**Appendix A:** Breakdown of BVH Build Phases

We measured the execution times of all individual steps in our BVH construction pipeline, as shown in Fig. 4, and report the results in milliseconds in Table 5. For scenes containing up to three million triangles, our DOBB post-processing step takes up to 1.15ms and increases to approximately 5ms for scenes with 13 million triangles.

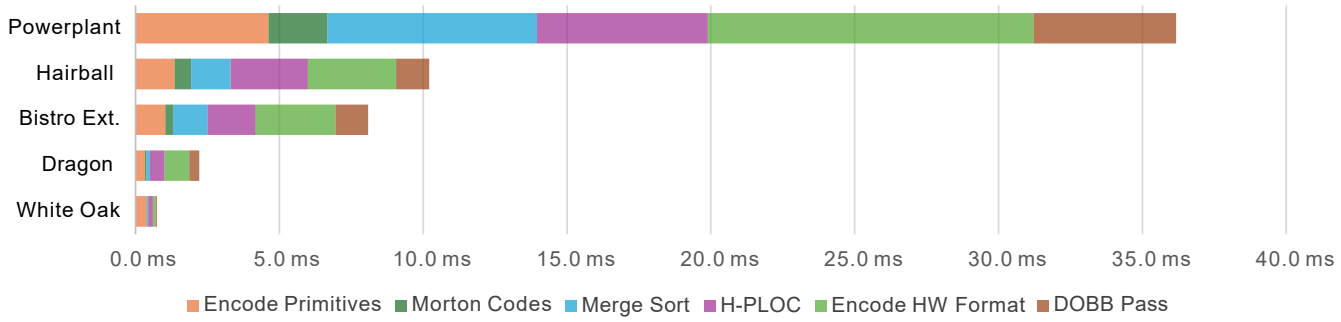



**Figure 4:** *Breakdown of BVH-8 build phases across our set of test scenes, showcasing the impact of DOBB-BVH.*

| Build Phases | White Oak | Dragon | Bistro Ext. | Hairball | Powerplant |
|---|---|---|---|---|---|
| Encode Primitives | 0.39 ms | 0.33 ms | 1.04 ms | 1.36 ms | 4.62 ms |
| Morton Codes | 0.01 ms | 0.05 ms | 0.26 ms | 0.58 ms | 2.05 ms |
| Merge Sort | 0.04 ms | 0.13 ms | 1.21 ms | 1.38 ms | 7.29 ms |
| H-PLOC | 0.16 ms | 0.51 ms | 1.67 ms | 2.67 ms | 5.94 ms |
| Encode HW Format | 0.09 ms | 0.86 ms | 2.77 ms | 3.07 ms | 11.32 ms |
| DOBB Pass | 0.05 ms | 0.35 ms | 1.13 ms | 1.15 ms | 4.95 ms |

**Table 5:** *Results of BVH-8 build phases in Figure 4.*

**Appendix B:** Analysis of Traversal Performance for Primary and Secondary Rays

We further evaluated the build times and traversal performance of our DOBB algorithm for both primary and secondary rays. Table 6 presents the build and traversal performance across BVHs with varying branching factors. Detailed analysis of BVH quality and traversal behavior for secondary (global illumination) rays is provided in Table 7 and Table 8.

| Scene | Approach | Build Time ms | | | Primary GRays/s | | | Secondary GRays/s | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BVH-4 | BVH-6 | BVH-8 | BVH-4 | BVH-6 | BVH-8 | BVH-4 | BVH-6 | BVH-8 |
| Hairball | AABB | 12.61 | 12.07 | 11.62 | 2.27 | 2.63 | 2.91 | 0.89 | 1.06 | 1.16 |
| | $OBB_{soGPU}$ | 14.96 (1.19×) | 13.26 (1.10×) | 12.82 (1.10×) | **3.19** (**1.40**×) | **3.62** (**1.38**×) | **4.16** (**1.43**×) | **1.43** (**1.35**×) | **1.66** (**1.43**×) | **1.66** (**1.43**×) |
| Bistro Ext. | AABB | 13.49 | 12.31 | 12.16 | 2.82 | 3.29 | 3.63 | 1.14 | 1.29 | 1.34 |
| | $OBB_{soGPU}$ | 15.57 (1.26×) | 13.56 (1.10×) | 13.56 (1.12×) | 3.22 (1.14×) | 3.78 (1.15×) | 4.27 (1.18×) | 1.56 (1.36×) | **1.82** (**1.41**×) | **1.97** (**1.47**×) |
| White Oak | AABB | 0.70 | 0.55 | 0.65 | 6.57 | 7.49 | 7.95 | 2.39 | 2.70 | 2.82 |
| | $OBB_{soGPU}$ | 0.76 (1.09×) | 0.687 (1.25×) | 0.71 (1.09×) | 6.64 (1.01×) | 7.61 (1.02×) | 8.04 (1.01×) | 2.48 (1.04×) | 2.80 (1.03×) | 2.93 (1.04×) |
| Dragon | AABB | 2.57 | 2.49 | 2.57 | 17.78 | 19.99 | 20.93 | 2.87 | 3.17 | 3.26 |
| | $OBB_{soGPU}$ | 3.22 (1.25×) | 3.09 (1.24×) | 3.02x (1.18×) | 18.19 (1.02×) | 20.41 (1.02×) | 21.08 (1.01×) | 3.00 (1.04×) | 3.26 (1.03×) | 3.37 (1.03×) |
| Powerplant | AABB | 51.02 | 49.50 | 48.46 | 3.54 | 3.92 | 4.09 | 1.73 | 2.11 | 1.87 |
| | $OBB_{soGPU}$ | 60.33 (1.18×) | 55.37 (1.12×) | 55.20 (1.08×) | **5.04** (**1.42**×) | **6.37** (**1.63**×) | **5.32** (**1.30**×) | 2.29 (1.33×) | **3.08** (**1.46**×) | **3.09** (**1.65**×) |

**Table 6:** *Hardware results of our GPU-based DOBB BVHs build algorithm across all branching factors 4–8 compared against an AABB tree and the relative factor within brackets (increased build time or improved performance).*

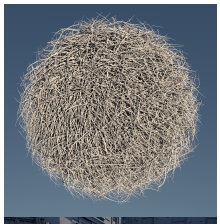
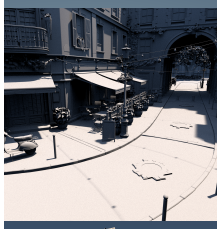
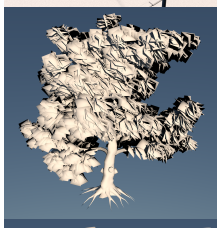
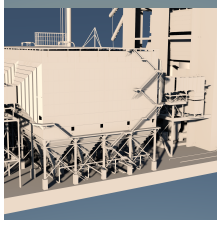
| | Scene [#Triangles] | Approach | Max. Iterations / Ray BVH-4 | BVH-6 | BVH-8 | Avg. Iterations / Ray BVH-4 | BVH-6 | BVH-8 |
|---|---|---|---|---|---|---|---|---|
|  | Hairball [2.9M] | AABB (Baseline) | 3735 | 409 | 378 | 34.3 | 28.9 | 25.9 |
| | | AABB → $OBB_{PC}$ | 212 | 159 | 151 | 20.8 | 17.2 | 15.4 |
| | | (Roofline Per-Child) | 0.06× | 0.39× | 0.40× | 0.61× | 0.60× | 0.60× |
| | | AABB → $OBB_{soCPU}$ | 346 | 180 | 176 | 22.2 | 18.7 | 16.9 |
| | | **Ours (Brute-Force)** | 0.09× | 0.44× | 0.47× | 0.65× | 0.65× | 0.65× |
| | | AABB → $OBB_{soGPU}$ | 1050 | 268 | 247 | 27.4 | 23.4 | 20.1 |
| | | **Ours (GPU-based)** | 0.28× | 0.66× | 0.65× | 0.80× | 0.81× | 0.78× |
|  | Bistro Exterior [2.8M] | AABB (Baseline) | 524 | 492 | 463 | 61.4 | 52.4 | 48.3 |
| | | AABB → $OBB_{PC}$ | 253 | 220 | 209 | 39.3 | 32.9 | 29.6 |
| | | Rel. Factor to AABB | 0.48× | 0.45× | 0.45× | 0.64× | 0.63× | 0.61× |
| | | AABB → $OBB_{soCPU}$ | 256 | 225 | 213 | 40.8 | 34.2 | 30.7 |
| | | | 0.49× | 0.46× | 0.46× | 0.66× | 0.65× | 0.64× |
| | | AABB → $OBB_{soGPU}$ | 361 | 317 | 316 | 52.5 | 43.5 | 39.3 |
| | | | 0.69× | 0.64× | 0.68× | 0.86× | 0.83× | 0.81× |
|  | White Oak [36K] | AABB (Baseline) | 189 | 157 | 147 | 15.2 | 13.0 | 12.0 |
| | | AABB → $OBB_{PC}$ | 155 | 111 | 104 | 12.7 | 10.9 | 10.0 |
| | | | 0.82× | 0.71× | 0.71× | 0.84× | 0.84× | 0.84× |
| | | AABB → $OBB_{soCPU}$ | 170 | 131 | 121 | 13.8 | 12.0 | 11.2 |
| | | | 0.90× | 0.83× | 0.82× | 0.91× | 0.93× | 0.93× |
| | | AABB → $OBB_{soGPU}$ | 184 | 146 | 128 | 14.7 | 12.6 | 11.6 |
| | | | 0.97× | 0.93× | 0.87× | 0.97× | 0.97× | 0.97× |
|  | Dragon [830K] | AABB (Baseline) | 226 | 195 | 194 | 9.0 | 7.5 | 6.8 |
| | | AABB → $OBB_{PC}$ | 120 | 98 | 91 | 7.6 | 6.4 | 5.8 |
| | | | 0.53× | 0.50× | 0.47× | 0.85× | 0.85× | 0.84× |
| | | AABB → $OBB_{soCPU}$ | 109 | 90 | 81 | 7.8 | 6.6 | 6.0 |
| | | | 0.48× | 0.46× | 0.42× | 0.87× | 0.88× | 0.88× |
| | | AABB → $OBB_{soGPU}$ | 154 | 131 | 110 | 8.6 | 7.1 | 6.5 |
| | | | 0.68× | 0.67× | 0.57× | 0.96× | 0.95× | 0.95× |
|  | Powerplant [12.8M] | AABB (Baseline) | 2892 | 2625 | 2061 | 31.6 | 26.1 | 23.2 |
| | | AABB → $OBB_{PC}$ | 447 | 467 | 475 | 25.8 | 20.9 | 18.4 |
| | | | 0.15× | 0.18× | 0.23× | 0.82× | 0.80× | 0.79× |
| | | AABB → $OBB_{soCPU}$ | 510 | 471 | 425 | 26.8 | 21.6 | 18.9 |
| | | | 0.18× | 0.18× | 0.21× | 0.85× | 0.83× | 0.82× |
| | | AABB → $OBB_{soGPU}$ | 1573 | 1358 | 971 | 27.4 | 22.3 | 19.6 |
| | | | 0.54× | 0.52× | 0.47× | 0.87× | 0.85× | 0.84× |

**Table 7:** *BVH quality and traversal statistics for secondary (GI) rays across different BVH widths for all datasets and OBB conversion algorithms.*

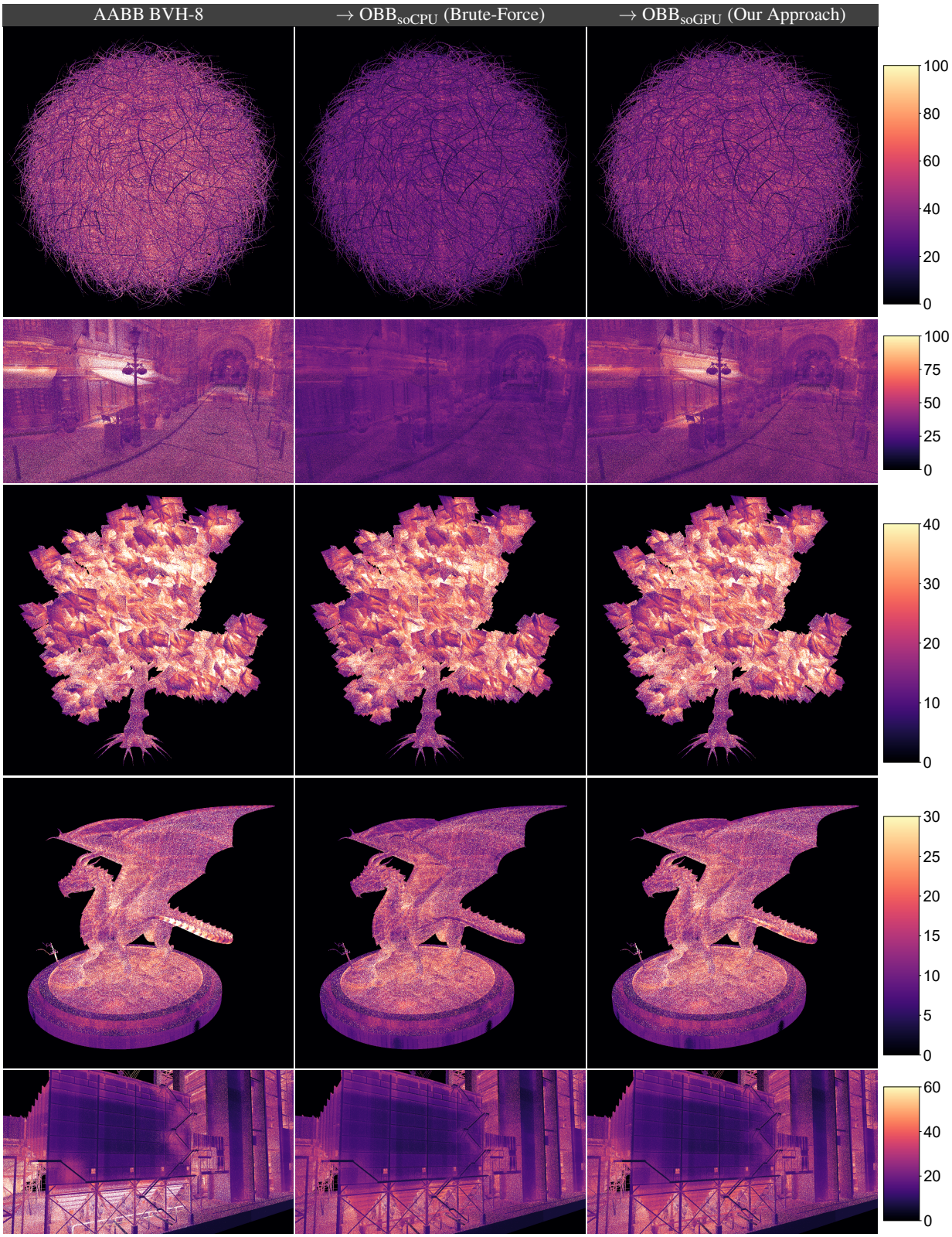



**Table 8:** *Visualizaton of traversal loop iteration counts at each pixel for secondary (GI) rays for our CPU-based and GPU-based DOBB BVHs compared to the baseline AABB BVH.*