

# PCB for low-cost particle detector

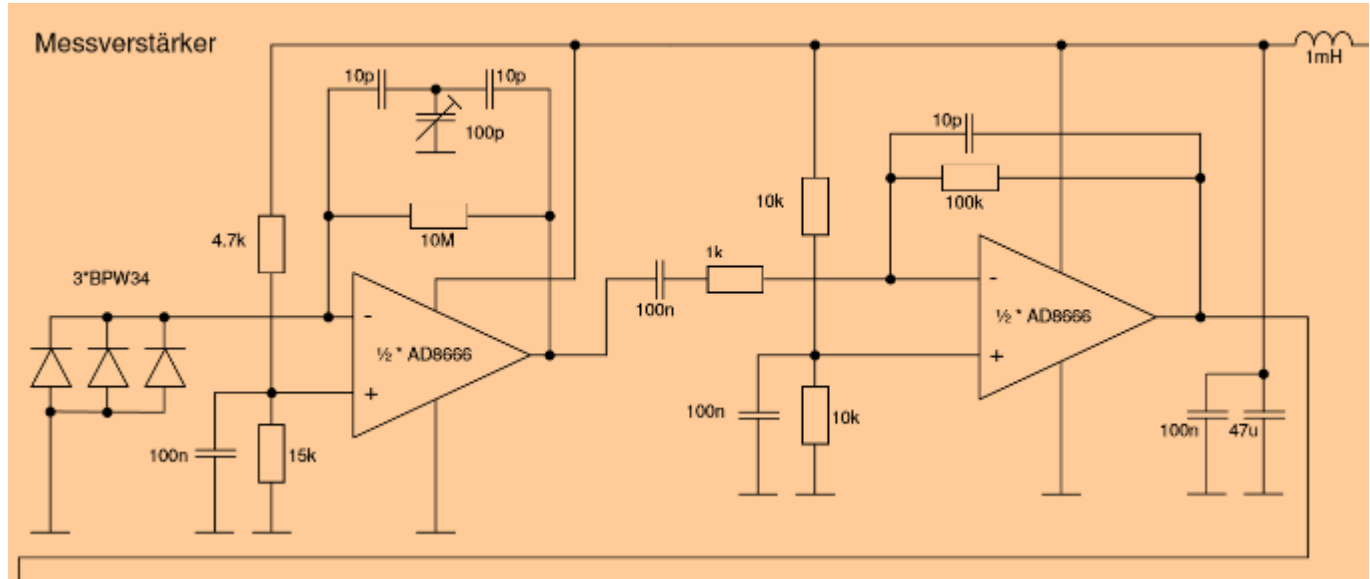
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Supervisors: Oliver Keller and Fabian Bernstein



# Original schematics

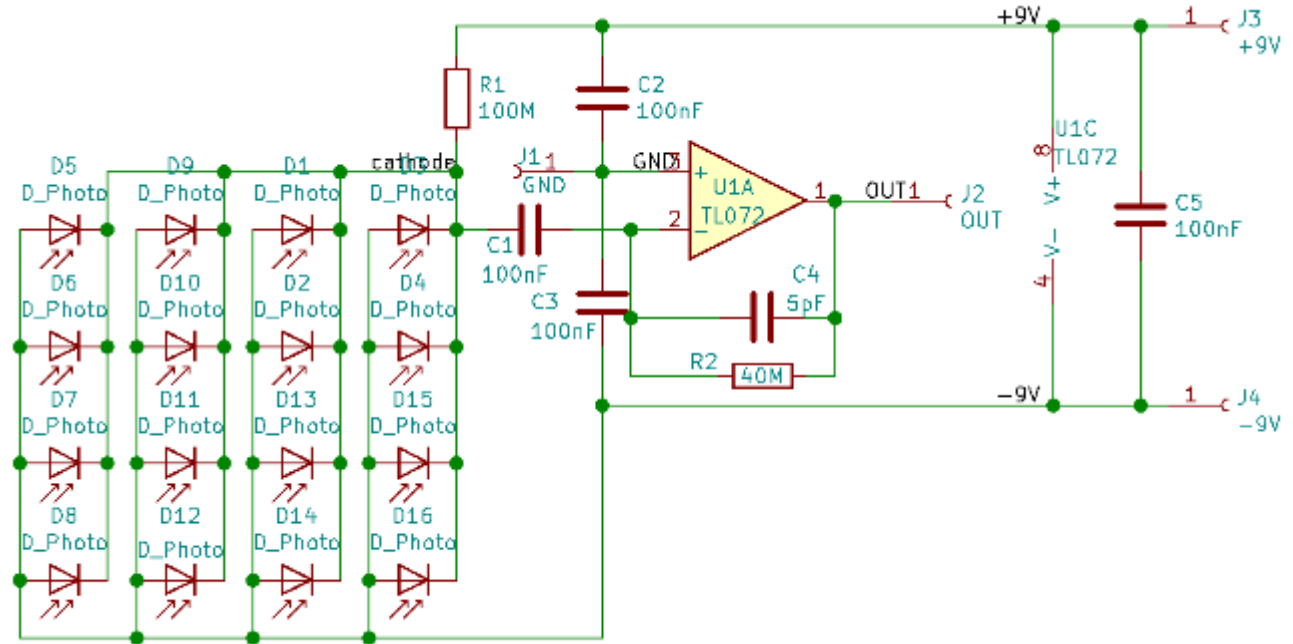
- Three diodes
- Two operational amplifiers
- One battery  
→ 9V



Stuttgarter Geigerle, <http://www.opengeiger.de/>

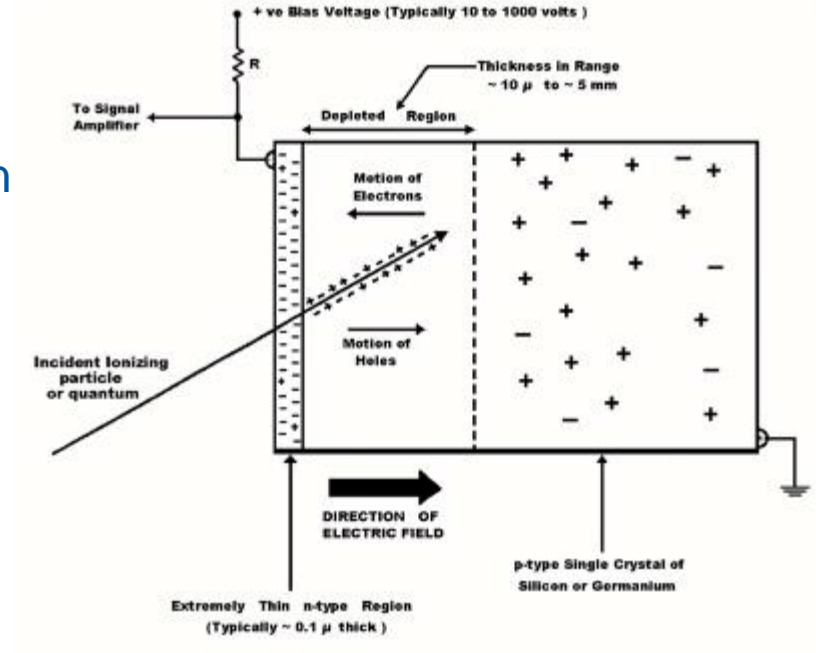
# Modified schematics

- Multiple BPW34 diodes
- One, simpler amplifier circuit
- Two batteries  
→ 18V



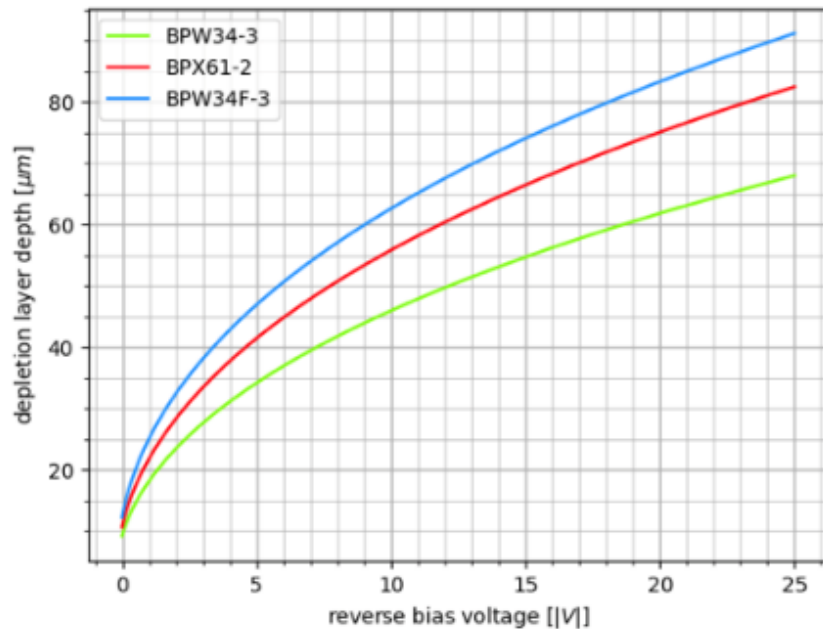
# Photodiodes

- Reverse operation
- Large non-conducting depleted region
- Ionising particles
  - Depleted region conducting
- Mostly  $\beta$  particles (few  $\gamma$ )



# Improvements

- Higher voltage
  - Wider depletion layer
  - More sensitive volume
- Simpler schematic
- Overall higher detection rate



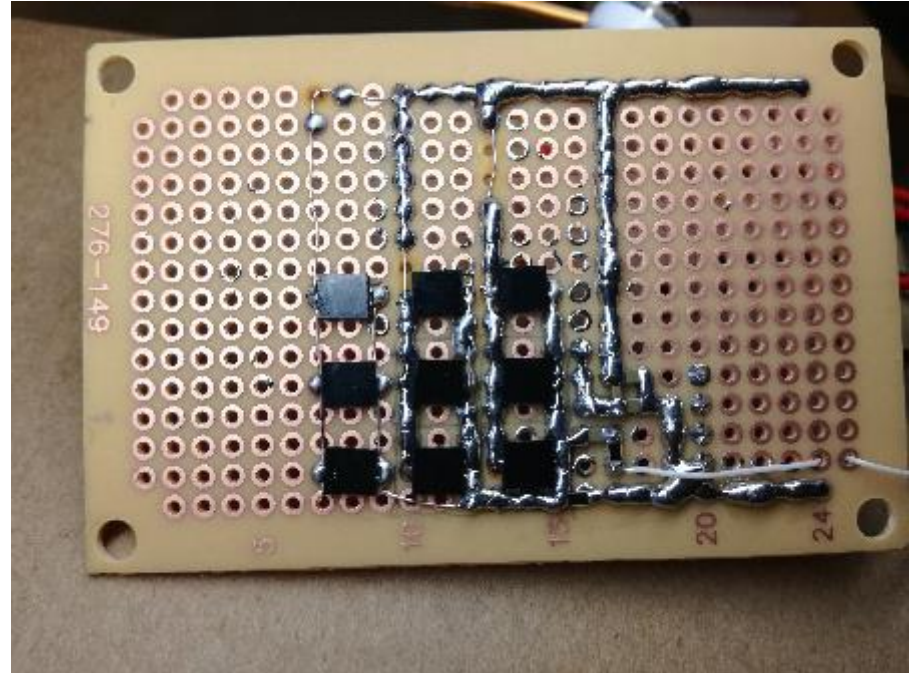
# Measurements

- No light
- Faraday cage
- Uranium glass

Configura tion	Total Counts per 10 mins	Diode Counts per 10 mins
2x2	509	127
3x3	757	84
2x2 old design	340	85

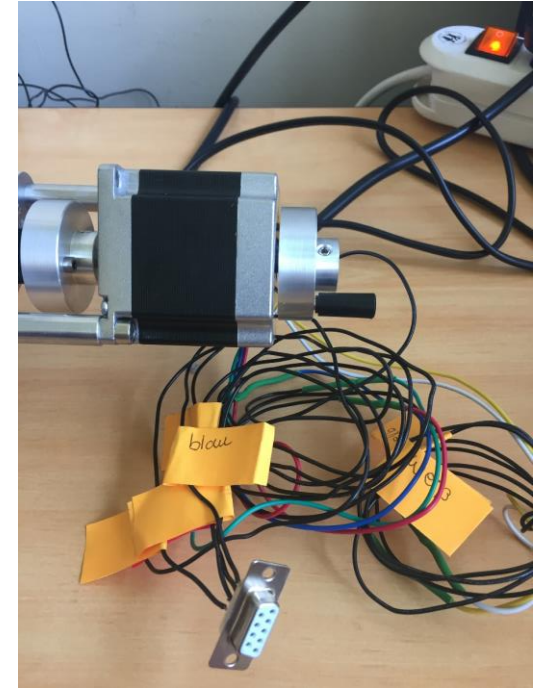
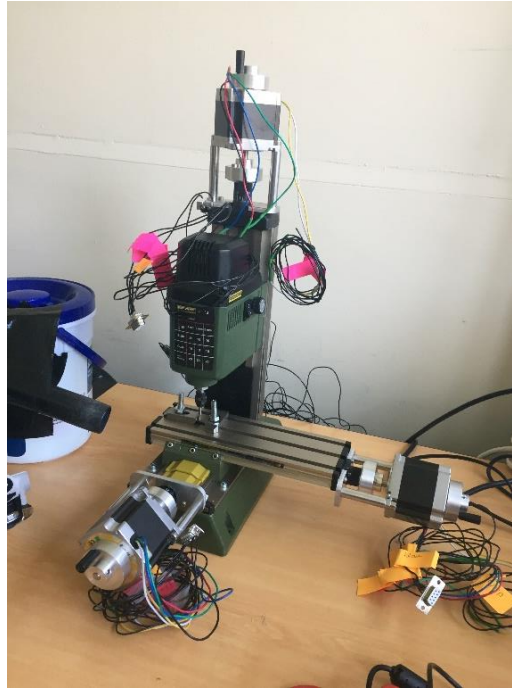


# PCB vs. Perfboard



# Conversion of the milling machine

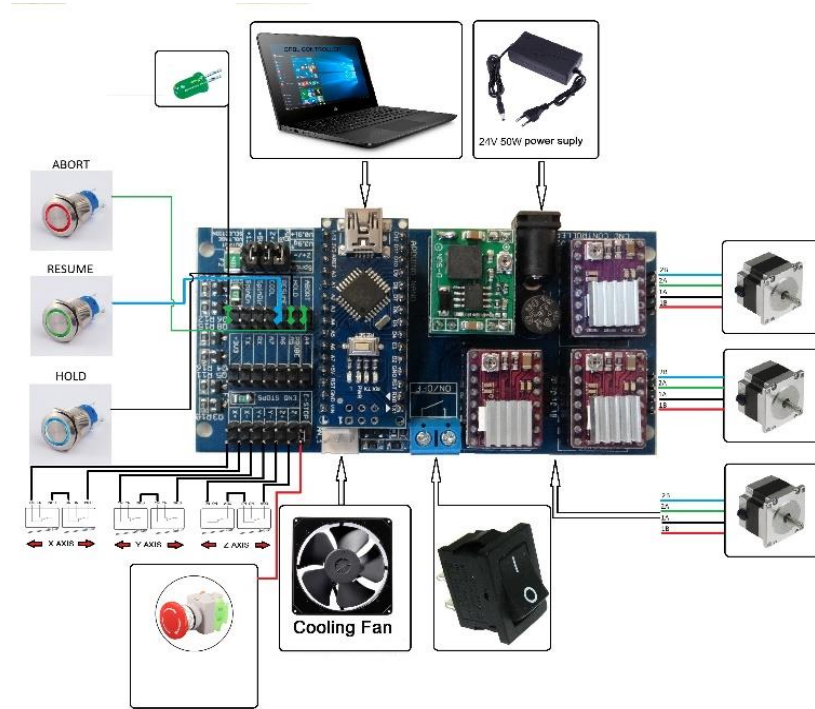
- Actuator motors
- Limit switches
- GRBL controller





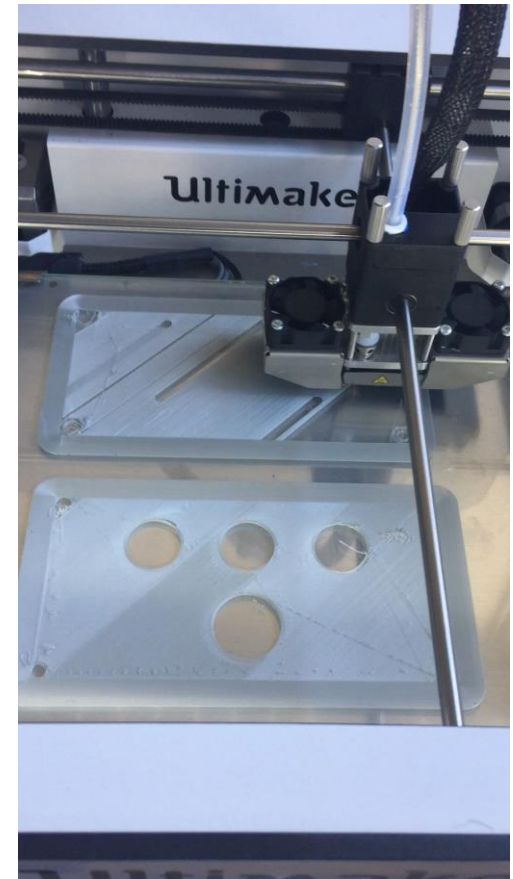
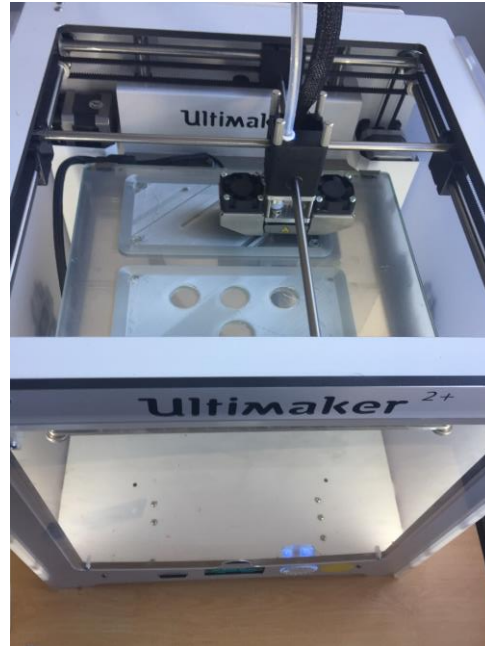
# Assembling the GRBL controller

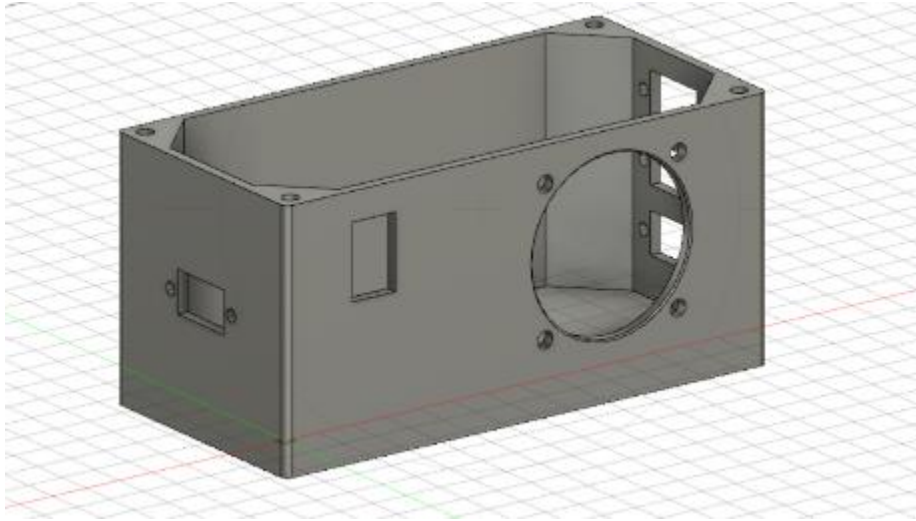
- 24V 50W power supply
- Actuator motors
- Arduino Nano V3 for computer connection
- Switches for abort, resume and hold
- ON/OFF switch
- Emergency stop switch
- Cooling fan
- Limit switches



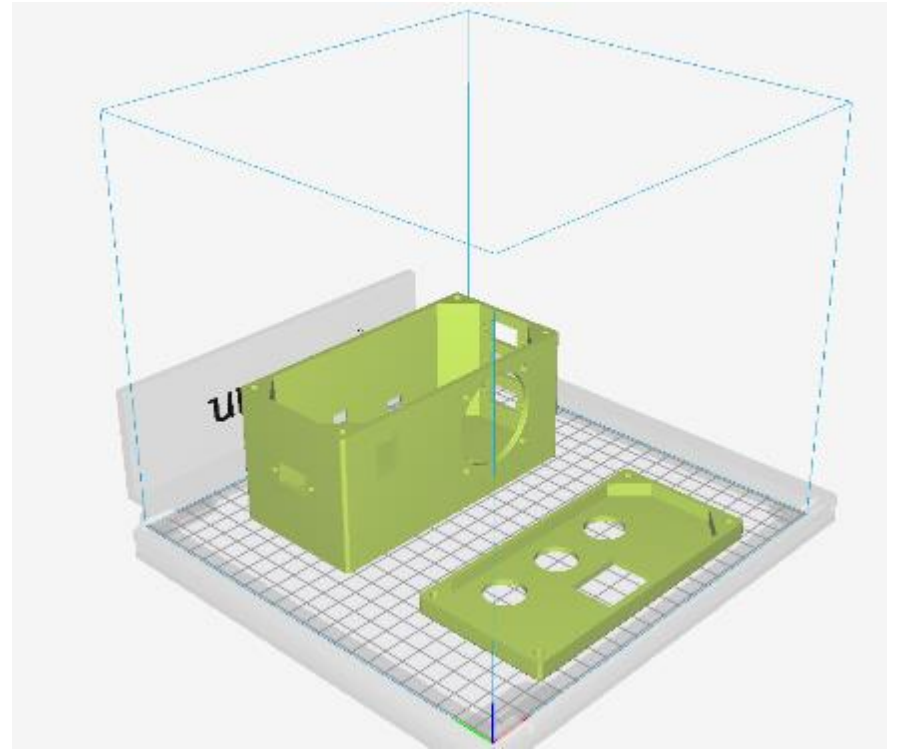
# Design of the casing

- Fusion 360
- Ultimaker cura
- 3D Ultimaker 2+ printer



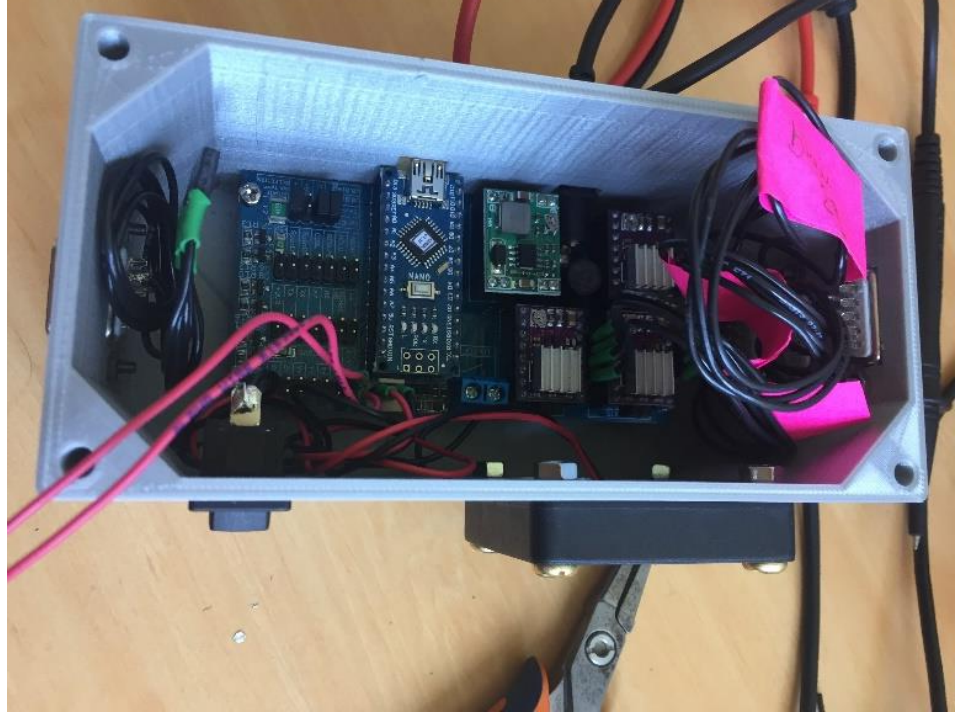


Fusion 360 (CAD)



Cura (CAM)

# Casing with integrated controller



# G-code

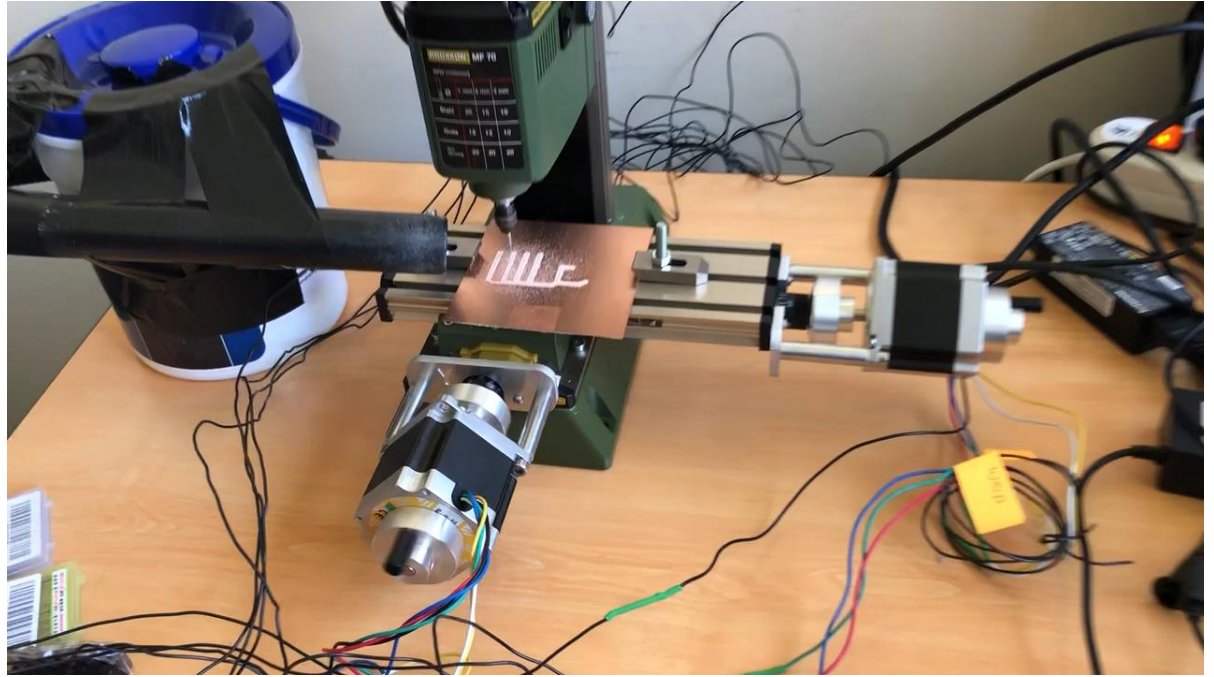
- Used mainly in computer-aided manufacturing to control automated machine tools like a CNC milling machine or a 3D printer
- It is the most widely used numerical control (NC) programming language

```
G01 X0.7093 Y0.6241 F80
G01 X0.7093 Y0.7512
G01 X0.7101 Y0.7370
G01 X0.7125 Y0.7229
G01 X0.7165 Y0.7092
G01 X0.7219 Y0.6961
G01 X0.7288 Y0.6836
G01 X0.7371 Y0.6720
G01 X0.7466 Y0.6614
G01 X0.7572 Y0.6519
G01 X0.7688 Y0.6436
G01 X0.7813 Y0.6367
G01 X0.7944 Y0.6313
G01 X0.8081 Y0.6273
G01 X0.8222 Y0.6249
G01 X0.8364 Y0.6241
```

G-code from the CNC milling machine



# Production of the circuit board





Thanks for CERN, our mentors and your attention