

Open source 3D multipurpose measurement
system for electromagnetic and acoustic field
mapping

**COSI
Measure**

Final

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- Demo of the machine
- Introduction
- Mechanical build
- Electronics
- Firmware
- Upgrades
- Future

Demo
Demo
Demo
Demo
Demo

Introduction

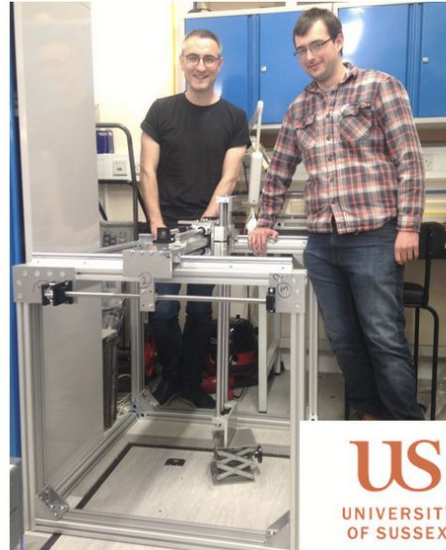
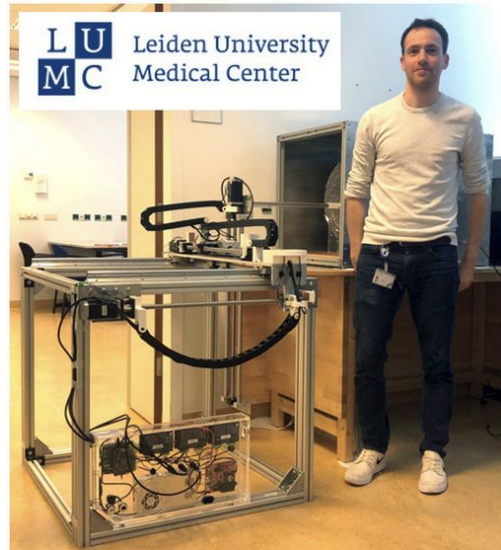
- Automatic measurement system with large volume
 - Map electromagnetic or ultrasound fields
 - Needs for high precision positioning (tens of microns)
 - Enough volume
 - Size limited by door size
- Replace current system using off-the-shelve CNC machine
- Future uses for MRI elmag field measurement

- Commercial measurement system
 - Price of tens of thousands CHF
 - Less versatile
 - Very high precision



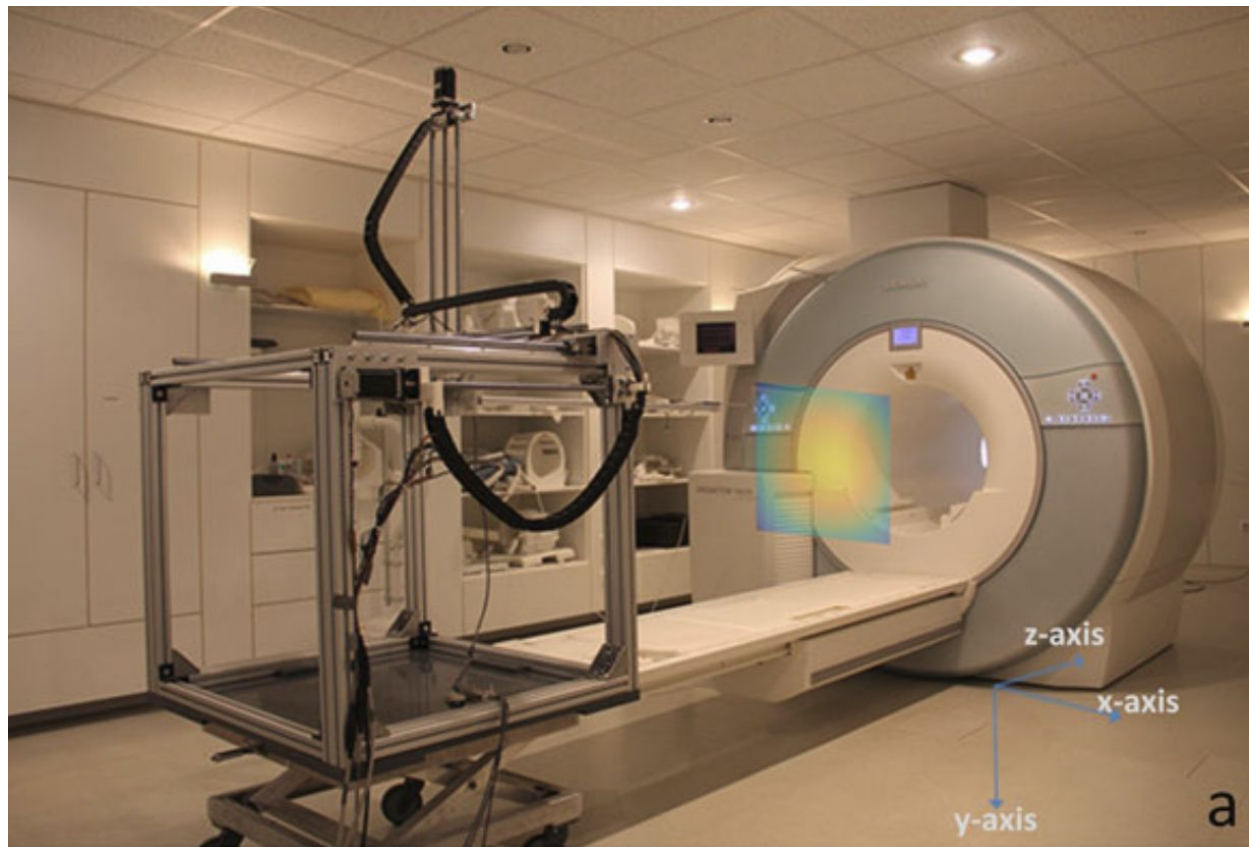
[Han H. Moritz R. Oberacker E. Waiczies H. Niendorf T and Winter L. "Open Source 3D Multipurpose Measurement System with Submillimetre Fidelity and First Application in Magnetic Resonance", Nature Scientific Reports. 7:13452. 2017](#)

- Open source COSI measure project
 - Costs of components: ~4000 CHF



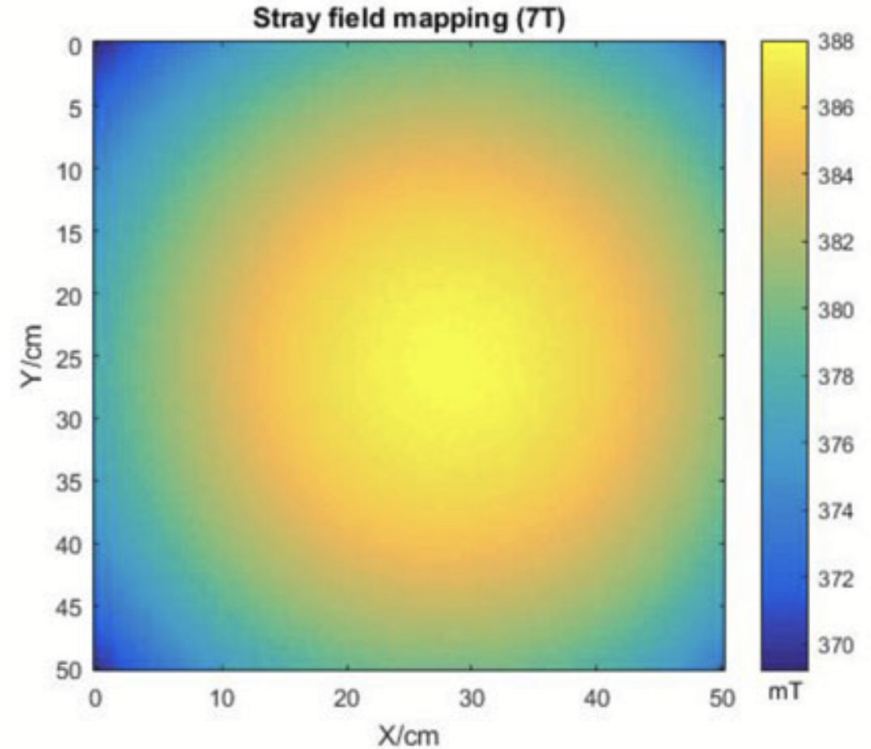
- Can accept various attachments at the end effector
 - hydrophones
 - magnetometers / hall sensor
 - other sensors (E field, temperature)
 - laser engraver / drill

- MRI



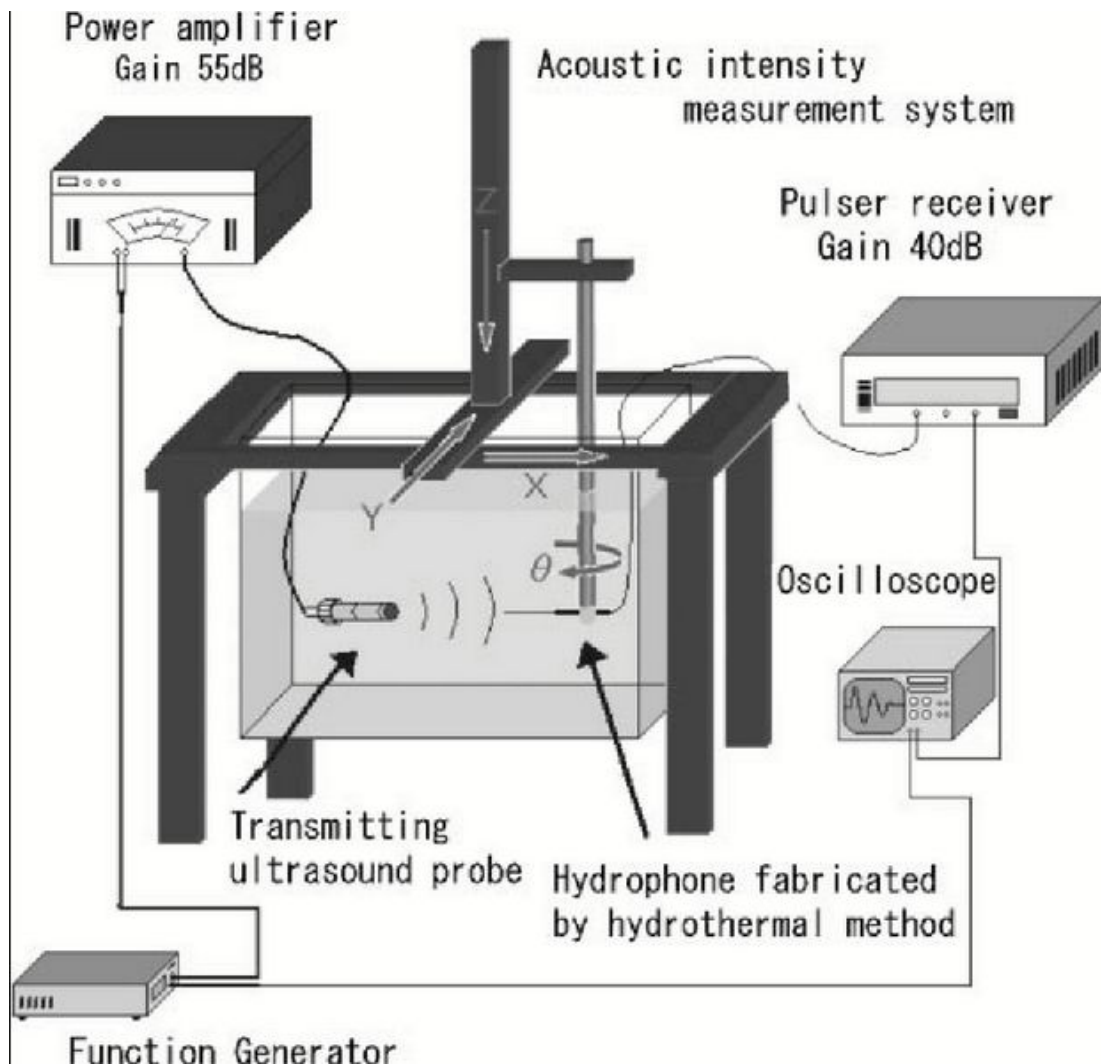
MRI

- Magnet
- Gradient coil
- RF coil characterisation
- Implant safety measurement



Applications

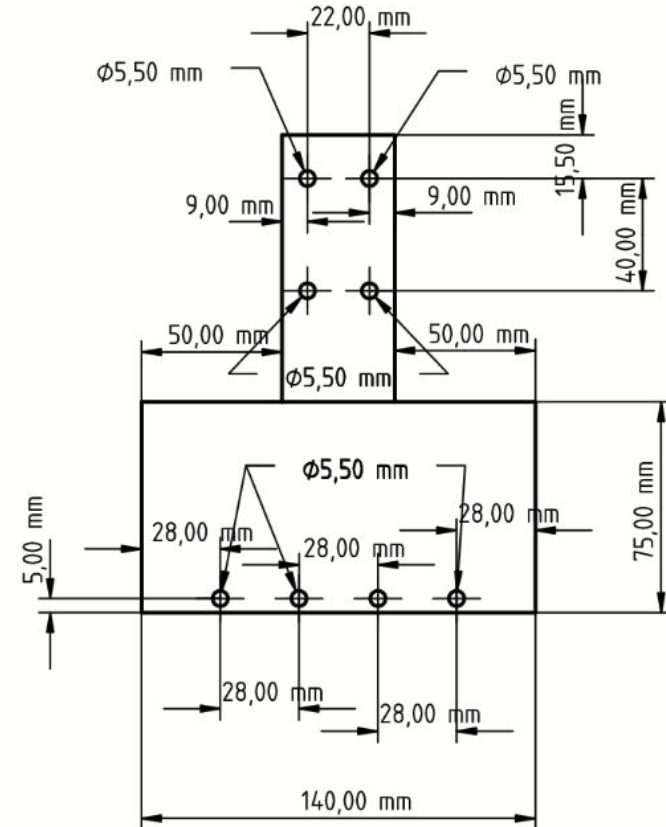
- Hydrophone sensor
- Ultrasound field

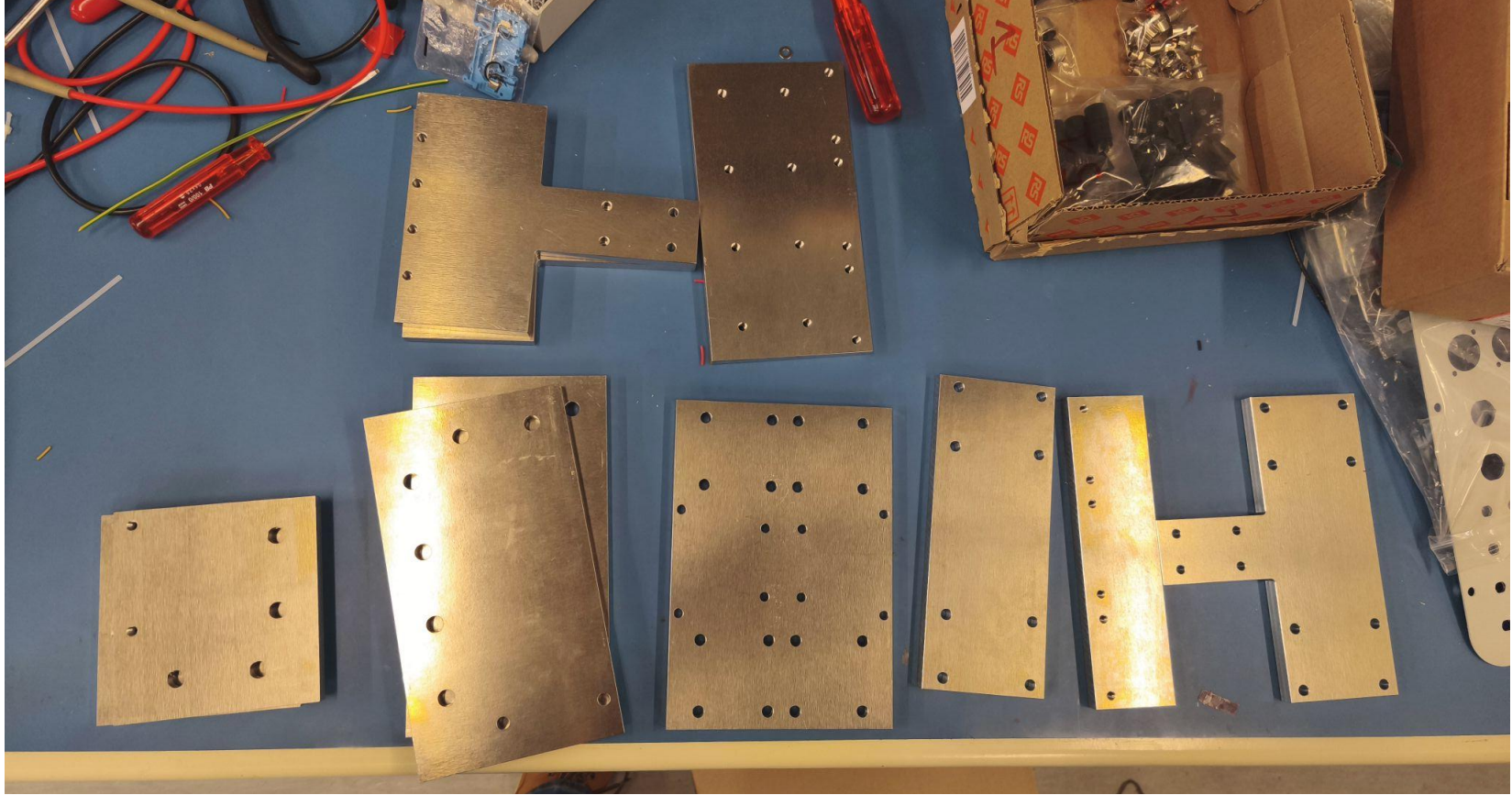


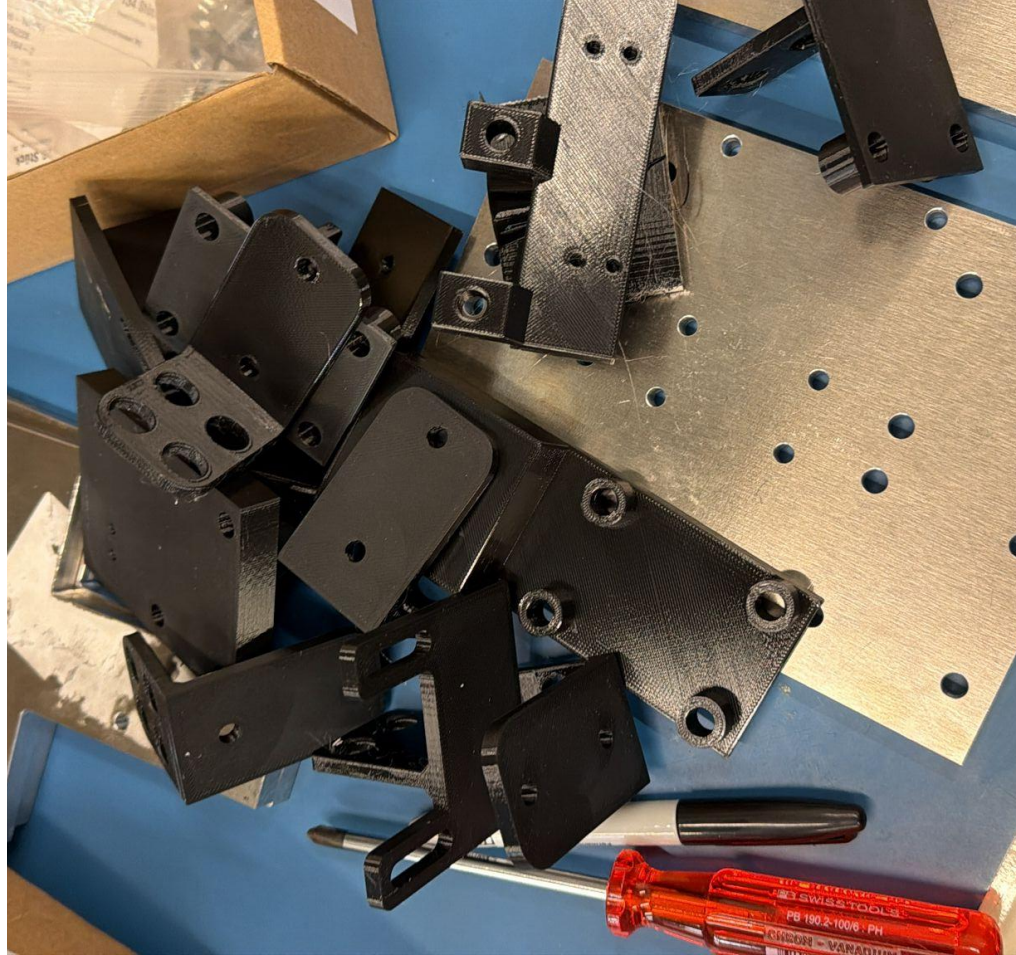
Mechanical build



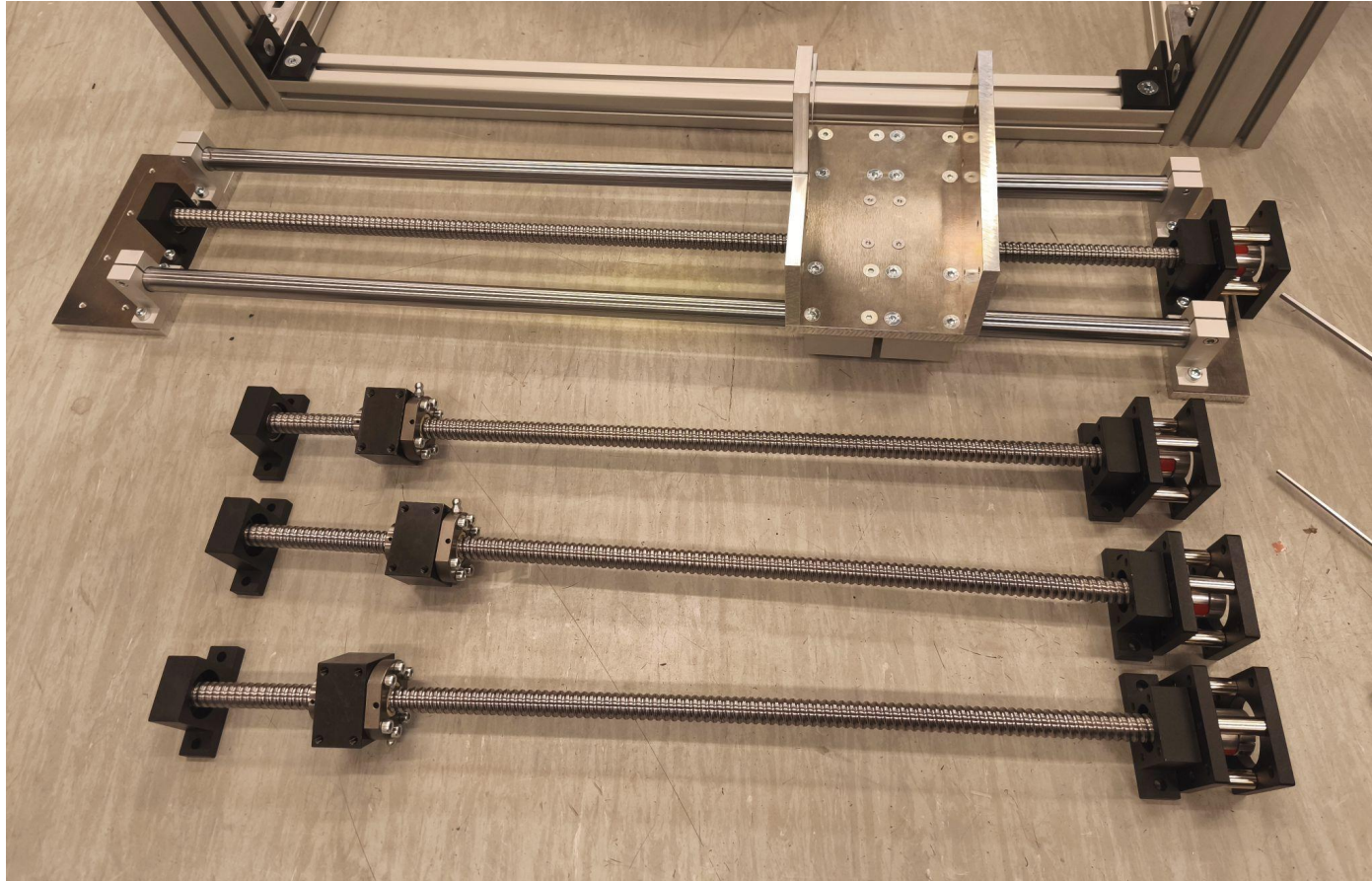
- Revise drawings for aluminum plates
- Machined at EPFL workshop
- Edit 3D models for parts (Motors, belts sensors)
- Print parts at 3D printer





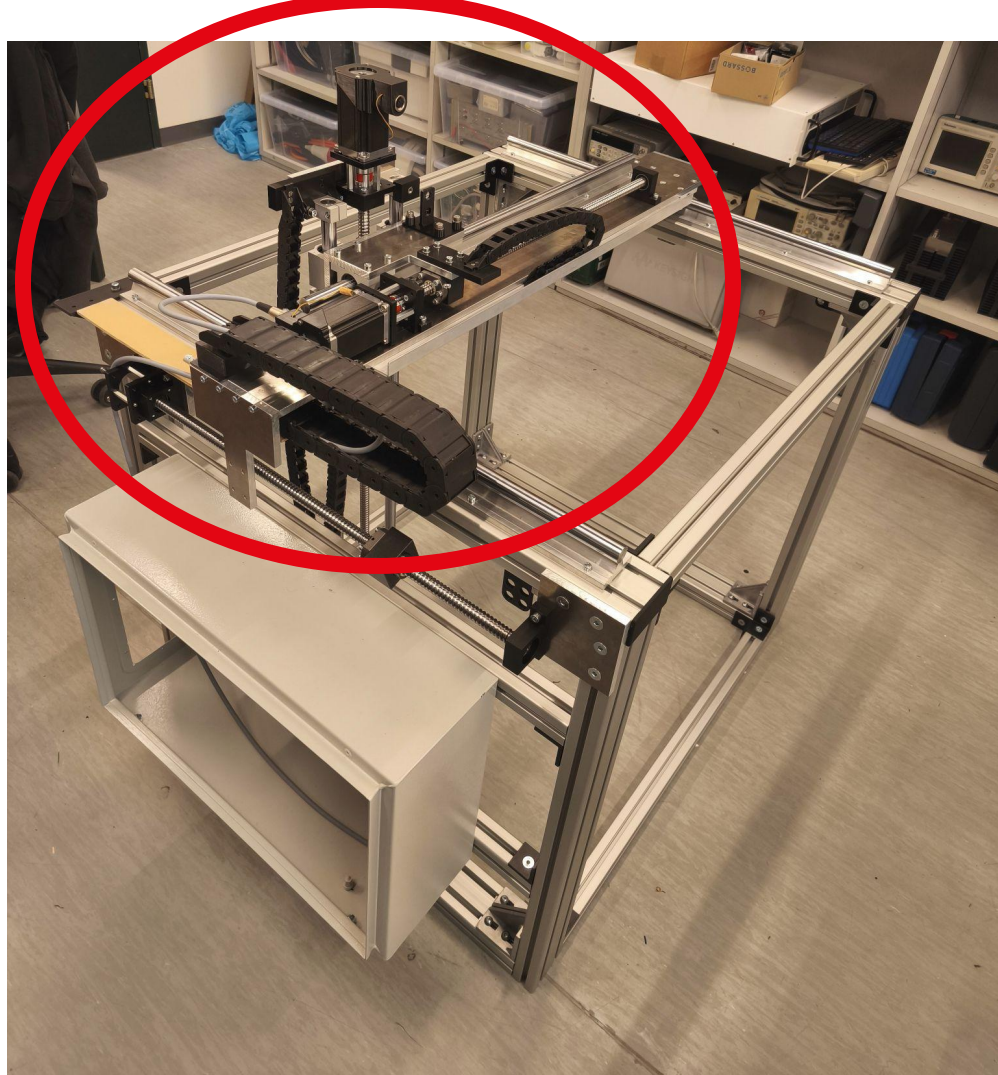


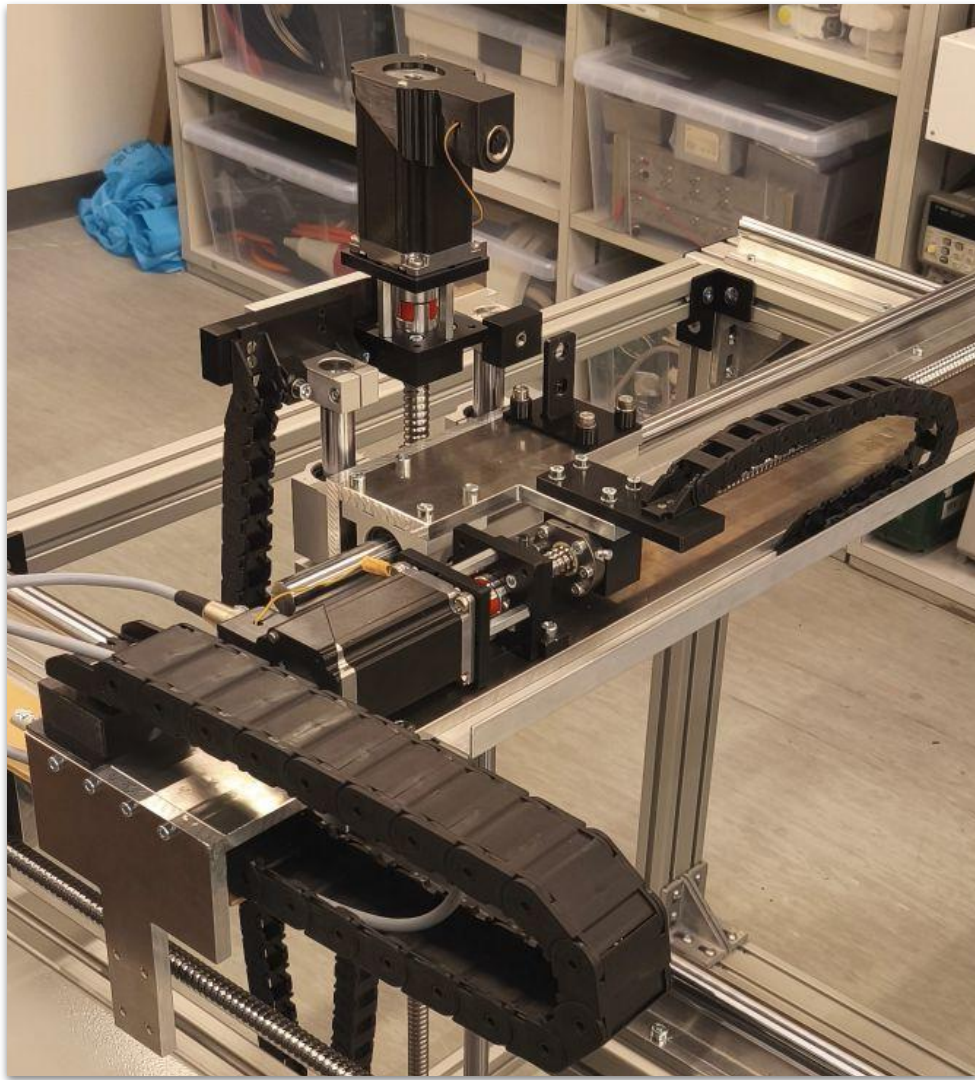






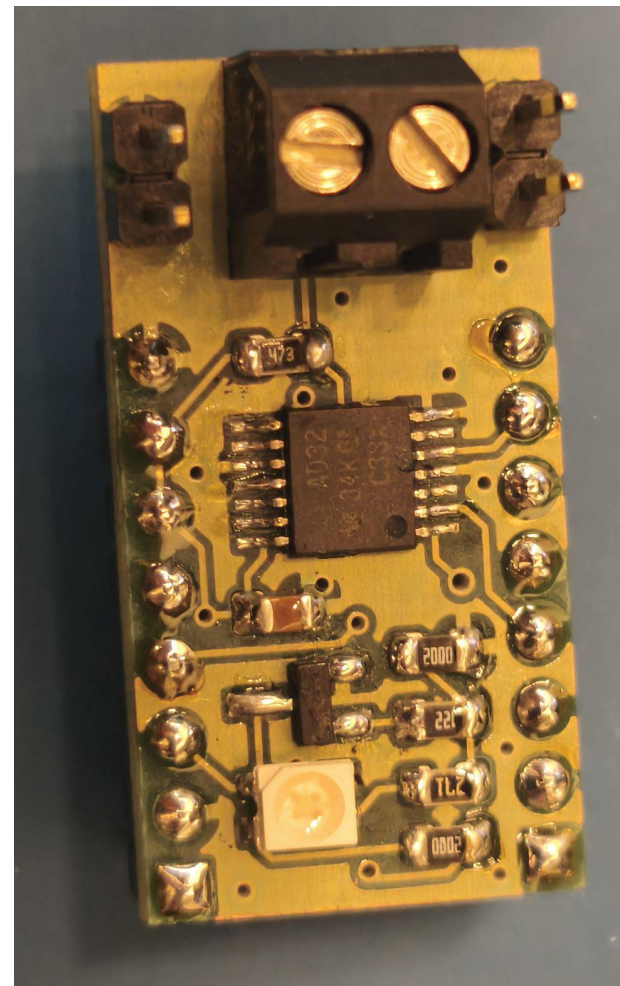


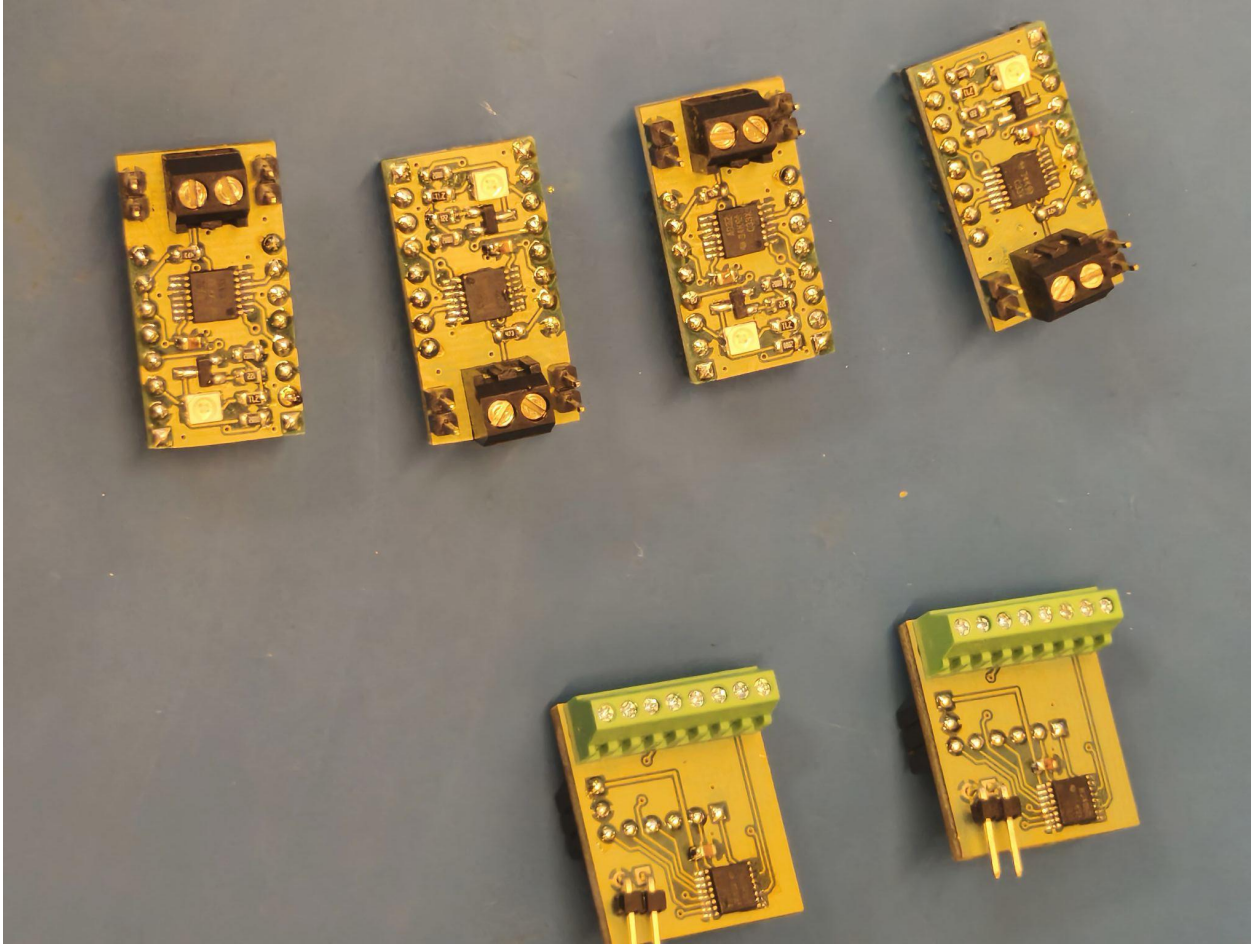


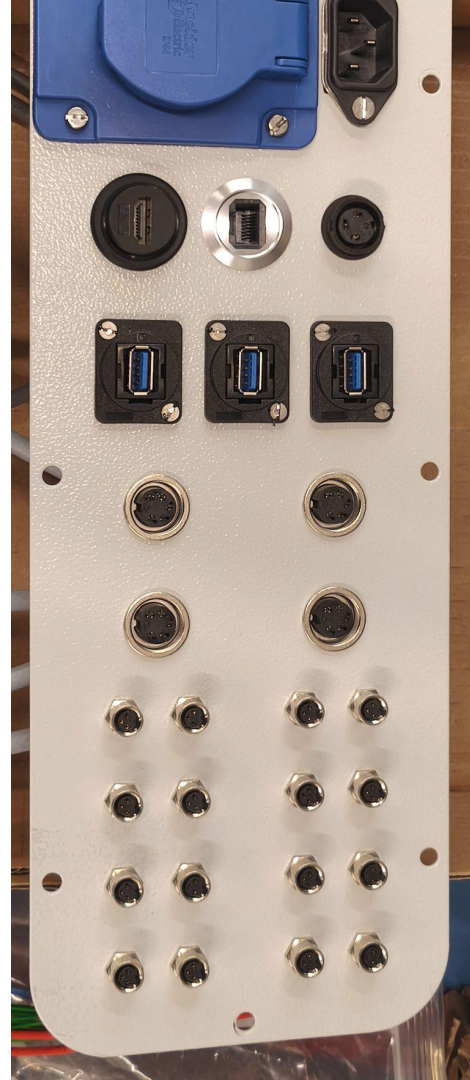
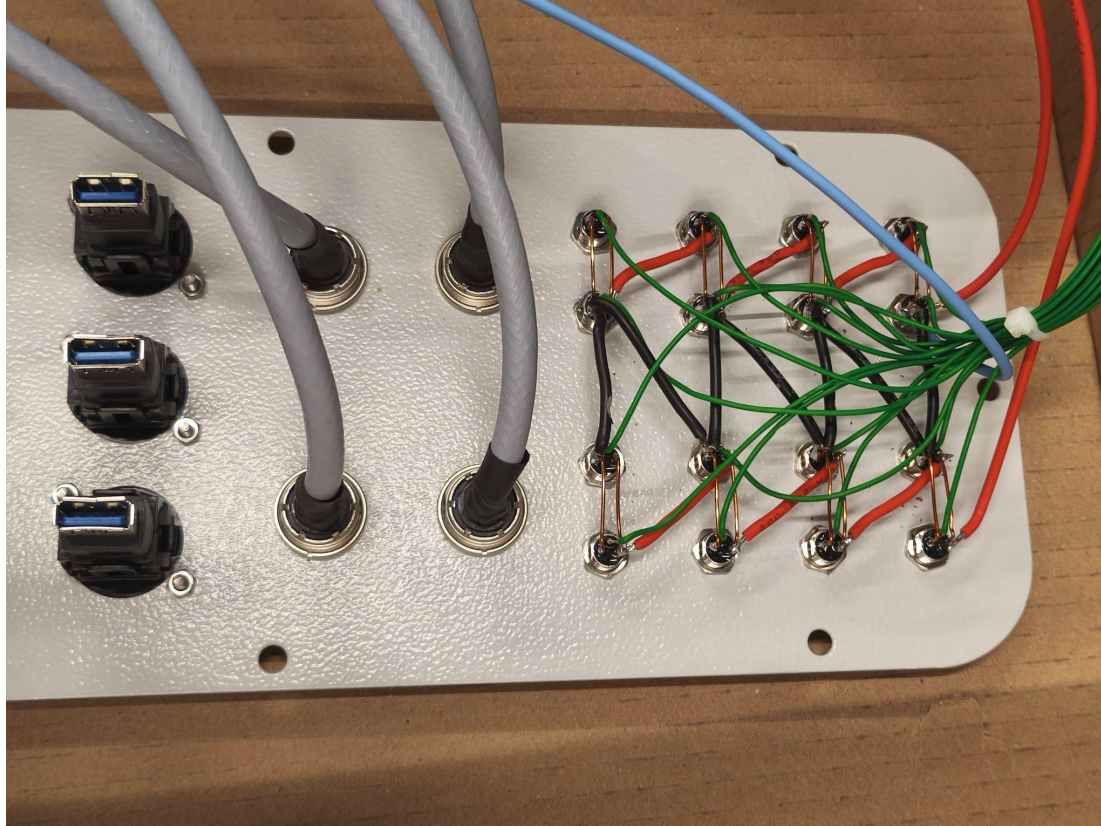


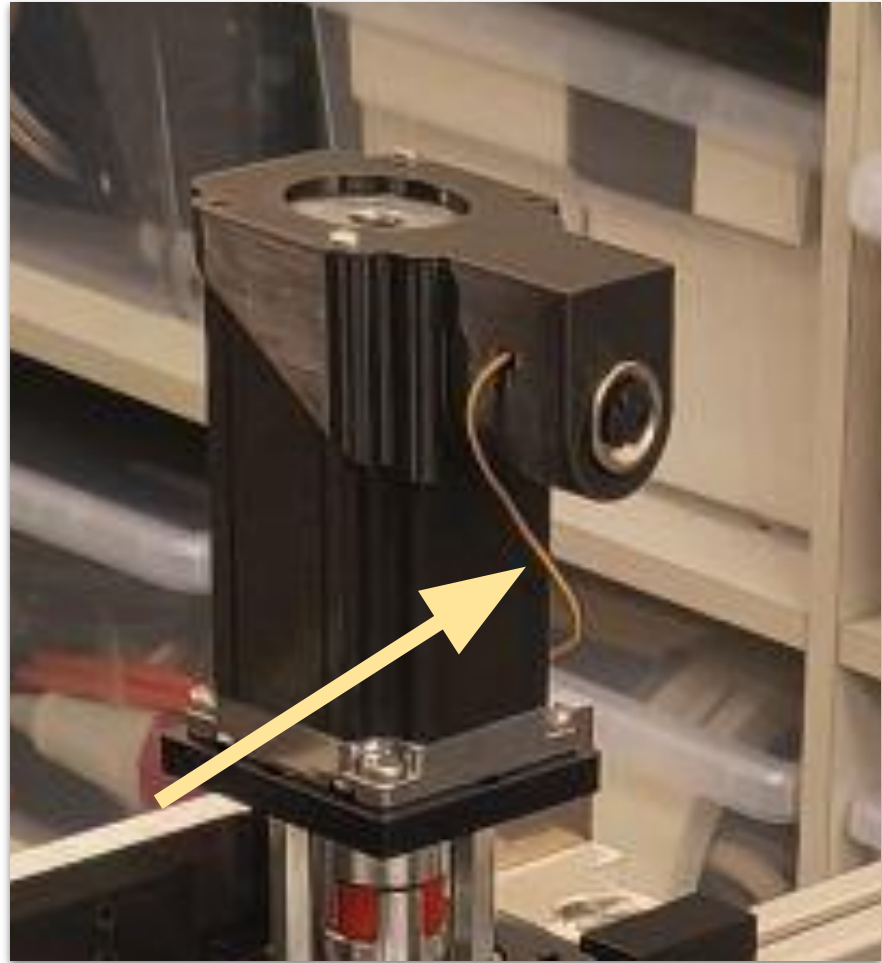
Electronics

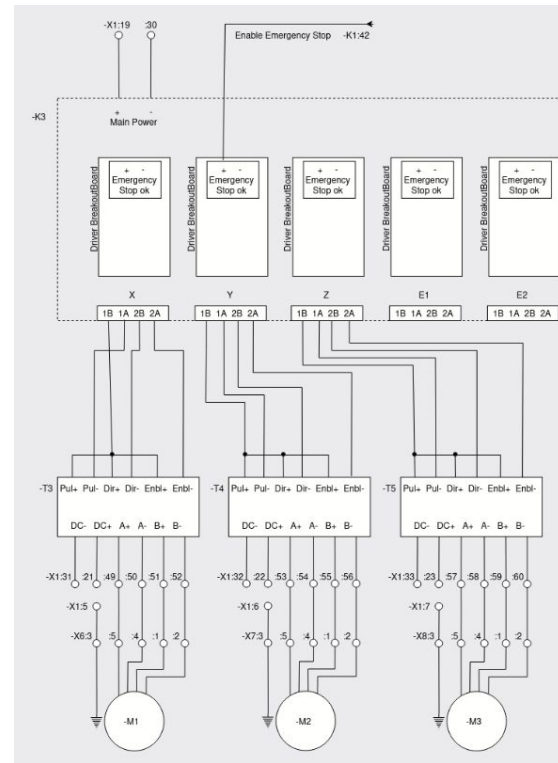
- PCBs manufactured at EPFL
- Soldering of PCBs with SMD parts

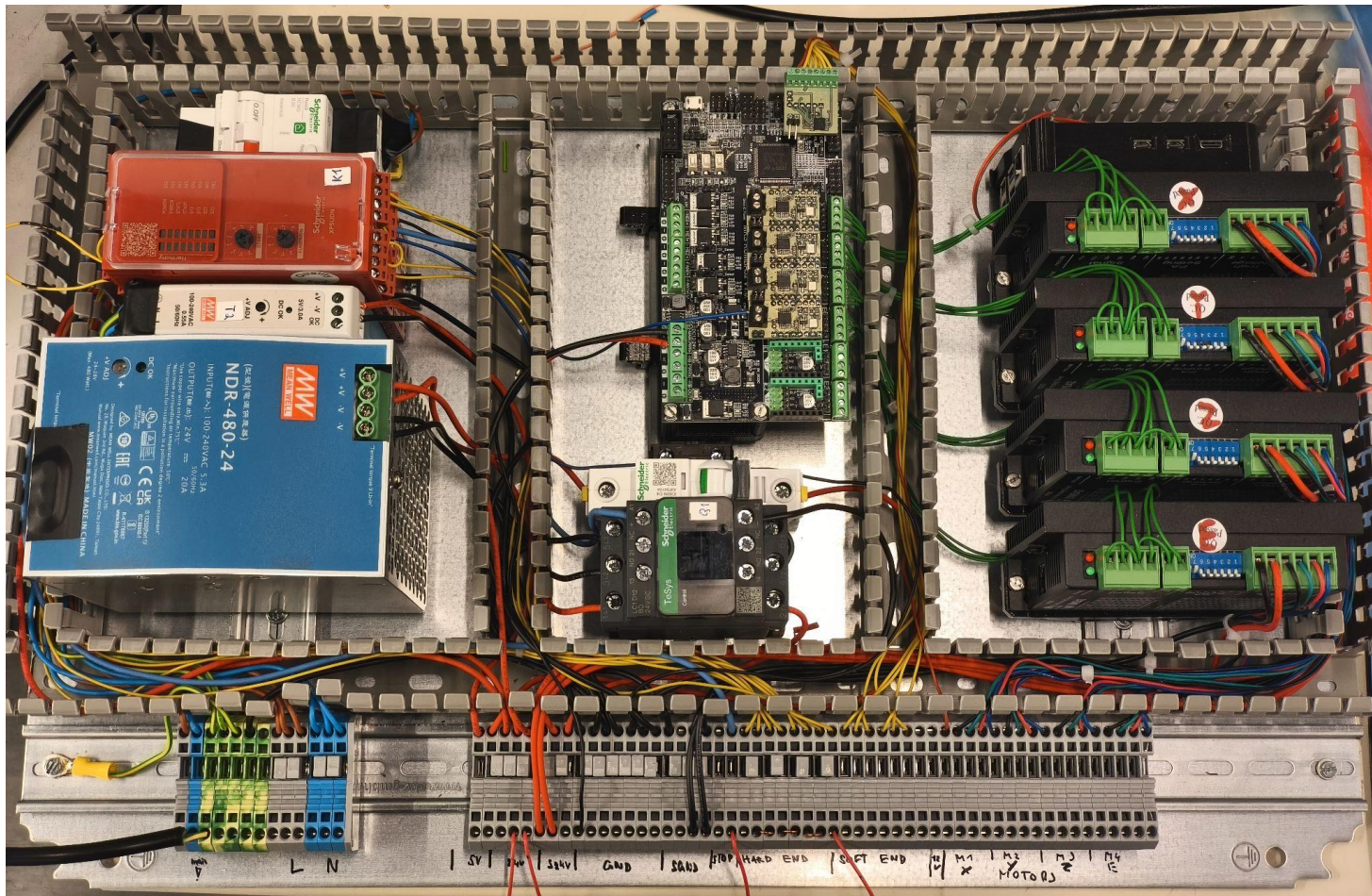


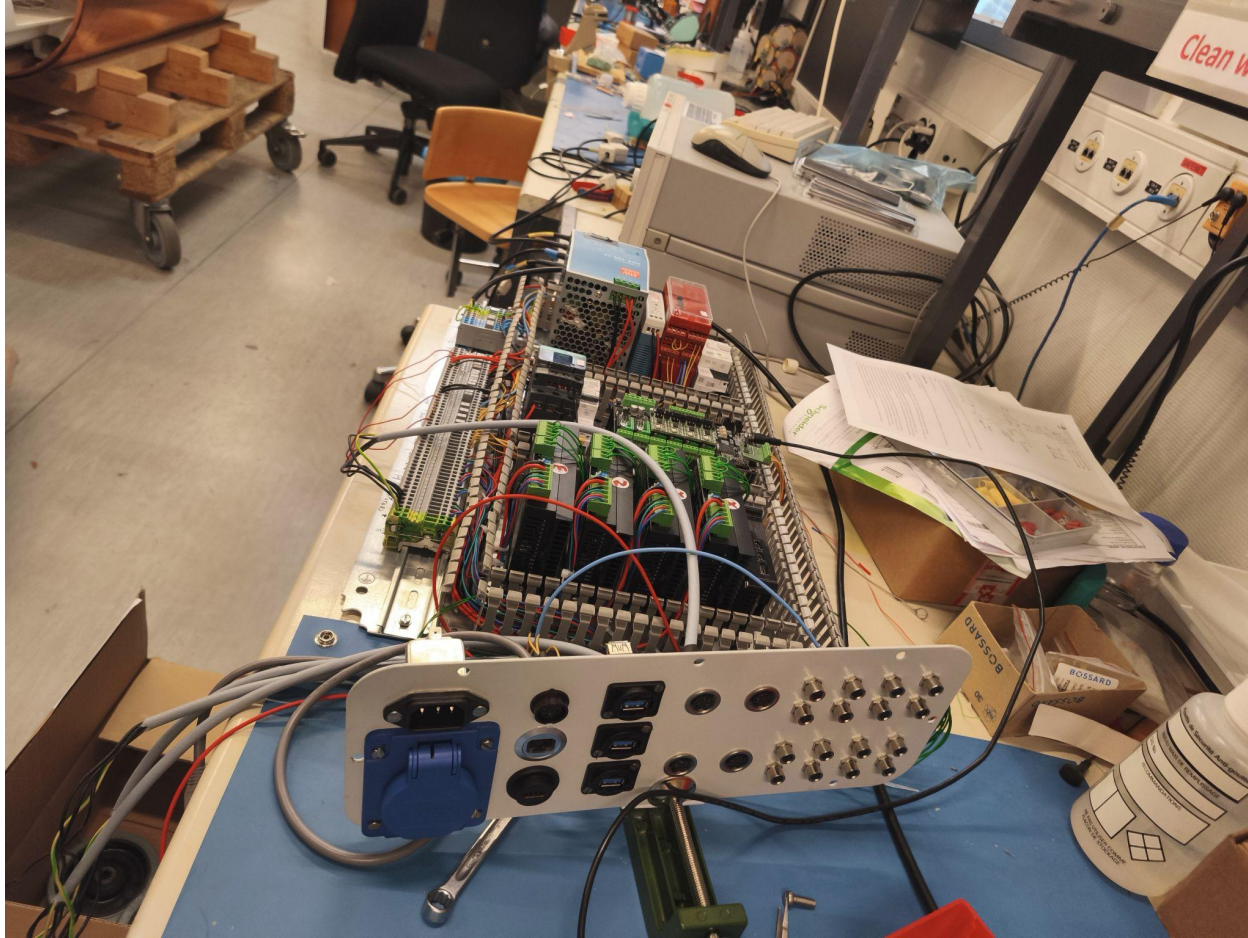


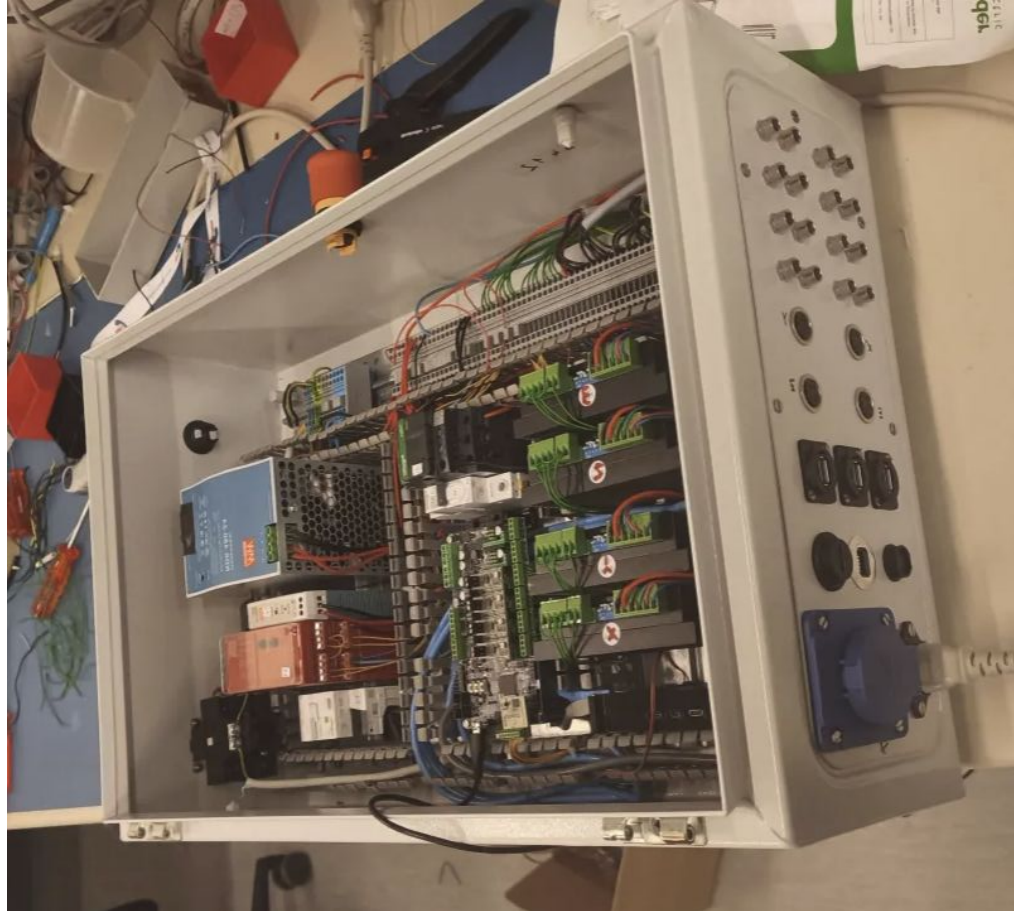












Added cabling for motors & sensors



Then a lot of testing... and fixing problems

Firmware

Standard 3D printer Marlin firmware

- Takes GCODE commands, wide compatibility
- Can be easily used with the existing hydrophone software setup
- Allows for changes

In the future, can be changed to Klipper

- Build-in raspberry PI computer

Several safety turn-off switches

- External safety connector

Motor protection

- Overcurrent and phase loss protection

Inductive sensors

- Software and hardware endstops

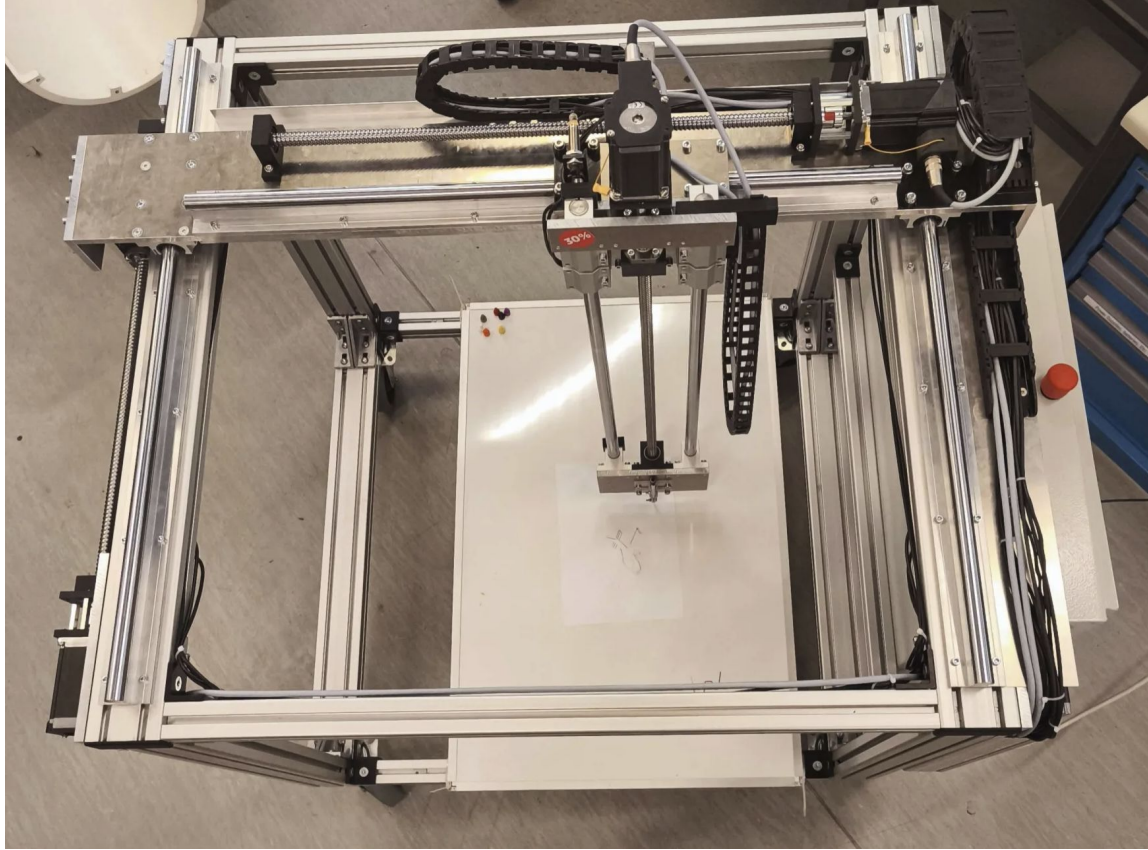
Normal off-the-shelves CNC printers do not have these features

Upgrades and changes

Upgrades

Doubled X motors

- improves accuracy
- firmware modification



Upgrades

Changed some components to reduce cost or simplify

- simplified sensor wiring, different connectors

Augment workspace by rotating Z gantry

- improved the distance in X by a few cm

Upgrades

Augment workspace by rotating Z gantry

What now?

What will happen with COSI

Characterize the precision and repeatability of the machine

- perform test using carbide scriber to make holes
- measure the spread of distances & calculate variance
- try to repeatedly hit the same spot after moving

Integrate with the hydrophone system and perform measurements

- Ensure safe operation

Make changes to the software based on experience with COSI over summer

Questions?