Laboratorio 4

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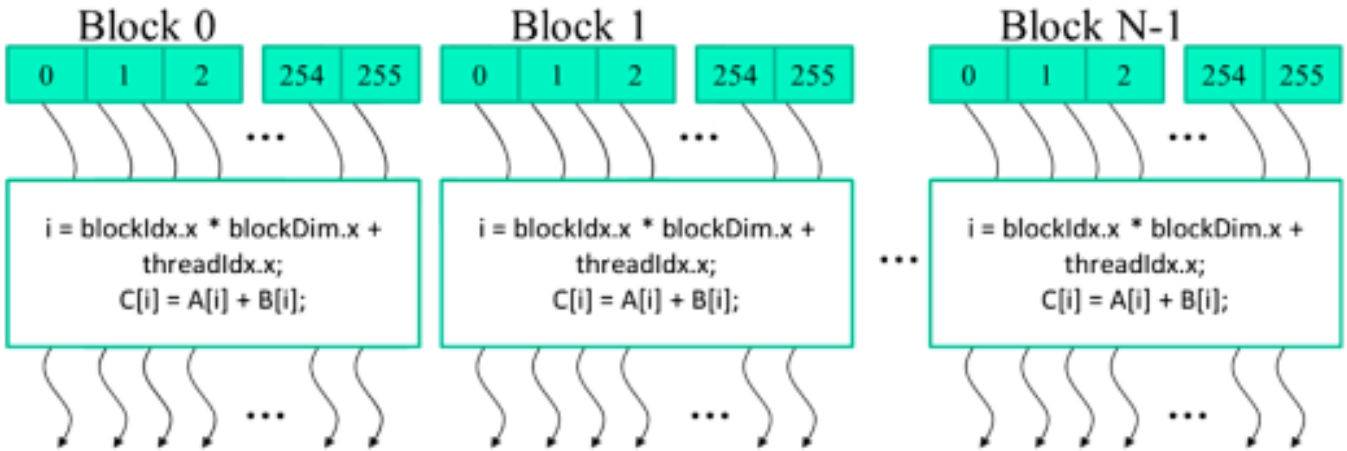
Threads y blocks



Estrategias e implementación

- Un seed por thread
- Un fotón por thread
- heats en unified memory

Estrategias e implementación

```
__global__ void init_curand(curandState* rng_states)
{
    int gtid = blockDim.x * blockIdx.x + threadIdx.x;
    // setup a seed for every thread
    curand_init((unsigned long long)clock(), gtid, 0, &rng_states[gtid]);
}
```

Estrategias e implementación

```
__global__ void photon(float* global_heat, float* global_heat2, curandState* rng_states)
{
    int gtid = blockDim.x * blockIdx.x + threadIdx.x;

    // a photon per thread and if PHOTONS is not a multiple of 32 cape it
    if (gtid <= PHOTONS) {
        curandState thread_rng_state = rng_states[gtid];
```

Estrategias e implementación

```
for (;;) {
    float t = -logf((float)curand_uniform(&thread_rng_state));
    x += t * u;
    y += t * v;
    z += t * w;
```

Estrategias e implementación

```
// atomic add
atomicAdd(&global_heat[shell], (1.0f - albedo) * weight);
atomicAdd(&global_heat2[shell], (1.0f - albedo) * (1.0f - albedo) * weight * weight);
weight *= albedo;
```

Estrategias e implementación

```
do {

    xi1 = 2.0f * curand_uniform(&thread_rng_state) - 1.0f;
    xi2 = 2.0f * curand_uniform(&thread_rng_state) - 1.0f;
    t = xi1 * xi1 + xi2 * xi2;

} while (1.0f < t);
```

Estrategias e implementación

```
if (weight < 0.001f) {
    if ((float)curand_uniform(&thread_rng_state) > 0.1f) {
        break;
    }
```

Optimización al kernel

- Arrays heat de memoria __shared__

Optimización al kernel

```
int gtid = blockDim.x * blockIdx.x + threadIdx.x;
int tid = threadIdx.x;

__shared__ float heat_block[SHELLS];
__shared__ float heat2_blocks[SHELLS];

if (tid == 0) {
    for (unsigned int i = 0; i < SHELLS; ++i) {
        heat_block[i] = 0;
        heat2_blocks[i] = 0;
    }
}
```

Optimización al kernel

```
// atomic add
atomicAdd(&heat_block[shell], (1.0f - albedo) * weight);
atomicAdd(&heat2_blocks[shell], (1.0f - albedo) * (1.0f - albedo) * weight * weight);
weight *= albedo;
```

Optimización al kernel

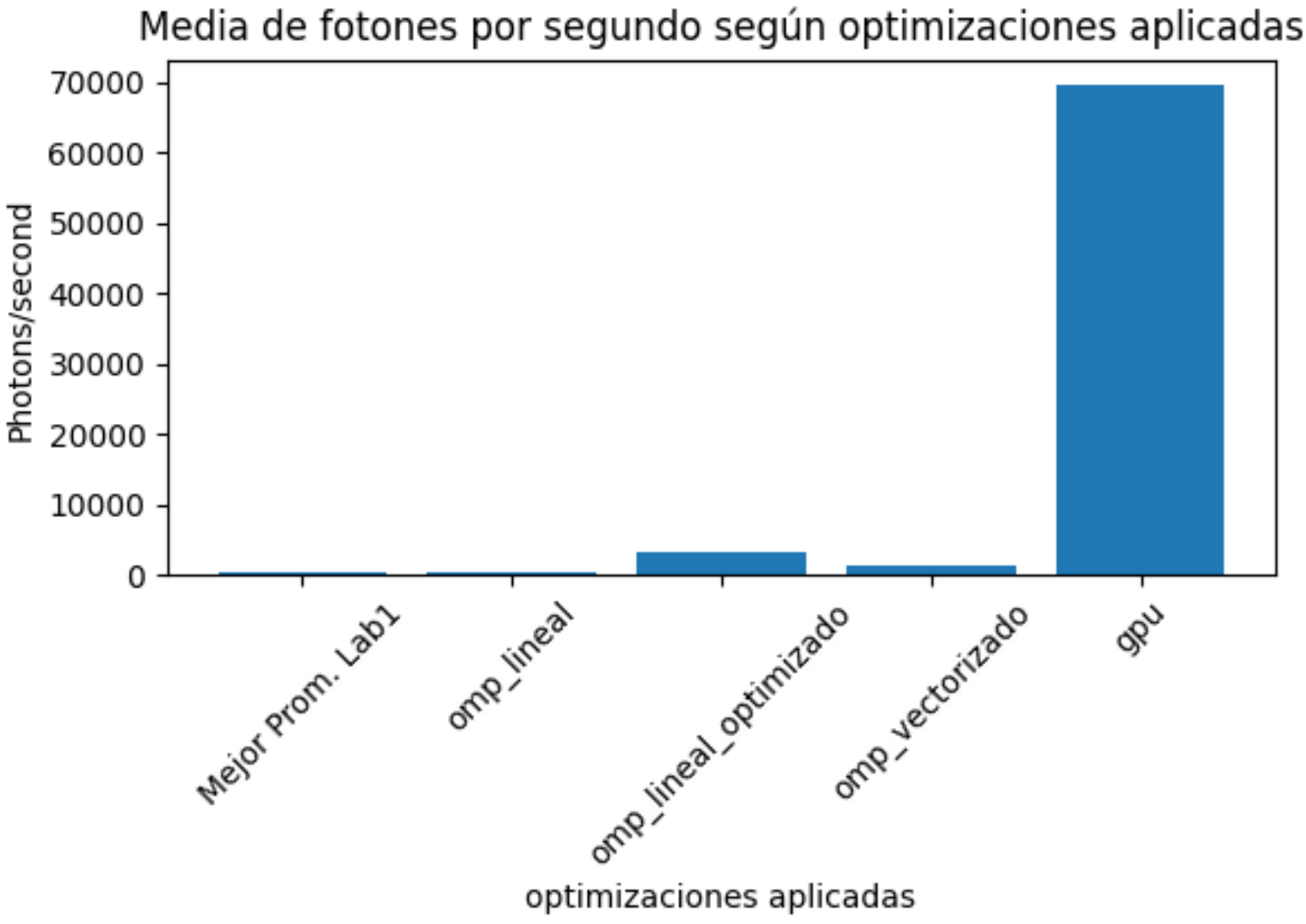
```
__syncthreads();

if (tid == 0) {
    for (unsigned int i = 0; i < SHELLS; ++i) {
        atomicAdd(&global_heat[i], heat_block[i]);
        atomicAdd(&global_heat2[i], heat2_blocks[i]);
    }
}
```

Optimización al kernel

```
double block_count = (PHOTONS + BLOCK_SIZE - 1) / BLOCK_SIZE;
unsigned int total_num_threads = block_count * BLOCK_SIZE;
```

Comparación con el resto de los labs



Roofline

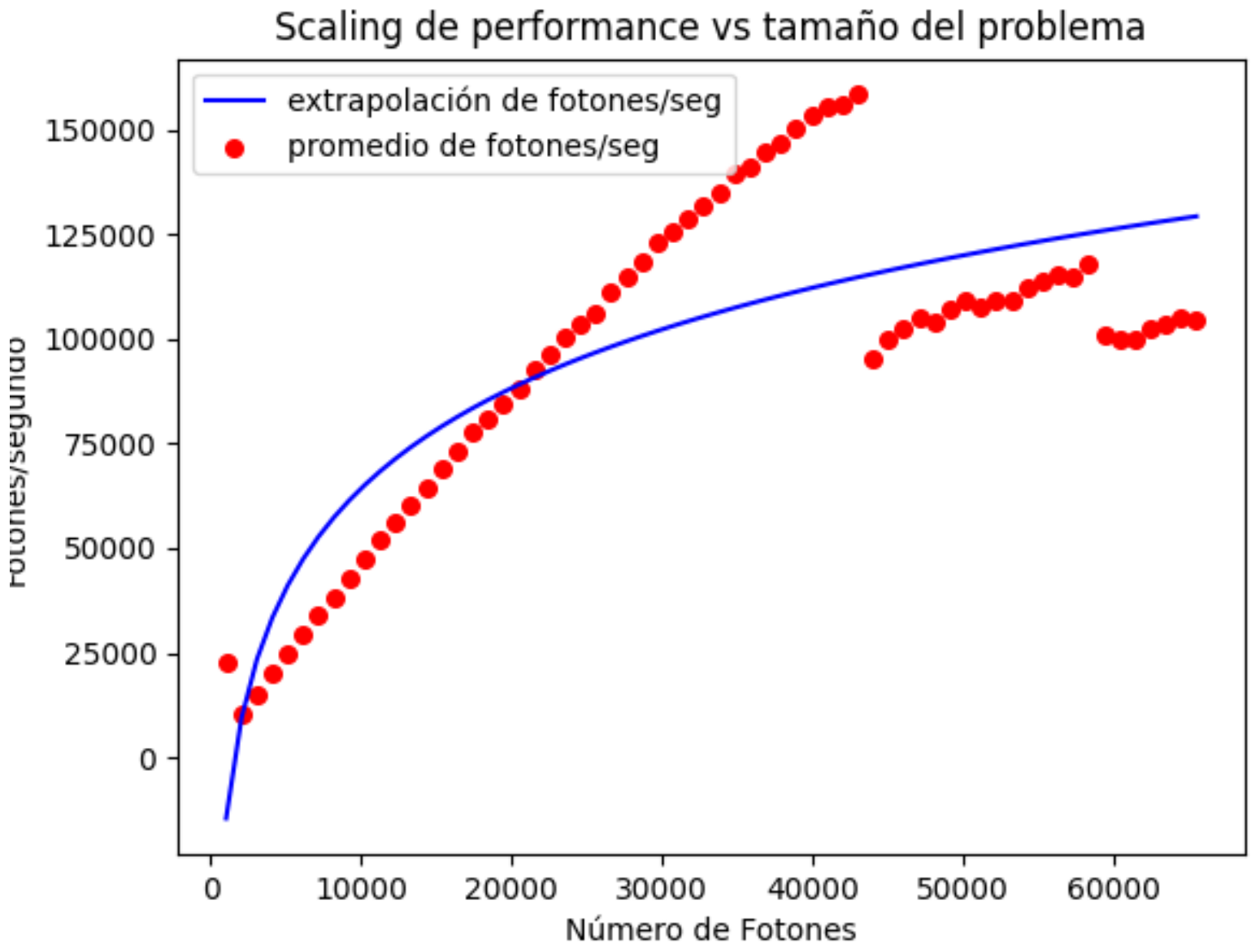
/opt/cuda/11.2.2/bin/ncu ./tinymcgpu

```
Section: Occupancy
------------------------------------------------------------------------------ --------------- ------------------------------
Block Limit SM                                                                        block                             16
Block Limit Registers                                                                 block                             10
Block Limit Shared Mem                                                                block                             53
Block Limit Warps                                                                     block                             12
Theoretical Active Warps per SM                                                        warp                             40
Theoretical Occupancy                                                                     %                          83.33
Achieved Occupancy                                                                        %                          14.77
Achieved Active Warps Per SM                                                           warp                           7.09
------------------------------------------------------------------------------ --------------- ------------------------------
```

Teórico: 83.33

Logrado: 14.77

Scaling


Scaling de performance vs tamaño del problema
extrapolación de fotones/seg
promedio de fotones/seg
150000
125000
100000
75000
50000
25000
0
0
10000
20000
30000
40000
50000
60000
Número de Fotones

Posibles mejoras

- Uso de arrays a nivel de warp
- Escalar el problema