Universität Hamburg
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MIN Faculty
Department of Informatics

Topology-Aware Routing of Electric Wires in FDM-Printed Objects

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TAMS

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Contents

Mission Statement

Full integration of electronic components and circuits into plastic objects in a single additive manufacturing process.

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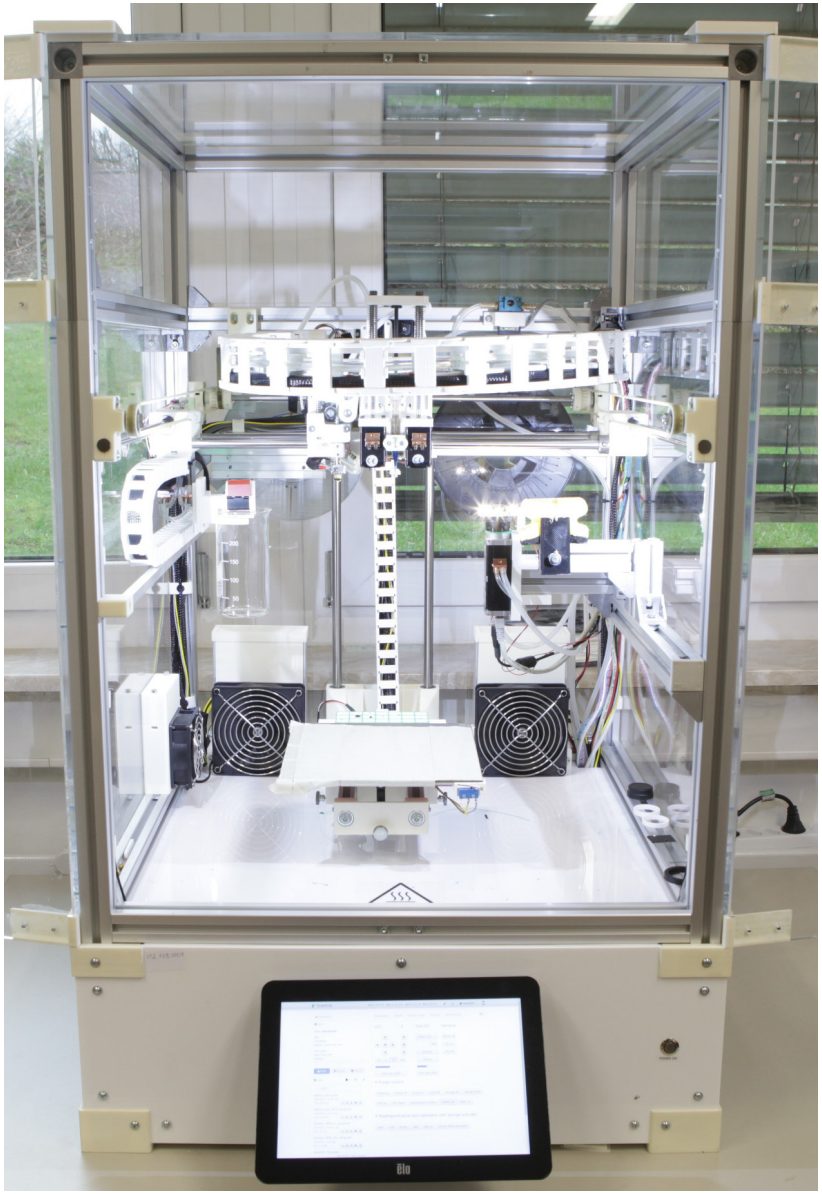
Full integration of electronic components and circuits into plastic objects in a single additive manufacturing process.

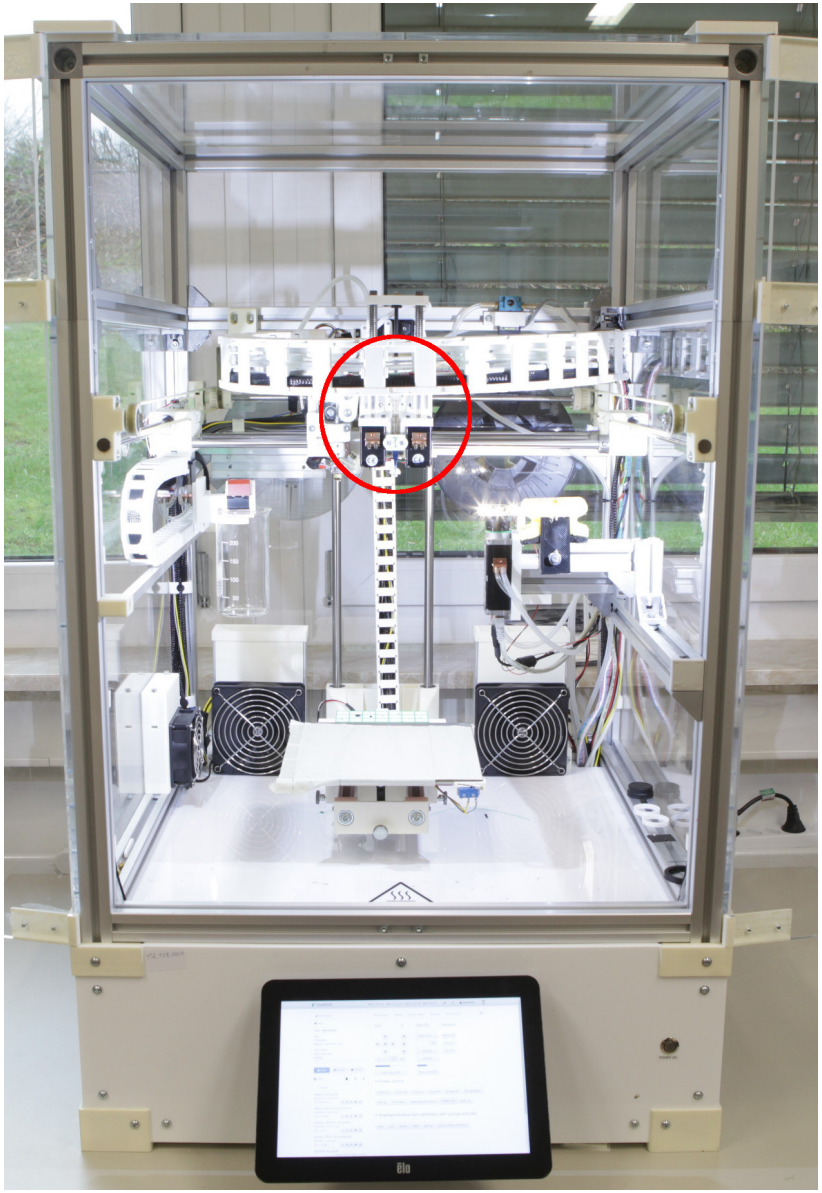
+ Keep it low-cost!

Hardware Setup

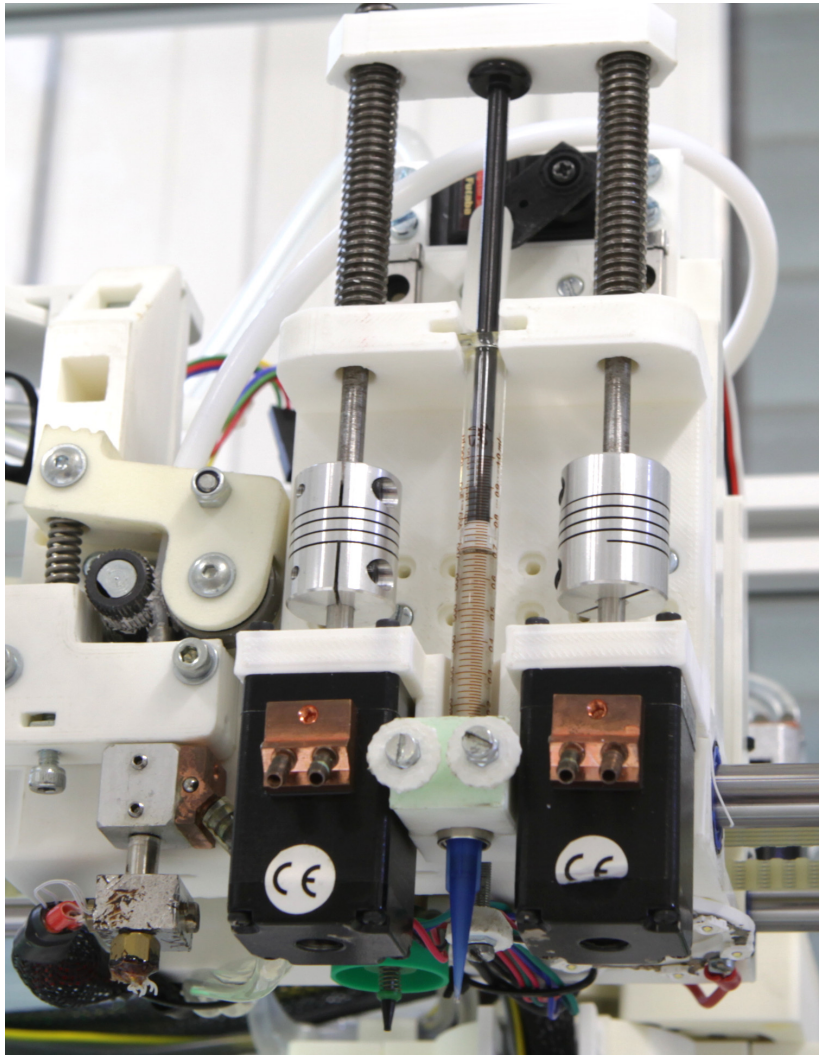
Slight modifications...



Hardware Setup

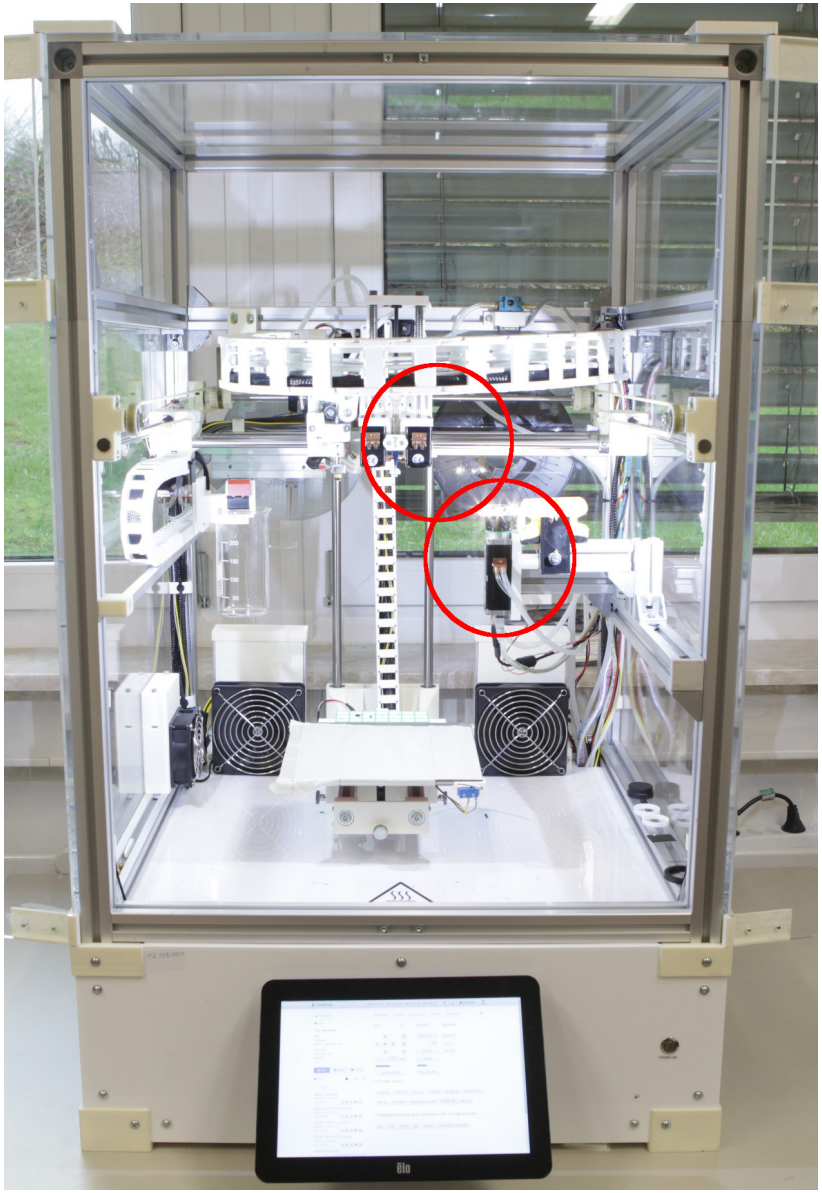


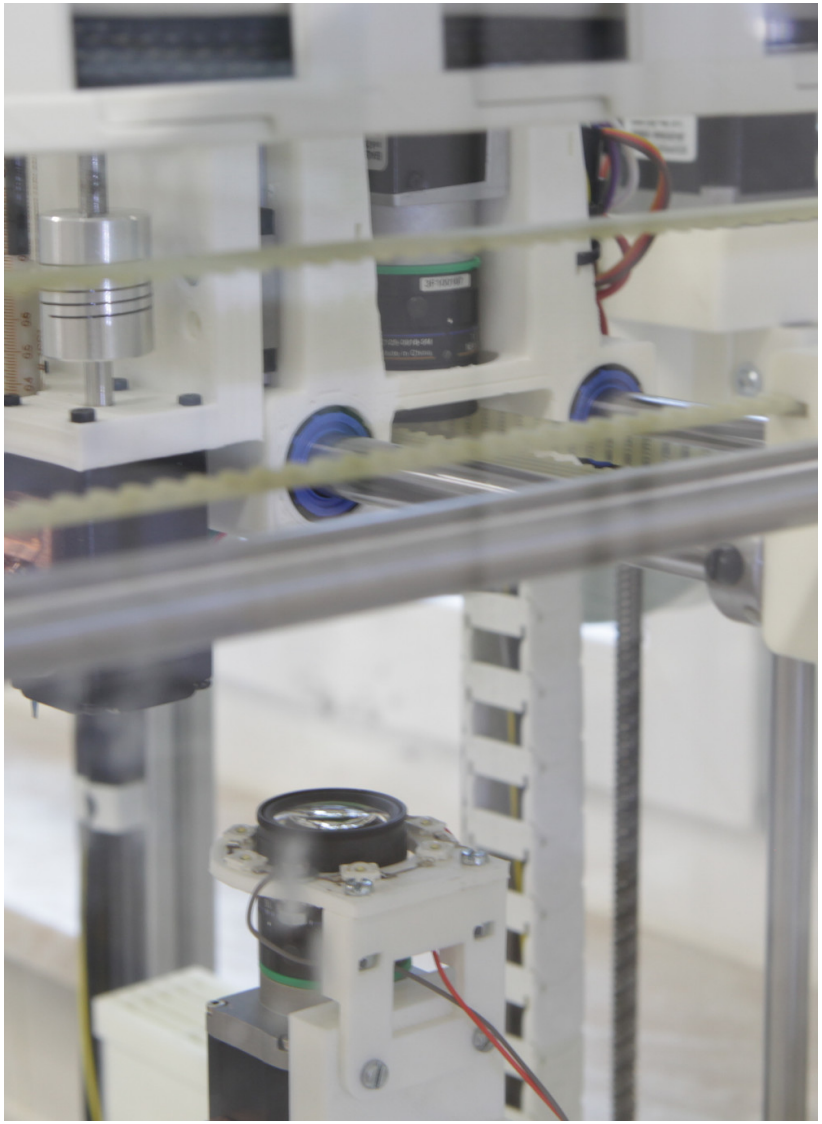
Conductive ink extruder



Hardware Setup

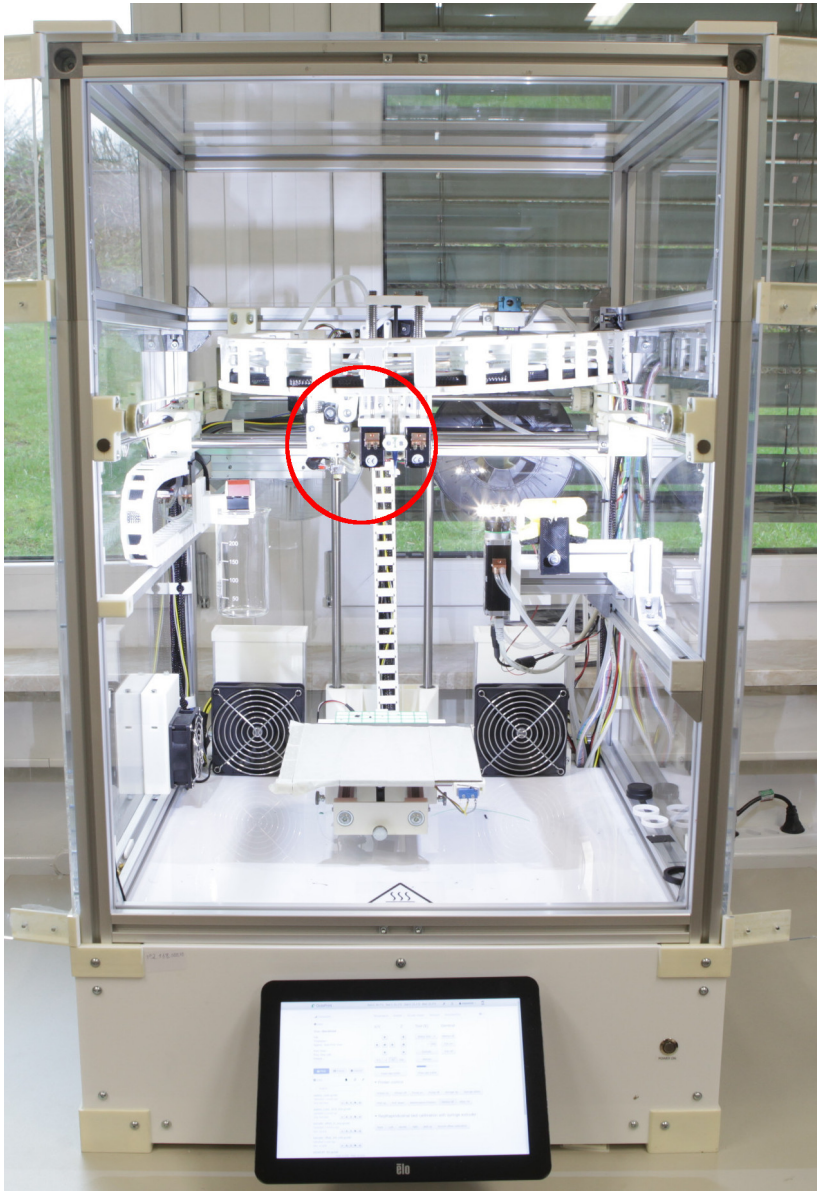
Cameras

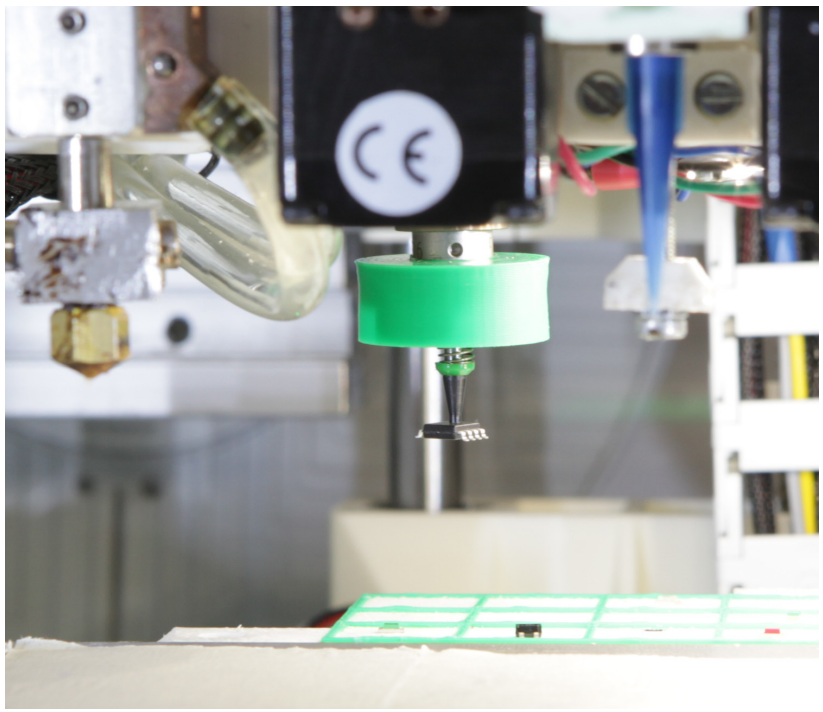




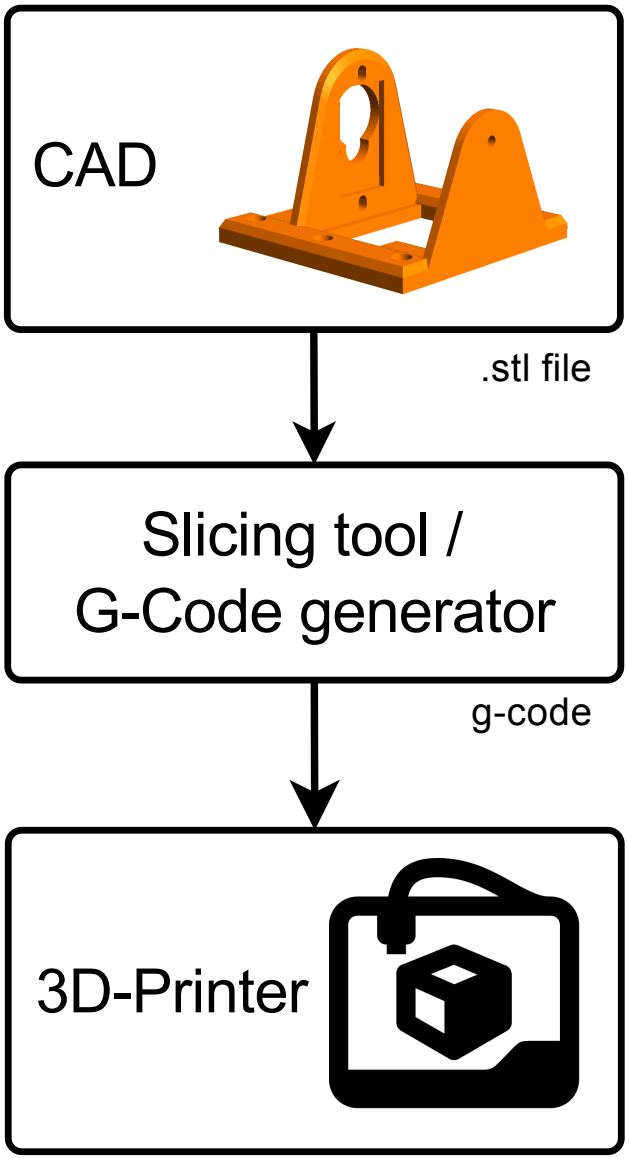
Hardware Setup

Vacuum gripper





Software tool-chain



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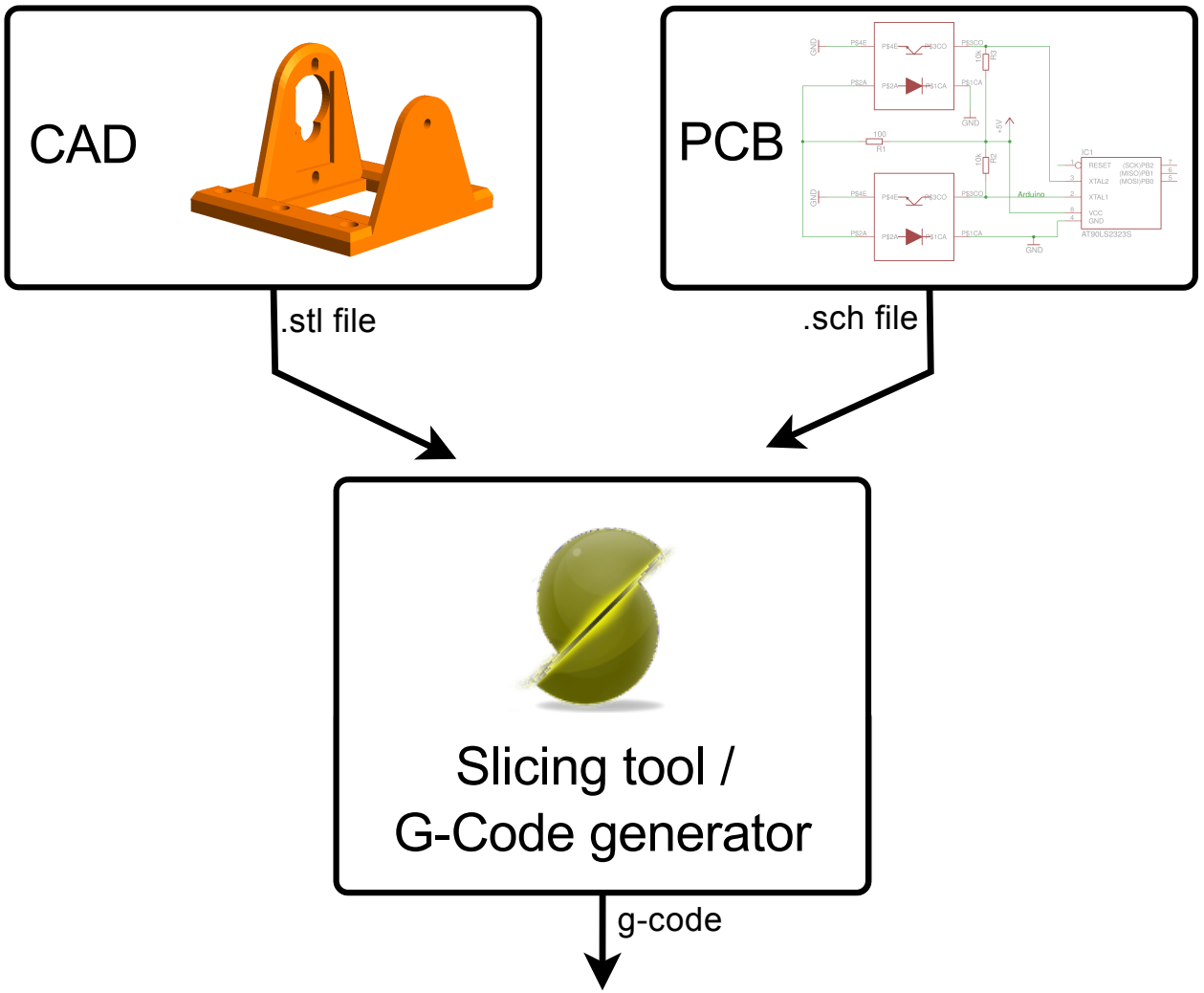

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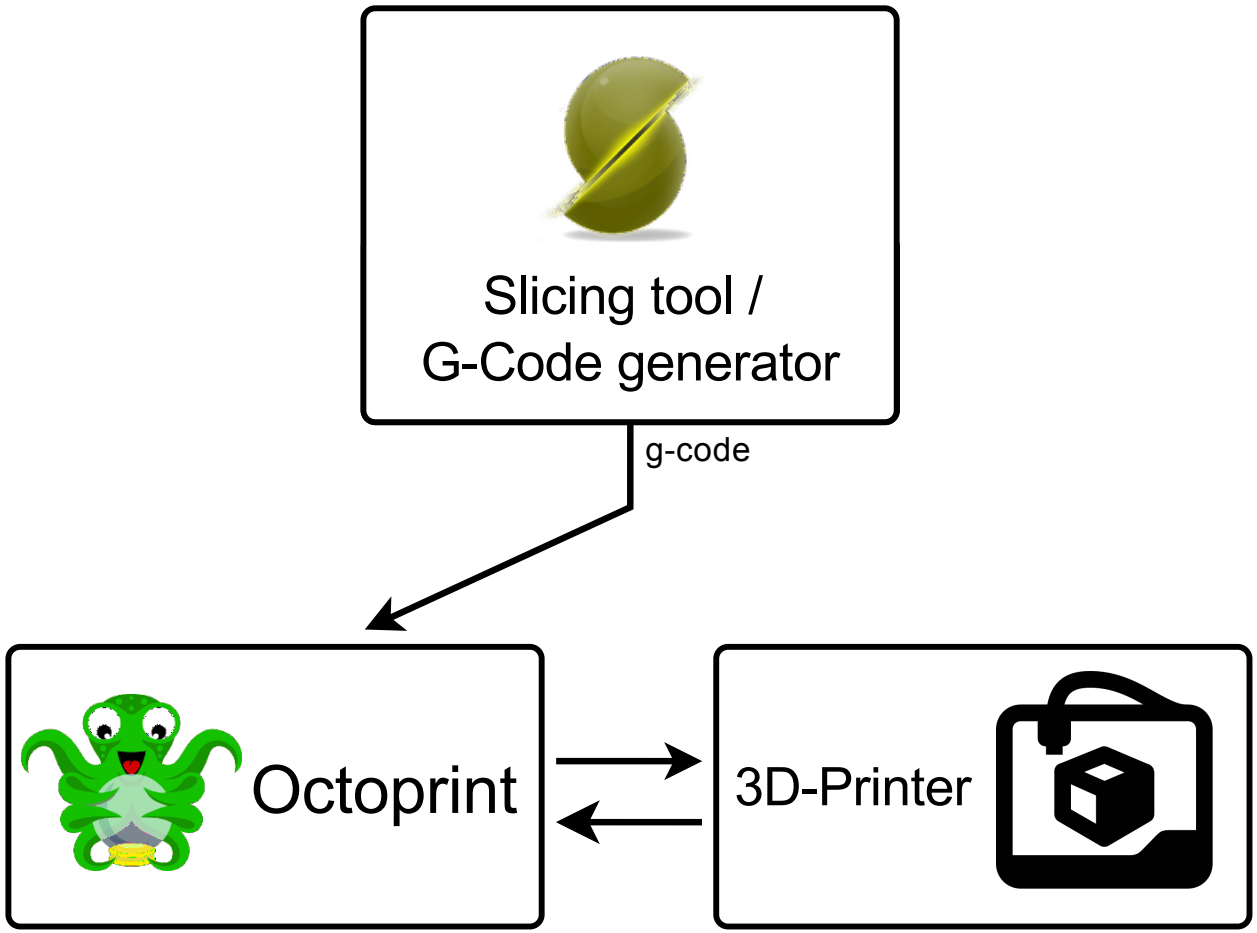
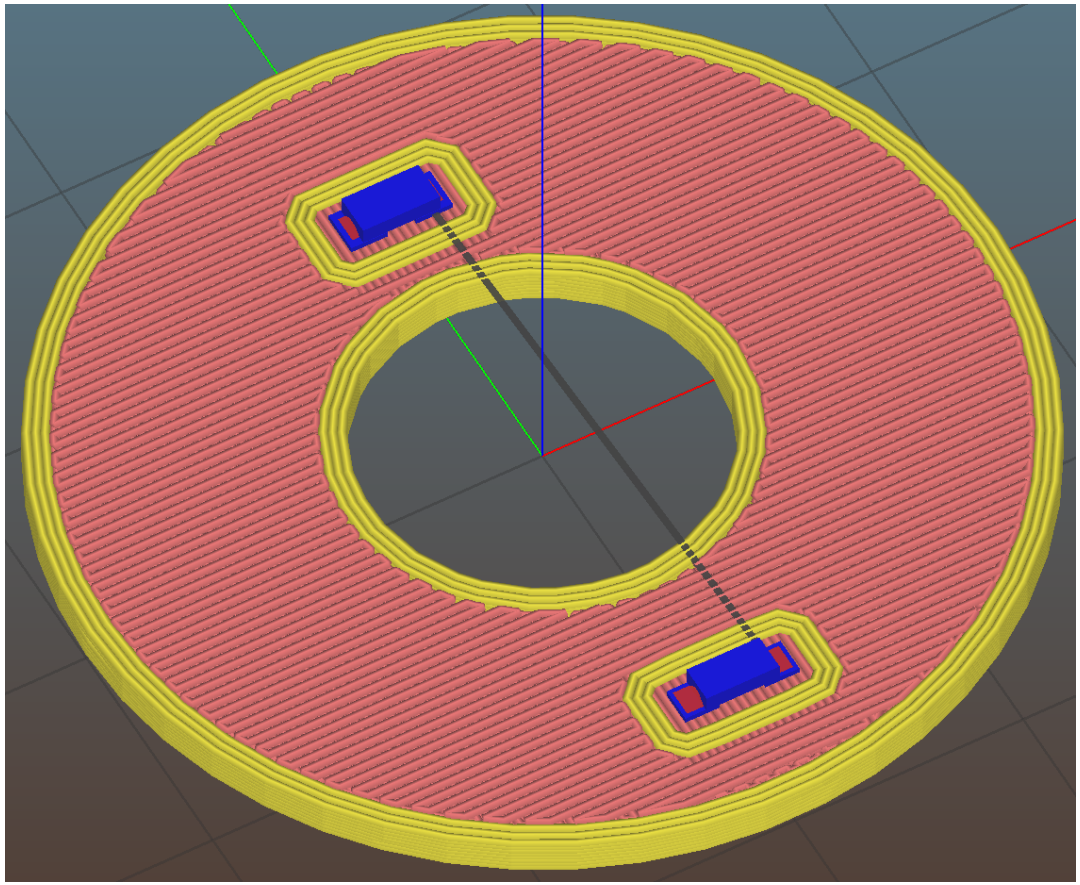


Video

Problem statement

- Align with object geometry
- Changing process parameters (extrusion width, perimeters, ...)
- Align with wires
- Interlayer connections



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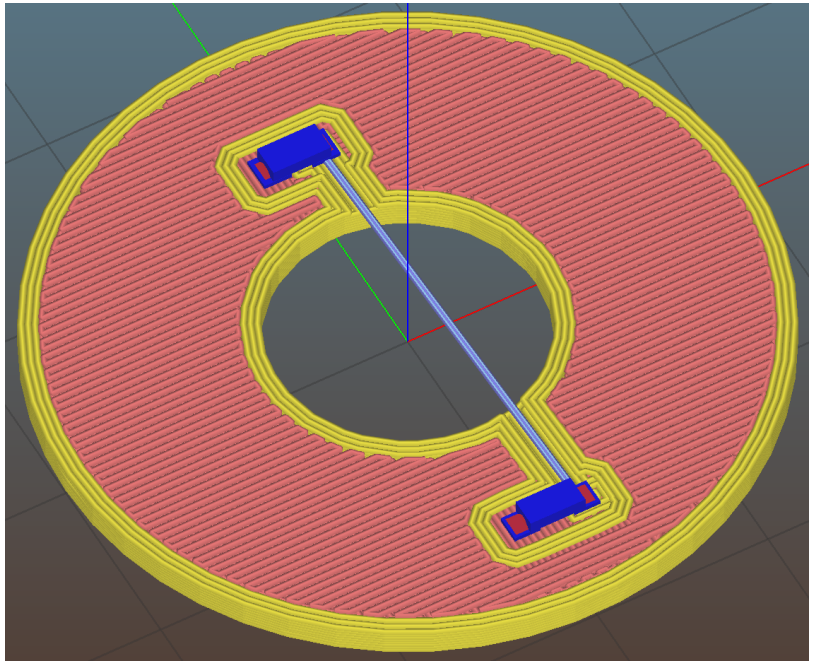

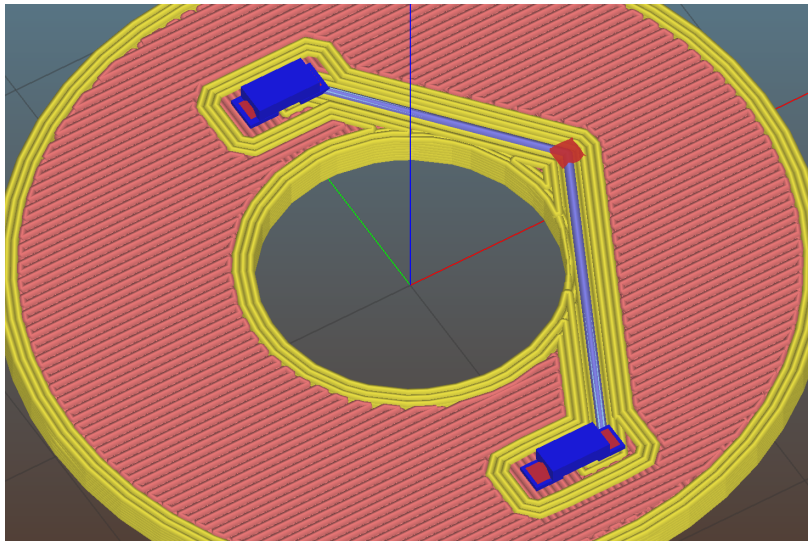

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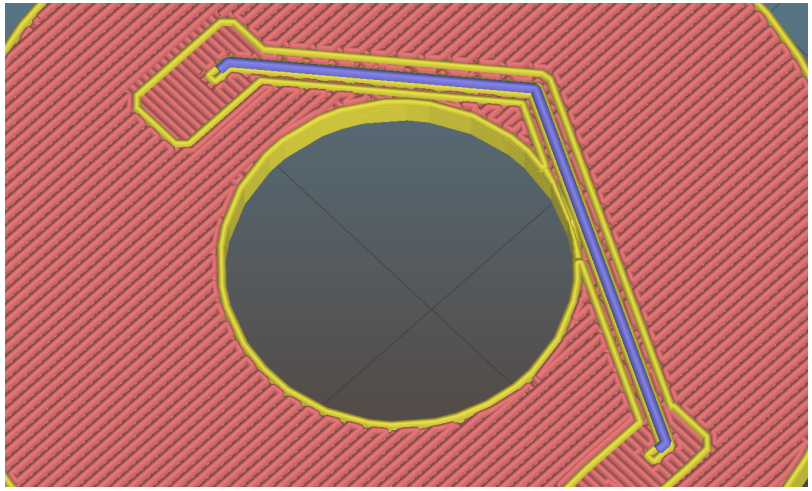

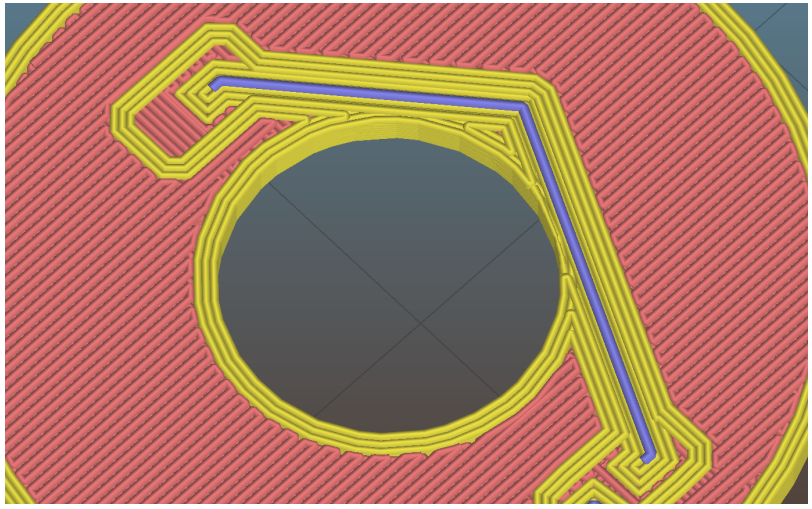

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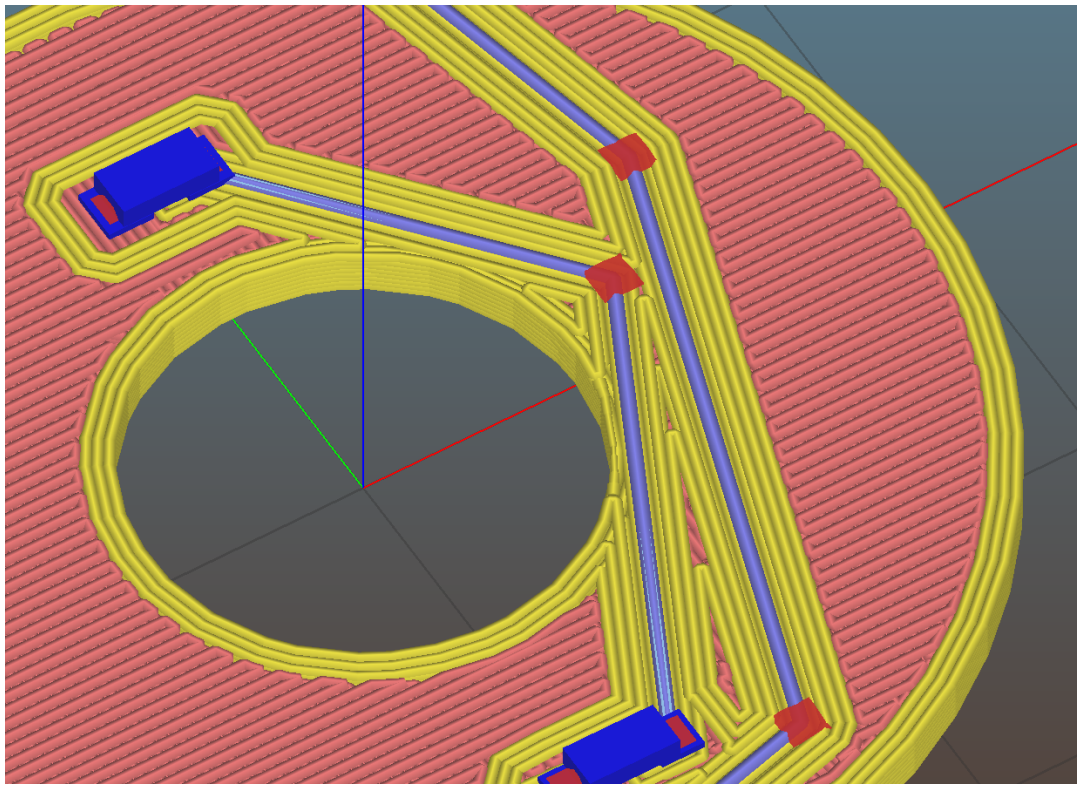

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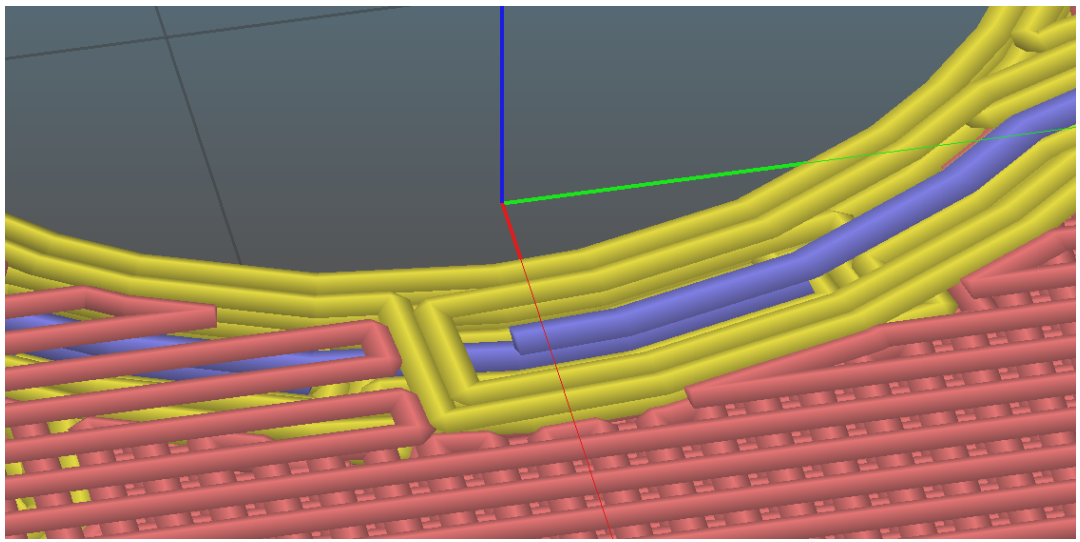

VLSI- / PCB-Routing??

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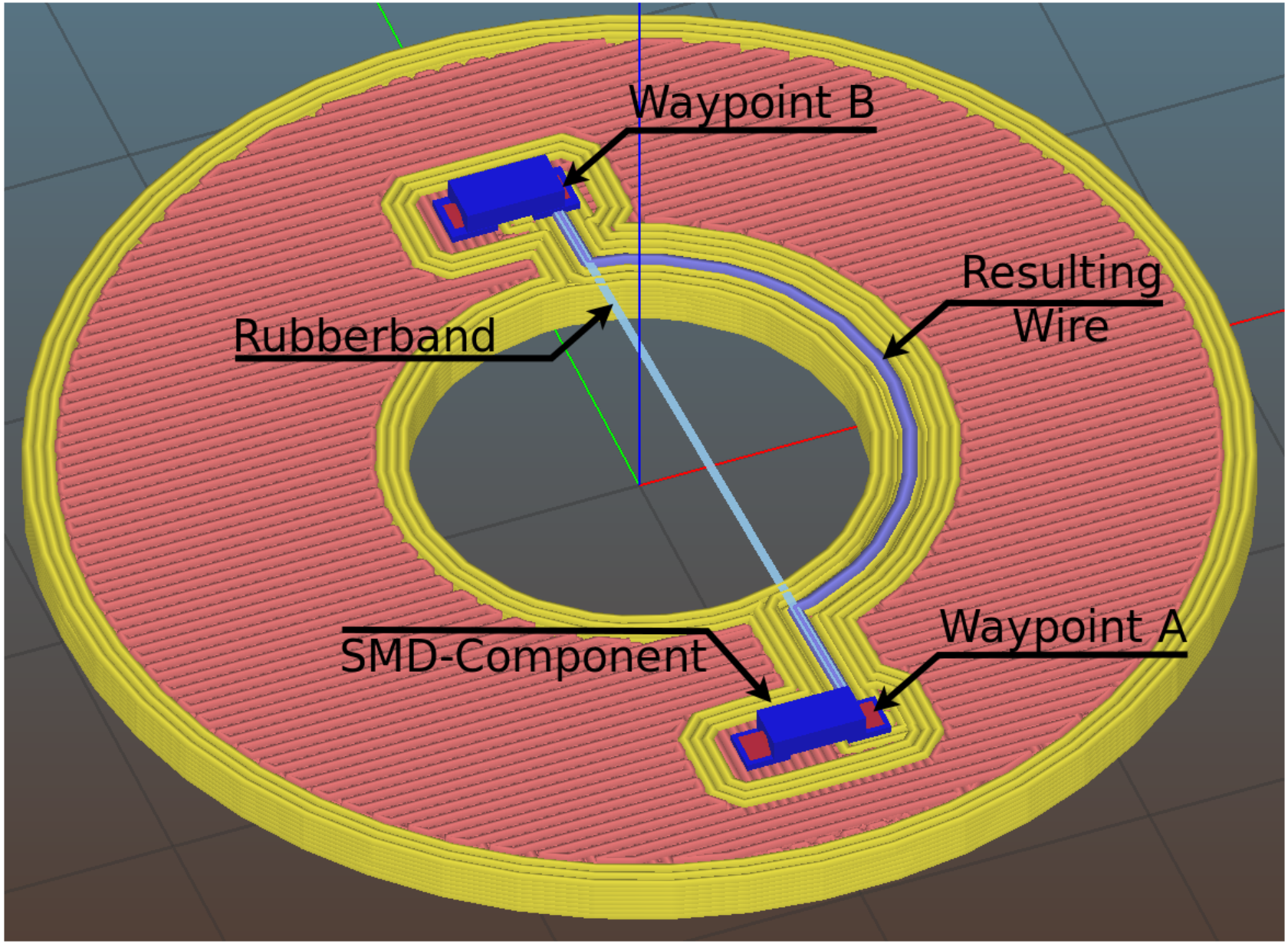
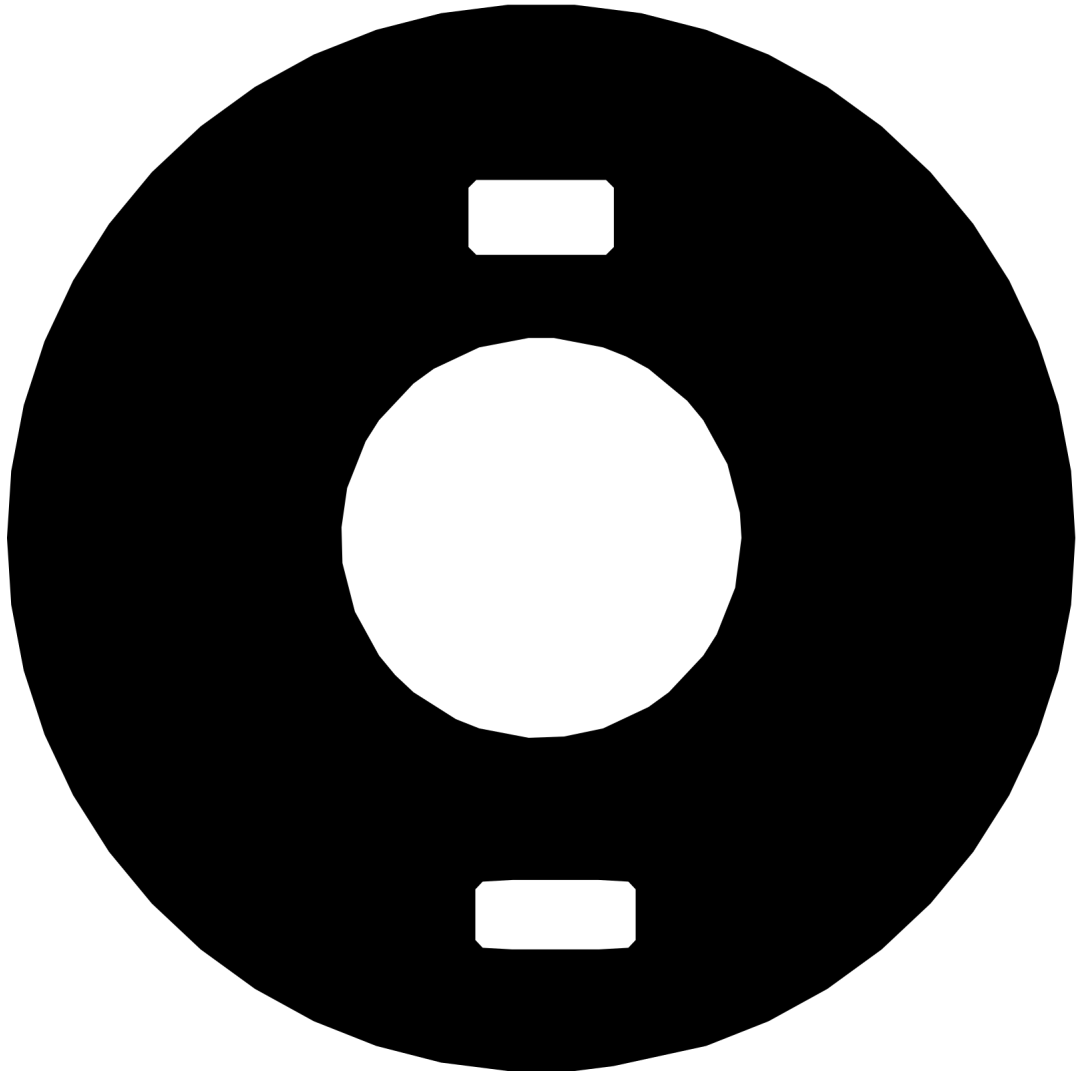
VLSI / PCB	**3D-printed**
Many components	Few components
Many connections	Few connections
Few layers	Many layers
High resolution	Low resolution
Simple geometries (PCB)	complex geometries (mesh)
"Process for circuit"	"Circuit for process"
Direct Z-Interconnects	?

Result for a single wire



Routing of a single wire

- Assemble routing-graph
- Existing contours
- Direct rubberband connections
- Infill-Grid
- A* routing



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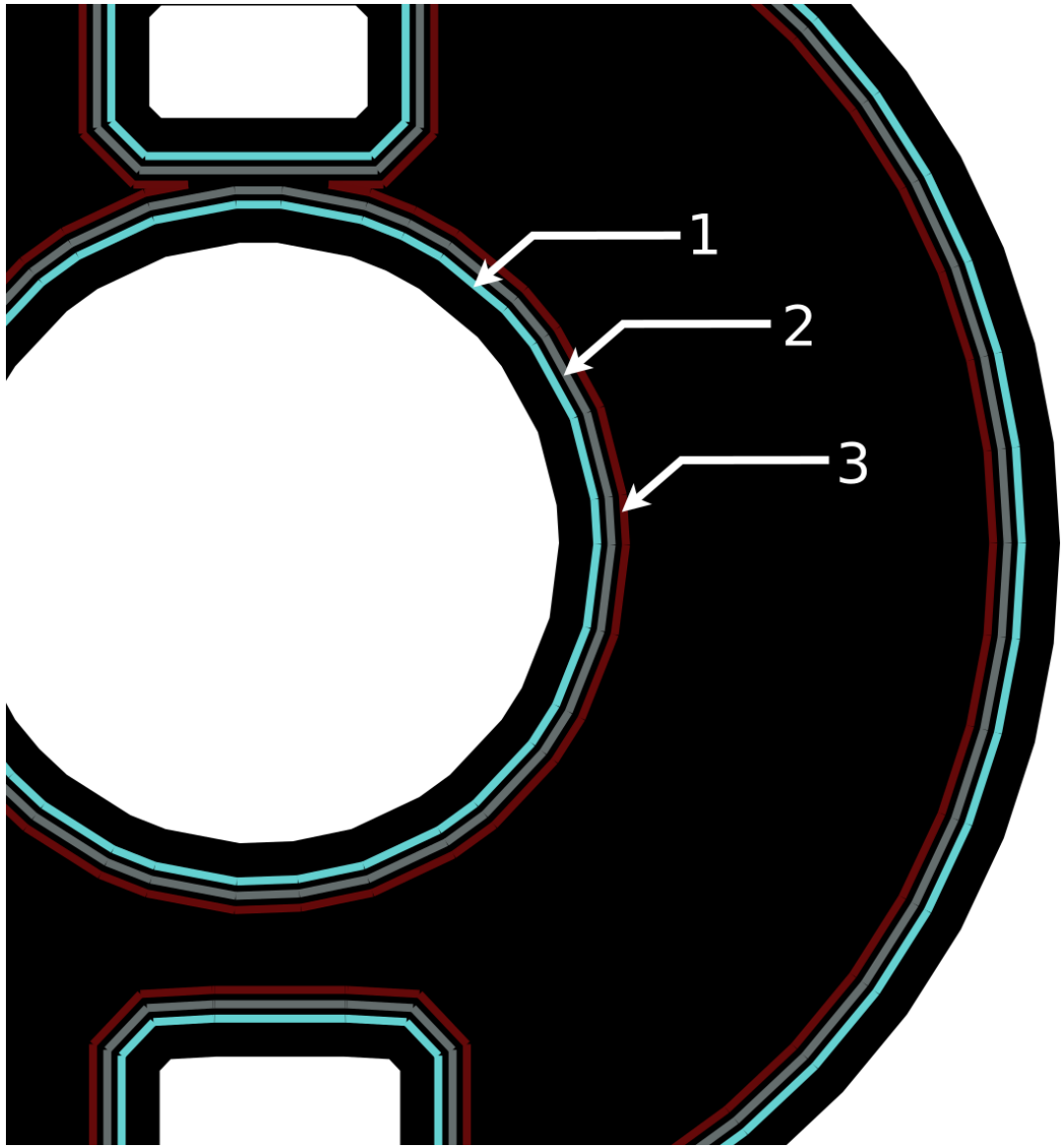

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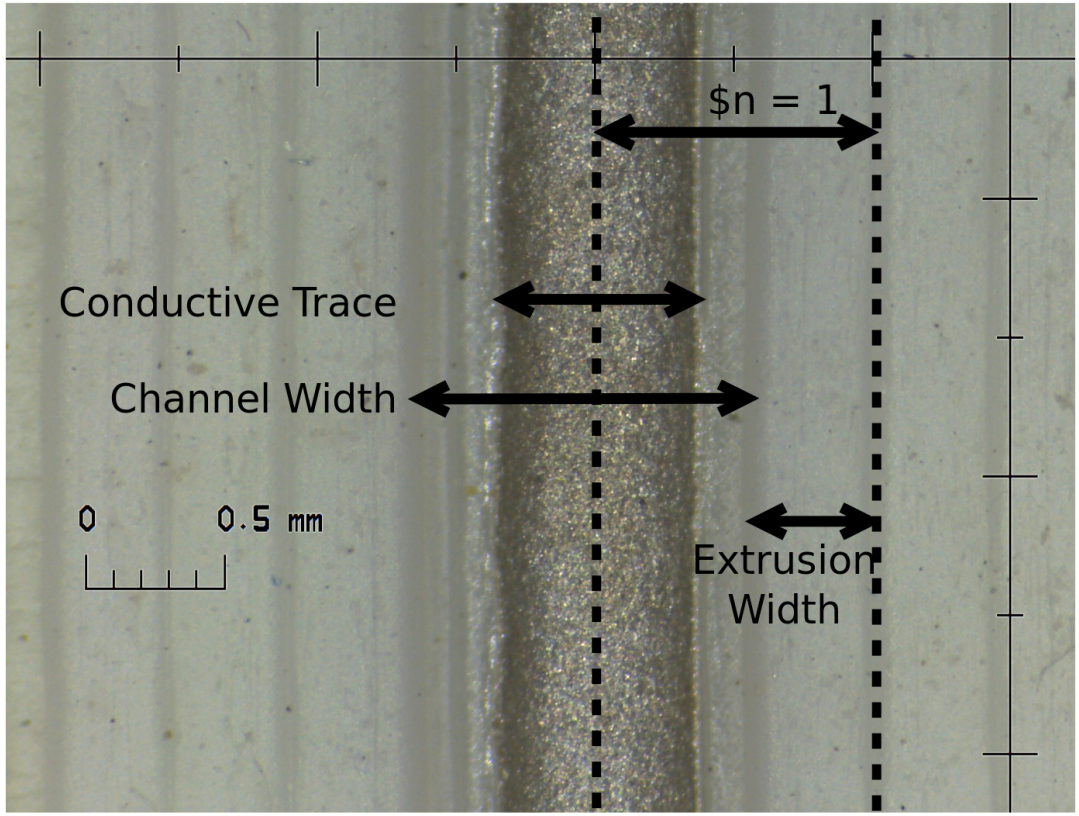

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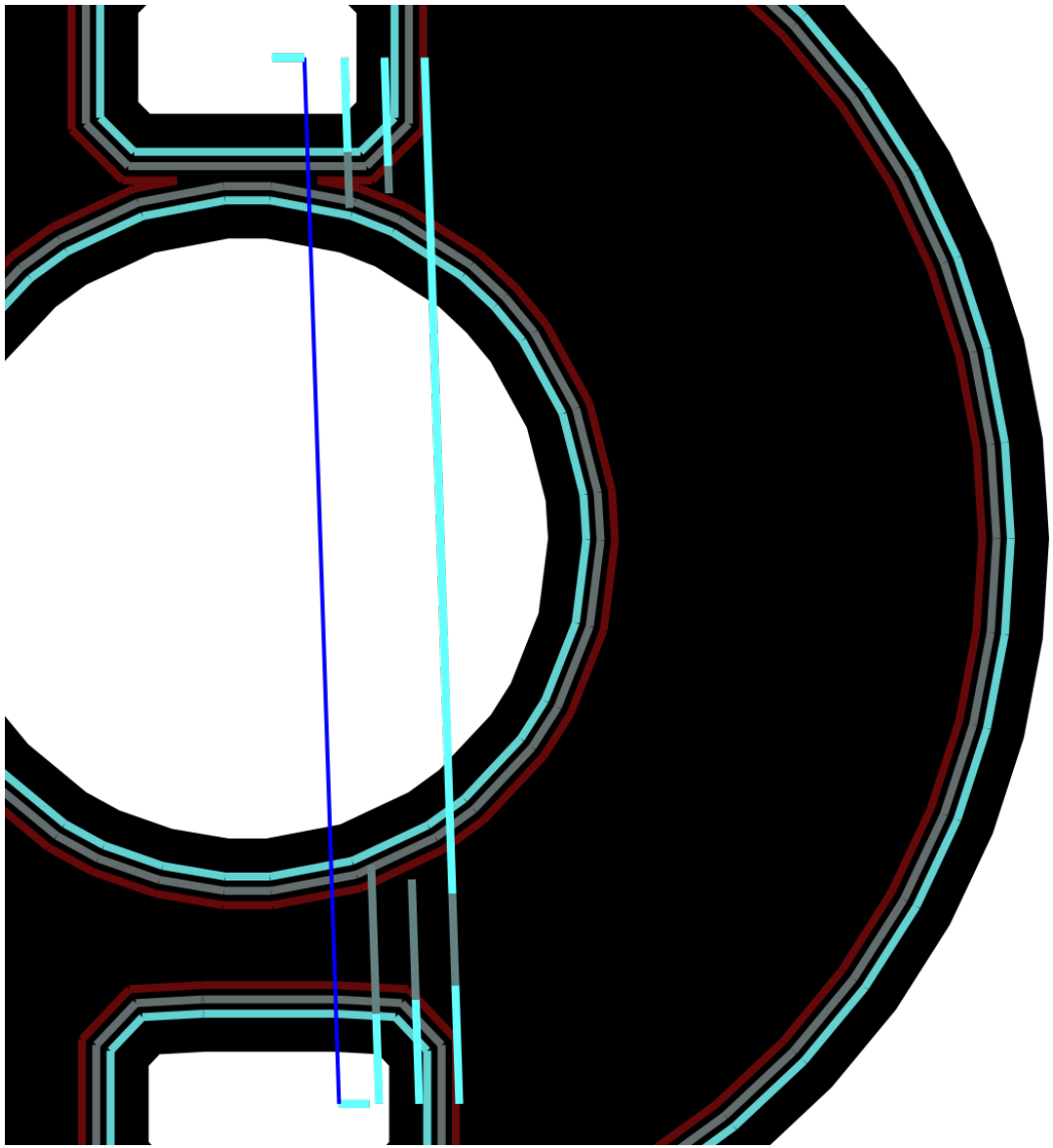

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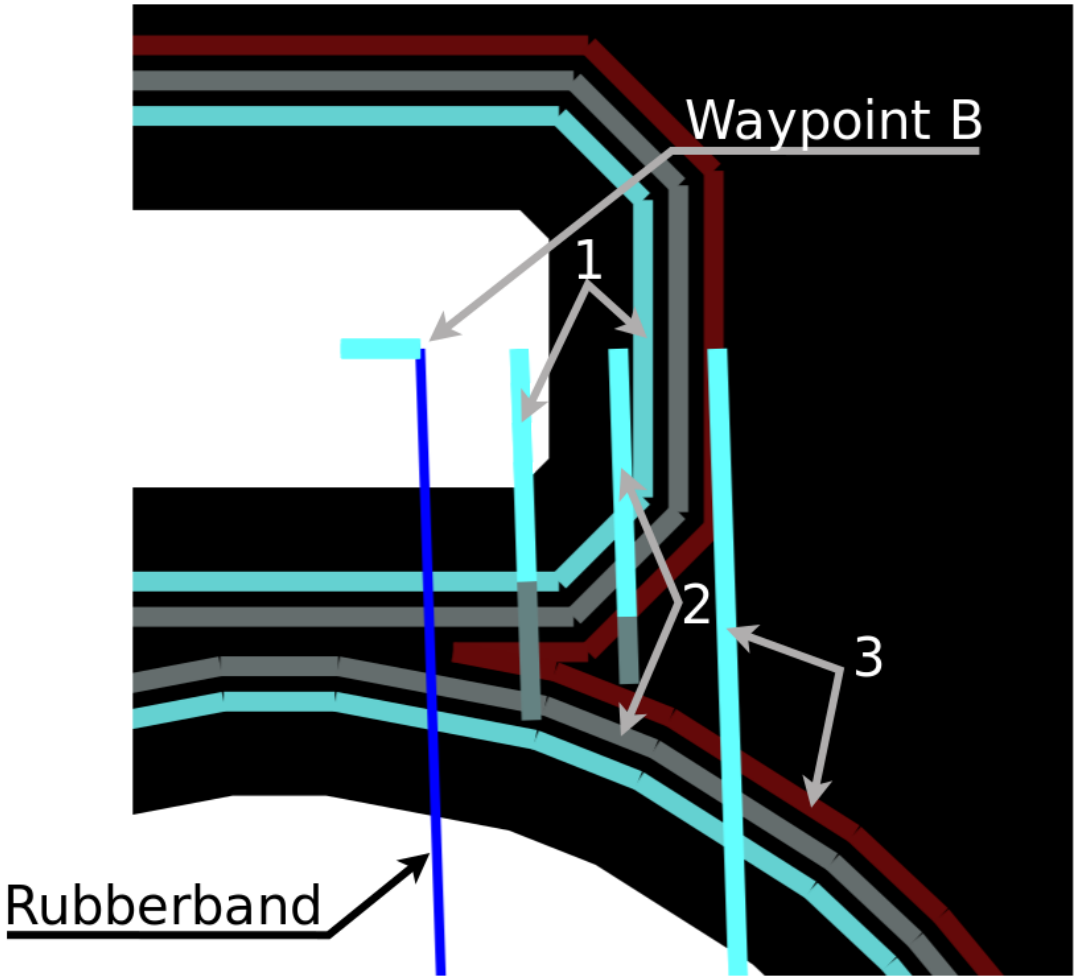

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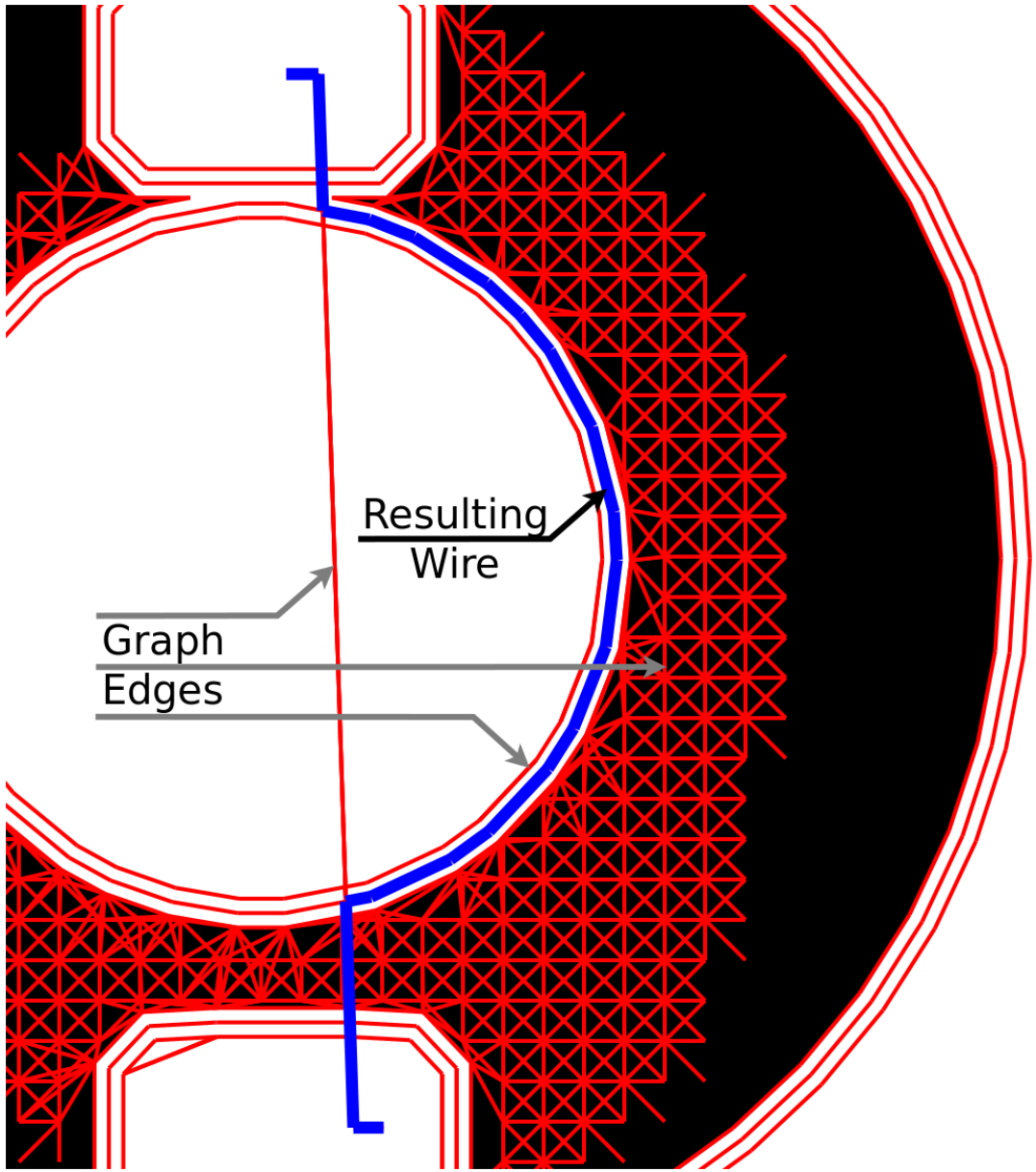

Inter-Layer connections

- Direct linear connections
- Dynamically exploring connections

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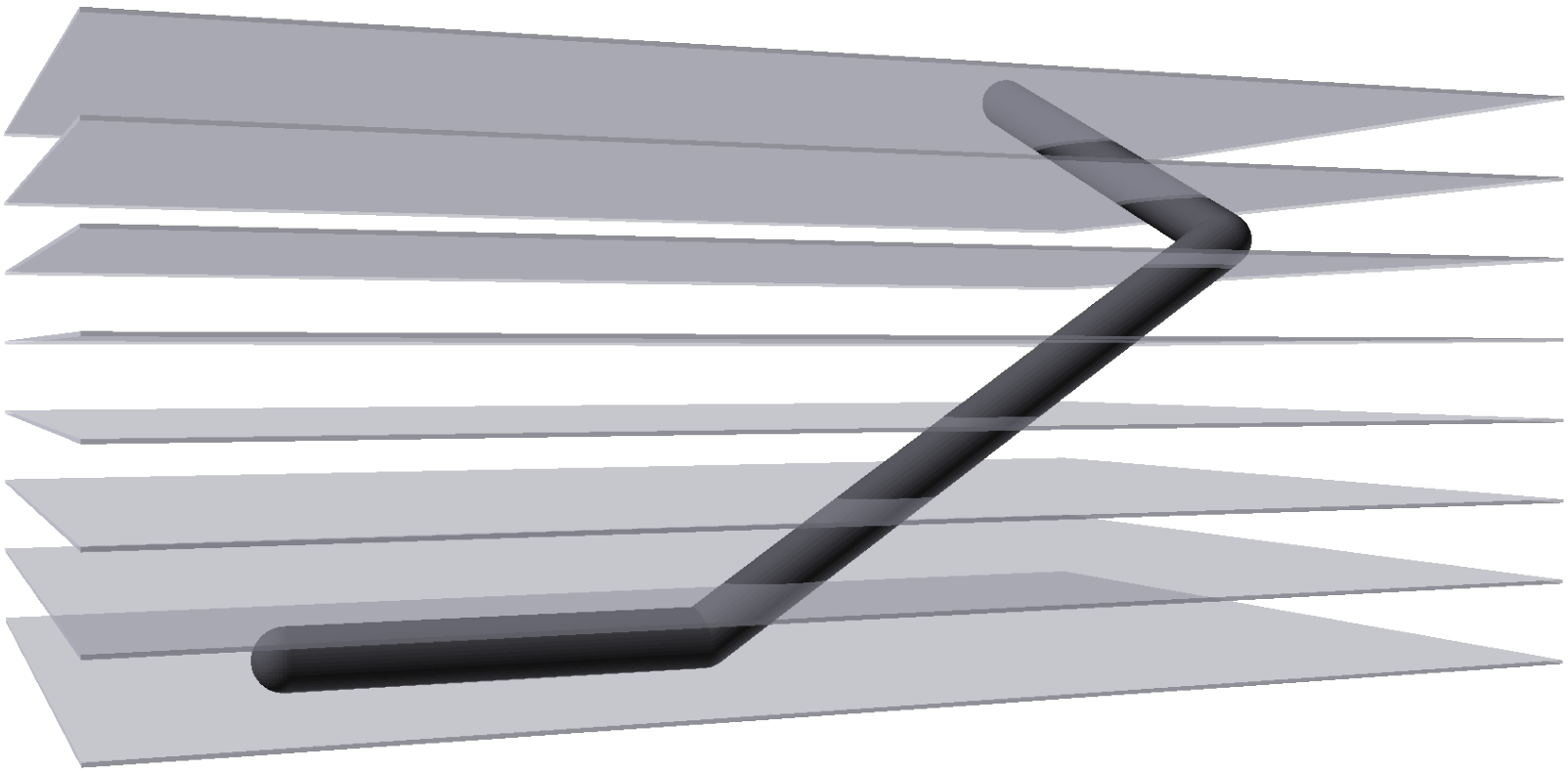
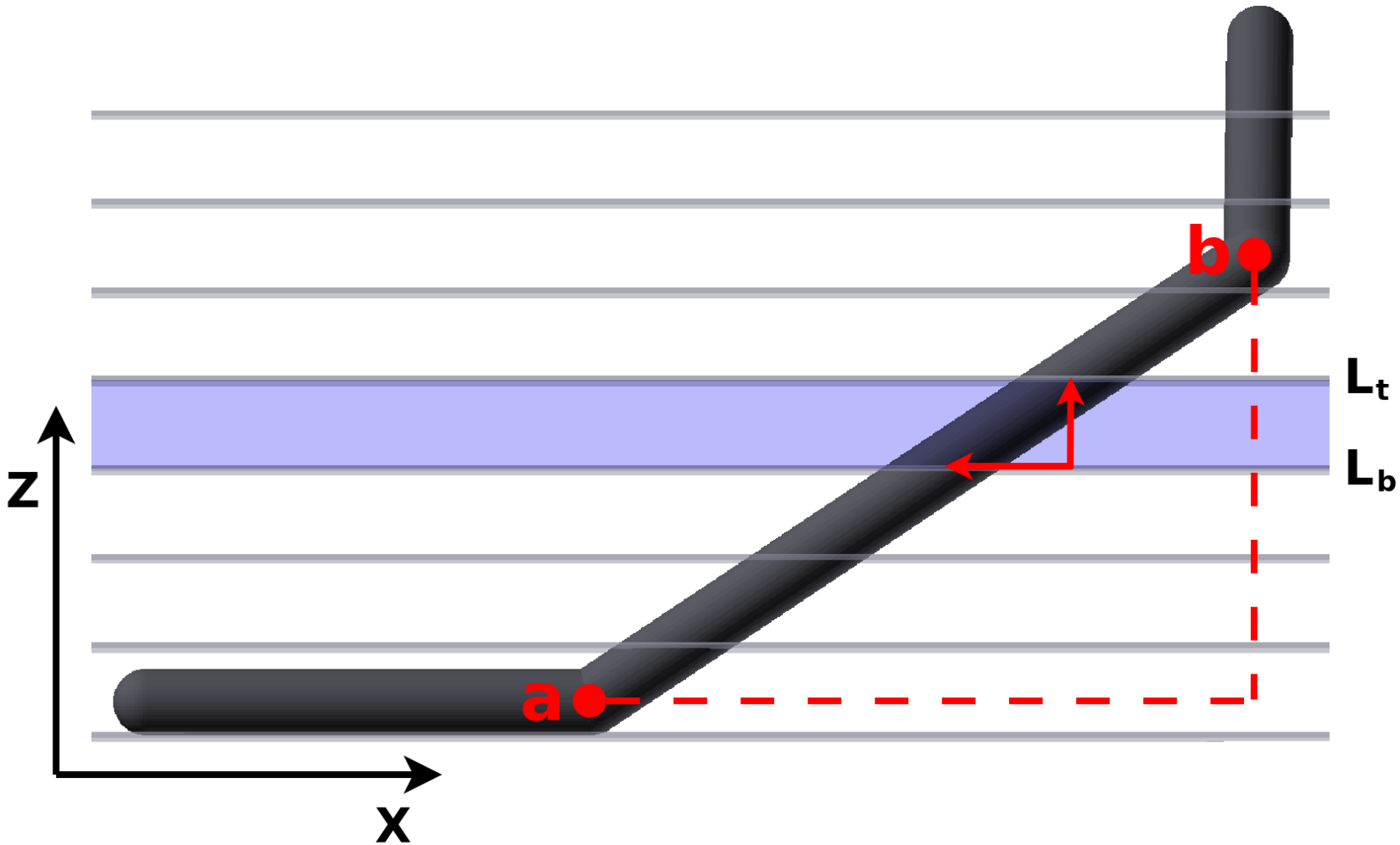
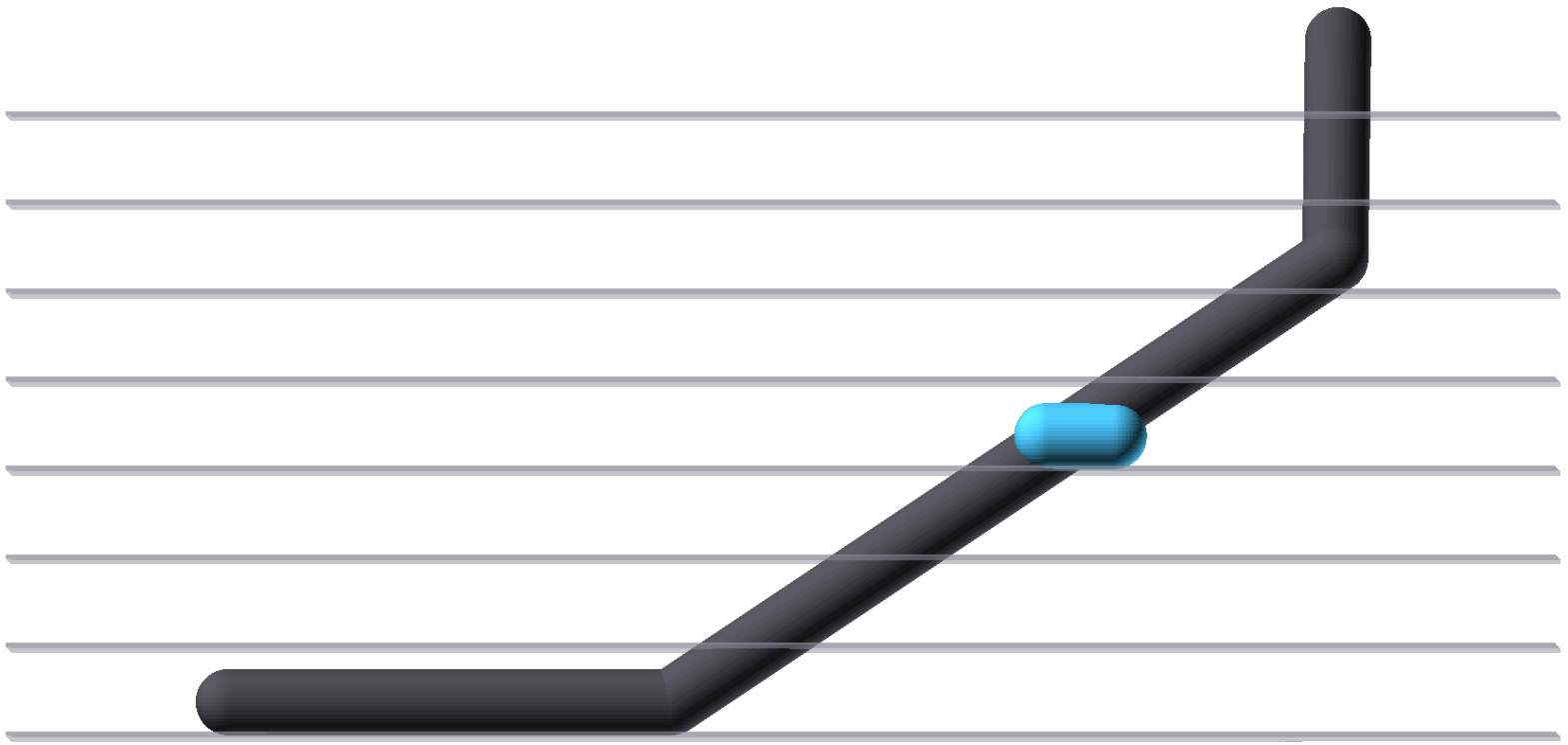


Direct linear connections

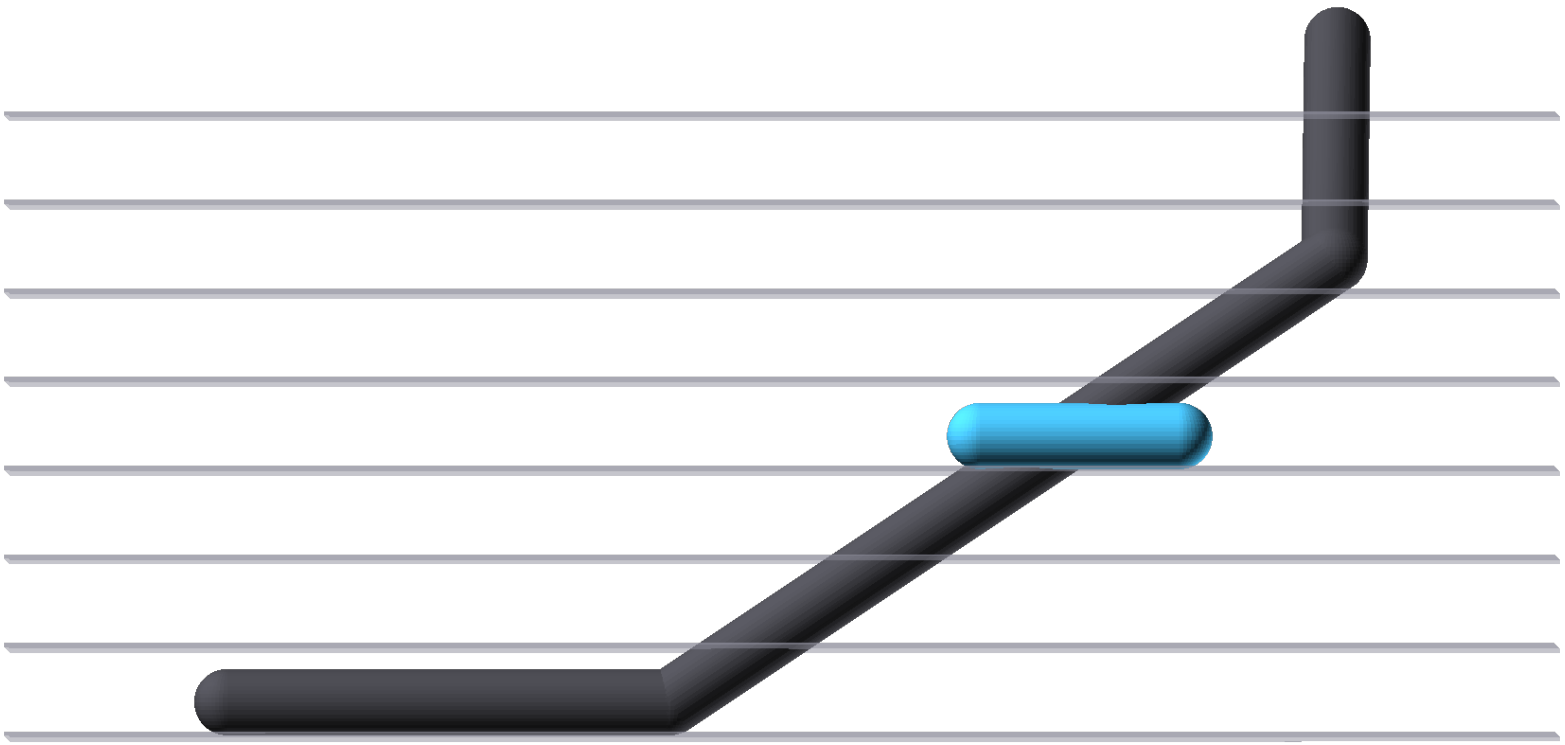


$$a'_x = a_x + (b_x - a_x) \cdot \frac{L_b - a_z}{b_z - a_z}$$

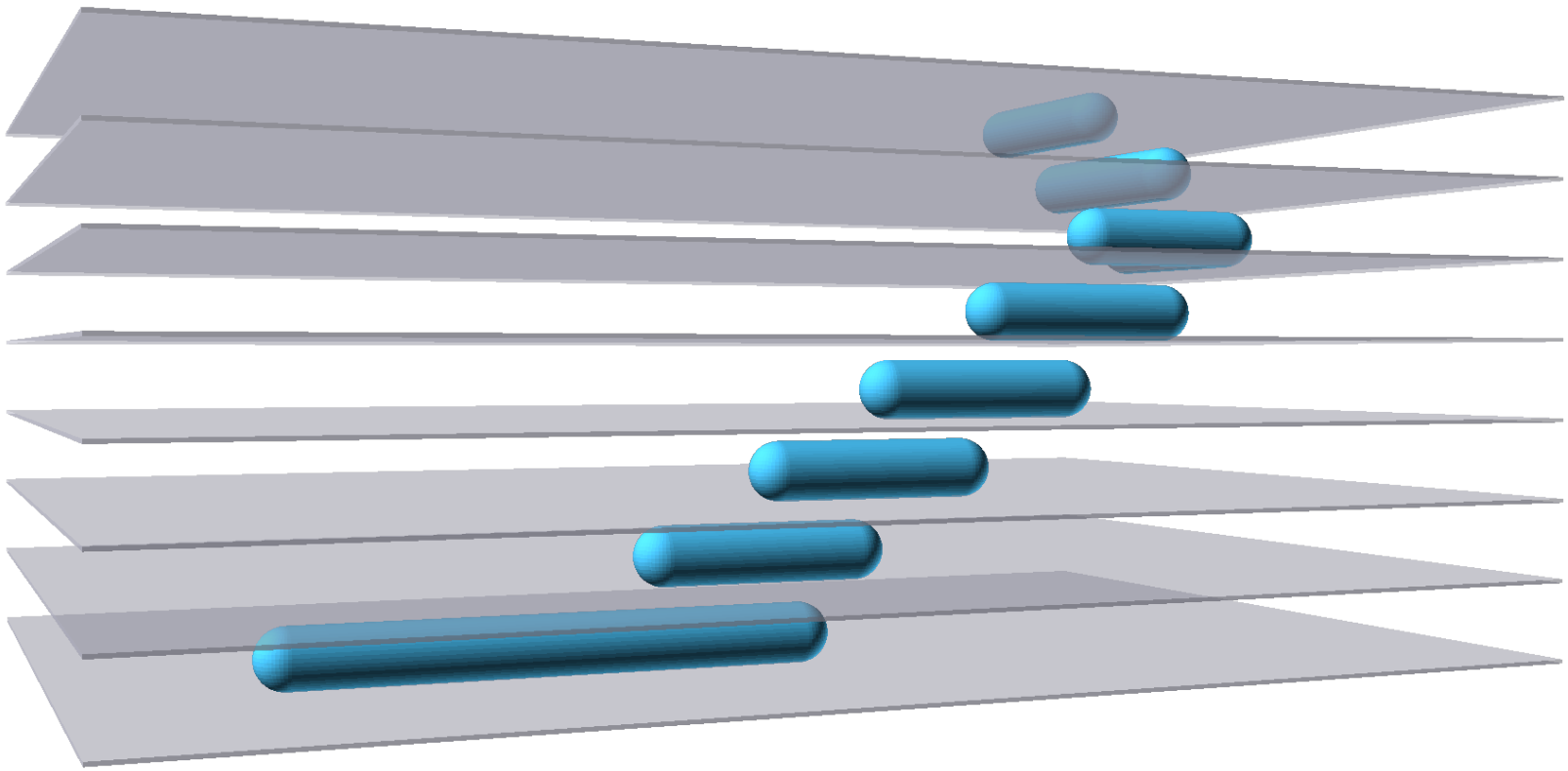
Direct linear connections



Direct linear connections



Direct linear connections



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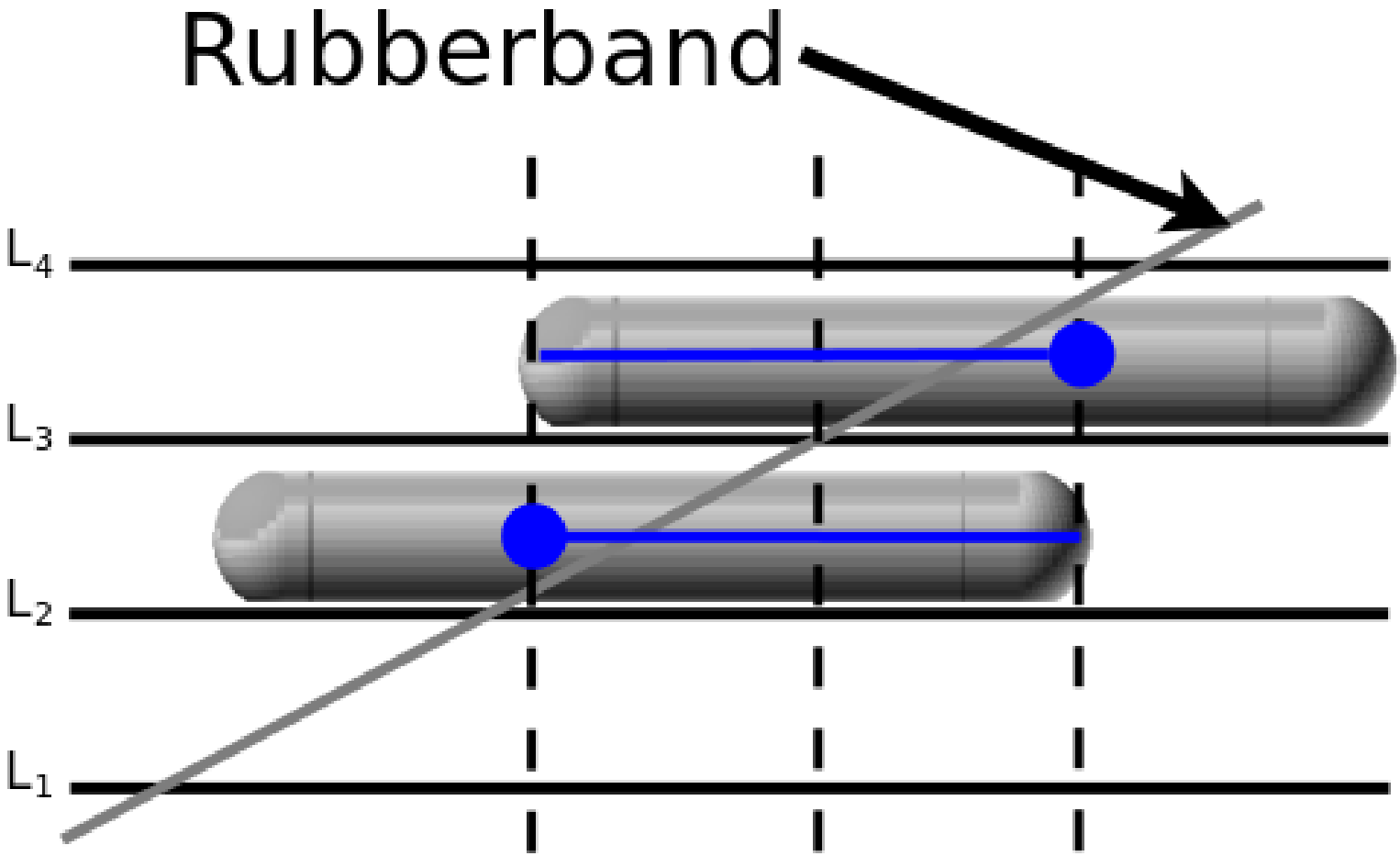

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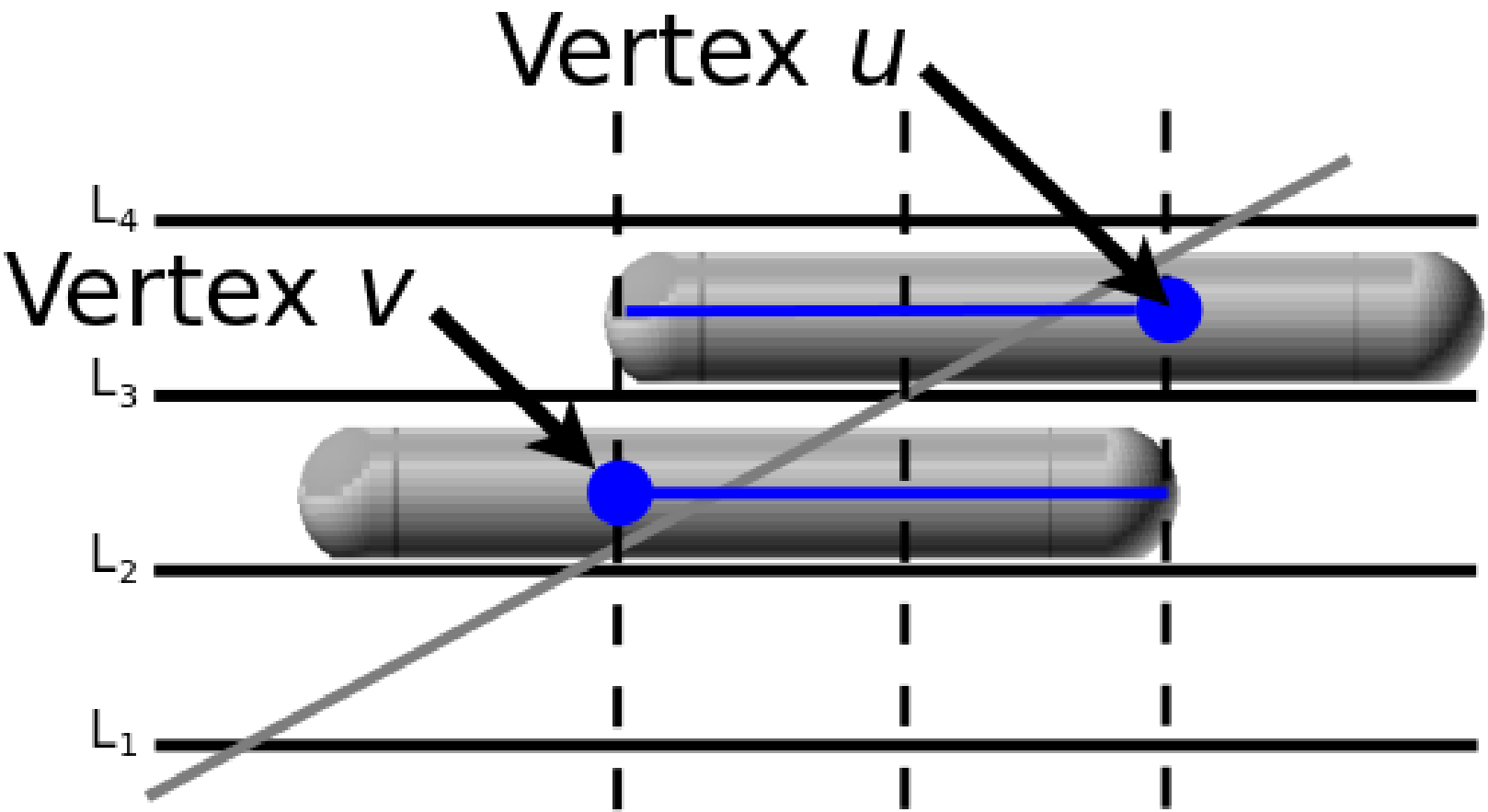

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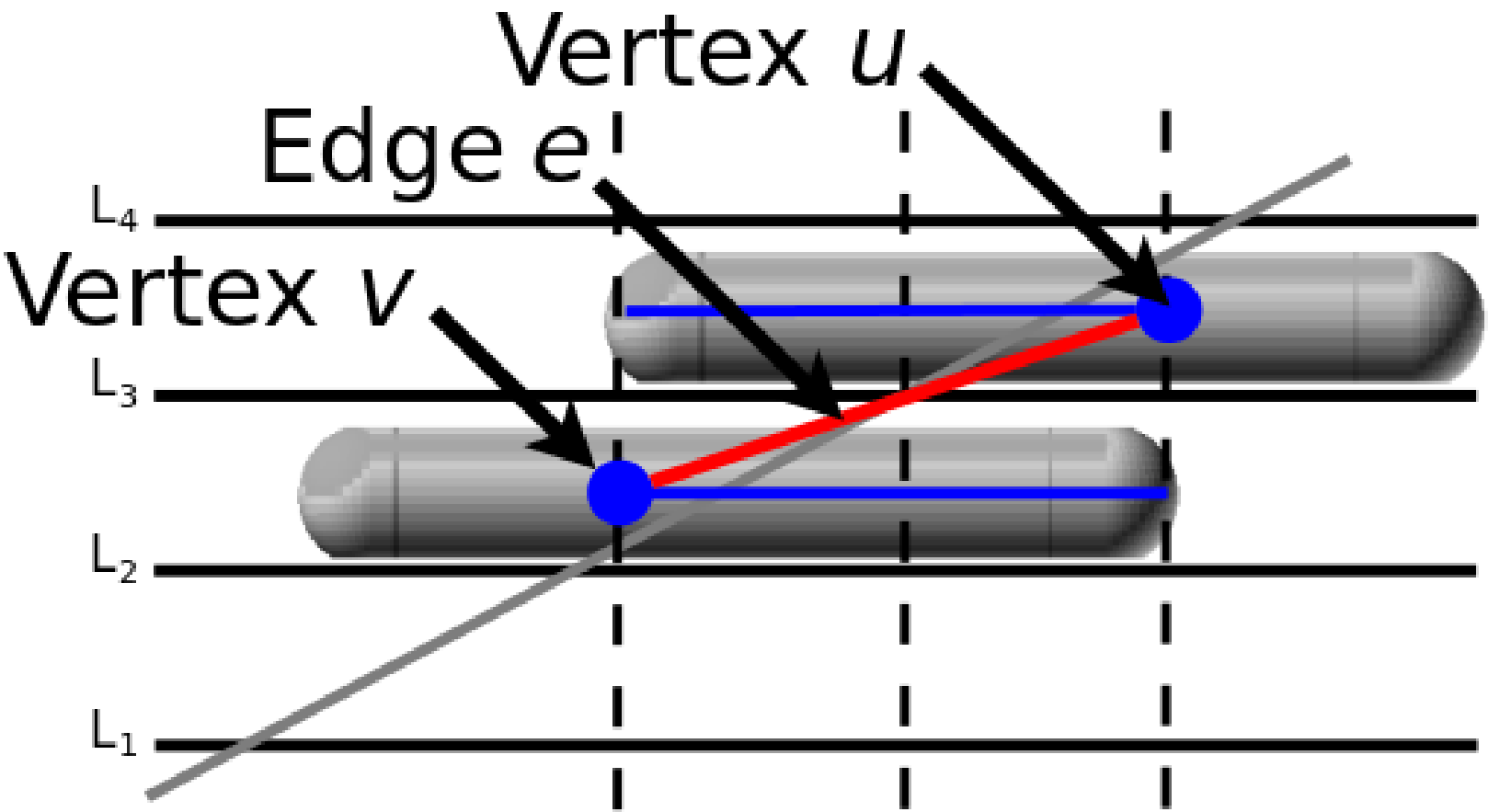
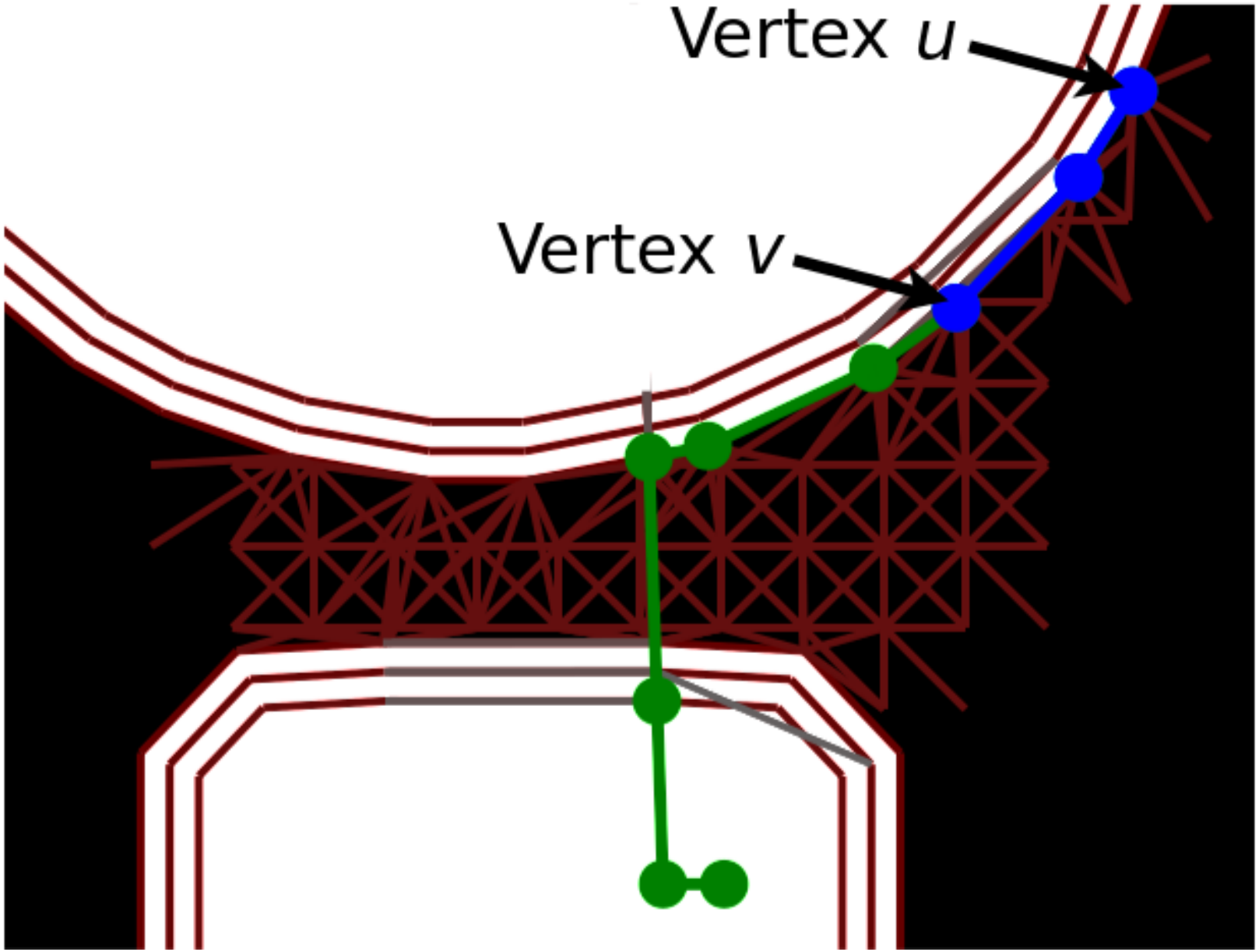


Dynamically exploring connections



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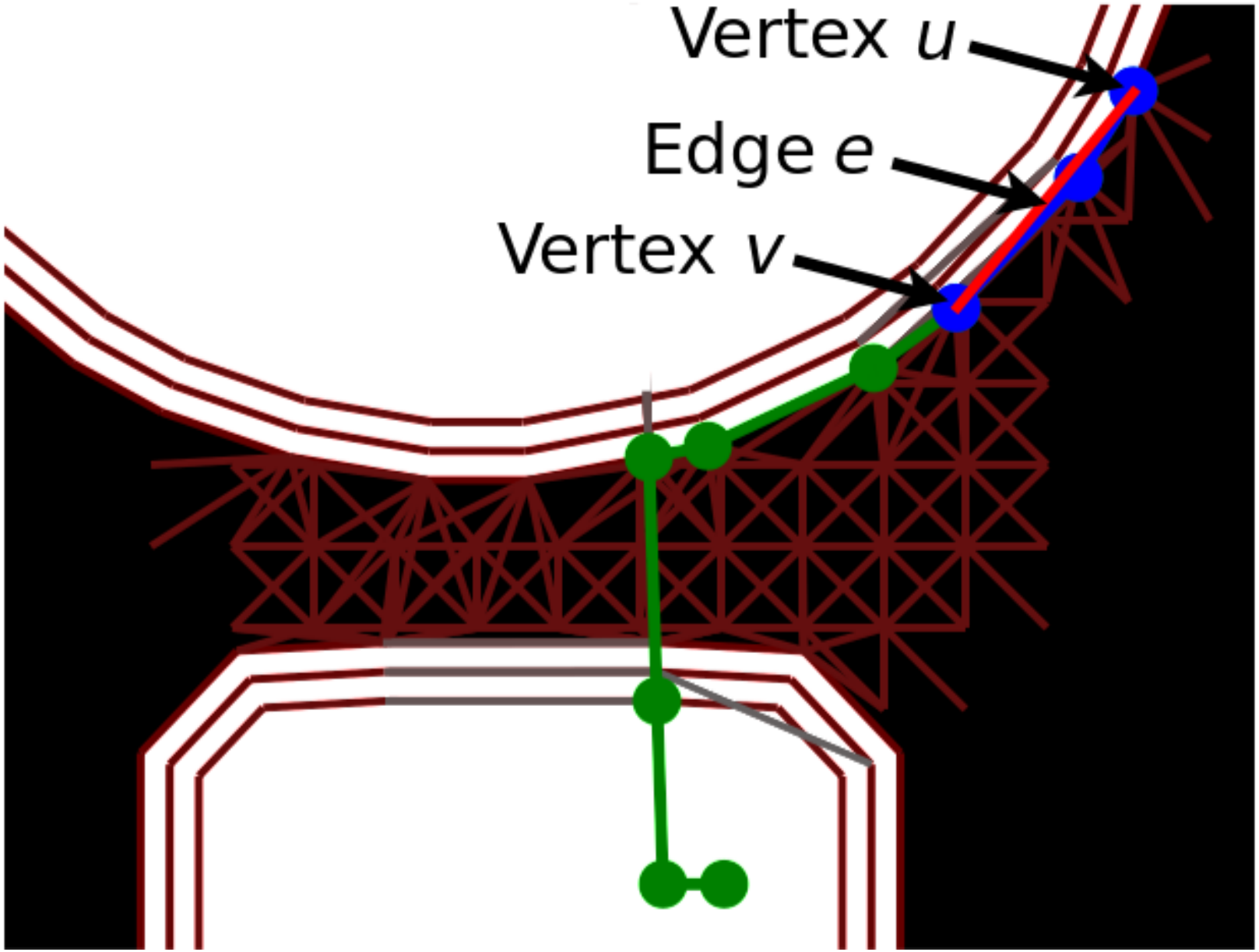
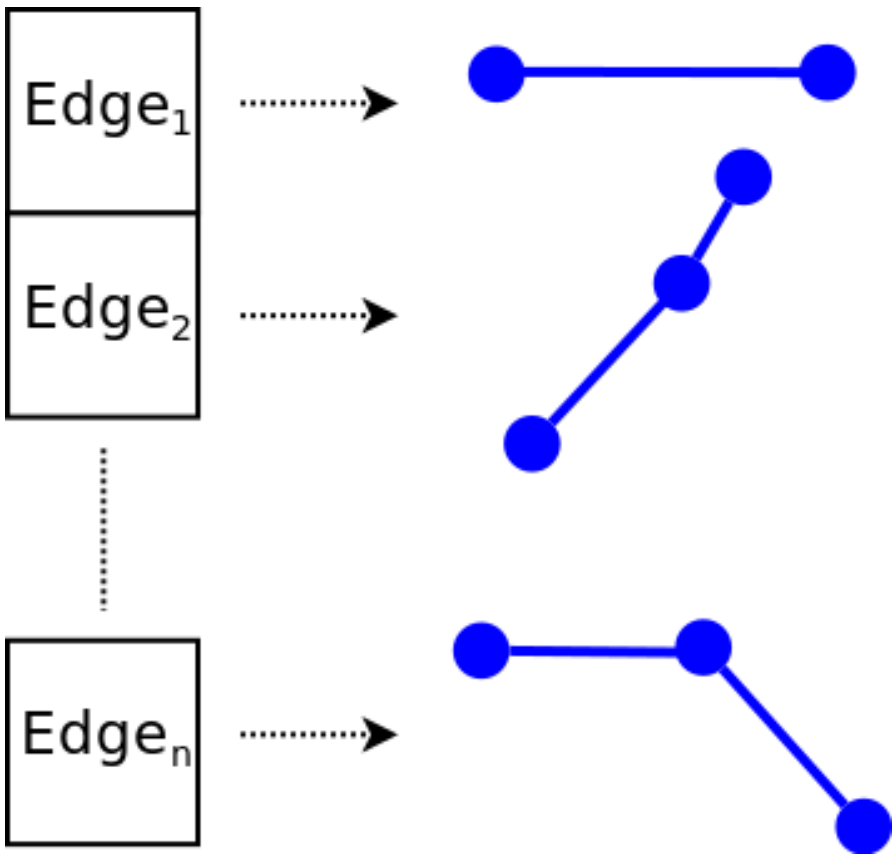
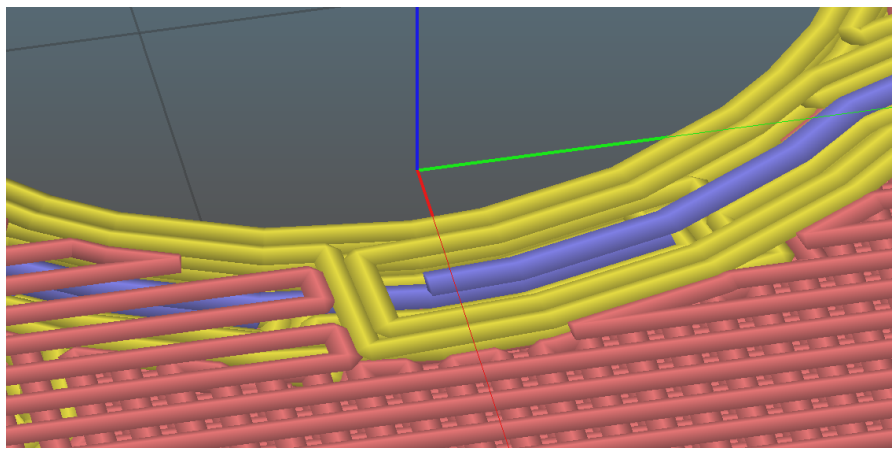
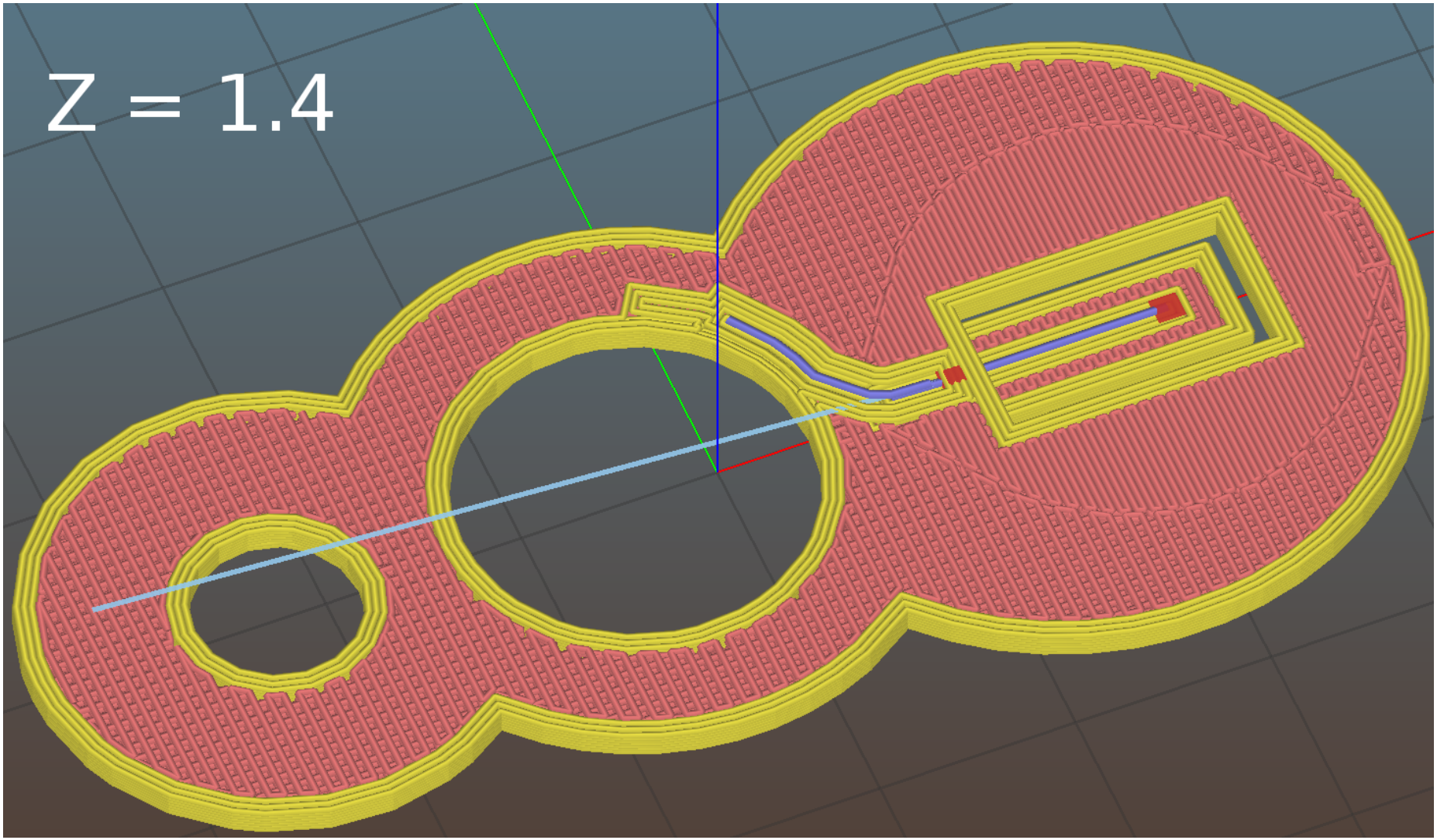


Overlapping wire segments





Result



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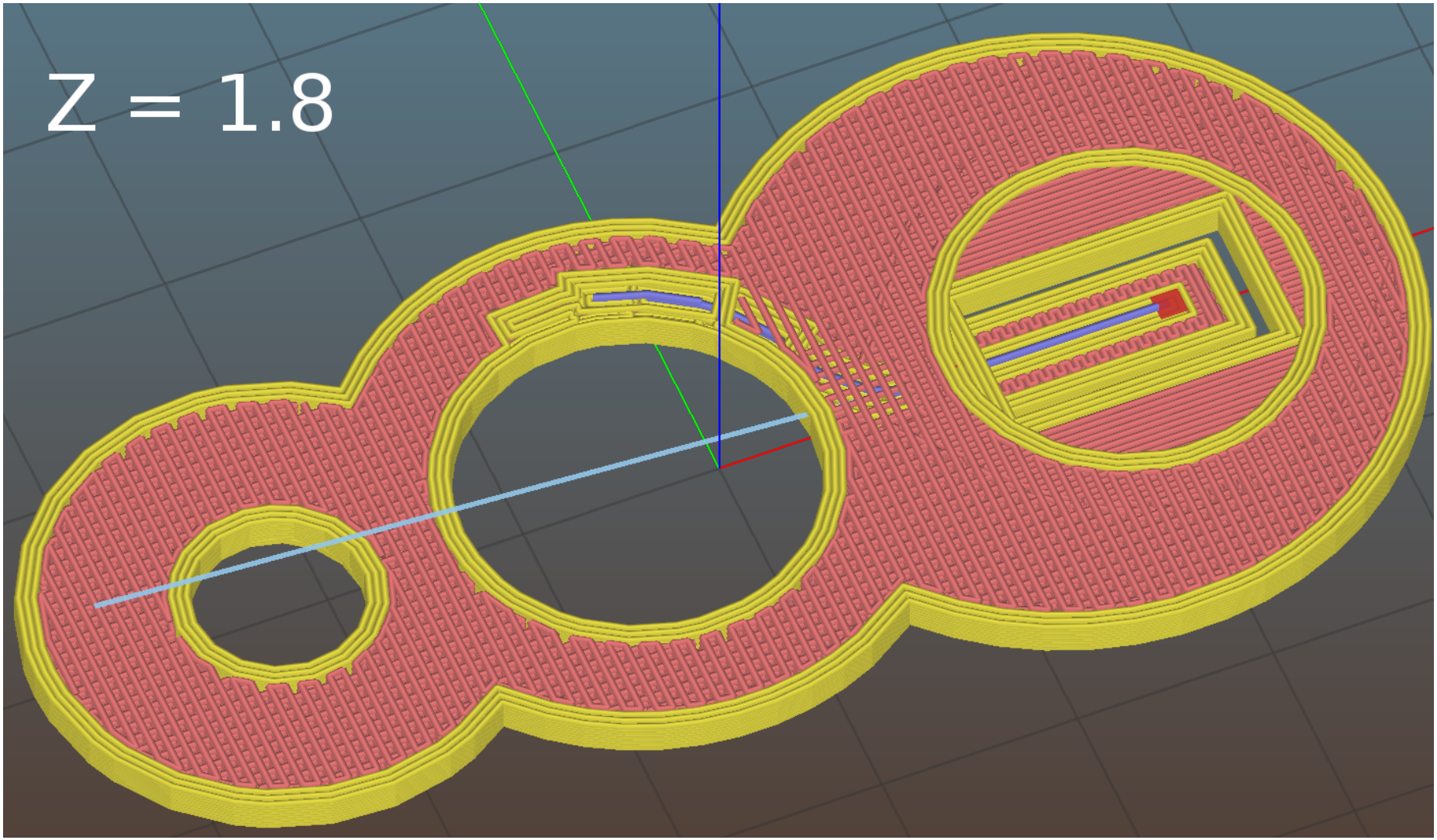

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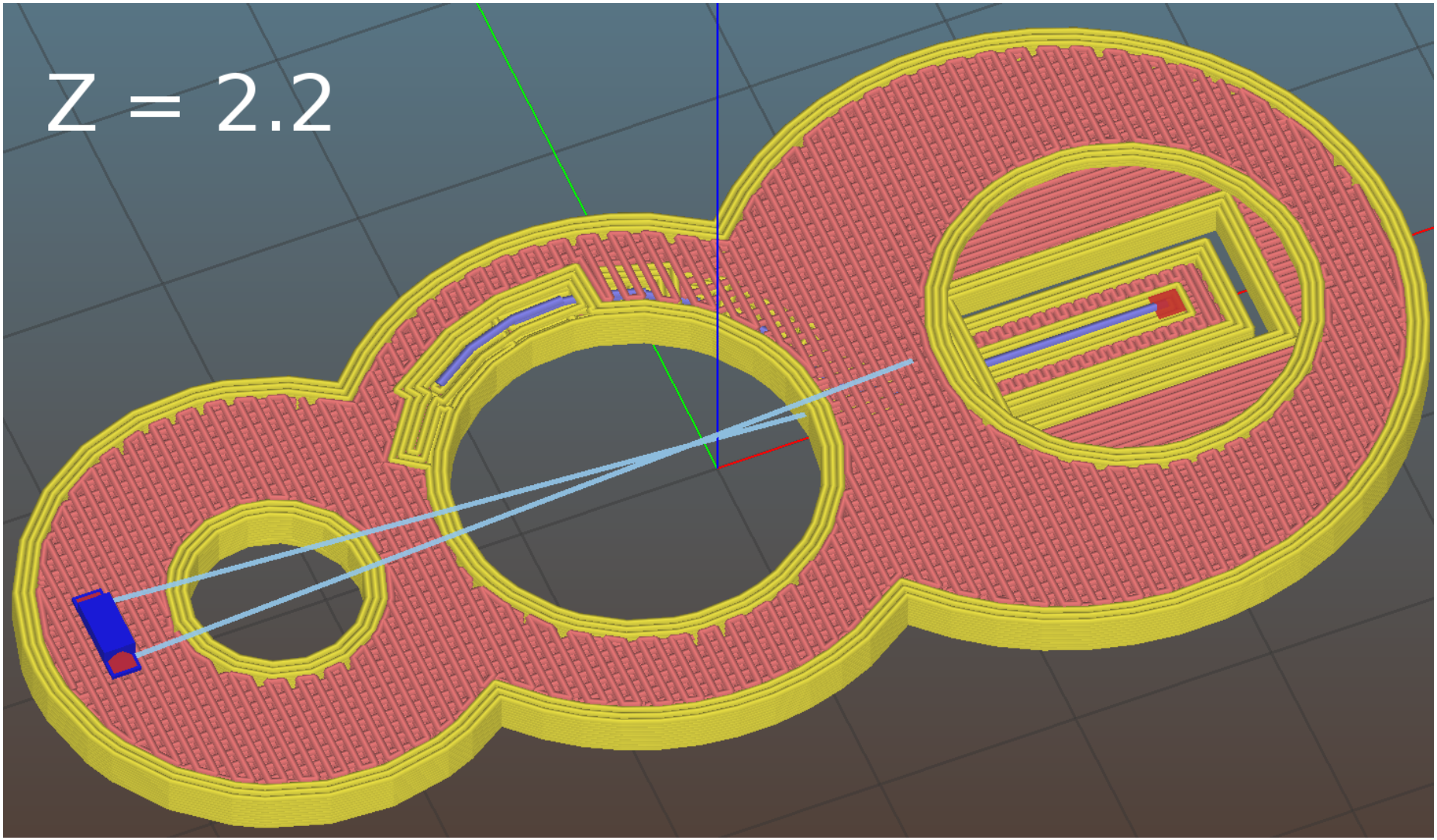

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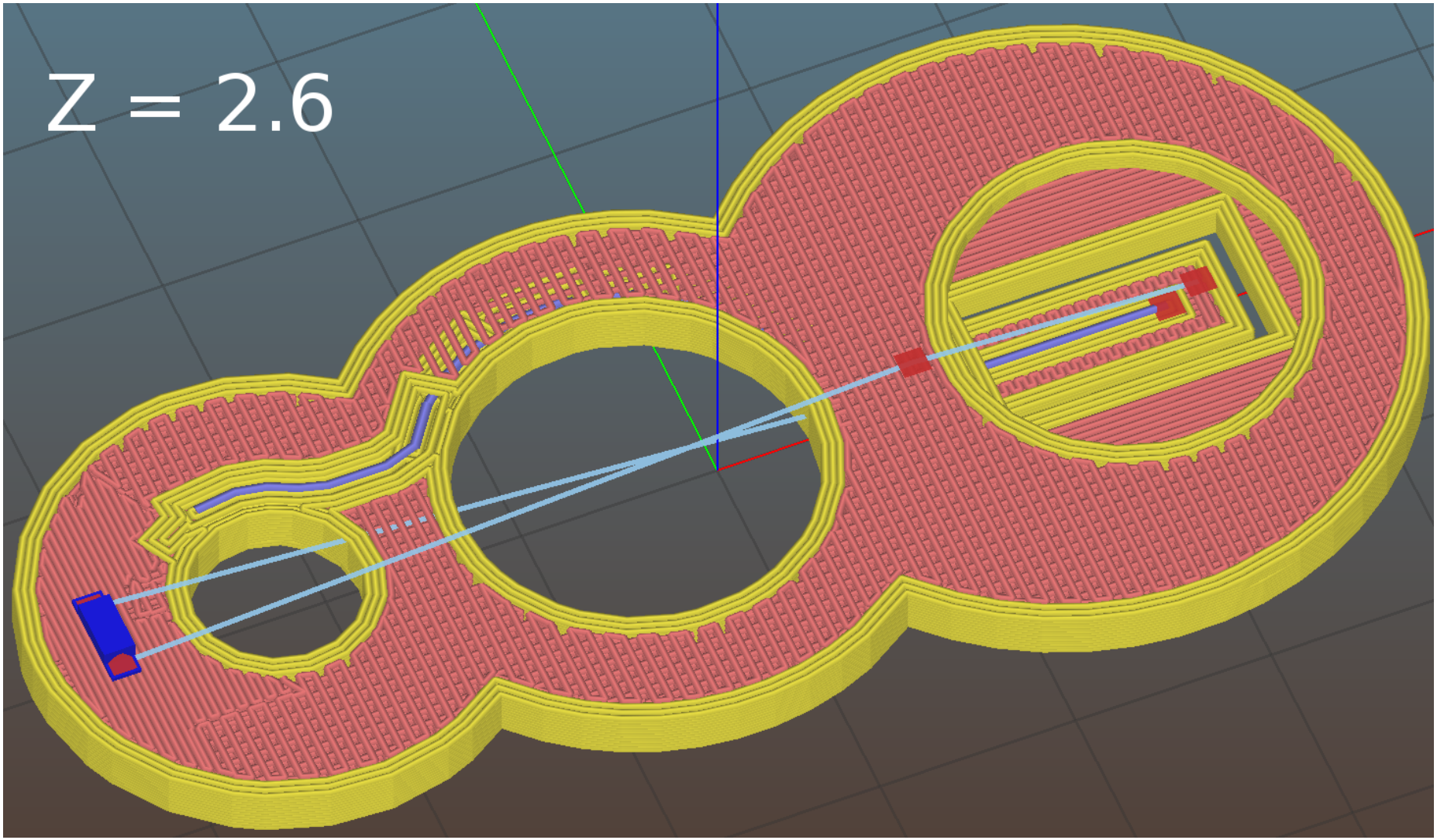

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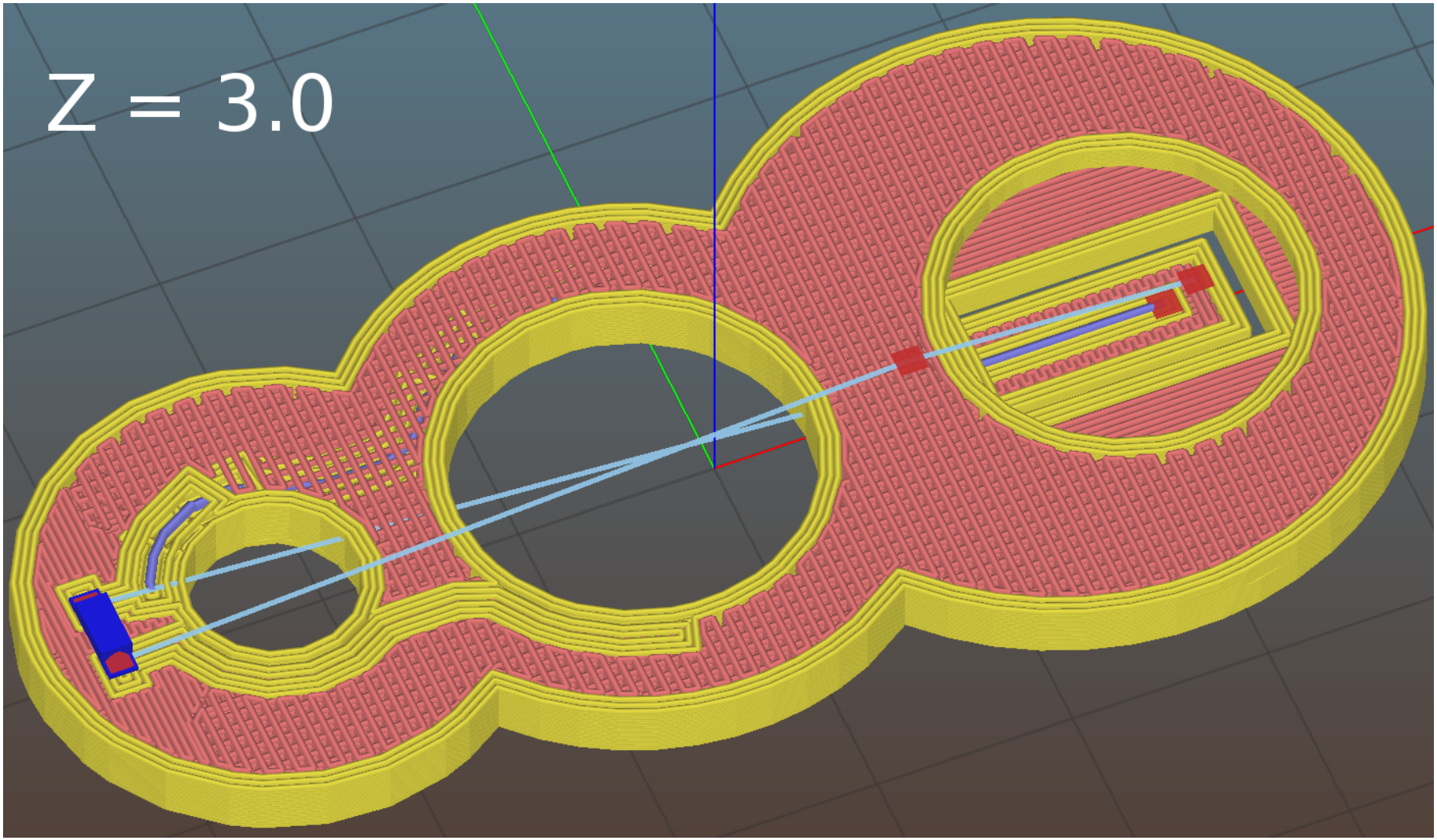

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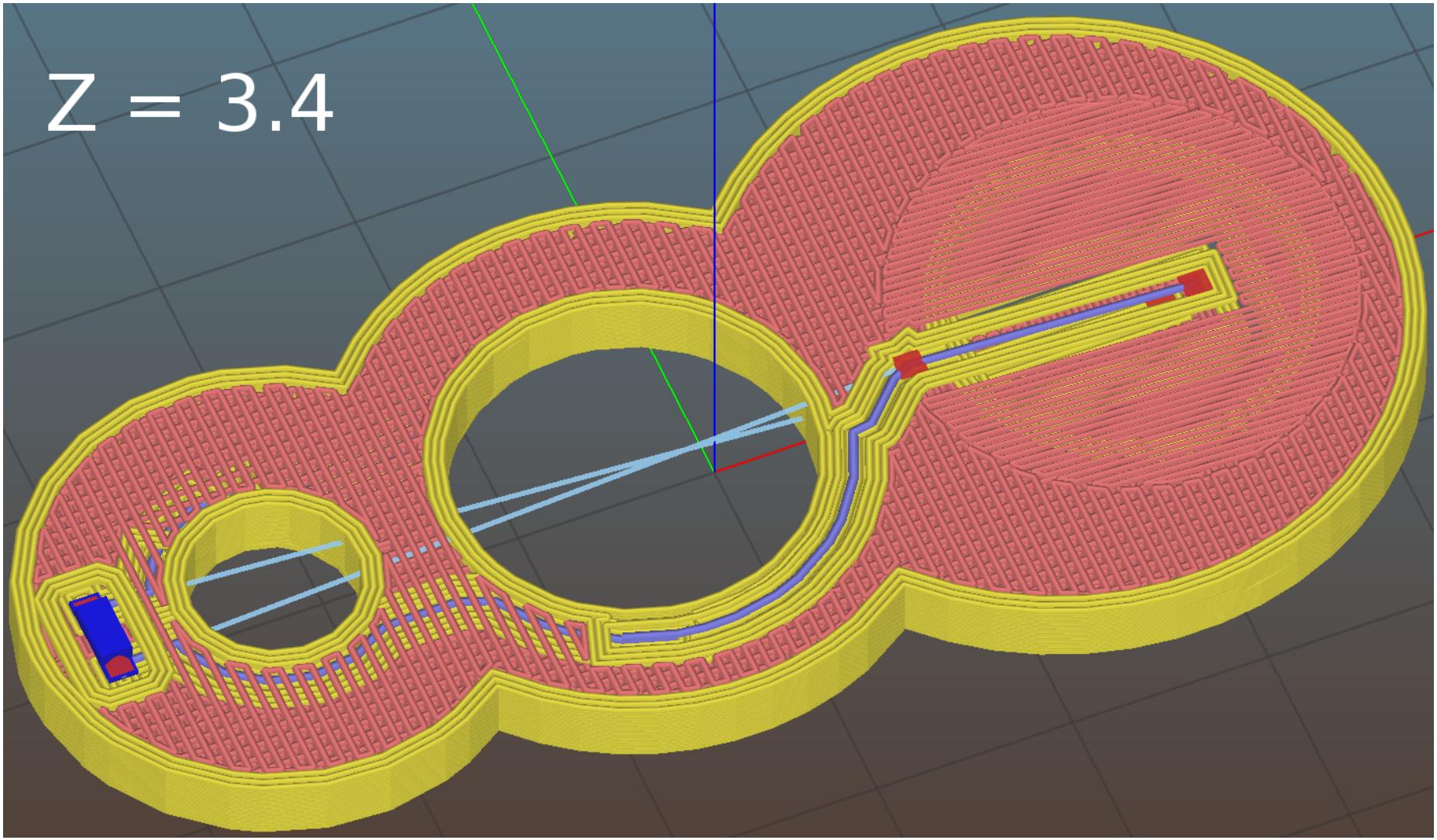

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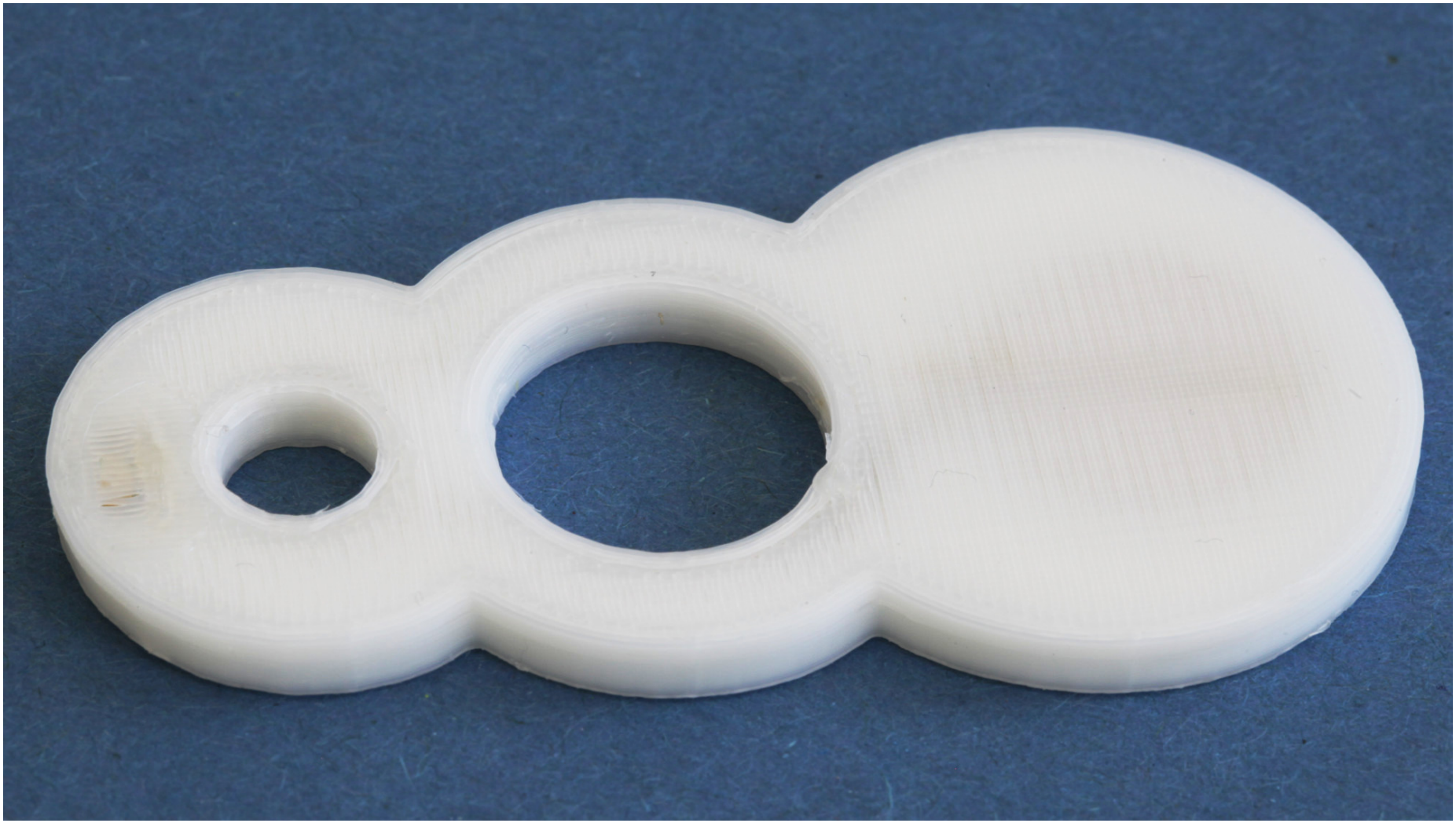
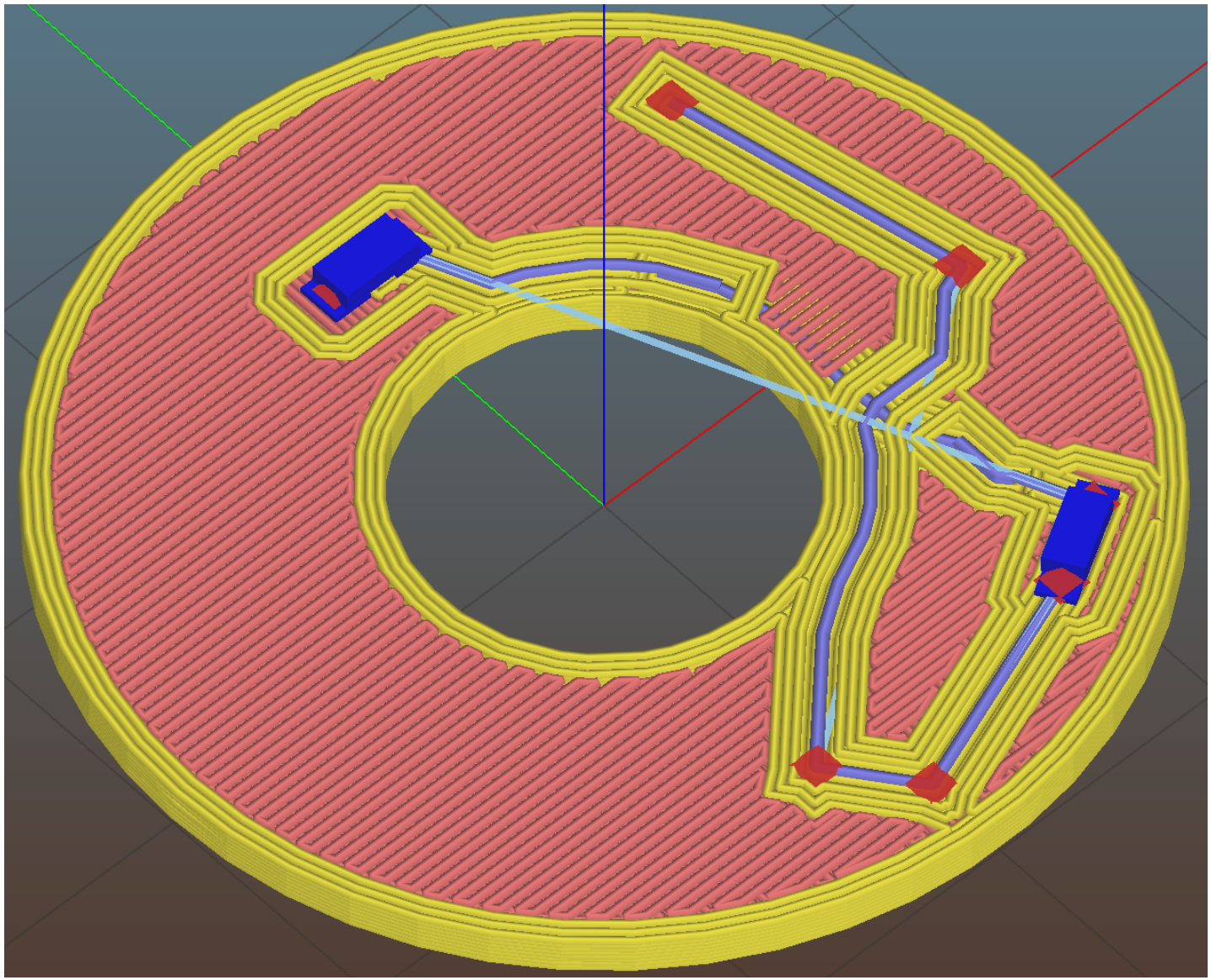


Wire collisions



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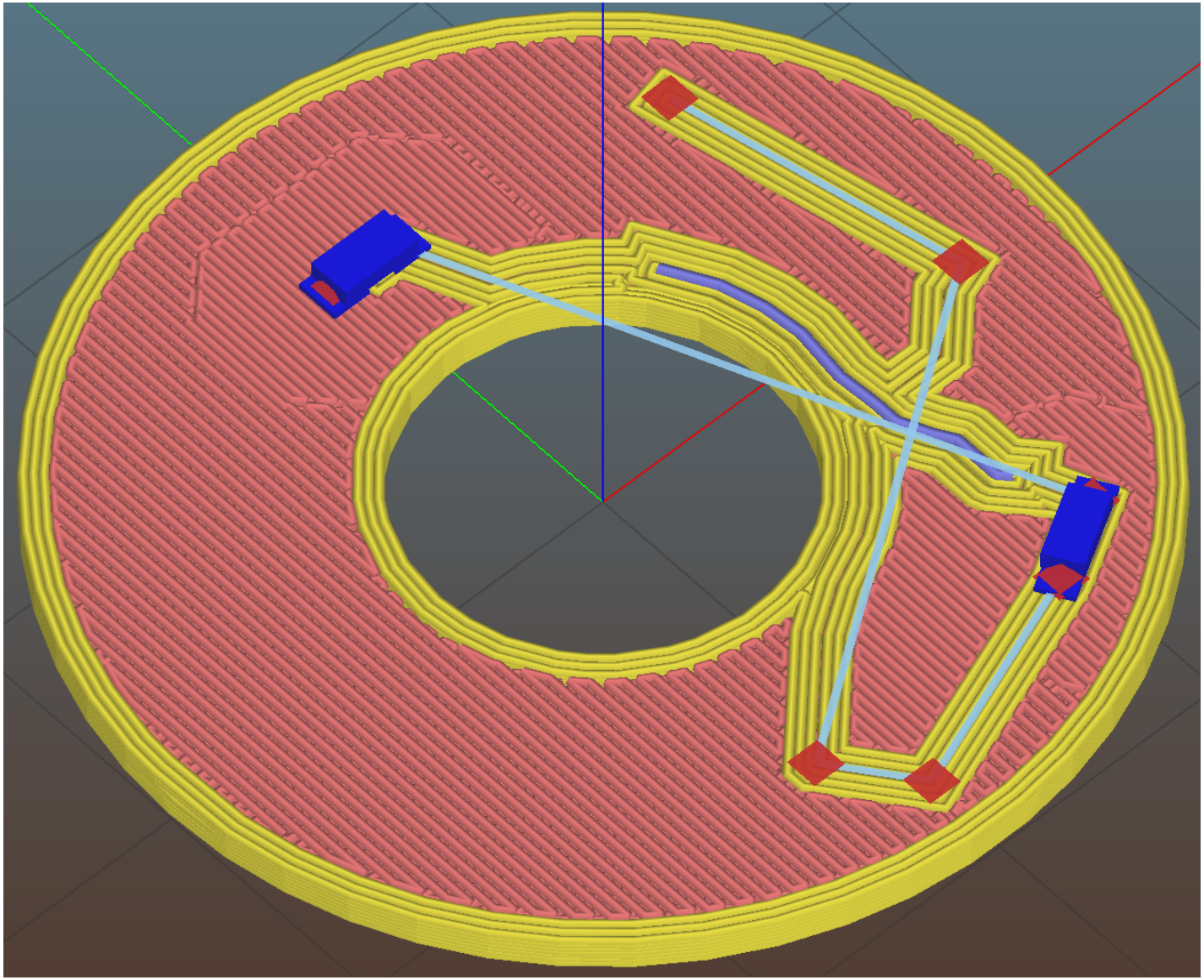

Q&A?

Download / Sourcecode:

tams.informatik.uni-hamburg.de/research/3d-printing/conductive_printing

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github.com/platsch/Slic3r