QGRAPHICS: QUANTUM SEARCHING FOR RAY TRIANGLE INTERSECTION

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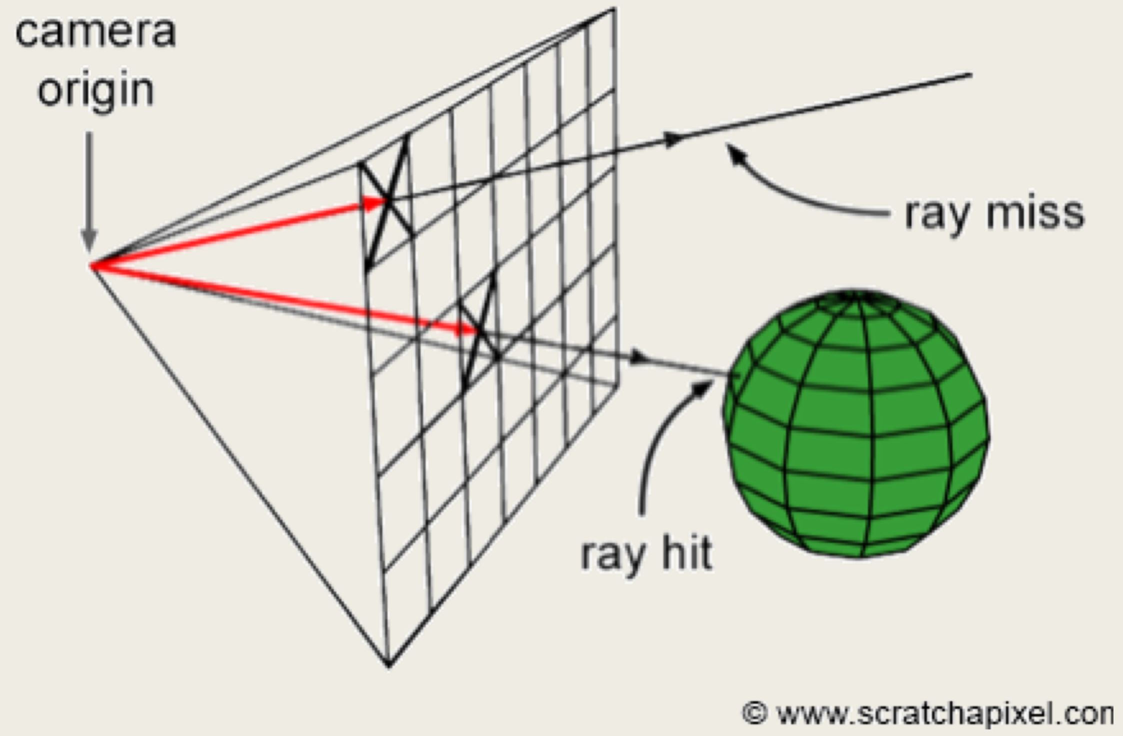
Ray Tracing

- Calculates the color of pixels by tracing the path that light would take through a virtual 3D scene which is described by a collection of geometric primitives (e.g., triangles).

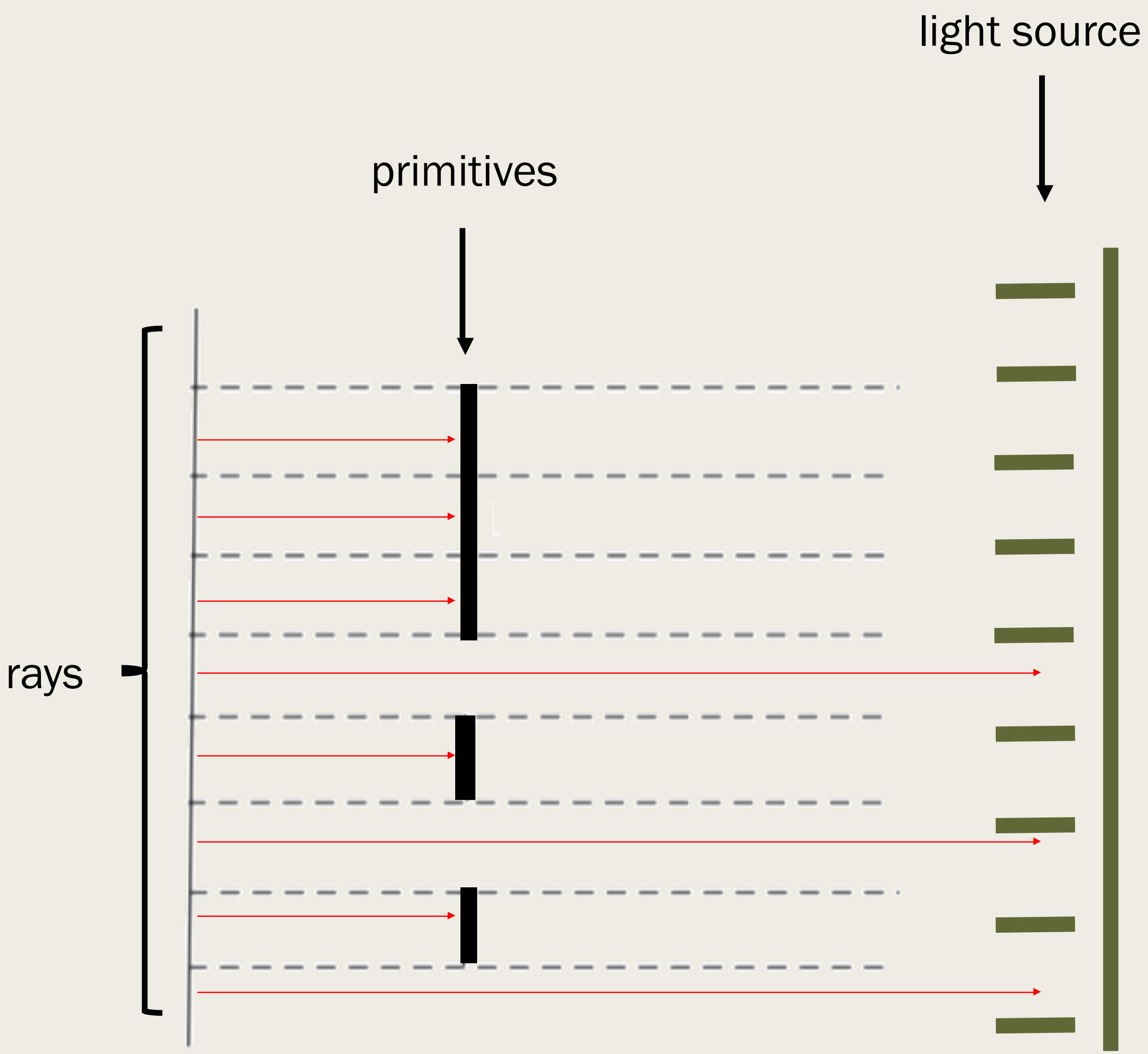
- The algorithm returns, for a given ray, which triangle it intersects closer to its origin.



The problem

- **Determine which rays intersect a geometric primitive.**

- For simplification the primitives will be 1D and perpendicular to the rays.
- A higher dimensional approach would require a large number of qubits/gates because of the great amount of calculations needed.



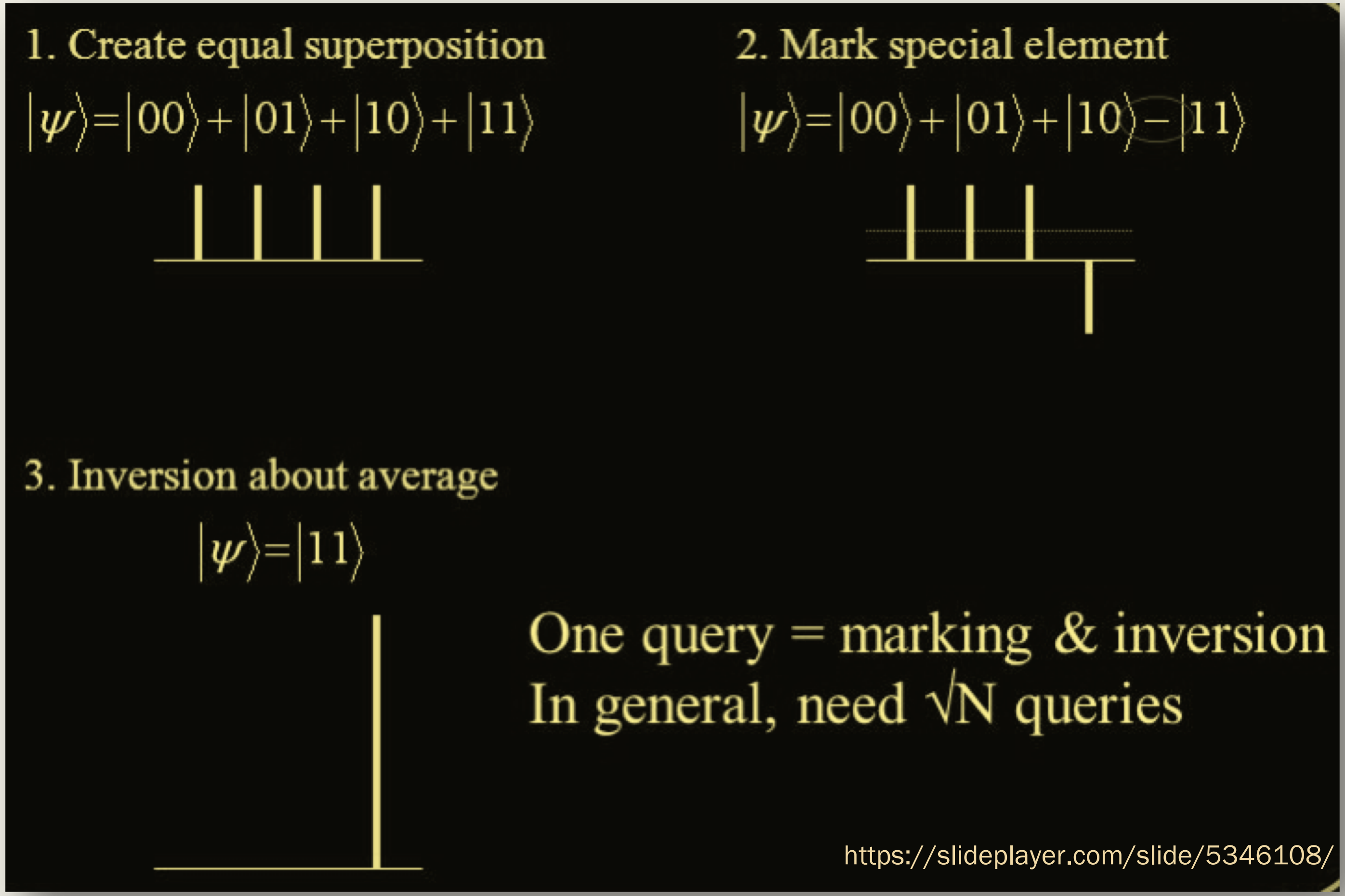
Classical Algorithm

```
for each ray{
        intersect with primitives{
                if intersect continue to next ray;
        }
}
```

- Complexity: O(R*P)
- Note: The primitives can be ordered, resulting in a O(R*log(P)) complexity although it requires a setup time and more memory.

Can we gain in complexity with a quantum strategy?

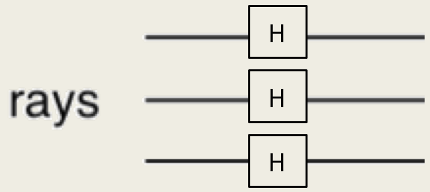
- Finding an intersection is a search algorithm so we'll use Grover's Algorithm in our problem.



Two Approaches

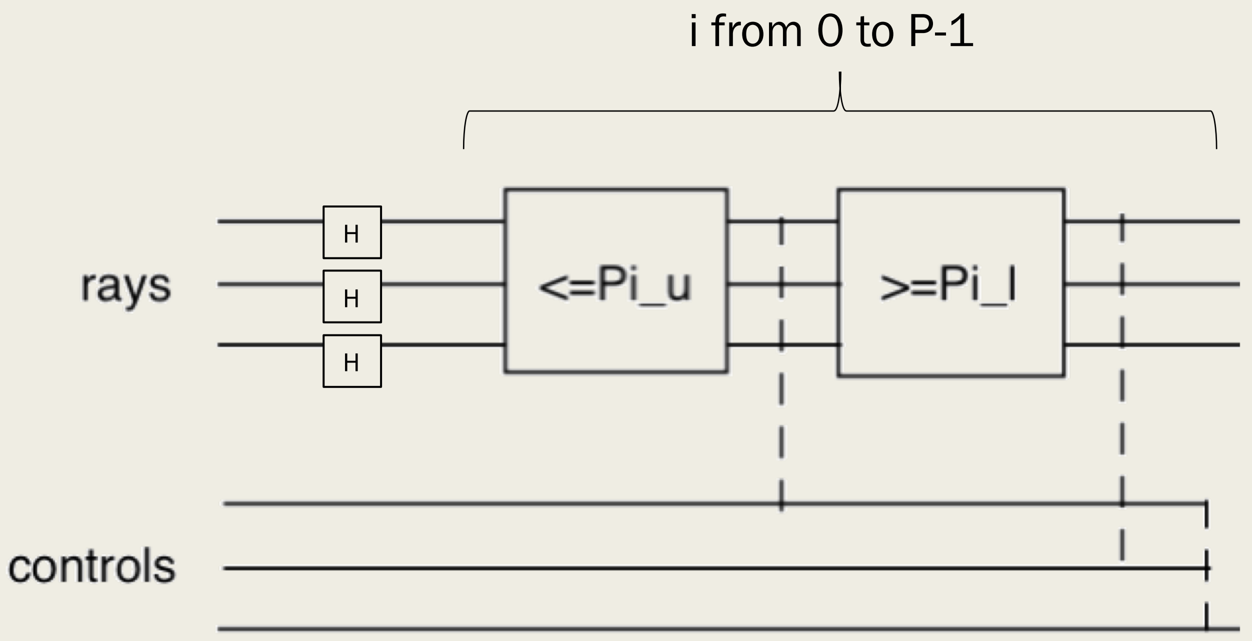
- *Superposition of the rays*
- *Superposition of the primitives*

Superposition of the rays

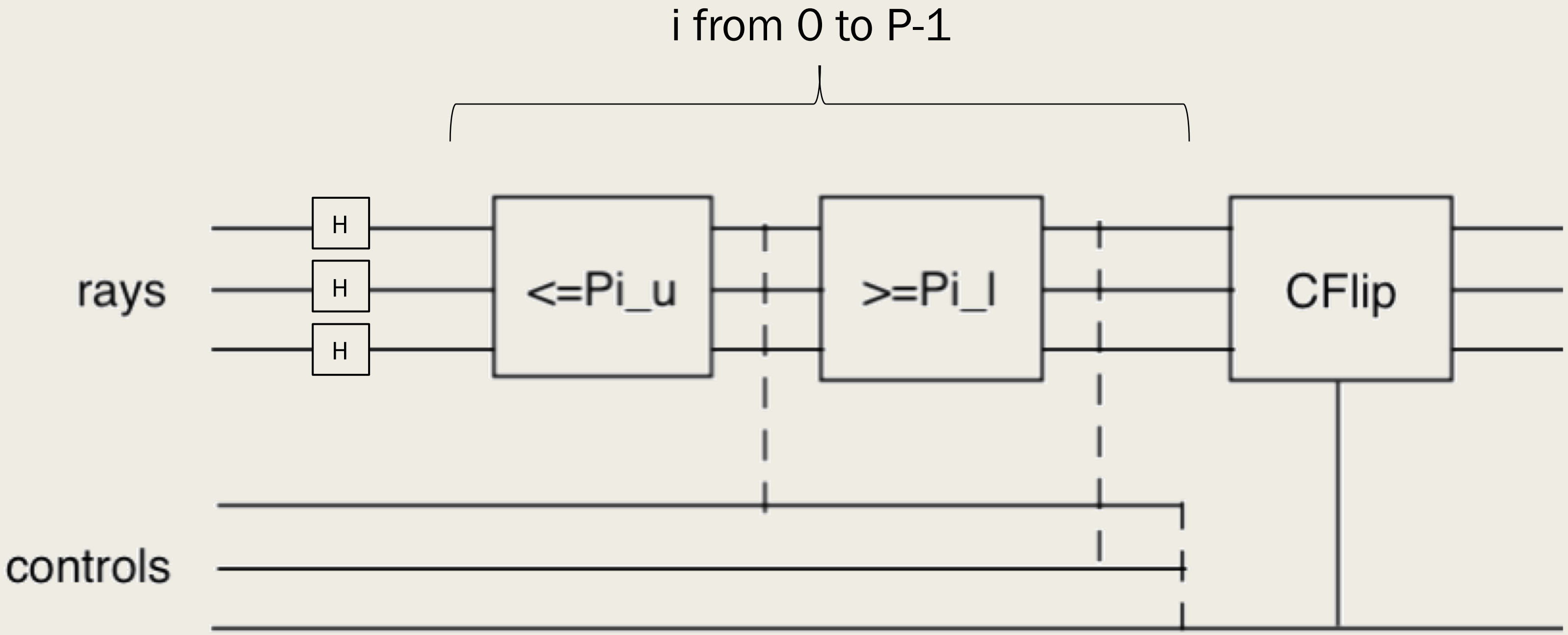



```
geom = [(1,3),(5,7),(9,11),(14,15)]
```

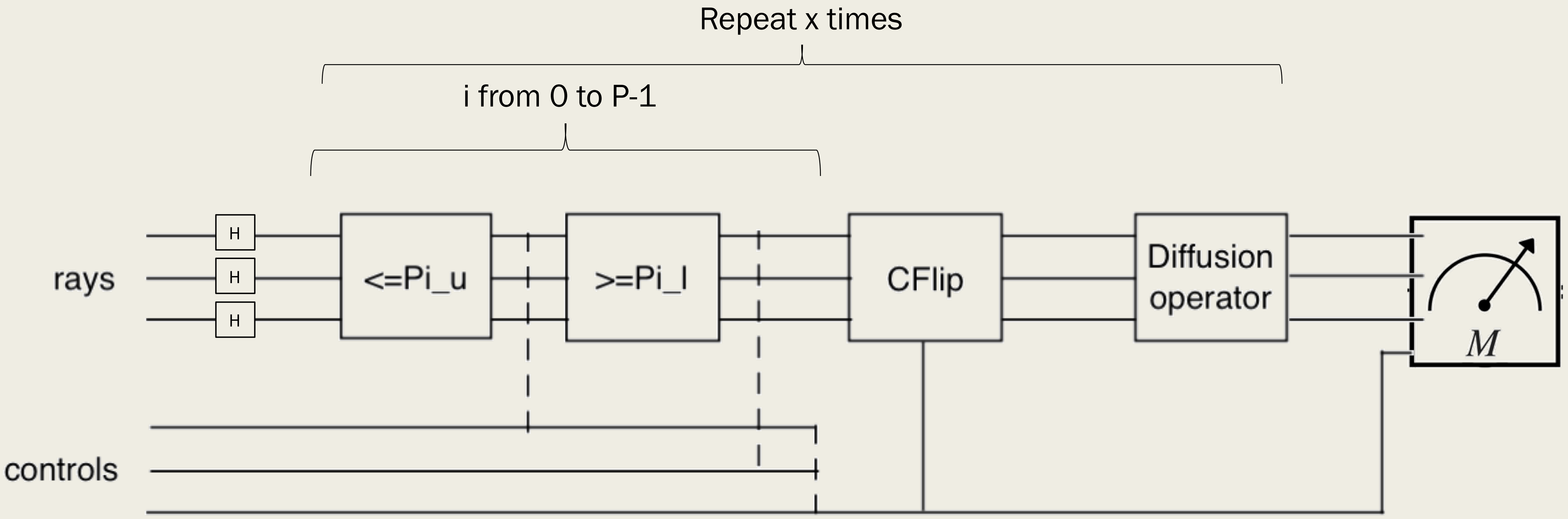
Superposition of the rays



Superposition of the rays



Superposition of the rays

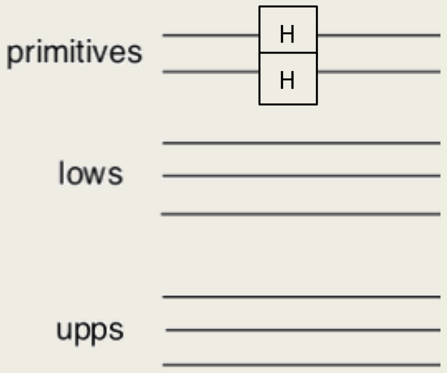


Superposition of the rays

- If we measure the control bit as 1 it is necessary to repeat the circuit without that ray from the superposition so we don't measure it again.

- Complexity: $O\left(\mathrm{R} * \sqrt{\frac{R}{\#sols}}\right)$

Superposition of the primitives




```
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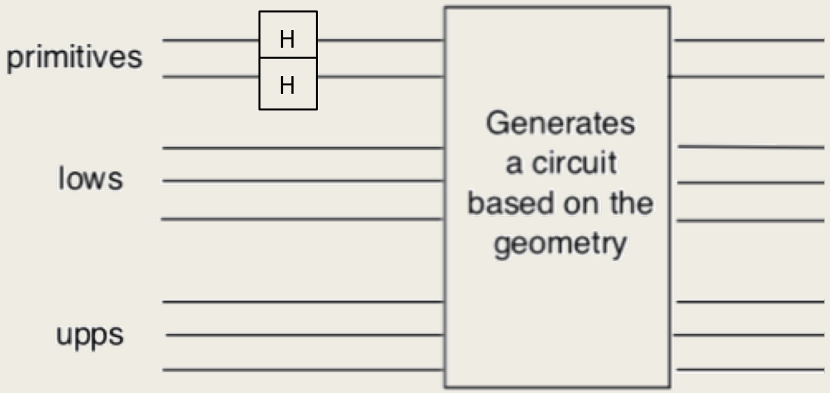
Superposition of the primitives

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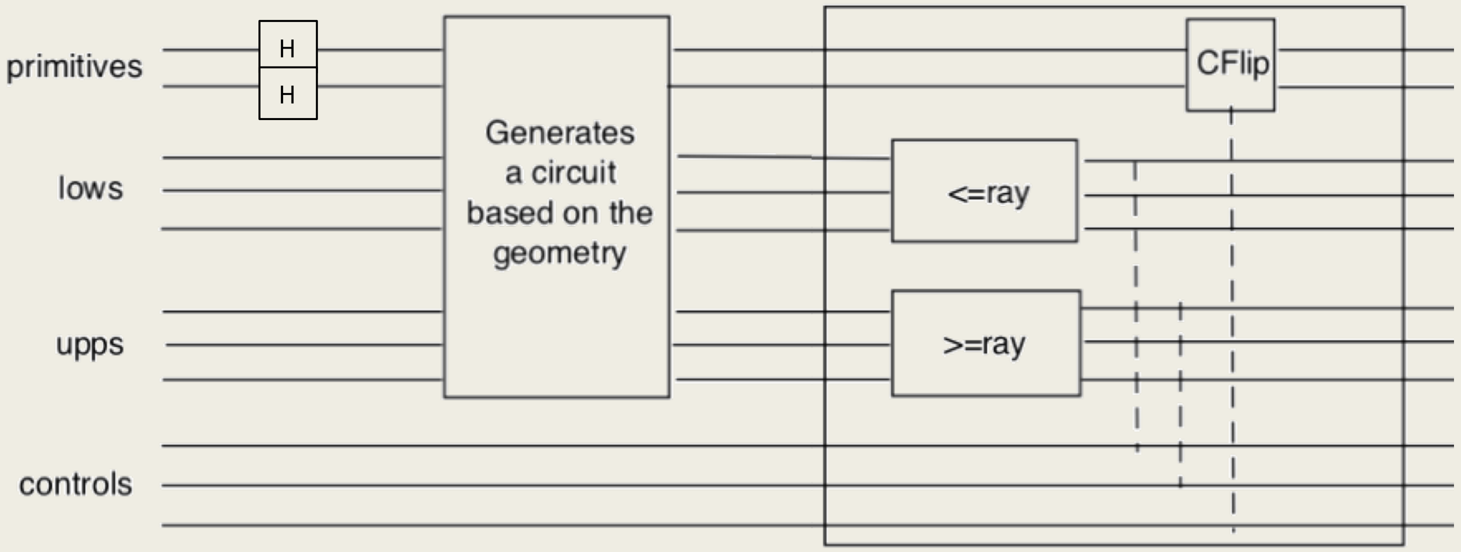
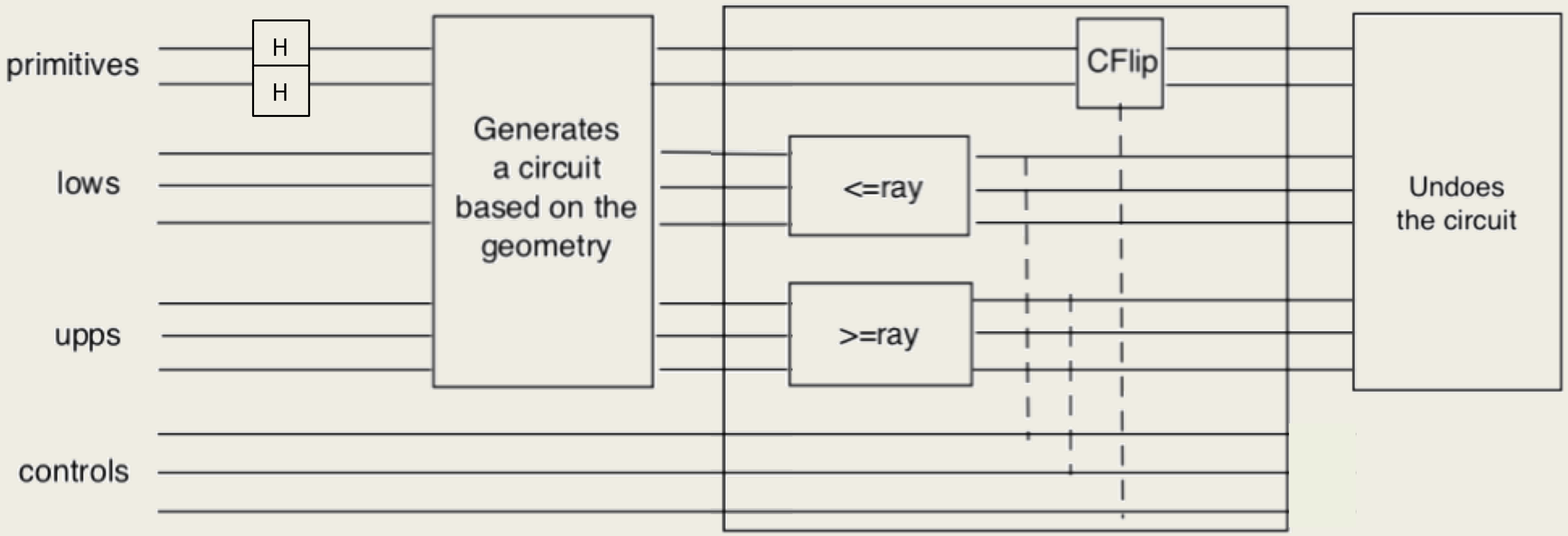
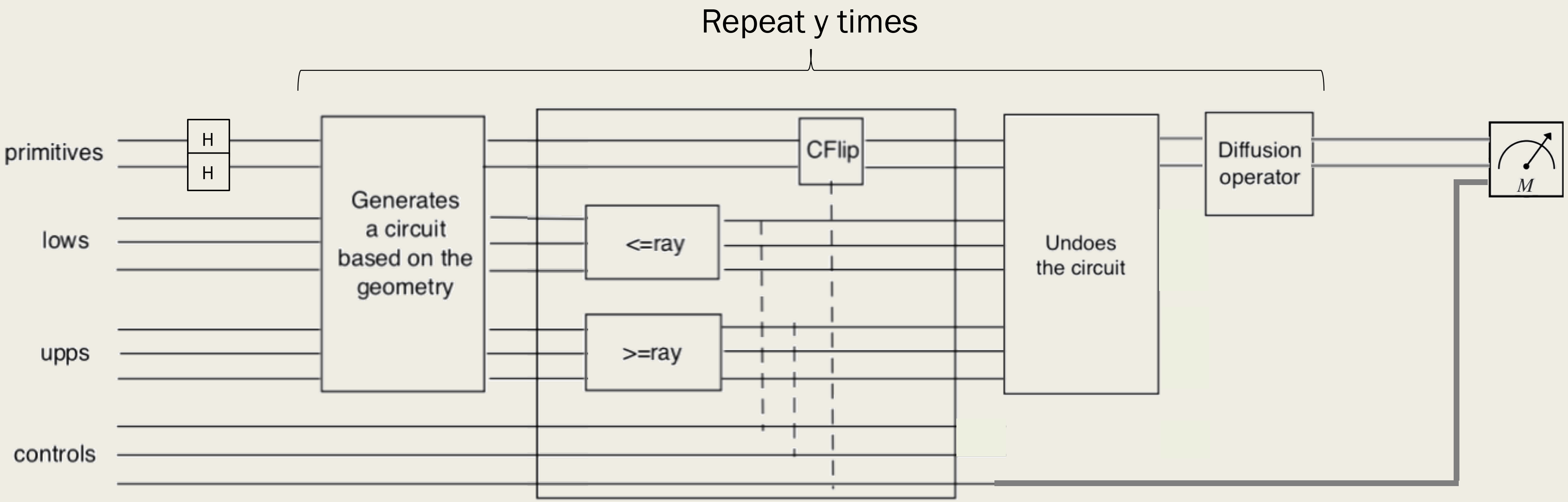
Superposition of the primitives



Superposition of the primitives



Superposition of the primitives



Superposition of the primitives

- Number of solutions: 0 or 1
- Complexity: $O(R*\sqrt{P})$
- Quadratic gain over the classical algorithm

Comparison

S. RAYS

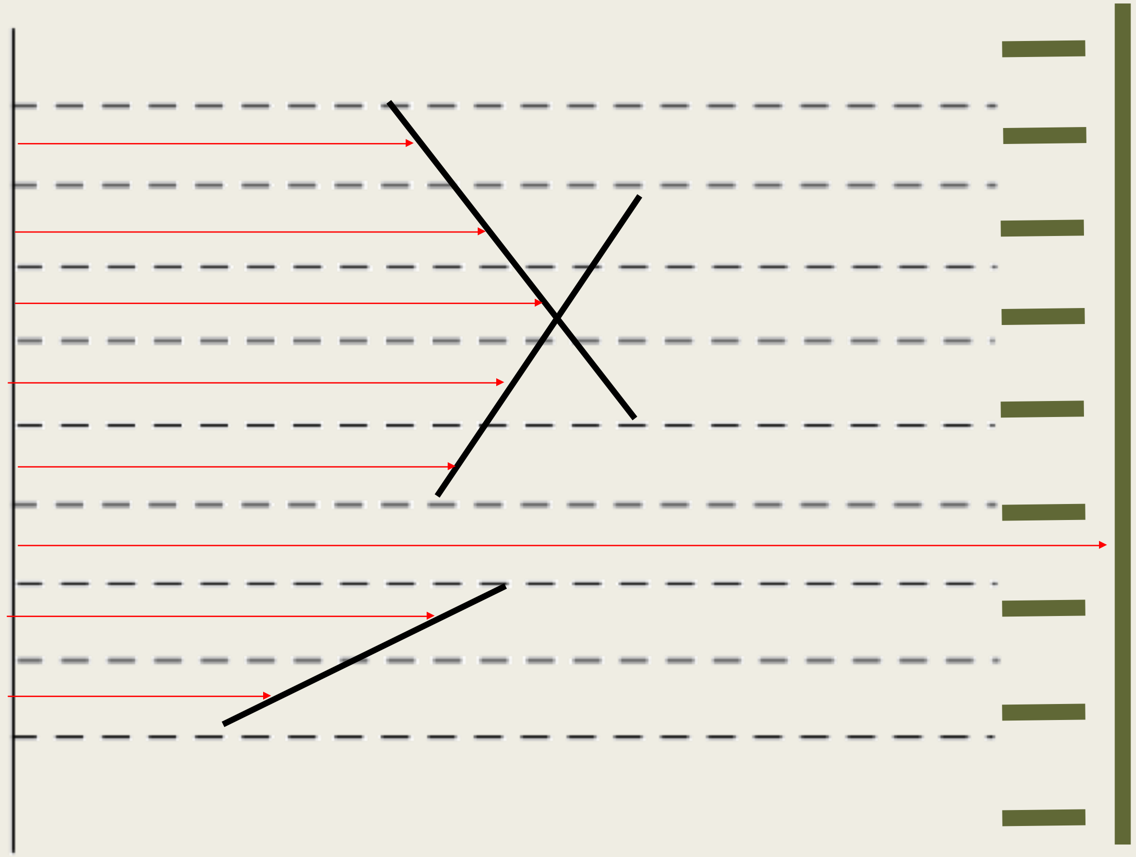
- Multiple solutions
- $O\left(R * \sqrt{\frac{R}{\#sols}}\right)$

S. PRIMITIVES

- Only 1 solution (or 0)
- $O(R*\sqrt{P})$

Future Work

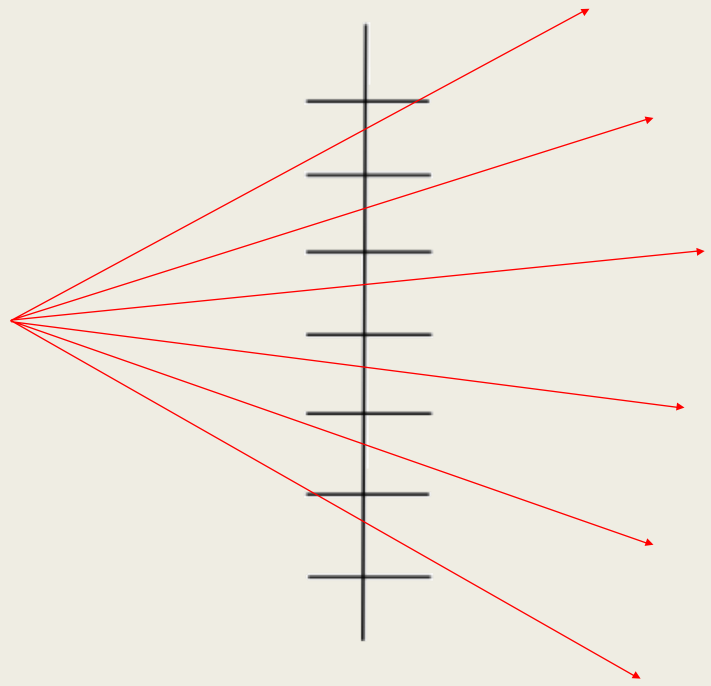
- Expand the geometric configuration:
  - *Rays on a plane*
  - *More complex primitives (2D primitives, inclined or intersecting primitives)*



Future Work

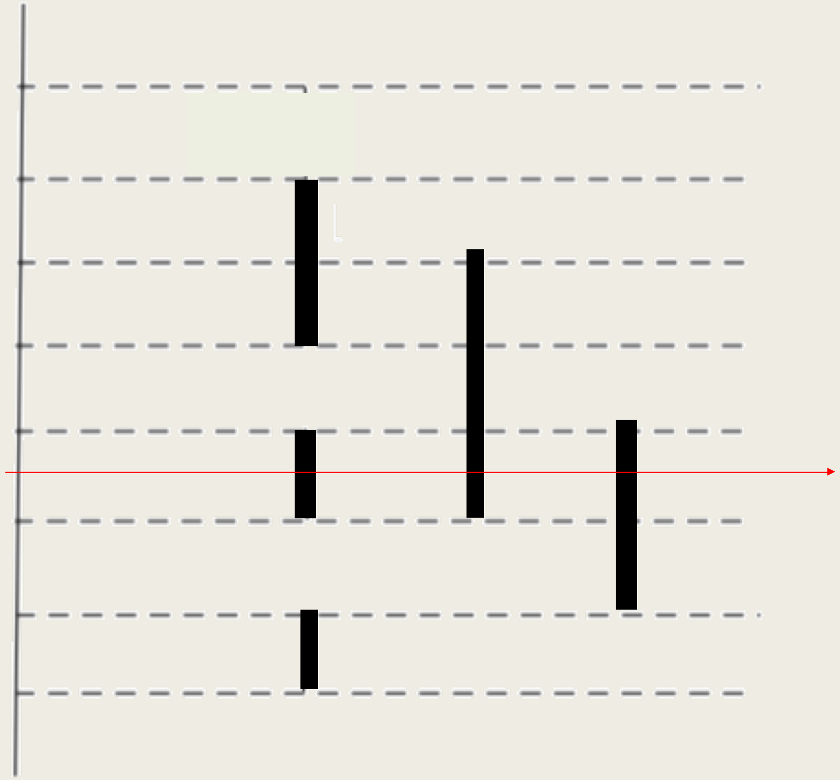
- Expand the geometric configuration:
  - *Rays on a plane*
  - *More complex primitives (2D primitives, inclined or intersecting primitives)*
  - *Non-parallel rays*

Depends on the capacity of the quantum machine to perform calculations.



Future Work

- Change the problem to:
  - *For each ray, what is the geometric primitive closest to the origin of the ray?*



- Error tolerance – real machine:
  - *Quantum error correction*

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