QUBO scaling (Update to 19.1.2023

A deeper look into:

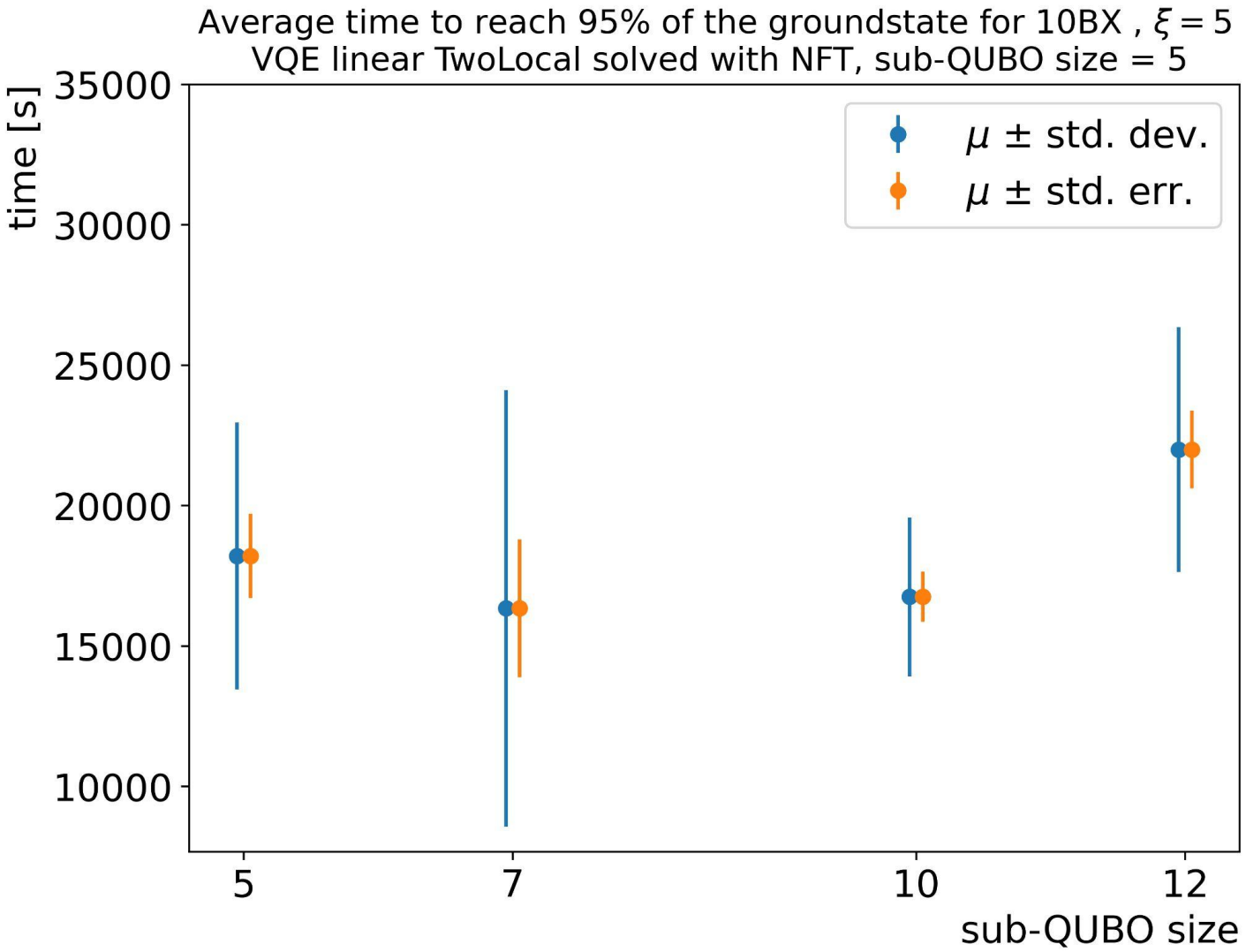
1) Time to solve of single sub-QUBOs
2) Time to reach 95% of the ground state energy
3) Success of solving a sub-QUBO

with respect to the sub-QUBO size

David Spataro
Hamburg, 26.01.2023

Results

xi=5, 10BX



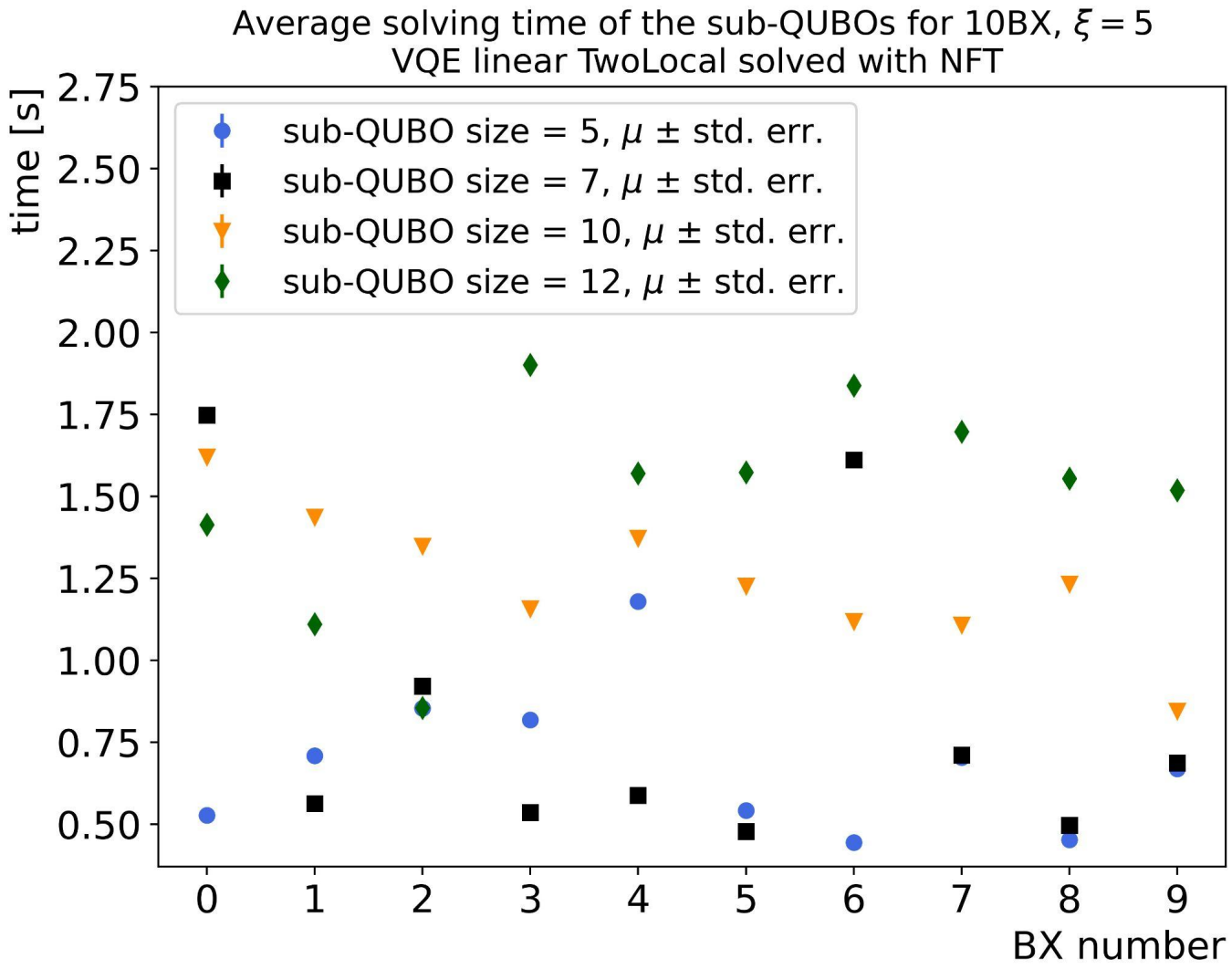
Average time to get to 95% of the ground state energy.

For sub-QUBO size 5, 7 and 10 this is achieved after 2 +/- 0 iterations.

For sub-QUBO size of 12 it is 3 +/- 0 iterations.

Results

xi=5, 10BX, sub-QUBO size = 12

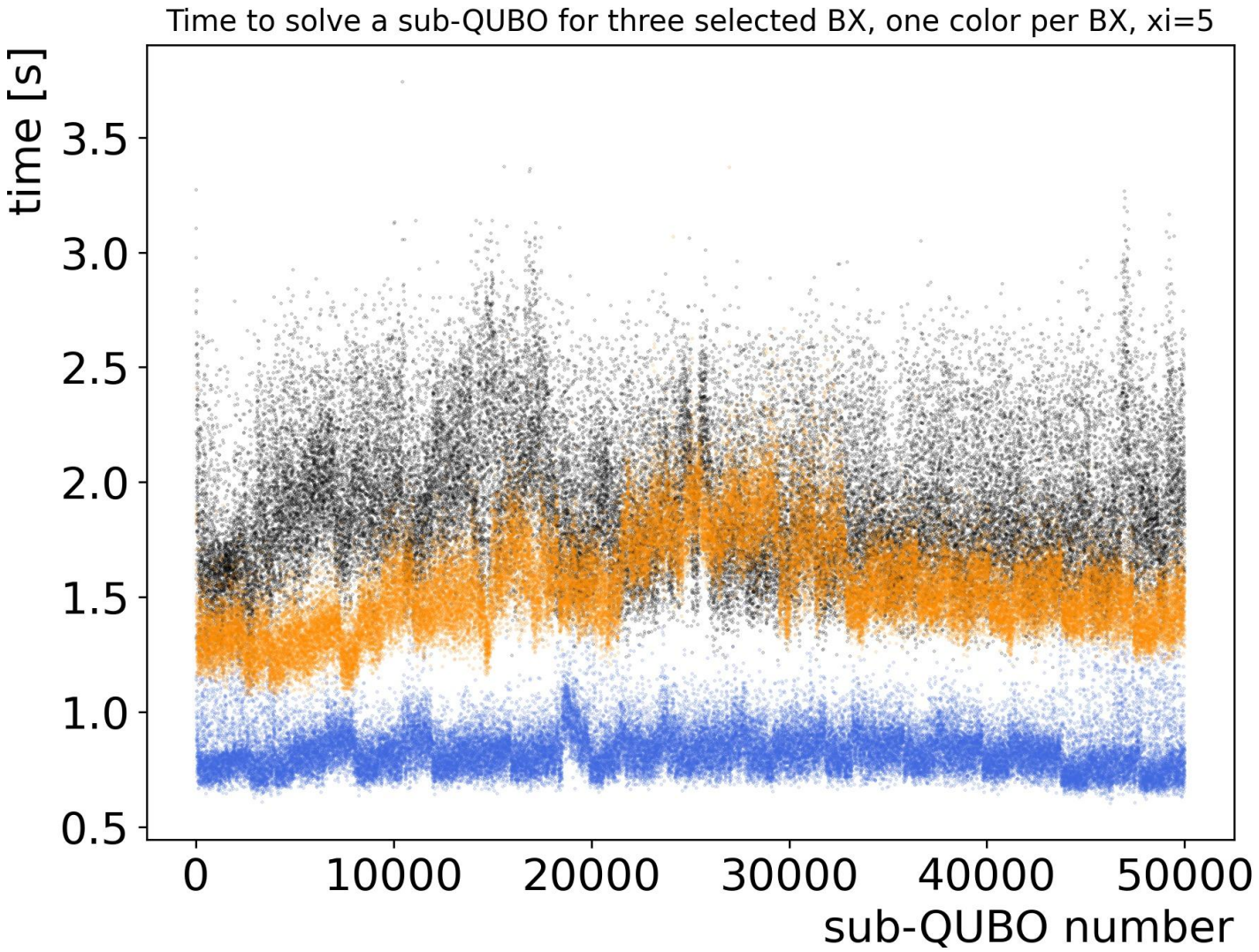


Average time for solving a sub-QUBO in dependency of the BX.

Explanation on what's actually happening on the following slides.

Results

xi=5, 3 BX, sub-QUBO size = 12



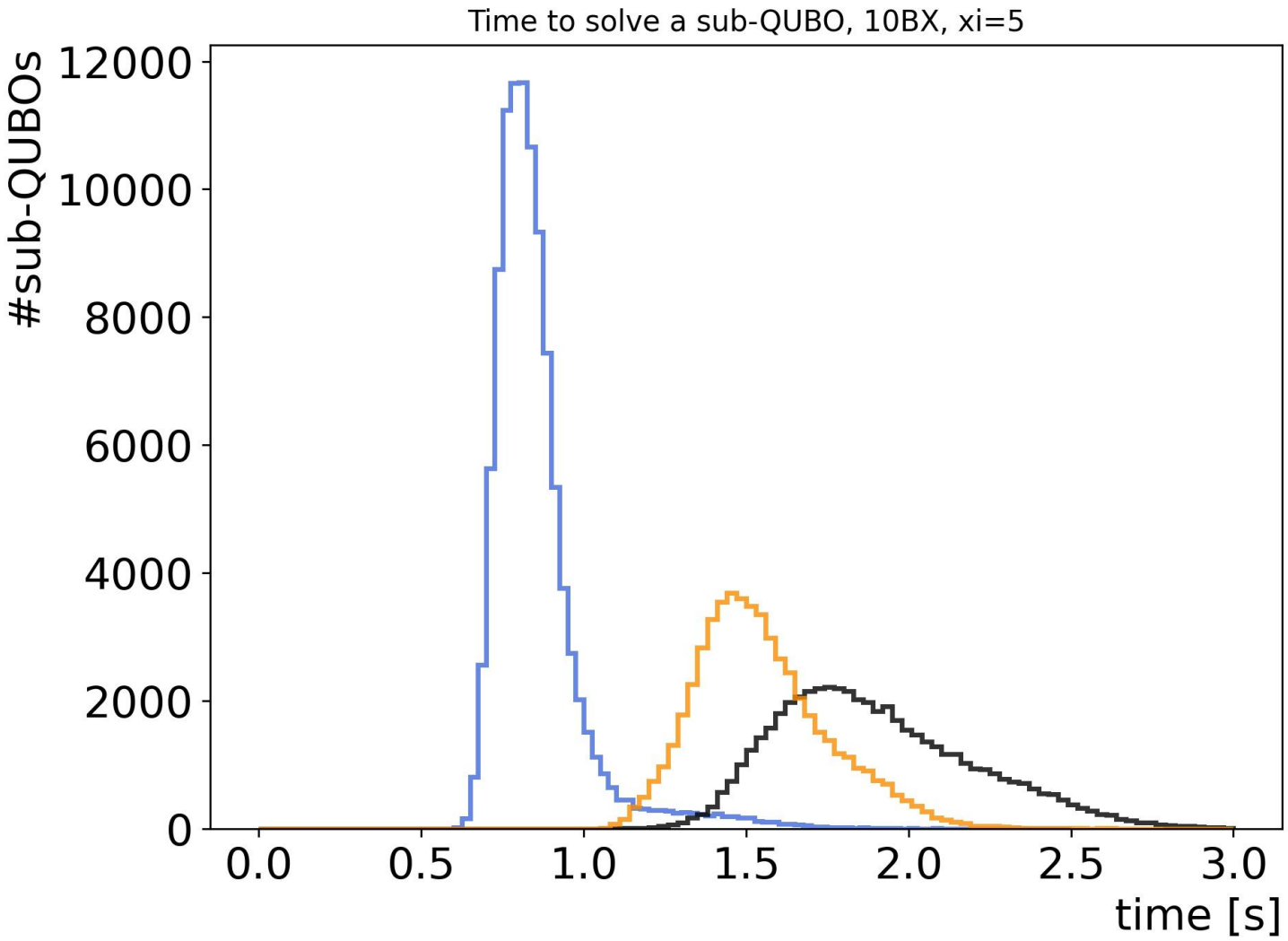
Solving time of the sub-QUBO dependant on the sub-QUBo number.

Each color represents a BX., each dot represents a sub-QUBO.

~12 impact list shown for each BX.

Results

xi=5, 3 BX, sub-QUBO size =12



Distribution of the sub-QUBO solving time for three BX

Each color represents a BX.

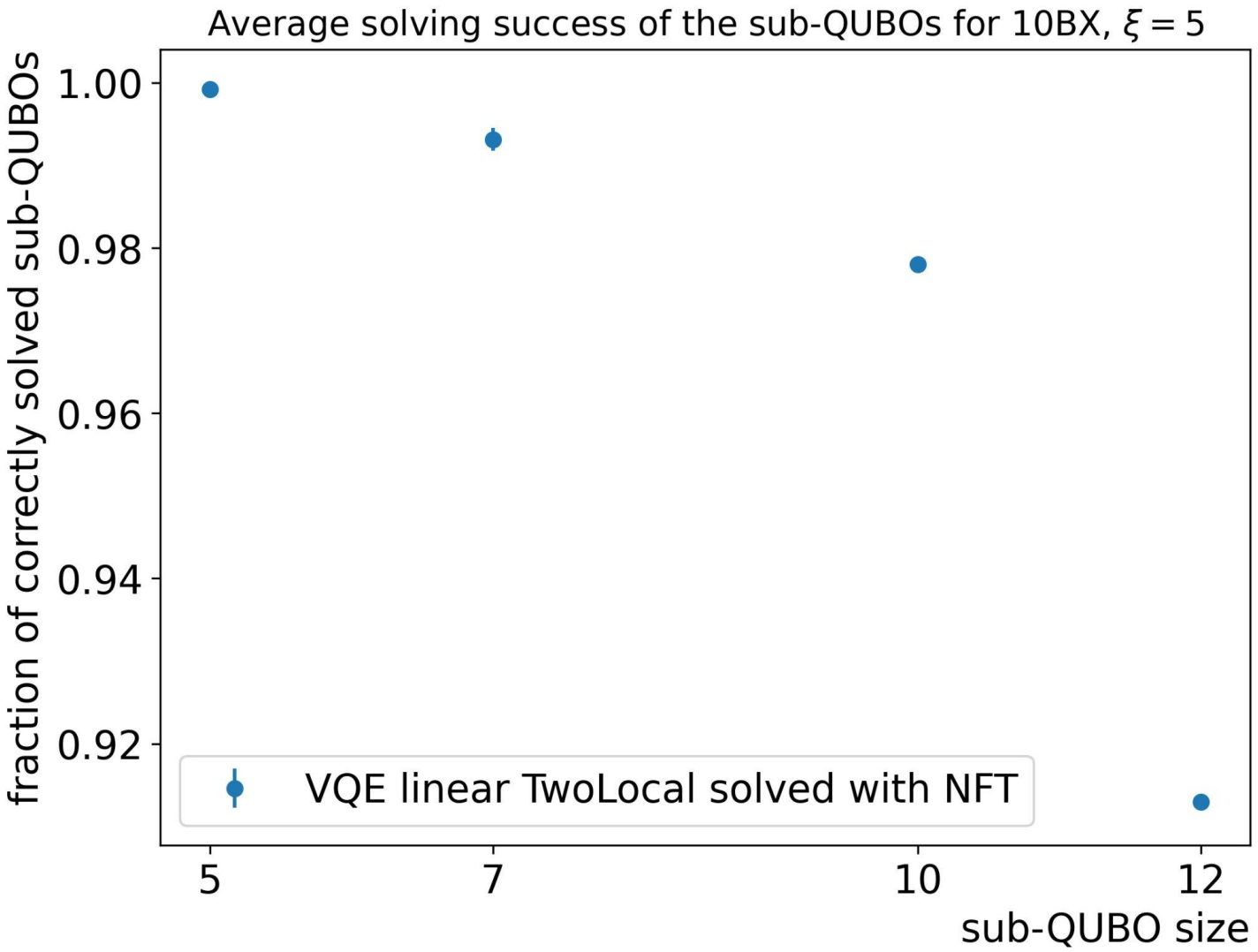
In total ~12 impact list iterations are shown which corresponds to ~50k sub-QUBOs

Results for different BX differ because they're run on different types of hardware on the cluster. Could not figure out how to run everything on the same hardware yet.

→ Running everything again on a laptop at the moment

Results

xi=5, 10BX for each sub-QUBO size



Average solving success for a sub-QUBO vs. sub-QUBO size.

NFT parameters derived from IBM calculation to have 99% sub-QUBO solving success rate.

Success rate decreases with sub-QUBO size. Worse than linear dependency.

Hamiltonian

xi=5, results for one Representative BX

- sub-QUBO size = 12

- data divided into 3709 sub-QUBOs
  - 3280 subQUBO matrices have no b_ij entries which means that triplets in these sub-QUBOs do not share any hit / have no connections/conflicts
  - 46 sub-QUBO matrices (~1.2%) have at least one b_ij entry ≠ 0

- hypothesis: sub-QUBO scaling in terms of efficiency / fake rate correlated to
  - the number of sub-QUBO matrices which have a b_ij entry ≠ 0
  - the average number of b_ij entry ≠ 0 per matrix

Additional conclusion: Investigation of different ansatz types would not improve the results. Additional entanglements would act as perturbance in the optimisation process. BUT: For a replacement of the impact list, this is a good idea!

Conclusion

The time until the solution reaches 95% depends highly on the hardware the QUBO is run. At least a factor of 2 is in the game.

The sub-QUBO solving efficiency drops with the size of the sub-QUBO. For a size of 16, the 95% level was not reached, so this data could not be shown.

Currently I am reprocessing data on a single laptop, so the machine is always the same. Expecting results for all 10BX in ~ week.