### AQGeTAD: DRONE TRAJECTORY OPTIMIZATION **UAS TRAFFIC MANAGEMENT Use-Case** QUANTUM COMPUTING SHAPING THE FUTURE OF UTM

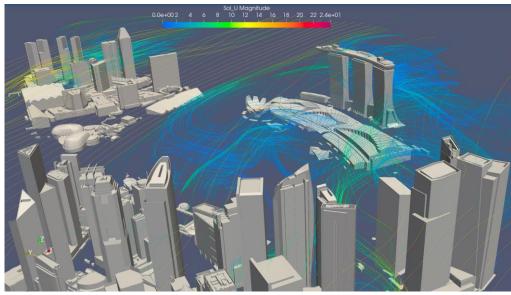
Frédéric **BARBARESCO** Quantum Algorithms & Computing Segment Leader THALES



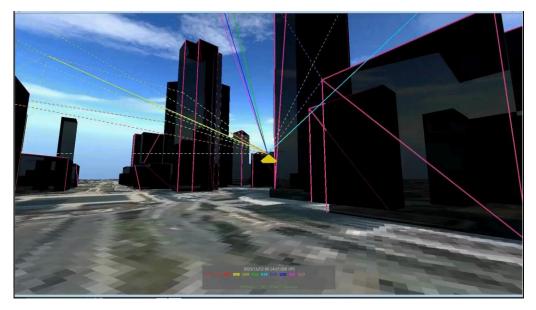








#### Wind/Turbulence Maps (NO-FLY Zone)



#### **GNSS** Drone **Positioning Accuracy**

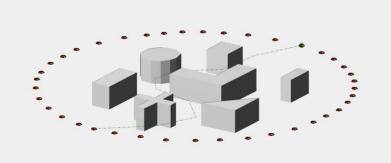
## THALES TOPSKY UAS

#### Mission Planning

**UAV** Operation planning

Strategic	Tactic		Authority		
TopSky – UAS Airspace Manager					
AIM & GIS		Conformance Monitoring			
Authorization & Notification		Strategic Deconfliction			
Risk Management		Fairness monitoring			
Emergency management		Noise management			







#### Trajectory Computation on QPU

#### **Drone Trajectory Optimization**

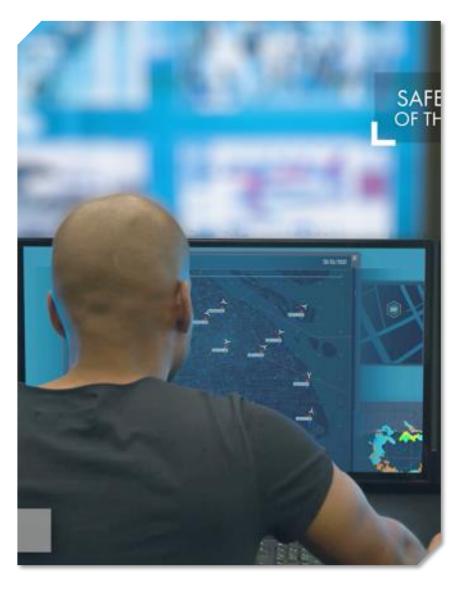


#### TopSky - UAS Surveillance

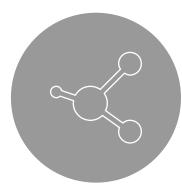
Traffic & Surveillance

Remote ID Service





#### Manage airspace access



#### Monitor traffic conformance

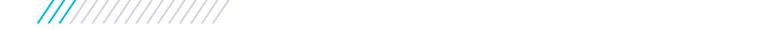






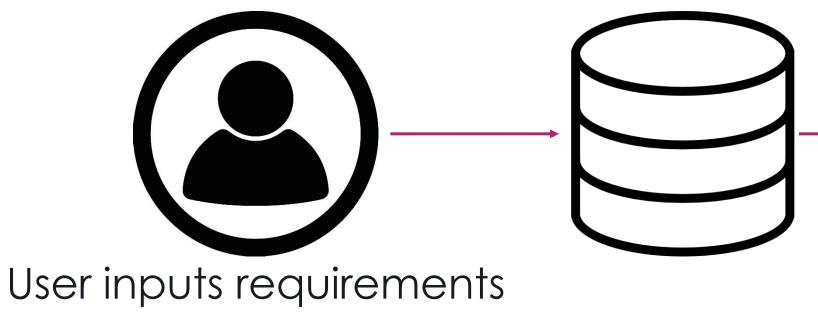


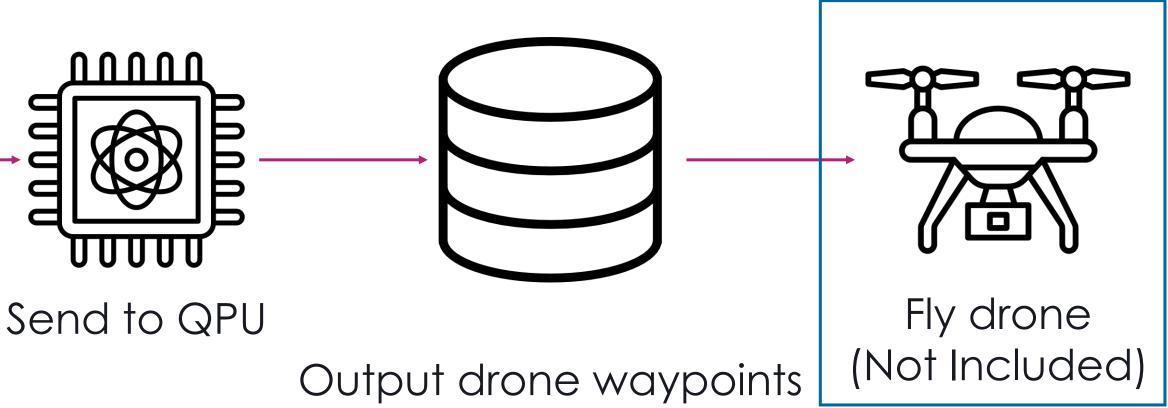




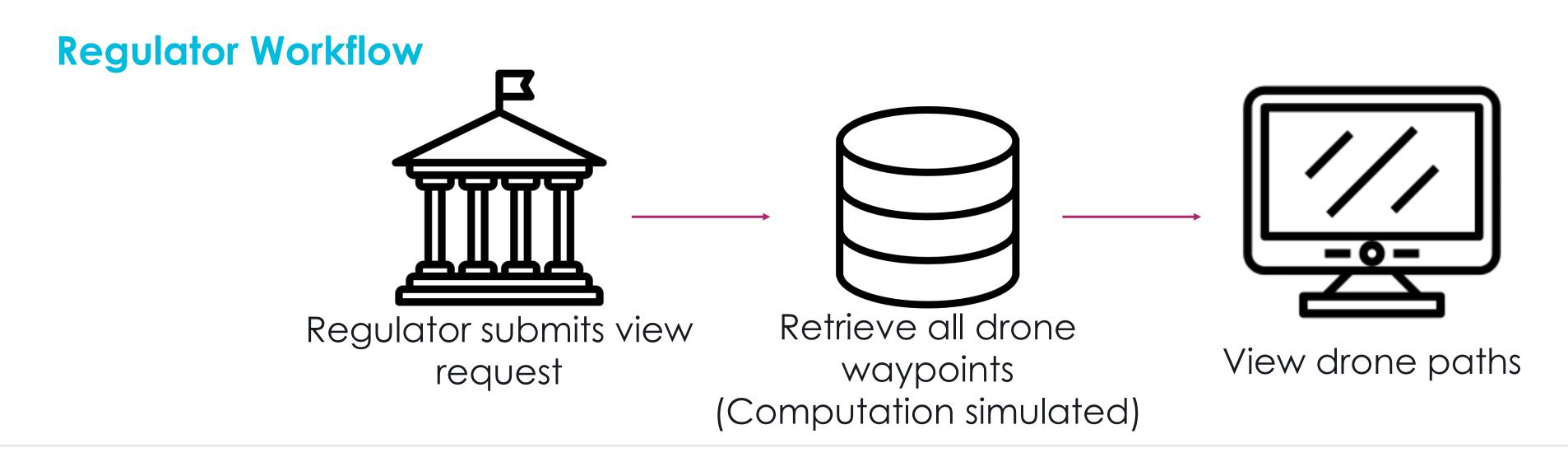
### **QPath end-to-end workflow**

#### **User Workflow**





Requirements stored









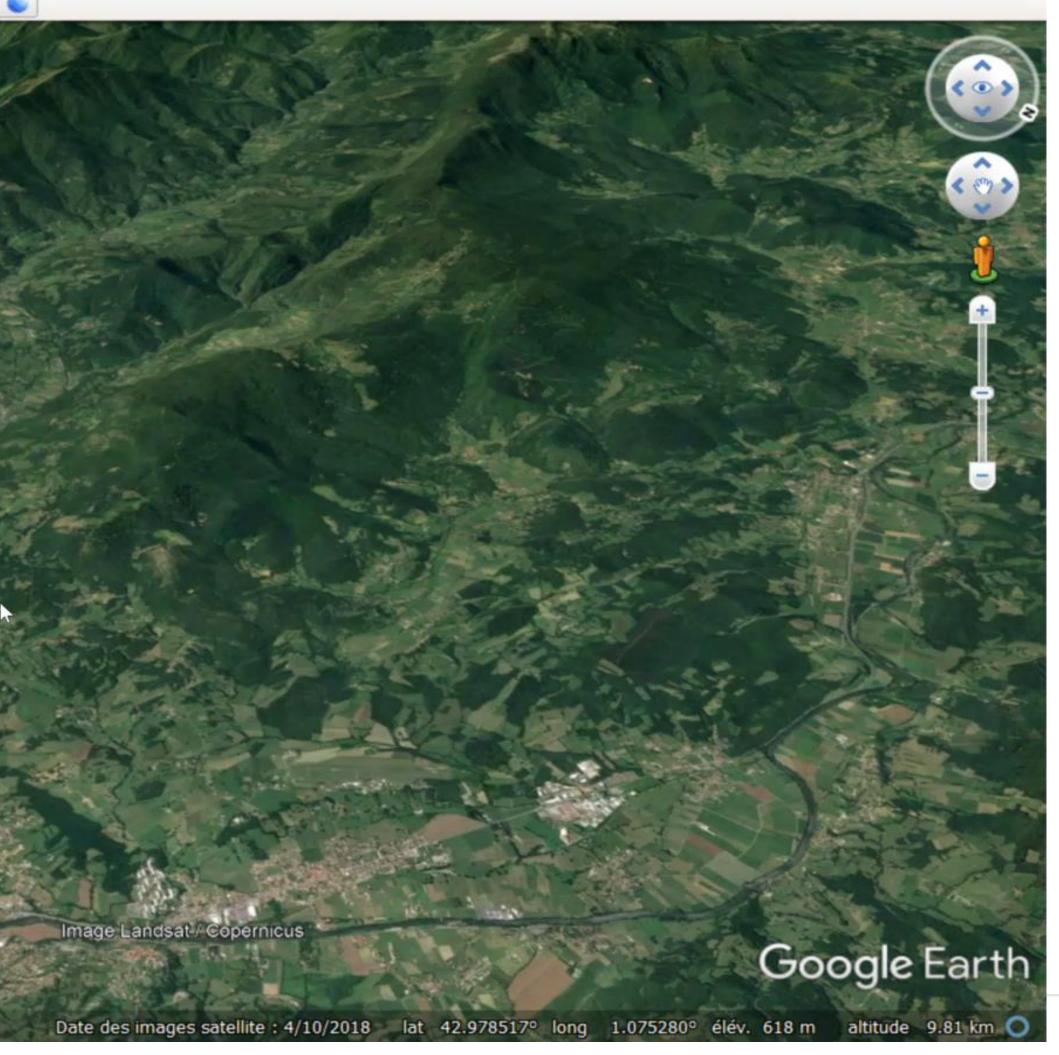


#### Other applications: Mission-planning for collaborative fleet/swarm of drones (safe landing proximity constraints, autonomy/energy constraints, « nofly zone » constraints, Gnss-Denied positioning accuracy constraints, communication constrained, observation constraints, ...)

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geo fencing	with the beautiest the second second
<ul> <li>exclusionZones</li> <li>start and stop</li> <li>2-ground vehicles initial planing</li> <li>&amp; GV trajectory</li> <li>3-SPYRANGER reconnaissance mission</li> <li>A_drone mission planning</li> <li>B - drone trajectories</li> <li>C - ROEM collaborative detection</li> <li>4-threats handling</li> <li>threats visibility zones</li> <li>ground vehicle approach trajectory</li> <li>collaborative reconnaissance mission by 3 cob</li> <li>shooting points</li> <li>collaborative trajectories</li> <li>destroy threats</li> <li>S-ground vehicle resume their initial mission</li> <li>&amp; ground vehicle trajectory</li> </ul>	
	and the second of the second s
<ul> <li>Calques</li> <li>Base de données principale</li> <li>Loading</li> <li>Frontières et légendes</li> <li>Lieux</li> <li>Photos</li> <li>Routes</li> </ul>	2 1984

Building a future we can all trust

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AQGeTAD - Quantum advantage for drone traffic management

Optimisation of drone trajectories using single photons decision making

Arno RICOU Credits to Giacomo FRANCESCHETTO for slides

### THALE5

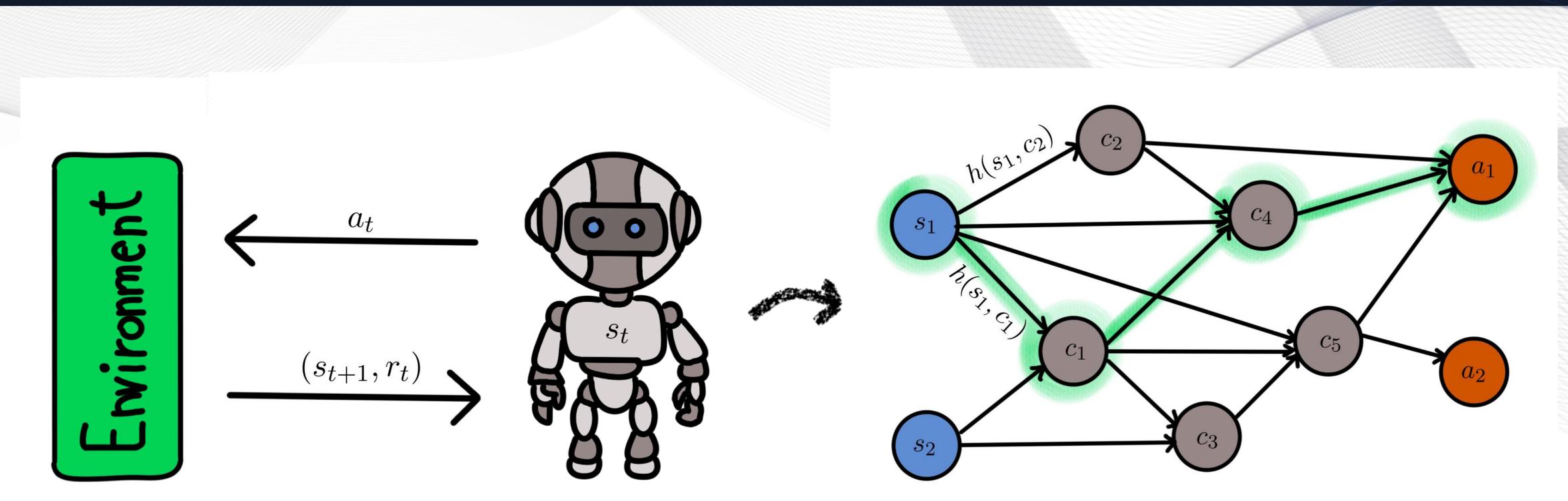


JUANDE





### Q Projective Simulation Reinforcement Learning and Decision Making

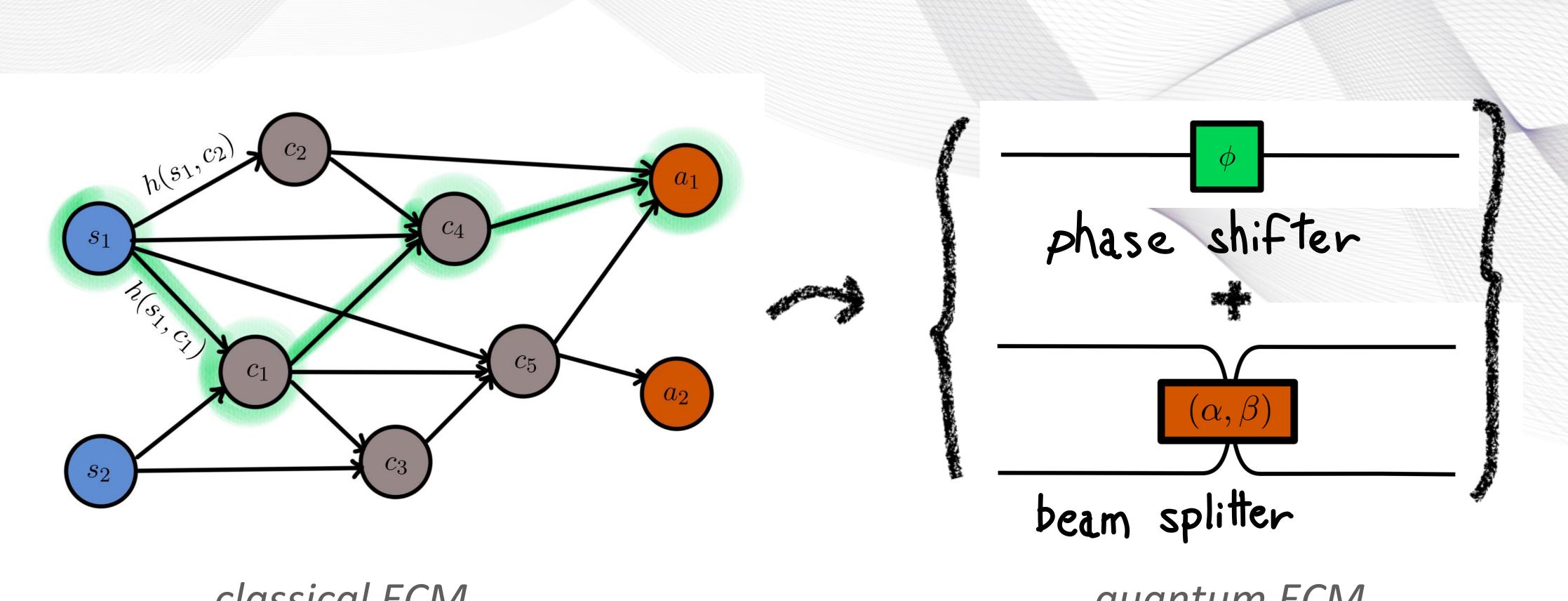


**goal**: maximize the long term accumulated reward

random walk through the Episodic Compositional Memory



# Quantum Optical Projective Simulation Quantized episodic compositional memory (ECM)

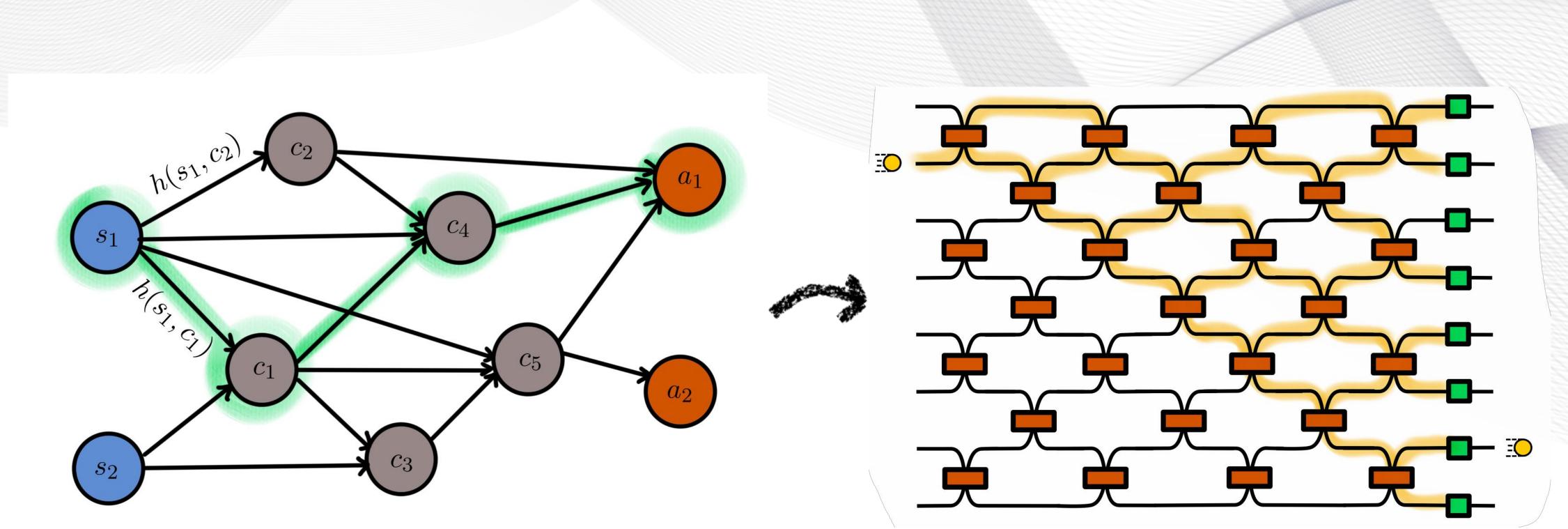


classical ECM

quantum ECM



### Quantum Optical Projective Simulation Quantized episodic compositional memory (ECM)

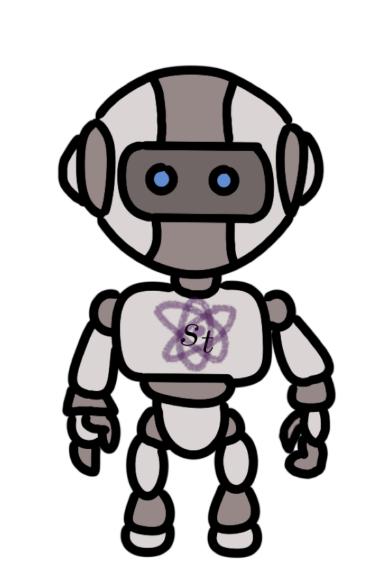


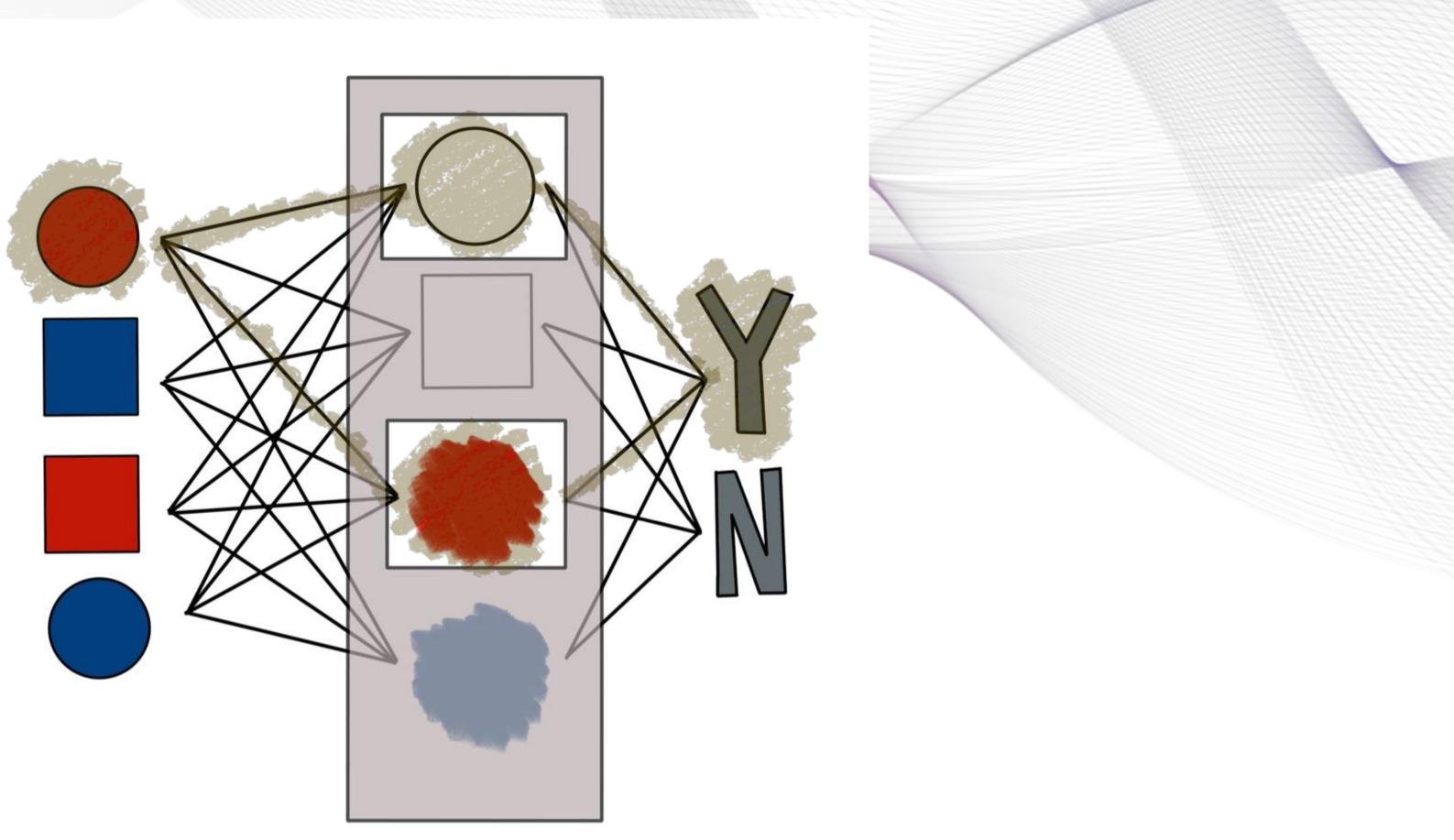
classical ECM

quantum ECM



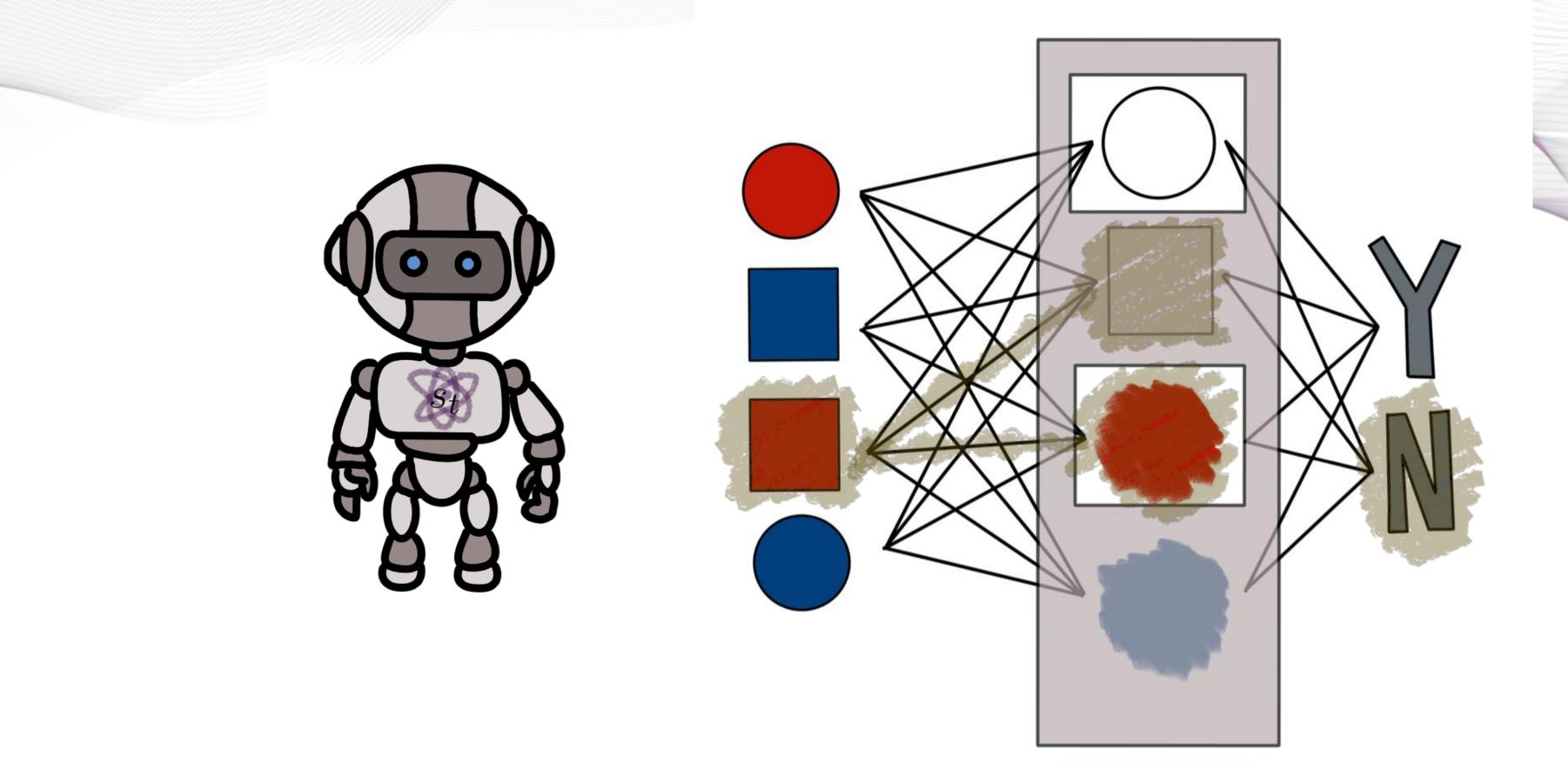
### Quantum Optical Projective Simulation A transfer-learning scenario : final stage





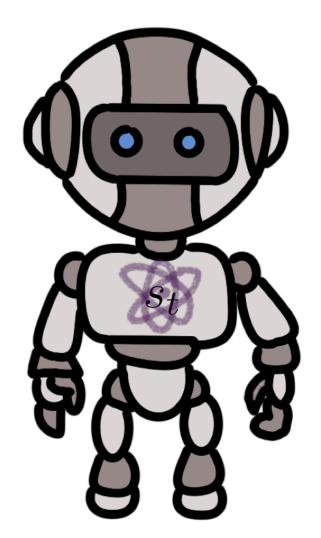


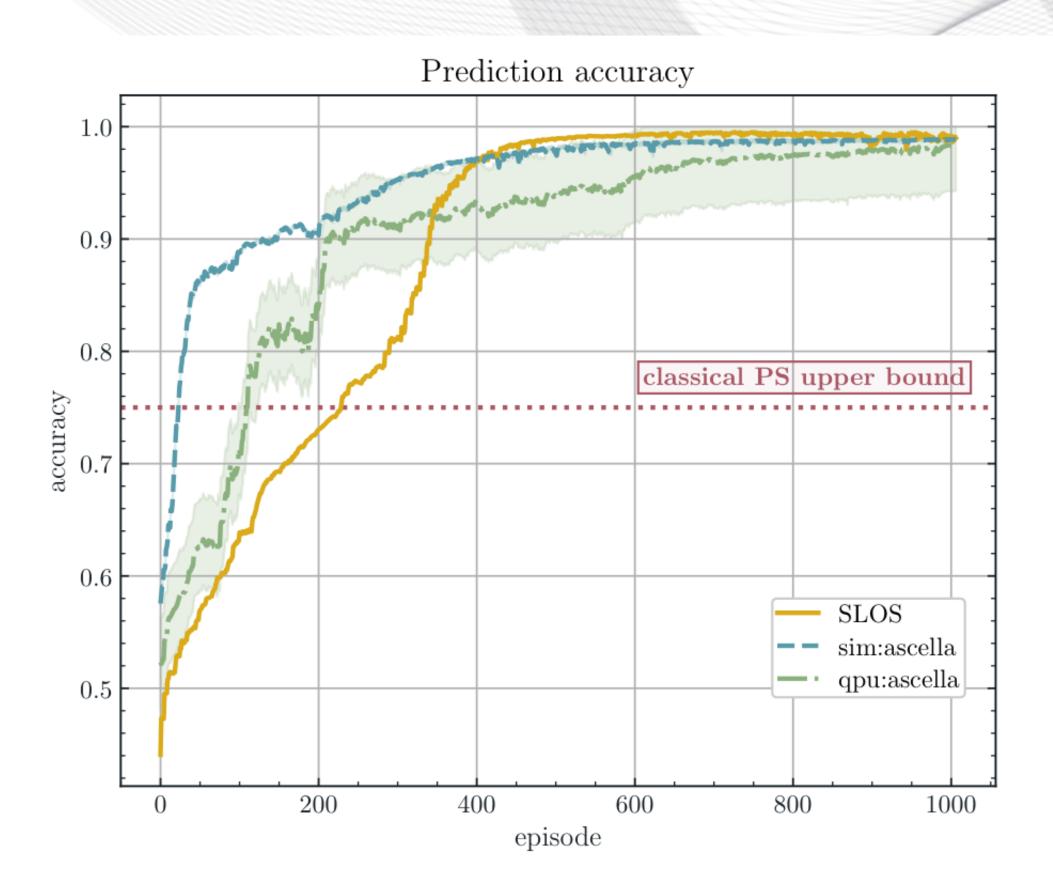
### Quantum Optical Projective Simulation A transfer-learning scenario : final stage





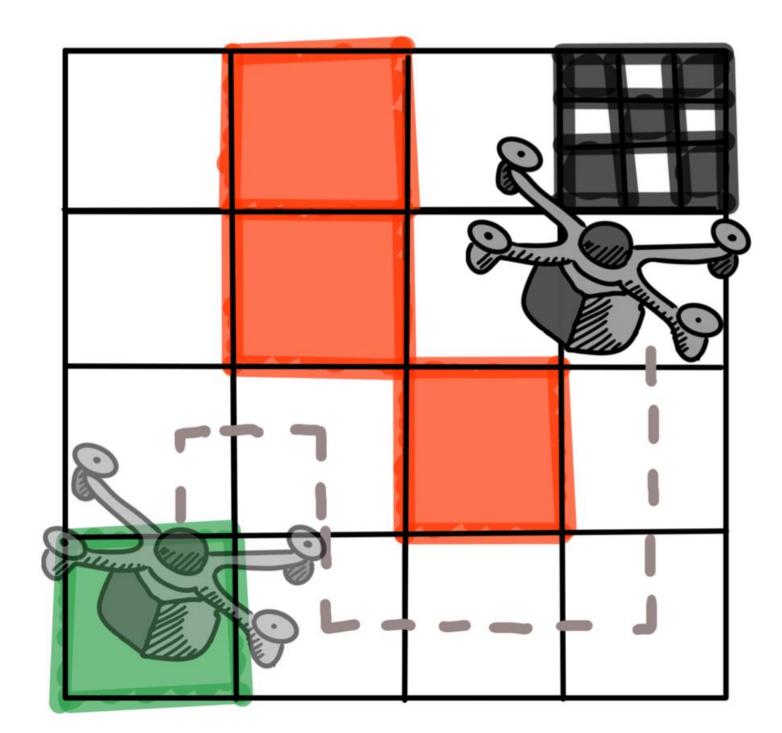
### Quantum Optical Projective Simulation A transfer-learning scenario : final stage



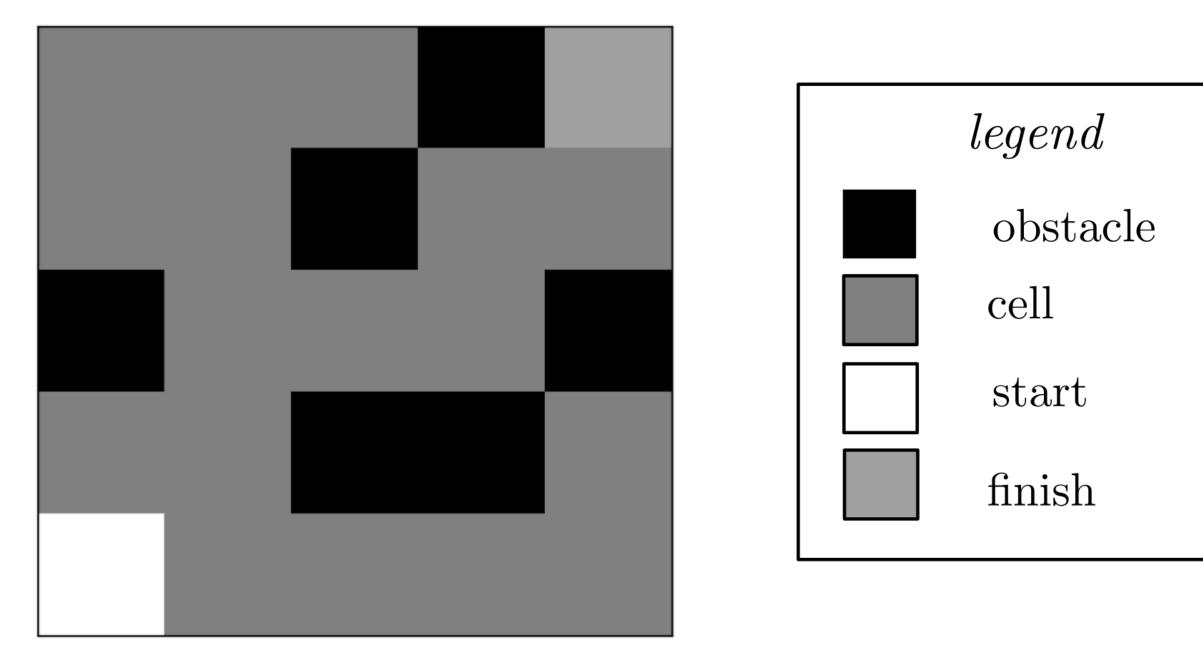




### Quantum Optical Projective Simulation QOPS solving a grid path-finding like problem

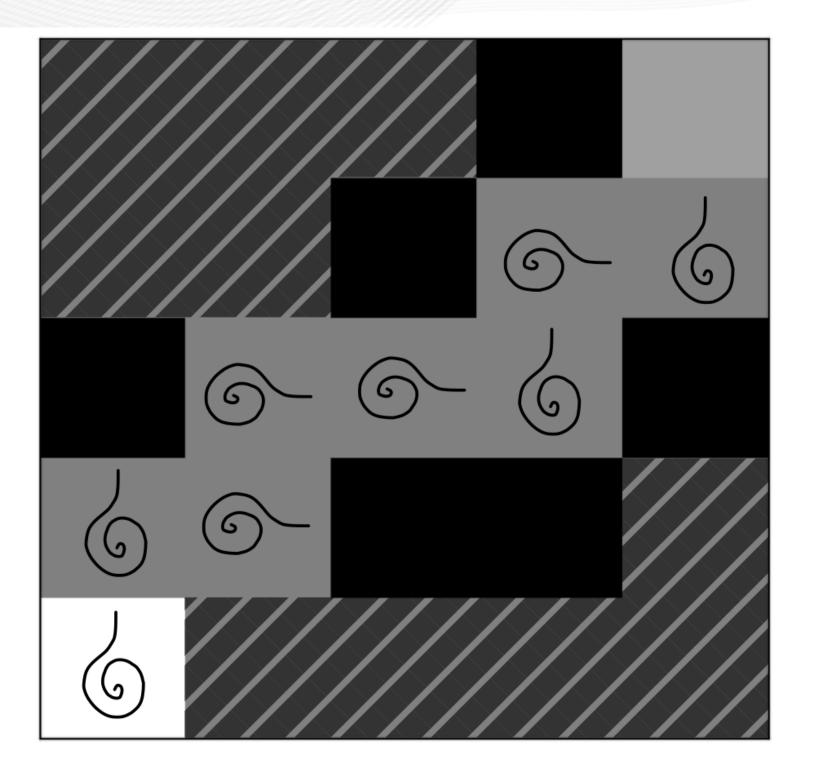


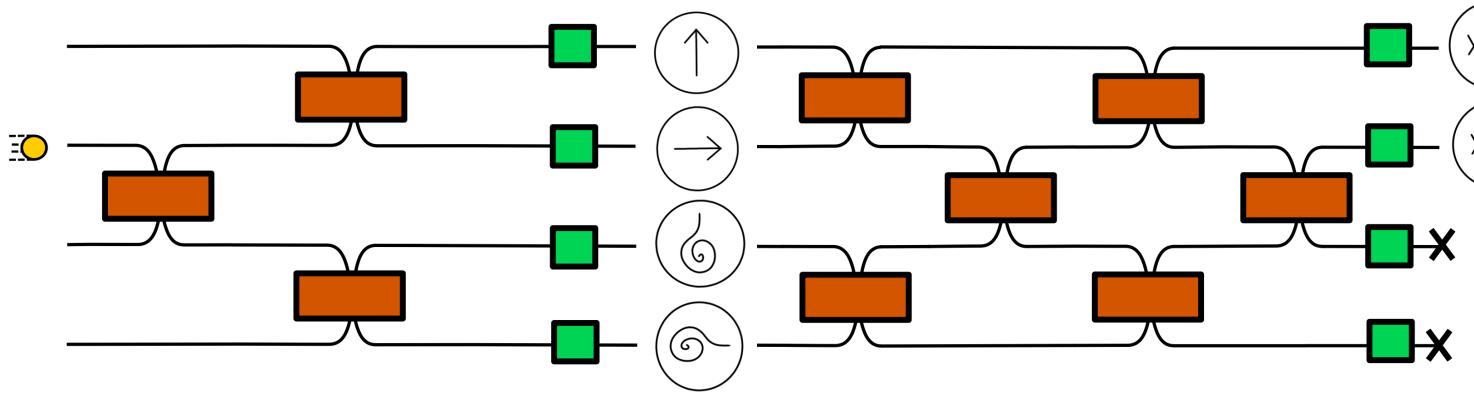






### Quantum Optical Projective Simulation QOPS solving a grid path-finding like problem





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			SLOS		
grid point	direction	wind	$p_{\rm single}$	$p_{ m double}$	
(0, 0)	up	down	0.001	0.999	
(0,1)	$\operatorname{right}$	down	0.993	0.007	
(1,1)	up	left	0.993	0.007	
(1,2)	$\operatorname{right}$	left	0.000	1.000	
(2,2)	$\operatorname{right}$	left	0.002	0.998	
(3,2)	up	down	0.000	1.000	
(3,3)	$\operatorname{right}$	left	0.000	1.000	
(4, 3)	up	down	0.000	1.000	



# Next steps

We also studied and will discuss this afternoon :

- Multi-photon in the quantum ECM
- Entangled photons in quantum ECM
- New applications for collision prevention with drones

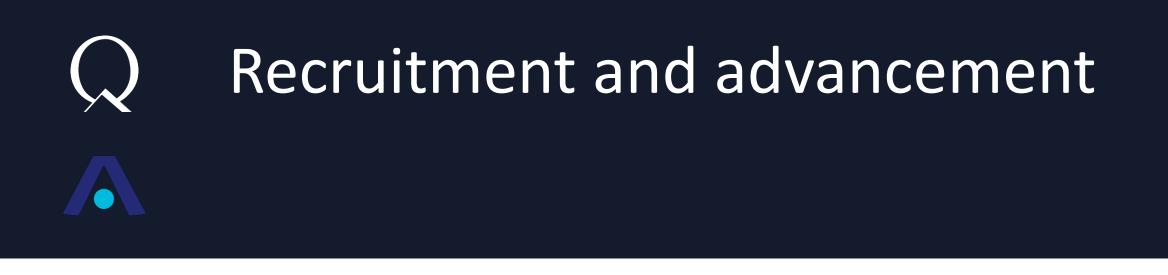
And plan to :

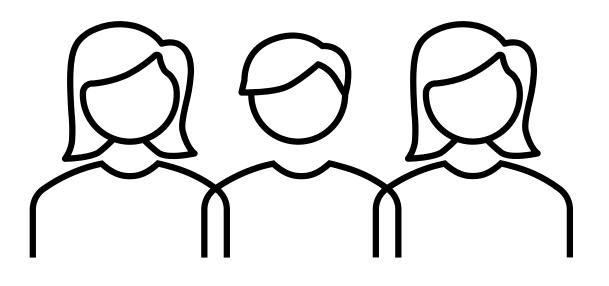
- Implement on QPU multi-photon quantum ECM for collision prevention
- *Optimize resources (modes, photons, parameters)*
- Benchmark with classical SoA and predict when quantum advantage will happen



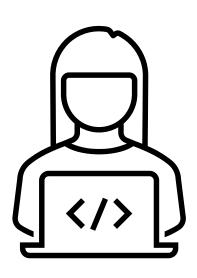
quantum ECM with multiple photons







*3 internships of six months recruited by Quandela for AQGeTAD* 



### 1 applications engineer working on it

