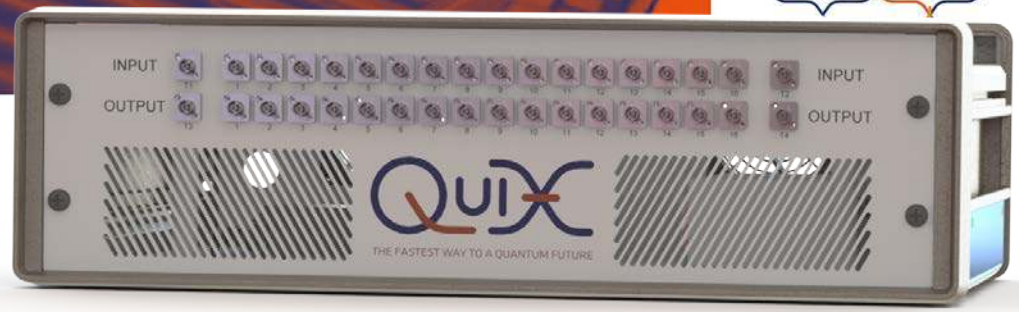
THE FASTEST WAY TO A QUANTUM FUTURE

# A Plug-and-Play Universal Photonic Processor for Quantum Information Processing

**Taballione et al. - Poster**

**Abstract:** Large-scale and programmable quantum photonic processors are needed to control photonic quantum computations that lead to a quantum advantage. Here, we present a universal 12-mode quantum photonic processor which is the largest of its kind to date. The processor is remotely controllable and seamlessly integrated with a dedicated control software, making the device fully plug-and-play.

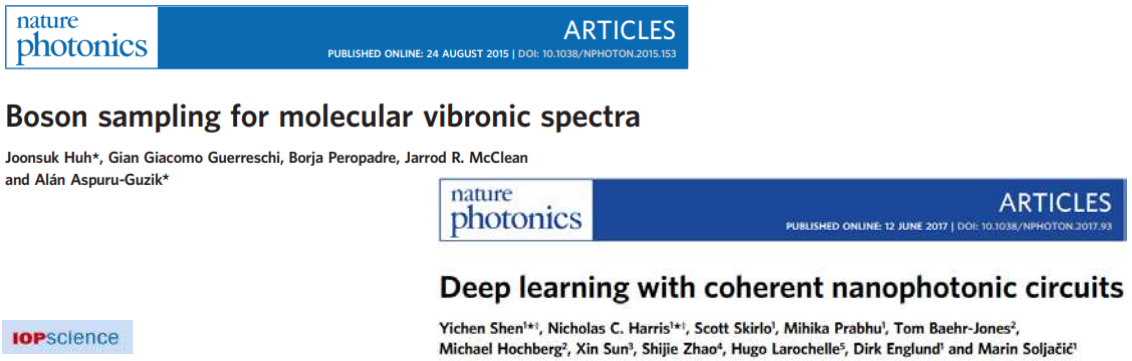



HOT CHIPS

# A Quantum Photonic Processor

## Applications and ideal setup

There are many diverse fields of research where quantum photonic processors find application, such as, for example: Quantum information processing, Quantum simulation - Quantum chemistry and (Quantum) machine learning.


nature photonics
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PUBLISHED ONLINE: 24 AUGUST 2015 | DOI: 10.1038/NPHOTON.2015.153

**Boson sampling for molecular vibronic spectra**

Joonsuk Huh*, Gian Giacomo Guerreschi, Borja Peropadre, Jarrod R. McClean and Alán Aspuru-Guzik*


nature photonics
ARTICLES
PUBLISHED ONLINE: 12 JUNE 2017 | DOI: 10.1038/NPHOTON.2017.93

**Deep learning with coherent nanophotonic circuits**

Yichen Shen[1*†], Nicholas C. Harris[1*†], Scott Skirlo[1], Mihika Prabhu[1], Tom Baehr-Jones[2], Michael Hochberg[2], Xin Sun[3], Shijie Zhao[4], Hugo Larochelle[5], Dirk Englund[1] and Marin Soljačić[1]



Applications of near-term photonic quantum computers: software and algorithms

Thomas R Bromley[1], Juan Miguel Arrazola[1], Soran Jahangiri[1], Josh Izaac[1], Nicolás Quesada[1], Alain Delgado Gran[1], Maria Schuld[1], Jeremy Swinarton[1], Zeid Zabaneh[1] and Nathan Killoran[1]

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**Accelerating recurrent Ising machines in photonic integrated circuits**

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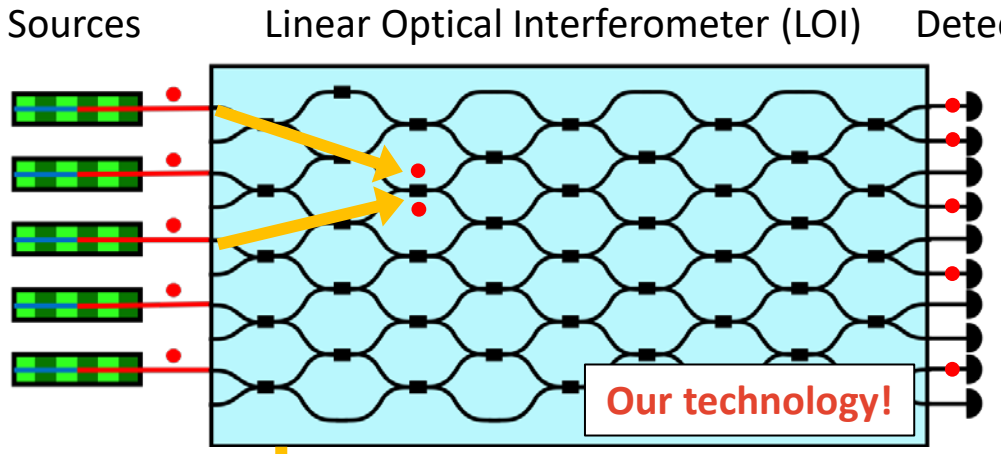
HOT CHIPS



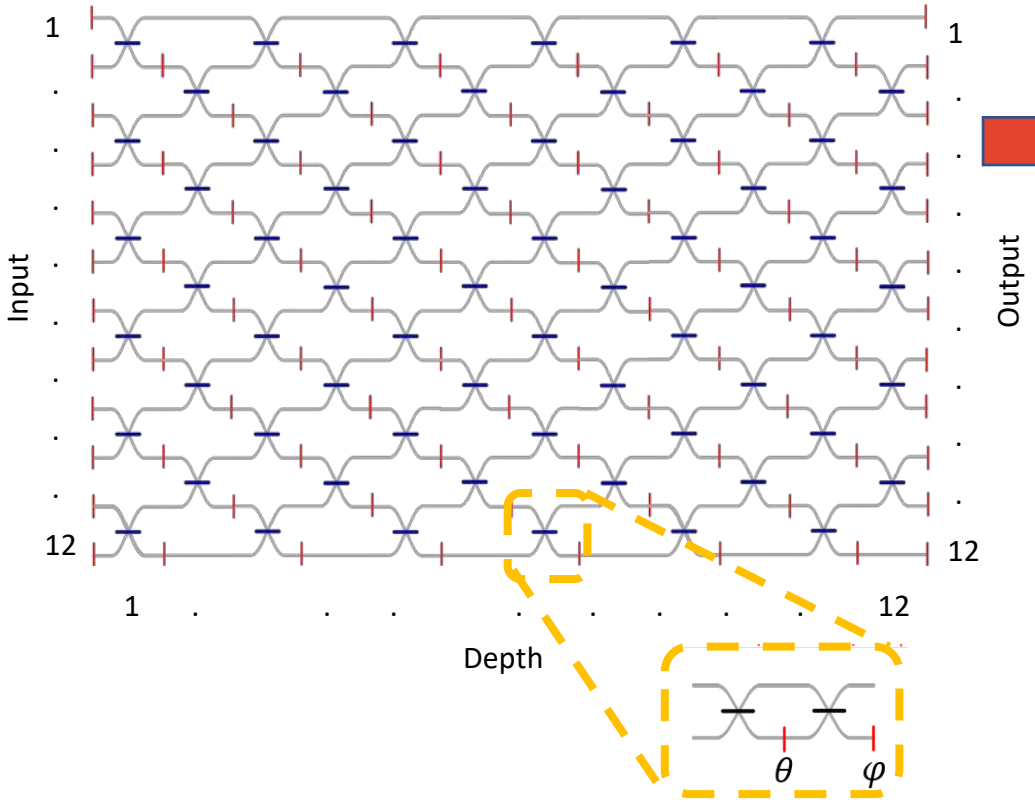

A Quantum Photonic Processor is a programmable Linear Optical Interferometer (LOI) that is remotely controlled by a standard PC that sets the probability of quantum light, e.g., single photons, to meet on a specific location of the LOI and exploit quantum interference.

QuiX

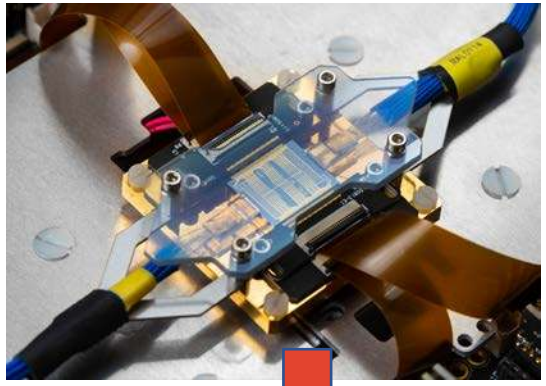
# Our 12-mode Universal QPP

## Plug-and-Play & the largest of its kind.

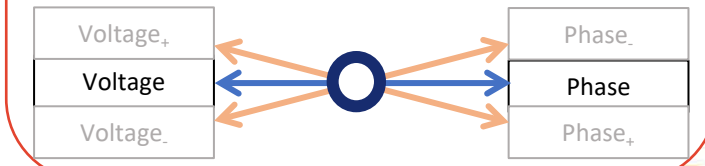
Thanks to our technology based on Stoichiometric Silicon Nitride waveguides we can realize a low-loss ( total loss ~ 3 dB) and fully-programmable 12-mode universal quantum photonic processor containing a total of 66 unit cells and 156 thermo-optic phase shifters. Our 12-mode processor is fully packaged optically (bonded PM fiber-array) and electronically (wire bonded to a PCB) and embedded in our control box that keeps the processor thermally stable (via active cooling) and comes with a seamless integration of our dedicated control software to program the desired quantum experiment in our processor.

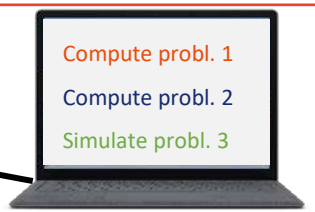



**Unit cell = TBS + PS**




**Dedicated Control Software:**
It controls each thermo-optic phase shifter independently, based on the calibrated relationship between the applied Voltage and the actual phase shift imparted to the light in the undelying waveguide.



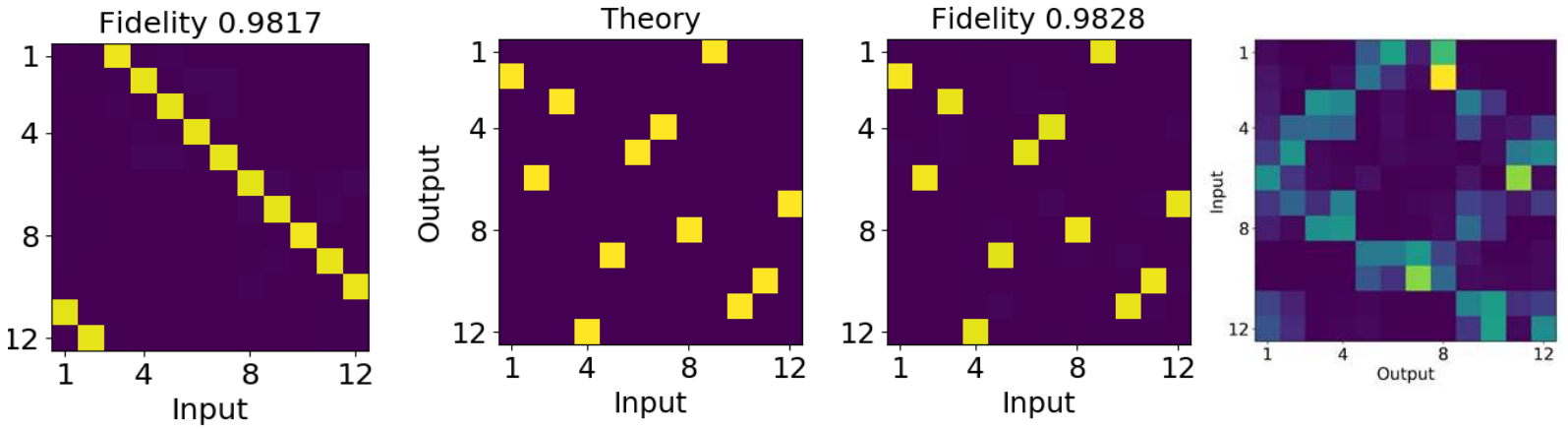



# Experimental results

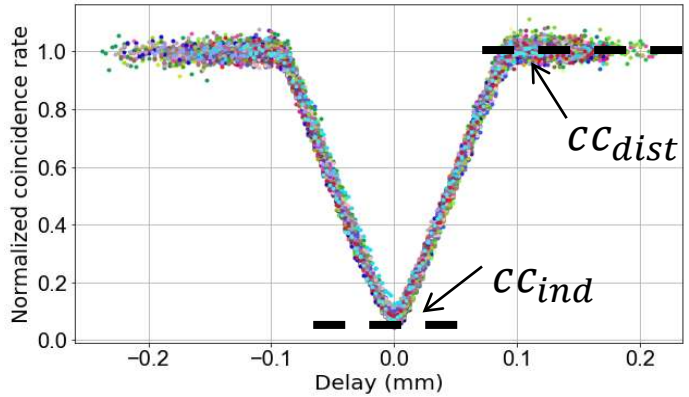
## Classical and Quantum

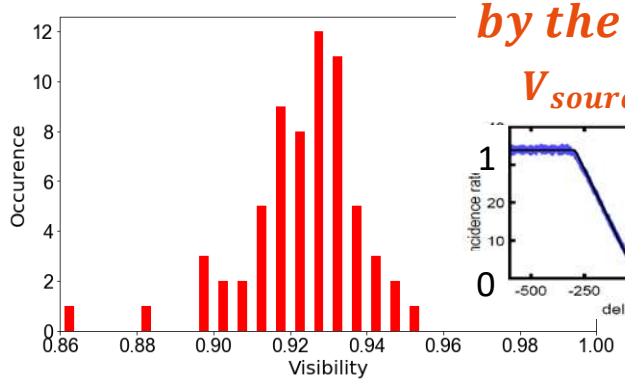
We perform a variety of classical and quantum experiments in order to demonstrate the universality, full-reconfigurability and preservation of quantum interference of our 12-mode processor. We measure more than 500 unitary transformations such as permutations, Fourier, Pauli X-gate and Haar random matrices with an average amplitude fidelity of $F \sim 0.98$ (ideal case $F = 1$) proving that we can perform any arbitrary unitary transformation. We then perfom 66 Hong-Ou-Mandel quantum interference experiments across the entire processor, measuring an average visibility for indistinguishable parametric down-converted single photons of 0.923. The reference visibility of the single photon source is 0.93 and this confirms that our processor preserves the quantum interference.

**Universality & Full-reconfigurability**




**Preservation Quantum Interference**




***Limited by the source!***

$V_{source} = 0.93$