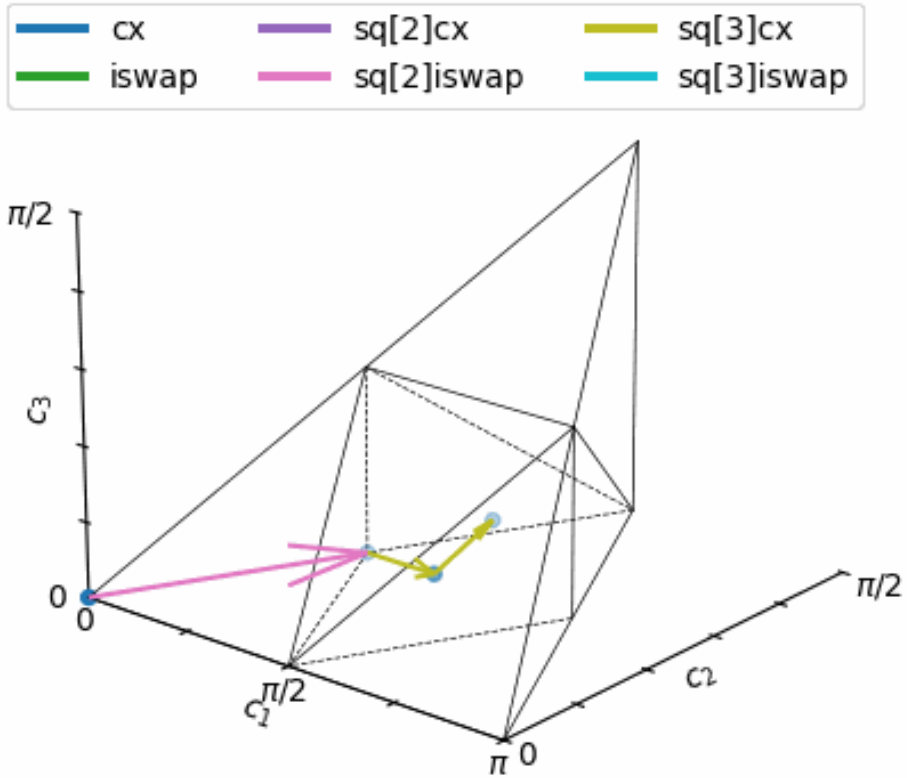
Optimal decomposition of two-qubit gates for heterogeneous quantum instruction sets

Evan McKinney
Quantum

evmckinney9@gmail.com
evm9.dev

Decomposition into a non ~XX ISA,
a feature unavailable to Qiskit.



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Project Overview
Evolving quantum hardware capabilities require new robust transpilation methods.

Our work enables circuit compilation into arbitrary hardware primitive operations.

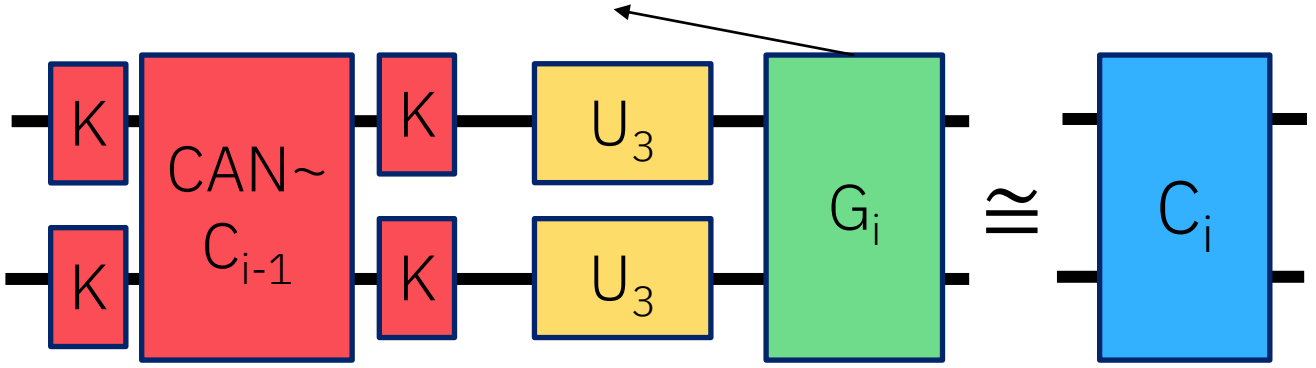
Current State for the Project
In this work, we reformulate decomposition into discrete segmentation of Cartan trajectories.

1. Use linear programming to solve for intermediate invariants satisfying *monodromy polytope* constraints.

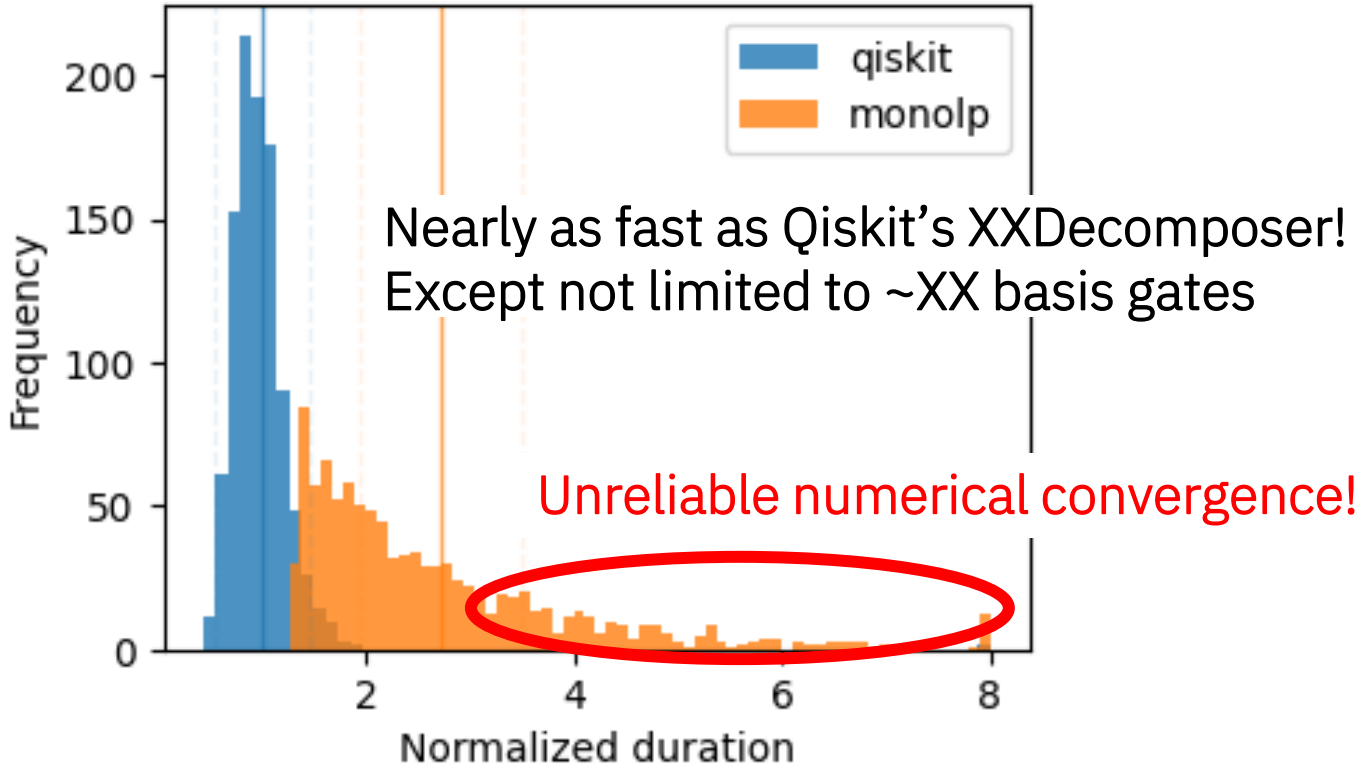
2. Use non-linear least squares to rapidly synthesize the interleaving single-qubit gates.

Future Vision for the Project
Refactor for performance gains and merge into core Qiskit functionality.

All 2Q gates can be specified by 3 invariants



Decomposition simplified into independent parts



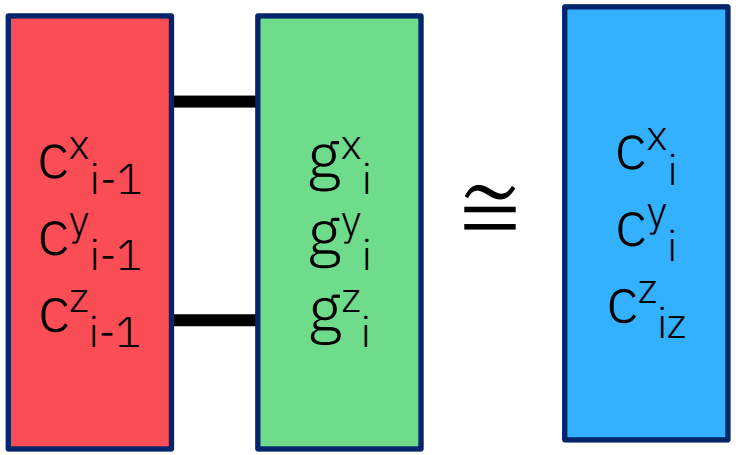
Optimal decomposition of two-qubit gates for heterogeneous quantum instruction sets

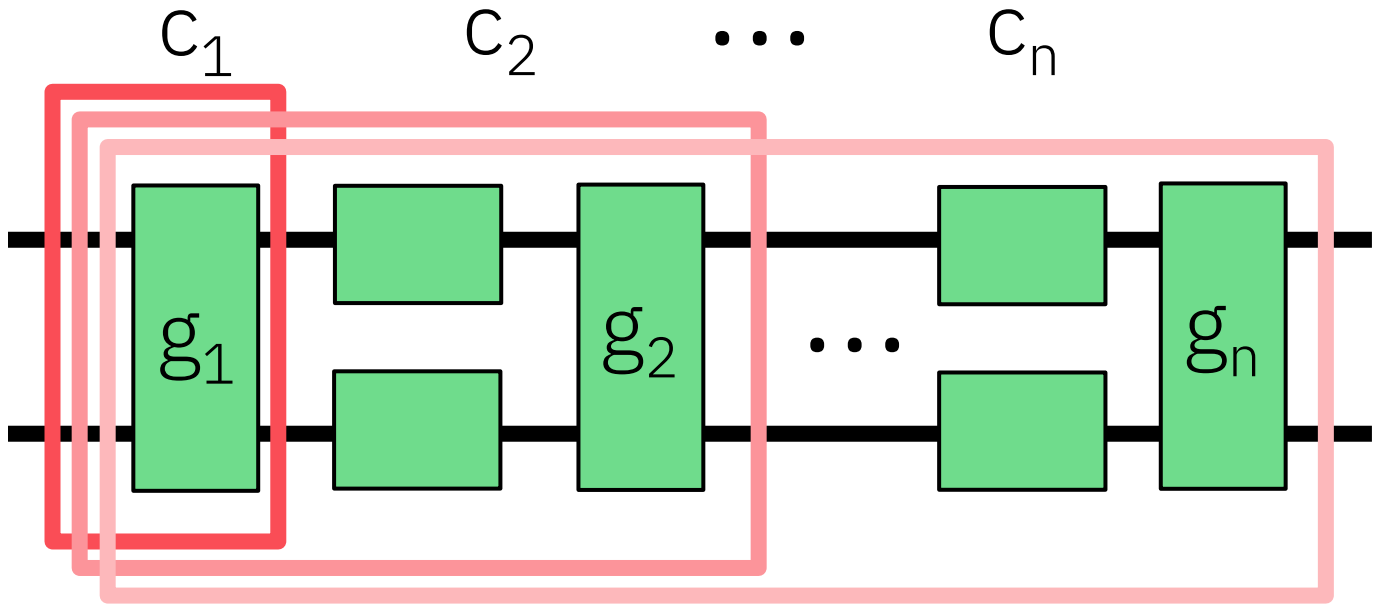
Satisfying all 72 **quantum Littlewood-Richardson** linear inequalities implies

given a circuit with invariant c_{i-1},

appending g_i, a gate from the device's instruction set,

can yield a circuit with invariant c_i.





Satisfy all $L_i(c_{i-1}, g_i, c_i)$ such that $\forall i, g_i \in \mathrm{ISA}$

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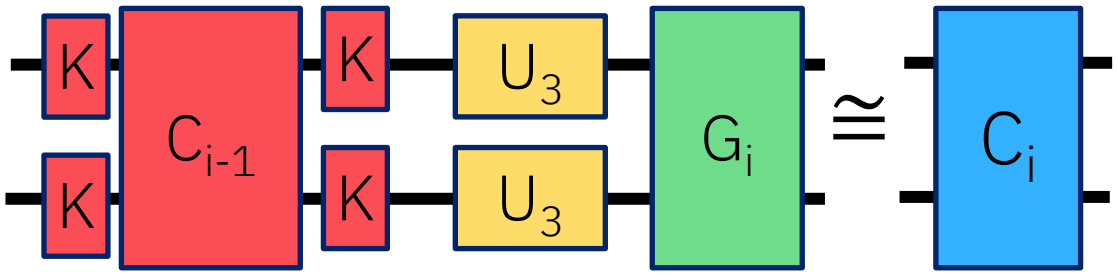
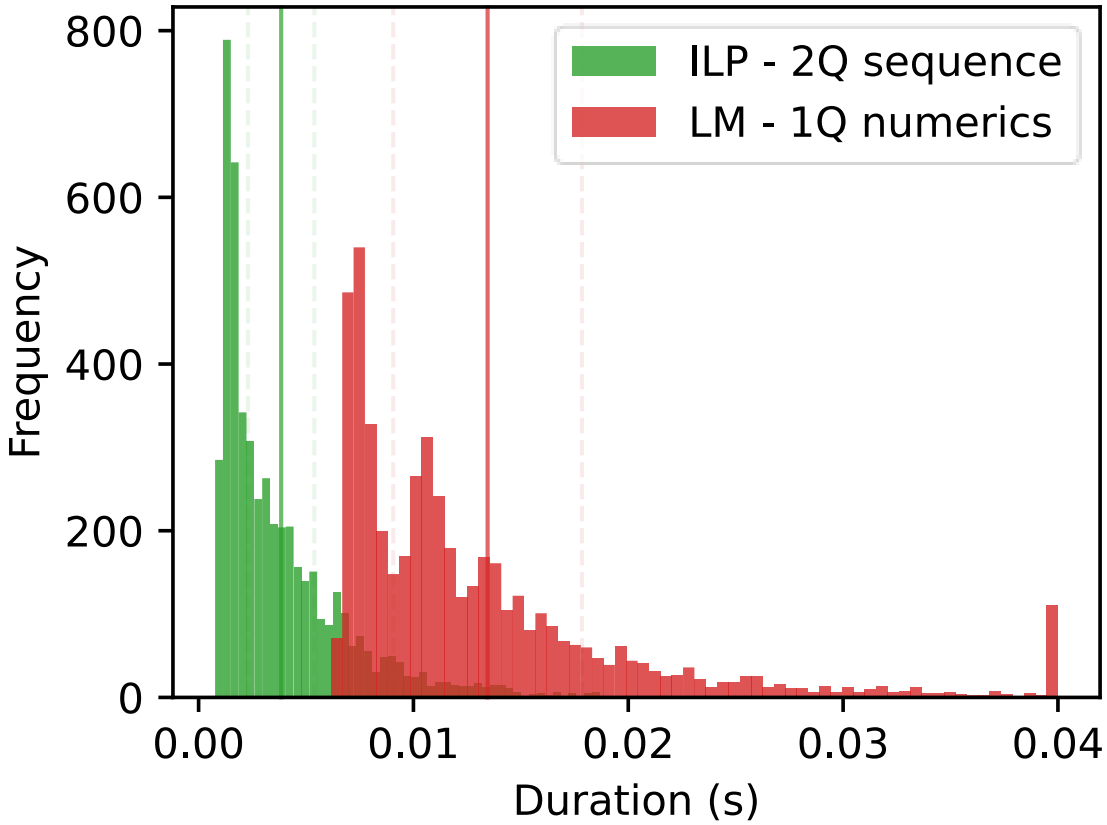
Given an optimized solution to $L_i(c_{i-1}, g_i, c_i)$,

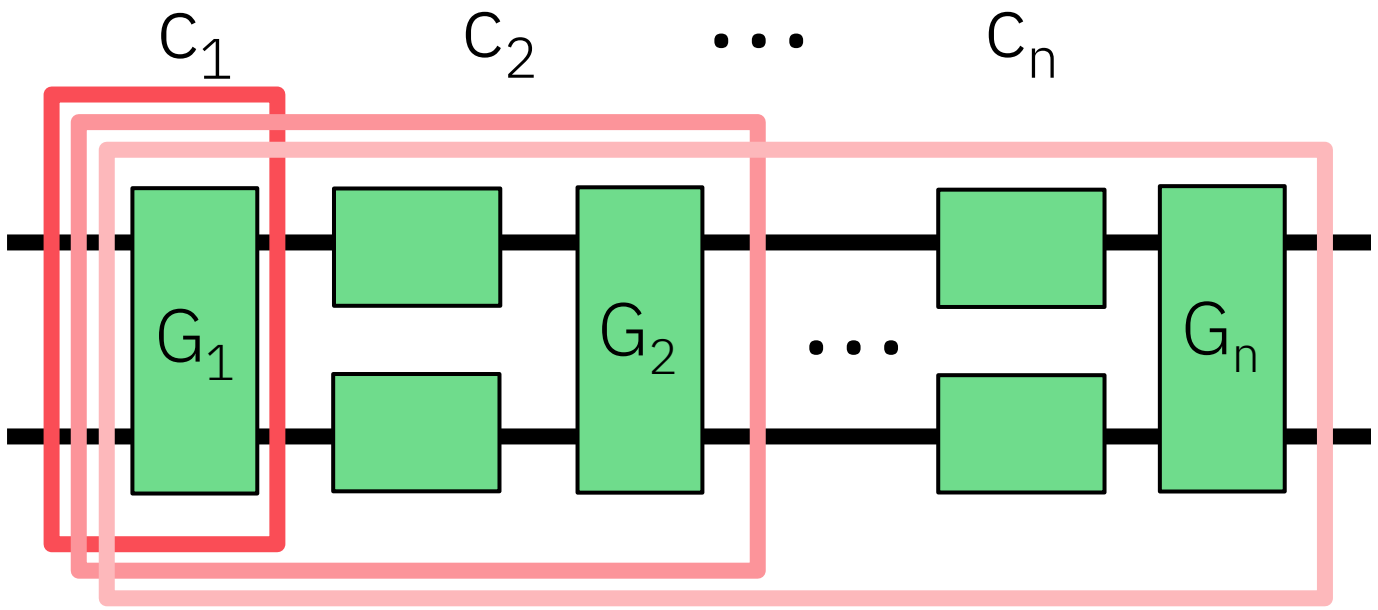


finalize decomposition by solving for the interleaving single-qubit gates.



Current solution times are dominated by root-finding numerics, we are investigating alternative parameterizations.

Y. Makhlin, **Quantum Info. Process. 1** (2002)
Peterson, et al. ***Quantum* 4** (2020)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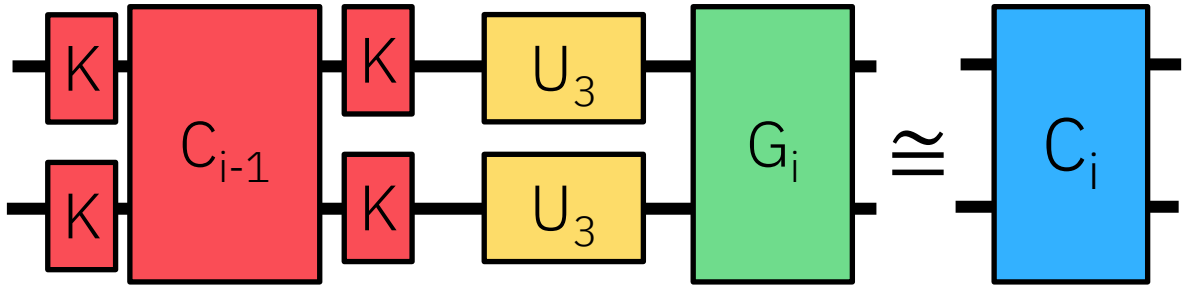
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