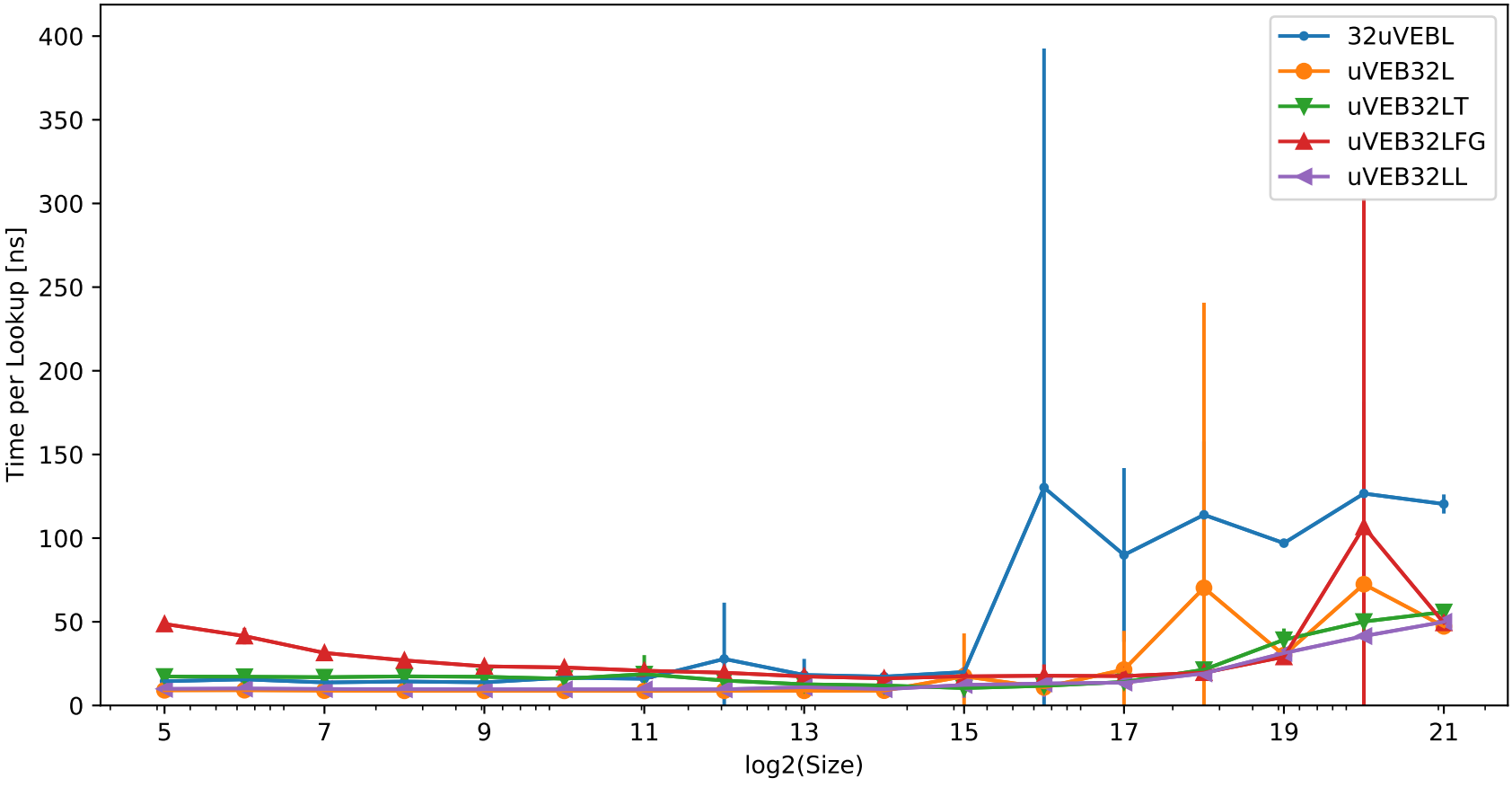
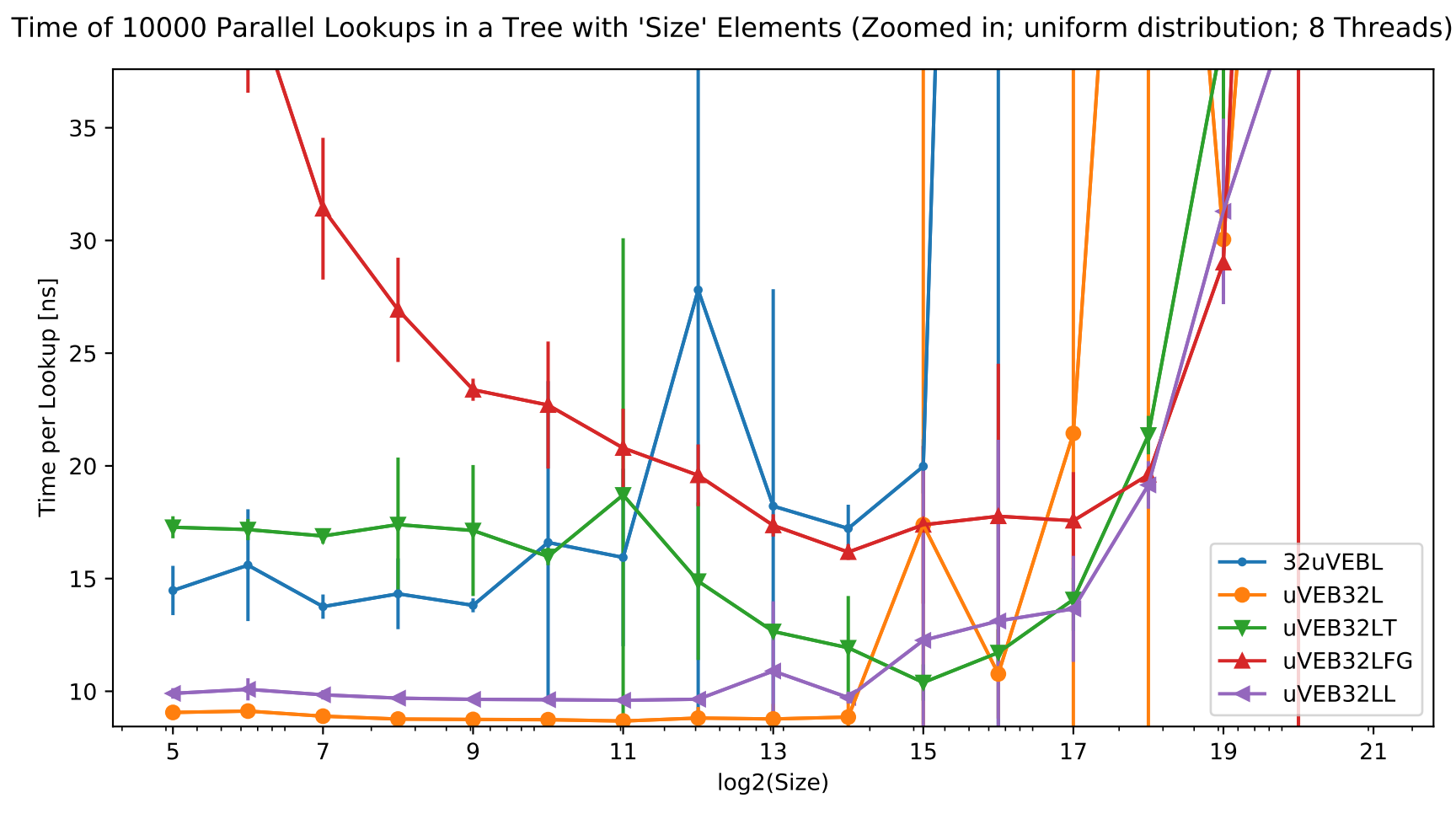
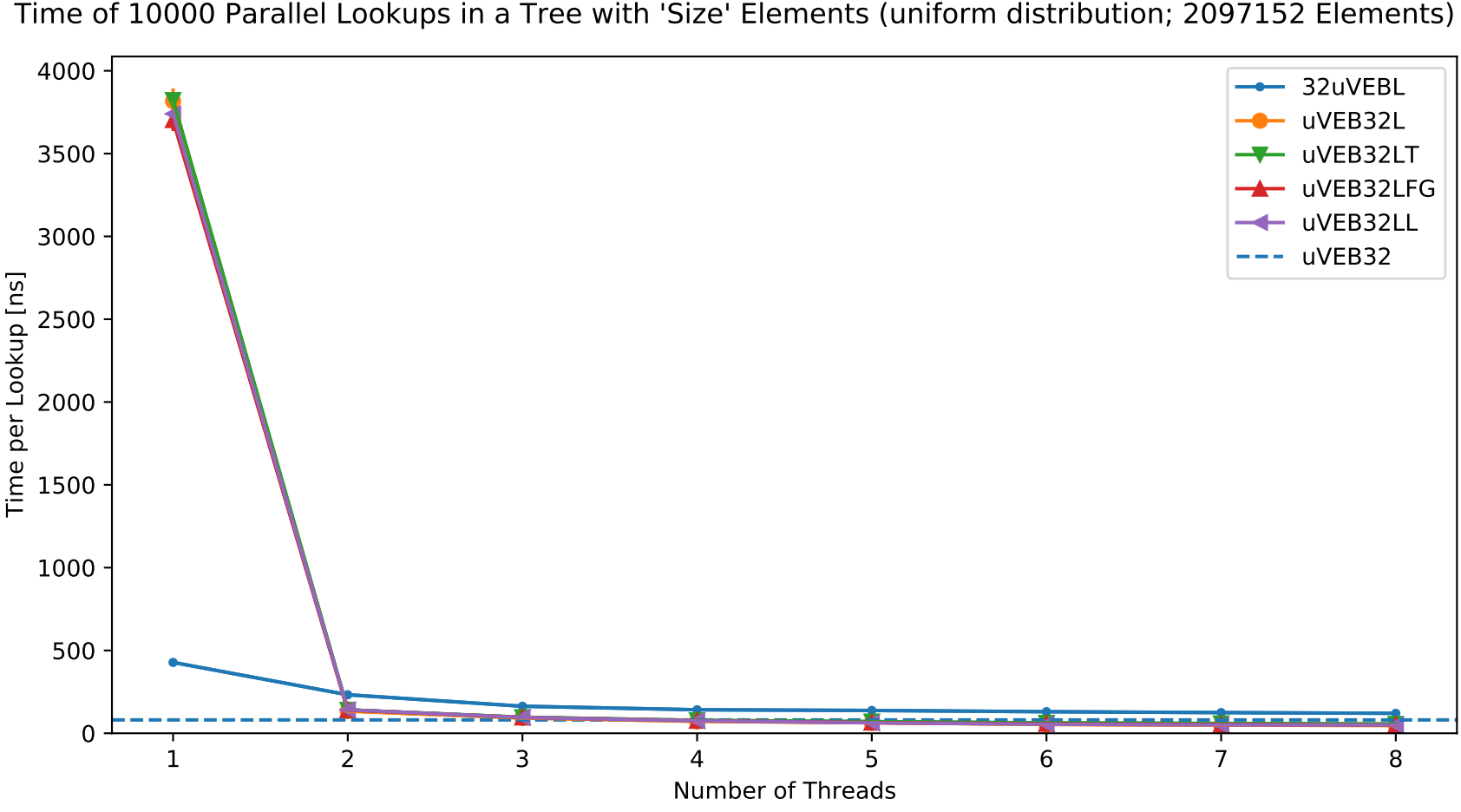
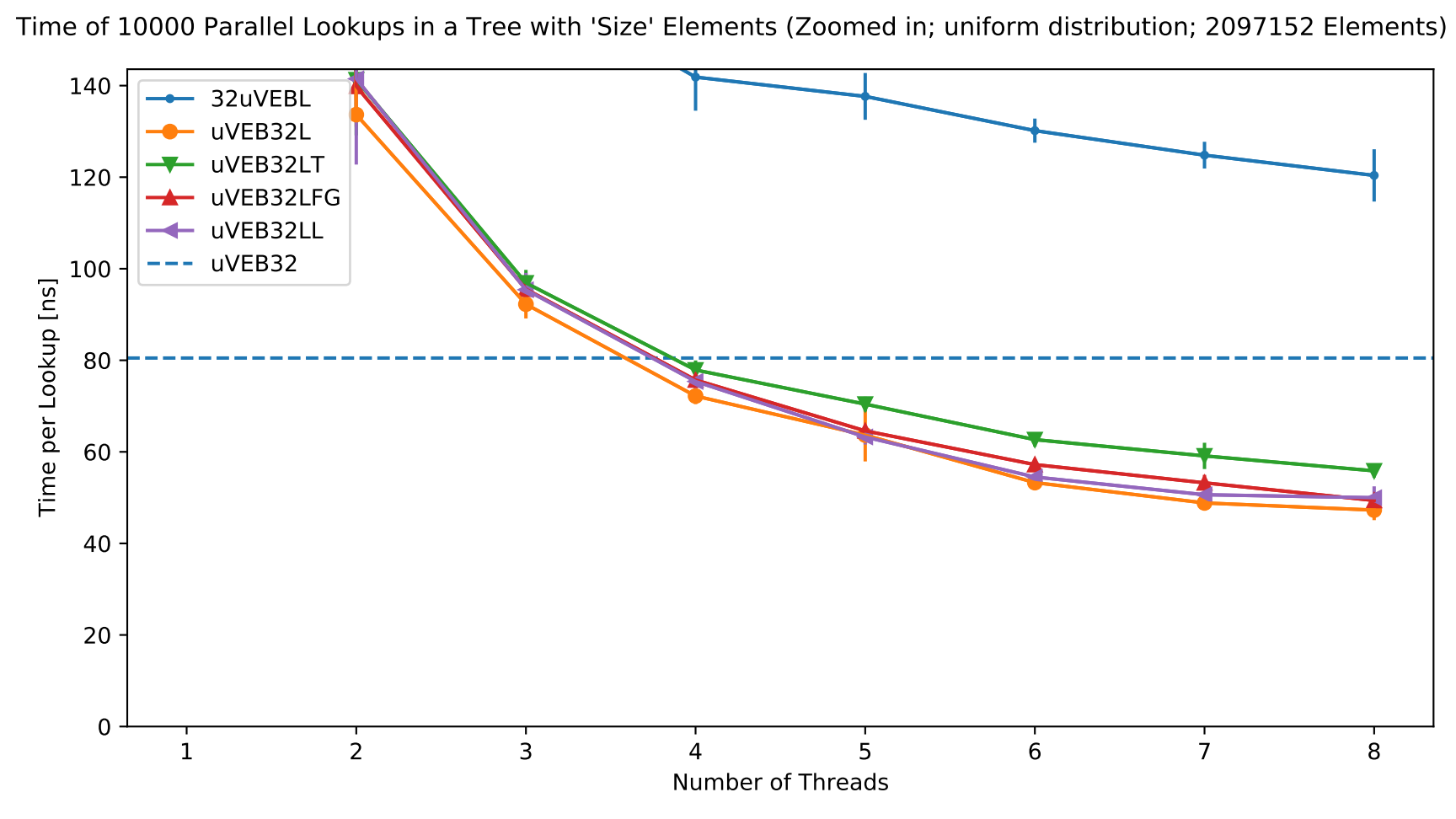
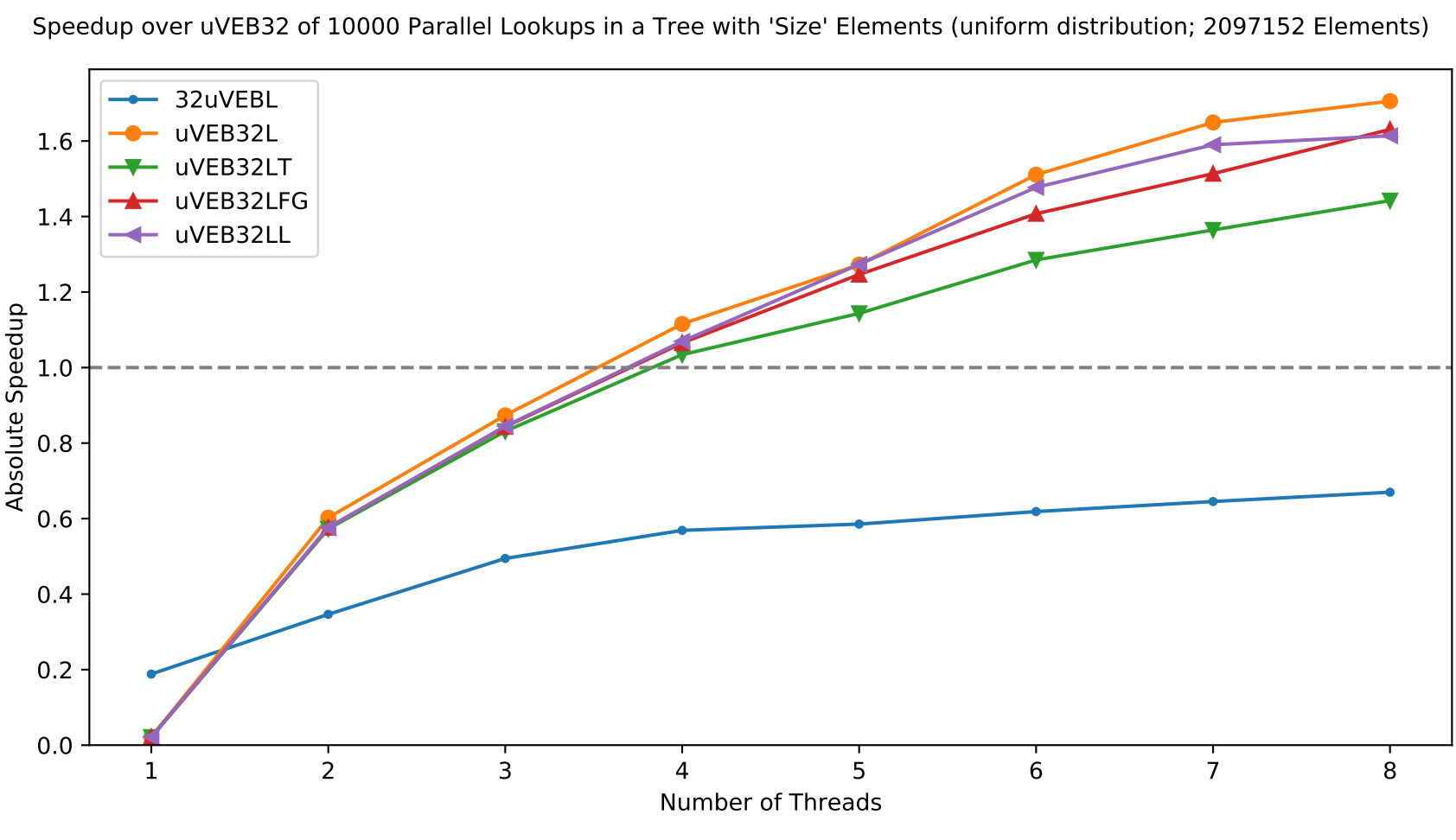
{K}std::set = std::set<uint{K}_t>, {K}uVEB = VanEmdeBoas<{K}>, {K}VEB = VanEmdeBoas<{K}, int{K}_t>, uVEB32 = VanEmdeBoas32<>, 32uVEBL = VanEmdeBoasLocked<32>, uVEB32L = VanEmdeBoas32Locked<>, uVEB32LT = VanEmdeBoas32LockedTop<>, uVEB32LFG = VanEmdeBoas32LockedFineGrained<>, uVEB32LL = VanEmdeBoas32Lockless.
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

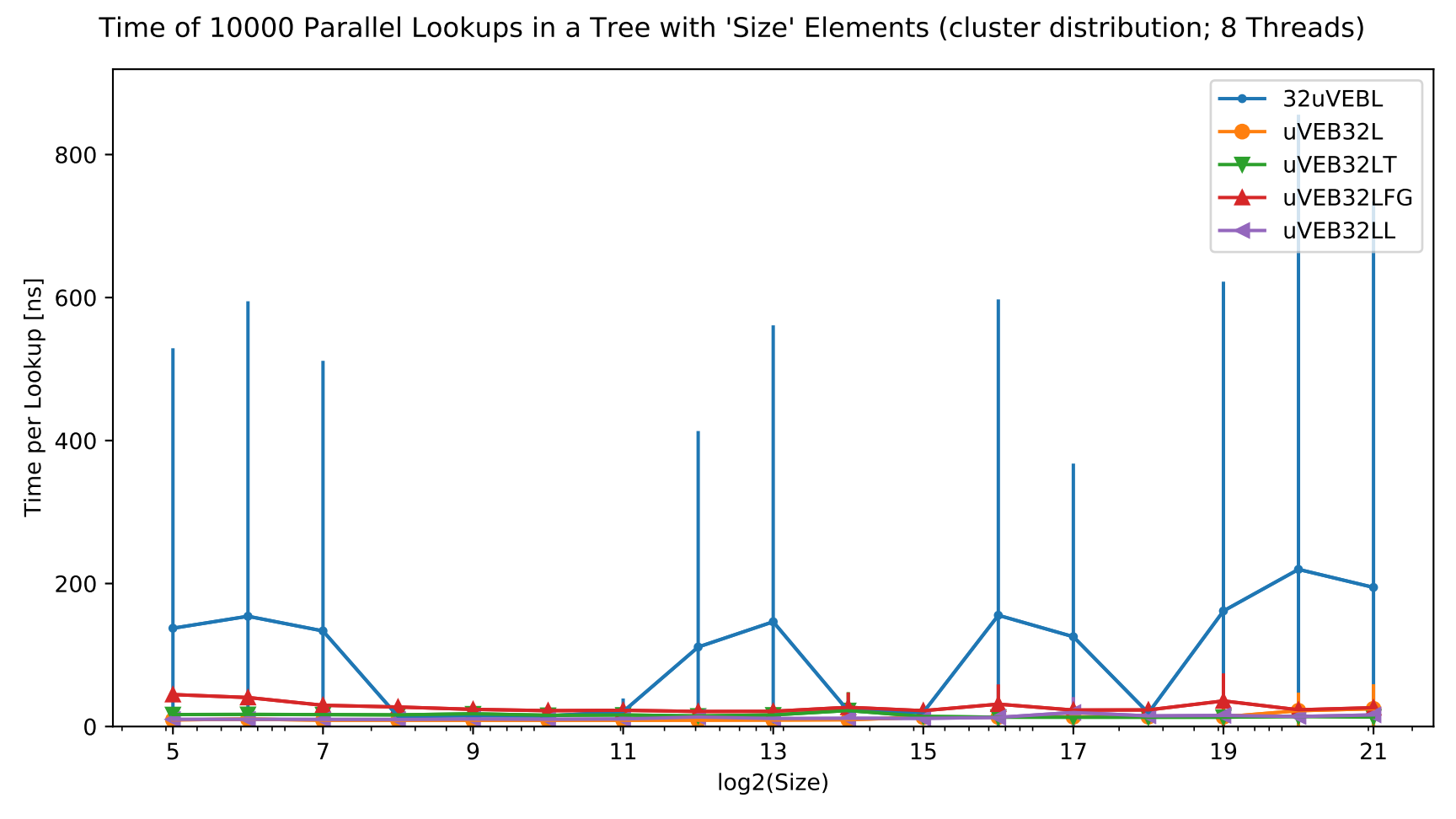

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (uniform distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
0
50
100
150
200
250
300
350
400
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

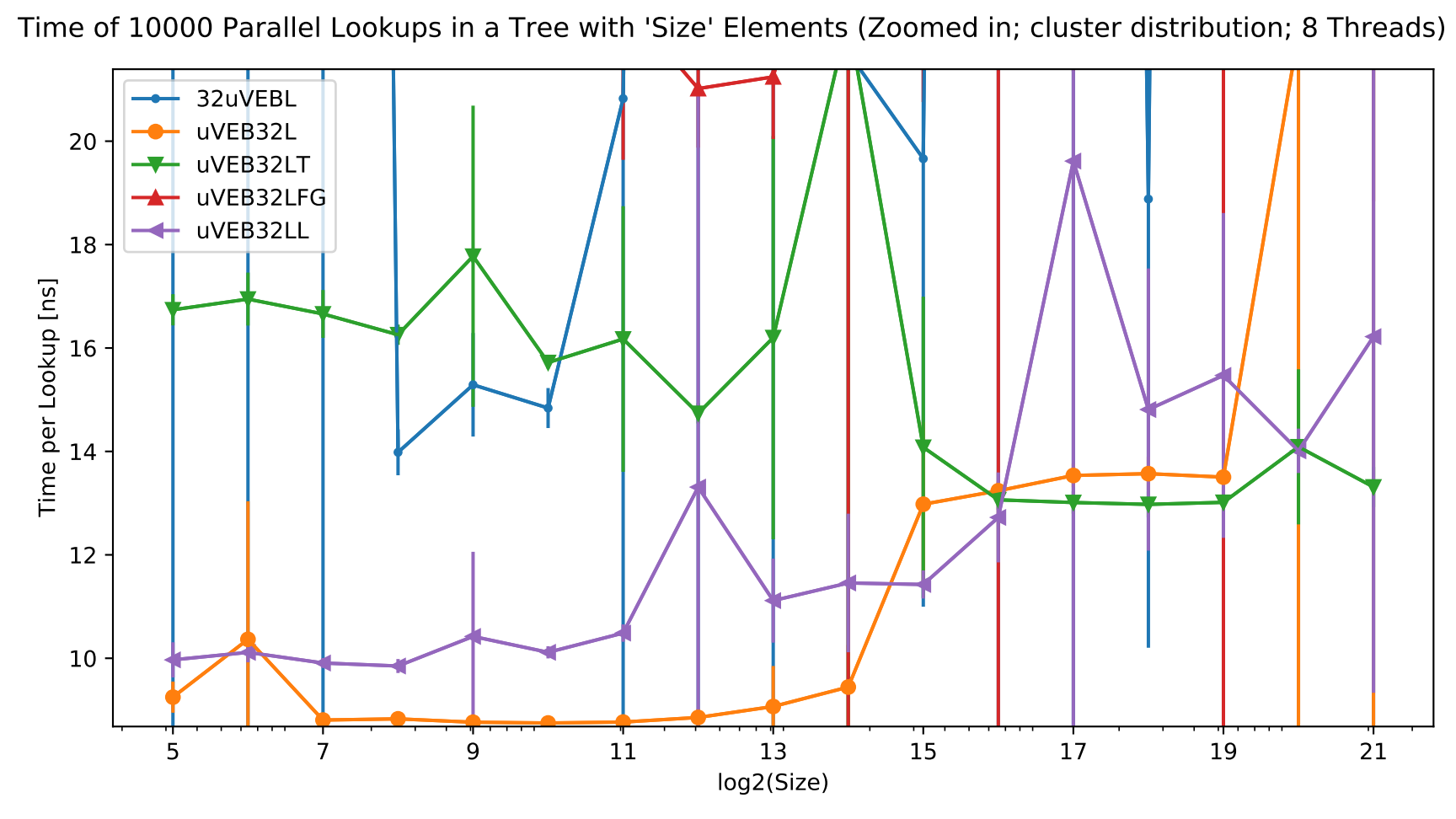

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; uniform distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
10
15
20
25
30
35
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

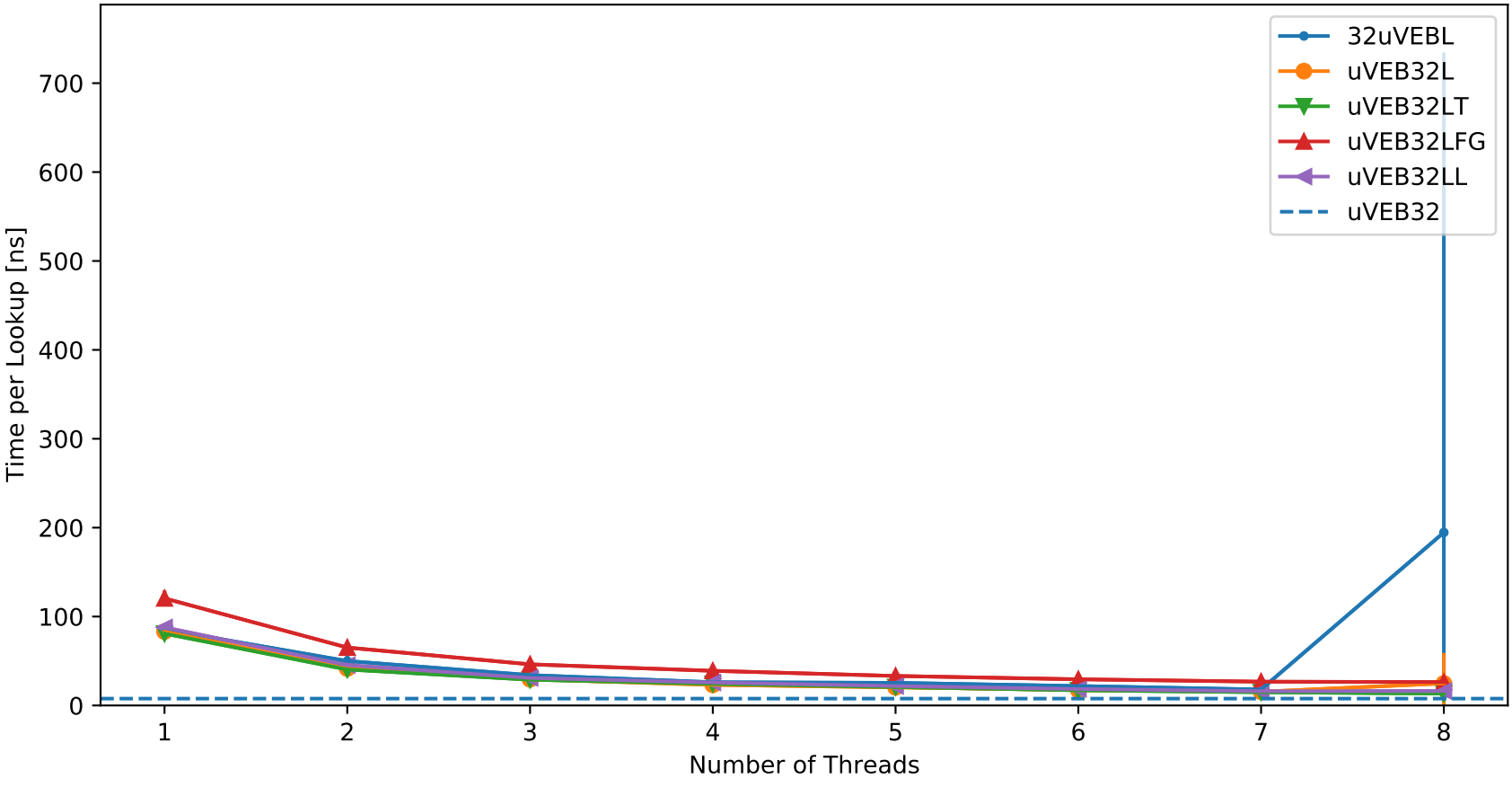

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (uniform distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
500
1000
1500
2000
2500
3000
3500
4000
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

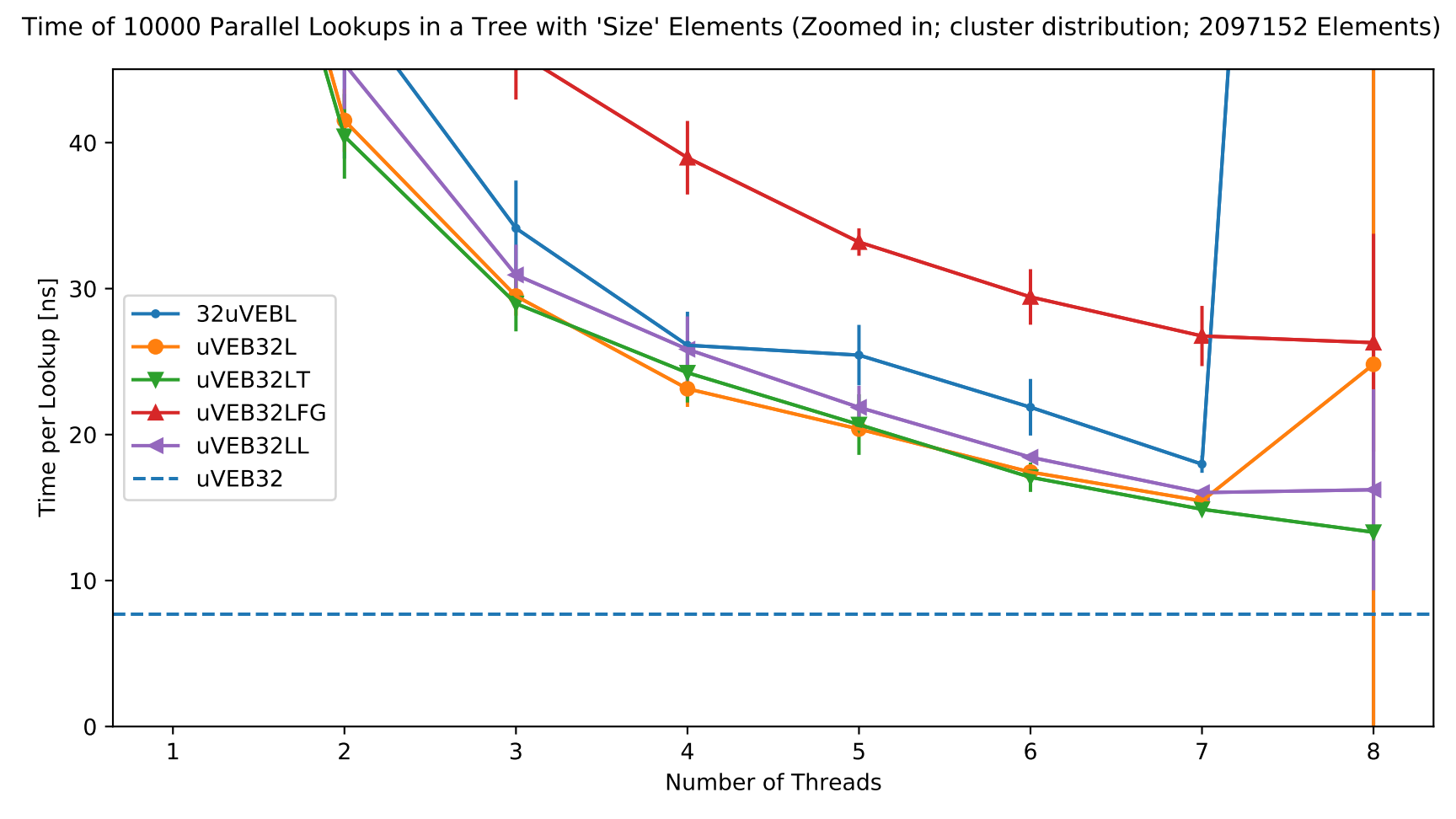

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; uniform distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32
Time per Lookup [ns]
Number of Threads
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7
8

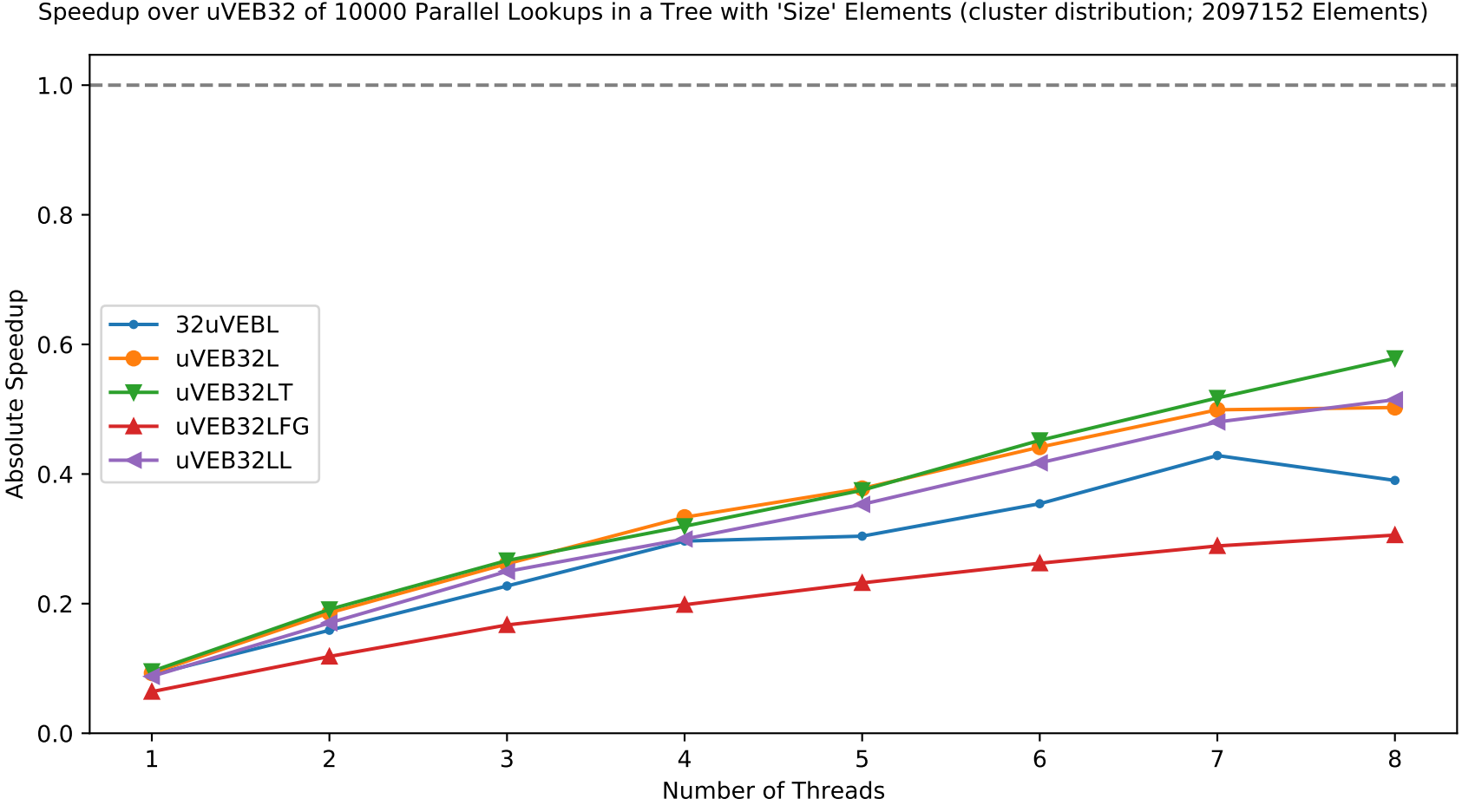

Speedup over uVEB32 of 10000 Parallel Lookups in a Tree with 'Size' Elements (uniform distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1
2
3
4
5
6
7
8
Number of Threads

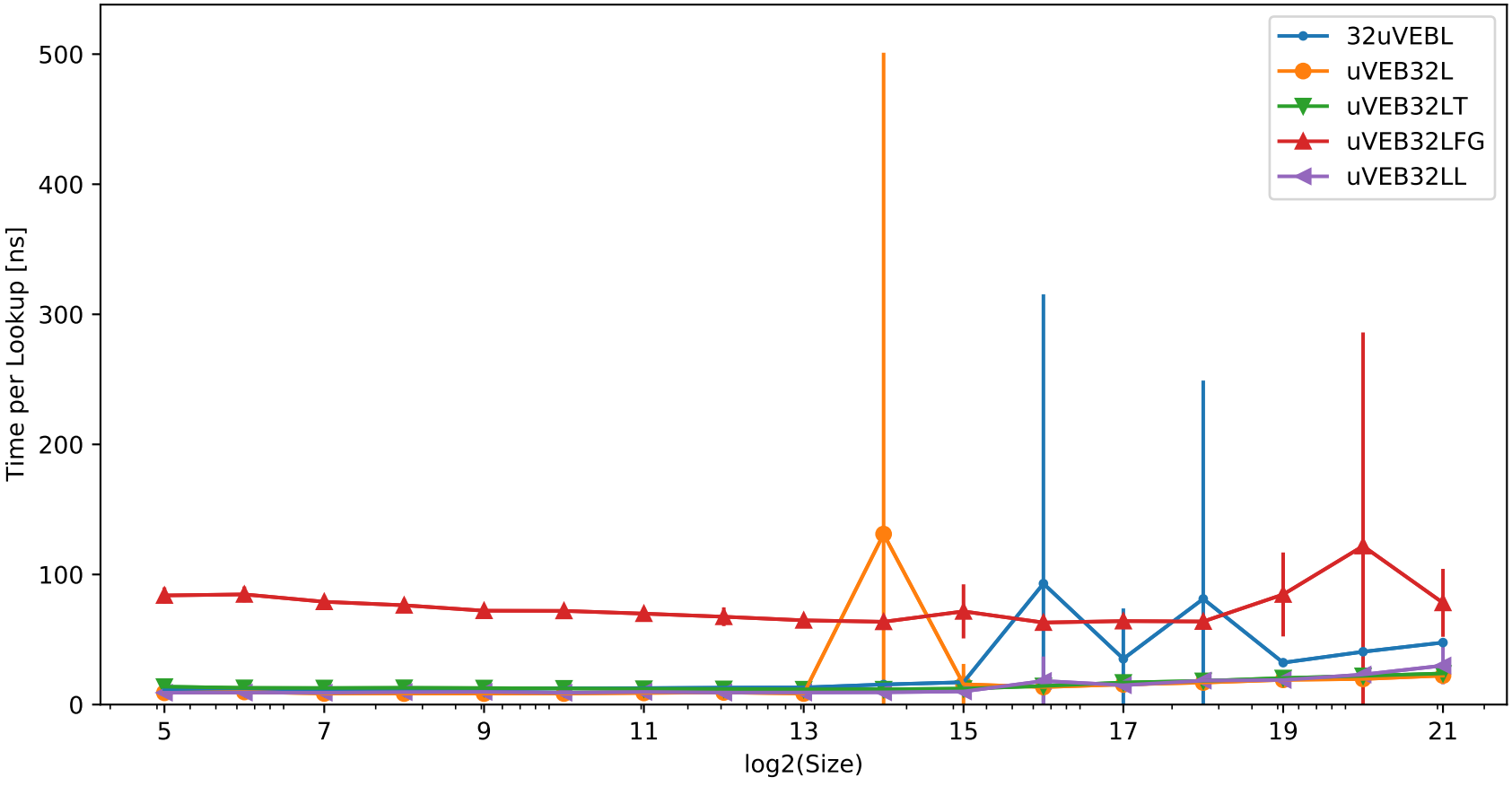

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (cluster distribution; 8 Threads)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Time per Lookup [ns]
0
200
400
600
800
5
7
9
11
13
15
17
19
21
log2(Size)

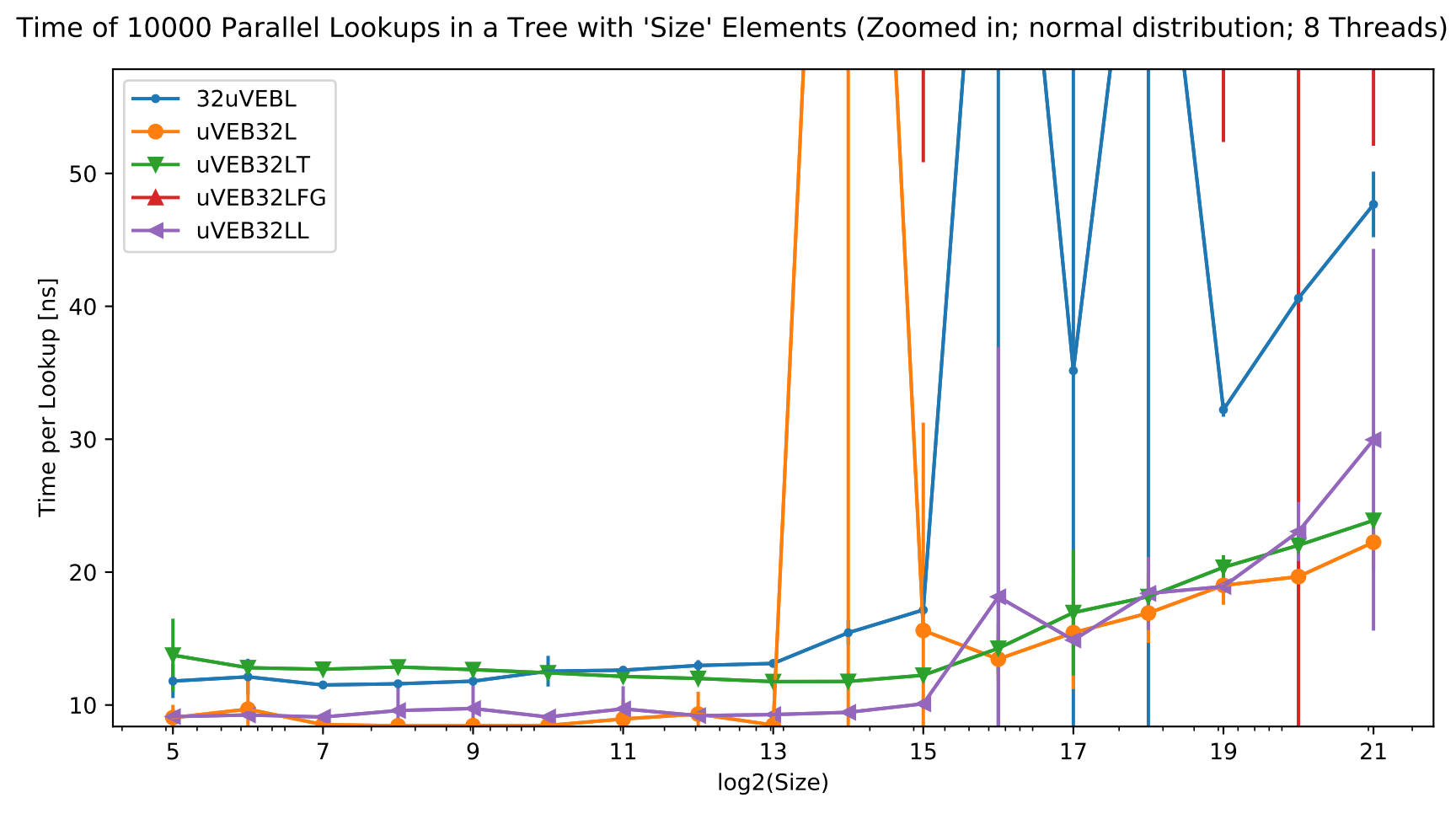

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; cluster distribution; 8 Threads)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Time per Lookup [ns]
10
12
14
16
18
20
5
7
9
11
13
15
17
19
21
log2(Size)

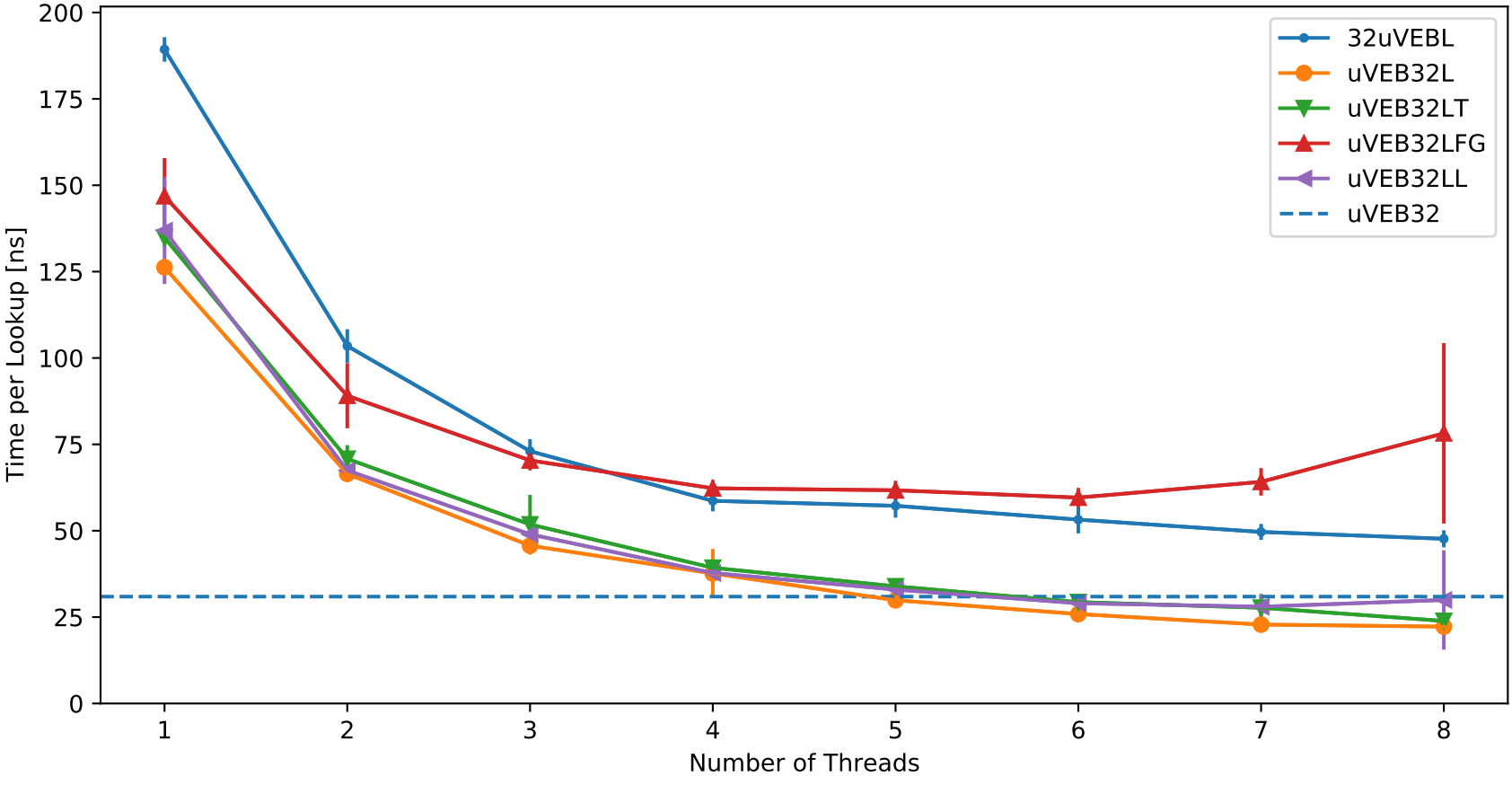

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (cluster distribution; 2097152 Elements)
Time per Lookup [ns]
0
100
200
300
400
500
600
700
Number of Threads
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

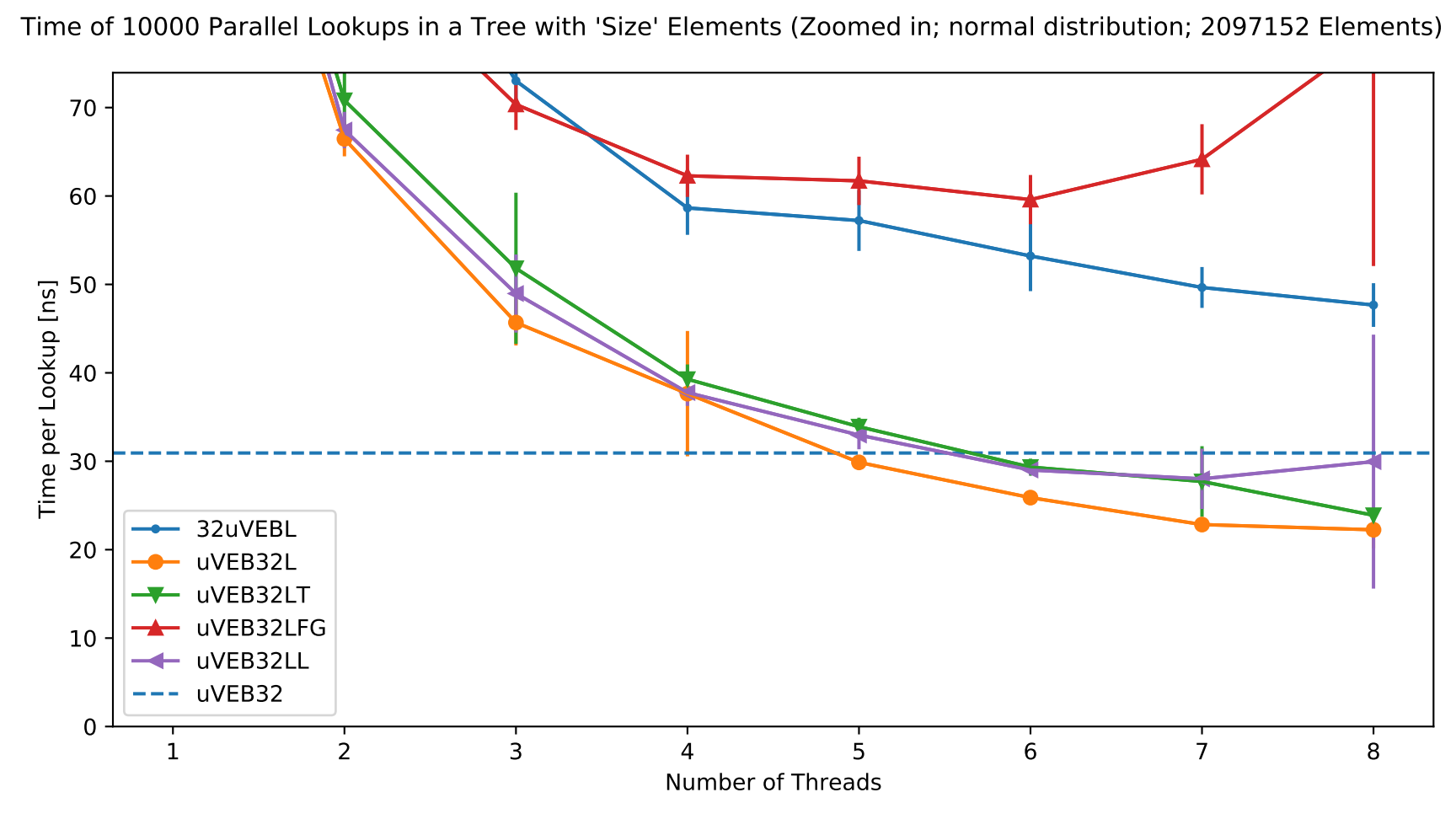

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; cluster distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
10
20
30
40
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

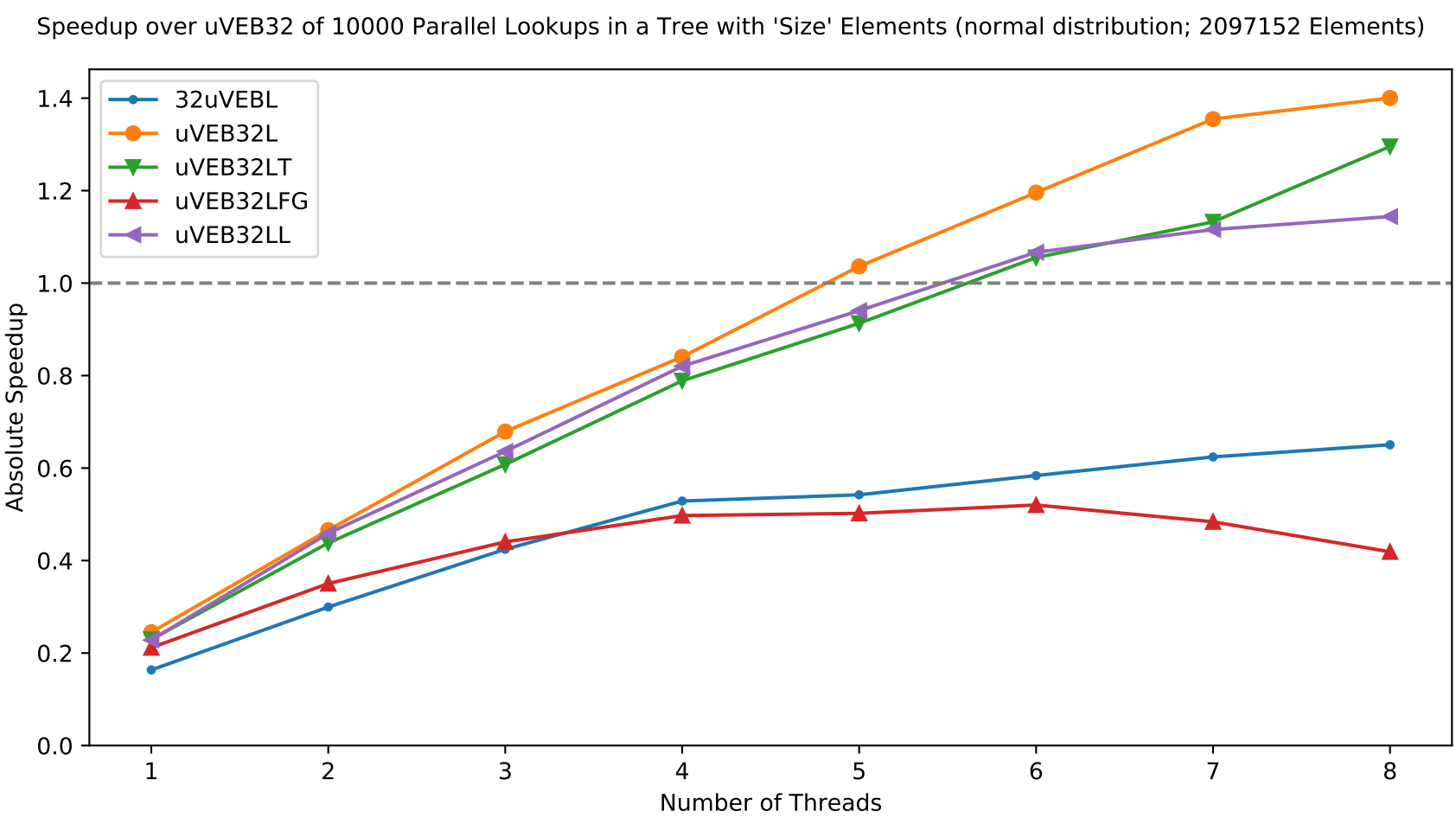

Speedup over uVEB32 of 10000 Parallel Lookups in a Tree with 'Size' Elements (cluster distribution; 2097152 Elements)
Absolute Speedup
Number of Threads
0.0
0.2
0.4
0.6
0.8
1.0
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

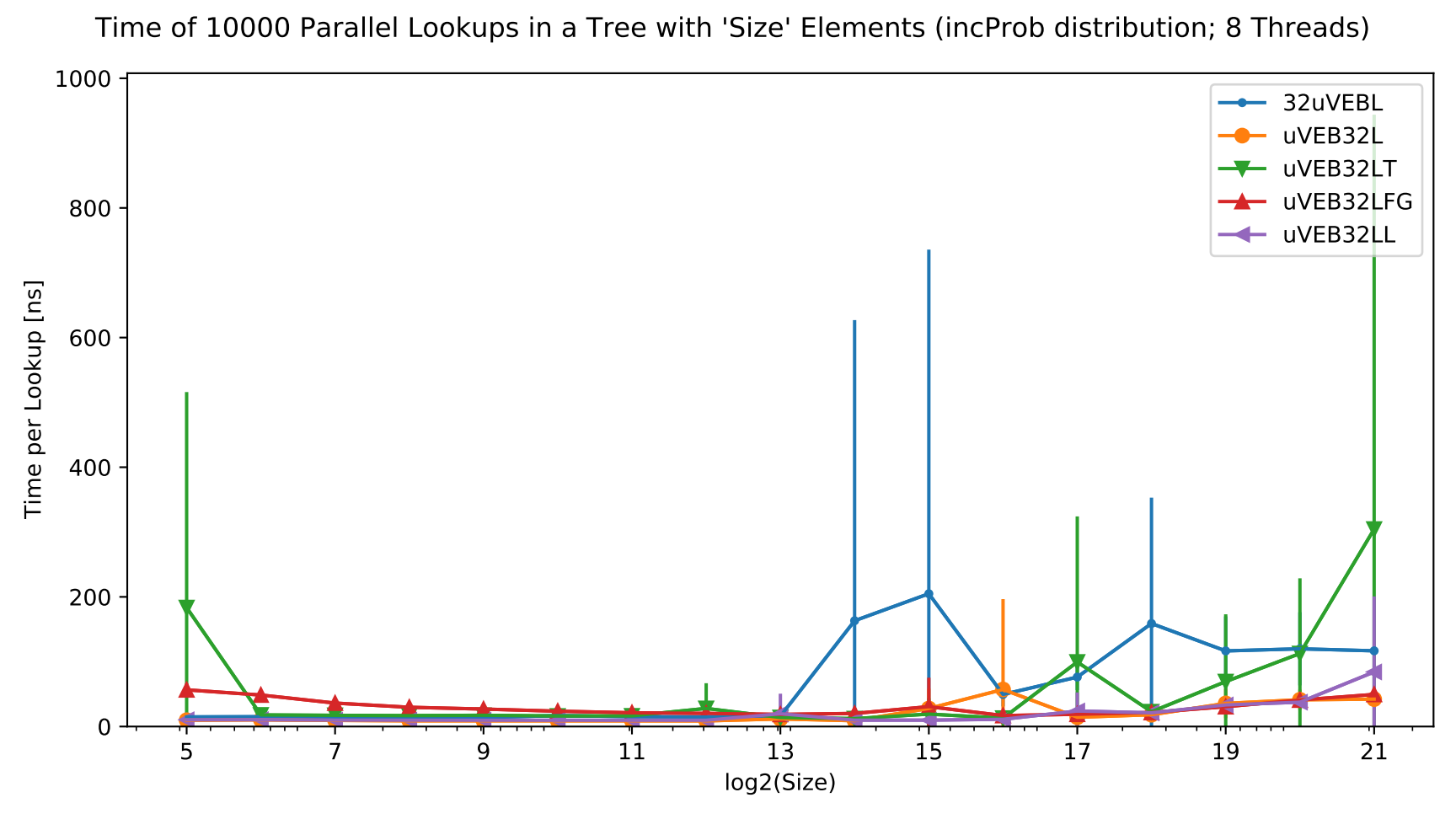

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (normal distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
0
100
200
300
400
500
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

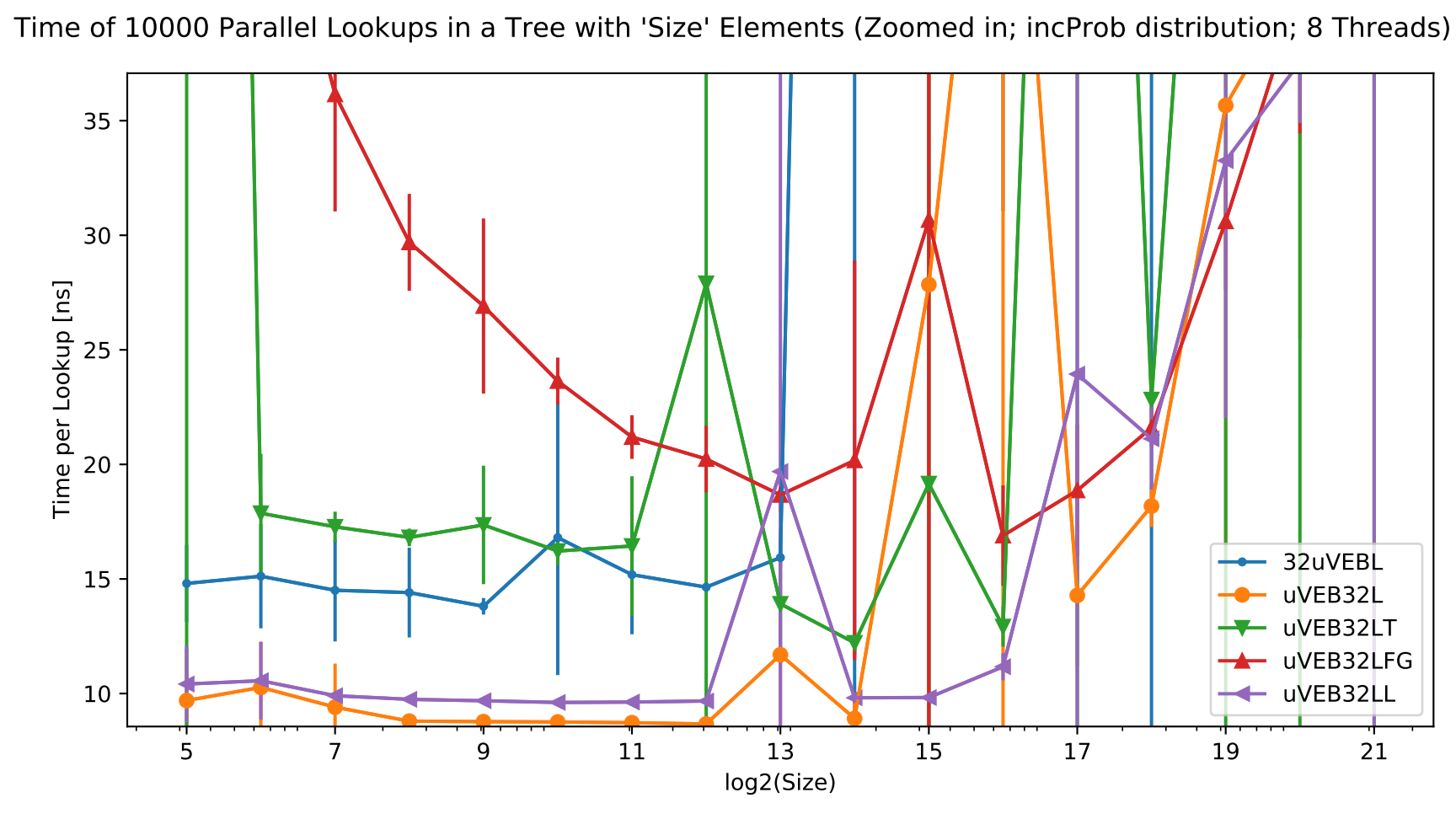

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; normal distribution; 8 Threads)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Time per Lookup [ns]
10
20
30
40
50
5
7
9
11
13
15
17
19
21
log2(Size)

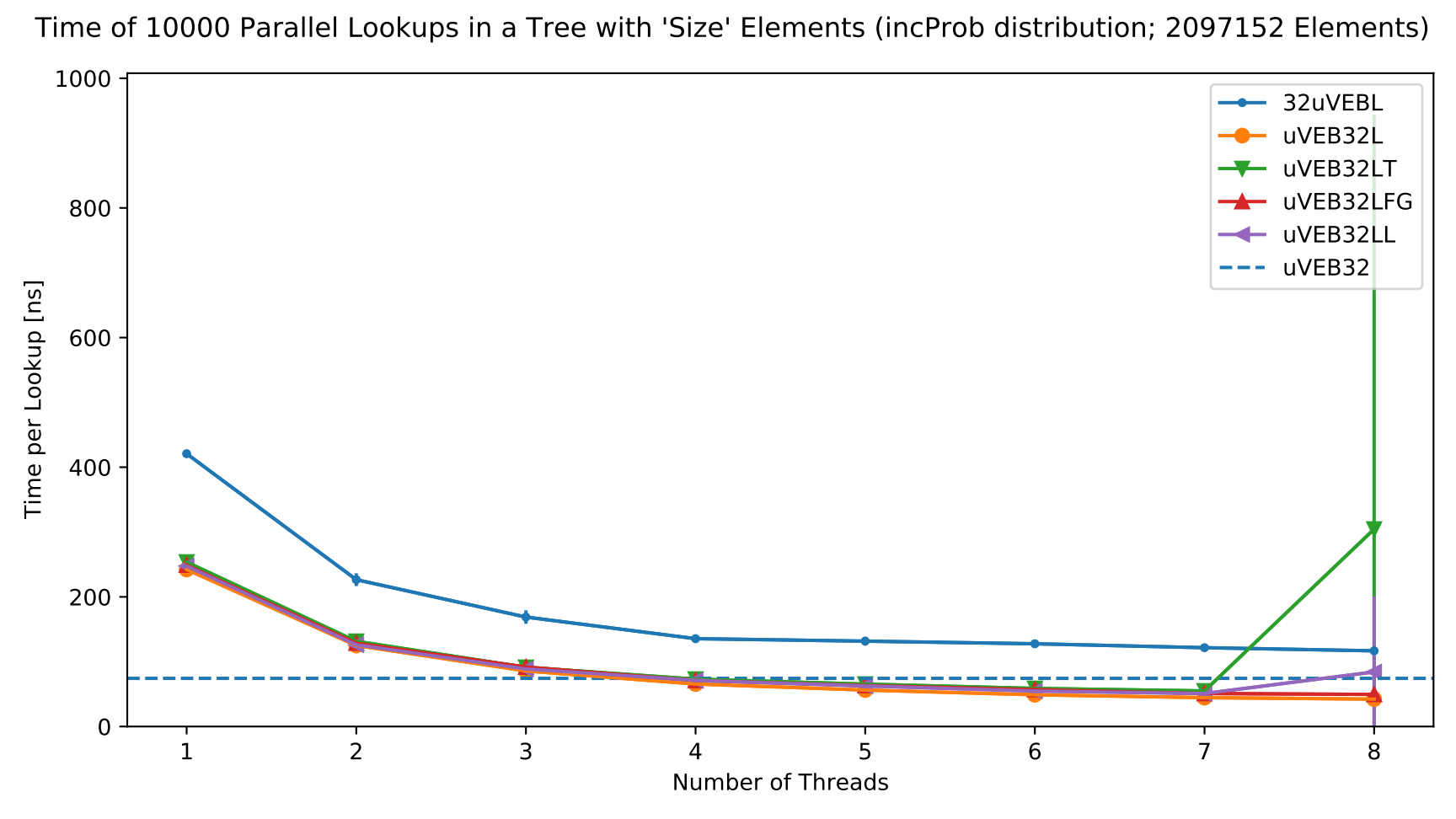

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (normal distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
25
50
75
100
125
150
175
200
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

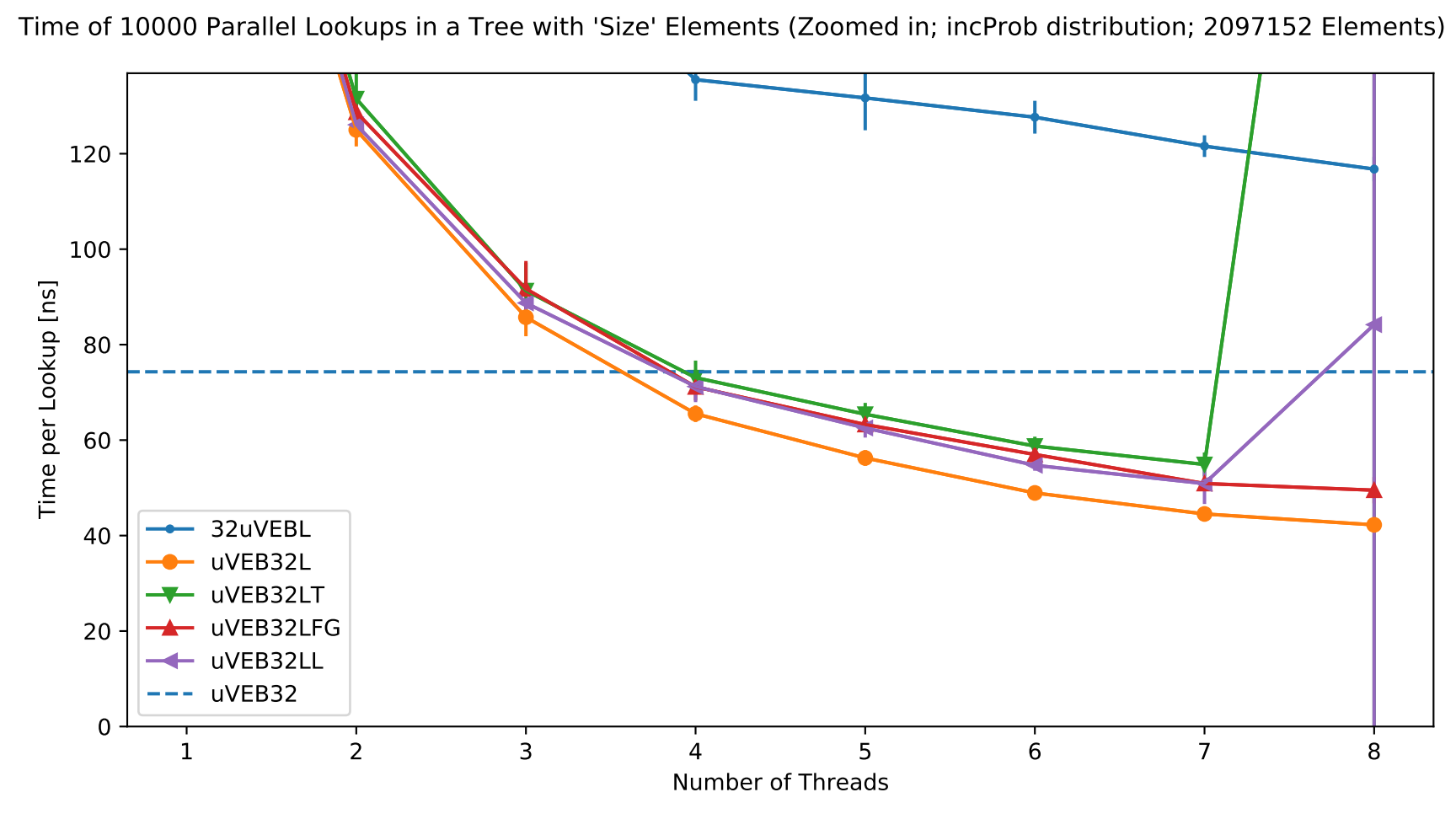

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; normal distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

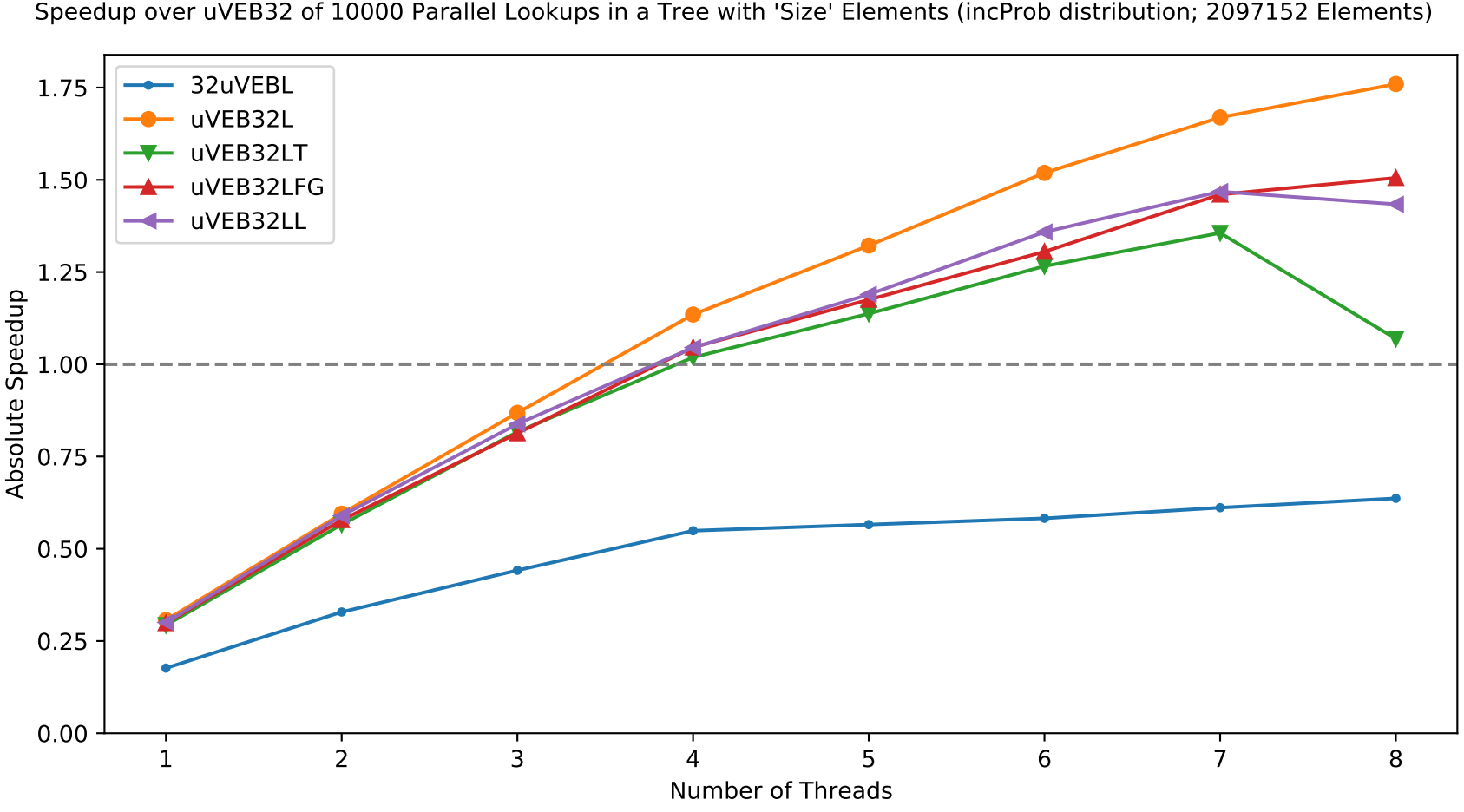

Speedup over uVEB32 of 10000 Parallel Lookups in a Tree with 'Size' Elements (normal distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
Number of Threads
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1
2
3
4
5
6
7
8

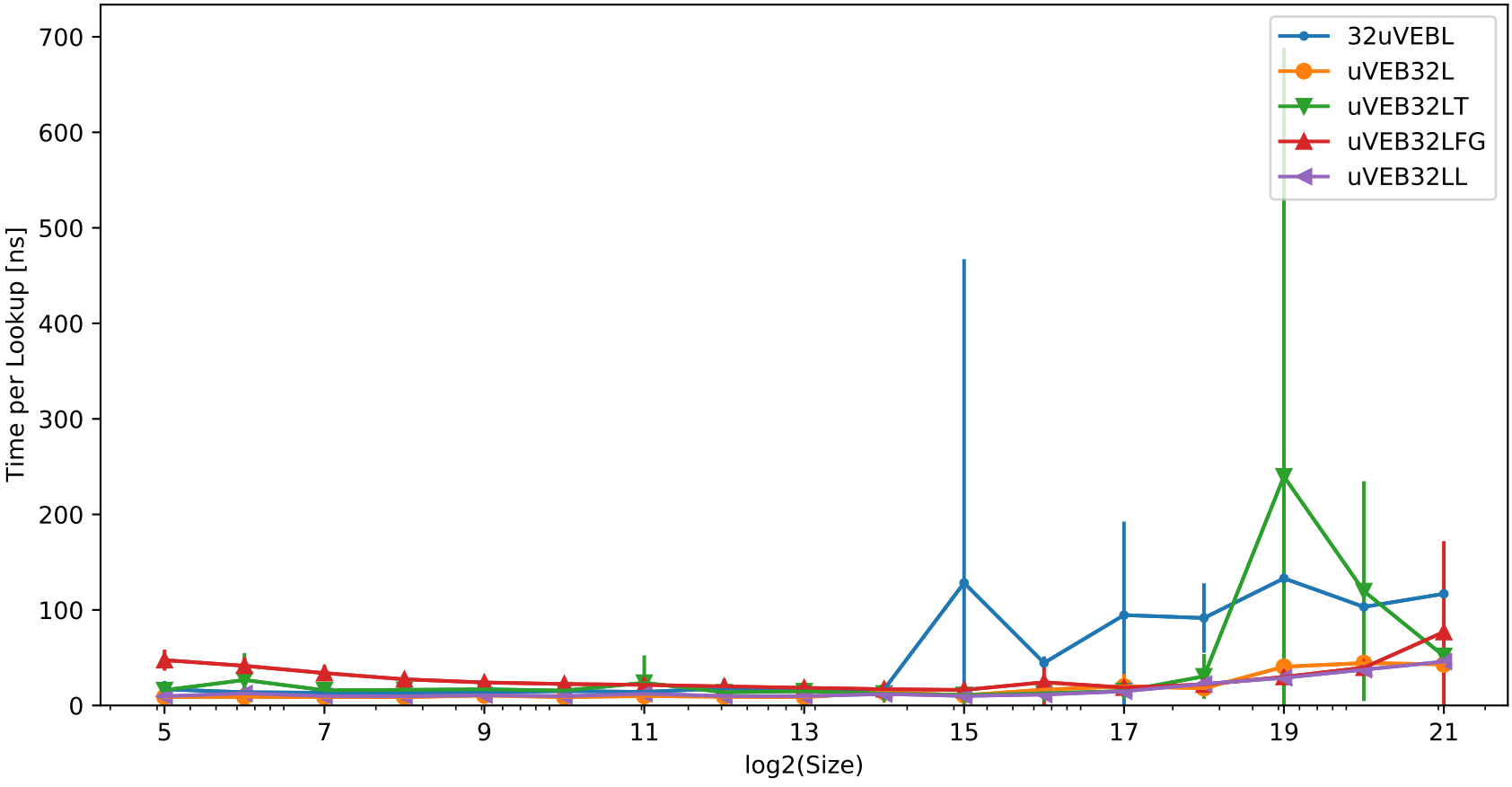

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (incProb distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
0
200
400
600
800
1000
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

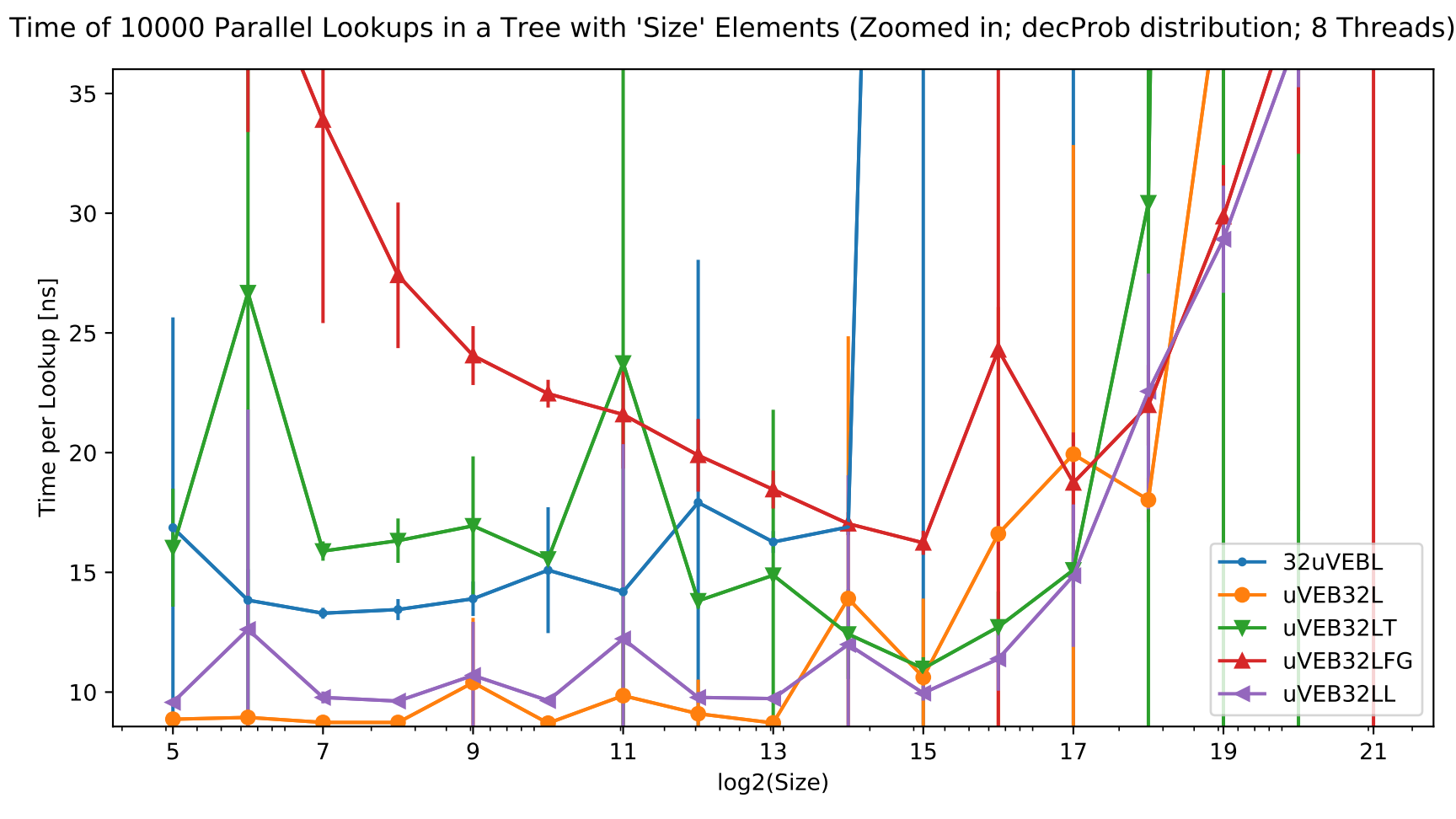

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; incProb distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
10
15
20
25
30
35
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL

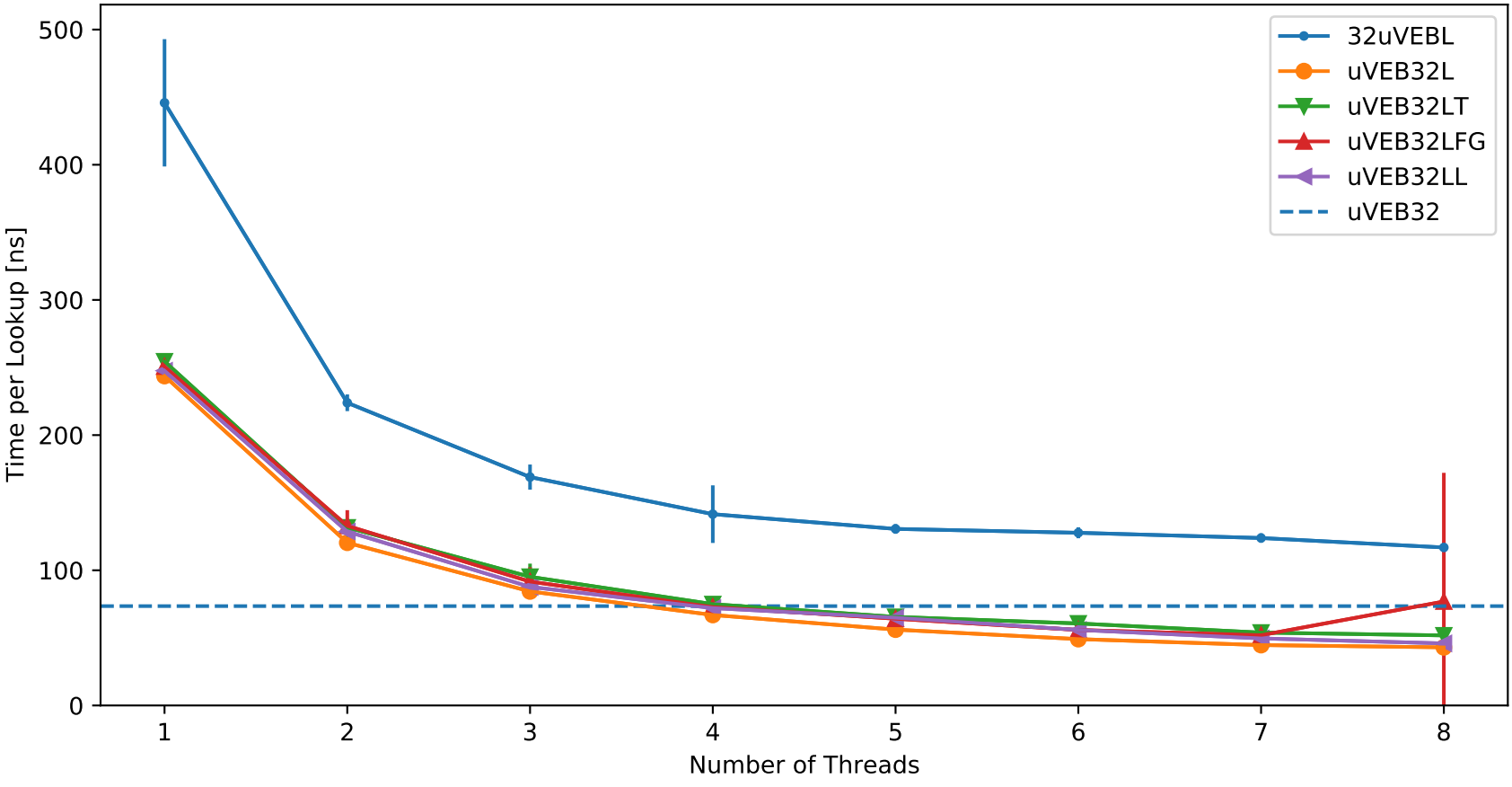

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (incProb distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
200
400
600
800
1000
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

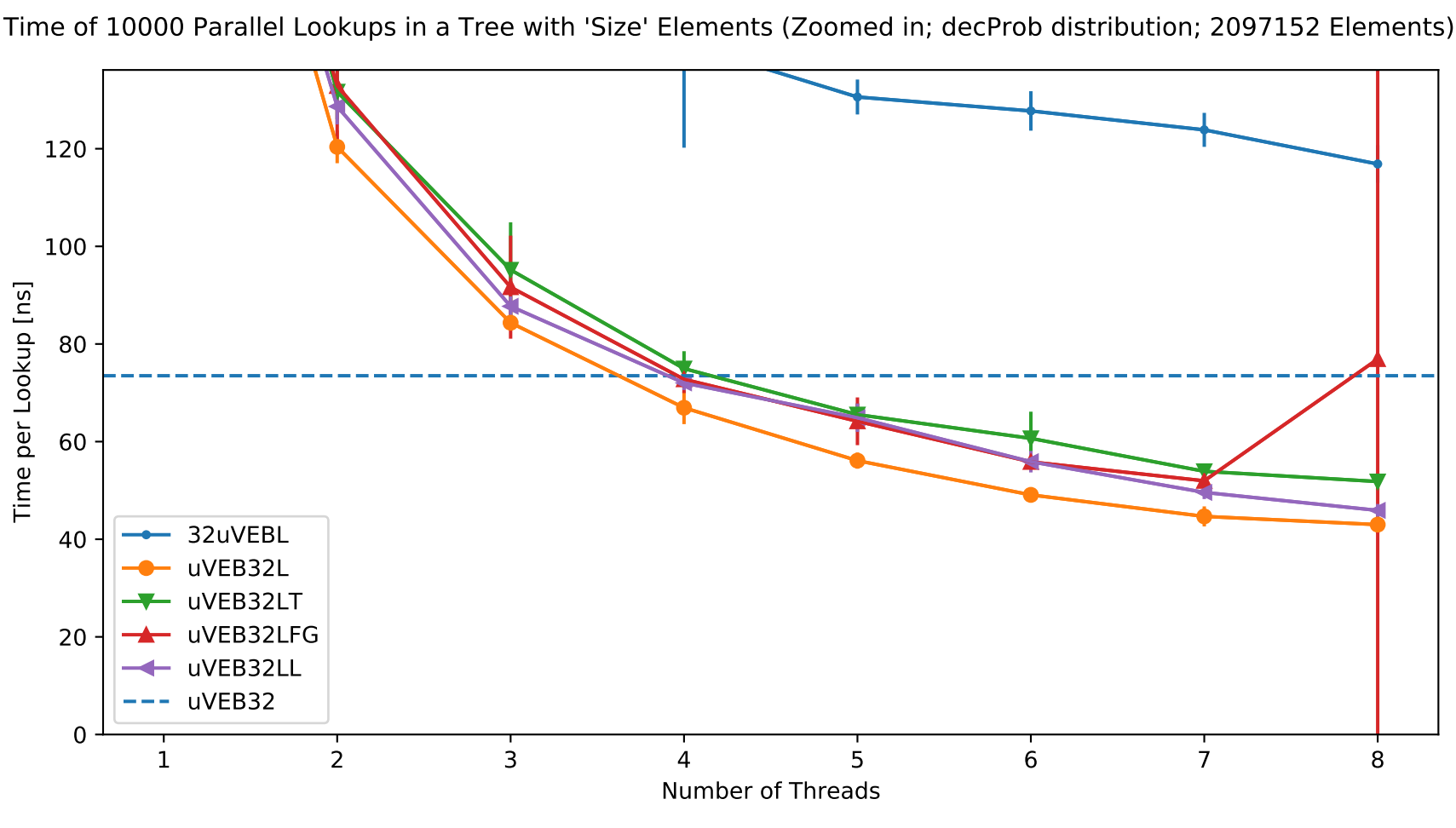

Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; incProb distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
20
40
60
80
100
120
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32

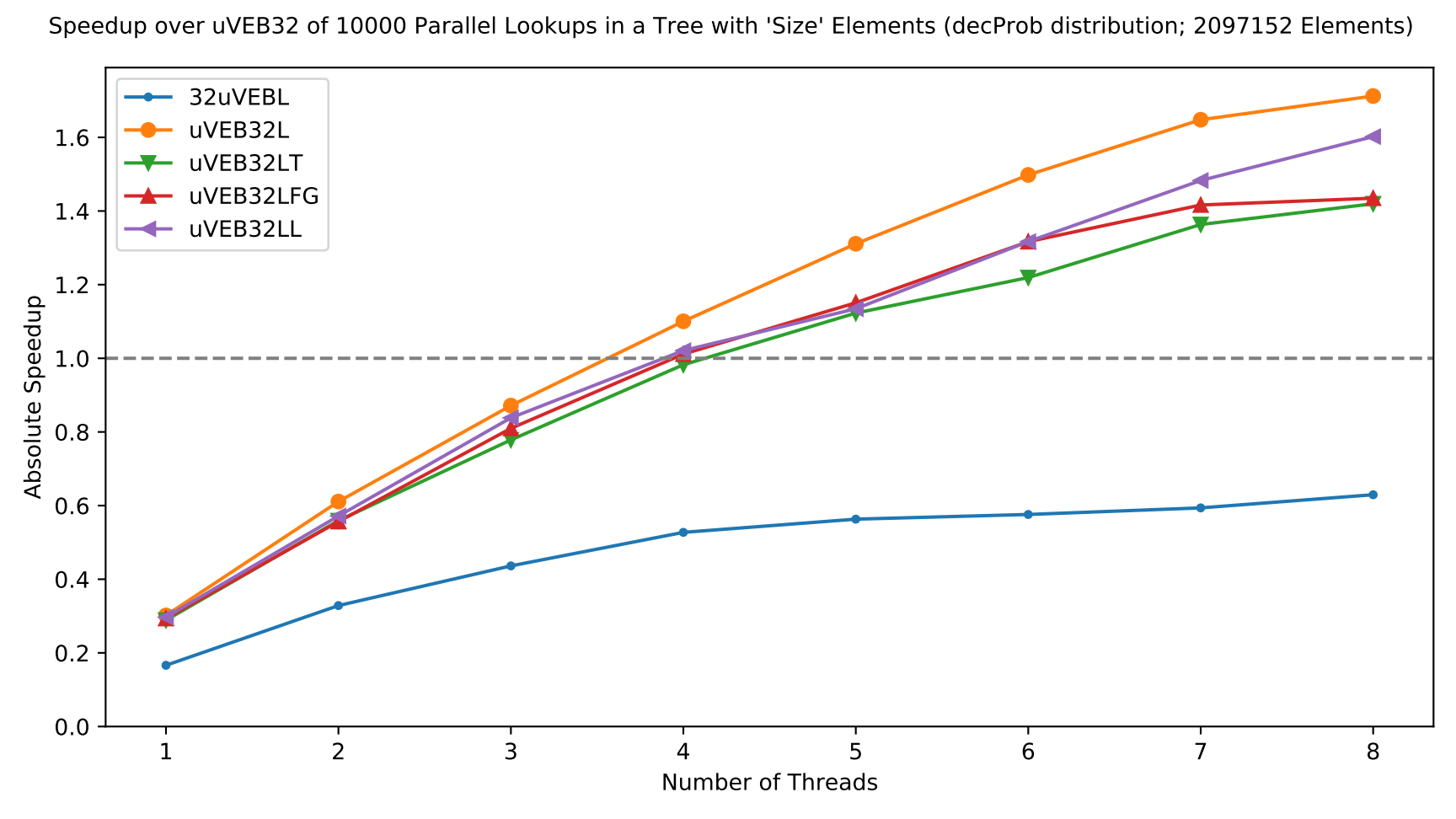

Speedup over uVEB32 of 10000 Parallel Lookups in a Tree with 'Size' Elements (incProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1
2
3
4
5
6
7
8
Number of Threads


Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (decProb distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
0
100
200
300
400
500
600
700
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL


Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; decProb distribution; 8 Threads)
Time per Lookup [ns]
log2(Size)
35
30
25
20
15
10
5
7
9
11
13
15
17
19
21
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL


Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (decProb distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
100
200
300
400
500
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32


Time of 10000 Parallel Lookups in a Tree with 'Size' Elements (Zoomed in; decProb distribution; 2097152 Elements)
Time per Lookup [ns]
Number of Threads
0
20
40
60
80
100
120
1
2
3
4
5
6
7
8
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
uVEB32


Speedup over uVEB32 of 10000 Parallel Lookups in a Tree with 'Size' Elements (decProb distribution; 2097152 Elements)
32uVEBL
uVEB32L
uVEB32LT
uVEB32LFG
uVEB32LL
Absolute Speedup
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1
2
3
4
5
6
7
8
Number of Threads