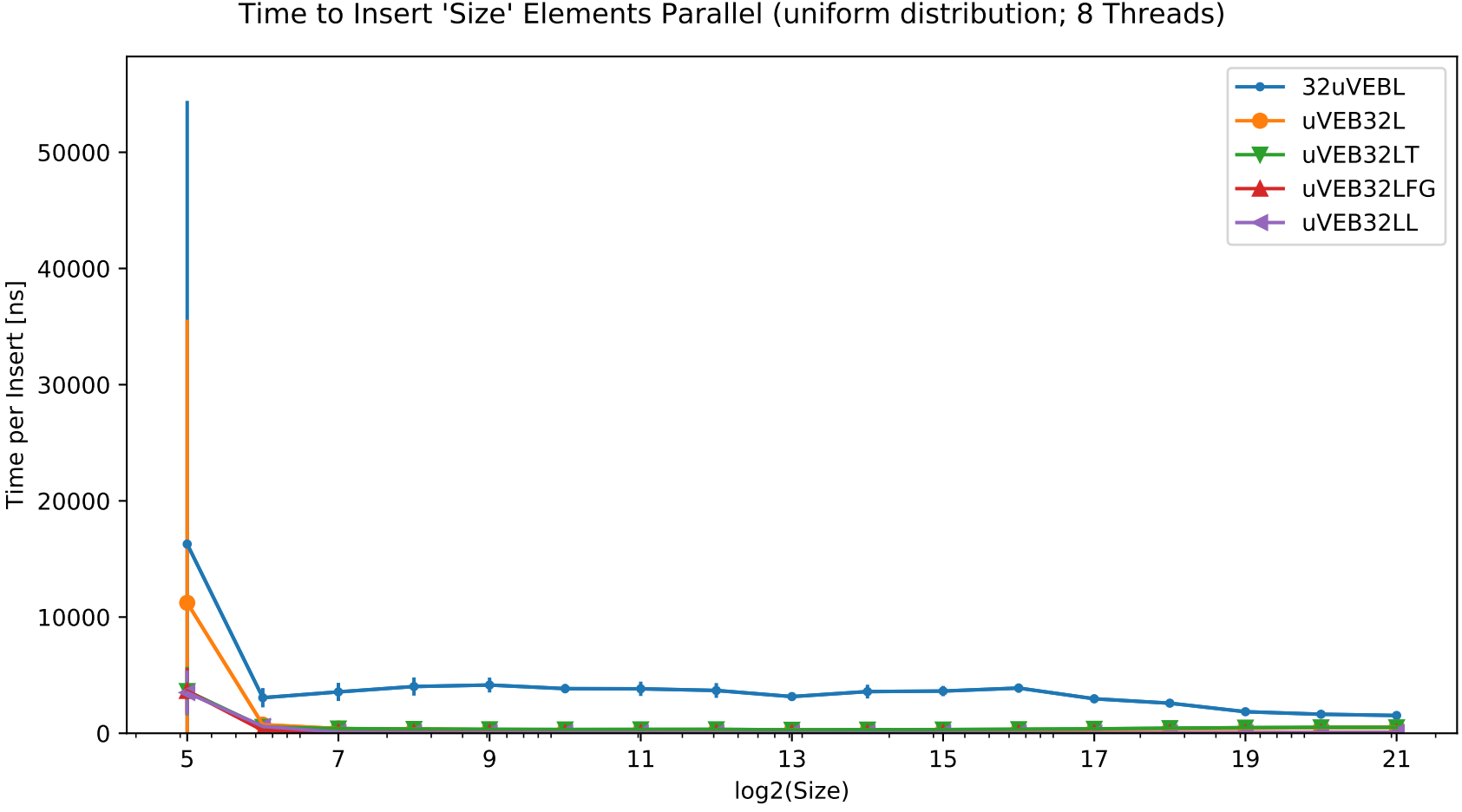
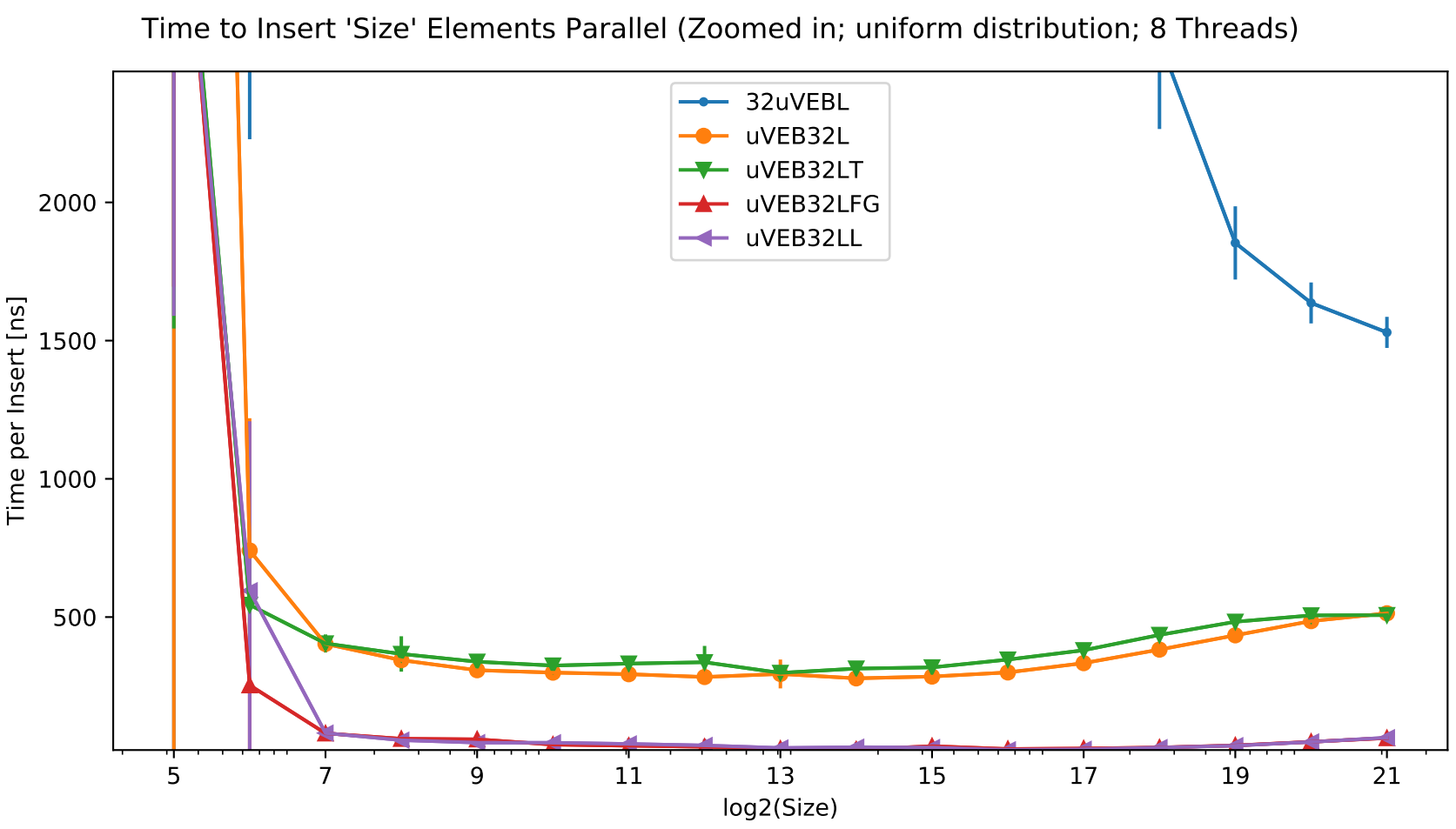
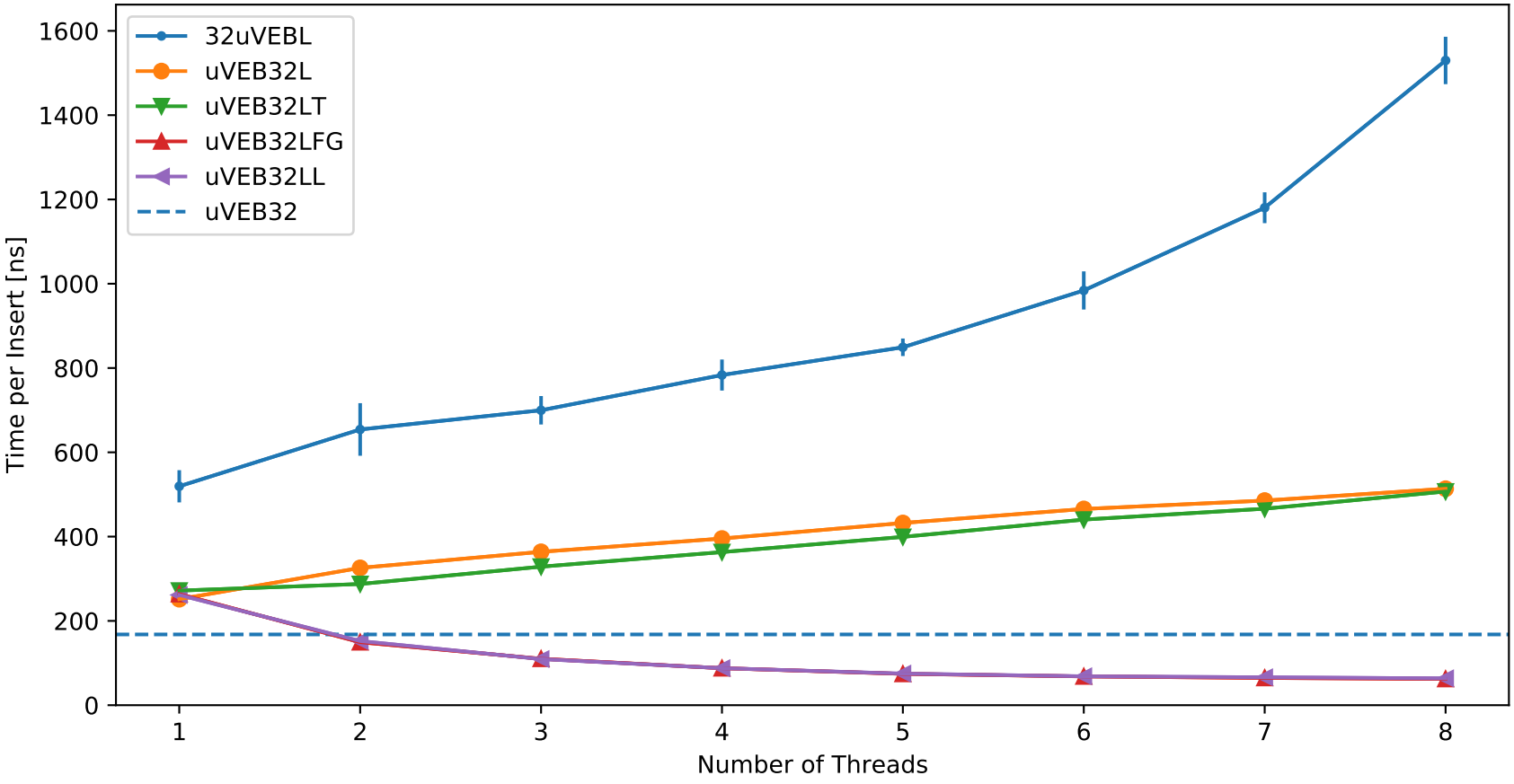
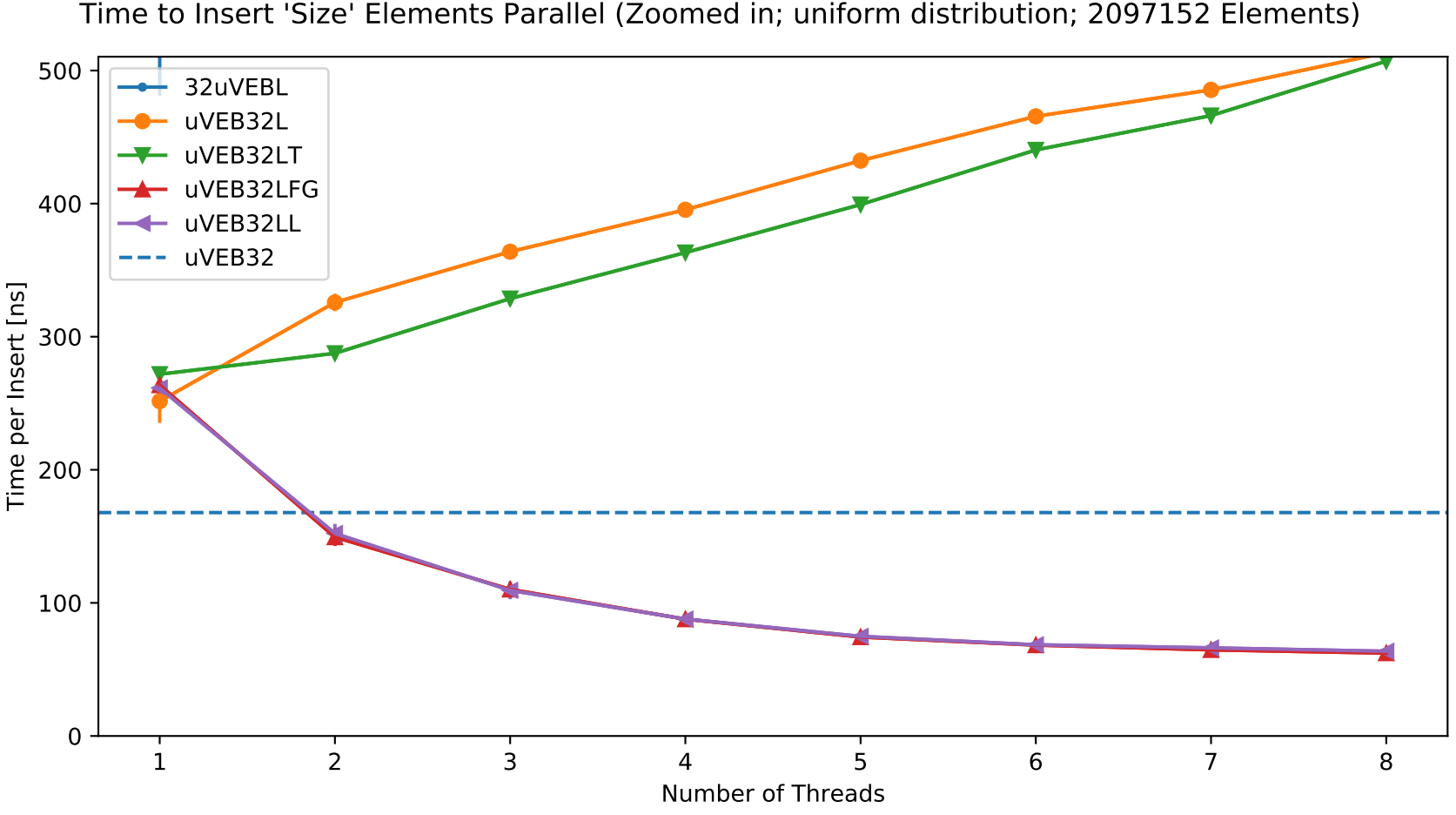
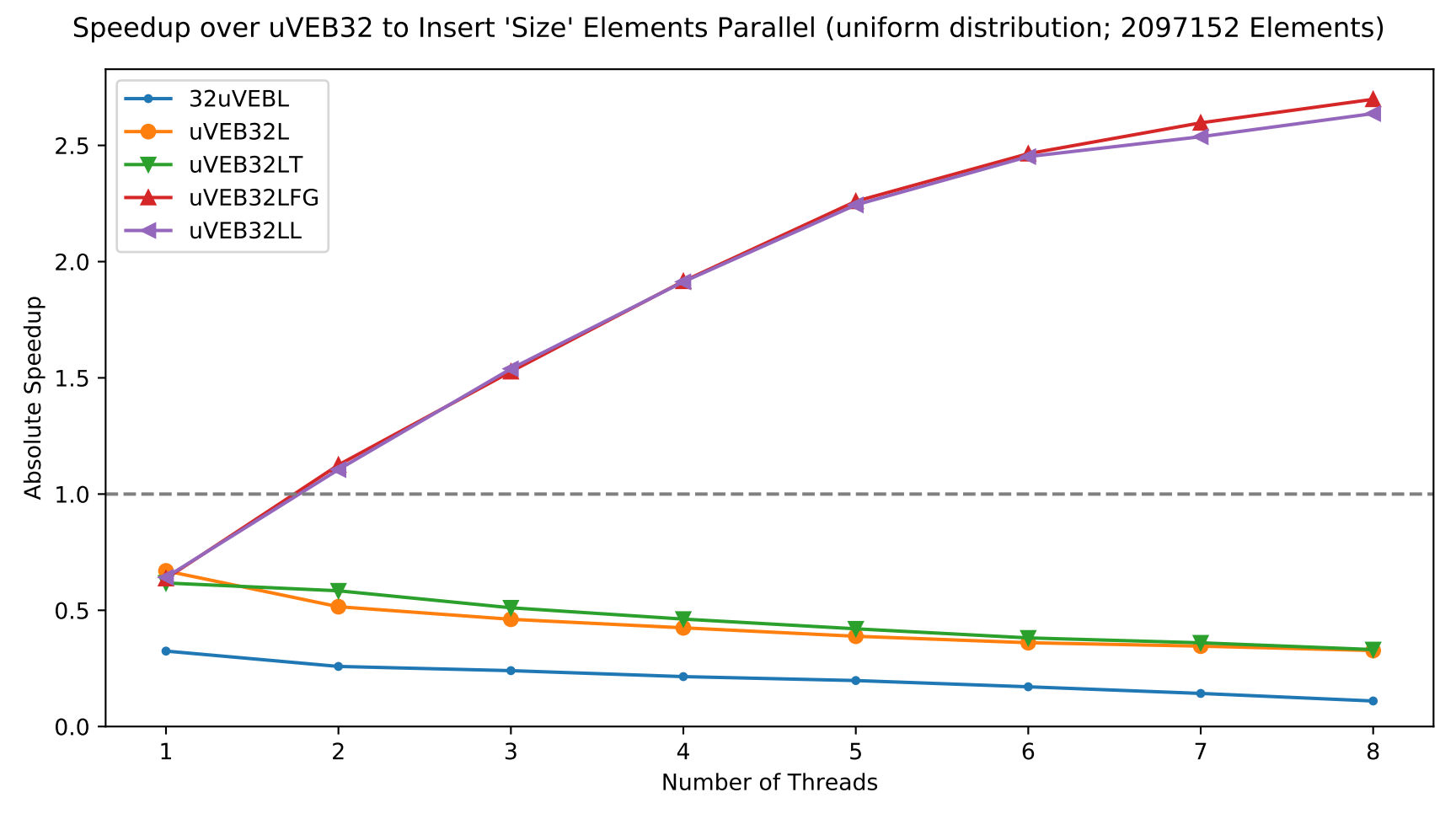
{K}std::set = std::set<uint{K}_t>, {K}uVEB = VanEmdeBoas<{K}>, {K}VEB = VanEmdeBoas<{K}, int{K}_t>, uVEB32 = VanEmdeBoas32<>, 32uVEBL = VanEmdeBoasLocked<32>, uVEB32L = VanEmdeBoas32Locked<>, uVEB32LT = VanEmdeBoas32LockedTop<>, uVEB32LFG = VanEmdeBoas32LockedFineGrained<>, uVEB32LL = VanEmdeBoas32Lockless.
No #defines => sf::contention_free_shared_mutex is used often; also bytell_hash_map by Malte Skarupke is used for VanEmdeBoas and VanEmdeBoasLocked (not VanEmdeBoas32 and its parallel variants)
Random distributions: uniform, cluster = random placed clusters with 1000 succeeding elements, normal = normal distribution with mean ~0/2^31 for signed/unsigned and std (2^31)/10, incProb = linear increasing probability where the smallest value has probability 0, decProb = linear decreasing probability where the largest value has probability 0
The operation is parallelized with OpenMP (static scheduling) and the time until completionis measured. Unlike for the sequential plots, the inserted elements are shuffled before insertion. This is relevant for the cluster distribution since it increases the probability that more than one thread tries to access the same bottom data structure at the same time because without shuffling most clusters are inserted by a single thread since the scheduling is static.
There are ten iterations for each data point.
Hardware: i7-7700HQ, 16GB DDR4 Windows Laptop

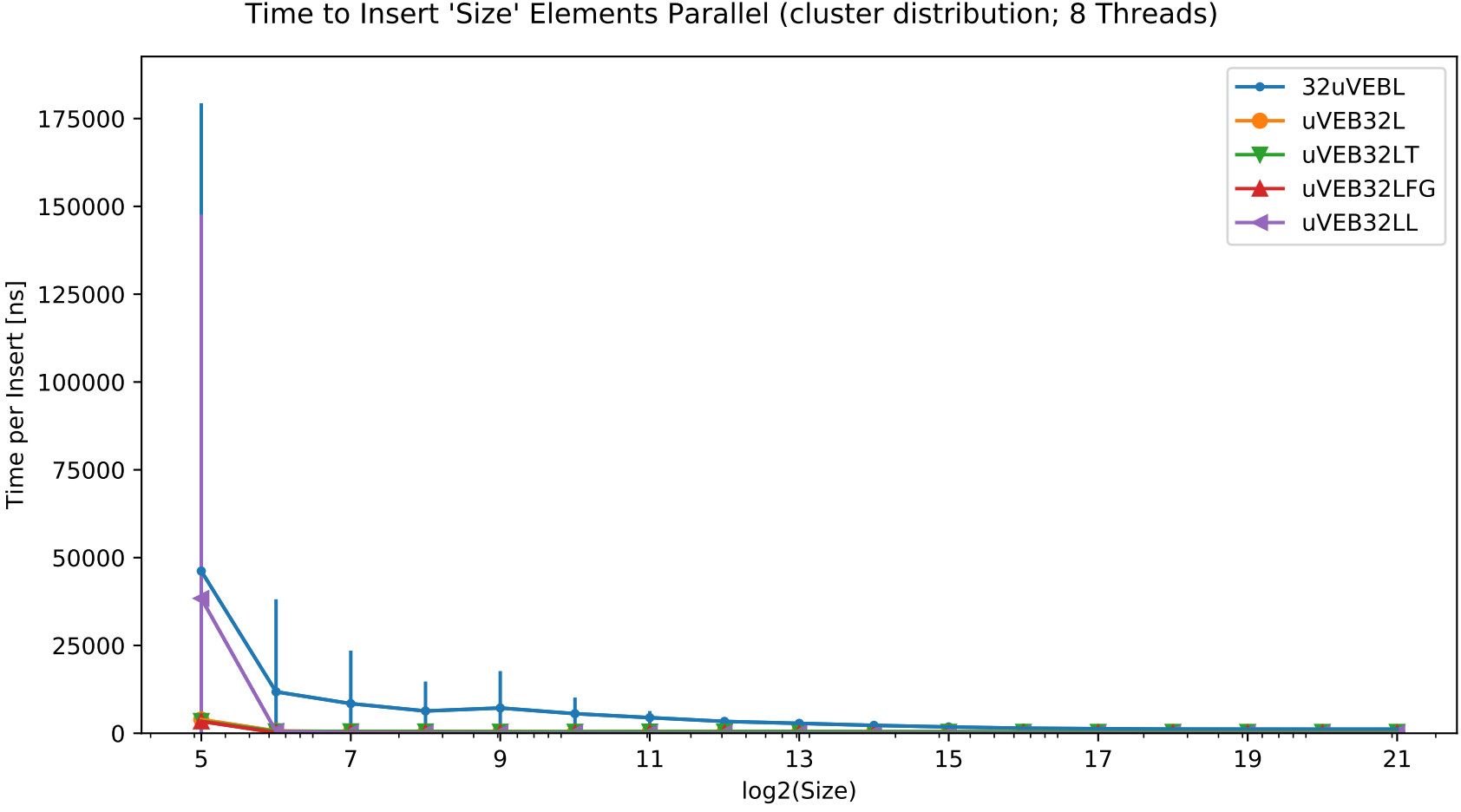

Time to Insert 'Size' Elements Parallel (uniform distribution; 8 Threads)
Time per Insert [ns]
50000
40000
30000
20000
10000
0
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

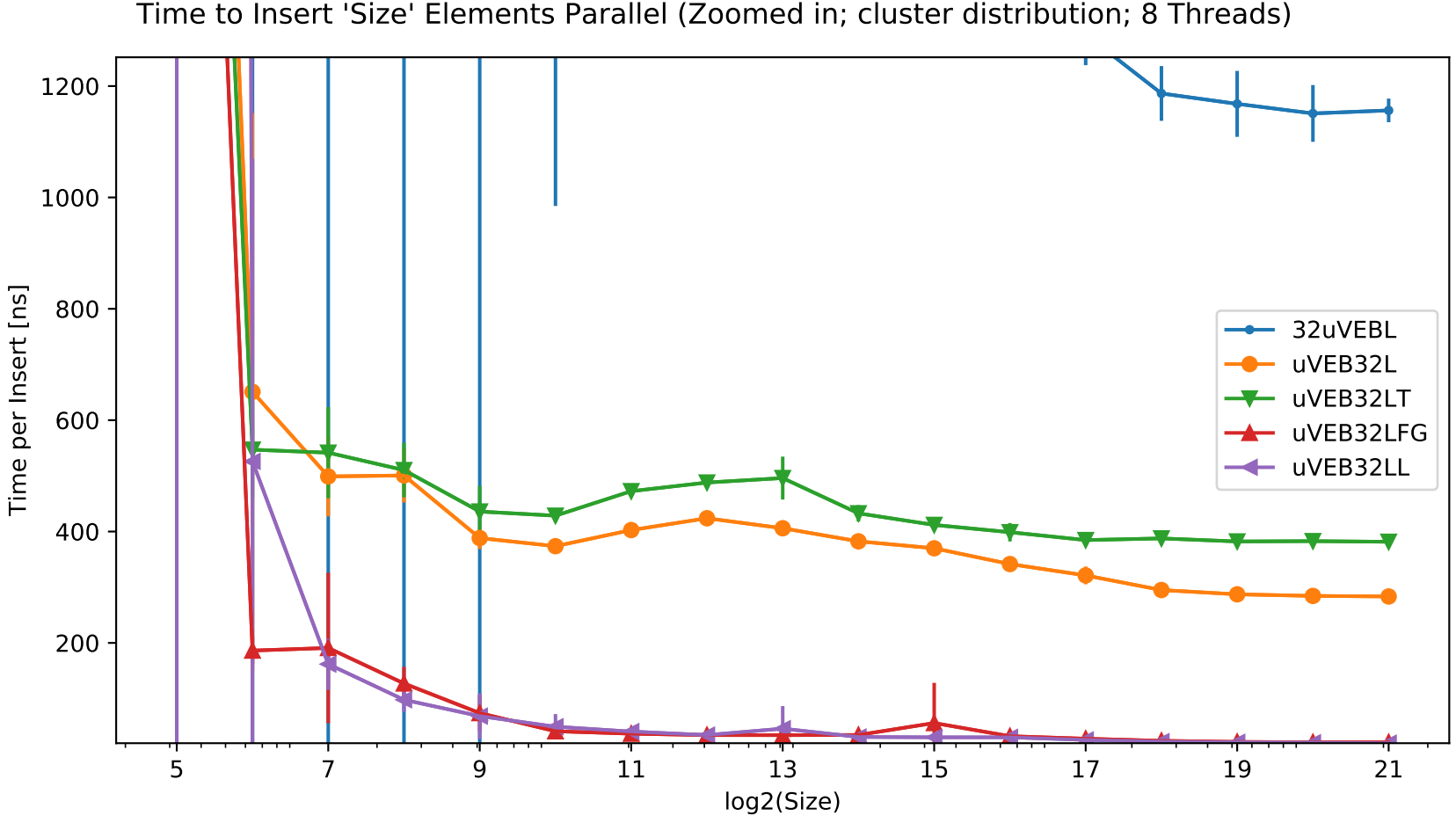

Time to Insert 'Size' Elements Parallel (Zoomed in; uniform distribution; 8 Threads)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Time per Insert [ns]
2000
1500
1000
500
5
7
9
11
13
15
17
19
21
log2(Size)

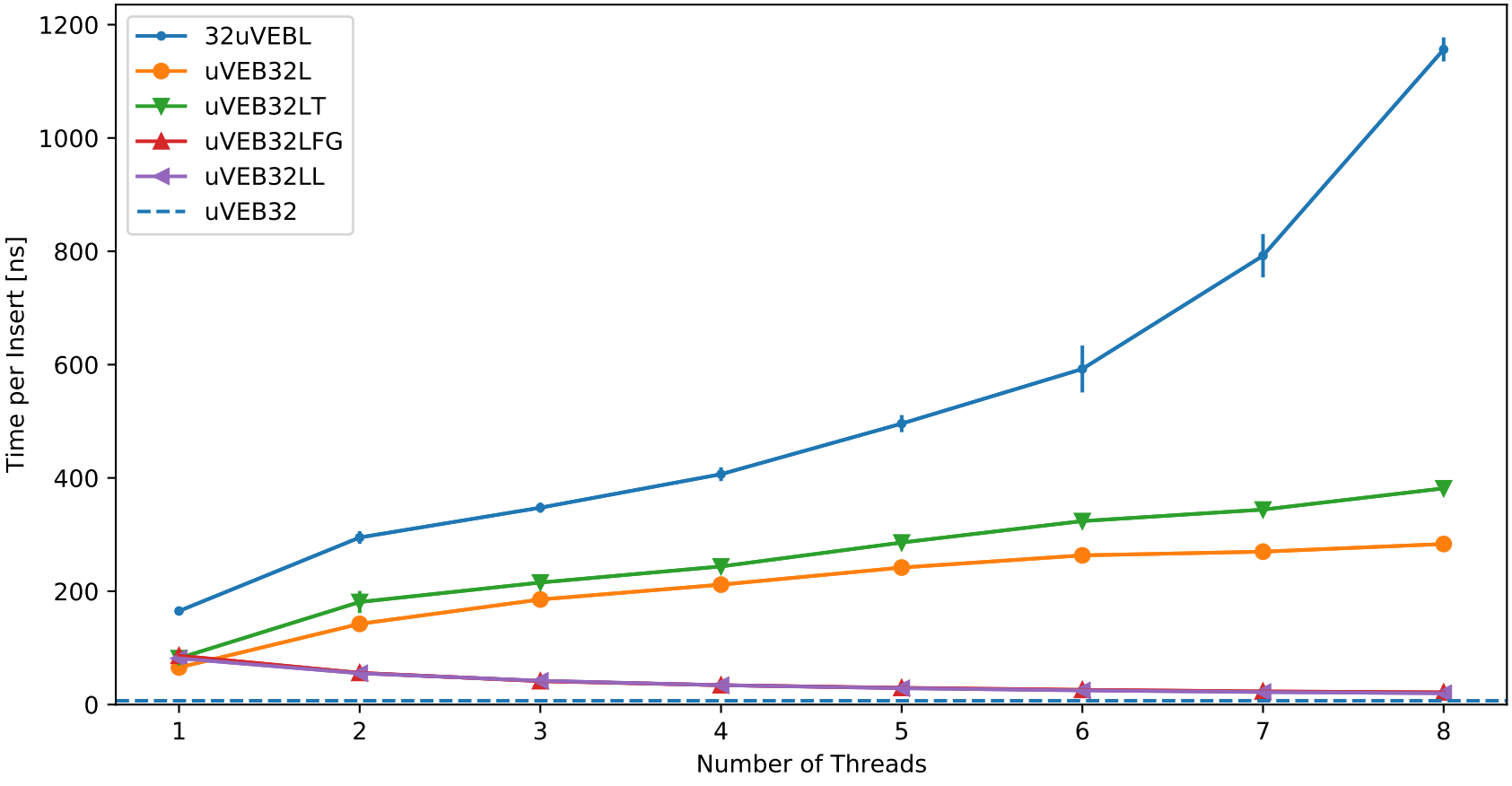

Time to Insert 'Size' Elements Parallel (uniform distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
200
400
600
800
1000
1200
1400
1600
1
2
3
4
5
6
7
8
Number of Threads

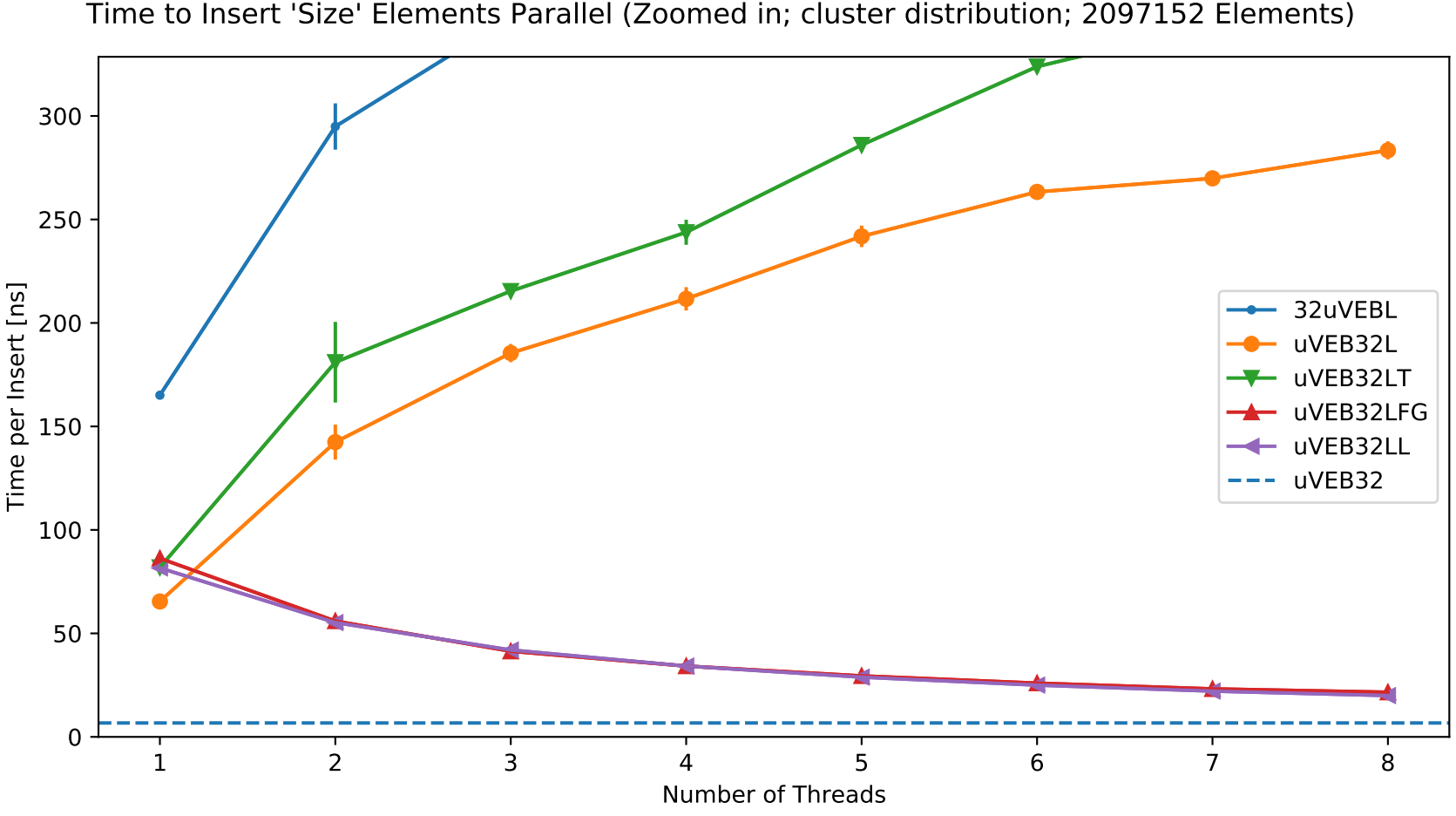

Time to Insert 'Size' Elements Parallel (Zoomed in; uniform distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
100
200
300
400
500
1
2
3
4
5
6
7
8
Number of Threads

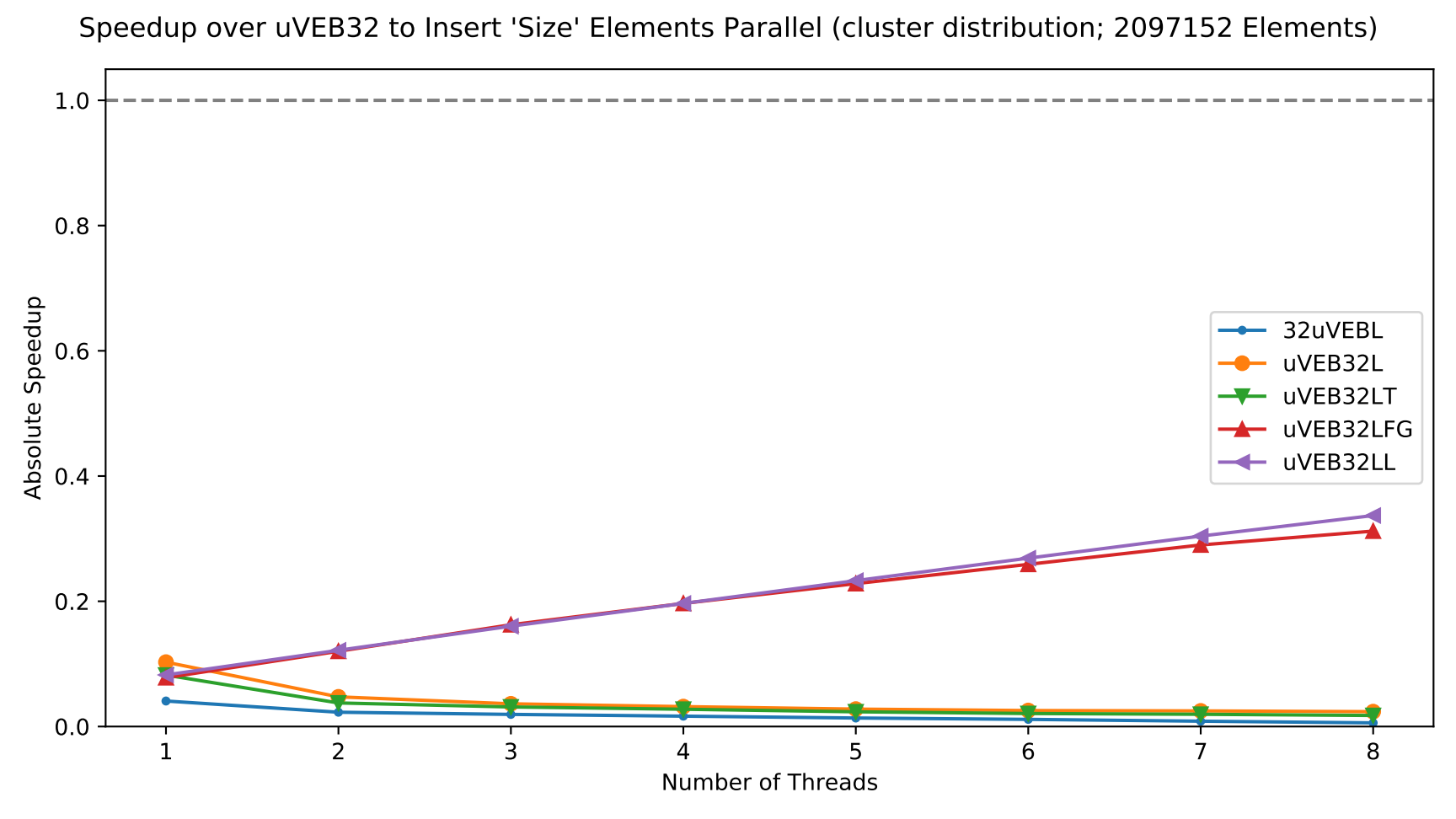

Speedup over uVEB32 to Insert 'Size' Elements Parallel (uniform distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.5
1.0
1.5
2.0
2.5
1
2
3
4
5
6
7
8
Number of Threads

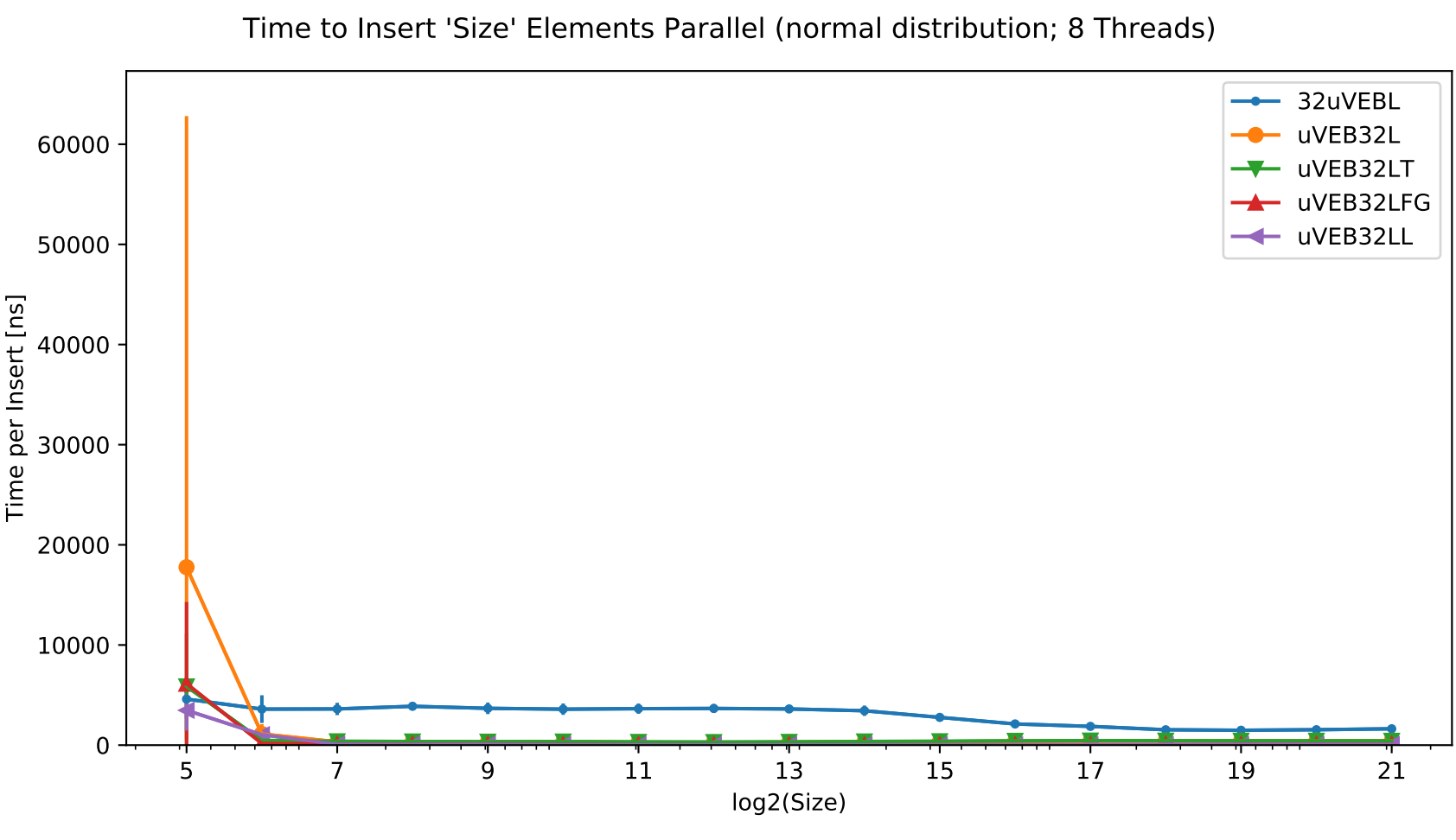

Time to Insert 'Size' Elements Parallel (cluster distribution; 8 Threads)
Time per Insert [ns]
log2(Size)
0
25000
50000
75000
100000
125000
150000
175000
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

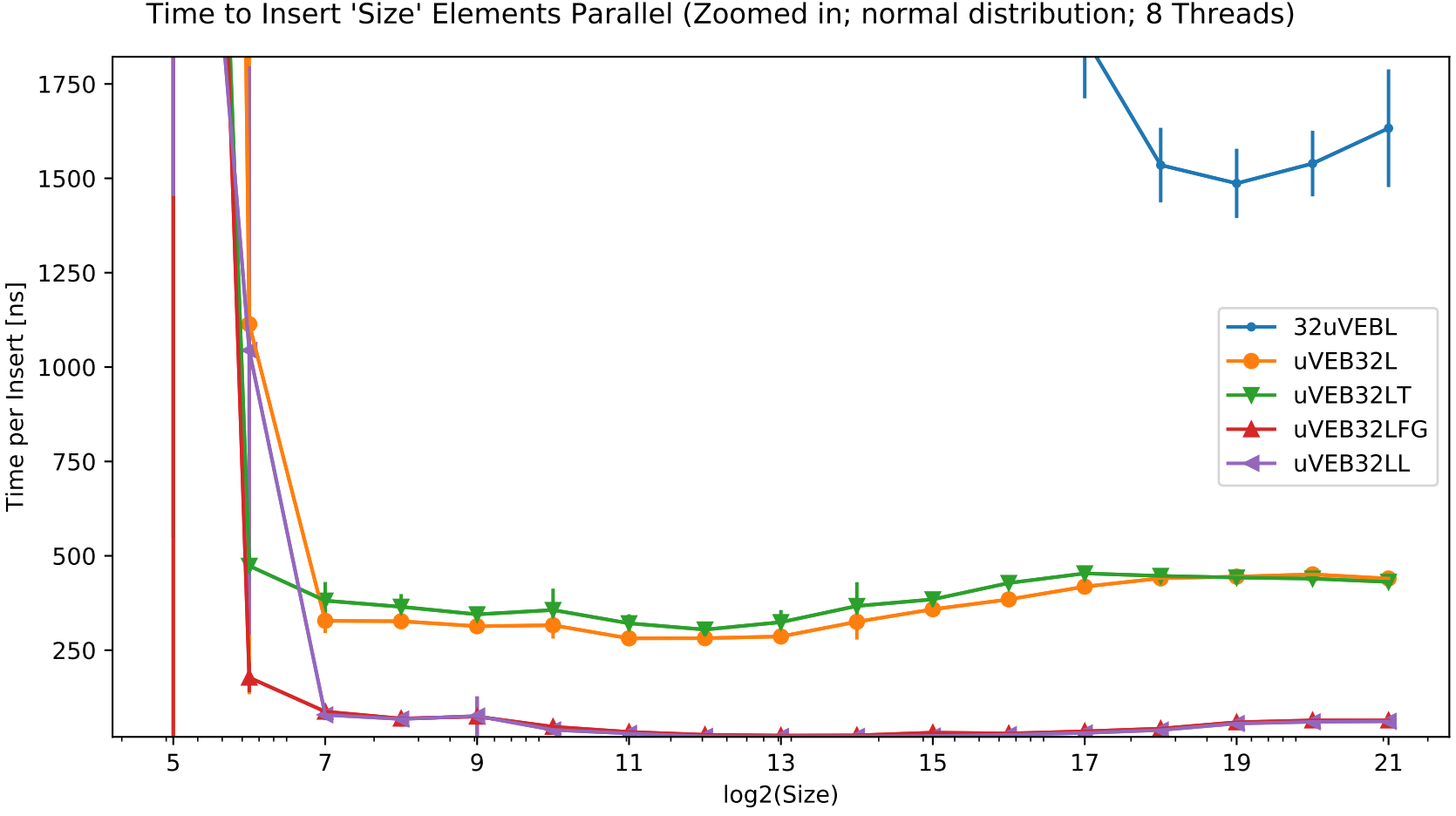

Time to Insert 'Size' Elements Parallel (Zoomed in; cluster distribution; 8 Threads)
Time per Insert [ns]
log2(Size)
1200
1000
800
600
400
200
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

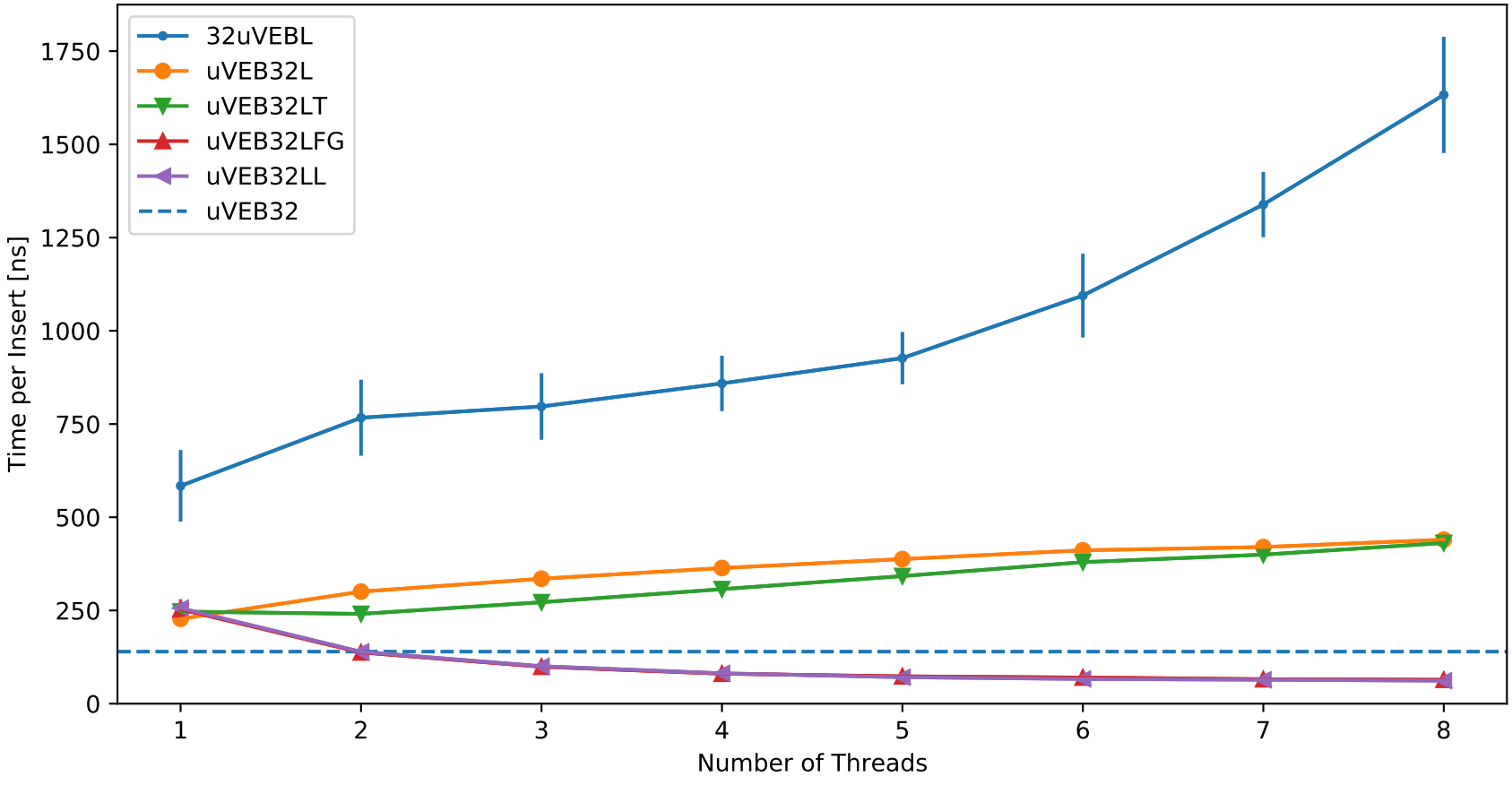

Time to Insert 'Size' Elements Parallel (cluster distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
200
400
600
800
1000
1200
1
2
3
4
5
6
7
8
Number of Threads

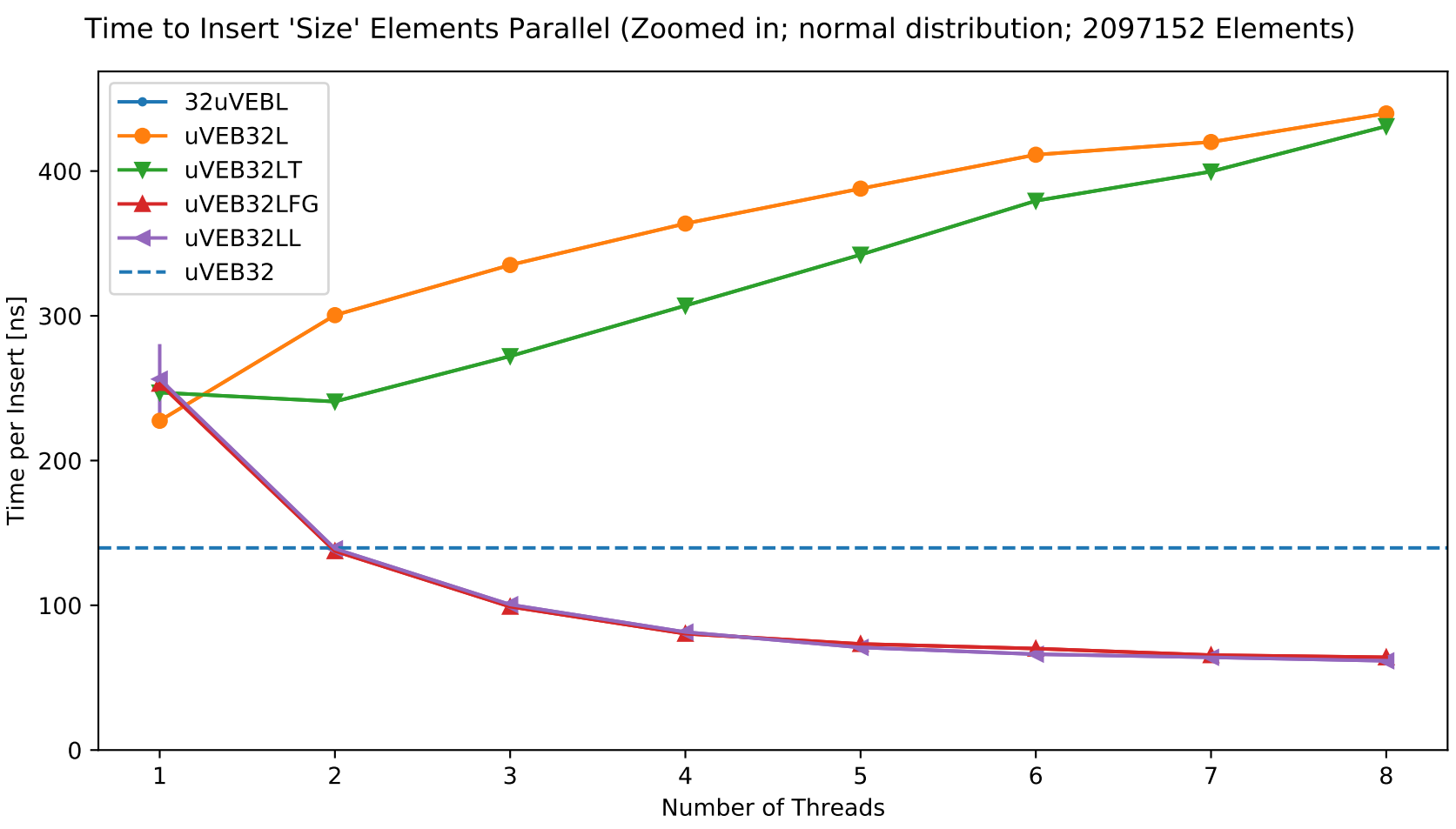

Time to Insert 'Size' Elements Parallel (Zoomed in; cluster distribution; 2097152 Elements)
Time per Insert [ns]
Number of Threads
0
50
100
150
200
250
300
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

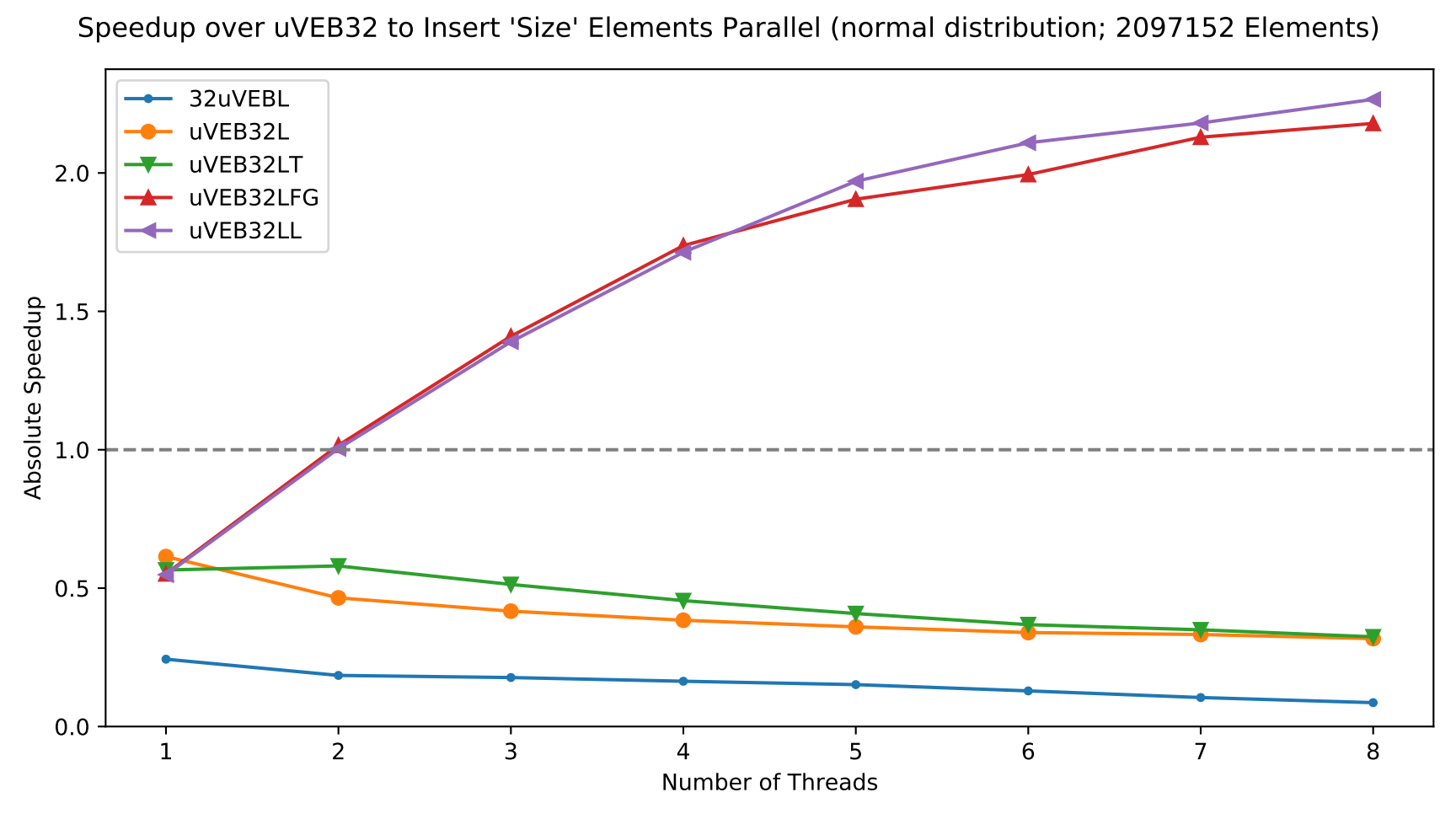

Speedup over uVEB32 to Insert 'Size' Elements Parallel (cluster distribution; 2097152 Elements)
Absolute Speedup
Number of Threads
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

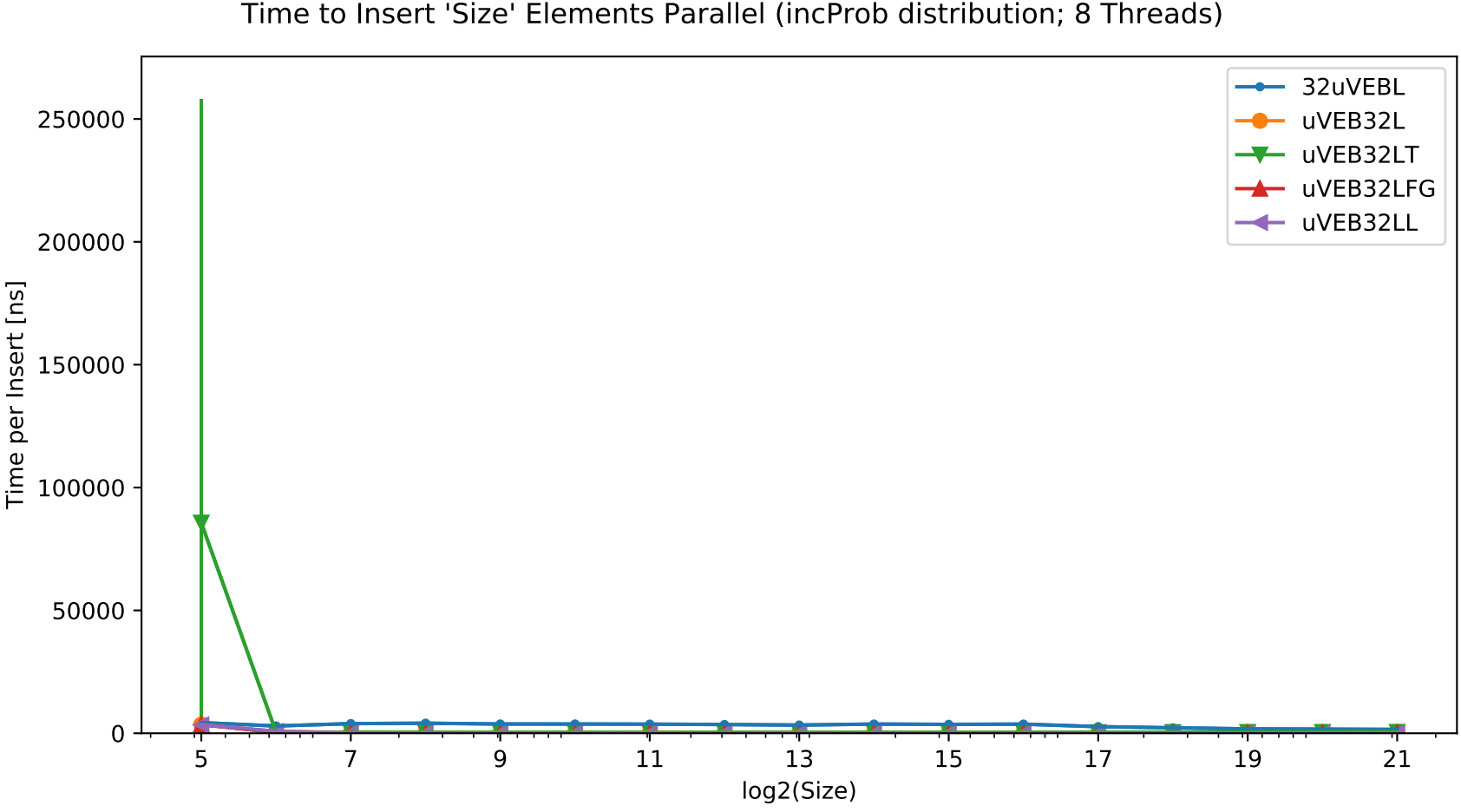

Time to Insert 'Size' Elements Parallel (normal distribution; 8 Threads)
Time per Insert [ns]
0
10000
20000
30000
40000
50000
60000
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

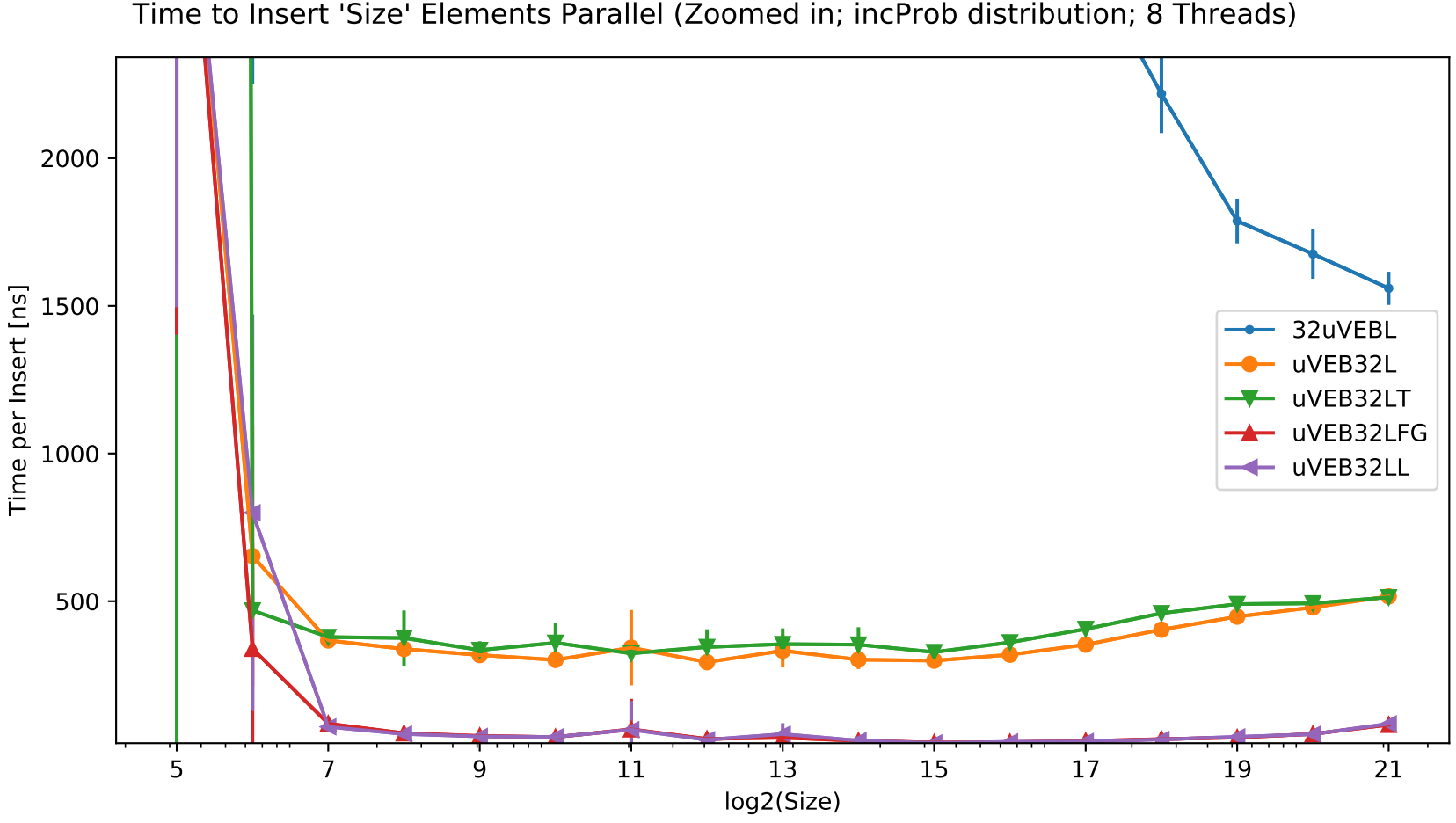

Time to Insert 'Size' Elements Parallel (Zoomed in; normal distribution; 8 Threads)
Time per Insert [ns]
1750
1500
1250
1000
750
500
250
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

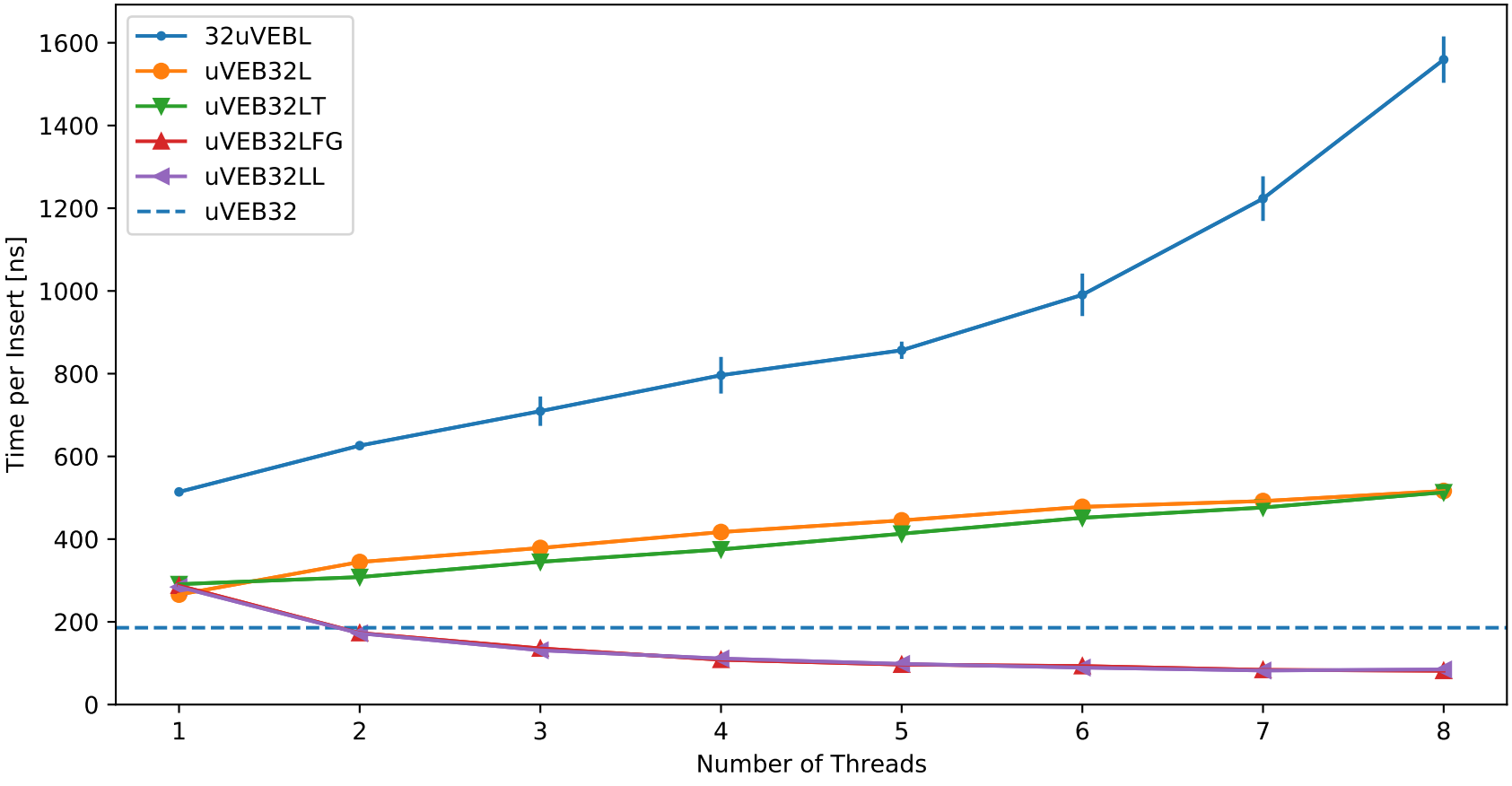

Time to Insert 'Size' Elements Parallel (normal distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
250
500
750
1000
1250
1500
1750
1
2
3
4
5
6
7
8
Number of Threads

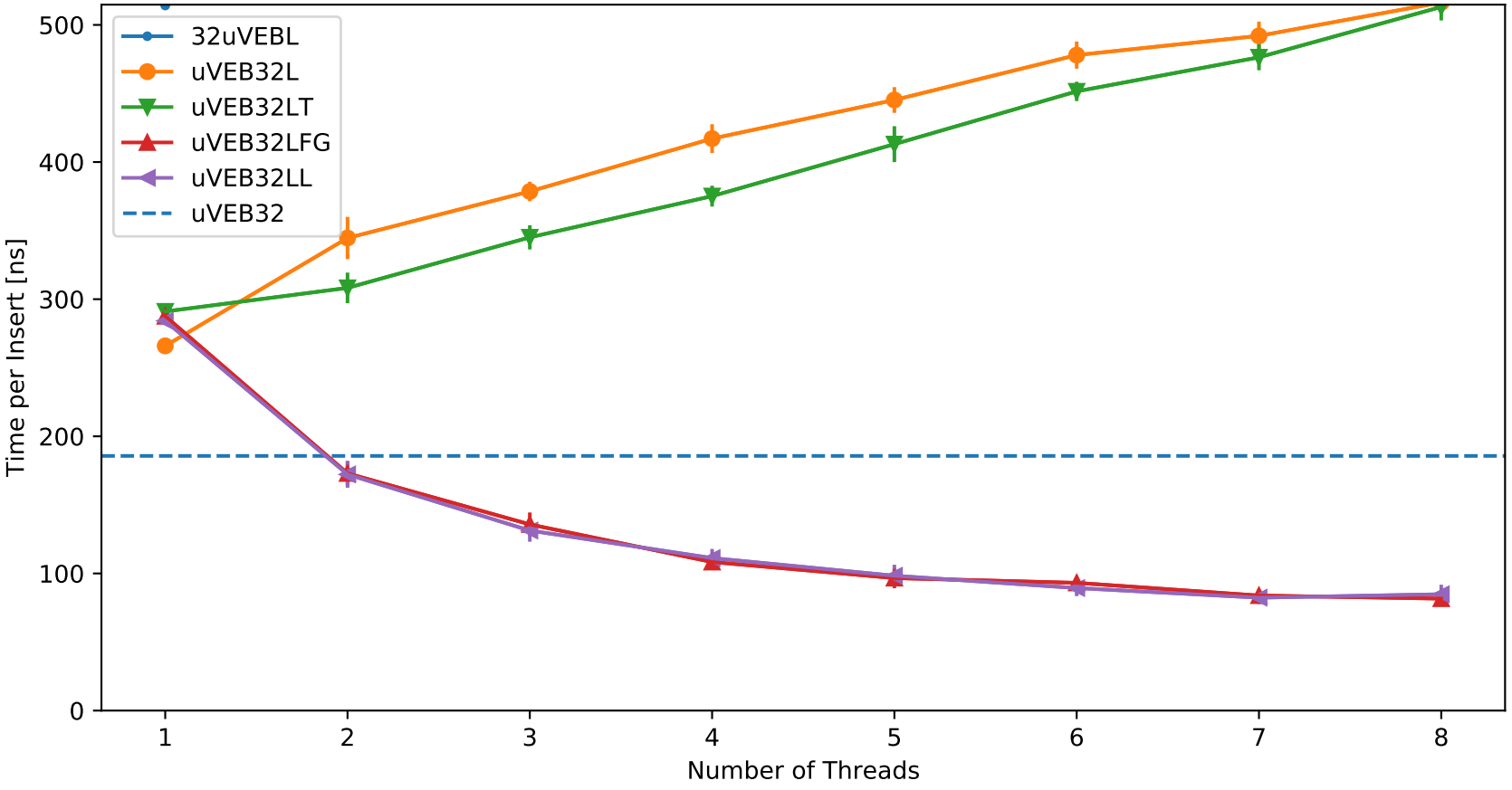

Time to Insert 'Size' Elements Parallel (Zoomed in; normal distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
100
200
300
400
1
2
3
4
5
6
7
8
Number of Threads

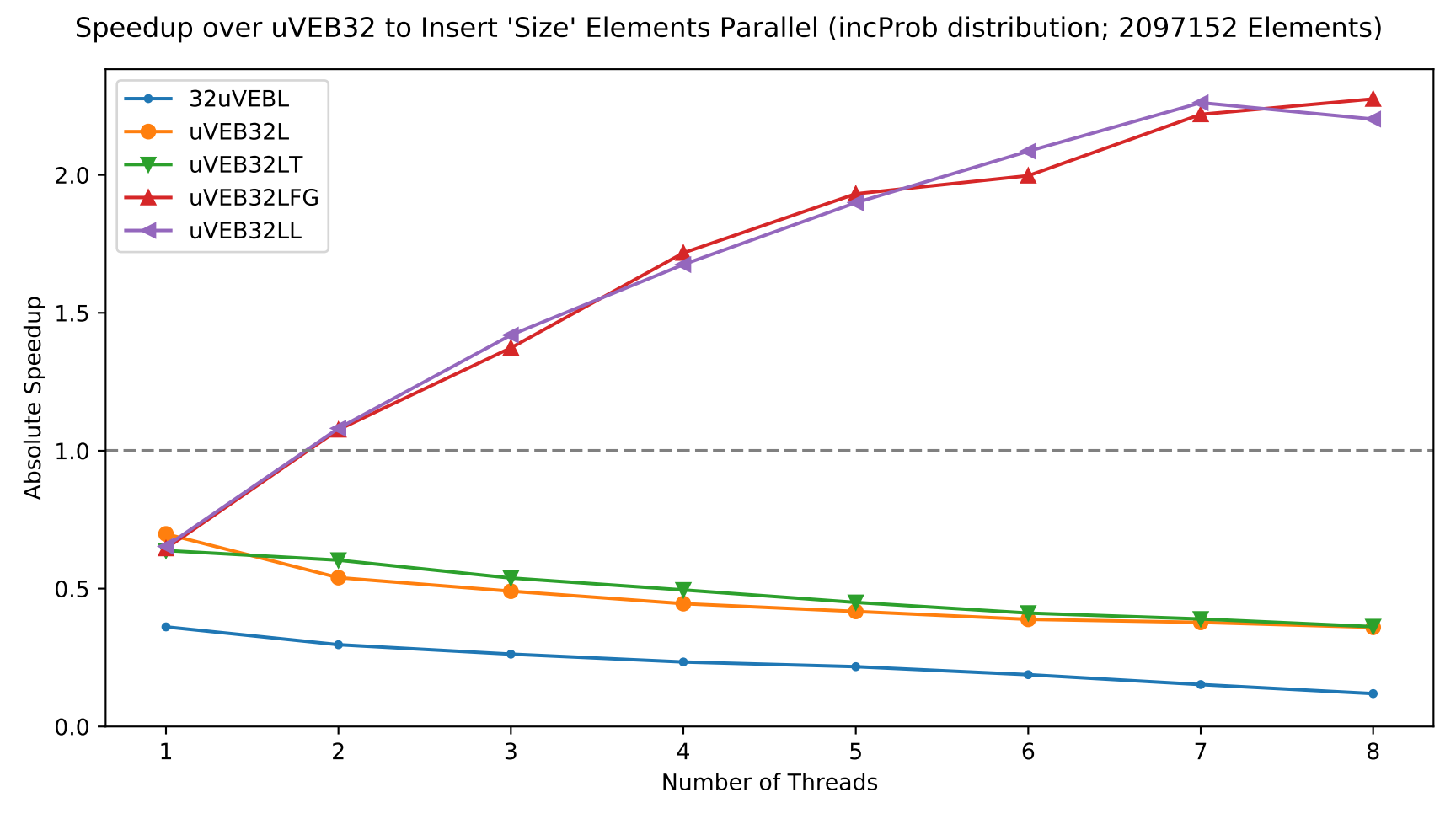

Speedup over uVEB32 to Insert 'Size' Elements Parallel (normal distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.5
1.0
1.5
2.0
1
2
3
4
5
6
7
8
Number of Threads

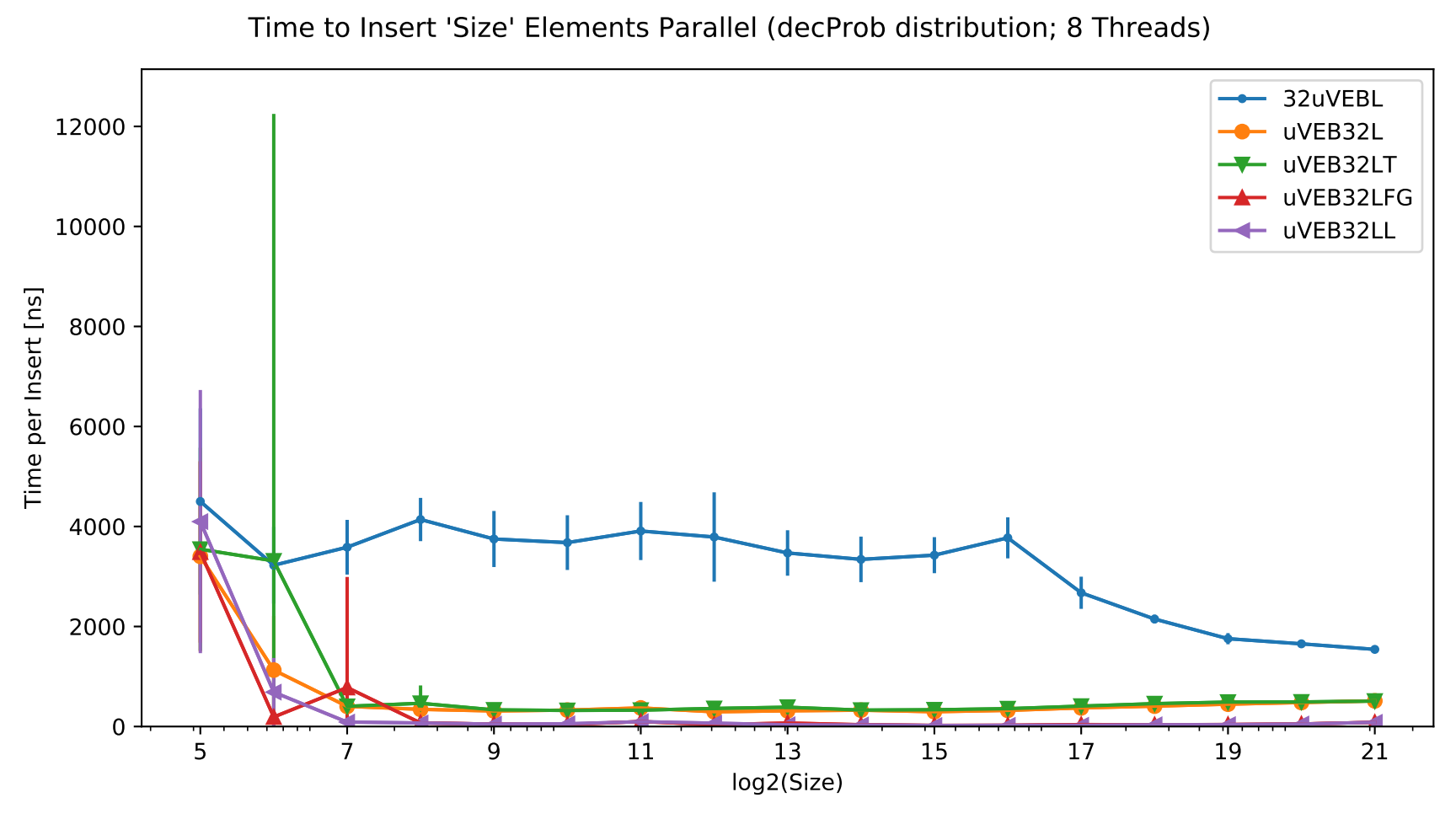

Time to Insert 'Size' Elements Parallel (incProb distribution; 8 Threads)
Time per Insert [ns]
250000
200000
150000
100000
50000
0
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

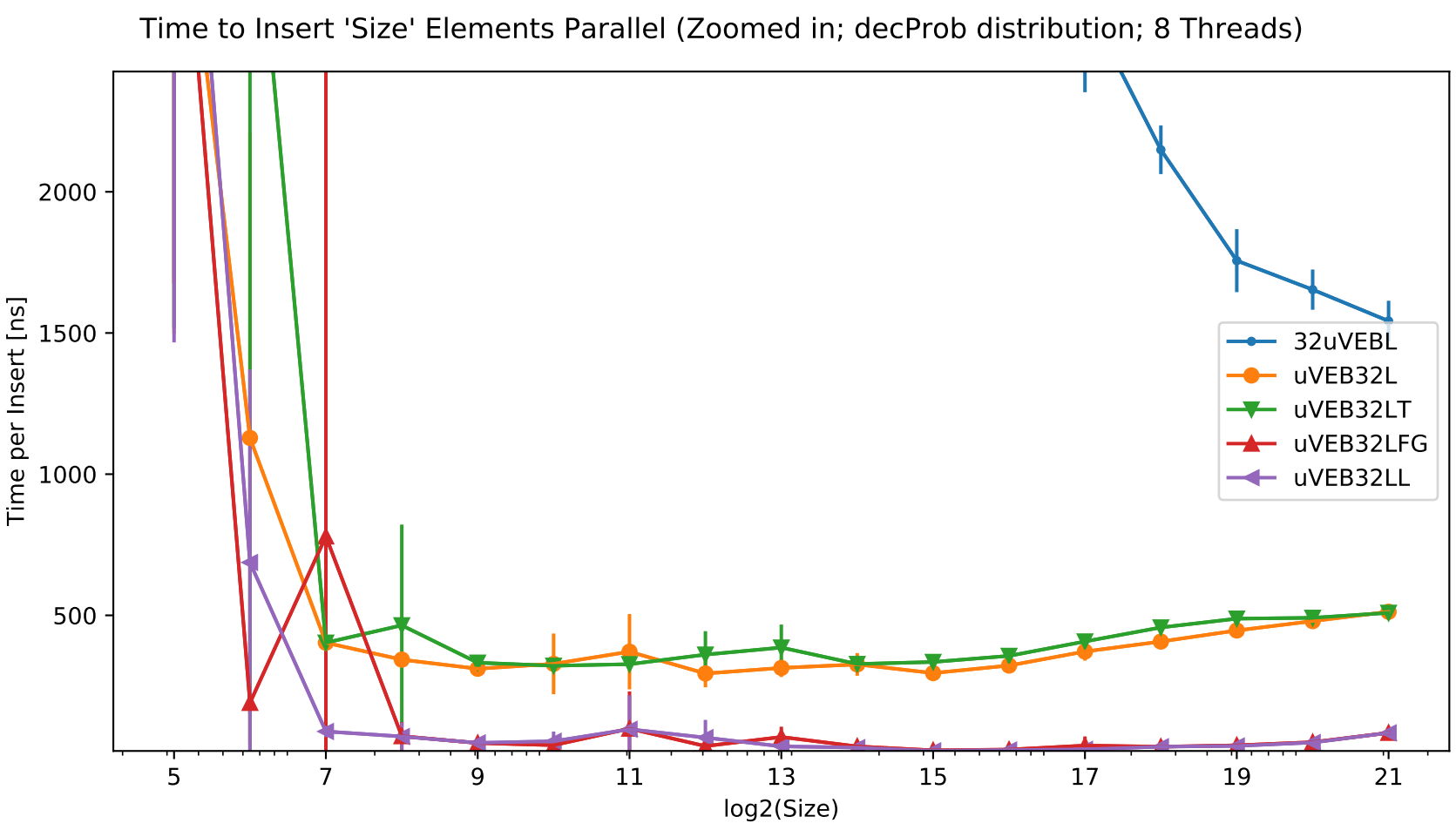

Time to Insert 'Size' Elements Parallel (Zoomed in; incProb distribution; 8 Threads)
Time per Insert [ns]
2000
1500
1000
500
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

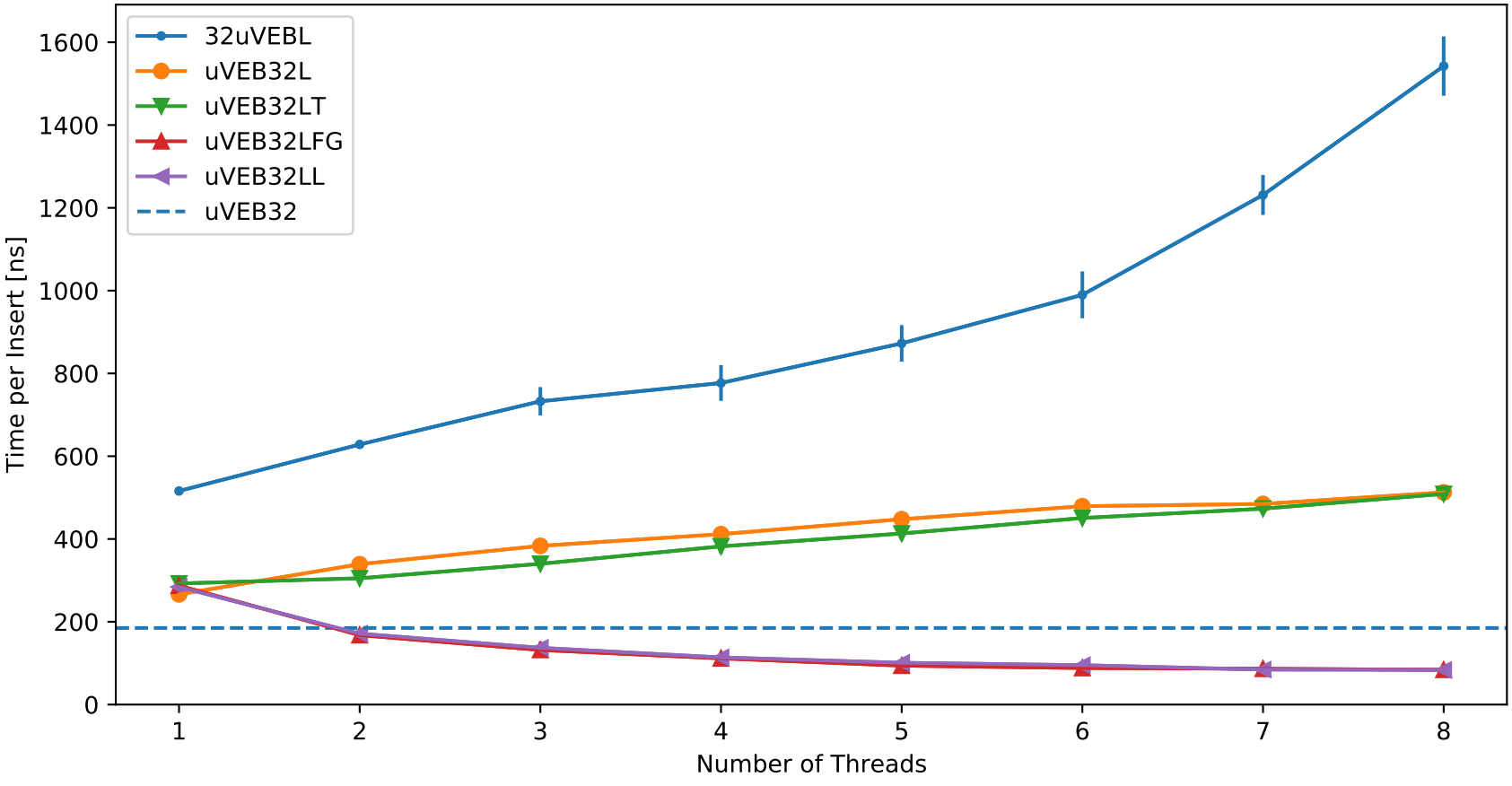

Time to Insert 'Size' Elements Parallel (incProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
200
400
600
800
1000
1200
1400
1600
1
2
3
4
5
6
7
8
Number of Threads

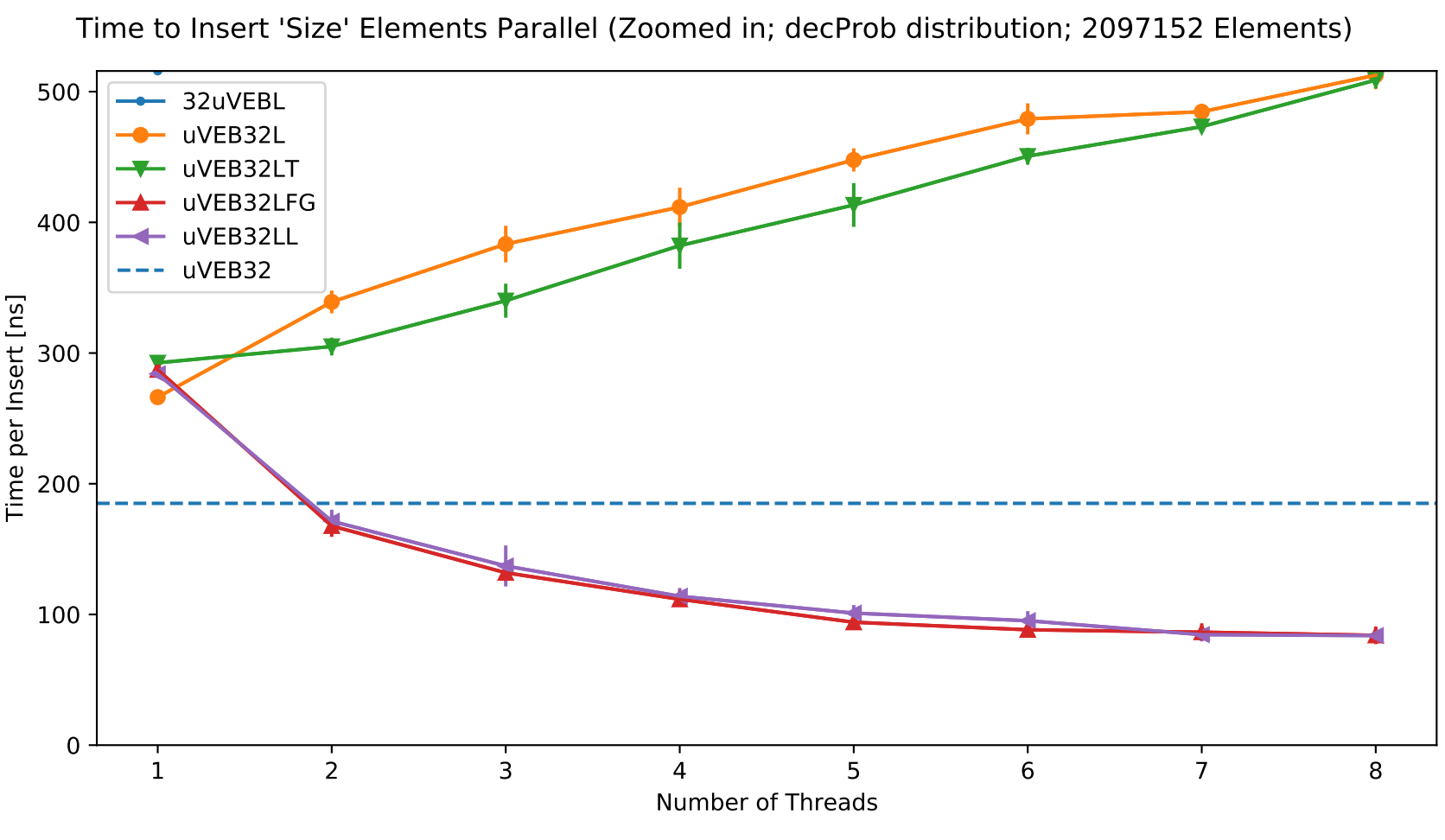

Time to Insert 'Size' Elements Parallel (Zoomed in; incProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
100
200
300
400
500
1
2
3
4
5
6
7
8
Number of Threads

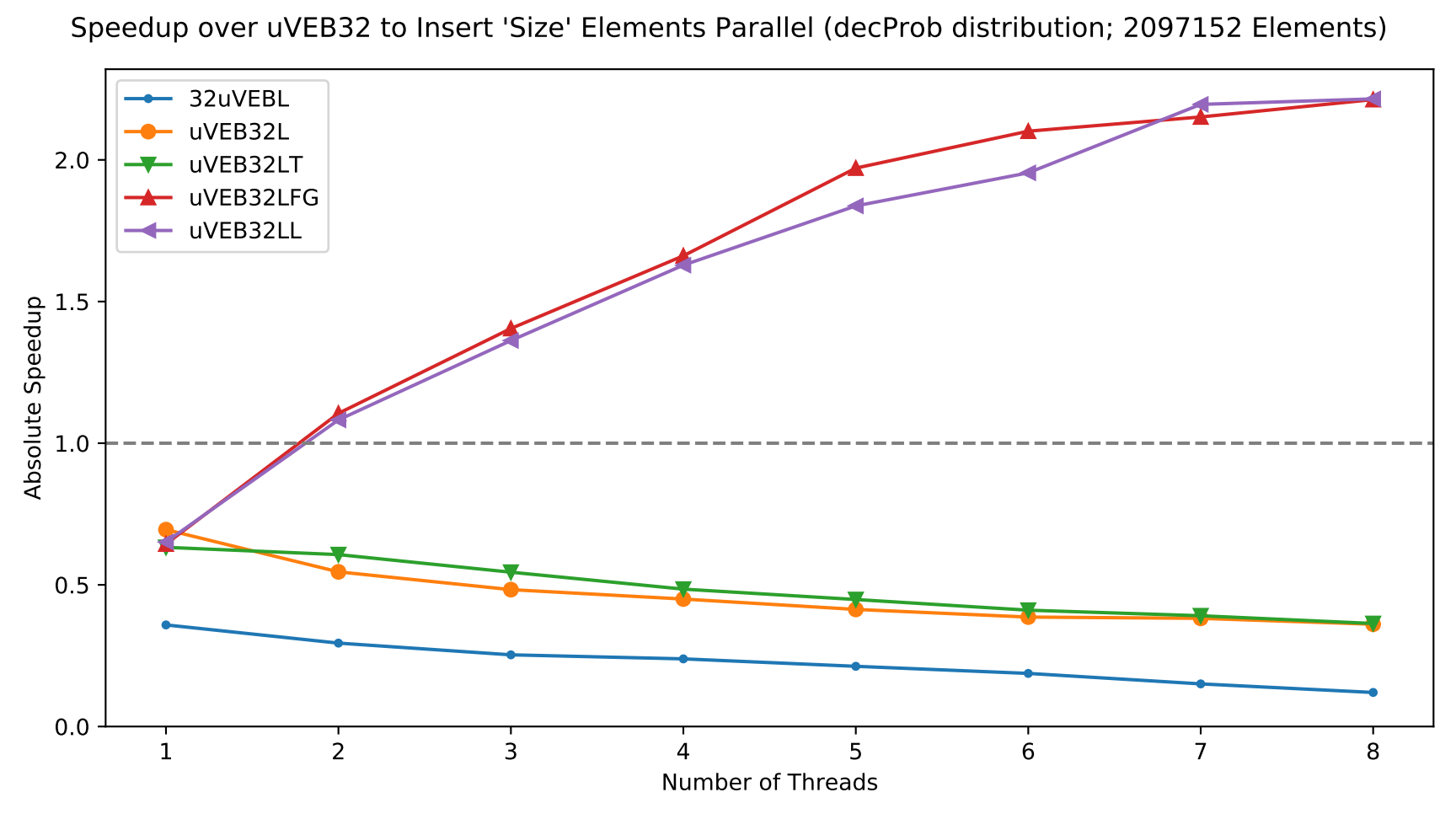

Speedup over uVEB32 to Insert 'Size' Elements Parallel (incProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.5
1.0
1.5
2.0
1
2
3
4
5
6
7
8
Number of Threads


Time to Insert 'Size' Elements Parallel (decProb distribution; 8 Threads)
Time per Insert [ns]
log2(Size)
0
2000
4000
6000
8000
10000
12000
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL


Time to Insert 'Size' Elements Parallel (Zoomed in; decProb distribution; 8 Threads)
Time per Insert [ns]
2000
1500
1000
500
5
7
9
11
13
15
17
19
21
log2(Size)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL


Time to Insert 'Size' Elements Parallel (decProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
200
400
600
800
1000
1200
1400
1600
1
2
3
4
5
6
7
8
Number of Threads


Time to Insert 'Size' Elements Parallel (Zoomed in; decProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Insert [ns]
0
100
200
300
400
500
1
2
3
4
5
6
7
8
Number of Threads


Speedup over uVEB32 to Insert 'Size' Elements Parallel (decProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.5
1.0
1.5
2.0
1
2
3
4
5
6
7
8
Number of Threads