

## **Stereotactic device compatible with a 4.7 tesla magnetic resonance imaging system (stereotactic\_device)**

### **Team Members**

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### **Problem Statement**

This project requires the design and fabrication of a stereotactic device used to minimize the movement of the heads of anesthetized animals whilst positioned within a 4.7 T magnetic resonance (MR) imaging scanner.\* The magnetic field within the scanner is approximately 100,000 times greater than the Earth's magnetic field and therefore significantly restricts the choice of materials that may be used. Consequently, the entire system should be constructed of MR-compatible materials that are non-magnetic and non-conductive, to avoid artifacts and distortion of the MR images. The device should fit into a range of MR coils used specifically for imaging mice or rats and should also be able to support the positioning of additional MR coils so that images may be obtained from different anatomical regions. Further refinements might include the incorporation of a warming unit, using circulating water or air, within the base of the device. The unit construction may involve the use of 3D printing techniques. In addition, the stereotactic device should also be compatible with a dedicated uCT/PET system so that images may be more easily merged between the three different imaging modalities. In addition to the design and fabrication processes, this project would provide the opportunity to gain some experience with the use of both a 4.7 Tesla dedicated animal MRI and a uCT/PET systems.

### **Client Requirements:**

- The unit cannot interfere with the imaging device (MRI compatible)
- The unit has to be able to fit within the rat coil (63mm diameter)
- Anesthetic mask must be able to reach the animal's mouth
- Animal's head should be stable and centrally aligned within the MRI
- The unit should be able to heat the mouse at a constant temperature, as programmed by the imaging technician.

### **Design requirements**

- The unit must be able to deliver an anesthetic to the animal using a mask.
- The restraining device will consist of ear pegs and a tooth restraint to stabilize the animal.
- The rodent's brain must be located in the center of the coil while in the restraint.
- The rat will be heated by an HTP-1500 Heat Therapy unit with a small animal heating pad.
- The rodent must be kept at a temperature within 5° of 37°C
- All motors and pumps must be kept at least 3m from the restraining unit.

### **Physical and Operational Requirements**

- a. *Performance Requirements* – The device should be able to be easily adjusted to fit the subjects. Specifically, the ear pegs should be able to be firmly adjusted to the mouse’s head. Also, the mouse’s mouth must be accessible for the anesthetic mask.
- b. *Safety* – The unit cannot harm the animal in any way, including over/underheating or excessive pressure on the skull.
- c. *Accuracy and Reliability* – The rat’s brain must be located directly in the center of the coil. Also, the rat’s head must be properly aligned so that the brain is level for proper orientation in the imaging plane. The heating unit must be able to automatically hold a constant temperature programmed by the technician.
- d. *Life in Service* – The unit should be able to withstand frequent use in a controlled, clinical environment for a long duration.
- e. *Shelf Life* – The unit should not degrade while in storage.
- f. *Operating Environment* – The unit should be able to withstand a strong magnetic field, up to 4.7 T, without deforming. Animal waste should not be able to affect the performance of the unit. The heating unit should not cause damage to the restraining device.
- g. *Ergonomics* - The device should be able to firmly restrain the animal without causing any harm. The device should be easily adjusted by the imaging technicians.
- h. *Size* – The unit must be able to fit within the specific diameters of the rat coil, 63 mm in diameter. All motors and pumps must be kept at least 3m from the restraining device. Since our design will not easily fit into the existing cradle (50mm diameter), we will fabricate our own cradle for use that is 63mm external diameter, 58mm internal diameter.
- i. *Weight* - The weight should be as minimal as possible, but able to support a 500g rat.
- j. *Materials* – All materials inside the MRI must be MR compatible. These materials are non-metallic such as plastic or silicon based products, or non-ferromagnetic. Non MR compatible materials must be kept 3m from the restraining unit. We will use nylon for the restraint and polycarbonate for the cradle.
- k. *Aesthetics* – The heating unit must be easy to read, preferably with numerous small visual indicators for the technicians to monitor.

### **Product Characteristics**

- a. *Quantity* – 1 restraining unit, one heating unit and one cradle will be fabricated. Ideally, the design will be such that future models can be built in a reduced size for the imaging of smaller mice.
- b. *Target Product Cost* – Budget will be adequate for the manufacturing of these units.

### **Miscellaneous**

- a. *Standards and Specifications* – The unit will fit within the client’s current testing protocol, thus no further board approval is necessary.
- b. *Customer* – The customer would prefer a unit with visual indicators and digital adjustment for the heating system.
- c. *Patient-related concerns* – The unit must be wiped down with an anti-septic solution in between rat subjects.
- d. *Competition* – There are numerous other similar stereotactic devices for small rodents. Examples are the KOPF Model 324 MRI Head Holder and the Harvard Apparatus 51624

Mouse Adaptor. However, no current models have an integrated heating element as well. This model is also specifically designed to fit the coils mentioned above.