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Instituto de Ingeniería Biológica y Médica

Hardware design beyond accessibility - How to empower researchers with appropriate open technology

Asst. Prof. Dr. Tobias Wenzel
twitter: @MakerTobey @WenzelLab

My research team:

High throughput analysis of cellular interactions with
bioimaging, microfluidics and multiomics.

Why build your own hardware?

Science. Reproducibility. Adaptation. Maintenance.

This slide deck as resource:

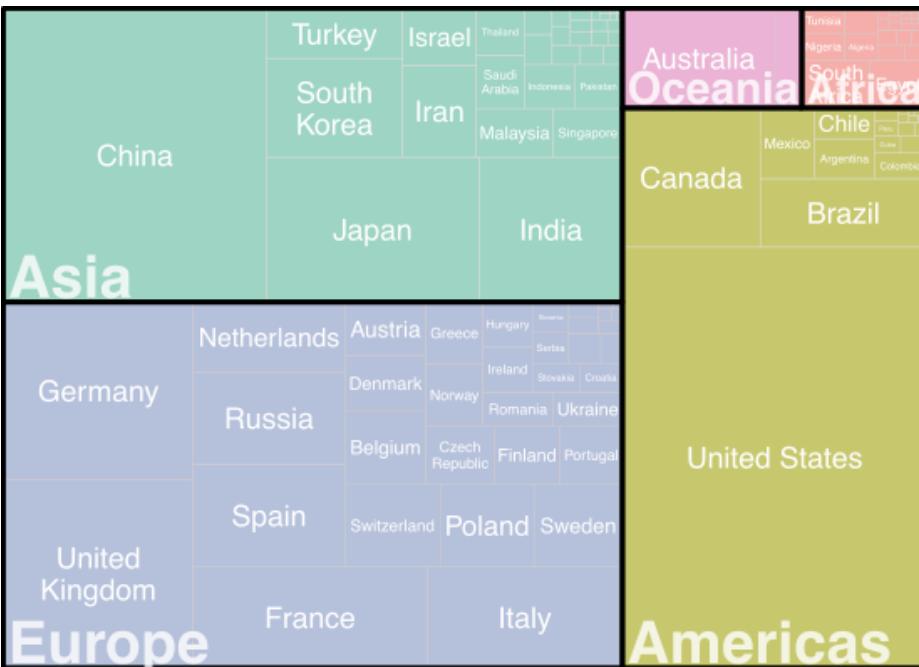
[https://github.com/LIBREhub/LIBREhub.github.io/tree/main/
images/slides/2024-05-06-Wenzel.pdf](https://github.com/LIBREhub/LIBREhub.github.io/tree/main/images/slides/2024-05-06-Wenzel.pdf)

Find all projects here: <https://github.com/wenzel-lab>

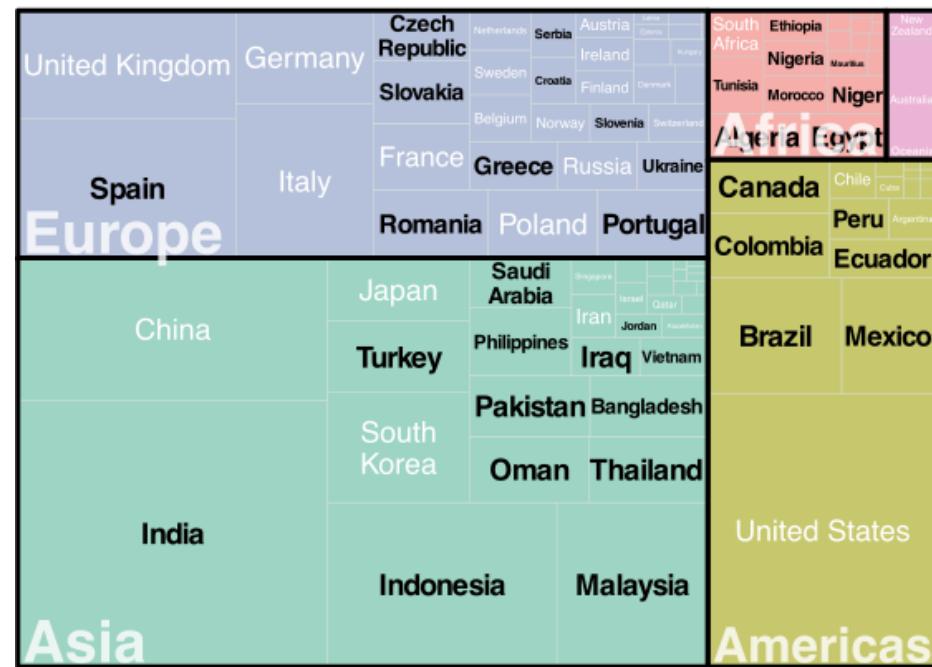
Open Source Hardware

Open source hardware is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design. (...) [OSHWA]

Does Open Hardware enable technology access?

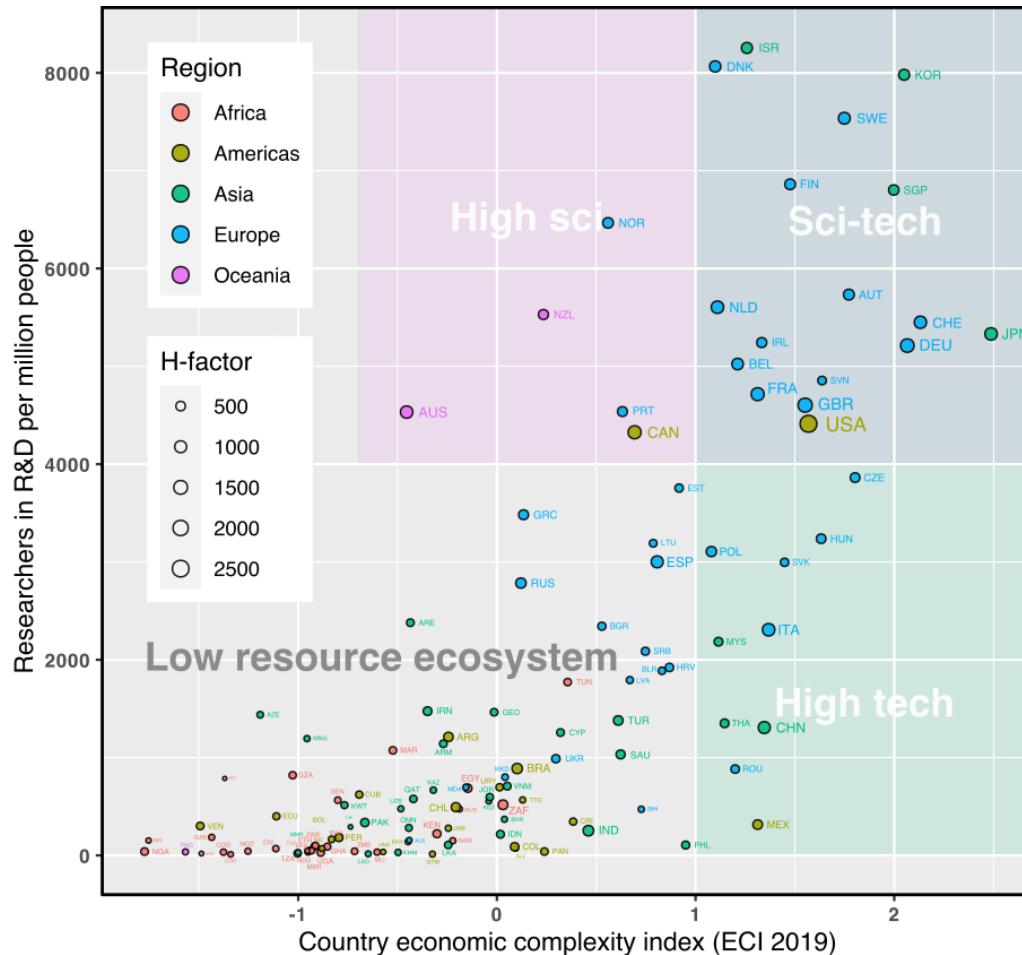


Distribution of total publications by regions:
Scimagojr, all citable documents 1996-2020 (58M)



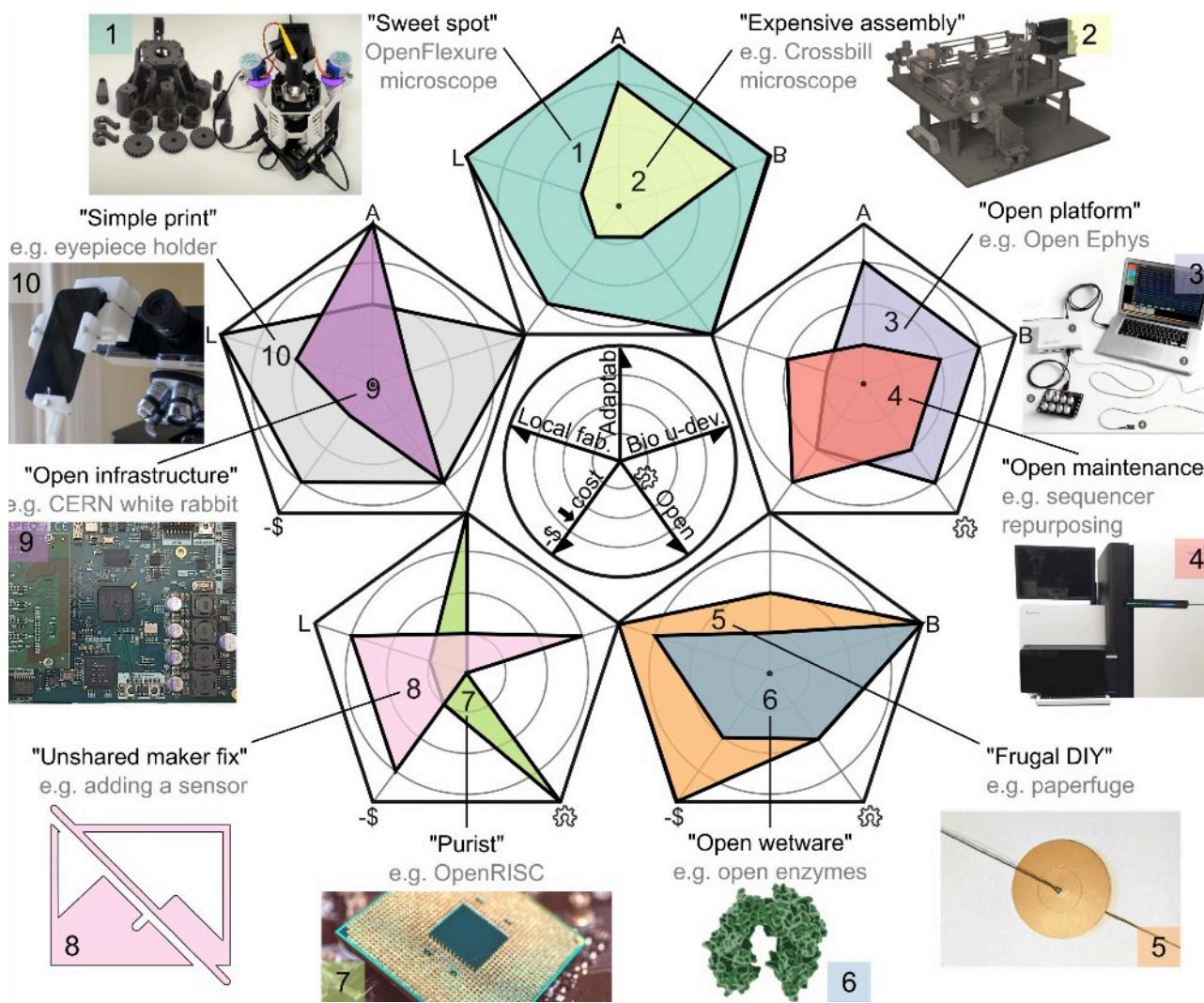
Publications with “Raspberry Pi” or “Arduino” in
the method section by regions: WoS & Scite (13k)

Limited access to fabrication methods and experts

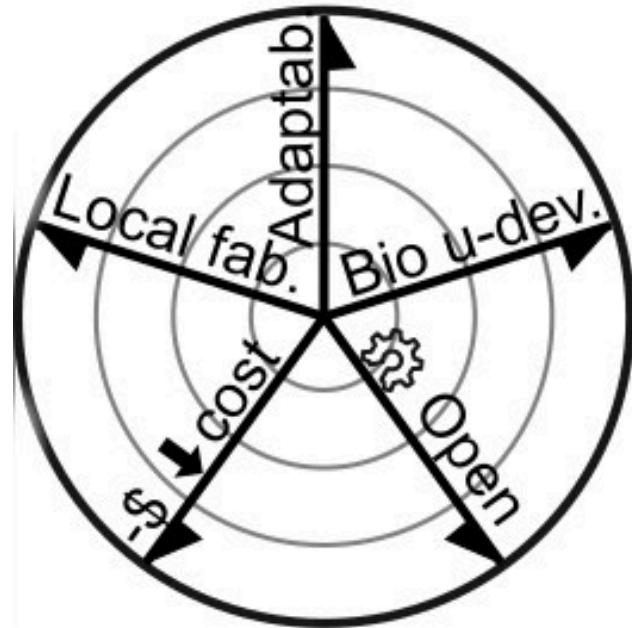


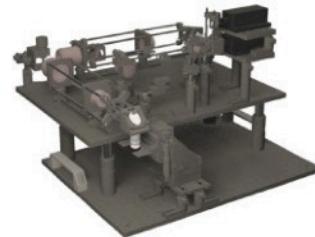
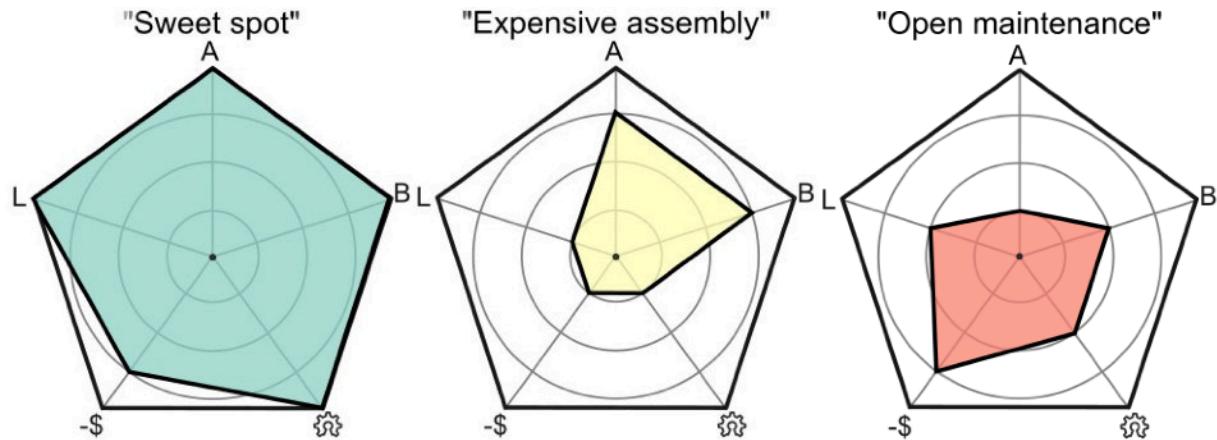
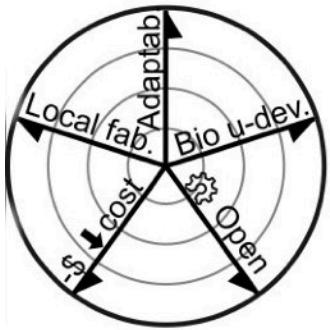
01/2023
Open hardware: From
DIY trend to global
transformation in
access to laboratory
equipment.
T. Wenzel

Types of Open Hardware



01/2023
*Open hardware:
From DIY trend to
global
transformation in
access to
laboratory
equipment.
T. Wenzel*





01/2023
Open hardware: From DIY trend to global transformation in access to laboratory equipment.
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Appropriate Technology

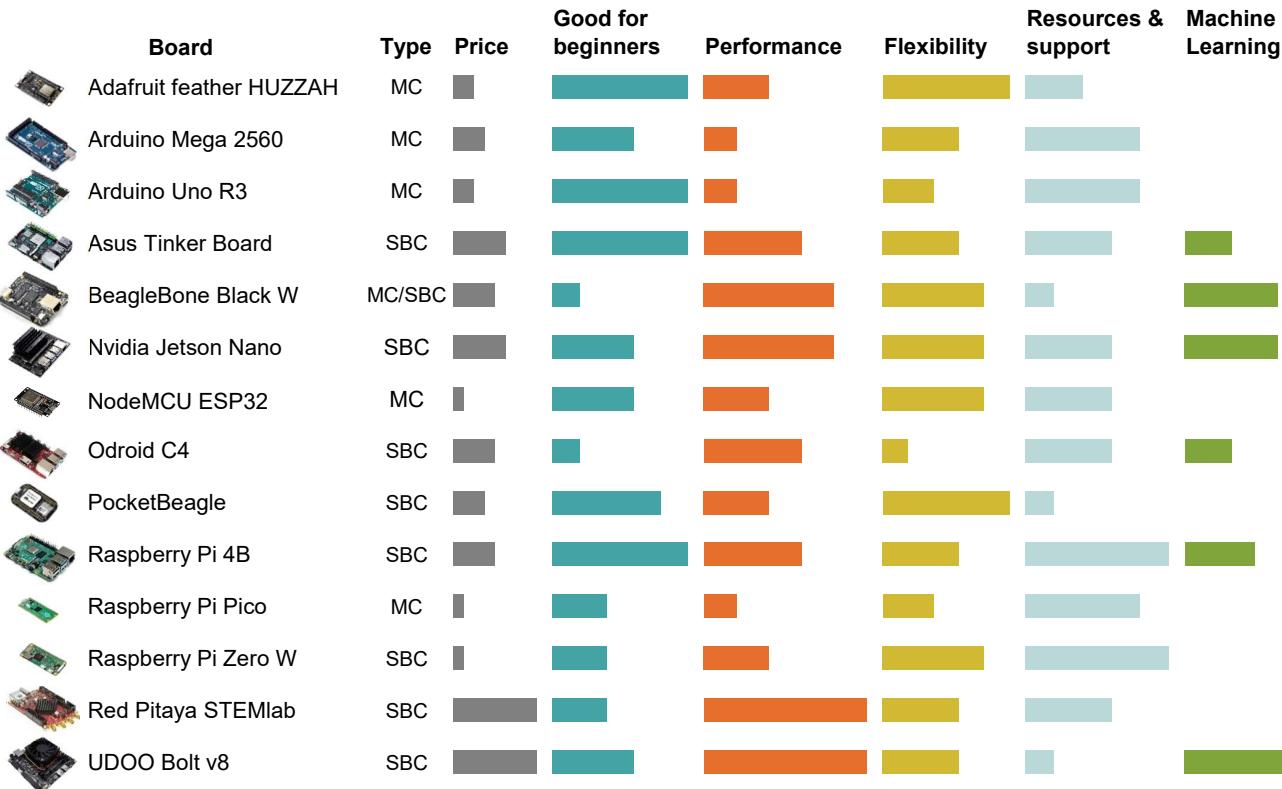
A technology is appropriate when it is “compatible with local, cultural, and economic conditions (i.e., the human, material and cultural resources of the economy), and utilizes locally available materials and energy resources, with tools and processes maintained and operationally controlled by the local population”

[Hazeltine B. Field Guide to Appropriate Technology. 2003.
DOI: 10.1016/B978-0-12-335185-2.X5042-6]

Appropriate Open Source Technology

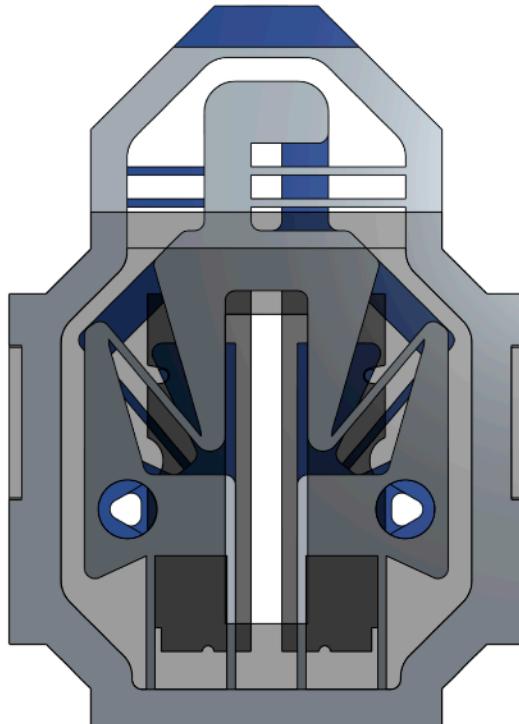
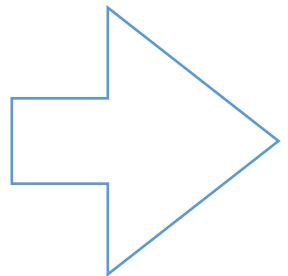
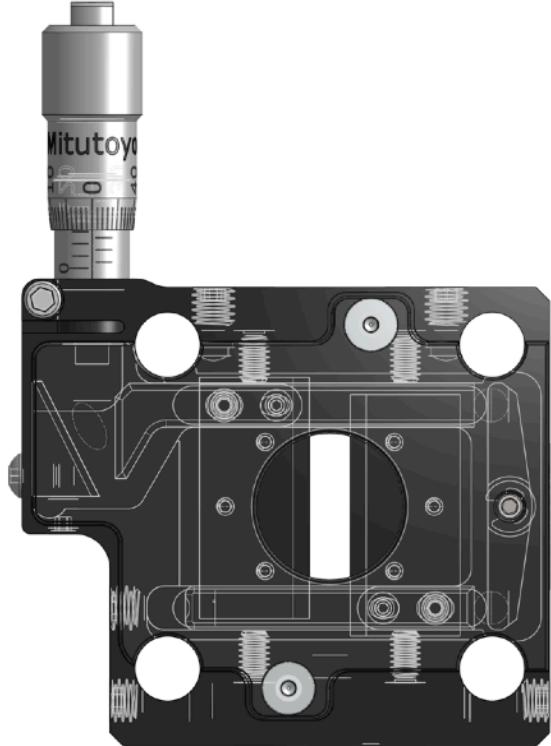
7 hardware design principles

#1 Use commonly available parts. Get started with Open Electronics

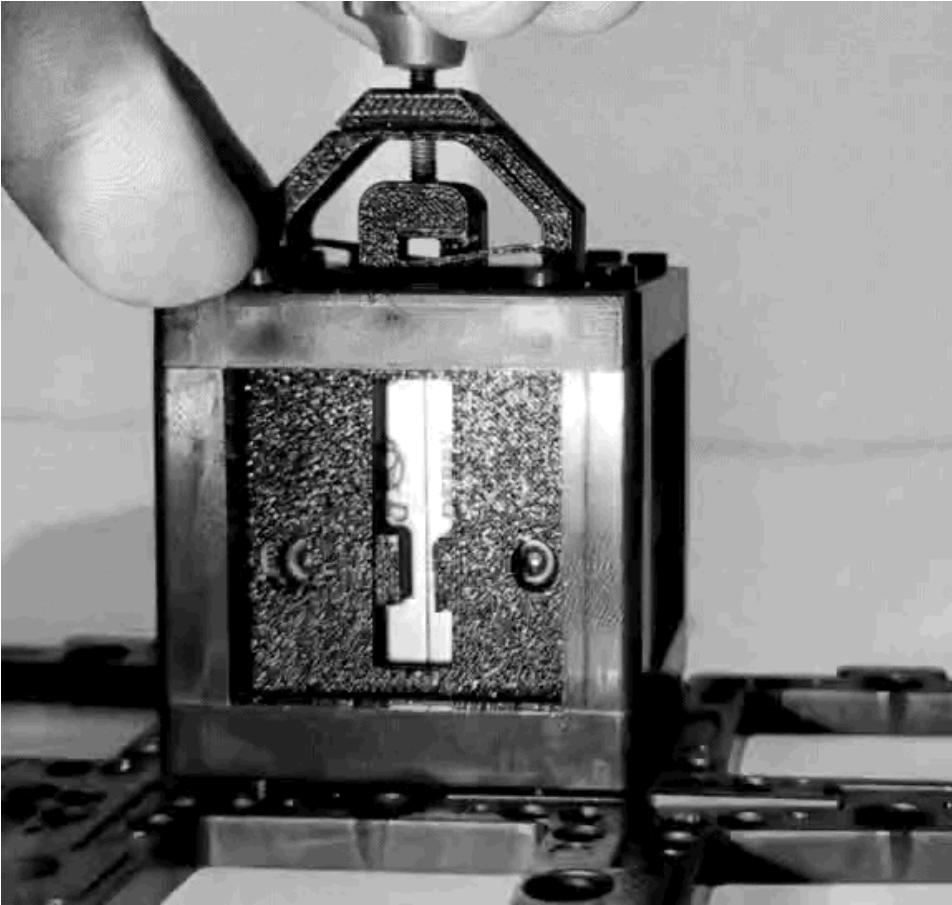
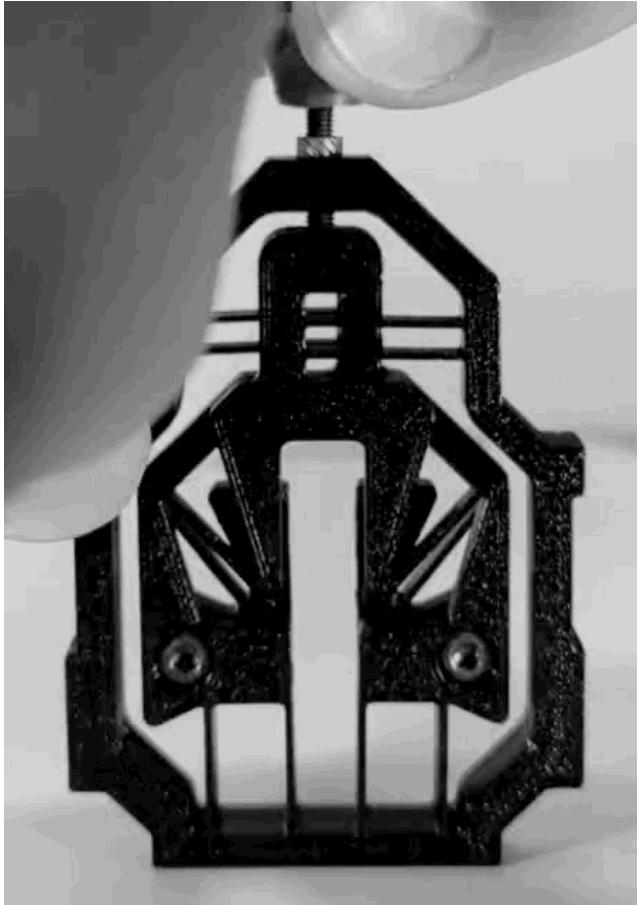


Open Hardware in Science:
The Benefits of Open
Electronics.
Oellermann Et all. 2022

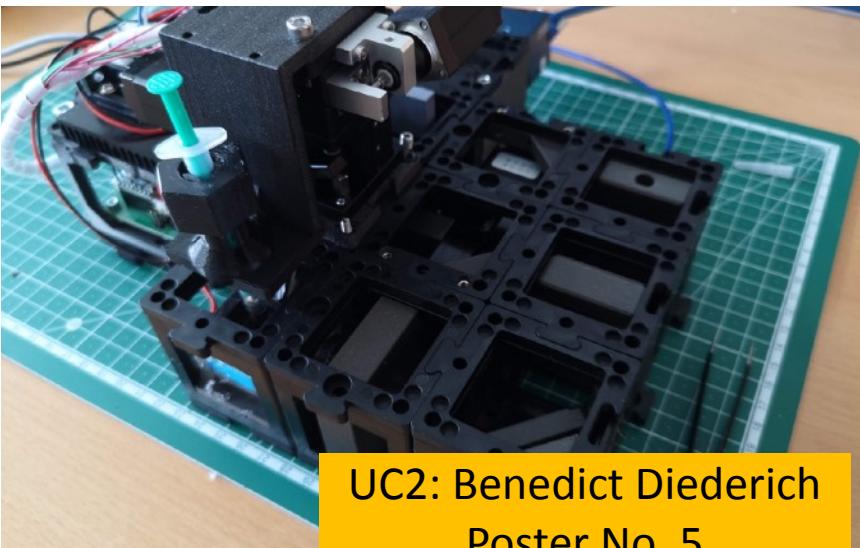
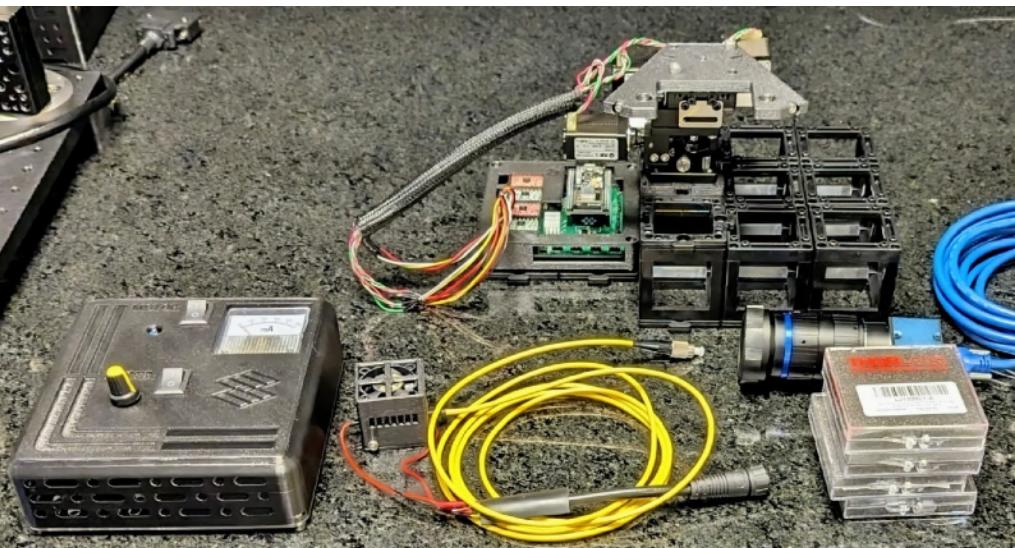
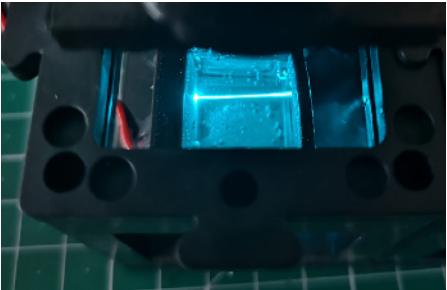
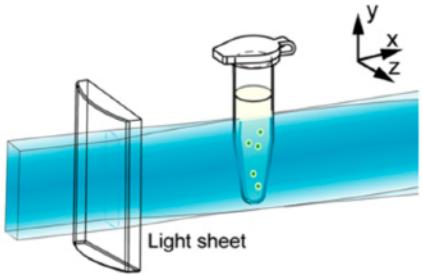
#2 Design for digital fabrication



Design for digital fabrication



3D-printed light-sheet microscope (UC2) + cell stretcher?



UC2: Benedict Diederich
Poster No. 5

#3 Share CAD files

Create ▾

Owned by me > WenzelLab

See also: CAD we share? Publishing reproducible microscope hardware. Diederich et all 2022

Owned by me
Recently opened
Created by me
Shared with me
Labels
Public

Trash

Name	Modified ▾	Modified by	Owned by
 syringe-pump <small>heat inserts WenzelLab</small>	5:35 PM May 2	Matías H	me
 custom-UC2-cubes <small>Main WenzelLab</small>	10:23 AM May 2	me	me
 strobe-enhanced microscopy stage <small>Main WenzelLab</small>	4:26 PM May 1	biodotpe	me
 Microscopy-high-load-vertical-translation-stage <small>Main</small>	3:46 PM Apr 29	Matías H	me
 Laser driver and fiber organizer <small>Main Edición Caja Matías</small>	4:10 PM Apr 22	Matías H	me
 custom-gridfinity <small>Main WenzelLab</small>	10:32 PM Apr 6	Matías H	me
 Microfluid_sorter <small>B1</small>	6:09 PM Apr 5	me	me
 parametric-gel-electrophoresis-chamber <small>Sheet-eletrode-based Parametric Gel Electrophoresis Box WenzelLab</small>	12:52 PM Apr 2	me	me
 Pipette Holder <small>Main (Vertical) WenzelLab</small>	10:38 AM Jan 12	Matías H	me

onshape - Pipette Holder Main (Ver... WenzelLab Share Search tools... alt+` c MakerTobey

Versions and history

Search history

Name Modified

- Main (Vertical) Matías H > Show change... 10:42 AM Jan 12
- Stand Matías H > Show change... 10:32 AM Jan 12
- E3 Matías H > Show change... 10:32 AM Jan 12
- Wall Matías H > Show change... 10:28 AM Jan 12
- C5 Matías H > Show change... 10:28 AM Jan 12
- C4 Matías H > Show change... 10:24 AM Jan 12
- Definitive 2024 Matías H > Show change... 10:15 AM Jan 12
- Screws Matías H > Show change... 10:14 AM Jan 12
- D3 Matías H > Show change... 10:14 AM Jan 12
- E2 Matías H > Show change... 10:14 AM Jan 12
- C3 Matías H > Show change... 10:13 AM Jan 12
- Horizontal Matías H > Show change... 10:13 AM Jan 12
- B3 Matías H > Show change... 10:13 AM Jan 12
- video Matías H > Show change... 12:36 PM Jan 2
- 2023 Matías H > Show change... 10:37 AM Jan 2
- E1 Matías H > Show change... 9:13 AM Nov 20 20
- C2 Matías H > Show change... 12:58 PM Nov 17 21
- D2 Matías H > Show change... 11:28 AM Nov 17 21
- B2 Matías H > Show change... 11:07 AM Nov 17 21

Configurations

Hanger Pin DI... 14 mm
Ellipse Width 22 mm
Ellipse Length 33 mm
Connector PI... 20 mm
Printing Supp... 0.2 mm

Features (33)

Filter by name or type

Default geometry

- Origin
- Top
- Front
- Right

Building (29)

- (*) libre = 3.002 mm
- Top Shape
- Height
- Sides Work (4)
- Structural Sheets Void (3)
- Edges (5)
- Mirror
- Plugs (2)
- Chamfer 0.4 mm.
- Type C: Off-Centered (10)

Parts (1)

Pipette

CAD collaboration and sharing (we use OnShape)

The image shows a screenshot of the OnShape CAD platform interface. The main workspace displays a 3D model of a blue pipette holder. The model is composed of various geometric features like ellipses, rectangles, and chamfers. A coordinate system with axes labeled 'Front', 'Top', and 'Right' is visible in the top right corner. On the left side, there's a vertical timeline of changes with colored circular markers indicating modification points. The top navigation bar includes standard CAD tools like Sketch, Measure, and Select. The top right corner has a user profile and search bar. The overall theme is collaborative design and sharing, as indicated by the title.

About

3D Models

33

Makes

25

Activity

Collections

10

**LIBRE hub**

@WenzelLab

↓ 1,000 ❤ 380

38 followers 4 following



Advanced



Expert



White Dwarf

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Message



Highlighted models

[All models](#)**Adaptable Pipette Holders**

7



0



↓ 35

**Strobe-enhanced microscopy stage**

7



0



↓ 14

**Moldular tube holders**

16



5



↓ 58

**96 well-plate locator stand**

20



5



↓ 78

**Optical filter cubes - openUC2 (improved)**

18



0



↓ 42

**Open-Source Syringe Pumps**

13



0



↓ 27

Strobe-enhanced microscopy stage

by Pierre Padilla-Huamantinco, Matías Hurtado-Labarca, and Tobias Wenzel
Latin American Hub for Bioimaging Through Open Hardware (LIBRE hub)

Strobe-enhanced microscopy stage

Build the 3-level microscopy stage

Print the plastic parts

Laser cut the acrylic parts

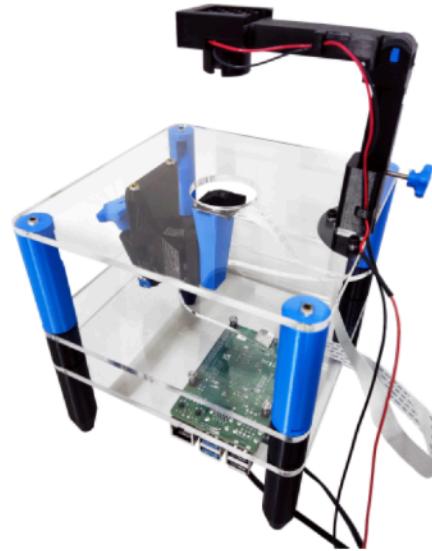
Assemble the focus mechanism

Assemble the basics optics module

Attach parts to the top plate

Attach parts to the middle plate

3-level microscopy stage



Before you start building the station, you will need to source all the components listed in our [bill of materials](#) (,) , which is given on the next page.

Instructions

#4 Detailed documentation and open license

- Documentation tool: <https://gitbuilding.io/>
- [BINA Builders working group](#)
- [Standardisation of practices in Open Source Hardware](#)
(2020) Bonvoisin, J Molloy, M Haeuer, T Wenzel
- [DIN SPEC 3105 Open Source Hardware](#)
F Arndt et al. (2020) DIN e.V.
- [Open Know-How](#) A Lamb et al. (2020) <https://openknowhow.org>
- [Global Open Science Hardware Roadmap](#) (2018) LFR Murillo, J Molloy, S Dosemagen, D Bild, F Grey, GP Irujo, H Toivonen, ...
- [Welcome to the Journal of Open Hardware](#)
(2017) LFR Murillo, T Wenzel

#5 Use and contribute



[Image data science with Python and Napari](#)

Course preparation

Day 1: Introduction to Python and Bio-image Analysis

Day 2: Image Filtering, Segmentation and Feature Extraction

Day 3: Napari Plugins: Developers Showcase

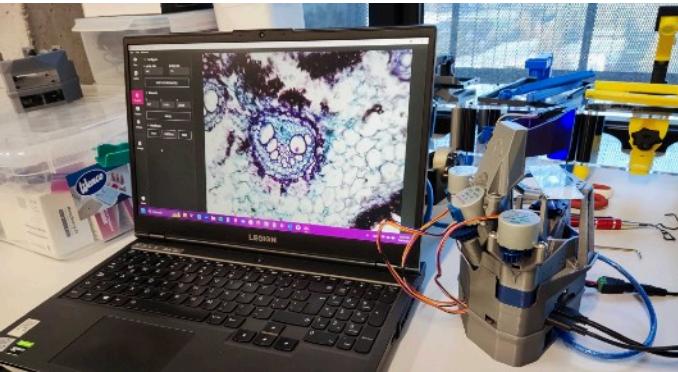


Image data science with Python and Napari

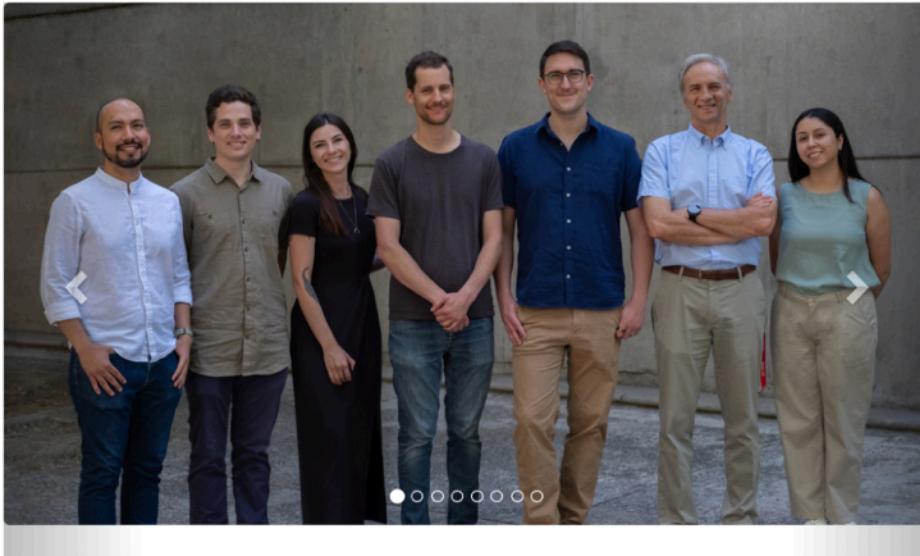
A first Latin America workshop #LIBREhub @napari #LABI - Latin America Bioimaging #MexicoBioimaging

This [Jupyter book](#) contains training resources for scientists who want to dive into image processing with Python and Napari. It specifically aims for scientists and students working with microscopy images in the life sciences. We presume the attendees have some basic python programming and image analysis knowledge. To get everyone on the same level, we start with Python programming basics. We will process images using [numpy](#), [scipy](#), [scikit-image](#), [SimpleITK](#) and [c1Esperanto](#). We will explore [Napari](#) for interactive image data analysis and the [Napari-Assistant](#) for generating [Jupyter Notebooks](#) from interactively designed image processing workflows.

Note: Before the course starts, all participants must complete the [course preparation page](#) - and make use of the Q&A session to ask questions about installation issues. The session on Python environments will be held on the day of the workshop. Please note that we kindly ask that you familiarise yourself with the software and hardware before the workshop session in order to simply use the given time effectively.



#6 Build and train a community



The Latin American Hub for Bioimaging Through Open Hardware (LIBRE Hub) is a training network for open source bioimaging hardware in Latin America with the goal to empower regional researchers through practical workshops, seminars, networking, and online resources adapted to local needs and republished in local languages.

New: YouTube training in Spanish (tip: use English subtitles)

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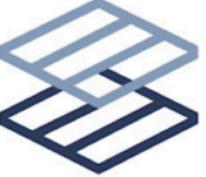
Music

Movies & TV

⋮

Si

LIBRE hub



@librehub · 295 subscribers · 37 videos

The Latin American Hub for Bioimaging Through Open Hardware (LIBRE_hub) is a training ...[more](#)

librehub.github.io and 4 more links

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ALINEACIÓN DE ELEMENTOS ÓPTICOS
CON LÁSER DE BAJO COSTO!

6:03

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de bajo costo
EN PRÁCTICA

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FOR BETTER RESEARCH

6:28

How open source instrumentation improves research impact

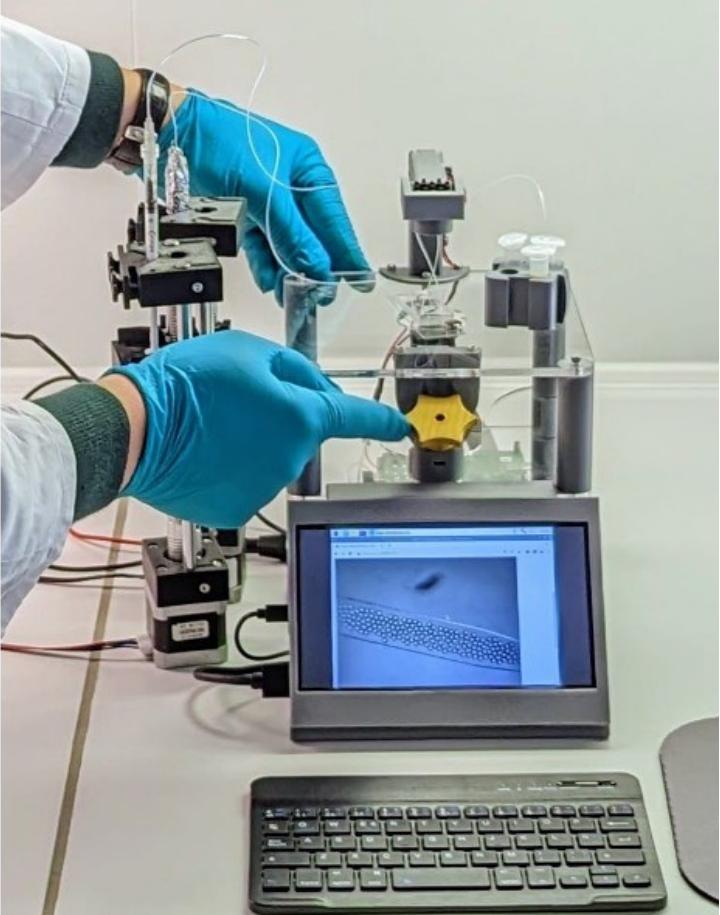
120 views • 1 month ago

#7 Accessible software (in python)

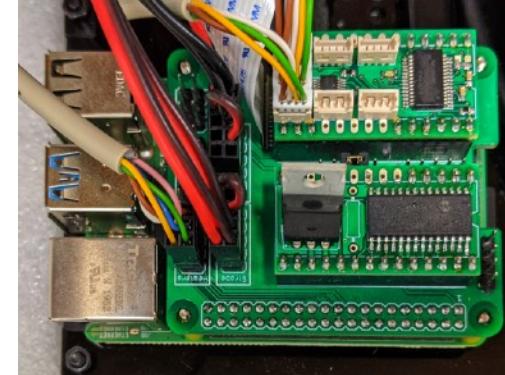
Own production for strobe, flow and sorter; SQUID; ImSwitch;
OpenFlexure; Napari; etc.

Two recent examples

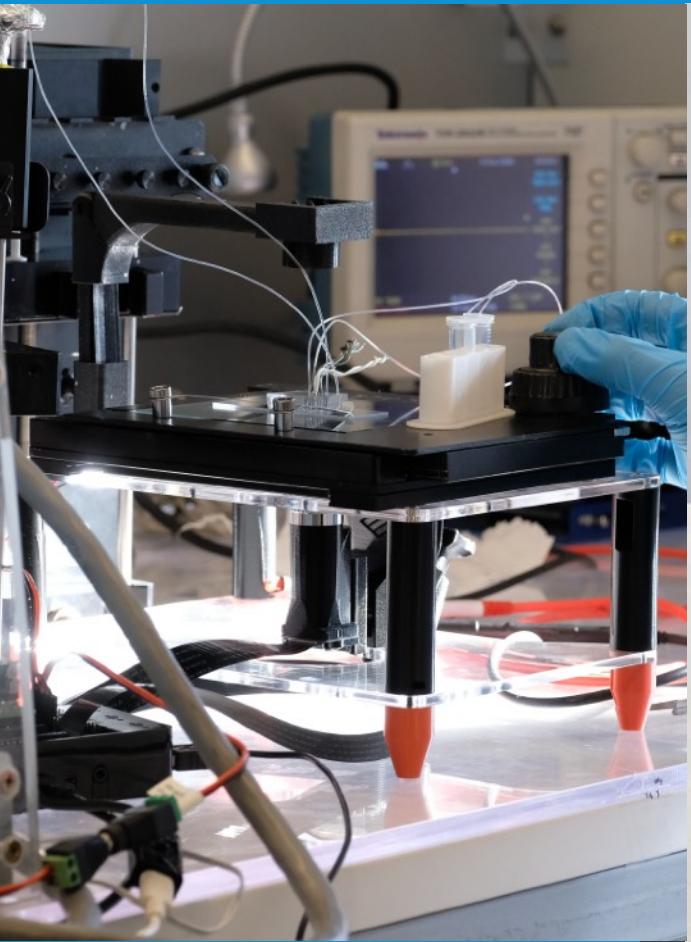
Open source strobe illumination microscopy stage



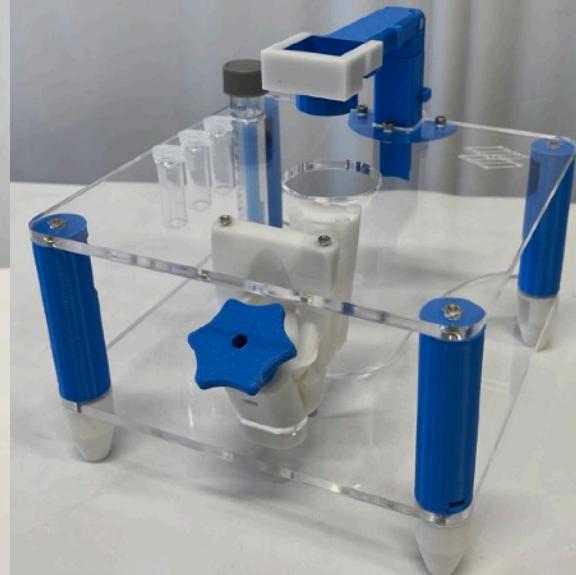
- Shared design files
- 3D printing
- Laser cutting
- RaspberryPi-based
- Standard components (M3 screws, Nema motors, rods)
- Low-cost (~170\$ + ~190\$ RPi + 250\$ Pumps)
- Detailed assembly instructions
- Use and contribute:
Focus (OpenFlexure) and pumps (MRI)



Adaptable



Discuss with Pierre Padilla:
Poster No. 17

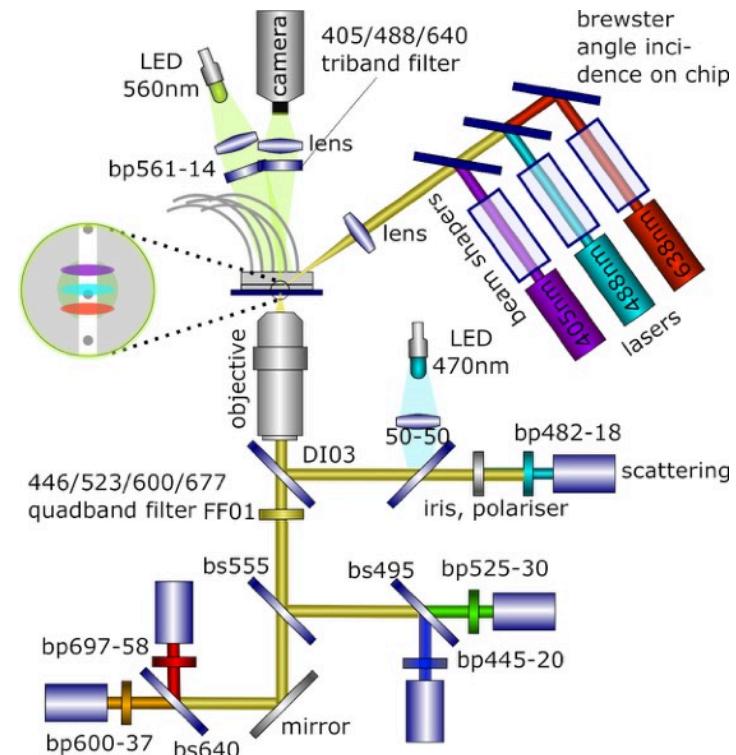
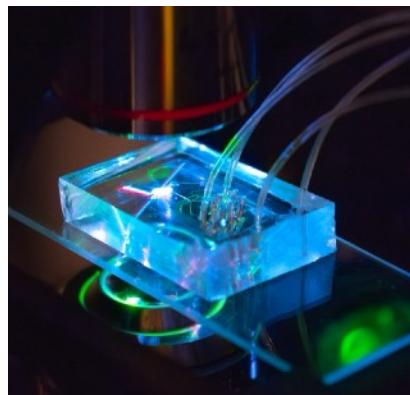
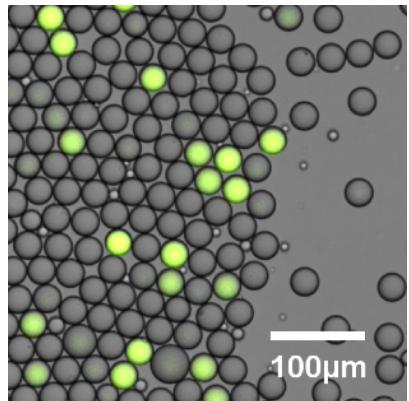
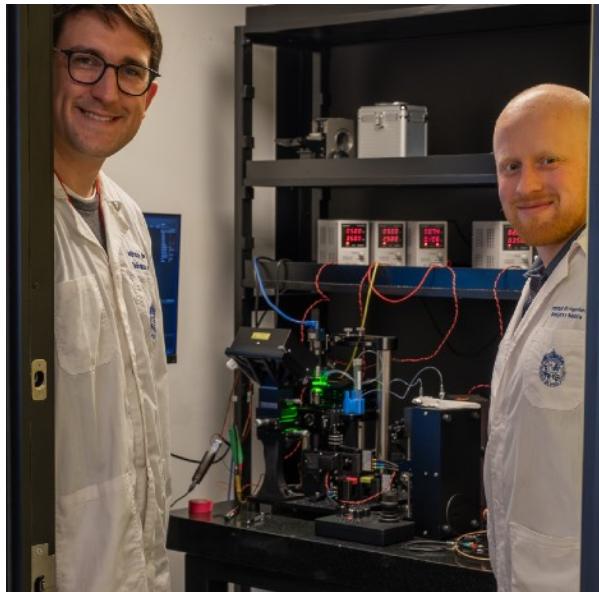


Community training in Latin America



Open source cytometry & droplet sorting (FADS)

- Microscope alignment stage(s)
- High-speed imaging with strobe
- Realtime FPGA electronics
- High voltage and electrodes on-chip
- Laser + Optics
- Pumps



Towards appropriate open source technology

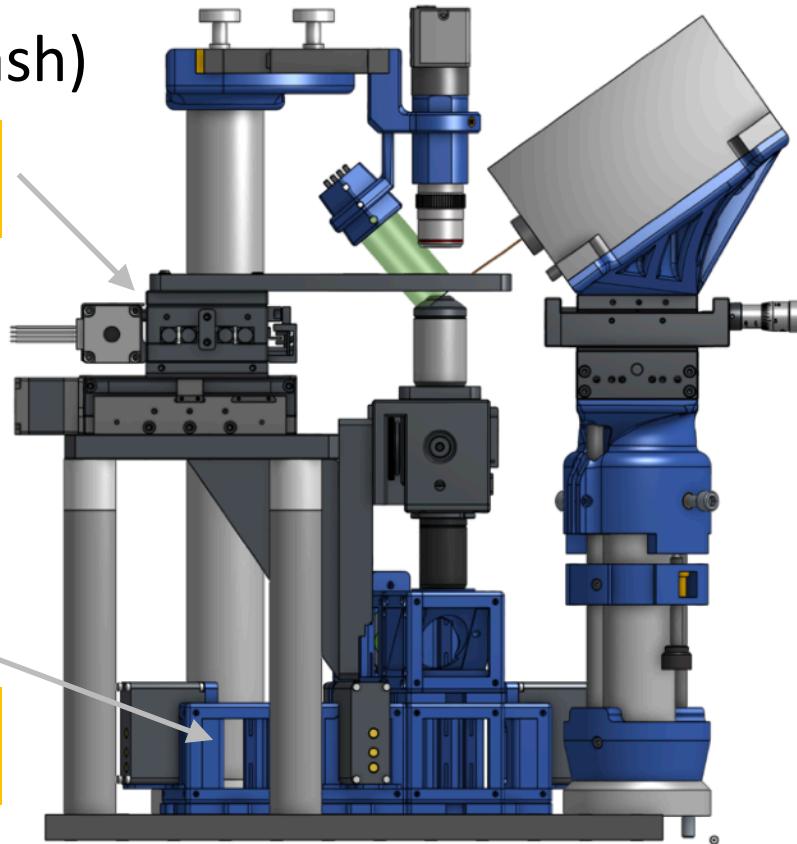
SQUID stage (Prakash)

Hongquan Li
Poster No. 12

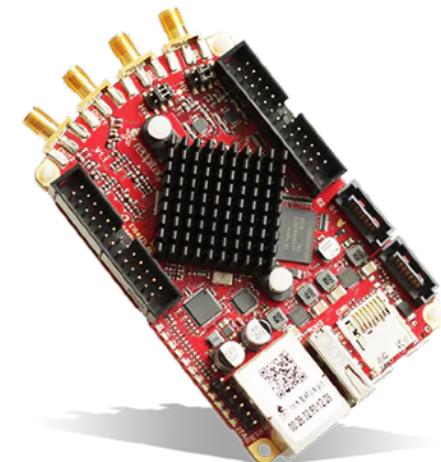
3D printed
parts (in blue)

UC2 optic cubes

Benedict Diederich
Poster No. 5



Python control on
RedPitaya FPGA
single board
computer



Empower Researchers with Appropriate Open Source Technology

- #1 Use commonly available parts
- #2 Design for digital fabrication
- #3 Share CAD files
- #4 Detailed documentation and open license
- #5 Use and contribute
- #6 Build and train a community
- #7 Accessible software (python)

¡Gracias! Discutamos...

We are growing.
PhD and technician positions available.



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Científico y Tecnológico

**Chan
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Initiative** CZI

BMBF Experiment.com



Image source: Evan Ingersoll &
³¹Gael McGill (Digizyme Inc, Brookline MA)