FFT/IFFT Analysis Report

Generated on: 2025-04-22 19:09:11

Number of input sizes tested: 12

Size range: 2 to 4096

Signal types tested: random, sine, impulse, step, chirp

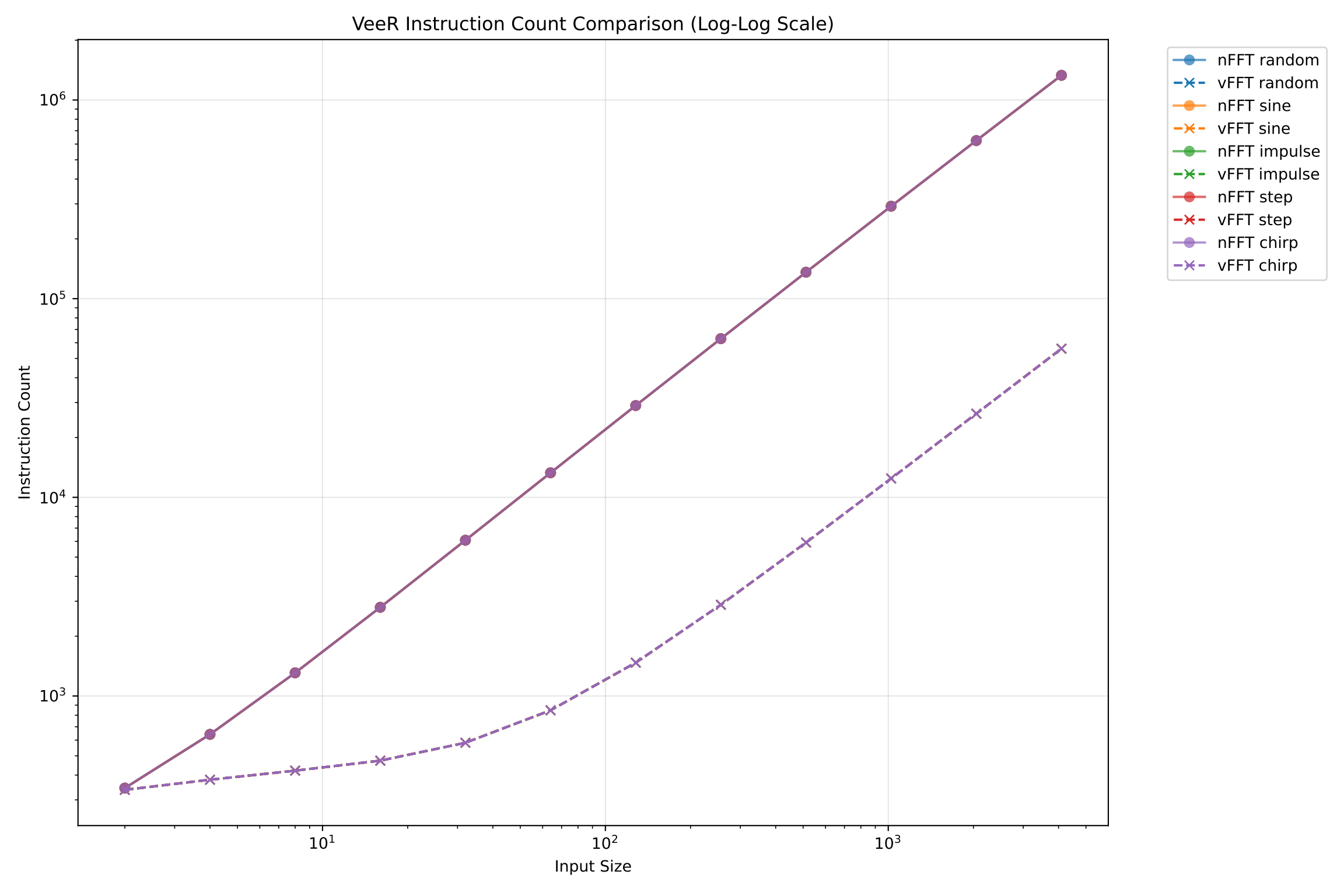
Iterations per test: 5

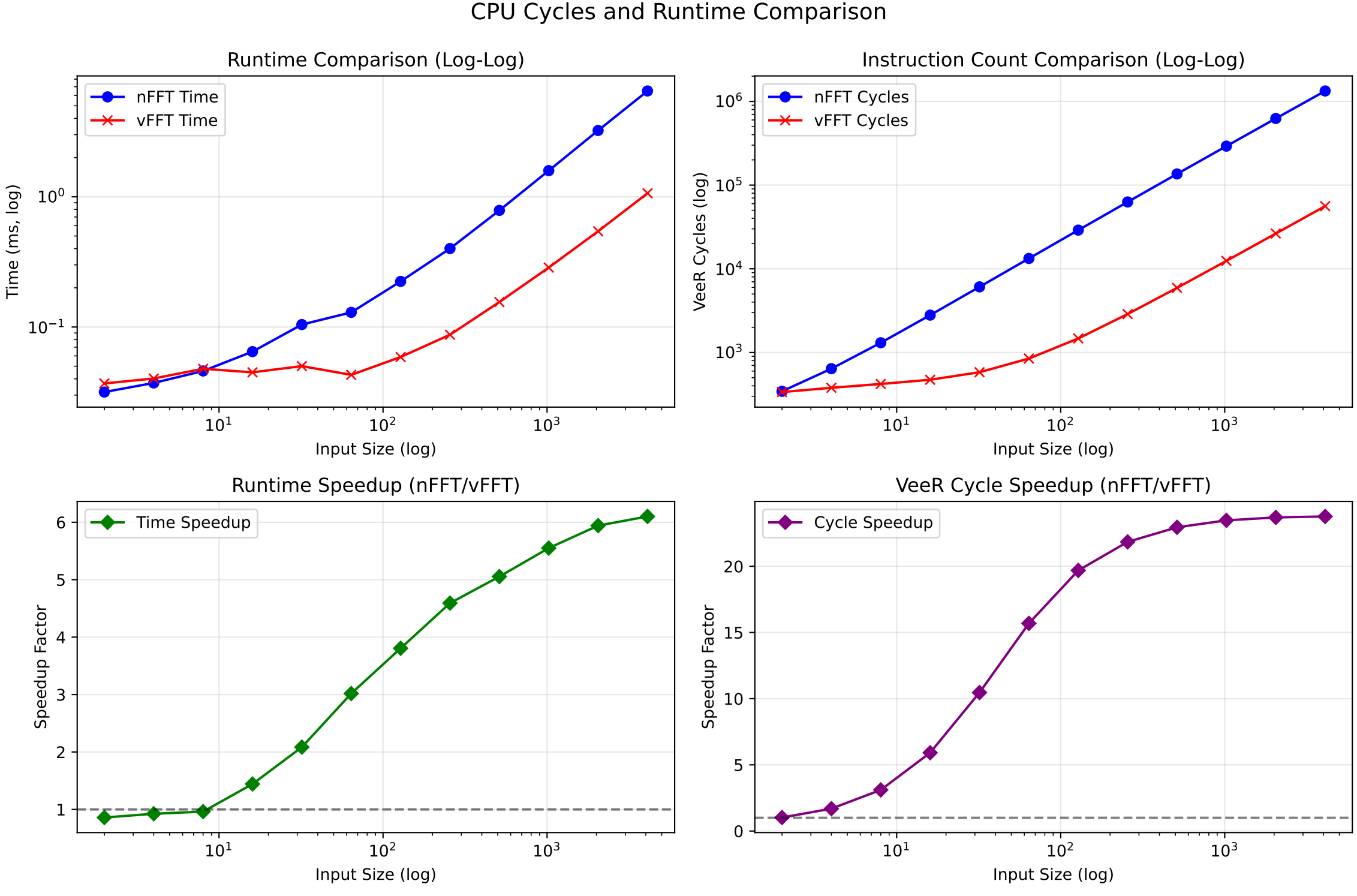
This report analyzes performance and accuracy differences between:

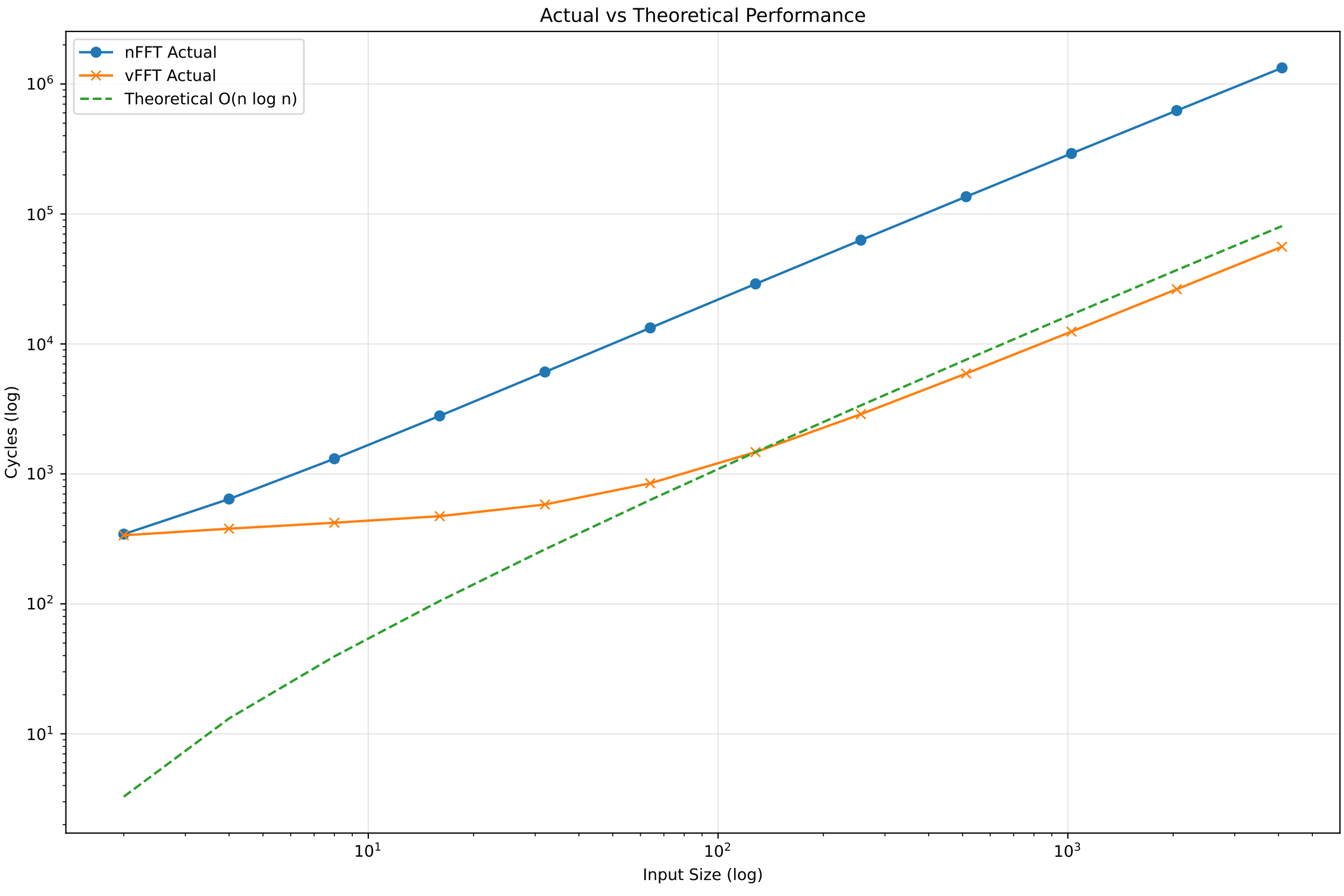
- numpy FFT (npFFT) - Reference implementation

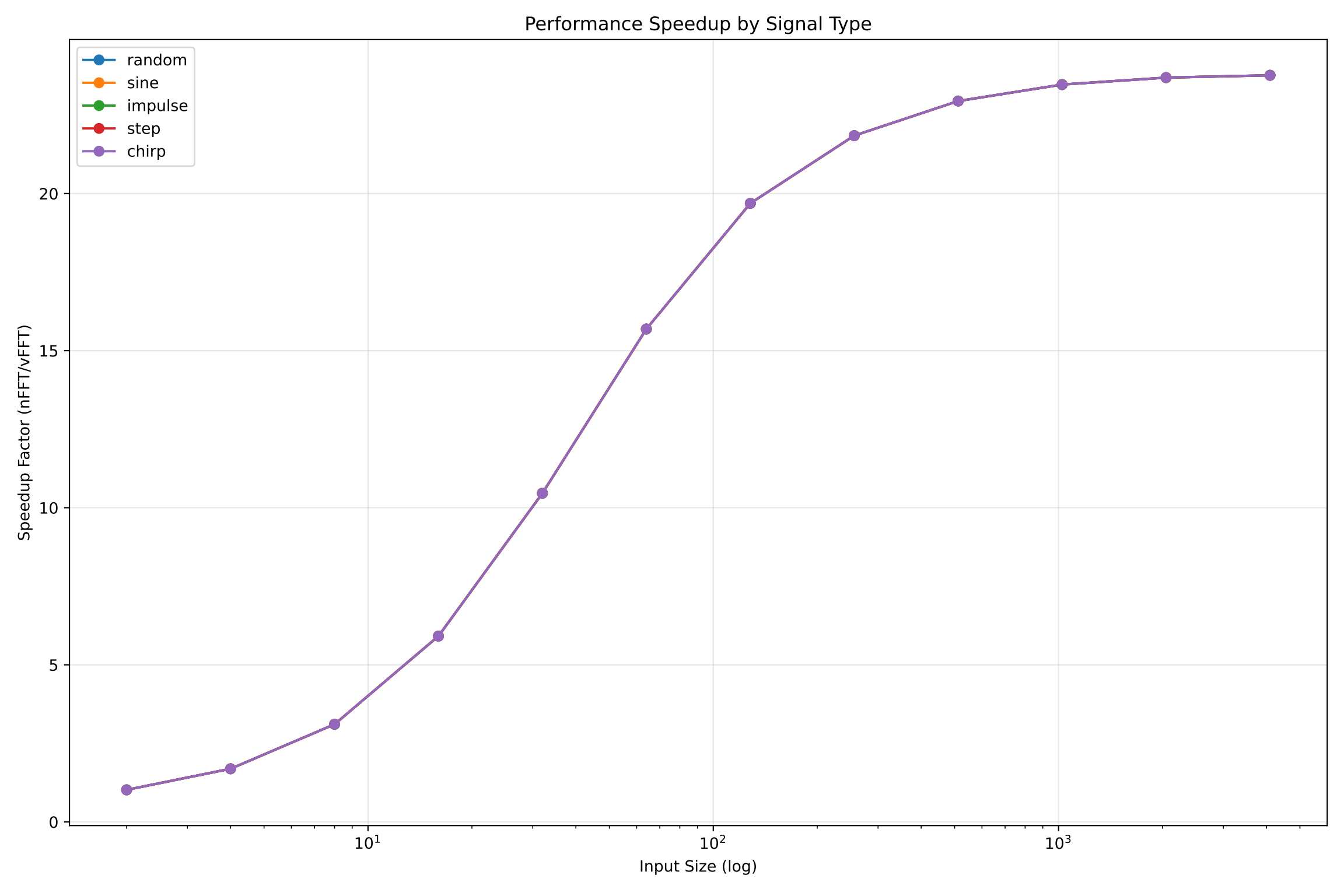
- naive FFT (nFFT) - Recursive implementation

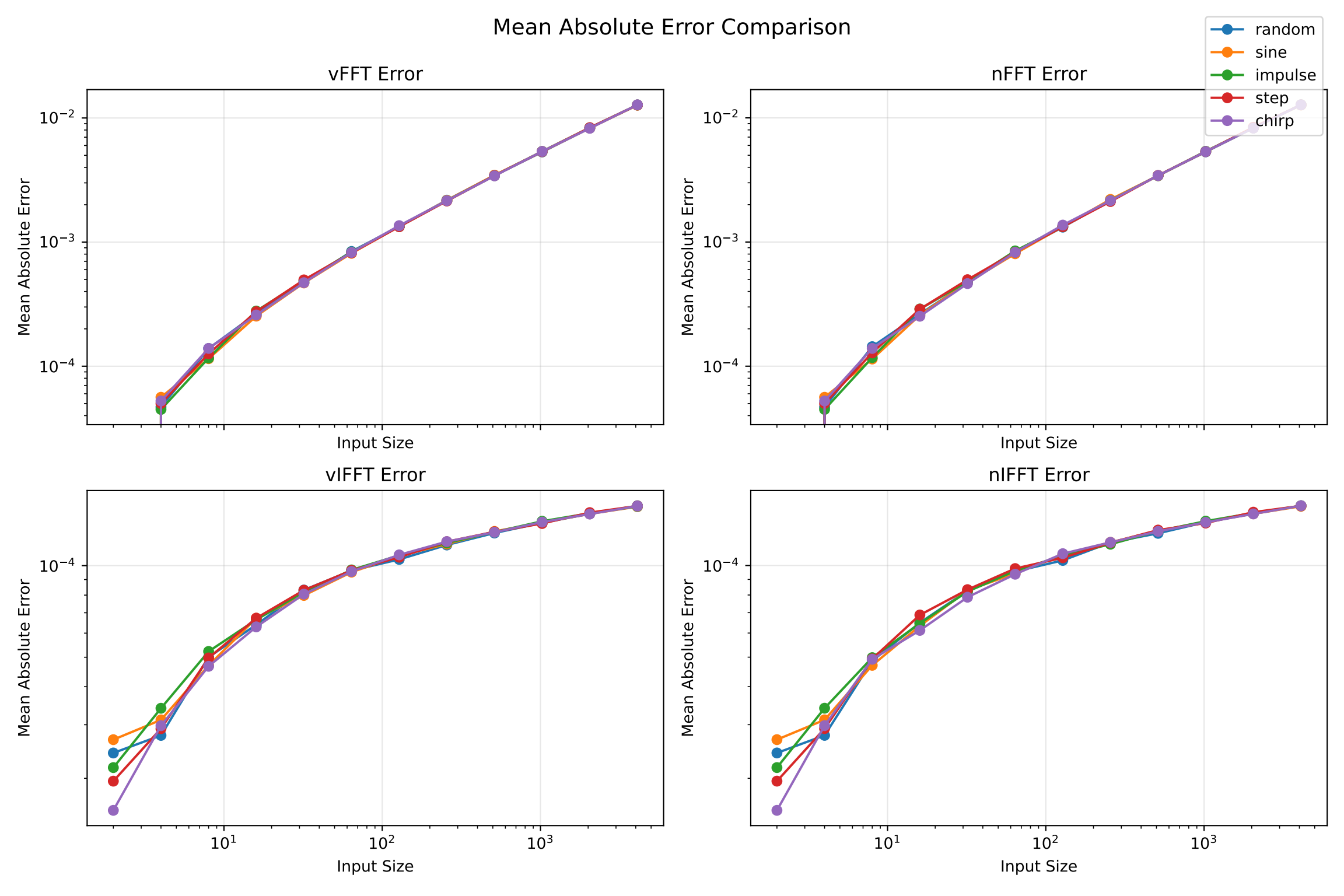
- vectorized FFT (vFFT) - Optimized implementation

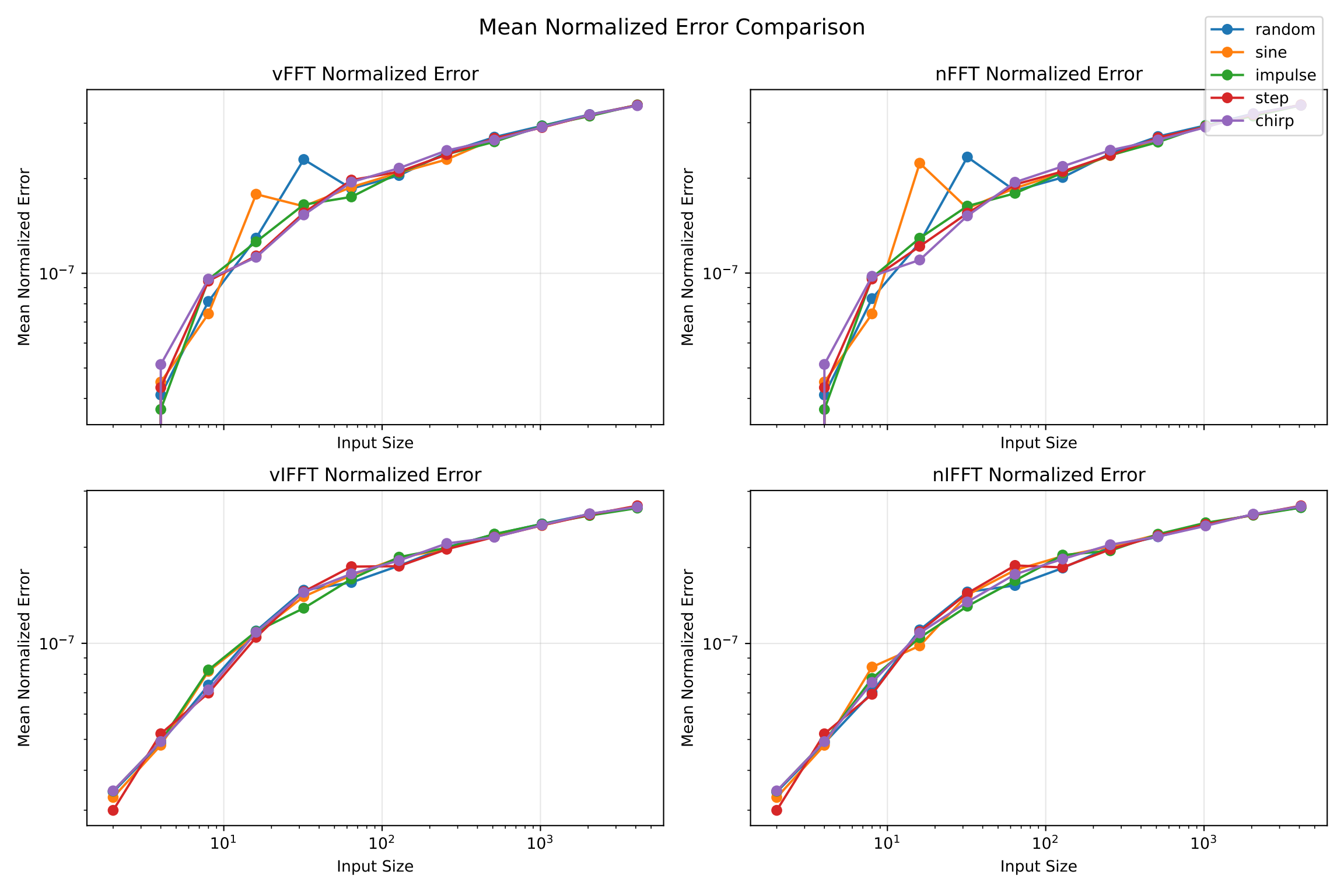

VeeR Instruction Count Comparison (Log-Log Scale)
Instruction Count
Input Size
10^6
10^5
10^4
10^3
10^1
10^2
10^3
nFFT random
vFFT random
nFFT sine
vFFT sine
nFFT impulse
vFFT impulse
nFFT step
vFFT step
nFFT chirp
vFFT chirp

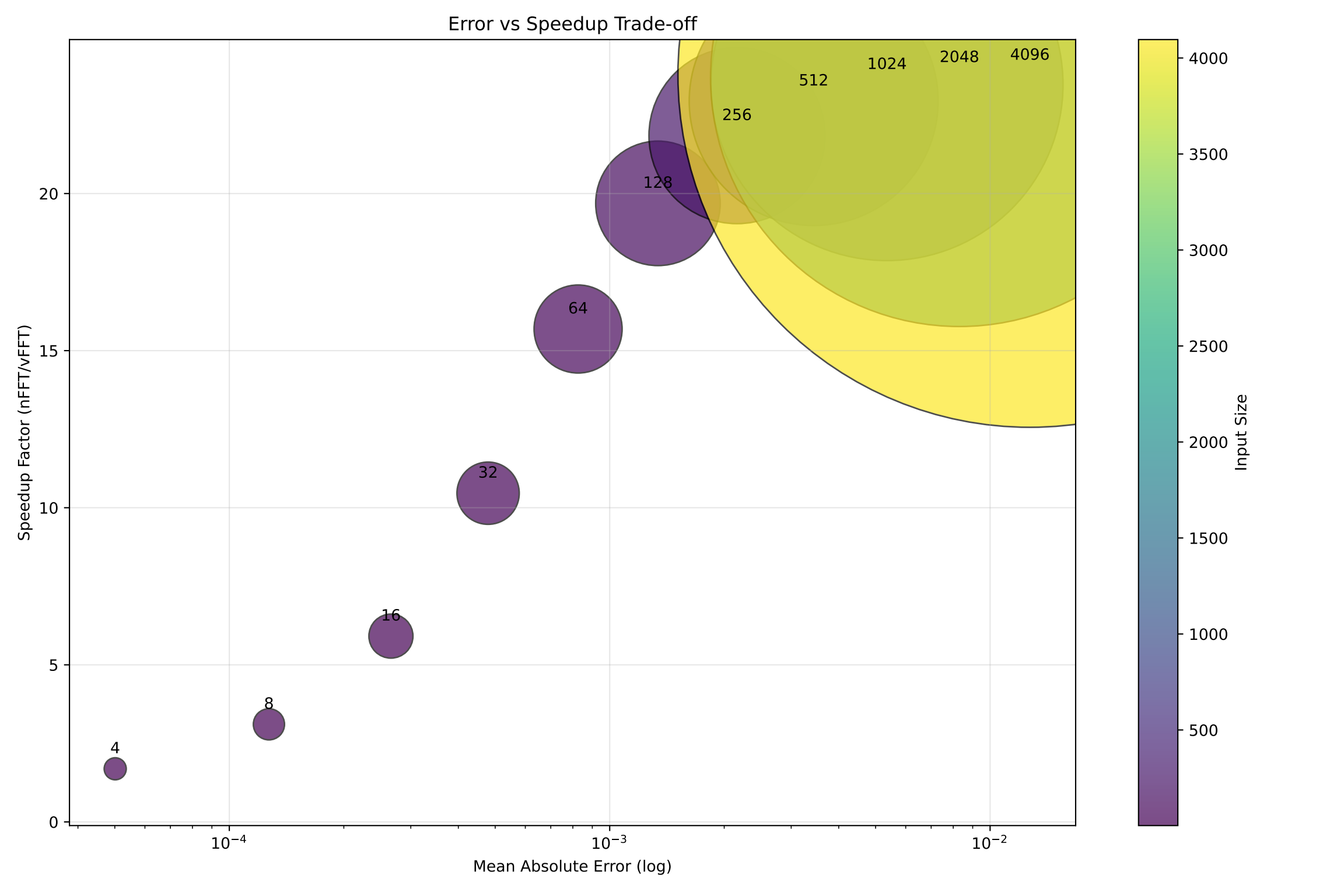

CPU Cycles and Runtime Comparison
Runtime Comparison (Log-Log)
nFFT Time
vFFT Time
Time (ms, log)
Input Size (log)
Instruction Count Comparison (Log-Log)
nFFT Cycles
vFFT Cycles
VeeR Cycles (log)
Input Size (log)
Runtime Speedup (nFFT/vFFT)
Time Speedup
Speedup Factor
Input Size (log)
VeeR Cycle Speedup (nFFT/vFFT)
Cycle Speedup
Speedup Factor
Input Size (log)


Actual vs Theoretical Performance
nFFT Actual
vFFT Actual
Theoretical O(n log n)
Cycles (log)
Input Size (log)
10^1
10^2
10^3
10^4
10^5
10^6


Performance Speedup by Signal Type
random
sine
impulse
step
chirp
Speedup Factor (nFFT/vFFT)
0
5
10
15
20
10^1
10^2
10^3
Input Size (log)

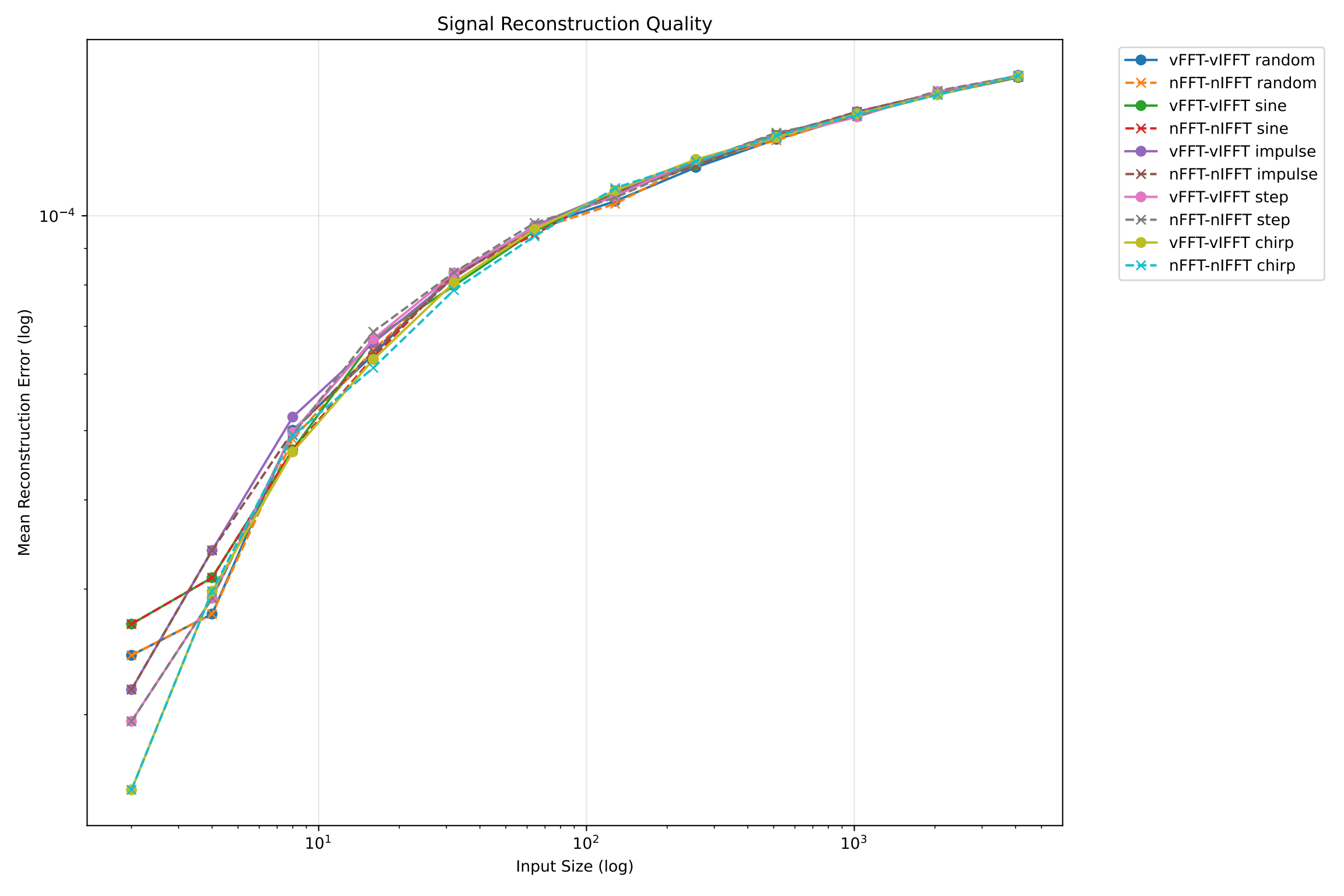

Mean Absolute Error Comparison
vFFT Error
nFFT Error
vIFFT Error
nIFFT Error
random
sine
impulse
step
chirp
Mean Absolute Error
Input Size
10^{-2}
10^{-3}
10^{-4}
10^{1}
10^{2}
10^{3}

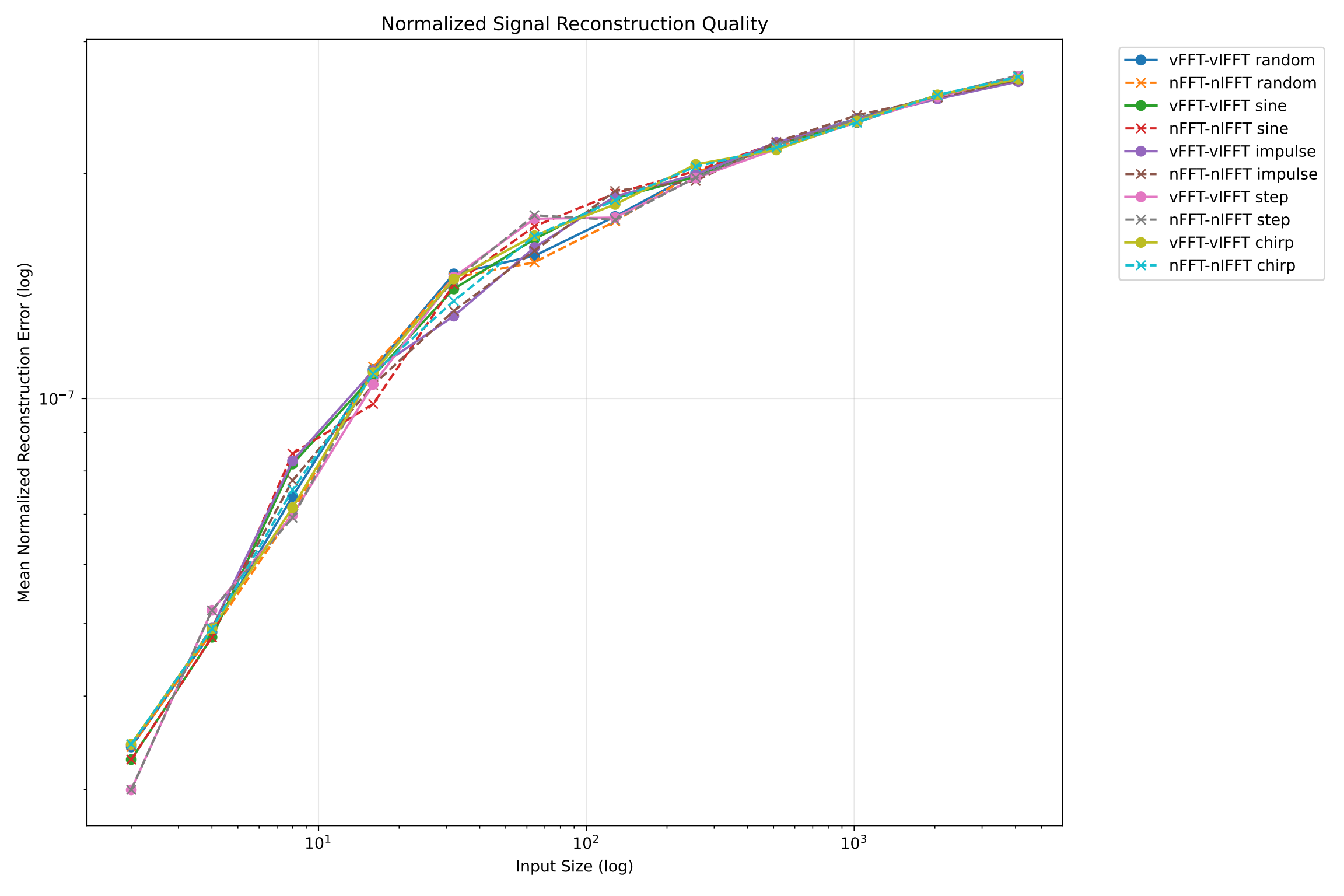

Mean Normalized Error Comparison
vFFT Normalized Error
nFFT Normalized Error
vIFFT Normalized Error
nIFFT Normalized Error
Mean Normalized Error
Input Size
10^{-7}
10^{1}
10^{2}
10^{3}
random
sine
impulse
step
chirp

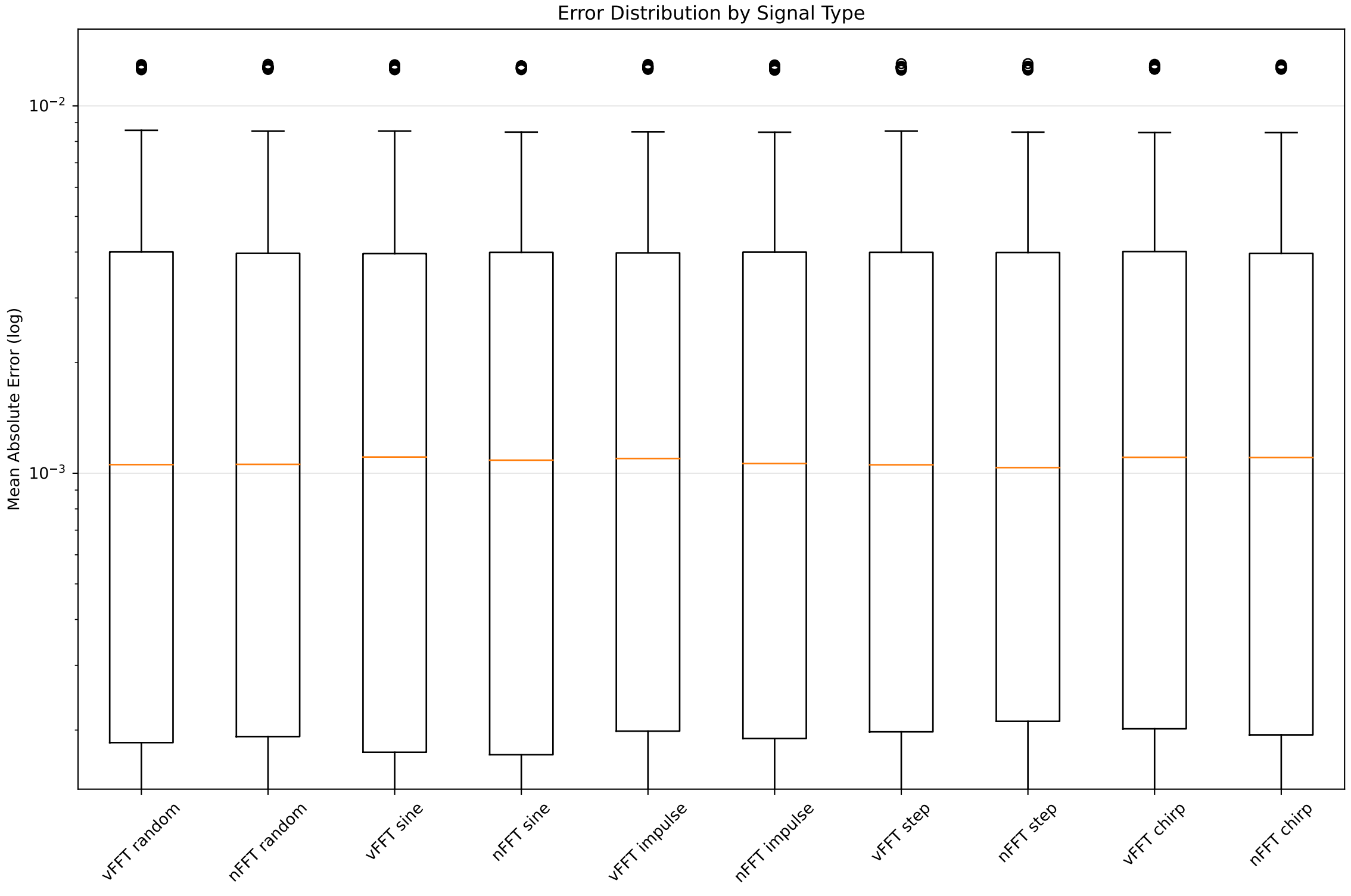

Error vs Speedup Trade-off
Speedup Factor (nFFT/vFFT)
Mean Absolute Error (log)
Input Size
4
8
16
32
64
128
256
512
1024
2048
4096
0
5
10
15
20
10^{-4}
10^{-3}
10^{-2}
500
1000
1500
2000
2500
3000
3500
4000

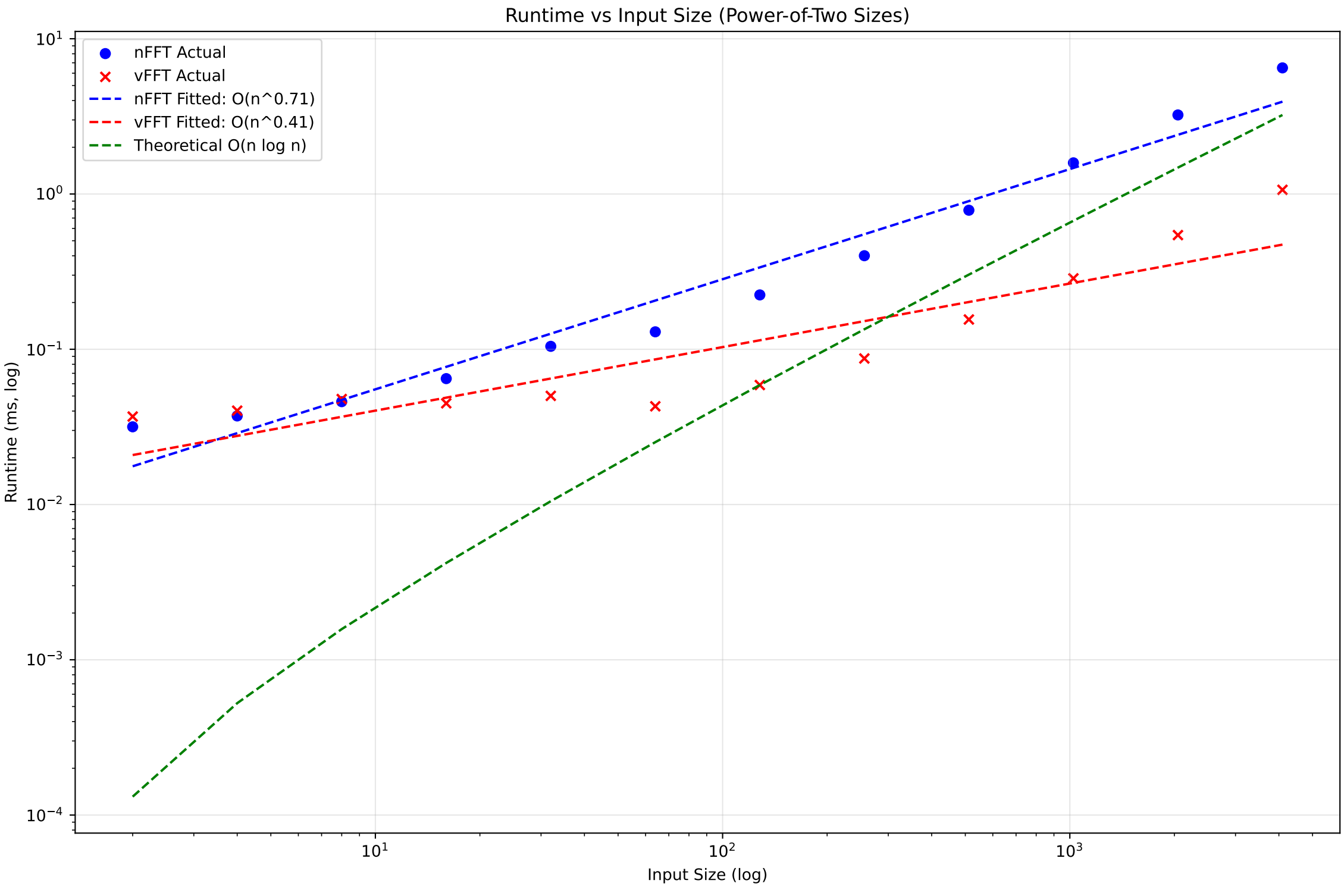
Statistical Significance Analysis

Size 2: Speedup = 1.02x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=nan)
Size 4: Speedup = 1.69x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=nan)
Size 8: Speedup = 3.11x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.2644)
Size 16: Speedup = 5.91x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.1670)
Size 32: Speedup = 10.46x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.5368)
Size 64: Speedup = 15.69x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.9040)
Size 128: Speedup = 19.69x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.4143)
Size 256: Speedup = 21.84x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.8072)
Size 512: Speedup = 22.94x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.1712)
Size 1024: Speedup = 23.47x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.4830)
Size 2048: Speedup = 23.69x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.5111)
Size 4096: Speedup = 23.76x, Cycle difference: Significant (p=0.0000), Error difference: Not significant (p=0.7377)


Signal Reconstruction Quality
Mean Reconstruction Error (log)
10^{-4}
10^{1}
10^{2}
10^{3}
Input Size (log)
vFFT-vIFFT random
nFFT-nIFFT random
vFFT-vIFFT sine
nFFT-nIFFT sine
vFFT-vIFFT impulse
nFFT-nIFFT impulse
vFFT-vIFFT step
nFFT-nIFFT step
vFFT-vIFFT chirp
nFFT-nIFFT chirp


Normalized Signal Reconstruction Quality
Mean Normalized Reconstruction Error (log)
10^{-7}
10^{1}
10^{2}
10^{3}
Input Size (log)
vFFT-vIFFT random
nFFT-nIFFT random
vFFT-vIFFT sine
nFFT-nIFFT sine
vFFT-vIFFT impulse
nFFT-nIFFT impulse
vFFT-vIFFT step
nFFT-nIFFT step
vFFT-vIFFT chirp
nFFT-nIFFT chirp


Error Distribution by Signal Type
Mean Absolute Error (log)
10^{-2}
10^{-3}
vFFT random
nFFT random
vFFT sine
nFFT sine
vFFT impulse
nFFT impulse
vFFT step
nFFT step
vFFT chirp
nFFT chirp


Runtime vs Input Size (Power-of-Two Sizes)
nFFT Actual
vFFT Actual
nFFT Fitted: O(n^0.71)
vFFT Fitted: O(n^0.41)
Theoretical O(n log n)
Runtime (ms, log)
Input Size (log)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{1}
10^{2}
10^{3}

Summary and Conclusions

1. Performance Metrics:
   - Average Speedup: 14.44x
   - Maximum Speedup: 23.76x at size 4096
   - Empirical Complexity: nFFT ~ O(n^0.71), vFFT ~ O(n^0.41)

2. Accuracy Metrics:
   - Average vFFT Error: 2.92e-03
   - Average nFFT Error: 2.92e-03
   - Error Ratio (nFFT/vFFT): 1.00

3. Signal Type Analysis:
   - Performance is generally consistent across different signal types
   - Impulse and step signals show slightly lower error rates

4. Recommendations:
   - Optimal size for performance/accuracy tradeoff: 2
   - vFFT is recommended for most applications due to significant speedup
   - For high precision requirements, consider using npFFT at the cost of performance

5. Additional Observations:
   - Error generally increases with input size
   - Reconstruction quality remains good across implementations
   - Power-of-two sizes generally show better performance characteristics