

ムーンショット目標6
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誤り耐性型大規模汎用 光量子コンピューターの研究開発

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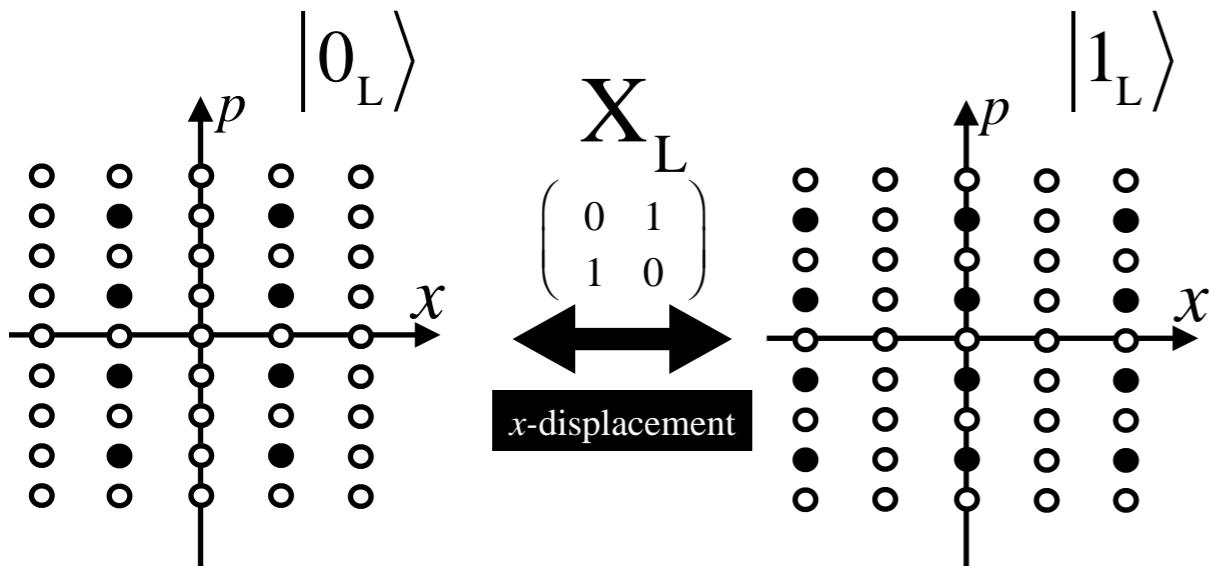


RIKEN
QUANTUM
COMPUTING

Fault-tolerant quantum computing

**GKP qubits
&
Logical operations**

**Logical qubits for
Quantum error correction**



D. Gottesman et al. PRA **64**, 012310 (2001)

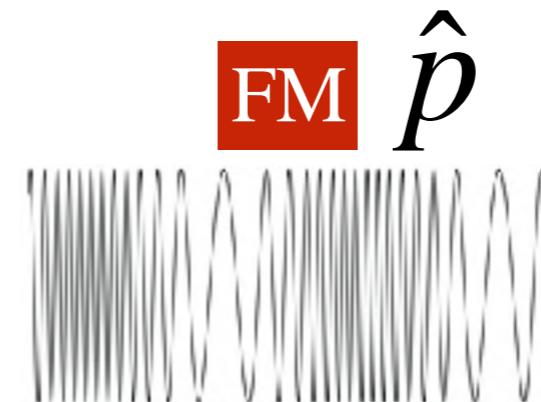


Complex amplitude

$$\hat{a} = \hat{x} + i\hat{p}$$

$$[\hat{x}, \hat{p}] = \frac{i}{2}$$

$$\hbar = \frac{1}{2}$$

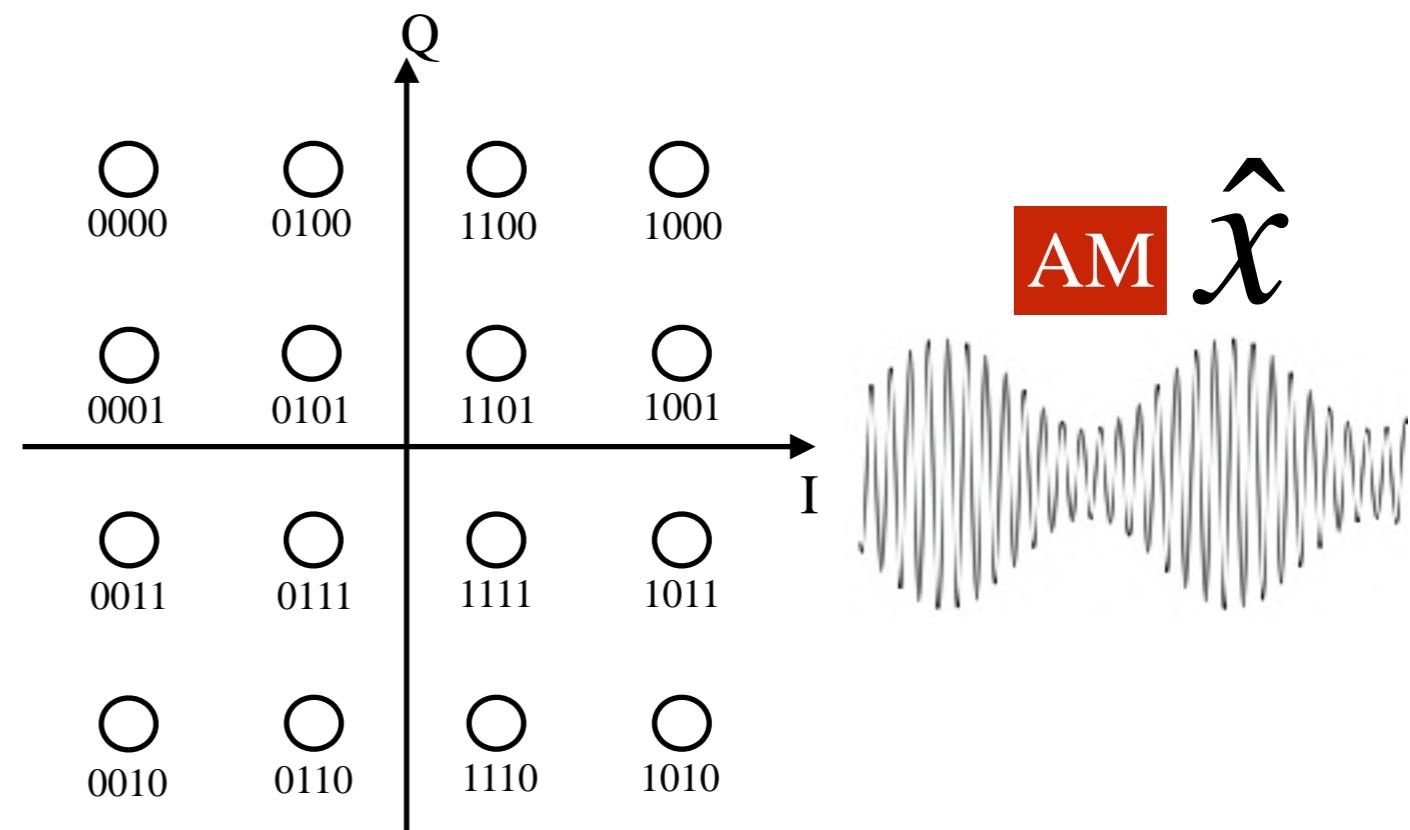


**Quadrature Amplitude Modulation
QAM**

Coherent communication

Radio

AM
FM



**GKP qubits
&
Logical operations**

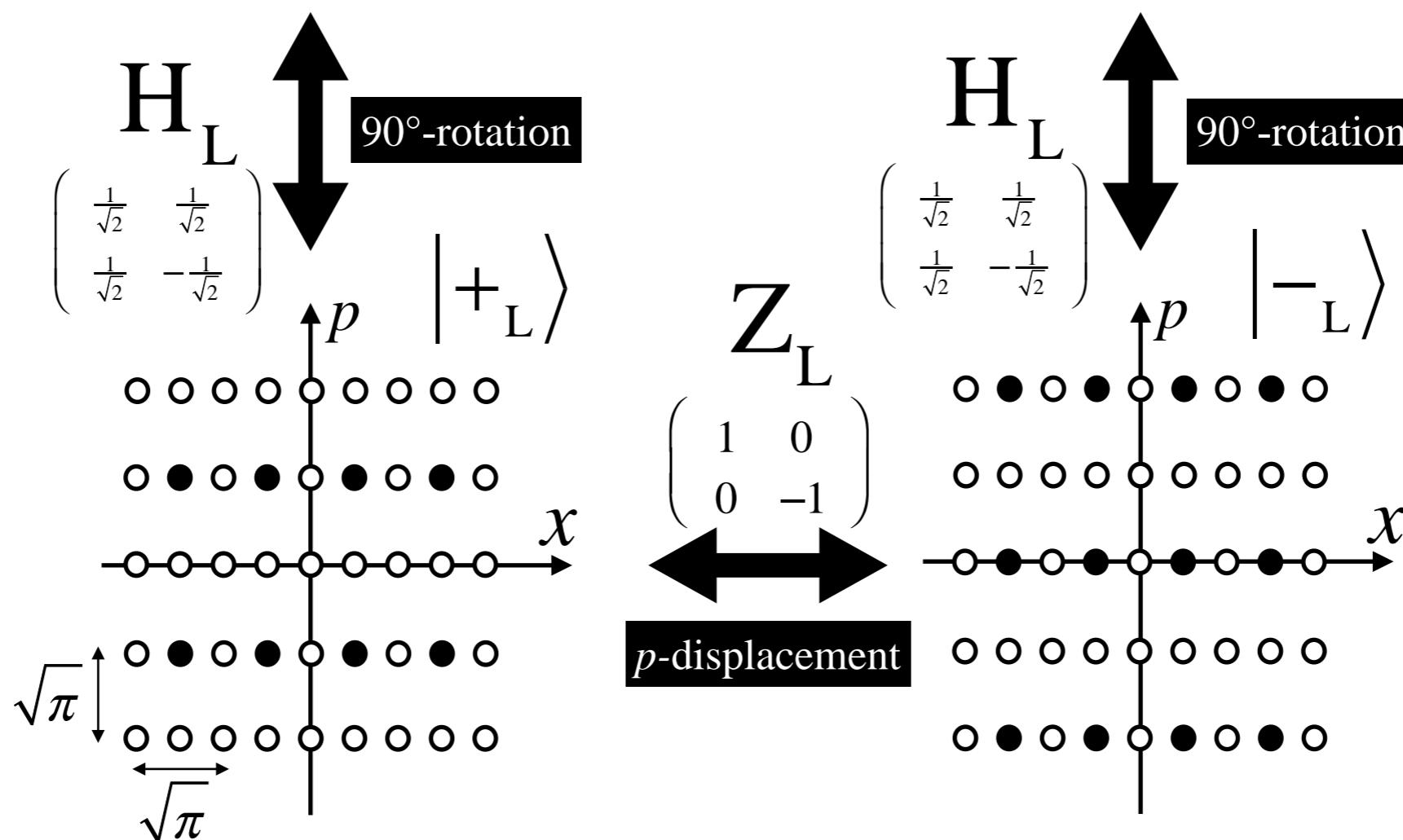
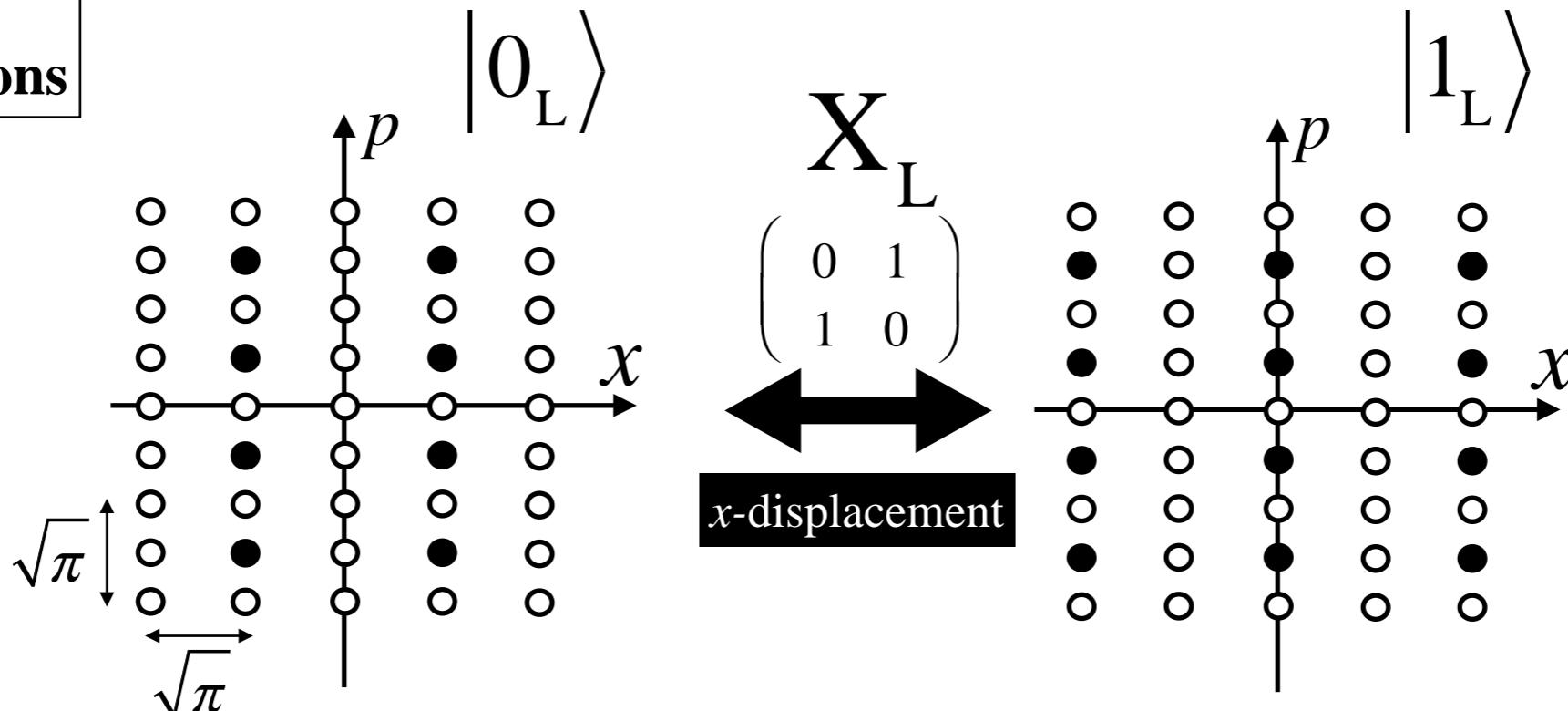
○ $+\infty$
● $-\infty$

Complex amplitude

$$\hat{a} = \hat{x} + i\hat{p}$$

$$[\hat{x}, \hat{p}] = \frac{i}{2}$$

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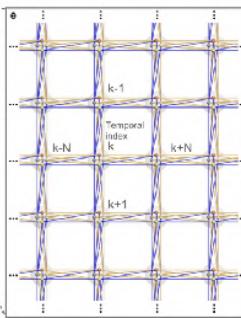
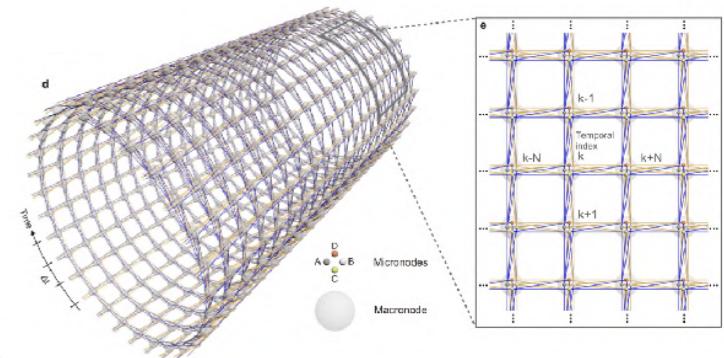
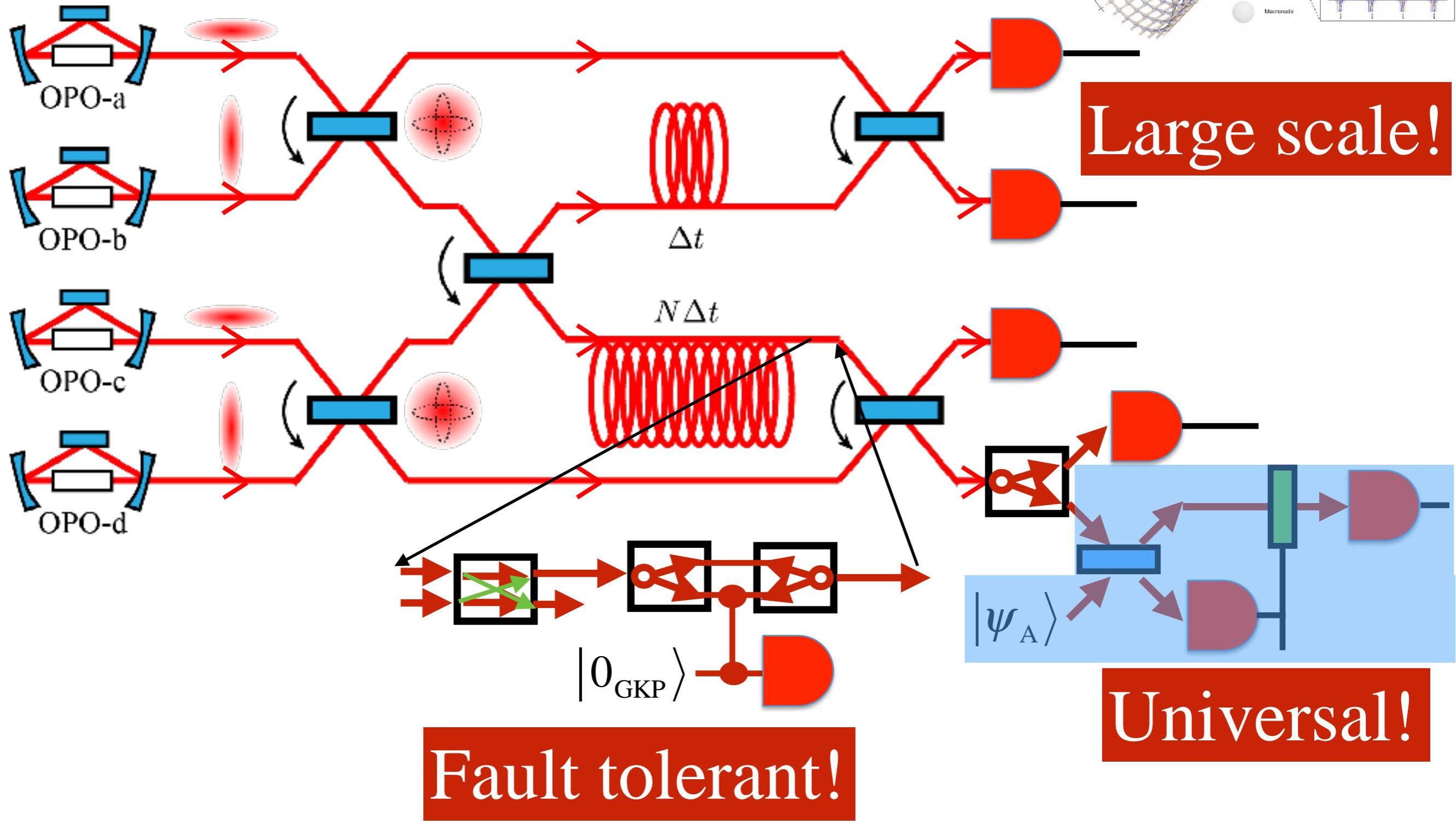
Clifford

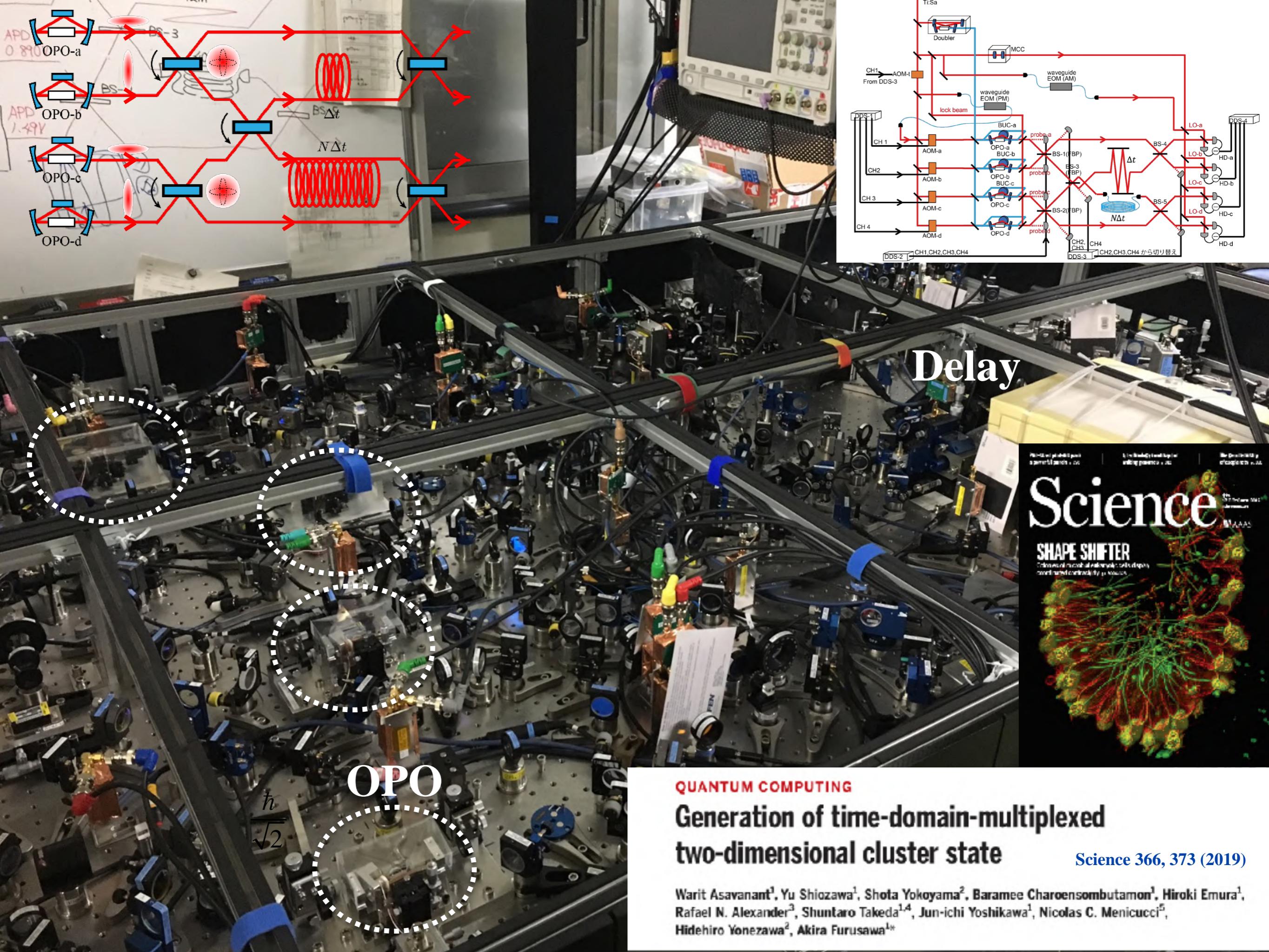
Gaussian

Goal



Homodyne measurement

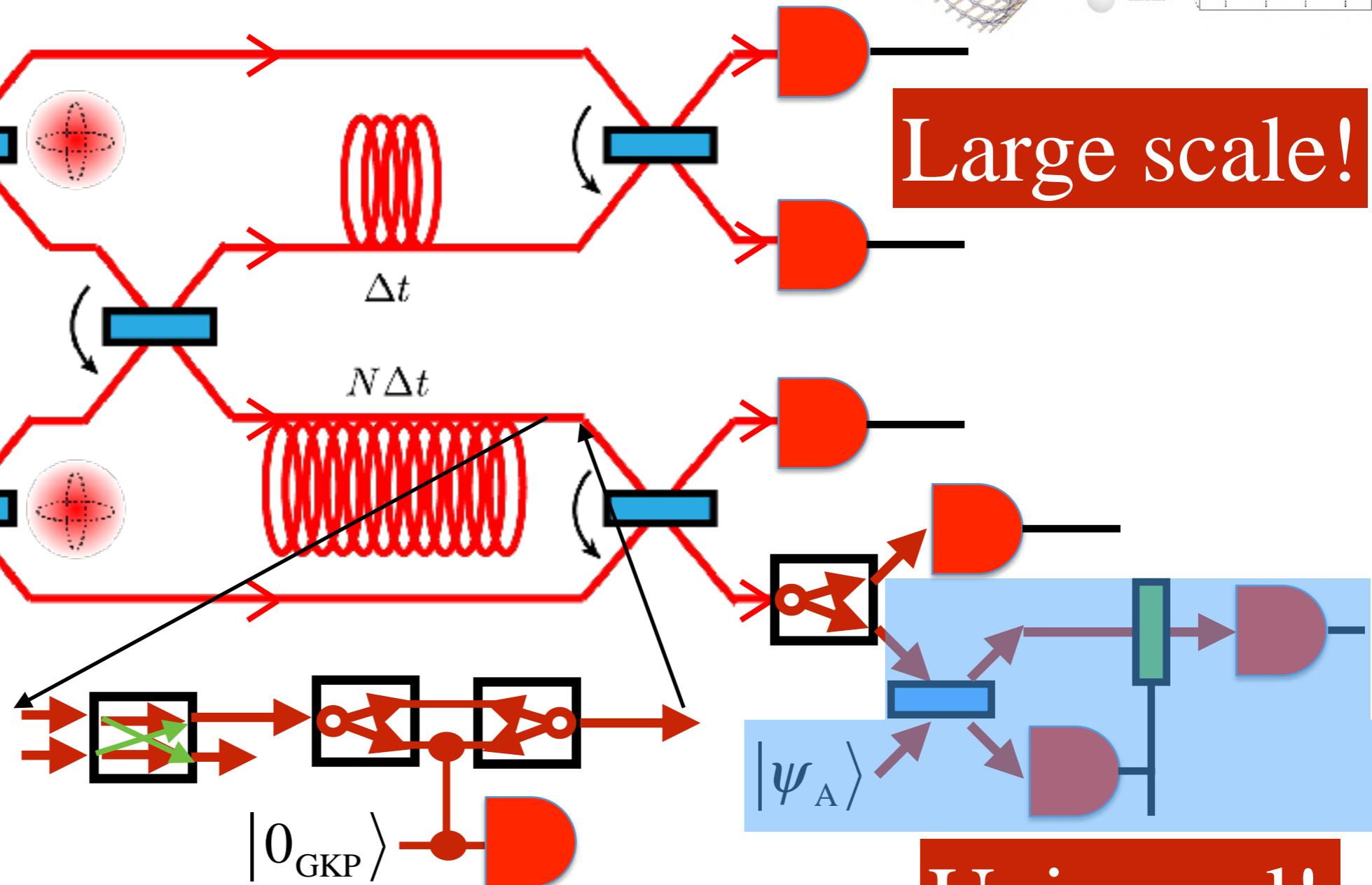
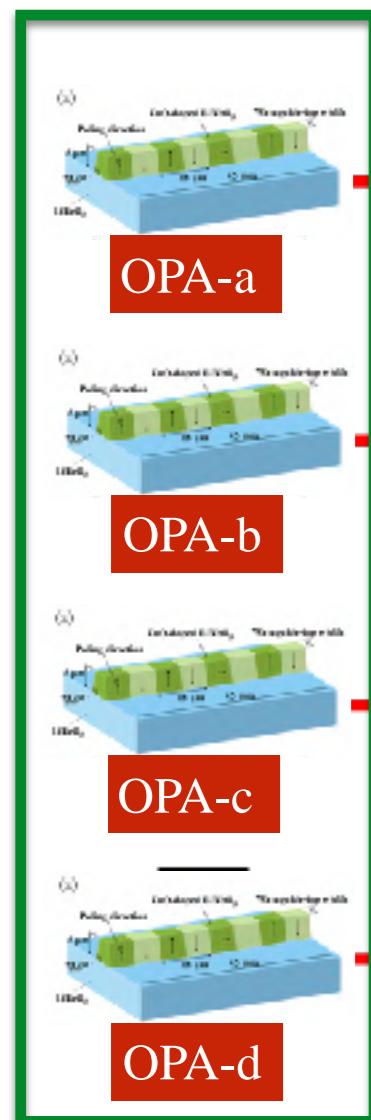
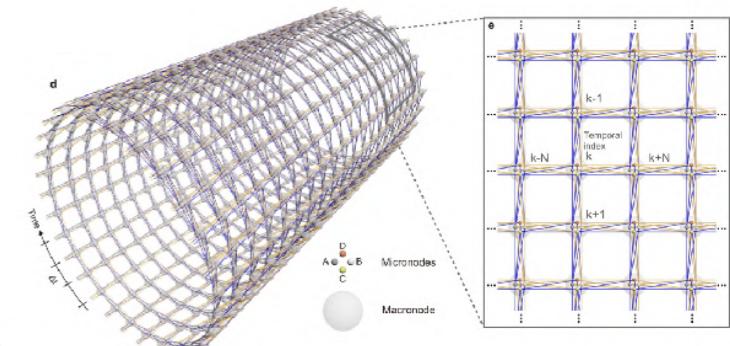




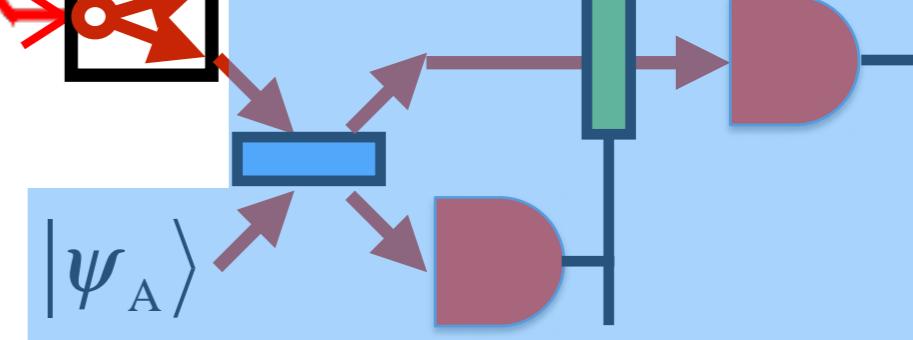
Goal



Homodyne measurement



Fault tolerant!



Universal!

OPA Squeezer

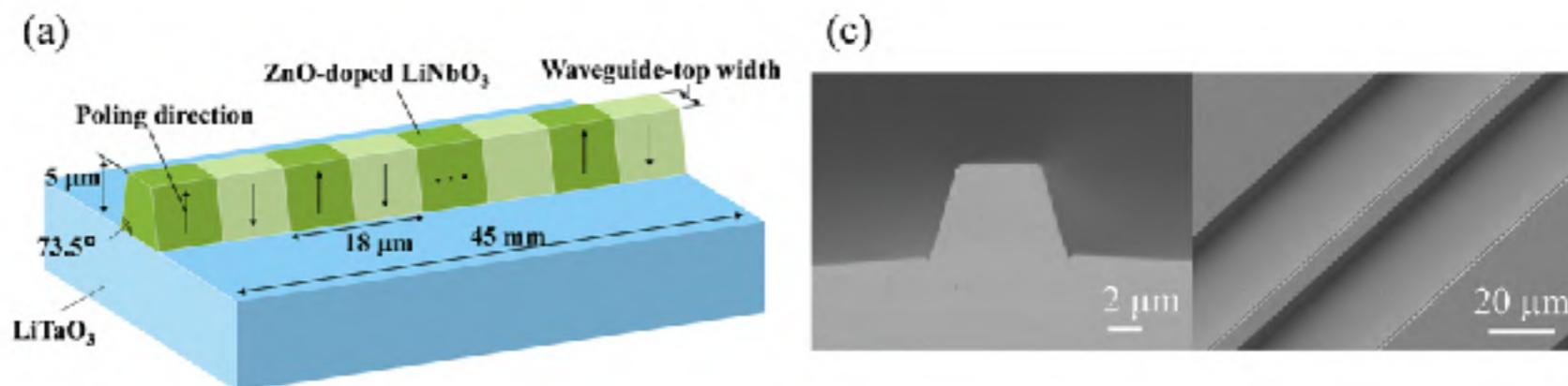
Continuous-wave 6-dB-squeezed light with 2.5-THz-bandwidth from single-mode PPLN waveguide



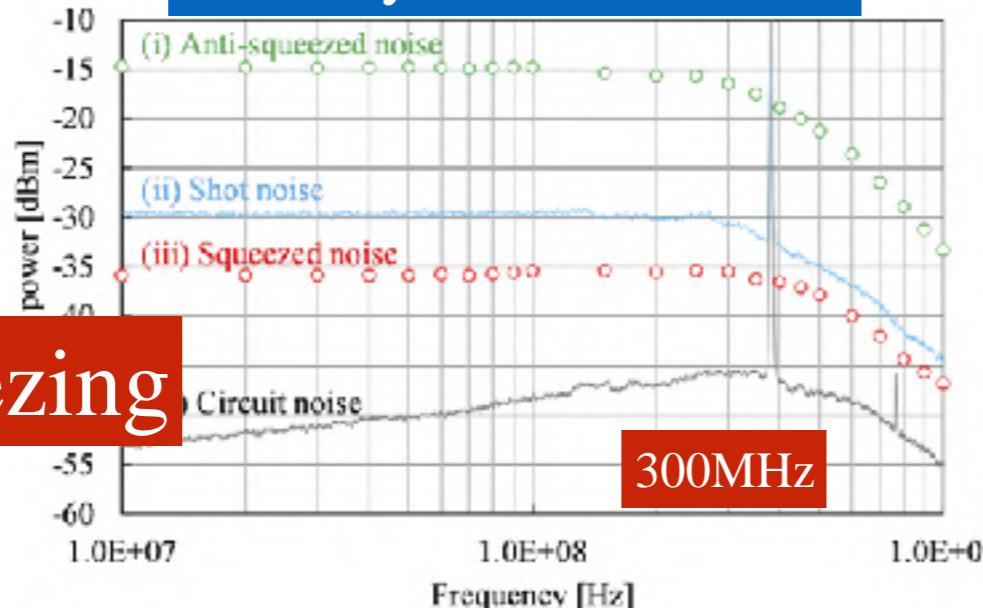
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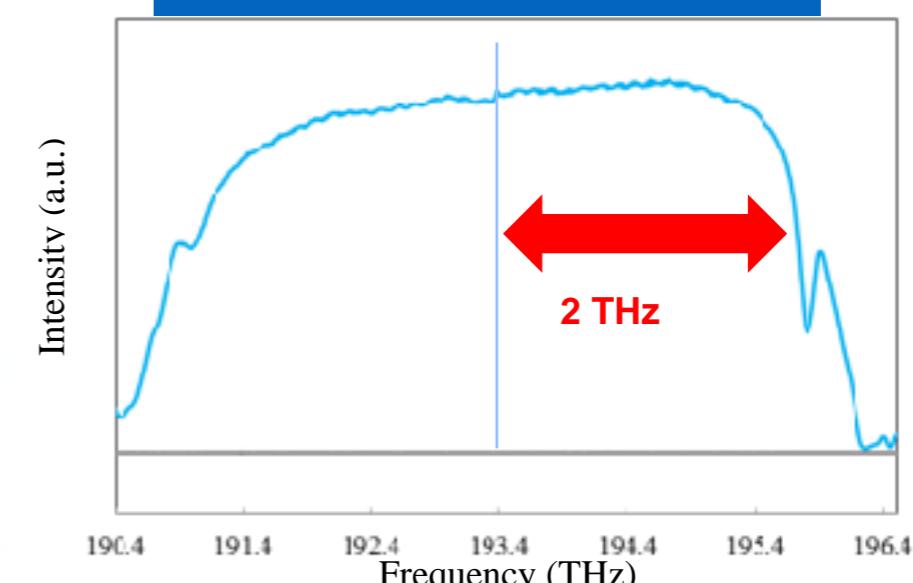


Homodyne measurement



6 dB squeezing

Parametric fluorescence



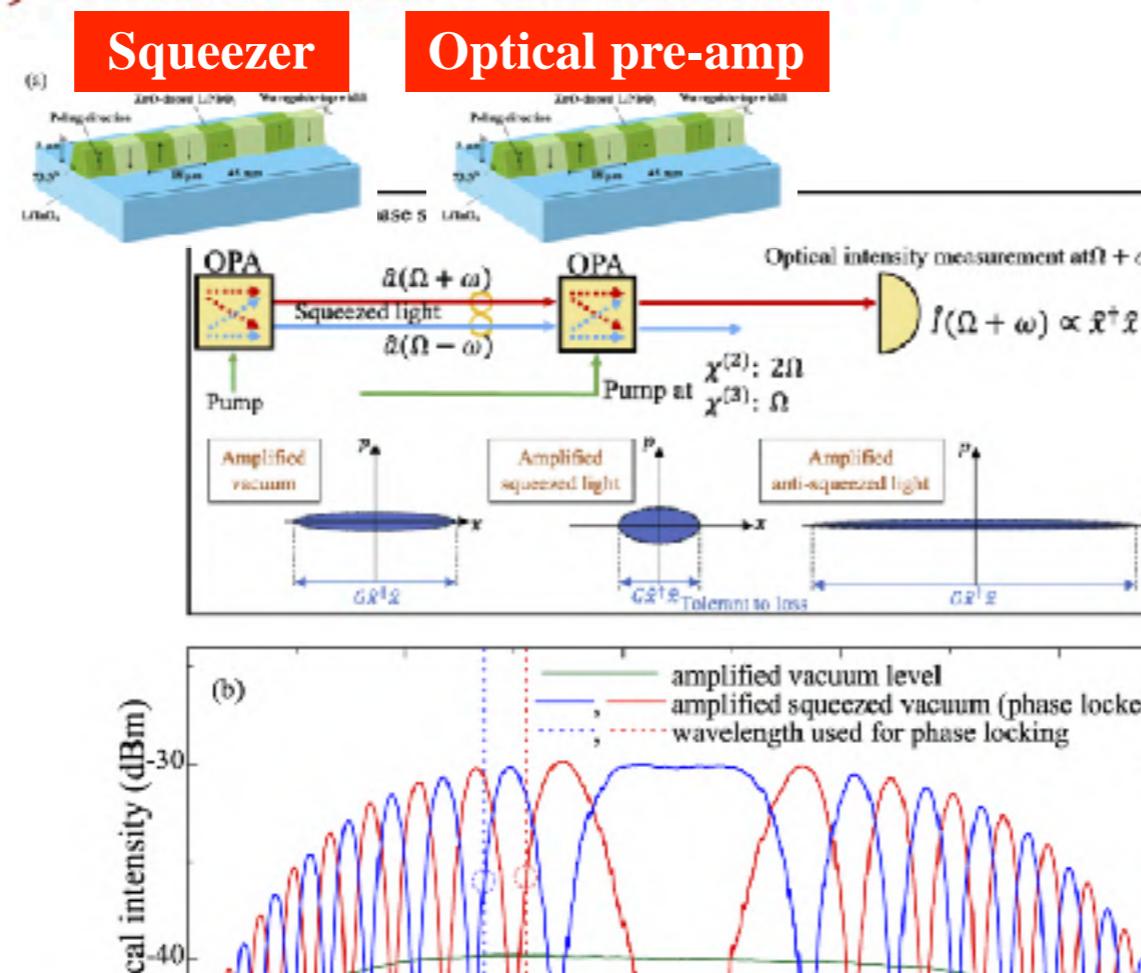
OPA

Squeezer

Optical
pre-amp

All-optical phase-sensitive detection for ultra-fast quantum computation

NAOTO TAKANASHI,¹  ASUKA INOUE,² TAKAHIRO KASHIWAZAKI,²
TAKUSHI KAZAMA,² KOJI ENBUTSU,² RYOICHI KASAHARA,²
TAKESHI UMEKI,² AND AKIRA FURUSAWA^{1,*}

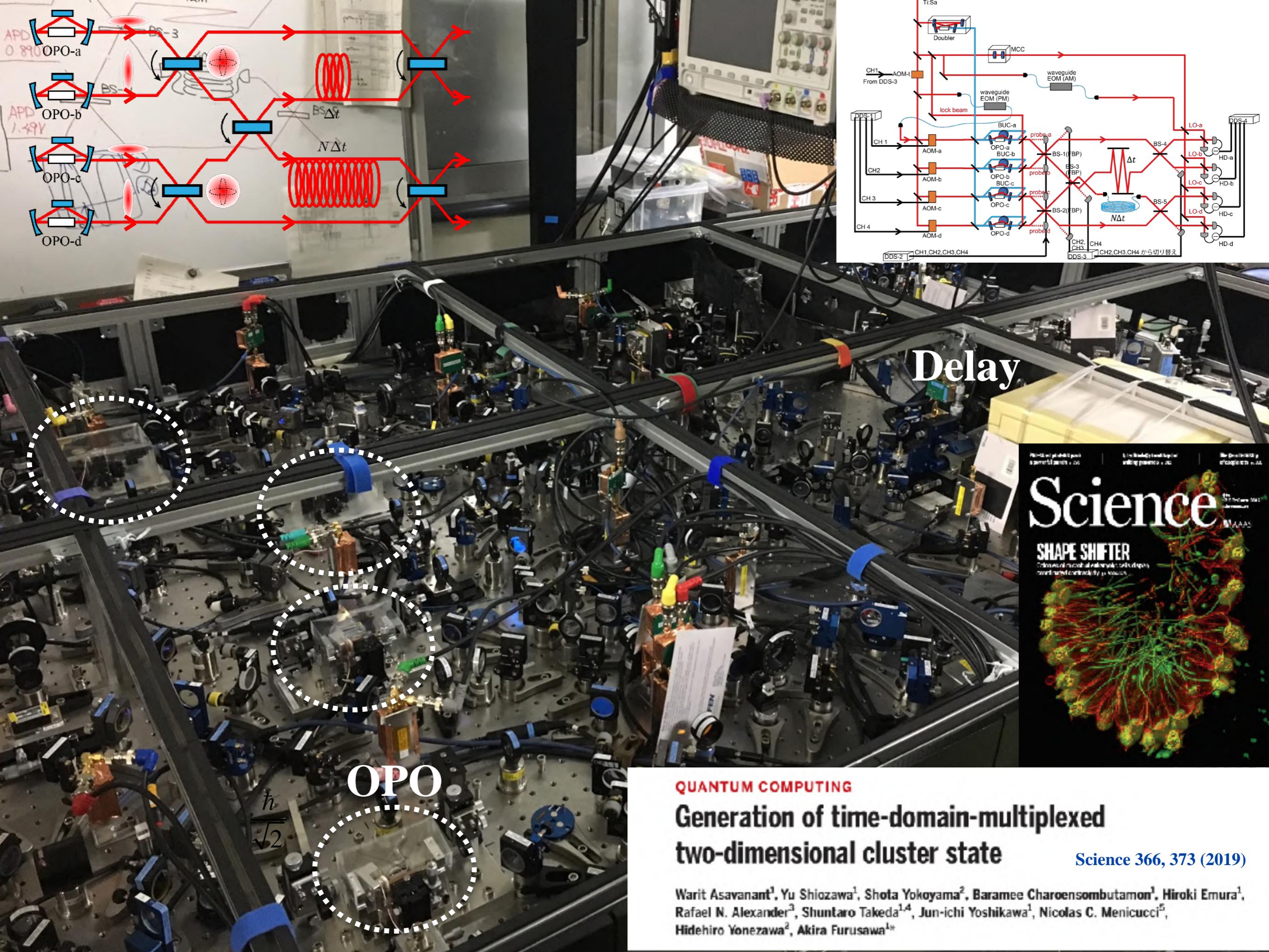


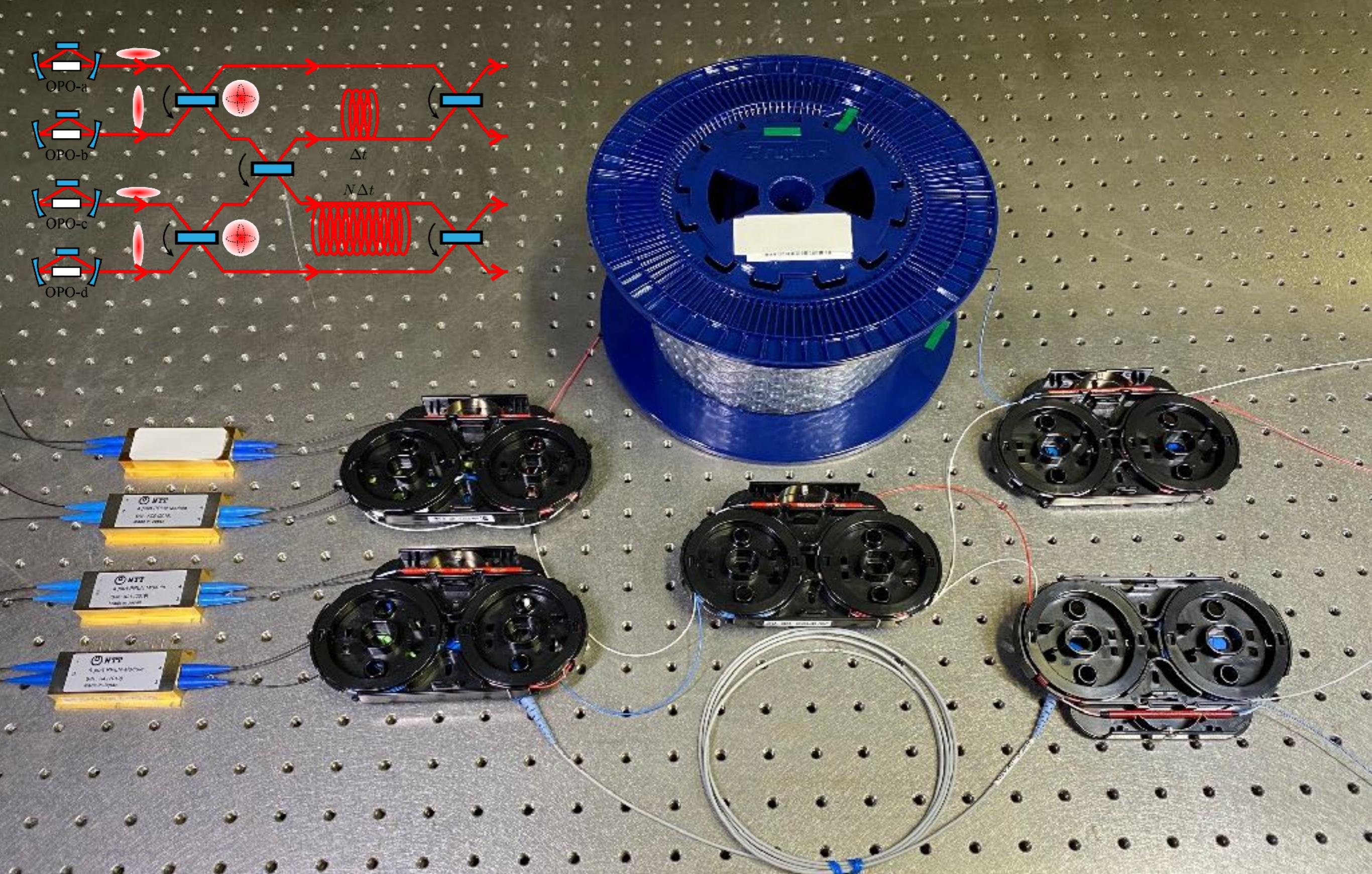
3 dB squeezing

6 dB squeezing

1 THz bandwidth

6 THz bandwidth





Large-scale optical quantum computer!!