

**R.E.C.O.R.D.**  
(Reward-Cost in Rodent Decision-making)  
**Arena setup guide**

Revision 1.1

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# Introduction

This assembly guide will serve to help you create the 3D printed rodent decision-making arena. The arena is assembled utilising SLA 3D printing and custom electronics to allow for a custom-made task to be used in the study of decision-making and disorders in rodents. Such flexibility allows for on the fly changes and adaptations to the experimental environment and process, as well as animal behaviour. Further, it enables the interchangeability and replacement of maze arenas and parts as they wear down over the course of thousands of behavioural trials. In this guide you will find the parts and materials, dimensions and measurements, along with links and assembly instructions, to our custom maze arenas and electronic system(s).

Directly below is a link to our Github repository with finished versions of the CAD drawings we used to 3D print the behavioural open-field arena. Under the “stl” directory, you will find STL files for each arena component, ready to print after download. The “cad” directory contains .dwg CAD files of each of the arena components, more convenient for editing.

<https://github.com/rjibanezalcala/RECORD/tree/main/3d-prints>

## Why 3D printed arenas?

We use 3D printing rather than store-bought or DIY because of the modularity and customizability it provides. We use 3D printing to create more customised platforms that can act as a simulated habitat for the animal subjects. The different individual components act as modifiable building blocks that can be reorganised to different shapes and sizes to accommodate for different test subjects such as either rats or mice. The arenas can also be built in different sizes to provide further freedom in customization. Our 3D-printed feeder is a custom design to fit the purpose of human-translatable cost and reward delivery, while also taking advantage of natural behaviours like foraging and threat avoidance. The corners of the maze are designed as a baseplate to hold any kind of variation on the cost/reward delivery system, for example, one may design an air puff nozzle to deliver cost instead. One may also choose to add more than 4 feeders to an arena for more resolution of the decision-making “range”.

## The RECORD open-field arena

### Materials

Below is a suggested list of materials for a square RECORD arena. We include the materials needed for a smaller 4 x 4 mouse arena, but the rest of this guide assumes an 8 x 8 rat arena.

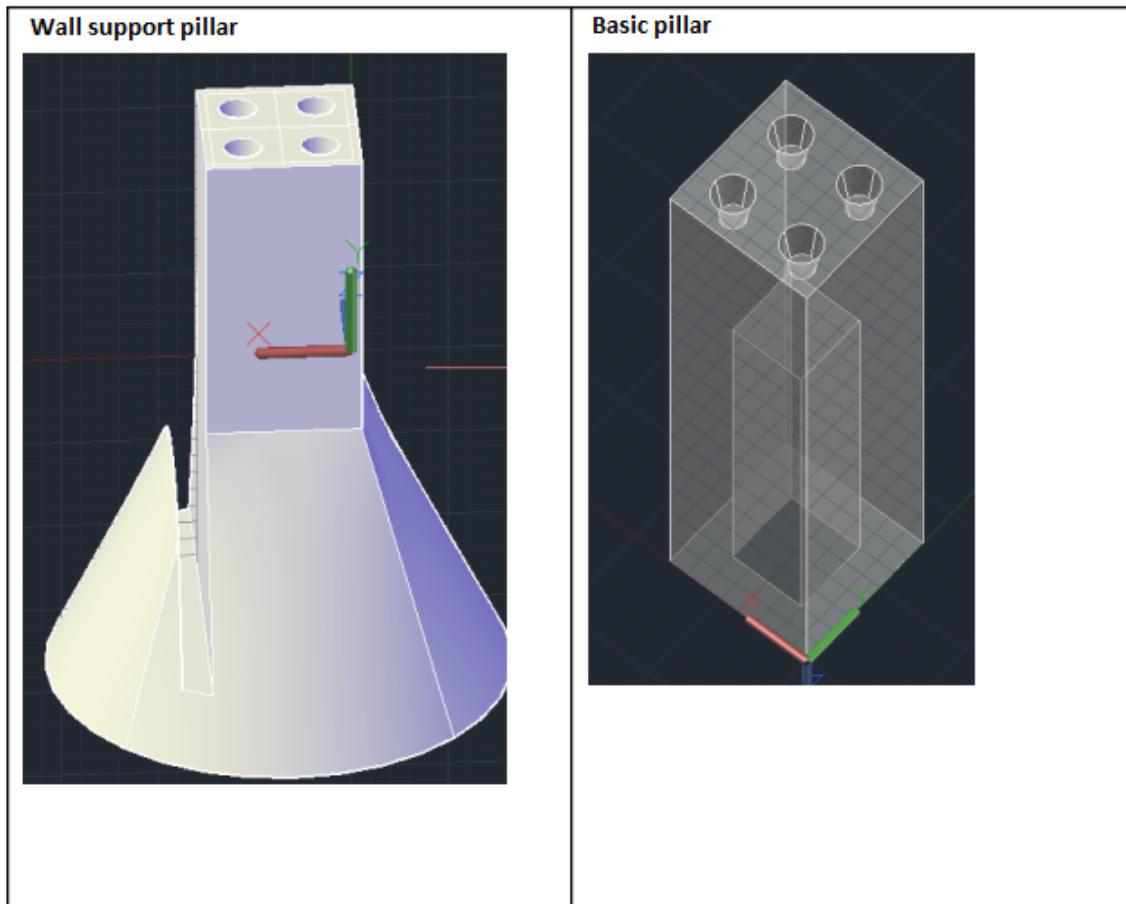
Component	Quantity for rat arena	Quantity for mouse arena	Approx. resin required per piece	Source
<b>3D print</b>				
Diagonal floor tile	15	3	40 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Diagonal%20Floor%20Tile.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Diagonal%20Floor%20Tile.stl</a>
Grid floor tile	15	3	40 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Grid%20Floor%20Tile.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Grid%20Floor%20Tile.stl</a>
Horizontal floor tile	15	3	40 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Horizontal%20Floor%20Tile.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Horizontal%20Floor%20Tile.stl</a>
Radial floor tile	15	3	40 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Radial%20Floor%20Tile.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Radial%20Floor%20Tile.stl</a>
Wall support pilar	12	8	62 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Wall%20Support%20Pillar%20v2.0.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Wall%20Support%20Pillar%20v2.0.stl</a>
Basic pillar	65	17	50 mL per piece	<a href="https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Basic%20Pillar%20v2.1.stl">https://github.com/rjibanezalcalal/RECORD/blob/main/3d-prints/stl/Basic%20Pillar%20v2.1.stl</a>
Feeder base tile	4	4	20 mL per piece	

				<a href="https://github.com/rjibanezalcalca/RECORD/blob/main/3d-prints/stl/Feeder%20Base%20Tile.stl">https://github.com/rjibanezalcalca/RECORD/blob/main/3d-prints/stl/Feeder%20Base%20Tile.stl</a>
Feeder	4	4	25.5 mL per piece	<a href="https://github.com/rjibanezalcalca/RECORD/blob/main/3d-prints/stl/Feeder%20v1.9.9.stl">https://github.com/rjibanezalcalca/RECORD/blob/main/3d-prints/stl/Feeder%20v1.9.9.stl</a>
<b>Other materials</b>				
Formlabs Form 3/3+ SLA printer *	-	-	-	<a href="https://formlabs.com/3d-printers/catalog/">https://formlabs.com/3d-printers/catalog/</a>
Formlabs Tough 2000 resin *	-	-	-	<a href="https://formlabs.com/materials/rough-durable/">https://formlabs.com/materials/rough-durable/</a>
Superglue	-	-	-	Local hardware store
Acrylic PVC sheet (opaque white) 48" x 24" x 0.125"	4	4	-	<a href="https://www.grainger.com/product/GRAINGER-APPROVED-Plastic-Sheet-0-125-in-Plastic-44ZTZ7">https://www.grainger.com/product/GRAINGER-APPROVED-Plastic-Sheet-0-125-in-Plastic-44ZTZ7</a>
Tools for cutting PVC sheet	-	-	-	Local hardware store
Spray paint primer Rust-Oleum 2x ULTRACover primer **	-	-	-	Local hardware store
Neon green spray paint **	-	-	-	Local hardware store

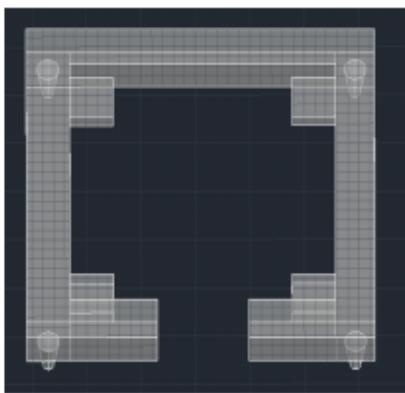
\* If desired, one may print the floor tiles using FDM printing instead, however, it is recommended that SLA printing is used for at least the feeders, as these must be water-tight and require

precision. Type of resin is not critical for the floor pieces as they do not bear much weight, but the wall support pillars may also require a tougher material for support of the arena walls.

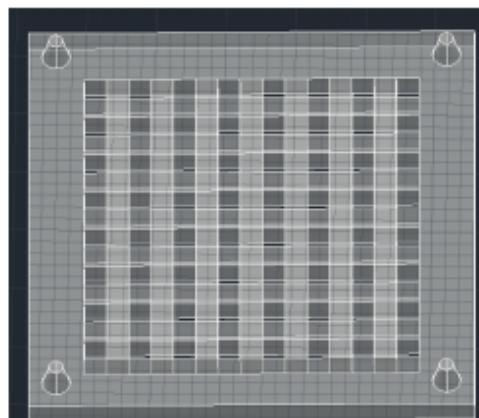
\*\* Only important if recording in with colour video. If recording under infrared, the colour of the arena floor is not as important.



**Feeder base tile**



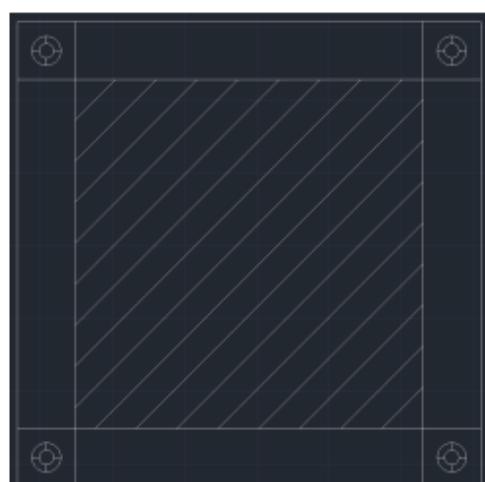
**Grid floor tile**



**Horizontal floor tile**



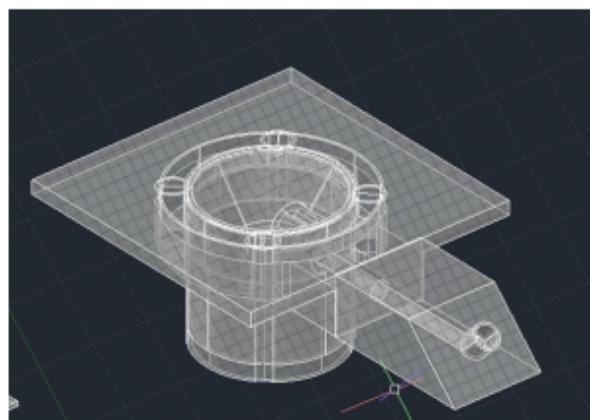
**Diagonal floor tile**



**Radial floor tile**



**Feeder**



# RECORD arena build guide

## Step 1:

*The arena floor was designed so it can be modified in scale to fit different size animal subjects, check if you need to modify for scale. See the table above to find out how many of each arena component you'll need.*

Lay the floor tiles face-down (nubs should face up) on a large, flat surface. Place the tiles down so that the diagonal tile quadrant diagonally opposes the radial quadrant, and the grid quadrant opposes the horizontal quadrant. Place a feeder base tile on each corner, with the opening on each side facing the same direction. Each quadrant should be 4 tiles by 4 tiles for a rat arena, and 2 tiles by 2 tiles for a mouse arena.

## Step 2:

Simple pillars are to be located wherever two or four tiles meet and at the corners. They should also be placed flush with the sides of the arena floor.

Each side of the arena floor should also have at least 2 (though we use three) wall support pillars to securely hold a wall on each side. Make sure that, on each side, the notches on the pillar base face out from the centre of the arena.

Doing so one quadrant at a time, super-glue the simple and support pillars to the underside of the arena. Use a flat, heavy object to press the components down while the glue cures and make sure the pillars do not tilt.



**Step 3 (optional):**

*If behavioural recordings will be done in colour video, or if the printed arena has a glossy finish, you may choose to paint the RECORD arena a colour that contrasts that of the rodent subjects. We chose a neon green colour as a general purpose colour for any breed of rat.*

Using a respirator and in a well ventilated area, spray one or two coats of primer onto the arena floor and the feeders. When the final primer coat has dried, spray the neon green paint onto the arena until the arena floor is uniformly coated. Let both the primer and paint dry in-between coats. Optionally, you may add an additional clear coat on top of the paint, however it is important that the arena floor has a matte finish to avoid glare.

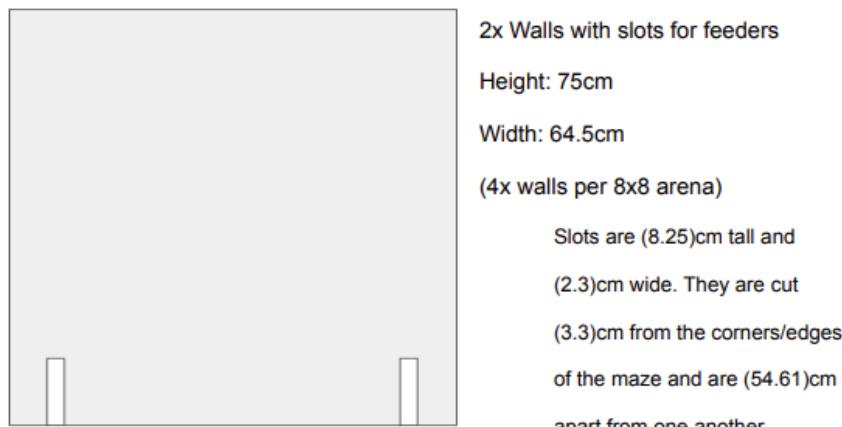
**Step 4:**

*The arena walls serve to not only prevent the rodents from wandering off and away from the RECORD arena, but also to prevent the animal from getting too distracted by the test environment. Because of this, the PVC sheets should be non-reflective and a neutral, solid colour. However, this does not mean that this design cannot be modified to add a pattern on the wall.*

Cut four acrylic PVC sheets to be about the length of 8 floor tiles or one side of the square arena (~64.5cm), and around 50 - 60 cm tall. Make sure that the walls fit snugly around the arena with little to no gap at the corners.

If the size of the sheets is satisfactory, pre-drill screw holes on either side of the sheet nearing the top of the sheet to add a corner bracket. This bracket will hold the sheets together to form a square.

Because the feeders need to jut out from the arena walls, measure and cut two slots on two of the sheets or wherever the open face of the feeder base tile faces. These slots must be as snug to the feeders as possible, while still allowing them to be lifted from the tail. We have provided approximate measurements in the figure below.



**Step 5:**

Join the four walls with a corner bracket on each corner and secure them with screws. The wall assembly should then be ready to be lowered onto the nooks at the base of each wall support pillar.

## Reward delivery assembly

### Materials

The reward delivery assembly involves five components:

Component	Quantity per arena	Measurements	Source
Food-grade plastic tubing	~ 458 cm	3 mm I.D.	
Zero-pressure Solenoid valves	4	½" Female pipe thread, Normally closed, 0 psi minimum operating pressure differential	<a href="https://www.grainger.com/product/ASCO-Solenoid-Valve-1-8-in-Pipe-4ELA1?searchQuery=4ela1&amp;searchBar=true&amp;tier=Not+Applicable">https://www.grainger.com/product/ASCO-Solenoid-Valve-1-8-in-Pipe-4ELA1?searchQuery=4ela1&amp;searchBar=true&amp;tier=Not+Applicable</a>
Hose barb adapters	8	½" barb to ½" male NPT (National Pipe Thread)	<a href="https://www.amazon.com/Metalwork-Adapter-Barbed-Connector-Fitting/dp/B07ZBQ146L">https://www.amazon.com/Metalwork-Adapter-Barbed-Connector-Fitting/dp/B07ZBQ146L</a>
Plastic syringe	4	60 cc	
Syringe tips	8	-	
Wide-base stand	~ 1 m tall	-	
Teflon tape	-	-	Local hardware store

The main purpose of the reward delivery assembly is to dispense liquid reward into the RECORD arena feeders. Solenoid valves allow us to electronically control how much liquid reward is dispensed by varying how long the valve remains open (see the RECORD user guide).

This part of the guide focuses on making only one reward delivery assembly. No more than one of these assemblies is needed per arena (unless more than four reward levels are implemented), and it is recommended that each is placed near its respective arena.

## Reward delivery assembly build guide

### **Preparation:**

Make sure to decide where in your setup the reward delivery assembly will be placed.

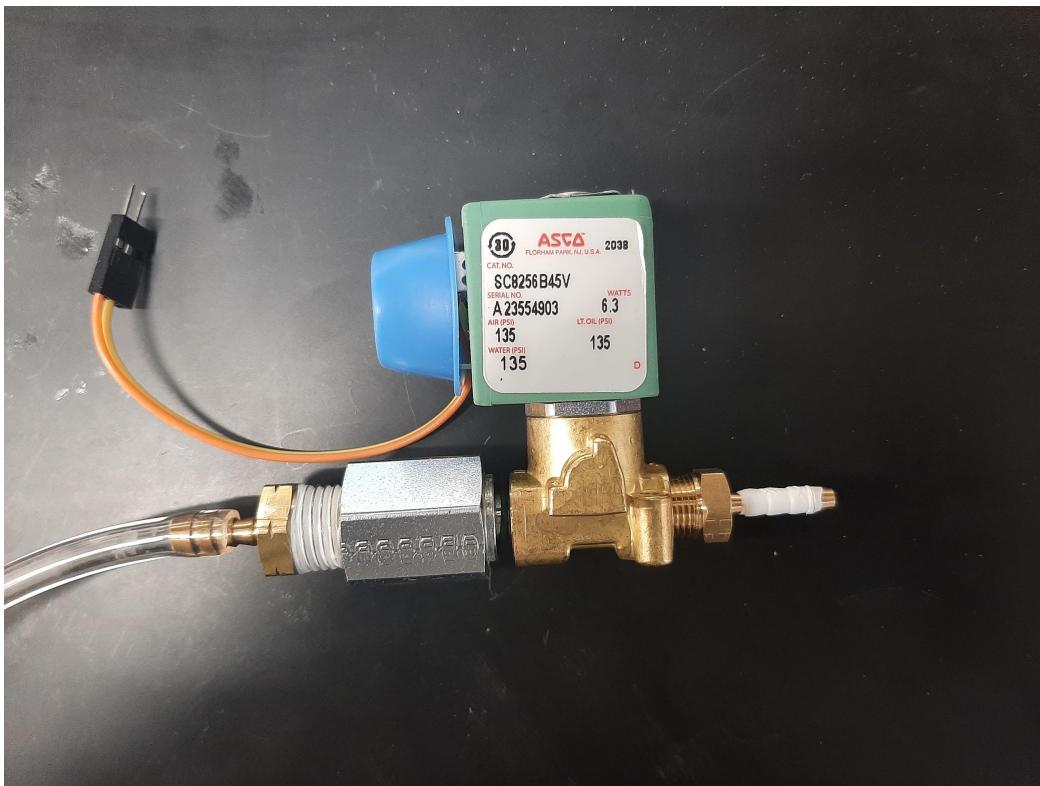
Take note of the distance between the stand and each of the feeder corners, as this will be important for determining how much tubing you'll need.

### **Step 1:**

Start by attaching two barb hose adapters to each end of the solenoid valve. If the adapter is not of the exact measurements, a pipe reducer can be used (see picture below). Wrap the thread of the adapters in teflon tape to ensure that no liquid leaks through the joints.

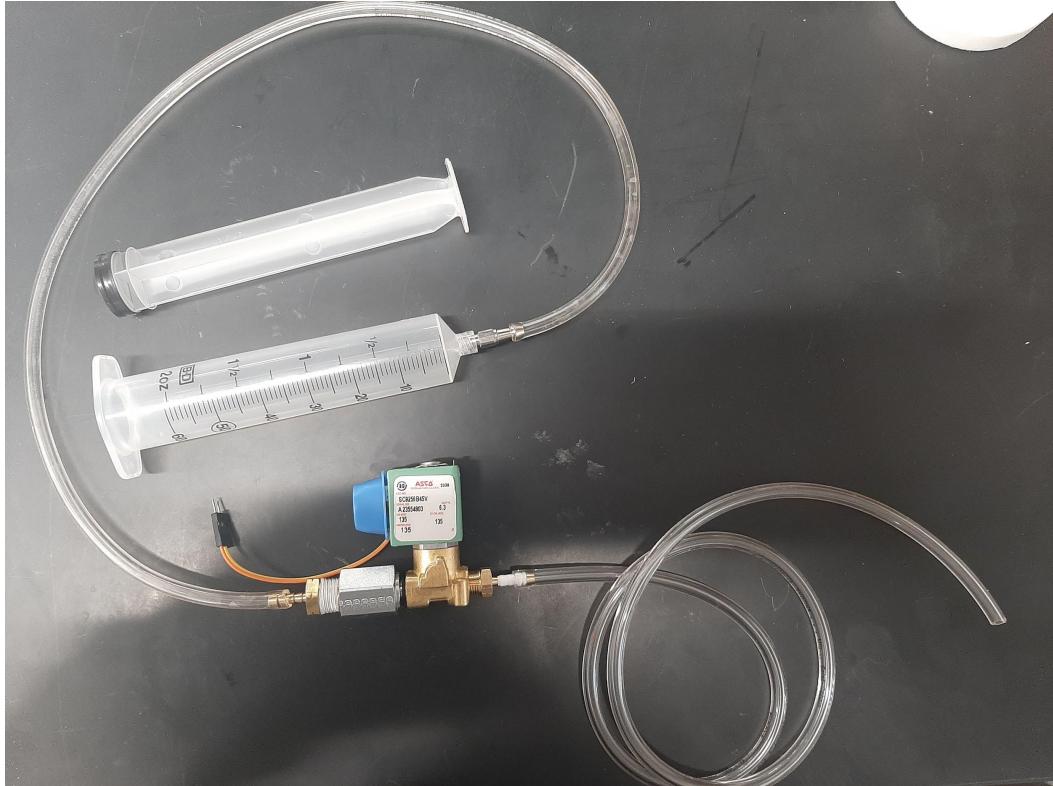
### **Step 2:**

Decide now which end will be the input (syringe to valve) and which will be the output (valve to feeder). Attach a shorter section of tubing (about 25 cm) to the valve input; this will be the tubing that will run from the liquid reward receptacle (syringe) to the valve. Next, attach a longer section of tubing to the output side of the valve. The output tubing should be long enough to extend from the valve to the feeder already installed onto an arena with some slack, so measure this before cutting the tubing.



**Step 3:**

Remove the plunger from the syringe. Attach the other end of the input tubing to a syringe tip and install the syringe tip onto the syringe. You may use the syringe plunger to test if there are any leaks between these components. Keep the plunger as it may help get rid of bubbles or clogs in the system.

**Step 4:**

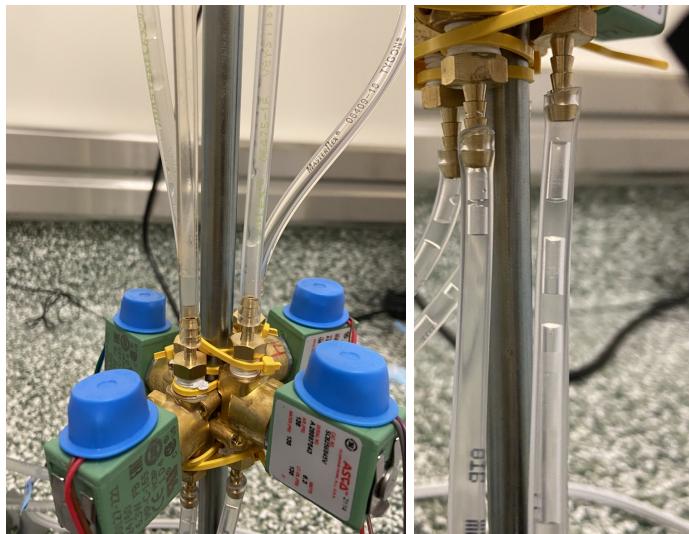
Repeat steps 1 through 3 for all four valves. Mount the four valve assemblies to the stand using braces or zip ties. All four syringes should be at around the same height, and the four valves should also be at around the same height. Keep in mind that the higher the syringes and valves are, the more pressure can build up in the system. Adjust the height of these components appropriately.

**Step 5:**

If you have not already, install all four feeders onto the arena. Attach the other end of the output tubings to the end of each of the feeders, keeping note and marking which valve and syringe corresponds to each feeder. Connect the RECORD valve cables to each of the valves. To test, fill the syringes with plain water and use the RECORD system with a serial console window (see RECORD user guide) to open the valves until the whole system is full with water and test if water can be delivered to the feeders.

**If the valves are working but the water is not running through properly:**

Make sure that the input tubing is properly inserted into the hose adapters and syringes. Also make sure that there isn't a large bubble in the system. Check if when opening the valves, the pockets of air move.



# Camera setup

The camera setup enables spatial tracking of the rodents on the record arena. There exist other spatial tracking methods, such as lighthouse tracking, but many may follow the same procedure described below. Here, we provide materials and a general setup guideline to follow for recordings in low- to no-light conditions with gigabit cameras, as we have used in our validated RECORD setups.

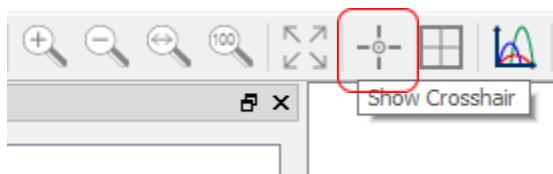
## Materials

Component	Quantity per arena	Specifications	Source
CMOS sensor with compatible lenses (Gigabit camera)	1	Gigabit, Infrared sensor *, 1280 px x 1024 px	<a href="https://www.baslerweb.com/en/products/cameras/area-scan-cameras/ace/aca1300-60gc/">https://www.baslerweb.com/en/products/cameras/area-scan-cameras/ace/aca1300-60gc/</a>
PoE (power over ethernet) power supply for camera	1	-	<a href="https://www.amazon.com/Injector-Adapter-1000Mbps-802-3af-Compliant/dp/B07V24C4M8/">https://www.amazon.com/Injector-Adapter-1000Mbps-802-3af-Compliant/dp/B07V24C4M8/</a>
PCIe ethernet adapter	1	One or multiple ports, Gigabit ethernet	<a href="https://www.amazon.com/Dual-Port-Gigabit-Network-Express-Ethernet/dp/B09D3JL14S/">https://www.amazon.com/Dual-Port-Gigabit-Network-Express-Ethernet/dp/B09D3JL14S/</a>
Extendable mounting autopole	< 1	Maximum length dependent on room size	<a href="https://www.manfrotto.com/us-en/autopole-black-extends-from-210cm-to-370cm-032bl/">https://www.manfrotto.com/us-en/autopole-black-extends-from-210cm-to-370cm-032bl/</a>
Autopole clamp	3	-	<a href="https://www.manfrotto.com/us-en/super-clamp-w-stud-035rl/">https://www.manfrotto.com/us-en/super-clamp-w-stud-035rl/</a>
Camera software	1	-	<a href="https://www.baslerweb.com/en/downloads/software-downloads/software-pylon-7-3-0-windows/">https://www.baslerweb.com/en/downloads/software-downloads/software-pylon-7-3-0-windows/</a>
Infrared (IR) illuminators *	2	-	<a href="https://axtontech.com/illuminators/ir-illuminator-smart-at-11s/">https://axtontech.com/illuminators/ir-illuminator-smart-at-11s/</a>

\* Needed if recording in low-light or no-light conditions.

## Animal spatial tracking guidelines

- The autopole should be placed directly above (but not necessarily centred with) the RECORD arena. This is where cameras and illuminators will be mounted onto.
- Place the autopole high enough so that it does not hinder access to the RECORD arena, but not so high that the camera cannot be adjusted to only have the arena floor in view.
- Mount the camera and IR illuminators onto their respective clamps before mounting onto the pole.
- Connect the cameras to your computer and open the camera preview to align the RECORD arena so that it is centred in the camera's view. The crosshair utility on the Pylon Viewer is especially helpful for this.



- If using spatial tracking software such as Ethovision XT, keep in mind that the arenas must always be in the same spot in order for the animal detection to work well. Otherwise, arena settings or detection settings will need to be adjusted every time.
- Use the Pylon Viewer software to adjust the resolution, image quality, colour, colour corrections, etc before starting any recordings. If using a Bonsai-driven setup, keep in mind you will need to export the camera features into a file and feed them into your Bonsai workflow.

# Resource table

[Under construction]