

Call 2021
Final Evaluation



Phomemtor

Photonic quantum memristor networks
Iris Agresti

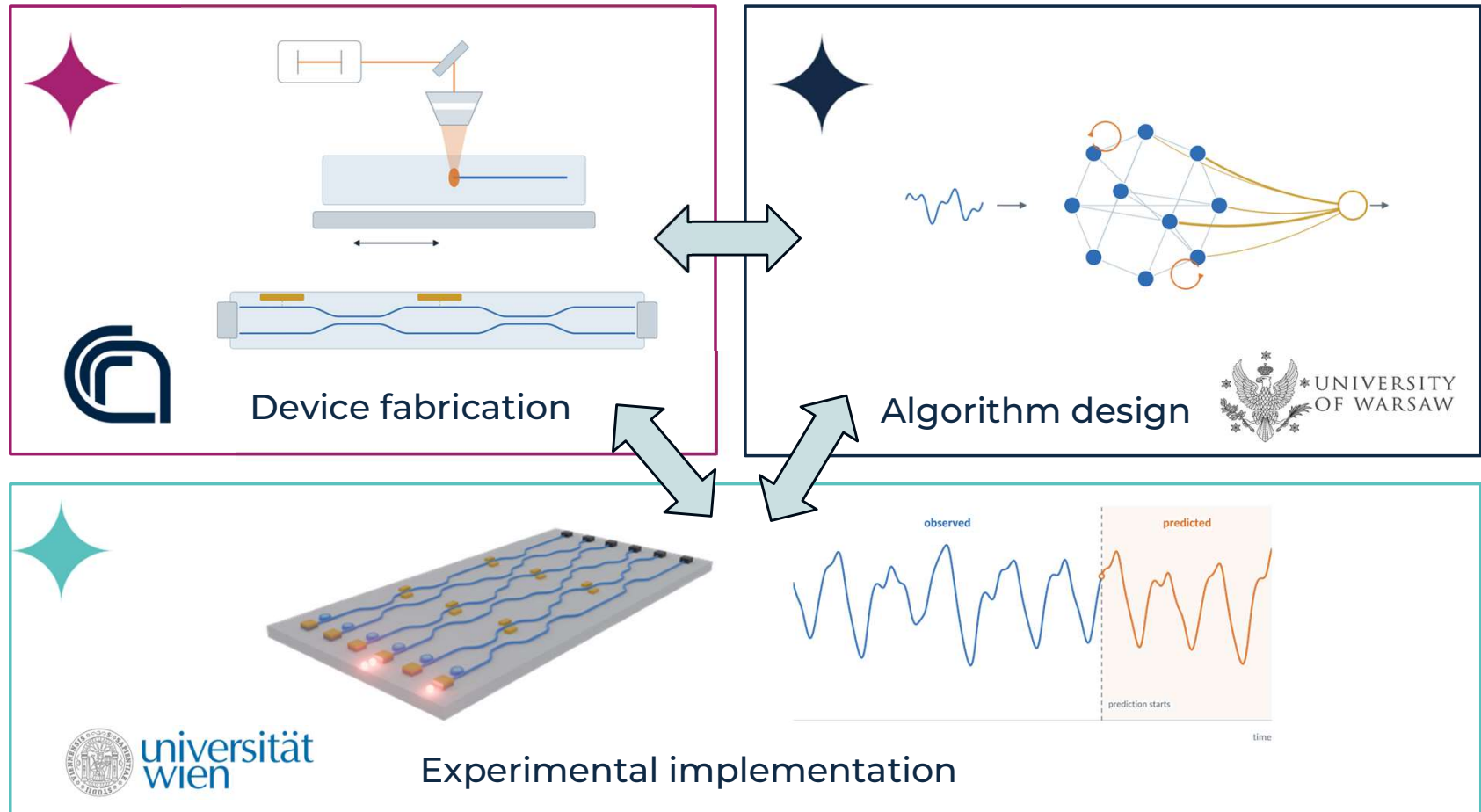


COLLABORATION (overview)





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COLLABORATION (overview)

Meetings

- Milan (03/2022),
 - Warsaw (10/2024)
 - Vienna (04/2025)
- with regular online meetings

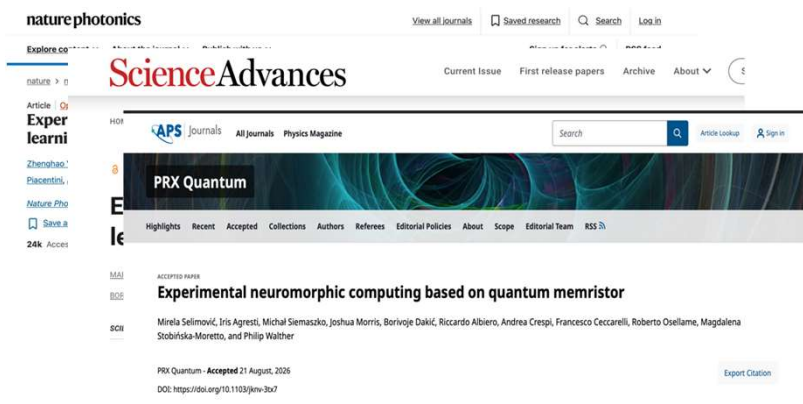
Mobility

15 documented research stays

F. Ceccarelli, CNR → UNIVIE, 09/2024
I. Agresti, UNIVIE → CNR, 02/2025
M. Siemaszko, UW → UNIVIE

Outputs

11 publications



Dissemination

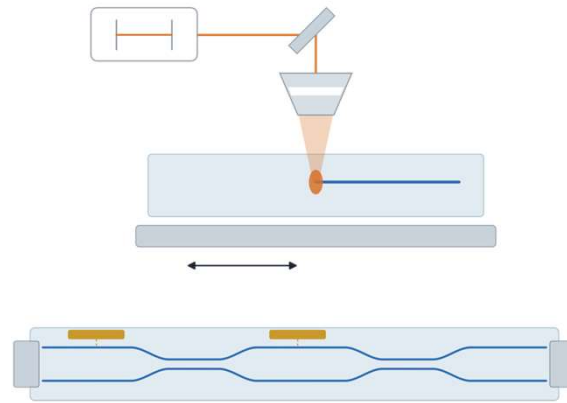
Active participation to international conferences



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COLLABORATION (overview)



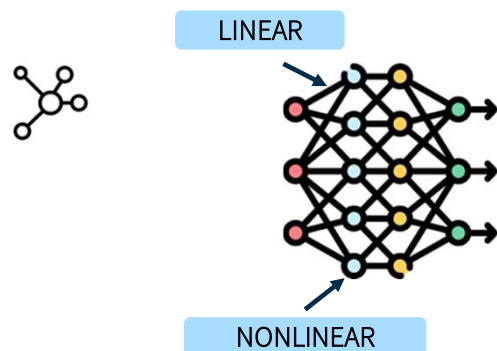
Circuit fabrication. Photonic circuit co-designed at UNIVIE and calibration was performed jointly between UNIVIE and CNR.

Shared code and data. Simulation and analysis codes and experimental datasets are exchanged across the three groups; project data are open to the scientific community and to the public.





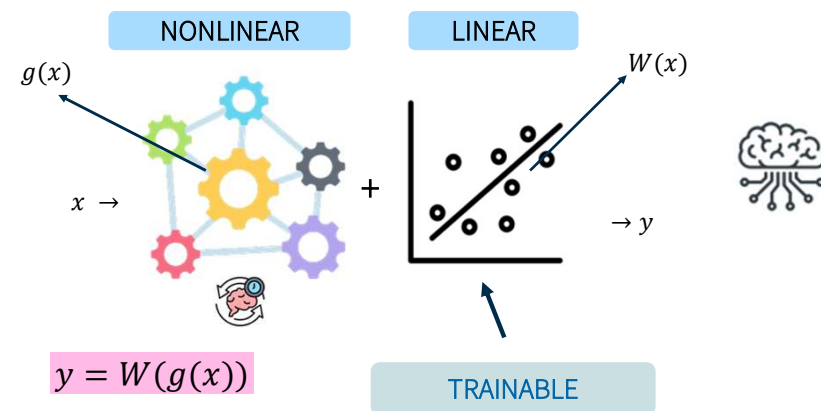
SUCCESS STORY (highlights)



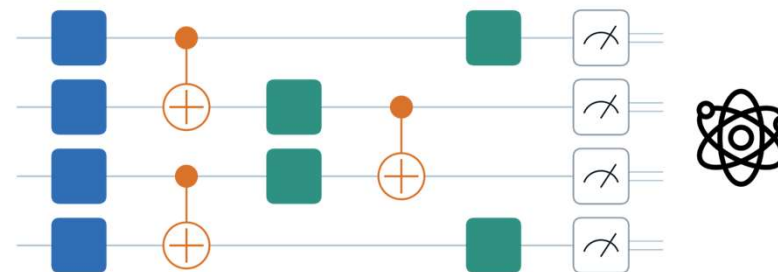
Machine learning models are very **versatile and powerful** but can be **inefficient**.

How can we implement nonlinearities?

CHALLENGE – the aim of your research

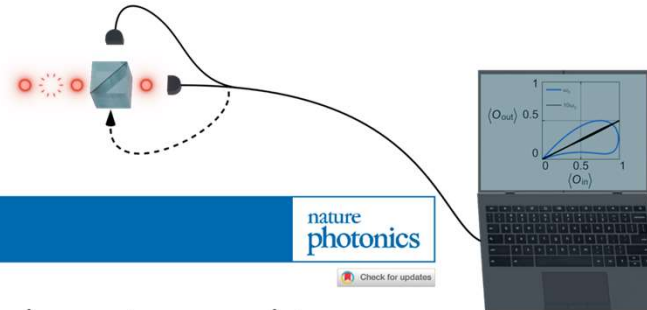


Neuromorphic architectures are more **efficient** and **quantum computing can boost** the performance of classical algorithms.





SUCCESS STORY (highlights)



ARTICLES

<https://doi.org/10.1038/s41566-022-00973-5>

nature
photonics

Check for updates

OPEN

Experimental photonic quantum memristor

Michele Spagnolo^{1,2,3}, Joshua Morris¹, Simone Piacentini^{2,3}, Michael Antesberger¹,
Francesco Massa¹, Andrea Crespi^{2,3}, Francesco Ceccarelli², Roberto Osellame³ and
Philip Walther^{1,4}

If we trace out the measured mode, the state is still coherent and it displays an hysteretical behaviour.

Can we use it for machine learning purposes?

$$|\psi\rangle_A = \sqrt{1 - |\alpha(t)|^2}|0\rangle + \alpha(t)|1\rangle$$

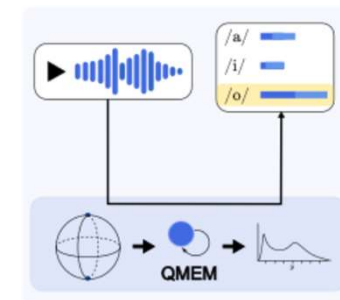
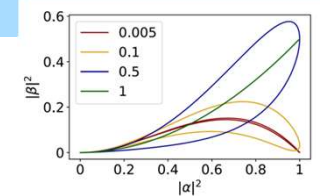
$$p_C = |\beta(t)|^2 = |\alpha(t)|^2(1 - R(t))$$

$$p_D = |\alpha(t)|^2 R(t)$$

$$\alpha(t) = \sin \frac{\pi t}{T_{osc}}$$

$$\dot{R} = |\alpha(t)|^2$$

$$R(\tau) = \int_{\tau}^{\tau+T} |\alpha(t)|^2 dt$$



SOLUTION – research approach

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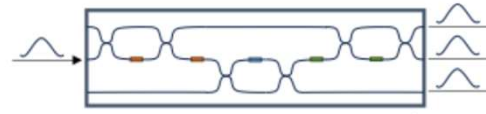




SUCCESS STORY (highlights)

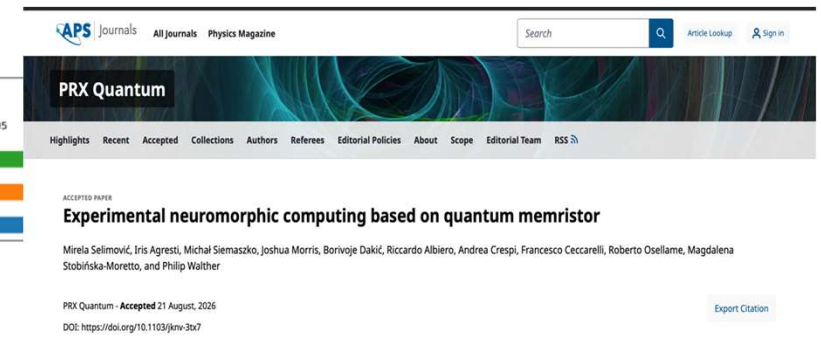
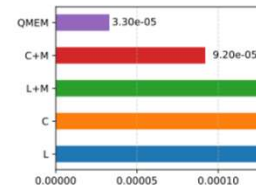
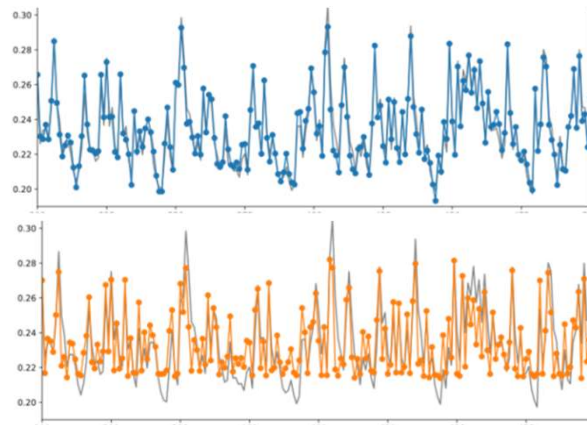
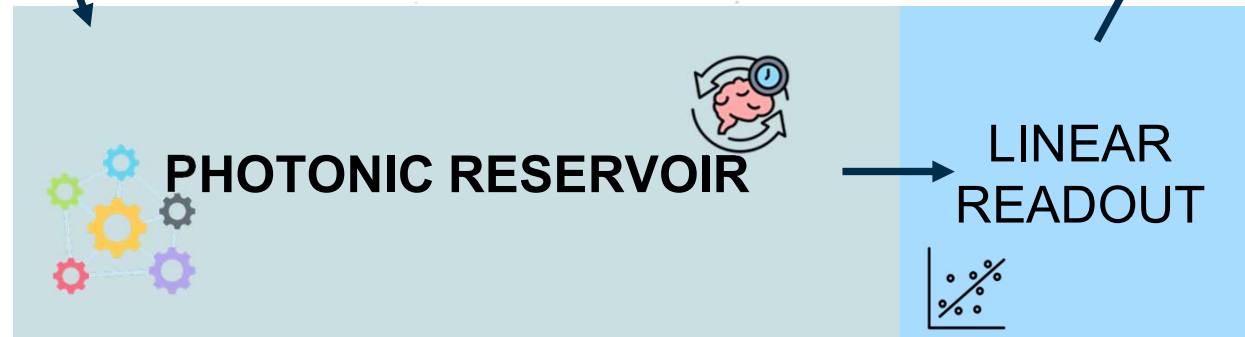
SEQUENTIAL INPUT

$x_0, x_1 \dots x_N$



SEQUENTIAL OUTPUT

$y_0, y_1 \dots y_N$



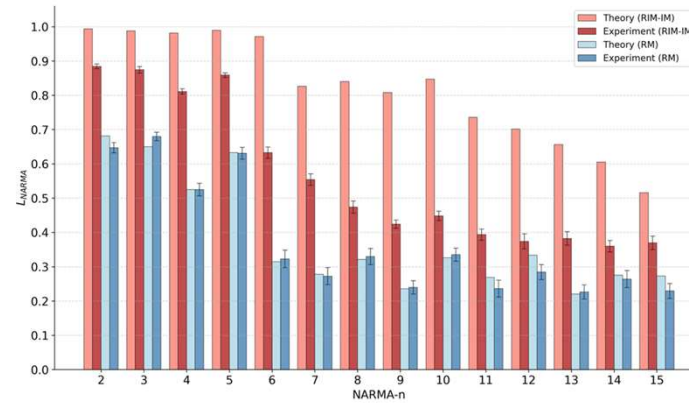
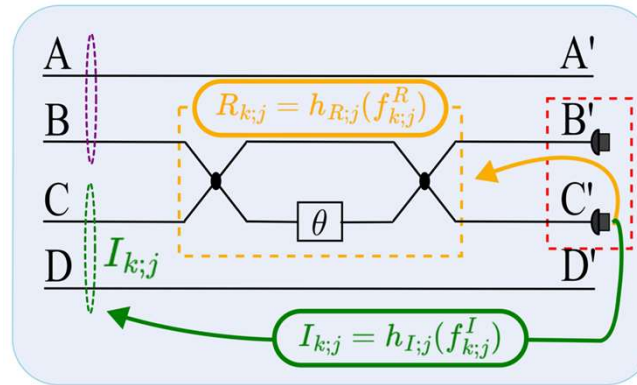
$$x(t+1) = \alpha x(t) + \beta x(t) \sum_{i=0}^{N-1} x(t-i) + \gamma u(t-N+1) u(t) + \delta$$

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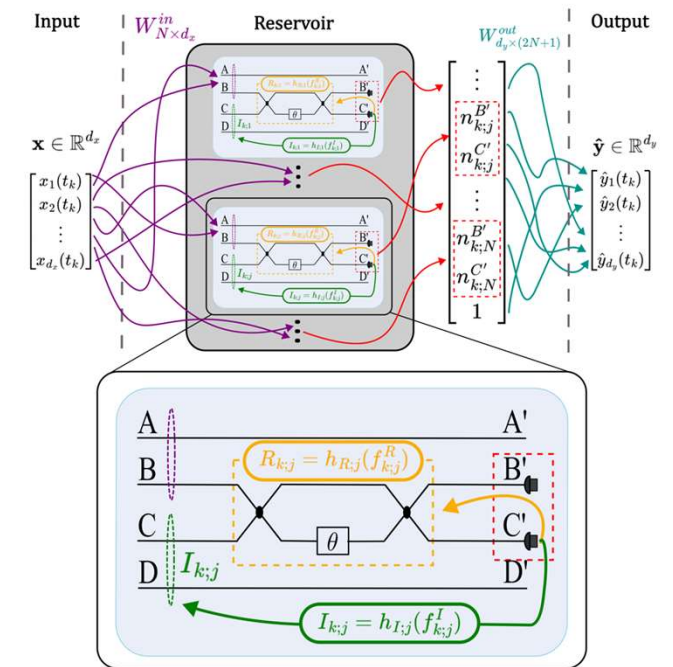




SUCCESS STORY (highlights)



Double feedback and multiple parallel units improve the performance

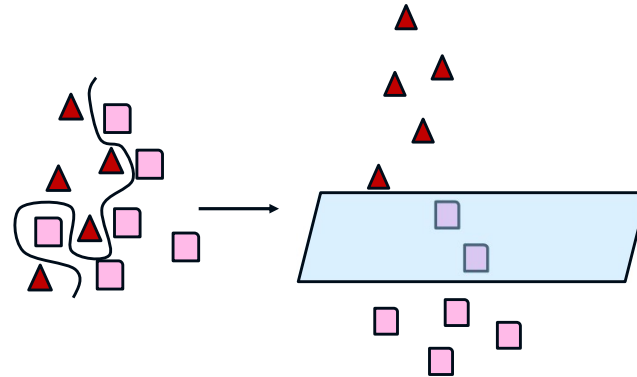


ON ARXIV SOON





SUCCESS STORY (highlights)



$$x_i \rightarrow \Phi(x_i) \rightarrow U_{x_i}|\psi\rangle$$

Can we get any boost using quantum effects?

nature photonics

View 5

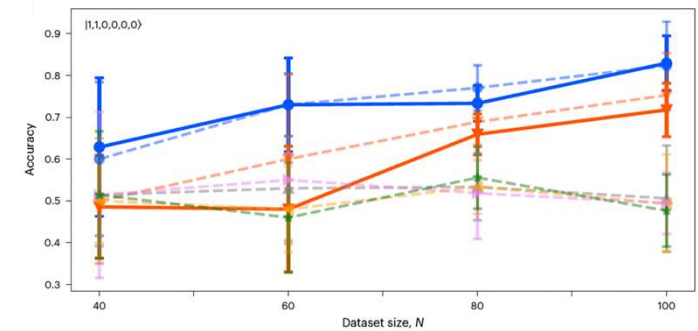
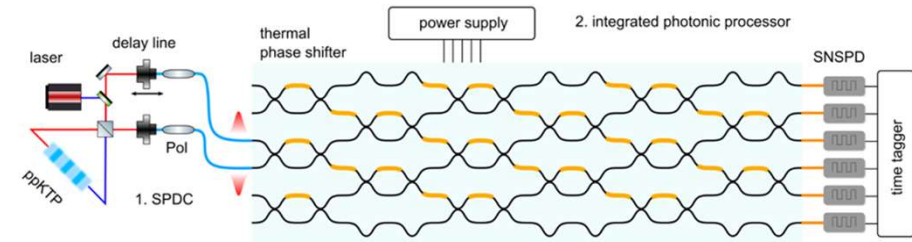
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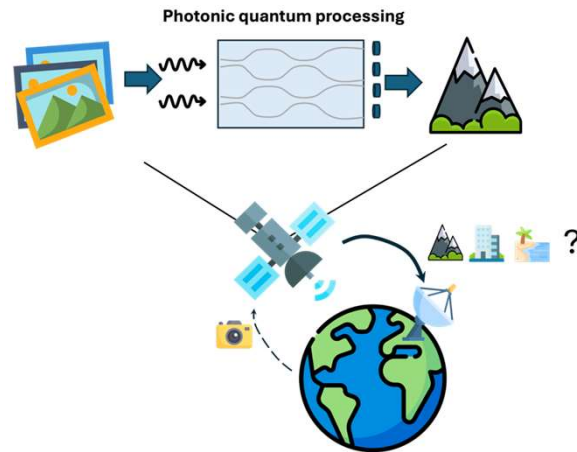
Experimental quantum-enhanced kernel-based machine learning on a photonic processor

[Zhenghao Yin](#) , [Iris Agresti](#) , [Giovanni de Felice](#), [Douglas Brown](#), [Alexis Toumi](#), [Ciro Pentangelo](#), [Simone Piacentini](#), [Andrea Crespi](#), [Francesco Ceccarelli](#), [Roberto Osellame](#), [Bob Coecke](#) & [Philip Walther](#)

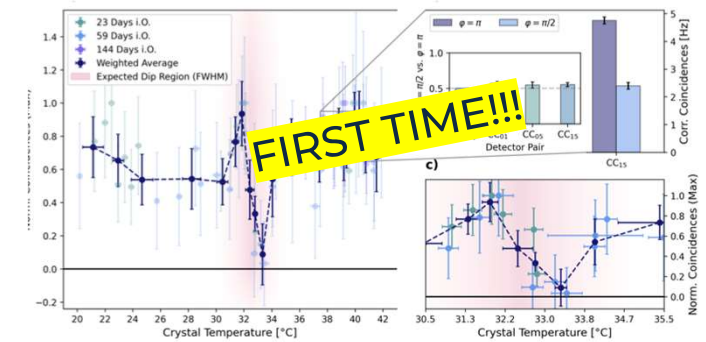
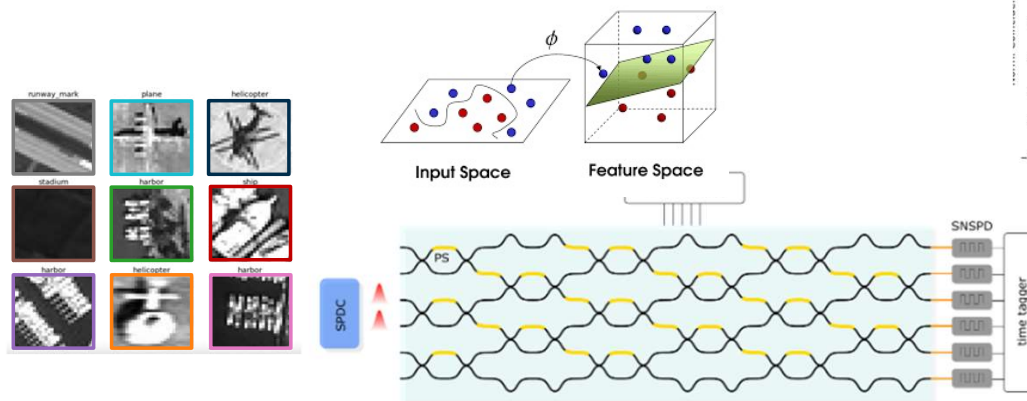




SUCCESS STORY (highlights)



Can we go to real world tasks?



NOW ON ARXIV!!

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IMPACT (potential users)

Relevant commercial applications

- Plug and play photonic modules (space-proof)
- Quantum enhanced classification algorithms



Cooperation with Quantum Flagship

EPIQUE (European Photonic Quantum Computer, Horizon Europe / Quantum Flagship) same photonic platform and components developed in PhoMemtor feed directly into the European photonic quantum computing effort.

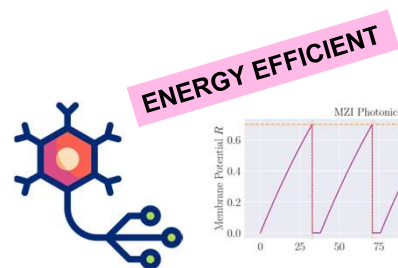
MSCA ITN APPQINFO

scientific overlap on quantum information processing

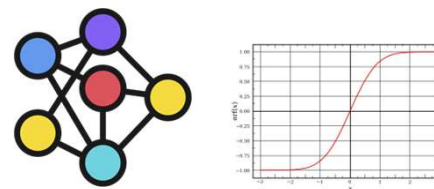


WHAT'S NEXT

- Quantum memristors as spiking neurons (?)

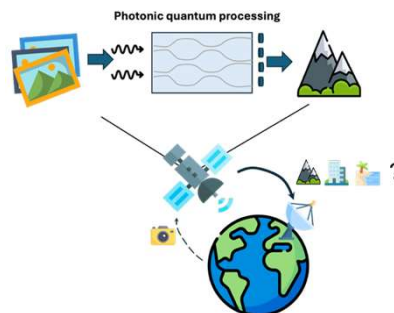


SPIKING NEURON



ARTIFICIAL NEURON

- Quantum computing in space





Co-funded by
the European Union