



Quantum Climate Challenge
2022

Reducing the climate impact of air travel via optimized routing

Team Quantimize



Quantimize



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Jezer Jojo

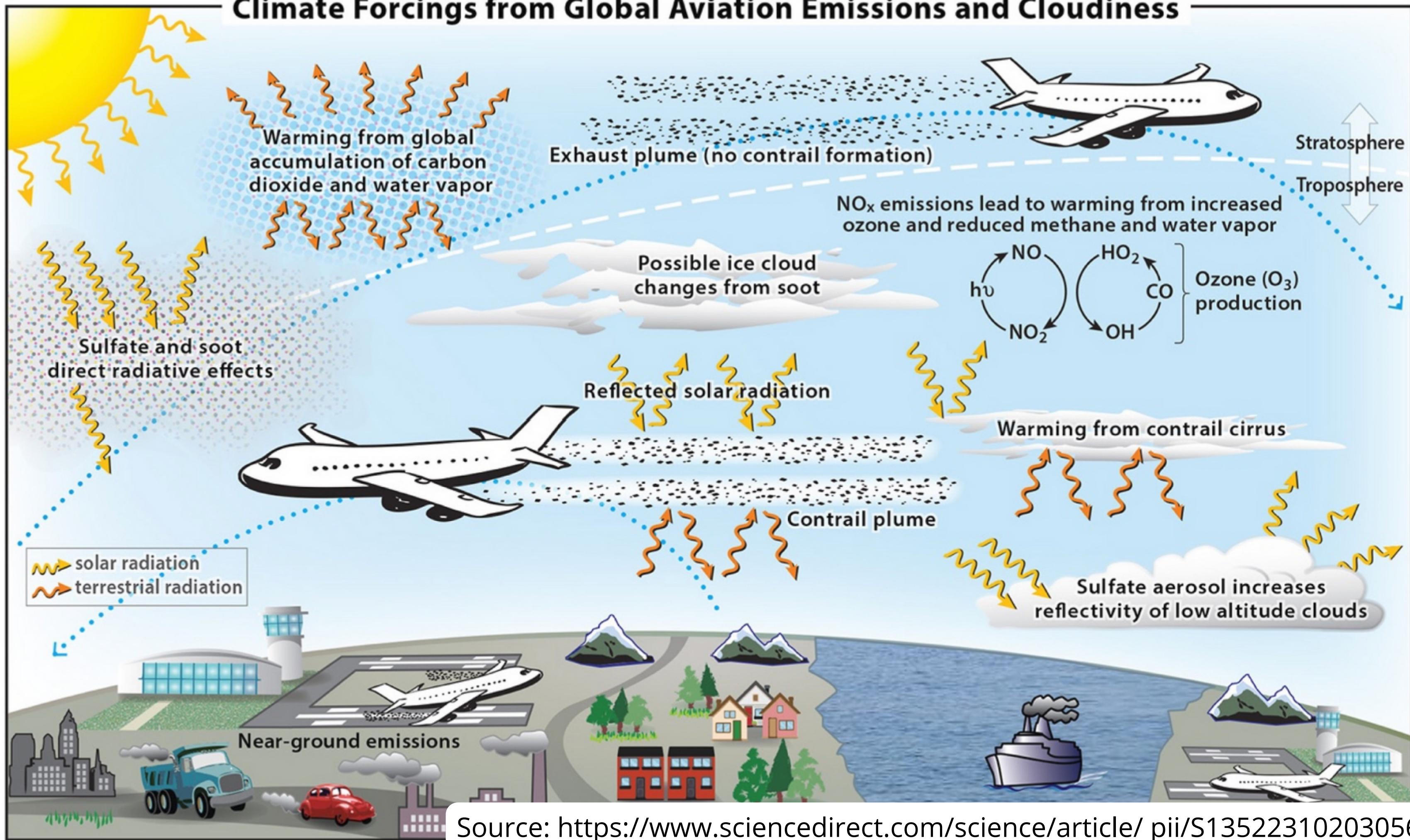
BSMS
IISER Pune



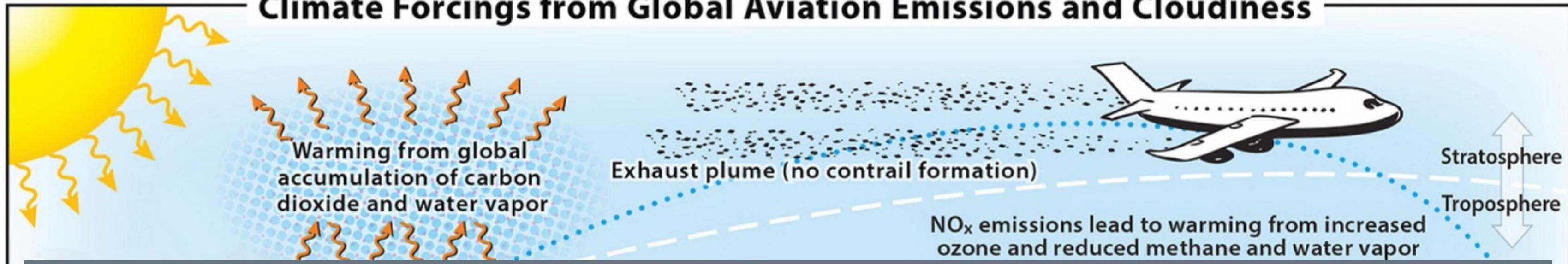
Winner of the local Qiskit Fall Fest 2021

2nd place at the Qiskit Global Hackathon 2021

Climate Forcings from Global Aviation Emissions and Cloudiness



Climate Forcings from Global Aviation Emissions and Cloudiness



The flight route matters!



Why Quantum?

Bit
(Classical Computing)

0



1

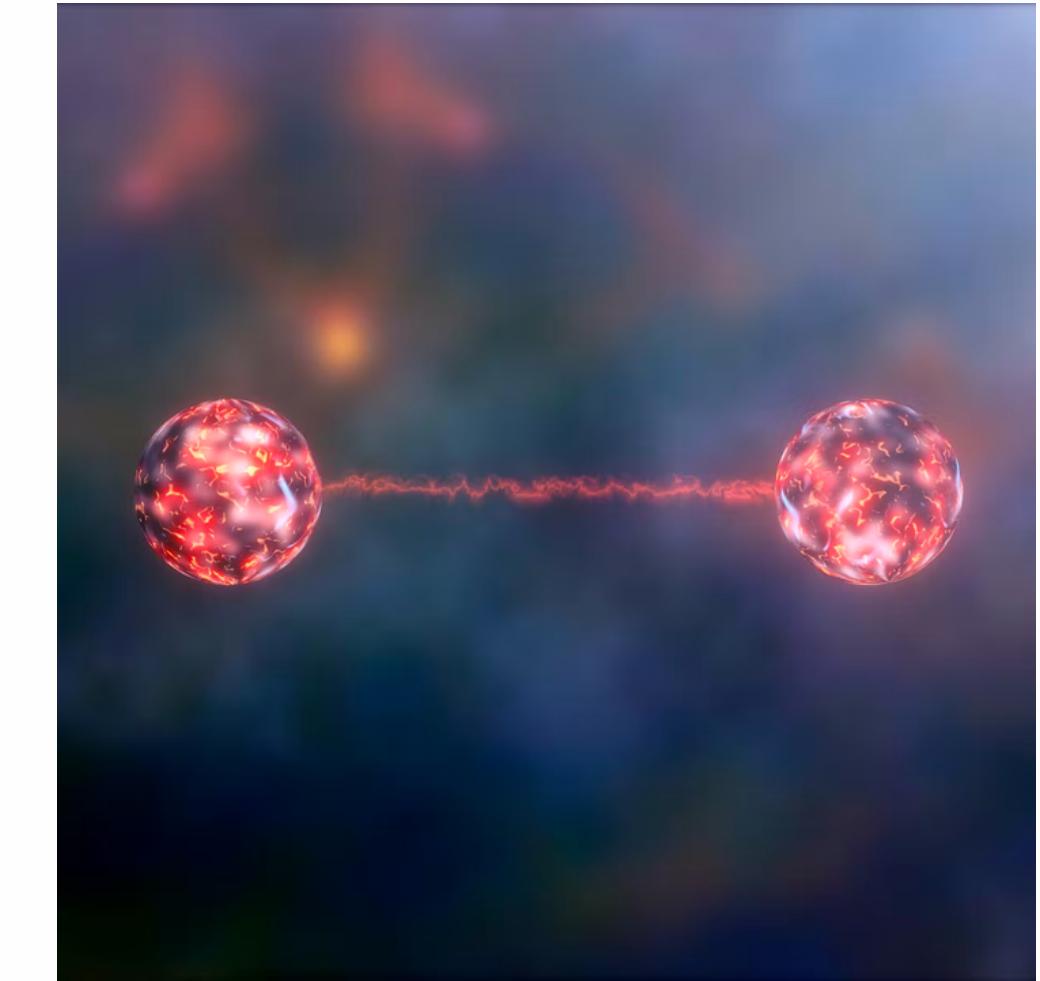


Qubit
(Quantum Computing)

0



1



Superposition

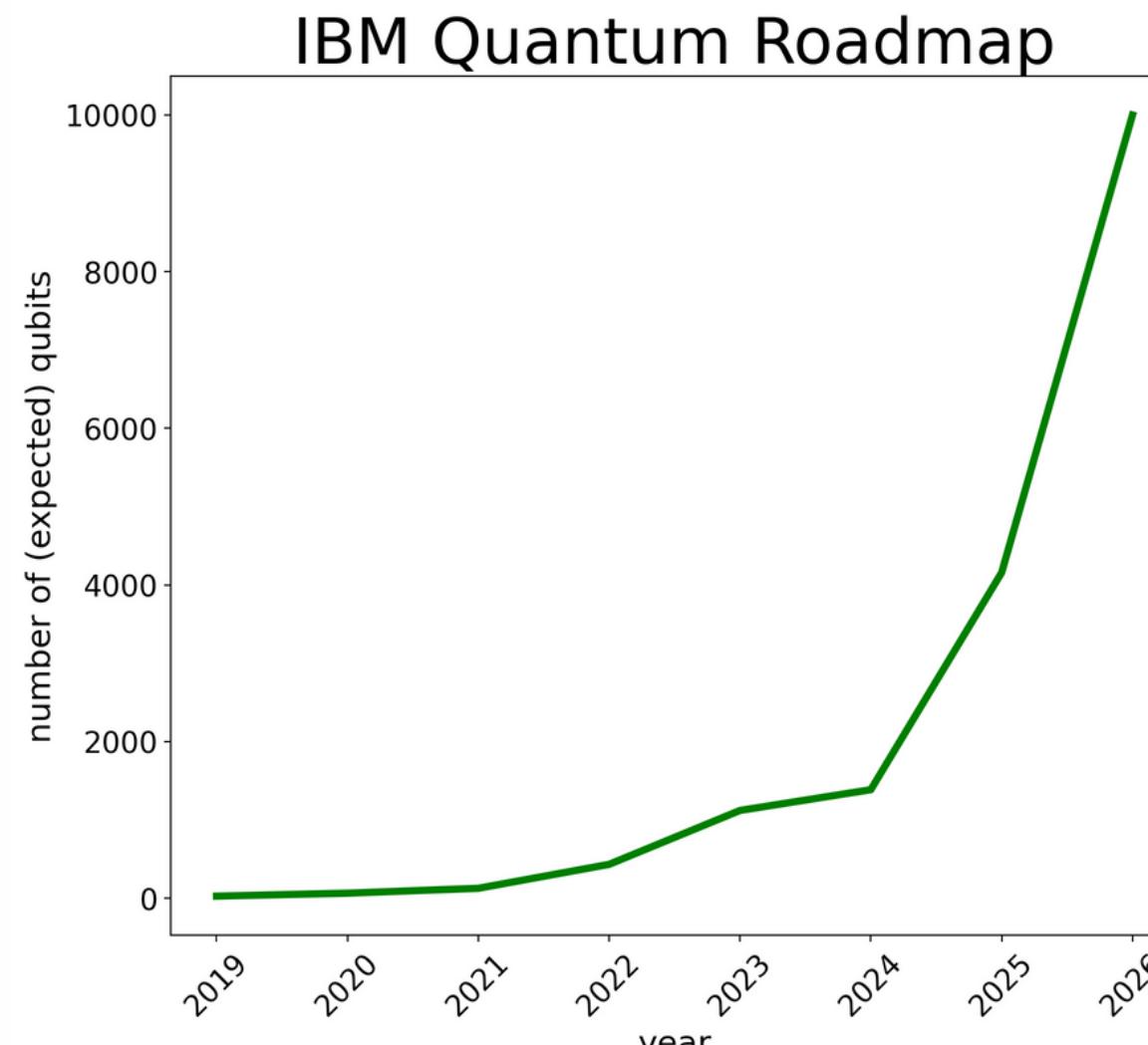
Entanglement

Quantum Parallelism:
"Many solutions evaluated simultaneously in one trial!"

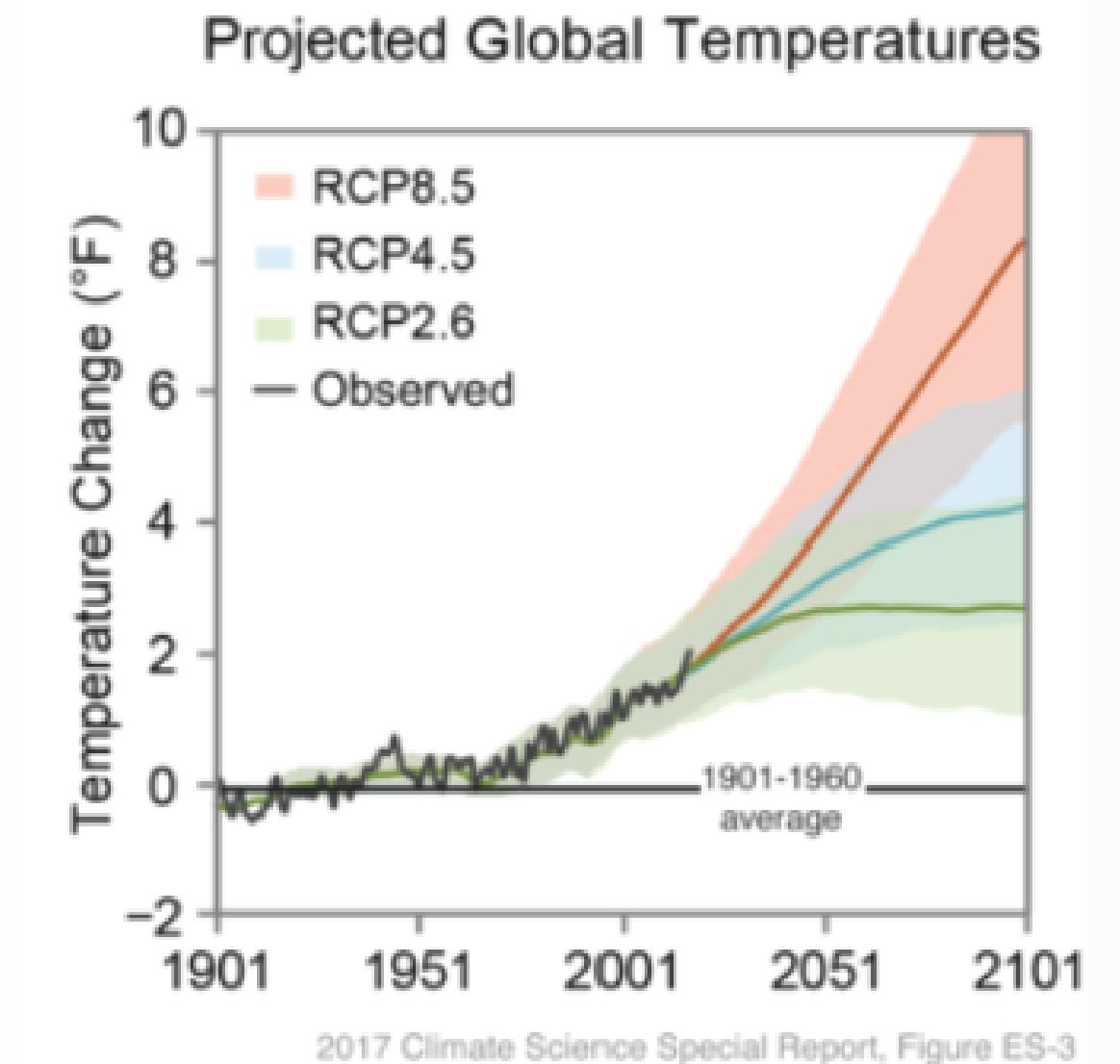
Why NISQ?

(Noisy Intermediate
-Scale Quantum)

We need a solution
soon!

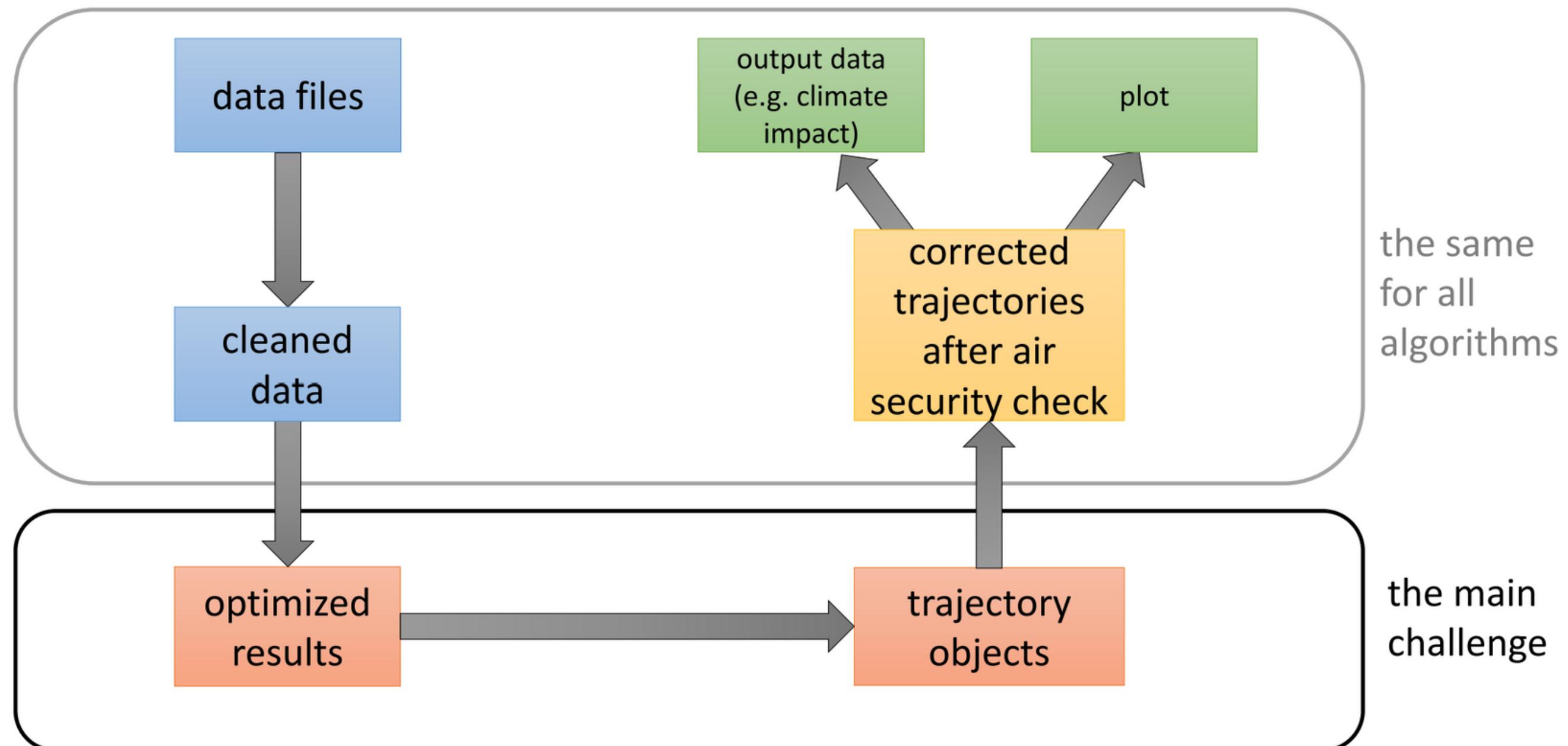


[https://research.ibm.com/blog/
ibm-quantum-roadmap-2025](https://research.ibm.com/blog/ibm-quantum-roadmap-2025)



<https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature>

Process Flow





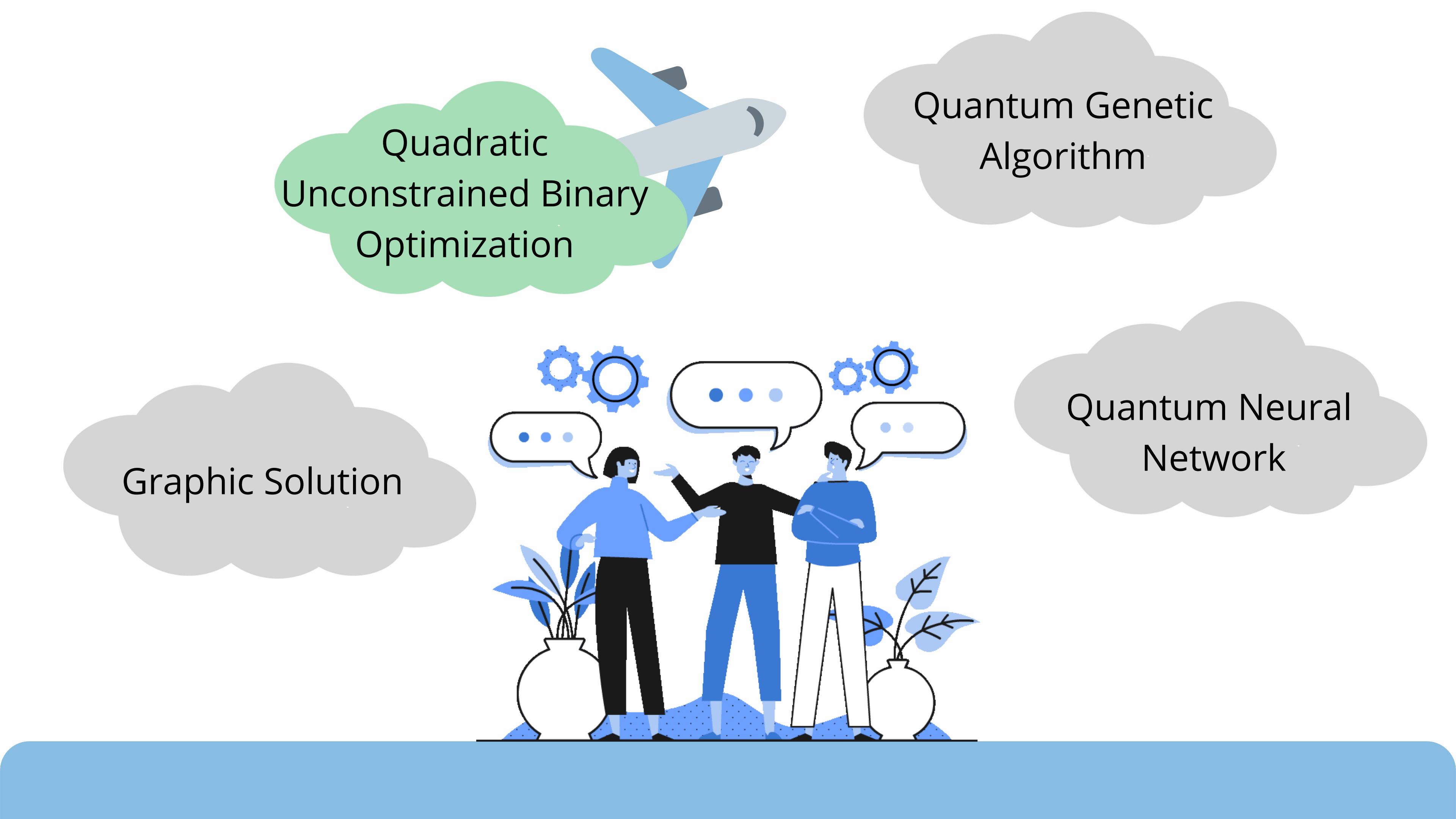
Quadratic
Unconstrained Binary
Optimization

Quantum Genetic
Algorithm



Graphic Solution

Quantum Neural
Network



Quadratic
Unconstrained Binary
Optimization

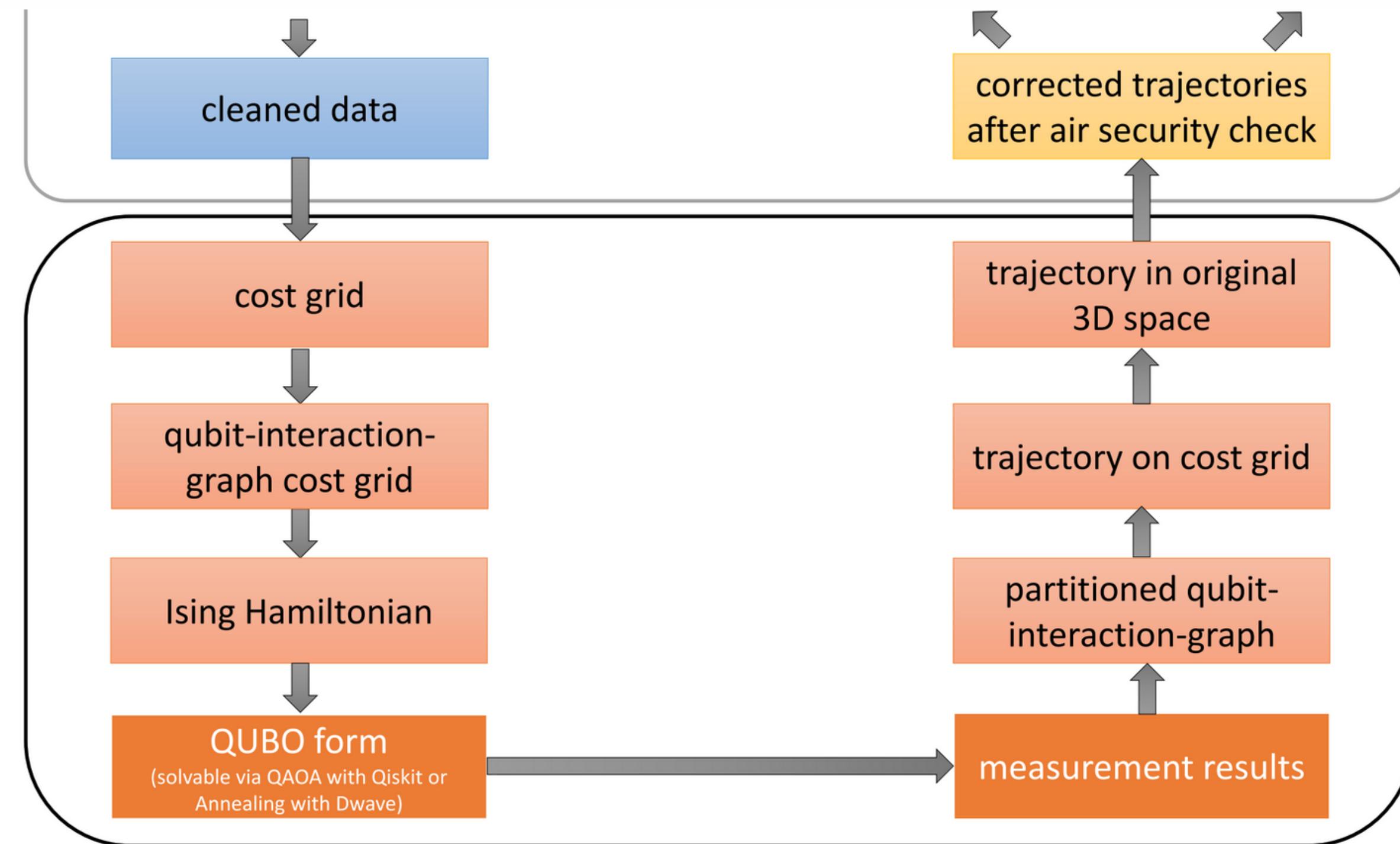
Quantum Genetic
Algorithm

Graphic Solution

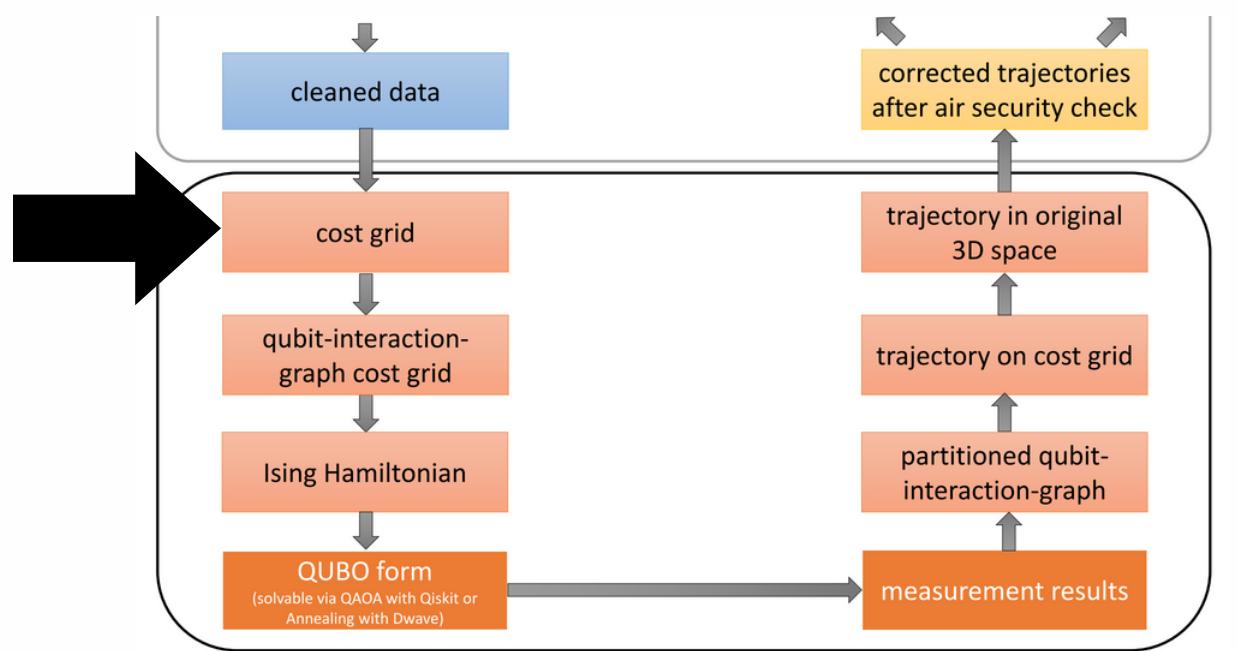
Quantum Neural
Network



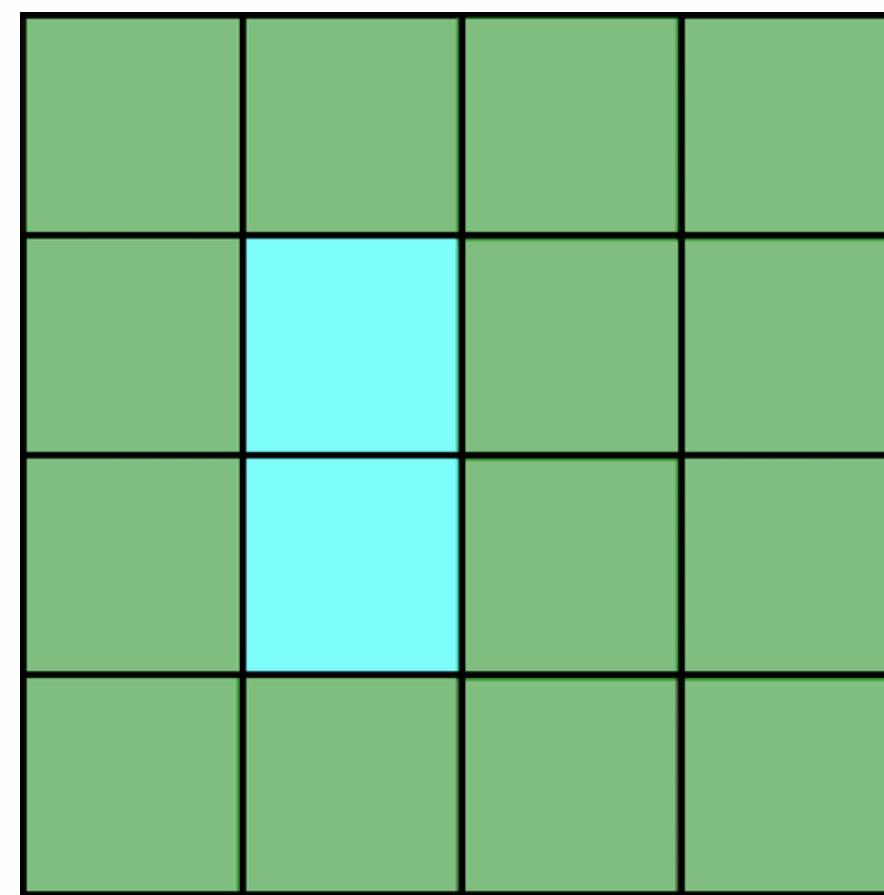
Quadratic Unconstrained Binary Optimization



QUBO 2D: Proof of principle

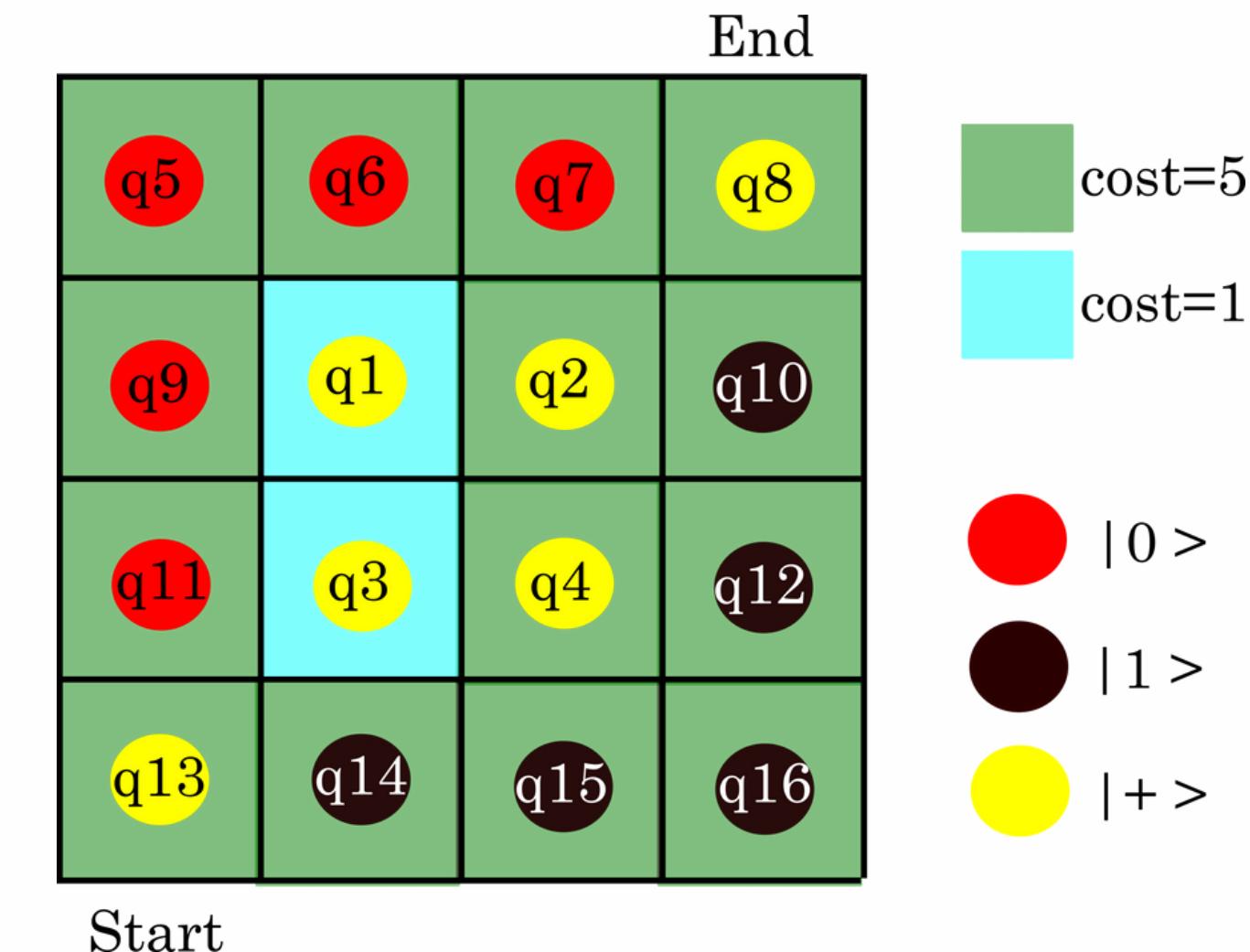
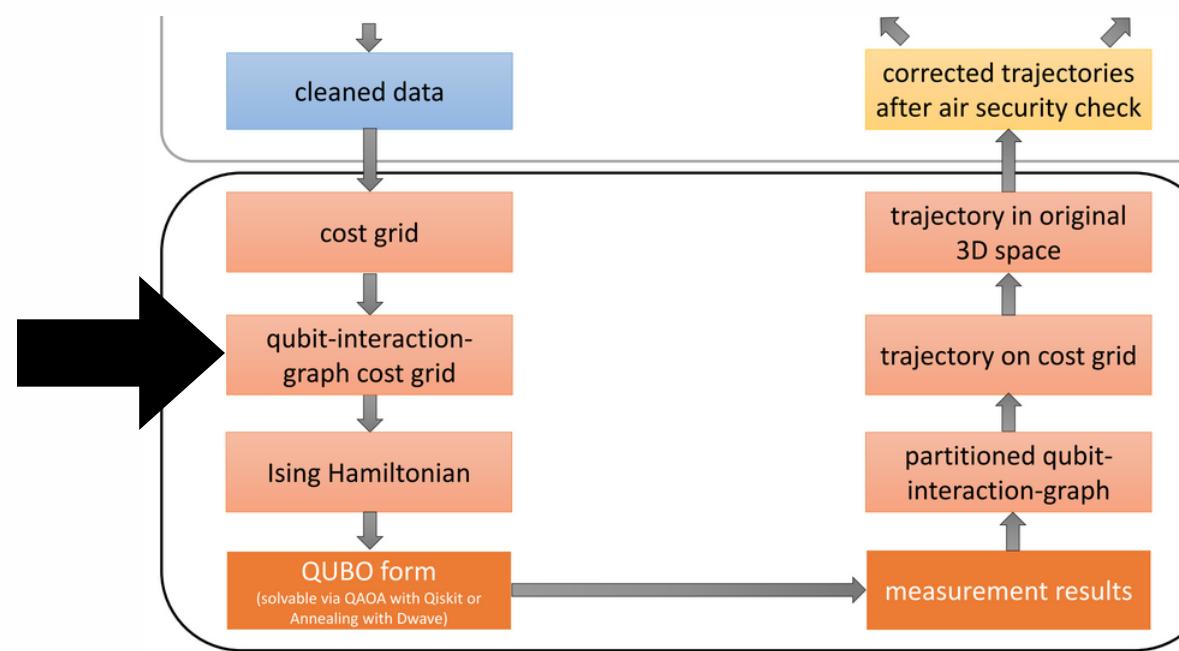


*discretize
atmospheric data
to cost grid*

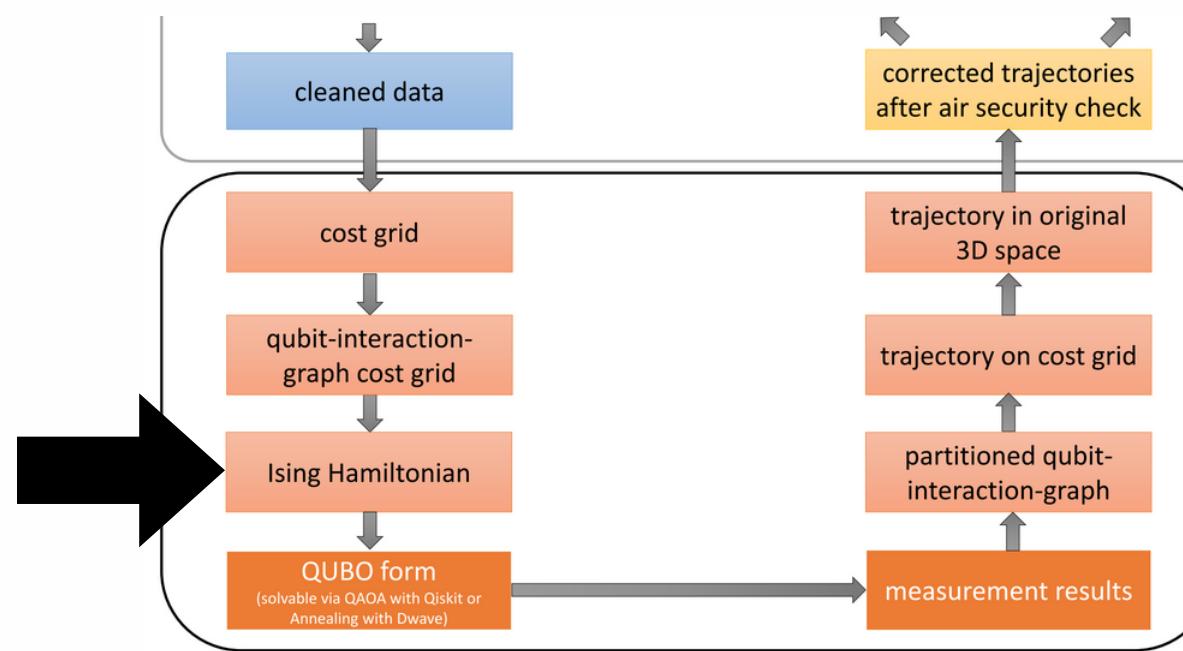


cost=5
cost=1

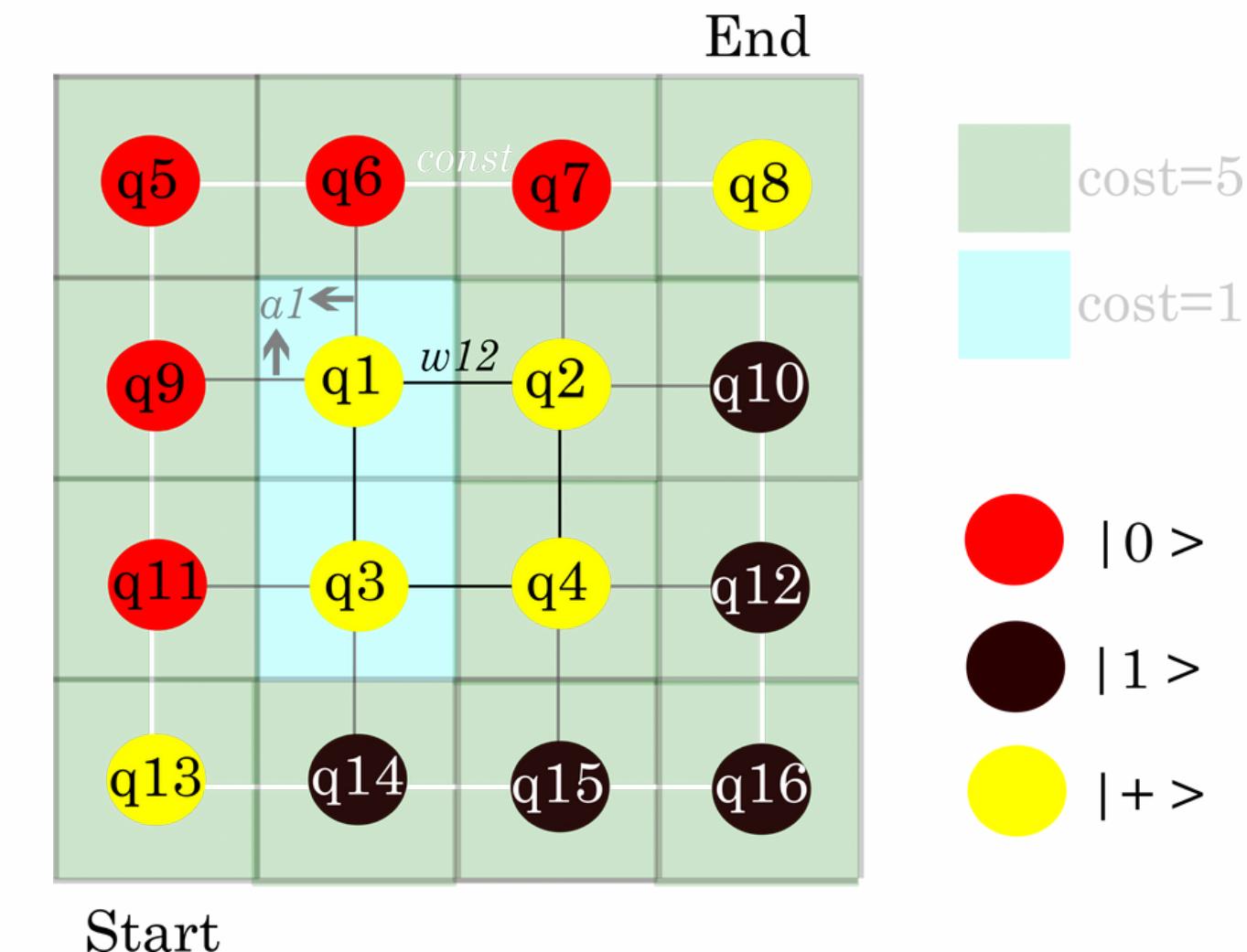
QUBO 2D: Proof of principle



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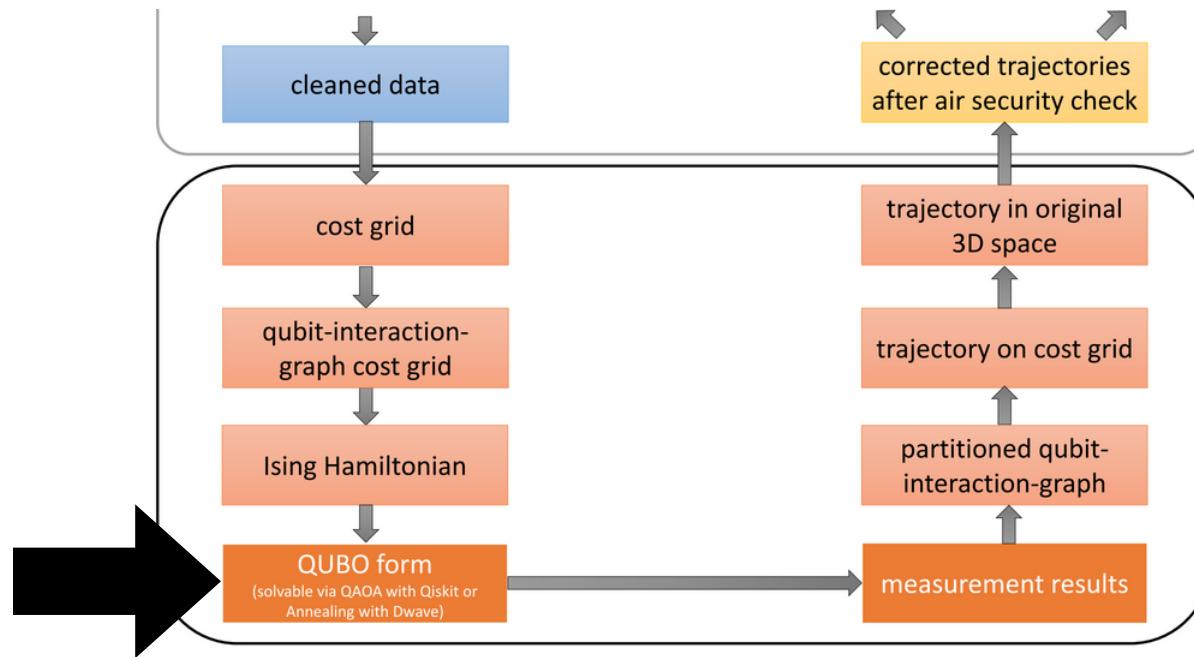


calculate cost Hamiltonian

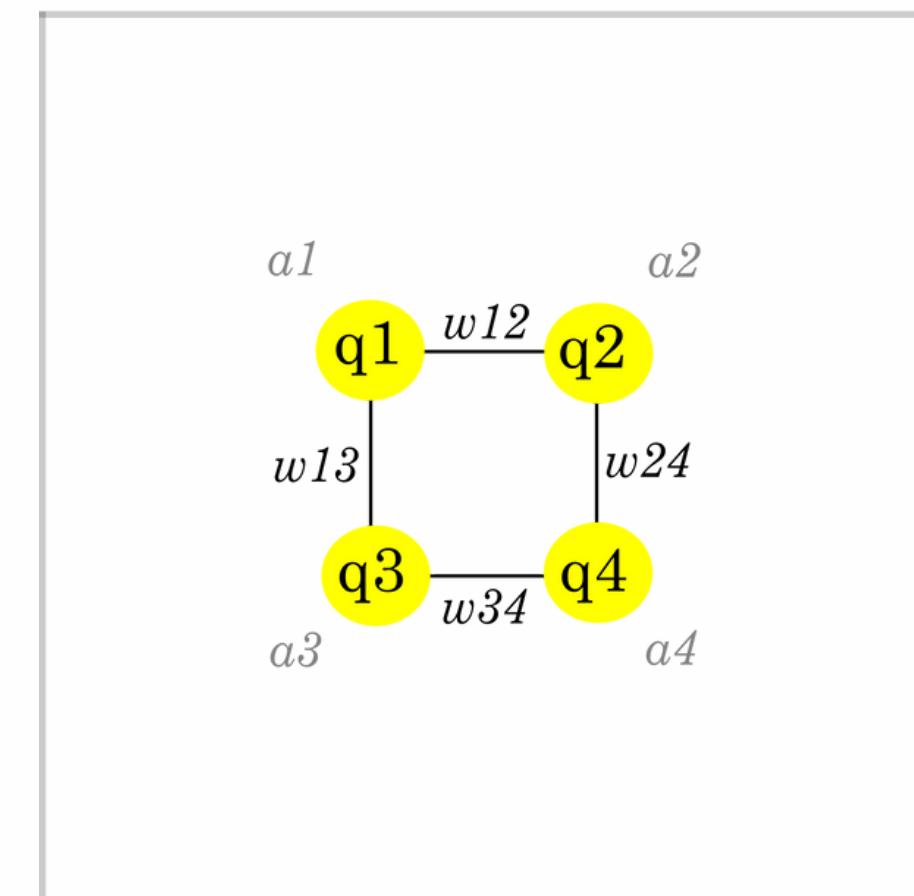


$$H_C = - \sum_{\langle i,j \rangle} w_{ij} Z_i Z_j - \sum_{i=1}^4 a_i Z_i$$

QUBO 2D: Proof of principle

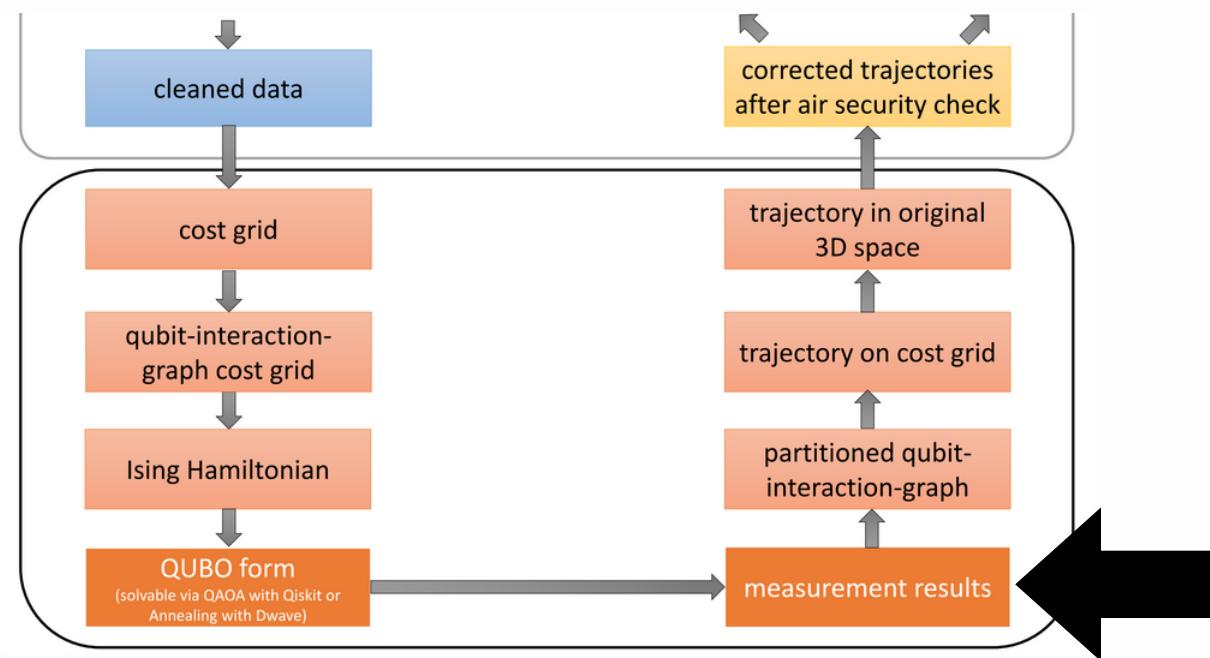


***formulate Hamiltonian
as QUBO problem,
solve via QAOA***

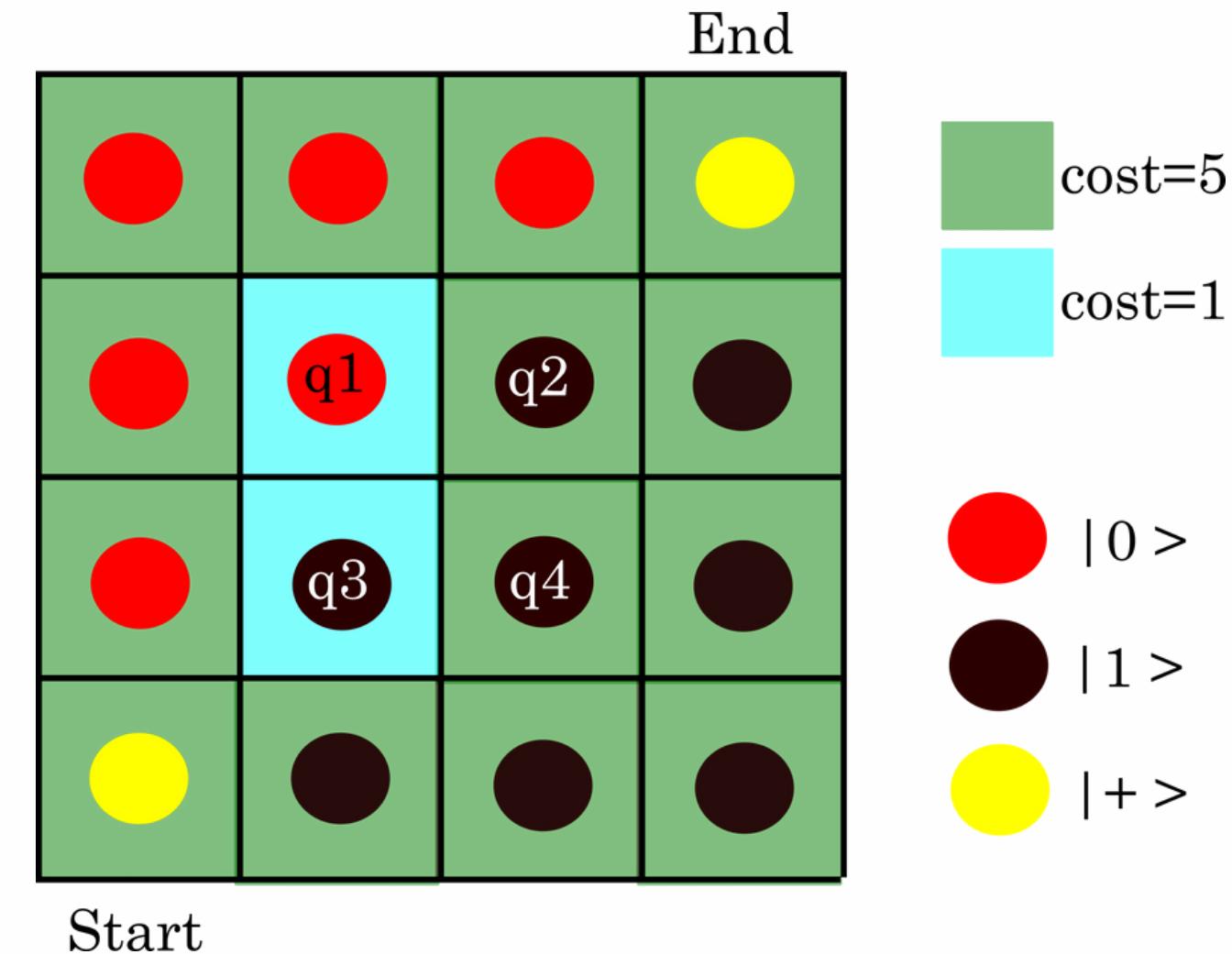


$$C = \sum_{\langle i,j \rangle} \tilde{w}_{ij} q_i (1 - q_j) + \sum_{i=1}^4 \tilde{a}_i q_i$$

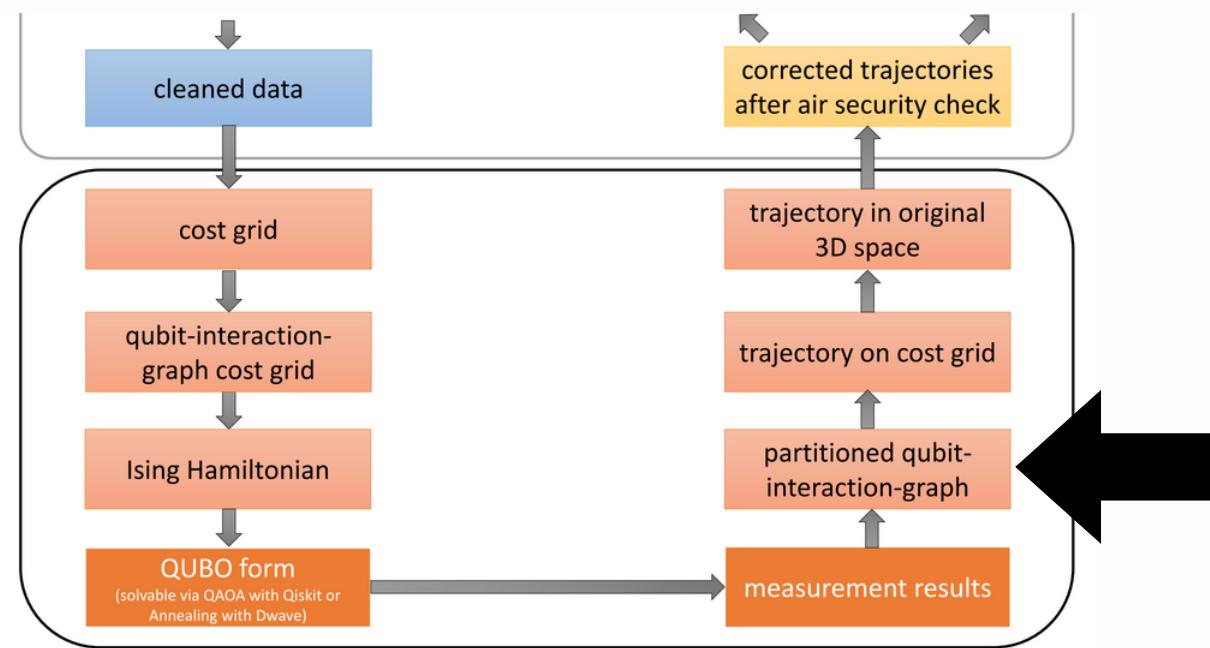
QUBO 2D: Proof of principle



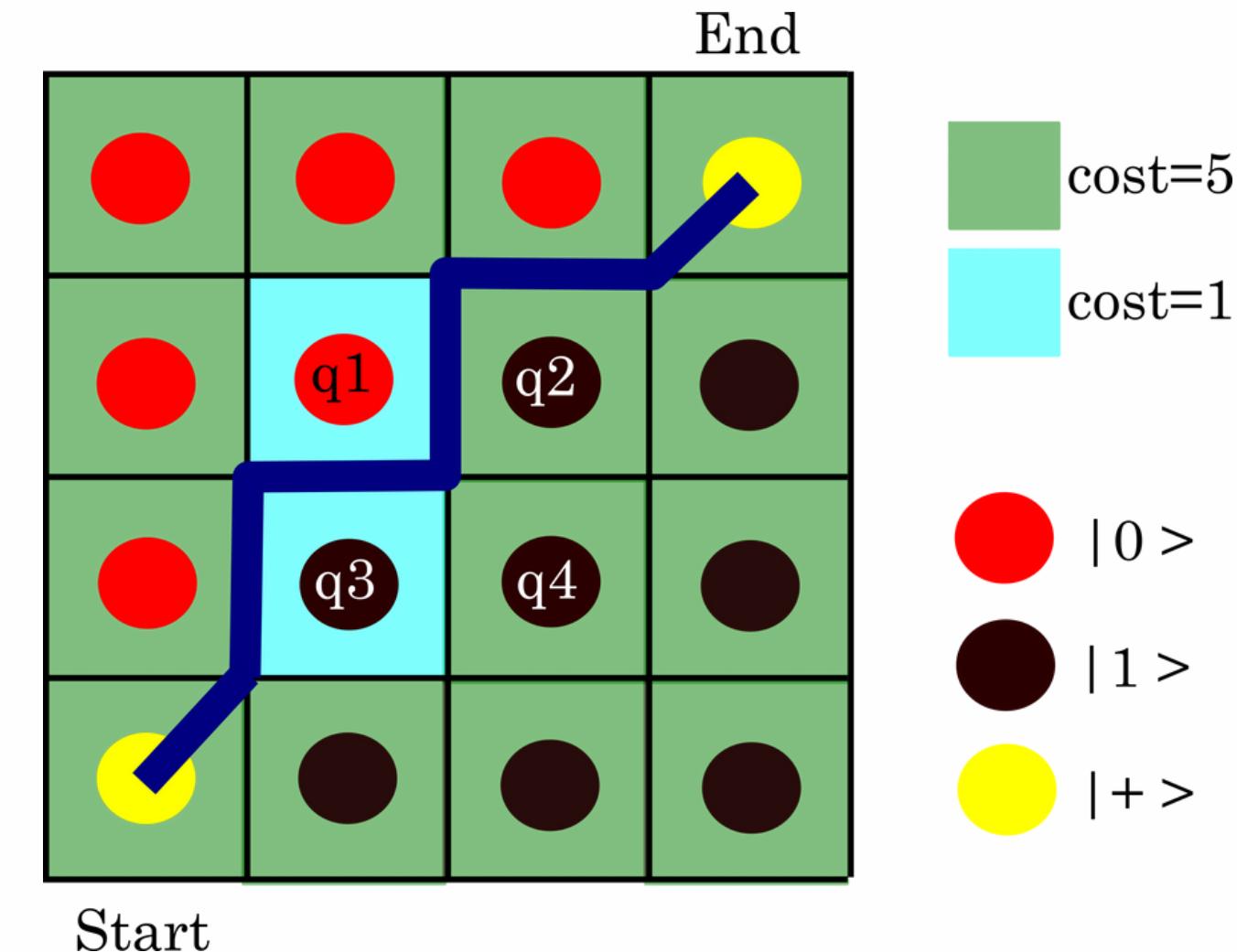
*obtain solution from
measurement results*



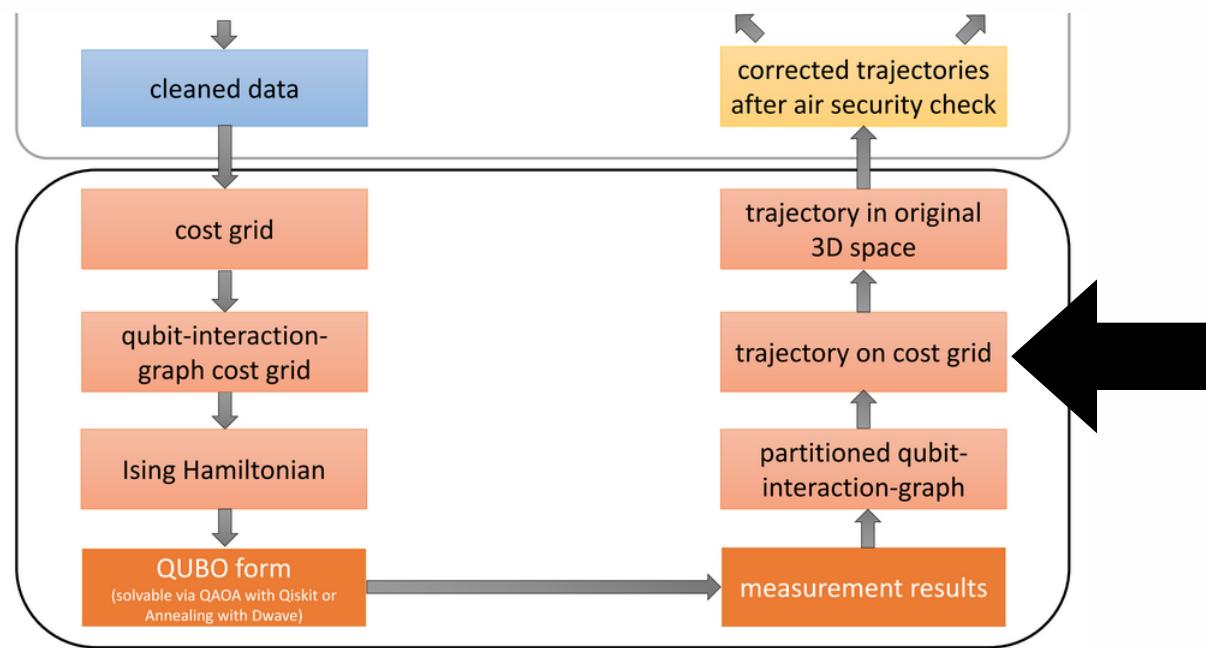
QUBO 2D: Proof of principle



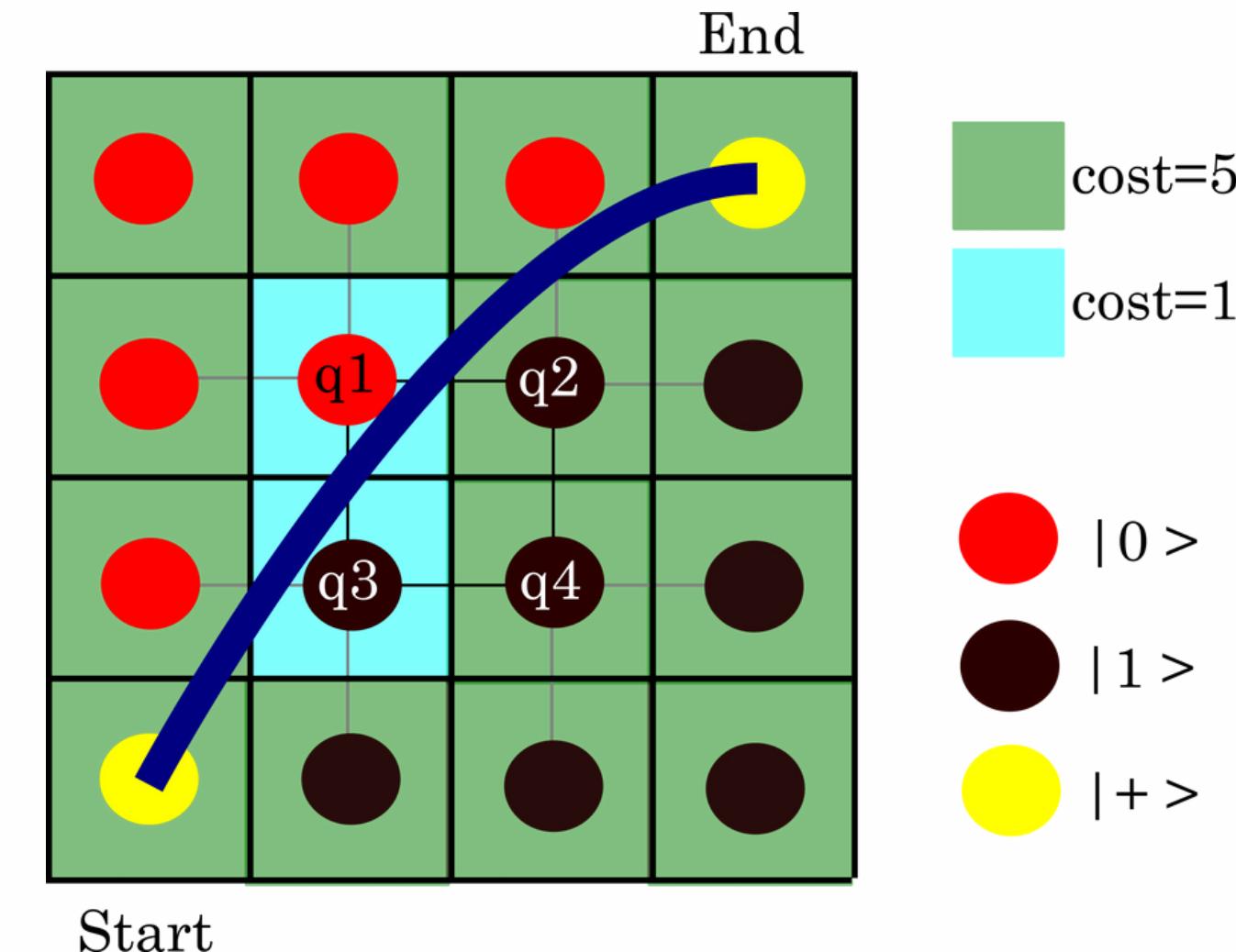
*cut graph into
2 sections
acc. to qubit values*



QUBO 2D: Proof of principle

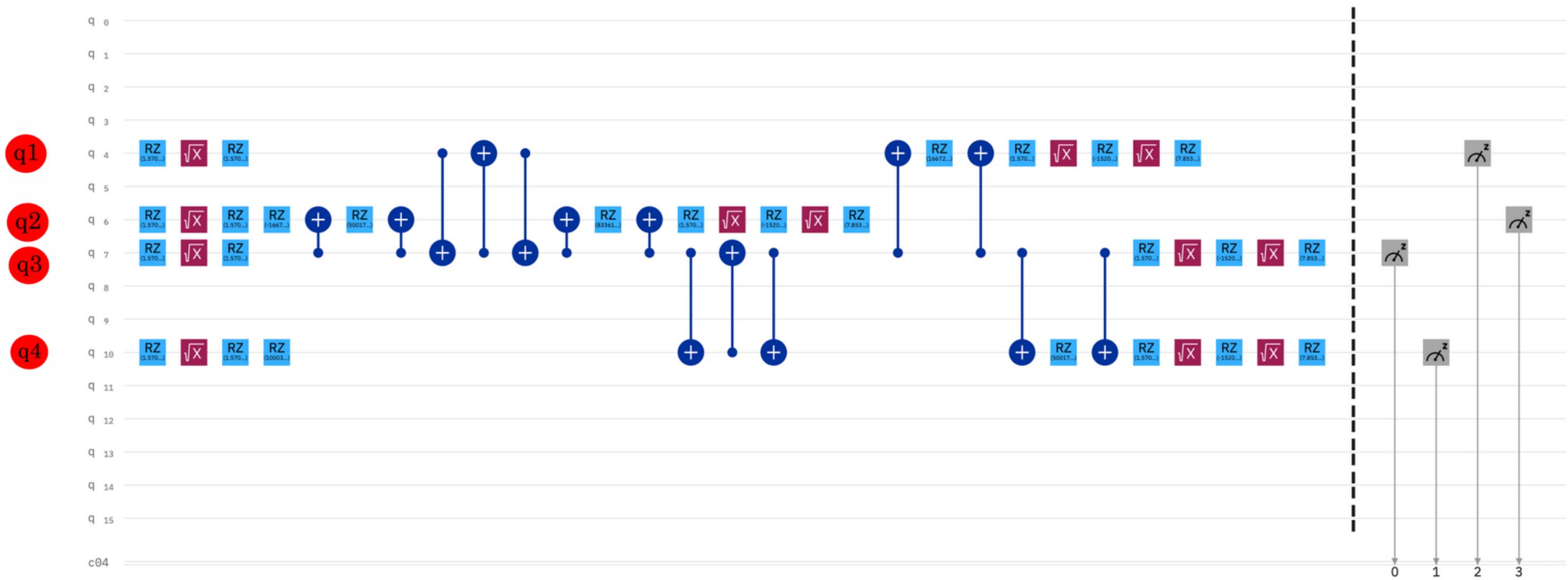


cutline = trajectory



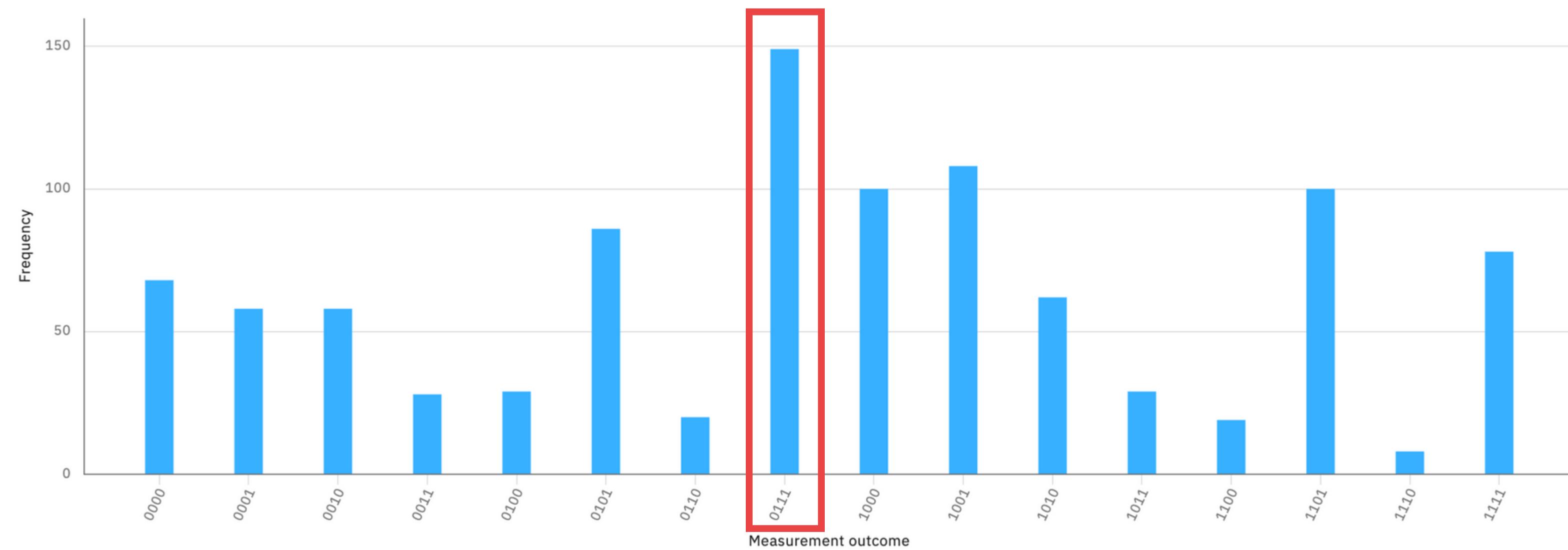
$$H_C = - \sum_{\langle i,j \rangle} w_{ij} Z_i Z_j - \sum_{i=1}^4 a_i Z_i$$

QUBO 2D: Experiment

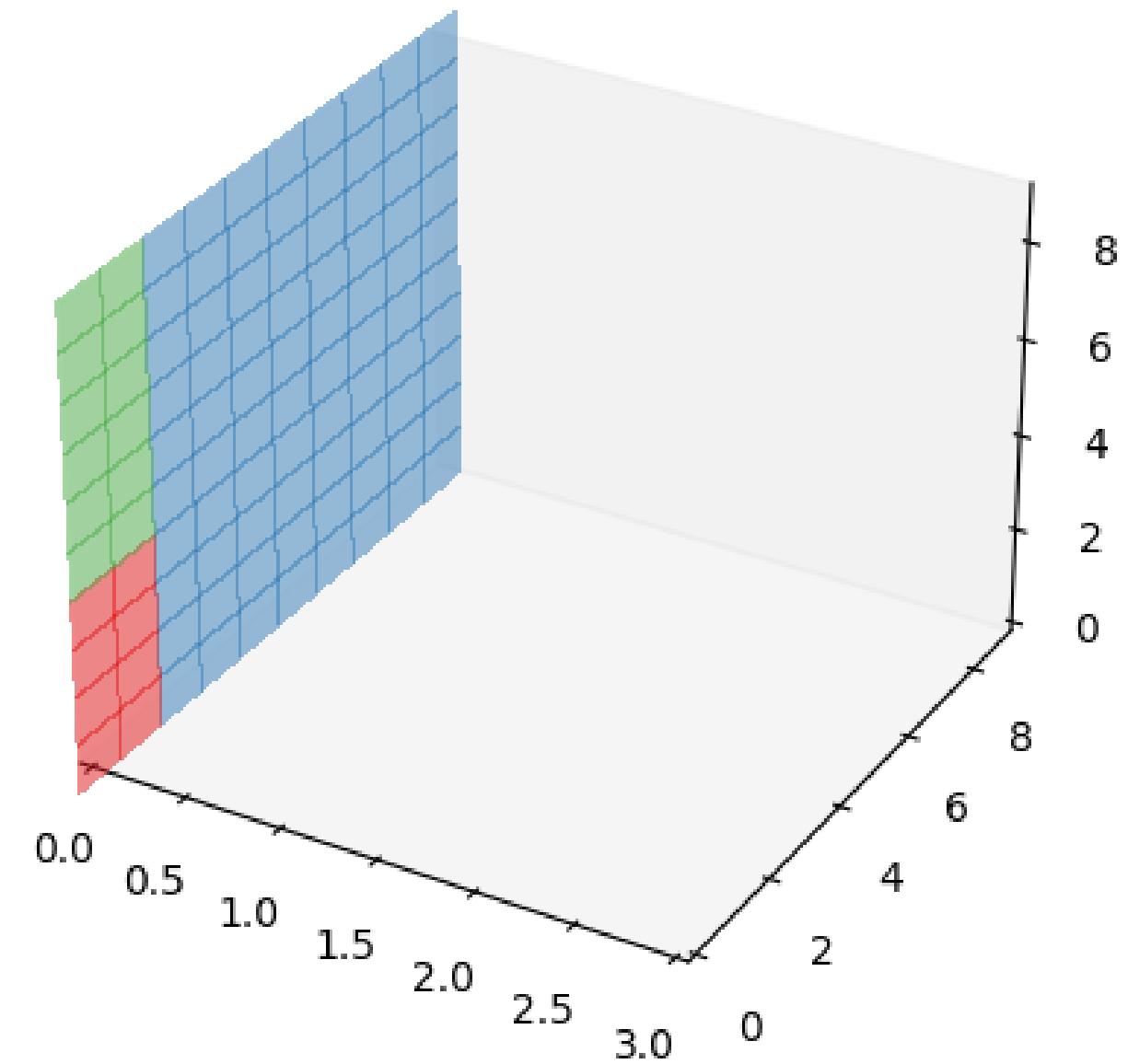


device: `ibmq_guadalupe`

QUBO 2D: Experiment

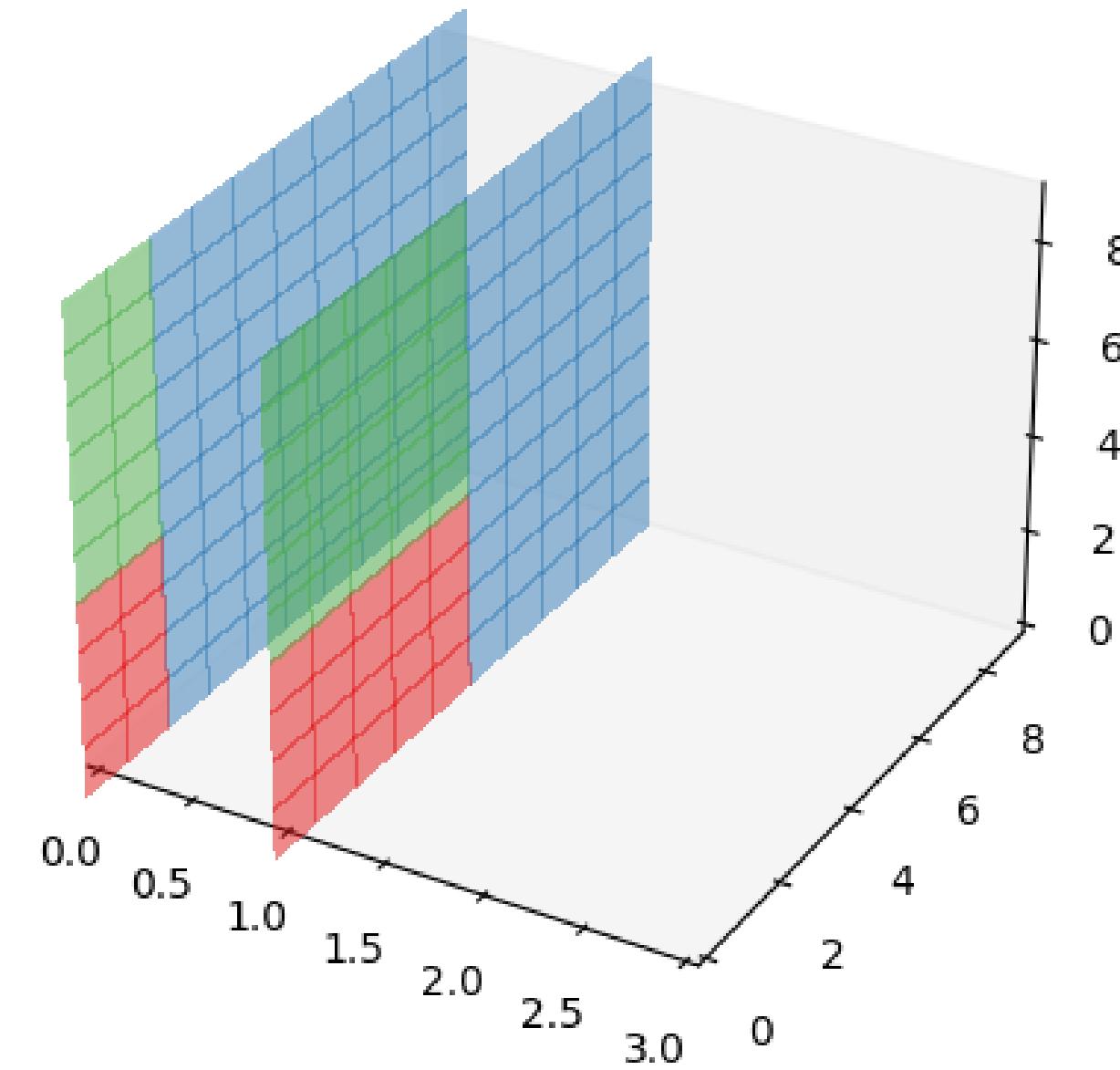


QUBO: Scaling up to 3D

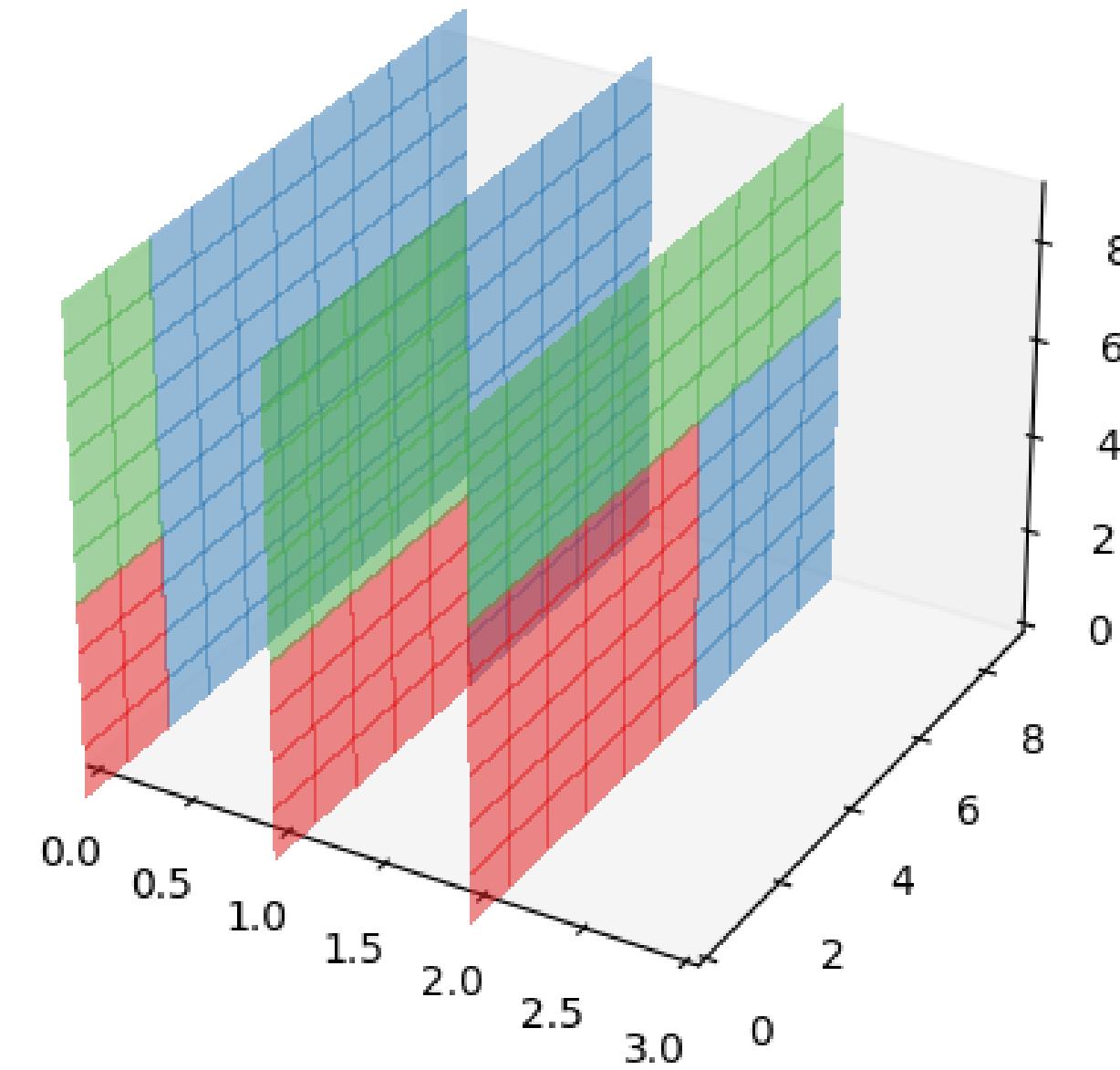


- Use of Qutrits
- Values available: 0, 1 or 2
- 3 Regions according to values
- Intersection of all regions:
active face**

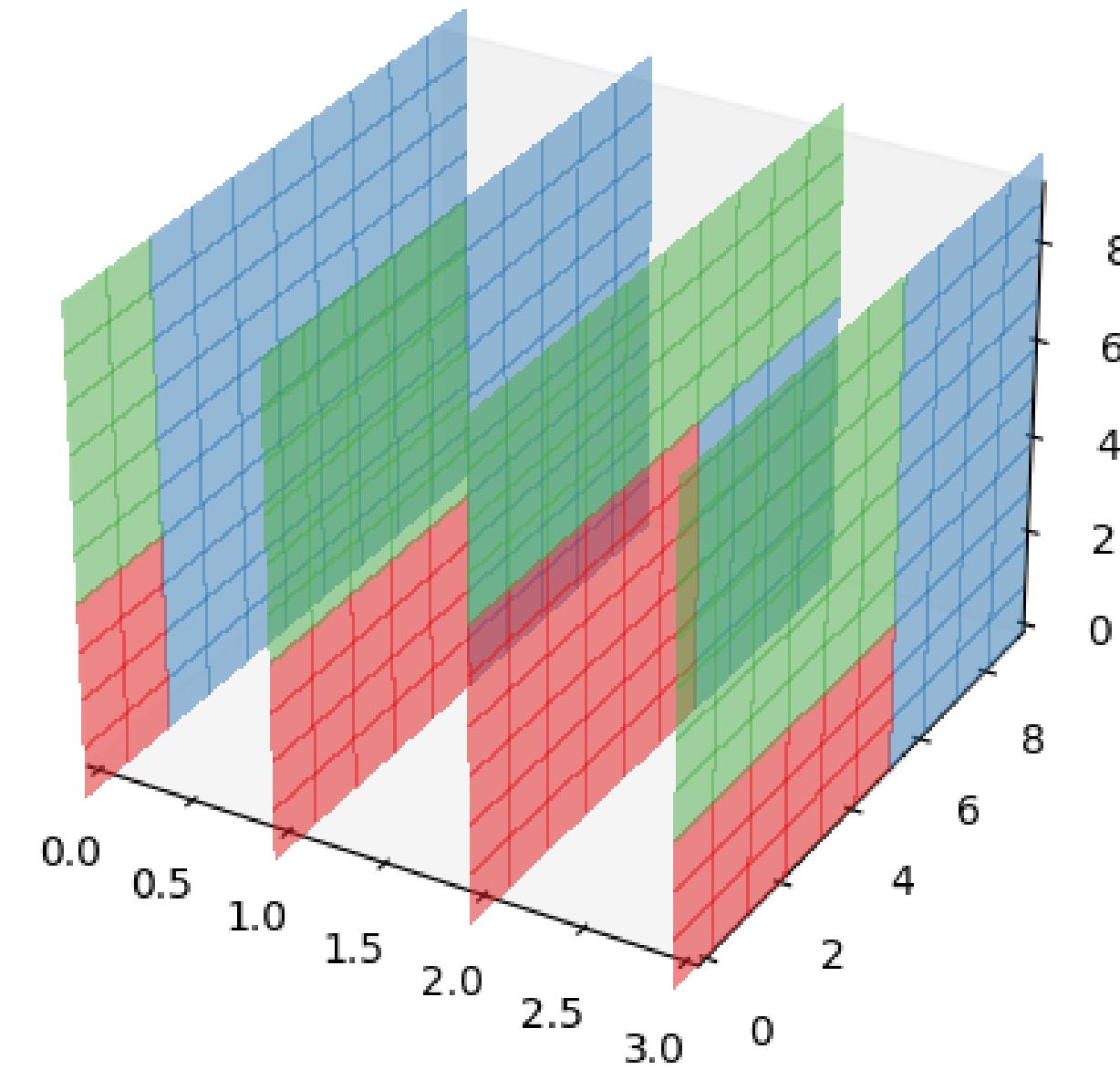
QUBO: Scaling up to 3D



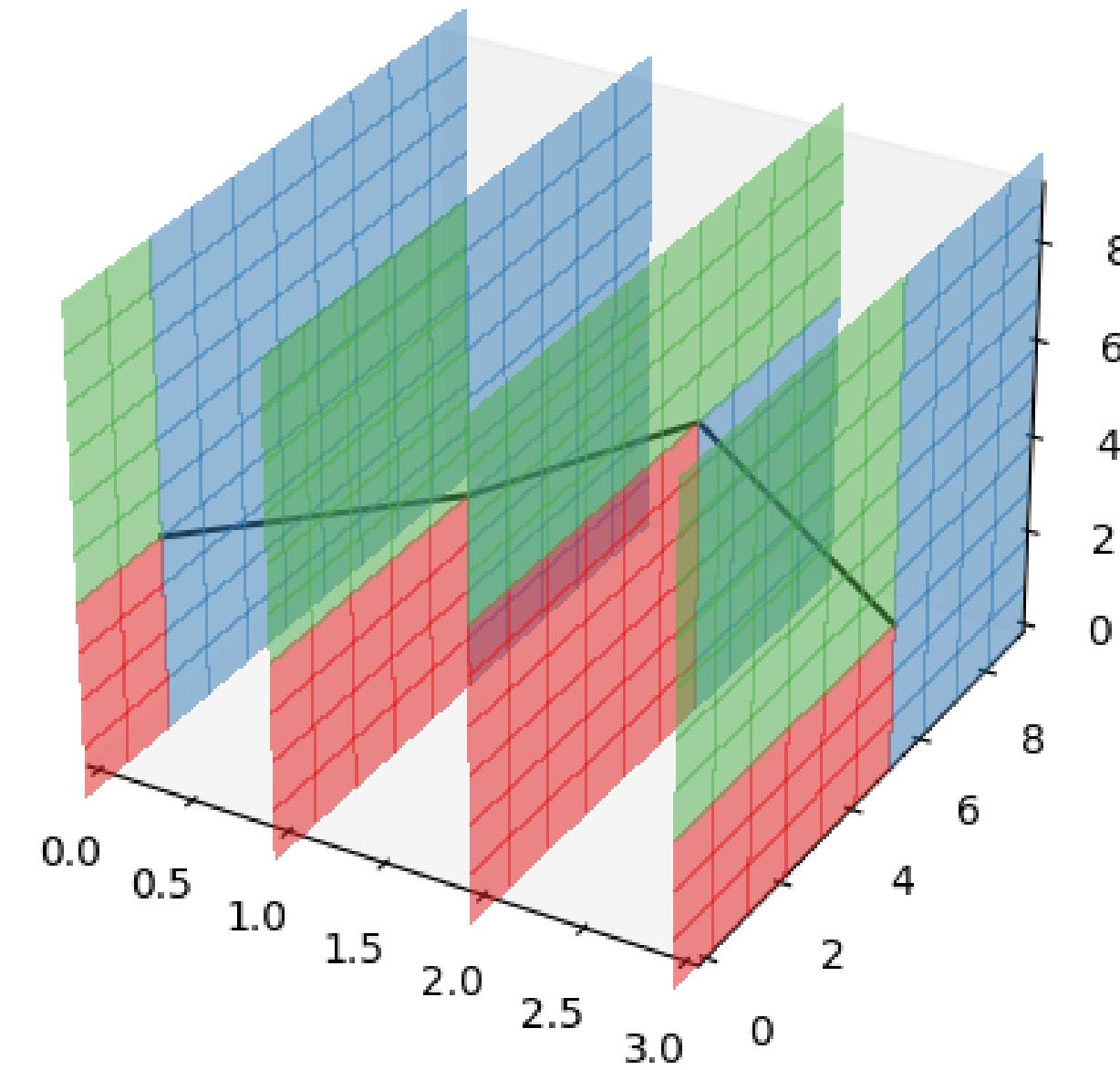
QUBO: Scaling up to 3D



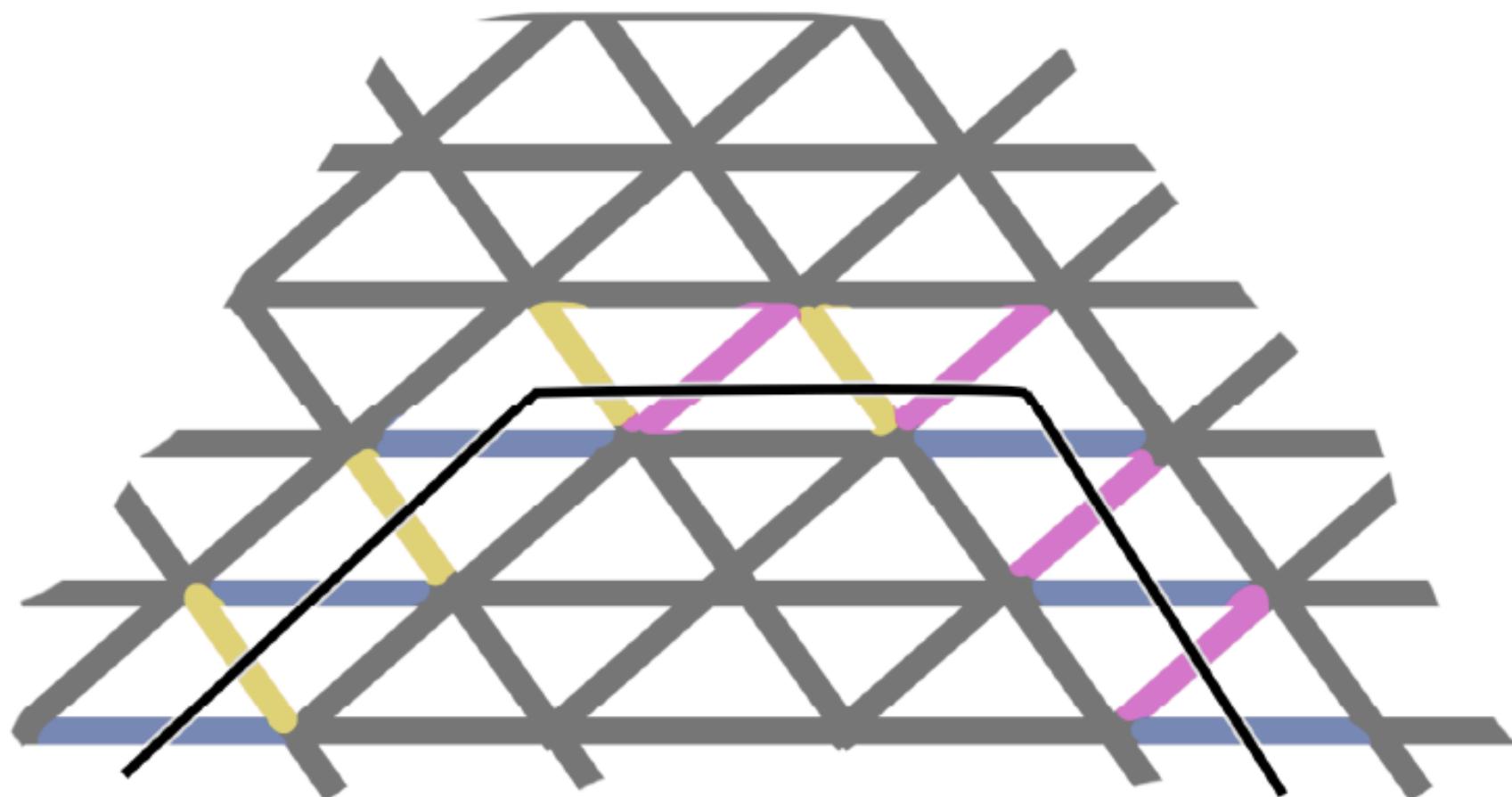
QUBO: Scaling up to 3D



QUBO: Scaling up to 3D



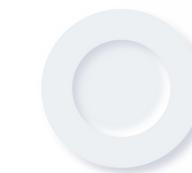
QUBO: Scaling up to 3D



Zoom into the 'colored' region



Lattice offset → triangular prisms



Differentiate lattice faces:



Cruise

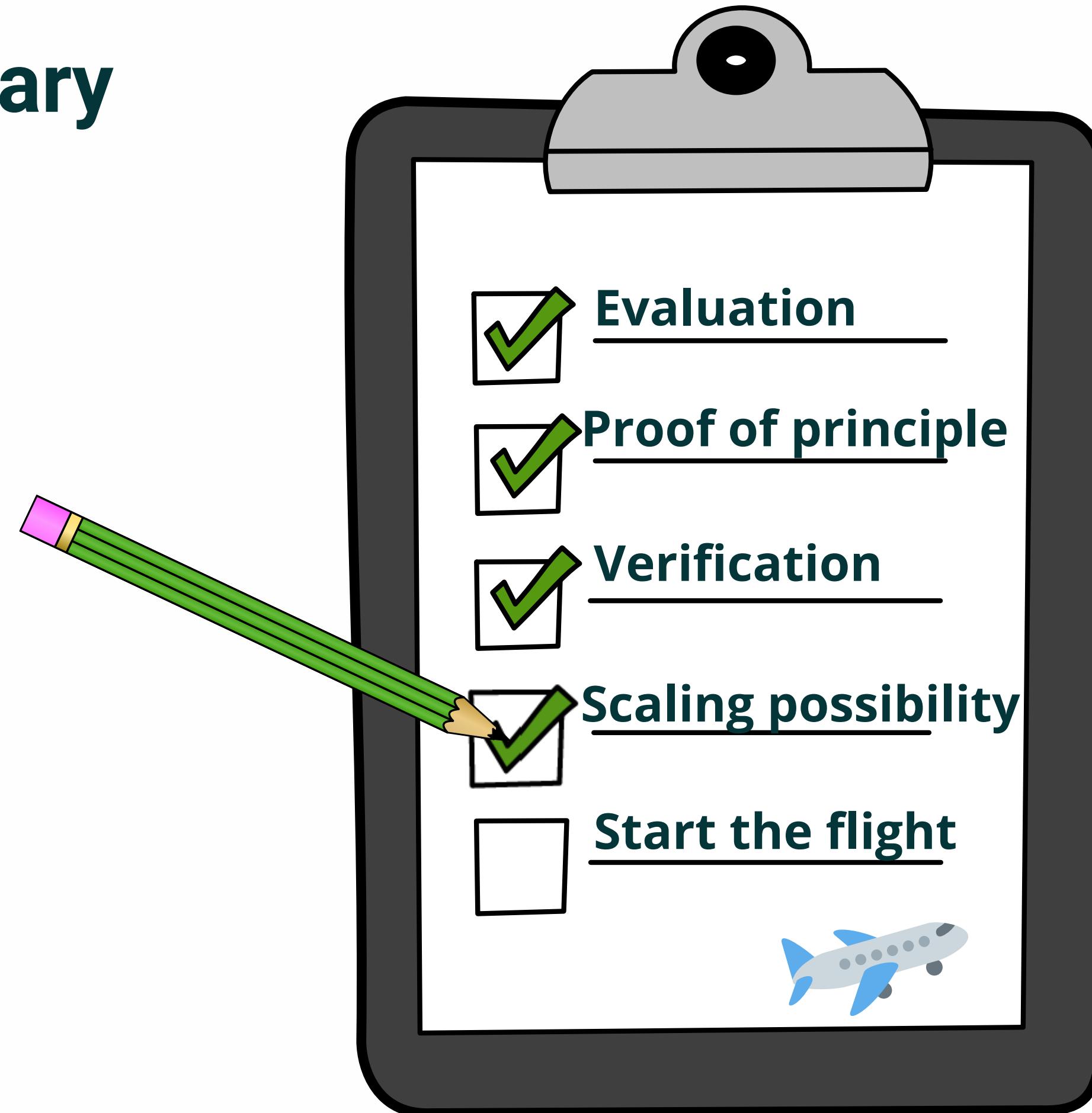


Climb

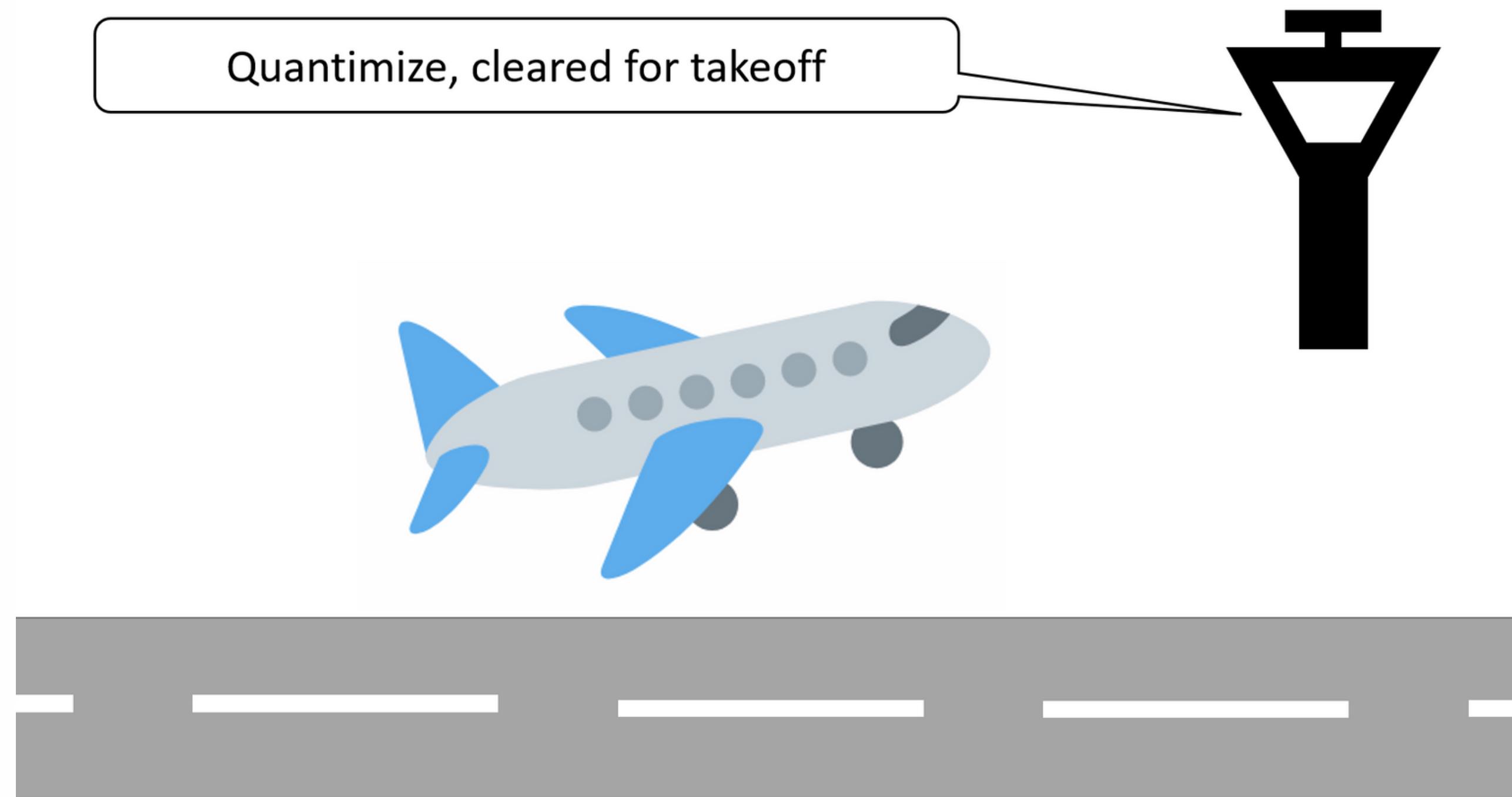


Descent

Summary

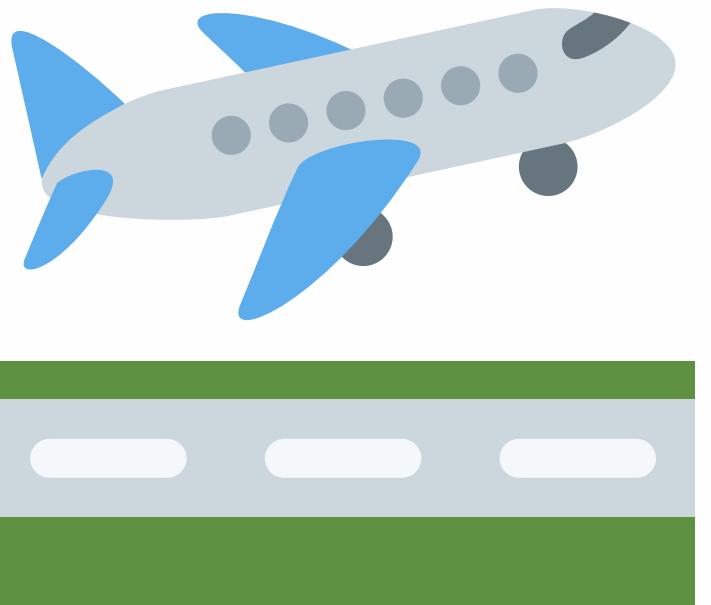


Summary



Outlook

- Mathematical improvement of the chosen lattice type for the 3D integration
- Improvements on the translation to the qubit grid
- Include time-evolving and more precise atmospheric data
- Including extra features, like landing etc.
- Improvements on the hardware (qutrits)



For more details

GitHub repository



Quantimize website





Thank you!