# 3D-Printable Platform for High-Throughput Small-Animal Imaging

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**TO THE EDITOR:** There is considerable interest in preclinical imaging techniques to increase throughput and reduce costs, as evidenced by recent and former publications in the field.[1–3] We write this letter to share a 3D-printable design that has been in use at our institution and several others for small animal PET/CT, and which we feel would likewise benefit the community, particularly at facilities that encourage DIY approaches. Our design is inexpensively manufactured with 3D-printers that are increasingly accessible at many institutions. Due to its compact size, it is easy to integrate with a wide variety of scanner models and apply to various imaging configurations. We have attached the design files in the electronic supplementary information of this letter, along with a short video demonstrating assembly of the components. We highly encourage the reader to watch the video, as it thoroughly details the ease of construction and utility of our design.

**METHODS**

The use of this design for murine PET/CT imaging was conducted under the protocol approved by the Institutional Animal Care and Use Committee (IACUC) and Research Animal Resource Center (RARC) of Memorial Sloan Kettering Cancer Center. The design (Fig. 1) was generated in the open-source computer-aided modeling software Blender®, making use of Boolean operations on geometric primitives and a small amount of basic mesh manipulation. Several inexpensive, commercially available components were utilized for connection to an anesthesia system:
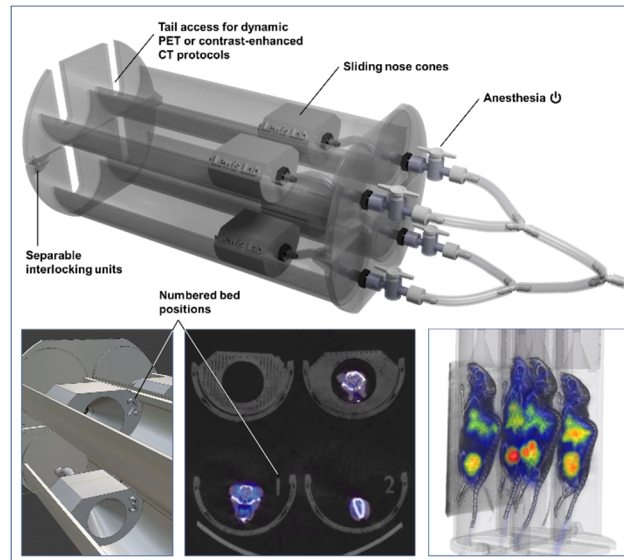
**FIGURE 1.** Top: Rendering of the 3D-printable multi-mouse imaging platform structure and design features. Bottom middle: Axial PET/CT images acquired using the platform. Bottom right: Overlay of PET and CT volume-rendered projections with bed geometry within 3D Slicer software.

- Barbed UNF male pipe adapter, ¼"-28 UNF × 1/8" ID (× 4; Cole Parmer #31501-54)

- Female Luer bulkhead, 1/4-28 UNF to 1/8" hose barb (× 4; Cole Parmer #45508-34)

- Stopcock with Luer connections, 1-way, male lock (× 4; Cole Parmer #30600-00)

- Male Luer with lock ring × 1/8" hose barb (× 4; Cole Parmer #45504-04)

- Barbed Y-Connector, 1/8" ID (× 3; Cole Parmer #30703-92)

- Tygon tubing, 3.1 mm ID (Cole Parmer #06440-16)

Following 3D printing, assembly requires only ~5 minutes using the following basic tools:

- Drill

- ¼"-28 UNF tap (Grainger #427R24)

- 8 mm open-end wrench (Grainger #36T946)

- Scissors or utility knife

The design has been tested for compatibility with the Siemens Inveon and Concorde MicroPET Focus 120 scanners, and care was taken to ensure the design would be easily modifiable should it need to be shortened, lengthened or otherwise adjusted for compatibility with other scanners, animal size, accommodation of experimental apparatus or other desired features.

## DISCUSSION

We encourage the reader to refer elsewhere[1–3] for a detailed discussion of resolution and image quality obtainable with standard radionuclides (e.g. $^{18}$F, $^{11}$C) in simultaneous multi-animal imaging. We stress that utilization of this or similar designs

for simultaneous multi-animal PET imaging demands that appropriate acceptance testing measures for quality assurance are conducted, especially when quantitative images are required. In addition to the standard NEMA NU-4 2008[4] tests for image quality, we recommend that some tests also be assessed at each bed position, including uniformity, spatial resolution, and activity recovery/spillover. As in the present design, the bed positions are offset from the center of the field of view (where spatial resolution is maximal), the spatial resolution should be known or evaluated to a radial extent at least as large the radius of a circle circumscribing the four bed positions (~4 cm). Additionally, as simultaneously imaging multiple mice typically involves elevated activities within the scanner field of view, it is critical to ensure the scanner count rate performance is taken into account to ensure accuracy of detector dead-time corrections. This is particularly important for non-standard radionuclides, as in addition to the aforementioned considerations: 1) many non-standard positron emitters emit concomitant gamma rays which may significantly contribute to dead-time counting losses, especially with elevated activities within the field of view associated with simultaneously imaging multiple mice, and 2) prompt gamma coincidences, which occur given radionuclides with gamma emissions within or down-scattering into the positron annihilation energy window (e.g. $^{86}$Y, $^{124}$I), are amplified when multiple mice are within the scanner field of view. We note that preclinical PET imaging workflows for mice often neglect corrections for attenuation and scatter due to their relatively minor impact for small animals such as mice; however, we recommend these corrections for multi-mouse imaging due to the increased quantity of attenuating material and increased likelihood of scatter. Finally, we note that there are no provisions included in our design for animal monitoring or body temperature maintenance, which may be required in, e.g., FDG imaging or extended scanning periods. Provisions for monitoring/temperature control may be added by the user, but should be evaluated by their IACUC prior to use.

## CONCLUSION

The use of multi-animal imaging protocols at our institution has greatly streamlined many imaging studies while reducing cost. We greatly value and encourage recent efforts, both commercially aligned as well as community-contributed, toward development of imaging solutions to increase throughput while maintaining quantitative accuracy.

## FUNDING ACKNOWLEDGEMENT AND DISCLOSURE

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