Effects of Noise on Expectation Value (2)
+ Readout Error Mitigation

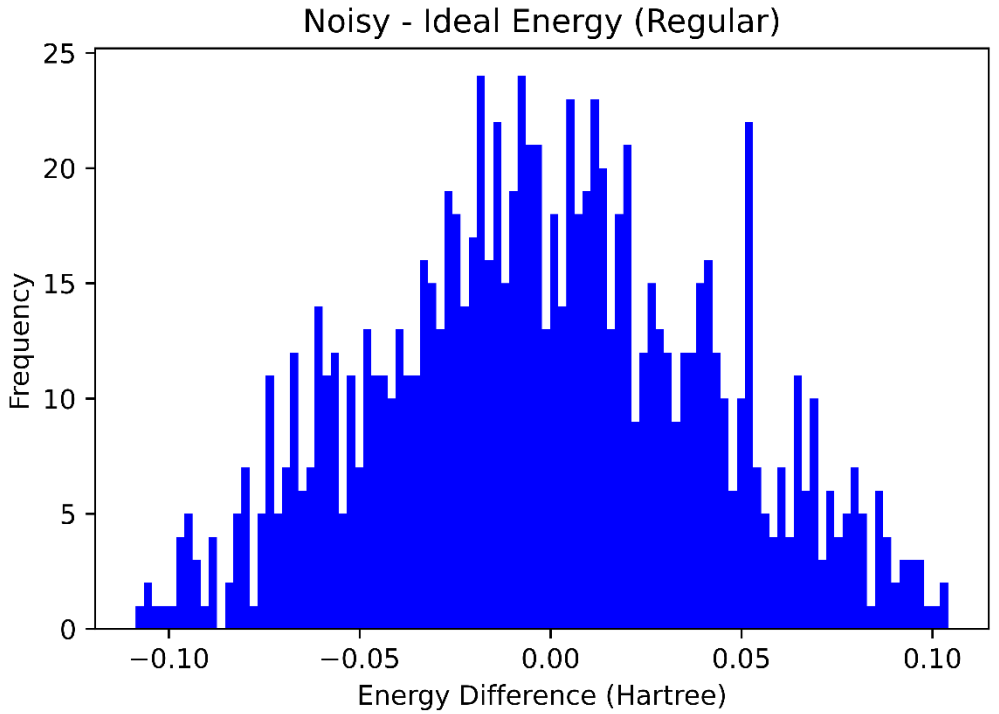
Results from Halloween Weekend

November 1, 2020

Recap

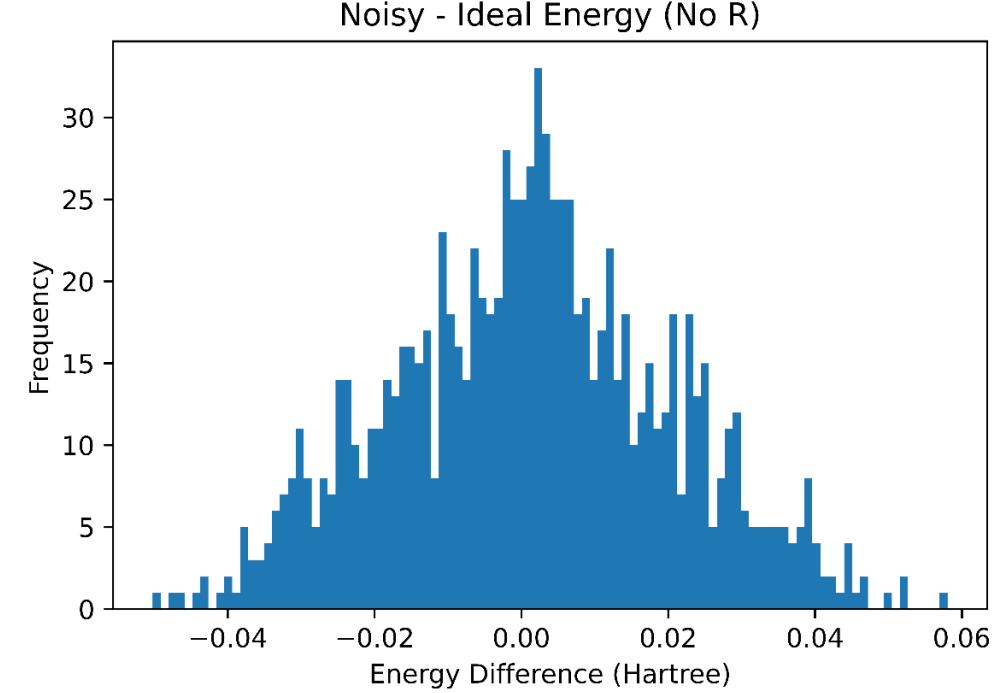
Experiment

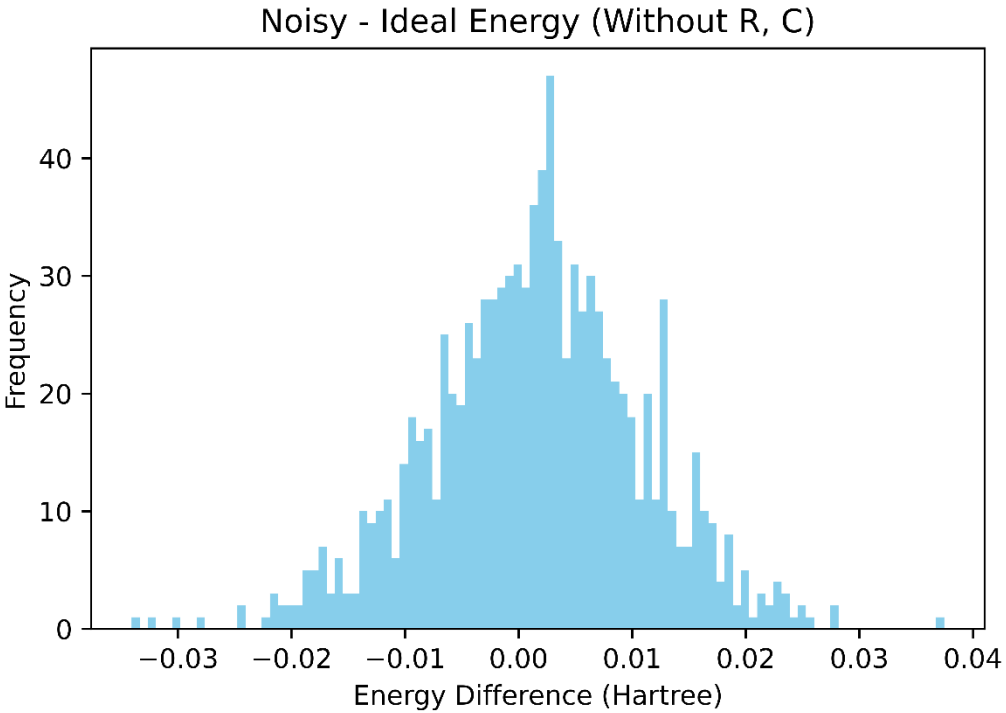
- Randomly choose the 3 parameter values in H2 UCSSD circuit from the range $(-\pi, \pi)$.
- Compute the energy on both noisy and ideal simulator(Fake London noisy sim used), and plot the differences.
- Do so 1000 times
- **Expected**: An assymetrical shift to the right with some outliers with negative energy difference (i.e. noisy being lower than ideal)
- **Outcome:** Roughly normal distribution, which is surprising.

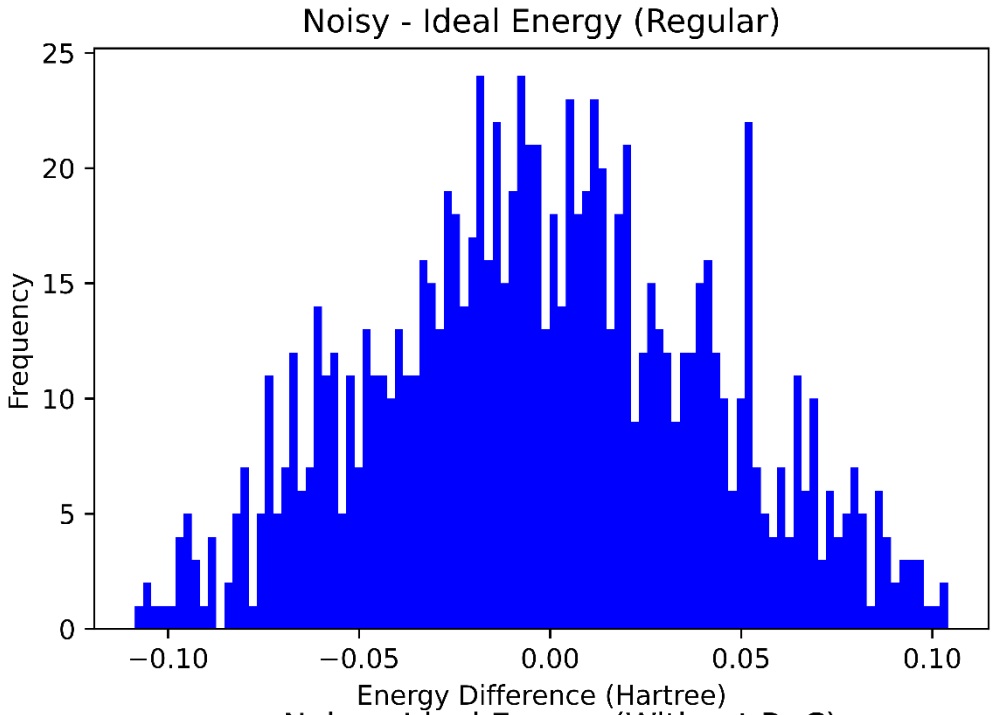


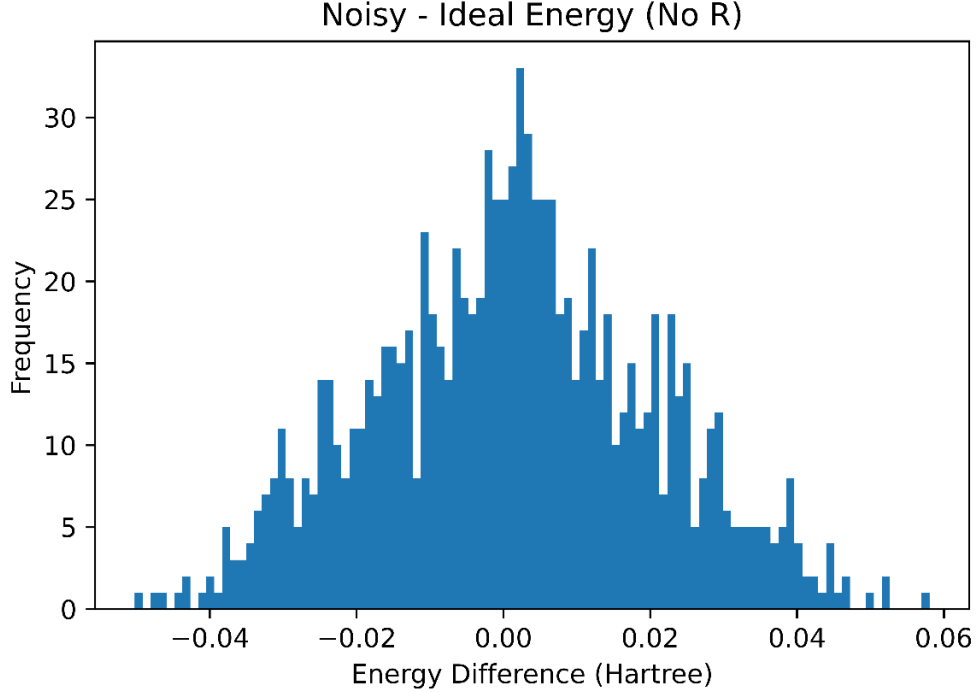
Recap
Isolating individual error types

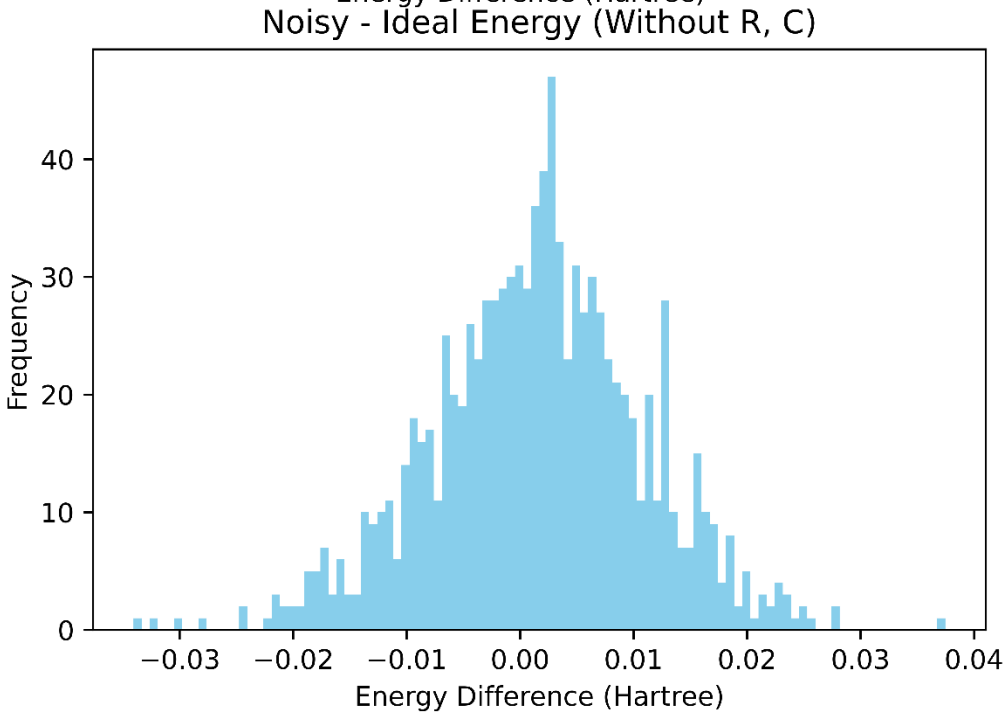
- (R) refers to readout errors and (C) refers to coherent errors, (I) refers to incoherent errors.
- There seems to be huge change in spread when we remove readout errors – approx. reduction by a factor of 3
- In the bottom plot, we **expect** incoherent errors to have some asymmetrical effect but that is not shown by the plot

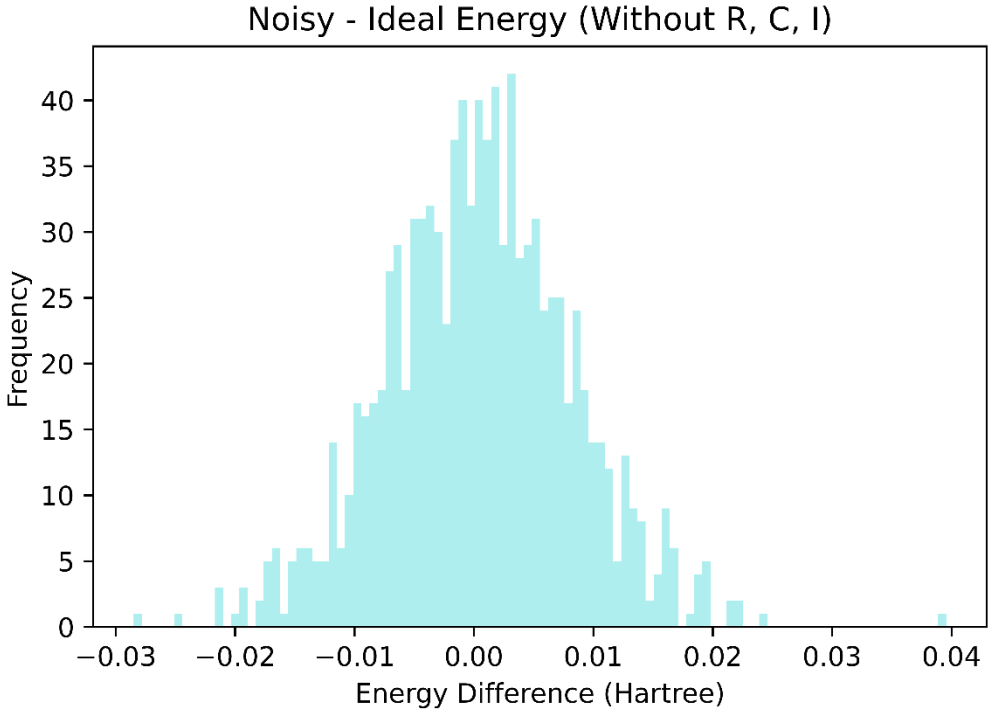





Noisy - Ideal Energy (Regular)
Frequency
Energy Difference (Hartree)


Noisy - Ideal Energy (No R)
Frequency
Energy Difference (Hartree)


Noisy - Ideal Energy (Without R, C)
Frequency
Energy Difference (Hartree)

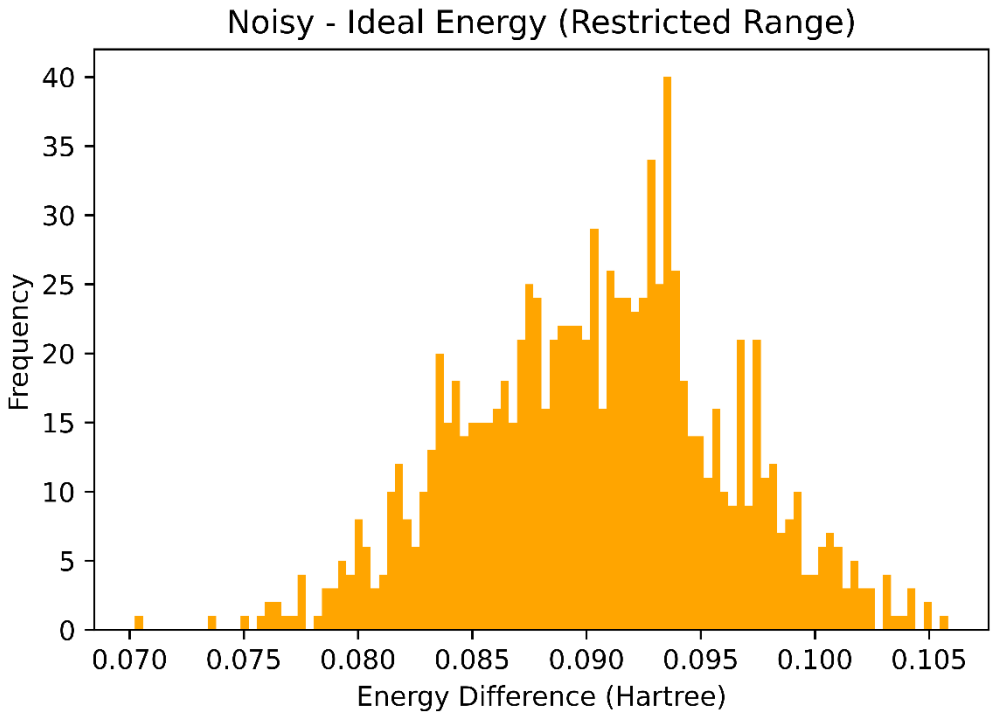

Noisy - Ideal Energy (Without R, C, I)
Frequency
Energy Difference (Hartree)

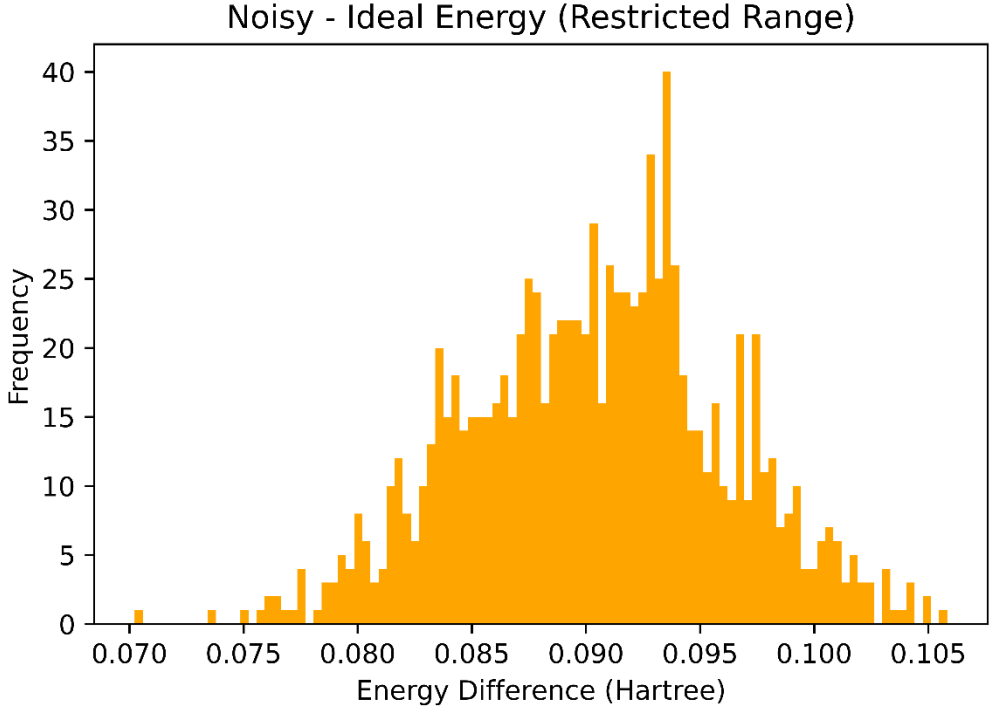
New

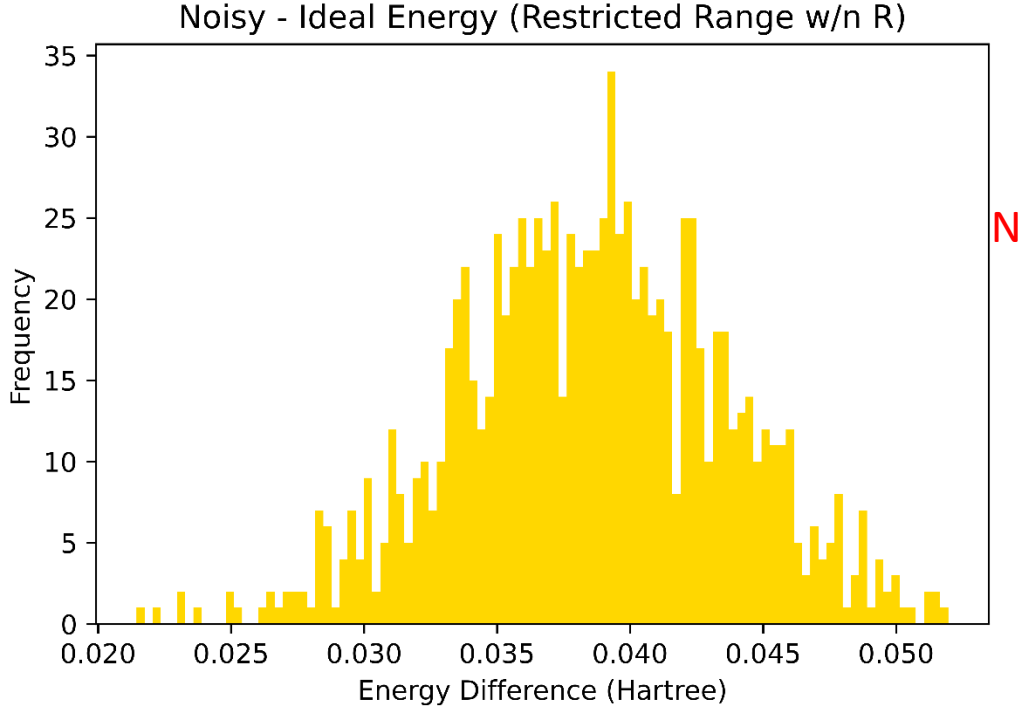
Recap

Restricting the Range of parameters about optimized parameters

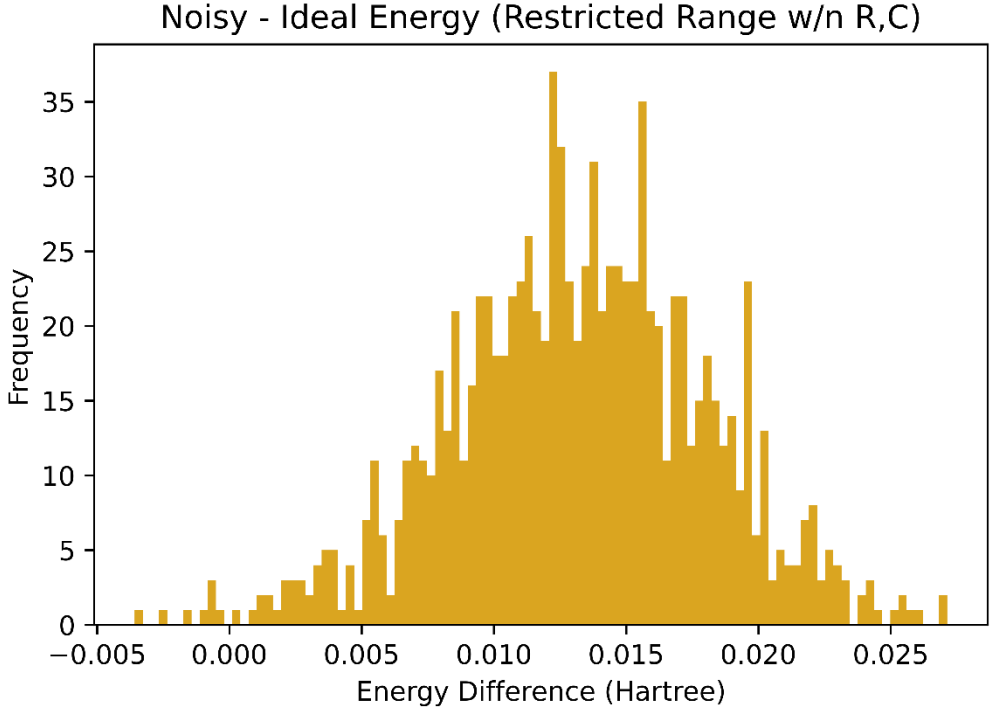
- Obtaining the parameters after VQE finished optimizing (H2 at 0.74 ang sep.) on FakeLondon noisy simulator, we get
- [0.00172129 -0.00182397 -0.11217598]
- So the range for the 3 parameters was restricted to :
- [0.0015 +/- 0.0005, -0.0015+/- 0.0005, 0.15+/- 0.05] Then sampling parameters from this range, we get the following plot.
- **Expected:** From slide 2, we would expect the same normal distribution centered at 0
- **Reality:** A significant asymmetrical shift to the right.



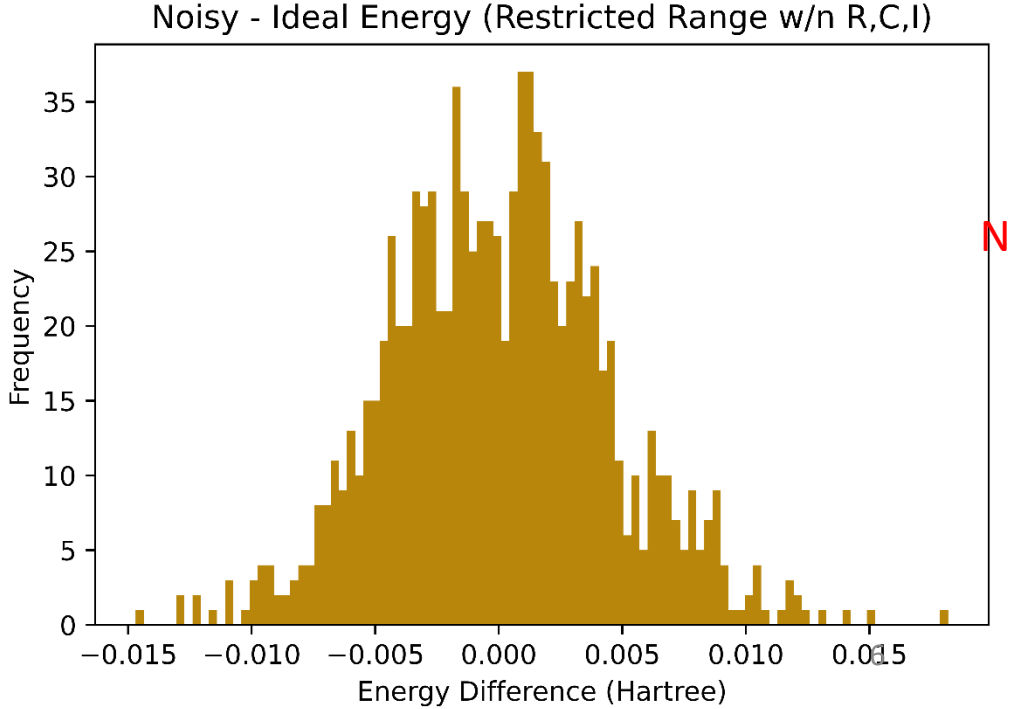

Noisy - Ideal Energy (Restricted Range)
Frequency
Energy Difference (Hartree)


Noisy - Ideal Energy (Restricted Range w/n R)
Frequency
Energy Difference (Hartree)

New


Noisy - Ideal Energy (Restricted Range w/n R,C)
Frequency
Energy Difference (Hartree)

New


Noisy - Ideal Energy (Restricted Range w/n R,C,I)
Frequency
Energy Difference (Hartree)

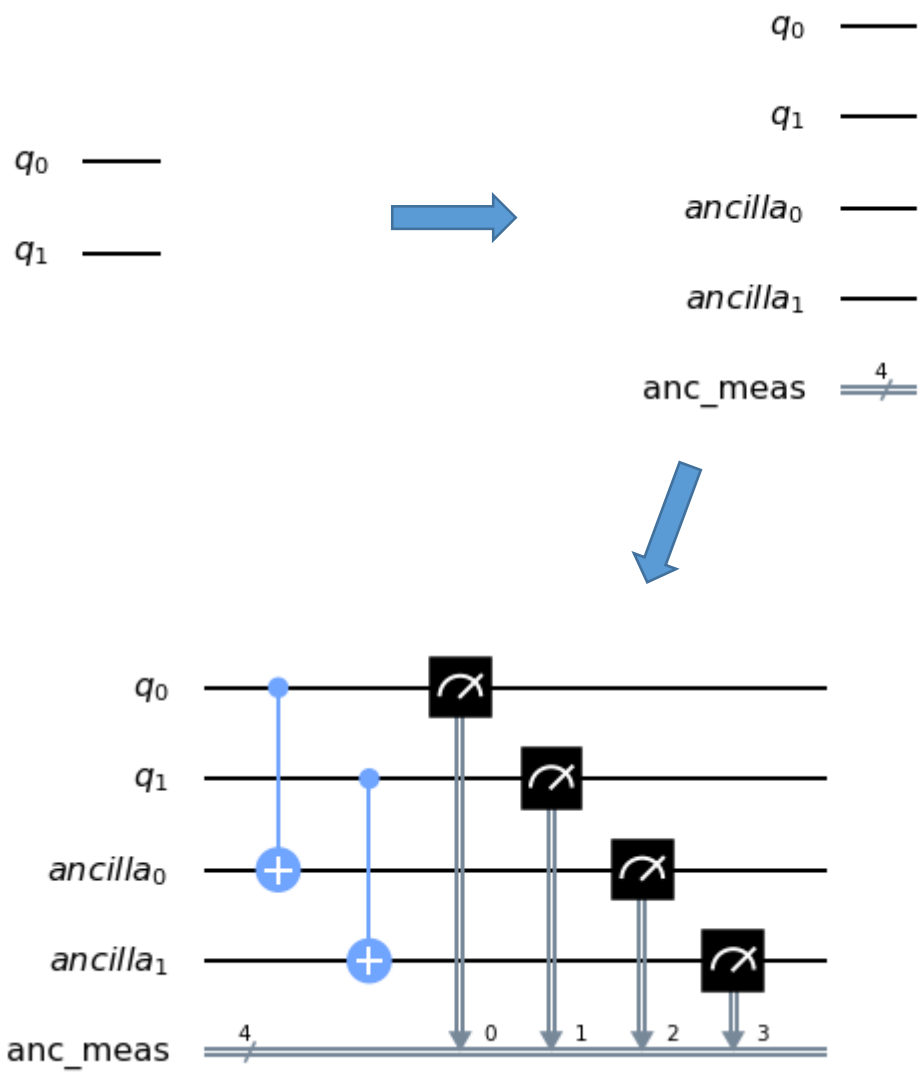
New

Readout Error Mitigation

Implementing the CNOT method discussed in last week's meeting on H2 VQE circuit

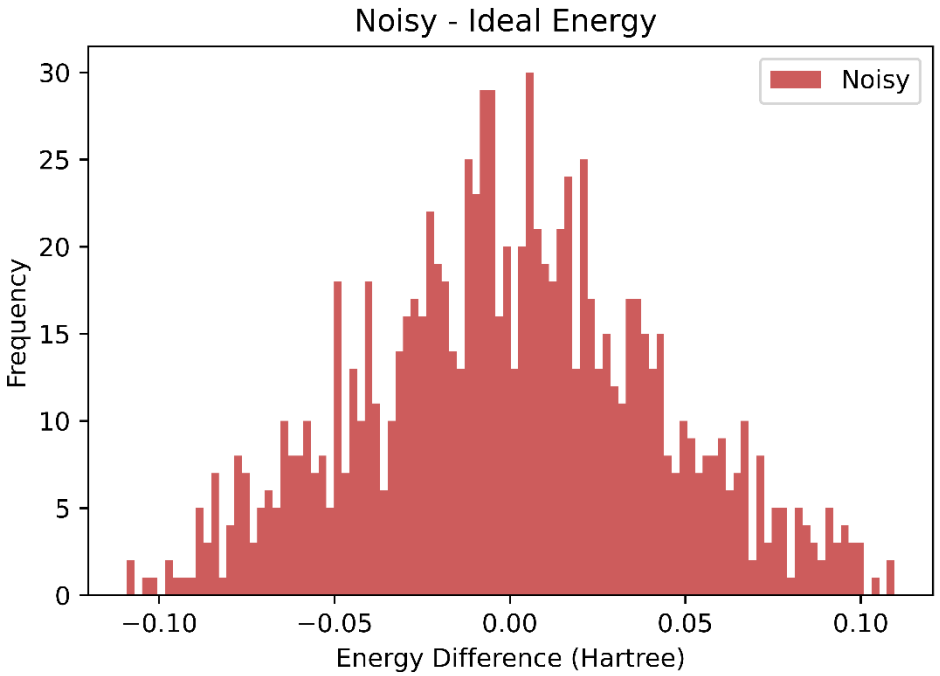
Readout Error Mitigation

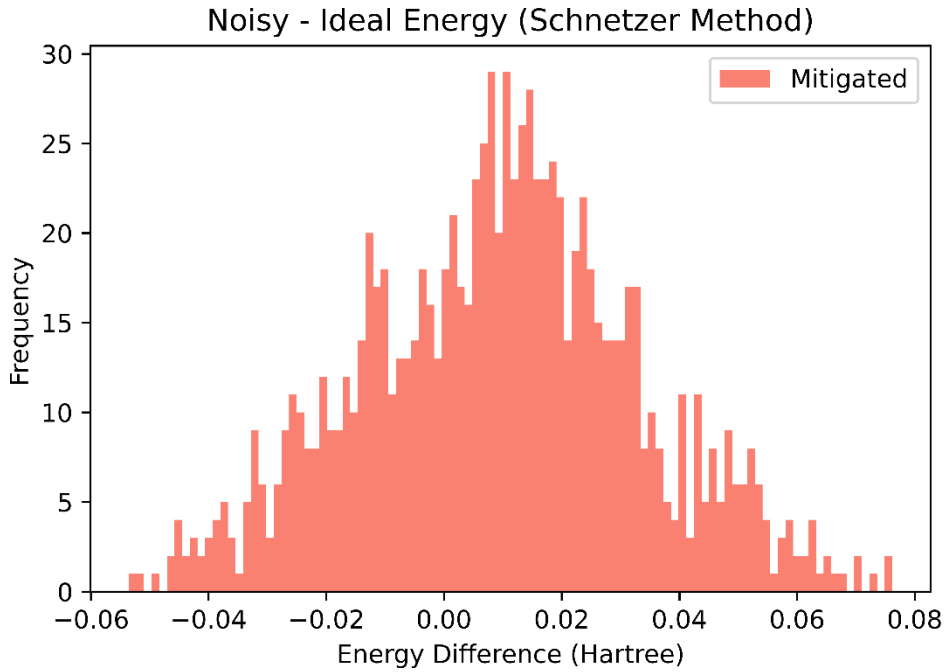
- Given a circuit, we double the number of qubits and use then entangle the old qubits with the new **“ancilla”** qubits.
- Measuring all the qubits, we **reject non-symmetric** outcomes i.e. |0001> is rejected because if 1st qubit is in 1 state then third qubit should also be in that state… we will accept |0101>
- Testing this method on circuit for VQE Hydrogen molecule.
- Conducting same experiments as in Slide 2 and slide 5



Regular Range $(-\pi, \pi)$

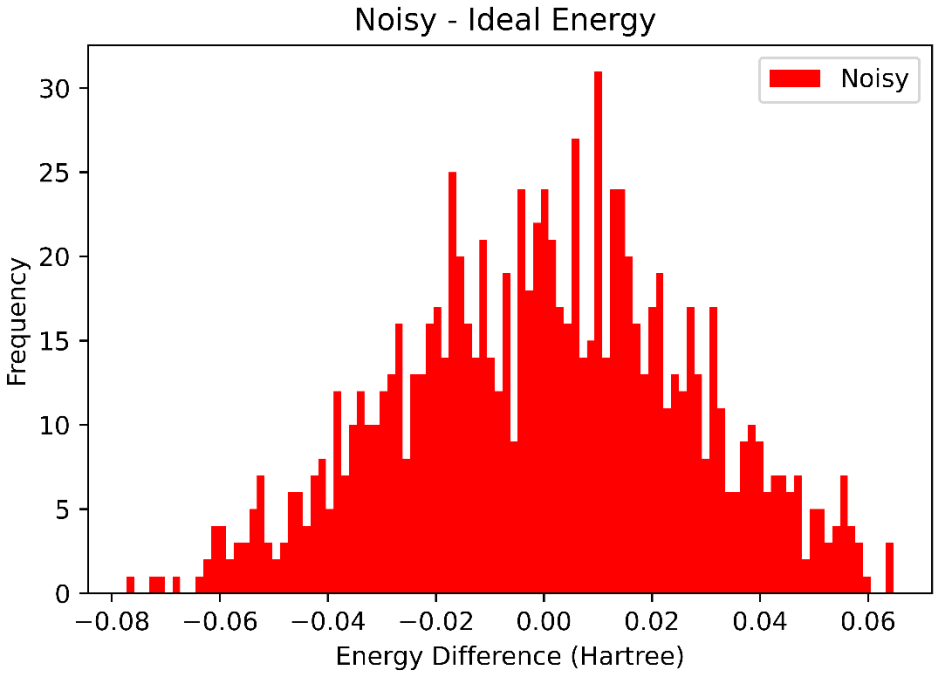
Full Noise Model

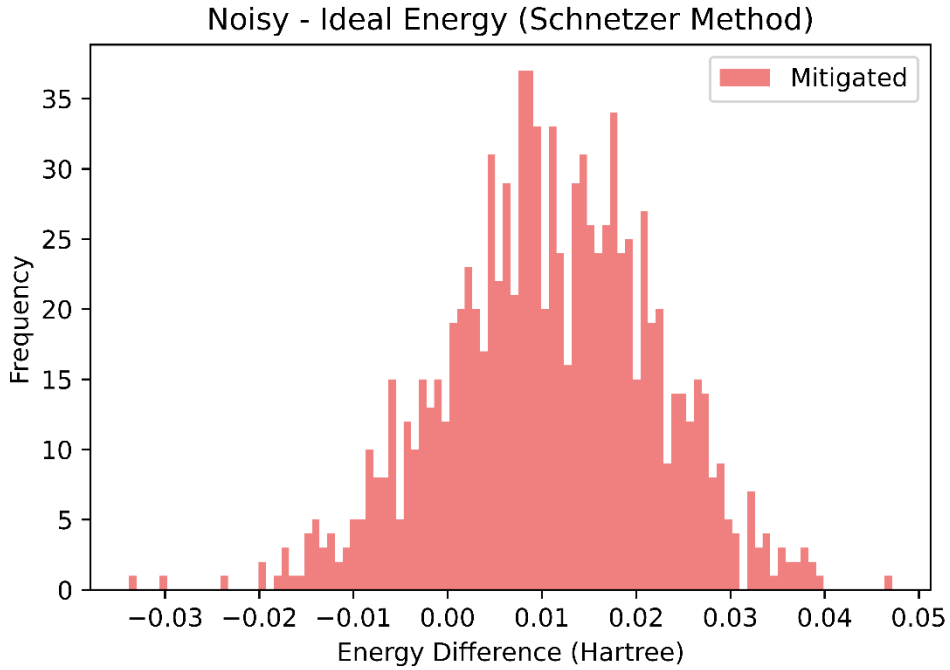




Regular Range $(-\pi, \pi)$

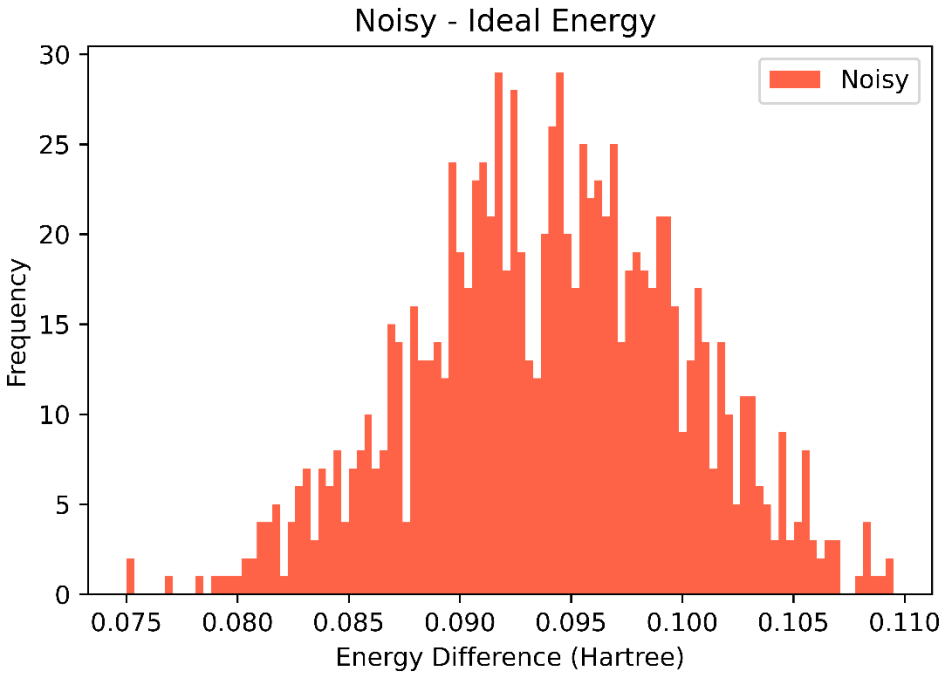
Only Readout Errors

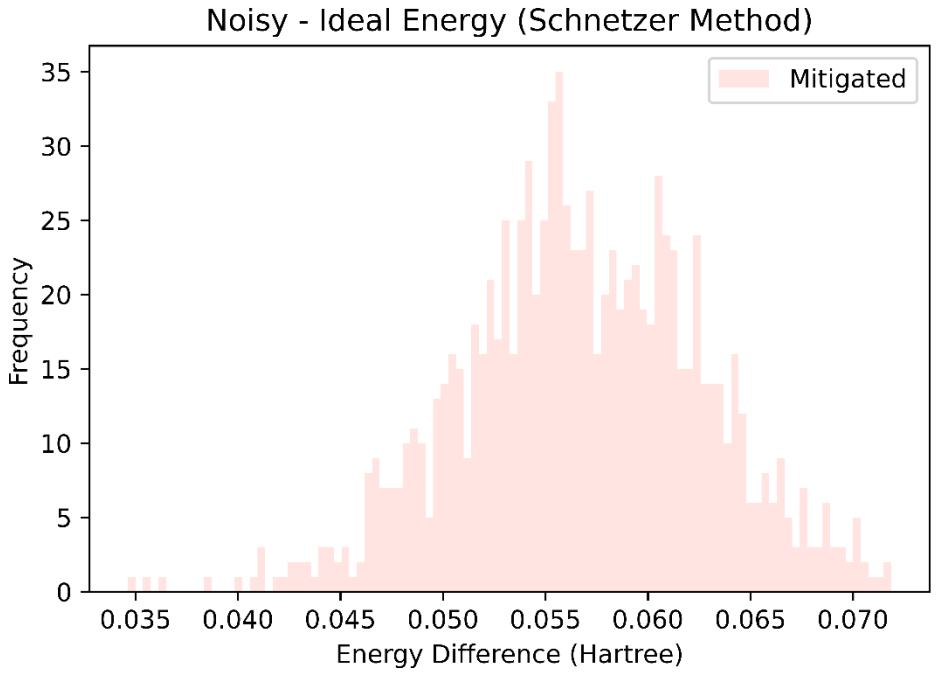




Restricted Range [(0.001, 0.002),(-0.002, -0.001), (-0.2, -0.1)]

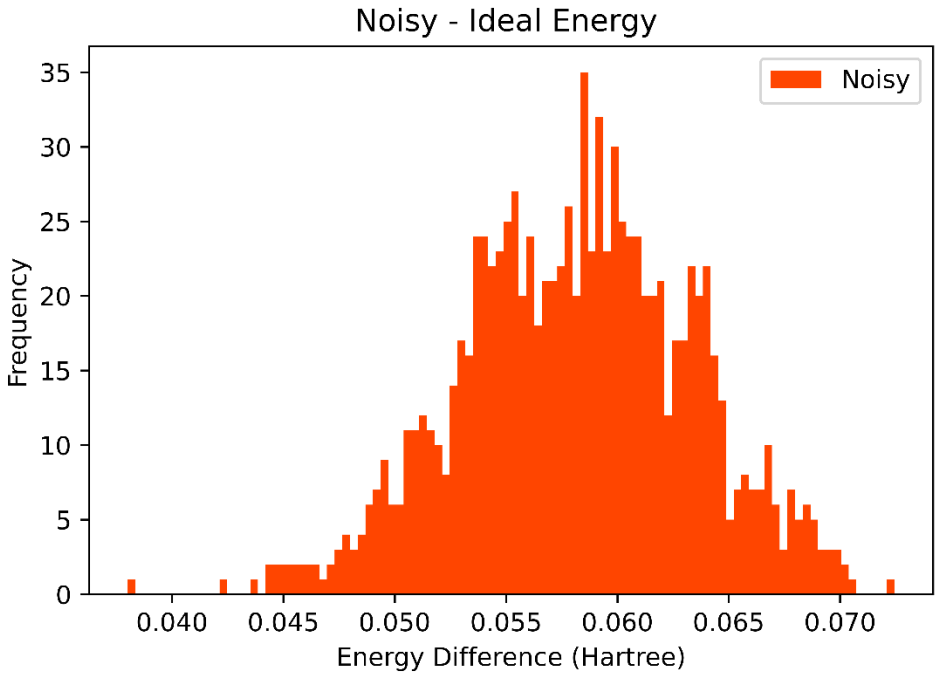
Full Noise Model

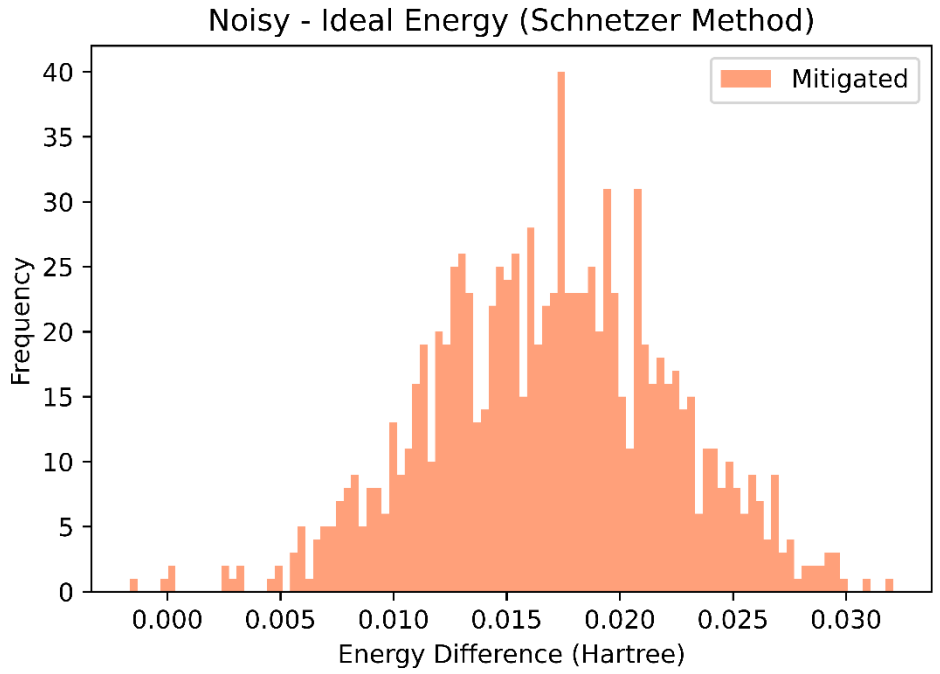




Restricted Range [(0.001, 0.002),(-0.002, -0.001), (-0.2, -0.1)]

Only Readout Errors





Optimized Parameters [0.00172129,-0.00182397, -0.11217598] Full Noise Model