Optical Technologies.

Leibniz Universität Hannover

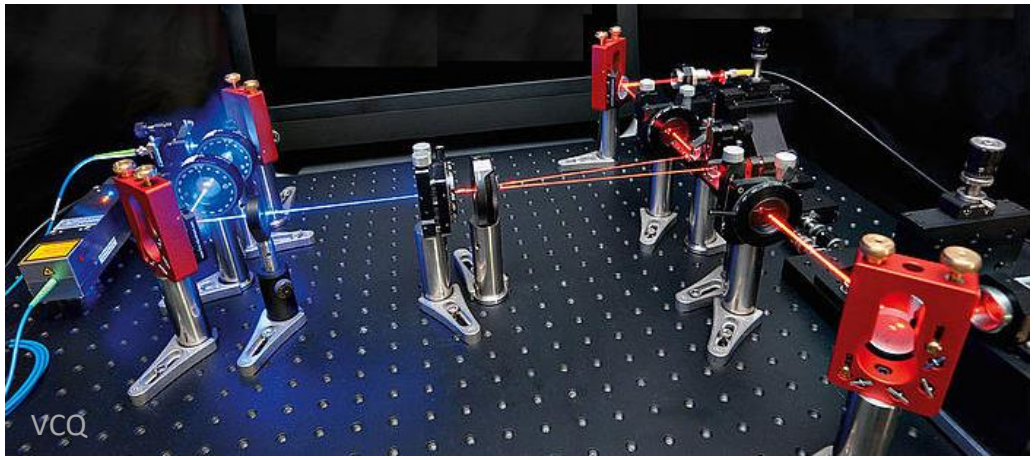
Photonic quantum technologies group

Prof. Dr. Michael Kues

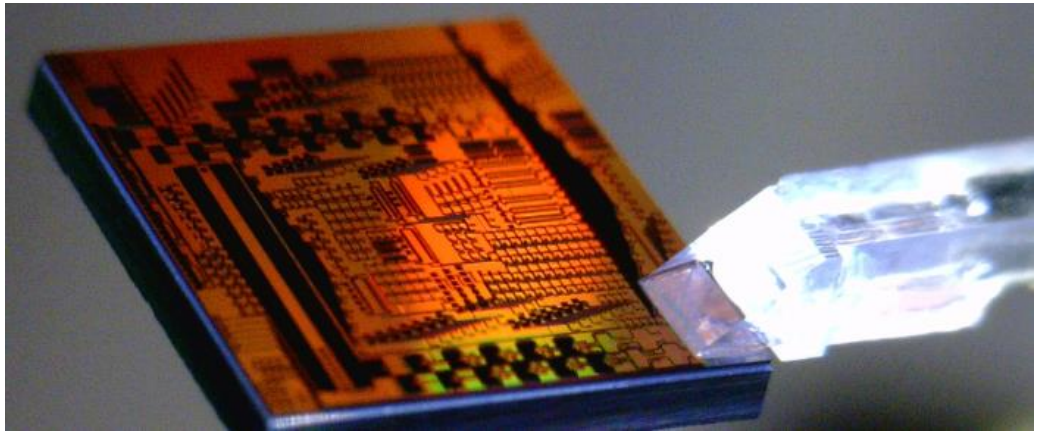
Hannover Center for Optical Technologies, Leibniz University Hannover

Quantum photonic systems for technology applications

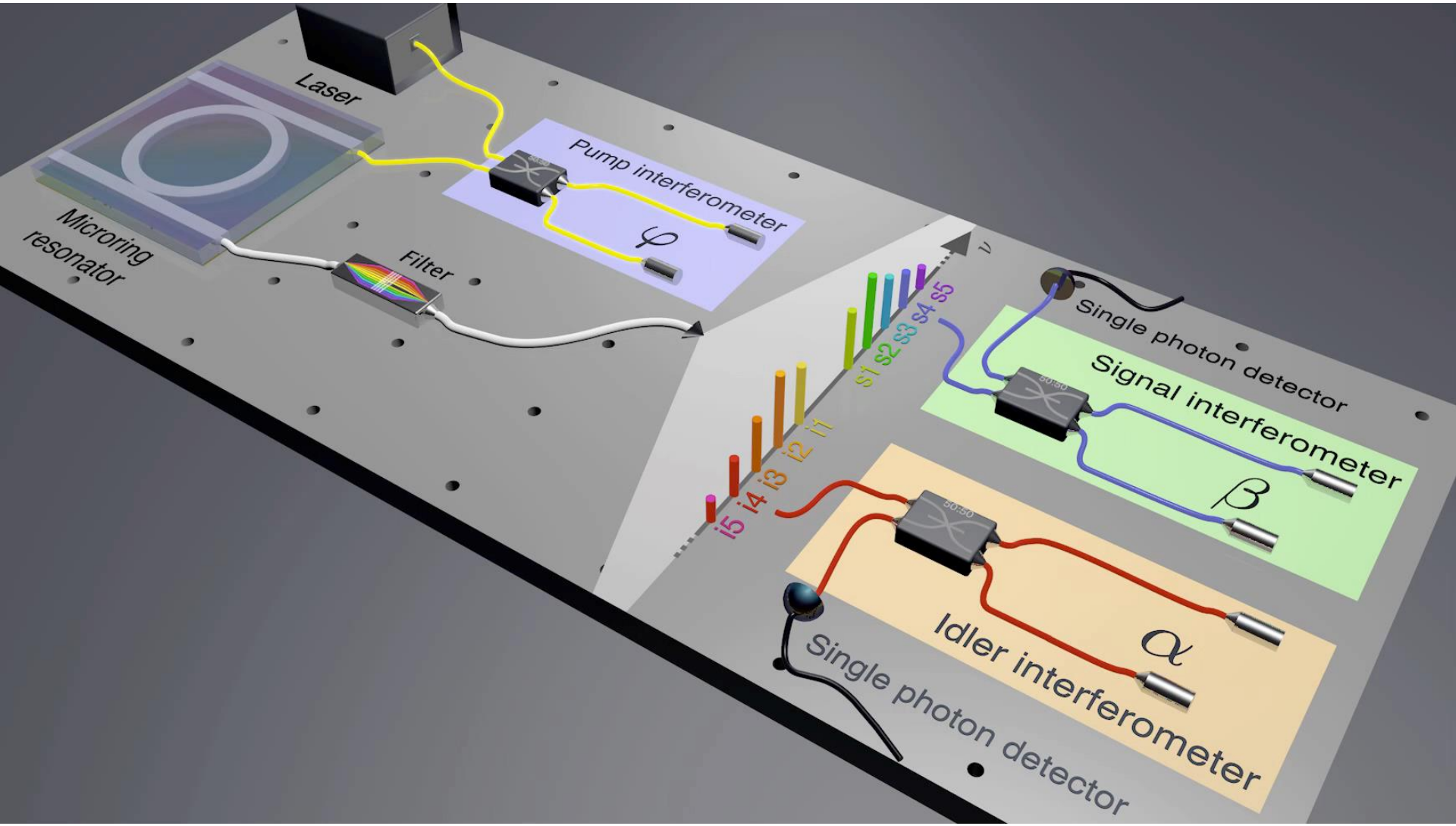
Bulk based systems



Photonic chips

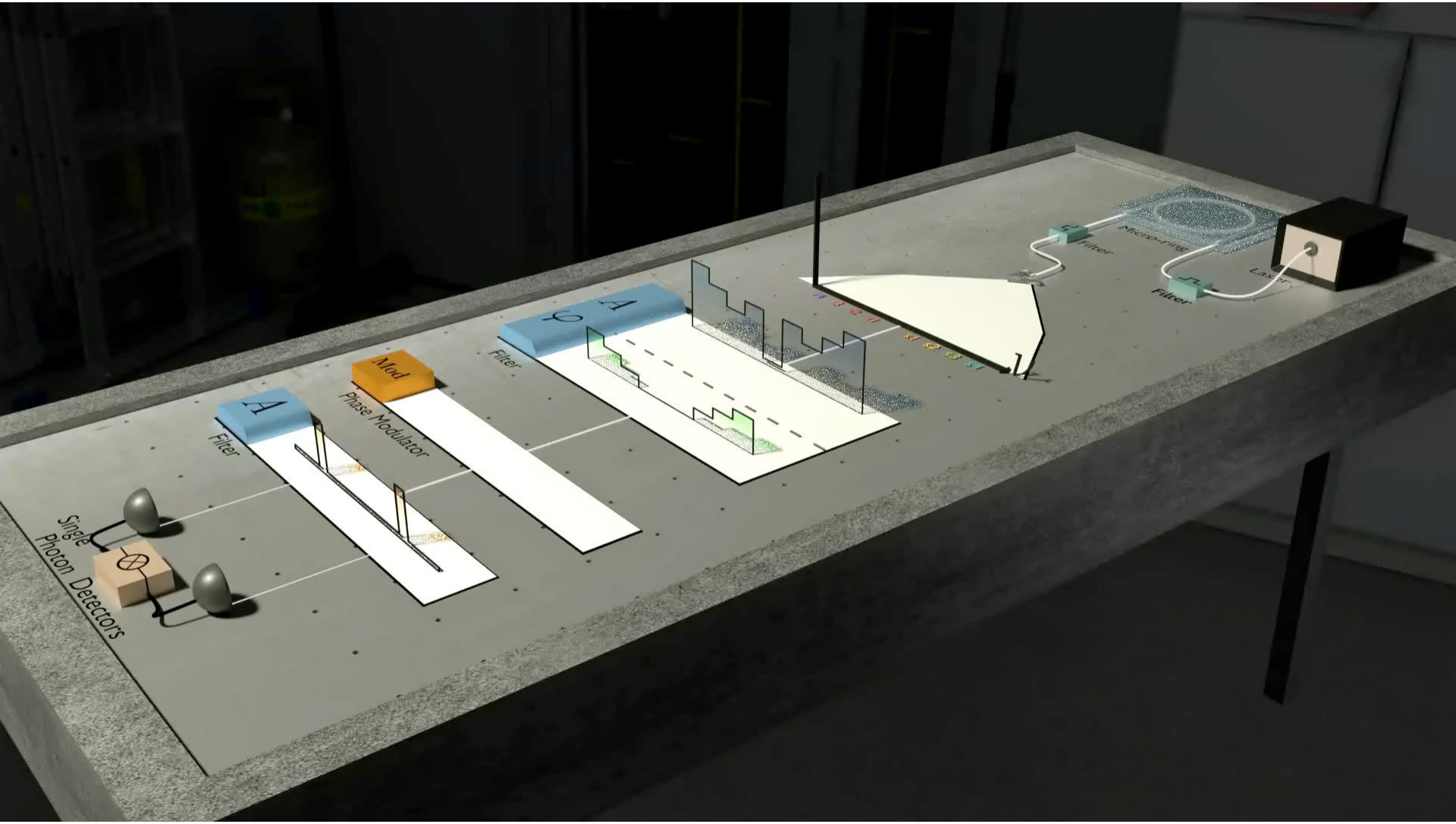


On-chip quantum frequency comb: time bin



C. Reimer, M. Kues, et al., *Science* **351**, 1176-1180 (2016).

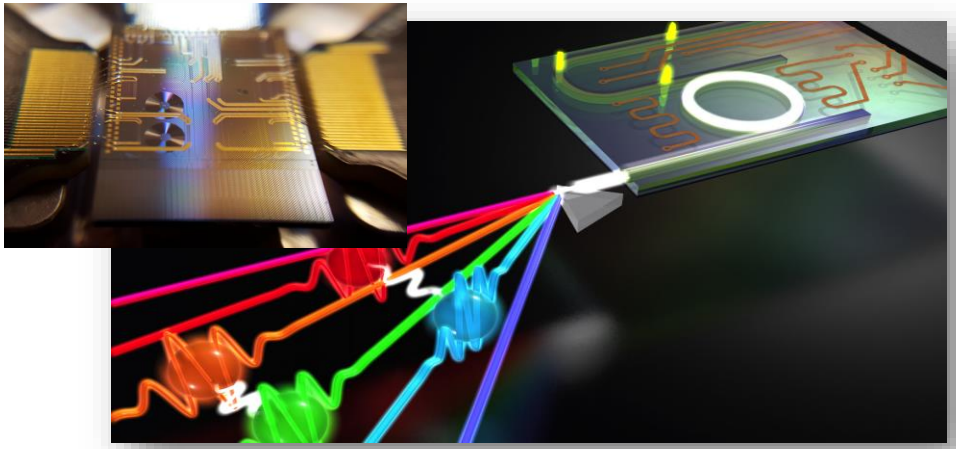
On-chip quantum frequency comb: frequency bin



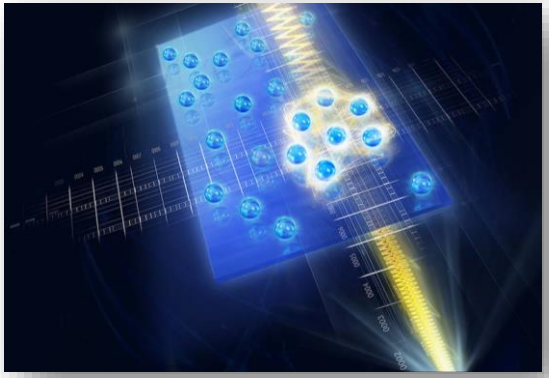
M. Kues, C. Reimer, et al., *Nature* **546**, 622 (2017).

“Photonic quantum technologies” Research Group

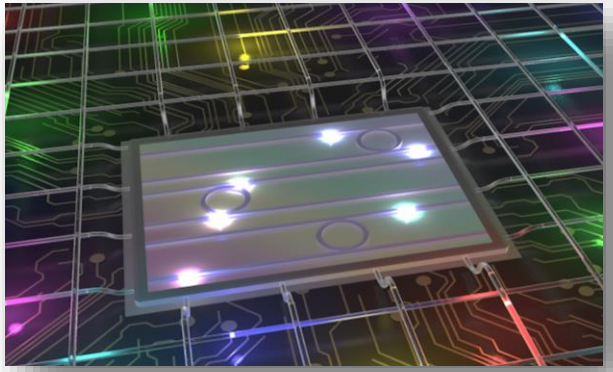
Integrated/fiber-based photonic systems



Quantum-enhanced measurement concepts



Quantum algorithms for optimization problems



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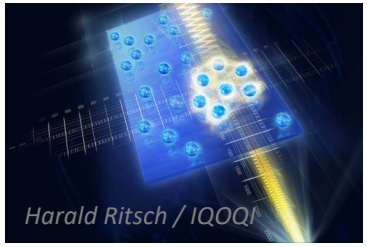
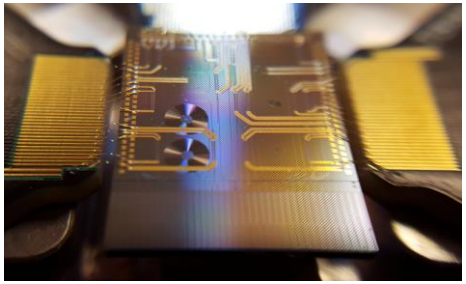
Quantum metrology and sensing



→ Enhanced resolution, precision, sensitivity

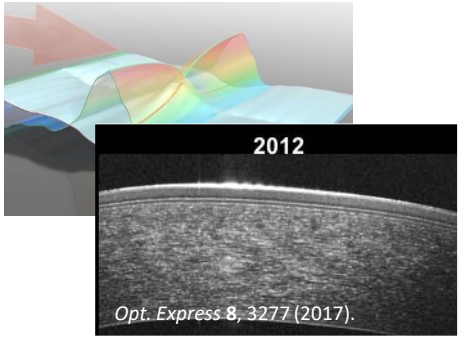
Science **328**, 879 (2010), *Science* **316**, 726 (2007), *Science* **321**, 1463 (2008).

Exploring and developing **quantum frequency combs** for …



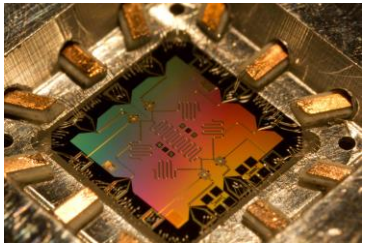
- **Integrated/fiber-based quantum-enhanced measurement systems**

- **New quantum metrology concepts**
  based on frequency comb nature and new processing scheme

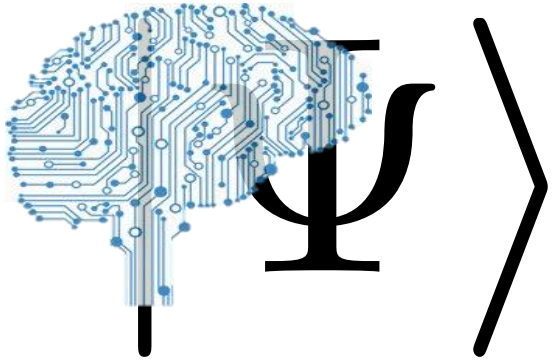


- **Imaging and spectroscopy**
  Quantum optical coherence tomography
  Sub-shot-noise spectroscopy

Quantum computing



Quantum machine learning



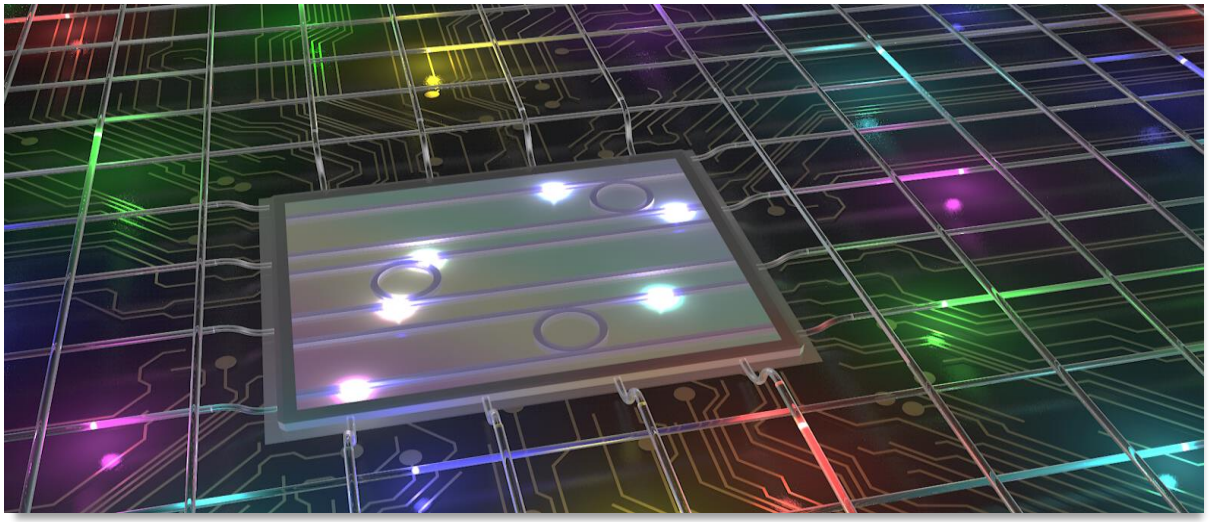
Accelerating machine learning
e.g. classification and clustering tasks

No **universal** processing …

… but **static defined** manipulations

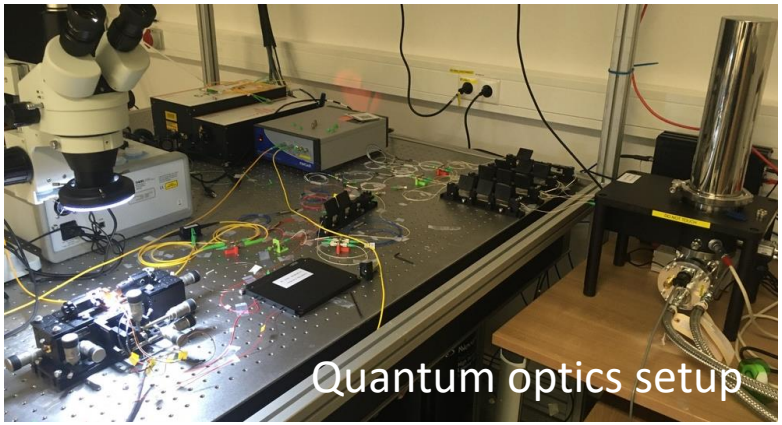
J. Biamonte, et al., *Nature* **549**, 194 (2017).

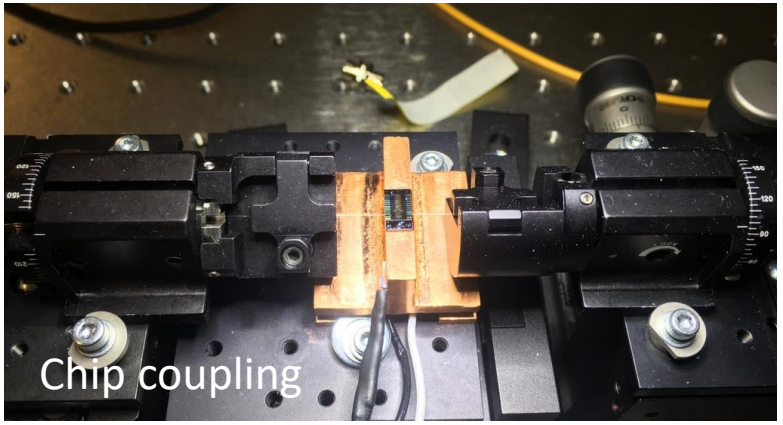
Quantum machine learning co-processors



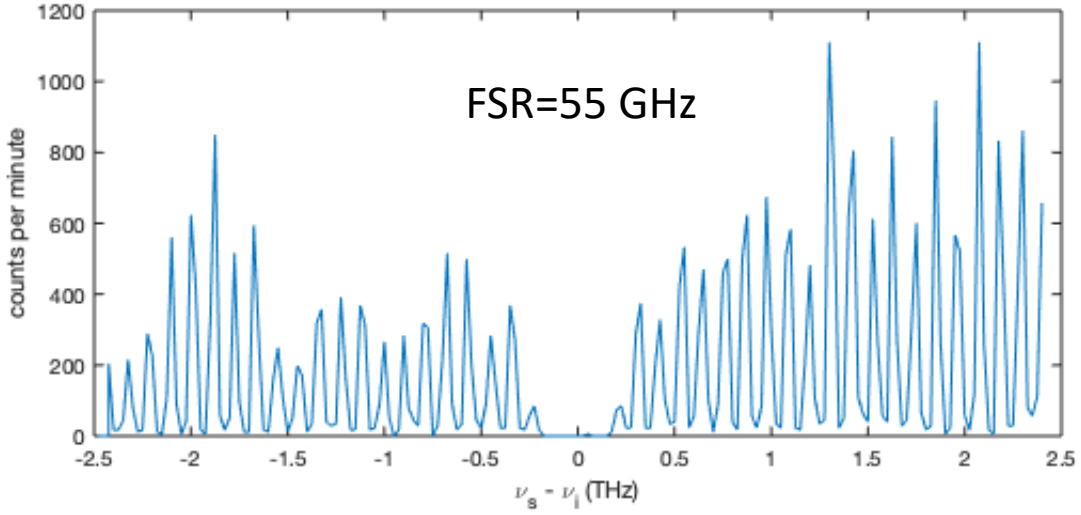
“Photonic quantum technologies” Research Lab

Quantum optics laboratory with cutting-edge equipment operational after 6 months





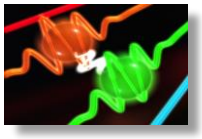
First on-chip quantum frequency comb in Germany/Europe



Bachelor and master thesis

- Detection of 4 photon states: building photon generation setup and develop quantum state analysis codes
- Quantum random number generator: Building up a chip coupling stage and photonic chip control
- Photonic machine learning: developing and simulating a photonic based setup for machine learning tasks
- High-dimensional quantum random walk: performing simulations and designing the experiment
- ....

“Photonic quantum technologies” Research Group



Post-doc

Alí M. Angulo Martínez

Raktim Haldar

PhD students

Anahita Khodadad Kashi

Hatam Mahmudlu

Group leader

Michael Kues

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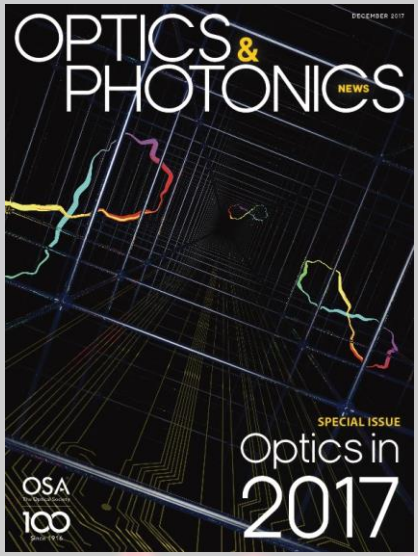
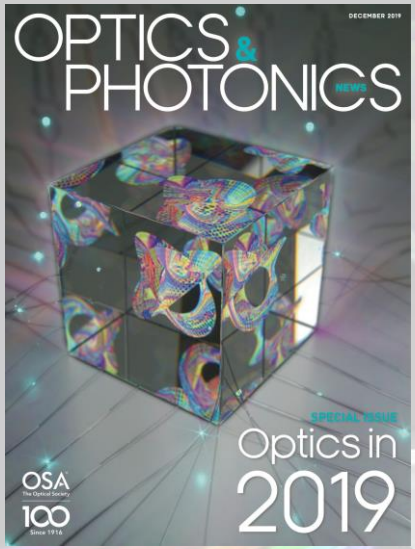
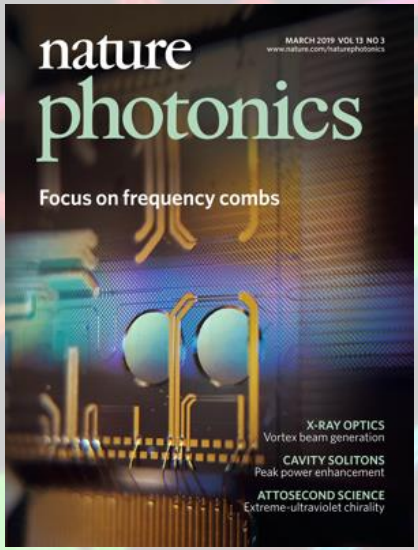
und Forschung







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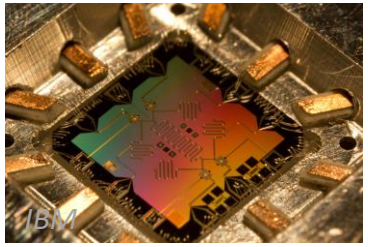
Leibniz Universität Hannover

Michael Kues
michael.kues@hot.uni-hannover.de

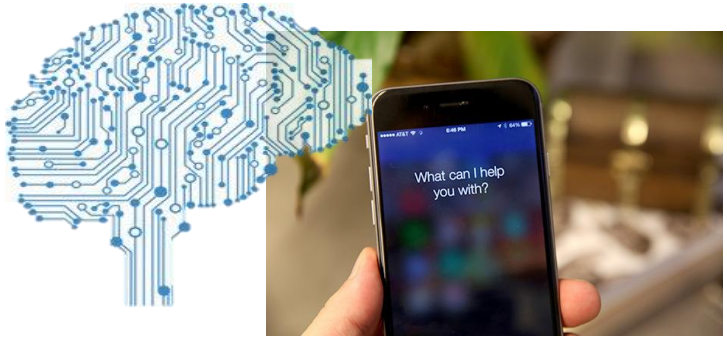
More details related to this work:

S. Sciara, M. Kues, et al. **Phys. Rev. Lett.** 122, 120501 (2019).
M. Kues, C. Reimer, et al., **Nature Photonics** 13, 170-179 (2019).
C. Reimer, M. Kues, et al., **Nature Physics** 15, 148–153 (2019).
M. Kues, C. Reimer, et al., **Nature** 546, 622 (2017).
M. Kues, C. Reimer, et al., **Nature Photonics** 11, 159-162 (2017).
P. Roztocki, M. Kues, et al., **Optics Express** 25, 18940 (2017).
Y. Zhang, C. Reimer et al., **Optics Letters** 42, 4391 (2017).
C. Reimer, M. Kues, et al., **Science** 351, 1176 (2016).
L. Caspani, M. Kues, et al., **Nanophotonics** 5, 351 (2016).
C. Reimer, M. Kues, et al., **Nature Communications** 6, 8236 (2015).
C. Reimer, L. Caspani, et al., **Optics Express** 22, 6535 (2014).

Quantum computing



Machine learning



Application fields:

Finance
Cyber security

Drug development
Medicine

Autonomous vehicles

Robotics

Current approaches: neuronal networks and large scale vectors → **large overheads**