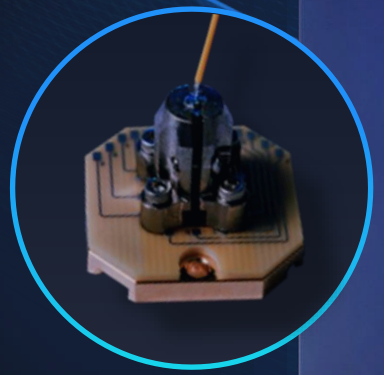
QUANDELA

Building optical quantum computers with solid-state single-photon sources



Niccolo Somaschi - cofounder

April, 26th 2022

EPIC – single-photon source and detectors meeting

Quandela – intro

Quandela is a Quantum Technology company with a strong focus on photonic qubits.

Our team develops state-of-the-art hardware, algorithms and software tools for the development of:

- Quantum Computing Platforms based on the manipulation of single and entangled photons (KLM, MBQC,…)
- Quantum Communication networks
- New generation of imagers and sensors

Founded in 2017

40 people,
(70 for Q4 – 2022)

2 Proprietary Patent + licensed ones

5 commercialized systems

SHOWROOM
9 rue léonard de Vinci
91300 Massy
France

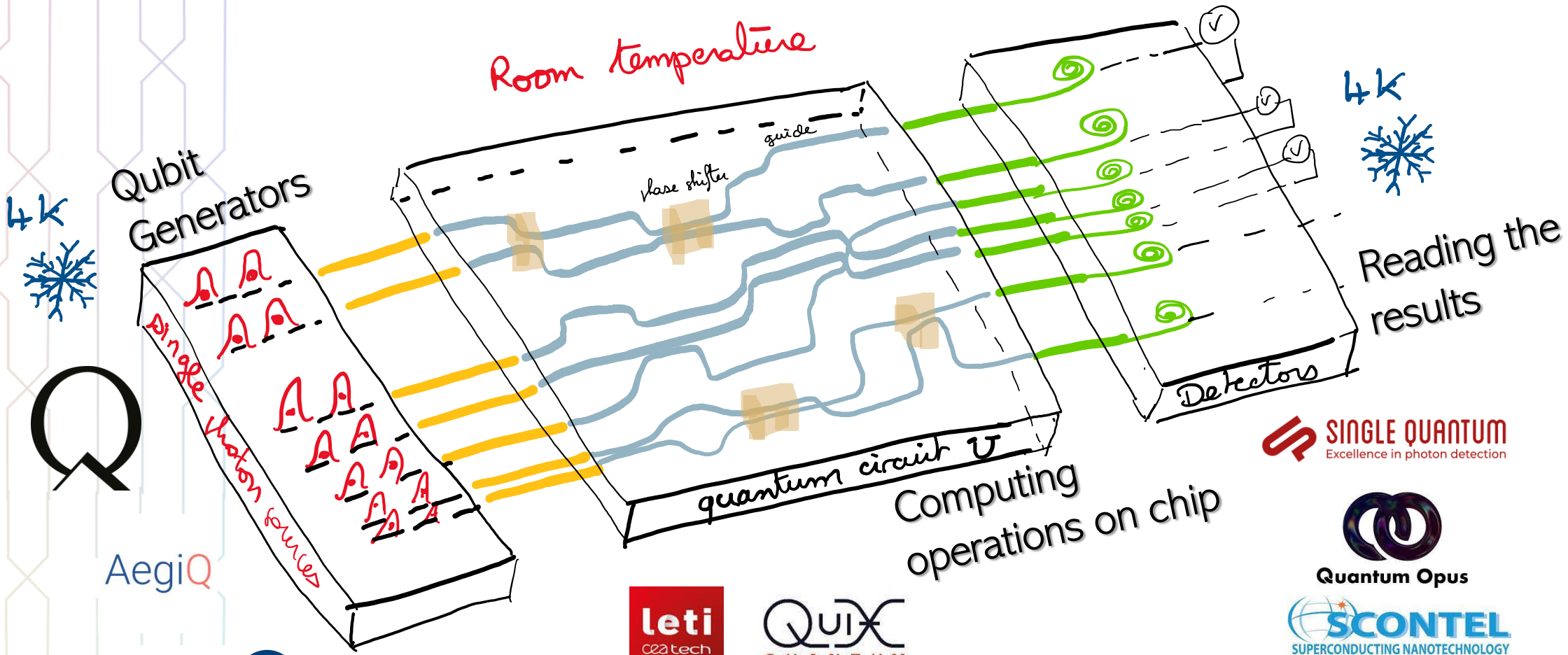
PARIS OFFICES
40 Rue du Louvre
75001 Paris
France

CLEANROOM – SEMICONDUCTOR DEVELOPMENT
10 boulevard Thomas Gobert
91100 Palaiseau
France

MUNICH OFFICES
Rumfordstraße 39
80469 Munich
Germany

A deterministic (single-photon source) generator of optical qubits

Architecture of an Optical Quantum Computer



AegiQ

Sparrow Quantum

leti cea tech

QUIX QUANTUM

LIGENTEC

...

SINGLE QUANTUM
Excellence in photon detection

Quantum Opus

SCONTEL
SUPERCONDUCTING NANOTECHNOLOGY
Detect everything you want

...

Qubit generation – sources

Probabilistic source

four-wave mixing / SPDC

$$|\psi_h\rangle \approx \frac{\lambda}{|\lambda|}|1_s\rangle + \frac{\lambda^2}{|\lambda|}|2_s\rangle$$

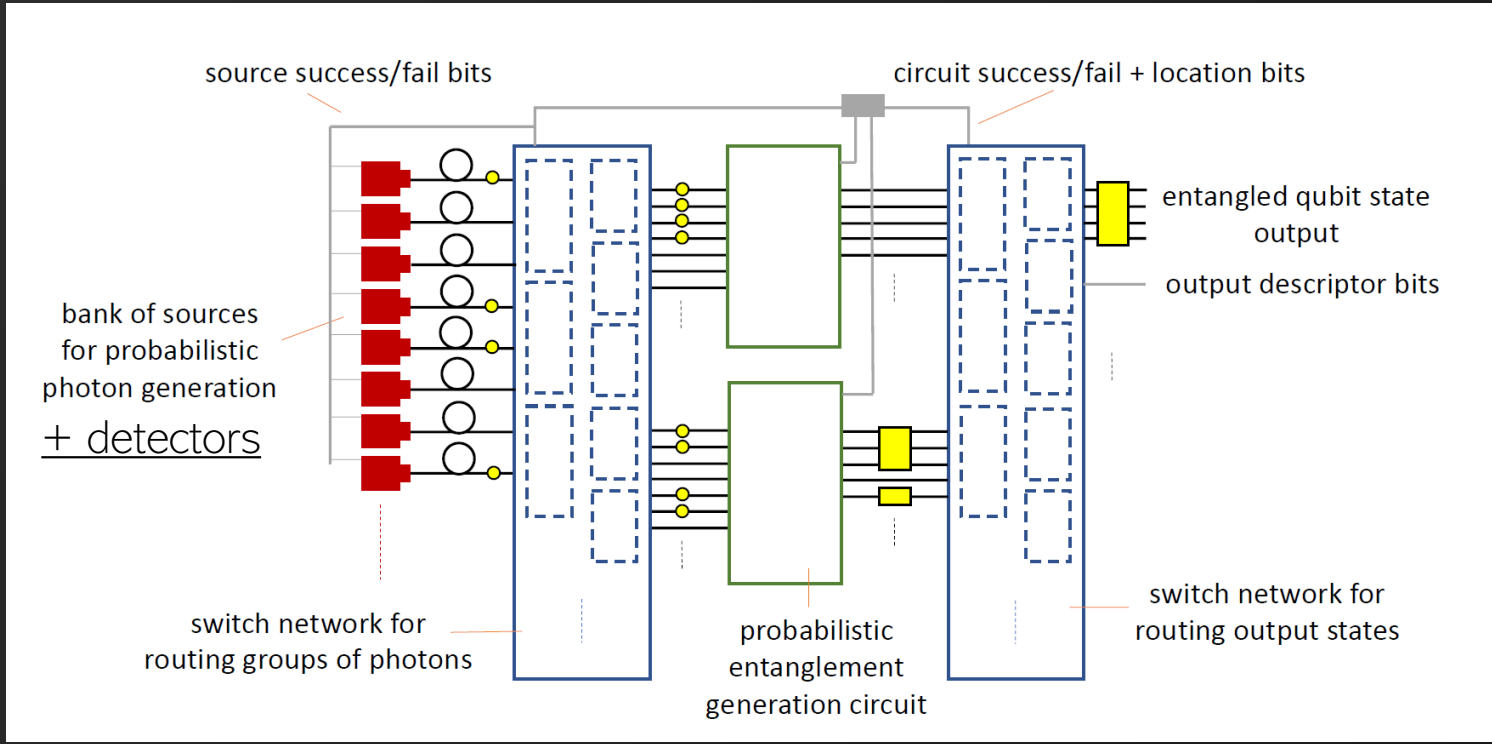
At low pump power $(|\lambda| \ll 1)$

$$B = |\lambda|^2 \quad g^{(2)}(0) \approx \frac{2P_s(2)}{P_s(1)^2} = 2|\lambda|^2 \ll 1 \text{ if}$$

$$B_s \approx 2\ \%$$

Poissonian statistics
→ Emission rate bounded to error rate

Multiplexing: large number of low-loss components

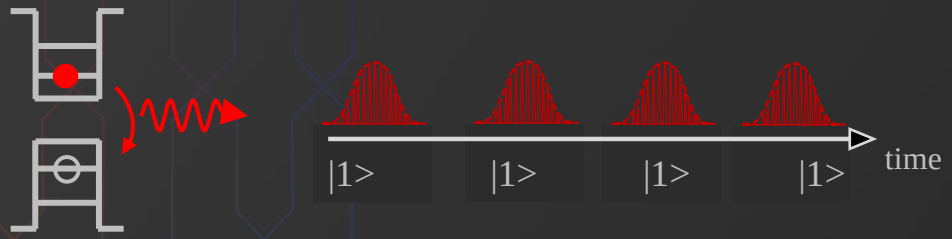


S. Bartolucci et al. Arxiv 2109/13760(2021)

Qubit generation – sources

Deterministic source

Quantum dots = artificial atoms



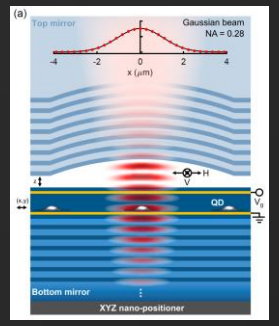
$$|\psi\rangle \approx \sqrt{p_0}|0\rangle + \sqrt{p_1}|1\rangle + \sqrt{p_2}|2\rangle, \quad (p_0 + p_1 + p_2 = 1)$$

$$B \to 1 \quad \& \quad g^{(2)}(0) = \frac{\sum n(n-1)p_n}{[\sum np_n]^2} \to 0$$

H. Wang et al Nature phottonics. 13, 770 (2019)
R. Uppu et al Science Advances 6, (2020)

Require 1 "near-perfect" device

N. Tomm, et al Nature nanotech. 16, 399 (2021)

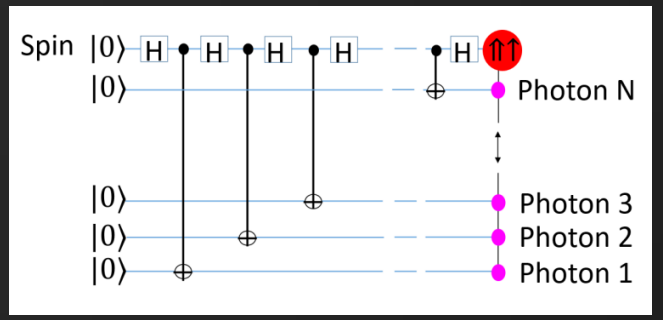


1 source (at the fiber output):

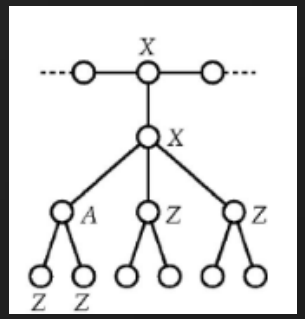
$B_s \approx 57\ \%$

Brightness (efficiency): Prob. Of emitting a photon / laser pulse

+ a spin



D. Gershoni arxiv:2108/05919, (2021)

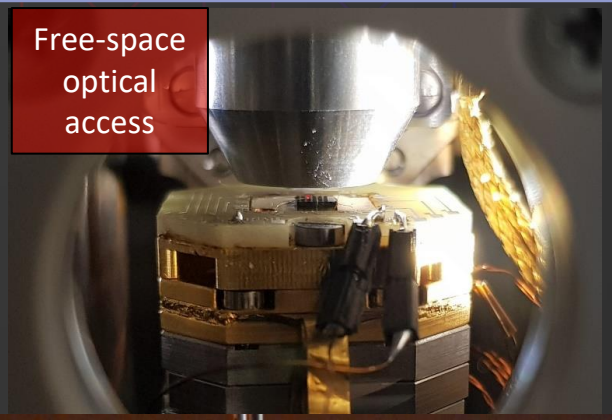


Loss-tolerant qubits

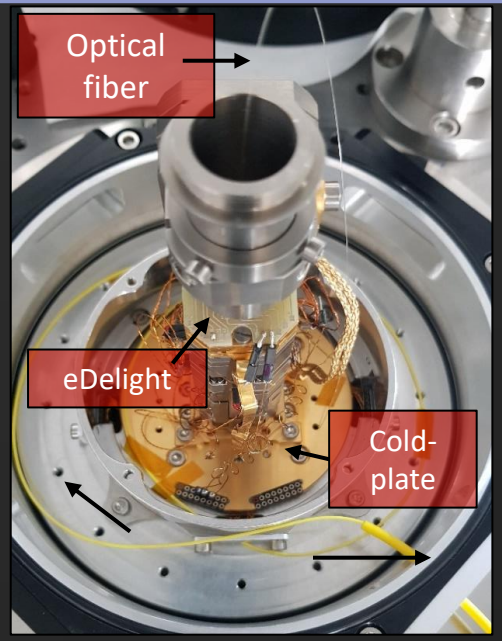
Ubiquitous for scale optical quantum computing via MEASUREMENT BASED approach

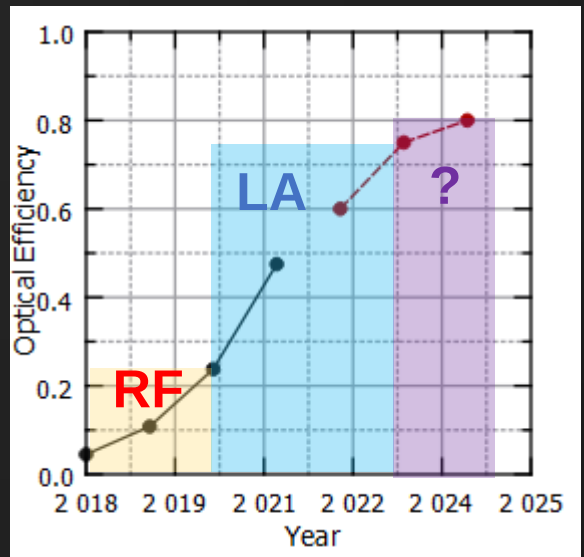
SP coupling and manipulation

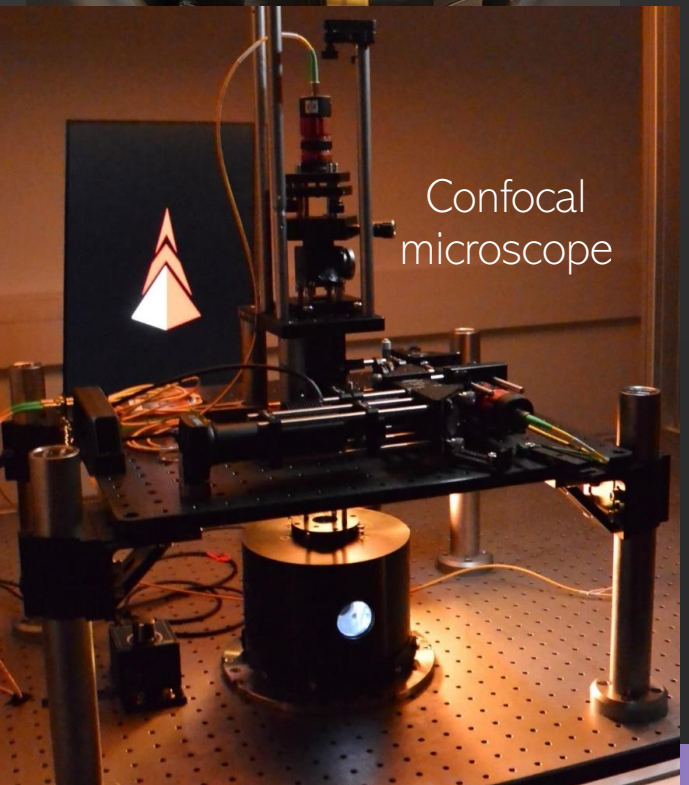
2017 2021 2022…

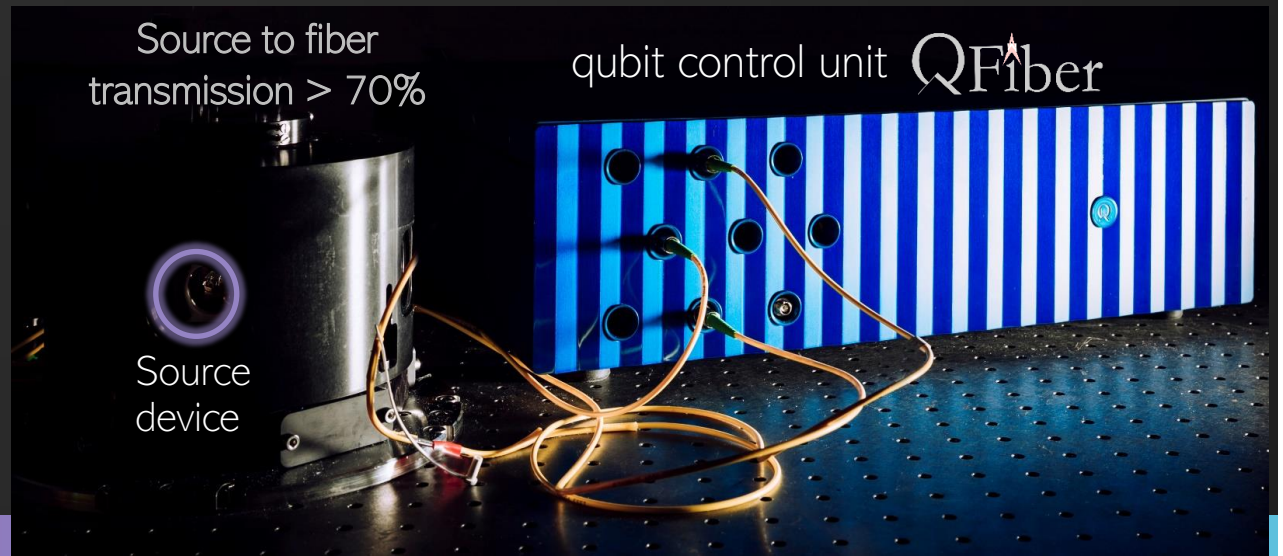


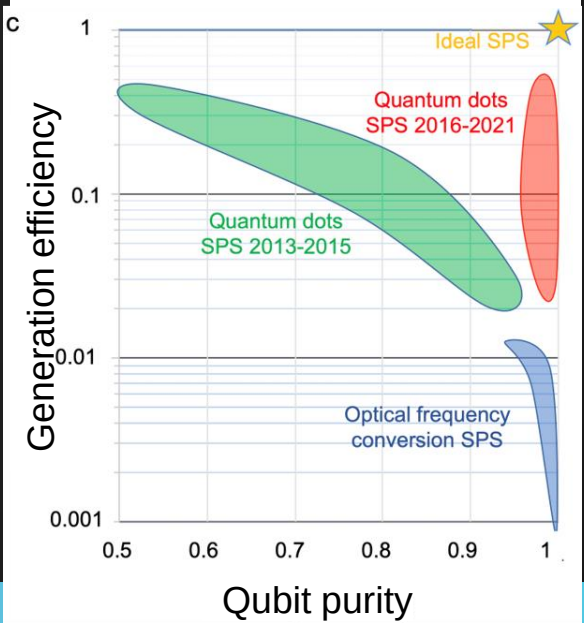
Based on a low-vibration cryostat with active alignment (nanopositioners)







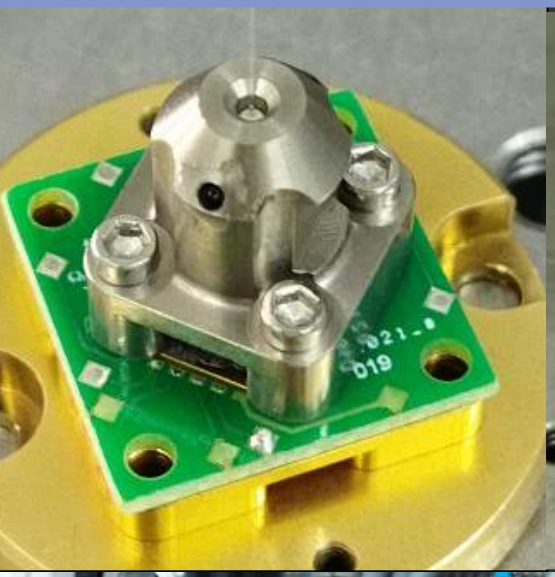


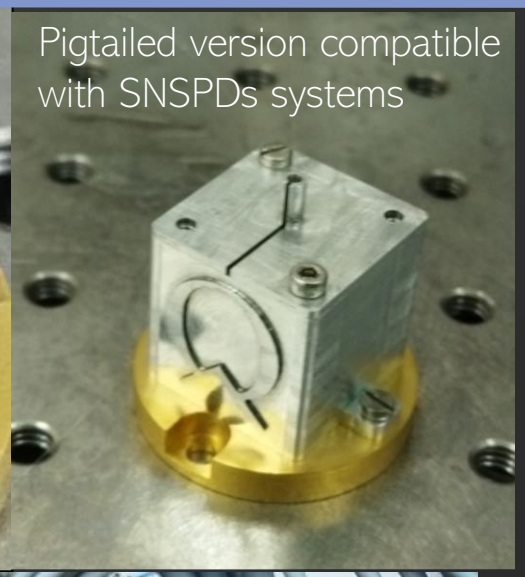


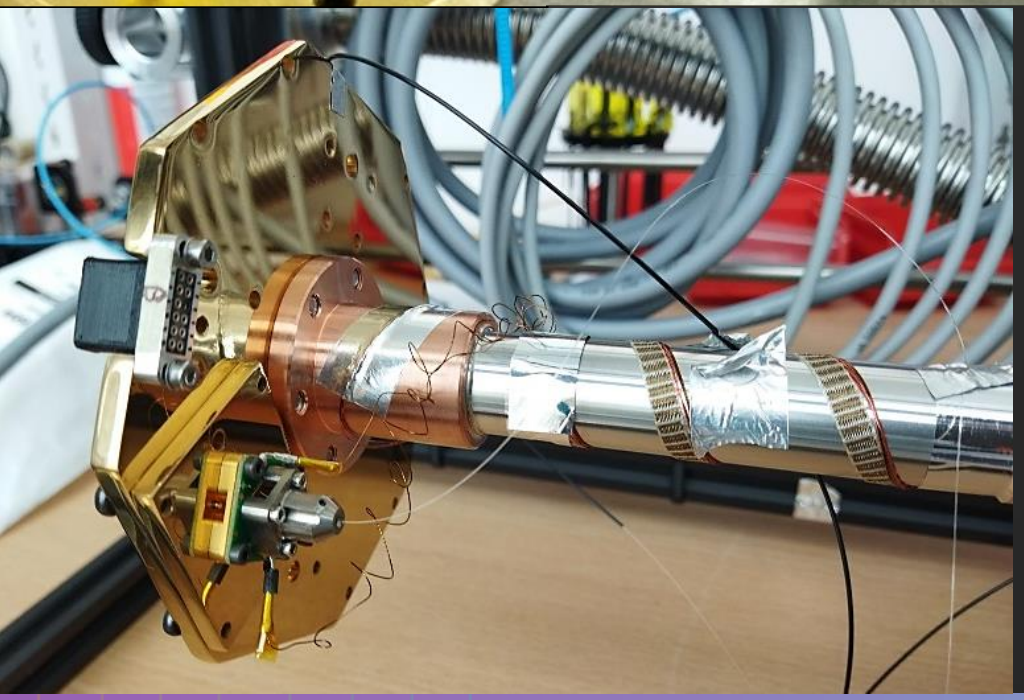
Prometheus

1. User interface - control
2. Lasers & Electronics
3. QDMX-6 Photonic Qubit Router
4. Qfiber – qubit control unit
5. Cryogenically cooled single-photon source
   (40 K or 4 K version)

SM Fiber pigtailed single-photon sources – first prototypes







Fiber to source coupling > 50 %

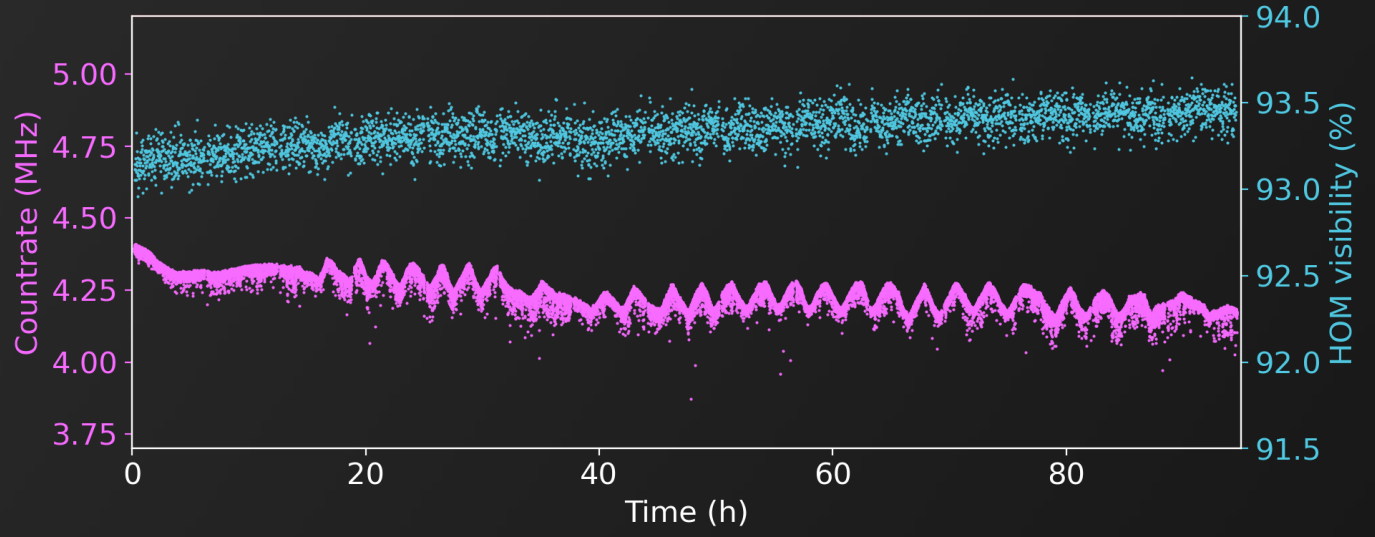
Brightness Fibered* 7 % (4 MHz)

SP purity g2(0) <5 %

HOM > 94 %

* Brightness fibered for standard active alignment = 25 %

Stability over 94 hours of operation



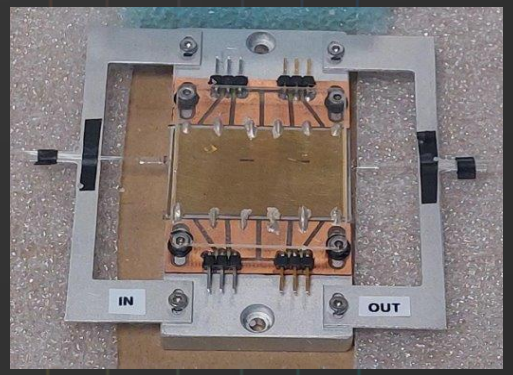
MosaiQ

Two-qubit QPU to generate Quantum-Certified Random Numbers

Measurement of Entangled Qubits → Certification via Bell inequalities → Stream of random bits → API → External applications

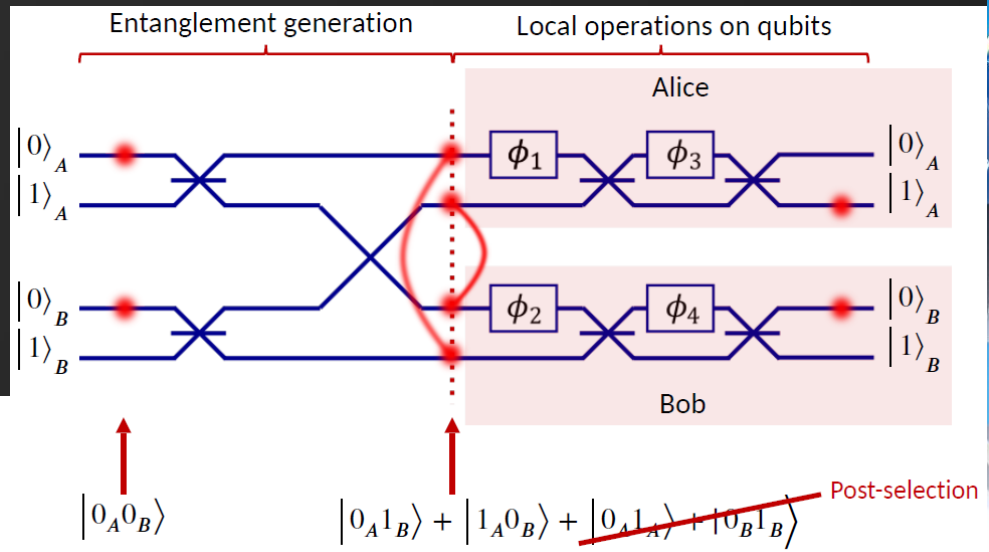
A unique approach:

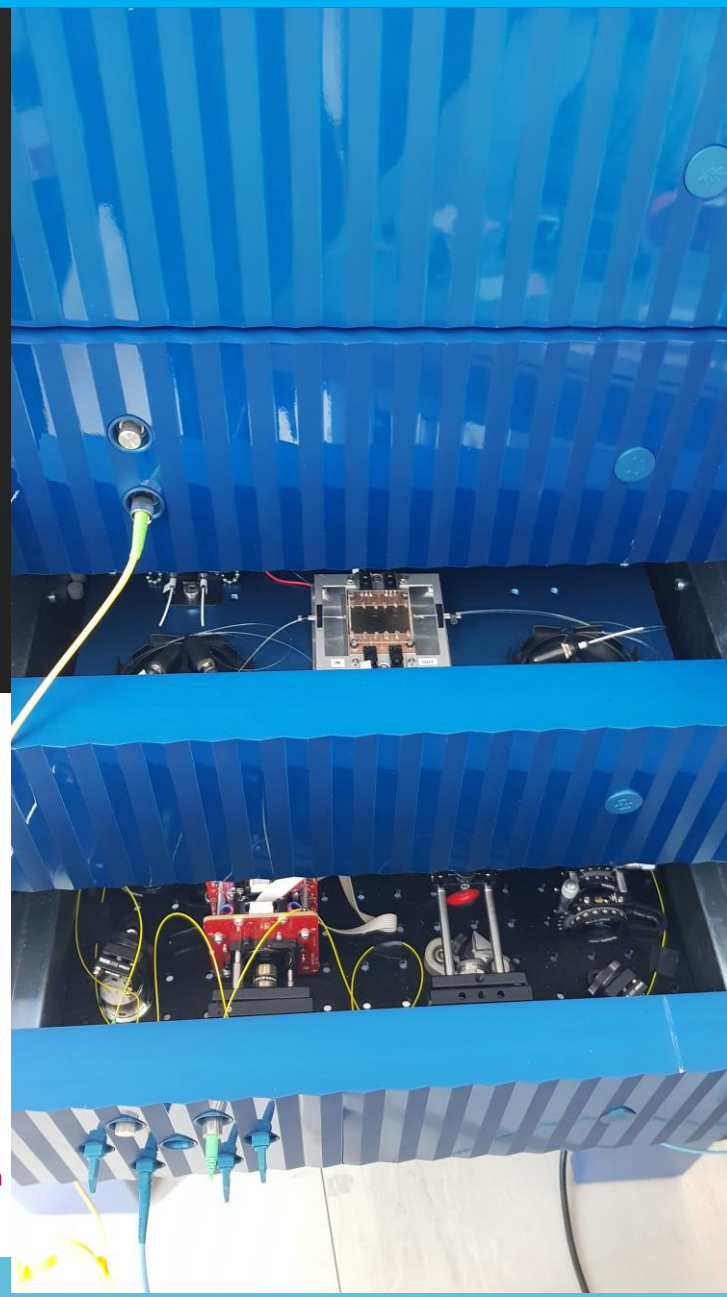
- Compact and certified
- Online or on premise
- Standalone
- 4000 bit/day (256)



5 cm

Applications: Cyber, Montecarlo sim., etc…





Data Encryption · IoT · Blockchain · Watermarking · PKI

Thank you.

…We are hiring!