Computer-aided design (CAD) helps to build and share experimental setups

Slides: https://aandreev.net/CAD

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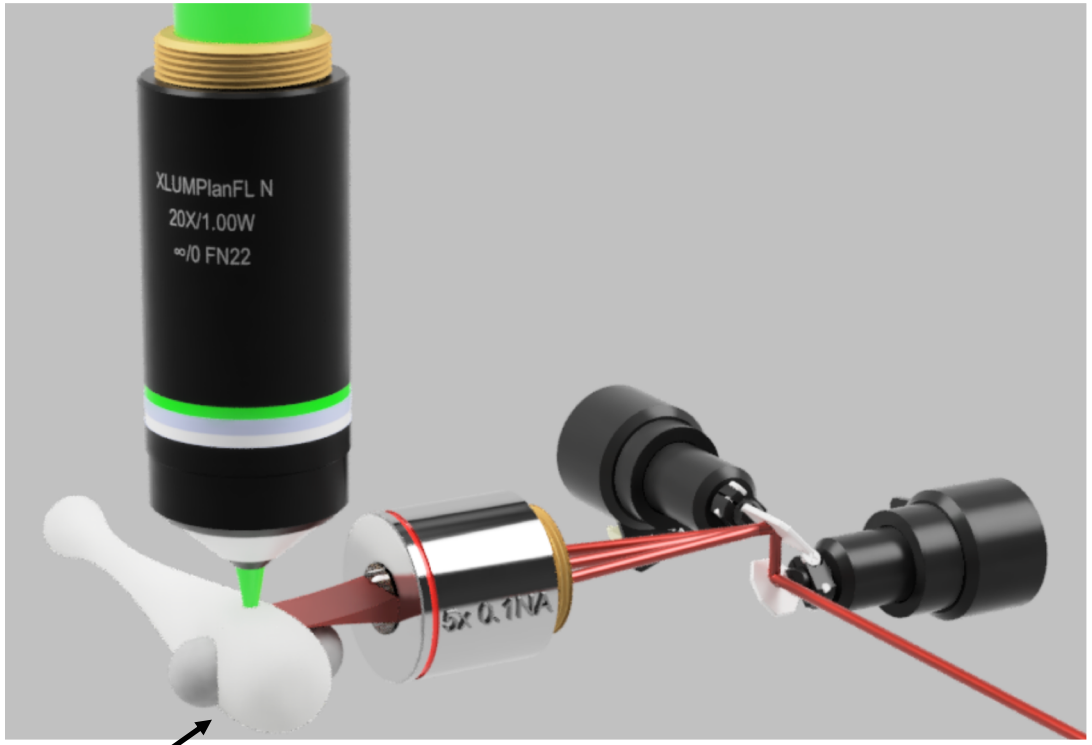
* Not affiliated with any company mentioned here

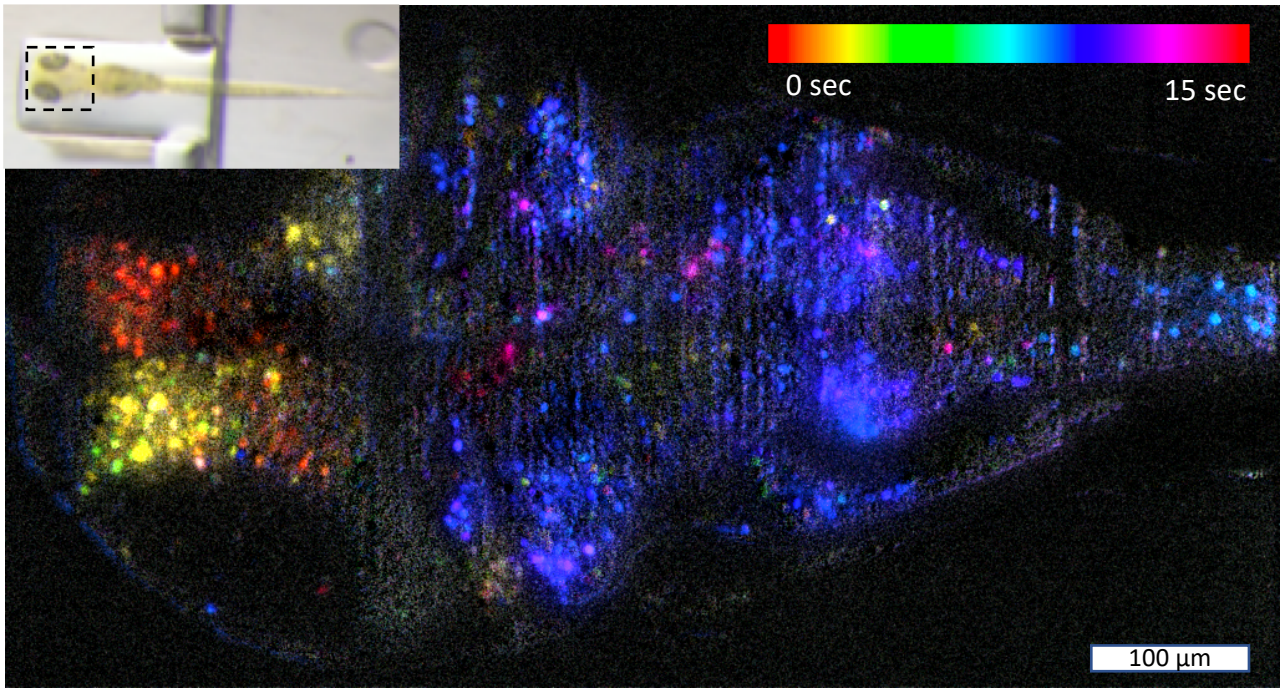
Hello, I build and modify custom microscopes for zebrafish brain imaging

Cartoon of a two-photon light-sheet microscope



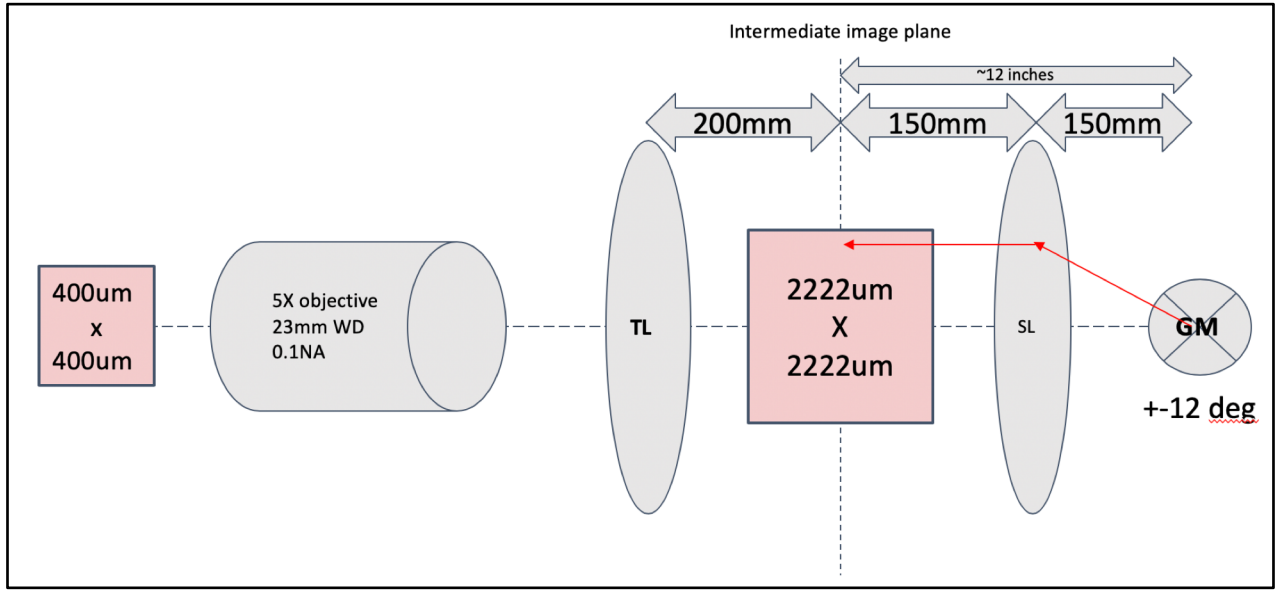
Zebrafish (model)

Zebrafish brain activity movie (temporal color-coding)



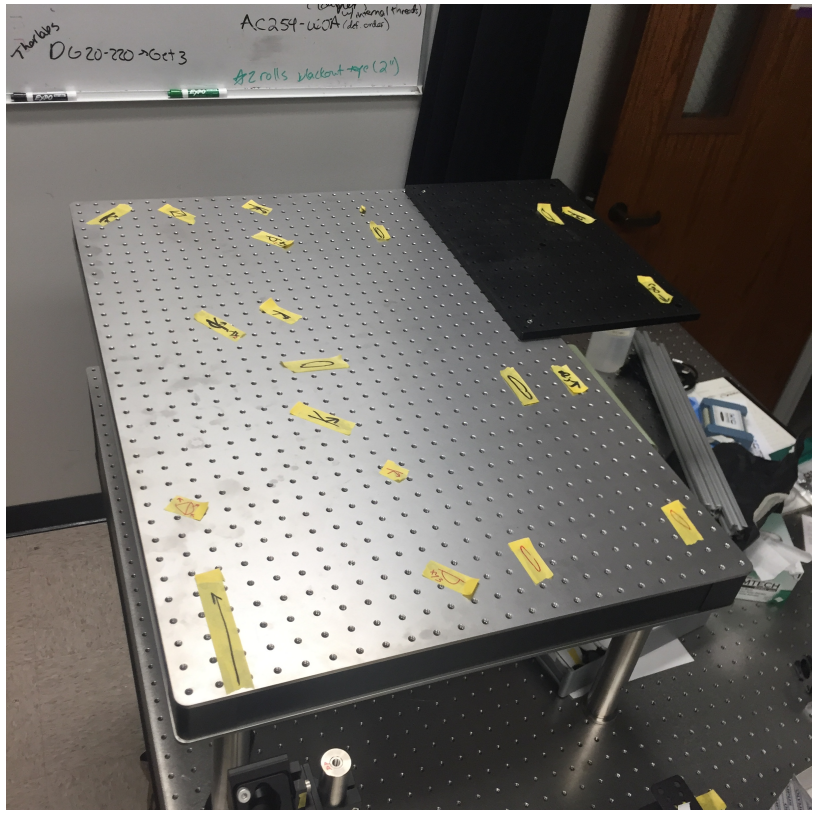
We always design: on paper, whiteboard, or PowerPoint. It is often imprecise and hard to communicate or edit

Use PowerPoint to sketch and estimate design of laser-scanning system



Like software code comments, any design is better than no design

Use painters tape to mark the layout on optical table



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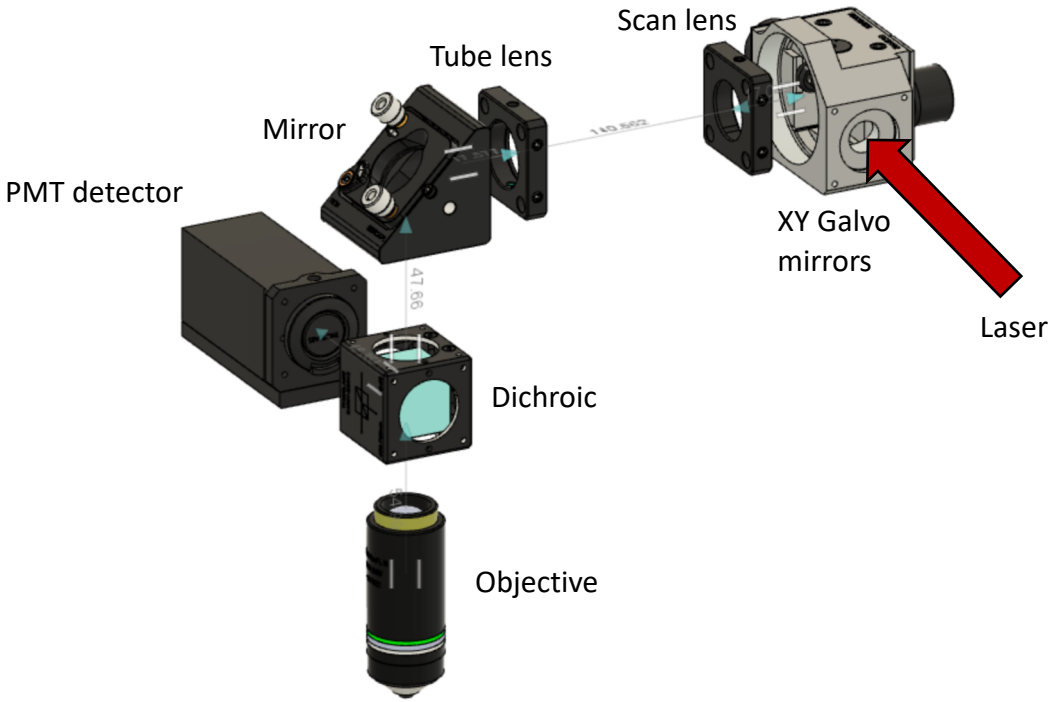
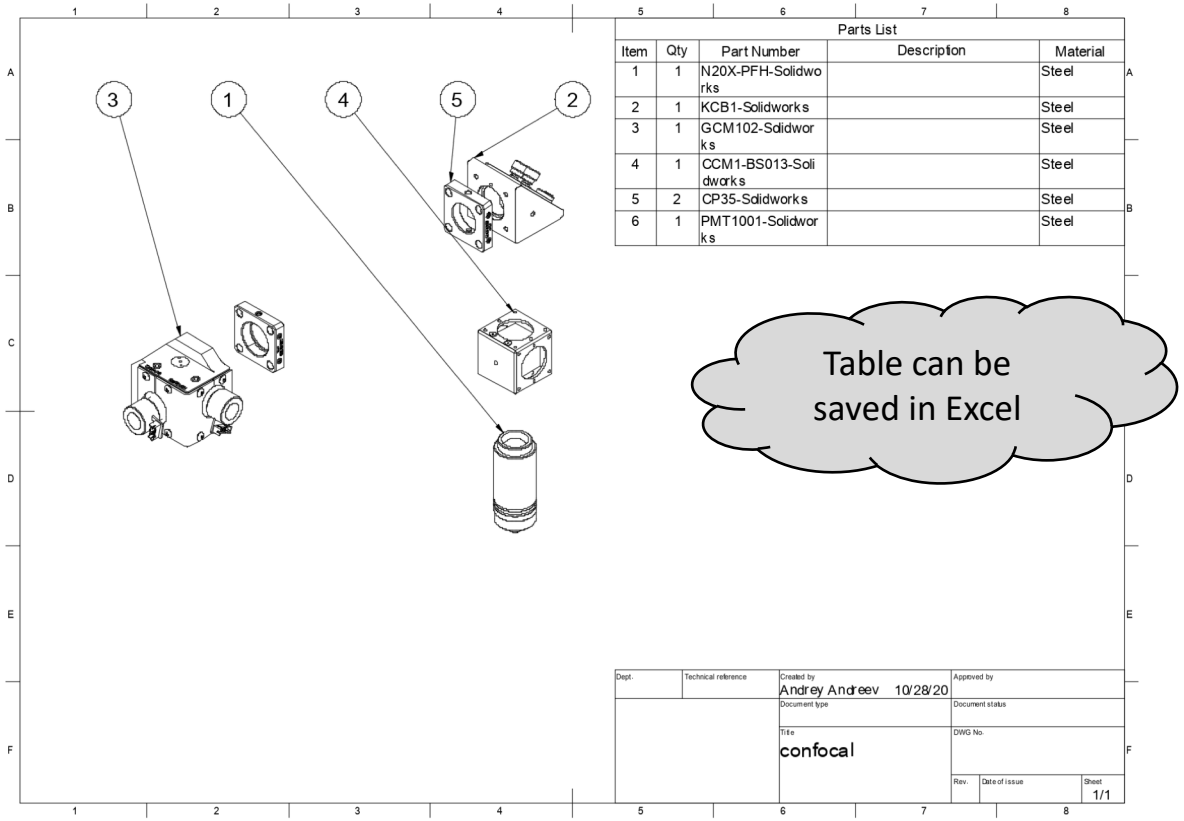
Example CAD workflow of 4 steps:

1. Download Thorlabs/Newport/McMaster-Carr parts
2. Use “Joints” to connect parts together along desired degrees of freedom
3. Check for conflicts, enter known distances, design necessary custom parts
4. Generate rendering for the paper, List of Parts, and technical drawings



Skeleton of 2P microscope, sketched in < 10min
(Autodesk Fusion360)



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Why CAD is not more widely used:

Potential concern:	Response:
CAD software is hard to use	It was like that until recently. Modern CAD software can be picked up and add value in a month. There are different levels of mastery, but each adds value to the paper
CAD is a waste of time, I need to be building!	Virtual assembling, checking for conflicts, and use CAD to render will save authors' time. Publishing CAD files, rendering, and drawings will save readers' time to understand, and replicate designs. CAD makes communication between engineer & biologists easier. Learning CAD is a useful skill for wide range of engineers.
CAD files are hard to share	File format and licensing issues are real. But journal editor will help with file placement. 5% of microscopy papers in *Nature Methods* already have CAD files attached
CAD software is expensive	Licensing issues *are* real, however there are free options such as Fusion360; software often free for academics; free and open-sources options get better (FreeCAD)
I don't do hardware	**Encourage your colleagues, or engineers that help you, to use CAD. It will save them time, make quality of their work higher, and make your shared papers more valuable**

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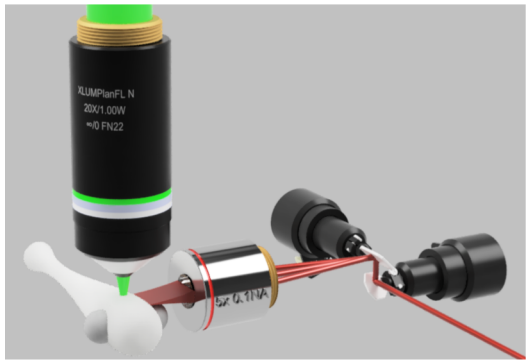
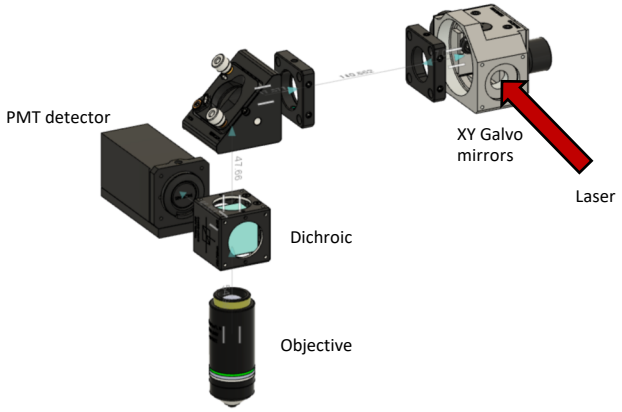
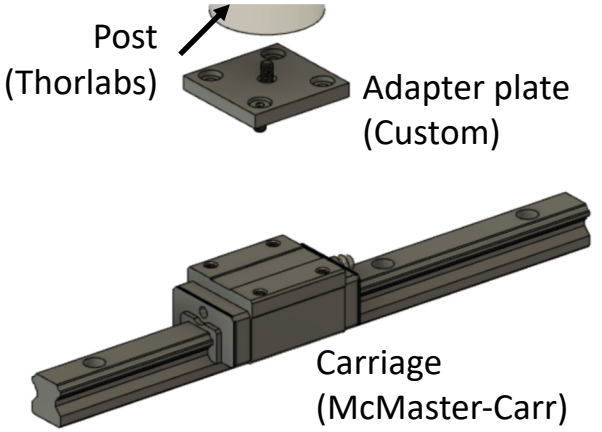
Computer design (CAD) is an accessible way to make design, assembly, and **communication** process better



Model sample, and design imaging around the sample



CAD can be used for teaching, and explaining principle behind design



Custom parts can be designed around existing models

Potential discussion points:

- More on process of assembly from parts
- Making rendering and animation
- Designing custom parts & adapters

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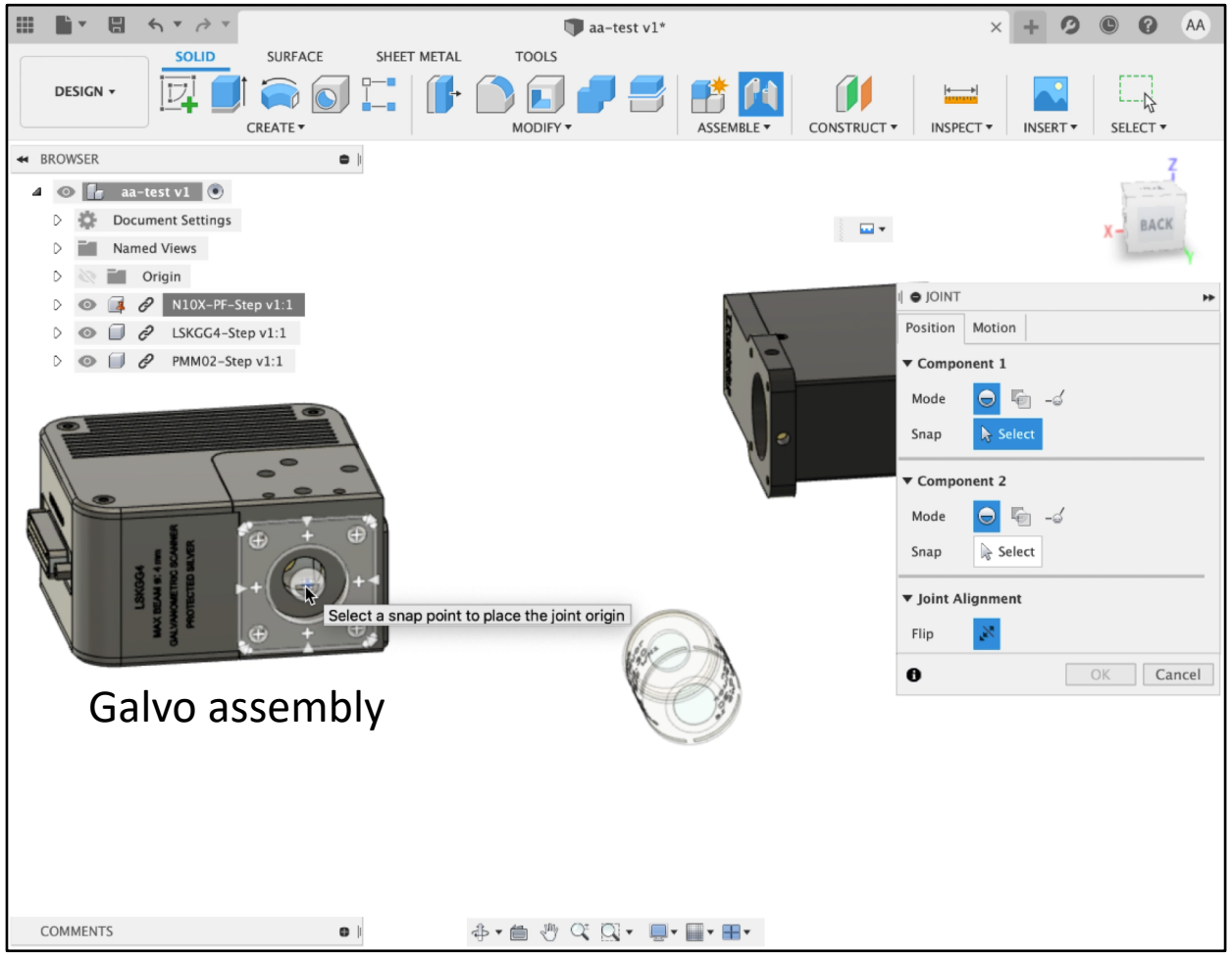
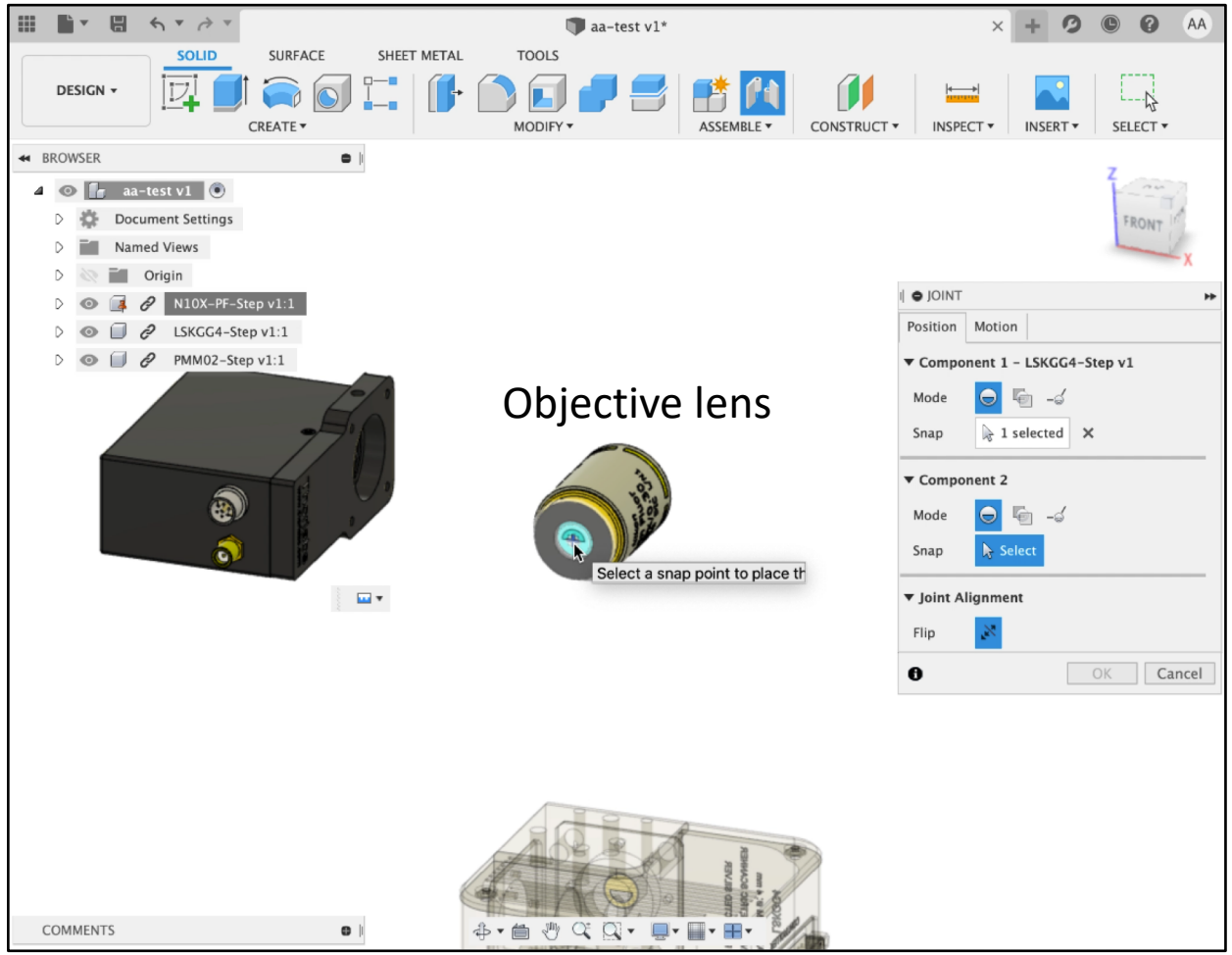
Example of assembly using joints:



Galvo assembly



Objective lens

- No need to precisely position models in 3D: Fusion360 “guesses” features such as axis of cylinders and mid-points
- Joint allows degree of freedom. For example, “slider” puts objects on axis like beads on a thread
- Very useful for assembling optical setup made of lenses, cameras, mirrors *etc*

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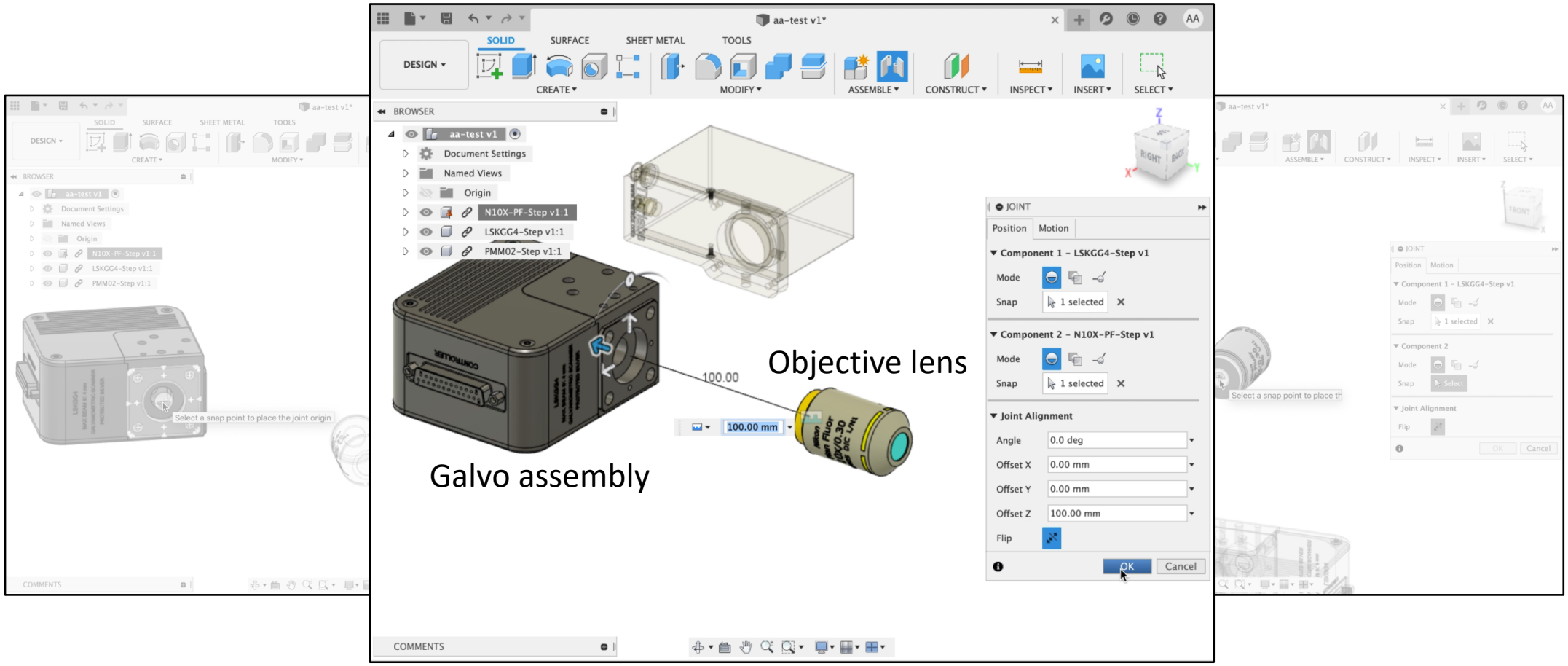

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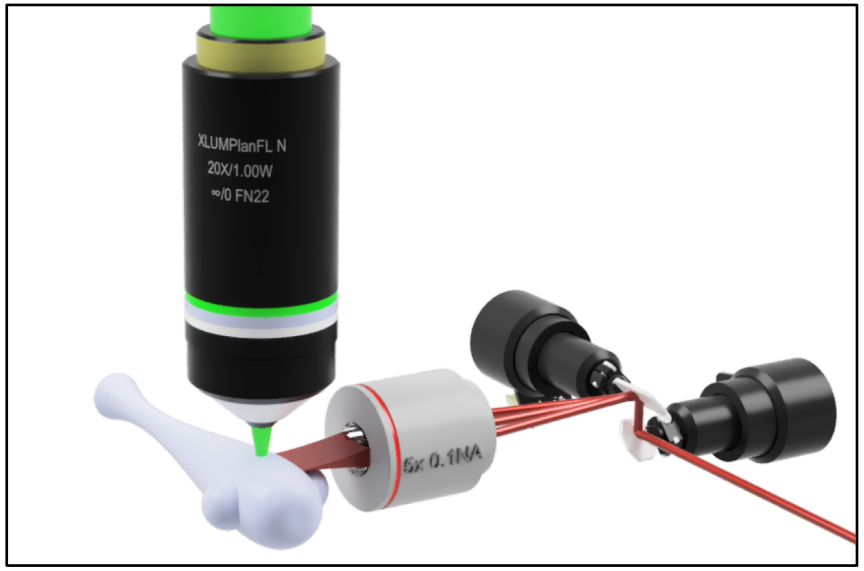
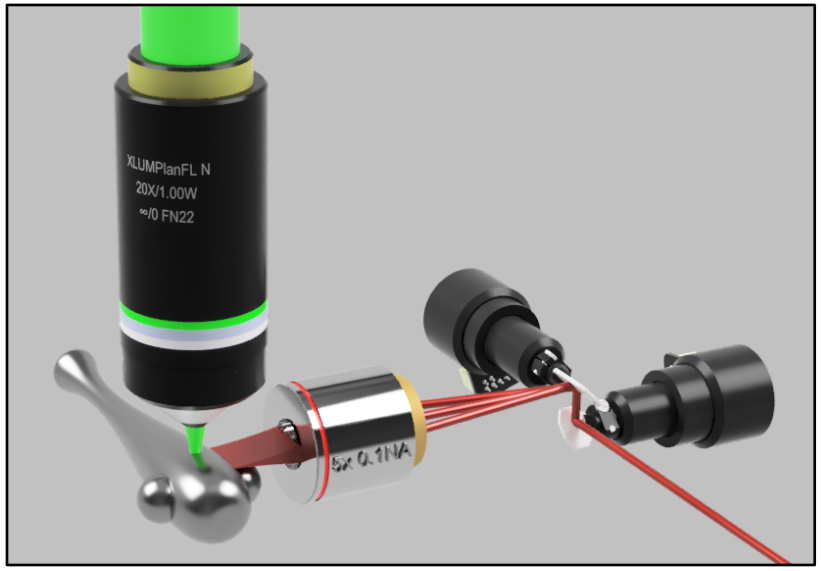
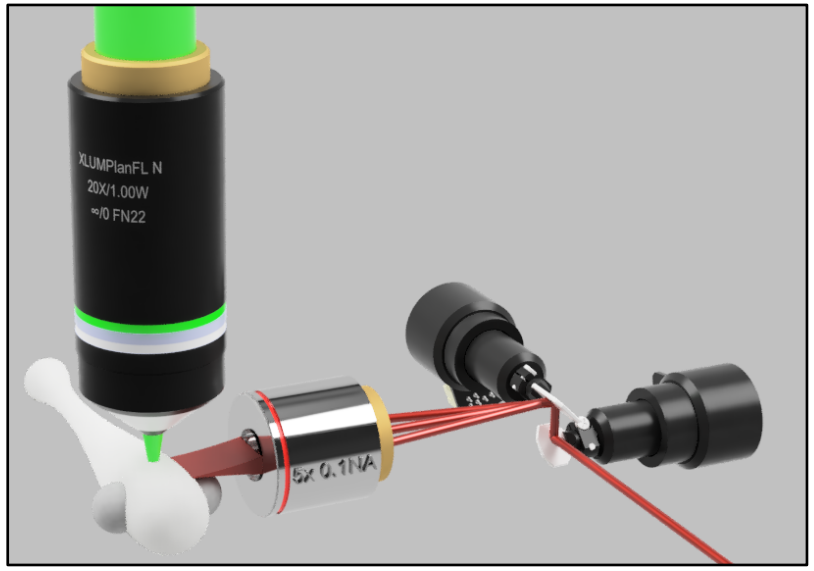
Example of rendering: zebrafish & light-sheet







- Rendering is done by selecting materials for each object
- Can rotate, adjust lighting, and backdrop

- “Show, don’t tell” – easier to explain principles by using real-world models
- Easy to iterate
- Partially based on real models, not over-simplifications

- Advanced technique: creating animation based on joints

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Example of rendering: animating model

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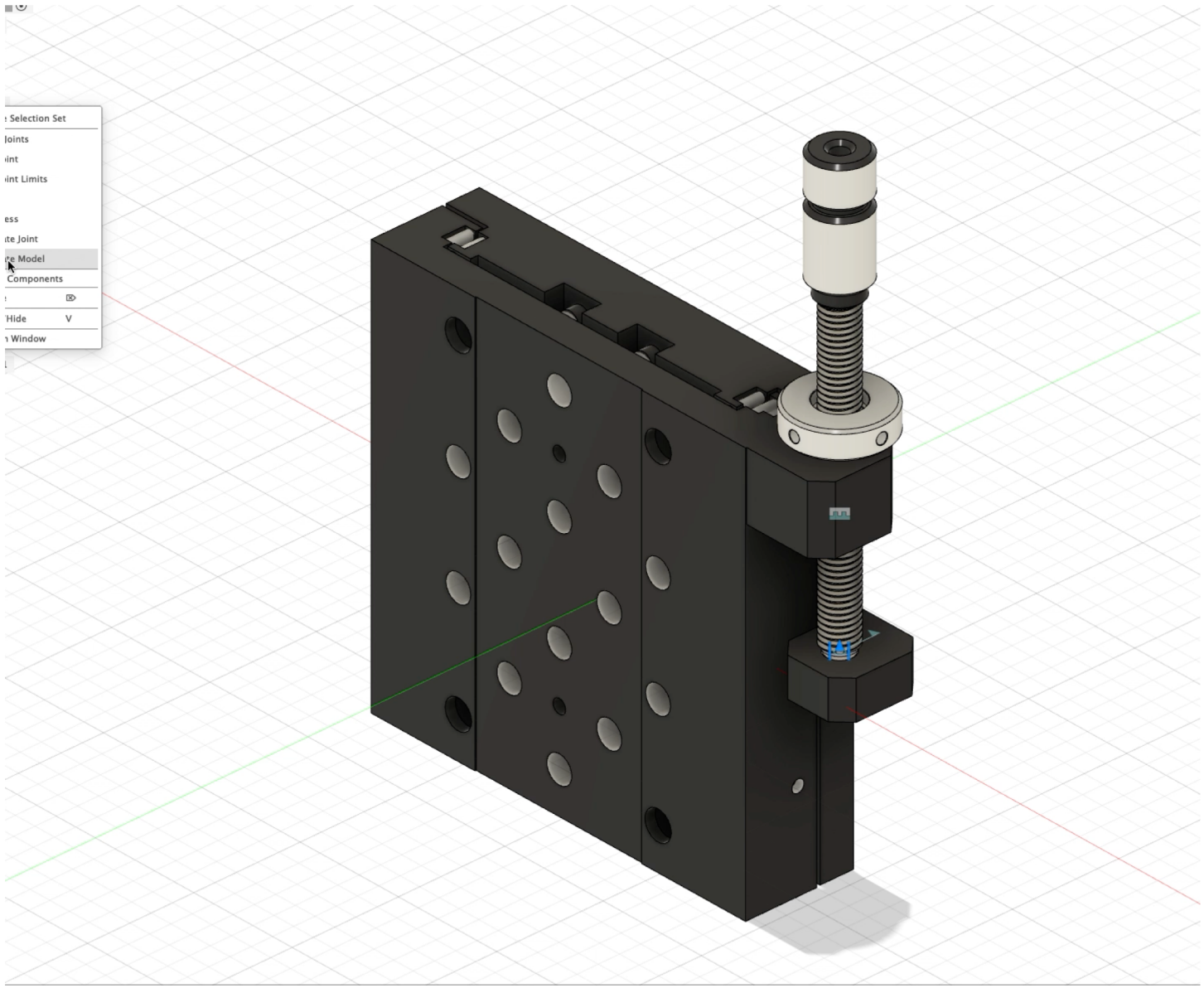
- **Advanced technique: creating animation based on joints**



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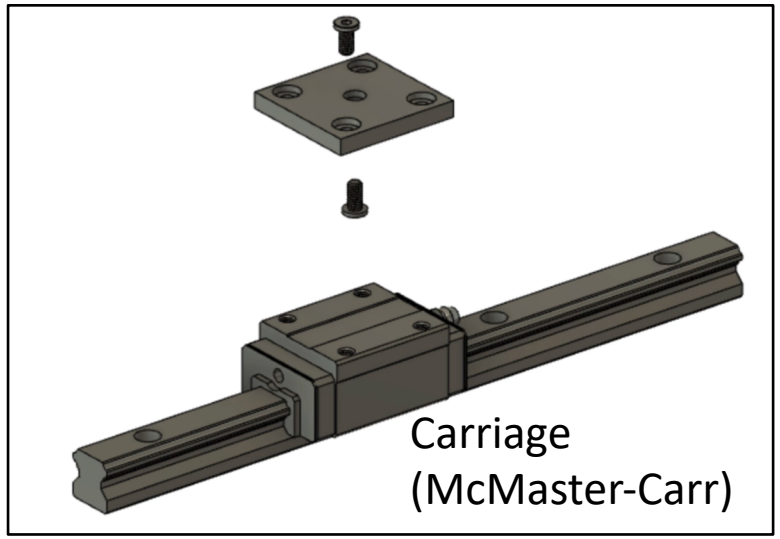
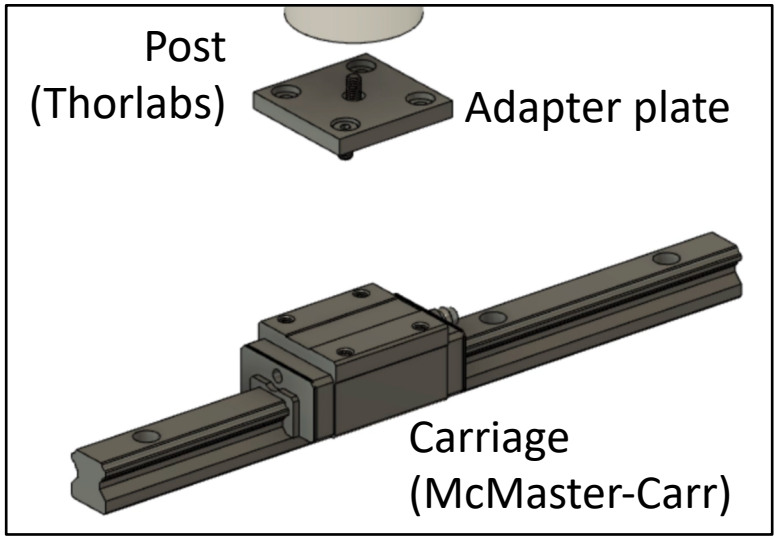
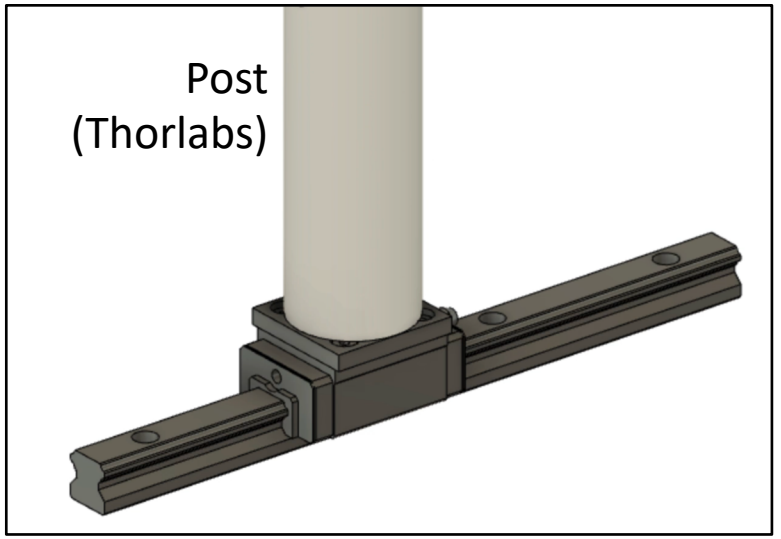
Example of fabrication: simple adapter plate







- Post has US holes, carriage (bottom) has metric holes
- Adapter plate is designed within the same software, using models from Thorlabs and McMaster-Carr
- Bolts are also imported from real models
- Final model can be sent for fabrication or 3D printing

- Design time: 10 min
- In that case, after reviewing the assembly video, we realized that's a bad design

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