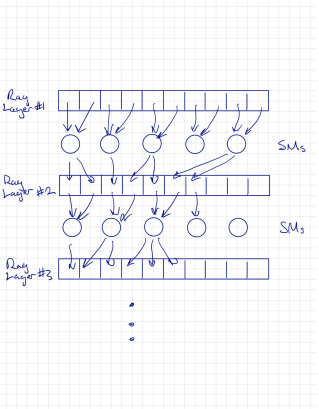
Parallel Ray Tracing

CUDA



Idea:
1. Execute ray simulation in iterations
2. Reassign new reflected and refracted rays each iteration
3. Compute surface colors from last layer and iterate backwards

Constraints:
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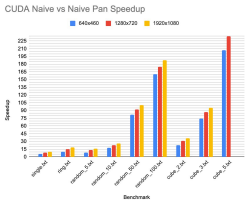
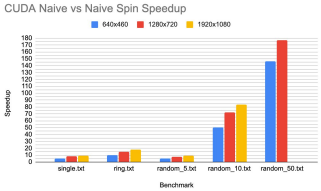
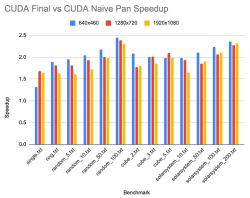
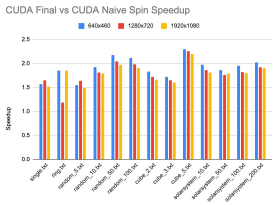
- Extremely memory intensive
- Dynamically scaling workload per layer
- Diffuse vs bounced rays not data parallel

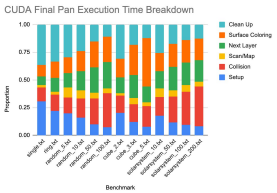
Benefits
- Collision checking is data parallel
- Tracing each ray is independent

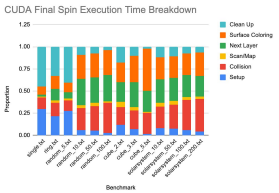


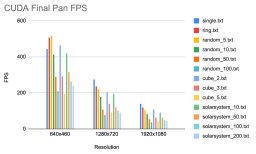


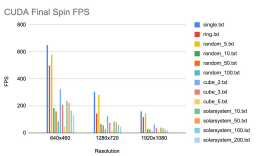












Conclusions:
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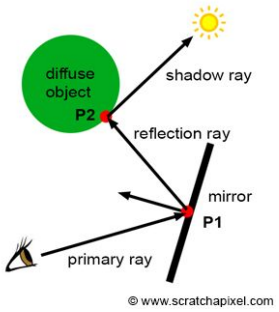
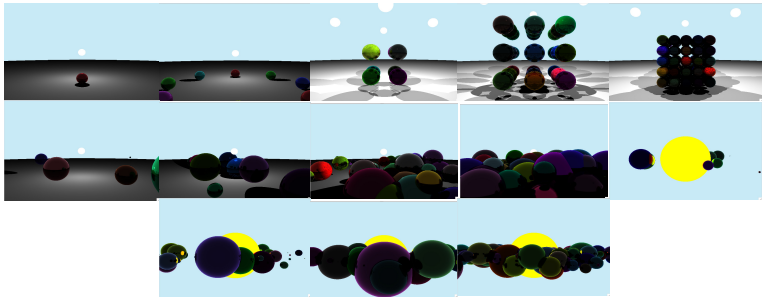
- Increasing object count less impactful than expected
- Ideal platform for ray tracing implementation

Background



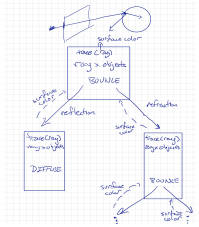
The ray tracing algorithm is a way to render a 3D scene to a 2D image by simulating the mathematical properties of light rays.

Benchmarks



Three Load Factors:
1. Resolution: 640x460, 1280x720, 1920x1080
2. Number of objects: 1 to 201
3. Number of non-diffusing rays: PAN vs SPIN

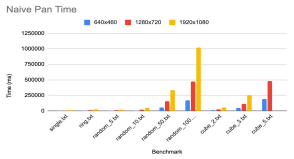
Naive Implementation

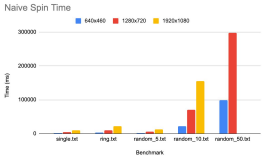


Idea:
For each ray, recursively trace it and all its scattered rays until ray depth or diffuse, then recursively backtrack to compute surface color.

Benefits:
- Simple to understand
- Create a complex and accurate simulation of real light and shadows

Drawbacks:
- Must check every object against every ray
- Recursion is expensive in practice
- Slow compared to rasterization



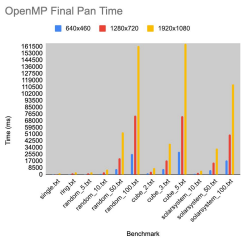


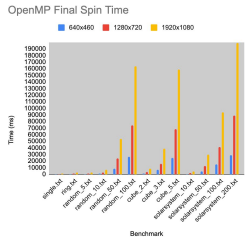
OpenMP/AVX

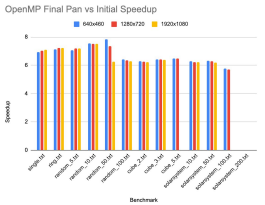
Idea:
1. Execute multiple ray simulations in parallel
2. Distribute workload evenly between threads
3. Optimize arithmetic computations with vector intrinsics

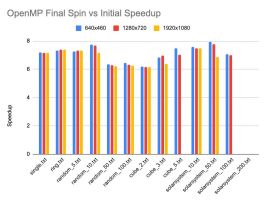
Constraints:
- Each layer depends on previous layer
- Nested and recursive structure harder to parallelize with OpenMP
- Using AVX intrinsics with complex data types

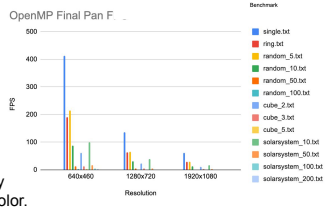
Benefits
- Tracing each ray is independent
- Dynamic scheduling prevents large load

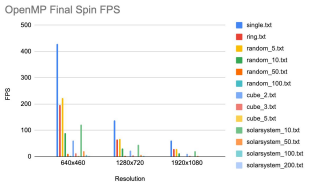


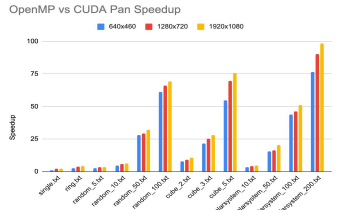


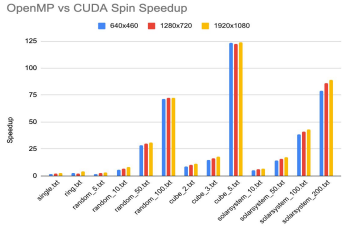












Conclusions:
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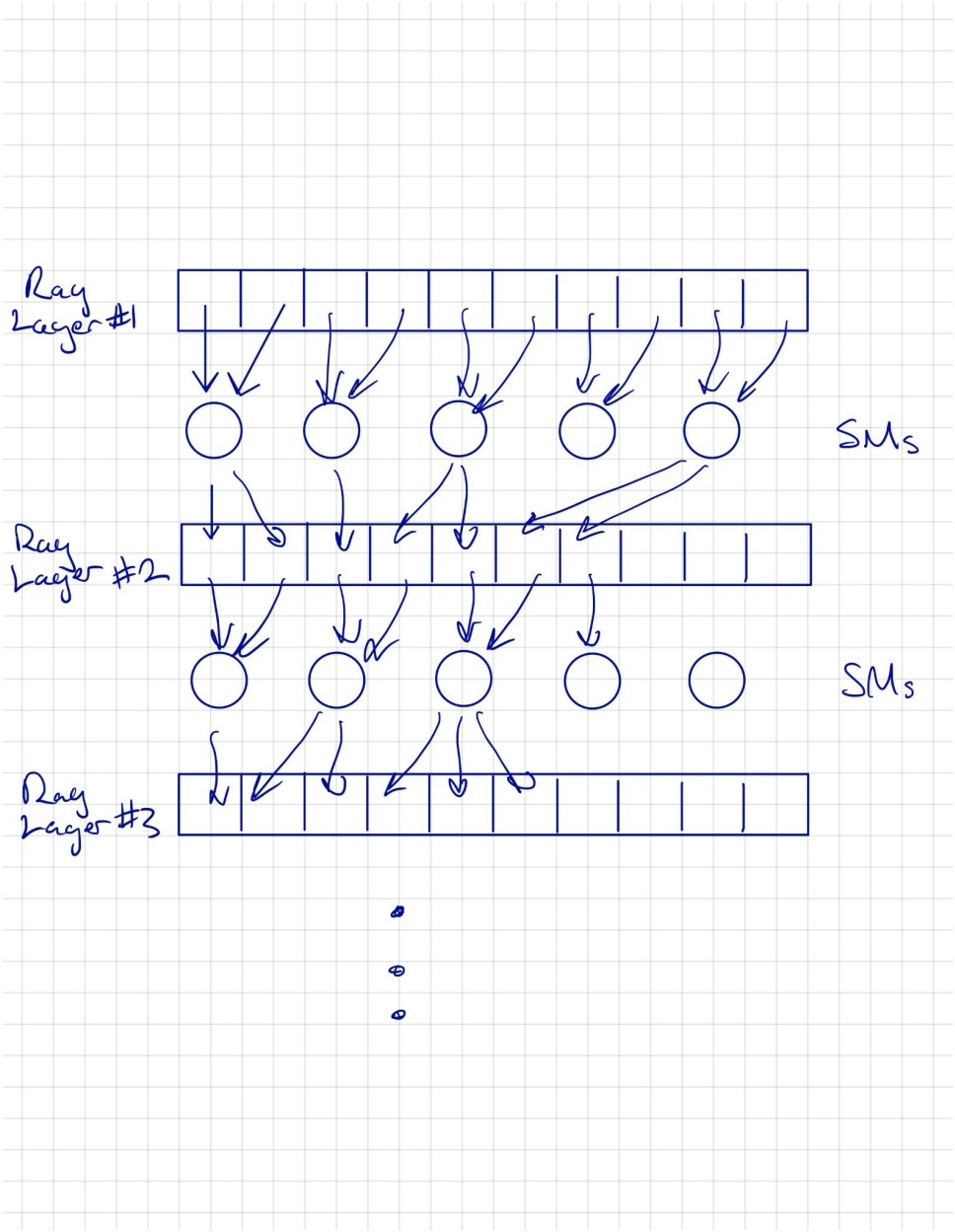

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Parallel Ray Tracing

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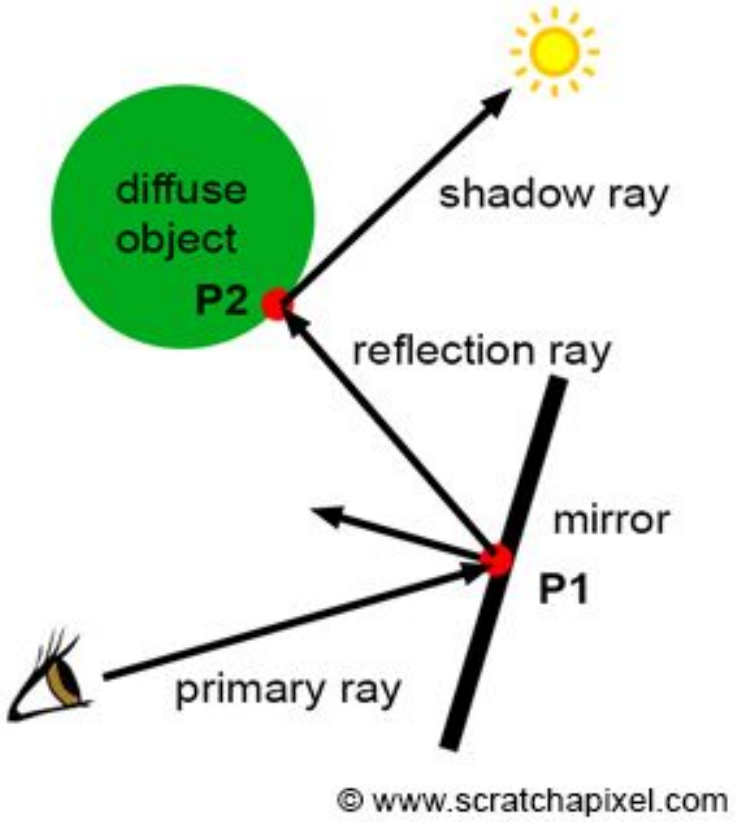

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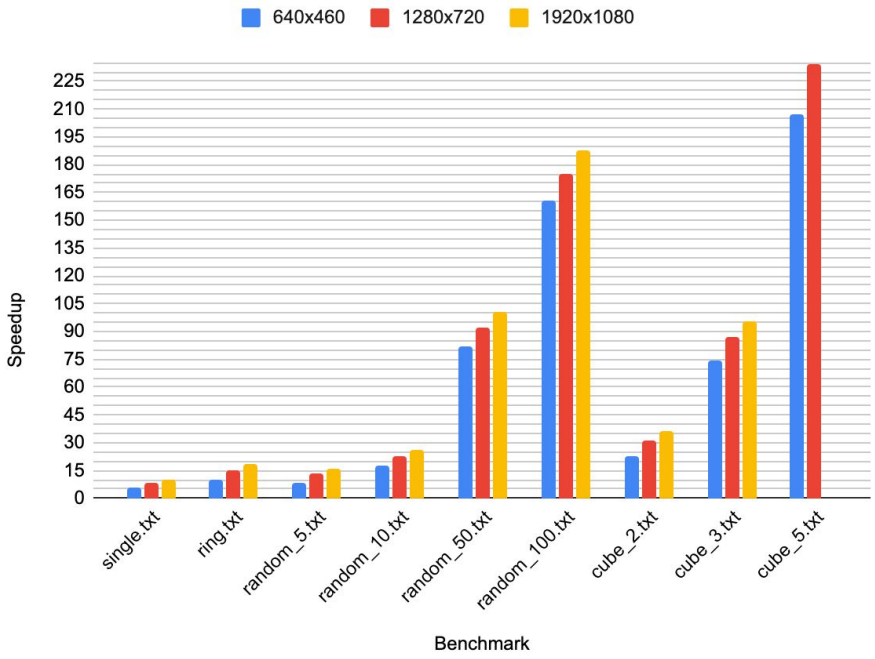
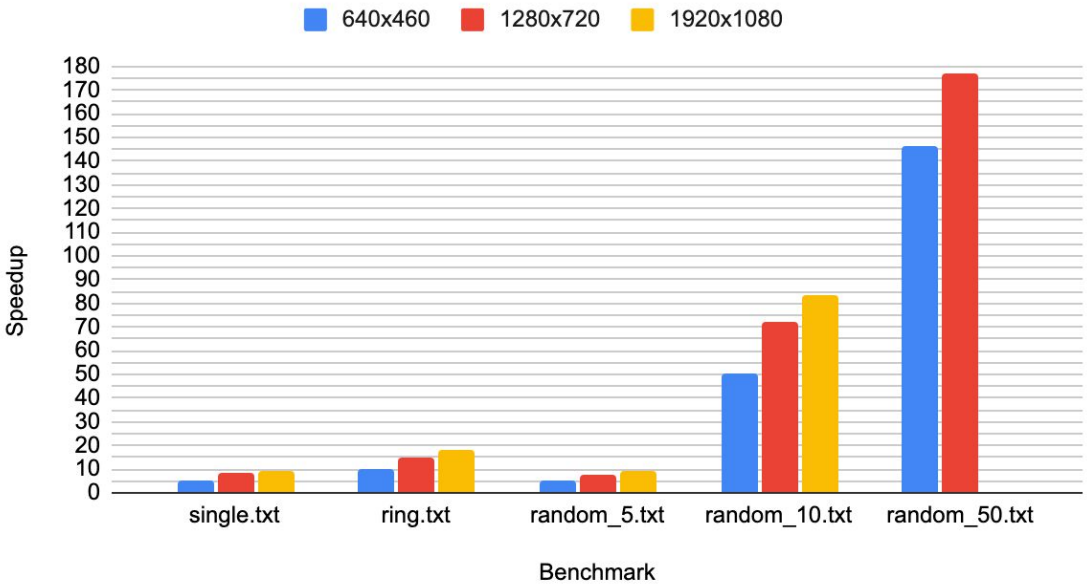
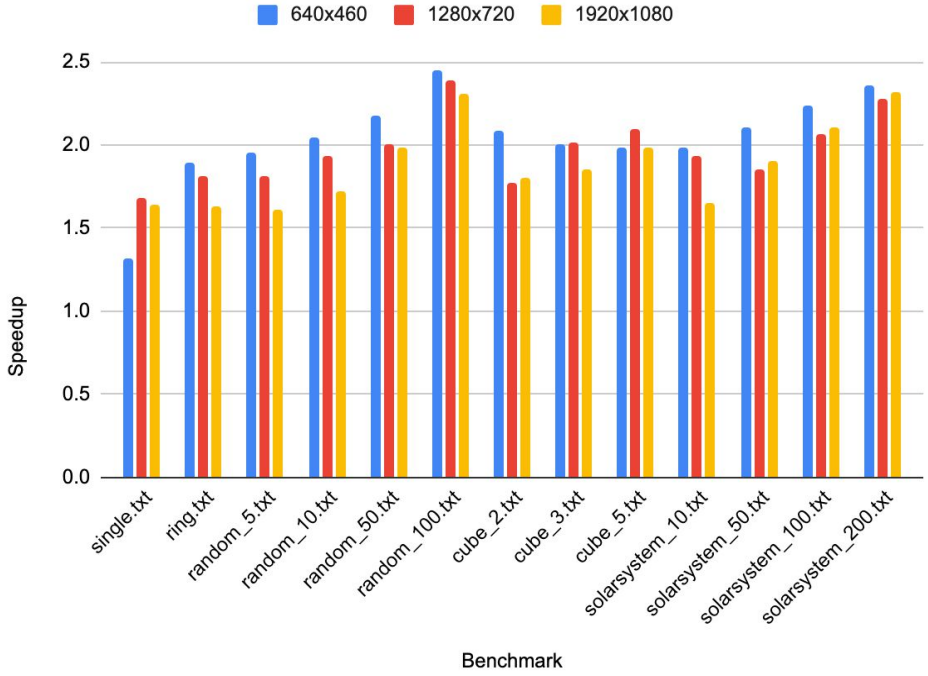
CUDA Naive vs Naive Pan Speedup



CUDA Naive vs Naive Spin Speedup



CUDA Final vs CUDA Naive Pan Speedup



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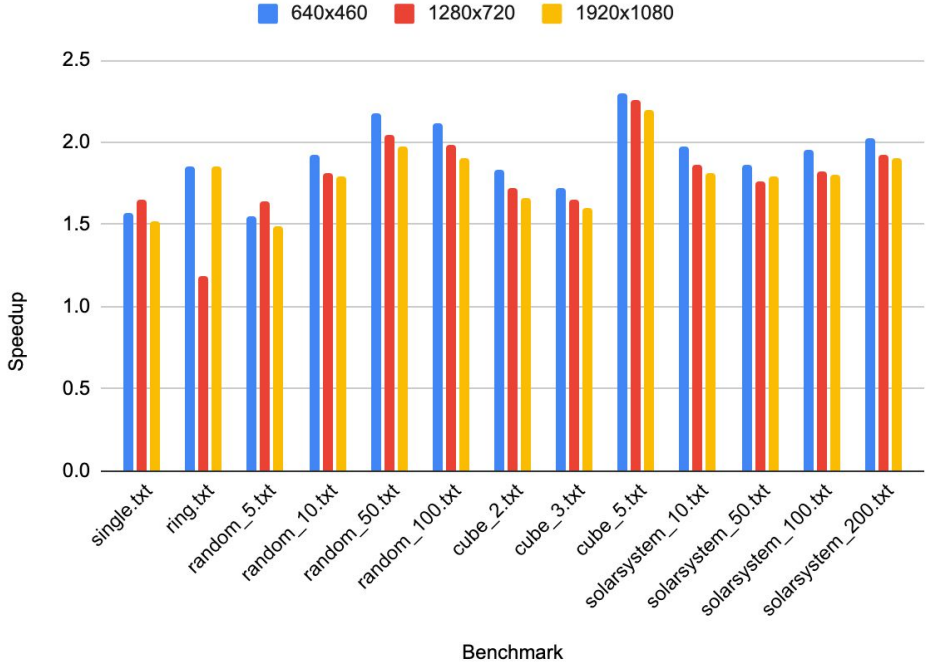

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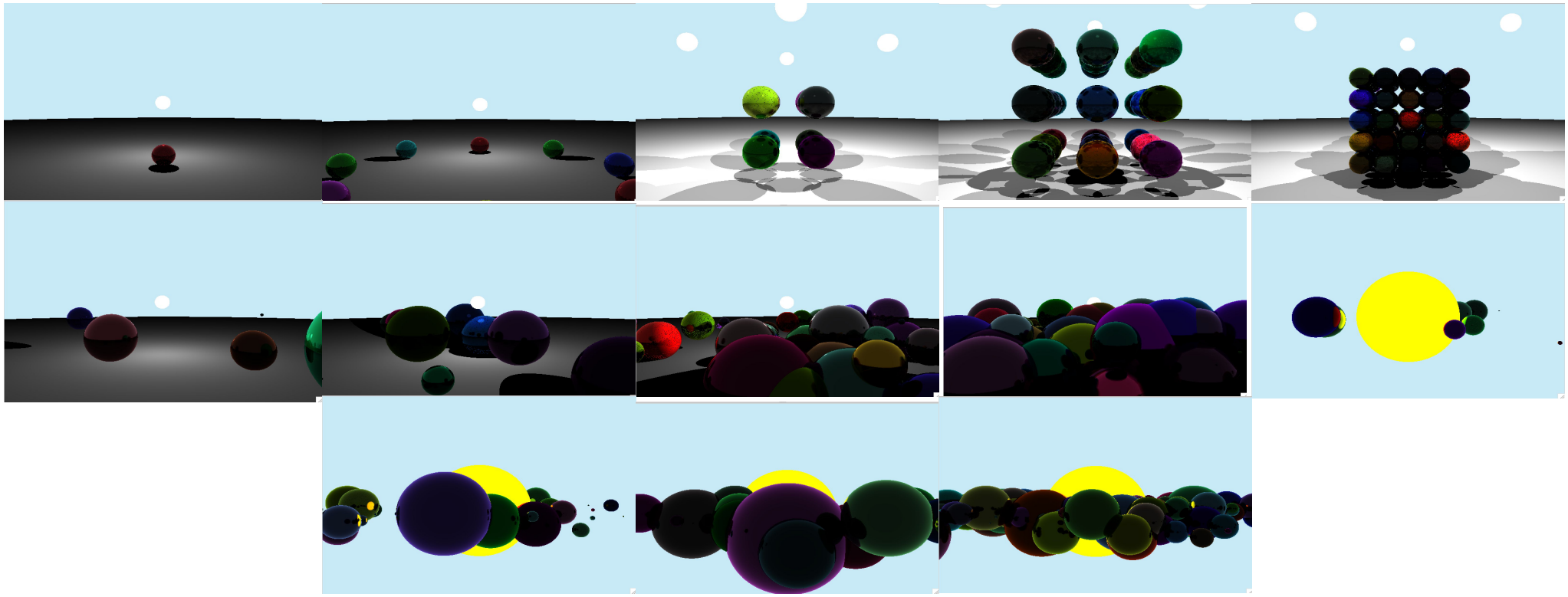

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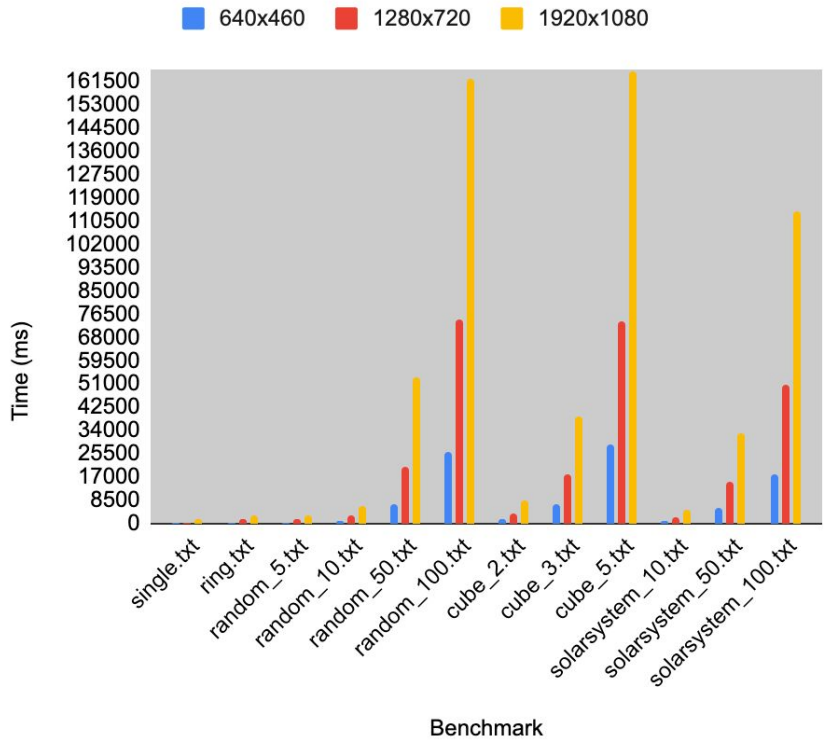

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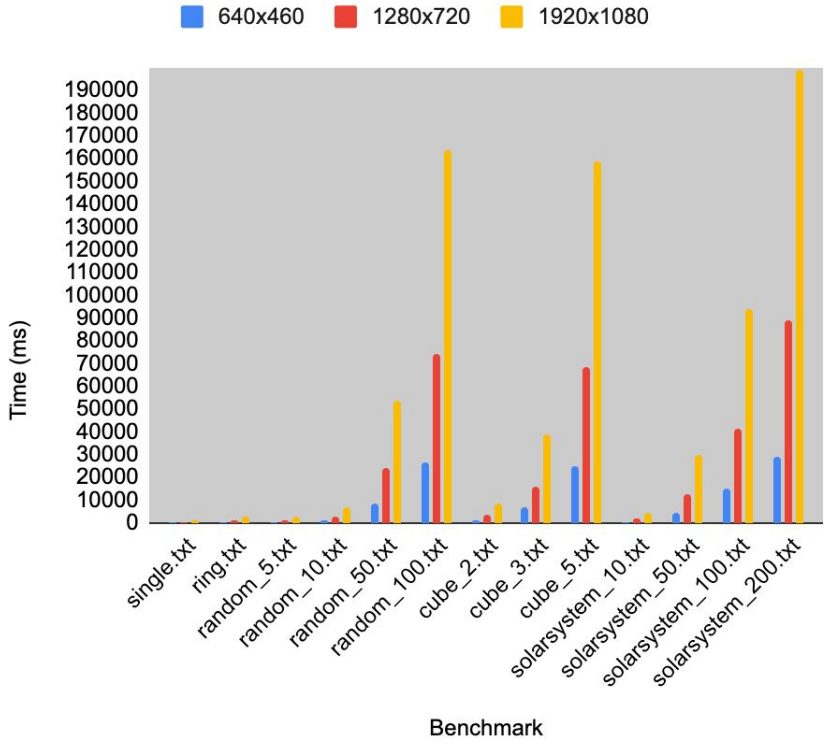
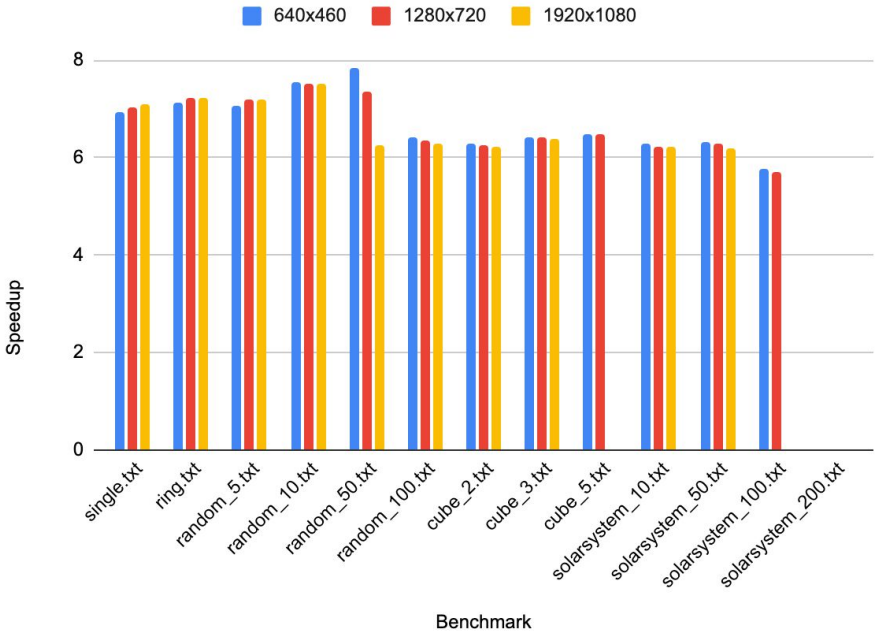


OpenMP Final Pan vs Initial Speedup



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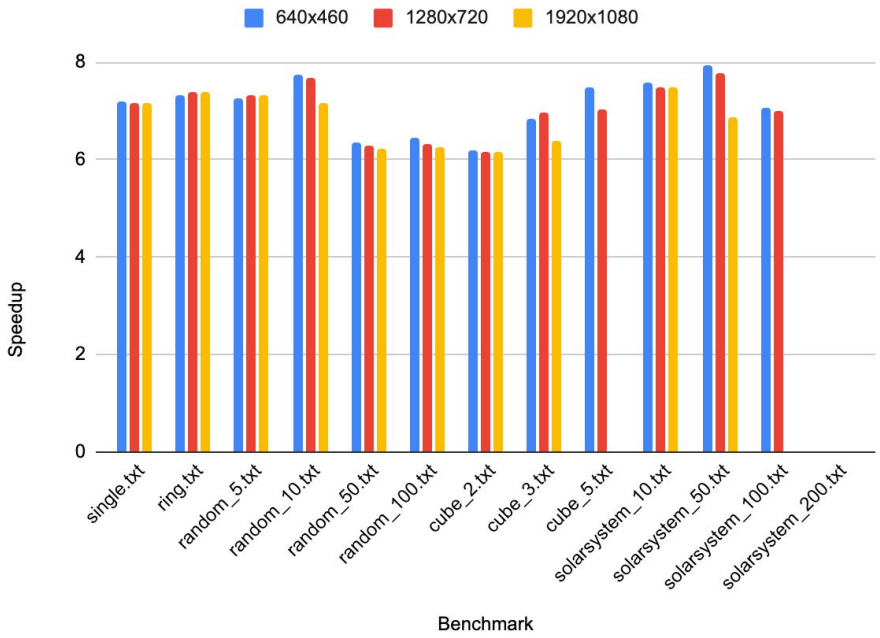

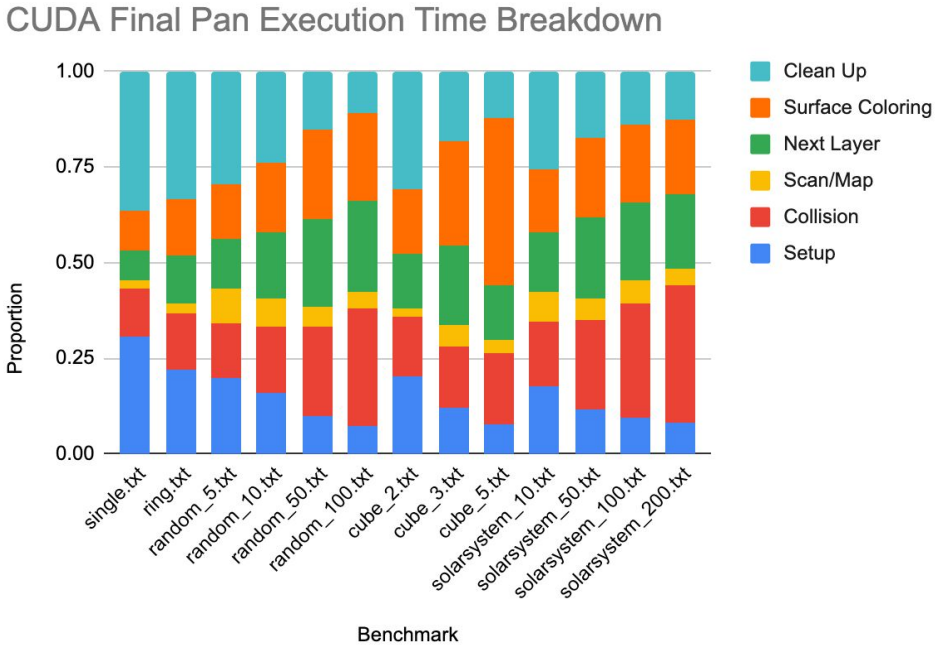

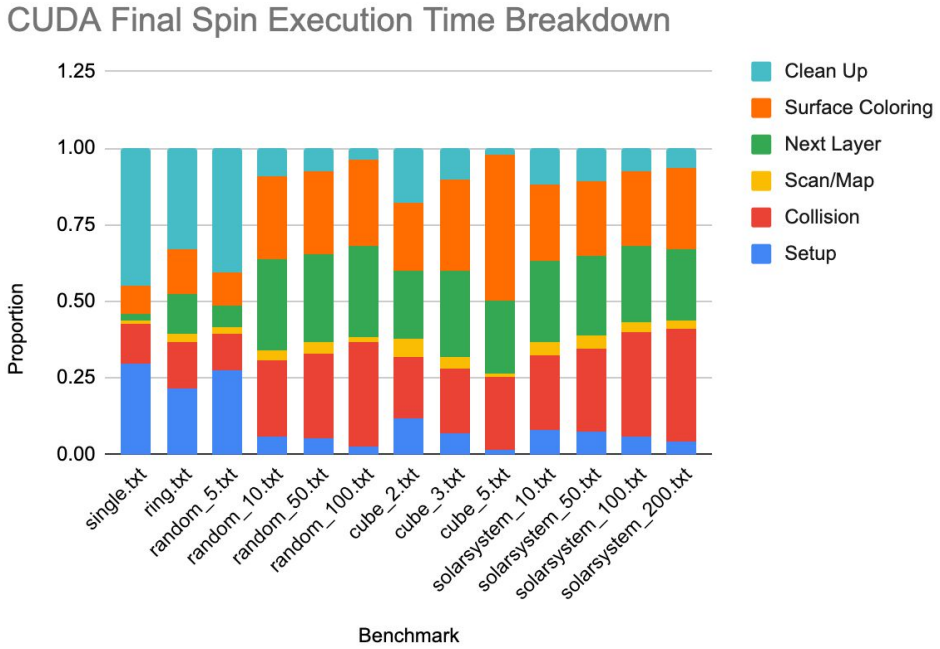

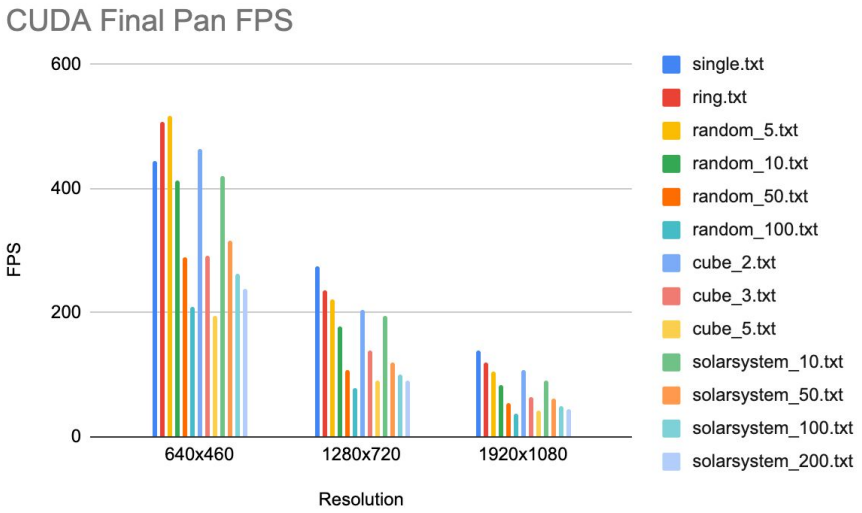

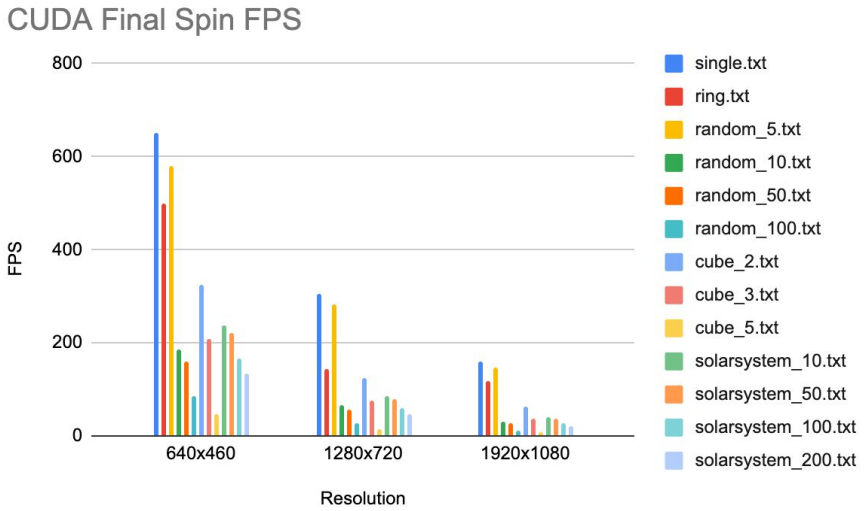

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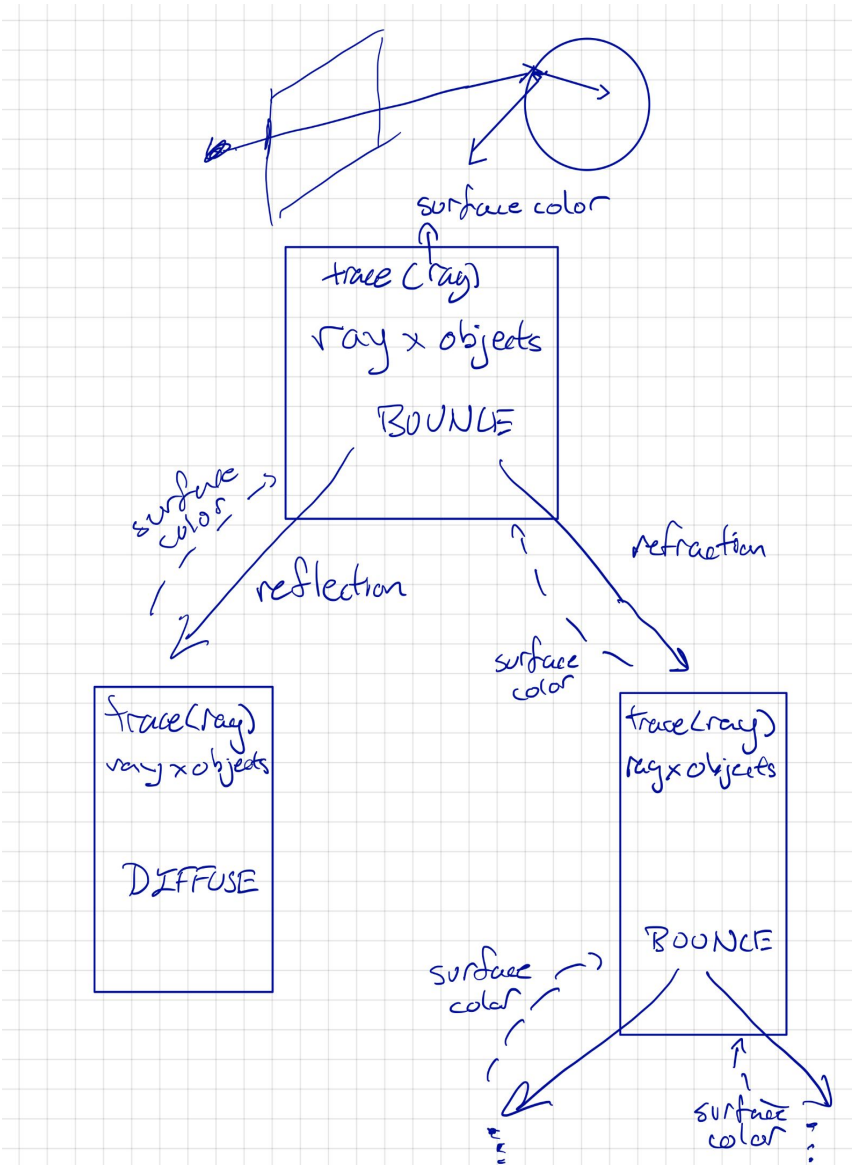

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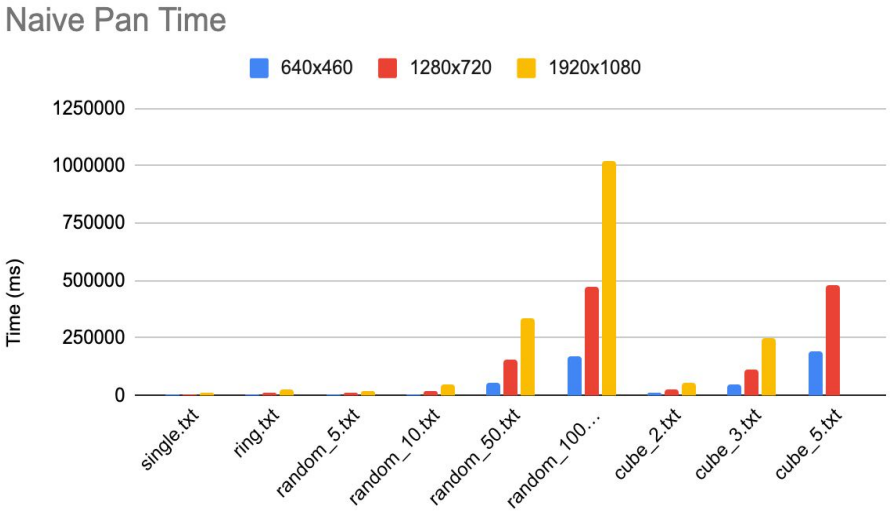

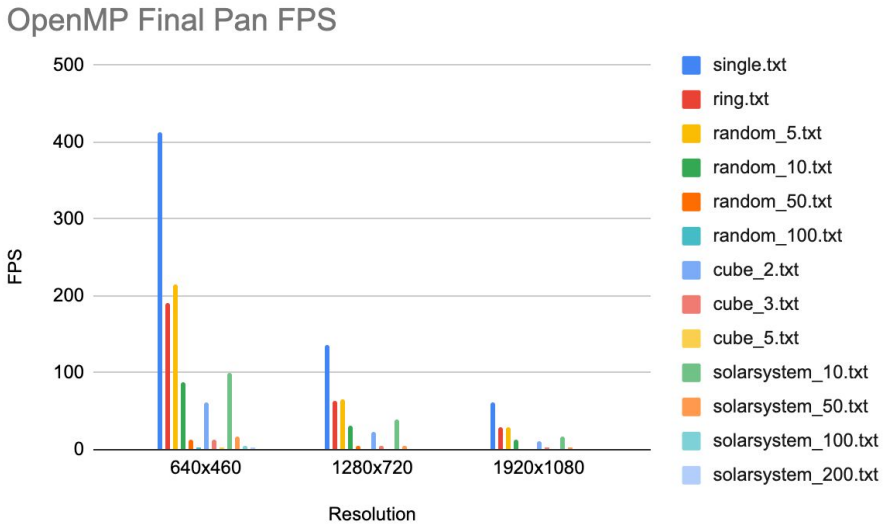

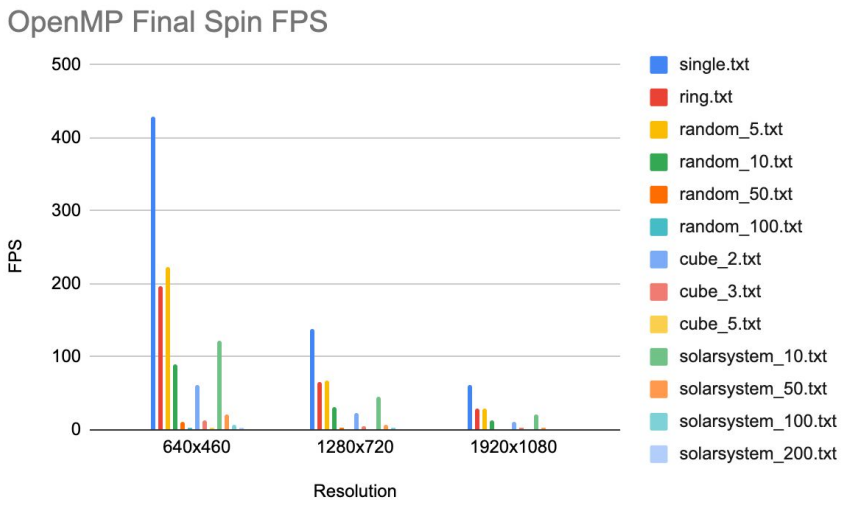

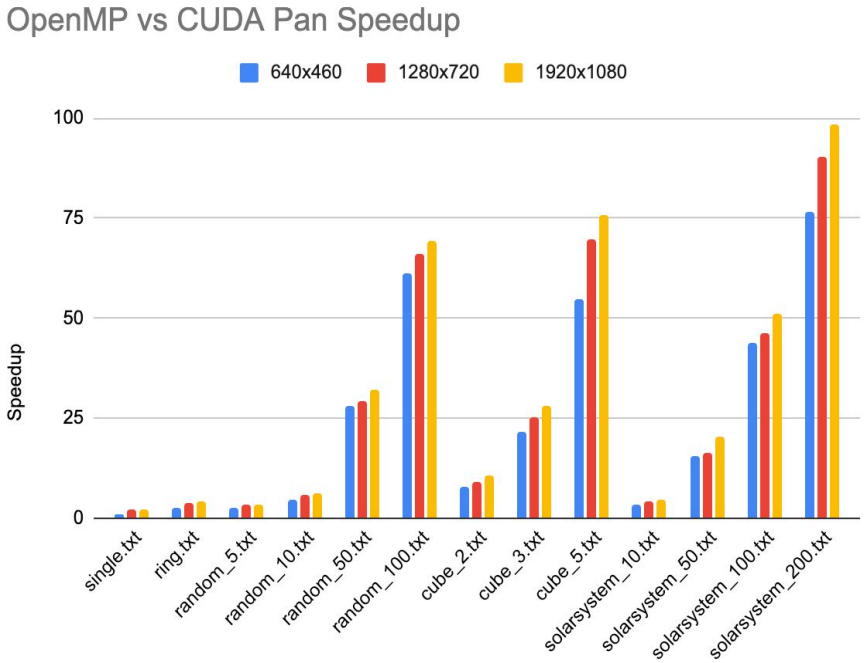

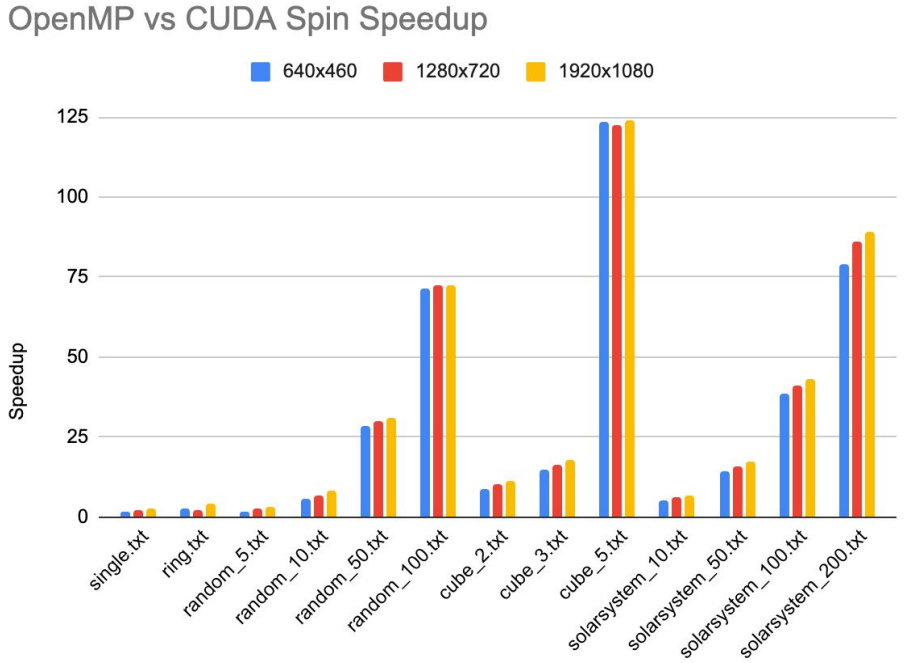

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