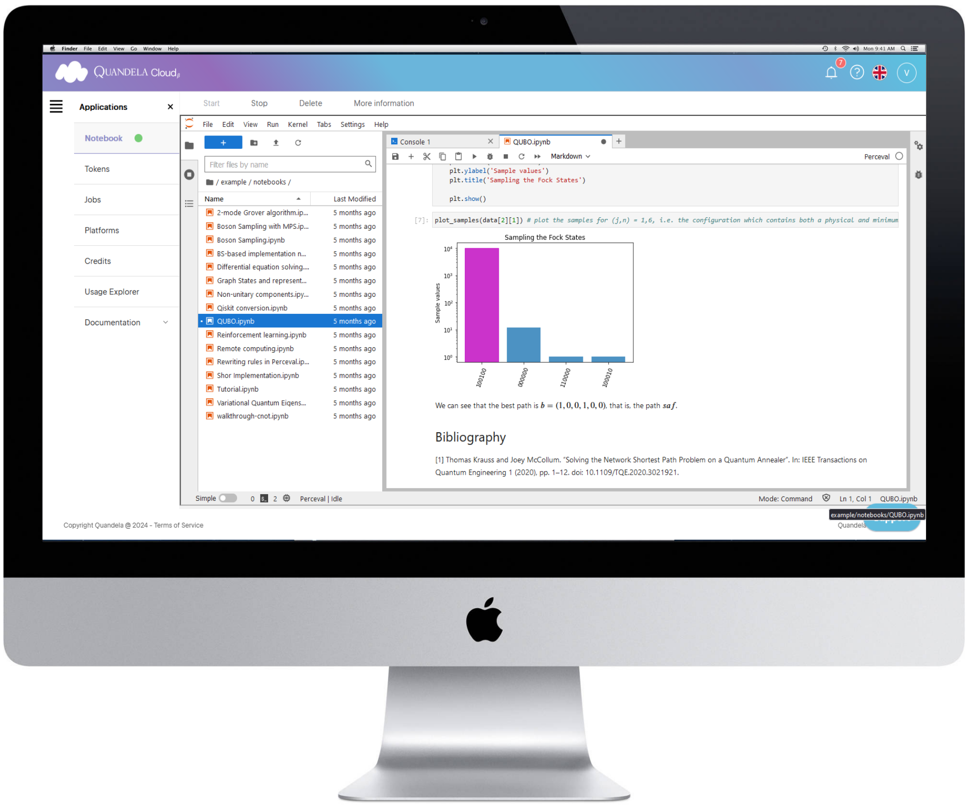
QUANDELA Cloud

Quantum Computing on the Cloud

PERCEVAL

Get started for free:
cloud.quandela.com

- Full Access to high-availability QPU and GPU-accelerated simulators
- Packaged Quantum Primitives through Quandela Quantum Toolbox
- Shot-Based Billing through different offerings for small experiments up to mission-critical enterprise access
- Token-Based REST API with multi-language SDK for integration in Business applications



Available Quantum Computers on Quandela Cloud

Since 2022	Q1 24	Q3 24
Ascella 6 photons 12 modes	Altair 8 photons 20 modes	Belenos 12 photons 24 modes

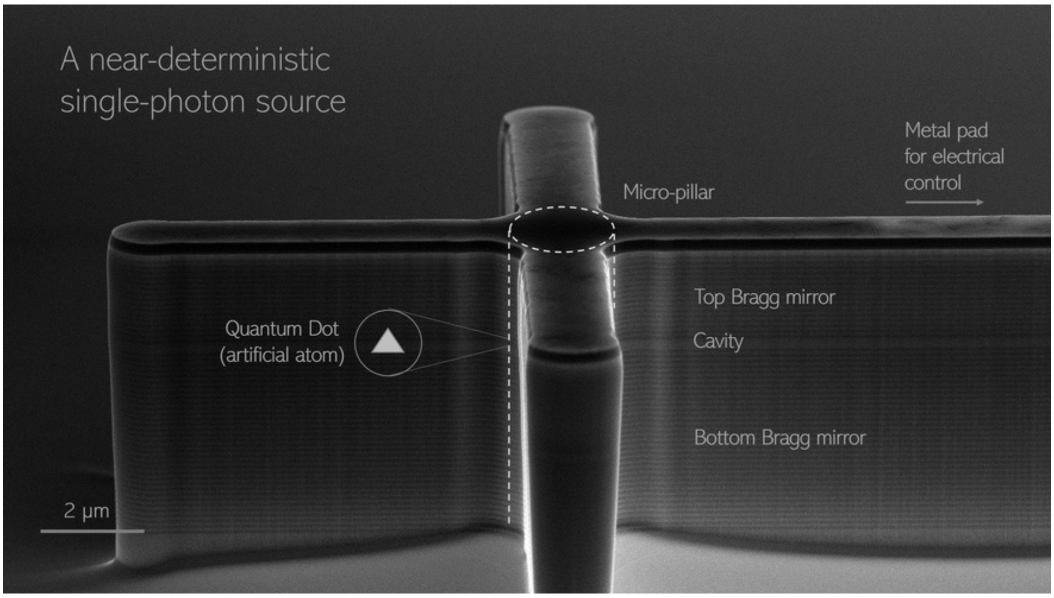
Watch our tutorial Videos on YouTube

https://www.youtube.com/@quandela2110

eDelight

Photonic Qubit Generator
Efficient and Deterministic

Solid-State
Single
Photon sources



Fully deterministic
Reliable
Efficient
Pure

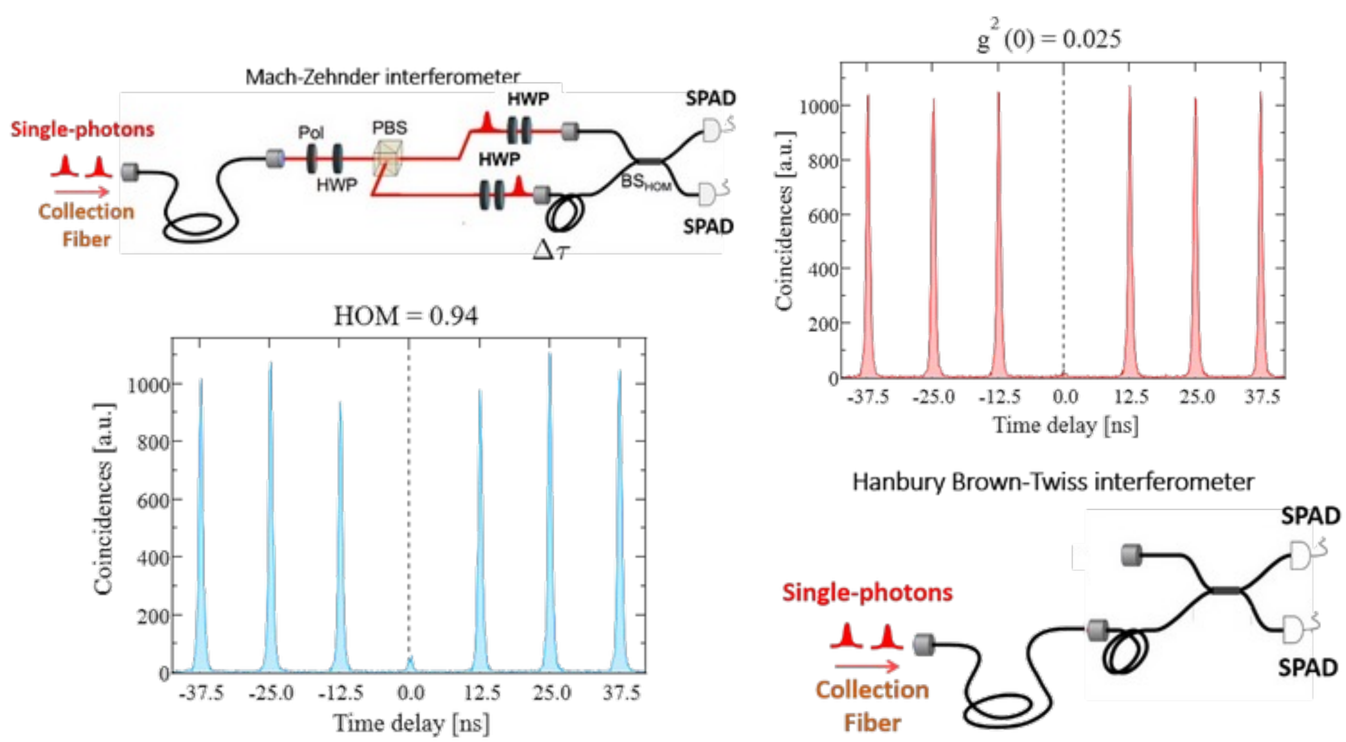
About Semiconductor Quantum Dots

eDelight utilizes semiconductor InAs Quantum dots as its primary sourcing elements, demonstrating near-ideal quantum emitter behavior. The precision and efficacy of our quantum dot system are enhanced through a deterministic coupling mechanism, where selected quantum dots are deterministically coupled with an optical cavity in the form of a micropillar.

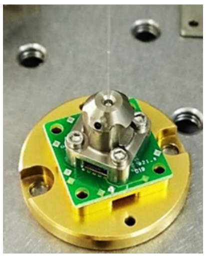
The micropillar's structure is crafted from doped semiconductors, enabling the application of a DC-voltage for fine-tuning the quantum dot transition. This meticulous adjustment results in a precise spectral matching of the emitted photon, achieved by orchestrating the recombination of charges within the quantum dot with the optical mode of the cavity. The integration of these advanced technologies ensures optimal control over individual quantum dots and enhances the collection of emitted photons, establishing eDelight as a pioneering solution in quantum emitter technology.

Read more:
P. Senellart et al., High-Performance Semiconductor Quantum-Dot Single-Photon Sources, Nature Nanotechnology **12** (2017)
N. Somaschi et al. Near-Optimal Single-Photon Sources in the Solid State, Nature Photonics **10** (2016)

High Brightness with low multiple photon emission and high photon indistinguishability

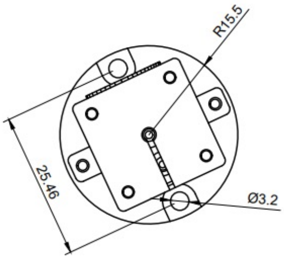


Patented Fiber Coupled
Integration of eDelight in cryostats



Since eDelight sources must be cooled down at a temperature below 6 Kelvin (K) to emit highly indistinguishable photons, Quandela has developed a unique method for the pigtail of one source with one single-mode fiber in order to facilitate the integration in standard Helium closed cycle cryocoolers.

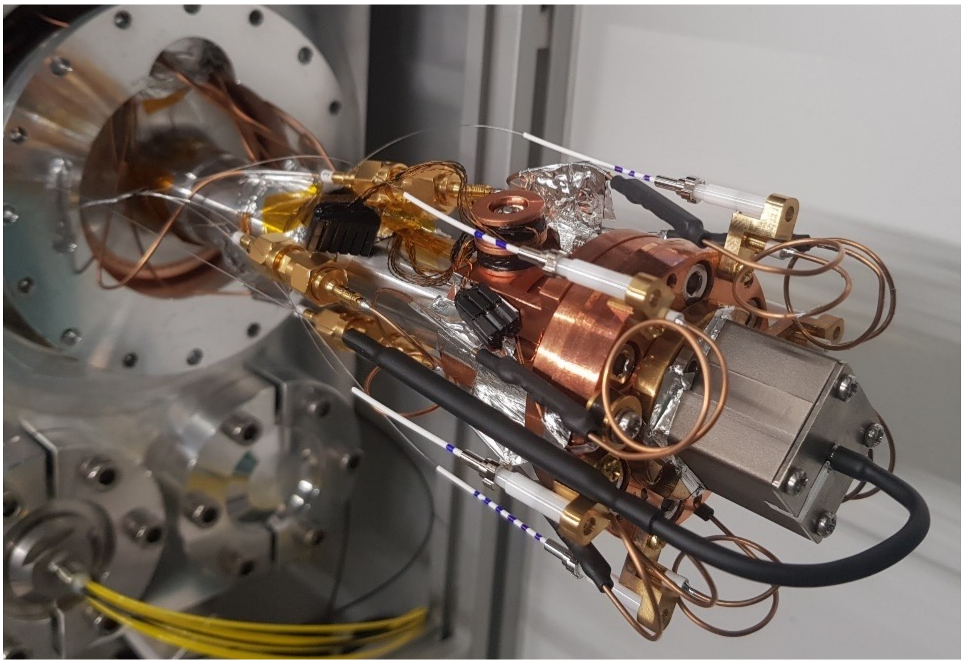
In one fabricated chip, around twenty (20) ***pillars (all of them integrating one quantum dot)*** are fabricated and the brightest source is then selected to be coupled to a single-mode fiber (whose core diameter is around 2 micrometers). The same fiber is used for the optical excitation and for the collection of generated photons.



One source is coupled to one fiber.

The pigtailed source can then be integrated with other devices as Superconducting Nanowire Single-Photon Detectors (SNSPDs) in the same cryostat chamber.

Contact us to check the compatibility of your existing system.



Patented Technology : Patent n° US11867957 delivered on January 9th 2024, PCT/FR2022/050805

Specifications / Requirements

Technology	Proprietary fabrication process and design, fully deterministic: a selected quantum dot coupled to the optical cavity mode.
Single-photon emission wavelengths	925nm (+/- 5nm) 780nm (+/- 5nm) Telecom wavelengths (1550nm) single photons available via a Frequency Conversion Module (optional)
Photon Polarization	All the photons have the same polarization
Minimal Guaranteed Fibered Brightness (photon presence per pulse probability)	From 17% to 26% (1)
Typical Single-photon generation rate at an excitation clock rate of 80MHz	> 20 M photons per second
Single-photon purity : $g^{(2)}(0)$	Typically 2%, < 3% guaranteed (2)
Indistinguishability	Typically 94%, > 92% guaranteed (3)
Single-photon bandwidth – emitter lifetime	1.2 (+/- 0.4) GHz , < 150 (+/- 50) picoseconds ''Fourier-transform-limited'' emission
Required laser pulse energy	about 10^{-13} J (per excitation pulse) – See Prometheus pages to see the laser options
Required operating temperature	< 6 Kelvin
Required Temperature stability	T. stability: < 50 mK
Pigtailed Device Dimensions	Height: 5cm – Diameter of the round plate: 3.1cm

(1) Depending on the chosen performance by the customer, typical brightness is higher than the minimal guaranteed brightness
(2) Second order correlation measured" via Hanbury Brown-Twiss interferometer
(3) Photon indistinguishability between successively emitted photons measured by "Hong-Ou-Mandel" interference measurements

Please note that these specifications are subject to change without any prior notice.

Some publications from our customers in 2023

B. Polacchi et al., Quantum teleportation of a genuine vacuum-one-photon qubit generated via a quantum dot source, arxiv:2310,20521 (2023)

M. Valeri et al. , Generation and characterization of polarization-entangled states using quantum dot single-photon sources, arxiv:2308,02422 (2023)

H. Cao et al., A Photonic Source of Heralded GHZ states, arxiv:2308.05709 (2023)

PROMETHEUS

The first Standalone Quantum-dot based Single-Photon Source

Cryostat, pulsed laser, solid-state single photon sources and active demultiplexer
–all in one system –

Optical Quantum technologies require long streams of identical single photons produced in a stable and robust manner.

The revolutionary concept and design of Prometheus' stand-alone single-photon source makes it the optimal solution for providing a high rate of single and indistinguishable photons for demanding quantum applications.

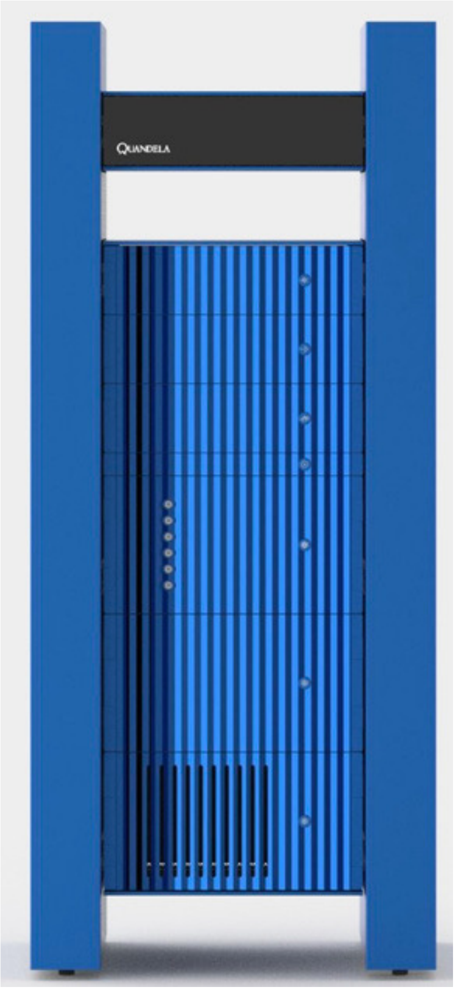
Ready for large-photon number applications

It consists of an all-in-one device that provides a stable stream of photons with a record brightness thanks to our proprietary technology.

Modular Design

Hence, with Prometheus, engineers and researchers can now focus their efforts on their ideas for the design of new experiments based on the manipulation of a large number of optical quantum bits.

An Optical Laboratory in one reliable and vertical device



Modules in the 19 inches rack format

After years of research and innovation, Prometheus is the only standalone device for the emission and the detection of single photons at record rates.

Inside Prometheus:

- A Helium closed cycle cryostat with air-cooled compressor ***(water cooling possible)*** integrating eDelight single photon sources and SNSPDs detectors ***(optional);***
- A 80-MHz pulsed laser used for the optical excitation of the source
- Optical and electronical modules for the use of the source and detectors
- *Optional Active Demultiplexer Q-DMX (from 6 to 12 outputs)*
- Vacuum Turbo Pump
- Main Computer with user-friendly control software

Applications:

Use of multiple single photons at the input of programmable interferometers. Photonic Integrated Circuits can be provided

All the modules are interconnected via optical fibers, which provides a modularity and upgradability.
Thus, the performance of the device can be upgraded, which will never be obsolete.

Specifications / Requirements

Technology	Proprietary fabrication process and design, fully deterministic: a selected quantum dot coupled to the optical cavity mode.
Single-photon emission wavelengths	925nm (+/- 5nm) 780nm (+/- 5nm) Telecom wavelengths (1550nm) single photons available via a Frequency Conversion Module (optional)
Photon Polarization	All the photons have the same polarization
Minimal Guaranteed Fibered Brightness (photon presence per pulse probability)	From 17% to 26% (1)
Typical Single-photon generation rate	> 20 M photons per second
Single-photon purity : $g^{(2)}(0)$	Typically 2%, < 3% guaranteed (1)
Indistinguishability	Typically 94%, > 92% guaranteed (2)
Single-photon bandwidth – emitter lifetime	1.2 (+/- 0.4) GHz , < 150 (+/- 50) picoseconds ''Fourier-transform-limited'' emission
Cooling Time	About 12 hours for the pumping and cooling to 4K
User Interface	All-in-one fully automated software on the integrated computer
Required Electrical Supply & Power Consumption	220V ; < 3kW For Air-cooled compressor
Physical dimensions (cm)	185 (h) x 108 (w) x 76 (d)

(1) Depending on the chosen performance by the customer, typical brightness is higher than the minimal guaranteed brightness
(2) Second order correlation measured" via Hanbury Brown-Twiss interferometer
(3) Photon indistinguishability between successively emitted photons measured by "Hong-Ou-Mandel" interference measurements

Please note that these specifications are subject to change without any prior notice.

QUANDELA

Q-DMX

The first active time-to-space demultiplexer for multiphoton applications; it combines optics and electronics in a compact module.

Now available for 6 photons and up to 12 photons adapted to
interface eDelight & Prometheus with integrated circuits.

Compact, Fast and Highly Transmittive for Single Photon Demultiplexing

One fibered input

Up to 12 fibered outputs

Controlled by a software

QUANDELA

Specifications / Requirements

Number of Fibered Outputs	From 6 to 12
Operation Wavelength	920-930 nm *(identical as eDelight & Prometheus)* 780 nm
Guaranteed Channel Transmission (measured in a single-mode 780HP fiber)	70%, typical transmission: 75%
Rise Time	$Tswitch \quad \sim 50\ ns$
Tunability of the plateau Time	Yes, via the software
Activation/Deactivation of outputs	Yes, via the software
Physical dimensions (cm)	15 (h) x 49 (w), 47 (d)
Weight	Optics: ~ 17 kg Electronics: ~4kg
Electrical connections	100V/120V/230 V, 50 Hz

<ins>PLEASE NOTE:</ins> for the installation of the fiber delay loops necessary to synchronize the outputs, please contact us.

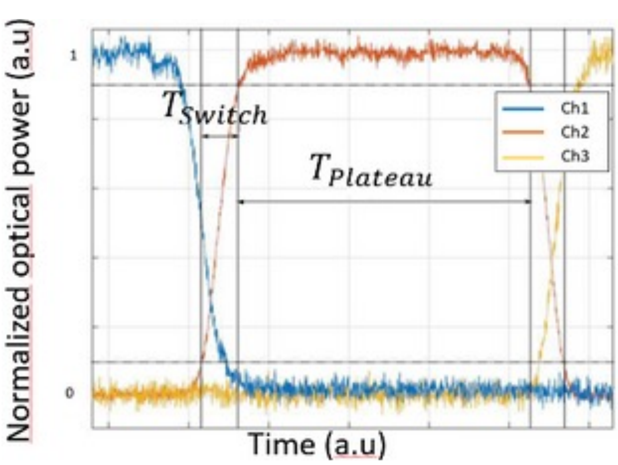
From the reported metrics it's possible to calculate the *N (nº of outputs)*-photon coincidence rate at the output of the Q-DMX.
From the values we can extract at first the "Filling factor":

$$FF = T_{plateau} \,/\, (T_{switch} + T_{plateau})$$

From which one can calculate the final rate of N coincidences at the output

$$C_N = rep.rate * FF * \frac{(\eta * Brightness)^N}{N}$$

(*rep. rate* represents the clock rate of the driving excitation laser and *brightness* identifies the *eDelight* device efficiency – previous pages).

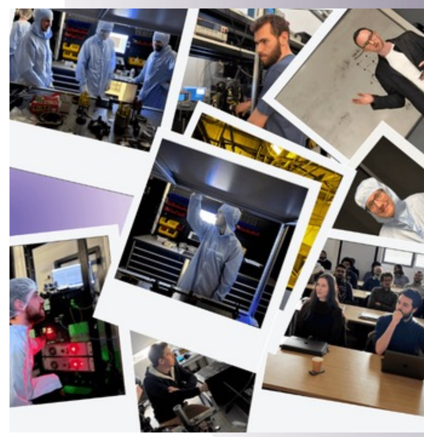


QUANDELA

Consider a Career in Quantum Technologies?
Join us

80+ Employees

15+ Nationalities



Exceptional Perks

Diverse, Dynamic, International Team

60M+ Raised Funds

15+ Publications

In 2024, more than 30 open positions in:

- Semiconductors
- Optics & Electronics
- Quantum Information Theory
- Sales & Marketing
- Software Development

APPLY NOW

https://apply.workable.com/quandela

QUANDELA

Relevant scientific publications:

Quantum-Dot-Based Single Photon Sources

- P. Senellart et al., High-Performance Semiconductor Quantum-Dot Single-Photon Sources, Nature Nanotechnology **12** (2017)

-N. Somaschi et al. 'Near-optimal single-photon sources in the solid state', Nature Photonics 10, 340 (2016)

-S. Thomas et al. 'Bright Polarized Single-Photon Source Based on a Linear Dipole' Phys. Rev. Lett. 126, 233601 (2021)

Photonic cluster state generation:

-S. Wein et al. Photon-number entanglement generated by sequential excitation of a two-level atom, Nature Photonics **16**, 374 (2022)

-N. Coste et al. High-rate entanglement between a semiconductor spin and indistinguishable photons, Nature Photonics **17**, 582-587 (2023)

Compatibility and interfacing with an active demultiplexer and other modules for quantum computing applications:

-Anton et al., 'Interfacing scalable photonic platforms: solid-state based multi-photon interference in a reconfigurable glass chip', Optica6 (2019)

-D. Istrati et al. 'Sequential generation of linear cluster states from a single photon emitter', Nature Comm. 11, 5501 (2020)

-M. Pont et al. Quantifying n-Photon Indistinguishability with a Cyclic Integrated Interferometer, Phys Rev X12.031033 (2022)

-M. Pont et al. 'High-fidelity generation of four-photon GHZ states on-chip', arXiv:2211.15626 (2022)

Single - Photon based Quantum Computing

- N. Maring et al. A General-Purpose single-photon based Quantum Computing Platform, arXiv:2306,00874 (2023) – Accepted for publication in Nature Photonics

- N. Maring et al. One nine availability of a Photonic Quantum Computer on the Cloud toward HPC Integration, arXiv:2308,14582 (2023)

- N. Heurtel et al. Perceval: A Software Platform for Discrete Variable Photonic Quantum Computing, Quantum **7,** 931 (2023)

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