Imperial College London

上海交通大學 SHANGHAI JIAO TONG UNIVERSITY

Experimental quantum fast hitting on hexagonal graphs

Carlo Di Franco

9th International Conference on Quantum Simulation and Quantum Walks
CIRM, Marseille, France
21st January 2020

Outline

- A feasible experimental platform for implementing quantum protocols
  - Standard glued tree problem
  - Hexagonal graph and its realisation
  - Experimental results
  - Summary

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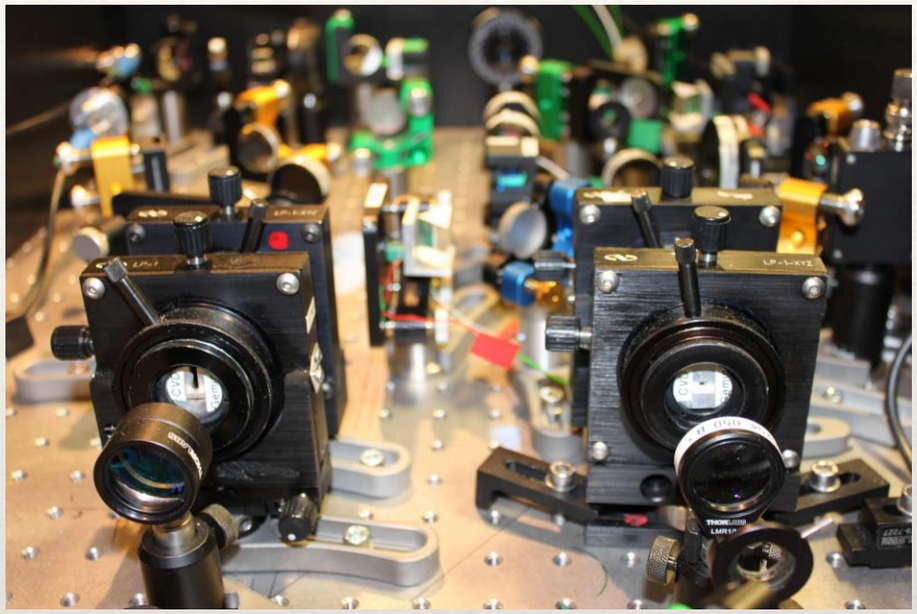
Experimental platform

Bulk optics experiments



Experimental platform

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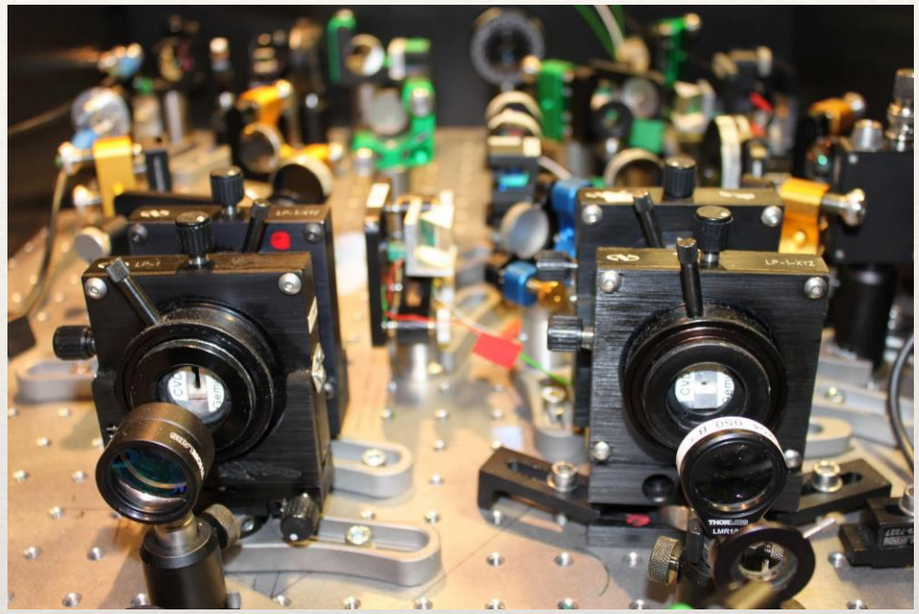
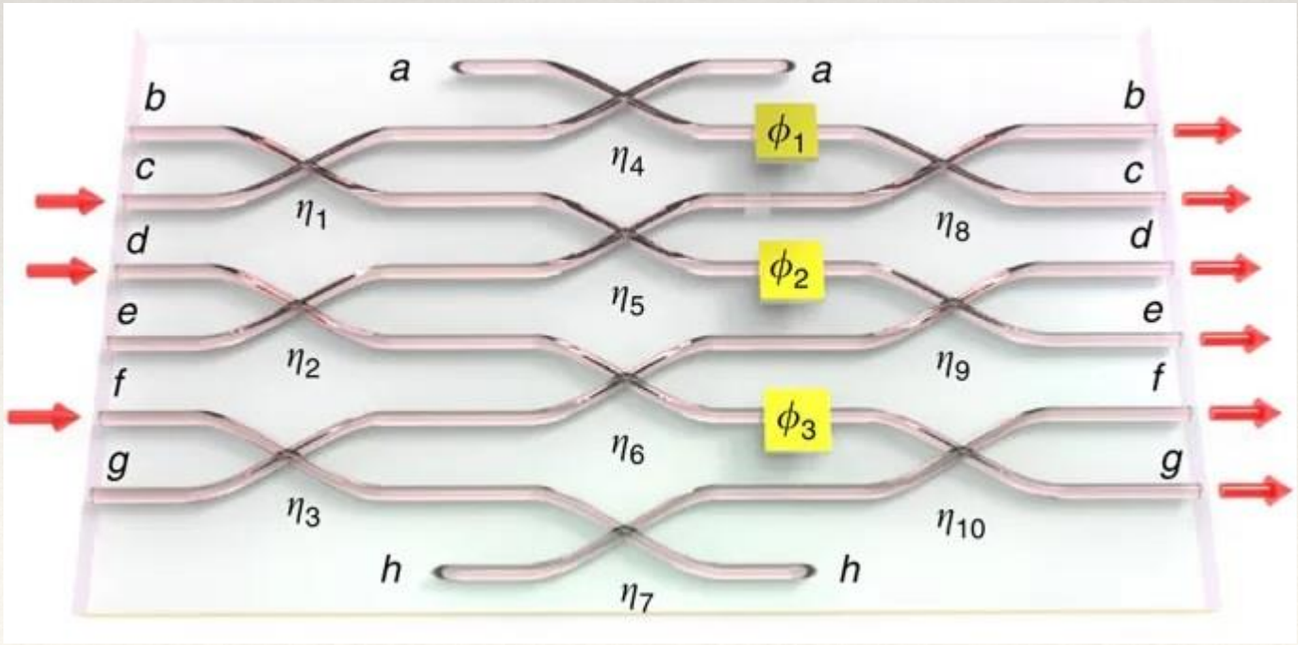
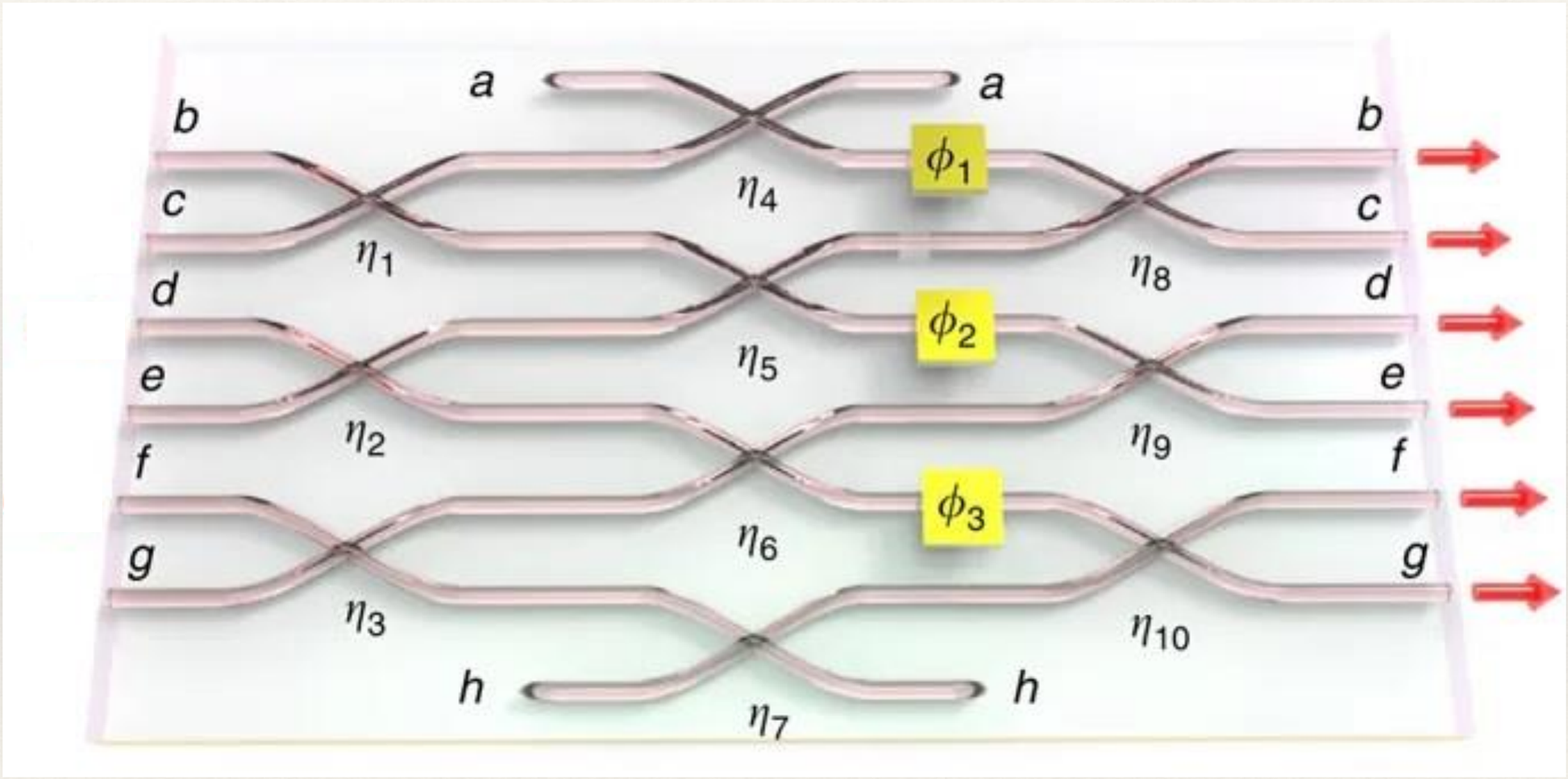




Integrated waveguide circuits

Experimental platform



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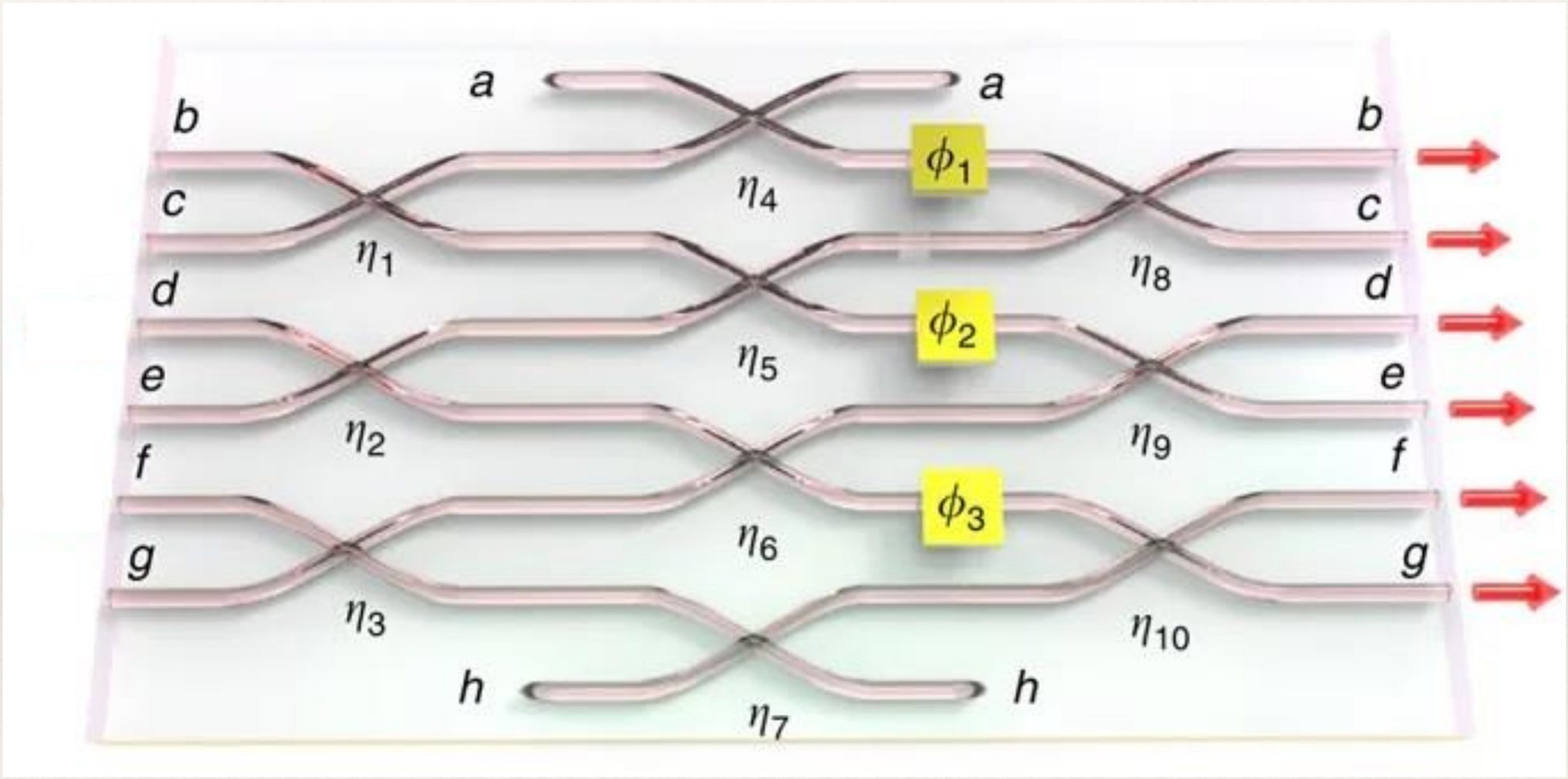

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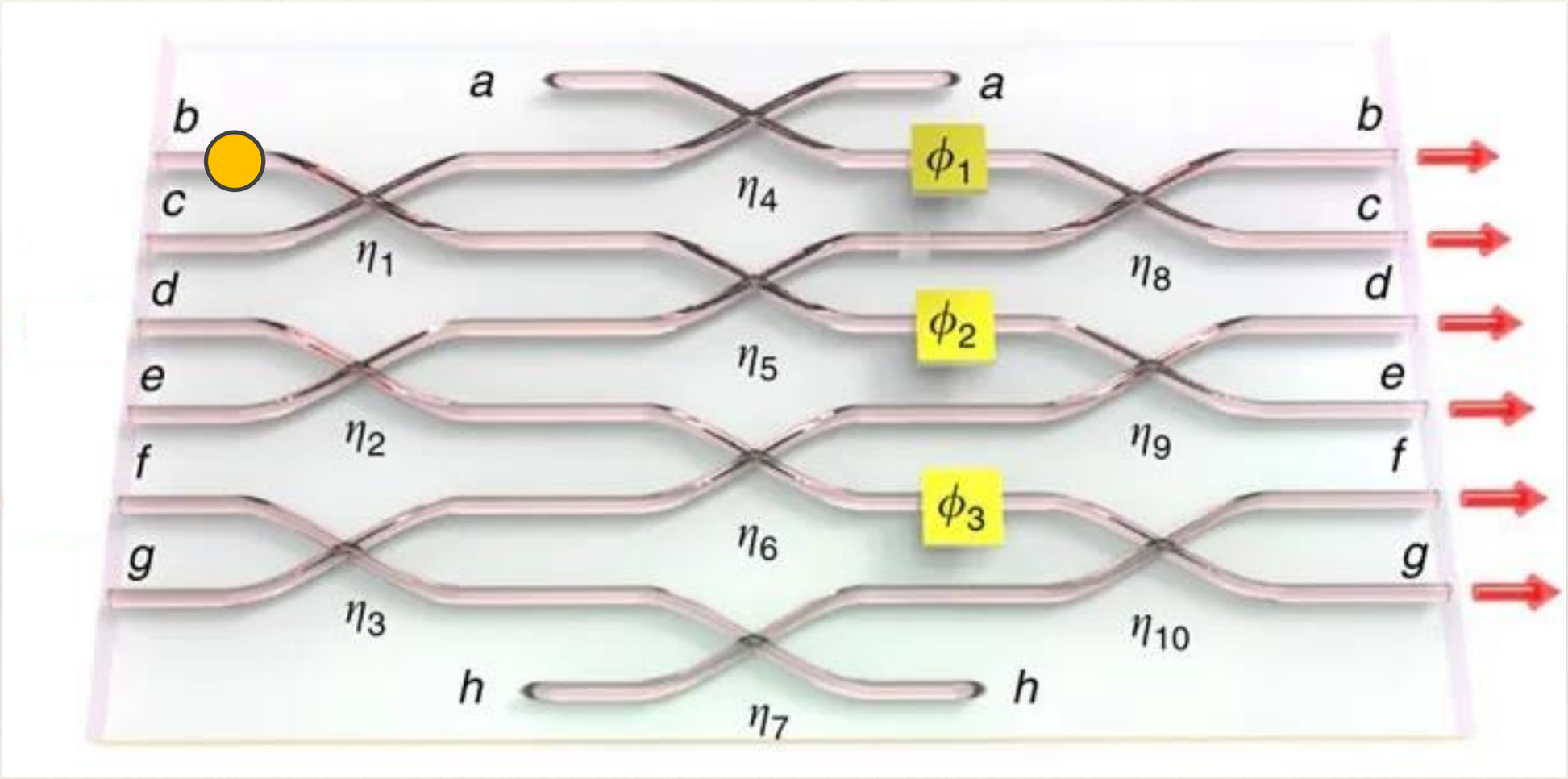

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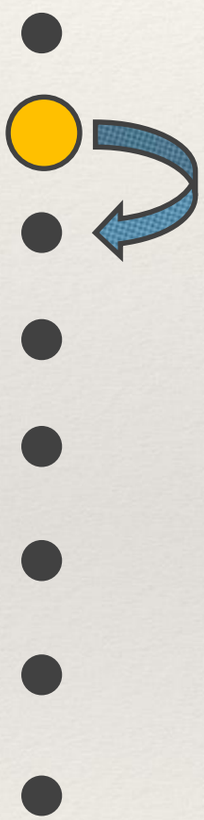

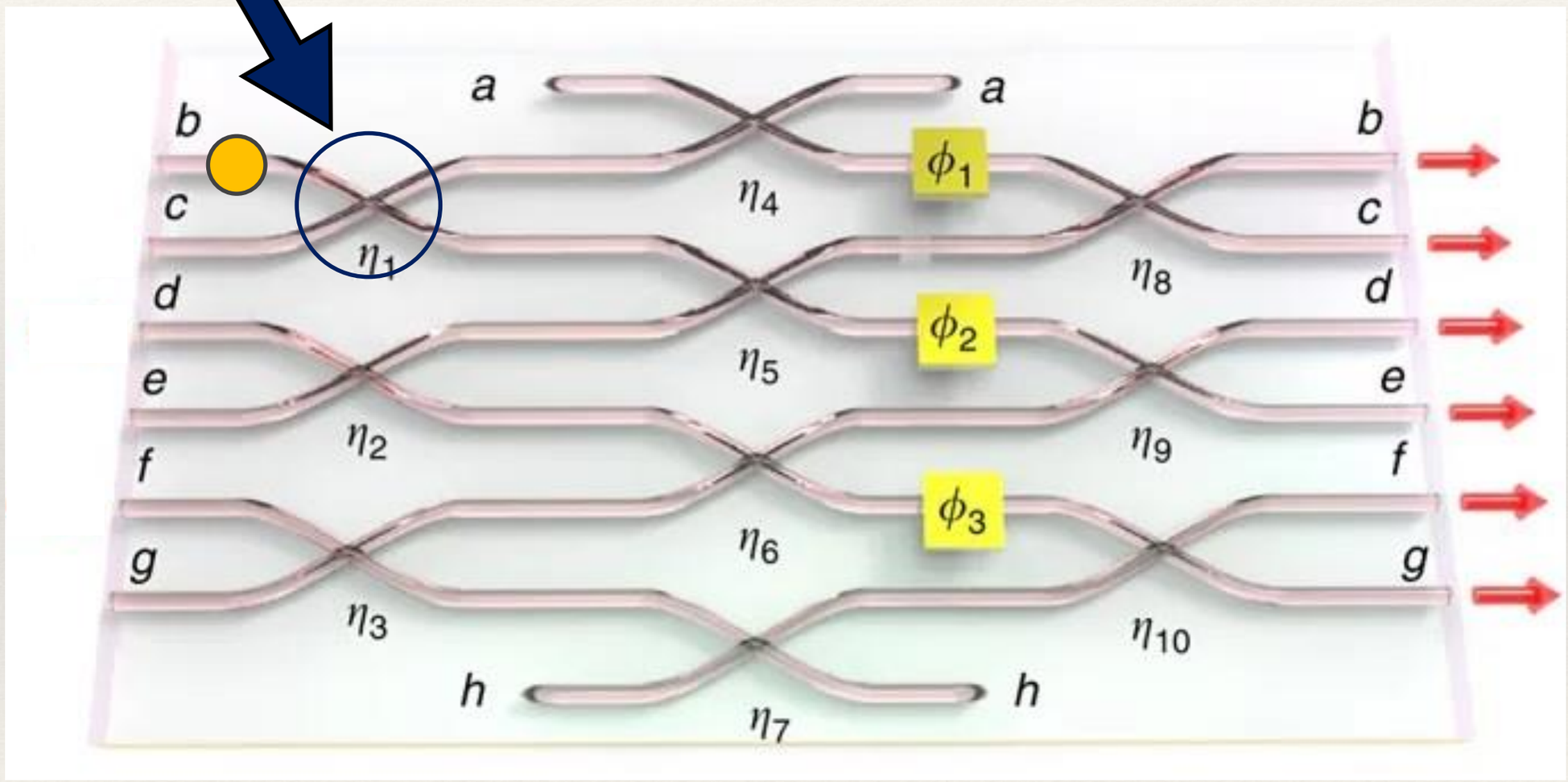

Experimental platform

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They can print 3D chips !

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2D graph + time

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Question: How to exploit it ?

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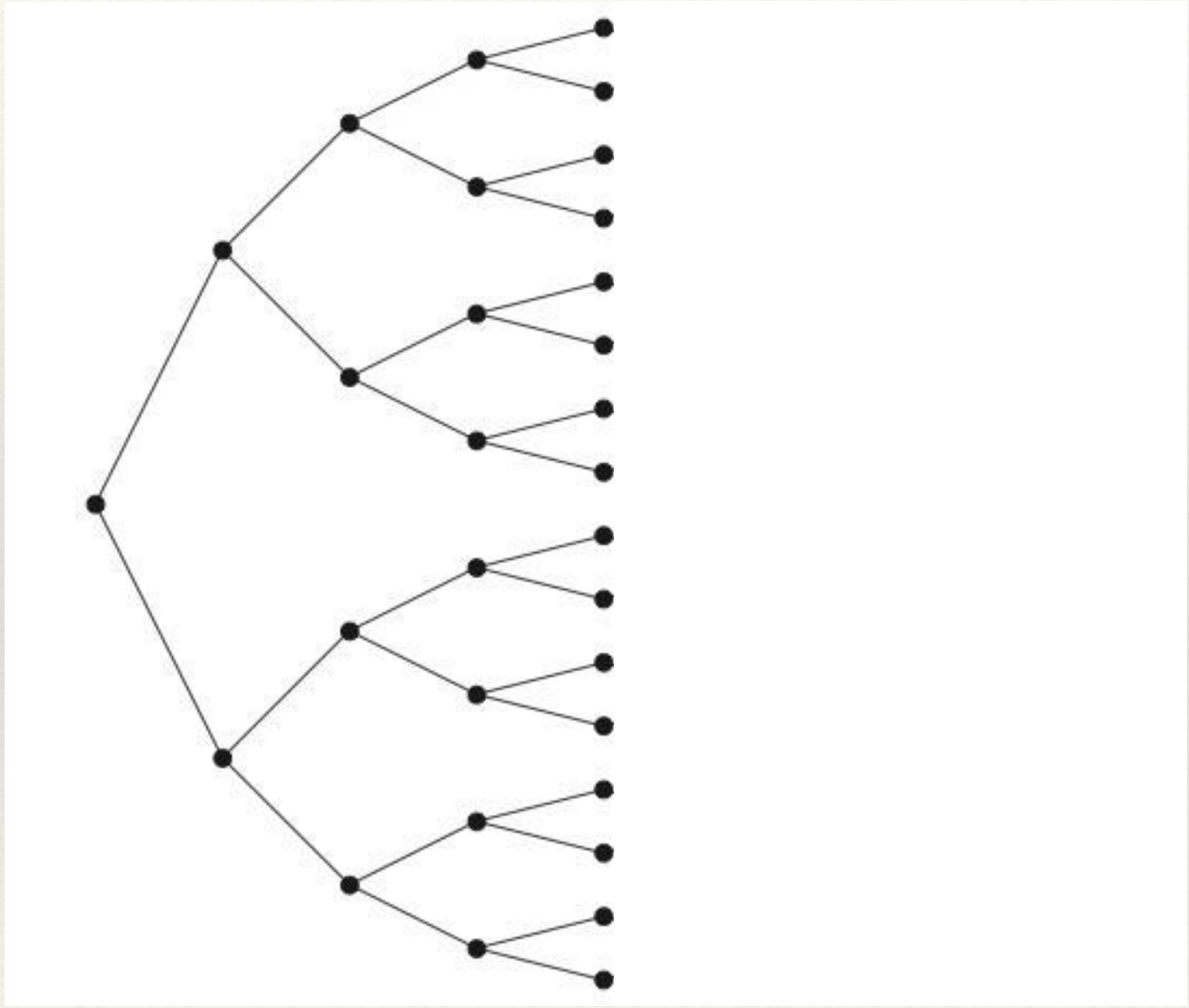
Glued tree



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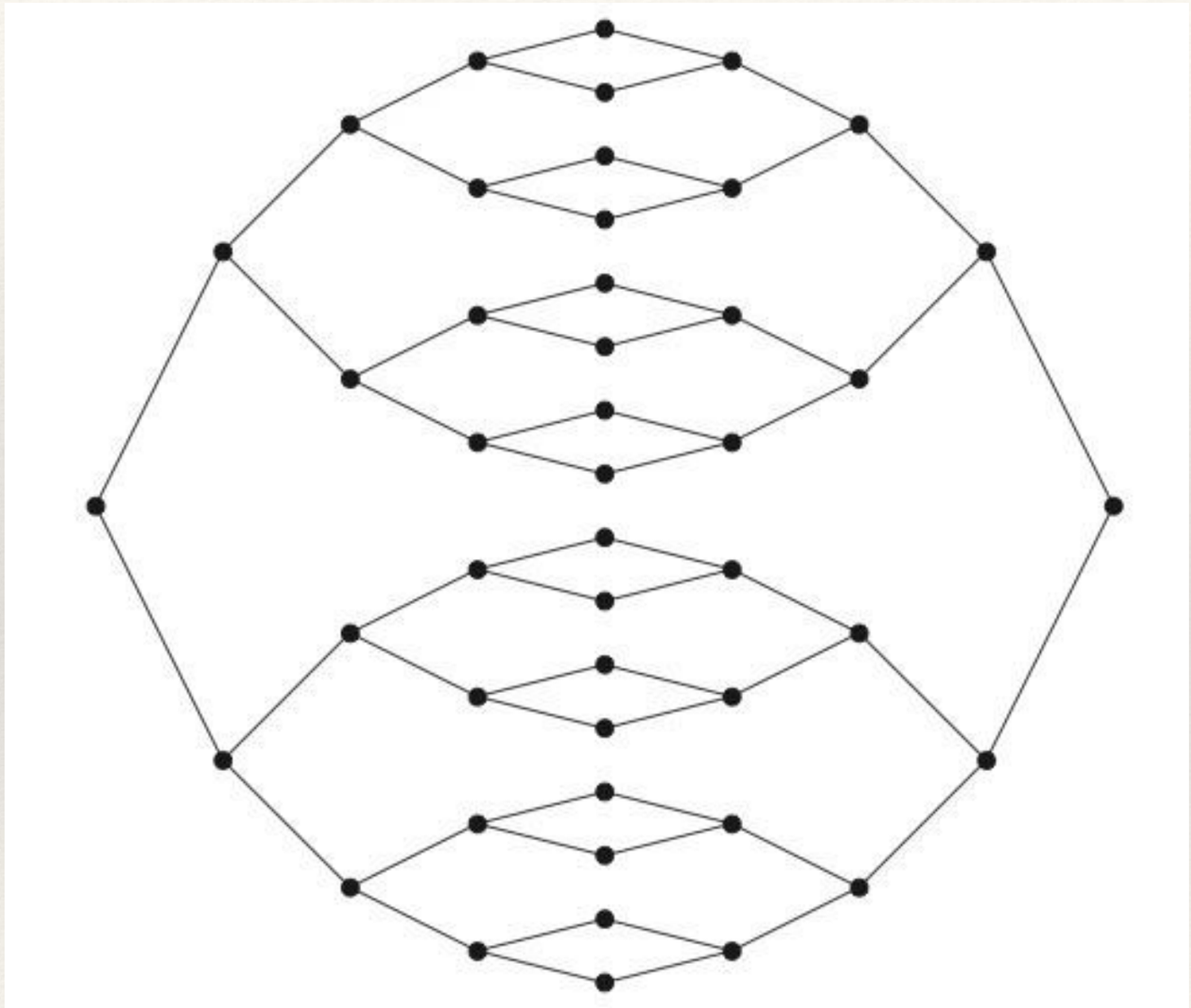
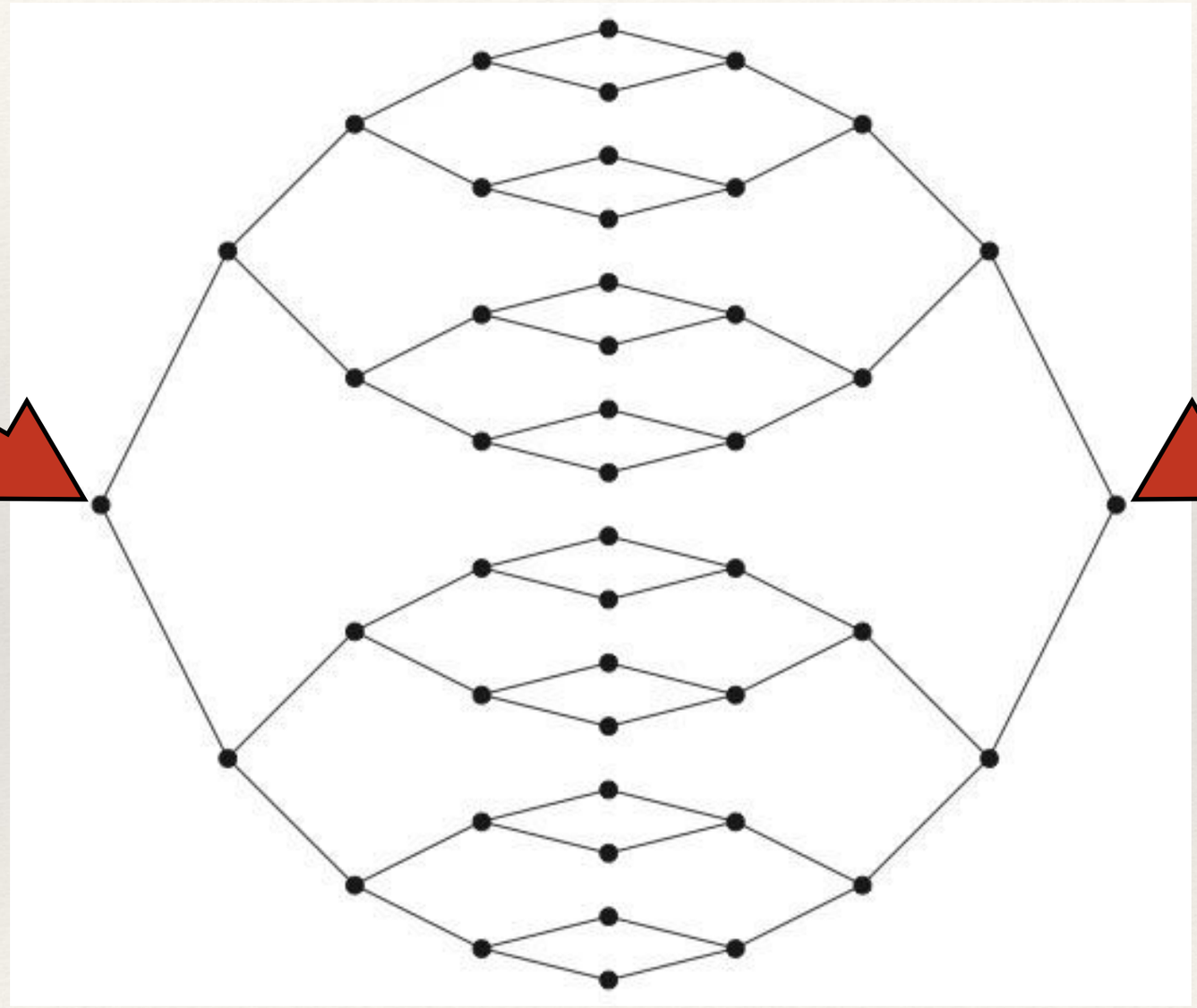


Glued tree

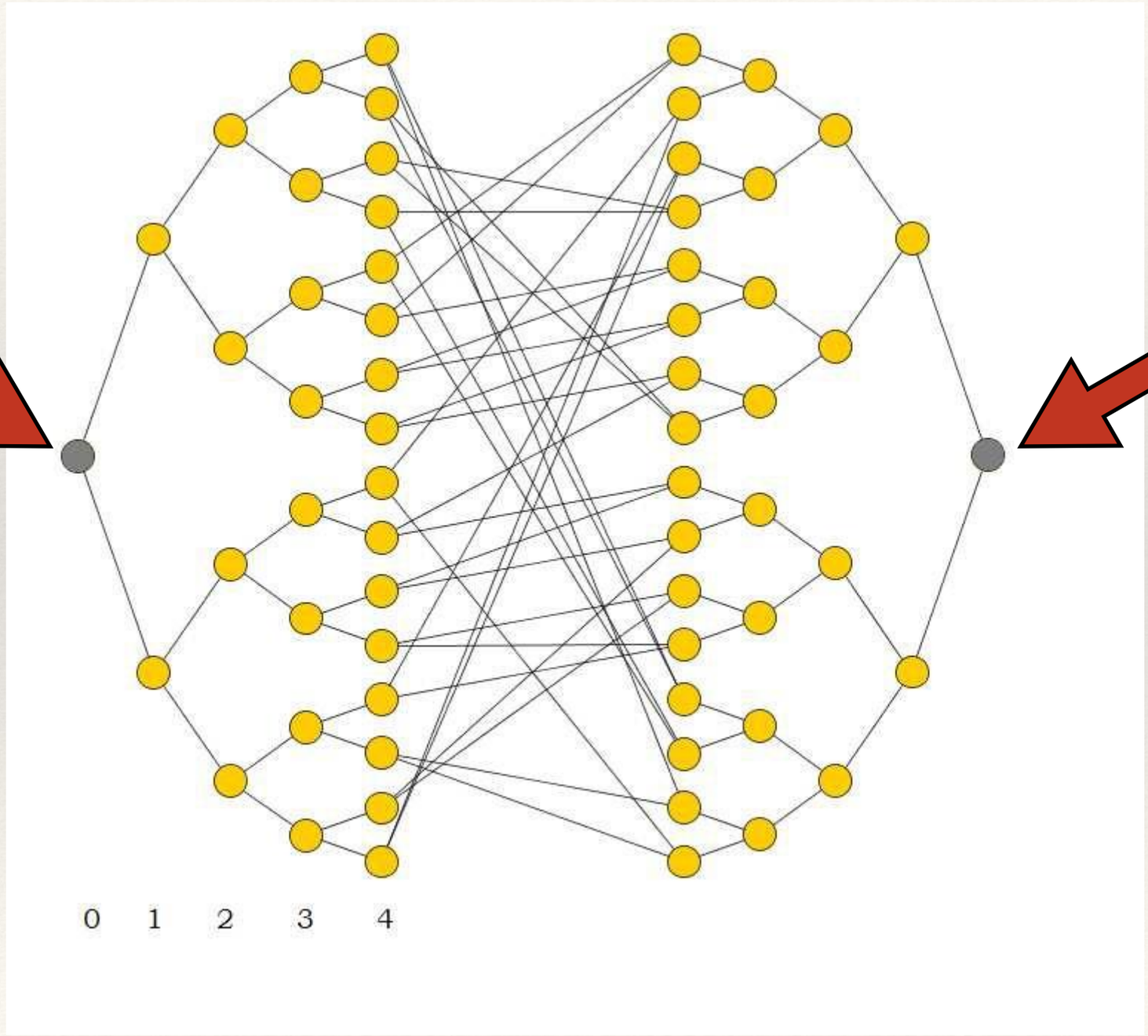
Entry



Exit

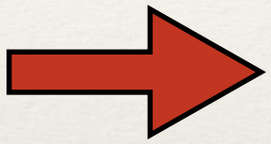
Glued tree

Entry



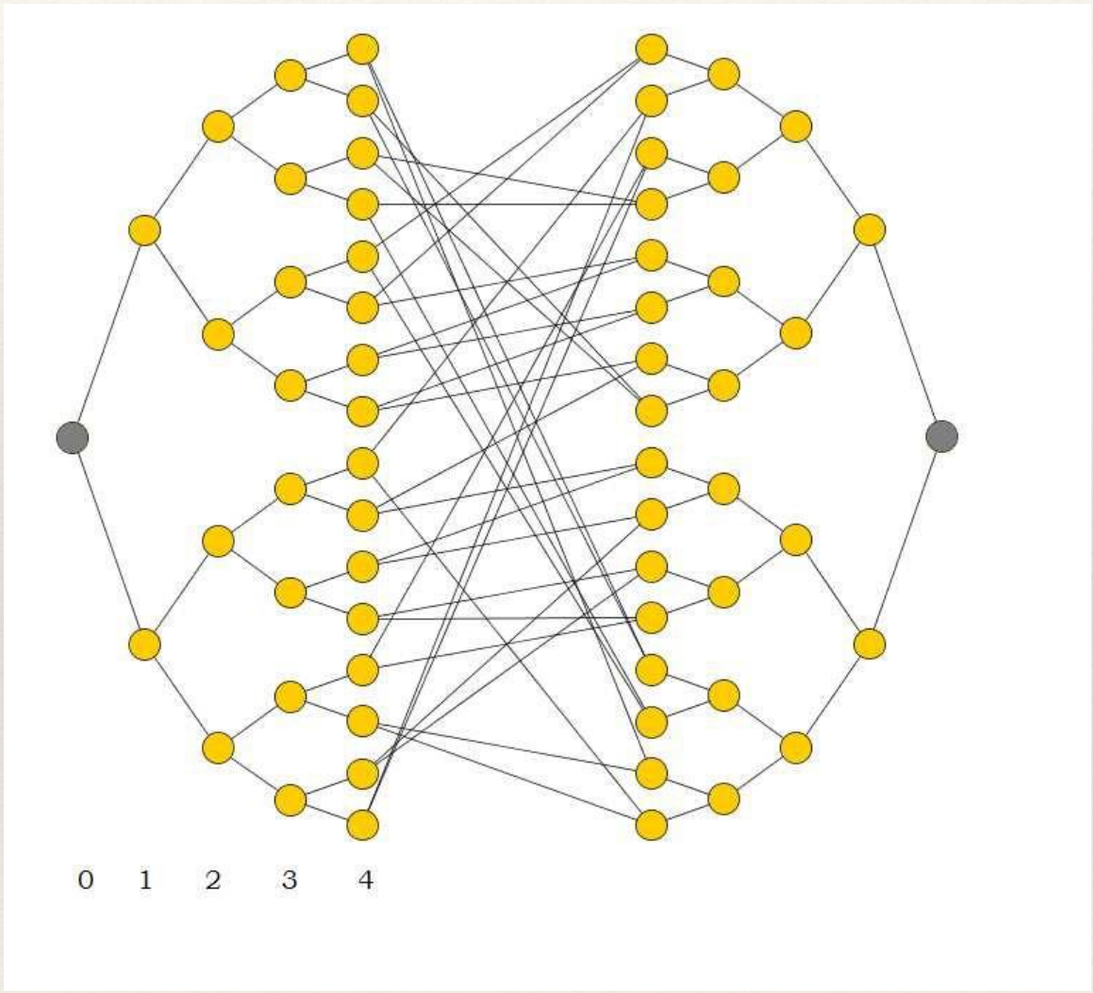
Exit

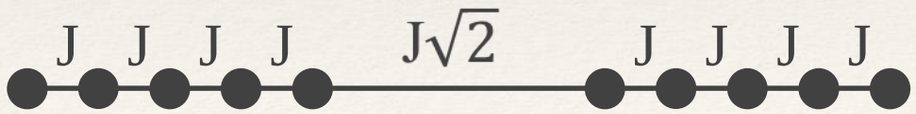
Glued tree

Classical  Exponential hitting time

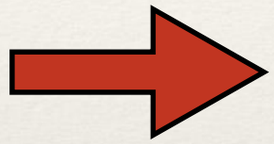
Glued tree

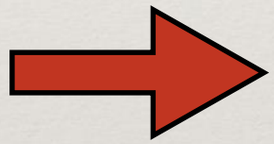
Quantum





Glued tree

Classical  Exponential hitting time

Quantum  Linear hitting time

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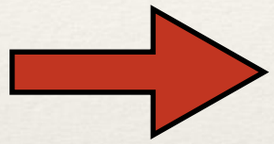
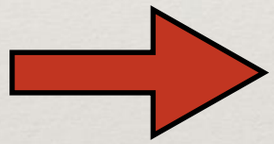
Classical  Exponential hitting time

Quantum  Linear hitting time

Reason: coherent evolution of the quantum walk

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Experimental implementation

Technical constraints:

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Number of nodes (waveguides) grows exponentially with the number of layers

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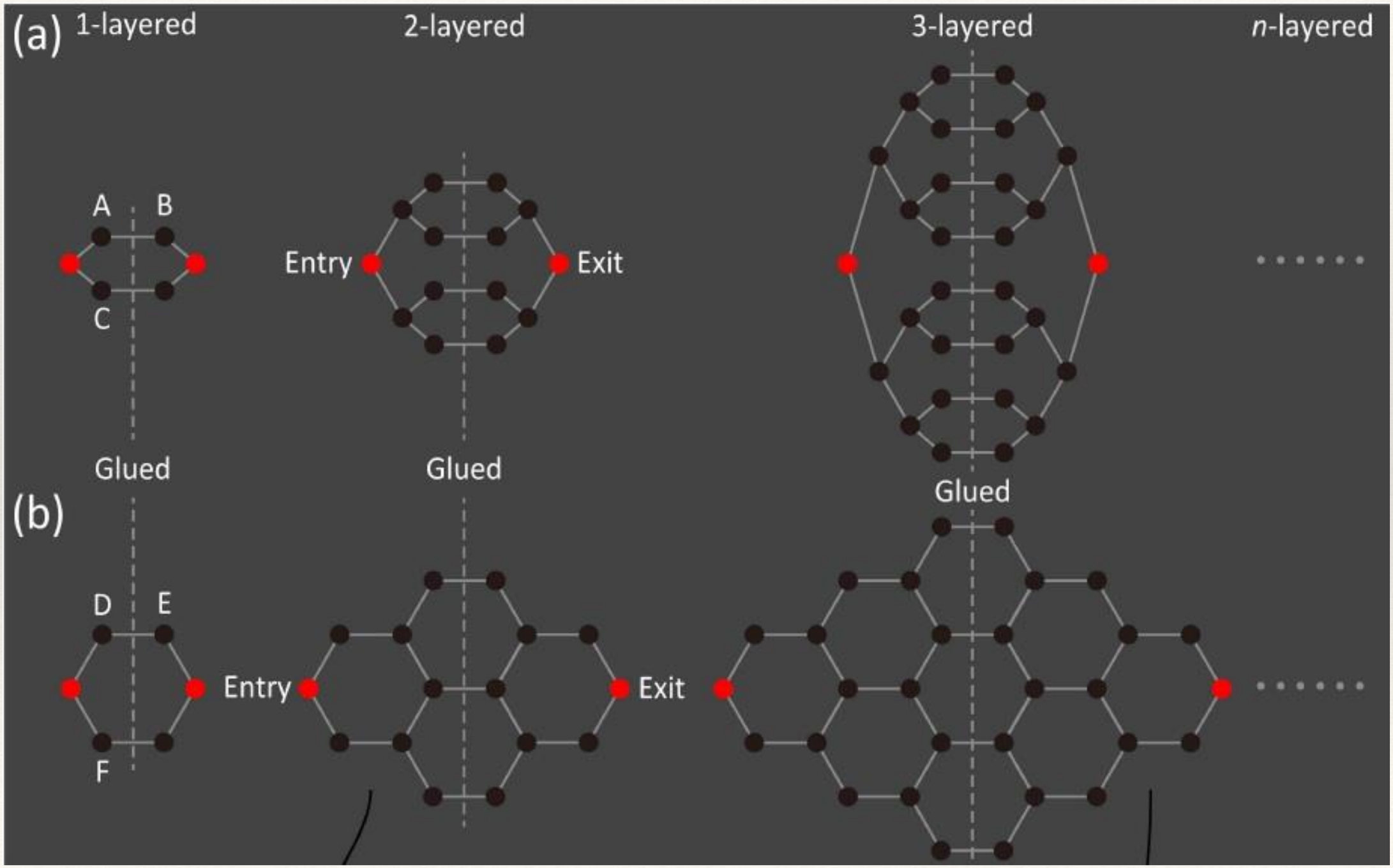
Number of nodes (waveguides) grows exponentially with the number of layers

Hopping term depends on the distance between the waveguides

Experimental implementation



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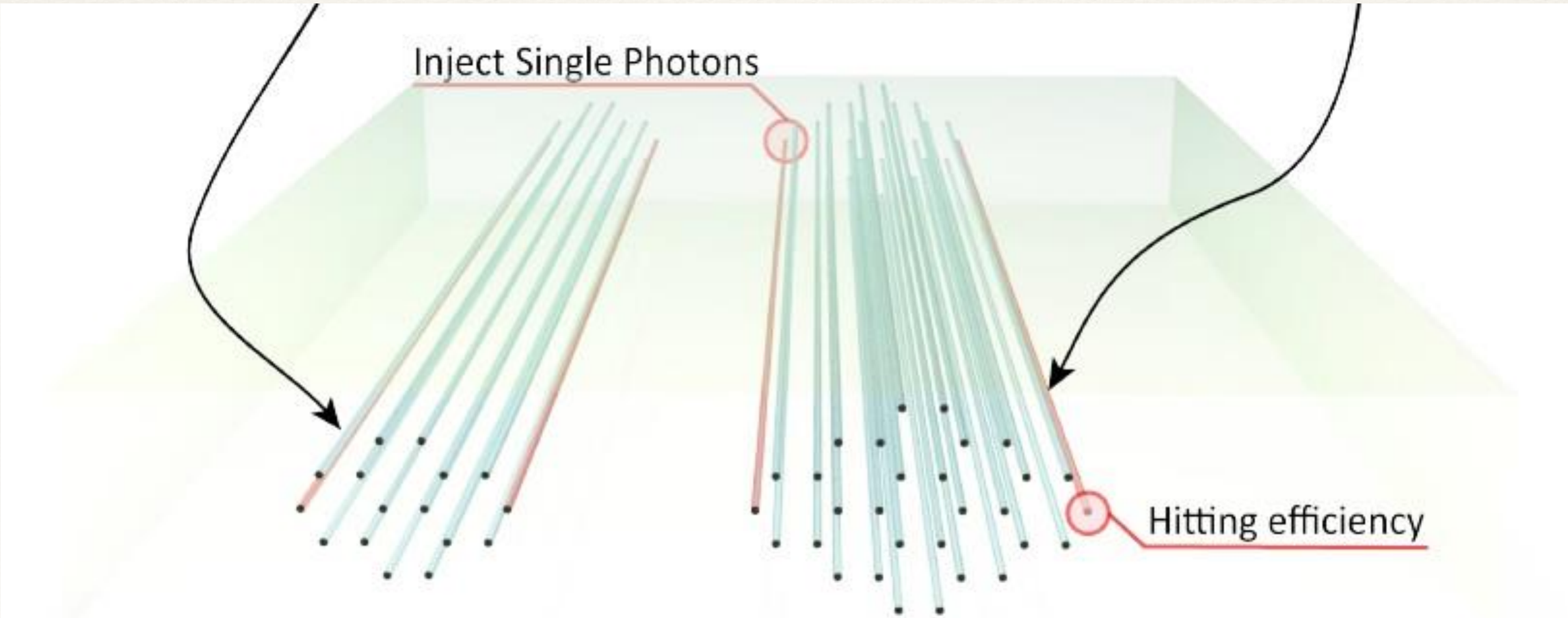

Hexagonal graph chip

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(a) 20.7mm (b) 22.7mm, (c) 24.7mm (d) 26.7mm (e) 28.7mm

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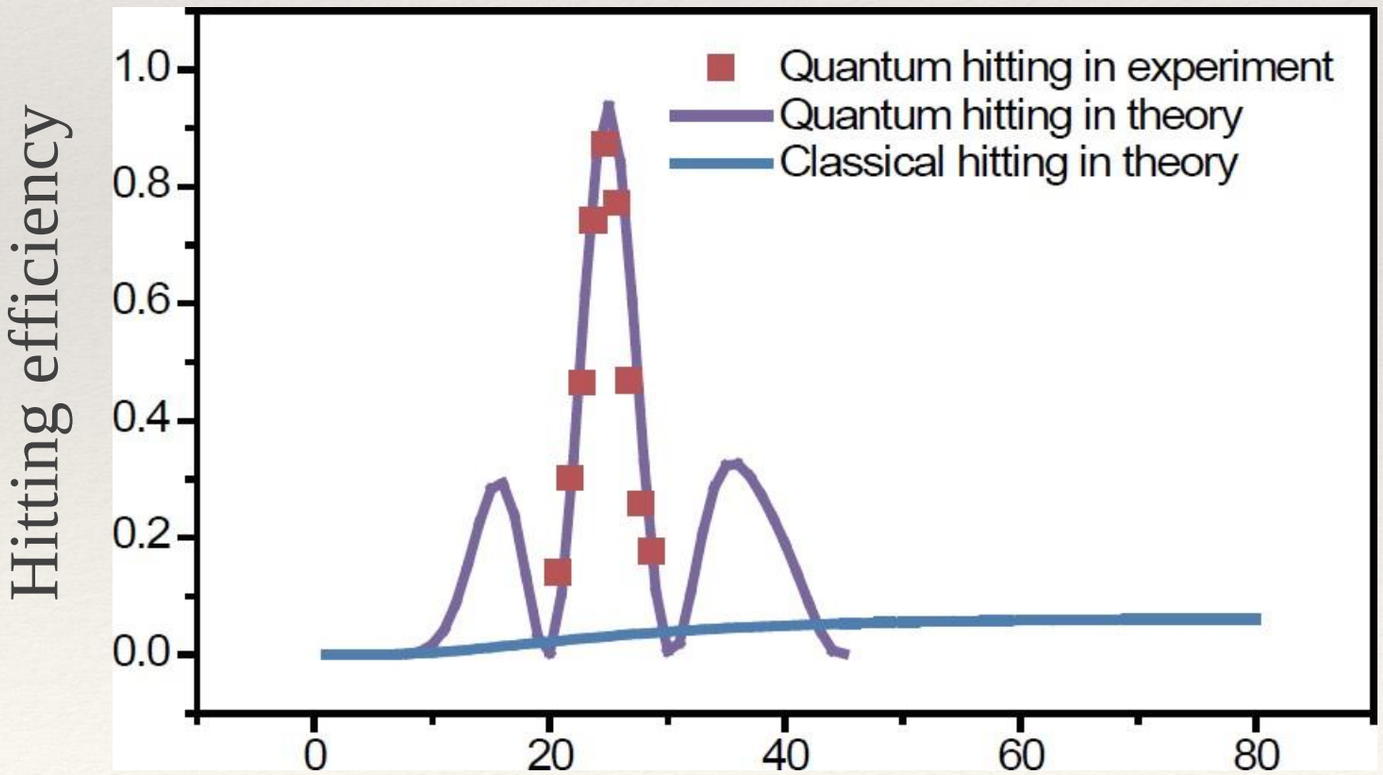

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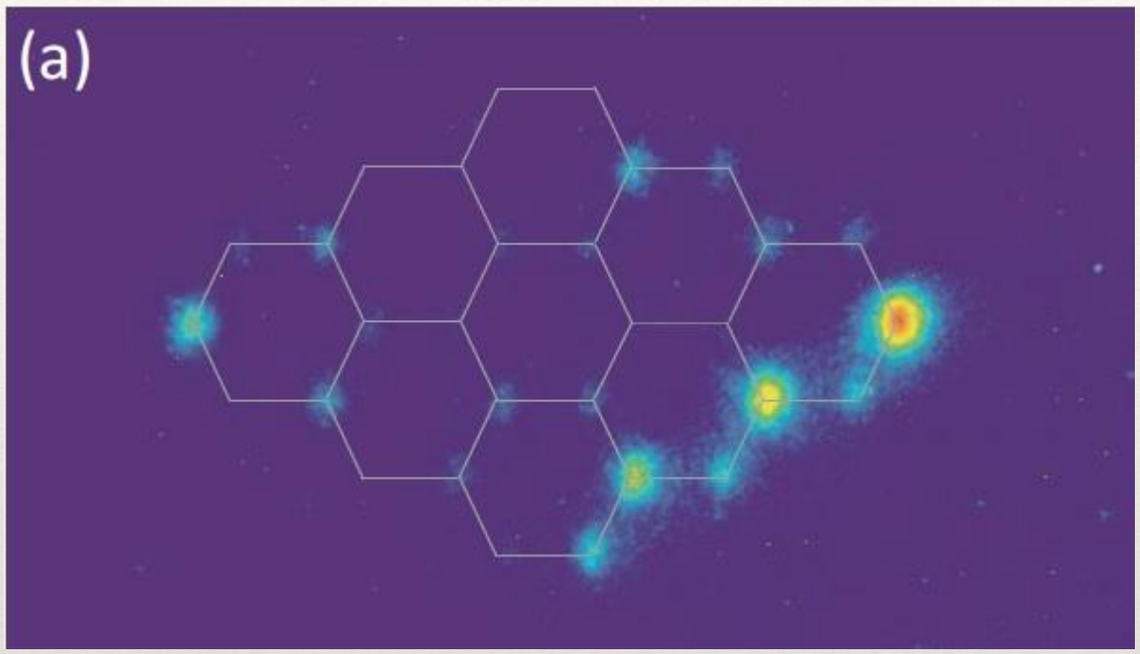

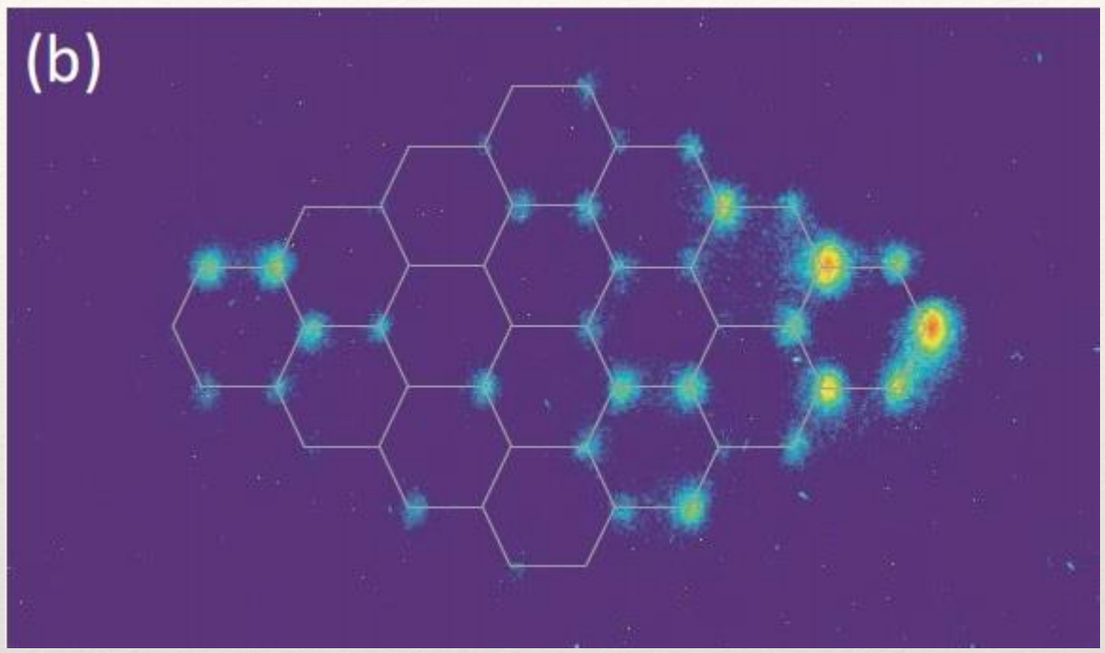

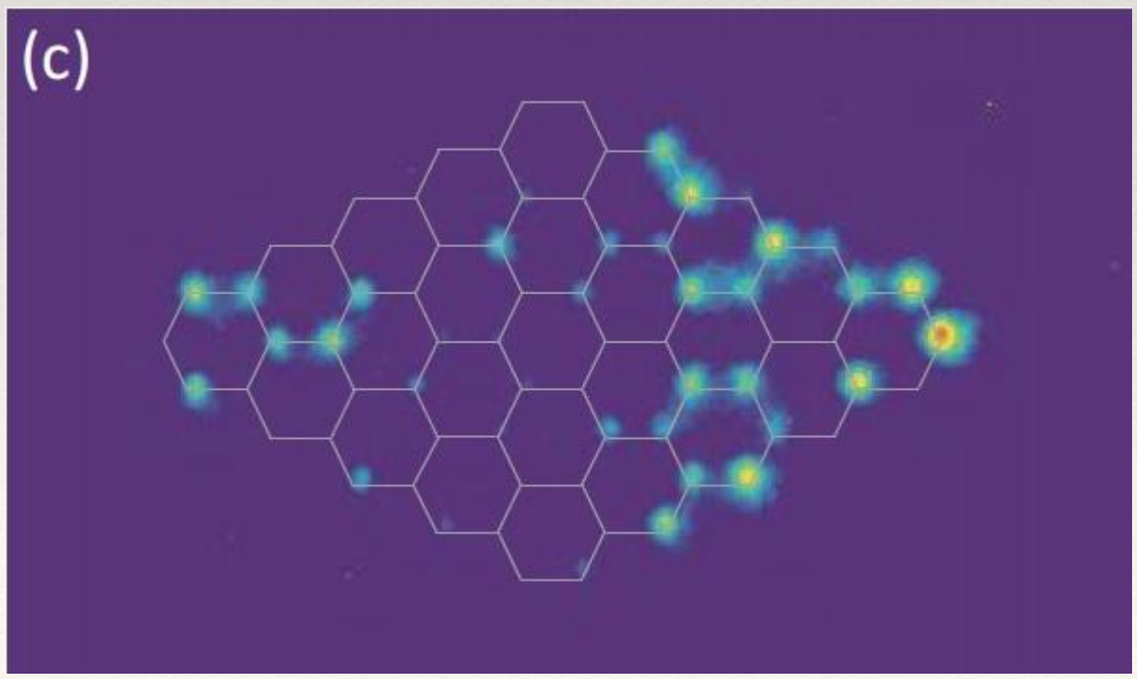

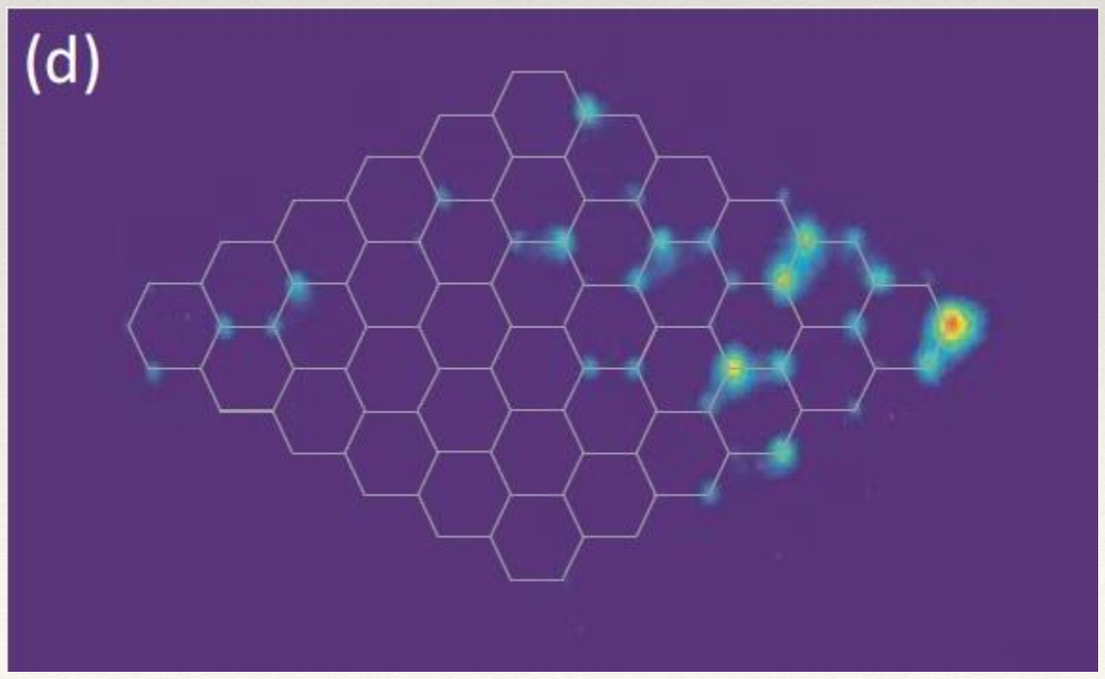

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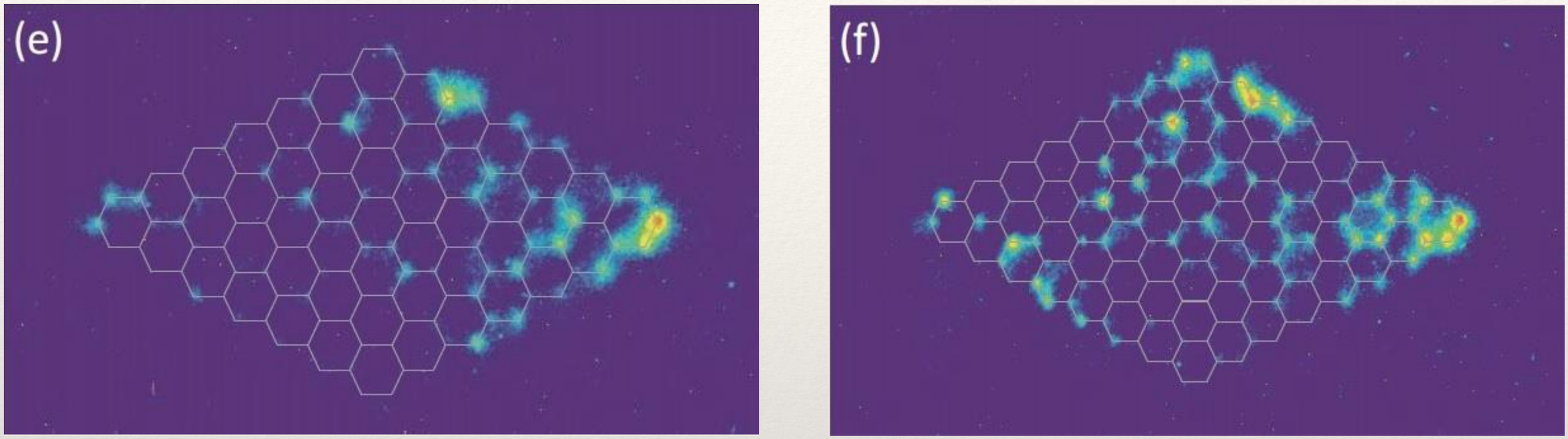
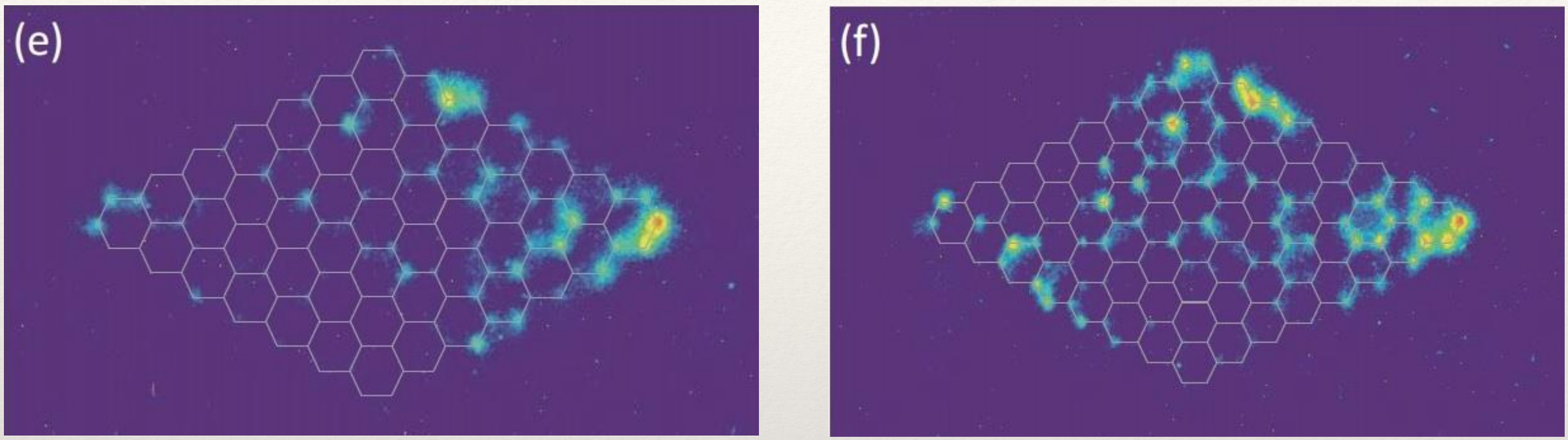


(a) 3 layers: 30.4mm,
(b) 4 layers: 43.7mm,
(c) 5 layers: 48.4mm,
(d) 6 layers: 61.8mm,
(e) 7 layers: 70.8mm,
(f) 8 layers: 85.8mm.

Experimental results



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Up to 160 nodes !

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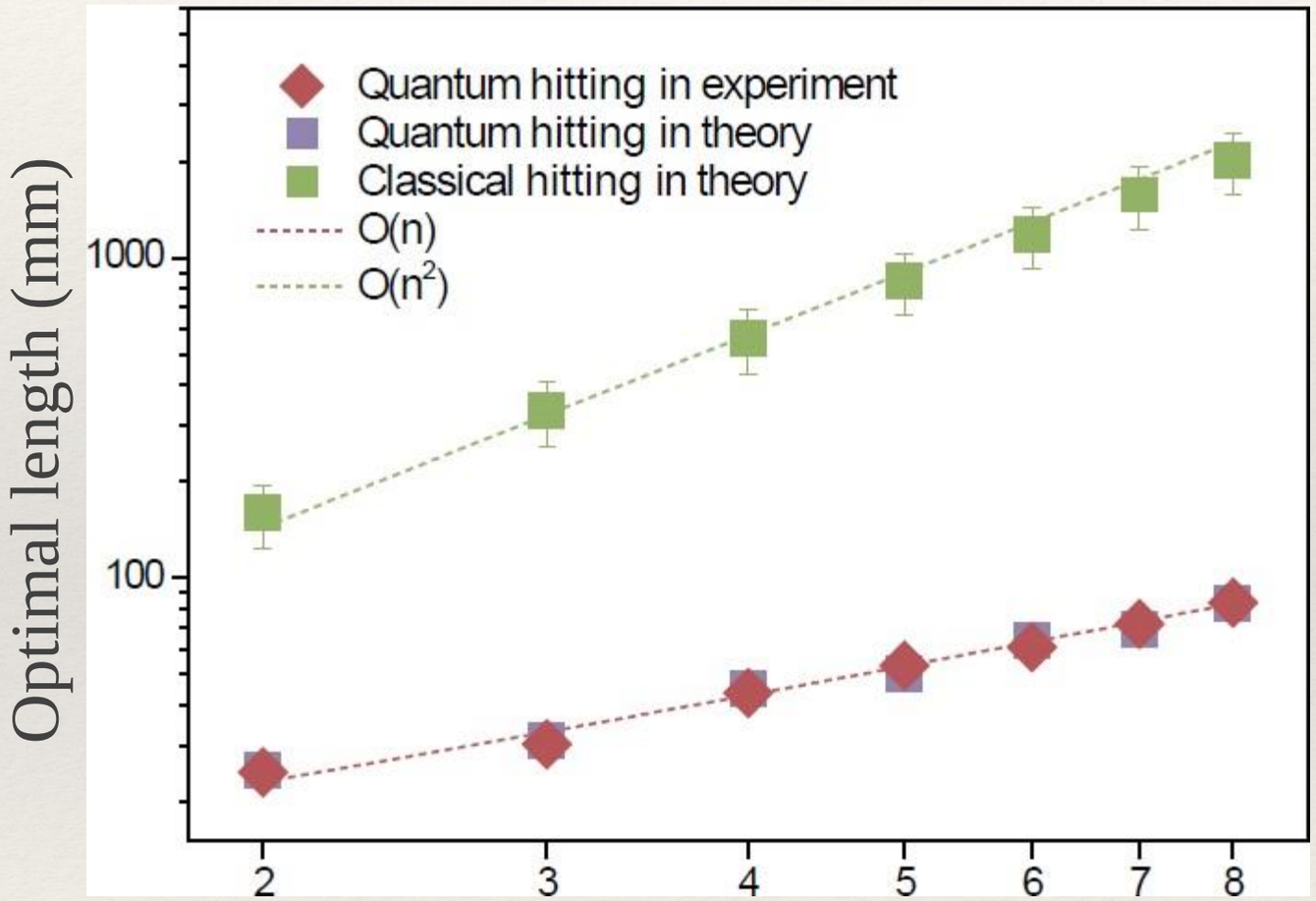

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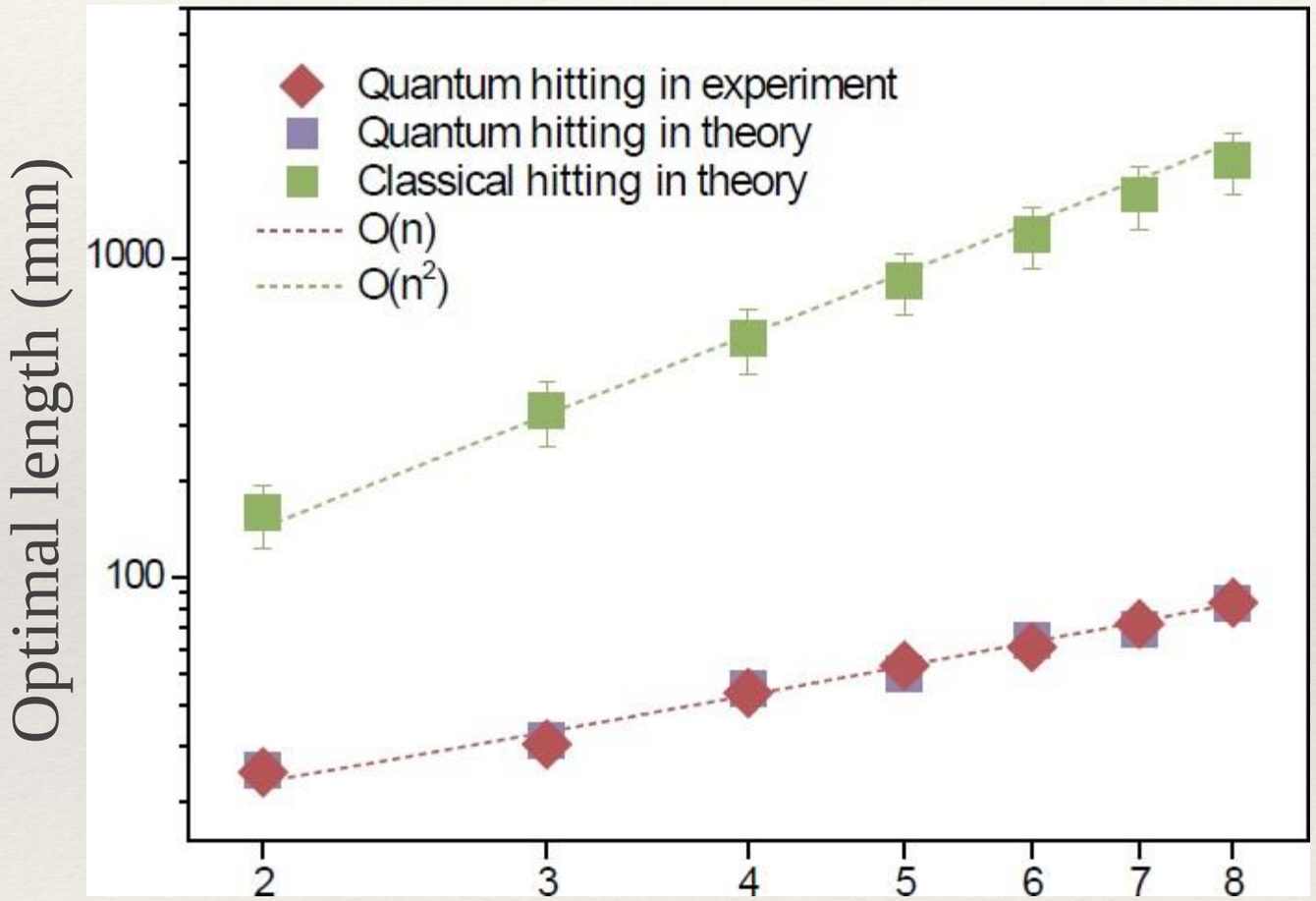

Quantum linear hitting time !

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- We experimentally demonstrated that the quantum hitting time grows linearly in our hexagonal structure
- We have a coherent evolution of a quantum walk on a graph with up to 160 nodes

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Thanks for your attention

H. Tang, C. Di Franco, et al., Nature Photonics **12**, 754 (2018)