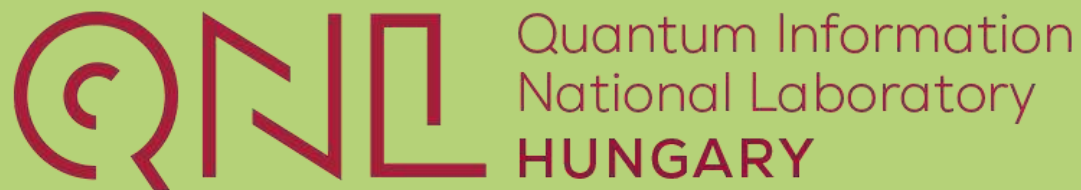


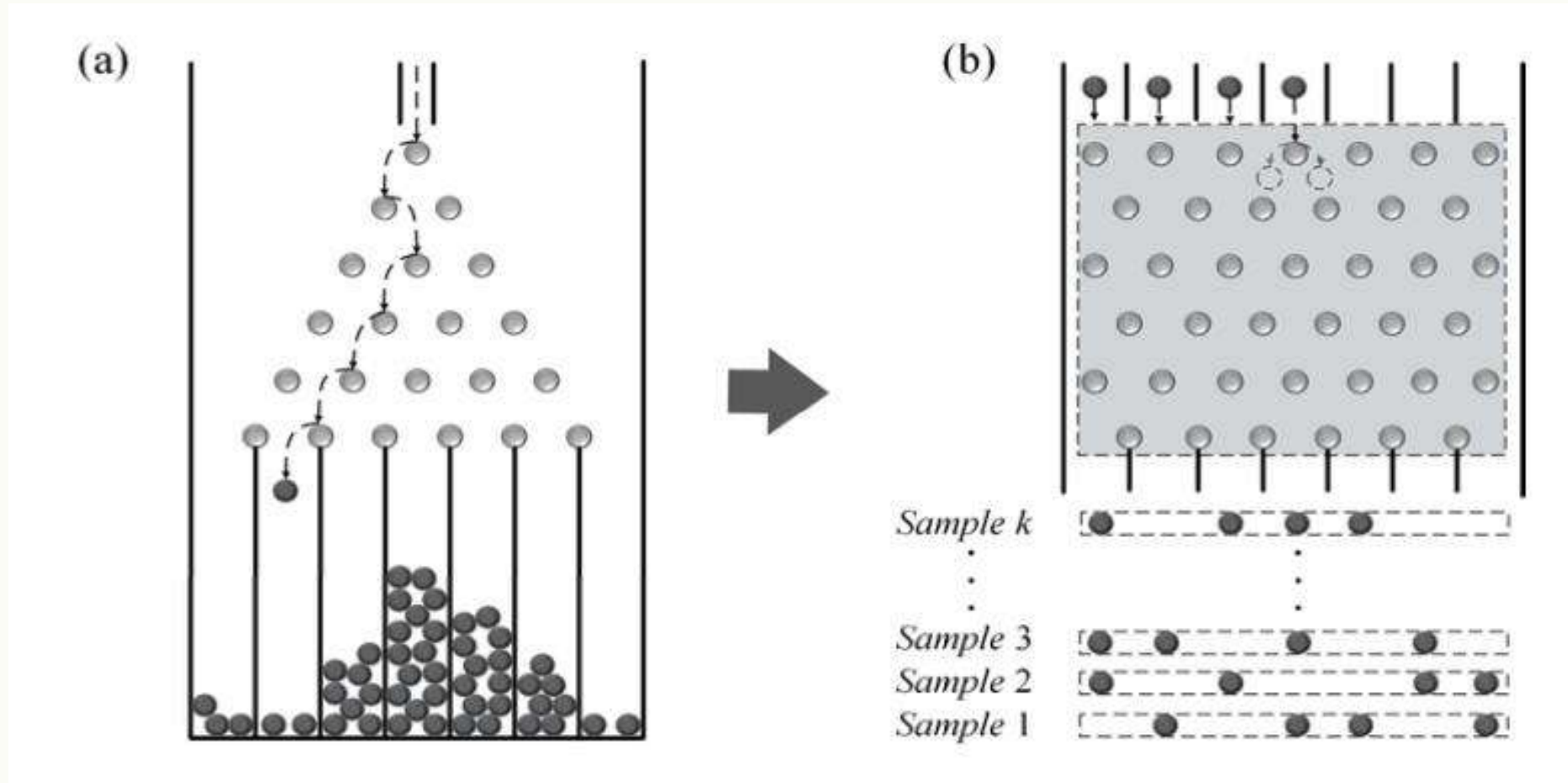
# WP4 OPTIKAI KVANTUMINFORMATIKAI LABORATÓRIUM KIÉPÍTÉSE

VATTAY GÁBOR (ELTE TTK FI)



AZ NKFI ALAPBÓL  
MEGVALÓSULÓ  
PROJEKT

# Kvantum Galton deszka



100  
output modes

Kvantum fölény (2020 December) “Jiuzhang”

Input optics

Phase Locking

# Boson Sampling

*PhysComp96*  
Full paper  
Draft, 13 May 1996

## Permanent Uncertainty: On the quantum evaluation of the determinant and the permanent of a matrix

Lidror Troyansky\* and Naftali Tishby  
Institute of Computer Science and Center for Neural Computation  
The Hebrew University  
Jerusalem 91904, Israel

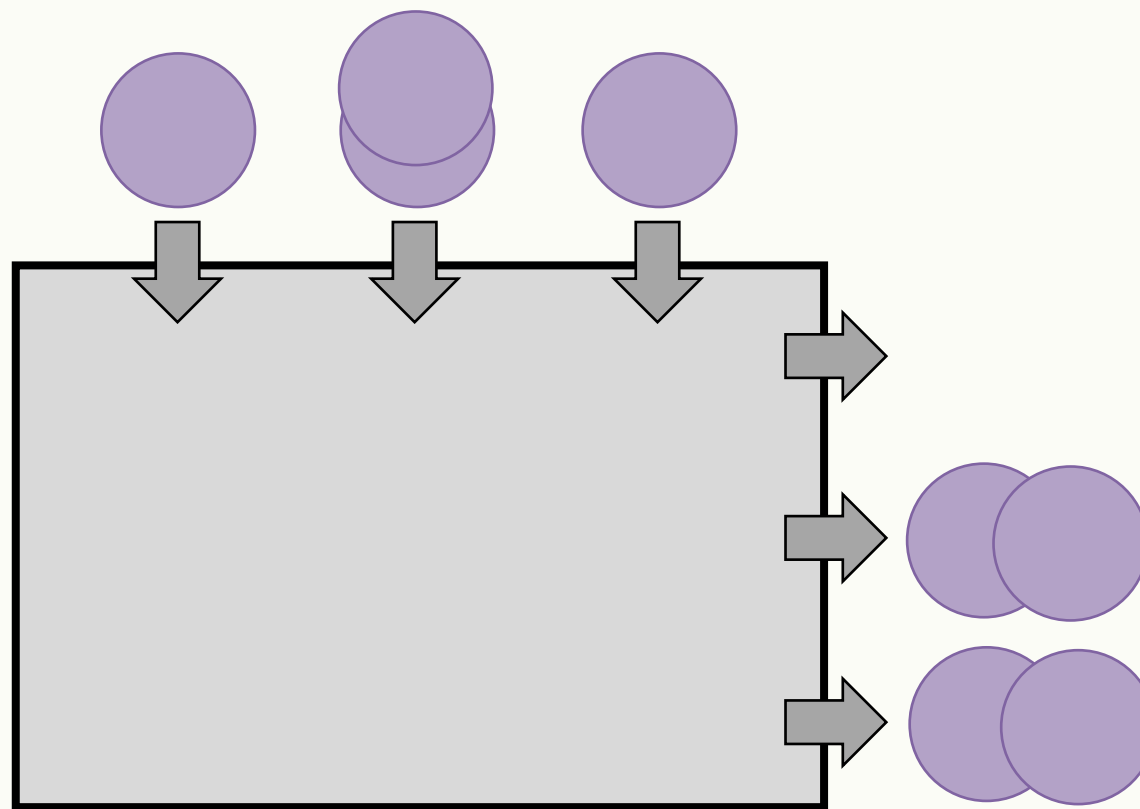
Electronic Colloquium on Computational Complexity, Report No. 170 (2010)



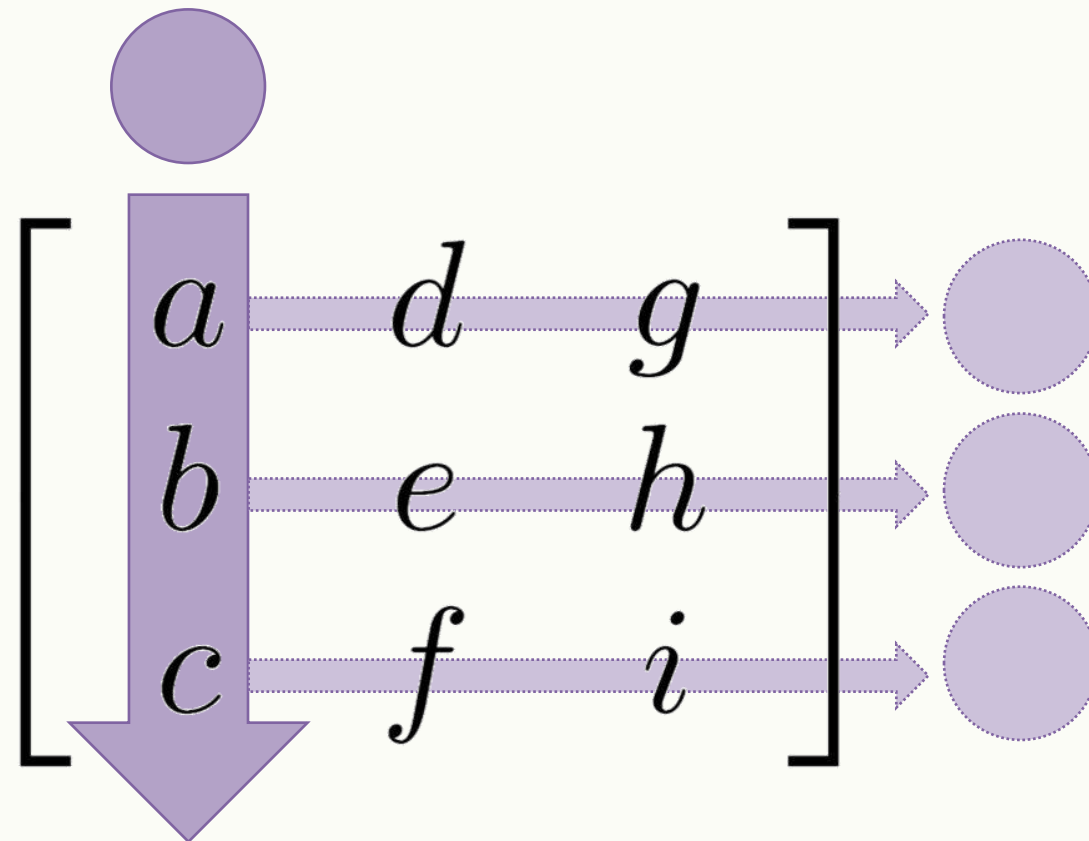
## The Computational Complexity of Linear Optics

Scott Aaronson\*      Alex Arkhipov†

# Labdák és rések (Klasszikus)

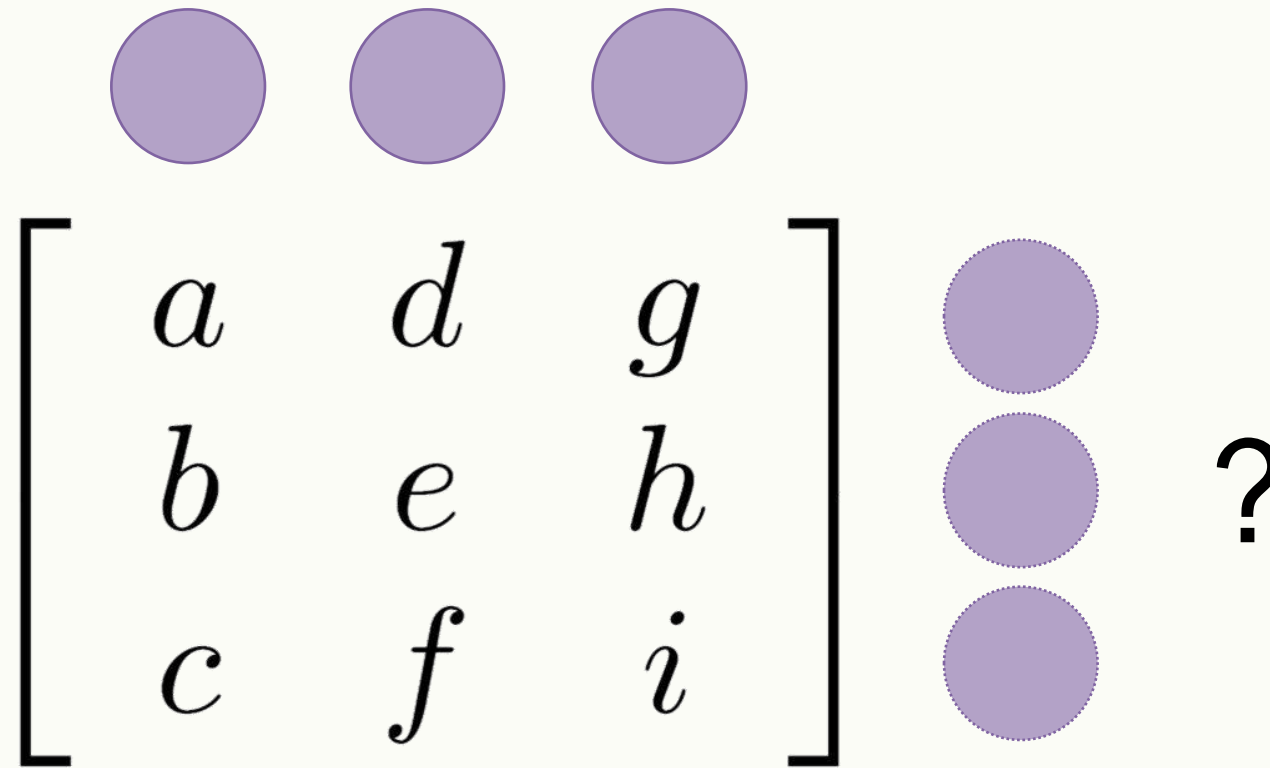


# Átmeneti valószínűség mátrix



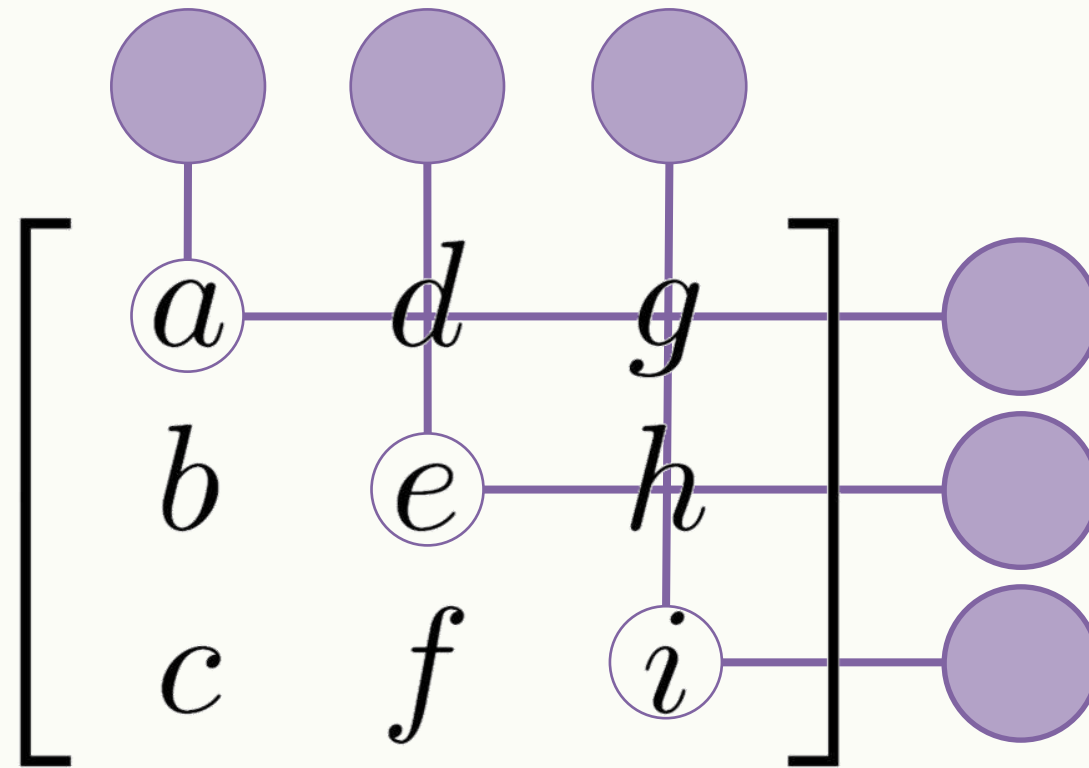
$$a, b, c \geq 0$$
$$a + b + c = 1$$

# Átmeneti valószínűség



Pr [one per slot] =

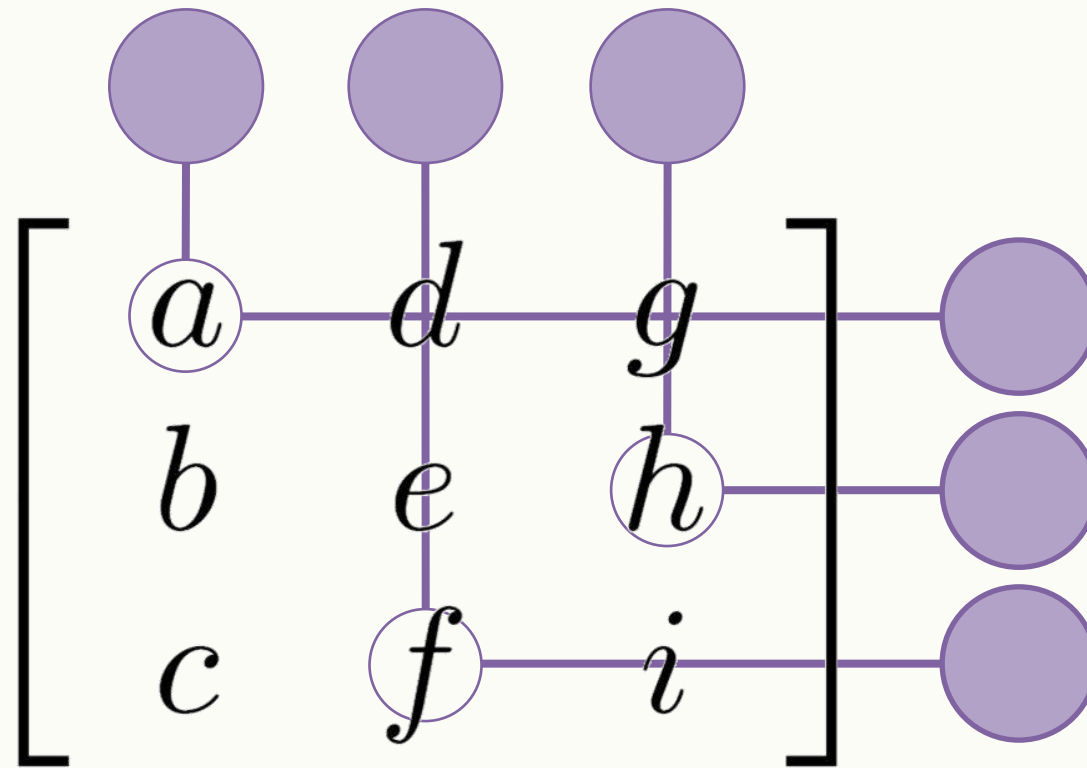
# Átmeneti valószínűség



$$\text{Pr [one per slot]} = aei +$$

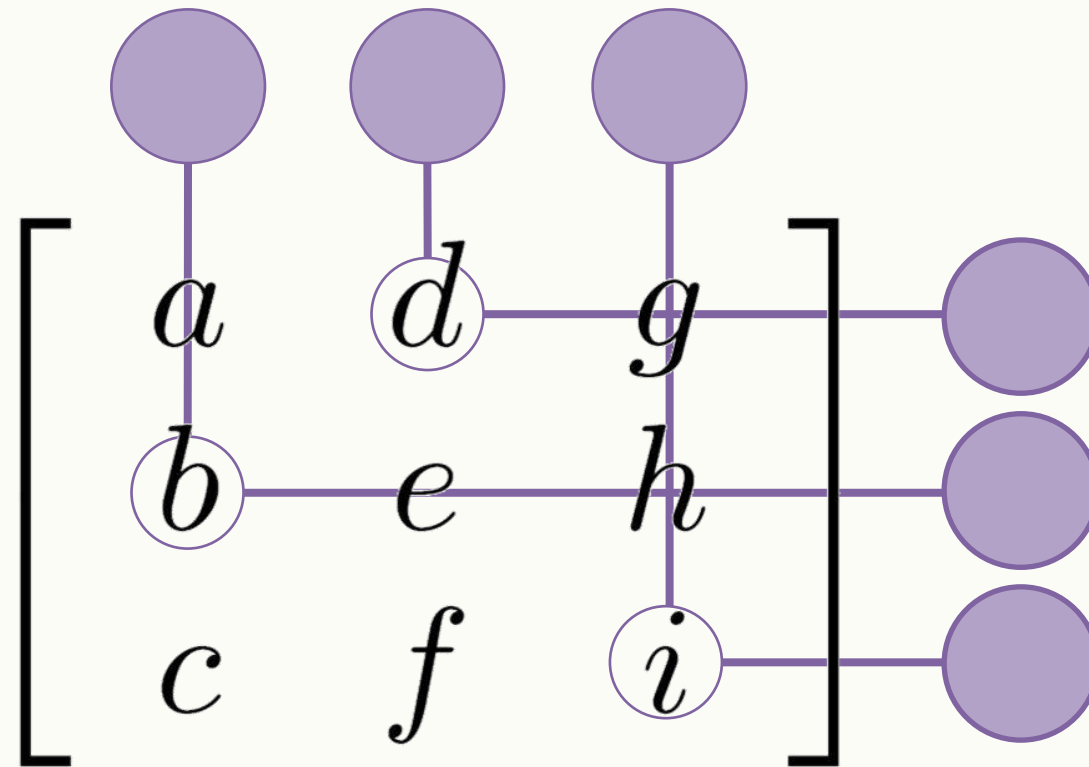


# Átmeneti valószínűség



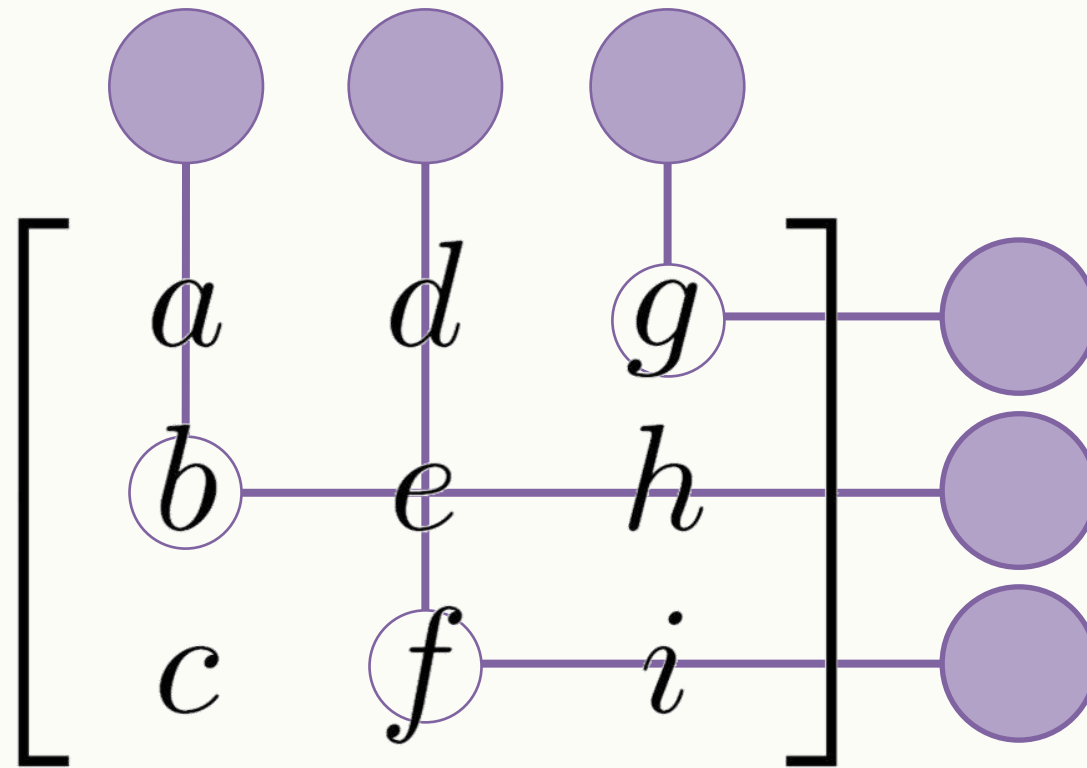
$$\text{Pr [one per slot]} = aei + afh$$

# Átmeneti valószínűség



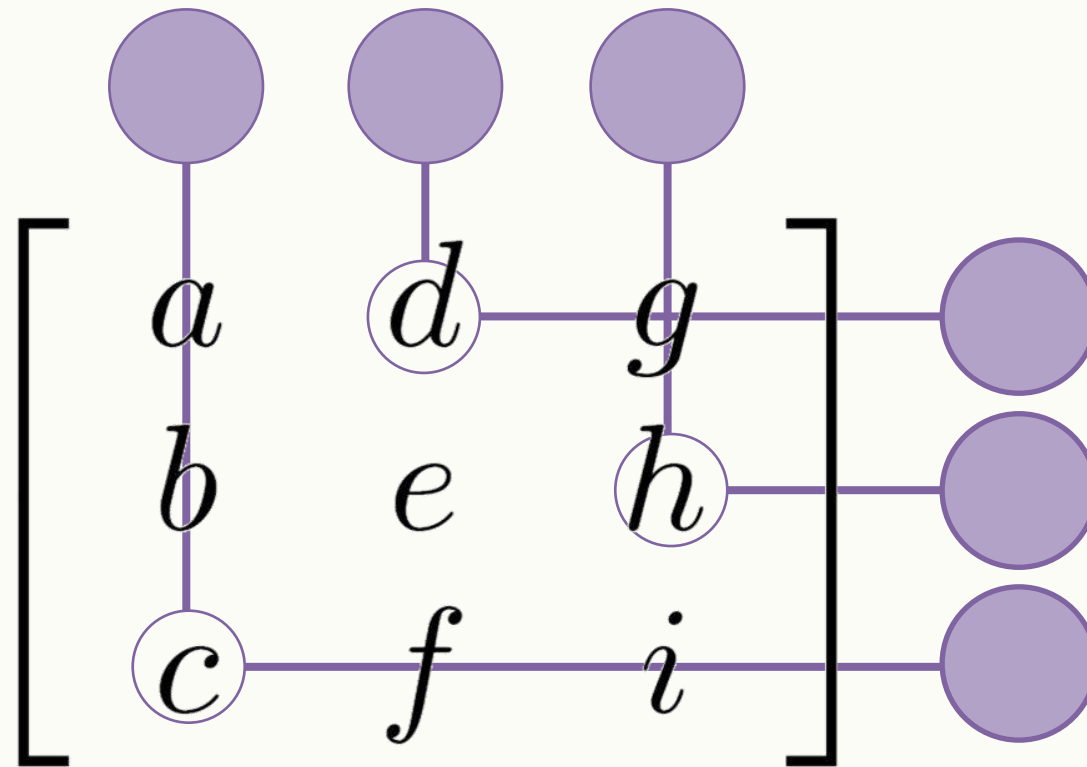
$$\text{Pr [one per slot]} = aei + afh + bdi$$

# Átmeneti valószínűség



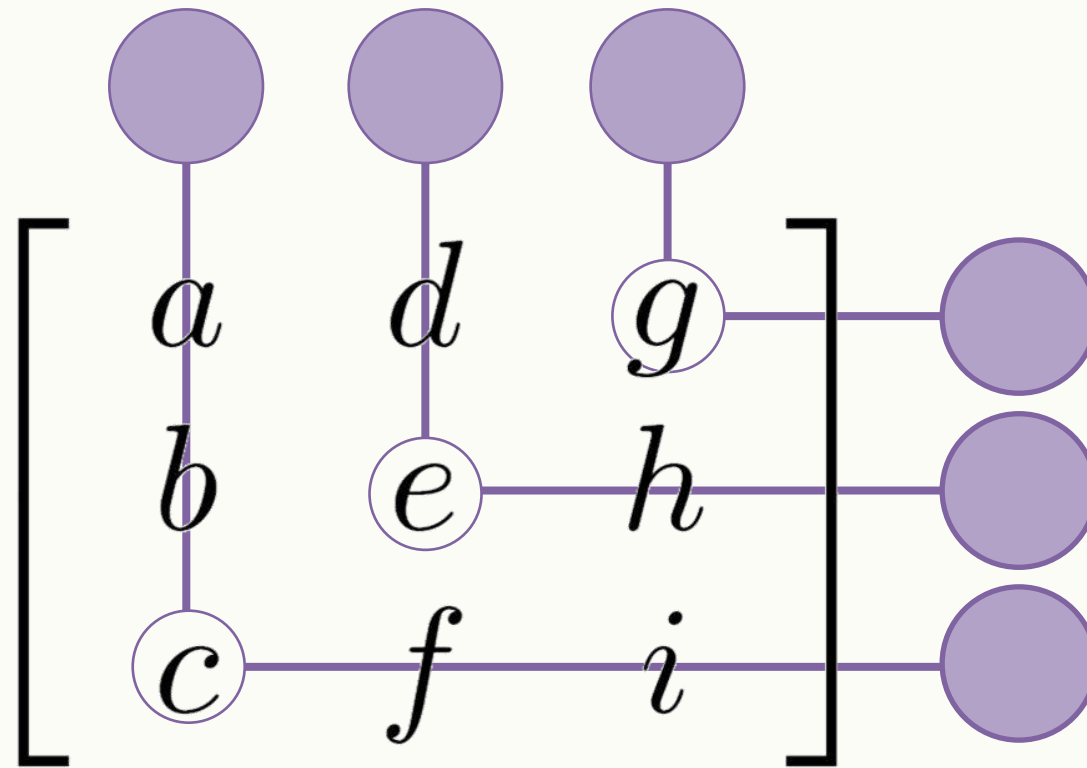
$$\text{Pr [one per slot]} = aei + afh + bdi + bfg$$

# Átmeneti valószínűség



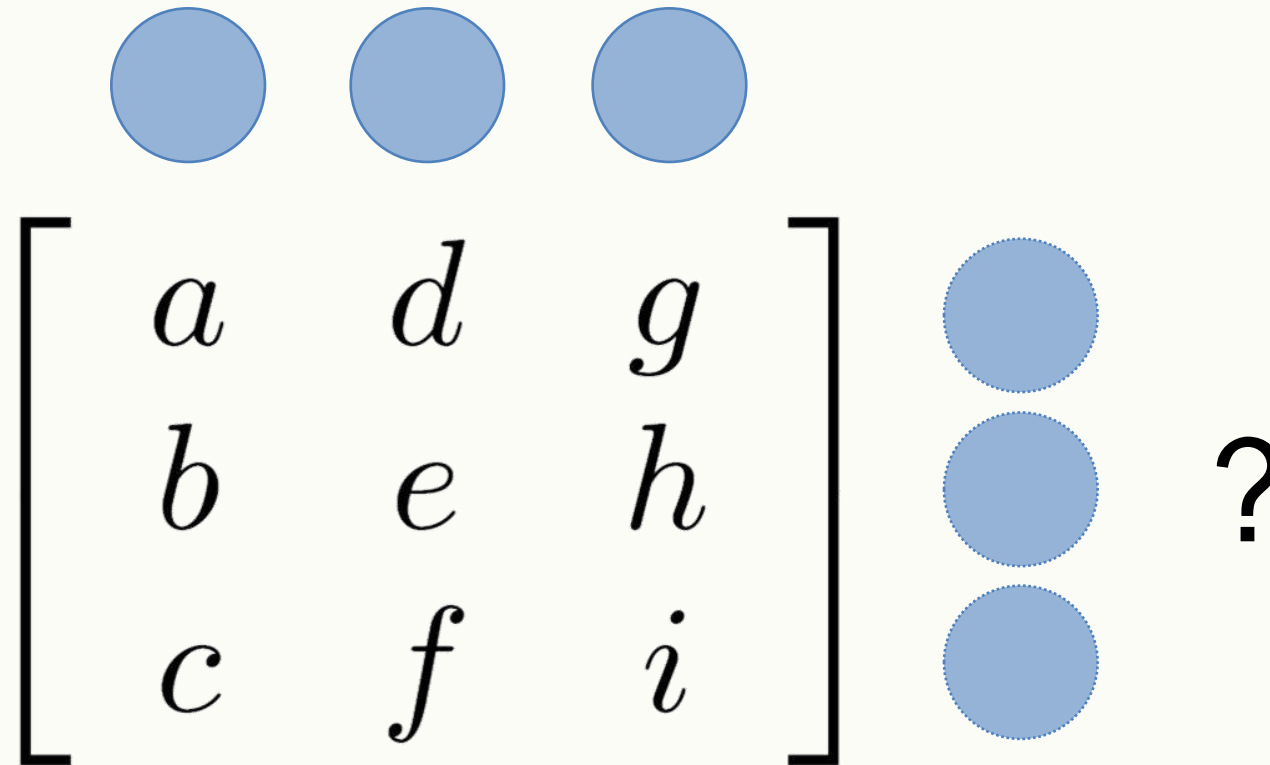
$$\text{Pr [one per slot]} = aei + afh + bdi + bfg + cdh$$

# Átmeneti valószínűség

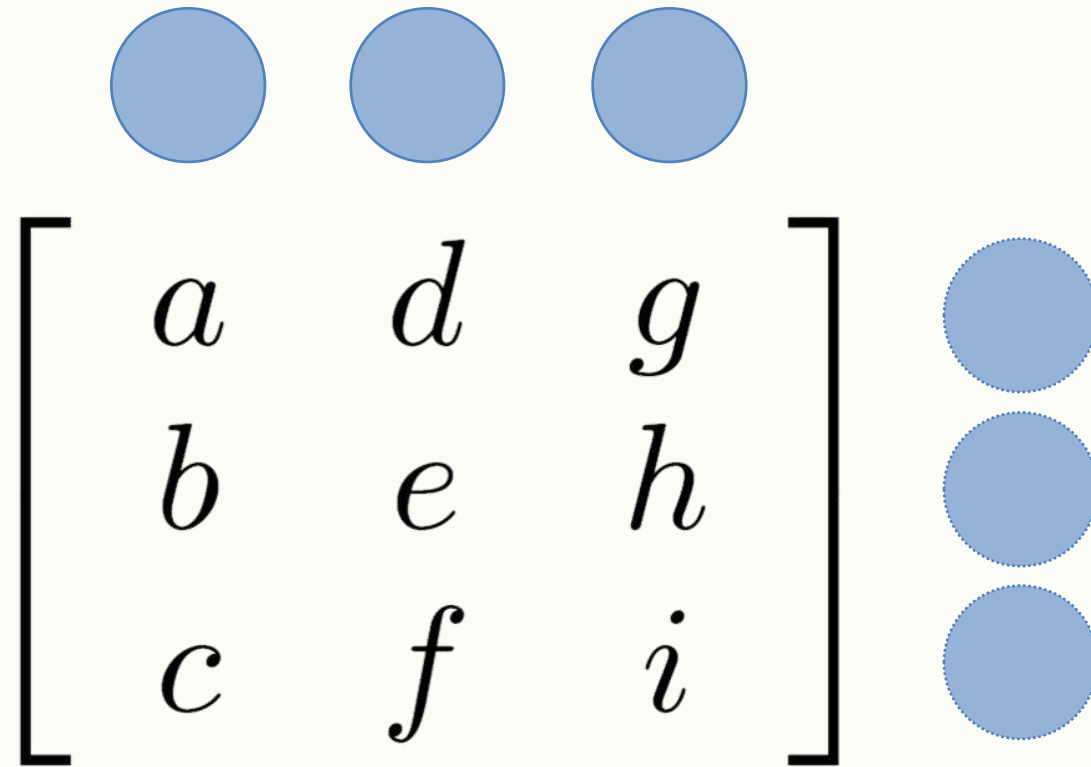


$$\begin{aligned} \text{Pr [one per slot]} &= aei + afh + bdi + bfg + cdh + ceg \\ &= \text{perm}(M) \end{aligned}$$

# Kvantummechanika: Átmeneti amplitudók



# Azonos Bozonok (pl. fotonok)

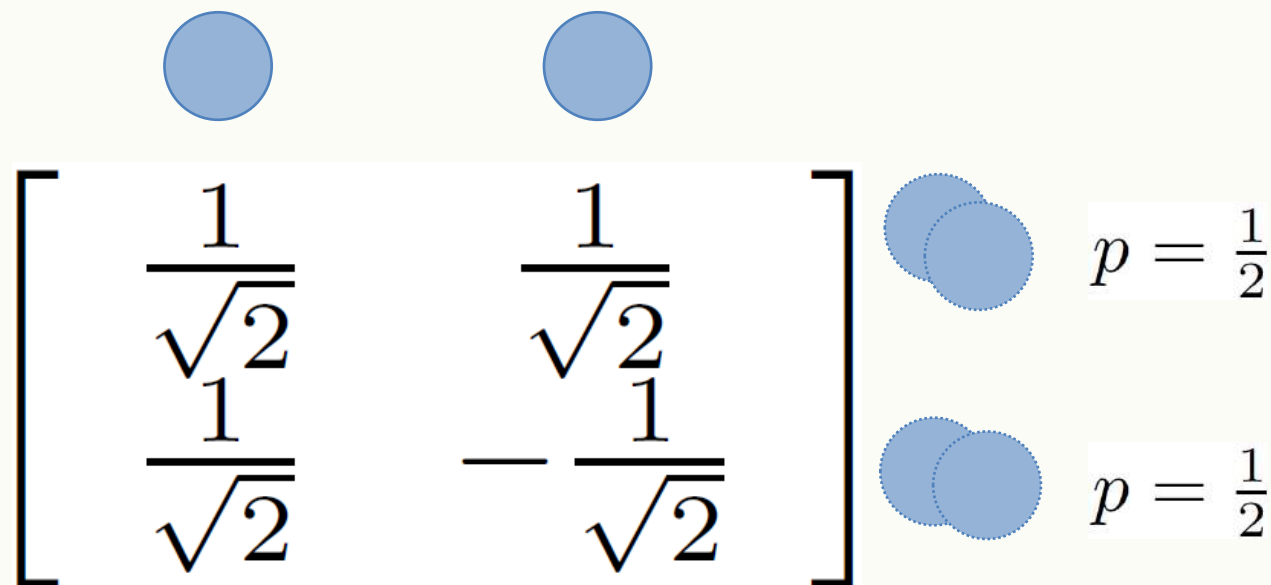


$$\text{Am [one per slot]} = aei + afh + bdi + bfg + cdh + ceg$$

$$= \text{perm}(M)$$

$$\text{Pr [one per slot]} = |\text{perm}(M)|^2$$

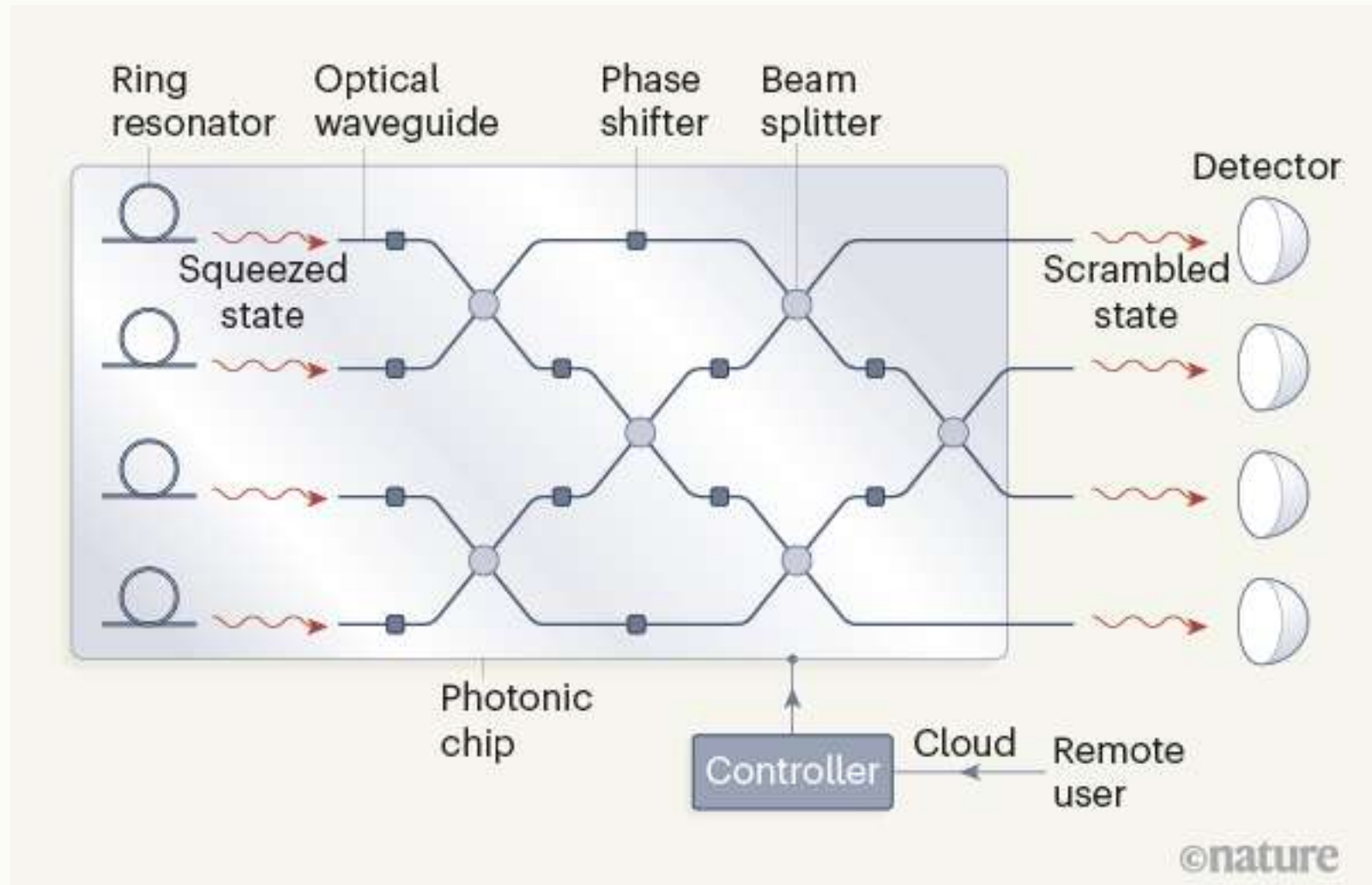
# Példa: Hadamard + Bozonok



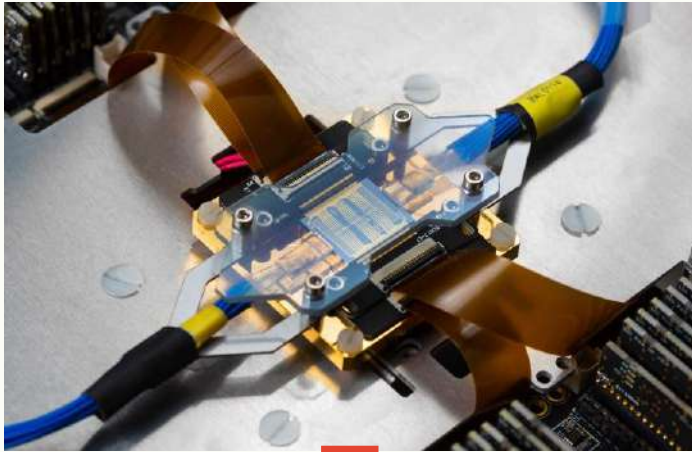
$$\text{perm}(M) = 0$$



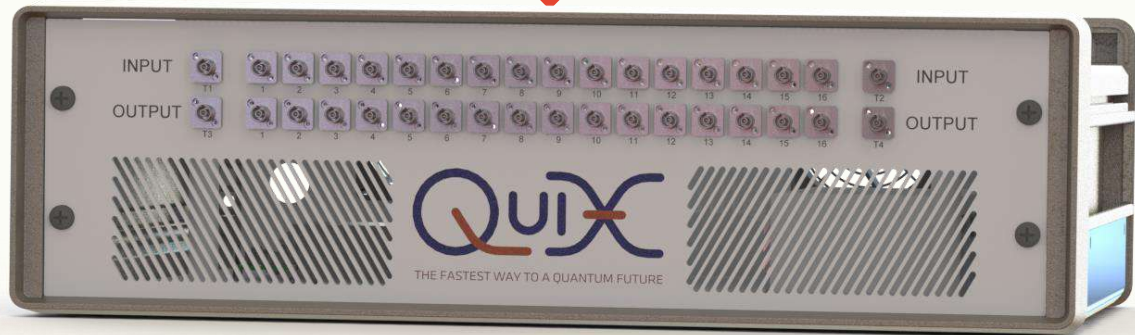
# Fotonikus chip



# QuiX hardware

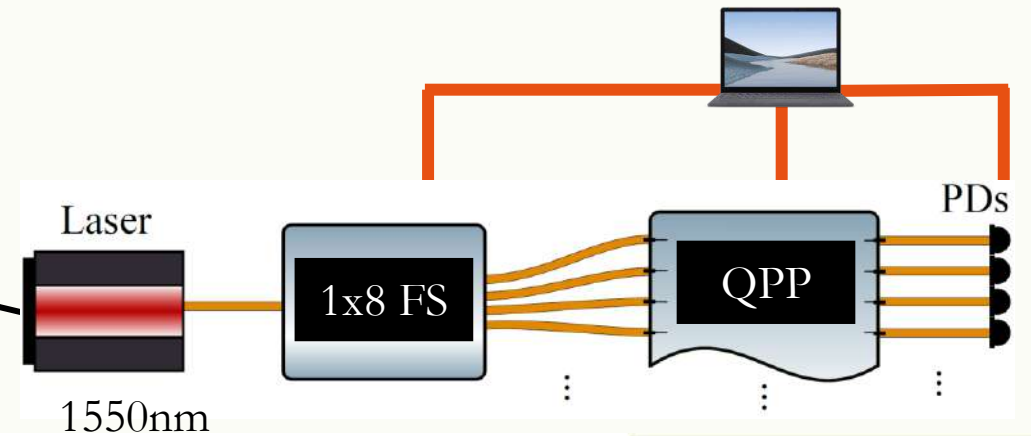


Photonic processor:  
8-modes @ 1550 nm



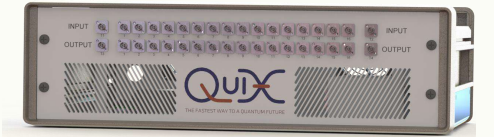
Control Box

Laptop + characterization equipment:  
Dedicated control software



# Control box

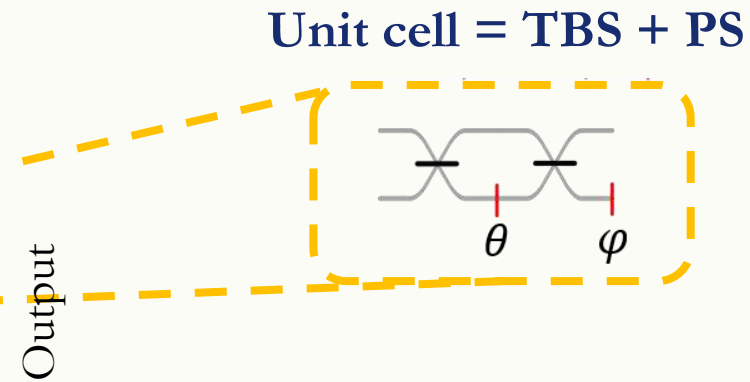
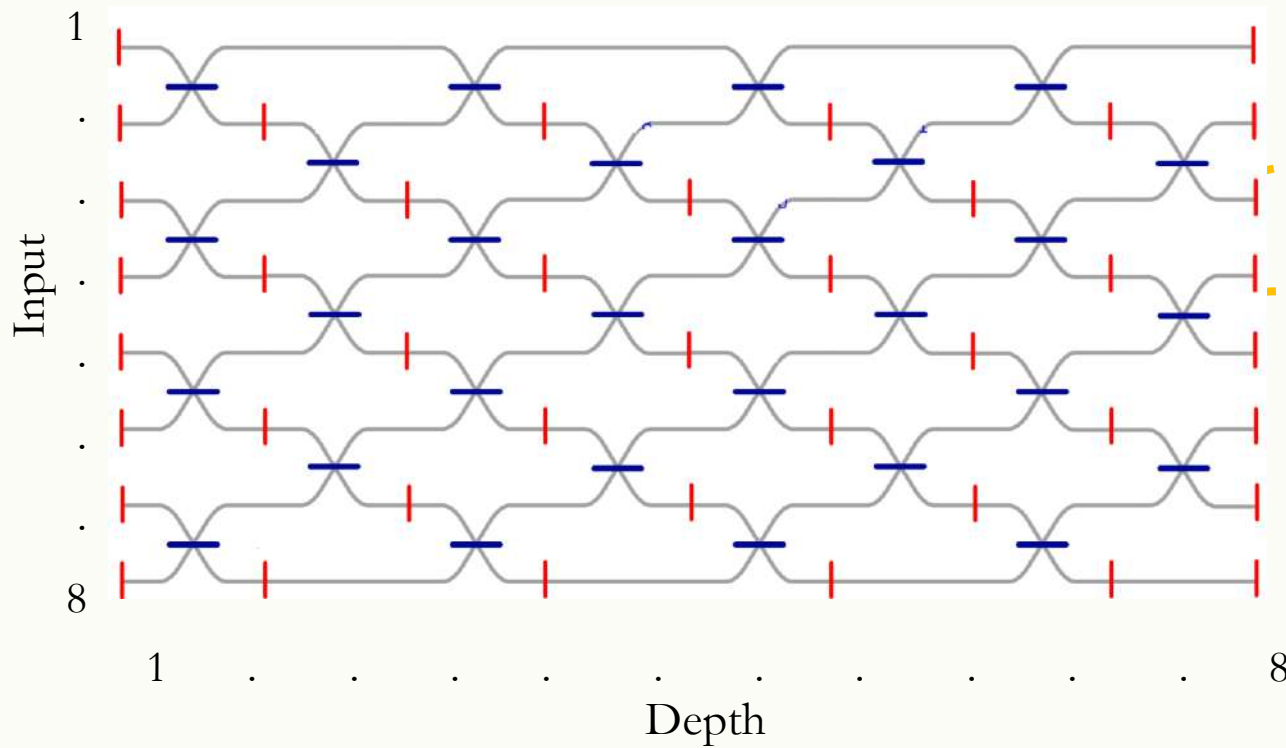
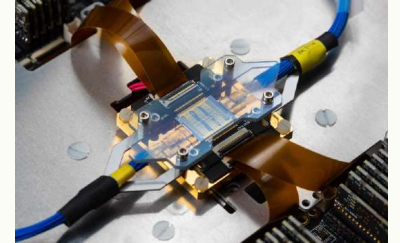
Dedicated control hardware



1. Drivers for independent control of thermo-optic actuators
2. TEC control
3. Water cooling
4. Power supply
5. Optical connections
6. 8-mode processor
7. Measurement equipment: source, switch, detectors

# 8-mode processor

Square topology, 28 unit cells, 56 tuneable elements

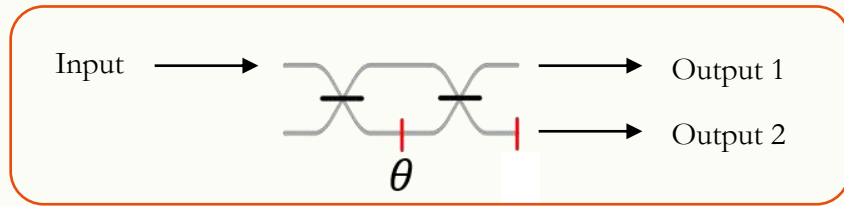


$$t = ie^{-\frac{i\theta}{2}} \begin{pmatrix} \sin \frac{\theta}{2} & -\cos \frac{\theta}{2} \\ -\cos \frac{\theta}{2} e^{-i\varphi} & -\sin \frac{\theta}{2} e^{-i\varphi} \end{pmatrix}$$

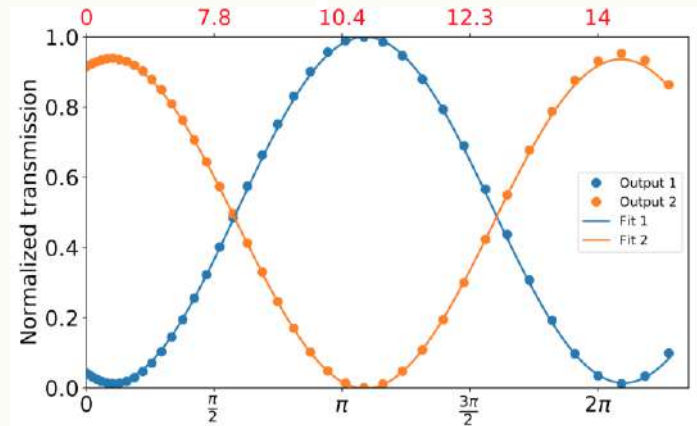
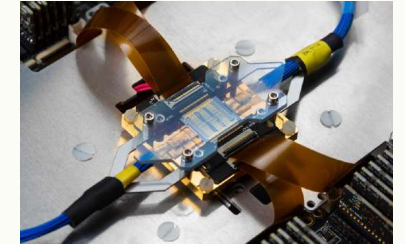
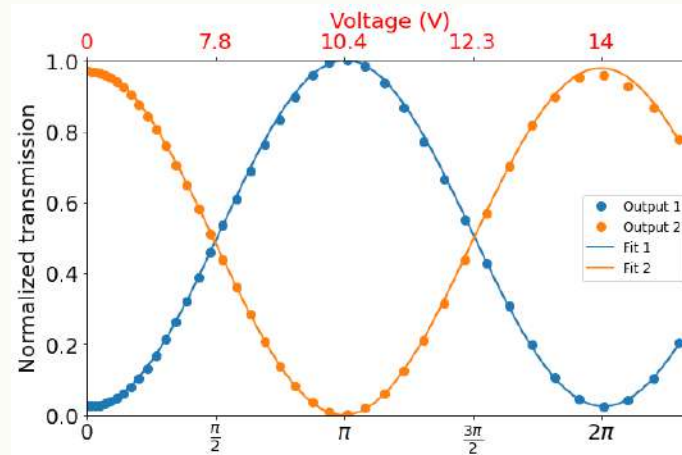
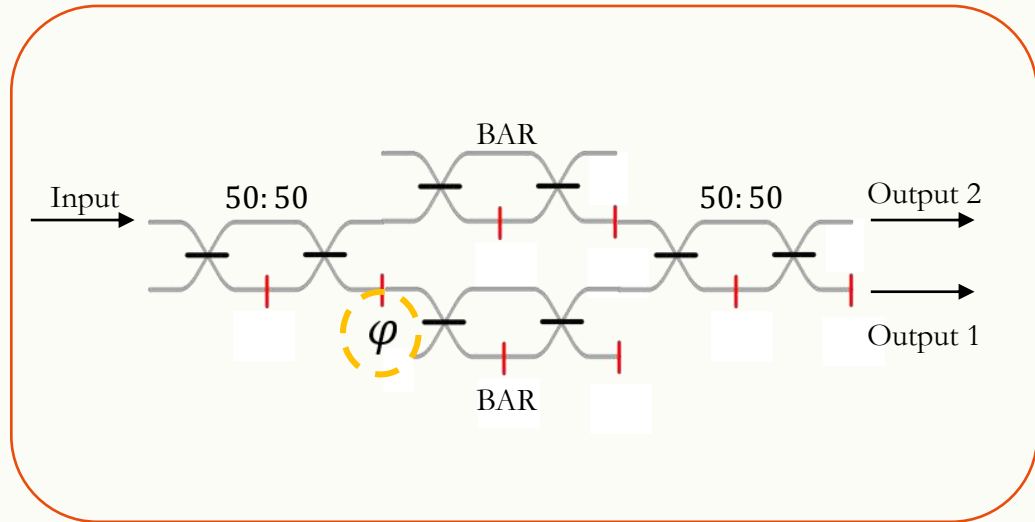
# 8-mode processor

Fully characterized

TBS

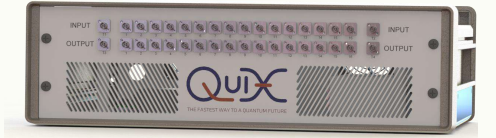


PS

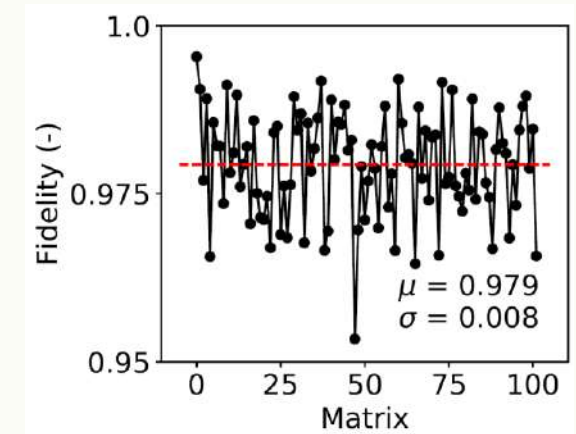
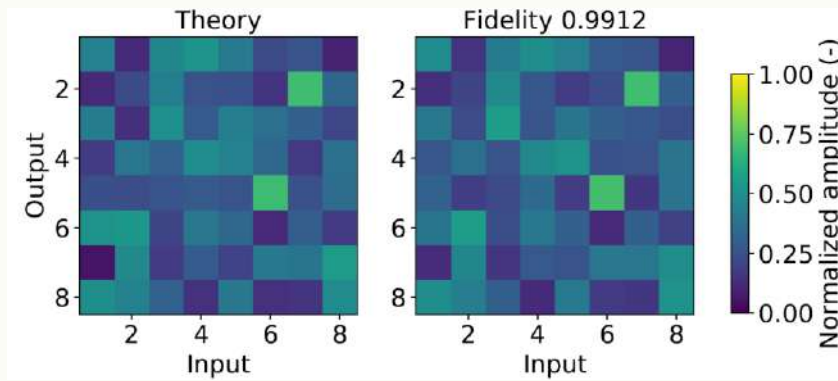
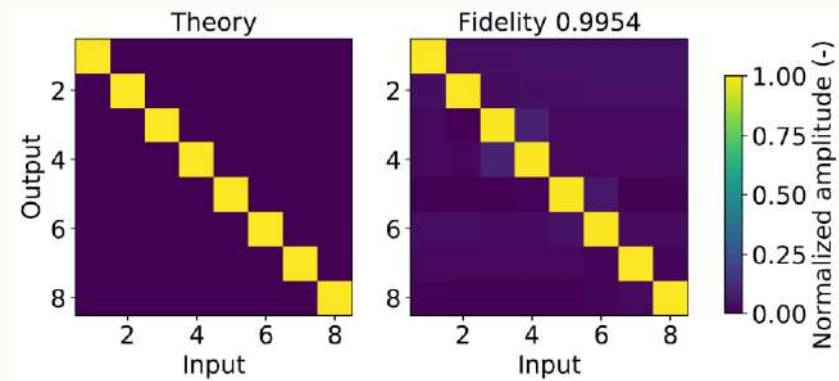
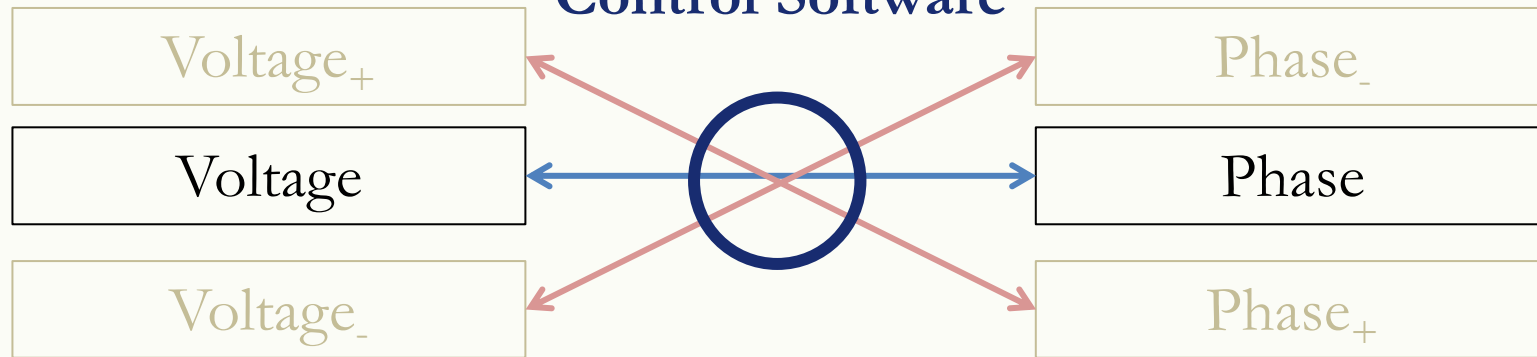


# QuiX software

Dedicated control software



## QuiX Control Software



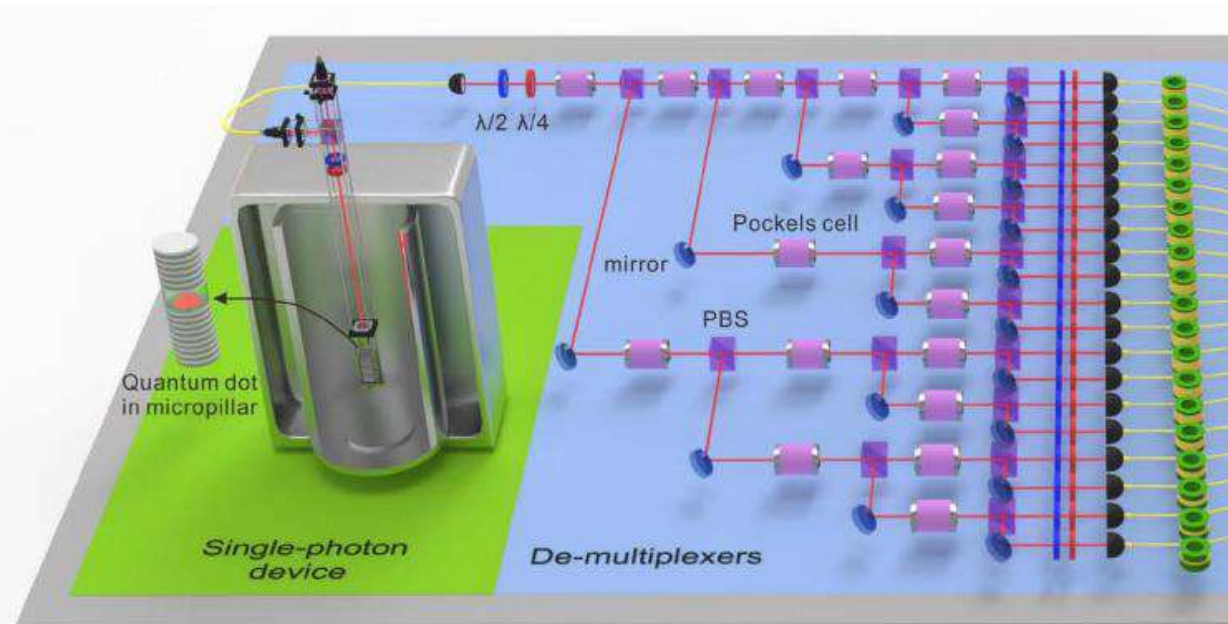
# Next generation of Plug & Play SPS system (available soon)



# Egyfotonforrás

## De-multiplexing :

1 highly efficient SP source + routing of  
temporally separated photons in different  
spatial modes





# eDelight

## Key Features:



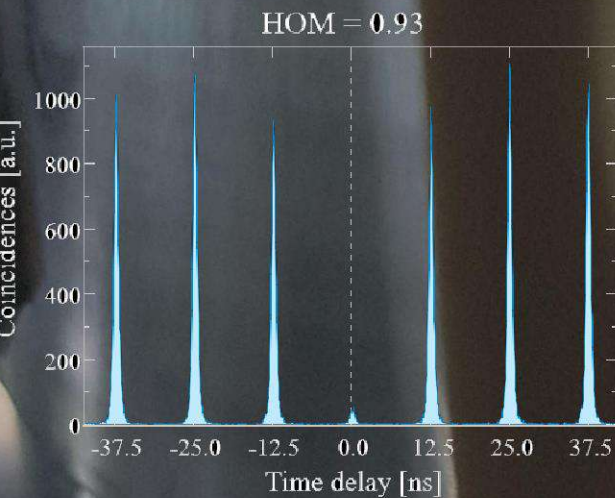
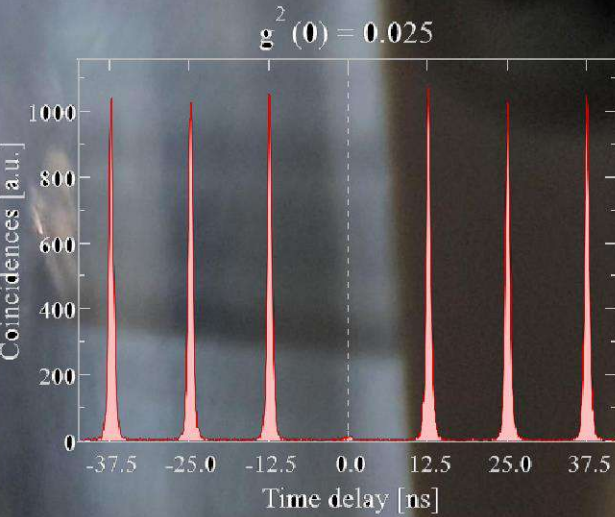
**SP purity**  
**> 97 %**



**Indistinguishability**  
**HOM**  
**> 92 %**



**Brightness**  
**> 10 % (several MHz)**



	State-of-the-art laser source (Optica Vol.5, issue 5, p. 514-517 – 2018) HOM = 90%	Quandela HOM > 92%	Speed-up
Rate: 1 photon - qubit	1.3 MHz	> 25 MHz	x 20
Rate: 3 photons - qubits	55 Hz	9 kHz	X 160
Rate: 8 photons - qubits	$10^{-8}$ Hz	0.5 mHz	X 50000

# FIN!



NEMZETI KUTATÁSI, FEJLESZTÉSI  
ÉS INNOVÁCIÓS HIVATAL

AZ NKFI ALAPBÓL  
MEGVALÓSULÓ  
PROJEKT