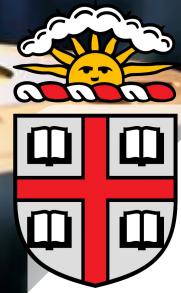




# Brown Quantum Initiative 2025 Hackathon

Brown University



# The Team



**Alfonso Gordon**

Graduate Student in the  
Masters in Biomedical  
Engineering



**Jake Lippert**

Undergraduate Student  
  
Bachelors of Science  
(Physics and Computer  
Science)



**Pamela Racines**

Graduate Student in the  
Masters of Innovation  
Management and  
Entrepreneurship (PRIME)



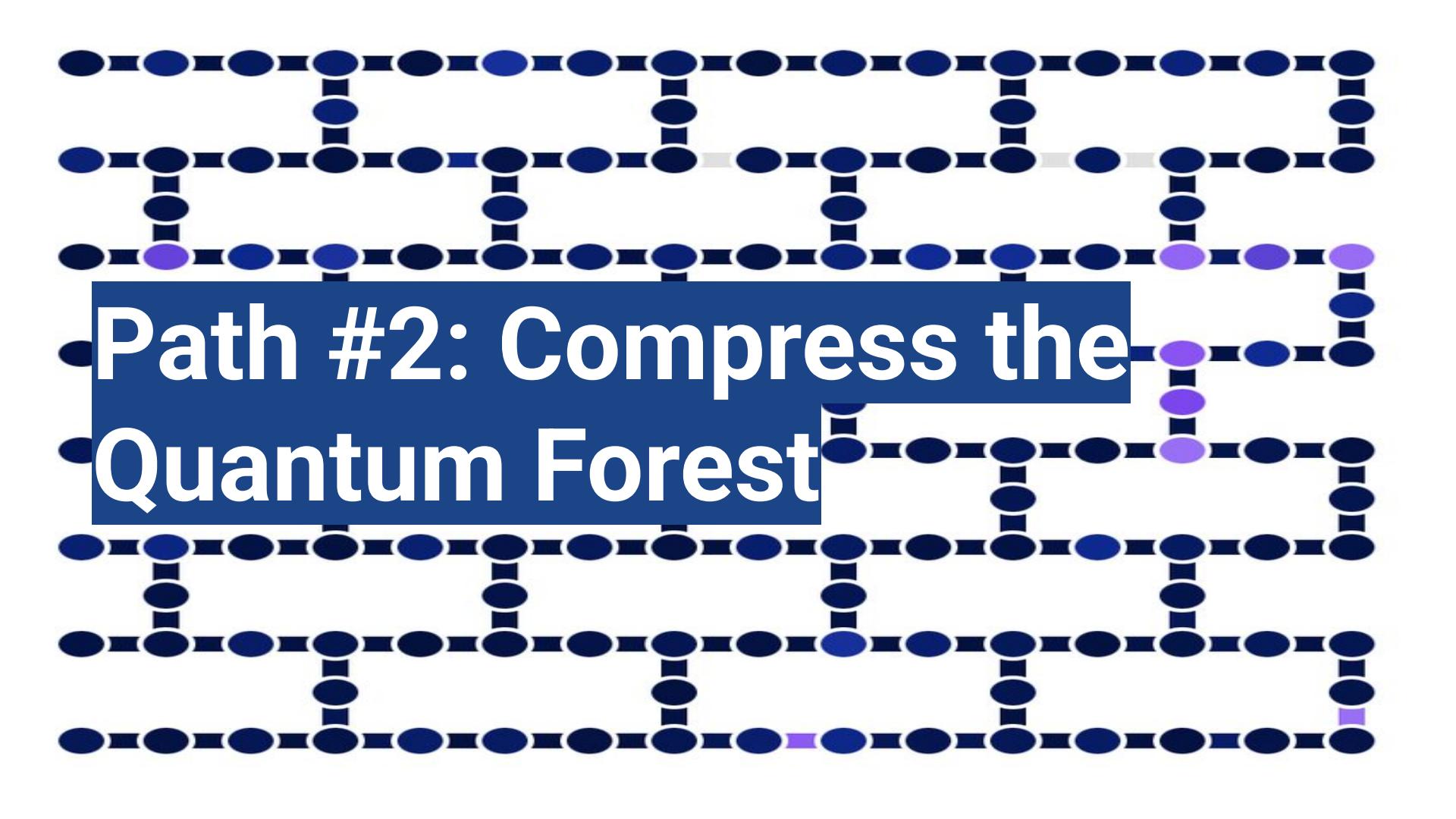
**Aradhya Jain**

Undergraduate student  
  
Bachelors of Science  
(Physics and Applied  
Math)

# Bruno's Path

[https://drive.google.com/file/d/1TyWJnL0SvlzFtdy1Ea7KC\\_Pii0K1IKdJ/view?usp=sharing](https://drive.google.com/file/d/1TyWJnL0SvlzFtdy1Ea7KC_Pii0K1IKdJ/view?usp=sharing)





## Path #2: Compress the Quantum Forest

# The problem

Three quantum circuits are provided,  
and the following question is posed:  
What is the most efficient  
representation of these circuits for  
two different architectures?

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A close-up photograph showing a person's hands interacting with a quantum computing interface. The hands are positioned over a light-colored surface, likely a laptop or tablet screen, which displays abstract, glowing shapes in shades of green, blue, and purple. The background is dark.

# Methodologies and tools

We used an open source tool called Qiskit to optimize the circuits

Qiskit’s “transpile” method can be used to efficiently optimize each circuit for both architectures!

# How Does this Transpilation Work?

## Step 1: Unroll the circuit

- Rewrite all quantum gates in terms of the computer's basis gates
  - Quantinuum H1-2: R, RZZ
  - IBM Fez: CZ, I, RZ, SX, X

## Step 2:

- Map quantum operations (logical qbits) onto hardware (physical qbits)
- Minimize the total distance between interacting qbits by
  - Placing heavily interacting qbits close together
  -

# How Does this Transpilation Work?

## Step 3: Unroll the circuit

- Merge consecutive rotations ( $Rz(a) + Rz(b) = Rz(a+b)$ )
- Cancel consecutive inverses ( $H + H = I$ )

## Note on determinism:

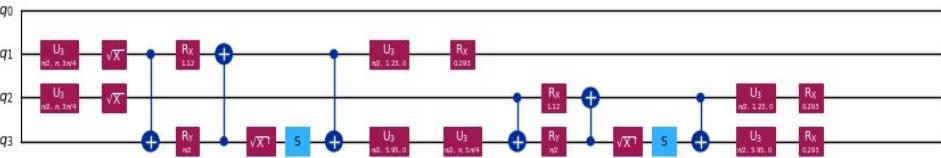
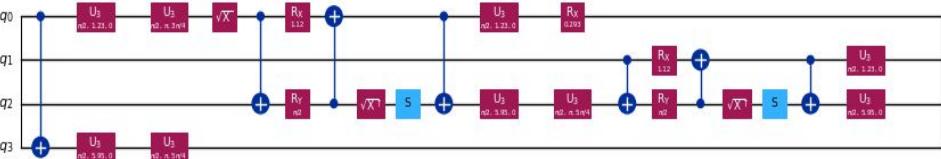
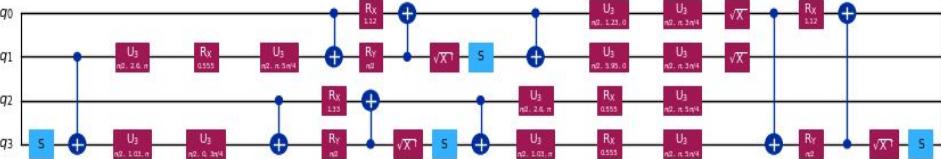
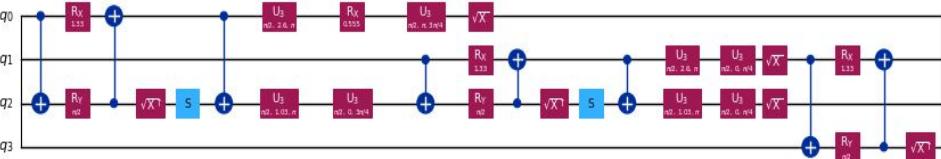
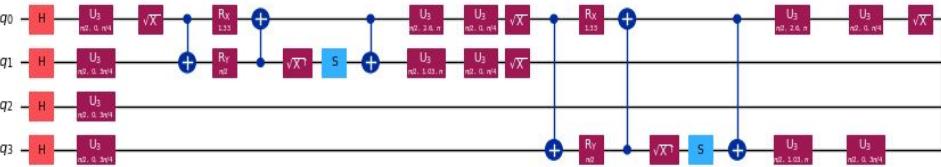
- Optimization level 3 uses the SABRE Algorithm (Simulated Annealing for Better Routing and Embedding) for SWAP routing
- This algorithm is stochastic, so it is not deterministic

# Key Findings

*Show where you are in the process and what's left to tackle*

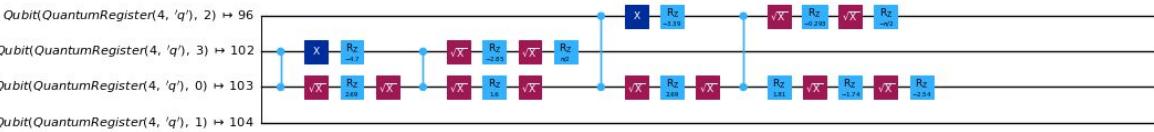
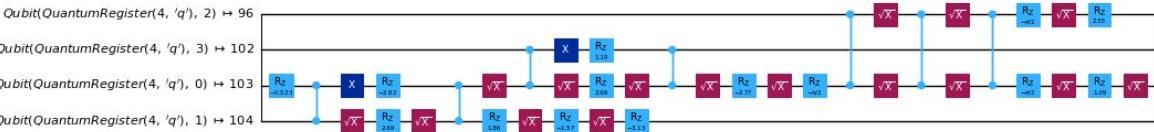
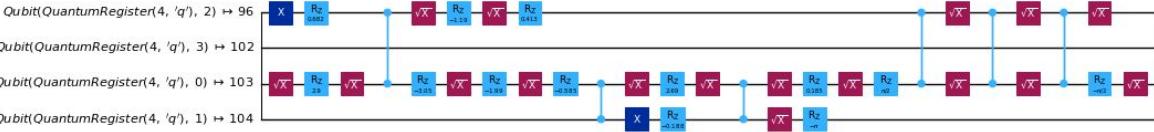
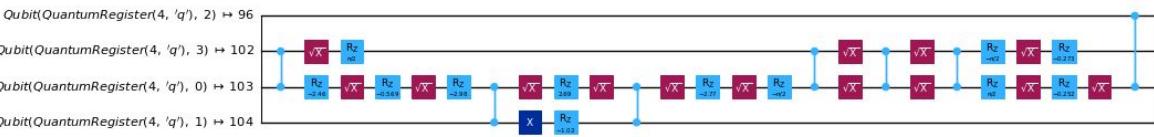
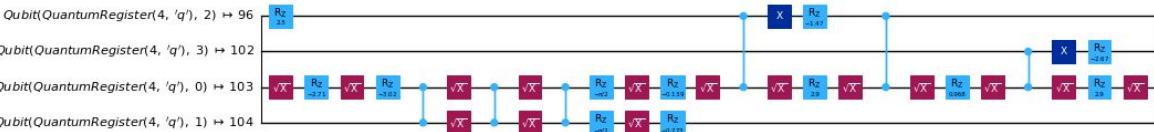
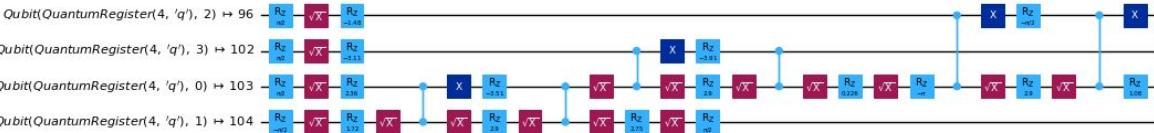
Given two-qubit gates	Optimised for the IBM Fez	Optimised for the Quantinuum H1-2
26		26
299	650	284
1695	1695	1695

# Unoptimized version



# Optimized version

Global Phase:  $\pi$



# Additional findings/ Challenges

During implementation, we faced a transpilation issue in Qiskit, so one teammate tested an R-based simulator to check limitations. We also encountered repeated circuit #284 errors at optimization level 3 and memory overload due to large circuit sizes. Additionally, visualization files exceeded size limits, so we adjusted parameters like scale and fold to successfully render smaller images.

The background of the slide is a nighttime photograph of a city skyline, likely New York City, viewed from an elevated vantage point. The Empire State Building is prominent in the center-left, its top illuminated with red, green, and blue lights. To its right is One World Trade Center, also with a lit spire. The sky is a deep purple and orange, suggesting a sunset or sunrise. Numerous other skyscrapers are visible, their windows glowing with interior lights.

The technology:  
GPS + RFID